Material budget and Integration with Far-forward area

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Outline

- Material budget (kick-off discussions at Pavia Meeting in May)
- Far-forward area

Material budget

Requirements: Taking into account that EIC is a low-energy machine (compared to HEP accelerators at LHC/HERA/RHIC) , we need as less as possible material at all directions !

EIC-HANDBOOK:

3.2 Detector Goals

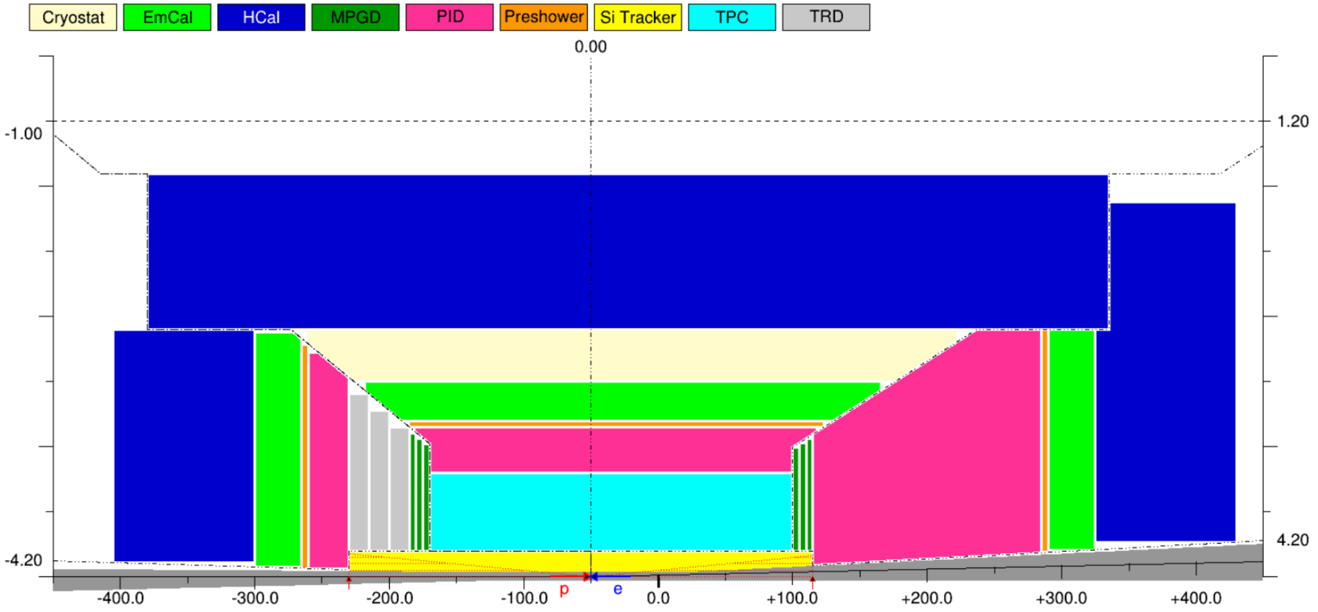
In the previous section we listed the requirements that can be derived from the key physics measurements at an EIC in terms of rapidity coverage, momentum reach, and electron, photon, and hadron identification. What evolves is a detector with the following key features:

- Hermetic coverage, close to 4π acceptance (pseudo-rapidity range up to ±4)
- Low material budget on the level of 3-5% of X/X_0 for the central tracker region
- Tracking momentum resolution in few % range
- Reliable electron ID
- Good π/K/p separation in forward direction up to ~50 GeV/c
- High spatial resolution of primary vertex on the level of <20 microns

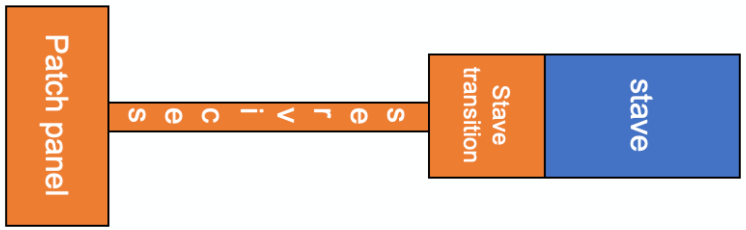
Reality: For all sensitive detectors we have to take into account support structures, we have to pull in/out data cables, high and low voltage cables, cooling and gas pipes.

Material budget

- Impact of a material budget on momentum resolution (or on Q2, inv mass, etc)
- Impact of material budget on the performance of the following sub-detector components.
- Impact on the low-momenta particles
- Minimize unwanted photon conversion in front of calorimeter
- Keep in mind an asymmetric beam energy setting at EIC (example, 5x100 GeV) : energy boost towards hadron-endcap.
- Include support structures, cooling and gas pipes , high and low voltage cabling, readout cables
- Find a way how to properly move out those cables/pipes (between the cracks)

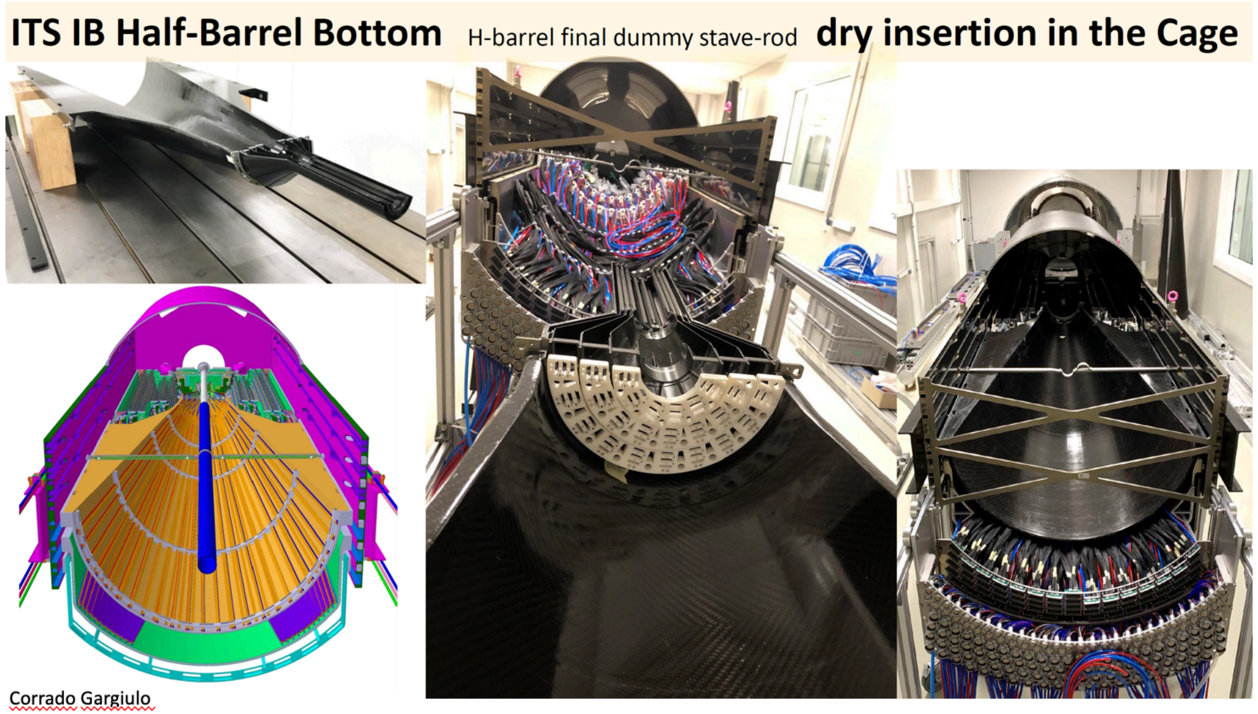


Vertex (most inner detector)



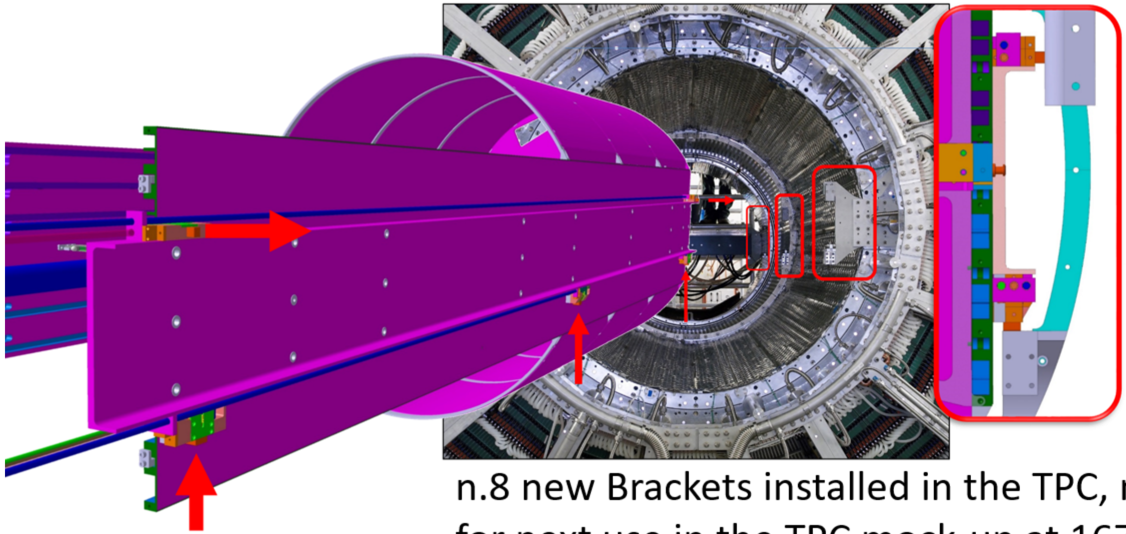
Leo Greiner
(see his talk
at Pavia meeting

