C.H.M. Broeders
W. Gudowski

22.02.2006

ISTC-Contact Expert Group on Nuclear Transmutation related Projects

MINUTES
Annual meeting – 2006, Brussels, January 30 - 31

Topical Summary
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Topical Summary of the ISTC-Contact Expert Group on Nuclear Transmutation related Projects Annual meeting – 2006, Brussels, January 30 - 31

The list of participants is given in Appendix 1. The proposed draft agenda was accepted (Appendix 2).
B. Rhode, J. Sanders, M. Hugon, D. McNelis and A. Bychkov were specially invited for the CEG meeting.

The CEG meeting consisted of three parts:

I. General issues, programmatic approach.
II. On-going projects reports
III. Analysis of proposals

I. General issues, programmatic approach

1. **W. Gudowski, Chairman CEG,**
   - thanked M. Hugon for his work as a secretary of the CEG Transmutation and Partitioning (T&P),

   - paid tribute to late four Russian scientists, leaders of ISTC projects, B. Murin (#1653), E. Efimov (#0559 and #2083), V. Barashenkov (#17, #2267), and Y. Shubin (#1372, #2578),

   - presented a "Short history of the CEG" (Appendix 3) with its main role as:
     - reviewing and putting priorities on ISTC project proposal in the nuclear transmutation field,
     - preparing and realizing a strategy and working plans for a broad collaboration between European / Western and Russian (CIS) partners using an ISTC frame,

   - reminded some milestones of CEG activities since 1998:
     - white Paper defining a CEG mode of operation,
     - lasting cooperation with many projects in Russia, Ukraine and Belarus, with a successful integration of those projects into a broad European collaboration, including projects funded through the European Framework Programs,
     - spectacular success of "Spallation Target Project" ISTC #559, bringing Pb-Bi technology into Europe, Japan, Korea and USA and originating many international projects including MEGAPIE in Würenlingen, KALLA-laboratory in Karlsruhe, Pb-Bi loops in Brasimone, Italy, Stockholm, Sweden and Mol, Belgium,

- gave a comprehensive overview of the ongoing ISTC projects, with particular attention to projects #B070 (**YALINA**) and #2267 (**SAD**), with creation and activities of the SAD/YALINA Steering Committee (SY-SC)
    - the SY-SC had five important meetings since the middle of 2004,
    - played an important role in integration of SAD and YALINA into the EC FP6 Integrated Project EUROTRANS,
    - the "Round table" discussion at JINR Dubna with participation of SY-SC members, JINR management and ISTC executive director caused that SAD was approved as a project of high priority at JINR with significant financial support committed by JINR

- emphasized the objectives of this CEG meeting:
    - coordinated support for integrated experiments SAD and YALINA for ADS and Transmutation, with integration in the EUROTRANS project,
    - continuation of YALINA experiments (extension of #B070 and links with #B1341),
    - continuation of the nuclear fuel-related projects: nitrides (#3080 - MATINE-2) and molten salts (#1606, #3261),
    - further support for the Pb-Bi technology project (#2048),
    - enhancing interest and coordination in the field of partitioning.

- Finally, W. Gudowski presented a vision of gradual transforming ISTC mechanisms into regular collaborative projects in the frame of the European Framework Programmes

2. **J. Sanders, European Commission,**
    - presented priorities of EC concerning ISTC, stressing that integration of ISTC projects into EC Framework Projects is encouraged,
    - mentioned that the mode of operation of the CEG on Transmutation related Projects has been successfully adopted by EC as a model for other CEG's and is strongly supported as a good mechanism of interactions with ISTC,
    - pointed out that recommendations of CEG's and priority lists are not binding for decision makers in EC, but have a very high and respected value.

3. **L. Tocheny, ISTC,**
    - put attention on the role of CEG for coordination with preparing the EC 7th Framework Program,
    - described the model of ISTC "partnership projects" and its applications:
        - USA is particularly active in developing partnership projects,
        - For EU only 10-20% of projects are partnership projects
    - mentioned that total funding of ISTC for "non-nuclear" projects is much larger than for nuclear ones,
    - gave information on other ISTC CEG's: e.g. Plant Life Management, VVER issues, and non-nuclear topics like aeronautics:
        - the CEG on Severe Accident Management (SAM) launched, in the environment of the ISTC WEB-service, a special WEB-page related to its activity. This page contains current and final project reports and CEG reports as well. Some information is restricted.
        - CEG SAM participated actively in an ISTC Specific Training Program. The CEG T&P should follow this examples.

4. **M. Hugon, European Commission,**
reported on the creation and activities of the ISTC CEG for Severe Accidents Management (SAM) projects.

- This CEG SAM has started with analyzing the problems with Corium and later it was extended to much broader topics.
- Currently, eight regular projects and one partnership project are managed by the CEG.
- Three to five more projects are expected after the ongoing preliminary phase.
- CEG discussions were preceded by on-site visits and workshops.
- Eight meetings have been organized in-turn in Russia and in EU countries, usually combined with visits of project recipient institutes and laboratories
- Links to EC FP6 projects are made (SARNET).

5. **A. Stanculescu, IAEA,**
presented ISTC related IAEA activities (Appendix 4).

- The Coordinated Research Project (CRP) on Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS) is the largest CRP at IAEA
- A significant part of this CRP is based on the experimental results of ISTC projects #2267 SAD and #B070 YALINA.

6. **C. Broeders, Chairman SY-SC**,

- reported on FZK collaboration with ISTC and on
- activities of the SAD / YALINA Steering Committee (Appendix 7).

7. **D. McNelis, US North Carolina University, George Russell Foundation,**

- gave general information about the current nuclear fuel cycle situation in USA,
- explained role and activities of the Russell Foundation in Washington, with support for smaller projects dealing with spent fuel management.

W. Gudowski proposed to try to revive the cooperation between EC and USA. Together with D. McNelis he will make an action plan to come to new cooperation with USA partner. Possible funding support by the Frank Russell Foundation for ISTC projects, e.g. #2267 SAD, will be further explored.

8. **B. Rhode, European Commission,**
pointed out that from EC point of view the CEG on Transmutation related Projects and other CEGs in nuclear area have been very successful and have a "pilot function" for creation of other similar CEG's or advisory bodies, also in "non nuclear" areas. She initiated discussion of the following aspects of ISTC support:

- the question of "smaller" vs. "larger" projects; larger projects are preferable but they carry a larger risk of failing approval,
- differences between project "prolongation" or "extension";
    - ISTC administrative procedures seem to make it easier to approve project *extensions*, rather than project *prolongations*,
    - The EC management prefers *new projects* to have more clearness for future decisions.
- that the recommendations of the CEG are not obligatory for EC, but have high importance for decision makers, together with other independent evaluations,

- that the main mission of ISTC is the employment of former nuclear weapon experts with current key aspects:
    - o the problem of unemployment of the weapon specialists in the “closed cities” in the Russian Federation. This aspect has special attention in the European Community and at international G8 meetings,
    - o possible links to activities in “closed cities” in current ISTC Project proposals should be clearly indicated.
- the importance of more mass media attention and more publicity for the role of ISTC.
- the role of ISTC in supporting Training and Education of young scientists. EC representatives explained that these activities are already covered by other EC programs and that it is not primary goal for ISTC.
- Identification of the current main objectives for ISTC projects:
    - o the gain of new knowledge about new recognized problems,
    - o sustainability,
    - o commercialization and
    - o non-proliferation.

Finally, B. Rohde gave the following recommendations for successful continuation of EC support for ISTC projects:
- o consideration of commercialization aspects,
- o collaboration with projects in “closed cities”,
- o preparation of strategy papers, with clear presentation of achieved results,
- o application for funding from resources allocated at G8 level meetings, e.g. for “closed city” support.

9. Generally, the EC representatives underlined the important contribution of nuclear waste transmutation in view of acceptable solutions for closing the back-end of the nuclear fuel cycle for sustainable energy production. They recognized the unique role of the SAD experiment in Dubna with respect to nuclear waste incineration, being the first technical realization of the coupling of all three major components of an Accelerator Driven System for nuclear waste incineration, namely:
    - a proton accelerator creating a high energy proton beam,
    - a spallation target producing a high energetic neutron source and,
    - a sub-critical assembly to produce fission neutrons for destruction of nuclear wastes.

    The integration in the 6. European Framework Program in the currently largest Integrated Project EUROTRANS is highly appreciated.

10. At the end of the meeting **W. Gudowsk**i reminded that **M. Hugon** not longer can be secretary of the CEG because of his new duties and he proposed as new secretary **C. Broeders**. This proposal was accepted by the participants by acclamation.

11. **W. Gudowski** further summarized the following next year CEG work plan:
- support for SAD continuation,
- revival of Partition issues with participation to the EUROPART meeting in Rome June 2006,

- support for collaboration of ISCT Molten Salt activities at RIAR Dimitrigrad, and KRI St. Petersburg, with the EC FP6 Project EUROPART,
- next CEG meeting will include more Partition issues,
- integration of several smaller nuclear data projects into one larger project with special emphasis on needs from the IP EUROTRANS DM5 NUDATRA and from the SAD project (BFS mock-up),
- prolongation of the ISTC Projects #2048, #2573, #2680, #B070,
- termination of ISTC Project #2578 with small improvements of the current draft version.
- Next CEG meeting is planned for Jan. 2006.

- The SAD/YALINA Steering Committee Meetings will be held depending on future developments, especially with respect to funding issues, but at least twice in 2006.

II. On-going projects reports

1. **ISTC Project #1606**, "Molten Salt Loop for Waste and Plutonium Disposal". **V. Ignatiev, KIAE,** informed about:
   - Progress on schedule with start of the phase 2 (Appendix 5).
     - Design and construction of unique experimental stand for actinide molten salts.
     - Stand was setup and put into operation at VNIIEF (Cheljabinsk-70).
     - The project team consists of experts from several institutes and may serve as a good example of ISTC approach.
   - Integrated into an IAEA CRP on dynamics of ADS.
   - Special attention was put on the preparation and scheduling of sessions of a project specific training program with planned workshops at CEA Cadarache in March, 2006, and later at VNIITF, Snezninsk.

Actions: *The report is approved, as well as plans with two-session technical training including the workshop in Snezhinsk (October-November 2006). Collaboration with the other projects on molten-salts study (RIAR, KRI) is highly recommended.*

2. **ISTC Project #2267,** "Creation of Subcritical Assembly Driven by Proton Accelerator (SAD)". **V. Shvetsov, JINR,** presented the current status of ISTC Project #2267 SAD in Dubna (Appendix 6).
   - Funding of SAD is a critical issue, but visible progress in resolving some of the economical issues can be observed,
   - significant improved perspectives have been developed since last reporting at SA-SC Meeting in Minsk December 2005:
     - "Special Economic Zone" (SEZ) in Dubna may bring cost reduction for projects like SAD of about 23-29%.
     - Good progress in reconstruction work at the proton accelerator PHASOTRON after the severe fire accident in April 2005; it is planned to recover the proton beam in April 2006.
     - After successful completion of ISTC Project #2267 Phase I, the Phase II can start immediately after approval by ISTC governing board.

- o Building construction licensing and negotiations for construction components with companies in the Dubna and Obninsk areas are in progress.
- o SAD fuel production is on schedule: fuel pellets will be delivered by the Mayak plant and fuel elements will be assembled with the modernized existing fuel production line for the IBR-30 reactor in Dubna.
- o For the construction costs of the SAD building, JINR Dubna has requested at the Russian Federation Ministry of Science and Education full SAD building construction costs of 100 Mrubles, .with reasonable perspective that a significant fraction will be approved.
- o In the case of approval of main funding contributions (ISTC and Russian Federation pending), construction of SAD building can start in 2006 and “beam on target” can be expected in 2009.
- o Specific critical and sub-critical experiments are planned in the BFS facility in Obninsk for licensing of SAD. Because this BFS experiment could become a critical issue, specification and financing of this experiment within ISTC Project #2267 or by means of other resources (integration within ISTC Project #2884?) must be clarified as soon as possible.
- o The details of the SAD funding plan, as proposed on the basis of “one-third- each” for JINR, IP EUROTRANS DM2 ECATS and ISTC, with possible other contributions were discussed intensively.

In a second contribution V. Shvetsov, JINR, presented updated information about SAD funding and ongoing negotiations (Appendix 12). The cost estimate table is based on the information in the “Statement of JINR on the scientific program of SAD in close cooperation with IP EUROTRANS ECATS activities”, see “Finance Issues” in Appendix 12 The data from this document is weighted with current estimates for possible reduction factors. Details of possible funding models and their consequences were analyzed in a constructive discussion. The fundamental requirement that 50% of ISTC funding must be paid to “former weapon specialists” was stressed by the ISTC representatives, as well as the applied very high ISTC funding contributions for the next years. ECATS representatives pointed out the necessity to have information about uncertainties in the weighting factors. It was agreed that V. Shvetsov will prepare as soon as possible a document with more detailed information about:

a. ISTC relevance of funding positions,
b. weighting factors with uncertainty estimates and
c. Russian and JINR contributions.

It was clearly recognized that fast successful continuation of the SAD Project needs approval of applied ISTC funding for phase II of ISTC Project #2267 at next ISTC Governing Board Meeting in April, 2006. Further it was recommended to decrease the short term follow-up contributions of ISTC. At the end of this discussions J. Sanders explained that he can prepare documents for decision making, but that because of the high costs for SAD, “higher level” decisions will be mandatory.

<u>Actions:</u> *V. Shvetsov prepares a SAD cost table containing reasonable absolute cost numbers, with corresponding risk information. Further, C. Broeders (chairman SY-SC) and V. Shvetsov, SAD Project Manager, are asked to prepare a document* *with the main scientific goals and with a list of potential users of the SAD facility in the future.*

3. **ISTC Project #2002** "Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons". The results of this project were presented by **V. Batyaev** and **Yu. Titarenko**, **ITEP,** (Appendix 8). The experimental results will be available in EXFOR format soon. It was mentioned that Post Graduate Training Courses are organized at ITEP Moscow. This offer will be forwarded to the collaborators and to CEG members, with more detailed information about participation by Western young scientists.

Actions: *The final report on ISTC #2002 is approved. It was recommended to clarify participation of Western young scientists to the Post Graduate Training Courses, organized by ITEP Moscow*

4. **ISTC Project #2680, IPPE,** "MATINE- Study of Minor Actinide Transmutation in Nitrides: Modeling and Measurements of Out-of-pile Properties". **W. Gudowski**, project collaborator, gave a short presentation of the current status of the ISTC Project #2680, based on the "Progress report on ISTC Project #2680", as prepared by L. Zabudko (IPPE), Obninsk (Appendix 9). This Project on Nitride fuel is strongly connected to the EC FP5 Project CONFIRM and to EC FP6 IP EUROTRANS DM4 AFTRA. Due to problems with the irradiation facility in Studsvik, the ISTC Project #2680 MATINE irradiation tasks will be done in the HFR reactor in Petten. As Nitride fuel could have problems with reprocessing, alternative solutions with carbide fuel are also under consideration.

Actions:: *The CEG recommends strongly the approval of the proposed prolongation of ISTC Project #2680 MATINE and encourages cooperation with fuel and irradiation target production by RIAR in Dimitrigrad.*

5. **ISTC Project #3261** "Study of curium thermodynamics in molten chlorides" . **A. Bychkov, RIAR,** presented the draft work plan of the project. In addition he gave a presentation on "Partitioning related ISTC projects at RIAR and a short overview of the Russian Partitioning program" (Appendix 11). Part of information was presented on behalf of **I. Smirnov**, KRI, St-Petersburg. Most of the discussed projects are related to molten salt research. Russian institutions have a long time experience with reprocessing and partition projects with various technologies in various areas of the Russian Federation. A. Bychkov informed that Rosatom initiates development of a new technological platform for nuclear power in Russia, which will certainly include a commercial fast reactor with closed fuel cycle, including Partition & Transmutation. The current planning utilizes Sodium as Fast Reactor coolant, but for a next step also Lead will be considered. New ISTC project proposals are:
    a. ISTC Partnership Project #3231 (RIAR-KAERI): "Separation of minor-actinides from rare-earth elements on a liquid metallic cathode in molten chlorides",
    b. ISTC Project #3261 "Study of curium thermodynamics in molten chlorides",
    c. ISTC proposal #3405 by KRI St. Petersburg, "Development and demonstration of the process for selective recovery of TPE from HLW using binary calixarene extractants".
    d. Further the "Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum" is under preparation.

A. Bychkov proposed at the end of his presentation the creation of a new CEG on "Partitioning of HLW and Partition in Advanced Fuel Cycle". This proposal was discussed in some detail. It was pointed out that the current CEG on Nuclear Transmutation Projects, in its initial stage, also evaluated Partition related projects, but that this issue had less contributions in favor of integral experiments in recent CEG work. It was proposed to revive evaluation of Partition related projects in the current CEG and to invite the representatives of European projects on Partition to future meetings of the current CEG. Available information will be sent to these representatives. A meeting of CEG members and Partition specialists is proposed for the fall of 2006. Several dates and places for such meeting were discussed (Dimitrigrad, Nimes, Rome).

Actions: *The final recommendation is to keep Partition & Transmutation together in the current CEG and to have a dedicated meeting during the planned EUROPART meeting on Partition in Rome, June 26-29, 2006.*

6. **E. Gonzalez**, CIEMAT, informed about ISTC projects for nuclear data assessment of current interest for CEG discussions, one proposal by L. Ponomarev, Kurchatov Institute, Moscow, and two proposals from BFS Obninsk. These projects are partly of high interest for IP EUROTRANS DM5 NUDATRA, but were approved without funding. A number of proposals on nuclear data measurements is being reformulated to a single project in view of support for IP EUROTRANS DM5 NUDATRA. An important link exists to the ISTC Project #2267 SAD by the highly recommended SAD mock-up studies in BFS for sub-criticality assessment for SAD licensing.

Actions: *The CEG strongly recommends to approve such SAD related experiments as soon as possible, either as part of ISTC Project #2267 SAD, or as a modification of the proposed ISTC project #2884.*

7. **ISTC Project #3266** "Experimental and theoretical study of the residual nuclide production in 40-2600 MeV proton-irradiated thin targets of ADS structure materials" **V. Batyaev, IPPE**, presented at the kick-off meeting of the ISTC Project #3266 details of proposed experiments and analysis, as logical continuation of the ISTC Project #2002 (presentation in Appendix 13). The proposed work plan is adapted to the availability of the ITEP U10 accelerator in 2006 due to planned modification of this installation. On request of the collaborators, the accuracy of the proton energy determination will be checked and possibly improved in view of comparison with the inverse kinematics measuring methods at GSI Darmstadt. Further the capabilities to measure absolute gas production rates will be assessed. It was mentioned that the selection of Tantalum as target material was initiated by inquiries from the TRADE project with Tantalum proton target. The chairman of the ISTC-Contact Expert Group on Nuclear Transmutation related Projects W. Gudowski concluded the successful kick-off of ISTC Project #3266.

<u>Actions:</u> *The Work Plan was approved, the list of collaborators will be updated.*

8. **ISTC Project #2578**, "Transmutation of radioactive nuclear waste – present status and requirement for the problem-oriented nuclear data base". **Y. Korovin, IATE,** Obninsk, presented the draft final report of this project (Appendix 14). Goal of the project is to review the status and outcome of the large set of completed

ISTC projects (totally > 30) related to nuclear data, from the following points of view:

- Modern requirements to nuclear data for:
  - P&T designers,
  - reactor and ADS physicists and
  - nuclear data libraries experts;
- Assessment of correspondence of the project results to these requirements;
- Proposals for new experiments.

In addition, recommendation for publication in scientific journals should be given. Y. Korovin has devoted great care to some special components of the project activity, e.g. the role of adequate theoretical models, role of Pu238 and its precursors in the nuclear fuel cycle, etc. On behalf of the project team, Y. Korovin presented some ideas and proposals for further activities.

E. Gonzalez, CIEMAT, project collaborator, presented a detailed analysis (Appendix 15) of the draft final project report. He concluded that the report is very valuable, but that some modifications should be recommended. Besides some Russian text passages still to be translated into English, the layout and content is generally acceptable. He made some proposals for improvements, especially in the section “Conclusions and Recommendations”.

Actions: *Modification of the Final Report along the lines of the recommendation of E. Gonzales and publication of a compact version in an international journal.*

III. Analysis of proposals

1. **ISTC Project #1606**, “Molten Salt Loop for Waste and Plutonium Disposal”, see presentation in **section II.1**

Actions: *send recommendation to ISTC.*

2. **ISTC Project #2048**, “Improvement of corrosion resistance of constructional steels in liquid Pb and Pb-Bi alloys by means of their surface modification with the help of pulsed electron beams and protective coatings”. **W. Gudowski, KTH,** collaborator, presented the proposal for an additional work plan on the prolongation of the ISTC project #2048 for two additional years with additional funding. Some documents provided by CEG member G. Müller, FZK, are reproduced in Appendix 11. The project #2048 is strongly supported by FZK and SCK-CEN, with partnership funding contributions by both institutions. The CEG strongly recommends approval of the proposed additional work plan for ISTC Project #2048.

Actions: *send recommendation to ISTC.*

3. **ISTC Project #2267,** “Creation of Subcritical Assembly Driven by Proton Accelerator (SAD)”: see presentations in **section II.2** and **II.3**.

Actions: *Recommendation to ISTC for continuation of the SAD project with **Phase II** including supporting SAD mock-up experiments at BFS Obninsk, either as part of #2267 or implemented within ISTC Project #2284.*

4. **ISTC Project #2573,** “Investigation of Processes of High-Performance Laser Separation of Lead Isotopes by selective Photoreactions for Development of Environmentally Clean Perspective Power Reactor Facilities”, **C. Broeders** mentioned this proposal in his presentation, see **section I.7**. Phase I of the project is successfully finished. SCK-CEN Mol, Belgium, and PSI Würelingen,

Switzerland, have expressed in a supporting document their interest in the technological results (large scale Lead isotopes separation at reasonable costs).

Actions: *Recommendation to ISTC for continuation with **Phase II** of this project if reasonable perspectives for long term large scale production units for Lead isotope separation can be expected.*

5. **ISTC Project #2680, IPPE,** "MATINE- Study of Minor Actinide Transmutation in Nitrides: Modeling and Measurements of Out-of-pile Properties", see presentation in **section II.4**

Actions: *The CEG recommends strongly the approval of proposed prolongation and encourages cooperation with fuel and irradiation target production by RIAR in Dimitrovgrad*

6. **ISTC Project #B-070**, **JIPNR**, "Experimental and theoretical research of the peculiarities of transmutation of long-lived fission products and minor actinides in a subcritical assembly driven by a neutron generator". **H. Abderrahim, SCK-CEN,** collaborator, informed about outcome, status and perspectives of the project. It is highly recommended to support extension of the project for two years. SCK-CEN intends to fund half of the sum for this prolongation.

Actions: *The CEG recommends strongly the approval of the proposed prolongation and encourages further cooperation with other international institutions*

7. A summary of the recommendations is given in (Appendix 16).

C.H.M. Broeders 22.02.2006

W. Gudowski

Minutes of the
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1) **V. Bhatnagar**, local organizer of the meeting, welcomed the participants. Following his proposal, the electronic copies of the planned presentations were collected on the computer for displaying, before arrival of the chairman, who arrived with some delay due to technical problems with the airplane in Stockholm. The list of participants is given in Appendix 1. The proposed draft agenda was accepted (Appendix 2),

2) **W. Gudowski**, chairman of the ISTC-Contact Expert Group on Nuclear Transmutation related Projects, also welcomed the participants and announced that during the meeting a new secretary of the CEG should be elected. He expressed his gratitude to M. Hugon for his very valuable contributions as secretary of the current CEG and wished him success for his future work in the framework of the CEG for Severe Accident Management. W. Gudowski pointed out in his introduction (Appendix 3) that this CEG meeting does not aim to prepare a priority list for ISTC project recommendation and support, as in previous CEG meetings, but to finalize a consistent working plan for supporting ongoing projects, especially ISTC #2267 SAD and ISTC #B070 YALINA. In his Introduction and annual report presentation he explained in his "Short history of the CEG" the main reason of the two-years period since the CEG meeting 2004; the strong supporting efforts of the SAD/YALINA Steering Committee (SY-SC), created at last CEG meeting in 2004, to coordinate support for integrated experiments for ADS and Transmutation. The SY-SC had five important meetings in this period, with substantial support for the main projects. Some more details are presented by the chairman of SY-SC (see below). Also several other support meetings with participation of CEG members took place. He summarized important issues of CEG since the first meeting in 1998. Some examples are: creation of white paper, establishment of lasting cooperation with many projects in Russia, Ukraine and Belarus, successful integration of many projects into collaboration in European projects, etc. He reminded the very successful "Spallation Target Project" ISTC #559, being the initiating origin of many Pb/Bi experimental activities in Europe. Although, the final goal, irradiation of the target in USA, could not be reached due to lack of experimental irradiation support in USA, the target still plays an important role in education of students at University of Nevada. He gave a comprehensive overview of the ISTC projects involved und some details on the SAD/YALINA Steering Committee Meetings. Important milestones in view of the realisation of SAD were:
   - commitments of IP EUROTRANS Domain 2 ECATS coordinators to support SAD by a substantial funding,
   - "round table" discussion at JINR Dubna with participation of SY-SM, JINR management and ISTC executive director,

- statement for cooperation of JINR SAD experiment with IP EUROTRANS, signed by four representatives of JINR Dubna and, • approval of SAD project by the JINR Program Advisory Committee (PAC). W. Gudowski stressed the changing ISTC environment, with shift to "partnership projects" and weaker cooperation between the ISTC partner EU, Japan, USA. As particular actual objectives of the CEG meeting he mentioned: to assure ISTC funding for SAD and full integration with EUROTRANS,
- to continue with YALINA experiments ("new" B70),
- to continue nitride projects (MATINE-2),
- to support continuation of the Pb-Bi technology project #2048 and
- to develop good strategy for support of nuclear data projects! As a vision he proposed a strategy to gradually transform EU-ISTC activities under EC Framework Programmes.

3. **J. Sanders** explained his new role in the area of ISTC support by EU. Recommendations have to be prepared for the next ISTC Governing Board Meeting in March 2006. Integration of ISTC projects in existing and new EC Framework Programmes is encouraged. The CEG for Transmutation is considered to become model for similar advising bodies in other EC research areas. Main expectation of the EC representatives of the current CEG Meeting is to obtain well balanced recommendations for future EC support for ISTC projects in the area of ADS and Transmutation. These proposals are not obligatory for EC, but have high importance for decision making, together with other independent evaluations. **L. Tocheny** underlined the remarks of J. Sanders and put attention on the role of CEG for preparation of the EC Framework Program 7. It was mentioned that "ISTC partnership projects" are increasing, especially with partner in USA. For Europe a contribution of 10-20% "ISTC partnership projects" is estimated. It was also stressed that ISTC funding for "non-nuclear" projects is much larger than for nuclear ones.

4. After lunch **M. Hugon** reported on the creation of an ISTC CEG for Severe Accidents Management. This CEG has started with analysing the problems with Corium and it is intended to broaden the topics of investigation. Currently, eight regular projects and one partnership project are involved. Three to five more projects are expected after the ongoing pre-selection phase. Several meetings have been organised, usually combined with visits of project locations. Links to EC FP6 projects are made (SARNET). **L. Tocheny** gave some additional information on other ISTC CEG's: e.g. Plant Life Management, VVER issues, and non-nuclear topics like aeronautics.

5. **A. Stanculescu** presented ISTC related IAEA activities (

Appendix 4). He stressed the interest of IAEA to extent the existing, mostly theoretical, benchmarking activities by experimental support. In this context, the recent IAEA “First Research Coordination Meeting of the Coordinated Research Project on Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS)” meeting in Minsk Dec. 2005, showed the interest of international researchers to utilize experimental results from ISTC projects, especially of the projects #2267 SAD and #B070 YALINA.

6. **V. Ignatiev** reported in some detail on the progress of the ISTC Project #1606 phase 2 (Appendix 5). The experimental part of the project is progressing on schedule, as well as the theoretical one being integrated in an IAEA CRP on dynamics of ADS. Special attention was put on the ISTC #1606 Training Activity with planned sessions at CEA Cadarache and VNIITF, Snezninsk.

7. **V. Shvetsov** presented the current status of ISTC Project #2267 SAD in Dubna (Appendix 6). Although the funding of SAD is still a critical issue, significant improved perspectives have been developed since last reporting at SAD/YALINA Steering Committee Meeting in Minsk, Dec. 2005. Now the Dubna region is officially one of six “Special Economic Zones” (SEZ) in the Russian Federation. The goals and objectives for SEZ creation are:
   - Manufacturing industry development,
   - Advanced technology branches development,
   - New kinds of products manufacturing,
   - Commercialization of scientific-and-technological developments, and
   - Fair competition between the countries.

By these measures cost reduction for projects like SAD is estimated to be 23-29%. Moreover, an increasing number of JINR member states is willing to participate in partial funding of SAD. Another very positive point is the progress of the reconstruction work at the proton accelerator PHASOTRON. After the severe fire accident in April 2005, it is planned to recover the proton beam in April 2006. After successful completion of ISTC Project #2267 phase I, the phase II can start immediately after approval by ISTC governing board. Building construction licensing and negotiations for construction components with companies in the Dubna and Obninsk areas are in progress. One critical path activity, fuel production, is observed very carefully; fuel pellets will be delivered by the Mayak plant and fuel elements will be assembled with the modernized existing fuel production line for the IBR-30 reactor in Dubna. For the construction costs of the SAD building, JINR Dubna has requested at the Russian Federation Ministry of Science and Education full SAD building construction costs of 100 Mrubles, with reasonable perspective that a significant fraction will be approved. In the case of approval of main funding contributions (ISTC and Russian Federation pending), construction of SAD building can start in 2006 and “beam on target” can be expected in 2009. A special critical and sub-critical experiment is planned in the BFS facility in Obninsk for licensing of SAD sub-criticality determination. Specification and financing of this experiment within ISTC Project #2267 or by means of other resources (integration within ISTC Project #2884?) must be clarified as soon as possible, because this BFS experiment also could become a critical issue. The details of the SAD funding plan, as proposed on the basis of “one-third-each” for JINR, ISTC and IP EUROTRANS DM2 ECATS, were discussed intensively. There is still some confusion concerning the different “efficiency” factors for resources from ISTC, EUROTRANS and JINR. V. Shvetsov is asked to prepare a table containing reasonable absolute cost numbers, with corresponding risk information.

8. **C. Broeders** reported on FZK ISTC collaborations and on the activities of the SAD/YALINA Steering Committee (Appendix 7). The ISTC Projects #2048 and #2573 were shortly mentioned in connection with ongoing prolongation activities. The highlights of the five Steering Committee Meetings in Dubna and Minsk were discussed in some detail.

9. The meeting on Tuesday Jan. 31, 2006, started with the presentation of the results of ISTC Project #2002 "Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons" by **V. Batyaev** (Appendix 8). The experimental results will be available in EXFOR format soon. It was mentioned that Post Graduate Training Courses are organized at ITEP Moscow. This offer will be forwarded to the collaborators and to CEG members, with more detailed information about participation by Western young scientists.

10. **W. Gudowski** gave a short presentation of the current status of the ISTC Project #2680 MATINE- "Study of Minor Actinide Transmutation in Nitrides: Modeling and Measurements of Out-of-pile Properties", based on the "Progress report on ISTC Project #2680" (Appendix 9), as prepared by **L. Zabudko** (IPPE), Obninsk. This Project on Nitride fuel is strongly connected to the EC FP5 Project CONFIRM and to EC FP6 IP EUROTRANS DM4 AFTRA. Due to problems with the irradiation facility in Studsvik, the ISTC Project #2680 MATINE irradiation will be done in the HFR reactor in Petten. As Nitride fuel could have problems with reprocessing, alternative solutions with carbide fuel are also under consideration. The CEG recommends strongly the approval of the proposed prolongation of ISTC Project #2680 MATINE and encourages cooperation with fuel and irradiation target production by RIAR in Dimitrigrad.

11. **A. Bychkov** gave a presentation on "Partitioning related ISTC projects at RIAR and a short overview of the Russian Partitioning program" (Appendix 10). Most of the discussed projects are related to molten salt research. Russian institutions have a long time experience with reprocessing and partition projects with various technologies in various areas of the Russian Federation. In 2006 a new technological platform will be established for a commercial fast reactor with closed fuel cycle, including Partition & Transmutation. The current planning utilizes Sodium as Fast Reactor coolant, but for a next step also Lead is considered. New ISTC project proposals are:
    a. ISTC Partnership Project #3231 (RIAR-KAERI): "Separation of minor-actinides from rare-earth elements on a liquid metallic cathode in molten chlorides"
    b. ISTC Project #3261 "Study of curium thermodynamics in molten chlorides"
    c. ISTC proposal #3405 by KRI St. Petersburg, "Development and demonstration of the process for selective recovery of TPE from HLW using binary calixarene extractants"
    d. Further the "Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum" is under preparation.

A. Bychkov proposed at the end of his presentation the creation of a new CEG on "Partition of HLW and Partition in Advanced Fuel Cycle". This proposal was discussed in some detail. It was pointed out that the current CEG on Nuclear Transmutation Projects in its initial stage also evaluated Partition related projects, but that this issue had less contributions in favour of integral experiments in recent CEG work. It was decided to revive evaluation of Partition related projects in the current CEG and to invite the representatives of European projects on Partition to future meetings of the current CEG. Available information will be sent to these representatives. A meeting of CEG members and Partition specialists is proposed for the fall of 2006. Several dates and places for such meeting were discussed (Dimitrigrad, Nimes, Rome). The final recommendation is to keep Partition & Transmutation together in the current CEG and to have a dedicated meeting during the planned EUROPART meeting on Partition in Rome, June 26-29, 2006.

12. **D. McNelis** gave some general information about the current nuclear fuel cycle situation in USA. He explained that he is representing a private funded organization, the Frank Russell Foundation in Washington, USA, among others supporting Spent Fuel Activity Projects without governmental funding. The primary focus is on the destruction of nuclear fuel and on nuclear waste reduction. **W. Gudowski** proposed to try to revive the cooperation between EC and USA. Together with **D. McNelis** he will make an action plan to come to new cooperation with USA partner. Possible funding support by the Frank Russell Foundation for ISTC projects, e.g. #2267 SAD, will be further explored.

13. **W. Gudowski** presented the proposal for an additional work plan on the ISTC project #2048 for the period 01.10.2005 till 30.09.2007 "Improvement of corrosion resistance of constructional steels in liquid Pb and Pb-Bi alloys by means of their surface modification with the help of pulsed electron beams and protective coatings". Documents provided by CEG member **G. Müller**, FZK, are available (11). The project #2048 is strongly supported by FZK and SCK-CEN, with partnership funding contributions by both institutions. The CEG strongly recommends approval of the proposed additional work plan for ISTC Project #2048.

14. **E. Gonzalez** informed about ISTC projects for nuclear data assessment of current interest for CEG discussions, one proposal by L. Ponomarev, Kurchatov Institute, Moscow, and two proposals from BFS Obninsk. These projects are partly of high interest for IP EUROTRANS DM5 NUDATRA, but were approved without funding. A number of proposals on nuclear data measurements is being reformulated to a single project in view of support for IP EUROTRANS DM5 NUDATRA. An important link exists to the ISTC Project #2267 SAD by the highly recommended SAD mock-up studies in BFS for sub-criticality assessment for SAD licensing. The CEG strongly recommends to approve such experiments as soon as possible, either as part of ISTC Project #2267 SAD, or as a modification of the ISTC project #2884 "Integral Experiments at BFS Critical Facilities for Justification of Minor Actinides Transmutation and Their Analysis".

15. **V. Shvetsov** presented updated information about SAD funding and ongoing negotiations (Appendix 12). The new cost estimate table is based on the information in the "Statement of JINR on the scientific program of SAD in close

cooperation with IP EUROTRANS ECATS activities", see "Finance Issues" in (Appendix 6). The data from this document is weighted with current estimates for possible reduction factors. Details of possible funding models and their consequences were analyzed in a constructive discussion. The fundamental requirement that 50% of ISTC funding must be paid to "former weapon specialists" was stressed by the ISTC representatives, as well as the applied very high ISTC funding contributions for the next years. ECATS representatives pointed out the necessity to have information about uncertainties in the weighting factors. It was agreed that **V. Shvetsov** will prepare as soon as possible a document with more detailed information about: • ISTC relevance of funding positions, • weighting factors with uncertainty estimates and • Russian and JINR contributions. It was clearly recognized that fast successful continuation of the SAD Project needs approval of applied ISTC funding for phase II of ISTC Project #2267 at next ISTC Governing Board Meeting in April, 2006. Further it was recommended to decrease the short term follow-up contributions of ISTC. At the end of this discussions **J. Sanders** explained that he can prepare documents for decision making, but that because of the high costs for SAD, "higher level" decisions will be mandatory.

16. The first part of the Tuesday afternoon session was devoted to the Kick-off meeting of ISTC Project #3266 "Experimental and theoretical study of the residual nuclide production in 40-2600 MeV proton-irradiated thin targets of ADS structure materials" and to the presentation of the final report on ISTC Project #2578 "Transmutation of radioactive nuclear waste – present status and requirement for the problem-oriented nuclear data base". **B. Rhode** joined the meeting in the course of the afternoon session for an extensive discussion of CEG and ISTC issues.

17. **V. Batyaev** presented at the kick-off meeting of the ISTC Project #3266 details of proposed experiments and analysis, as logical continuation of the ISTC Project #2002 (presentation in Appendix 13). He mentioned that the LANL code MCNPX can not be validated within the project because of export limitation for Russian scientists in USA. This is considered to be a severe draw-back because this code is now becoming an international standard tool for nuclear reactor simulations, including ADS. The proposed work plan is adapted to the availability in 2006 of the ITEP U10 accelerator due to planned modification of this installation. On request of the collaborators, the accuracy of the proton energy determination will be checked and possibly improved in view of comparison with the inverse kinematics measuring methods at GSI Darmstadt. Further the capabilities to measure absolute gas production rates will be assessed. It was mentioned that the selection of Tantalum as target material was initiated by inquiries from the TRADE project with Tantalum proton target. The chairman of the ISTC-Contact Expert Group on Nuclear Transmutation related Projects **W. Gudowski** concluded the successful kick-off of ISTC Project #3266.

18. **Y. Korovin** presented the final report of the ISTC Project #2578, "Transmutation of radioactive nuclear waste – present status and requirement for the problem-oriented nuclear data base" (Appendix 14). During the presentation some details were discussed, e.g. the role of Pu^{238} and its precursors in the nuclear fuel cycle. **E. Gonzalez** commented the available draft report (comments in Appendix 15). Besides some Russian text passages still to be translated into English, the layout

and content is generally acceptable. However, he also made some proposals for improvements, especially in the section “recommendations”.

19. **B. Rhode** joined the meeting during the final session for an extensive discussion of ISTC and CEG issues. In her general introduction she pointed out that from EC point of view the current CEG in the nuclear area is very successful and will be considered to have “pilot function” for creation of further similar CEG advisory bodies, including “non nuclear” areas. Future strategies for the ISTC activities were discussed in some detail. The question, to recommend support for several smaller projects or for a few larger well integrated ones, could not be answered definitely. Although larger projects are preferable, one has to consider the risk of failing approval. Differences between project “prolongation” or “extension” were also discussed. ISTC administrative procedures seem to make it easier to organise project extensions, rather than project prolongations. The EC management prefers new projects to have more clearness for future decisions. The recommendations of the CEG are not obligatory for EC, but have high importance for decision making, together with other independent evaluations. **B. Rhode** stressed the main mission of ISTC that 50% of the funding must be paid to “former weapon specialists”. Currently, the problem of unemployment of these specialists in the “closed cities” in the Russian Federation have special attention in the European Community and at G8 meetings. Possible links to activities in “closed cities” in current ISTC Project proposals should be clearly indicated. Further, publication of “success stories” is highly encouraged by the management of EC ISTC support. On the role of ISTC support for Training and Education of young scientists, EC representatives underlined that this activity is already supported by other EC programs, e.g. the Marie Curie Actions, and can not be primary goal for ISTC, being weapon specialists support. The following main objectives for ISTC projects at present time were mentioned:
    - the gain of new knowledge about new recognized problems,
    - sustainability,
    - commercialization and
    - non-proliferation.

    B. Rhode gave the following recommendations for successful continuation of EC support for ISTC projects:
    - consideration of commercialization aspects,
    - specification of connections to “closed cities”,
    - preparation of strategy papers, with clear presentation of achieved results,
    - application for funding from resources allocated at G8 level meetings, e.g. for “closed city” support.

    Generally, the EC representatives underlined the important contribution of nuclear waste transmutation in view of acceptable solutions for closing the back-end of the nuclear fuel cycle for sustainable energy production. They recognized the unique role of the SAD experiment in Dubna with respect to nuclear waste incineration, being the first technical realization of the coupling of all three major components of an Accelerator Driven System for nuclear waste incineration, namely:
    - a proton accelerator creating a high energy proton beam,
    - a spallation target producing a high energetic neutron source and,
    - a sub-critical assembly to produce fission neutrons for destruction of nuclear wastes.

The integration in the 6. European Framework Program in the currently largest Integrated Project EUROTRANS is highly appreciated.

20. At the end of the meeting **W. Gudowski** reminded that **M. Hugon** not longer can be secretary of the CEG because of his new duties and he proposed as new secretary **C. Broeders**. This proposal was accepted by the participants by acclamation.
    W. Gudowski summarized the following next year CEG work plan:
    - support for SAD continuation,
    - revival of Partition issues with participation to the EUROPART meeting in Rome June 2006,
    - collaboration of Molten Salt activities at RIAR Dimitrigrad, and KRI St. Petersburg, with the EC FP6 Project EUROPART,
    - next CEG meeting will include more Partition issues,
    - integration of several smaller nuclear data projects into one larger projects with special emphasis on needs from the IP EUROTRANS DM5 NUDATRA and from the SAD project (BFS mock-up),
    - prolongation of the ISTC Projects #2048, #2573, #2680, #B070,
    - termination of ISTC Project #2578 with small improvements of the current draft version. Next CEG meeting is planned for Jan. 2006. The SAD/YALINA Steering Committee Meetings will be held depending on future developments, especially with respect to funding issues, but at least twice in 2006.

21. A compact summary of the recommendations of the current CEG meeting is given in (Appendix 16).

22. Appendices

Appendix 1

List of participants

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Appendix 2

ISTC-Contact Expert Group on Nuclear Transmutation related Projects

Annual meeting – 2006

Part of the CEG meeting will be also devoted to summary of the Project # 2578: "Transmutation of radioactive nuclear waste – present status and requirement for the problem – oriented nuclear data base. Approach to scheduling the experiments (reactor, target, blanket)"

The meeting will take place in Brussels, January 30 - 31 (Monday, Tuesday) 2005. Beginning: January 30 (Monday) at 10:30. Adjourn January 31 (Tuesday) at 17:00.

Place: **EC, Building CDMA, 21, rue de Champs de Mars, 1050 Brussels**
January 30: Meeting Room SDR4 (Floor: 0)
January 31: Room 03/102 (Floor: 3)

Agenda:

Monday, January 30

10:30 – 10:40	Welcome and local arrangements – V. Bhatnagar
10:40 – 11:00	Introduction and Annual Report presentation - W. Gudowski
11:00 – 12:00	Presentation of the present ISTC policy, interactions with CEG + more – Jürgen Sanders/Barbara Rhode
12:00 – 12:30	IAEA activities in transmutation field – Alexander Stanculescu
12:30 - 13:00	Experiences from other CEG's, possibilities of closer collaboration – Michel Hugon, Lev Tocheny

13:00 – 14:30 Lunch

14:30 - 16:00	General overview of the ISTC projects collaborating with the 6th EU Frame Programme projects. Part I (in particular projects #1606, #2002, #2048, #2680, #3266 + more) Recently approved projects and projects waiting for evaluations/approvals. **Attention for Project #3266: only short information at this time. Special topic on the agenda on Tuesday, Jan. 31.** V. Ignatiev, Y. Titarenko, W. Gudowski, V. Bhatnagar

16:00 – 16:20 Coffee break

Collaborator reports on specific ISTC projects:

16:20 -17:40 Status of the SAD (#2267) and Yalina (B70) projects. In particular collaboration and funding issues. Reports from the SAD/YALINA Steering Committee meetings and ECATS meetings. Strategy for other "supporting" projects
C. Broeders, V. Shvetsov, H. Abderrahim, W. Gudowski, E. Gonzalez

17:40 – 18:20 Discussion

18:20	ADJOURN

Evening: dinner together following suggestions of our EC-hosts,

Tuesday, January 31

9:00 – 11:00	*Continuation of the CEG main topics*
14:00-17:00	*Review of the Projects #2578 and #* 3266*; "Kick off" of these projects*
9:00 – 9:20	Review and ranking of the projects in the pipeline – W. Gudowski + all
9:20 – 11:00	**Working plan for 2006-2007**:
9:20 – 10:00	Broadening of the CEG scope
9:20 – 9:50	Partitioning related projects at RIAR and short overview of Russian Partitioning program – A. Bychkov + L. Tocheny
9:50 – 10:00	Discussion
10:00-10:45	*Collaboration between CEG, ISTC office and ISTC Secretariat and Strategy for further integration of the ISTC projects with the European FP projects - V. Bhatnagar, , J. Sanders, L. Tocheny, W. Gudowski* *Introduction of* ***W. Gudowski*** *(5 min.)* *EU Framework programs and ISTC – seeking a synergy and long term strategy:* ***V. Bhatnagar*** *(continuation of our on-going discussion since some time –* ***25 min****.)* *ISTC perspective:* ***J. Sanders (15 min)***
10:45-10:55	*Discussion*
10:55-11:05	*Revitalization of the collaboration with USA, Japan and S. Korea – W. Gudowski and all*
11:05-11:20	**Coffee break**
11:20 -11:40	Action Plan for 2006
11:40 -13:00	CEG-Kick-off of the Project # **3266 – Y. Titarenko, V. Batyaev.**
13:00 - 14:00	**Lunch**
14:00 – 14:30	Discussion and recommendations for # 3266 – H. Abderrahim
14:30 – 16:00	**Summary of the Project # 2578:** "Transmutation of radioactive nuclear waste – present status and requirement for the problem – oriented nuclear data base. Approach to scheduling the experiments (reactor, target, blanket)" - Yu. Korovin
16:00-16:20	**Coffee Break**
16:20 – 16:40	Discussion on #2578 and recommendations – E. Gonzalez

16:40 – 17:00	Miscellaneous
17:00	**Adjourn**

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Appendix 3

Introduction of W. Gudowski

Contact Expert Group on ISTC Transmutation related Projects

Annual Meeting 2006

January 30-31, 2006

Brussels

Curt Mileikowsky – 1923-2005

A man of many interest and a good friend of mine, one of the founder of this CEG

In last years we lost some more of our good collaborators

- B.P. Murin, Moscow, project manager of # 1653
- E. Efimov, Obninsk, project manager of #559
- V. Barashenkov, Dubna, one of grandfathers of SAD
- Y. Shubin, Obninsk, co-coordinator of the project #1372

Short History of the CEG

Contact Expert Group for ISTC Transmutation related projects - so called ADS CEG has been officially established in January 1998 during a meeting in Brussels. It was an initiative based on the Swedish experiences from the time when Sweden was an individual funding party of the International Science and Technology Centre and yet a member of the European Union.

After some discussions between **Didier Gambier** (EU), **Steve Gitomer** (USA) and **Waclaw Gudowski** (KTH, Sweden) an idea of a Contact Expert Group got very soon the support of the scientific, “transmutation” community.

After meeting in Brussels and after intensive and fruitful discussions it was agreed: what to do and how to build a collaboration network. Rules for CEG were later formalised in the CEG White Paper, which was for the first time written down during the meeting in Cadarache. In Brussels - 98 we could see participation of the industrial partners from USA (Tony Favale and Mario Carelli). The industrial interest in transmutaion weakened with time when it became clear that the time perspective and economical prospects are out of the short-time scale.

Waclaw Gudowski was elected to be a chairman of the Group and Mario Carelli became a secretary. Then Michel Hugon was elected as a secretary

Short History – ”Plenary” Meetings

- 1998 – Brussels
- 1999 – Cadarache
- 2000 – Seoul
- 2001 – Stockholm, CEG is becoming more and more European, following very fruitful collaboration with the European Projects in the 5th and 6th FP
- 2002 – Karlsruhe
- 2003 – Brussels
- 2004 – Brussels
- 2006 - Brussels

Support meetings

- Obninsk – series of meetings related to the project #559 and #1372 (1998, 2000, 2001
- Snezhinsk – 2001 and 2004 (”stormy” meeting of the project # 1606)
- St. Petersburg, Project #2048 (2002), #2068 (2003)
- A number of meetings in Moscow and Dubna, Projects # 1372 and SAD #2267 (1998, 2000, 2002, 2004, 2005)
- Minsk, Yalina - #B70 related meetings (2000, 2003, 2004, 2005)
- Yerevan, 1998 Project #A131

White Paper – defines mode of operation of the CEG – update 2003

ISTC Contact Expert Group (**CEG**) on Nuclear Transmutation related research provides the venue for experts from the funding parties to shape up the policy and to formulate a common approach for soliciting, prioritising and directing the efforts of ISTC-funded projects. **CEG** provides the framework and opportunity for building a lasting co-operation between laboratories and research groups from ISTC funding countries and the laboratories of recipient countries (Russia and CIS-countries).

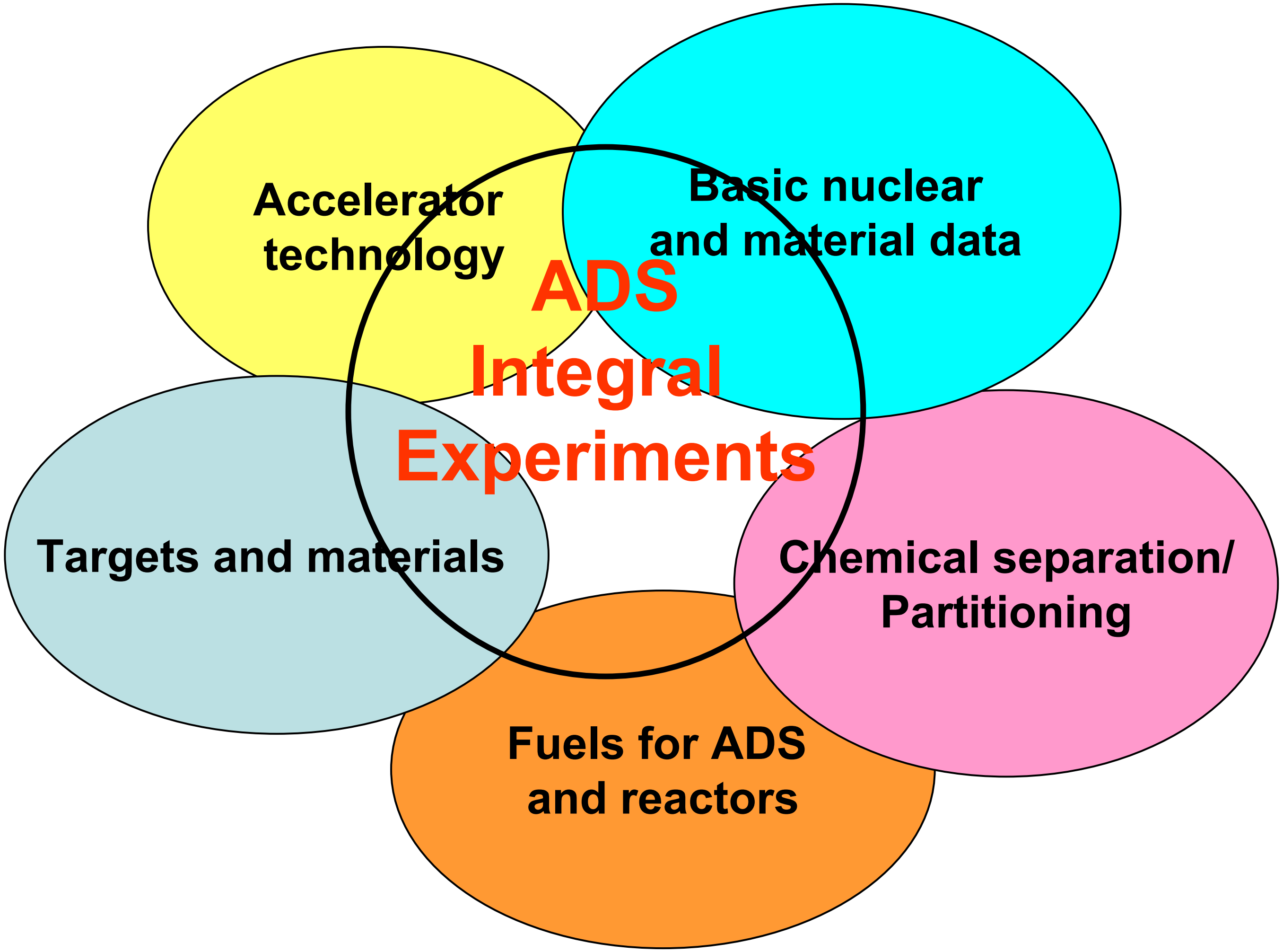
CEG, based on expertise of its members and their involvement in reviewing ISTC projects, has identified five major areas where projects are soliciting. These areas are:

- Accelerator technology
- Basic nuclear and material data and neutronics of ADS and reactor based transmutation systems
- Targets and materials including basic material data.
- Fuels related to ADS and reactor based transmutation systems
- Chemical separation

CEG considers these five areas equally important and foresees that available funding will be divided roughly equally among these areas.

CEG is expecting that all the projects submitted to ISTC in these 5 areas will be forwarded to the CEG chairman for consideration. CEG will review the projects and will recommend the priority for approval and level of funding. The priorities of projects will be set to: **high**, **medium**, **low** or **not recommended.**

CEG – Area of interest



The biggest achievements of CEG

- Very good collaboration with the EC, in particular DG12/DG Research, and ISTC office
- Establishing really good platform of LASTING collaboration with over **40 ISTC projects in Russia, Ukraine and Belorus**
- Successful integration of many projects into collaboration with European projects as well as bilateral contacts
  - Spectacular success of the ”spallation target project” for the first time a very big device was exported from Russia and consequently – FREE OF COSTS TRANSFER OF INTERESTING Pb/Bi technology:
    - 3 major European facilities have been built based on this project: KALLA facilty at FZK, CIRCE in Brasimone and TALL in Stockholm
    - European MEGA-PIE project is ”a child” of this ISTC project

The biggest achievements of CEG

- Very successful collaboration in nuclear data field, a lot of synergy and efficiency achieved
- Nuclear fuel collaboration – an advanced nuclear nitride fuel experiments of big interest for European partners
- Series of unique monographies !

