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Using passive converters to enhance detection efficiency of 100-MeV neutrons

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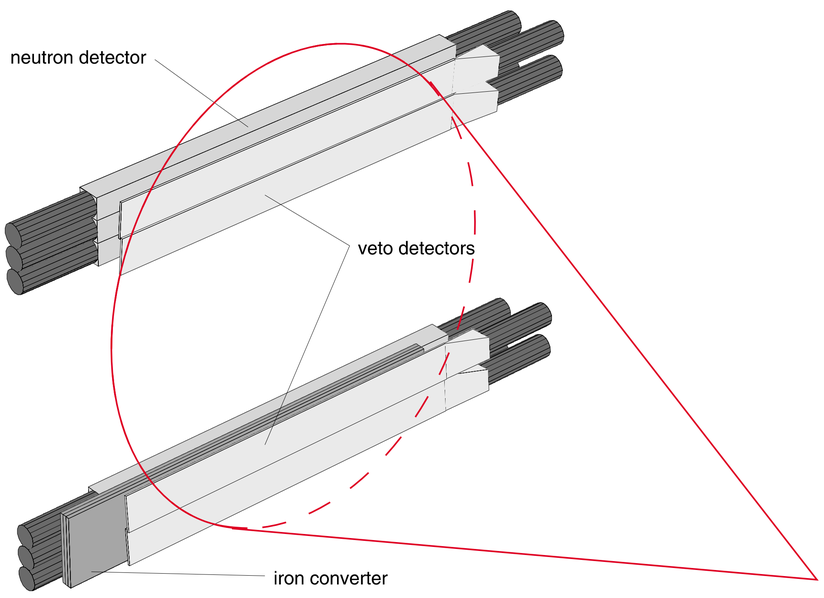
Abstract The effect of passive iron converters on the detection efficiency of neutrons in a plastic scintillator was investigated at energies of 20 to 140 MeV. An enhanced detection efficiency for neutron energies above 70 MeV was found using iron converters of 2–3 cm thickness. The experimental results are compared to a simulation.

Motivation Passive converters are widely applied in neutron calorimeters used for high-energy physics experiments. However, experimental data for an iron-plastic combination at energies around 100 MeV do not exist. With the presented experiment, we determined the lower energy limit for increasing the detection efficiency of a plastic scintillator by adding a passive iron converter.

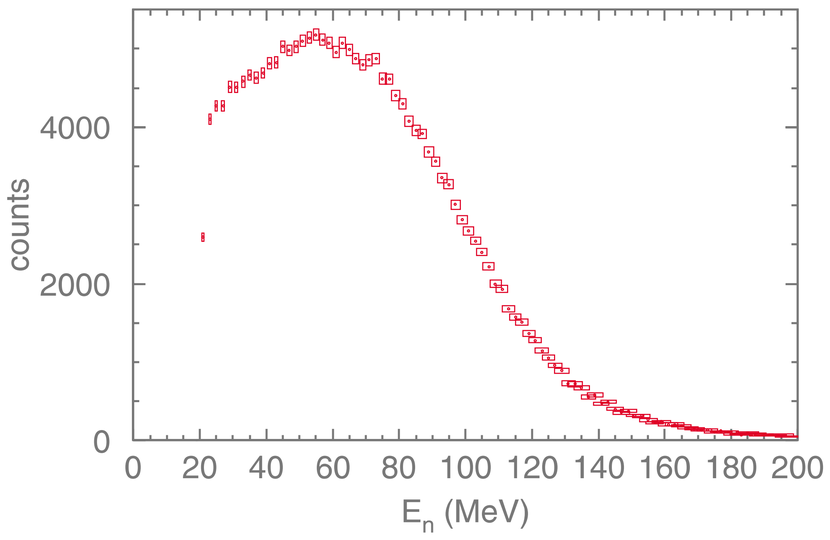


Schematic view of the detector setup. The lower detector set is equipped with a converter. Red lines indicate the cone of emitted neutrons.

