Probing small-size configurations
in high-*t* photo/electroproduction
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Real and Not-So-Real Compton Scattering

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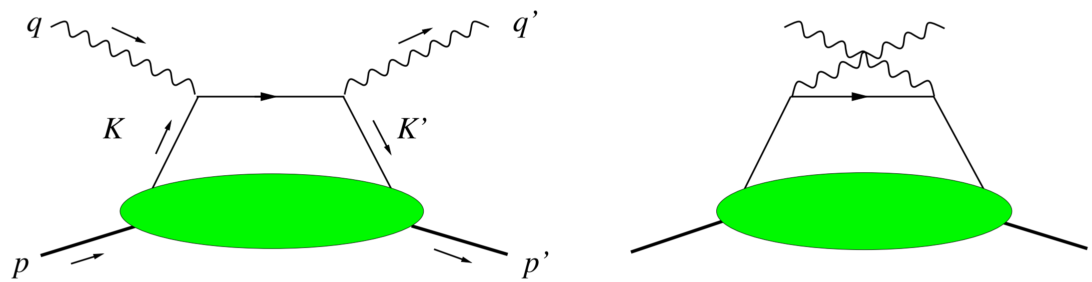
Compton Scattering at High $p_{\perp}$

- A probe of high momentum quarks
  - Produced either non-perturbatively or perturbatively
  - Small size configurations required
- Sub-asymptotic amplitude modeled ~~by Feynman mechanism~~. “Handbag” amplitude
  - Klein-Nishina amplitude on a single high-momentum quark
    - A. Radyushkin
    - P. Kroll, M. Diehl, et al
    - G. Miller, et al.
    - Brodsky et al.
  - Extended Regge, J-M Laget.



