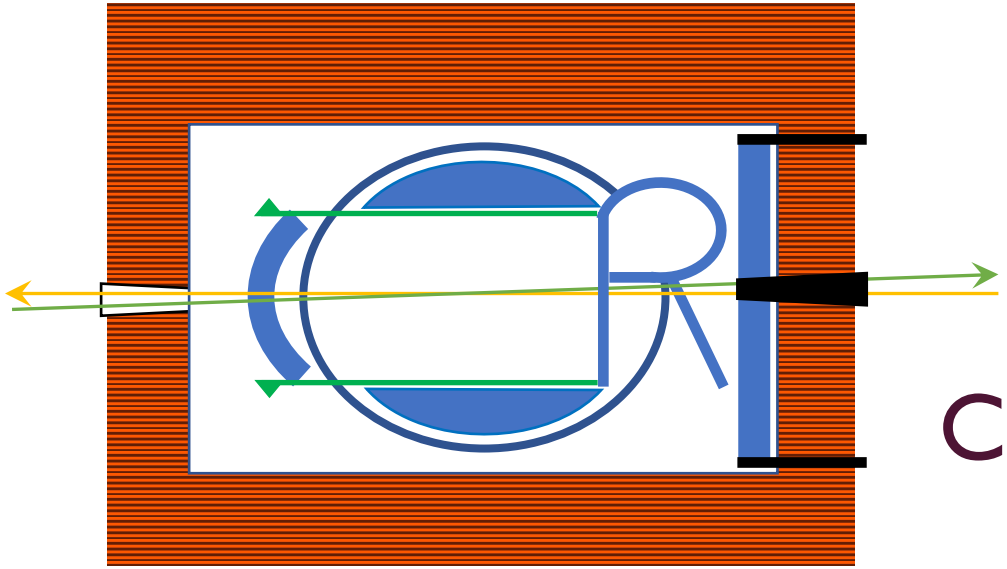

EICUG Annual Meeting
1-5 August 2021
https://indico.bnl.gov/event/11463

CORE FAR-FORWARD DETECTORS

CHARLES HYDE
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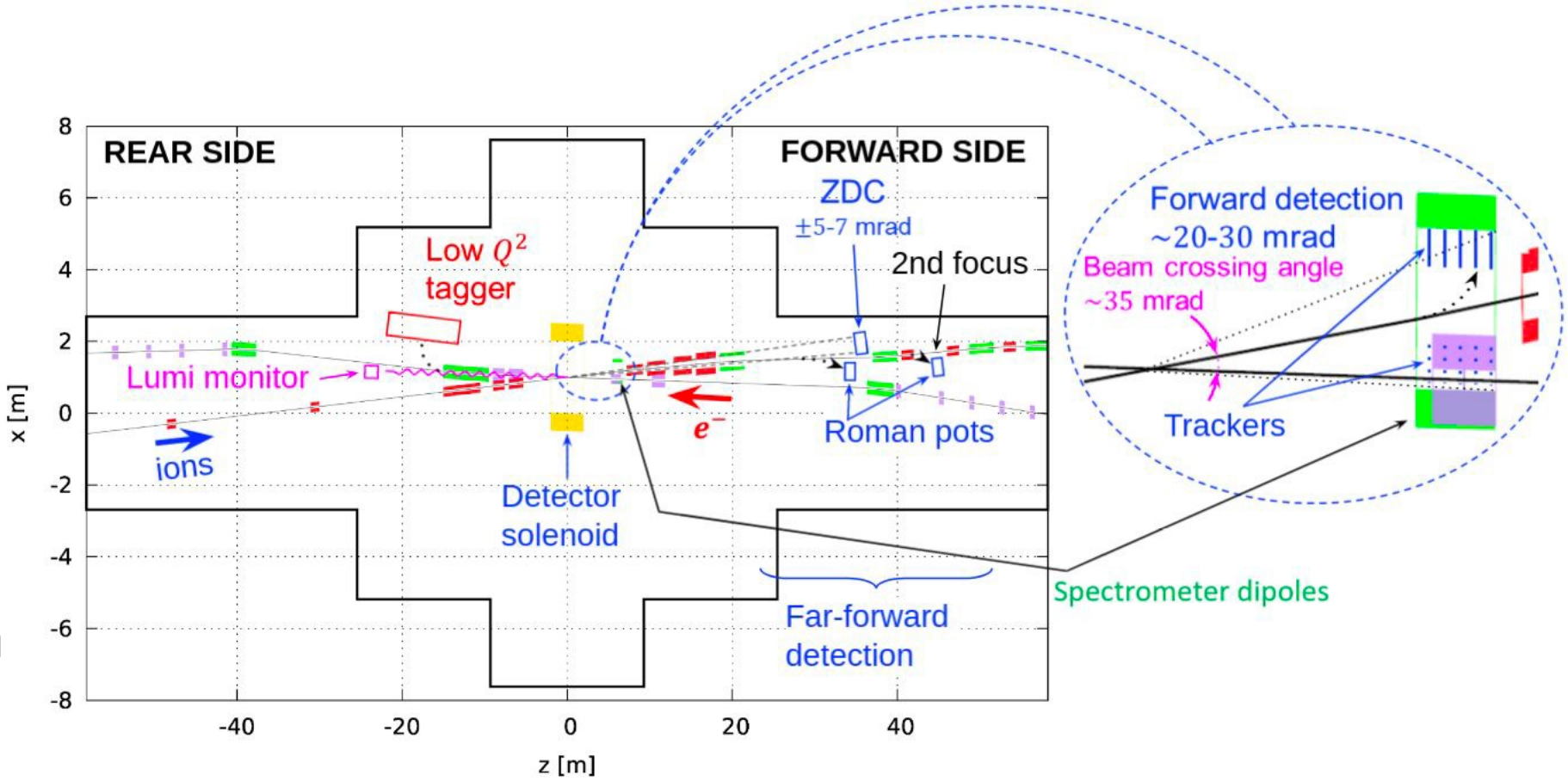
OLD DOMINION UNIVERSITY