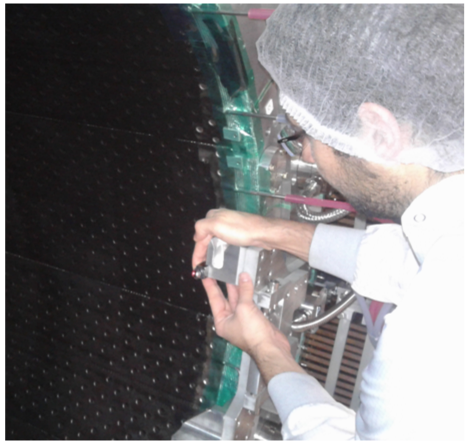
	Stave X/X0	Stave transition (per 100 cm^2 of Si surface)	Services (per 100 cm^2 of Si surface)	Patch panel (per 100 cm^2 of Si surface)
ITS3 like vertexing	~0.1%	6.66 cm^3 of material with X/X0 of 0.031 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.002 per traversed cm	4.32 cm x 1cm x 1 cm with 0.03423 X/X0 per traversed cm
ITS3 like barrel (up to 1.5m length)	0.55 %	4.286 cm^3 of material with X/X0 of 0.0306 per traversed cm	1.905 cm^2 cross section with X/X0 of 0.002 per traversed cm	2.778cm x 1cm x 1 cm with 0.03423 X/X0 per traversed cm
ITS3 like disc (up to 60 cm diameter)	0.24%	6.66 cm^3 of material with X/X0 of 0.031 per traversed cm	2.96 cm^2 cross section with X/X0 of 0.002 per traversed cm	4.321 cm x 1cm x 1 cm with 0.03423 X/X0 per traversed cm



Cage Insertion Test in the TPC @ P2

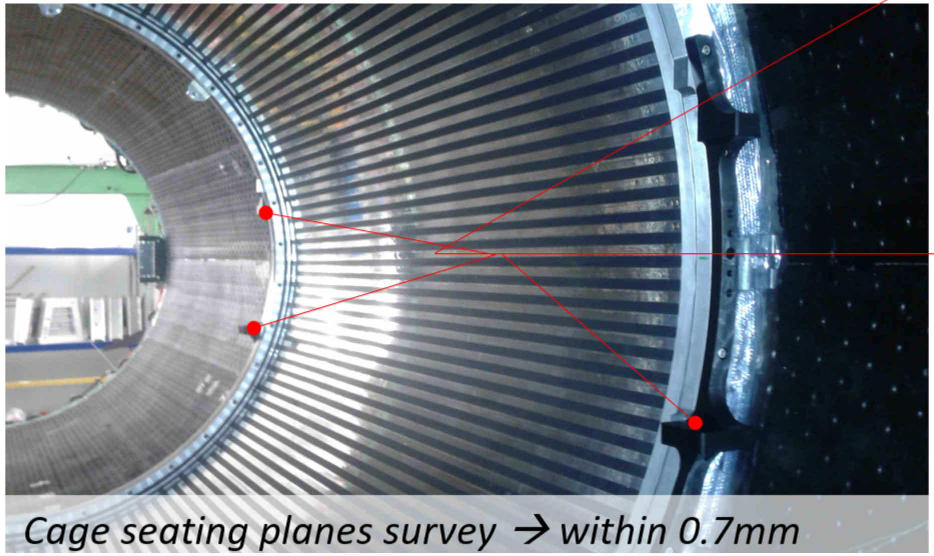
New Cage/TPC brackets fit check and positions survey → done WK50

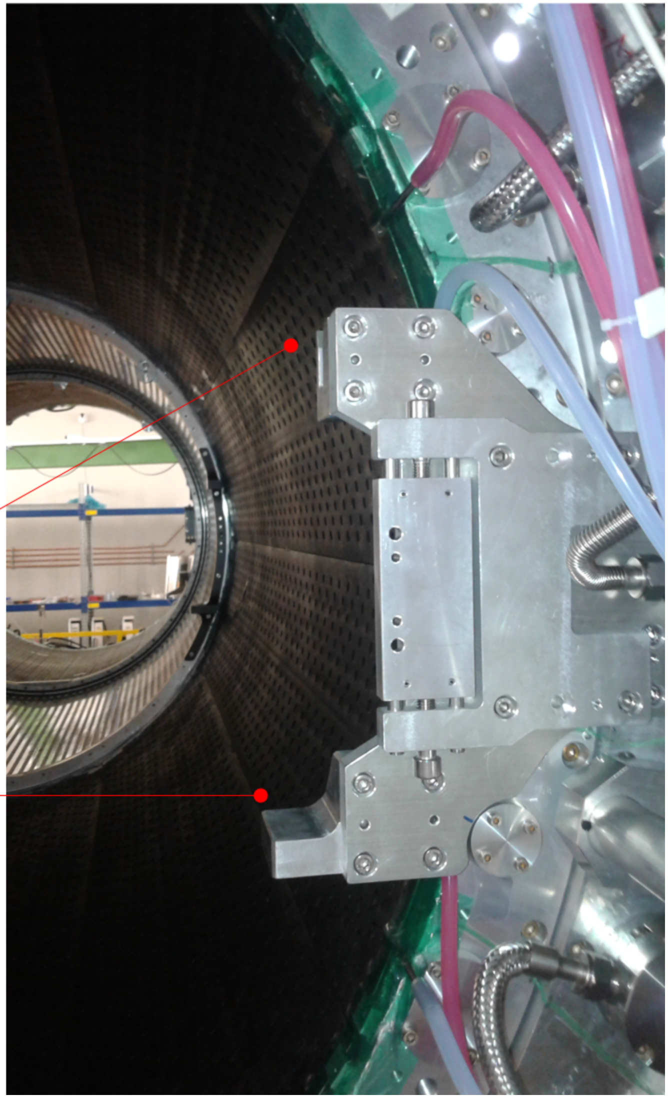




n.8 new Brackets installed in the TPC, measured and dismounted for next use in the TPC mock-up at 167


Survey


Cage seating planes survey → within 0.7mm



Corrado Gargiulo

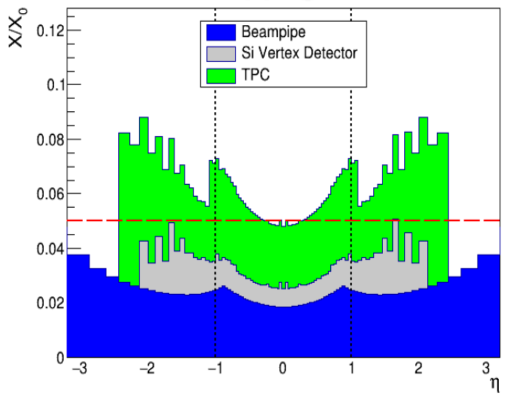
Tracking

Qinhua Huang for CEA Saclay'sEIC group

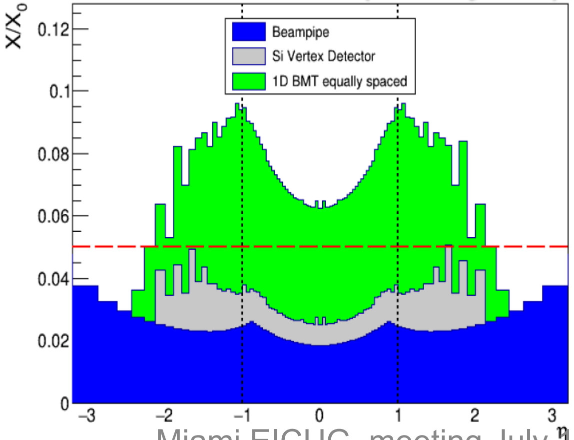
Material budget

- Material scan for TPC, 1D and 2D readout MPGD trackers
- N.B. Handbook requires a X/X0<5% for central tracker
- 2D readout can achieve this goal

