Measuring Time-Like Compton Scattering at the EIC with Detector 1 and at JLAB with CLAS12

Kayleigh Gates
University of Glasgow, Scotland

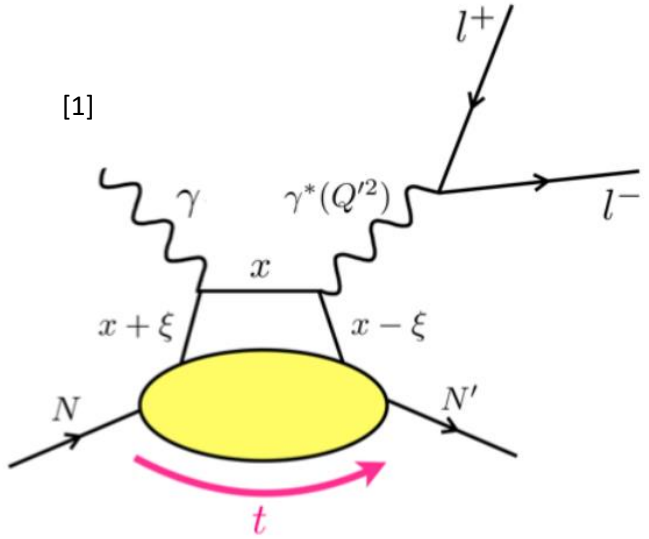
Time-Like Compton Scattering (TCS)

- Exclusive process, often referred to as inverse of Deeply Virtual Compton Scattering (real photon production).
- A real photon interacts with the target nucleon, causing release of virtual photon which decays into a lepton pair.

$$ep \rightarrow e'p'\gamma^*$$
$$\gamma^* \rightarrow \mu^+\mu^- \; or \; e^+e^-$$

- TCS gives access to GPD's via interference with Bethe Heitler Process

[1]



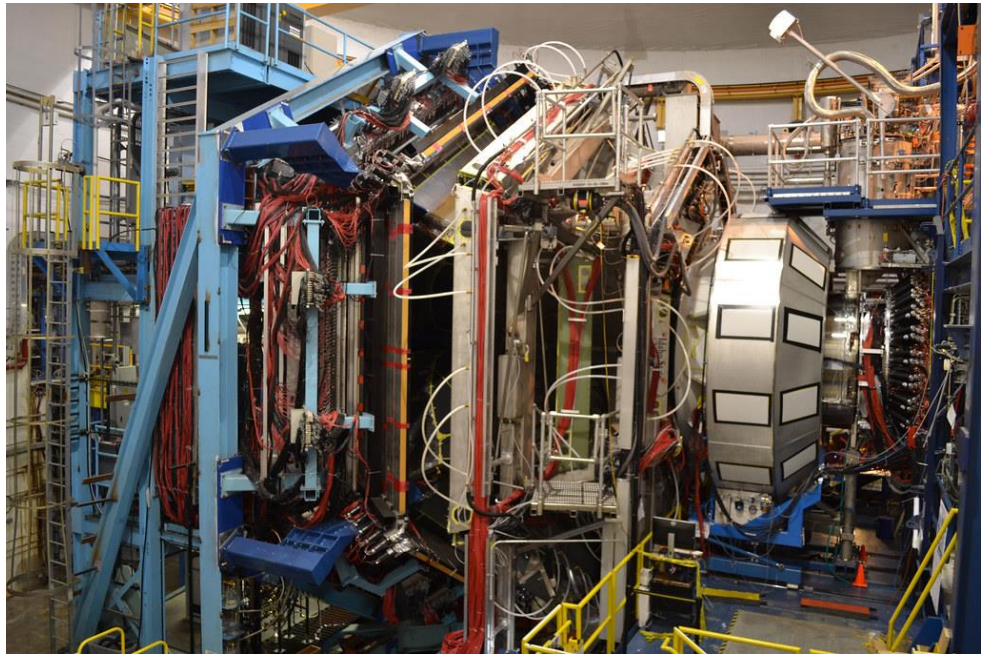
$$Q^2 = -q^2 = -(k-k')^2$$
$$t = (p'-p)^2 = (q-q')^2$$
$$Q'^2 = q'^2 = (l^+ + l^-)^2$$

[1] Science Requirements and Detector Concepts for the Electron-Ion Collider: EIC Yellow Report e-Print: 2103.05419 [physics.ins-det]

