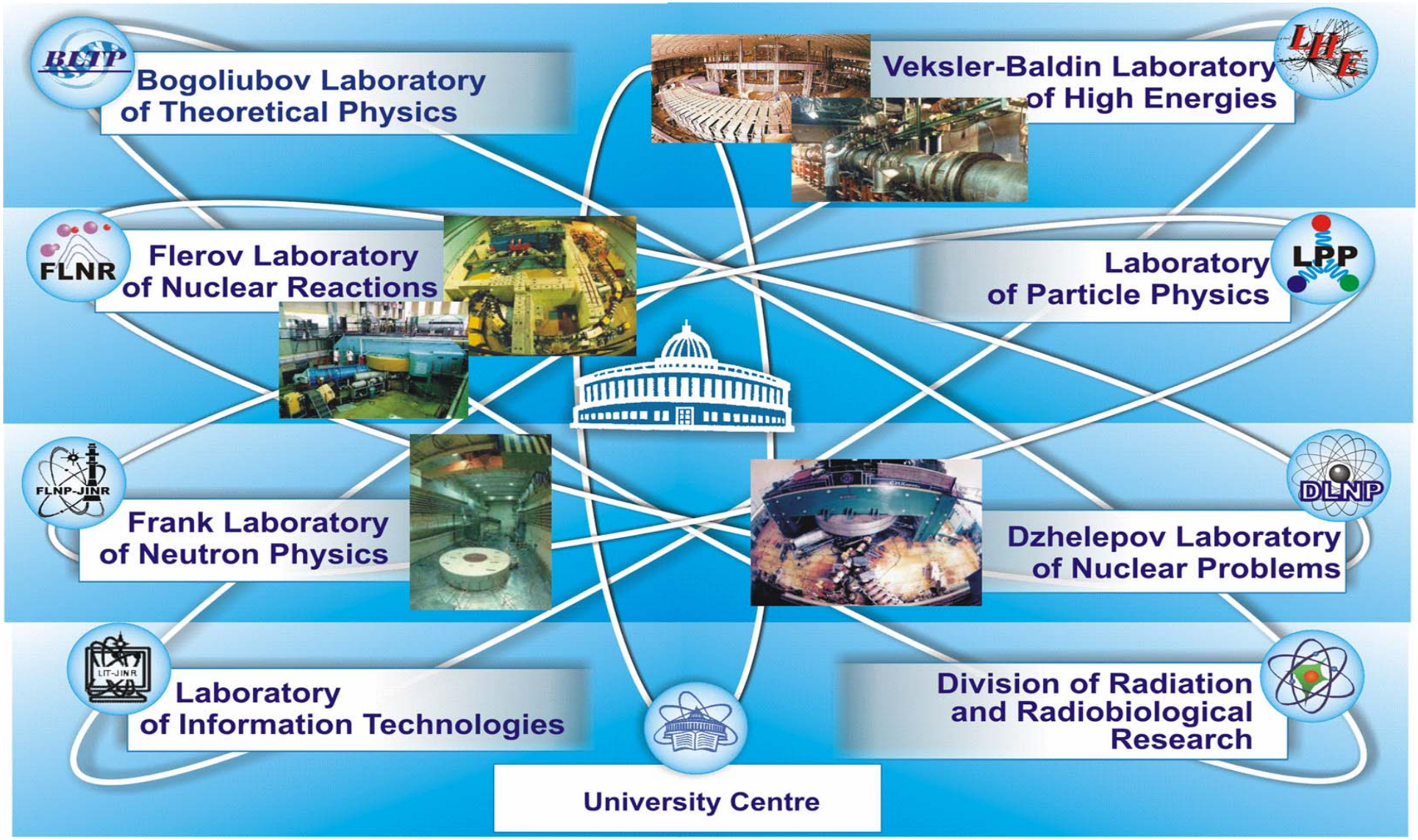
ISTC #2267 (SAD) Project: Objectives, Tech. Description, Status, Financing Issues

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

FLNP JINR NIKIET GSPI VNIINM MAYAK



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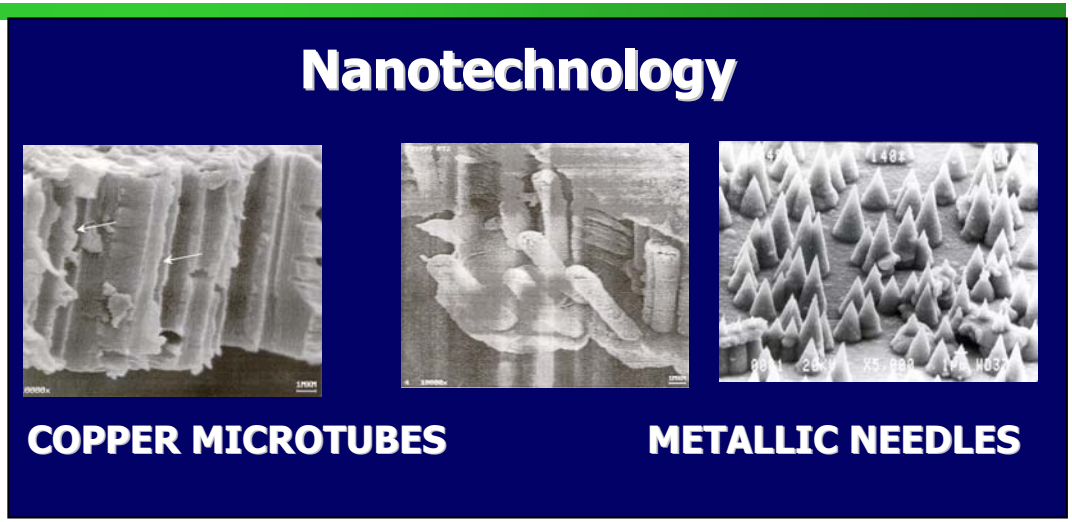
SEZ in DUBNA

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



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%

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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;

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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

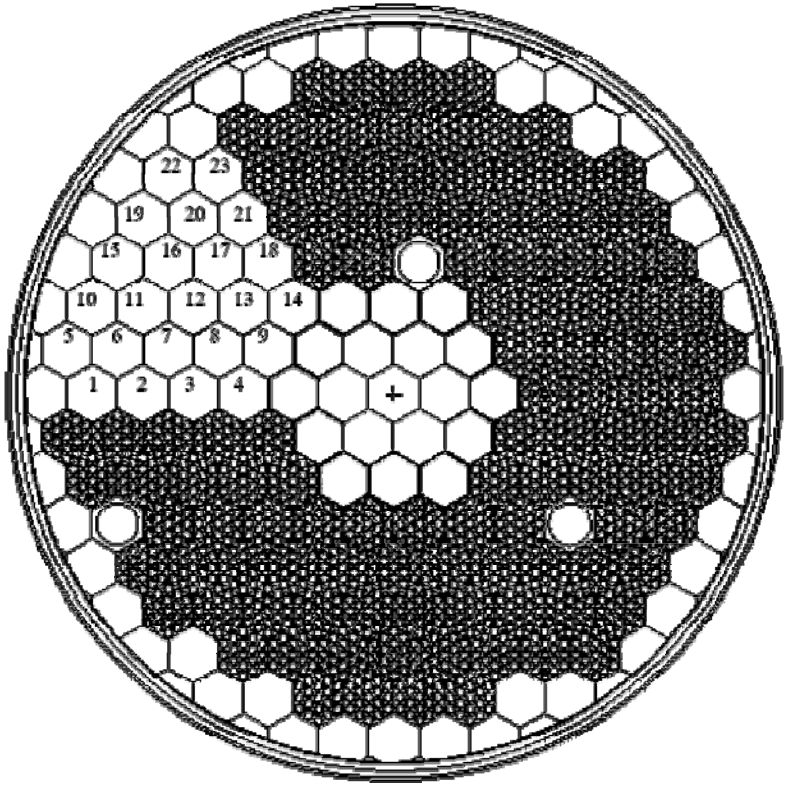
- **Forschungszentrum Karlsruhe - FZK, Institut für Reaktorsicherheit, Dr. Cornelis Broeders;**
- **Kungliga Tekniska Högskolan - KTH, Nuclear and Reactor Physics, Prof. Waclaw Gudowski;**
- **Centro de Investigaciones Energéticas Medioambientales y Technologies - CIEMAT , Dr. Enrique Miguel Gonzalez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