The biggest ”non-technical” achievements of CEG

- Very trustful collaborative atmosphere, even with the most “closed” labs: Arzamas, Chelyabinsk, Obninsk. Good insight for European partners into these labs (even if not without some sparks)
- A large step towards regular scientific and technical collaboration and exchange, a good starting point for further development into full inetgration to FPs
- Excellent collaboration with EC and ISTC office in Moscow

Important Additional Initiative of CEG aside of the White Paper Mission

- **SAD-Yalina Steering Committe. First meeting – July, 2004. Activity based on agreed Charter**
  - The purpose of the SAD/YALINA-B Steering Committee is the coordination of the ISTC projects with integral experiments with source-driven sub-critical systems and integration of those projects with the European ADS-related activities. Currently, the ISTC project #2267 (Sub-critical Assembly Dubna, SAD) and the #B070 successor experiment with lead booster (YALINA-B) are involved. Other experiments under consideration will be included if corre-sponding proposals for ISTC projects decision board will be prepared.
  - Chairman – C. Broeders, FZK, see his report

Important Additional Initiative of CEG aside of the White Paper Mission

- Very good collaboration with IAEA
  - Common CRP on Yalina and SAD
  - A lot of concerted actions on ADS

- National and partnership projects/programs between ISTC supported institutes and European institutes
  - KTH – Sosny
  - FZK – St. Petersburg/Obninsk
  - SCK-CEN – Obninsk/St. Petersburg

Stimulating exchange of students

CEG related ISTC Projects

#554 - Measurements of the Fission Neutron Multiplicity Distribution in Spontaneous Fission of Cm-244, Cm-248 andin Fission of U-233 and Pu-239 Induced by Thermal and Low Energy Neutrons. Shpakov V I, Khlopin Institute. Collaborators – IRMM. Completed

#839 - Experimental and Theoretical Study of the Yields of Residual Product Nuclei Produced in Thin Targets Irradiated by 100-2600 MeV Protons, Y. Tiaternko, ITEP. Completed.

 # 1145: Nuclear-Physics Investigations Aimed at the Solution of Weapon Plutonium Conversion and Long-Lived Radioactive Wastes Transmutation Problems , E.F. Fomushkin, sarov. Completed. TENDL.

#1486 – Experimental and Theoretical Justification of the Cascade Scheme of the Subcritical Molten-Salt Reactor for Transmutation of Long-Lived RW of the Nuclear Fuel Cycle. L.I. Ponomariev, Research Coordination Center on the Problem of Muon Catalyzed Fusion and Exotic Quantum Systems. Project approved by GB, March 16, 2000. Collaborators:Univ. of Birgham, Completed.

#1606 – Experimental Mock-up of Molten Salt Loop of Accelerator-Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium. Stage 2: Experimental Study of Molten Salt Technology for Safe, Low-Waste and Proliferation Resistant Treatment of Radioactive Waste and Plutonium in Accelerator-Driven and Critical Systems. Zherebtsov/Ignatjev. VNIIKChT, Kutchatov, High Temperature Electrochemistry Institute. Project approved by GB, March 16, 2000. On-going, applying for prolongation. Collaborators CEA, BNFL

#1653 – Proton (ion) Linacs for Accelerator Driven Transmutation Technology (ADTT) (Monograph Edited by Professor Boris P. Murin). I.V, Shumakov, MRTI (Radio Techniques). KTH, CEA + more Project approved by GB, March 16, 2000. Completed

#B404 – Actinide Nuclear Data Evaluation, V.M. Maslov, Sosny Institute. Project approved by GB, March 16 2000.. Completed

CEG related ISTC Projects

 # 1372: Complex Radiochemical and Activation Analysis of Long-life Nuclear Waste Transmutation in Fast Reactors and in the Beams of High Energy Accelerators - Transmutation effectiveness of nuclear waste, E. Ya. Smetanin, IPPE-JINR, KTH, FZK + more. Completed.

 # 1418: Lead cooled reactor with inherent safety. Monography. . A. Filin (NIKIET). Completed

 # 1749: Measurements of the cross sections of fast and resonance neutrons induced fission of minor actinides for their transmutation with accelerator-driven systems Fission cross sections for minor actinides. B.I. Fursov, IPPE. Pending, too expensive.

 # 1755: Experimental study of fast and fast-thermal accelerator driven systems on the basis of BFS-1 – microtron complex. B. Kochurov, ITEP, IPPE. Pending

 # 1828: Measurements of the Prompt Neutron Spectra of Minor Actinides. Fast Neutron Induced Fission of ^{241}Am and ^{243}Am, Thermal Neutron Induced Fission of ^{243}Cm. Leonard V. Drapchinsky, Khlopin. Funded by Japan. Completed

 # 1886: "Investigations of the irradiation and thermomechanical endurance of the beam window of ADS neutron generating target" , Yuri V. Konobeev Related to the project # 559. Pending.

 # 1971: Neutron Induced Fission Cross-Sections of Pu240, Am243 and W in the Energy Range 1 – 200 MeV. Oleg A. Shcherbakov, Gatchina – St. Petersnurg

Approved and completed. JAER/JNC

CEG related ISTC Projects

2199: Neutron cross-sections in the resonance energy range and nuclear level densities for fission products, Th, ^{233}U. Boris V. Zhuravlev , IPPE.

2257: Proton accelerator based intense source of radioactive ions for nuclear physics experiments. Not supported

2267: Creation of Sub-critical Assembly Driven by Proton Accelerator (SAD). V.Shvetsov, Dubna. FZK, KTH, CIEMAT, CEA. On-going.

2299: Experimental and theoretical research of the basic parameters of interaction of intense relativistic nuclear beams with matter. Not supported

CEG related ISTC Projects -2003

Project Number	Shorttitle	Priority by CEG	Total cost k$
1444	Liquid Electronuclear Target	4	**93**
2213	Fission Cross Sections of Tungsten Isotopes	17	**200**
2214	Innovative Reactor Concepts and Fuel Cycles	4	**49.8**
2253	Investigation of the delayed neutron characteristics	High	**360**
2264	Interaction of Ion Beams with Matter	3	**350**
2391	Carbon Materials for Nuclear Waste Storage and Transmutation	low	**377**
2405	Experimental Nuclear-Physics Data for Transmutation	16	**595**
2524	Nuclear data lib. for heavy nuclei	medium	**204**
2563	Induced radioactivity in heavy ions reactions	3	**350**
2578	Analysis of Radwaste Transmutation Data (Korovin)	High	**80**
2582	Minor Actinides Transmutation Study at Critical Assembly		**50**
2603	A Database of Critical Experiments	3	**280**
2604	Fission fragments angular measurements	low	**296**
2635	Nuclear Data Reactions Data Base for Internet	5	**157**
2661	Reactors with Lead coolant	unassessed	**95**
2680	Study of M inor Actinide Transmutation in Nitrides: modelling and measurements of out-of-pile properties - MATINE	18	**400**

CEG related ISTC Projects -2203

Project Number	Shorttitle	Priority by CEG	Total desired cost k$
1251	Neutron- and heat- physical experiments with cylindrical targets bombarded with medium-energy protons	HIGH	**255**
1606	Experimental Mock-Up of Molten Salt Loop of Accelerator-Based Facility for Transmutation of Radioactive Waste and Conversion of Military Plutonium	**HIGH**	**450**
1749	Measurements of the fission X-sections of MA in fast and resonance neutrons (Furtsov)	MEDIUM	680 reduce to 400
2002	Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons	HIGH	**150**
2884	Integral Experiments at BFS Critical Facilities for Justification of Minor Actinides Transmutation and their Analysis (Matveenko)	**High**	764/ Reduce to 600
2925	Measurement of transmutation properties of minor actinides irradiated in intermediate reactor neutron spectrum (RIAR)	**High**	862
2931	**Experimental and theoretical verification of a precision method for electronic controlling the RedOx-potential of molten salts for reactors, transmutation of long-lived RW, and non-aqueous reprocessing SNF.**	LOW	
2952	Measurement of differential and integral fission cross-sections of ^{237}Np, ^{238}Pu, ^{241}Am, ^{242m}Am and ^{243}Am nuclides to optimize burning out of nuclear fuel waste	Consideration/No European coll	
B1108	**Neutron Data for Actinides up to 200 MeV**	LOW	210

Reviews 2004-2005

Project #	Shorttitle	Manager	Institution
2253.2	Delayed neutron characteristics from the fission of compound nuclei ^{233}Th, ^{234}U, ^{235}U, ^{244}Am, ^{238}Np, ^{246}Cm, ^{233}Pa, ^{234}Pa, ^{239}Np, ^{240}Np at the excitation energies from 5 to 20 MeV.	V. Furman	Dubna
2711	Measurement of neutron induced fission cross sections for 238U, 232Th, 209Bi, natPb, 197Au and natW in the energy range 20-175 MeV	Larisa A.Vaishnene	PNPI Gatchina
2853	Measurement of energy and isotope dependencies of fission cross sections of heavy nuclei induced by proton in energy range of 200-1000 MeV	Alexander A.Kotov	PNPI Gatchina
2928	Liquid Metal Coolant for High-Temperature Fast Reactors	P.N. Alekseev	Kurchatov
2931	Experimental and theoretical verification of a precision method for electronic controlling the RedOx-potential of molten salts for reactors, transmutation of long-lived RW, and non-aqueous reprocessing SNF	L.Shimkevich	Kurchatov
2961	Development of High Temperature Uranium Carbide Target–Ion Source Units for Production of Isotopes Far from Stability	Panteleev,V N	PNPI Gatchina
2878	Digital technology for the detection and control of fissile materials in devices with pulsed neutron sources	Romodanov,	MEPhI
3020	“Development of oxygen sensors, systems of control of oxygen content in lead coolants for test loops and facilities	Y.I. Orlov	IPPE
3266	Experimental and theoretical study of the residual nuclide production in 40-2600 MeV proton-irradiated thin targets of ADS structure materials	Y. Titarenko	ITEP
3084-STCU	Development of methods and equipment for increasing cyclotron complex power and efficiency its industrial using		

Activities 2004-2005

Focus on some projects of particycular importance:

– SAD/Yalina steering committee, see presentation of C. Broeders, number of meetings in Dubna/Moscow + Eurotrans ECATS
  - SAD project – ongoing integration with Eurotrans
  - YALINA project – continuous developemnt of the project, integration with Eurotrans. Development of bilateral contacts, trainee program

Meeting in Moscow, Jan. 2004

- **Actions and decisions:**
- #2002 is recommended to apply for prolongation for the EUROTRANS/TRADE related objectives. TRADE has some partnership funding. This topic will be presented on the next CEG meeting and the recommendations will be forwarded to EC. C. Broeders is a key-collaborator
- #2405 – a question of European co-funding will be presented and discussed at the CEG meeting. Key-collaborators: W. Gudowski, E. Gonzalez , C. Broeders
- #1251 - Neutron- and heat- physical experiments with cylindrical targets bombarded with medium-energy protons – V. Belyakov-Bodin – a proposal to “revive” this project for EUROTRANS/TRADE-oriented objectives will be presented at the CEG meeting by C. Broeders
- #2578 – it was agreed by the collaborators that the project should SKIP the TASK3:” “***Development of ideas on the transmutation potential of FB, ADS and specialized hybrid fusion reactor blankets”*** and starts immediately. Collaborators wish to receive progress reports every 3 months. Key-collaborators: C. Broeders, E. Gonzalez, W. Gudowski.

ISTC Projects Meetings #2267 (SAD) and #1372 in Dubna, January 26-27, 2004

Establishing of the SAD/YALINA Steering Committee

CONCLUSIONS AND ACTION PLAN

SAD-project

The foreign collaborators are somewhat concern that the SAD-project did not get yet a real momentum. In particular:

- The design studies are not really converging at the moment and we do not see a coherent approach at the moment. There is a very urgent need for very close collaboration between NIKIET designers and the rest of the project. In simple words we do not perceive that a real coherent TEAM-WORK has been started. The same concern is valid for the important topic of subcriticality measurements/monitoring
- The fuel for SAD is of course of outmost importance. The collaborators were not really convinced that the fuel manufacturing and delivery is really ensured and we urge the project management to promptly clarify this issue
- The dialog with licensing authorities has been already initiated but having in mind very tight time schedule we consider that much more attention should be paid to this issue
- The foreign collaborators have not been really convinced that the necessary constructional work is possible to be done in the time frame suggested in the workplan and presented on the meeting.
- The collaboration between different international partners at JINR could be much more intensive and more coherent. Foreign collaborators see a great potential of collaborative tasks of JINR member states, but this work must be intensified and get much bigger attention and support of the JINR management

ISTC Projects Meetings #2267 (SAD) and #1372 in Dubna, January 26-27, 2004

- **ACTION PLAN:**
- The strong SAD steering committee should be established immediately, consisting at least of SAD-project management (project manager and chief designer), key foreign collaborators (CEA, FZK, CIEMAT, KTH, EC) and ISTC manager, possibly key-collaborators from the JINR member states . CEG will nominate their representatives, V. Shvetsov will suggest other members. This steering committee must be recognised by JINR-management. It is also suggested to have a broader scientific committee for SAD, consisting of scientific/technical representatives of all parties participating in SAD-project
- The Steering Committee should have continuous electronic information update and meet at least 3 times a year to monitor the project progress.
- Foreign collaborators see a very necessity of stronger support for SAD from the JINR management. **We do not see good prospects for this project if it does not become an official, high priority JINR-project**. Project manager with his team should take up this issue with JINR management.
- The benchmark-design group has been established and dr. Lopatkin is chairing this group. Foreign collaborators expect that this group will bring very soon a full coherency into design work and will create a real team-work
- Highest priority should be immediately put on the following tasks:
  - Final design (hopefully solved in action above)
  - Fuel manufacturing, qualification and delivery. We appreciate very much the choices of highest possible qualification (quality) of the fuel ensuring SAD to be a good validation experiment
  - Close interactions with licensing authorities to avoid any “show-stoppers” in the licensing process
  - Planning and progressing of the necessary constructional work including adjustment at the accelerator complex.
- SAD team should intensify its contacts, collaboration and information exchange with running project MUSE and other EU-projects, and in particular with EUROTRANS project proposal.
- Foreign collaborators with a great interest see at different subcritical experiment ideas (like the one presented by dr. Chigrinov), and we would encourage these activities if they do not disturb SAD-planning and experimenting. In fact we would like to see a full synergy between those ideas.

ISTC Projects Meetings #2267 (SAD) and #1372 in Dubna, January 26-27, 2004

#1372

Foreign collaborators are seriously concerned about some part of this project.

We suggest a following, immediate action plan:

- Project management will deliver in at highest 3 weeks a detail report on the fulfilment of the Working plan. Foreign collaborators would like to see a very simple “task-after-task” analysis of the approved Working Plan and a progress/completion report on every single topic.
- Project management will present an “in promptu” remediation plan convincing us that the last measurement session on the LVE-accelerator will produce expected, reliable data. If no reasonable assurance can be given that the experiments will give quality data appropriate conclusions should be drawn by the project management.
- The most recent progress report will be distributed to the collaborators as soon as possible

Charter of the SAD/Yalina Steering Committee

Purpose

- **The purpose of the SAD/YALINA-B Steering Committee is the coordination of the ISTC projects with integral experiments with source-driven sub-critical systems and integration of those projects with the European ADS-related activities.. Currently, the ISTC project #2267 (Sub-critical Assembly Dubna, SAD) and the #B070 successor experiment with lead booster (YALINA-B) are involved. Other experiments under consideration will be included if corresponding proposals for ISTC projects decision board will be prepared.**

Membership

- **Initially the Steering Committee is composed of representatives from the ISTC collaborating parties: EU (Germany, France, Sweden, Spain), the SAD and YALINA-B project management and of the Polish JINR cooperation. It may be expanded as necessary and upon agreement to include other participating countries, like other JINR members etc. The list of committee members is given in attachment 1.**

Objectives

The objectives of the Steering Committee are

- **to prepare and provide guidance and advice on a scientific program for ADS ISTC integral experiments, currently SAD and YALINA-B, and to supervise the progress of the construction of these experiments,**
- **to ensure that the scientific program of SAD, YALINA-B and possible other ISTC experiments, will address the needs of the European and international efforts for ADS research and contribute towards the realization of an ADS demonstration facility,**
- **to offer a forum for the participating countries and collaborators to provide input into planning of the experimental programmes,**
- **to ensure scientific and technical participation in the experiments and their analysis.**

Charter of the SAD/Yalina Steering Committee

Implementation

- **The Steering Committee will give advice to funding organizations for the installation, commissioning, planning and execution of the experimental program:**
  - **review program plans provided by project leadership,**
  - **oversee progress of efforts concerning:**
    - **construction of the facility,**
    - **instrumentation,**
    - **safety and commissioning,**
    - **quality of experimental work ensuring its validation quality,**
    - **long term scientific activities**
- **The Steering Committee will support the projects by:**
  - **establishing an effective collaboration and cooperation with JINR and ISTC,**
  - **coordinating the participation of partners in the SAD/YALINA-B related efforts, including exchange of experimental support if possible,**
  - **disseminating the reports and the results of experiments,**
  - **providing collaboration links with European and other interested groups.**
- **The Steering Committee promotes strongly the continuous support of ISTC and EU for SAD, YALINA-B and possible other projects with source-driven sub-critical systems.**
- **The Steering Committee meets three times a year and in between meetings uses electronic communication.**
- **The Steering Committee reports to the ISTC Contact Expert Group on Transmutation related projects (CEG). Minutes from every meeting, and action plan updated between meetings, will be reported to CEG.**

1st SC-meeting- Dubna - 13 July 2004

1 The SC members agreed to record, in addition to the action plan, the following general conclusions as the outcome of the first SC Meeting:

- By the end of December 2004, the SAD project manager will provide a cost assessment for the SAD construction. Resp. V. Shevstsov.
- The issue of final disposal of SAD activated structures was raised; an action was put on the SAD project manager to initiate preliminary discussions on this subject with the appropriate persons at JINR. Resp. V. Shevstsov
- The SC expects strong commitment on the side of JINR for the construction and operation of the SAD facility, and asks the SAD project manager to convey this message to the JINR management. Resp. V. Shevstsov and C. Broeders
- The SC took note that the IAEA Coordinated Research Project (CRP) on analytical and experimental benchmark analyses of sub-critical systems driven by an external neutron source was approved by the Agency. The CRP will start in 2005. The SC acknowledged that both projects, SAD and YALINA, would greatly benefit from the participation in this CRP. Forms for research agreement and contract proposals were distributed by the IAEA representative in the SC, and the participants were encouraged to submit proposals for participation in the CRP. Resp. A. Stanculescu
- The SC acknowledges that SAD fuel manufacture was initiated, and that no cliff-edges were encountered at this stage of the fuel manufacturing process. The SC also took note of the fact that the fuel assembly grids will be manufactured at JINR.

2 Next meeting: it is planned to hold the Second SC Meeting on 20 and 21 January 2005 in Minsk, Belarus.

SAD/YALINA-B 2. SCM Minsk, 24-25 January 2005

- Action plan from the 2-nd SAD/YALINA SC meeting
  - **SAD short term actions**
    - Project time schedule with identified critical paths and milestones of special importance for EUROTRANS: 10 Feb. 2005 with 1-st draft distributed by Feb.6: responsible V. S.
    - Cost assessment, linked to the TS, exploring ISTC funding and ISTC-channeling and “Russian template”: 10 Feb. 2005 with 1-st draft distributed by Feb.6: responsible V. S.
    - Cost assessment should be prepared according to the timeline with well defined parts for salary, design work, equipment manufacturing and construction work: responsible V. S.
    - Template for the cost assessment will be kindly provided by H.A.A. by Jan.28 2005: responsible H.A.A.
    - The document “White Paper”, summarizing the objectives and the most important deliverables of the SAD. First draft to be prepared by Jan.31. This document will contribute to development of the “comparison table”/C.B./, which is the separate document, first circulation by Feb 1: final draft - Feb. 8 2005 responsible: C.B.&V.S.
    - The additional funding options are to be explored for example: USA or Japan support for physical security system of SAD/V.S./, collaborators co-funding/SC members/, Japan and/or USA through ISTC/W.G, C.B. &V.S./.
  - SAD management prepares request to ISTC executive director for current project prolongation caused by exchange rate effect till the end of 2005.
  - SAD management prepares the ISTC application for the Phase II as a prolongation of the SAD project for the second GB meeting of 2005.
  - Recommendation from the SC to the EUROTRANS committee on the SAD experiment: Jan 31, responsible: SC members
  - SAD management prepares annual report on ISTC project #2267 with description of the SAD design by the end of Feb. 2005.
  - **YALINA actions**
    - Formal proposal for continuation of the YALINA experiment. The proposal should have strong synergy components with SAD: by the Feb. 15 2005, responsible S.Ch., V.S. & C.B.
    - Calibration of the YALINA detectors at MOL facility. Yu. Pepelyshev from SAD team participates this activity.: by June 30 2005, responsible: S.Ch. & H.A.A.
  - **General actions**
    - The Polish group from UMM prepares benchmark on SAD target induced activity.: first input by the end of Feb. 2005, responsible: G.D. with intensive consulting needed from C.B.&E.G.
    - The SAD/YALINA collaborators create a group of young students/researchers/engineers to join experimental work on YALINA and SAD. The seed of this group already exists.
    - SAD/YALINA collaborators to submit proposals for Research agreements and Research contracts to IAEA for the CRP “ …ADS benchmarking… ”.: by the end of Feb. 2005.

Third Meeting of the SAD/YALINA-B Steering Committee (SC) JINR Dubna, Frank Laboratory of Neutron Physics, June 27-28, 2005

- On June 28 SAD realisation was discussed in a “Round Table” session. Participants were: C. Broeders, Y. Gohar, W. Gudowski, N. Jousten, F. Mellier, L. Tocheny, V. Shvetsov, A. Sissikian (Dierctor General of JINR), D. Villamarin, JINR-chief engineer and Dr. Olszewski, chief engineer of the Accelerator
  - The estimated total costs and the possible contributions of the partner were discussed in some detail. The differences between Russian full cost calculation model and ISTC payment, mainly for personal costs, was explained. ISTC cost model is more effective, but only can be applied for restricted tasks. W. Gudowski proposed the following partition:
  - 1/3 JINR, Dubna, mainly for infrastructure
  - 1/3 ISTC, mainly for personal costs in Russia and nuclear installation (fuel manufacturing)
  - 1/3 IP EUROTRANS/ECATS, mainly for experiment support
  - At this stage no absolute numbers were fixed, but the expectation was expressed that detailed negotiations for real realisation of the project can lead to significant cost reduction. The discussion to solve the financing of SAD was very constructive:

Meeting Eurotrans-SAD, September 16, 2005

- JINR Committment document signed
- Funding discusses

- JINR Program Advisory Committee meeting Nov. 7-8, 2004
  - Presentation of SAD by WG
- 4th Meeting of SAD/Yalina SC – Minsk, December 2005

Problems to solve..

- A new period in ISTC activities, drastically changed political climate and scene:
  - Partially successful shift towards ”partnership projects” mainly with USA
  - Weak collaboration between ISTC partners i.e. USA, EU and Japan in funding of really common projects
- CEG continues grass-root activities, a lot of projects became very successful
  - Lasting links to towards European Projects
  - Openess of Russian labs – (is this period is passing over ??)

Particular objectives:

- Assure ISTC funding for SAD and full integration with Eurotrans
  - How about supporting projects
- Continue with Yalina experiments (”new” B70)
- Continue nitride projects (Matine-2)
- Pb-Bi technology – project #2048
- Good strategy for nuclear data projects!

Vision

- A strategy to gradually transform EU-ISTC activities under FrameWork programme
  – We have a vision, but it is not politically anchored
  – Better focus of ISTC projects, more “business-like like” approach or research on European conditions
- Partnership program **does not work** well with European partners
  – WE CAN MAKE A CHANGE!

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Appendix 4

Presentation of A. Stanculescu IAEA

International Atomic Energy Agency

Coordinated Research Project (CRP) on "Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems"

Alexander Stanculescu
Nuclear Power Technology Development Section

ISTC Contact Expert Group Meeting
EC, Brussels, 30 – 31 January 2006

Outline

- ❑Coordinated Research Project (CRP) Mechanism
- ❑Scope and Objective of the CRP on "Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems"
- ❑Planning of the CRP

Coordinated Research Projects (CRPs)

- Mechanism for collaborative R&D work through international team-building
- Implemented in relation to a well defined research topic on which an appropriate number of institutions are invited to collaborate
- Effective means of bringing together researchers in both developing and industrialized countries to solve a problem of common interest

Agency's Role in a CRP: Coordinate the R&D Carried out by the Selected Institutions

- ❑ Appointment of a Project Officer within the Technical Division initiating the specific research activities with demonstrated competence in the topic covered by the research
- ❑ Ensuring that the subject of research is clearly defined and that each research institution participating in the CRP undertakes research according to an agreed work plan

Agency's Role in a CRP (cont'd)

- Ensuring that the **scientific and technical methodologies** proposed by the participating national institutions are **appropriate and relevant to the CRP's research topic**
- Ensuring that the CRP's research will
  - Make **optimum use of existing information** and contribute to **filling knowledge and/or technology gaps** in the field of research
  - Permit a **comparison of research results** from different institutions

Agency's Role in a CRP (cont'd)

- **Informing** members of the CRP on important **developments that affect the field of research** concerned
- **Assisting** the participating institutions in **obtaining information** and, where necessary, **materials needed for the CRP's research**

Agency's Role in a CRP (cont'd)

- **Arranging Research Coordination Meetings (RCMs) of all scientists collaborating in the research**
- **Providing financial grants under contract to support the research (in developing countries), and inviting all participating scientists to attend RCMs at Agency's cost**

What is the Objective of this CRP?

- To provide an information exchange and collaborative research framework (as requested by interested Member Sates) for R&D efforts aiming at ensuring that the tools to perform detailed simulations of transmutation systems are available

What Do We Want to Achieve in this CRP?

- Improve understanding of physics of the coupling of external sources with sub-critical cores
- Use integrated calculation schemes to perform computational and experimental benchmark analyses
- Make use of experimental data to substantiate analytical benchmark exercises

What Is The Desired Outcome of this CRP?

- Contributing to the advancement of the efforts under way in the interested Member States towards the proof of practicality of transmutation concepts

What Will Be the Output of this CRP?

- IAEA Technical Report that
  - Summarizes the analytical and experimental benchmarks
  - Concludes on the validation status of the integrated calculation and simulation schemes used
  - Identifies remaining open issue and R&D needs
  - Indicates possible future role for the Agency
- Publications in peer-reviewed journals and papers at international conferences

Who Is Participating?

Contracts Summary as of 30 November 2005:

- ARG: CNEA, Bariloche
- BEL: SCK·CEN, Mol
- BRA: CNEN/IPEN/CEN, São Paulo
- BYE: NAS/JIPNR, Minsk
- CPR: CNNC/CIAEA, Beijing
- FRA: CEA, Cadarache
- FRA: CNRS/IN2P3
- GER: FZ Rossendorf
- GER: FZ Karlsruhe
- HUN: BUTE/INT, Budapest

Who Is Participating? (cont'd)

- ITA: Politecnico di Torino
- JPN: JAEA, Tokai-mura
- NEL: NRG, Petten
- PAK: PAEC/PINSTECH, Islamabad
- POL: AGH-UST, Krakow
- POL: IAE, Otwock-Swierk
- RUS: ITEP, Moscow
- RUS: Moscow Phys. Society
- RUS: KI/MUCATEX, Moscow
- JINR: Frank Laboratory of Neutron Physics, Dubna

Who Is Participating? (cont'd)

- SPA: Universidad Politécnica de Madrid
- SPA: CIEMAT, Madrid
- SWE: RIT, Albanova University Centre, Stockholm
- UKR: Kharkov Institute of Physics & Technology
- USA: Argonne National Laboratory

⇒**Bottom line: 25 Institutions in 18 Member States and 1 International Organization**

Planned Benchmark Exercises

- YALINA Booster $\Rightarrow$ experiment analyses and comparisons calculation/experiment
- Spallation target parametric study with experimental validation
- Benchmarks on FEAT $\Rightarrow$ energy dependence and source efficiency; TARC $\Rightarrow$ neutron fluence and ^{99}Tc transmutation; and SAD shielding
- Analytical and numerical benchmarking of methods and codes for ADS kinetics

Planned Benchmark Exercises, cont'd

- Benchmark on the Kyoto University Critical Assembly (KUCA, 14 MeV neutrons/150 MeV protons) ⇒ analyses of the experiments and comparison calculation/experiment
- Kharkov Institute for Theoretical Physics (KIPT) electron based ADS benchmark ⇒ design analyses, comparison calculation/experiment for the target design
- ADS performance, burnup codes, and transmutation experiments ⇒ validation of burnup codes, minor actinide data, IBR-30 benchmark, etc

Implementation Plan

- 5 – 9 Dec. 2005: Kick-off research coordination meeting (RCM)
  - Agree upon the topical areas to be covered
  - Identify lead organisations (responsibilities)
  - Produce detailed task and work plans, as well as milestones and deadlines
- 2007 and 2008: 2nd and 3rd RCM, respectively
  - Review progress
  - With particular consideration to the status of the experimental programmes, identify needed improvements/modifications to the tasks and/or work plans, in particular considering

Implementation Plan, cont'd

- 2009: 4th RCM
  - Status review
  - Final inputs and final draft of the CRP report
  - Definition of open issues and R&D needs, as well as possible Agency role
- 2010: Publication of final CRP technical report

For more information, please visit
http://www.iaea.org/inis/aws/fnss/

Thank You !

…Atoms for Peace

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Appendix 5

Presentation of V. Ignatiev

Progress in ISTC-1606 phase 2

Participating Institutions: VNIITF, RRC KI, IHTE, VNIIkHT

Foreign Collaborators: BNFL, CEA, CEC RTD, EdF, FZK, IAEA, KTH, NRI

Phase 2 Duration: November 2004 – April 2007

Presented by Victor Ignatiev

RRC-Kurchatov Institute, ignatiev@quest.net.kiae.su

for ISTC CEG meeting, Brussels, EC, January 30-31, 2006

Task#1606 Objectives

- To examine and demonstrate the feasibility of different molten salt systems: actinide burner and thorium system to reduce long lived waste toxicity and to produce efficiently electricity in closed fuel cycle
- Focus is placed on the experimental and theoretical evaluation of single stream transmuter system fuelled with different compositions of TRU trifluorides from LWR spent fuel without U-Th support

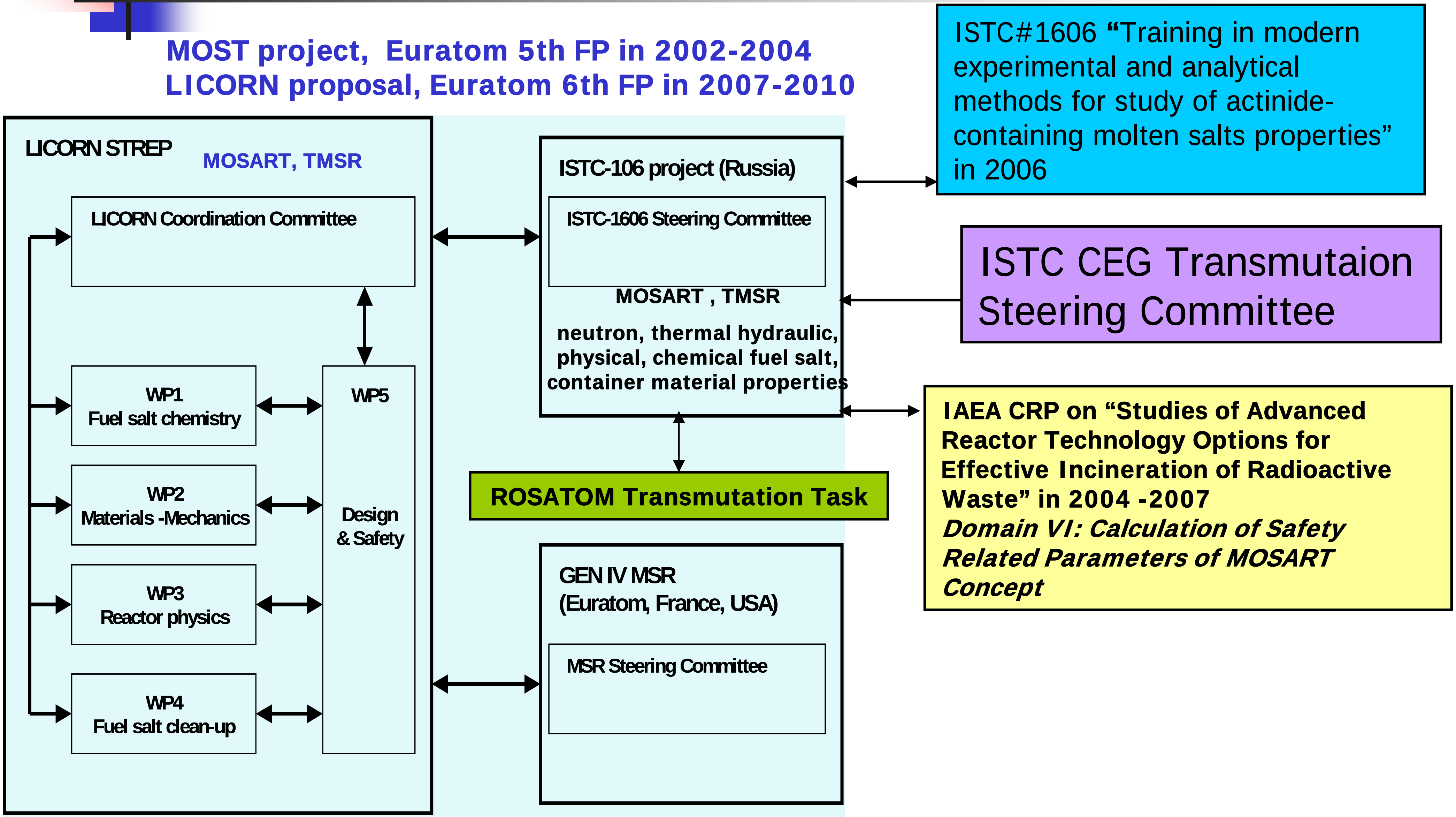
Task#1606 work packages

- WP 1: Study on neutronic and thermal hydraulic properties of cores, of selected MOSART and MS thorium systems operated in forced convection mode, accounting for technology constrains
- WP 2: Measurement of selected fuel salts key physical and chemical properties
- WP 3: Experimental verification of Ni-Mo alloys for fuel circuit in corrosion facilities with on-line redox measurement

New experimental data received in our studies feed into conceptual design efforts, which also fit to the need of EU partners

Co-operation with EU partners

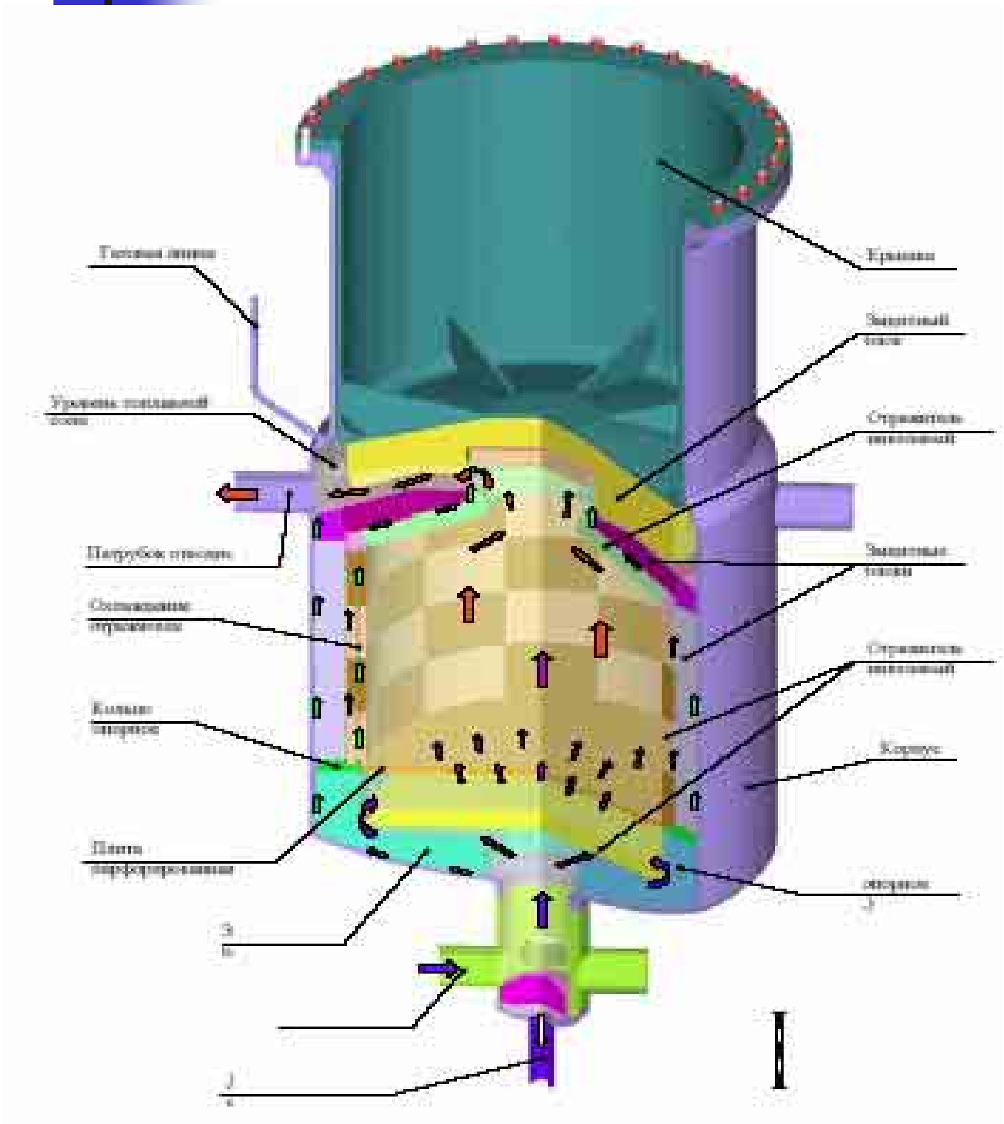
MOST project, Euratom 5th FP in 2002-2004
LICORN proposal, Euratom 6th FP in 2007-2010

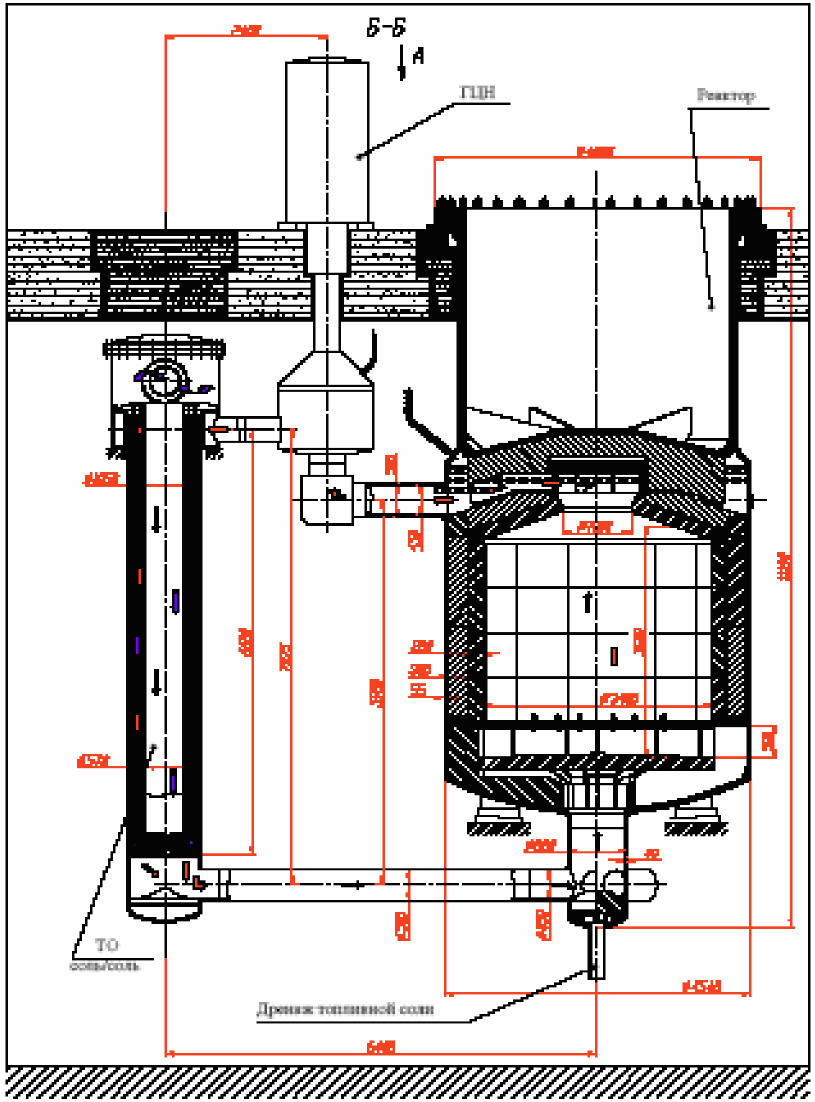


2500MWt MOSART concept

- 2500MWt MOSART system has homogeneous cylindrical core with 0.2 m graphite / nickel reflector
- Fuel salt is molten 58NaF-15LiF-27BeF_2 (mole%) fuelled by $TRUF_3$ from UOX / MOX PWR spent fuel
- The removal times for soluble fission products (rare-earth trifluorides) is considered as 1 year
- Diameter / height of the core are 3.4 m / 3.6 m
- The salt inlet temperature is assumed as 600°C
- The fuel salt specific power is about 47 W/cm^3
- The effective flux is near $1 \cdot 10^{15}$ n/cm^2/s
- Salt volume out of the core is 18.4m^3

2500MWt MOSART Sectional View





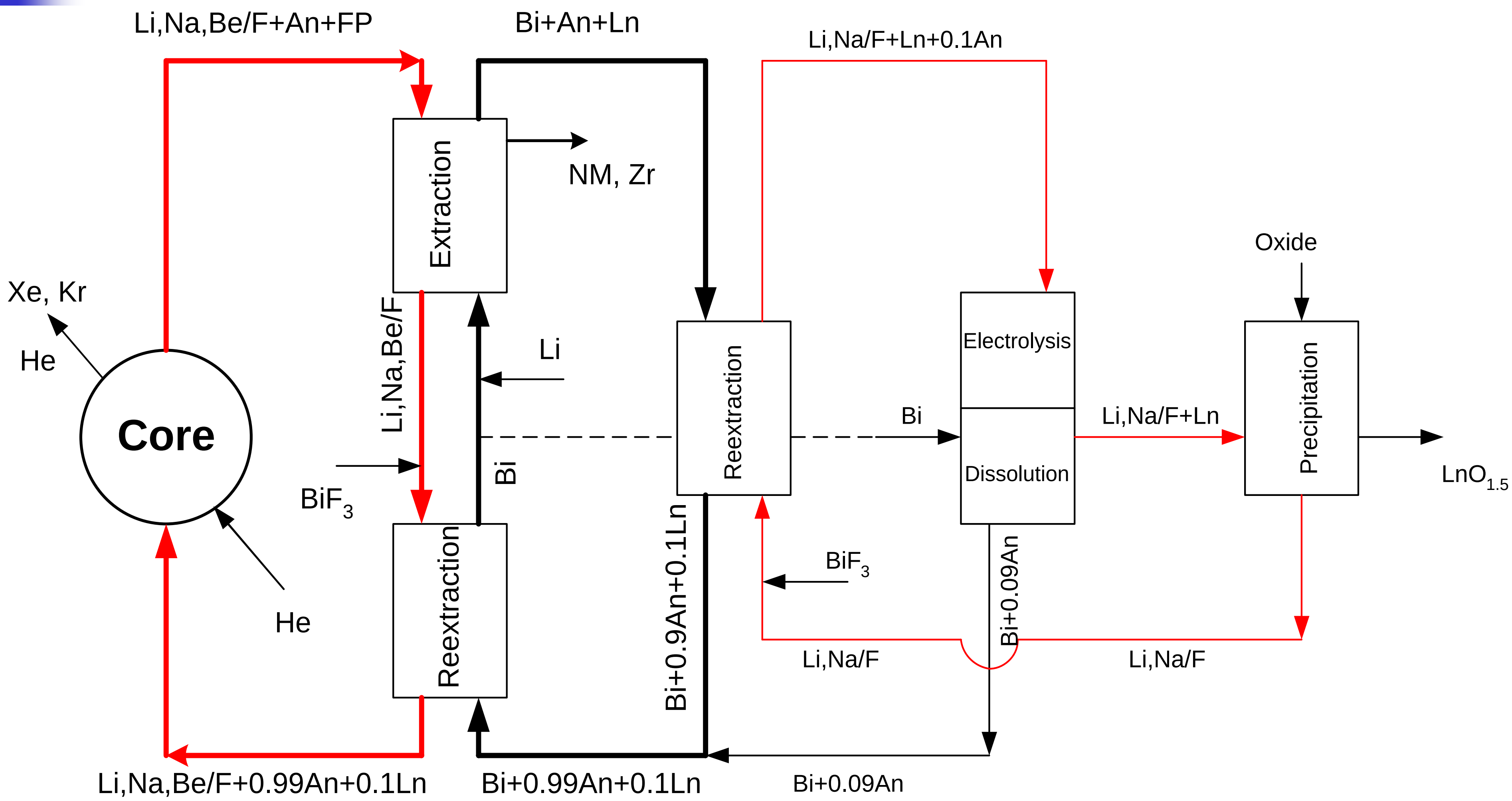
Na,Li,Be/F MOSART fuel and its clean up

Start up and feed material compositions, in mass %.

Scenario	1	2	3
Np	6.42	6,51	0,84
Pu238	3.18	2,77	6,34
Pu239	43.93	48,36	8,44
Pu240	21.27	19,97	34,89
Pu241	13.52	8,30	9,33
Pu242	7.88	6,25	18,7
Am241	0.55	5,56	1,4
Am243	2.33	1,69	4,65
Cm	0.92	0,59	5,07

Component	Cycle times	Removal operation
Kr, Xe	50 sec	Sparging with He
Zn, Ga, Ge, As, Se,Nb,Mo, Cd,In,Sn,Sb,Te, Ru,Rh,Pd,Ag,Tc	2.4 hr	Plating out on surfaces + To off gas ystem
Zr	1 -3 yrs	Reductive extraction, Oxide precipitation, Electrodeposition
Ni, Fe, Cr		
Np, Pu, Am, Cm		
Y, La, Ce, Pr, Nd, Pm, Gd, Tb, Dy, Ho, Er, Sm, Eu		
Sr, Ba, Rb, Cs	>30 yr	
Li, Be, Na		Salt discard

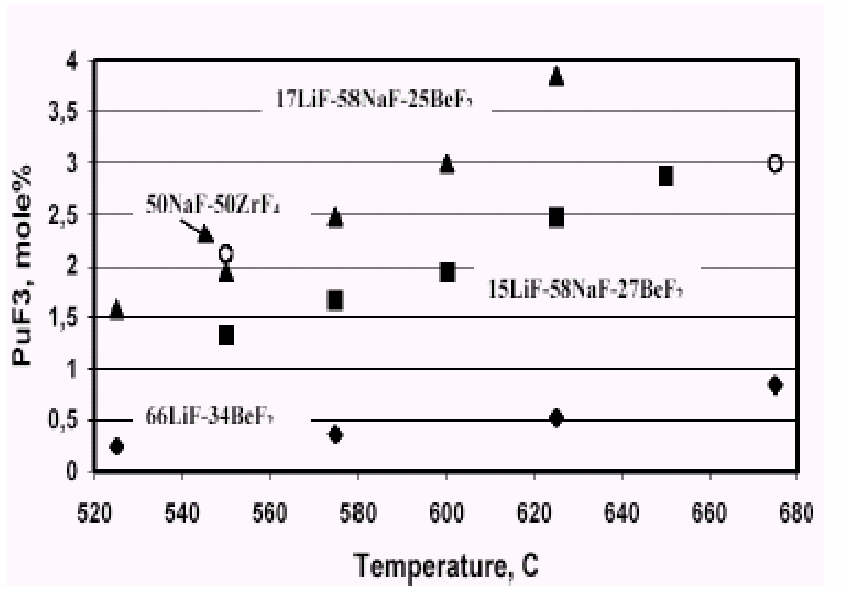
Na,Li,Be/F MOSART fuel clean up



Na,Li,Be/F Transport properties

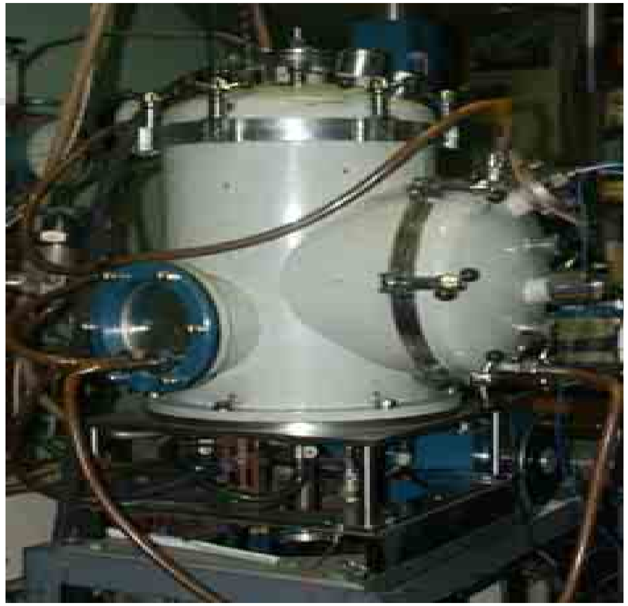
Composition, mol%	58NaF-15LiF-27BeF_2	479 C
Solubility of PuF_3, mole%	lnP = –6334/T [K] + 8.38	1.94
Viscosity, m^2/s	ν= 0.136·exp{2914/T[K]}	3.75
Heat capacity, $J{\cdot}kg^{-1}{\cdot}K^{-1}$	$C_p \neq f(T) = 2090$	2090
Thermal conductivity, W/(m•K)	λ =0.838+0.0009([C]-610.3)	0.837
Density, g/cm^3	2.163-0.406(t[C]-601.4)	2164
Prandtl number	$Pr = \eta * C_p / \lambda$	*11.6*
Reynolds number	$Re = 4G/D/\eta/\pi$	*706930*
Vapor pressure, Pa	$Ln\ p = 18.920 – 1.469*10^{-4} T(K) – 25283/T + 0.9819\ ln(T)$	
Temperature, C	500-800	600

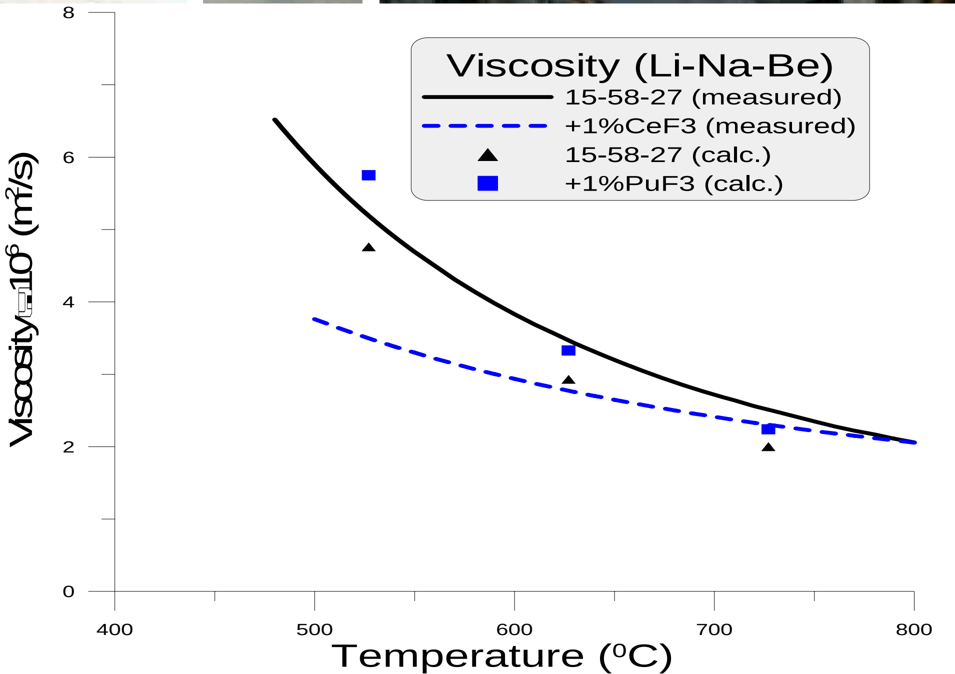
LiF	NaF	BeF_2	T_{melt}, ^0C
7	64	29	515-536
13	58	29	486-500
15	58	27	479
17	58	25	494-496
22	57	21	570



Transport properties studies: Phase 2

- Measurement of viscosity for molten 15LiF-58NaF-27BeF$_2$ (mole%) mixture fuelled by actinide trifluorides simulators (CeF$_3$)
- Measurement of density for molten 17LiF-58NaF-25BeF$_2$ (mole%) mixture
- Selection of the Th containing fuel composition for the further studies
- Evaluation of properties for Th-containing solvent selected



