Helicity Dependent Cross Sections in η Photoproduction off Quasi-Free Protons and Neutrons

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PANIC 2014

UNI BASEL

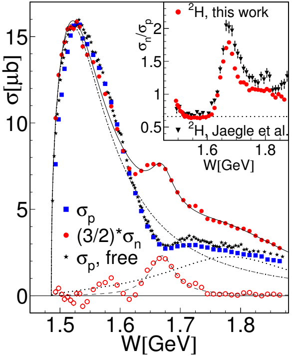
MAINZER MIKROTRON

Outline

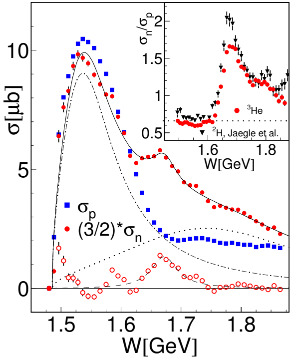
Motivation

different resonance contributions to proton and neutron

γ**N(d)** $\rightarrow \eta$**N**



γ**N(^{3}He)** $\rightarrow \eta$**N**



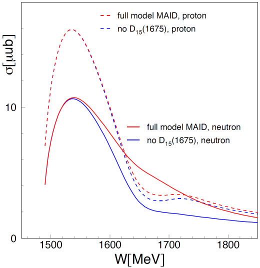
D. Werthmüller et al., Phys. Rev. Lett. 111, 232001

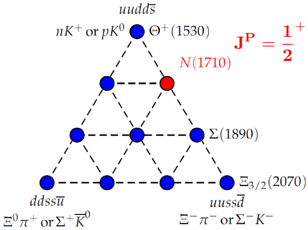
$\Rightarrow$ use polarization observables to identify amplitudes and quantum numbers

Nature of this Structure is unknown

1. **etaMAID:**
   Large contribution of the $D_{15}(1675)$
   ➢ high value for the branching ratio of $\Gamma_{\eta N}/\Gamma_{tot} = 17\%$
   (PDG: $\Gamma_{\eta N}/\Gamma \simeq 0 - 1\%$)
   (L.Tiator, NSTAR2005)

2. **Chiral Soliton model:**
   non-strange member of the baryon antidecuplet: $P_{11}(1680)$.
   bigger coupling to the neutron than to the proton
   (D.Diakonov et al., arXiv:hep-ph/9703373v2)





Double Polarization Observable E

- **circularly polarized beam** P_γ
- **longitudinally polarized target** P_T

Observable	Spin Orientation
$\sigma_{1/2}$	$\uparrow\downarrow$, $\downarrow\uparrow$
$\sigma_{3/2}$	$\uparrow\uparrow$, $\downarrow\downarrow$

- measure the asymmetry:

$$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}} = \frac{\sigma_{1/2} - \sigma_{3/2}}{2\sigma_{tot}}$$

Double Polarization Observable E

- $\nexists$ polarized deuterium $\Rightarrow$ dButanol: $\mathbf{C_4D_9OD}$
- 2 ways to measure E:

w/o carbon subtraction:

$$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{2\sigma_{tot}}$$

with carbon subtraction:

$$E = \frac{\sigma_{1/2} - \sigma_{3/2}}{\sigma_{1/2} + \sigma_{3/2}}$$

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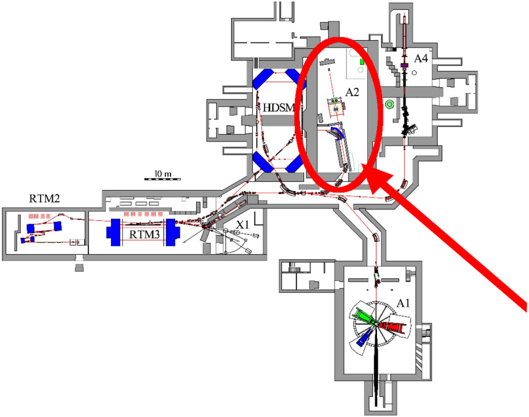
	dButanol	Carbon	η/h	
July 13	9 days	-	$\sim$ 25'000	
Feb 14	5 days	3 days	$\sim$ 30'000	
Jan/Feb 14	25	-	$\sim$ 3'000	➢ lin. pol., trigger,...

