universitätbonn

Measurement of polarization observables I^s and I^c in the reaction $\vec{\gamma}p \rightarrow p\pi^0\pi^0$ with the CBELSA/TAPS experiment

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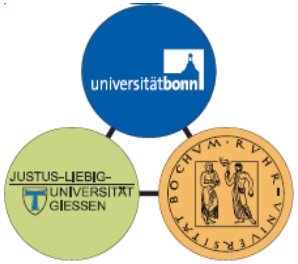
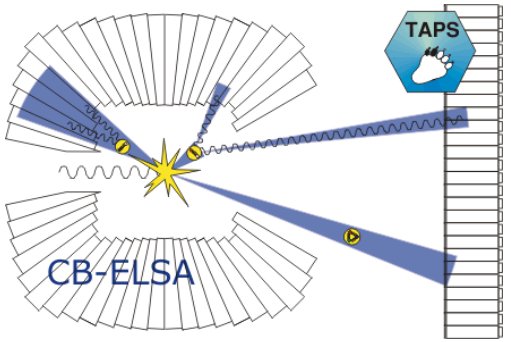
for the CBELSA/TAPS Collaboration

The 8th International Workshop
on the Physics of Excited Nucleons
Newport News, 19.05.2011





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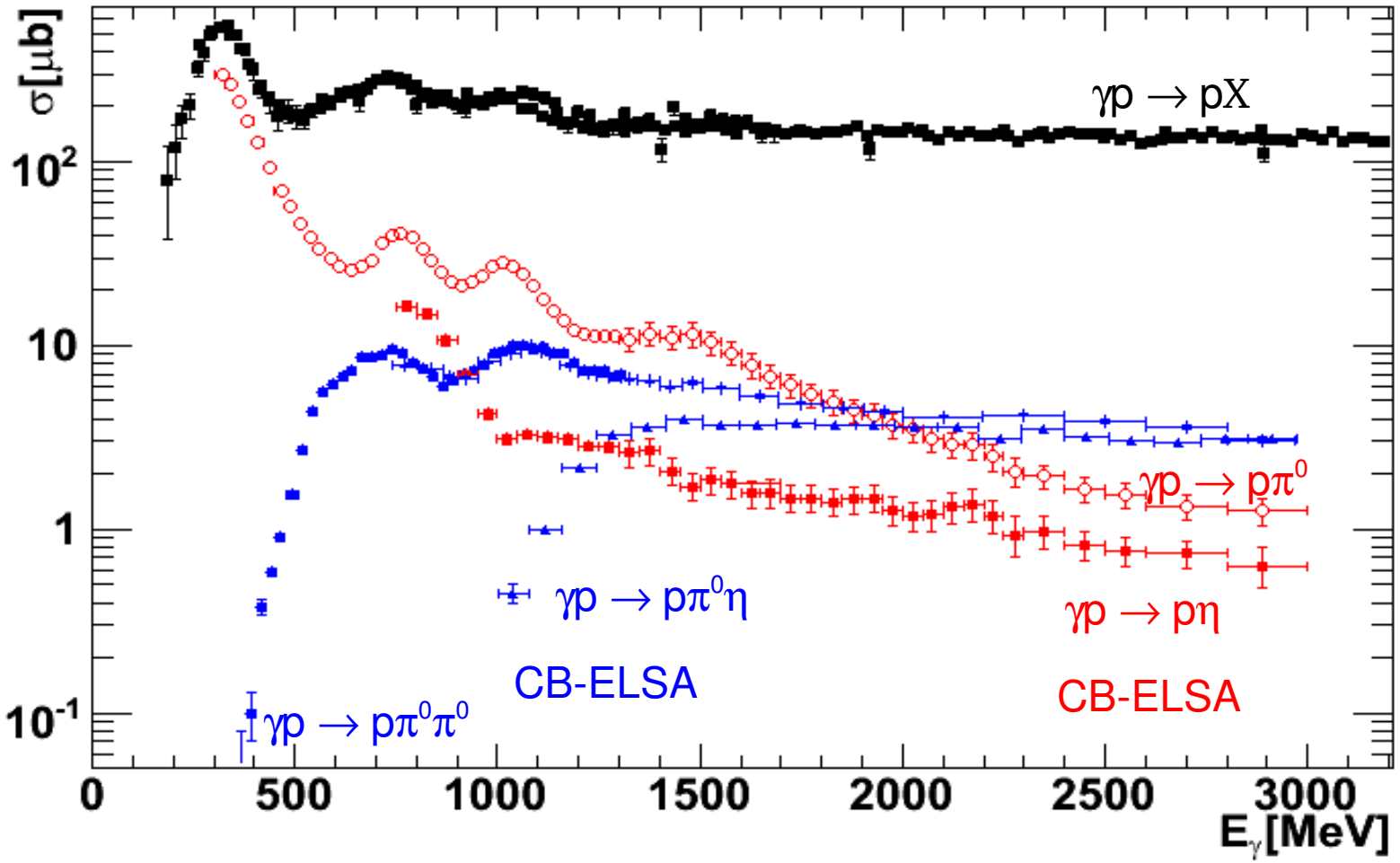
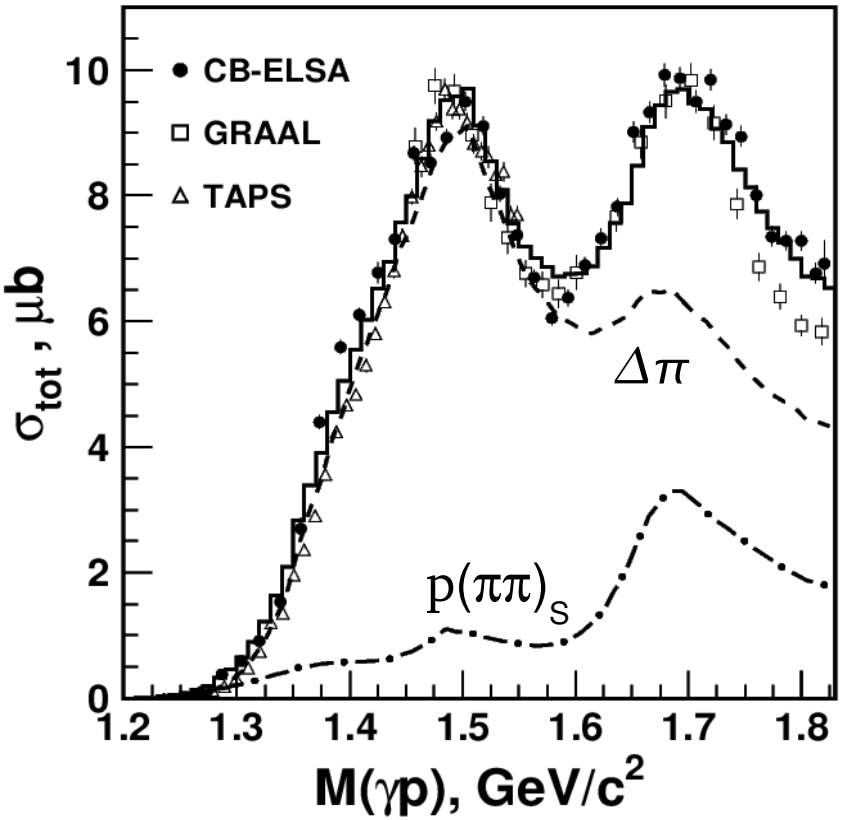
Introduction