γp → γp

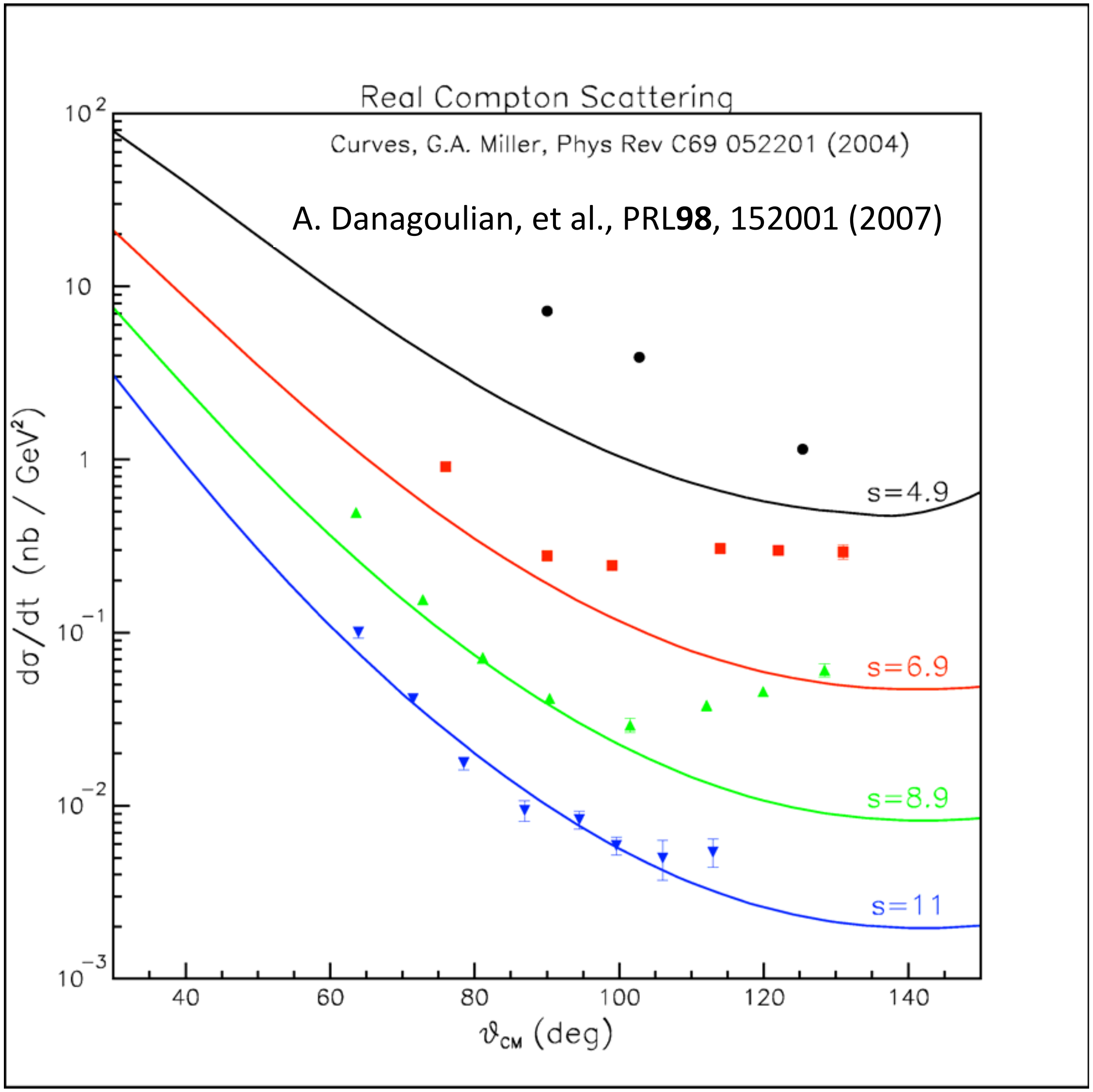
E99-114 Statistical errors only

Light Front Cloudy Bag Model
(only 3-quark content included
at large x for RCS

Handbag amplitude &
Wavefunction ansatz

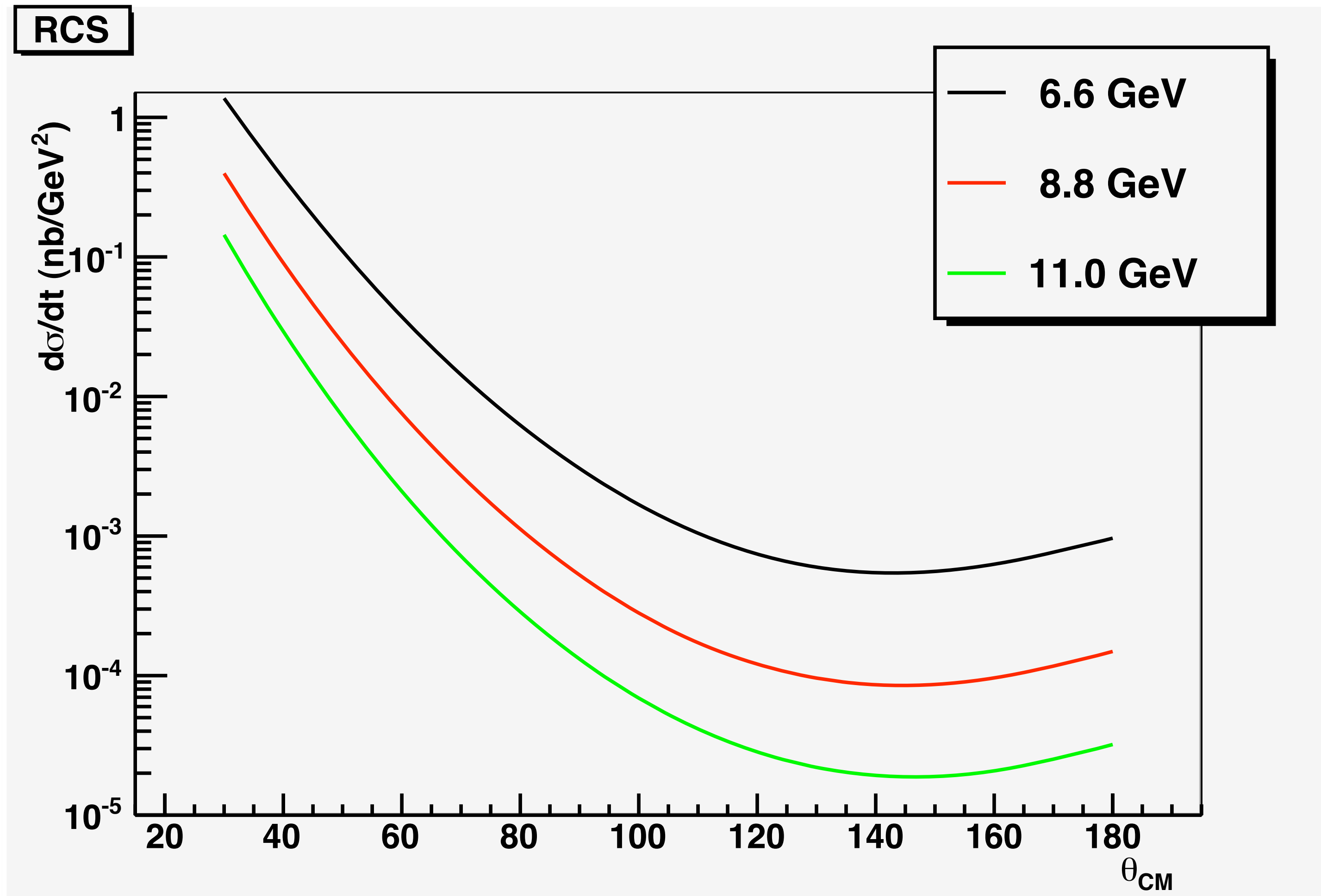
$$\Phi(k_1,k_2,k_3) = \frac{(spin)N}{\left[M_{123}{}^2+\beta^2\right]^\gamma}$$

