Potential SAD activities with significant contribution from EU partners

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In addition to the contribution from W. Gudowski and C. Broeders, we propose below a list of actions that could help defining the working plan of SAD within ECATS, and where significant contributions from the European partners is expected.

a) BFS experiments during SAD construction

The proposal is to use the BFS assembly during SAD project preparation in a SAD-like configuration with a PNG (5 10^6 n/pulse, 1 μs pulse width, 20 Hz repetition rate). At BFS, subcriticality ranges from critical configuration down to deep subcriticality. This series of experiments should study and characterize a clean configuration built with lead and fuel similar to SAD. The two main objectives of this study will be: first, to allow the calibration of the simulation tools that will be used to model SAD; second, to allow the development of an experimental technique that can be transferred directly to the SAD facility to be during the start-up period for subcriticality measurements by PNS methods, and which will accumulate the experience from MUSE, YALINA and JINR experiments with IBR-30 booster. Additionally, if the schedule of SAD fuel fabrication and SAD construction allows it, it will be interesting the use of the actual SAD fuel in the BFS facility to determine its β_{eff} and to simulate the start-up phase of SAD.

These activities could be arranged in the following tasks:

1. Design of the most suitable BFS configurations
2. Set-up of the selected configurations
3. Calibration of the detectors and electronic chains present in BFS
4. Transport and tuning to BFS of the data acquisition systems used during the MUSE experiments
5. Calibration and monitoring of the (D-T) source during the experiments
6. Determination of the kinetic parameters of the system in the critical configuration
7. Kinetic experiments in subcritical configurations with k_{eff} = 0.95 and 0.97
8. Analysis of the experimental results
9. Detailed description of the configuration to be used as international benchmark (simulation code calibration)
10. To study the possibility to load BFS with the SAD fuel in a critical configuration in order to determine the kinetic parameter β_{eff} of SAD fuel.

b) Start-up experiments using the (D-T) source

The start-up phase will be highly influenced by the results obtained in BFS. It is foreseen that two configurations will be loaded during this phase of the experiments. First with k_{eff} = 0.97 and the final configuration with k_{eff} = 0.95. These two configurations will help validating the PNS reactivity measurement techniques for SAD. The objective for this phase is the calibration and implementation of different techniques (BFS and MUSE kinetic techniques), and to determine the reactivity of the system before initiating the accelerator phase.

These activities could be arranged in the following tasks:

1. Design of the two configurations
2. Set-up of the configurations
3. Calibration of the detectors and electronic chains present in SAD to work with low intensity source (pulse mode)
4. Transport and tuning to SAD of the data acquisition systems used during the MUSE and BFS experiments
5. Calibration and monitoring the (D-T) source
6. Validation of the thermal neutron shielding for diagnostic techniques
7. Estimation of SAD kinetic parameters with the simulation tools calibrated at BFS
8. Kinetic experiments in the subcritical configuration to determine the reactivity of the system
9. Analysis of the experimental results
10. To study of a core heating system to perform the kinetic experiments at the same temperature conditions that will be found with the proton accelerator

c) Test and calibration of the actual spallation target outside SAD

Although a series of experimental tests have been performed with a simulated target, it will be necessary to perform a calibration of the actual target foreseen for SAD.

These activities could be arranged in the following tasks:

1. Dedicated off-core cooling system for the spallation target
2. Set-up of the same detector systems as in the previous target experiments
3. Measurement of the neutron source intensity and energy distribution

d) Experiments using the 660 MeV proton accelerator

The experimental campaign using the proton accelerator will be carried on a configuration with k_{eff} around 0.95. The key point of this phase will be the validation of an experimental technique based on a power to reactivity relationship and of the electronics and analysis of kinetic reactivity determination methods at significant power. The first technique cannot provide an absolute reactivity monitoring, hence, the second will be used as a reference calibration. Several objectives should be covered in this phase. First, it should provide a guide to license a nuclear reactor coupled with a proton accelerator; second, it will be the first time reactivity determination techniques are experimentally validated at power. Third, it should allow the experimental validation of high energy transport and associated shielding requirements for radiological protection during operation. Fourth, it will provide the necessary tools to investigate the radiological effect of a spallation source in the decommissioning of ADS. Last, it will provide an extensive experimental data set that will allow the validation of computational tools used for the design of a future ADS.

These activities could be arranged in the following tasks:

1. Determination of the detectors and electronic chains required in SAD to work at full power
    i. Using fast extraction
    ii. Using slow extraction
2. Calibration of the detectors and electronic chains at full power

    i. Using fast extraction
    ii. Using slow extraction
3. Development and validation of new data acquisition systems adapted to work with current mode detectors for kinetic measurements
    i. Using fast extraction
    ii. Using slow extraction
4. Definition of experiments
    i. Using fast extraction (area method, slopes method)
    ii. Using slow extraction (source jerk, integrated slopes method, power to reactivity method)
    iii. Simulation support for the experiments
5. Monitoring of the accelerator and the importance of the source
    i. Online monitoring of the beam current
    ii. Monitor the number of neutrons per proton (part of source important)
    iii. Monitor the geometric distribution of primary neutron source (diagnostics for source importance)
6. Neutron fluence determination across large thickness shielding
    i. Definition and set-up of the detectors
    ii. Measurement of the neutron fluence after lead, concrete and iron shielding
    iii. Comparison with the results obtained by simulation codes
7. Determination of the effects of using the thermal neutron shielding in the kinetic experiments
8. Kinetic experiments using fast extraction mode of the accelerator: area method and slopes method
9. Kinetic experiments using slow extraction mode of the accelerator: source jerk and integrated slopes method
10. Calibration of SAD power
11. Determination of the techniques that will be used to calibrate the power to reactivity technique
12. Experiments of power to reactivity online monitoring
13. Feedback experiments
    i. Temperature variation of the fuel
    ii. Fast reactivity variation using insertion or extraction of absorbers
    iii. Oscillation of reactivity with absorbers and/or fissile material
14. Static and kinetic measurements of the axial and radial(?) fission rate traverses to validate simulation codes
15. Interpretation of the experimental results

e) Similarities and differences between the experimental results in different conditions (points a, b and d)

Extensive simulations should allow the calibration of simulation tools and the study of the correlation between the different reactivity determination techniques.

f) Post-irradiation experiments

1. Extensive post-irradiation program to determine the spallation fragments in the target and fission products in the fuel
2. The experimental results will be used to validate simulation tools and for international benchmarking