SRCs Studies at the EIC

Florian Hauenstein,
EMC/SRC Workshop
03/26/21

SRC at EIC: JLab on Steroids

JLab

Exclusive SRC
Tagged DIS

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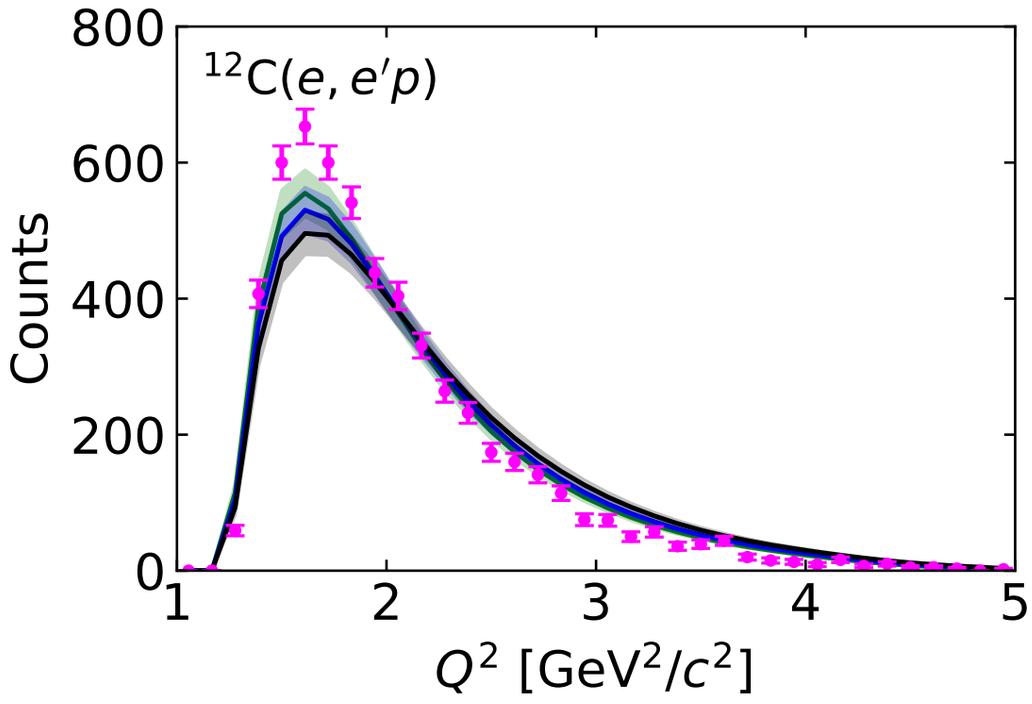
EIC

- larger recoil momentum acceptance
- higher Q^2
- A-2 detection?

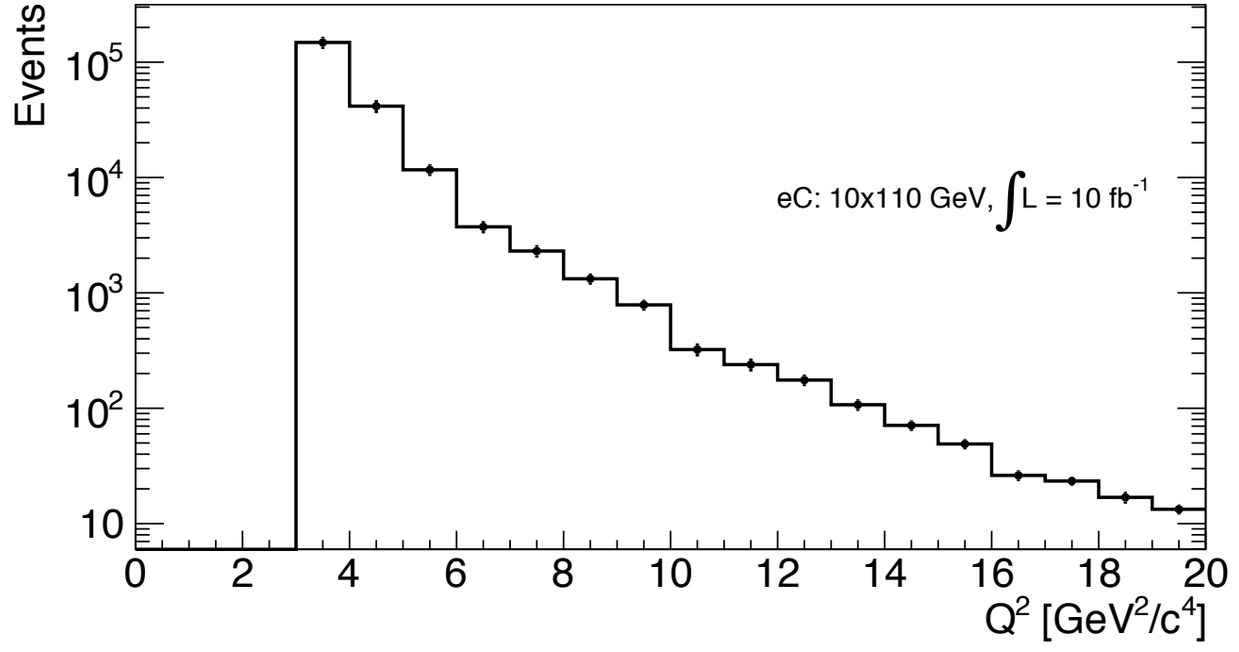
Higher Q^2 Coverage

JLab



Schmidt, Nature 578, 540544 (2020)

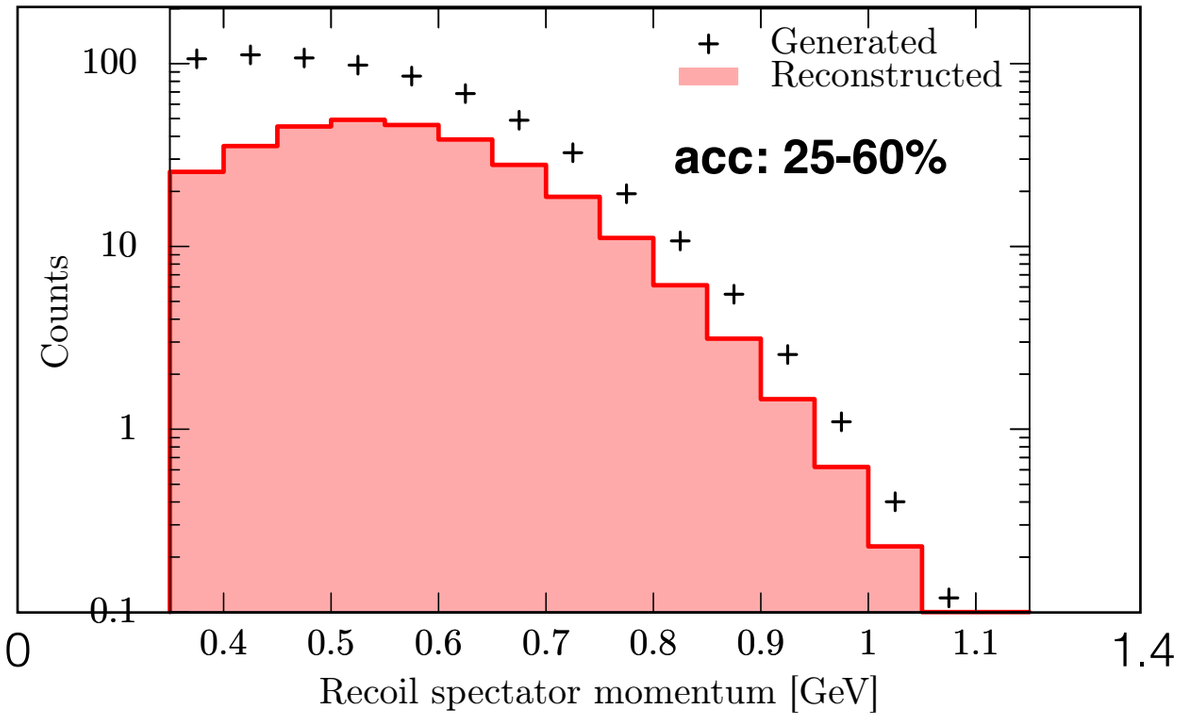
EIC



- Better understanding of reaction mechanism
- Search for 3N-SRCs

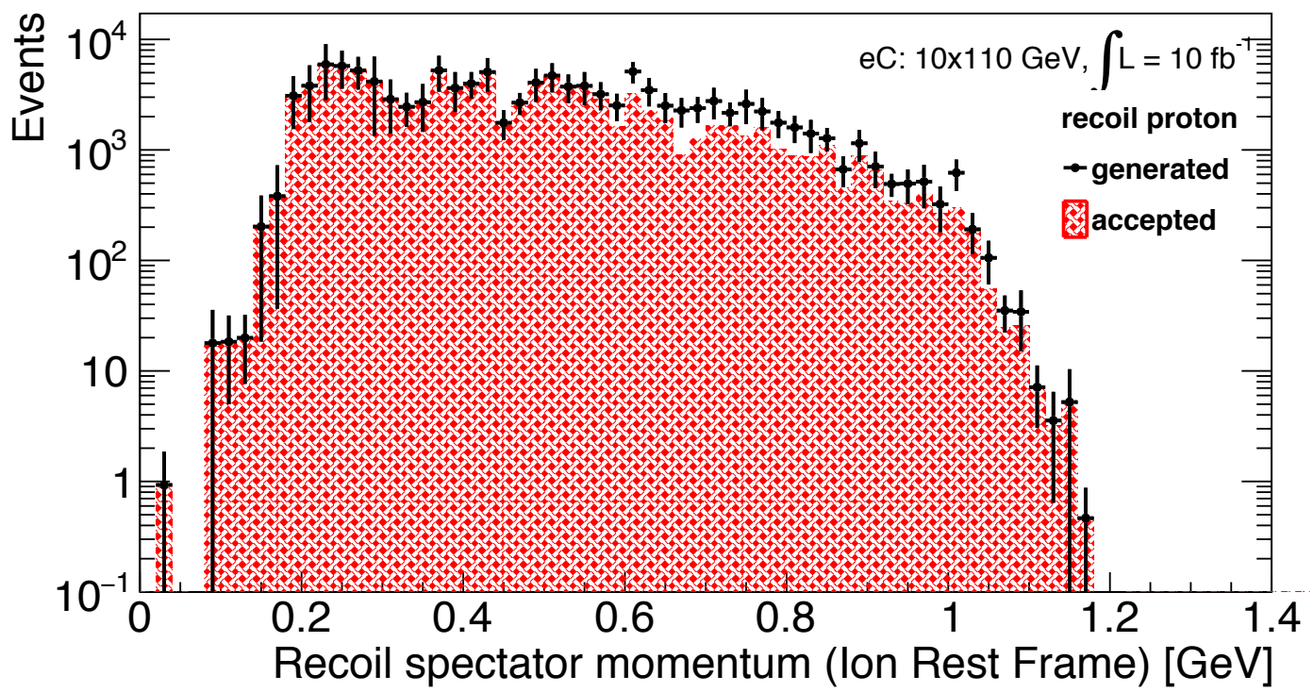
Larger Recoil Momentum Acceptance

JLab



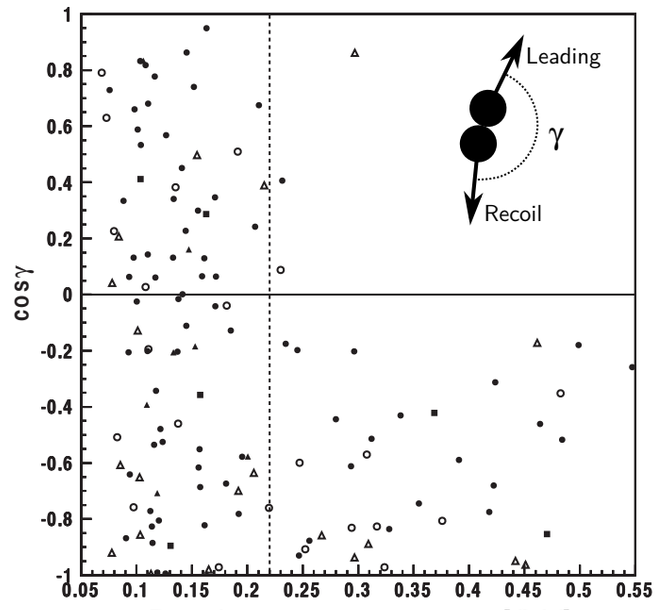
Schmidt, Nature 578, 540544 (2020)

