BeAGLE's eye view: Deuteron Difficulties

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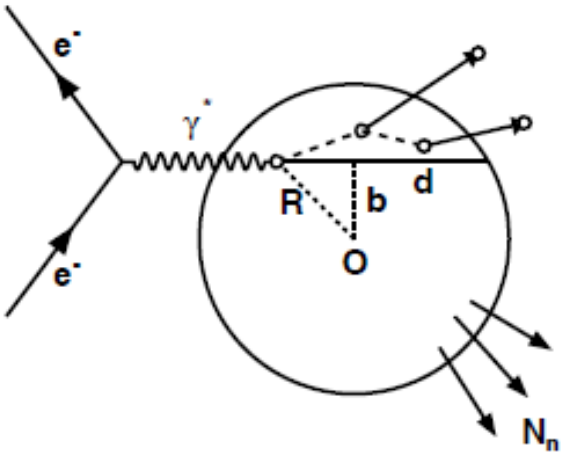
BeAGLE – Benchmark eA Generator for LEptoproduction

- Aschenauer, MDB, Lee, Zheng (+Armesto+Dupré)
- Merger of
  - Pythia – hard interaction (adding RAPGAP option)
  - Glauber + optional multinucleon shadowing
  - Optional (radiative) jet quenching PyQM (off today)
  - DPMJET3-F (DPMJET3+Fluka) – nuclear response
- Tuned to ZEUS forward nucleons, FNAL E665 slow neutrons, + HERMES
  - Working on E665 e-by-e charged hadrons (SC)

Key Features of BeAGLE



Multistep process.

Hard interaction (DIS or diffractive) involving one or more nucleons.

Intra Nuclear Cascade w/ Formation Zone

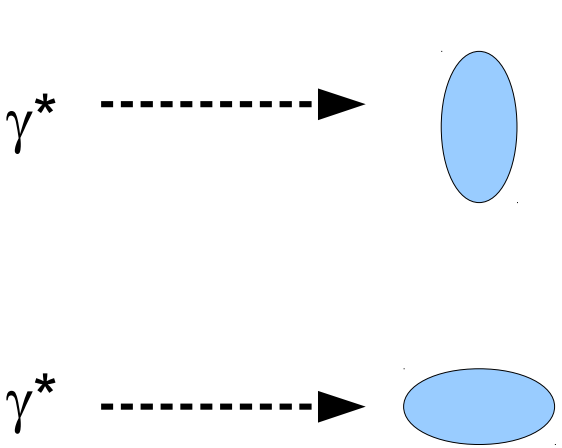
Excited nuclear remnant will decay:
Fission &/or evaporation of nucleons
De-excitation by gamma emission.

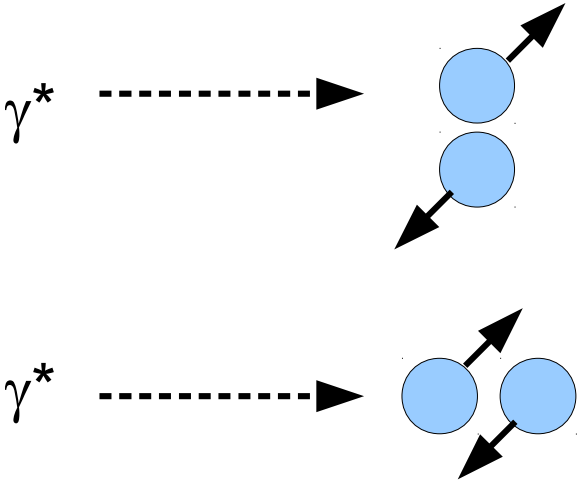
Try to model both hard process AND nuclear interaction.

It helps if A is big enough (12?) to leave a substantial remnant which can be modeled in the ion rest frame as a collection of on-mass-shell nucleons with Fermi motion sitting in a mean field.

BeAGLE not optimized for e+D!

Main problem – Everything lives on mass shell.
No remnant to absorb energy-momentum imbalance.





$W^{\mu} = \{\nu+M_d; 0, 0, \mathrm{sqrt}(\nu^2+Q^2)\}$

$W^{\mu} = \{\nu+E_n+E_p; 0, 0, \mathrm{sqrt}(\nu^2+Q^2)\}$

Note: DPMJET3-F has the same problem. Minimized due to minimal p_F.
So DPMJET3-F is not ideal for detector optimization for SRC.

Solutions

- First attempt (for today) using upgraded BeAGLE
  - Impulse approximation (struck + spectator)
  - All relative p,n momentum from the initial state
  - Ad hoc adjustment of final state particle 4-momenta to match correct total 4-momentum of original γ^*+D
- Next steps: input from Christian Weiss
  - Conserve p^+,p_T adjust only p^- of non-spectators
  - Get spectator p^+, p^-,p_T from light-cone wavefunction?
- Then?: FS effects? Non-impulse approximation...

Fermi momentum at a collider

BeAGLE (& DPMJET & Pythia) use on-mass-shell nucleons which sit in a mean-field nuclear binding + Coulomb potential.

In nuclear target rest frame:

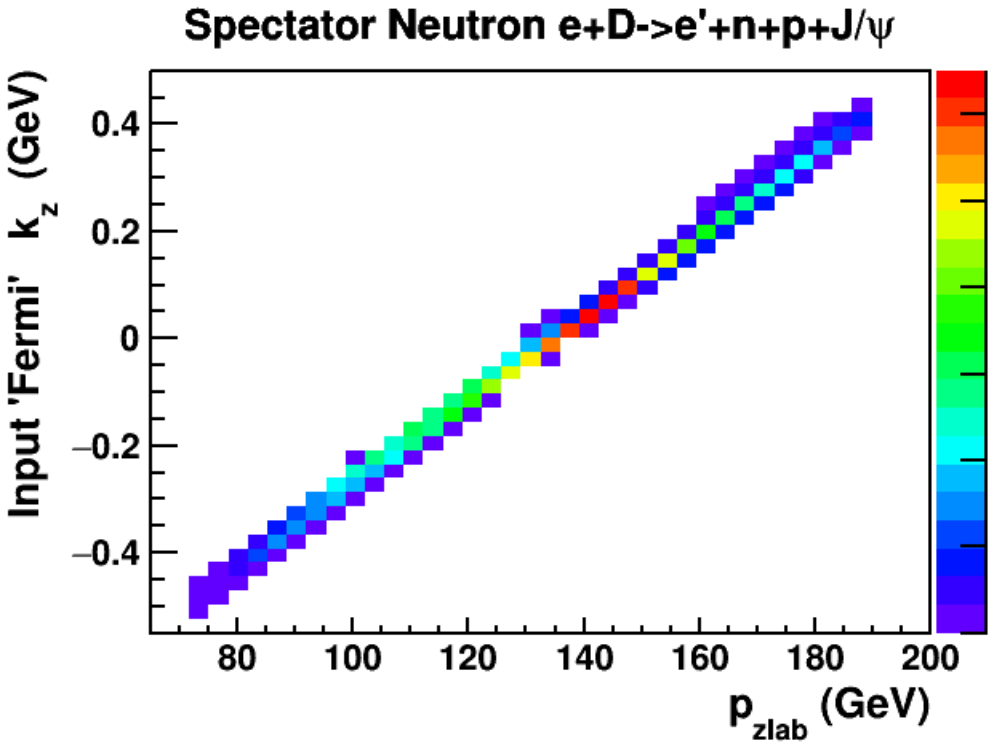
$P^{\mu} = \{M; 0, 0, 0\}$ OR $\{M+E_{kinF}; k_{xF}, k_{yF}, k_{zF}\}$

