2nd EIC Yellow Report Workshop

Pavia University (held online), 20-22 May 2020

Parallel session
Inclusive, SIDID, Jet & HQ

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for the Tracking WG

Ongoing activities and available results

Ongoing activities:

- working on the following main deliverables:
  - ✓ evaluate all-silicon vs hybrid (silicon & gaseous) trackers
  - ✓ compare realistic alternatives (TPC, MPGD options) for gaseous detectors, barrel and forward
- preliminary performance studies (mainly EicRoot-based simulations):
  - ✓ central region Si-vertex + TPC + Fast MPGD Layers **advanced**
  - ✓ Cylindrical Micromegas (MPGDs) **just started**
  - ✓ endcap region GEM (MPGDs) trackers **just started**
  - ✓ all-silicon (barrel) tracker + forward/backward silicon disks **advanced**
  - ✓ comparisons all-silicon vs BeAST (Si-vertex + TPC + MPGDs) concepts **ongoing**
- effort on Fun4All and ESCalate frameworks:
  - ✓ first implementations of all-silicon tracker in Fun4All and G4E **ongoing**
  - ✓ plan to implement realistic material and services for all the tracking detectors **just started**

Available results:

- relative momentum and pointing resolutions (in different configurations and options)
- angular resolutions at DIRC (Si-vertex + TPC + Fast MPGDs different options)

Outline for today's discussion

Hybrid/gaseous detector options:

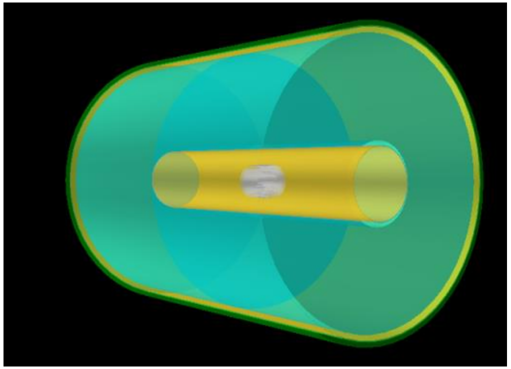
- central region Si-vertex + TPC + Fast MPGD Layers:
  - ✓ 3 options studied: no MPGDs + 2 different configurations with MPGDs before/behind DIRC
  - ✓ angular resolution before and behind DIRC position, relative momentum resolution
- cylindrical micromegas:
  - ✓ alternative to TPC, 2 different layer arrangements studied
  - ✓ Angular resolutions at DIRC position, relative momentum resolution
- material budget considerations
- pros/cons summary table

Silicon detector trackers:

- all-silicon tracker option:
  - ✓ tapered all-silicon in Fun4All, first estimates of the angular resolutions
- all-silicon and Si+TPC tracker studies
- pros/cons all-Si vs hybrid trackers

Si-vertex + TPC + MPDGs

Matt Posik, for eRD6

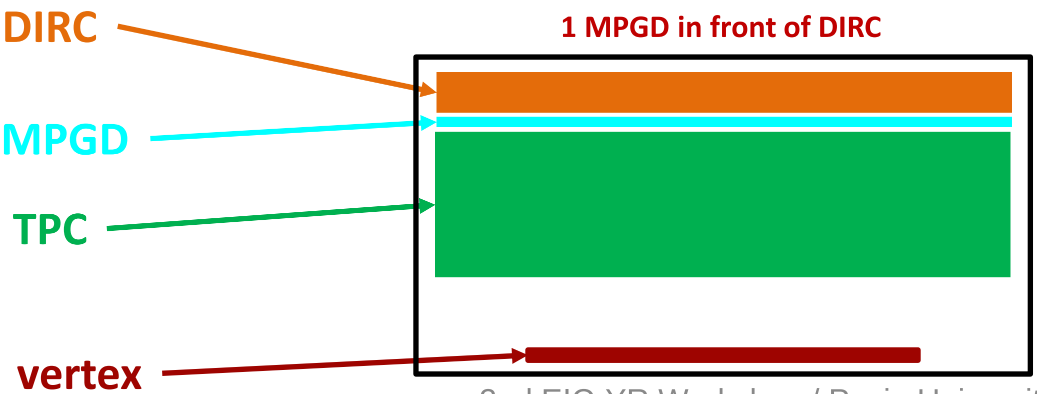


Detector setup:

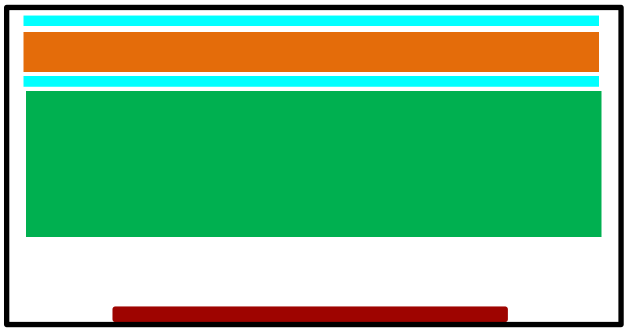
- Si-vertex tracker: 4 layers of 20 $\mu m \times 20\ \mu m$
- TPC: No distortion corrections, field cage and end cap materials included
  - Transvers Dispersion: 40 $\mu m/\sqrt{D}$
  - Transverse Resolution: 90 μm
  - Longitudinal Dispersion: 1 $\mu m/\sqrt{D}$
  - Longitudinal Resolution: 500 μm
- MPGDs in µTPC mode: $100\ \mu m \times 100\ \mu m\ (\phi \times Z)$
- 3 configurations investigated
  - No MPGDs
  - One MPGD layer in front of DIRC
  - 2 MPGD layers sandwiching DIRC

