Detector Integration Status and CAD Design

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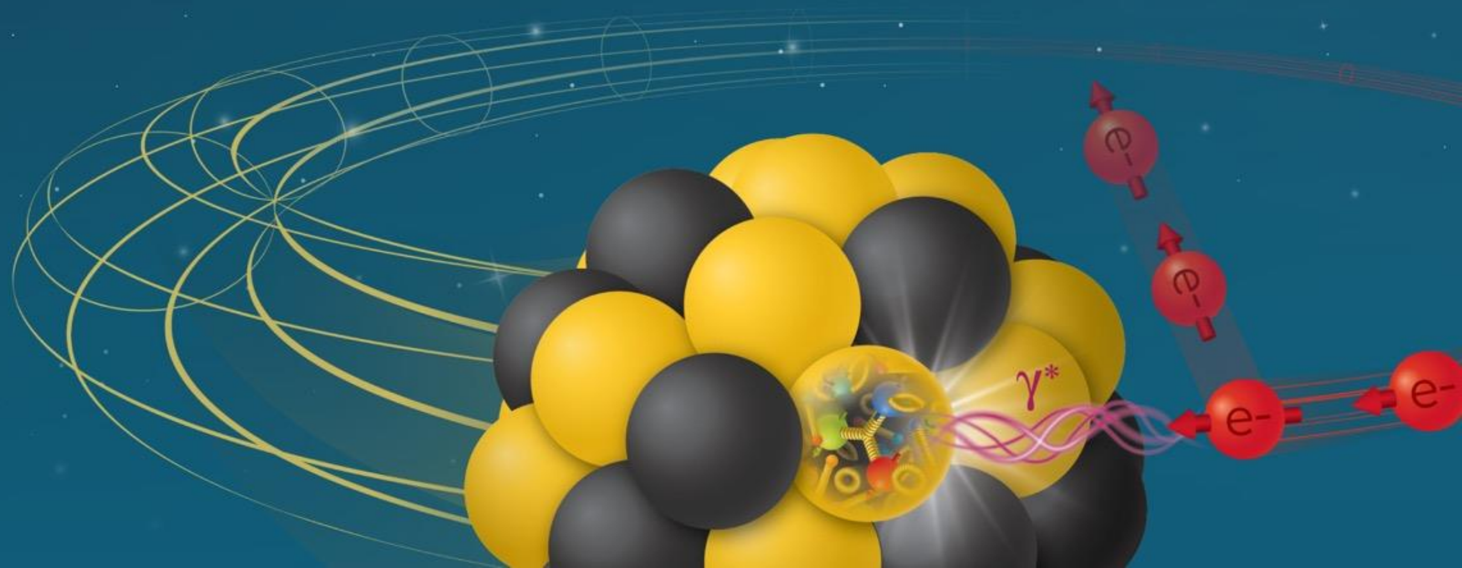
Incremental Design and Safety Review
of the EIC Tracking Detectors
March 20-21, 2024

Electron-Ion Collider



Charge Questions Addressed

1. Are the technical performance requirements appropriately defined and complete for this stage of the project?
2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?
3. Are the current designs and plans for detector, electronics readout, and services sufficiently developed to achieve the performance requirements?
4. Are plans in place to mitigate risk of cost increases, schedule delays, and technical problems?
5. Are the fabrication and assembly plans for the various tracking detector systems consistent with the overall project and detector schedule?
6. Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?
7. Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?

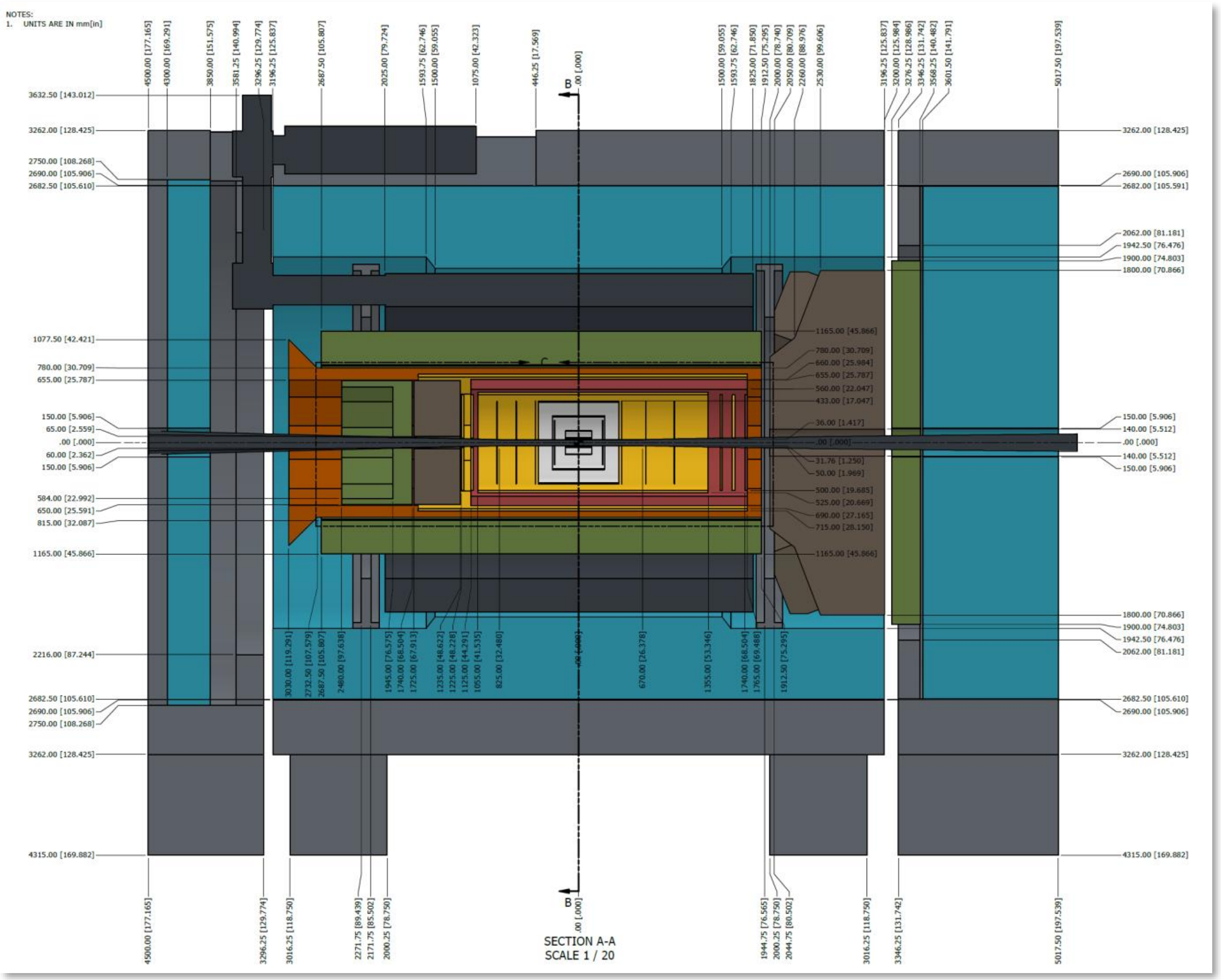
EPIC Integration, Installation and Infrastructure Team:

