BERKELEY LAB
Bringing Science Solutions to the World

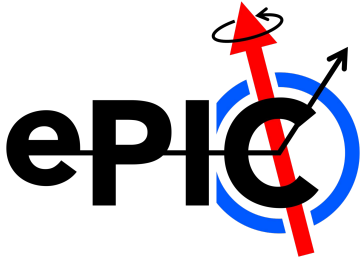
U.S. DEPARTMENT OF ENERGY
Office of Science

ePIC Tracking System

Shujie Li

With many thanks to Ernst Sichtermann and Nicole Apadula

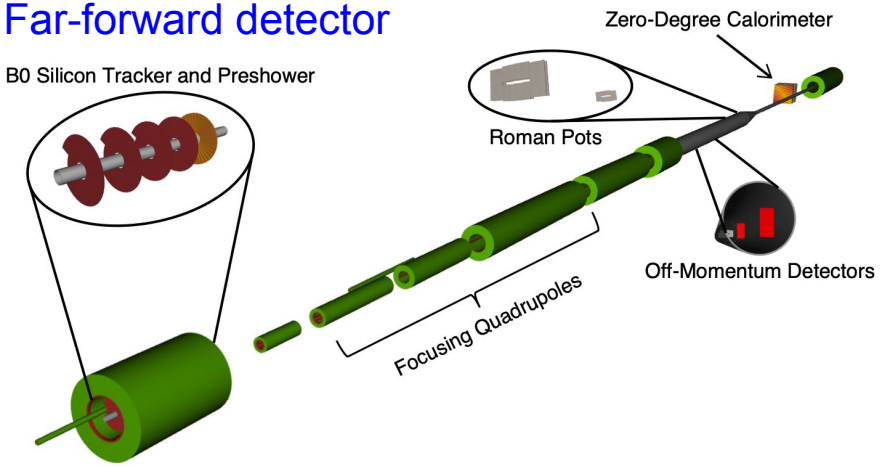
2023 RHIC/AGS Annual Users' Meeting
August 2nd, 2023



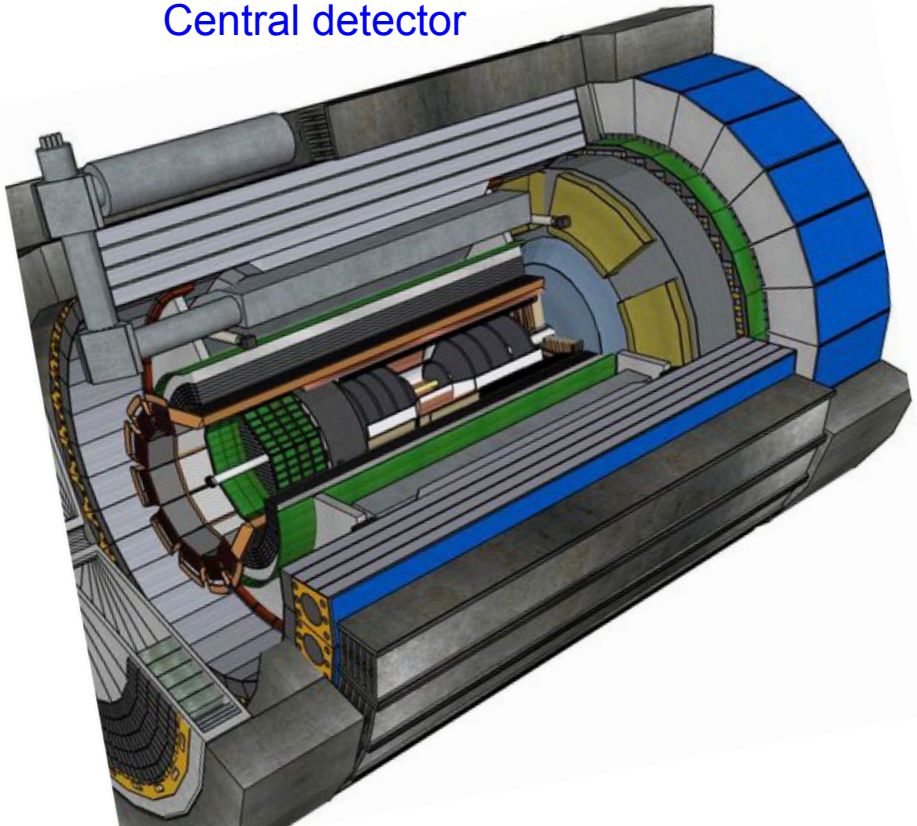
ePIC Tracking System

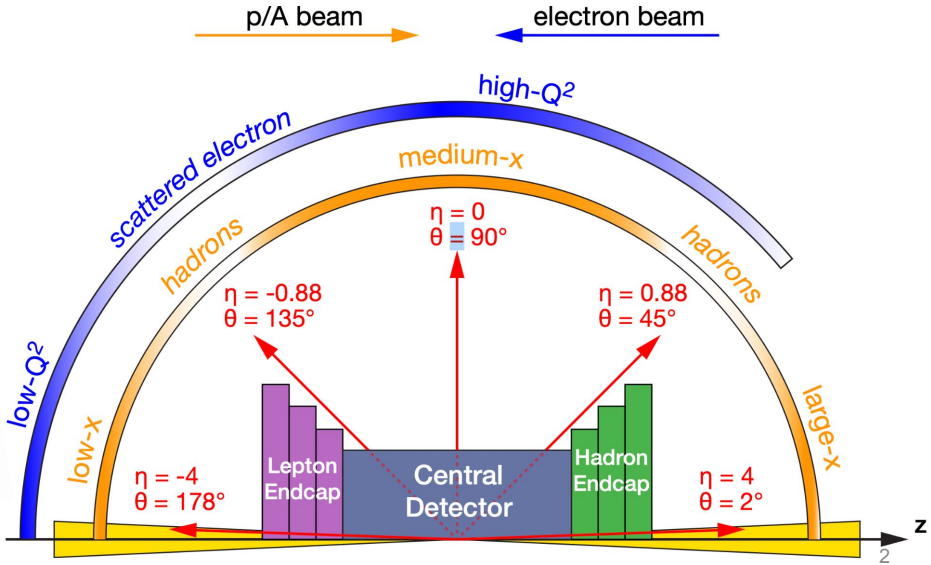
See Alex Jentsch's talk

Far-forward detector

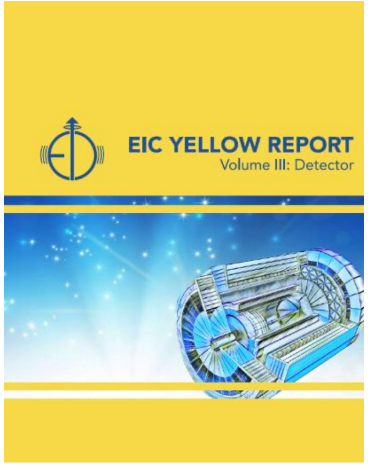


Central detector





Central Tracker Design



- Yellow Report
- Detector 1 proposals
- ePIC:
  - Arches
  - Brycecanyon
  - Craterlake
  - …

