Update on Detection of SRC nucleons in EIC kinematics

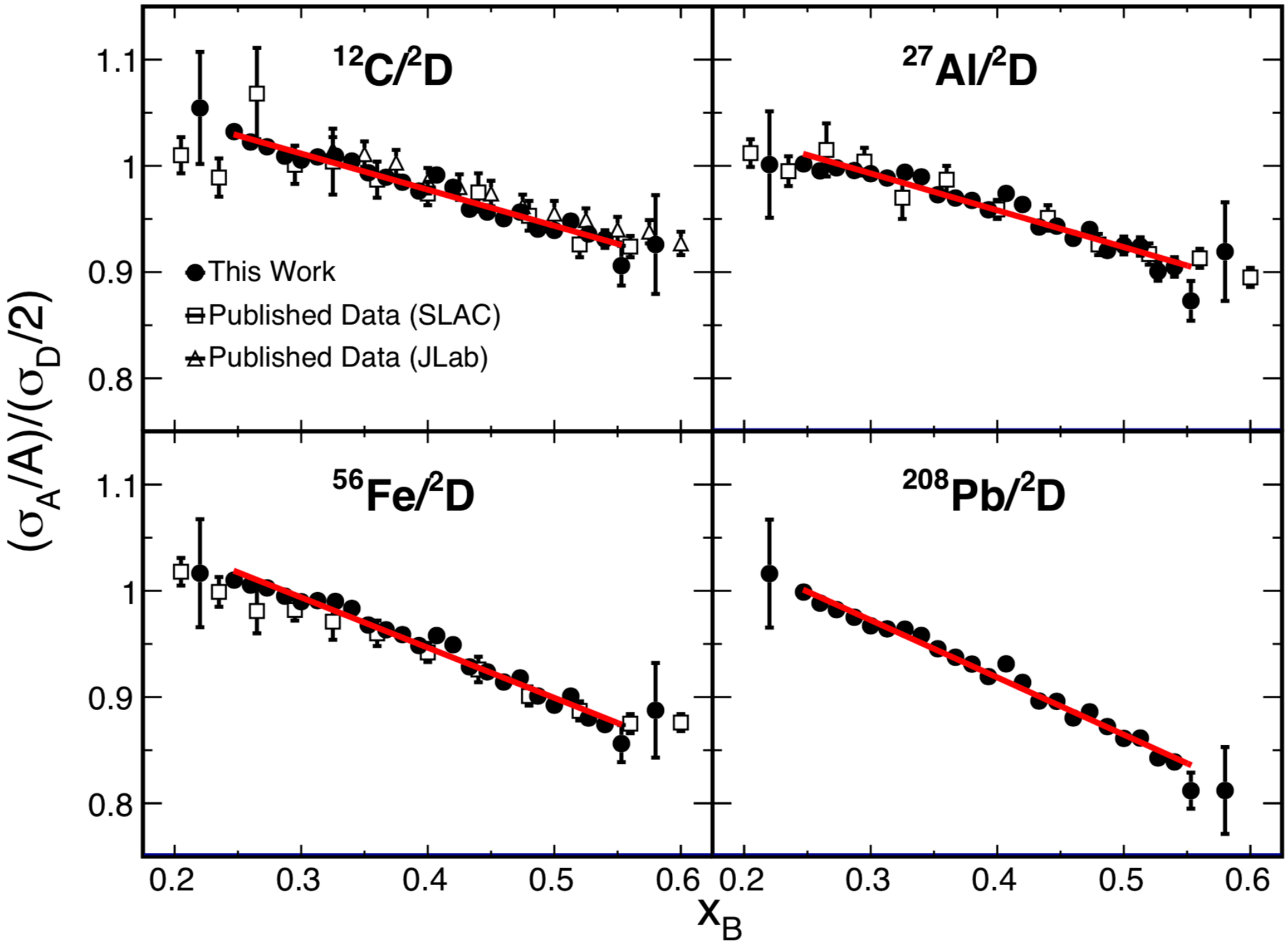
Florian Hauenstein,
EIC Workshop
03/19/20

Overview

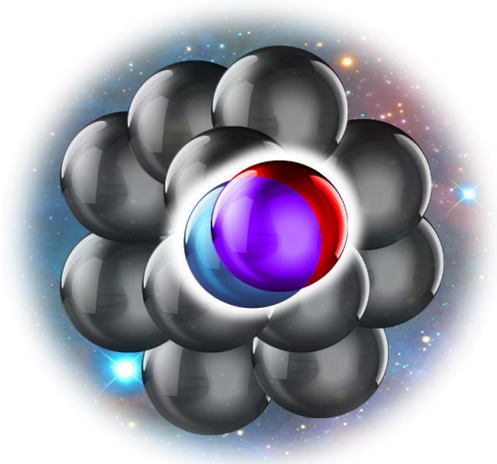
- EMC-SRC Recap
- Tagged DIS-SRC
- Status of simulations
- Outlook and Summary

EMC Effect in Different Nuclei

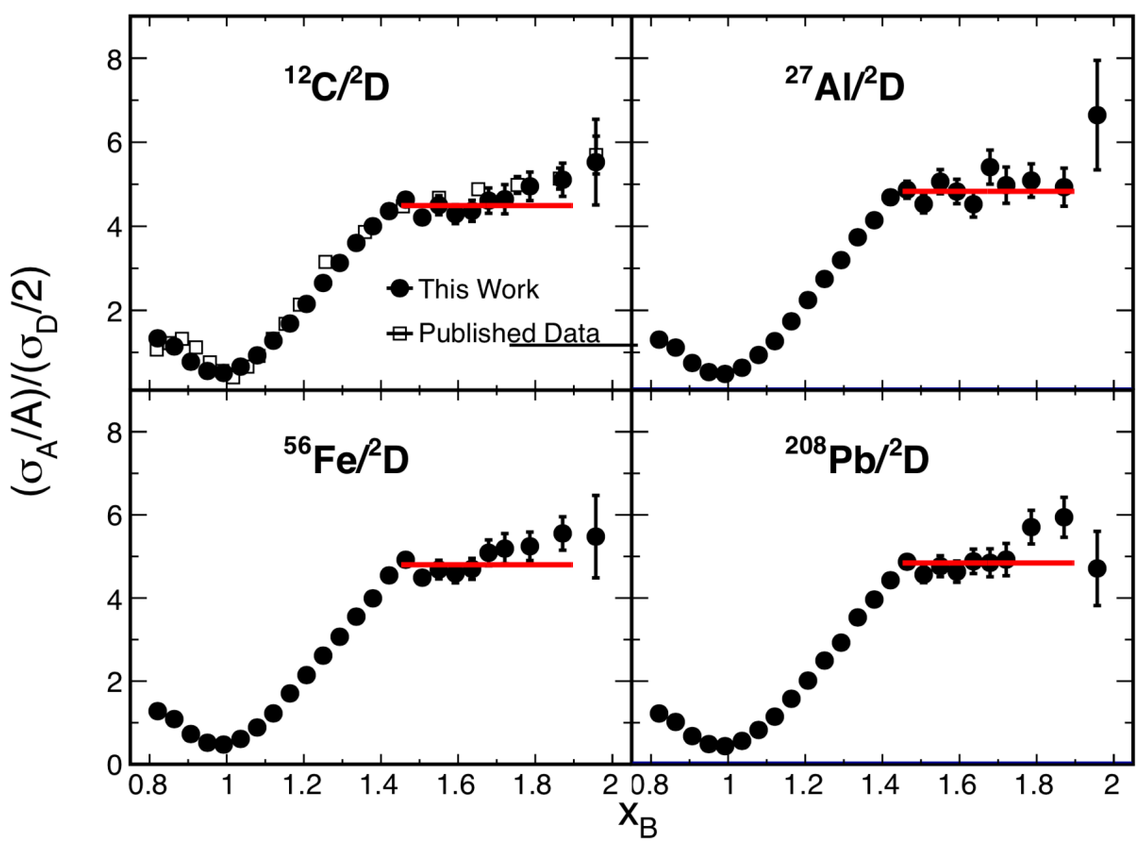
B. Schmookler et al. (CLAS collaboration), Nature 566, 354 (2019)



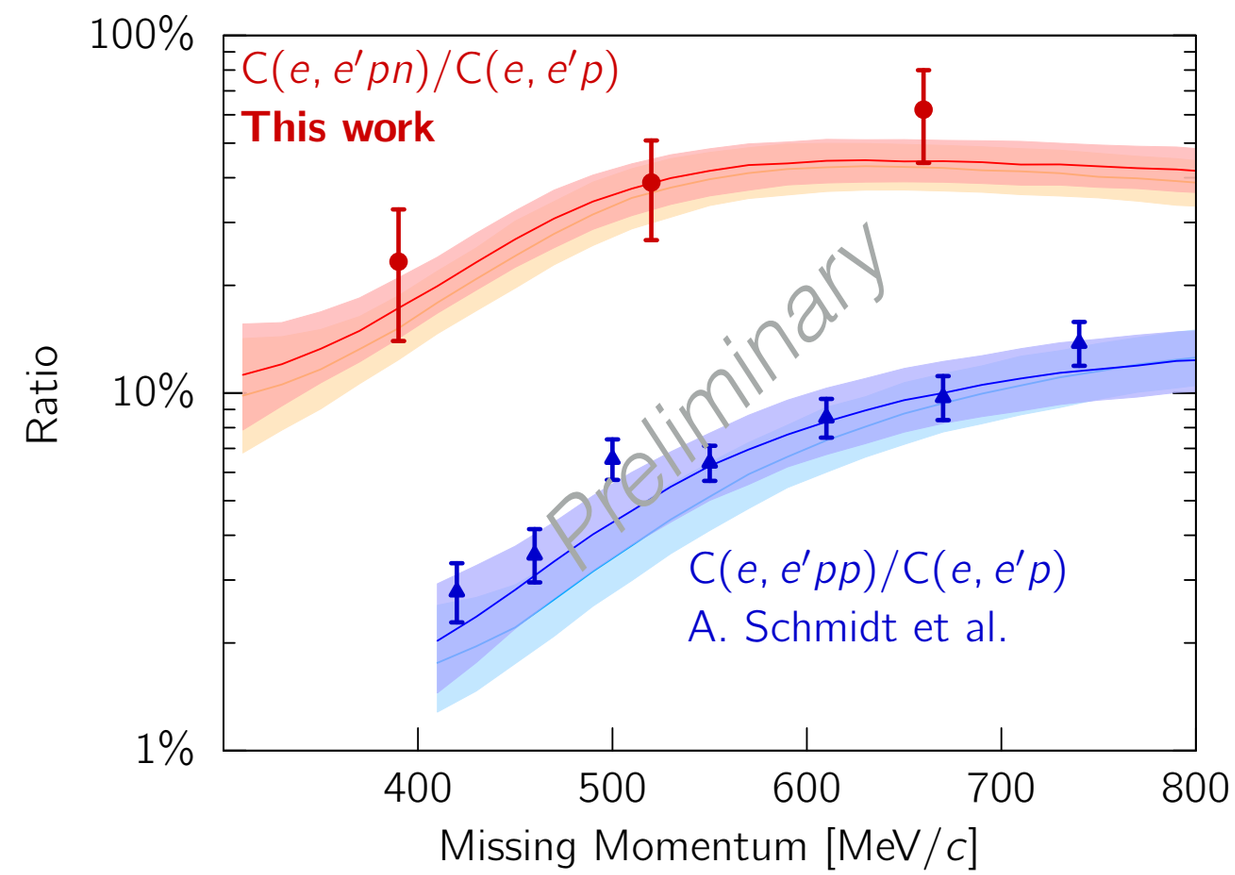
SRC Recap



- Nucleon pairs that are close together in the nucleus
- *high relative* and *lower c.m.* momentum compared to the Fermi momentum $\mathbf{k_F}$
- np-dominance



