Virtual Compton Scattering at Jefferson Lab : preliminary results at $Q^2 = 1.$ and 1.9 GeV^2

S. Jaminion

Virtual Compton Scattering at JLab : Preliminary results Q^2 = 1. and 1.9 GeV^2

E93050 collaboration
for the hall A Collaboration of Jefferson Lab.

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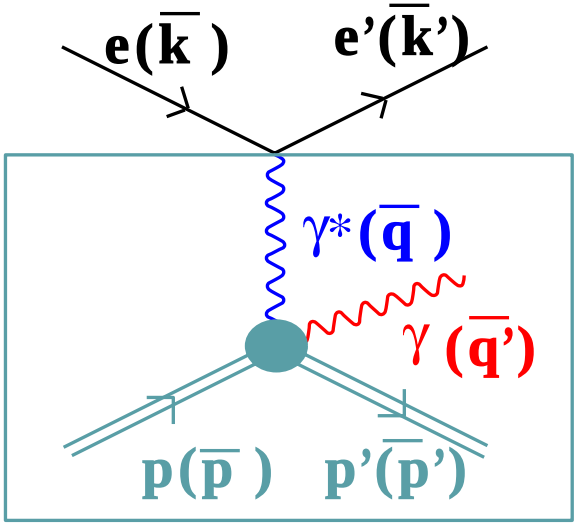
SANTORINI 2001
Electromagnetic Interactions with Nucleons and Nuclei
2-7 october 2001

Virtual Compton Scattering below π^0 threshold



hadronic system $\gamma^* p \rightarrow \gamma p$

$\bar{q} = \left(\bar{k} - \bar{k}'\right)$ and $Q^2 = -\bar{q}^2$

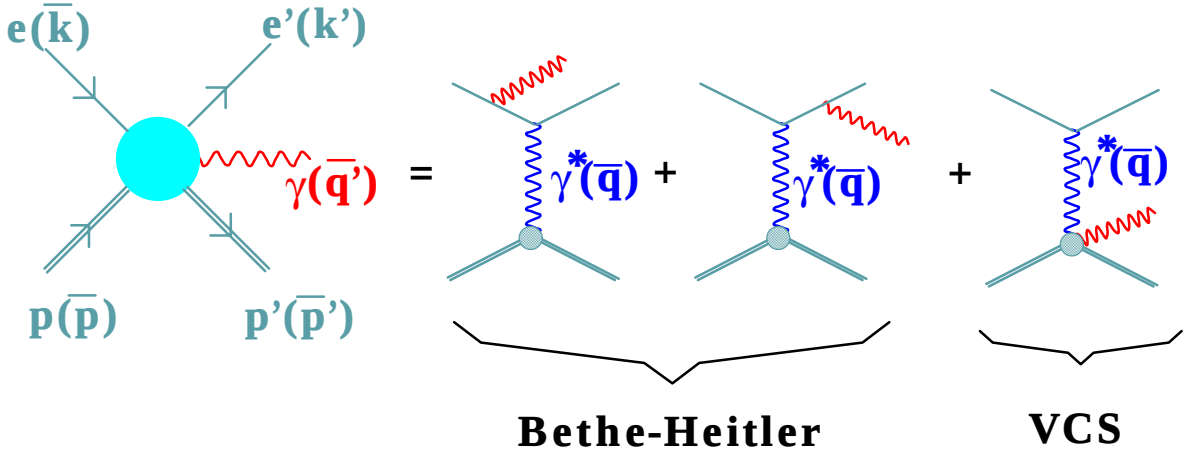
- Real Compton Scattering $(\gamma p \rightarrow \gamma p)$ $\alpha, \beta \left(Q^2 = 0\right)$
- Virtual Compton Scattering : $\alpha, \beta \left(Q^2 \neq 0\right)$ + new observables

Generalized Polarizabilities of the nucleon

goal : to constrain models of nucleon structure at low energy

Generalized Polarizabilities

- Photon electroproduction is the coherent sum of 2 processes



- VCS : γ is emitted by
  - ▲ nucleon : **Born** term entirely calculable

    (proton electromagnetic form factors : G_E^P and G_M^P)
  - ▲ excited state : **Non Born** term : UNKNOWN

➡ photon electroproduction amplitude :

$$T^{ep\gamma} = \underbrace{T^{BH} + T^{B}}_{\text{calculable}} + \underbrace{T^{NB}}_{\text{unknown (GPs)}}$$

P Guichon : develop amplitude in polynomial of q'_{cm}

(q'_{cm}= outgoing photon momentum in $(\gamma^* p)$ center mass)

(P. Guichon and M. Vanderhaegen, Prog.Part. Nucl. Phys. **41** (1998) 125)

Low Energy Theorem (F.E. Low, Phys. Rev. **96** (1954) 1428)

$$d^5\sigma^{ep\gamma} = d^5\sigma^{BH+B} + \underbrace{\Phi q'_{cm}}_{\text{phase space factor}} \left[M_0 - M_0^{\text{BH+B}}\right] + O\left(q'^{\,2}_{cm}\right)$$

- $\left(M_0 - M_0^{\text{BH+B}}\right)$ is the lowest order term containing an effect of Generalized Polarizabilities (know combination)
- 6 GPs are needed to describe $T^{ep\gamma}$

  (D.Drechsel *et al,* Phys. Rev. **C55** (1997) 424)
- 5 GPs in unpolarized case, and we extract two structure functions $P_{LL} - \frac{1}{\varepsilon} P_{TT}$ and P_{LT} at given Q^2

Photon electroproduction cross section

BH+B cross section

G_M^p : Bosted parametrisation

(P.E. Bosted, Phys. Rev. **C51** (1995) 409)

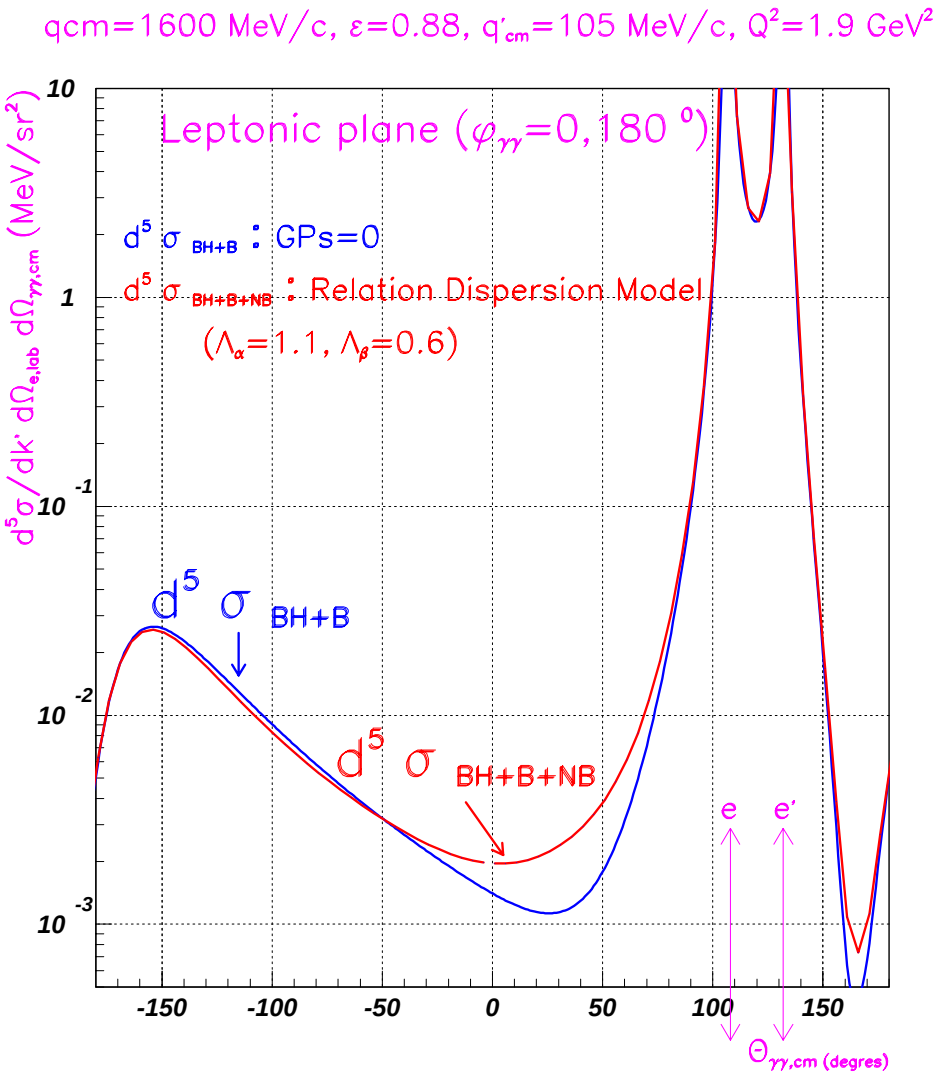
G_E^p : ratio measured at Jefferson Lab :

$$\frac{\mu_P G_E^P(Q^2)}{G_M^P(Q^2)}$$

(M.K. Jones, *et al,* Phys. Rev. Lett. **84** (2000) 1398)

