universitätbonn

Polarized Photon Beams for the BGO-OD Experiment at ELSA

supported by DFG SFB/TR16

Thomas Zimmermann
On behalf of the BGO-OD collaboration

Physikalisches Institut
Universität Bonn

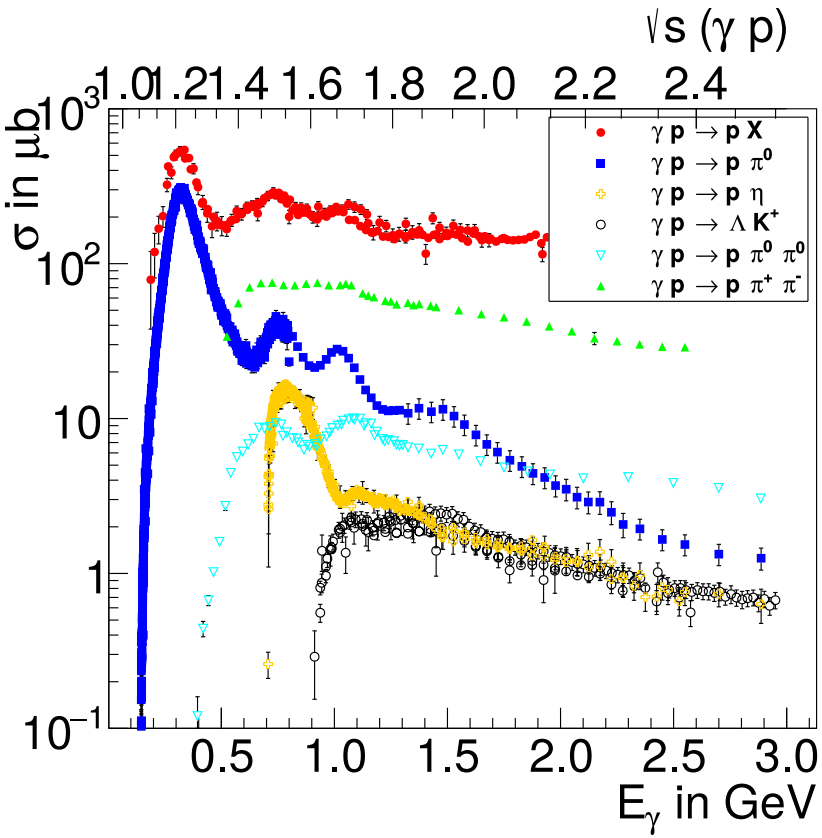
NStar 2015
Osaka, 24. May - 27. May 2015

universitätbonn

Outline

universitätbonn

Motivation

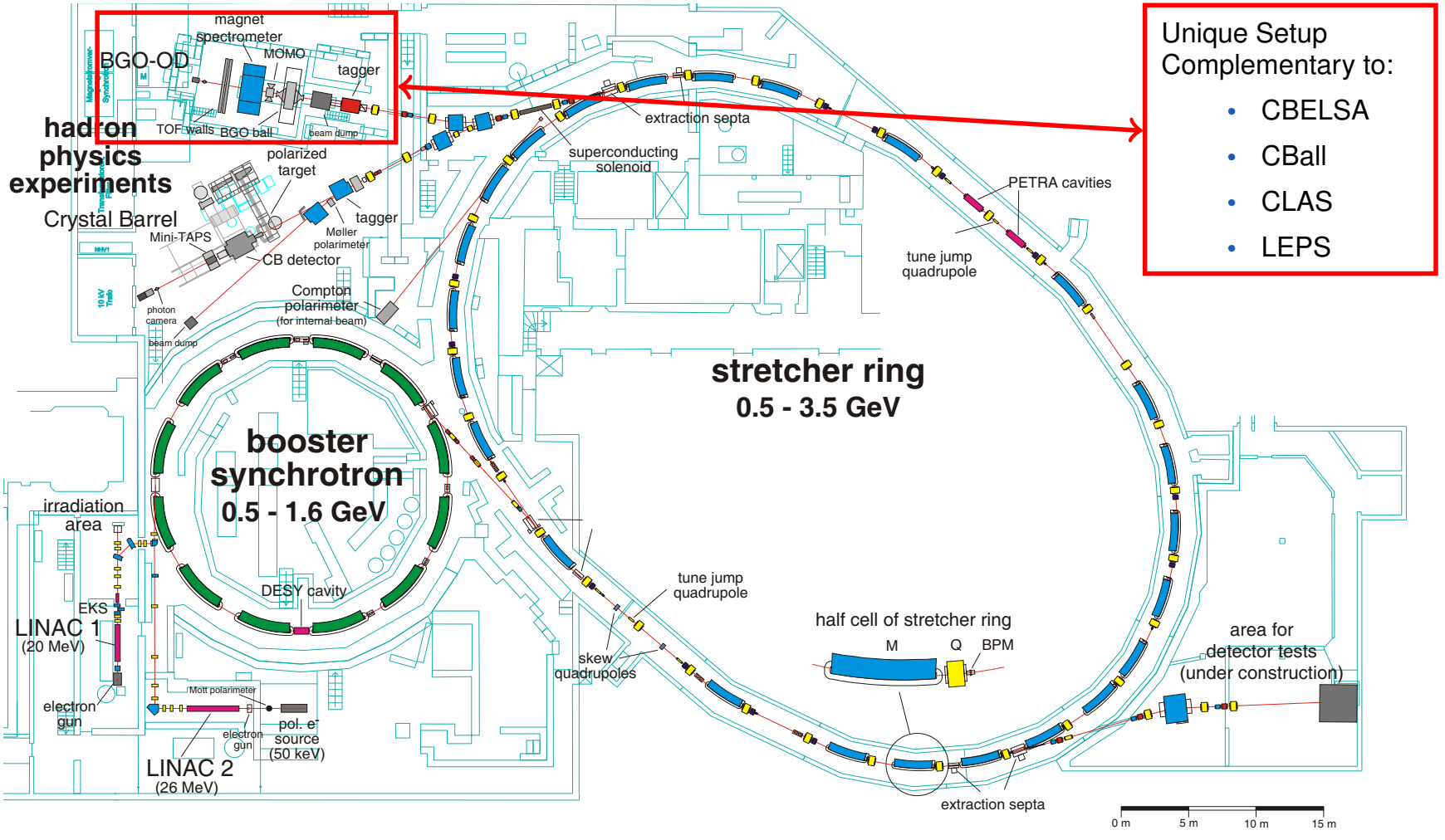


- Nucleon/Baryon excitations
- Pion nucleon scattering
- Quark models: missing resonances
- Photo production
- Polarization
- Disentangle states
- Complete experiment [a]