[2] Horn, T., Y. Illieva, F. J. Klein, P. Nadel-Turonski, R. Paremuzyan, and S. Stepanyan. 2011, *AIP Conference Proceedings*. Vol. 1374. Virginia. https://doi.org/10.1063/1.3647199

CLAS12 Detector – Jefferson Lab

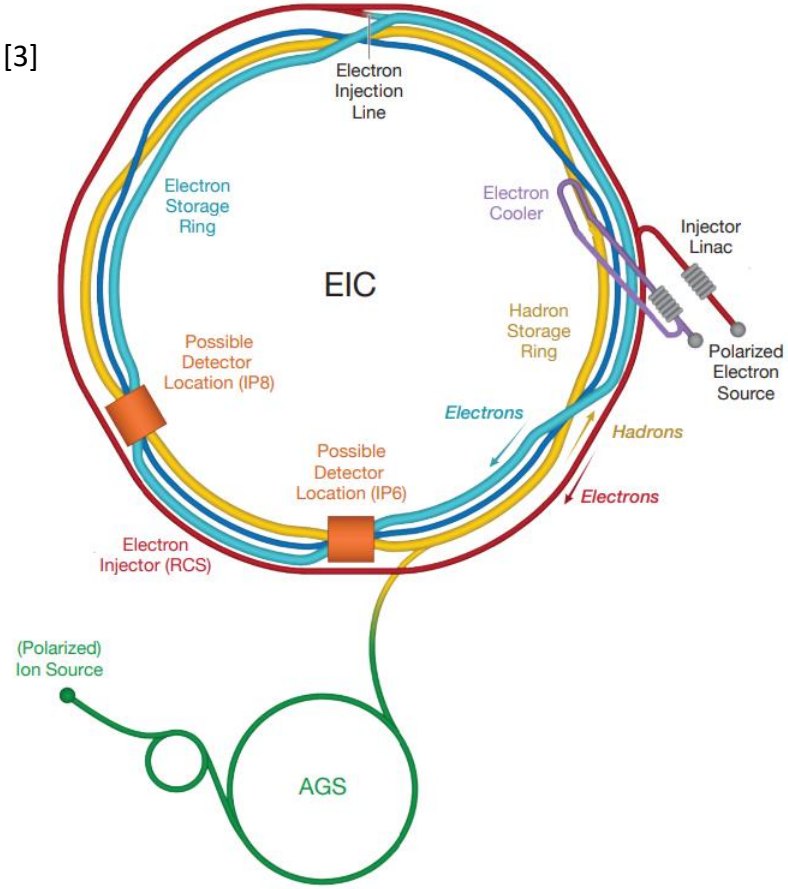
- 2π azimuthal angular coverage
- Polar angle θ coverage 35◦ – 125◦ provided by the central solenoid magnet and detector
- Forward polar angle range > 35◦ provided by a forward superconducting torus magnet and forward detector.
- Coverage allows for efficient detection of both charged and neutral particles.



The Electron Ion Collider

- Polarised electron and ion collisions allow access to different GPDs, and can allow studies of TCS on proton and deuteron.
- High collision luminosity crucial for TCS due to its low cross section.
- Wide range of centre of mass energies, around 20-100 (140) GeV[1] gives access to range of momentum fraction x.

[3]