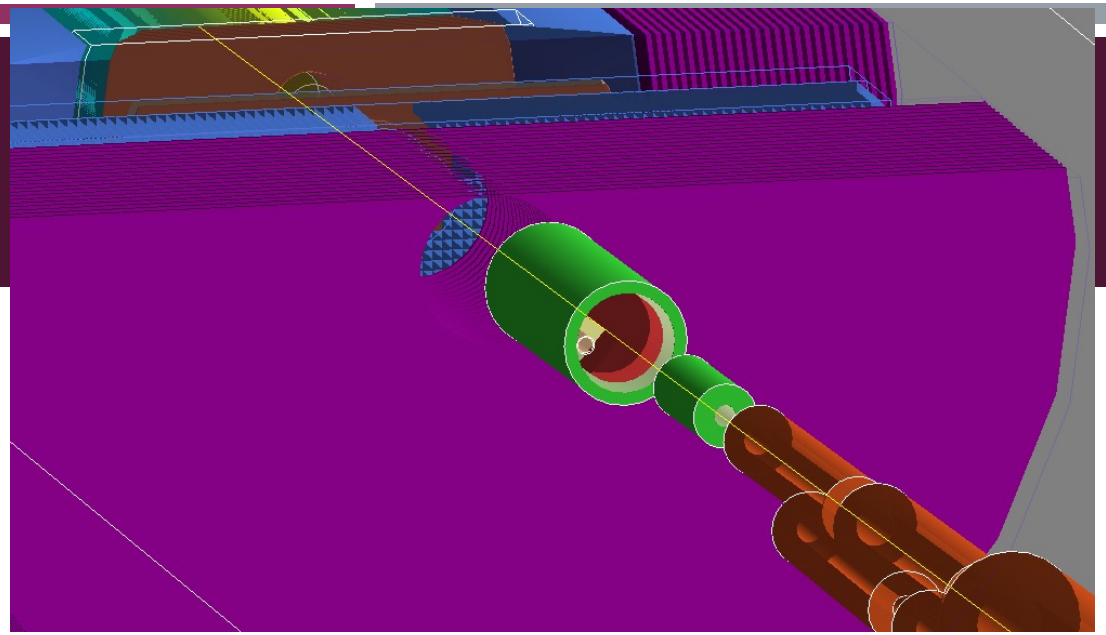
IP8

- Forward Dipole: ionBXSP01
- Far-Forward, Off-Momentum Tracker $z \in [24, 36]$m
  - ZDC: $z \approx 36$ m.



