EIC 2nd Detector -- Tracking

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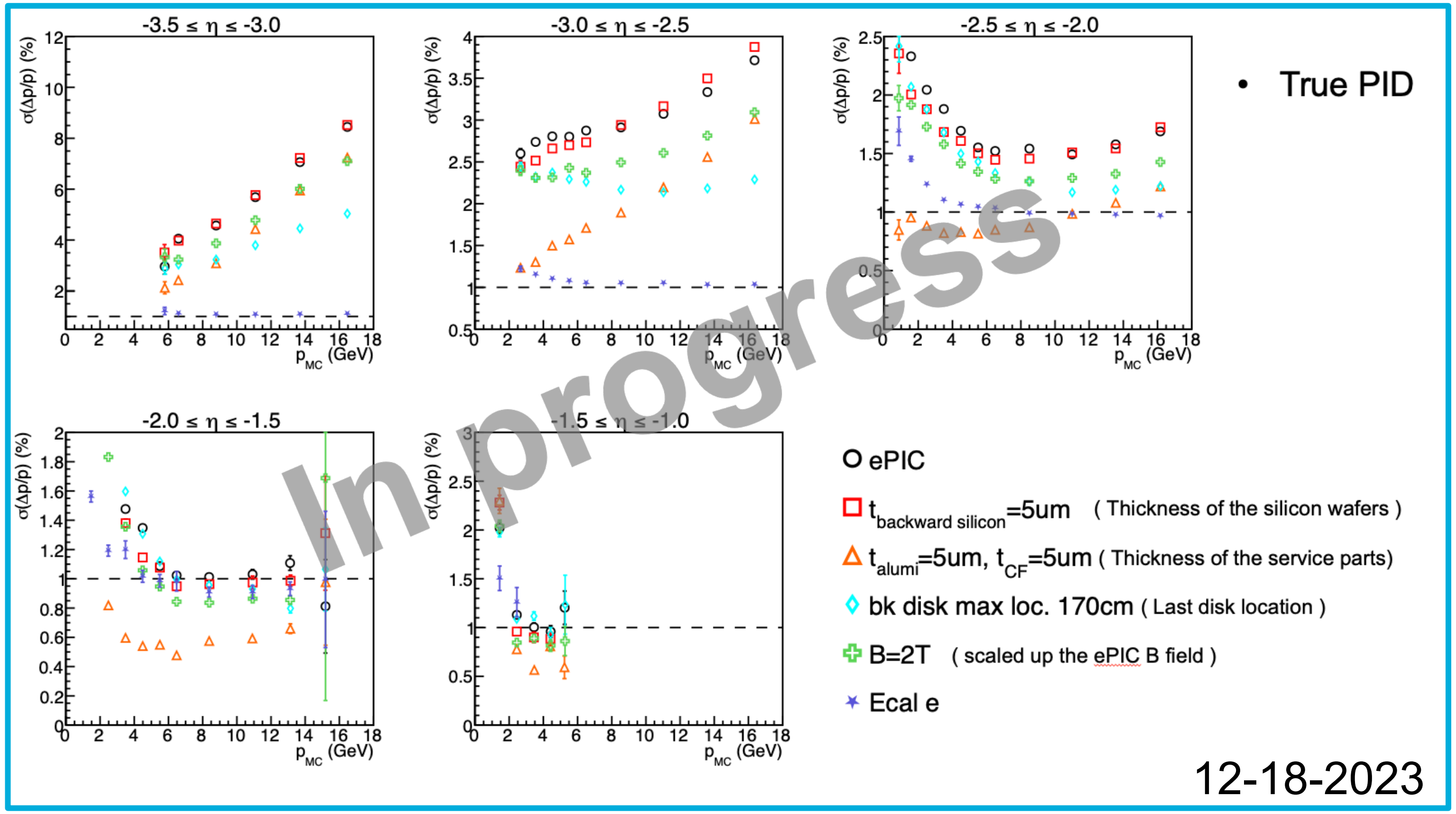
04-09-2024

The Original Direction

- Improve the backward momentum resolution to below 1%
  - very challenging
  - Working on a simulation note to summarize the study



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New Direction

- Shifting the focus from an all-silicon design to a mixed-tracking technologies design
  - Pros: (1) More hits: better pattern recognition, redundancy, resistance against backgrounds
    (2) Complementary
  - Cons: higher material budget
- Potential tracking technologies: scintillating fiber, drift chamber, TPC…
  Other Suggestions are welcome!

