

DOUBLE POLARIZATION OBSERVABLES IN η ELECTROPRODUCTION

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A1 Collaboration

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● Introduction

- ▶ Why η production?
- ▶ Structure of η production amplitudes

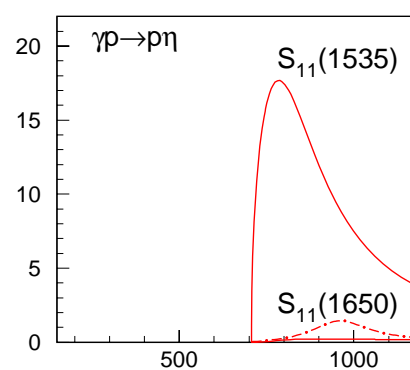
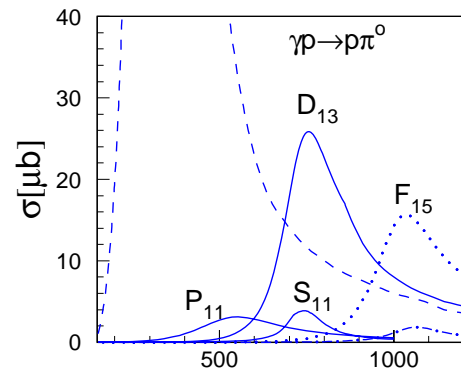
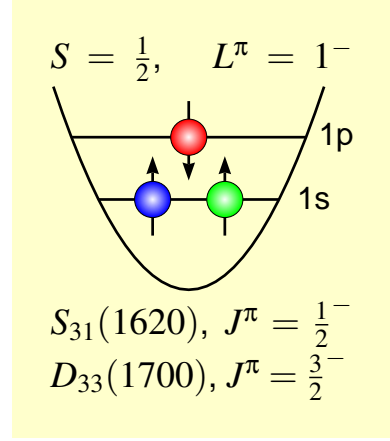
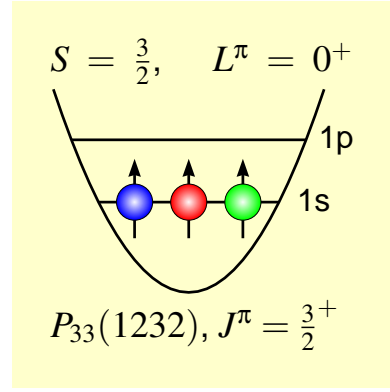
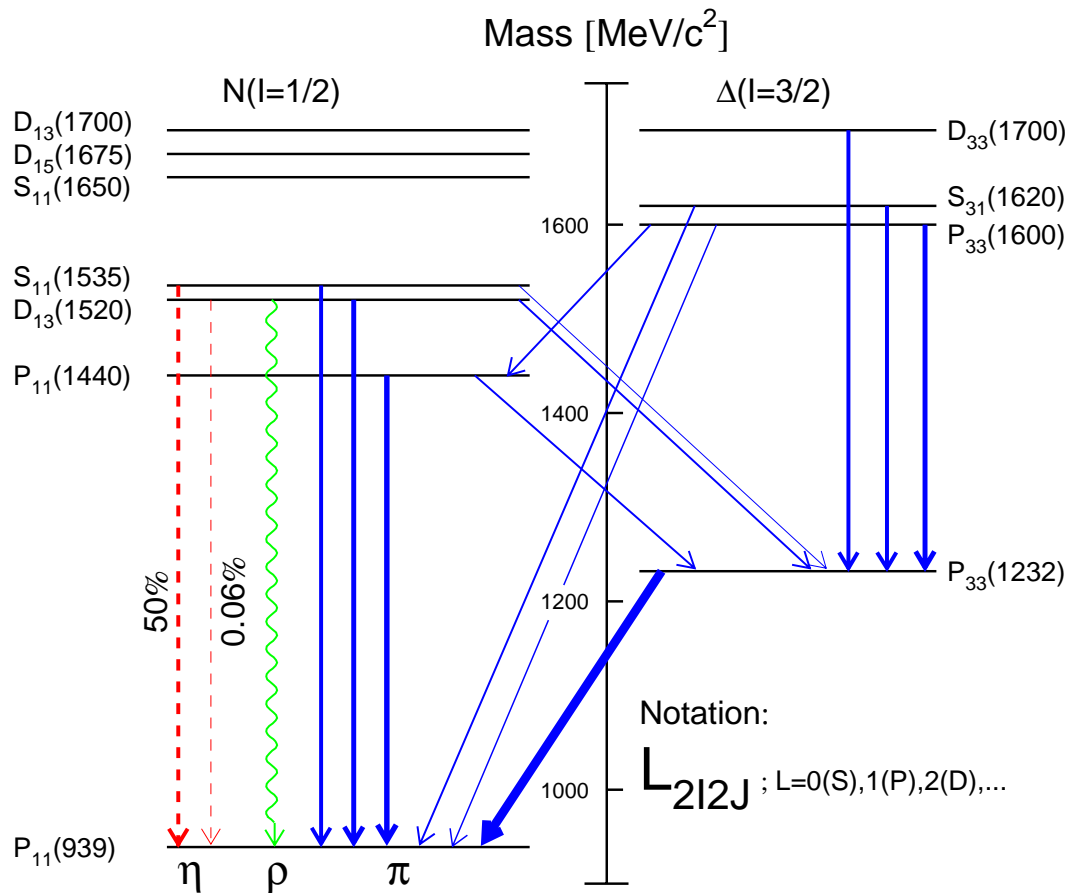
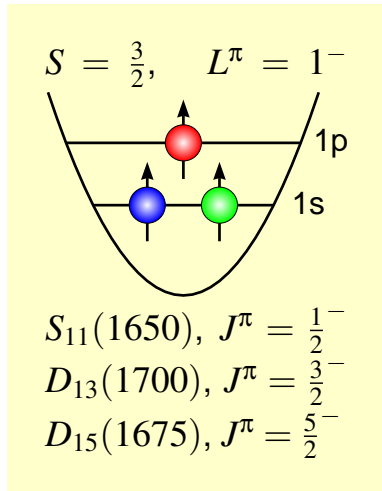
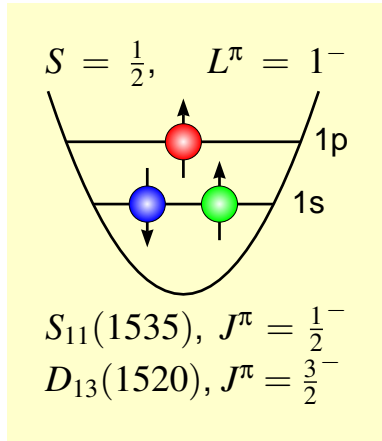
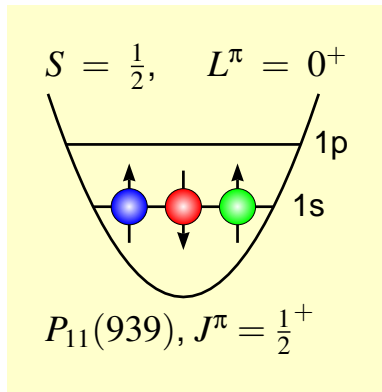
● Open issues

