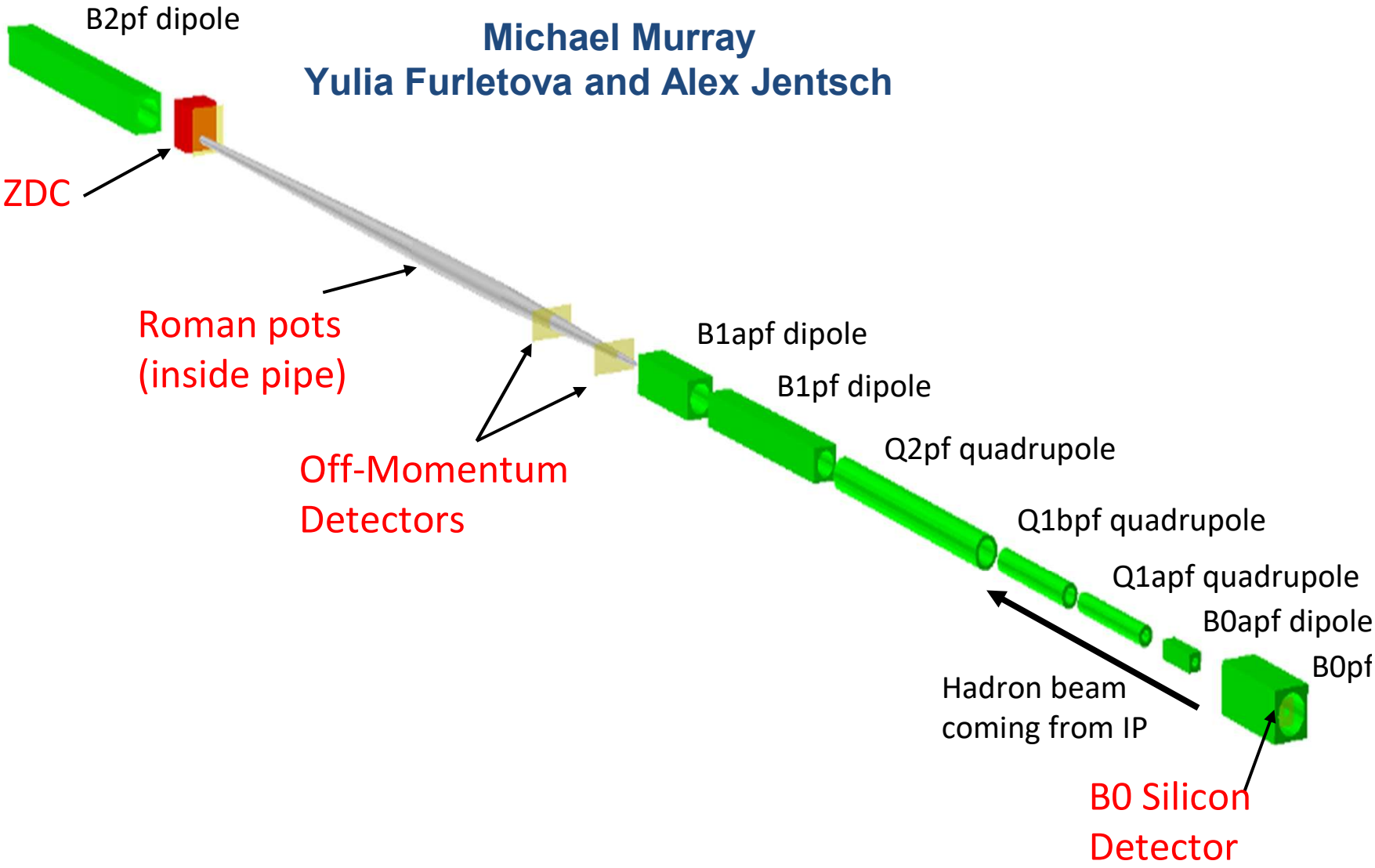
Detector Matrix Update: Forward Region

Michael Murray
Yulia Furletova and Alex Jentsch



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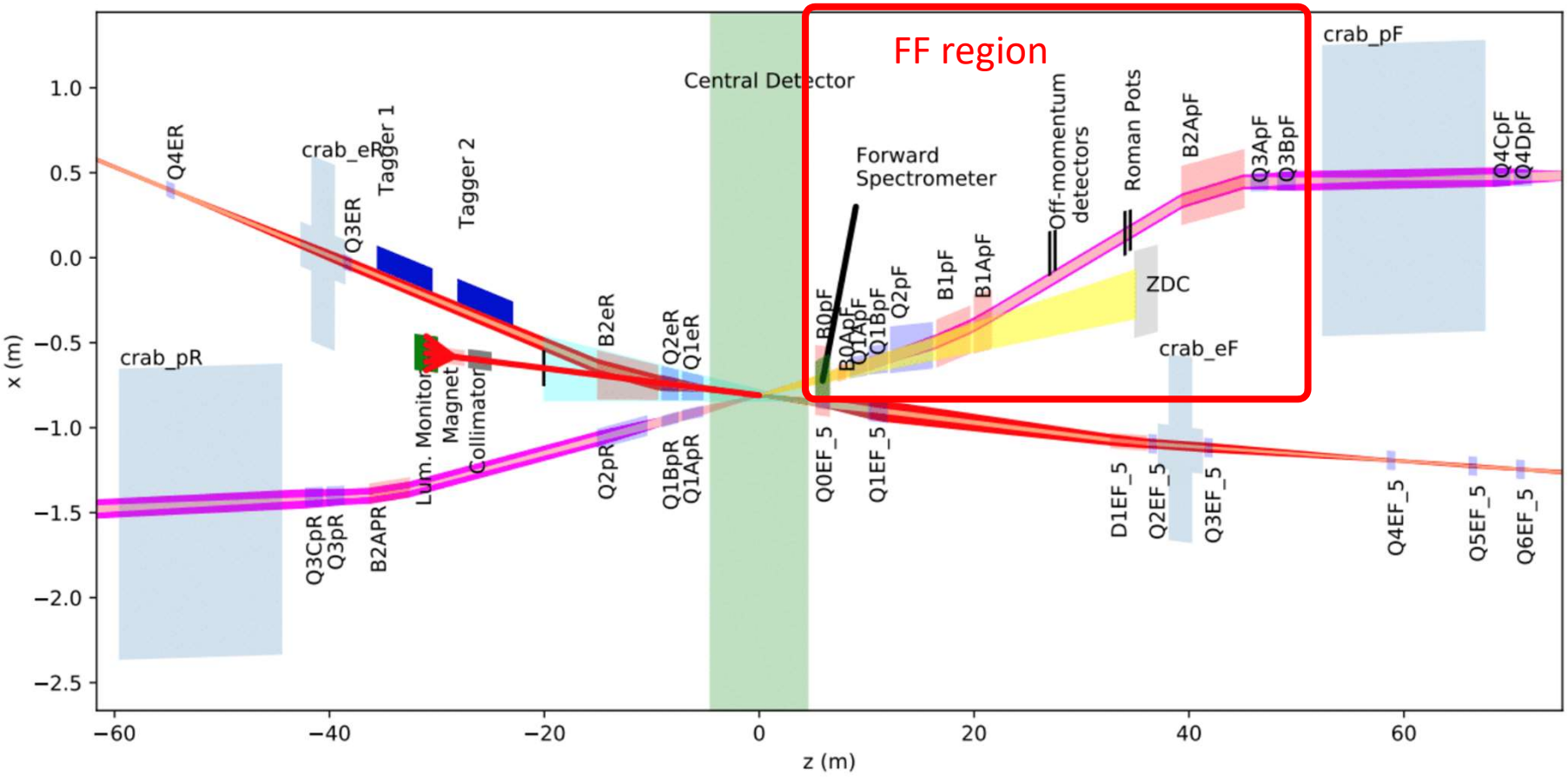
Detector Acceptance

Detector	Detector Position (x,z)	Angular Acceptance	Notes
ZDC	(0.96m, 37.5m)	$\boldsymbol{\theta}$ < 5.5 mrad	About 4.0 mrad at $\varphi \sim \pi$
Roman Pots (2 stations)	(0.845m, 26m) & (0.936m, 28m)	0.0* < $\boldsymbol{\theta}$ < 5.0 mrad	$0.65 < x_L < 1.0$ 10σ cut
Off-Momentum Detectors	(0.8, 22.5m) & (0.85m, 24.5m)	0.0 < $\boldsymbol{\theta}$ < 5.0 mrad	Roughly $0.4 < x_L < 0.6$
B0 Sensors (4 layers, evenly spaced)	x = 0.19m, 5.4m < z < 6.4m	5.5 < $\boldsymbol{\theta}$ < 20.0 mrad	Could change a bit depending on pipe and electron quad.