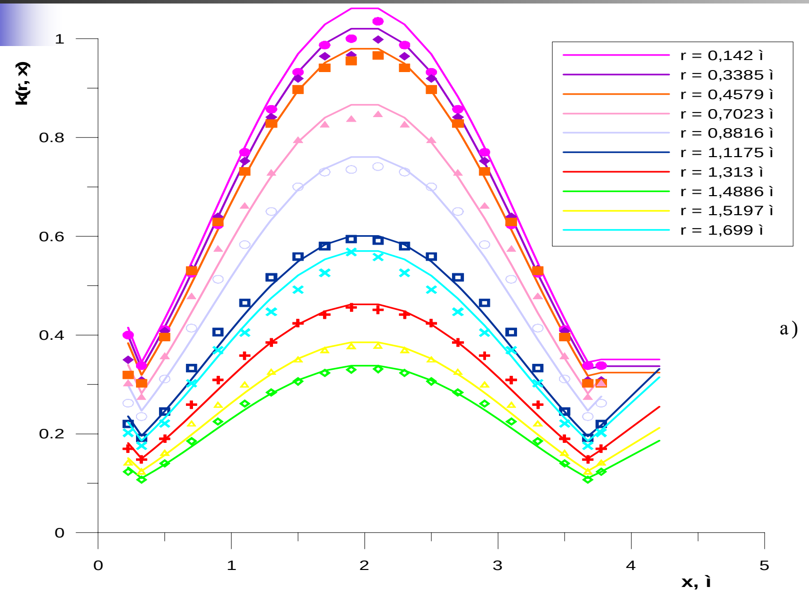


Neutronic & thermal hydraulics

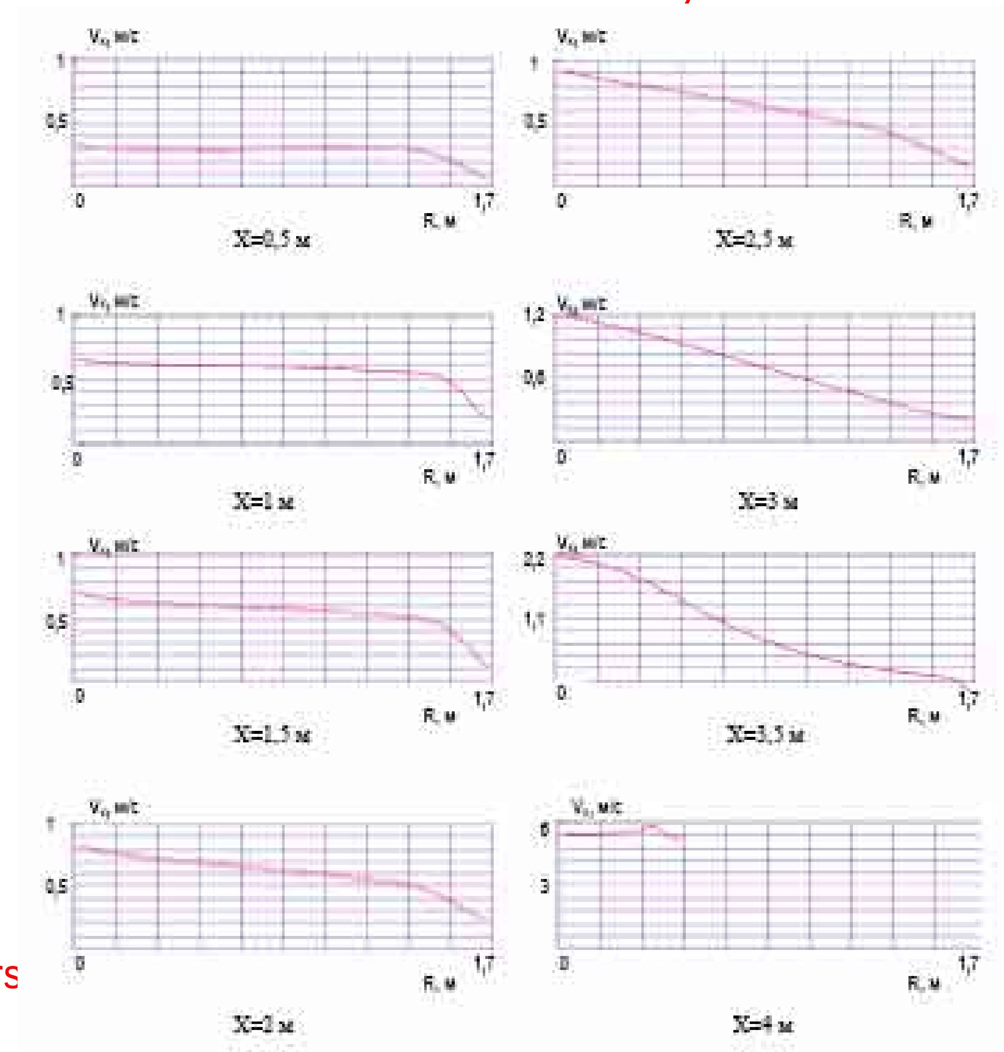
Coupling MCNP / MCU with material evolution code

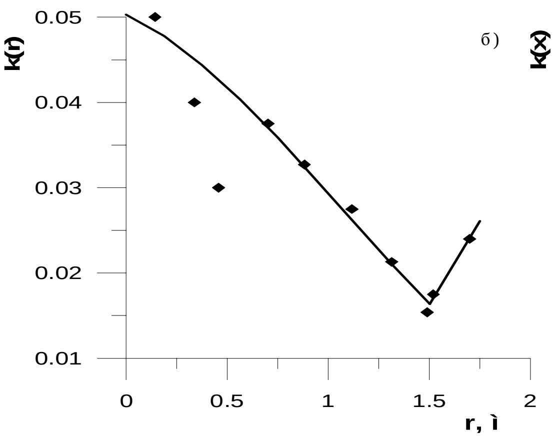
3D Power distributions: MCNP and MCU codes up to 6 millions histories

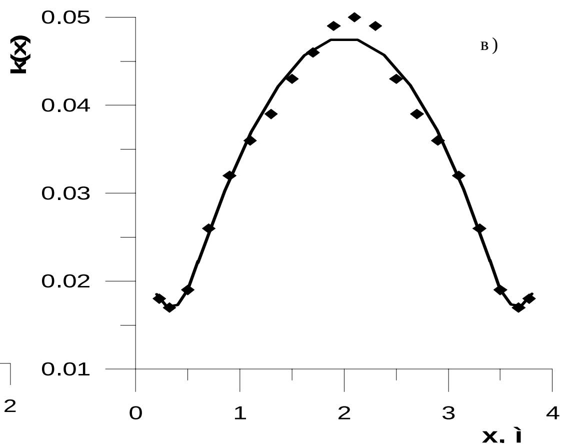
3D Thermal hydraulics: Flow Vision code with > 80000 working cells



Velocity V_x along reactor height X for different radius R, m/s





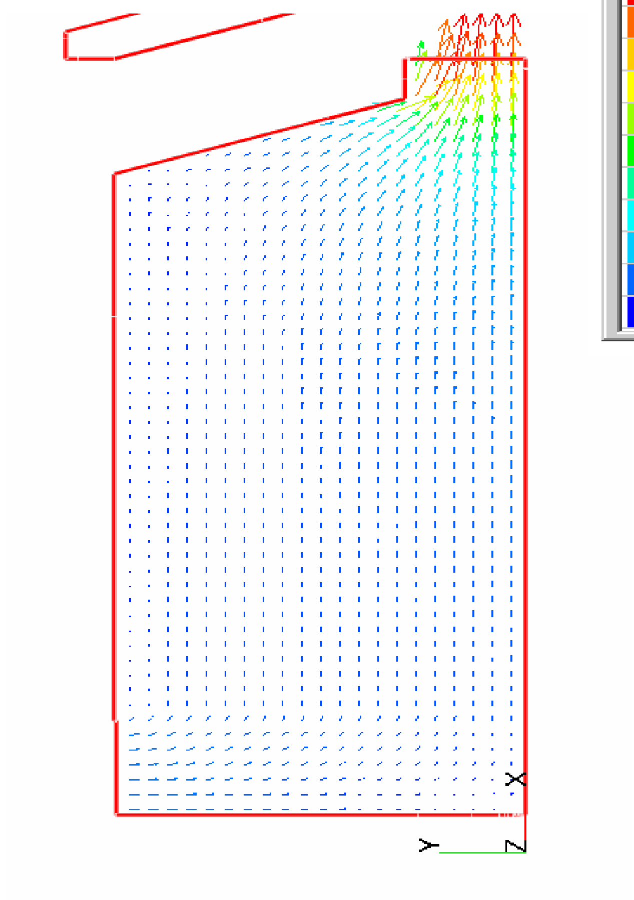


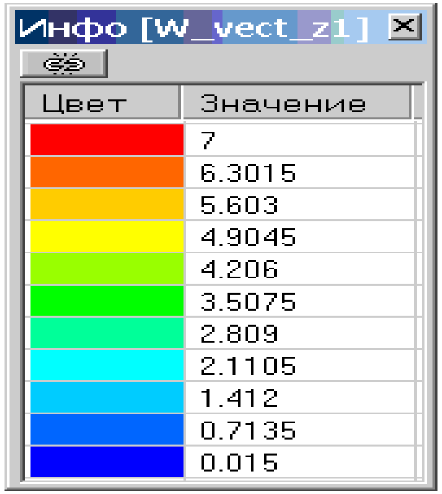
a – core wit graphite reflector; b,c – axial/ radial reflectors

Reflectors power due to n+γ radiation is 2.2% of total

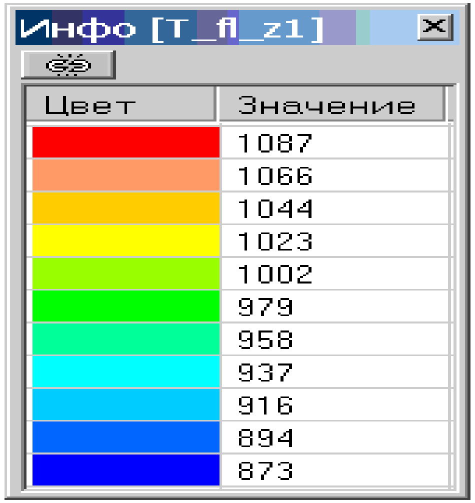
Velocity and temperature distributions in core with 20cm graphite reflector:

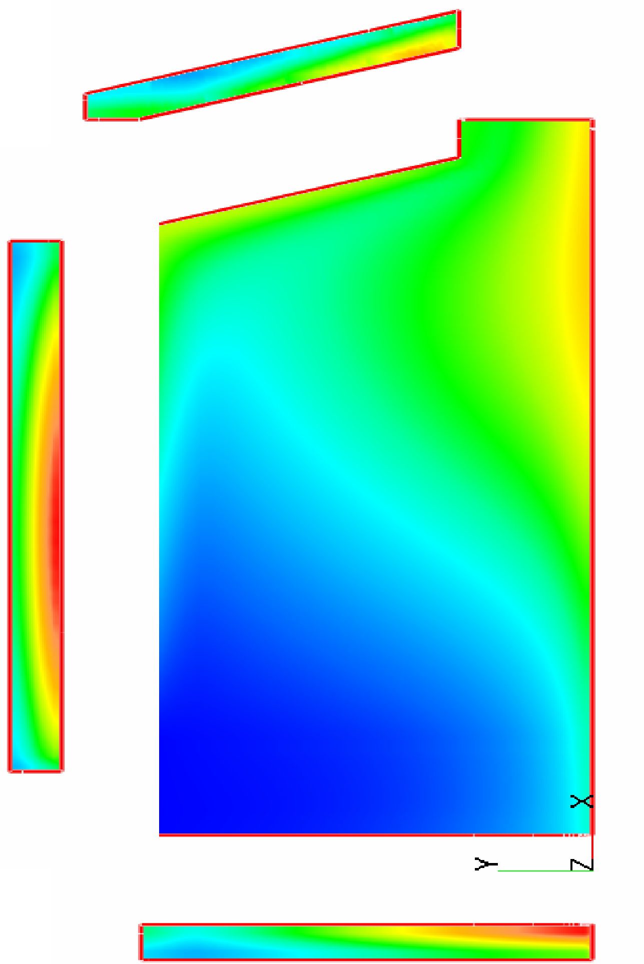
Conic Reflector, Salt Inlet at Bottom Periphery (H_t=50cm), Distribution Plate (porosity 0.32)



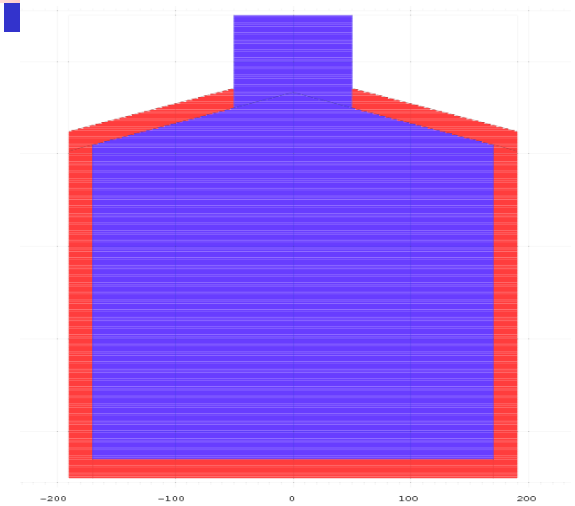


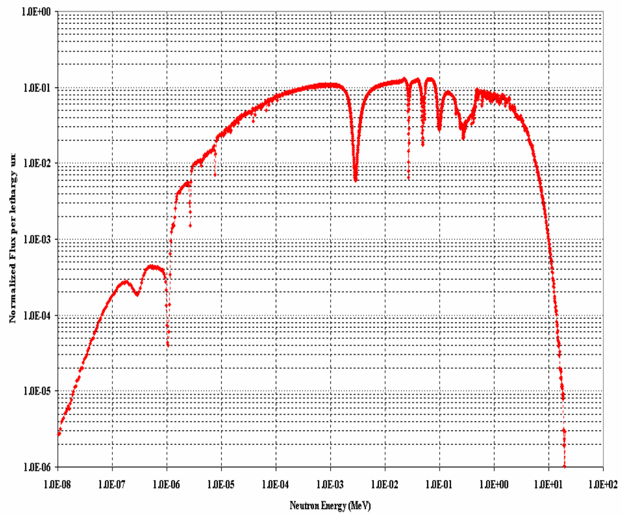
T_f^{max}=1036K
T_r^{max}=1087K
$<T_f>^{out}$=988K

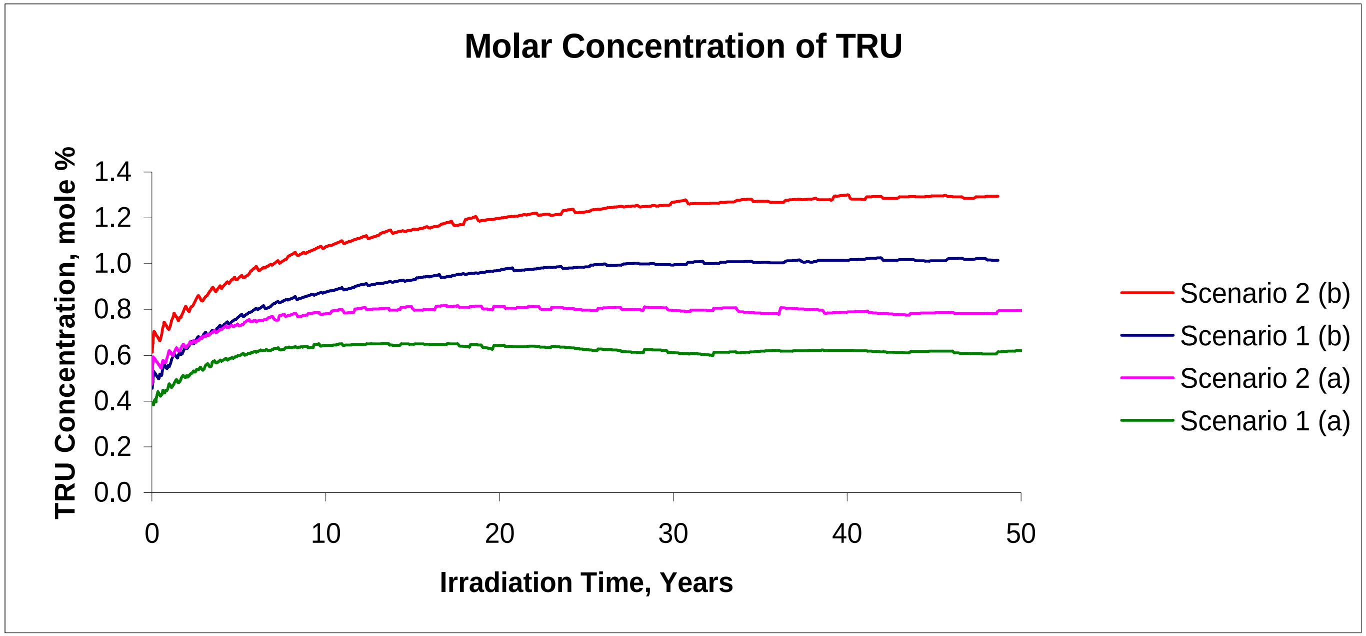




MOSART core benchmark







Library	k-eff
Feynberg	RRC-KI
ENDFB V,VI MCUDAT-2.2	0.99791 0.98930
Rineski	FZK
JEFF 3.0	0.99285
JENDL 3.3	1.01023
ENDF 6.8	0.98474
Malambu JEFF 3.1	SCK-CEN 1.00905
Da Cruz JEFF 3.0 JEFF 3.1	NRG 0.99335 1.01210

Reactivity coefficients for Na,Li,Be/F MOSART core

T_{salt}, K	T_{ref}, K	ρ_{salt}, g/cm^3	Doppler $\Delta K_{eff}/(T_t\text{-}900)$, pcm/K	Total $\Delta K_{eff}/(T_t\text{-}900)$, pcm/K
900	950	2.15261		
1000	1050	2.11201	-1.178 (-2.054*)	-3.225 (-4.237*)
1100	1150	2.07141	-1.222	-3.279
1200	1250	2.03081	-1.152	-3.333
1300	1350	1.99021	-1.134	-3.322
1400	1450	1.94961	-1.137	-3.356
1500	1550	1.90901	-1.093	-3.408
1600	1650	1.86841	-1.068	-3.449

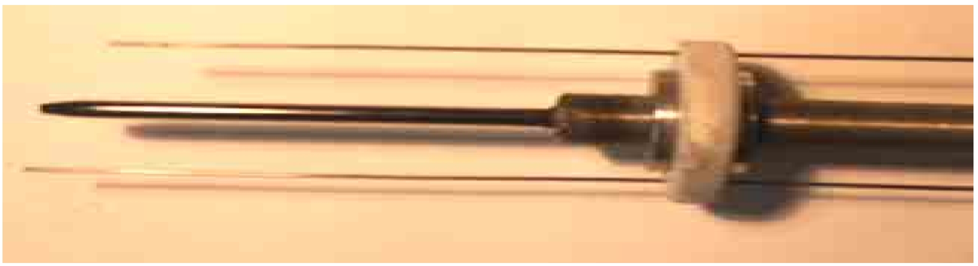
MCU with DLC/MCUDAT-2.2: 6 mln histories
for isothermal core and *for 8 radial and 10 axial zones

Primary heat exchanger

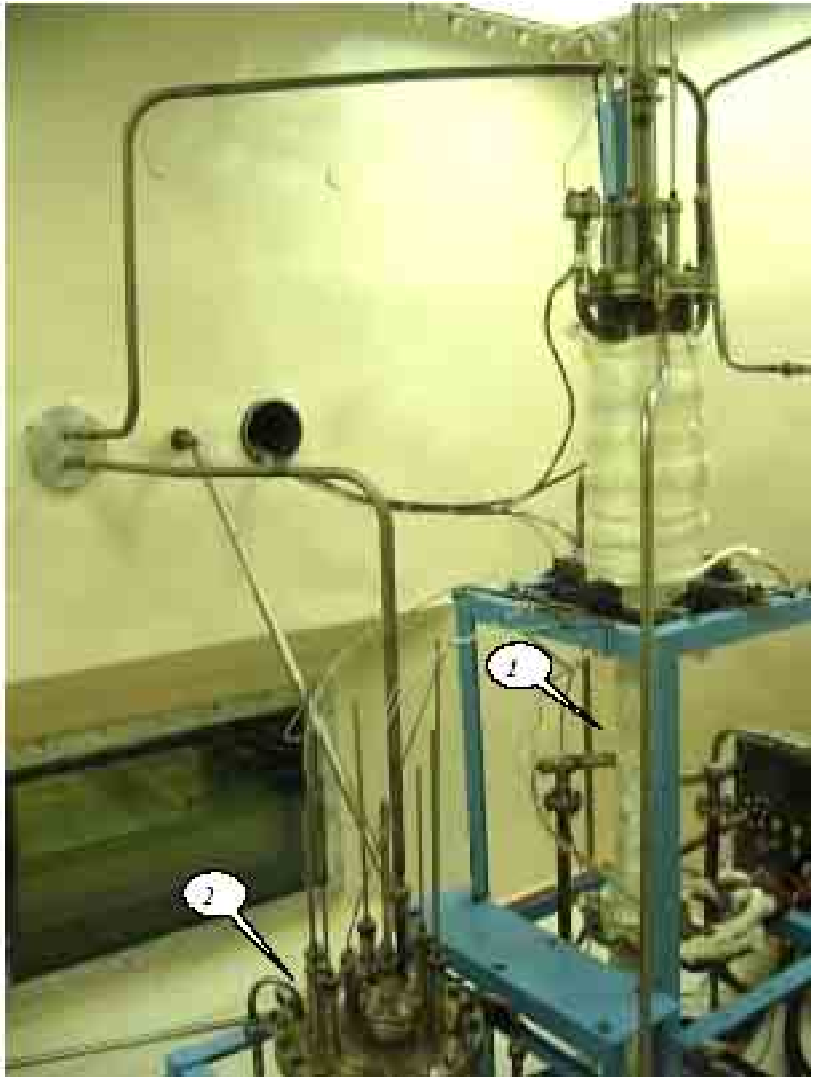
Configuration	Vertical
Fuel salt (tube), inlet / outlet temperature, C	600/ 715
Coolant salt (shell) inlet / outlet temperature, C	450/ 620
Fluid velocities ($v_1=v_2$), m/s	5
Tube OD, mm	Ø10x1
Tube pitch, S_i mm	12.2
Down flow tube ID D_1 , м	0.57
Heat exchanger OD, D_2 , m	1.05
Tube number for 4 heat exchangers, N	18591
Heat exchanger length, L, m	6.6
Total heat transfer coefficient K_Σ, W/m^2	5700
Pressure drop, ΔP_Γ, MPa	0.66
Total fuel salt volume in tubes, V, m^3	6.2

Corrosion studies: Phase 2

- Compatibility test (1200hrs) between 15LiF-58NaF-27BeF$_2$ salt and Ni - based alloys in loop with redox potential measurement
- 200hrs test on effect of PuF$_3$ addition in 15LiF-58NaF-27BeF$_2$ salt on compatibility with Ni - alloys
- Te corrosion study between 15LiF-58NaF-27BeF$_2$ salt and Ni - Mo alloys

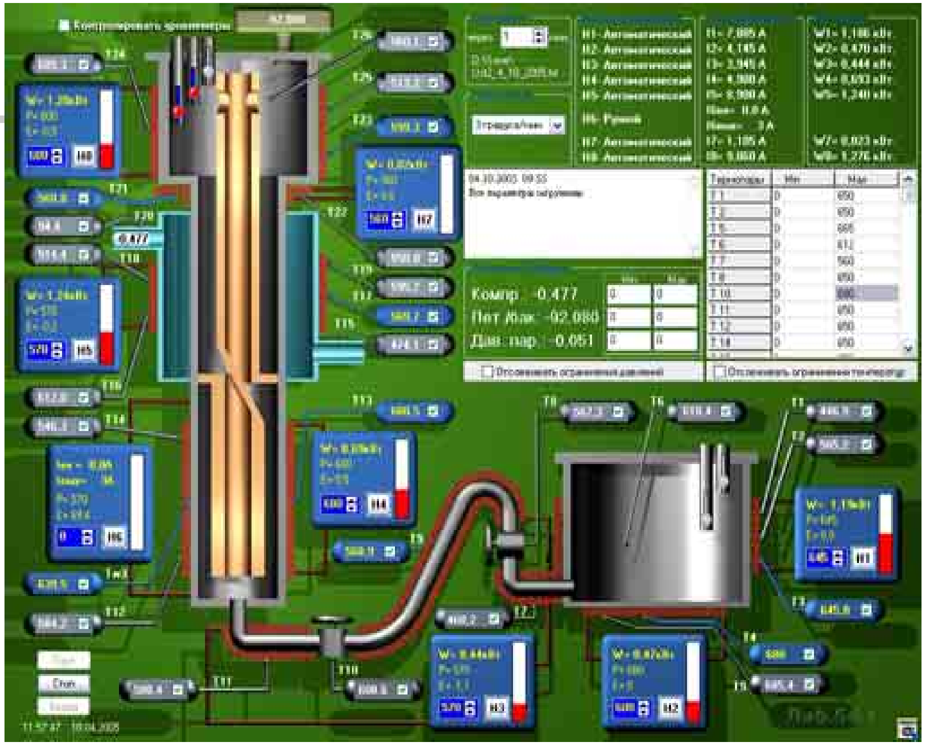


Diaphragm-free meter with dynamic berillium reference electrode for redox potential measurement in BeF$_2$ / PuF$_3$ containing melts

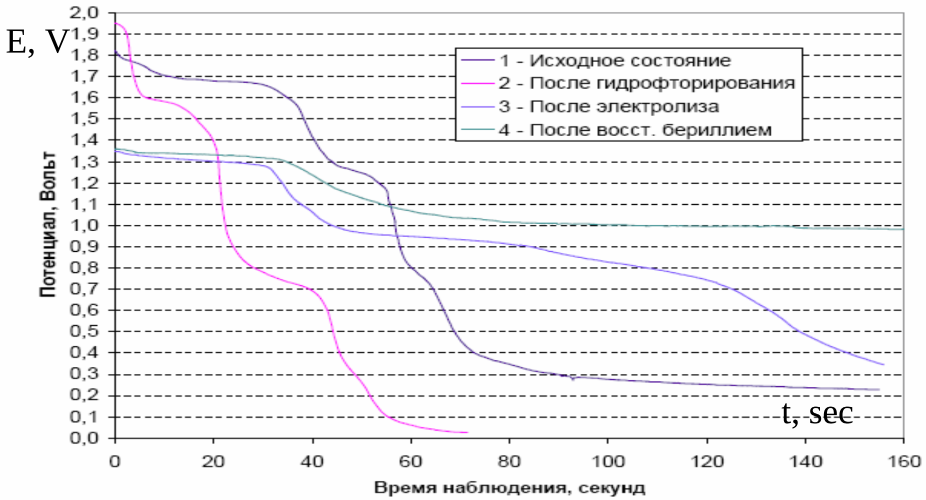


Na,Li,Be/F Salt purification procedure

1. **Hydrofluorination by a HF –He mixture in order to remove solid and dissolved oxides**
2. **Electrolysis to remove dissolved nickel**
3. **Treatment by metallic beryllium in order to remove rest of nickel and iron ions**

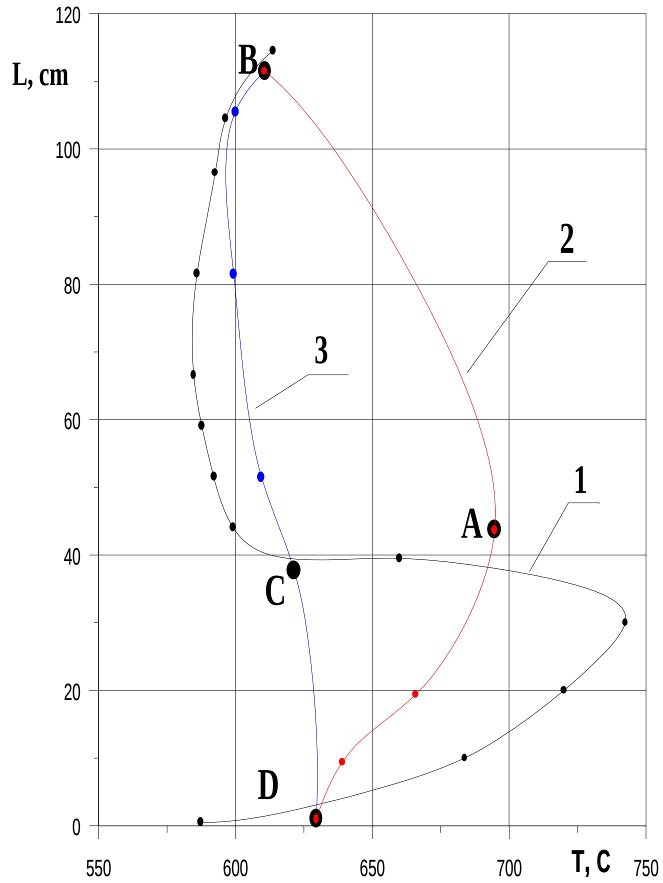


Salt charge after clean up procedures	T_s, ^0C	Impurities in salt, mass. %			Red Ox, V
		Ni	Fe	O	
100 hrs in drain tank	650	0.39	0.057	0.3	1.58
75 hr circulation in loop + 3 hrs of He bubbling in drain tank	590	1.01	0.042	0.34	1.78
14 hrs of HF-He +3 hours of He sparging	580	0.57	0.047	0.08	1.95
34 hrs of electrolysis + He sparging	575	0.038	0.001	0.06	1.34
12 hrs of metallic Be treatment	580	0.014	0.017	0.08	1. 3



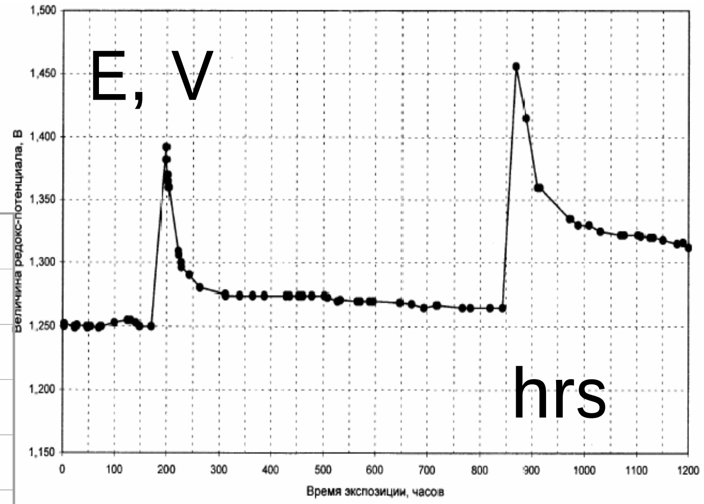
Thermal convection corrosion test

Specimens of HN80M-VI, HN80MTY and MONICR from loop hot leg exposed 1200 hrs at temperatures from 620^{0}C till to 695^{0}C showed uniform corrosion rate from 2 μm/year to 4 μm/year



Analysis of salt impurities, mas.%

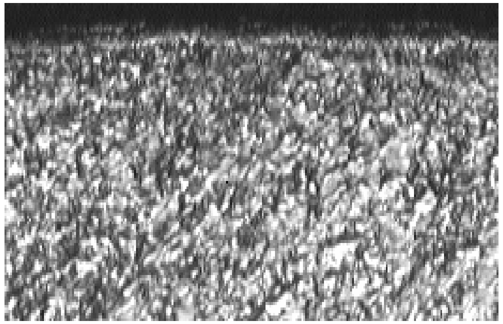
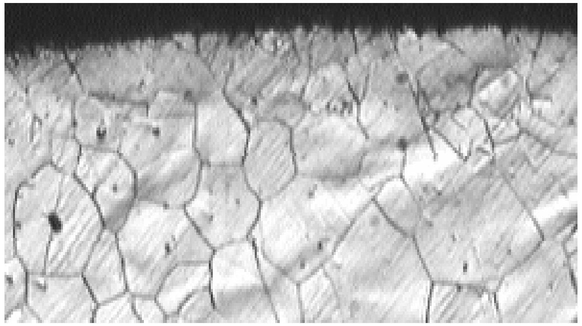
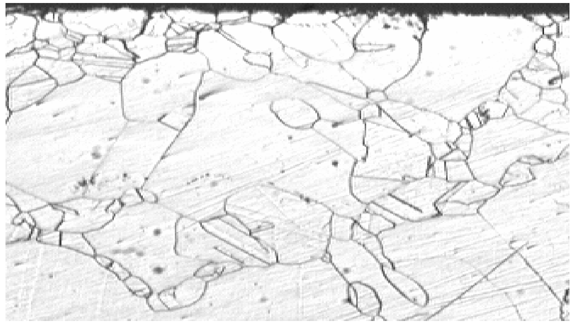
hrs	0	1200
Ni	0.0030	0.0019
Fe	0.0165	0.0040
Cr	0.0026	0.0037
Mo	-	<0.0002
Nb	-	<0.0001
Al	-	0.0049
Ti	0.0099	0.0005
Ba	-	<0.0001
Mg	0.0041	0.0040
Mn	0.0006	0.0003
Ca	0.0300	0.0070
Cu	-	<0.0001
Si	-	-
Sr	0.0005	0.0004



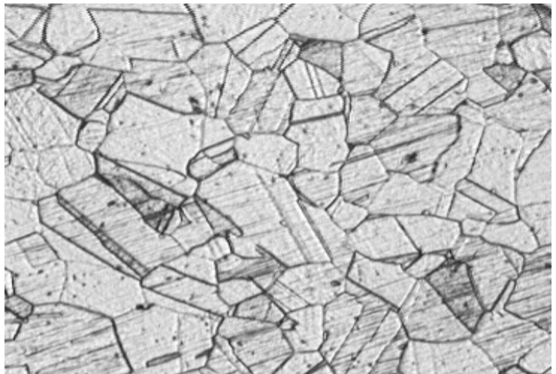
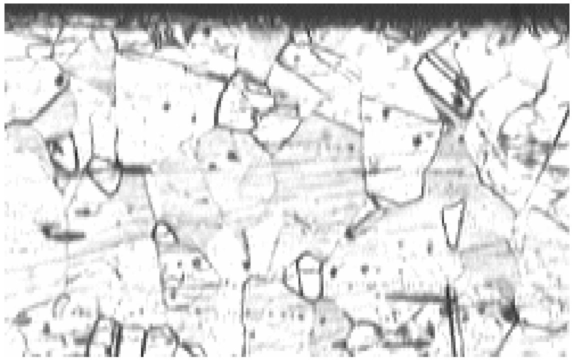
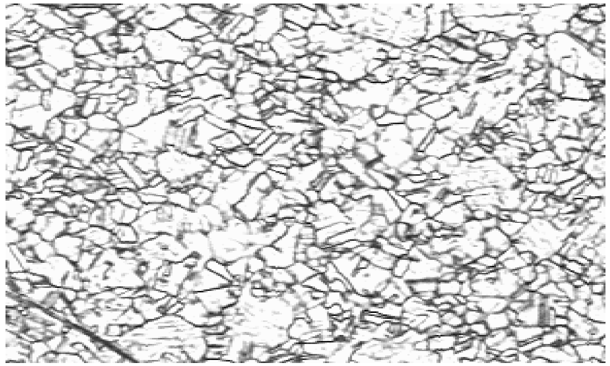
Examination of specimens:

HN80M-VI, 1.5% Nb | HN80MTY, 1% Al | MONICR 2.3% Fe

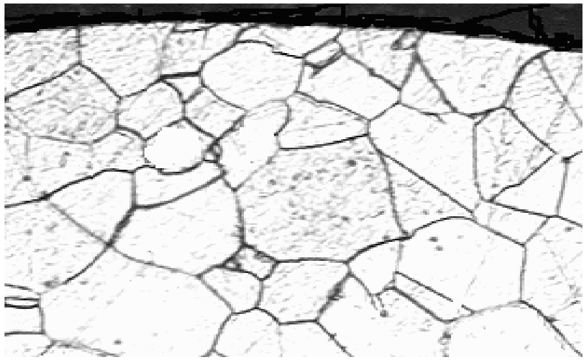
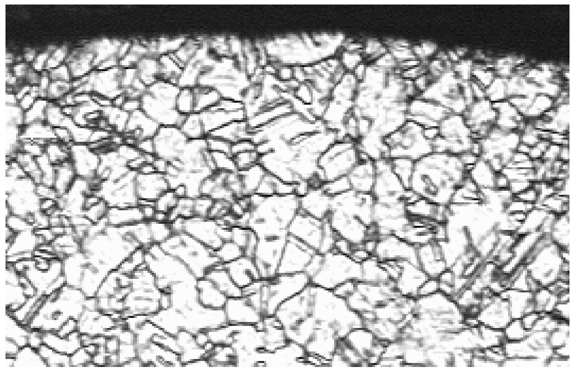
After 100hrs exposition in flash salt at 650C, E=1.6E

After preliminary thermal treatment

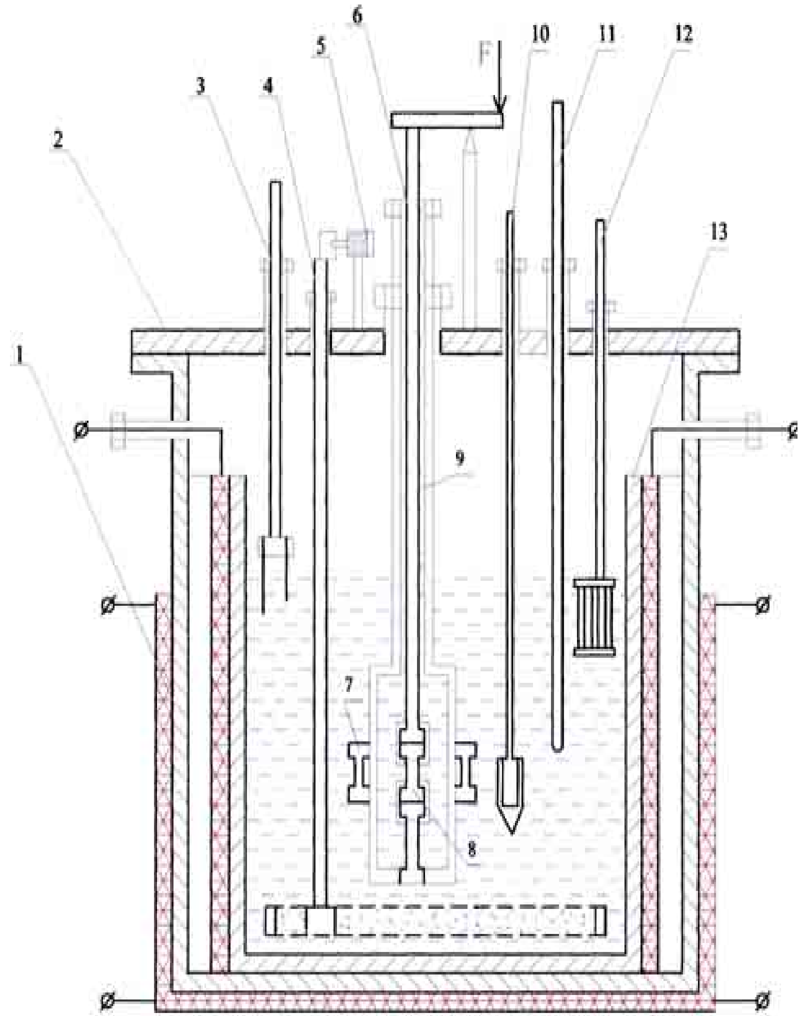




After1200 hrs exposition in loop, E=1.2V

Studies on interaction of tellurium with Ni - Mo alloys

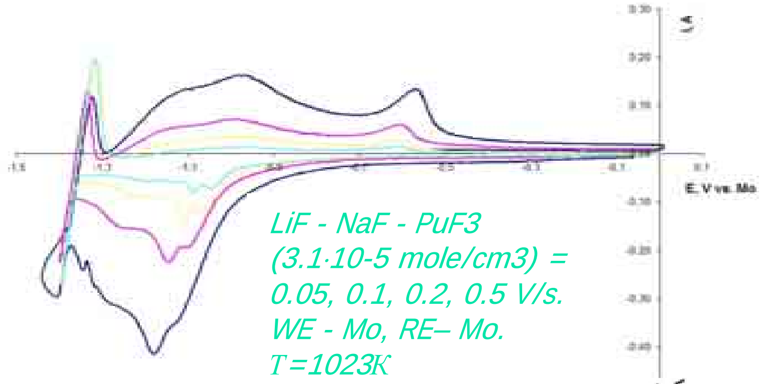
- Interaction of specimens with Te vapor (capsule, source – Cr_3Te_4)
- Interaction of specimens with Te in Na,Li,Be/F salt (capsules with pure solvent and additions of NiF_2 / FeF_2, source – Cr_3Te_4)
- Tests of specimens under stress in salt – tellurium environment (T=750C, t=250hrs, source –Cr_3Te_4, redox potential control, salt mixing)

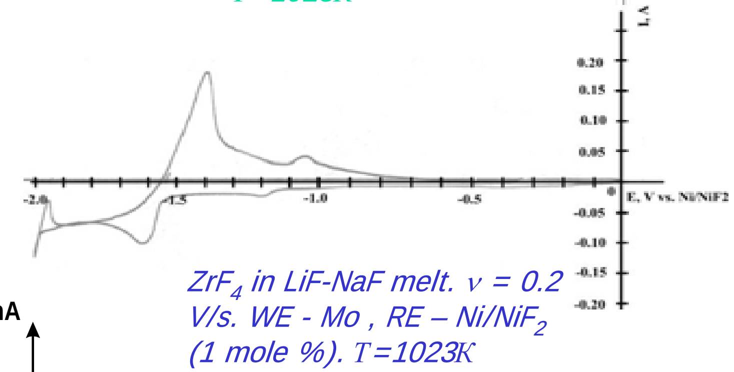


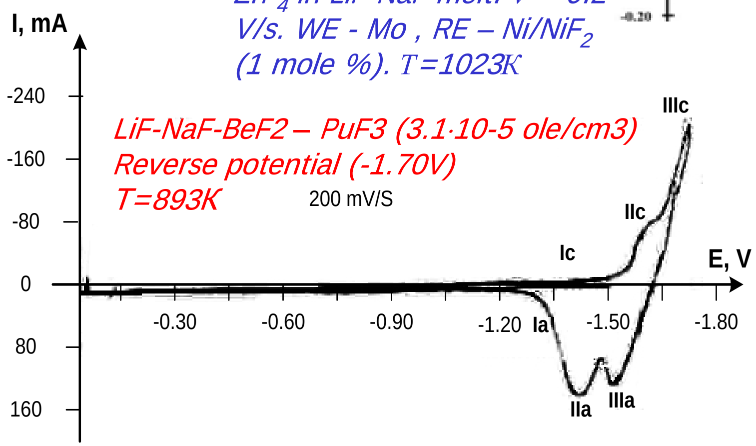
Fuel salt clean up: Phase 2

- Investigation of the influence of metal solvent nature on An/Ln separation in case of liquid Bi and Sb. Measurements of RE's and Pu distribution in system (liquid metal-Li) – (Na,Li,Be/F)
- Studies on electrochemical properties (conditional standard electrode potentials, ion behavior, activity coefficients etc.) of Pu and RE's and their trifluorides in molten Li,Na/F and Na,Li,Be/F systems
- Determination of PuF_3 free energy of formation on the base of standard potential measurements solid-state galvanic in cells
- Development of Ni-NiF_2 reference electrode based on boron nitride container for electrochemical studies in Na,Li,Be/F

Electrochemical study







Equilibrium potentials of the Pu^{3+}/Pu, Zr^{n+}/Zr, Be^{2+}/Be, Na^{+}/Na couples in 60LiF-40NaF and 15LiF-58NaF-27BeF_2 (mole%) melts were determined:

$E_{Zr2+/Zr} \approx -1.55 \pm 0.02V$ (Li,Na/F; 1023K)

$E_{Pu3+/Pu} = E_{Na+/Na} + 0.30V \approx -1.63 \pm 0.02V$ (Li,Na/F; 1023K)

$E_{Ln3+/Ln} < E_{Na+/Na} = -1.93 \pm 0.01V$(Li,Na/F; 1023K)

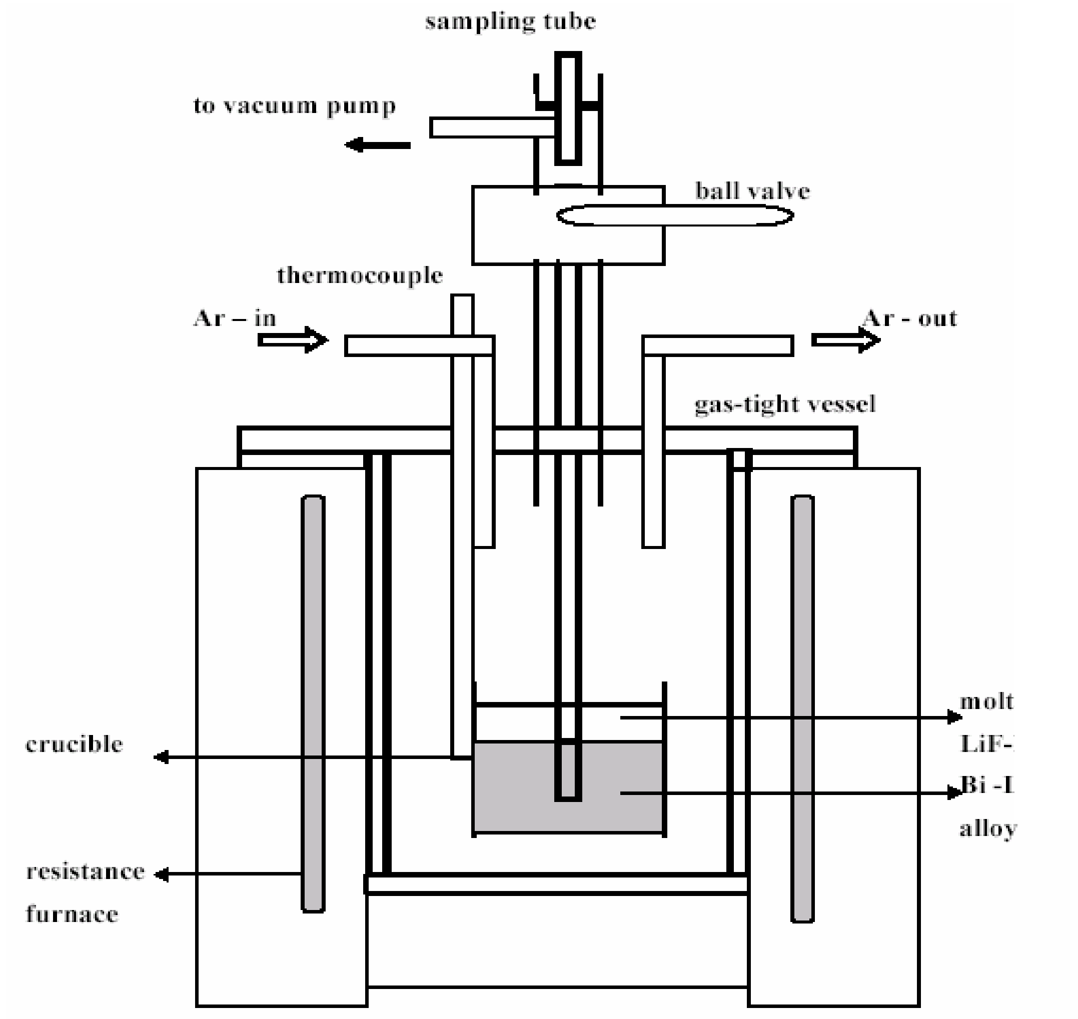
$E_{Zr2+/Zr} = -1.50 \pm 0.02V$ (Li,Na,Be/F; 873K)

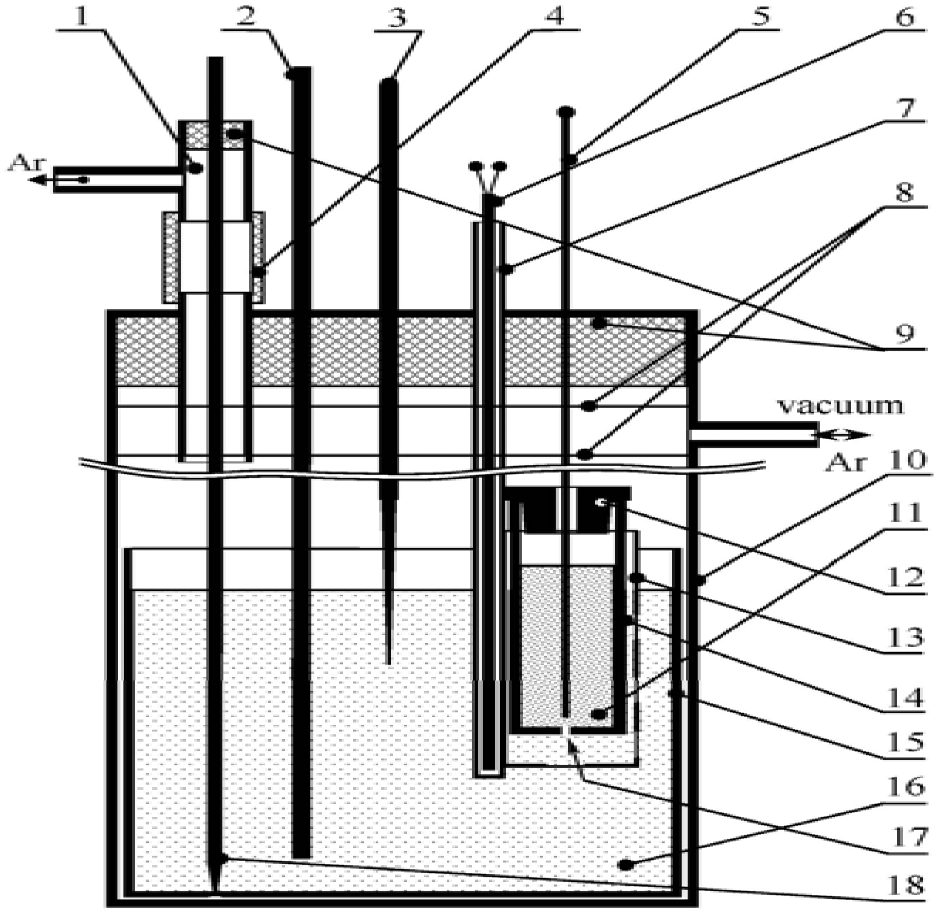
$E_{Pu3+/Pu} = E_{Na+/Na} + 0.15V \approx -1.75 \pm 0.05V$(Li,Na,Be/F; 893K)

$E_{Be2+/Be} = (-1.90 \pm 0.01V)$ (Li,Na,Be/F; 893K)

Assumption was made concerning alloying of Pu with Be, Na and Ni in process of Pu ions electrochemical reduction in system

Fuel salt clean up





2 – glassy-carbon auxiliary electrode; 3 – glassy-carbon working electrode; 5 – nickel reference electrode; 11 – melt in reference electrode; 14 – graphite crucible with pyrolytic boron nitride coat; 15 – nickel crucible; 16 – test melt;

ISTC#1606 Training Activity

“Training in modern experimental and analytical methods for study of actinide-containing molten salts properties”

- *The objective of the training is to gain experience and practical skills in the novel experimental methods for MSR technology study and development, which will be applied to the Work plan of the Project 1606 Phase 2*

Session 1: CEA-Cadarache, France, 2006, March, 06-10

Session 2 : VNIITF, Snezinsk, Russia, 2006, November

Program of Session 1

day	type	schedule	topics	providers
day 1	lecture	3 hours	MSR general features, status of MSR in FP6 and Gen IV	CEA (C. Renault)
	training	3 hours	MOST database	CEA (C. Eichenbaum)
day 2	lecture	3 hours	MSR different concepts	EDF (D. Lecarpentier)
	training	3 hours	Pre-design of MSR concepts (COPERNIC)	CEA (C. Thevenot)
day 3	lecture	3 hours	MSR reactor physics	EDF (D. Lecarpentier), CEA (O. Koberl)
	training	3 hours	Analysis of temperature feedback coefficients (sensitivity analysis with APOLLO2)	CEA (O. Koberl), EDF (D. Lecarpentier)
day 4	lecture	3 hours	Physico-chemical properties of molten salts : modeling and databases	JRC-ITU (R. Konings), EDF (E. Walle), CEA (O. Gastaldi)
	training	3 hours	ITU database (www.f-elements.net), database on Labview	JRC-ITU (R. Konings), EDF (E. Walle), CEA (N. Simon)
day 5	lecture	3 hours	Materials in molten salt environment (corrosion, control of salt,…)	CEA (C. Cabet), CNRS (S. Sanchez)
	training	3 hours	Formation of the potential/acidity diagram of a metal in a molten salt; description of corrosion/passivity domains	CEA (C. Cabet), CNRS (S. Sanchez)

Program of Session 2

day	type	schedule	topics	lecturers
day 1	lecture	3 hours	MSR thermal-hydraulics and fuel cycles considerations	EDF (D. Lecarpentier)
	training	3 hours	Pre-design of MSR concepts (COPERNIC)	FZK (M. Schikorr), CEA (C. Renault)
day 2	lecture	3 hours	MSR safety aspects	CEA (C. Renault), FZK (M. Schikorr)
	training	3 hours	Pre-design of MSR concepts (COPERNIC)	FZK (M. Schikorr), CEA (C. Renault)
day 3	lecture	3 hours	Fuel salt clean-up (techniques, flow-sheets)	CEA (O. Gastaldi, H. Boussier), EDF (E. Walle)
	training	3 hours	Simulation of MSR reprocessing unit	CEA (N. Simon, O. Gastaldi), EDF (E. Walle)
day 4	seminar	3 hours	ISTC-1606 developments	ISTC#1606 team
	visit	3 hours	MS experimental facilities	ISTC#1606 team

Papers prepared within 2005-2006

MS7

- Electrochemical study of zirconium, lanthanides and TRU in fluoride melts *by R. Zakirov, V. Ignatiev, A. Panov, A. Toropov, V. Afonichkin, Paper 114*
- Physical properties of Na,Li,Be/F MOSART fuel salt *by V. Ignatiev, Y.Golovatov, A. Merzlyakov, A. Panov, V. Subbotin,* Paper 082
- *Alloys compatibility with fuel and coolant salts by V. Ignatiev, A. Surenkov, V. Fedulov, V. Afonichkin, A. Bovet, V. Subbotin, A.Toropov, Paper 080*

NURETH 11

- Measurement of transport properties for molten Na,Li,Be/F mixtures *by A. Merzlyakov and V. Ignatiev, Paper 083*

ICENES'05

- Characteristics of MOlten Salt Advanced Reactor Transmuter systems *by V. Ignatiev, O. Feynberg, V. Smirnov, A. Tataurov, G. Vanukova, R. Zakirov*

Papers prepared within 2005-2006

GLOBAL 2005

- Integrated Study of Molten Na,Li,Be/F Salts for LWR Waste Burning in Accelerator Driven and Critical Systems, *Ignatiev V., O. Feynberg, A. Merzlyakov, A. Surenkov, A. Tataurov, G. Vanukova, Raul Zakiro*[1]**,** *V. Subbotin, A. Toropov, A. Panov*[2]*, V. Afonichkin, V. Khokhlov*[3]*, Paper 027.*

ICAPP' 06

- Experience with Alloys Compatibility with Fuel and Coolant Salts and their Application to MOlten Salt Actinide Recycler & Transmuter, *Ignatiev V., A. Surenkov, I. Gnidoi, V. Fedulov, V. Afonichkin, A. Bovet, V. Subbotin, A. Toropov, Paper 6002*

PHYSOR 2006

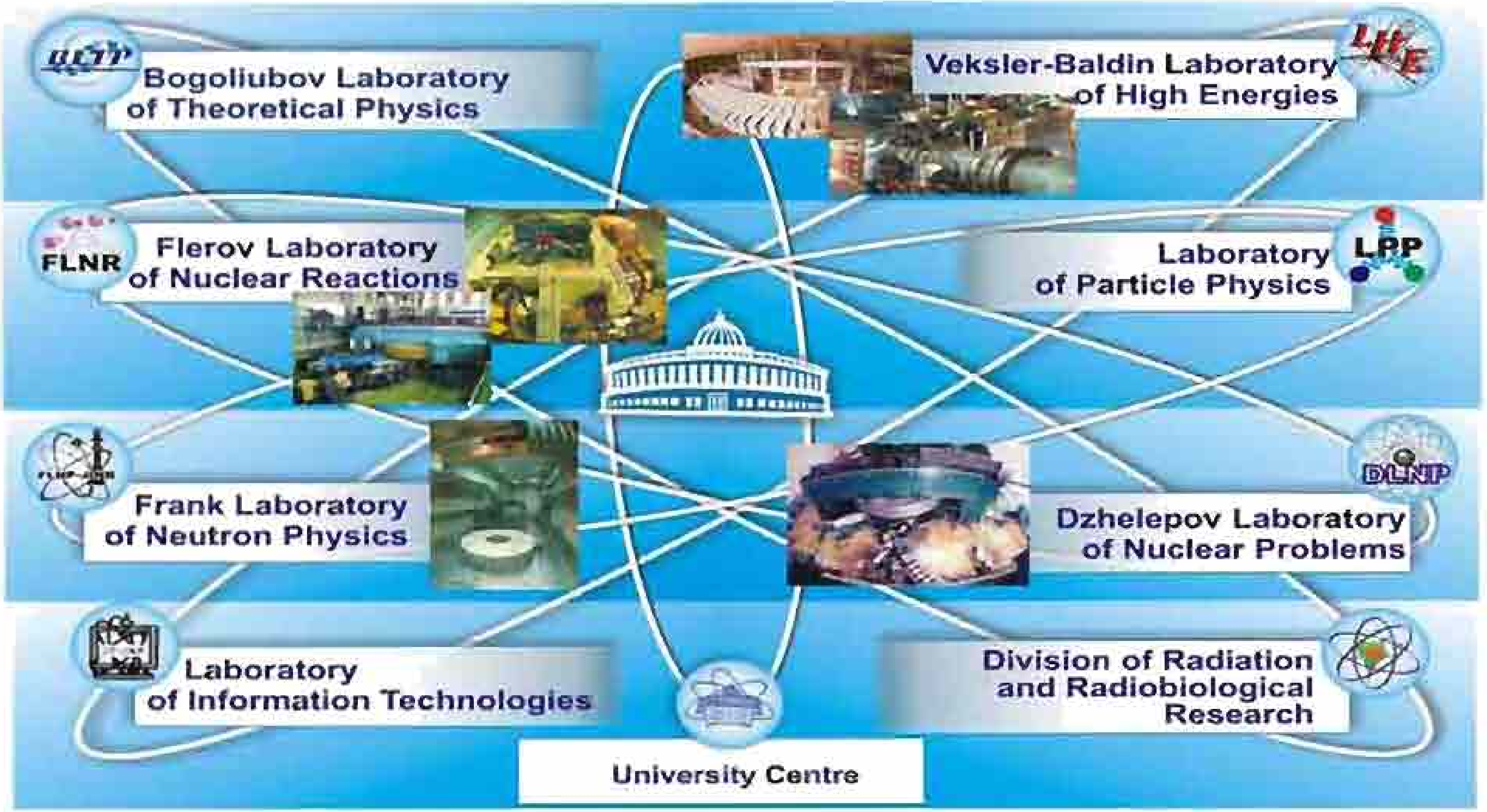
- Safety-related neutronics parameters of a molten salt actinide recycler and transmuter, *A. Rineiski, V. Ignatiev, D. Da Cruz, S. Dulla, O. Feinberg, E. Malambu, W. Maschek, A. Stanculescu, M. Szieberth, S. Wang*

Appendix 6

Presentation of V. Shvetsov - SAD

ISTC #2267 (SAD) Project: Objectives, Tech. Description, Status, Financing Issues

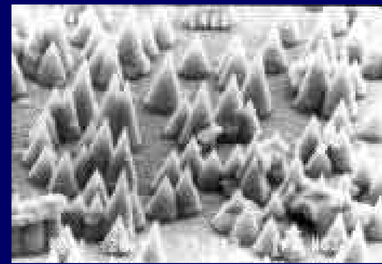
ISTC Contact Expert Group on Nuclear Transmutation related Projects,
Jan. 30-31 2006, Brussels


Bogoliubov Laboratory of Theoretical Physics
Veksler-Baldin Laboratory of High Energies
FLNR
Flerov Laboratory of Nuclear Reactions
Laboratory of Particle Physics
LPP
Frank Laboratory of Neutron Physics
DLNP
Dzhelepov Laboratory of Nuclear Problems
Laboratory of Information Technologies
Division of Radiation and Radiobiological Research
University Centre

SEZ in DUBNA

On December 21 2005, the Prime Minister of the Russian Federation M.Fradkov signed Resolution № 781 on the establishment of a Special Economic Zone in the territory of the town Dubna. On Jan 18 2006 it was legalized by town/region authorities

Nanotechnology



COPPER MICROTUBES

METALLIC NEEDLES

Radiation monitoring and safety

http://www.rosoez.economy.gov.ru/ru/

....

