The Color Transparency Experiment

The search for color transparency through the A(e, e′p) reaction at 12 GeV

Latiful Kabir
(For the Hall-C Collaboration)
Mississippi State University

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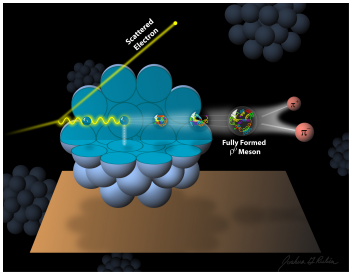
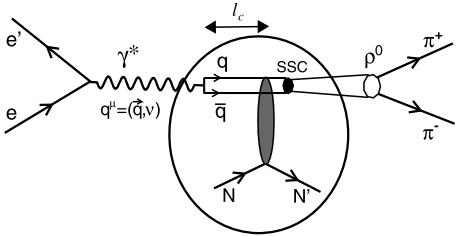
Outline

Color Transparency (CT)

- The final/initial state interaction of hadrons with the nuclear medium must vanish for exclusive processes at high momentum transfer $\Rightarrow$ QCD
- Color transparency is the reduction in interaction due to "squeezing and freezing" at high momentum transfer.
- CT first proposed by Brodsky and Mueller in 1982.

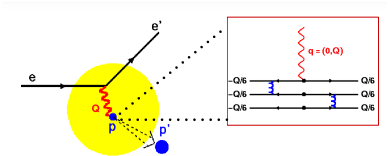


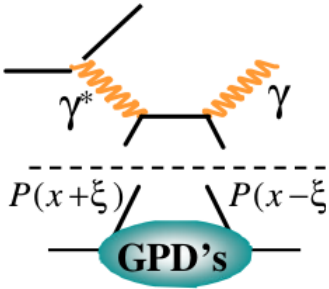


- CT is a robust prediction of QCD. The onset of CT has been observed in mesons, but is unconfirmed for baryons.

Motivation: CT in Intermediate Energies

- CT is required to explain DIS data.
- Onset of CT would be a signature of the onset of QCD degrees of freedom in nuclei.
- The onset of CT is related to the onset of factorization, which is an important requirement for accessing GPDs in deep exclusive meson production.
- Understanding hadron propagation through nuclear matter.





Signature for CT

- Nuclear transparency is the ration of cross-sections for exclusive processes from nuclei to nucleons.
- The signature of CT is an increase in the nuclear transparency.

$$T = \frac{\sigma_N}{A\sigma_0}$$

σ_0 = free (nucleon) cross-section
$\sigma_N = \sigma_0 A^\alpha$

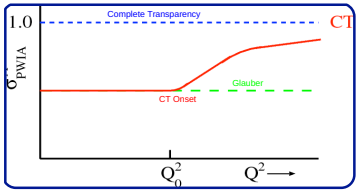
$$T = A^{\alpha-1}$$

- CT onset searches:
  1) Baryon (proton) transparency
     - A(p, 2p): BNL
     - A(e, e′p): SLAC, JLab
  2) Meson (pions and ρ^0-meson)
     - A(π, di-jet): Fermi Lab
     - A(γ, π^-p): JLab
     - A(e, e′π^+): JLab
     - A(e, e′ρ^0): DESY and JLab