EIC



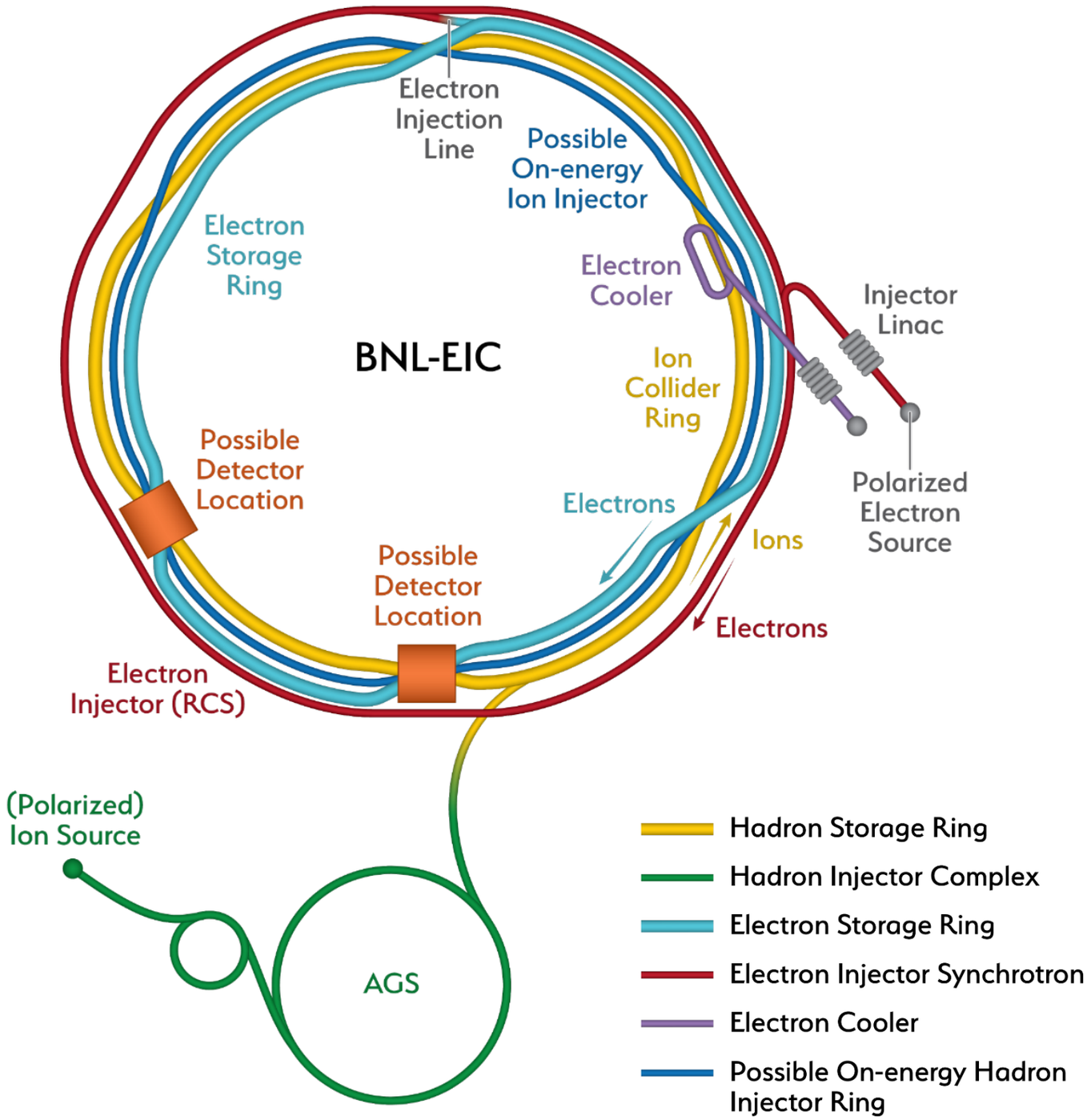
EIC Yellow Report, Section 7.3

- Full range acceptance of recoils
- Probing SRC onset



Piasetzky, PRL 97, 162504 (2006)

Electron Ion Collider



- Electron: 5-18 GeV
- Proton up to 275 GeV
- Ions
  - 41 GeV/A
  - 100-135 GeV/A
- 2 interaction points
- polarized beams

Tagged SRC Measurements at EIC

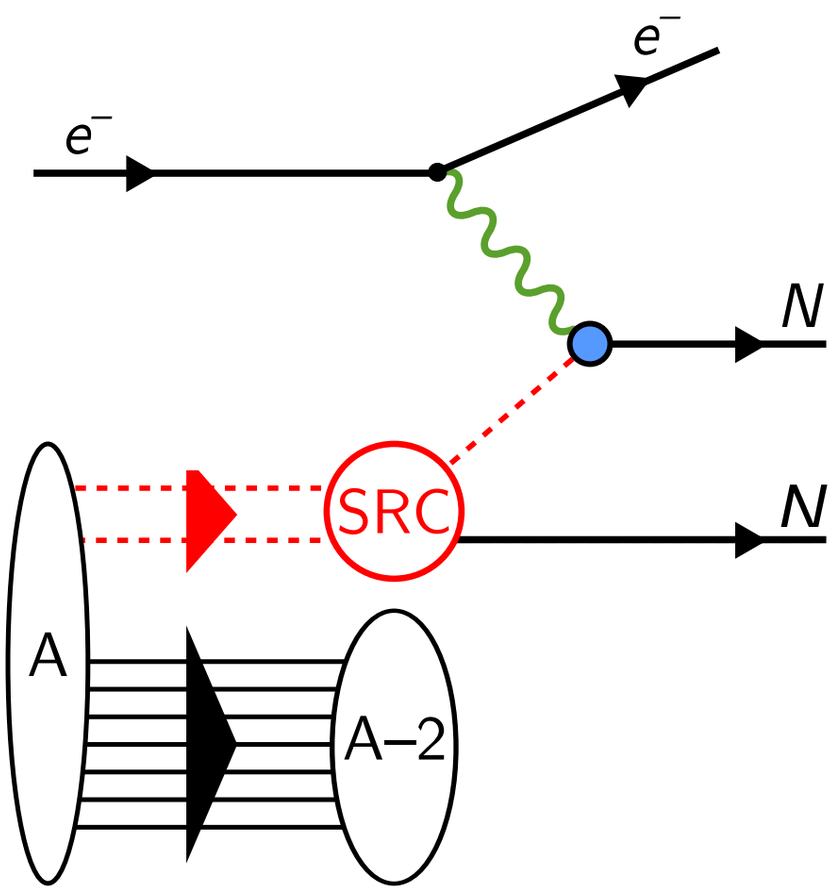
- Kinematics
  - DIS
  - Quasi-elastic (QE)

- Feasibility
  - Rates
  - Detector requirements (focus on forward ion direction)
  - Optimal beam energies

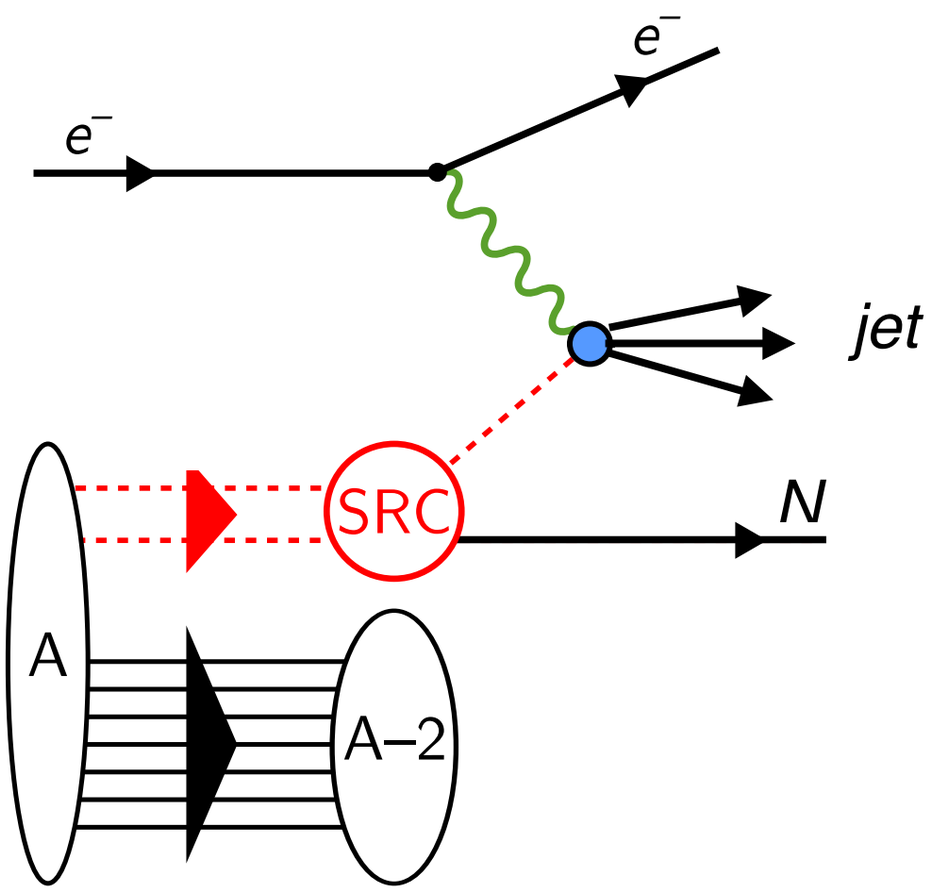
- Tools
  - *GCF-SRC* event generator
  - *BeAGLE* - eA event generator
  - *g4e* - Geant4 simulation for EIC
  - *EICroot* - Geant4 simulation for EIC

SRC Reaction Topologies

GCF-QE



GCF-DIS



- Recoil and A-2 distributions independent on photon interaction

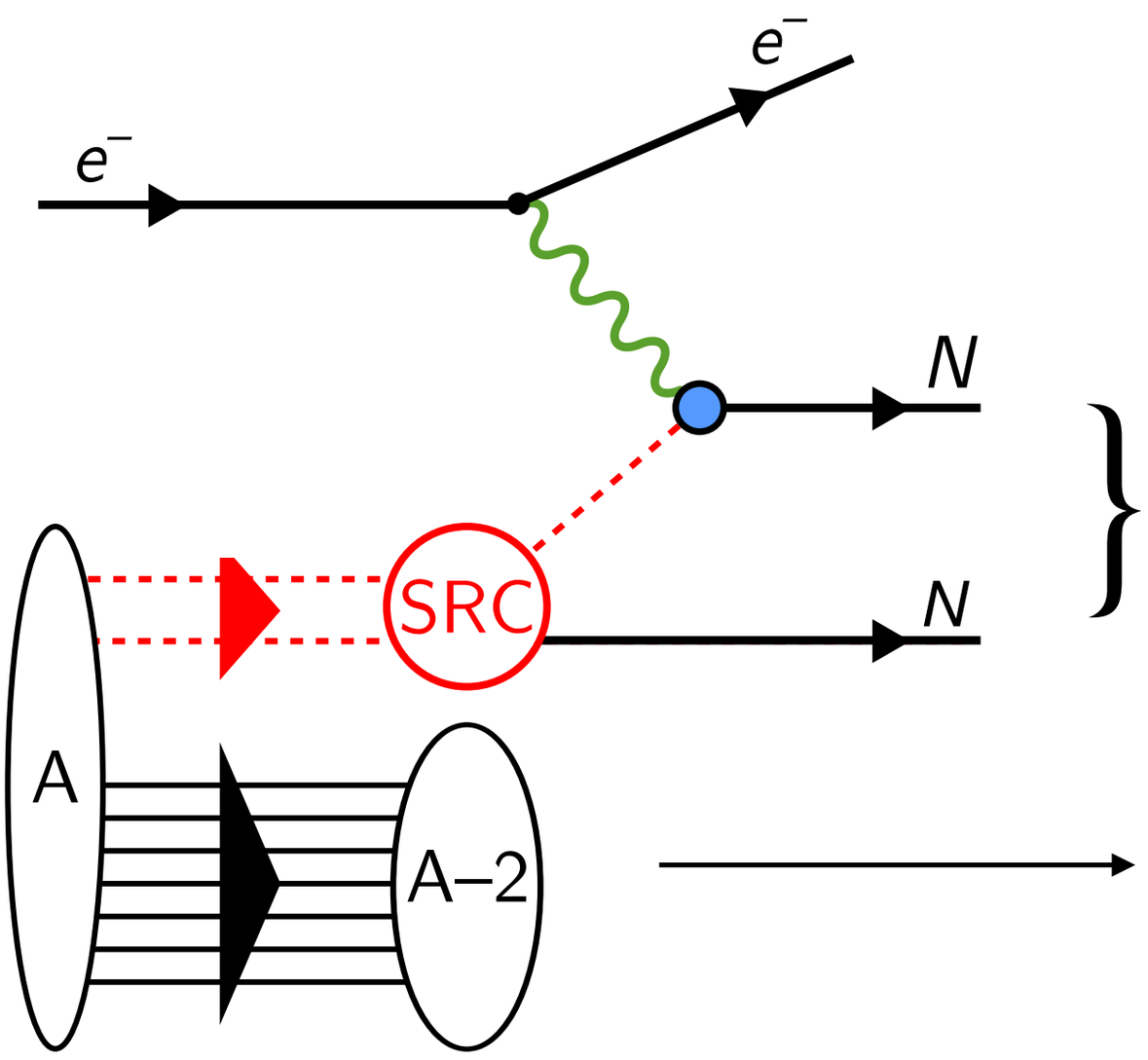
—> **GCF-QE as a baseline for recoil tagging in DIS**

