Measurement of polarisation observables in neutral double pion photoproduction off the proton with the CBELSA/TAPS experiment

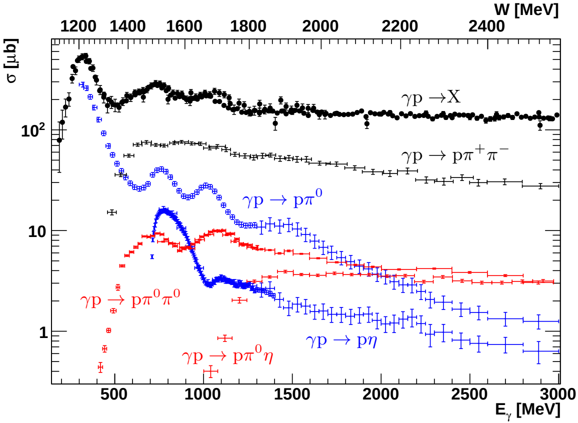
Tobias Seifen
for the CBELSA/TAPS collaboration

Helmholtz-Institut für Strahlen- und Kernphysik
der Universität Bonn

31.08.2015

Photoproduction

investigate excitation spectrum of baryon resonances
⇒ gain understanding of QCD in non-pertubative regime



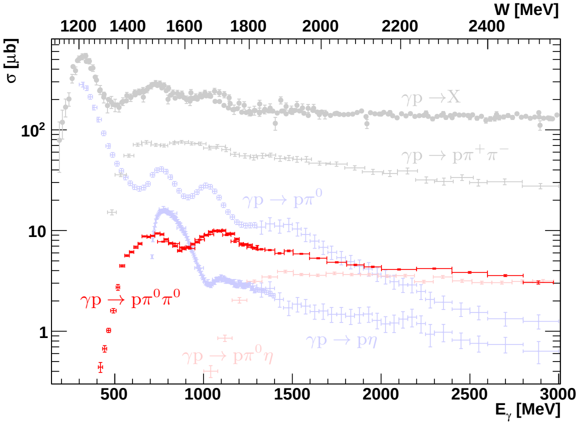
extraction of contributing resonances ⇒ Partial Wave Analysis

BUT: PWA solutions contain ambiguities

⇒ can be resolved by polarisation observables

Photoproduction

investigate excitation spectrum of baryon resonances
$\Rightarrow$ gain understanding of QCD in non-pertubative regime

