Real Compton Scattering (RCS) Measurements at Hall A of Jefferson Lab

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For e99-114 collaboration

- **RCS experiment completed in March 2002**

Data being analyzed

- **Outline:**

- Theoretical Overview

- Experimental setup, MC analysis

- Results

- Summary

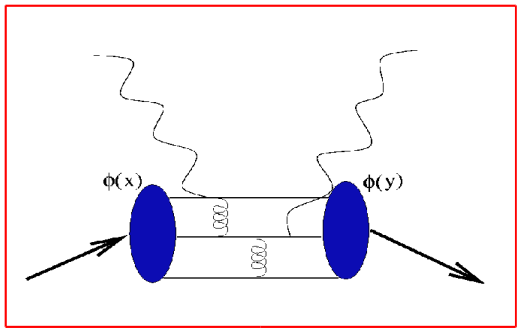
Different Models for RCS on the Nucleon

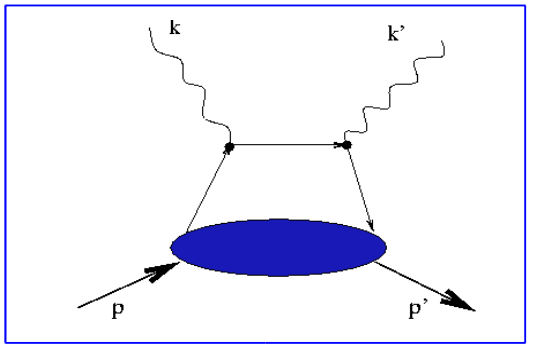
Purpose of the experiment: Compare competing theoretical mechanisms of Compton scattering on a proton, trying to determine which one is dominant at accessible energies – Gluon Exchange Mechanism, or Soft Overlap ("Handbag") Mechanism.

$$\frac{d\sigma}{dt} = \frac{f\left(\theta_{CM}\right)}{s^{n}} \quad n=6$$

$$\frac{d\sigma_{RCS}}{d\sigma_{KN}} \approx R_V^2(t)$$

Dominant at higher (how "high"?) energies.





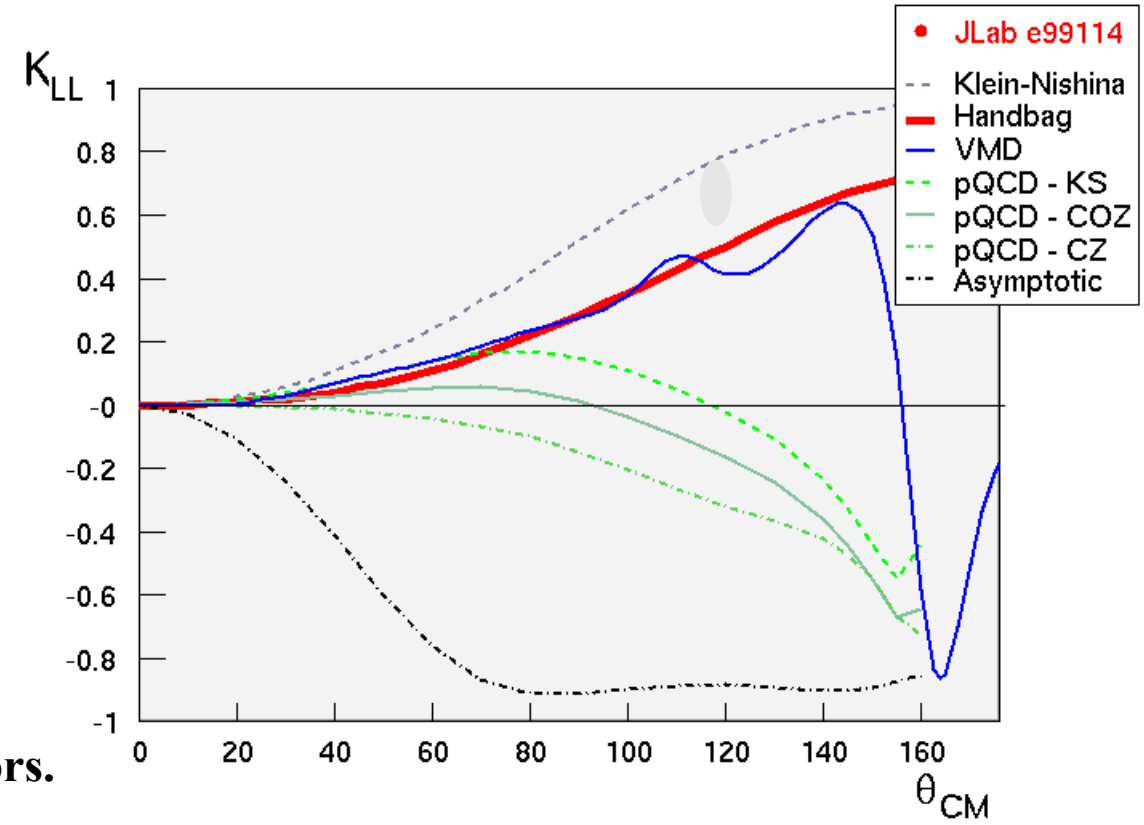
Polarization transfer to proton:

$$K_{LL} = \frac{d\sigma\ (+\uparrow) - d\sigma\ (-\uparrow)}{d\sigma\ (+\uparrow) + d\sigma\ (-\uparrow)}$$