- ▶ Polarized Target Asymmetry
- ▶ Structure of the $S_{11}(1535)$ Resonance

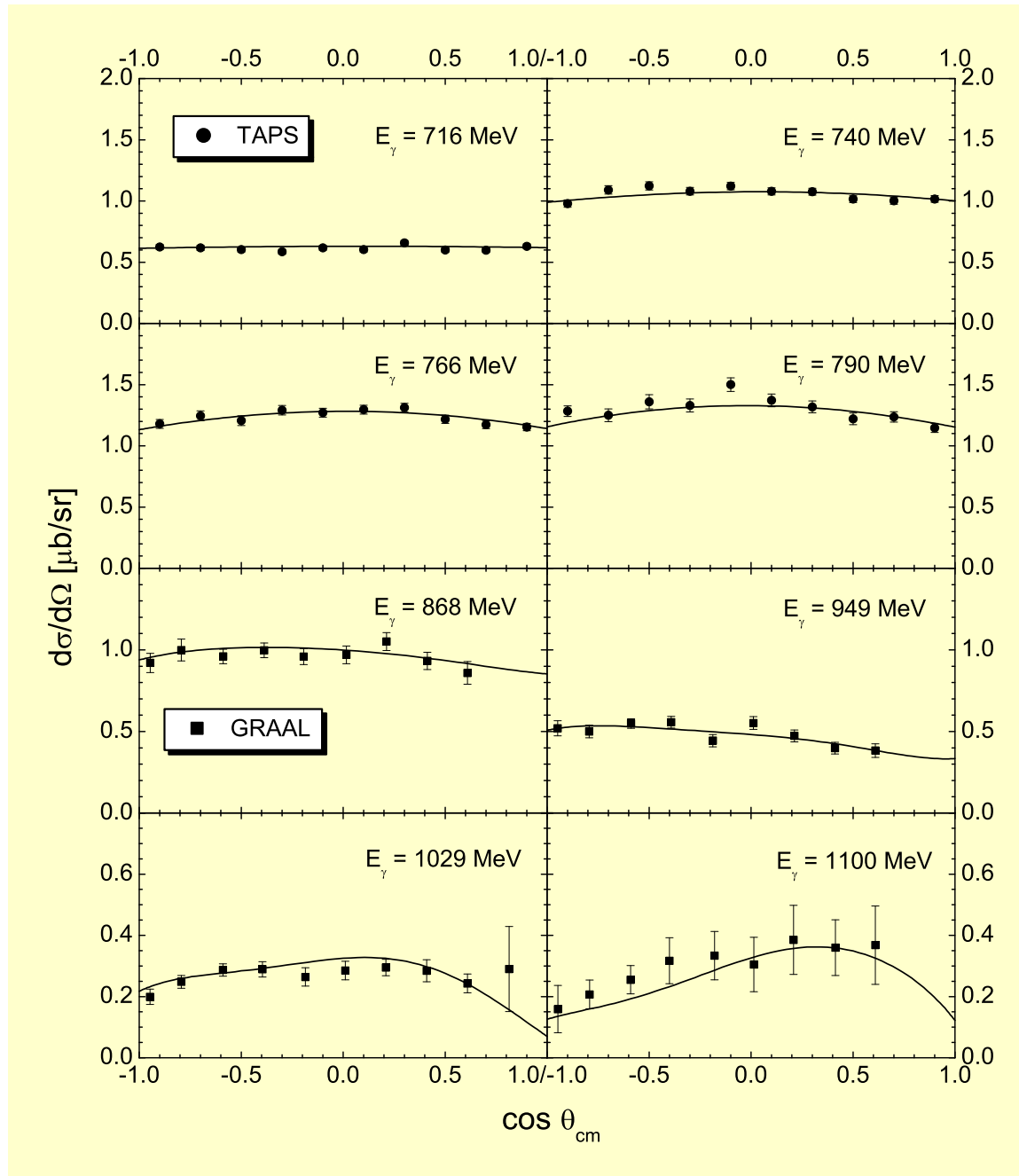
● Double-Polarization Experiment

- ▶ Double-Polarization Observables
- ▶ Recoil Polarimetry
- ▶ Extraction of Polarizations

Resonance Structure of the Nucleon



Differential Cross Section

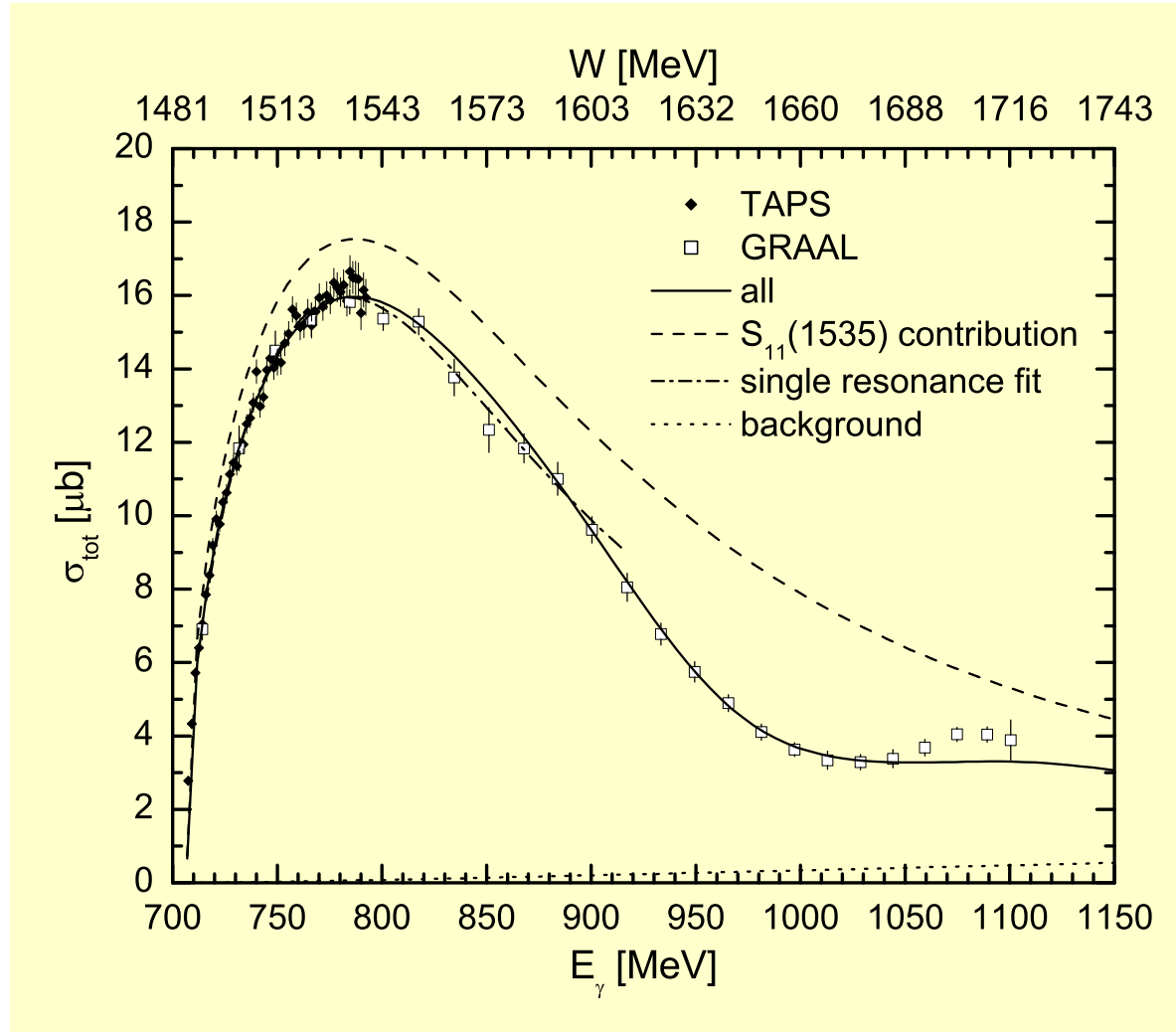


Low Energy:

● Isotropic angular distribution

⇒ *s*-wave dominant!

