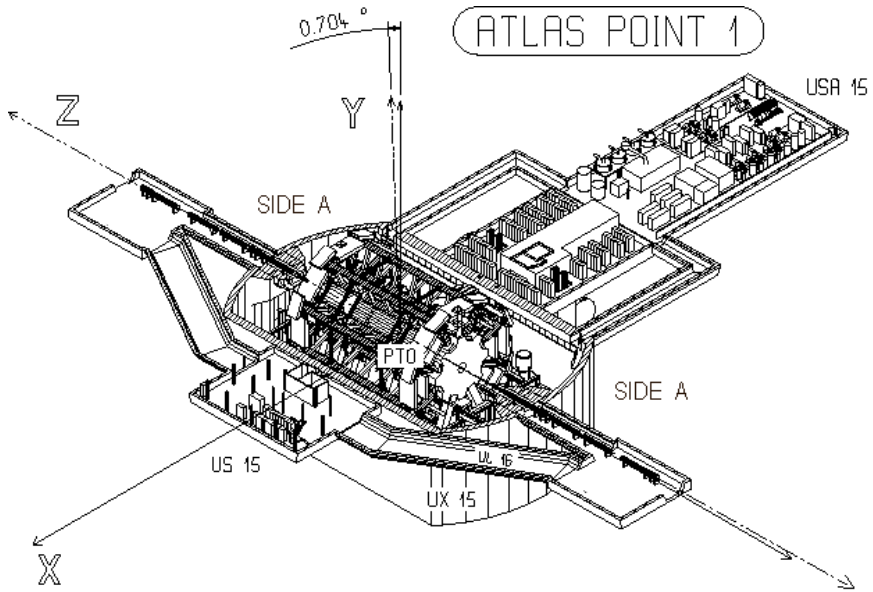
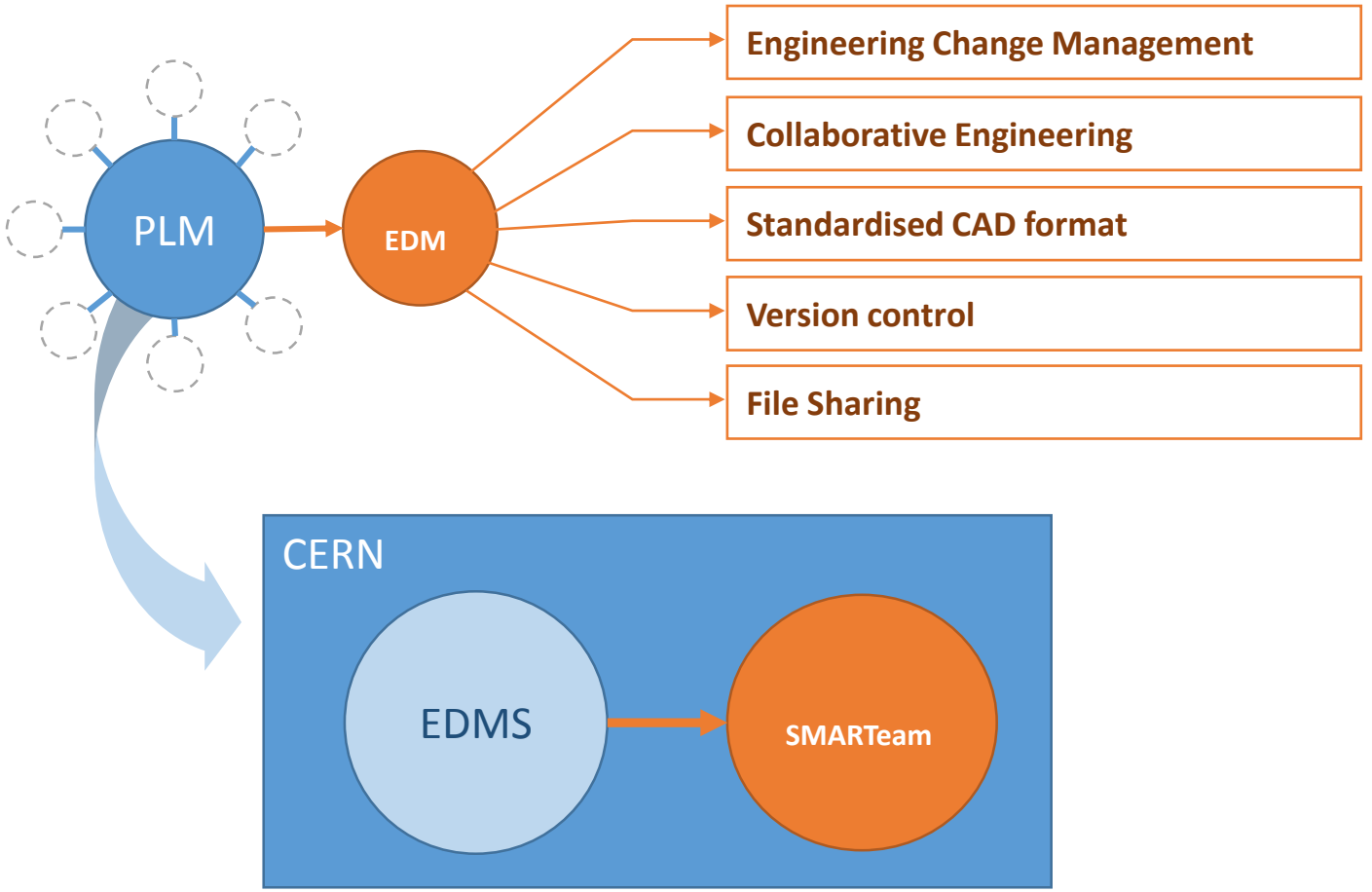
Development of Analysis and Synthesis Methods for Geometry Modeling of ATLAS Detector

Archil Surmava

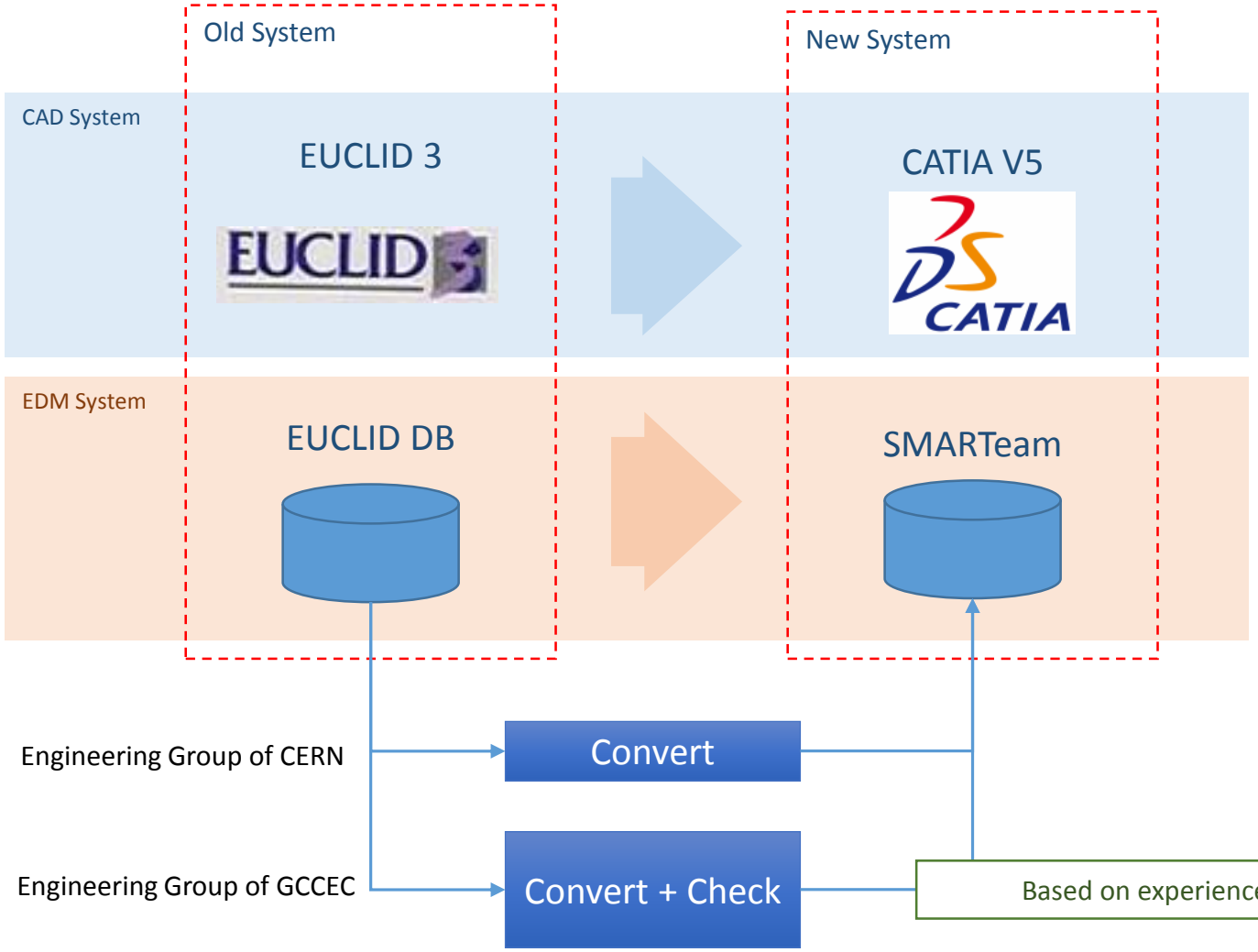
EDM system for ATLAS Experiment



- Long – 44 meters
- Diameter – 25 meters
- weighs ~7,000 tons
- 100 meters below ground
- 10’000’000 Engineering units



