

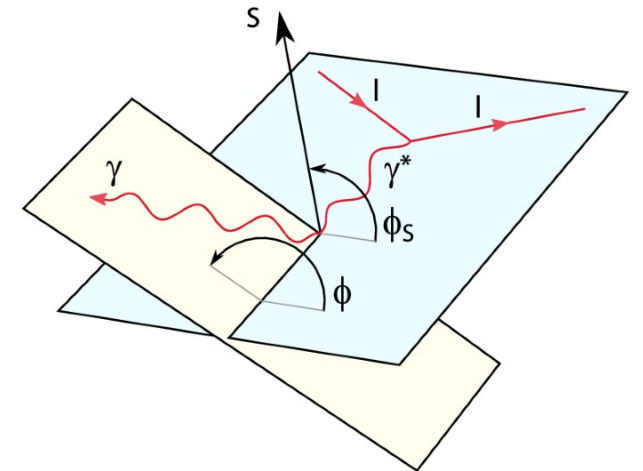
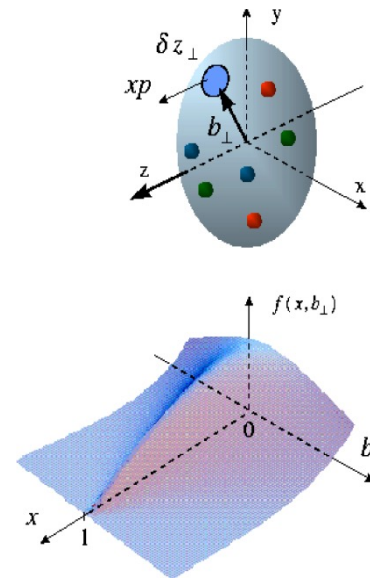
Exclusive Reactions Working Group Update

ECCE IB Meeting
27/09/21

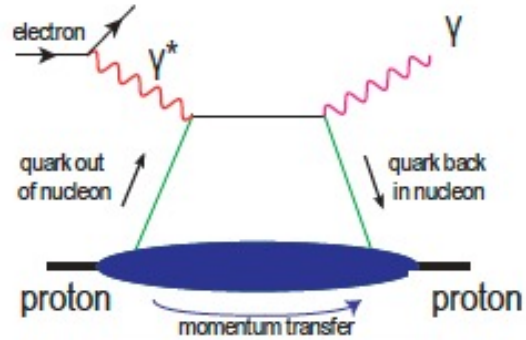
Co-convenors:

J. Roche (Ohio University)

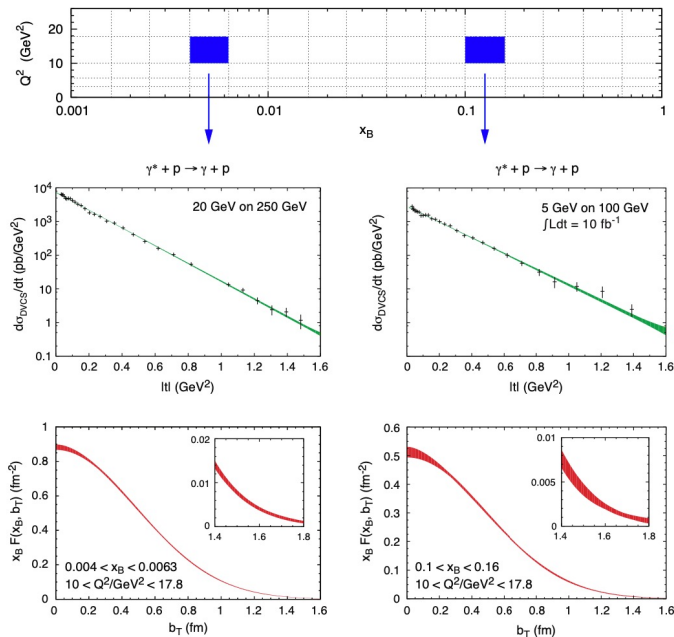
R. Montgomery (University of Glasgow)



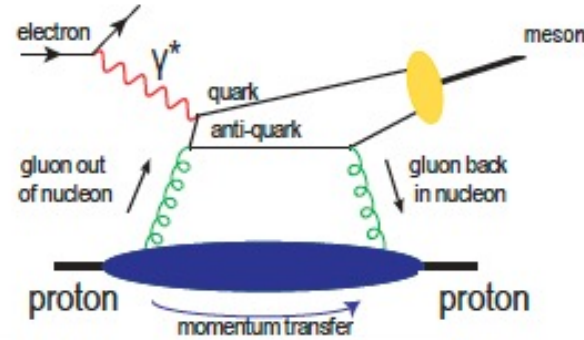
EIC Exclusive Physics and Priorities for our Group