Total Cross Section

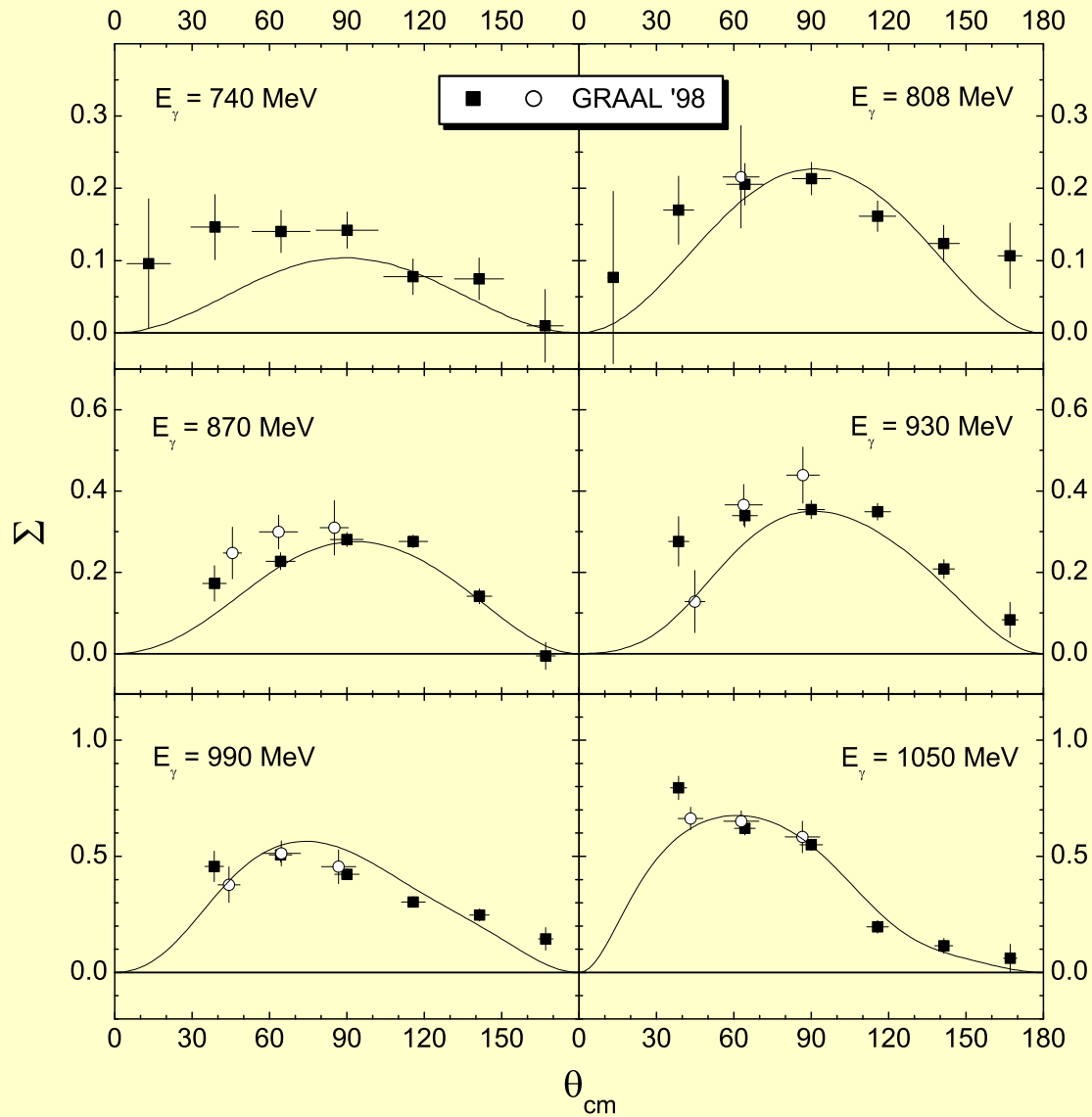


● Resonance structure in s -wave \Rightarrow dominant $S_{11}(1535)$ resonance

● Background is small

Polarized Beam Asymmetry Σ

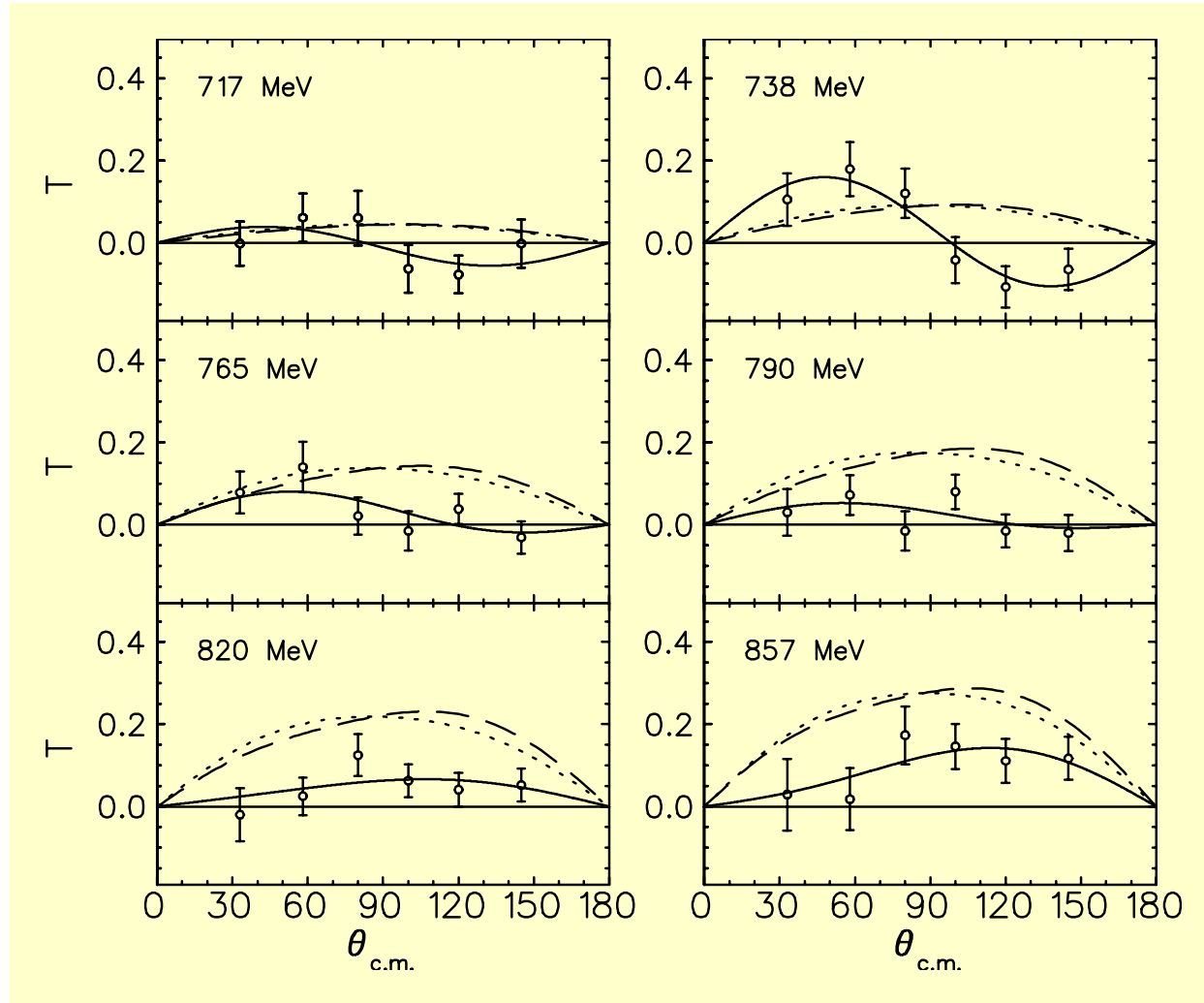
$$\Sigma = 3 \sin^2 \theta \Re [E_{0+}^* (E_{2-} + M_{2-})] / |E_{0+}|^2$$



- Transverse polarized photon beam
- Interference with $S_{11}(1535)$
- Sensitive to $D_{13}(1520)$
- $\beta_{\eta N} = (0.06 \pm 0.003)\%$