Parameters β,γ, m_q
fitted to H(e,e')p



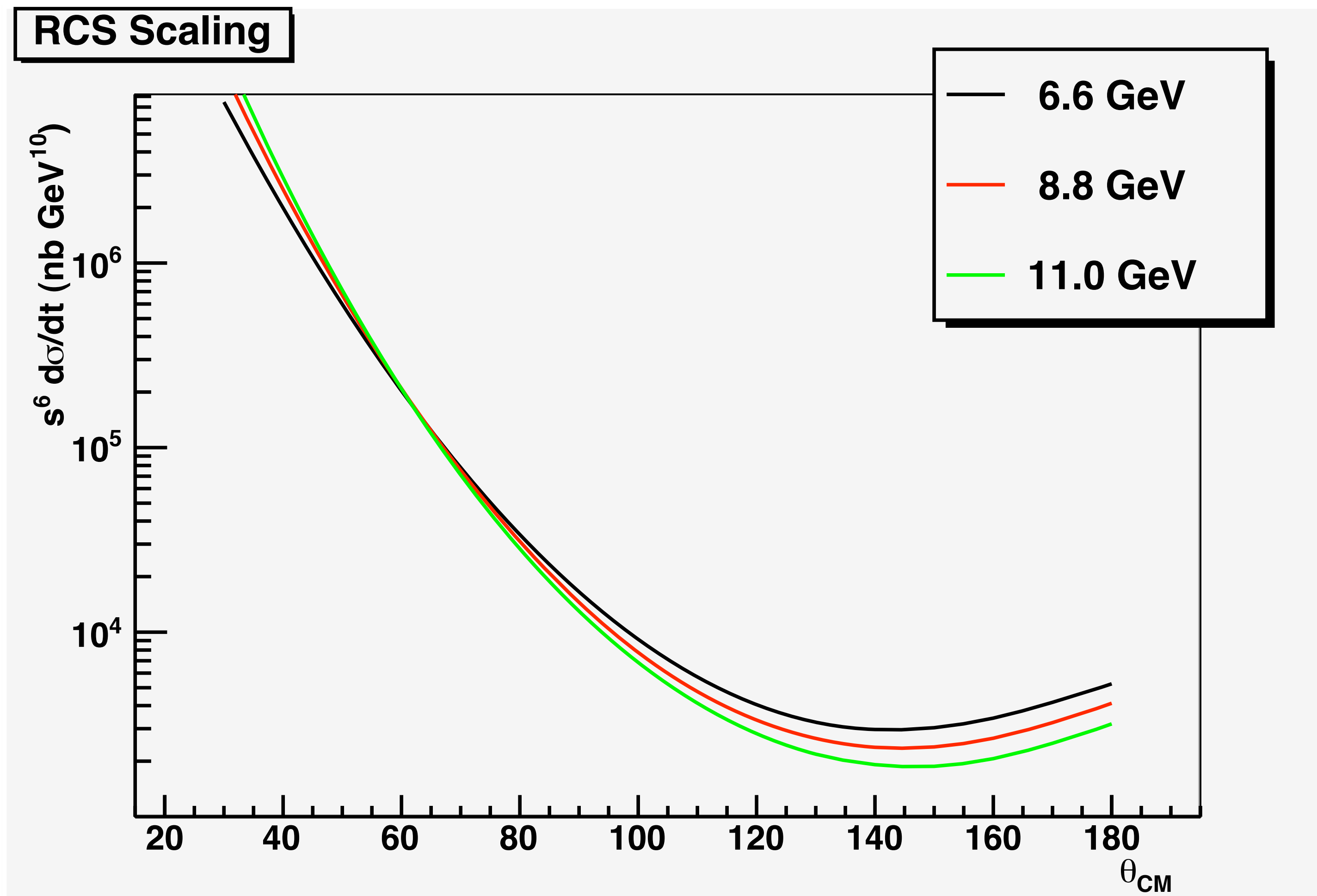
Real Compton Scattering at 12 GeV

- G.A. Miller model curves



RCS Scaling

- Precocious s^{-6} scaling of Compton scattering from constituent quarks.
- G.A. Miller



RCS Polarization Observables

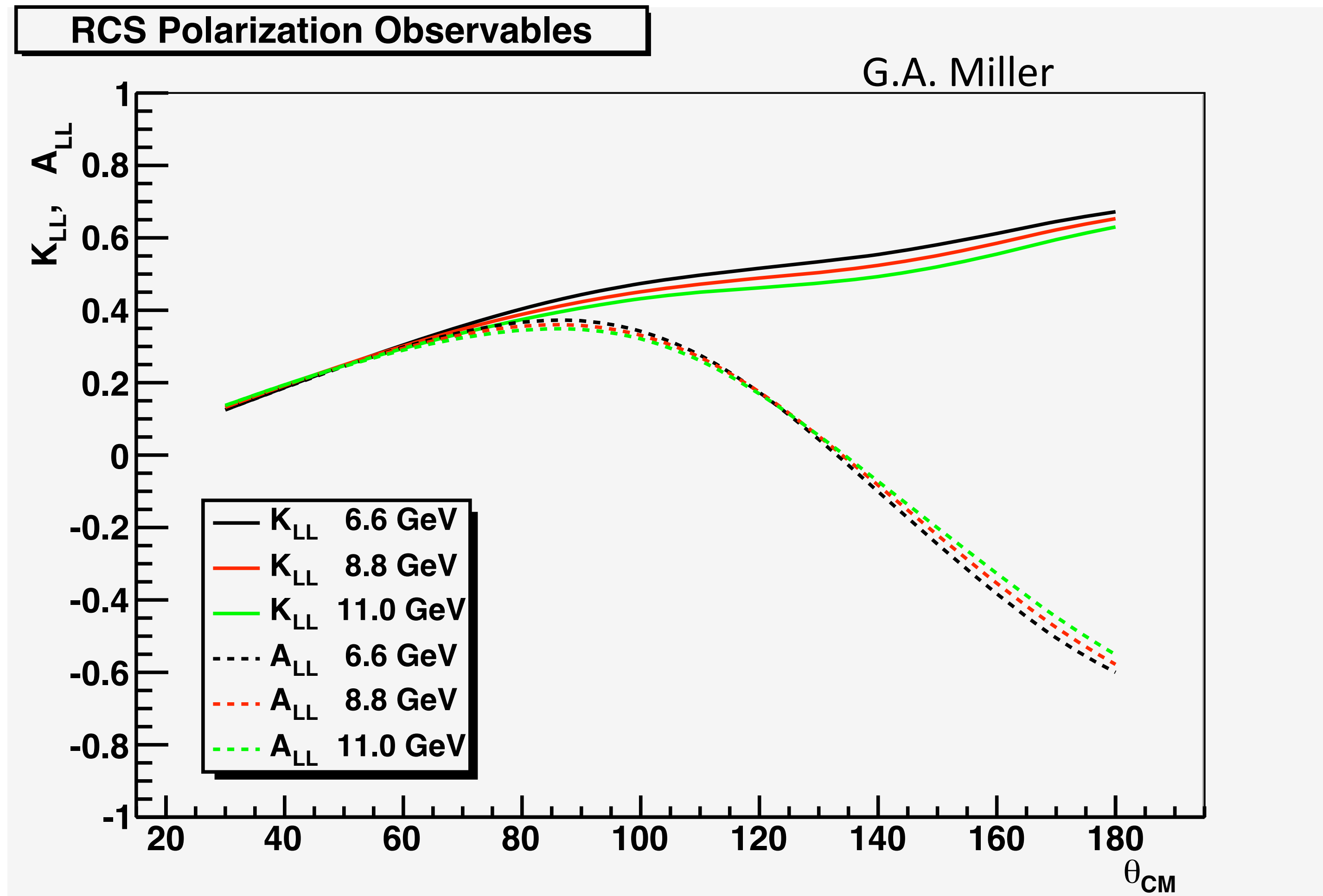
- K_{LL}:

$$\vec{\gamma} + p \rightarrow \gamma + \vec{p}$$

- A_{LL}:

$$\vec{\gamma} + \vec{p} \rightarrow \gamma + p$$

- On-shell massless quarks $A_{LL}=K_{LL}$

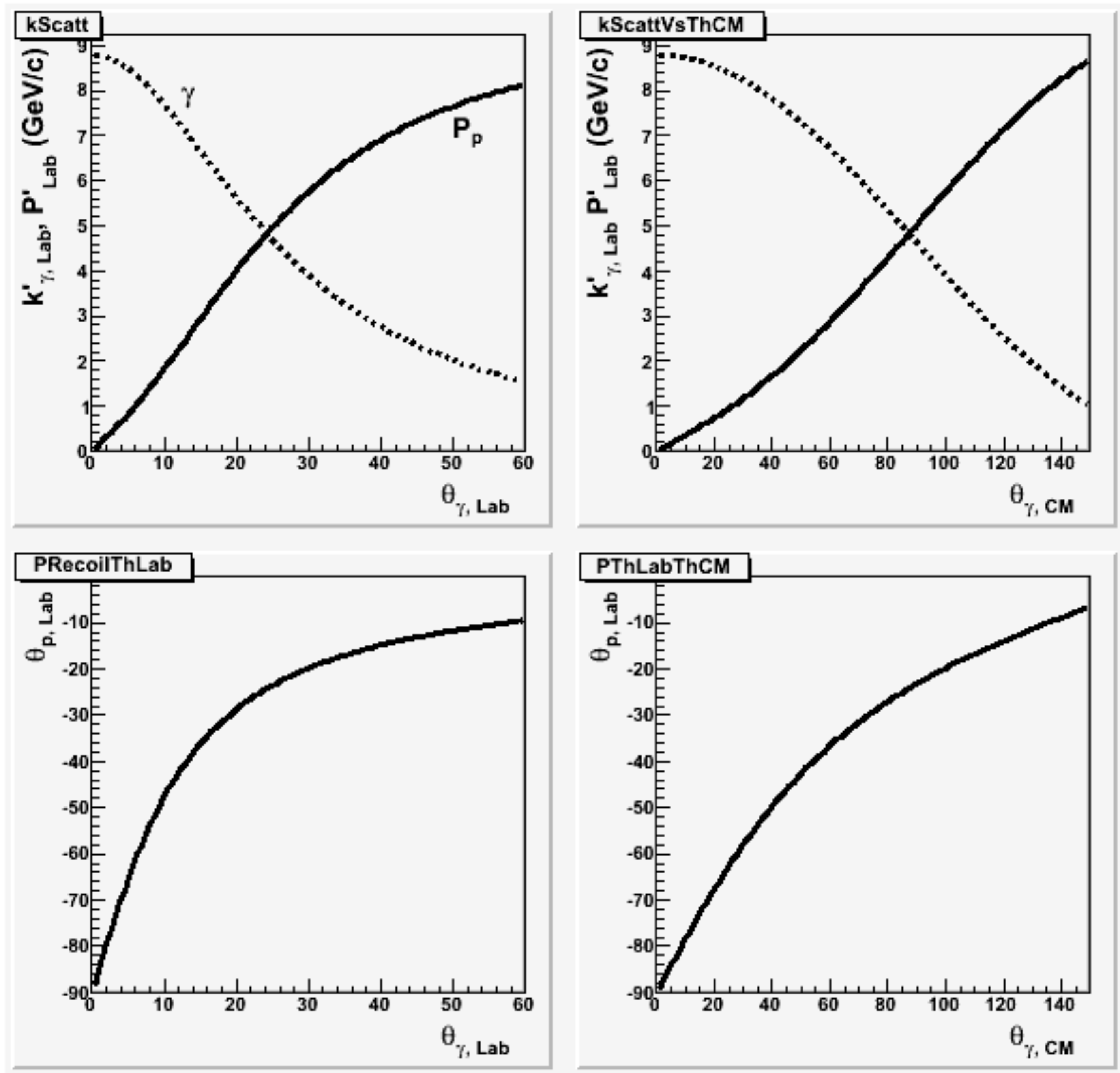


Experimental Approaches

- Spectrometers (Halls A & C)
  vs Full Acceptance (Halls B & D)
- So far, correlated final state means spectrometer$\otimes$calorimeter yields largest product of luminosity$\otimes$acceptance.
- Recoil Polarimeter (44 cm CH + 50 cm C)
  Efficiency x (Analyzing Power)^2 = 4.5×10^{-3} at p_p= 3 GeV/c
- Polarized Targets
  - NH_3 electron luminosity ≈ 10^{35}/cm^2/s
    - P_p≈70%
  - HD ice, photon beams
    - P_P ≈ 70%