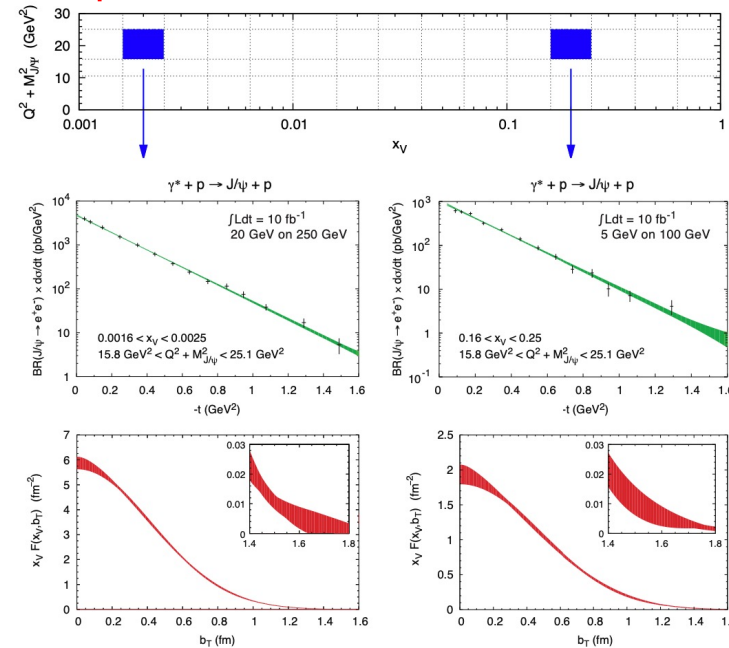
γ production (DVCS) from ep



From EIC “white paper”



J/ψ production (DVMP) from ep



To demonstrate ECCE can deliver exclusive physics of EIC, priorities :

- DVCS
- DVMP

Absolutely key for:

- GPD extractions
 - nucleon OAM and spin
- Transverse profiles of quarks and gluons
- multi-dimensional imaging of quarks and gluons in nucleons/nuclei

Exclusive Studies and Team Members

- Physics Convenors: C. Camacho (Orsay); R. Reed (LU)
- Exclusive Co-convenors: J. Roche (OU); R. Montgomery (UoG)
- **DVCS ep: I. Korover, MIT (NAS topic 1)**
- **DVCS eA (^4He): G. Penman, UoG (NAS topic 1 and 7)**
- **DVMP ep: N. Santiesteban, MIT; S. Fegan, UoY; M. Boer, VT (NAS topic 1 and 4)**
- **DVMP eA (several A) (J. Frantz, OU) (NAS topic 1, 8, (7))**
- Above closely linked to and working together with eA diffractive studies within diffractive group, M. Baker, D. Gangadharan, A. Schmidt, P. Steinberg (BNL, UH, GW)
- **Timelike Compton Scattering ep (K. Gates, UoG) (NAS topic 1)**
- **All of above reactions require far forward instrumentation**
 - Final state particles for exclusivity
 - Low p_t acceptance, t-reconstruction important for physics
 - Separation of coherent from incoherent...
- Working in collaboration with assistance from diffractive group - W. Li (W&M) and A. Schmidt (GW)
 - Lot's of computational assistance from Bill – thank you a lot

NAS topics:

=====

- 1) Tomographic Imaging of Quarks and Gluons
- 2) Heavy-quarkonia exclusive production at threshold
- 3) 3D imaging in Momentum Space
- 4) Gluon spin and orbital motion
- 5) Transverse motion in polarized nucleons
- 6) Propagation of energetic quarks through matter
- 7) Properties of Nuclei in QCD
- 8) Diffraction