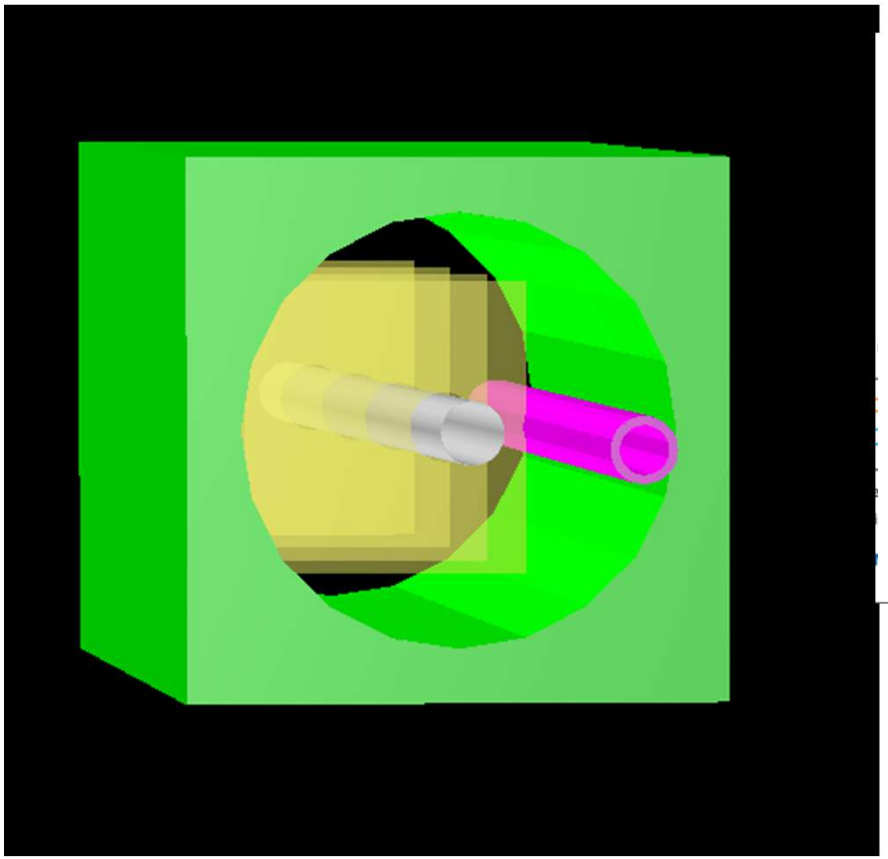
Scope of the Forward Region

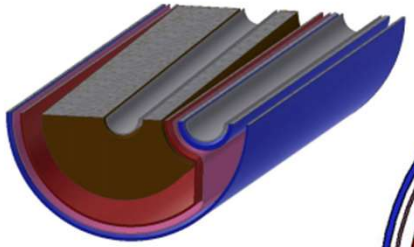


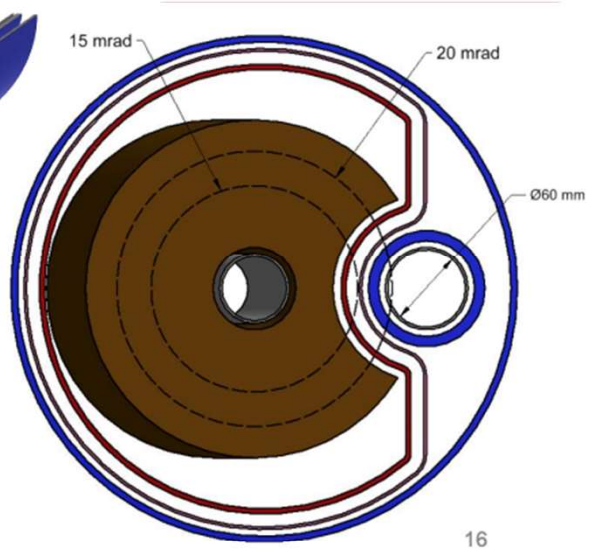
A wide range of physics has been simulated

- e+p DVCS events with proton tagging.
- e+d exclusive J/Psi events with proton or neutron tagging.
- e+He3 with spectator proton tagging
- e+He4 coherent He4 tagging.
- e+Au events with neutron + photon tagging to veto breakup
- Meson structure with neutron tagging ($ep \rightarrow \pi \rightarrow e'\ n\ X$).
- Lambda decays ($\Lambda \rightarrow p\ \pi^-$ and $\Lambda \rightarrow n\ \pi^0$)

Tracking within the B0 magnet





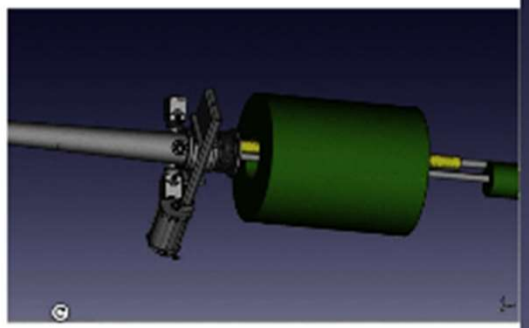


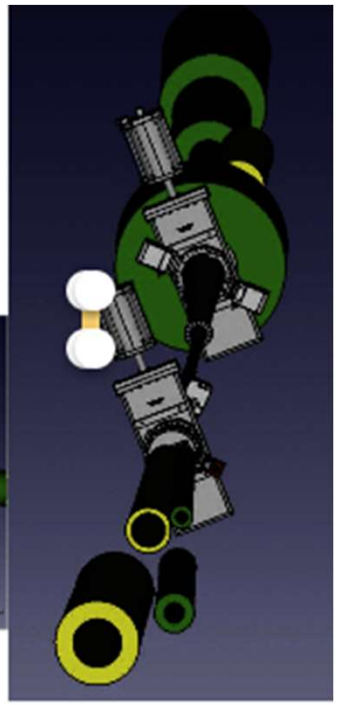
- Depth of 1.2m allows for several silicon planes and EM cal
- Adding a pre-shower would help with photon identification
- Can detector particles that leave the beam pipe
- Spatial asymmetry affects acceptance

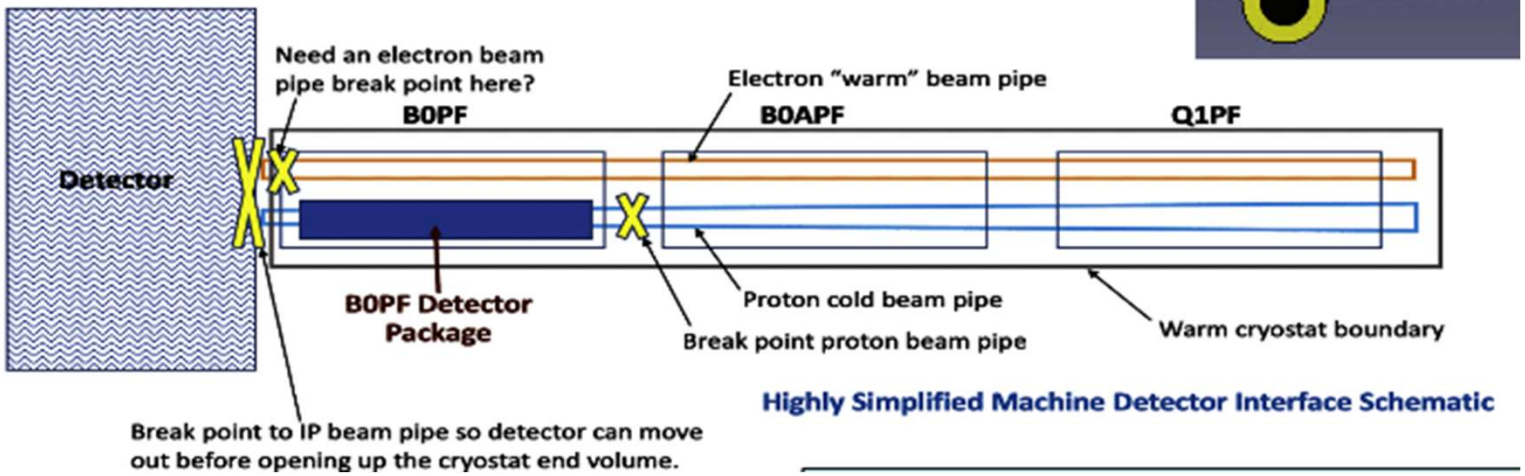
Integration is complex in B0

B0 integration

- HCAL and vacuum pumps in front of B0 tracker => high background area
- Possible additional sub-detectors are: Pre-shower or EMCAL after B0 tracker for photons detection.
- Detector maintenance



