Reconstruction of Nuclear Fragments in IP-8

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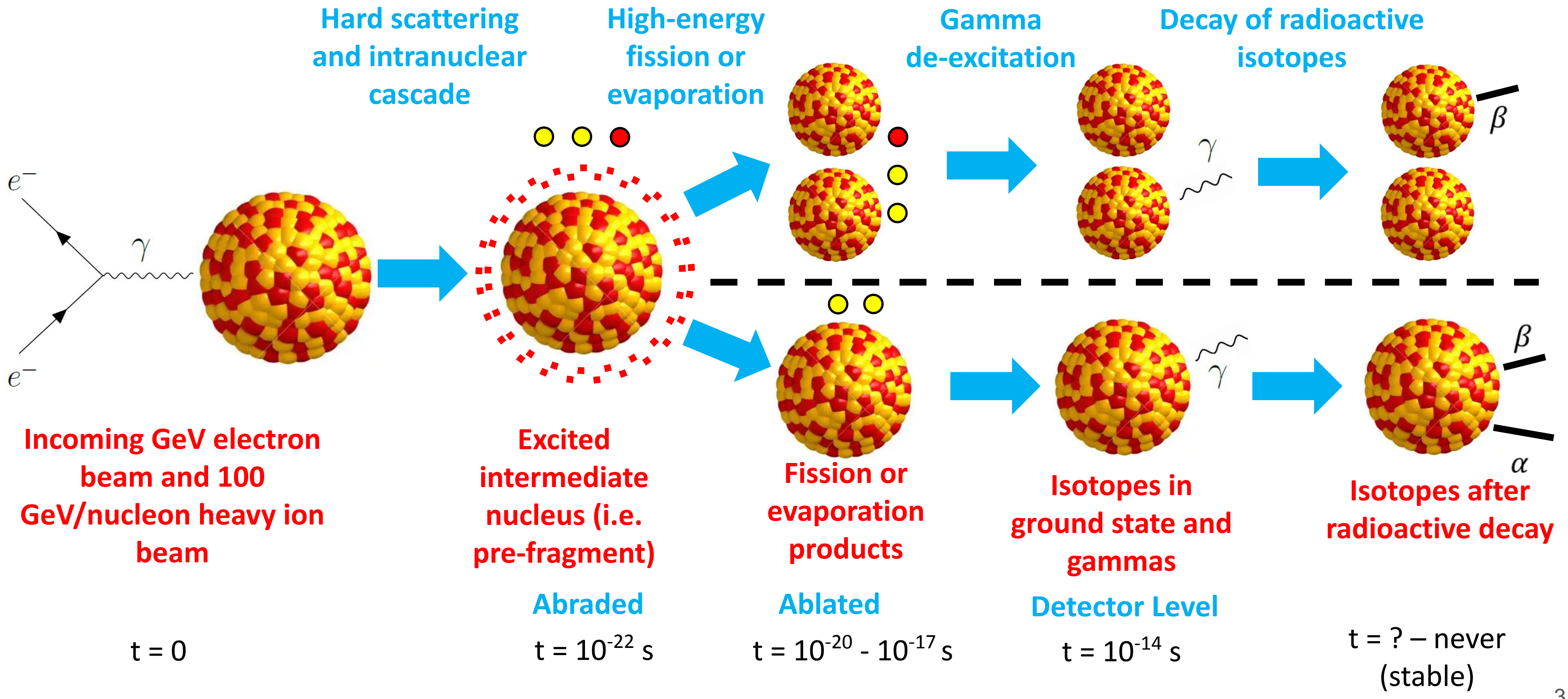
Introduction

