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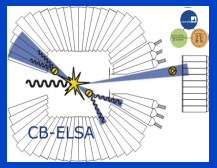
Measurement of the double polarisation observable G with the Crystal Barrel Experiment @ ELSA

Marcus Grüner

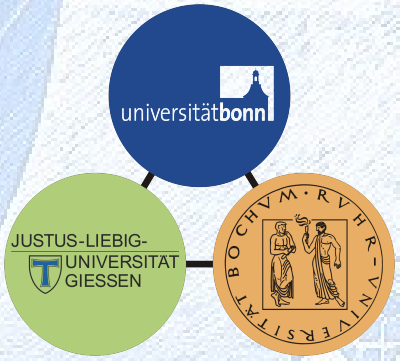
for the

CBELSA/TAPS Collaboration

Deutsche Forschungsgemeinschaft DFG



Helmholtz-Institut für Strahlen- und Kernphysik der Uni Bonn



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- the Crystal Barrel/TAPS experiment @ ELSA
- polarisation observables
- data analysis
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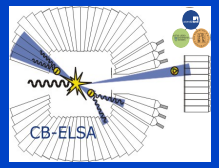
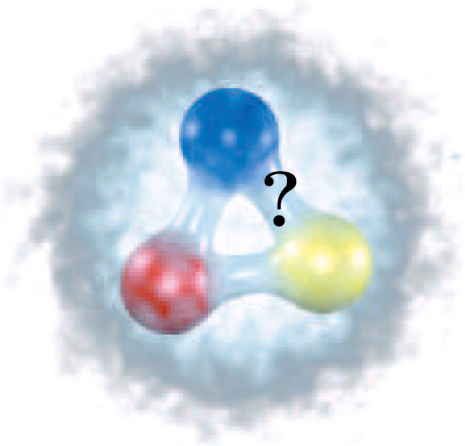
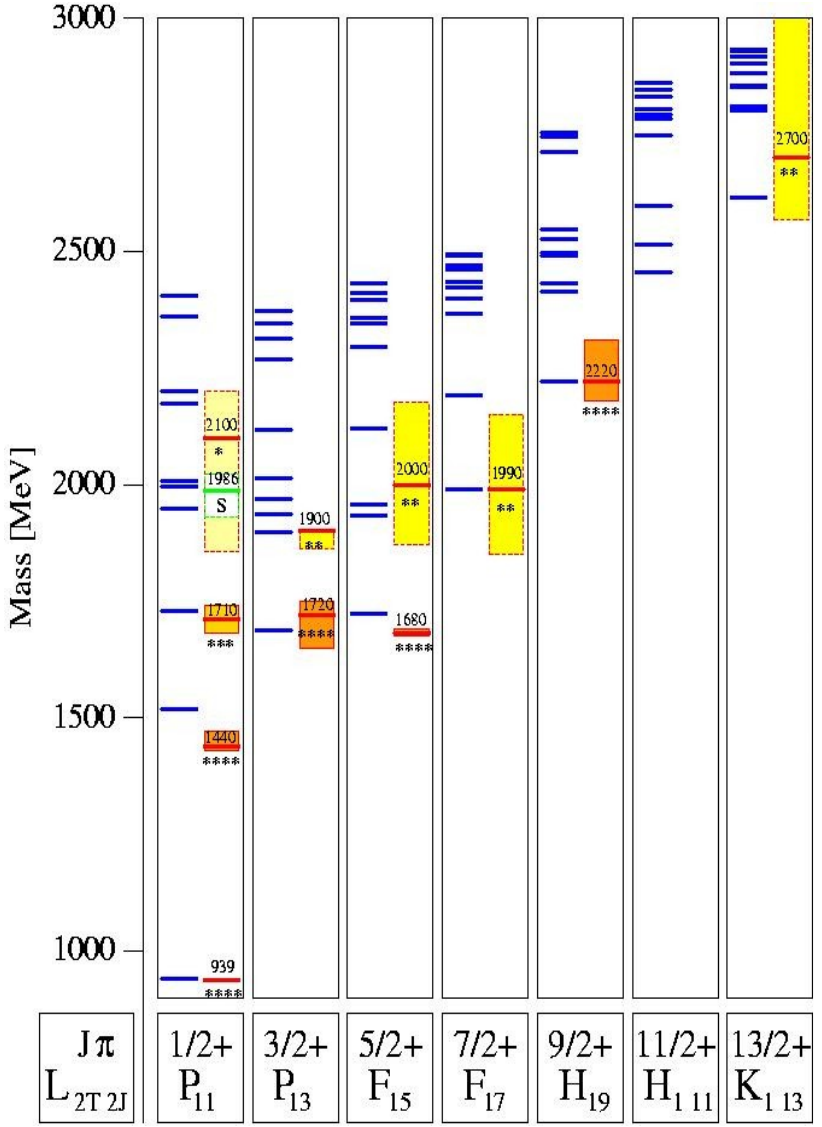
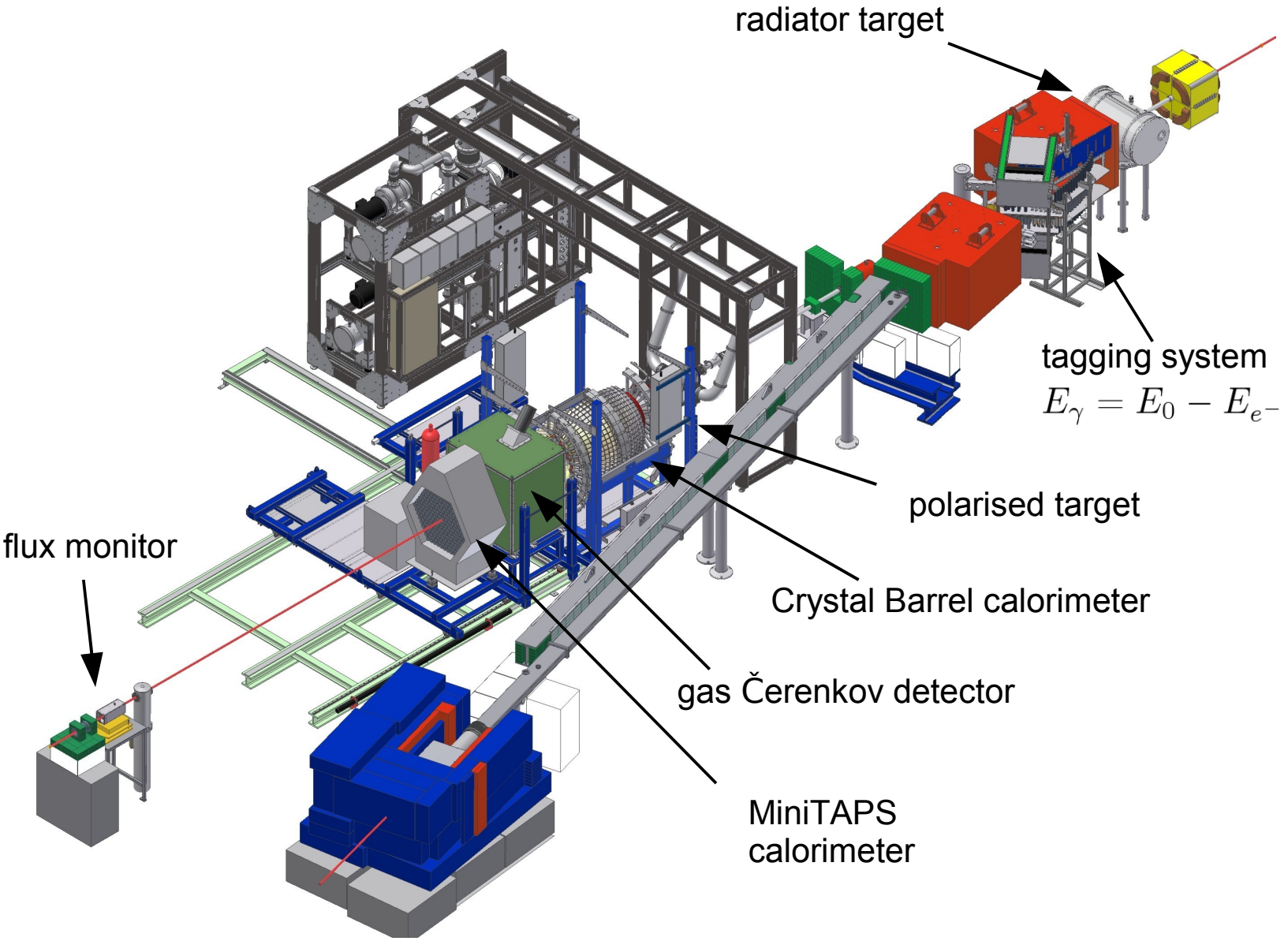