B. Schmookler et al., Nature 566, 354 (2019)

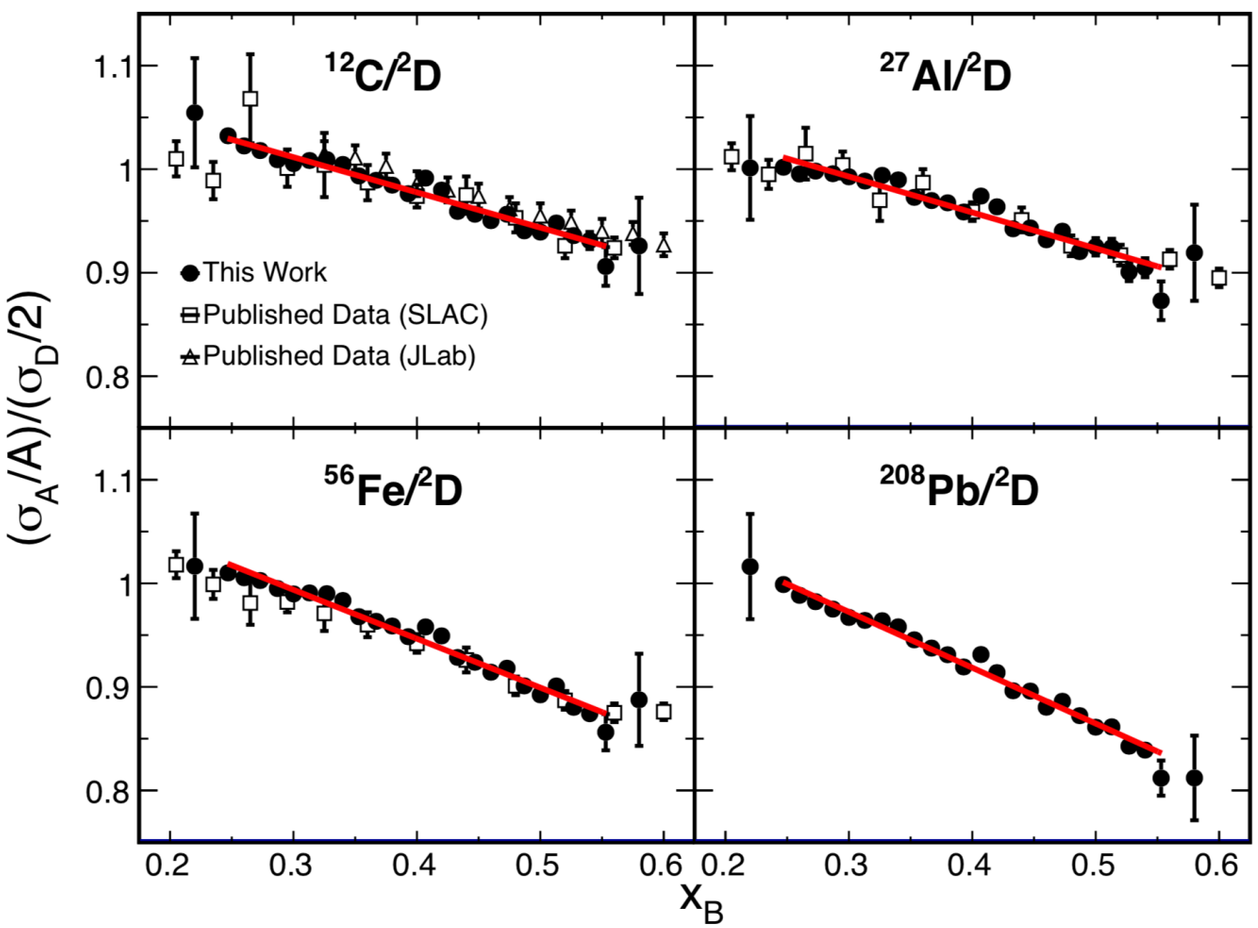


from Jackson Pybus' talk, EIC workshop Jan 2020

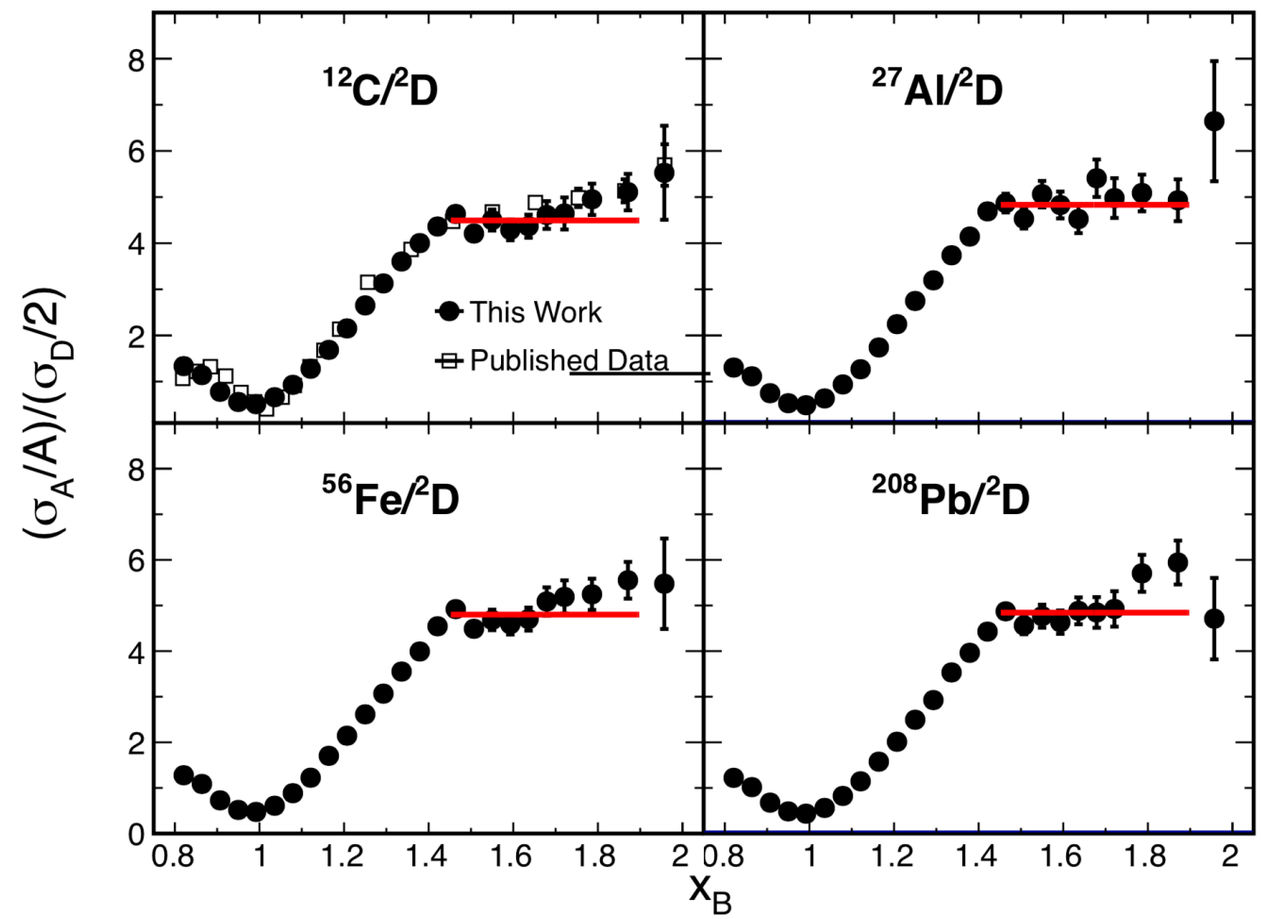
EMC - SRC correlation

B. Schmookler et al. (CLAS collaboration), Nature 566, 354 (2019)

DIS



Quasi-Elastic

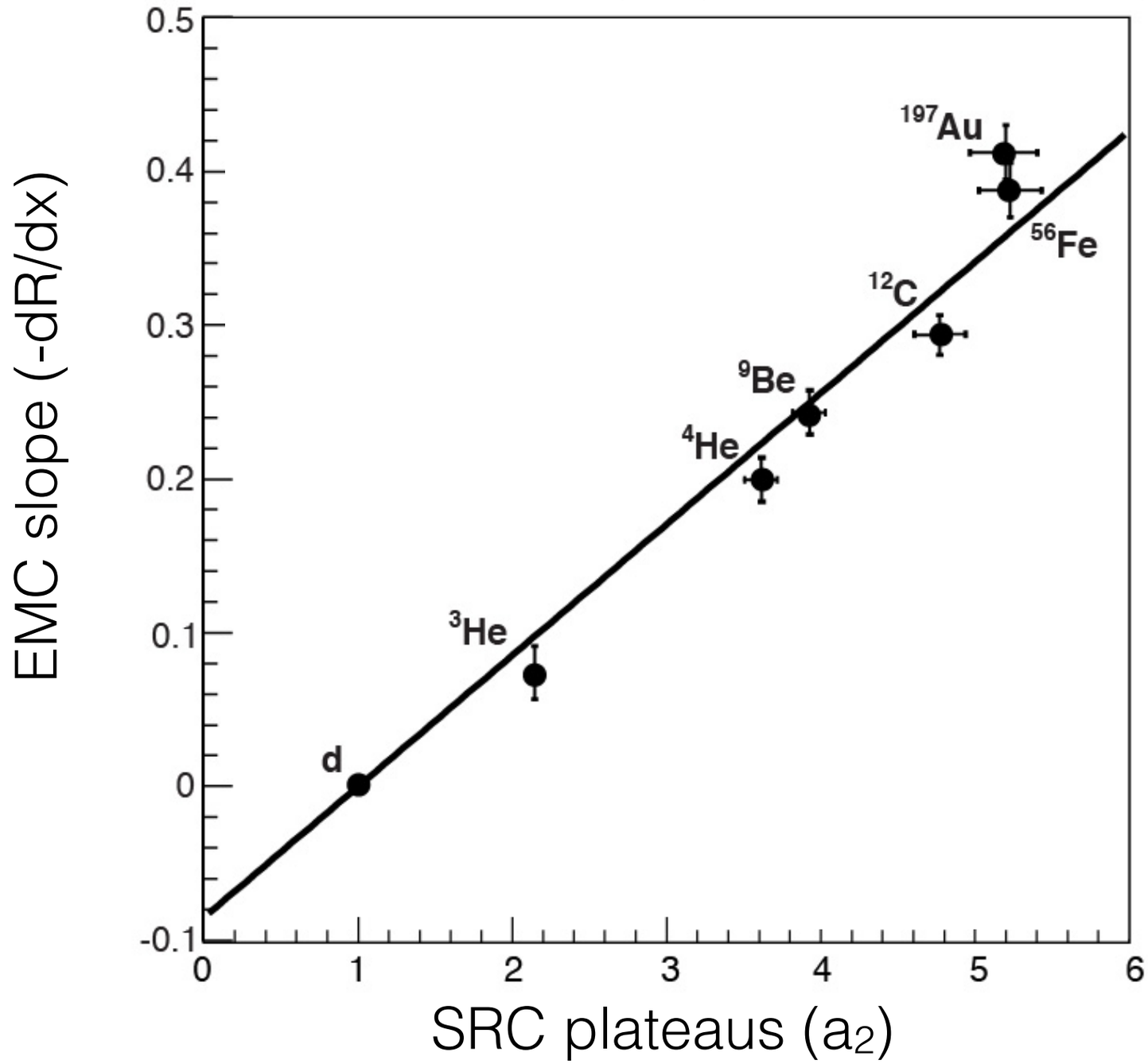


—> EMC slope

—> SRC plateaus (a_2)

EMC - SRC Correlation

Weinstein et al., PRL 106, 052301 (2011), Hen et al.,PRC 85, 047301(2012)



- Are high-momentum nucleons responsible for the EMC effect?

