Double polarization measurements with the Crystal Barrel/TAPS experiment at ELSA

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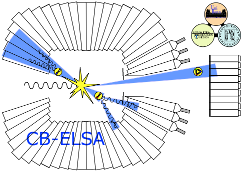

25/05/2011

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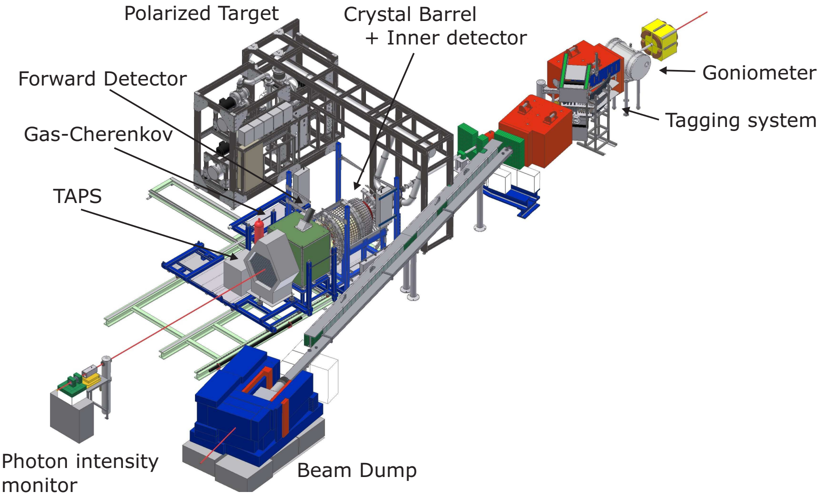
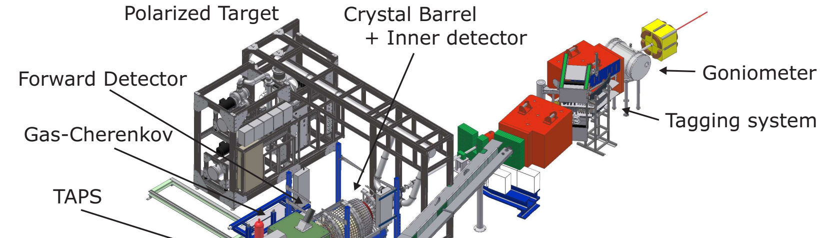
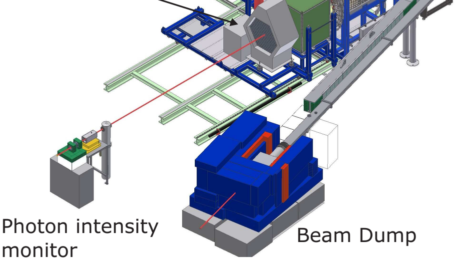
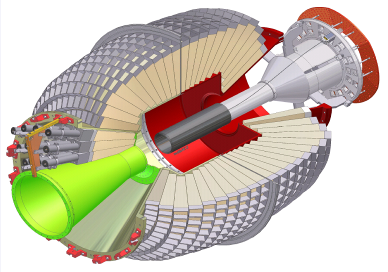
The Crystal Barrel/TAPS experiment



