The double polarization observable E in η'-photoproduction

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Outline

1. Motivation
2. Experimental Setup
3. Event Selection
4. Extraction of the observable E
5. Results

Baryon spectroscopy

- Goal: study dynamics of constituents
  inside the nucleon

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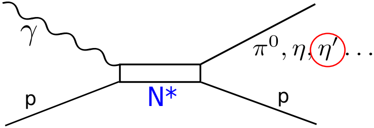
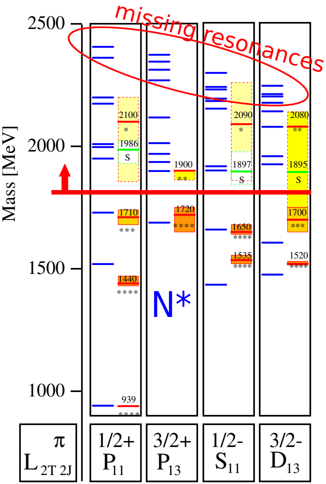
Photoproduction of single
pseudoscalar meson



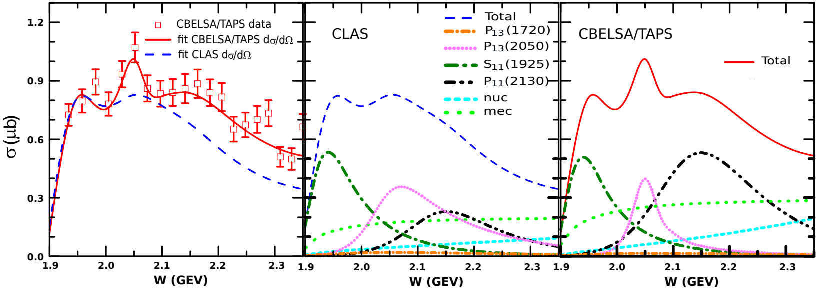


U. Loering et al., Eur.Phys.J. A, 10:395-446, 2001

- η' (T=0) $\rightarrow$ exclusive access to intermediate states N^* with T=1/2
- Probe mass range $W > 1896\,\mathrm{MeV}$

Cross section data in η'-photoproduction

- Discrepancies between measured cross section data of CLAS and CBELSA/TAPS



Huang et al., arXiv:1208.2279v1, (2012)

- The cross section alone is not sufficient to disentangle all resonance contributions unambiguously

Polarization observables

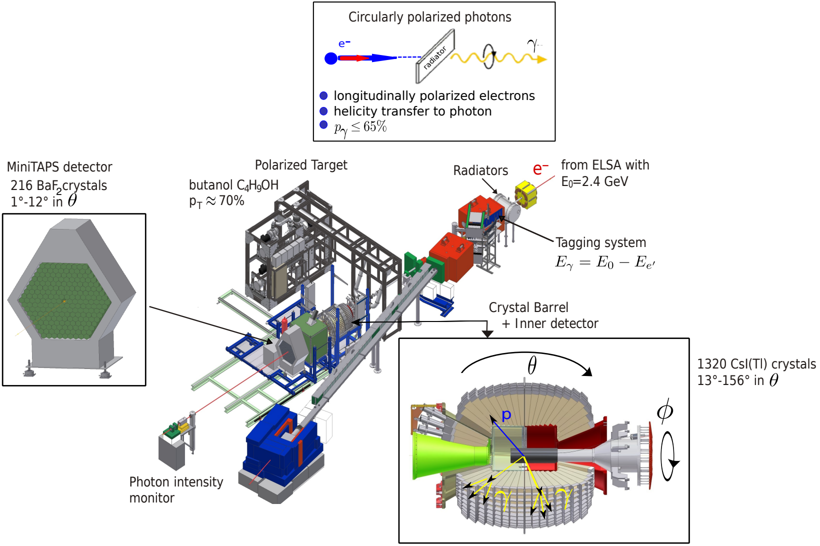
- Two categories: single polarization and double polarization observables (beam-target, beam-recoil, target-recoil)
- For unambiguous solution: $\geq$ 8 carefully chosen observables are required (Chiang and Tabakin, Phys.Rev.,C55:2054-2066, 1996)