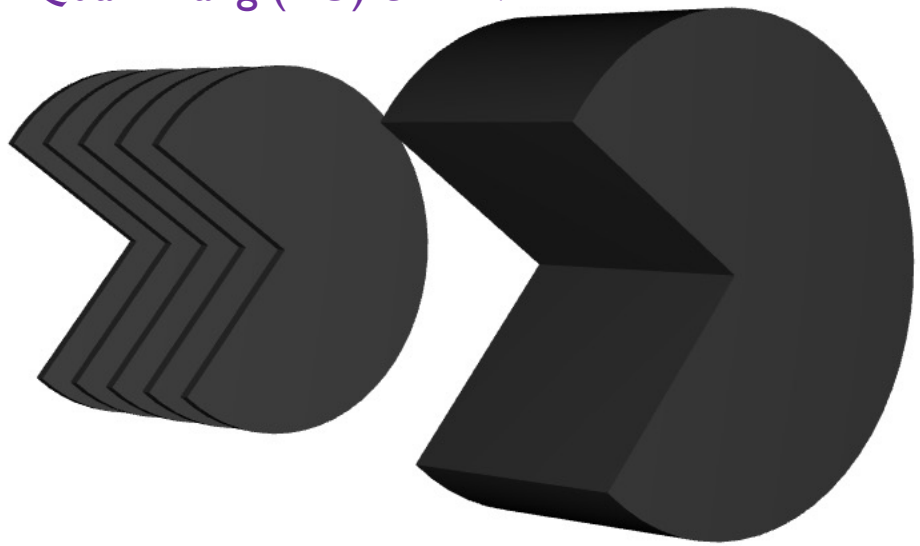
- Secondary focus: z=45 m.
  - x_L acceptance up to 0.99 at $p_T = 0$, and up to 0.997 at $p_T = 1$ GeV (P=275 GeV)
- Far Backward: 0° tagger (AKA low-Q^2 tagger).
  - After first downstream-electron dipole.