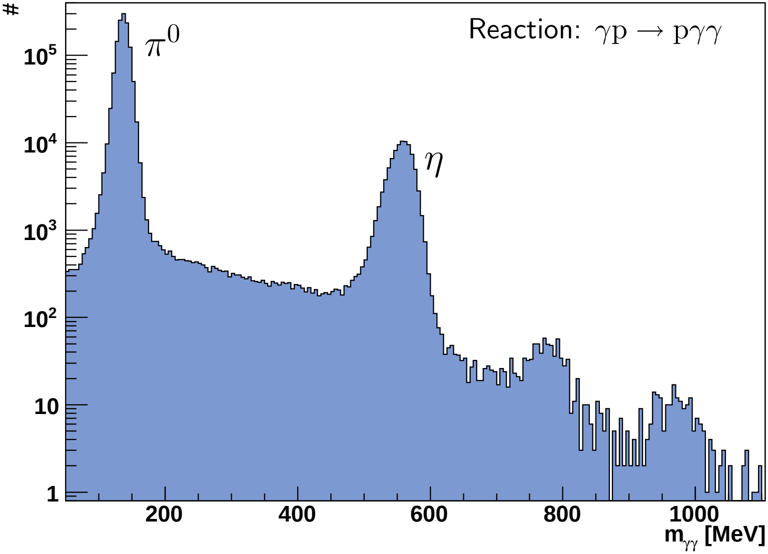
The Crystal Barrel/TAPS experiment

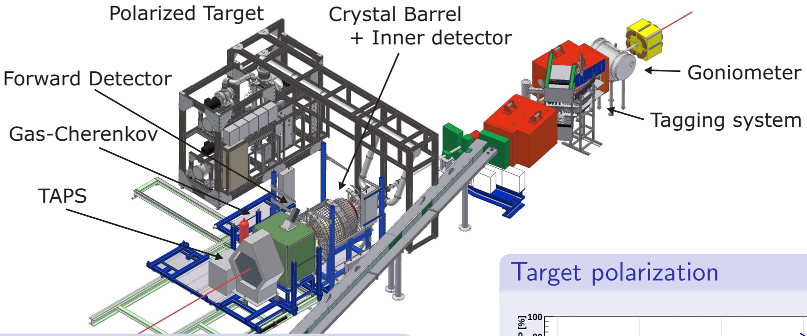
Crystal Barrel



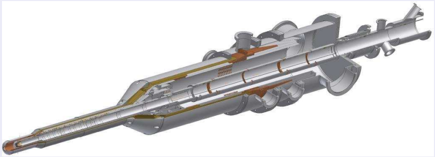
Meson Reconstruction



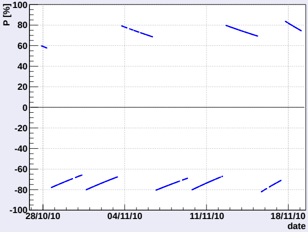
The Crystal Barrel/TAPS experiment



Frozen Spin Target



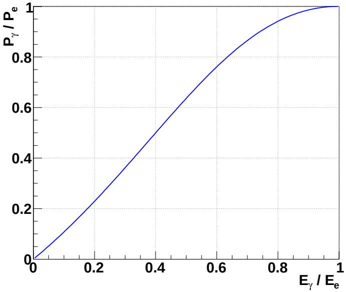
Target polarization



Polarized Photon Beams

circularly polarized:

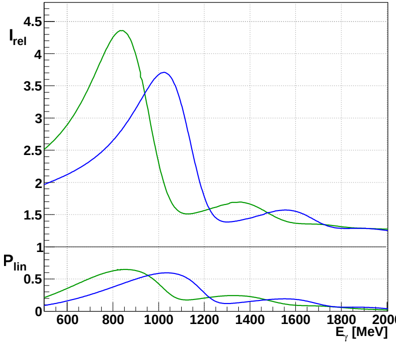
- bremsstrahlung of longitudinally pol. electrons
- helicity transfer:



- measurement of electron polarization using Møller polarimeter

linearly polarized:

- coherent bremsstrahlung using diamond crystal
- crystal orientation defines plane of linear polarization

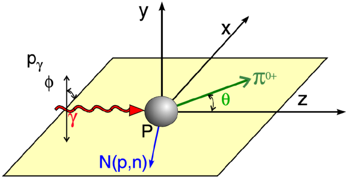


Polarization Observables

photoproduction of pseudoscalar mesons:

- all 3 single polarization observables
- 4 double polarization observables

can be measured with the Crystal Barrel/TAPS experiment



photon pol.		target pol. axis		
		x	y	z
unpolarized	σ		T	
linear	$-\Sigma$	H	$-P$	G
circular		F		$-E$

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}(\theta,\phi) = \frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}(\theta) \cdot \Big[1 - P_\gamma^{\text{lin}}\,\Sigma(\theta)\cos(2\phi)$$
$$+P_x \cdot \left(-P_\gamma^{\text{lin}}\,H(\theta)\,\sin(2\phi) + P_\gamma^{\text{circ}}\,F(\theta)\right)$$
$$+P_y \cdot \left(-P_\gamma^{\text{lin}}\,P(\theta)\,\cos(2\phi) + T(\theta)\right)$$
$$+P_z \cdot \left(P_\gamma^{\text{lin}}\,G(\theta)\,\sin(2\phi) - P_\gamma^{\text{circ}}\,E(\theta)\right)\Big]$$

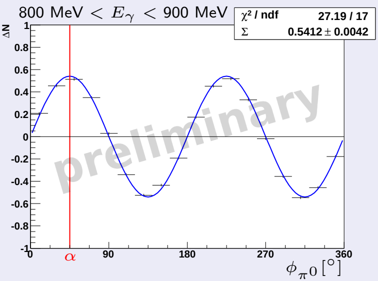
[1] W.-T. Chiang, F. Tabakin, Phys. Rev. C 55 (1997)