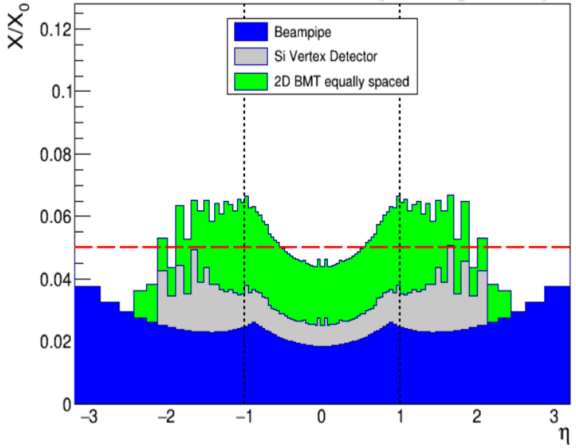
TPC



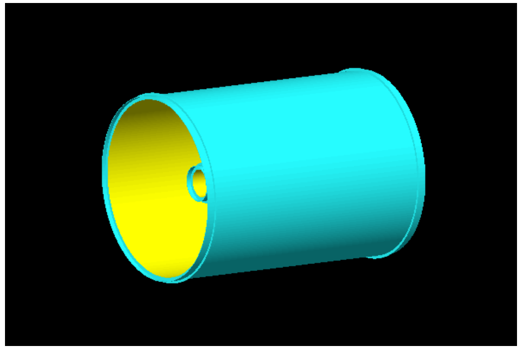
MPGD 1D RO (12 layers)



MPGD 2D RO (6 layers)

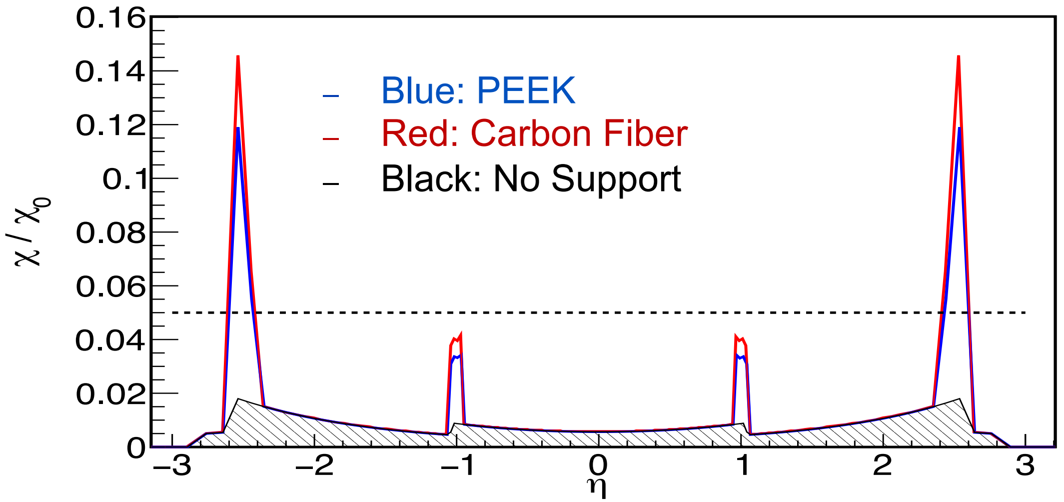


M. Posik, eRD6/ Micro-Rwell Trackers



- Support Ring Structure Geometry
  - Tube: thickness = 0.5 cm, length = 7.2 cm
  - Ring (inner): thickness = 1.6 cm, length = 1.2 cm
  - Ring (outer): thickness = 0.5 cm, length = 1.2 cm
- Material Scan
  - 2 micro-Rwell cylinders
    - Inner det. radius = 12.5 cm (length = 120 cm)
    - Outer det radius = 80.0 cm (length = 200 cm)

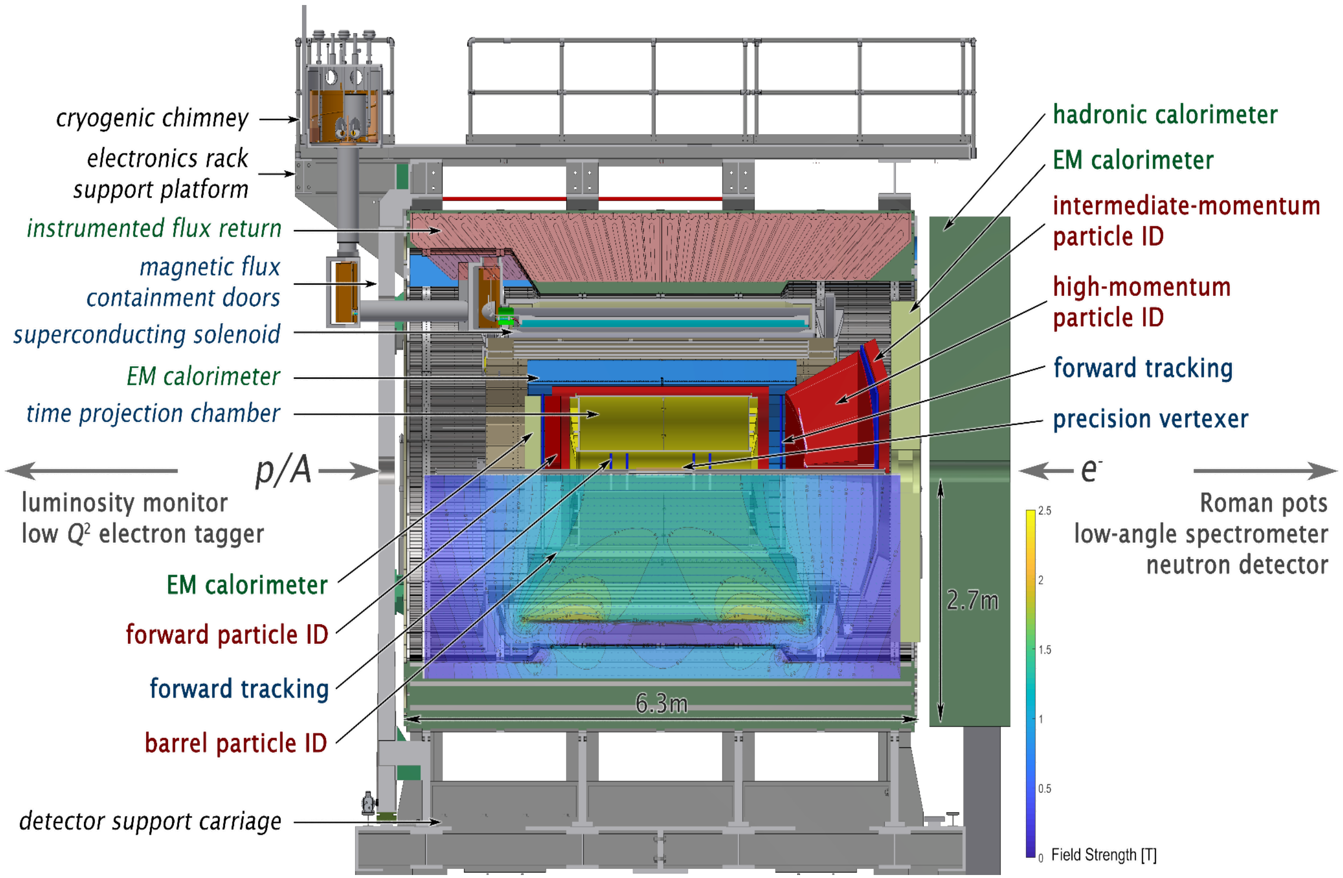
Inner tracker length = 2.0 m Outer tracker length = 2.0 m