For Soft Overlap --

$$K_{LL} \approx K_{LL}^{KN} \frac{R_A(t)}{R_V(t)}$$

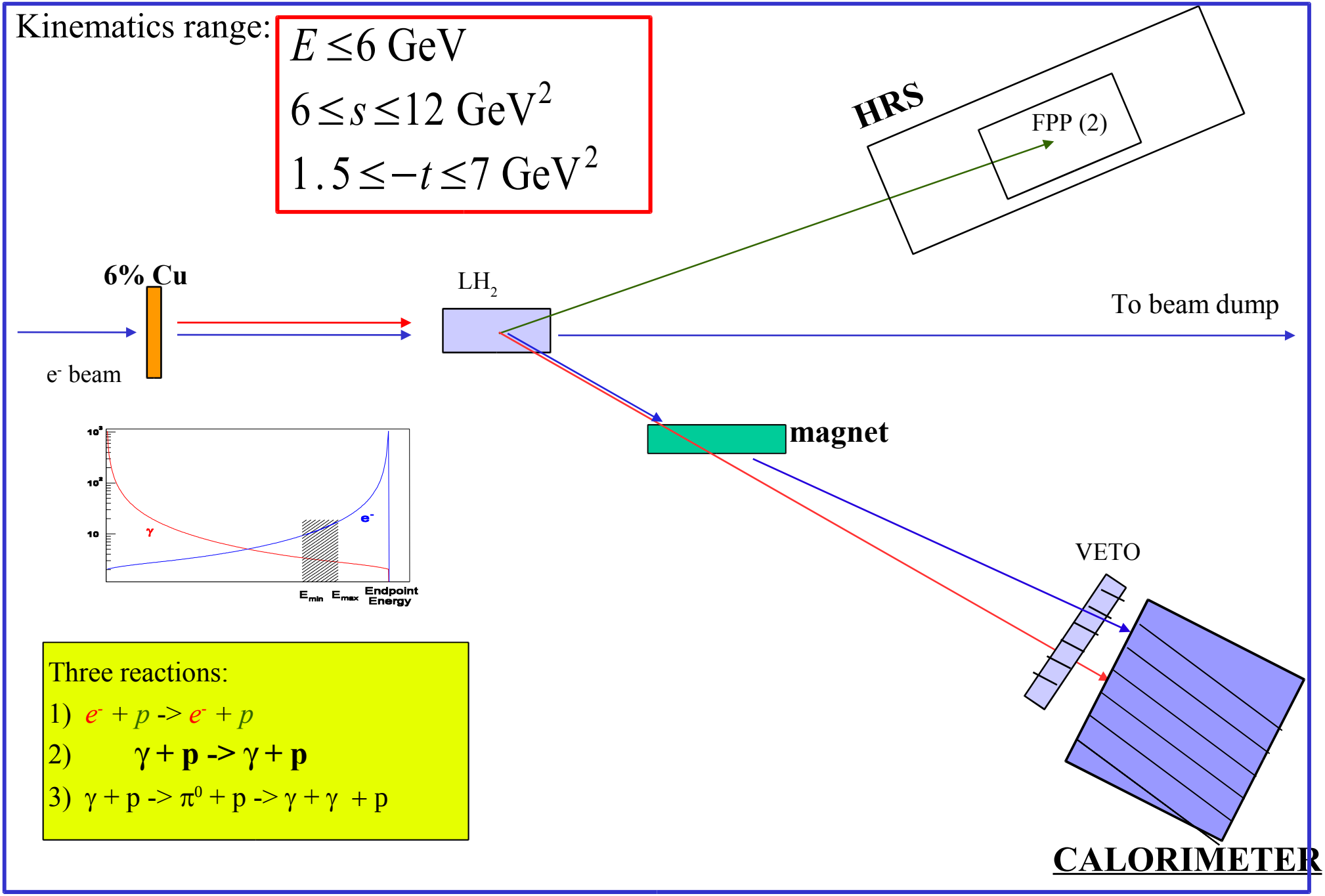
- Radically different predictions by the two mechanisms.
- **Depends only on the ratio of the form factors.**



Experimental setup and procedure

Kinematics range:

$$E \leq 6 \text{ GeV}$$
$$6 \leq s \leq 12 \text{ GeV}^2$$
$$1.5 \leq -t \leq 7 \text{ GeV}^2$$



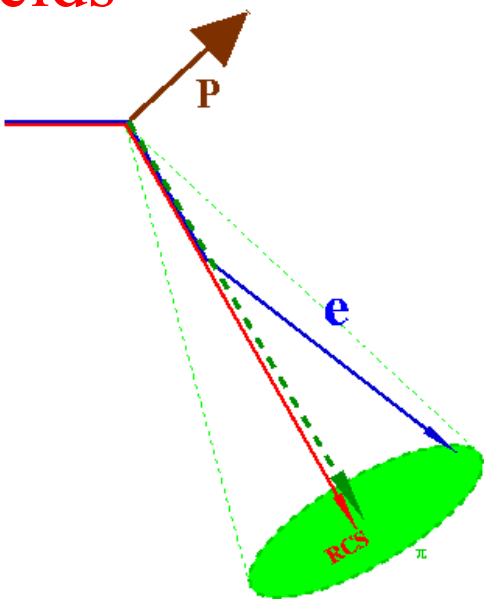
Three reactions:

1) $e^- + p \rightarrow e^- + p$
2) $\gamma + p \rightarrow \gamma + p$
3) $\gamma + p \rightarrow \pi^0 + p \rightarrow \gamma + \gamma + p$

Separation of event types and extraction of yields

- Using 2-body kin. plot Δy vs. Δx – in plane and coplanar correlation between proton and scatterer

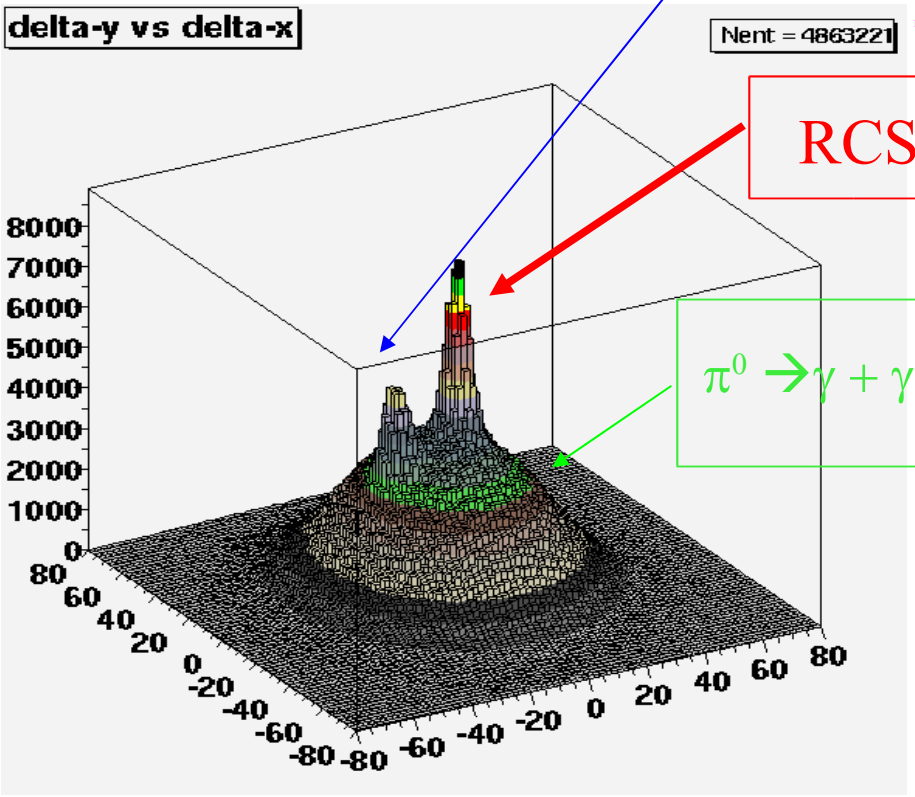
- Use MC to fit.

