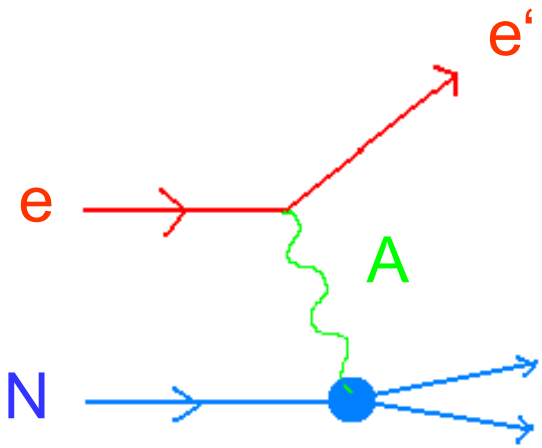
Polarized total photoabsorption cross sections

1. The role of polarization in e.m. processes

2. Sum rules and total cross sections

3. GDH - Experiment at ELSA

Polarization in el. magn. processes



Interaction energy

$$j_\mu \cdot A^\mu$$

$\rho \cdot \Phi$ — Coulomb

$\frac{e}{m}\vec{p} \cdot \vec{A}$ — Convection current

$\frac{e}{2m}\mu \cdot \vec{\sigma} \times \vec{B}$ — Spin current

$\rho \cdot \Phi$

$\frac{e}{m}\vec{p} \cdot \hat{q}$

$\frac{e}{m}p_\perp$

$\frac{e \cdot \mu}{2m}\vec{\sigma} \times \vec{q}$

longitudinal

transverse

Total cross sections:

$$\sigma = \varepsilon \cdot \sigma_L + \sigma_T + h \cdot P_x \sqrt{2\varepsilon(1-\varepsilon)}\,\sigma'_{LT} + h \cdot P_z \sqrt{1-\varepsilon^2}\,\sigma'_{TT}$$

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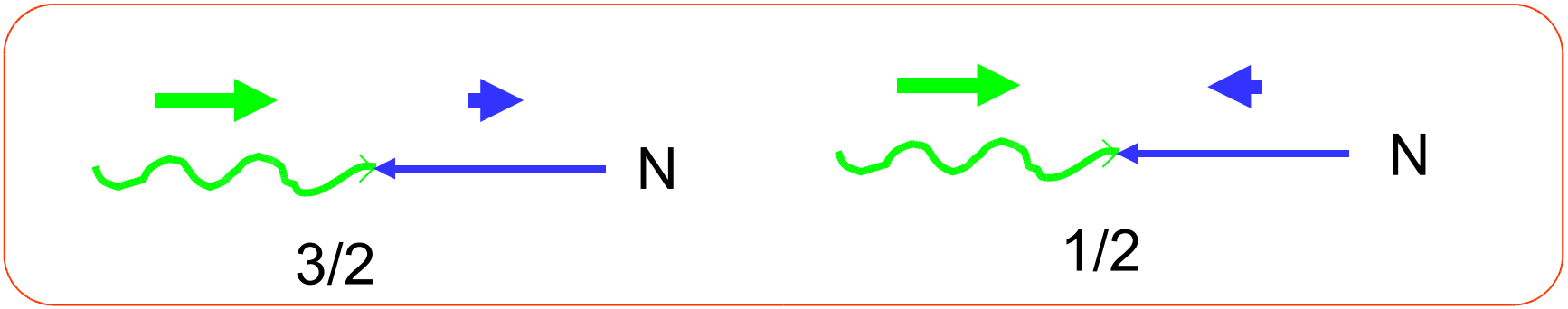
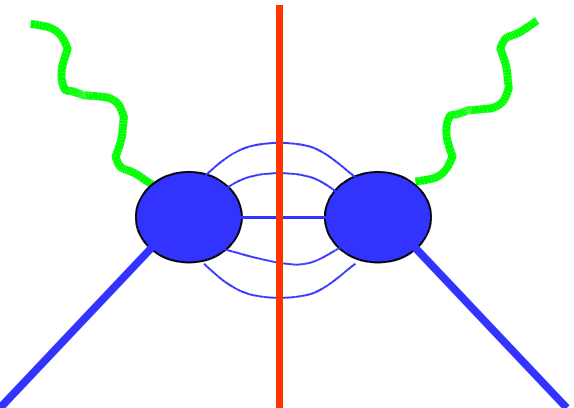


Forward Compton:

$$T(\nu, \theta = 0) = \vec{\varepsilon'^*} \cdot \vec{\varepsilon} \cdot f(\nu) + i\vec{\sigma} \cdot (\vec{\varepsilon'^*} \times \vec{\varepsilon}) \cdot g(\nu)$$



$$\mathrm{Im} f(\nu) = \frac{\nu}{8\pi}(\sigma_{1/2}(\nu) + \sigma_{3/2}(\nu)) = \frac{\nu}{4\pi}\sigma_T(\nu)$$