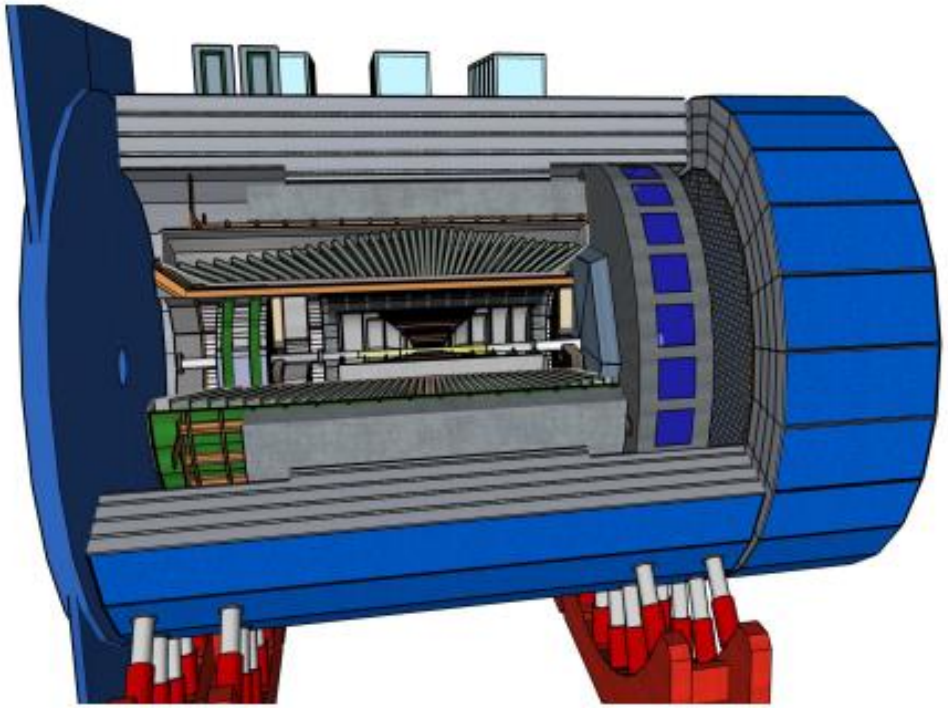
[1] Science Requirements and Detector Concepts for the Electron-Ion Collider: EIC Yellow Report e-Print: 2103.05419 [physics.ins-det]

[3] Newsroom Media & Communications Office. (2020). *U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility.* Available: https://www.bnl.gov/newsroom/news.php?a=116996. Last accessed 15/04/2022.

EPIC Detector

- Repurposed BaBar superconducting solenoid providing 1.4T field
- Hermetic detector necessary for exclusive reconstruction
- Many detectors integrated in the beam line, e.g Roman Pots (RP), B0, Zero-Degree Calorimeter (ZDC)

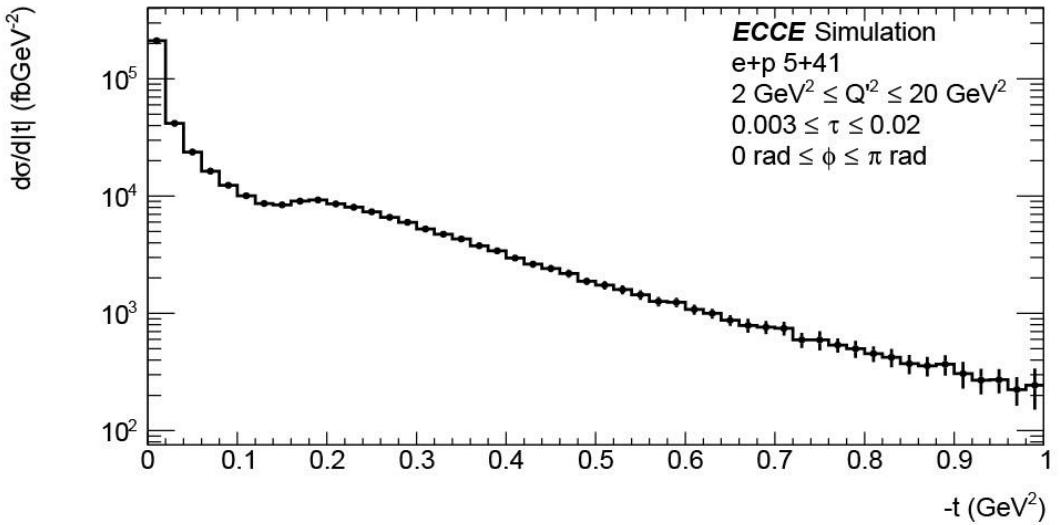
[4]