SEZ Creation: Goals and objectives

- Manufacturing industry development
- Advanced technology branches development
- New kinds of products manufacturing
- Commercialization of scientific-and-technological developments
- Fair competition between the countries

Cost Reduction for SEZ Residents

Costs	*Industrial-and-Production SEZ*	*Technological-and-Innovative SEZ*
Administrative barriers	5-7%	3-5%
Infrastructure	10-12%	8-10%
Concentration of production	5%	7%
Taxes	3-5%	5-7%
Total	23-29%	23-29%


Saint Petersburg
Dubna
Moscow
Tomsk
Elabuga
Lipetsk
Russia
International boundary
National capital
Railroad
Road
0 250 500 750 Kilometers
0 250 500 750 Miles
Lambert Conformal Conic Projection, SP 47/62 N
ARCTIC OCEAN
KAZAKHSTAN
CHINA
MONGOLIA
JAPAN
IRAN

SAD Project Objectives

- Coupling all major components of ADS;
- Core design, safety assessment, licensing;
- k_{eff} control and monitoring;
- Shielding from high energy neutrons;
- Experiments on core neutronics, reactivity feedbacks, transmutation reaction rates

Experimental Program

- **Qualification of subcriticality monitoring, experiments with PNG;**
- **Validation of the core power/beam current ratio;**
- **Tests and calibrations of the actual spallation target;**
- **Post-irradiation and on-line spallation products yields investigation;**
- **Transmutation reactions rates, integral cross sections and spectral indices measurements;**
- **Interpretation and validation of experimental data, codes validation, benchmarking;**

Participating Organizations

ISTC project #2267 was started at Nov 2003

- **JINR - leading organization, scientific supervisor;**
- **GSPI - the general designer;**
- **NIKIET – subcritical blanket and target designer;**
- **VNIINM - the developer of a fuel element;**
- **IA “Mayak” - manufacturer of the fuel;**

About 180 people at present are working on project

Foreign Collaborators

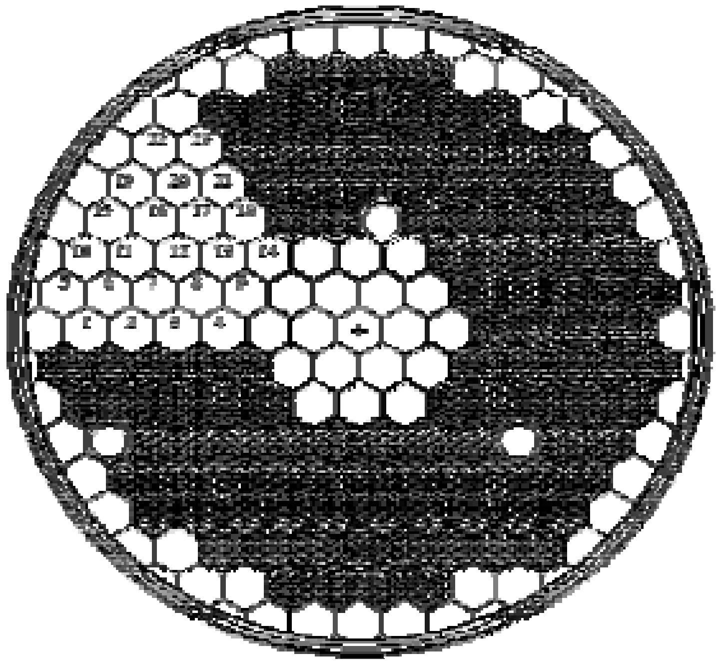
- Forschungszentrum Karlsruhe - FZK, Institut für Reaktorsicherheit, Dr. Cornelis Broeders;
- Kungliga Tekniska Högskolan - KTH, Nuclear and Reactor Physics, Prof. Waclaw Gudowski;
- Centro de Investigaciones Energéticas Medioambientales y Technologies - CIEMAT , Dr. Enrique Miguel Gonzalez Romero;
- Commissariat a l'Energie Atomique - CEA, Cadarache, Dr. Frederic Mellier;

Basic Data

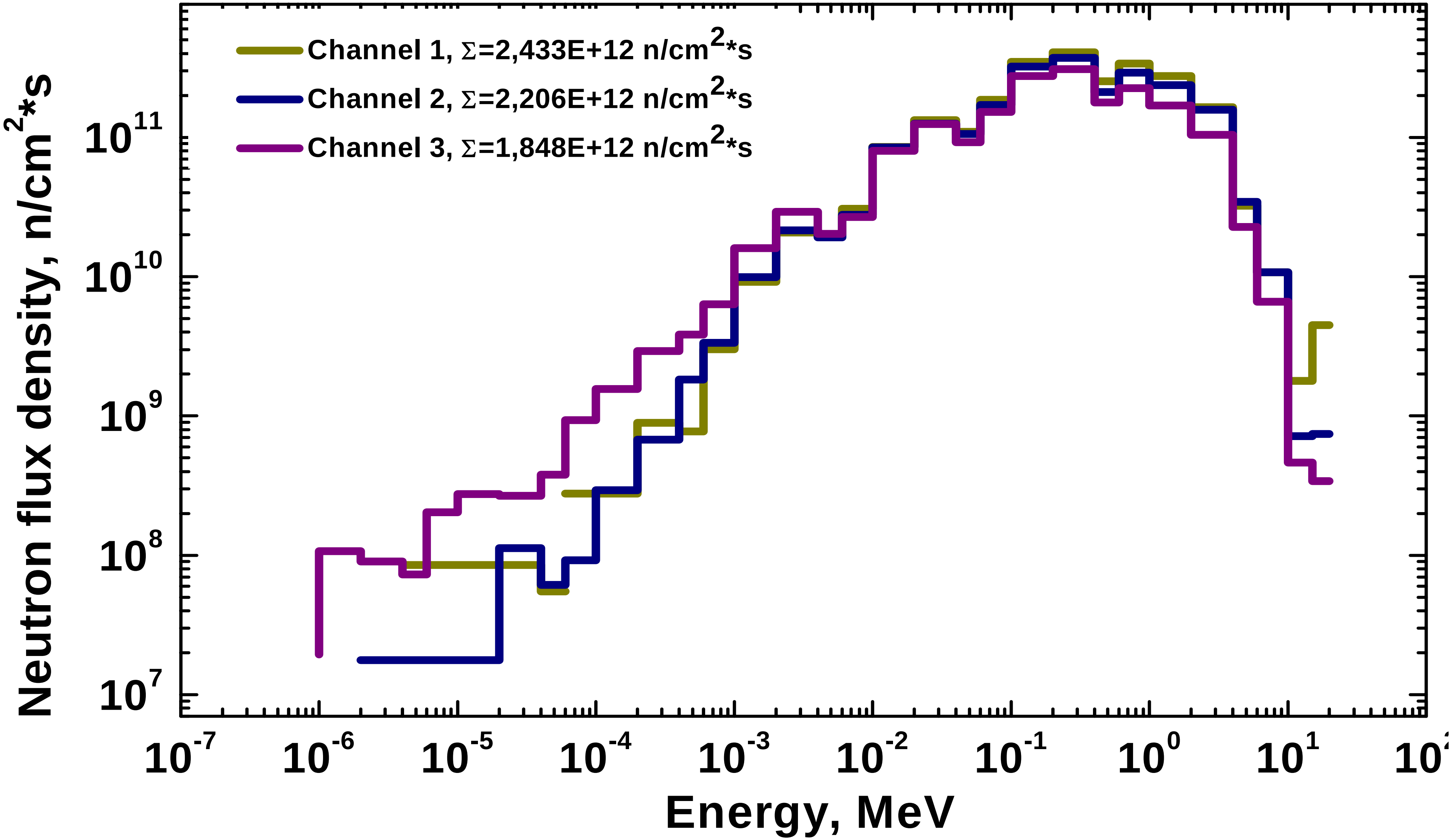
k_{eff}	~0,95
Fuel loading	< 420 kg
Fission power	27,6 kW
Cooling	air
Core	
Coolant flow rate, G	~ 0,6 kg/s
velocity, v	10 m/s
Presure, P *(inlet)*	0,12-0,135 MPa
Temperature, T *(inlet, outlet)*	50/96 ºC
Target (Pb)	
Coolant flow rate, G	~ 0,0067 kg/s
Velocity, v	50 m/s
Pressure, P *(inlet)*	0,12-0,135 MPa
Temperature, T *(inlet, outlet)*	50/125 ºC

Subcritical Blanket/calculations

Number of cells for FAs	141
Number of loaded FAs	134
Number of loaded Pb prisms	7
fuel loading (UO_2-PuO_2)	396,9 kg
density of fuel	10,2 g/cm^3
PuO_2 content in fuel	29,5 % (w.)
U enrichment	0,7 % (^{235}U)
Height of fuel	58 cm



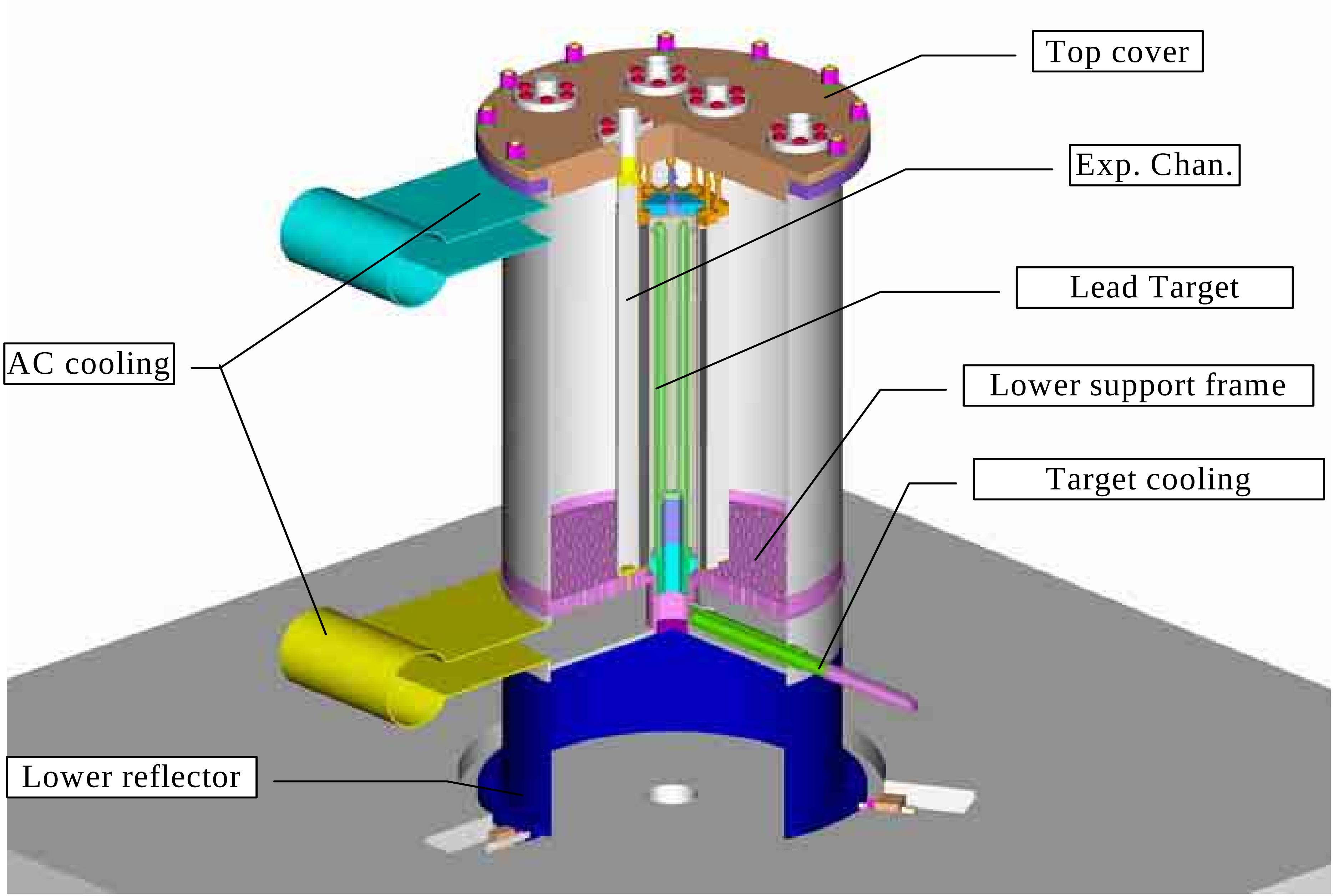
Subcritical Blanket/calculations



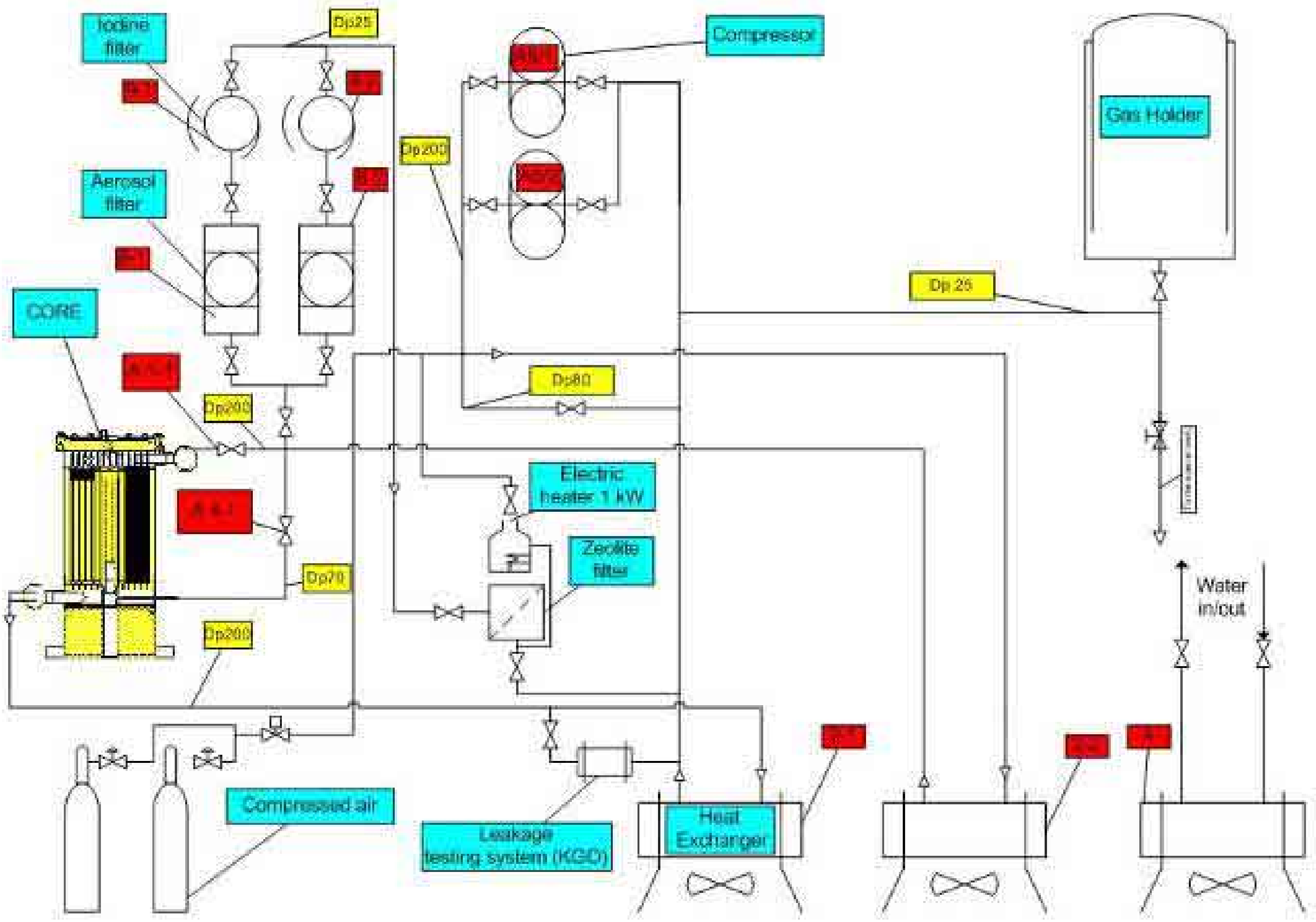
Subcritical Blanket/ neutronics

Calculated K_{eff}	0.9515
Neutron lifetime	$2.4 \cdot 10^{-5}$ s
Fission power	**27.6 kW**
Averaged neutron flux	**$1.7 \cdot 10^{12}$ 1/(cm$^2 \cdot$s)**
Peak factor of heat generation (height)	1.21
Heat generation in SAD parts:	
Fuel	25.96 kW
Target (neutron and photon from fissions)	97.3 W
Core cladding	204.3 W
Side Pb reflector	565.4 W
B_4C	204.6 W
Concrete	771.1 W
Pu decay	~250 W
Fuel	
Max power density	**18 W/cm^3**
Max flux of fast neutrons (E> 0,1 MeV)	$2.4 \cdot 10^{12}$ 1/(cm$^2 \cdot$s)
Max fluence of fast neutrons	$8.0 \cdot 10^{19}$ 1/cm^2

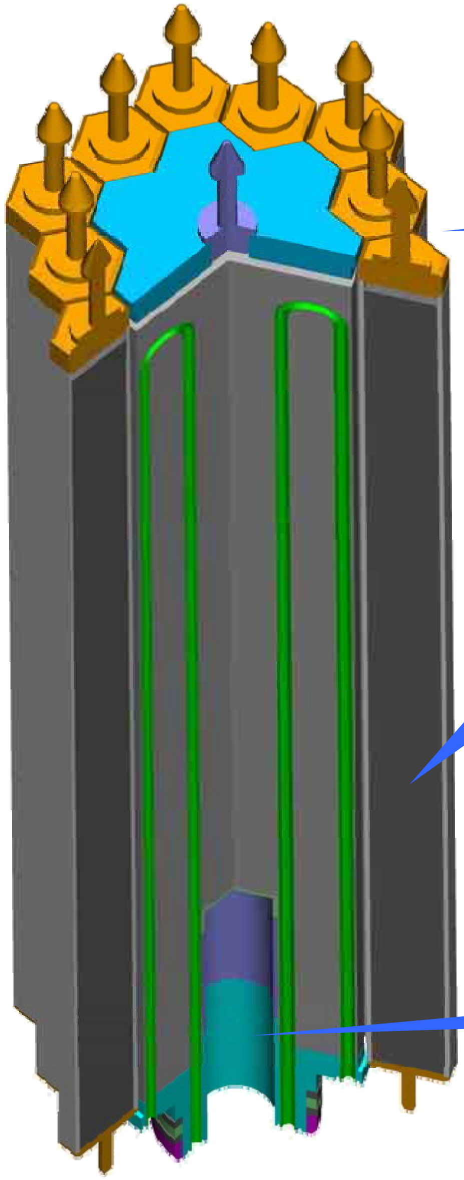
Subcritical Blanket/design

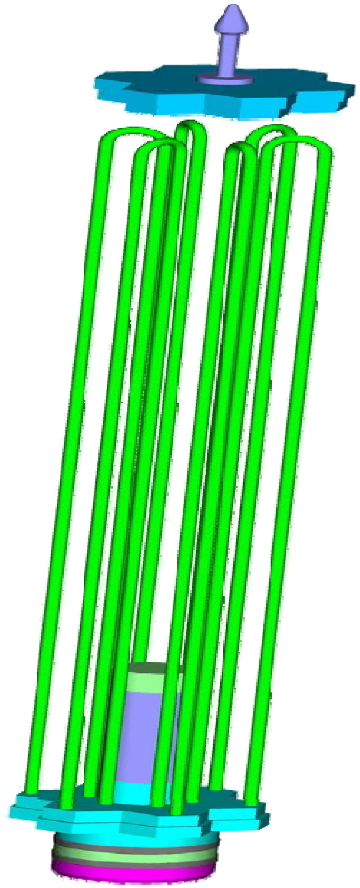


Cooling System



Target/design

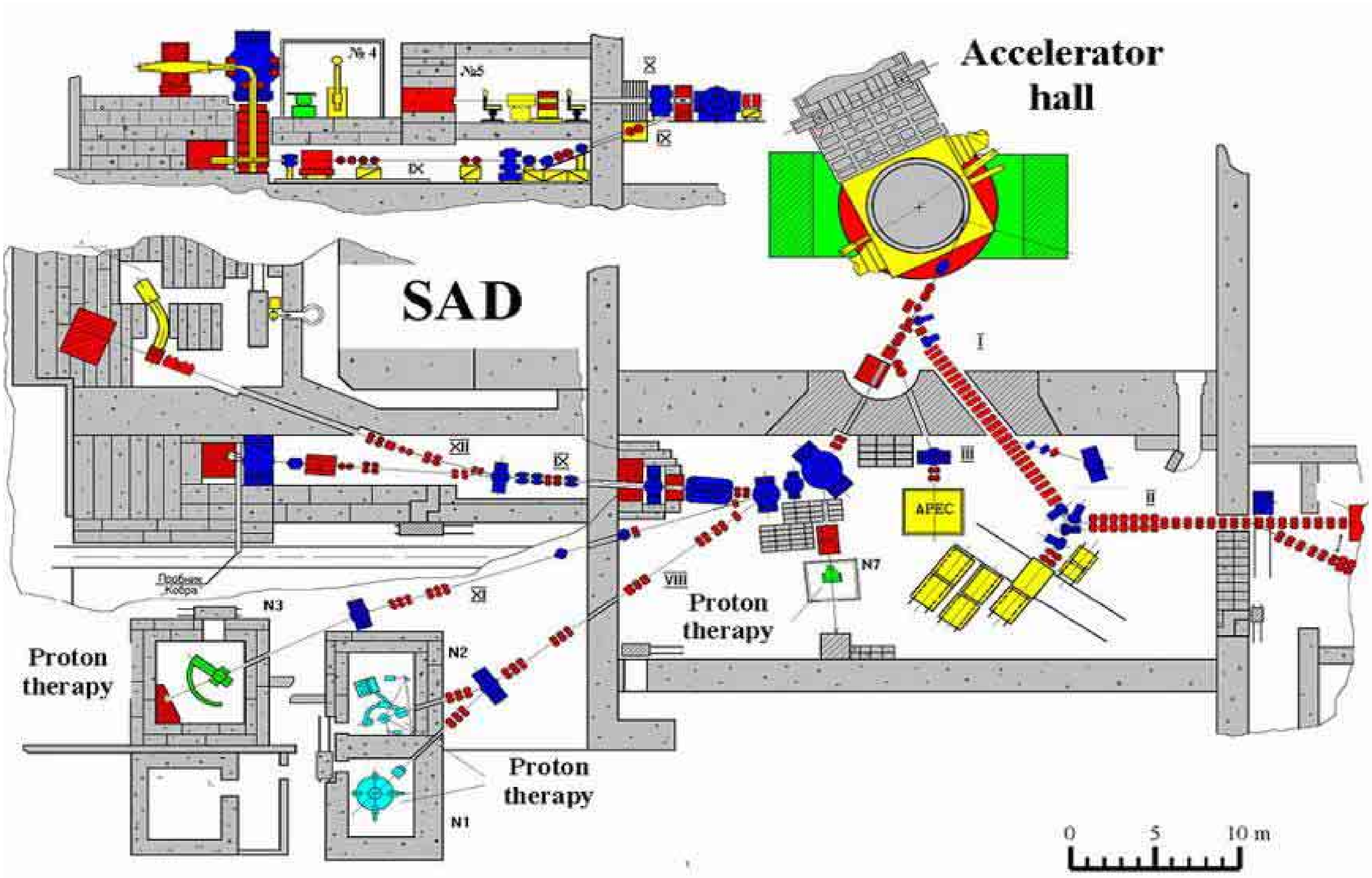




Target/neutronics

Proton beam	
Energy	660 MeV
Beam power	1 kW
Target	
neutron generation	12.95 n/p
total neutron leakage from target	12.73 n/p
side neutron leakage from target	12.22 n/p
total energy of leakage neutrons	103.2 MeV/p
total heat generation	840 W
neutron source for blanket	$1.143 \cdot 10^{14}$ n/s

Phasotron Accelerator


Accelerator
hall
SAD
№ 4
№5
APEC
N7
N3
N2
N1
Proton
therapy
Proton
therapy
Proton
therapy
0
5
10 m

Proton Beamline

- OM-1 deflecting magnet (900 kg, 30 kW) – 9
- C- deflecting magnet (1200 kg, 30 kW) – 2
- Correcting magnet (150 kg, 4.5 kW) – 6
- ML-3 quadruple lens (340 kg, 35 kW) – 9
- Vertical bending magnet (50 t, 15 kW) – 2
- Beam diagnostics
  - **Inductive sensor – 6**
  - **Profilemeters – 12**
  - **Monitor ionization chambers – 2**
- Beam line length 37.6 m

Initial data for SAD FE design

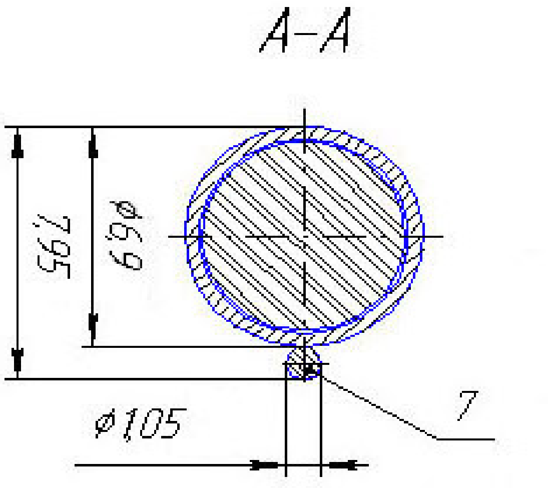
Operating Conditions

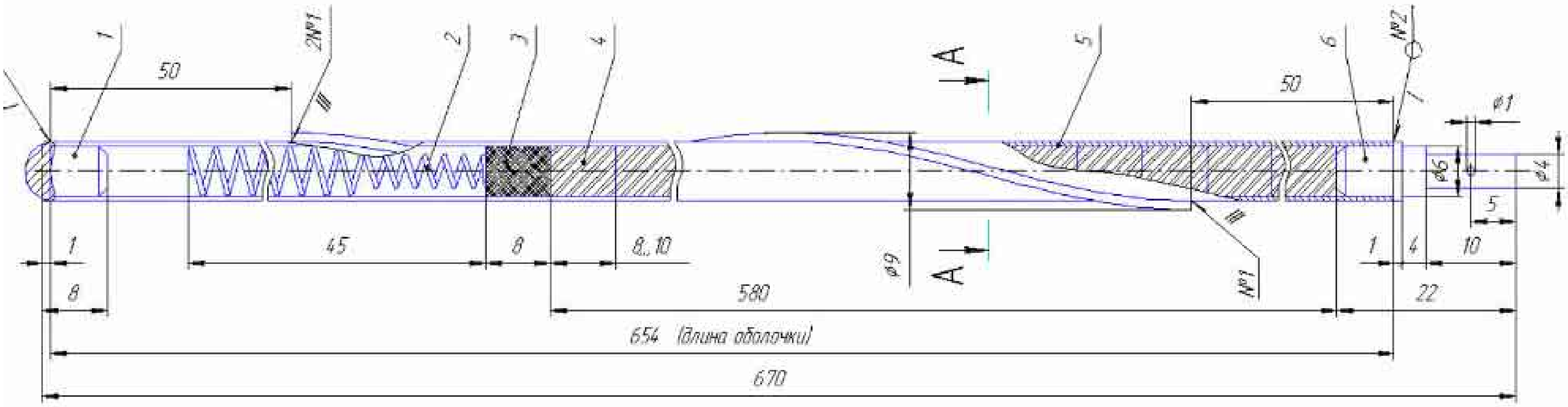
- Maximum Dose for Constructional Materials of Fuel Element – 0.25 dpa.
- Fuel Maximum Burn up – 0.1 % h.a.
- Maximum Linear Power of Fuel Element – 0.275 kW/sm.
- Maximum Temperature of Fuel Element Cladding - 150°C.
- Core Coolant - Dry, Dust-free Air.
- Maximum Coolant Temperature at Core Output - 125°C.
- Fixed Resource of Fuel Element for Operation of Installation at Nominal Power (27 kW) – 10000 h.
- Fixed Core Lifetime of Fuel Element - 10 years.

Processing Requirements for Fuel Element

- Uranium and Plutonium Feed Powders, which are used for BN-600 MOX Fuel Fabrication.
- Constructional Materials of Standard BN-600 Fuel Elements.
- MOX Fuel Pellets Fabrication at "MAYAK".
- Fuel Element Fabrication at "MAYAK".
- Fuel Element Quality Control by "MAYAK" Control Procedures and Equipment.
- Components Fabrication at MSZ JSC.

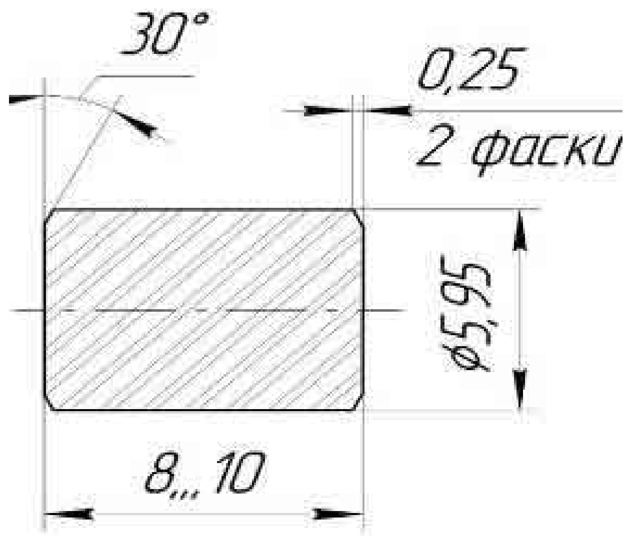
FE design


A–A
7,95
ø9,9
ø1,05
7


1
2№1
2
3
4
A
5
6
№2
50
50
ø1
ø6
ø4
5
1
45
8
8...10
ø9
1
4
10
8
580
№1
22
654 (длина оболочки)
670

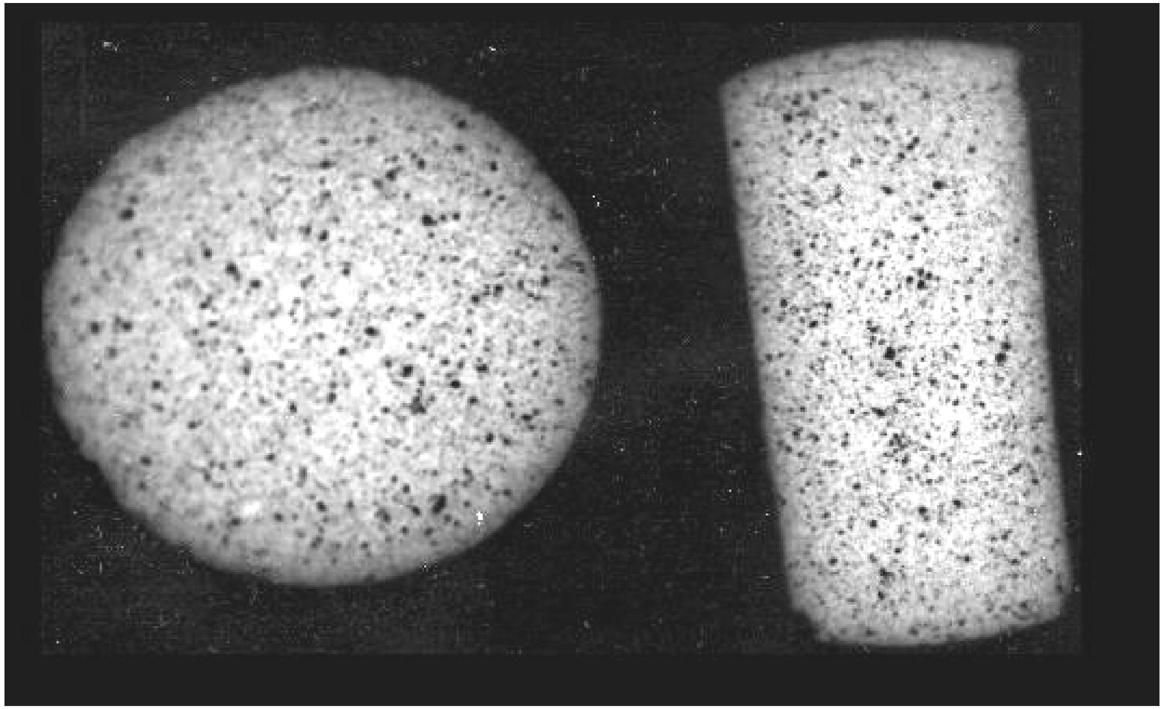
Fuel pellet design parameters

Mass share of U and Pu sum , %, not less	87.6
^{239}Pu conditional mass in Pu dioxide, %, not less	95.0
^{235}U conditional mass in U dioxide, % not more	0.7
Pu conditional mass share to U and Pu sum, %	30.0±0.3
Oxygen ratio	1.98
Density, g/sm^3	10.4±0.2
Impurities mass share, %, not more	
Aluminum	0.02
Calcium	0.02
Magnesium	0.02
Iron	0.03
Silicon	0.02
Nickel	0.02
Chromium	0.02
Nitrogen	0.01
Carbon	0.01
Fluorine + Chlorine	0.005
Grain size, µm, not more	70



Pellets parameters control

Pu distribution homogeneity study



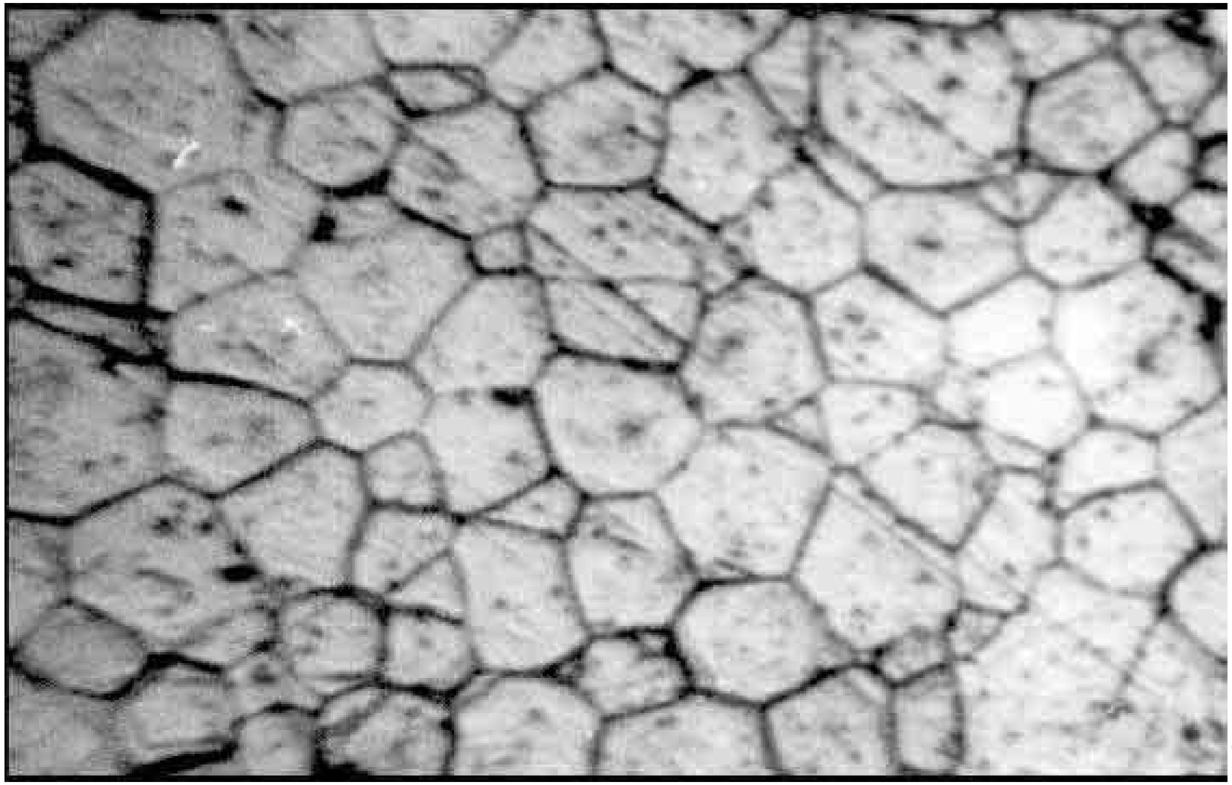
α-radiography

Pu zones less than 100 mkm in diameter

Pu zones area less than 10% of microsection area

No Pu zones observed here

Grain and pore dimensions



Grain diameter should be < 50 mkm (20-25 for that sample)

Microscopy study of the microsections processed in HNO_3 and HF acids

Pores diameter < 100 mkm and area less than 10% of microsection area

ФЕДЕРАЛЬНОЕ АГЕНТСТВО
ПО АТОМНОЙ ЭНЕРГИИ

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕНН
УНИТАРНОЕ ПРЕДПРИЯТИЕ
"ПРОИЗВОДСТВЕННОЕ
ОБЪЕДИНЕНИЕ
"МАЯК"
ул. Ленина, д.31, г. Озерск, Челябинская обл., 456
тел. (35130) 2 50 11, факс (35130) 2 38 26,
e-mail: mayak@po-mayak.ru
ОКПО 07622740, ОГРН 1027401177209,
ИНН/КПП 7422000795/742150001

АКТ

01.12.2005 № 20-35

комиссионной приемки опытной парт
топливных таблеток подкритической
SAD

Комиссия, назначенная приказом А.І
в составе:

Председатель: В.Н. Швецов -

Заместитель председателя: Б.И. Рябов -

Члены комиссии:
От ФГУП «ПО «Маяк» С.Н. Кириллов -
С.Н. Елсуков -
А.Н. Перминов -
Ю.А. Бердюгин -
А.И. Бобылев -
От ФГУП ВНИИНМ И.С. Головнин -
Ю.А. Иванов -
От КПИ А.В. Музруков -

Произвела комиссионную приемку о
ФГУП «ПО «Маяк» по договору № 20-
институтом ядерных исследований, согласн

На рассмотрение комиссии предъявл

- опытная партия таблеток общей массо
№ 15/20 (600,8 г), № 16 (535,5 г), № 18 (651,
г), № 23/2 (326,4 г);
- технический проект твэла установ
ВНИИНМ;
- план мероприятий № 20-1159 от 30.04.
установочной партии топливных таблеток;
- программа № ЦЛ/295 от 09.02.2004
сердечников твэлов из МОКС-топлива;
- отчетная документация технического

Комиссия решила:

1. Принять представленные результаты по изготовлению опытной партии таблеток.
2. ОИЯИ представить полученные экспериментальные данные (масса и высота топливного столба) Главному конструктору установки SAD для уточнения параметров установки.
3. Полученные результаты использовать при разработке РКД на твэл.
4. ПО "Маяк" провести дополнительные исследования с таблетками опытной партии под контролем ОТК:
   - Набрать от каждой партии таблеток по 3 топливных столба высотой 580±10 мм
   - Измерить высоту и массу столба
   - Измерить диаметр таблеток в набранных столбах
   - Подготовить фотографии шлифов (не менее 3-х шт.) и результаты авто α-радиографии.
5. Полученные результаты по п. 4 представить ОИЯИ и ВНИИНМ до 25.12.2005г.
6. Участок по изготовлению топливных таблеток подготовлен к изготовлению установочной партии.

Председатель В.Н. Швецов

заместитель председателя Б.И. Рябов

члены комиссии: С.Н. Кириллов

~~С.Н. Елсуков~~

А.Н. Перминов

Ю.А. Бердюгин

И.С. Головнин

Ю.А. Иванов

А.В. Музруков

А.И. Бобылев

ления топливных таблеток 311.307.001

боте «Отработка режимов изготовлен
ой установки SAD в производственн

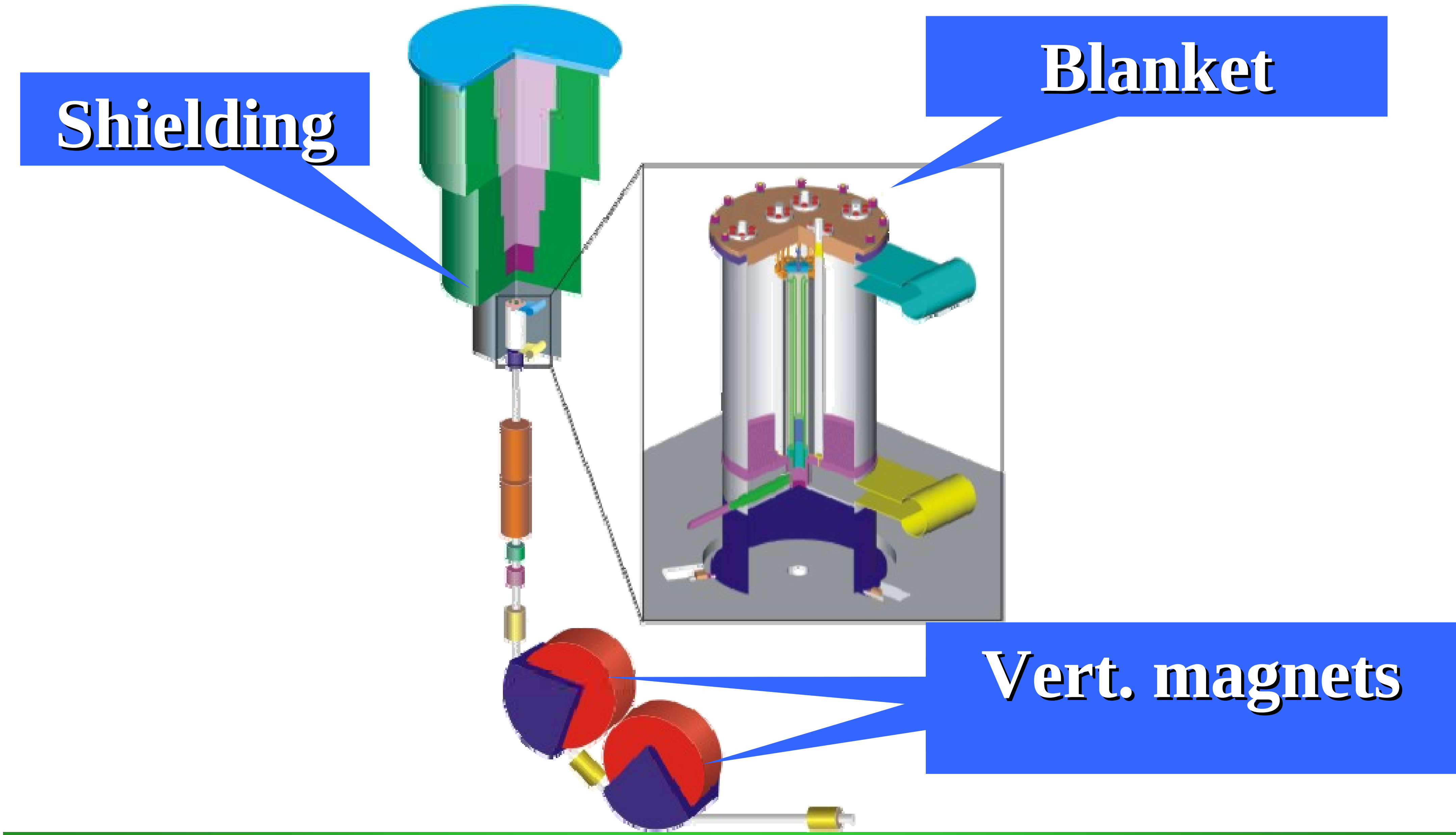
аблеток опытной партии представлены

	Результат контроля				
	Номер партии спекания				
	18	20/1	21	22/30	23/2
4	87,96	87,90	88,28	88,30	88,20
32	30,04	30,13	29,81	30,08	30,11
9	1,99 – 1,99	1,99 – 1,99	1,97 – 1,97	1,99 – 1,99	1,98 – 1,99
22	10,36	10,22	10,25	10,23	10,25
30	10,41	10,25	10,33	10,33	10,29
	578	580	580	586	580
,1	155,7	153,6	152,6	155,6	154,0
04	0,003	0002	0.002	0,003	0,001
01	0,001	0,001	0,001	0,003	0,001
01	0,001	0,001	0,001	0,001	0,001
1	0,01	0,01	0,01	0,005	0,007
03	0,003	0,003	0,003	0,002	0,005
02	0,004	0,001	0,001	0.001	0,001
04	0,004	0,005	0,005	0,005	0,001
02	0,002	0,002	0,002	0,002	0,002
09	0,009	0,007	0,007	0,006	0,008
03	0,004	0,003	0,003	0,003	0,003

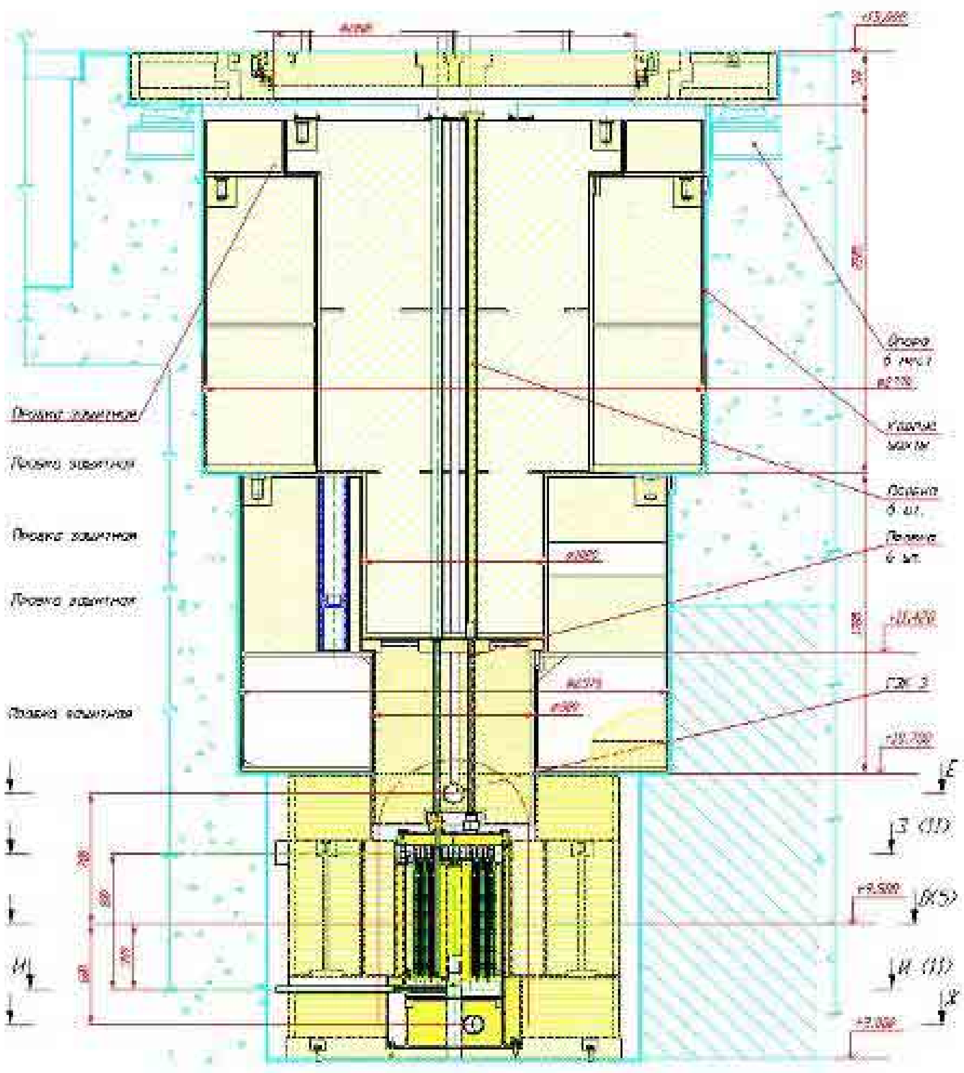
В норме для всех партий

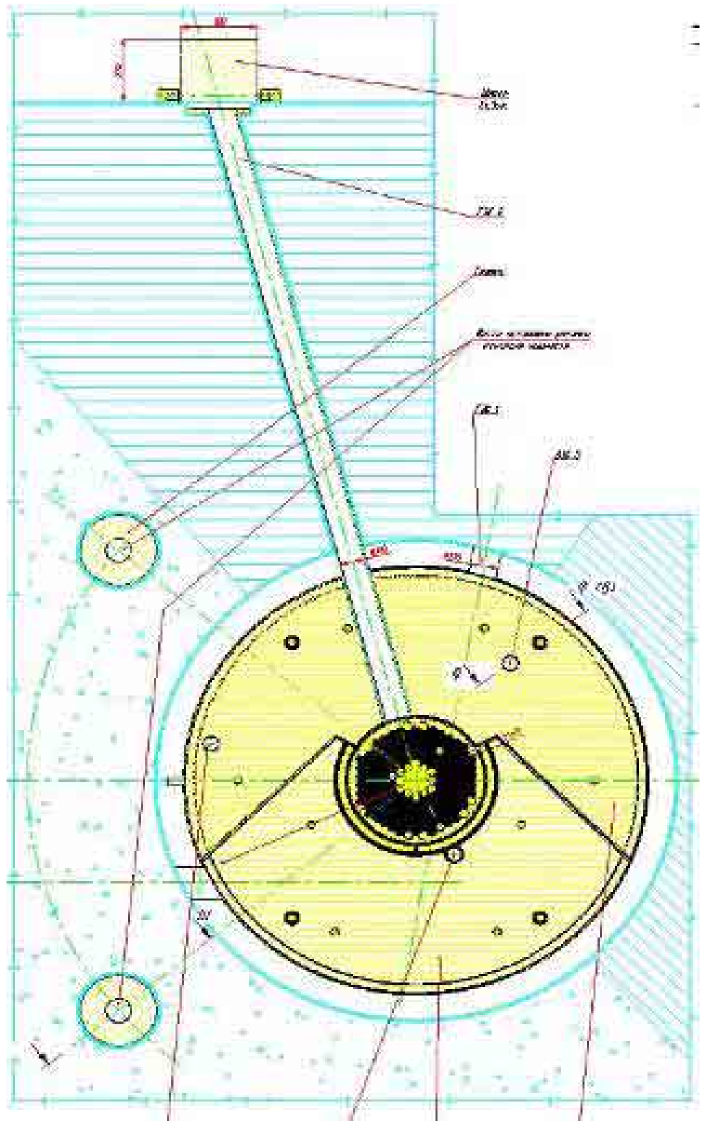
ния таблеток:
изготовленный ОАО МСЗ (с истекшим
цию на соответствие ТУ);
готовленный на ПО «Маяк», согласованный

