Neutron Spectroscopy at PIK Reactor in Gatchina

Subcommittee Spectroscopy (CREMLINplus WP3)

6th Working Group Meeting
Neutron Spectroscopy development for reactor PIK

26. November 2021

Meeting location: Online meeting

Subcommittee leader: K. Schmalzl

Subcommittee participants: V. García Sakai**,** E. Klementiev, J. Kulda, W. Lohstroh, M. Monkenbusch, J. Voigt

Excused: M. Russina

NRC KI PNPI presentations: S. Grigoriev, I. Zobkalo, Y. Kireenko, N. Kovalenko

Distributed: Subcommittee members, S. Grigoriev for further distribution

The infrastructure project CREMLINplus is dedicated to further enhance the European-Russian collaboration in the field of large-scale research infrastructures and projects. The main objective is to scientifically and technically develop and strongly advance Russian megascience projects, not only for Russian but also for international access.

Within the work-package WP3 the activities towards further development of the high-flux neutron reactor PIK in Gatchina are funded. An international scientific Advisory committee (PIK-SAC) was set up to give strategic recommendations. Instrument subcommittees provide specific recommendations on construction and layout of the instruments, while the technical subcommittees provide advice on moderators, neutron optics, detectors and sample environment.

In the present meeting the PNPI scientists have reported on the current status of the instrument construction as well as on the related difficulties and challenges.

The focus was on the thermal three-axis spectrometer (TAS) IN1 and on the cold TAS IN2, whose status of optimization calculations and of preliminary design has been discussed. We thank all the PNPI scientists for their presentations, for the information provided and for the lively discussions.

The commissioning of the PIK reactor started in 2019 with a test operation at a power of 100kW. A ramp up of its power up to 10 MW is still expected this year, with the full reactor power of up to 100 MW to be reached in 2023 and afterwards. The start of user operation is planned for 2024. The instrument construction has started in the beginning of this year and its completion is foreseen in 2024. In total 20 experimental stations should be installed in three stages, amongst them 13 instruments for condensed matter research, until 2024. Stage 2 has started and comprises four experimental stations, amongst them the thermal TAS IN1 in the reactor hall and the cold TAS IN2 in the guide hall. Completion of construction is envisaged for 2023. Further three spectroscopy instruments in the guide hall, the thermal TAS IN3, a time-of-flight spectrometer TOF (IN4) and neutron-spin-echo instrument (NSE) SEM are foreseen to be launched in stage 3 in 2022. For the cold TAS IN2 and for the TOF, which are now situated at the channels HEC-3 and HEC-2, respectively, the present floorplan provides different positions in the guide hall as compared to the last meeting. Whereas HEC-3 is fed by an already existing vertical cold neutron source, the design and possible bi-spectral character of the second horizontal cold neutron source at channel HEC-2 is still under discussion.

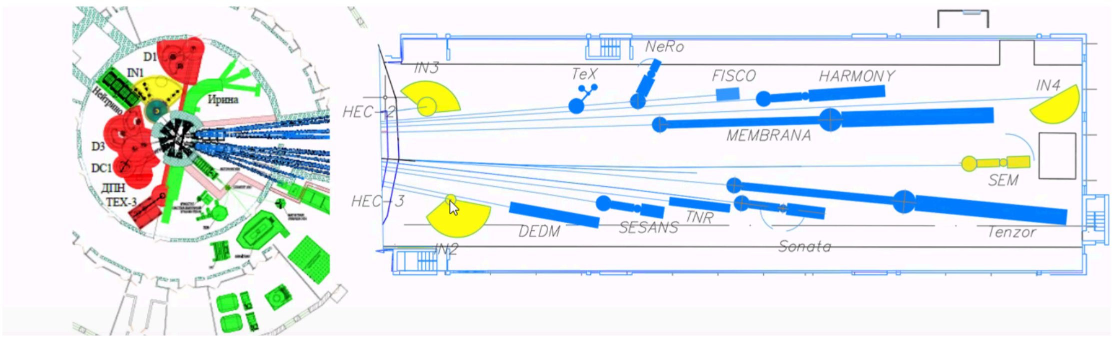

Figure: Floorplan of experimental stations in the reactor hall and in the neutron guide hall as presented in this meeting. The spectroscopy instruments are marked in yellow.

The subcommittee appreciated the presentations given by the PNPI scientists. We were encouraged by the progress that has been made since the last meeting. We have appreciated that the guide shielding has been incorporated into the floor plan. We were very pleased to see first iterations for the simulation of the biological protection of the TAS IN1 and IN2. They are an important piece of work, providing the basis for a detailed instrument design. We are looking forward to see further progress along this line.
We were also pleased to learn about a two-months visit of the future IN2 instrument scientist O. Usmanov at the FRMII in Munich to learn from existing TAS spectrometers and we encourage similar activities in the future.