No MPGD

1 MPGD in front of DIRC



2 MPGDs “sandwiched” DIRC

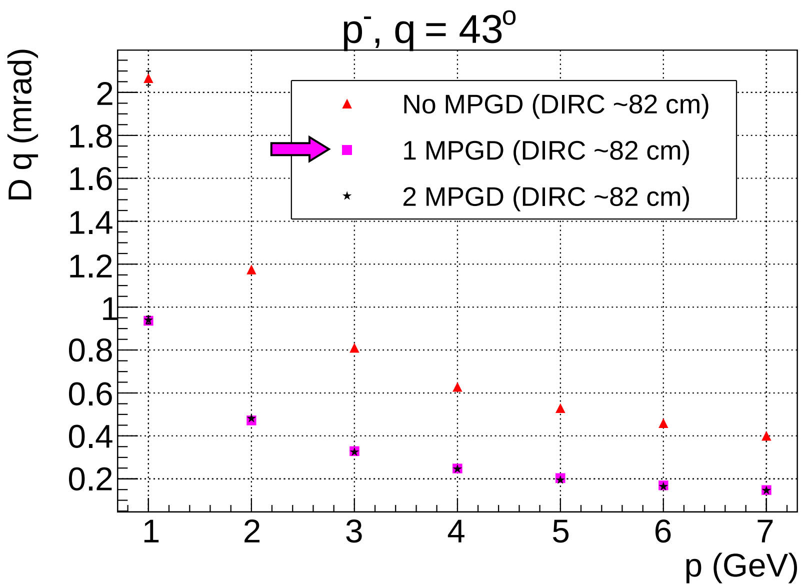


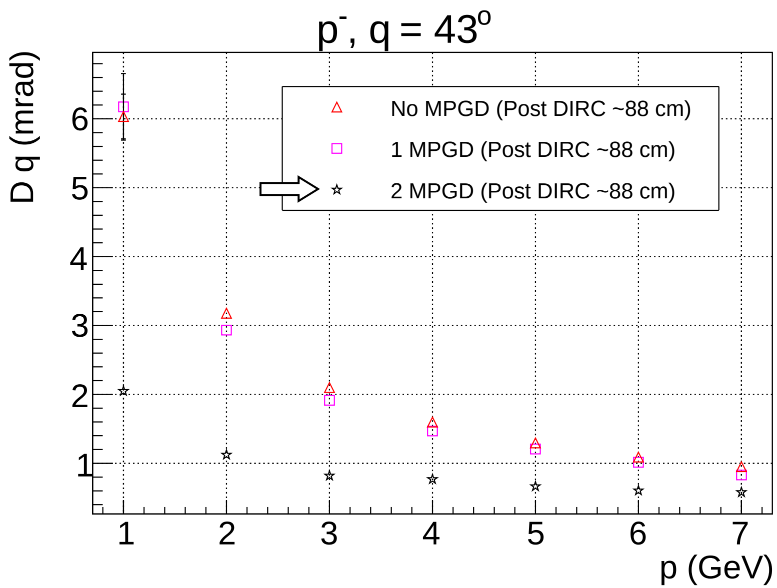
Si-vertex + TPC + MPDGs

Matt Posik, for eRD6

Angular resolution Δθ before and after the DIRC:

- B = 1.5 T,
- Solid Markers: At DIRC (~82 cm)
- Open Markers: Behind DIRC (~88 cm)
- Significant improvement seen in angular resolution behind the DIRC with MPGD layers sandwiching it
  - Angular resolution Δθ ~ 0.25 mrad before DIRC