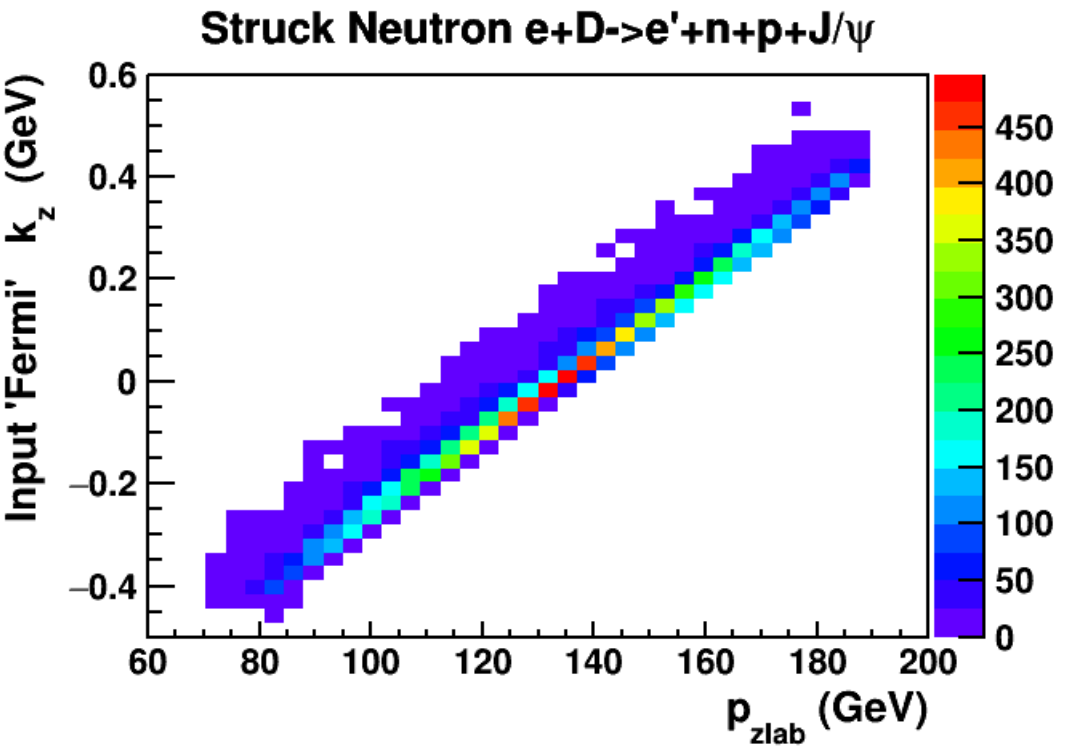
In lab collider frame:
$P^{\mu} = \{\gamma M; 0, 0, \gamma\beta M\}$ OR $\{\gamma M+\gamma\beta k_{zF}+\gamma E_{kinF}; k_{xF}, k_{yF}, \gamma\beta M+\gamma k_{zF}\}$

Since $\beta \sim 1$ and $E_{kinF} << k_{zF}$:

$E \sim p_z \sim E_{beam} (1 + k_{zF}/M)$

18x135 e+D "Fermi" effect

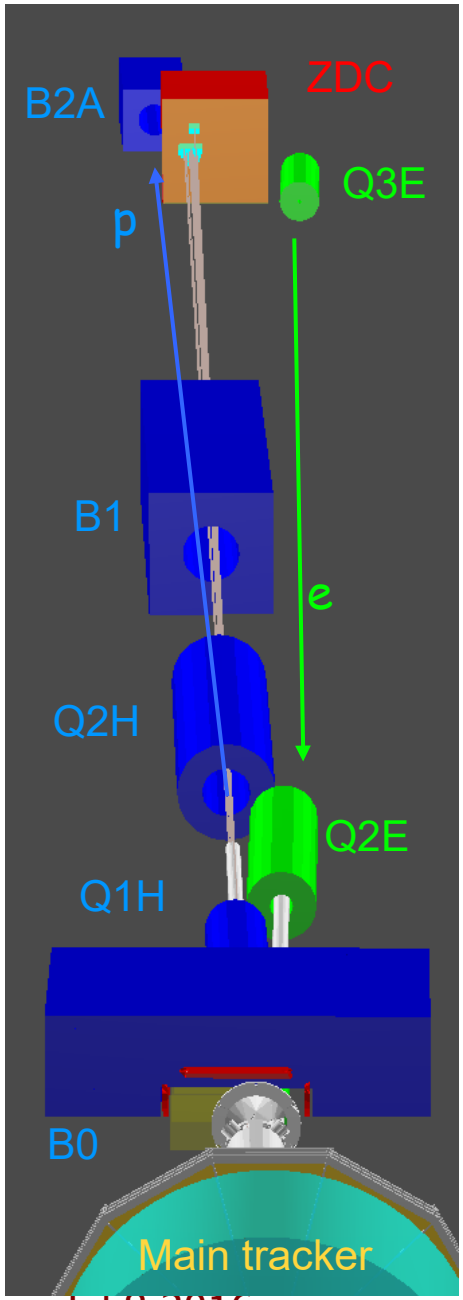




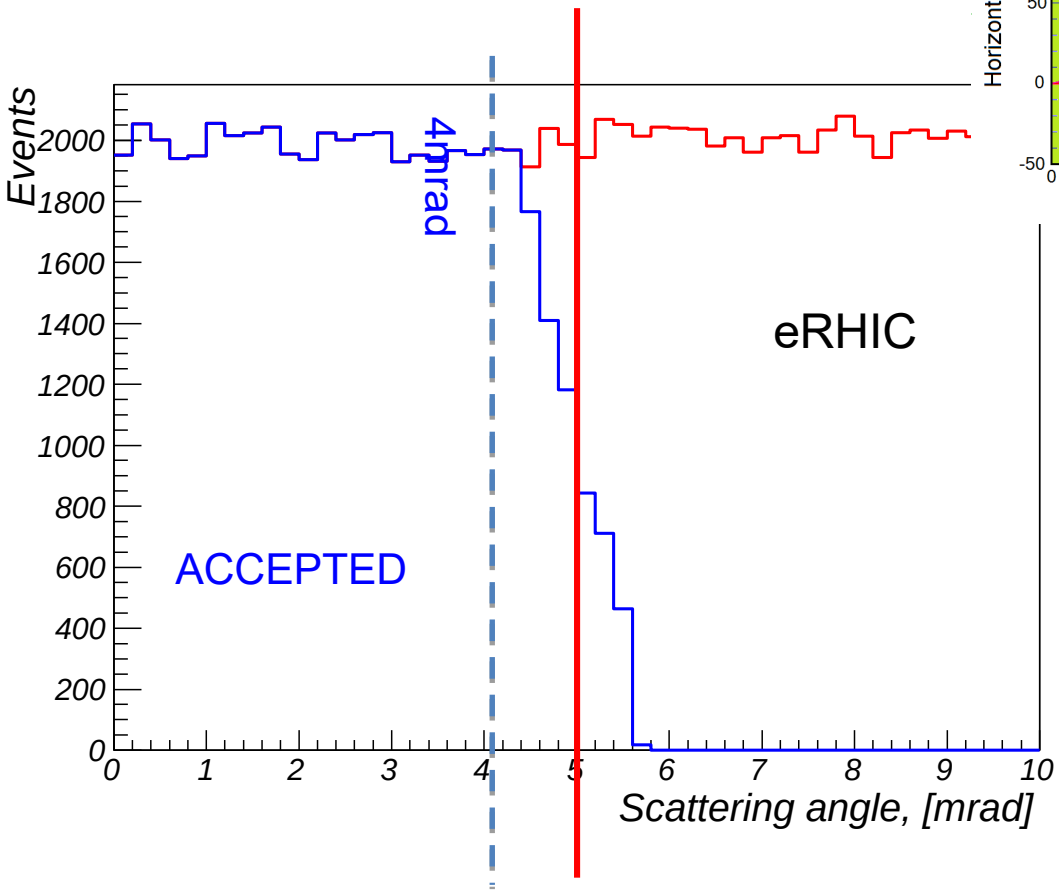
Any p-kick (IS or FS) along the “z” direction in the ion rest frame is magnified!

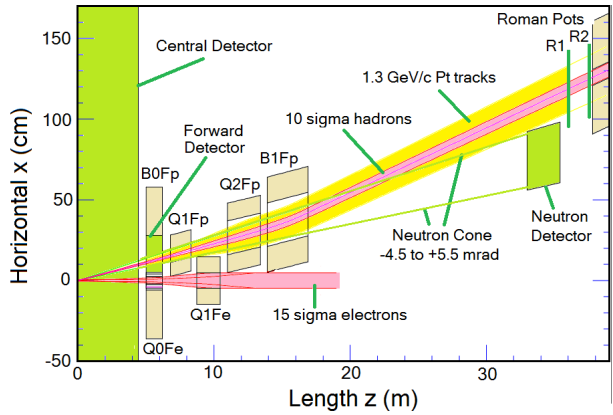
Minor point: z in this plot is defined along γ*D axis not eD axis.

Angular acceptance for neutrons



→ NB: here particles generated flat in θ
→ ZDC is handled as a "black hole" volume



