NeuLAND demonstrator performance in EOS experiments

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The NeuLAND demonstrator is a fraction of the neutron detector R^{3}B-NeuLAND[1)], which is being built at FAIR in Germany. Since the beginning of 2015, it has been used within the SAMURAI experimental setup at RIKEN. It consists of 400 plastic scintillator bars arranged in 8 planes with 50 bars oriented either horizontally or vertically. The size of each bar is 250×250×5 cm^3, which makes the total depth of detector 40 cm.

The detector is usually placed at 0° to the beam line downstream of the SAMURAI magnet to detect neutrons from peripheral reactions of a radioactive beam particle on a target, whereas charged particles are bent away. A VETO detector consisting of eight 1-cm-thick plastic scintillator paddles is mounted in front of NeuLAND to reject background, mostly produced from beam-like particles in the fragment branch (typically ~5% of events).

In the experiments S015 and S022 (April/May 2016),[2)] where the nuclear EOS was studied in central collisions of Sn isotopes, the detector was placed at 30° to the beam line. The proton/neutron and triton/^{3}He yield ratios and flows were measured. NeuLAND was used to detect light charged particles, such as hydrogen and helium ions, together with neutrons and gammas. The VETO detector in this study of central collisions plays an essential role for the distinction of charged and neutral particles in contrast to other experiments, where neutrons are expected to be dominant and the VETO serves for background discrimination only.

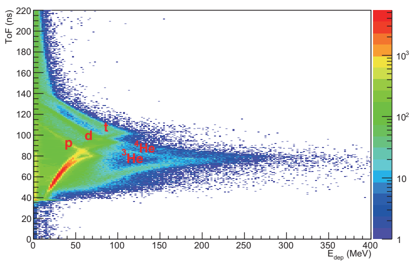

Fig. 1. Particle identification plot in the 1st plane.

A considerable amount of light charged particles (~40% of events) with a large range of energies (from zero to the beam energy) was detected in the NeuLAND demonstrator. Figure 1 shows the time of flight vs. deposited energy in the first plane of NeuLAND. The spectrum exhibits characteristic lines for the various charged particles, and protons, deuterons, tritons, ^{3}He, and ^{4}He are identified.

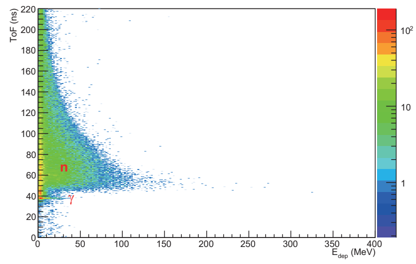

Fig. 2. Particle identification plot in the 1st plane with a strong VETO condition.

To check the performance of the suppression of charged particles, the same spectrum was produced again (Fig. 2) with a condition on events where no hit was recorded in the full VETO detector (strong VETO condition). A loss of neutrons with that condition was evaluated from Geant simulations, and it was on a percent level.

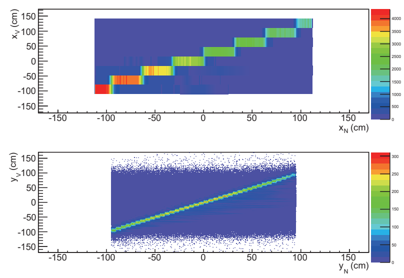

Fig. 3. Spatial correlation between hits in NeuLAND and VETO detectors.

In order to analyze charged particles and neutrons in the same events, a more elaborated VETO analysis is under investigation, including spatial correlation between hits in NeuLAND (x_N, y_N) and VETO (x_V, y_V) (Fig. 3), as well as timing correlations. The set of VETO hits needs to be linked to hits in NeuLAND to determine unambiguously which NeuLAND hits originate from charged particles and which from neutrons.

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References
1) http://www.fair-center.de/fileadmin/fair/experiments/NUSTAR/Pdf/TDRs/NeuLAND-TDR-Web.pdf.
2) R. Shane et al. Nucl. Instr. Meth. A **784**, 513 (2015).