PHOENICS (Bonn): Polarized target asymmetry T

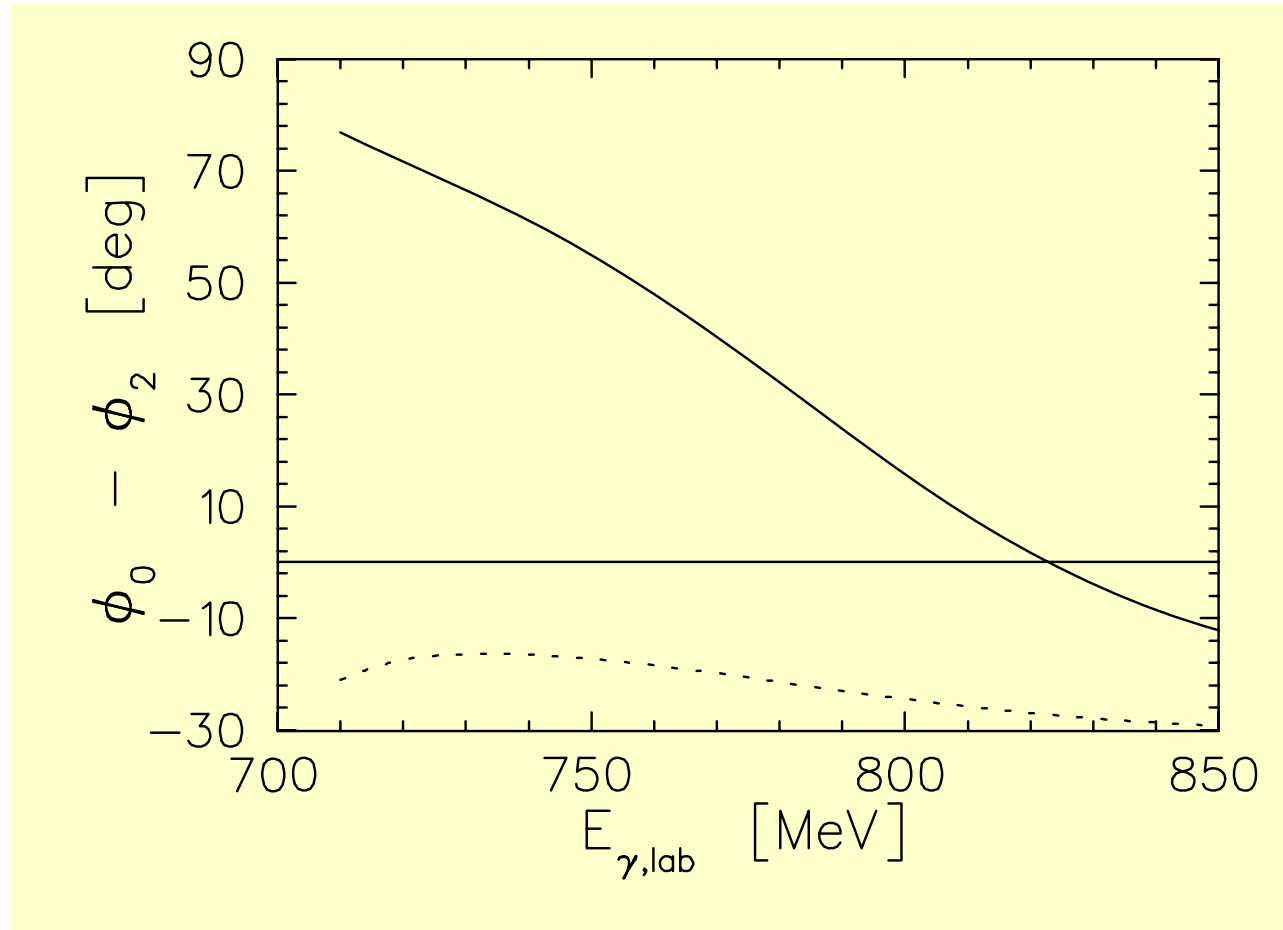
$$T \approx 1/\sigma \{ 3 \sin \mathfrak{I}[E_{0+}^*(E_{1+} - M_{1+})] - 3 \sin \theta \cos \theta \mathfrak{I}[E_{0+}^*(E_{2-} + M_{2-})] \}$$



- ◊ A. Bock *et al.*, Phys. Rev. Lett. 81, 534-537 (1998)
- Standard fit to all data
- - - Without $D_{13}(1520)$
- Phase rotation between E_{0+}^* and $(E_{2-} + M_{2-})$

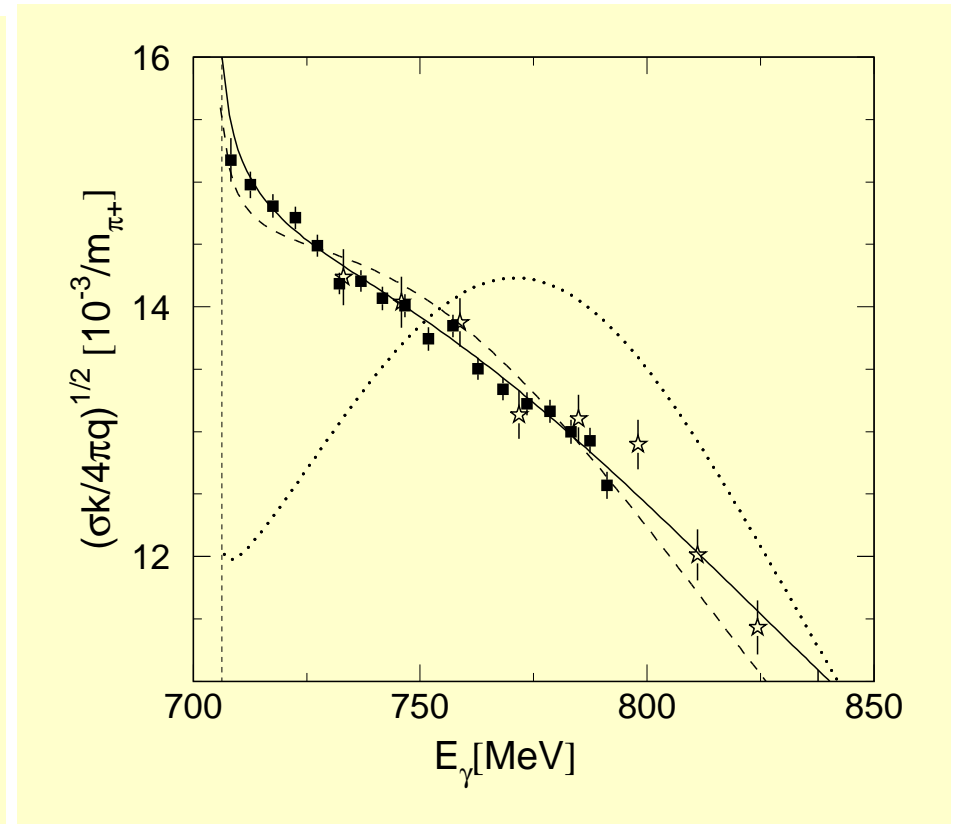
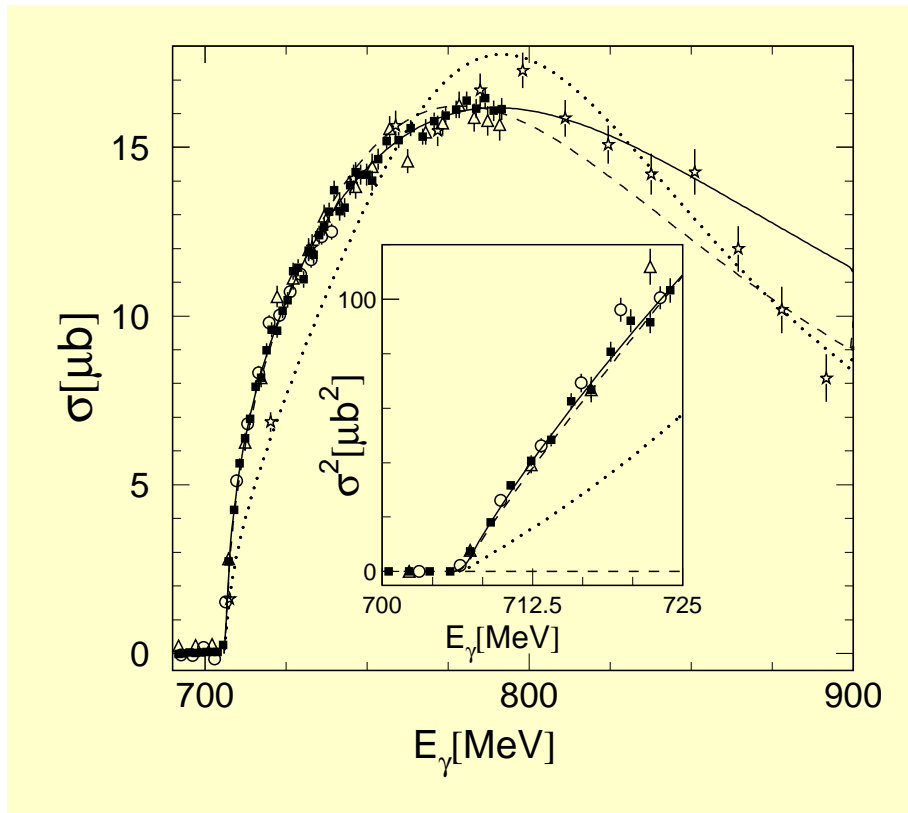
Phase problem

$$\sigma T \approx 3 \sin \mathfrak{I} [E_{0+}^* (E_{1+} - M_{1+})] - 3 \sin \theta \cos \theta \mathfrak{I} [E_{0+}^* (E_{2-} + M_{2-})]$$



- Phase-difference $\phi_0 - \phi_2$ between E_{0+} and $(E_{2-} + M_{2-})$ has to be adjusted!
- Problem of the $S_{11}(1535)$ - or of the $D_{13}(1520)$ -resonance?
- Breit-Wigner shape?