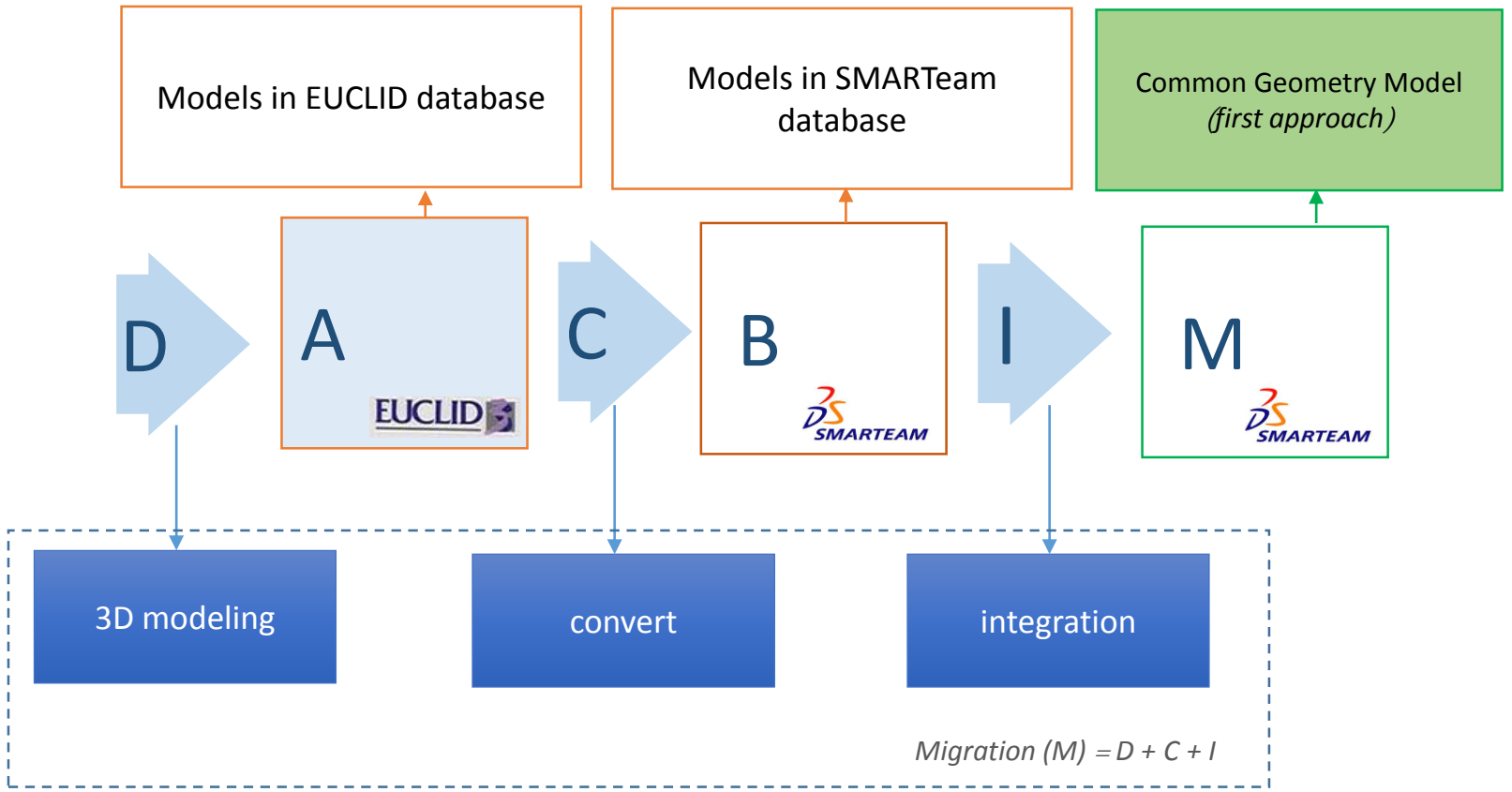
Changing of EDM/CAD system. Migration of the models



Migration problems

1. Have not CATIA structure tree
2. There are similar models
3. Some models does not exist
4. Models with conversion fault
5. Synchronization between detailed and simplified models
6. Incomplete models
7. Identical models
8. Unknown models, that did not appertain to ATLAS components
9. Unstructured models - wrong position on CATIA tree
10. Converted models with wrong name
11. Models with wrong position
12. Models with unnecessary parts

Geometry Model of ATLAS Detector



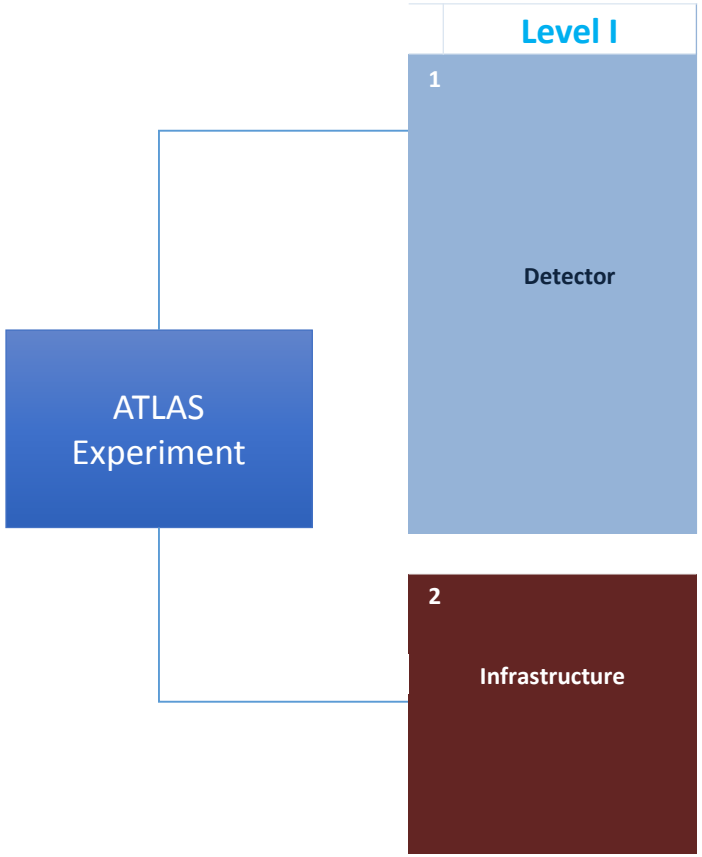
Migration problems

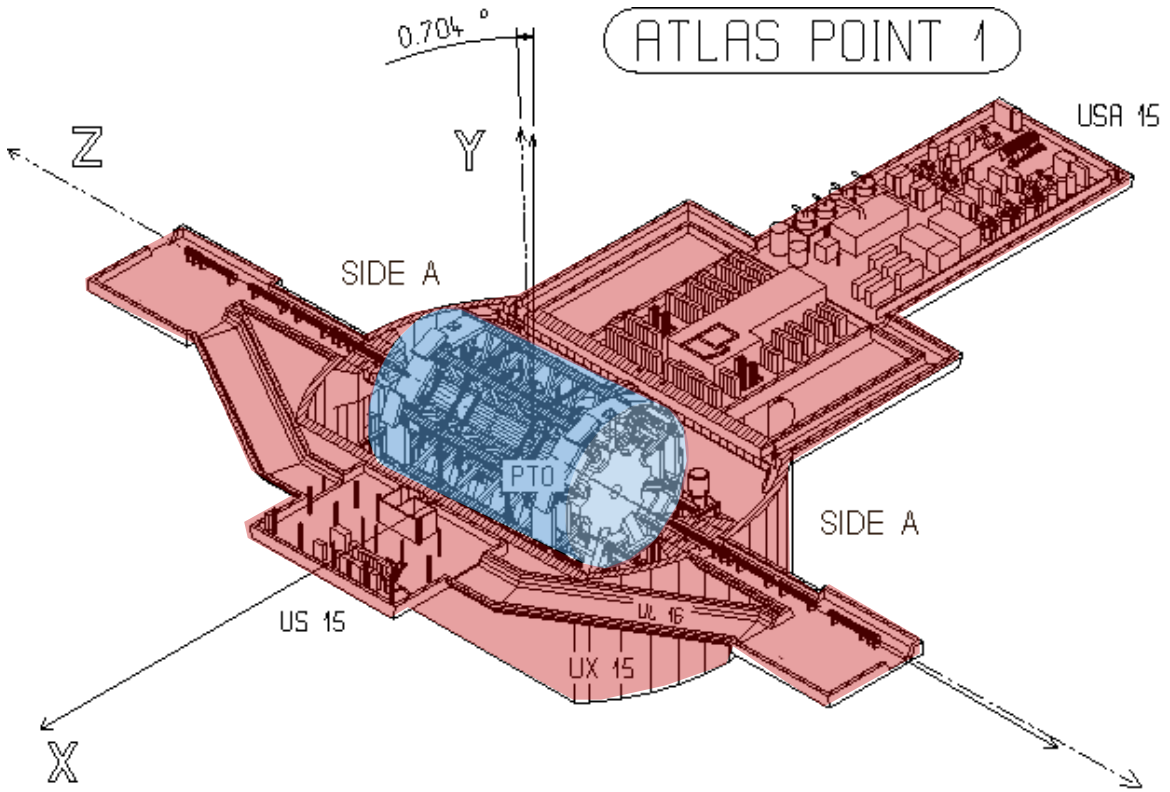
1. Have not CATIA structure tree — I
2. There are similar models — I
3. Some models does not exist — D
4. Models with conversion fault — C
5. Synchronization between detailed and simplified models — D
6. Incomplete models — D
7. Identical models — I
8. Unknown models, that did not appertain to ATLAS components — I
9. Unstructured models - wrong position on CATIA tree — I
10. Converted models with wrong name — C
11. Models with wrong position — I
12. Models with unnecessary parts — D