Basic Data

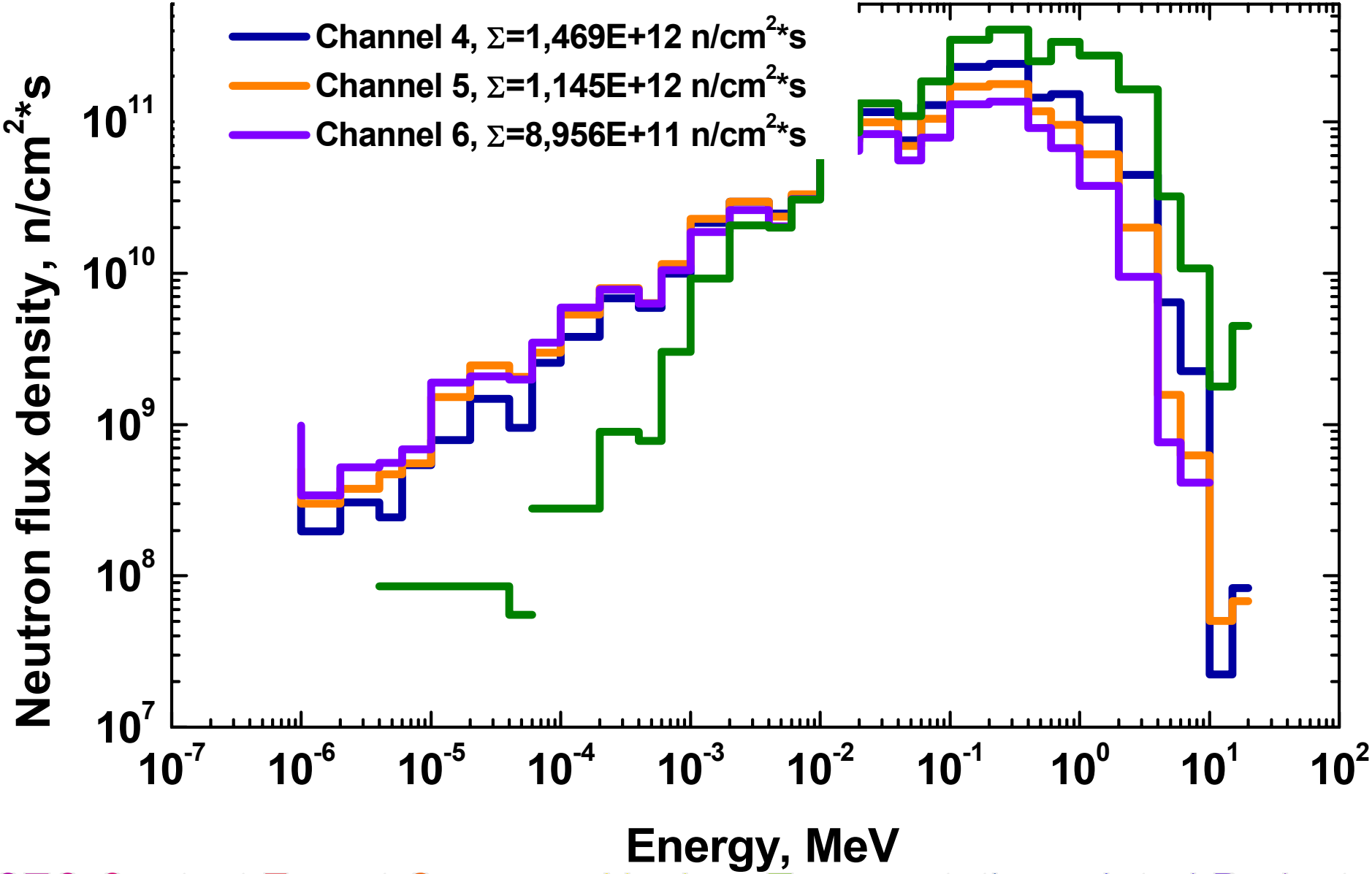
k_{eff}	~0,95
Fuel loading	< 420 kg
Fission power	27,6 kW
Cooling	air
Core	
Coolant flow rate, G	~ 0,6 kg/s
velocity, v	10 m/s
Presure, P *(inlet)*	0,12-0,135 MPa
Temperature, T *(inlet, outlet)*	50/96 ºC
Target (Pb)	
Coolant flow rate, G	~ 0,0067 kg/s
Velocity, v	50 m/s
Pressure, P *(inlet)*	0,12-0,135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