[a] Chiang and Tabakin. *Phys. Rev. C*, 55:2054–2066, 1997

universitätbonn

ELSA

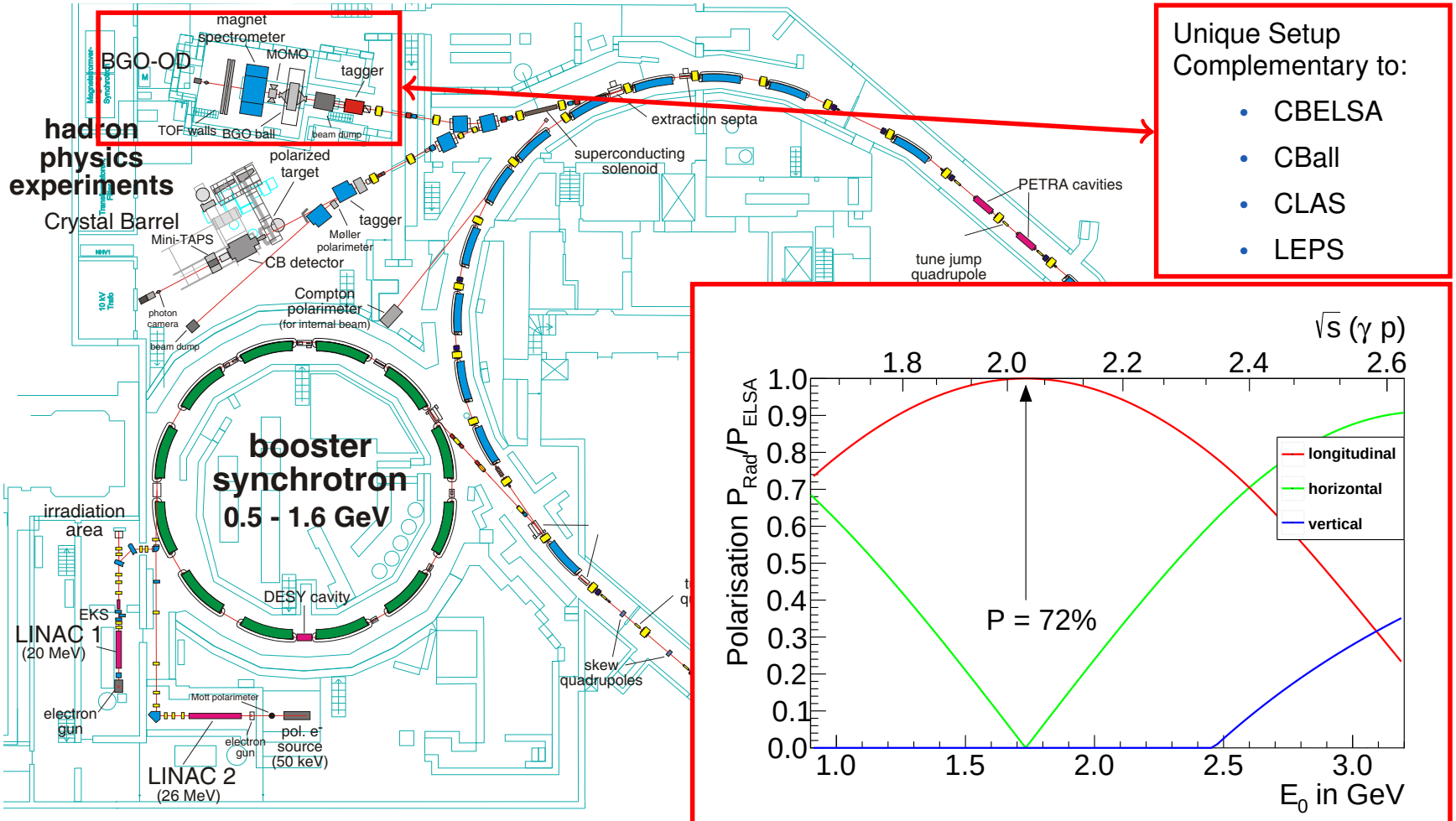


Unique Setup
Complementary to:

- CBELSA
- CBall
- CLAS
- LEPS

universitätbonn

ELSA



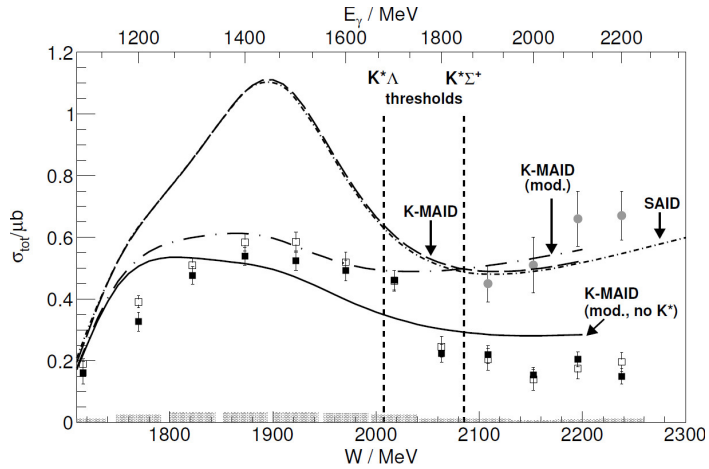
Unique Setup
Complementary to:

- CBELSA
- CBall
- CLAS
- LEPS

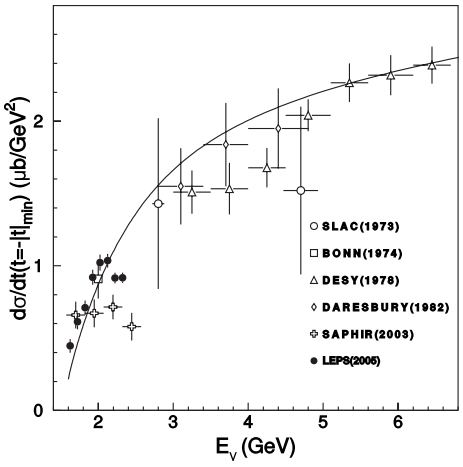
universitätbonn

Energy Region

- Maximum linear polarization at $E_0/2$
- Maximum circular polarization at $E_0 \sim 1.7\,\text{GeV}$ ($W \sim 2\,\text{GeV}$)
- Energy region of unresolved/missing resonances
- K^*Y thresholds
- ω and η' thresholds
- Non-understood "bump" structure in ϕ photoproduction