1. Rahul Sharma (BNL) – Chief Mechanical Engineer
2. Walt Akers (JLAB) – Systems Integration
3. Roland Wimmer (BNL)– Mechanical Engineer
4. Dan Cacace (BNL) – Mechanical Engineer
5. Alex Eslinger (JLAB) – Mechanical Engineer – pfRICH and dRICH Design
6. Ron Lassiter (JLAB)– Forward Detectors - Mechanical Engineer
7. Karim Hamdi (BNL)– Mechanical Designer
8. Tim Camarda (BNL) – Electronics Engineer
9. Jim Kelsey (MIT Bates) – Mechanical Engineer
10. Avishay Mizrahi (MIT) – Mechanical Engineer - DIRC
11. Joshua Crafts (CUA) – Postdoc - EEEMCAL
12. Tom O'Connor and Kevin Bailey (ANL) – Barrel EMCAL Design
13. Andreas Jung (Purdue University) – AC LGAD and Carbon Fiber Support Structure
14. Sushrut Karmarkar (Purdue University) – AC LGAD and Carbon Fiber Support Structure
15. Johnathan Smith (JLAB)
16. Eric Anderssen and Joe Silber (LBNL)
17. Seung Joon Lee (JLAB) - MPGDs

Regular weekly engineering meetings are held to discuss and resolve engineering problems and check progress. Hope to add more Mechanical Engineers and Mechanical Designers to the group soon as the project evolves.

Outline

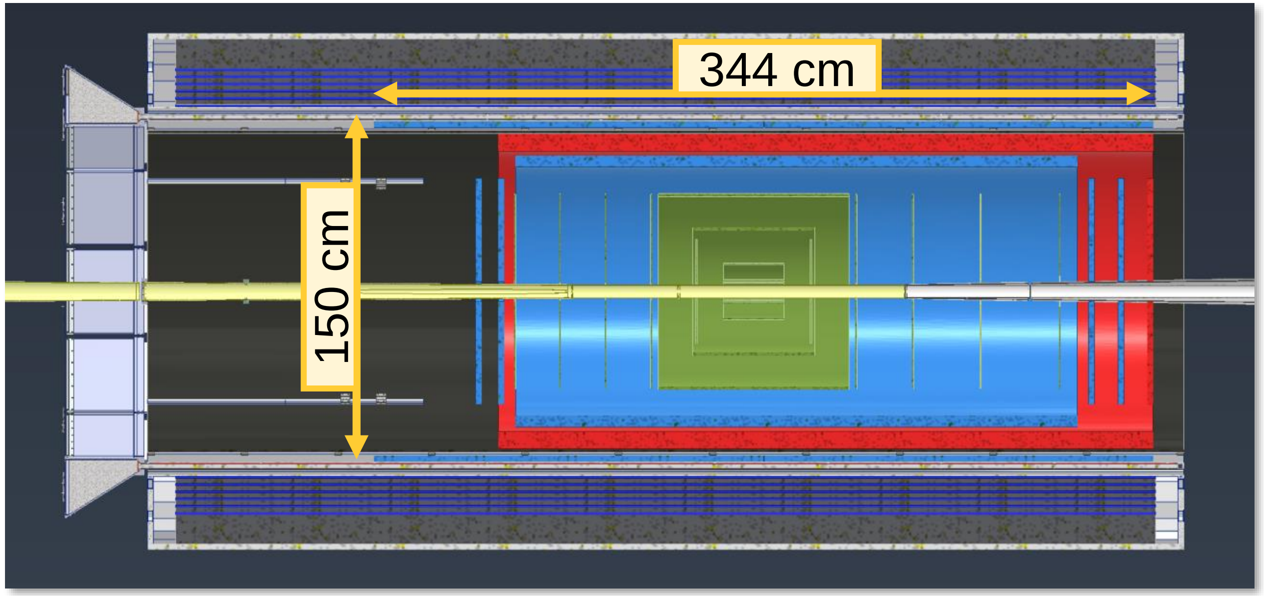
- Charge Questions
- EPIC Engineering Team
- Detector Integration
  - Detector overviews
  - Layout
  - Support Structures
- Services
  - Routing
  - Layout
  - Space Envelopes
  - Material budgets
- Summary

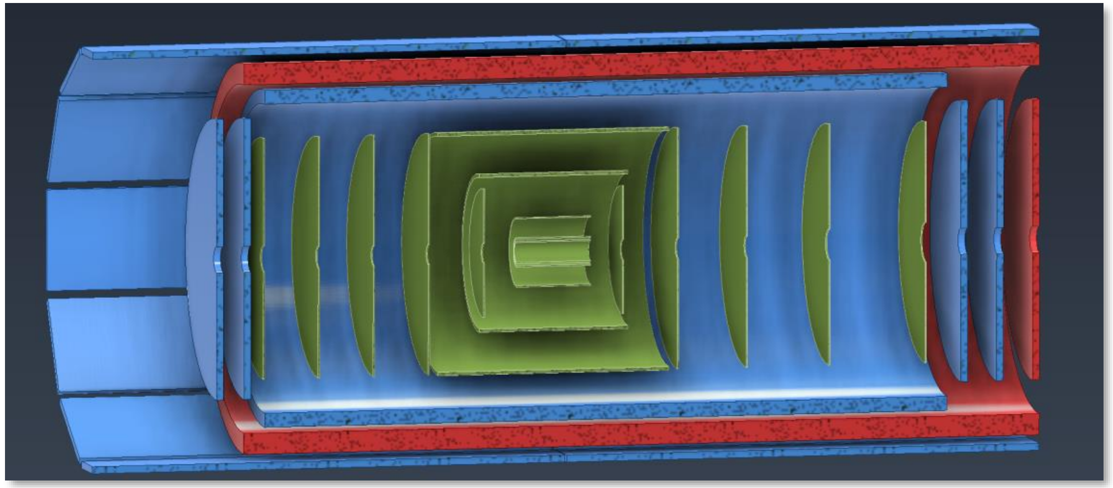


Detector Integration

Charge 3, 6

- Red: AC-LGAD Tof
  - Main barrel
  - HE Disk
- Blue: MPGDs
  - Outer MPGDs
  - Inner MPGD Barrel
  - (2) EE Disks
  - (2) HE Disks
- Green: Silicon Trackers
  - (3) Inner barrels
  - (2) Outer barrels
  - (5) EE Disks
  - (5) HE Disks



