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Spallation Neutron Source GNEIS[1]

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Abstract—A brief description of the spallation pulsed neutron source and neutron TOF spectrometer GNEIS based on the 1 GeV proton synchrocyclotron of PNPI in Gatchina is presented. The main parameters of the GNEIS are given in comparison with the analogous world-class facilities. The experimental capabilities of the GNEIS are demonstrated by the examples of some nuclear physics and applied research experiments carried out during four decades of its operation.

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DESCRIPTION OF NEUTRON SOURCE

The 1 GeV proton synchrocyclotron at the PNPI was commissioned in 1969. A few years later (1975), spallation neutron source and TOF spectrometer GNEIS have been developed at the accelerator and put into operation [1]. Since that time GNEIS was effectively used for neutron-nucleus interaction studies utilizing the time-of-flight technique over a wide range of neutron energies from thermal up to hundreds of MeV, both for basic nuclear physics and applied research. The water-cooled lead target ($40 \times 20 \times 5$ cm^3) of the GNEIS neutron source is located inside the accelerator vacuum chamber (Fig. 1) below the median plane. When the circulating proton bunch is deflected to strike the target, the short (~10 ns) pulses of fast neutrons are produced at a repetition rate of ≤50 Hz. At the average internal proton current of 3 μA and neutron yield of ~20 n/p for 1 GeV protons, the average intensity of fast neutrons is equal to ~3×10^{14} n/s. Neutron source is supplied with a polyethylene moderator ($30 \times 10 \times 5$ cm^3) located above the target and median plane. The target and moderator are moved remotely in vertical and radial directions for optimum position during the accelerator and neutron source tuning. Five neutron beams are transported using evacuated flight tubes through the 6 m thick heavy concrete shielding wall of the accelerator main room into the experimental hall of the GNEIS. The beams are equipped with brass/steel collimators, steel shutters and concrete/steel beam dumps. Measurement stations for experimental installations are located in the GNEIS building (15×30 m^2) at the flight path distances of 35–50 m. Neutron beams nos. 1–4, whose axes pass through the moderator, are characterized by a $1/E^{\alpha}$ ($\alpha = 0.65$–0.92) neutron spectrum shape being well suited for measurements at resonance energies (1 eV–100 KeV). Neutron beam no. 5, whose axis "looks" at the surface of bare lead target, has a typical spectrum shape with spallation and cascade components in the neutron energy range 0.1–1000 MeV.

COMPARISON WITH OTHER FACILITIES

At present, on the European neutron landscape 4 pulsed neutron sources located in Russia can be specified, namely: GNEIS (Gatchina), IREN and IBR-2 (Dubna), IN-06 (Troitsk). Currently, only first 2 facilities are used for neutron resonance TOF spectroscopy and only the GNEIS effectively competes with the best neutron sources/TOF facilities operated in other countries. In Table 1 below, a comparison of the GNEIS with the world-class facilities is given. It should be emphasized that the GNEIS and other spallation neutron sources have much higher upper limit of neutron spectra (up to 1 GeV) than those based on the electron Linacs (below 100 MeV). This feature makes spallation neutron sources indispensable for investigations at intermediate energies (several hundred MeV).

EXPERIMENTS AT THE GNEIS

High intensity and energy resolution of the GNEIS enable to perform measurements of neutron total and partial cross sections (e.g. capture, fission, etc.) with high precision and reliability. In the inserts of Fig. 1 are shown titles of the main experiments carried out at the GNEIS. The first one was dedicated to study of the $(n,\gamma f)$-reaction in ^{235}U and ^{239}Pu in energy range 1–200 eV, which means a neutron-induced fission after

[1] The article is published in the original.

