Potential contribution from the SAD project to ECATS
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1. Qualification of sub-criticality monitoring

During SAD project we're planning to create experimental technique on the basis of the BFS assembly in SAD-like configuration with PNG (10^8 n/s, 1 mks pulse width, 20 Hz repetition rate). Subcriticality ranges from critical configuration down to deep subcriticality. This experimental technique/techniques will accumulate to the experience from MUSE, YALINA and JINR experiments with IBR-30 booster. Developed technique will be transferred directly to the SAD facility and applied during start-up period for subcriticality measurements by PNS area and PND methods. Experiments at BFS are planned during the second half-year of project implementation during the stage of working design (point 3.1 in work plan and time schedule). At the physical startup stage (point 10.8 of the work plan, 12.7 of the time schedule) during core loading the k_{eff} will be increased up to 0.98 with measurements using PNG after that configuration with k_{eff} = 0.95 will be left and experiments with spallation target and pulsed proton beam will be continued.

Extensive calculations and experiments will be performed in order to validate sub-criticality calculations. Particular attention will be paid to assess importance of the source neutrons through "vertical profiling" measurements (traversing neutron generator vertically). Possible we can also put neutron generator to different channels to track "importance" of the source.
Less promising methods (Feynman alpha, Rossi alpha) will also be studied in order to make eventual final out-selection (perfect topic for the students and thesis work)
Special attention will also be paid to influence of neutrons coming back to the system from the the close environment (reflector, walls etc.).

Effects of spectral shifts originated from "moderating inserts" in core environment and "capture inserts" in core itself will also be investigated in subcriticality monitoring aspect.
I would also suggest here special investigations – as it has been already initiated in XADS – on applying "proton/neutron source (accelerator in the final ADS) characteristics" for subcriticality determination in particular using RANDOM events.
Can we gain anything on investigation of random fluctuation/ perturbations of the neutron/proton source. We can "randomize" our neutron generator signal, can't we?
Dependency on different spallation target material (Pb and W) will be assessed. It is important – W will significantly perturb the neutron field and alter the neutron importance.

2. Validation of generic dynamic behavior of an ADS in a wide range of sub-critical levels, sub-criticality safety margins and thermal feedback effects

See paragraph 1. Thermal feedbacks at SAD will be negligible because of fast spectrum, MOX fuel, low power density and low temperatures.
However, we are discussing and assessing simulation of dynamic behavior through external (mechanical ??) perturbation . I think a special think-tank of young people should be put on this topic. Increase of system power and influences of coolant flow variations are also considered for a second stage

3. Validation of the core power/beam current relationship

Beam current and shape will be monitored at different places along beam line using inductive sensors, ionization chambers and profilemeters. Beam current will be measured with high precision. Power level will be monitored by two certified channels with 3 neutron sensors (high sensitivity fission chamber - $\eta_1 \approx$ 1,2 $cm^{-2}*s^{-1}$; low sensitivity fission chamber $\eta_2 \approx 6*10^{-3}$ $cm^{-2}*s^{-1}$; boron current chamber $\eta_3 \approx 1*10^{-14}$ $cm^{-2}*s^{-1}$). Additional neutron sensors could be installed in SAD experimental channels. Beam diagnostics and power control channels design is fulfilled within design stage of ISTC project #2267.
I think we need some more work here: dependency on core power/beam relation on reactivity changes and source proton/neutron importance. Extensive measurements and calculations will be done for different subcriticality levels and different core configurations ("simulations" of burnup effect). A METHODOLOGY for periodic "calibration" of core power/beam current relation will be developed. Technical solutions will be suggested.

In the profound study of different measurement techniques for reactivity monitoring in an ADS, performed within in the MUSE-4 program, the method based on the current-to-flux reactivity indicator has appeared to be the major candidate for on-line monitoring (see Chapter 9). At a constant reactivity, the ratio between the neutron flux monitored in a detector in the core and the proton beam current is proportional to the efficiency of the source protons. By studying the dependence of the source efficiency on different possible variations of the target-core properties, a good estimation of the stability of the current-to-flux reactivity indicator can be obtained. Possible transients that might affect ψ^* are, for instance, a change in the beam direction or the beam impact location, the proton energy or the target temperature. Over longer periods, the change in isotopic composition of the fuel due to burnup, or the modification of the core geometry during reloading, might change the source efficiency. In order to assure the reliability of the reactivity indicator, these factors, potentially able to affect the proton source efficiency or the detector efficiency, should be monitored continually or checked on a regular basis.

4. Start-up and shut-down procedures, Instrumentation validation and specific dedicated experimentation

This is an integral part of the SAD project in its initial experimental phase and has to be developed following both our scientific goals and regulatory requirements. Detail procedures will be developed, instrumentation will be setup, extensively tested and implemented.

5. Interpretation and validation of experimental data, Benchmarking and code validation activities etc

During SAD project realization the facility (especially central part – target unit and fuel assemblies – and reflector) will certified with high precision. Each fuel element will have own certificate with fuel isotopic content (^{239}Pu content will be given with 10^{-4} accuracy, ^{238,240,241,242}Pu – with 10^{-5} accuracy), fuel weight/density with accuracy 10^{-4}). Construction materials also will be certified according to the GOST standards. It'll give the possibility for precise modeling of the subcritical assembly and benchmarking/code validation activities.