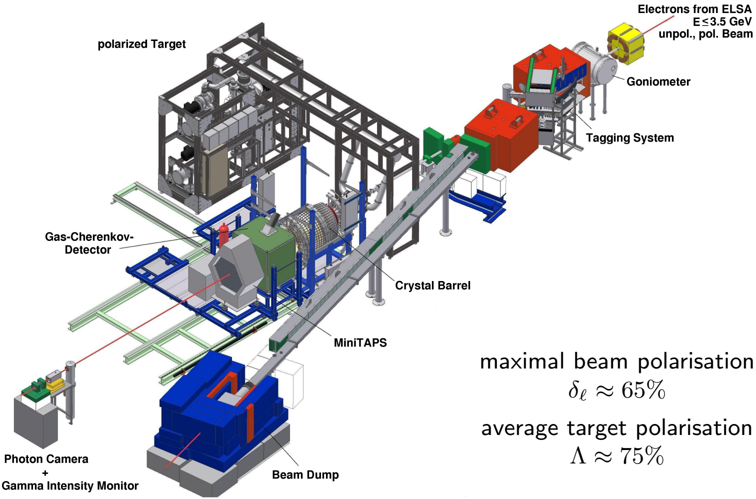


extraction of contributing resonances $\Rightarrow$ Partial Wave Analysis

BUT: PWA solutions contain ambiguities

$\Rightarrow$ can be resolved by polarisation observables

The Crystal Barrel/TAPS experiment

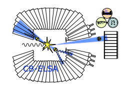


maximal beam polarisation

$\delta_\ell \approx 65\%$

average target polarisation

$\Lambda \approx 75\%$



universitätbonn

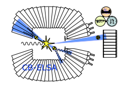
Introduction

Event selection

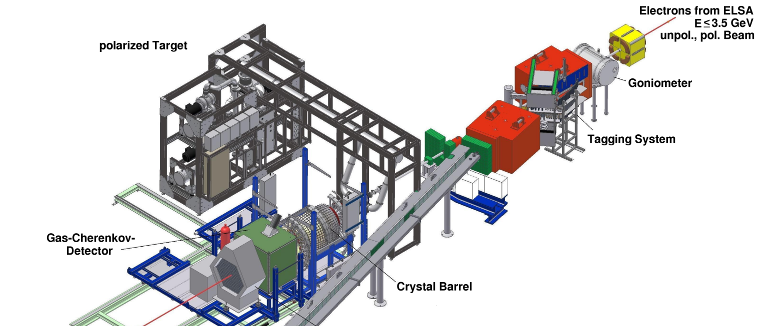
2-body kinematics

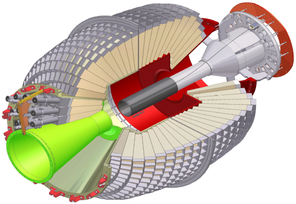
3-body kinematics

Summary



The Crystal Barrel/TAPS experiment





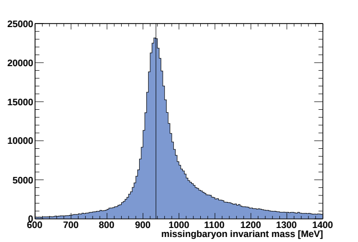
Event selection

selection of $\gamma p \to p\pi^0\pi^0 \to p4\gamma$

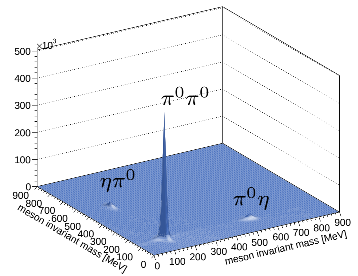
cuts on

- charge
  (1 charged + 4 neutral)
- ϑ, φ difference of p to 4γ
- mass of calculated proton

missing mass

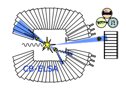


meson mass



kinematic fit: $\gamma p \to X\pi^0\pi^0$

- eliminates combinatorical background
- anticut on $p\pi^0\eta$
- cut on CL > 0.1

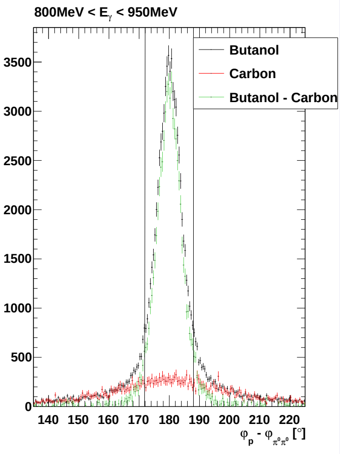


Introduction
Event selection
2-body kinematics
3-body kinematics
Summary

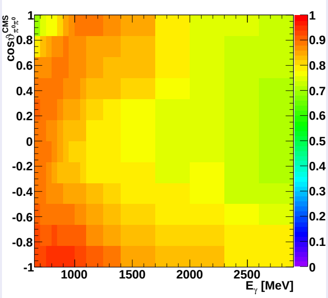
Dilution factor f

- p in LH2 not polarisable $\Rightarrow$ butanol (C_4H_9OH)
- unpolarised p in C and O

determination of f

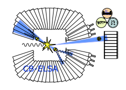


$\gamma \mathrm{p} \to \mathrm{p}\pi^0\pi^0$



dilution factor

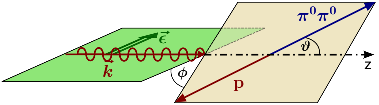
$$f = \frac{N_{\mathrm{Butanol}} - N_{\mathrm{C}}}{N_{\mathrm{Butanol}}}$$



2-body kinematics

photoproduction of two pseudoscalar mesons
quasi 2-body approach $\Rightarrow$ single meson photoproduction

Photon Polarisation		Target x	Target y	Target z
unpolarised	σ		T	
		H		G
linear	Σ		P	
circular		F		E