Dispersion Relation formalism

D. Drechsel,
M. Gorchtein,
A. Metz,
B. Pasquini,
M. Vanderhaegen



$$\theta_{\gamma\gamma\, cm} \in [-260°, +100°]$$

VCS experiments

- 1st experiment at **Mami** (1995-1997)

  Generalized Polarizabilities at $Q^2 = 0.33$ GeV^2

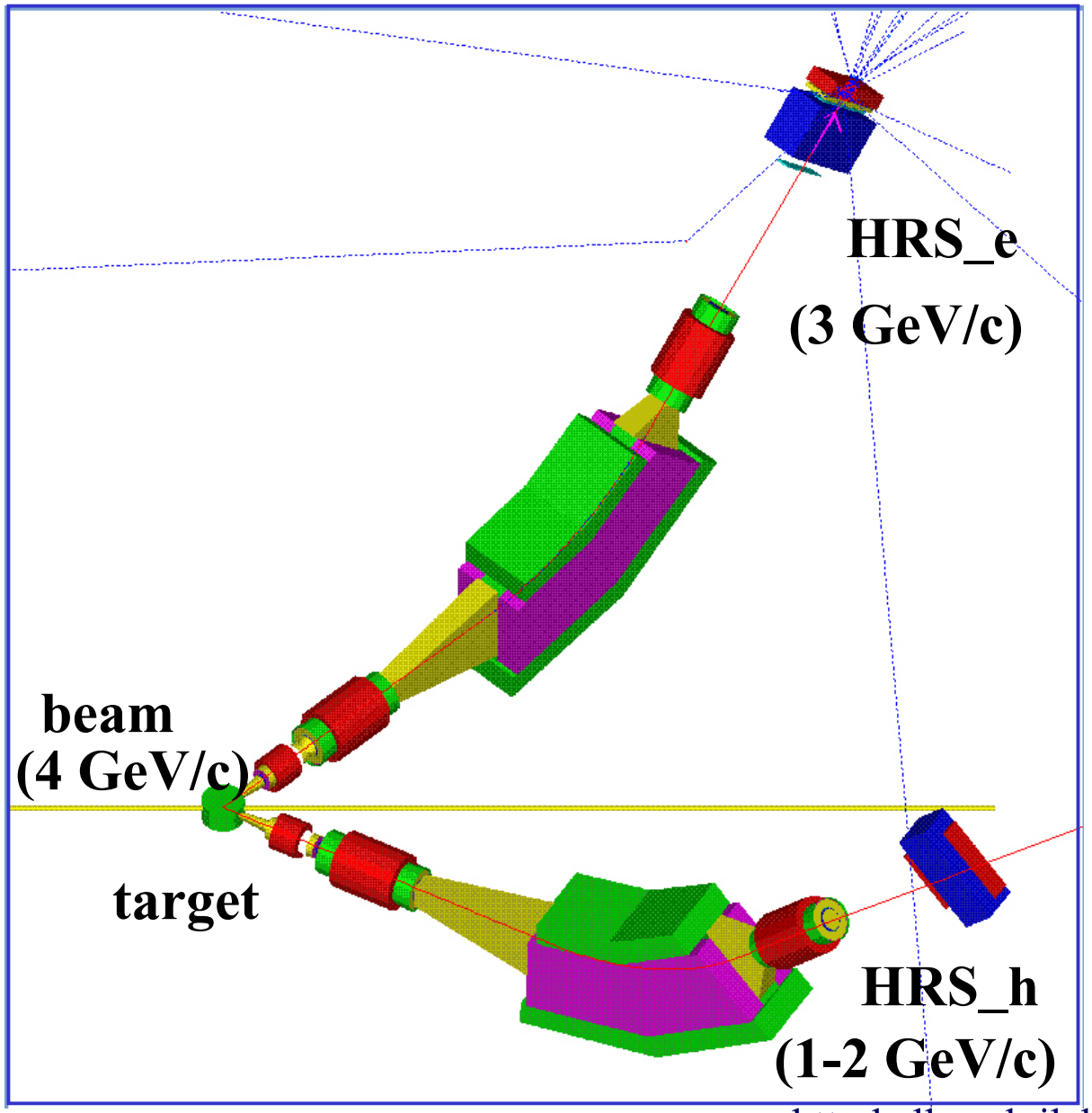
  (J. Roche, *et al,* Phys. Rev. Lett. **85** (2000) 708)

- 2nd experiment at **Jefferson Lab** (march-april 1998)
  - Generalized Polarizabilities at $Q^2 = 1$ and 1.9 GeV^2
  - VCS in resonance region

- 3rd experiment at **Bates** at $Q^2 = 0.05$ GeV^2 (2000)

- 4th experiment at **Bates** in resonance region (2001)

Jefferson Lab : Hall A



Spectrometer resolution at target (FWHM) :