Requirements:

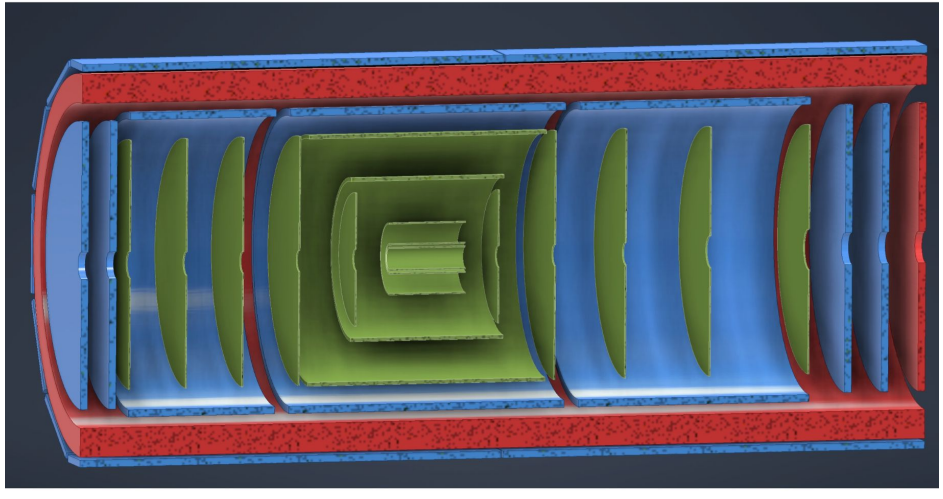
- High pattern recognition efficiency
- High spatial resolution
- Low material budget
- Good time resolution

Technologies:

- Monolithic Active Pixel Silicon (MAPS)
- MicroPattern Gaseous Detector layers (MPGD)
- AC-LGAD ToF (See Satoshi Yano's talk)

Current Tracking Configuration
"Craterlake"

From ePIC tracking WG, June 2023
https://indico.bnl.gov/event/19854/



SVT MPGDs ToF (fiducial volume)

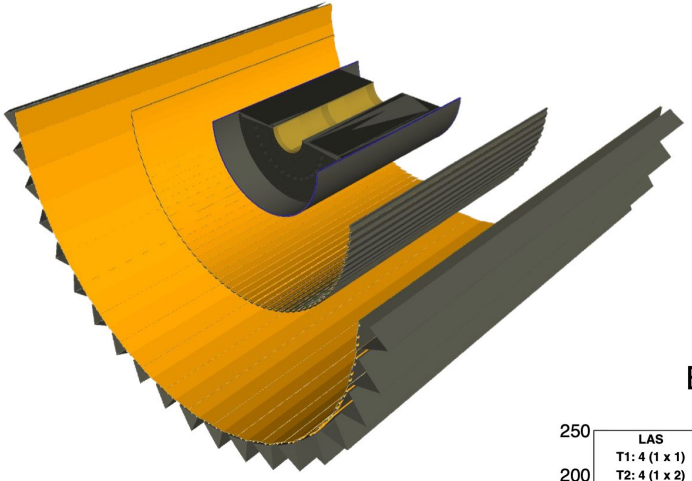
Silicon trackers:
- 3 vertex barrels
- 2 outer barrels
- 5 disks (forward/backward)

MPGDs:
- Inner barrel (forward/central/backward)
- Outer barrel (MPGD+DIRC)
- 2 disks (forward/backward)

AC-LGAD ToF:
- 1 forward disk
- 1 barrel

Silicon Vertex Tracker (SVT)

High spatial resolution for charged particle tracking
Low material budget

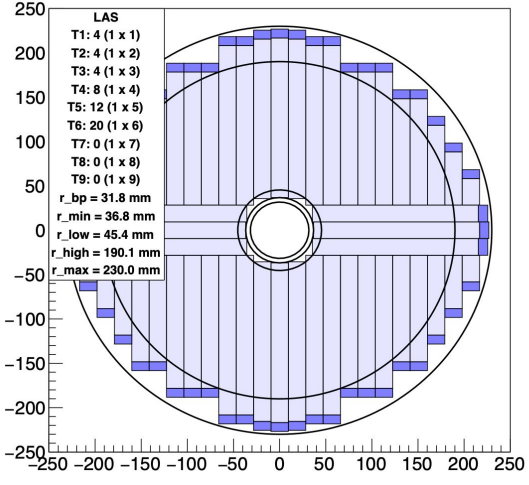


- 3 inner vertex barrels
  - ITS3, 65nm MAPS sensor
  - 20x20um pixels
  - 0.05% X/X0
- 2 outer barrels
  - ITS2 staves
  - 0.55% X/X0
- 5 disks (forward/backward)
  - ITS2
  - 0.24% X/X0

Ongoing R&D:

- eRD104: readout and power
- eRD111: mechanical structure and cooling
- eRD113: sensor characterization

