

Study of the $\eta' \rightarrow \pi^0 \pi^0 \eta$ decay with the Crystal Ball at MAMI-C

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Talk outline

- What η' decays can be studied with the Crystal Ball at MAMI-C
- Study of $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6 \gamma$
- Backgrounds to $\gamma p \rightarrow \eta' p \rightarrow \pi^0 \pi^0 \eta p \rightarrow 6 \gamma p$:
 $\gamma p \rightarrow \pi^0 \pi^0 \pi^0 p \rightarrow 6 \gamma p$
(including $\gamma p \rightarrow \Sigma^+ K_s^0 \rightarrow \pi^0 \pi^0 \pi^0 p$) and
 $\gamma p \rightarrow \pi^0 \eta p \rightarrow 4 \pi^0 p \rightarrow 8 \gamma p$
- Final remarks

η' decays with the Crystal Ball at MAMI-C

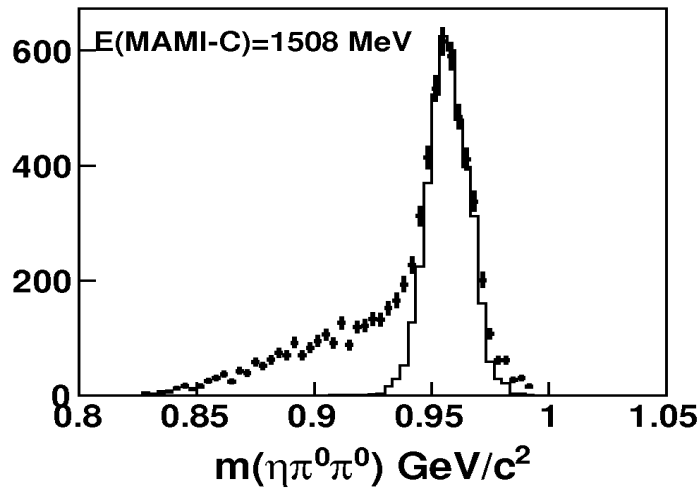
- Neutral decay modes of η' are poorly known and can be studied with the CB
- $\eta' \rightarrow \pi^0 \pi^0 \pi^0$ and $\eta' \rightarrow \gamma\gamma$ decay modes with small BR have large background when η' is produced in $\gamma p \rightarrow \eta' p$
- Main focus is on $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6\gamma$ which allows to study $\pi \eta$ scattering

Selection of $\gamma p \rightarrow \eta' p \rightarrow \pi^0 \pi^0 \eta p \rightarrow 6\gamma p$ events

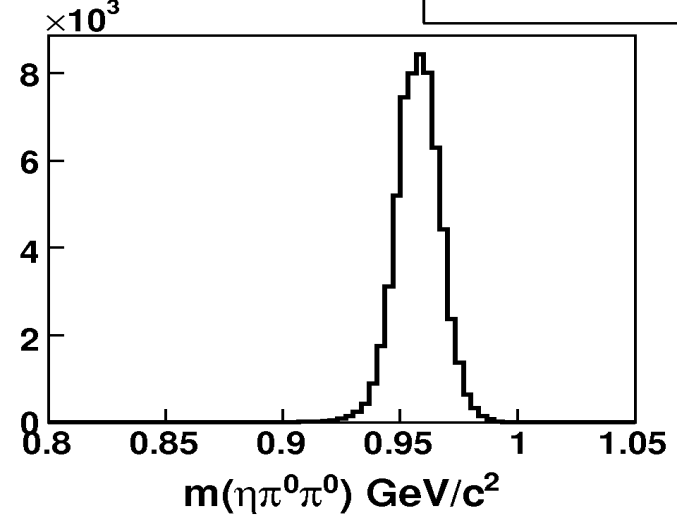
- Incident-photon energy is unknown as the maximum tagging energy is 1402 MeV for 1508-MeV MAMI-C beam and 1446 MeV for 1557-MeV beam; the $\gamma p \rightarrow \eta' p$ threshold is 1.45 GeV
- Detection of the recoil proton is required to improve the resolution and background suppression
- kinematic fit is used to select $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6\gamma$ events
- background from $\gamma p \rightarrow \pi^0 \pi^0 \pi^0 p \rightarrow 6\gamma p$ is suppressed by the comparison of the probabilities for both the hypotheses
- further suppression of $\gamma p \rightarrow \pi^0 \eta p \rightarrow 4\pi^0 p \rightarrow 8\gamma p$ background by tightening the CL cut
- final acceptance for $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6\gamma$ events is $\sim 30\%$
- Rate of taking good events $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6\gamma / \eta \rightarrow 3\pi^0$ is $\sim 1/1000$ for 1508-MeV beam and $\sim 3.5/1000$ for 1557 MeV