Beam Asymmetry Σ

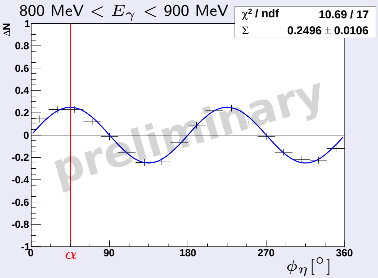
- linearly polarized photon beam (angle of pol. plane: $\alpha = 45°$)
- unpolarized target

$$\Delta N(\phi) = \frac{1}{P_{\text{beam}}} \cdot \frac{N_\perp - N_\parallel}{N_\perp + N_\parallel} = \Sigma \cdot \cos(2(\phi - \alpha))$$

$\vec{\gamma}\mathrm{p} \rightarrow \mathrm{p}\pi^0$

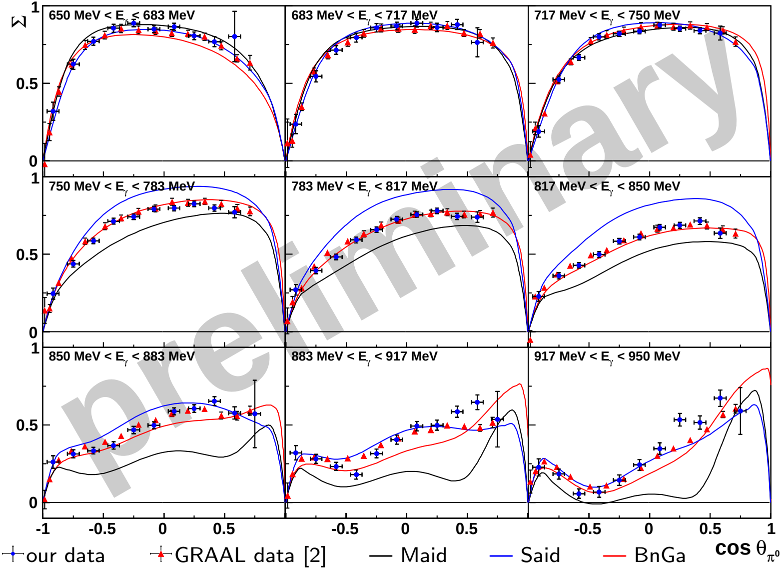


$\vec{\gamma}\mathrm{p} \rightarrow \mathrm{p}\eta$



Note: target material butanol $\rightsquigarrow$ also small contribution from C

π^0 Photoproduction: Beam Asymmetry Σ



Note: target material butanol ⇝ also small contribution from C

[2] O. Bartalini *et al.*, Eur. Phys. J. A **26**, 399-419 (2005)

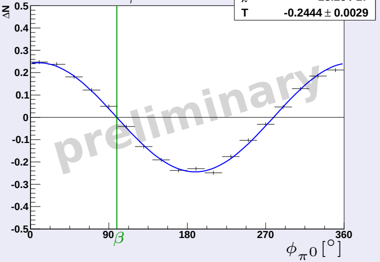
Target Asymmetry T

- unpolarized beam
- transversely polarized target (direction of pol.: $\beta = 99°$)

$$\Delta N(\phi) = \frac{1}{f P_{\text{target}}} \cdot \frac{N_\uparrow - N_\downarrow}{N_\uparrow + N_\downarrow} = T \cdot \sin(\phi - \beta)$$

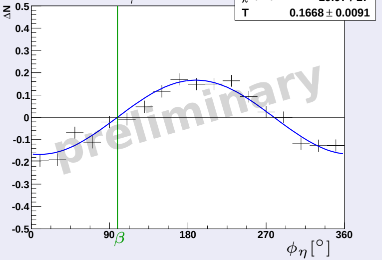
$\gamma\vec{p} \rightarrow p\pi^0$

700 MeV $< E_\gamma <$ 800 MeV



$\gamma\vec{p} \rightarrow p\eta$

800 MeV $< E_\gamma <$ 900 MeV



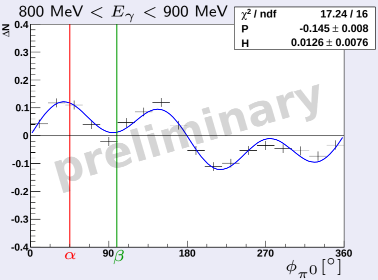
Recoil Polarization P and Observable H

- linearly polarized photon beam (angle of pol. plane: $\alpha = 45°$)
- transversely polarized target (direction of pol.: $\beta = 99°$)