``Tagged SRC for medium and heavy ions at EIC'' (LDRD1912)

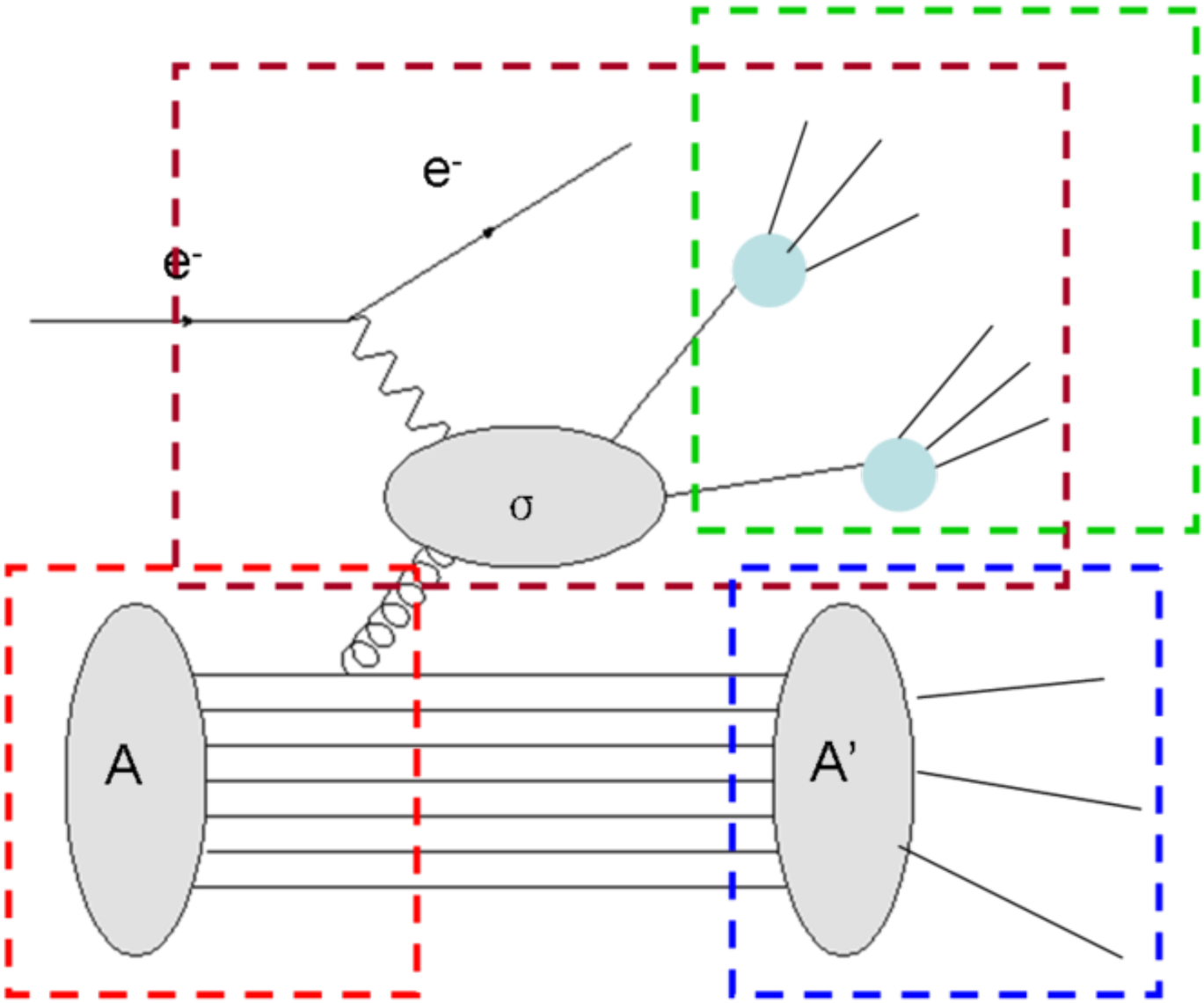
- Feasibility of tagged SRC in DIS
  - Rates
  - Resolution
  - Detector requirements (focus on forward direction)
  - Required beam energies

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

- First step - Tagged Quasi-elastic SRC@EIC

BeAGLE - Benchmark eA Generator for LEptoproduction

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



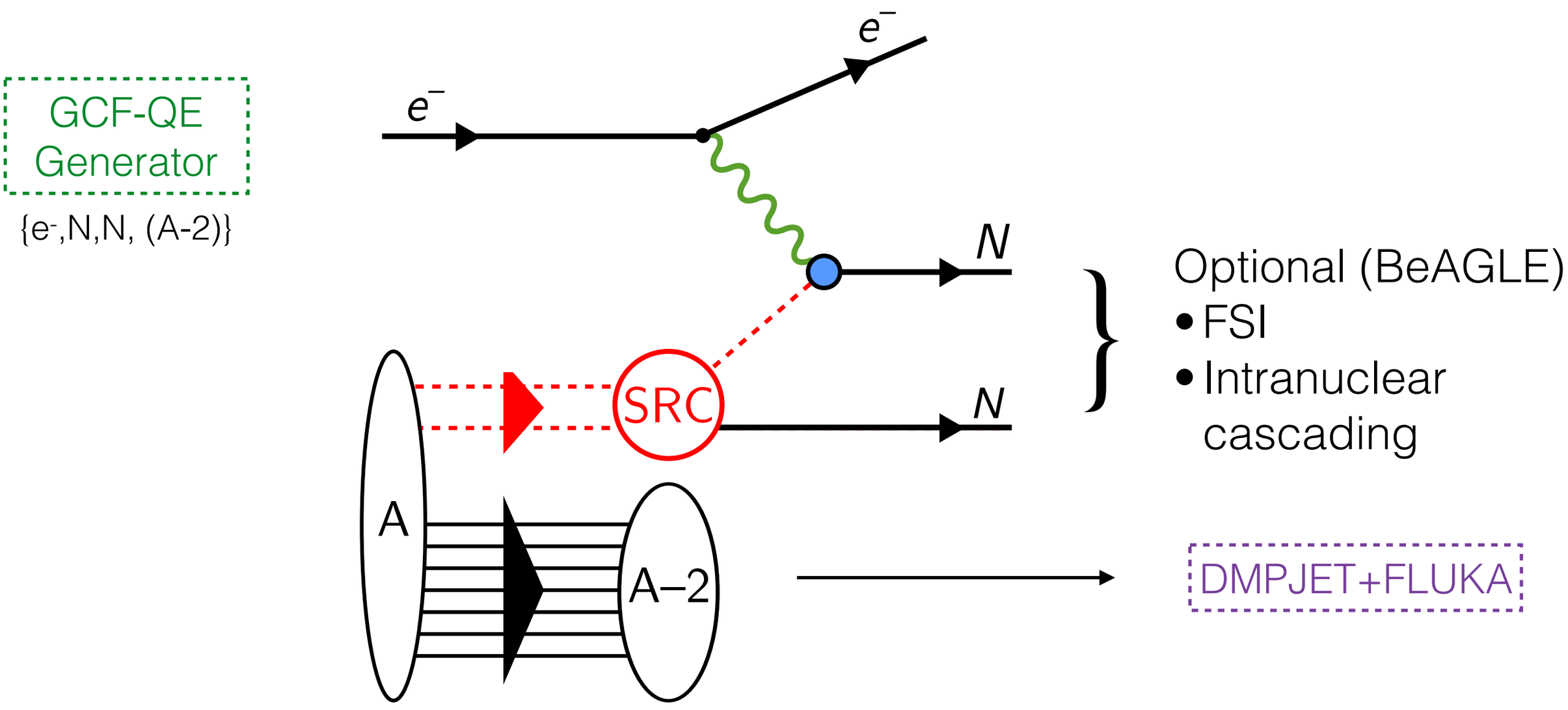
Merger of

- 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

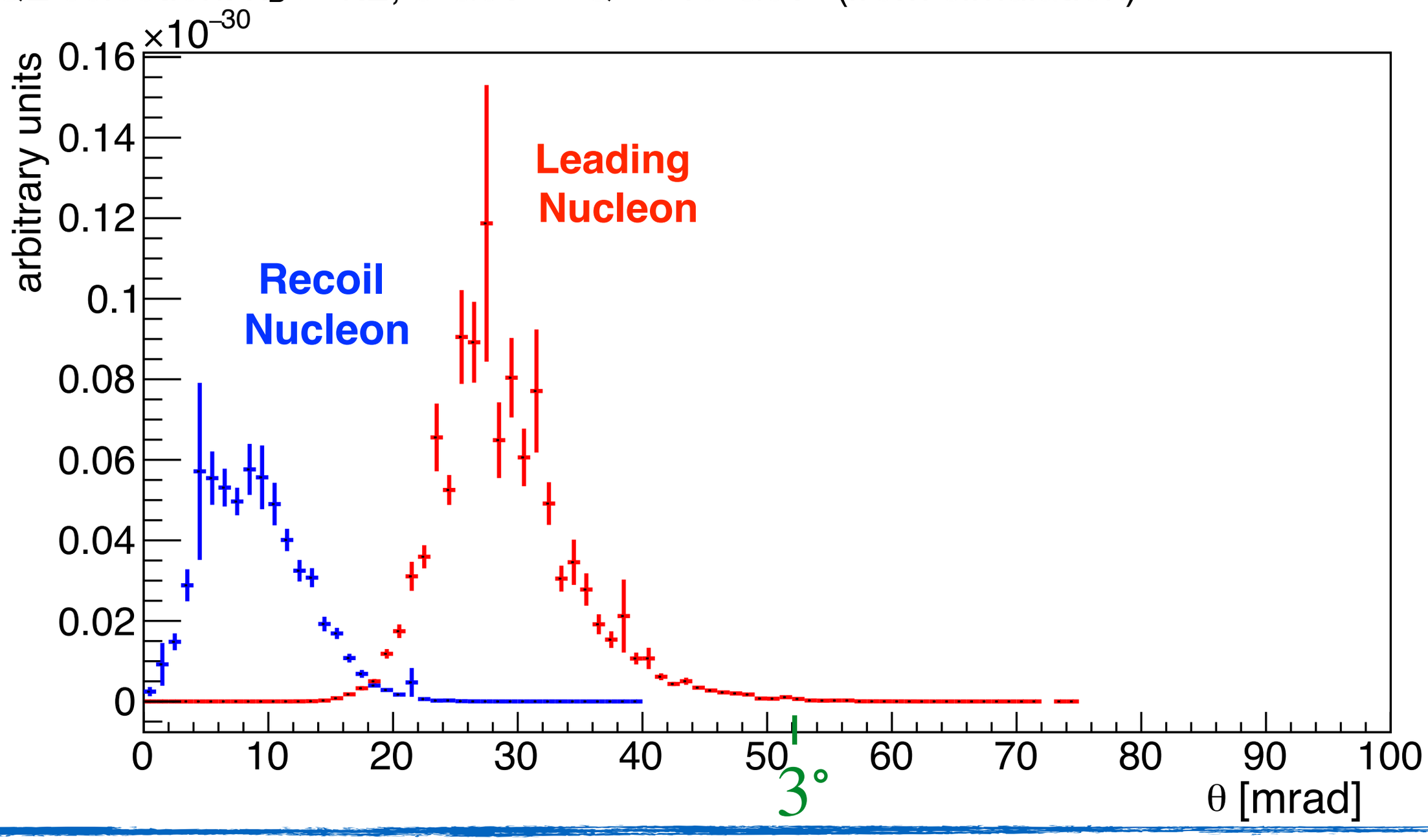
GCF-SRCs and BeAGLE

- GCF = Generalized Contact Formalism (A. Schmidt et al., Nature 578, 540 + references)
- GCF-DIS in development
- GCF-Quasielastic (QE) implemented
- (A-2)-system handled by DPMJET3+FLUKA



