Studies of Fission at EIC

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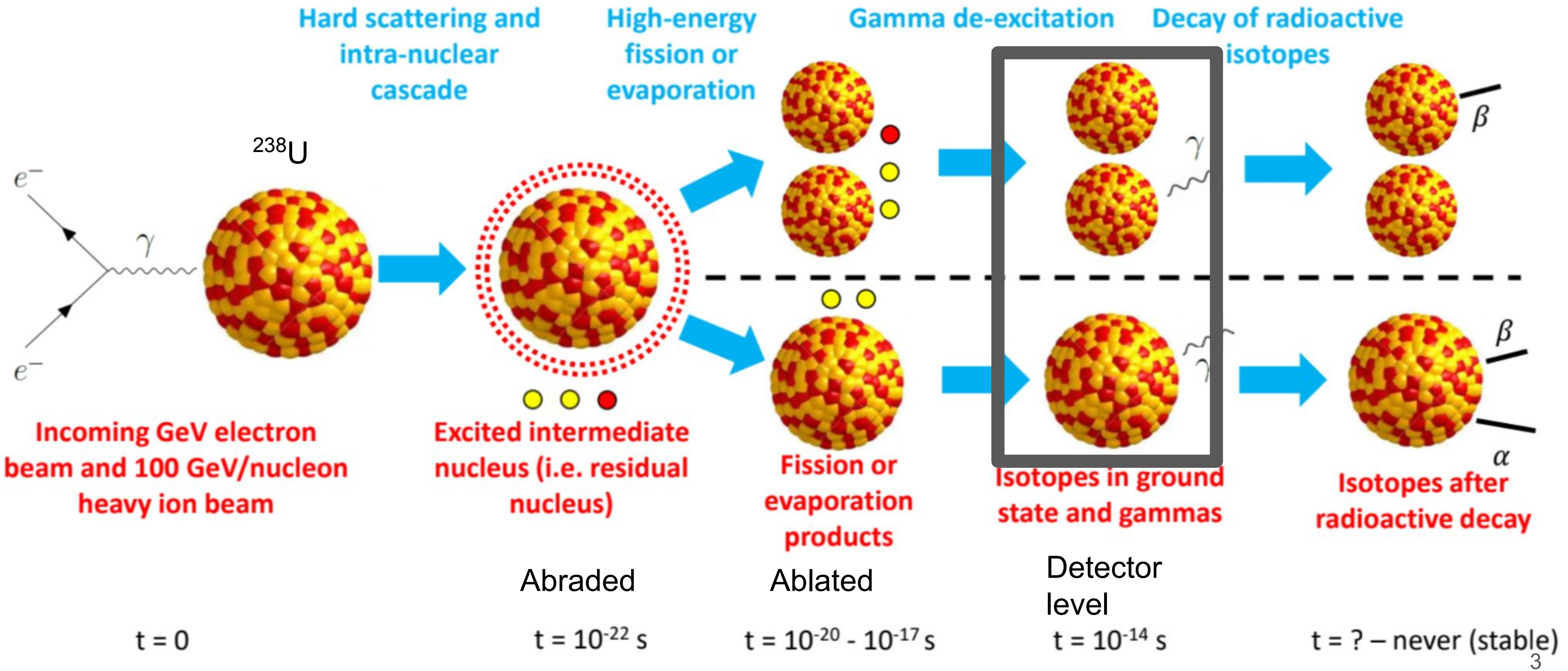
Motivations

- The EIC experiment host the possibility of providing electron-heavy nuclei collision and possibility of measuring produced nuclear fragments.
- What kind of detection methods will resolve the spectrum of isotope fragments?
- Can one use these to address open questions in fission?
- Can one use these to search for exotic isotopes?
- How will these results contribute complement to the work done in other rare isotope facilities?

Nuclear fragment production at the EIC



Slides from: Barak Schmookler

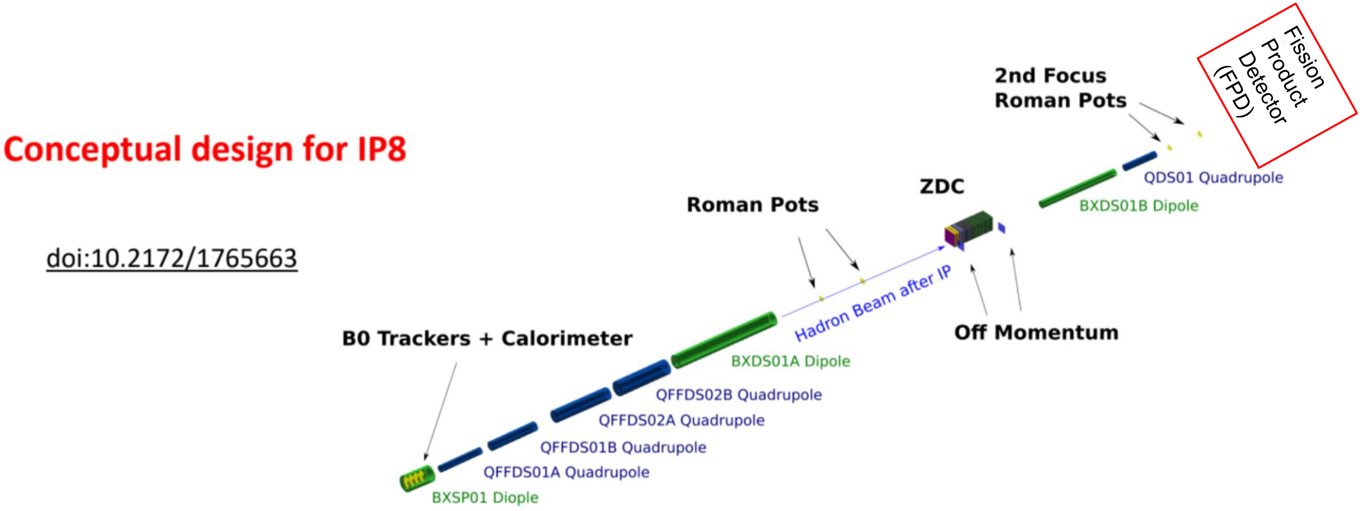
Terms used

Abraded: nucleons that is scattered off the ^{238}U beam

Ablated: excited pre-fragment decay outward nucleons

Pre-fragment: excited nucleus remaining from e-^{238}U collision

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

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Simulation

- BeAGLE + FLUKA simulation of scattering + decay
  - Using ABLA07 and FREYA as alternative
- Gent4 and DD4Hep simulation of detector response