IP8 (FIRST) FORWARD DIPOLE



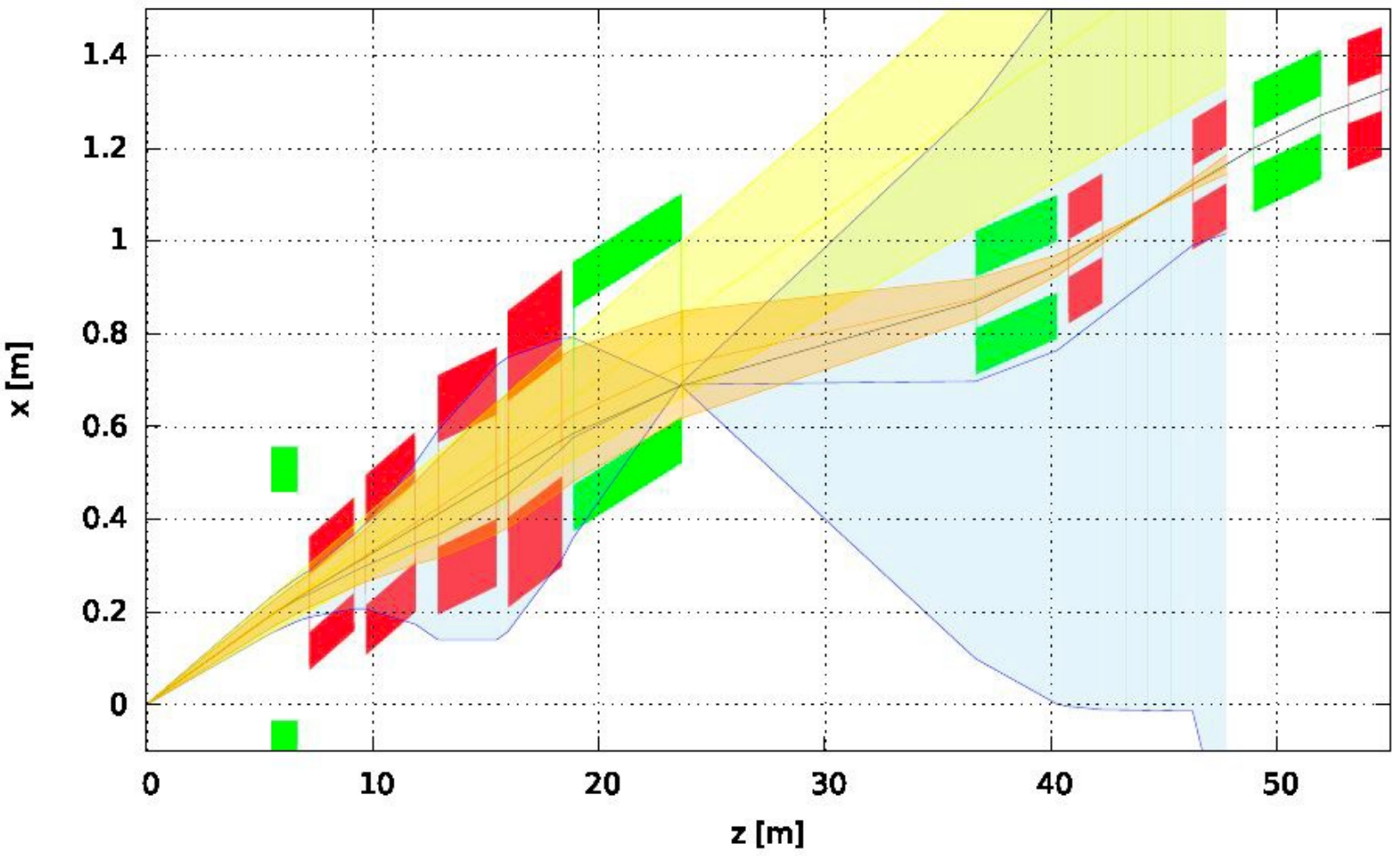
- Forward Dipole: ionBXSP01
  - Approx. [7,20] mrad partial acceptance
  - Fixed Si Tracker disk layers
    - Pile-up (up to 500 KHz from ep physics)
      Beam-Gas calculations in progress (eRD21)
    - Marginally compatible with MAPS
    - At least one AC-LGAD layer
  - 20 cm $PbWO_4$ EMCal
    - 10 cm for nuclear decay photons
    - 20 cm for pi0

Quan Wang (KU) eRD27



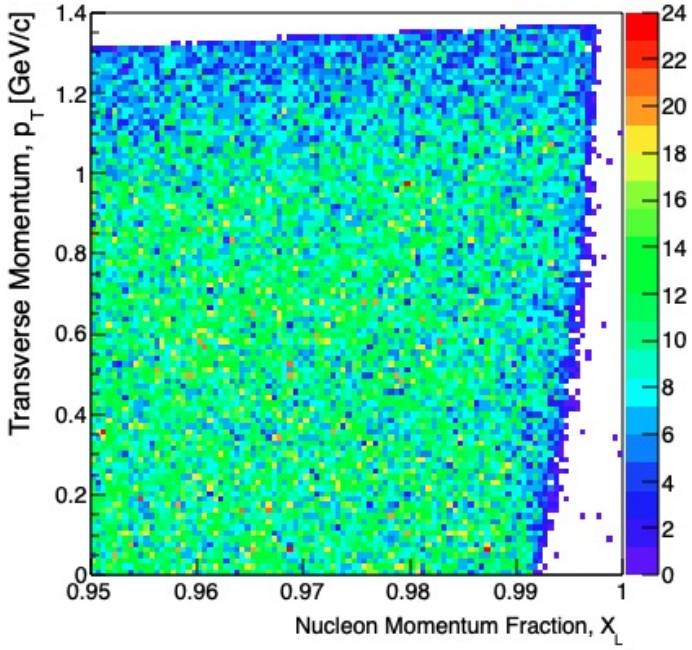
IP-8 OPTICS WITH SECONDARY FOCUS

- Neutrons ±7mrad
- Protons ±5mrad
  - Δp/p = 0, $x_L=1$
  - $p_T \leq 1.37$ GeV
- Protons ±7mrad
  - Δp/p = –0.5, $x_L=0.5$
  - pT = 0.96 GeV