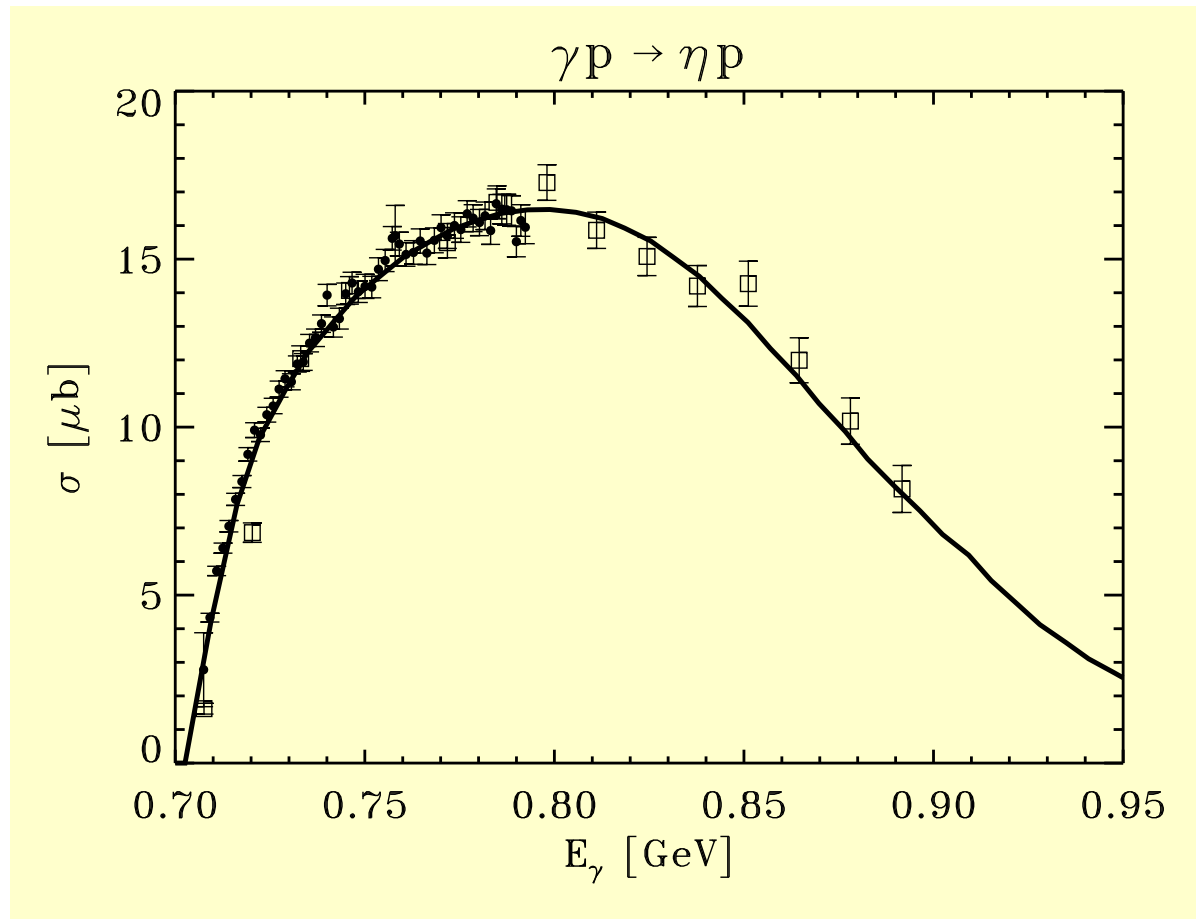
s -wave Dominance $\Leftrightarrow S_{11}(1535)$?



- Angular distribution: flat
- Energy dependence is well described by Breit-Wigner shape
- **But:** Reduced cross section $\approx E_{0+}$ is **flat!** (energy dependent width!)

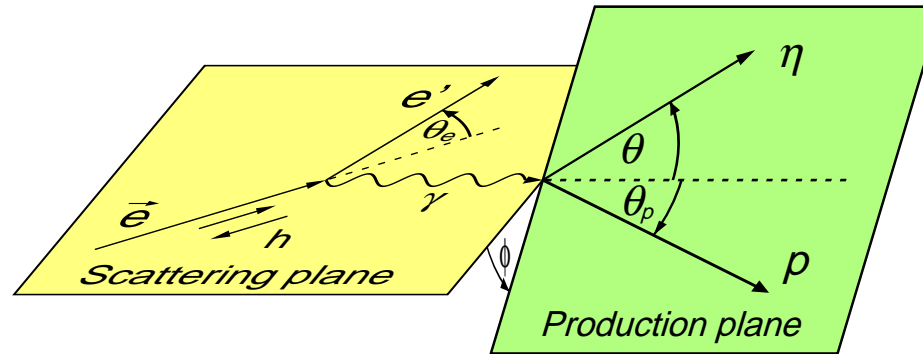
... anything can produce a flat energy dependence!

Example: Dynamical generated $S_{11}(1535)$ -Resonance



- Chiral Lagrangian + coupled channels
- No resonance!
- Interpretation (in that paper): **bound $K\Sigma$ state**

Double polarization experiment



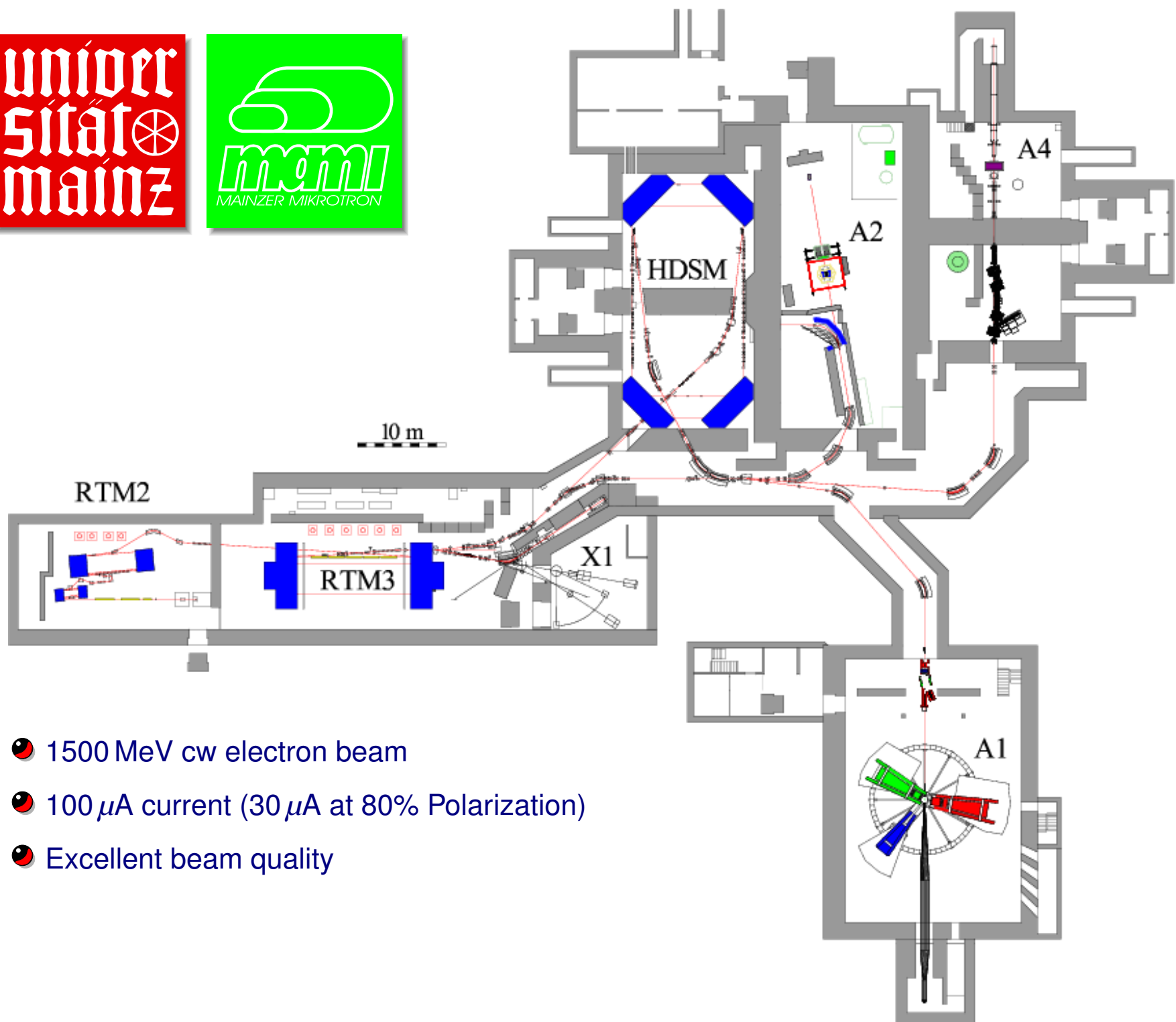
P_y : similar interference as σT !