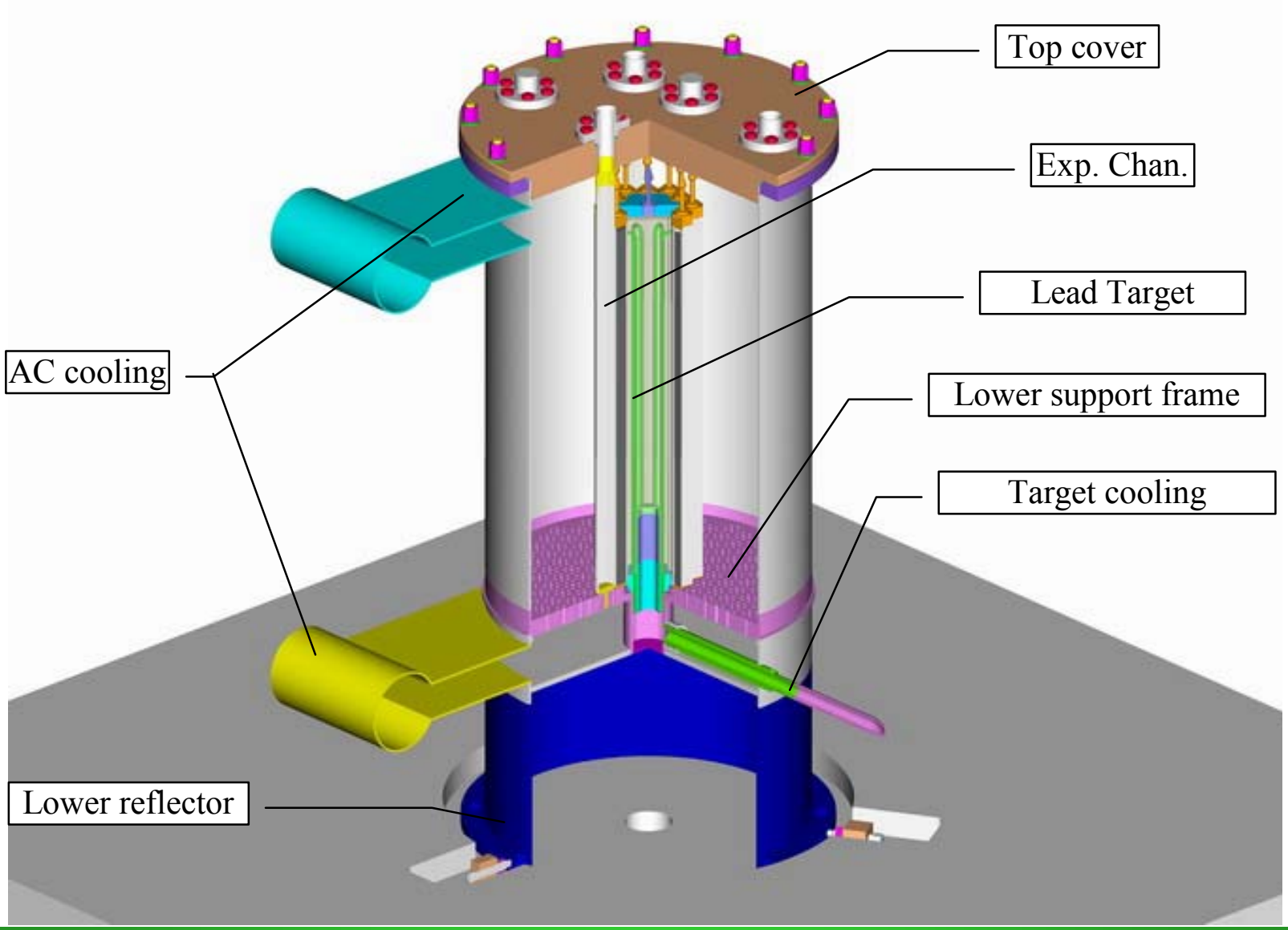
Subcritical Blanket/calculations



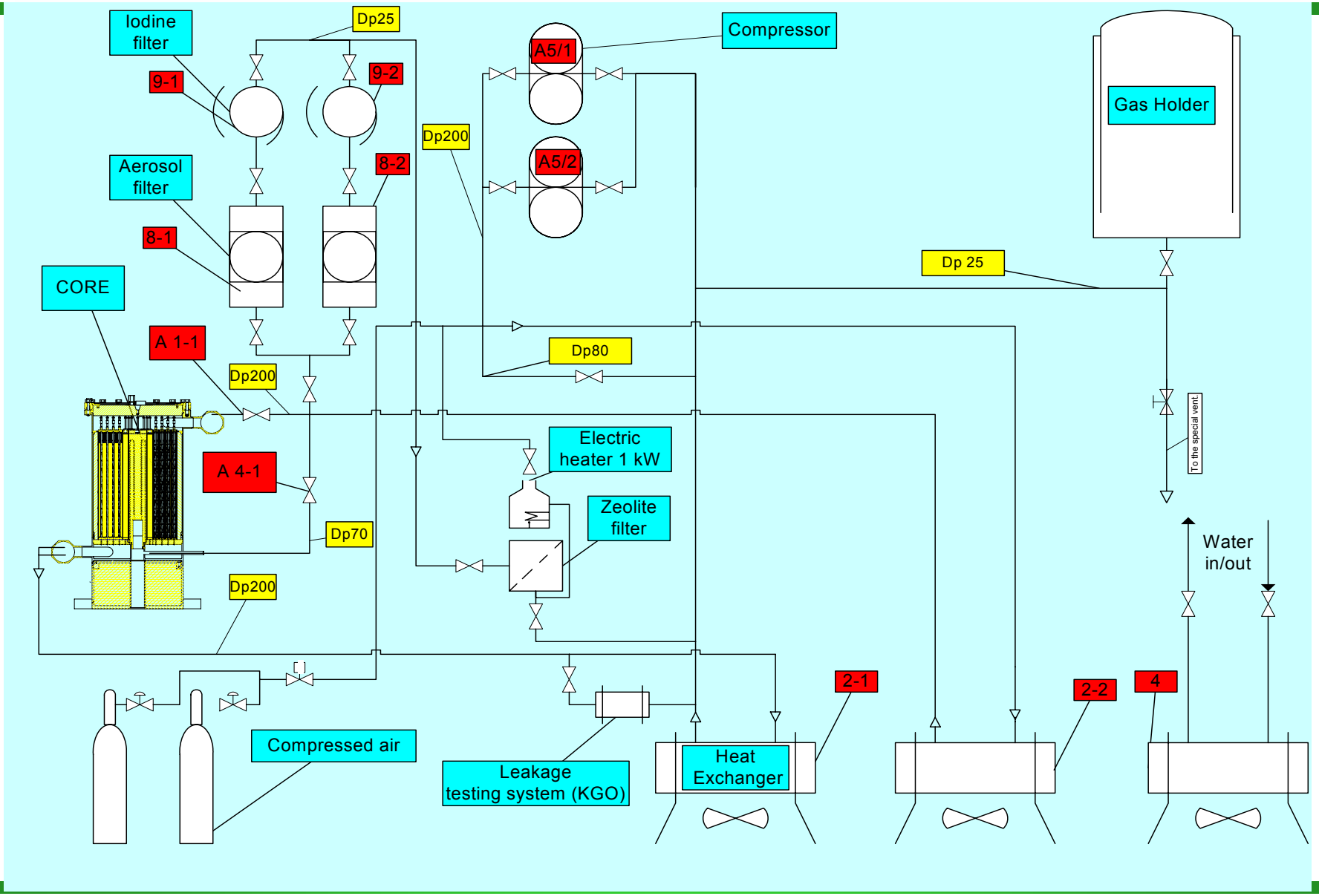
Subcritical Blanket/ neutronics

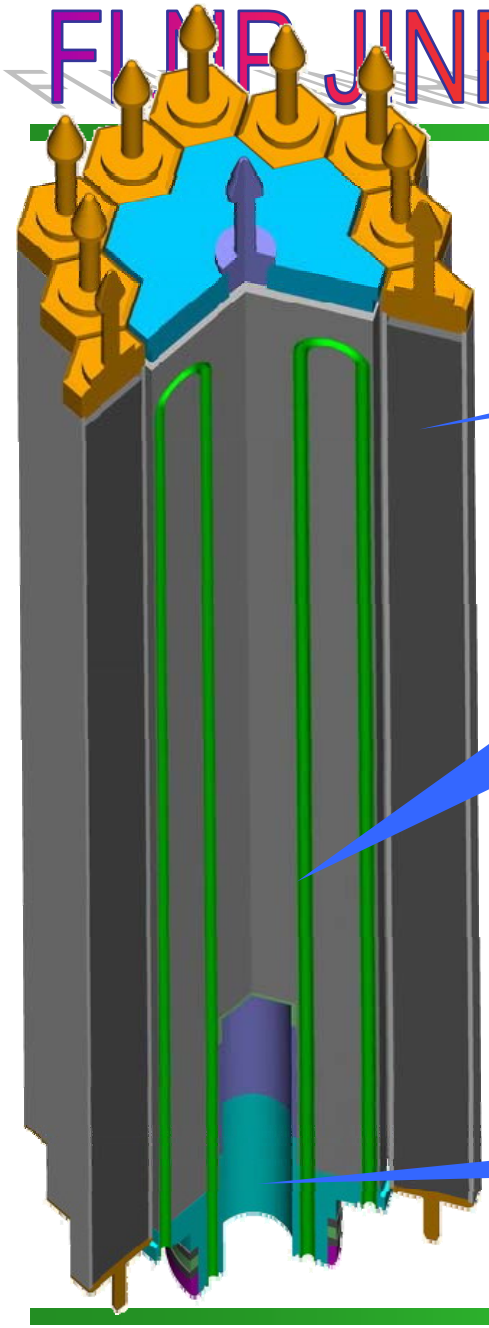
Calculated K_{eff}	0.9515
Neutron lifetime	$2.4 \cdot 10^{-5}$ s
Fission power	**27.6 kW**
Averaged neutron flux	**$1.7 \cdot 10^{12}$ 1/(cm^2·s)**
Peak factor of heat generation (height)	1.21
Heat generation in SAD parts:	
Fuel	25.96 kW
Target (neutron and photon from fissions)	97.3 W
Core cladding	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·s)
Max fluence of fast neutrons	$8.0 \cdot 10^{19}$ 1/cm^2