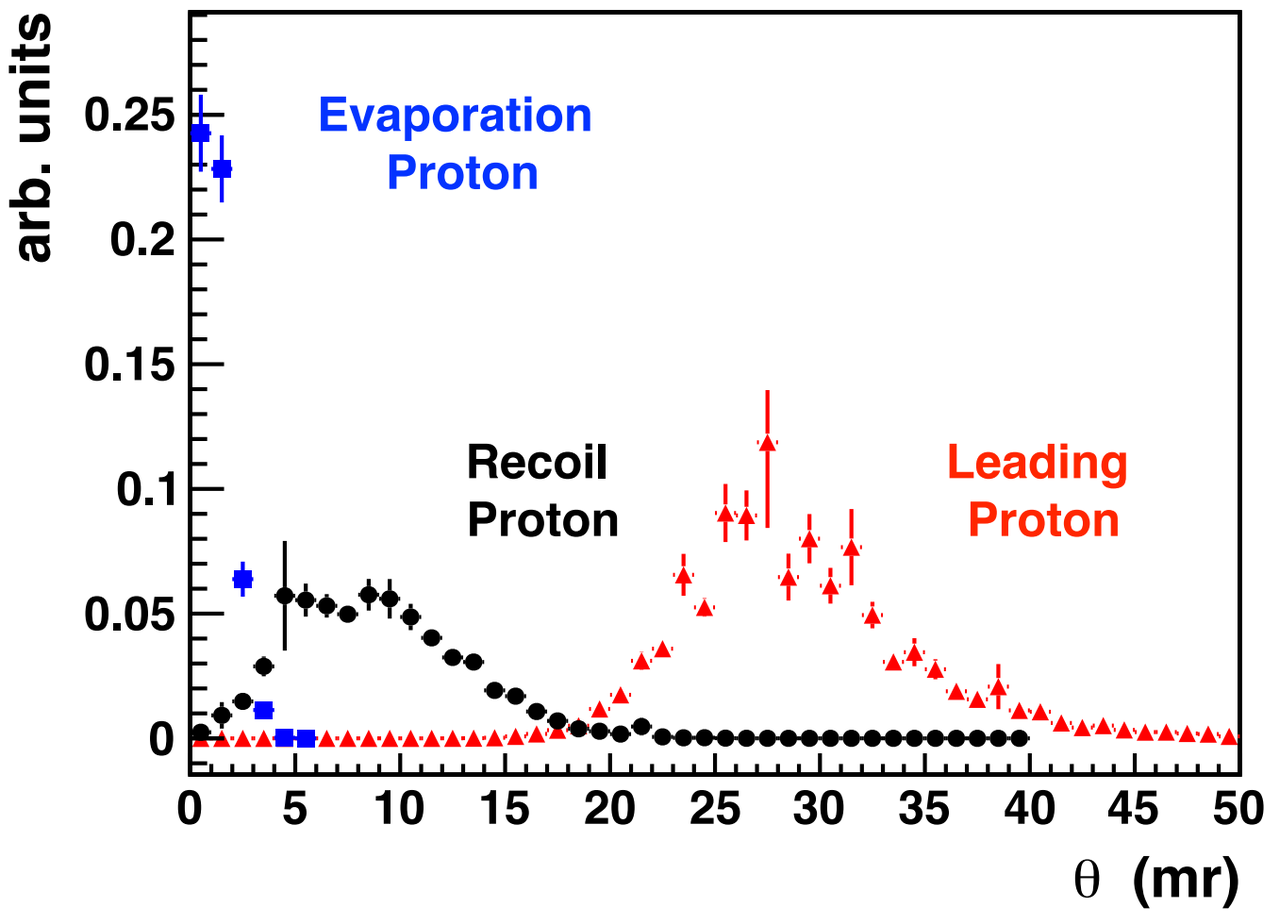
Old QE Simulation Results

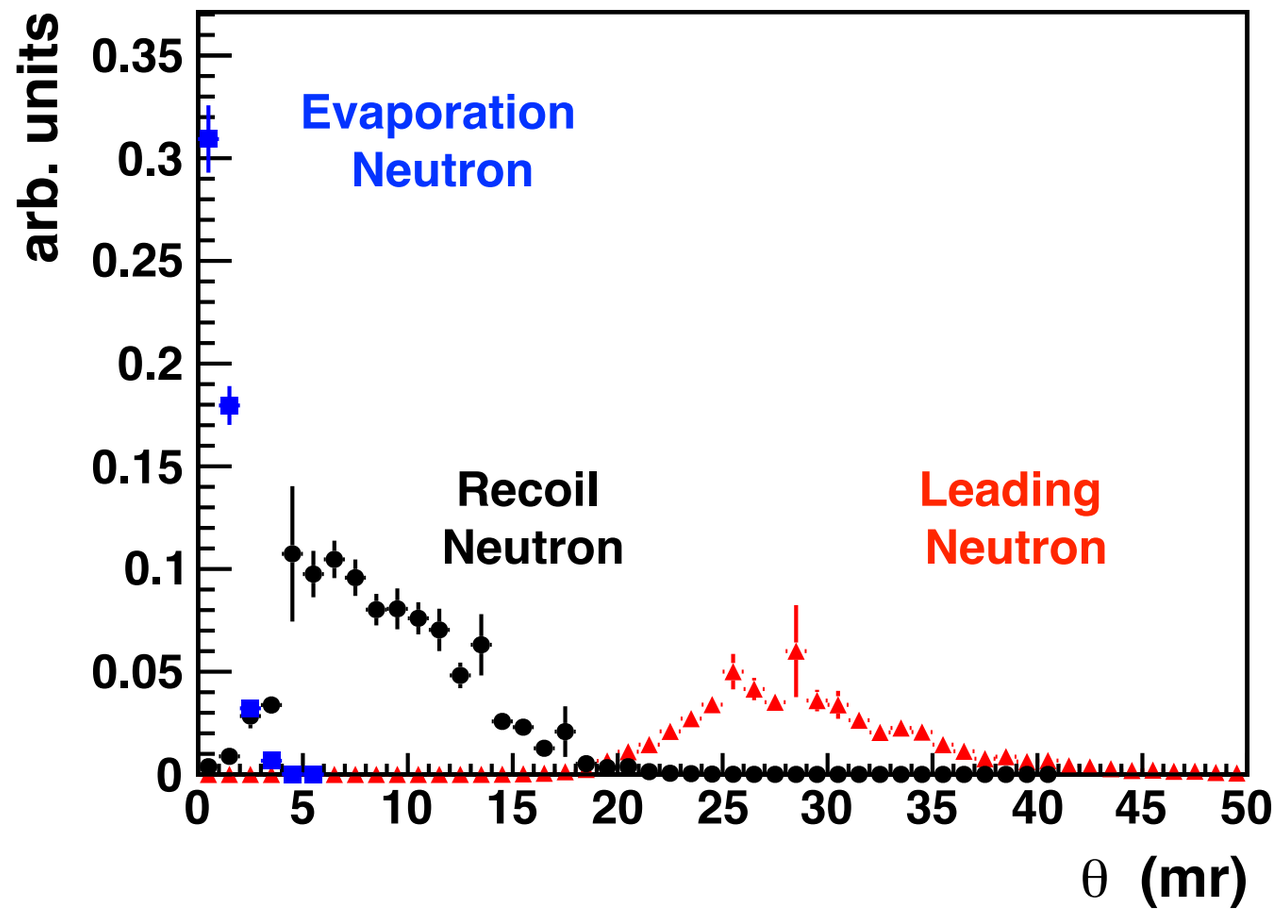
- e+C, 5GeV + 50GeV/nucleon
- $\sqrt{s}$ = 110 GeV ≙ fixed target P_e = 537 GeV
- no crossing angle. no intra-nuclear cascading, no FSI
- QE selection: $x_B > 1.2$, 3 $GeV^2 < Q^2 < 10$ GeV^2 (from simulation)



Old QE Simulation Results (2)

- e+C, 5GeV+50GeV/nucleon, $\sqrt{s}$ = 110 GeV, no crossing angle. no intra-nuclear cascading, no FSI, $x_B > 1.2$, 3 $GeV^2 < Q^2 < 10$ GeV^2





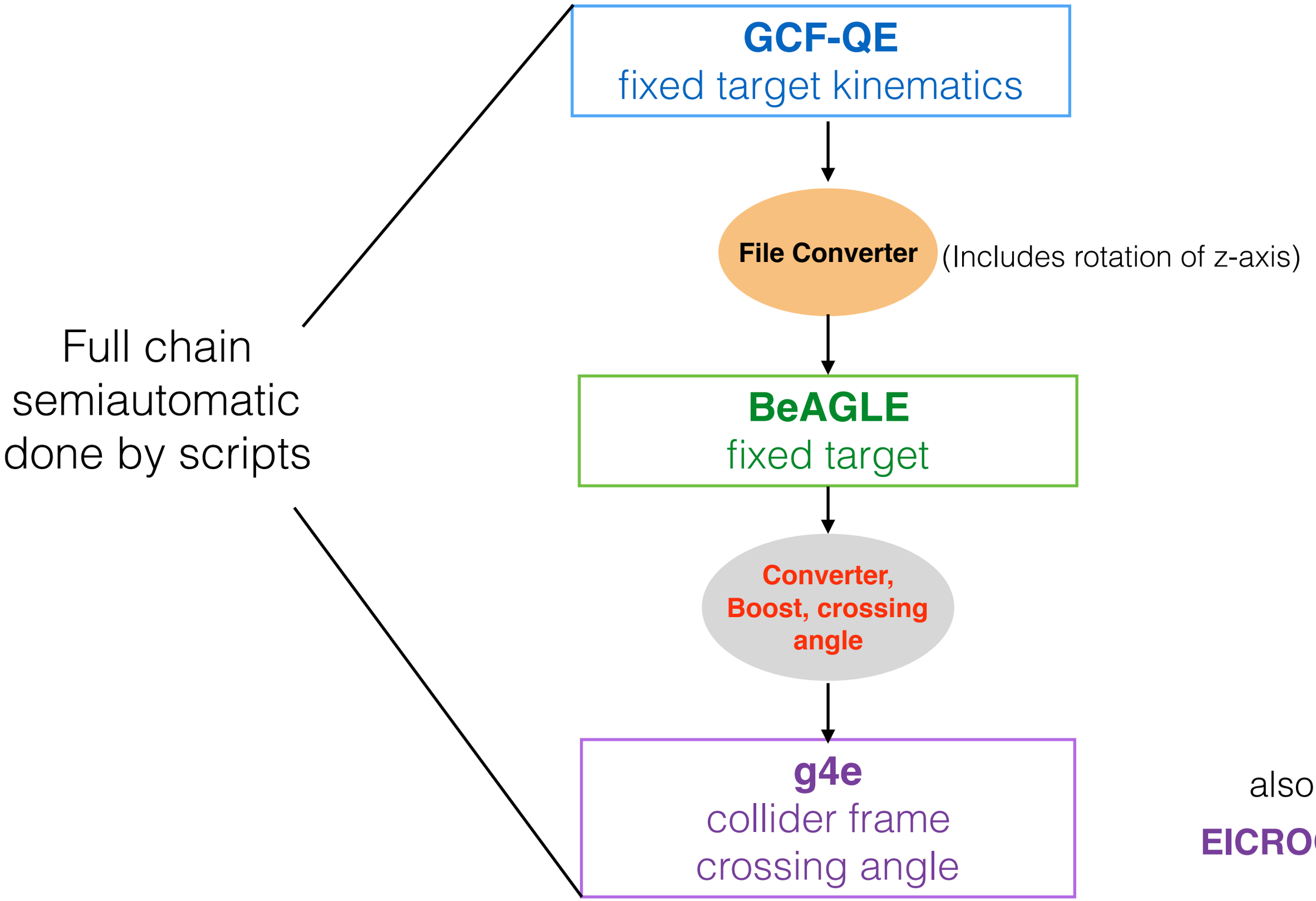
- Leading, recoil, evaporation nucleons well separated
- Redo for eRHIC kinematics

Kinematics - Collider and Fixed Target

Target	fixed target P_e [GeV]	sqrt(s) [GeV]	P_e [GeV]	P_p [GeV]	$P_p * Z / A$ [GeV]
d	2931.6	104.9			
He-4	2950.3	148.4	**10**	**275**	137.5
C-12	2952.3	257.1			
d	1066.1	63.2			
He-4	1072.9	89.5	**10**	**100**	50
C-12	1073.6	155.3			
d	437.3	40.6			
He-4	440.1	57.4	**10**	**41**	20.5
C-12	440.4	99.9			

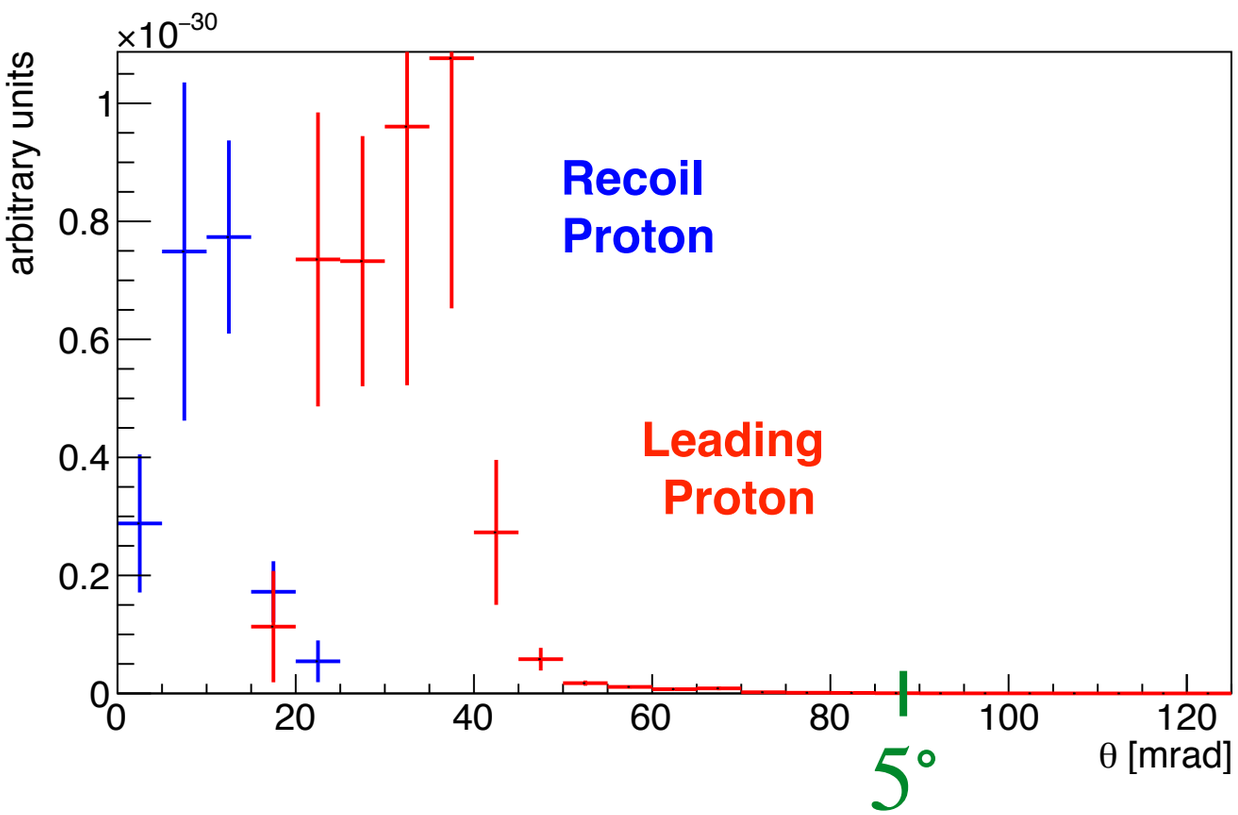
CMS energy constant for GCF and EIC simulation