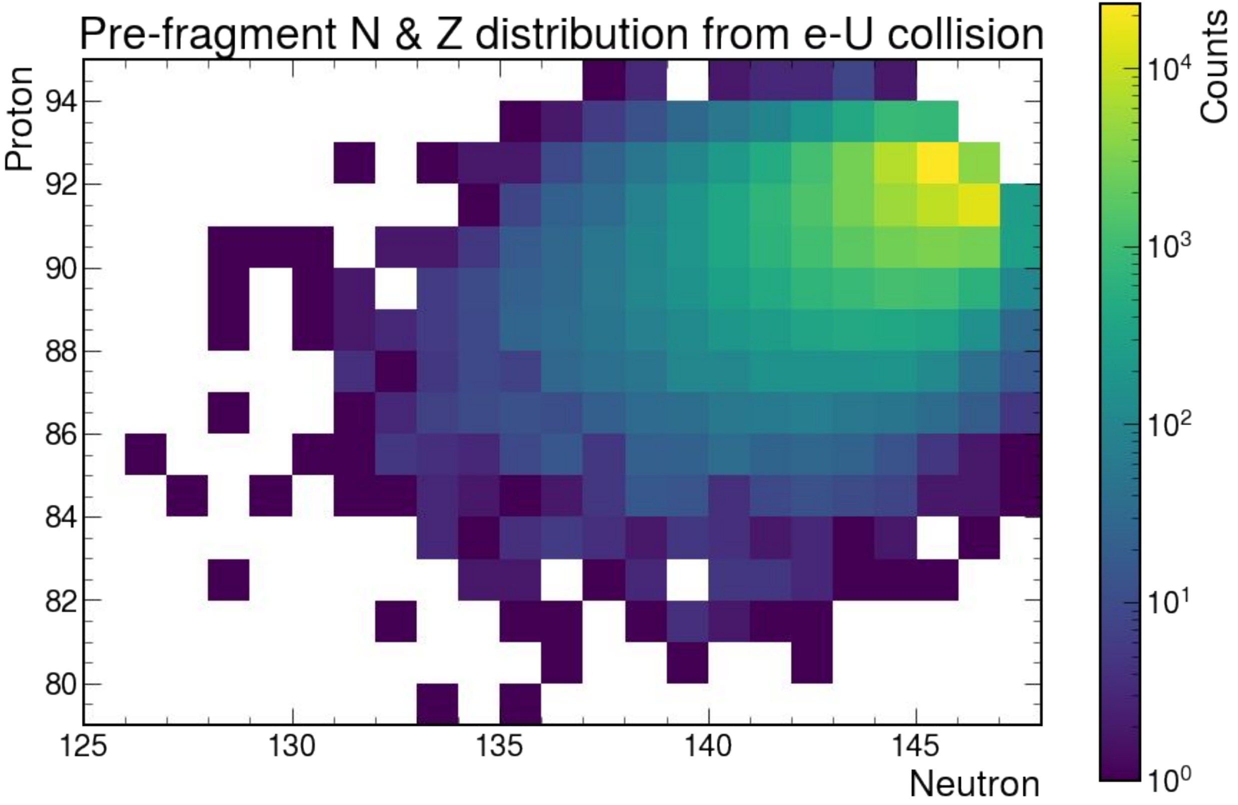
Tracking:

- Excited pre-fragment production distribution
- Decay fragmentation of isotope(s)
- Detector reconstruction of fragments with escaped nucleons

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



BeAGLE + FLUKA

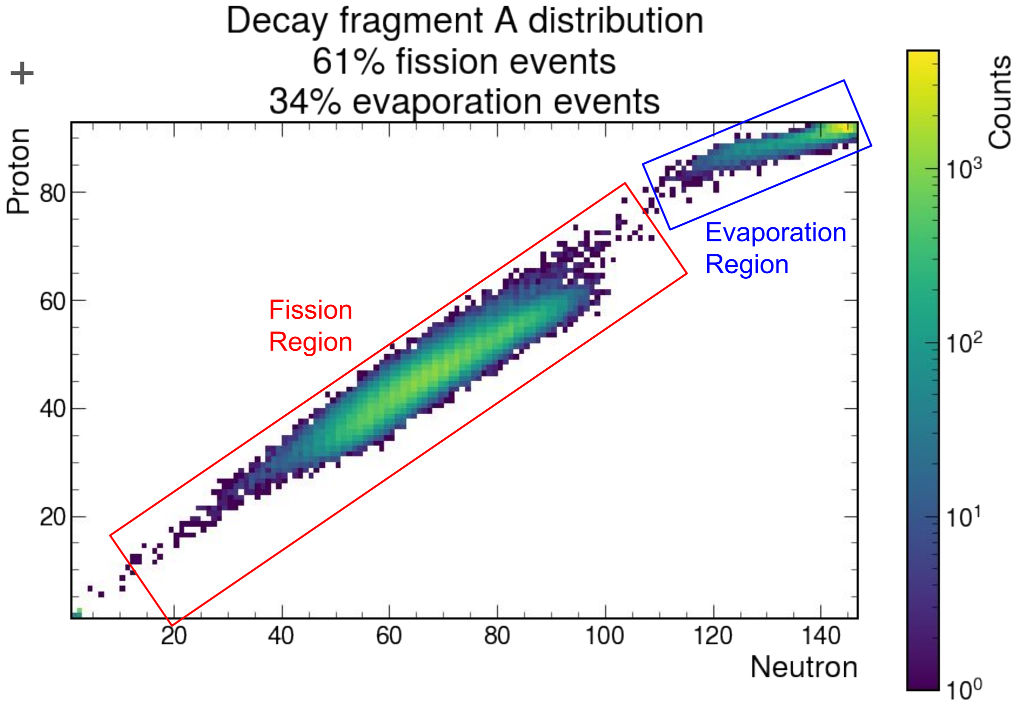
100000 event generation of scattering + decay process of e+^{238}U collision