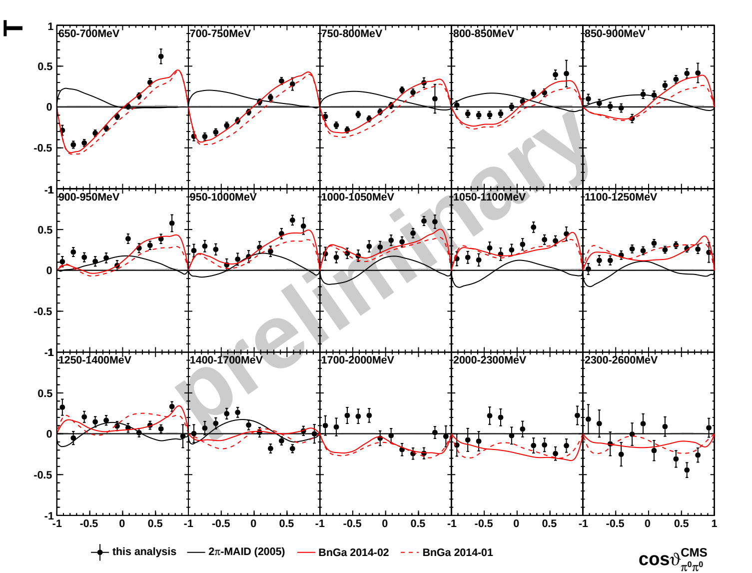


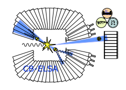
$$\frac{d\sigma}{d\Omega}(\theta,\phi) = \frac{d\sigma}{d\Omega}(\theta) \cdot \Big[1 - \delta_\ell\, \Sigma(\theta)\cos(2\phi)$$
$$+\Lambda_x \cdot \big(\delta_\ell\, H(\theta)\,\sin(2\phi) + \delta^\odot\, F(\theta)\big)$$
$$+\Lambda_y \cdot \big(-\delta_\ell\, P(\theta)\,\cos(2\phi) + T(\theta)\big)$$
$$+\Lambda_z \cdot \big(\delta_\ell\, G(\theta)\,\sin(2\phi) + \delta^\odot\, E(\theta)\big)\Big]$$

C. G. Fasano, F. Tabakin, B. Saghai
Phys. Rev. C46, 2430 (1992)

Results $\gamma p \to p(\pi^0\pi^0)$

Target asymmetry vs. $\cos\vartheta$



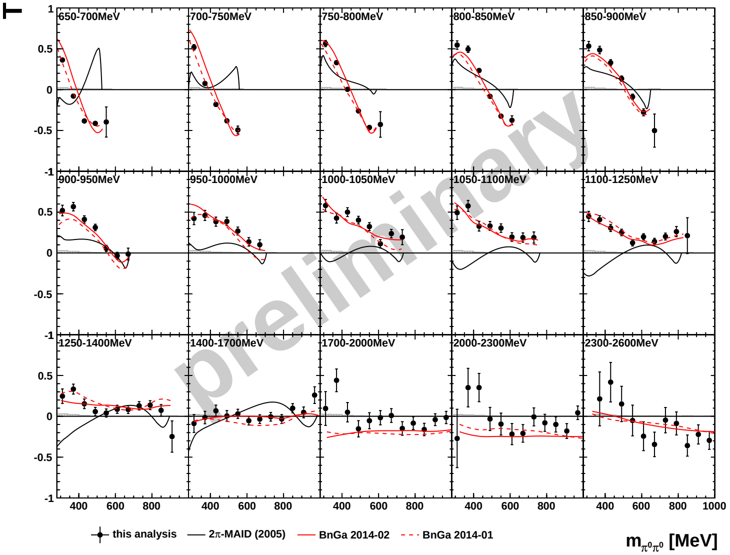


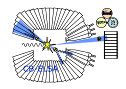
universitätbonn

- Introduction
- Event selection
- **2-body kinematics**
- 3-body kinematics
- Summary

Results $\gamma p \to p(\pi^0\pi^0)$

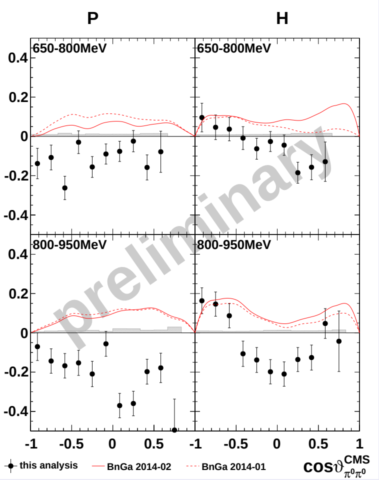
Target asymmetry vs. $m_{\pi^0\pi^0}$



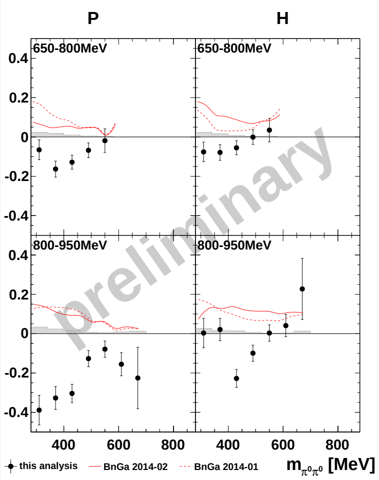


Double polarisation observables P and H

P and H vs. $\cos\vartheta$

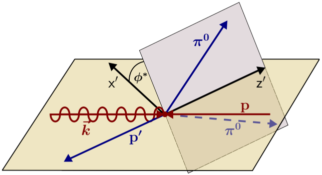


P and H vs. $m_{\pi^0\pi^0}$



$\Rightarrow 2\pi^0$-photoproduction not yet fully understood

3-body kinematics



Photon Pol.		Target Pol. Axis		
		x	y	z
unpolarised	σ	P_x	P_y	P_z
linear $\sin(2\phi)$	I^s	P_x^s	P_y^s	P_z^s
linear $\cos(2\phi)$	I^c	P_x^c	P_y^c	P_z^c
circular	$I^\odot$	$P_x^\odot$	$P_y^\odot$	$P_z^\odot$