General Layout



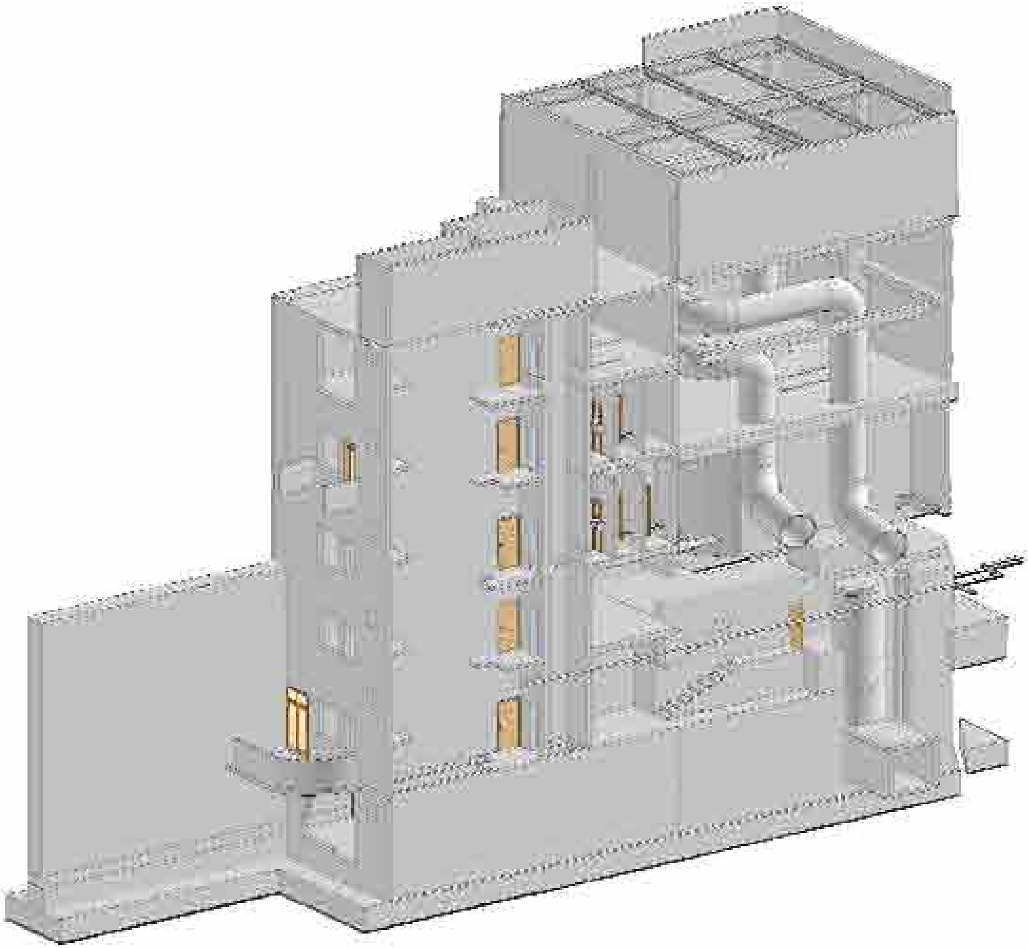
General Layout





SAD Building

Parameter	Value
Site area, m^2	350
Total area, m^2	950
Building volume, m^3	8300
Bulk concrete volume, m^3	1900
Steel shielding, ton	290
Bulk heavy concrete volume, m^3	25
Soil shielding volume, m^3	2000
Excavated soil volume, m^3	4000
Concrete retaining wall necessary to dismount, m^3	350

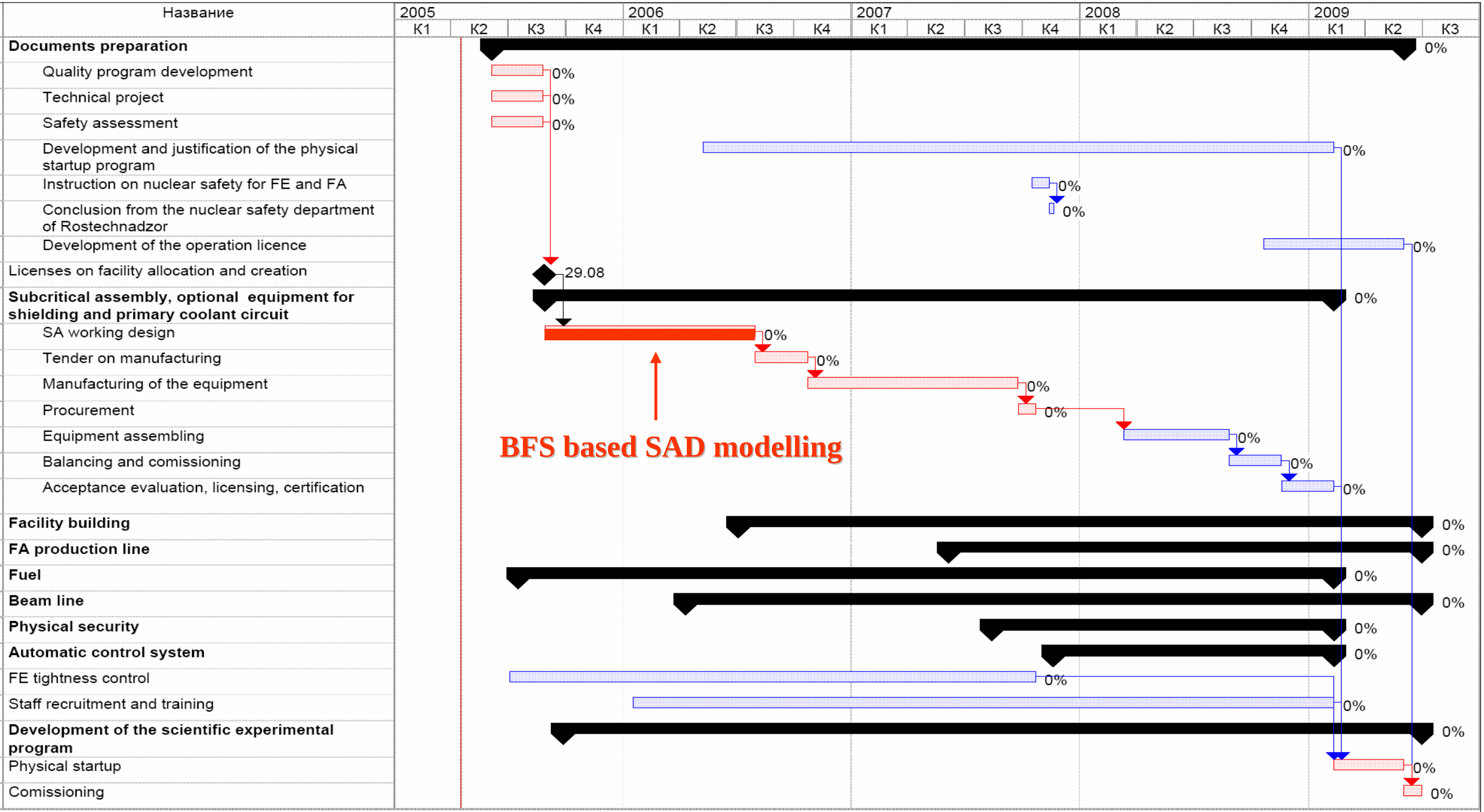


Project Status

- **Technical project of the subcritical blanket: completed;**
- **Technical project of the beam line: completed;**
- **Technical project of the fuel element: completed;**
- **Fuel pellets manufacturing technology: developed;**
- **Preproduction batch of the fuel pellets: manufactured;**
- **General engineering project: completed;**

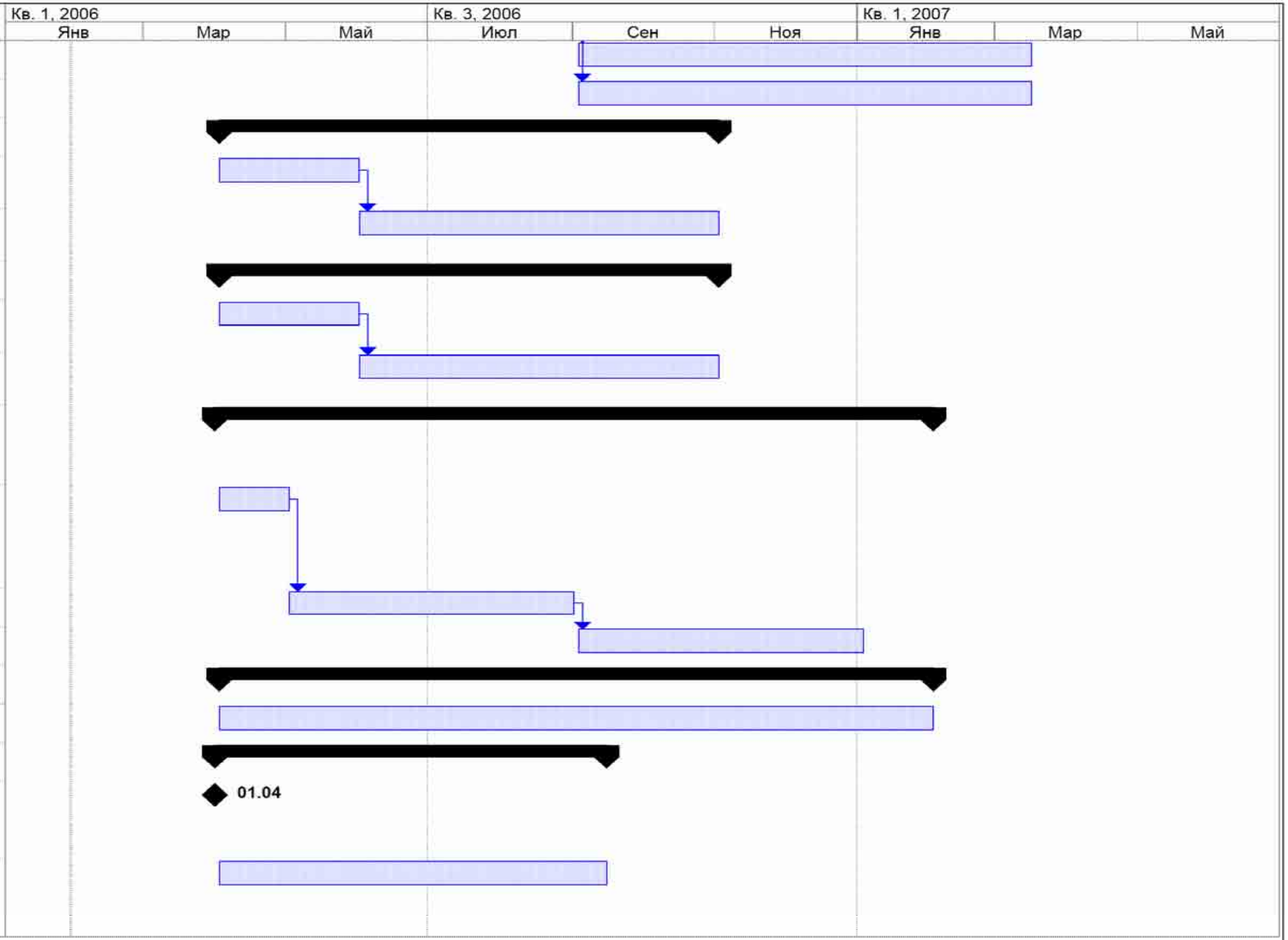
Licensing started some project documents already approved by Rostechnadzor (former Gosatomnadzor)

Project Timeline /4 years/



Project Timeline / 2006 /

Ид.	СДР	Название задачи
21	5.2	Vertical deflecting magnets ma
22	5.3	Magnetic elements manufactur
23	6	**Physical security**
24	6.1	PS conceptual specification development
25	6.2	Tender participants selection
26	7	**Automatic control system**
27	7.1	ACS conceptual specification development
28	7.2	Tender participants selection
29	8	**Development of the scientific experimental program, physical startup**
30	8.1	Requirement specifications on experimental channels (EC)
31	8.2	EC technical project
32	8.3	EC working design
33	8.4	**SAD modelling at BFS**
34	8.4.1	Experimental program
35	9	**SAD assembly licensing**
36	9.1	Delivery of the SAD safety assessment report to foreign collaborators
37	9.2	License on SAD facility allocation and construction



Financing Issues

Statement of

Joint Institute for Nuclear Research (JINR)

on the scientific working programme of the Sub-critical Assembly Dubna (SAD) project, in close co-operation with the Domain DM2 ECATS activities of the European sponsored integrated project EUROTRANS.

During the 4th SAD / YALINA Steering Committee Meeting dated September 15-16, 2005 in Dubna Russian Federation, JINR representatives discussed with representatives of the EUROTRANS project (EUROpean Research Programme for the TRANSmutation of High Level Nuclear Waste in an Accelerator Driven System) the working programme of SAD facility in relation to the Domain DM2 ECATS (Experimental activities on the Coupling of an Accelerator, a spallation Target and a Sub-critical blanket) of the EUROTRANS project.

Domain DM2 ECATS aims to provide validated experimental input from relevant experiments at sufficient core power to get feedback effects related to the coupling of an accelerator, a spallation target and a sub-critical blanket in order to assist the design of XT-ADS (eXperimental facility demonstrating the technical feasibility of Transmutation in an Accelerator Driven System) and EFIT (European Facility for Industrial Transmutation). These experiments shall also provide design input on the dynamics / kinetic behaviour, on experimental techniques for such a coupled system with feedback effects. Biological shielding, safety and licensing are important issues of this project.

The JINR representatives agree to make a commitment to extend the present SAD project in order to support the needs of the EUROTRANS project, especially the validation of: sub-criticality management, assessment and control of experimental methods, start-up / operational / shut-down procedures, shielding, and generic dynamic behaviour of an ADS in a wide range of sub-critical levels. The planned Russian experiment SAD will be performed to meet the agreed EUROTRANS requirements of ~30 kW reactor core power, and especially of Work Package WP2.3 of Domain DM2 ECATS.

The Working Programme of SAD, its Time Schedule and Budget over the full duration of DM2 ECATS (ending March 2009) was discussed and committed by the JINR representatives. The JINR representatives are committed to get the associated accelerator fully operational again in due time prior to start-up operation of the SAD facility in 2006.

The JINR representatives agree to exchange scientific-technical staff (especially Masters, PhD, and Post Doctoral students) with the EUROTRANS partners so as to use this unique opportunity of co-operation of human resource and training tools.

The JINR representatives presented the SAD project (working programme, time schedule) during the 2nd ECATS Meeting in Brussels dated to 20.04.2005. The estimated realisation time is 4 years. First protons on a spallation target are planned to be at the end of 2009. The design operation time of SAD is 10.000 hours at nominal

estimated realisation time is 4 years. First protons on a spallation target are planned to be at the end of 2009. The design operation time of SAD is 10.000 hours at nominal power. The JINR representatives understand that the future operation of SAD to be a common endeavour of European and Russian partners.

The JINR representatives assume that the project can be realised providing that JINR and DM2 ECATS of EUROTRANS fund SAD project at the level 1/3 each under the condition that another 1/3 of the necessary funding will be provided by ISTC. At present time JINR is ready to take responsibility on 1.2 M Euro funding, having in mind that the rest of the funds necessary to cover 1/3 of the project cost will be covered by a collaboration that will be created in Russia.

Detailed commitment from JINR will be given after the meeting of JINR Program Advisory Committee on nuclear physics which is planned for November 9-10 2005.

The assumed cost split for the project is given in the following table.

Cost split for the SAD project funding numbers are in M Euro

Year	ECATS	ISTC	JINR	
			Budget	Collaboration
2006	1.7 + 0.6 (in kind contribution)	0.8	0.1	*
2007		1.5	0.1	*
2008		0.4	0.5	*
2009			0.5	*

* Numbers to be clarified after creation of the collaboration

A.N.Sissakian
JINR Director designate

M.G.Itkis
Director of the FLNR JINR

A.G.Olshevsky
Director of the DLNP JINR

V.N.Shvetsov
Deputy director of the FLNP JINR

Dubna
September 16 2005

Financing Issues #2267 Extension

10. **Financial Information**

Estimated Aggregated (or for the Institute) Expenditures by Recipient

	Category	I & II Quarters		1 st Year		2 nd Year		3 rd Year		Total	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	Grant Payments:										
	Category - I	0,00	80000,00	0,00	326734,00	0,00	0,00	0,00	0,00	0,00	326734,00
	Category - II	0,00	93000,00	0,00	153300,00	0,00	0,00	0,00	0,00	0,00	153300,00
	Category - III	0,00	4000,00	0,00	20320,00	0,00	0,00	0,00	0,00	0,00	20320,00
	Category - IV	0,00	10000,00	0,00	56240,00	0,00	0,00	0,00	0,00	0,00	56240,00
	Total Grant Payments	0,00	187000,00	0,00	556594,00	0,00	0,00	0,00	0,00	0,00	556594,00
	Equipment:										
.1	Capital Equipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
.2	Non-Capital Equipment	0,00	9000,00	0,00	31006,00	0,00	0,00	0,00	0,00	0,00	31006,00
.3	Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Total Equipment	0,00	9000,00	0,00	31006,00	0,00	0,00	0,00	0,00	0,00	31006,00
	Materials/Supplies										
.1	Materials/Supplies	0,00	0,00	0,00	30000,00	0,00	0,00	0,00	0,00	0,00	30000,00
	Total Materials	0,00	0,00	0,00	30000,00	0,00	0,00	0,00	0,00	0,00	30000,00
	Bank Fees	0,00	0,00	0,00	8400,00	0,00	0,00	0,00	0,00	0,00	8400,00
	Other Direct Costs:										
.1	Technological Energy	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
.2	Communications	0,00	0,00	0,00	4000,00	0,00	0,00	0,00	0,00	0,00	4000,00
.3	Subcontracts/Seminars	0,00	0,00	0,00	110000,00	0,00	0,00	0,00	0,00	0,00	110000,00
.4	Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Total ODC	0,00	0,00	0,00	114000,00	0,00	0,00	0,00	0,00	0,00	114000,00
	Travel										
	Internal ***	0,00	0,00	0,00	5000,00	0,00	0,00	0,00	0,00	0,00	5000,00
	Outside CIS	0,00	0,00	0,00	15000,00	0,00	0,00	0,00	0,00	0,00	15000,00
	Total Travel	0,00	0,00	0,00	20000,00	0,00	0,00	0,00	0,00	0,00	20000,00
	Overhead/Retainage	0	0	0	0	0	0	0	0	40000,00	0,00
	Total	0,00	196000,00	0,00	760000,00	0,00	0,00	0,00	0,00	40000,00	760000,00
	Grand Totals	**196000,00**		**760000,00**		**0,00**		**0,00**		**800000,00**	

Remarks: * (1) - Cash flow through Recipient Account

** (2) - Cash flow through ISTC

*** - Include Local and inside CIS travel

Financing Issues SAD in EUROTRANS

DM2 WORKPLAN : SUMMARY

WP2.1 : Qualification of sub-criticality monitoring and of the core power/beam current relationship

WP2.2 : Validation of the generic dynamic behavior of an ADS in a wide range of sub-criticality levels and with consideration of thermal feedback effects

WP2.3 : Spallation target and fast subcritical core coupling : Physics, Safety, Design and Construction

WP2.4 : Evaluation of licensing and commissioning aspects deduced from SAD, RACE and YALINA in view of the XT-ADS necessities

Financing Issues SAD in EUROTRANS

DOMAIN 2

Full Title : Experiment on the Coupling of an Accelerator, a spallation Target and a Sub-critical blanket (ECATS)

Task2.3.1 : SAD Programme Assessment by European partners of ECATS

Milestones :

M2.14 Positive approval and funding of the follow-up project of ISTC #2267 (April 2006). If this Milestone is not reached and if no positive approval is expected up to July 2006, the engagement of ECATS in the SAD project will be immediately stopped

M2.15 Delivery of the SAD safety report to the DM2 ECATS Co-ordinator

M2.16 Positive written approval of funding scheme for SAD by JINR (date : April 2006). If this Milestone is not reached and if no positive approval is expected up to July 2006, the engagement of ECATS in the SAD project will be immediately stopped

M2.17 If the partners of ECATS cannot positively approve the three Milestones M2.12 to M2.14, then the Governing Council has to decide whether the SAD related activities are finally stopped and the budget allocated for SAD activities should be foreseen for other activities

Financing Issues JINR activity

SAD project will be reported at Scientific-Technical Council #3 of RosAtom

SAD project was included into the JINR Roadmap on Nuclear Physics

RF Ministry on Science and Education is supporting projects with large volume of building construction and modernization. Total volume of investments for all Russian organizations is on the level of 85 billion rubles (3 billion $). JINR request for SAD amounts 100 Mrubles – all SAD building construction costs. Working documentation for zero level is ready so in case of success JINR could start building construction in 2006.

Appendix 7

Presentation of C. Broeders

Report on

ADS-related ISTC Project Collaborations at FZK

(Projects #2048, #2405, #2524, #2573 and #2578)

Activities Chairman SAD/YALINA Steering Committee

C.H.M. Broeders, FZK/IRS-NR

Current status of FZK ISTC collaborations (1)

Cross section measurements:

- **St. Petersburg Russia**
  - **#540, #1309, #2213, #2257 Neutron induced fission cross sections 20-160MeV Project manager (PM) Prof. Eismont, continuation on schedule**
  - **#964, #2524 Model development heavy nuclei fission cross sections in wide energy range, PM Dr. Yavshits, no significant feedback (see below). New proposal for collaboration, see below.**
- **Moscow Russia**
  - **#839, #2002 residual spallation products, PM Dr. Titarenko. Extension of #2002 for TRADE project was proposed, but failed due to problems with TRADE Project (stopped). Now continuation in new project #3266 is proposed, discussion at this meeting.**

Current status of FZK ISTC collaborations (2)

Integral physics measurements:

- **Obninsk/Dubna Russia**

  - **#1372 Radiochemical and activation analysis of long life nuclear waste, joint project of IPPE Obninsk and JINR Dubna, PM Dr. Smetanin. Status of this project not fully clear, but several problems happened during execution**

  - **#2267 SAD, creation of proton driven sub-critical system, PM Dr. Shvetsov. SAD was main subject of support in past two years. More details in report on SAD/YALINA Steering Committee**

  - **Minsk Sosny Belarus #B070 YALINA, sub-critical thermal system with powerful neutron source. PM Dr. Kievitskaya. YALINA has now broad international support. More details in report on SAD/YALINA Steering Committee**

    - **New proposal by S. Yavshits, KRI St. Petersburg for "*Experimental Investigations of Electron-Accelerator-Driven Transmutation Technologies (E-ADTT)*", (12/2005), copies of proposals available.**

Current status of FZK ISTC collaborations (3)

Technological projects:

- **Snezhinsk, Ekaterinburg, Moscow:**
  - **#1606 Molten Salt Loop for Waste and Plutonium Disposal, PM Dr. Grebyonkin, no relevant actions after visit to Snezhinsk 01/2004**
- **St. Petersburg**
  - **#2048 Improvement of Corrosion Resistance of Constructional Steels, PM Dr. Engelko. Decisions required for prolongation of the project! See comments of G. Müller**
- **St. Petersburg**

#2573 Laser Separation of Lead Isotopes, PM Dr. Yudin, decisions pending for approval of second stage of project. Common meeting in summer 2005, First stage was finished satisfactorily with two new collaborator commitments: SCK-CEN and PSI.
More details may be provided at CEG meeting on request

ISTC Project #2524

***Project title*: Development of nuclear data library for nucleon-induced reactions on heavy nuclei in wide energy region**

***Project manager*: Sergey G. Yavshits**

***Leading institution*: V.G.Khlopin Radium Institute St. Petersburg**

***Collaborators*: Texas A&M University, IAEA, Kyungpook National University, FZK**

***Duration*: 36 months, costs USD204000**

***Funding*: USA**

***Remark*: FZK was involved by ISTC in the end formulation of the proposal. Links with 6. ECFP IP EUROTRANS WP5 NUDATRA are encouraged. No feedback up till now. Probably only collaborators from funding parties are informed about progress**

ISTC Project #2578

Project title: **Transmutation of radioactive nuclear waste – present status and requirement for the problem – oriented nuclear data base. Approach to scheduling experiments (reactor, target, blanket)**

Project manager: **Yuri A. Korovin**

Leading institution: **INPE, Obninsk**

C*ollaborators*: **KTH, FZK, IAEA**

Duration: **12 months, costs USD80000**

Funding: **EC**

Remark: **The proposal was presented at ISTC meeting in Moscow. Recommendations of collaborators were included in final version of proposal at Moscow meeting.**
Final presentation at this CEG meeting.

ISTC Project #2573

***Project title*: Investigation of processes of high – performance laser separation of lead isotopes by selective photoreactions for development of environmentally clean perspective power reactor facilities**

***Project manager*: Yudin A. Mihailovich**

***Leading institution*: NIIEFA, St. Petersburg,**

C*ollaborators*: FZK

***Duration*: 24 months, costs USD800000**

***Funding*: EC, upper limit Euro175239, $USD11000 authorized for first phase author will demonstrate support and interest of EU community.**
Decisions pending for approval of second stage of project. Common meeting June 2005. First stage was finished satisfactorily with two new collaborator commitments: SCK-CEN and PSI. More details may be provided at CEG meeting on request

Activities of SAD/YALINA Steering Committee

- **The SAD/YALINA SC was established at our last CEG meeting, to support integral ADS and Transmutation related ISTC projects**

- **Five SC Meetings were organized (electronic and paper copies of all minutes are available at this CEG meeting):**

  - **SY-SCM 1, JINR Dubna, July 13, 2004**
  - **SY-SCM 2, JIPNR Minsk, January 24-25, 2005**
  - **SY-SCM 3, JINR Dubna, June 27-28, 2005**
  - **SY-SCM 4, JINR Dubna, September 15-16, 005**
  - **SY-SCM 5, JIPNR Minsk, December 5-6, 2005**

Highlights SY-SCM 1 Dubna, July 13, 2005

- **Proposed Charter for SAD/YALINA Steering Committee was accepted**
- **Status and progress of main projects SAD and YALINA were presented and discussed in detail**
- **Foreign collaborators stressed assessment of "Dynamics Experiments" in SAD**
- **SC recommended creation of SAD brochure and short leaflet**
- **Synergies/collaborations with other ISTC projects for creation of SAD were discussed: ISTC Project #1372, SAD startup support by (new ISTC experiment?) at BFS/Obninsk**
- **Role of high energy neutrons in SAD was stressed**
- **Main issues of the meeting were time schedules and reliable cost estimates**
- **Action plan was agreed for following areas: SAD design, radiation shielding and general issues**

Highlights SY-SCM 2 JIPNR Minsk, January 24-25, 2005

- **New funding perspectives for SAD in EC FP6 IP EUROTRANS in connection with withdrawal of TRADE contribution**
- **First detailed cost and time schedule estimates for SAD; 432 Mroubles (≈12 MEuro), reachable ambitious goal to have first physics experiments in SAD in 2008**
- **Presentation of YALINA booster experiments with mixed neutron spectra**
- **Discussion of power increase options in SAD**
- **Proposal for target irradiation benchmark based on SAD preparation experiments**

Highlights SY-SCM 3 JINR Dubna, June 27-28, 2005

- **Dubna Director Designate A. Sissakian underlined the important role of SADS in the JINR Dubna roadmap.**
- **Funding problems for SAD were recognized; cost optimization by "ISTC channeling" was proposed: 6 MEuro realistic?**
- **Discussion of consequences of PHASOTRON fire in April 2005**
- **Proposal for funding scheme "one third each": JINR Dubna, ISTC, IP EUROTRANS**
- **Round table discussion with Management of JINR Dubna and ISTC Executive Director N. Jousten => SAD realization is an ambitious project, realizable without recognizable technical killing issues, but with challenges for the funding**
- **YALINA is well integrated in international projects (DOE, EC IP EUROTRANS). Next experiments series will be done with "booster" mixed spectrum configuration**

Highlights SY-SCM 4 JINR Dubna, September 15-16, 2005

- **Main objective: clarification of funding modalities in framework of “one third each” scheme.**
    - **IP EUROTRANS has made commitments for this solution.**
    - **Corresponding ISTC support channels are in discussion with good perspectives.**
    - **Formal commitments of JINR Dubna are required to enable progress with EUROTRANS cooperation.**
- **YALINA is proceeding as scheduled. Creation of International Science Laboratory (ISL) with YALINA is discussed and recommended.**
- **PHASOTRON could be visited after April fire**
- **Statement of JINR on scientific working program of SAD with IP EUROTRANS Domain 2 ECATS was signed by four key representatives of JINR**

Highlights SY-SCM 5 JPINR Minsk, December 5-6, 2005

- **The SY-SCM5 was held in conjunction with IAEA RCM for CRP on ADS Benchmarks**
- **IP EUROTRANS DM2 ECATS was presented by designated coordinator G. Granget**
- **With support of SY-SC members the SAD project was approved by the Program Advisory Committee (PAC) of JINR Dubna. However, additional external funding support is recommended.**
- **Technical progress of SAD is on schedule.**
- **Organizational aspects for formal prolongation of ISTC projects SAD and YALINA**
- **Letters of recommendation for SAD and YALINA were prepared by collaborators**
- **Draft proposal for creation of International Center of Excellence for Transmutation (ICE-TR) in Minsk was prepared.**

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Appendix 8

Presentation of V. Batyaev

ISTC Project #2002 Brief Review

Yu.E. Titarenko[1], V. F. Batyaev[1], A.V. Ignatyuk[2],

[1] *Institute for Theoretical and Experimental Physics (ITEP), 117218 Moscow, Russia*
[2] *Institute for Physics and Power Engineering (IPPE), 249020 Obninsk, Russia*

CONTENT:

- *Formal information*
- *Tasks*
- *Results & Report*
- *Co-operation with collaborators*
- *Results applications in other projects*
- *Next project*

ISTC#2002: Formal information

Title: *Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons*

Duration: *1 January 2002 – 30 October 2004,*

Financing party: *EU*

Budget: *$ 346 527.18*

Collaborators

- *Royal Institute of Technology (**W. Gudowsky**)*
- *Los-Alamos National Laboratory (**S. Mashnik**)*
- *CEA / DRN / DER / CEN Cadarache (**M. Salvatores, I. Slessarev**)*
- *Johannes Gutenberg-Universitat Mainz, (**H.O. Denschlag**)*
- *Tokyo Institute of Technology (**M. Saito**)*

Real colloborators:

- European Commission, **Vade Bhatnagar**
- Royal Institute of Technology, **Waclaw Gudowski,**
- Forschungszemntrum Karlsruhe Institut für Kern und Energiete, **Colnelis H.M. Broeders,**
- Commissariat a l'Energy Atomique, CEN – Cadarache, **M. Salvatores, Igor S. Slessarev,**
- Zentrum fuer Strahlenschutz und Radiooekologie, **R. Michel**
- Commissariat a l'Energy Atomique, CEA Saclay, **S.Leray**
- Los Alamos National Laboratory, **G.J. Van Tuyle, S.G. Mashnik, R.E. Prael,**
- Japan Atomic Energy Research Institute (JAERI), **Hiroshi Takada,**

Prologue: the project is an extension of the researches carried out under:

- ISTC Project#17 (1994-1996, USA)*Feasibility study of the basic technologies for weapon plutonium conversion and for long-lived radioactive waste transmutation*
- ISTC #839 (1997-1998; 1999-2000, Japan, EU, Norway) *Experimental and Theoretical Study of the Residual Product Nuclide Yields in Thin Targets Irradiated with 100-2600 MeV Protons*

Brief info available via http://tech-db.istc.ru/ISTC/sc.nsf/html/projects.htm?open&id=2002

ISTC#2002 TASKS and RESULTS (1)

Task	Result
1. Manufacture of samples	**57** pairs of samples (Al+target) were manufactured
2. Calibration of spectrometer; stability tests	CANBERRA GC2518 spectrometer was calibrated every week during the γ-measurements period
3. Adjustment of the 600 MeV proton beam extraction	600 MeV proton beam extraction adjusted. The used beam became capable to provide protons of any energy up to 2.6GeV
4. Irradiation of experimental samples	**57** pairs of samples (Al+target) were irradiated on ITEP accelerator
5. Gamma-spectrometry of the samples	**2207** γ–spectra were measured, including **1548** from targets, **659** – from monitors.

List of irradiations:

Targets	Proton energy [GeV]										
	0.04	**0.07**	**0.1**	**0.15**	**0.25**	**0.4**	**0.6**	**0.8**	**1.2**	**1.6**	**2.6**
^{208}Pb	x	x	x	x	x	x	x	x	x	x	x
^{207}Pb	x	x	x	x	x	x	x	x	x	x	x
^{206}Pb	x	x	x	x	x	x	x	x	x	x	x
^{nat}Pb	x	x	x	x	x	x	x	x	x	x	x
^{209}Bi	x	x	x	x	x	x	x	x	x	x	x

Project #2002 TASKS and RESULTS (2

Task	Result
6. Processing of the gamma-spectra	All the measured gamma spectra were processed in automatic mode and then **411089** found gamma lines were reprocessed in interactive mode, including **408987** from targets, **2102** from monitors
7. Identification of gamma-lines and determination of residual radioactive nuclide yields,	***5972*** nuclide yields were determined + 22 cross sections of $^{27}Al(p,x)^{24}Na$, $^{27}Al(p,x)^{7}Be$ monitor reactions
8. Theoretical simulations and calculations by different codes,	**9** codes were used for simulations: LAHET (Bertini, Isabel) INCL4+ABLA, CASCADE, CASCADE-2004, LAQGSM+GEM2, CEM03, CASCADO, LAHETO
9. Updating the models and codes on the basis of comparison with the new experimental data obtained	**2** codes were modified: LAHETO (on the base of LAHET), CASCADO (on the base of CASCADE)
10. Preparation of reports.	The final technical report was issued and got permission for dissemination. Summary technical report, activity report and technology implementation plan were also submitted to the ISTC. **http://www.nea.fr/html/science/egsaatif/ISTC2002-final-report.pdf**

the ISTC has no objection to sending the #2002 Final Report and the data therein to OECD/NEA in favor of advances in science and international scientific cooperation.

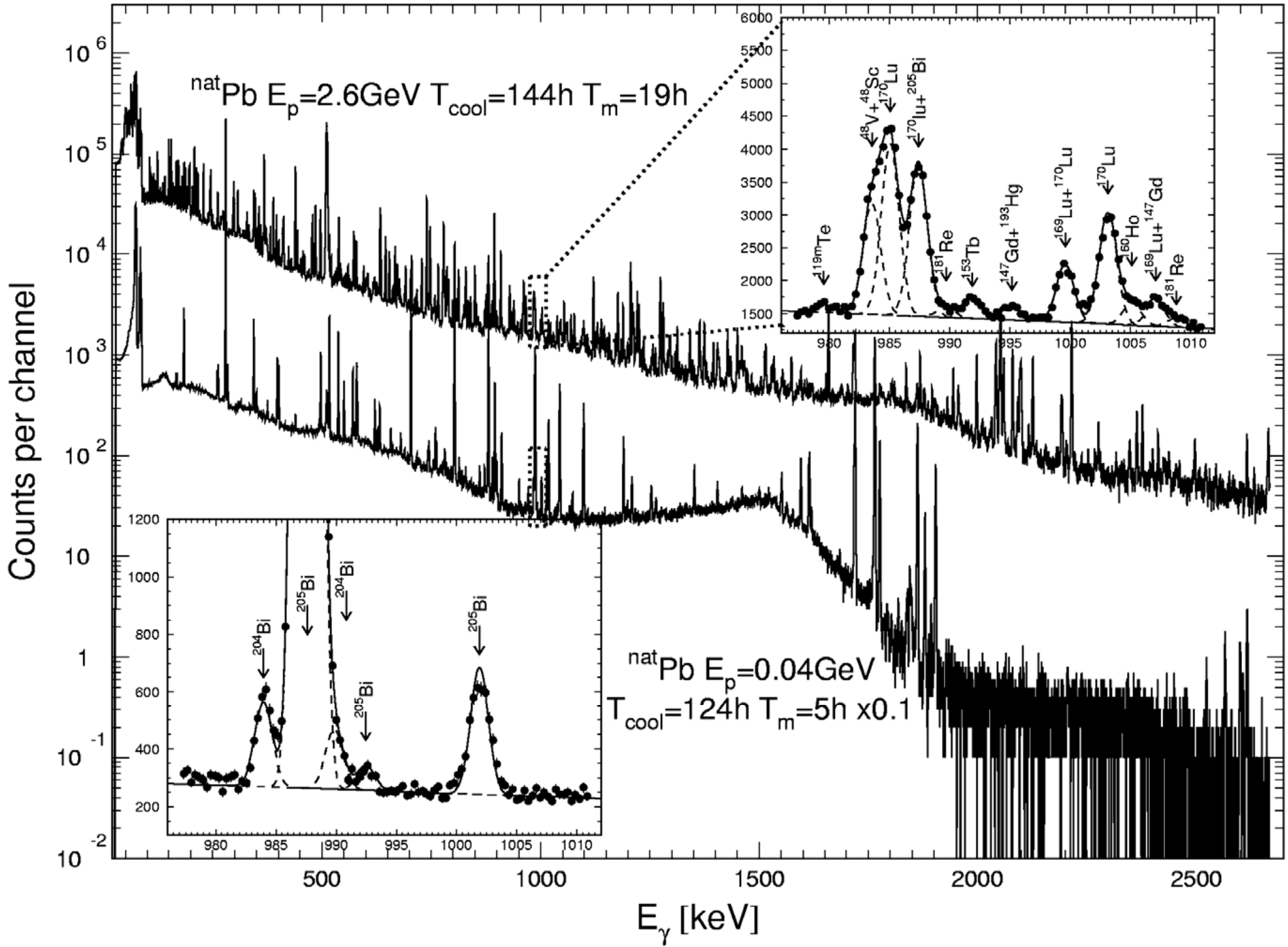
Sincerely,

Norbert Jousten
Executive Director

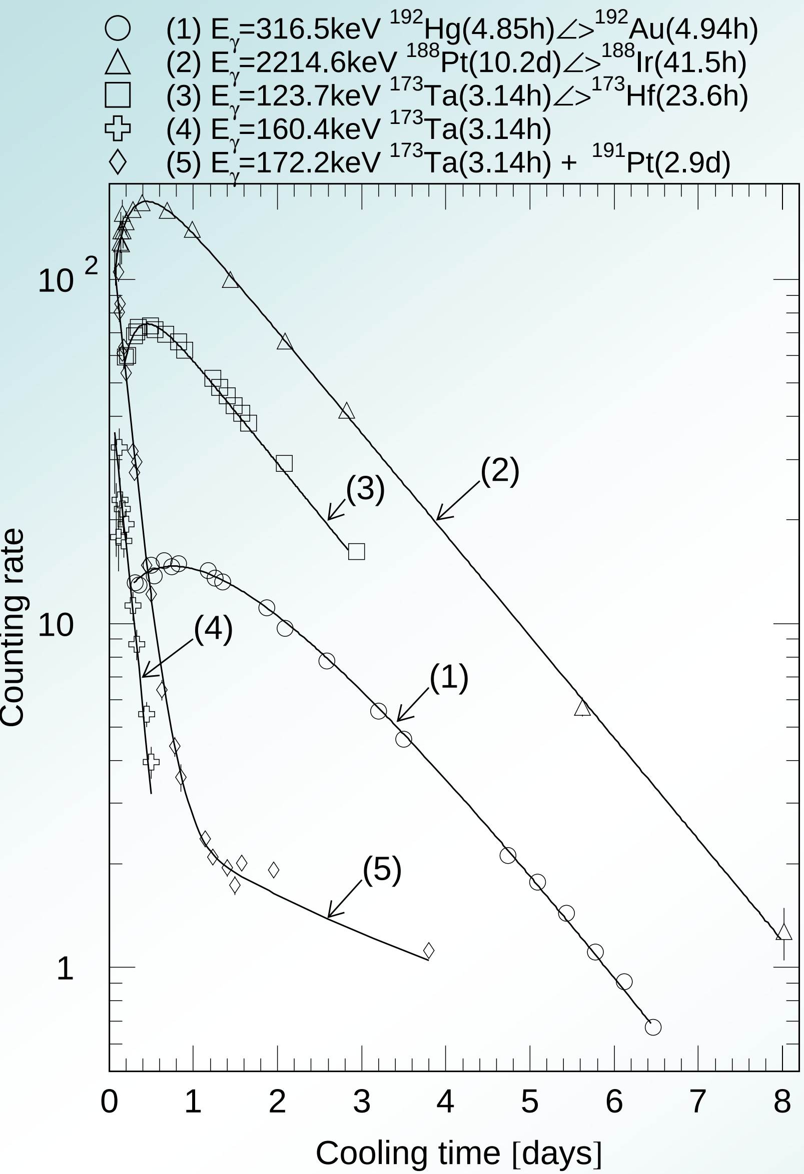
The numerical data also were sent to OECD/NEA to be inserted to the EXFOR database

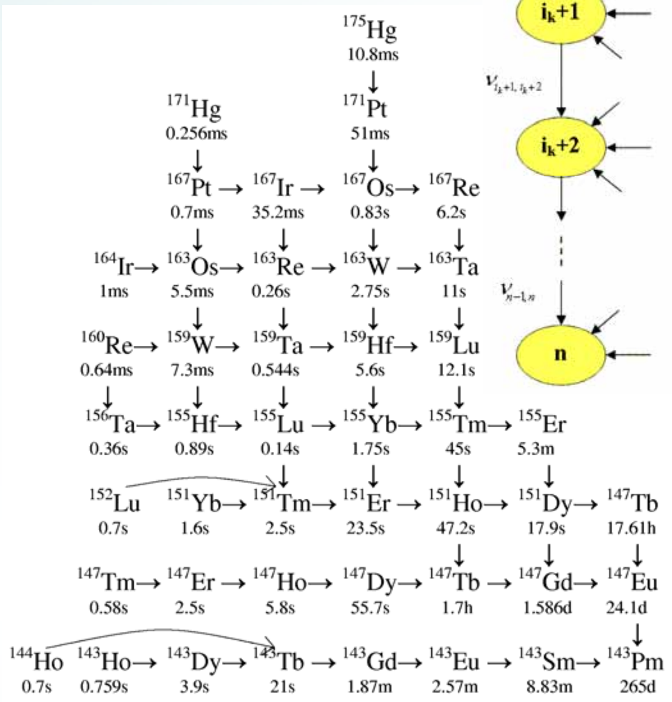
Apart of the Report and Conferences (ICRS10, ND2004, AccApp05) Proceedings, the results are expected to be published in Phys. Rev.

Gamma – spectra measurements

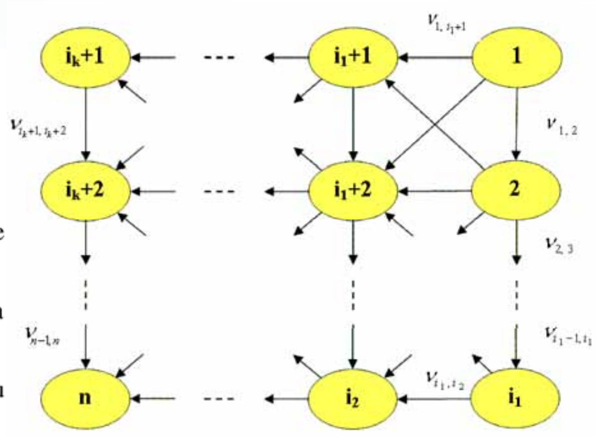


Determination of cross sections





^{143}Pm decay chain



$$R_1^{cum/ind} = \frac{1}{N_{Tag}\eta_2\varepsilon_2}\cdot\frac{B_1^*}{F_1}\cdot\frac{1}{\nu_{12}}\left(1-\frac{\lambda_1}{\lambda_2}\right),$$

$$R_2^{ind} = \frac{1}{N_{Tag}\eta_2\varepsilon_2}\left[\frac{B_2^*}{F_2}+\frac{B_1^*}{F_1}\frac{\lambda_1}{\lambda_2}\right],$$

$$R_2^{cum} = R_2^{ind}+\nu_{12}R_1^{cum/ind} = \frac{1}{N_{Tag}\eta_2\varepsilon_2}\left[\frac{B_1^*}{F_1}+\frac{B_2^*}{F_2}\right]$$

$$\boxed{\sigma = R/\Phi_p}$$

ISTC Project #2002 results (3)

Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons

Target	Proton Energy (GeV)										
	0.04	0.07	0.1	0.15	0.25	0.4	0.6	0.8	1.2	1.6	2.6
^{nat}Pb	18	28	43	63	95	116	141	154	171	181	178
^{208}Pb	8	28	36	63	94	113	141	154	170	182	172
^{207}Pb	9	29	42	65	94	112	140	152	170	180	171
^{206}Pb	13	28	46	65	94	112	139	156	170	180	171
^{209}Bi	13	35	50	71	106	128	147	162	183	192	198

TOTAL number of measured yields: 5972

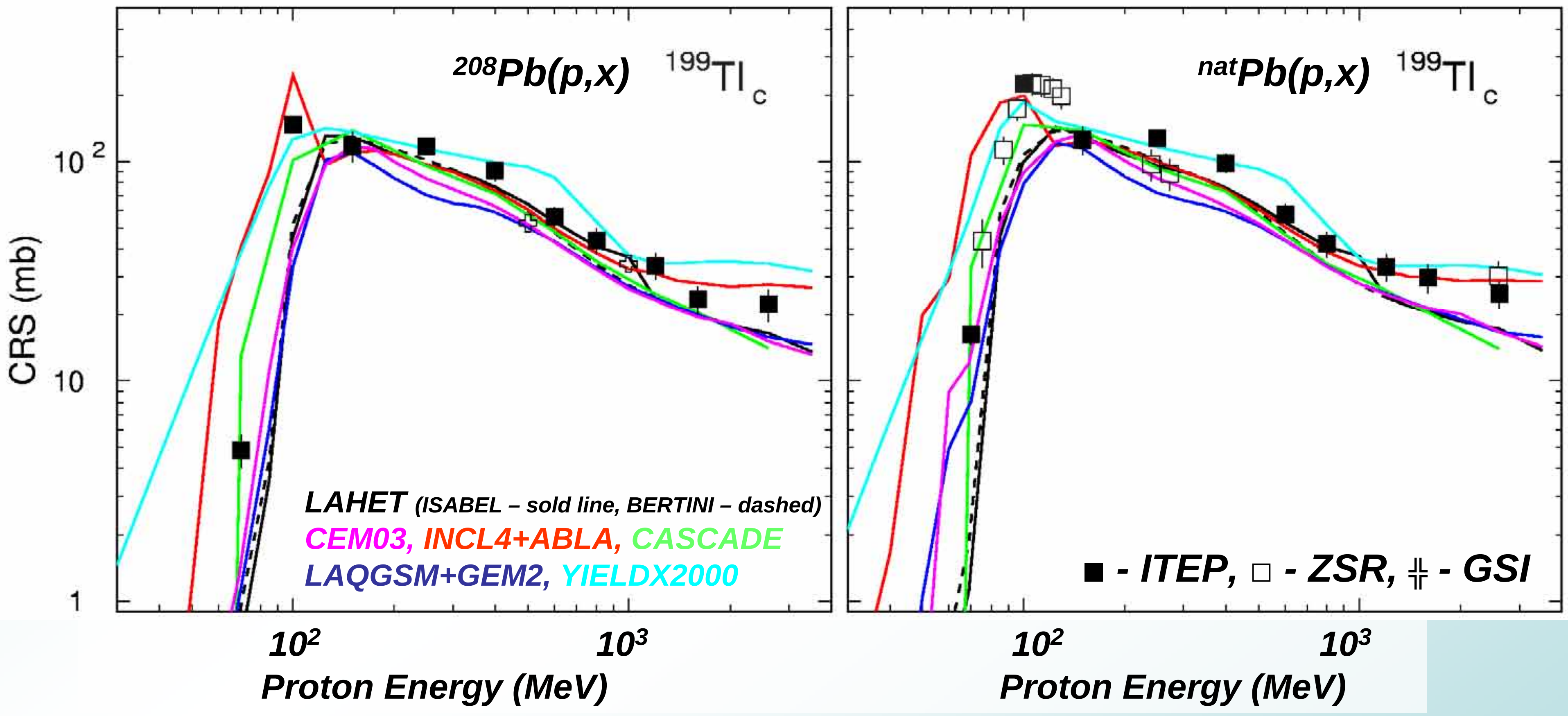
- Detailed information on reaction rates per each gamma-line presented!
- Decay chains description presented

- Isotopic composition of targets

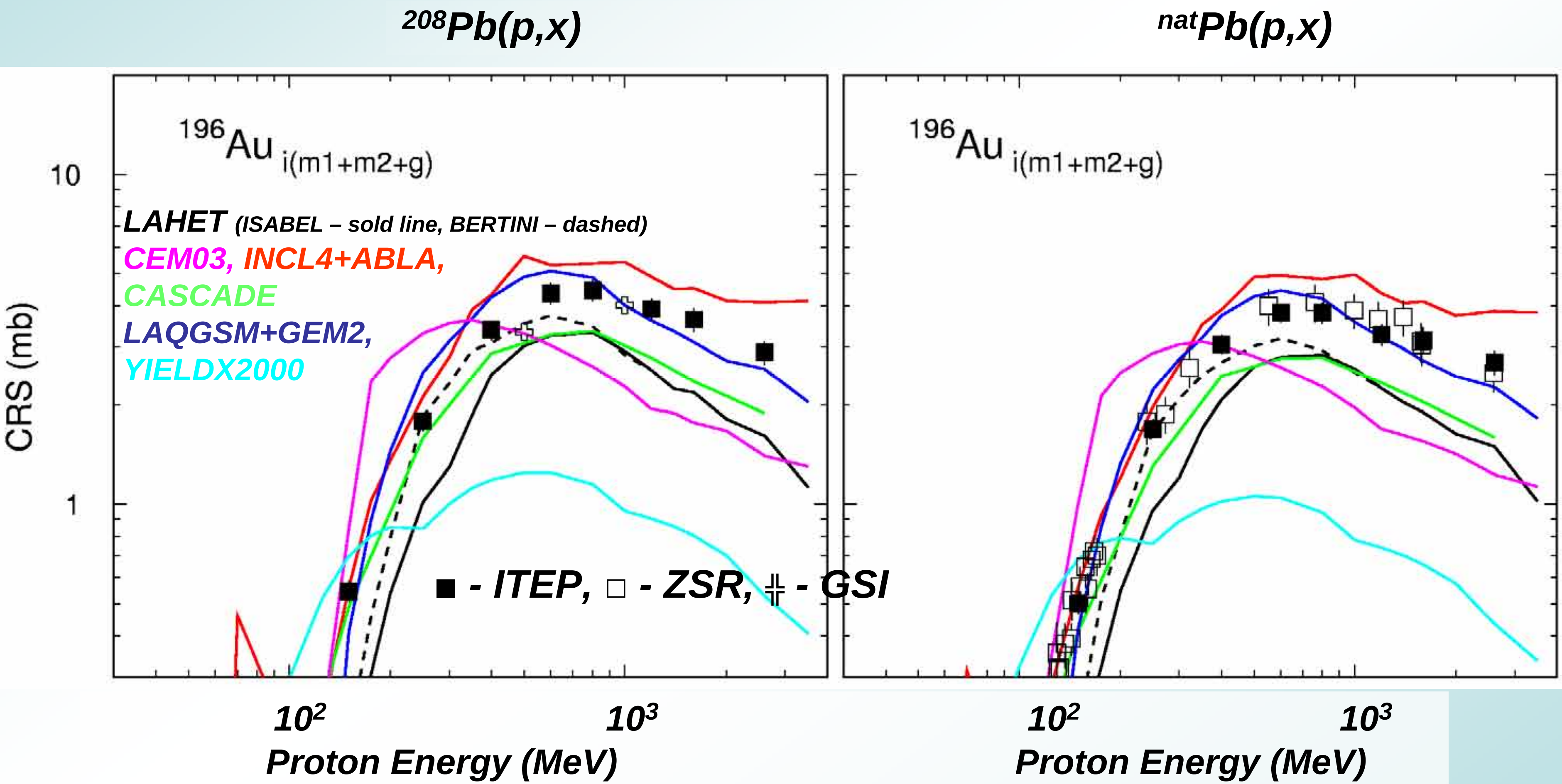
Targets	Isotopic composition, %				
	^{204}Pb	^{206}Pb	^{207}Pb	^{206}Pb	^{209}Bi
^{208}Pb	<0.01	0.87	1.93	97.2	-
^{207}Pb	<0.01	1.39	93.2	5.41	-
^{206}Pb	0.19	92.3	5.1	2.41	-
^{nat}Pb	1.4	24.1	22.1	52.4	-
^{209}Bi	-	-	-	-	>99.9

Final Technical report:
http://www.nea.fr/html/science/egsaatif/ISTC2002-final-report.pdf

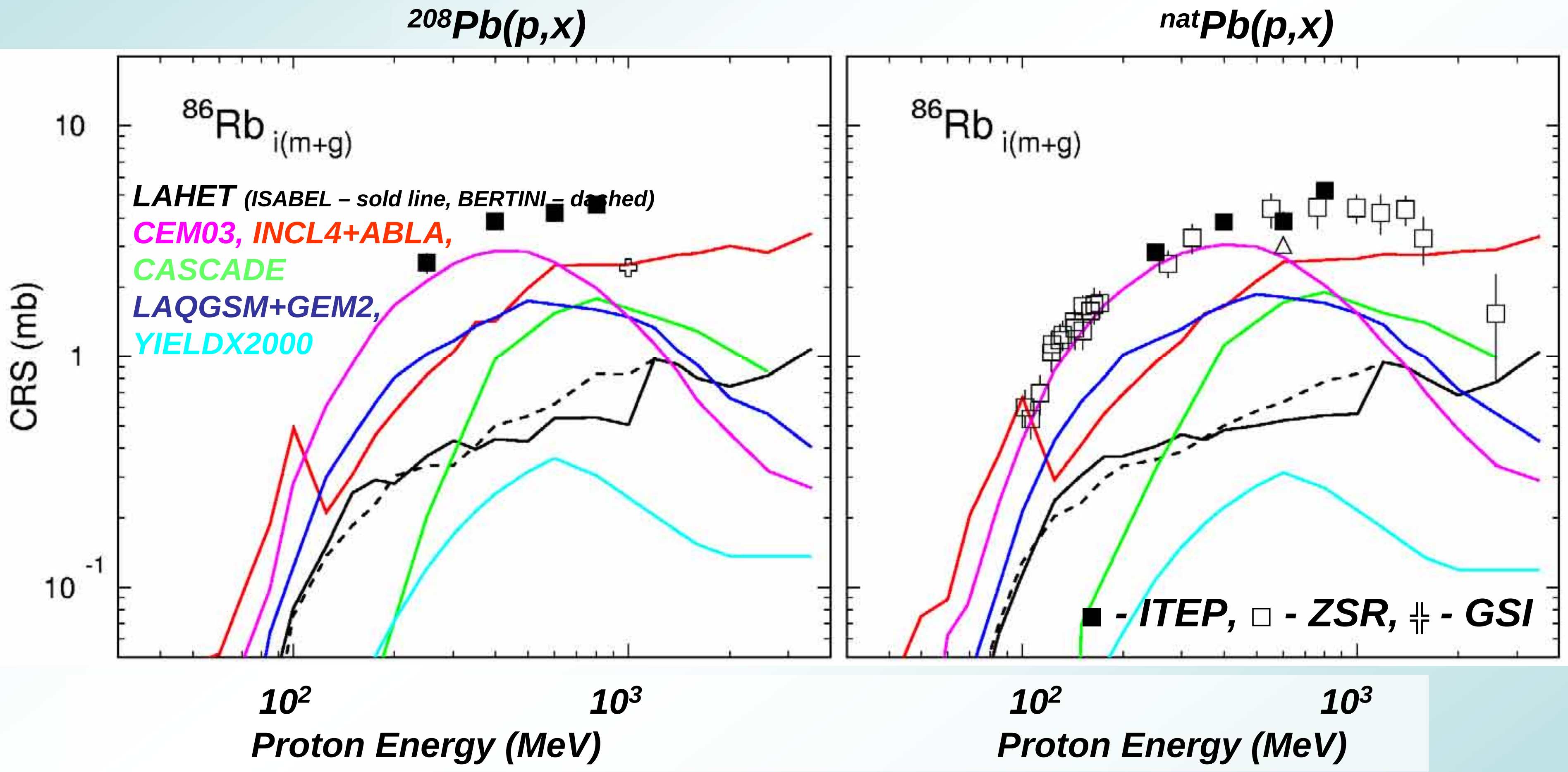
^{208}Pb-, ^{nat}Pb(p,x) excitation functions (1)