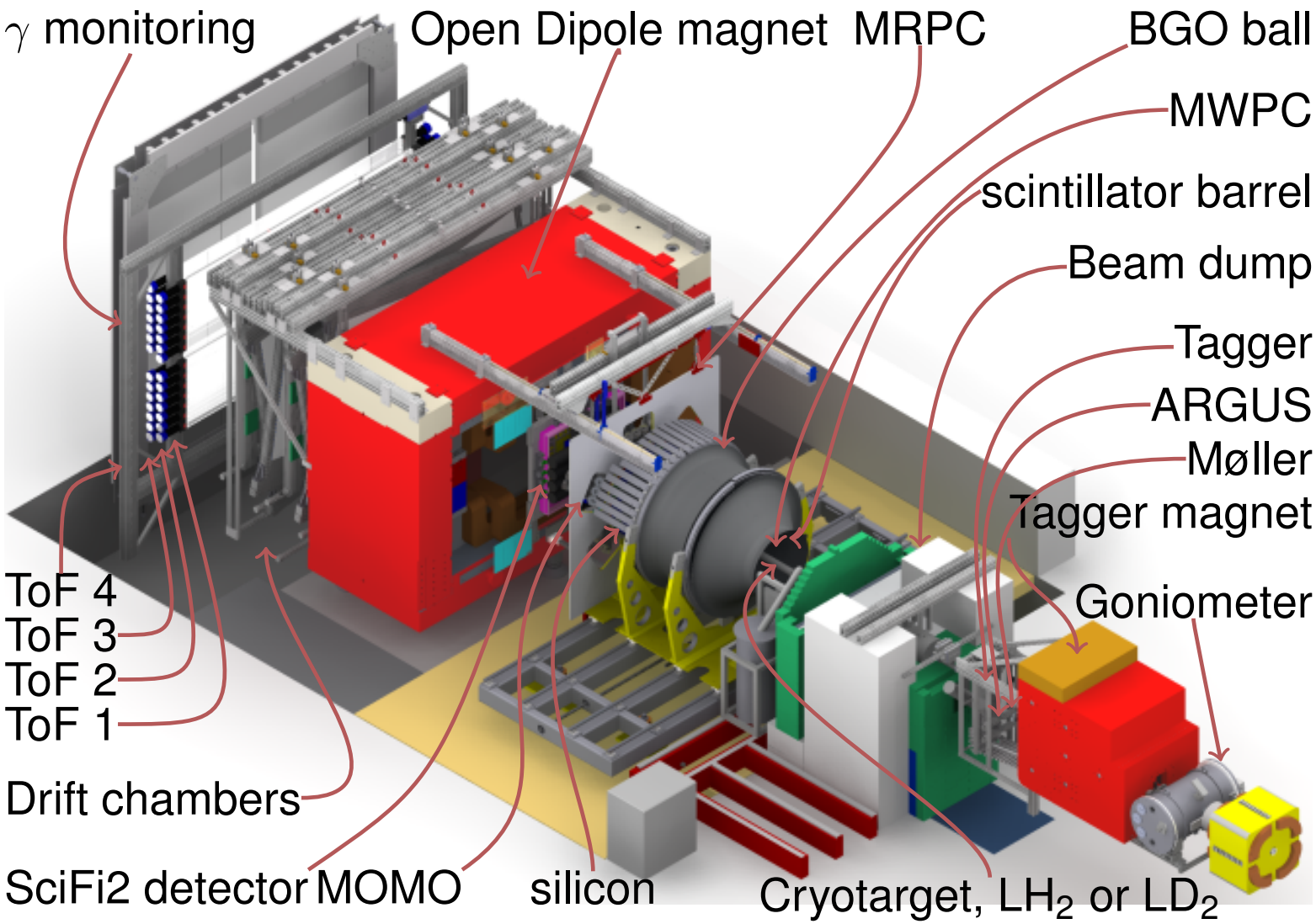
R. Ewald et al. *Physics Letters B*, 713(3):180 – 185, 2012