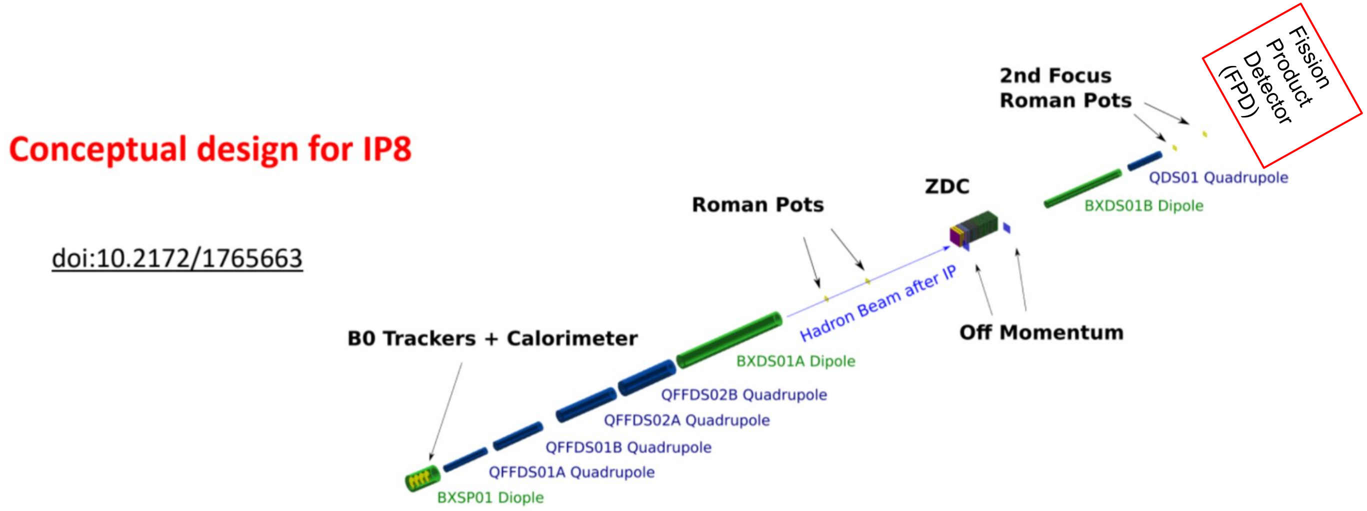
- EIC e-A collisions have the possibility of inducing fission or evaporation of the excited pre-fragment nucleus, as well as Fermi-breakup and multi-fragmentation
- We use the BeAGLE event generator to model the initial scattering + intranuclear cascade; and FLUKA and ABLA07 to then simulate the decay of the excited pre-fragment
- Previous studies of production and detection of nuclear fragments were shown at the 2023 EIC UG meeting (here)
- Focus in this presentation will be on the reconstruction of the pre-fragment based on nuclei and escaped nucleons

One way the 2nd focus can be used – Nuclear fragments



Slide from: Barak Schmookler

EIC Detectors – far-forward region



- B0 and ZDC detect escaped neutron and gamma ray
- Roman Pots detect the fragment trajectory and A/Z
- Fission Product Detector (cherenkov or scintillator) detects fragment Z

Slides from: Barak Schmookler

BeAGLE + FLUKA

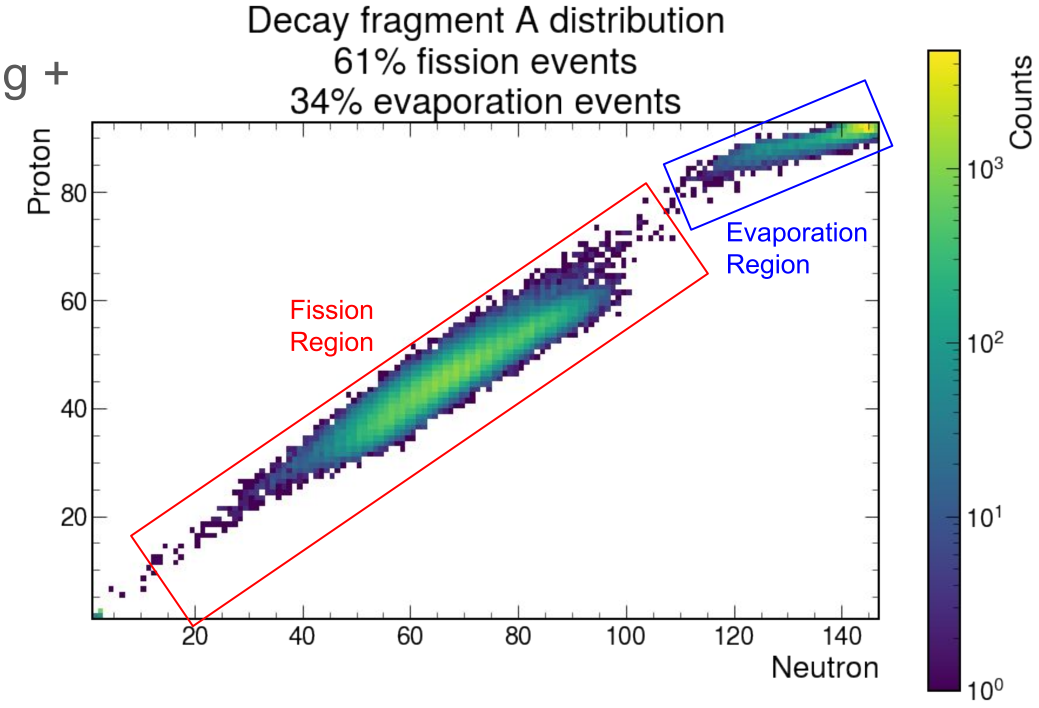
100,000 event generation of scattering + decay process of e+^{238}U collision