Subcritical Blanket/design



Cooling System

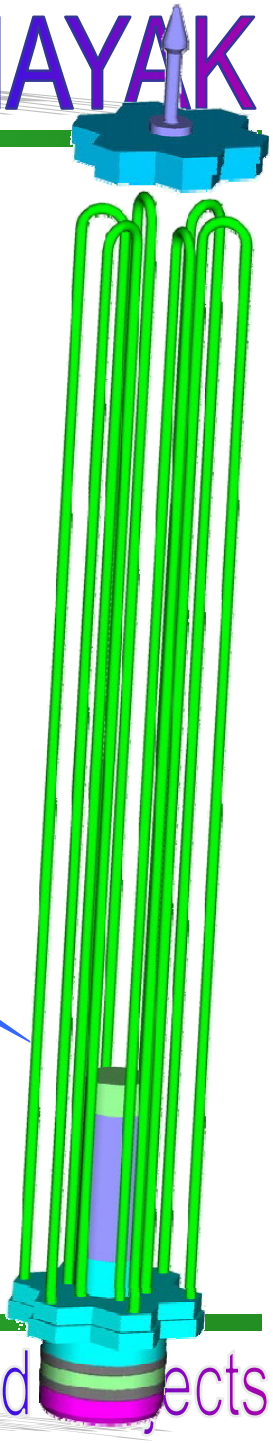




Lead Prisms

Air Channels

Beam Input



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

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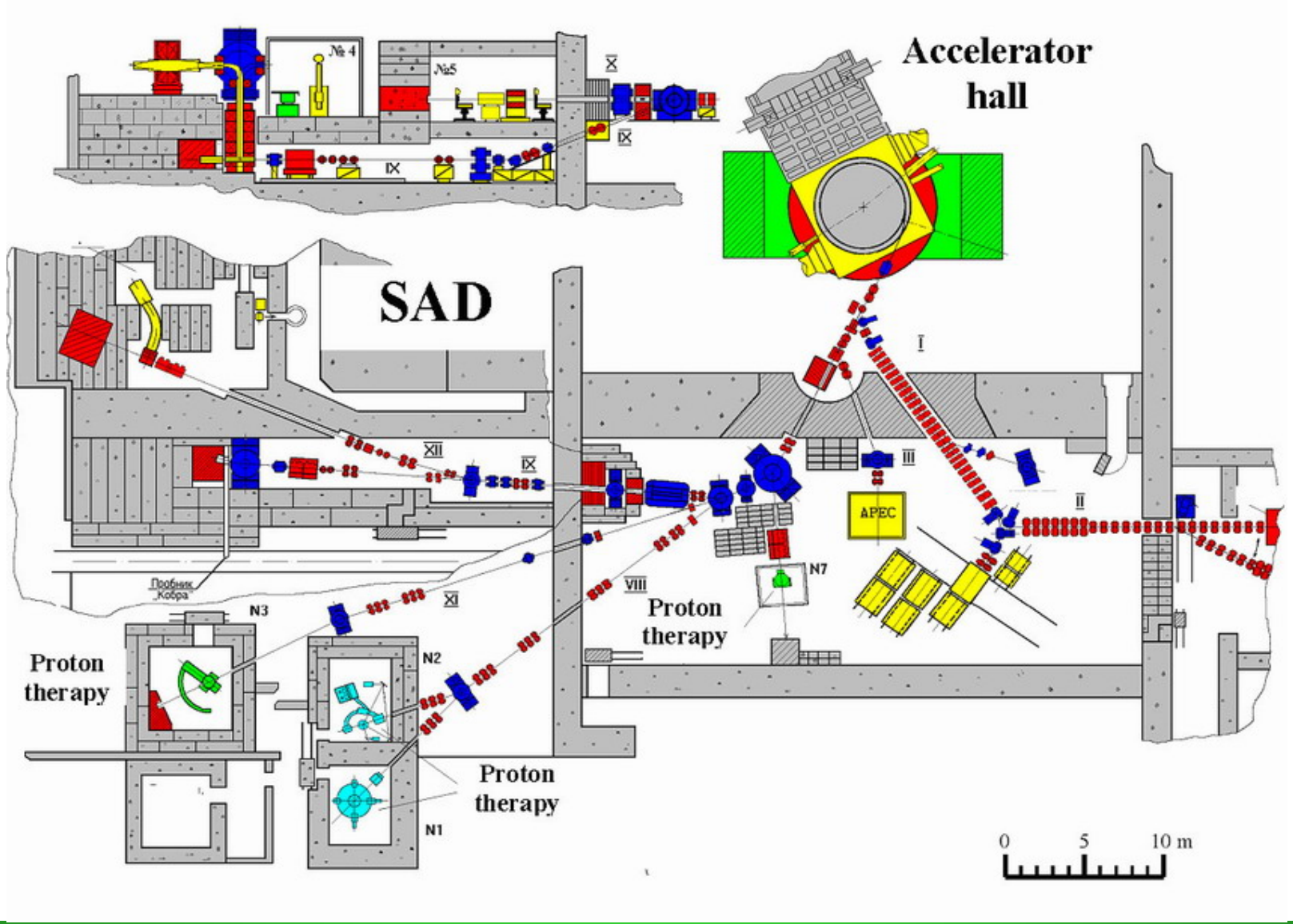
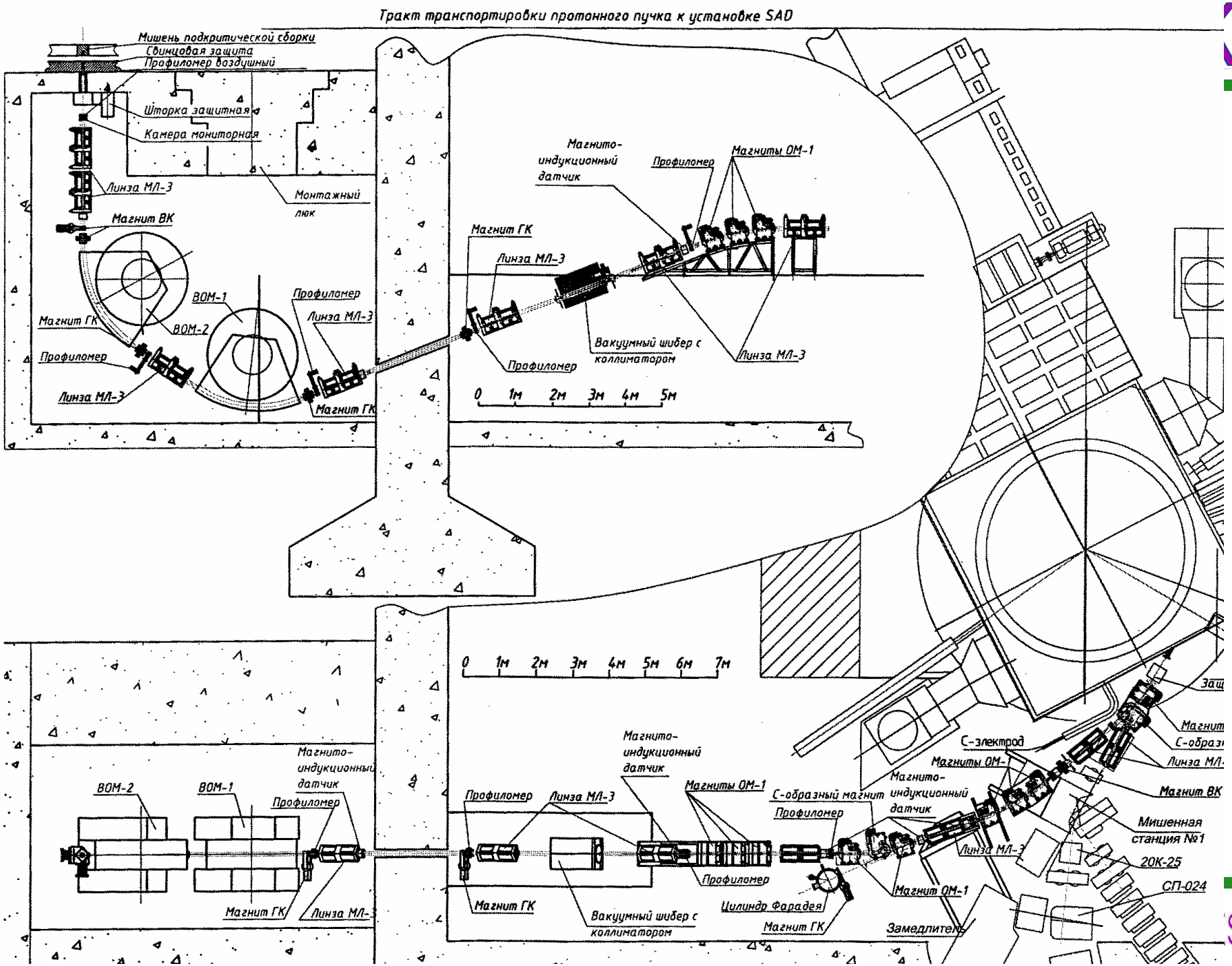



Тракт транспортировки протонного пучка к установке SAD
Мишень подкритической сборки
Свинцовая защита
Профиломер воздушный
Шторка защитная
Камера мониторная
Линза МЛ-3
Монтажный люк
Магнит ВК
ВОМ-1
ВОМ-2
Магнит ГК
Профиломер
Линза МЛ-3
Магнито-индукционный датчик
Магниты ОМ-1
Вакуумный шибер с коллиматором
0 1м 2м 3м 4м 5м
0 1м 2м 3м 4м 5м 6м 7м
С-электрод
С-образный магнит
Мишенная станция №1
20К-25
СП-024
Цилиндр Фарадея
Замедлитель

