Upgrade of the SCAN-3 spectrometer at Nuclotron

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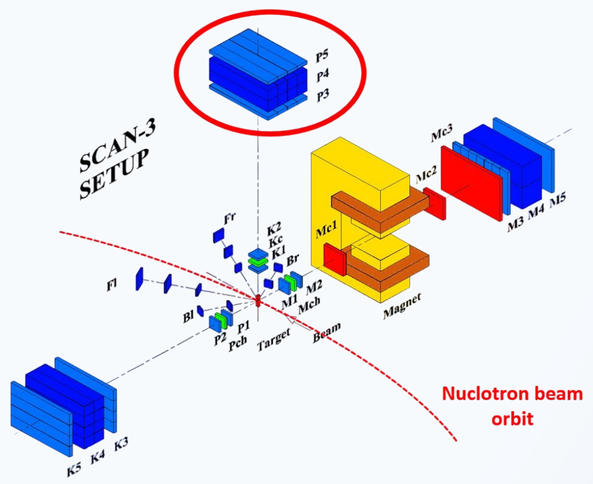
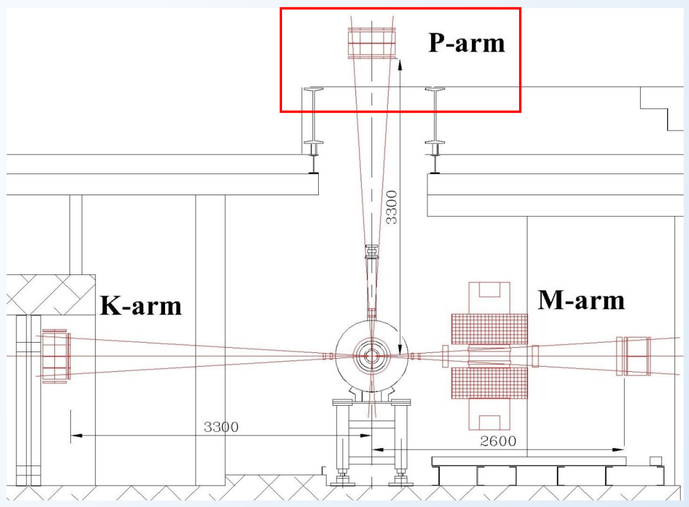
Abstract. *The SCAN-3 spectrometer has been upgraded to the three-arm configuration. A new arm was added to the spectrometer in 2022. The arm represents a setup of six multilayer neutron detectors orientated under 90 degree to other arms. The main aim of the additional arm is the determination of background components of the studied processes with the registration of correlated pairs by the TOF method.*

The SCAN-3 spectrometer

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 high-interactive 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 100÷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.





Assembling of the multilayer neutron detector

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 80 x 18 x 3 cm^3. Scintillation blocks (material: PVT) for modules were selected by light attenuation length and grouped by similar characteristics.

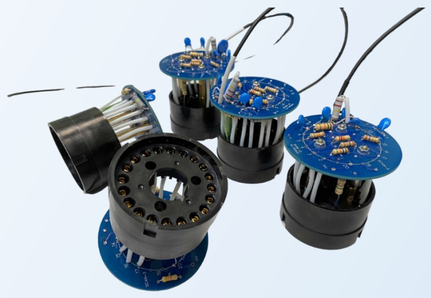
Extraction of signals from blocks is performed by two independent sets of PMTs:

- Two Philips XP2041 (or Hamamatsu R1250) PMTs located on opposite ends of the blocks provide simultaneous readout of signals from all blocks.
- Two PMT-87s located on opposite ends of the blocks provide readout of optical signals from each scintillator. This allows getting additional and independent measures from each individual block.

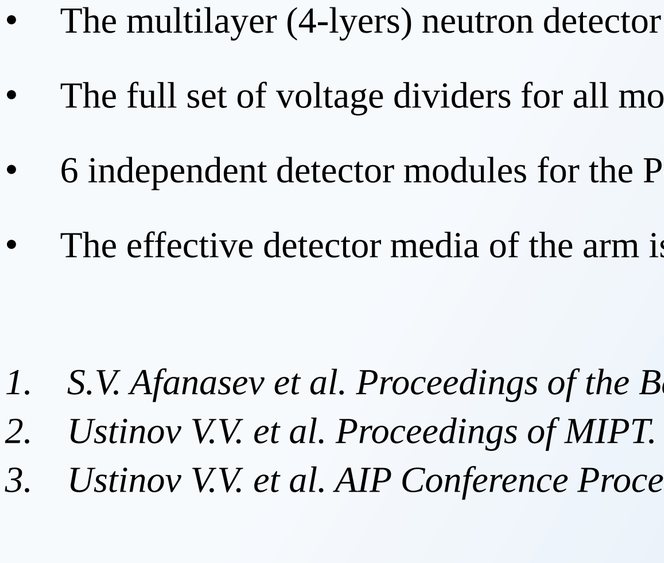
Total readout channels of each module is 10. Additionally, the calibration system based on the optical fibers is installed inside the module to monitor each channel.

The temporal resolution not lower 200 ps and the spatial resolution not lower 3 cm (longitudinal as well as transverse coordinate) are expected for four-layer detector based on the testing of previous prototypes of multilayer neutron detector [2, 3].

Moreover, mass production of voltage dividers for PMT-87 and XP2041 has been performed. There are 14-stage voltage dividers for PMT-87 (48 pcs. for P-arm) and 20-stage voltage dividers for XP2041 (6 pcs. for P-arm).



Installation of the P-arm - October 2022



The P-arm of the SCAN-3 spectrometer represents a 3x2 modules setup. Installation of all modules in the arm was completed in 2022.

When neutrons pass through the detector, they interact with an average of two scintillators in each module. Since the thickness of one layer in the module is 3 cm, the total detector media of the whole arm is 24 cm. This roughly corresponds to 25% neutron registration efficiency.

LeCroy discriminators and VME TDC modules for the PMT-87 and VME TQDC module for the XP2041/R1250 are used as readout electronics.

Summary

- The multilayer (4-lyers) neutron detector has been developed. The detector is based on the 3 cm PVT scintillation plates.
- The full set of voltage dividers for all modules (6) have been produced.
- 6 independent detector modules for the P-arm have been production. A 24-items detector (P-arm) is ready for operation.
- The effective detector media of the arm is 24 cm, what corresponds to neutron registration efficiency which is about 25%.

References:

1. *S.V. Afanasev et al. Proceedings of the Baldin ISHEPP XXIII, EPJ Web of Conferences 138, 09002 (2017).*
2. *Ustinov V.V. et al. Proceedings of MIPT. 2021. V. 13, N 3. P. 122–132.*
3. *Ustinov V.V. et al. AIP Conference Proceedings 2377, 030018 (2021).*

AYSS-2022, JINR