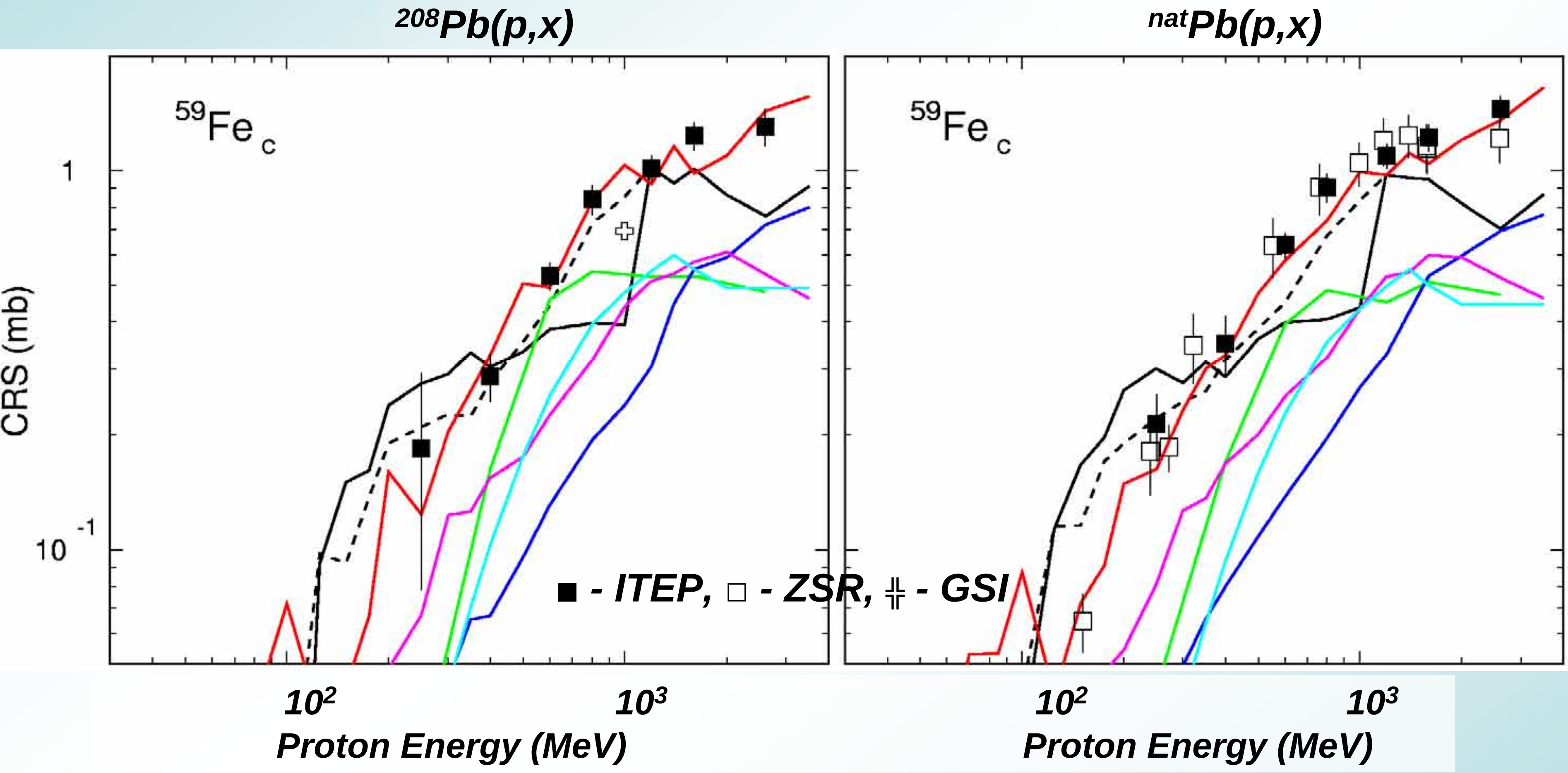
^{208}Pb-, ^{nat}Pb(p,x) excitation functions (2)



^{208}Pb-, ^{nat}Pb(p,x) excitation functions (5)



^{208}Pb-, ^{nat}Pb(p,x) excitation functions (2)

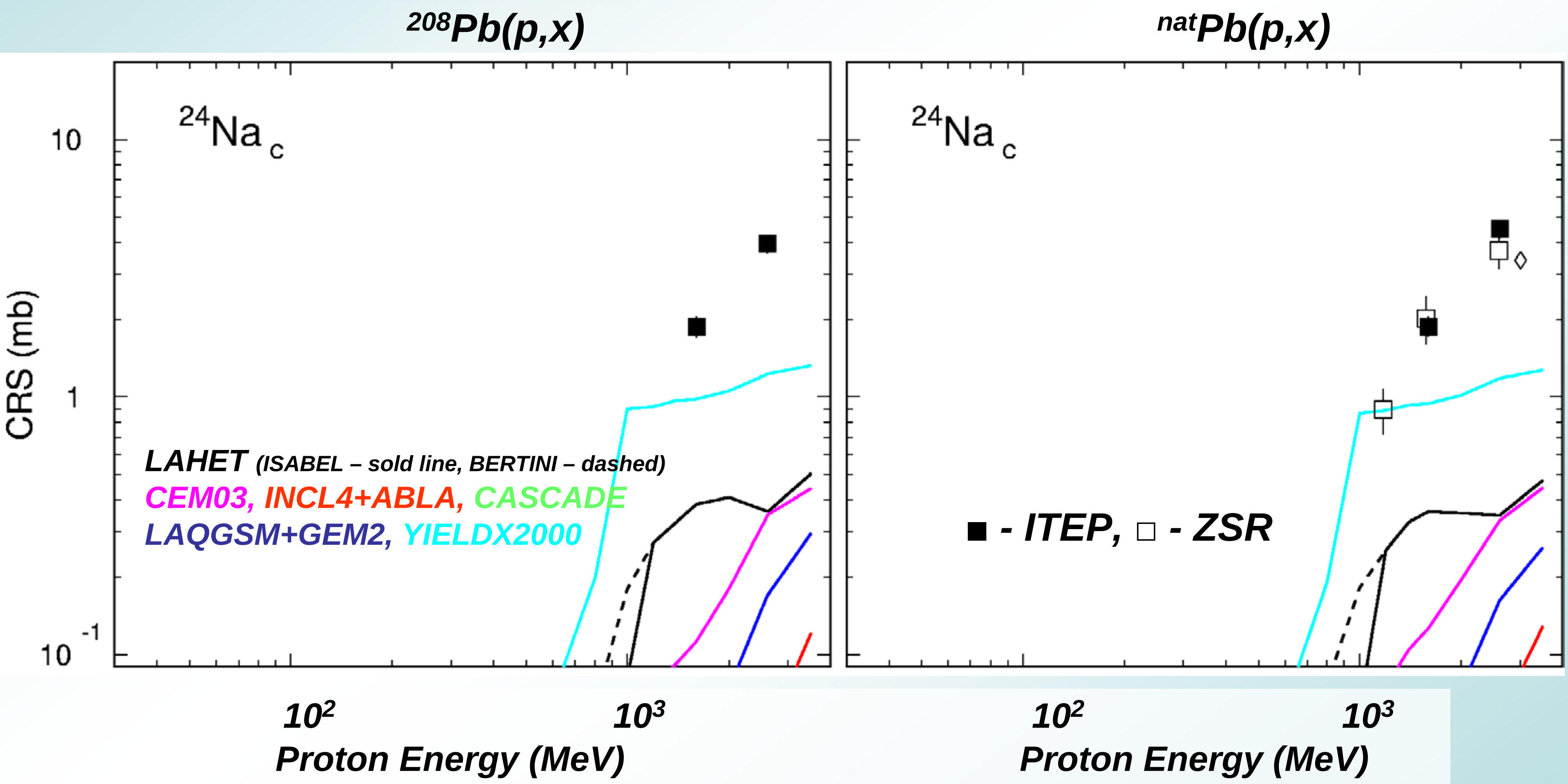


LAHET ***(ISABEL – sold line, BERTINI – dashed)***

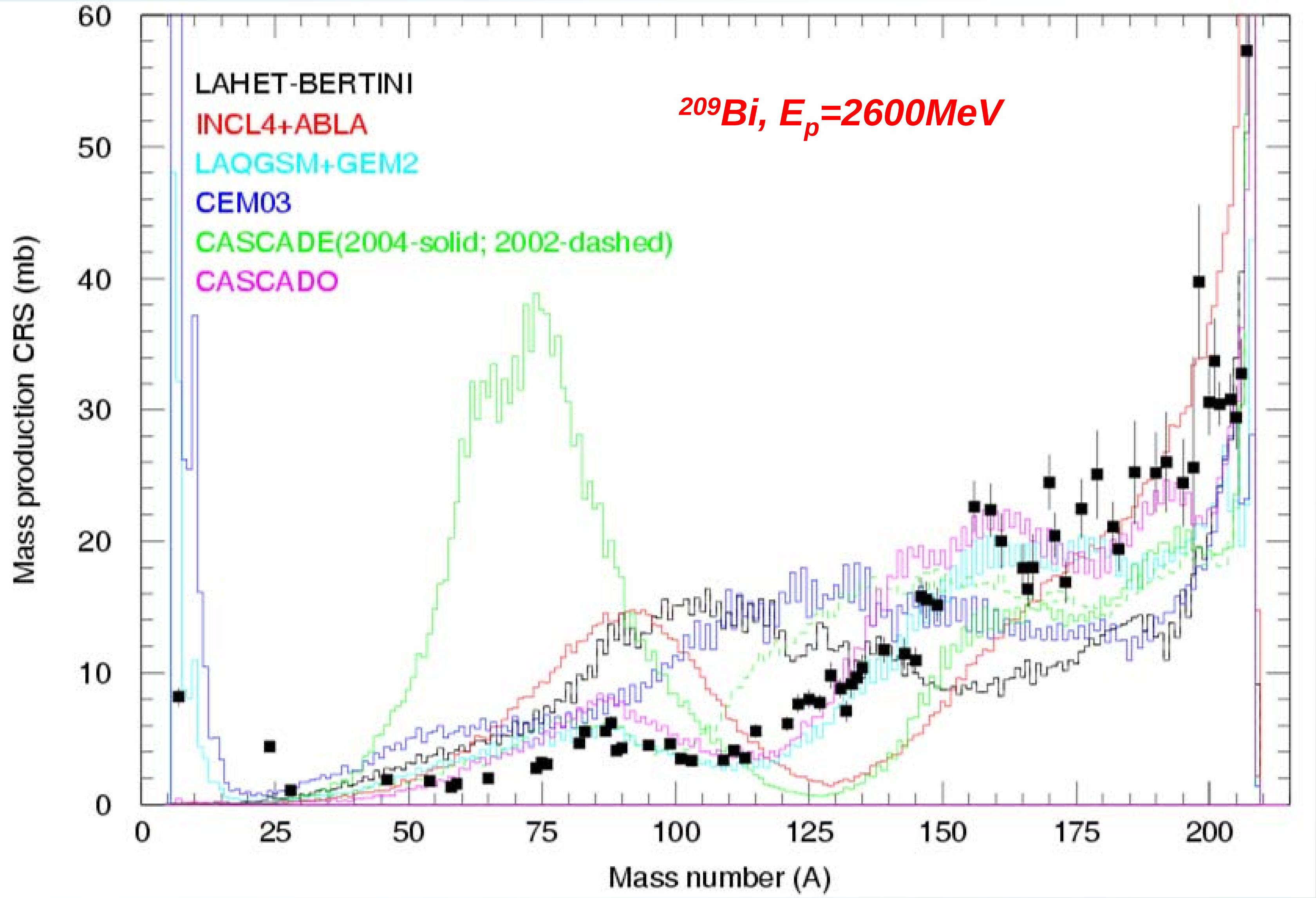
CEM03, INCL4+ABLA, CASCADE

LAQGSM+GEM2, YIELDX2000

^{208}Pb-, ^{nat}Pb(p,x) excitation functions (6)



Mass production



The simulation codes prediction power

Mean squared deviation factor <F>

$$< F >= 10^{\sqrt{A}},$$

$$A =< (\lg(\sigma_{cal,i} / \sigma_{\exp,i}))^2 >$$

Table 44: Mean squared deviation factors <F> separately for different energy groups and ranges of products (A>30) and for all comparisons as well.

Code	Product mass (A)			Proton energy (E_p, GeV)			**Total**
	A>170	140<A<170	30<A<140	E_p <0.1	0.1<E_p <1.0	E_p >1.0	
ISABEL	1.81	1.81	2.87	4.88	2.13	–	**2.16**
BERTINI	1.75	1.93	2.75	4.26	2.06	1.97	**2.10**
INCL4+ABLA	1.90	3.74	2.22	4.63	2.18	2.13	**2.25**
CASCADE	1.77	2.01	6.93	4.93	3.93	2.44	**3.25**
CASCADE-2004	1.93	1.47	5.54	6.54	3.23	2.42	**2.94**
LAQGSM+GEM2	1.98	2.32	2.71	3.03	2.35	2.09	**2.26**
CEM03	1.98	2.07	2.25	2.08	1.77	2.39	**2.07**
CASCADO	1.99	2.22	2.83	2.69	2.33	2.22	**2.29**
LAHETO	1.99	1.96	1.98	4.85	1.76	–	**1.98**

Results application in other projects

Project	Results	Application
2002	***Residual nuclide yields in lead and bismuth***	**Projects with lead (lead-bismuth) targets: SAD (ISTC#2267), MYRRHA (Belgium), etc. Prediction of target activation (including long-lived!) at the design stage. Measurements.**
839	*Residual nuclide yields in various targets, including tungsten, mercury, etc.*	Projects with alternative (Hg, W) targets: SNS, etc
1145, **2405**	*High-energy neutron spectra,* *Threshold reaction rates*	Neutron spectra unfolding , W-Na, Pb target Two benchmarks for IAEA CRP

Cooperation with foreign collaborators

• **S.Mashnik (LANL)** conducted simulation the Project-measured residual product yields by CEM03 and LAQGSM+GEM2 codes
• **A. Boudard (CEA-Sacley)** provided (26/09/2003) the INCL4+ABLA code to calculate the product nuclide yields and made some comments (6/04/2004) on the code operation results.

The tentative results of the Project were sent to:

C.H.M. Broeders (FZK)	5 February 2003; ^{nat}Pb 600MeV to use for the MEGAPIE and PDS-XADS Projects
E. Gonzales (CIEMAT)	6 March 2004
K.H. Schmidt (GSI)	10 December 2004 (draft report)
W. Gudowski (KTH)	17 December 2004 (draft report)

Discussion of the next ISTC proposal (ISTC Project #3266):

S.Leray (CEA-Sacley)	October 2004, December 2004, August 2005
R.Michel (ZSR)	January 2005
C.H.M. Broeders (FZK)	December 2004
S. Mashnik: (LANL)	December 2004
H. A. Abderrahim (SCK)	October 2004, December 2004
T. Fukahori (JAERI)	October 2004, December 2004, February 2005

The discussed Project #3266 was approved for funding in October 2005. The Workplan is to be discussed 31 January 2006.

From: "Tokio Fukahori" <fukahori@ndc.tokai.jaeri.go.jp>
To: "'Yury Titarenko'" <Yury.Titarenko@itep.ru>
Subject: RE: ISTC Project #3266
Date: Tue, 22 Nov 2005 13:32:14 +0900

Dear Yury

Thank you for your information. I have just submitted the form to JAEA for the collaborator.

The ISTC project #839 and #2002 have been very useful as following reason;

1) To polish up model code
2) To validate JENDL/HE
3) To be used evaluation for JENDL/HE

best regards,
Tokio

Tokio FUKAHORI
Nuclear Data Evaluation Group
Nuclear Science and Energy Directorate
Japan Atomic Energy Agency
TEL: +81-29-282-5907
FAX: +81-29-282-5766
HP-URL: <http://wwwndc.tokai-sc.jaea.go.jp/>
http://wwwndc.tokai-sc.jaea.go.jp/

The post-graduate students training:
T. Kobayashi (October 2004); C.-M. Persson, M. Tesinsky (February 2006)

ISTC Project #3266

The Project #3266 was approved for funding in October 2005

Financing party - EU
Budget – k$430

The Workplan is to be discussed by CEG 31 January 2006

List of irradiation runs for beta-active nuclide production measurements.

Targets	Proton energies (MeV) 40	70	100	150	250	400	600	800	1200	1600	2600
^{56}Fe +	x	x	x	x	x	x	x	x	x	x	o
^{nat}Cr	x	x	x	x	x	x	x	x	x	x	x
^{nat}Ni	x	x	x	x	x	x	x	x	x	x	x
^{93}Nb	x	x	x	x	x	x	x	x	x	x	o
^{181}Ta	x	x	x	x	x	x	x	x	x	x	x
^{nat}W	x	x	x	x	x	x	x	x	x	x	o

o – the irradiations were made under the ISTC Project#839.

+ Additionally, ^{56}Fe will be irradiated by 300, 500, 750, 1000 and 1500 MeV prot
to be compared with recent GSI measurements!

List of irradiation runs for alpha-active nuclide (^{148}Gd) production measurements.

Targets	Proton energies (MeV) 600	800	1600	2600
^{181}Ta	x	x	x	x
^{nat}W	x	x	x	x

Isotopic composition of the targets

Isotope	Number of samples	Isotopic composition, %
^{56}Fe	15	^{54}Fe-0.3, ^{56}Fe-99.5±0.1, ^{57}Fe-0.2, ^{58}Fe-<0.05.
^{nat}Cr	11	^{50}Cr-4.345 , ^{52}Cr-83.789 , ^{53}Cr-9.501, ^{54}Cr-2.365 .
^{nat}Ni	11	^{58}Ni-68.077, ^{60}Ni-26.223, ^{61}Ni-1.140, ^{62}Ni-3.634, ^{64}Ni-0.926
^{93}Nb	10	^{93}Nb > 99.9
^{181}Ta	15	^{180}Ta-0.012, ^{181}Ta-99,988.
^{nat}W	14	^{180}W-0.12, ^{182}W-26.50, ^{183}W-14.31, ^{184}W-30.64, ^{186}W – 28.43.

68 short (~0.7h) irradiations
8 long (~20h) irradiations
~130h accelerator time

For comparison:
ISTC#2002 took **37h** acc.time
(disregarding time for accelerator preparation and beam adjustment)

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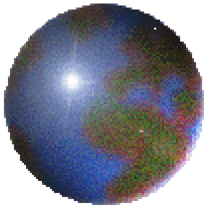
Appendix 9

Report on ISTC Project #2680 by L. Zabudko



MATINE-Study of Minor Actinide Transmutation in Nitrides: Modeling and Measurements of Out-of-pile Properties

L.Zabudko *(IPPE), Obninsk, Russia*

Progress report on ISTC Project #2680

Meeting of Contact Expert Group on ISTC Transmutation related Projects.
Brussels, January 30-31, 2006.

Introduction

- **On May, 1 2004 the Project has started . The duration of the Project is 29 months.**
- **Objective - to identify the optimum fuel pin design that would perform well under irradiation in ADS fast neutron spectrum**
  - **Fuel (Pu,Am,Cm,Zr)N (with ZrN=50-65%, Pu/Am/Cm=40/50/10)**
- **Three Institutes –IPPE, VNIINM, RIAR-are participations. CEA (France) and KTH (Sweden) are collaborators.**

MATINE Scope of activity

Task 1: compilation of literature data on nitride fuels and on MA containing fuels. The objective of this task is to perform input data for the codes calculation

Task 2: Experimental study of out-of-pile PuZrN properties: high temperature stability, thermal conductivity, high temperature creep, linear expansion

Task 3: Modeling of (Pu,Am,Cm, Zr)N behavior under irradiation up to 35at% in ADS (pellet for helium, sodium and lead-bismuth bonded fuel pin, vibro for helium-bonded pins only). Parameters to be investigated and determined: optimum range of power density; allowable cladding temperature, burn-up value.

Task 4: Technical – economical assessments of fabrication feasibility of (PuAmCmZr)N with (60±10) at% ZrN and with 10 at% Cm at RIAR site.

Task 1- completed. The report is handed to ISTC and collaborators (CEA, KTH)

Review of literature data on UN, UPuN, UN+ZrN, PuN+ZrN properties as well as, on fuel compositions with MA is done. Today most proved relationships on basic properties of (Pu, Am, Cm, Zr) N are proposed: **thermal expansion coefficient, Young module, Poisson module, creep rate, thermal conductivity, gas release, maximum allowable temperature, fission gas release.**

No experimental swelling data for ZrN fuel. At stress-strain state calculation of pins with ZrN fuel the model of “spherical cells” developed for dispersion type inert matrices fuels is adopted for swelling estimation. The model requires matrix creep data that are absent. In Task 2 some additional measurements of ZrN creep are planning to be done that have to specify the parametric calculations.

Big uncertainty with He release from fuel matrix. Additional analysis of NIMPHE , BORA-BORA experiments will be done .

Task 2 (VNIINM, Moscow)

PuZrN fabrication technology is finalized with ZrN as a dummy. Relations between density of sintered PuZrN samples and density of compressed samples (compression pressure), sintering time and temperature have been studied.

(Pu,Zr)N samples with ZrN=60mol% of 85%th , 93%th density, met to the specifications, have been fabricated using direct nitridation of metals. Nitride powders were mixed using a patented electro-vortex blending method (rotating ferro-magnetic needles) - solid solution received.

Creep and thermal conductivity of (Pu,Zr)N samples are measured.

(Pu,Zr)N creep rate about one order lower than UPuN, recommended for modeling, thermal conductivity – good agreement with CEA data.

Task 3 –IPPE, Obninsk.

CARE code : calculations of max burn-up, He production, fission gas production are done.

FACIC code (**F**uel **A**ssembly **C**hannel **I**sobar **C**alculation) for ADS core thermo-hydraulic calculation is developed. Optimization of FA design in order to get allowable values of Pb-Bi coolant rate, inlet coolant temperature, max clad temperature – is done.

DRAKON-3D code – is developed for temperature and stress-strain state calculation. Model of spherical cells (MSC) is developed for fuel swelling. The model will be verify using BORA-BORA PIE data (PuZrN irradiation in BOR-60).

Parametric comparative calculations of He-bonded pin performance for different pellet fuel creep laws (from literature review and from VNIINM Task 2 measurements) are completed; possible problem due to FCMI are revealed.

Example of DRAKON calculations

Fig.1.Clad hoop and axial stresses axial distribution at EOL (33.5at%)

Fig.2. Clad hoop and axial stresses per time at axial section 50% of core height

Fig.1

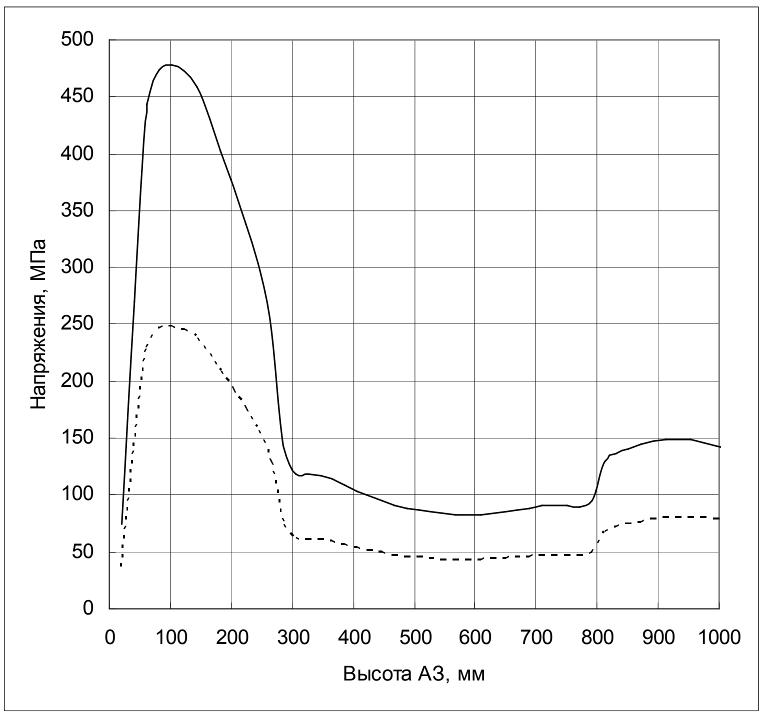
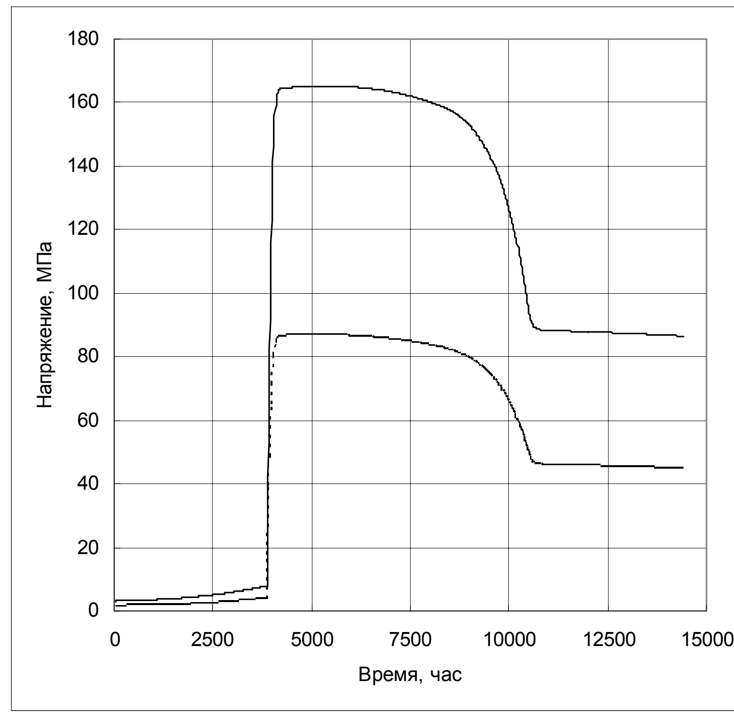


Fig.2



Task 4 –completed (RIAR, Dimitrovgrad). **The report is handed to ISTC and collaborators (CEA, KTH)**

The possibility is considered of fabrication on RIAR site of (Pu, Am, Cm, Zr)N fuel, (60±10)at% ZrN and 10at% Cm sufficient for manufacturing of 2 BOR-60 fuel pins- ~0.6 kg . Fuel pins manufacturing comprises the following main stages:

- chlorination of the initial components;
- production of MA nitrides;
- nitride fuel production;
- manufacturing of fuel pins.

High cost of full-scale pin fabrication (885 000 euro) is completely determined by Cm cost. As the initial stage of the researches, the manufacturing of the micro fuel pin or the special irradiation device is possible with the purpose of the expenses decrease.

Conclusion

- 7 quarters work on ISTC MATINE- #2680- project is completed.
- PuZrN solid solution samples have been fabricated. PuZrN high temperature creep and thermal conductivity measurements are finalized. High temperature stability measurements are under completion. Thermal expansion coefficient will be measured additionally.
- Calculation modeling of (PuAmCmZr)N fuel in ADS core is under completion

- DRAKON-3D code has been developed (stress-strain, temperature and clad damage calculations);
- model for fuel swelling calculation is developed;
- all necessary input data are prepared (properties relation for fuel and EP-823 cladding steel; He and fission gas production – CARE code calculation; axial temperature distribution of clad outer surface by FACIC code calculation);
- comparative calculations of He-bonded pin performance are completed; possible problem due to FCMI are revealed;
- calculations of Na- and Pb-Bi-bonded pins performance are under completion.
- Modernization of VIKOND code: model of vibro fuel thermal conductivity, fuel restructuring, gap conductance. Vipac fuel performance estimations are done using fuel swelling rate 1%/1at% (accordingly, for fissile fraction of ADS three zones -0,35%, 0.4%, 0.5% per 1at%)

Proposal for new ISTC Project
"MATINE -2: Study of MA Transmutation in INErt-matrices fuels: modelling and measurements of out-of-pile properties"

- Results of in-pile performance calculation made in MATINE have shown that liquid metal bonded fuels may perform well up to the target burn-up of 30%. He- bonded fuels however may exhibit problems at high-burn-ups in ADS core. The reason is fuel swelling rate under high linear ratings and low level of fuel creep that leads to the severe fuel-cladding mechanical interaction (FCMI). Since He bonding is preferable to remain compatible with aqueous reprocessing options, alternative fuel compositions are of interest.
- One of the possible options are the composite materials based on porous matrix made of refractory compounds, like Zr carbide or its solid solutions, with heavy nuclides incorporated into the pores. The fuel is developed in VNIINM, Moscow.

Proposal for new ISTC Project
"MATINE -2: Study of MA Transmutation in INErt-matrices fuels: modelling and measurements of out-of-pile properties"

- Relative simple fabrication technique, including the absence of dust operations with high radioactive materials, since the last ones are introduced into matrix pores as liquid solutions. Thermal destruction process, mixed oxides formation as thin film on matrix pores surface.
- Porous Zr carbide matrix of required diameter and length is fabricated prior to the filling by actinides. All basic stages of technological route may be robotized. Matrix porosity 20-80%.
- Formation of mixed oxides even of those nuclides that don’t form solid solution in melt (e.g., Np+Am). The possible solid solutions: Pu-Am-Np-Cm, U-Np-Am-Cm, Np-Am-Cm-Th, Pu-U, U-Th etc.
- Irradiated fuel reprocessing may be carried out using traditional routes of radiochemical facilities.

Project Proposal

"MATINE -2: Study of MA Transmutation in INErt-matrices fuels: modelling and measurements of out-of-pile properties"

- The objective of the Project - identification of uranium-free fuel types that would perform well under irradiation to high burn-up in ADS fast neutron spectrum . The possibility to use ZrC porous matrix impregnated by heavy nuclides oxides is proposed for investigation.
- The calculation modeling of neutronics and thermo-hydraulics will optimize ADS core parameters for effective actinides transmutation. The basic result – substantiation of PuAmCmO2-ZrC fuel pins performance. **IPPE, Obninsk.**
- Fabrication and properties measurement of PuO2-ZrC fuel : thermal conductivity, creep, linear thermal expansion, Young module – required input data for the calculation. **VNINM, Moscow.**
- On the base of MATINE-1 estimations the vipac PuAmZrN granulate samples and CmN powder will be fabricated. Thermal stability will be measured. **RIAR, Dimitrovgrad.**
- **Project duration – 2.5 years, cost US $ 500 000.**

Comments

- 1) Bochvar lyckades tillverka (Pu,Zr)N med mycket hög densitet: 93% av den teoretiskt maximala. Ingen annan har lyckats med detta. Deras speciella metod för att blanda materialen (elektromagnetiska roterande nålar) verkar vara mycket effektiv,
- 2) Modellering visar att stavar med blyfyllning kan möjliggöra hög utbränning av nitridbränslen, medan heliumfyllning kan ge problem med hög svällning. Eftersom vi önskar utveckla ett bränsle med heliumfyllda stavar i Eurotrans, föreslår Bochvar att i MATINE2 prova tillverkning av ett hybridbränsle som består av aktinidoxid i en zirkoniumkarbidmatris. Alltså ett cercerbränsle med hög värmeledningsförmåga. Det skulle vara ett intressant alternativ till cermetbränslet baserat på molybden, som nu är prioriterat i AFTRA.

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Appendix 10

Presentation of A. Bychkov

Partitioning related ISTC projects at RIAR and short overview of Russian Partitioning program

CEG Meeting, January 2006

Russian programs on partitioning
(some history)

In 1980-s – partitioning of Np from spent fuel was implemented into "Mayak" Plant, separation of Am+Cm/REE and extraction of Cs+Sr were tested on real HLW

1993-2001 – Minatom Program "RECYCLE":

Participants: MAYAK Reprocessing Plant, Bochvar Institute, Kurchatov Institute, RIAR, IPPE, Moscow Institute of Physical Chemistry of RAS

- **Main tasks**
  - Separation and collecting of **I, Tc, Am**
  - Development of reactor conceptions of FP and MA incineration (transmutation)

1999 (until now) – FS and R&D of advanced RT-2 Conceptions and followed conceptions for LWR reprocessing plant

- Technologies
  - Advanced (or extended) PUREX, Fluoride Volatility technology, DDP, supercritical CO2 extraction, others

Russian programs on partitioning
(some history)

2003-2005 – Preparation of new Russian Program "Construction of the BN-800 fast reactor with closed fuel cycle demonstration"

Start of plutonium fuel cycle in Russia (MOX fuel) and utilization of accumulated "power grade" Pu and Application of developed technologies and using of previously constructed facilities and buildings (as possible)

- Possible technologies for MOX fuel production
  - RIAR – pyrochemical + vibropacking with Am burning
  - Bochvar Institute – codeposition GRANAT technology and pelletizing
- Possible technologies for MOX fuel reprocessing demonstration
  - RIAR – pyrochemical reprocessing with MA partitioning and vibropacking
  - Bochvar Inst. – simplified PUREX, GRANAT and pelletizing (no partitioning)
- **Russian State Duma** supported this program as innovative program

2000 (until now) – Program of BREST fast reactor

- Main approaches to BREST fuel cycle
  - So-called "on site" close fuel cycle (i.e. location of fuel cycle facility on the same site with reactor unit) Pyrochemical reprocessing
  - Homogeneous recycle of MA in frame of BREST close fuel cycle

Russian programs on partitioning

2006

Partitioning will be included into new integrated conception:

NEW

TECHNOLOGICAL PLATFORM

Commercial fast reactor with closed fuel cycle (included P&T)

Current and completed ISTC Projects related to partitioning

Examples of
Completed ISTC Proiects related to partitionina

Integrated projects

- ISTC 17
- ISTC 1606
- ISTC 272

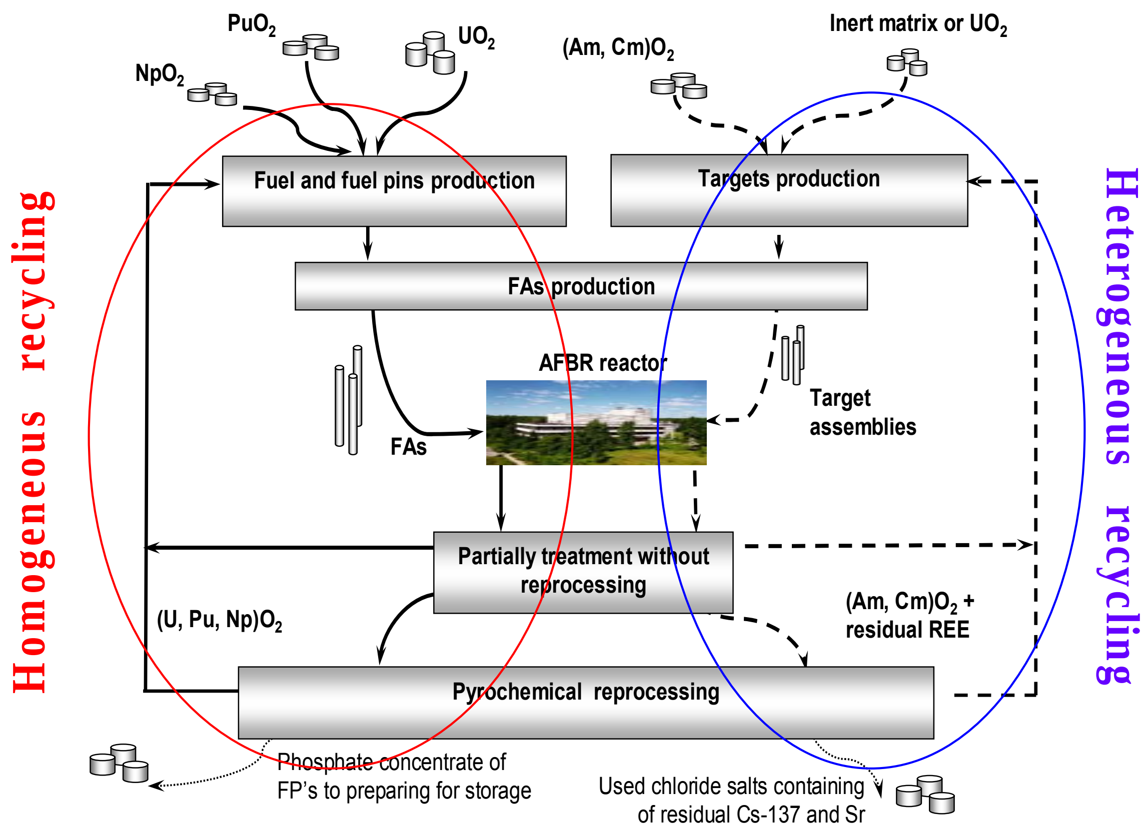
Pyrochemical partitionir

- ISTC 279

Targets

- ISTC 2680

DOVITA fuel cycle



RESEARCH INSTITUTE OF ATOMIC REACTORS

ISTC project 3261

Study of curium thermodynamics in molten chlorides

Objectives

- **Reactions of formation for oxygen curium compounds**

- equilibrium constants (and Gibbs energy change) for reactions of curium oxygen compounds formation versus temperature;

- equilibrium constants (and Gibbs energy change) for reactions of curium oxygen compounds formation versus the inverse effective radius of solvent cation.

- **Reactions of formation for oxygen-free curium compounds**

- standard potential for redox pair (and Gibbs energy change) versus temperature;

- standard potential for redox pair (and Gibbs energy change) versus the inverse effective radius of solvent cation.

- **Simulation of curium behavior in molten chlorides**

  Pourbaix diagrams

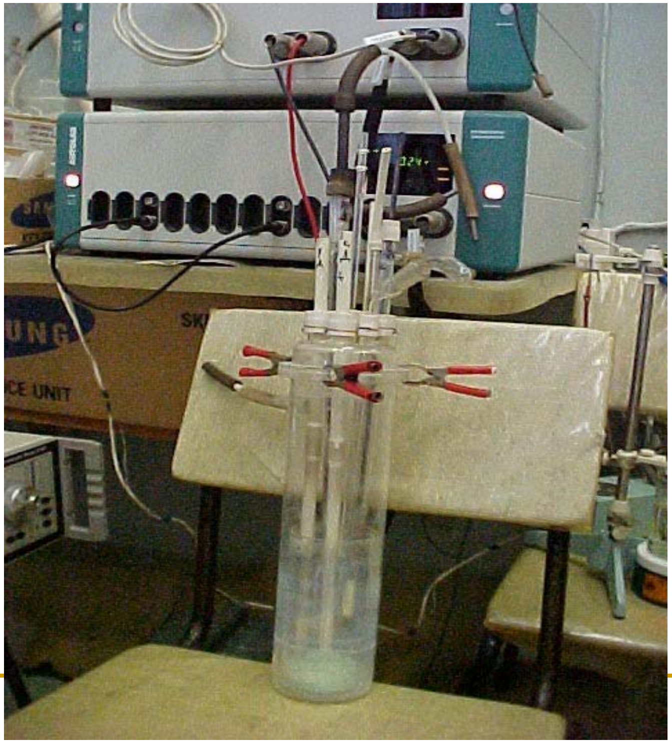
Study of curium thermodynamics in molten chlorides

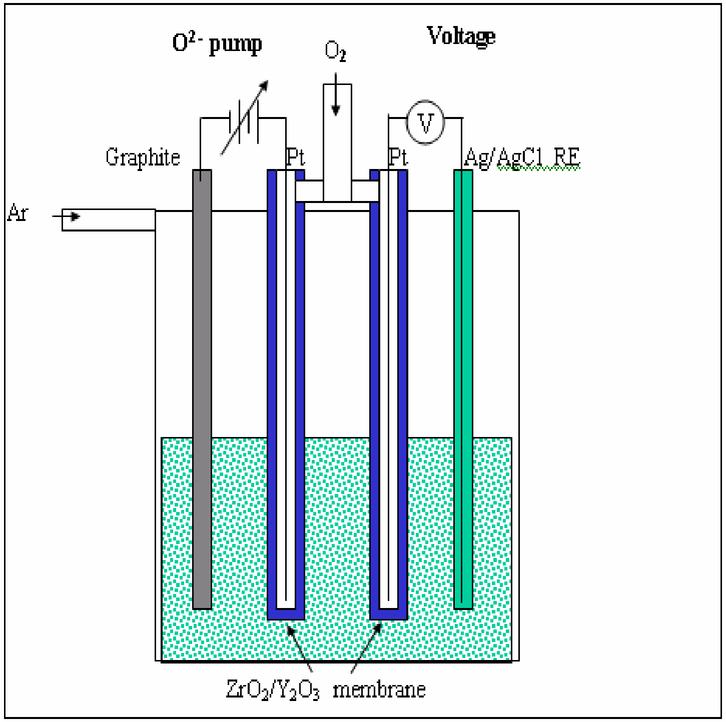
Investigation methods

•**Thermodynamics of formation for oxygen curium compounds**

Potentiometric titration with oxygen pump

<u>advantage</u> - small concentration of Cm in melt) versus high cost of Cm reagents





Study of curium thermodynamics in molten chlorides

Investigation methods

•Thermodynamics of formation of oxygen-free curium compounds

Method of EMF

Cyclic Voltammetry

Chroho Potentiometry

necessary request - Cm concentration in melt must be more than 3wt% (interaction of Cm with melt is negligible)

•Simulation of curium behavior in molten chlorides

Study of curium thermodynamics in molten chlorides

Conditions

Molten salts
LiCl-KCl, NaCl-CsCl, NaCl-KCl

•Temperature range
450^{o}C - 850^{o}C

•Cm content
10^{-4} – 10^{-2} mol/kg (Potentiometric titration)
(2 – 5) 10^{-1} mol/kg (EMF, Cyclic Voltammetry, ChrohoPotentiometry)

Common information

Duration of project	**24 months**
Estimated total cost	**$300,000.00**
Participants	**RIAR**

ISTC Partner Project 3231 (RIAR-KAERI)

Separation of minor-actinides from rare-earth elements on a liquid metallic cathode in molten chlorides

Objectives:

Task 1: Polarization curves on electrodeposition of actinides and lanthanides on bismuth and cadmium cathodes

Task 2. Electrodeposition tests for effective separation of actinides and lanthanides on liquid-metal cathodes

Task 3. Effect of uranium content in molten salt to electrodeposition and separation of actinides and lanthanides on liquid metallic cathode

- Actinides - U, Np, Am, Cm,
- REE - Nd, La, Ce
- Systems: - Bi / LiCl-KCl and Cd / LiCl-KCl

ISTC Projects related to partitioning

New proposals

Research area of pyrochemical (non-aqueous) methods for MA/FP partitioning development

Melts/ media	Electrochemical methods				Oxides Precipi-tation	Metalli-zation
	Liquid cathodes	Solid cathodes	Anodic dissolution	E/Chem. oxide titration		
Chlorides	Cd, Bi, Ga	Al,	+	+	+	+
Fluorides	Bi, Ga, Al, Pb	-	+	+	+	-
Cl^- /F^-	Cd, Bi, Ga, Al, Pb	Al,	+	+	+	-
Molibdates	-	+	-	-	+	-
RTIL	Ga, Hg	Zn, Cu, Ni, Al, …	+	-	-	-

+ Methods of Volatility of Fluorides and /or Chlorides

Future ISTC proposals for studies

Continuation of recently investigated subjects:

Molten Salt chemistry of Am and Cm for fluorides

- Phase II for ISTC 3261 – for partitioning
- As continuation of ISTC 1606 – for recycling as molten salt fuel components

Partitioning of MA/REE in molten fluorides

with liquid cathodes

Application of Room Temperature Ionic Liquids for Separation of TPE and REE

RIAR proposal for ISTC project

The research program includes the following stages:

- search for the RTIL with a rather wide electrochemical window (first of all, with a high stability to cation electrochemical reduction), study of its physical and electrochemical properties, compatibility with other solvents
- study of solubility of the TPEs and REEs salts with different anions (NO^{3-}, Cl^-, F^-, CN^-) in the chosen RTILs
- study of composition of the complexes and electrochemical behavior of the TPEs and REEs in the chosen RTILs
- analysis of the possibility of cathodic deposition of actinides and lanthanides in the alloy form with transient metals (Zn, Cu, Ni, Al and others) and/or on a liquid metallic cathodes (Ga, Hg) in the chosen RTILs, study of conditions of the electrochemical TPEs and REEs separation in the given systems
- Analysis of the possibility of creating the extraction-electrochemical system to separate the TPE and REEs using RTILs

Chemical problems of minor actinides partitioning for transmutation in aqueous processes

Proposals of

V.G. Khlopin Radium Institute, St. Petersburg

Development and demonstration of the process for selective recovery of TPE from HLW using binary calixarene extractants
ISTC proposal 3405

The work will include the following:

- systematic study of physical chemical properties of new calixarene extractants with functional groups of different types;
- determination of correlations between structure - selectivity and structure - stability for these extractants;
- development of flowsheet variant for recovery from HLW and separation of TPE - REE fractions by calixarene extractants;
- prolonged dynamic tests of the elaborated process.

Amide and heterocyclic extractants

- **Idea:** search of extractant with **adequate selectivity** (ß Am/Eu ~ 30) and very **high hydrolytic** stability.

- Alkyl-aryl diamides of pyridine-dicarboxylic acid and bis-tetrazole derivatives of pyridine gave good results in An/Ln separation. These systems work only in polar diluents and exhibit high hydrolytic stability and acceptable selectivity (ß Am/Eu ~ 20-50) in high acidic media.

Zirconium salt of dibutyl phosphoric acid

- ISTC proposal : "**Partitioning of Long-lived Radinuclides Using the Mixture of Short Alkylphosphoric Acids or their Zirconium Salts and Chlorinated Cobalt Dicarbollid**"
- The main goal of the project is investigation of An and Ln extraction and separation using a TBP hydrolysis product – dibutyl phosphoric acid (HDBP) and its acid zirconium salt (ZS HDBP) in the buffer range of acidity and using HDBP or ZS HDBP in mixture with Chlorinated Cobalt Dicarbollide in the polar fluorinated diluent.

Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum

Participating Institutions

- **Federal State Unitary Enterprise "State Scientific Center of the Russian Federation – Research Institute of Atomic Reactors",** Dimitrovgrad
- **Federal State Unitary Enterprise " State Scientific Center of the Russian Federation –Institute of Physics and Power Engineering,** Obninsk

Governmental Agency

Federal Agency for Nuclear Power (Rosatom)

Project Duration

36 months

Project estimated total cost

815 000 $US

Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum

Scope of Activities

- **Task 1 covers the work related to the selection of a set of isotopes to be tested, substantiation of the target design and requirements to the substances to be irradiated**

- **Task 2 covers irradiation of the targets in BOR-60, information acquisition on irradiation conditions and calculation-analytical support of irradiation**

- **Task 3 consists in examination of irradiated targets and includes development of the precision procedures for determining the key elements and their analysis**

- **Task 4 includes development of the irradiation models, analysis of data according to the irradiation program, acquisition and analysis of data by the irradiation conditions and calculation-analytical support of irradiation.**

Experimental study on actinide transmutation in the BOR-60 fast reactor neutron spectrum

Expected Results and Their Application

The following results will be obtained:

- **Verified data on MA nuclear constants**
- **Accuracy estimate of the findings**
- **Recommendations for modification of nuclear constants files for reactor codes**

The proposed Project will provide:

- **experimental data for verification of neutron sections for the selected set of actinides**
- **results of the comprehensive analytical examination of the irradiated targets containing actinide nuclides: isotope sample composition, content of actinides and fission products**
- **verified nuclear-physical actinide constants based on the results of the integral reactor experiments**

New experimental data obtained under the Project would be used for verification of the estimated neutron data and the development of more precise constants for calculation codes that are used in design of radioactive waste burning facilities. Moreover the new data will provide recommendations on actinide transmutation in fast reactors

ISTC Project proposals from RIAR: Preparation of monographies related to P&T and advanced fuel cycle

- V.Nickolaev, E.Karelin, R.Kuznetsov, Yu.Toporov. Technology of Transplutonium Elements – second edition and translation to English and publishing
- V.Radchenko, M.Ryabinin, etc. Physical Metallurgy of Transplutonium Elements – preparation Russian and English editions

- A.Mayorshin Fuel elements with vibropacked oxide fuel – preparation Russian and English editions
- O.Skiba, A.Bychkov, V.Ivanov. Pyroelectrochemical process in nuclear fuel cycle – preparation Russian and English editions

Proposal for new Contact Expert Group

- **Partitioning of HLW**
- **Partitioning in Advanced fuel cycle**

Subjects:

- Search of new methods for Actinides and Long-lived fission products separation for transmutation
- Search of advanced methods for recycling of transmutation targets or molten salt fuel
- Integration of partitioning and recycling processes with transmutation facilities

Participants: Russia, EU, Japan, Rep.Korea …

Proposal for new Contact Expert Group (for discussion)

Possibility to elaborate and demonstrate of new ISTC roles:

- **“Umbrella” organization for new applied scientific projects**
- **Regulation and organization of multilateral projects and studies**

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Appendix 11

Information documentation for ISTC Project #2048 by G. Müller

Forschungszentrum Karlsruhe
In der Helmholz-Gemeinschaft

Institut für Hochleistungsimpuls- und
Mikrowellentechnik

Leiter: Prof. Dr. Dr. h.c. M. Thumm

Forschungszentrum Karlsruhe GmbH, Postfach 3640, D-76021 Karlsruhe

Datum:	24.01.2006
Bearbeiter:	Dr G. Müller
Telefon	07247 / 82 4669
Telefax	07247 / 82 2256
Ihre Mitteilung:	

Dear Dr. J. Sanders,

I am writing you on behalf of the collaborators of the ISTC 2048 project. The collaborators are Ms Dr. Dolores Gómes-Briceno (CIEMAT), Ms Dr. Anne Terlain (CEA) and myself. The purpose of the project is to develop methods of improvement of the corrosion resistance of constructional steels operating in liquid-metal coolants such as Pb and Pb-Bi. Such coolants are supposed to be used in accelerator driven reactors (ADS), which are presently under development in Europe, USA and Japan for burning of radioactive nuclear waste. The corrosion problem, especially for the high loaded parts like the fuel cladding, is one of the key issues which has to be solved.

In the course of the project execution by our Russian colleagues (project executors) a method of essential improvement of the corrosion resistance of steels was developed. This very advanced and promising method is based on steel surface alloying with Al using a pulsed intense electron beam. As the result of this modification very efficient new anticorrosive barriers are formed. They efficiently work in the liquid-metal coolants for temperatures exceeding even 500 °C. This was demonstrated in a series of corrosion tests, carried out at Russian loops with a large number of flat and cylindrical specimens of European steels (316 L, 1.4970, T91).

This project is very successful and the results are important for the currently ongoing work on the European Transmutation Demonstrator, which is under development within the 6th Framework Program. Our large European project IP-EUROTRANS started April 2005 will be continued for the next 3 years. All collaborators of the ISTC2048 are strongly involved in IP-EUROTRANS in responsible positions (WP and Task leaders). ISTC2048 is strongly linked to the material tasks of IP-EUROTRANS (DEMETRA) and is recognized as a very important and complementary contribution to our needs. For example some necessary experiments in liquid Pb-loops at temperatures higher than 550°C can only be performed in Russia, because such experimental facilities are currently not available in Europe and also world wide.

Unfortunately ISTC2048 was finished in September 2005. To accomplish the very promising technology of surface protection, developed during the first three years we are convinced that the project must be extended for additional 36 month. During this second stage the technology has to be extended for the use of real full scale reactor parts, namely fuel cladding elements; to develop real fuel cladding specimens from T91 steel with overall defect-free surface alloyed layer; to estimate additional corrosion-mechanical properties of the modified surface layers in flowing Pb Pb-Bi at temperatures up to 600 °C; to check the corrosion resistance at abnormal operating conditions like very low and very high oxygen concentrations and accidental superheating; to estimate to a certain level the influence of neutron irradiation on thermal fatigue of the modified layer…..

Meanwhile SCK-CEN has agreed to join the prolongation of #2048 as collaborator and sponsor (see support letter of SCK-CEN). To express the enormous interest on the prolongation of this project FZK is also willing to give a financial support to the project (90 k€ over 3 years, 30 k€/a). With the Russian participants we have agreed to extend the overall project duration by one year (3 years instead of 2 years) keeping the overall budget. An increase of the project duration is very reasonable due to the ambitious goals of the project and ensures a good link to IP-EUROTRANS over the whole remaining project duration. The detail adaptation of the work plan has to be done after approval of the project by the financing party (EU). As collaborators of the ISTC project №2048 we will actively take part in investigations and in the evaluation of the project results. The suggested budget for additional 36 month is very reasonable and we would be very pleased about funding of the second stage of the ISTC2048 by the European Community.