T. Mibe et al. *Phys. Rev. Lett.*, 95:182001, 2005

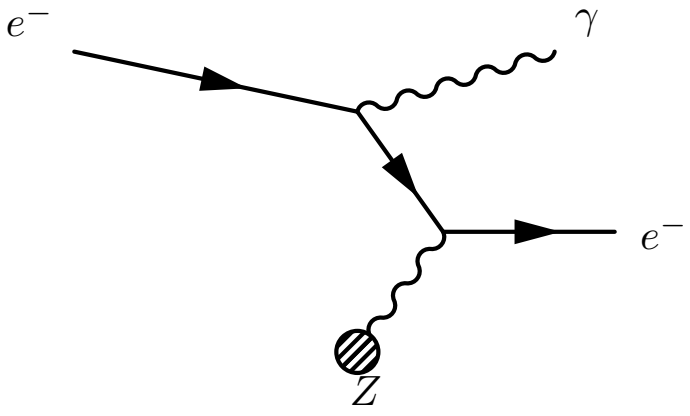
universitätbonn

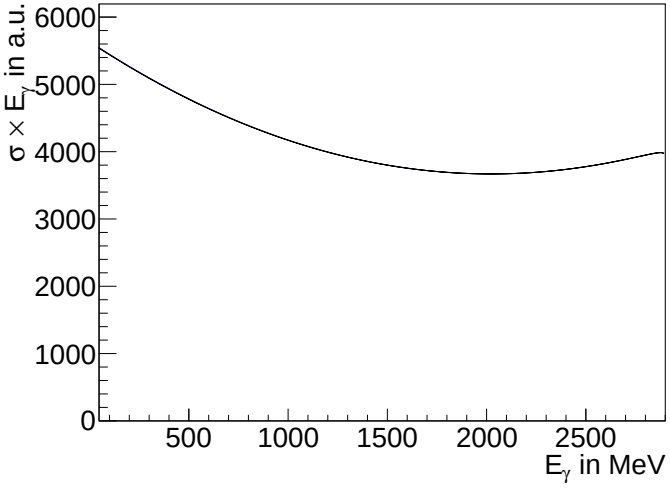
BGO-OD Experiment



universitätbonn

Bremsstrahlung

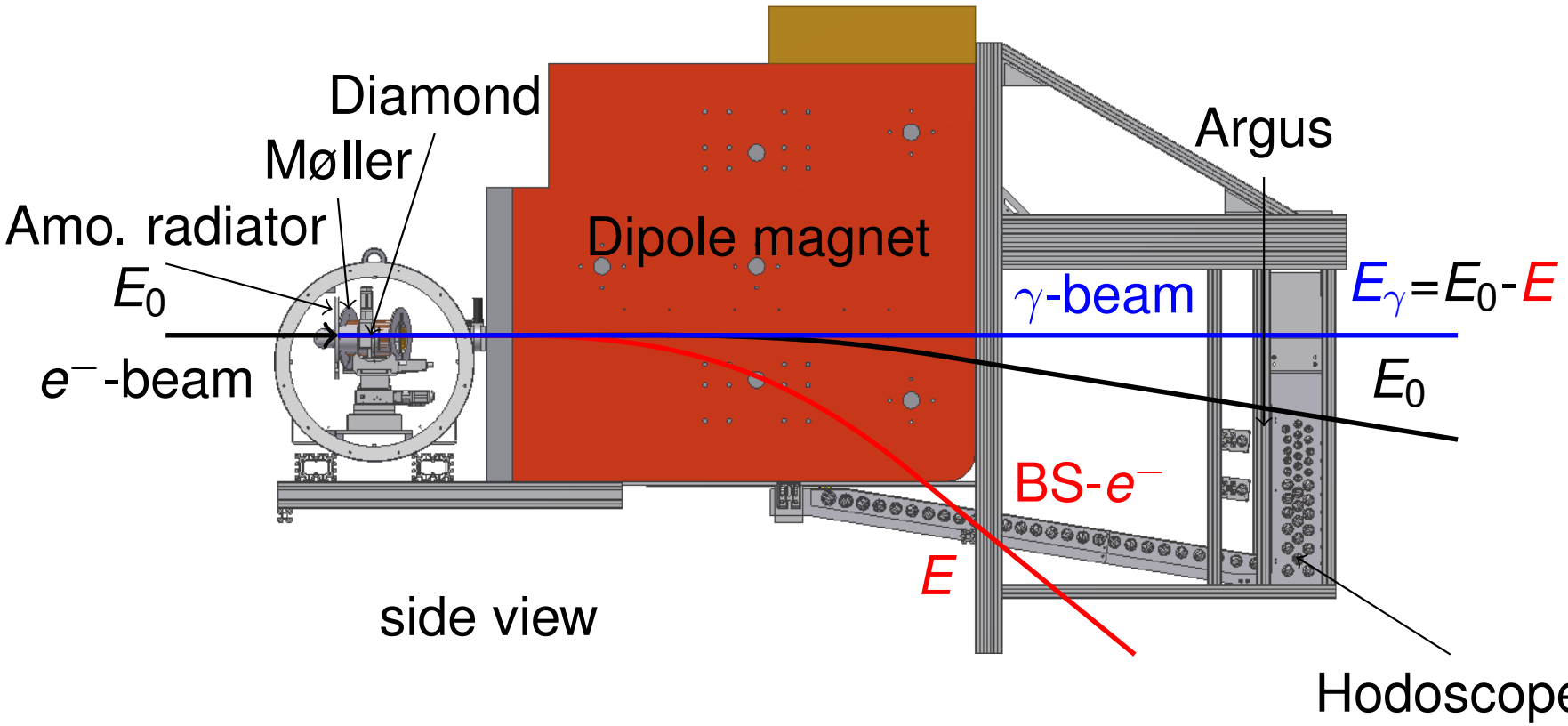




- Amorphous radiator
- EM field vector in scattering plane
- Azimuthal distribution isotropic
  $\rightarrow$ no polarization
- Continuous energy spectrum
  $\sigma_{BS} \sim 1/E_\gamma$

universitätbonn

Tagging System



Coverage: $10\% < E_\gamma < 90\%$ (of E_0)

Resolution: $0.5\% < \Delta E_\gamma < 2.1\%$ [×¼ (Argus SciFi Hodoscope)]

universitätbonn

Linear Polarization

- Using diamond radiator
- Coherent scattering
- Certain $\vec{g}$'s contribute
- Rotate crystal such that only single $\vec{g}$ possible

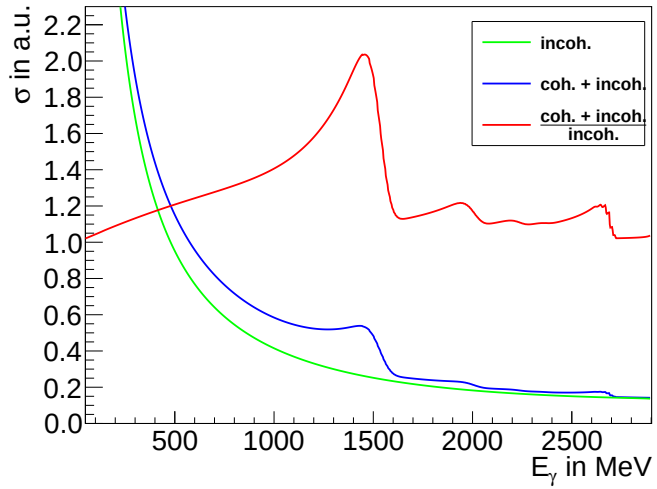
→ Single scattering plane

→ Defined polarization plane

→ Linearly polarized photon beam

Laue Bragg:

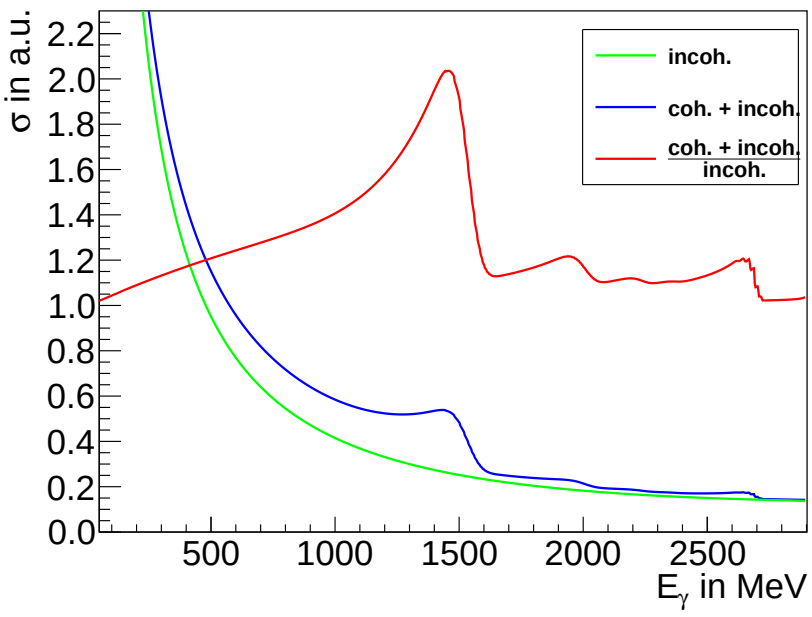
$$2d \sin\Theta = n\lambda = \vec{q} = n\vec{g}$$