Goal: Gain a good understanding of the spectrum and properties of baryon resonances



At high energies:
Multi-meson final states play a role of increasing importance!

Introduction



CB-ELSA fit (BnGa-PWA)
including additional data from:
single-meson production,
$\pi^- p \rightarrow n2\pi^0$ (Crystal Ball),
P_{11}-, S_{11}-, P_{33}-, D_{33}- πN
partial waves

event-based
maximum-likelihood fit

⇒ Determination of resonance properties:
m, $\Gamma_i(\Delta\pi^0, N(\pi\pi)_S, P_{11}\pi, D_{13}\pi, \ldots)$

PWA:
$D_{33}(1700) \rightarrow \Delta\pi$ decays dominantly either with L=0 or L=2

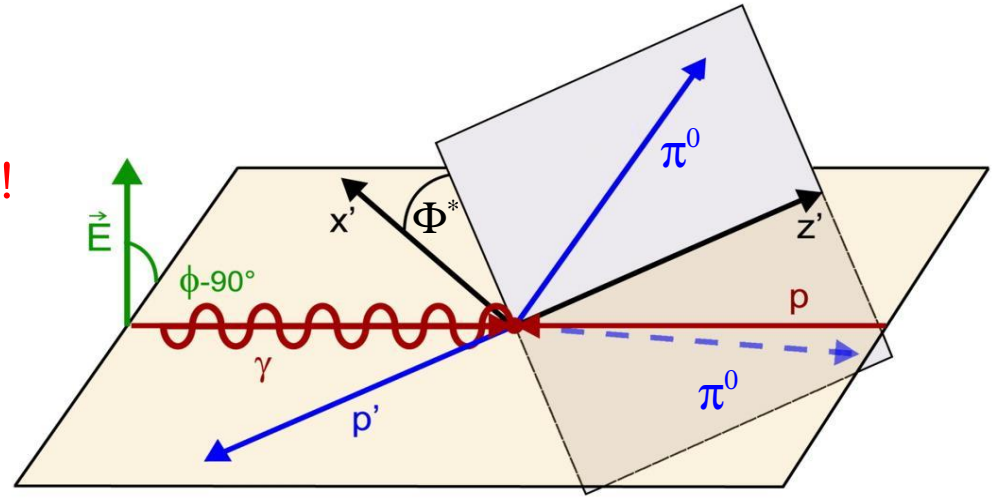
Measurement of polarization observables necessary !

For a complete experiment, 15 observables are needed!

W. Roberts and T. Oed, Phys. Rev. C 71, 055201 (2005)

Introduction

- Three-particle final state: additional plane !
- Additional polarization observables in comparison to single meson final state

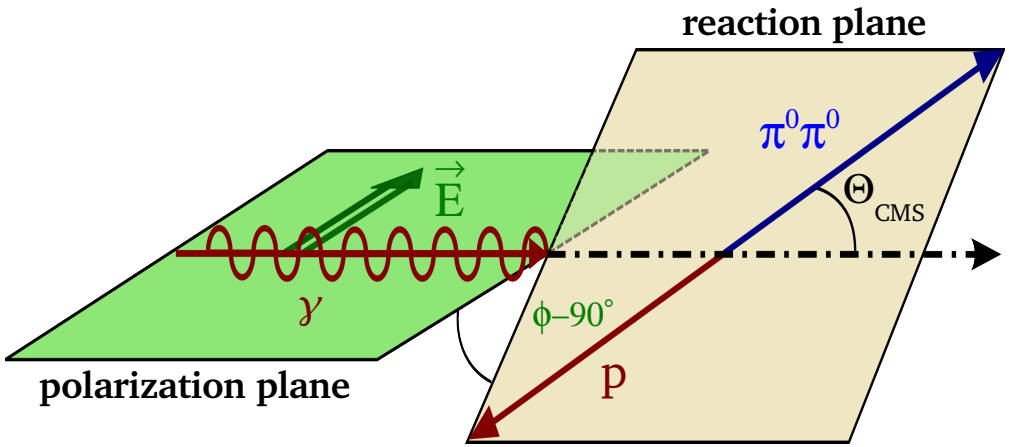


Linearly polarized photon beam, unpolarized target:

