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Author(s)	Evgeniy Altinbaev NRC KI PNPI), Richard Hall Wilton (ESS)
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Neutron detector requirements for a pilot application on the neutron reflectometer SONATA at PIK

One of the activities of the CREMLINplus project is aimed to deepen the cooperation and develop the frontier technologies of registration of both, charged particles and neutrons. One of the objectives of the corresponding work package 7 “Joint development of detector technologies” is the development of next generation of neutron detectors. In order to fulfill the objective, the first deliverable to be reached is the collaborative definition of the specifications for the beyond state-of-art detector technology for the instrumentation of the Russian Megascience project PIK.

As a result of intense discussions between experts in the field of neutron registration from European and Russian research infrastructures and institutes ESS, JINR, NRC KI PNPI, UNIMIB, the field of neutron reflectometry was chosen as a perspective one for the implementation of novel technologies. As an object of implementation of novel detector technologies, the high-flux neutron reflectometer SONATA was chosen. The reflectometer SONATA is designed to study thin and atomically thin films, layered and laterally ordered structures, magnetism in these structures and processes at layer boundaries with fast kinetics, as well as at the interface between the solid and liquid phases. The use of polarized neutrons will significantly increase the potential of the instrument, since it will become possible to study the magnetism of the surfaces, layered and laterally ordered structures. Along with the classical scheme of polarized neutron reflectometry, a scheme with vector analysis of polarization will be implemented. Thus, it is possible to obtain more detailed and reliable information on the magnetic state of nanolayers, as well as to develop elements of innovative neutron spin (spin manipulation) optics.

The model of the reflectometer SONATA is shown in Fig. 1. The concept of the SONATA neutron reflectometer contains a number of innovations that define unique experimental possibilities:

- variation of operating wavelengths and time-of-flight resolution in fairly wide ranges, as well as complete elimination of parasitic slow neutrons (making the main contribution to the background) using a chopper with a limited passband;

- a combination of vertical and horizontal focusing onto the sample to achieve maximum possible fluxes with the option of reflectometry with a fan-shaped beam;

- polarization analysis in a wide range of angles using a fan-shaped analyzer;

- measurements with vector analysis of the polarization of the reflected beam;

- fast switching between survey modes: slit / quasi-point geometry; time-of-flight / constant wavelength technique; standard / fan beam option; unpolarized / polarized beam mode.

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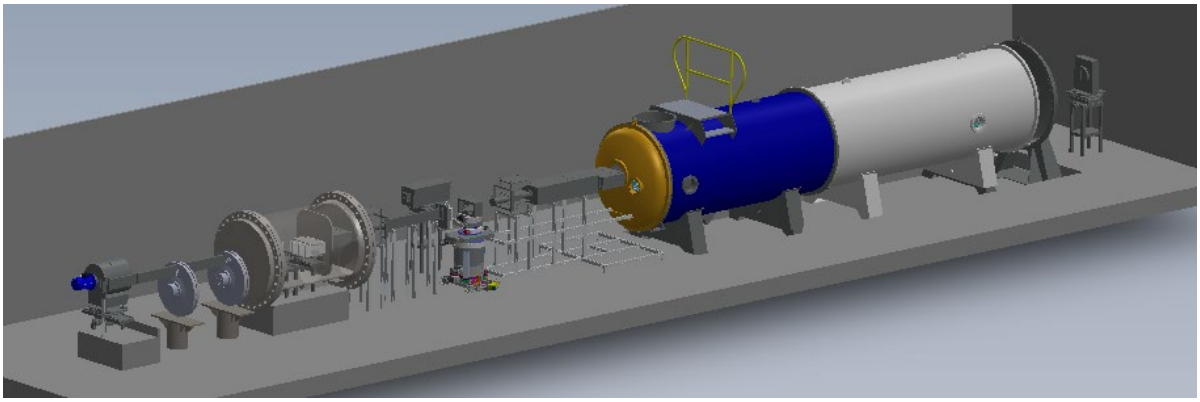

Fig. 1 Model of the future reflectometer SONATA at research reactor PIK.

The ambitious set of specifications for the chosen instrument require high efficiency, large sensitive area and a small pixel size for the neutron detector. On the basis of technology for neutron detection developed at ESS and ILL, namely “Multi-Blade”, the set of specifications for the detector for the neutron reflectometer SONATA at PIK has been elaborated as follows:

- Sensitive area: 100x130 mm^2
- Spatial resolution: 0.5x3.5 mm^2 (FWHM)
- Count rate: 100 MHz overall; 50 kHz per pixel at 10% dead time
- Efficiency: 44% for thermal neutrons with 2Å wavelength
- Neutron converter: Isotope Boron-10
- Detector type: multi-blade

Such detector system will enable to realize scientifically highly competitive research at the future SONATA reflectometer at PIK.

As a result of the planned cooperative work, the task of the development of Next Generation Neutron Detectors will be fulfilled and the objective on the development of next generation of neutron detectors will be reached.

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