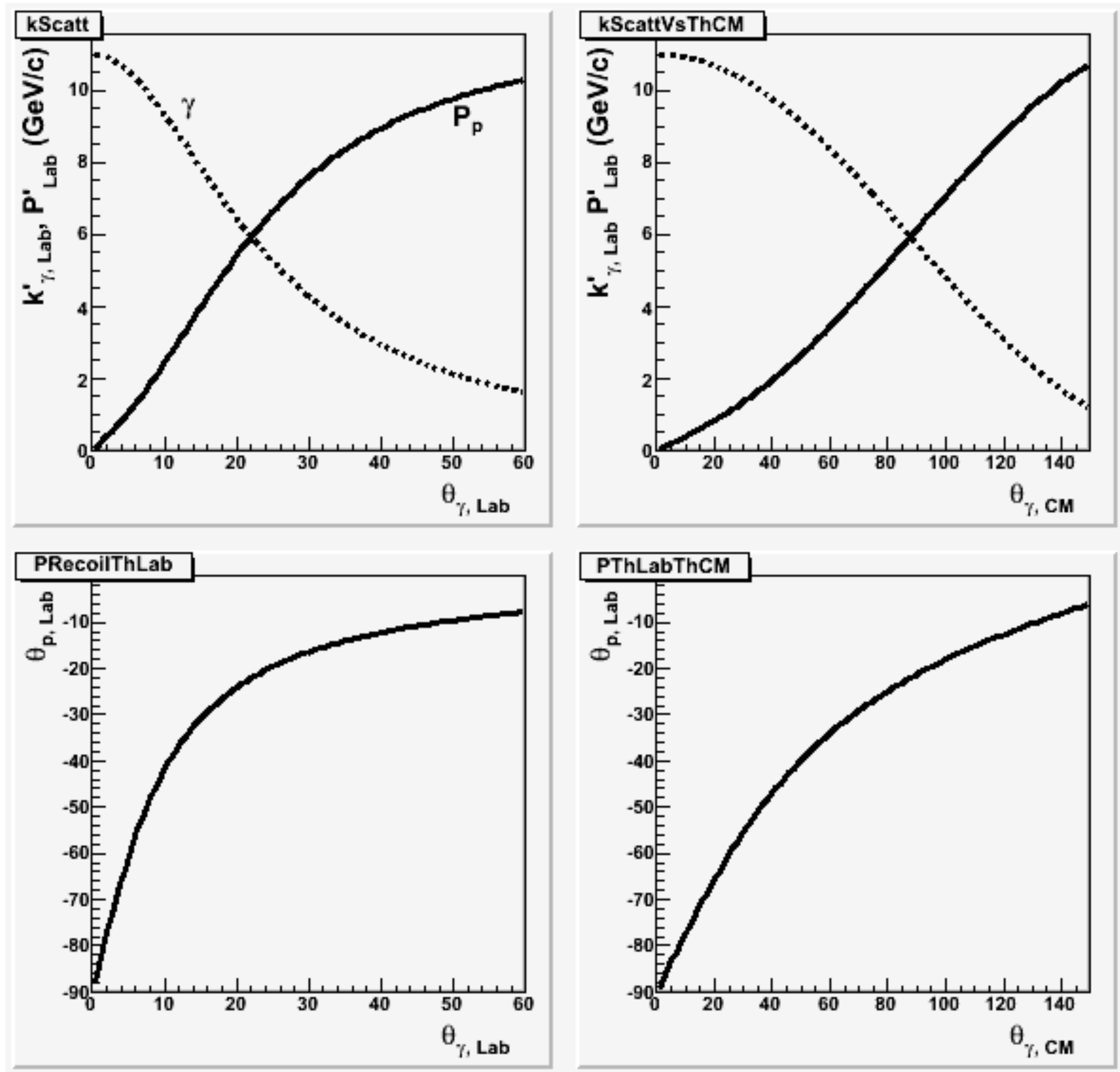
RCS Kinematics

- 8.8 GeV Photon incident



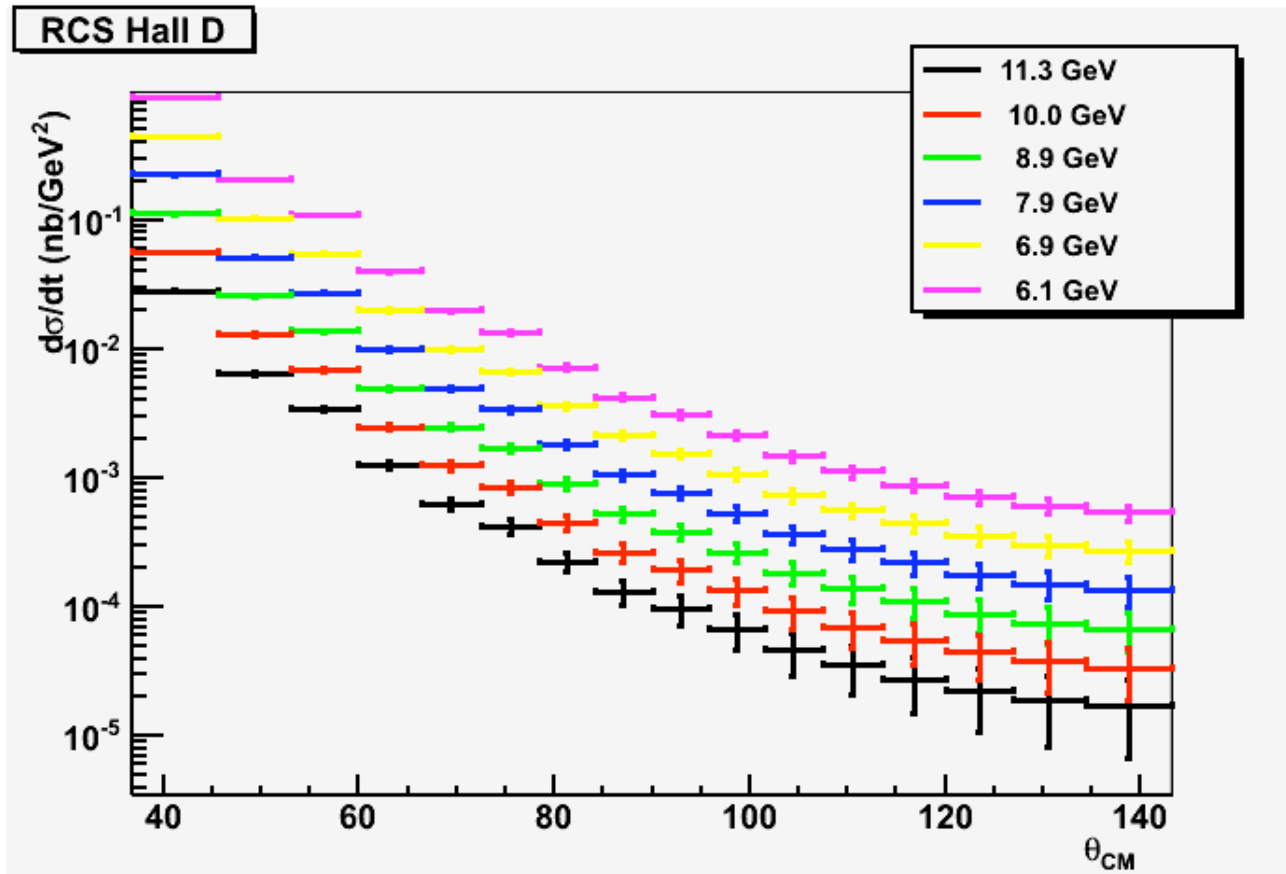
RCS Kinematics

- 11 GeV Photon incident



Hall D Count Rate Estimates

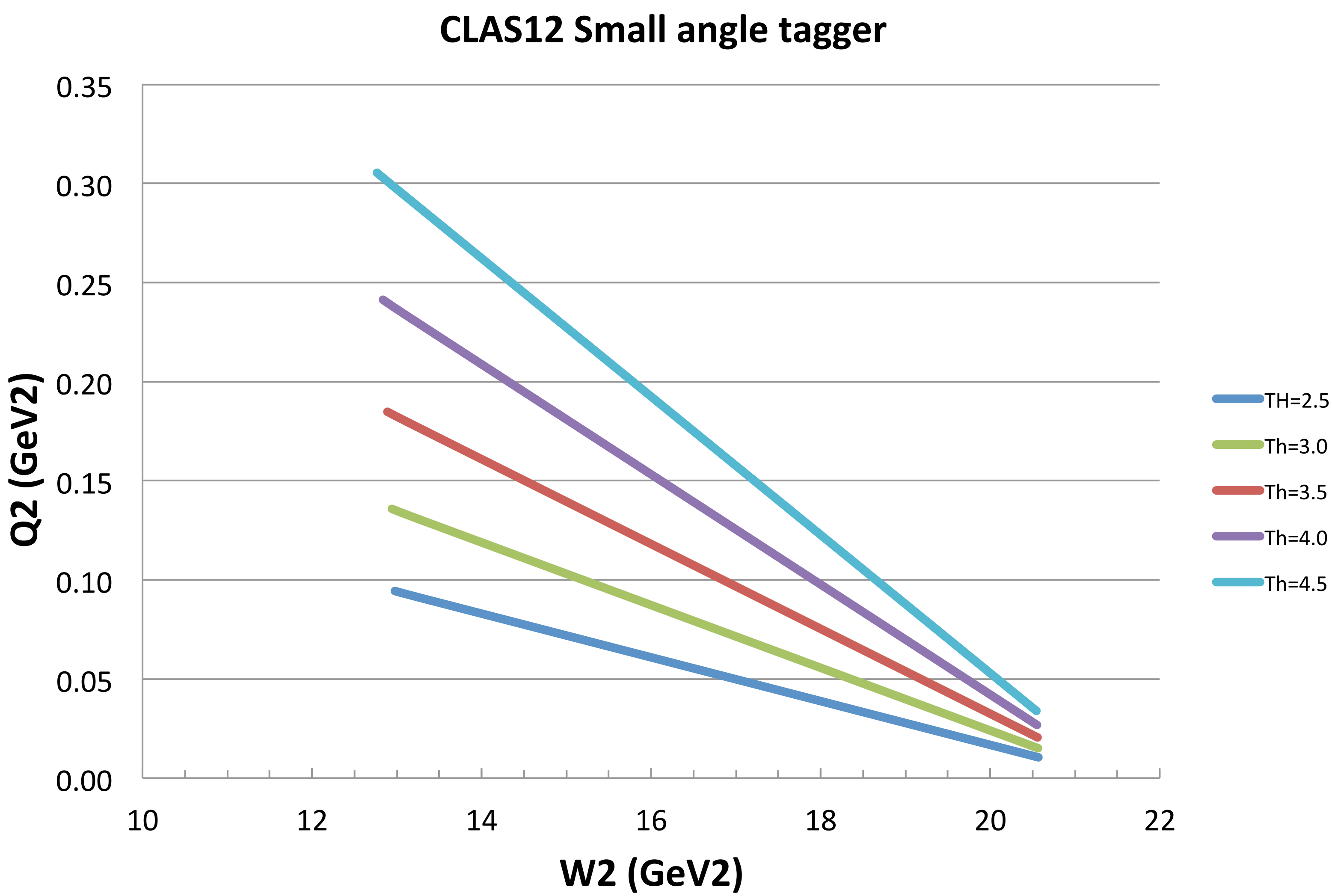
- Dedicated run, photon flux $d\Phi_\gamma \approx (2 \bullet 10^8/s)\, dk_\gamma/k_\gamma$
- Target 2 g/cm^2.
- One month
- Energy bins span factor of 2 in $d\sigma$



Virtual Compton Scattering

- Naïve idea: Measure the size of the constituent quark in the handbag amplitude
- Dynamical complications
  - Longitudinal and Transverse amplitudes
  - Longitudinal momentum transfer
  - Challenge for theory
- Two kinematic domains
  - $\Lambda^2 \approx Q^2 << -\Delta^2$ CLAS12
  - $Q^2 \in [1, 2 GeV^2] << -\Delta^2$ Hall A,C