Initial data for SAD FE design

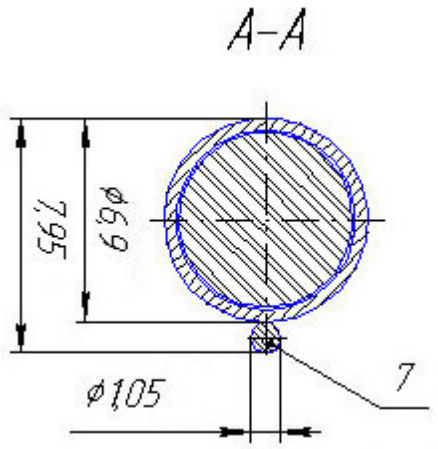
Operating Conditions

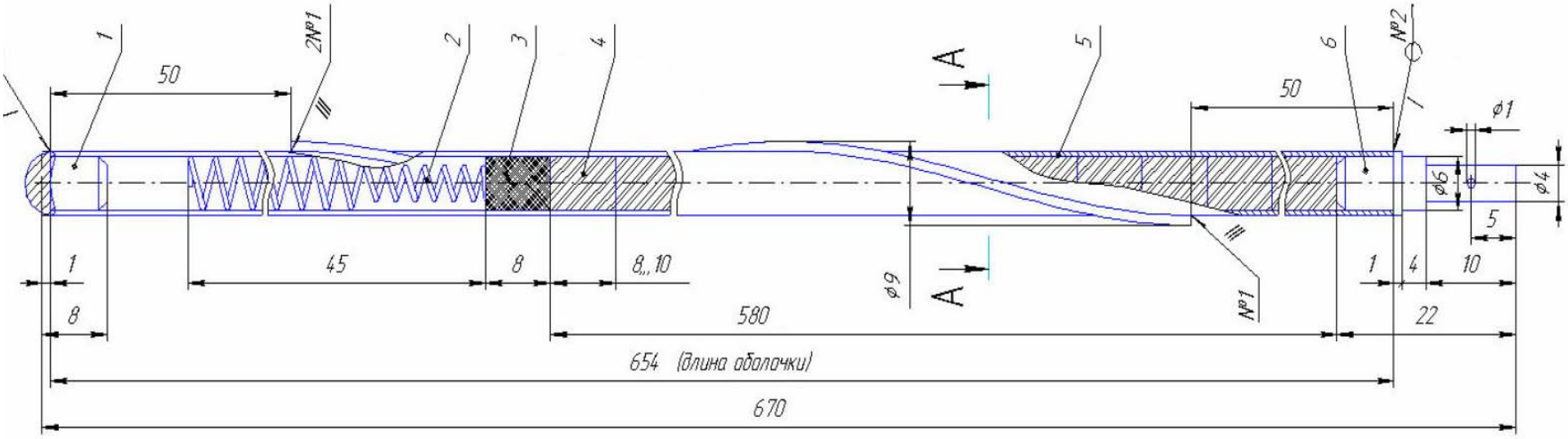
- Maximum Dose for Constructional Materials of Fuel Element – 0.25 dpa.
- Fuel Maximum Burn up – 0.1 % h.a.
- Maximum Linear Power of Fuel Element – 0.275 kW/sm.
- Maximum Temperature of Fuel Element Cladding - 150°C.
- Core Coolant - Dry, Dust-free Air.
- Maximum Coolant Temperature at Core Output - 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.

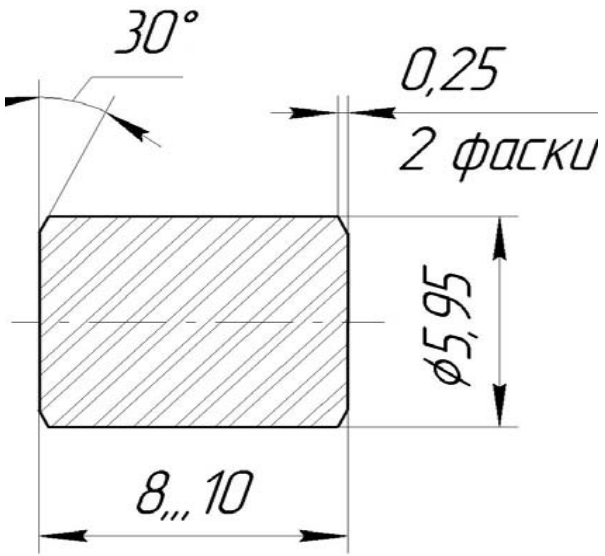
FE design


A–A
7,95
6,9ϕ
ϕ1,05
7


1
50
2№1
2
3
4
A
5
50
6
№2
ϕ1
ϕ6
ϕ4
5
1
45
8
8,,10
ϕ9
A
№1
1
4
10
8
580
22
654 (длина оболочки)
670

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

Fuel pellet design parameters



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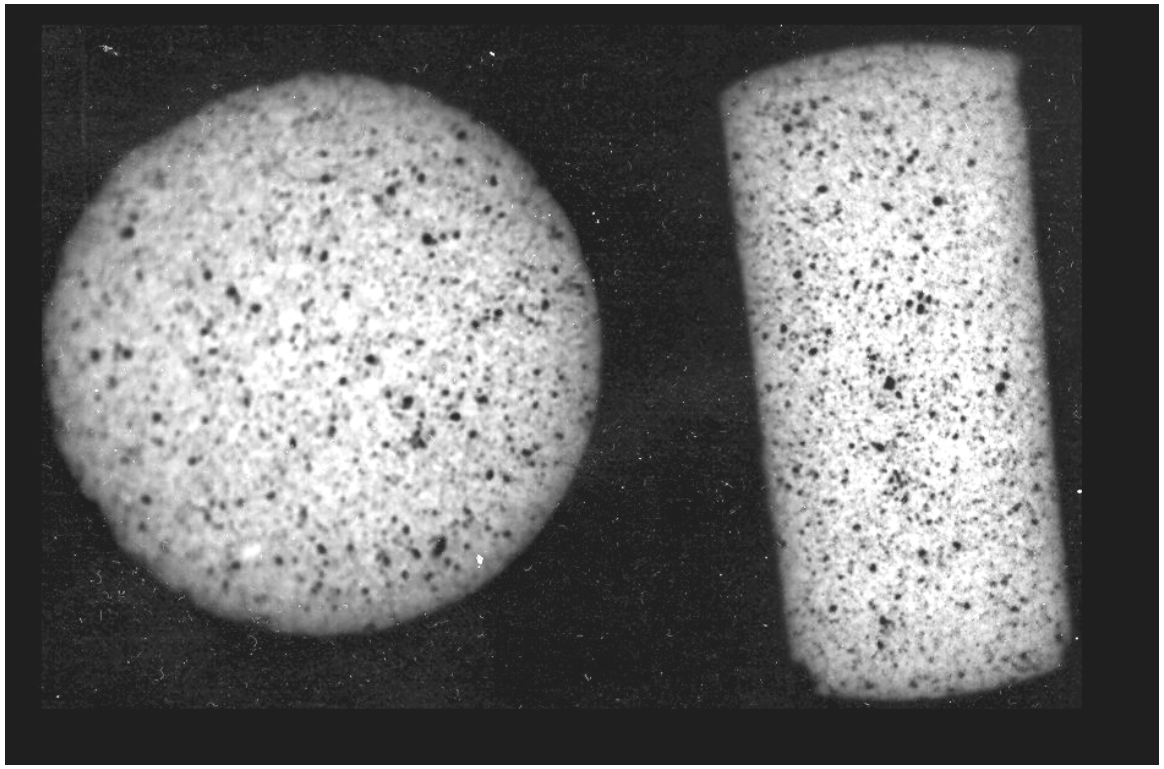
Pu distribution homogeneity study