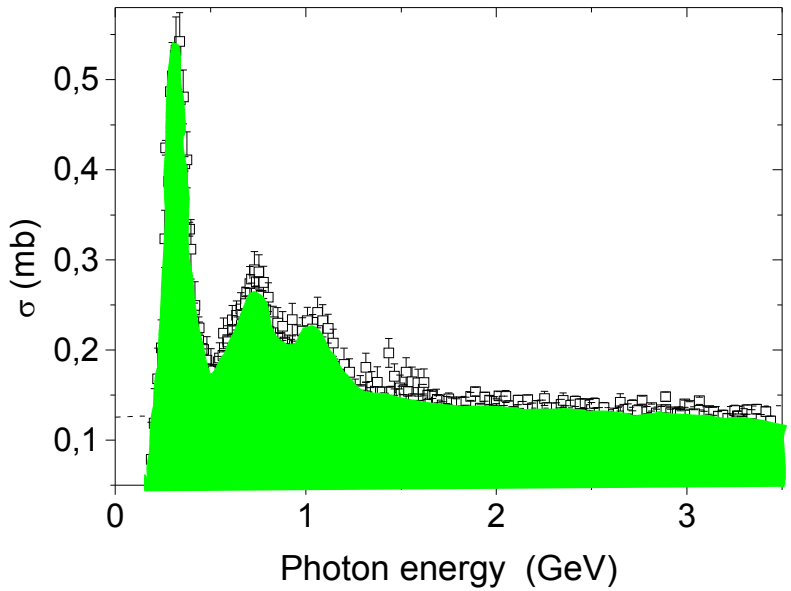
$$\mathrm{Im} g(\nu) = \frac{\nu}{8\pi}(\sigma_{1/2}(\nu) - \sigma_{3/2}(\nu)) = -\frac{\nu}{4\pi}\sigma'_{TT}(\nu)$$

Born terms determine low energy expansion:

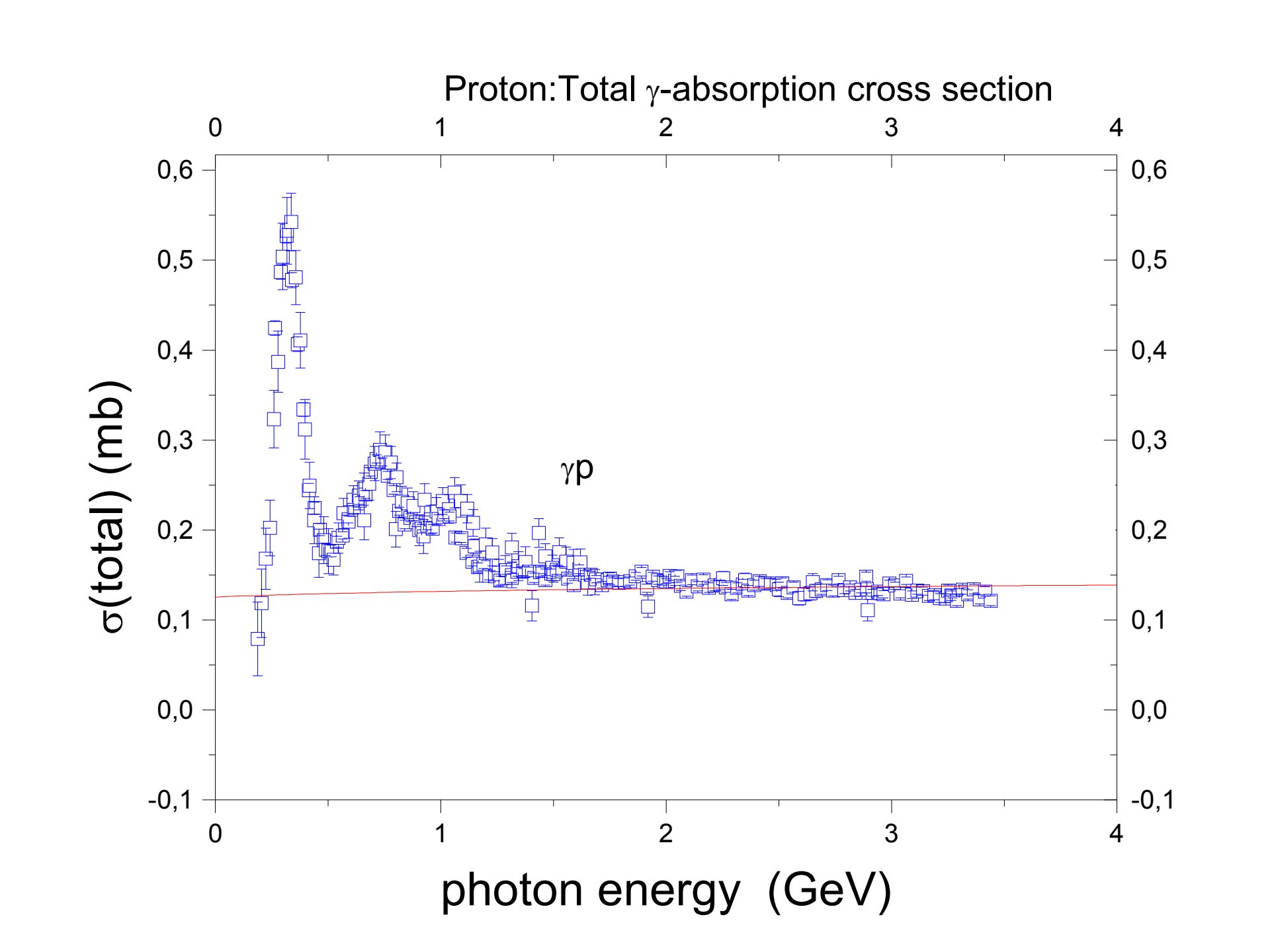
$$f(\nu) = -\underbrace{\frac{e^2 \cdot e_N^2}{4\pi \cdot m}}_{\text{Thomson}} + \underbrace{(\alpha+\beta)}_{\text{El.+magn. polarizability}}\nu^2 + O(\nu^4) \qquad g(\nu) = -\frac{e^2 \cdot \kappa_N^2}{8\pi \cdot m^2}\nu + \underbrace{\gamma_0}_{\text{Forward spin polarizability}} \cdot \nu^3 + O(\nu^5)$$