baryon spectrosopy





Crystal Barrel/TAPS @ ELSA



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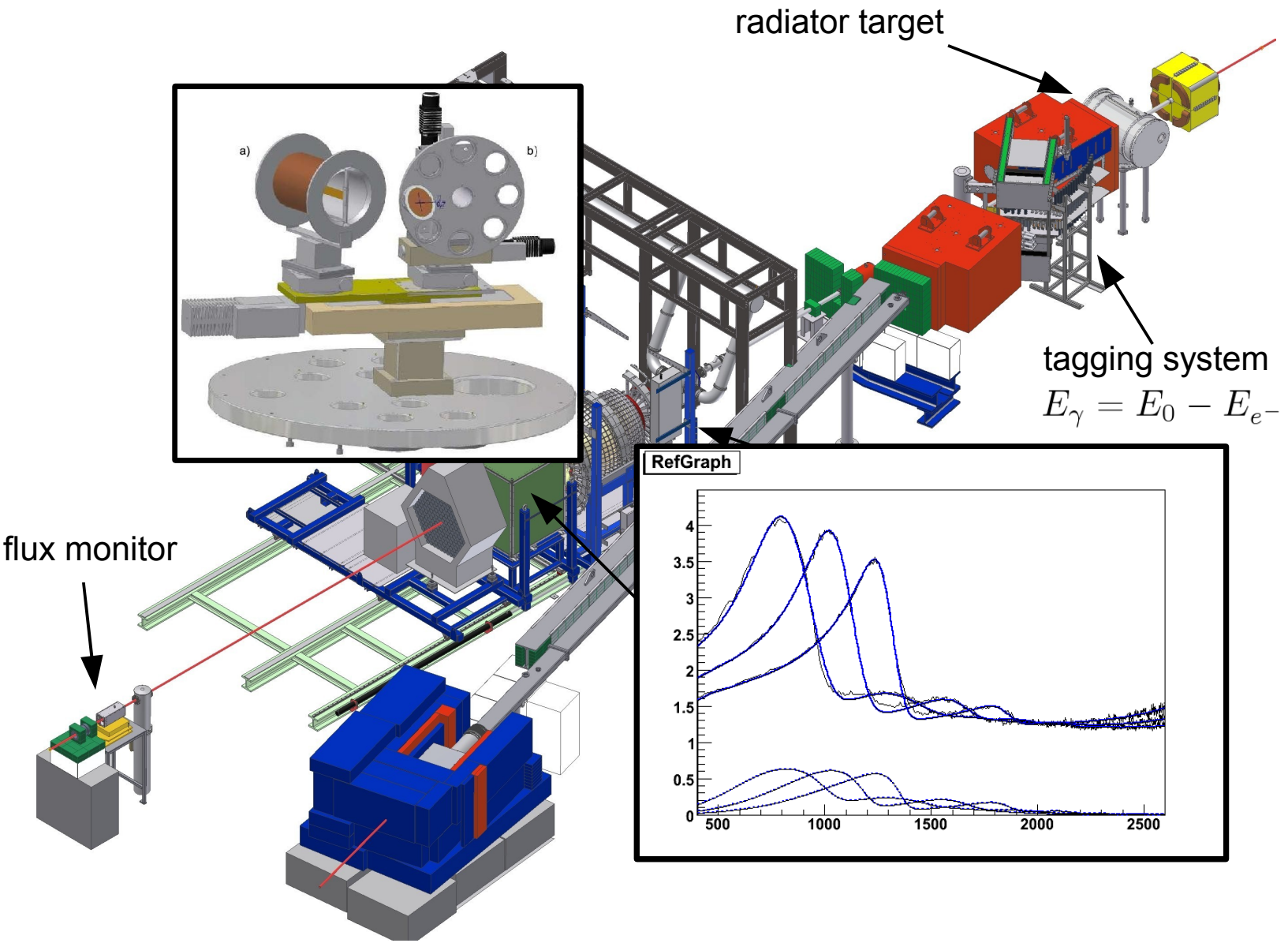

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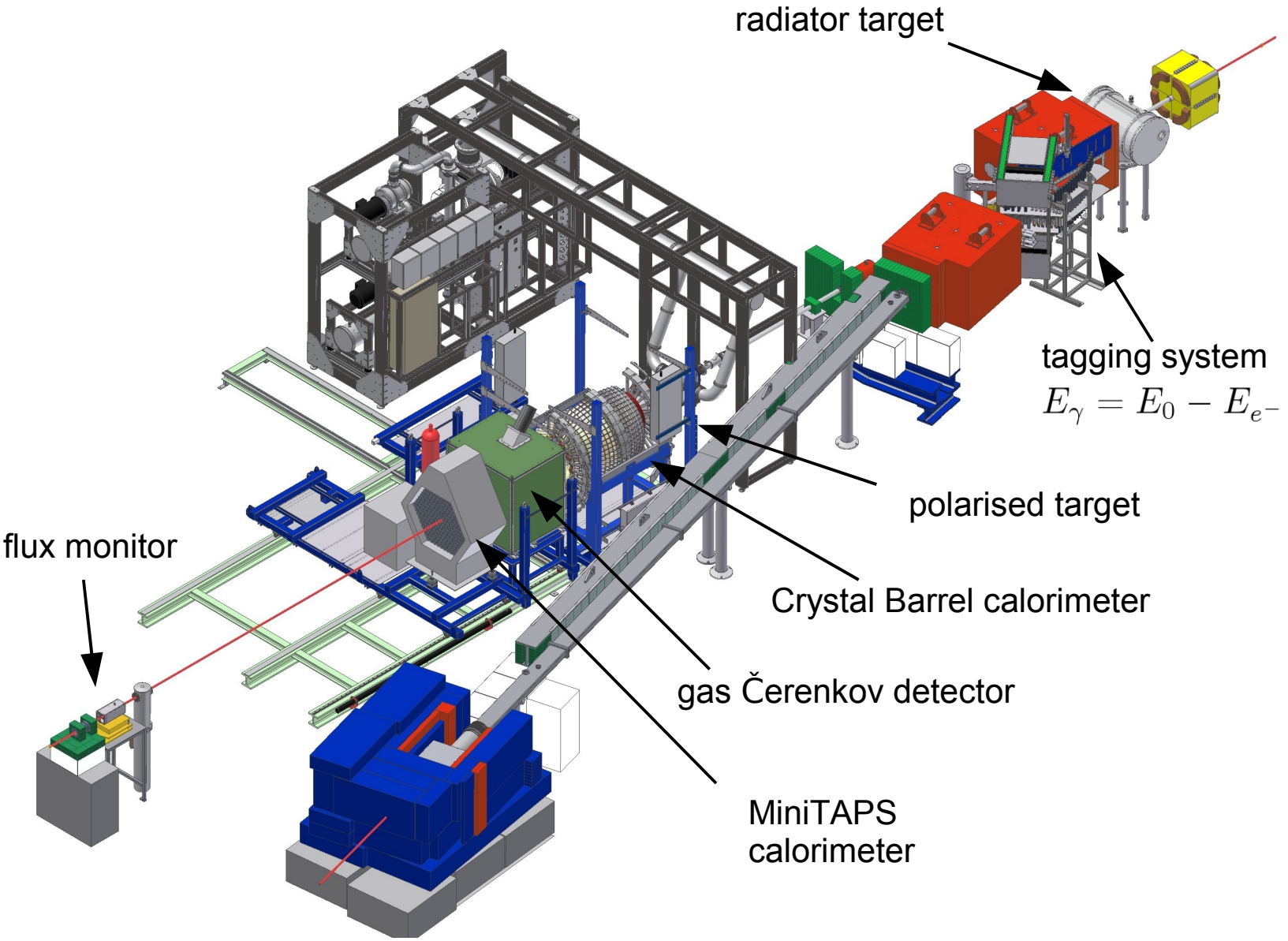