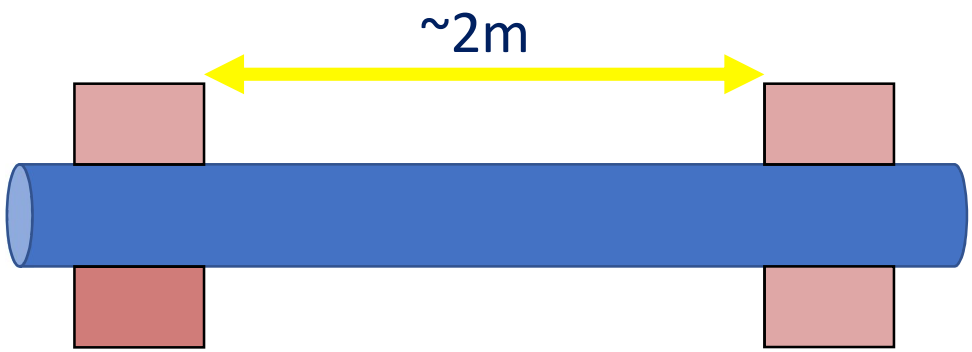




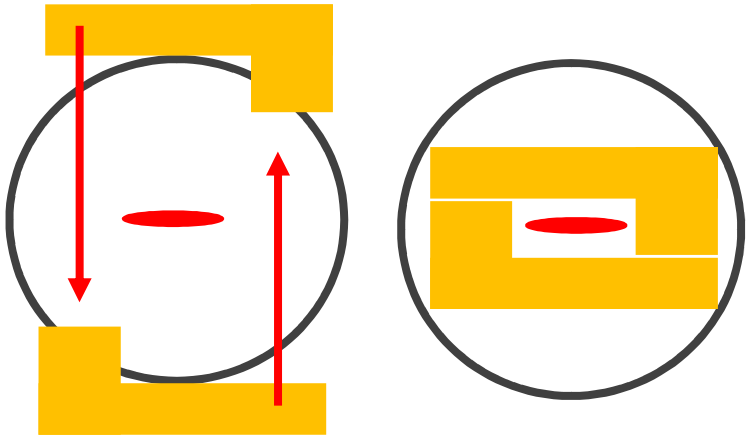
Highly Simplified Machine Detector Interface Schematic

Roman Pots

- For safety, sensors are at ~10σ distance from beam
- This limits the low p_T acceptance
  - 275 GeV – 1σ = 1.79 mm (HA) / 3.58 mm (HD)
  - 100 GeV – 1σ = 2.45 mm (HA) / 5.13mm (HD)
  - 41 GeV – 1σ = 6.14 mm

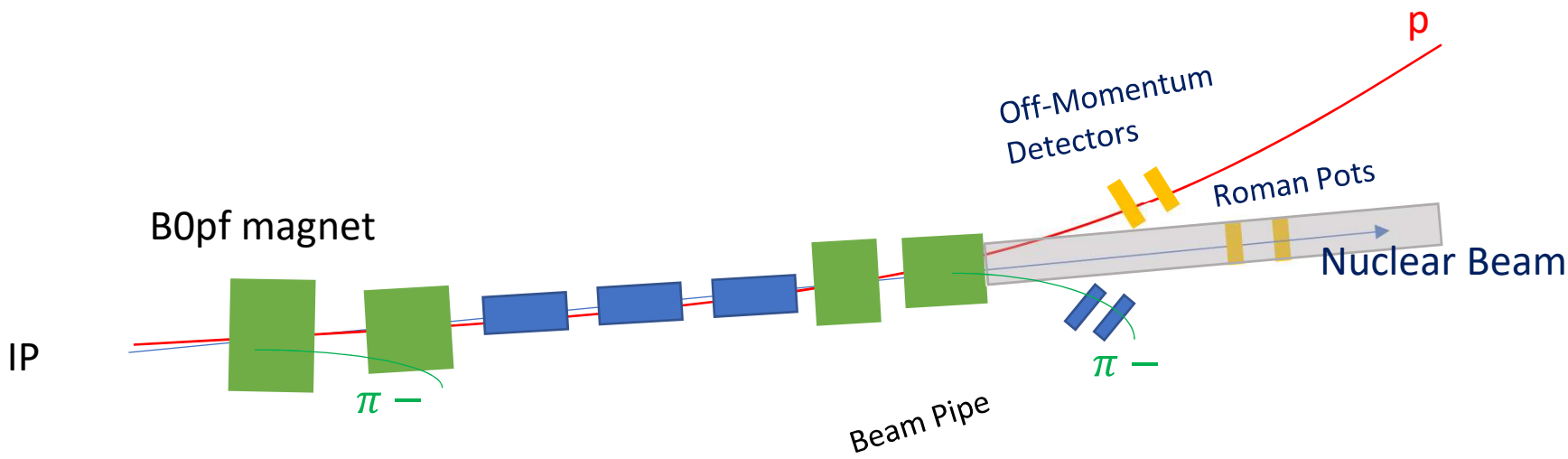


10σ cut places a limit on low-p_T acceptance.



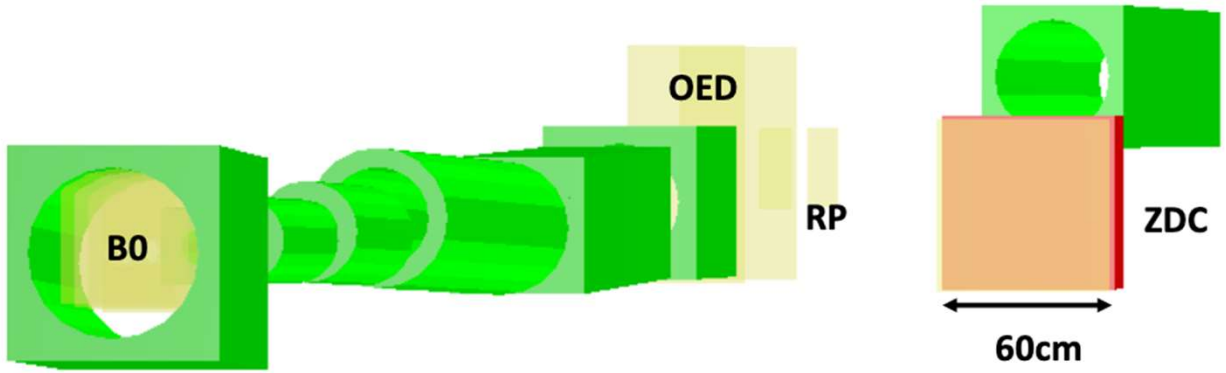
Off-Momentum Detectors

- Needed for measuring protons from nuclear breakup.
- Sensors on the other side can detect negative π^- from Λ decay.