60510 fission di-fragment events

33650 evaporation events

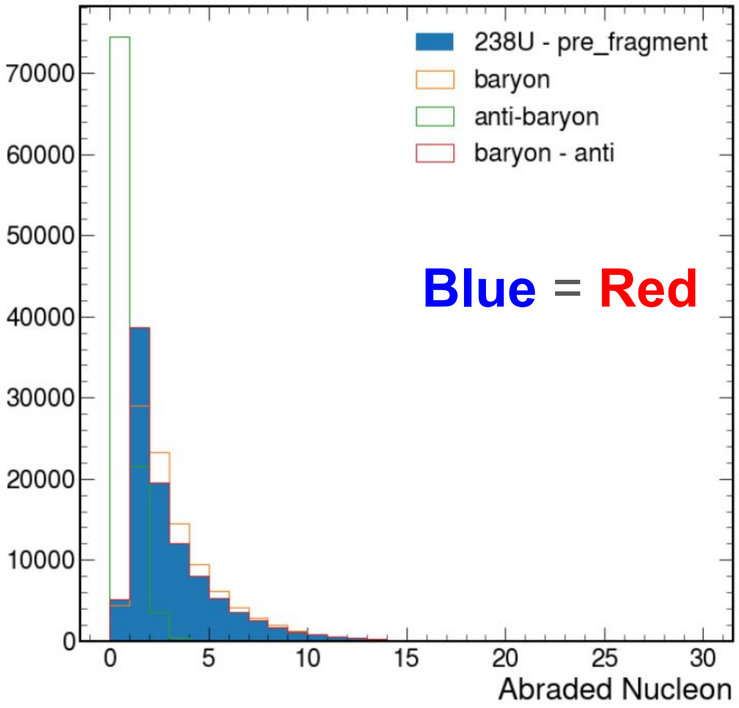
Other events includes: 6%

- Multi-fragmentation
- Fermi-breakup



Nucleon production in BeAGLE – abrasion stage

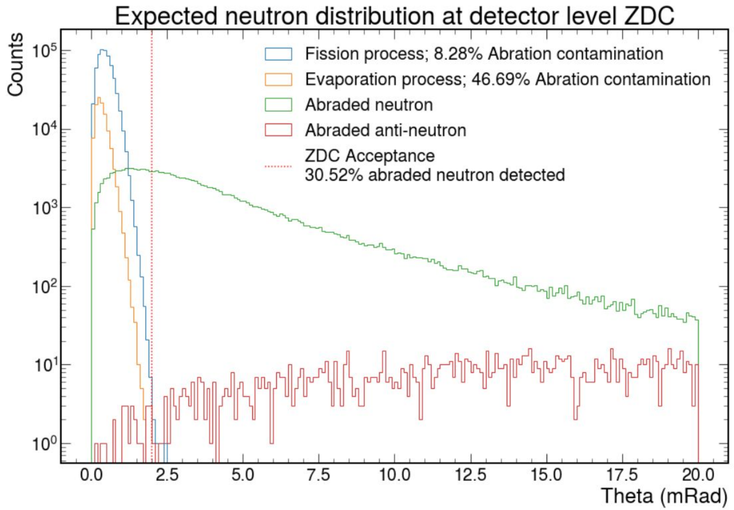
- There is both baryon and anti-baryon production during the intranuclear cascade
- Reconstruction of the pre-fragment needs to consider all these particles as background
- Anti-neutrons have the same response as neutrons in ZDC