Increasing the number of hits could improve tracking resolution

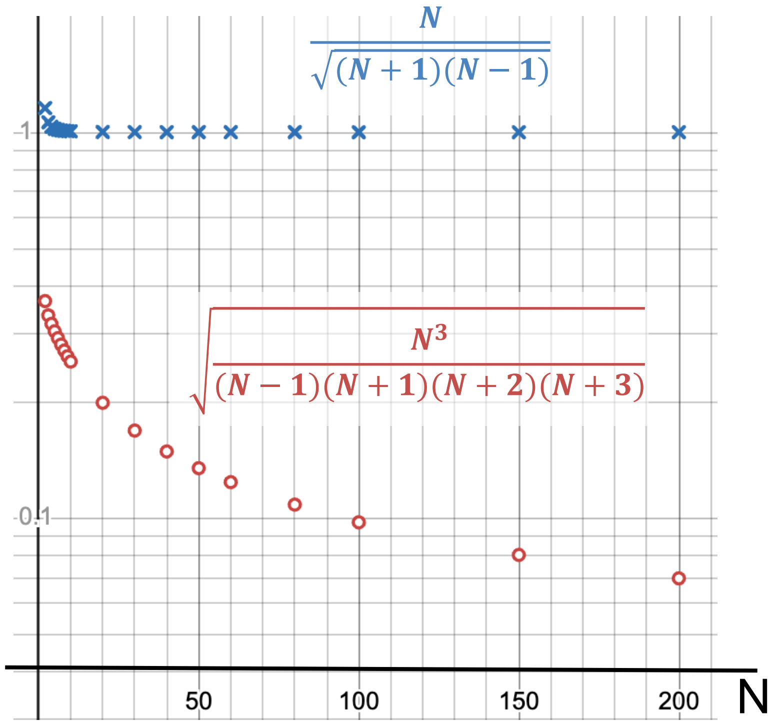
NIMA 910 (2018) 127

Resolution from detector pixel

$$\frac{\Delta p}{p}_{res} = \frac{\sigma_{pix} \cdot p}{0.3BL^2}\sqrt{\frac{720N^3}{(N-1)(N+1)(N+2)(N+3)}}$$

Resolution from multiple scattering

$$\frac{\Delta p}{p}_{ms} = \frac{N}{\sqrt{(N+1)(N-1)}} \frac{0.0136\sqrt{X/X_0}(1+0.038 \cdot ln\sqrt{X/X_0})}{0.3BL \cdot \frac{p}{\sqrt{m^2+p^2}}}$$

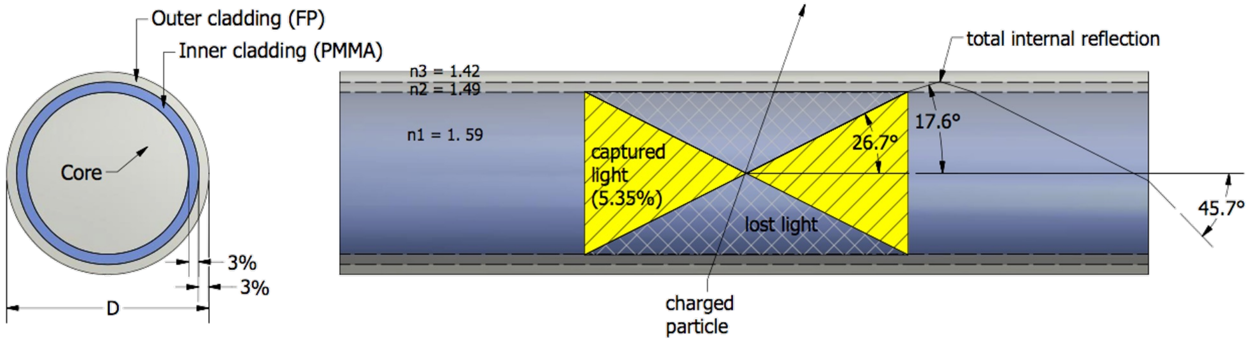


LHCb: arXiv:2305.10515
CERN-DRDC-2024-001

Scintillating Fiber (LHCb)