$$\alpha+\beta = \frac{1}{2\pi^2}\int_{\nu_0}^{\infty} \frac{\sigma_T(\nu')}{\nu'^2} d\nu' \qquad \frac{\pi \cdot e^2 \cdot \kappa_N^2}{2m^2} = \int_{\nu_0}^{\infty} \frac{\sigma_{3/2}(\nu') - \sigma_{1/2}(\nu')}{\nu'} d\nu'$$

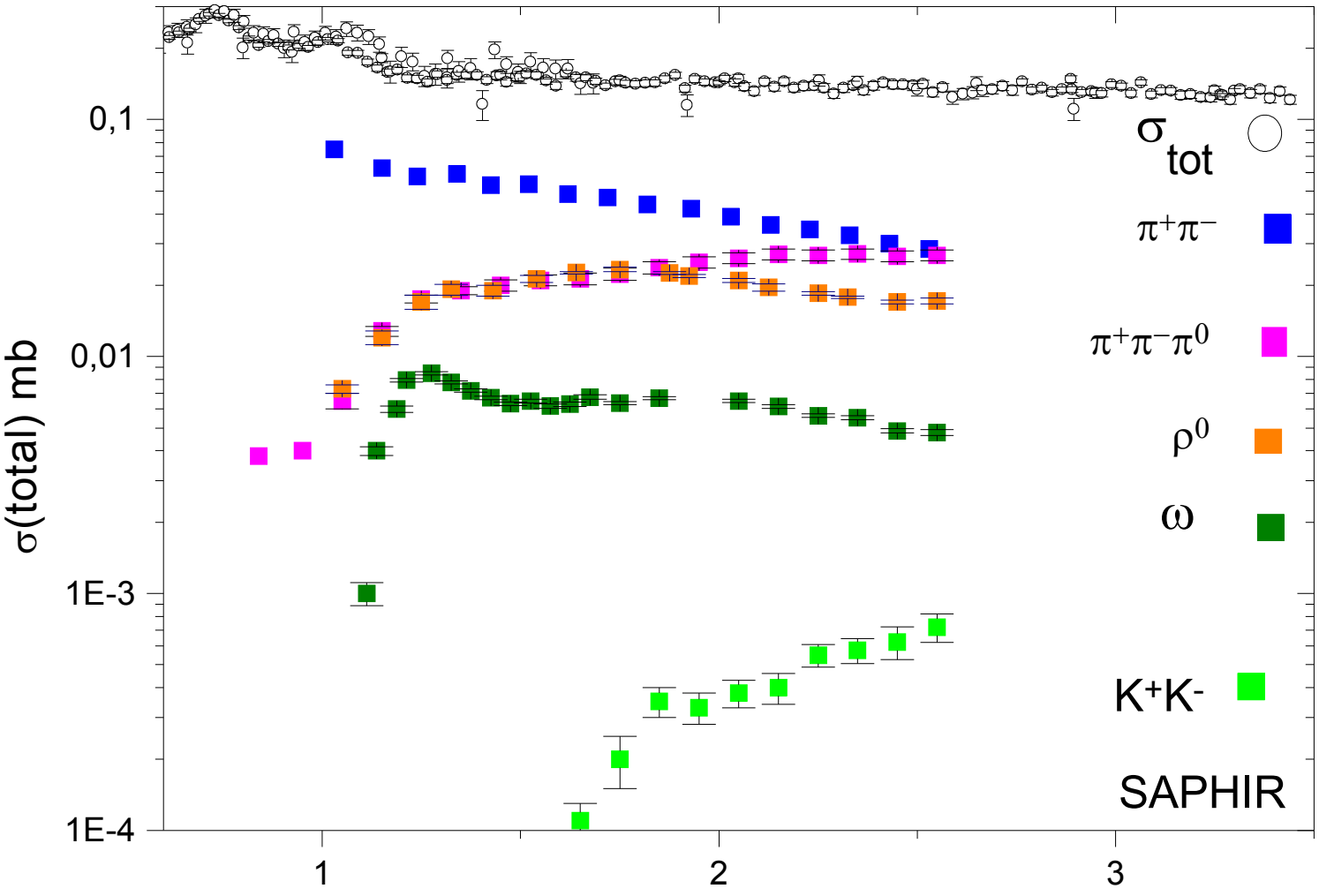
$$\gamma_0 = -\frac{1}{4\pi^2}\int_{\nu_0}^{\infty} \frac{\sigma_{3/2}(\nu') - \sigma_{1/2}(\nu')}{\nu'^3} d\nu'$$