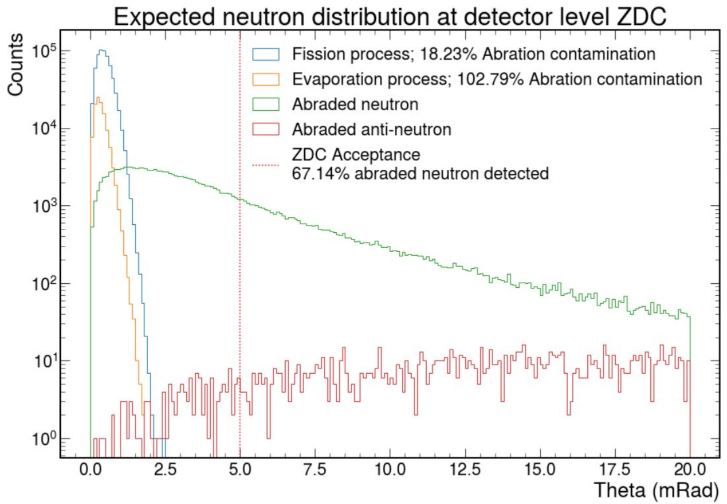


Results from FLUKA

- Kinematics of neutrons from the BeAGLE+FLUKA simulation show a confined region within the ZDC acceptance that the ablated neutrons will hit.
- Abraded nucleons within the angular cut will result in background noise for reconstructing the pre-fragment

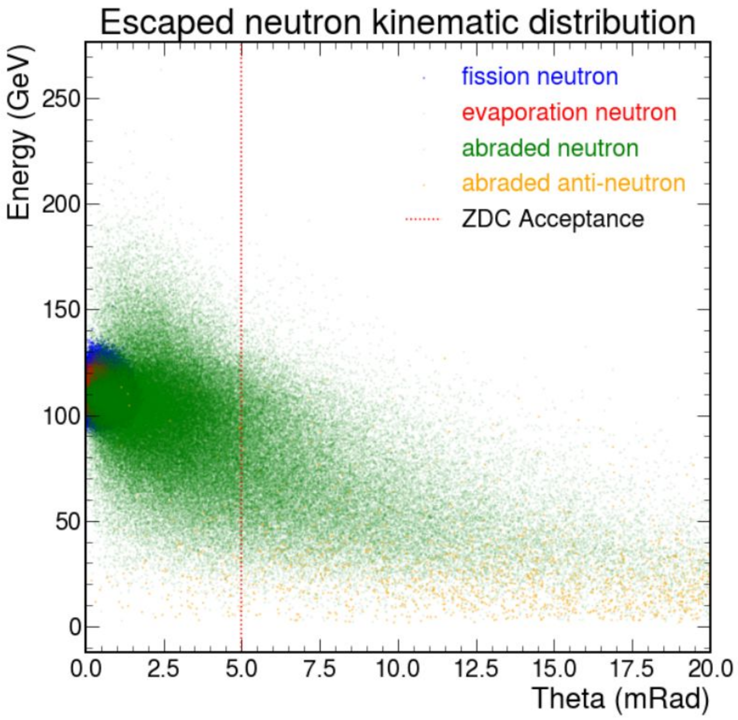
Abraded nucleons: produced in the hard scattering or intranuclear cascade.
Ablated nucleons: produced during the de-excitation of the excited pre-fragment.





Neutron kinematics

- Abraded neutrons have a wide range of angular and energy spectrum
- Ablated neutrons are confined into smaller theta and close to the beam energy