Decomposition Steps

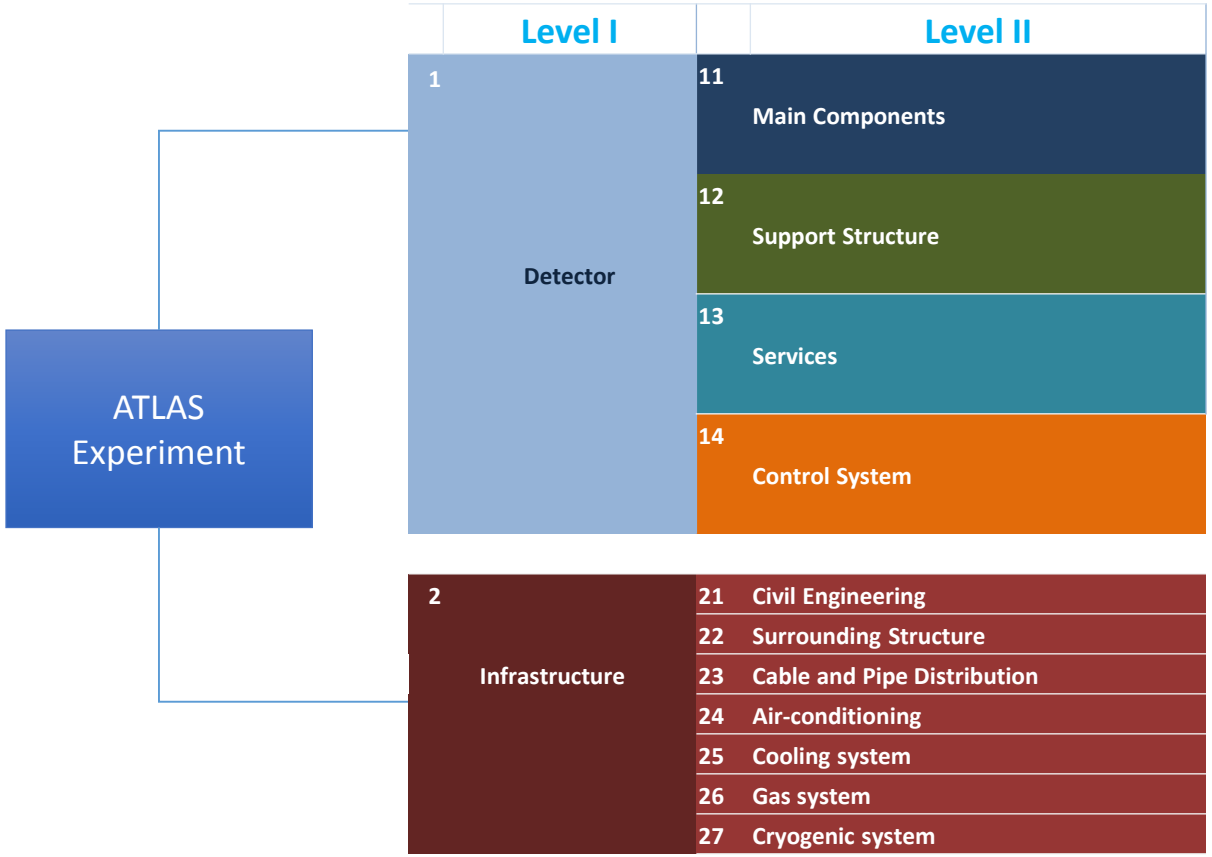
1. Functional Decomposition
2. Spatial Decomposition
3. Symmetry Decomposition

Functional decomposition of ATLAS Detector (Level I)





Functional decomposition of ATLAS Detector (Level II)



Provides discovering and curving of particle direction

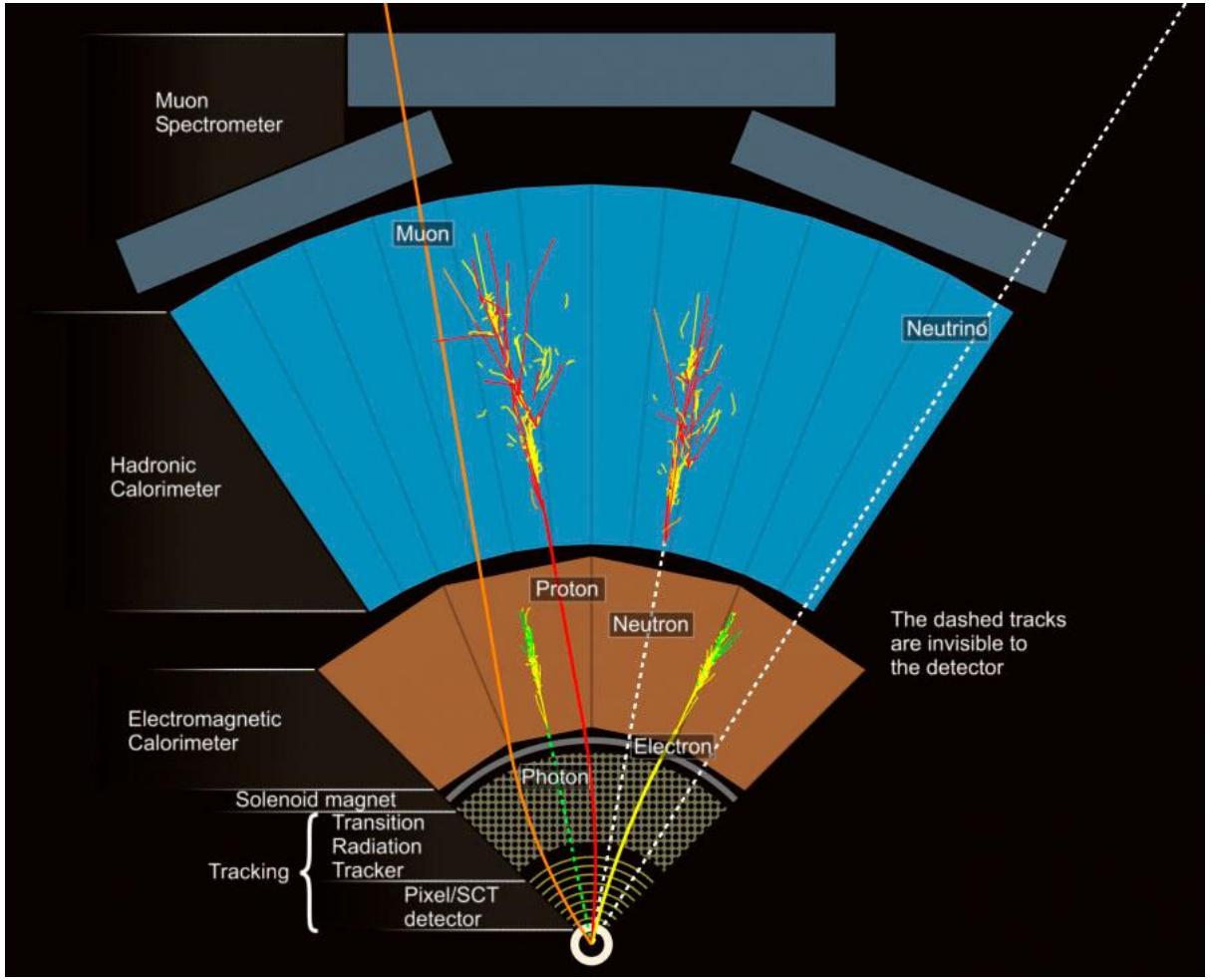
Provides mechanical stability, access and positioning of detector construction

In services are united electric and optic cables

Provides control parameters for normal operation of detector

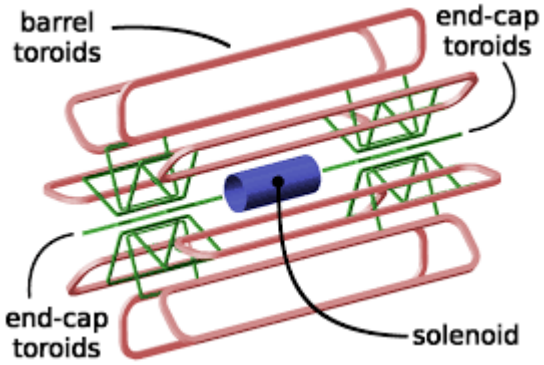
Functional decomposition of ATLAS Detector (Level III, IV)

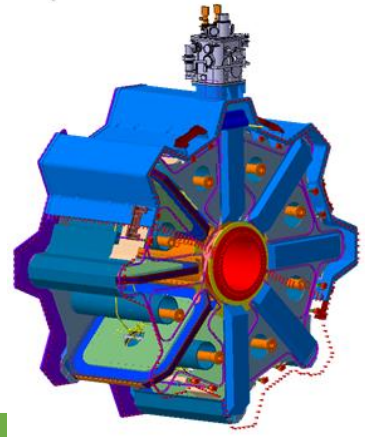
Level II	Level III	Level IV
11 Main Components	111. Magnet system	
		111.1 Solenoid
		111.2 Toroid
	112. Inner Detector	
		112.1 Pixel
		112.2 SCT
		112.3 TRT
	113. Calorimetry	
		113.1 Lar
		113.2 Tile
	114. Muon Spetrometer	
		114.1 Barrel
		114.2 Endcap
	115. Shilding	
		115.1 Disk shilding
		115.2 Forward shilding
		115.3 Moderate shilding
		115.4 Lar cal shilding plugs
		115.5 Toroid shilding
		115.6 Nose shilding
	116. Beam Pipe	

