GEOMETRY TAGGING FOR HEAVY IONS AT JLEIC

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Abstract

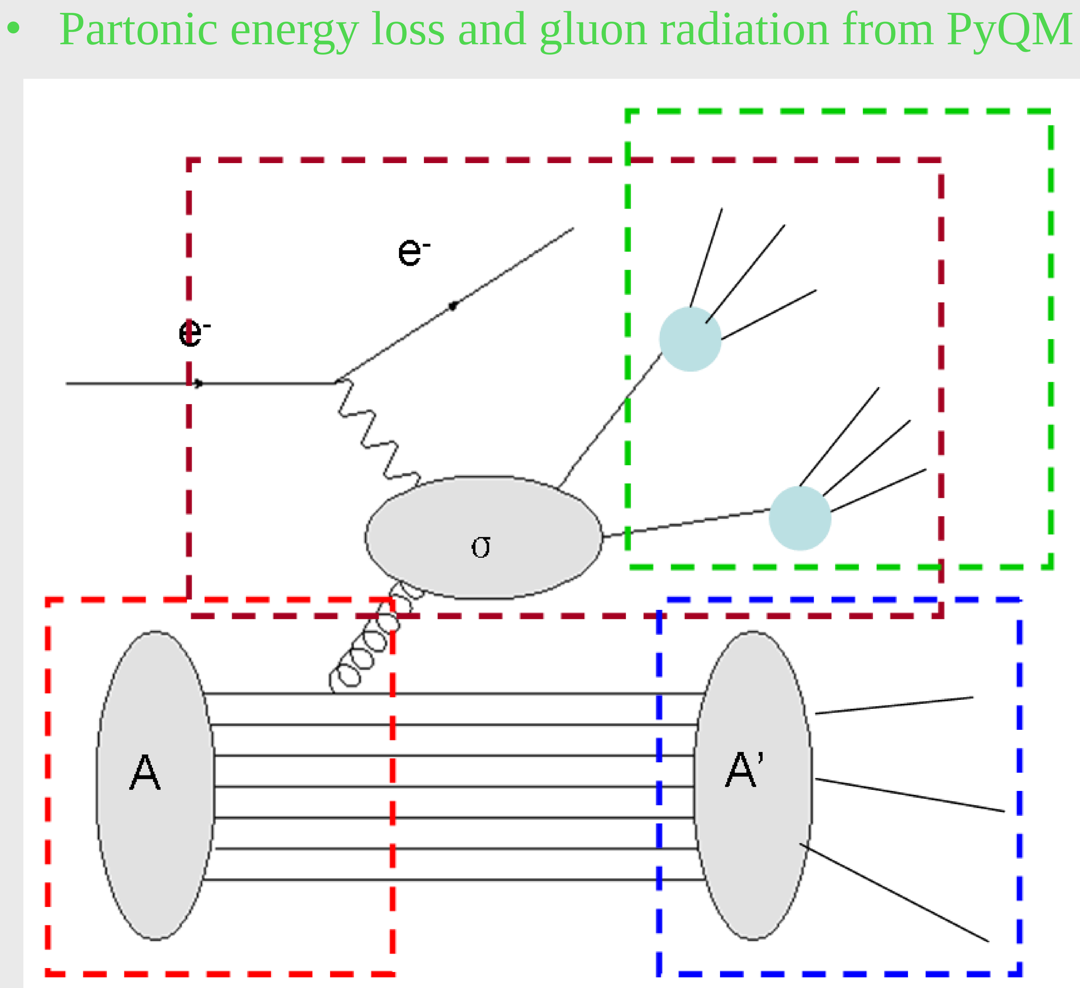
Geometry tagging is an experimental technique for selecting event samples where one can, on a statistical basis, control the geometry of the collision in order to make more incisive physics measurements. Several physics measurements at the EIC would benefit significantly from the use of this technique, including studies of gluon anti-shadowing, studies of ***parton propagation, attenuation and hadronization*** in the nucleus, and ultimately the search for ***parton saturation*** [1]. The JLEIC [2] full-acceptance detector, with full acceptance to forward-going neutrons, protons and nuclear fragments and a high data-taking rate is ideally suited to such geometry tagging. We improve, tune, and apply existing modeling codes, BeAGLE [3], Sartre [4], and GEMC, and detector descriptions to study this physics.