SAD experiments may also be used to validate newly developing routines for neutron importance determination in the continuous energy Monte Carlo codes.

6. Qualification of the proton beam reliability and the beam transport line, Pb-Bi or Pb-spallation target design in association with relevant proton beam and the effects of spallation residues including that of polonium

Two replaceable targets: W and Pb will be used in SAD-experiment. The design of targets is different due to the difference in physical properties and different neutronics. Detailed calculations of the targets neutronics are fulfilled at design stage of the ISTC project #2267. Experiments with bare lead targets irradiated at JINR Phasotron aimed to measure spallation products yield with He loop technique were prepared in the beginning of 2005. Experiments will be continued at JINR Nuclotron accelerator. At the working design stage of the SAD facility the design of the lead and tungsten targets with He loops will be developed.
Proton beam line qualification was considered at design stage of the ISTC project #2267.
IMPORTANT!!
Extensive "post irradiation" tests are foreseen for the SAD spallation targets. Special attention will be paid to Po production and Po migration in the Pb spallation target. Samples of the Pb reflector will also be investigated in order to assess radiological and decommissioning problems related to use of Pb in ADS.

Validation of "radiological/radiation protection" calculations are badly necessary!! We already observed large discrepancie between code predictions and our experimental results!

7. Safety and licensing issues of different component parts as well as that of the integrated system as a whole

Safety assessment report for the assembly is already fulfilled within ISTC project #2267 (NIKIET project). Safety assessment of the integrated system is under preparation and will be ready in June 2005. Immediately after that the licensing procedure will be started. All preparatory tasks are completed at present time. List of required documents/actions is prepared with phone numbers/addresses of the corresponding authorities, commissions, and agencies. At present in Russia the new version of the "Safety Regulations for Nuclear Installations" – main normative document is under preparation. JINR, NIKIET and GSPI are involved in preparation of this new version, specifically in elaborating the rules for ADS systems (in old version such category didn't exist).

All documents related to Safety and licensing issue will be translated into English in order to supply our Western collaborators with relevant information and data. Clearly a lot of requirements and procedures are NOT TRANSFERABLE to other countries but we can prepare kind of GENERIC SAFETY AND LICENSING document for ADS , where some general, basic requirements (probably 80-90% of requirements for S&L are not country specific) will be addressed. Or we can try to match SAD S&L documents against e.g. NRC (we do not have European requirements yet, but they may come in few years..)

8. Radiation shielding and radiation doses

The presence of the 660 MeV proton accelerator in SAD introduces a new dimension to the radiation shielding concerns, compared to the operation of critical reactors, due to the long range of high-energy neutrons created in the spallation reactions. The SAD experiments provide a good opportunity to validate the pre-calculations of the radiation doses at various places outside the biological shielding.

A sketch of organizational solution and financial efforts:

ECATS collaborators will be particularly involved in the following items:

1. Qualification of sub-criticality monitoring:
ECATS will take special responsibility for this topic:
   a) Contributing to instrumentation
   b) Participation in experiments on BFS
   c) Preparing theoretical foundations (if necessary) for modified/new techniques of subcriticality monitoring
   d) Processing and interpretation of all experimental data
   e) Preparing final reports and publications with evaluation and recommendations (selection of the technique, out-selection of non-performing techniques)

2. Validation of generic dynamic behavior of an ADS in a wide range of sub-critical levels, sub-criticality safety margins and thermal feedback effects:
   a) Detail investigations of possible experiments to "simulate" dynamics of SAD without altering the design principles
   b) Implementation – if appropriate – experimental techniques and participation en experiments
   c) Processing and interpretation of the data
   d) Report and recommendations

3. Validation of the core power/beam current relationship

ECATS takes full responsibility for this package, designing necessary detection system, participation in experiments, processing and interpretation of data, final reports and evaluations

4. Start-up and shut-down procedures, Instrumentation validation and specific dedicated experimentation

ECATS will be consultative partner. Full responsibility on the SAD-team. We can contribute with instrumentation.

5. Interpretation and validation of experimental data, Benchmarking and code validation activities etc
ECATS takes full responsibility for this package in a close collaboration with the SAD team.
ECATS is responsible for all simulations, code improvements, uncertainty analysis etc
SAD-team guarantees necessary precision of all material, istopic and geometry data.

6. Qualification of the proton beam reliability and the beam transport line, Pb-Bi or Pb-spallation target design in association with relevant proton beam and the effects of spallation residues including that of polonium

The SAD team responsible for this task. ECATS makes assessment of the target design, benchmarks all data on different targets.
Po- and post-irradiation investigation done by SAD team.

ECATS can take responsibility (with UMM involvement) for measurements on bare targets, such as: beam heating power, radiation fields around the target with the use of dosemeters and microdosimetric counters (for validation of calculations), time structures of the beam and the generated neutron field (original and with spectra modified by inserted moderators; also for testing the experimental equipment)

In beam transport issues ECATS may give some evaluations and feedback.

7. Safety and licensing issues of different component parts as well as that of the integrated system as a whole

The SAD-team fully responsible. Transfer of all documents to ECATS. Assessment and analysis done by ECATS. Feedback to the SAD team.

8. Radiation shielding and radiation doses

ECATS – co-partner (UMM group contributes to experiments). Simualtions and interpretation of results, final report done by ECATS.