$$\frac{d\sigma}{dt} \propto e^{-bt}$$

$$b = \frac{1}{3}(R_h^2 + R_p^2)$$

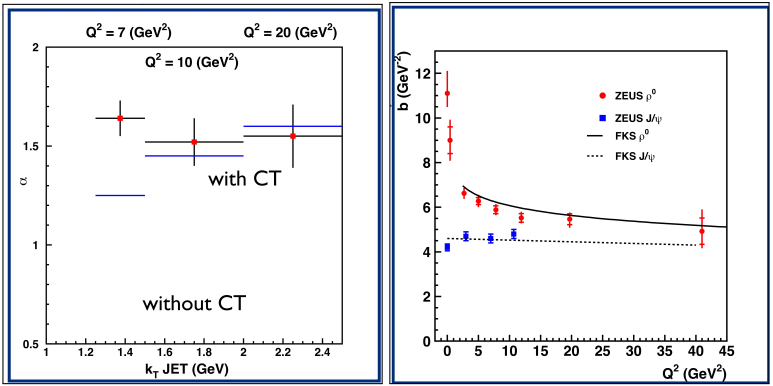
$$\sigma_{\mathrm{PLC}} \approx \sigma_{hN}\frac{b^2}{R^{h^2}}$$



Color Transparency at High Energies

- Color transparency is well established at high energies. The onset of CT is of primary interest.

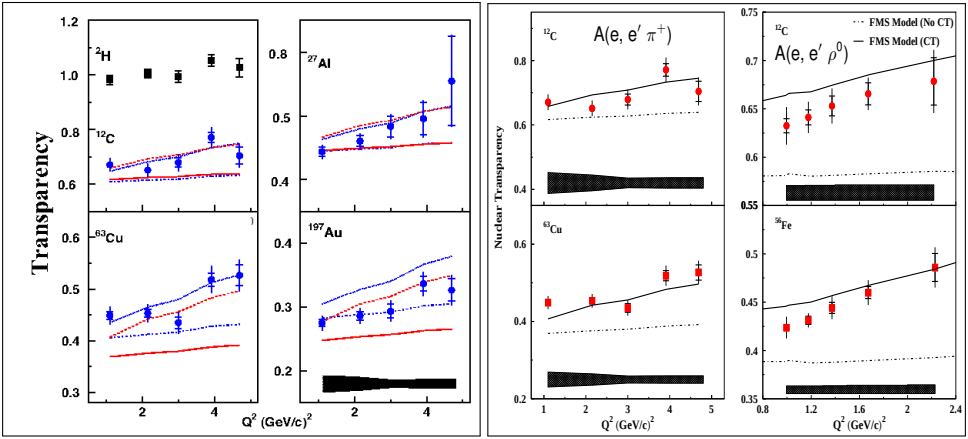
Aitala *et al.* PRL 86, 4773 (2001)



(a) Coherent diffractive dissociation of pions at Fermi lab

(b) Vector meson production at large Q^2 at HERA

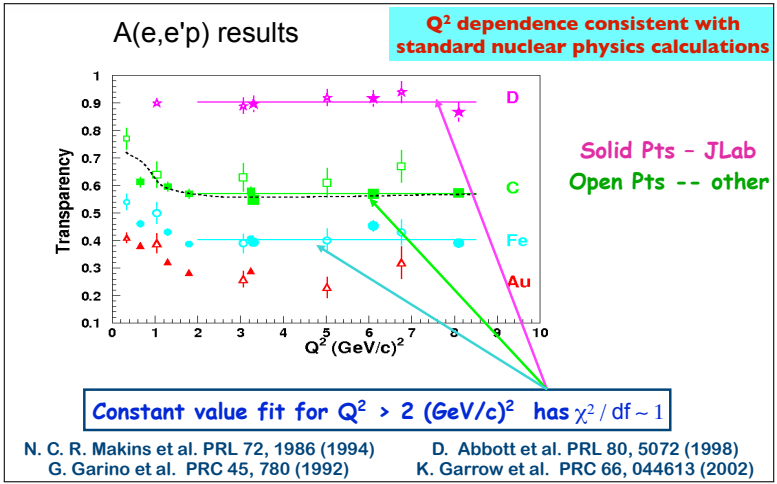
Previous Measurements: CT onset search at JLab



B.Clasie *et al.* PRL 99:242502 (2007) X. Qian *et al.* PRC81:055209 (2010) L. El Fassi *et al.* PLB 712,326 (2012)

- Hall-C experiment E01-107 (Pion electroproduction) and CLAS experiment E02-110 (ρ electroproduction) consistent with prediction of CT