GCF and BeAGLE

- GCF-DIS in development
- GCF-Quasielastic (QE) implemented
- (A-2)-system handled by BeAGLE's DPMJET3+FLUKA

GCF-QE Generator

{e⁻,N,N, (A-2)}



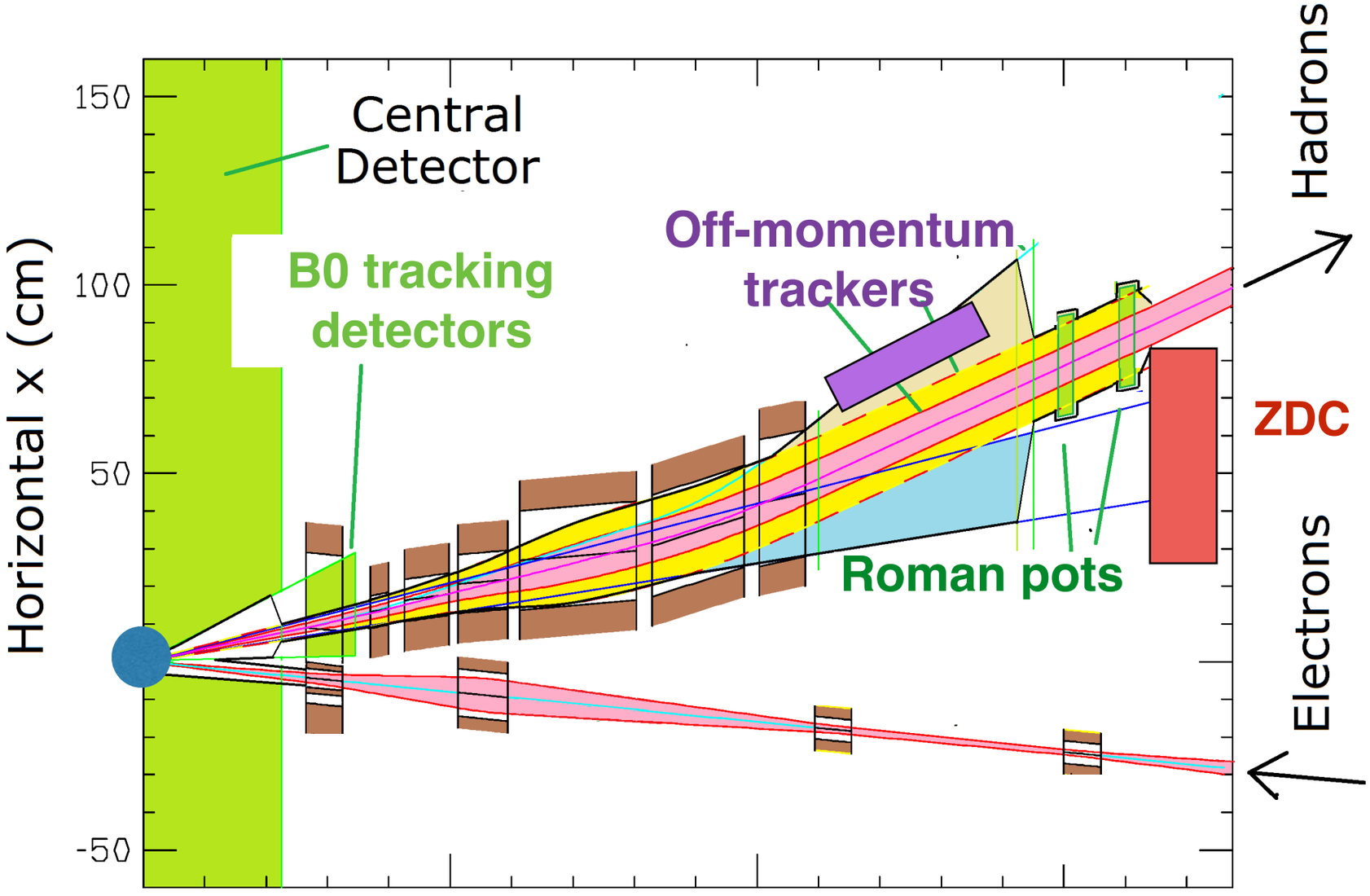
Optional (BeAGLE)
- Intranuclear cascading

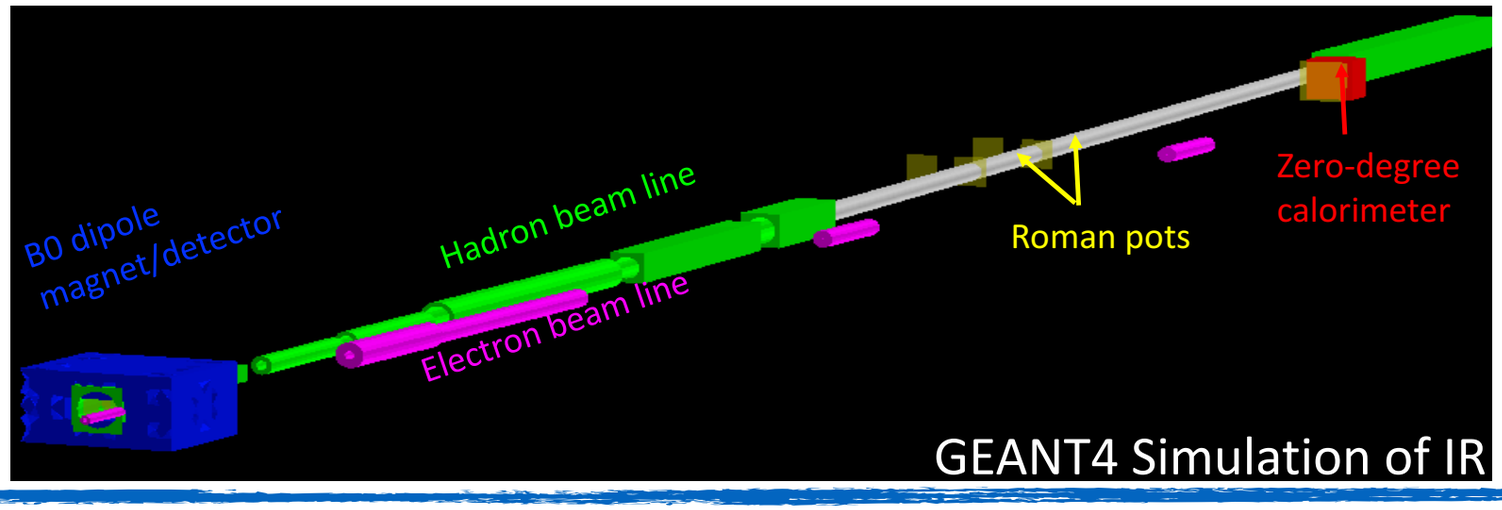
DMPJET+FLUKA

QE Simulations

- Beam energies (``Standard settings“)
  - 5 GeV e^- x 41 GeV/A ions
  - 10 GeV e^- x 110 GeV/A ions
- Ions
  - Deuterium
  - ^{12}C
- **$10fb^{-1}$ luminosity = 1 year of EIC**
- GCF event generator with Q^2 = [2.5 GeV^2 - 250 GeV^2]
- Analysis cuts
  - x > 1.2
  - Q^2 > 3 GeV^2
- Acceptance study with *g4e* 1.3.8

Detectors for Far-Forward Hadrons



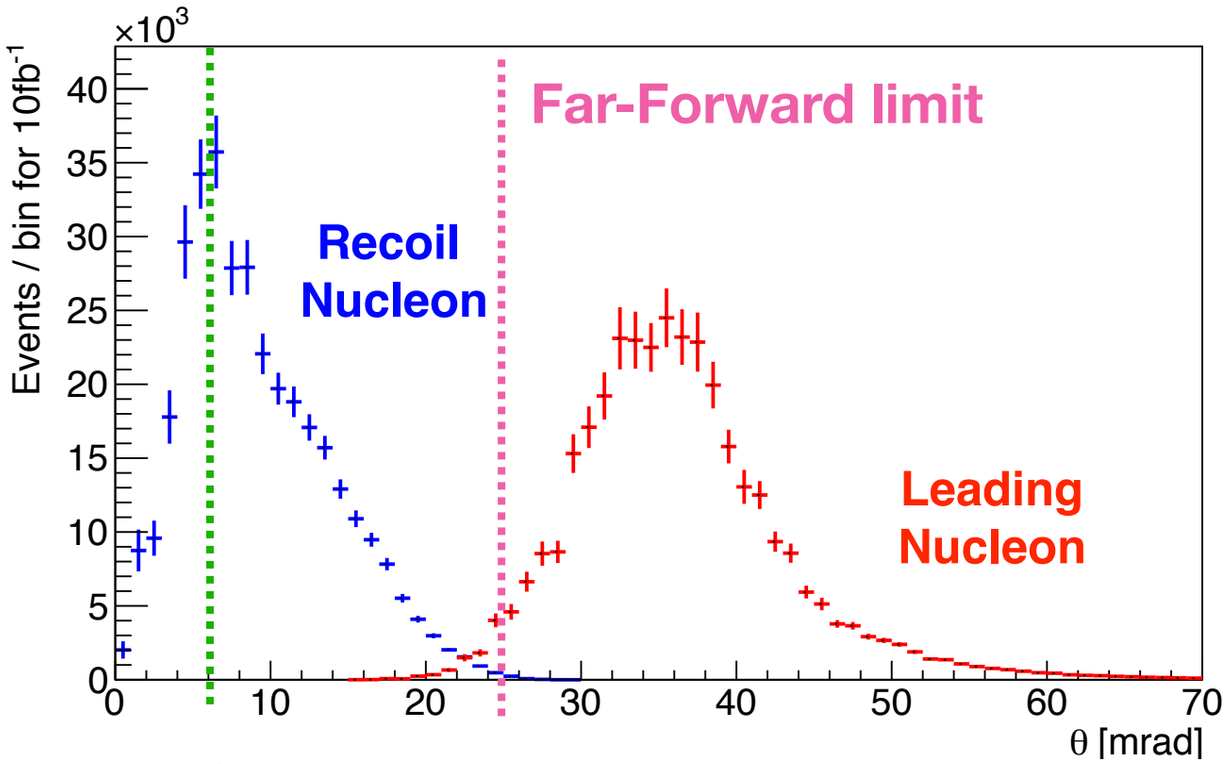


- **Zero Degree Calorimeter (ZDC)**
  - Neutrons & Photons
  - **±5 mrad**
  - 60x60cm^2
- **B0 sensors**
  - **6-20 mrad**
  - Silicon detectors
- **Off-momentum**
  - Positive particles
  - Moveable
- **Roman Pots**
  - ~0-5 mrad
  - Silicon detectors