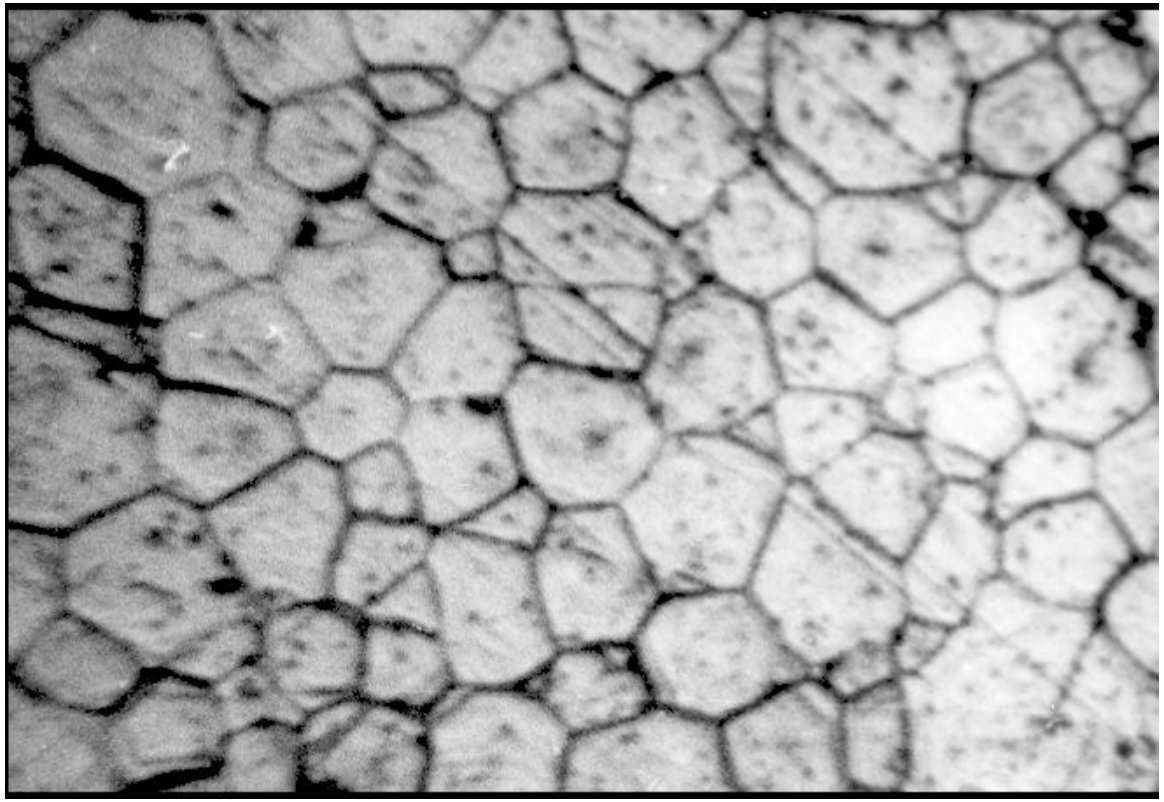
α-radiography

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



Microscopy study of the microsections processed in HNO_3 and HF acids

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

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

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,
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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 массой
№ 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 к

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 изготовлени
ой установки SAD в производственн

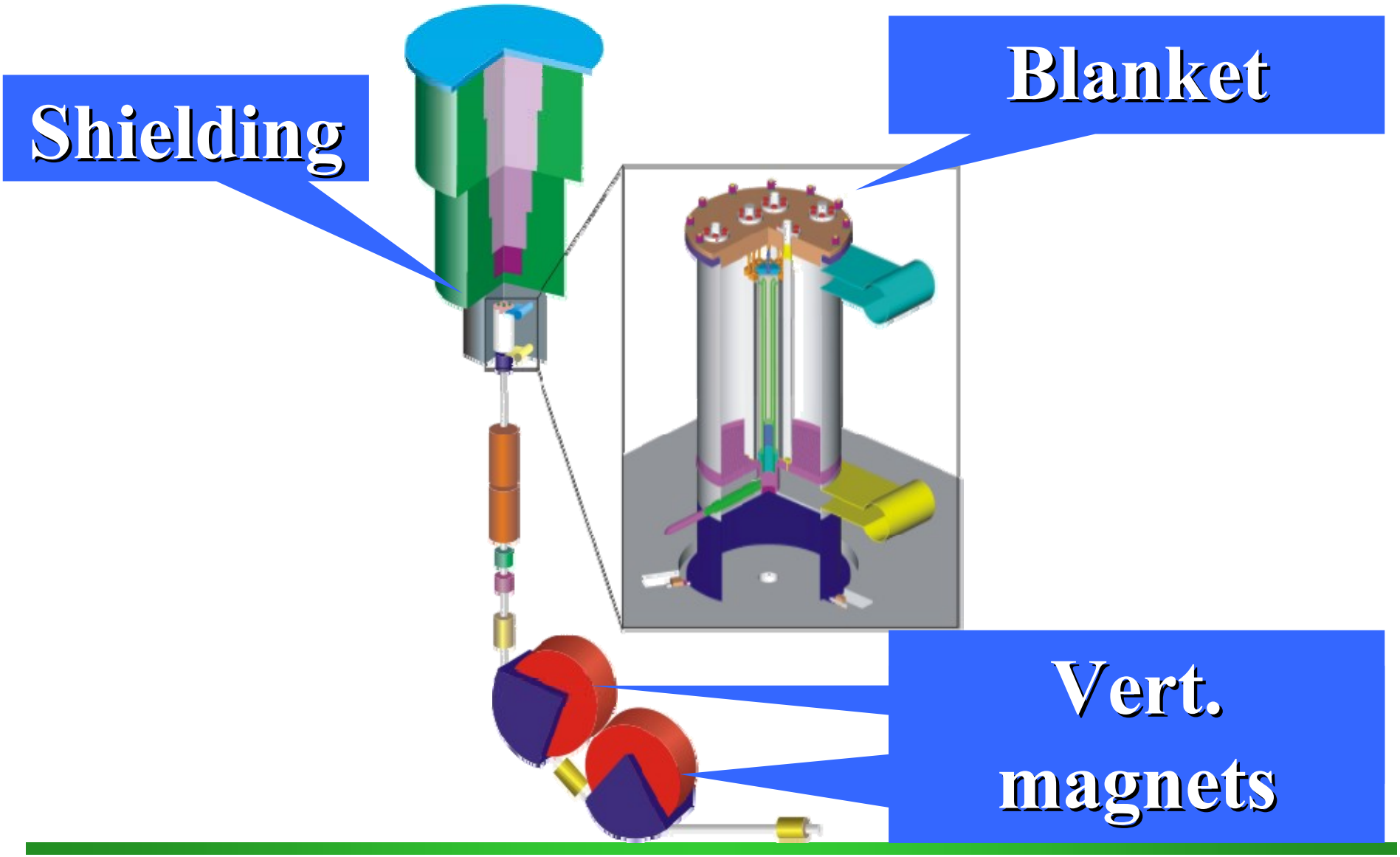
таблеток опытной партии представлены

	Результат контроля				
	Номер партии спекания				
	18	20/1	21	22/30	23/2
4	87,96	87,90	88,28	88,30	88,20
2	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
	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