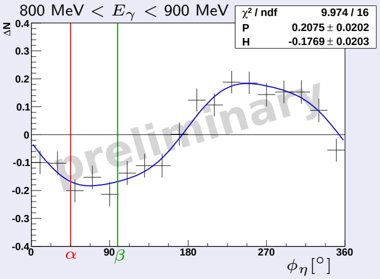
$$\Delta N(\phi) = \frac{1}{f P_{\text{beam}} P_{\text{target}}} \cdot \frac{(N_{\perp\uparrow} - N_{\perp\downarrow}) - (N_{\parallel\uparrow} - N_{\parallel\downarrow})}{(N_{\perp\uparrow} + N_{\perp\downarrow}) + (N_{\parallel\uparrow} + N_{\parallel\downarrow})}$$

$$= (P \sin(\phi - \beta)\cos(2(\phi - \alpha)) + H \cos(\phi - \beta)\sin(2(\phi - \alpha)))$$

$\vec{\gamma}\vec{\mathrm{p}} \to \mathrm{p}\pi^0$



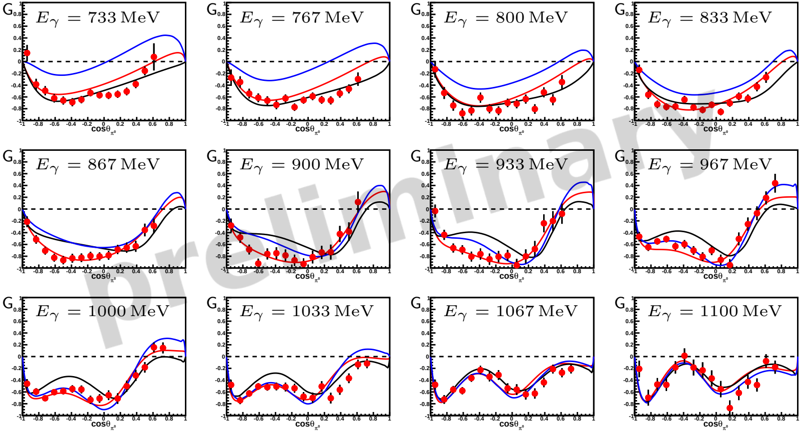
$\vec{\gamma}\vec{\mathrm{p}} \to \mathrm{p}\eta$



Double Polarization Observable G

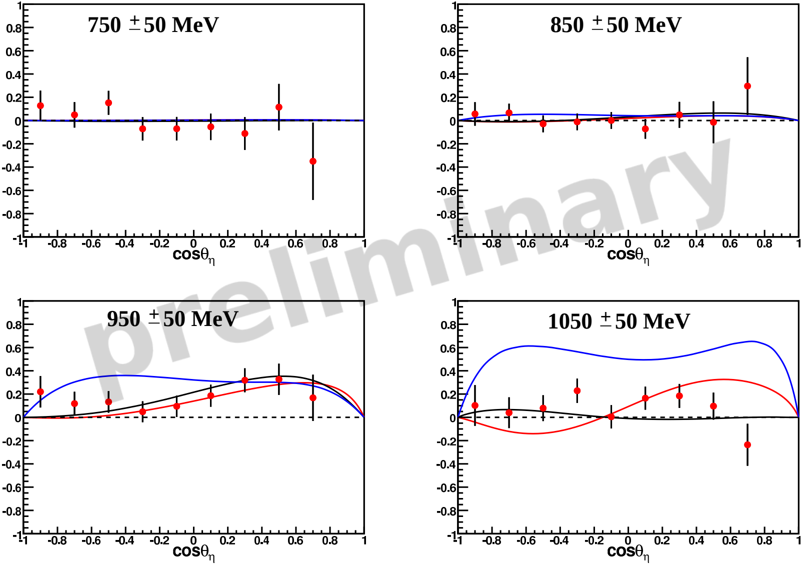
linearly polarized beam, longitudinally polarized target:

$$\frac{d\sigma}{d\Omega}(\phi) = \frac{d\sigma}{d\Omega}_0 \cdot \left(1 - P_\gamma^{\text{lin}}\,\Sigma\cos(2\phi) + P_\gamma^{\text{lin}} P_z\, G\sin(2\phi)\right)$$