Goals

- Implementation of model codes **B**enchmark **eA** **G**enerator for **Le**ptoproduction (BeAGLE) and Sar*tre* at JLAB, interfacing them to detector simulations and making any needed improvements
- A detailed study of the resolution of the nuclear geometry parameters d (distance traveled in the nucleus after first collision) and b (impact parameter) using the JLEIC Full Acceptance Detector
- A detailed study of the efficiency and purity of the tag for deeply virtual coherent exclusive vector meson production on heavy nuclei
- Simulated physics results showing the ability of JLEIC to use geometry tagging to address key goals of the EIC Program:
  - study the sensitivity of JLEIC to gluon saturation and
  - a detailed study of light and heavy flavor propagation in the target nucleus

BeAGLE and Sartre

- BeAGLE [3] and Sar*tre* [4] are implemented at Jlab
- Feynman diagram and structure of BeAGLE
  - A hybrid model consisting of DPMJet, PYTHIA, and PyQM using the nPDF EPS09
  - Nuclear geometry by DPMJet using nPDF EPS09
  - Parton level interaction and jet fragmentation from PYTHIA
  - Nuclear evaporation and breakup, gamma de-excitation and hadronic intra-nuclear cascade from DPMJet
  - Partonic energy loss and gluon radiation from PyQM



References

[1] A. Accardi et al., arXiv:1212.1701 [nucl-ex].
[2] S. Abeyratne et al., arXiv:1504.07961 [physics.acc-ph].
[3] https://wiki.bnl.gov/eic/index.php/BeAGLE
[4] T. Toll, T. Ullrich, Phys. Rev. C87 (2013) 024913
[5] V.S. Morozov et al., in Proc. of DIS18, to be published

Acknowledgements

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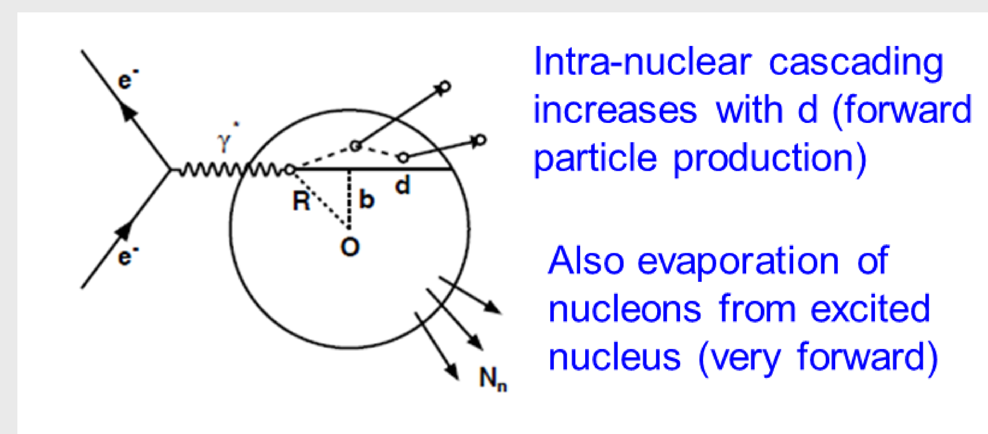
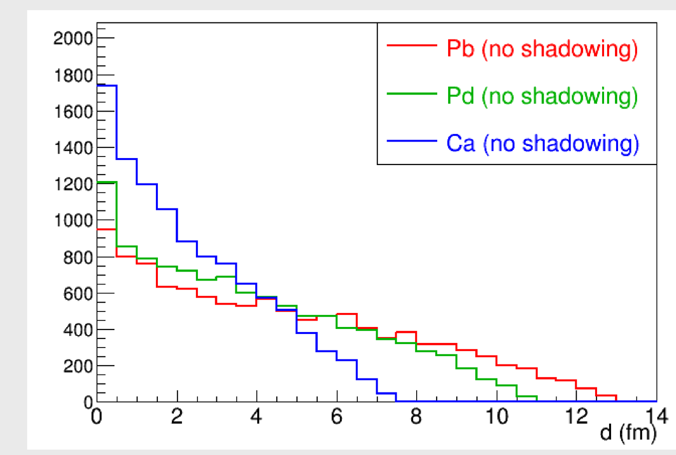
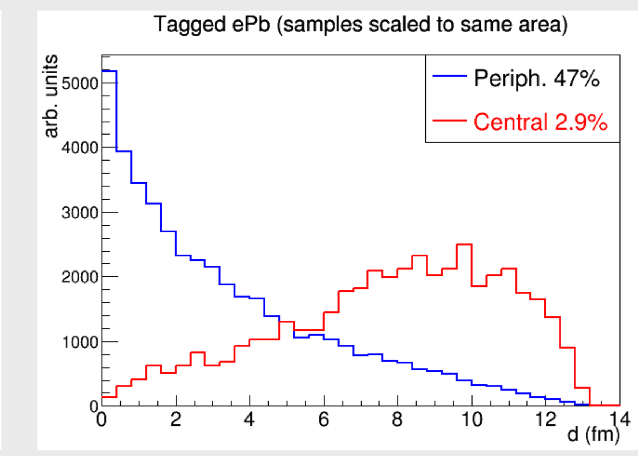
Nuclear Geometry Parameters