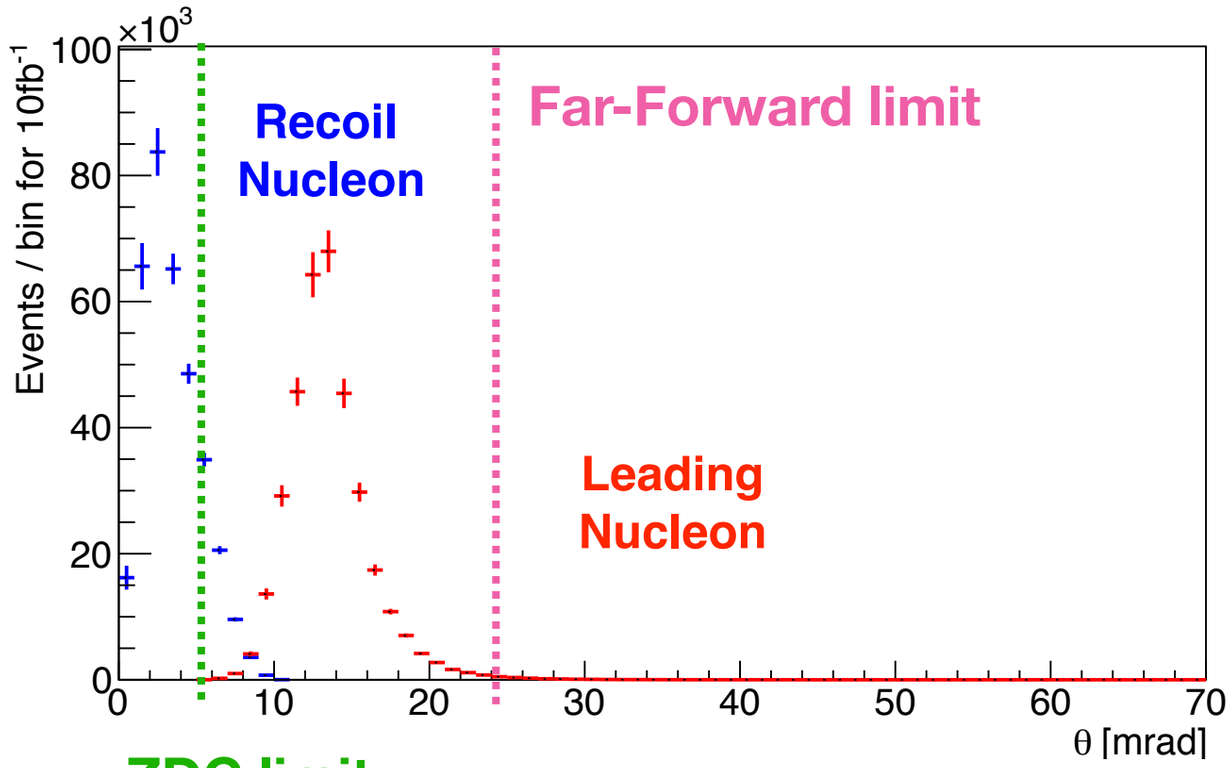
Angular Distributions

no crossing angle, **no FSI**, cuts: $x_B > 1.2$, $Q^2 > 3$ GeV^2

5 x 41/A



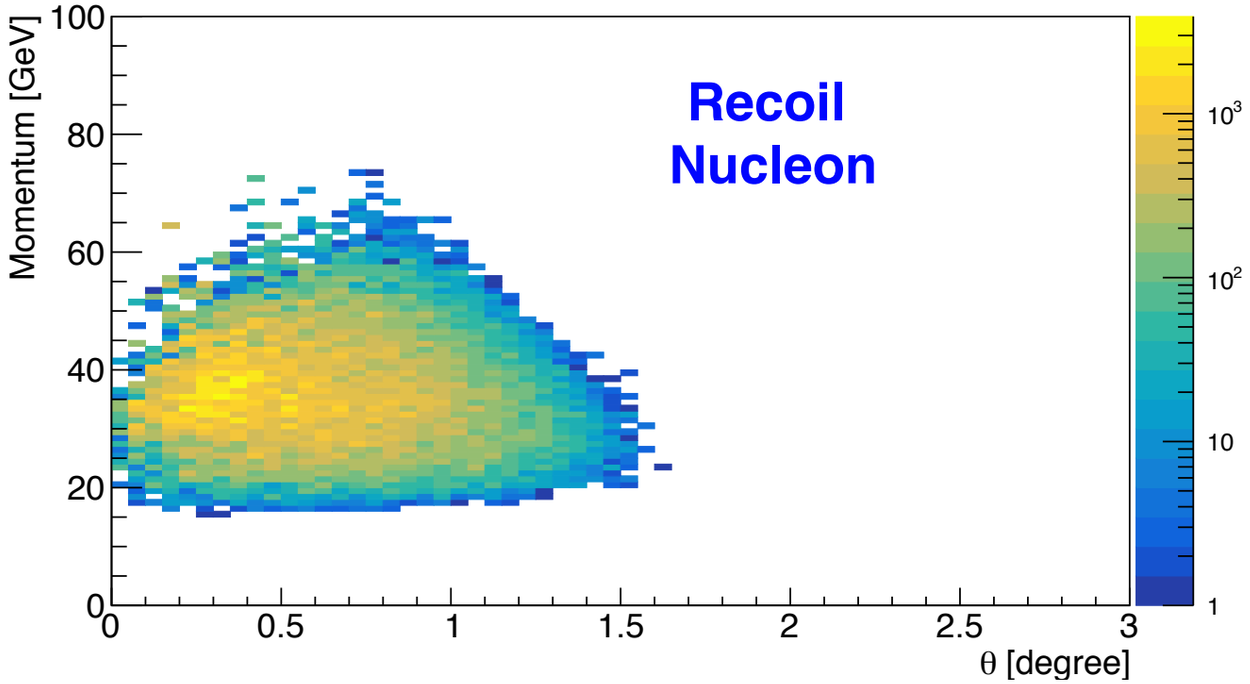
10 x 110/A

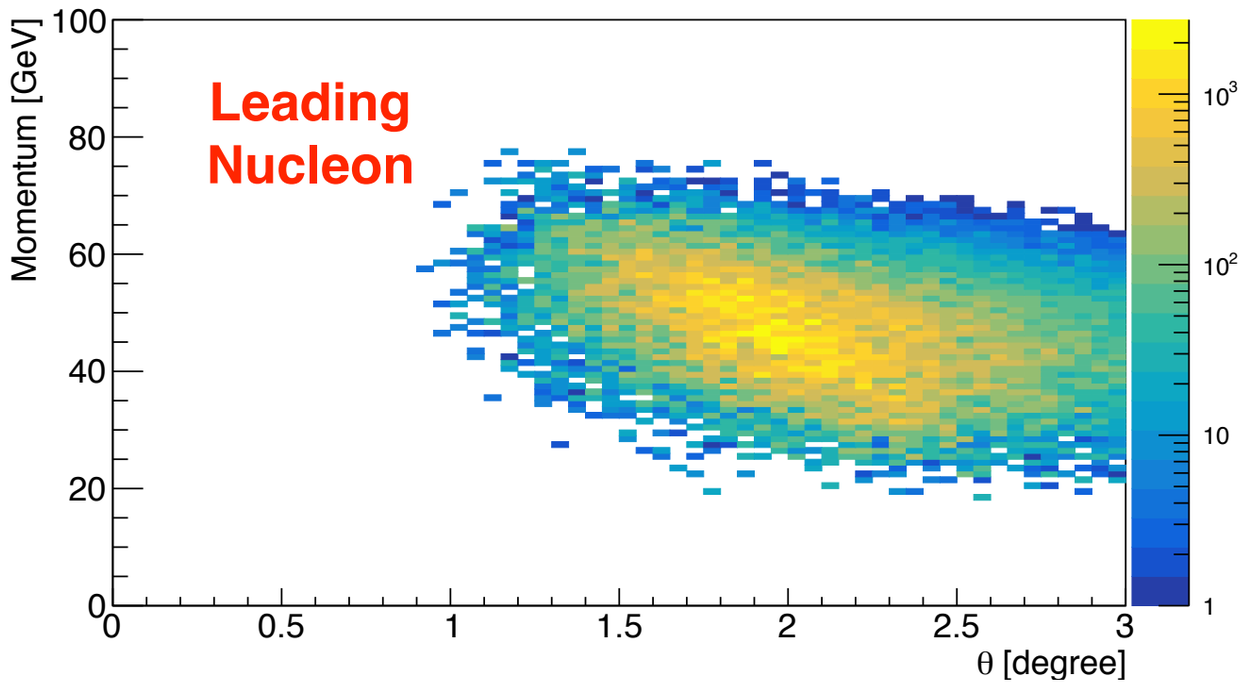


- Leading and recoil nucleons well separated
- Similar for neutrons and protons

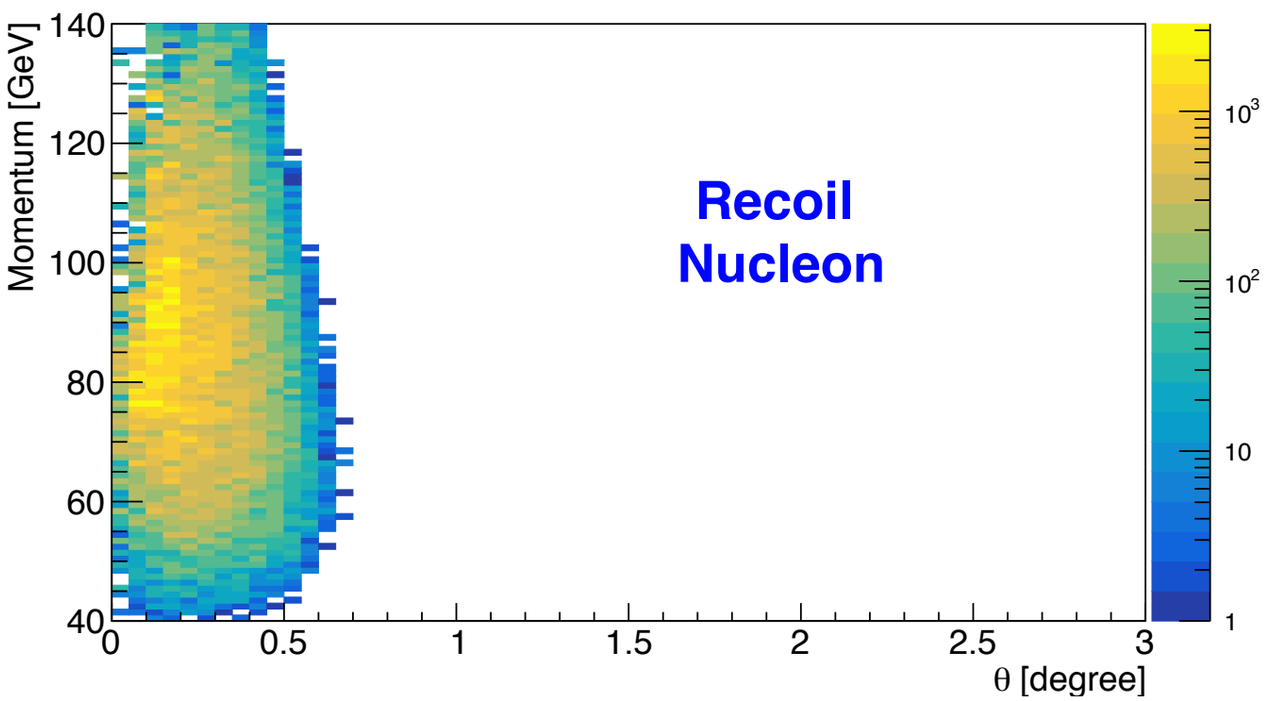
Hadron Kinematics: Leading and Recoil for e+C