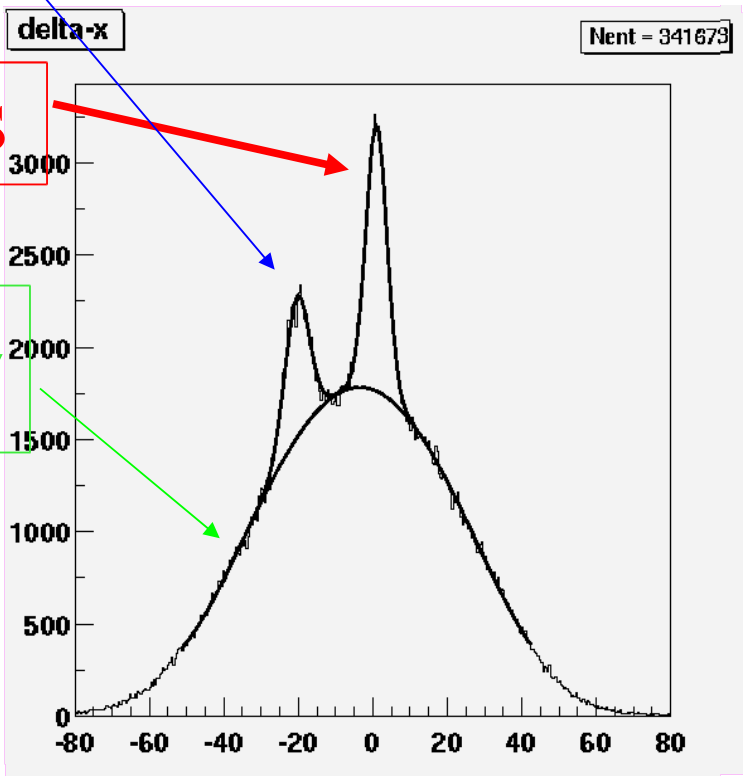


(ep)

RCS

$\pi^0 \rightarrow \gamma + \gamma$





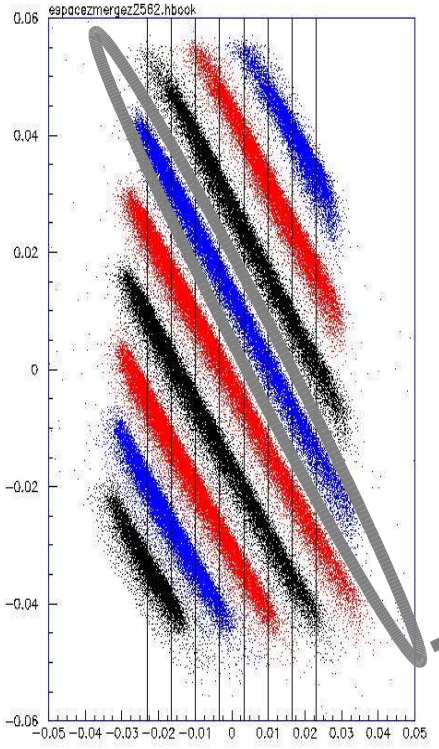
Testing the Monte Carlo -- using "controlled" ep data

- Elastic ep data – known cross-section : move spectrometer's central momentum to scan the detector plane.

$p_c = 1.711$ *Gev/c*

Measured cross-section $(1.0 \pm 0.7)\%$ > Bosted parametrization

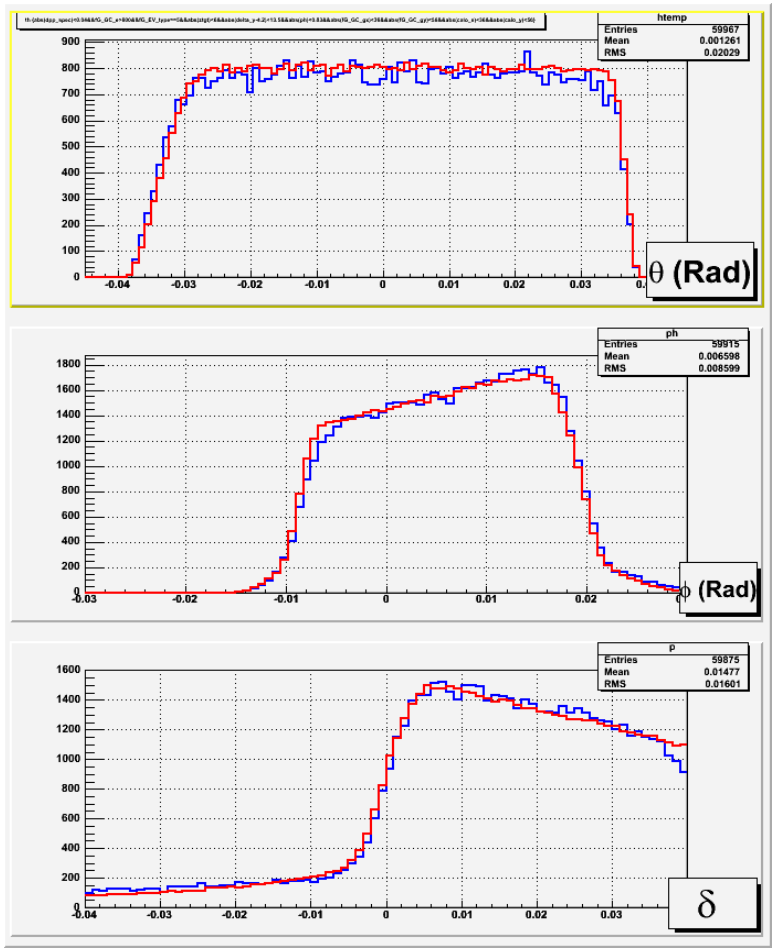
$$\delta\,\delta = \frac{\Delta p}{p_c}$$

