# Tests of scintillation Fibers for the compact neutron Detector NeuRad*

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**We have constructed three prototypes of the fiber-based scintillation neutron detector and tested their light yield in response to $\gamma$-ray sources. The derived energy threshold of detection of protons scattered by incident neutrons in the prototypes is 0.5 MeV.**

The theoretical and experimental ways of searches for neutron radioactivity expected for exotic extremely neutron-rich nuclei have been recently proposed [1]. The first indication on this not-observed yet phenomenon has been obtained [3] for $^{26}$O whose lifetime is 4 ps. Such a lifetime of $^{26}$O should correspond to the very small decay energy of 1 keV [2] which is difficult to measure with the present neutron detectors. The experiment on observation of the neutron radioactivity can be performed at the Super-FRS with a suitable neutron detector. In the proposed tracking experiment, radioactive beam produces short-lived isotopes which decay in flight. The fragments resulted from the neutron radioactivity are detected by tracking detectors which determine the vertex point of the radioactive decay. The neutron detector provides spatial coordinates of neutrons and their angles respective to the heavy residue. Since the expected angles are extremely small, the neutron detector should have a fine spatial resolution.

The neutron detector NeuRad (Neutron Radioactivity) with a high spatial resolution has been proposed for future experiments at the Super-FRS NUSTAR [4]. The detector is based on spaghetti-like scintillation fibers with small cross areas. Neutrons scattered in fibers produce recoil protons causing light flashes which are optically trapped inside the fibers and then are read-out on both fiber ends. We have tested multi-clad fibers BCF12 (produced by Saint Gobain) whose dimensions of $2 \times 2 \times 250$ mm$^3$ allow for a fine spatial resolution.

We have assembled three samples of the fibers: (i) without additional painting of fibers, (ii) with a white paint on each fiber in order to prevent a light cross-talk between the fibers, and (iii) with a black paint. Each sample consisted of 64 fibers assembled into a $8 \times 8$ bundle whose end has been glued by epoxy glue and polished by using a diamond tool. The test setup comprised of the fiber bundle viewed by the PMT Hamamatsu R7600 followed by the fast amplifier, the 5 GHz digital oscilloscope with the spectroscopic functions, and the sources of $\gamma$-rays, $^{137}$Cs and $^{60}$Co. The light flashes cased in fibers by the Compton-scattered $\gamma$ rays were converted into the electrical signals, amplified and directed into the oscilloscope where the amplitude spectra were accumulated. All spectra had the shapes typical for a Compton effect. The maximum energies of the Compton spectra (i.e., Compton edges) are 1118 keV for $^{60}$Co and 477 keV for $^{137}$Cs. The respective maximal amplitudes of signals allowed to produce calibration curves for each sample, which is shown in Fig. 1. The values of maximal amplitudes *A* were obtained by fitting the spectra tails corresponding to the Compton edges.

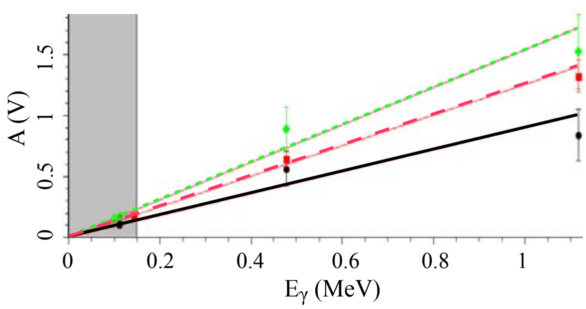


Figure 1: The calibration curves for all prototypes of the fibers scintillation detector NeuRad. The solid, dashed and dotted lines correspond to the black-painted, white-painted and not-painted prototypes, respectively. The grey area shows the threshold of $\gamma$-ray detection.

The obtained calibrations allow to find the detection thresholds for each fiber prototype. The amplitude range where the Compton effect disappears in the measured spectrum are shown by the grey area (see Fig. 1) whose highest value corresponds to the concluded threshold energy. The highest threshold is in the black prototype, of 160 keV. The assumed total systematic uncertainty is 20%.

In summary, the measured light yields and the derived detection thresholds of the three prototypes of the scintillating fibers BCF12 have demonstrated detection of $\gamma$-rays at least down to 160 keV. Thus the lowest-measured energy of protons scattered by incident neutrons should be 500 keV. This conclusion opens a way for more tests of the NeuRad performance, in particular its spacial and time resolutions.

## References

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