60510 fission di-fragment events

33650 evaporation events

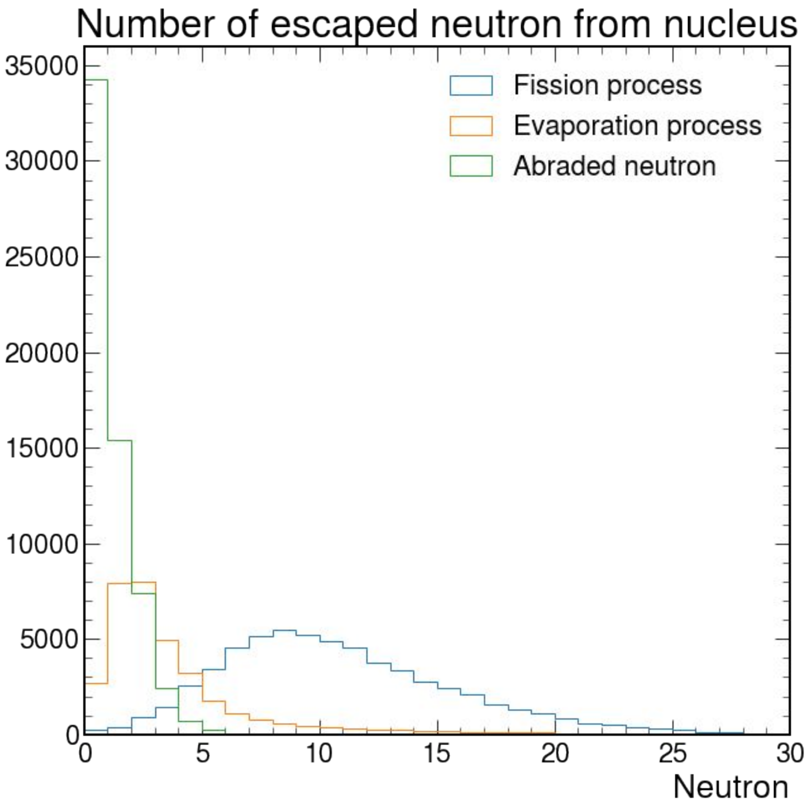
Other events includes: 6%

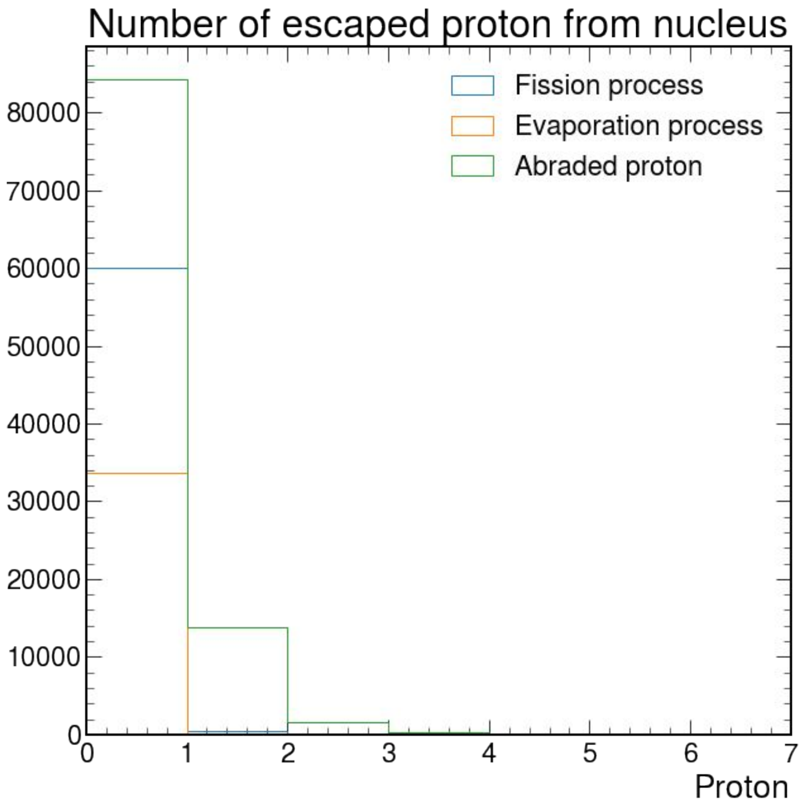
- Multi-fragments
- Fermi-breakup



Cascade nucleon distribution

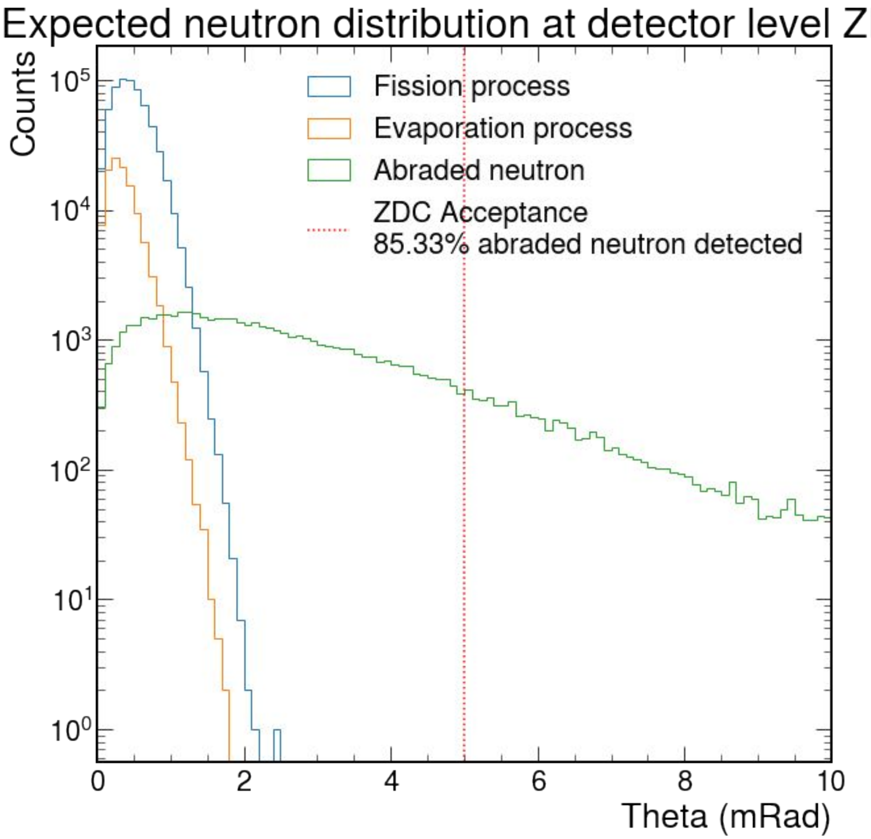
Most cascade neutron are from decay process than abrasion; protons are significantly less