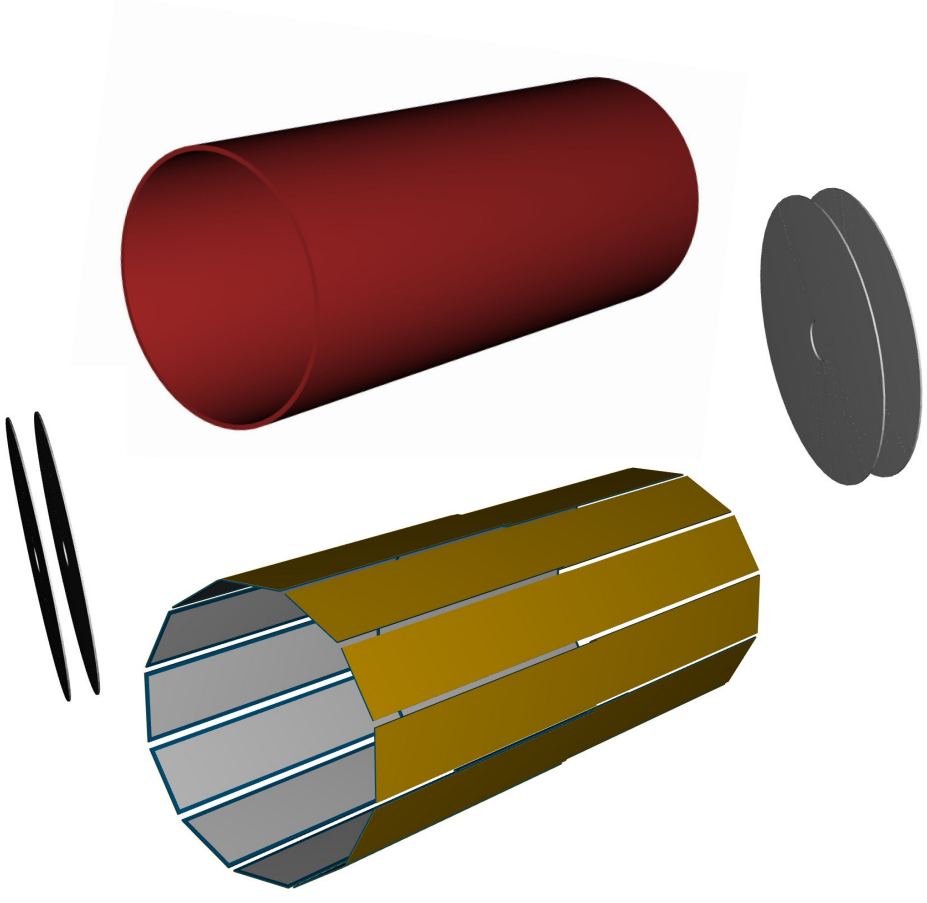
Example: ED0/HD0

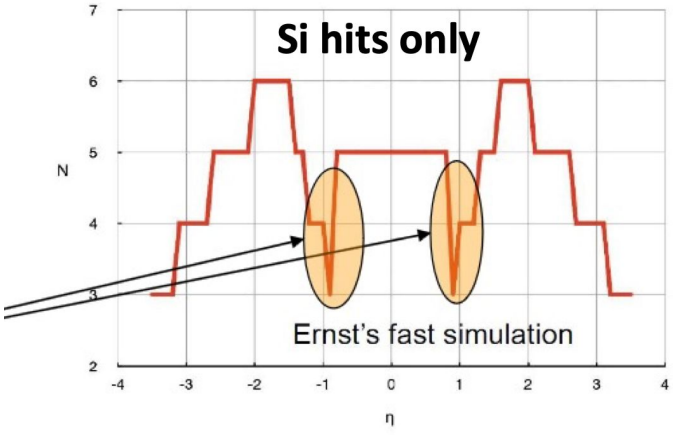


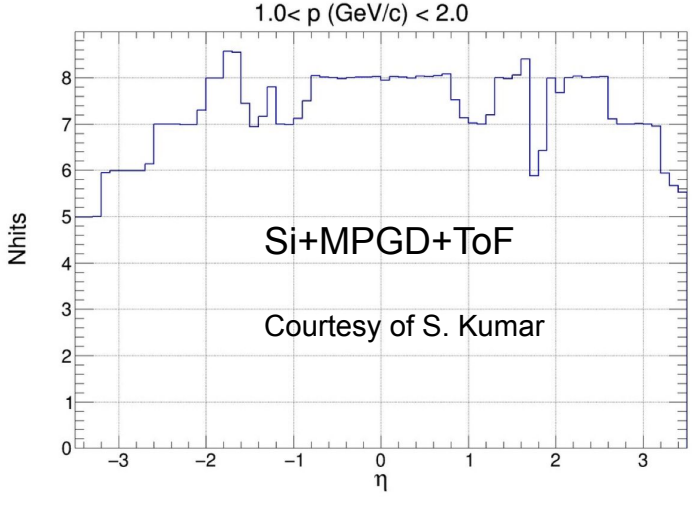
MPGD

Additional hits for pattern recognition

Fast timing info for signal/background separation

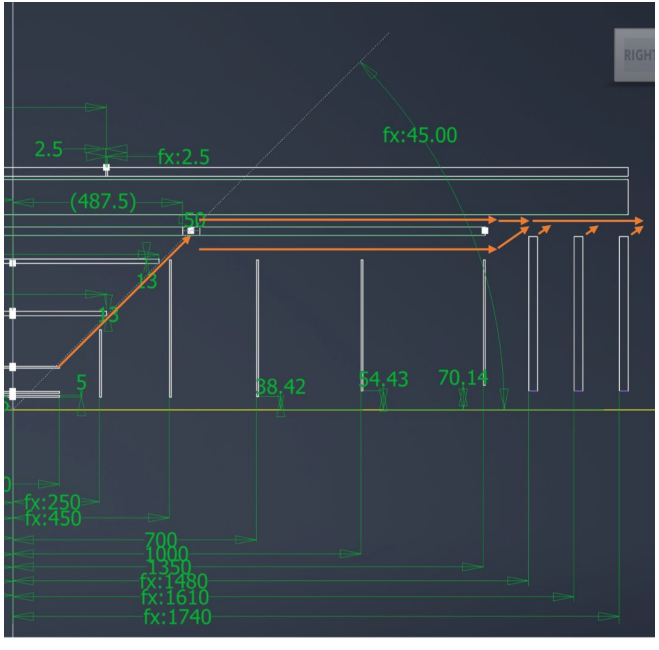






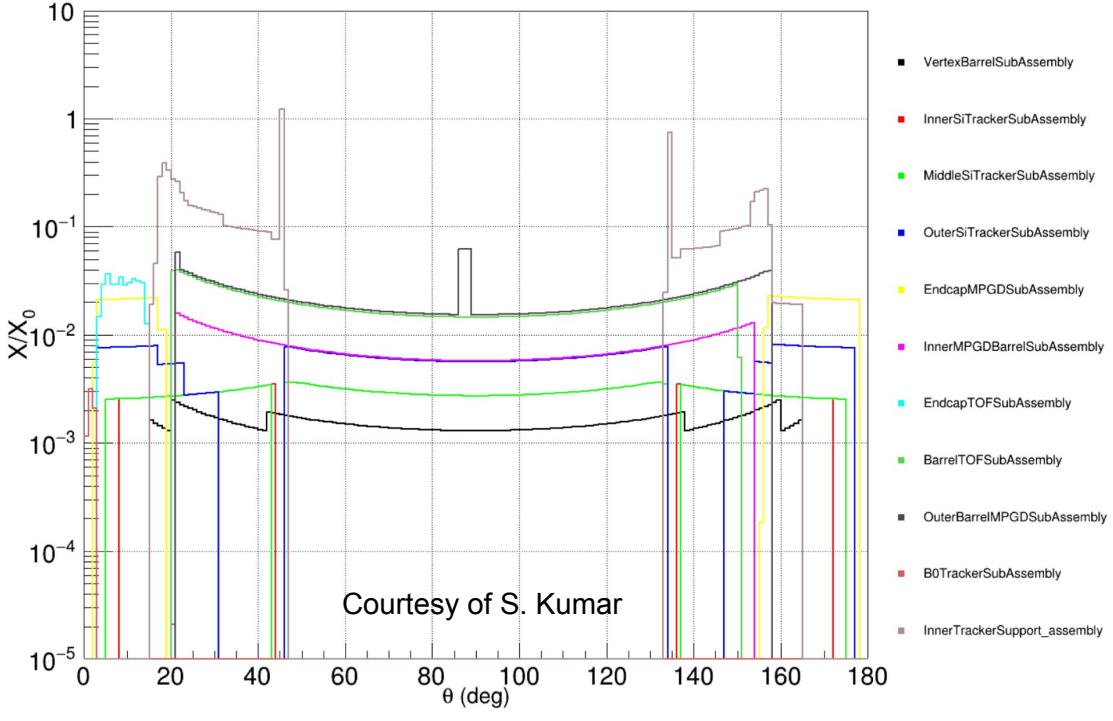
Services and Materials

Cables guided out along the carbon supporting cone



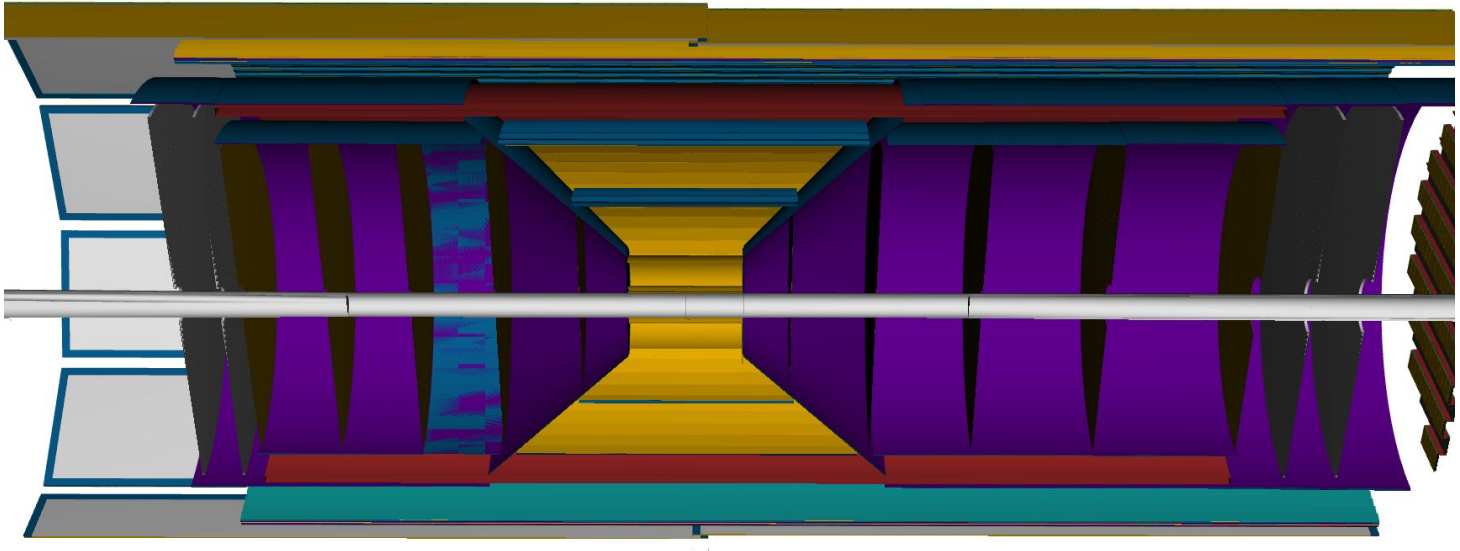
Courtesy of E. Sichtermann

Material Scan



Geometry in DD4hep Simulation