Double-clad polystyrene fiber

- D=250 um → hit pos. res. < 70 um
- 8k photons per MeV of ionization energy
- Excited electron decay times=2.4 ns
- Attenuation length~3.5 m



Hamamatsu SiPM (MPPC S13552 – H2017)

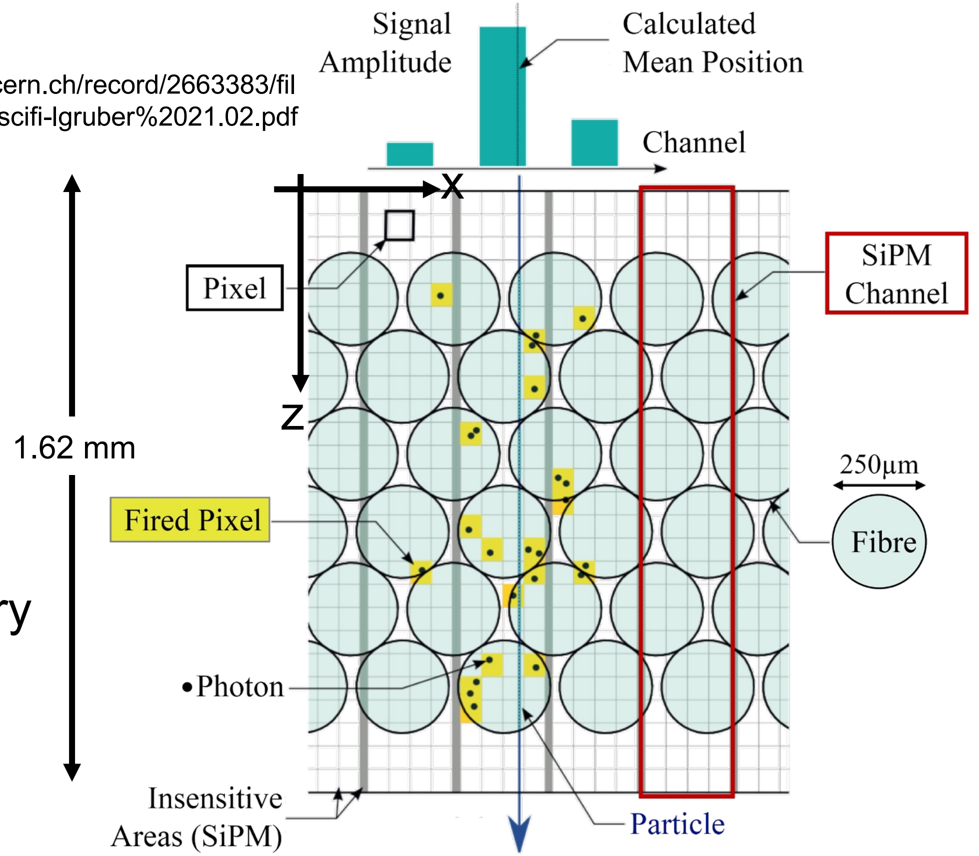
- Pixel size ~ 60 um
- <10% noise cluster rate with front-end clustering and -50 ℃ cooling using Novec

Material budget=1.1% x 12 layers

Technology advancement

- Scintillating fiber with improved radiation hardness
- Modify claddings to boost light yield
- Cryogenic cooled SiPMs with microlenses for light recovery