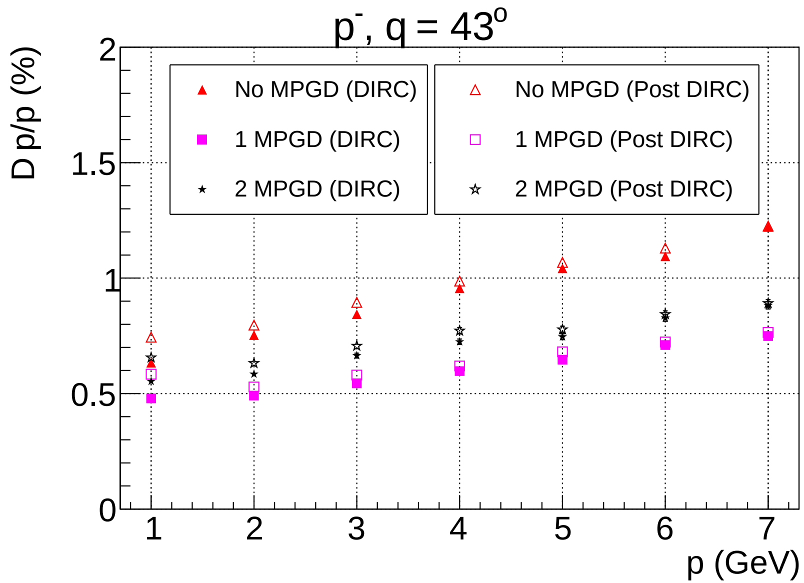


Si-vertex + TPC + MPDGs

Matt Posik, for eRD6

Relative momentum resolution:

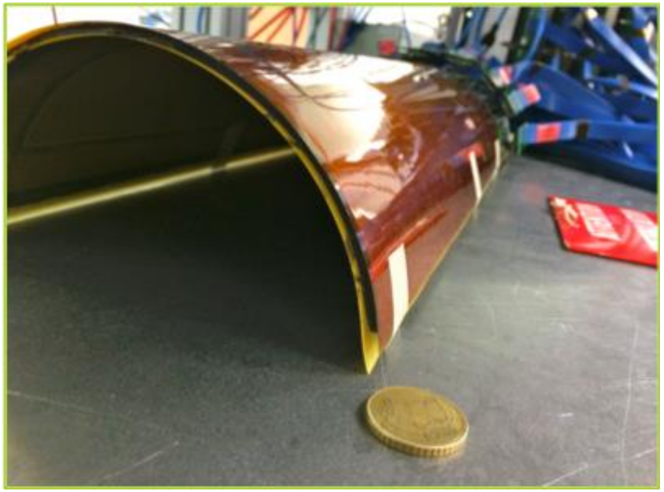
- One MPGD layer in front of DIRC significantly improves momentum resolution
- A second MPGD after DIRC slightly degrades performances because of multiple scattering in DIRC bar
    - However it is not really an issue as this data point is not needed for the momentum



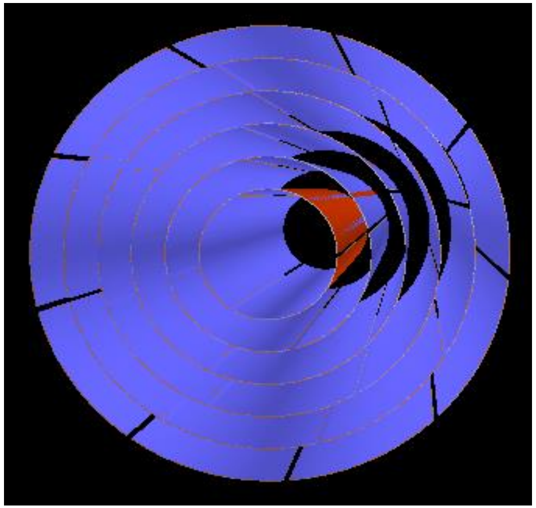
Cylindrical Micromegas

Qinhua Huang, CEA Saclay

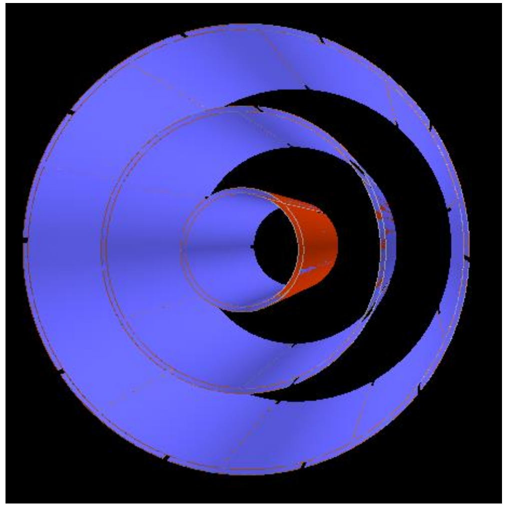
- Barrel MPGD tracker as TPC alternative:
  - Curved MPGD tiles with low material budget
  - Micromegas technology is being used in CLAS12
  - Possibly readout 2D coordinates on a single layer
- Simulation and performance study are under the ePhenix context
  - ePhenix TPC is replaced with the tracker
  - R is from 20 to 80cm, 2 tracker configs are studied