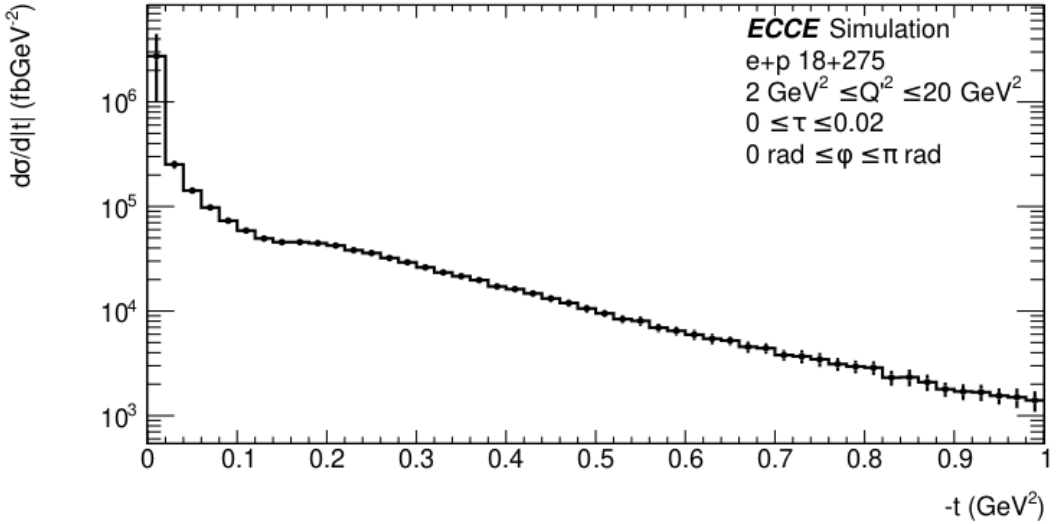


[4] Tanja Horn CUA/JLab. *ECCE Detector.* Available: https://indico.bnl.gov/event/13614/contributions/58010/attachments/38779/64096/ECCE_Detector-nb.pdf.

Preliminary t Cross Section

- Beam energy 5x41 at the top, and 18x275 on the bottom.
- The scale of the cross section is in femtobarns (fb) and is binned in $Q'^2, \tau(= \frac{Q'^2}{2(p.q)})$ and ϕ
- Multi-dimensional binning of cross section shown possible and that it is feasible to access a range of t across the kinematic region of interest.





Thank you!

PLEASE FEEL FREE TO COME AND FIND ME FOR QUESTIONS, AND GO AHEAD AND CHECK OUT MY POSTER!

References

TCS:

- Time - like Compton scattering: Exclusive photoproduction of lepton pairs, Edgar R. Berger(Ecole Polytechnique)M. Diehl(DESY)B. Pire(Ecole Polytechnique)(Oct, 2001) Published in: *Eur.Phys.J.C* 23 (2002) 675-689, e-Print: hep-ph/0110062 [hep-ph]
- Pierre Chatagnon. Nucleon Structure studies with CLAS12 at Jefferson Lab: Timelike Compton Scattering and the Central Neutron Detector. PhD thesis, Paris-Saclay, Orsay, France, October 2020.
- Horn, T., Y. Illieva, F. J. Klein, P. Nadel-Turonski, R. Paremuzyan, and S. Stepanyan. 2011. "Timelike Compton Scattering." *AIP Conference Proceedings*. Vol. 1374. Virginia. https://doi.org/10.1063/1.3647199

Yellow Report:

- Science Requirements and Detector Concepts for the Electron-Ion Collider: EIC Yellow Report: R. Abdul Khalek(Vrije U., Amsterdam and Nikhef, Amsterdam), A. Accardi(Hampton U. and Jefferson Lab), J. Adam(Brookhaven), D. Adamiak(Ohio State U.), W. Akers(Jefferson Lab)et al.(Mar 8, 2021) e-Print: 2103.05419 [physics.ins-det]

EpIC:

- B. Berthou *et al., PARTONS: PARtonic Tomography Of Nucleon Software: A computing platform for the phenomenology of Generalized Parton Distributions*, Eur. Phys. J. C78 (2018), 478, DOI: 10.1140/epjc/s10052-018-5948-0
- Aschenauer, E.C., Batozskaya, V., Fazio, S., Gates, K., Moutarde, H., Sokhan, D., Spiesberger, H., Sznajder, P. and Tezgin, K., 2022. EpIC: novel Monte Carlo generator for exclusive processes. arXiv preprint arXiv:2205.01762.

ECCE:

- C Pinkenburg. Fun4all - the eic software group website. URL:https://eic.github.953io/software/fun4all.html
- Newsroom Media & Communications Office. (2020). *U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility.* Available: https://www.bnl.gov/newsroom/news.php?a=116996. Last accessed 15/04/2022.
- Tanja Horn CUA/JLab. ECCE Detector. Available: https://indico.bnl.gov/event/13614/contributions/58010/attachments/38779/64096/ECCE_Detector-nb.pdf.