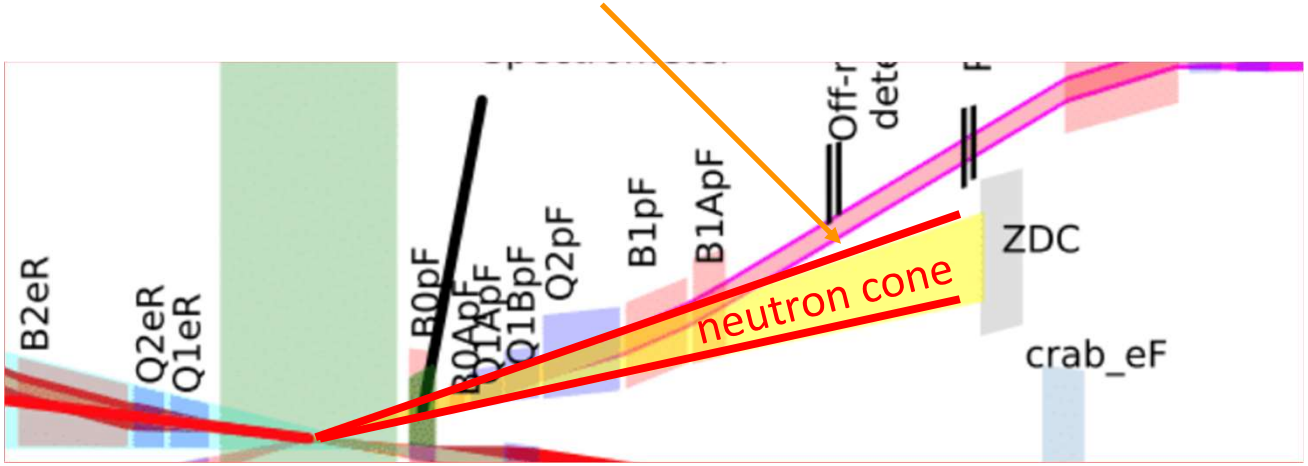


- No low-p_T cutoff - sensors are outside the beam pipe.
- Very off-momentum particles can be lost in the quads.

ZDC measures forward neutrons & photons



- Acceptance limited by bore of magnet where neutrons exit.



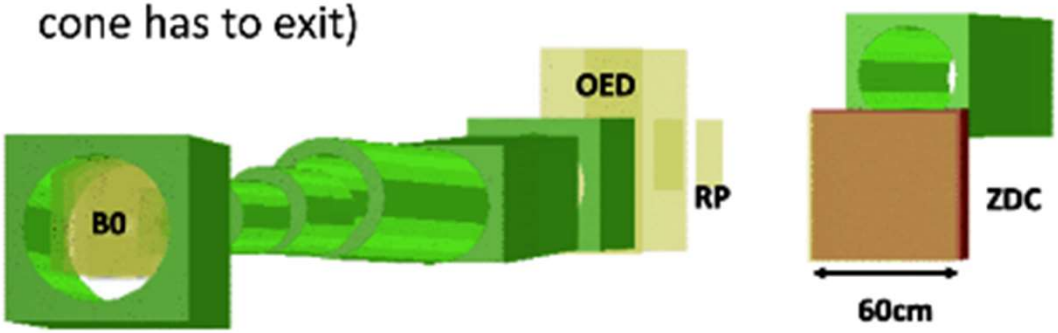
Zero-degree Calorimeter

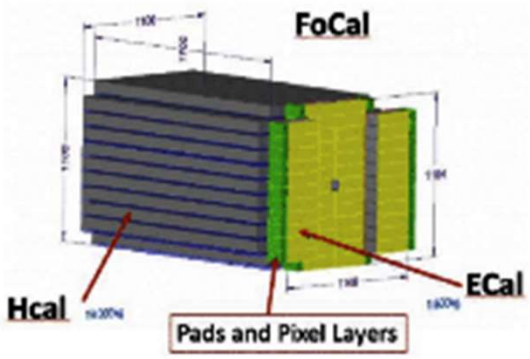
For detection of neutrons and photons

Acceptance:

$0<\theta<4.5$ mrad

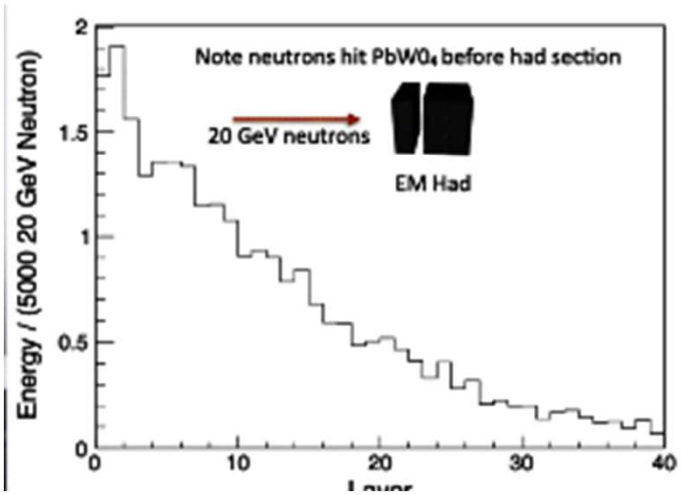
(Limited by bore of magnet where the neutron cone has to exit)

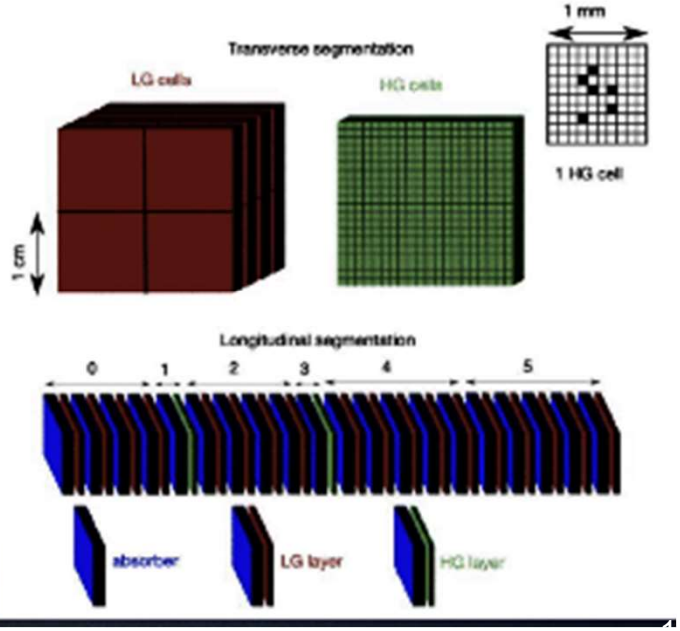




HCal: ~2K channels

- ALICE FoCal
- ATLAS/CMS ZDC





Neutron & proton acceptance & resolution

Neutrons:

Uniform acceptance for $0<\theta<4.5$ mrad., up to 5.5 mrad on one side

$\sigma_E/E=(50\%)/\sqrt{E} \oplus 5\%$

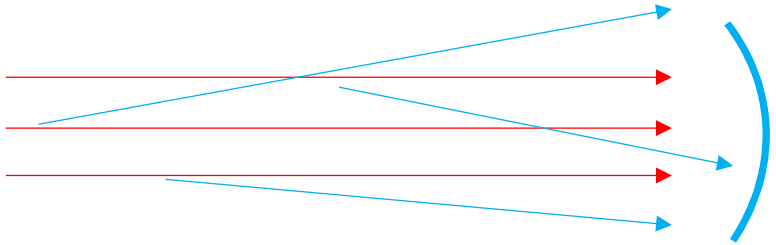
Assume angular resolution of $\sigma\_\theta=(3 \text{ mrad})/\sqrt{E}$

