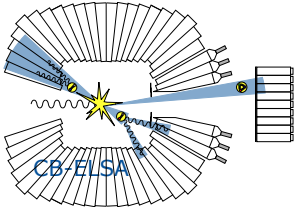
Measurement of polarisation observables in multi-meson photoproduction off the proton with the CBELSA/TAPS experiment

Tobias Seifen



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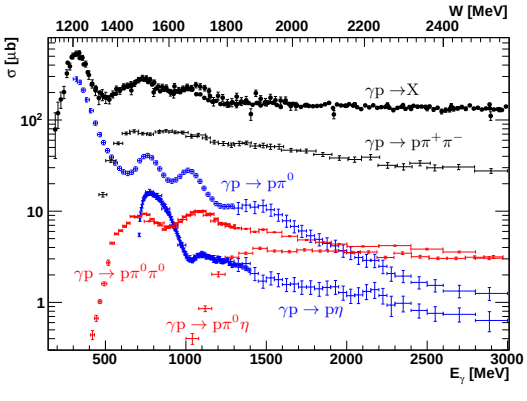
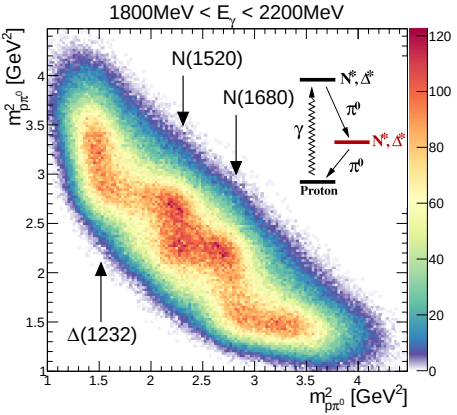
Introduction

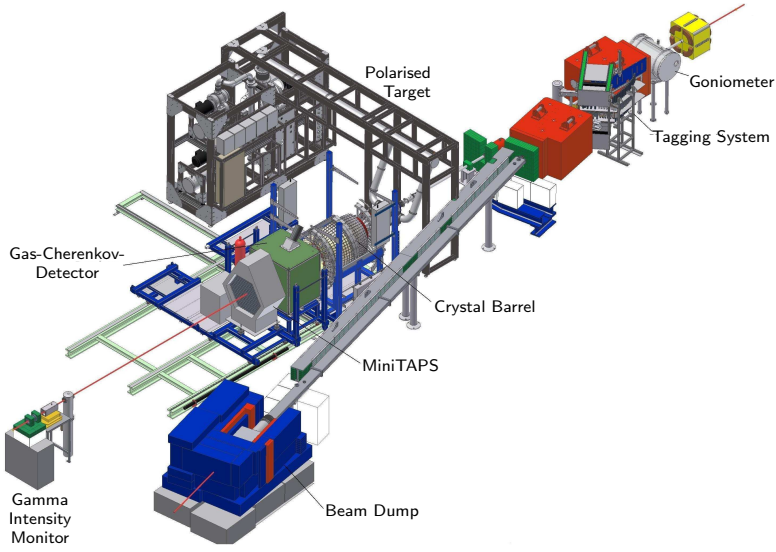




$\gamma p \rightarrow p\pi^0\pi^0$

- importance increases with E_γ
- access to sequential decays
- less background amplitudes than $p\pi^+\pi^-$ but cannot discriminate between N^*/Δ^*

The Crystal Barrel/TAPS experiment



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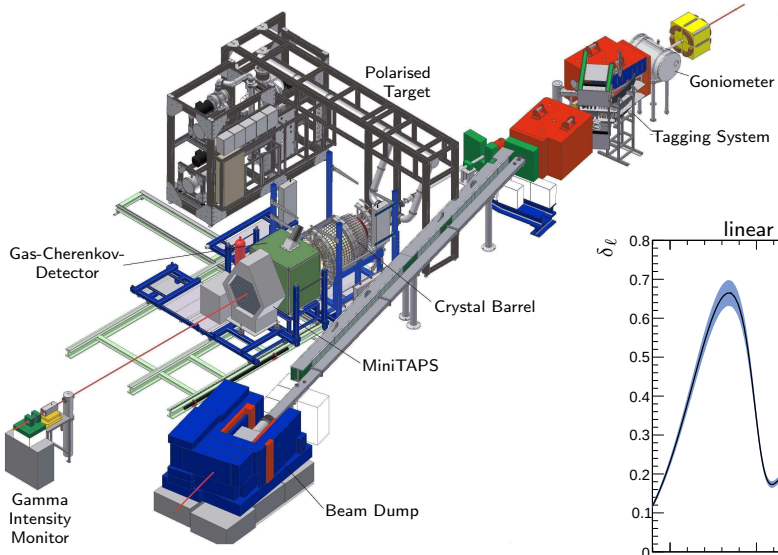