X/X0 ~ 0.3% per layer



6 equidistant layers

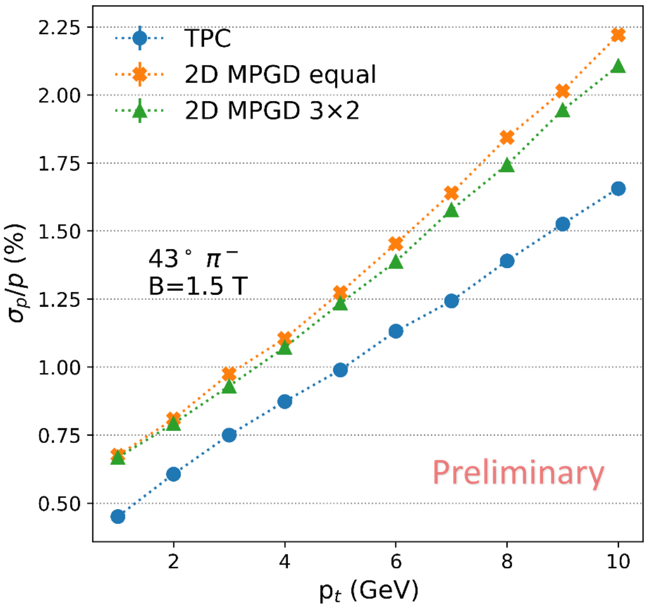


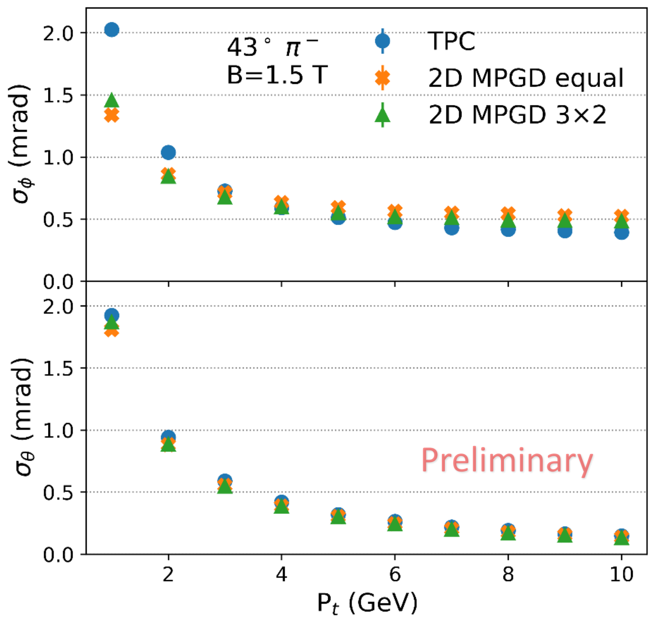
6 layers arranged as 3x2

Cylindrical Micromegas

Qinhua Huang, CEA Saclay

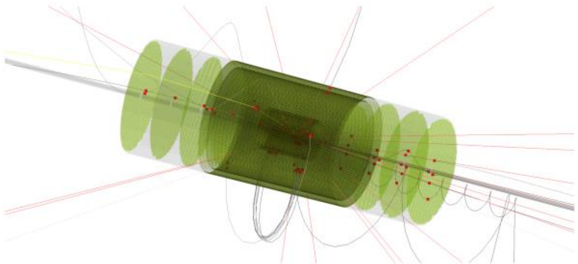
- Compare momentum/angular resolutions at DIRC (r=81.5cm) of different configs
  - Each point contains 10k π^- shot from (0,0,0) and with a constant θ=43°
  - Track reconstruction includes SVTX measurements: σ(R/ϕ/Z)=5μm
  - For TPC: σ(ϕ)=200μm, σ(Z)=500μm
  - For MPGD: σ(ϕ)=150μm, σ(Z)=150μm
- Vigorous R&D ongoing at CEA Saclay to verify a potential improvement of the performance with micro-TPC mode



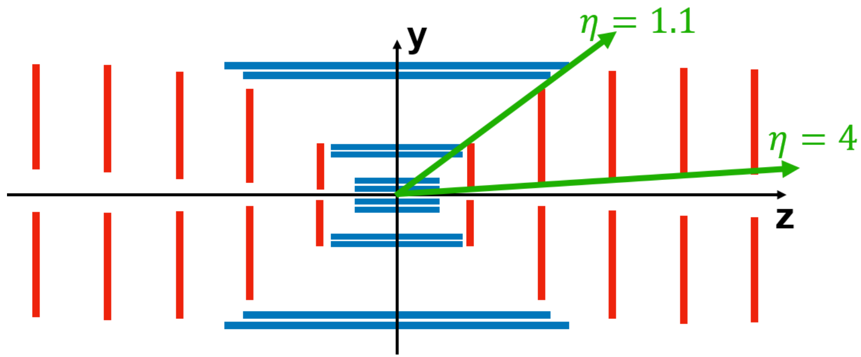


All-silicon angular resolutions

Rey Cruz-Torres, Winston DeGraw - UCB



Tapered All-Si Tracker in Fun4All



Functionality added by Chris Pinkenburg to project momenta onto cylinders or planes

Kalman Filter: PHG4TrackFastSim

Generation (~5M events):
vertex: (0,0,0)
momentum: (0,50 GeV/c)
$|\eta|$: (0,4)
ϕ: (0,2π)