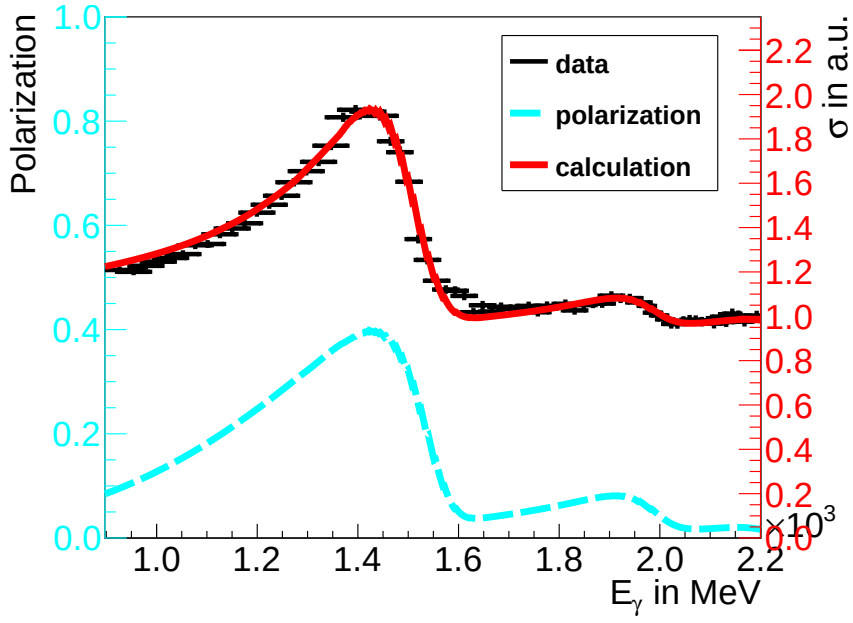


universitätbonn

Determination of Polarization

- Analytical calculation of Bremsstrahlung Intensity Spectra

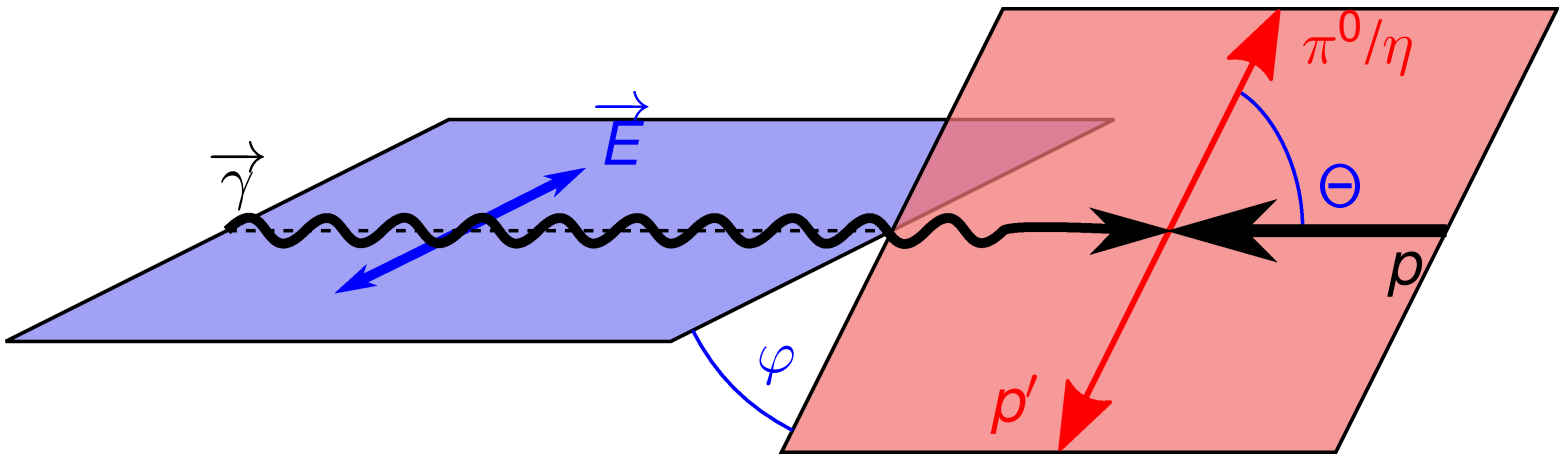




universitätbonn

Very preliminary consistency check

Σ in $\vec{\gamma} p \to p\pi^0, \vec{\gamma} p \to p\eta$



polarization plane reaction plane

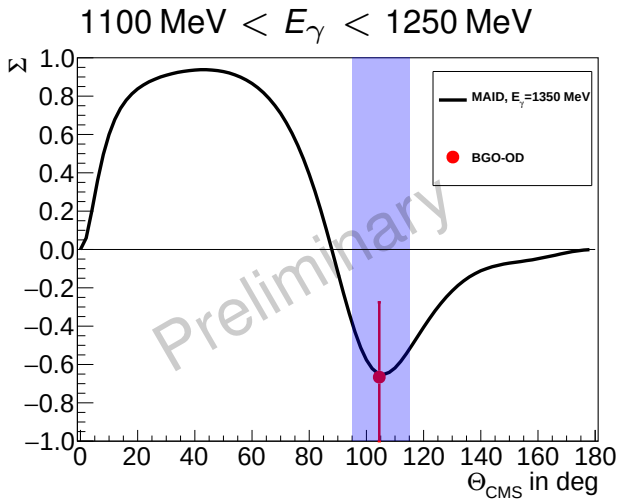
$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_0}{d\Omega} \cdot (1 - P\Sigma \cos(2\varphi))$$