Photon		Target x	Target y	Target z
unpolarized	σ	–	T	–
linearly	Σ	H	-P	-G
circularly	–	F	–	-E

blue: measured with Crystal Barrel at ELSA in diff. reactions

- Double polarization observable E: circularly polarized beam photon & longitudinally polarized target

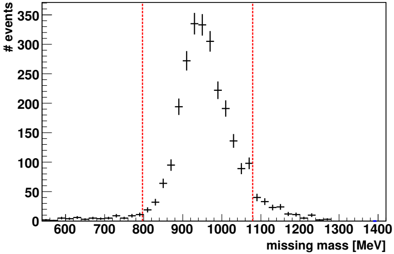
The CBELSA/TAPS experiment

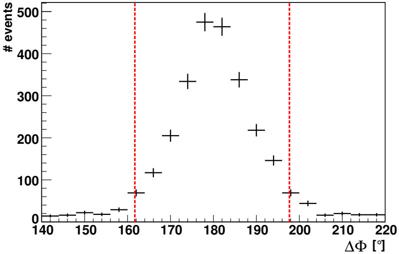


Selection process of $\eta' \to \gamma\gamma$ (BR: 2.2%)

Selected events had to fulfill kinematic constraints:

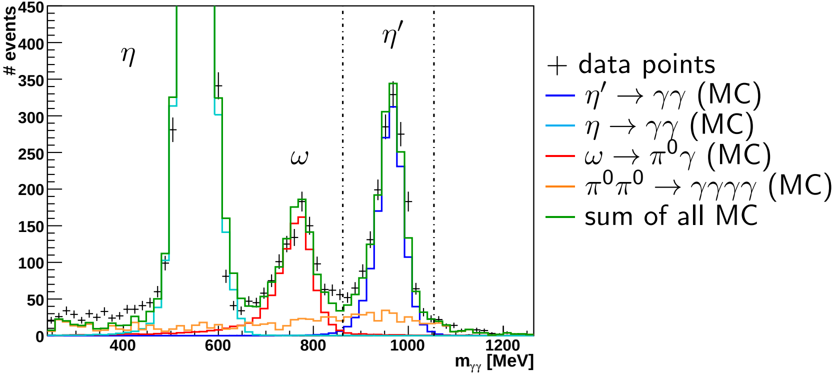
- 3 hits in calorimeters (1 charged and 2 neutral particles)
- Proton: calculated as missing mass of $\gamma p \to \eta' X$
- Agreement of missing mass and measured charged particle in θ
- Collinearity of η' and proton
- Beam photon: $E_\gamma > 1447\,\mathrm{MeV}$ and time coincident with reaction products





Selection process of $\eta' \to \gamma\gamma$

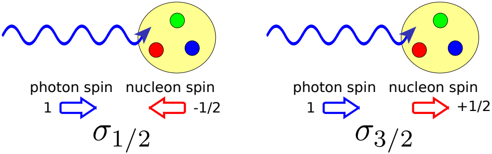
- The $\gamma\gamma$ invariant mass:



- Approximately 1600 η' events are selected with a background contamination of 15% (mainly $\pi^0\pi^0$)

The observable E

- Helicity asymmetry
- Two possible spin configurations



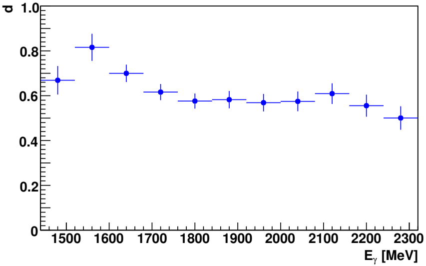
- Helicity dependent cross section:

$$\sigma^{1/2\ (3/2)} = \sigma_0 \cdot [1 \pm p_T p_\gamma \cdot E]$$

The observable E

$$\sigma_B^{1/2\,(3/2)} = \sigma_H \cdot [1 \pm p_T p_\gamma \cdot E] + \sigma_C$$

$$\left.\begin{array}{l} \sigma_B^{1/2} - \sigma_B^{3/2} = \sigma_H \cdot 2 p_T p_\gamma \cdot E \\ \sigma_B^{1/2} + \sigma_B^{3/2} = 2 \cdot (\sigma_H + \sigma_C) \end{array}\right\} \Rightarrow E = \frac{\sigma_B^{1/2} - \sigma_B^{3/2}}{\sigma_B^{1/2} + \sigma_B^{3/2}} \cdot \frac{1}{p_T p_\gamma} \cdot \frac{1}{d}$$