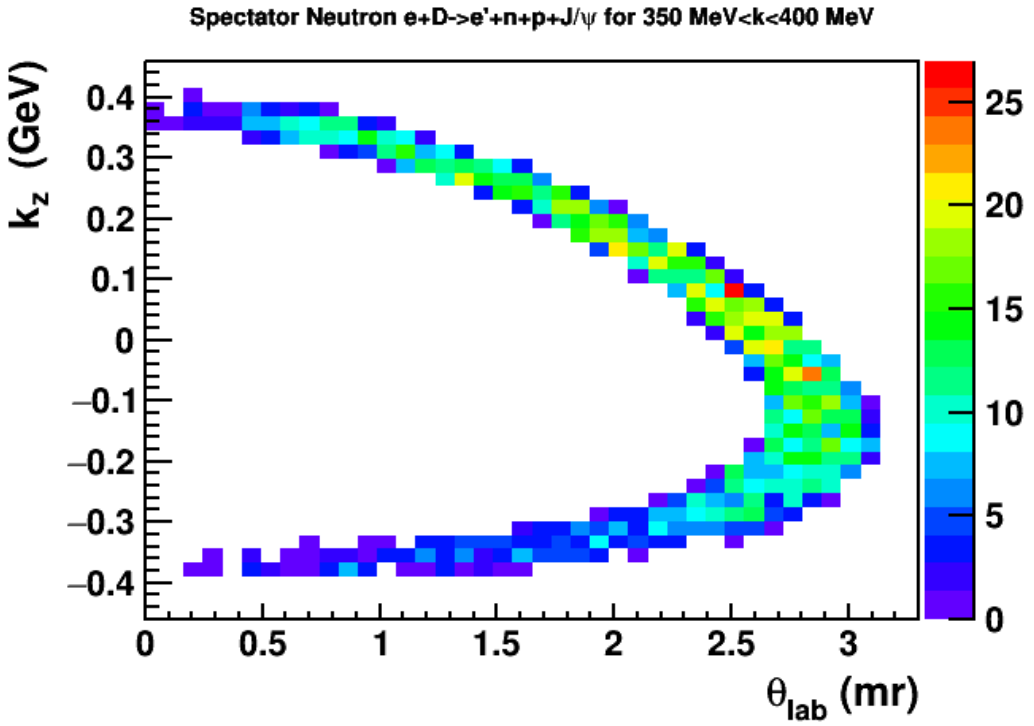


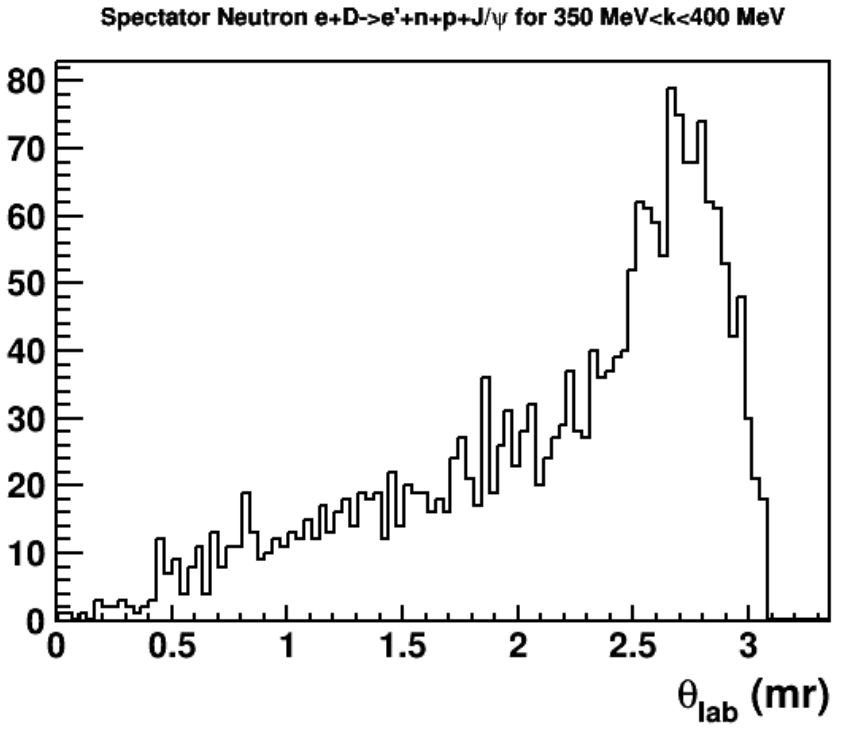
→ NB: space for ZDC needs to be increased for better hadronic shower containment

Achieve the 4 mrad acceptance requirement

From A. Kiselev

Spectator neutrons for k~375 MeV



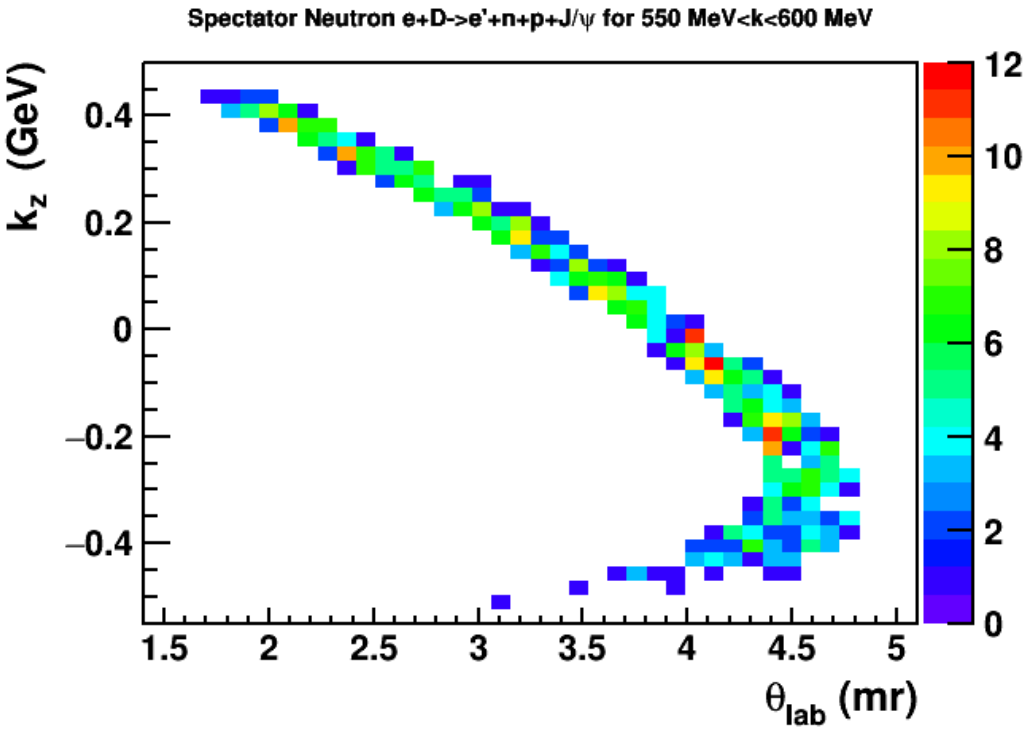


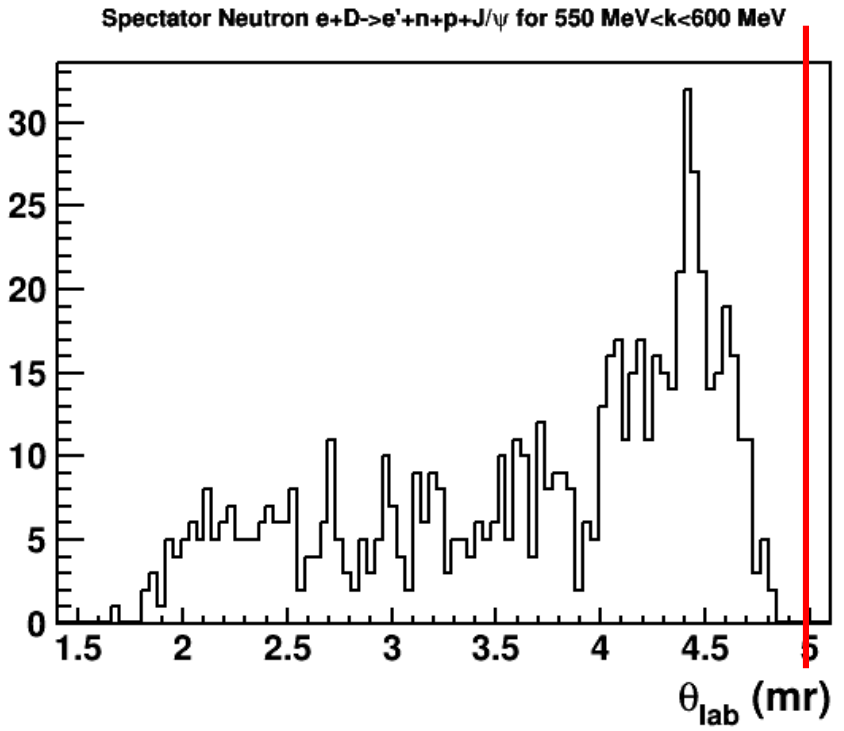
Spectator neutrons are easy to detect

Spectator protons look similar to neutrons – also easy??