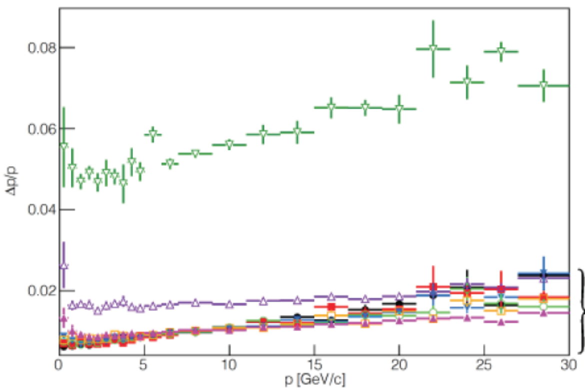
Additional parameters:
generated particle (π^+,π^-,μ^-,e^-)
B field: 1.5, 3.0 T (solenoidal)

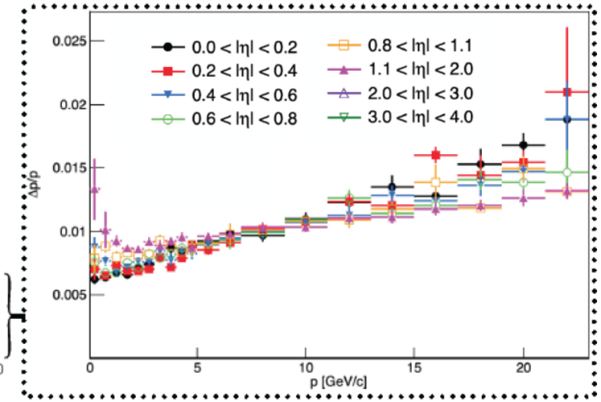
Only the silicon is implemented in the simulation
No support structure/services implemented