$$P_y \sim \sin\theta \Im \left\{ E_{0+}^* (3 \cos\theta (E_{2-} - 3M_{2-}) - 2M_{1-}) \right\} + \dots$$

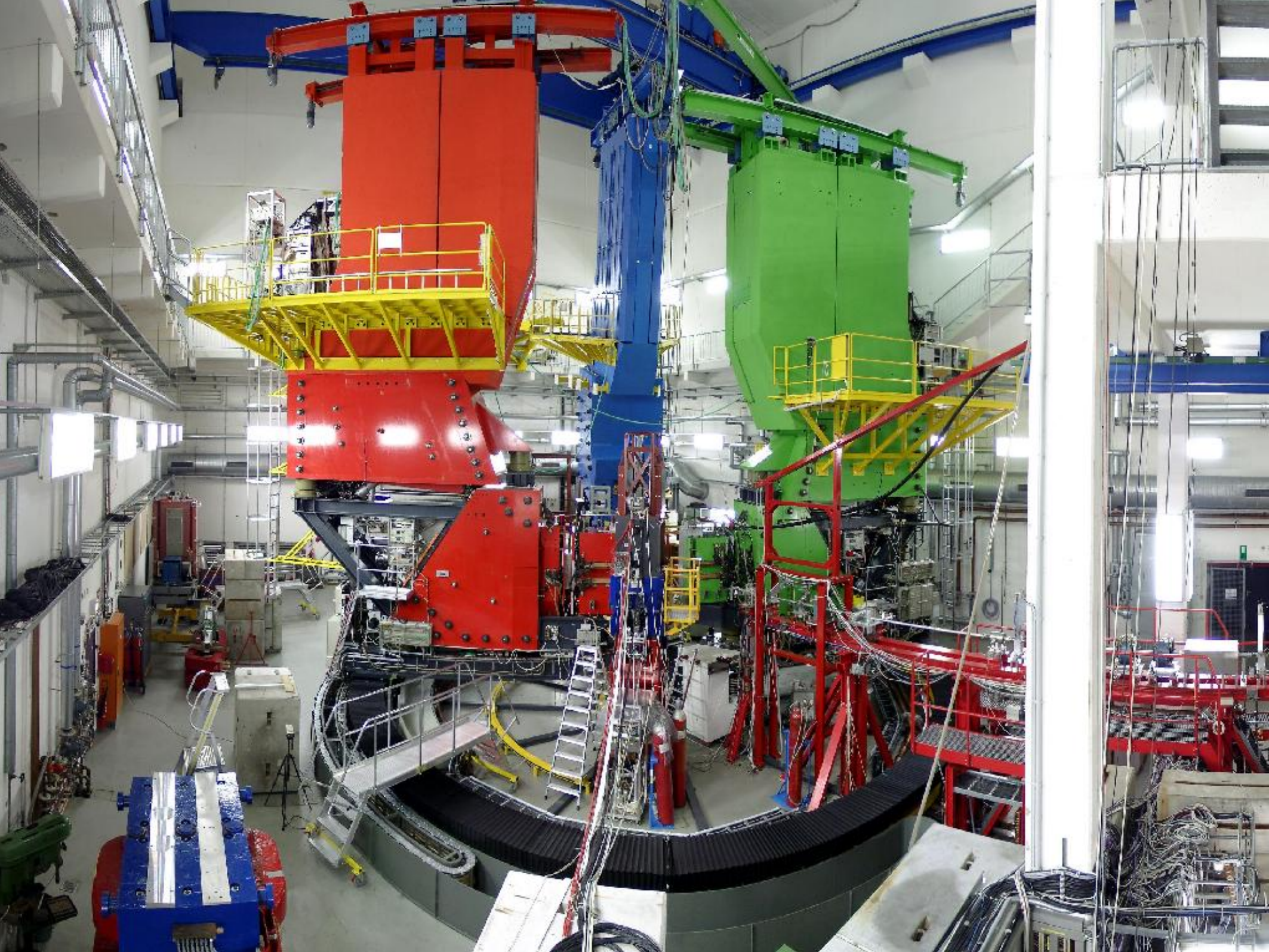
P_x^h, P_z^h : dominated by $|E_{0+}|^2$

$$P_x^h \sim -\sin\theta \left[|E_{0+}|^2 - \Re \left\{ E_{0+}^* (E_{2-} - 3M_{2-}) \right\} \right]$$