- Version 23.07 (Craterlake) for July simulation campaign
  https://github.com/eic/epic/tree/main
- Up-to-date geometry with detailed material descriptions
- Simplified disk geometry (trapezoid instead of staves)
- Use effective thickness of cables assuming uniform azimuthal distribution



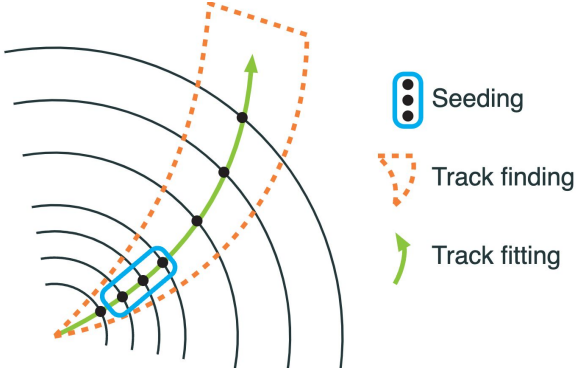
Track Reconstruction

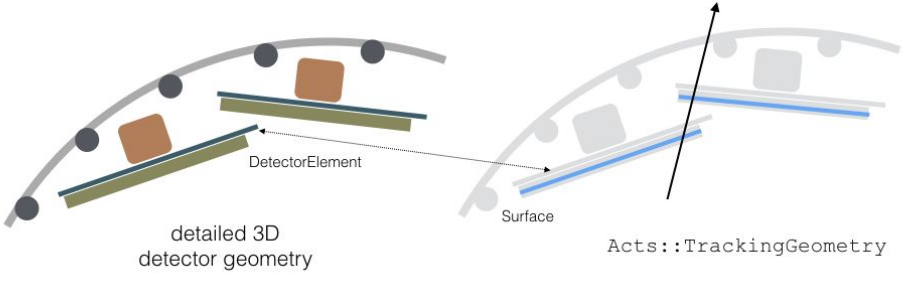
- Reconstruction Framework (**EICrecon** http://eicrecon.epic-eic.org/)
  - Hits digitization
  - Track finding/fitting:

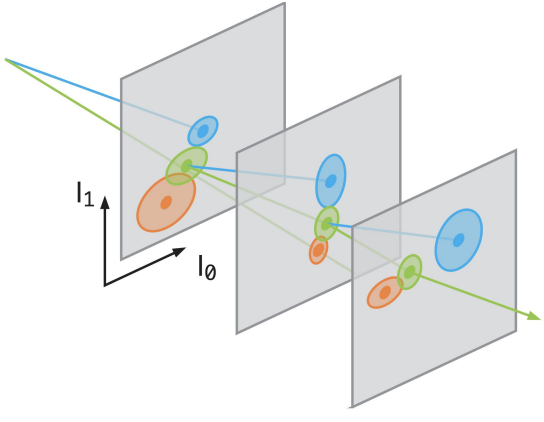
arXiv:1910.03128

A Common Tracking Software

- **Combinatorial Kalman Filter (CKF)**
  - Combined track finding and fitting
  - Realistic seeder to provide initial guess



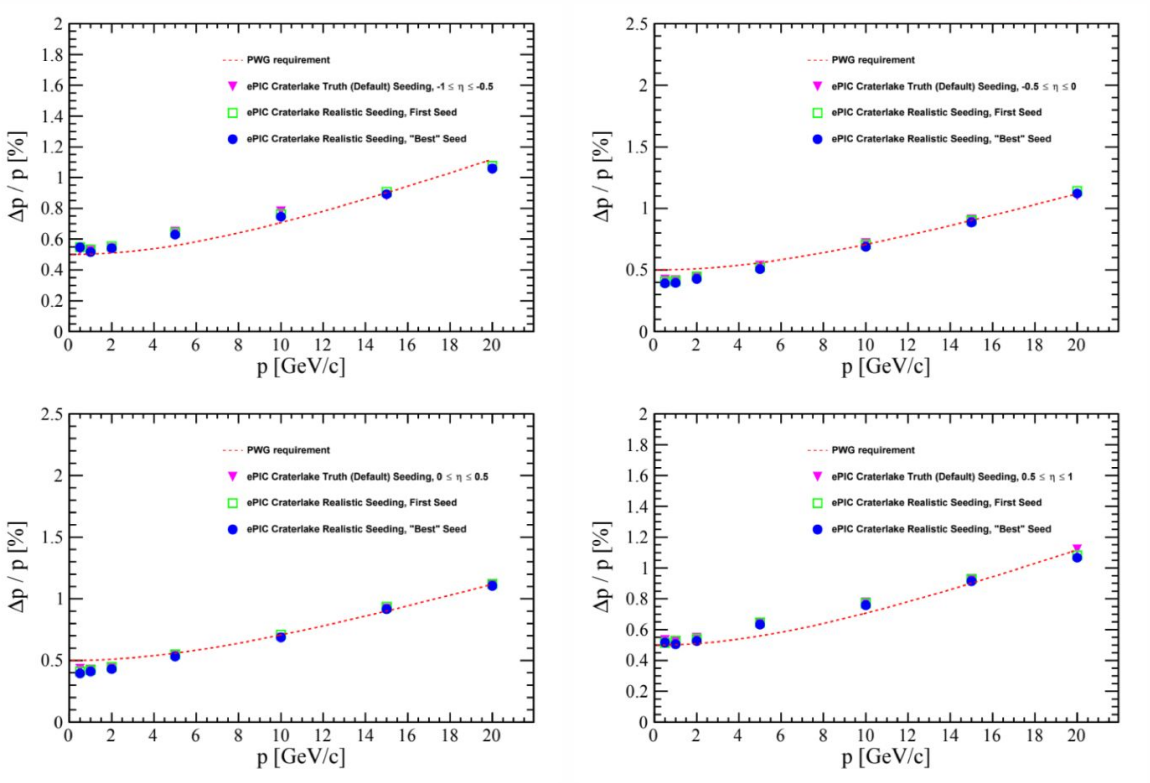




Performance Study

- Single pion events to study the momentum resolution dp/p
- no background
- Realistic seeding v.s. Truth seeding

Mid-rapidity: eta bins: -1, -0.5, 0, 0.5, 1

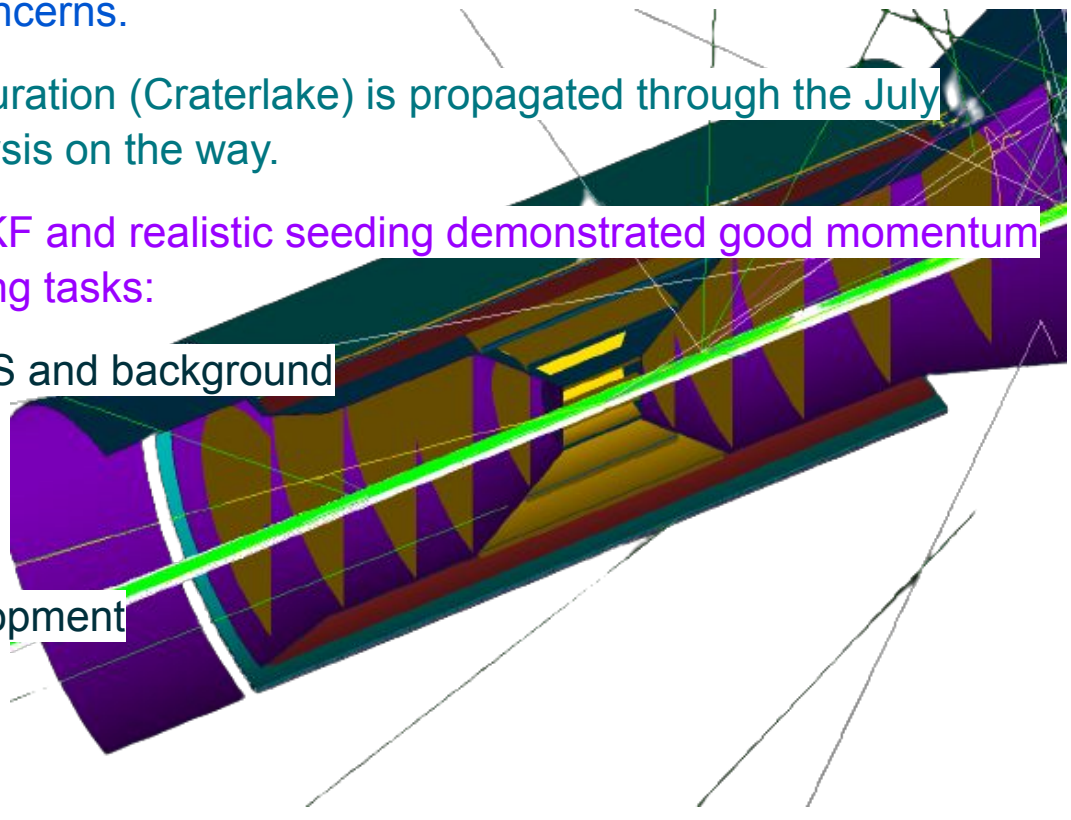


Courtesy of S. Maple

See https://indico.bnl.gov/event/20126/ for details

Summary

- ePIC tracking system combines MAPS and gas detector technologies to fulfill EIC physics requirements. The actual configuration is under development, with several R&D projects to address technical concerns.
- The most recent tracking configuration (Craterlake) is propagated through the July simulation campaign, data analysis on the way.
- The track reconstruction with CKF and realistic seeding demonstrated good momentum and angular resolutions. Ongoing tasks:
  - Performance study with DIS and background
  - Vertexing and PID
  - Use timing information
  - Far-forward tracking development