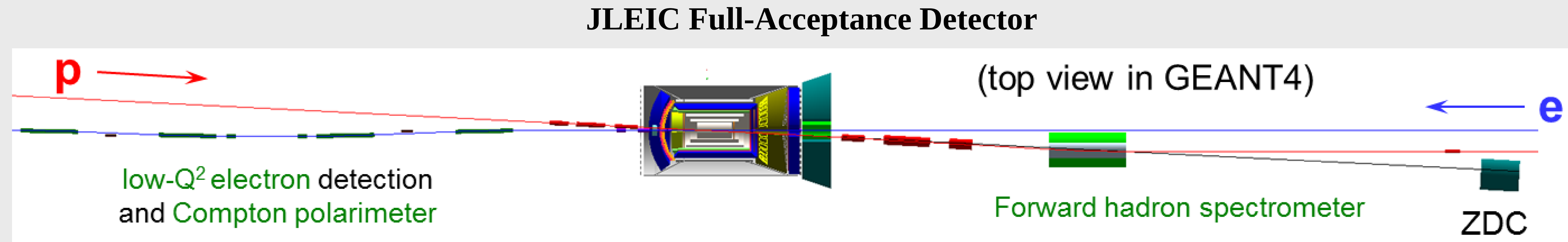
- Geometry tagging allows us to determine the impact parameter ***b*** and the path length ***d*** in the nucleus after the interaction by detecting the final state
  - Nuclear fragments & particles in ion direction
- Without tagging, the average ***d*** in a nucleus scales as the radius ($A^{1/3}$)
  - Middle plot below shows 40 < A < 197
- Tagging allows us to select (bins with) events for which the average ***d*** is very different from that for the entire nucleus
  - Plot on the right-hand side below (evaporation ***n*** multiplicity tag)