Sum rules: Absorption strength at high energies → static properties

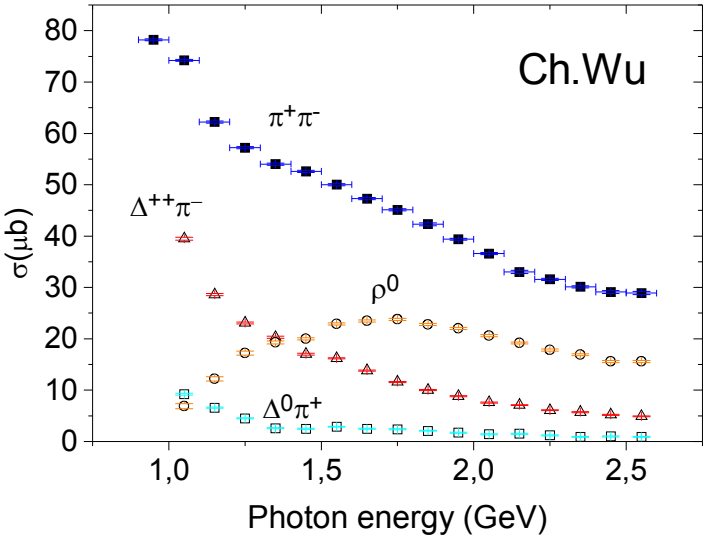

Proton:Total γ-absorption cross section
σ(total) (mb)
photon energy (GeV)
γp
0
1
2
3
4
0,6
0,5
0,4
0,3
0,2
0,1
0,0
-0,1