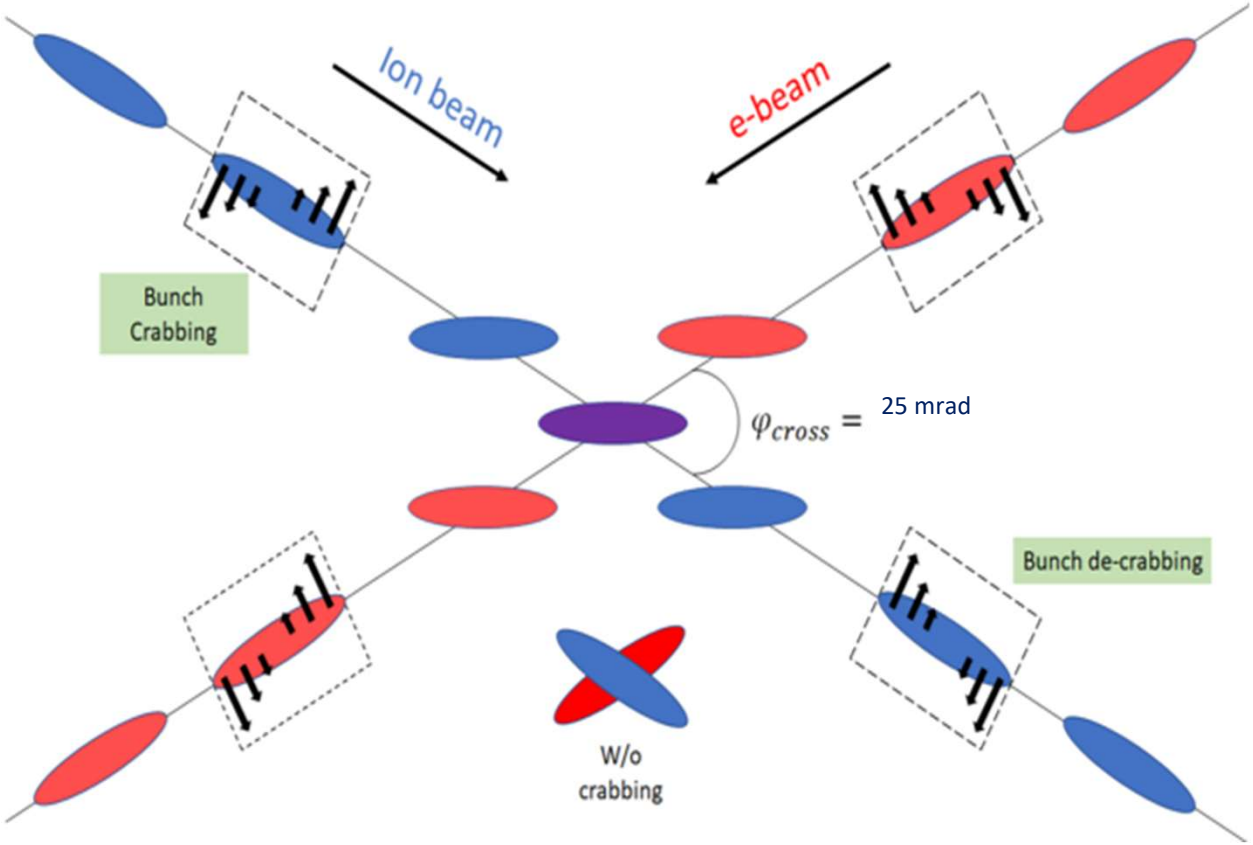
Protons:

- Uuniform acceptance for $6 < \theta < 13$ mrad (20mrad on the other side) – "B0"
- Protons with p_Z > 60% p_{beam} hit the Roman Pots
  - 275 GeV: Assume uniform acceptance for $0.5<\theta<5.0$ mrad
  - 100 GeV: Assume uniform acceptance for $0.2<\theta<5.0$ mrad
  - 41 GeV: Assume uniform acceptance for $1.0<\theta<4.5$ mrad
- Protons with p_Z between 25 and 60% of p_{beam} hit off momentum detectors
- Uniform acceptance for $0.0<\theta<2.0$ mrad
- For $2.0<\theta<5.0$ mrad, only accepted for $|\varphi|>1$ radian
- σ_{pT} ~ 3% for pT > 550 MeV/c, σ_p ~ 0.5%

Resolution: Smearing Contributions

- Angular divergence
- Crab cavity rotation
- Detector Choices
  - Pixel size, transfer matrix, etc.

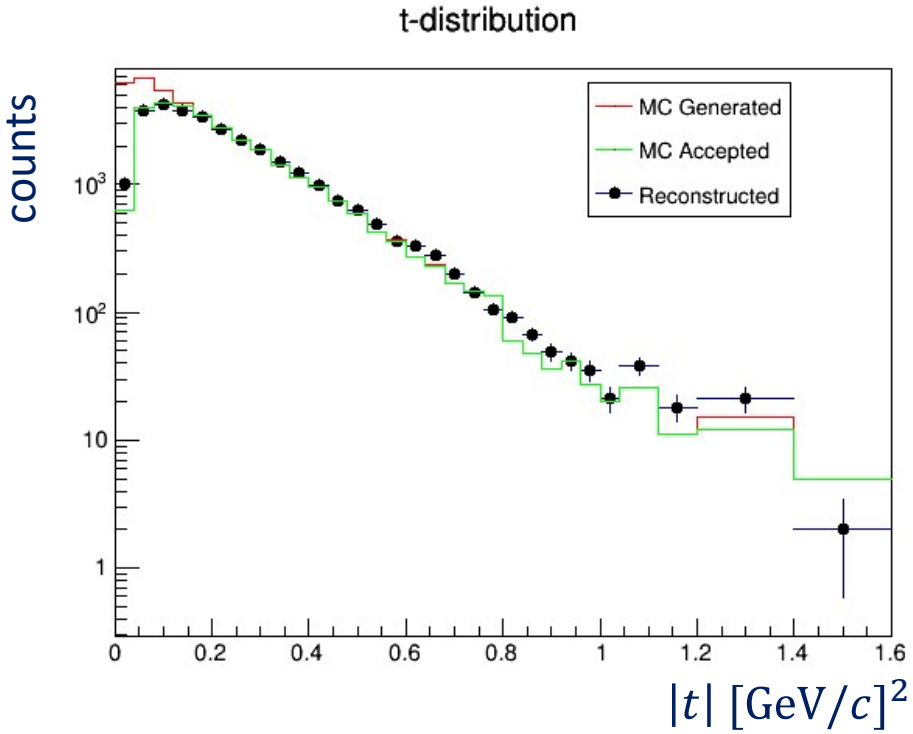


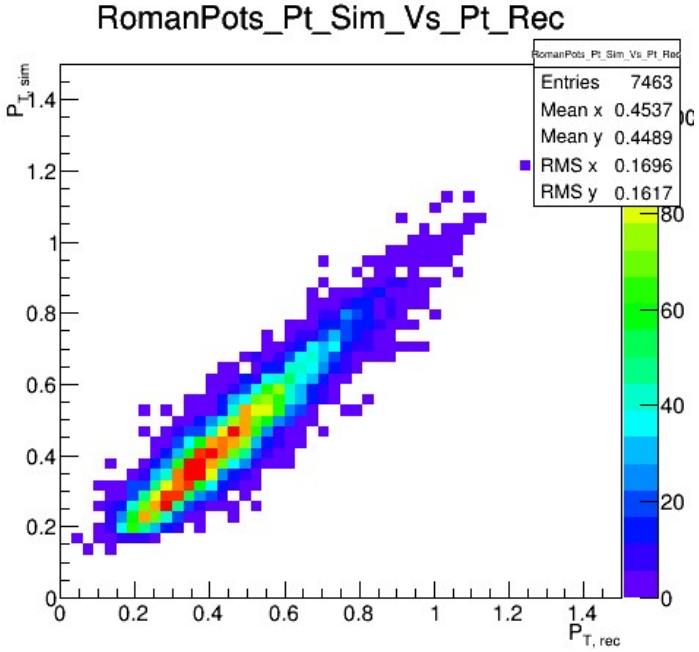


Examples of simulations

DVCS at 275 GeV

- Reconstruction includes all smearing effects.
- Bin migration present, but the slope can still be accurately extracted.