Invariant mass of $\pi^0\pi^0\eta$ for $\gamma p \rightarrow \pi^0\pi^0\eta p \rightarrow 6\gamma p$ candidates
for 1508-MeV beam (15% background in $\eta' \rightarrow \pi^0\pi^0\eta$)

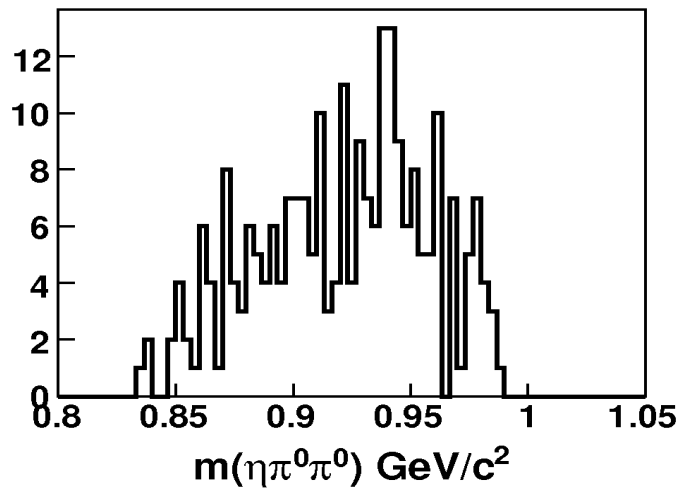
Data $\gamma p \rightarrow \eta\pi^0\pi^0 p \rightarrow 6\gamma p$ Entries 6784



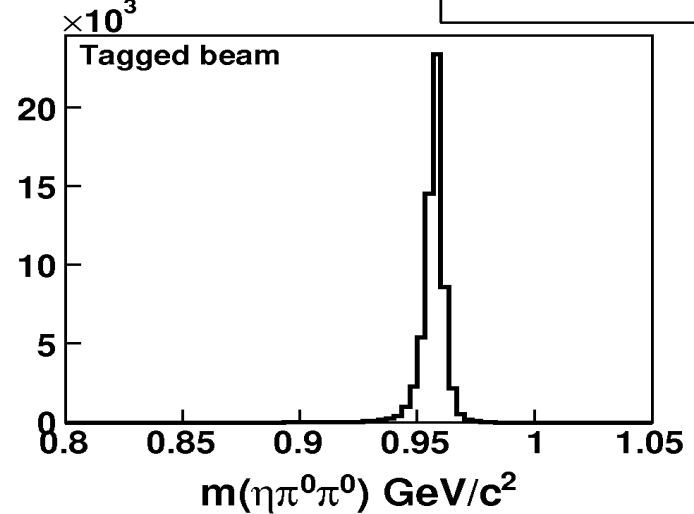
MC $\gamma p \rightarrow \eta' p \rightarrow \eta\pi^0\pi^0 p \rightarrow 6\gamma p$ Entries 59534



MC $\gamma p \rightarrow \pi^0\pi^0\pi^0 p \rightarrow 6\gamma p$ Entries 240

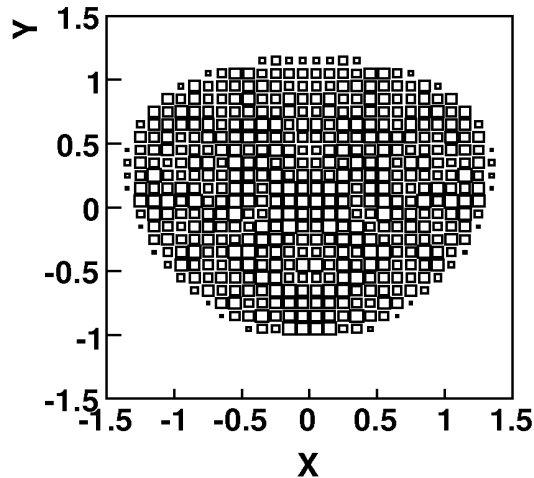


MC $\gamma p \rightarrow \eta' p \rightarrow \eta\pi^0\pi^0 p \rightarrow 6\gamma p$ Entries 58986