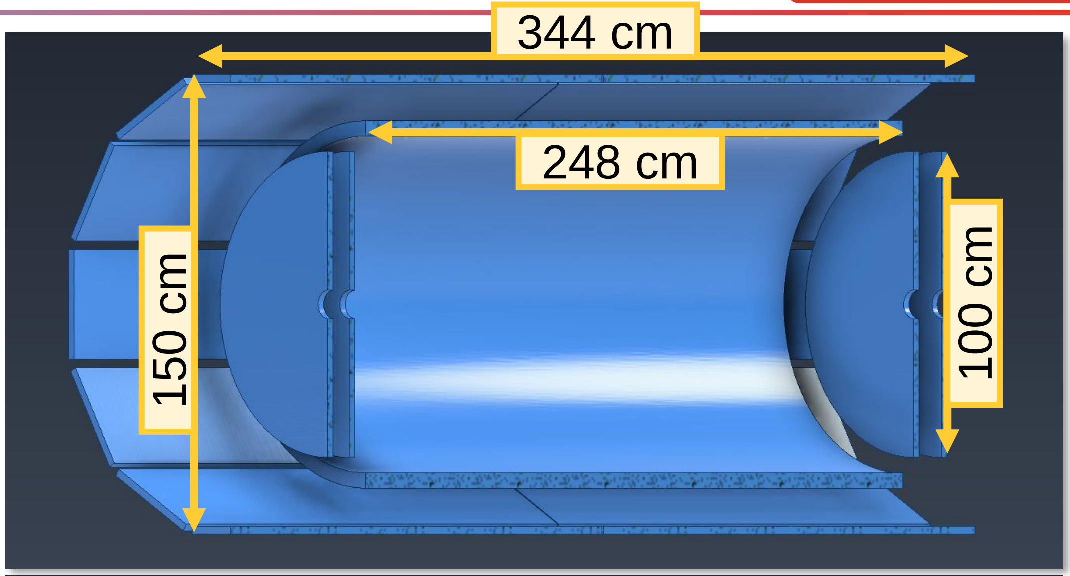


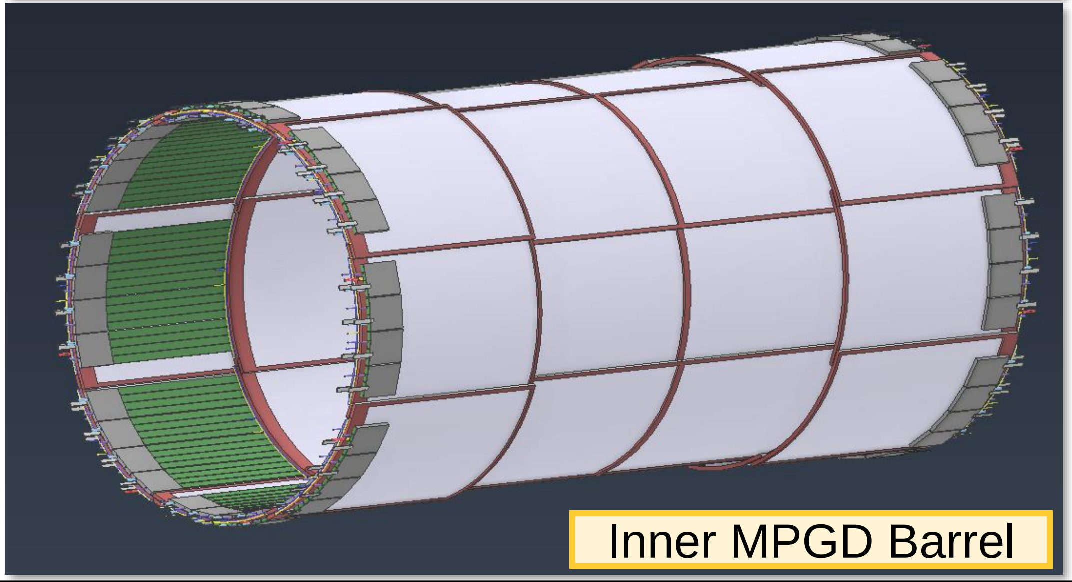
MPGD Overview

Charge 3, 6

- Outer MPGDs
  - (24) Modules, 12 sectors each broken in half
- Inner MPGD Barrel
  - (32) Modules, (8) in azimuth and (4) in Z
- (4) Disks
  - Likely to be segmented in quarters or halves

Subsytem	Item	Quantity	Diameter (cm)	Cross Area (cm^2)	+50% Packing for Bundles
Inner MPGD	Hv	40	0.32	3.22	4.83
	LV	50	1.163	53.12	79.67
	Gas	20	0.4	2.51	3.77
	Cooling	33	0.625	10.12	15.19
	Signal	60	0.1	0.47	0.71
MPGD Disk	Hv	6	0.32	0.48	0.72
	LV	48	0.63	14.96	22.44
	Gas	12	0.4	1.51	2.26
	Cooling	12	0.625	3.68	5.52
Outer MPGD	FEE PWR	24	1	18.85	28.27
	FEE data	12	0.32	0.97	1.45
	2kv Hv	12	0.6	3.39	5.09
	Flat Signal Cables	552	0.3	331.20	496.80
	Gas	24	0.4	3.02	4.52
	Cooling	40	0.63	12.47	18.70