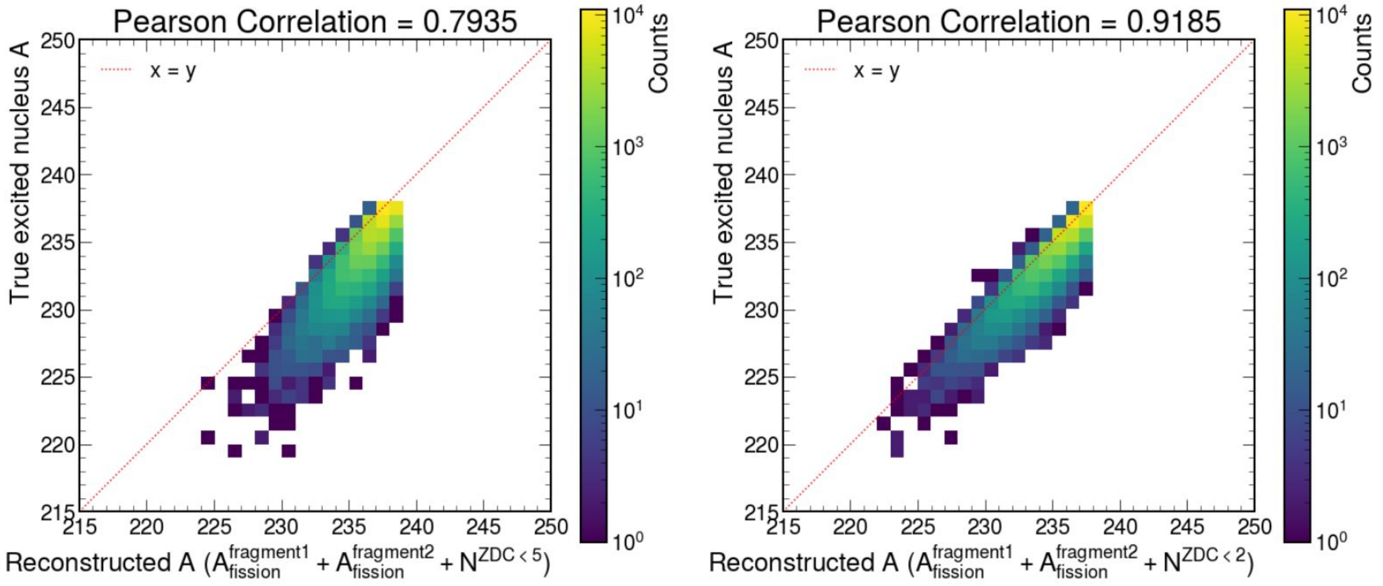
Abraded nucleons: produced in the hard scattering or intranuclear cascade.
Ablated nucleons: produced during the de-excitation of the excited pre-fragment.

Fission reconstruction using only neutrons

Using neutrons seems to be enough for reconstructing the pre-fragment

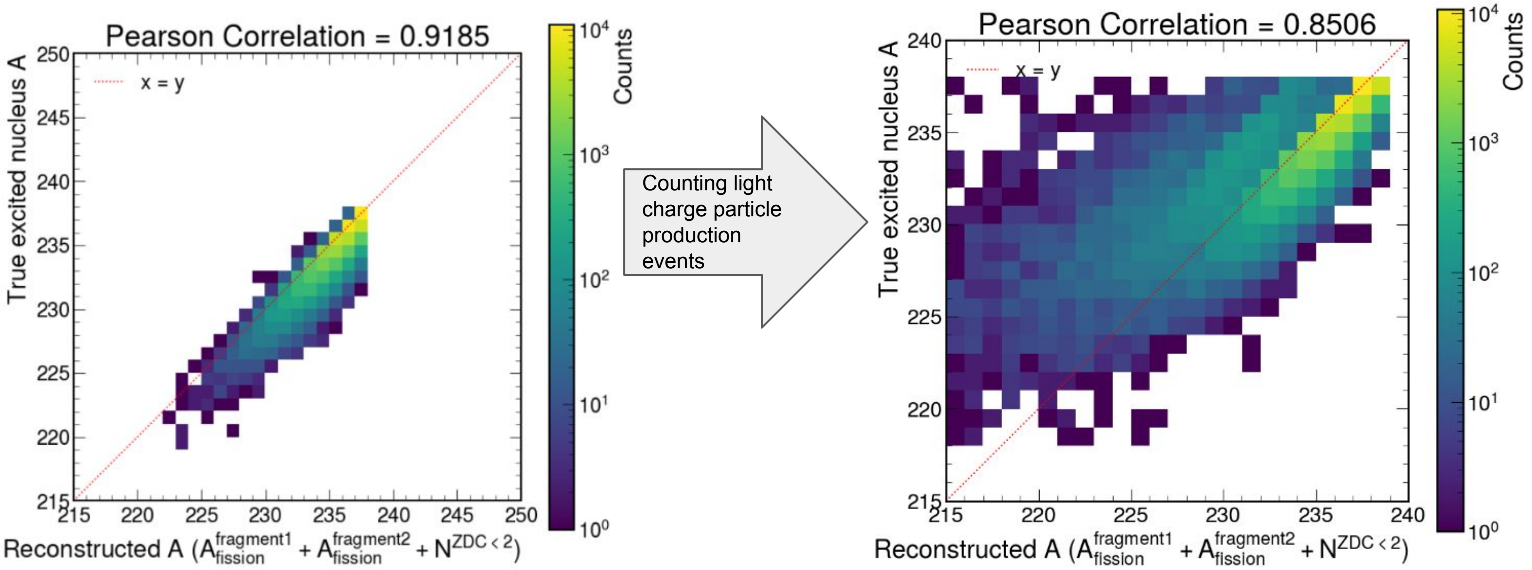
Reconstructing the A of fragment 1(2) will require the Roman Pots and a detector to determine Z.