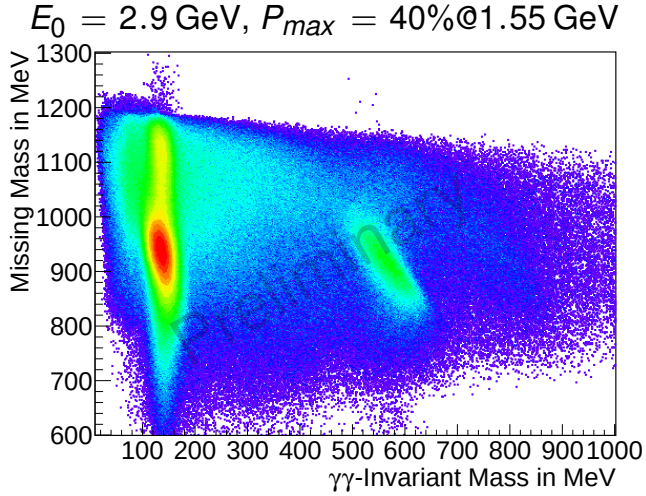
degree of polarization

beam asymmetry

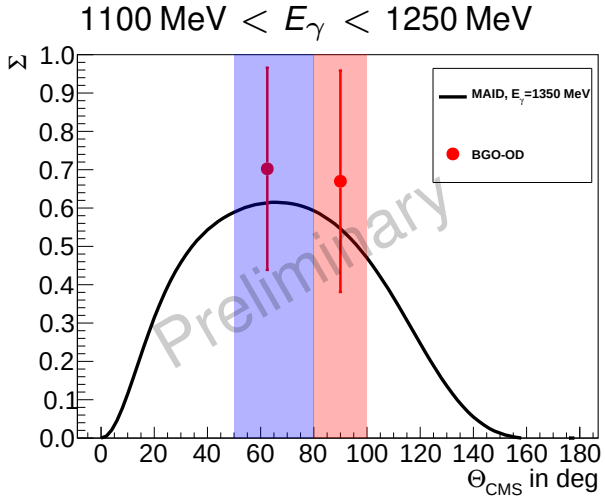
Beam Asymmetry Σ: First Data

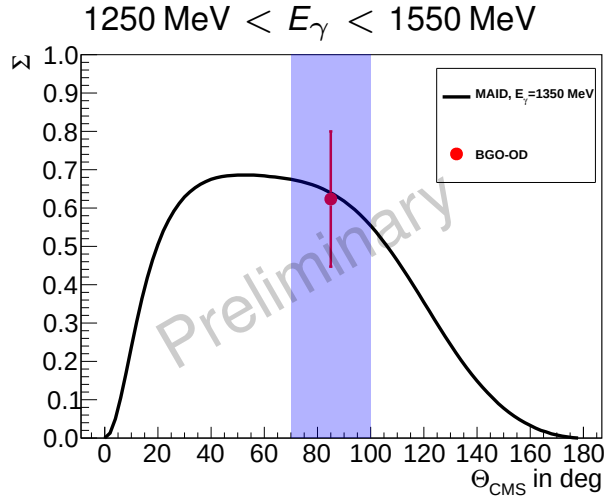
$\gamma p \to \pi^0 p$





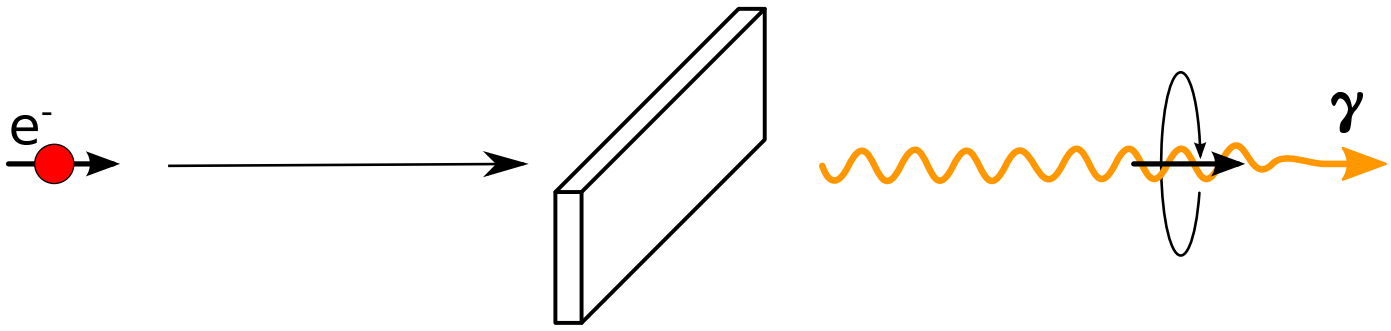
$\gamma p \to \eta p$

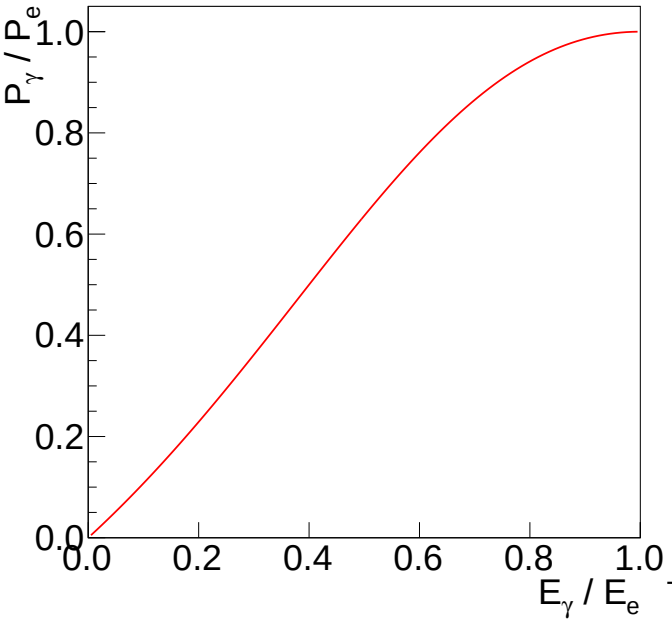




A. Bella. Phd thesis in preparation, Universität Bonn

Circularly Polarized Photons





- e^- polarization $\Rightarrow$ γ polarization
- Exactly described by QED[a]
- Required: absolute e^- polarization

[a] Haakon Olsen and L. C. Maximon. *Phys. Rev.*, 114:887–904, 1959

universitätbonn

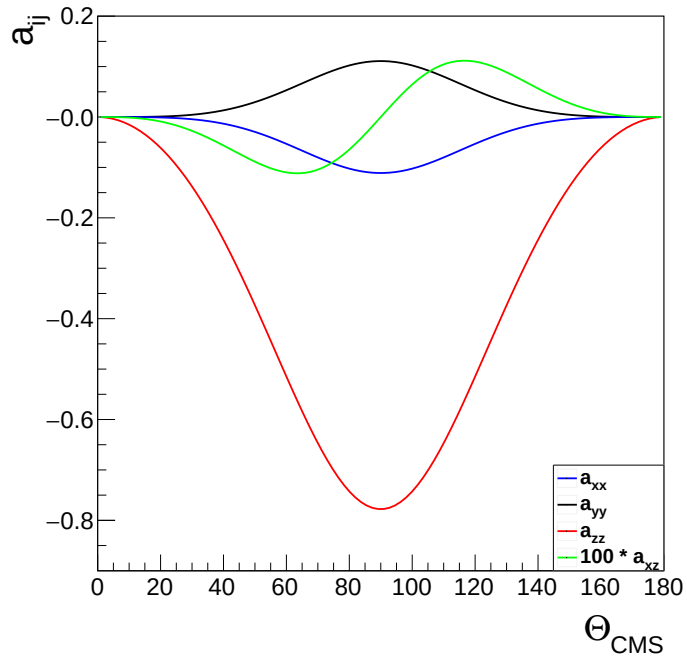
Møller Polarimetry

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega} = \frac{\mathrm{d}\sigma_0}{\mathrm{d}\Omega}\left(1 + a_{ij} P_i^{beam} P_j^{target}\right)$$