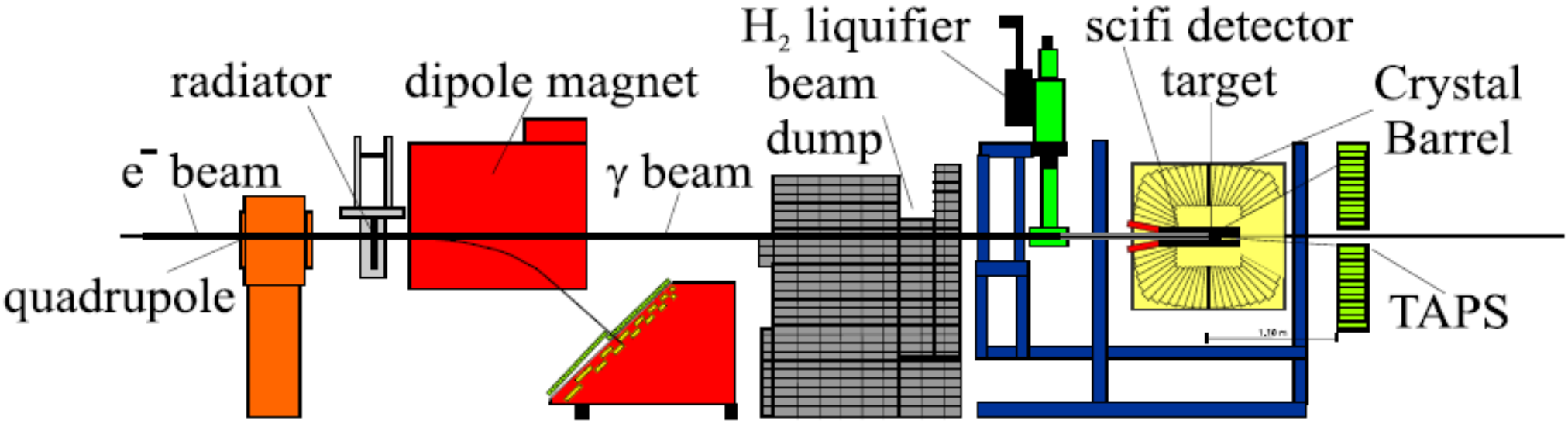
$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 \{1 + \delta_l [I^s \sin(2\phi) + I^c \cos(2\phi)]\}$$

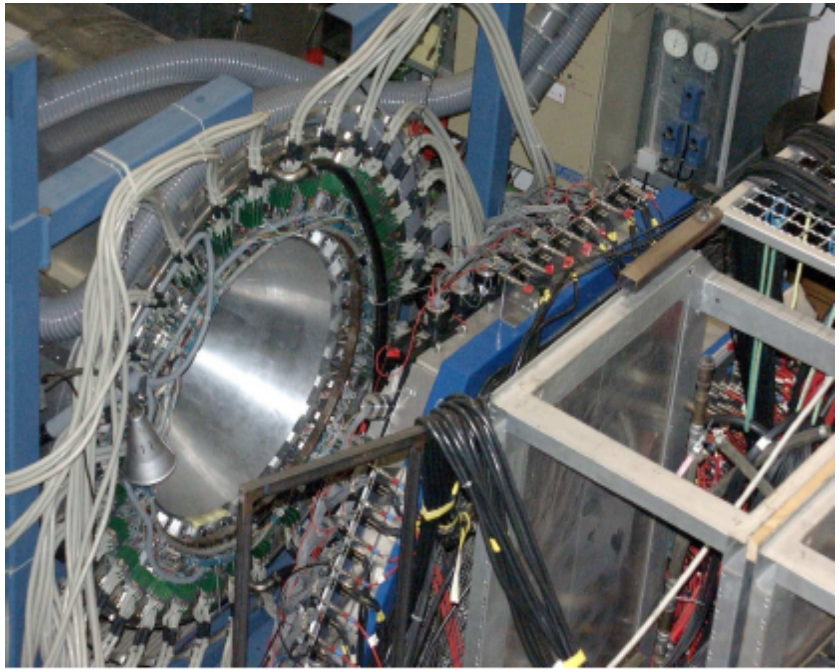
Quasi two-body consideration:

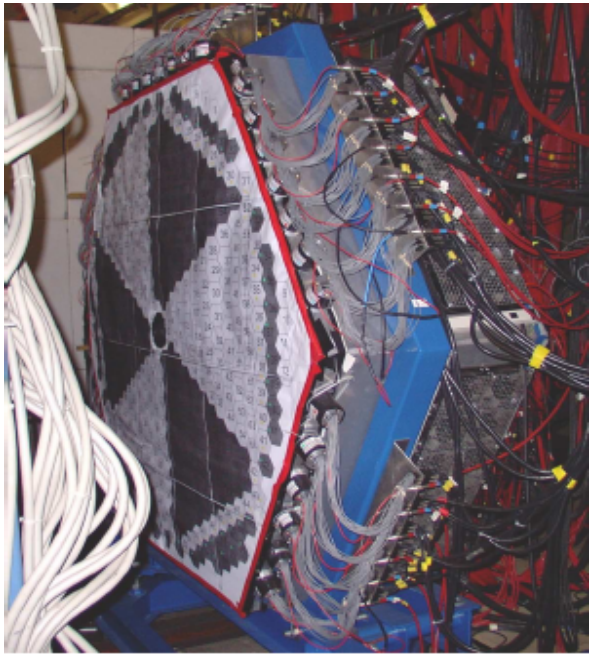
$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 [1 + \delta_l \Sigma \cos(2\phi)]$$