https://cds.cern.ch/record/2663383/files/vci2019-scifi-lgruber%2021.02.pdf

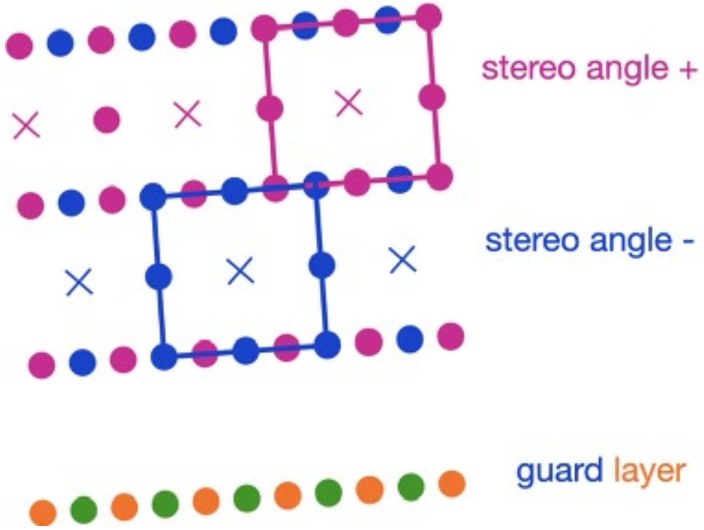


IDEA: EPJ Plus (2022) 137:231
MEG II: NIMA 936 (2019) 501

Drift Chamber (IDEA/MEG II)

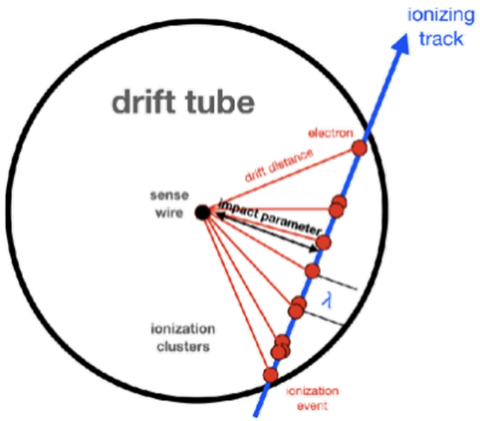
<u>Reduction of material</u>
by storing helium gas in the wire support endplates
IDEA: $0.016X_0$ ($0.05X_0$) in the barrel (forward and backward) region

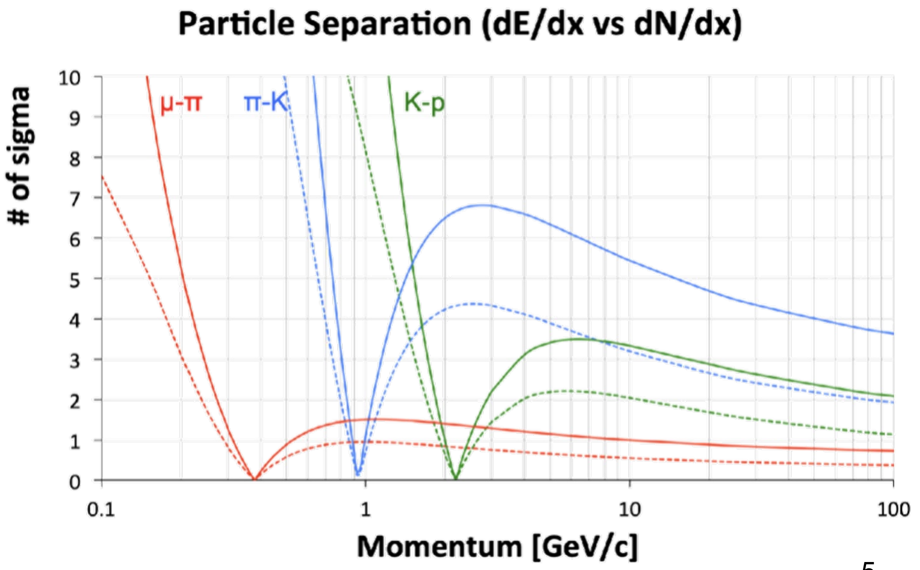
<u>More uniform equipotential surface</u>
A high ratio of the field to sense wires and a high wire density by enmeshes the positive and negative stereo angle orientations
IDEA: 4 m long, r = 35-200 cm, 400k wires, res ~ 100 um



<u>PID capability</u> with the cluster counting method
Adding timing information to the wires to count individual ionizing events of the traversing track and dE/dx information

Technology advancements
- Carbon-fiber wire vs tungsten wire reduce X/X_0 by a factor of 5
- Low - mass service/cooling structures
- See Andy's slides from last week