Backups

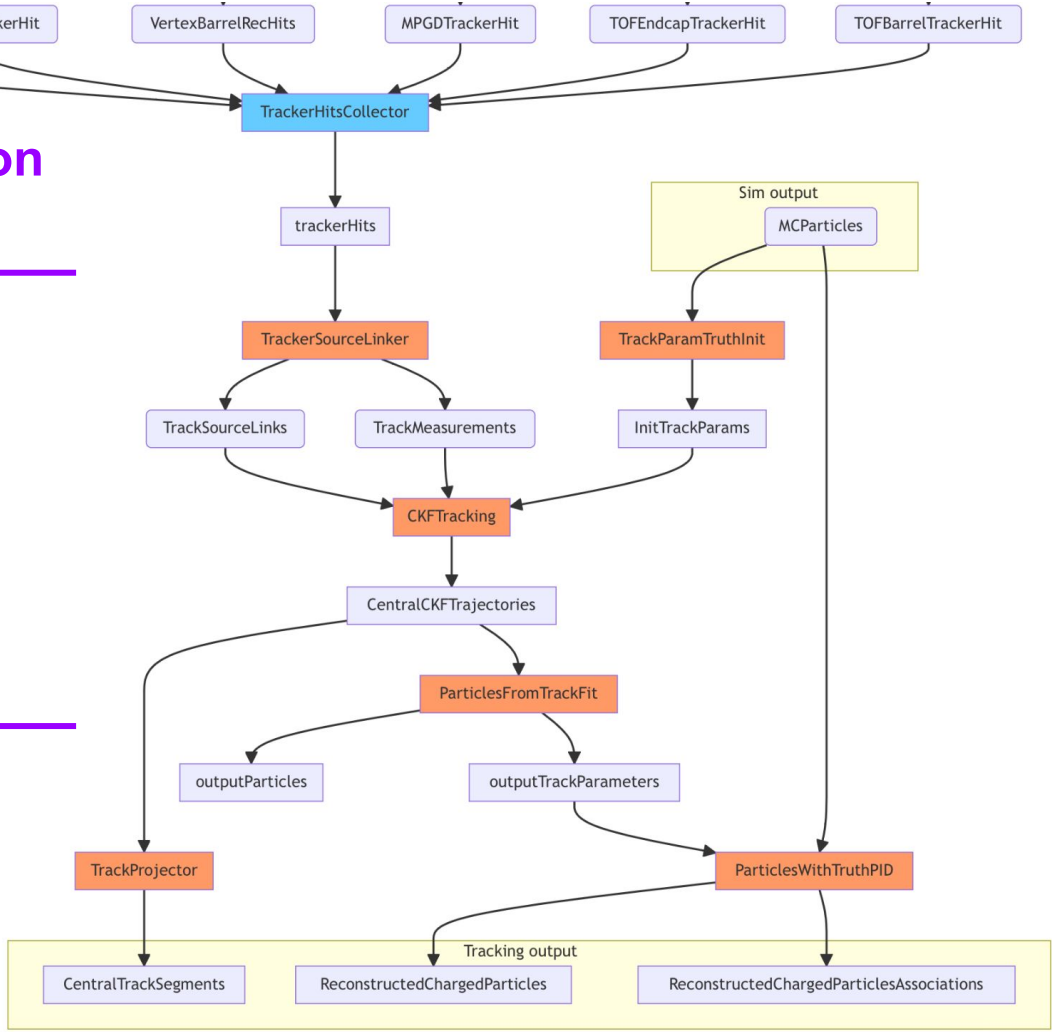
Track Reconstruction in EICrecon

Full diagram at https://eic.github.io/EICrecon/#/design/tracking?id=full-diagram

Space point formation