The CBELSA/TAPS experiment







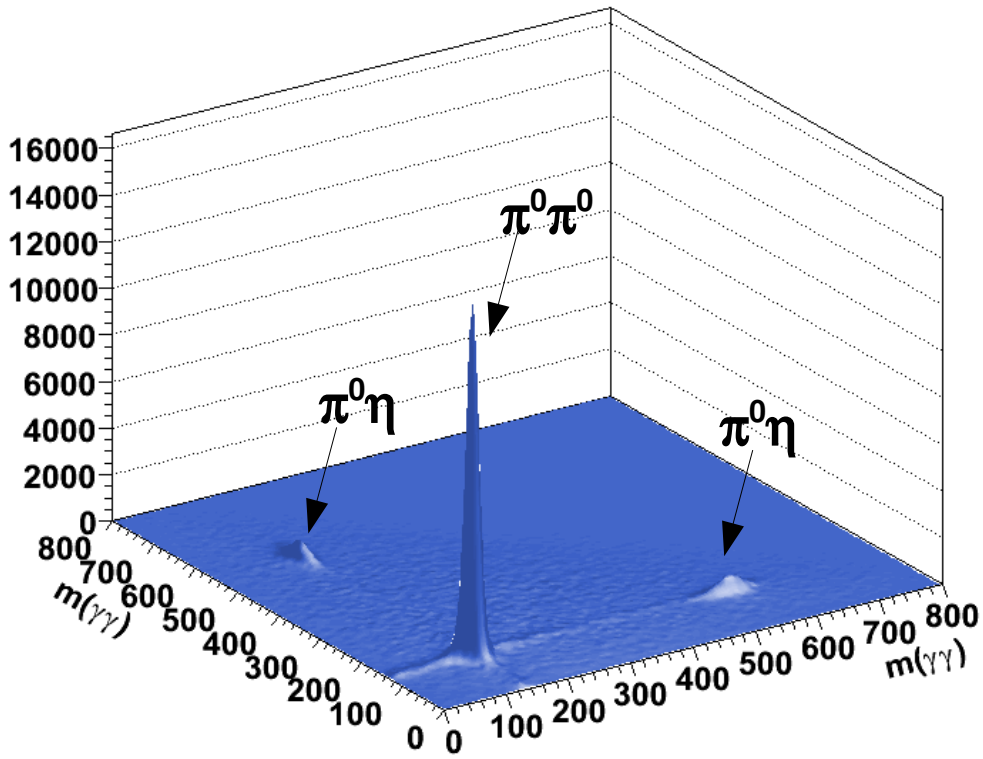
The data

CBELSA/TAPS:

A: $Pol_{max} = 49.2\%$ @$E_\gamma = 1300$ MeV

B: $Pol_{max} = 38.7\%$ @$E_\gamma = 1600$ MeV

- Produced via coherent bremsstrahlung at a diamond crystal
- Liquid hydrogen as target material



Data selected for 4γ (+proton) events

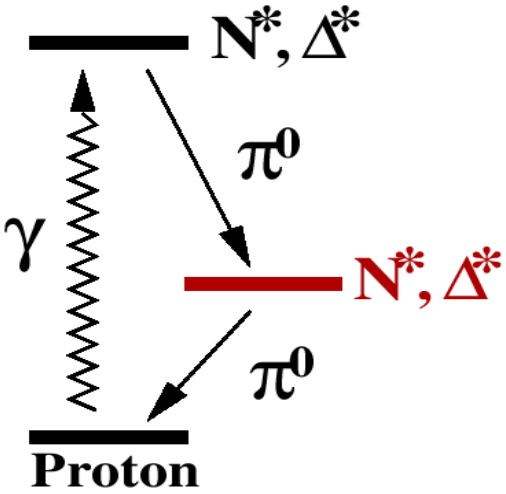
$\gamma p \rightarrow p \pi^0 \pi^0$ clearly observed!

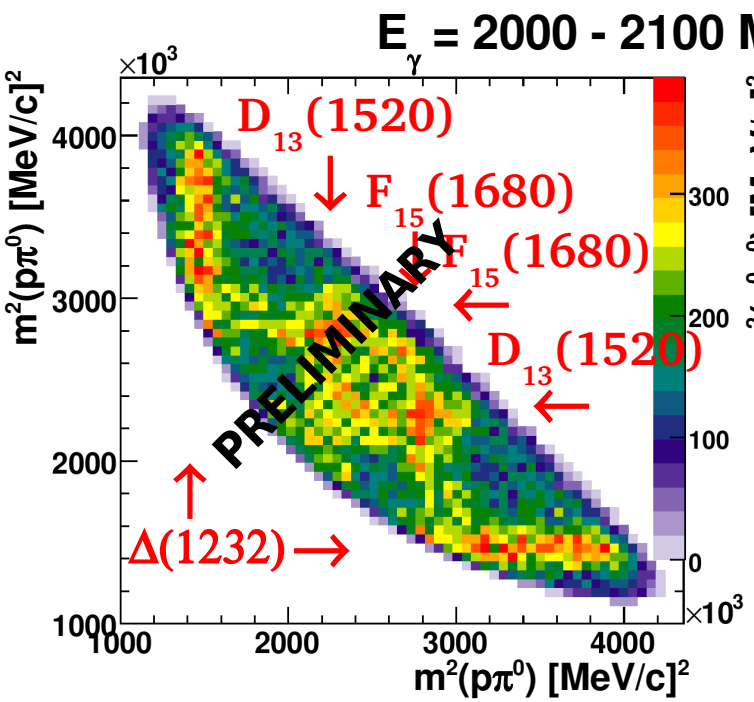
- Preselection on invariant mass, coplanarity, missing mass
- Kinematic fit: $CL_{\pi\pi} > CL_{\pi\eta}$ and $CL_{\pi\pi} > 10\%$

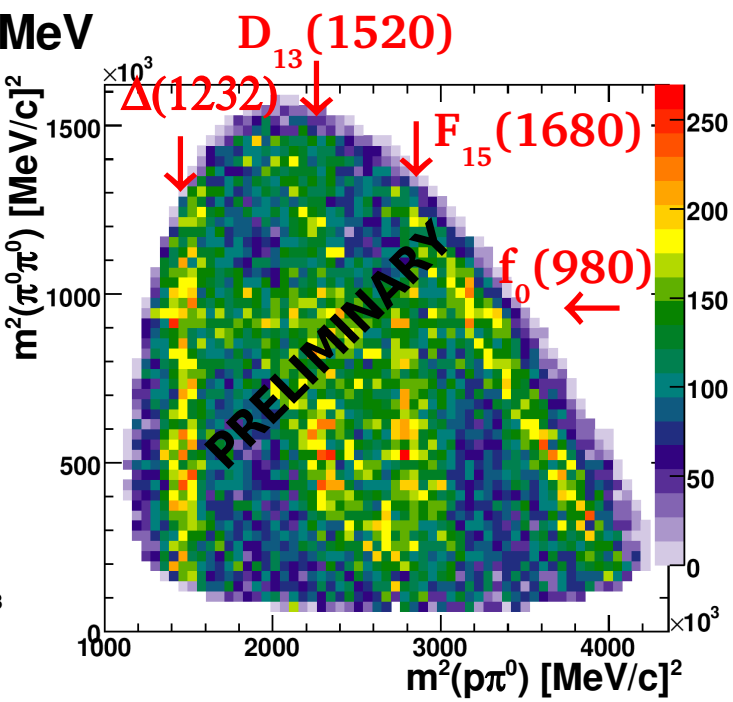
560,000 events used for determination of polarization observables ($E_\gamma = 970 - 1650$ MeV)