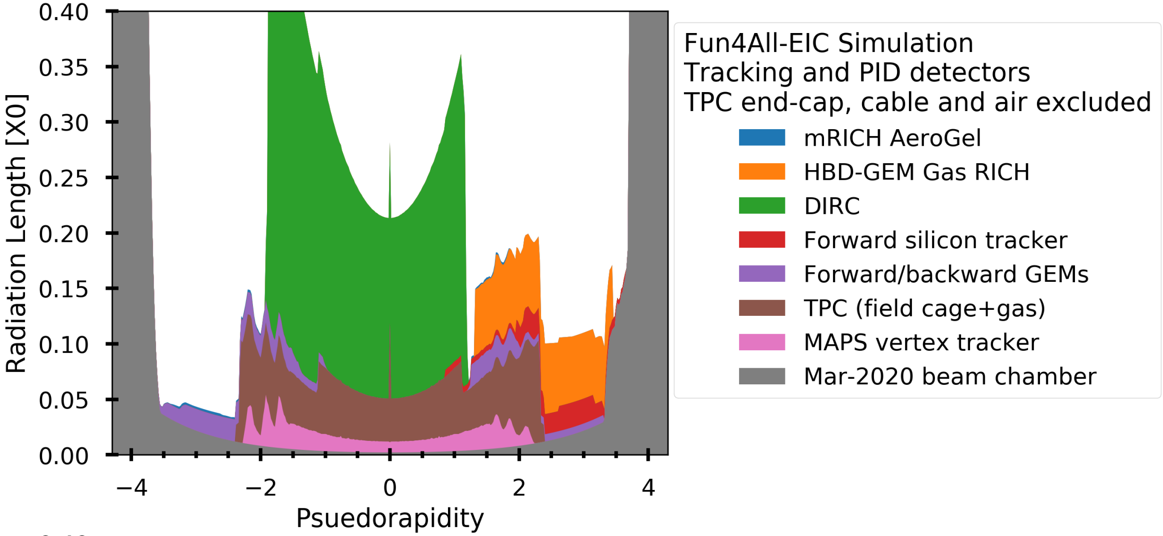


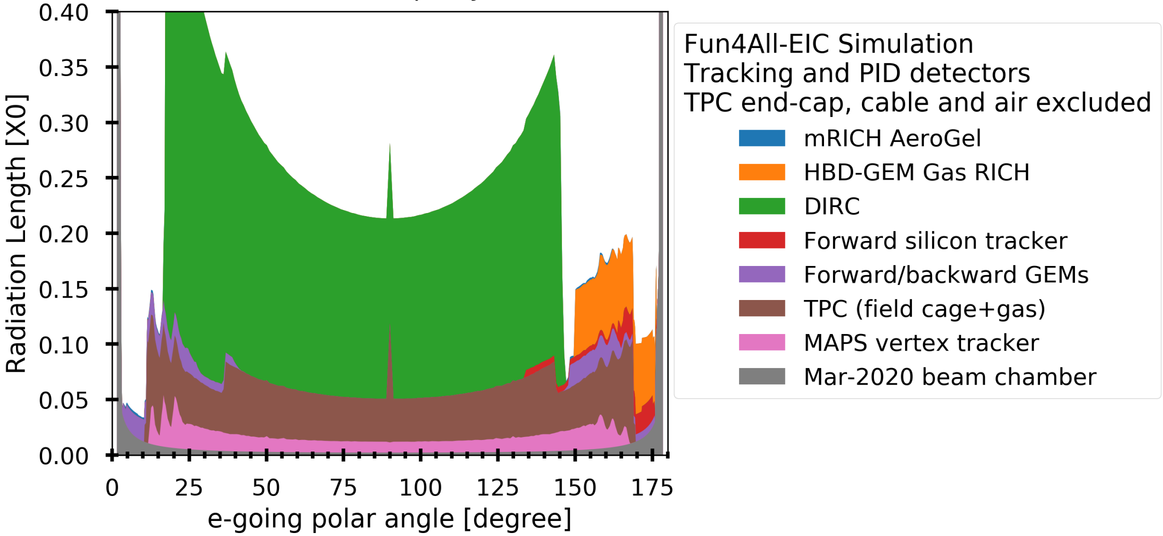
Jin Huang

sPHENIX detector model used in this study

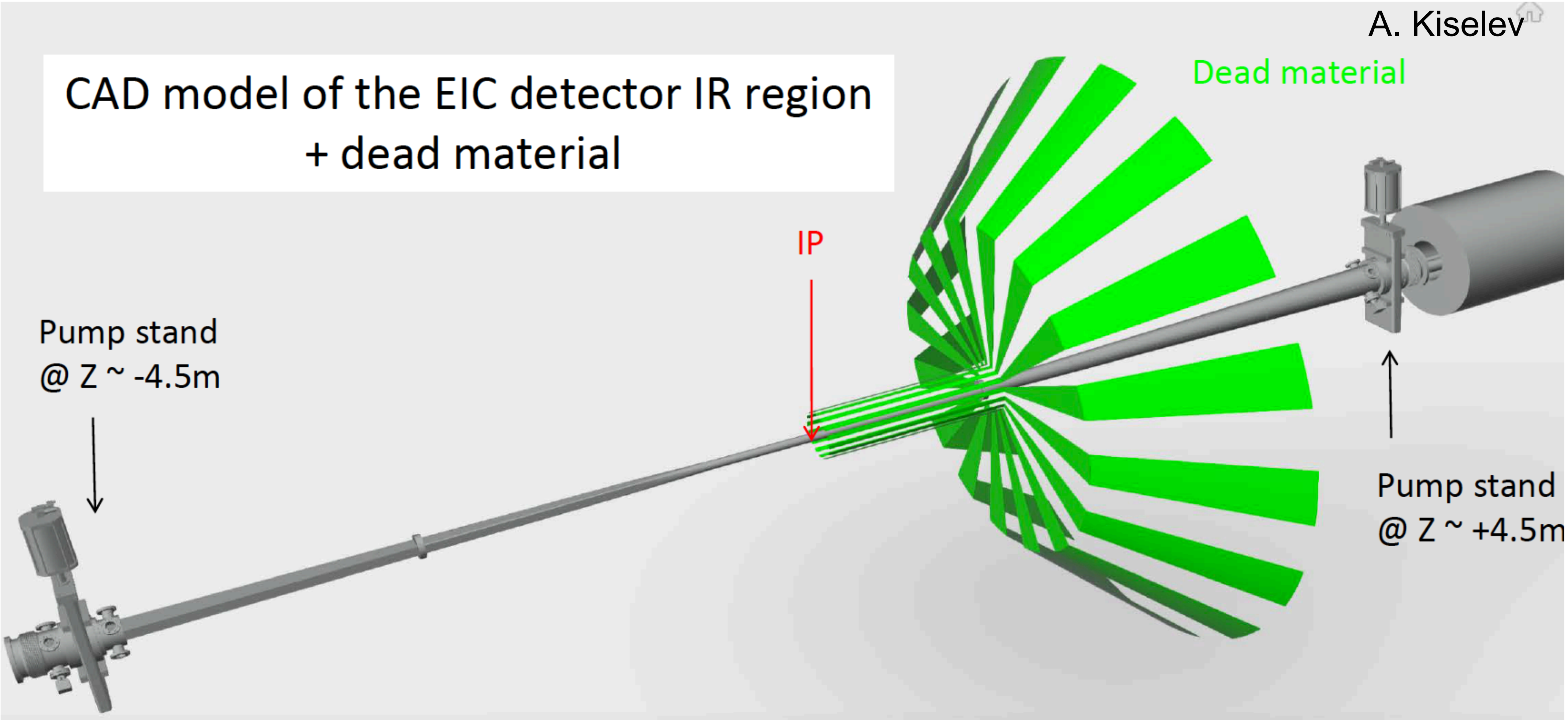
2014 concept: arXiv:1402.1209 [nucl-ex], 2018 update: sPH-cQCD-2018-001







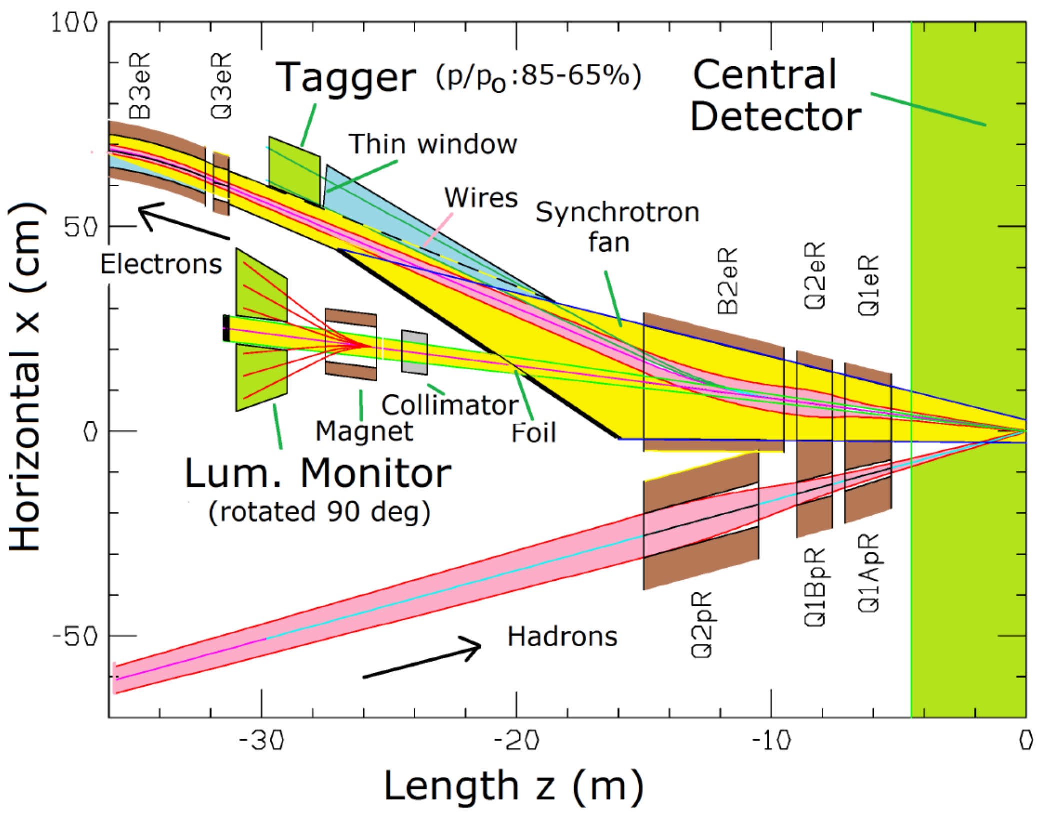
A possible software implementation (by Alexander)