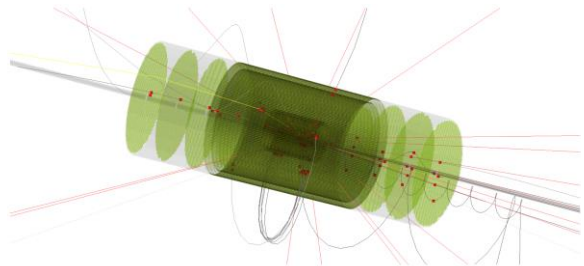
B = 1.5 T, π^-

Relative momentum resolution vs p

Rey Cruz-Torres, Winston DeGraw - UCB

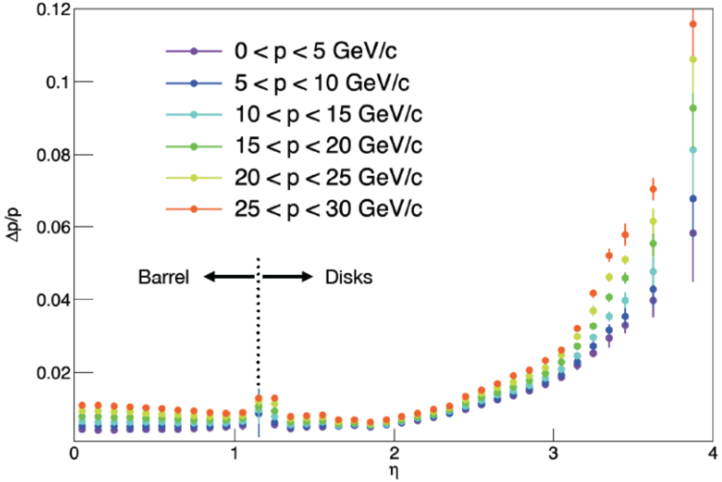




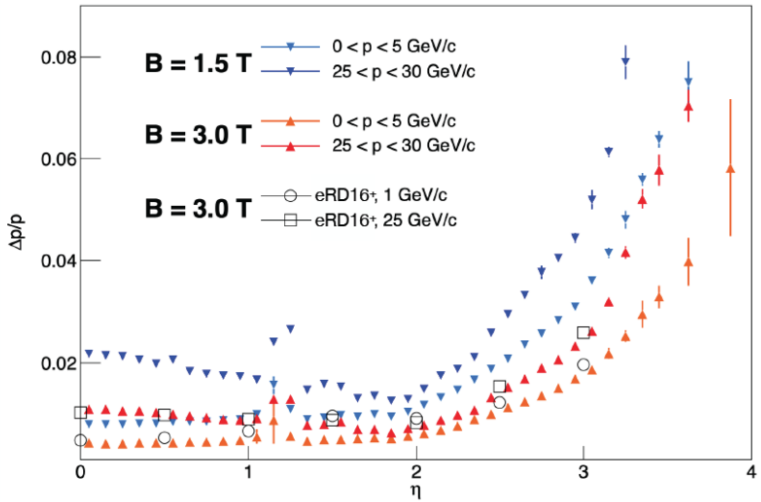


Relative momentum resolution vs η

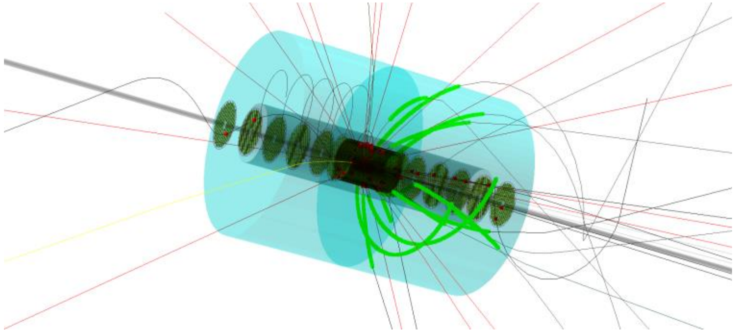
B = 3.0 T, π^-



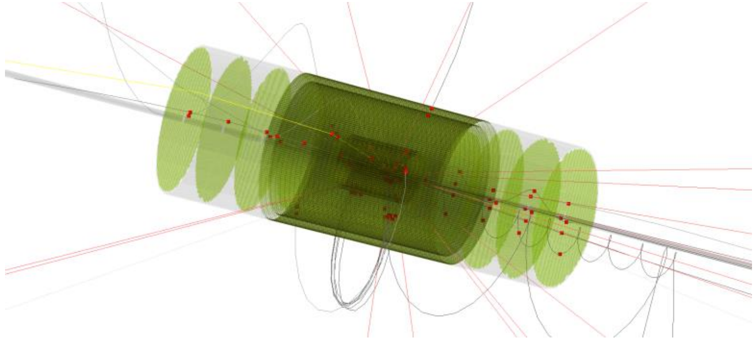
π^-



All-silicon and Si+TPC studies



Beast TPC + Si barrels and disks ("hybrid")



Si barrels and disks ("all silicon")

All-silicon layout:

Two eRD18 vertex layers, seven eRD16 "tapered" equidistant disks in a BeAST configuration, and an ALICE-like outer barrel, in a 3T solenoidal field

<u>In addition:</u>

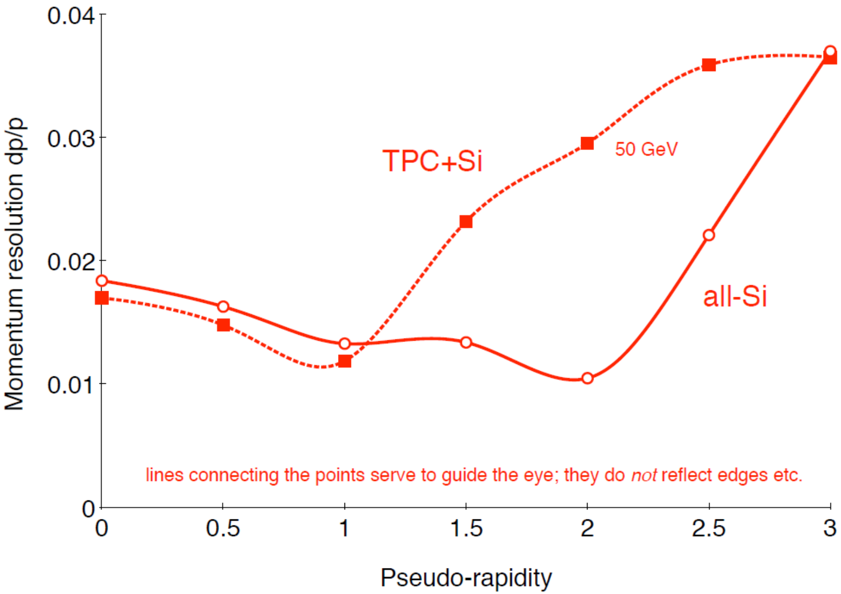
Material cones/cylinders surrounding the disks were implemented to make a start on the effects associated with support structures, read-out infrastructure, etc.