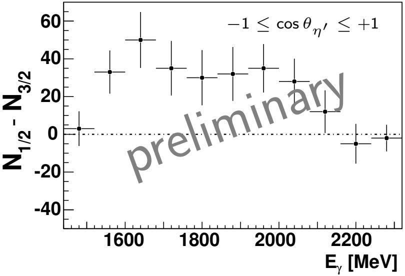


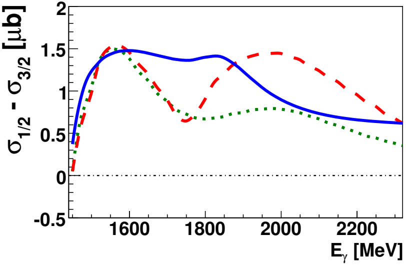
dilution factor:

fraction of polarizable protons

$$d = \frac{\sigma_H}{\sigma_H + \sigma_C}$$

Count rate difference in η' photoproduction





Predictions:

- η'-MAID model:
  (L. Tiator, Int.J.Mod.Phys. A22, 2007)

  — η'-MAID

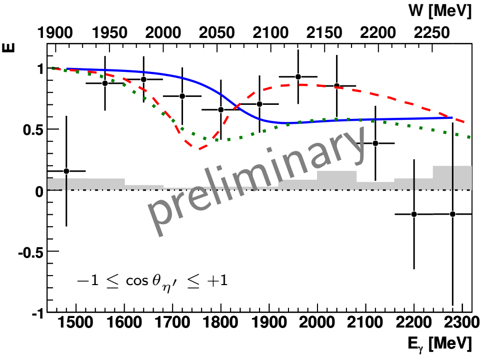
  $S_{11}(1904)$
  $P_{11}(2083)$
  $P_{13}(1926)$
  $D_{13}(2100)$

- Huang et al. model:
  (Huang et al., arXiv:1208.2279v1, 2012)

  - - - CBELSA/TAPS
  · · · CLAS

  $S_{11}(1925)$
  $P_{11}(2130)$
  $P_{13}(2050)$
  $P_{13}(1720)^{****}$

Results of $E(E_\gamma)$ in η' photoproduction



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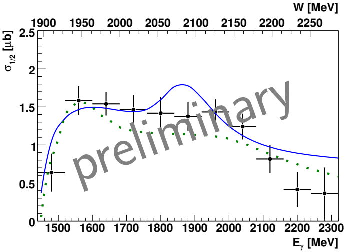
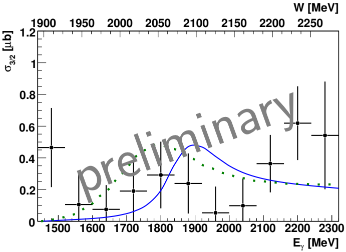
Helicity dependent cross sections $\sigma_{1/2}$ and $\sigma_{3/2}$

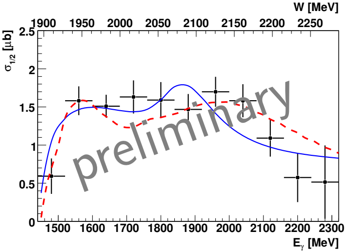
$$\sigma_{1/2} = \sigma_0(1 + E p_\gamma p_T) \qquad \sigma_{3/2} = \sigma_0(1 - E p_\gamma p_T)$$