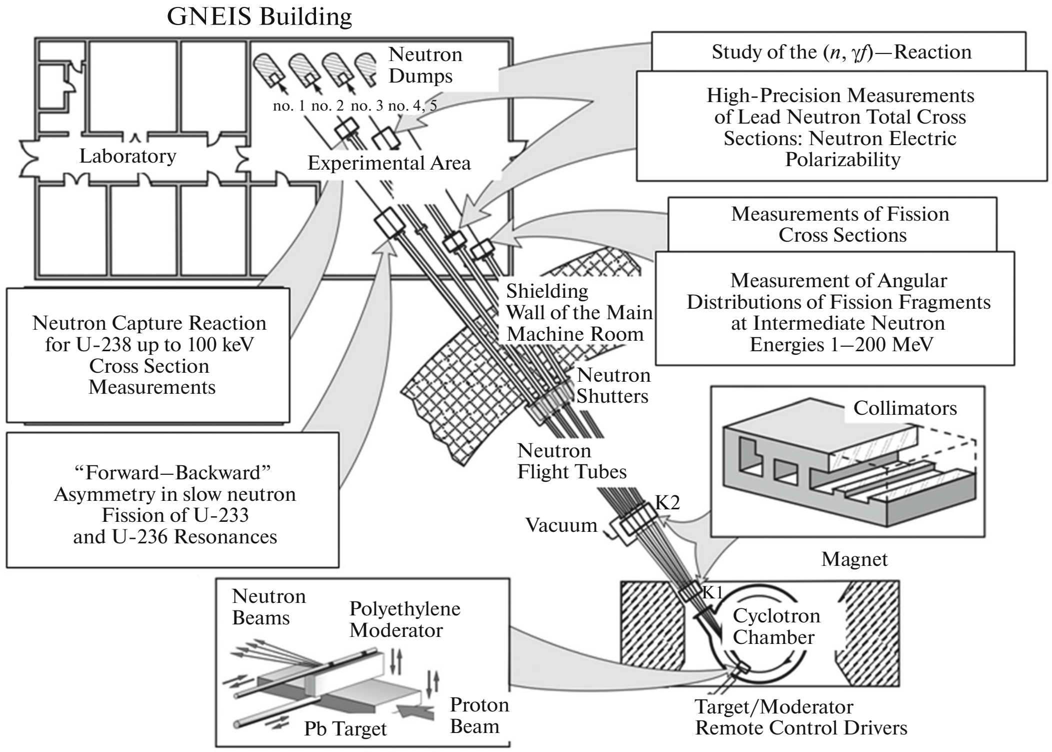

Fig. 1. General layout of the GNEIS facility.

preliminary emission of one or more γ-quanta [2, 3]. In the other experiment, a so-called "class-II" 720 eV—resonance was investigated in the subthreshold fission of ^{238}U [3]. An accuracy of the cross section measurements of the next experiment [4] was increased from 1–2% [2, 3] to 0.2–0.5% per point with the aim to evaluate effect of "forward-backward" asymmetry of fission fragments and parameters of the very weak p-resonances non-observed by usual methods in slow neutron fission of ^{233}U and ^{235}U. A value of neutron electric polarizability was reliably obtained from the results of high-precision measurements of total cross sections of lead isotopes below 10 keV [5]. The unique experimental data for a number of actinides and non-fissile nuclei have been obtained from the measurements of fission cross sections [6, 7] and fission fragment anisotropy [8] in the energy range 1–200 MeV, where the GNEIS successfully competes with LANSCE and n_TOF. During the last years, a neutron beam no. 5 of the GNEIS with atmospheric-like neu-

Table 1. Parameters of the GNEIS and other neutron sources. A quality coefficient of the neutron source is defined as: intensity/(pulse width)^2. The quality coefficient value marked by*) corresponds to 10 ns pulse width

Neutron source (laboratory)	Intensity (10^{15} n/s)	Pulse width, ns	Quality (10^{30} n/s^3)
GNEIS (PNPI, Gatchina)	0.3	10	3.0
IREN (JINR, Dubna, project)	1.0	400	0.0062
n_TOF (CERN, Switzerland)	0.4	6	11
LANSCE (LANL, USA)	10	1–125	100*)
ORELA (ORNL, USA)	0.13	2–30	1.3*)
GELINA (IRMM, Belgium)	0.025	1	25

tron spectrum is intensively used for radiation testing of the electronic components [9].

CONCLUSIONS

Owing to its unique parameters, the GNEIS neutron source and TOF spectrometer still occupy an important place in the world list of neutron facilities effectively used for science and technology. It would be impossible without the efforts of many people at the Petersburg Nuclear Physics Institute whose creative activity and kind assistance are highly appreciated.

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