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

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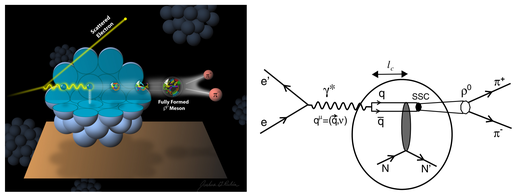
**Abstract:** The suppression of the final-state interactions of a hadron propagating through the nuclear medium at high momentum transfer is known as the color transparency (CT) and is a robust prediction of QCD. The onset of CT is of extreme interest in hadronic physics. For example, the onset of CT is related to the onset of factorization, which is an important requirement for accessing GPDs in deep exclusive meson production. The onset of CT has been observed in mesons but is unconfirmed for baryons. However, an enhancement in the transparency was observed in A(p, 2p) reactions at BNL. The E12-06-107 experiment in Hall-C seeks to measure the proton transparency up to the highest $Q^2$ achievable using the 12-GeV beam at the Jefferson Lab. The experiment used SHMS-HMS spectrometer pair to perform the coincidence measurement from the reaction A(e, e′p). The proton momentum range covered in the experiment overlaps with the region where the enhancement was observed at BNL, and hence this experiment will help verify the origins of the enhancement and at the same time search for the onset of CT for protons. We took data last spring and the analysis is now well advanced.

## Color Transparency (CT)

- The final/initial state interaction of hadrons with the nuclear medium must vanish for exclusive processes at high momentum transfer ⇒ QCD.
  - Color transparency is the reduction in interaction due to "squeezing and freezing" at high momentum transfer.





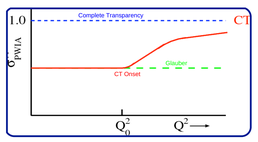


The concept of CT is illustrated using meson. In our experiment we are interested in CT in baryon (proton)

- Experimentally the signature of CT is an increase in the nuclear transparency.

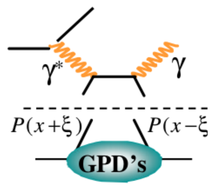
$$T = \frac{\sigma_N}{A\sigma_0}$$

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




## Motivation For CT Experiment

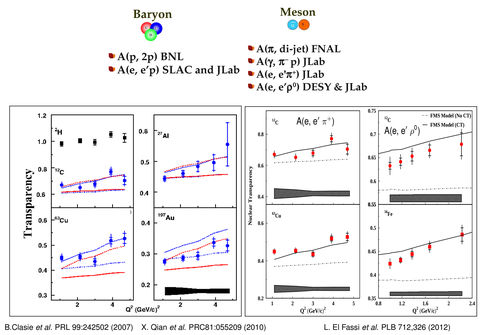
- CT is a robust prediction of QCD. The onset of CT has been observed in mesons, but is unconfirmed for baryons.
- Onset of CT would be a signature of the onset of QCD degrees of freedom in nuclei.




GPD

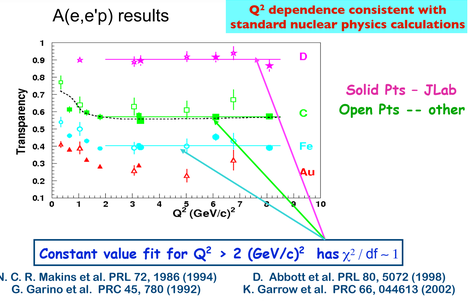
- The onset of CT is related to the onset of factorization, which is an important requirement for accessing GPDs in deep exclusive meson production.
- Understanding hadron propagation through nuclear matter.

## Previous Measurements



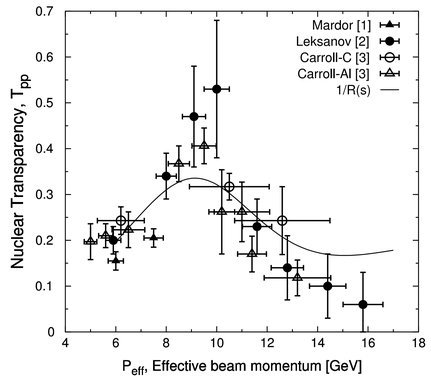

B.Clasie *et al.* PRL 99:242502 (2007) X. Qian *et al.* PRC81:055209 (2010) L. El Fassi *et al.* PLB 712,326 (2012)

Results from Hall-C experiment E01-107 (Pion electroproduction) and CLAS experiment E02-110 ($\rho$ electroproduction) are consistent with the prediction of CT.



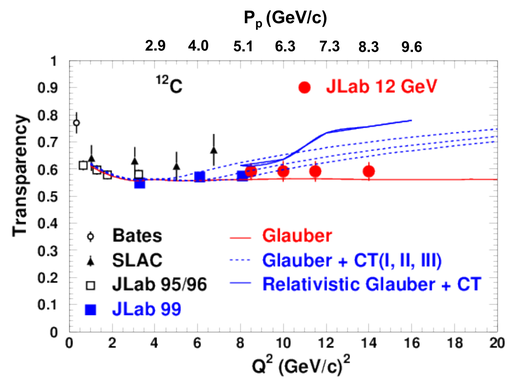

N. C. R. Makins et al. PRL 72, 1986 (1994) G. Garino et al. PRC 45, 780 (1992) D. Abbott et al. PRL 80, 5072 (1998) K. Garrow et al. PRC 66, 044613 (2002)

CT experiments up to maximum $Q^2$ achievable with 6 GeV beam found no evidence for CT in baryons.