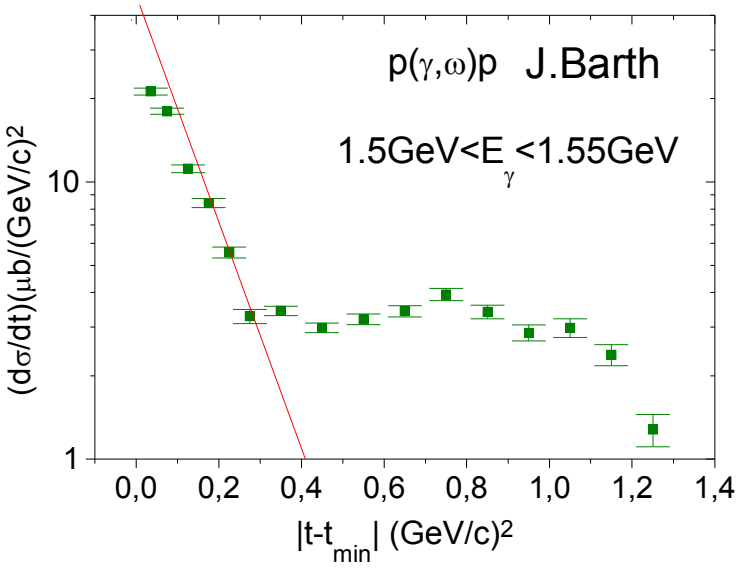
ELSA -data: Total cross sections

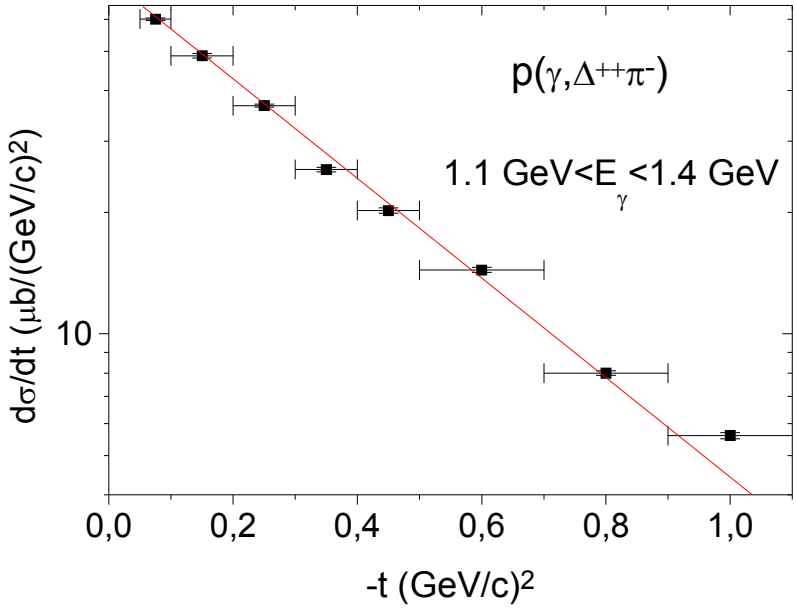


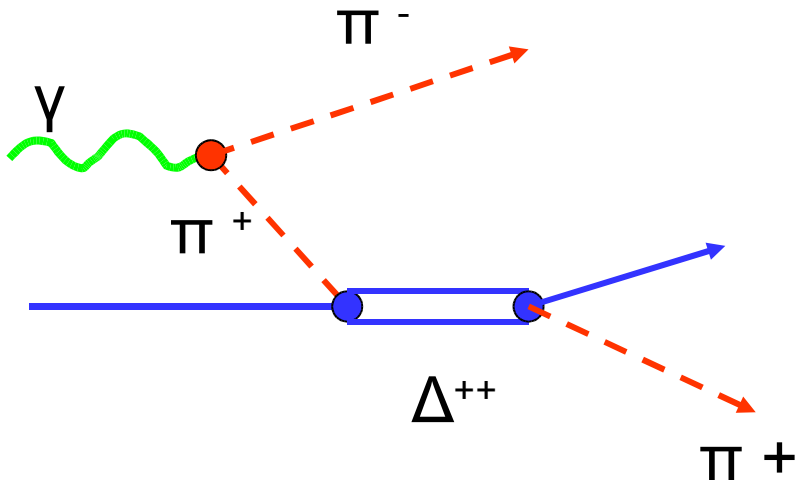
photon energy (GeV)