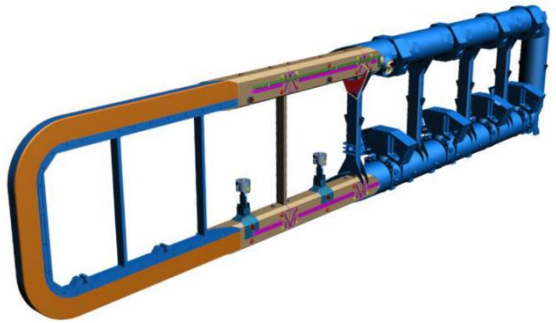


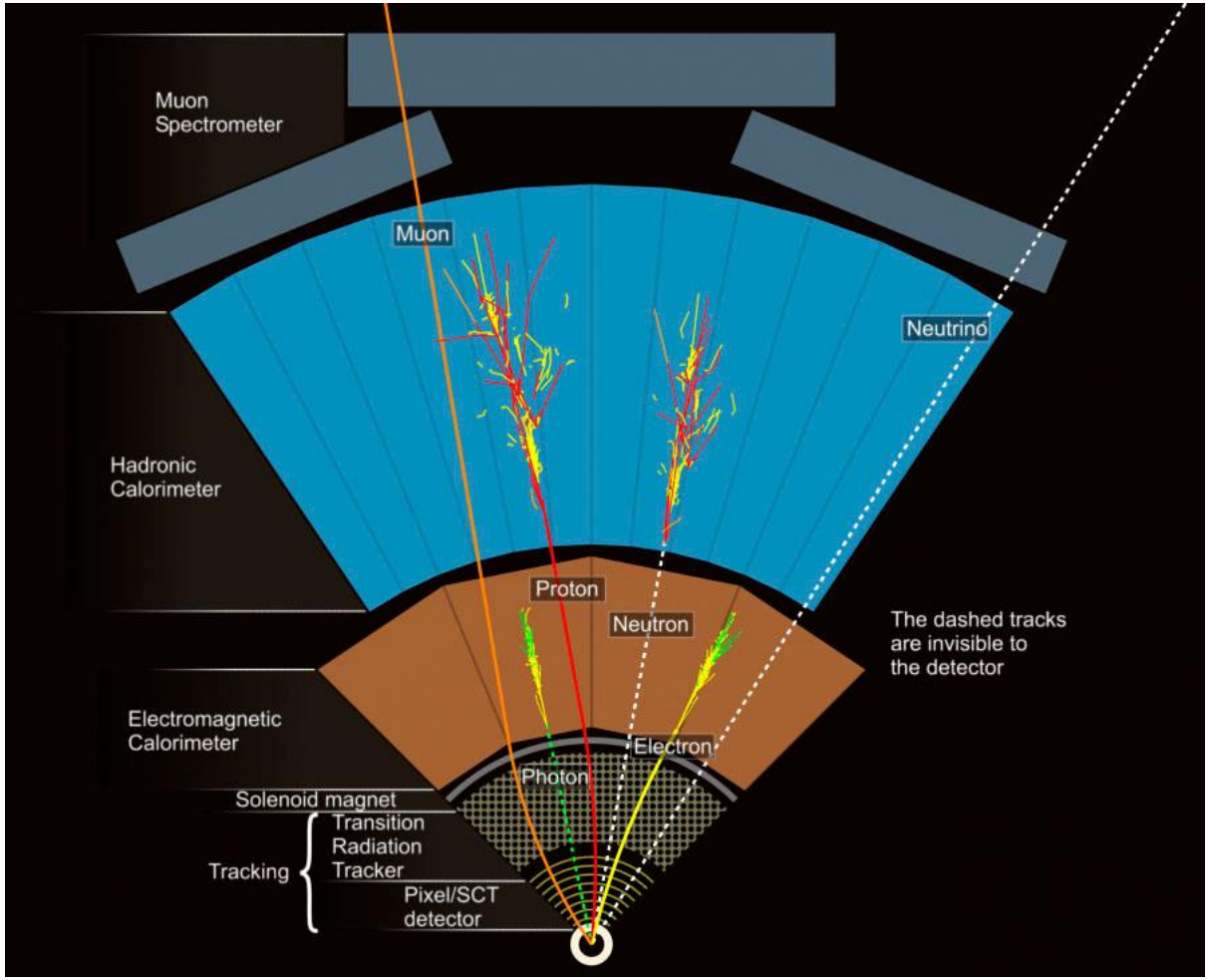
Magnet system

111.	Magnet system			
	111.1	Solenoid	EA	
	111.2	Toroid		
			111.21 Barrel	EA
			111.22 EndCap	EA



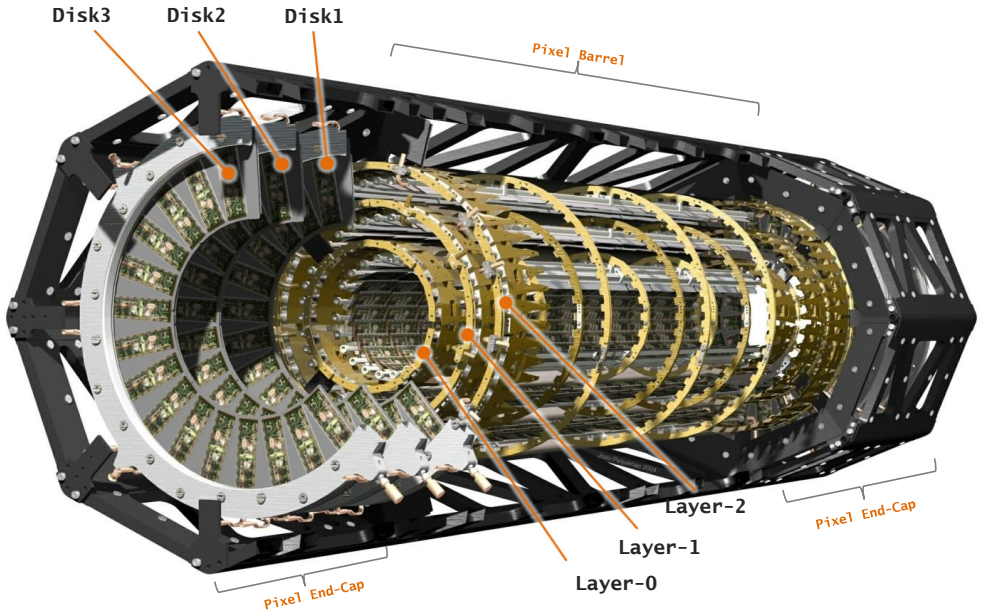


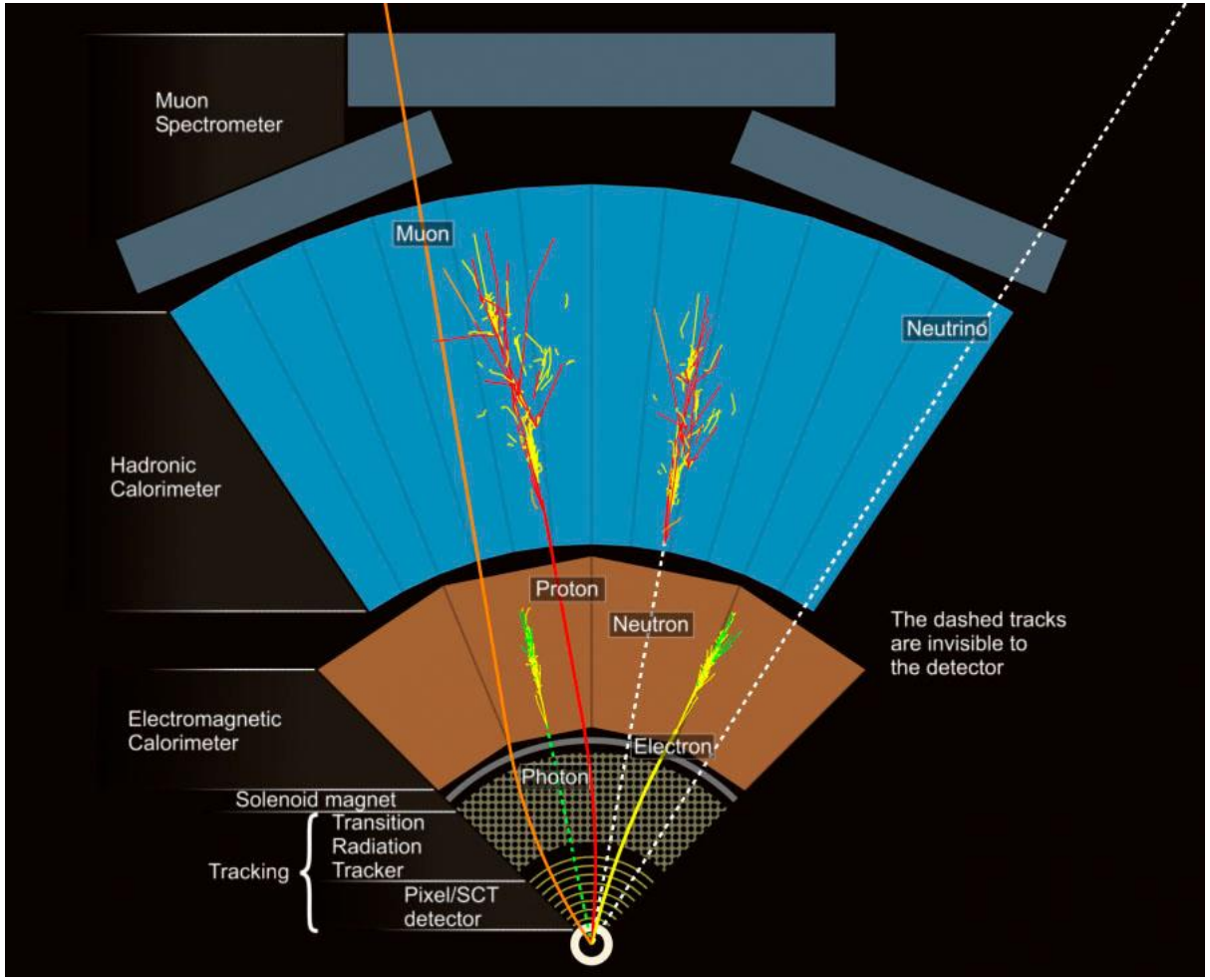




Inner Detector - Pixel

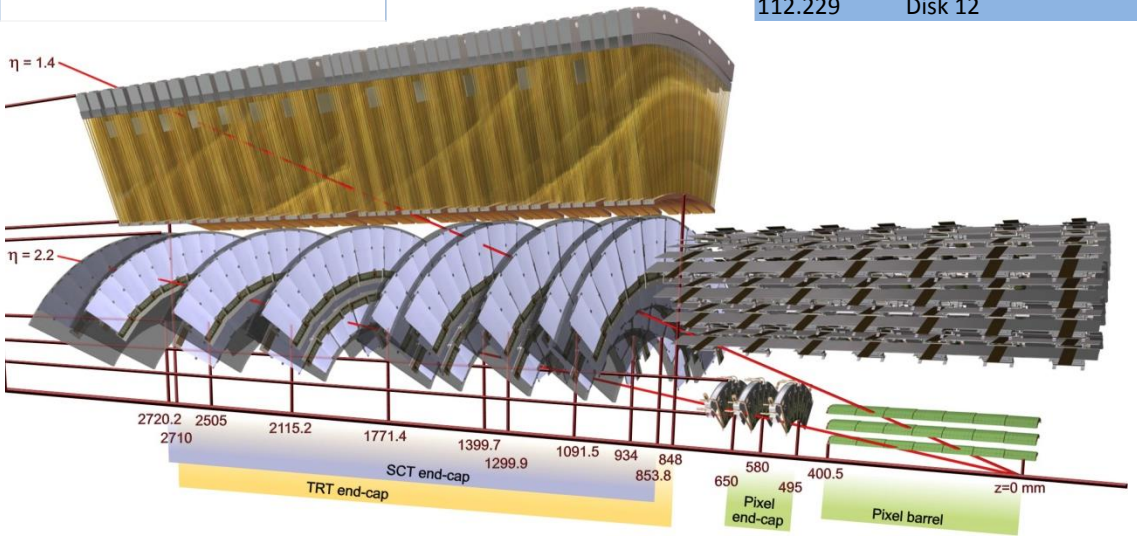
112. Inner Detector			
	112.1 Pixel		
		112.11 Barrel	
			112.111 Layer 0
			112.112 Layer 1
			112.113 Layer 2