Spectator neutrons for k~575 MeV

(but $|k_z|$ < ~450 MeV)



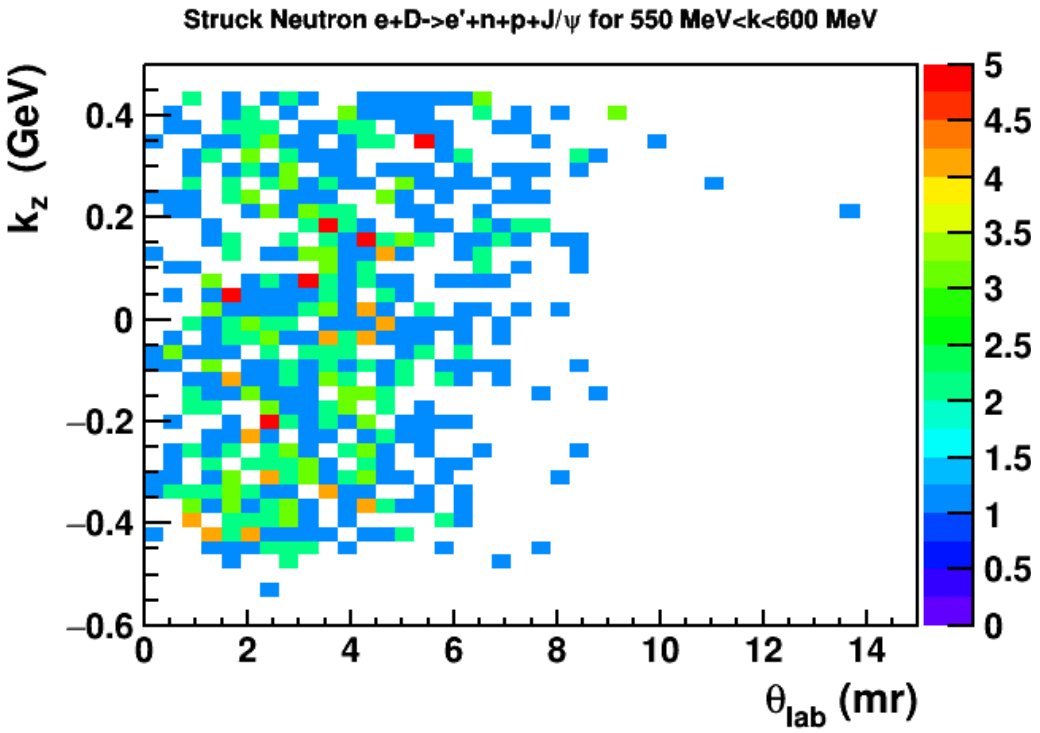


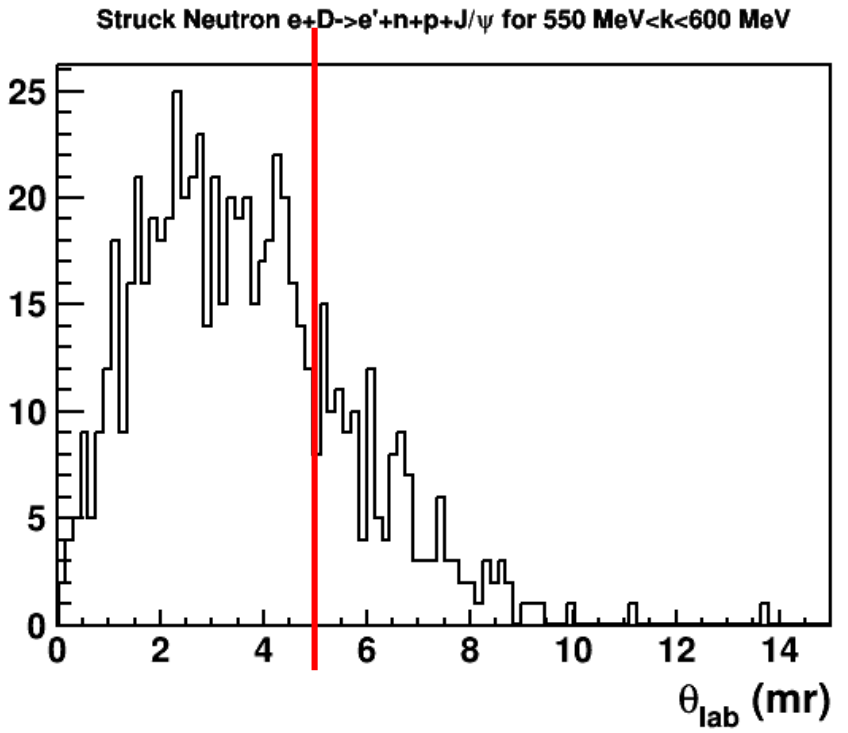
Spectator neutrons still detectable

Spectator protons?

Struck neutrons for k~575 MeV

(but $|k_z|$ < ~450 MeV)



