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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 deg 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 time-of-flight method (TOF). Moreover by the SCAN-3 spectrometer will be studied η-mesonic nuclei.

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INTRODUCTION

The SCAN-3 spectrometer [1] is designed to detect charged particles ($\pi^{\pm}$, $K^{\pm}$, p), neutrons and the low energy nuclei fragments produced in collisions of the NUCLOTRON high energy beam particles on a different targets. 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 precision of neutron energy measurements, it is necessary to measure the of neutrons by the time-of-flight method with a time resolution not lower than σ_t = 400 ns and spatial resolution not lower than σ_L = 8 cm. A new scintillation detector (P-arm) has been developed to solve this complex problem.

ASSEMBLING OF THE MULTILAYER NEUTRON DETECTORS

The P-arm has been designed as a six independent modules. Each module consists of four scintillation blocks assembled to a unified cluster (Fig. 1) [2]. Thus, the P-arm represents a 24-item scintilattion detector. Such configuration is used to achieve the required spatial resolution. Dimensions on each item in the modul are $80 \times 18 \times 3$ cm^3. The scintillation blocks (material: PMMA) of each module were selected and grouped by light attenuation length (Fig. 2).

Extraction of signals from blocks is performed by two independent sets of PMTs [2]:

• Two Philips XP2041 (or Hamamatsu R1250) PMTs located on opposite sides of the cluster and

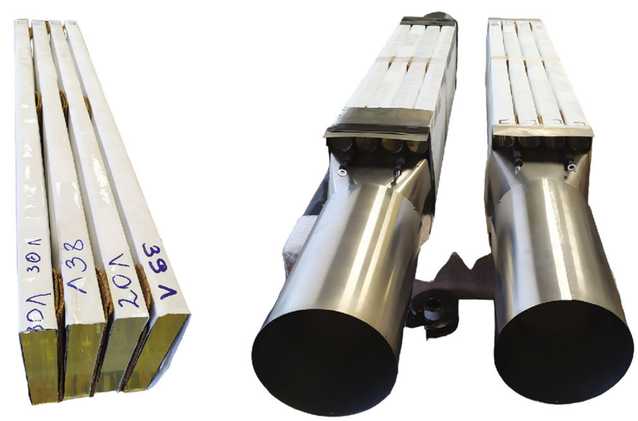

Fig. 1. Assembling of four-layer cluster from scintillation blocks.

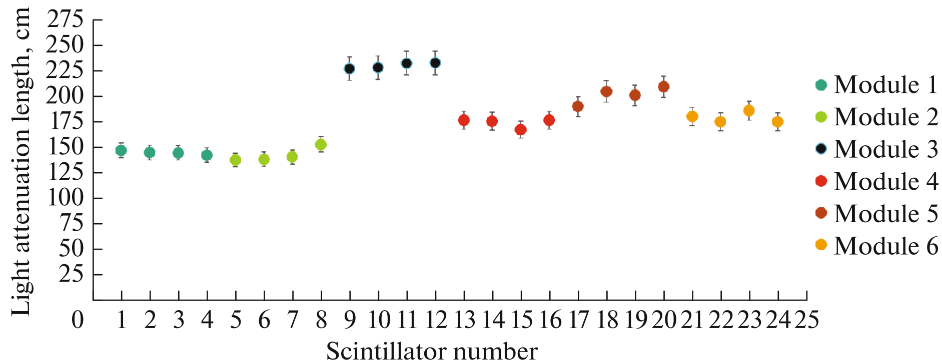

Fig. 2. Selection of scintillation blocks for each module.