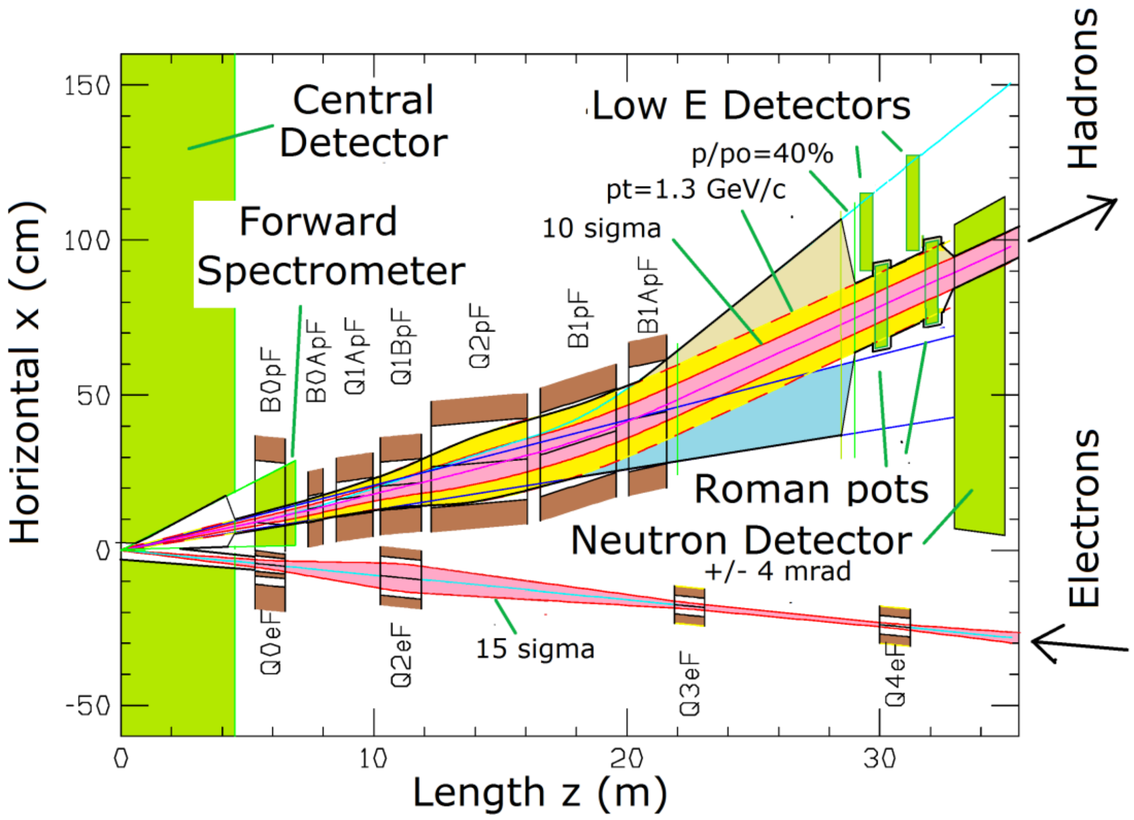


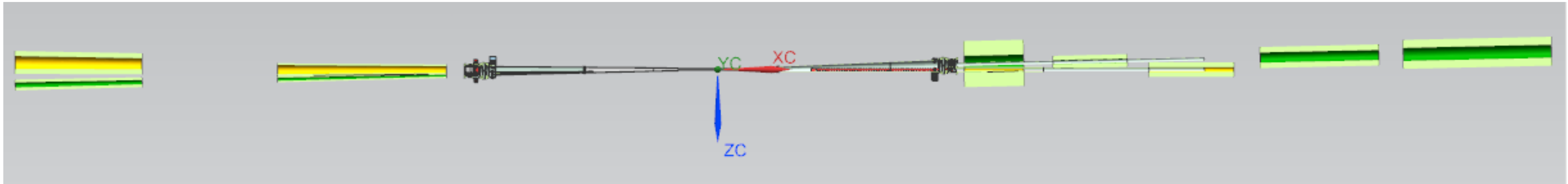
- Describe the dead material distribution according to the proposed scheme
- Describe the way you "route the material away"
- Export as a STEP file -> can overlay with the IR/detector engineering drawings

Integration with Far-forward area

Integration with Far-forward area







Integration with Far-forward area

- Placement of Far-forward areas detectors are almost independent from the central detectors. But a synchronization will be very important!

- Transition area: disks along the beam-line and tracker inside B0-dipole.

- Far-forward main detectors includes:
  - ✓ B0 tracker
  - ✓ Roman-Pots
  - ✓ Off-momentum tracker
  - ✓ Zero Degree Calorimeter for neutral particles (neutron, gammas).

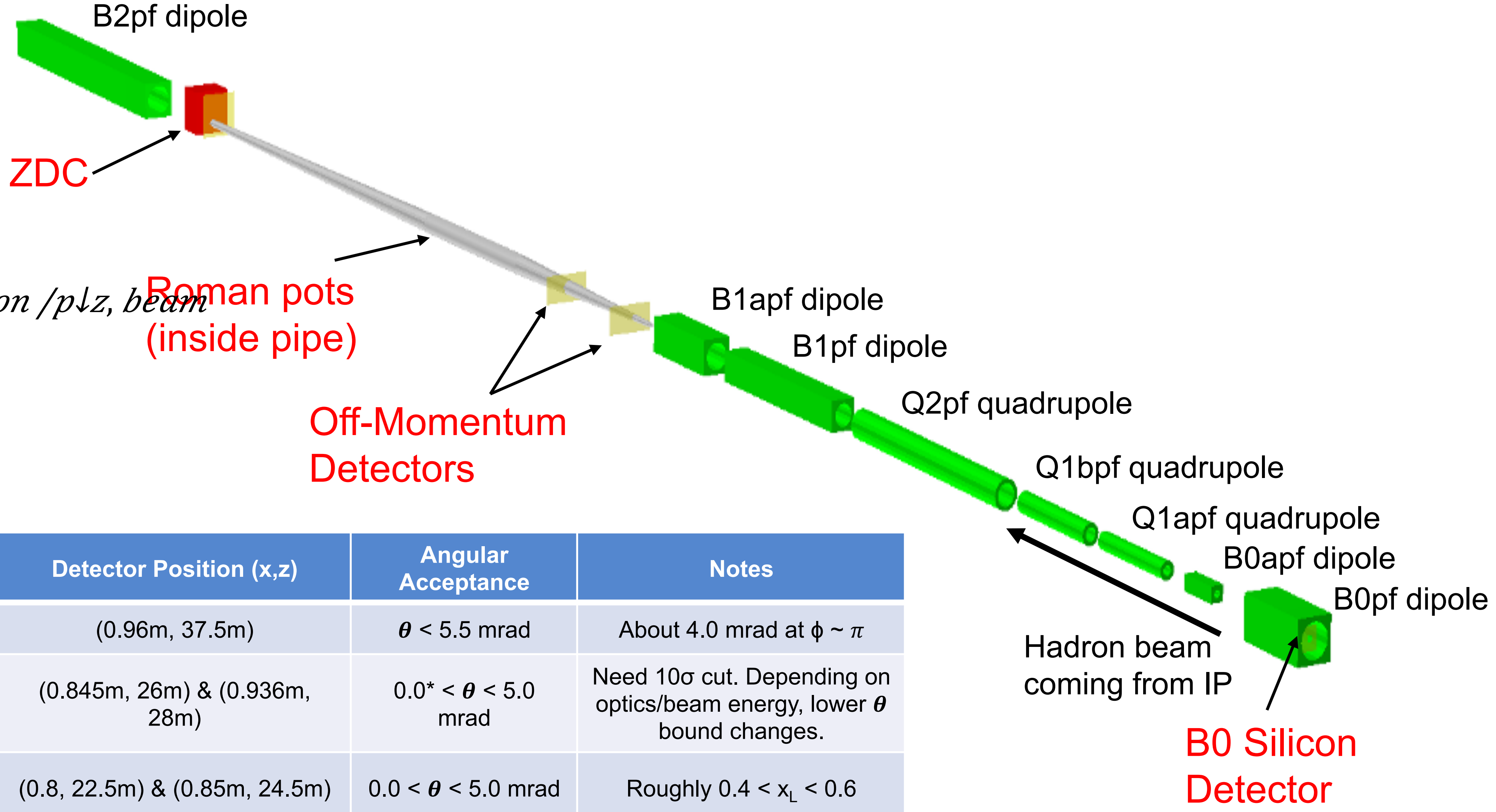
  Possible additional detectors: photon detection at B0, tracker for negative charge particles between B1 and ZDC, possible PID detectors.