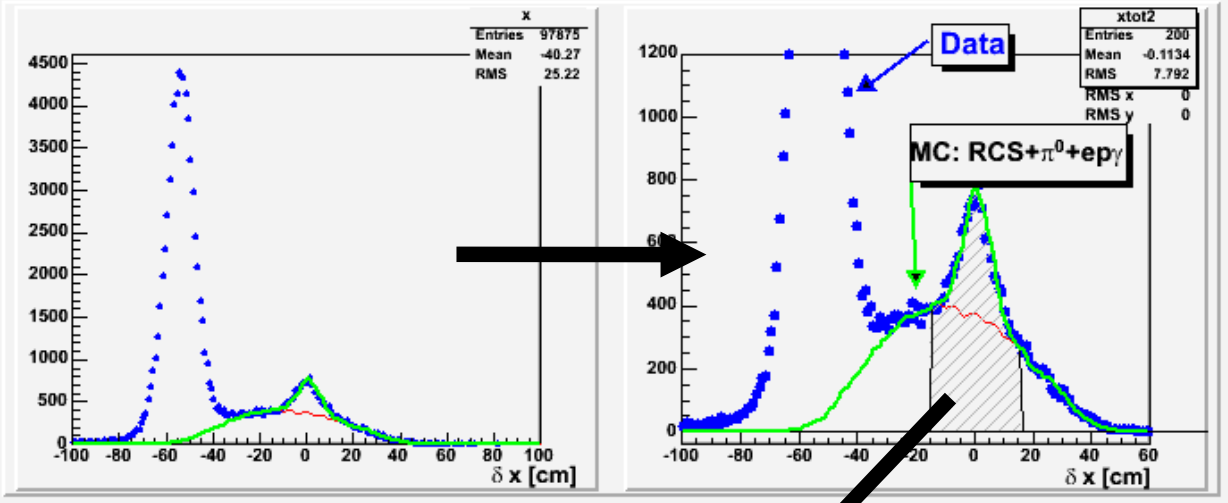


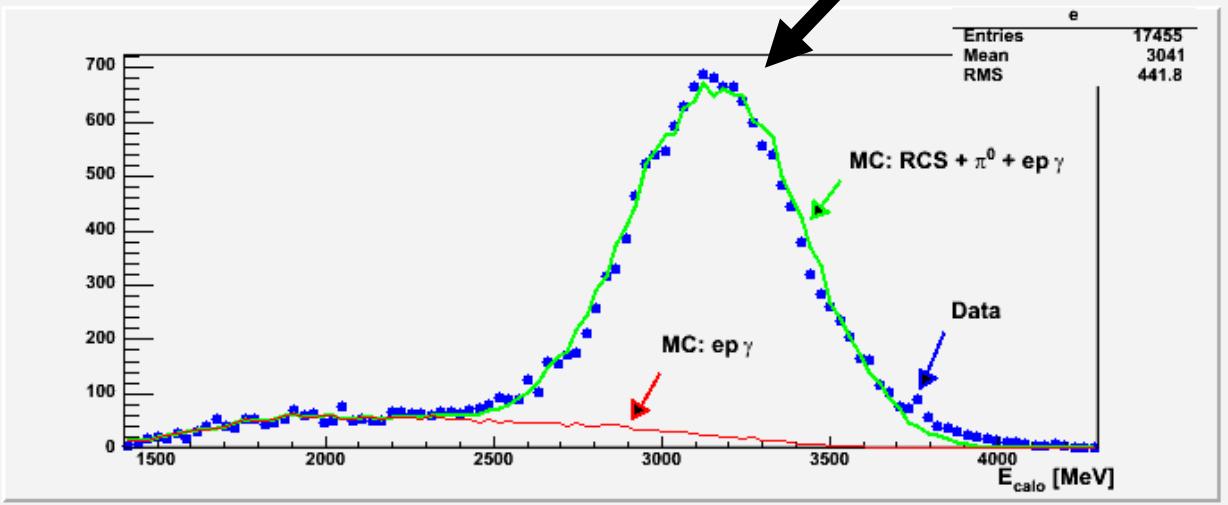
in-plane angle (Rad)

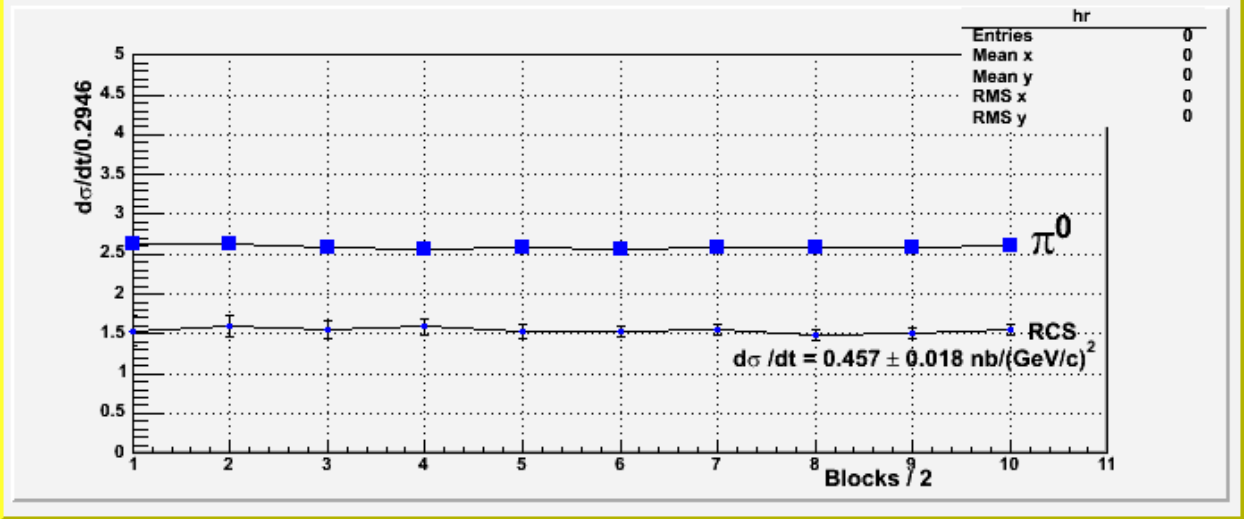
—— :MC

—— :Data









Production data: RCS+epγ+π^0

- Plot δx (in-plane correlation)
- Use (δx && δy) cuts to isolate π^0, determine scaling ratio
- Place cut on central peak, look on $E_{calorimeter}$: RCS + epγ + π^0
- Determine ratio for RCS and epγ
  => $\sigma = f_{rcs} * \sigma_0$
- Look on the dependence of f_{rcs} on acceptance cuts: conclusion – very stable.

Polarization observables: Final results

Results obtained by David Hamilton for K_{LL} and K_{LT}:

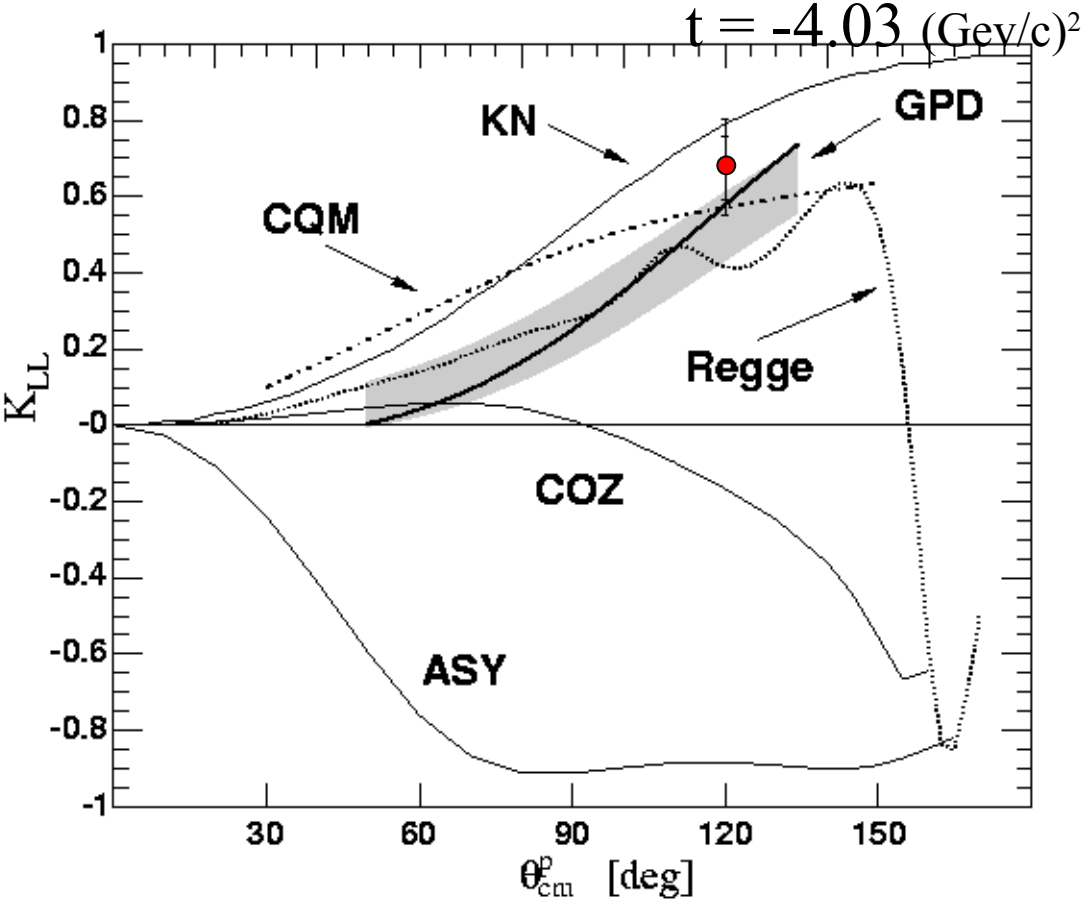
- $K_{LL} = 0.678 \pm 0.08 \pm 0.04$
- $K_{LT} = 0.114 \pm 0.08 \pm 0.04$

