

Exclusive Physics Update

EIC-UK Meeting
07/12/22

UK-affiliated Co-convenors of Working Group:

Rachel Montgomery (University of Glasgow)

Daria Sokhan (CEA Saclay/University of Glasgow)

(US-based co-convenors: S. Klein, A. Schmidt)

On Behalf of *Many* from:

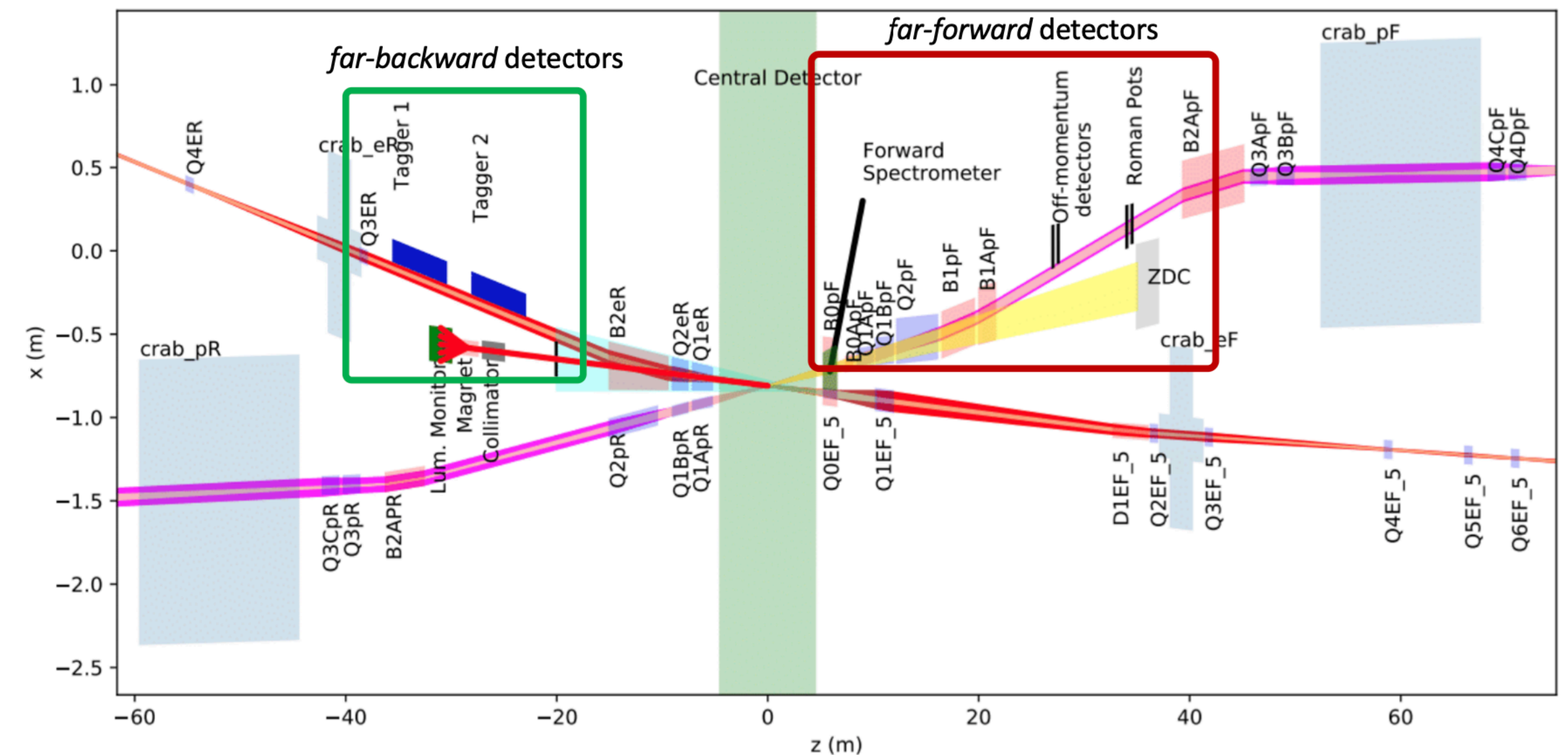
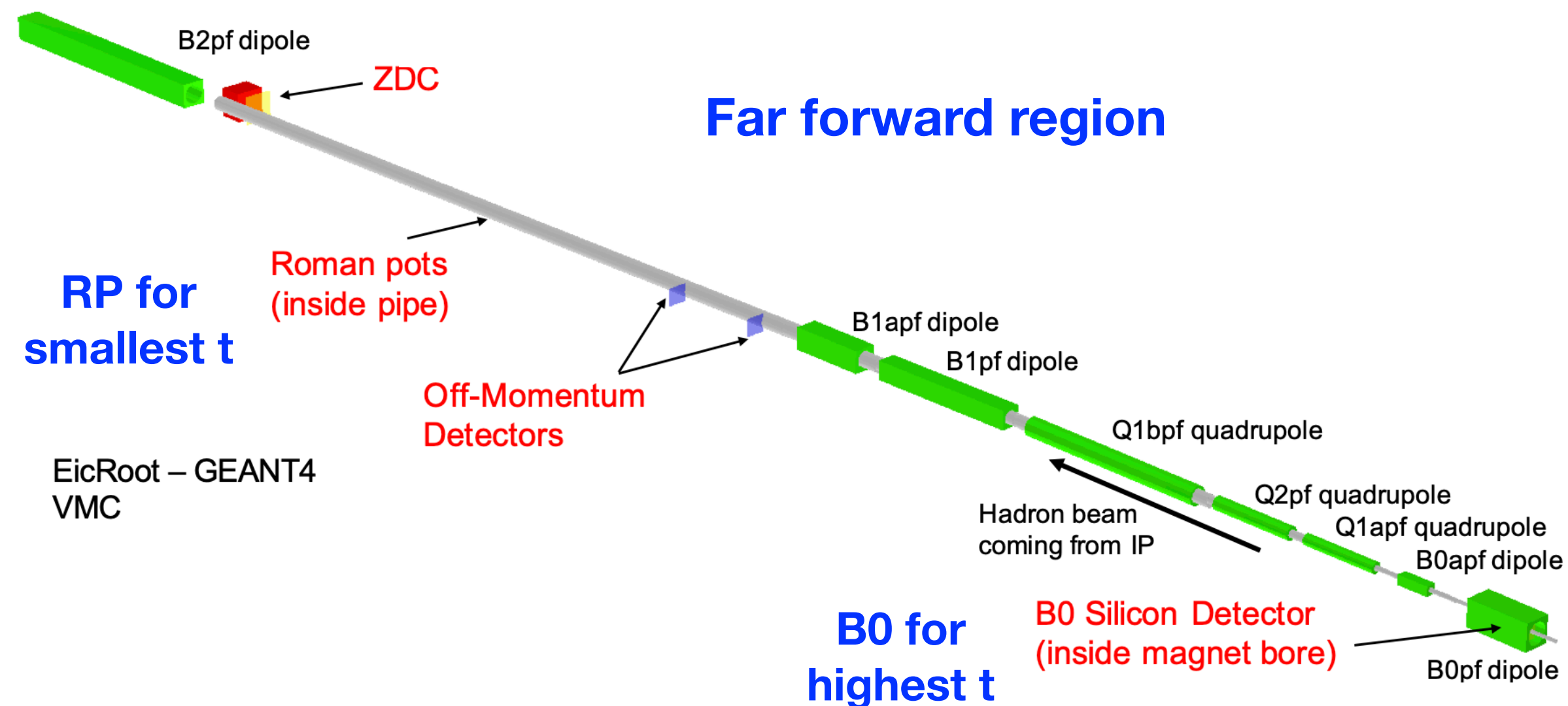
EPIC Exclusive, Diffractive and Tagging Working Group



