Search for N*(1685) in Real Compton Scattering: First Results

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Why Compton Scattering?


There two other reactions to search for N*(1685)

\[ \gamma n \rightarrow K^0 \Lambda \]

The threshold is \( \sim 1.62 \) GeV. Problems are near-threshold effects overlapping with Fermi motion smearing, FSI, background reactions

\[ \gamma N \rightarrow \pi \pi N, \gamma N \rightarrow \pi \pi \pi N, \gamma N \rightarrow \omega N, \gamma N \rightarrow \rho N \]

all having peculiarities near \( 1.72 \) GeV, plus low efficiency of the GRAAL detector for this final state.
GRAAL forward lead-scintillator wall ("Russian Wall")

V.Kouznetsov et al., NIM A 487 (2002) 396.

An assembly of 16 modules. Each module is a sandwich of four 3000x40 mm2 bars with 3 mm thick lead plates between them. A 25 mm thick steel plate at the front of the module acts as a main converter and as a module support.
Particle identification and performance

- Performance of the Russian Wall at GRAAL:
- TOF resolution – 0.6 ns (FWHM)
- Angular resolution – 2-3 deg (FWHM)
- Photon efficiency – 95%
- Neutron efficiency – 22%
The GRAAL detector makes it possible the simultaneous study

\[ \gamma p \rightarrow \eta p \quad \gamma n \rightarrow \eta n \]
\[ \gamma p \rightarrow \pi^0 p \quad \gamma n \rightarrow \pi^0 n \]
\[ \gamma p \rightarrow \gamma p \quad \gamma n \rightarrow \gamma n \]

on the quasi-free proton and quasi-free neutron in the same experimental run.
The main problem of Compton scattering measurements is the π⁰ background.

Symmetric π⁰ decay, two photon hits are mixed in one BGO cluster.

Asymmetric π⁰ decays, the second low-energy photon may not be detected.
First Step: Study of $\pi^0$ background

SAID Data Base

$\gamma p \rightarrow \pi^0 p$: Bump structure near $W=1.65-1.7$ GeV

$\gamma n \rightarrow \pi^0 n$: Almost no data

There is a need to study $\gamma n \rightarrow \pi^0 n$
π⁰ Data analysis

- Detection of two photons in the BGO ball and the recoil proton/neutron in the forward detectors;
- Cut on the neutron/proton missing mass;
- Cut on the $2\gamma$ invariant mass;
- Cut on the square of the pion missing mass;
- Complanarity;

Reaction yields

γp→π⁰p: Bump structure at $W\sim1.7$ GeV  
γn→π⁰n: No bump structure

See also Talk of Bernd Krusche by Monday.

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V.Kuznetsov, NNR Workshop,  
June 8 - 10 2009, Edinburgh
Rejection of $\pi^0$ background

Symmetric decays are rejected by the analysis of cluster shapes in the BGO Ball. Efficiency of this rejection is $\sim 99\%$. If the pion is emitted at backward angles, its energy is low. Such events are suppressed.

Asymmetric decays: If the first photon is emitted at the backward angles, the low-energy second photon can be detected in the Russian Wall or the BGO Ball.

$\rightarrow$ Discrimination of Compton scattering from $\pi^0$ events is possible at backward angles.
Data analysis

- Detection of only one photon in the BGO Ball and the recoil proton/neutron in the Russian Wall;
- Complanarity;
- Cut in the neutron/proton TOF and angle;
- Cut on the proton/neutron missing mass;
- Cut on the squared photon missing mass;
- Cluster-shape analysis.

After that Only Compton and $\pi^0$ events (asymmetric decays) are selected.
$\gamma p \rightarrow \gamma p$ Simulations

Missing Energy $E_{\text{mis}} = E_{\text{tag}} - E_p(\Theta_p) - E_{\gamma}$
$\gamma p \rightarrow \gamma p$ on the free proton at $150 < \Theta_{cm} < 165$ deg

Data

Simulations

Counts

Counts
Compton $\sim 20-40\% \pi^0$

Free proton
Bump structure at $W \sim 1.7$ GeV in $\pi^0$ background similar to that seen in $\gamma p \rightarrow \pi^0 p$ data.

Quasi-free neutron: narrow bump at $W = 1.685$ GeV in Compton, flat $\pi^0$ background.

$150 < \Theta_{cm} < 165$ deg

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Peak at $W=1.685$ GeV in the cross section corresponds to the enhanced Compton peak in the Missing Energy spectrum.

Cross Check
Different Binning

Counts

Tagging Channels

Counts

Tagging Channels

Counts

Tagging Channels

Counts

Tagging Channels
\( \gamma n \rightarrow \gamma n \) and \( \gamma n \rightarrow \eta n \) graphs showing counts and differential cross sections.
Summary

First results on Compton scattering on the neutron reveal the peak at $W \approx 1.685$ GeV which is not seen in Compton scattering on the proton. Being considered in conjunction with the results on eta photoproduction, this observation supports the existence of $N^*(1685)$. 
Thanks for your attention!
π⁰ Data analysis

- Detection of two photons in the BGO ball and the recoil proton/neutron in the forward detectors;
- Cut on the neutron/proton missing mass;
- Cut on the 2γ invariant mass;
- Cut on the square of the pion missing mass;
- Complanarity;

Reaction yields

\[ γp → π^0 p: \text{Bump structure at } W \sim 1.7 \text{ GeV} \]

\[ γn → π^0 n: \text{No bump structure} \]

See also Talk of Bernd Krusche by Monday.