$\vec{\gamma}\vec{p} \to p\pi^0$ — Maid — Said — BnGa A. Thiel (Bonn)

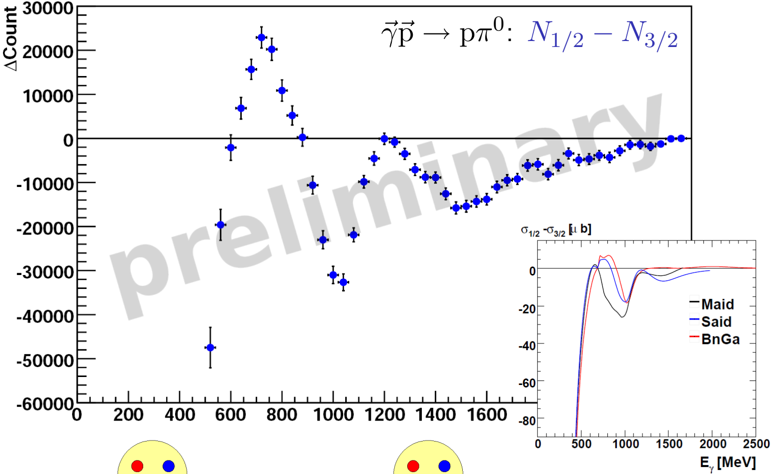
Double Polarization Observable G

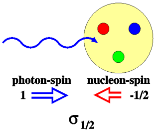


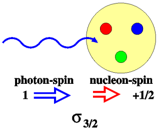
$\vec{\gamma}\vec{\mathrm{p}} \rightarrow \mathrm{p}\eta$ — Maid — Said — BnGa A. Thiel (Bonn)

Double Polarization Observable E

circularly polarized beam, longitudinally polarized target:



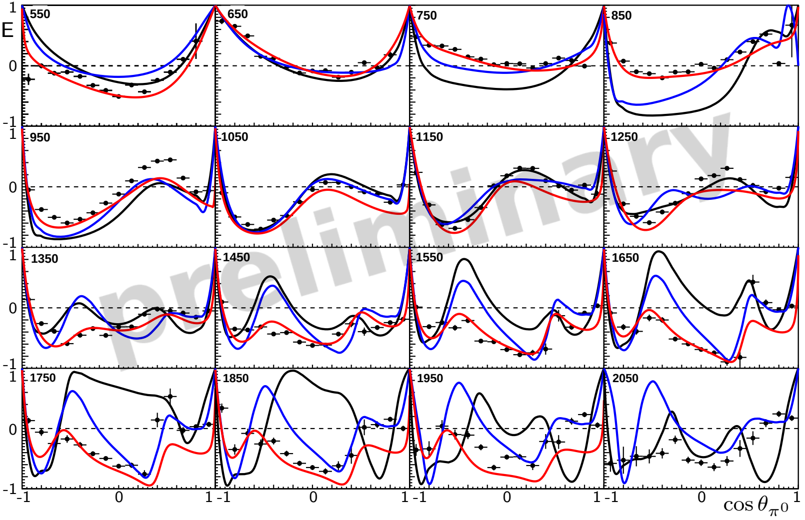




M. Gottschall (Bonn)

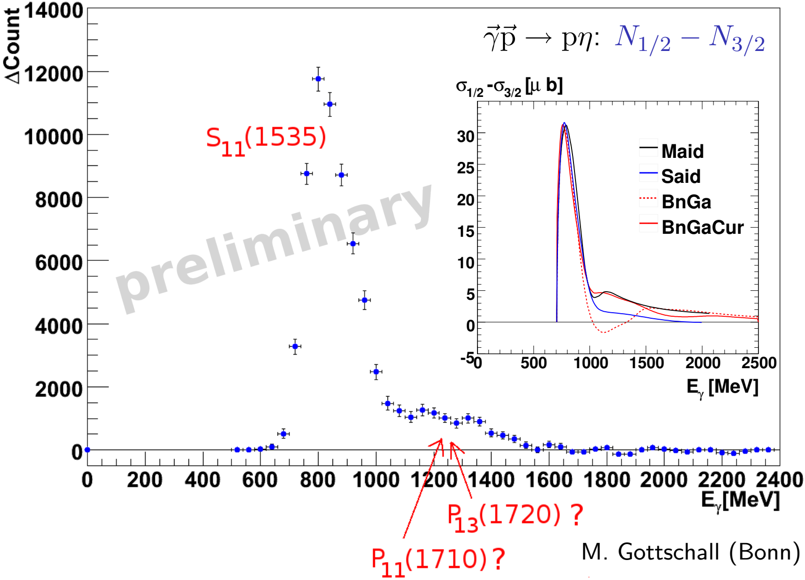
π^0 Photoproduction: E

circularly polarized beam, longitudinally polarized target:



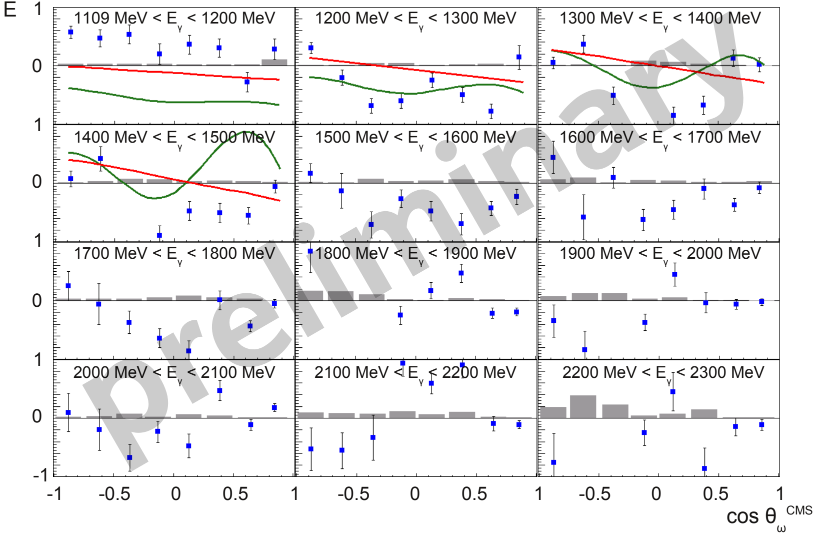
M. Gottschall (Bonn)

η Photoproduction: E



M. Gottschall (Bonn)

ω Photoproduction: E

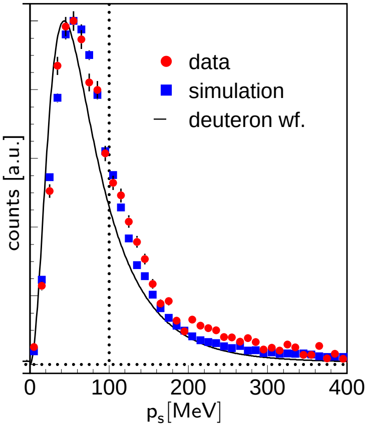


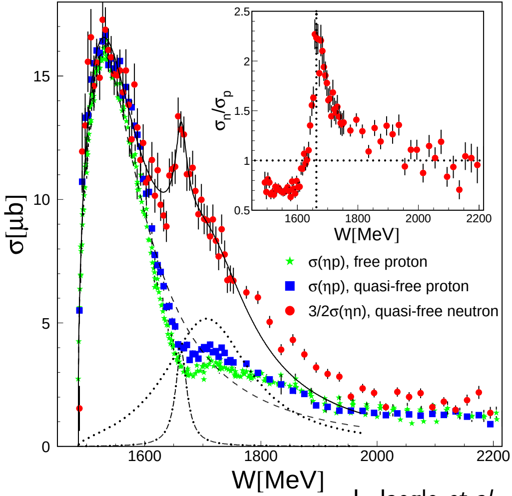
■ this work (H. Eberhardt, Bonn)
— A.V. Sarantsev et al., Eur. Phys. J. A 39 (t-channel)
— A.V. Sarantsev et al., Eur. Phys. J. A 39 (incl. s-channel)

Deuteron target: quasi-free $\gamma n \to \eta n$

unfold effects of fermi motion: use $\gamma d \to \eta np$ kinematics:

calculate T of neutron
and $\vec{p}$ of spectator proton





I. Jaegle *et al.*

Summary

First double polarization data has been taken with the Crystal Barrel/TAPS experiment at ELSA:

- linearly or circularly polarized photon beam
- longitudinally or transversely polarized target
- ongoing measurements with D-butanol target

Preliminary results shown:

- π^0 and η photoproduction:
  - Target Asymmetry T
  - Recoil Polarization P
  - Double Polarization Observables E, G, and H

  $\rightsquigarrow$ One step closer towards the complete experiment.
- $\pi^0\pi^0$ photoproduction, ω photoproduction

The new results will be important input for PWA.