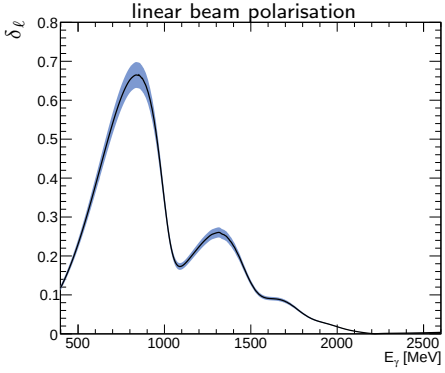

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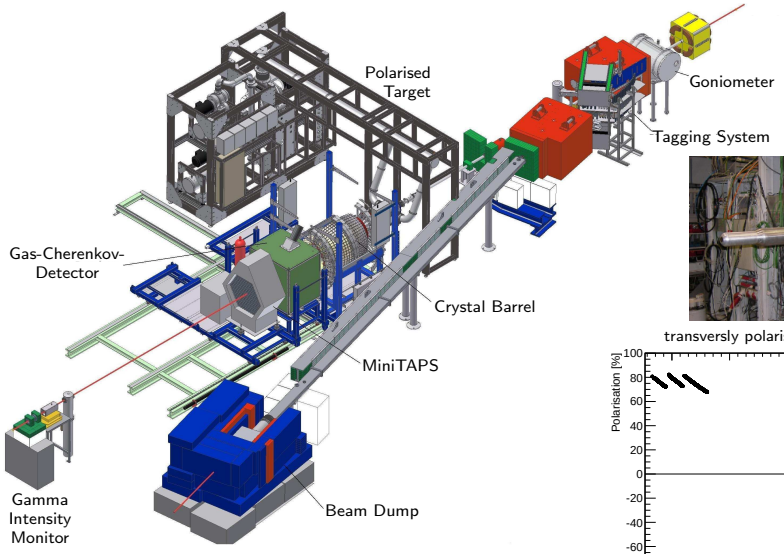
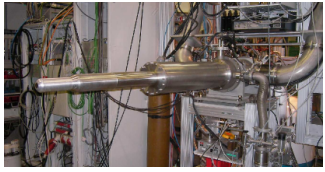
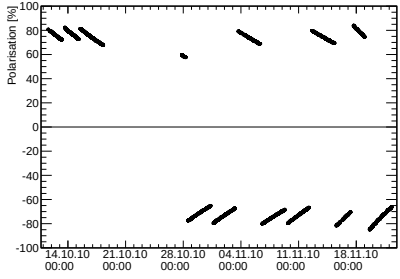




transversly polarised butanol target (C_4H_9OH)



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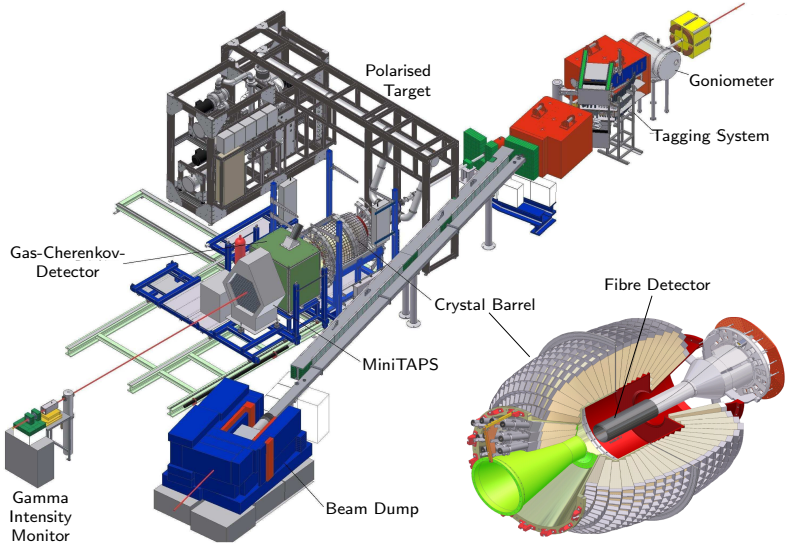
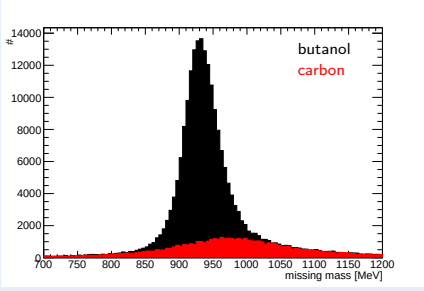