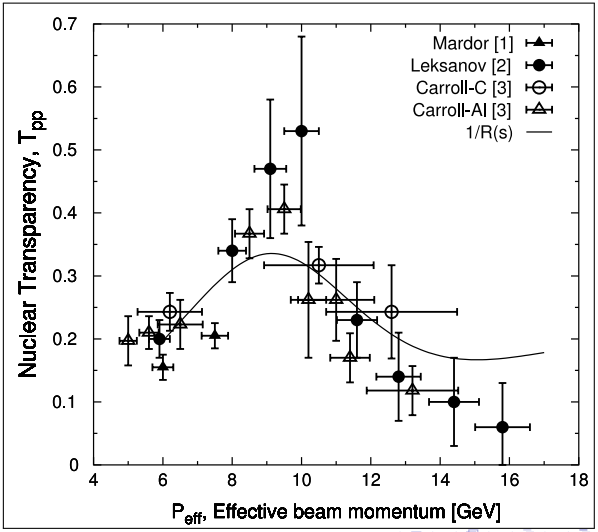
Previous Measurements: CT experiment at JLab



- No evidence for CT at 6 GeV

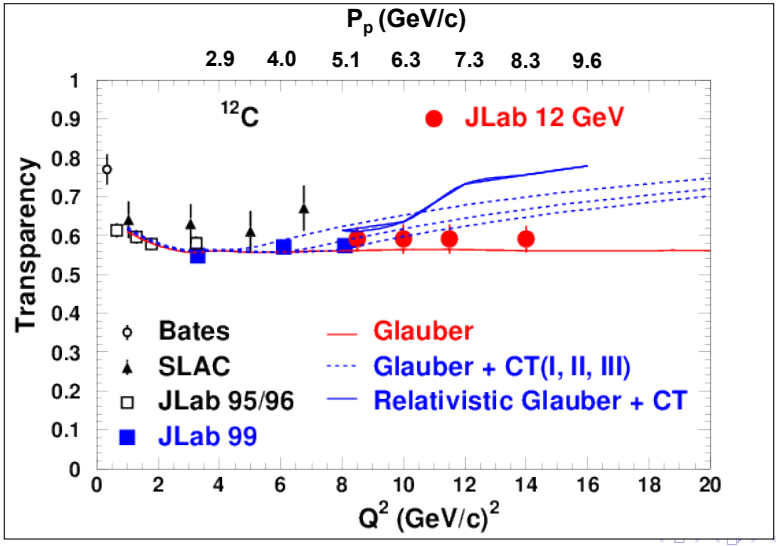
Previous Measurements: BNL Result

- (p, 2p) experiment at BNL found an enhancement in the transparency.
- Decreases at higher momentum.
- Result inconsistent with CT only
- Can be explained by including additional mechanisms such as nuclear filtering or charm resonance.



A. Leksanov *et al.* PRL 87 (2001)
J. L. S. Aclander *et al.* PRC 70 (2004)

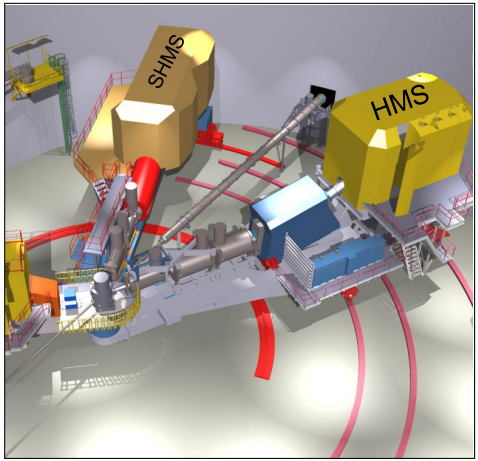
Color Transparency Experiment at JLab in 12 GeV Era