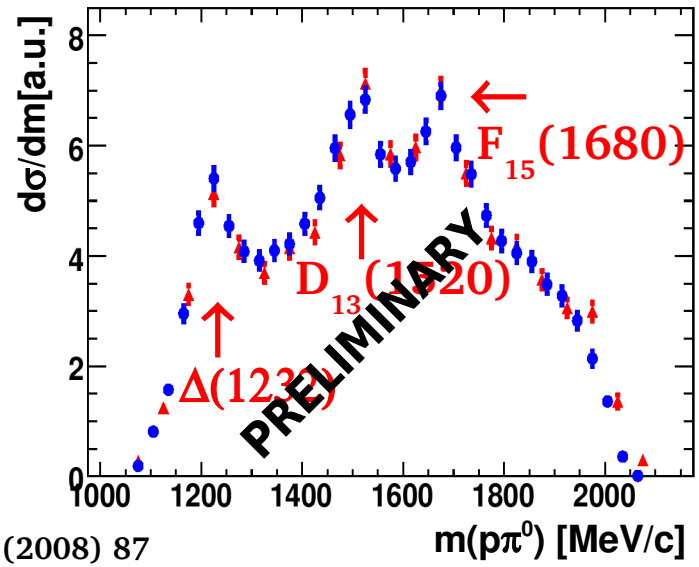
After cuts: background contamination < 1%

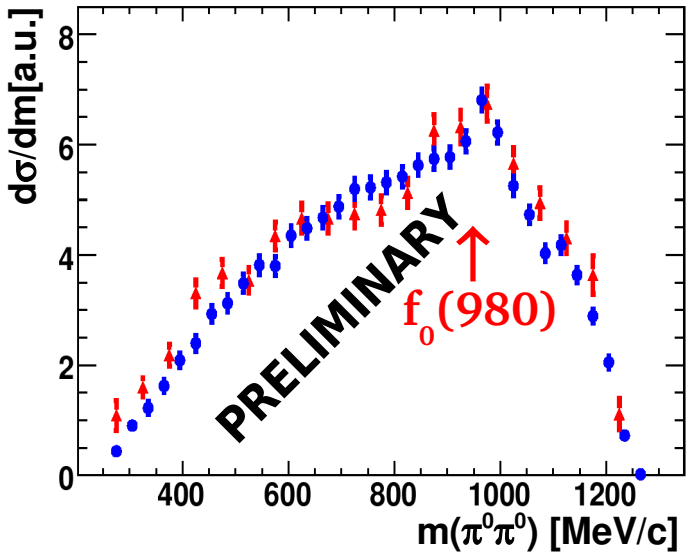
Sequential decays











CB-ELSA data

E_γ = 2000 - 2200 MeV

U. Thoma, M. Fuchs et al., PLB 659 (2008) 87

CBELSA/TAPS data

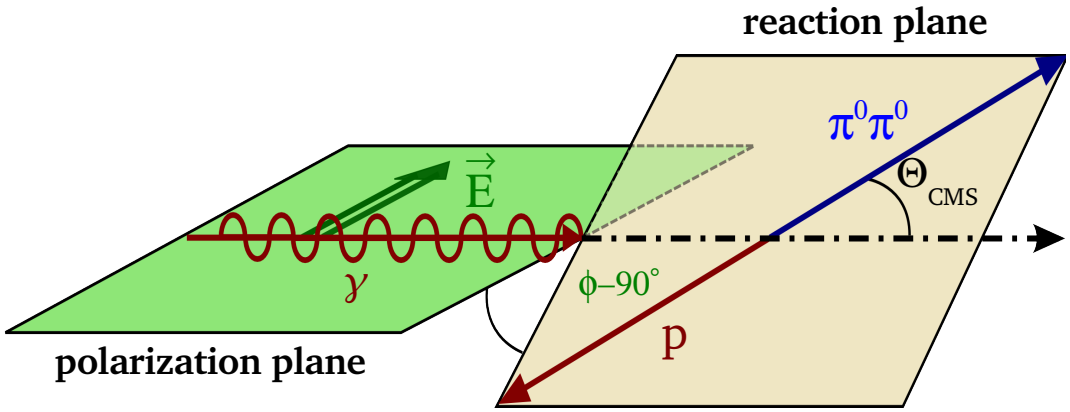
E_γ = 2000 - 2100 MeV

Clear observation of cascade decays

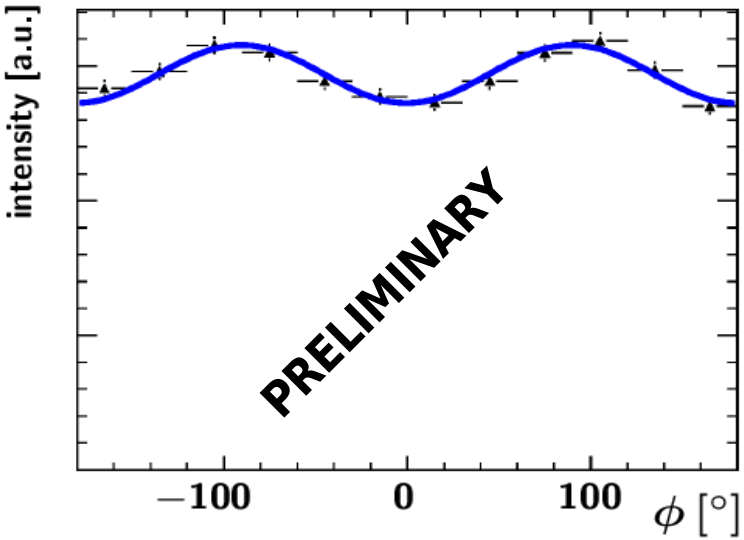
Polarization observable Σ

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 [1 + \delta_l \Sigma \cos(2\phi)]$$

Quasi two-body consideration:

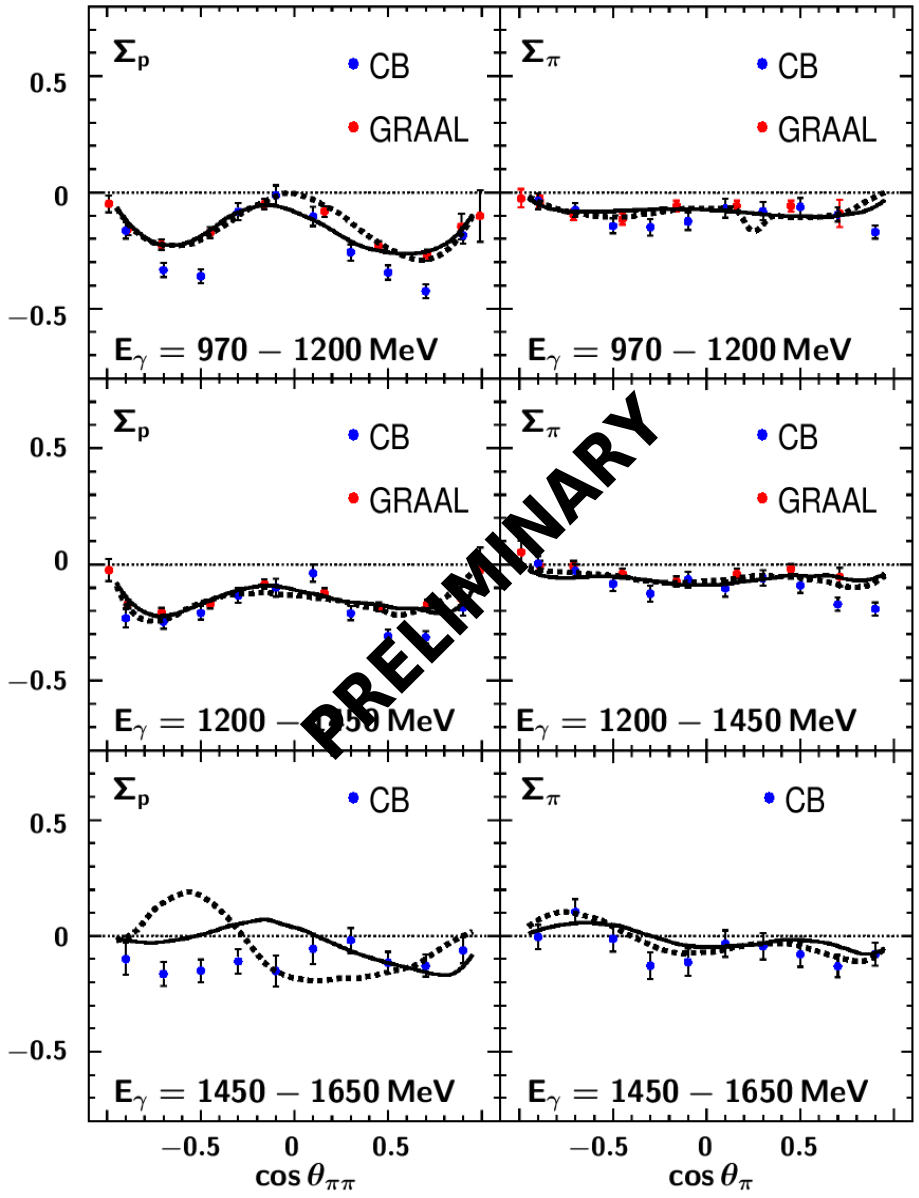


$f(\phi) = A + B\cos 2\phi$



Solid: $D_{33}(1700) \rightarrow \Delta\pi_{(D\text{-wave})}$ dominant

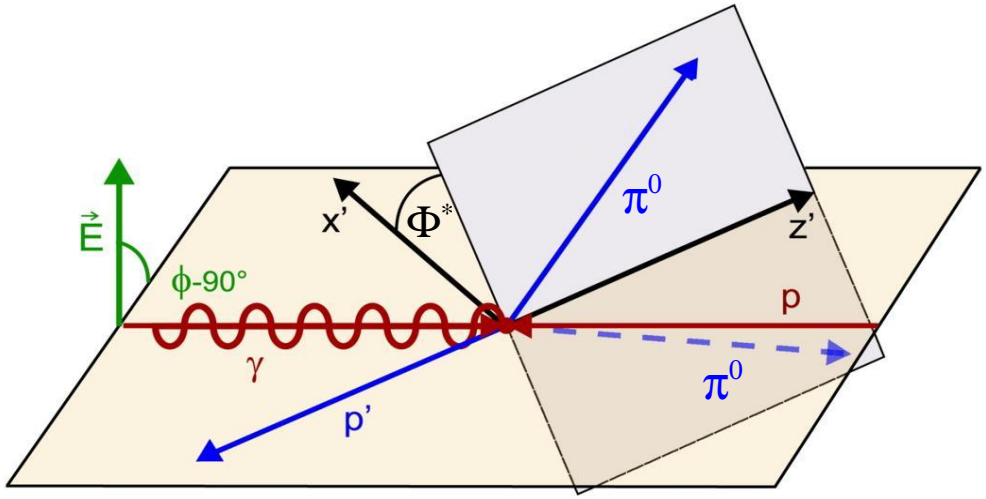
Dashed: $D_{33}(1700) \rightarrow \Delta\pi_{(S\text{-wave})}$ dominant



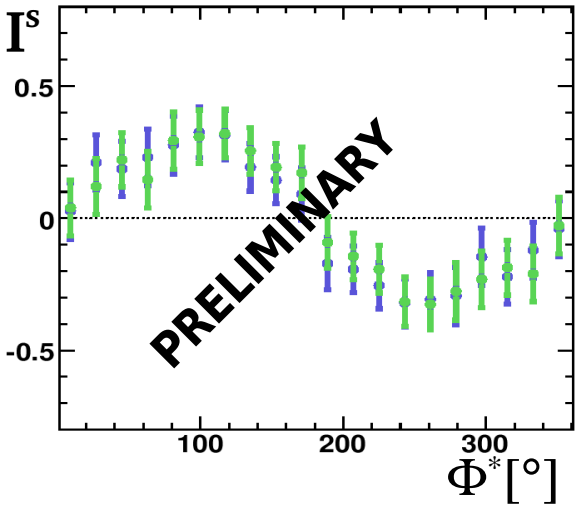
BnGA PWA solutions (PLB 659(2008) 87)