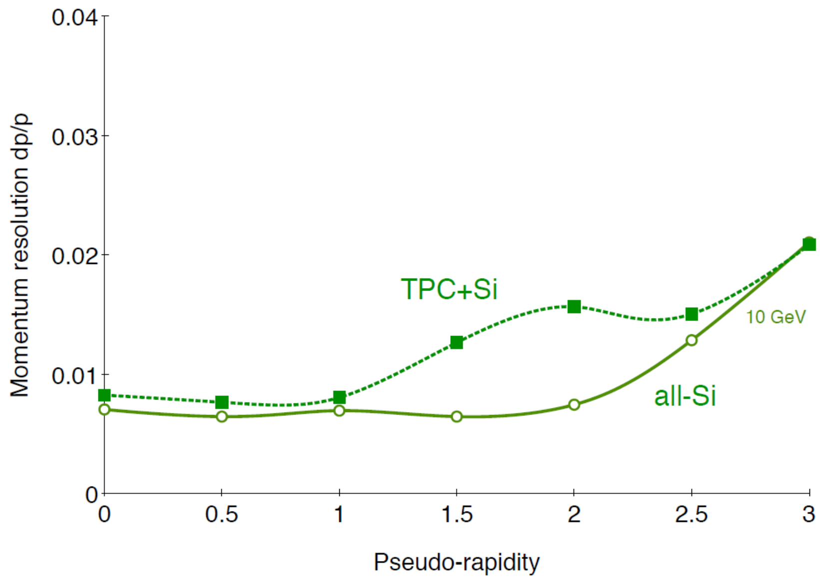
Ernst Sichtermann et al, eRD16

All-silicon and Si+TPC studies

Ernst Sichtermann et al, eRD16

Momentum resolution as a function of pseudo-rapidity

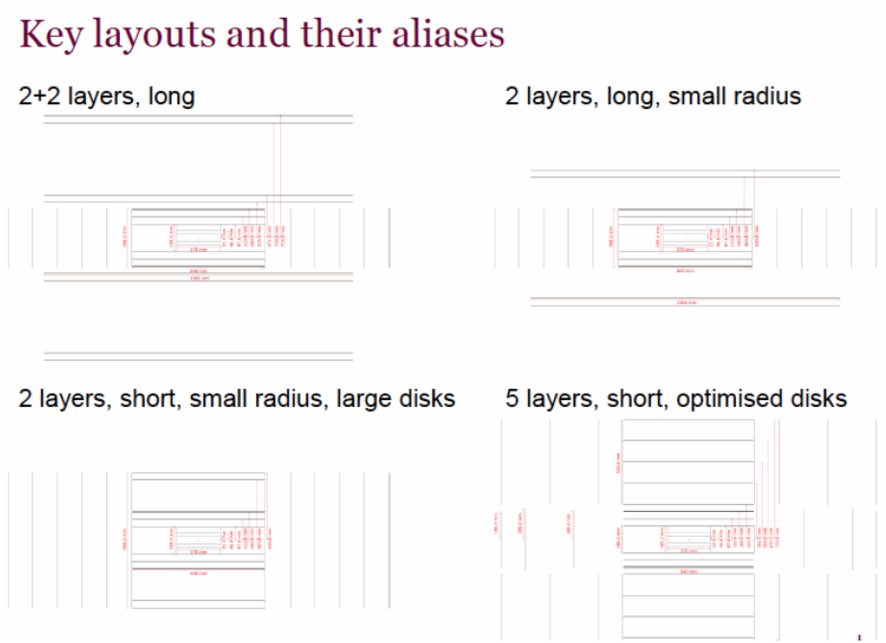


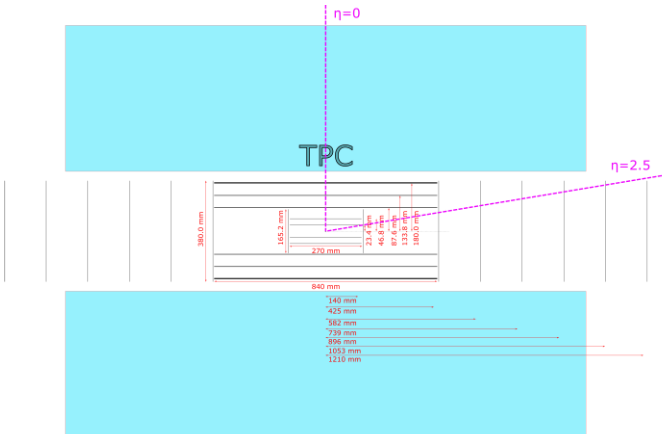


Håkan Wennlöf et al, UoB

All-silicon and Si+TPC studies

- Various all-silicon layouts tested
- Parameters used:
  - Particle: e-
  - Momentum range: 0 to 50 GeV/c
  - Pseudorapidity range: $0 \leq \eta \leq 2.5$
  - Pixel size: 20x20 μm^2
  - Magnetic field: uniform 1.5 T
  - Layer thickness in "TPC replacement": 0.8 $\%X_0$