dispersive angle (vertical)
θ_{tg} : 2 mrad

transverse angle (horizontal)
ϕ_{tg} : 0.6 mrad

transverse coordinate
y_{tg} : 1.5 mm

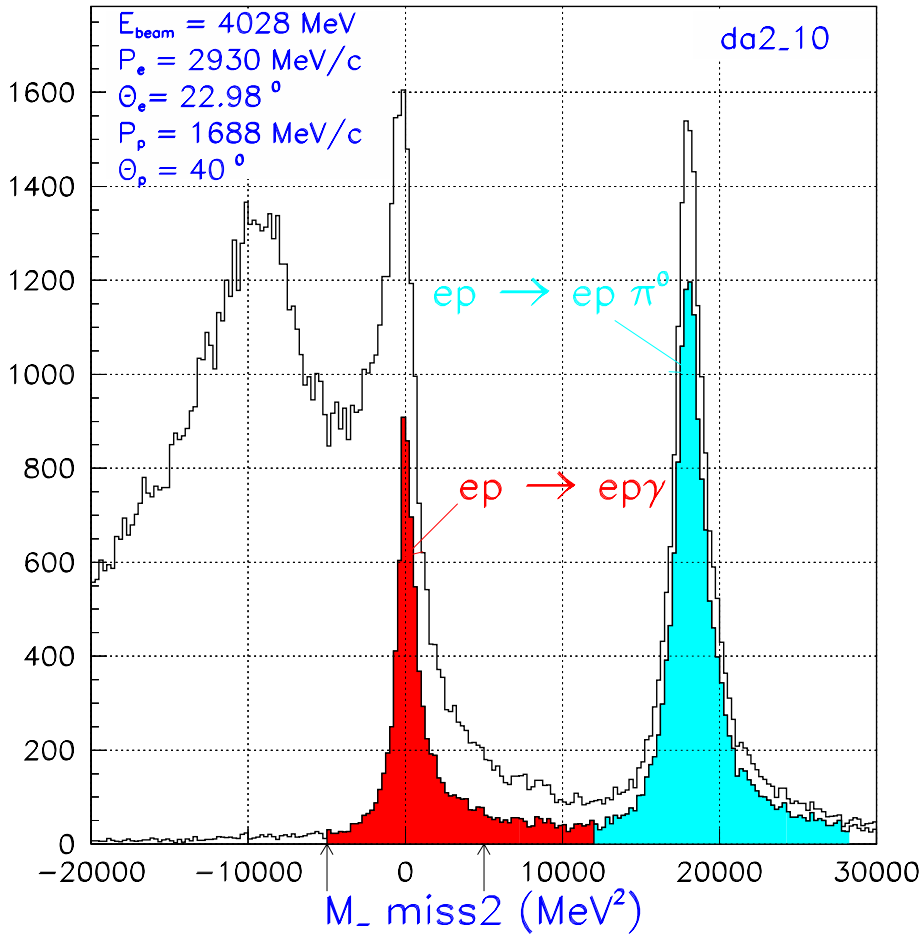
relative momentum
δ : 1.10^{-4}

http:hallaweb.jlab.org/equipement/high_resol.html

Missing mass for events in coincidence

electron and proton are detected in coincidence

→ γ is a missing particle



Kinematic conventions

VCS below π^0 threshold : momentum of outgoing photon

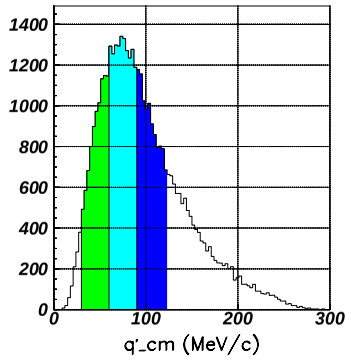
$q'_{cm} \leq 126$ MeV/c

- 3 bins in q'_{cm}

$q'_{cm} \in [30,60]$ MeV/c

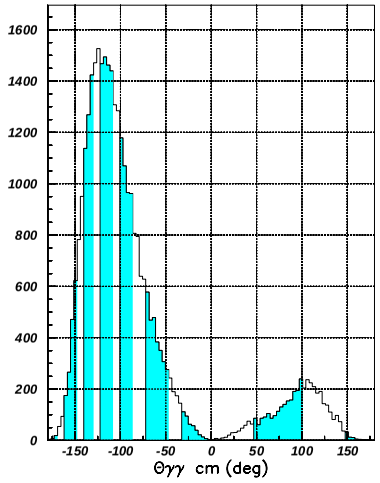
$q'_{cm} \in [60,90]$ MeV/c

$q'_{cm} \in [90,120]$ MeV/c



and we have data above π^0 threshold at Q^2=1 and 1.9 GeV^2

- 18 bins in in-plane angle $\theta_{\gamma\gamma cm}$

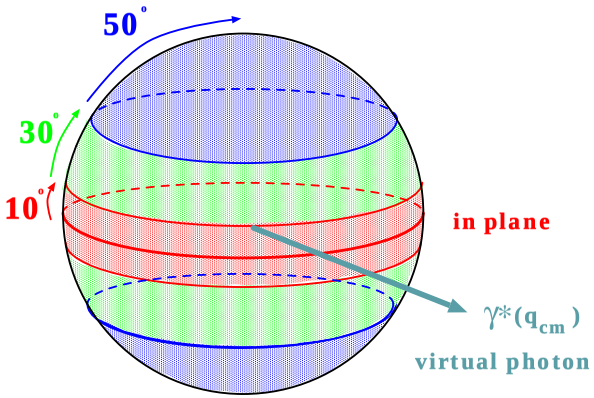


- 3bin in out-of-plane angle

[0°:50°]

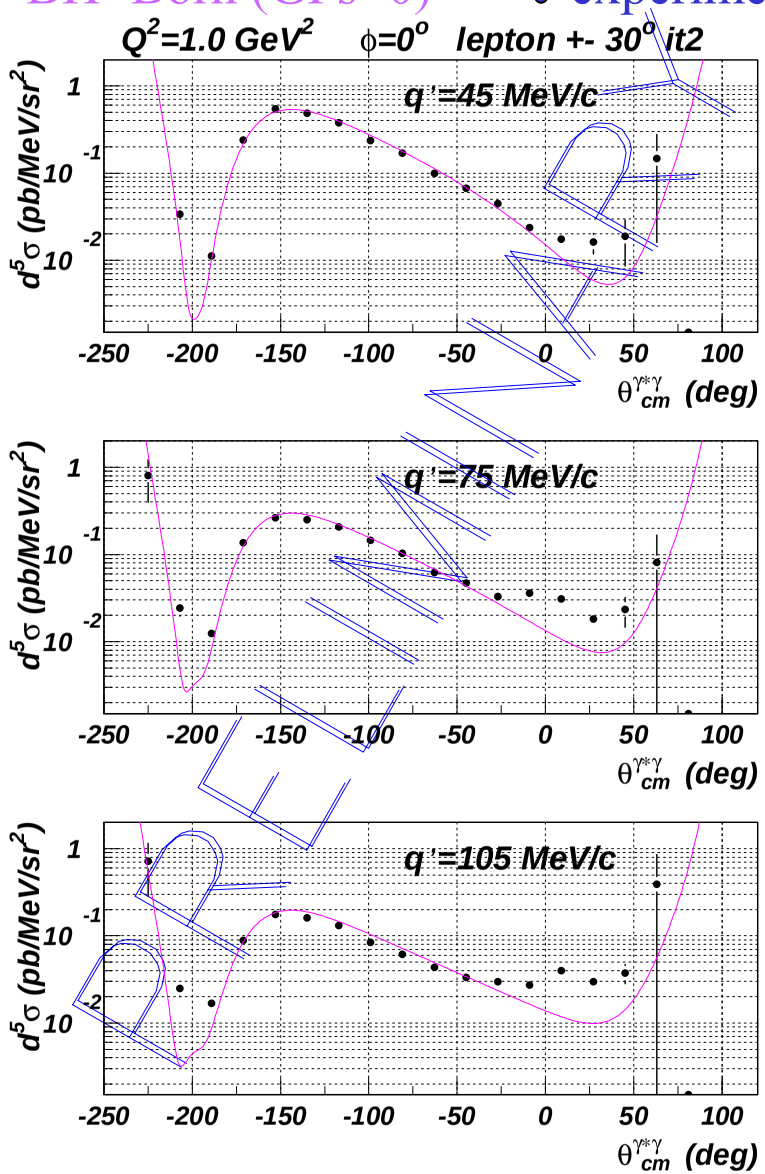
[50°:80°]

[80°:90°]