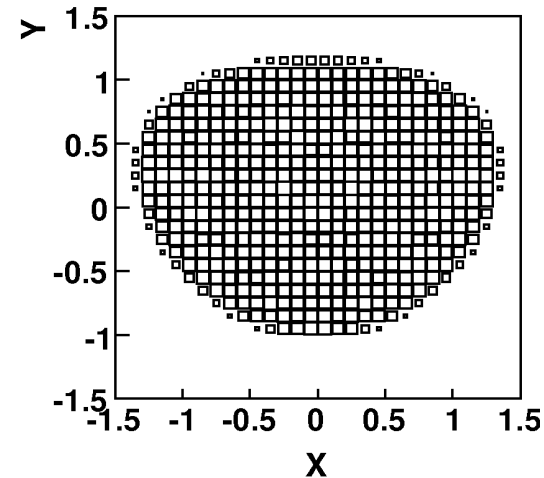


The $\eta' \rightarrow \pi^0 \pi^0 \eta$ Dalitz plot can be described by $M^2 = A(|1 + \alpha Y|^2 + cX^2)$. GAMS2000: $\alpha = -0.058 \pm 0.013$ and $c = 0.00 \pm 0.03$ based on 5K events

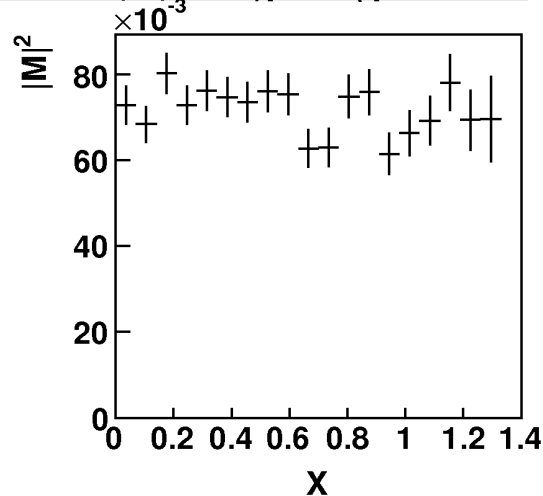
Data $\gamma p \rightarrow \eta' p \rightarrow \eta \pi^0 \pi^0 p \rightarrow 6\gamma p$



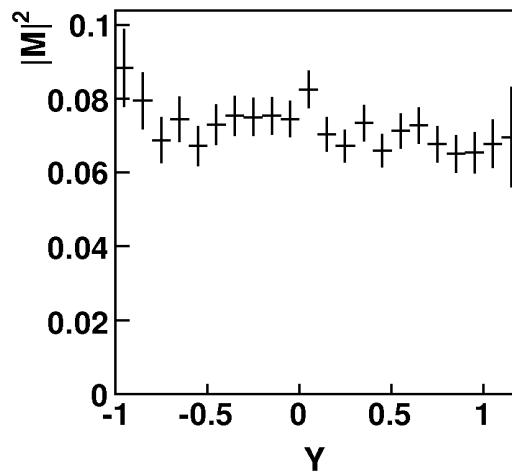
MC $\gamma p \rightarrow \eta' p \rightarrow \eta \pi^0 \pi^0 p \rightarrow 6\gamma p$