- We need an engineering support for beam-pipe design in the far-forward areas for finetuning position and sizes (ongoing)

Far-forward preliminaries

Alex Jentsch

$x_L = p_{z,nucleon} / p_{z,beam}$

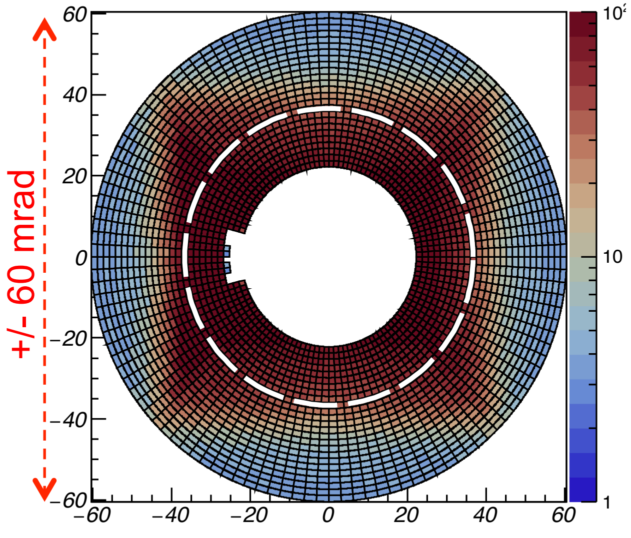


Detector	Detector Position (x,z)	Angular Acceptance	Notes
ZDC	(0.96m, 37.5m)	θ < 5.5 mrad	About 4.0 mrad at $\phi \sim \pi$
Roman Pots (2 stations)	(0.845m, 26m) & (0.936m, 28m)	0.0* < θ < 5.0 mrad	Need 10σ cut. Depending on optics/beam energy, lower θ bound changes.
Off-Momentum Detectors	(0.8, 22.5m) & (0.85m, 24.5m)	0.0 < θ < 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 < θ < 20.0 mrad	Could change a bit depending on pipe and electron quad.

Beampipe, electron acceptance

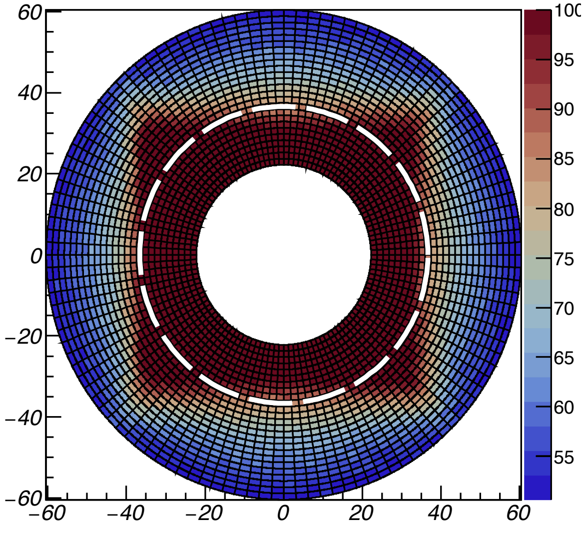
A. Kiselev

Material in acceptance, [%]



+/- 60 mrad

First Si disk at this distance, [cm]



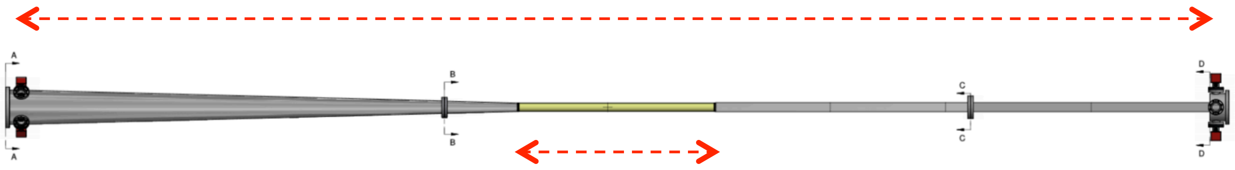
+/- 60 mrad

Central area (around IP) ok
Beryllium beampipe
Diameter 62.0 mm inner, 63.5 mm outer
Later: water cooling

Cones & rectangles: Al (needs improvement)

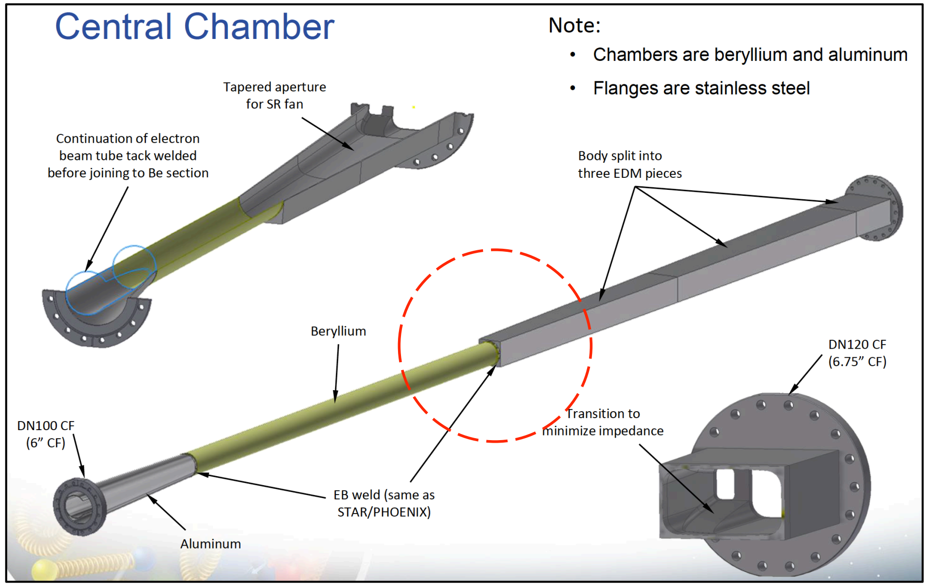
Plots: -4.5 < η < -3.5 band; white circle: η = -4.0

+/- 4.5 m



< 1.5 m

Side view

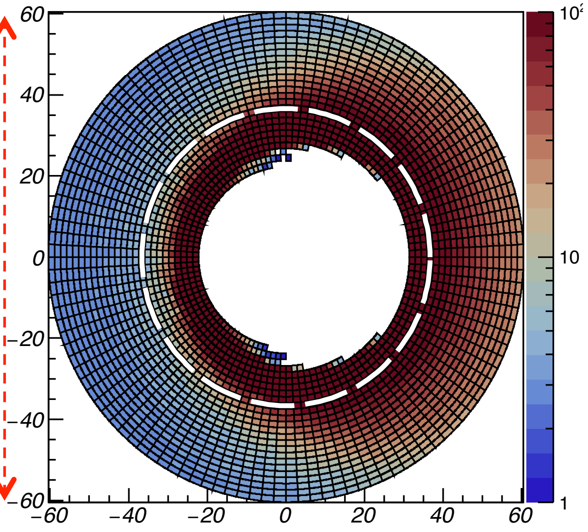


Beampipe, hadron acceptance

A. Kiselev

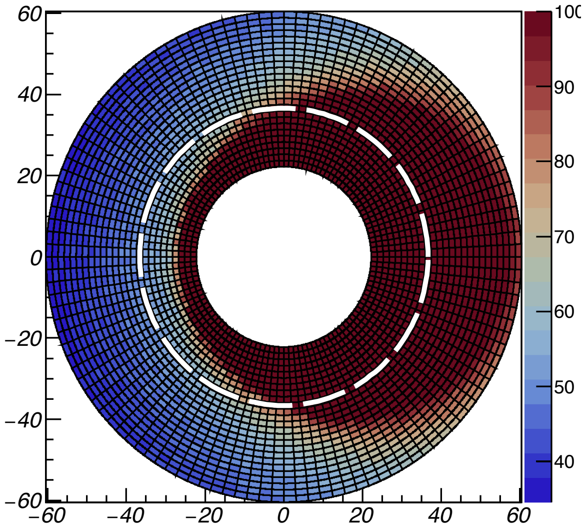
Material in acceptance, [%]

+/- 60 mrad



+/- 60 mrad

First Si disk at this distance, [cm]



