Double neutral pion photoproduction off the proton
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Meson Photoproduction

Meson photoproduction off the nucleons is one of a prime tools to study the properties of the strong interaction in the non-perturbative domain of QCD. Single pion photoproduction has been studied intensively to get informations for nucleon resonances especially for the $\Delta$-excitation, while double pion photoproduction gives complementary informations, particularly on resonances that couple weakly to a single pion. Among three channels, the double neutral pion channel ($\gamma p \rightarrow \pi^0\pi^0p$) is the most selective one, which provides interesting details because Born terms are strongly suppressed and $\rho$ meson can not directly decay into two neutral pions. Moreover, interesting physics involving two indistinguishable $\pi^0$ system can be investigated through this channel.

Bremssstrahlung photons are generated by inserting a carbon fiber to 1.2 GeV circulating electrons in a synchrotron ring. Scattered electrons produce Bremsstrahlung photons are are generated by inserting a carbon fiber to 1.2 GeV circulating electrons in a synchrotron ring. Scattered electrons are bended to Tagger system to determine the energy of bremsstrahlung photons with energy resolution 1-3 MeV.

Event Selection

Reaction $\gamma p \rightarrow \pi^0\pi^0p \rightarrow 4\gamma p$ is reconstructed by detecting its final state products 4 photons and one proton. Event from FOREST dataset survived after following selection condition will be accepted as true event for $\gamma p \rightarrow \pi^0\pi^0p$:

- Two pairs of photons with time difference within [-1,1] ns.
- One charged cluster in time window [1,10] ns (Figure 1) with respect to the average time of four photons ($t_{4\gamma}$). No other clusters within [1,10] ns.
- Kinematic fitting

All kinematic variables are fitted to the hypothesis of $\gamma p \rightarrow \pi^0\pi^0p$. The fitting result of chi-square($\chi^2$) probability are used in confidence level (CL) cut.

7 constraints are applied (4 from energy-momentum conservation and other 3 from invariant masses of two pions and one proton). Event with chi-square probability larger than 20% will be accepted(Figure 2).

The error estimation of kinematic variables are checked by PULL distribution (Figure 3). It is sufficiently close to a normal Gaussian distribution N(0,1).

Background Events Subtraction

Accidental coincident events between FOREST and Tagging spectrometer have been eliminated by subtraction of scaled distributions of random background events outside the true coincidence time window.

FOREST Detector System (90% solid angle cover)

LEPS Backward Gamma (252 Lead/Scintillating fiber) Res.: 7% @ 1GeV

SCIffors III (192 CsI) Res.: 3% @ 1GeV

Preliminary Results

- Invariant mass of two photons and missing mass of $\gamma p \rightarrow \pi^0\pi^0X$

Figure 4. Left: Two photons invariant masses $m(\gamma_1, \gamma_2)$ vs. $m(\gamma_1, \gamma_3)$. Right: Missing mass (mx) spectra for $\gamma p \rightarrow \pi^0\pi^0X$. $x^0$ and proton signal are clearly shown in invariant mass and missing mass spectra.

- Total cross section of $\gamma p \rightarrow \pi^0\pi^0p$ has been obtained preliminarily and compared with previous data (Figure 5).

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\begin{align*}
\text{Entries:} & \quad 853277 \\
\text{Mean:} & \quad 0.114 \\
\text{RMS:} & \quad 0.239
\end{align*}
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\begin{align*}
\text{Entries:} & \quad 2604148 \\
\text{Mean:} & \quad 0.4025 \\
\text{RMS:} & \quad 1.02
\end{align*}
\]

Figure 5. Up: Acceptance. Down: Total cross section for $\gamma p \rightarrow \pi^0\pi^0p$. 

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\begin{align*}
\text{Entries:} & \quad 372234 \\
\text{Mean:} & \quad 136.3 \\
\text{RMS:} & \quad 1.057
\end{align*}
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