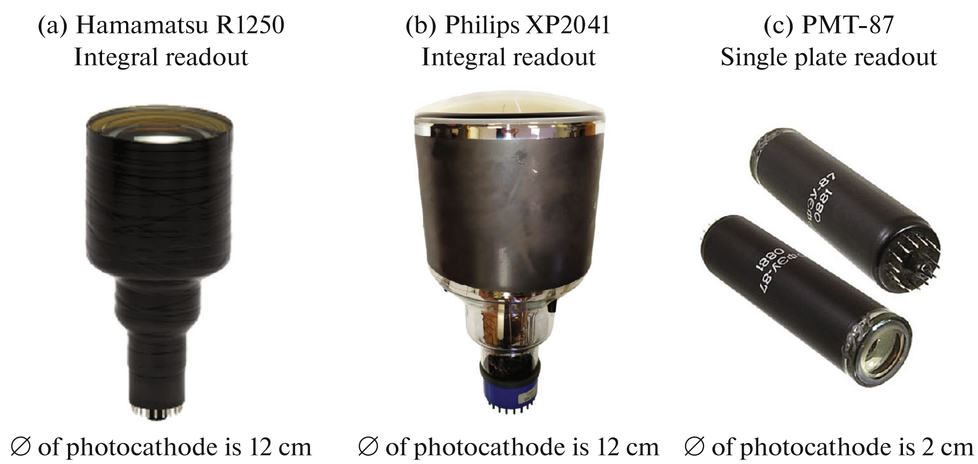

Fig. 3. Optical parts of detectors.

readout all scintillation blocks simultaneously (Figs. 3a, 3b).

• Two PMT-87s located on opposite sides of the individual block. This way provide readout of optical signals from each independently scintillator (Fig. 3c). It allows to get the additional time signal information from each individual block.

The total number of channels for module is 10: 2 channels from XP2041 and 8 channels from PMT-87. Additionally, the calibration system based on the optical fibers is installed inside the module to control each channel.

The time resolution σ_t < 200 ps and the spatial resolution of 3 cm (both longitudinal and transverse coordinates) are expected for 4-lyaer detector. The data based on the results of previous tests [2, 3].

The mass production of voltage dividers for PMT-87 and XP2041 has been performed to equip all detectors. 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

The P-arm layout of the SCAN-3 spectrometer represents a 3 × 2 modules setup as shown at Fig. 4. Installation of all modules in the arm is performed in 2022 (Fig. 5).

Passing the high energy neutrons (energy region 90–300 MeV) through the P-arm detector, interact on average with 2–3 scintillators per module (Fig. 2) [3]. Since the thickness of one layer in the module is 3 cm, the total detector media is 24 cm. This approximately corresponds to 25% neutron registration efficiency.

A two types of the readout electronics has been installed to collect data:

• LeCroy 3412 discriminators and VME TDC64 modules to detect time signals from the PMT-87;