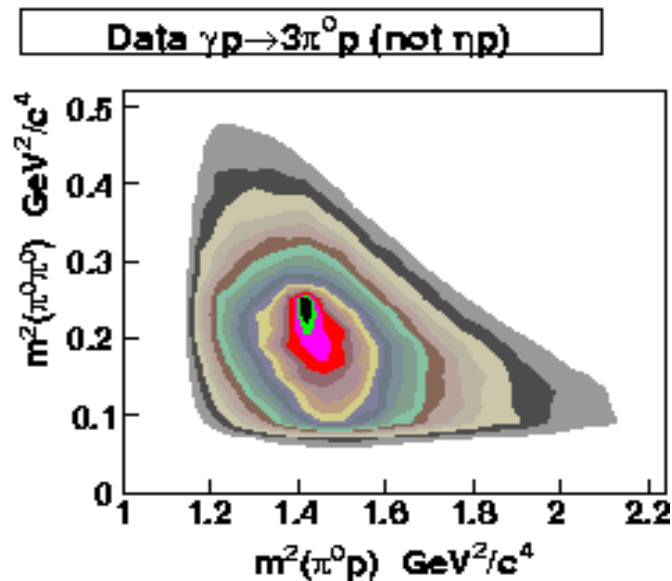
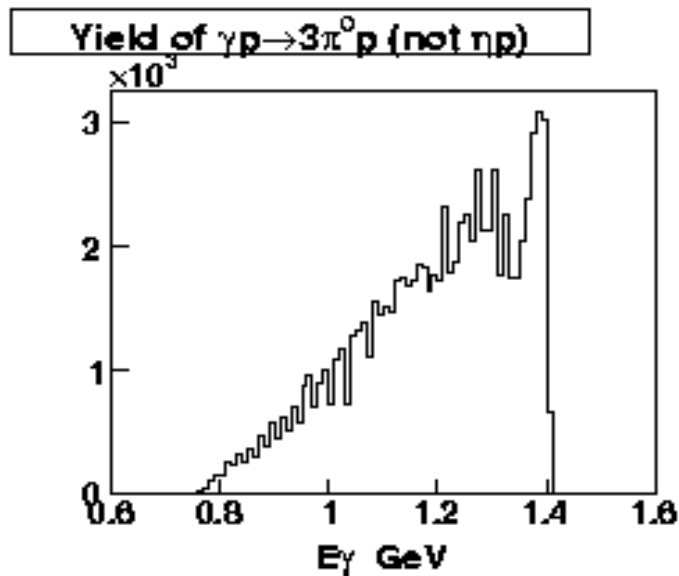
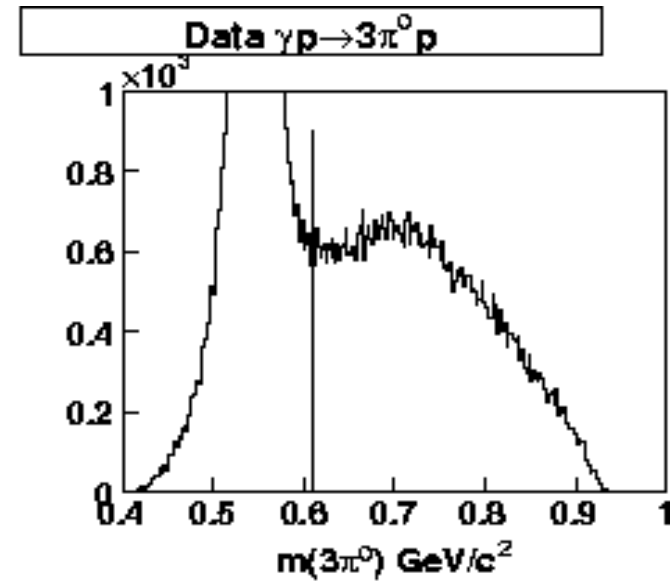
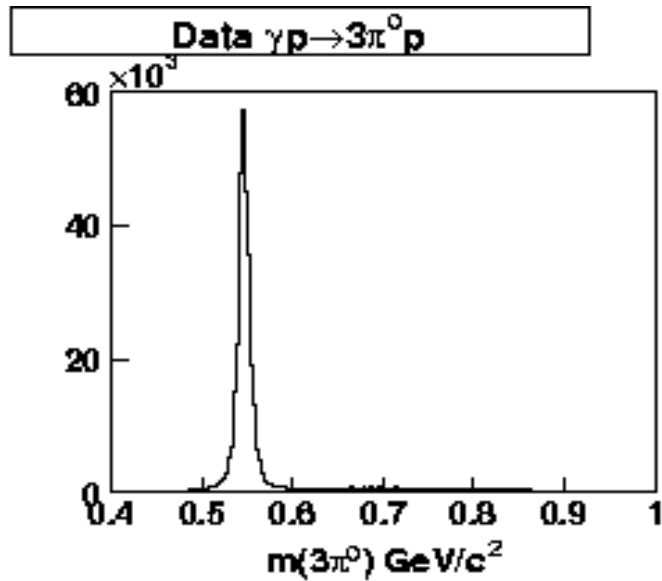
$|M|^2$ for $\gamma p \rightarrow \eta' p$