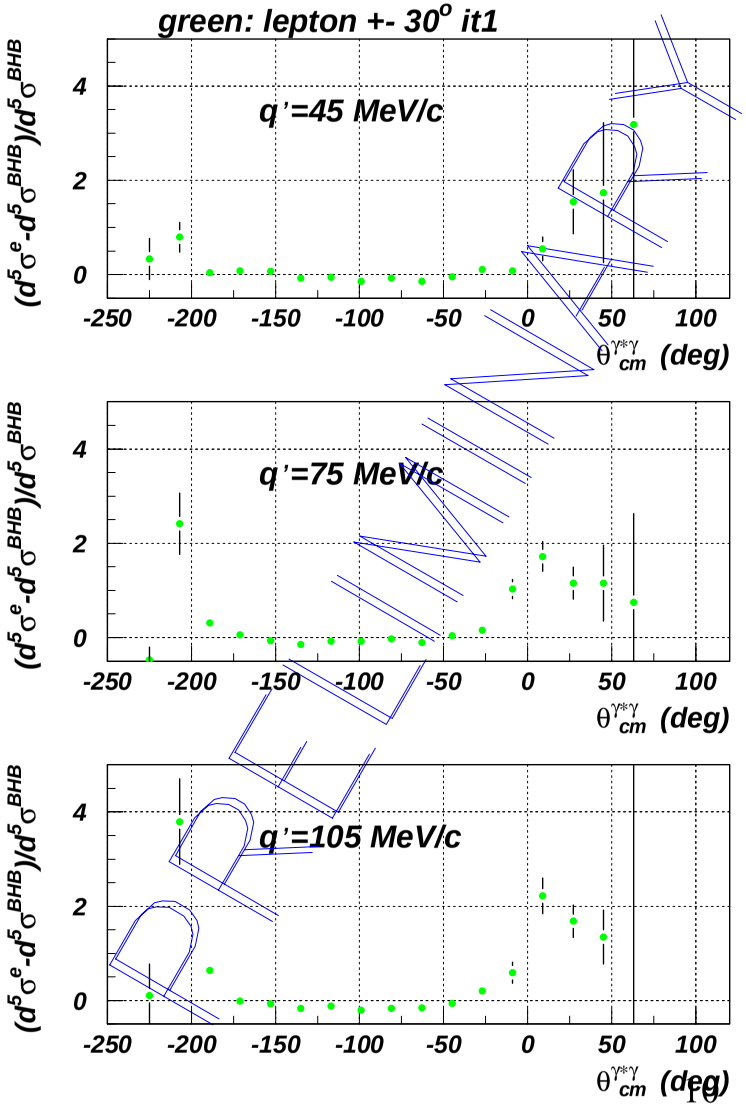


Cross section and ratio at $Q^2 = 1.\ \mathrm{GeV}^2$

— BH+Born (GPs=0) • experimental



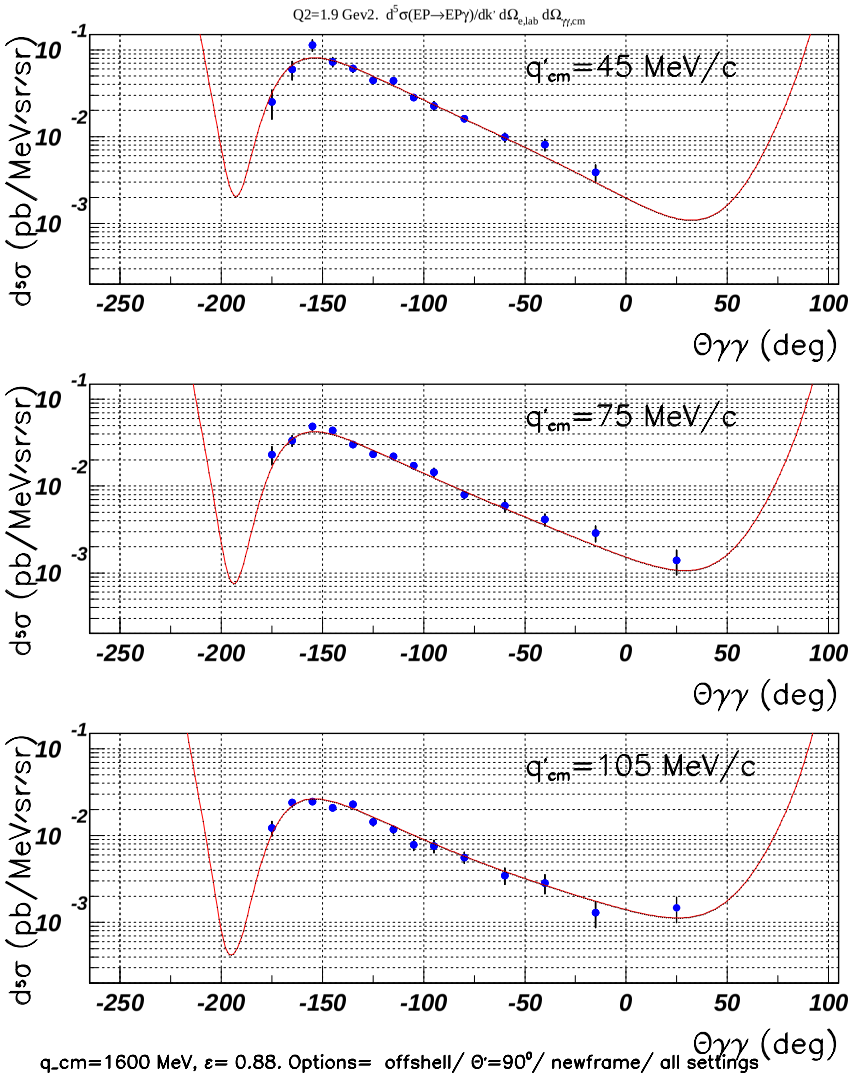
$$\frac{d^5\sigma^{ep\gamma} - d^5\sigma^{BH+B}}{d^5\sigma^{BH+B}}$$