Sincerely Yours,

Dr. Georg Mueller

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Appendix 12

Updated information on SAD funding by V. Shvetsov

SAD Cost Assessment (full costs), Russian kroubles of Dec. 2004

	Equipment, work	Building work (BW)	Installation work (IW)	Equipment manufacturing or purchase	Other work	Total
1	Multiplying blanket, including working design and automatic control system		5 920,00	54 434,20	31 556,80	91 911,00
2	Beam transport line		2 000,00	22 226,50		24 226,50
3	Building construction	93 600,00				93 600,00
4	Fuel temporary storage equipment (doors, containers etc.)		1 738,20	23 582,00		25 320,20
5	Blanket and target cooling system		3 336,00	13 650,00		16 986,00
6	Air flow system for radiation control system		90,00	450,00		540,00
7	Detection system for nonhermetic FE		120,00	3 950,00	1 000,00	5 070,00
8	Fuel elements manufacturing and delivery			42 220,50		42 220,50
9	Physical security system		14 405,00	18 468,00	7 756,00	40 629,00
10	FE storage room equipping, FA production line creation		20,00	1 800,00		1 820,00
11	Radiation control system		335,00	16 500,00		16 835,00
12	Hoisting devices		380,00	4 100,00		4 480,00
13	Geodesical support			1 150,00	1 782,00	2 932,00
14	Special television			1 974,00		1 974,00
15	Auxiliary systems (water supply, sewer, heating, ventilation, electricity, communication and signalling)	1 718,00	4 267,00	9 650,00		15 635,00
16	Land improvement	396,00				396,00
	Subtotal:	**95 714,00**	**32 611,20**	**214 155,20**	**42 094,80**	**384 575,20**
17	Rise in the cost of the installation work in winter time, 1,5% from BW and IW	1 435,71	489,17			1 924,88
18	Premium for the commissiioning				1 924,88	1 924,88
19	Temporary buildings and structures, 1,8% from BW and IW	1 722,85	587,00			2 309,85
20	Working design				26 700,00	26 700,00
21	Project examination				1 068,00	1 068,00
22	Follow-on over building works - 0,2% from subtotal				769,15	769,15
23	Technical supervising, 0,8% from subtotal				3 076,60	3 076,60
24	Unforeseen costs, 3% from subtotal	2 871,42	978,34	6 424,66	1 262,84	11 537,26
	Total:	**101 743,98**	**34 665,71**	**220 579,86**	**76 896,27**	**433 885,82**

SAD Cost Assessment (ISTC channeling), Russian kroubles of Dec. 2004

	Equipment, work	Building work (BW)	Installation work (IW)	Equipment manufacturing or purchase	Other work	Total
1	Multiplying blanket, including working design and automatic control system		1 926,44	30 433,20	6 311,36	38 671,00
2	Beam transport line		400,00	13 335,90		13 735,90
3	Building construction	65 520,00				65 520,00
4	Fuel temporary storage equipment (doors, containers etc.)		347,64	14 149,20		14 496,84
5	Blanket and target cooling system		667,20	8 190,00		8 857,20
6	Air flow system for radiation control system		18,00	270,00		288,00
7	Detection system for nonhermetic FE		24,00	2 370,00	200,00	2 594,00
8	Fuel elements manufacturing and delivery			25 332,30		25 332,30
9	Physical security system		14 405,00	18 468,00	7 756,00	40 629,00
10	FE storage room equipping, FA production line creation		4,00	1 080,00		1 084,00
11	Radiation control system		67,00	16 500,00		16 567,00
12	Hoisting devices		380,00	4 100,00		4 480,00
13	Geodesical support			690,00	356,40	1 046,40
14	Special television			1 974,00		1 974,00
15	Auxiliary systems (water supply, sewer, heating, ventilation, electricity, communication and signalling)	1 030,80	853,40	5 790,00		7 674,20
16	Land improvement	237,60				237,60
	Subtotal:	**66 788,40**	**19 092,68**	**142 682,60**	**14 623,76**	**243 187,44**
17	Rise in the cost of the installation work in winter time, 1,5% from BW and IW	1 001,83	286,39			1 288,22
18	Premium for the commissiioning				1 288,22	1 288,22
19	Temporary buildings and structures, 1,8% from BW and IW	1 202,19	343,67			1 545,86
20	Working design				5 340,00	5 340,00
21	Project examination				213,60	213,60
22	Follow-on over building works - 0,2% from subtotal				486,37	486,37
23	Technical supervising, 0,8% from subtotal				1 945,50	1 945,50
24	Unforeseen costs, 3% from subtotal				7 295,62	7 295,62
	Total:	**68 992,42**	**19 722,74**	**142 682,60**	**31 193,07**	**262 590,83**

SAD funding distribution:

- ISTC –
  - SAD core, beamline & building working design
  - SAD Automation & Control System design
  - SAD Physical Security System
  - SAD equipment manufacturing (inc. beamline components)
  - SAD FE production
  - BFS experiment (shared with ECATS)

SAD funding distribution:

- ECATS –
  - SAD equipment manufacturing (beamline components)
  - SAD Physical Security System
  - BFS experiment (shared with ISTC)

SAD funding distribution:

- JINR –
  - SAD building construction
  - SAD equipment manufacturing (beamline components)
  - Personnel recruitment & training
  - Accelerator M&O during startup

Statement of

Joint Institute for Nuclear Research (JINR)

on the scientific working programme of the Sub-critical Assembly Dubna (SAD) project, in close co-operation with the Domain DM2 ECATS activities of the European sponsored integrated project EUROTRANS.

• •

The JINR representatives assume that the project can be realised providing that JINR and DM2 ECATS of EUROTRANS fund SAD project at the level 1/3 each under the condition that another 1/3 of the necessary funding will be provided by ISTC. At present time JINR is ready to take responsibility on 1.2 M Euro funding, having in mind that the rest of the funds necessary to cover 1/3 of the project cost will be covered by a collaboration that will be created in Russia.

• •

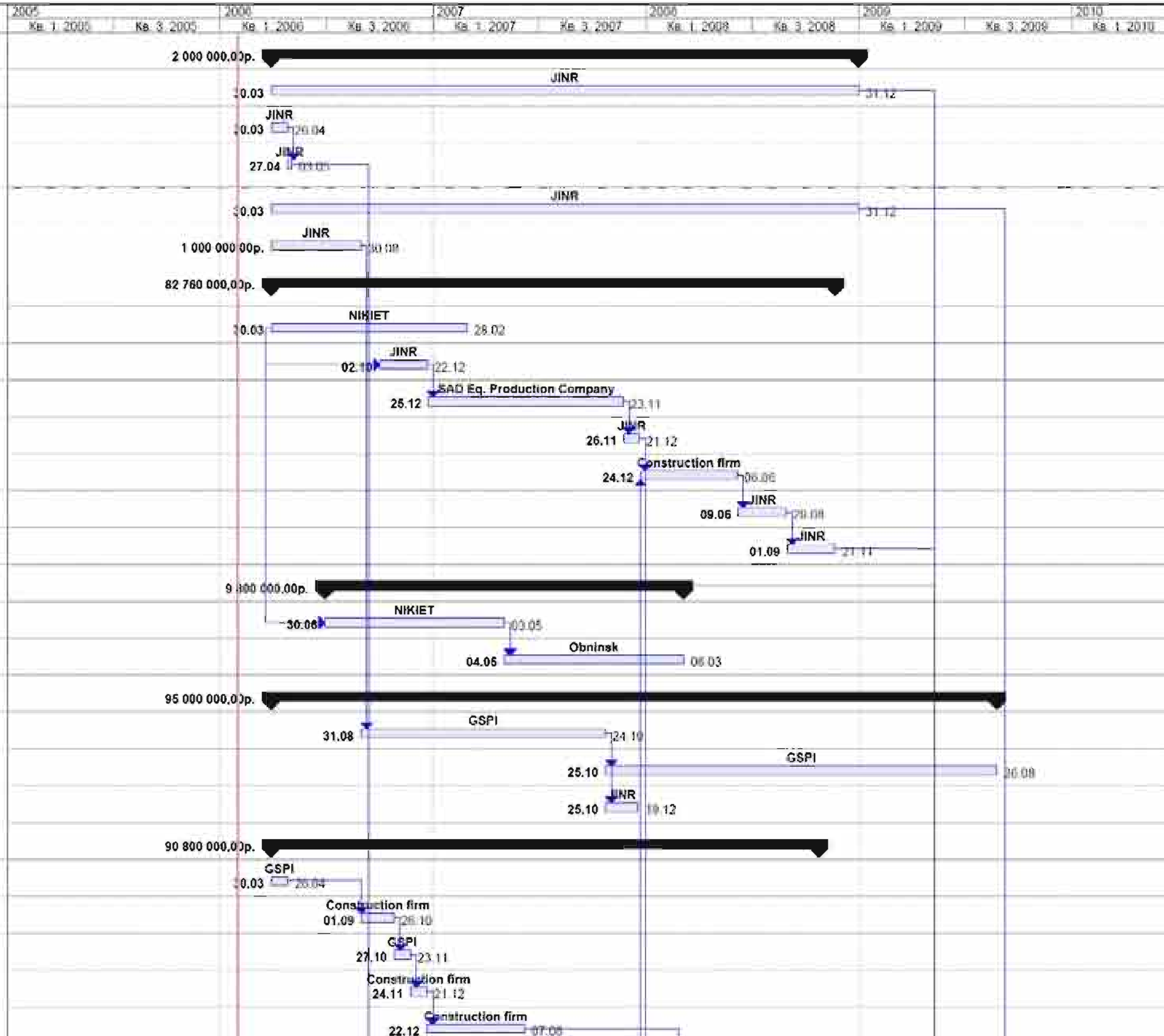
The assumed cost split for the project is given in the following table.

Cost split for the SAD project funding numbers are in M Euro

Year	ECATS	ISTC	JINR	
			Budget	Collaboration
2006	1.7 + 0.6 (in kind contribution)	0.8	0.1	*
2007		1.5	0.1	*
2008		0.4	0.5	*
2009			0.5	*

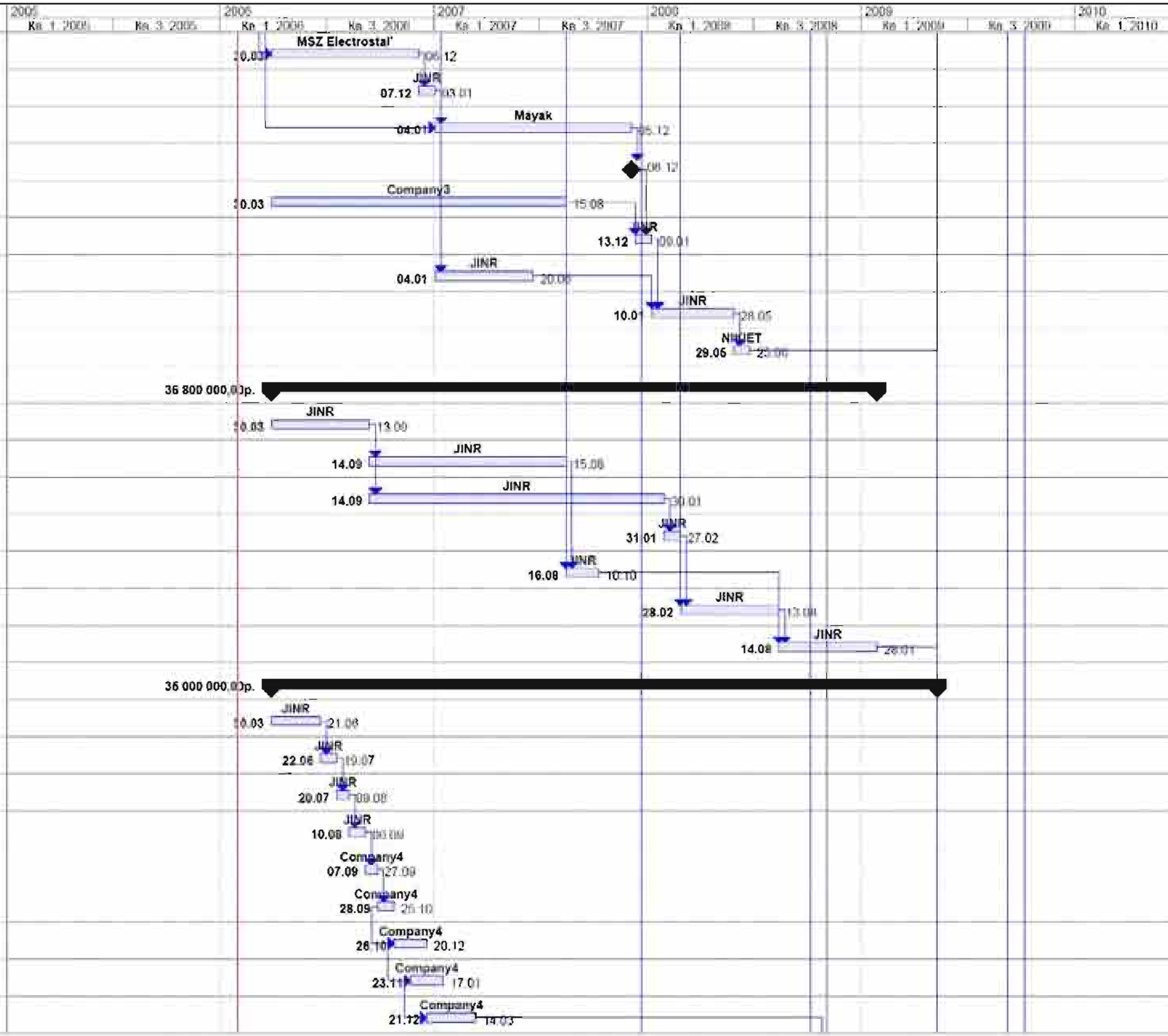
* Numbers to be clarified after creation of the collaboration

Ид.		СДР	Название
1		1	**Documents preparation**
2		1.1	Development and justification of the physical startup program
3		1.2	Instruction on nuclear safety for FF and FA
4		1.3	Conclusion from the nuclear safety department of Rostechnadzor
5		1.4	Development of the operation licence
6		2	**Licenses on facility allocation and creation**
7		3	**Subcritical assembly, optional equipment for shielding and primary coolant circuit**
8		3.1	SA working design
9		3.2	Tender on manufacturing
10		3.3	Manufacturing of the equipment
11		3.4	Procurement
12		3.5	Equipment assembling
13		3.6	Balancing and comissioning
14		3.7	Acceptance evaluation, licensing certification
15		4	**SAD modelling at BFS**
16		4.1	Experiment design
17		4.2	BFS experiments
18		5	**Facility building**
19		5.1	Working design (building drawings)
20		5.2	Working design (equipment assembling)
21		5.3	Tender on building construction
22		**5.4**	**Building consruction**
23		5.4.1	Geophysical investigation of the soil to be excavated
24		5.4.2	Excavation, existing constructions dismantling
25		5.4.3	Geological engineering and geodesic survey
26		5.4.4	Foundation building
27		5.4.5	Building construction

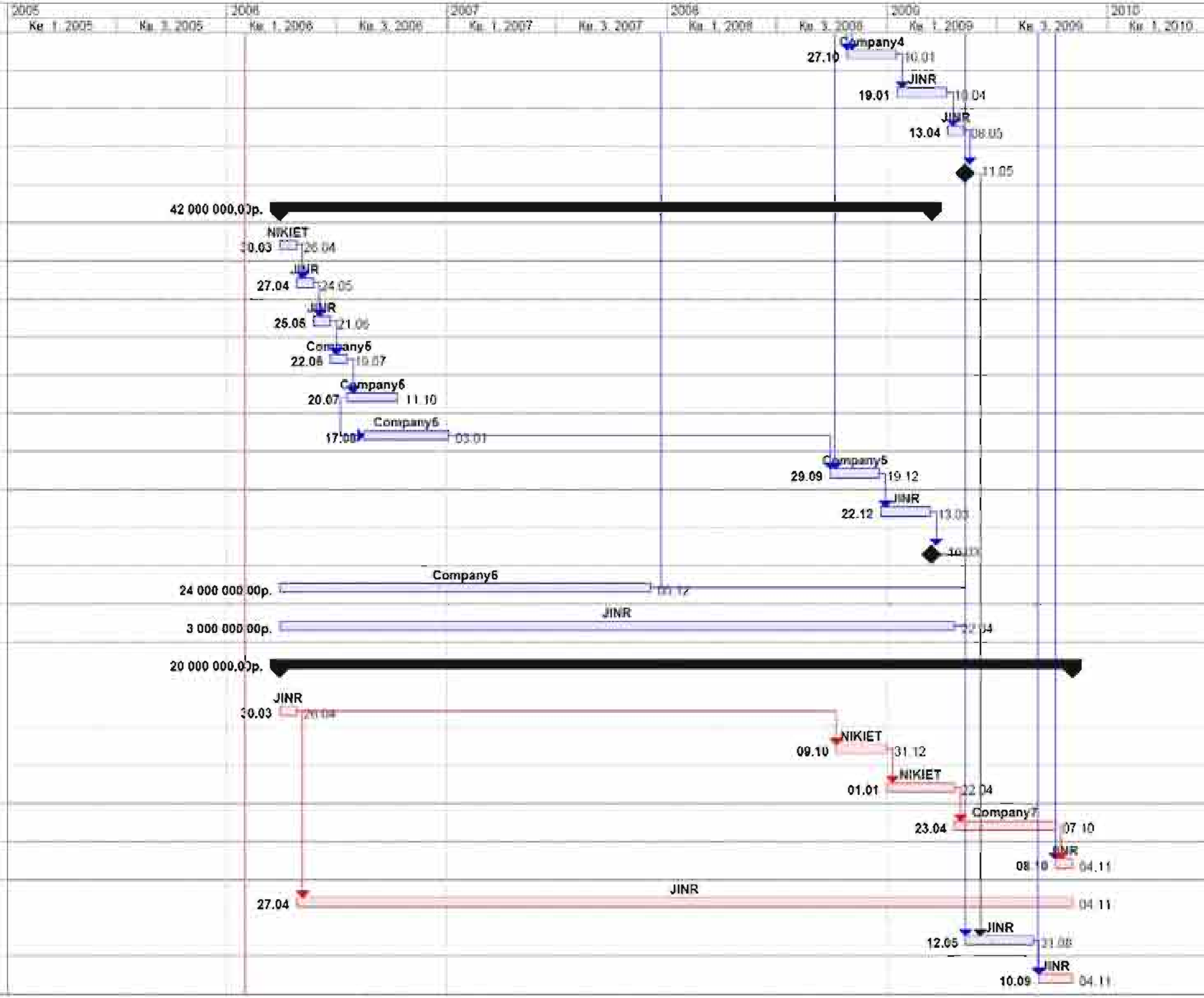


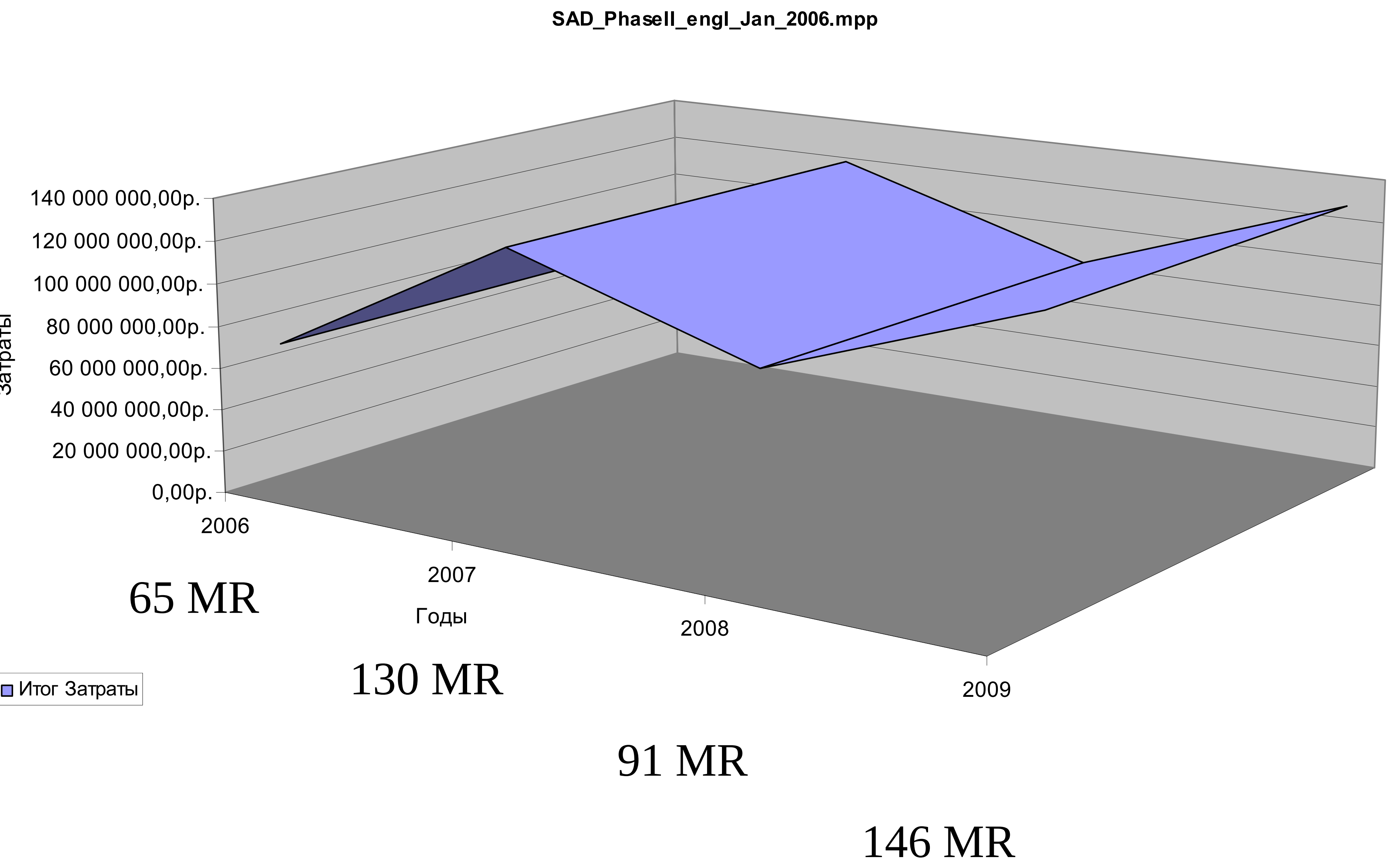
Ид		СДР	Название
28		5.4.6	Working design of the special crane
29		5.4.7	Manufucturing of the special crane
30		5.4.8	Special crane assembling and putting into operation
31		5.4.9	Equipment assembling in concrete bulk
32		5.4.10	Finishing of the construction works
33		5.4.11	Dining restoring
34		5.4.12	Rough finishing
35		5.4.13	Fine finishing
36		5.4.14	Land improvement
37		**6**	**FA production line**
38		**6.1**	**FE storage room equipping**
39		6.1.1	Calculation of the critical masses
40		6.1.2	Recuirement specifications on equipment
41		6.1.3	Technical project
42		6.1.4	Equipment manufacturing
43		6.1.5	Consthuction and assembling work
44		6.1.6	Design work on containers
45		6.1.7	Containers manufacturing
46		**6.2**	**FA production line creation**
47		6.2.1	FE and FA imitators manufacturing
48		6.2.2	Design of the production line
49		6.2.3	Conctruction and assembling work
50		6.2.4	Putting into operation
51		6.2.5	FA technology development
52		**7**	**Fuel**
53		7.1	Pellets fabrication
54		7.2	Component parts manufacturing

Ид		СДР	Название
55		7.3	Cladding tube manufacturing
56		7.4	Cladding tube delivery to Mayak
57		7.5	FE production
58		7.6	FE acceptance and certification
59		7.7	Design and manufacturing of FE transport containers
60		7.8	FE delivery to JINR
61		7.9	FA components manufacturing
62		7.10	FA production
63		7.11	Core assembling
64		8	**Beam line**
65		8.1	Beamline working design
66		8.2	Vertical deflecting magnets manufacturing
67		8.3	Magnetic elements manufacturing
68		8.4	Magnetic elements delivery to JINR
69		8.5	Vertical magnets assembling
70		8.6	Beam line equipment assembling
71		8.7	Beam line balancing and commissioning
72		9	**Physical security**
73		9.1	Vulnerability estimation
74		9.2	Conceptual specification development
75		9.3	Tender participants selection
76		9.4	Tender, conclusion of a contract
77		9.5	Requirements specification
78		9.6	Technical project
79		9.7	Sketch project
80		9.8	Working design
81		9.9	Equipment manufacturing and delivery



Ид		СДР	Название
82		9.10	Equipment assambling
83		9.11	Balancing and commissioning
84		9.12	Equipment training
85		9.13	Commissioning
86		10	**Automatic control system**
87		10.1	Conceptual specification development
88		10.2	Tender participants selection
89		10.3	Tender, conclusion of a contract
90		10.4	Requirements specification
91		10.5	Design work
92		10.6	Equipment manufacturing and delivery
93		10.7	Equipment assambling
94		10.8	Balancing and commissioning
95		10.9	Commissioning
96		11	**FE tightness control**
97		12	**Staff recruitment and training**
98		13	**Development of the scientific experimental program, physical startup**
99		13.1	Requirement specifications on experimental channels (EC)
100		13.2	EC technical project
101		13.3	EC working design
102		13.4	EC equipment manufacturing
103		13.5	EC equipment assembling, balancing and comissioning
104		13.6	Development of the experimental program
105		14	**Physical startup**
106		15	**Comissioning**

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Затраты
2006
2007
2008
2009
Годы
Итог Затраты
65 MR
130 MR
91 MR
146 MR

#2267 Extension for 2006

Task 1 Subcritical assembly (SA), optional protection and first loop equipment

Task description and main milestones	Participating In
1.1 SA working design; 1.2 Tender on manufacturing; 1.3 Final report preparation.	1- NIKIET, Moscow, Ru 2- JINR, Dubna, Russia

Description of deliverables	
1	Technical report

Task 2 Facility building

Task description and main milestones	Participating In
2.1 Working design (building drawings); 2.2 Working design (equipment assembling); 2.3 Tender on building construction; 2.4 Final report preparation.	1- GSPI, Moscow, Russi 2- JINR, Dubna, Russia

Description of deliverables	
1	Technical report

Task 3 FA production line

Task description and main milestones	Participating In
3.1 Technical project; 3.2 Design work on containers; 3.3 FE and FA imitators manufacturing; 3.4 Design of the production line; 3.5 Final report preparation.	1- JINR, Dubna, Russia 2- VNIINM, Moscow, R 3- NIKIET, Moscow, Ru

Description of deliverables	
1	Technical report

Task 4 Fuel

Task description and main milestones	Participating In
4.1 Pellets fabrication; 4.2 Technology on pellets storage development; 4.3 FE components order; 4.4 Final report preparation.	1- JINR, Dubna, Russia 2- VNIINM, Moscow, R 3- IA Mayak, Ozersk, Ru

Description of deliverables	
1	Technical report

Task 5 Beam line

Task description and main milestones	Participating Institutions
5.1 Beamline working design; 5.2 Vertical deflecting magnets manufacturing; 5.3 Magnetic elements manufacturing; 5.4 Final report preparation.	1- JINR, Dubna, Russia 2- GSPI, Moscow, Russia

Description of deliverables	
1	Technical report

Task 6 Physical security

Task description and main milestones	Participating Institutions
6.1 PS conceptual specification development; 6.2 Tender participants selection; 6.3 Final report preparation.	1- JINR, Dubna, Russia 2- GSPI, Moscow, Russia

Description of deliverables	
1	Technical report

Task 7 Automatic control system

Task description and main milestones	Participating Institutions
7.1 ACS conceptual specification development; 7.2 Tender participants selection; 7.3 Final report preparation.	1- JINR, Dubna, Russia 2- GSPI, Moscow, Russia

Description of deliverables	
1	Technical report

Task 8 Development of the scientific experimental program

Task description and main milestones	Participating Institutions
8.1 Requirement specifications on experimental channels (EC); 8.2 EC technical project; 8.3 EC working design; 8.4 SAD modeling at BFS (experimental program); 8.5 Final report preparation.	1- JINR, Dubna, Russia 2- NIKIET, Moscow, Russia

Description of deliverables	
1	Technical report

Task 9 SAD licensing

Task description and main milestones	Participating Institutions
9.1 Delivery of the SAD safety assessment report to foreign collaborators; 9.2 License on SAD facility allocation and construction; 9.3 Final report preparation.	1- JINR, Dubna, Russia

Description of deliverables	
1	SAD safety assessment report

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Appendix 13

Presentation of ISTC Project #3266 by V. Batyaev

ISTC Project #3266 Kick-off

Yu.E. Titarenko, V.F. Batyaev

Institute for Theoretical and Experimental Physics (ITEP), 117218 Moscow, Russia

CONTENT:

- *Formal information*
- *Scope of activities*
- *List of irradiations*
- *Irradiation schedule*
- *New equipment requirements*

ISTC-Contact Expert Group on Nuclear Transmutation related Projects Annual meeting.
January 30 – 31, 2006, **EC, Building CDMA, 21, rue de Champs de Mars, 1050 Brussels**

ISTC#3266: Formal information

Title: *Experimental and theoretical study of the residual nuclide production in 40-2600 MeV proton-irradiated thin targets of ADS structure materials*

Dates: Approved for funding in October 2005. Expected duration *2^{nd} quarter 2006 – 3^{rd}(or 4^{th}) quarter 2008*

Financing party: *EU*

Budget: *$ 430 000*

Collaborators

- SCK-CEN (***Hamid Ait Abderrahim, Edouard Malambu, Thierry Aoust***)
- Royal Institute of Technology (***Waclaw Gudowsky***)
- Universitat Hannover / Zentrum fur Strahlenschutz und Radioekologie (ZSR) (***Rolf Michel***)
- CEA / DSM / DAPNIA/CEN Saclay / Service de Physique Nucleaire (***Sylvie Leray***)
- Forschungszentrum Karlsruhe Technik und Umwelt / Institut fuer Reaktorsicherheit (***Cornelis H.M. Broeders***)
- Los Alamos National Laboratory / Nuclear Physics Group (T-16) (***Eric Pitcher, Stepan Mashnik***)
- Oak Ridge National Laboratory (***Phillip D. Ferguson***)
- JAERI / Nuclear Data Center (***Tokio Fukahori***)
- Georgia Institute of Technology / The Nuclear & Radiological Engineering & Health Physics Program of the George W. Woodruff School of Mechanical Engineering (***Nolan E. Hertel***)
- + *OECF/NEA* (***Enrico Sartori***)

Prolog: the project is an extension of the researches carried out under:

- ISTC Project#17 (1994-1996, USA)*Feasibility study of the basic technologies for weapon plutonium conversion and for long-lived radioactive waste transmutation*
- ISTC #839 (1997-1998; 1999-2000, Japan, EU, Norway) *Experimental and Theoretical Study of the Residual Product Nuclide Yields in Thin Targets Irradiated with 100-2600 MeV Protons*
- *ISTC # 2002 (2002-2004, EU): Experimental and theoretical studies of the yields of residual product nuclei produced in thin Pb and Bi targets irradiated by 40-2600 MeV protons*

Brief info available via http://tech-db.istc.ru/ISTC/sc.nsf/html/projects.htm?open&id=3266

ISTC Project #3266

List of irradiation runs for beta-active nuclide production measurements.

Targets	Proton energies (MeV) 40	70	100	150	250	400	600	800	1200	1600	2600
^{56}Fe +	x	x	x	x	x	x	x	x	x	x	o
^{nat}Cr	x	x	x	x	x	x	x	x	x	x	x
^{nat}Ni	x	x	x	x	x	x	x	x	x	x	x
^{93}Nb	x	x	x	x	x	x	x	x	x	x	o
^{181}Ta	x	x	x	x	x	x	x	x	x	x	x
^{nat}W	x	x	x	x	x	x	x	x	x	x	o

o – the irradiations were made under the ISTC Project#839.

+ Additionally, ^{56}Fe will be irradiated by 300, 500, 750, 1000 and 1500 MeV proton to be compared with recent GSI measurements!

Isotopic composition of the targets

Isotope	Number of samples	Isotopic composition, %
^{56}Fe	15	^{54}Fe-0.3, ^{56}Fe-99.5±0.1, ^{57}Fe-0.2, ^{58}Fe-<0.05.
^{nat}Cr	11	^{50}Cr-4.345 , ^{52}Cr-83.789 , ^{53}Cr-9.501, ^{54}Cr-2.365 .
^{nat}Ni	11	^{58}Ni-68.077, ^{60}Ni-26.223, ^{61}Ni-1.140, ^{62}Ni-3.634, ^{64}Ni-0.926
^{93}Nb	10	^{93}Nb > 99.9
^{181}Ta	15	^{180}Ta-0.012, ^{181}Ta-99,988.
^{nat}W	14	^{180}W-0.12, ^{182}W-26.50, ^{183}W-14.31, ^{184}W-30.64, ^{186}W – 28.43.

The Workplan is to be discussed by CEG 31 January 2006

List of irradiation runs for alpha-active nuclide (^{148}Gd) production measurements.

Targets	Proton energies (MeV) 600	800	1600	2600
^{181}Ta	x	x	x	x
^{nat}W	x	x	x	x

Accelerator time requirements:

68 short (~0.7h) irradiations
8 long (~20h) irradiations
~130h accelerator time

For comparison:
ISTC#2002 took **37h** acc.time
(disregarding time for accelerator preparation and beam adjustment)

ISTC#3266 scope of activities

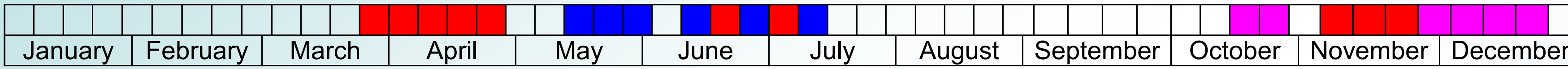
Scope of activities: the similar as in ISTC#2002 + alpha measurements !
(irradiation, alpha-spectra measurements, spectral analysis, ^{148}Gd CRS determination)

1. *Manufacture of samples (1-4 quarters) - 76 samples (68 – for beta, 8 – for alpha measurements)*
2. Adjusting of the additional detector for gamma-measurement (1-2 *quarters*)
3. *Calibration of spectrometers; stability tests (1-10 quarters)*
4. *Irradiation of experimental samples (1-8 quarters)*
5. *Gamma-spectrometry of the samples (1-9 quarters) (68 samples)*
6. *Processing of gamma-spectra (1-9 quarters)*
7. *Identification of gamma-lines and determination of radioactive residual nuclide yields (1-10 quarters)*
8. Pre-starting procedure to operate the alpha detector (1-4 quarters)
9. Alpha-spectrometry of the W and Ta samples (5-8 quarters) (8 samples)
10. Processing of the alpha-spectra, determination of the ^{148}Gd yield (9-10 quarters)
11. *Theoretical simulations by different codes (1-9 quarters): LAHET (we failed to get MCNPX from RSICC), CEM03 (LANL), LAQGSM(LANL), INCL4 (from CEA-Sacley), INCL5 (SCK), CASCADE-2004 (?: Jaipur Univer.), CASCADO, LAHETO.*
12. *Updating the models and codes on the basis of the new experimental data obtained under the Project (3-10 quarters)*
13. *Sending the experimental results to the Worldwide Network of Nuclear Data Centers via Center for Nuclear Structure and Reaction Data (Russia) (8-10 quarters)*
14. *Preparation of technical reports (5, 6, 9, 10 quarters)*

ISTC #3266 Irradiation schedule

ITEP U10 accelerator complex is being intensively modified to provide heavy ion beams. So, unlike previous years, in 2006 just 10 of 22 accelerator weeks are planed for protons.

Planed schedule for ITEP U-10 accelerator runs for 2006 year:



Protons
^{12}C ions
^{27}Al ions

Therefore, the previous schedule mode of irradiations used under ISTC#839&2002 cannot be applied further.

→ **We need <u>additional Ge-detector</u> (Canberra) to double the rate of irradiations (at least 12 targets during 1 accelerator run which last about a month).**

For comparison: during ISTC#2002 average rate of irradiations was 5-7 irradiation per 1 acc.run, irradiations being uniformly time distributed during a run

→ **We need to have manufactured samples (and 2nd detector) by the end of March**

However,

ISTC regulations do not allow spending money before a project signing!

Moreover, we cannot even make an order of the detector!

So,

First quarter of the Project will be partially "lost" to purchase Ge-detector probably leading to some delay of the project results.


Hoping for successful further collaboration !
KONIJN
KREEFTEN
FILETS DE SOLE
À L'OSTENDAISE
TONGFILETS
Thank you

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Appendix 14

Presentation of results of ISTC Project #2578 by Y. Korovin

ISTC PROJECT #2578

"TRANSMUTATION OF RADIOACTIVE NUCLEAR WASTE – PRESENT STATUS AND REQUIREMENT FOR THE PROBLEM-ORIENTED NUCLEAR DATA BASE"

Project Manager Yu. Korovin

Contents

- Introduction
- The project #2578
- Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste
- Nuclear Data Evaluation and Development of Nuclear Models for Heavy Nuclei
- Effect of Nuclear Data Uncertainties on Radiation Damage of Structural Materials
- Project Analysis
- Main Results
- Recommendations for Differential Experiments
- Recommendations for Integral Experiments
- Recommendations on the Evaluated Data Preparation

Introduction

The transmutation of long lived actinides and, to a lesser extent, of fission products is becoming an important aspect of the overall nuclear fuel cycle assessment.

Reactors dedicated to transmutation are now being considered for introduction in the nuclear fuel cycle for burning radwaste: critical (fast reactors) and subcritical (of the ADS type) reactors.

WE NEED:

- **reliable nuclear data are required for calculating the neutronics characteristics of critical (fast reactors) and subcritical (of the ADS type) reactors**
- **improved accuracy in cross-sections for minor actinides**
- **reliable data for estimating radiation damage of ADS**

Introduction (2)

During the last decade there have been launched a number of **ISTC (International Science and Technology Center)** projects in Russia associated with analysis of nuclear data used in analysis of nuclear waste transmutation.

The project #2578 (19 months, 2004 - 2005)

The project goal is to elaborate the essential requirements for the theoretical and experimental studies supported by ISTC in addressing the radwaste transmutation problem

Project Tasks:

1. **Assessment of the present-day demand for nuclear data (on actinide and FP transmutation).**
2. **Analysis and expert evaluation of the projects completed in accordance with Task 1.**
3. **Development of ideas on the transmutation potential of FB, ADS and specialized hybrid fusion reactor blankets.**

The project #2578

Foreign Collaborators

1. International Atomic Energy Agency -
   Alexander Stanculescu
2. CIEMAT (Spain) –
   Enrique M. Gonzalez-Romero
3. Forschungszemntrum Karlsruhe Institut für Kern und Energiete (Germany) -
   Cornelis H.M. Broeders
4. Japan Atomic Energy Research Institute (Japan) -
   Tokio Fukahori
5. Royal Institute of Technology (Sweden) -
   Waclaw Gudowski

The project #2578

Personnel Commitments

Category I (weapon scientific and technical personnel)

Name	Organization
KOROVIN Yuriy Alexandrovich	Obninsk State University for Nuclear Power Engineering (INPE)
BLOKHIN Anatolii Ivanovich	Institute for Physics and Power Engineering (IPPE)
IGNATYUK Anatoliy Vladimirovich	Institute for Physics and Power Engineering (IPPE)
LOPATKIN Alexandr Victorovich	Research and Development Institute for Power Engineering
MATVIENKO Igor Pavlovich	Institute for Physics and Power Engineering (IPPE)
TITARENKO Yuriy Efimovich	Institute for Theoretical and Experimental Physics (ITEP)
FOMUSHKIN Edward Feodorovich	RENC-VNIIEF
SHMELEV Anatolii Nikolaevich	Moscow Engineering Physics Institute (State University)
EISMONT Vilen Pavlovich	Khlopin Radium Institute
YAVSHITS Sergey Georgievich	Khlopin Radium Institute

The project #2578

Personnel Commitments

Category II (other scientific and technical personnel)

Name	Organization
STANKOVSKIY Alexei Yurievich	Obninsk State University for Nuclear Power Engineering (INPE)
PILNOV Gennady Borisovich	Obninsk State University for Nuclear Power Engineering (INPE)
CHUKREEV Felix Evgenievich	RRC Kurchatov Institute
ARTISUK Vladimir Vasilevich	Obninsk State University for Nuclear Power Engineering (INPE)
LUKASEVICH Ivan Borisovich	Research and Development Institute for Power Engineering
BATYAEV Vyacheslav Felixovich	Institute for Theoretical and Experimental Physics (ITEP)

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

- During the last few years, there have been a number of attempts to estimate nuclear data needs as related to problem of RW transmutation and to highlight priorities for the future experimental and evaluation work.

- To evaluate uncertainties in both the available and required data on minor actinides, their influence on the neutronics characteristics of the fast reactor core were investigated.

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

Existing and required (in brackets) uncertainties of actinide cross-sections (the calculations were made at IPPE for the BN-800 reactor)

Nuclide	Capture cross-section, %	Fission cross-section, %	Inelastic scattering cross-section, %
Np-237	15 (5)	7 (3)	30 (10)
Pu-238	25 (10)	10 (5)	40 (30)
Pu-239	6 (4)	3 (5)	20 (15)
Pu-240	10 (5)	5 (5)	20 (15)
Pu-241	15 (5)	5 (3)	20 (20)
Am-241	10 (5)	10 (5)	30 (10)
Am-242m	30 (10)	15 (5)	40 (30)
Am-243	30 (10)	10 (5)	30 (30)
Cm-242	50 (10)	15 (5)	30 (30)
Cm-243	50 (10)	15 (5)	30 (30)
Cm-244	30 (20)	10 (5)	30 (30)

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

- The analogous analysis has been performed recently for the subcritical reactor with Pu/MA nitride fuel (MA/Pu ratio equal to 2), lead-bismuth cooled and driven by an accelerator. This burner is representative of most current proposals, as indicated in different international programs.
- The greatest influence on the total uncertainty is exerted by the cross-sections in the energy range below 20 MeV. High-energy (above 20 MeV) data do not have a significant impact on most neutronics reactor parameters, except for the values related to radiation damage of materials.

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

- The most of the ADS projects deal with lead-bismuth eutectic for the target material and blanket cooling. It necessitates possessing accurate nuclear data at high neutron energies. **The associated data presented in ENDF/B-VI, JENDL-3.2, BROND-2 are not consistent. The difference achieves 40-50%.**
- The contributions of minor actinides and fission products to the total transmutation rate in ADS-based transmuters are different from those in conventional reactors, which shows how important the influence of MA data uncertainties is. And this, in its turn, determines waste repository parameters.

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

Decay heat uncertainty. It shows the component breakdown and their evolution with time.

Contribution to decay heat (%)	t = 0	t[a] = 10 days	t = 1 month	t = 1 year	t = 10 years
Actinides: Fission products:	23% 77%	86% 14%	90%[b] 10%	94%[b] 6%	100%[c] -
Uncertainty in decay heat due to actinides:	±10%	±11%	±11%	±14%	±65%

(a) time after shut-down ;
(b) mostly due to Cm-242 and Cm-244 ;
(c) mostly due to Cm-242, 245 and 246.

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

The uncertainty due to the actinide contribution to full decay heat results in the total uncertainty on this parameter for ADS being 2-3 times higher than the value currently achieved for conventional reactors

Short list of the cross-sections uncertainties

Isotope	Cross-section	Bound. [(a)]	Accuracy achieved (%)	Accuracy required (%)
Pu^{239}	σ_{fiss}	4	6.5	3.4
		5	4	3.1
Np^{237}	σ_{fiss}	3	25	8.0
		4	25	5.1
	ν	4	5	4.1
Am^{243}	σ_{cap}	4	40	10.4
		5	40	5.5
		6	40	5.1
		7	20	5.9
		8	20	6.3
	σ_{fiss}	2	20	7.6
		3	20	6.2
		4	20	5.4

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

Isotope	Cross-section	Bound. [a]	Accuracy achieved (%)	Accuracy required (%)
Cm^{241}	σ_{fiss}	2	40	10.0
		3	40	8.5
		4	40	5.0
Cm^{245}	σ_{fiss}	5	30	9.7
		6	30	9.6
Fe^{56}	σ_{inel}	4	20	4.9

(a)

Group	Upper boundary (MeV)	Group	Upper boundary (MeV)
1	19.6	9	$9.12 \cdot 10^{-3}$
2	6.07	10	$2.04 \cdot 10^{-3}$
3	2.23	11	$4.54 \cdot 10^{-4}$
4	1.35	12	$2.26 \cdot 10^{-5}$
5	0.498	13	$4.00 \cdot 10^{-6}$
6	0.183	14	$5.40 \cdot 10^{-7}$
7	$6.74 \cdot 10^{-2}$	15	$1.00 \cdot 10^{-7}$
8	$2.48 \cdot 10^{-2}$		

Assessment of the Present-day Demand for Nuclear Data on Transmutation Nuclear Waste

To sum up, it should be mentioned that the following areas cause much concern in terms of uncertainties:

- Data on the following microscopic MA cross-sections: σ_f, σ_c, σ_{in}. It is imperative to carry out experiments and to obtain evaluated data in the energy range of 10 MeV to 0.1 – 1 keV.
- Data in the energy range above 20 MeV which have a significant influence on certain reactor parameters, in particular, on the radiation damage evaluation.
- Data on decay heat which basically depend on the data for minor actinides (Cm, in particular).

Energy region below 20 MeV:

The statistical models work well and major problems here are related to correct choice of model parameters (fission barriers and level density parameters).

Energy region from 20 to 200 MeV and above 200 MeV:

significantly rises the contribution of preequilibrium processes both in the form of nucleon-nucleon interactions (intranuclear cascades) and processes of system relaxation into equilibrium state (Griffin exciton models, etc.) Various versions of statistical model with preequilibrium emission are applied.

It is widely accepted to use intranuclear cascade models only above 200 MeV, where various versions of statistical model with preequilibrium emission can be applied.

Such approach leads to inconsistency of models at 200 MeV. European colleagues who use TALYS code below 200 MeV and INCL intranuclear cascade model above 200 MeV will face the same problem.

Nuclear Data Evaluation and Development of Nuclear Models for Heavy Nuclei

Problem:

- Neglecting the cascade part of reaction with nucleons below 200 MeV leads to wrong value of compound nuclei formation cross-section, which is initial for the models preequilibrium emission. At the same time, taking into account the cascade processes in the whole energy region above 20 MeV eliminate the necessity of model joining at 200 MeV and leads to consistent description of reaction mechanism in the whole energy range above 20 MeV. At the same time, it is necessary to keep all the advantages of statistical models obtained at describing the cross-sections of reactions with nucleons below 20 MeV.

Radionuclide Production for p+184W at the Proton Energy 1.6 GeV. Number of residuals is 91

Factor	Bertini/ Dresner	Bertini/ ABLA	ISABEL/ Dresner	ISABEL / ABLA	INCL4/ Dresner	INCL4/ ABLA	CEM2k	CASCADE (original)	CASCADE/ ASF (present result)
H	6.89	5.67	5.45	5.91	5.25	6.08	5.88	4.90	4.51
D	0.48	0.44	0.44	0.44	0.38	0.40	0.45	0.35	0.33
F	1.87	2.63	2.60	2.83	2.73	2.57	3.60	2.85	1.69

$$H=\left(\frac{1}{N}\sum_{i=1}^{N}\left(\frac{\sigma_i^{exp}-\sigma_i^{calc}}{\Delta\sigma_i^{exp}}\right)^2\right)^{1/2},\quad D=\frac{1}{N}\sum_{i=1}^{N}\left|\frac{\sigma_i^{exp}-\sigma_i^{calc}}{\sigma_i^{exp}}\right|,\quad F=10^{\left(\frac{1}{N}\sum_{i=1}^{N}\left[\log(\sigma_i^{exp})-\log(\sigma_i^{calc})\right]^2\right)^{1/2}}$$

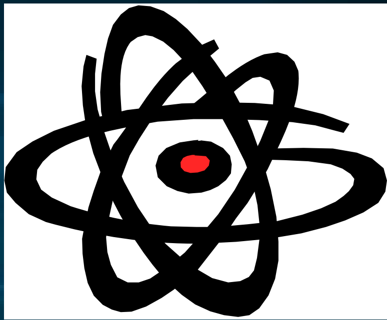
Cascade models

- were primary developed to describe high-energy processes with branched interactions and practically in all the codes the description of the statistical part of the reaction is considered very simplistically.

- Modern cascade models have to describe fast reaction part, preequlibrium model with multiple particle emission from excited nuclei, to describe the process of establishing equlibrium and Huser-Feshbach formalism and statistical part.

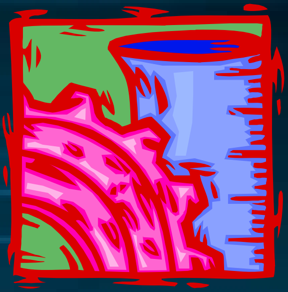
Cascade models

It is necessary:



- to improve the model for calculation of fission barriers with accuracy better than 1 MeV
- develop a model for correct accounting the dependence of barrier from excitation energy
- develop models and perform calculations of fragment yields from excited nuclei both for evaluation of ADS target activation and for estimation of their influence on the ADS performance

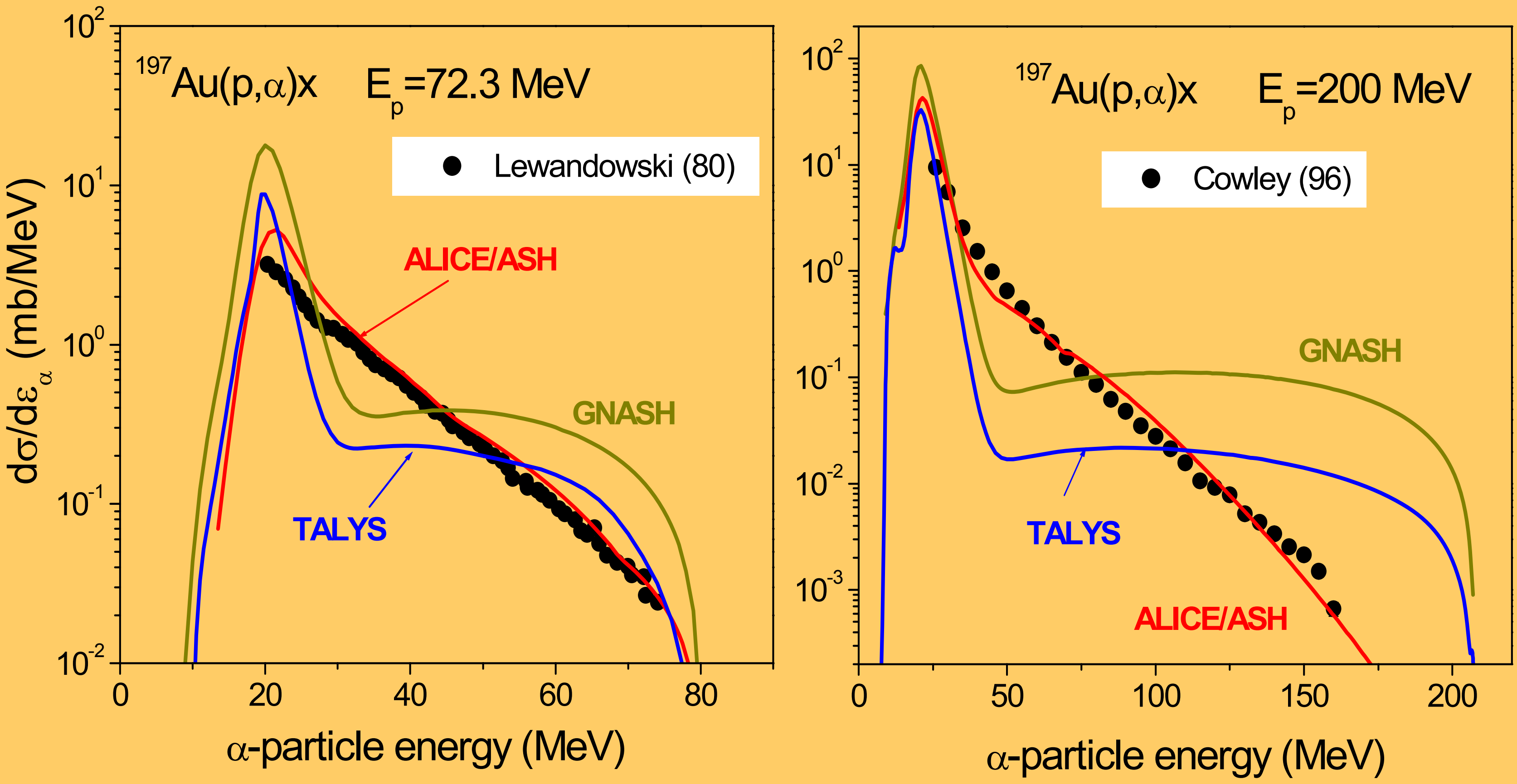
Effect of Nuclear Data Uncertainties on Radiation Damage of Structural Materials



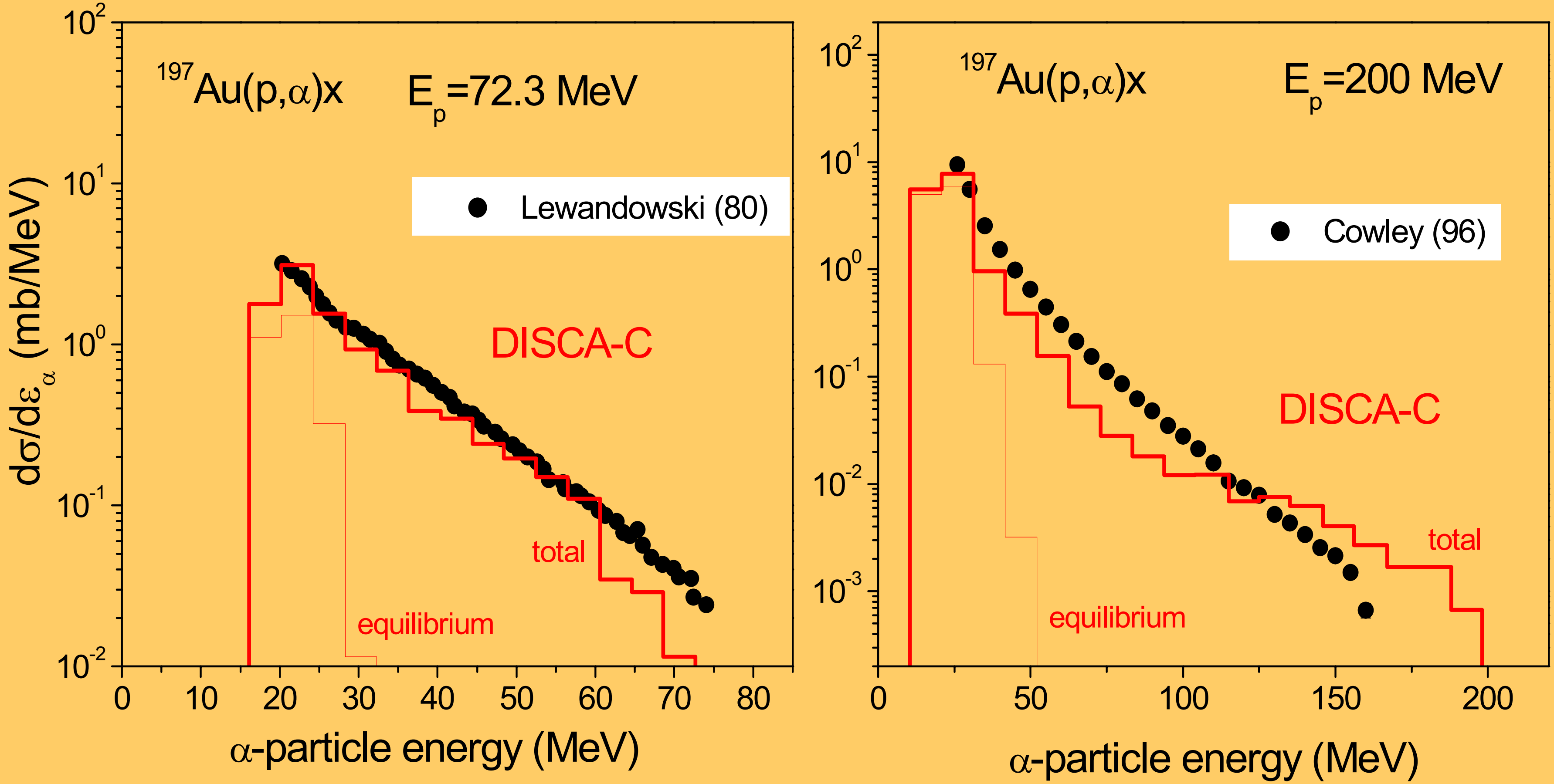
The gas production rates due to proton interactions with matter exceeds the gas generation rate due to neutron by more than one order of magnitude.