Reconstructing fission isotopes + neutron
with ZDC 5 mRad or 2 mRad



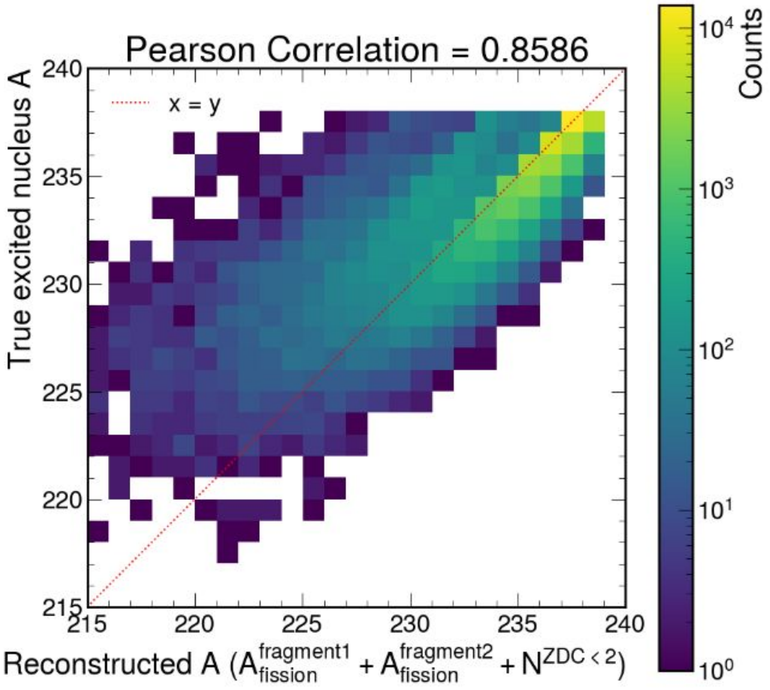
Light charge nuclei events

- The previous plot filtered away events with light charged particles (Deuterium, He3, He4), which consist of ~7% of the fission events
- But we hope to also detect and differentiate those particles, so we are expecting the same reconstruction as before



Results from ABLA - reconstruction

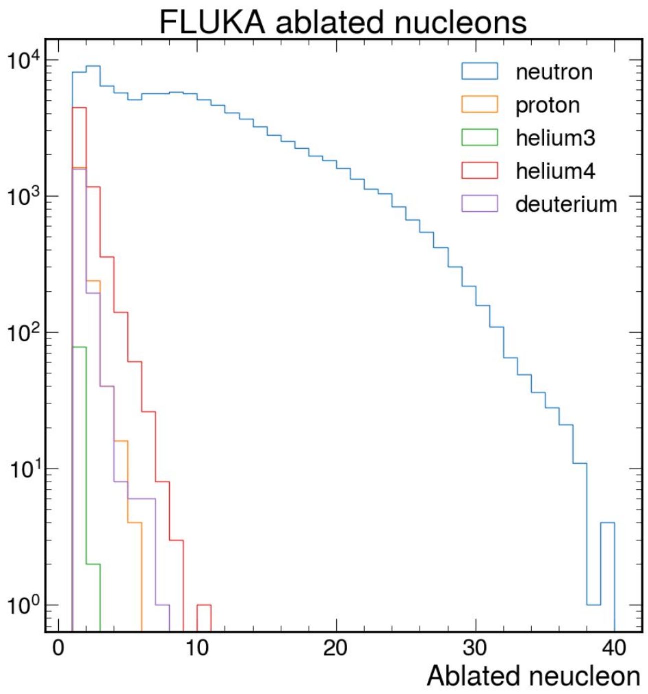
- We also use ABLA and follow the same method to find the fragments from fission events and reconstruct the pre-fragment based on the neutrons ablated from the decay model
- The same abraded neutrons were applied as background in FLUKA and ABLA, since we use the pass the same set of BeAGLE events into both de-excitation codes.