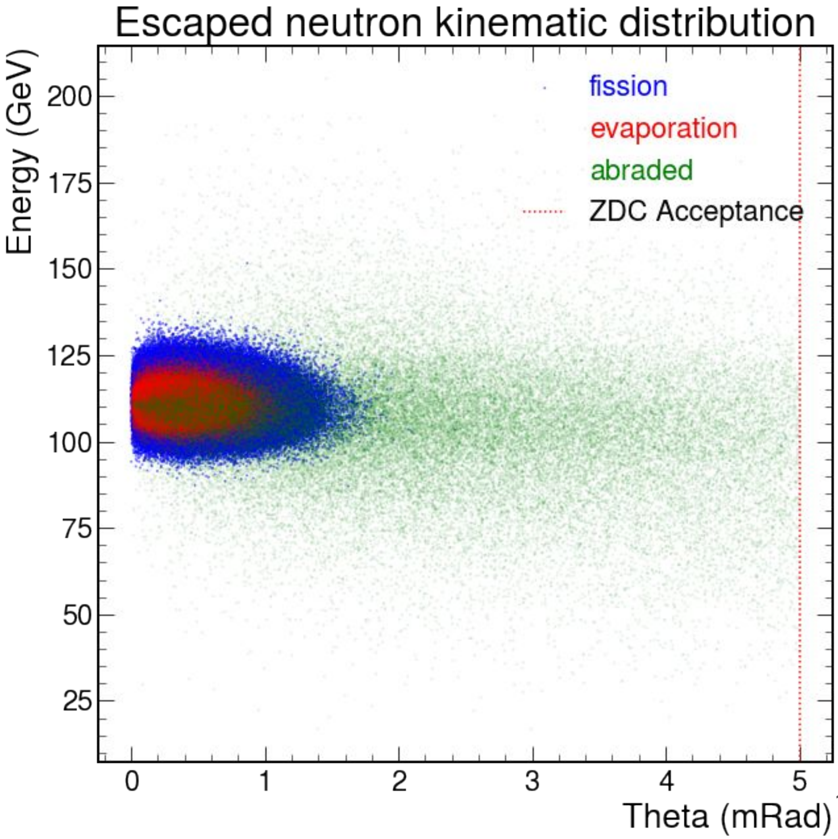




Cascade nucleon distribution - cont.

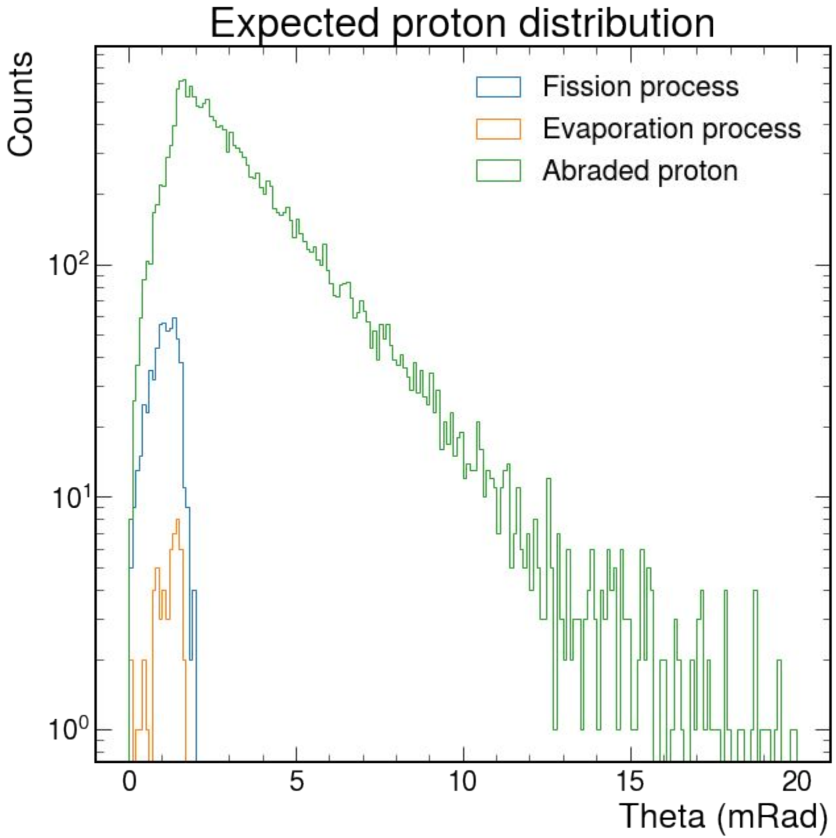
All of ablation neutron and most of abraded neutrons are within the range of ZDC

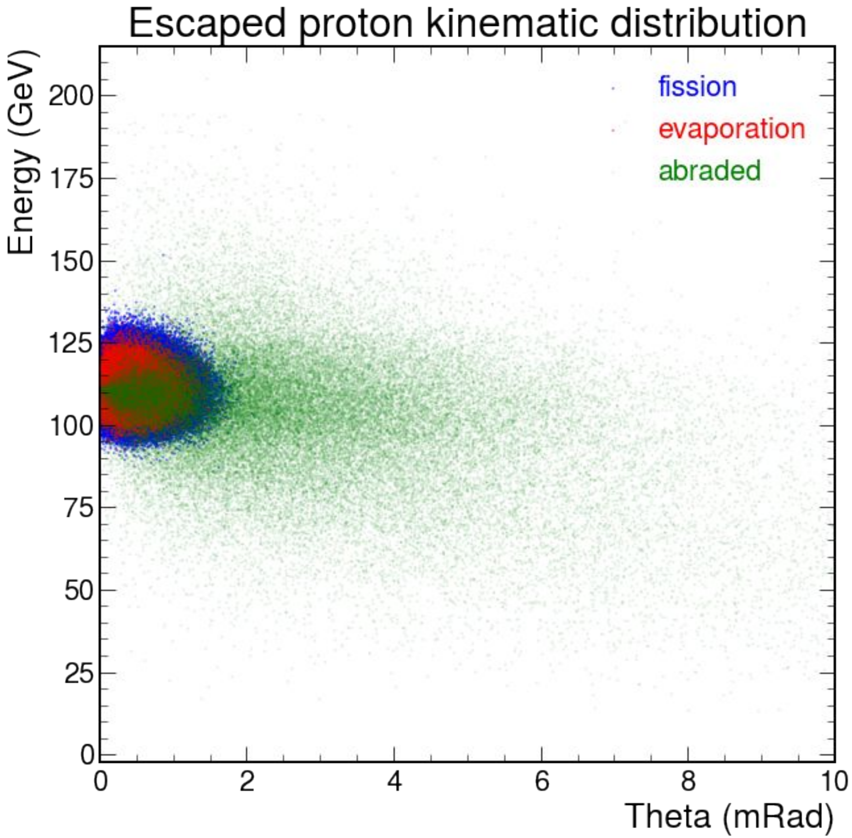




Cascade nucleon distribution - cont.