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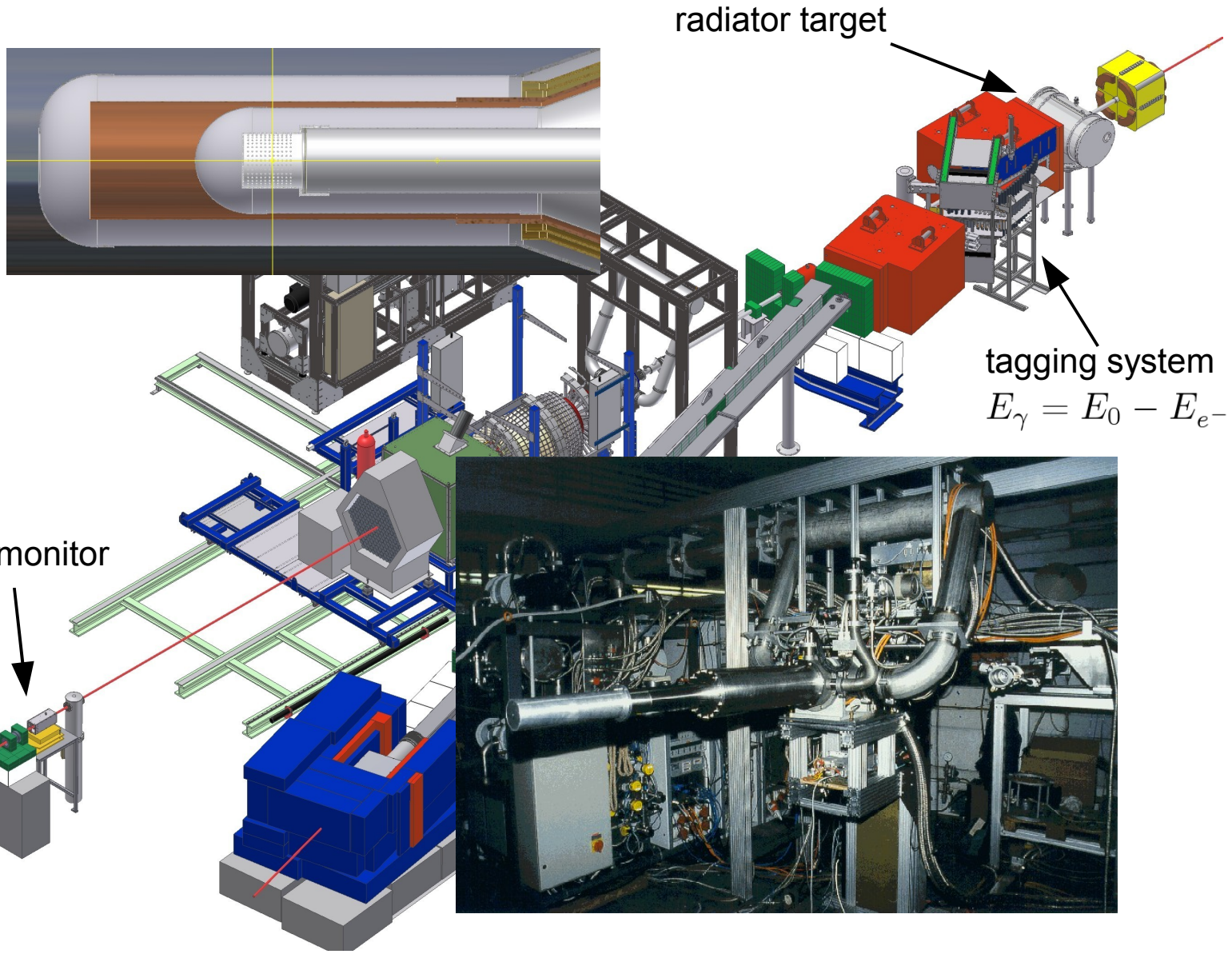
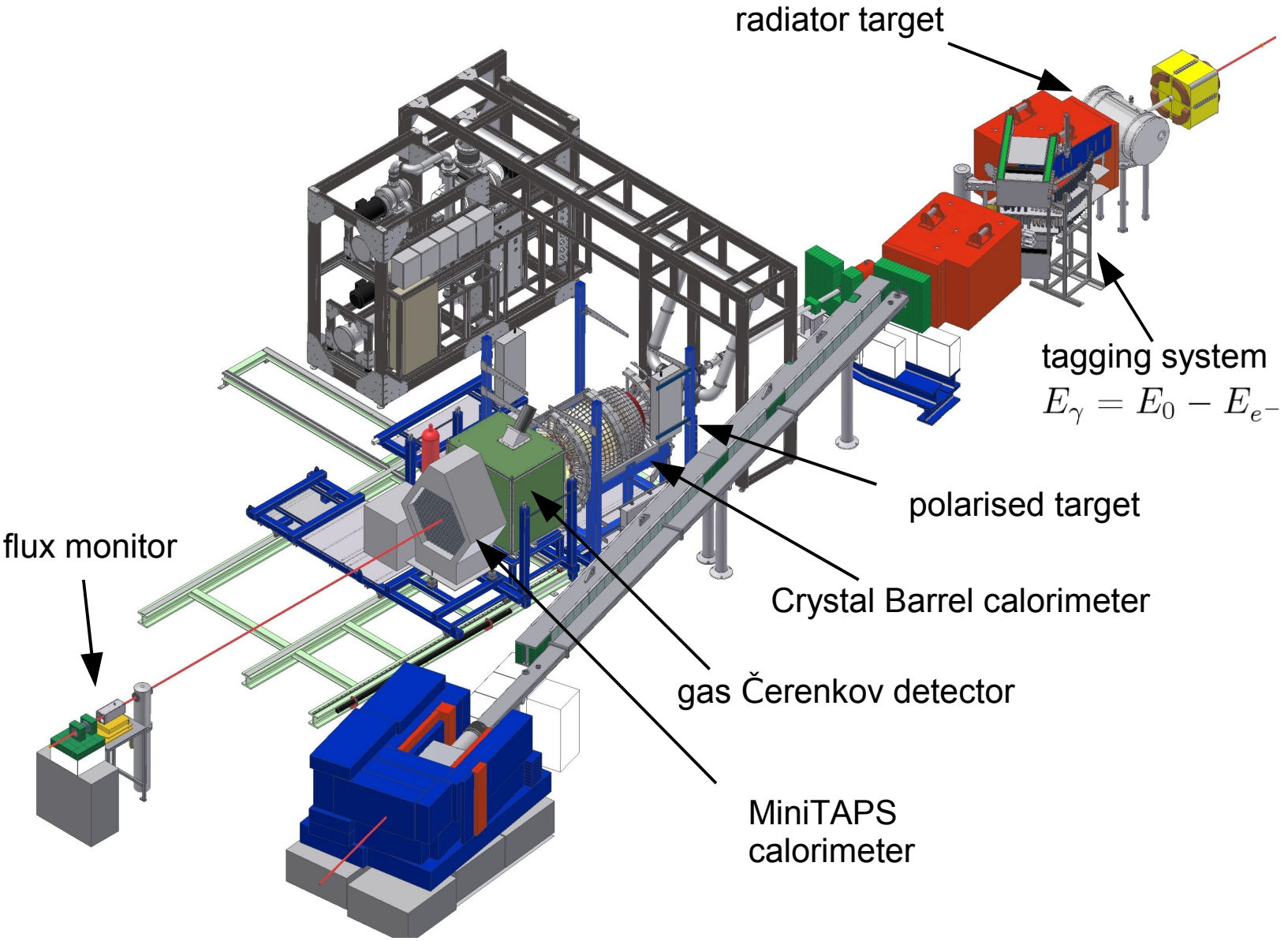
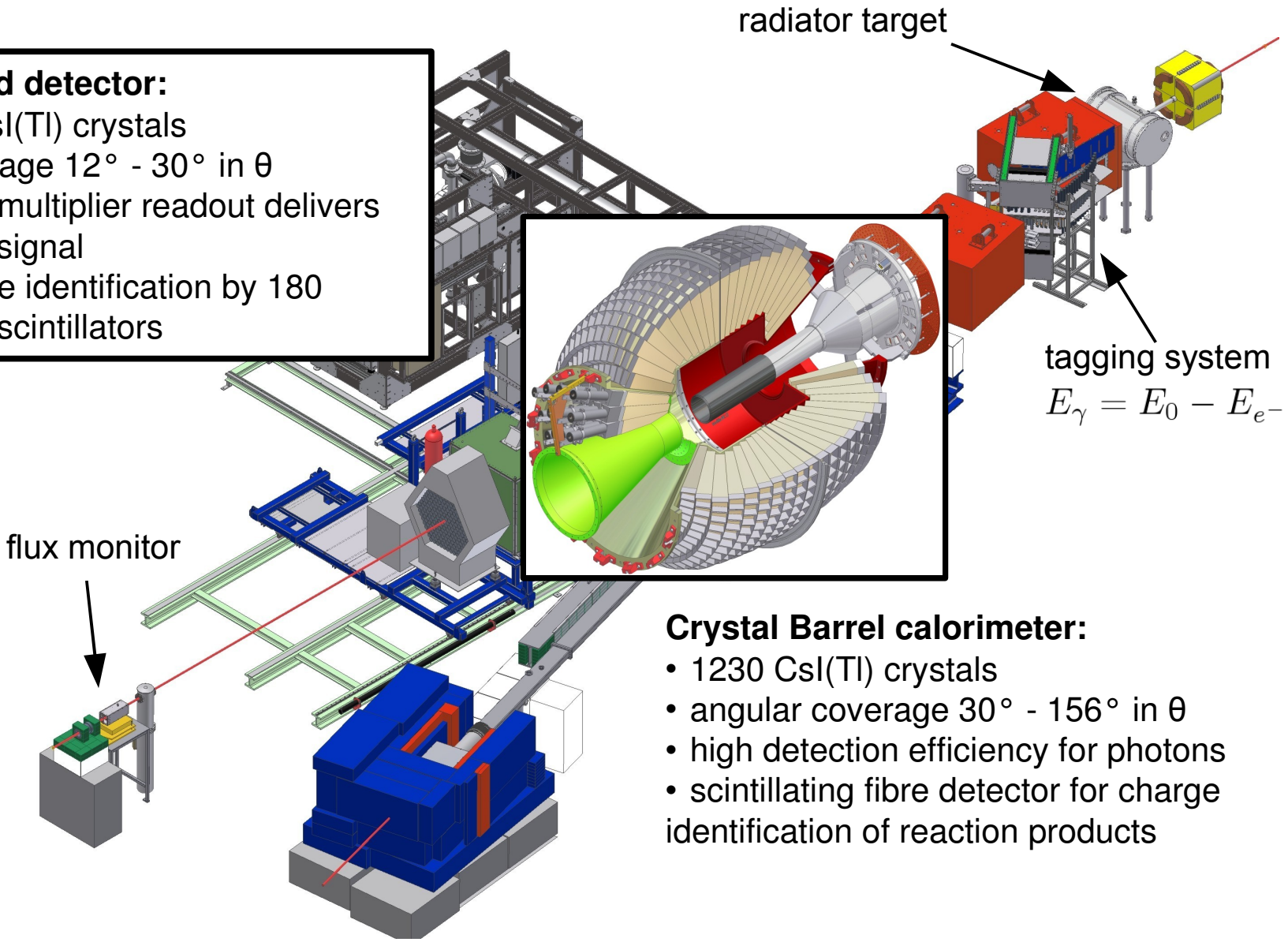