		112.12 EndCap	
			112.121 Disk 1
			112.122 Disk 2
			112.123 Disk 3

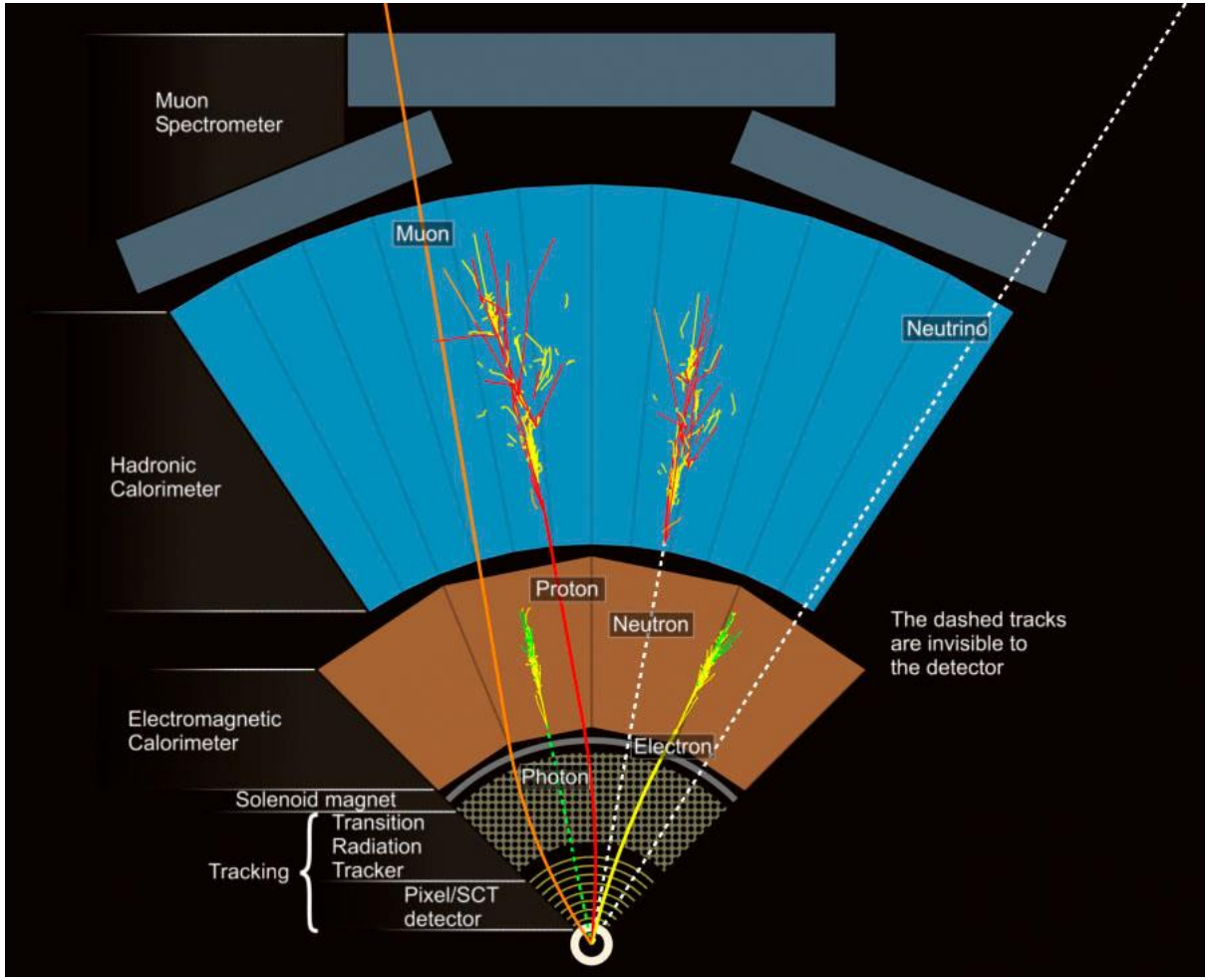




Inner Detector - SCT

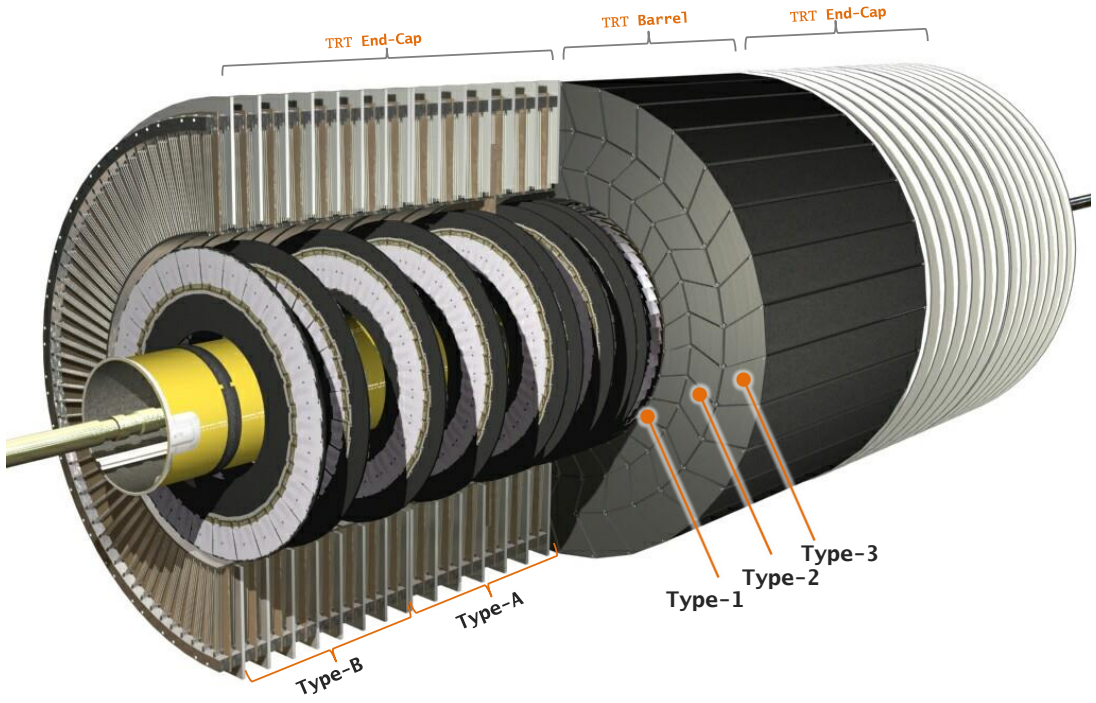
112.2 SCT		
	112.21 Barrel	
		112.211 Layer 3
		112.212 Layer 4
		112.213 Layer 5
		112.214 Layer 6
	112.22 EndCap	
		112.221 Disk 4
		112.222 Disk 5
		112.223 Disk 6
		112.224 Disk 7
		112.225 Disk 8
		112.226 Disk 9
		112.227 Disk 10
		112.228 Disk 11
		112.229 Disk 12