$$a_{zz} = -\frac{7}{9} \text{ at } \Theta_{CMS} = 90°$$

$$A_{zz} = \frac{N^{\uparrow\downarrow} - N^{\uparrow\uparrow}}{N^{\uparrow\downarrow} + N^{\uparrow\uparrow}} = a_{zz} P_z^{beam} P_z^{target}$$

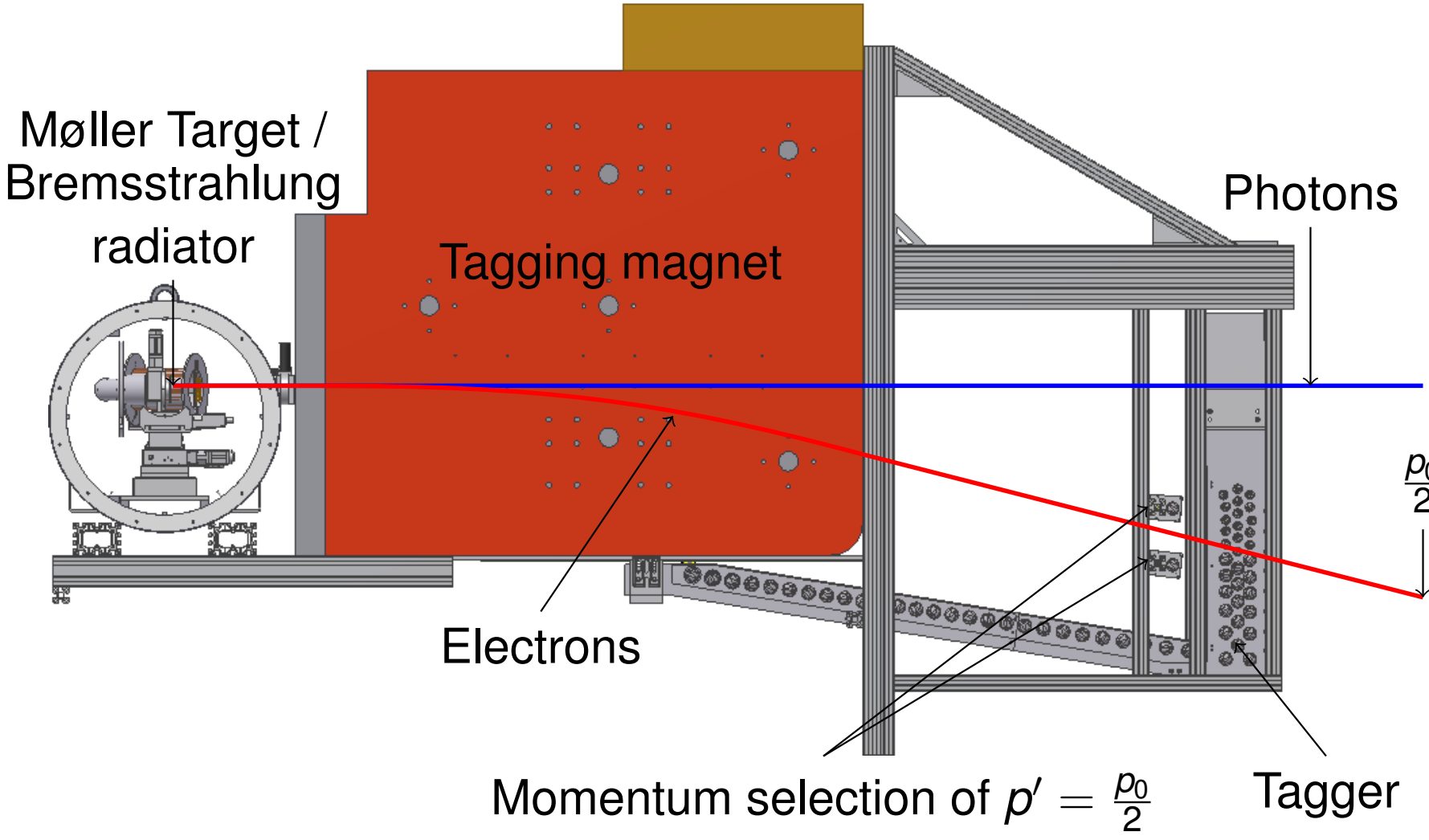
$$\Rightarrow \quad P^{beam} = \frac{A_{zz}}{P^{target} a_{zz}}$$



Source: B. Wagner et al. *Nucl. Instr. Meth. Phys. Res. A*, 294(3):541 – 548, 1990