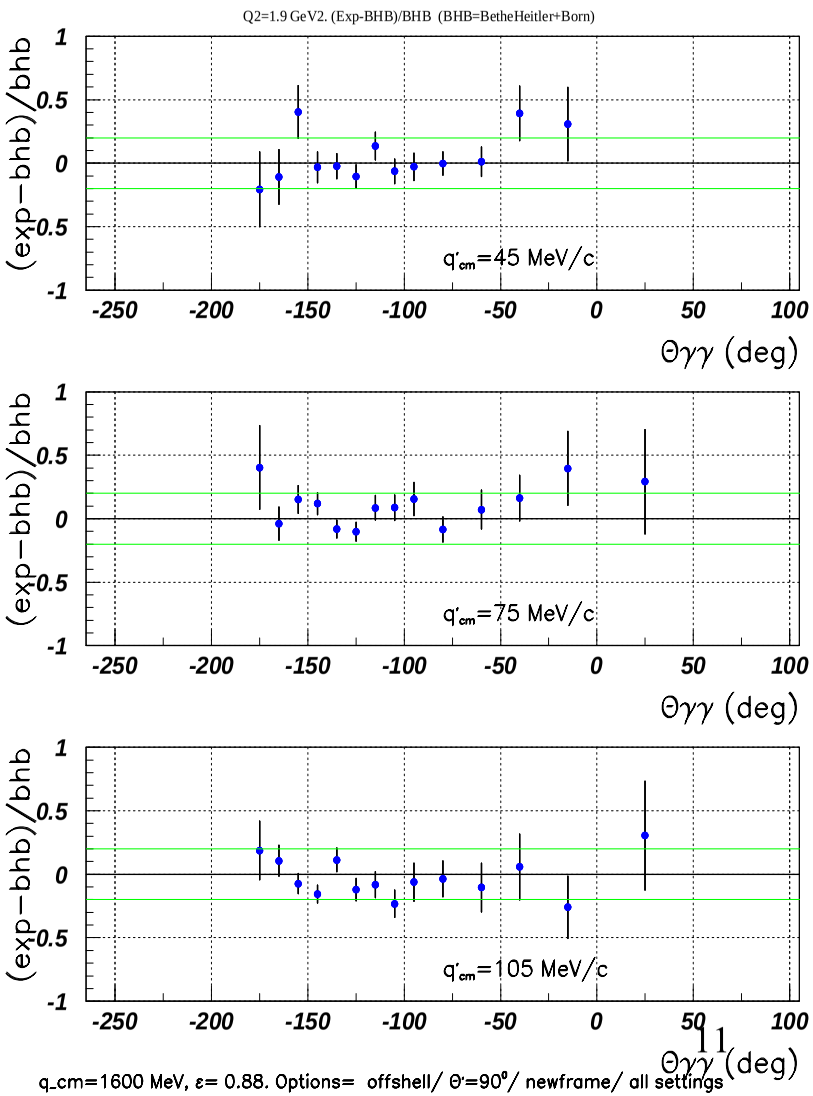


Cross section and ratio at $Q^2 = 1.9$ GeV^2

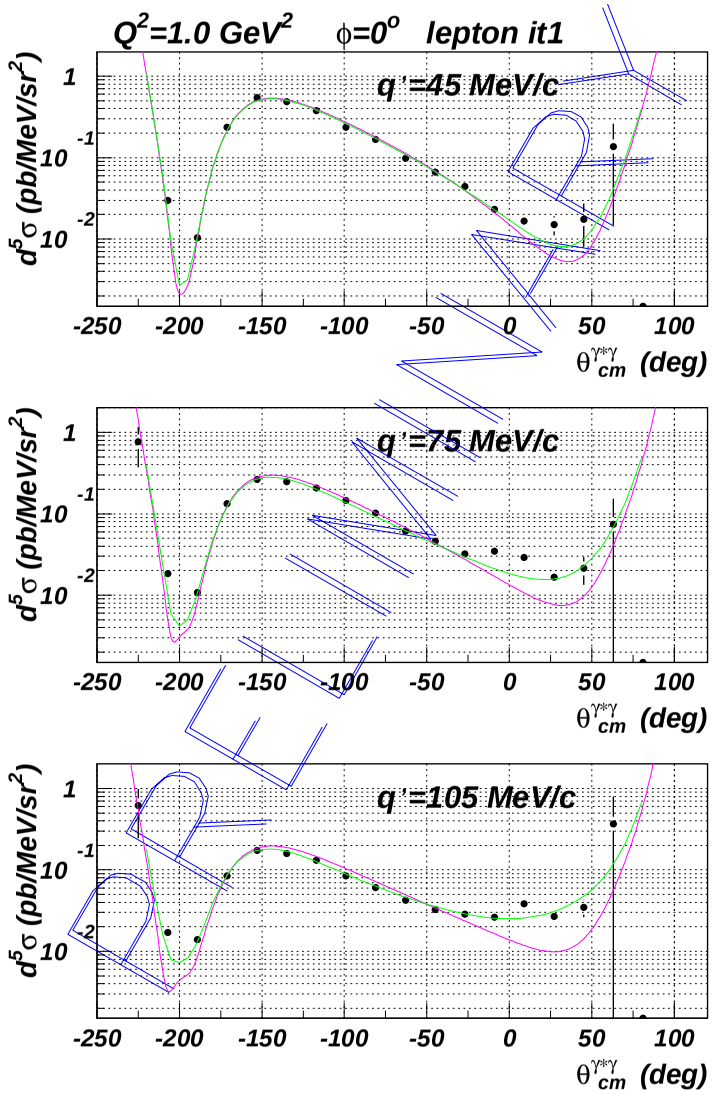
— BH+Born (GP s=0) • experimental

$$\frac{d^5\sigma^{ep\gamma} - d^5\sigma^{BH+B}}{d^5\sigma^{BH+B}}$$



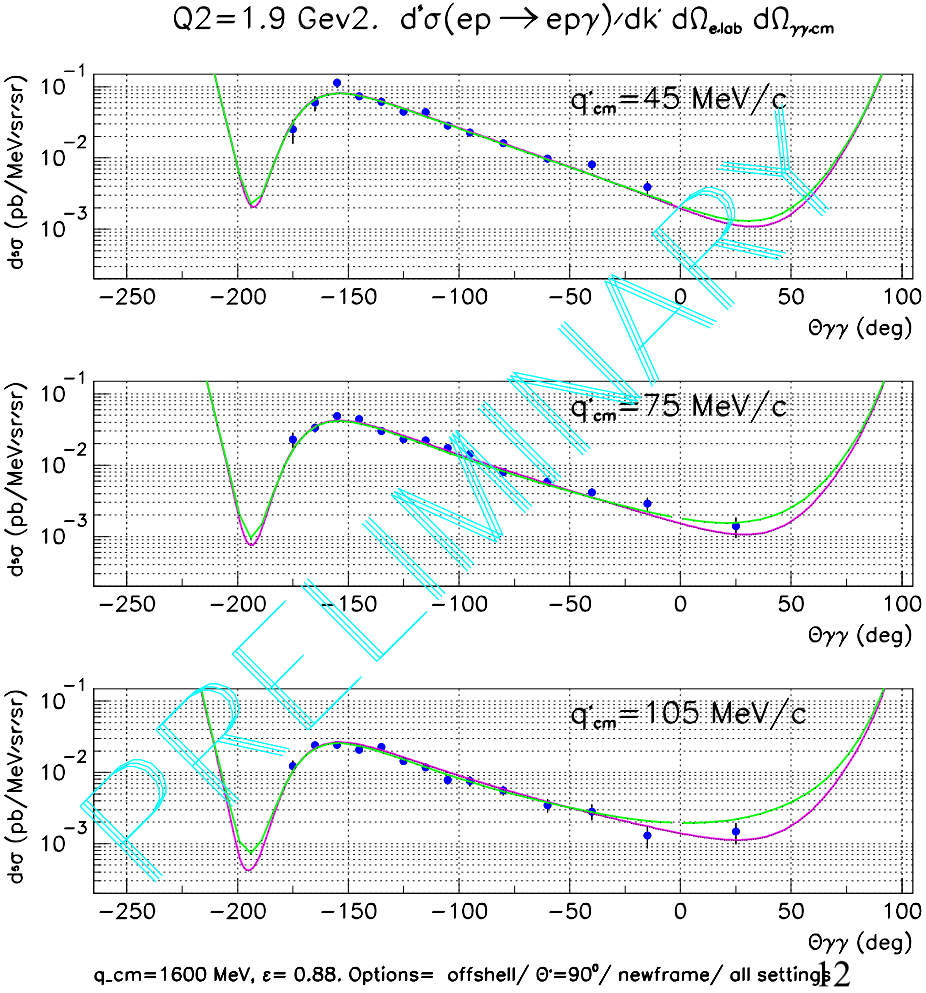


Cross section at $Q^2 = 1.$ GeV^2 and $Q^2 = 1.9$ GeV^2



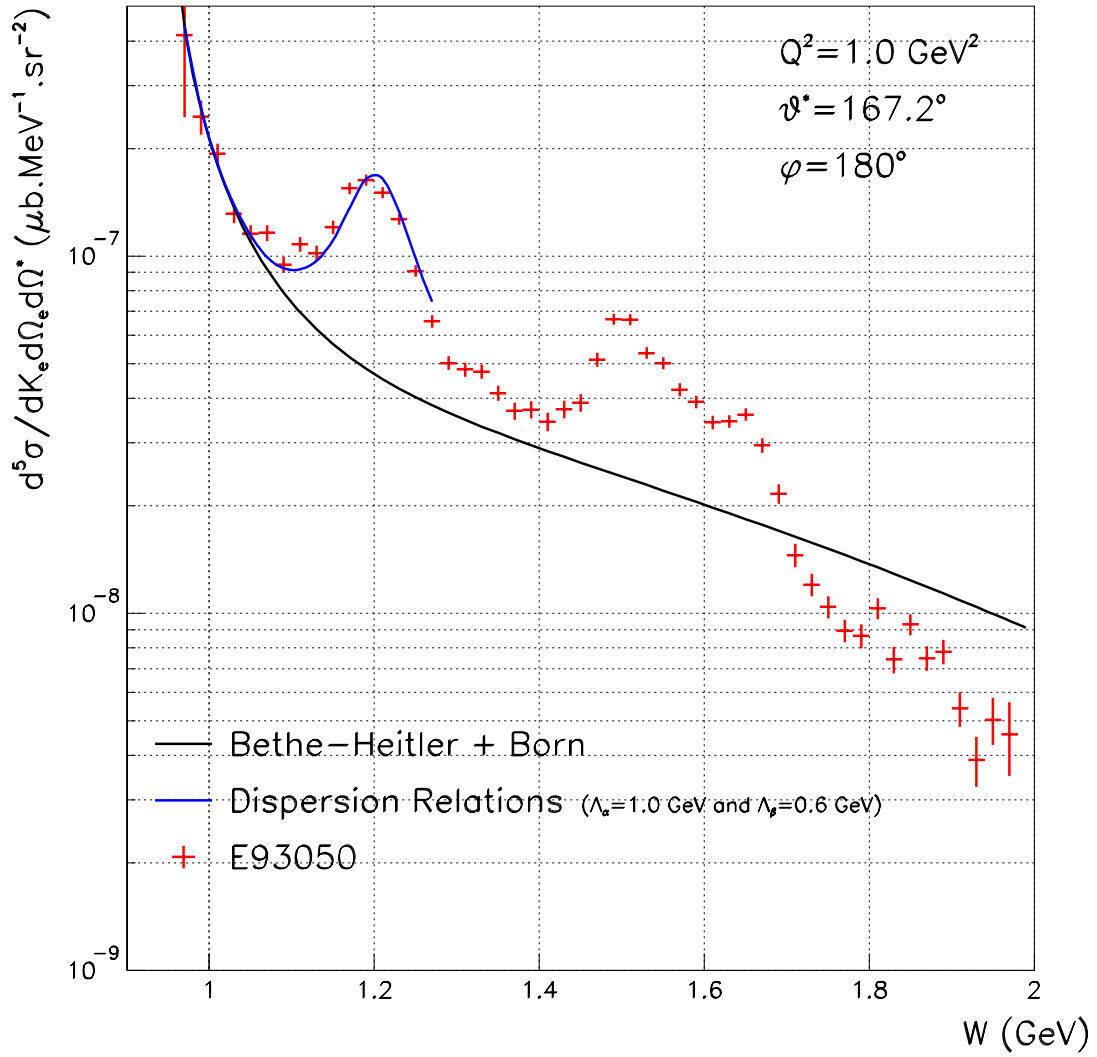
— BH+Born (GPs=0)

— Dispersion Relation Formalism



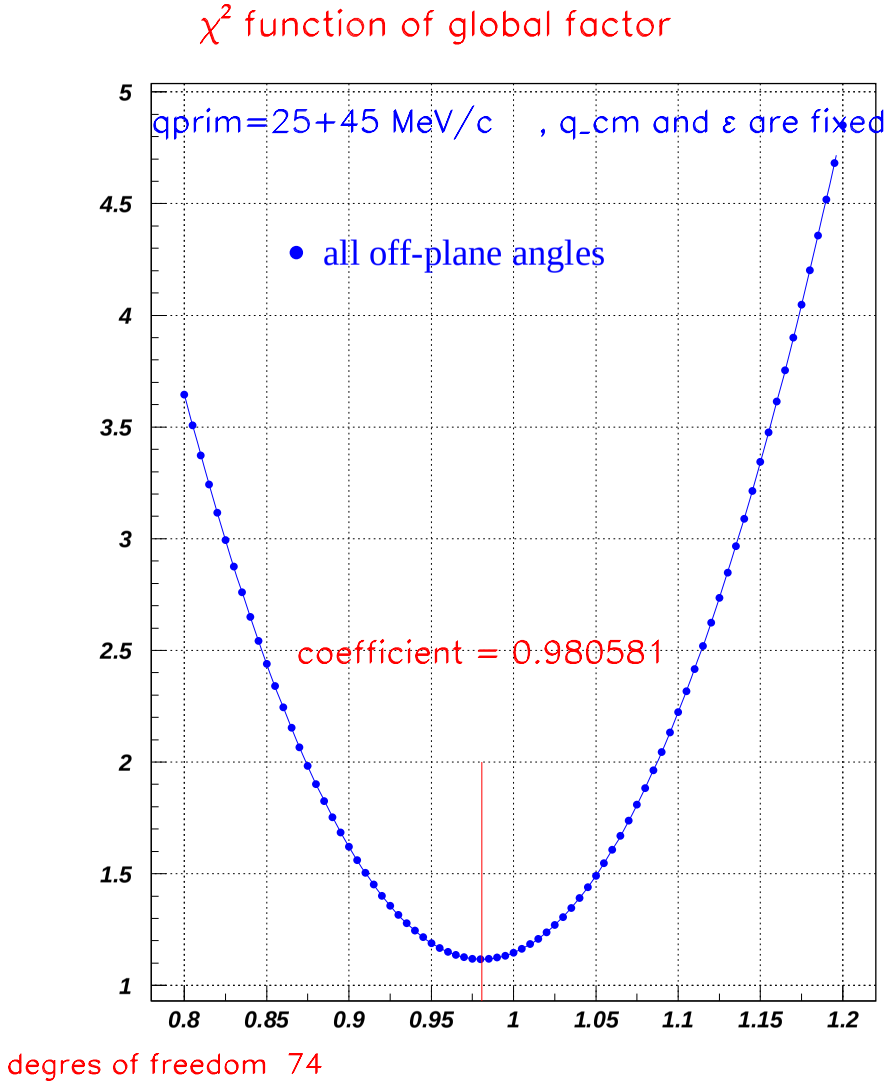
Virtual Comton Scattering in resonance region

for the Hall A collaboration



Global normalization factor at $Q^2 = 1.9$ GeV^2

$$\chi^2 = \frac{1}{N}\sum_{i=1}^{N} \frac{\left(d^5\sigma_{\exp} - d^5\sigma_{BH+B}\right)^2}{\left(\Delta d^5\sigma_{\exp}\right)^2}$$