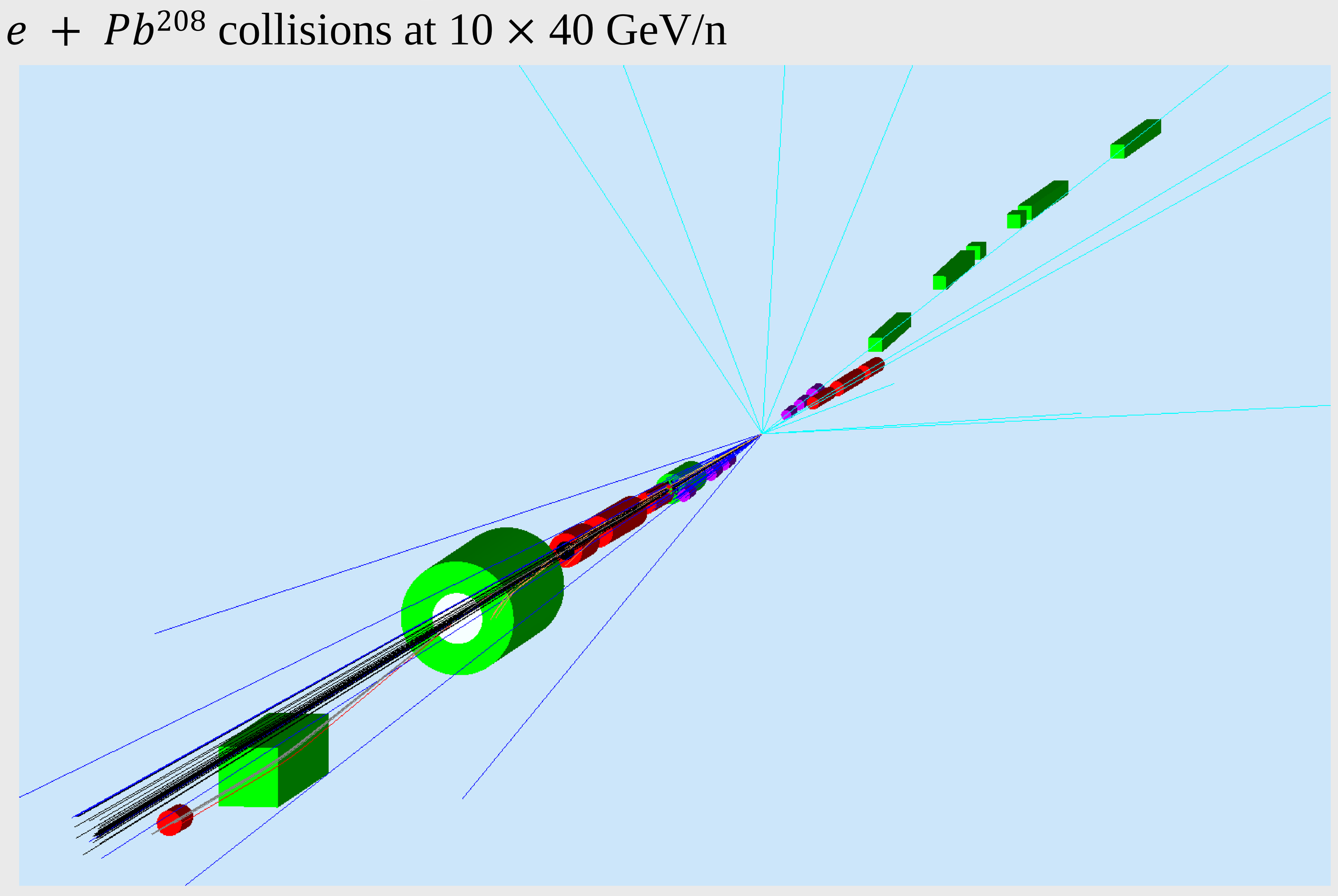


JLEIC Full-Acceptance Detector



Sample Tracks of BeAGLE Events

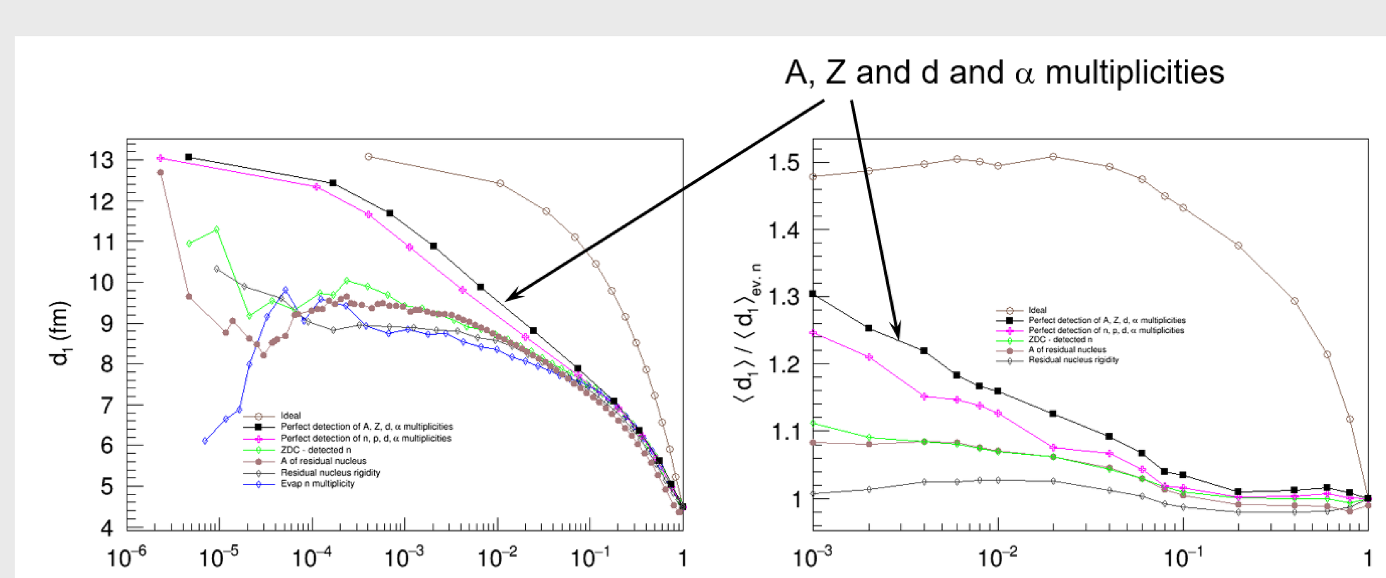
$e + Pb^{208}$ collisions at 10 × 40 GeV/n