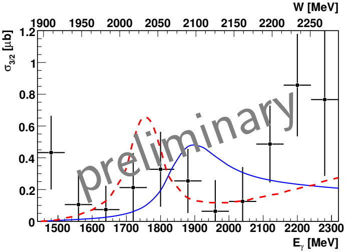
using $\sigma_{0,\mathrm{CLAS}}$





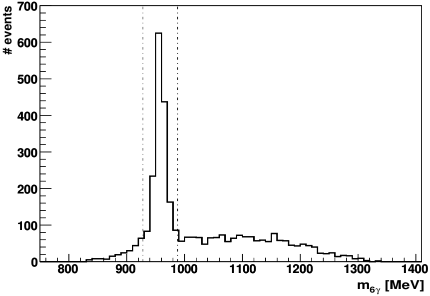
using $\sigma_{0,\mathrm{CB}}$





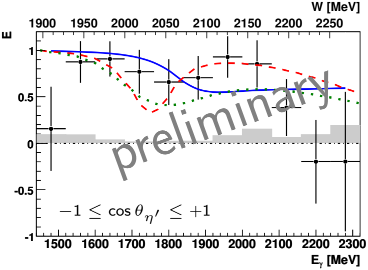
Summary and Outlook

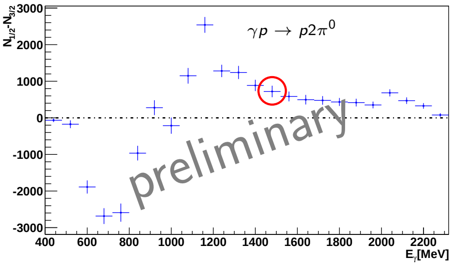
- The observable E was determined in $\vec{\gamma}\vec{p} \rightarrow \eta' p$
- Results:
  - Resonances contribute mainly to $\sigma_{1/2}$
  - Deviations to models observed e.g. near threshold and higher energies
  - New information for model calculations
- Enhance statistics with additional decay mode $\eta' \rightarrow \pi^0\pi^0\eta \rightarrow 6\gamma$



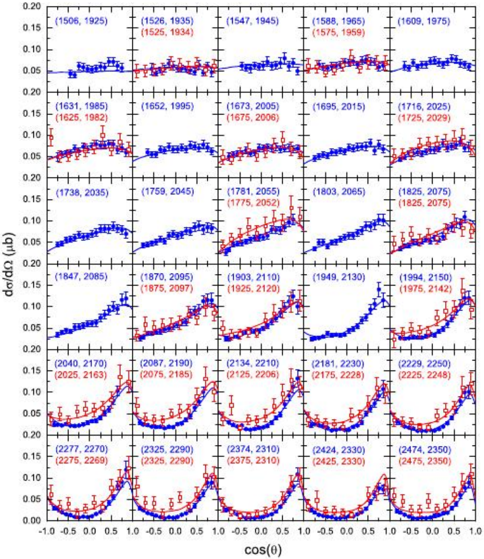
Influence of $2\pi^0$-background on the observable E

- positive sign of count rate difference in $2\pi^0$-photoproduction
- need to correct the observabe E in η'-photoproduction downwards



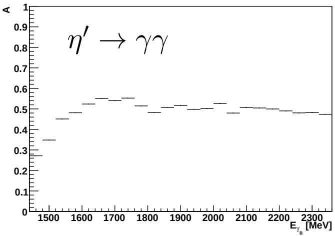


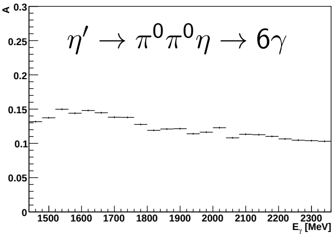
Measured η' cross section data



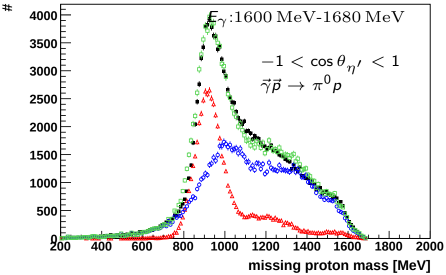
Huang et al., arXiv:1208.2279v1, 2012

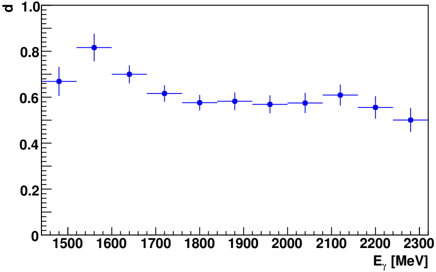
Acceptance of both decay modes





Dilution factor





- black: butanol data
- red: hydrogen data
- blue: carbon data
- green: sum of scaled hydrogen and carbon distributions