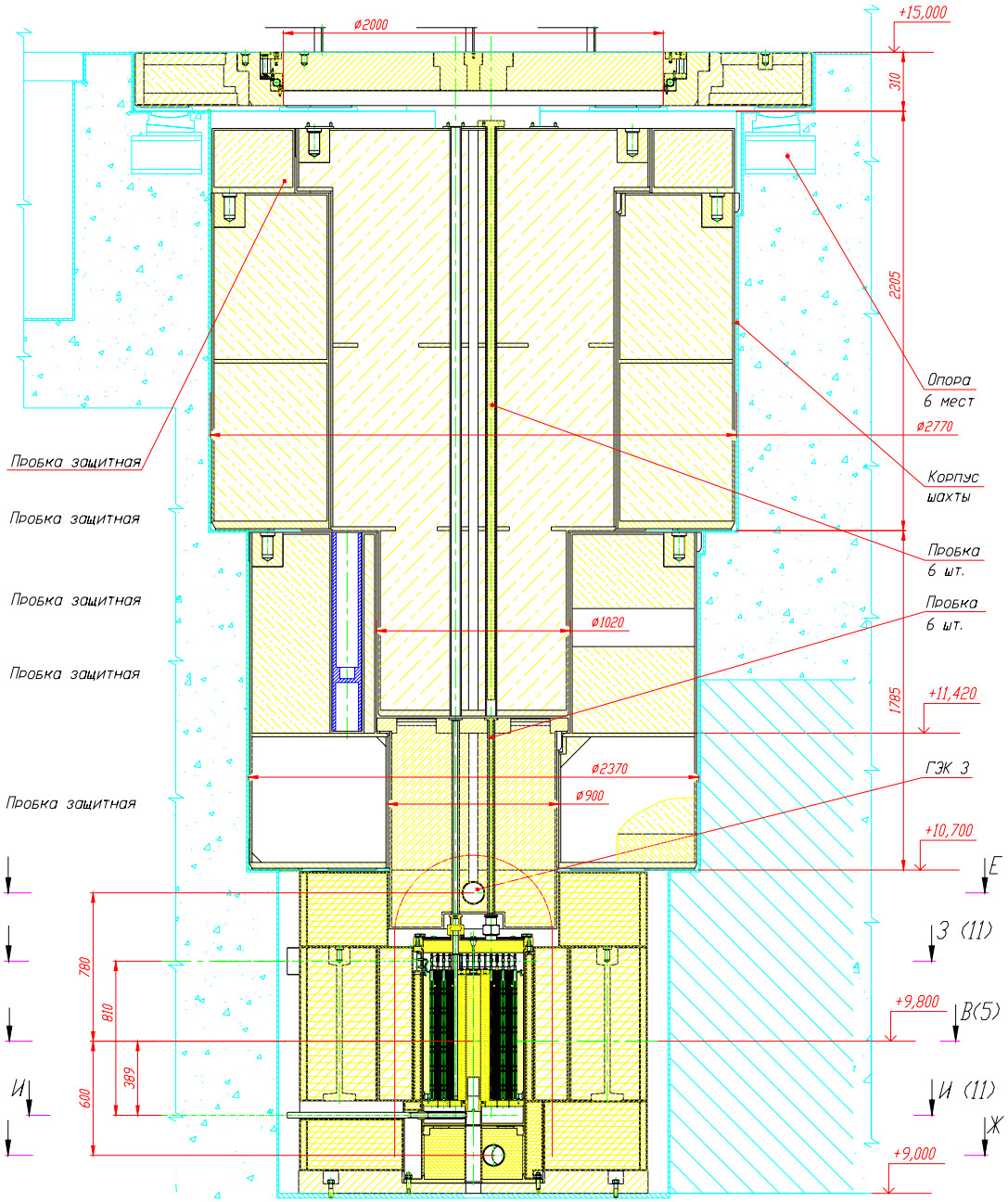
В норме для всех партий

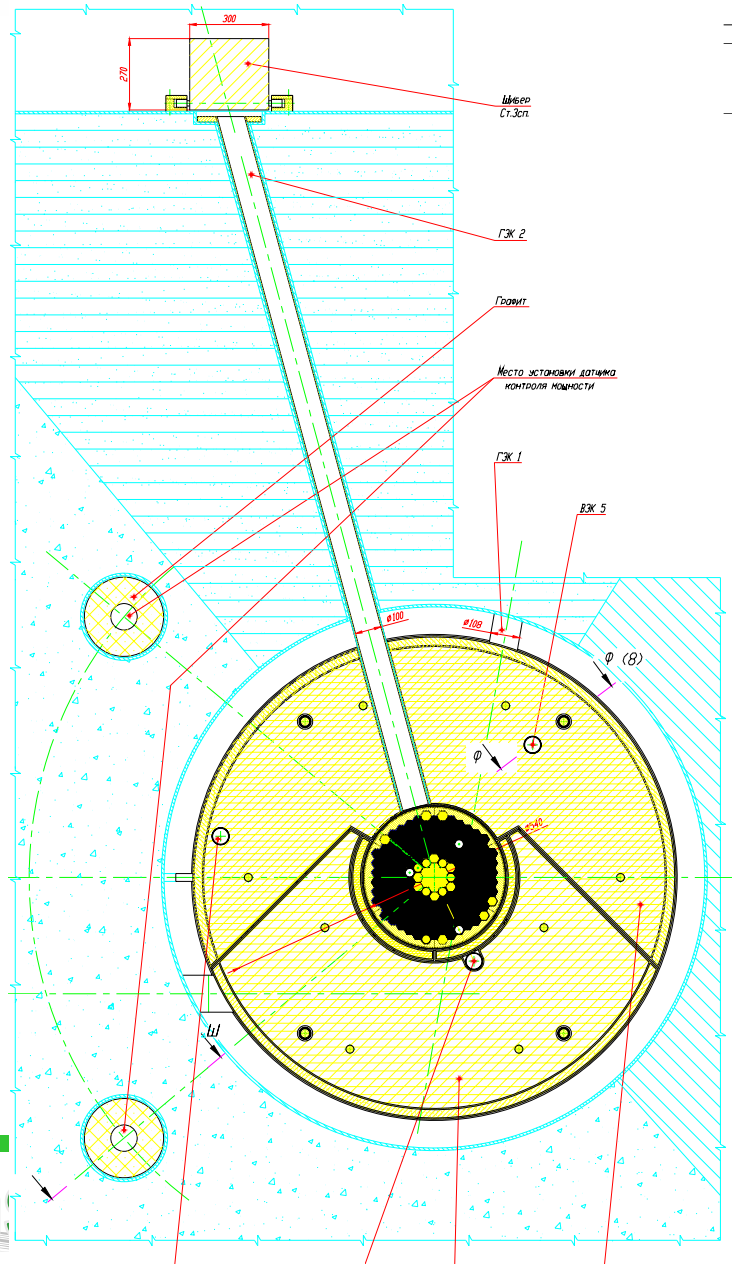
ия таблеток:
изготовленный ОАО МСЗ (с истекшим
цию на соответствие ТУ);
говленный на ПО «Маяк», согласованный

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

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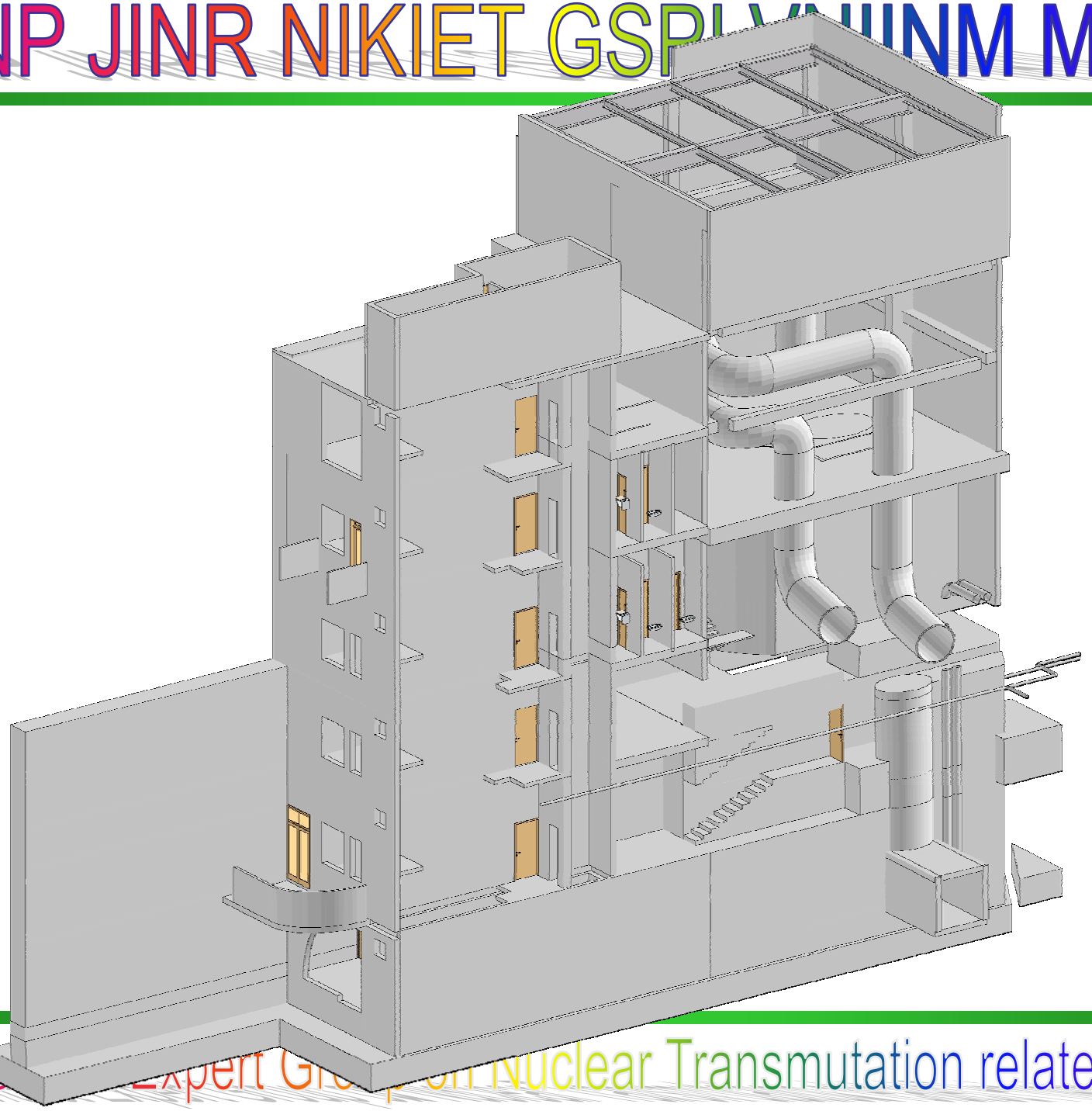