Tagging in *d*

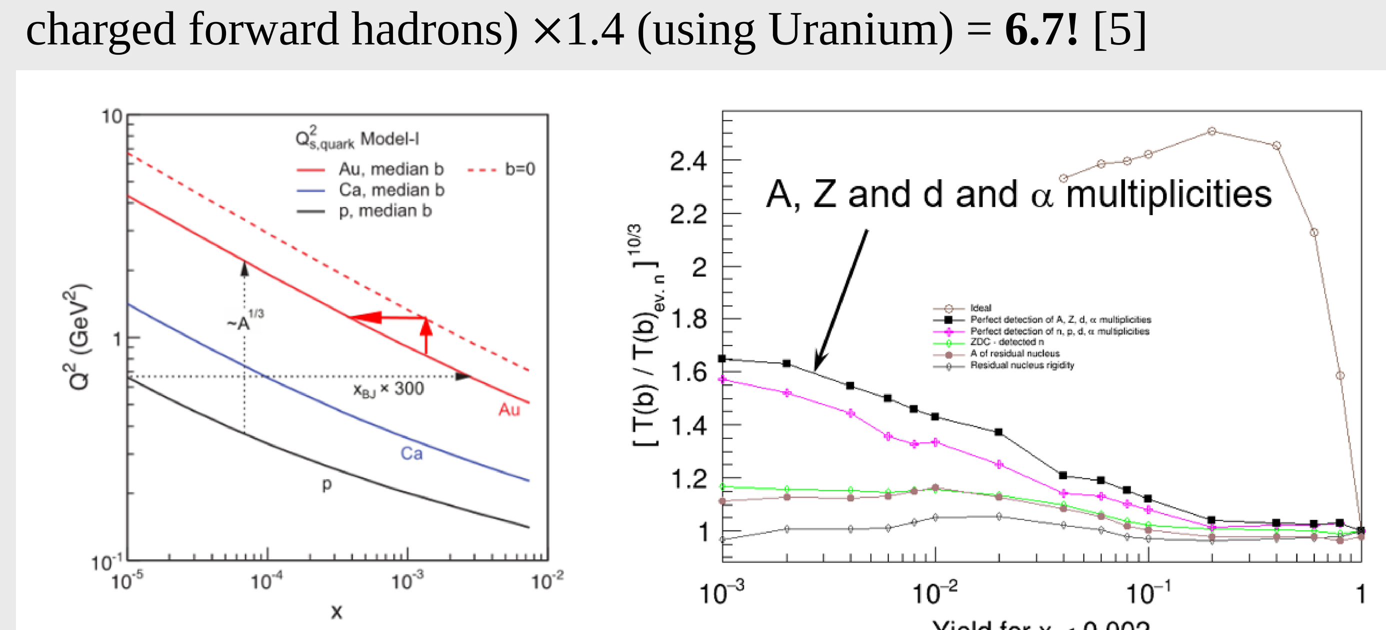
Tagging options [5]:

- ideal (assuming that d of each event is known),
- nuclear remnant's A and Z and the d and α multiplicities,
- combination of the n, p, d, and α multiplicities,
- multiplicity of all detectable neutrons,
- nuclear remnant's A,
- nuclear remnant's magnetic rigidity,
- evaporation neutron multiplicity.



Tagging in *b*

Effective energy boost: 3.2 (using evapoartion neuterons) × 1.5 (using charged forward hadrons) ×1.4 (using Uranium) = **6.7!** [5]



Coherent Exclusive Diffraction [5]

- Coherent diffraction (nucleus is intact) gives transverse spatial gluon distribution
- Need to suppress incoherent background
- Vetoing stages
  - Forward: $\pi^{+/-}$, $K^{+/-}$, $p/\bar{p}$, $n/\bar{n}$, or γ with $E_\gamma > 40$ MeV through FFQs
  - Full: Forward + $\pi^{+/-}$, $K^{+/-}$, or $p/\bar{p}$ through the first spectrometer dipole
  - Full + photons: Full + γ with $E_\gamma >$ 40 MeV through the first dipole