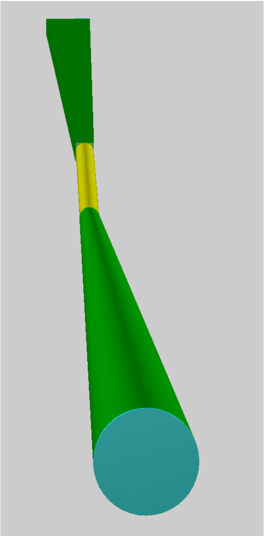
+/- 60 mrad

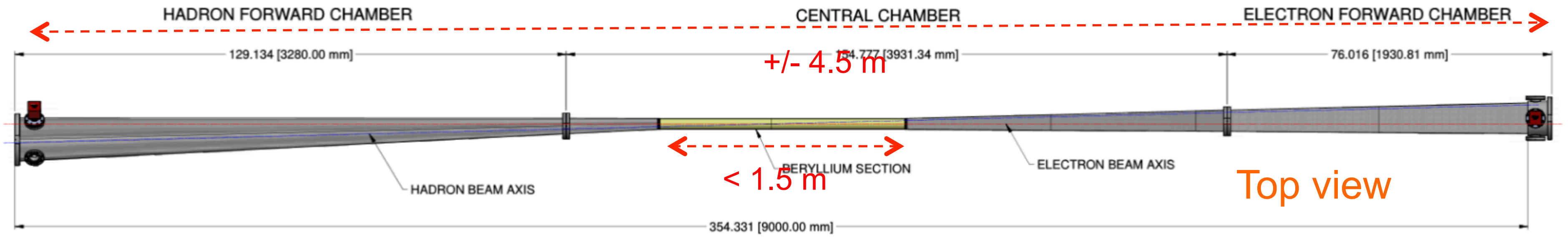
Central area (around IP) ok
Beryllium beampipe
Diameter 62.0 mm inner, 63.5 mm outer
Later: water cooling

H-pipe cone: Al (needs improvement)

Plots: 3.5 < η < 4.5 band; white circle: η = 4.0

ROOT TGeo model used for the scans





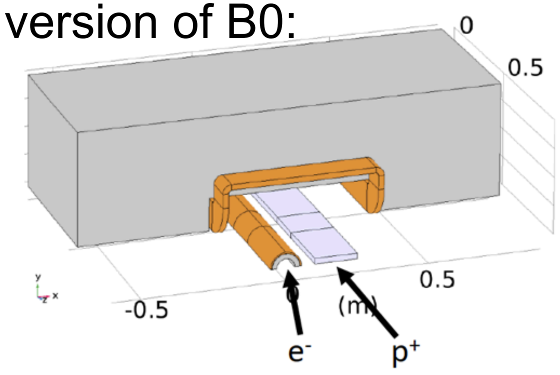
Top view

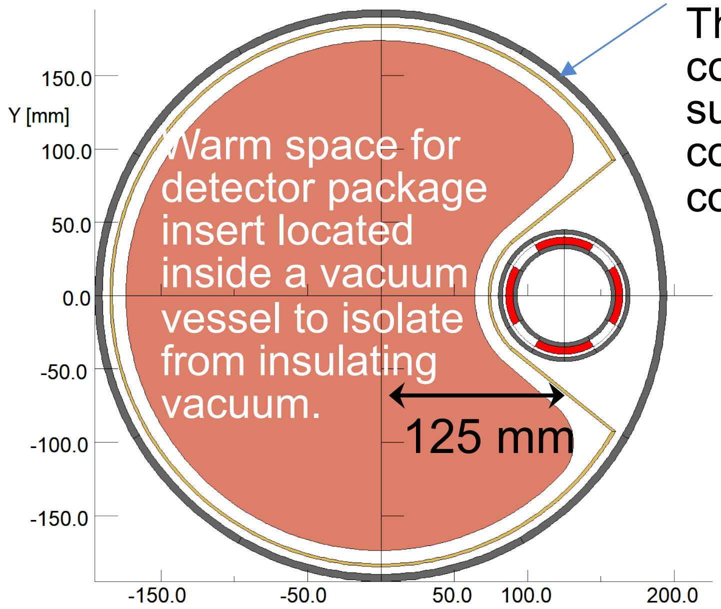
New version of B0 dipole

Holger Witte, Brett Parker

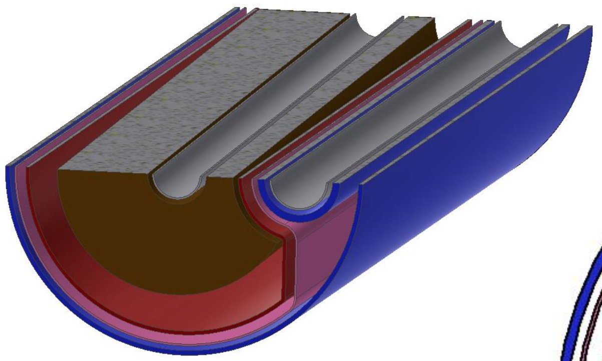
- Create zero field line at electron beam axis by overlapping large diameter main quadrupole and dipole coils.

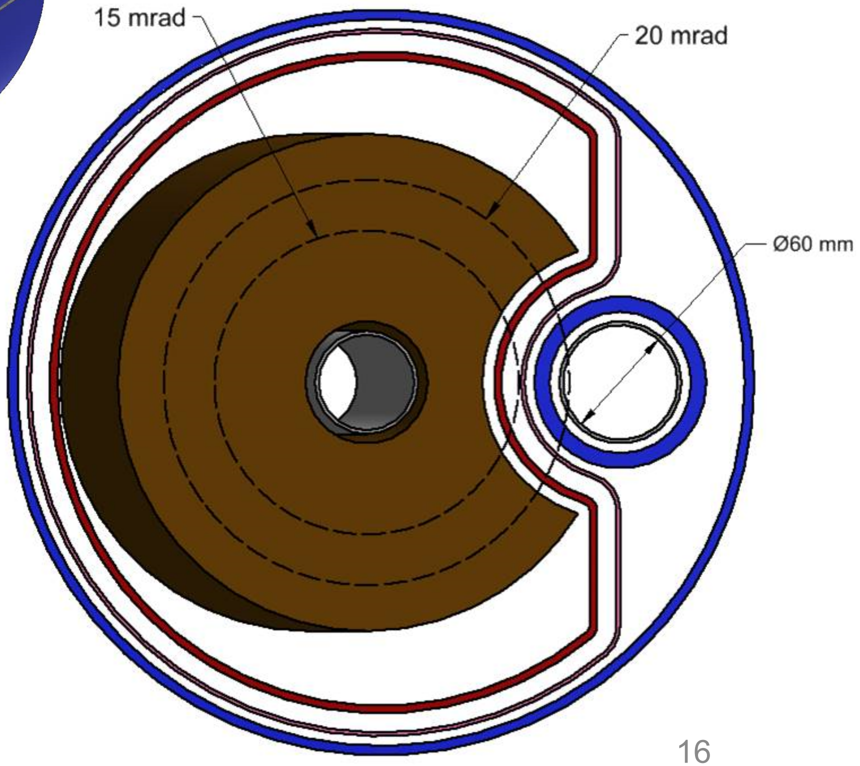
Old version of B0:

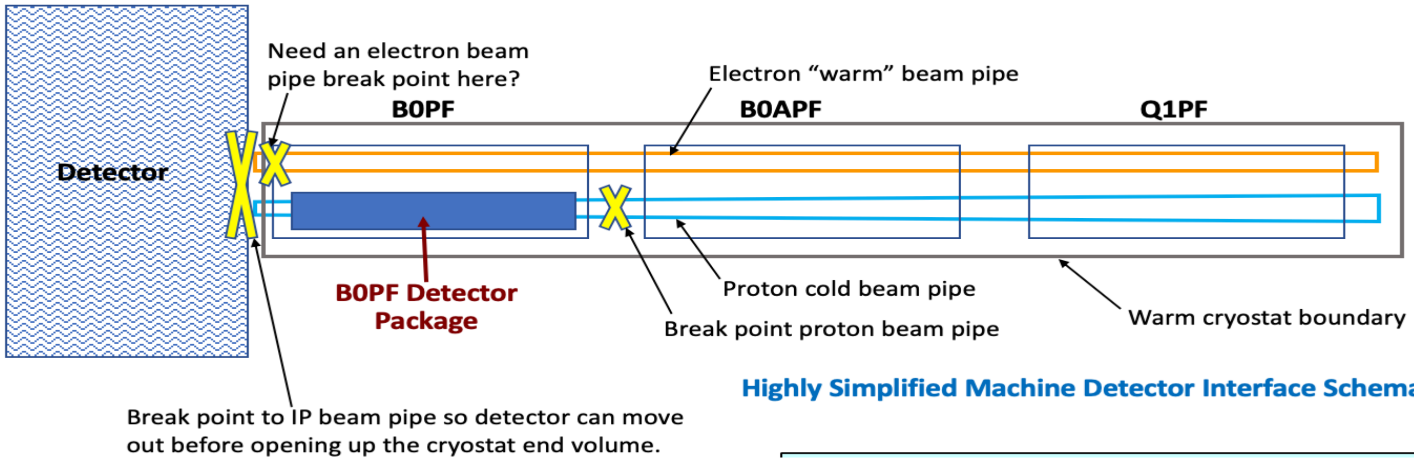




The main quad and dipole coils are wound on this support tube which is then a cold surface as the inner LHe containment.