Virtual Compton Scattering with a small angle tagger in CLAS12

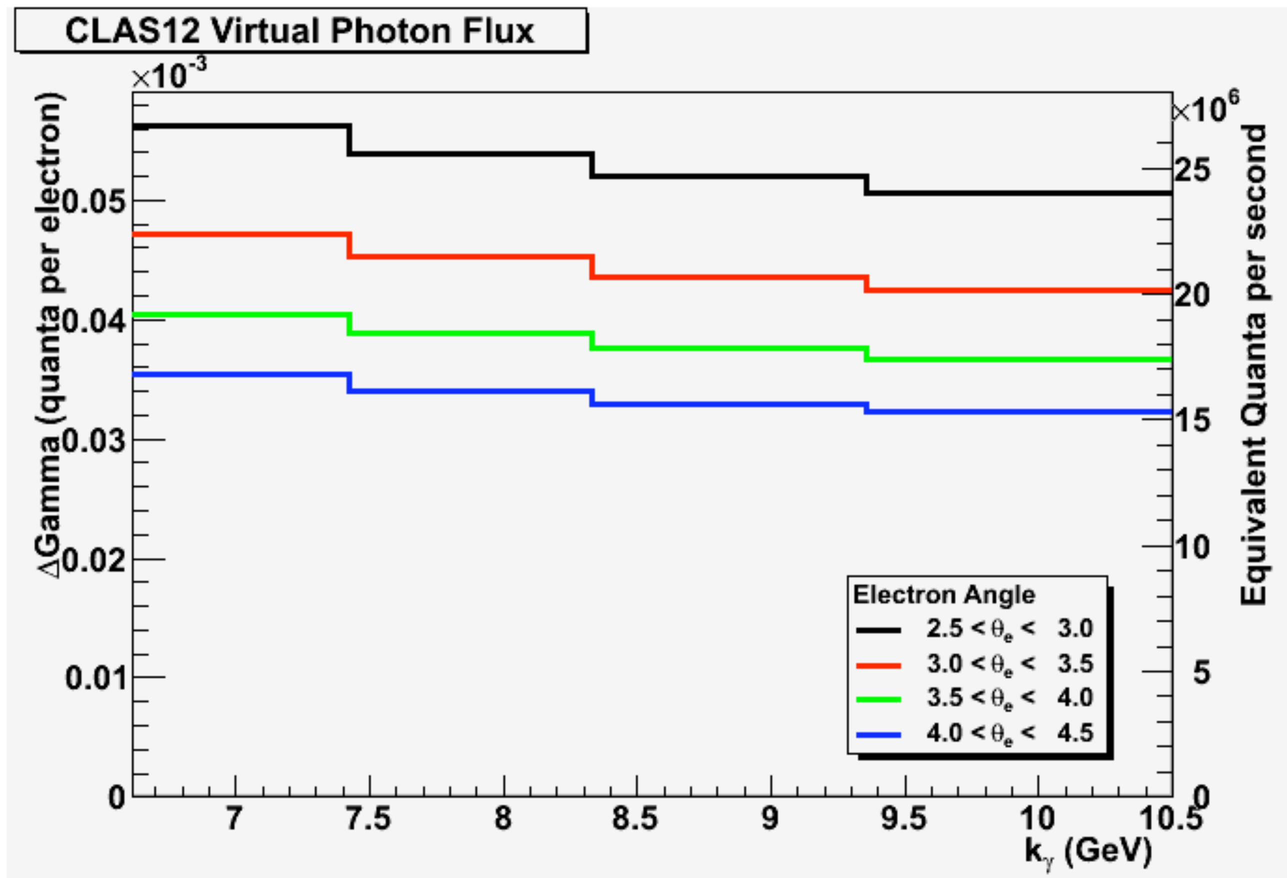


Virtual Photon Flux (CLAS12)

$$\frac{d\sigma(e,e'\gamma)}{dE'd\Omega dt} = \Gamma \frac{d\sigma(\gamma,\gamma)}{dt} + BH + I$$

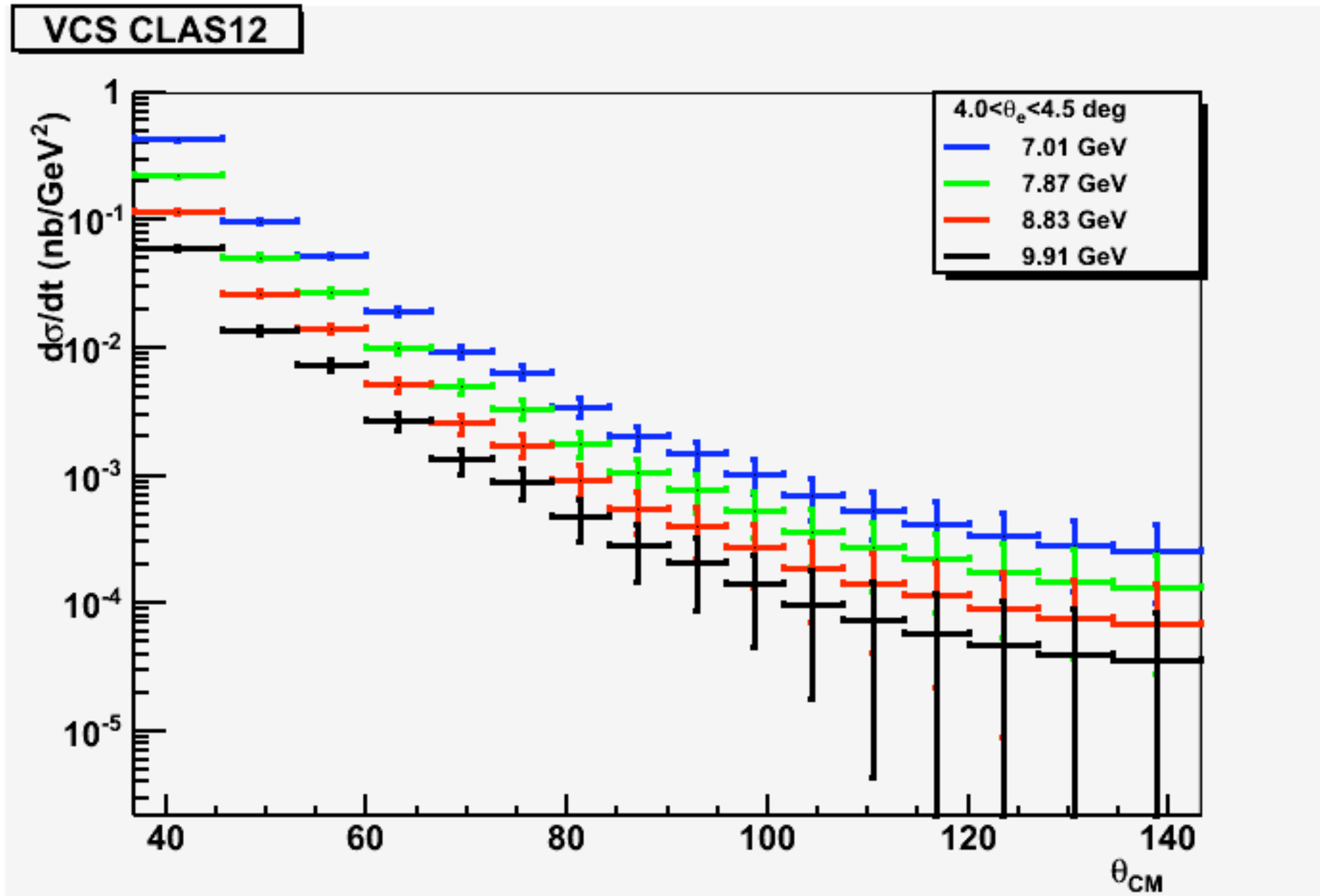
$$\int dE'\, d\Omega \Gamma = \int dE'\, d\Omega \frac{\alpha}{2\pi^2} \frac{E'}{E} \frac{W^2 - M^2}{2MQ^2} \frac{1}{1-\varepsilon}$$

- Photon Flux at 10^{35} on 5 cm LH_2.
- $\geq 1.5 \bullet 10^7$/s per bin



Low Q^2 VCS yield in CLAS12
(neglecting BH and interference)

- One month on 5 cm LH_2 target.



