Testing of the multiplayer neutron detector on the LPI neutron channel

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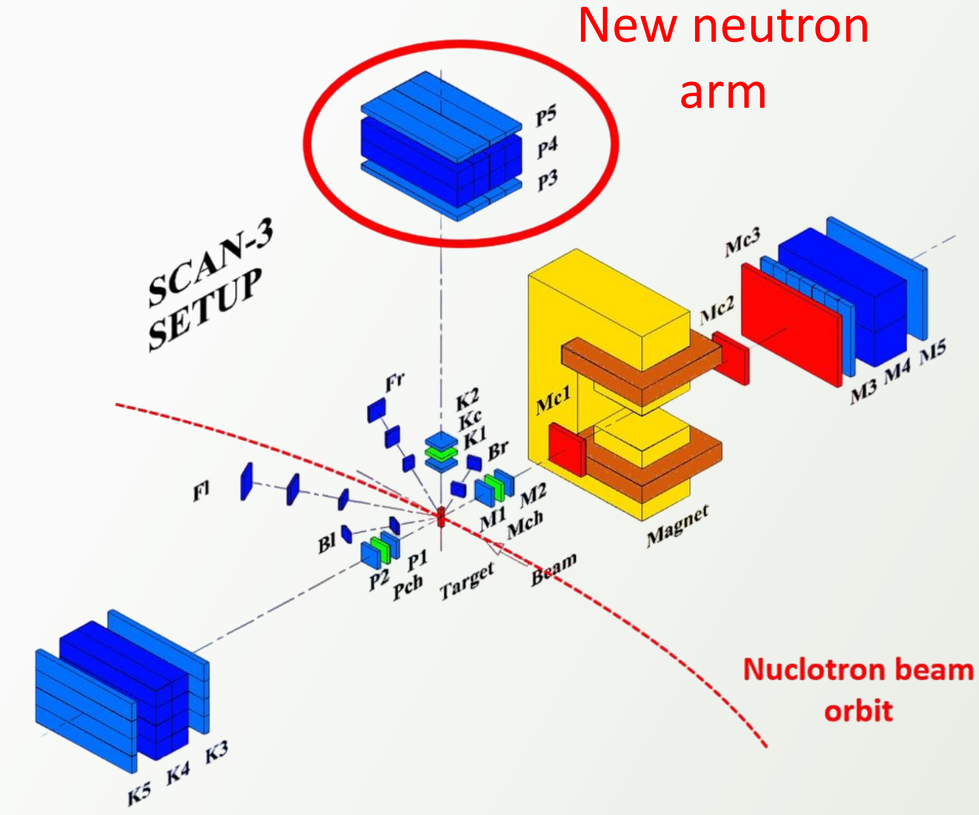
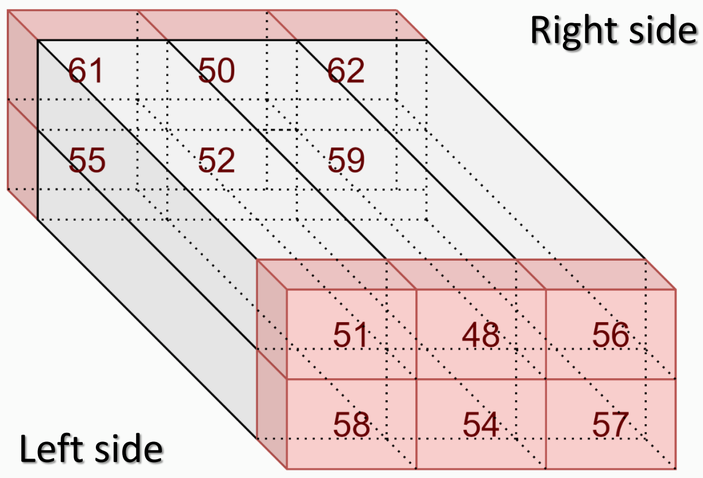
Abstract. *One of the SCAN-3 multilayer neutron detectors on the neutron channel in LPI (Troitsk) has been studied. The photodisintegration reaction of a deuteron was used to form a neutron beam. The report describes the procedure for creating a neutron channel, the channel parameters, as well as the results obtained during the work.*

The SCAN-3 spectrometer [1] is designed to detect charged particles ($\pi^{\pm}$, $K^{\pm}$, p), neutrons and nuclei fragments with low energy produced in the target by collisions of the Nuclotron beam particles with target nuclei. One of the tasks of the spectrometer is to detect neutrons from the decay of the η-meson nucleus via $n\pi$- and pn- channels. To reach the required accuracy of neutron energy measurements in energy region 90÷300 MeV, it is necessary to measure the TOF (δt) of neutrons with an accuracy not lower than δt = 400 ps and δL = 8 cm (spatial resolution) simultaneously.

A 24-items neutron scintillation detector divided into 6 independent modules (P-arm) has been developed to solve this complex problem. Each module of the P-arm consists of four scintillation blocks collected to a unified assembly [2]. It is necessary to achieve the required spatial resolution. Dimensions on each item are 800×180×30 mm^3. Extraction of signals from blocks is performed by two independent sets of PMTs: Hamamatsu R1250 (or Philips XP2041) and PMT-87 (or Philips XP2972). The total number of channels for each module is 10.





The P-arm of the SCAN-3 spectrometer represent a 3×2 modules setup as shown in the picture. Passing the high energy neutrons in energy region 90÷300 MeV through the P-arm detector, it interact on average with 2÷3 scintillators per module [3]. Thus, P-arm has efficiency of neutron registration is about 25%.

As a result of tests of the P-arm detector modules on cosmic rays, the time resolution of modules are 250÷270 ps for modules with readout by Hamamatsu R1250 and 770÷830 ps for modules with readout by Philips XP2041. The time resolution of individual blocks with readout by Philips XP2972 is about 620÷650 ps obtained under irradiation by cosmic rays.

A channel of labeled neutrons is required to tests the neutron detectors of SCAN-3 in real conditions. A deuteron photodisintegration reaction was used to form labeled neutron beam. For this task, two-arm facility has been created at the P.N. Lebedev Physical Institute of the RAS (LPI). The facility consist of a neutron arm with the modules under study and a proton arm. The main elements of the setup are: a photons beam forming system, a thin deuterated polyethylene target $(C_2D_4)_n$, a fast trigger counter, a proton scintillation detector, oriented by 90±2.7 degrees to the gamma beam axis, and a neutron detector located by 60±5.5 degrees to the beam axis to isolate events with the required energy. The intensity of equivalent photons at the channel is $2 \cdot 10^9$ photons/s what should ensure the intensity of neutron events in a fixed angular range is about 1 neutron/s.

Two test shifts were conducted to set up the channel of labeled neutrons in the middle of 2024. However, due to technical problems at the LPI accelerator, it was not possible to carry out full-fledged measurements of the multilayer neutron modules. It is expected to complete testing of all modules and return them back to the SCAN-3 spectrometer by the middle of 2025 (by the planned launch time of the NICA accelerator complex).

Summary

- A channel of labeled neutrons to test the SCAN-3 neutron detectors has been developed.
- The first measurements were carried out at the facility, and the first events of labeled neutrons were obtained.
- It is planned to conduct full complex studies of the SCAN-3 neutron detectors in 2025 on the created neutron channel at LPI (Troitsk).

References

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3. ***S.V. Afanasev et al.*** *Upgrade of the SCAN-3 Spectrometer at Nuclotron. Physics of Particles and Nuclei Letters, 2023, Vol. 20, No. 5, pp. 1232–1235.*

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