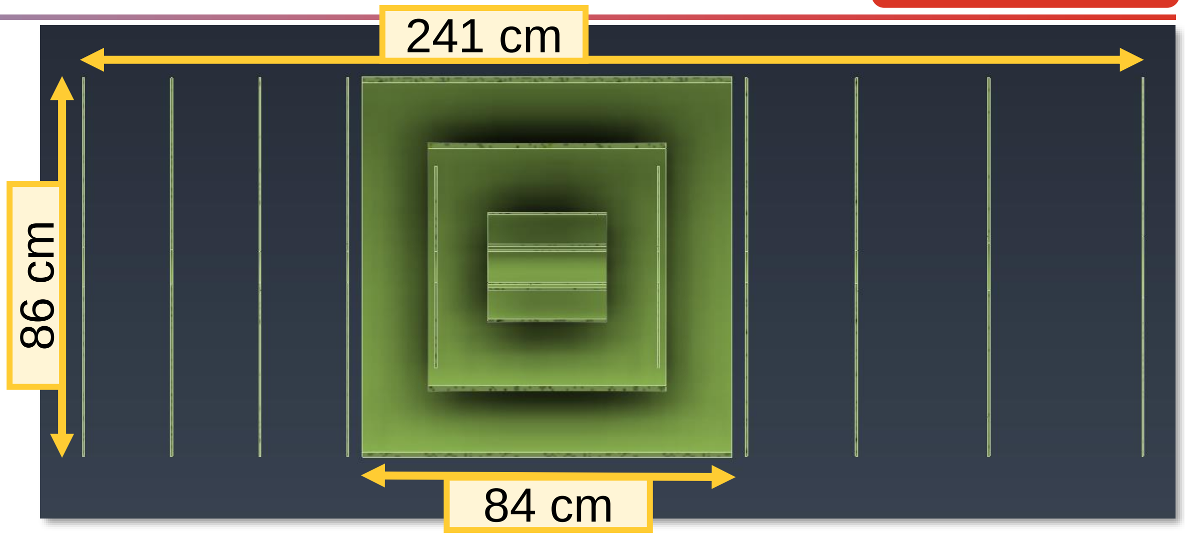


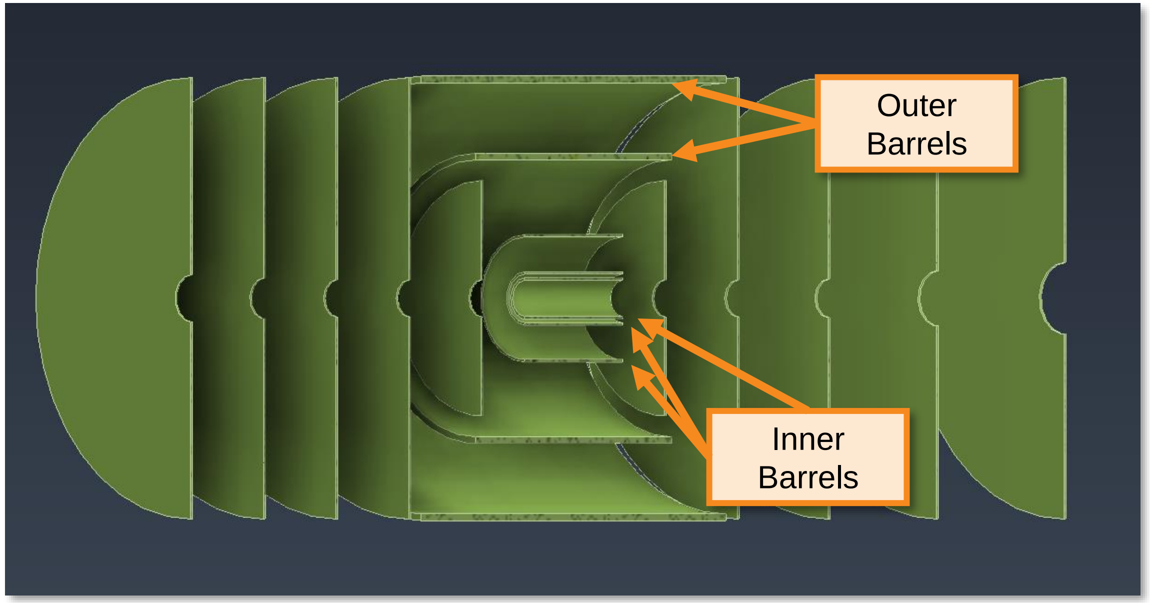
Silicon Trackers Overview

Charge 3, 6

- (3) Inner barrels
  - Innermost barrel sits right around beampipe
- (2) Outer barrels
- (5) EE Disks
- (5) HE Disks

Subsytem	Item	Quantity	Diameter (cm)	Cross Area (cm^2)	+50% Packing for Bundles
Vertex Silicon	LV digital	12	0.8	6.03	9.05
	Sensor Bias	34	0.2	1.07	1.60
	Data *	204	0.6	57.68	86.52
	Cooling	12	0.3	0.85	1.27
Sagita Silicon	LV serial power	29	0.9	18.45	27.67
	Signal Bias	771	0.3	54.50	81.75
	Data *	771	0.2	24.22	36.33
	Cooling *	356	0.3	25.16	37.75
Silicon Disks	Sensor Bias	1100	0.3	77.75	116.63
	cooling	550	0.63	171.45	257.17
	LV current	92	0.9	58.53	87.79
	Data	1100	0.3	77.75	116.63

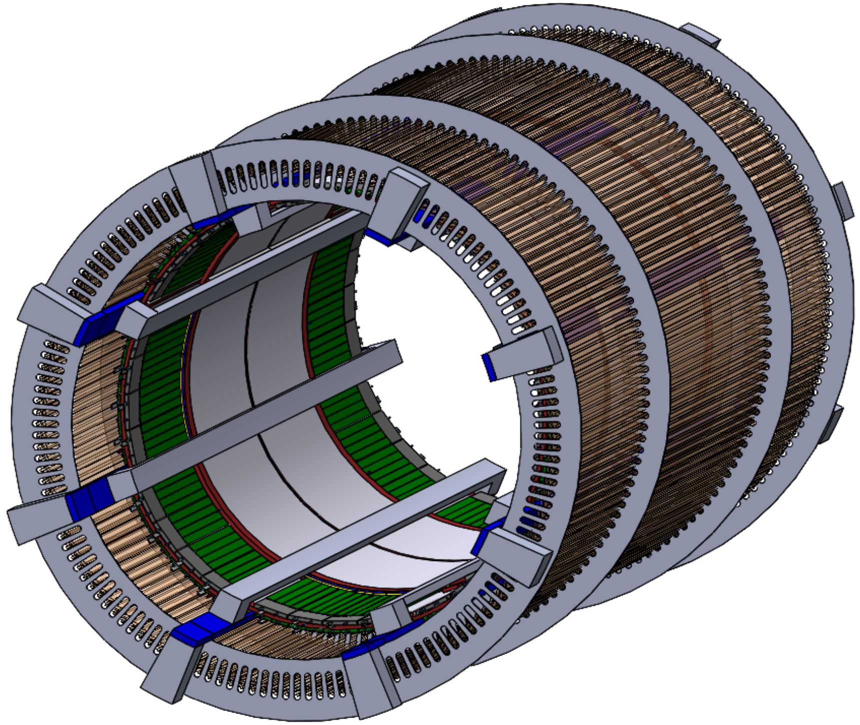




AC-LGAD ToF Overview

Charge 3, 6

- Main barrel
  - Made up of 144 staves
- HE Disk
  - Only 1 disk in the forward direction