Generalized Polarizabilities

Photon electroproduction cross section five fold differential :

$$d^5\sigma^{ep\gamma} = d^5\sigma^{BH+B} + \Phi\, q'_{cm} \underbrace{\left[M_0 - M_0^{\mathrm{BH+B}}\right]}_{\Delta M_0} + O\left(q'^{\,2}_{cm}\right)$$

M_0 - M_0^{BH+B} : contains the Generalized Polarizabilities

$$M_0 - M_0^{BH+B} = v_{LL}\left(P_{LL}(q_{cm}) - \frac{1}{\varepsilon}P_{TT}(q_{cm})\right) + v_{LT}P_{LT}(q_{cm})$$

kinematic coefficients

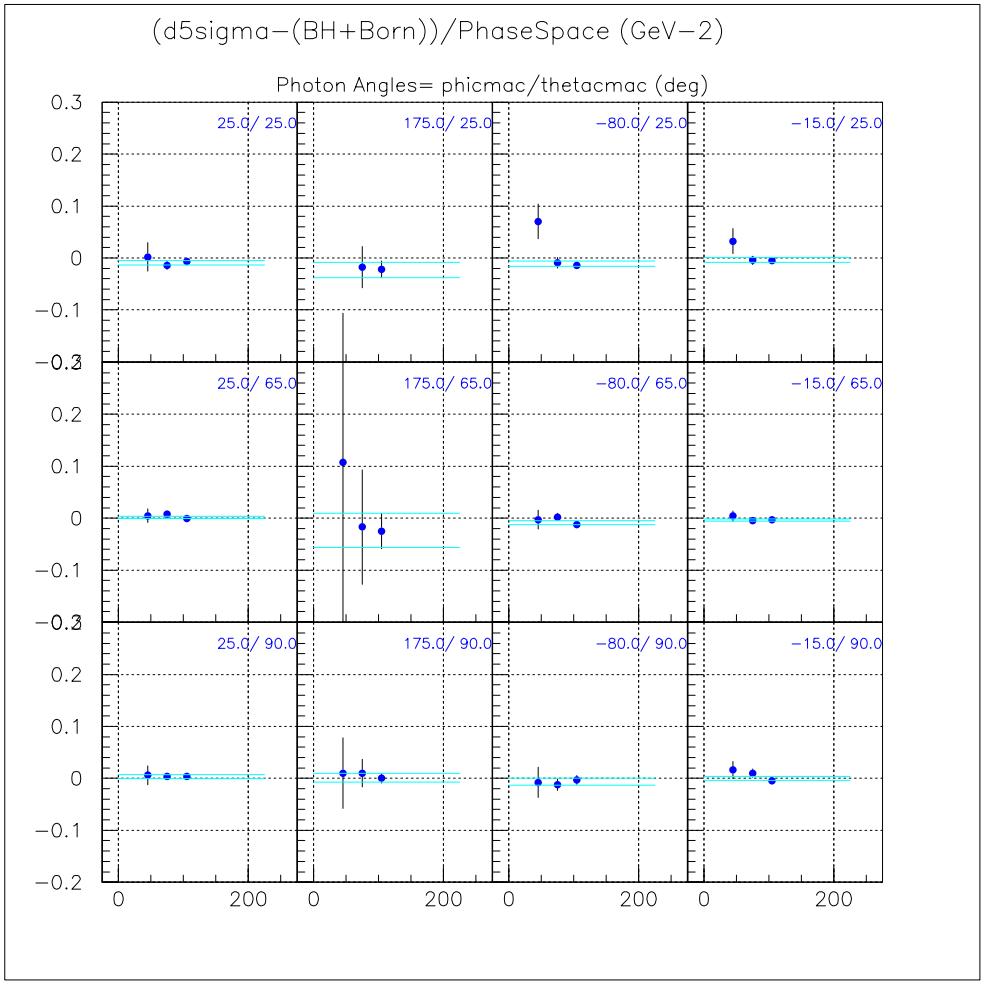
Extrapolation at q'_{cm}=0 MeV/c at $Q^2 = 1.9$ GeV^2

ordinate : $\Delta M = \dfrac{d^5\sigma_{\exp} - d^5\sigma_{BH+B}}{\Phi q'_{cm}}$

abscissa : q'_{cm}

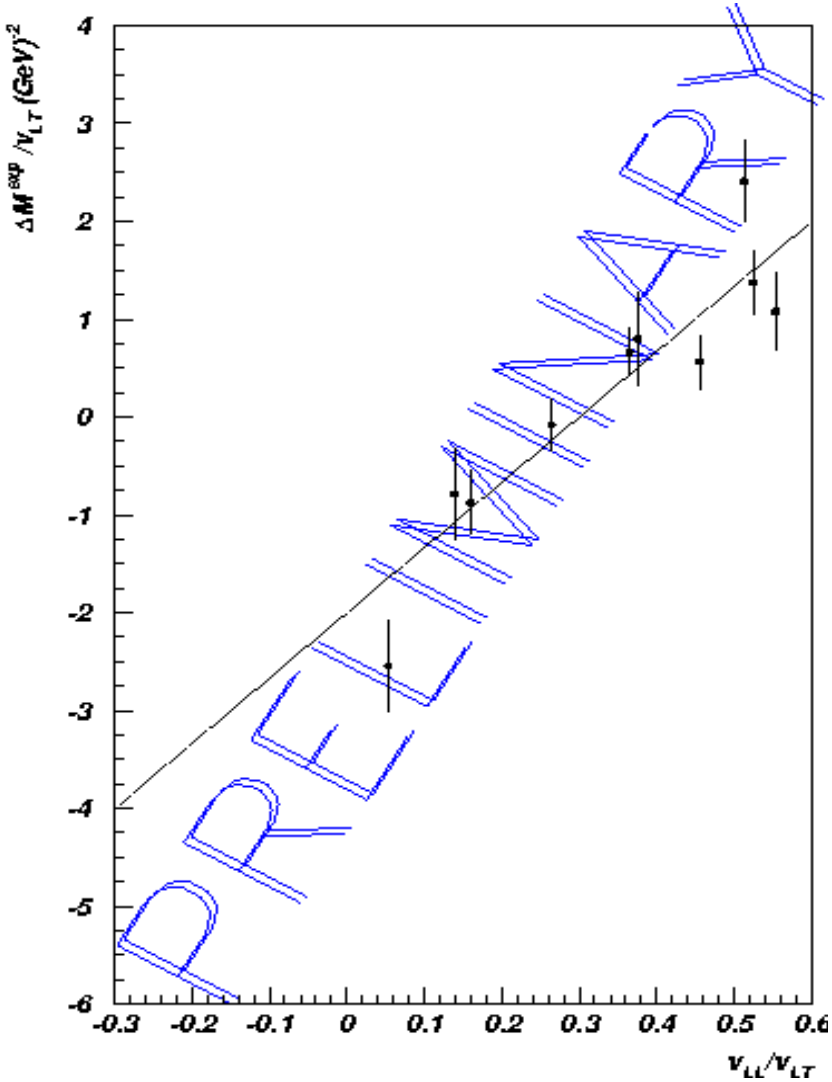
below π^0 threshold :