Event selection

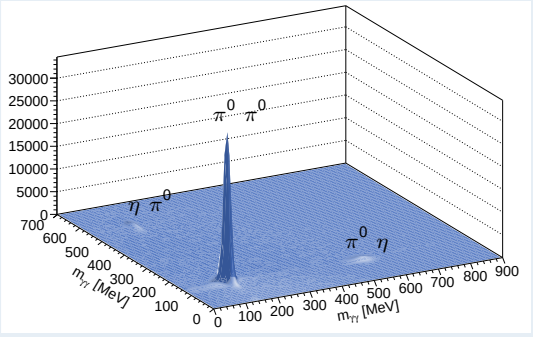
Selection of $\gamma p \to p\pi^0\pi^0 \to p4\gamma$
cuts on

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

missing mass



meson mass

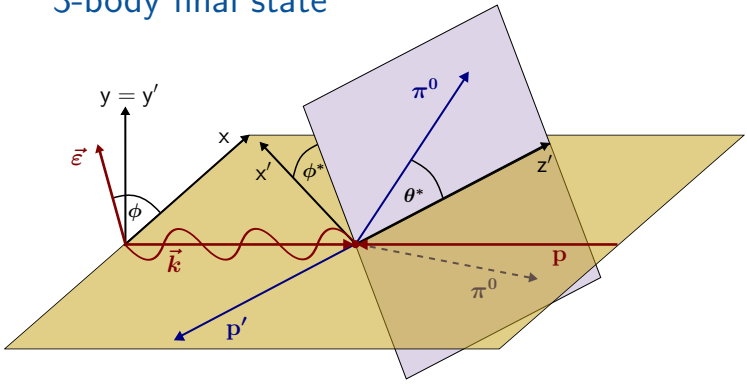


after all cuts
global background $\lesssim 1.5\,\%$

3-body final state

5 kinematic variables:

- E_γ
- $\cos\vartheta_{\pi^0\pi^0}$
- $m_{\pi^0\pi^0}$
- $\phi^*_{\pi^0\pi^0}$
- $\theta^*_{\pi^0\pi^0}$