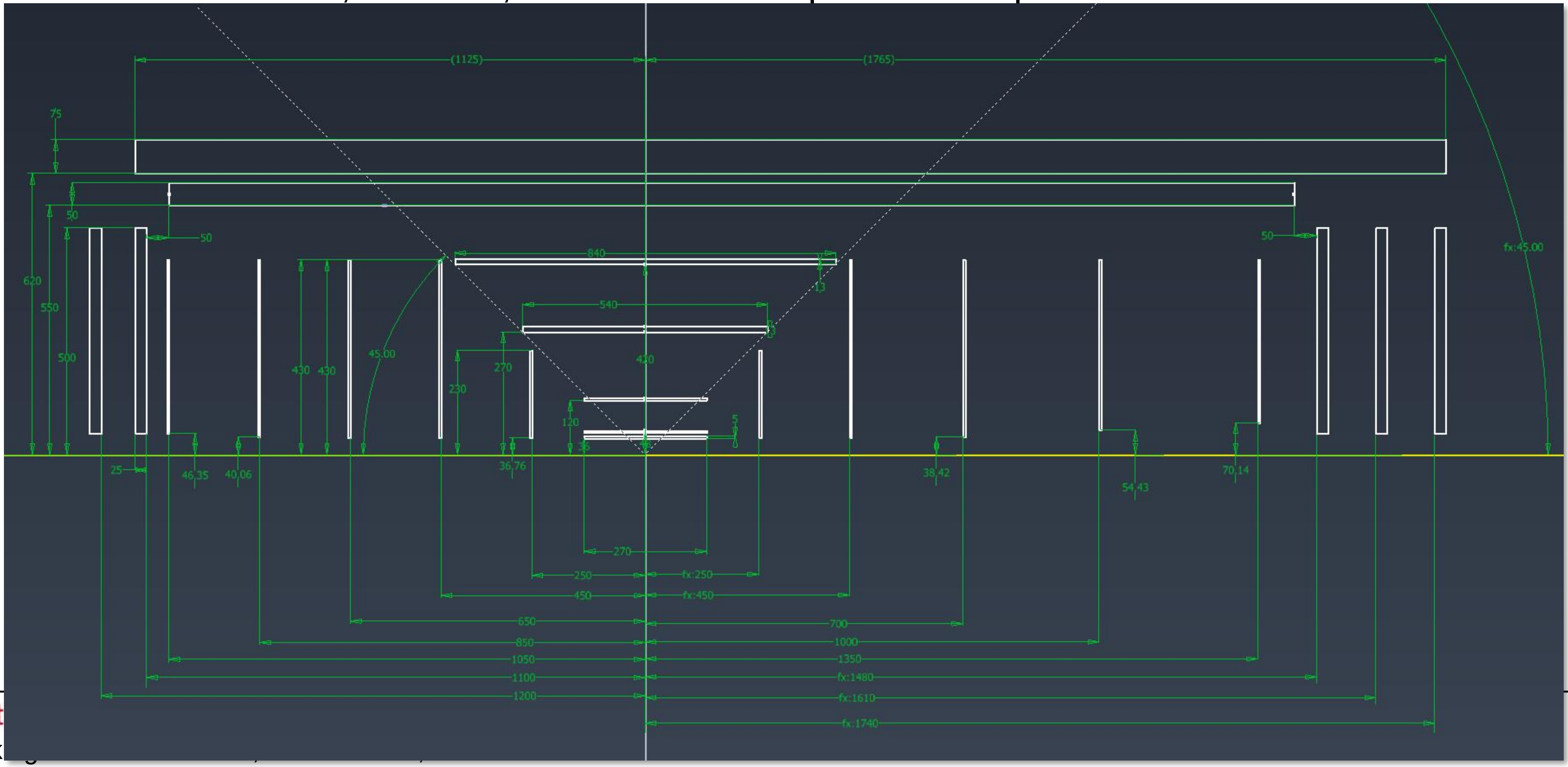


Subsytem	Item	Quantity	Diameter (cm)	Cross Area (cm^2)	+50% Packing for Bundles
AC LGAD TOF	LV FEE	72	0.63	22.44	33.67
	HV FEE	144	0.15	2.54	3.82
	Fiber *	144	0.6	40.72	61.07
	Aluminum	144	0.5	28.27	42.41

Detector Integration Layout

Charge 3, 6

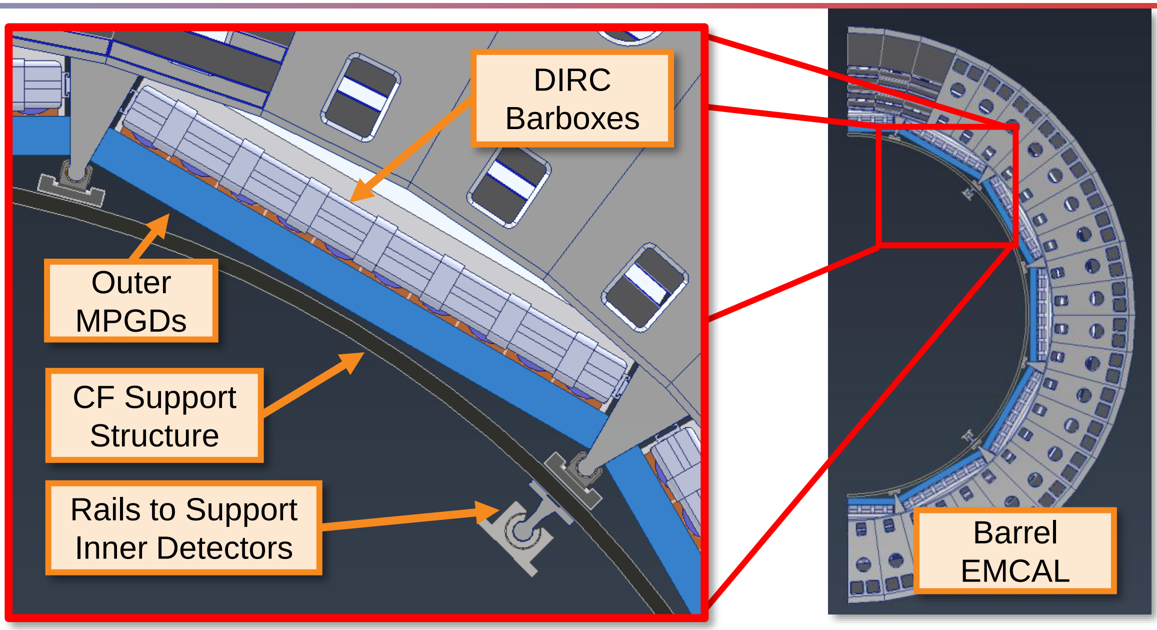
- All the inner tracker space envelopes laid out together
  - Used for detectors, services, and electronics space envelopes

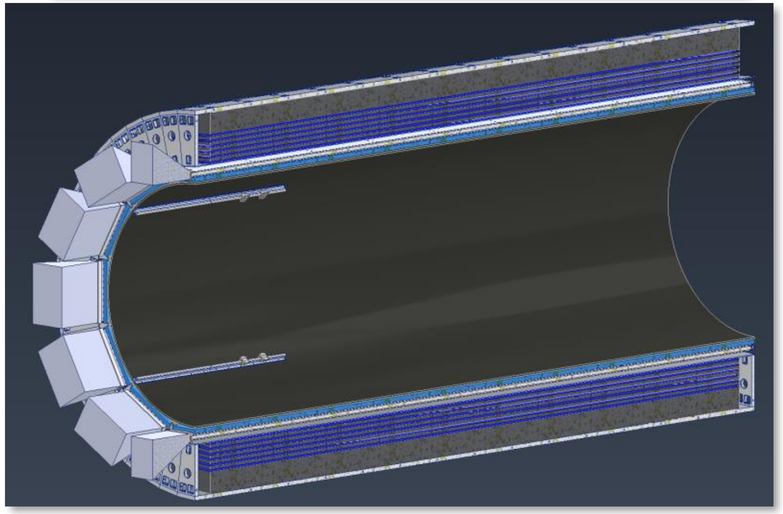


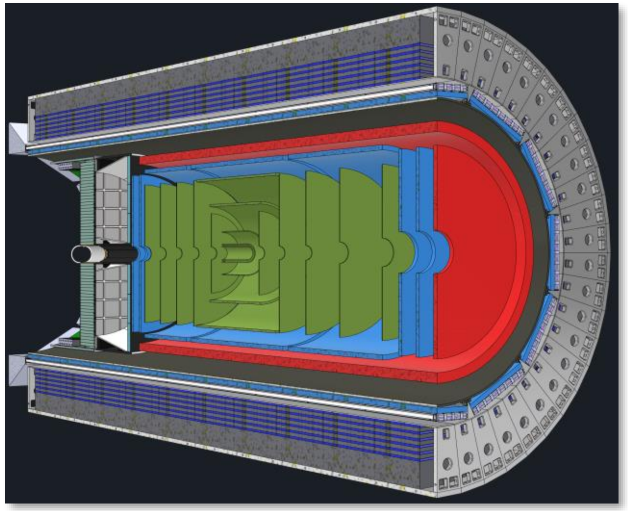
Support Structures

Charge 3, 6

- Current plan is to use barrel EMCAL for the support of the Inner Detectors
- Outer MPGDs and DIRC barboxes will be nested in the area between the rails
- A carbon fiber support structure supported from the Barrel EMCAL will house and support all the inner detectors
- Gaps between the EEEMCAL and the carbon fiber cylinder will allow for services to be brought out