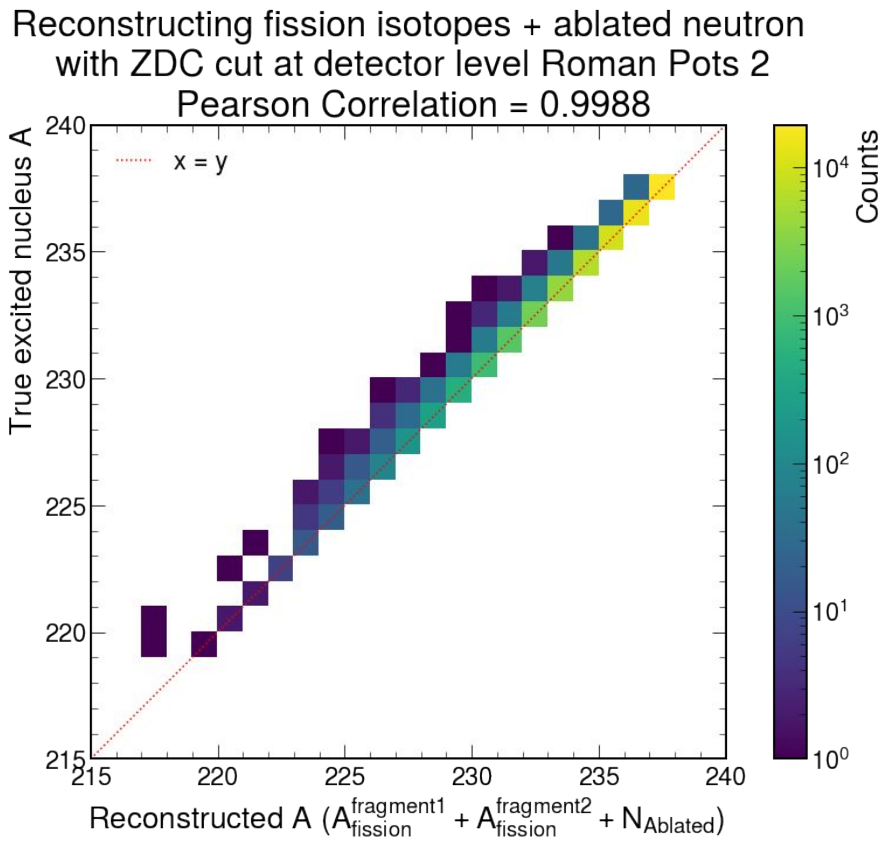
Cascade protons dominates by abrasion rather than decay

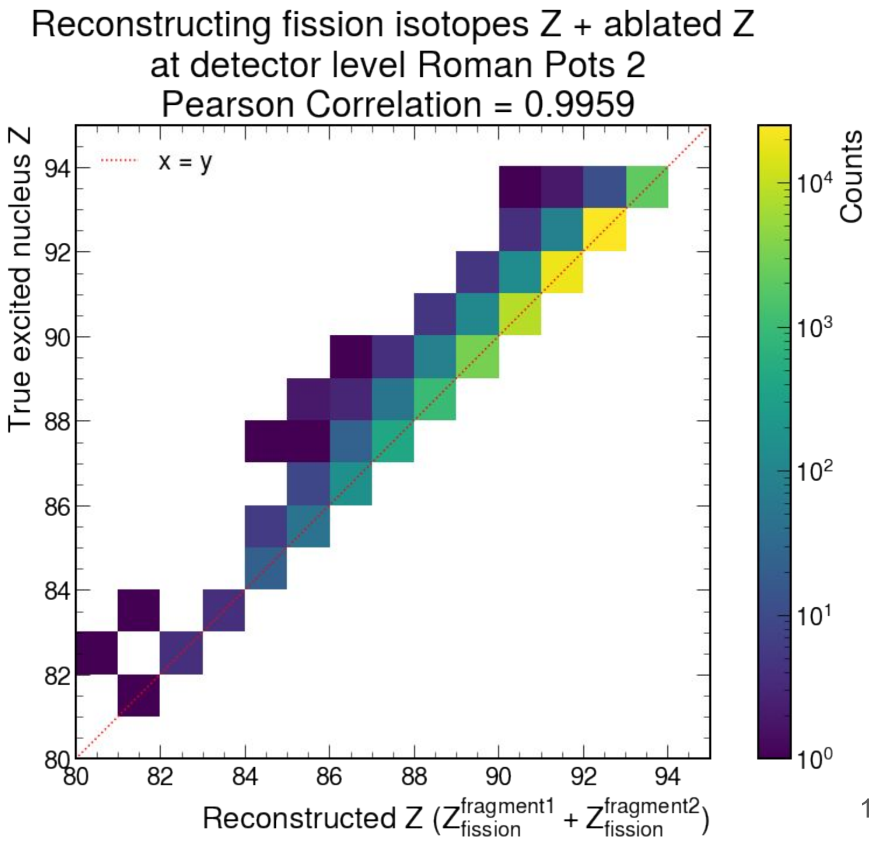




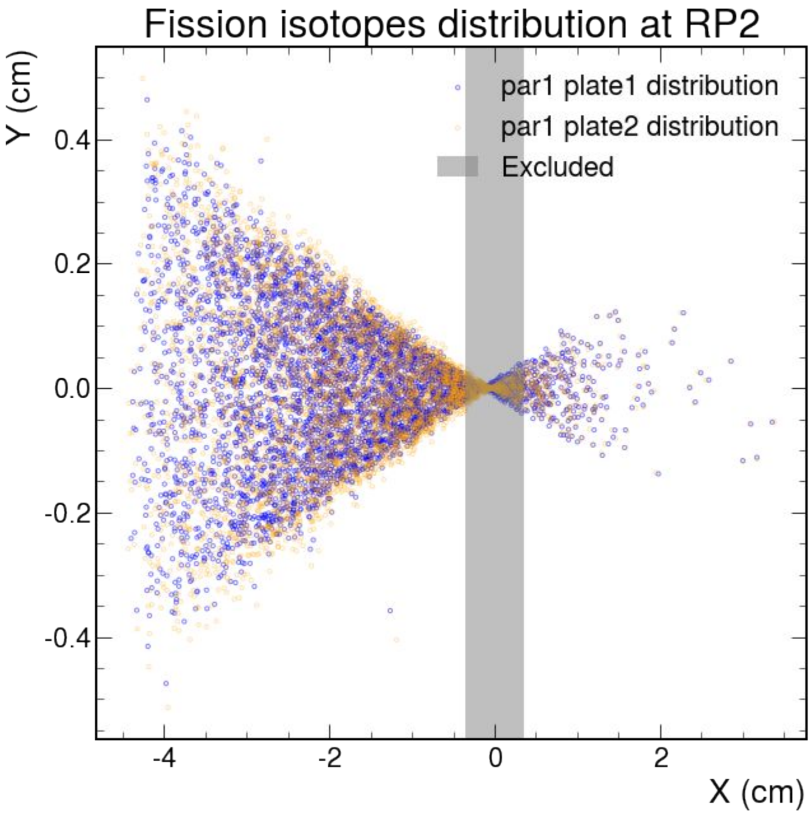
Reconstructing isotope at detector level