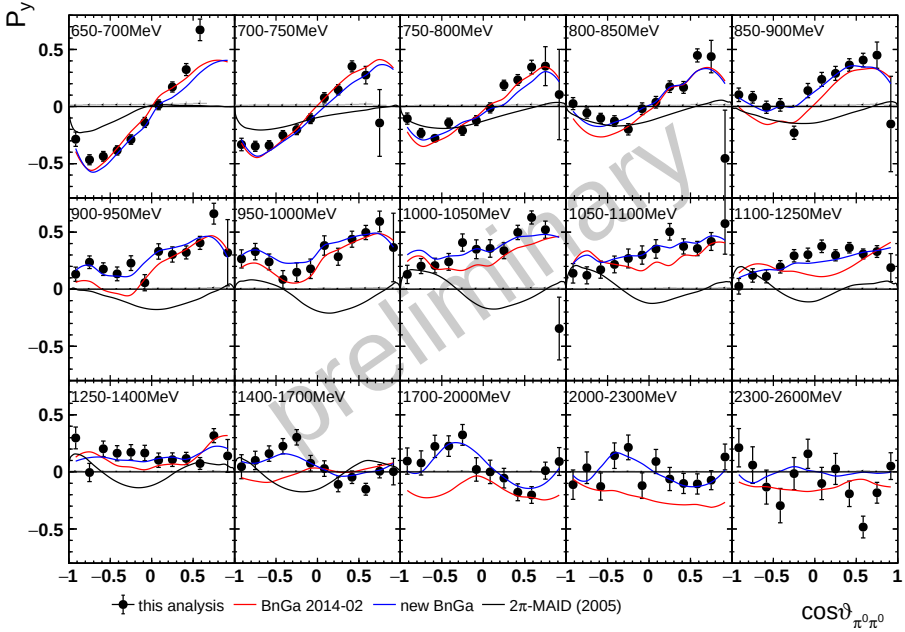
Polarisation Observables

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

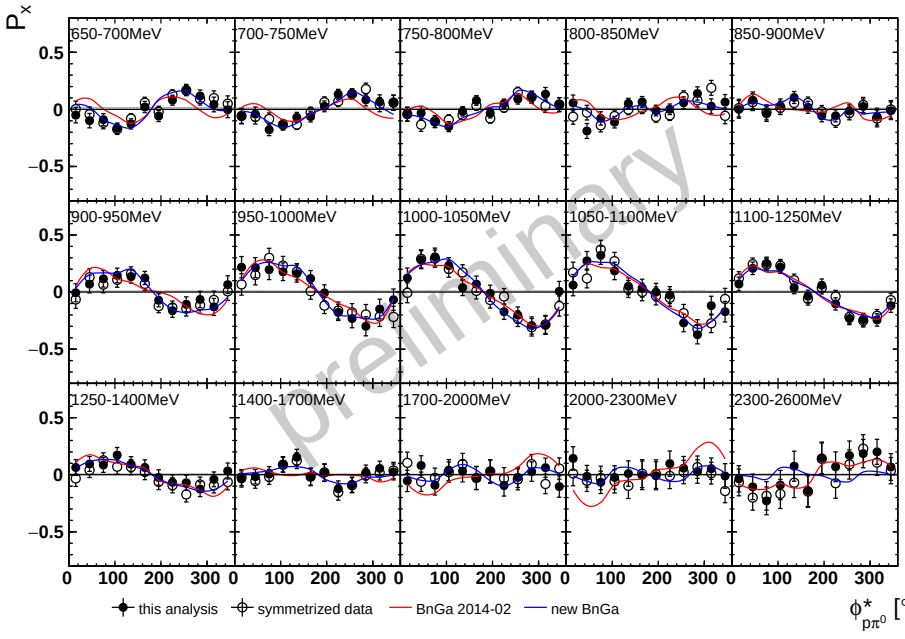
W. Roberts, T. Oed, Phys. Rev. C 71 (2005)

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	$I^\odot$	$P_x^\odot$	$P_y^\odot$	$P_z^\odot$