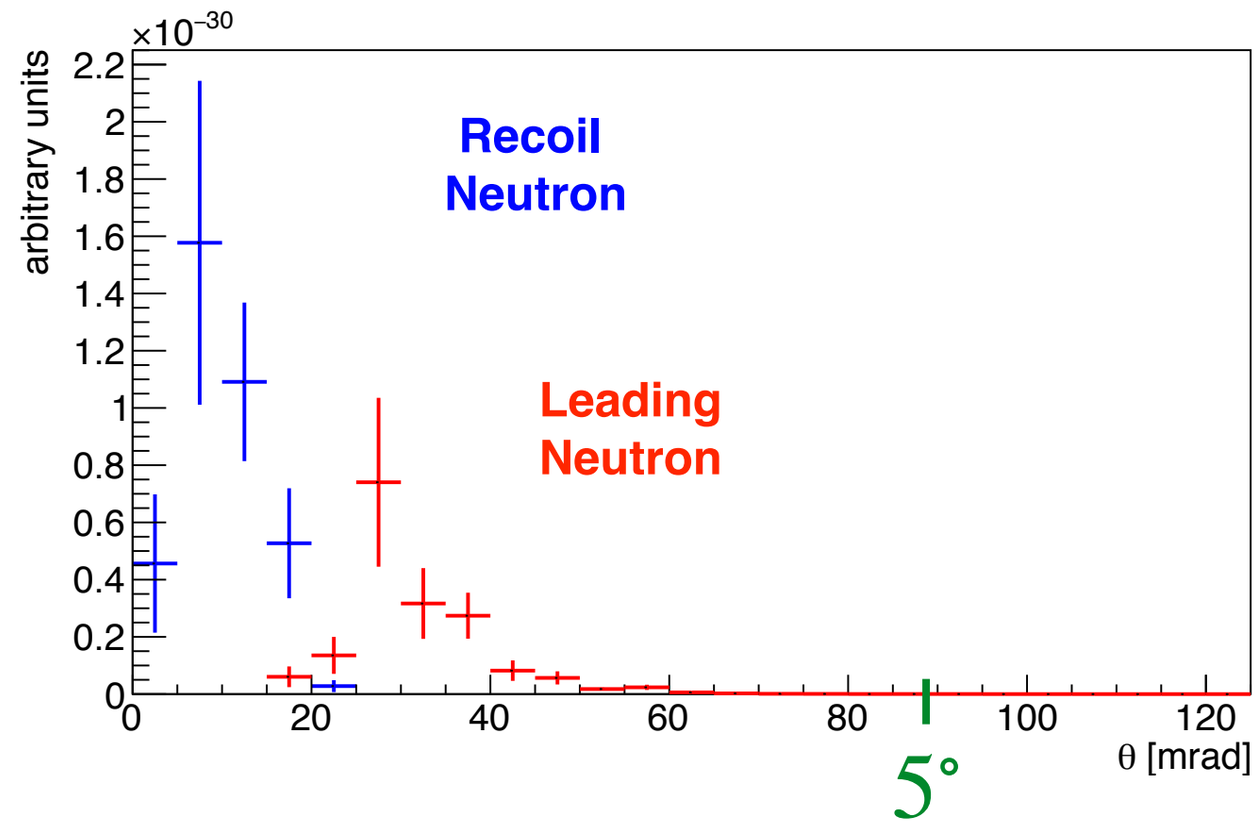
Simulation Chain



QE Results for e+C, 10x50GeV/nucleon

no crossing angle, no intra-nuclear cascading, no FSI, QE cuts: $x_B > 1$, $Q^2 > 3$ GeV^2



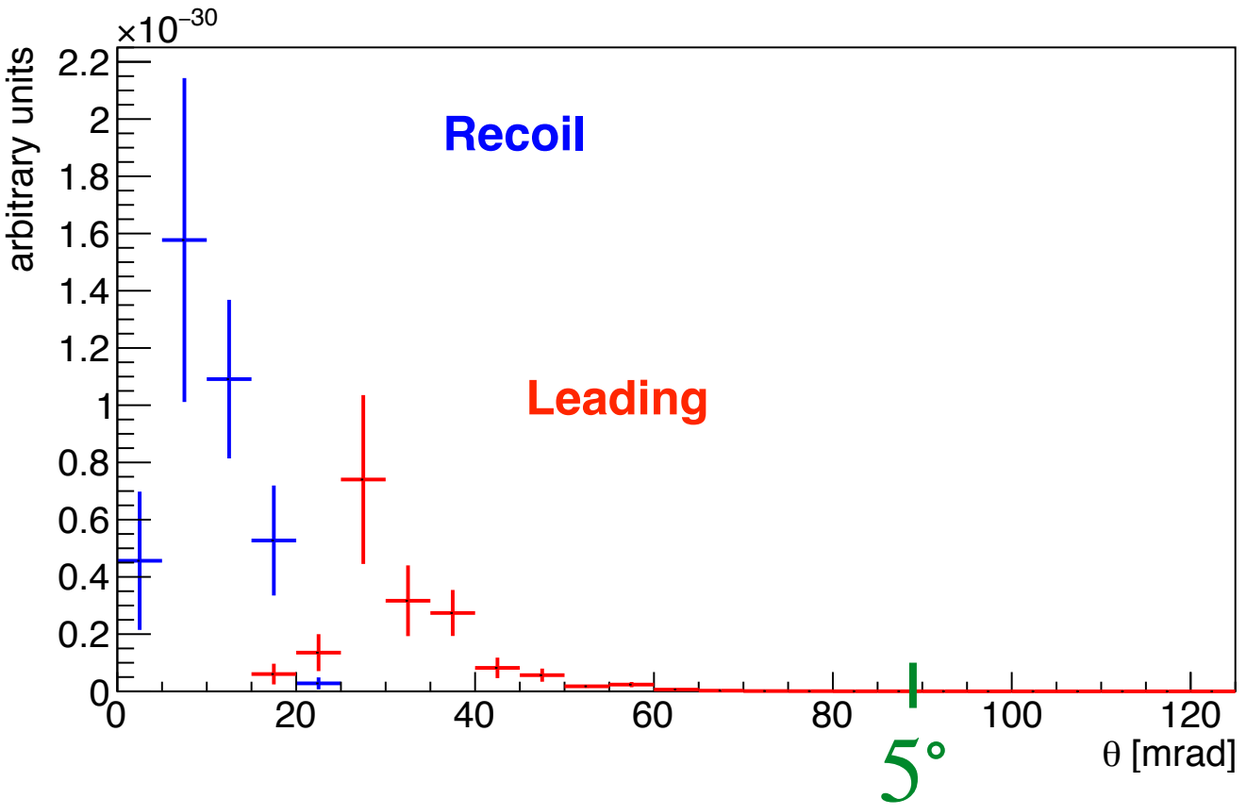


- Leading and recoil nucleons well separated
- Similar for neutrons and protons

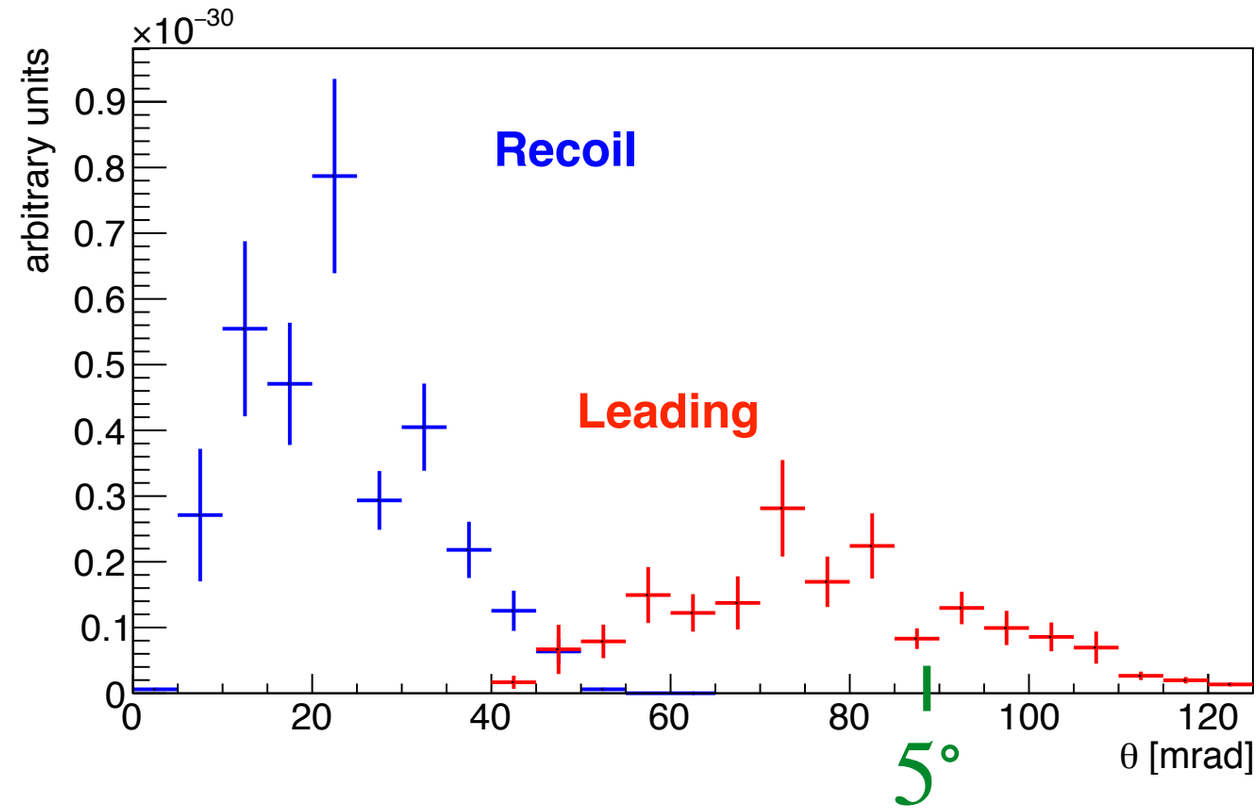
QE Results for e+C, Different Ion momenta

no crossing angle, no intra-nuclear cascading, no FSI, QE cuts: $x_B > 1$, $Q^2 > 3$ GeV^2