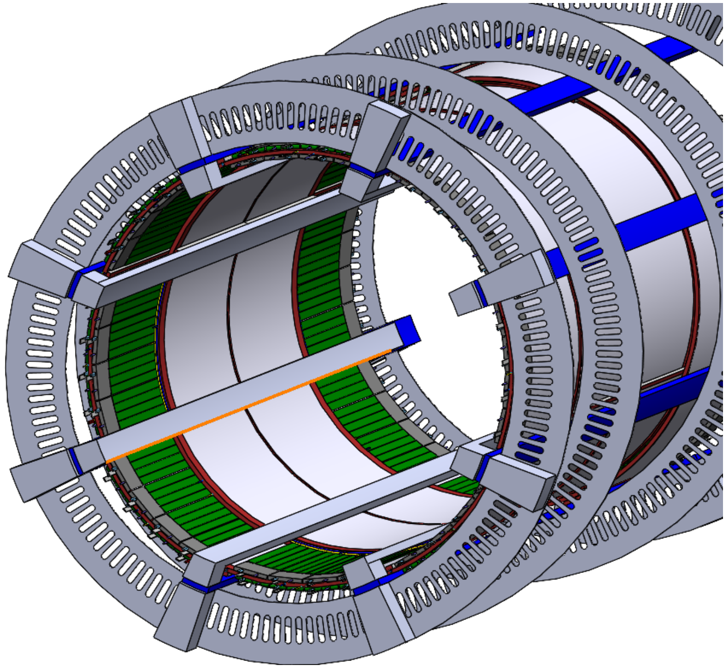


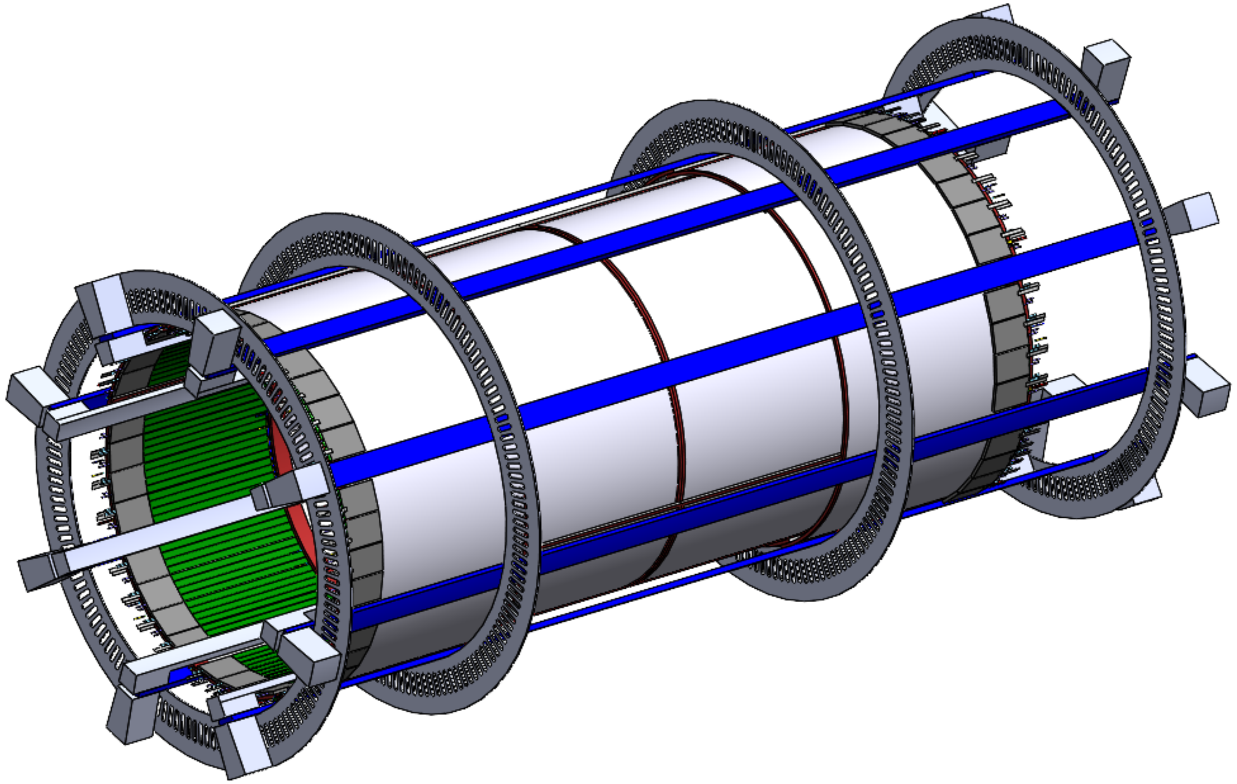


Inner Support Structures

Charge 3, 6

- Will work with the carbon fiber tube to directly support the inner detectors.
- Made up of two sub-assemblies that will be integrated together