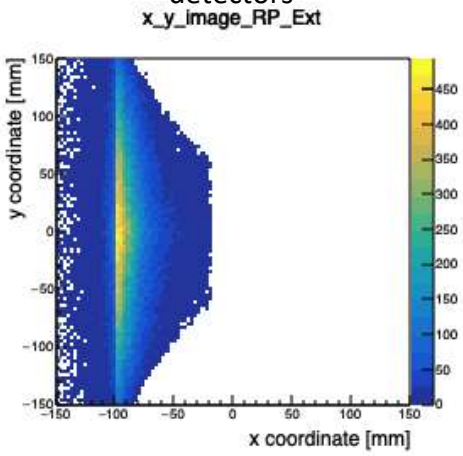


e+d → p + n + J/Ψ

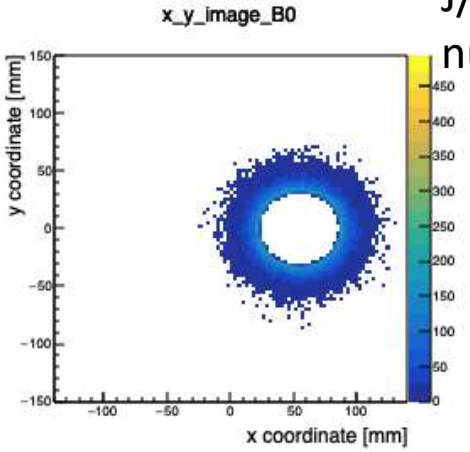
Neutron spectator/leading proton case.

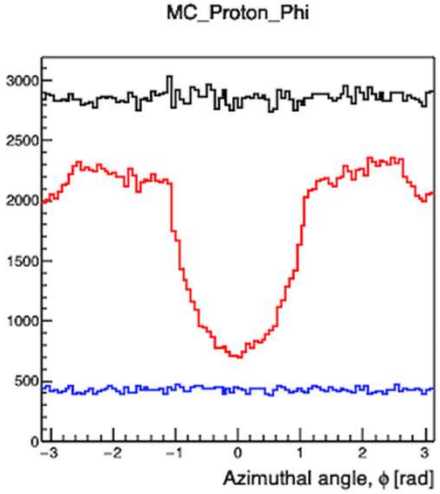
Incol
J/Ψ (
nucl

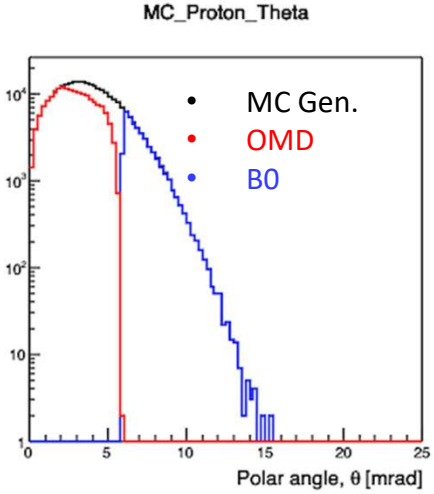
Off-momentum detectors

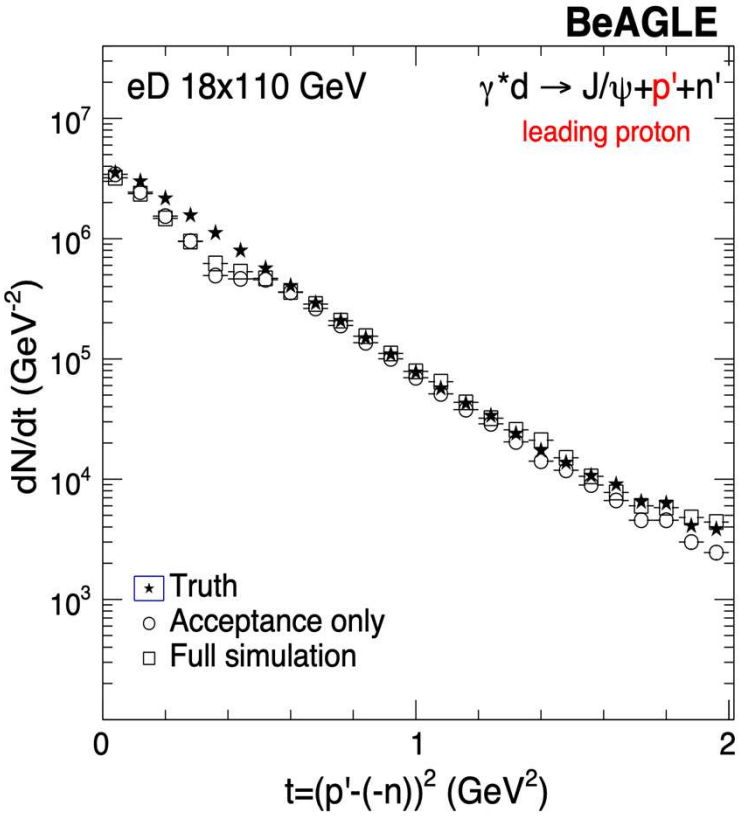


Single B0 plane







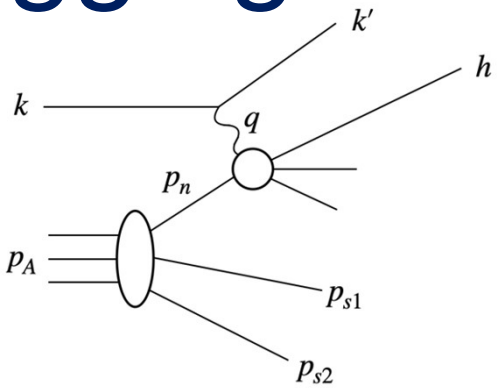


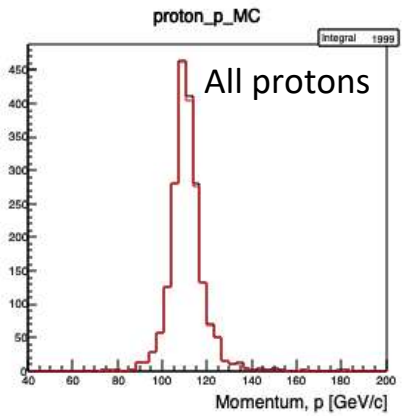
t-recons

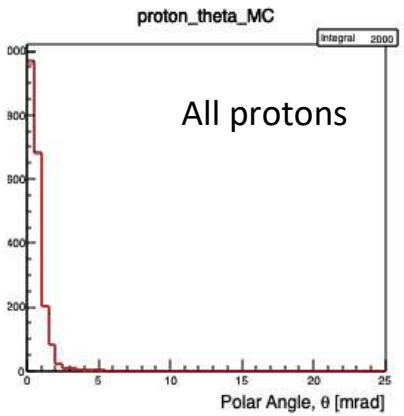
Good timing is assumed here (i.e. vertex smearing removed). If this contribution was not removed, the slope would be distorted.

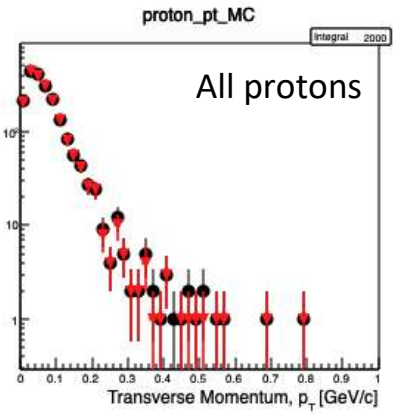
e+3He spectator proton tagging

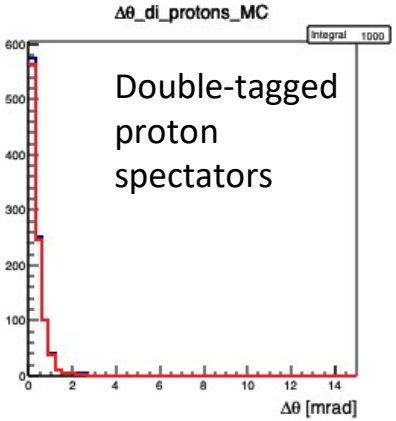
- Acceptance good for tagging 2 protons.
- More detailed study underway.
  - Top row: 10x110GeV/n BeAGLE DIS
  - Bottom row: 10x110 GeV/n SRC