Publication accepted by Physical Review Letters

$$K_{LL} \approx K_{LL}^{KN} \frac{R_A(t)}{R_V(t)}$$

- Single -quark mechanism dominates
- $R_A(t) / R_V(t) \sim 1$

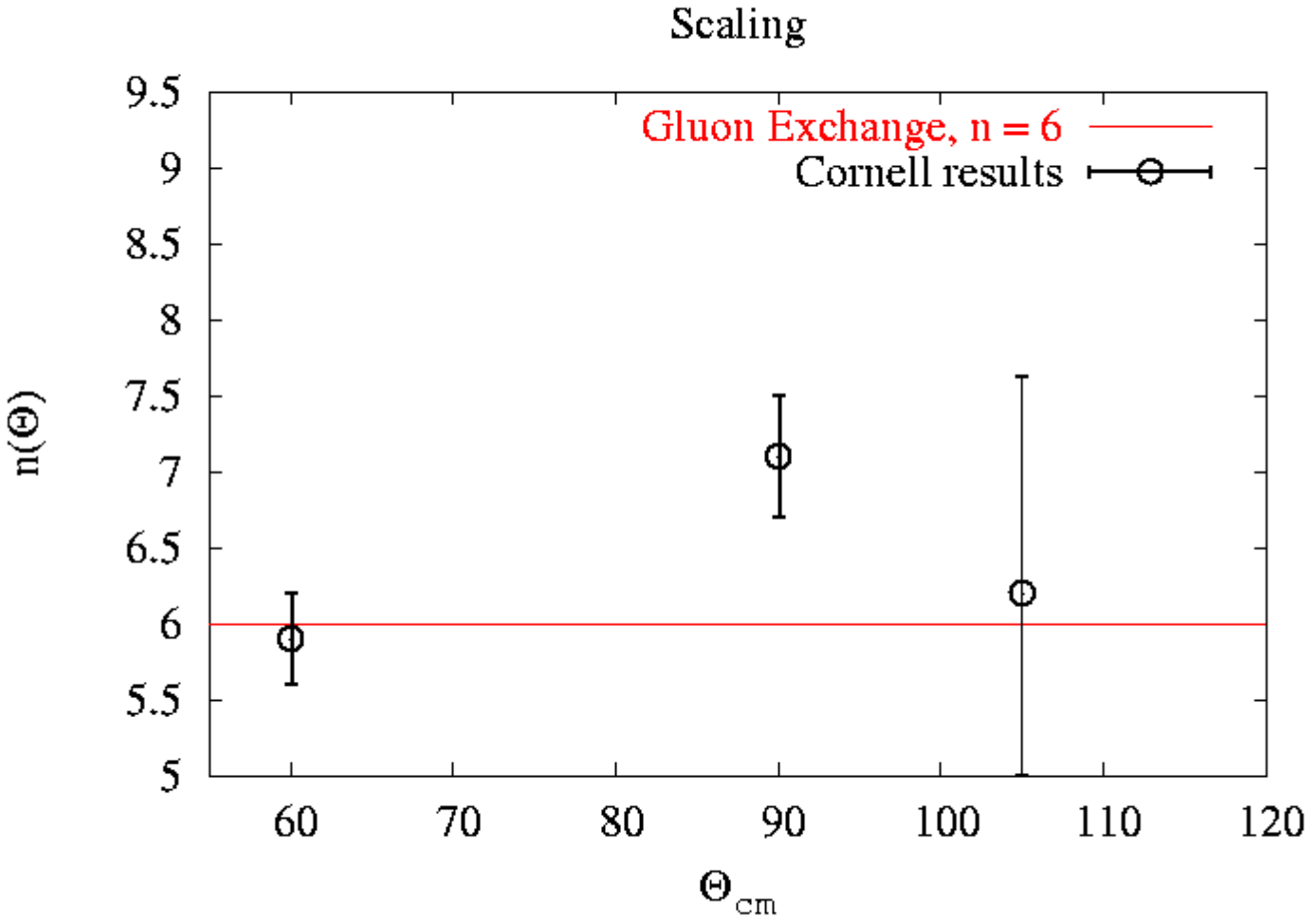
  => struck quark carries p spin



n=6 scaling of the data

Gluon Exchange: $\frac{d\sigma}{dt} = \frac{f\left(\theta_{CM}\right)}{s^n}\ n=6$