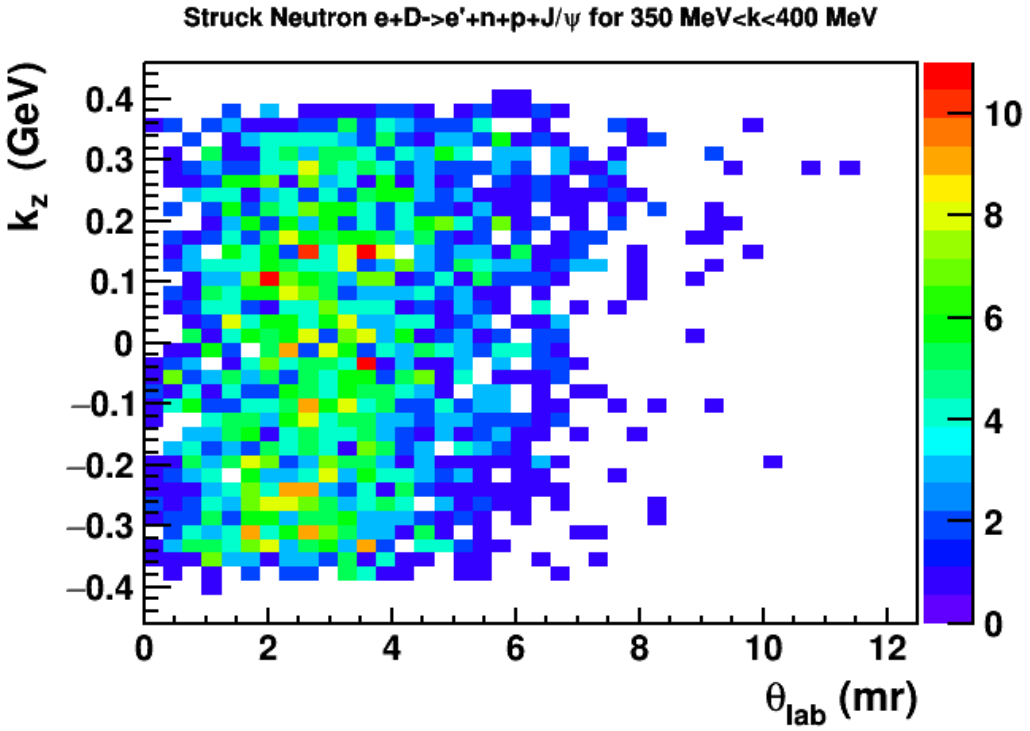


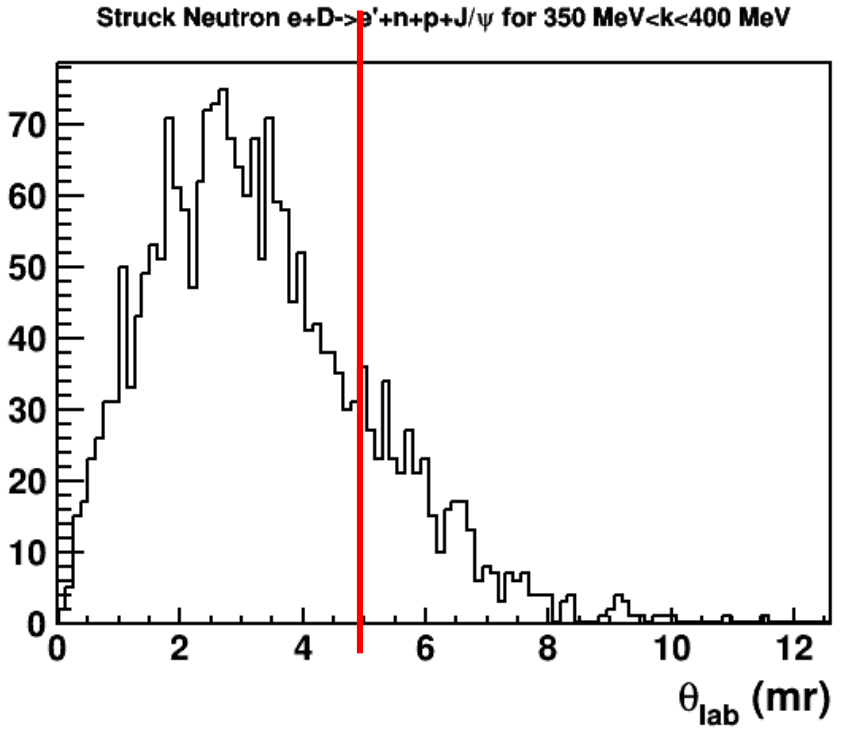
Struck neutrons not fully contained in ZDC

Again, struck protons have a similar distribution

Struck neutrons for k~375 MeV

(but $|k_z|$<450 MeV)