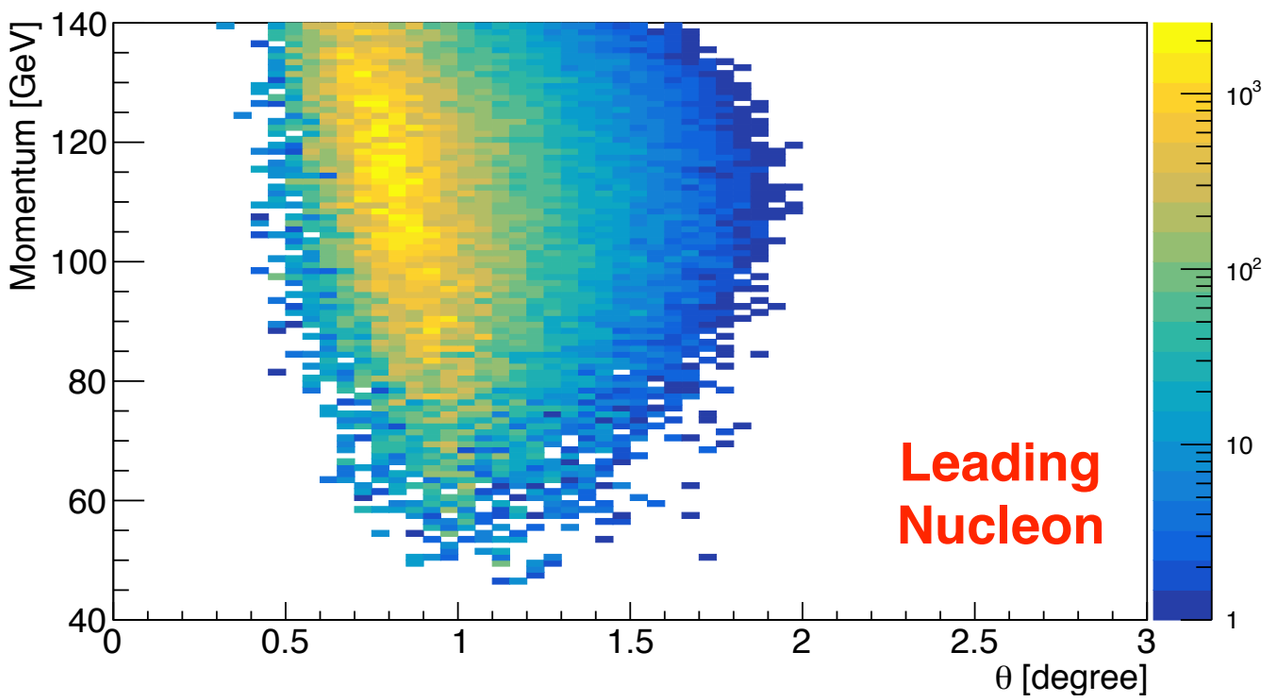
5GeV x 41GeV/nucleon





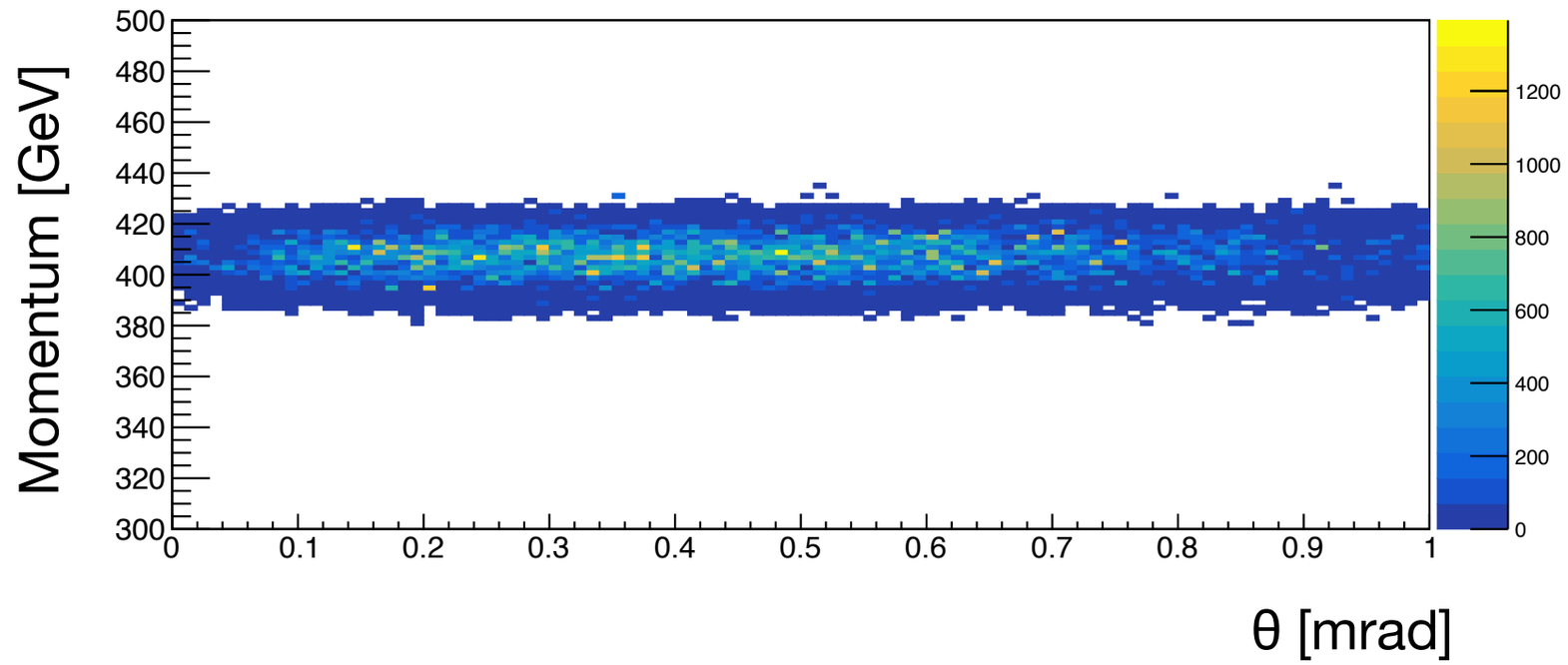
10GeV x 110GeV/nucleon

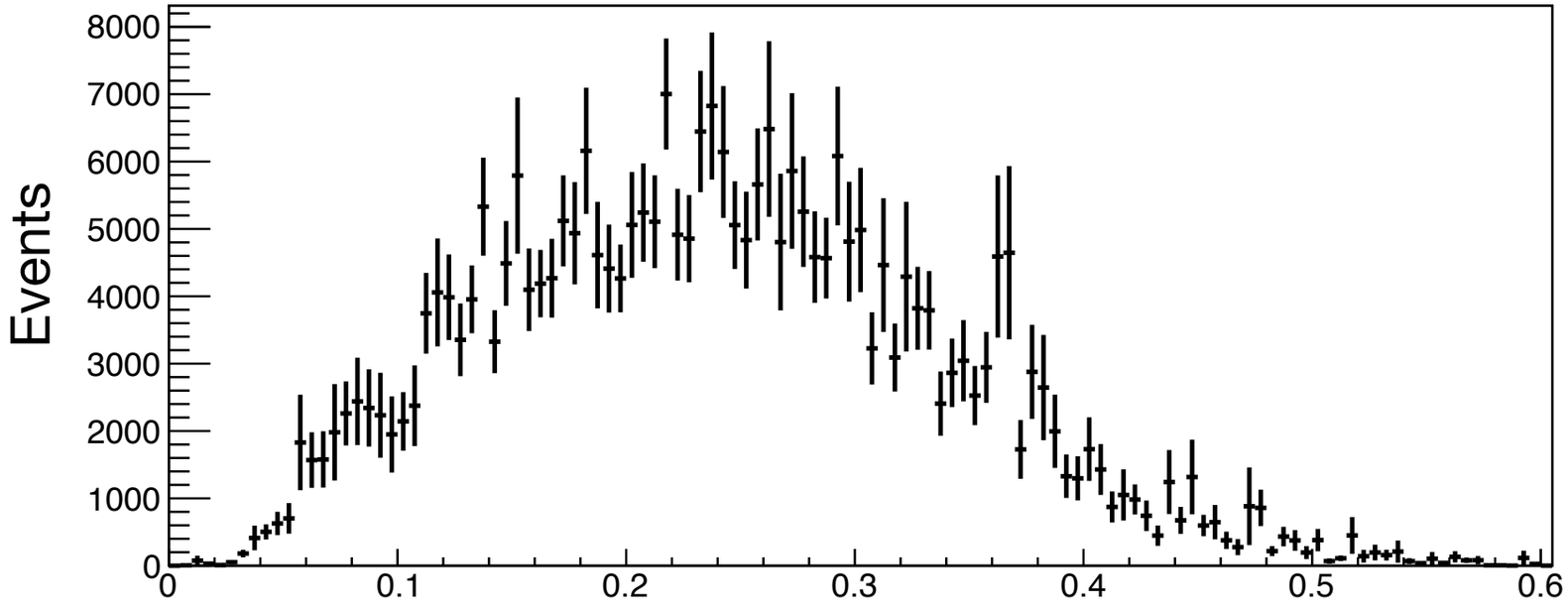




A-2 Acceptance

- e+C
- 5 x 41/A
- Boron-10 (np/pn)

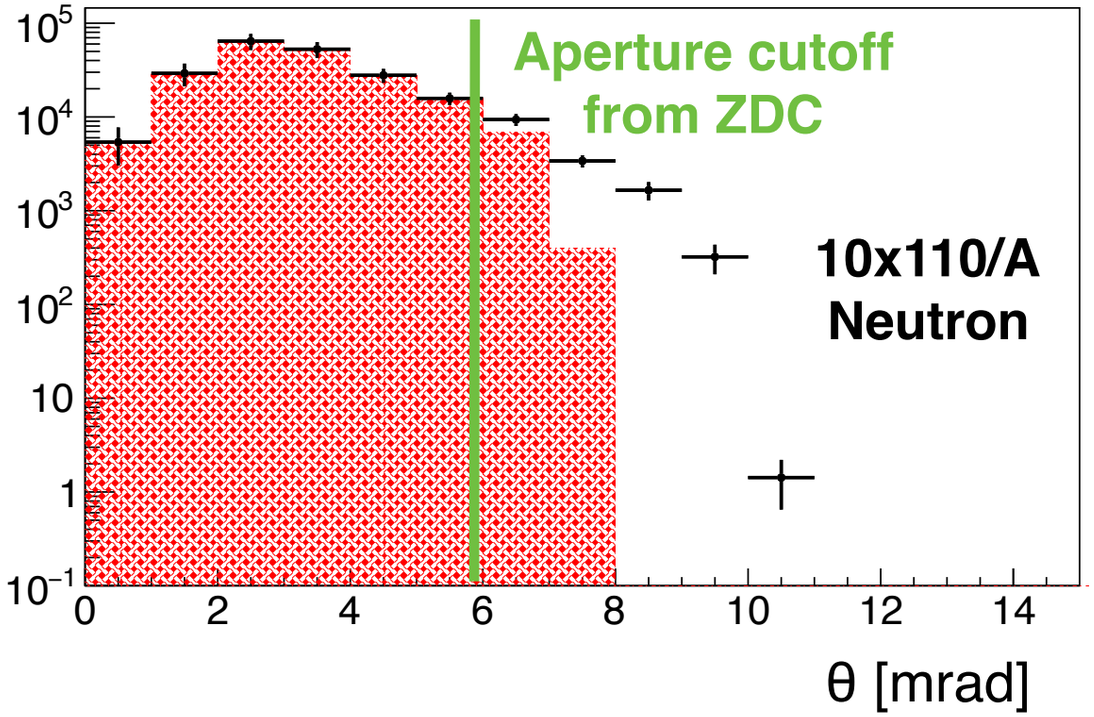




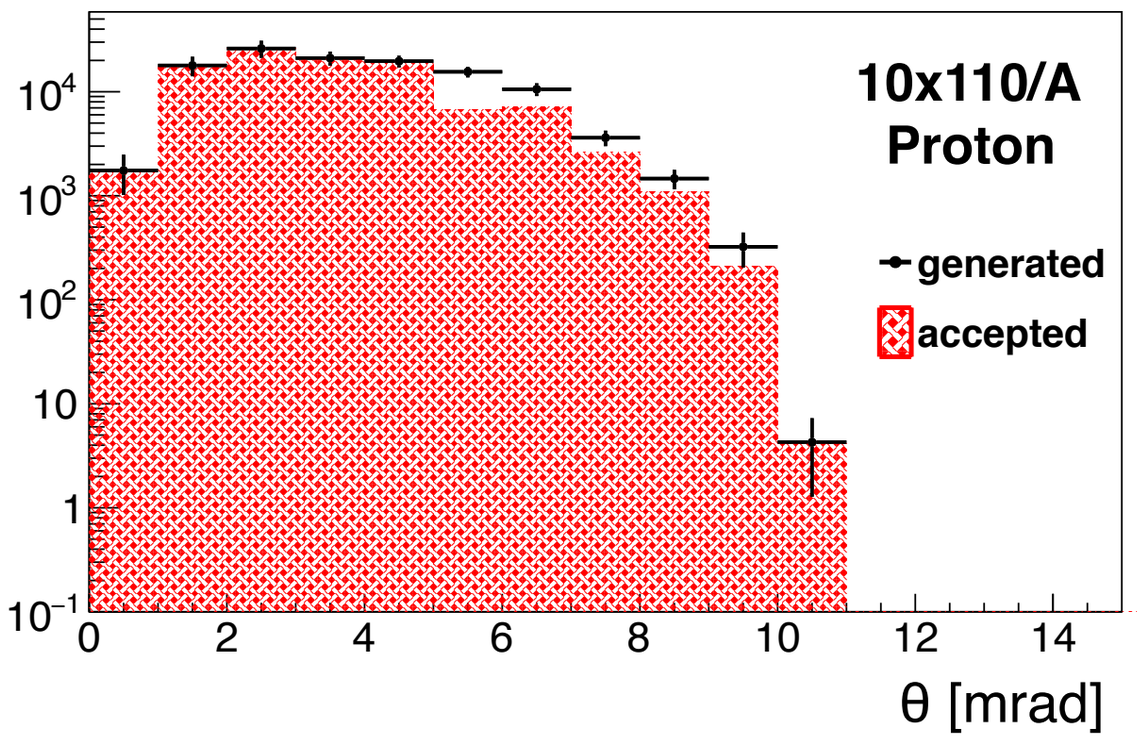
—> A-2 below 1 mrad, Be-10 (pp) and C-10 (nn) similar