Handbag: n(t) =~ 6



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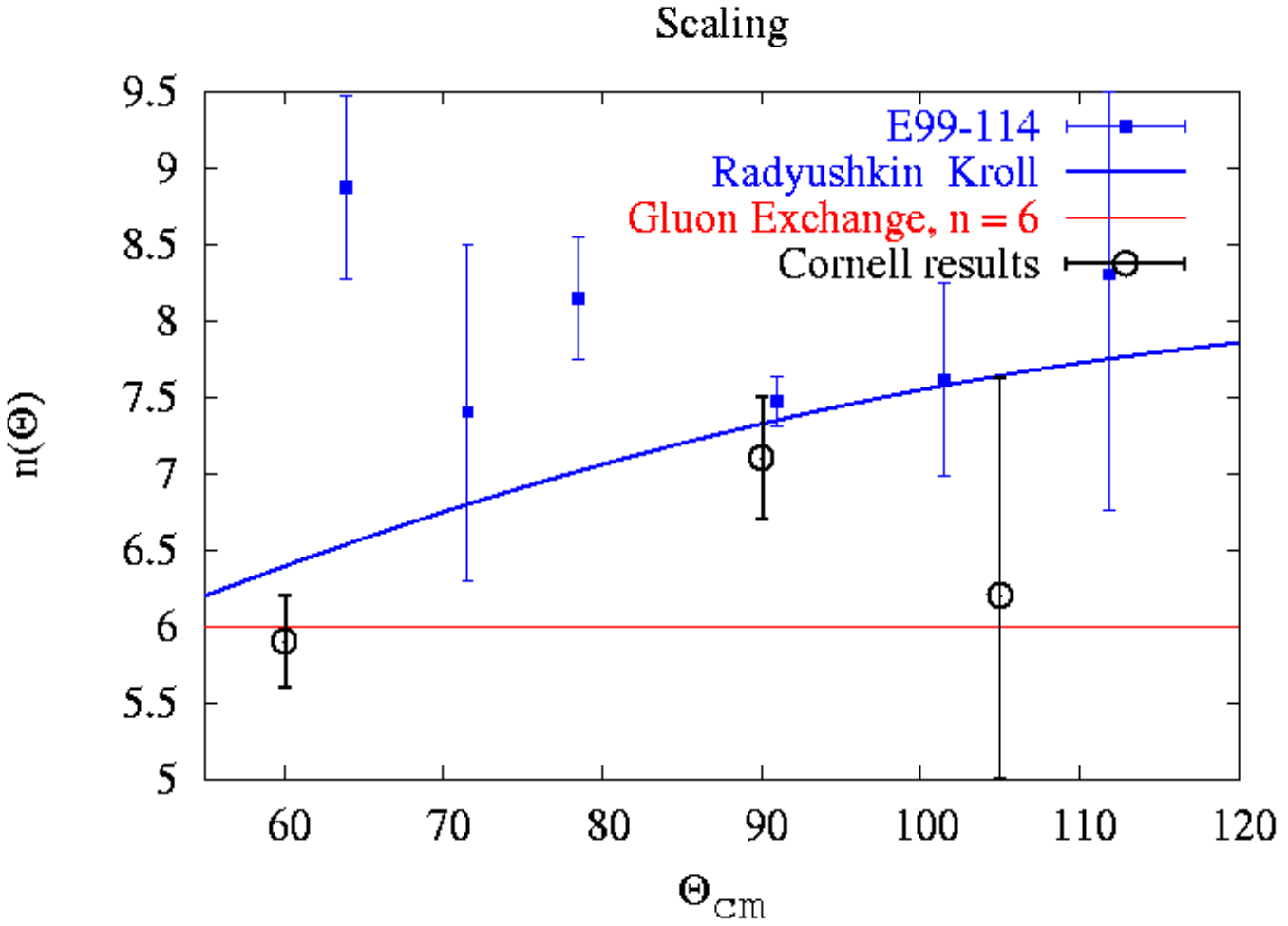
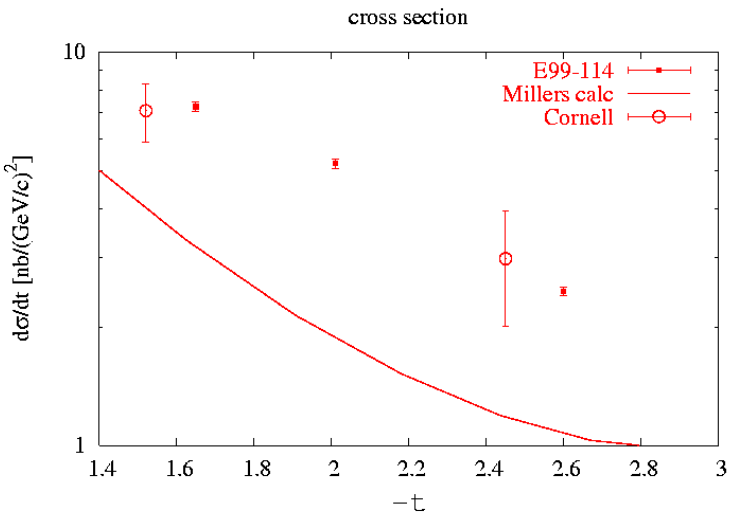
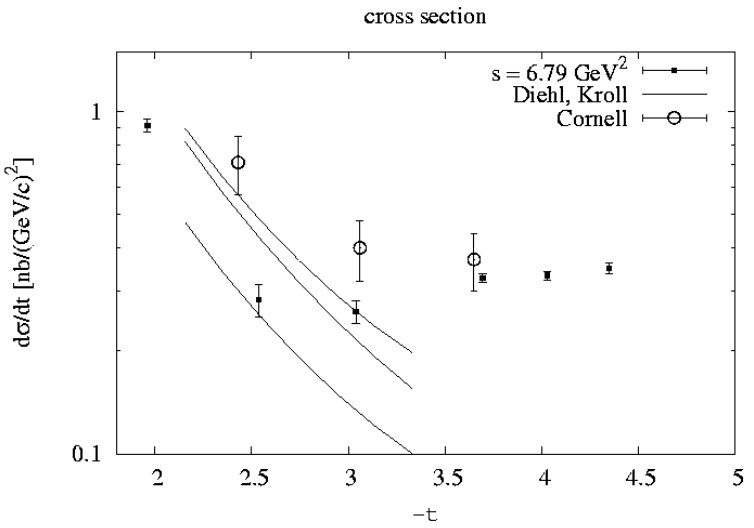
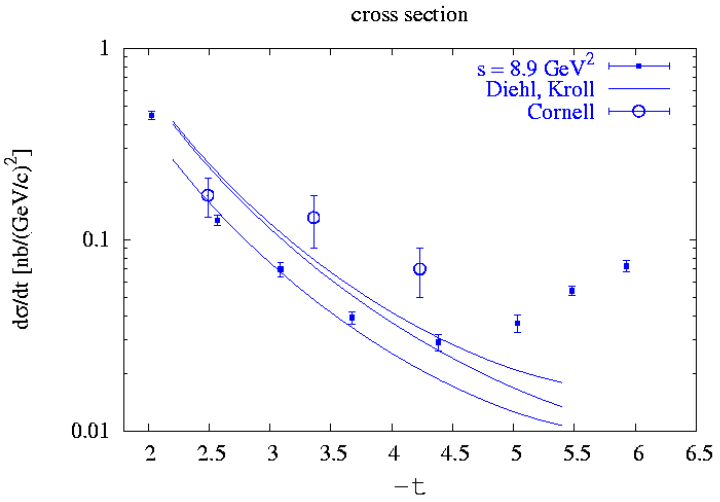
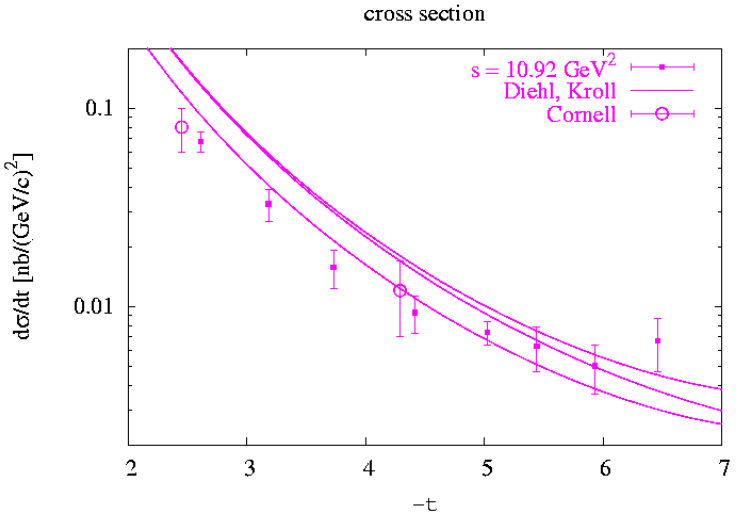