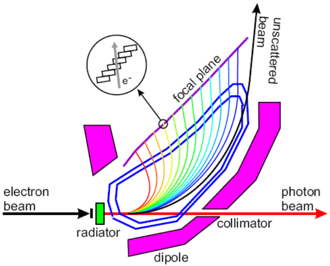
MAinzer MIcrotron: Electron Accelerator



A2 Experimental Hall

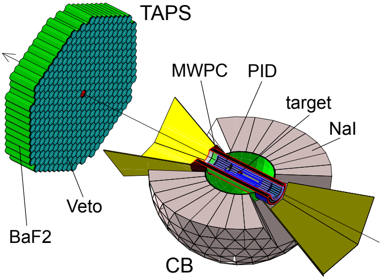
Bremsstrahlung Tagging

$$E_\gamma = E_{e^-}^{beam} - E_{e^-}^{tagged}$$



Experiment: Setup

- Circularly polarised tagged photon beam
- **Crystal Ball**: Highly segmented sphere made of NaI
- **PID**: Cylinder of scintillation counters surrounds target, charged particle detector
- **TAPS**: Forward wall, BaF_2 & $PbWO_4$ crystals
- **Target**: longitudinally polarised $\sim 65\%$



geometrical acceptance close to 4π

Reaction Identification

➢ **neutral and charged particles:**

	$\sigma_\mathbf{p}$ $\gamma p \rightarrow \eta p$	$\sigma_\mathbf{n}$ $\gamma n \rightarrow \eta n$
$\eta \rightarrow 2\gamma$	$2n$ & $1c$	$3n$
$\eta \rightarrow 6\gamma$	$6n$ & $1c$	$7n$

➢ **find best combination with χ^2 test:**

$\eta \rightarrow 2\gamma$ (σ_n):

$$\chi^2 = \frac{(m_k(\gamma\gamma) - m_\eta)^2}{(\Delta m_k(\gamma\gamma))^2} \quad k = 1, ..., 3$$

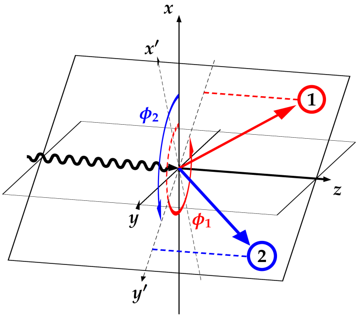
$\eta \rightarrow 6\gamma$:

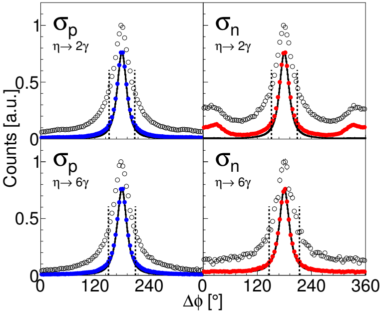
$$\chi^2 = \sum_{k=1}^{3} \frac{(m_k(\gamma\gamma) - m_{\pi^0})^2}{(\Delta m_k(\gamma\gamma))^2}$$

Background Suppression

Coplanarity:

$$\Delta\phi = \phi_N - \phi_\eta$$



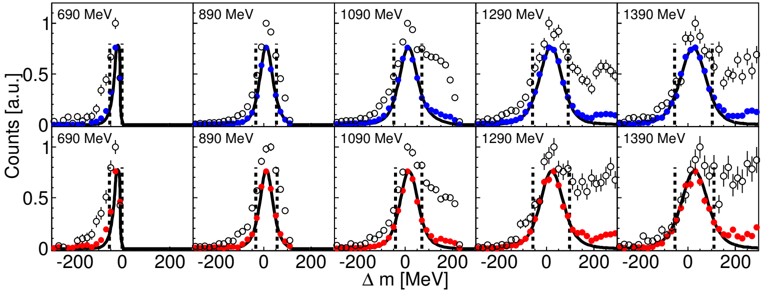


cut on $\pm 2\ \sigma$

Background Suppression

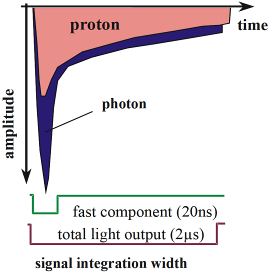
Missing Mass:

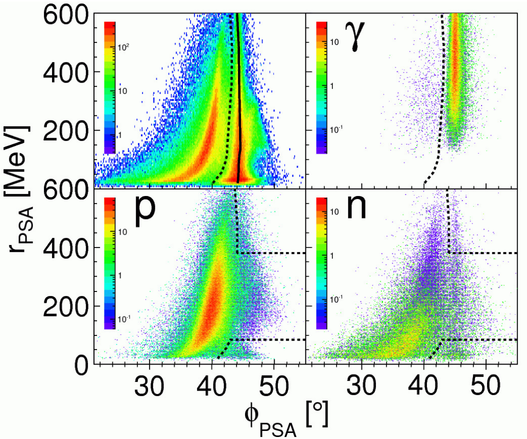
$$\Delta M = |P_{Beam} + P_N - P_\eta)| - m_N$$



cut on $\pm 1.5\ \sigma$

Pulse Shape Analysis (TAPS)



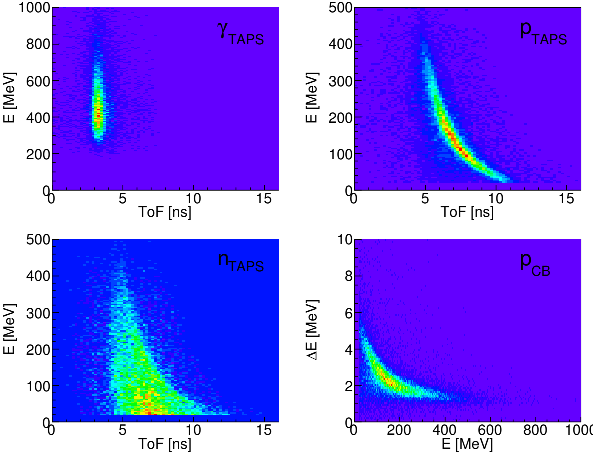


Photon : 3σ

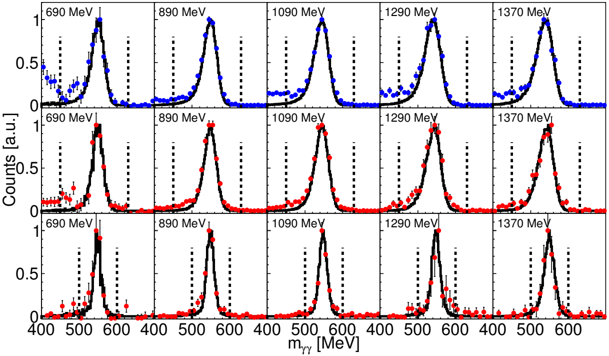
nucleon: exclusion zone]85,380[MeV

Other identification possibilities

energy versus time of flight and ΔE versus E



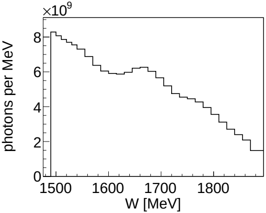
Invariant Mass Distributions



- integrate $m_{\gamma\gamma}\,(E, \cos(\theta))$ 2γ: 450-630 MeV 6γ: 500-600 MeV