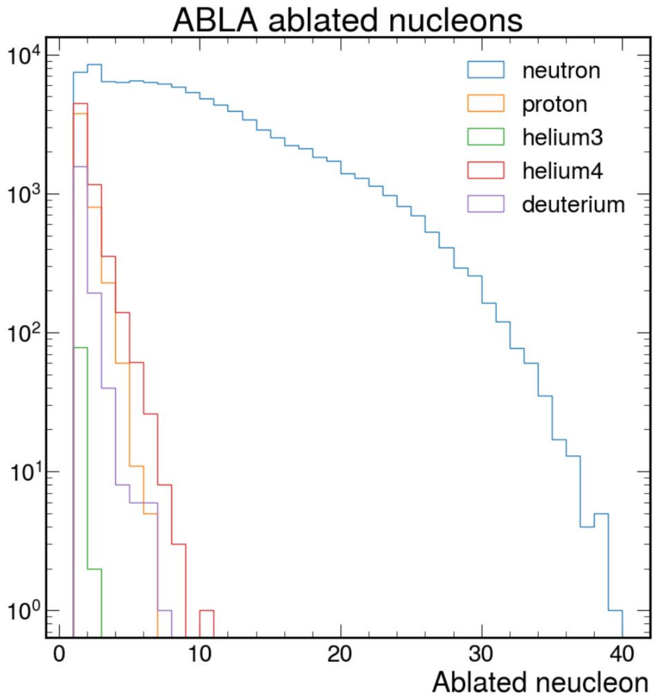


Comparing ablated nucleons from FLUKA and ABLA

The pre-fragment decay process can produce nucleons and light charge particles.

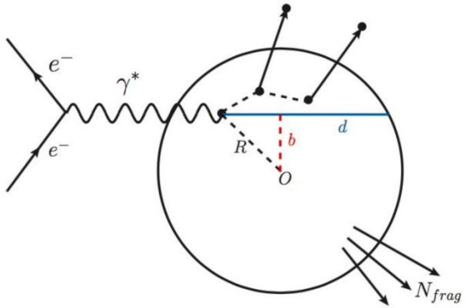
FLUKA and ABLA are in general agreement on production rates.