Crystal Barrel/TAPS @ ELSA



Crystal Barrel/TAPS @ ELSA

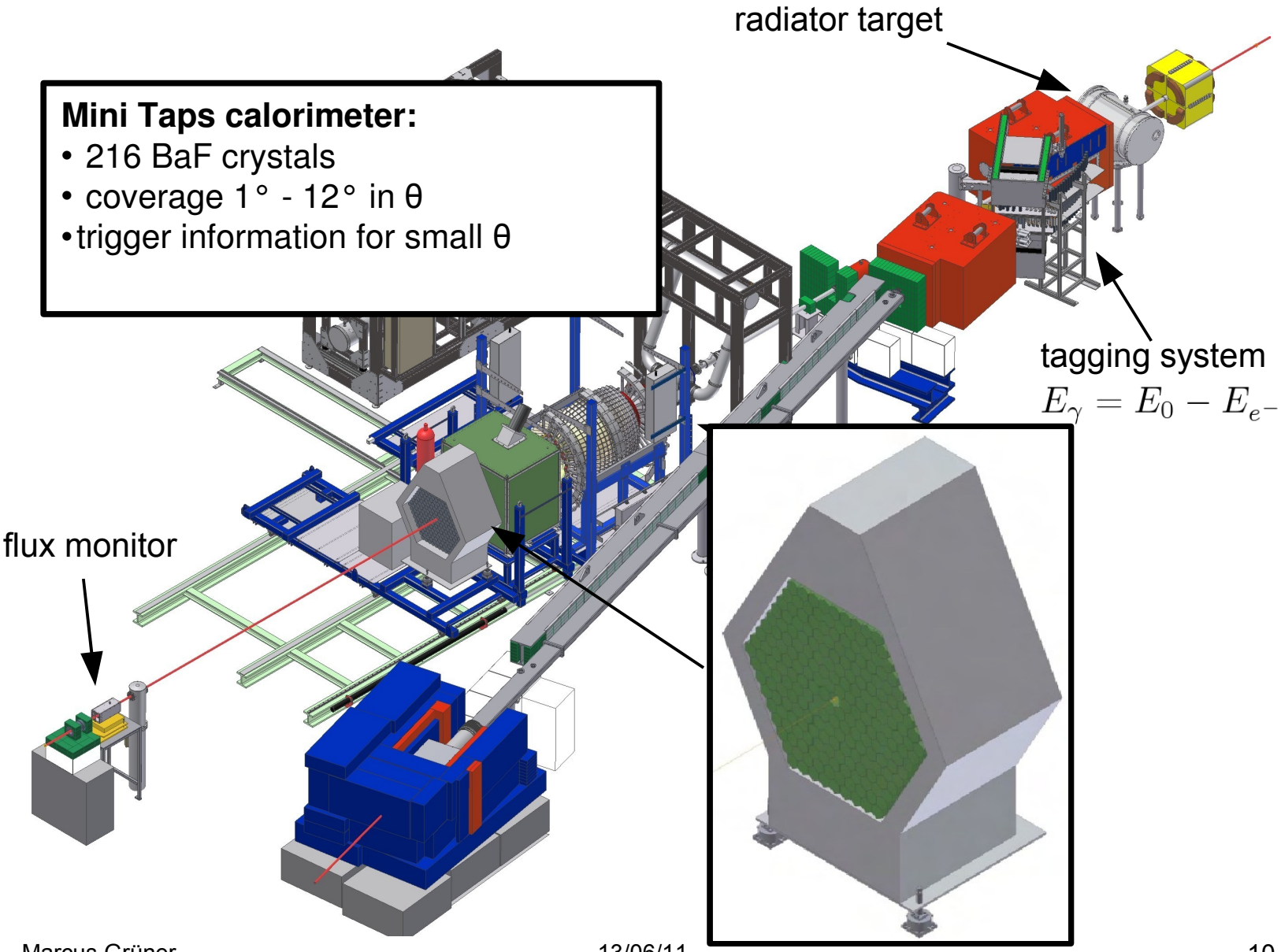
forward detector:
- 90 CsI(Tl) crystals
- coverage 12° - 30° in θ
- photomultiplier readout delivers trigger signal
- charge identification by 180 plastic scintillators



Crystal Barrel calorimeter:
- 1230 CsI(Tl) crystals
- angular coverage 30° - 156° in θ
- high detection efficiency for photons
- scintillating fibre detector for charge identification of reaction products

Crystal Barrel/TAPS @ ELSA

Mini Taps calorimeter:
- 216 BaF crystals
- coverage 1° - 12° in θ
- trigger information for small θ



The „complete” experiment

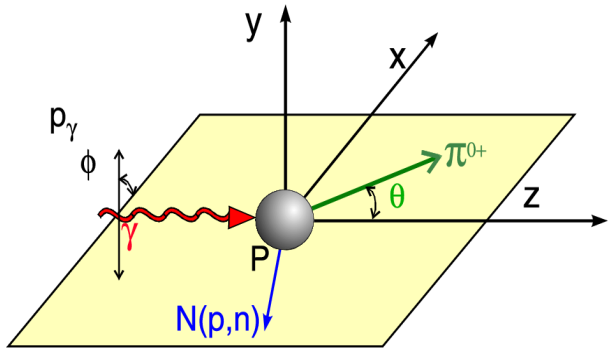
A complete model independent partial wave analysis demands:

- $\frac{d\sigma}{d\Omega}$ and 3 single polarisation observables
- 4 properly chosen double polarisation observables

[Chiang, Tabakin, Phys. Rev C55 (1997)]

Crystal Barrel/TAPS @ ELSA:

Photon Polarisation		**Target Polarisation** X	Y	Z
unpolarised	σ	-	T	-
linear	$-\Sigma$	H	(-P)	-G
circular	-	F	-	-E

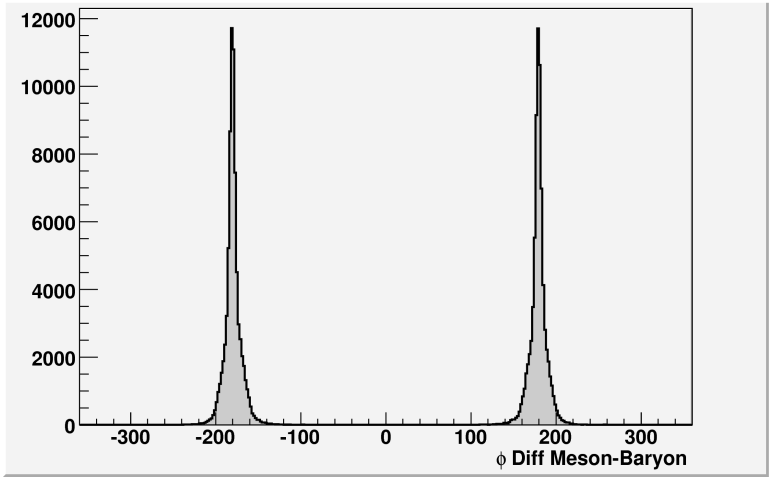


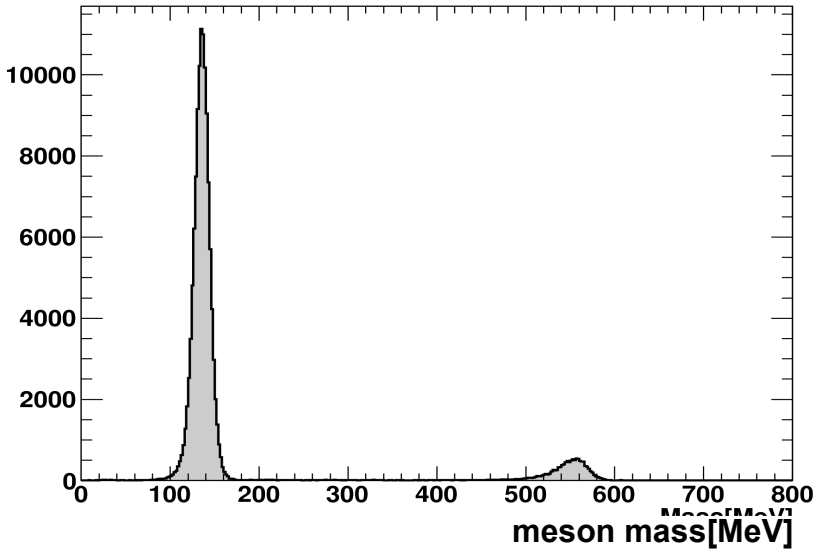
$$\frac{d\sigma}{d\Omega}(\theta,\phi) = \frac{d\sigma}{d\Omega}(\theta)[1 - p_\gamma^{lin}\Sigma(\theta)cos(2\phi) + p_x \cdot (-p_\gamma^{lin}H(\theta)sin(2\phi) + p_\gamma^{circ}F(\theta)) - p_y \cdot (+p_\gamma^{lin}P(\theta)cos(2\phi) + T(\theta)) - p_z \cdot (-p_\gamma^{lin}G(\theta)sin(2\phi) + p_\gamma^{circ}E(\theta))]$$