FIRST ORDER OPTICS @ SECONDARY FOCUS

A. Jentsch
Acceptance study

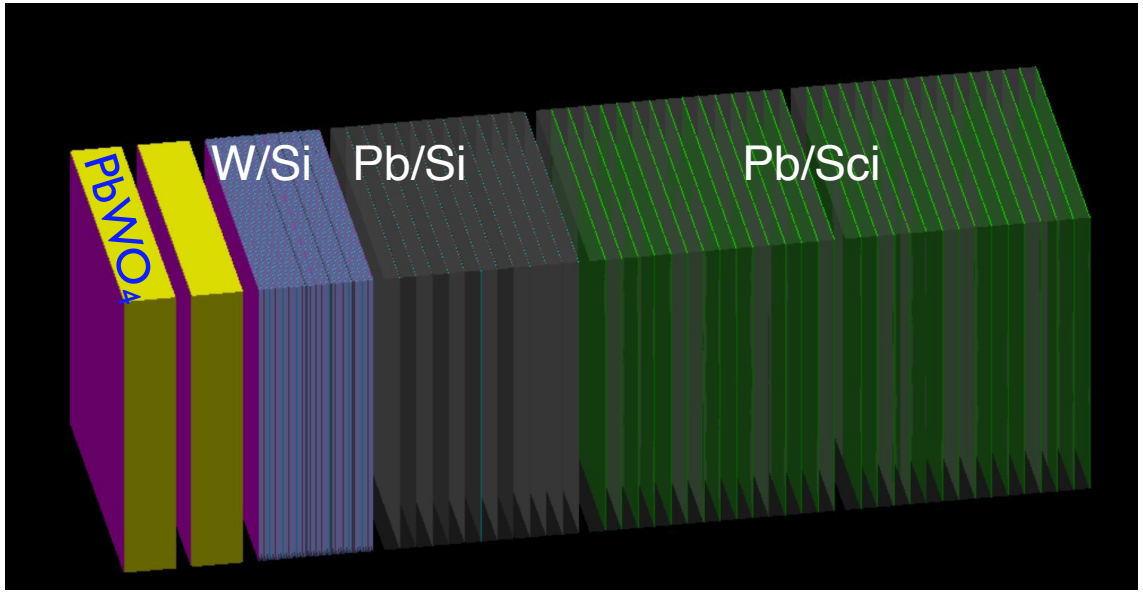


$x_L \approx (1-x_B)$

- $\begin{bmatrix} x \\ x' \end{bmatrix}_{SF} = \begin{bmatrix} \langle x'|x\rangle & \langle x|\delta\rangle \\ \langle x'|x'\rangle & \langle x'|\delta\rangle \end{bmatrix} \begin{bmatrix} x' \\ \delta \end{bmatrix}_{IP} \oplus \begin{bmatrix} \langle x|x\rangle \\ \langle x'|x\rangle \end{bmatrix} x_{IP}$
  - 10 sigma "Beam-Stay-Clear" ≈ 4 mm
- Invert matrix to reconstruct [x'(IP), p]
  - Three LGAD trackers at z_{SF}, and $z_{SF} \pm$ *1m*.
  - Resolution depends upon $\sigma(x_{IP})$, and $\sigma(x_{SF})$, $\sigma(x'_{SF})$
    - 30 ps AC-LGAD resolution limits $\sigma(x_{IP})$ to intrinsic ≈ *0.1*mm
  - Resolution is **independent** of $\sigma(x'_{IP})$, $\sigma(p_{Beam})$
  - Reconstructing $\Delta^\mu = (P' - P)^\mu$ **is** sensitive to beam smearing