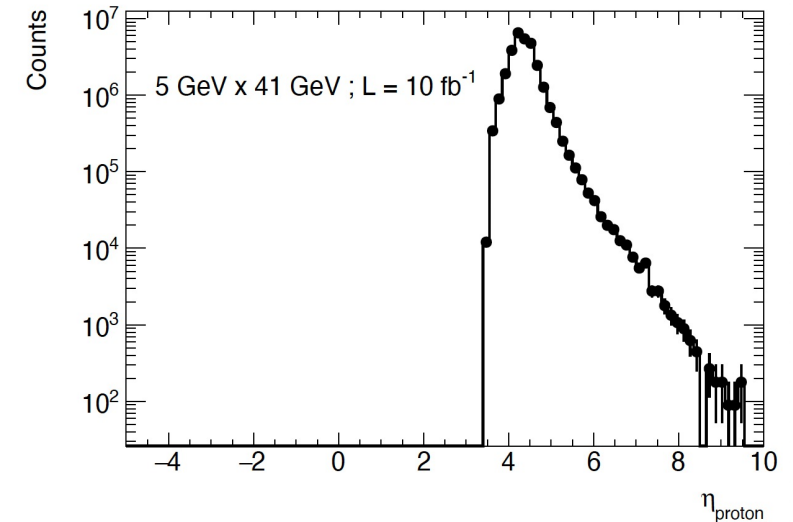
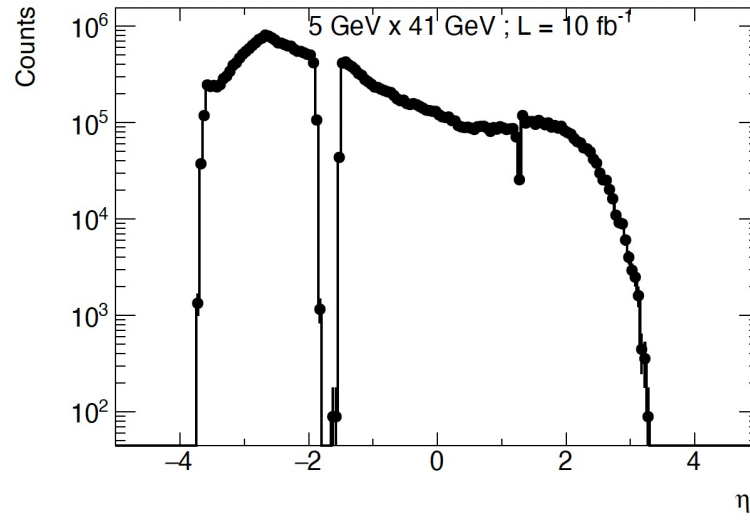
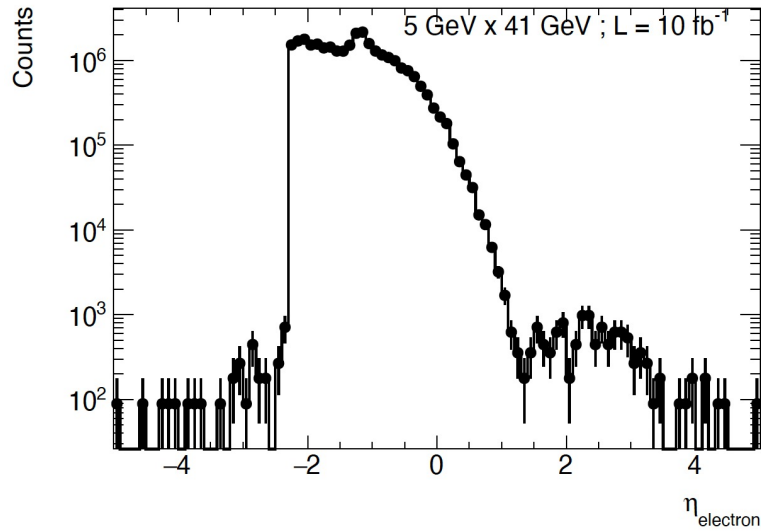
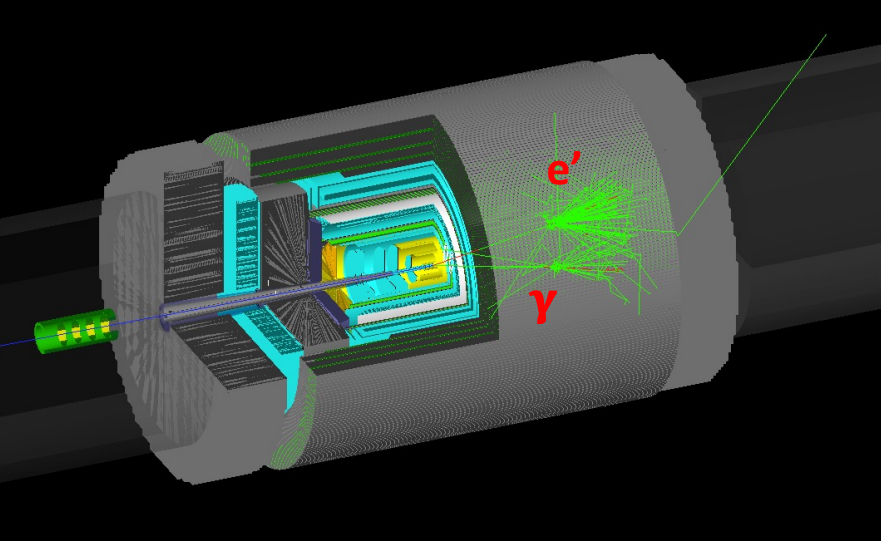
What Plots Are We Currently Aiming For?

- **DVCS ep, DVCS eA, DVMP ep, TCS ep**
 - pseudorapidity distributions for final state particles
 - detector acceptance
 - detector efficiency vs pseudorapidity for final state particles
 - detector acceptance
 - physics quantities distributions (e.g. phase space plots for $x_B/t/p_T$ vs Q^2 , ϕ , missing mass or invariant mass)
 - detector acceptance and performance/resolution
 - money plot: differential cross section vs physics variables (t , p_T , Q^2 , x_B) (for DVCS ep show DVCS² vs full process)
 - low p_T acceptance in forward region
- **DVMP eA**
 - money plot: differential cross section vs t and vs Q^2
 - low p_T acceptance in forward region
 - rejection in forward region
 - detector efficiency vs pseudorapidity for final state particles
 - detector acceptance
 - (additionally, if time allows, related detector performance and explanatory plots concerning forward rejection linked to/from P. Steinberg/diffractive note)