- Maintain heavy UK-related involvement and leadership
 - Co-convenors (D. Sokhan CEA/Saclay, R. Montgomery UoG)
 - Researchers and PhD students leading roles in several reactions/studies
 - D. Sokhan, D. Glazier (UoG), R. Montgomery, S. Fegan (UoY), K. Gates (UoG), G. Penman (UoG)
 - TCS, XYZ spectroscopy, DVCS eA, DVMP ep
 - 2 PDRA @ UoG ready to participate (O. Jevons, H. Jiang)
- Many hadron structure topics under study
- Key topics:
 - Origin of hadron mass
 - Origin of nucleon spin
 - 3D structure of nucleons and nuclei
 - Gluon structure of nucleons and nuclei
 - ...plus any further topics which may arise

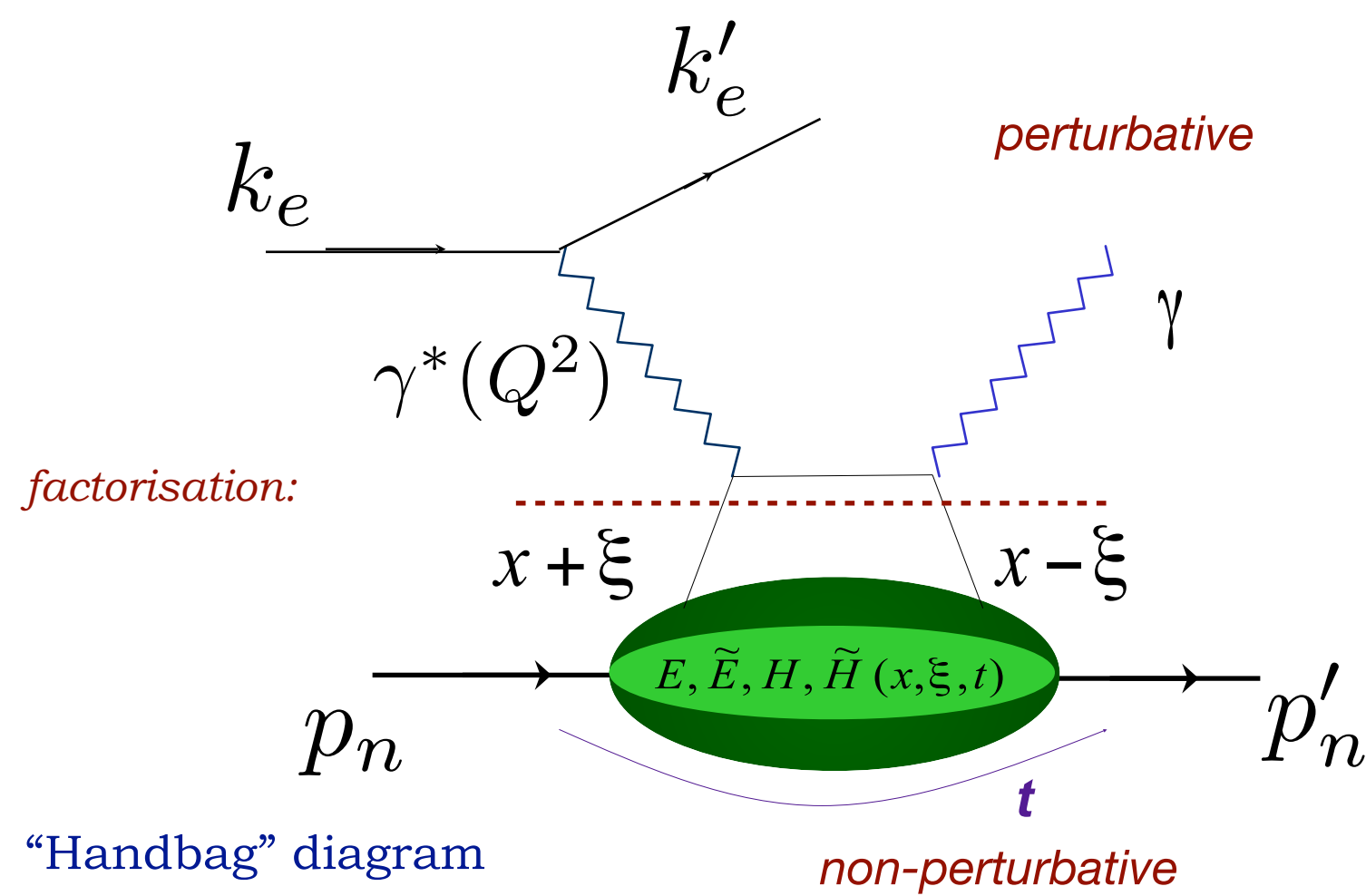
Requirements for Working Group

- Exclusive reactions = **complete measurements**
- Need to measure:
 - Scattered lepton, scattered nucleon/nuclei (intact/dissociated), other particles produced in reaction
- Demands:
 - Acceptance, resolutions, PID → phase space, kinematic binning, background reduction
 - **Far forward instrumentation essential for tagging and t reconstruction**
 - $t = (p_{N'} - p_N)^2$, access to small t , and wide range of t crucial
 - Far backwards relevant for e.g. XYZ spectroscopy, background in TCS