10 GeV x 50GeV/nucleon



10 GeV x 20.5GeV/nucleon

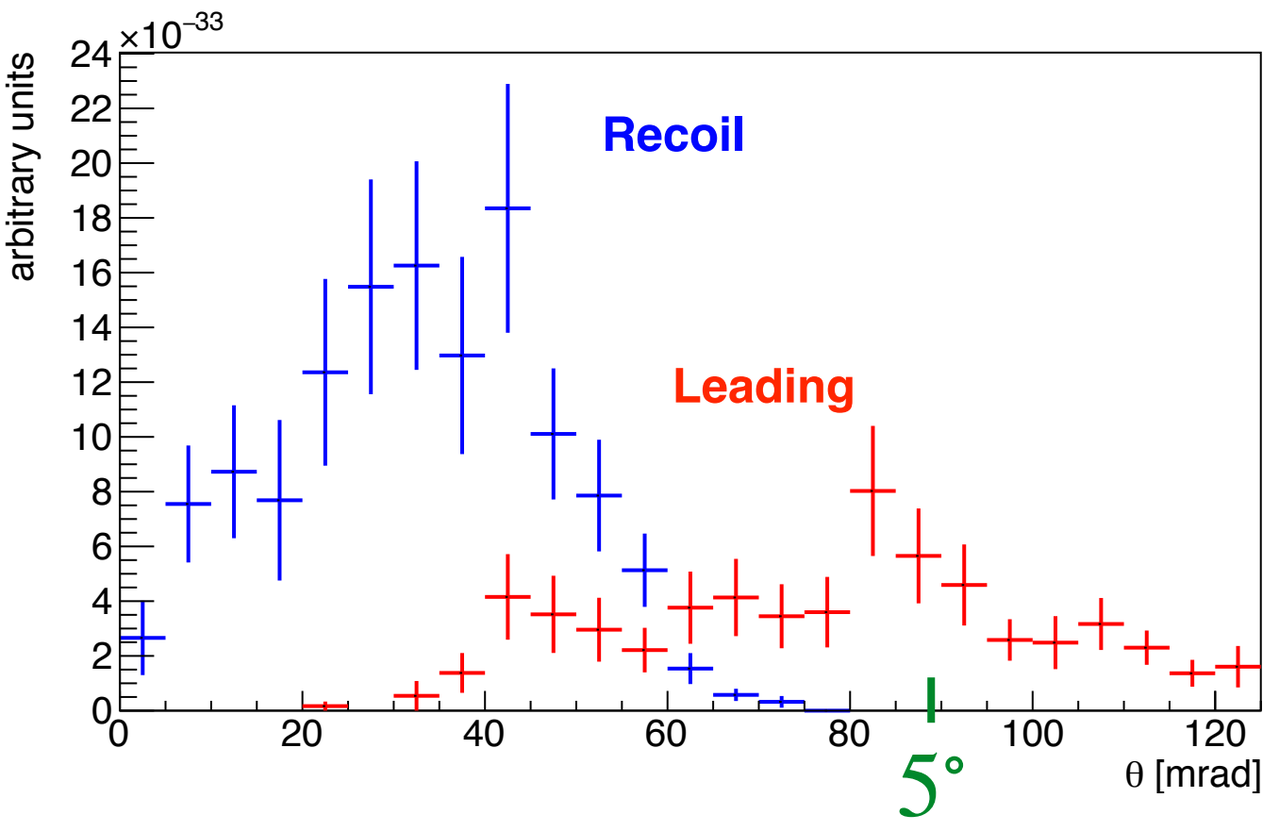


- Good separation for both kinematical settings
- Lower Ion momenta
  - Larger angular spread
  - less forward boost

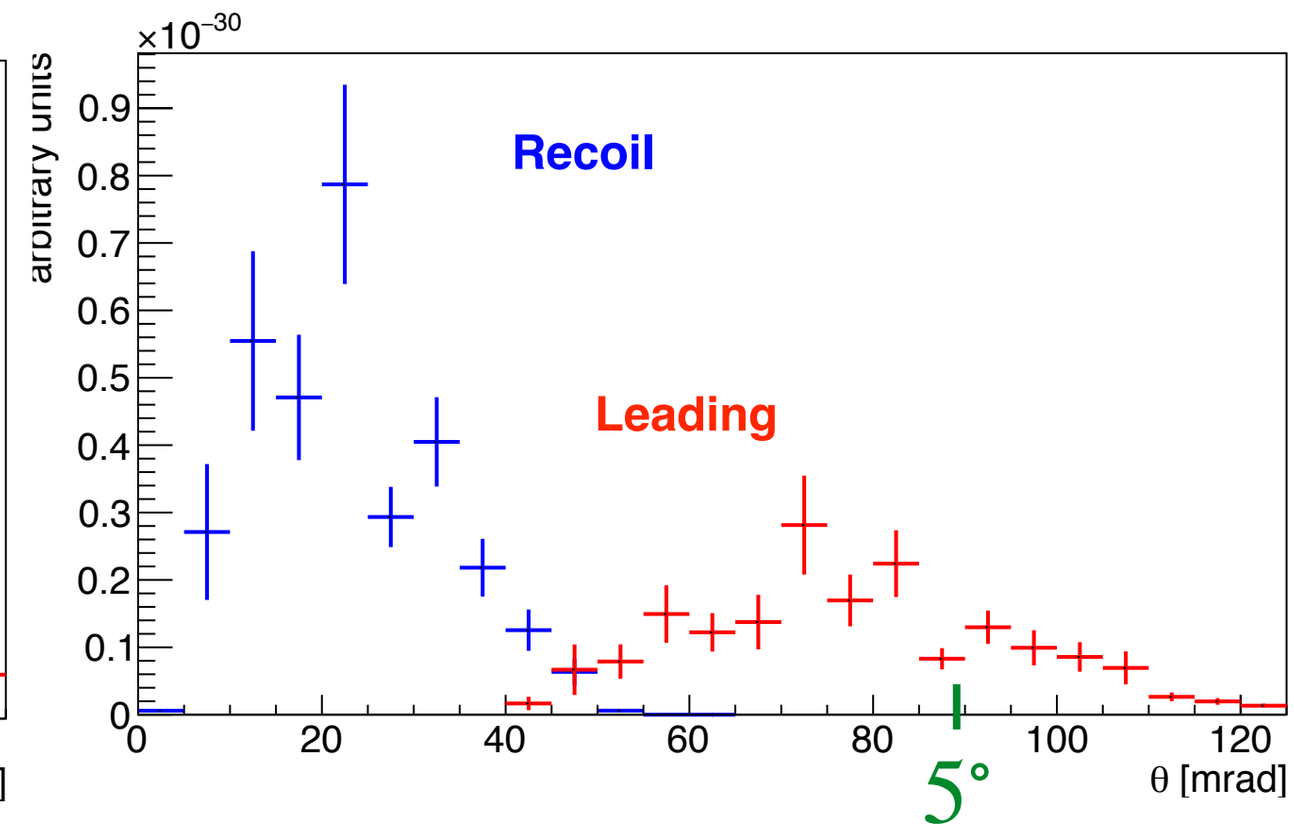
QE Results e+C and e+D@20.5GeV/Nucleon

no crossing angle, no intra-nuclear cascading, no FSI, QE cuts: $x_B > 1$, $Q^2 > 3$ GeV^2

e+D



e+C

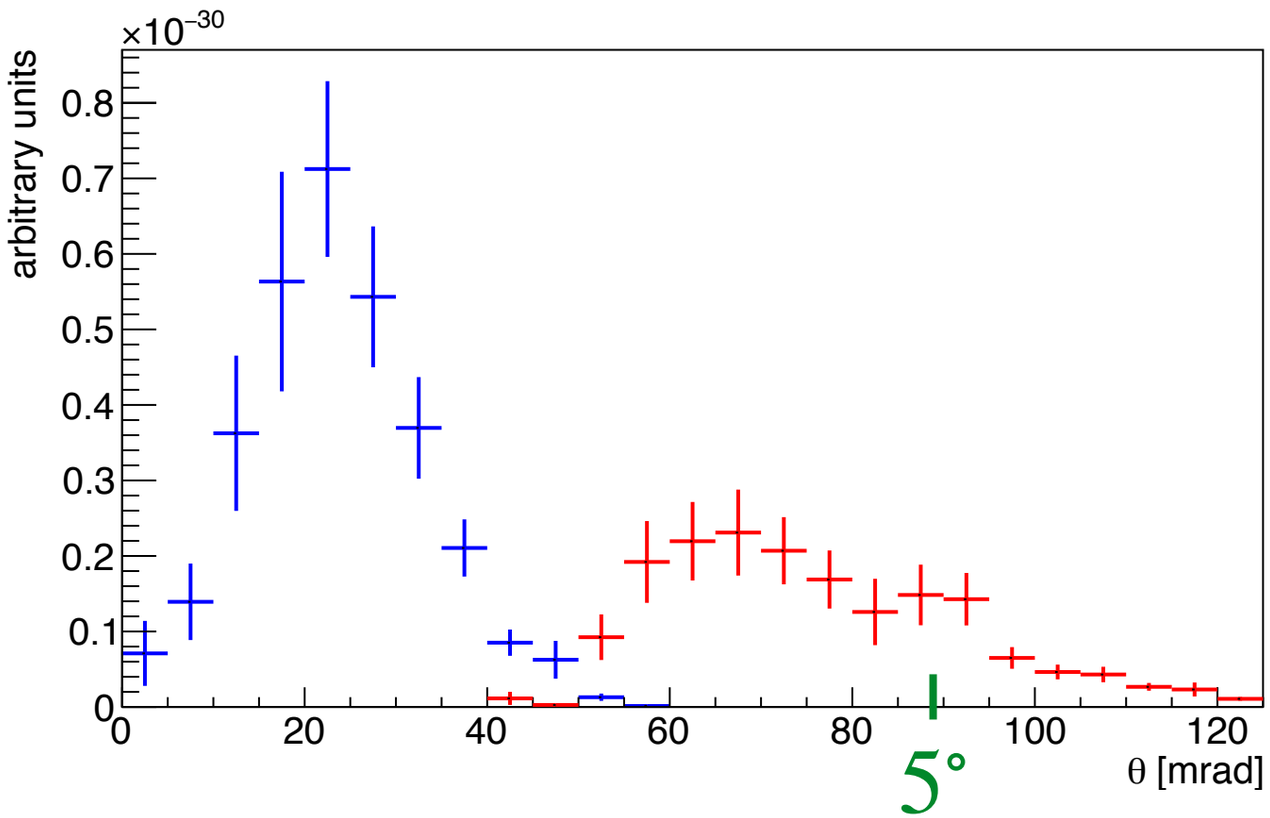


- Separation a little worse for e+D than for e+C
- Less CM energy for e+D at same ion momentum

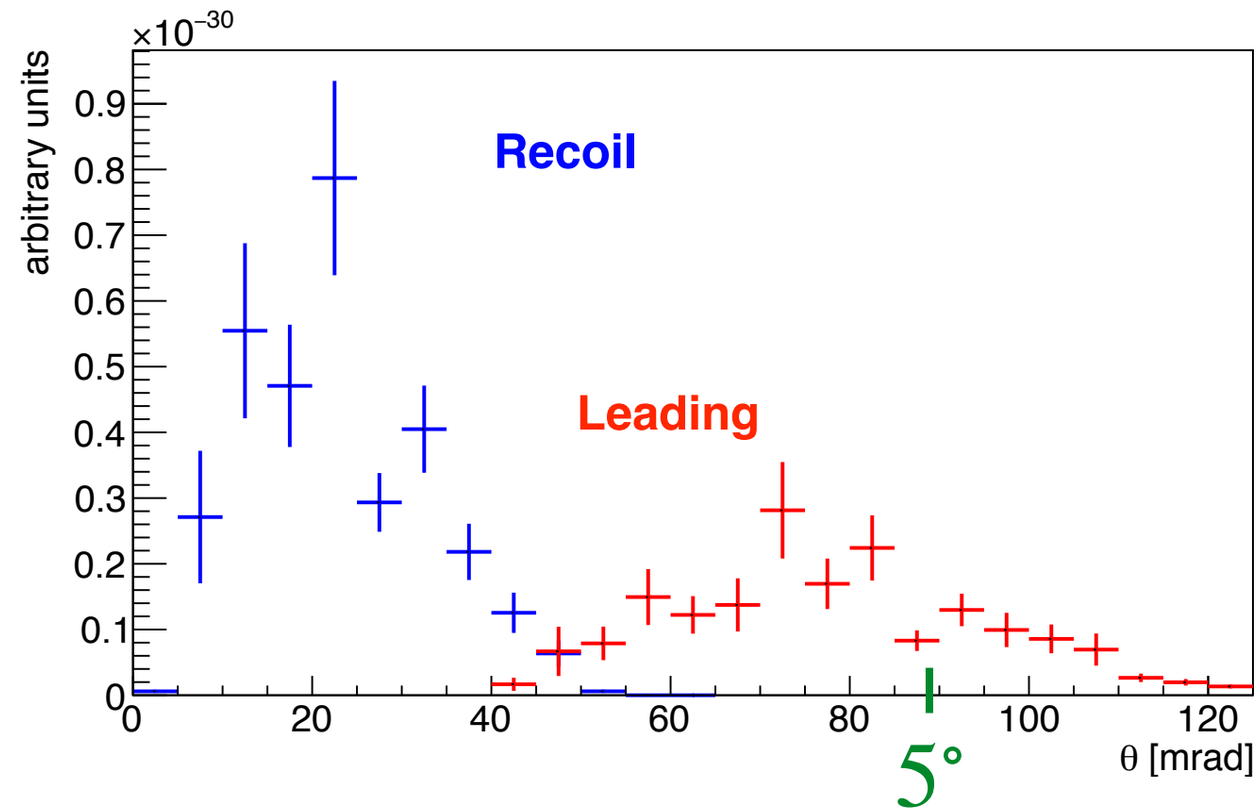
e+C@20.5GeV/Nucleon: Effect of E* in GCF

no crossing angle, no intra-nuclear cascading, no FSI, QE cuts: $x_B > 1$, $Q^2 > 3$ GeV^2