Vector mesons

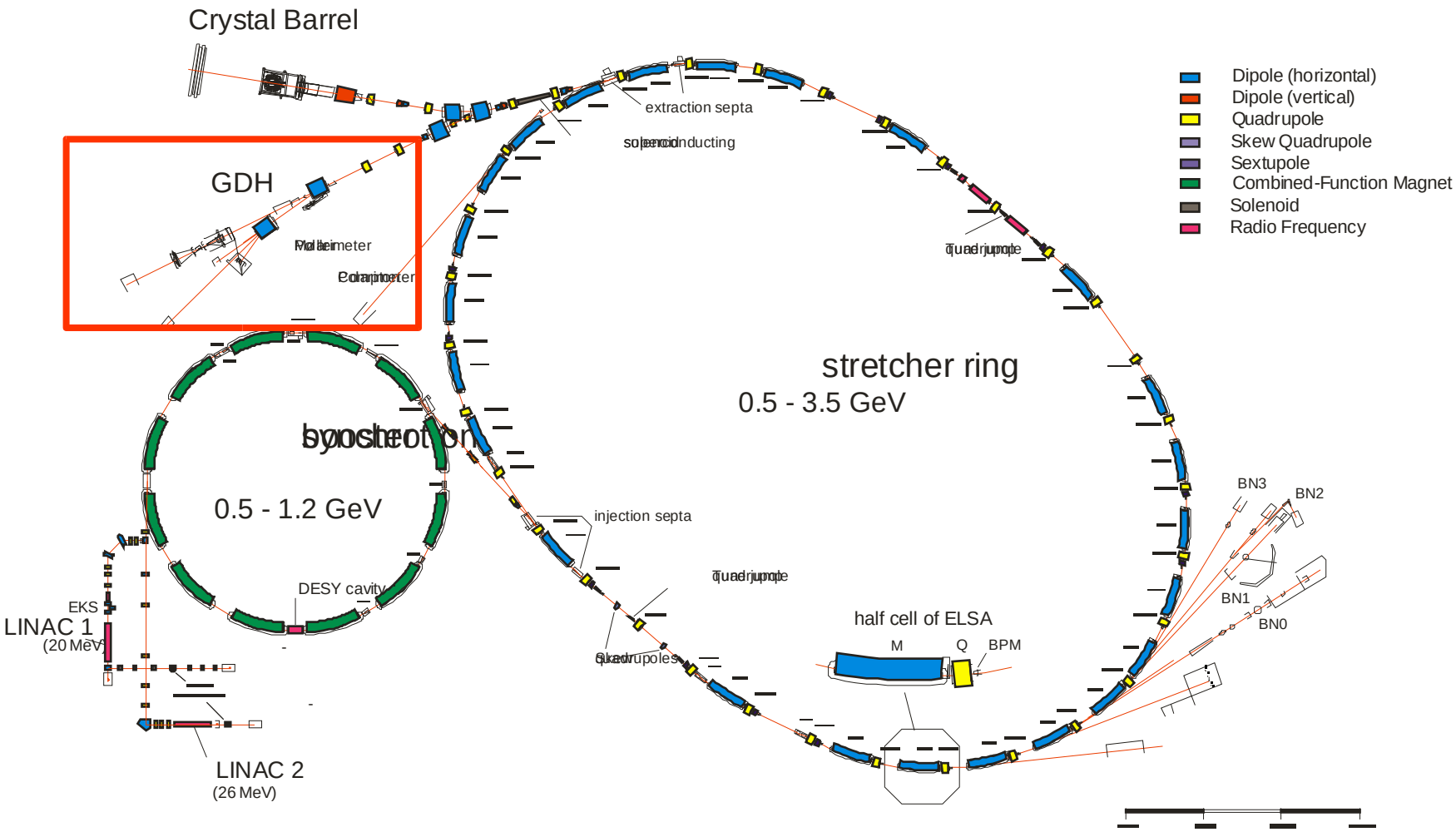

Ch.Wu
σ(μb)
Photon energy (GeV)
π+π-
Δ++π-
ρ0
Δ0π+


p(γ,ω)p J.Barth
1.5GeV<Eγ<1.55GeV
(dσ/dt)(μb/(GeV/c)2
|t-tmin| (GeV/c)2


p(γ,Δ++π-)
1.1 GeV<Eγ<1.4 GeV
dσ/dt (μb/(GeV/c)2)
-t (GeV/c)2


π -
γ
π +
Δ++
π +

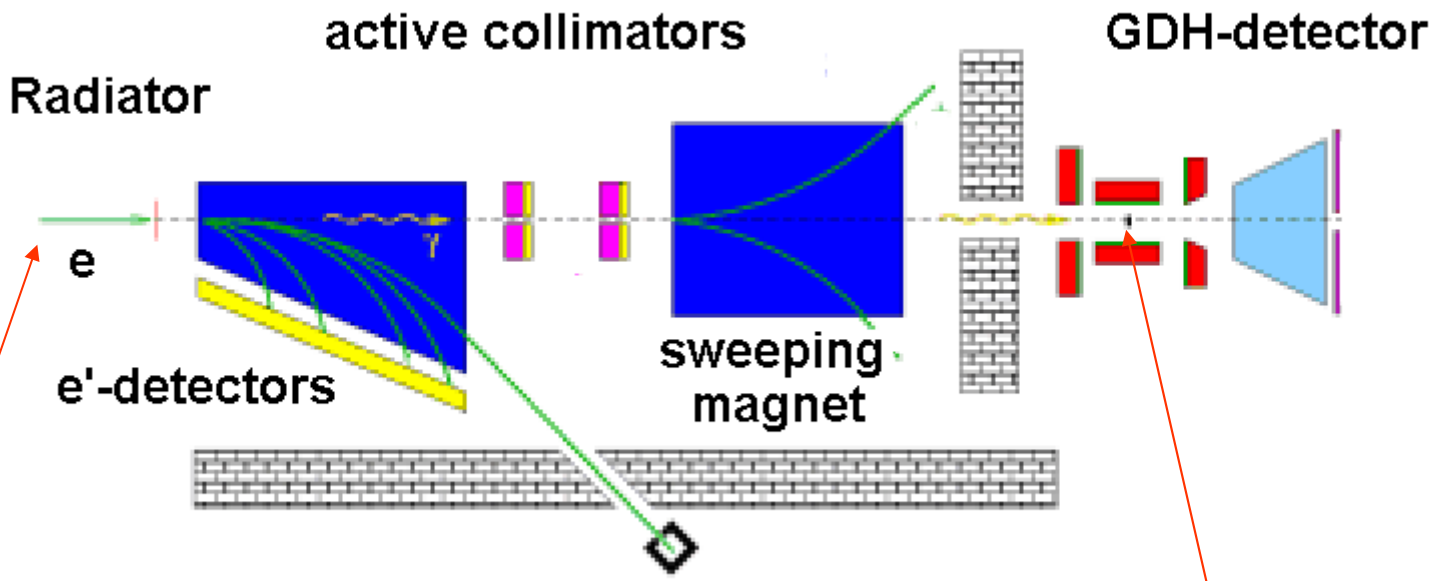
Electron Stretcher Accelera



GDH - Collaboration

Bochum, Bonn, Erlangen, Ghent, Saclay, Glasgow, Göttingen, Lund, Mainz, Miyazaki, Moscow, Nagoya, Pavia, Tübingen, Yamagata