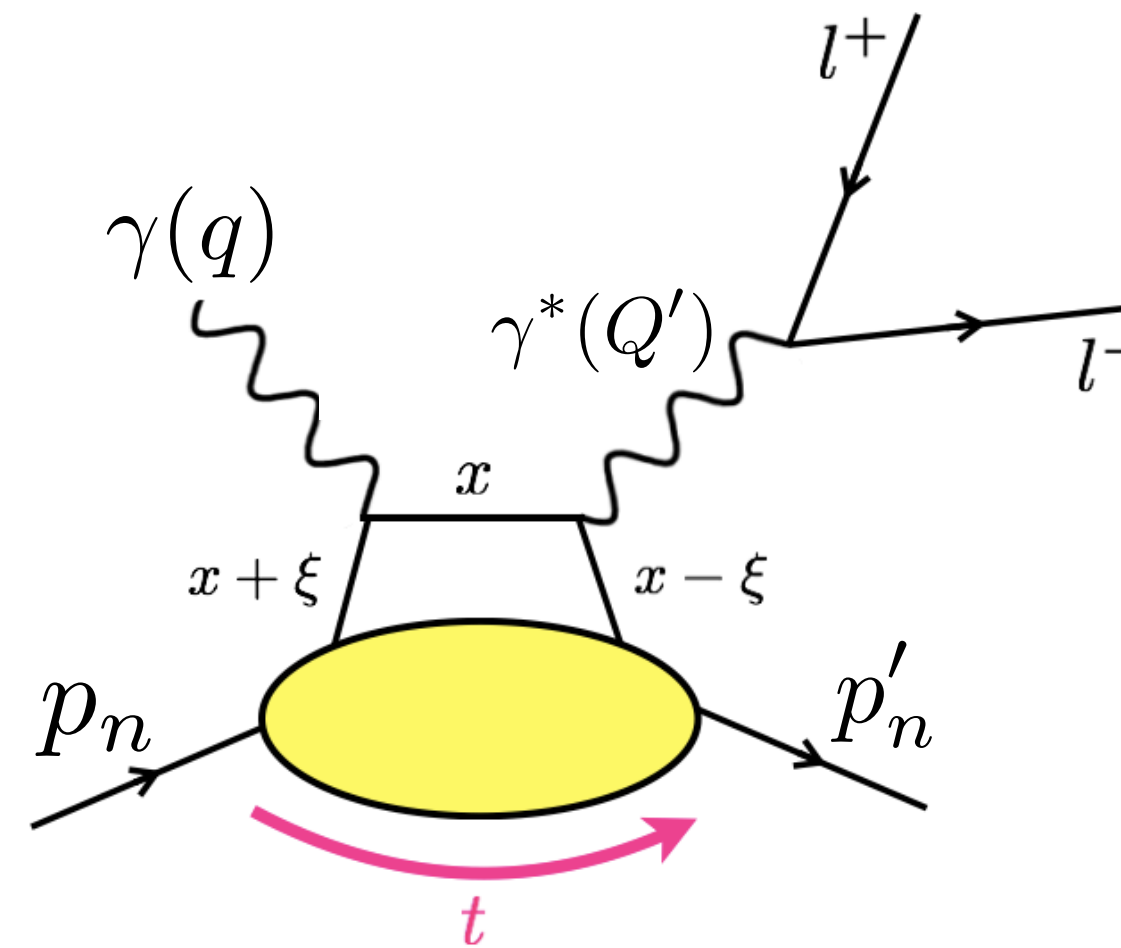
Example Topics

DVCS



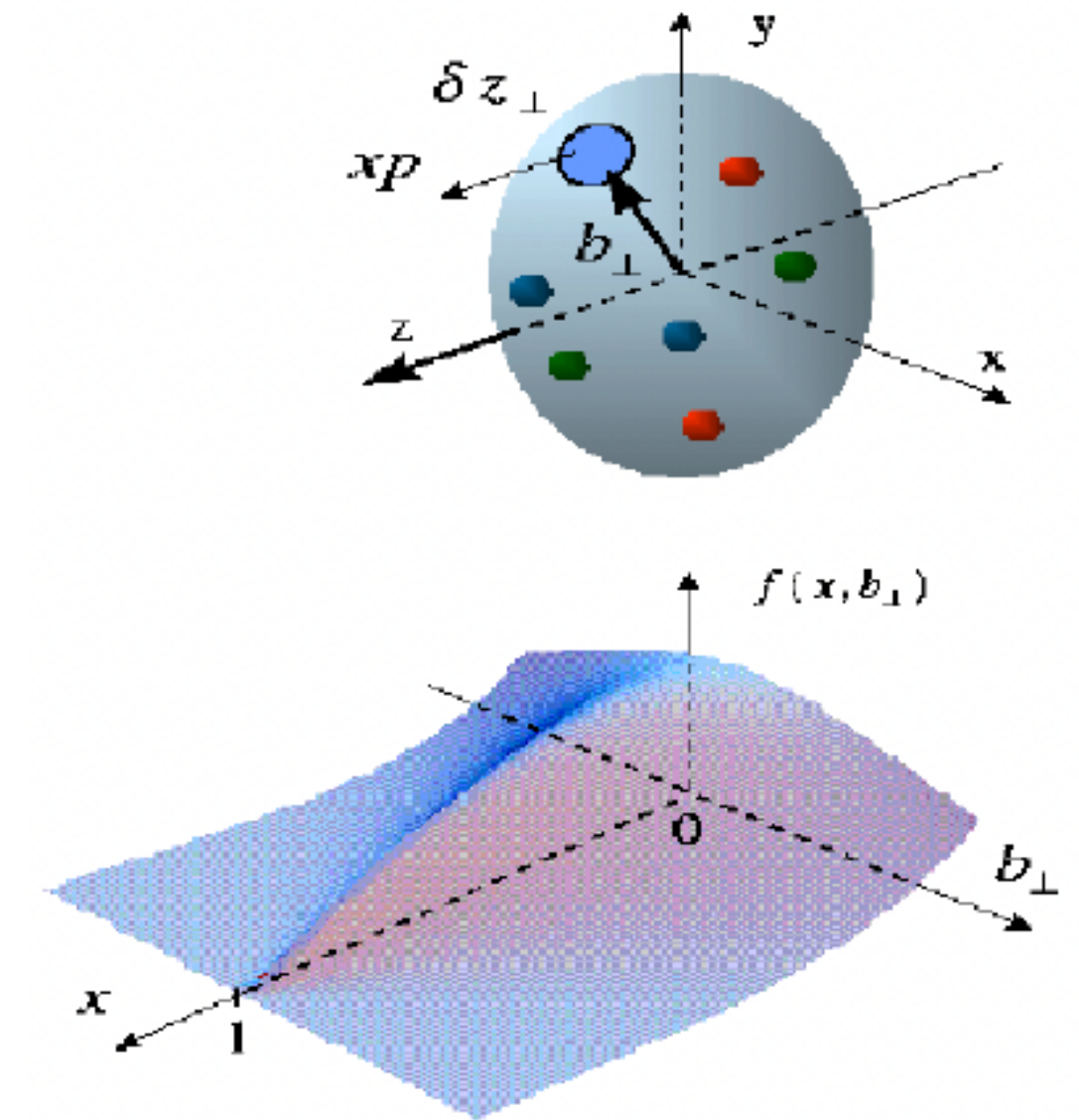
- High Q^2 , low $t \rightarrow$ access 4 parton helicity-conserving chiral-even **GPDs**

TCS



- Real photon interacts with target nucleon, releases virtual photon, decays to leptons
- Complimentary to DVCS
- Verification of **GPD** universality
- Sensitivity to pressure distribution