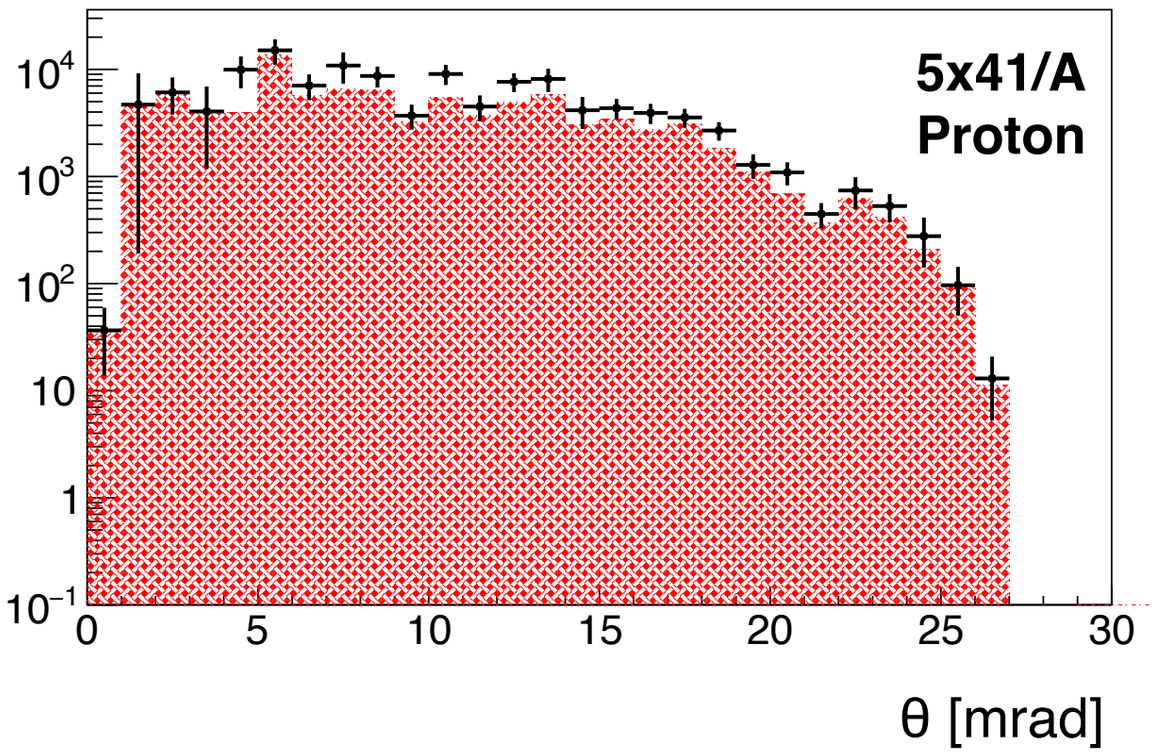
—> challenging to detect with Roman Pots