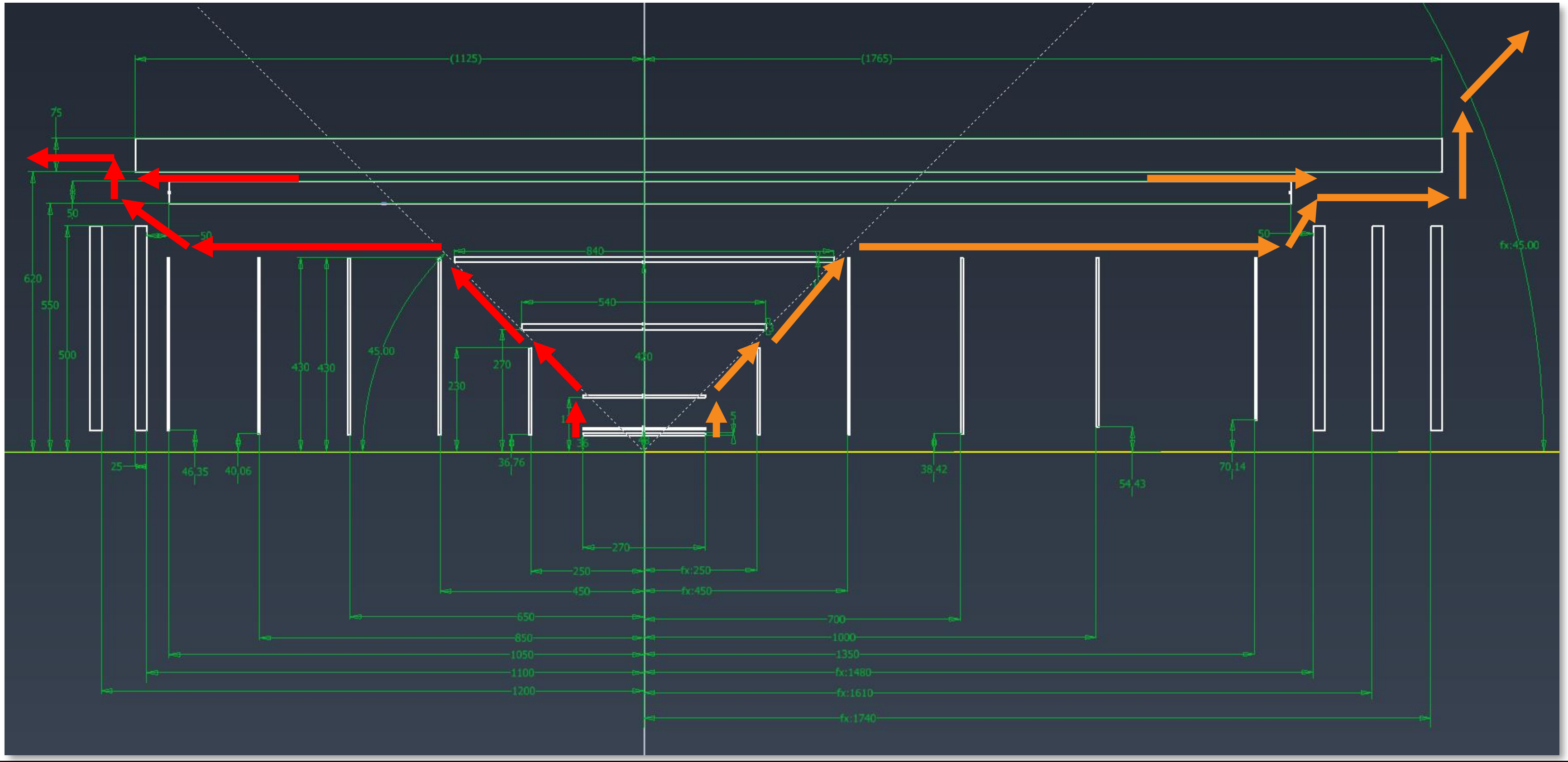




Services Routing

Charge 3

- Used 2 main paths for getting the services out from the inner trackers.
  - Red path on the electron end and orange path on the hadron end.
  - Used estimates from the subgroups to figure gaps needed at various bottle necks



Services Space

Charge 3

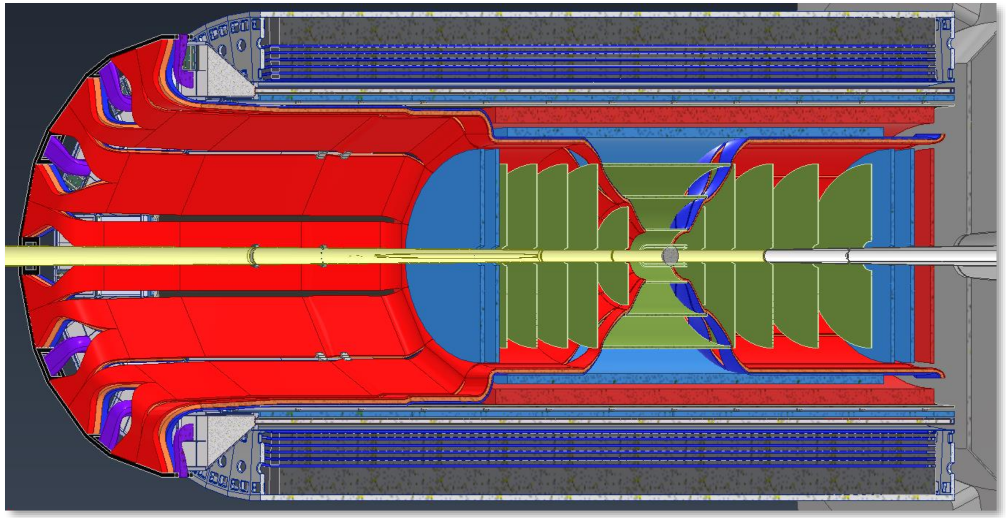
- Estimates for cabling, cooling, gas, etc. were collected from all the various subgroups
- Looked into where bottlenecks might occur based off the models
- We compiled all the estimates and added space where needed

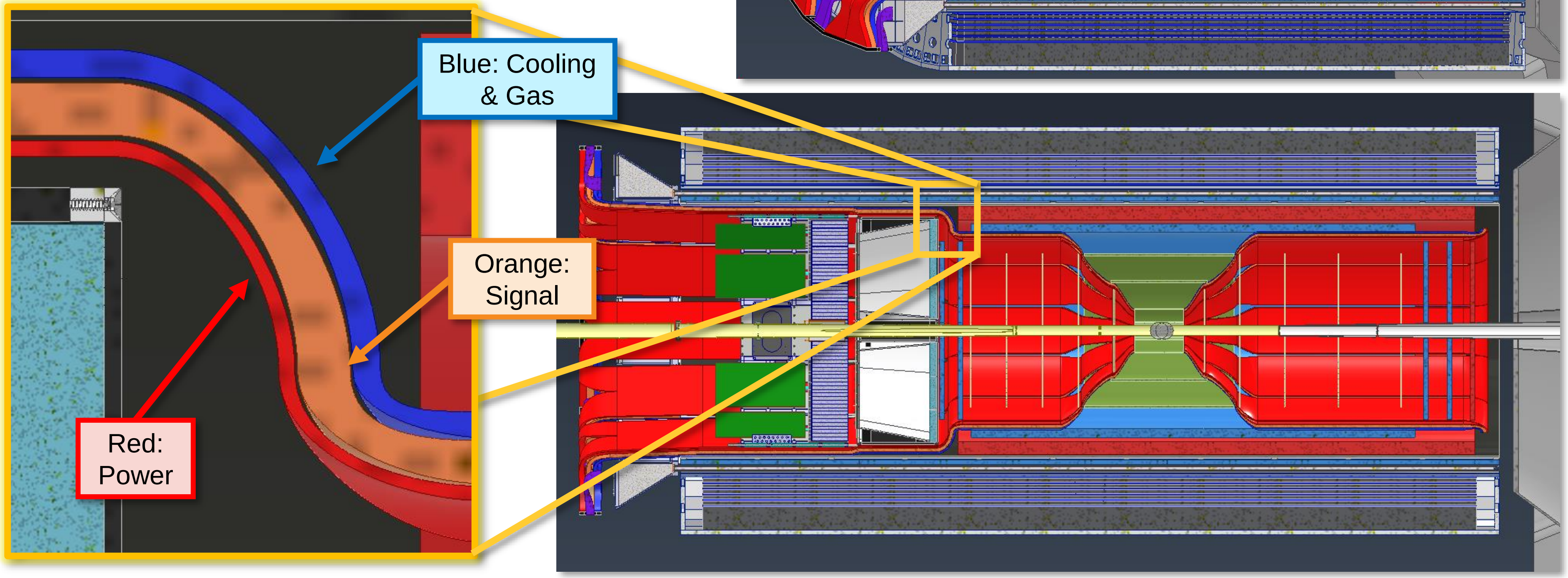
Subsytem	Cross Area (cm^2)	+50% Packing for Bundles	+50% for MISC spacing needs	Used Space		
Red Path IP to pfRICH Inner face						
Total	853.72	1280.58		1800.00	Used space:	71.14%
Red Path From pfRICH to EEEMCAL Inner face						
Total	920.17	1380.26	1725.32	2240.00	Used space:	77.02%
Red Path From EEEMCAL to Flux Return Bars						
Total	2497.31	3745.97	4096.57	9650.97	Used space:	42.45%
Orange Path From IP to AC-LGAD Disk						
Total	759.74	1139.61		1998.05	Used space:	57.04%
Orange Path From AC-LGAD disk to Aerogel						
Total	1559.01	2338.51	2937.96	4084.07	Used space:	71.94%
Orange Path From dRICH Aerogel to Dogbones						
Total	1597.23	2395.84	3023.96	4964.00	Used space:	60.92%
Orange Path From 4 to 5						
Total	2286.07	3429.11	4573.86	12189.38	Used space:	37.52%