E* = 0



E* = 7 - 27 MeV



- Leading and recoil nucleons well separated
- No strong effect

Summary and Outlook

- GCF-QE scripts and simulations ready to go
  - e+D, e+He and e+C
  - 3 Ion momenta (41GeV, 100GeV, 275GeV)
- Recoil and leading nucleons well separated
- Lower ion momenta settings preferred

Near term:

- Study of FSI and intra-nuclear cascading effects via BeAGLE
- GCF-QE events through g4e and EICROOT (A. Jentsch)
  - Distributions on detectors
  - Resolution effects
- Increase statistics

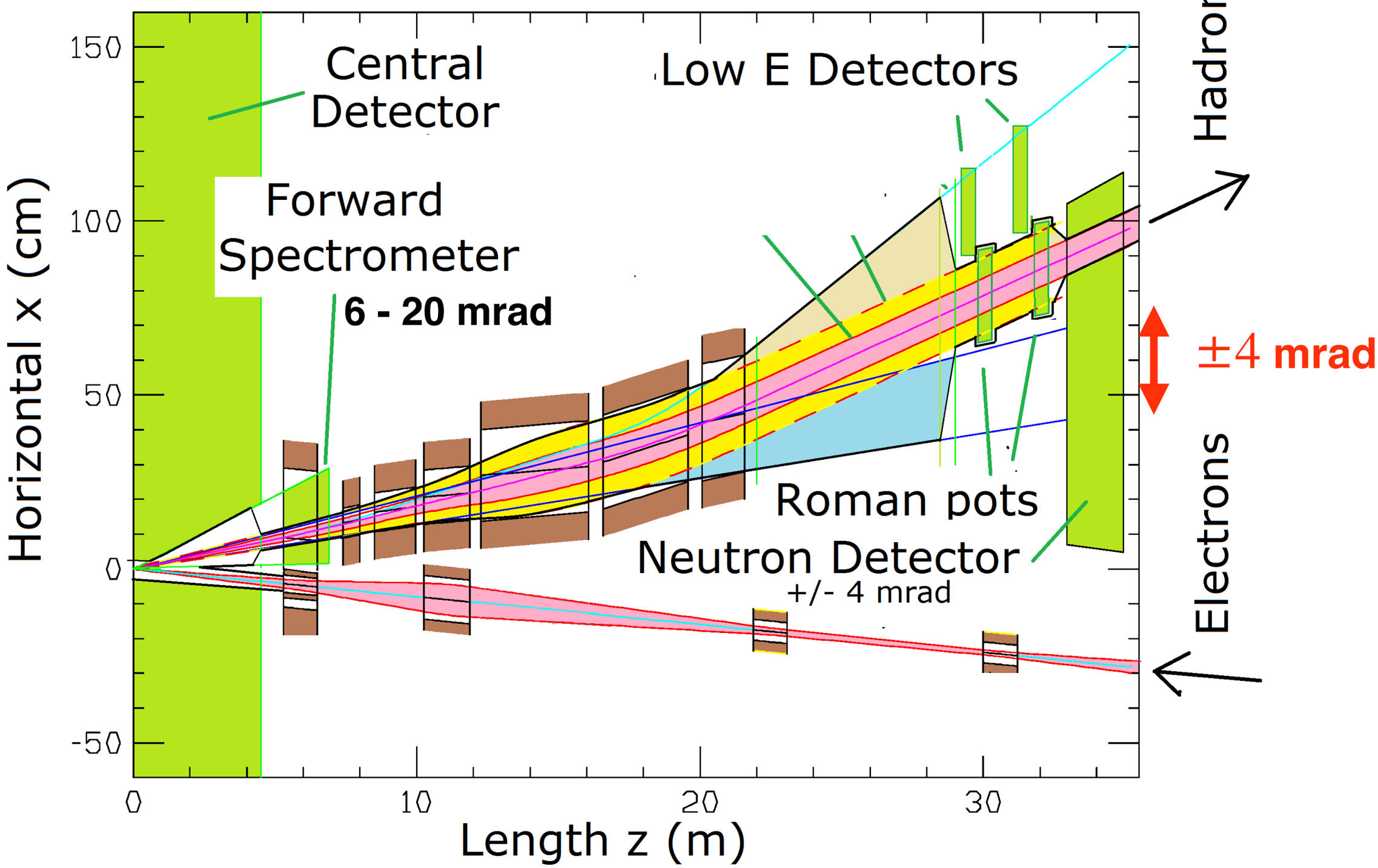
Far term:

- Simulation of GCF-DIS events
- Yellow report section

Back up slides

eRHIC Interaction Point

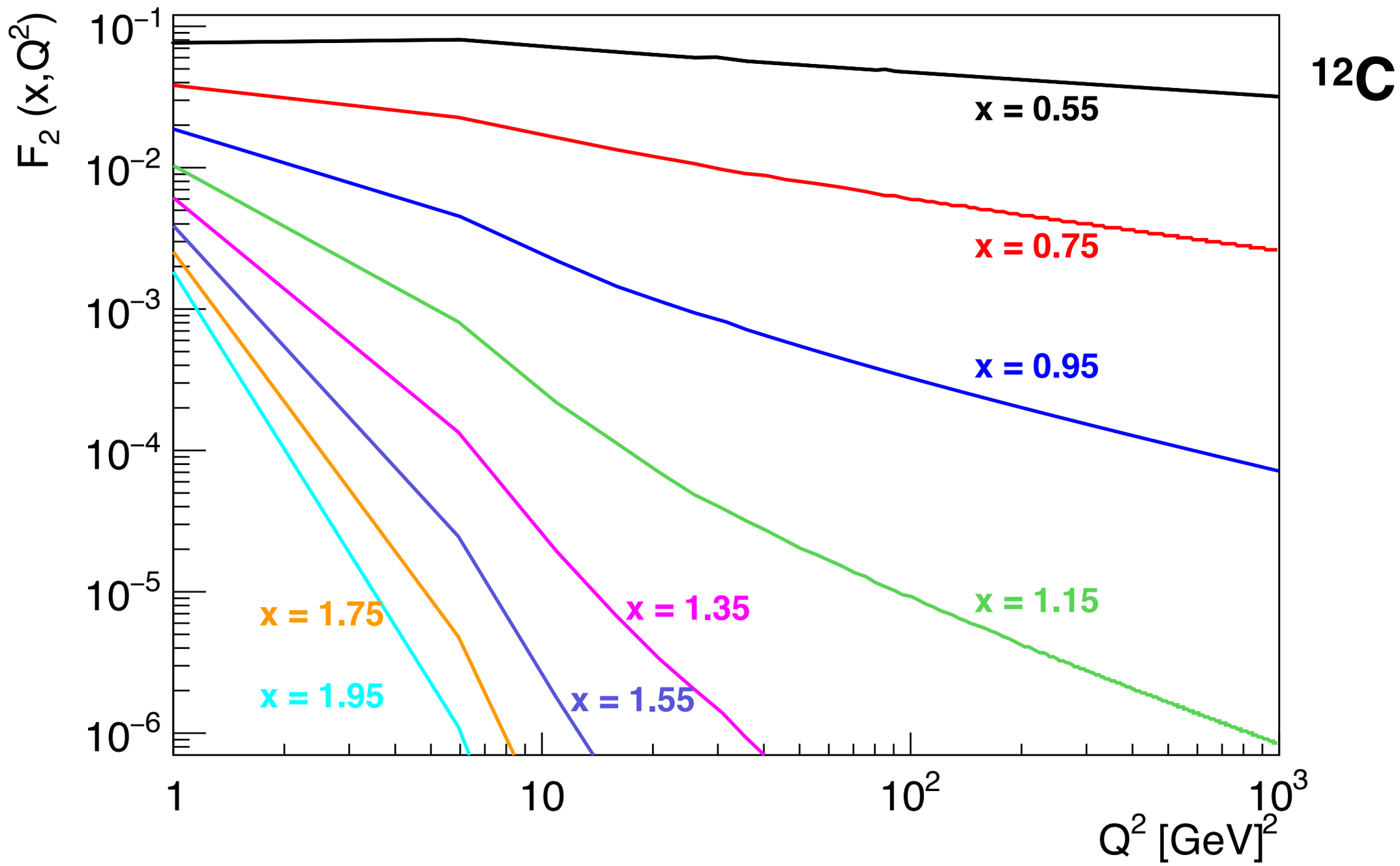
Holger Witter talk, EIC meeting Oct 2019,
https://indico.fnal.gov/event/21416/timetable/#20191009



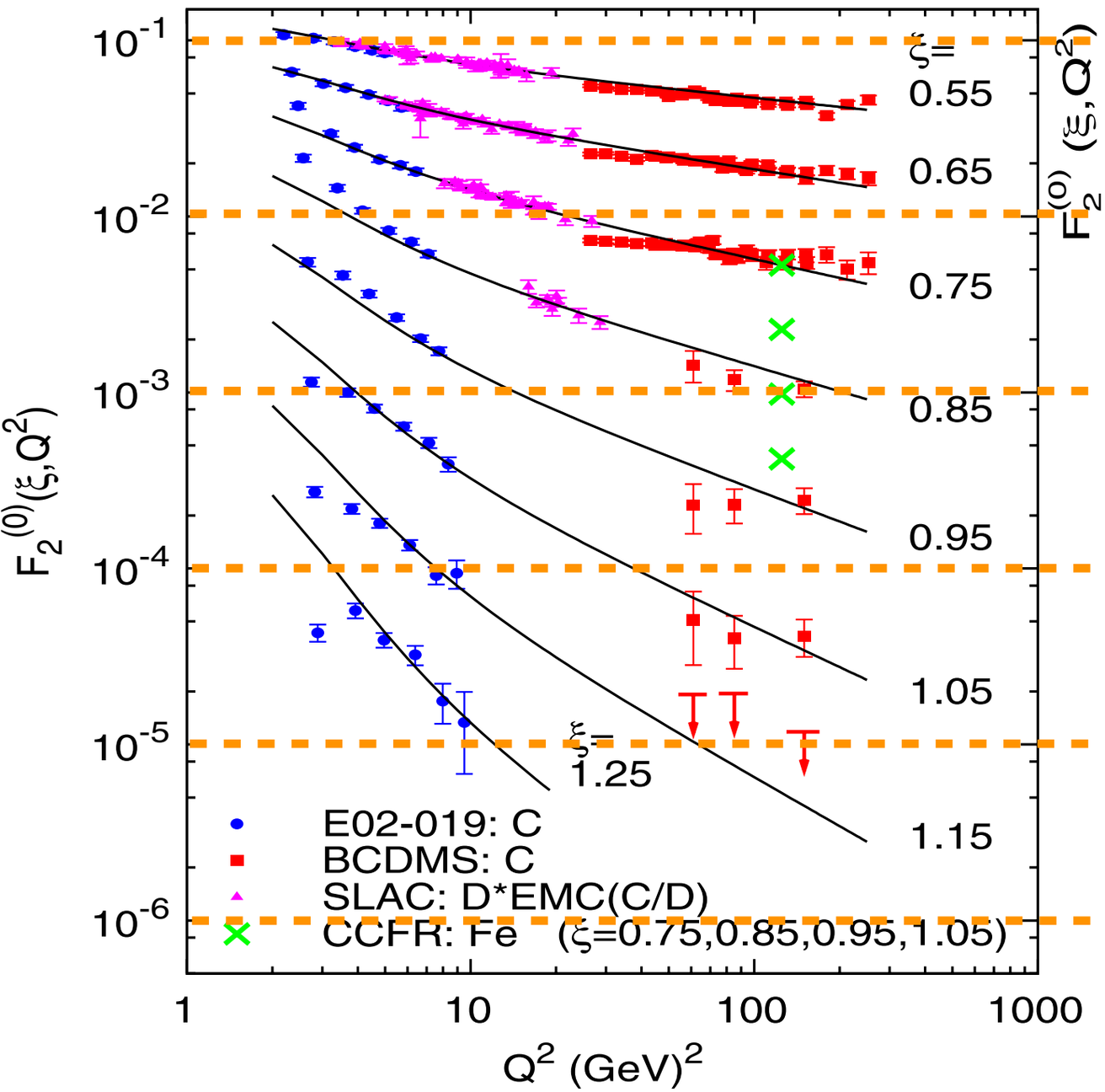
DIS Rates for High-x

based on super-fast quark yield parametrization, N. Fomin PRL 105, 212502 (2010)