Target asymmetry P_y

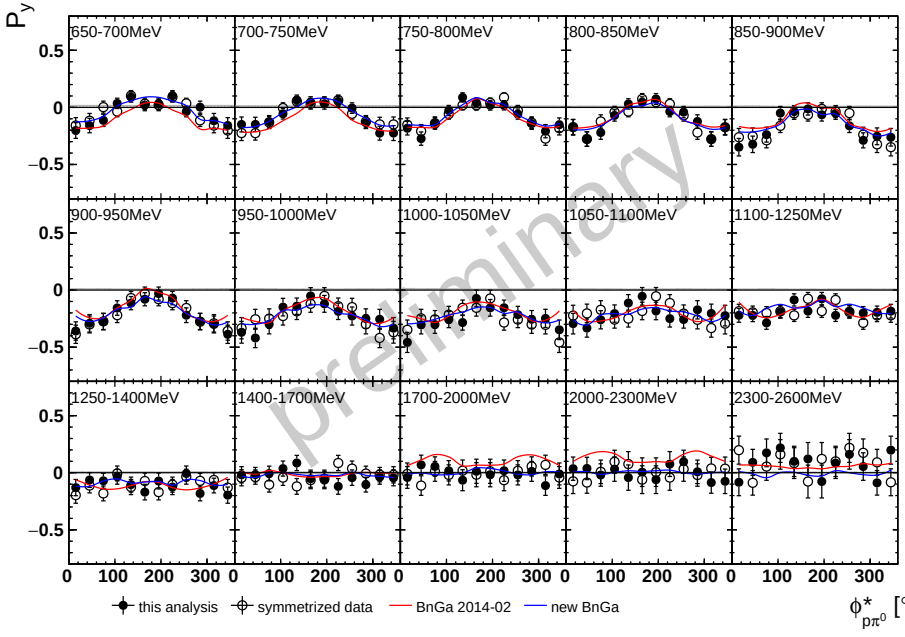


Target asymmetry P_x



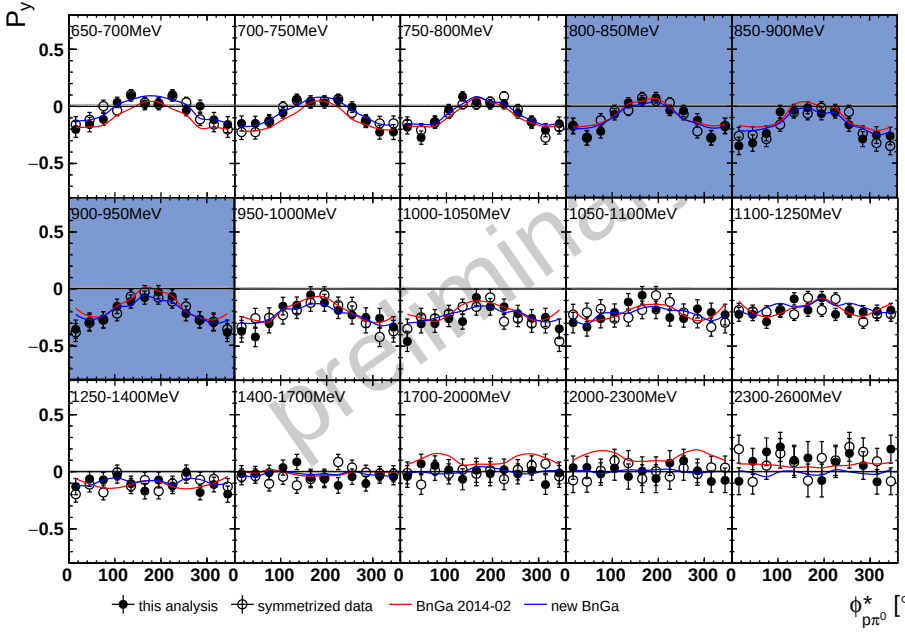
symmetry property
$P_x(2\pi - \phi^*)$
$= -P_x(\phi^*)$

Target asymmetry P_y



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

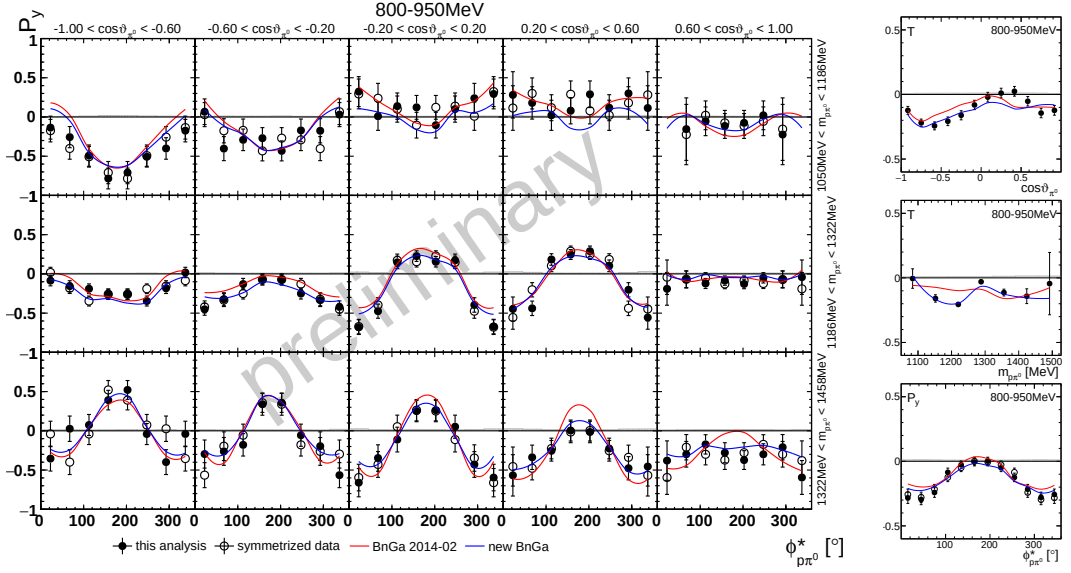
Target asymmetry P_y



symmetry property

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

Target asymmetry P_y - 4D



Branching ratios

$\Delta(1910)\frac{1}{2}^+$, $\Delta(1920)\frac{3}{2}^+$, $\Delta(1905)\frac{5}{2}^+$, $\Delta(1950)\frac{7}{2}^+$