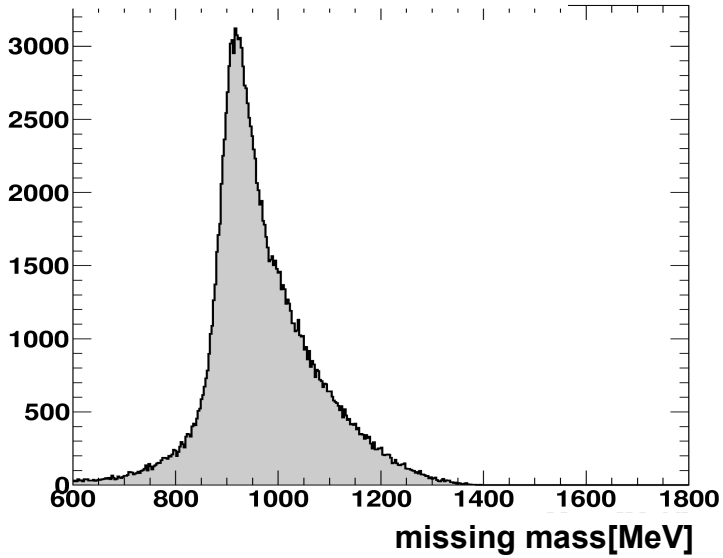
Event selection for $\vec{\gamma}\vec{p} \rightarrow p\pi^0 \rightarrow p\gamma\gamma$

cuts on raw data:

- multiplicity: 3 hits in the calorimeters
- charge: 1x charged 2x neutral
- time
- coplanarity: $\Delta\phi$
- colinearity: $\Delta\theta$
- proton missing mass
- meson mass







The observables $\sum$ and G

$$\frac{d\sigma}{d\Omega}|_H(\theta,\phi) = \frac{d\sigma}{d\Omega}|_H[1 - p_\gamma^{lin}\Sigma_H cos(2\phi) + p_z p_\gamma^{lin} G sin(2\phi)]$$

longitudinally polarised protons p_z

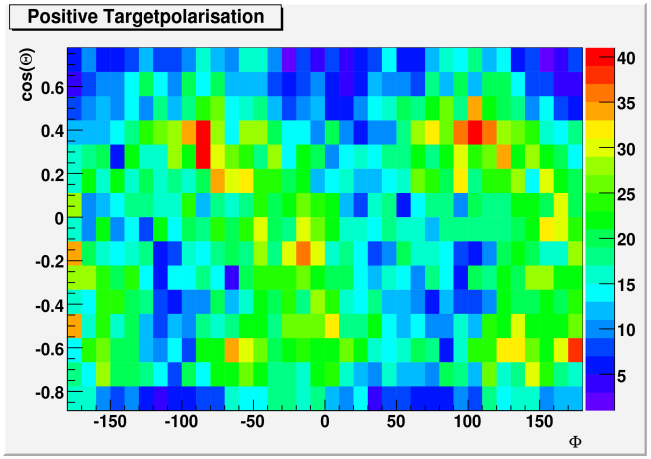
- Target material butanol C_4H_9OH
- contribution of reactions on protons bound in (C,O)

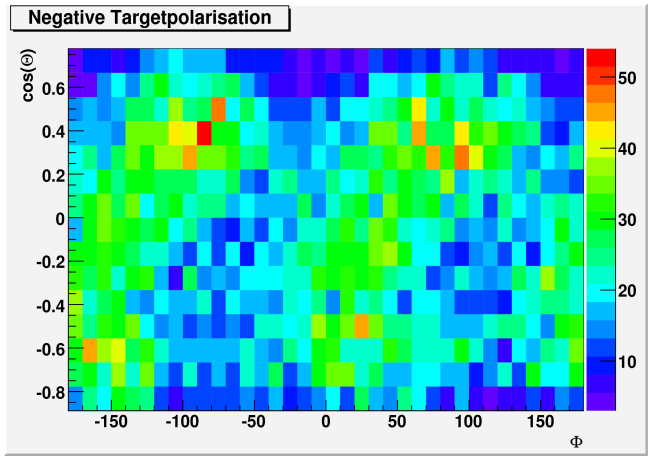
$$\frac{d\sigma}{d\Omega}|_C(\theta,\phi) = \frac{d\sigma}{d\Omega}|_C[1 - p_\gamma^{lin}\Sigma_C cos(2\phi)]$$

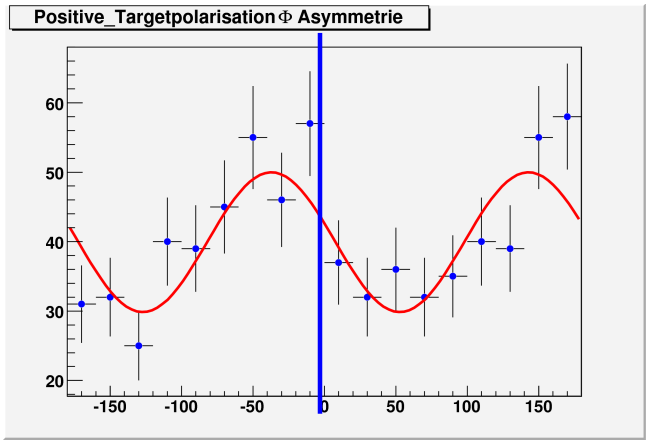
$$N(\theta,\phi) = (N_C + N_H) - (N_C + N_H)\Sigma p_\gamma^{lin} cos(2\phi) + N_H p_z p_\gamma^{lin} G sin(2\phi)$$

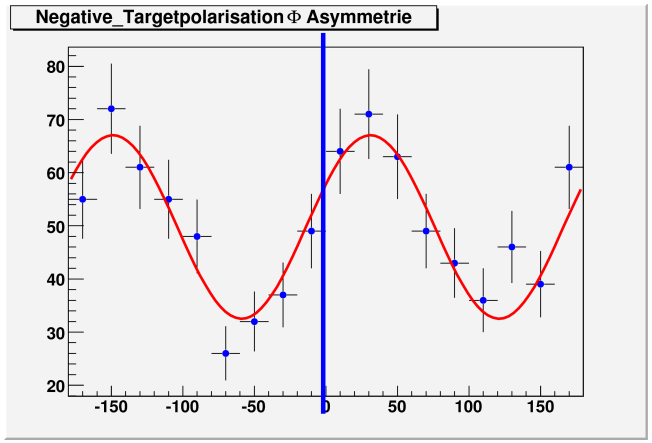
$$N = A - B cos(2\phi) + C sin(2\phi)$$

Meson Asymmetries









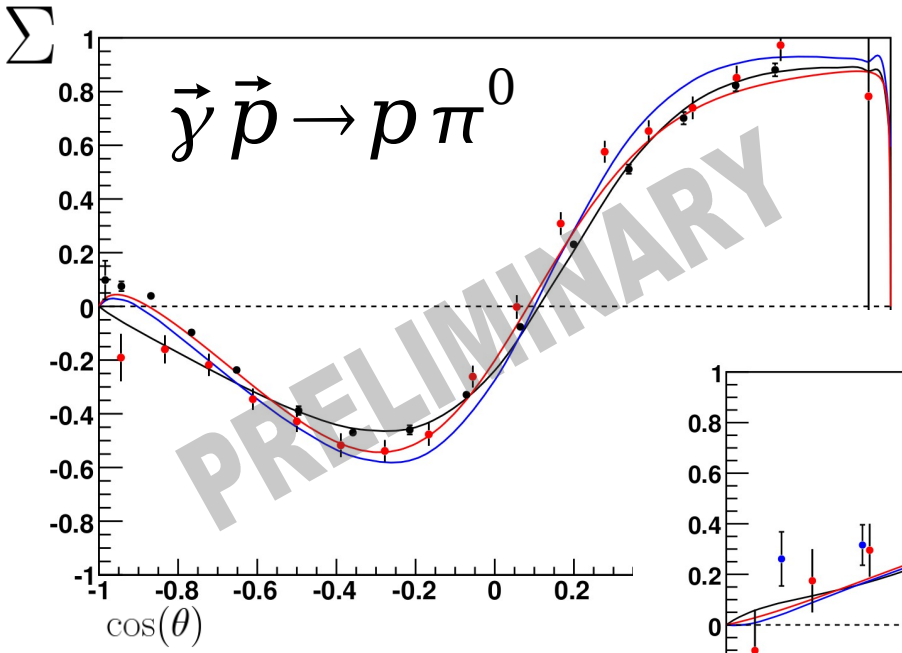
$\vec{\gamma}\,\vec{p} \rightarrow p\,\pi^0$