Preliminary Cross Sections

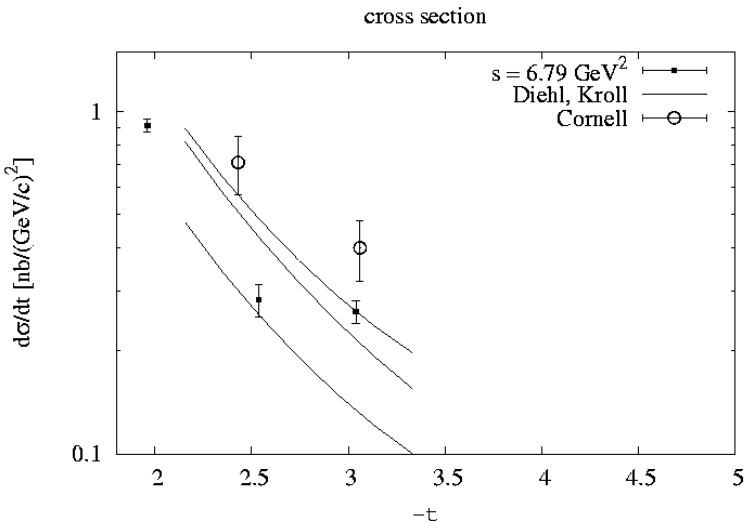


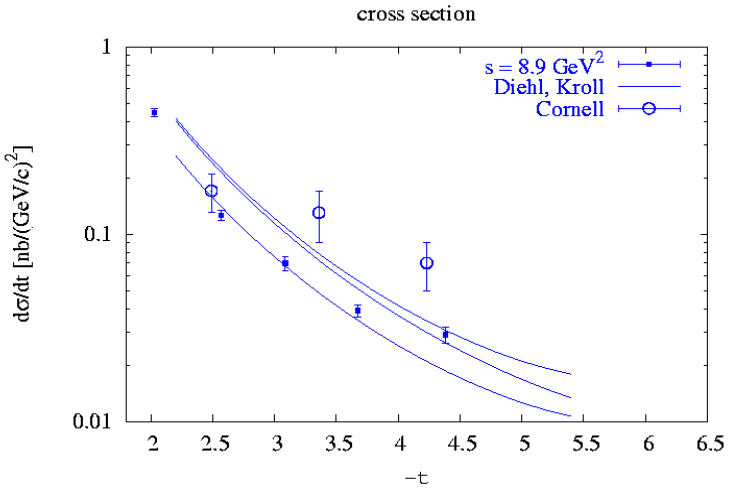


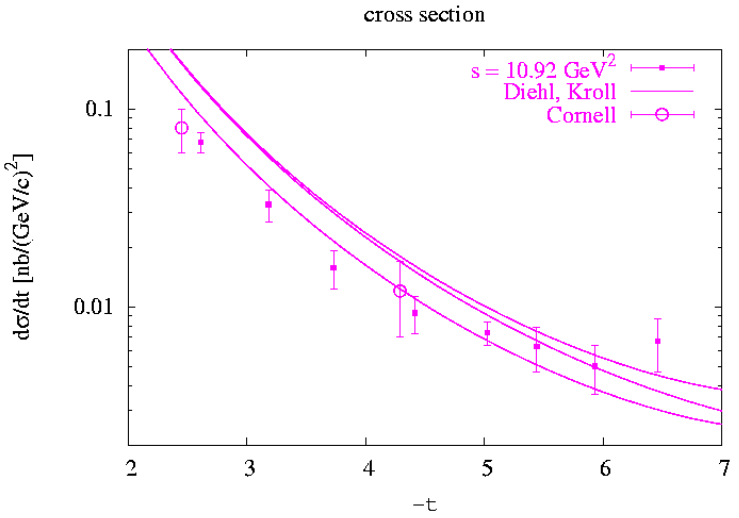




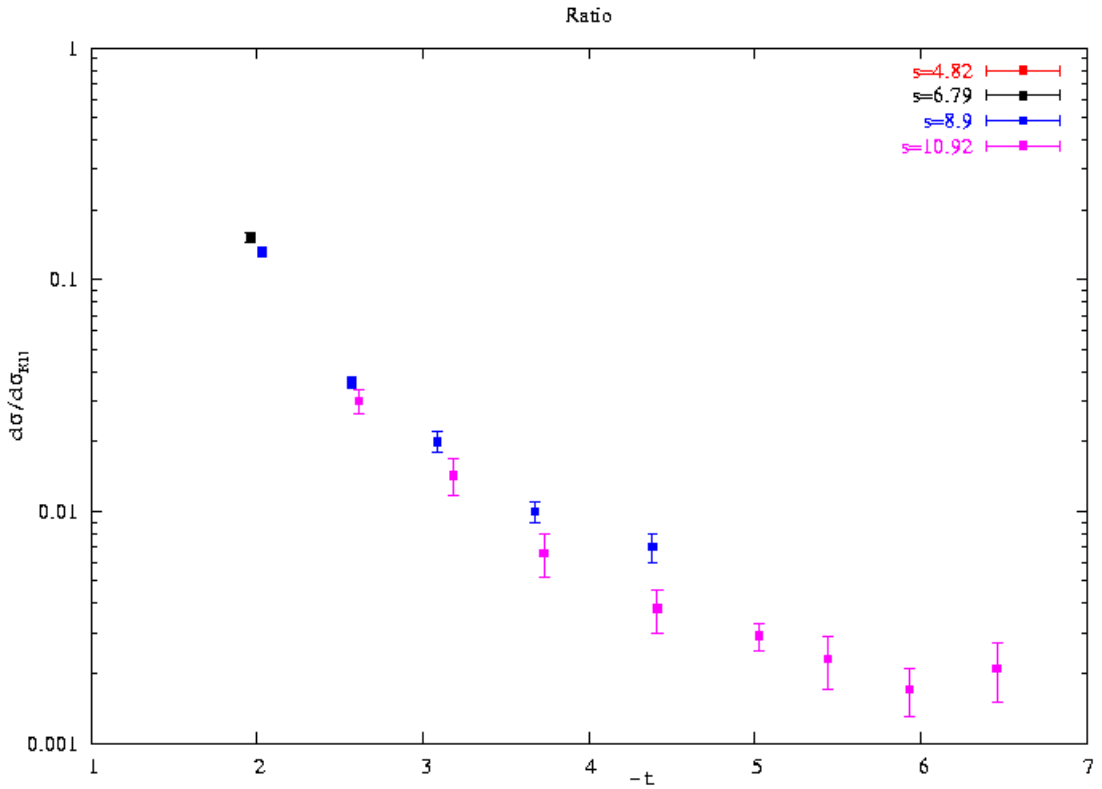
Preliminary Cross Sections, | u | > 2.2



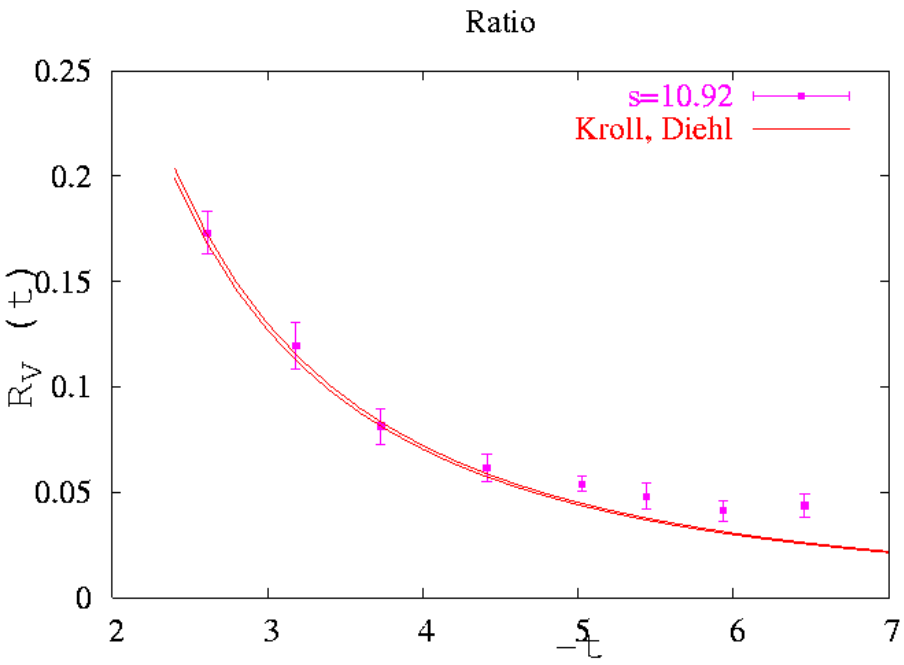




$\left(\frac{d\sigma_{RCS}}{d\sigma_{KN}} \right)$ Ratio

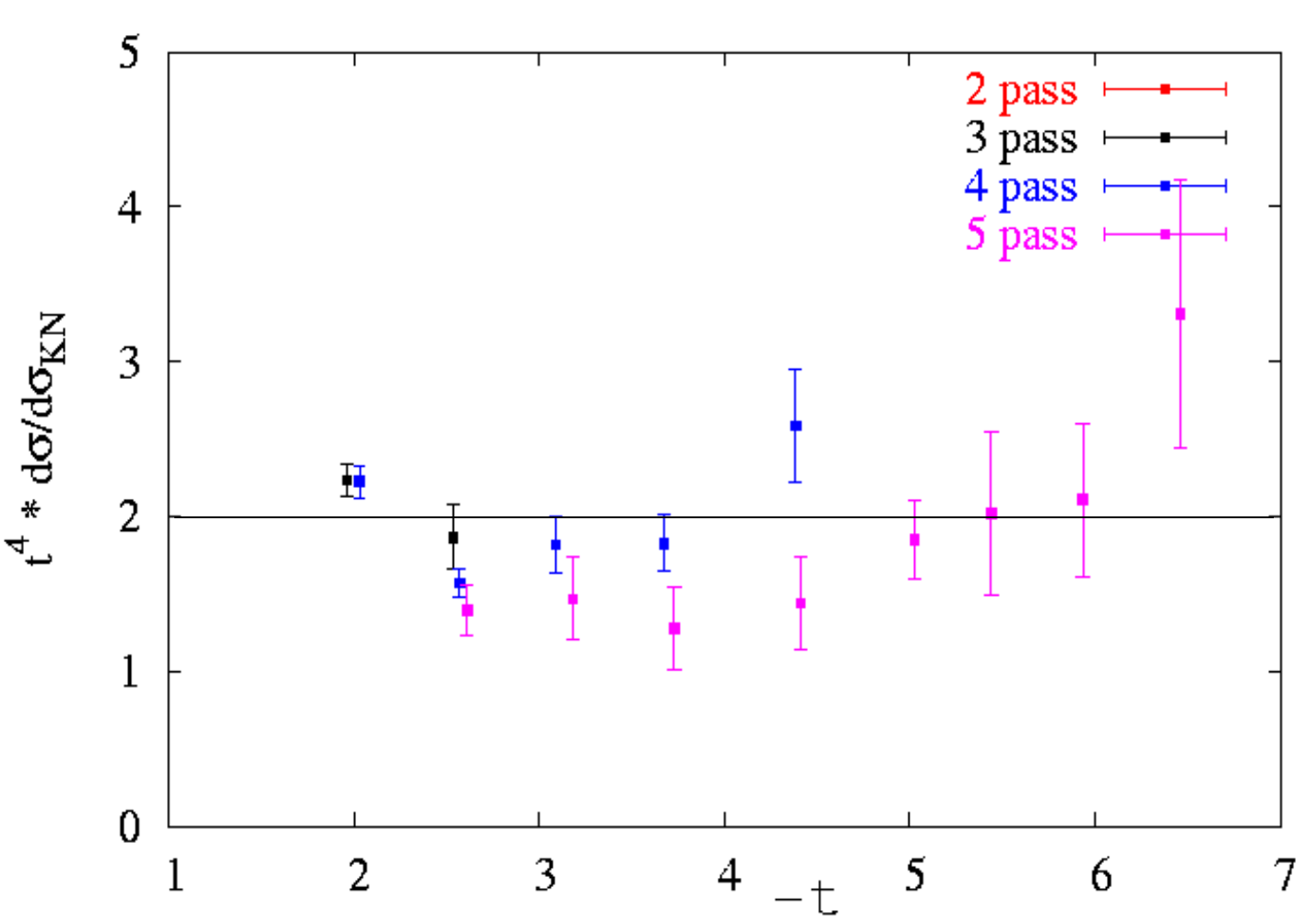


$$\left(\frac{d\sigma_{RCS}}{d\sigma_{KN}} \right) \approx R_V^2(t)$$



- A model-independent feature of Handbag Mechanism
  - s independence of $d\sigma/d\sigma_{KN}$
- Observed for some of the data with $|u| >> m_p^2$

$t^4 * d\sigma/d\sigma_{KN}$ Scaling of Cross Section



- For handbag, $t^4 * d\sigma/d\sigma_{KN}$ nearly independent of s,t
- Data for s,-t,-u > 2.5 GeV^2 in rough agreement

Conclusions:

- Polarization transfer asymmetry final results ready:
  - $R_A(t) \sim R_V(t)$
  - Results clearly favor the Soft Overlap Mechanism.

- Analysis of unpolarized cross section data using Monte Carlo is complete.
  - High u points seem to indicate s-independence of $d\sigma/d\sigma_{KN}$
  - Decent $d\sigma/dt$ agreement between theoretical model and data
  - $n(\theta)$ scaling: clear disagreement with Constituent Quark Counting Rule, and some agreement with Handbag

--> "Soft Overlap" Handbag Mechanism

  - Model seems to somewhat overestimate $d\sigma/dt$ for higher s
  - $n(\theta)$ disagreement at lower values of θ_{CM}