Direct measurement of A&Z of excited nuclei from fragments and neutrons from ZDC





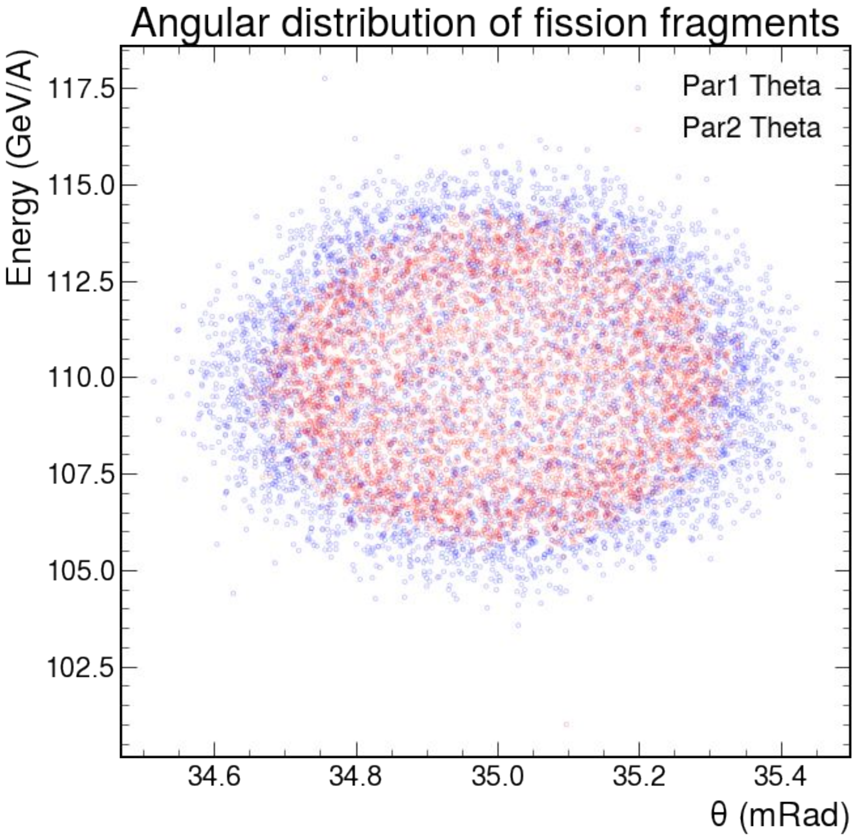
Gen4 2nd Roman Pots simulation



Fragment separation in X is larger than Y, due to configuration of magnets

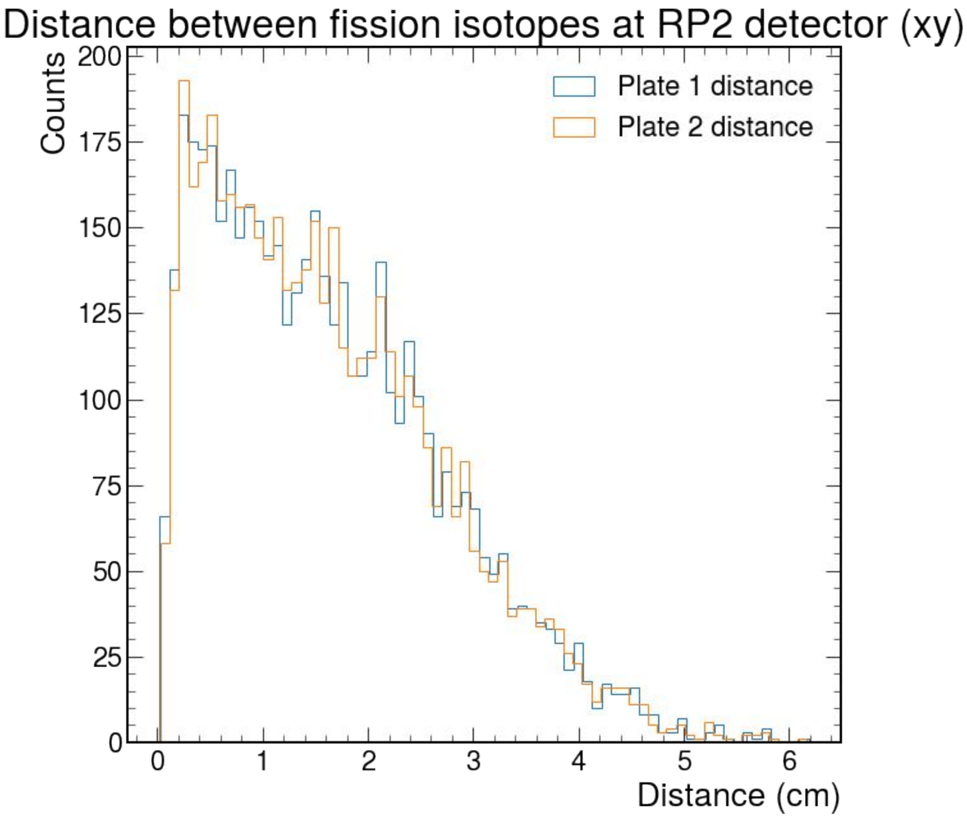
Magnet effects accounted for fragment separation

Fission isotope kinematics



Momentum of the fragments concentrate on a range of ~110 +- 5 GeV/A

Separation between isotopes



Pixelated detector design with a separation of less than 1 cm is required to efficiently separate the two fragments