GPDs

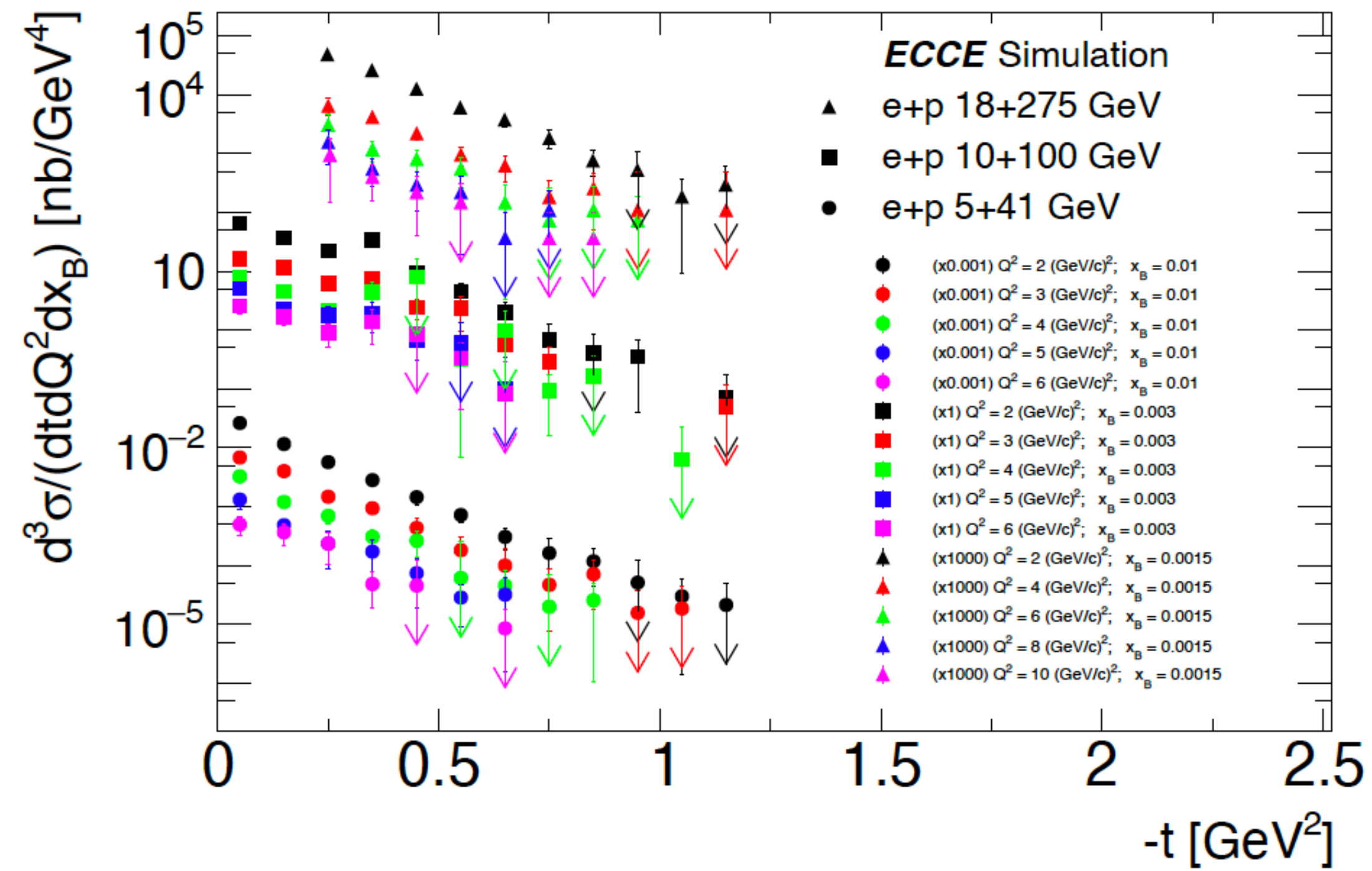


- GPDs provide access to:**
- Nucleon 3D tomography
 - Nucleon spin

Example Topics

DVCS

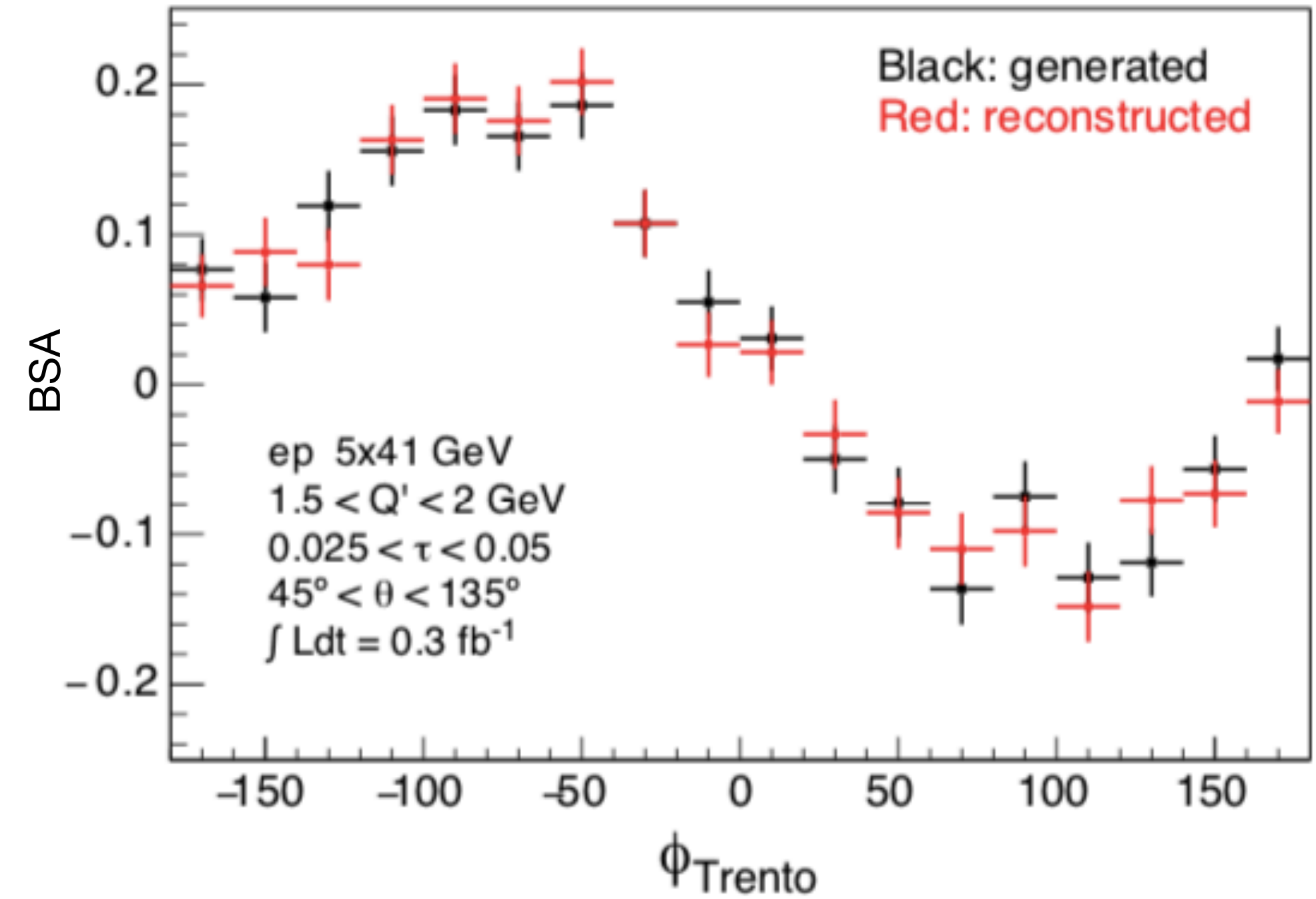
ECCE - I. Korover



Forward instrumentation crucial for t

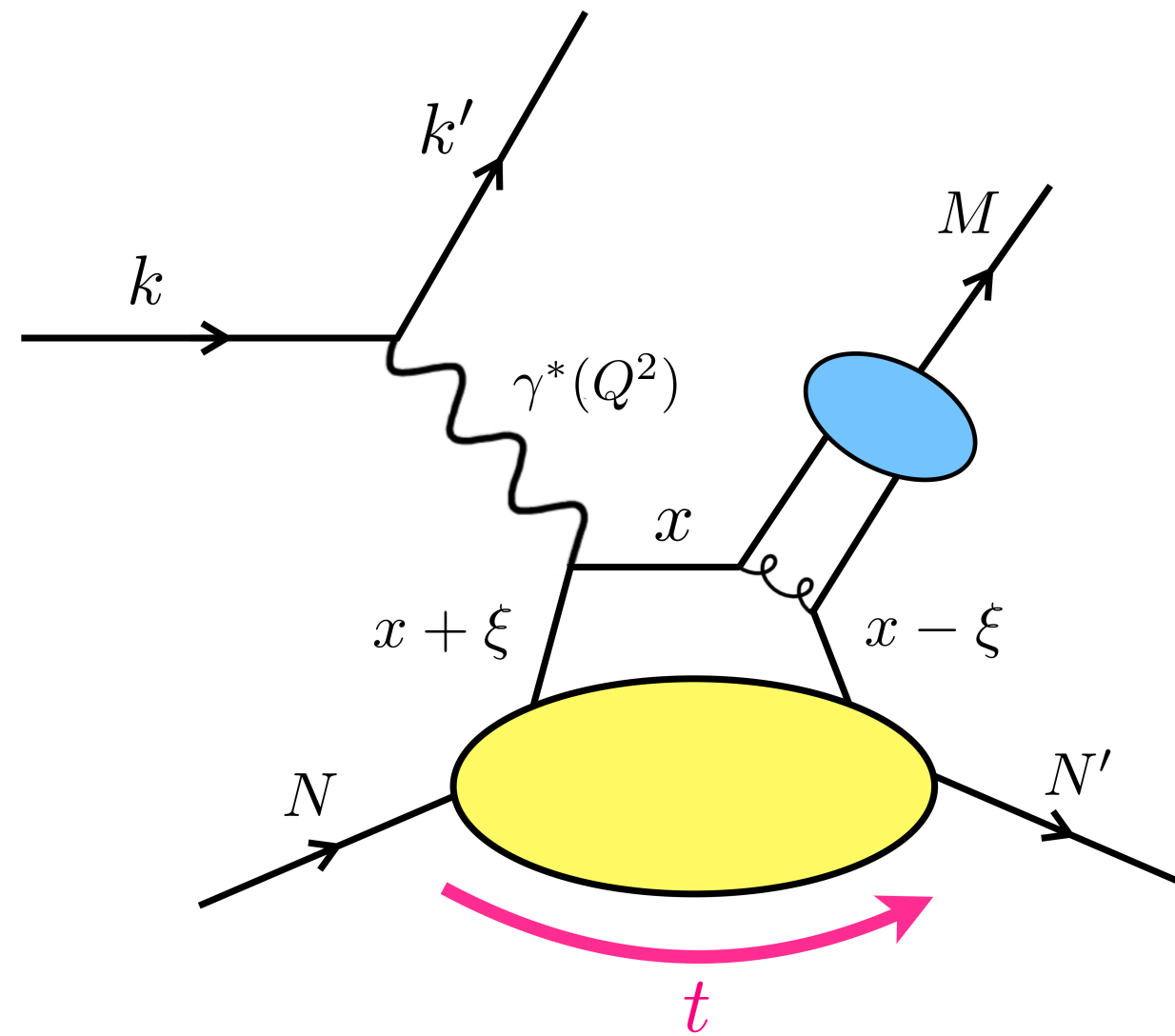
TCS