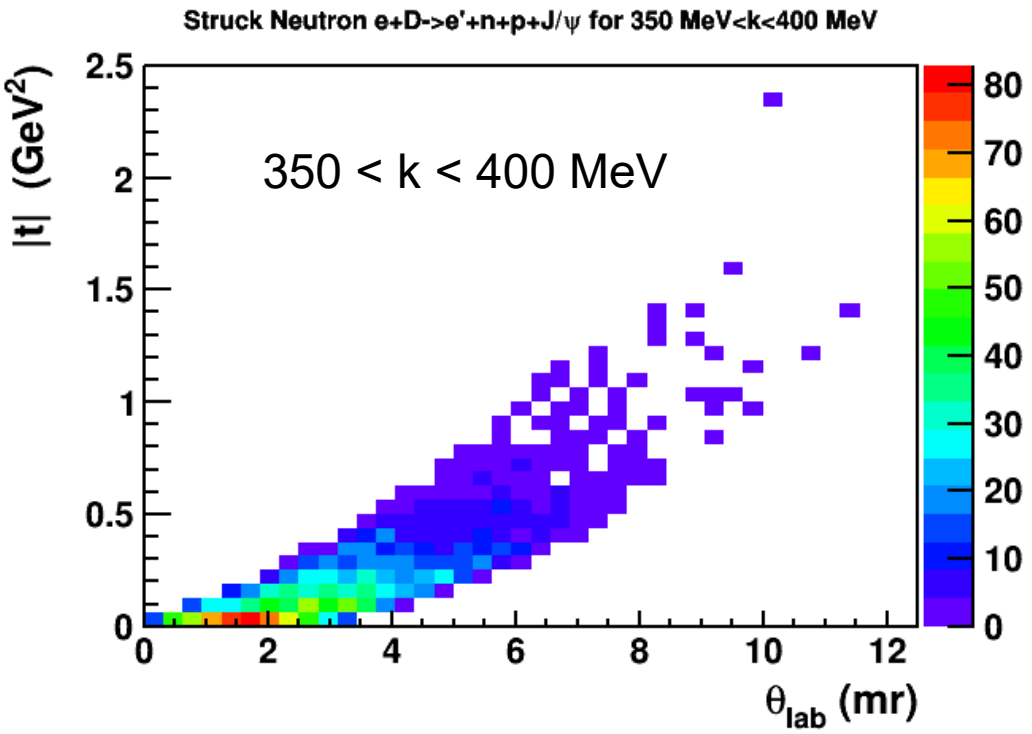


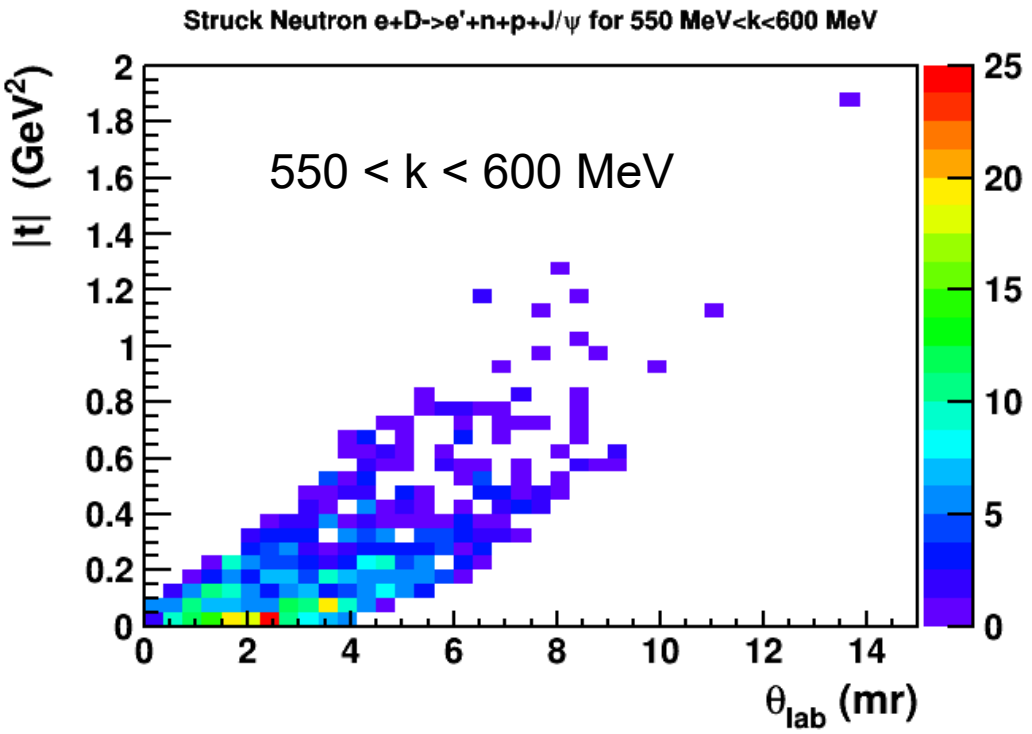


Struck neutrons still not fully contained in ZDC

Struck protons have a similar distribution

Struck neutrons affected by collision



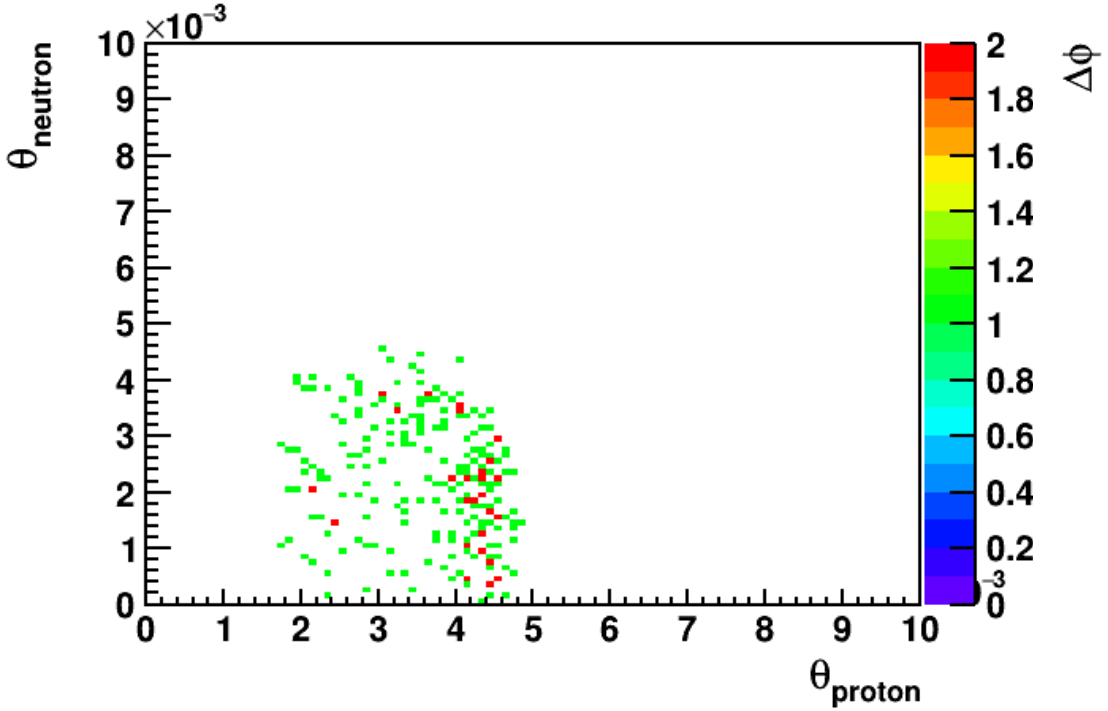


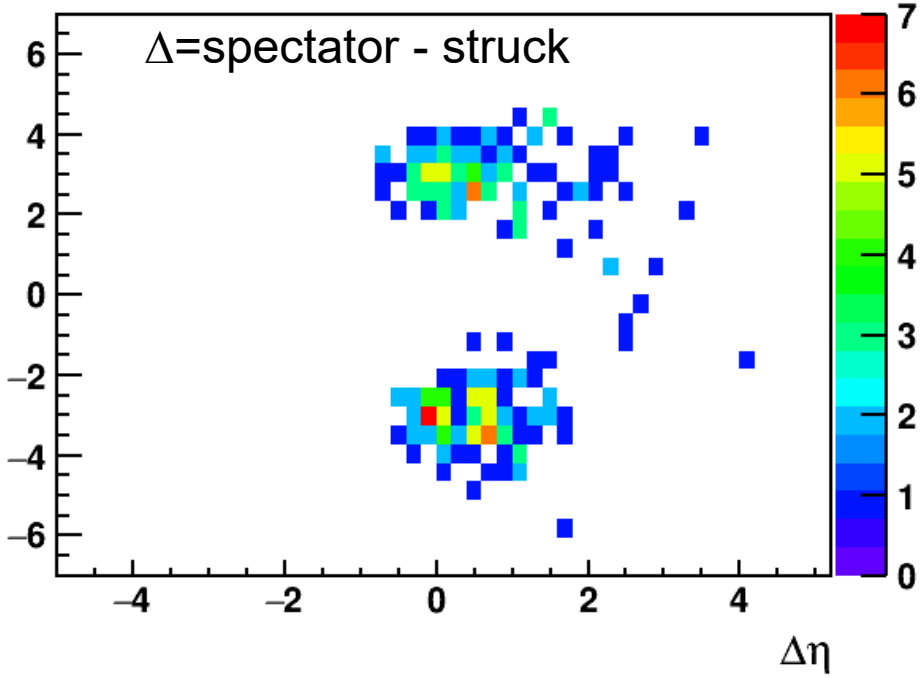
Keeping $|t|<0.1$ GeV^2 should contain neutrons in ZDC

Should also keep nucleon breakup in check.