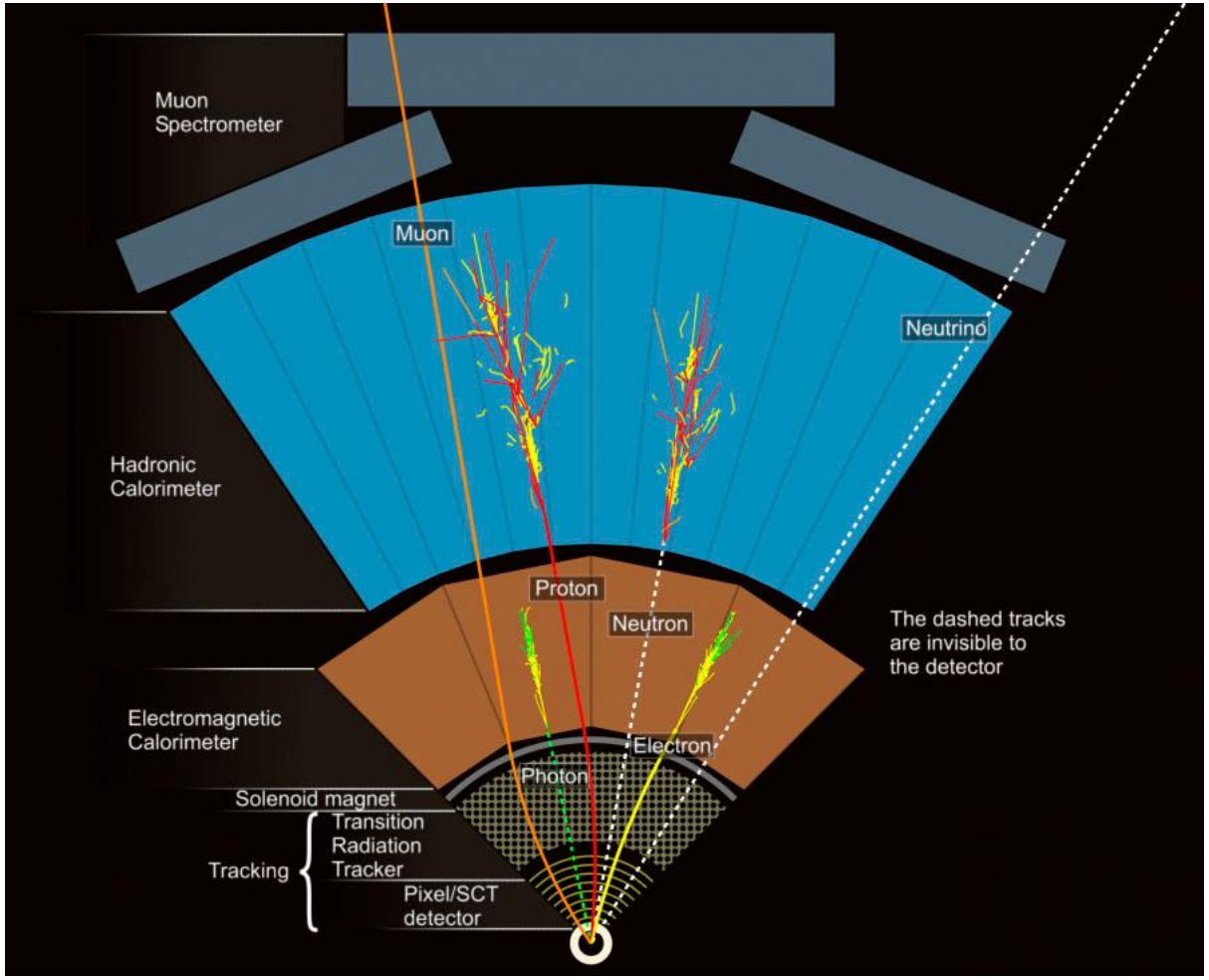




Inner Detector - TRT

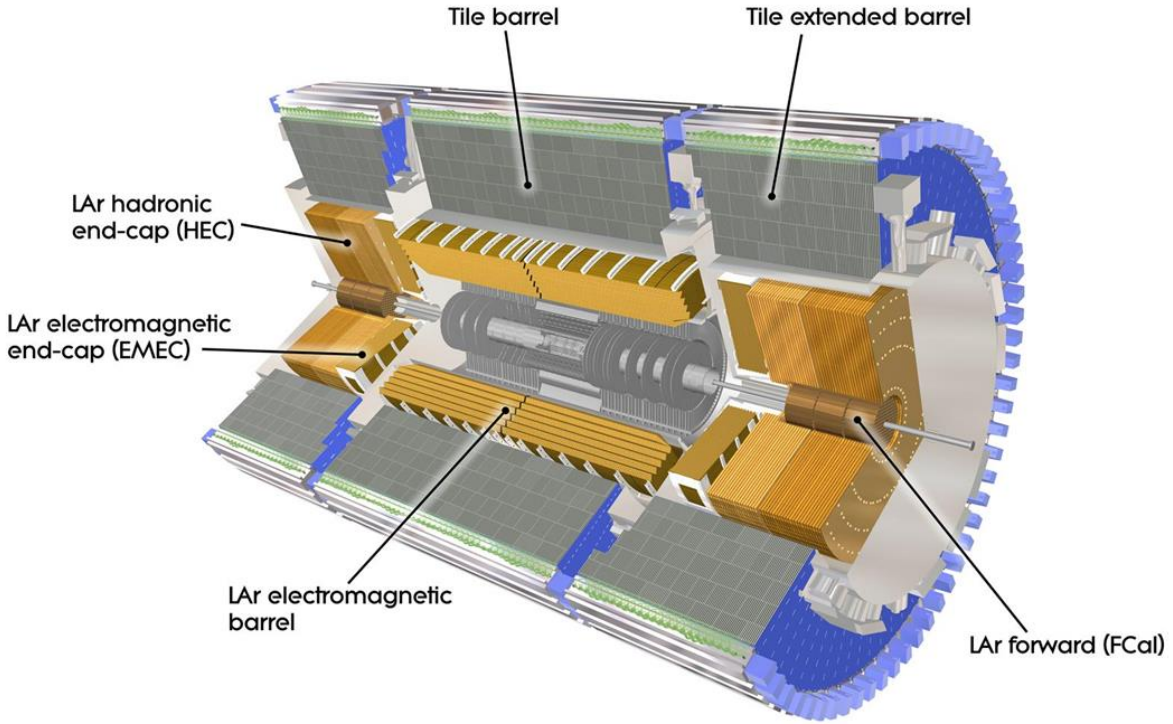
112.3 TRT		
	1.1.2.3.1. Barrel	
		112.311 Type 1
		112.312 Type 2
		112.313 Type 3
	1.1.2.3.2. EndCap	
		112.321 Type A
		112.322 Type B

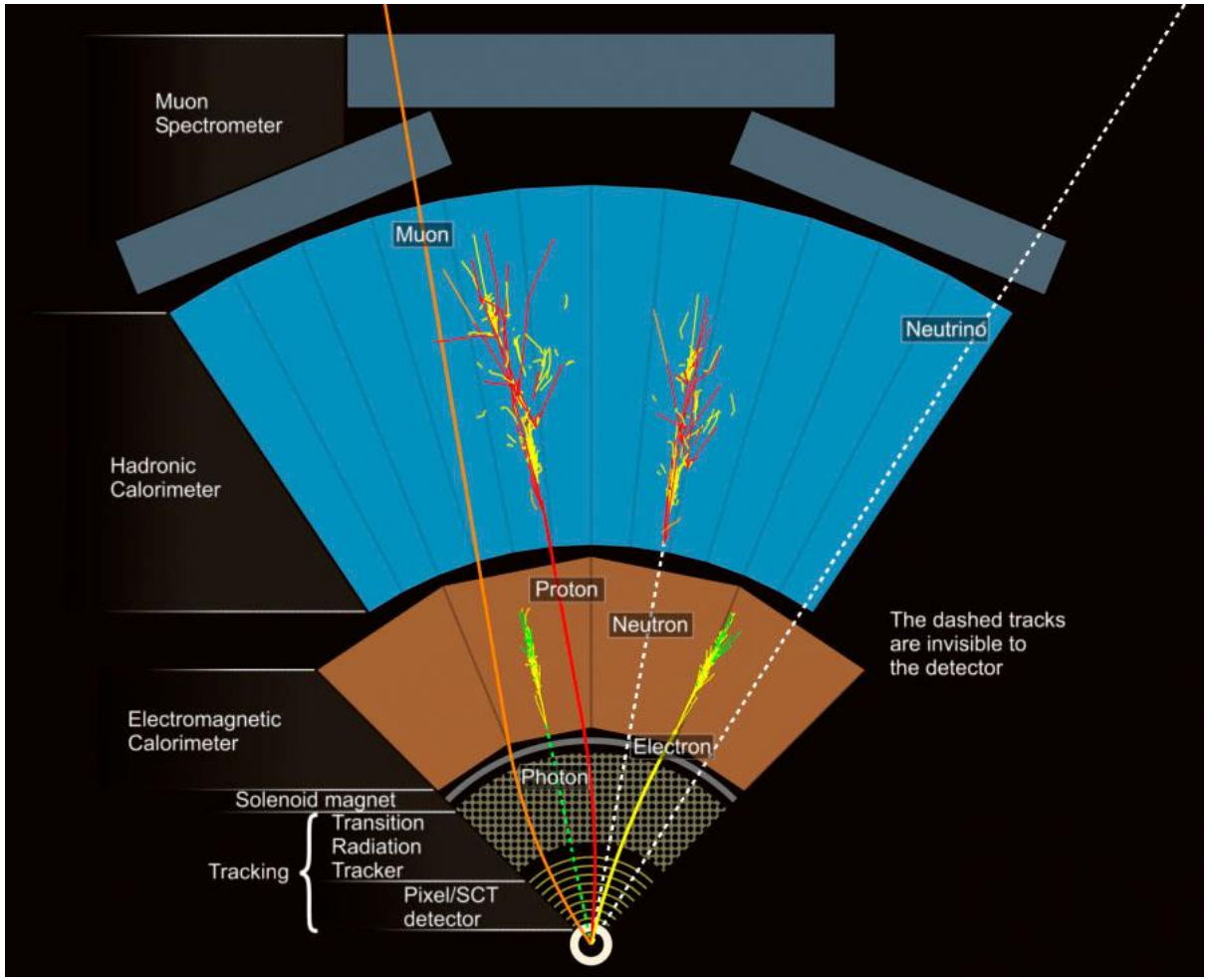




Calorimeter

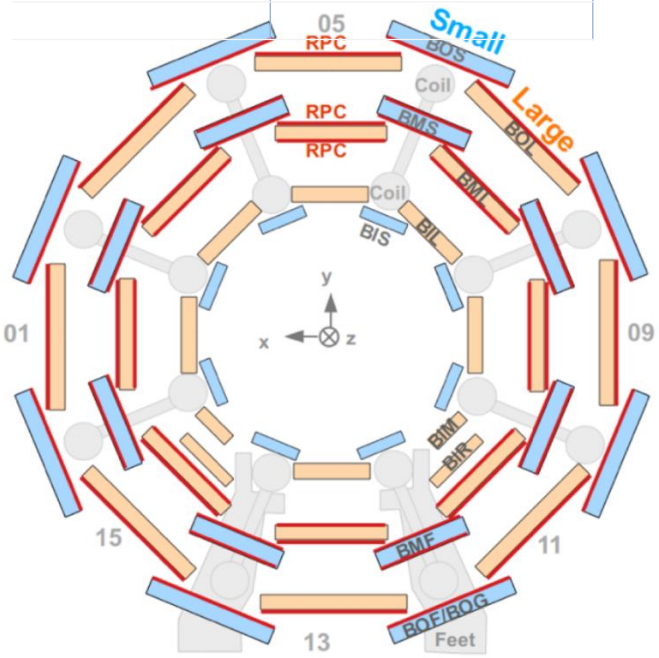
113. Calorimetry			
	113.1 Lar		
		113.11 Barrel	
		113.12 EndCap	
			113.121 EMEC
			113.122 HEC
			113.123 FCal
	113.2 Tile		
		113.21 Barrel	
		113.22 Barrel extended	