CT Experimental Setup and Requirements

- **Trigger:** Coincidence mode.
- **Spectrometers:** SHMS for proton and HMS for electron.
- **Detectors:**
  Standard detector packages from SHMS and HMS for PID.
- **Target:**
  10 cm LH_2 (Heep check)
  Al dummy (Background)
  6% ^{12}C (Production)
- Kinematic settings:

Q^2 [GeV^2]	θ_{SHMS} [deg]	$P^{central}_{SHMS}$ [GeV/c]	θ_{HMS} [deg]	$P^{central}_{HMS}$ [GeV/c]
8.0	17.1	5.122	45.1	2.131
9.5	21.6	5.925	23.2	5.539
11.5	17.8	7.001	28.5	4.478
14.3	12.8	8.505	39.3	2.982



Experimental Setup: HMS

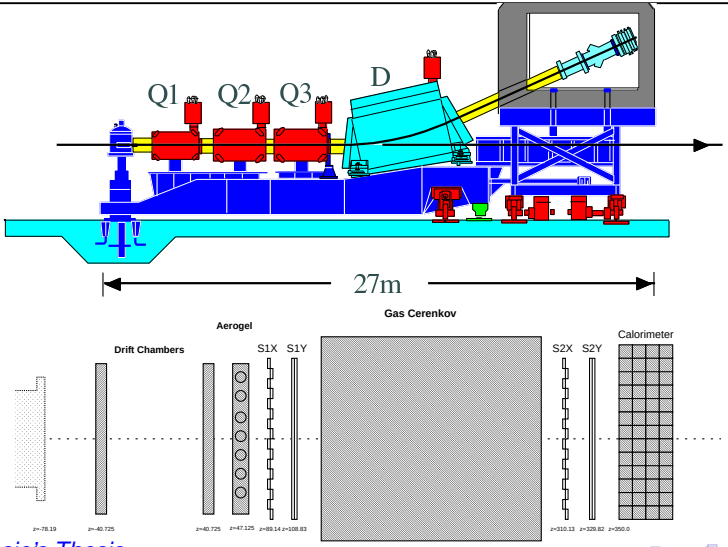
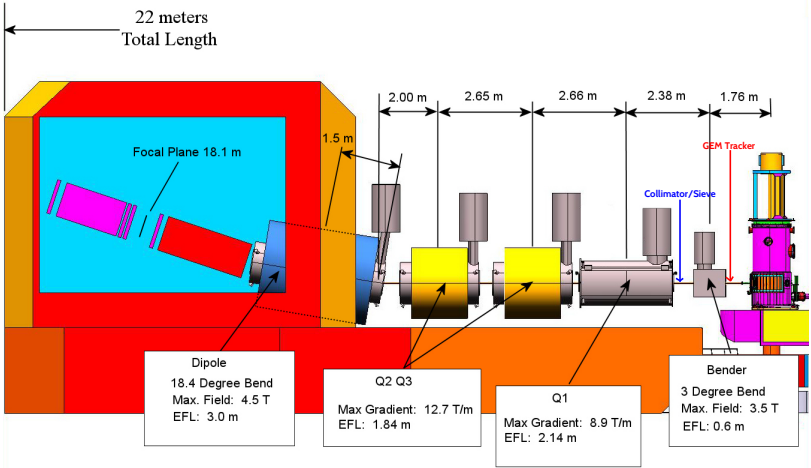