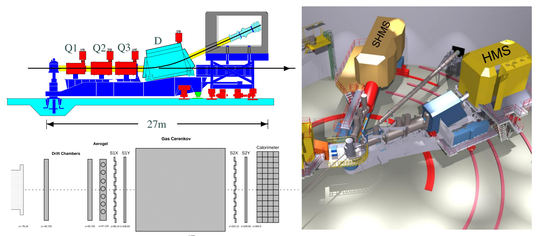



The A(p, 2p) experiment at BNL found an enhancement in the transparency. However, it also shows an reduction at higher momentum. This result is inconsistent with CT only. But it can be explained by including additional mechanisms such as nuclear filtering or charm resonance.

## CT at 12GeV: Current Experiment



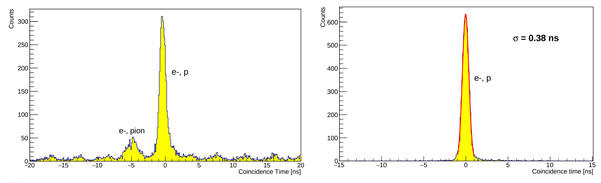

Current CT experiment at 12 GeV has a significant overlap with the $Q^2$ region covered by the BNL experiment. Thus the experiment will help explain the origion of the enhencement, and at the same time look for the on-set of CT for proton.




The experiment used SHMS as the hadron arm and HMS as the electron arm.

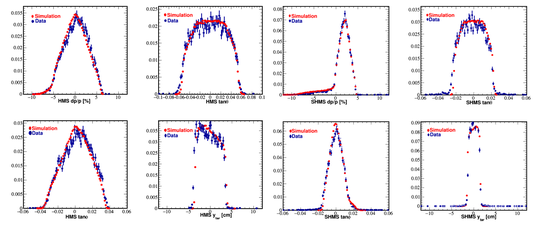
| $Q^2$ [GeV$^2$] | $\theta_{SHMS}$ [deg] | $P^{central}_{SHMS}$ [GeV/c] | $\theta_{HMS}$ [deg] | $P^{central}_{HMS}$ [GeV/c] |
|---|---|---|---|---|
| 8.0 | 17.1 | 5.122 | 45.1 | 2.131 |
| 9.5 | 21.6 | 5.925 | 23.2 | 5.539 |
| 11.5 | 17.8 | 7.001 | 28.5 | 4.478 |
| 14.3 | 12.8 | 8.505 | 39.3 | 2.982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

**Trigger:** Coincidence mode.
**Spectrometers:** SHMS for p HMS for e-.
**Target:** 10 cm $LH_2$ (Heep check) Al dummy (Background) 6% $^{12}$C (Production)
**Beam current:** 65 $\mu$A

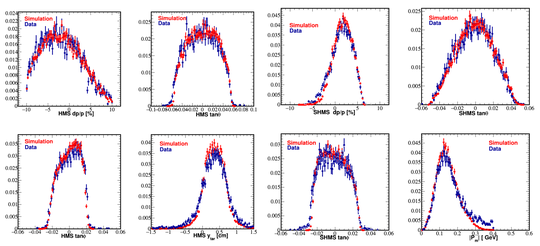



The left plot shows coincidence-time taken intentionally with accidentals. The right plots shows typical coincidence-time during the experiment with very few accidentals.

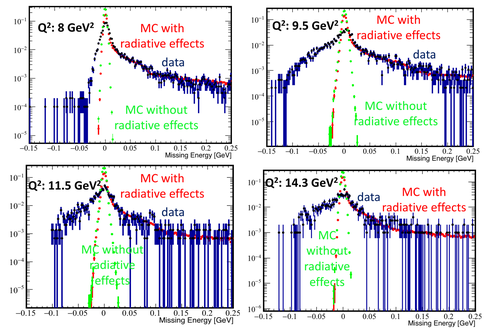
## Data Quality




Reconstructed quantities from HMS(left) and SHMS (right) with LH2 target at $Q^2 = 8.0$ GeV$^2$




Reconstructed quantities from HMS(left) and SHMS (right) with the production target $^{12}$C at $Q^2 = 8.0$ GeV$^2$




Hydrogen radiative effects are in agreement with simulation.

## Conclusion

- The experiment aims to search for the onset of CT for protons and will help understand hadron propagation through the nuclear matter.
- Because of the overlap with BNL $Q^2$ region, it will resolve the dilemma related to the enhancement observed.
- The analysis to extract transparency is well advanced. We are finalizing detector calibrations, efficiencies and other systematics.