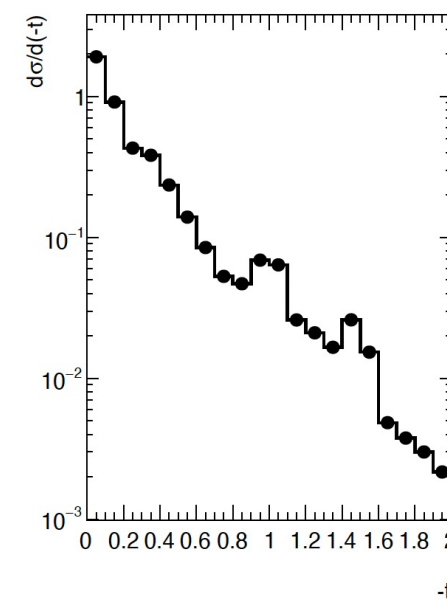
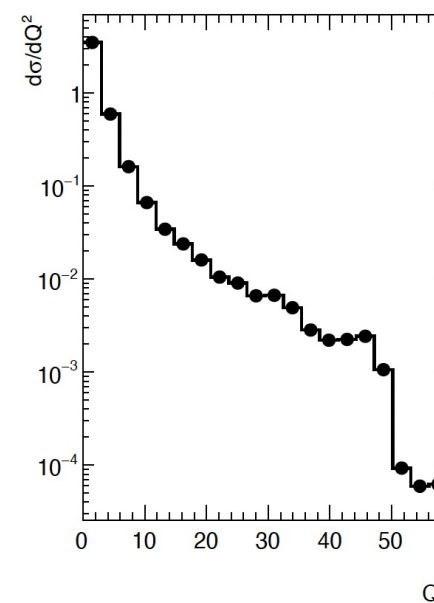
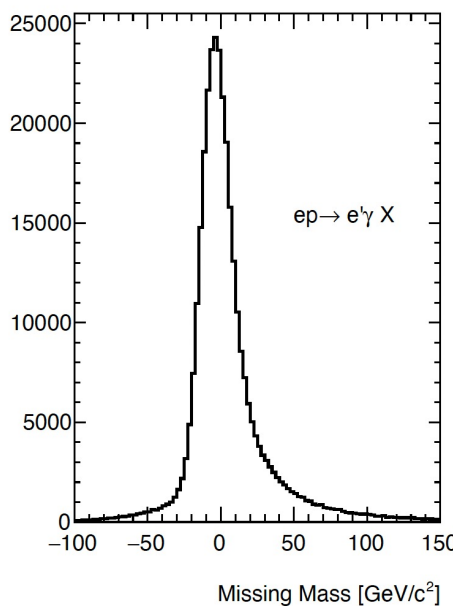
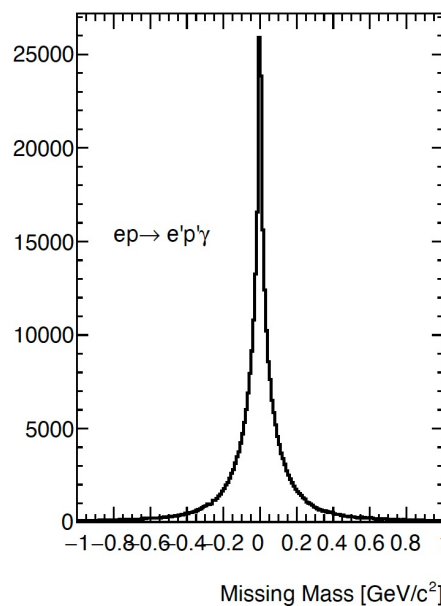
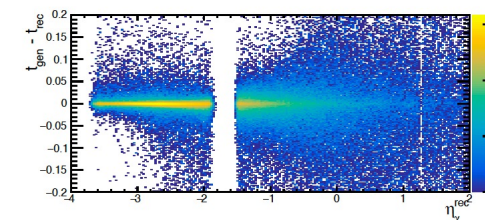
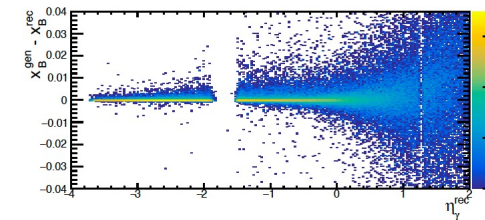
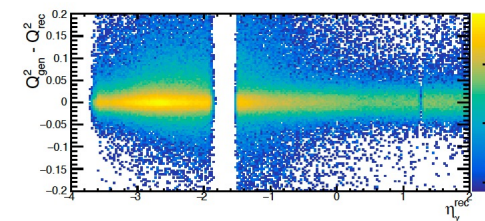
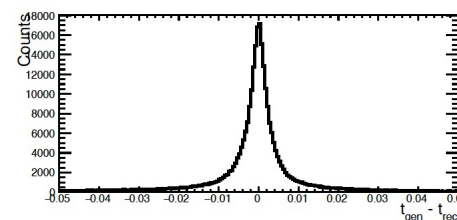
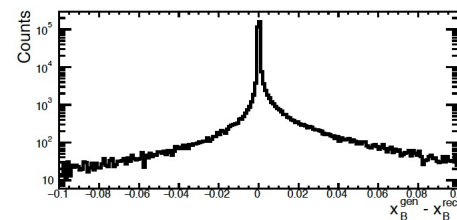
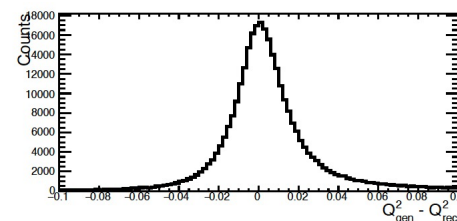
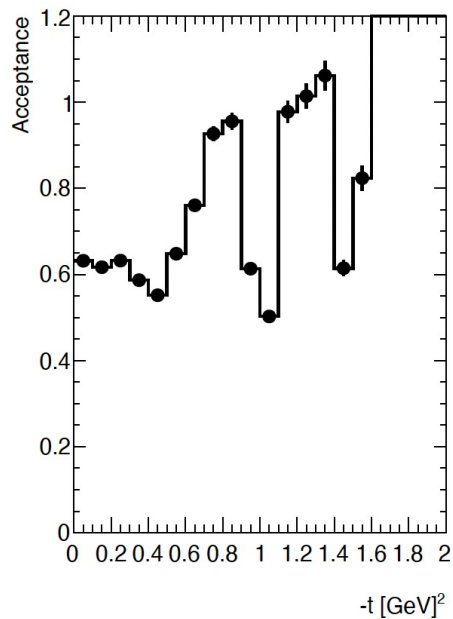
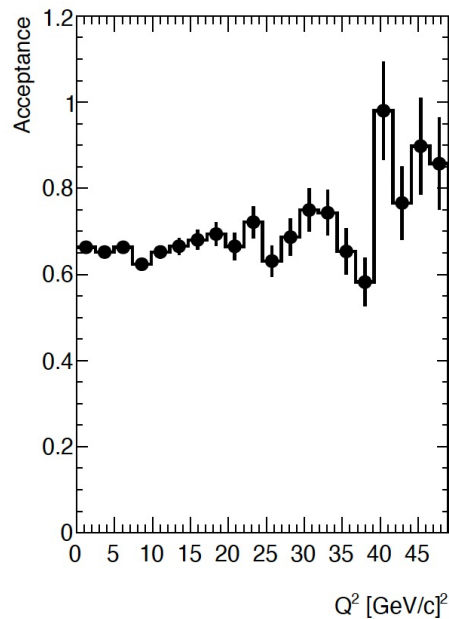
Nb: All plots shown today are preliminary/under study. Supplied by names indicated to give a flavour of our status...