E = 1066 MeV

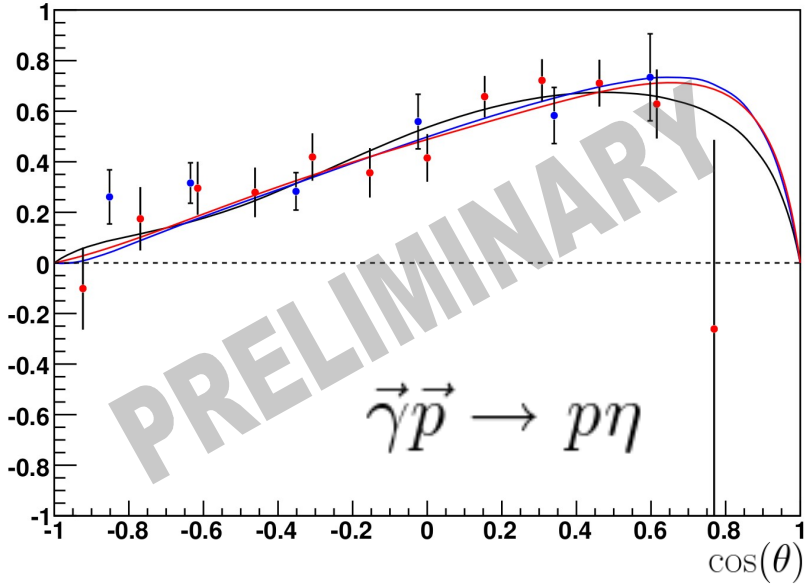
$$N = A - B\cos(2\phi) + C\sin(2\phi)$$

$$\Sigma = \frac{1}{p_\gamma^{lin}} \frac{B}{A} \qquad G = \frac{N_C + N_H}{N_H} \frac{1}{p_z p_\gamma^{lin}} \frac{C}{A}$$

Beam asymmetry Σ



E_γ = 1050 MeV

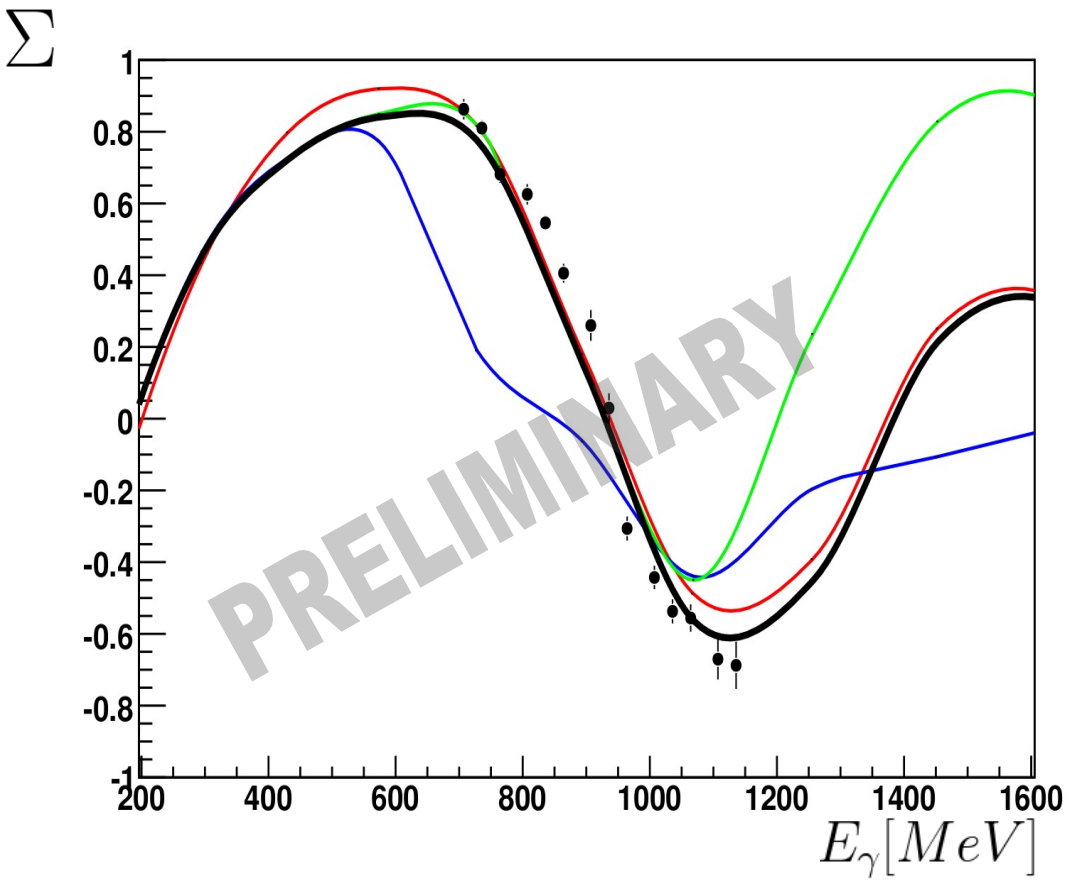


- A.Thiel CB/TAPS @ ELSA
- D.Elsner CBELSA/TAPS
- GRAAL (O. Bartalini, Eur. Phys. J A26, 399 (2005))

Bonn-Gatchina PWA
SAID-Analysis
MAID-Analysis

Beam asymmetry Σ in $\vec{\gamma}\vec{p} \rightarrow p\pi^0$

θ_{cms} = 110°

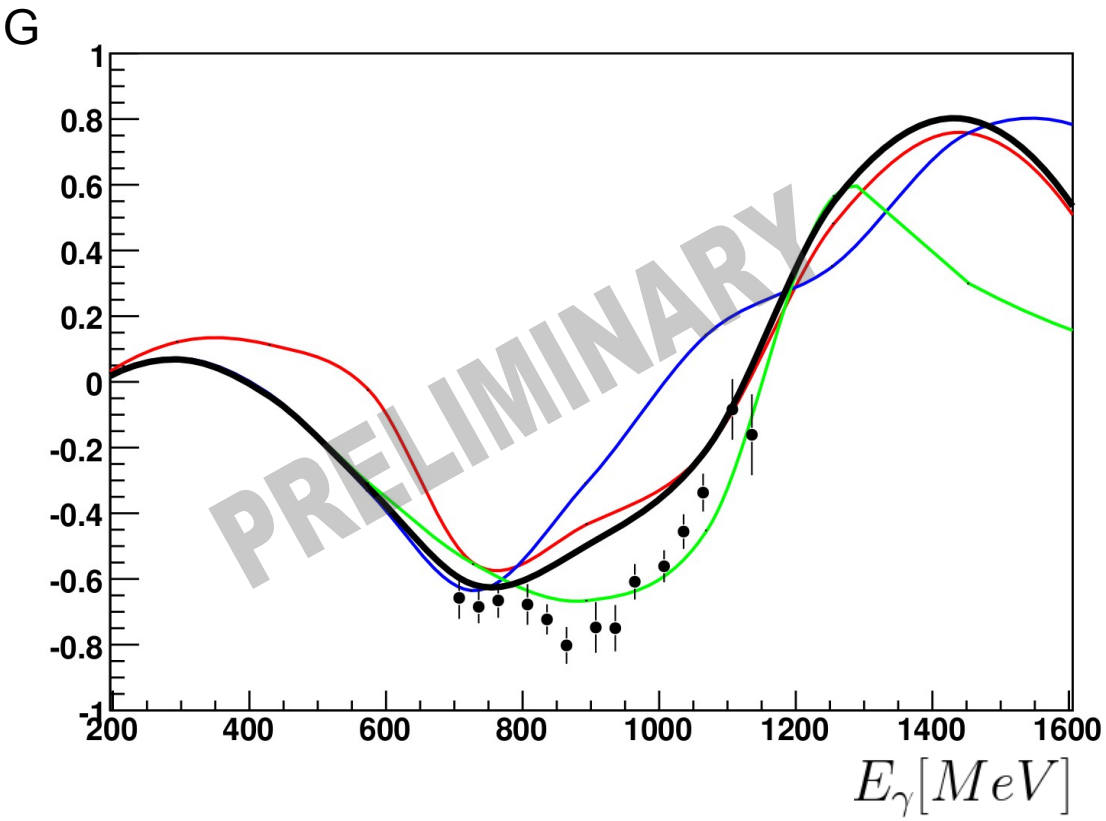


MAID
without P_{11}(1400)
without D_{13}(1520)
without F_{15}(1680)