Correlations

For struck neutron, spectator proton – lab variables
$|t|<0.1$ GeV^2, $550 < k < 600$ MeV $|k_z|<450$ MeV





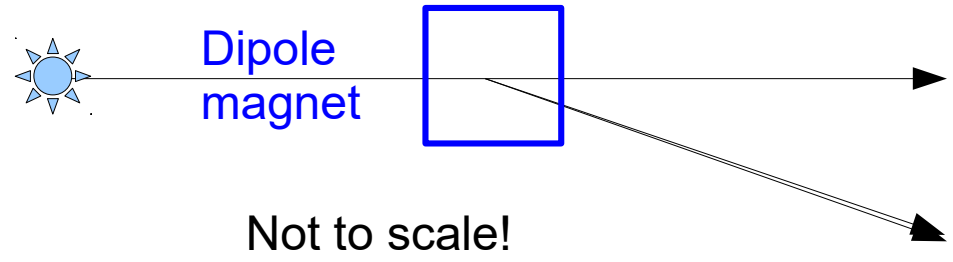
Recall η=-ln tan (θ/2)

Keeping $|t|<0.1$ GeV^2 contains forward nucleons in $\theta<5$ mr!

Nucleons are back to back (in this simulation!)

Forward acceptance at a collider

Forward proton acceptance in e+p is DIFFERENT from e+D

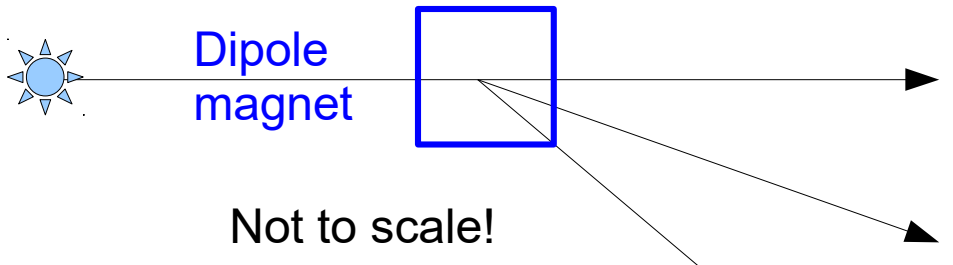


n (θ=0)

p (beam or $p_z=p_{zbeam}$ & θ=0)

Main ep→p challenge:
AVOID BEAM

Don't use proton acceptance plots from e+p for e+D!



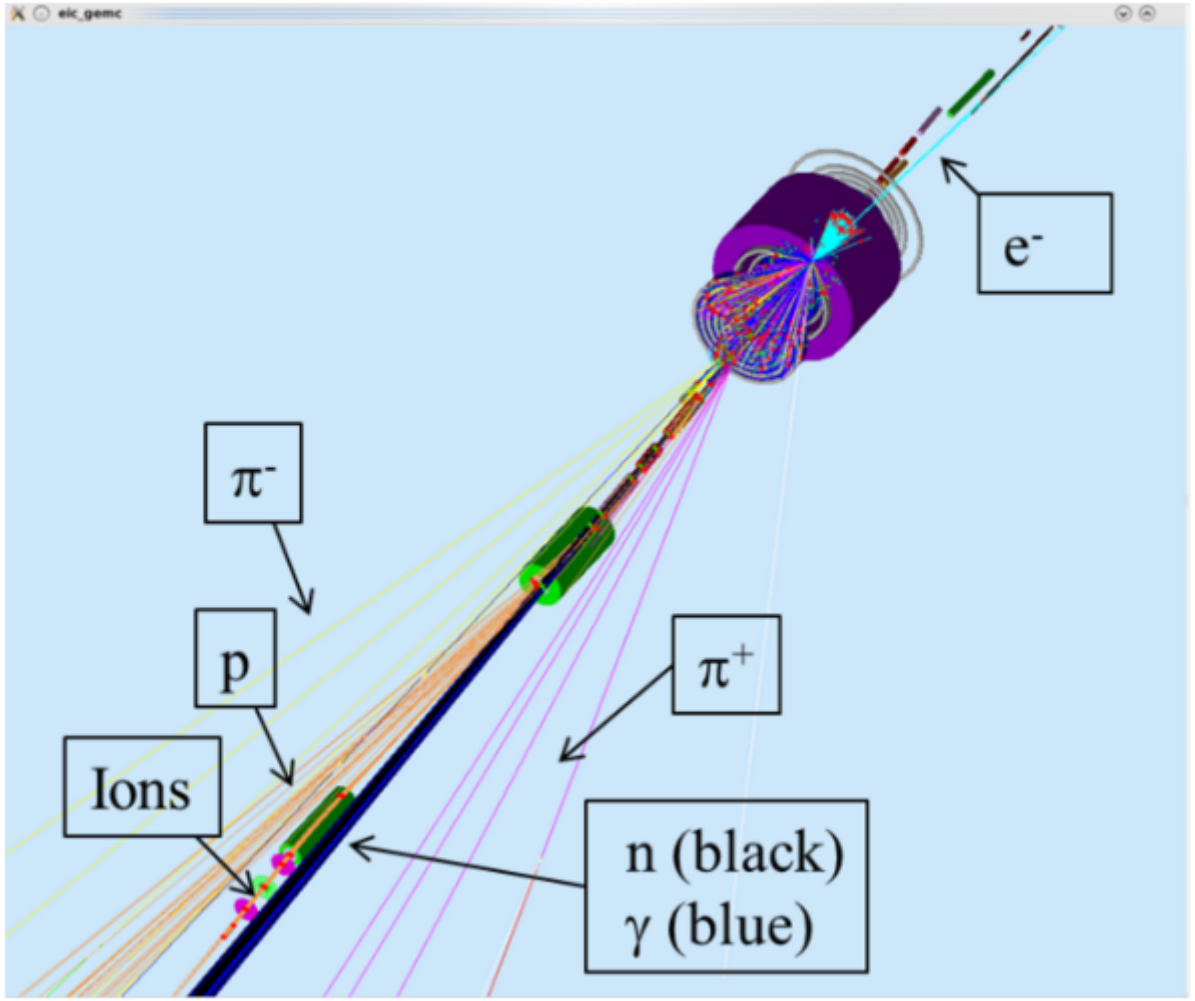
n (θ=0)

A (beam)

p ($p_z=p_{zbeam}/A$ & θ=0)

Main eD→p challenge:
MAGNET APERTURE

Full JLEIC e+Pb simulation



From Morozov, Wei et al.

Multiple events superimposed.

BeAGLE+GEMC

e+D will not look too different in the forward direction.