DVCS ep ($ep \rightarrow ep\gamma$)

- **MILOU3D** generator [[hep-ph/0411389v1](https://arxiv.org/abs/hep-ph/0411389v1)] (access to DVCS; BH; DVCS+BH+INT)
- Current status:
 - Simulated at IP6 for: 5x41; 10x100; 18x275 GeV
 - Plots from list completed except inclusion of acceptance of proton in forward region
- Outstanding:
 - Include acceptance of final reconstructed **proton** (underway)
 - Add pure DVCS contribution to cross section plots to compare with full process (to-do)
- Example plots from list shown for 5x41 setting (other settings exist, not shown)

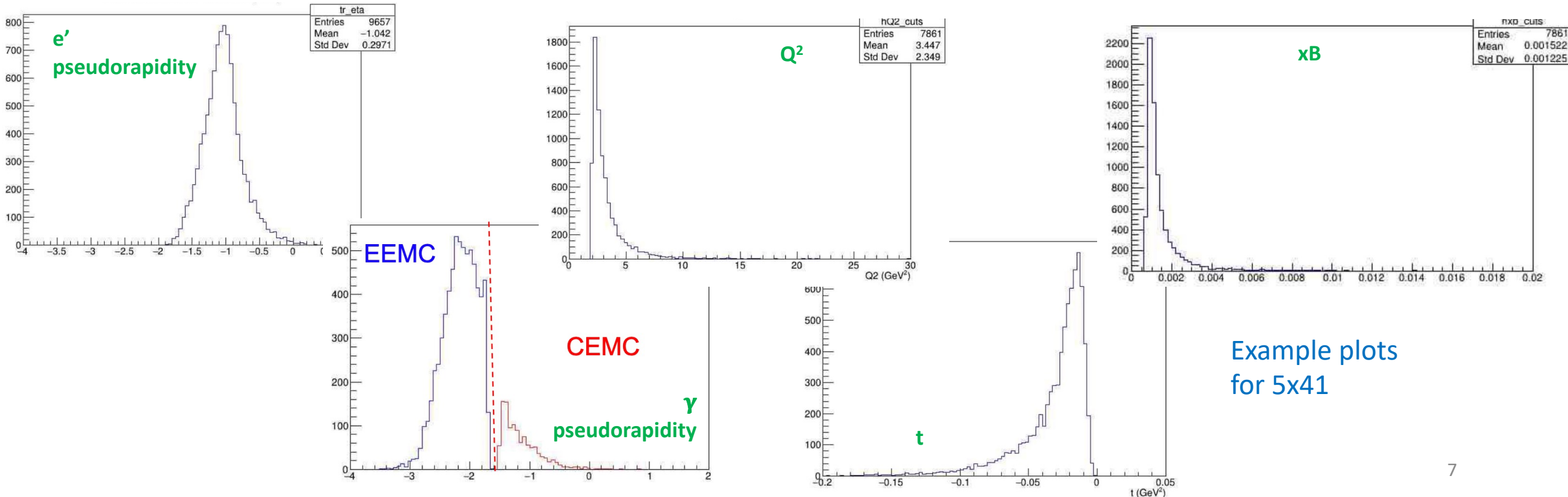
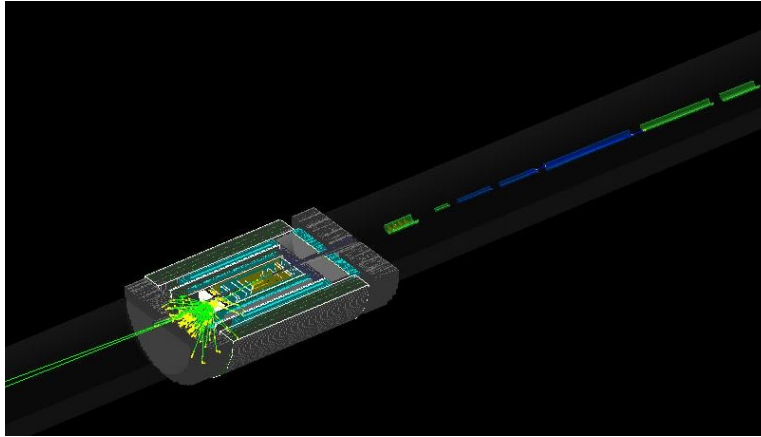