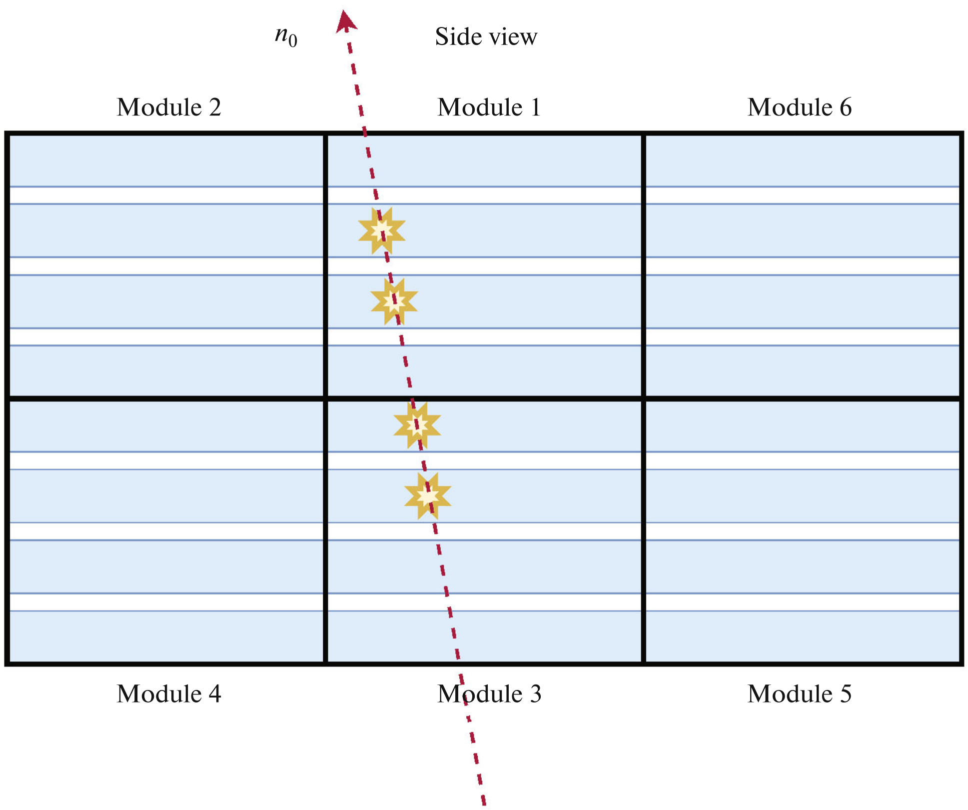

Fig. 4. Simulation of the neutron passage thought a 24-item neutron detector.

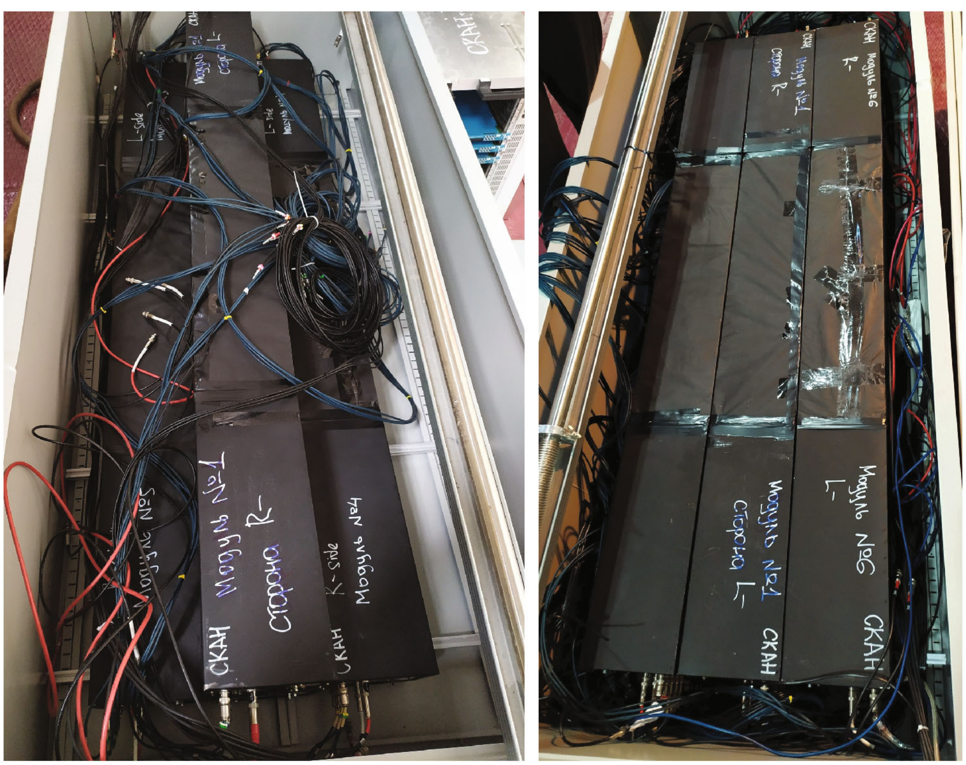

Fig. 5. Installation of the modules in the P-arm.

• VME TQDC16 modules to direct detect time signals from the XP2041/R1250 and to organizate internal trigger.

CONCLUSIONS

The six independent modules of neutron detector for the P-arm have been produced. Thus, a 24-item neutron detector is ready for operation. The effective detector media of the arm is 24 cm, which corresponds to the neutron registration effciency of about 25%.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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