- A.Thiel CB/TAPS @ ELSA

Observable G in $\vec{\gamma}\,\vec{p} \rightarrow p\,\pi^0$

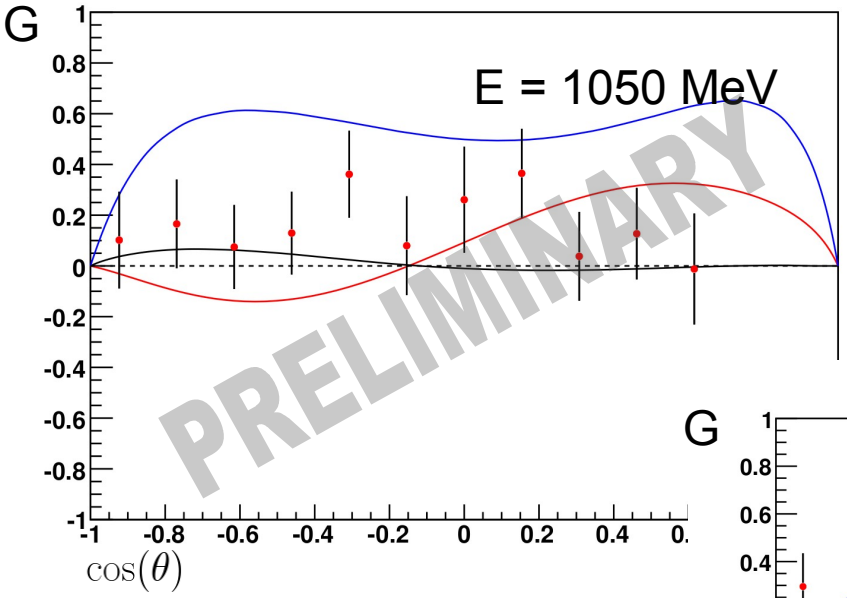
θ_{cms} = 110°

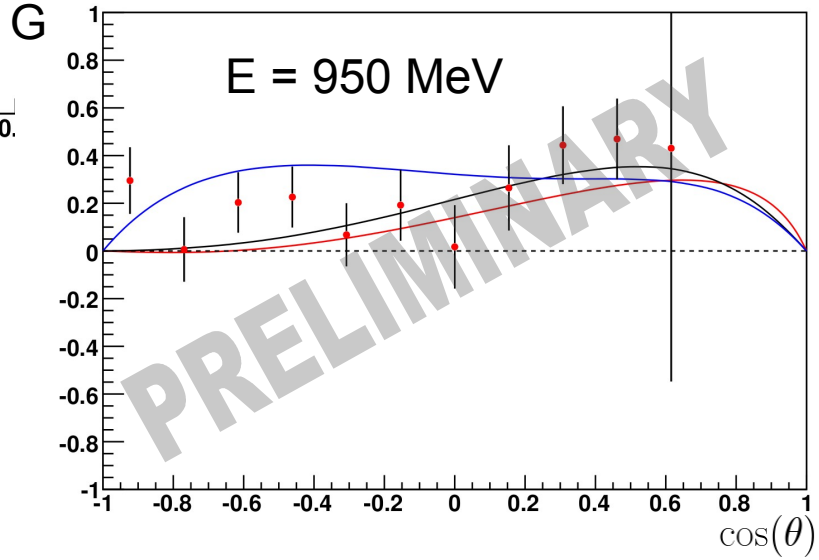


MAID
Withou P_{11}(1440)
without D_{13}(1520)
without F_{15}(1680)

- A.Thiel CB/TAPS @ ELSA

Observable G in $\vec{\gamma}\vec{p} \rightarrow p\eta$



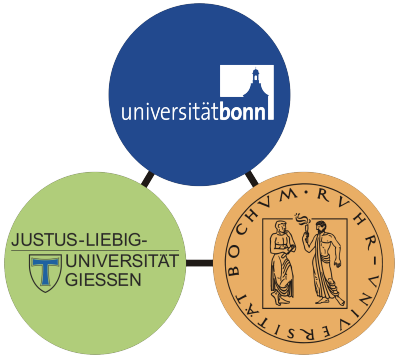


- A. Thiel CB/TAPS @ ELSA

Bonn-Gatchina PWA
SAID-Analysis
MAID-Analysis

summary

- Polarisation observables are necessary to describe the nucleon excitation spectrum by a partial wave analysis without ambiguities.
- With the Crystal Barrel/TAPS setup @ ELSA it is possible to measure single and double polarisation observables in different reaction channels.
- These measured datasets provide new constraints for the partial wave analysis.



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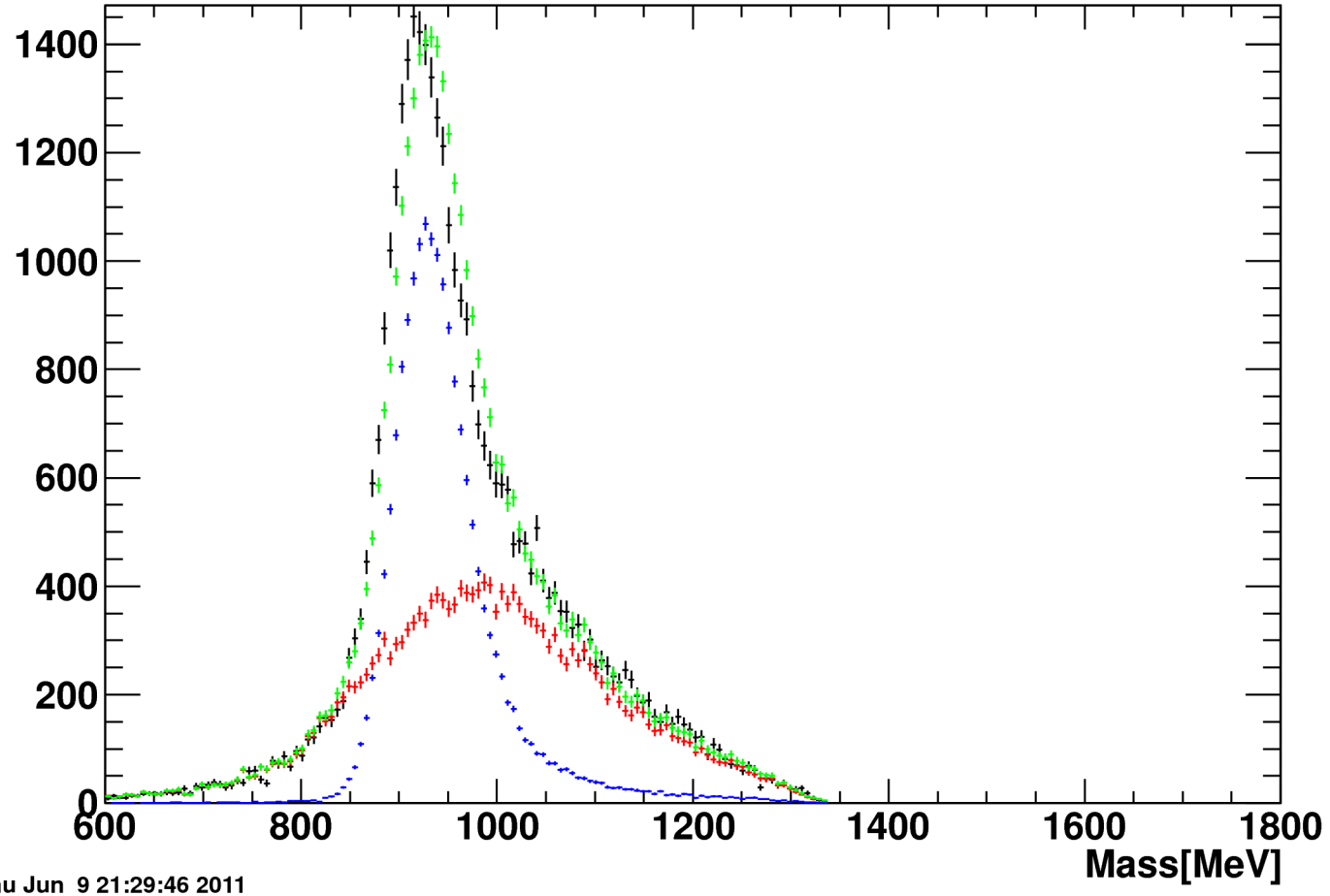
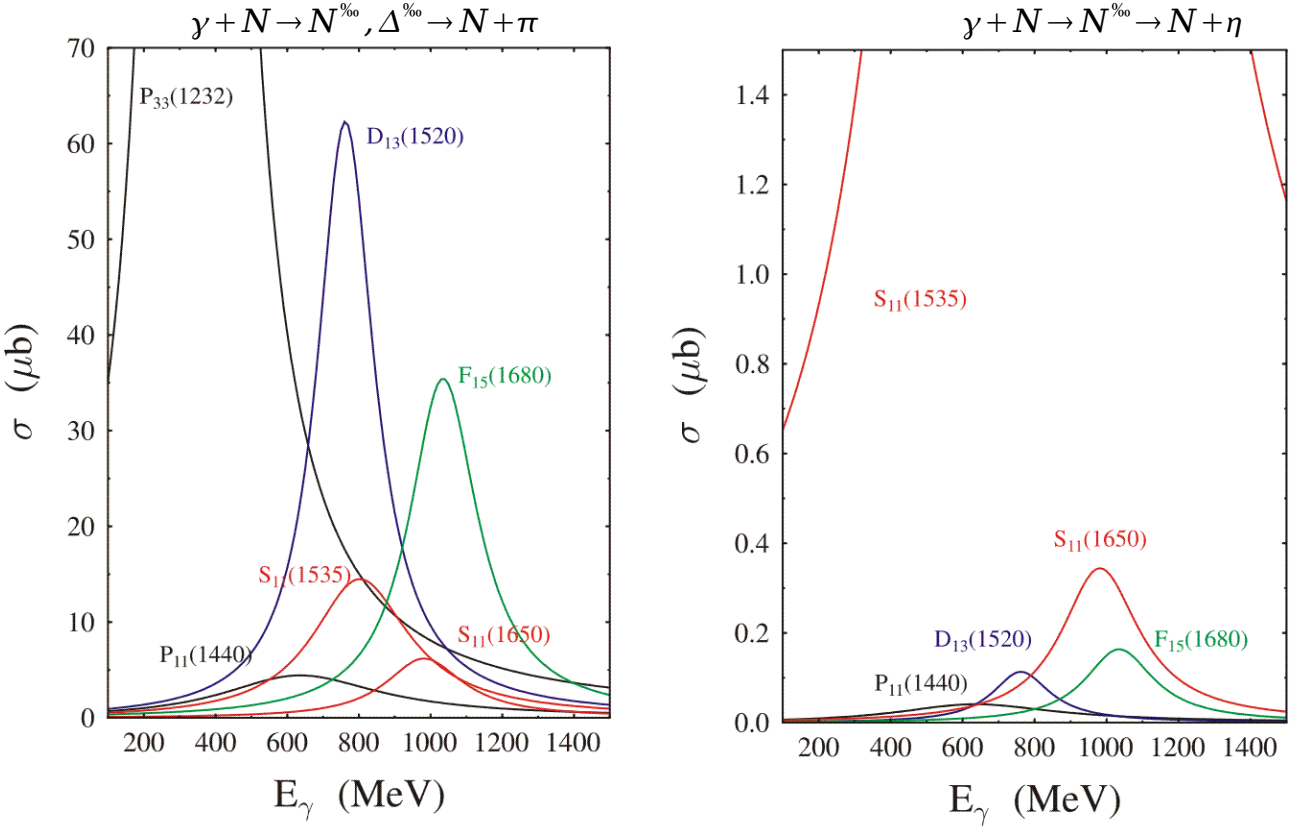
The Dilution Factor