*Diagram from B. Clasie's Thesis

Experimental Setup: SHMS

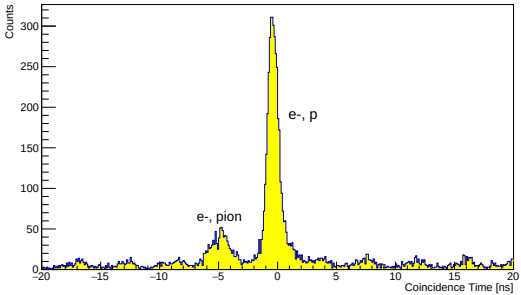


Coincidence Time

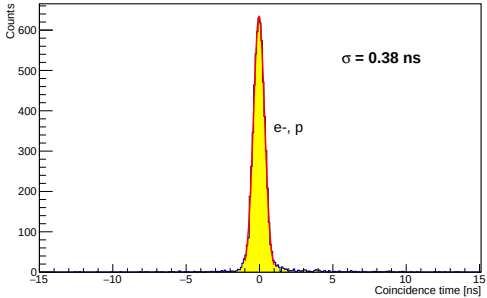
$$t_{\text{coin}} = t^{\text{tar}}_{\text{electron}} - t^{\text{tar}}_{\text{proton}}$$

$$t^{\text{coin}}_{\text{corrected}} = (t_{\text{trigger}-1} - \Delta t^{P}) - (t_{\text{trigger}-4} - \Delta t^{H})$$

$$\Delta t^{H(P)} = \Delta t^{H(P)}_{(1)} + \Delta t^{H(P)}_{(2)} + \Delta t^{H(P)}_{(3)}$$