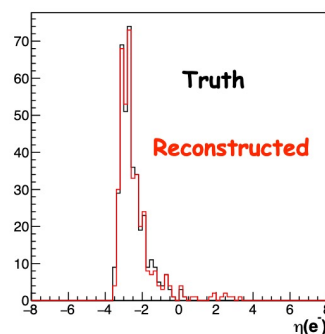
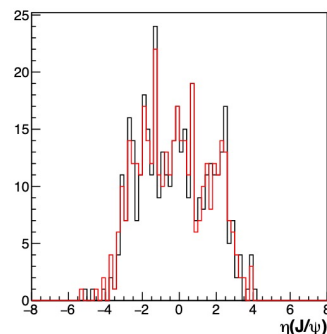
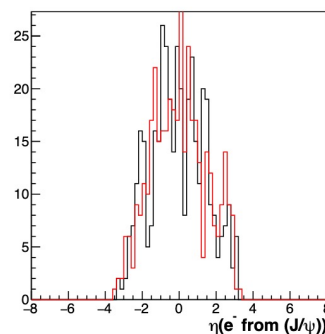
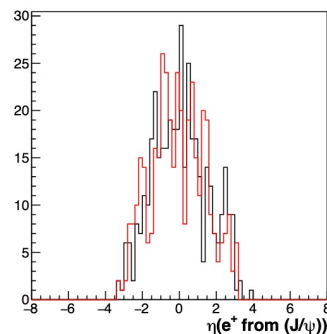
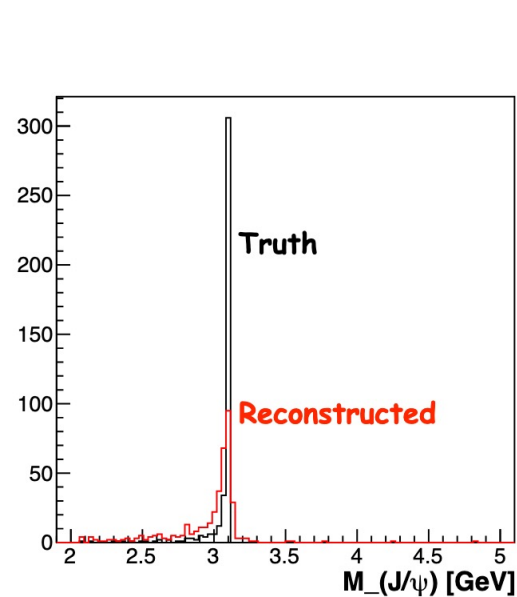
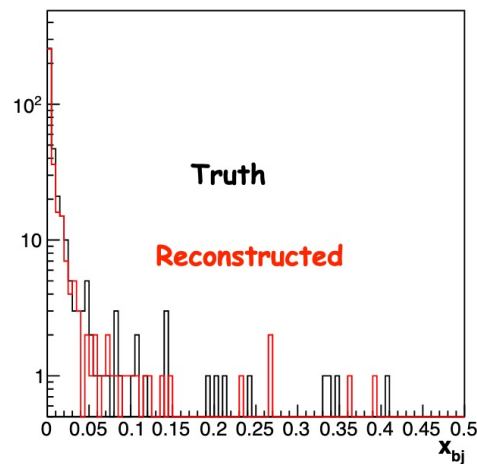
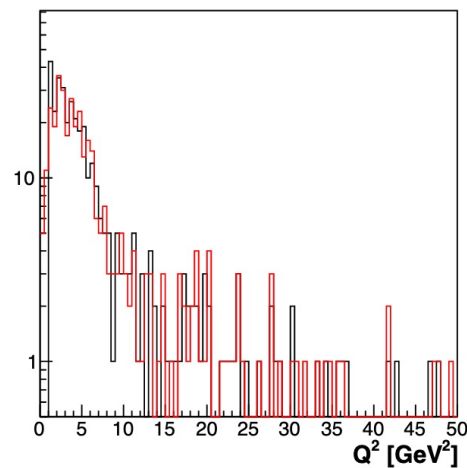
5 x 41