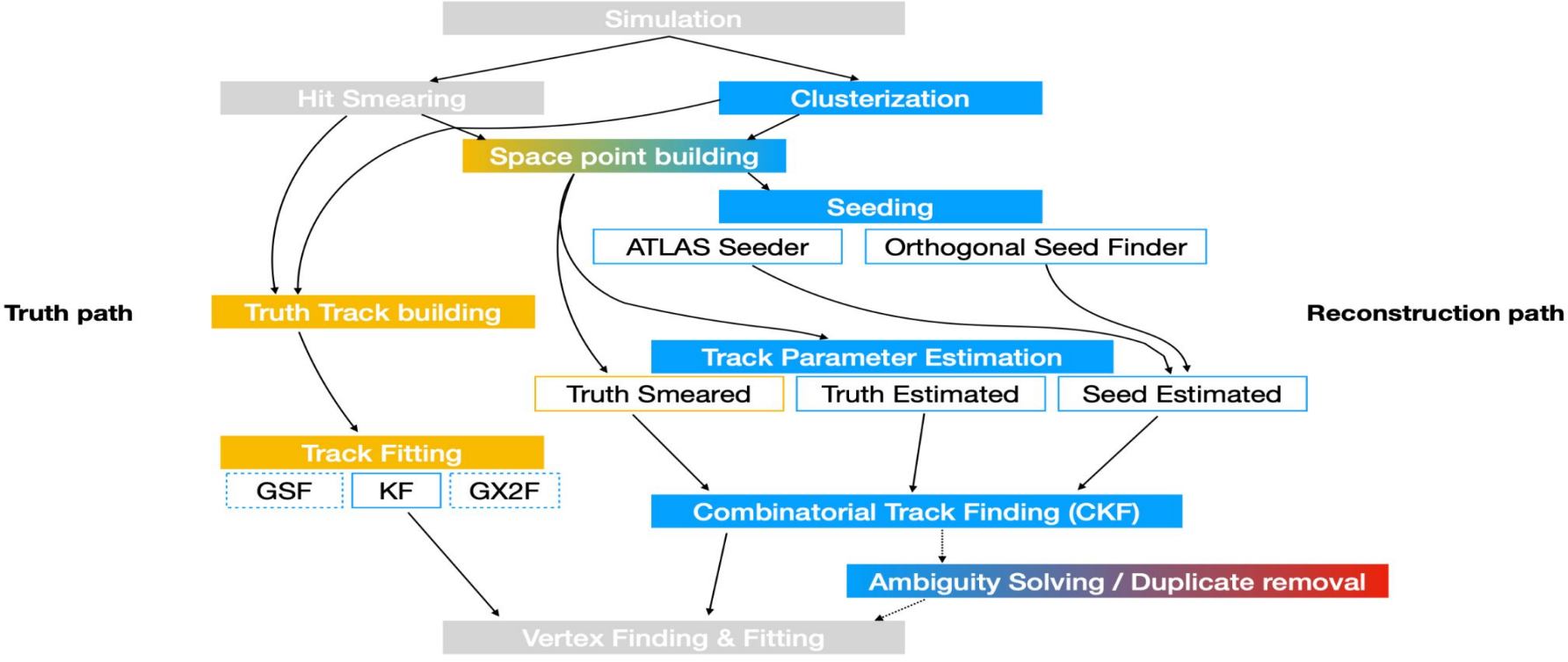
Track finding/fitting with

Track info in output



ACTS: Core Functionality

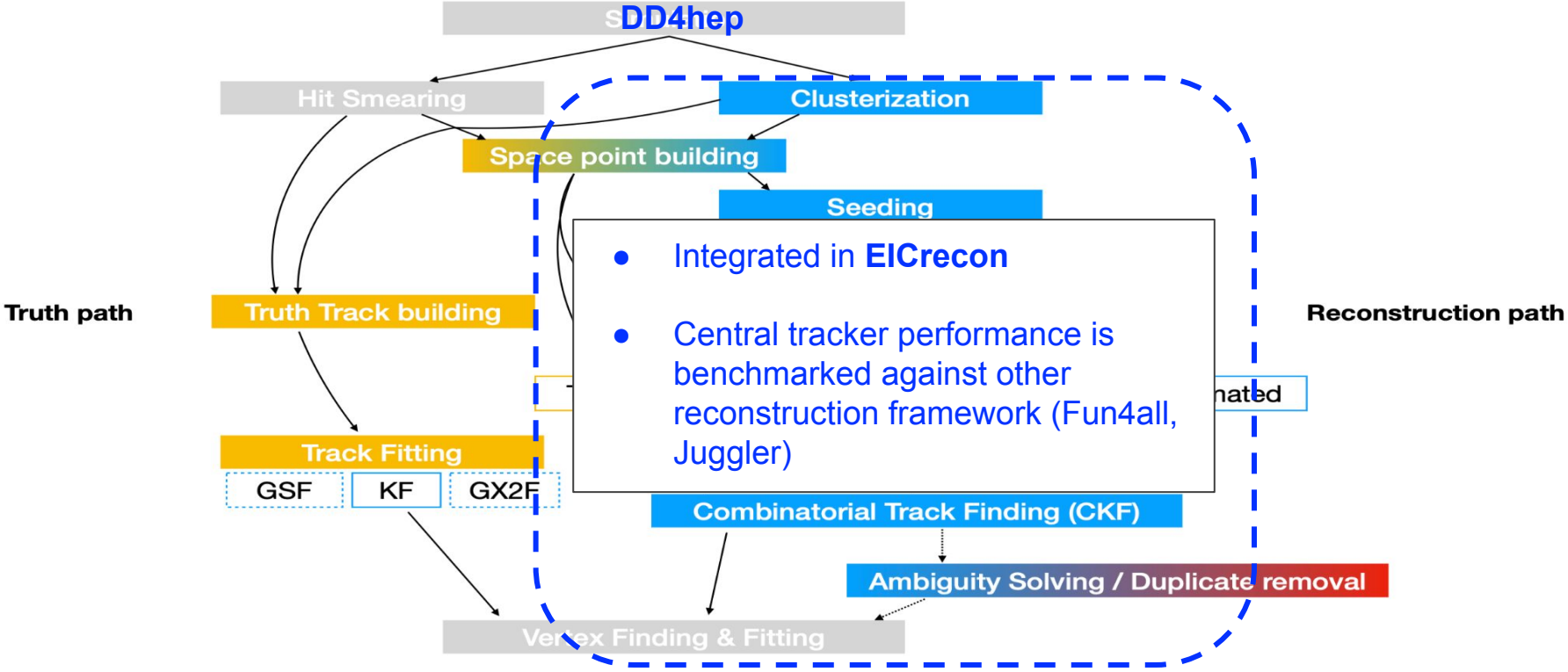
https://acts.readthedocs.io/en/latest/index.html