ZDC

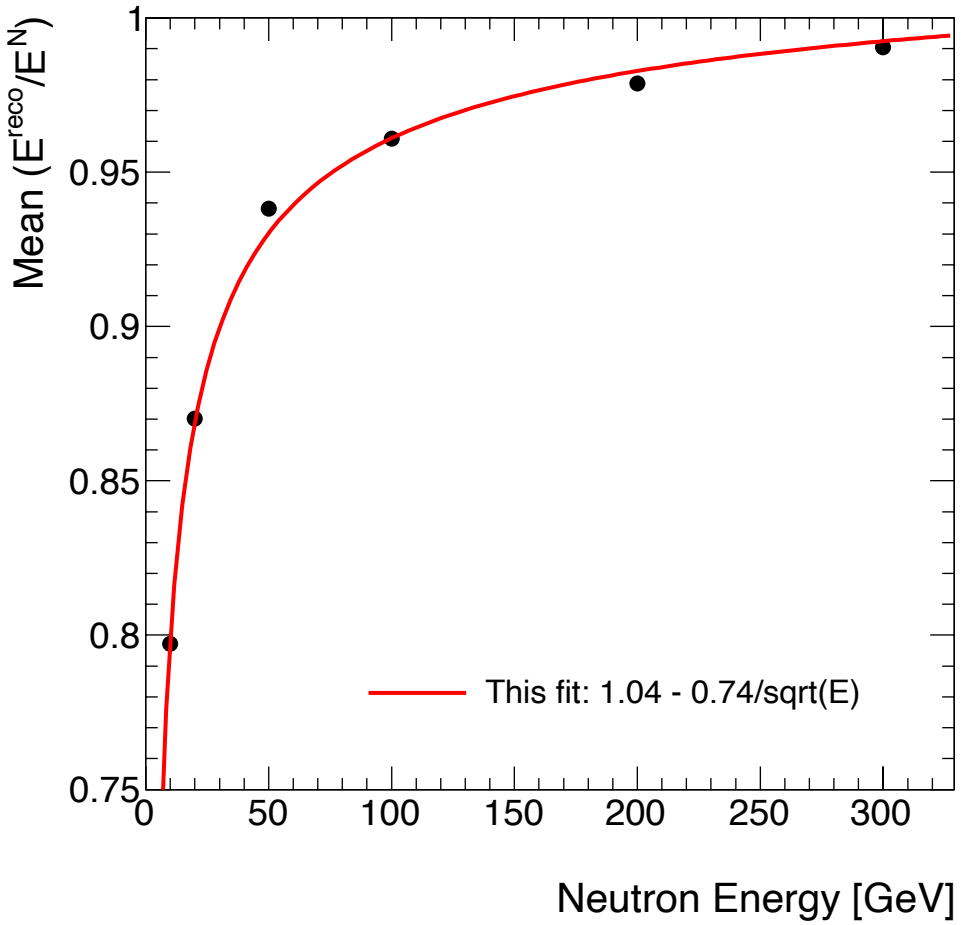
ALICE/FOCAL inspired design

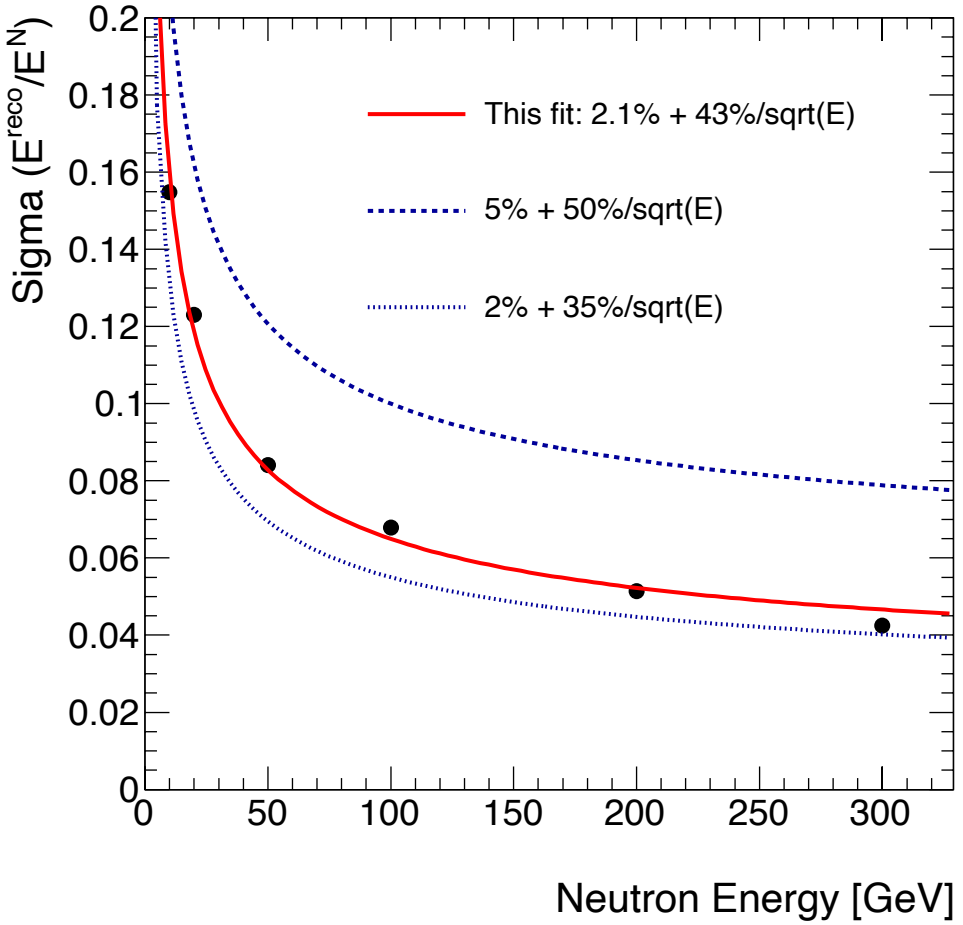


High resolution $PbWO_4$ EMCal in two layers $10X_0$ & $15X_0$:

- First layer for nuclear decay photons.
  - $^{208}Pb^*$: every decay cascade has at least one photon ≥ 2.6 MeV.
    →Boost to ≥ 260 MeV.
- Total absorption
  - **Decay photons from π^0**
  - Up to ~full beam energy 275 GeV

ZDC NEUTRON RESOLUTION: (SHIMA SHIMIZU, eRD27)





RIGIDITY OF OFF-MOMENTUM PARTICLES: $K = P/Q$

- Deuteron Beam $K = P_0$
  - Proton Spectator, $K \approx \frac{1}{2}P_0 + \frac{k}{M}$
  - $x_L \approx 0.5, \quad \delta \approx -0.5$
- ^{4}He beam $K = (2P_0)/2 = P_0$
  - Proton Spectator: $K \approx \frac{1}{4}(2P_0)$

    $x_L \approx 0.5, \quad \delta \approx -0.5$
  - ^{3}He Spectator $K \approx \frac{3}{4}(2P_0)/2$

    $x_L \approx 0.75, \quad \delta \approx -0.25$
  - ^{3}H Spectator $K \approx \frac{3}{4}(2P_0)$