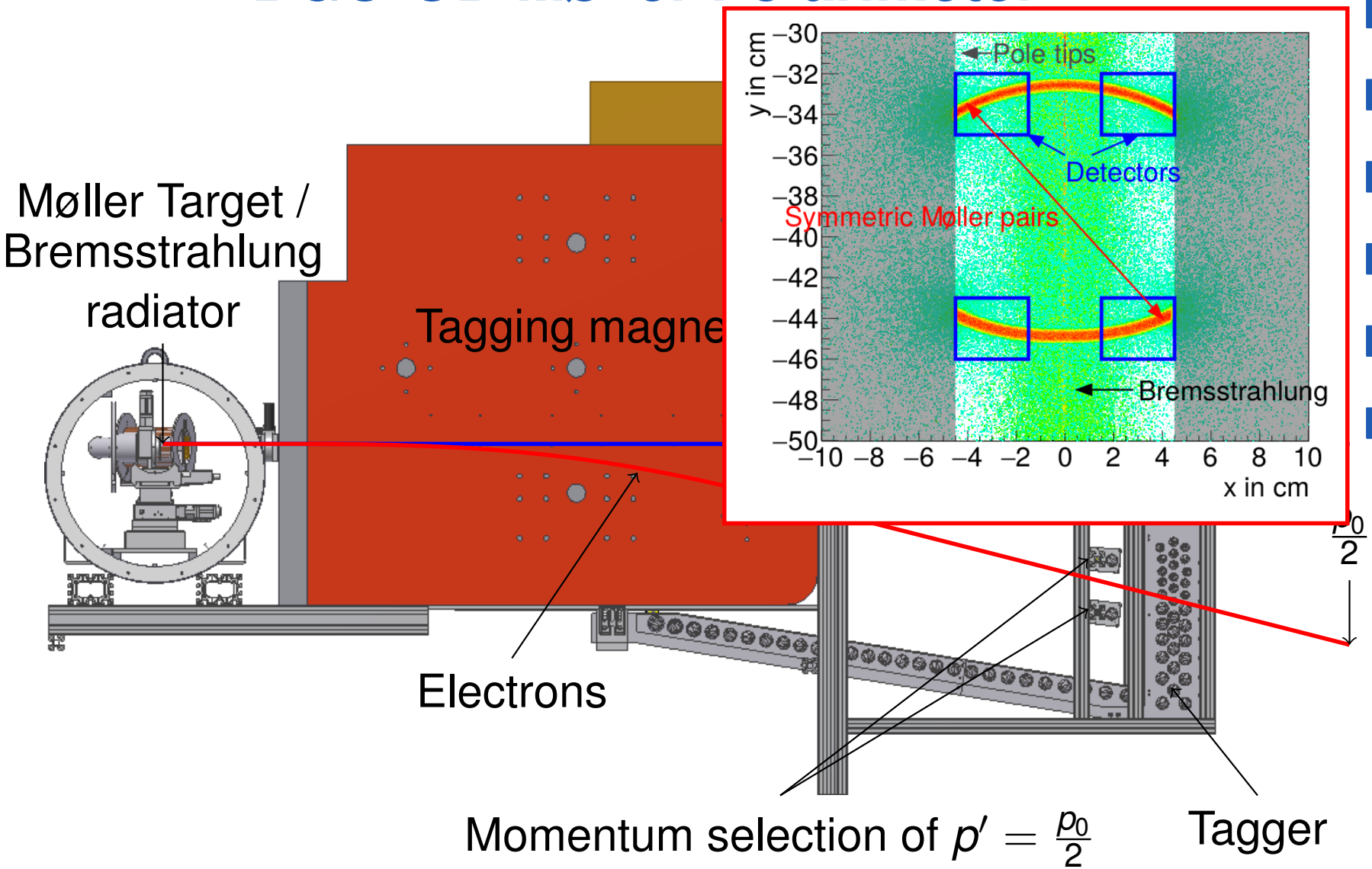
universitätbonn

BGO-OD Møller Polarimeter



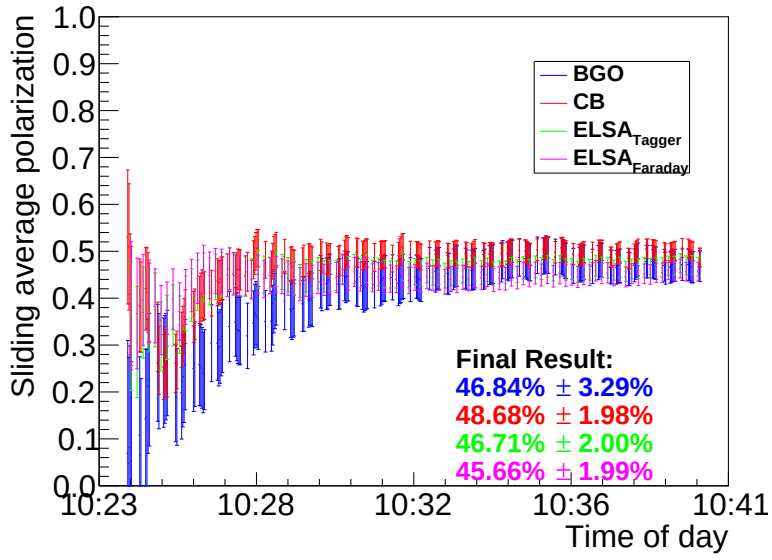
universitätbonn

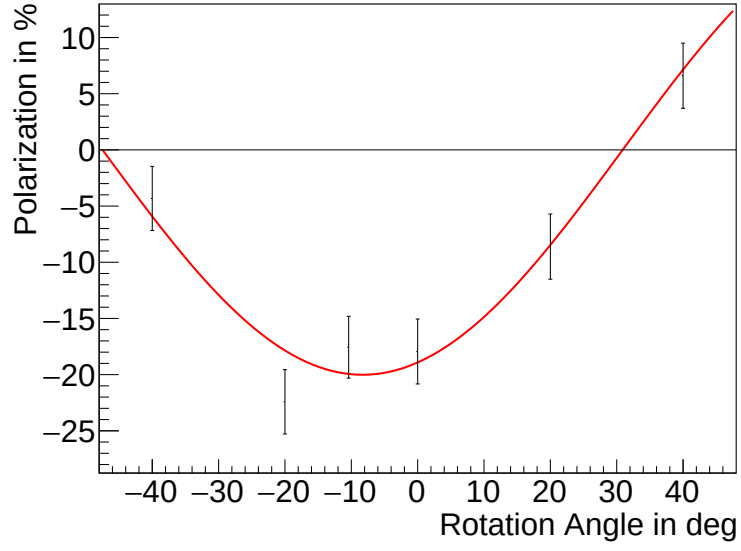
BGO-OD Møller Polarimeter



e^- Polarization Measurements

- e^- Helicity flipped every spill
- Luminosity normalized
- Spin rotation:
  - Rotate spin at e^- source
  - Expected: sinusoidal modulation of polarization





universitätbonn

Summary & Outlook

- BGO-OD Experiment has linearly and circularly polarized γ-beam
- We understand the degree of polarization
- Degree of linear polarization determined analytically
- First linear polarization data consistent with the world data
- Møller polarimeter works $\Rightarrow$ e-beam polarization

universitätbonn

A. Bella.
Phd thesis in preparation, Universität Bonn.

Chiang and Tabakin.
Phys. Rev. C, 55:2054–2066, 1997.

B. Wagner et al.
Nucl. Instr. Meth. Phys. Res. A, 294(3):541 – 548, 1990.

R. Ewald et al.
Physics Letters B, 713(3):180 – 185, 2012.

T. Mibe et al.
Phys. Rev. Lett., 95:182001, 2005.

Haakon Olsen and L. C. Maximon.
Phys. Rev., 114:887–904, 1959.