Planned simulation studies and milestone

-Measurement of A and Z from RPs and FPD

-Measurement of gamma and N from B0 and ZDC

=Cross-section of A&Z fragments and excited pre-fragment

=Gamma ray yield of A&Z fragments

=Neutron of A&Z fragments

=Spin correlation of fragments

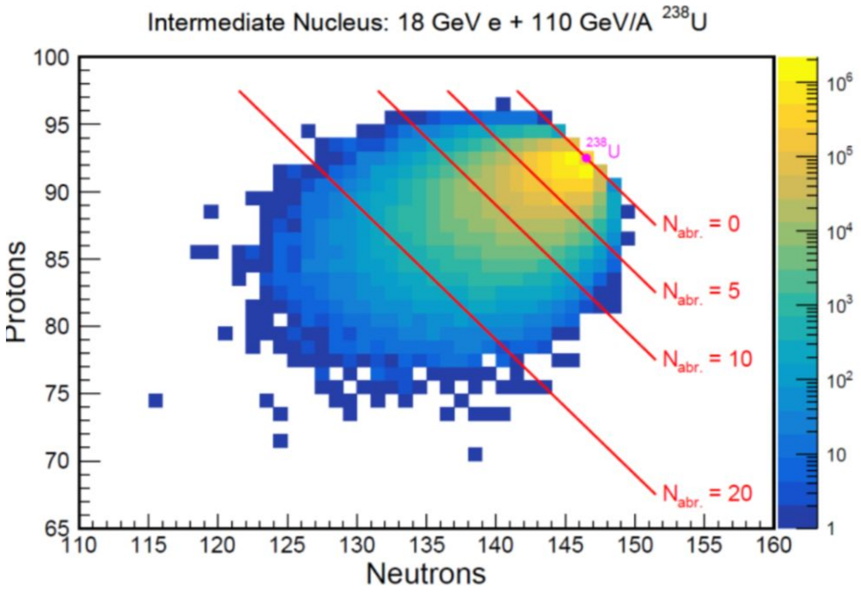
Summary

- Studied kinematic distribution of nucleons from abrasion, evaporation and fission.
- ZDC acceptance is enough to measure all fission/evaporation and most abrasion.
- Fragment Z-tagger needs to be pixelated at the <1 cm level in horizontal direction to be able to measure 2 fragments.
- Simultaneous measurement of fragments Z and ZDC neutrons seems enough to reconstruct the excited nucleus mass number.

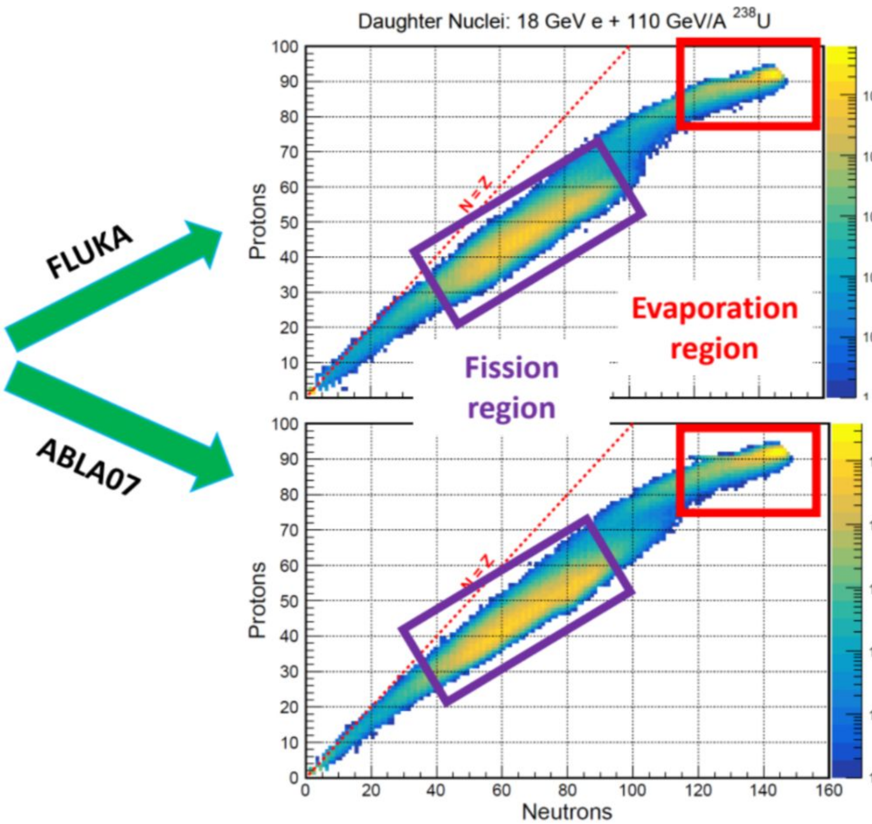
Backup

Decay distribution of the remaining excited nucleus

BeAGLE simulation



10 million events simulated



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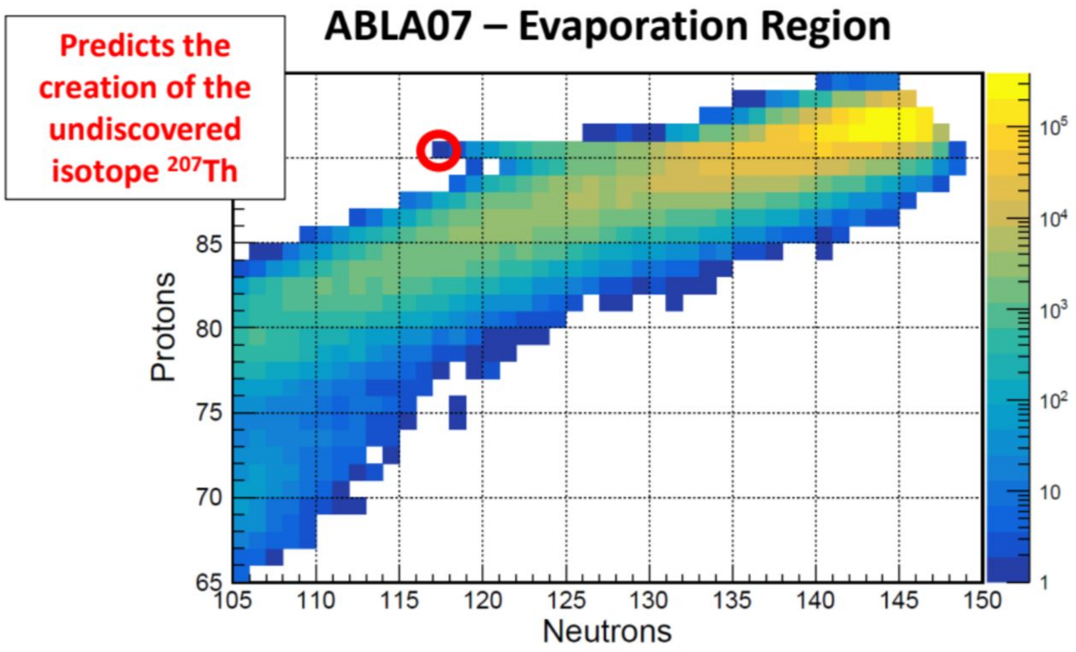
Exciting physics boundaries