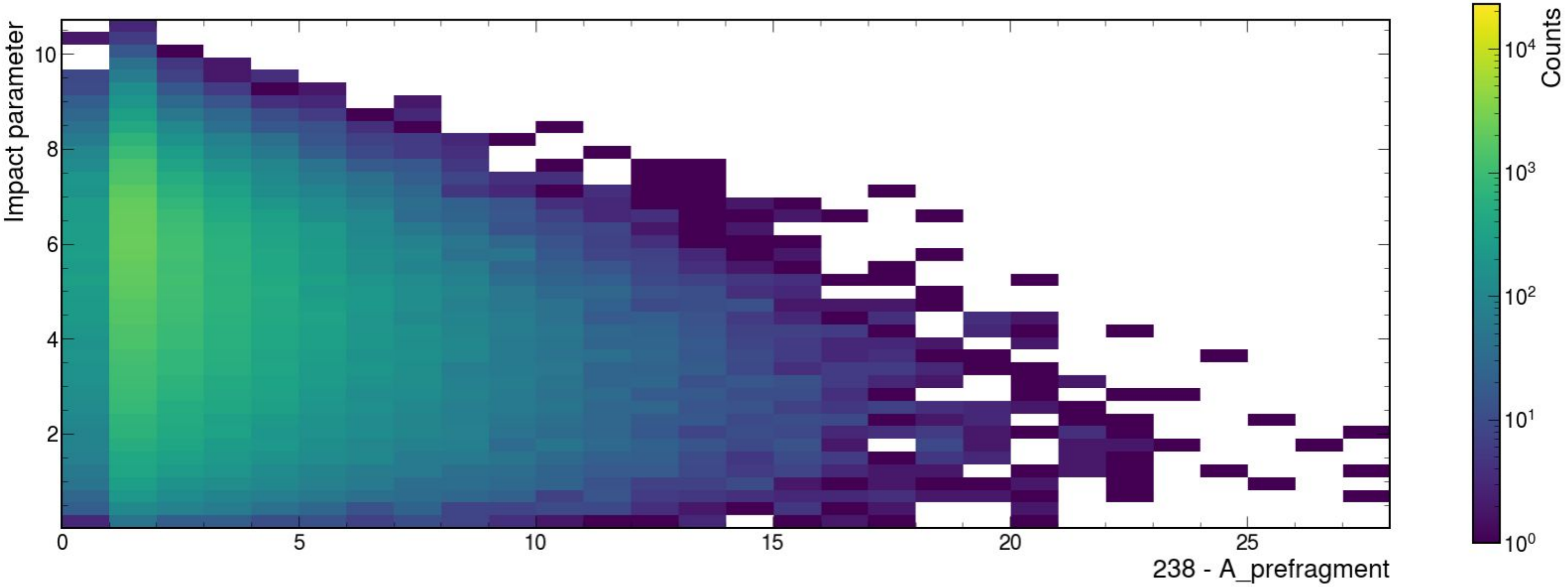




Impact parameter anti-correlation

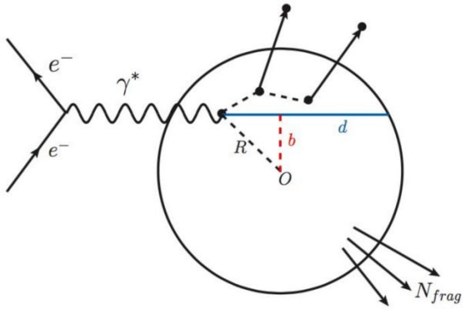
Anti-correlation between impact parameter (b) vs. ablated nucleons for possible hadronization studies

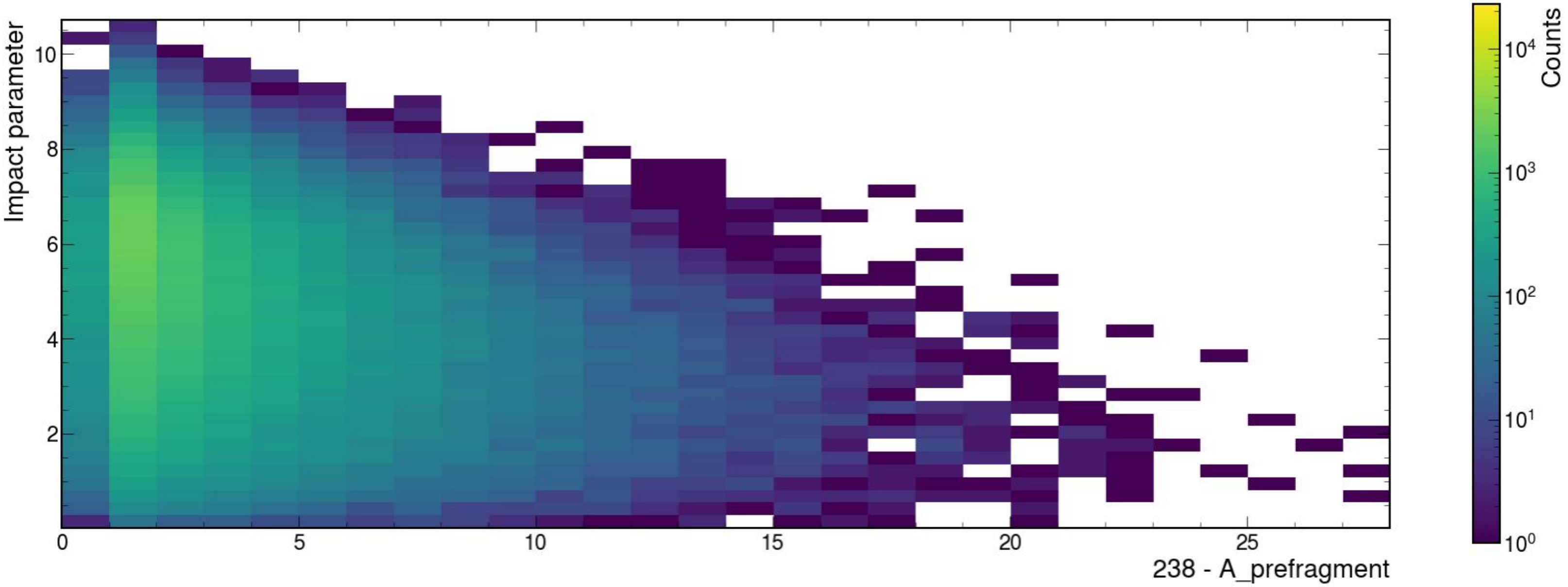




Increasing the number of abraded nucleons (A_beam - A_prefragment) means a larger intranuclear cascade – which happens more often in central collisions.

So, reconstruction of the pre-fragment can allow a potentially more robust way to determine centrality than using only the neutrons in the ZDC.





Backup

BeAGLE excited pre-fragment production distribution

Production of excited pre-fragment nuclei can have a variety of N & Z combination from the ^{238}U beam

What we want to measure