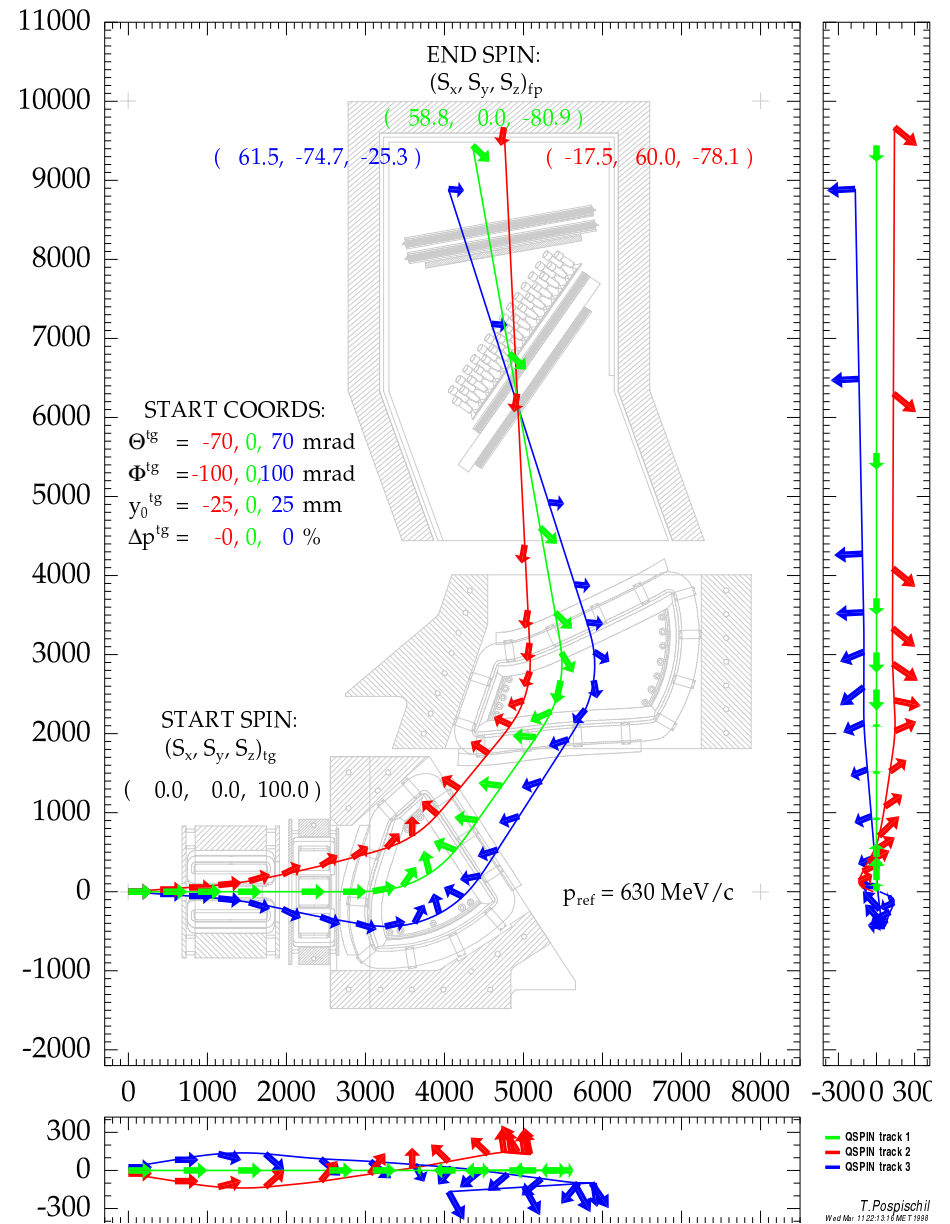
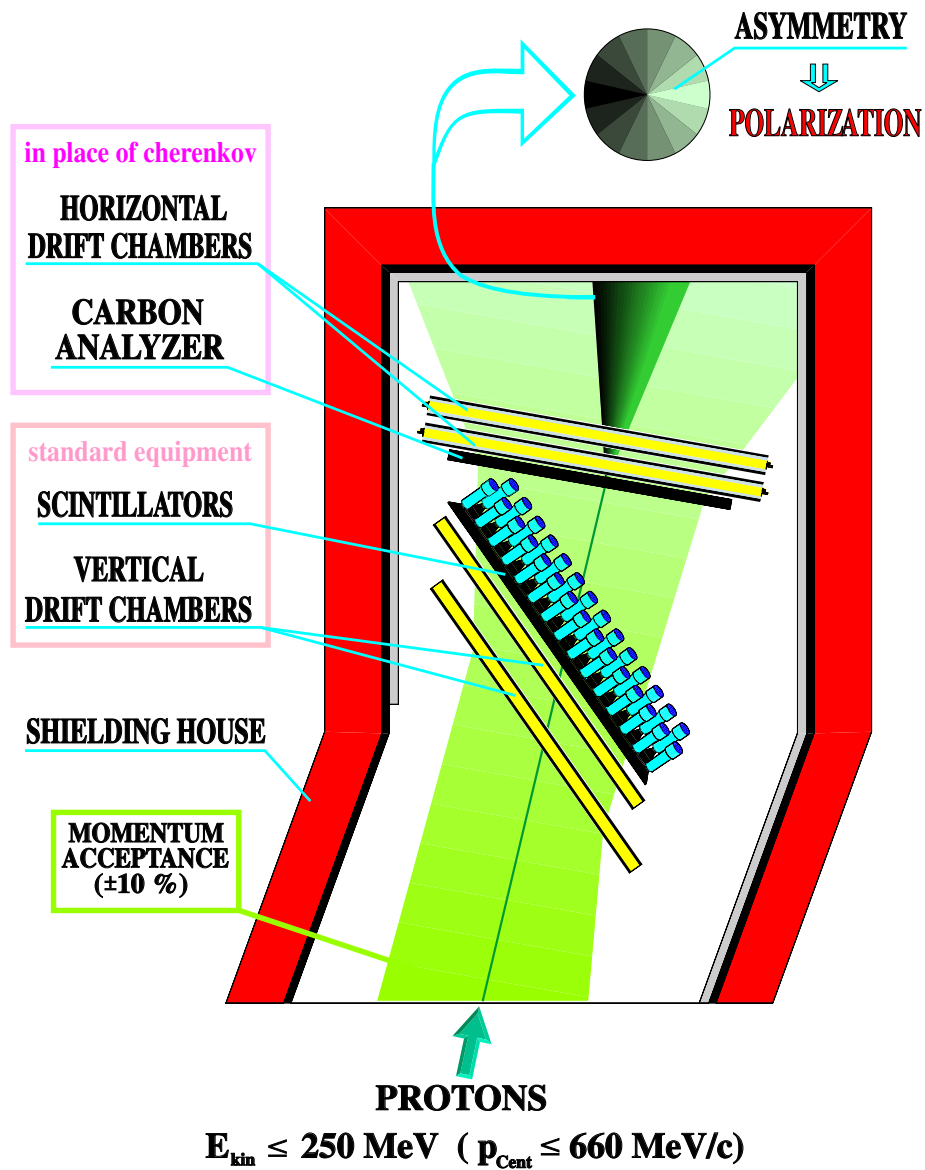
$$P_y^h \sim \cos\theta |E_{0+}|^2 - 2 \Re \left\{ E_{0+}^* [M_{1-} - \cos\theta (E_{2-} - 3M_{2-})] \right\}$$



- 1500 MeV cw electron beam
- 100 μA current (30 μA at 80% Polarization)
- Excellent beam quality

