Production of the η meson in quasi-free proton-neutron collisions near the kinematical threshold

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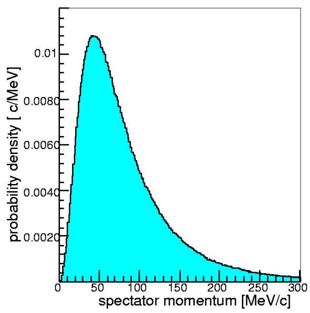
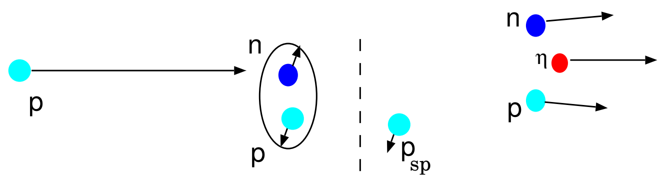
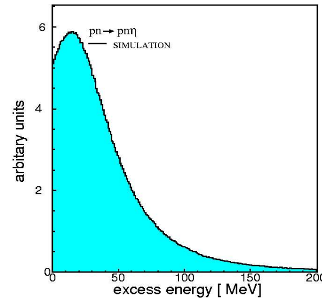
In order to meaasure pn-->pn*meson* reactions by means of a proton beam it is necessary to use a nuclear target, since a pure neutron target does not exist. Naturally, least complications in the interpretation of the experiment will be encountered when using the simplest nuclei. Therefore, deuterons are used as a source of neutron and for the evaluation of the data an impulse approximation is exploited. The measurement is conducted with a proton beam with momentum of 2.075 GeV/c scattered on a deuteron cluster target. The identification of the pn-->pnη reaction is based on the measurement of the four-momentum vectors of the outgoing nucleons and the η meson is identified via the missing mass technique.



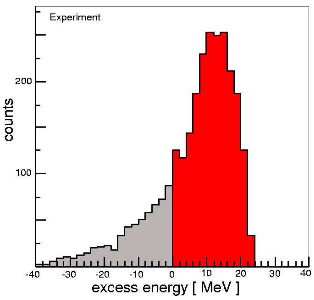
Momentum distribution of nucleons inside a deuteron calculated from Paris potential [1].



The nucleons bound inside a deuteron are not at rest. For the analysis of the data the proton from a deuteron is considered as a spectator which does not interact with the bombarding proton but rather escapes untouched and hits the detectors. The internal momenta of nucleons inside a deuteron cause that the total energy for the proton-neutron reaction varies from event-to-event. Therefore, in the case of near-thershold measurements, where the cross section grows rapidly with increasing excess energy, the total center-of-mass energy $\sqrt{s}$ has to be determined on an event-by-event level. On the other hand, the internal motion of the nucleons inside a deuteron enables to scan a large range of excess energies with a constant beam momentum.



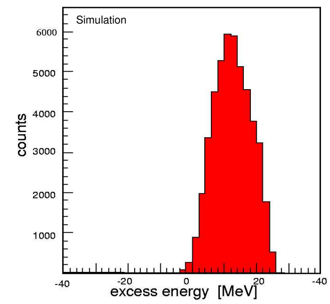
Distribution of the excess energy for the quasi-free pn-->pnη meson production process.



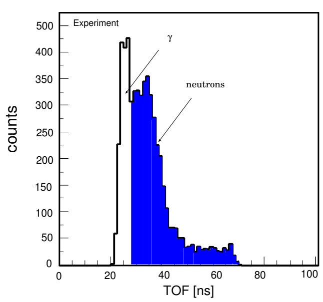
Experimental distribution of the excess energy determined with respect to the pnη threshold

Left and right figures show spectra of the excess energy in respect to the pnη system as obtained in the experiment and the Monte Carlo calculation for the pn-->pnη reaction. The remarkable difference between the distribution comes from the fact that in reality additionaly to the pn-->pnη process also the multi-pion production is registered.

Spectator proton four-momentum $P_{sp}=(E_{sp},\vec{p}_{sp})$ is measured in a silicon pad detector. This allows to establish the four-momentum vector of the colliding neutron, $P_n = (m_d-E_{sp},-\vec{p}_{sp})$, and hence the total energy for the proton-neutron reaction: $s = |P_{beam} + P_n|^2$. The method of identification of charged particles is demonstrated on poster 1. The fast neutron is separated from gamma quanta by the time of flight spectrum between the target and the neutral particle detector.

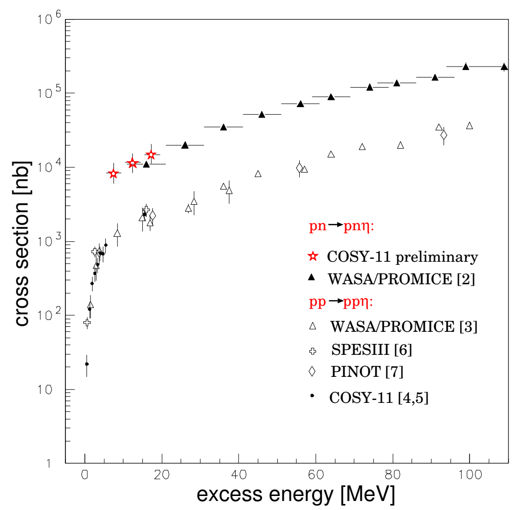


Distribution of the excess energy for the pn-->pnη reaction simulated taking into account the properties of the detection system

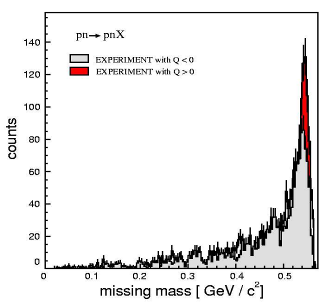


Time of flight distribution determined between the target and the neutron detector [4]. First peak orignates from gamma quanta and the continuous spectrum from registration of neutrons.

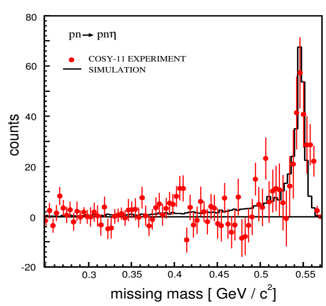
The η and multi-pion production cannot be distinguished from each other on the event-by-event basis by means of the missing mass technique. However, we can determine the number of the registered pn-->pnη reactions from the multi-pion background comparing the missing mass distributions for Q values larger and smaller than zero.



Preliminary results of the total cross section for the η meson production in the quasi-free proton-neutron scattering. Diamonds indicate COSY-11 preliminary results and the other points show experimental data from other experiments.



Missing mass spectra of the pn-->pnX process determined for the excess energies larger and less than zero



Missing mass spectrum for Q > 0 after the subtraction of the multi-pion background. The superimposed solid line, normalized in amplitude to the data points, corresponds to the Monte-Carlo simulation.

REFERENCES:

1 M. Lacombe et al., Phys. Rev. **C 21** (1980) 861.
2. WASA/PROMICE: H. Calen et al., Phys. Rev. **C 58** (1998) 2667.
3. WASA/PROMICE: H. Calen et al., Phys. Lett. **B 366** (1996) 39.
4. COSY-11: P. Moskal et al., AIP Conf. Proc. **No. 717** (2004) 907.
5. COSY-11: J. Smyrski et al., Phys. Lett. **B 474** (2000) 182.
6. SPESIII: F. Hibou et al., Phys. Lett. **B 438** (1998) 41.
7. PINOT: E. Chivassa et el., Phys. Lett. **B 322** (1994) 270.