ATHENA - D. Sokhan



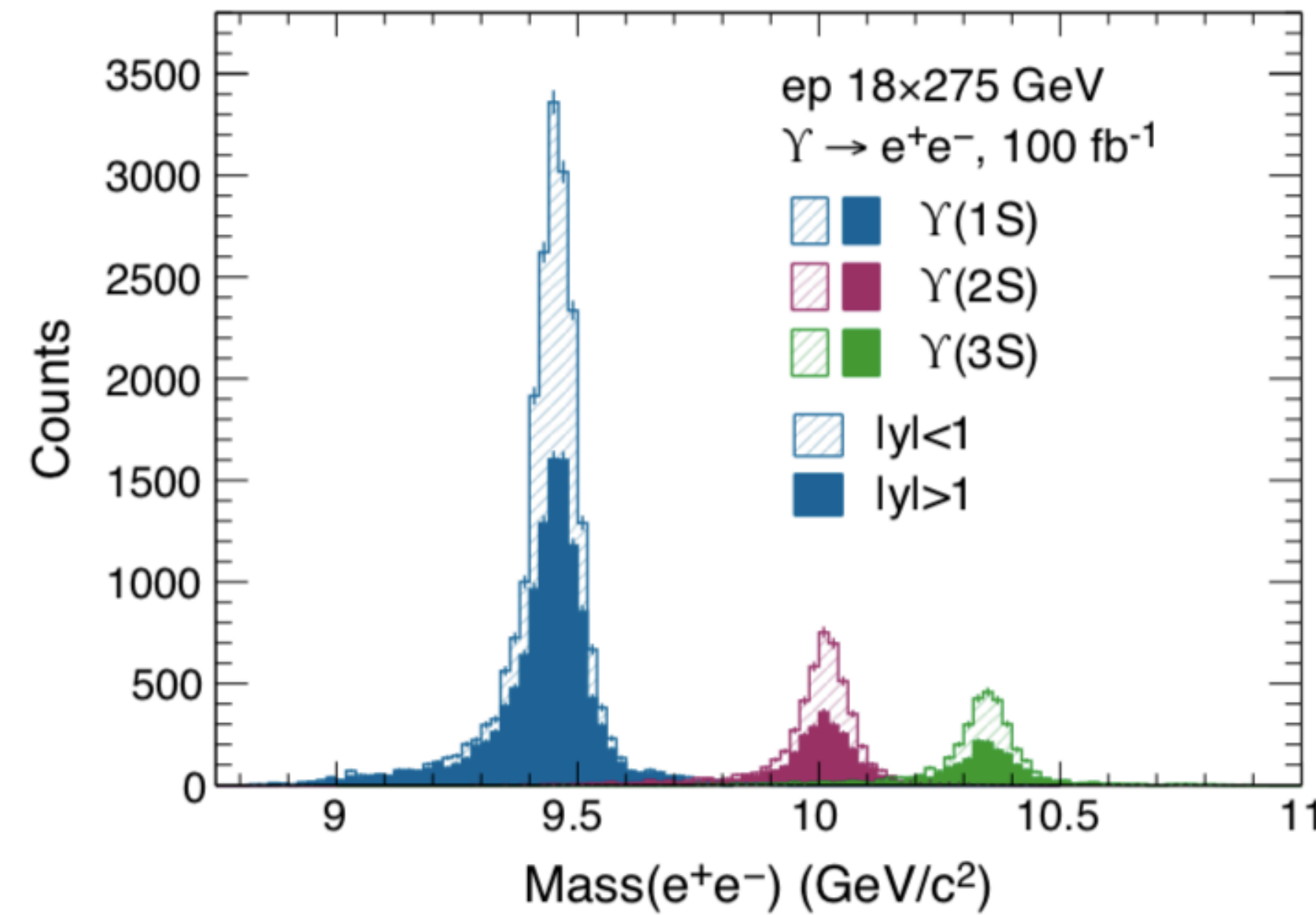
Needs excellent lepton acceptance in central detector

Coherent Vector Meson Production in eA

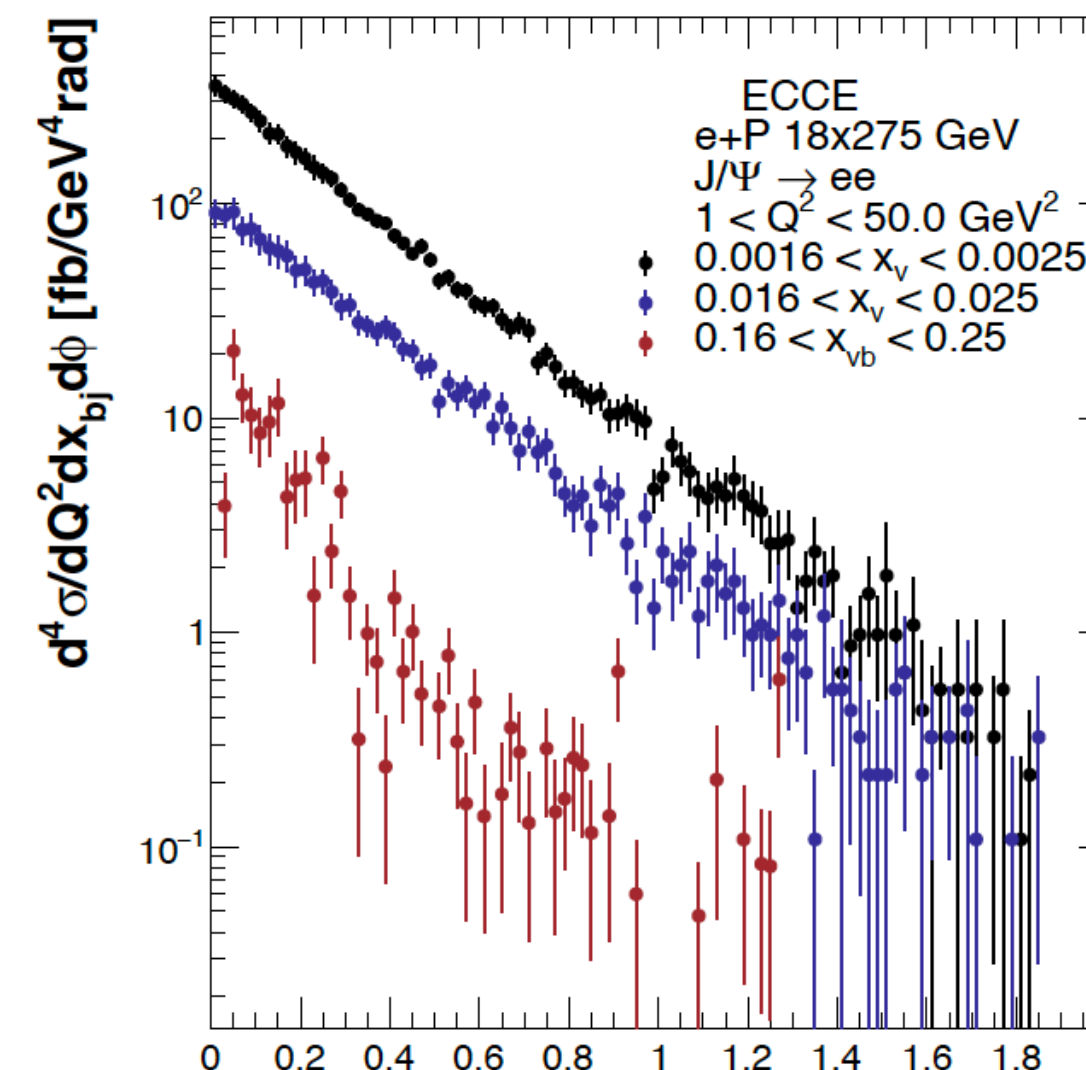


- Hard exclusive electro-production of vector mesons
- Access gluon GPDs
 - multi-dimensional imaging!