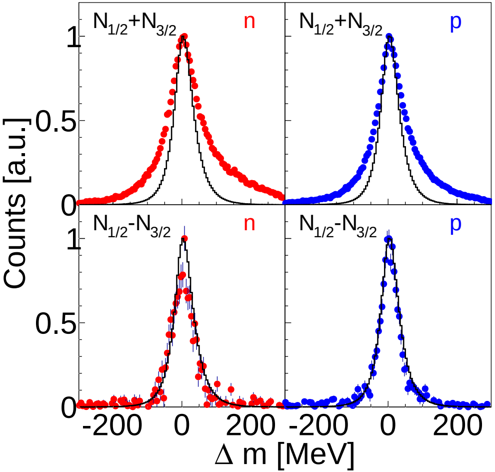
Cross Sections

- normalize with photon flux



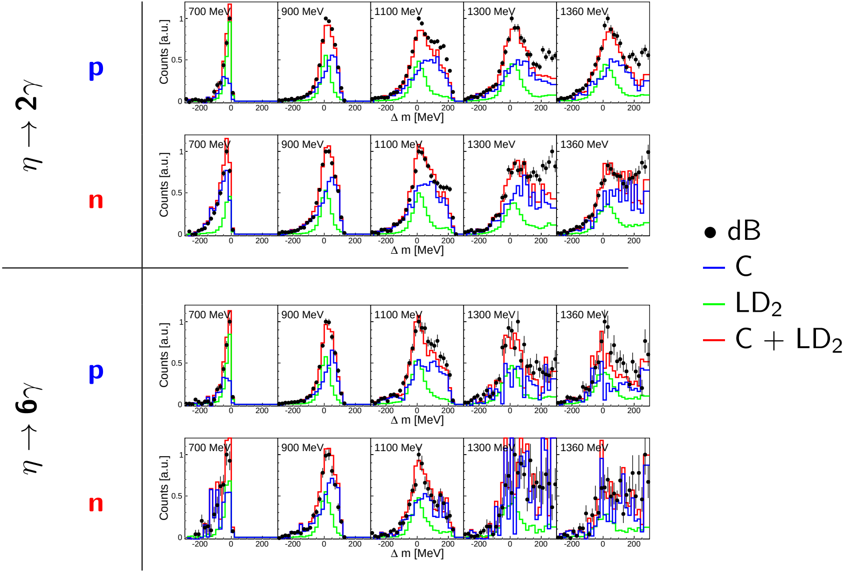
- detection efficiency correction (MC): energy and θ dependent
- MC not perfect $\rightarrow$ nucleon detection efficiency correction from hydrogen data
  $\gamma + p \rightarrow \eta + p$ $\qquad \gamma + p \rightarrow \pi^0 + \pi^+ + n$

Carbon Subtraction

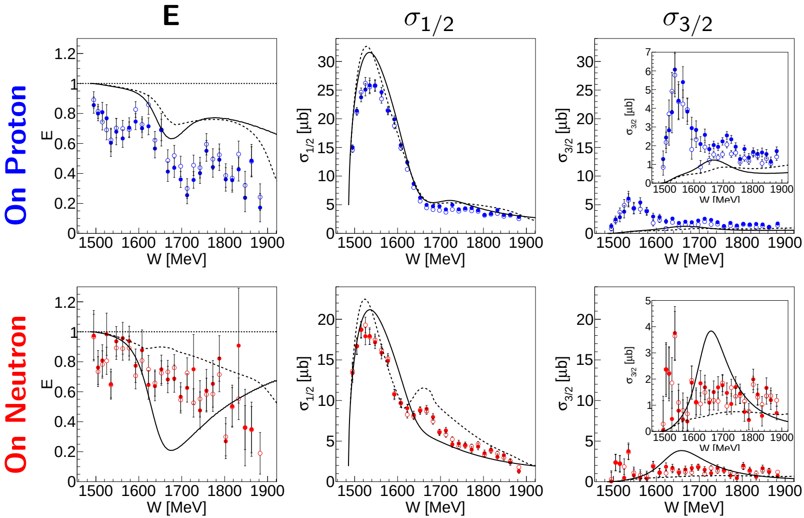


- $N_{1/2} + N_{3/2}$: carbon contribution $\rightarrow$ carbon subtraction needed!
- $N_{1/2} - N_{3/2}$: no carbon left!

Carbon Subtraction



η Asymmetries - Preliminary



○ direct • carbon subtracted —MAID --- BnGa

Conclusion

- preliminary asymmetries for $\gamma p \rightarrow \eta p$ and $\gamma n \rightarrow \eta n$
- η bump only in $\sigma_{1/2}$: S_{11}, P_{11} resonance?
- Further investigation has to be done: Discrepancy in S_{11} region of proton $\rightarrow$ nucleon efficiency?

Thanks for your attention

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