- BR into $N(938)\pi$ or $\Delta(1232)\pi$ $\approx 48\,\%$
- BR into $N(1520)\pi$, $N(1535)\pi$ or $N(1680)\pi$ $\approx 6\,\%$

$N(1880)\frac{1}{2}^+$, $N(1900)\frac{3}{2}^+$, $N(2000)\frac{5}{2}^+$, $N(1990)\frac{7}{2}^+$

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spatial wave function

- $S = \frac{1}{\sqrt{2}}[0s \times 0d] + \frac{1}{\sqrt{2}}[0d \times 0s]$

$N(1880)\frac{1}{2}^+$, $N(1900)\frac{3}{2}^+$, $N(2000)\frac{5}{2}^+$, $N(1990)\frac{7}{2}^+$

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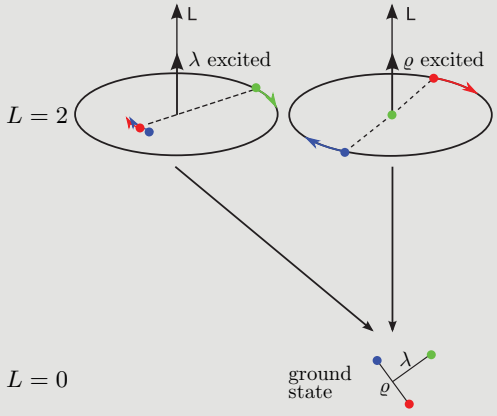
- BR into $N(1520)\pi$, $N(1535)\pi$, $N(1680)\pi$ or $N\sigma$ $\approx 23\,\%$

spatial wave function

- $M_S = \frac{1}{\sqrt{2}}[0s \times 0d] - \frac{1}{\sqrt{2}}[0d \times 0s]$
- $M_A = -[0p \times 0p]$

Harmonic oscillator

orbital excitation $L = 2$

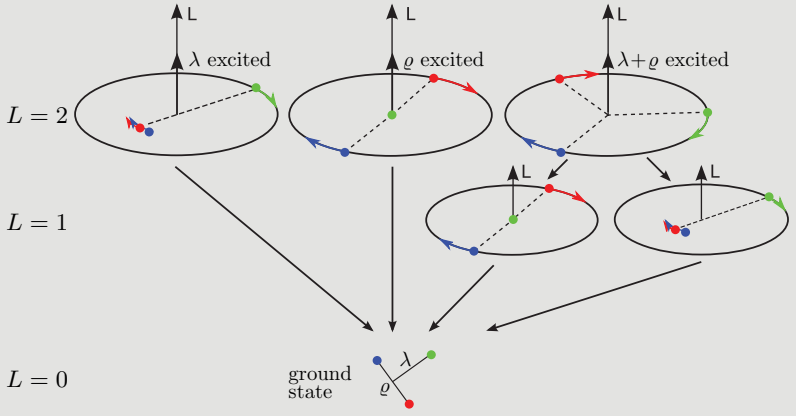


dominant decays:

- single oscillator excitation
  $\rightarrow$ ground state

Harmonic oscillator

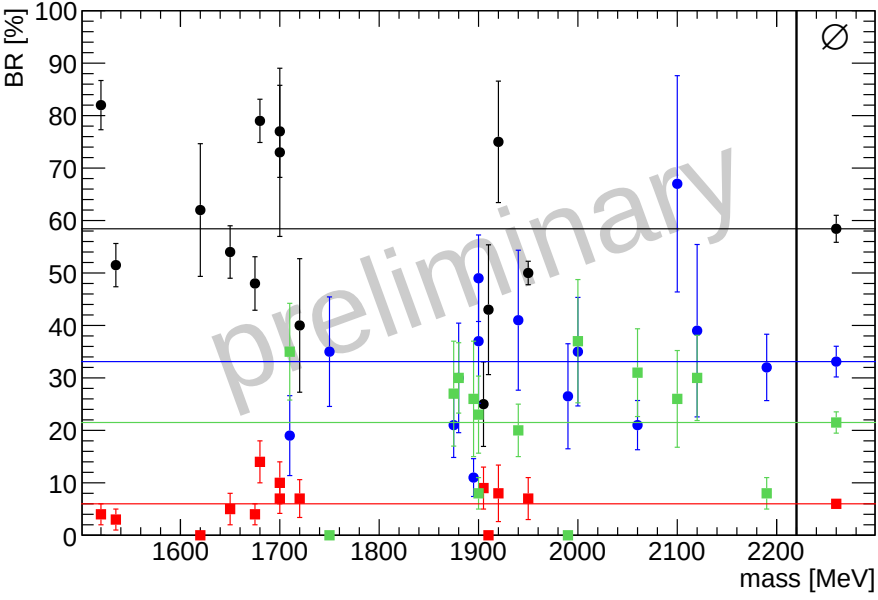
orbital excitation $L = 2$



dominant decays:

- single oscillator excitation
  → ground state
- dual oscillator excitation
  → sequential decay
- mixed oscillator
  → both occur

Branching ratios



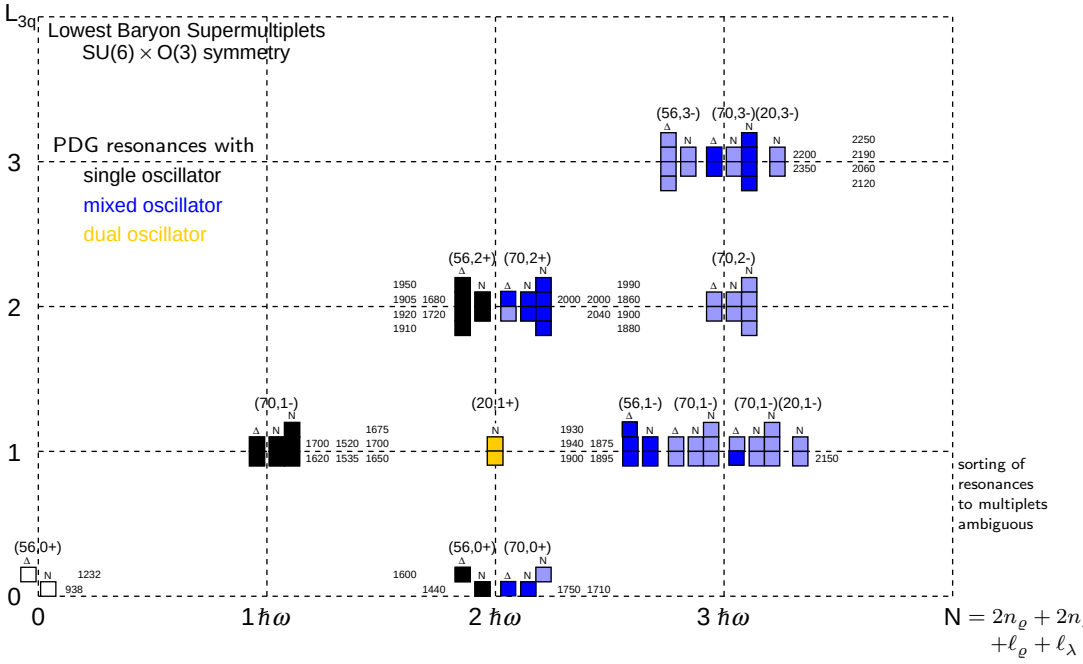
single oscillator decays into $N(938)\pi$ or $\Delta(1232)\pi$

decays into $N(1520)\pi$, $N(1535)\pi$, $N(1680)\pi$ or $N\sigma$

mixed oscillator decays into $N(938)\pi$ or $\Delta(1232)\pi$

decays into $N(1520)\pi$, $N(1535)\pi$, $N(1680)\pi$ or $N\sigma$

SU(6)×O(3) supermultiplets



Summary

Crystal-Barrel/TAPS experiment ideally suited for the measurement of asymmetries

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

- clean event sample selected ($\sim 1.5\%$ background)
- observables $P_x, P_y, P_x^s, P_x^c, P_y^s, P_y^c$ determined in multiple kinematic variables
- for $E_\gamma \leq 1250\,\mathrm{MeV}$ observables determined in 4D

BnGa-PWA $\Rightarrow$ branching ratios of resonances

$\hookrightarrow$ hints for wave function structure of baryon resonances

further analysis of multi-meson final states

- $p\pi^0\pi^0 + p\pi^0\eta$: beam polarisation observables I^s, I^c at high energies
- $p\pi^0\pi^0$: double polarisation observables $P_x^s, P_x^c, P_y^s, P_y^c$ at higher energies