$|M|^2$ for $\gamma p \rightarrow \eta' p$

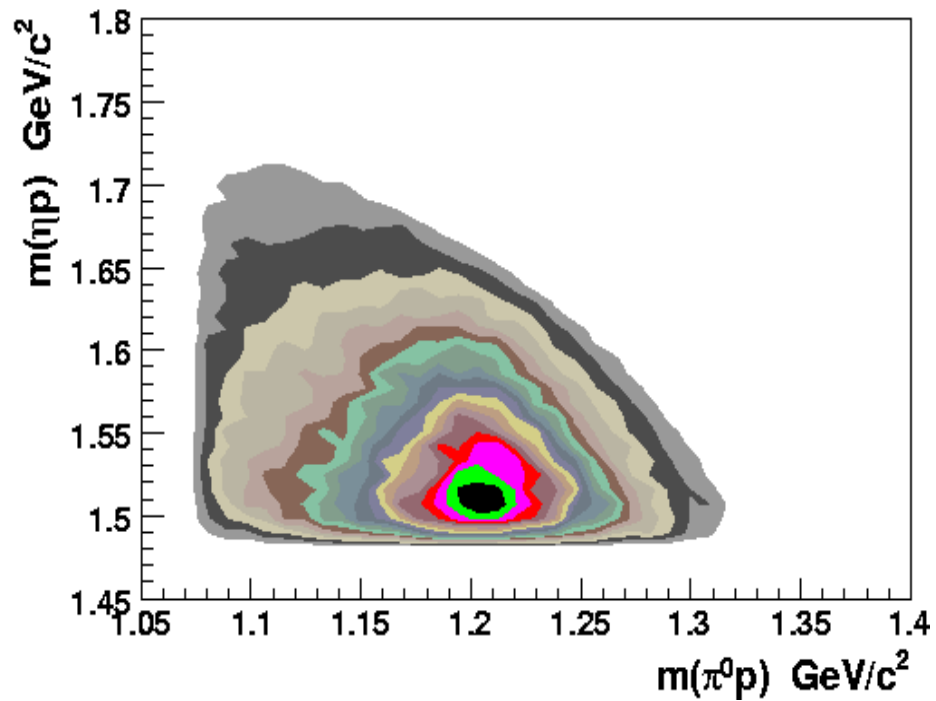


Process $\gamma p \rightarrow \pi^0 \pi^0 \pi^0 p \rightarrow 6\gamma p$ contributes to the $\eta' \rightarrow \pi^0 \pi^0 \eta \rightarrow 6\gamma$ background if $m(\pi^0 \pi^0 \pi^0)$ is close to the η' mass

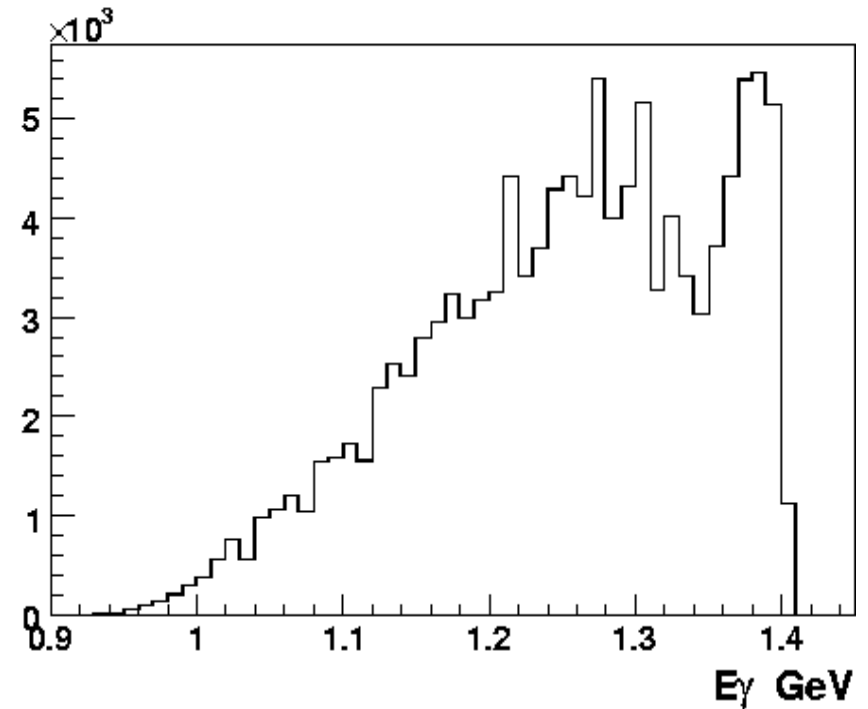


Background process $\gamma p \rightarrow \pi^0 \eta p \rightarrow 4\pi^0 p$ can be understood
via measuring $\gamma p \rightarrow \pi^0 \eta p \rightarrow 4\gamma p$

$\gamma p \rightarrow \pi^0 \eta p \rightarrow 4\gamma p$



Yield of $\gamma p \rightarrow \pi^0 \eta p \rightarrow 4\gamma p$ (without scaler correction)



Final remarks

- Present data-taking rate for η' at MAMI-C is too small to have sufficient statistics in the $\eta' \rightarrow \pi^0 \pi^0 \eta$ Dalitz plot: $\sim 4\text{K}$ events collected in 2007 with 1508-MeV beam; $\sim 10\text{K}$ expected in 2009 with 1557-MeV beam
- Tagging the beam energy is needed to improve the resolution and the signal-to-background ratio