eC - Recoil Nucleon Acceptances



	p	n
5 x 41/A	75 %	37 %
10 x 110/A	87 %	96 %



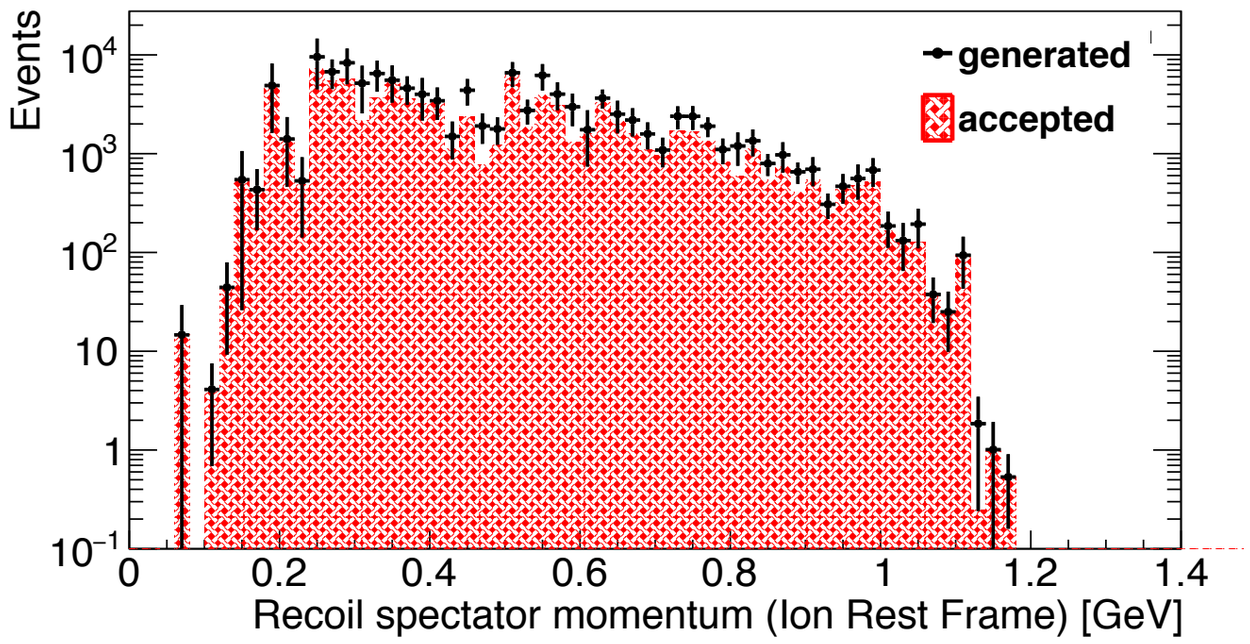


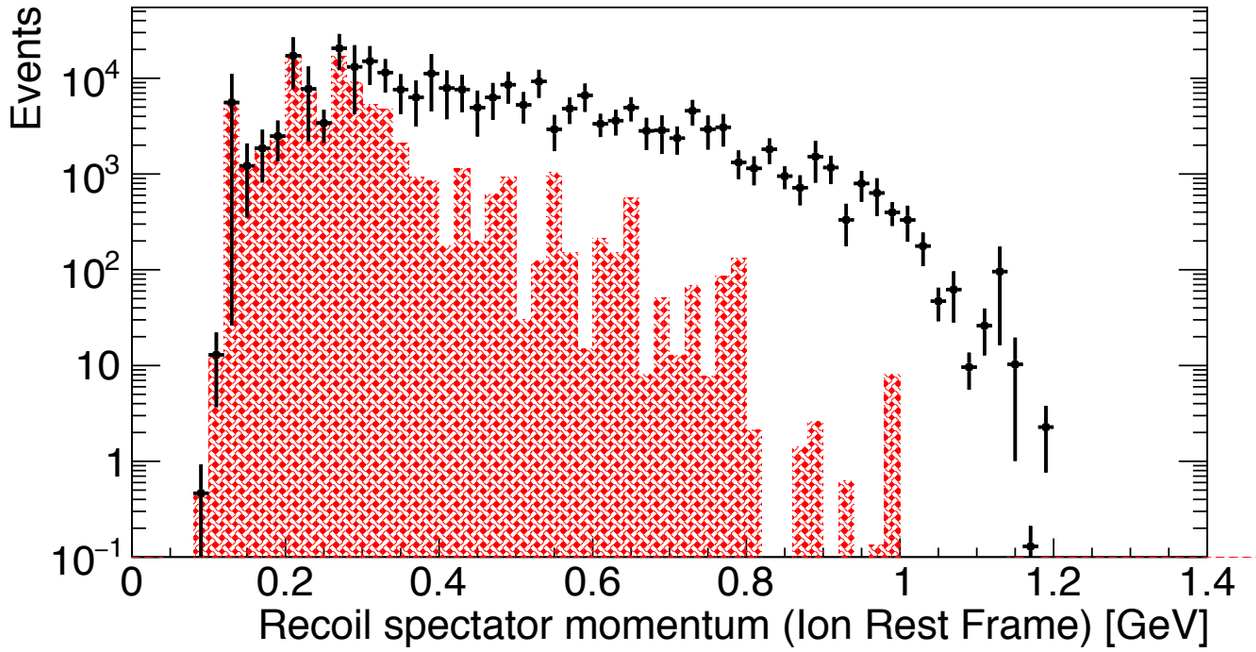
Recoil Momentum Distribution P_{IRF}

Proton

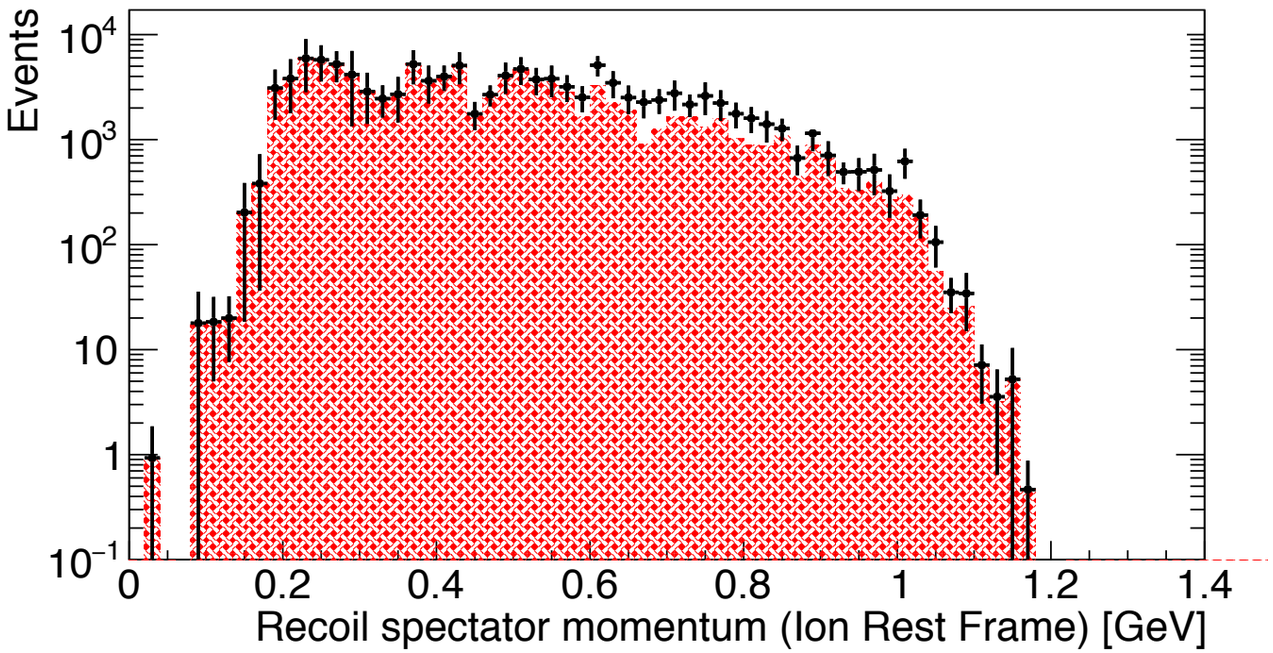
eC: 5 x 41/A, L =10fb^{-1}

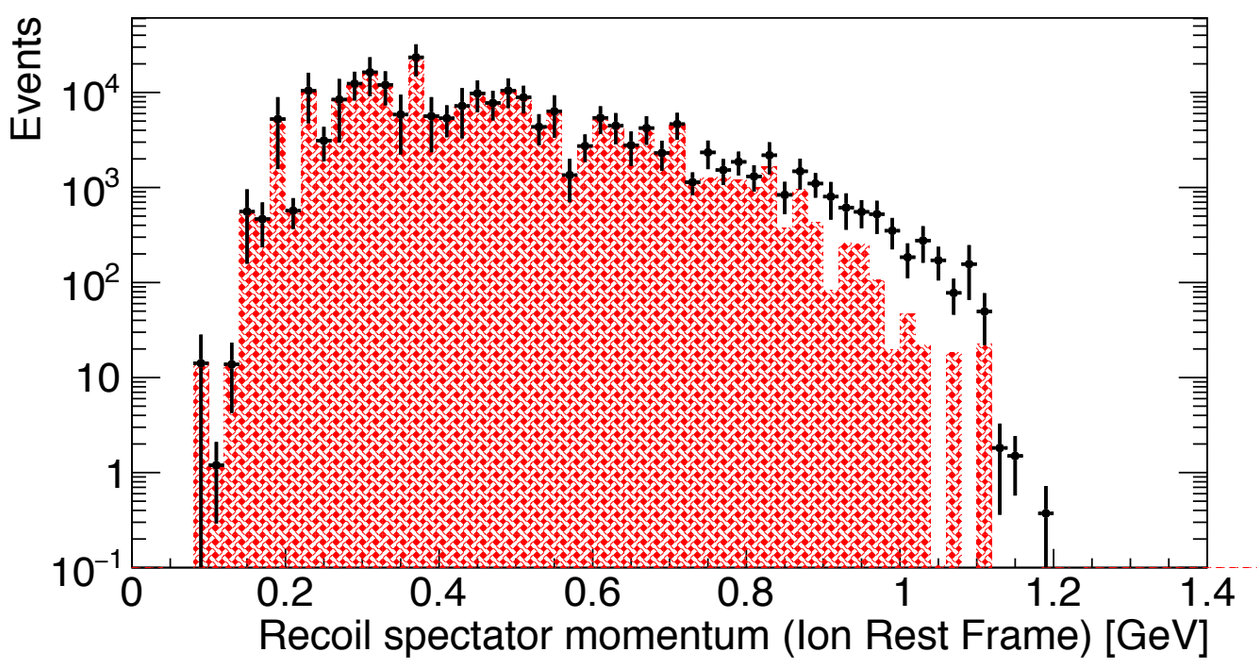
Neutron





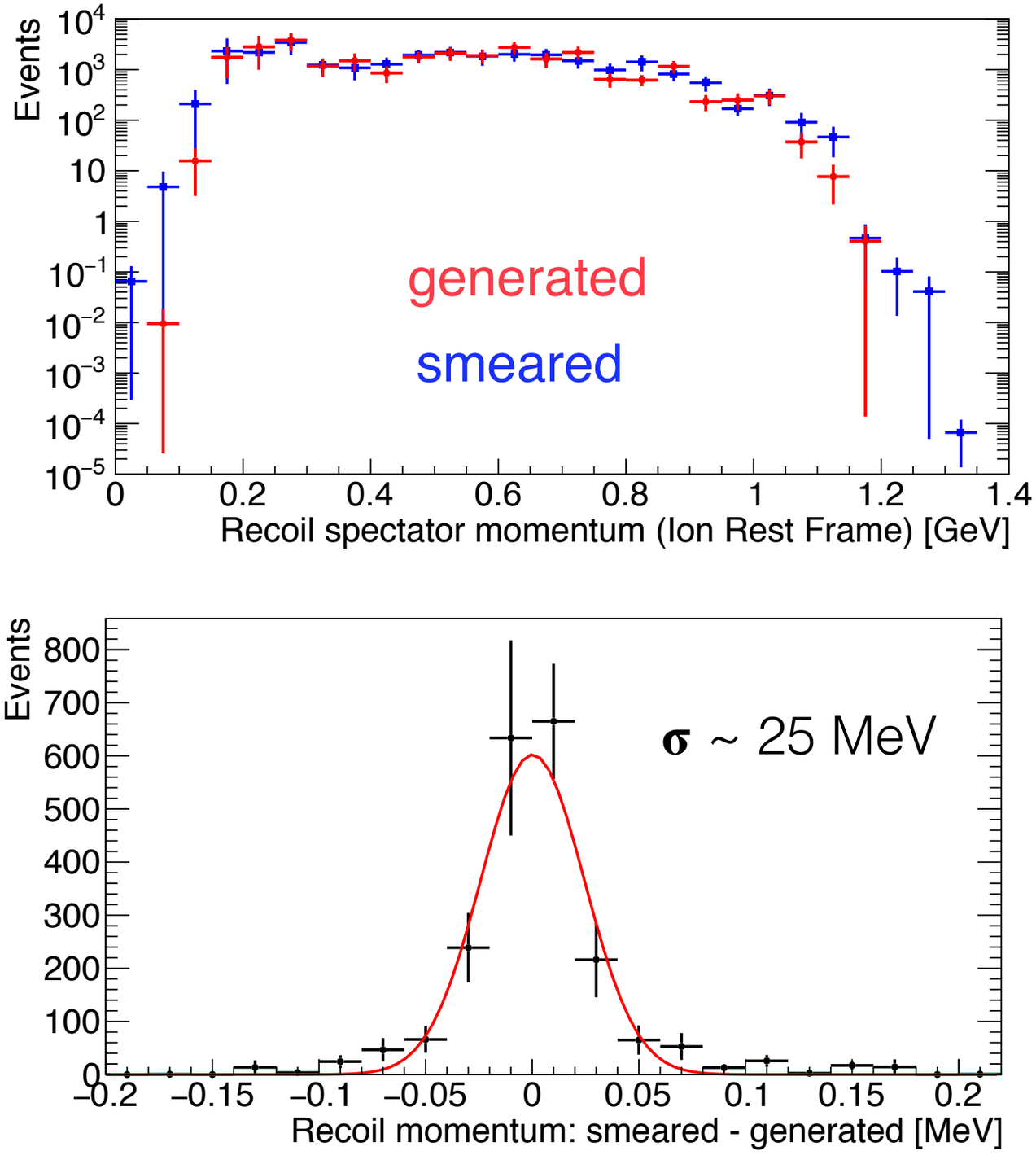
eC: 10 x 110/A, L =10fb^{-1}



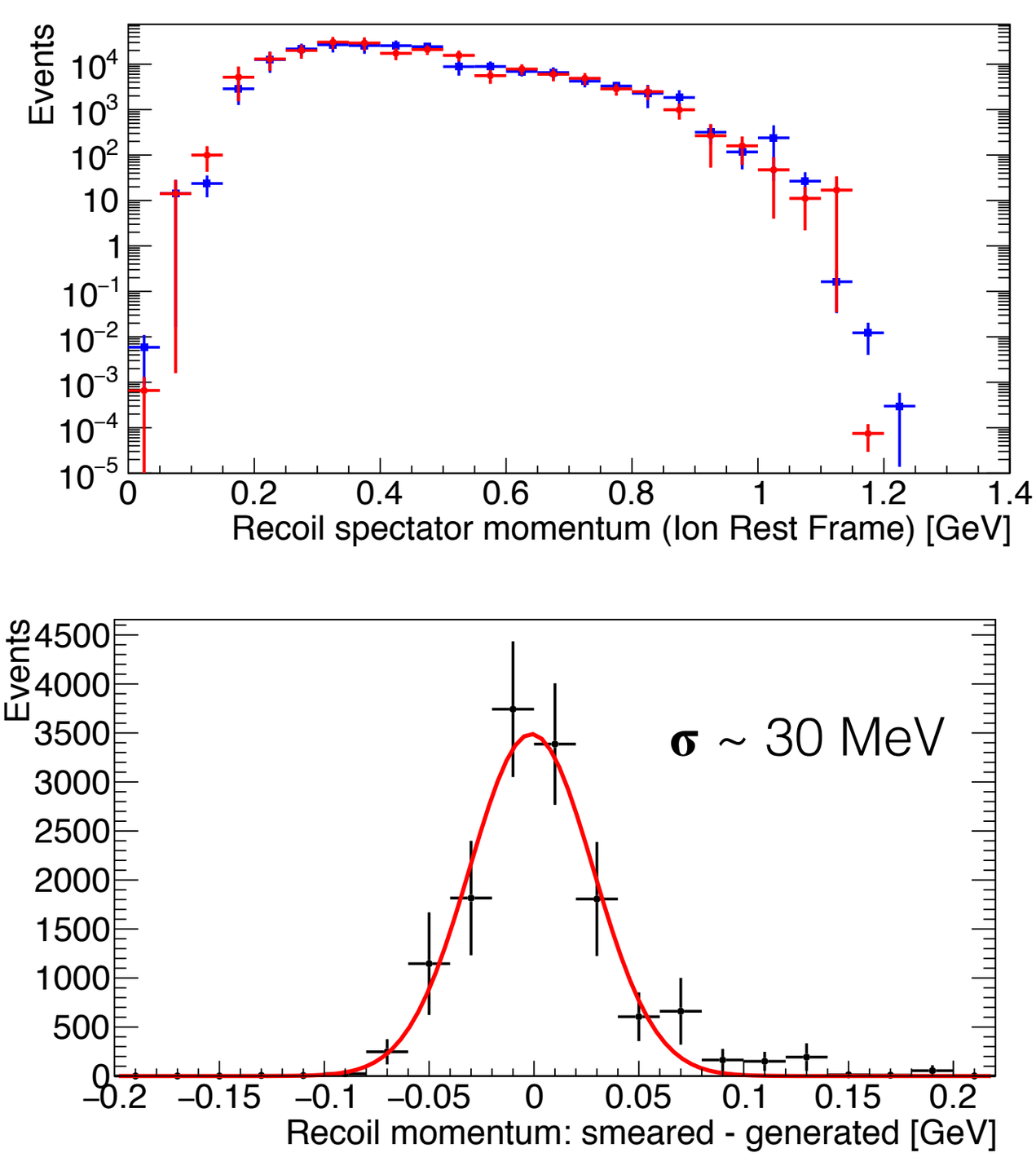


Recoil Smearing and Resolutions at 10x110/A

Proton



Neutron



Summary

- Recoil tagging at EIC
  - higher Q^2 reach
  - full recoil acceptance from SRC onset

- Tagging of SRC recoils feasible at EIC (YR Section 7.3)
  - clear separation of recoil and leading nucleons
  - good coverage of recoil momentum distribution
  - larger recoil acceptance for 110/A ions

- Tagging of A-2
  - direct measurement of pair cm momentum
  - detection challenging with Roman Pots due to low angles

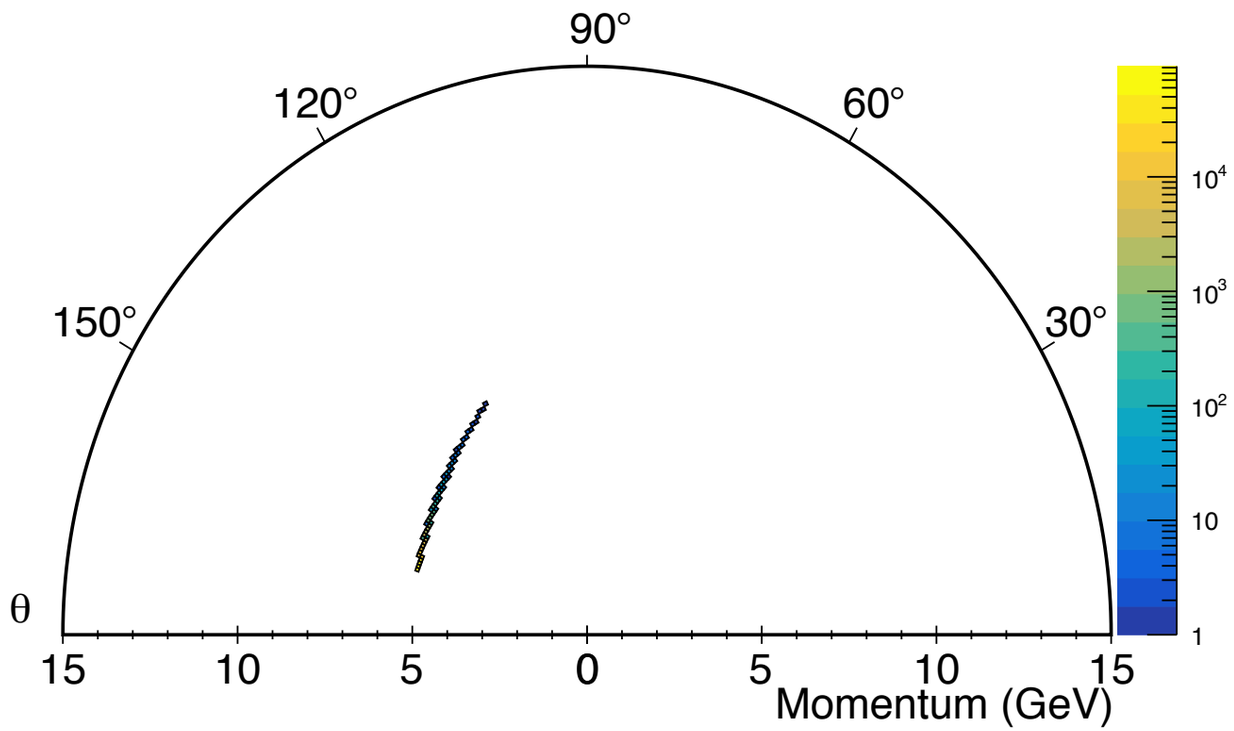
- Next step:
  - publication
  - explore tagged SRC-DIS measurements

Backup slides

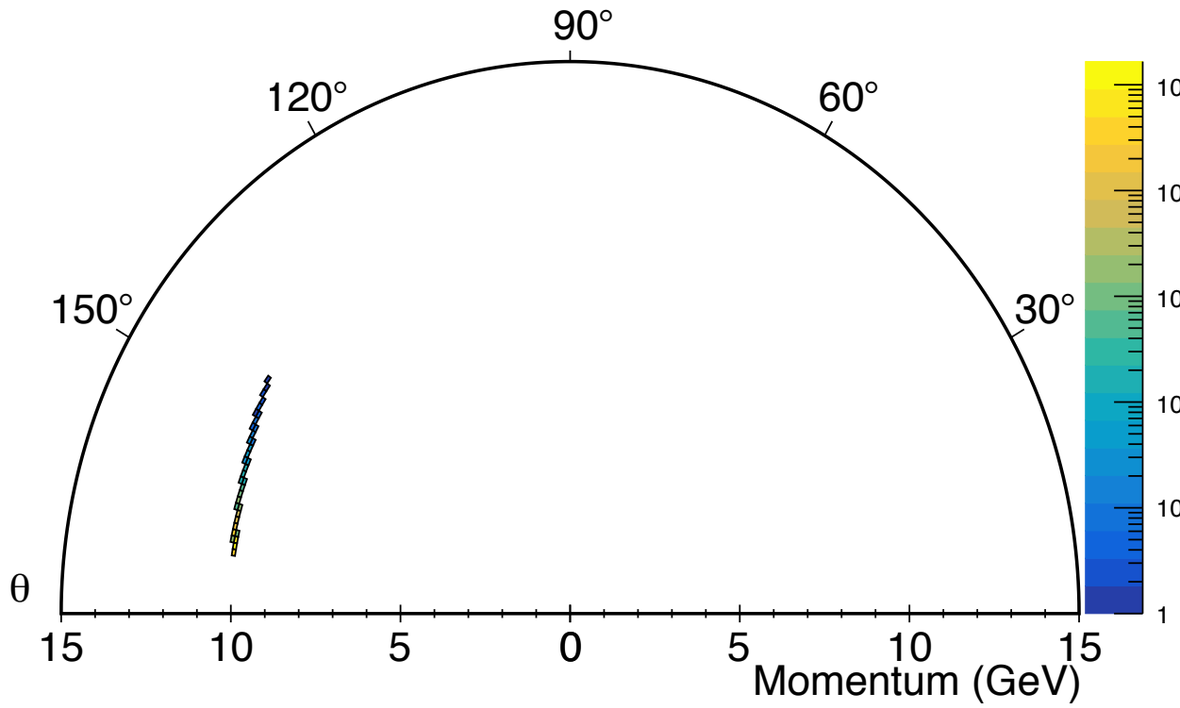
Electron Kinematics e+C

no crossing angle, no intra-nuclear cascading, cuts: $x_B > 1.2$, $Q^2 > 3$ GeV^2