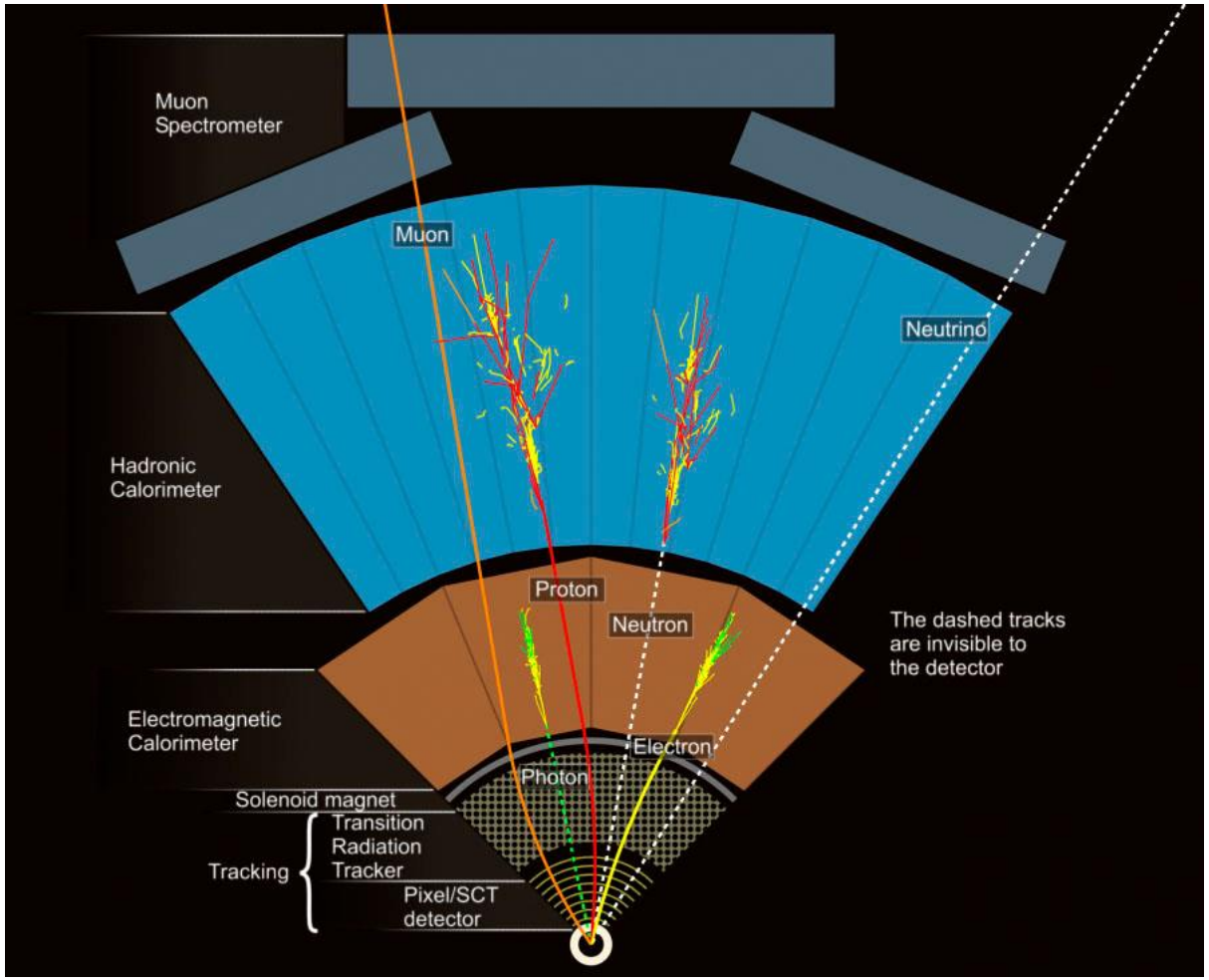




Muon Spectrometer - Barrel

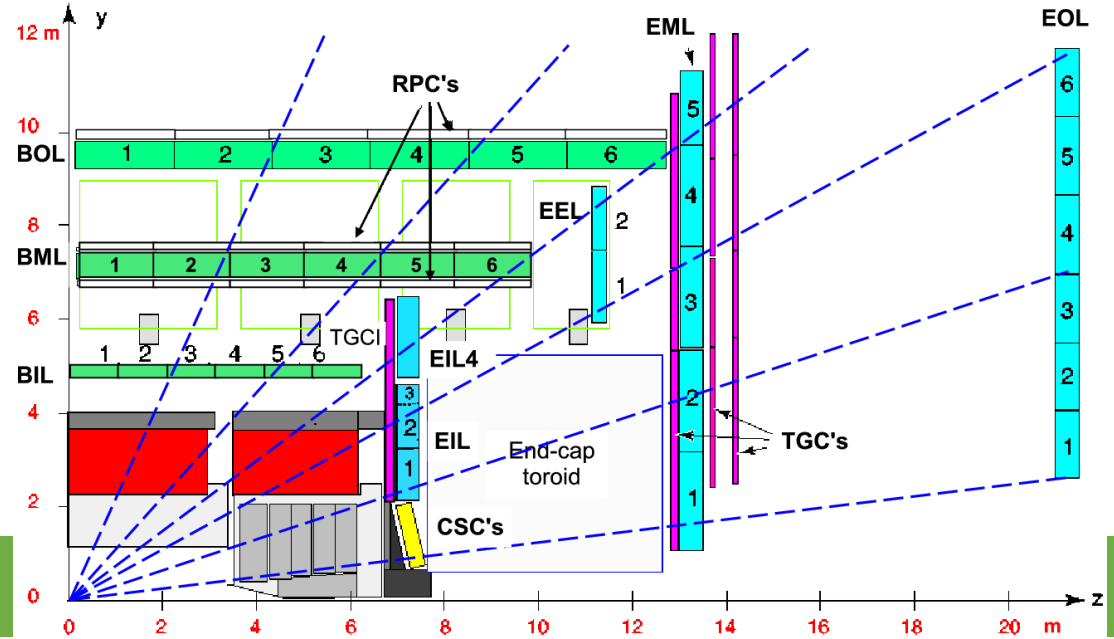
114. Muon Spetrometer				
	114.1 Barrel			
		114.11 BI Inner		
			114.111	BIL
			114.112	BIS
			114.113	BIR/BIM
		114.12 BM Middle		
			114.121	BML
			114.122	BMS
			114.123	BMF
		114.13 BO Outer		
			114.131	BOL
			114.132	BOS
			114.133	BOF/BOG