extrapolation by a constant

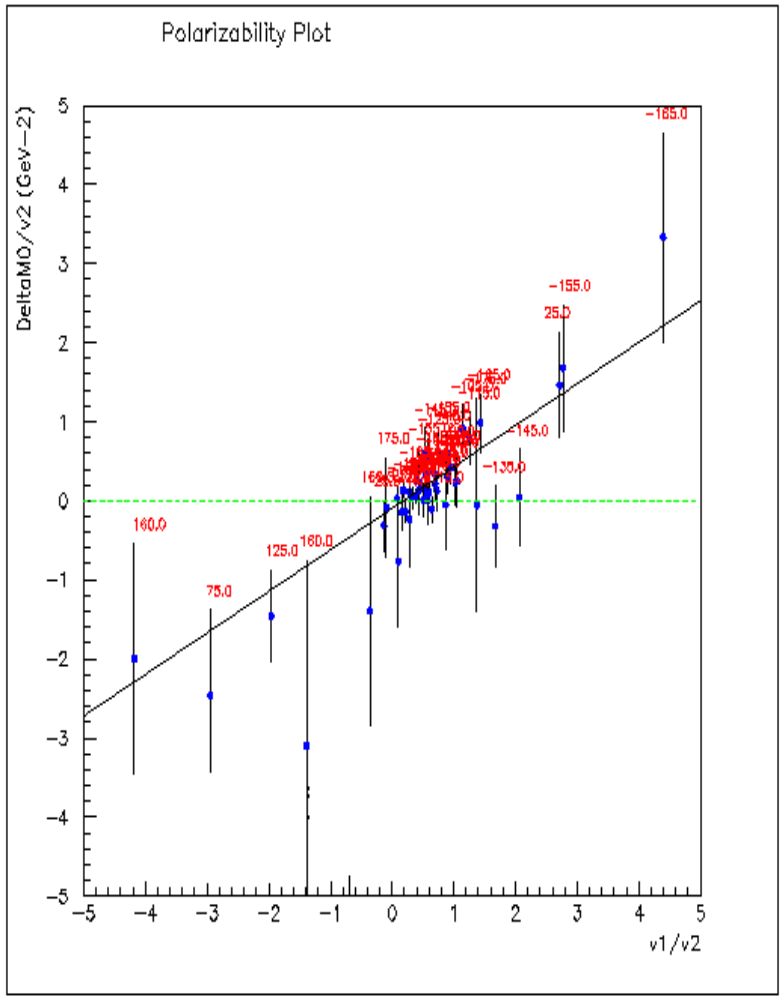


Generalized Polarizabilities extraction

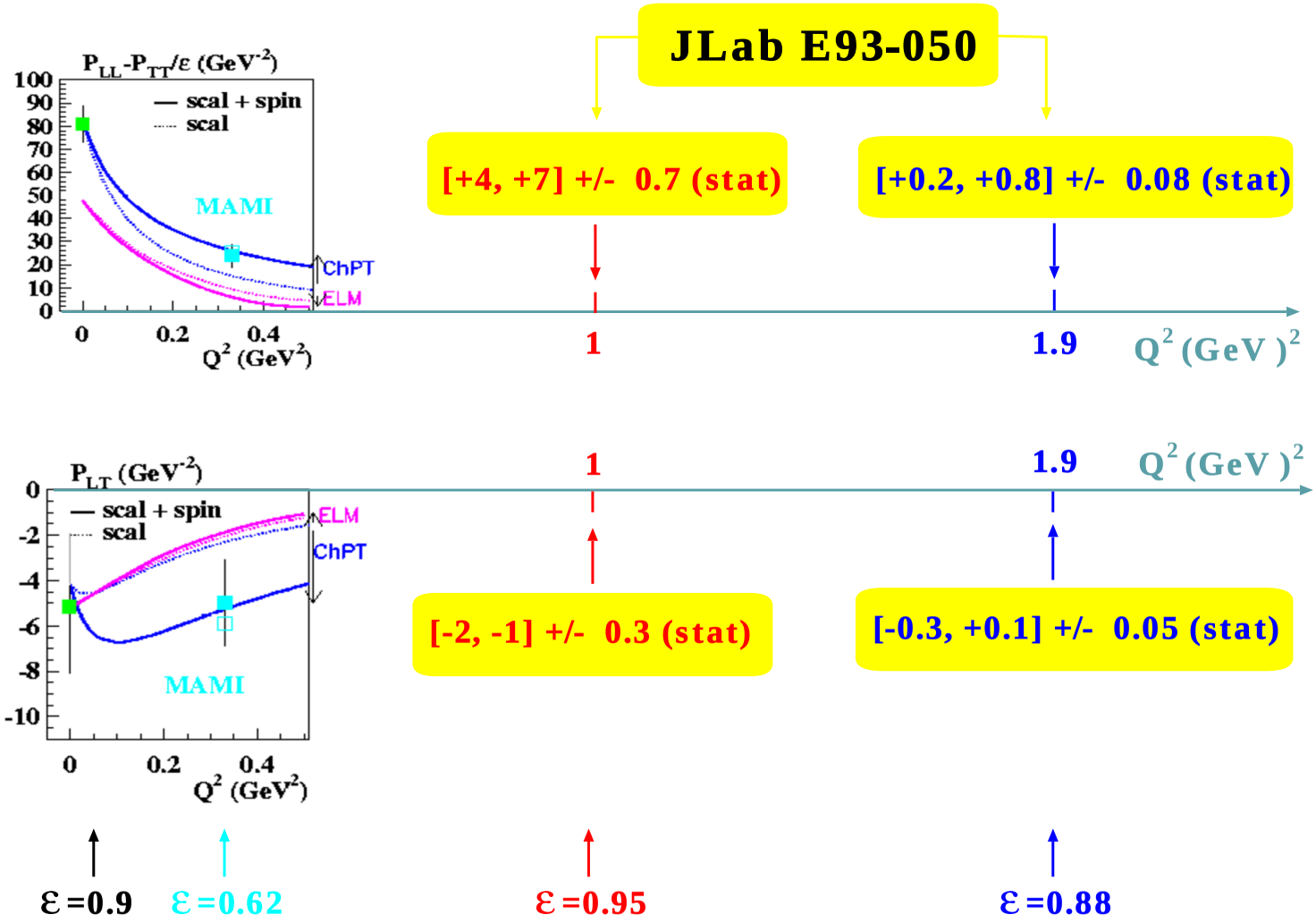
at Q^2=1.0 GeV^2



at Q^2=1.9 GeV^2



Preliminary values of Generalized Polarizabilities



Gm proton: from Bosted param.

Ge proton: from Jlab muGe/Gm

Conclusion

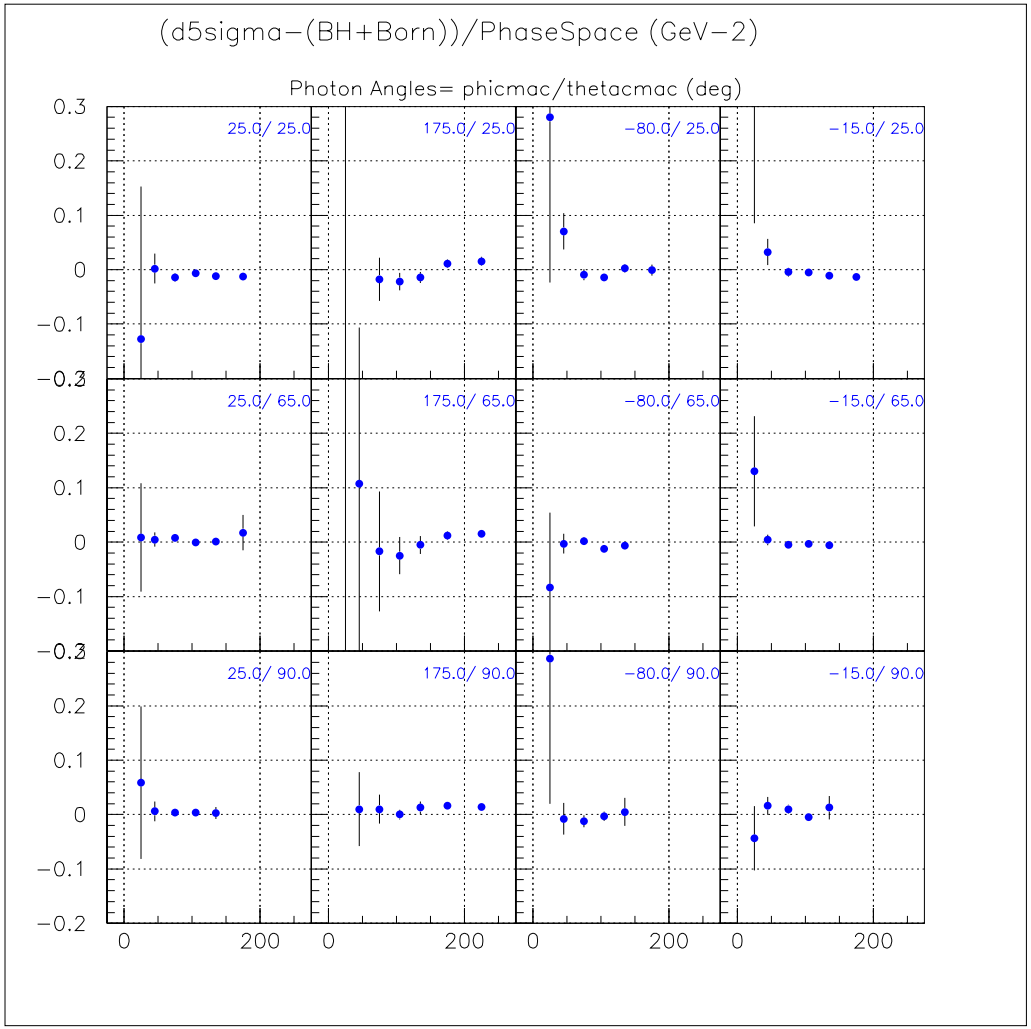
- first extraction of Generalized Polarizabilities

$$P_{LL} - \frac{1}{\varepsilon} P_{TT} \text{ and } P_{LT} \text{ at } Q^2 = 1 \text{ and } 1.9\ GeV^2$$