$$G = \frac{N_C + N_H}{N_H} \; \frac{1}{p_z p_\gamma^{lin}} \; \frac{C}{A}$$



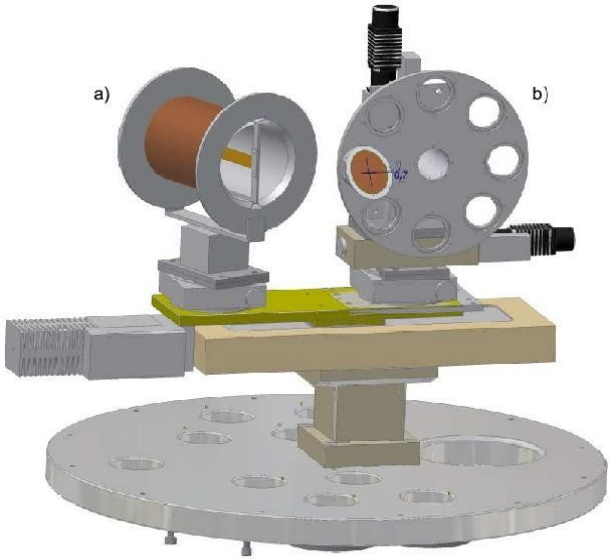
π and η photoproduction

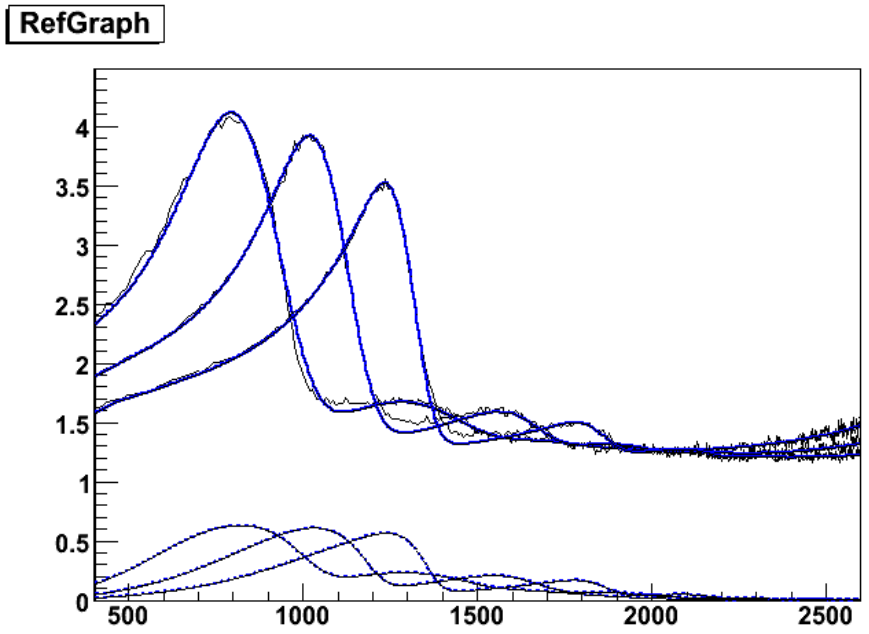


- The nucleon excitation spectrum has overlapping resonances.
- For a complete description of the spectrum with a partial wave analysis, it is necessary to measure polarisation observables.

Production of linearily polarised photons

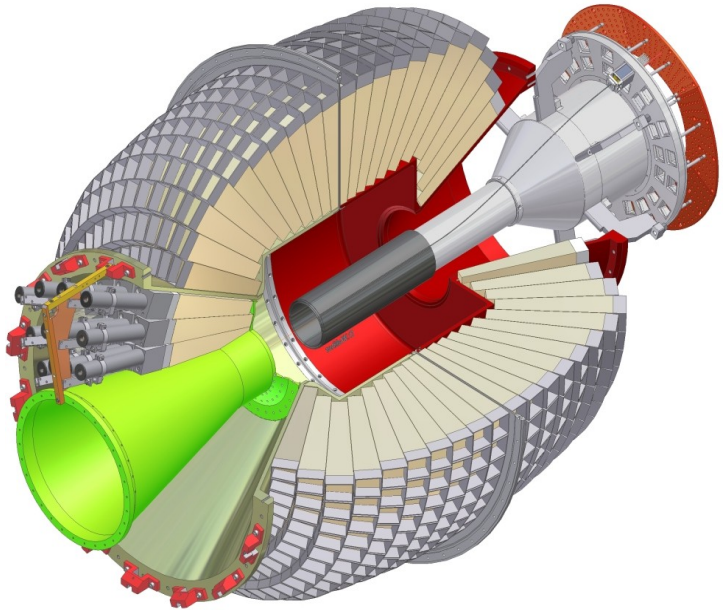
- with a goniometer different bremsstrahl radiators can be positioned in the beam with high accuracy
- coherent scattering of the e^- beam on a diamond cristal creates polarisation degrees of up to 65%
- photons are tagged in energy by a tagging spectrometer system

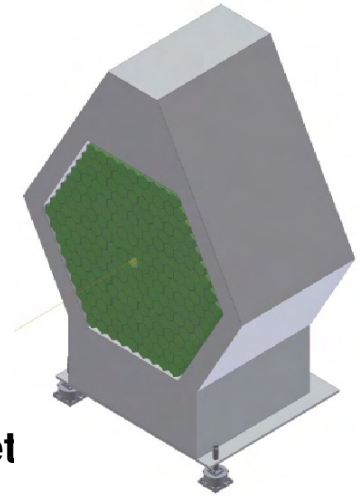




main detector components

Crystal Barrel calorimeter:
- 1230 CsI(Tl) crystals
- angular coverage 30° - 156° in θ
- high detection efficiency for photons
- scintillating fibre detector for charge identification of reaction products





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