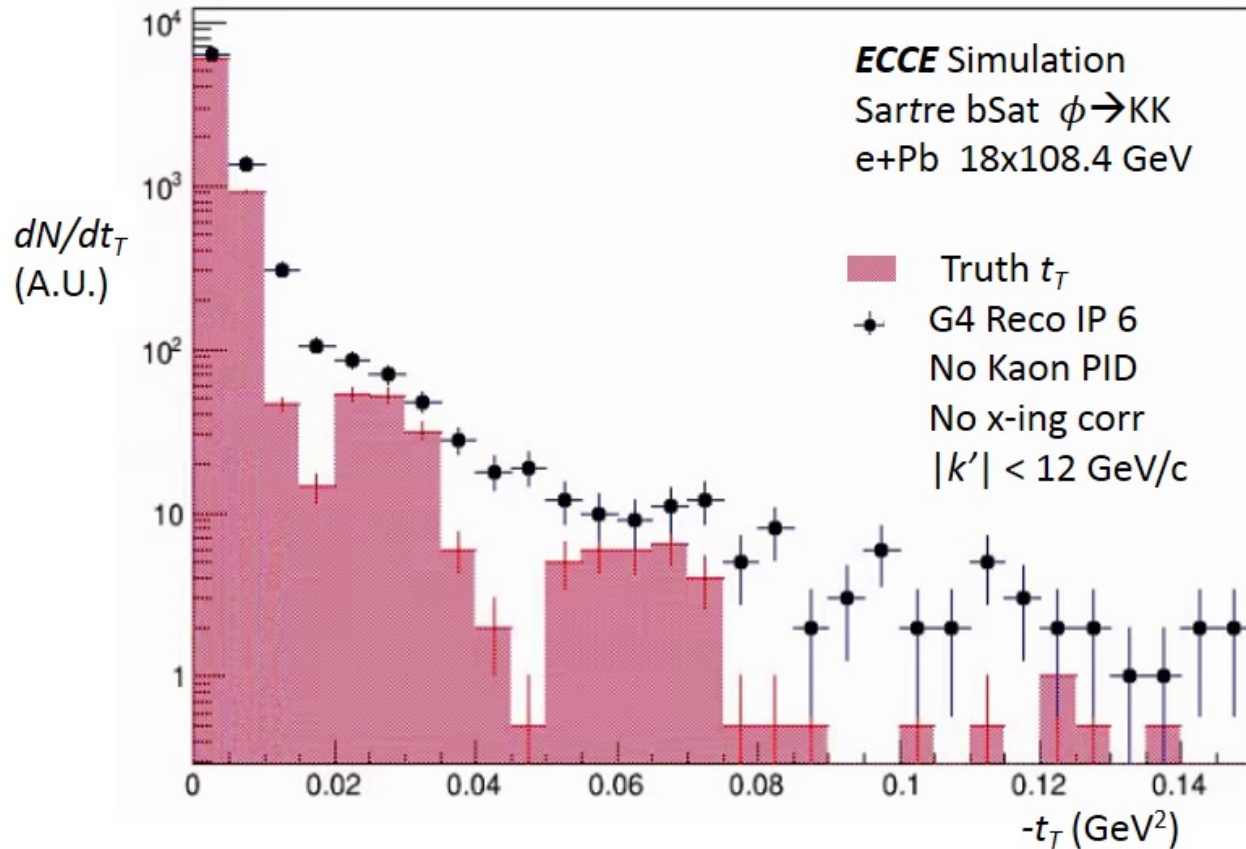
DVCS eA ($e^4\text{He} \rightarrow e^4\text{He}\gamma$)

- **TOPEG** generator (<https://gitlab.in2p3.fr/dupre/nopeg>)
- Plan **IP6 and IP8 : 5x41 (per nucleon)** (and higher setting if time allows)
- Current status:
 - Framework for plots mostly completed (finalising reconstructed helium)
 - 5x41 fun4all output exists
- Outstanding:
 - Scale plots for **efficiency and cross sections** (underway)
 - Include acceptance of final reconstructed **helium** (underway)