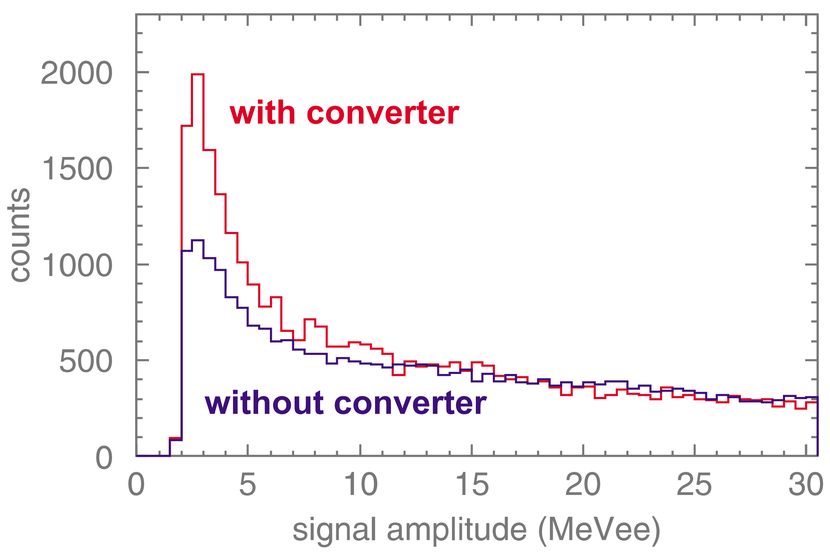
Schematic cross section of the experimental setup.

Experiment The experiment was performed at the RIKEN Accelerator Research Facility.

- Neutrons from 100 MeV/u ^{13}C impinging on a 2 cm Al target.
- Gamma-separation by time of flight.
- Two symmetrically arranged identical detector sets (part of the NEUT detector array [2]).
- One of the detector sets equipped with 2 or 3 cm iron converter.



Measured neutron energy distribution. Errors based on the time resolution and statistics are indicated by rectangles.

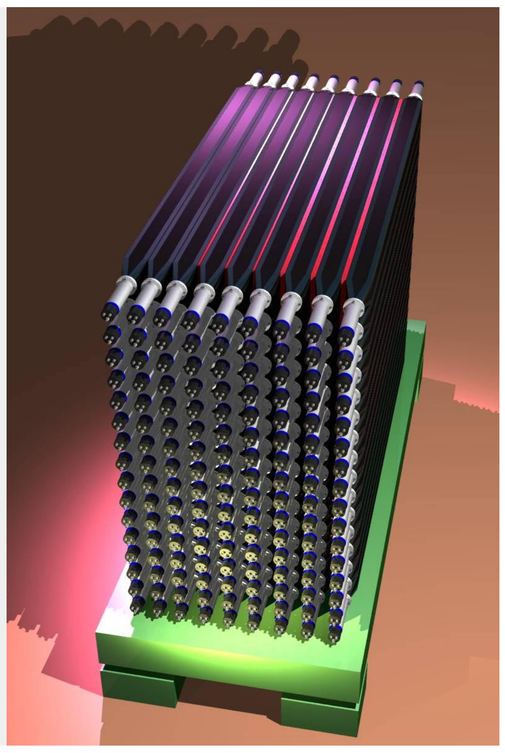


Measured signal amplitudes for 90–100 MeV neutrons with a 2 MeVee threshold cut. The blue histogram represents the energy spectrum of a detector set without converter, while the red histogram shows the spectrum of a detector set with 3 cm iron converter.

The image to the right shows a conceptual view of the Modular Neutron Array (MoNA), which will employ passive iron converters in order to boost detection efficiency for neutrons with energies above 100 MeV.