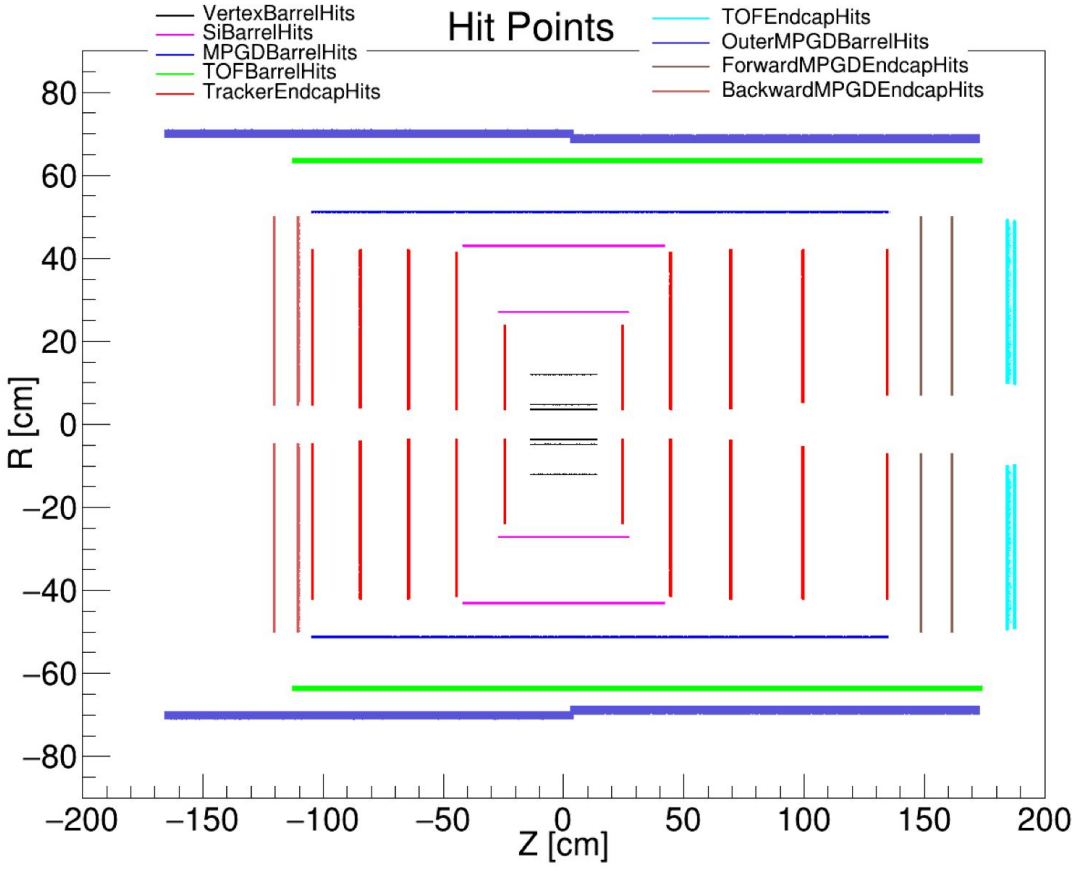
courtesy of A. Salzburger

ACTS for ePIC

https://github.com/eic/EICrecon

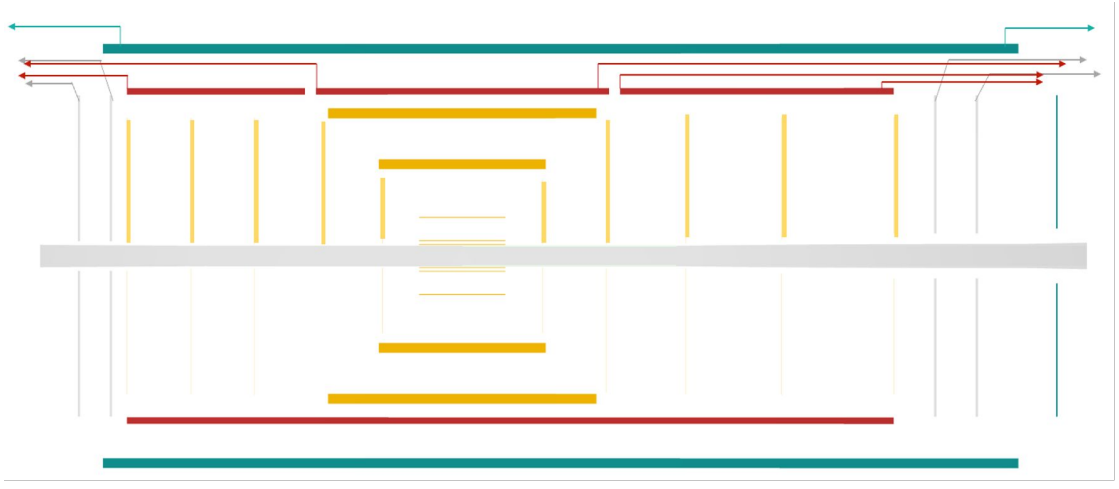


courtesy of A. Salzburger


Hit Points
VertexBarrelHits
SiBarrelHits
MPGDBarrelHits
TOFBarrelHits
TrackerEndcapHits
TOFEndcapHits
OuterMPGDBarrelHits
ForwardMPGDEndcapHits
BackwardMPGDEndcapHits
R [cm]
Z [cm]
80
60
40
20
0
−20
−40
−60
−80
−200
−150
−100
−50
0
50
100
150
200

MPGD Services

	Al Thickness (cm)
(BE1 + BE2 + IB1 + IB2 + OB1) z < -167.5	0.850
(BE1 + BE2 + IB1 + IB2) -167.5 < z < -120	0.574
(BE1 + IB1 +IB2) -120 < z < -110	0.443
(IB1 +IB2) -110 < z < -105	0.312
(IB2) -105 < z < -48.75	0.156
() -48.75 < z < 48.75	0.000
(IB3) 48.75 < z < 53.75	0.156
(IB3 + IB4) 53.75 < z < 135	0.312
(IB3 + IB4+IB5) 135 < z < 148	0.468
(IB3 +IB4 +IB5 + FE1) 148 < z < 161	0.599
(IB3 +IB4 +IB5 + FE1 +FE2) 161 < z < 174	0.730
(IB3 +IB4 +IB5 + FE1 +FE2 + OB2) 174 < z	1.006



https://indico.bnl.gov/event/20126/contributions/78817/attachments/48721/82868/GeometryandSevices.pdf

Crater Lake (23.07.2)

Negative Endcap Region

	Z-position	Rmin	Rmax
Si Disk (1)	-250 mm	36.76 mm	240 mm
Si Disk (2)	-450 mm	36.76 mm	415 mm
Si Disk (3)	-650 mm	36.76 mm	421.4 mm
Si Disk (4)	-850 mm	40 mm	421.4 mm
Si Disk (5)	-1050 mm	46.35 mm	421.4 mm
MPGD Disk (1)	-1100 mm	46.5 mm	500 mm
MPGD Disk (2)	-1200 mm	46.5 mm	500 mm

Central Region

Detector	Z min	Z max	R
Si Vertex (1)	-240 mm	240 mm	36 mm
Si Vertex (2)	-240 mm	240 mm	48 mm
Si Vertex (3)	-240 mm	240 mm	120 mm
Si Barrel (1)	-260 mm	260 mm	270 mm
Si Barrel (2)	-420 mm	420 mm	430 mm
Inner MPGD Barrel	-1050 mm	1350 mm	510 mm
Barrel ToF	-1125 mm	1740 mm	630 mm
Outer MPGD Barrel	-1740 mm	1675 mm	695 mm

Positive Endcap Region

	Z-position	Rmin	Rmax
Si Disk (1)	250 mm	36.76 mm	240 mm
Si Disk (2)	450 mm	36.76 mm	415 mm
Si Disk (3)	700 mm	38.46 mm	421.4 mm
Si Disk (4)	1000 mm	53.43 mm	421.4 mm
Si Disk (5)	1350 mm	70.14 mm	421.4 mm
MPGD Disk (1)	1480 mm	70.14 mm	500 mm
MPGD Disk (2)	1610 mm	70.14 mm	500 mm
ToF Disk	1870 mm	85 mm	500 mm