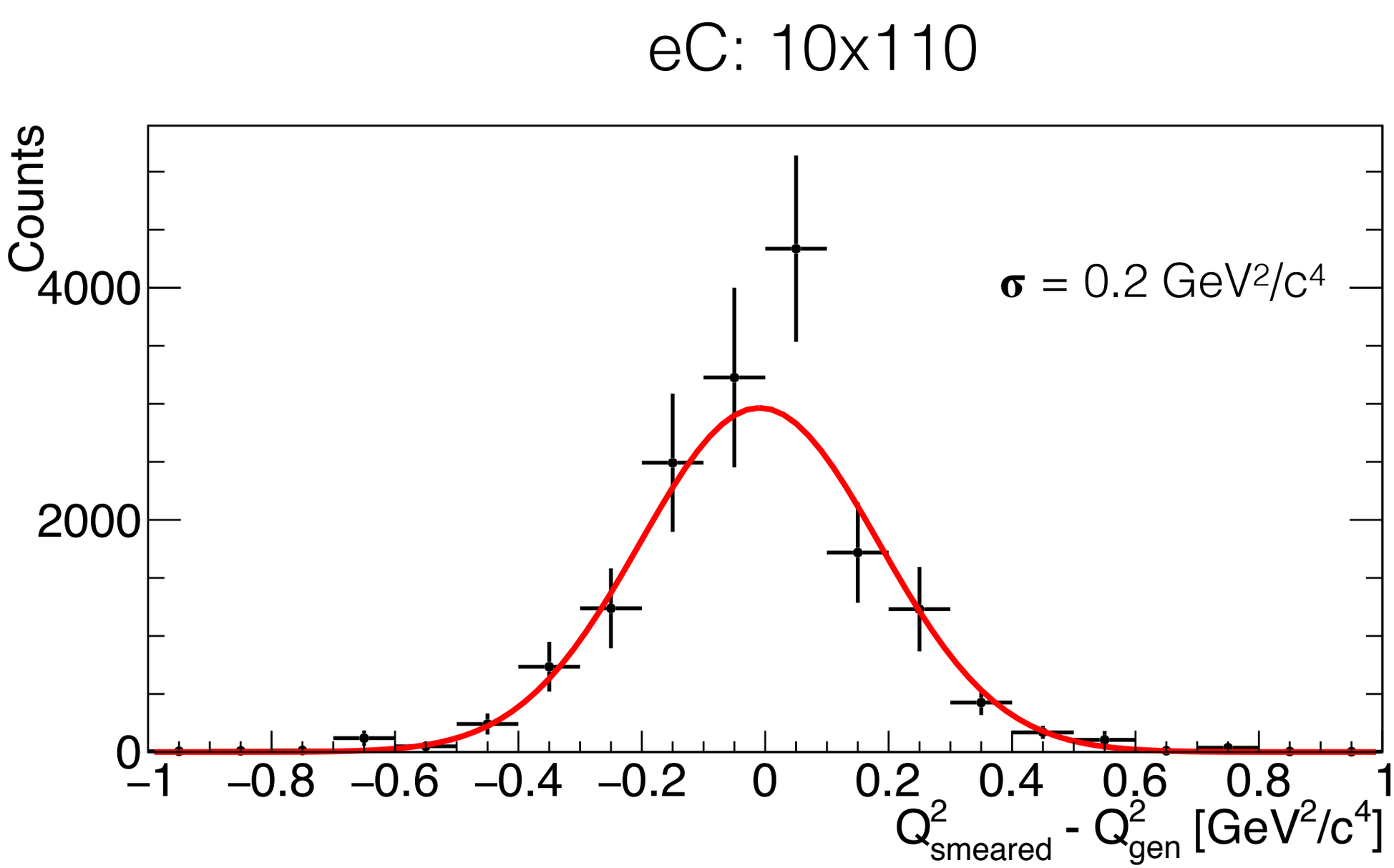
5 x 41/A, L =10fb^{-1}



10 x 110, L =10fb^{-1}

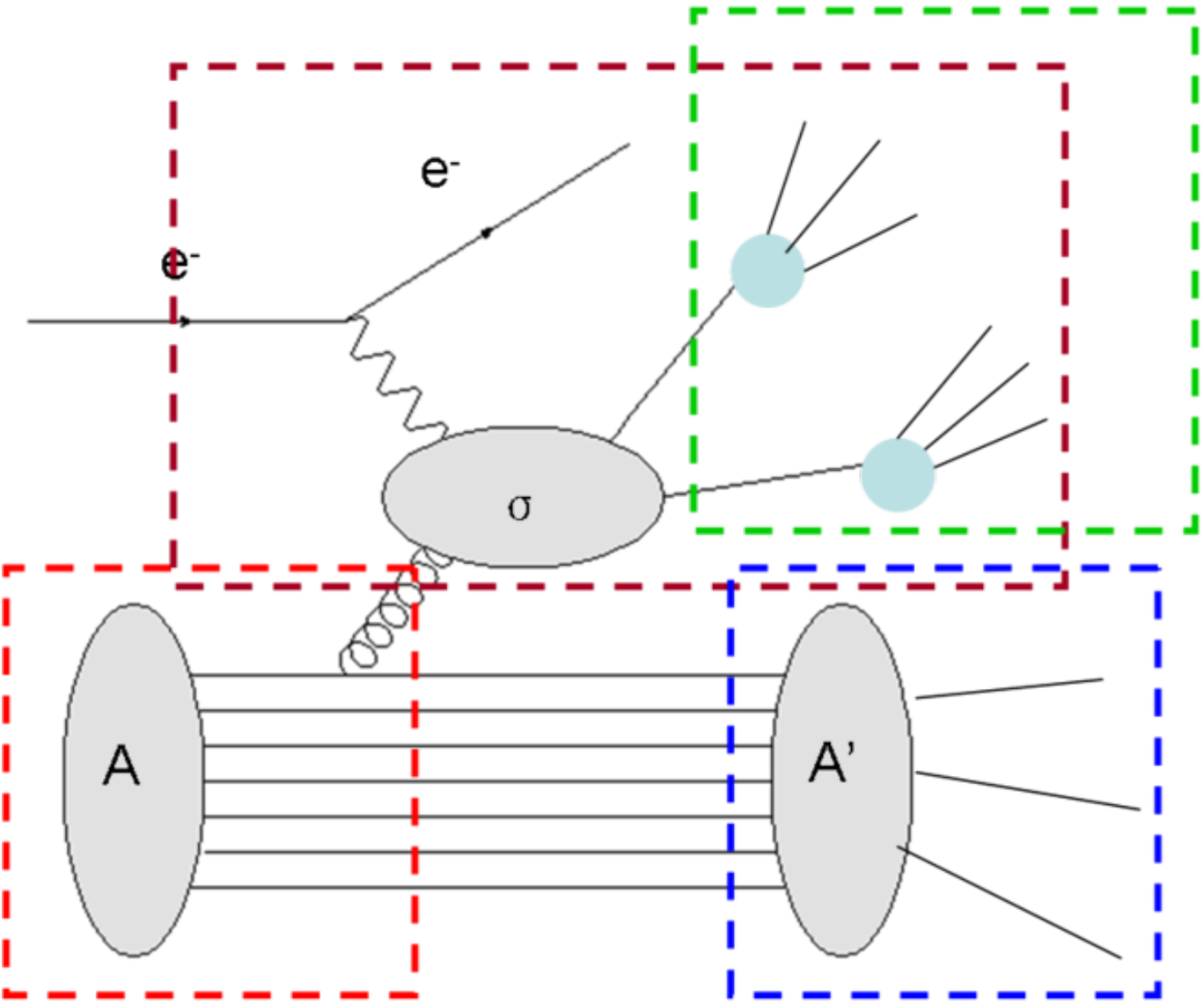


Q^2 Resolution



BeAGLE - Benchmark eA Generator for LEptoproduction

Mark Baker, E. Aschenauer, J.H. Lee, L. Zheng



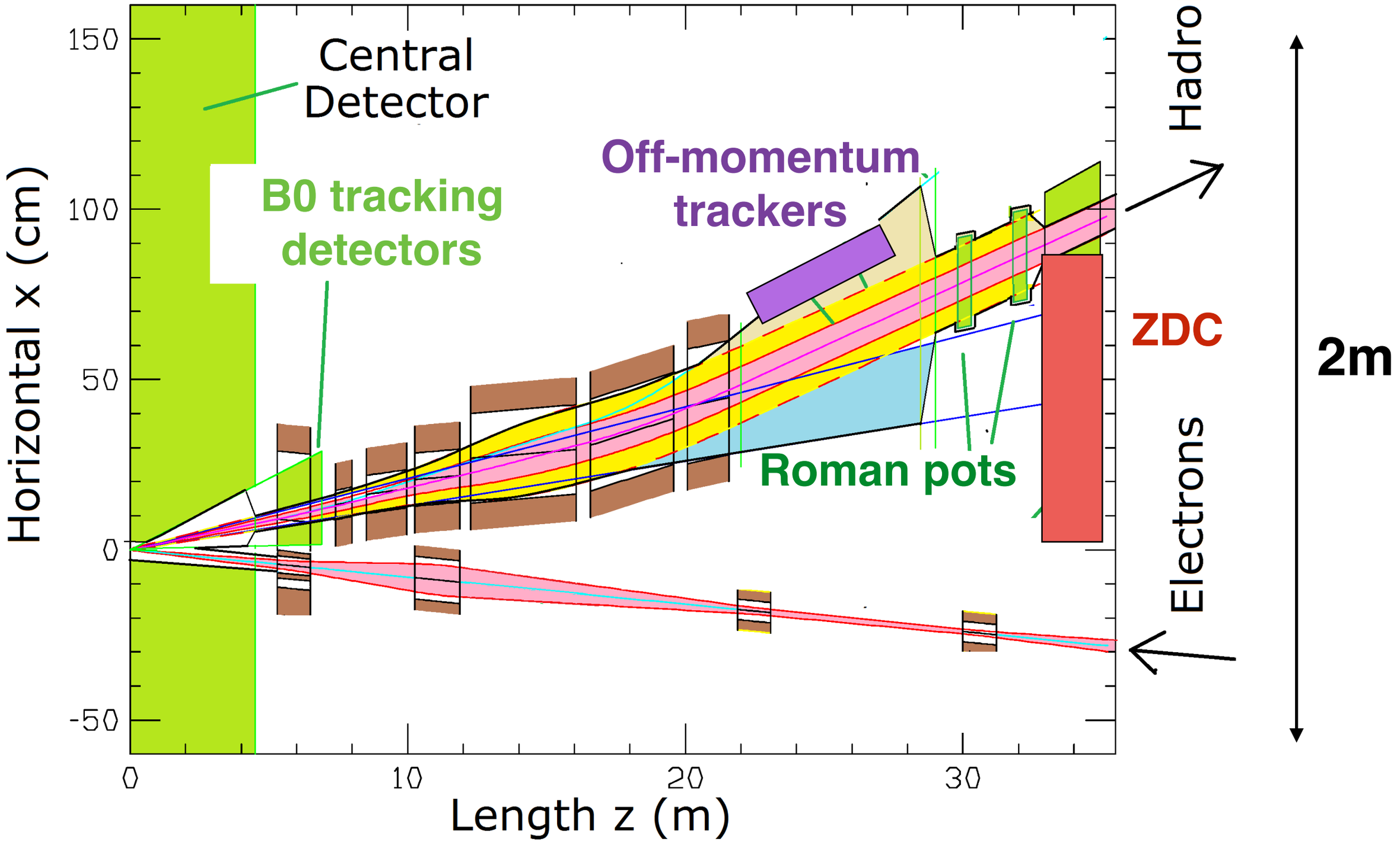
Merger of

- PYTHIA 6 (hard interaction)
- Energy loss of partons: PyQM
- Nuclear environment
  - DPMJET
  - nPDF from EPS09
- Nuclear evaporation by DPMJET3+FLUKA

https://wiki.bnl.gov/eic/index.php/BeAGLE

Far-Forward Detectors

EIC Design, https://wiki.bnl.gov/eic/upload/EIC.Design.Study.pdf



QE Simulation Results (no crossing angle, no FSI)

e + C (5 GeV + 41 GeV)