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega} \cdot \Big\{ (1 + \Lambda_x P_x + \Lambda_y P_y) + \delta_\ell \cdot \Big[\sin(2\phi) \cdot \big(I^s + \Lambda_x P_x^s + \Lambda_y P_y^s \big) + \cos(2\phi) \cdot \big(I^c + \Lambda_x P_x^c + \Lambda_y P_y^c \big) \Big] \Big\}$$

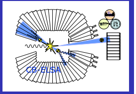
W. Roberts, T. Oed, Phys. Rev. C 71 (2005)

symmetry properties

$$P_x(2\pi - \phi^*) = -P_x(\phi^*)$$
$$P_y(2\pi - \phi^*) = +P_y(\phi^*)$$

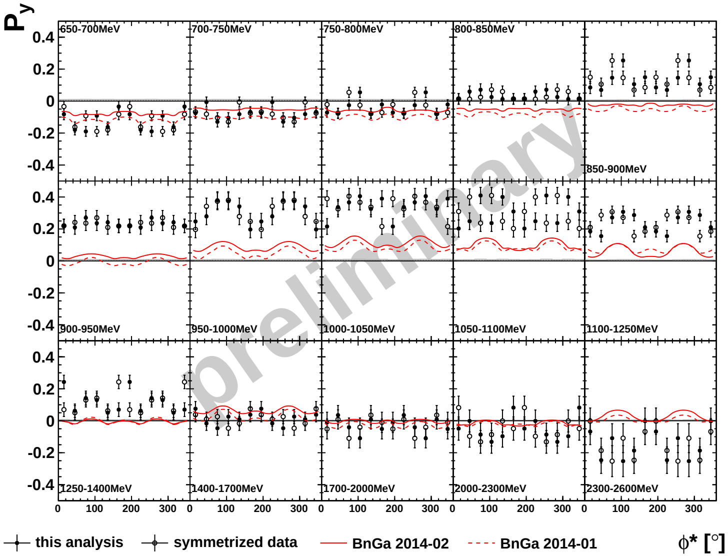
if identical particles in decay plane:

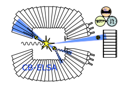
$$\mathcal{O}(\phi^*) = \mathcal{O}(\phi^* + \pi)$$



Target asymmetry P_y

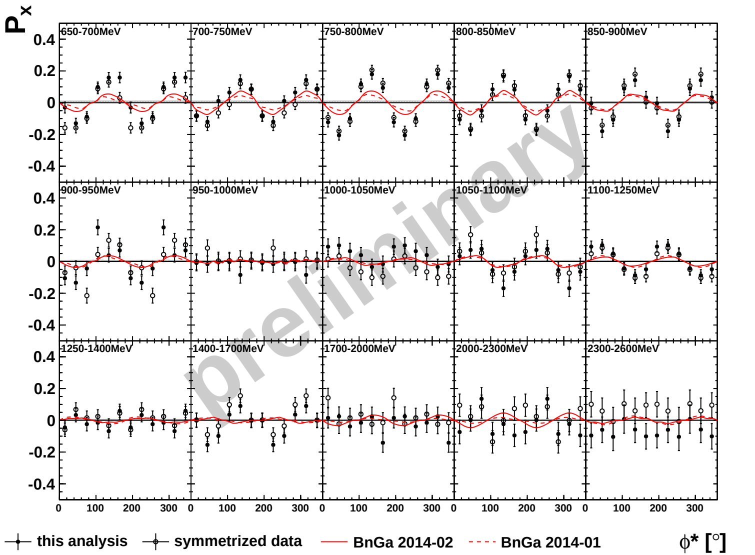
$\gamma p \to p(\pi^0\pi^0)$





Target asymmetry P_x

$\gamma p \rightarrow p(\pi^0\pi^0)$



universitätbonn

Introduction

Event selection

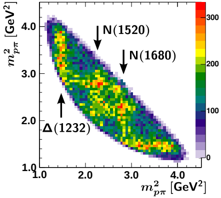
2-body kinematics

3-body kinematics

Summary

Summary

new measurement of polarisation observables in $\gamma p \to p\pi^0\pi^0$



reaction $\gamma p \to p\pi^0\pi^0$

- in quasi 2-body kinematics $\Rightarrow T, P, H$
- in full 3-body kinematics $\Rightarrow P_x, P_y$
- only $p(\pi^0\pi^0)$ shown here, $(p\pi^0)\pi^0$ also analysed

large discrepancies between the PWA predictions and the data

$\Rightarrow$ $2\pi^0$-photoproduction not yet fully understood

$\Rightarrow$ new valuable information for PWA

supported by:

Deutsche Forschungsgemeinschaft DFG

within SFB/TR16