General Recommendations:

- We understand that the present schedule of the instrument construction is imposed by the general funding scheme of the PIK project, nevertheless we would like to emphasize that the given timeline is unrealistic. Unexpected delays at all stages of instrument design and component procurement are highly probable and have to be anticipated, particularly in the course of the construction of first instruments of a given type. We strongly advise the PNPI teams to assess program risks and have mitigations in place for the PIK instrumentation program (at all levels, budget, resourcing, schedule).

- All instruments proposed for the reactor and guide halls, including those foreseen at a later stage towards developing a future international access program, have to be incorporated into a general floor plan with realistic footprints. In particular, estimates of adequate shielding for neutron guide systems must be incorporated into the floor plan.

- In the present meeting we have learned that the neutron guides that will serve all the instruments in the reactor hall and in the guide hall are foreseen to be fabricated in-house and have to be produced until 2023. As several kilometers of guides will be necessary, we strongly recommend to critically assess the real capacity for neutron guide production at the PNPI.

- For all the instruments to be built in the first round, it is of crucial importance to produce now, detailed conceptual design documentation, which will play a crucial role in the subsequent program steps (e.g., procurement). This will require appropriate resourcing. At present it appears that only two draftsmen and/or engineers will be available to work on the whole ensemble of the instrument projects, which is not sufficient for the amount of work this entails. This situation, if continued, will not only slow down the progress of the program but could lead to low quality documentation and will create significant risks. The subcommittee strongly recommends to allocate adequate design work resource to the instrument projects, and we estimate the need for an equivalent of about one year of full-time draftsman/engineer capacity per instrument to be built.

- We re-emphasize our previous recommendation that, in a first stage, the PNPI efforts should be concentrated on the construction of a single cold TAS, a single TOF and a single NSE spectrometer. The subcommittee strongly recommends, as a first priority, to concentrate on the design and construction of the cold TAS IN2 in the neutron guide hall. A modern state-of-the art cold-neutron TAS will provide an indispensable tool for investigations in quantum magnetism and in studies of modern functional materials being part of the forefront of current condensed matter physics

Recommendations Specific to the TAS Spectrometers:

- We reiterate our previous recommendation to thoroughly analyze the primary shielding and the platform needed for the thermal TAS IN1 in the reactor hall in terms of the allowed floor load (with a sufficient margin). With the primary spectrometer close to the reactor source these equipments may easily surpass a weight of 100 tons.

- The subcommittee stresses the importance of offering high magnetic fields both on the thermal TAS IN1 and on the cold TAS IN2 for state-of-the-art research in magnetism. Particular attention has to be paid to the design of the instruments and of their environment (shielding, platforms, cranes) in order not to interfere with stray fields of the magnets. It is to be expected that in the foreseeable future, cryomagnets with fields up to 25 Tesla will become available and will become highly requested in the context of the cold neutron spectroscopy (IN2), where fields of such a magnitude permit to directly influence the Hamiltonian of the investigated systems. In the same context possible interference with other instruments all over the guide hall has to be accounted for from the beginning (consideration for instrument positioning, in particular with spin-echo systems).

- We recommend using a symmetric focusing layout of the IN1 and IN2 instruments with equal distance of the virtual source and the sample from the monochromator to achieve a clean and symmetric beam profile. Also the shape of the beam profile will be better preserved with wavelength changes.

- In the experimental area for IN1 a rectangle has been marked as ‘not accessible’. This area would be highly important for lattice dynamics experiments. Here high momentum transfers (high scattering angles on the samples) in combination with high incident energies (low take-off angles on the monochromator) have to accessed frequently. We strongly recommend to explore the possibilities of a time-sharing access (partial platform removal for occasional access to the trap).

- We advise to build the neutron guide to IN2 with a guide width of 6-8 cm and a coating at the outer side of m=2.5. A higher coating would amplify higher orders in the guide and impact on the design of the velocity selector, of the polarizing cavity and of the shielding of the instrument.

- In addition, the team should consider boron-coating the lamellas of the selector, to reduce the shielding needed around the selector. For the velocity selector and the polarizing cavity, a detailed shielding study should be done.

Recommendations Specific to the TOF Spectrometer:

- No presentation dedicated to the TOF spectrometer was given, but the consideration of a future bi-spectral source will be beneficial for this instrument. Detailed simulations should be started in due time.

Recommendations Specific to the NSE Spectrometer:

- The subcommittee agrees with the proposition to build a resonance spin echo instrument with MIEZE option instead of a wide-angle spin-echo instrument. This option will fit within the available space in the guide hall which is limited due to neighboring instruments (SANS). A scientific case based on magnetism and in-house research already exists.

- In considering the appropriate positioning of this instrument, it is very important that the team consider proximity with the SANS machine Tensor and the use of magnets up to several Tesla for sample environment. Thus either an adequate heavy μ-metal shielding around the magnetically sensitive beam volume is indispensable and has to be calculated, or a new position for the NSE considered.