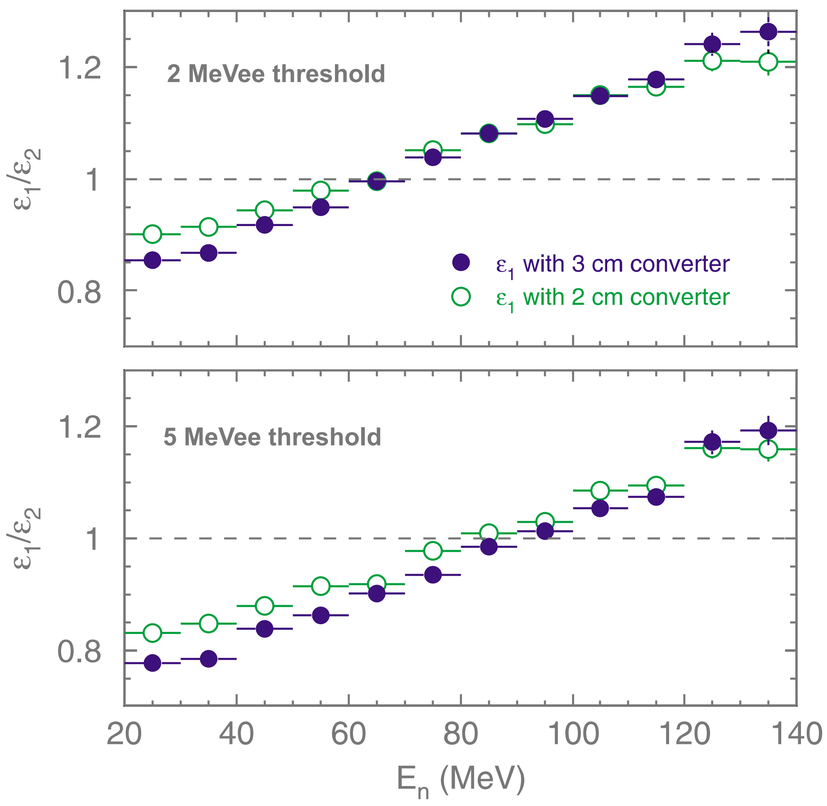
The converters (red) are placed in front of the last six layers of the array.

For more information, see the poster on MoNA in this session (#2214 by B. Luther).

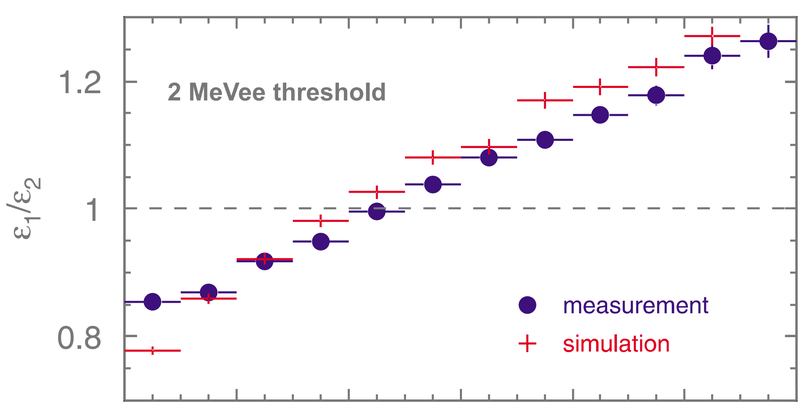


Results The results of this experiment are presented as detection efficiency ratios in dependence of neutron energy. An efficiency ratio larger than one indicates an enhancement of detection efficiency by the passive converter.

- For neutrons below 70 MeV the detection efficiency is reduced by the converter.
- Above 100 MeV neutron energy, the converter improves detection efficiency by at least 10% (2 MeVee threshold cutoff).
- The increase in detection efficiency depends on the threshold setting.



Experimental efficiency ratios for two different converter thicknesses and two different threshold cutoff values.



Comparison of experimentally determined efficiency ratios and data from GEANT [3] simulations employing a 3 cm converter. The comparison is shown for two different threshold values.

References

[1] Th. Blaich et al., Nucl. Instr. and Meth. A314 (1992) 136.
[2] T. Nakamura et al, Phys. Lett. B 331 (1994) 296.
[3] GEANT Detector Description and Simulation Tool, available at http://wwwinfo.cern.ch/asd/geant/.

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