Service Routing

Charge 3

- Broke the services up into 3 separate categories- Power, Signal, Cooling & gas
- The volumes of the sections increase as they progress along the paths mentioned before

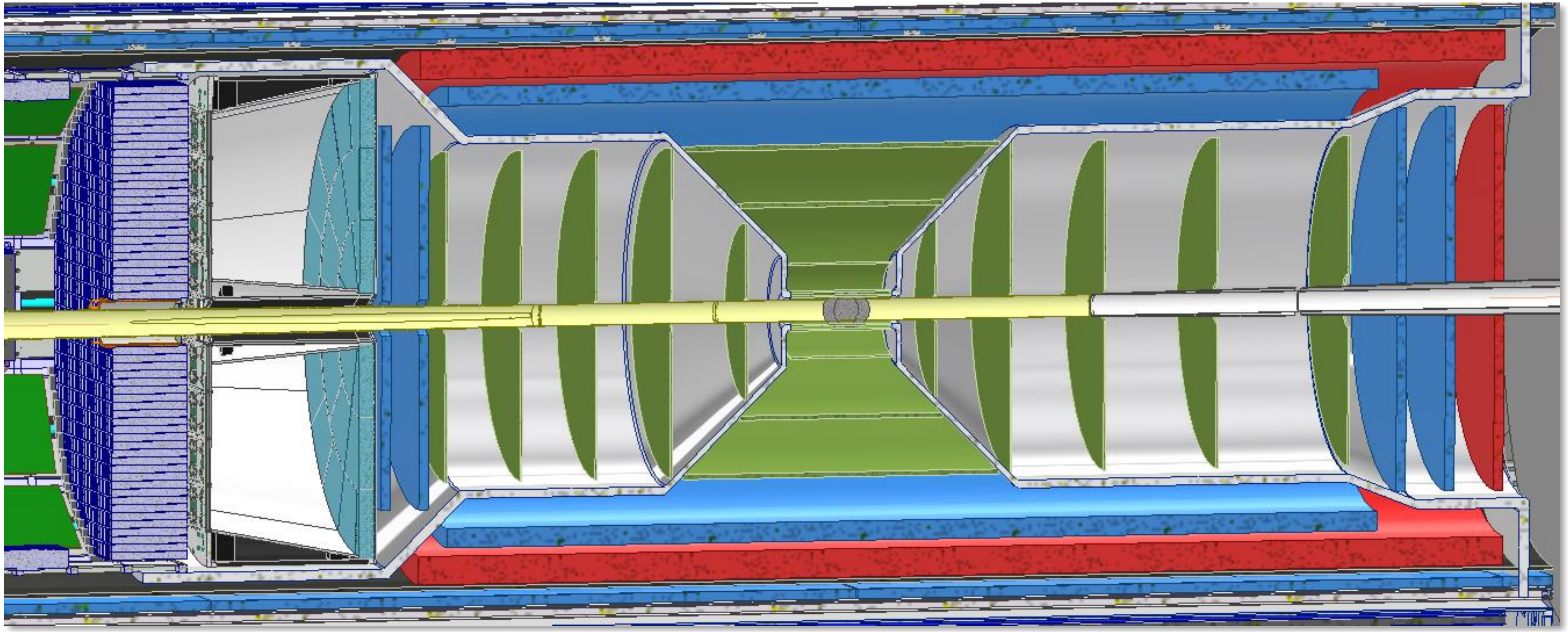




Material Budget

Charge 3

- The Collaboration has been running simulations to account for the impact of the services on tracking
  - Below: Average total material particles will see leaving from IP
  - Using these simulations to optimize layouts



Detector Electronics Power & Services

Charge 3

Detector	Type	Front End LV Power	HV Bias	LV Power Supply Type	HV Power Supply Type	Power Supply Location	LV Power Feed	LV Feed Cables (Tray Rated)	Cooling (Board Electronics)
EE MPDG Disk	uRWELL	350W	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19” rackmount	10V @ 315A	2x 10AWG	Liquid
Outer Barrel MPGD	uRWELL	1.6kW	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19” rackmount	10V @160A	12x 12AWG	Liquid
Inner Barrel MPGD	uRWELL	700W	1.5W@1.5kV	MDH-07/16	CAEN A1515BV	S. Platform, 19” rackmount	10V@120A	15x 12AWG	Liquid
MAPS Disk	EIC-LAS	3kW	Derived from LV system	MPV 4018I	N/A	S. Platform, 19” rackmount	3.6V@ 960A	48x 10AWG	Liquid
MAPS Sagita Layer3	EIC-LAS	680W	Derived from LV system	MPV 4018I	N/A	S. Platform, 19” rackmount	2.4V@ 194A	16x 12AWG	Liquid
MAPS Sagita Layer4	EIC-LAS	1.4kW	Derived from LV system	MPV 4018I	N/A	S. Platform, 19” rackmount	4.8V @ 235A	18x 12AWG	Liquid
MAPS Vertex	EIC-LAS	200W	Derived from LV system	MPV 4018I	N/A	S. Platform, 19” rackmount	1.2V @ 60A	4x 12 AWG	Liquid

Summary

- The current designs for the detectors, their services, and their electronics are well developed for the current phase of the project
- These designs are all integrated into the larger detector model
- Services, electronics and readouts are integrated into the model along with sufficient contingency spacing should any adjustments be needed
- Adjustments and optimizations are quickly worked into the larger integrated model to ensure that all components mesh

Backups