ATHENA - Y. Ji



- Upsilon production
- Mass resolution good enough to separate states



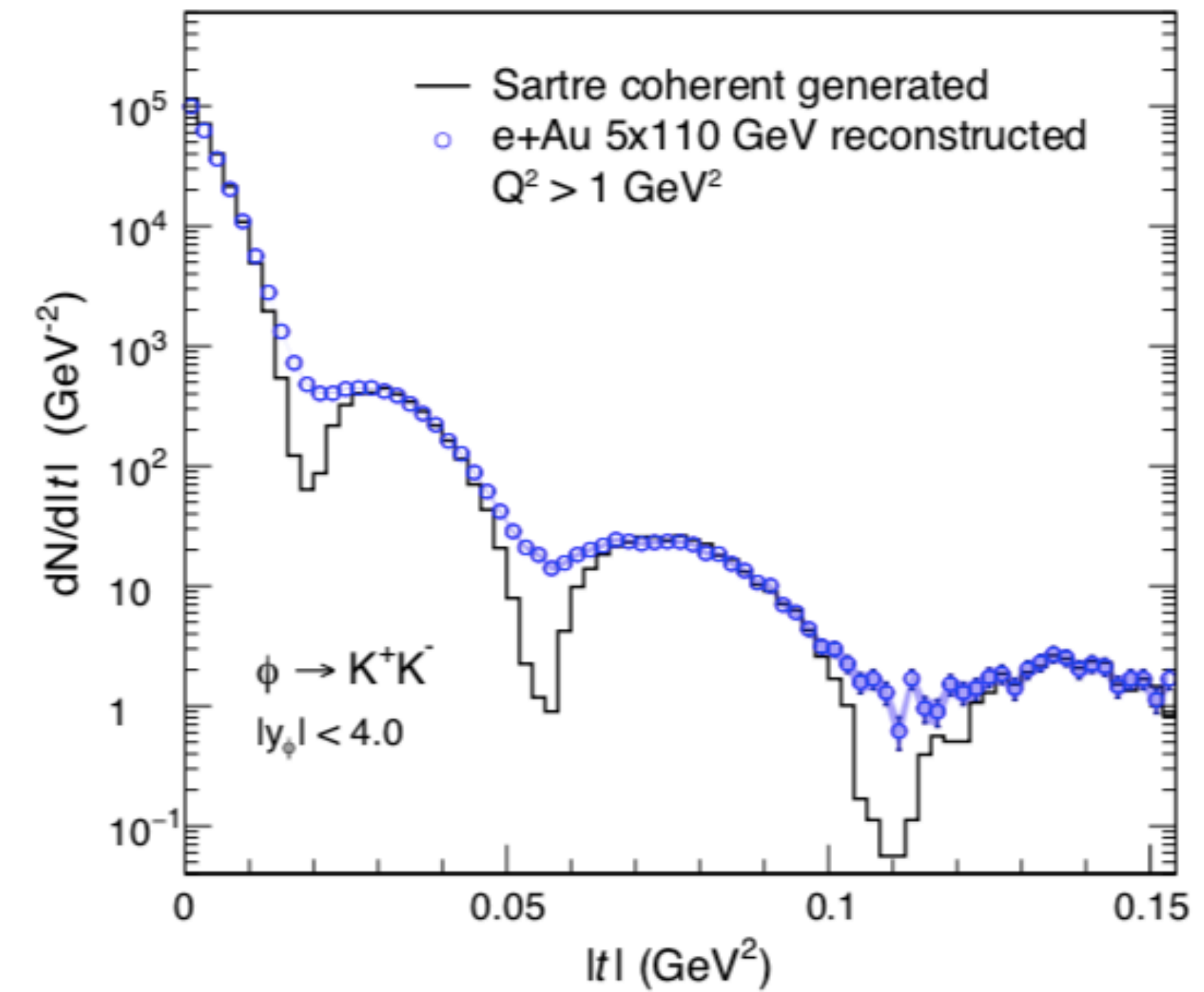
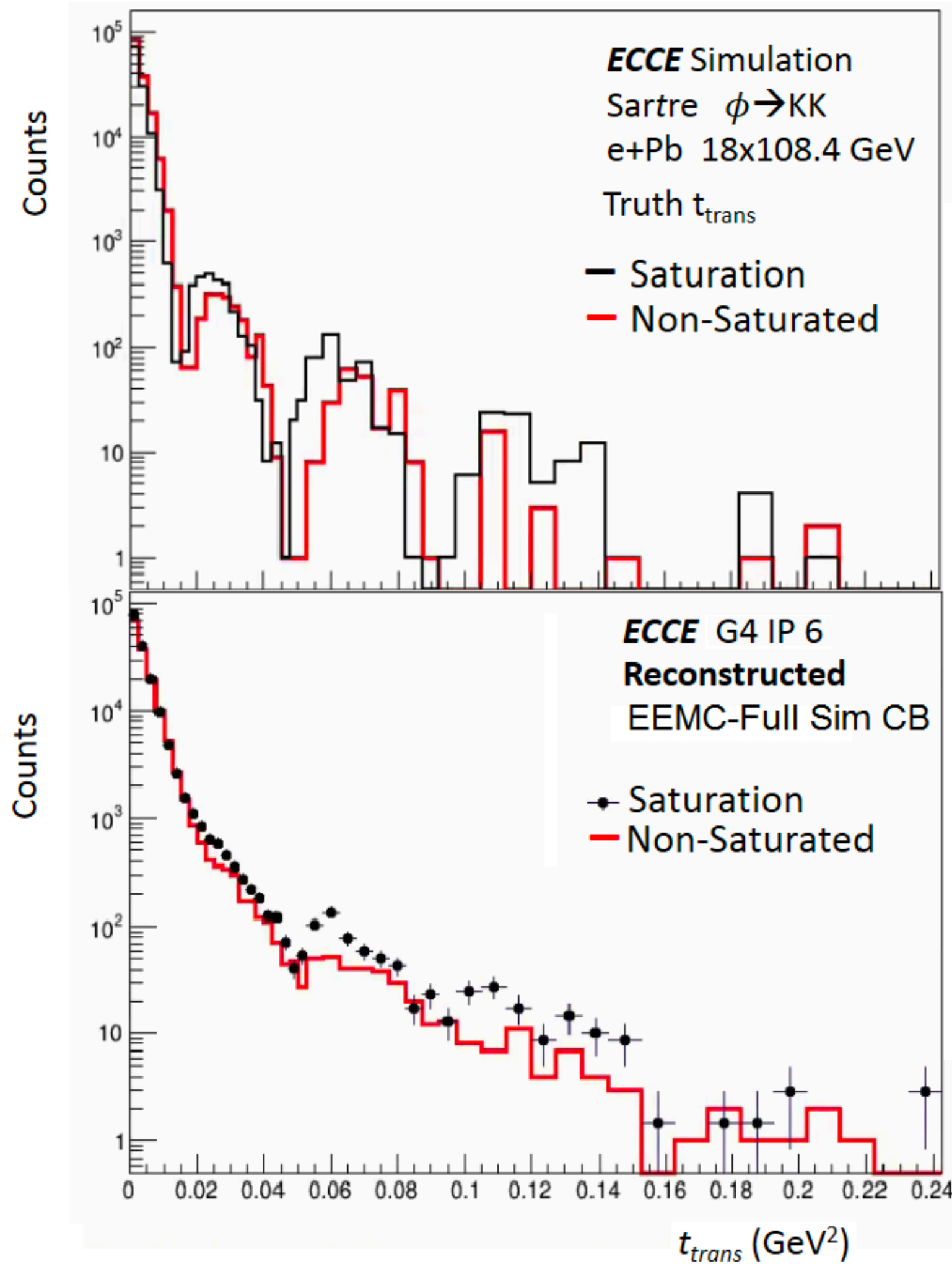
ECCE - N. Santiesteban -t [GeV²]