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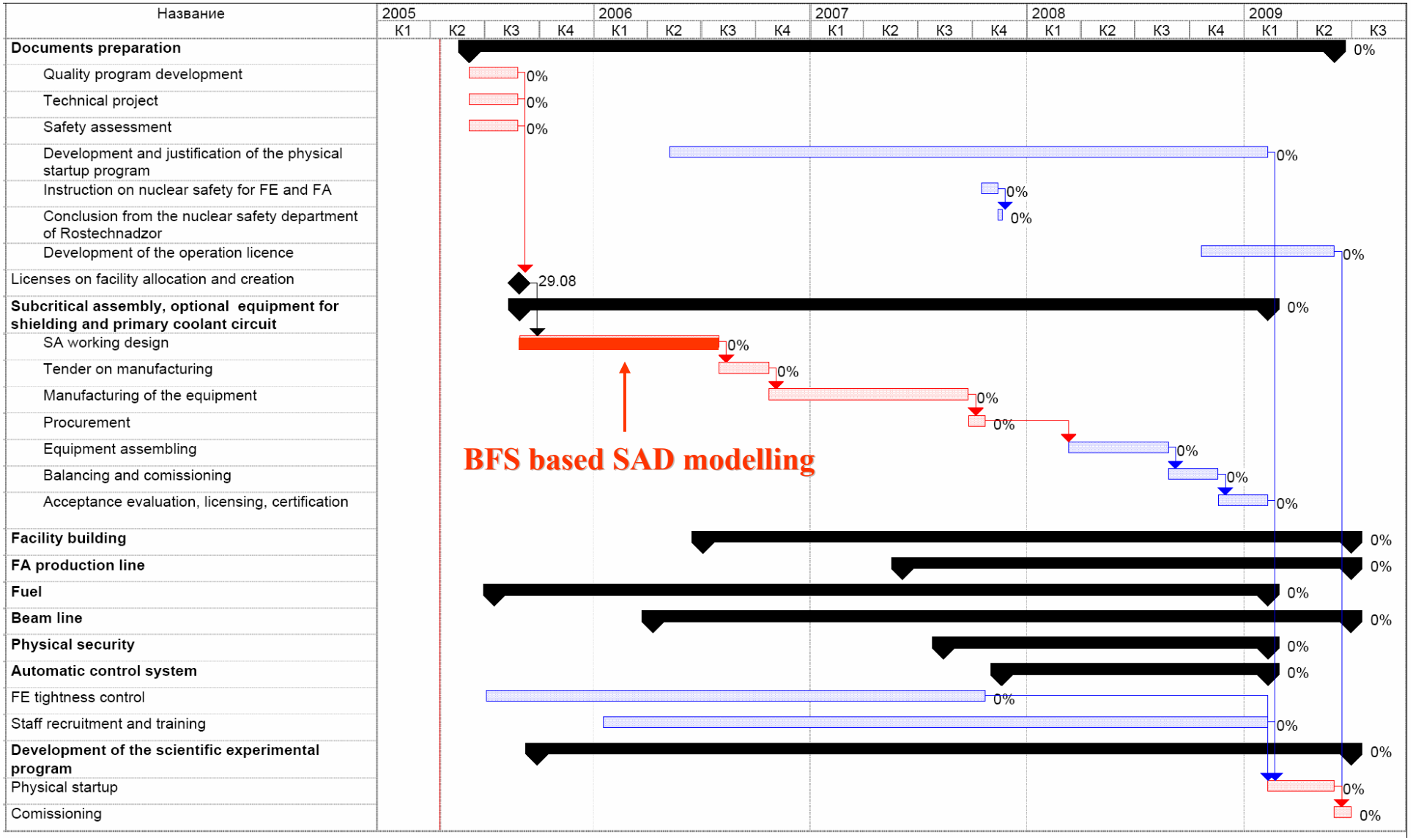
Project Status

- **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;**

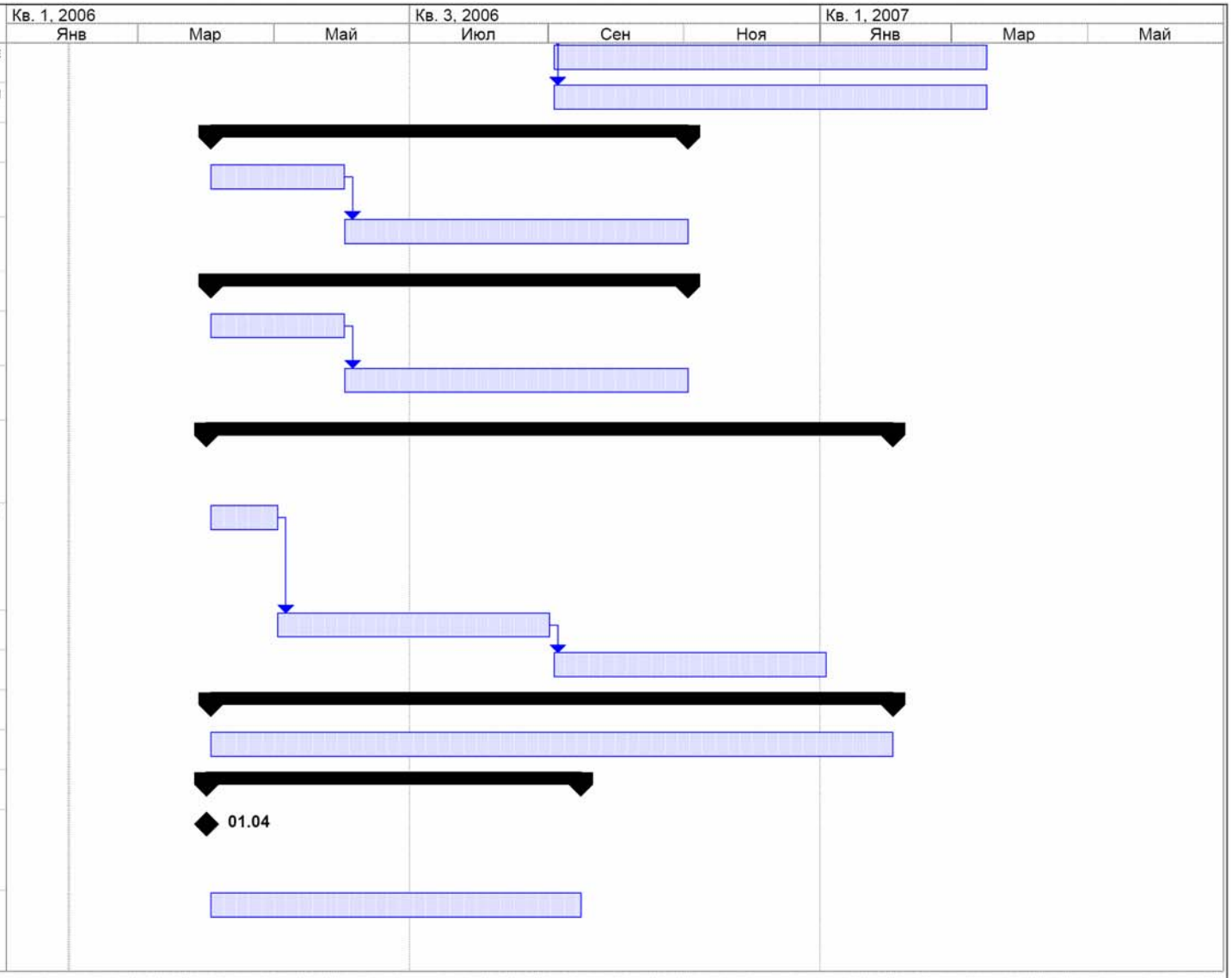
Licensing started some project documents already approved by Rostechnadzor (former Gosatomnadzor)

Project Timeline /4 years/



Project Timeline / 2006 /

Ид.	СДР	Название задачи
21	5.2	Vertical deflecting magnets ma
22	5.3	Magnetic elements manufactui
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 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	0.8	0.1	*
2007	+ 0.6 (in kind	1.5	0.1	*
2008	contribution)	0.4	0.5	*
2009			0.5	*

* Numbers to be clarified after creation of the collaboration

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JINR Director designate

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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.