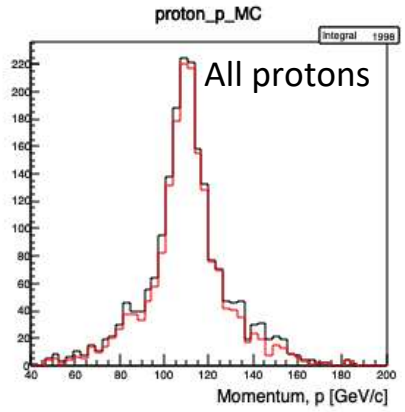


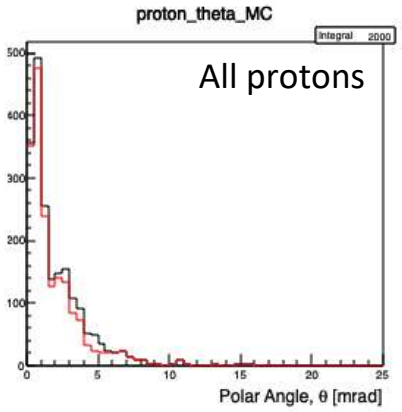


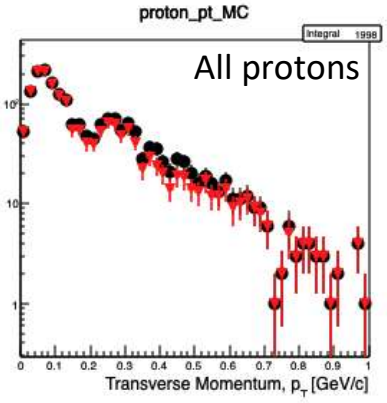


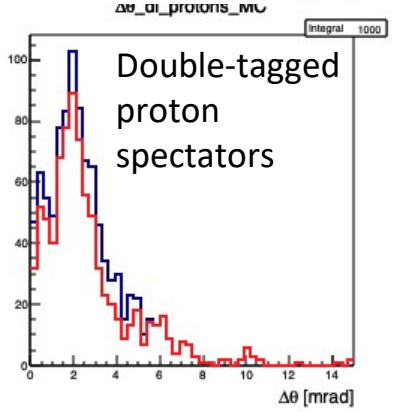








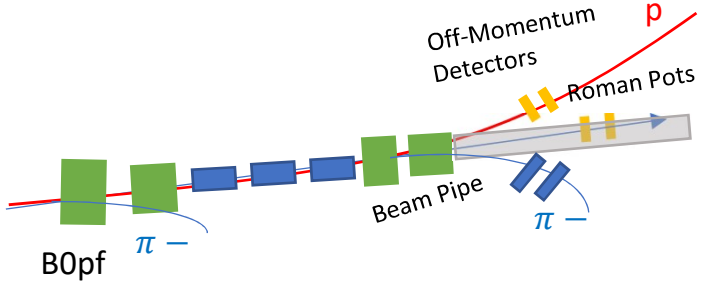


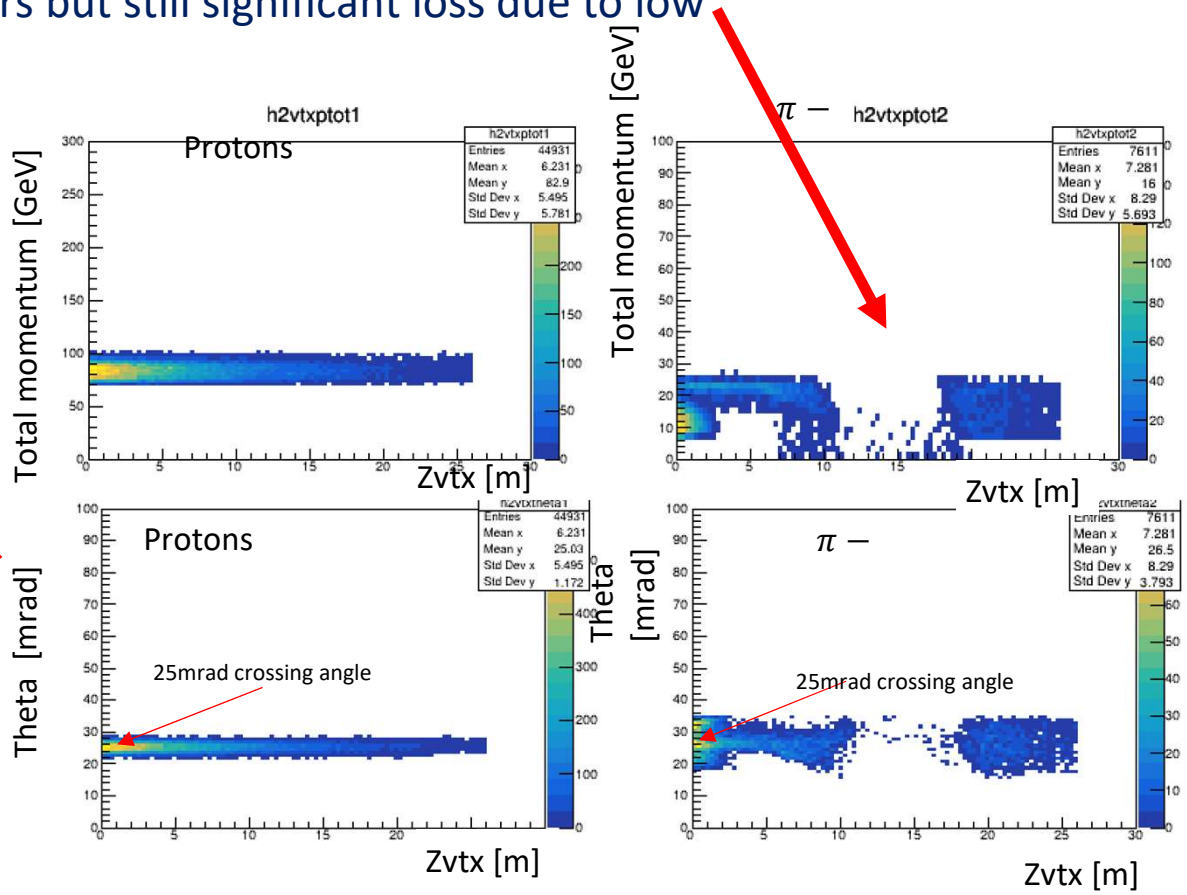


$\Lambda \rightarrow p\ \pi^-$ and $\Lambda \rightarrow n\ \pi^0$

Example (10x100 GeV): ~100% detection for protons from Lambda. Significant loss π^- along the beam line (FFQs) due to low momentum of those pions.

Detecting lamb decays is hard because of long lifetime. Need to tag π^- in additional off momentum detectors but still significant loss due to low momentum





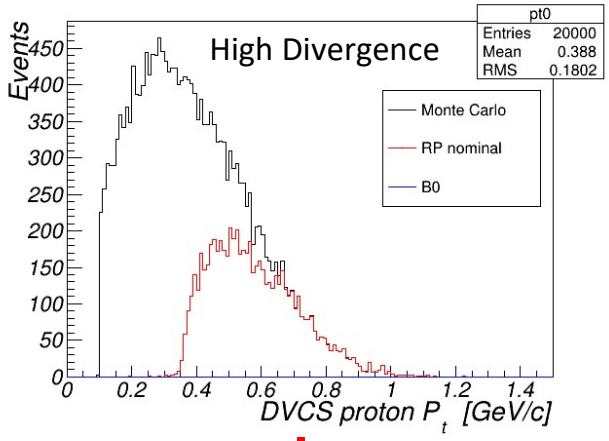
Summary

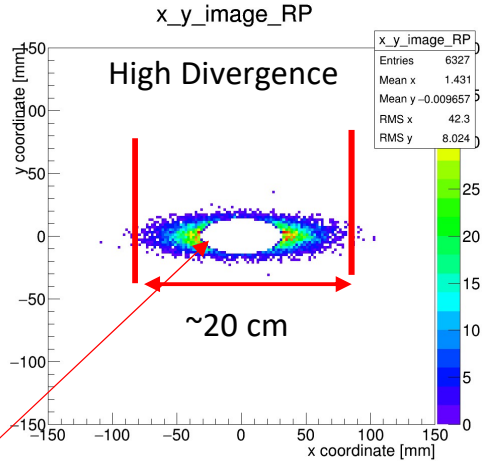
- Extensive simulations of physics processes show that with anticipated technologies the Far Forward Suite of Detectors can achieve baseline physics goals.
- Work continuing to maximize physics potential and to produce more realistic detector configurations.
- Alex Jentsch will provide more details tomorrow