- we have to determine the systematic errors

- other approach using data below *and* above π^0 threshold together with dispersion relation formalism

ΔM below and above π^0 threshold

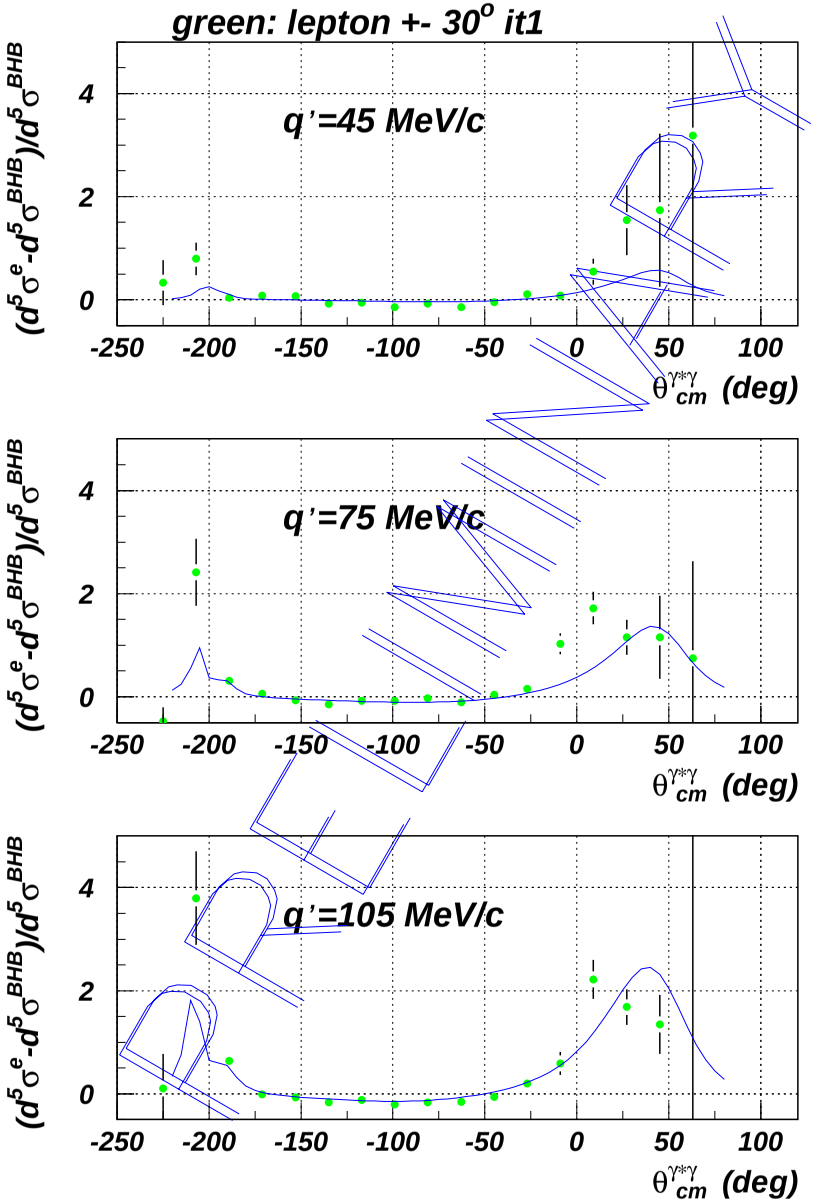


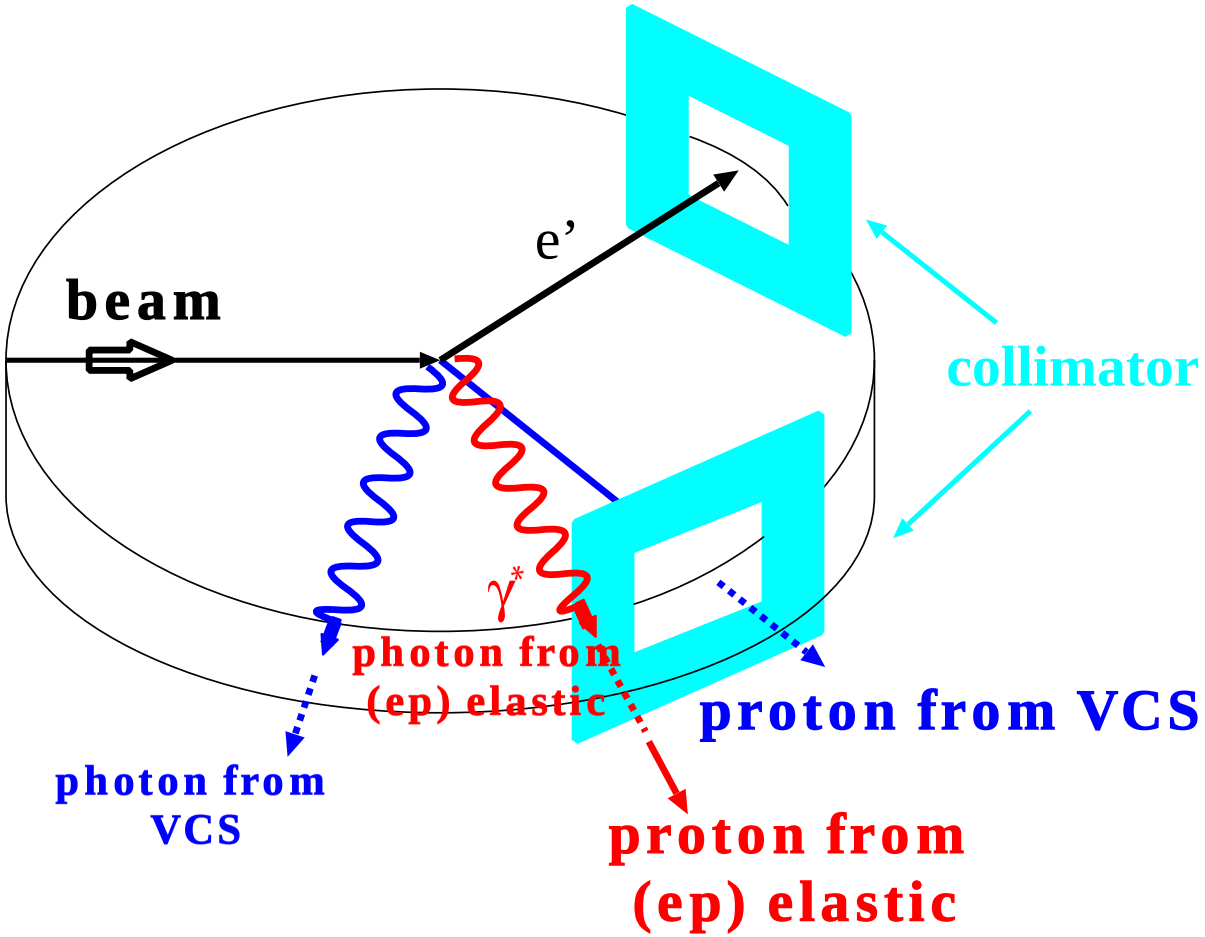
Ratio at $Q^2 = 1.0$ GeV^2

$$\frac{d^5\sigma^{ep\gamma} - d^5\sigma^{BH+B}}{d^5\sigma^{BH+B}}$$

— Dispersion Relation Formalism

- experimental




e'
beam
collimator
γ^*
photon from
(ep) elastic
proton from VCS
photon from
VCS
proton from
(ep) elastic