VCS in Hall A

- $50\mu A \times 11$ GeV incident on 1 g/cm^2 H_2
  - $L = 2 \bullet 10^{38}/cm^2/s$
- 2 GeV Scattered electron in HRS at 12.5°
  - Q^2=1 GeV^2
  - $\Delta\Phi_\gamma = (I_e/e)\,\Gamma\Delta\Omega\Delta k' = 2.8 \bullet 10^8$ quanta/sec
  - Photon Luminosity is 40× CLAS12 VCS case
- Detect Proton in SBS, Photon in Calo
  - Azimuthal acceptance $\phi \approx \pm\theta_V/\sin\theta$
  - at $\theta_\gamma^{CM}=90°$, $\theta_\gamma^{Lab} \approx 25°$, $\theta_P^{Lab} \approx 30°$
  - with =100mr, $\Delta\phi$=400mr ≈ $2\pi/16$
  - A single Q^2, Δ^2 bin will count 2.5× faster at Q^2=1.0 GeV^2 in Hall A than at at Q^2=0.2 GeV^2 in CLAS
- Old 4 GeV proposal PR94-106 HRS^2

Conclusions

- A diverse program of VCS and RCS Cross section measurements is feasible, spanning all four Halls.
  - More detailed theory of VCS is needed, including BH ampitude
    - (only full calculation is Kroll, Shürmann, Guichon with diquark model).
- Polarization observables need detailed study.
  - B. Wojtsekhowski et al.

VCS - DiQuark

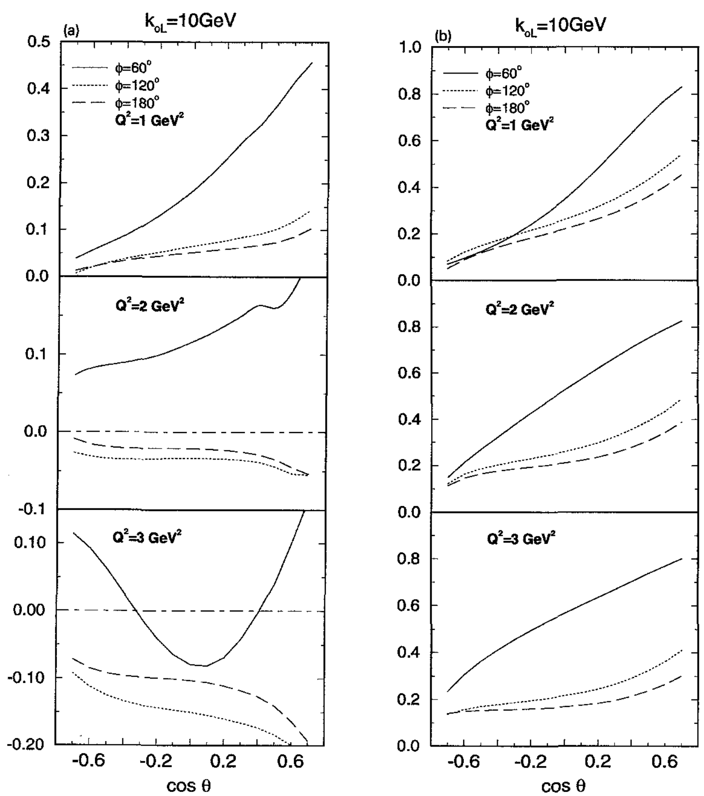


Fig. 6. The difference of the full photon electroproduction cross section and the VC contribution to it over the full cross section versus $\cos\theta$ for several combinations of values of the beam energy k_{0L}, Q^2 and the azimuthal angle ϕ. (a) $s = 5$ GeV^2, (b) 10 GeV^2.

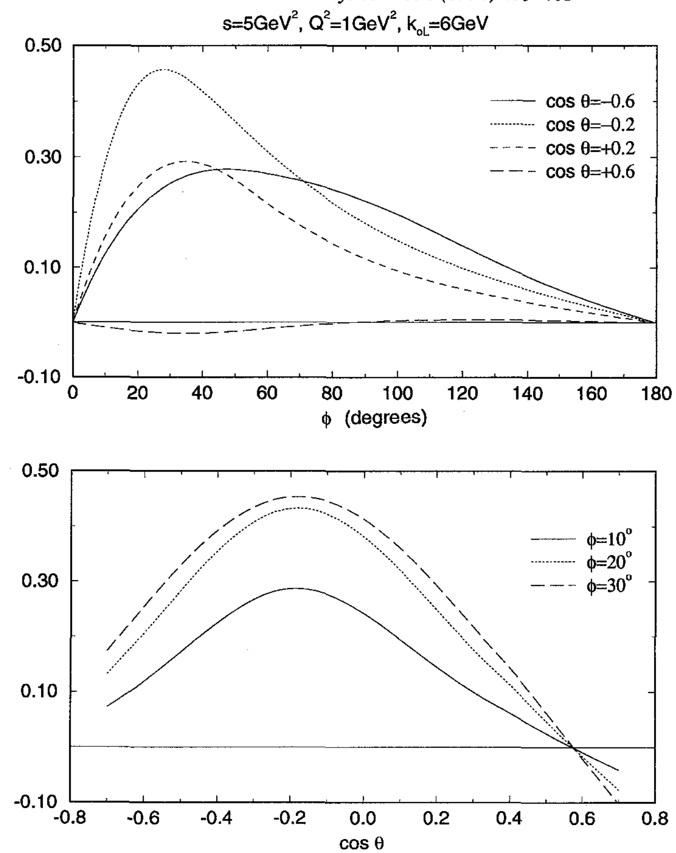


Fig. 8. The electron asymmetry at CEBAF. Top: A_L versus ϕ for several values of $\cos\theta$. Bottom: A_L versus $\cos\theta$ for several values of ϕ.