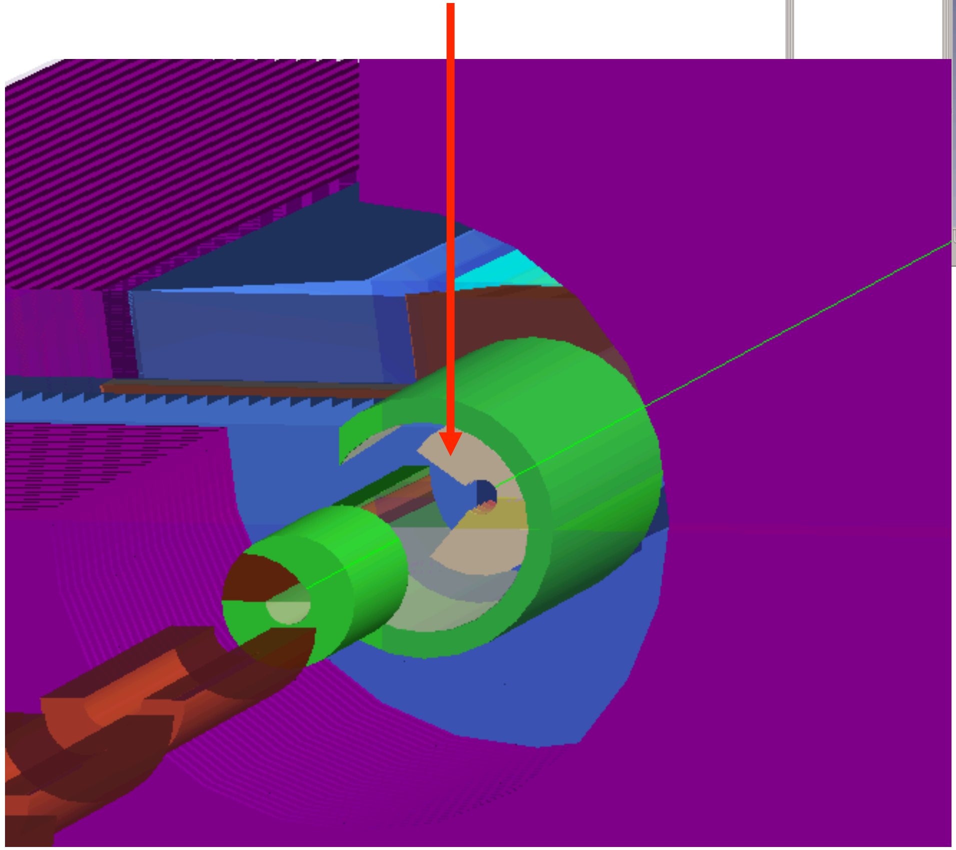


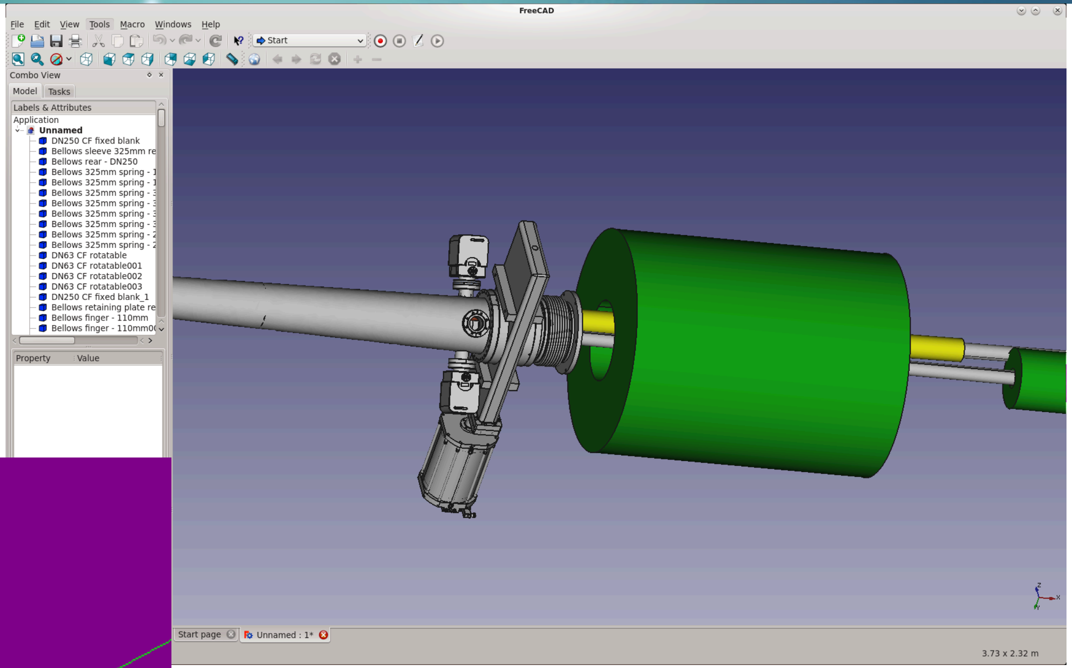




Highly Simplified Machine Detector Interface Schematic

B0-dipole sensors

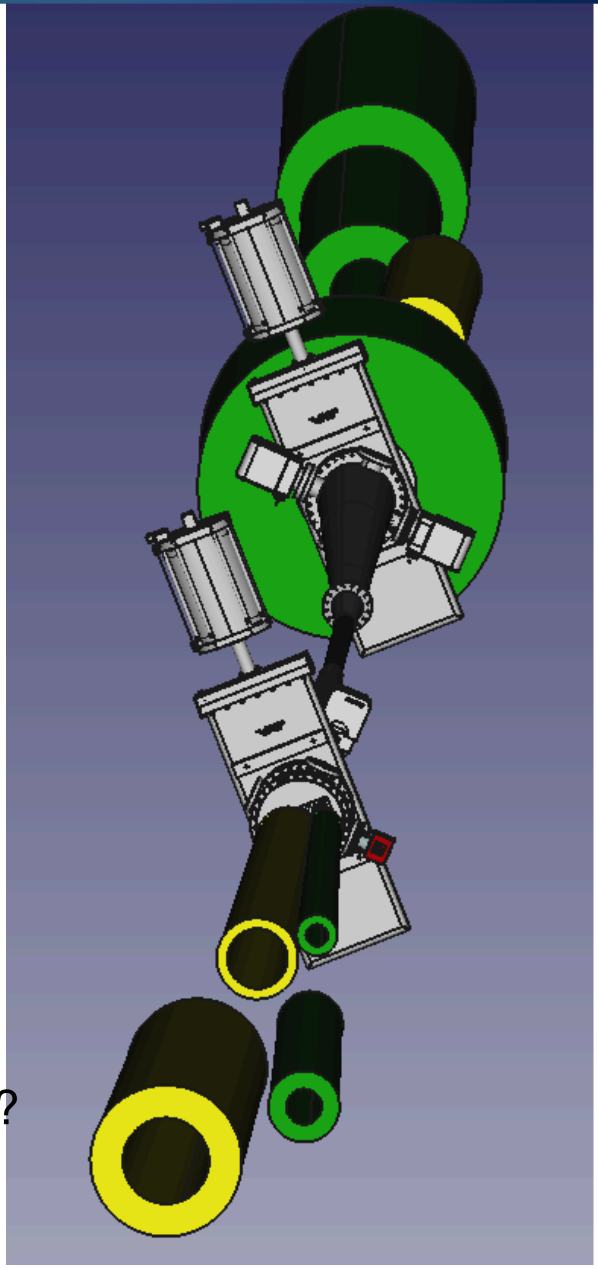




-shape of B0 tracker : asymmetric in φ due to the crossing angle)

-Vacuum pumps in front of B0 tracker (high background area)

-Pre-shower or EMCAL after B0 tracker?



Conclusions/actions

- Each detector sub-component is currently working on estimations of amount of materials needed for support structure, cablings and how to better distribute them.
- Impact of the material budget needs to be taken into account in the simulation work.
- Preliminary placement of far-forward sub-detectors is done, finetuning is ongoing.
- Work on beam-pipe design and overall detector assembly/maintenance has been started

Backup

GEMTRD (e/π separation)

Single module (X/X0) :
Radiator (10cm) ~ 1.5 % X_0 (for fleece, could go down with mylar foils)
Xenon gas (2.0 cm) ~ 0.1% X_0
Triple GEM with readout at active area ~ 0.7% X_0
(could go down to 0.4%, current eRD6)