New neutron-deficient isotopes in Z = 89-94 region

Possibility of undiscovered Thorium-207

Advantage over RIB facilities:

- Short flight time
- Possible higher production cross section



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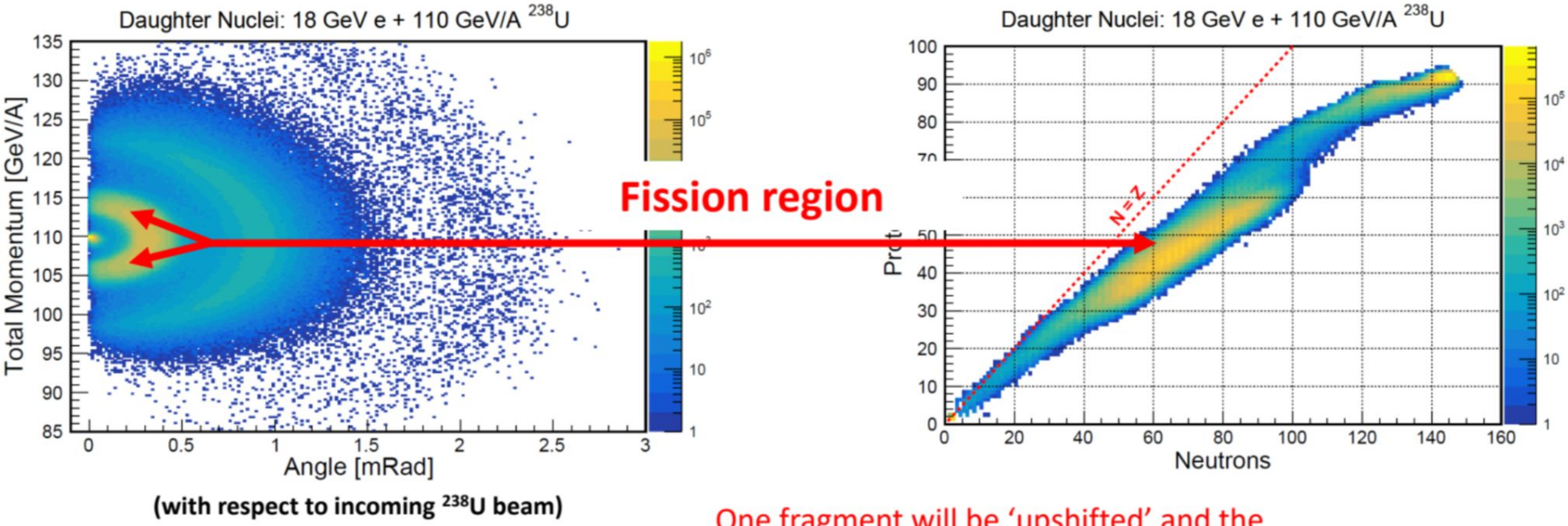
Kinematics of produced nuclear fragments



One fragment will be 'upshifted' and the other 'downshifted'. Both fission fragments can be registered in coincidence.

BeAGLE + FLUKA

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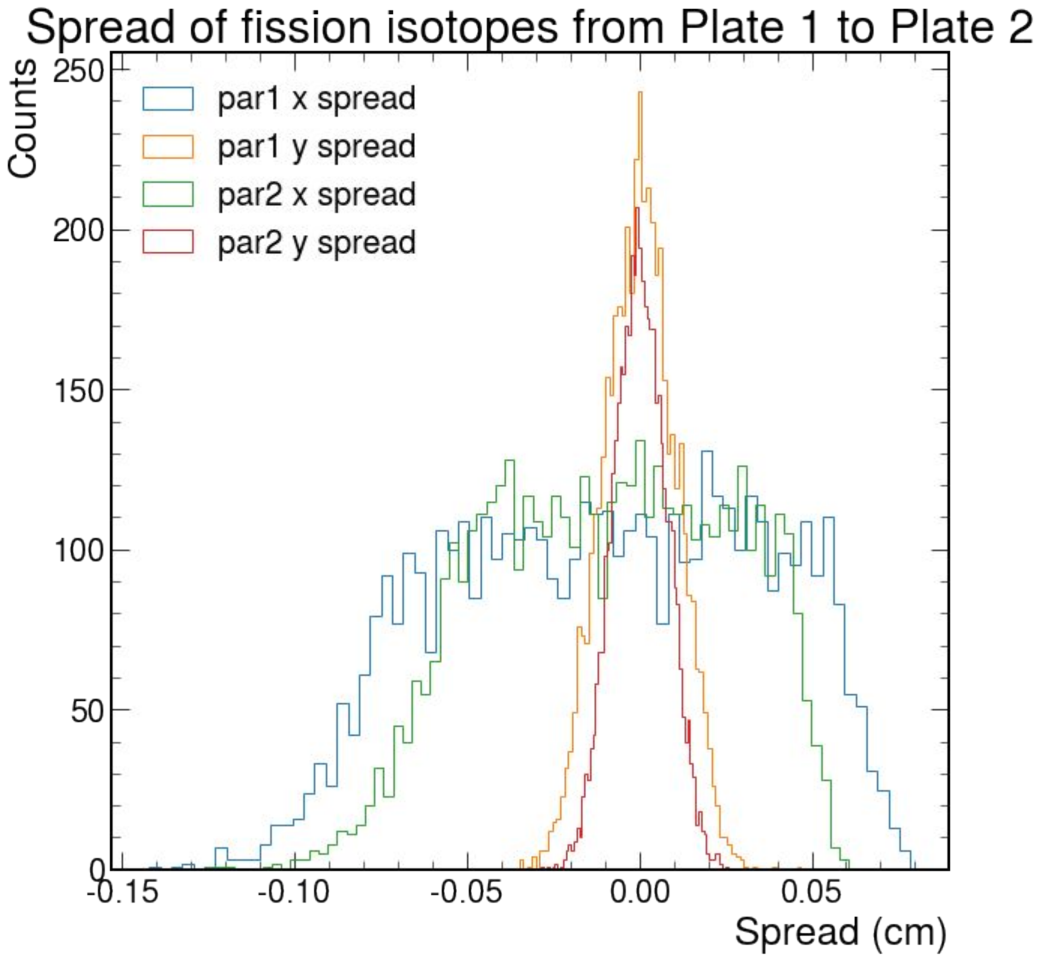
15m spread


Spread of fission isotopes from Plate 1 to Plate 2
Counts
250
200
150
100
50
0
par1 x spread
par1 y spread
par2 x spread
par2 y spread
-0.15
-0.10
-0.05
0.00
0.05
Spread (cm)

Fragment kinematics