- J/ψ production
- Central detector essential to reconstruct J/ψ
- Forward detectors for -t

Coherent Vector Meson Production in eA

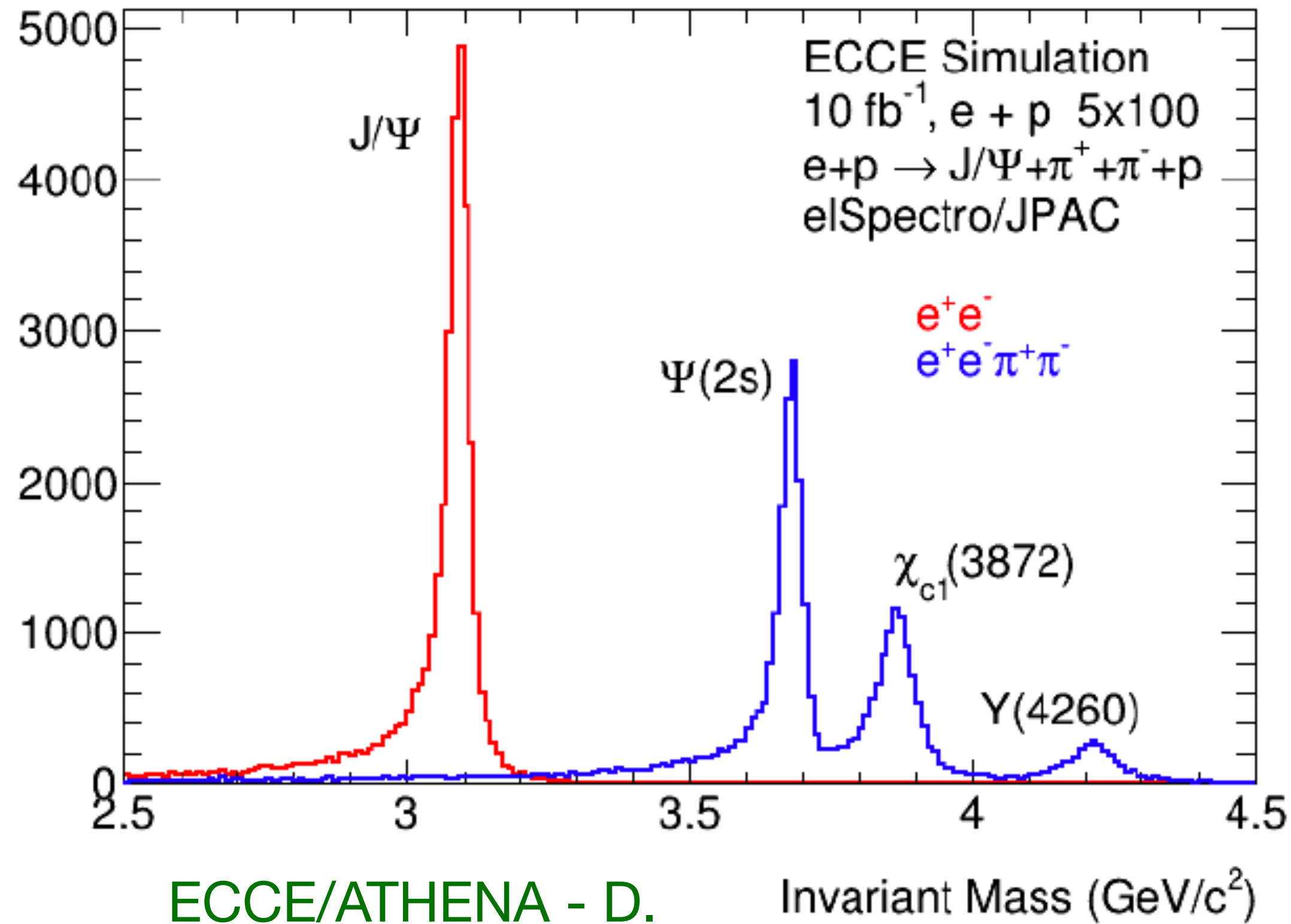
- Access gluon distributions in nuclei
- Gluon saturation effects
- Reconstruct t from leptons/mesons in central detector
- t -resolution needed to resolve minima
- Suppression of incoherent background using far forward

ECCE - J. Frantz/P/ Steinberg



ATHENA - K. Tu

XYZ Spectroscopy



- Spectroscopy of mesons with charm quarks
- New states have unexpectedly narrow widths inconsistent with quark model predictions
- Enough resolution to separate states

Example Topics

- Further topics studied:
- DVCS ed → neutron DVCS → quark-flavour separation of GPDs
- DVCS ^4He → GPDs, EMC effect, coherent vs incoherent DVCS studies (G. Penman)
- Meson form factors and structure functions via scattering from meson cloud → emergent hadronic mass
- Backwards u-channel meson production → transition distribution amplitudes, di-quark correlations
- Near threshold production of J/ψ → access to trace anomaly in QCD → hadron mass
- Double tagged $e^3\text{He}$ DIS → neutron spin structure A_1^n
- **Not** exhaustive list of EIC exclusive/diffractive/tagging physics topics!

