Neutron response of the HADES time-of-flight detectors*

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In the HADES detector, charged-hadron ID is based mostly on energy-loss, momentum and time-of-flight information [1]. The latter, in particular, is obtained from resistive-plate chambers, the RPC [2], at small polar angles ($15° - 45°$) and from plastic scintillators, the TOF [3], at large angles ($45° - 85°$). Using data gathered in August 2014 with a secondary pion beam [4-6], we have now also investigated the response of these systems to fast neutrons.

In this experiment, aimed mostly at studying baryon resonances in $\pi^- + p$ reactions, a π^- beam of 690 MeV/c impinged on a 46 mm thick polyethylene (CH_2) target. Detecting a coincident $\pi^-\pi^+$ pair in HADES and applying 4-momentum conservation, the missing-mass distribution shown in Fig. 1 is obtained. The exclusive reaction on hydrogen, $\pi^- + p \rightarrow \pi^- + \pi^+ + n$, can be selected by cutting on the neutron mass peak and thus tagged neutrons with known 4-momentum can be prepared. The right side of Fig. 1 shows the difference distributions of polar angle and momentum of these tagged neutrons w.r.t. the corresponding values of so-called *neutral hits* observed in the RPC. As neutral hits we consider isolated hits not associated with any of the fully reconstructed and identified charged tracks through HADES and we calculate their momentum from the time of flight by assuming a straight neutron trajectory originating at the event vertex. The remarkably strong correlations between expected and actually measured hits we take as proof that we do indeed observe neutron interactions in the RPC. Similar results (not shown) are also obtained for the plastic scintillator rods.

Comparing the number of actually observed with the number of calculated neutral hits we can determine the neutron detection efficiency as a function of angle and momentum. Figure 2 shows our preliminary result based on 1/4 of the total available statistics. Neutron detection efficiencies are of order $O(10^{-2})$ and both, RPC and TOF, display a strong momentum dependence. Note that our RPC result is consistent with findings from a study done by the R3B collaboration on their prototype RPC modules [7]. The response of plastic scintillator to fast neutrons has been investigated extensively in the past [8] and calculations based on those data are in fair agreement with our result (see Fig. 2).

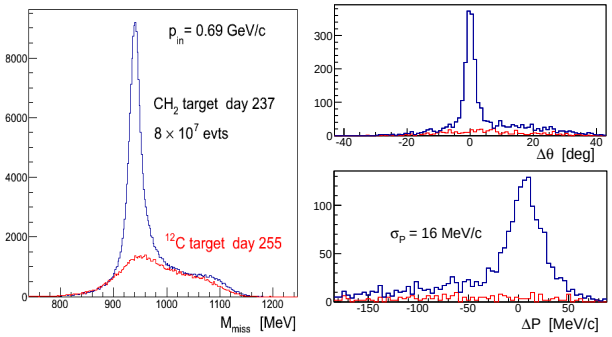

Figure 1: Left: measured missing-mass distribution of $\pi^-\pi^+$ pairs in the $\pi^- + p \rightarrow \pi^- + \pi^+ + n$ reaction. Right: angle and momentum differences of observed and expected neutral hits in the HADES RPC. Background from reactions on carbon nuclei (shown in red) has been obtained in a separate measurement done with a ^{12}C target.

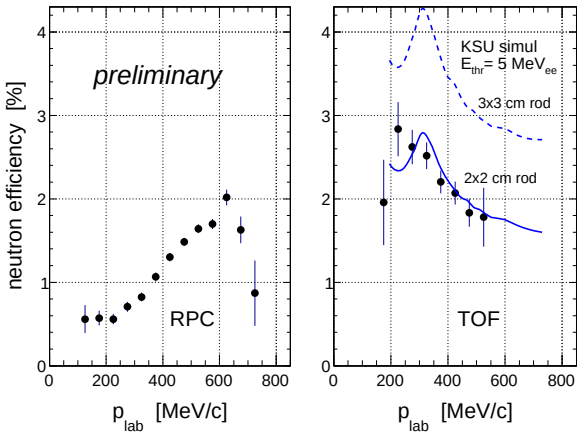

Figure 2: Measured neutron detection efficiency as function of neutron momentum in RPC (left) and TOF (right). The lines are calculations done with the KSU model [8] for 2×2 cm and 3×3 cm plastic scintillator rods, respectively.

References

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* Work supported by EMMI.
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DOI:10.15120/GR-2015-1-MU-NQM-HADES-20