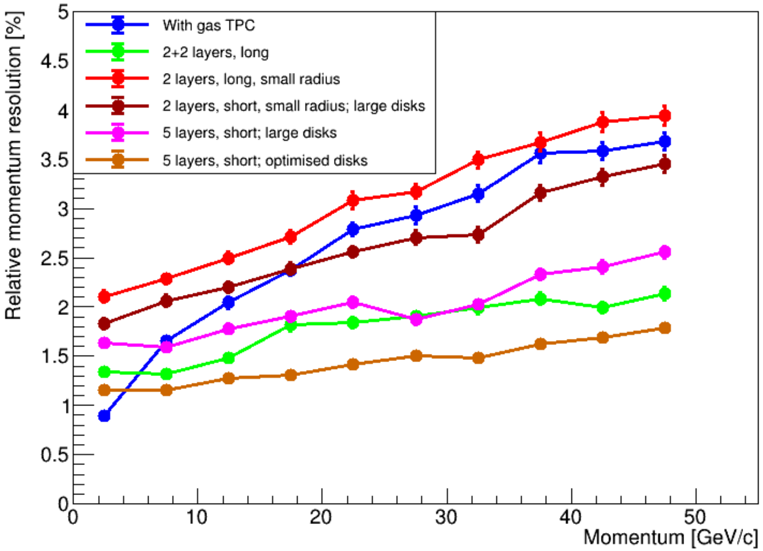




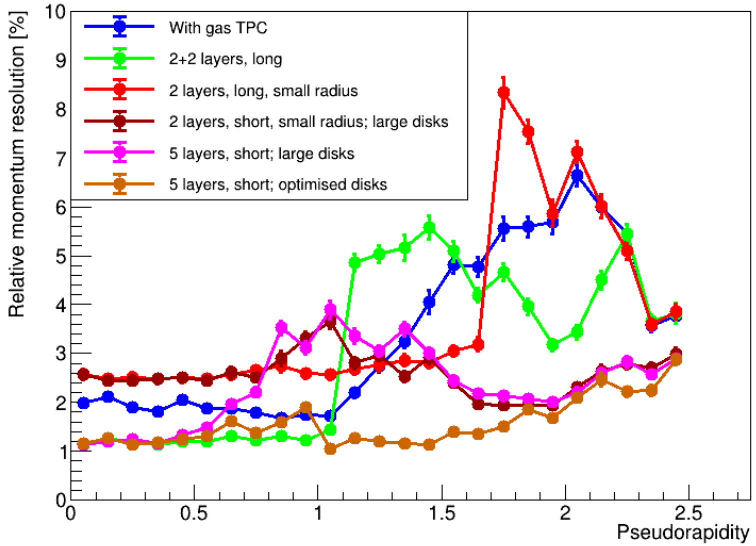
Håkan Wennlöf et al, UoB

All-silicon and Si+TPC studies

Relative momentum resolution vs p



Relative momentum resolution vs η

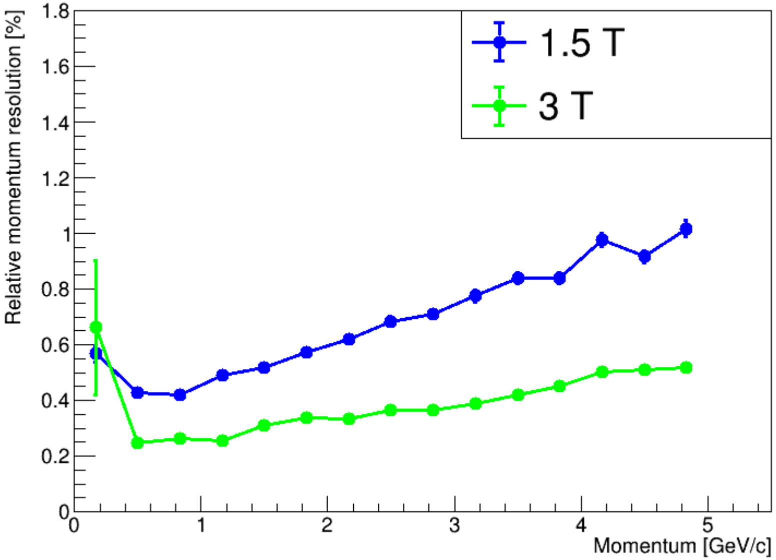


- Large disk coverage is important to keep resolution at higher η
- All-silicon layout can outperform Si+TPC at p≥5 GeV/c
- Pointing resolutions do not change much between layouts, apart when layers are missed

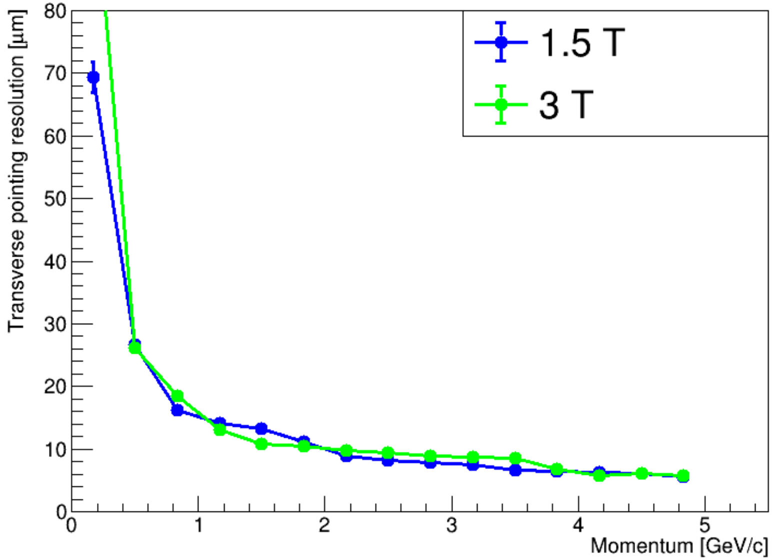
Håkan Wennlöf et al, UoB

All-silicon and Si+TPC studies

Relative momentum resolution



Transverse pointing resolution



- Large improvement in relative momentum resolution
- Little difference in pointing resolutions
  - Transverse pointing resolution gets worse at 3 T at the lowest momenta, due to spiralling