K. Helbing et al.

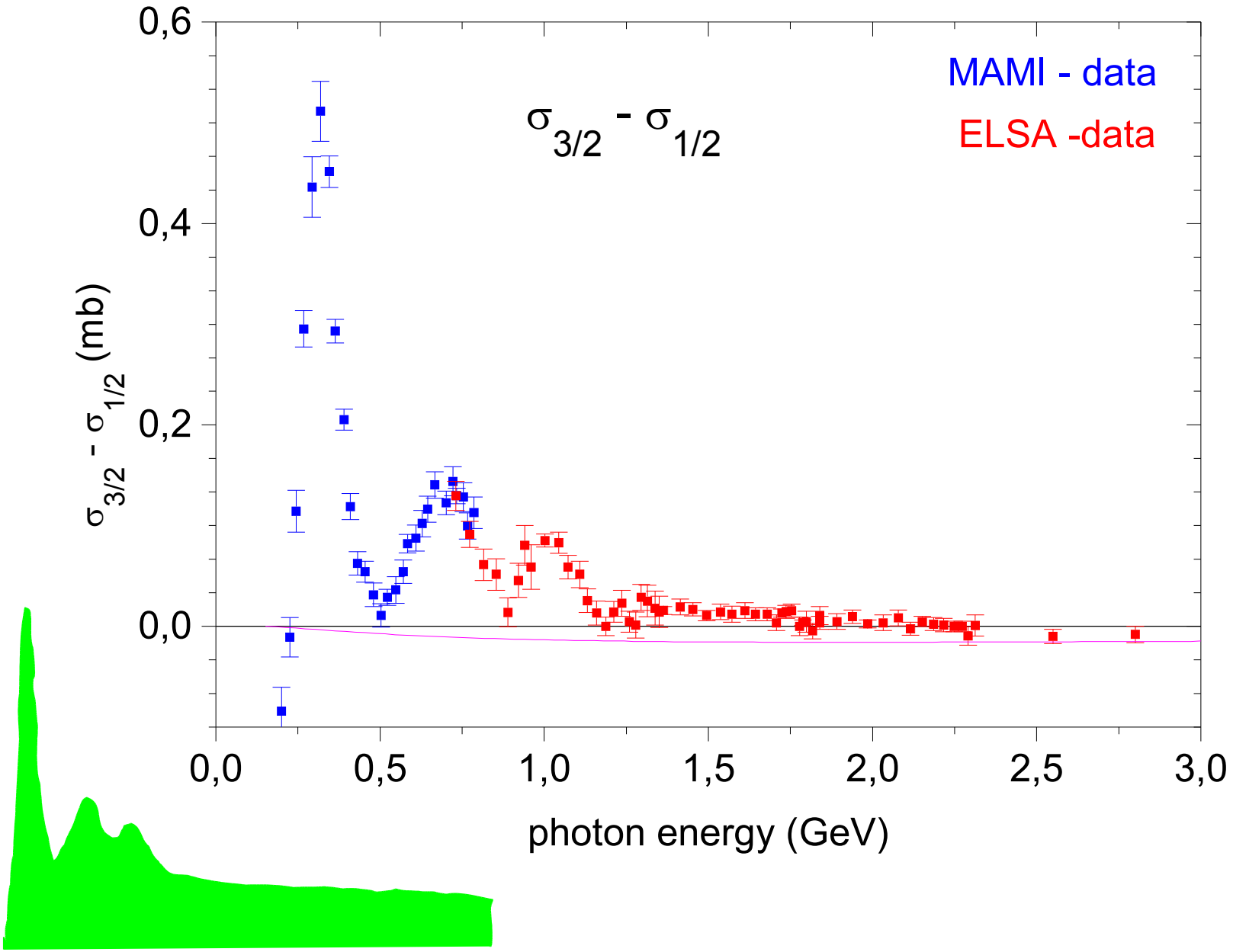


Polarized beam

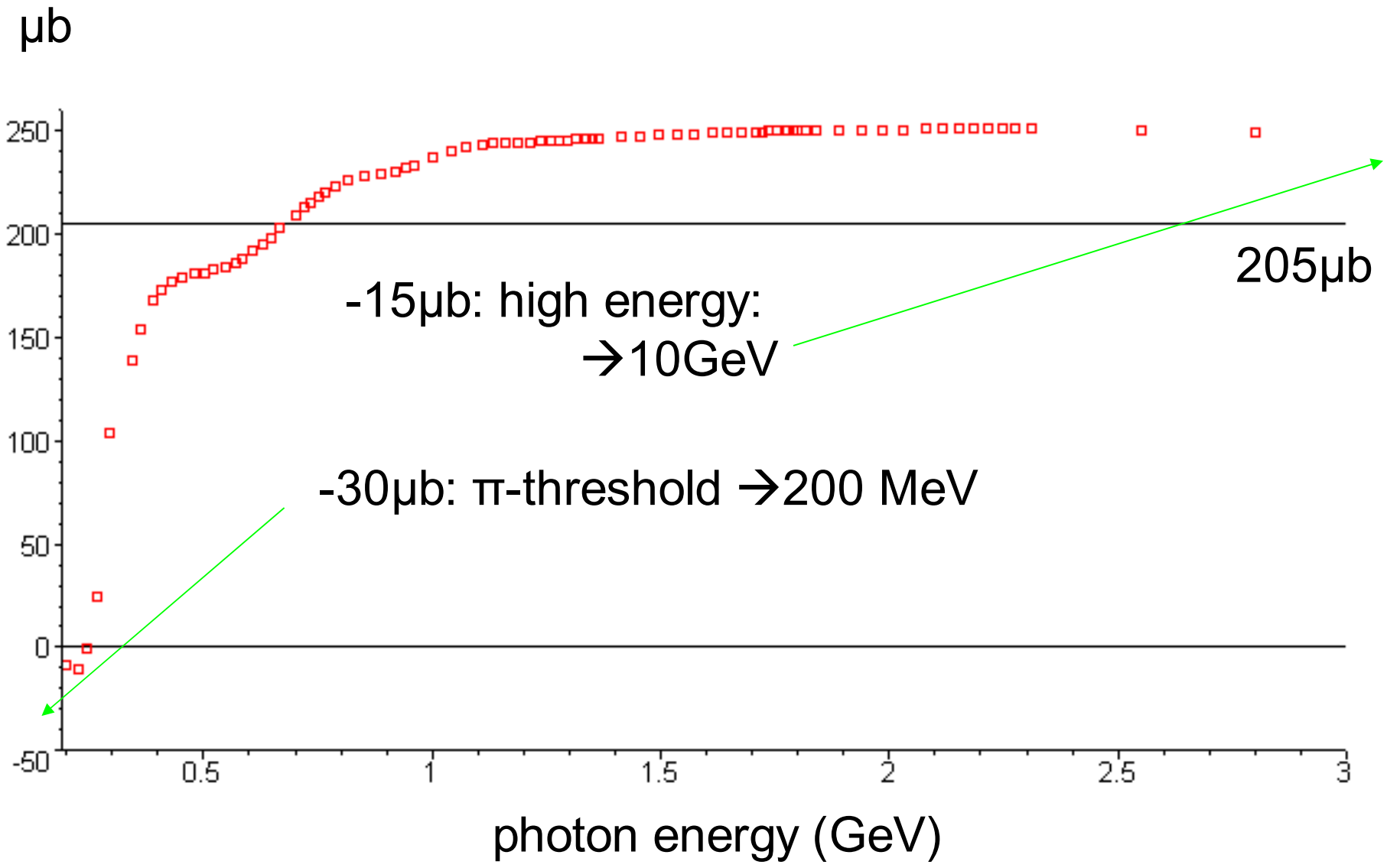
W. Hillert

Polarized target

H. Dutz


MAMI - data
ELSA -data
$\sigma_{3/2} - \sigma_{1/2}$
$\sigma_{3/2} - \sigma_{1/2}$ (mb)
0,6
0,4
0,2
0,0
0,0
0,5
1,0
1,5
2,0
2,5
3,0
photon energy (GeV)