Polarization observables I^s and I^c

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_0 \{1 + \delta_l[I^s \sin(2\phi) + I^c \cos(2\phi)]\}$$



π^0 in the production plane

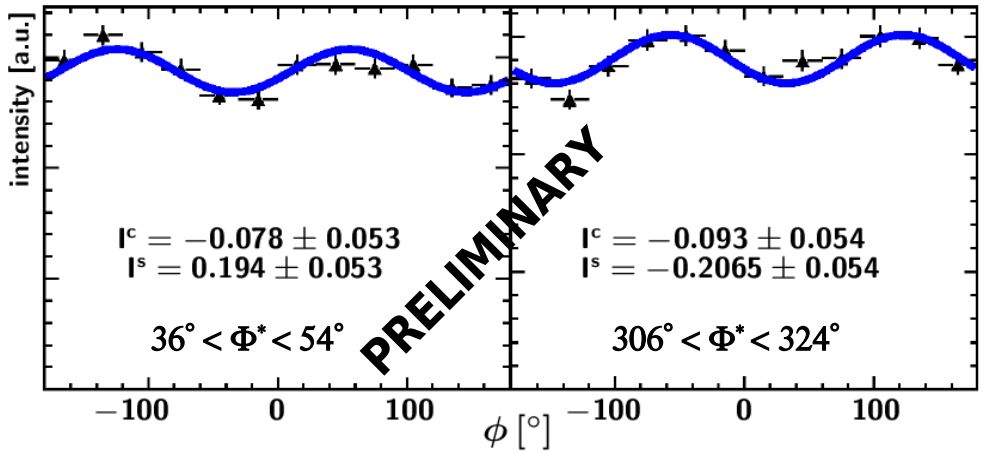


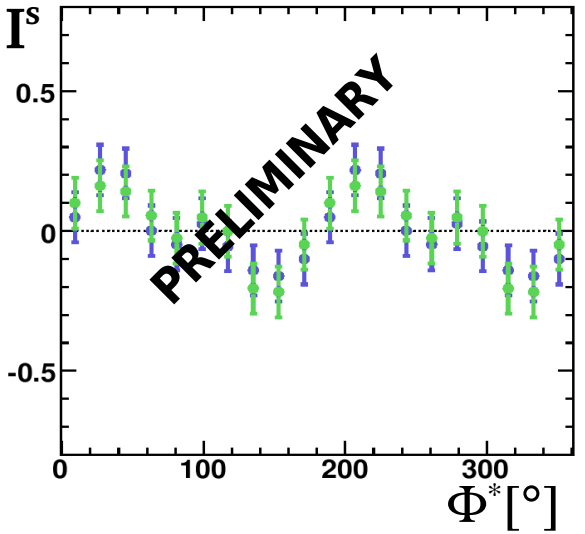
$$I^c(\Phi^*) = I^c(2\pi - \Phi^*)$$
$$I^s(\Phi^*) = -I^s(2\pi - \Phi^*)$$

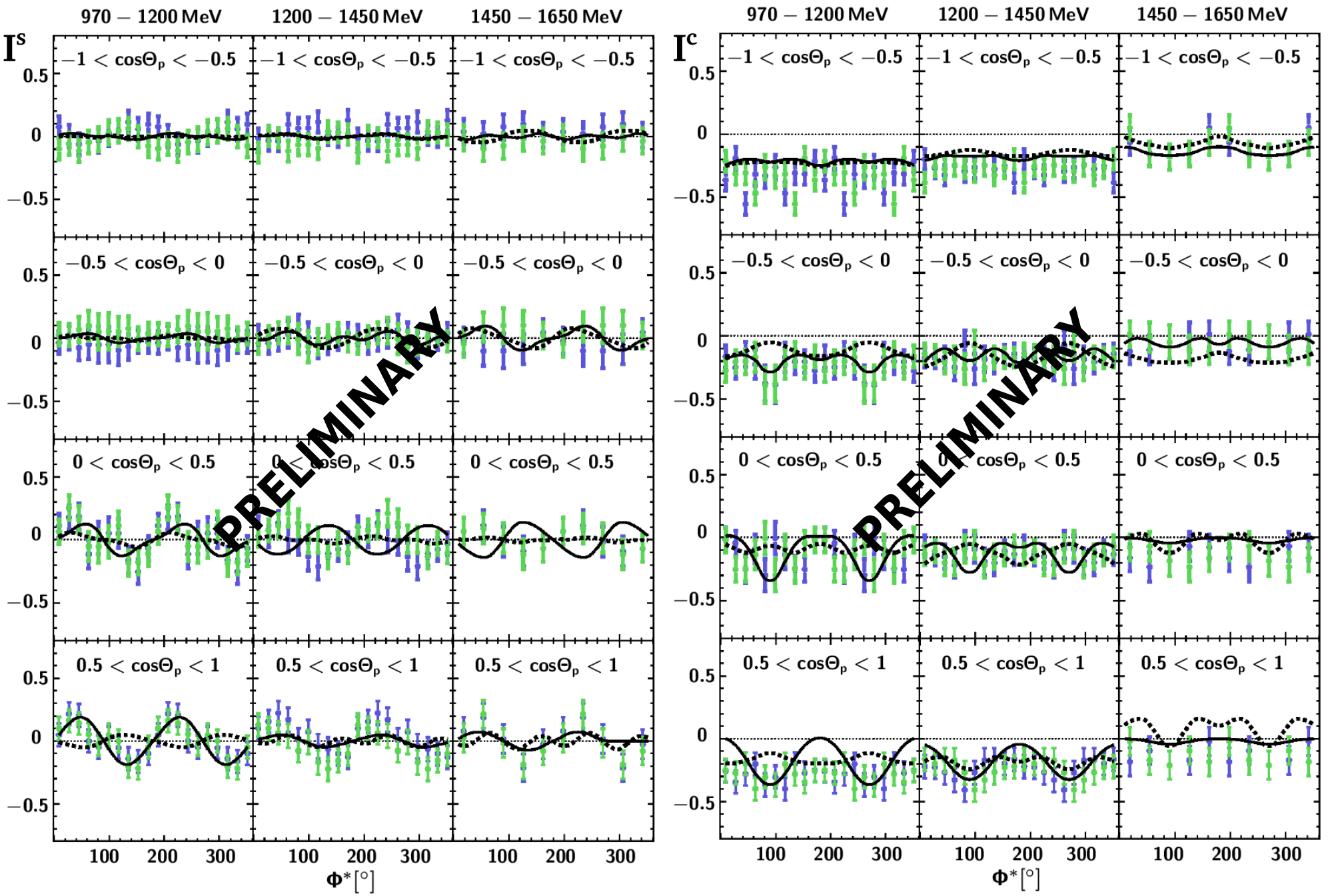
$$I^{s(c)}(\Phi^*) = I^{s(c)}(\Phi^* + \pi)$$