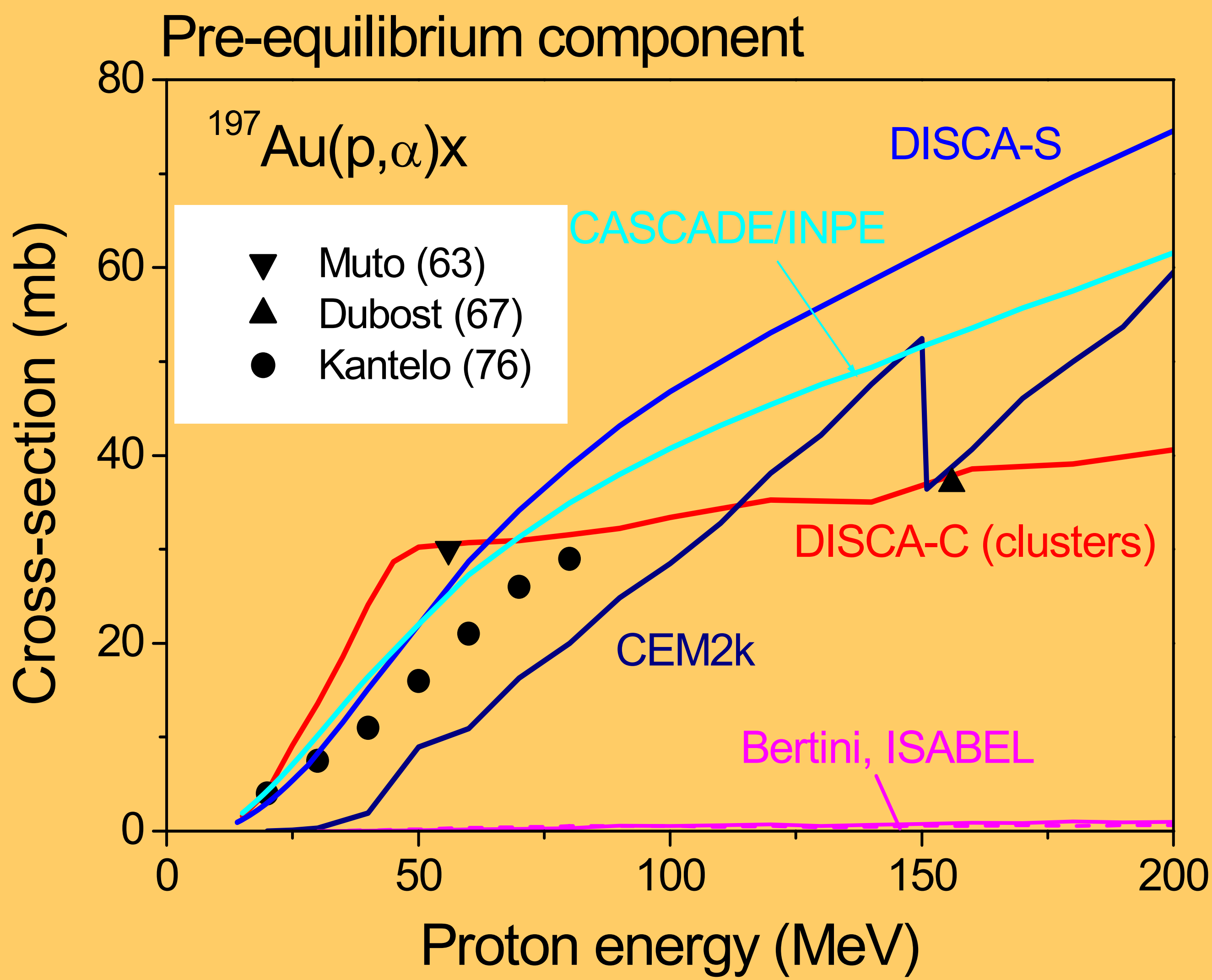
This is significant feature of irradiation conditions compared to standard fission reactor spectrum. The concentrations of helium and hydrogen differ in almost one order between each other, but owing to high mobility of hydrogen because of diffusion at high temperatures its concentration reduces.

GNASH, TALYS and ALICE/ASH

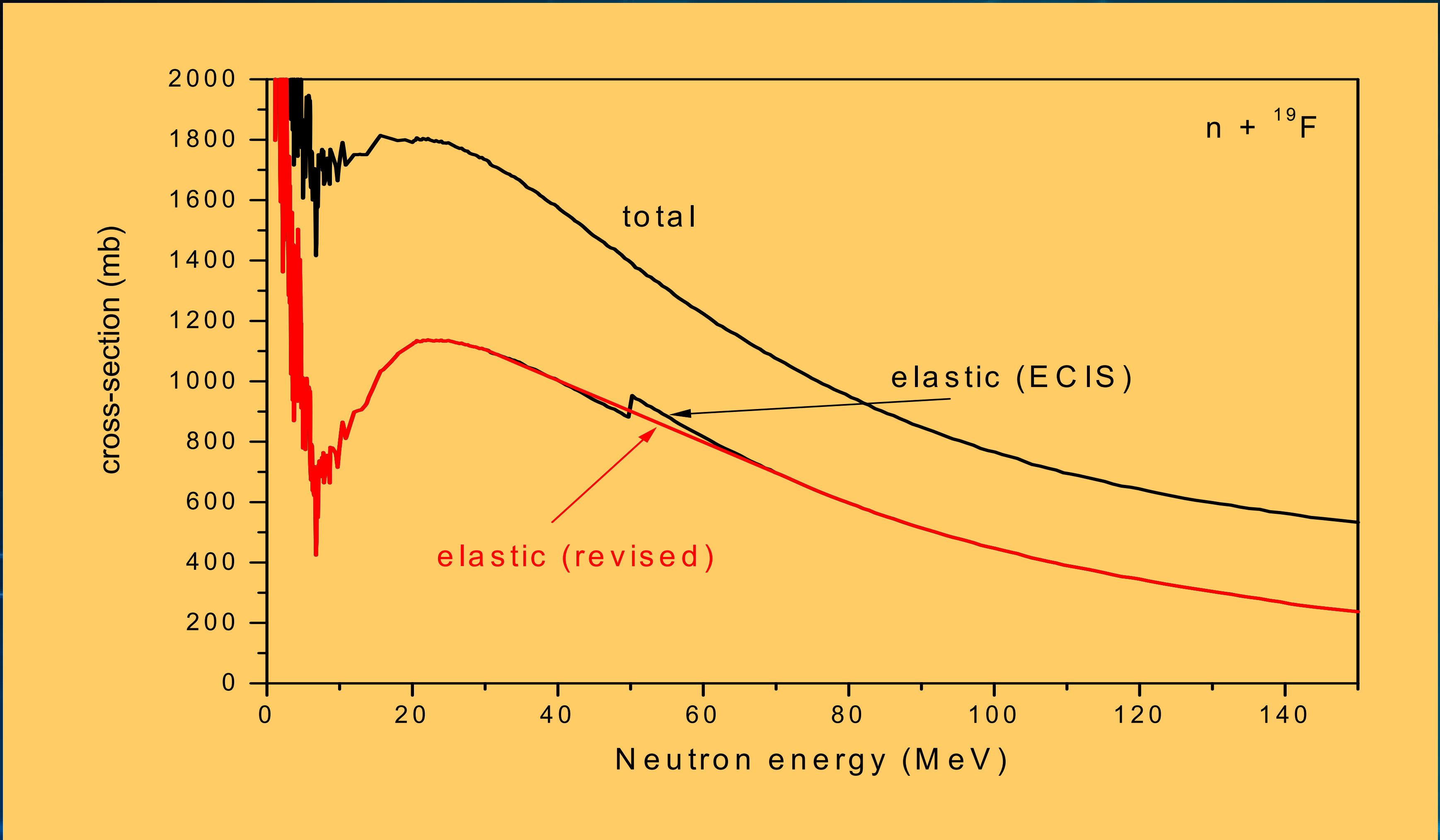


INC (clusters) +EQ model. DISCA-C




Pre-equilibrium component
^{197}Au(p,α)x
Muto (63)
Dubost (67)
Kantelo (76)
DISCA-S
CASCADE/INPE
DISCA-C (clusters)
CEM2k
Bertini, ISABEL
Cross-section (mb)
Proton energy (MeV)
0
20
40
60
80
0
50
100
150
200

Difficulties at Cross-section Evaluation for Light Nuclei



Models for Radiation Damage Calculations

To obtain realistic estimation of lifetimes of the materials in such conditions, the experimental data are necessary

Data on dpa and gas production rate uncertainties

	Max. dpa	Max. Helium production rate	Max. hydrogen production rate	Max (He / dpa)
$\Delta I_{no\_correlation}$	±29.9	±43.6	±28.5	±45.5
ΔI_{PEC} (a)	±48.9	±59.1	±53.1	±67.4

(a) Partial correlation in energy

Models for Radiation Damage Calculations

The radiation damage characteristics might be calculated by using of NJOY code. It uses the NRT formulas for the calculation of the damage energy.

But such calculation is not correct for:

- **the light secondary ions at the energies, where electronic loss is not proportional to $E^{1/2}$**
- **the case of noticeable difference between Z and A for the secondary ion and material**
- **compounds**

The IOTA (Ion TrAnsport in Materials) has been developed

Nuclear Data for Radiation Damage Issues

The code *IOTA* was developed to obtain the total number of primary defects created in materials, the displacement cross-section and the space defect distribution. The simulation of the ion movement in the media is performed **with the help of the different approaches**:

- *binary collision approximation (BCA)*
- *Monte Carlo method.*

The experimental data for ion stopping power are used for the calculation. Besides that, the special edition of the *IOTA* code allows to consider the inelastic nuclear interactions of the primary protons with materials. It uses the inelastic displacement cross-sections calculated with the help of the intranuclear cascade evaporation model for a wide number of materials

Project Analysis

The projects analyzed can be roughly subdivided into 3 groups:

1. **Projects related to the measurement of microscopic nuclear data (cross-sections, spectra, multiplicities, etc.);**
2. **Projects related to studying the interaction of charged particles with different materials;**
3. **Integral experiments carried out by using blanket mockups to investigate the integral neutron physics characteristics of the facilities.**

Project Analysis

16 ISTC projects of status 6 (Project underway) and status 8 (Project completed) related to evaluating and measuring micro-data were analyzed.

Project Analysis

##	TITLE	Status	Dates From / To	Manager	Leading institute / Collaborators
Nuclear data measurements					
183.1, 183.2	**Fission-Neutron Spectra for Minor Actinides**	**8**	1995 / 1999	L.Drapchinsky	KRI /FZK, CEA, JAERI, ENEA, Belgonucleaire
304	**Measurements and Analysis of Basic Nuclear Data for Minor Actinides**	**8**	1995 / 1997	N.Rabotnov	IPPE /JAERI, LANL
471	**Neutron Fission and Capture Data**	**8**	1996 / 1998	V.Furman	JINR /EC
540	**Measurement of cross-sections for nuclear fission by 15<En<160 MeV neutrons for fundamental and applied purposes**	**8**	1997 / 1999	V.Eismont	KRI / Uppsala Univ., FZK

Project Analysis

554	**Fission-Neutron Multiplicity Distributions in the Spontaneous Fission of Cm-244, Cm-248 and in the Neutron Induced Fission of U-233 and Pu-239**	8	1997 / 1999 2001 / 2003	V.Shpakov	KRI / EC
609	**Neutron Induced Fission Cross-sections of Some Actinides and other Heavy Nuclei in Energy Region 1-200 MeV**	8		O.Scherbakov	PNPI / JAERI
731	**Benchmark Data on Gamma-ray Production for Fusion Application**	8	1997 / 2000	A.Ignatyuk	IPPE / JAERI
1309	**Comparison of Proton- and Neutron-Induced Fission Cross Sections of Lead and Neighboring Nuclei in the 20-200 MeV Energy Region**	8	1999 / 2002	V.Eismont	KRI / EC, FZK, Uppsala Univ.

Project Analysis

1828	**Measurements of the Prompt Neutron Spectra of Minor Actinides. Fast Neutron Induced Fission of 241Am and 243Am, Thermal Neutron Induced Fission of 243Cm**	**8**	2001 / 2004	L.Drapchinsky	KRI / FZK, Belgonucleaire , CEA
1971	**Neutron Induced Fission Cross-Sections of Pu-240, Am-243 and W in the Energy Range 1–200 MeV**	**8**	2001 / 2004	A.Laptev	PNPI / LANL
2253	**Investigation of the Delayed Neutron Characteristics from the Fission of Compound Nuclei Th-233, U-234, U-235, Am-244, Np-238, Cm-246, Pa-233, Pa-234, Np-239, Np-240 at the Excitation Energies from 5 to 20 MeV**	**6**	2004 /	W.Furman	JINR / LANL, CEA, ENEA, JAERI

Project Analysis

Nuclear data evaluations					
B-003	**Evaluation of Actinide Nuclear Data**	**8**	1996/ 1998	V.Maslov	IRPCP / JAERI
B-404	**Evaluation of Nuclear Data for Th-U Fuel Cycle**	**8**	2001 / 2003	V.Maslov	IRPCP / JAERI
964	**Development of Model Code and Theoretical Data Library on Fission Cross Sections for Wide Energy Range**	**8**	1999 / 2001	S.Yavshits	KRI / FZK
2524	**Development of Nuclear Data Library for Nucleon-Induced Reactions on Heavy Nuclei in Wide Energy Region**	**6**	2003 /	S.Yavshits	KRI / Kyungpook Univ., Texas A&M Univ., FZK, IAEA

Project Analysis

Proposed projects				
##	TITLE	Status	Manager	Leading institute
217	Capture Cross-Section Measurements of Short-Lived Nuclei with the Pulse Neutron Source	3	L.Drapchinsky	VNIIEF
969	Measurement and Evaluation of the Thorium Fuel Cycle Neutron Data	3	N.Kornilov	IPPE
1049	Level Density Studies Based on Measurements of Evaporation Spectra and Cross-Section Fluctuations in Nuclear Reactions	3	B.Zhuravlev	IPPE
1069	Double-Differential Prompt Neutron Spectra Measurements in 248cm Spontaneous Fission. Calculation and Evaluation of Prompt Neutron Spectra in Fission of Neptunium, Americium and Curium Isotopes	3	O.Batenkov	Khlopin Radium Institute

Project Analysis

1191	Measurement of Reaction Cross Sections Leading to Production and Destruction of Radioactive Material	3	A.Filatenkov	Khlopin Radium Institute
1227	Transuranium Radionuclides: Producing Highly Enriched Isotope Samples, Measuring Emission Probabilities of Radiations and Decay Data Evaluation	3	V.Chechev	Khlopin Radium Institute
1749	Measurements of the Cross Sections of Fast and Resonance Neutrons Induced Fission of Minor Actinides for Their Transmutation with Accelerator-Driven Systems	3	B.Fursov	IPPE
2199	Neutron Cross-Sections in Resonance Energy Range and Nuclear Level Density for Fission-Products, Th, 233-U	3	B.Zhuravlev	IPPE
B-379	Actinide Nucleon-Indused Fission Cross Sections up to 150 MeV	3	V.Maslov	IRPCP

Project Analysis

12 ISTC project of status 6 (Project underway) and status 8 (Project completed) related to studying the interaction of charged particles with different materials were analyzed.

Project Analysis

##	TITLE	Status	Dates From / To	Manager	Leading institute / Collaborators
157	Spallation Experiment with Tungsten Target	8	1995 / 1996	V.Belyakov-Bodin	ITEP / JAERI
187	Development of a Nuclear Data System for the Radiation Problems of High and Intermediate Energy Physics	8	1995 / 1996	E.Gelfand	MRTI RAS / IAEA
477	Nuclear-physical experiment with chloride target	8	1997 / 1998	V.Belyakov-Bodin	ITEP / JAERI
839	Experimental and Theoretical Study of the Yields of Residual Product Nuclei Produced in thin Targets Irradiated by 100-2600 MeV Protons	8	1997 / 1998	Yu.Titarenko	ITEP / CEA, JAERI

Project Analysis

839 (2)	Experimental and Theoretical Study of the Yields of Residual Product Nuclei Produced in thin Targets Irradiated by 100-2600 MeV Protons	8	1999 / 2001	Yu.Titarenko	ITEP / JAERI, CEA, Royal Inst., Universitat Hannover (ZSR), ENEA
1145	Nuclear-Physics Investigations Aimed at the Solution of Weapon Plutonium Conversion and Long-Lived Radioactive Wastes Transmutation Problems	8	1999 / 2002	E.Fomushkin	VNIIEF / JAERI
1309	Measurements and Comparison of Proton- and Neutron-Induced Fission Cross Sections of Lead and Neighboring Nuclei in the 20-200 MeV Energy Region	8	1999 / 2002	V.Eismont	KRI / EC, FZK, Uppsala Univ.
1405	Proton Induced Fission Cross Sections for Heavy Nuclei in the Energy Range 200-1000 MeV	8	1999 / 2001	V.Vovchenko	PNPI / JAERI

Project Analysis

2002	Proton-Pb and Proton-Bi Reaction Yields	8	2002 / 2004	Yu.Titarenko	ITEP / Royal Inst., LANL, CEA, Gutenberg-Universitat, Tokyo Inst.
2213	Fission Cross Sections of Tungsten Isotopes	6	2002 /	V. Eismont	KRI / Uppsala Univ., EC, FZK
2267	Construction of the Subcritical Assembly with Combined Neutron Spectra Driven by Proton Accelerator at Proton's Energy 660 MeV for Experiments on Long Lived Fission Products and Minor Actinides transmutation"	6	2005 /	V.Shvetsov	JINR / CEA, Royal Inst.; FZK, EURATOM-Ciemat
2405	Experimental Nuclear-Physics Data for Transmutation	6	2005 /	E.Fomushkin	VNIIEF / LANL

Project Analysis

Proposed projects

#	##	TITLE	Status	Dates From / To	Manager	Leading institute
	1251	Neutron- and Heat- Physical Experiments with Cylindrical Targets Bombarded with Medium-Energy Protons	3		V.Belyakov-Bodin	ITEP
	1314	Measurement and Analysis of Fission Cross Sections of Heavy Targets Induced by 30-3000 MeV Protons	3		V.Eismont	KRI
	3266	Experimental and Theoretical Study of the Residual Nuclide Production in 40-2600 MeV Proton-Irradiated Thin Targets of ADS Structure Materials	2		Yu.Titarenko	ITEP

Project Analysis

Along with new micro-data, the analysis of the integral experiments provides valuable (and in some cases crucial) information.

11 ISTC projects (Status 6-8) of this kind were analyzed

Project Analysis

- Table

##	TITLE	Status	Dates From / To	Manager	Leading institute / Collaborators
017	Feasibility study of technologies for accelerator based conversion of military plutonium and long-lived radioactive waste	8	1994 / 1996	V.Kazaritsky	ITEP / LANL, CERN
304	Measurements and Analysis of Basic Nuclear Data for Minor Actinides	8	1995 / 1997	N.Rabotnov	IPPE / JAERI, LANL
559	Pilot Flow Lead-bismuth Target of MW Power for Accelerator-Driven Systems	8	1996 / 1998	E.Yefimov	IPPE / FZK, Royal Inst. of Technology, LANL, CEA

Project Analysis

910	Execution of the Complex of Benchmark Experiments for Testing the Nuclear Data of Vanadium - Main Component of Low-Activation Structural Materials for Perspective Nuclear Energetics	8	1997 / 2000	D.Markovskiy	RRC KI / IAEA, FZK
910 (2)	Execution of the Complex of Benchmark Experiments for Testing the Nuclear Data of Vanadium - Main Component of Low-Activation Structural Materials for Perspective Nuclear Energetics	8	2001 / 2002	D.Markovskiy	RRC KI / FZK, JAERI, IAEA
1145	Nuclear-Physics Investigations Aimed at the Solution of Weapon Plutonium Conversion and Long-Lived Radioactive Wastes Transmutation Problems	8	1999 / 2002	E.Fomushkin	VNIIEF / JAERI

Project Analysis

1372	Analysis of Long-Lived Nuclear Waste Transmutation in Fast Reactors and High Energy Accelerators	8	2002 / 2005	E.Smetanin	IPPE / EC
1486	Experimental and Theoretical Justification of the Cascade Scheme of the Subcritical Molten-Salt Reactor for Transmutation of Long-Lived Radioactive Wastes of the Nuclear Fuel Cycle	8	2001 / 2003	L.Ponomarev	MUCATEX/ JAERI, Tokyo Inst., LANL
2267	Construction of the Subcritical Assembly with Combined Neutron Spectra Driven by Proton Accelerator at Proton's Energy 660 MeV for Experiments on Long Lived Fission Products and Minor Actinides transmutation" (Phase I: Design, Design Documentation and Safety Substantiation)	6	2005 /	V.Shvetsov	JINR / CEA, Royal Inst.; FZK, EURATOM -Ciemat

Project Analysis

2582	**Experimental Study of Minor Actinides Transmutation Problem at BFS-73-1 Fast Critical Assembly**	**6**	**2005 /**	**A.Kochetkov**	IPPE / KAERI, Idaho Natl. Eng. and Envir. Lab.
2680	**Study of Minor Actinide Transmutation in Nitrides: Modelling and Measurements of Out-of-pile Properties**	**6**	**2005 /**	**L.Zabud'ko**	IPPE / Kungl Tekniska Hogskolan, CEA

Project Analysis

Proposed projects

735	**Transmutation of Radioactive and Transuranium Isotopes by High-Energy Neutrons of the Thermonuclear Reactor**	**3**	**I.Kuzmitsky**	VNIIEF / SKB (Swedish Nucl. Fuel and Waste Manadgement Co.)
1755	**Experimental Study of Fast and Fast-Thermal Accelerator Driven Systems on the Basis of BFS-1 – Microtron Complex**	**3**	**B.Kochurov**	ITEP
2661	**Analytical and Experimental Substantiation of Neutron-Physical Characteristics of Fast Reactors with Lead Coolant**	**3**	**I.Matveenko**	IPPE

Project Analysis

2884	**Integral Experiments at BFS Critical Facilities for Justification of Minor Actinides Transmutation and Their Analysis**	**3**	**Yu.Khomiakov**	IPPE
2925	**Measurement of Transmutation Properties of Minor Actinides Irradiated in Intermediate Reactor Neutron Spectrum**	**3**	**M.Melnik**	RIAR

Main Results

The main results of the completed ISTC projects can be summarized as follows.

1. The spectra of prompt spontaneous fission neutrons from ^{240}Pu and ^{242}Pu as well as fission neutrons from thermal neutron fission of ^{243}Cm and ^{245}Cm were measured. Also the prompt neutron multiplicity distributions were measured for spontaneous fission of ^{244}Cm and 248Cm and for fission of ^{235}U and ^{239}Pu by thermal neutrons.
2. There were performed for ^{237}Np the measurements of integral neutron inelastic scattering cross-sections, fission neutron spectra and mass-energy distributions of fission fragments for energies of emitted neutrons corresponding to first plateau of fission cross-section.
3. In the energy range from 1 to 7 MeV the detailed measurements of fision cross-sections for ^{238}Pu, ^{242m}Am, 243, $_{244,\ 245,\ 247Cm}$ were done.

Main Results (2)

4. The fission cross-sections for neutron induced fission of $^{204, 206, 207, 208}Pb$, ^{209}Bi ^{232}Th, ^{233}U, ^{237}Np, ^{239}Pu, ^{243}Am at the energies from reaction threshold up to 200 MeV were measured.
5. The energy dependence change of delayed neutron yields for ^{237}Np in the energy range corresponding to first plateau was measured. The analogous experiments are carried out at present for ^{233}U, ^{232}Th, ^{239}Pu, and ^{241}Am, for ^{239}Pu the incident neutron energy range will be expanded up to 18.0 MeV.
6. The systematic measurements and analysis for the basic structural materials of spectra and integral gamma-ray production yields from the interactions with 14-MeV neutrons were performed.
7. The evaluations were done and the general-purpose files were created for isotopes ^{232}Th, $^{231, 233}Pa$, $^{232, 233, 234, 238}U$, ^{239}Np, $^{238, 242}Pu$, $^{241, 242g\&m}$, ^{243}Am, $^{243, 245, 246}Cm$ in the incident neutron energy range up to 20 MeV and for isotopes ^{237}Np, ^{240}Pu, ^{241}Am at the neutron energies up to 150 MeV.

Main Results (3)

A large amount of experiments with charged particles was performed:

8. A comparison and verification of the methods for determining reaction product yields resulting from proton-nuclei interaction were made. An experiment was designed and performed whose aim was to irradiate targets made of ^{63}Cu, ^{65}Cu by 1.2 GeV protons with subsequent processing of results independently in ITEP and JAERI. To determine the yields of radioactive product nuclei formed in target and structural materials, various thin targets were irradiated 47 times ($^{182,183,184,186}W$ at the proton energy of 0.2, 0.8 and 1.6 GeV; ^{nat}W, ^{56}Fe, ^{58}Ni, and ^{93}Nb at 2.6 GeV; ^{232}Th, ^{nat}U, ^{99}Tc at 0.1, 0.2, 0.8, 1.2 and 1.6 GeV; ^{59}Co and $^{63,65}Cu$ at 0.2, 1.2, 1.6 and 2.6 GeV; ^{nat}Hg at 0.1, 0.2, 0.8 and 2.6 GeV and, in addition, ^{208}Pb at 1.0 GeV) and 4050 values of cumulative and independent yields of residual radioactive product nuclei with half-lives from 8 minutes to 32 years. The experimental values of nuclear reaction product yields were compared with the values calculated by LAHET, CEM95, CEM2k, CASCADE, CASCADE/INPE, YIELDX and INUCL which model hadron-nuclei interactions.

Main Results (4)

9. The independent and cumulative yields of radioactive residual product nuclei in thin targets made only of the isotopes of Pb ($^{206,207,208,nat}Pb$) and bismuth (^{209}Bi) were determined experimentally and modeled theoretically. Thin targets made of $^{206,207,208,nat}Pb$ and ^{209}Bi were irradiated 55 times (at the proton energy of 04, 0.07, 0.10, 0.15, 0.25, 0.4, 0.6, 0.8, 1.2, 1.4, 1.6, 2.6 GeV) and more than 5900 cumulative and independent yields of residual radioactive product nuclei with half-lives from 8 minutes to 32 years were determined. Besides, apart from standard modeling of experimental results by using various codes, some work was done on LAHET and CASCADE modification and new versions LAHETO and CASCADO were developed, respectively.

Main Results (5)

10. Measurements were made of the secondary neutron spectra from "thin" W – Na targets irradiated by 0.8 and 1.6 GeV protons. Prompt neutron spectra were measured of the fission induced by bombarding isotopes of thorium, uranium and neptunium by 50 and 100 MeV protons. The double differential cross-sections of neutron generation, with due account for errors, are given for 22 groups in the energy interval from 3.10 to 330 MeV. Fission cross—sections were measured for $^{204, 206, 207, 208}$Pb and for ^{209}Bi and ^{205}Tl. The fission cross-sections were determined for natPb and ^{209}Bi (mono-isotope). Absolute neutron- and proton-induced fission cross-sections for natPb and 209Bi have uncertainties about 10%. The data on neutron-induced fission cross-sections for the above nuclides are consistent with those found in other literature, the maximum discrepancy (for 209Bi at 97MeV neutron energy) is about 20 %. The data on proton-induced fission cross-sections are also consistent with the data available in literature.

Main Results (6)

Among the results achieved in the frameworks of ISTC projects related to integral experiments the following might be highlighted:

11. The effective fission cross-sections and reactivity coefficients for Np-237 and Am-241 at the fast critical assemblies BFS-67, -69 (IPPE) spectra were measured.
12. The effective fission cross-sections for 235U, 237Np, 238Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{244}Pu, ^{241}Am, ^{242m}Am, ^{243}Am, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm were measured on the spectra of BIGR reactor, molten salt blankets MSB-1, -2 (VNIIEF) and thermal reactor MAKET (ITEP).
13. The isotopic composition change of U-235, Np-237, Pu-238, -240, Am-241 and Cm-244 samples irradiated in the commercial fast reactor BN-350 with integral fluence ~ 2.2 1023 n/cm^2 was obtained.

Main Results (7)

14. Interesting data were obtained while examining the power density distribution and threshold reaction rates in thick W- and NaCl+$PbCl_2$ targets irradiated by 0.8, 1.0 and 1.2 GeV protons. The investigated parameters are of great importance to the analysis and implementation of ADS projects. The measurement results of the threshold reaction rates for ^{209}Bi, ^{197}Au, ^{181}Ta, ^{169}Tm, ^{115}In, ^{nat}In, ^{93}Nb, ^{65}Cu, ^{63}Cu, ^{64}Zn, ^{59}Co, ^{27}Al, ^{19}F, ^{12}C and absorbed doses inside and on the external surface of “thick” W-Na target irradiated by 0.8 GeV protons are presented. The calculation modeling of the measured reaction rates was made by means of the LAHET code used to calculate a stream of particles as well as excitation functions of the nuclides formed available in the MENDL, MENDL2p and IEAF libraries (in the range of ~100 MeV) and in the LAHET calculations at the energies above 100 MeV. The experimental and calculation results were compared and the most essential discrepancies were analyzed, a further study will be made into the neutron field characteristics on the external surface of the “thick” Pb target irradiated by 0.8 GeV protons.

Main Results (8)

15. The completed ISTC Project #1486 devoted to investigation of feasibility to create MA burner on the basis of molten-salt cascade subcritical reactor revealed the necessity to improve the MA microscopic data, especially for ^{237}Np, ^{242m}Am.

16. The started ISTC Project #2267 (SAD) might identify new requirements for future experiments and data evaluations in the course of Project implementation

Recommendations for Differential Experiments

From the analysis of completed ISTC projects and present-day requirements to accuracy of nuclear data related to MA transmutation in ADS, it might be concluded that the first priority list of reactions to be studied includes:

- Neutron inelastic scattering on ^{243}Am;
- Neutron induced fission of ^{244}Cm above ~200 keV;
- Neutron capture on ^{238}Pu, ^{237,238}Np;
- (n,2n) reaction on ^{235}U, ^{238}U, ^{239}Pu;
- (n,xn) reactions on Pb and Bi isotopes in the wide energy range (up to proton beam energies if lead, bismuth or lead-bismuth is assumed to be a spallation target material and coolant).

Recommendations for Differential Experiments (2)

The ultimate goal of obtaining reliable evaluated data files covering all the needs of ADS-related pending and forthcoming projects would require performing the following experiments:

1. Measurement of the total neutron yield, total neutron spectra and fission neutron spectra for isotopes of Th, Pa, U, Np, Pu, Am, as well as for spallation target materials Ta, W, Pb, Bi, irradiated by neutrons and protons of energies from 20 MeV up to 1 GeV.
2. Measurement of the total gamma yield and emission spectra for isotopes of Th, Pa, U, Np, Pu, Am in the energy region 20 MeV – 1 GeV.
3. Measurement of fission product yields for transuranics at the energies 20 - 200 MeV.

Recommendations for Differential Experiments (3)

4. Obtaining the excitation functions for reactions (n,xn), (n,pxn), (n,2pxn) etc for isotopes of Th, Pa, U, Np, Pu, Am at the primary neutron energies 20 – 200 MeV as well as for analogous reactions initiated by protons.
5. Measurements of the resistivity damage rates necessary for evaluation of damage energy cross-sections for iron, chromium, nickel and other components of steels at the energies 20 MeV – 1 GeV.

Recommendations for Differential Experiments (4)

6. Measurements and analysis of the total yields, time and energy dependencies of characteristics of delayed neutrons from fission of Np-237, Am-241, Am-242m by fast neutrons.
7. Carrying out the sensitive measurements of neutron capture and fission cross-sections for minor actinides at resonance and fast neutron energies to define the accuracy of nuclear data.
8. Measurements of excitation functions to obtain secondary reaction alpha- and beta-active product yields from spallation target unit structural materials irradiated by protons and neutrons with energies up to ~ 1 GeV.

Recommendations for Integral Experiments

Integral experiments as applied to physics of innovative nuclear reactors and ADS is reasonable if the following conditions necessarily satisfied:

- The principal choice of the transmutor type is made, i.e. materials and zone dimensions are specified.
- Material composition and geometry dimensions of characteristic physical zones of an experimental prototype and designed installation should be comparable, i.e. space and energy distribution of neutron fields should be close.

Recommendations for Integral Experiments (2)

- The verification of nuclear data should be performed on the basis of experimental results and their evaluated version has to be included in the open nuclear data library; or the experimental results with estimated uncertainty and the detailed description of the experimental installation (geometries, material compositions, temperatures) are described (or will be described at the final stage of experiments), which will be used by the developer of the transmutor to verify the calculation methods.

Recommendations for Integral Experiments (3)

Unfortunately, these conditions were not satisfied in the experimental works performed in the framework of ISTC projects.

It is necessary to perform additional works (if it is possible after several years passed from the experiment completion) on analysis and representation of experimental results. It would be useful to create data bank of evaluated or described in details completed experiments open for general use, at the condition of mutual consent of customers and performers.

Recommendations for Integral Experiments (4)

- To assure that the future experimental works will not follow the experiments performed, the serious co-ordination of working plans of Projects in the framework of unified scientific and technical policy is necessary, if the latter is a standard practice of ISTC. But before that, it is necessary to formulate such policy, that is to take a decision on the transmuter type) - to formulate the ultimate definite goal. In Russia, the great experience of successful carrying out the huge experimental programs with clear ultimate goal is accumulated.

Recommendations for Integral Experiments (5)

- If the installation with fast neutron spectrum and heavy metal coolant will be accepted for the purpose of MA transmutation, it is obvious (based on results described in Chapter 3.2 of the Project Final Report) that integral experiments should be accentuated on verification of nuclear data for ^{237}Np, $^{238,242}Pu$, Am, Cm, new structural materials, lead and bismuth.

Recommendations for Integral Experiments (6)

These tasks are partially solved in the already formulated Projects:

- creation of special benchmarks to test neutron data for Pb and Bi in the spectrum close to ADS one (ISTC Projects 2661 and 3239);
- creation of benchmarks to test and refine neutron data for MA in the various fast spectra characteristic to ADS with different kinds of coolant and fuel (ISTC Project 2884).

Recommendations for Integral Experiments (7)

- It is expedient also to realize the integral experiment on the designing of ADS model most close to the commercial installation design, and to study its neutronics characteristics. Experiments should be evaluated, should have detailed description and accordingly on their basis the international data comparison should be done.
- Besides the stated above, the experiments on the MA and Pu samples irradiation in the spectrum close to ADS one might be useful, as well as the analysis of isotopic composition change.

Recommendations on the Evaluated Data Preparation

The following works on the preparation of new nuclear data files, which are absent at present, or contain the insufficient information on nuclear data, necessary for calculation of transmutation installation:

Recommendations on the Evaluated Data Preparation (2)

1. Forming the files of recommended neutron and proton data for the total actinide chain from Th to Cm at the energies up to 150-200 MeV with inclusion the information on the secondary gamma-quanta production and complete information on data uncertainties and corresponding correlation matrixes. It is necessary to perform the following tasks:

Recommendations on the Evaluated Data Preparation (3)

- The estimation of neutron and proton integral and differential cross-sections on the basis of analysis of available experimental data and developed in the framework of ISTC projects new theoretical methods of cross-section description at the intermediate (up to 200 MeV) energies;
- On the basis of energy release balance analysis in the fissionable nuclei and with the use of theoretical models to prepare the consistent sets of the evaluated nuclear data of secondary gamma production for the total number of actinides, relied on available experiments on energy release for the basic fuel elements.
- Creation of consistent correlation uncertainty matrixes of recommended cross-section data for the basic fuel elements;

Recommendations on the Evaluated Data Preparation (4)

2. Forming the files of recommended data on fission products yields for actinides from Th to Cm at the neutron and proton energies up to 150 – 200 MeV.
3. Specification of radioactive nuclei characteristics in the fission products region on the basis of experimental works performed in Russia during last 15 years, and preparation of corrected files containing the data on radioactive decay modes for essential nuclides.

CONCLUSION

The analysis of the ISTC Projects associated with accelerator-driven waste transmutation reveals the following important issues to be outlined

•The main bulk of the ISTC supported activity deals with improvement of nuclear data for transuranics isotopes (differential experiments: cross-sections in a broad energy interval, neutron yields, etc) and their effect on the integral characteristics of the facilities (integral experiments).

CONCLUSION (2)

- The nuclear data obtained are significant only at the early stages of transmutation i.e. for the short irradiation time.
- In the foreseen Accelerator-Driven Systems concepts, the equilibrium transmutation cycle is characterized by dominant role of Pu-238 (about 25% in the isotopic mixture of all the heavy isotopes in the blanket). Uncertainty in its capture cross-section is 20% while the required accuracy is 10%.

CONCLUSION (3)

- The similar characteristics for Am-241 are 10 and 5%, correspondingly.
- It seems to be important to improve nuclear data particularly for Pu-238 and adjacent isotopes Np-237 and Np-238.
- Experimental data on the yield of residual nuclides accumulated in spallation target (spallation products) were obtained mainly for the short-lived nuclides characteristic to the small proton fluence.

CONCLUSION (4)

- Accumulation of long-lived rare earth nuclides was out of consideration. Nevertheless some of these nuclides (**like for example ^{146}Sm ($T_{1/2}$=1×10^{8} yrs), ^{148}Gd ($T_{1/2}$=74.6 yrs), ^{150}Gd ($T_{1/2}$=1.8×10^{6} yrs) , ^{154}Dy ($T_{1/2}$=3×10^{6} yrs)**) appear to be of high toxicity due to their alpha decay mode.
- In addition to that some of them are known to be neutron poisons with anomalously large neutron capture cross-sections. It seems to be of importance to identify the domains of proton energies and neutron spectra in which their accumulation could significantly affect the safety of accelerator-driven transmuters.

CONCLUSION (5)

- There has been observed a large discrepancy in cross-sections between neutron induced ((n,xn), (n,pxn), (n,2pxn), etc) and similar proton-induced reactions for transuranics , estimated by various models in the energy interval 20 – 150 MeV. It seems to be instructive to conduct the relevant experimental studies for isotopes of Th, U, Np, Pu, Am to validate theoretical models and computer codes. For the first priority one could reasonably put the reactions producing long-lived toxic nuclides like $^{238}U(n,7n)^{232}U$, for example.

CONCLUSION (6)

- The endurance of structural materials under irradiation might happen to be of crucial importance in justification of the transmutation strategy. Currently, the accumulated damage dose (in terms of displacements-per-atom), characteristics of gas accumulation is predicted with the accuracy of 15%. This accuracy was well assumed for the conventional reactors at the early stages of their development. At the energies of about 1 GeV uncertainties in these characteristics approach to 25 – 50%. Needless to say, this gives a rather shaky estimation of the lifetime of structural components in the spallation target region. In this connection, it seems to be instructive to improve the data base for prediction of damage dose and gas accumulation.

Obninsk State Technology University for Nuclear Power Engineering has a number of codes and libraries for calculations and evaluations of nuclear data for transport, heating, shielding and medical applications.

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Appendix 15

Comments on final report of ISTC Project #2578 by E. Gonzales

ISTC PROJECT 2578
Comments from E. Gonzalez (CIEMAT)

Transmutation of radioactive nuclear waste – present status and requirement for the problem-oriented nuclear data base. Approach to scheduling the experiments (reactor, target, blanket).

(April 1, 2004 - May 31, 2005 , Project duration: 14 months)

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Foreign collaborators: IAEA, CIEMAT, KTH, FZK, JAERI

- Introduction
- Analysis of projects performed or proposed
- Assessment of the present-day demand for nuclear data on transmutation nuclear waste
- Recommendations

Projects related to neutron microscopic data :

- Nuclear data measurements,
- Nuclear data evaluations

Projects with status 8 or 6:

183.1, 183.2, 304, 471, 540, 554, 609, 731, 1309, 1828, 1971, 2213, 2253, B-003, B-404, 964, 2524

Projects with status 3:

217, 969, 1049, 1069, 1191, 1227, 1749, 2199, B-379

	Measurements, energy region			Deliverables	
Nuclide	Thermal	Intermediate	Fast + above 20 MeV	EXFOR	Evaluated files
^{232}Th		σ_f, σ_c – 471	σ_f – 540, 609 TNY, DNY – 2253	471, 540	B-404, 964 (20-200 MeV)
^{231}Pa					B-404
^{233}Pa			DNY – 471		B-404
^{232}U					
^{233}U		DNY – 471, γ – 471	σ_f – 540, 609, TNY, DNY – 2253	540	B-404, 964 (20-200 MeV)
^{234}U		σ_f – 471 σ_c–471	TNY, DNY - 2253	471,	B-404, 964 (20-200 MeV)
^{235}U	ν - 554		σ_f – 609	554	964 (20-200 MeV)
^{236}U			σ_f – 471 ν - 471	471,	964 (20-200 MeV)
^{238}U			σ_f – 540, 609, DNY - 2253	540	B-404, 964 (20-200 MeV)
^{237}Np	DNY – 2253	σ_f – 471 σ_c–471 DNY – 471 γ – 471	σ_f – 304, 540, 609 DNS – 2253	471, 540	304, 964 (20-200 MeV)
^{238}Np					B-003
^{239}Np			DNY – 471		
^{238}Pu					B-003
^{239}Pu	ν - 554	DNY – 471, γ - 471 ν - 554	σ_f – 540, 609	540, 554	964 (20-200 MeV)
^{240}Pu			SFNS – 183 σ_f – 1971	183	
^{241}Pu					
^{242}Pu			SFNS – 183 σ_f – 471, ν - 471	183 471	B-003
^{241}Am			σ_f – 304, 471 ν – 471 PNS - 1828	471	304, B-003
^{242}Am					B-003
^{242m}Am	NS - 183		σ_f – 304,	183,	304, B-003
^{243}Am			σ_f – 304, 471, 540, 1971 ν - 471 PNS – 1828, TNY, DNY - 2253	471	304, B-003
^{243}Cm	PNS - 1828		σ_f – 304,		304, B-003
^{244}Cm			SFNS – 183, ν - 554	183, 554	
^{245}Cm	NS – 183, DNY - 2253		σ_f – 471 ν – 471	183, 471	B-003
^{246}Cm			SFNS – 183	183,	B-003
^{248}Cm			ν - 554	554	
^{252}Cf	PNS - 1828		ν - 554, PNS - 1828	554	

No data available

Absent deliverables

Notes:

Information available only to some ISTC members or not fully available (at least for the report) for:

471: EXFOR – data are partially available but no Final report
540: EXFOR – data are partially available but no Final report
554: EXFOR – data are partially available but no Final report or publications available
609: No outcome available
1309: EXFOR – data are partially available but no Final report
1828: No EXFOR or Final Report only 1 publication
1971: No outcome available
2213: No outcome available (project is underway)
2253: No outcome available (project is underway)

It would be good to identify actions and schedules to improve the present status

Projects related to interaction of charged particles with materials

	Projects, parameters to measure
Thin targets (measurement and evaluation of cross-sections)	187 – p: tot,el,inel,($d^2/dEd\Omega$, p,xn) etc.; 839 – (p,x); 839.2 – (p,x); 1145 – ($d^2/dEd\Omega$, p,xn); 1309 – (p,f); 1314 – (p,f); 1405 – (p,f) 2002 – (p,x) in Pb, Bi; 2213 – (p,f) in W 3266 – (p,x) Fe,
Complex experiments (reaction rates, integral and spectral parameters)	157 – energy release, reaction rates in W target; 477 – energy release, reaction rates in PbCl target; 2405 – reaction rates in Pb target.
Development of pilot installation	2267 – (p,x) in target and structural materials in their comparison with results of the Projects No. 839, 2002 and 3266.

Projects related to integral experiments

Project number	Title	Status	Dates From / To
017	Feasibility study of technologies for accelerator based conversion of military plutonium and long-lived radioactive waste	**8**	1994 / 1996
304	Measurements and Analysis of Basic Nuclear Data for Minor Actinides	**8**	1995 / 1997
559	Pilot Flow Lead-bismuth Target of MW Power for Accelerator-Driven Systems	**8**	1996 / 1998
910	Execution of the Complex of Benchmark Experiments for Testing the Nuclear Data of Vanadium - Main Component of Low-Activation Structural Materials for Perspective Nuclear Energetics	**8**	1997 / 2000
910 (2)	Execution of the Complex of Benchmark Experiments for Testing the Nuclear Data of Vanadium - Main Component of Low-Activation Structural Materials for Perspective Nuclear Energetics	**8**	2001 / 2002
1145	Nuclear-Physics Investigations Aimed at the Solution of Weapon Plutonium Conversion and Long-Lived Radioactive Wastes Transmutation Problems	**8**	1999 / 2002
1372	Analysis of Long-Lived Nuclear Waste Transmutation in Fast Reactors and High Energy Accelerators	**7**	2002 / 2005
1486	Experimental and Theoretical Justification of the Cascade Scheme of the Subcritical Molten-Salt Reactor for Transmutation of Long-Lived Radioactive Wastes of the Nuclear Fuel Cycle	**8**	2001 / 2003
2267	Construction of the Subcritical Assembly with Combined Neutron Spectra Driven by Proton Accelerator at Proton's Energy 660 MeV for Experiments on Long Lived Fission Products and Minor Actinides transmutation" (Phase I: Design, Design Documentation and Safety Substantiation)	**6**	2005 /
2582	Experimental Study of Minor Actinides Transmutation Problem at BFS-73-1 Fast Critical Assembly	**6**	2005 /
2680	MATINE - Study of Minor Actinide Transmutation in Nitrides: Modelling and Measurements of Out-of-pile Properties	**6**	2005 /

Projects related to integral experiments (proposed)

735	Transmutation of Radioactive and Transuranium Isotopes by High-Energy Neutrons of the Thermonuclear Reactor	I.Kuzmitsky	VNIIEF / SKB
1755	Experimental Study of Fast and Fast-Thermal Accelerator Driven Systems on the Basis of BFS-1 – Microtron Complex	B.Kochurov	ITEP
2661	Analytical and Experimental Substantiation of Neutron-Physical Characteristics of Fast Reactors with Lead Coolant	I.Matveenko	IPPE
2884	Integral Experiments at BFS Critical Facilities for Justification of Minor Actinides Transmutation and Their Analysis	Yu.Khomiakov	IPPE
2925	Measurement of Transmutation Properties of Minor Actinides Irradiated in Intermediate Reactor Neutron Spectrum	M.Melnik	RIAR

Other recent proposals

 # 3176 *Measurement and evaluation of cross sections for minor actinides in low energy region* Oleg E. Kolyaskin, RRC Kurchatov Institute.

 # 2952 *Measurement of energy dependence fission cross sections for minor actinides in high neutron energy range*, Igor A. Ivanin, RFNC-VNIIEF.

 # 1749 + # 2925 + # 2884 *formed a joint coordinated program linked to NUDATRA*

Recently 3176+2952+1749+2925? are being reformulated as a single project

ASSESSMENT OF THE PRESENT-DAY DEMAND FOR NUCLEAR DATA ON ACTINIDE AND FP TRANSMUTATION

Data requirement for code development (design of experimental and pilot facilities)

- Required nuclear data accuracy
- Current status and perspectives of nuclear data evaluation and development of nuclear models for heavy nuclei
- Effect of nuclear data uncertainties on radiation damage of structural materials

Analysis of transmutation facility parameter sensitivity to various nuclear data

- Density variation effect on effective neutron multiplication factor in the blanket
- Scoping analysis of the integral parameters sensitivity to nuclear data

ASSESSMENT OF THE PRESENT-DAY DEMAND FOR NUCLEAR DATA ON ACTINIDE AND FP TRANSMUTATION

Table 3.1. Existing and required (in brackets) uncertainties of actinide cross-sections.

Nuclide	Capture cross-section, %	Fission cross-section, %	Inelastic scattering cross-section, %
Np-237	15 (5)	7 (3)	30 (10)
Pu-238	25 (10)	10 (5)	40 (30)
Pu-239	6 (4)	3 (5)	20 (15)
Pu-240	10 (5)	5 (5)	20 (15)
Pu-241	15 (5)	5 (3)	20 (20)
Am-241	10 (5)	10 (5)	30 (10)
Am-242m	30 (10)	15 (5)	40 (30)
Am-243	30 (10)	10 (5)	30 (30)
Cm-242	50 (10)	15 (5)	30 (30)
Cm-243	50 (10)	15 (5)	30 (30)
Cm-244	30 (20)	10 (5)	30 (30)

Table 3.4. Cross-Sections Uncertainties for Selected Cross-Sections: Original Uncertainty and Required Uncertainty to Meet Integral Parameter Target Accuracy

.Isotope	Cross-section	Bound. (a)	Accuracy achieved (%)	Accuracy required (%)
Pu239	σ_{fiss}	4	6.5	3.4
		5	4	3.1
Pu241	σ_{fiss}	6	10	5.6
Np237	σ_{fiss}	3	25	8.0
		4	25	5.1
	ν	4	5	4.1
Am241	σ_{cap}	4	40	7.5
		5	40	5.5
		6	40	5.1
		7	20	5.9
		8	20	6.3
		9	20	6.9
	σ_{fiss}	2	20	5.6
		3	20	4.6
		4	20	3.9
	ν	3	5	3.8
		4	5	3.3
Am243	σ_{cap}	4	40	10.4
		5	40	5.5
		6	40	5.1
		7	20	5.9
		8	20	6.3
	σ_{fiss}	2	20	7.6
		3	20	6.2
		4	20	5.4
	σ_{inel}	3	50	12.6
		4	50	7.6
		5	50	12.0
		6	50	12.2

Isotope	Cross-section	Bound. (a)	Accuracy achieved (%)	Accuracy required (%)
Cm241	σ_{fiss}	2	40	10.0
		3	40	8.5
		4	40	5.0
Cm245	σ_{fiss}	5	30	9.7
		6	30	9.6
Fe56	σ_{inel}	4	20	4.9
N15	σ_{el}	4	5	3.9
Pb	σ_{inel}	1	40	20.4
		2	40	9.8
		3	40	10.6
		4	40	10.1
	$\sigma_{(n,2n)}$	1	100	21.5
Bi	σ_{inel}	1	40	18.8
		2	40	8.1
		3	40	9.3
		4	40	14.0
	$\sigma_{(n,2n)}$	1	100	17.5
	σ_{dpa}	1	20	20.0
		2	20	12.0
		3	20	12.1
		4	20	8.8
		5	20	20.0
		6	20	20.0
		7	20	10.9
	$\sigma_{(n,\alpha)}$	1	20	10.8
		2	20	20.0
	$\sigma_{(n,p)}$	1	20	15.1
		2	20	12.4
		3	20	20.0

Identified needs of nuclear data:

1) Uncertainties and covariances – still very scarce on data libraries and badly needed for reliable assessment of uncertainties
2) Data on microscopic MA (+coolant and structural materials) cross-sections (σ_f, σ_c, $\sigma_{in,}$ $\sigma_{n,xn}$) affecting to the basic neutronic parameters: mainly energies < 10 MeV (particularly fast energies).
3) Data and models in the energy range above 20 MeV which have a significant influence on certain reactor design or performance like shielding, radiation damage evaluation (incl. gas production) or power vs beam intensity. Data for model validation.
4) Data on waste, decay heat and other aspects affecting the fuel cycle and the facilities activation. Notably the spallation fragments production.
5) Data defining or related to equilibrium fuels for scenarios with continuous recycling of actinides (particularly Pu238).
6) Integral experiments for final validation

Recommendations

The chapter needs some improvements: better outline to identify the rationale from the previous chapters, more clear summary on different needs, available infrastructures and experience on efficiency of different project types rather than prioritizing the future experiments.

Recommendations for differential experiments

List...

Recommendations for integral experiments

Neutronic parameters
Target irradiation
Low power demonstration facilities

Recommendations on the evaluated data preparation

Cross section files: to 150-200 MeV, with full covariance matrixes,using models to complete missing experimental information
Fission products yields for all actinides (Th to Cm) up to 150 MeV
Completing and correcting nuclear data decay libraries

Recommendations for differential experiments

1) Measurement of the total neutron yield, total neutron spectra and fission neutron spectra for isotopes of Th, Pa, U, Np, Pu, Am, as well as for spallation target materials Ta, W, Pb, Bi, irradiated by neutrons and protons of energies from 20 MeV up to 1 GeV.
2) Measurement of the total gamma yield and emission spectra for isotopes of Th, Pa, U, Np, Pu, Am in the energy region 20 MeV – 1 GeV.
3) Measurement of fission product yields for transuranics at the energies 20 - 200 MeV.
4) Obtaining the excitation functions for reactions (n,xn), (n,pxn), (n,2pxn) etc for isotopes of Th, Pa, U, Np, Pu, Am at the primary neutron energies 20 – 200 MэВ as well as for analogous reactions initiated by protons.
5) Measurements of the resistivity damage rates necessary for evaluation of damage energy cross-sections for iron, chromium, nickel and other components of steels at the energies 20 MeV – 1 GeV.
6) Measurements and analysis of the total yields, time and energy dependencies of characteristics of delayed neutrons from fission of Np-237, Am-241, Am-242m by fast neutrons.
7) Carrying out the sensitive measurements of neutron capture and fission cross-sections for minor actinides at resonance and fast neutron energies to define the accuracy of nuclear data.
8) Measurements of excitation functions to obtain secondary reaction alpha- and beta-active product yields from spallation target unit structural materials irradiated by protons and neutrons with energies up to ~ 1 GeV.

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Appendix 16

Compact summary of recommendations from CEG 2006 meeting Brussels

Project	Status	Short characterization	Recommendations / Comments
1606	Phase II starting	Molten Salt Technology	Synthesis with RIAR activities?
2048	Running	Material properties improvement	Prolongation
2267 SAD	Phase I successfully completed	ADS experimental setup	Fast continuation with Phase II
2573	Phase I successfully completed	Lead isotope separation	Continuation with Phase II
2578	Finished	Summary of Nuclear Data related ISTC Projects	Small modifications of draft final report
2680 MATINE	Running	Minor Actinides and Nitride Fuel	Prolongation
2884 + other	Reformulation as single project	Nuclear data measurements and integral experiments	Focussing on SAD licensing and on NUDATRA support
B070 YALINA	Running	Neutron Source Driven Sub-critical Assembly	Prolongation

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