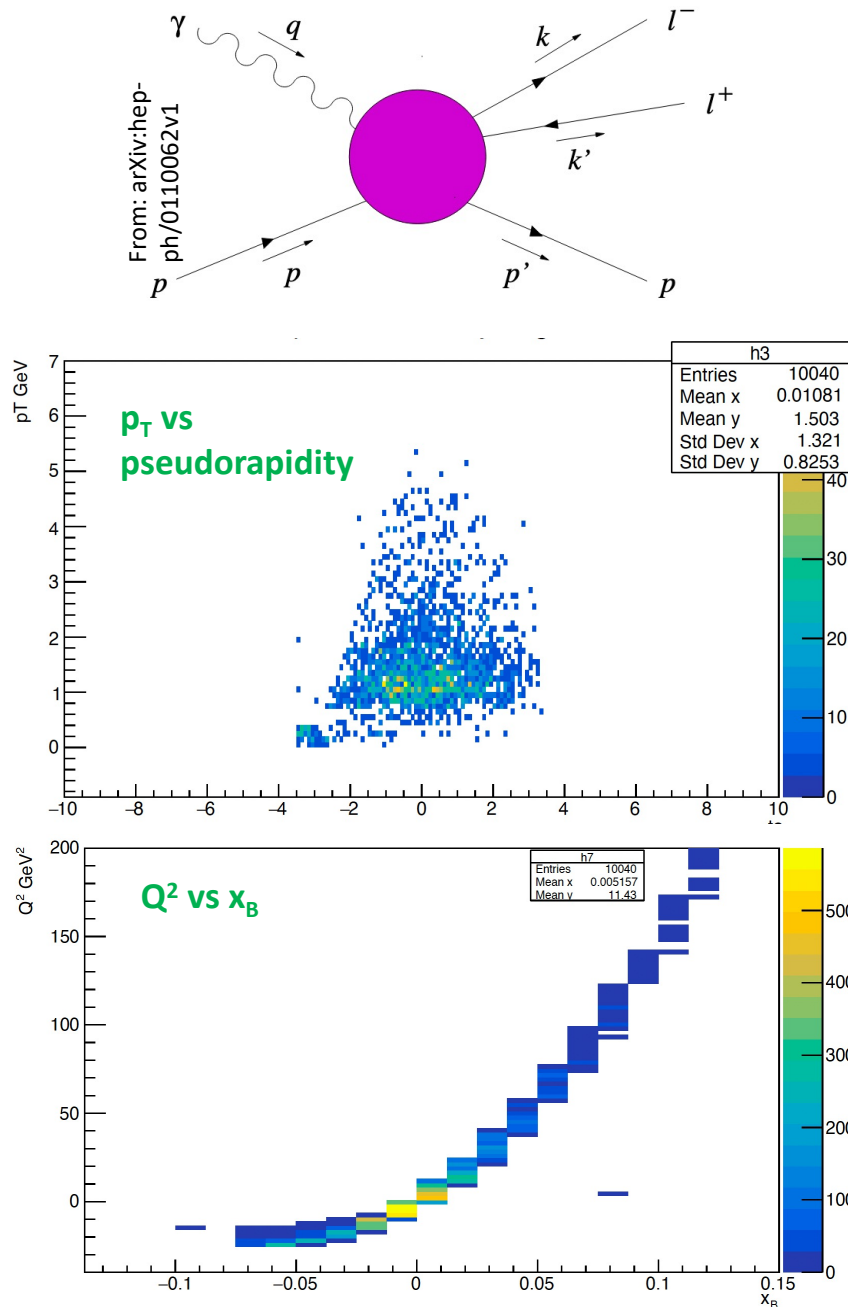
- **IAger** generator
(https://eicweb.phy.anl.gov/monte_carlo/lager)
- Plan **IP6 and IP8** : 5x41; 5x100; 10x100; 18x275 GeV
- Current status:
 - IAger generator files ready (S. Fegan)
 - **Fun4all** output for IP6 and IP8: 10x100, 18x275 GeV
 - **Analysis underway:**
 - e^+, e^-, e' and J/ψ reconstructed
 - some physics plots checked
 - (missing mass, Q^2 , x_B)
- Outstanding:
 - scale plots for **efficiency and cross sections** and final physics plots (underway)
 - include acceptance of final **proton** (underway)
 - complete fun4all simulations (to-do)
 - if time, include other mesons, e.g. rho, omega, upsilon... - M. Boer VT generator
- **Example plots for 18x275 shown**



- Some comments on plot (J. Frantz, P. Steinberg):
 - Plot resolution limited by tracking resolution for electron in very far forward region
 - Plan to check if either using calorimeter info instead of tracking, or limiting phase space improves shape
 - 5x41 setting may help tracking resolution impact

- Selected ϕ due to greater sensitivity to gluon saturation than J/ψ
- Sartre generator (<https://sartre.hepforge.org/>)
- Plan IP6 and IP8 :
 - 18x108.4(Pb) GeV
 - equivalent setting for Zr
 - ie 4 money plots (see left example)
 - 5x41 possibility (time permitting)
 - e+Au possibility (but low priority)
- Current status:
 - Fun4All output for 18x108.4GeV Pb at IP6
 - Fun4All output for BeAGLE incoherent background for Pb and Zr, and both IP
 - $\rho \rightarrow \pi^+\pi^-$ Sartre generator output for final state mis-ID background study
 - Main analysis script for money plot set up
- Outstanding (to-do):
 - Fun4All processing for Zr ϕ signal and ρ background
 - Inclusion of backgrounds to money plot
 - Add additional graphs (e.g. pseudorapidity or physics distributions, these should be quick)

Timelike Compton Scattering



- Exclusive photoproduction of heavy timelike photon which decays to lepton pair (e^+e^-)
- Analogous to DVCS ep and **complementary for access to GPDs**
 - test spacelike-timelike and universality of GPDs
- Generator:
 - **EpIC** - P. Sznajder (Warsaw Inst. Nucl. Studies) and K. Tezgin (BNL)
 - Recently updated for this round of EIC proposal studies (liaison via UoG)
- Current status:
 - **Simulated for IP6: 5x41; 10x100; 18x275**
 - **Working on analysis**
 - Reconstructed physics variables
 - Working on event selection and reconstruction
 - Starting to work in tandem with DVMP since same final state
- Outstanding:
 - Complete analysis
 - **Final event selection/reconstruction technique**
 - Create pseudorapidity, efficiency and cross section plots

Summary

- Reactions for NAS topics 1, 4, 7, 8 being studied in Exclusive Reactions Working Group
 - Priority DVCS and DVMP reactions are focused on topic 1 – tomographic imaging of quarks and gluons
- Low p_t acceptance and t-reconstruction crucial for priority DVCS and DVMP reactions
- DVMP eA also insightful study for tracking resolution capabilities
- All generators were new to us
- Team is progressing very quickly with analysis and mass simulations
 - Plots constantly being produced
 - End goals clear
 - Expect no show-stoppers
- Global to-do: re-run all reactions with most recent detector implementation/on-going mass simulation (campaign 2) (timescale for sims ~1wk)
- Have a note set up but need to start filling it in ...