proton in the production plane

$$f(\phi) = A + B\sin 2\phi + C\cos 2\phi$$



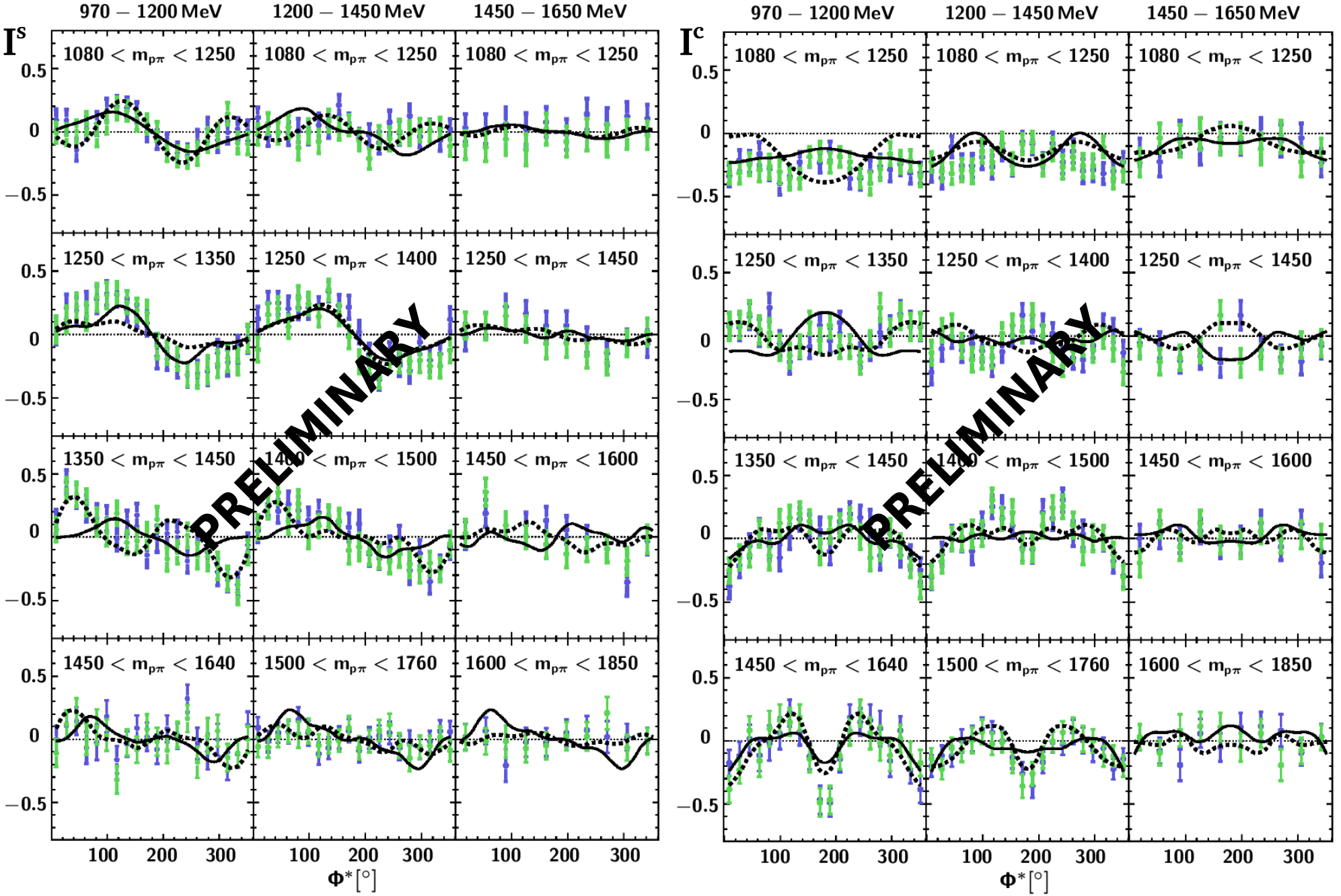




Solid: $D_{33}(1700) \rightarrow \Delta\pi_{\text{(D-wave)}}$ dominant

Dashed: $D_{33}(1700) \rightarrow \Delta\pi_{\text{(S-wave)}}$ dominant

$I^s(\Phi^*) = -I^s(2\pi - \Phi^*)$ $I^c(\Phi^*) = I^c(2\pi - \Phi^*)$



Solid: $D_{33}(1700) \rightarrow \Delta\pi_{\text{(D-wave)}}$ dominant

Dashed: $D_{33}(1700) \rightarrow \Delta\pi_{\text{(S-wave)}}$ dominant

Summary

- Sequential decays observed: $\gamma p \rightarrow N^*/\Delta^* \rightarrow \Delta\pi$, $D_{13}(1520)\pi$, $F_{15}(1680)\pi$
- Determination of the polarization observable Σ
- First measurement of the observables I^S and I^C in $\vec{\gamma} p \rightarrow p \pi^0\pi^0$
- New constraints for the PWA

Supported by the Deutsche Forschungsgemeinschaft (SFB/TR-16)