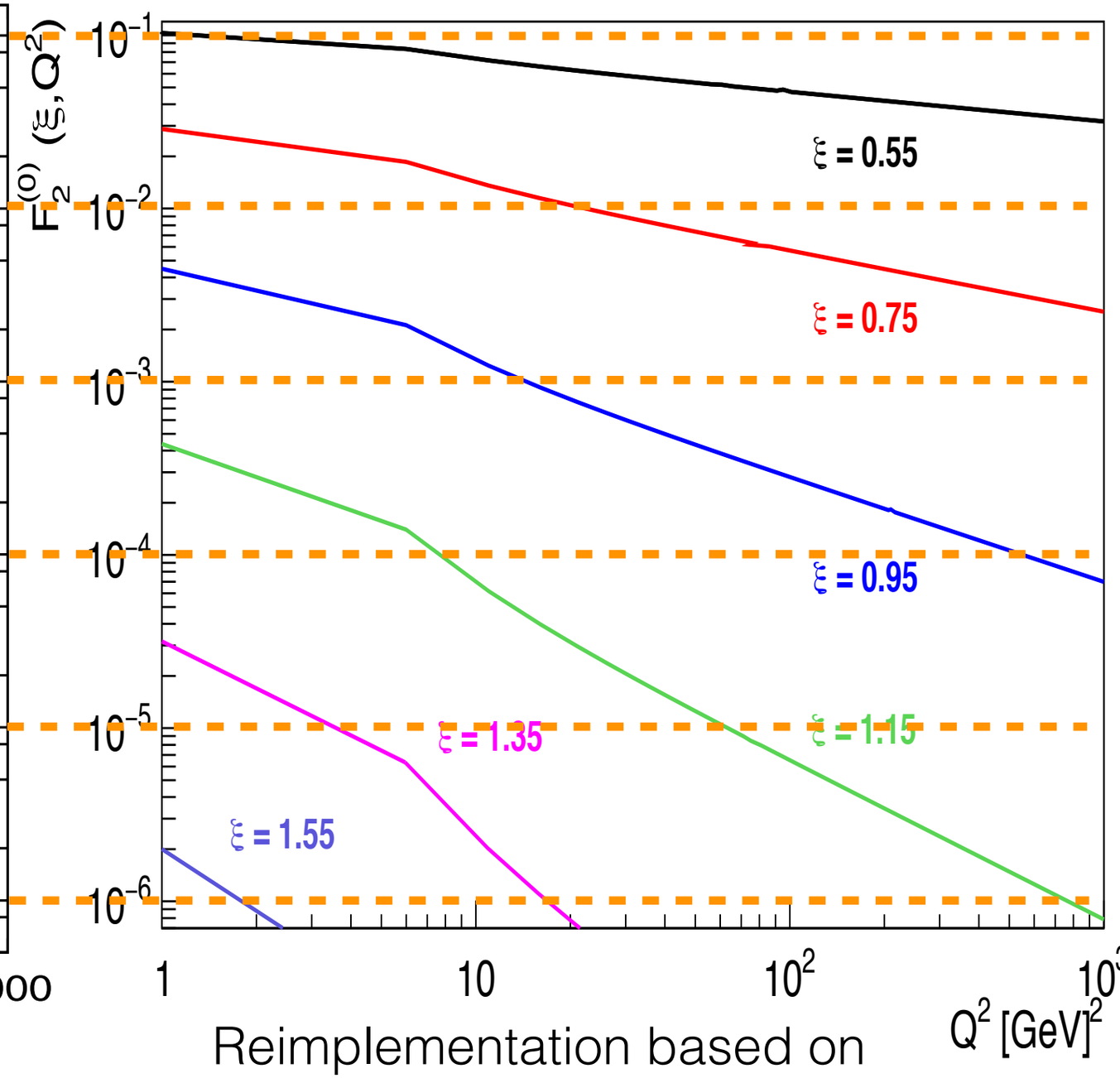
(alternative model: J. Freese et al. Phys. Rev. D 99, 114019)



F_2 from N. Fomin Paper and Reimplementation



N. Fomin PRL 105, 212502 (2010



Reimplementation based on N. Fomin scripts

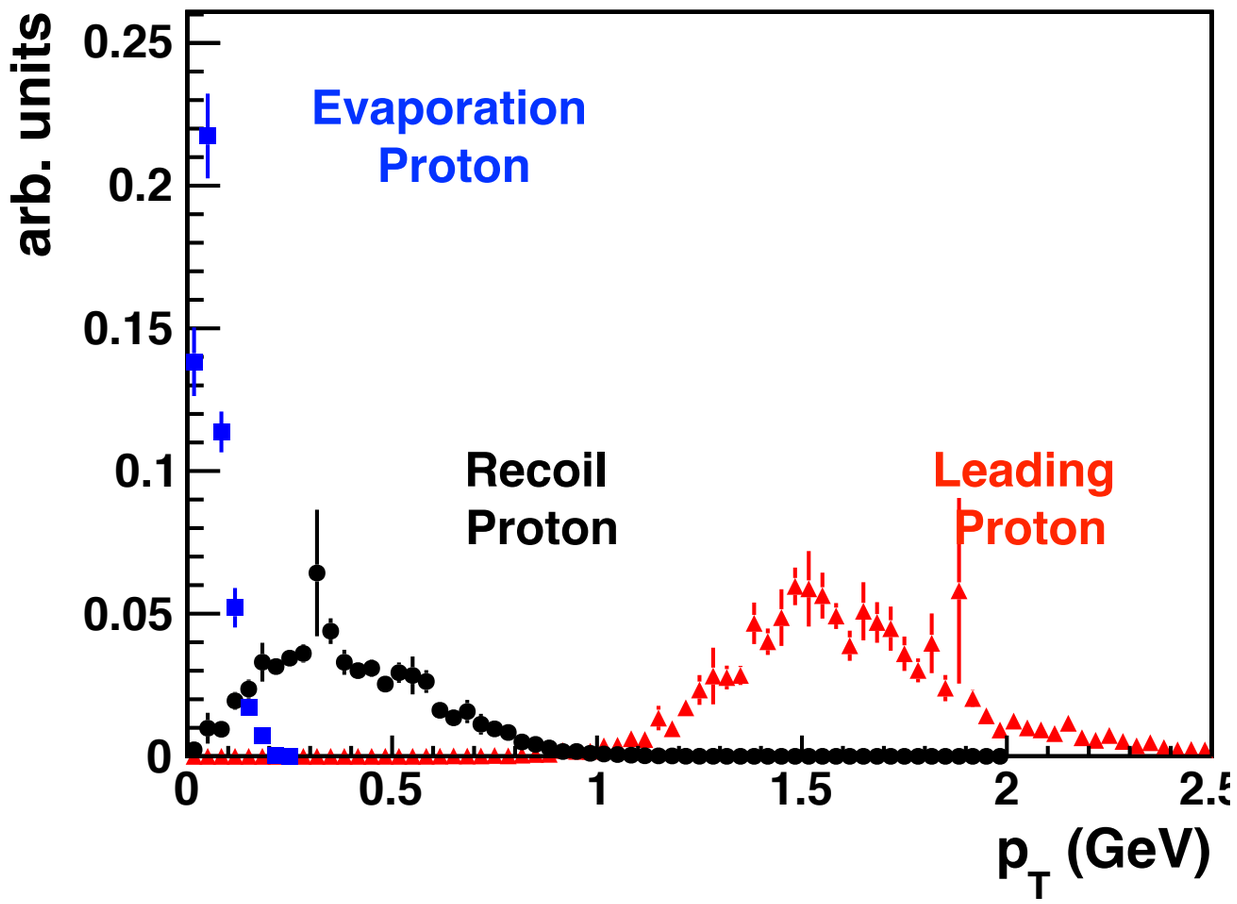
QE Event Handling Procedure

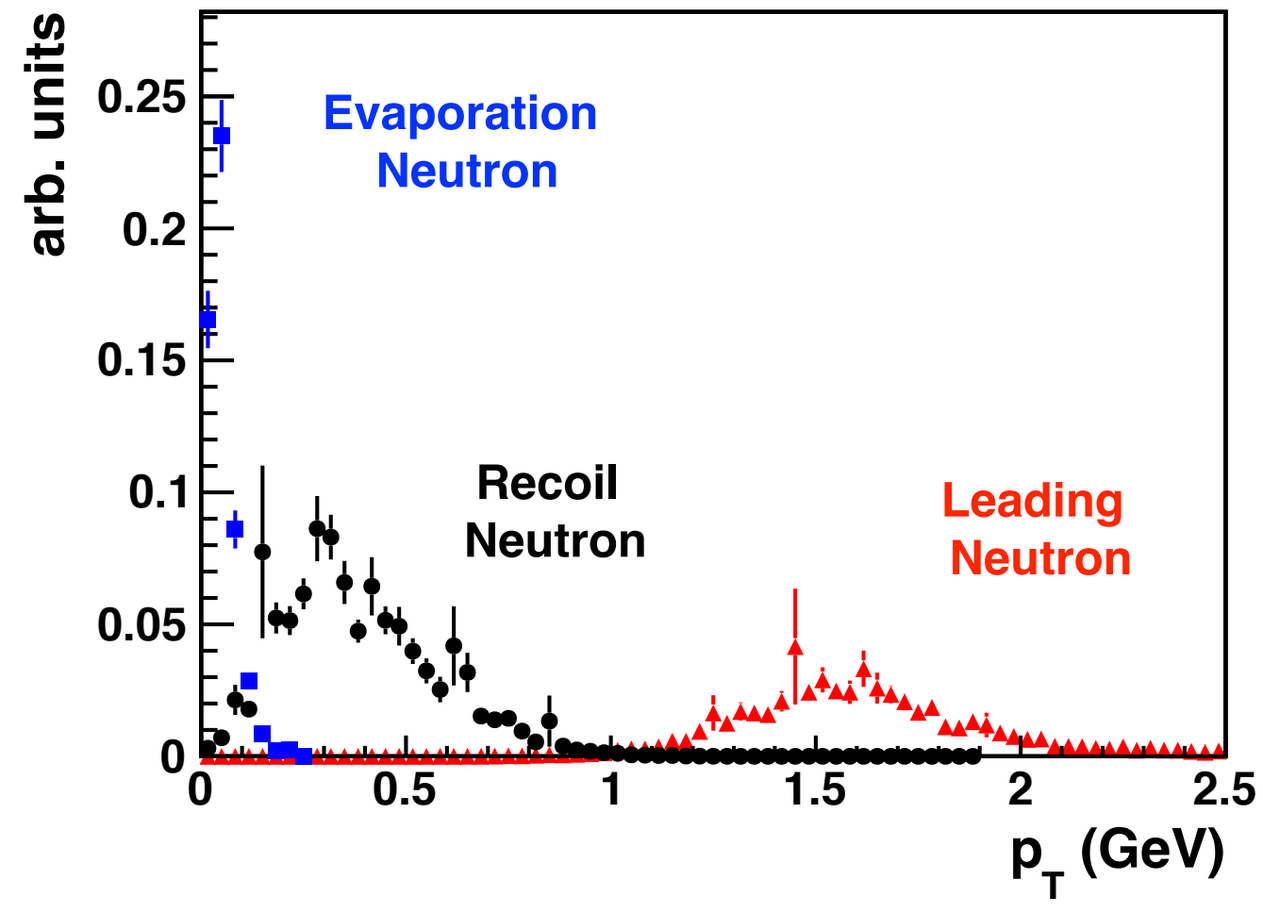
- GCF-QE output of electrons at fixed target
- Process through BeAGLE and convert to ROOT-file

- **Fixed target events to collider events**
  - Boost from lab to c.m.s with fixed target kinematics
  - Boost from c.m.s to collider lab with e+C(He,d) (10xP_p*Z) beams
- **Add crossing angle (-25mrad)**
  - Boost along x-axis with beta = 0.025
  - Rotate along y-axis by 0.025 mrad

QE Simulation Results (no crossing angle)

e + C (5 GeV + 50 GeV)





- Leading, recoil, evaporation nucleons well separated
- Expecting similar separation of evaporation and recoil nucleons for DIS

Note: This results are without FSI and intranuclear cascading