Backup

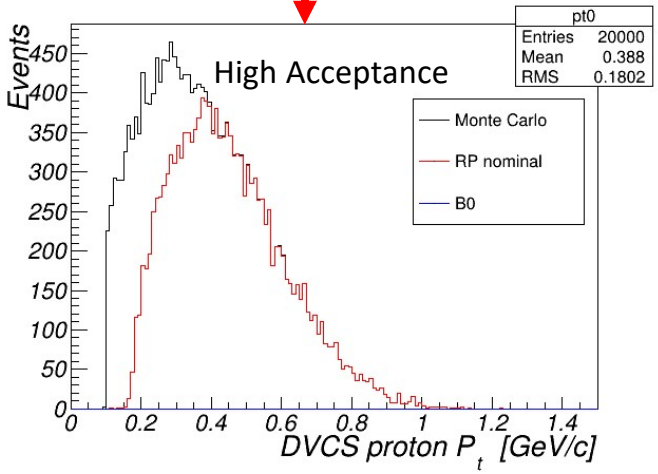
DVCS Snapshot – 275 GeV

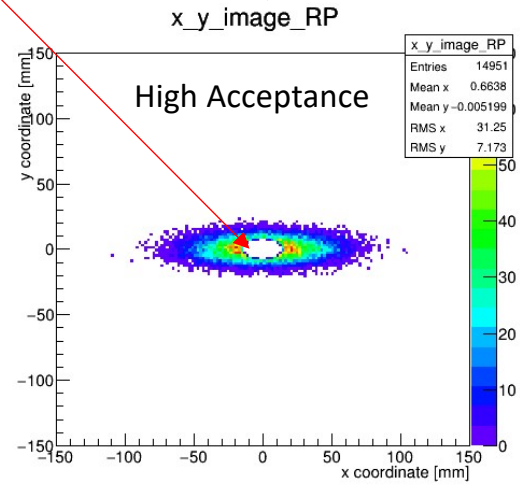
- MILOU - 275 GeV DVCS Proton Acceptance
- Relevant detectors: Roman Pots and B0

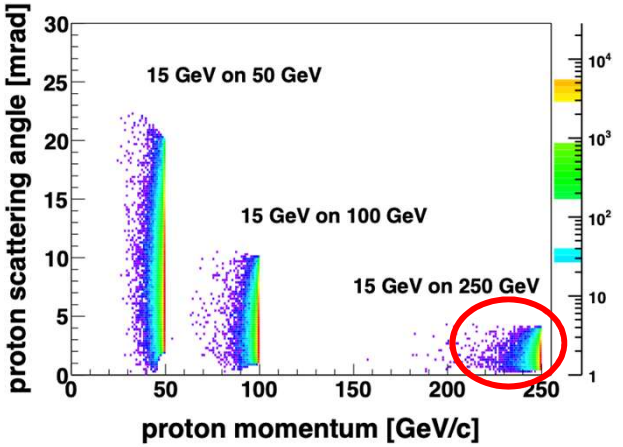




10σ cut



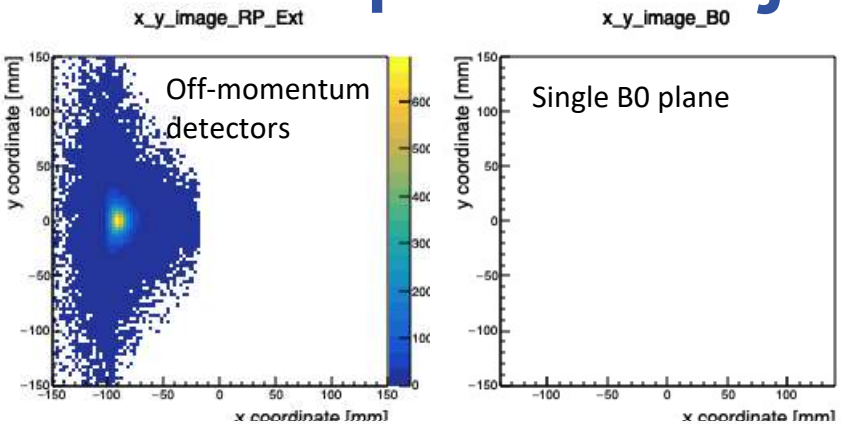




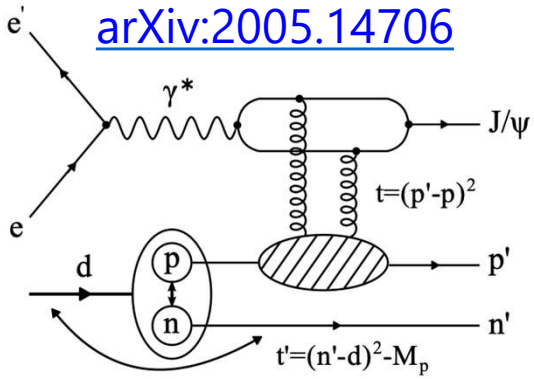
<u>High Divergence:</u> smaller $\underline{\beta^*}$ at IP, but bigger $\underline{\beta(z = 30m)}$ -> higher lumi., larger beam at RP

<u>High Acceptance:</u> larger $\underline{\beta^*}$ at IP, smaller $\underline{\beta(z = 30m)}$ -> lower lumi., smaller beam at RP

e+d -> p + n + j/Psi

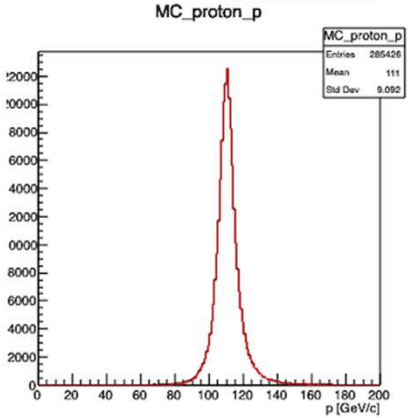


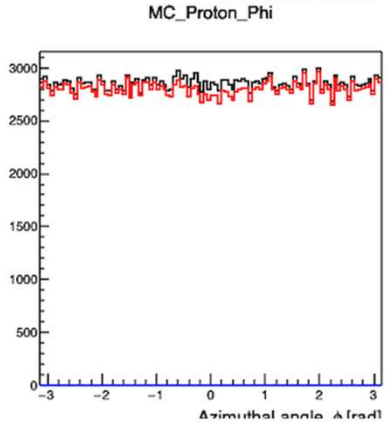
Particular process in BeAGLE: incoherent diffractive J/psi production off bounded nucleons.

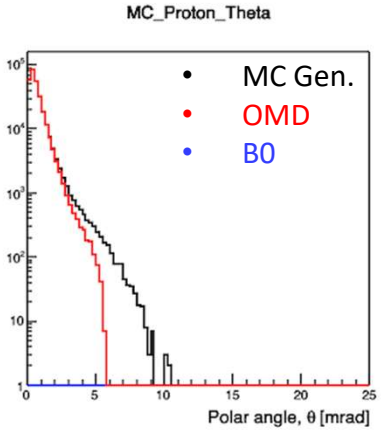


arXiv:2005.14706

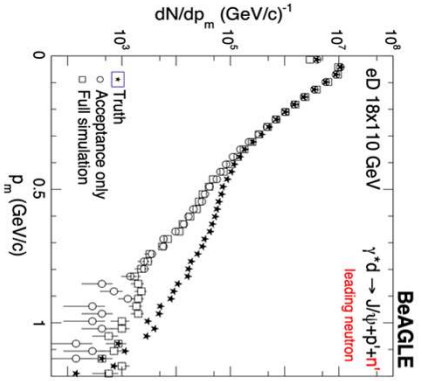
18x110GeV

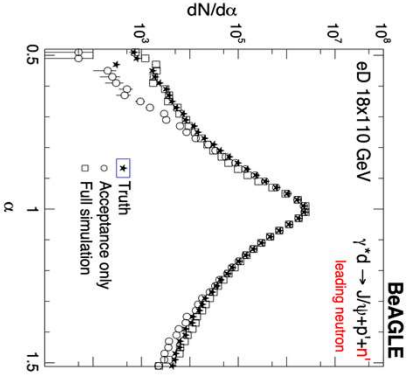






Proton spectator case.





Some examples of observables (light-cone momentum fraction, α), and missing-momentum (p_m).