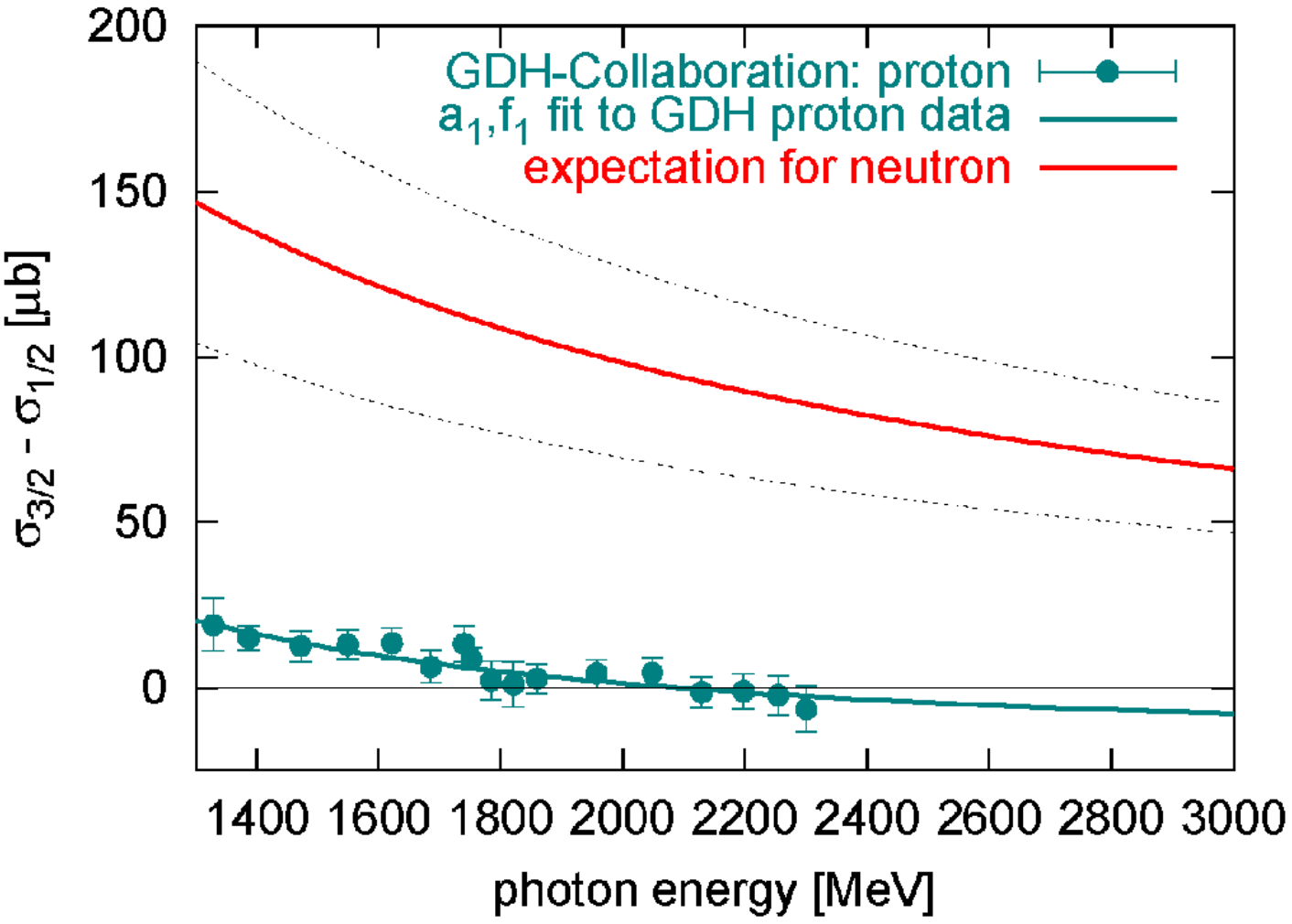
GDH-Integral as measured at ELSA/MAMI



Exp./Calculation	E_γ [MeV]	I_{GDH} [μb]
ELSA	800 - 2800	28.0 ± 2.1
MAMI	200 - 800	226 ± 13
Drechsel et al.	140 -200	-30 ±3
Bianchi et al.	> 2800	-15
Σ		209
From κ		205

Zeitler
Speckner

Expectation for the neutron!



Helbing

$$\gamma_0 = -\frac{1}{4\pi^2}\int_{\nu_0}^{\infty}\frac{\sigma_{3/2}(\nu')-\sigma_{1/2}(\nu')}{\nu'^3}d\nu'$$

Zeitler
Speckner