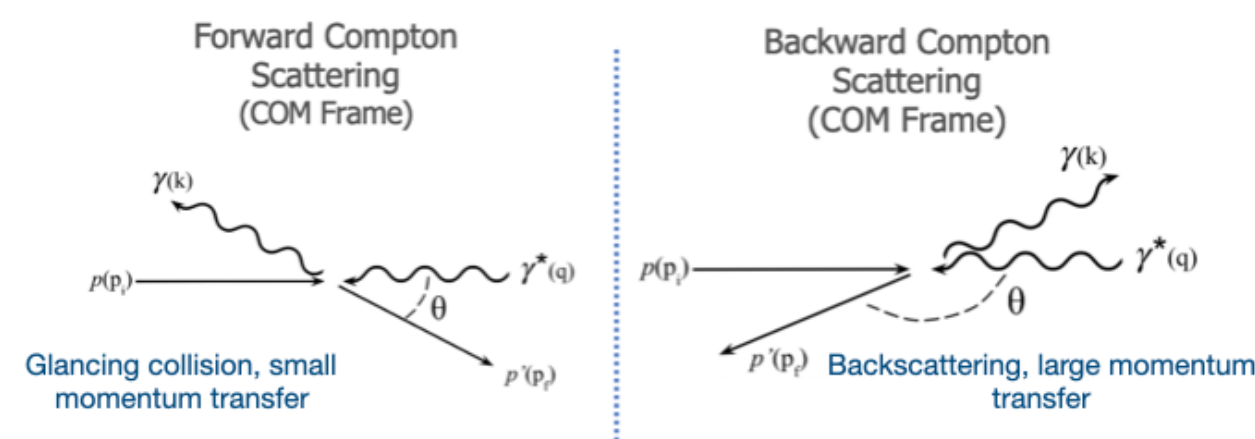
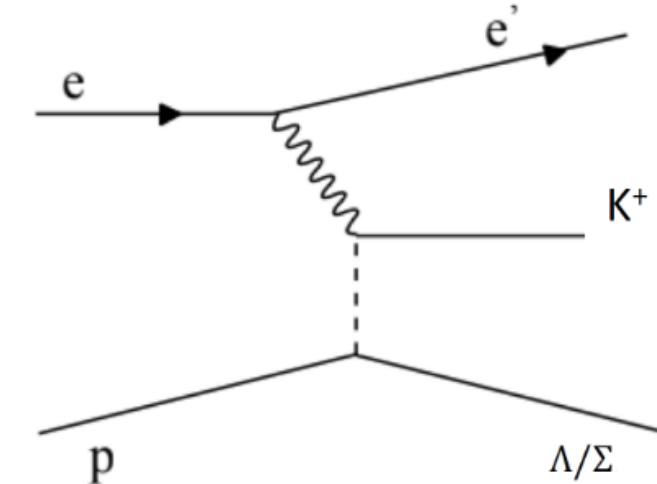
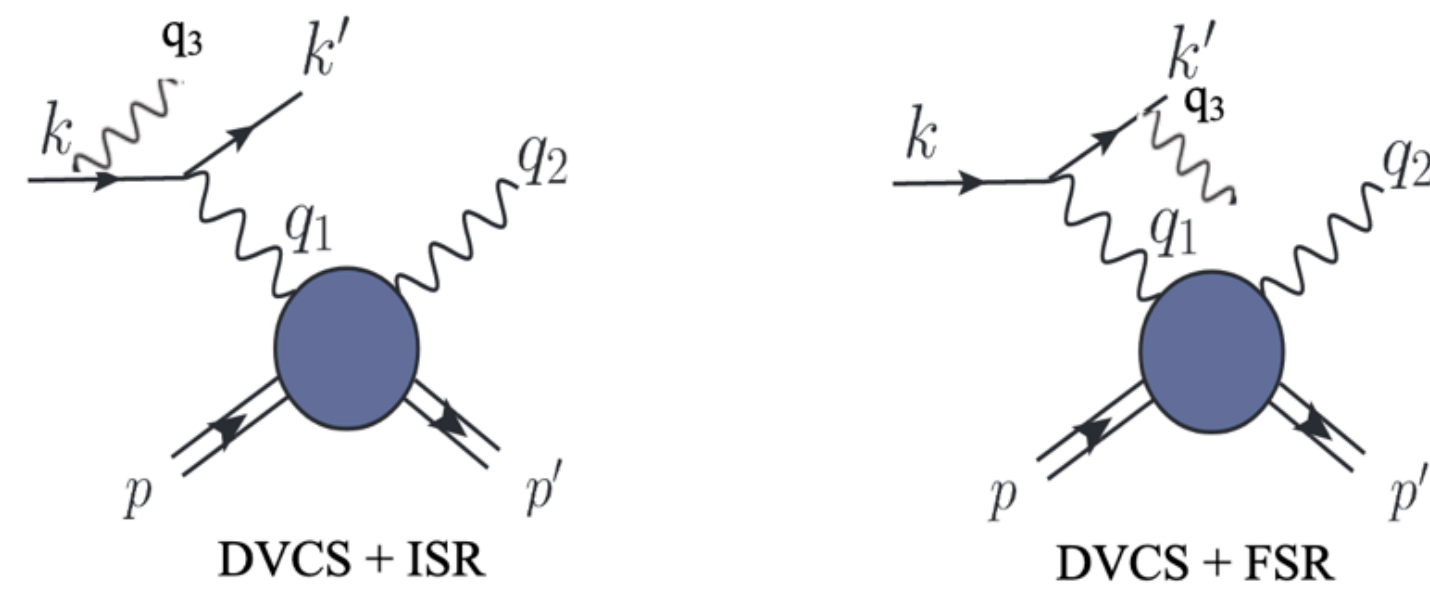
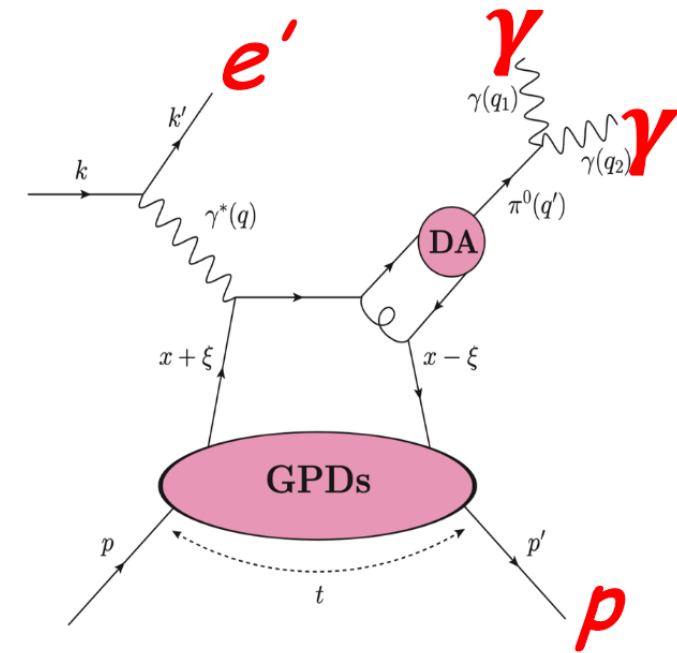
Status

- Exclusive physics WG has many different generators for reactions
 - e.g. EpIC, MILOU3D, TOPEG, IAger, eSTARlight, SARTRE, BeAGLE, elSpectro, DEMPgen
- **Currently awaiting full Geant4 EPIC detector simulations for exclusive physics WG**
- When outputs ready, will analyse
- Examples of currently planned analyses:

DVCS ep	DVCS e ⁴ He UoG (G. Penman, R. Montgomery)	TCS ep Saclay/UoG (D. Sokhan, K. Gates)	Diffraction vector meson productions (e.g. J/ψ, φ...)	J/ψ production UoY (S. Fegan)
Pion/kaon Form Factors	Pion/kaon Structure Functions	XYZ Spectroscopy UoG (D. Glazier)	Backwards u-channel production of vector mesons, DVCS	Upsilon production

Green = UK-affiliated involvement

Meanwhile...Generator Developments On-going



- π^0 background ($ep \rightarrow e'p'\pi^0 \rightarrow e'p'\gamma\gamma$) for DVCS ($ep \rightarrow e'p'\gamma$)
 - Barrel EM calorimetry design, under study
- Radiative corrections in DVCS
 - Not large at EIC kinematics
- Testing **EpIC generator** developments from theorists (D. Sokhan, K.Gates)
 - Key for DVCS and TCS
- **Kaon elastic form factor F_K** via generator upgrade
 - Previously only F_π ; F_π generation also improved
- Feasibility studies of **backwards u-channel DVCS**
 - Access TDAs, partonic correlations, transverse locations of hadronic constituents
- Limitations of **Good-Walker paradigm in eA vector meson photoproduction** (links coherent and incoherent to average nuclear config and event by event fluctuations)

Summary...

- UK-related leadership and participation very strong in WG
- Broad range of nucleon and nuclei structure topics
- Developments on generator updates and background studies
- Awaiting full detector simulation outputs
- Stay tuned
- Anyone interested is welcome
 - Meet Mondays, 5pm (UK time)
 - Mailing list: <https://lists.bnl.gov/mailman/listinfo/eic-projdet-excldiff-l>
 - Contact: rachel.montgomery@glasgow.ac.uk or daria@jlab.org

...Thank you...