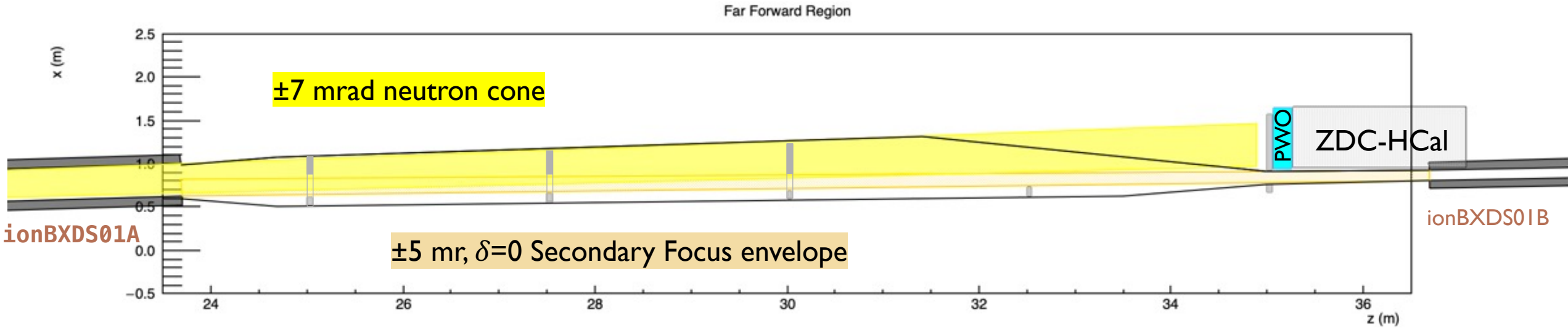
    $x_L \approx 1.5, \quad \delta \approx +0.5$: Super-Elastic!

- $^{78}_{28}Ni$ evaporation residue in $^{238}_{92}U$
  - K(Ni) = 1.077 P_0
- Consider 1cm Quartz Cherenkov detector at secondary focus:
  - $N_\gamma[200nm, 600nm] = 850 \cdot Z^2$
  - Resolve charge of evaporation residue: $\sigma(Z) \approx 1/Z$.
  - Possible Rare Isotope program at EIC Barak Schmookler, SBU.

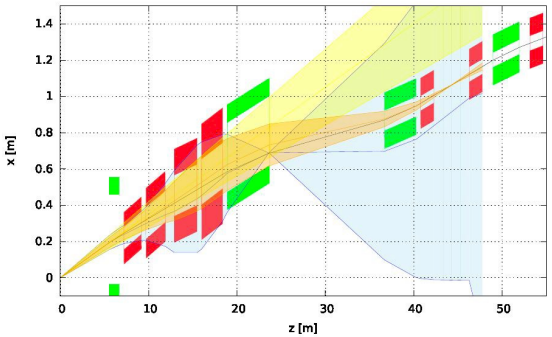
OPTIONS FOR THE OFF-MOMENTUM DETECTORS

- Fixed Detectors outside the vacuum envelope
  - Simpler. Less interference with ZDC. More options for Detectors
  - Mutiple scattering in beam pipe from shallow crossing angles
    - Vacuum pipe fills main dipole aperture of 40 cm bore
    - Zig-zag beampipe envelope at +20mrad, –100 mrad angles → all particles exit at ≤ 100 mrad
- Fixed Detectors inside the vacuum envelope
  - Profile is large to avoid envelope of particles to be detected at RP position of 45 m.
- Roman Pots inside the vacuum envelope
  - Perhaps needed to cover full ion range from 41 MeV to 275 MeV

CONCEPT FOR FIXED OFF-MOMENTUM TRACKERS IN VACUO



- δ<–0.1, ≤±5mr envelope (at IP) exits forward beam envelope at ≤ 20 mrad
- Particles tracked in up to 3 stations at z= 25.0, 27.5, 30.0, 32.5, 35.0 m
  - Exit window 100 mr to final tracking station and ZDC.
- minor ZDC conflict with ionBXDS01B (to be resolved…)



FAR BACKWARD

- Low-Q^2, Photo-Production Tagging
  - Supplementary "third-arm" to Pair-Spectrometer Luminosity Monitor
- Not your usual scintillator tagger array (2.5 A electron beam and 1 A ion beam)
- Tagging Rate at L=10^{34} ➔ $R_\gamma^{Tag} \approx (100KHz) \ln \frac{k_e^{Max}}{k_e^{Min}} \approx$ 100 KHz
- Si Tracker MAPS + LGAD
- $PbWO_4$ Calorimeter to resolve possible background issues in tracker

OPEN to NEW IDEAS, COLLABORATION with ECCE, ATHENA, and OTHERS

THANK YOU

With support from
DOE, BNL, SURA-CNF, SBU-CFNS