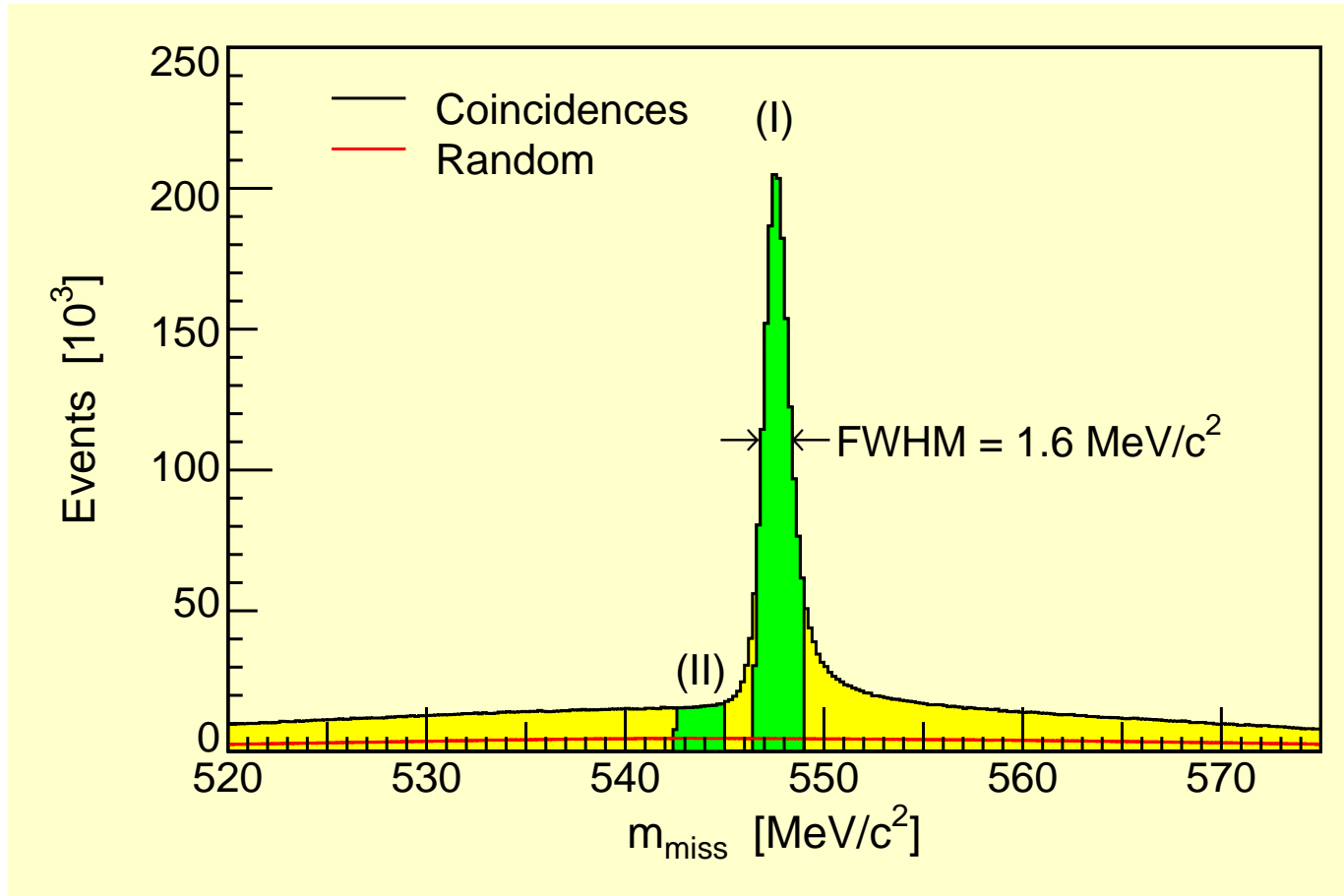


Focal Plane Polarimeter



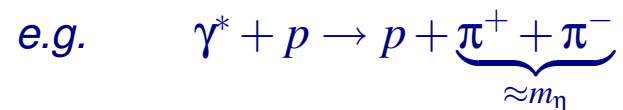
Missing mass

$$m_{miss}^2 = (e + p_{in} - e' - p_{out})^2$$

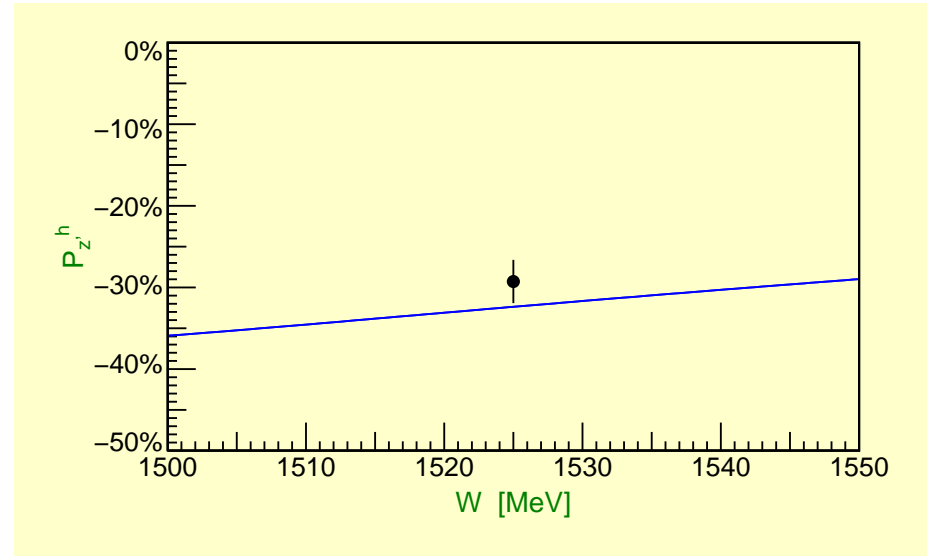
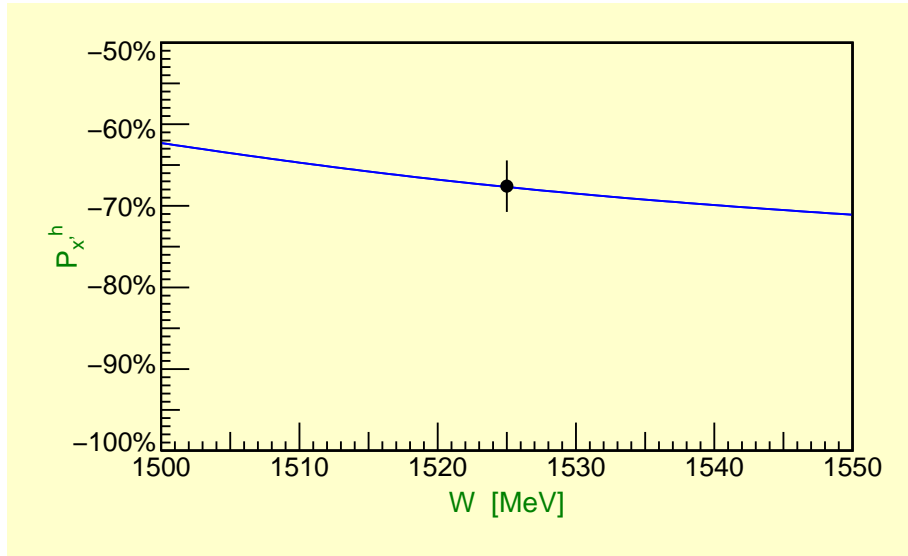


● Random background $\approx 2\%$

● Physical background $\approx 8\%$



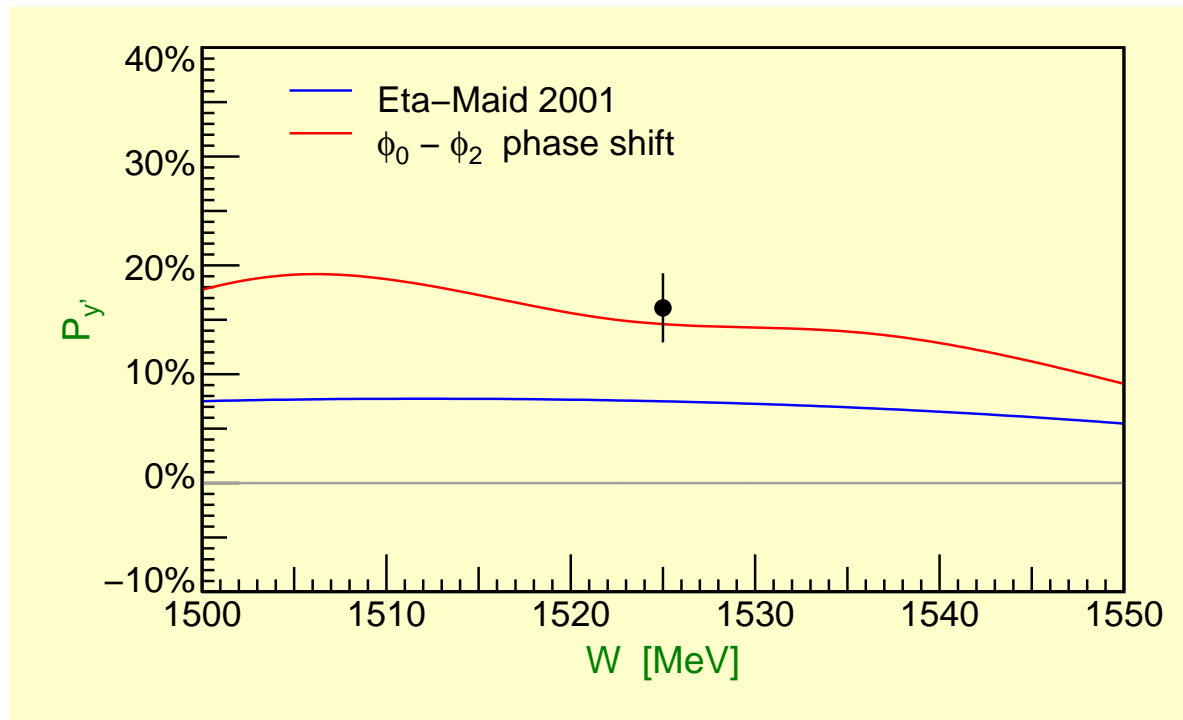
Result: Helicity-Dependent Polarization



No surprises:

- Dominant $|E_{0+}|^2$
- Consistent with existing data
- No visible S_{0+} contribution

Result: Helicity-Independent Polarization



- Clear deviation from Eta-Maid
 - Consistent with phase rotation $\phi_0 - \phi_2$
- ⇒ consistent with ELSA results on T

Summary

η Photo- and Electroproduction

- Clean probe to investigate isoscalar resonances of the nucleon
- Cross section s -wave dominated
- Polarized target asymmetry T not understood

New experiment with beam-recoil double polarization

- P_x^h and P_z^h as expected \Rightarrow s -wave structure, multipole content consistently reproduced
- P_y deviation from model, but consistent with target asymmetry T
- \Rightarrow Problem of T still persists
 - ▶ Problem of the phase $\phi_0 - \phi_2$?
 - ▶ Breit-Wigner prescription not sufficient?
 - ▶ Structure of the $S_{11}(1535)$?

Next steps

- Photoproduction (ELSA, MAMI): Observables T , G
- Electroproduction: Longitudinal Coupling