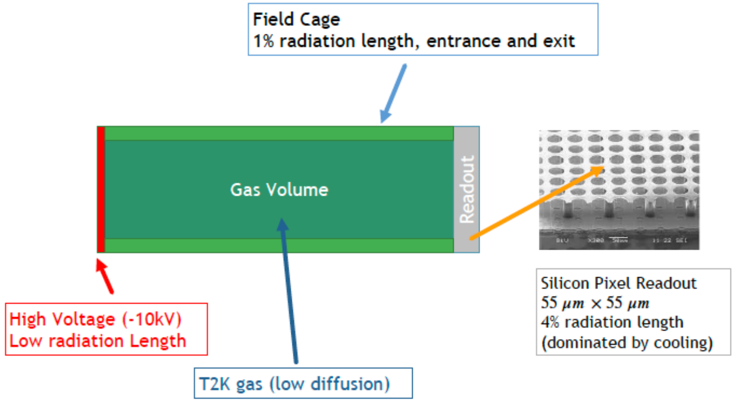
Also, see EIC Generic R&D 13

TPC/mini TPC

GridPIX aka miniTPC

https://indico.bnl.gov/event/18414/contributions/76157/attachments/47563/80668/EIC_Technology_Inventory_Temple.pdf

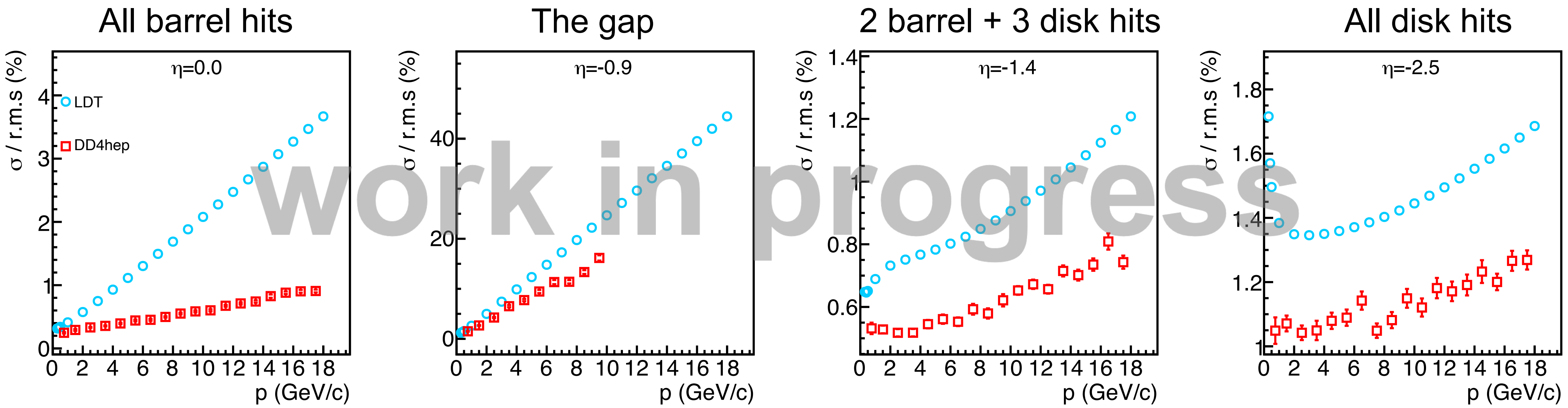
- Basic idea: Small ΔR TPC with Si Pixel readout on one endcap
  - PID ($\pi - K - p$) from 100 MeV/c to 800 MeV/c
  - Tracking with large number of hits (pattern recognition)
  - Works only in barrel (field!)
- GridPIX
  - Avalanche grid in front of 55 x 55 μm_2 pixels.
  - >90% efficiency for single electrons.
  - Small area is not particularly expensive: 1800 chips (order/produce/test 3600) = $716k
  - Careful: 1.2-5.4 kW of power
  - Services bulky: Gas, power, cooling
  - Realistic X/X_0?



Reality check:
- Very compelling for D2
- Provided tracking an dE/dx (compare with ToF/AC-LGAD)
- Excellent Pattern recognition
- Less sensitive to backgrounds
- Generic R&D ongoing
- Need to see concrete prototype

LDT Fast Simulation

- ePIC craterlake silicon detector as baseline
  - Barrel: cylindrical, Silicon layer (option for TPC)
  - Forward/backward: Silicon disk
- Goals
  - Validating the LDT simulation
  - Implement TPC in the detector setup



Summary

- Shift focus on mixed-tracking technologies design in tracking simulation
  - Reliable tracking
  - Complementary
- LDT fast simulation
  - Working on simulation validation
  - Implement TPC later on