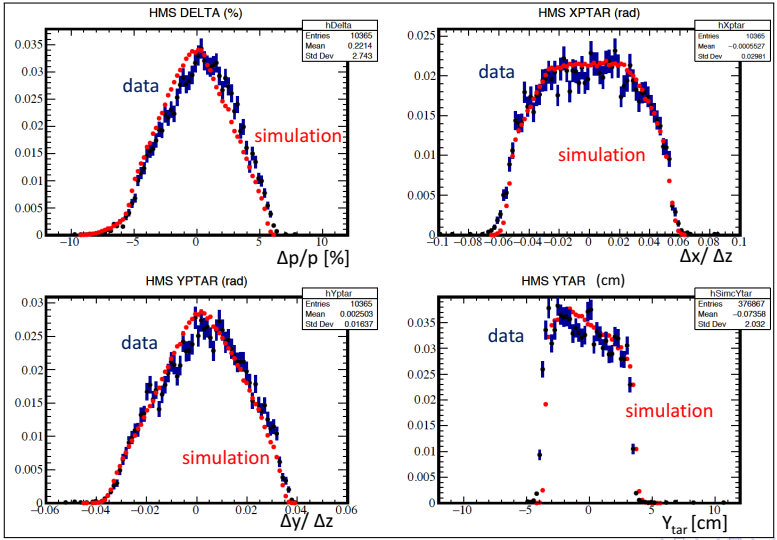


(a) Coincidence time with accidental

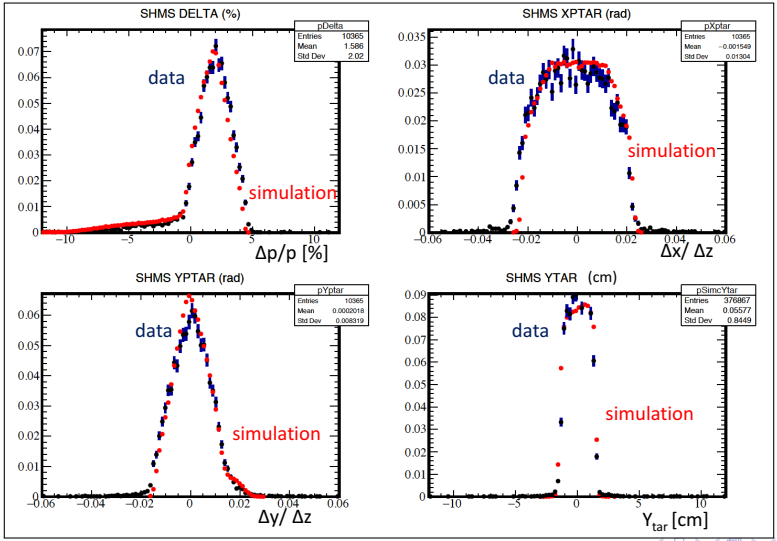


(b) Coincidence time for CT

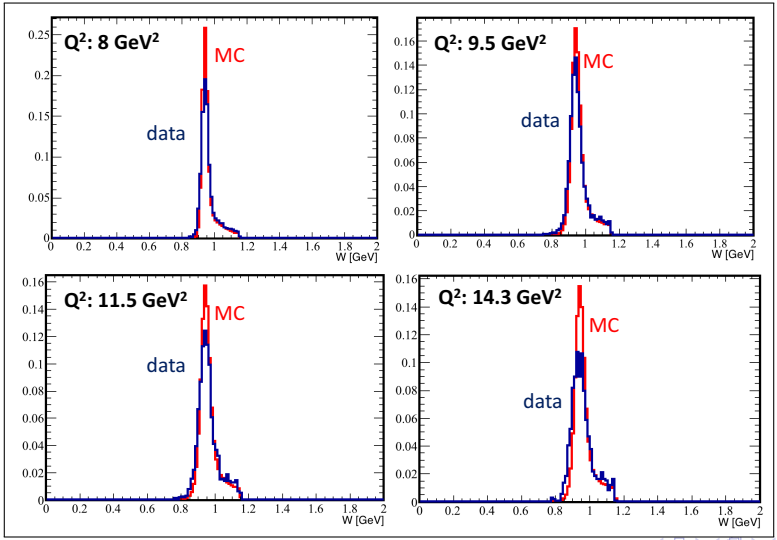
LH_2 Data at Q^2 = 8 GeV^2 : Data vs Simulation



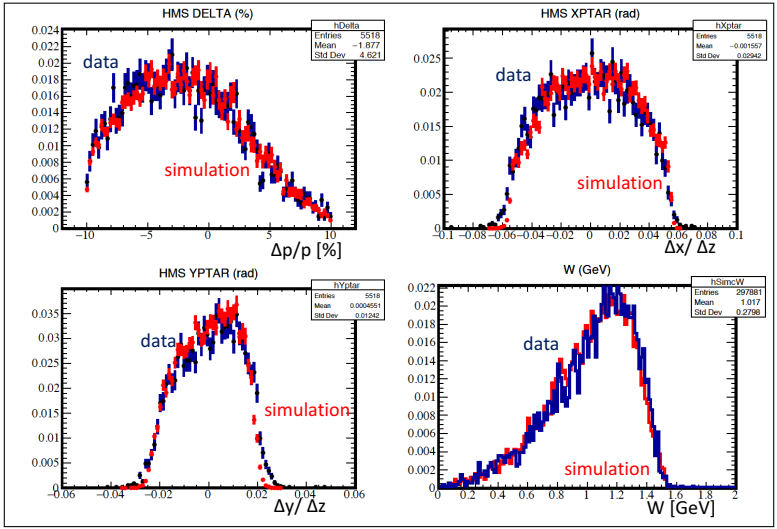
LH_2 Data at Q^2 = 8 GeV^2: Data vs Simulation



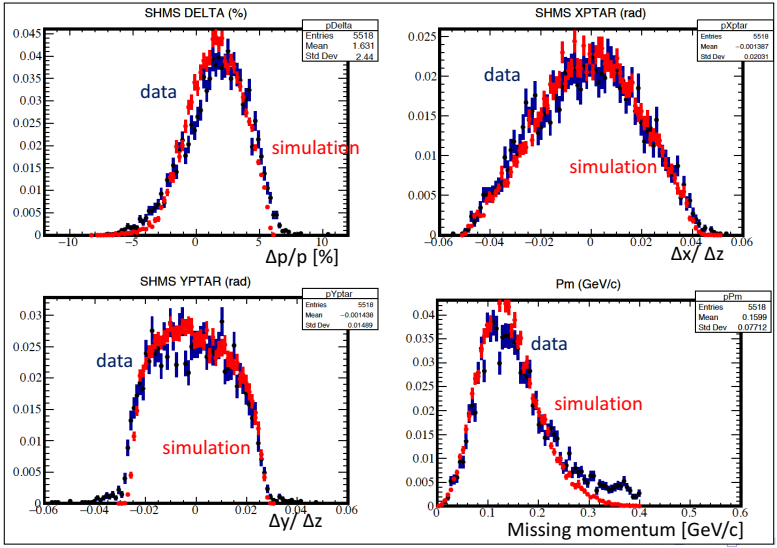
LH_2 W [GeV] Distribution: Data vs Simulation



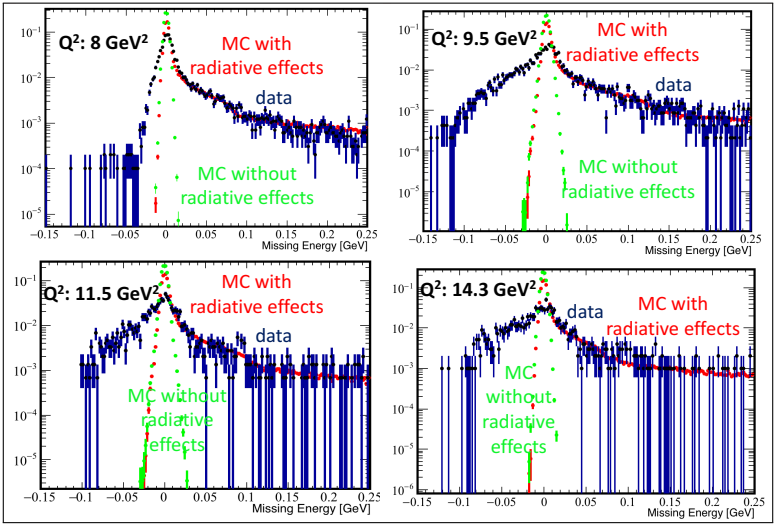
^{12}C Data at Q^2 = 8 GeV^2: Data vs Simulation



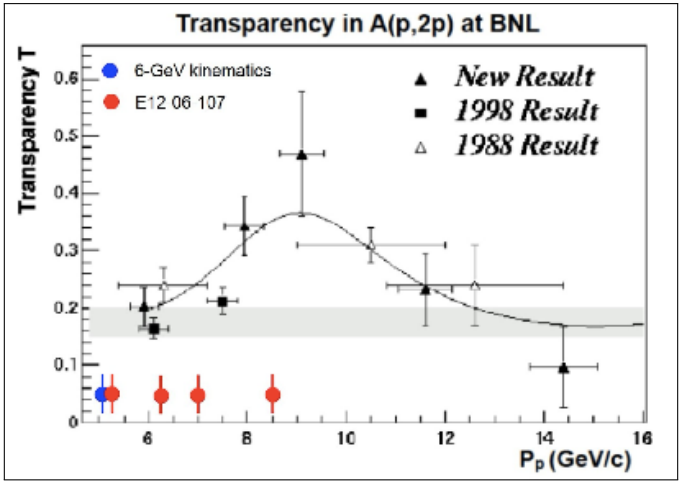
^{12}C Data at Q^2 = 8 GeV^2: Data vs Simulation



Hydrogen Radiative Tail: Data vs Simulation



Projection of the data points



BNL results:
PRL **87**, 212301 (2001)
PRL **81**, 5085 (1998)
PRL **61**, 1698 (1988)

Summary and Current Status

- The experiment aims to search for the onset of CT for protons and help understand hadron propagation through the nuclear matter .
- The proton momentum range covered in this experiment overlaps with the region where the enhancement was observed at BNL $\Rightarrow$ Will help verify the origins of the enhancement.
- We have collected four data points in the Q^2 range 8 - 14.3 GeV^2.
- The preliminary analysis shows that data to be of good quality.
- The analysis to extract transparency is in progress.
- Preliminary result by the end of this year!

Thank You!