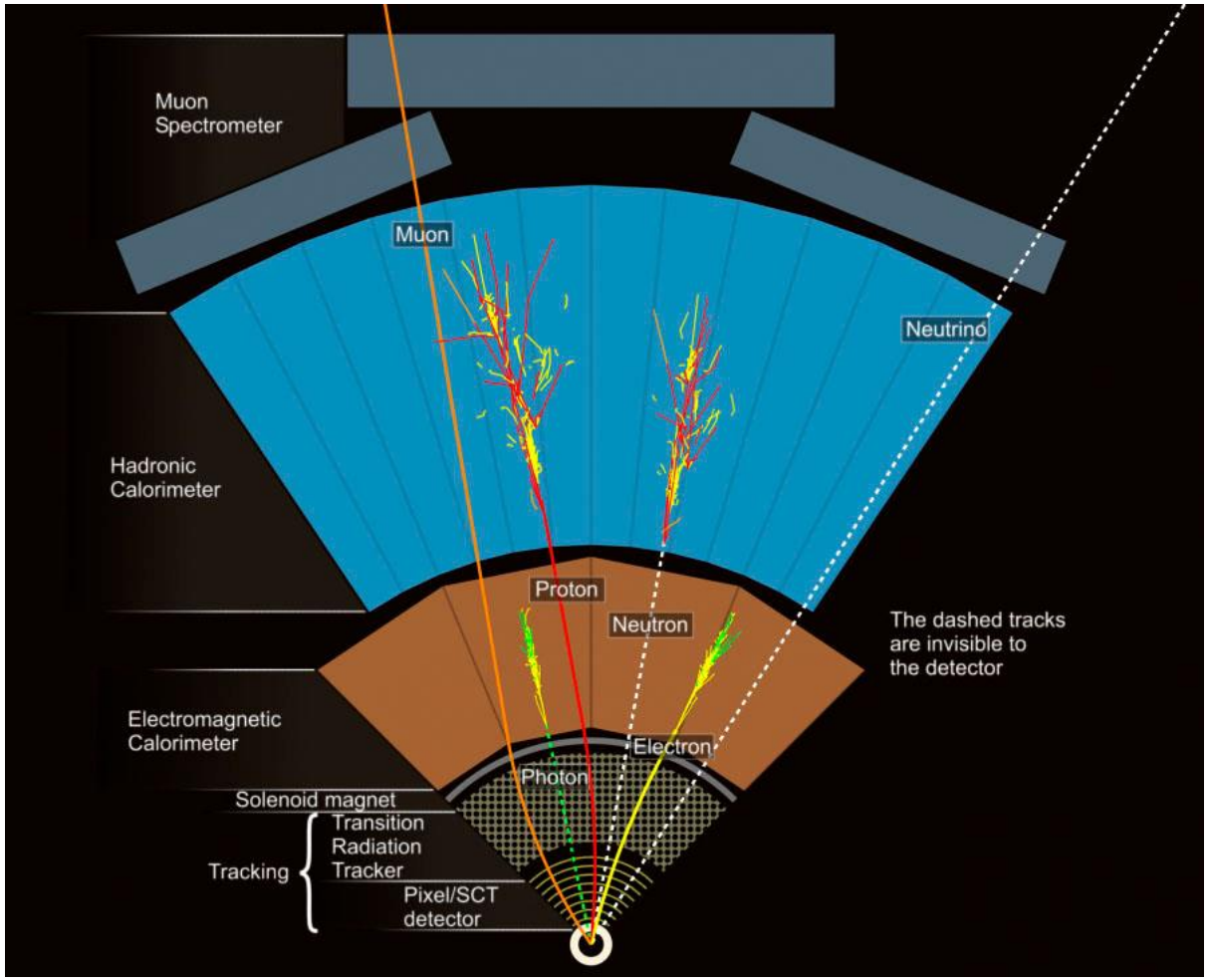




Muon Spectrometer - Endcap

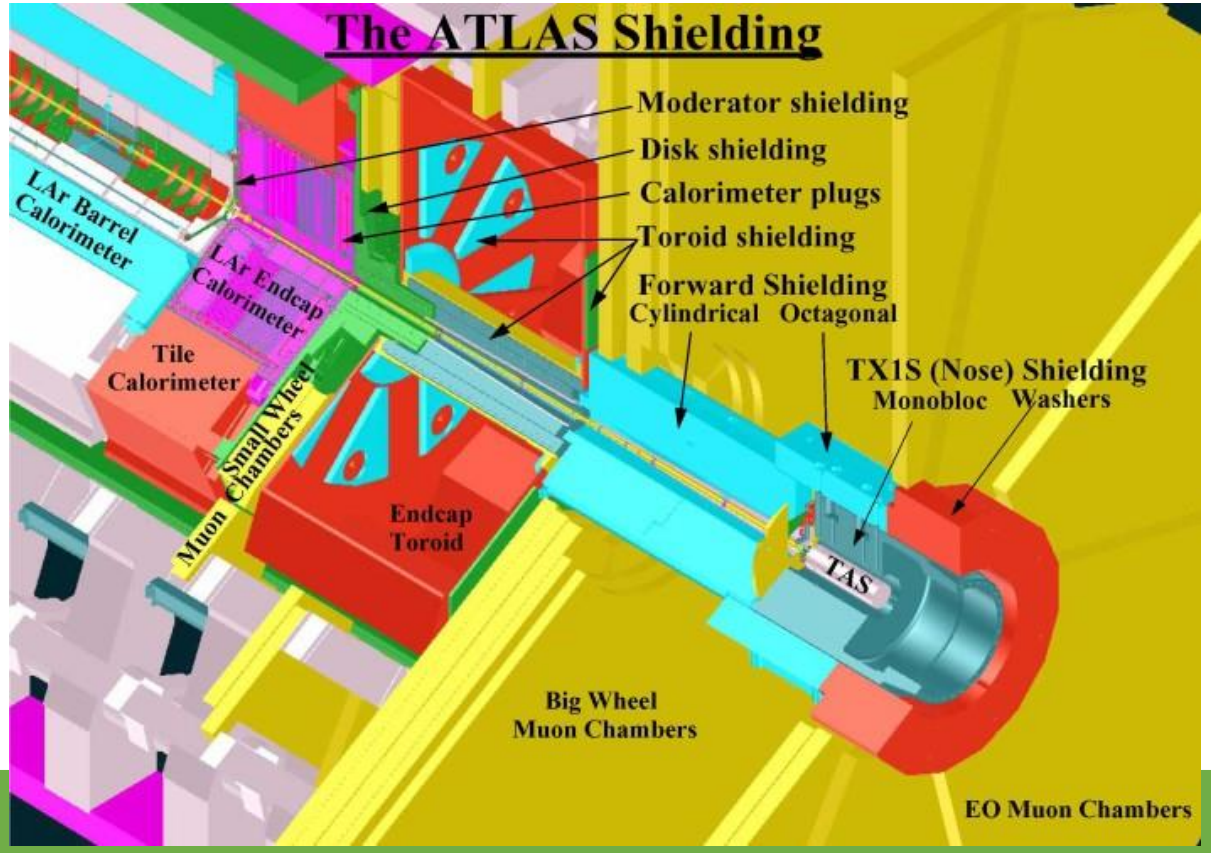
114.2 Endcap			
	114.21	EI Small wheel	
		114.211	EIL/CSCL
		114.212	EIS/CSCS
		114.213	TGC(I)
	114.22	EE Extra wheel	
		114.221	EEL
		114.222	EES
	114.23	EM Big wheel	
		114.231	EML
		114.232	EMS
		114.233	TGC(M1,M2,M3)
	114.23	EO Outher wheel	
		114.241	EOL
		114.242	EOS



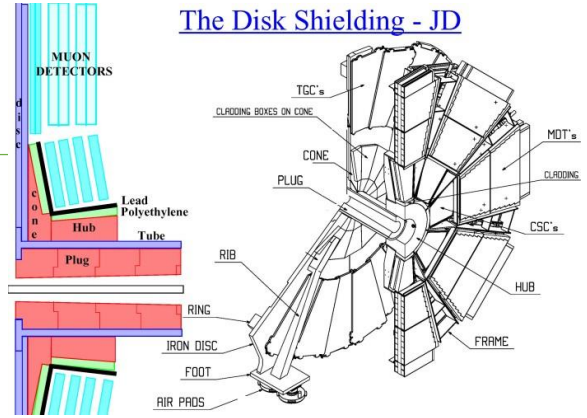


Shielding

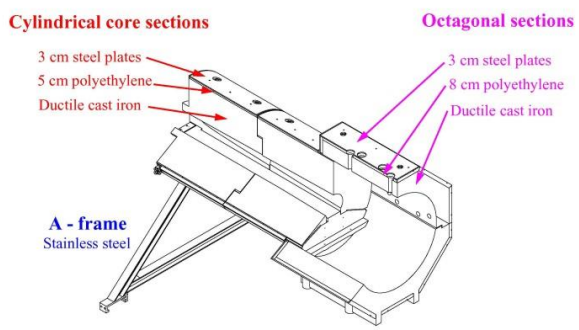
115.	Shielding		
	115.1	Disk shielding	
	115.2	Forward shielding	
	115.3	Moderate shielding	
	115.4	Lar cal shielding plugs	
	115.5	Toroid shielding	
		115.51	Toroid Inner Bore Tube
		115.52	Endcap Toroid Shieldeing
	115.6	Nose shielding	



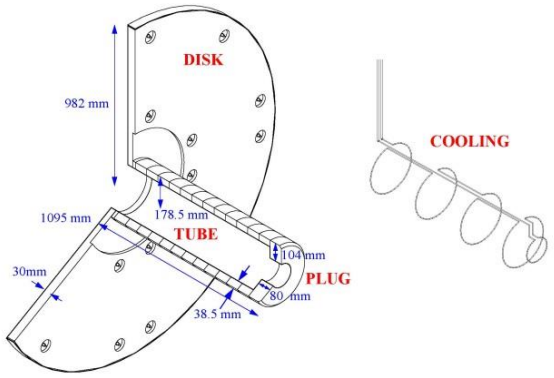
The Disk Shielding - JD



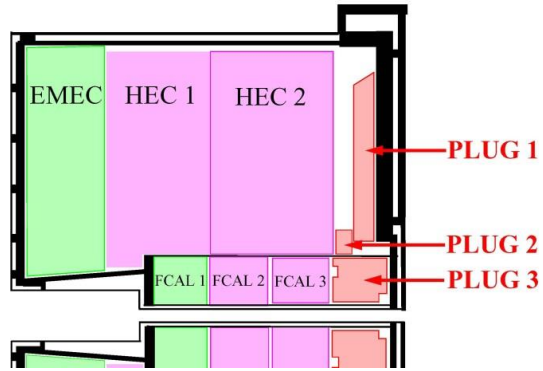
The Forward Shielding - JF



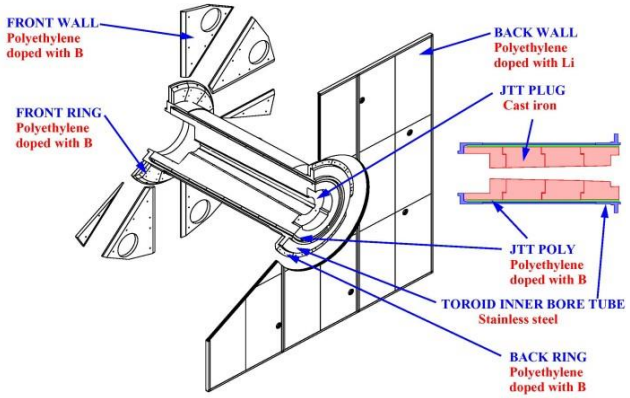
The Moderator Shielding - JM



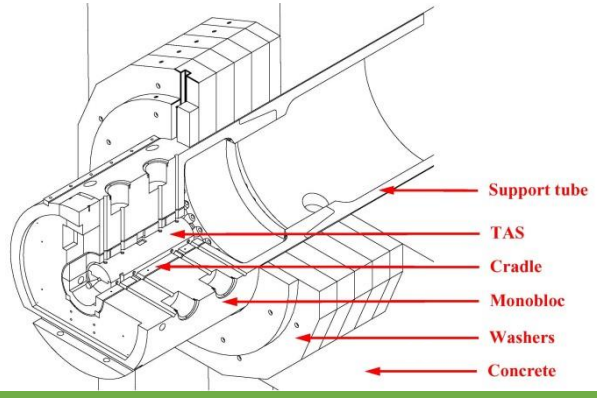
The LAr Calorimeter Shielding Plugs



The Toroid Shielding - JT



The Nose Shielding - JN



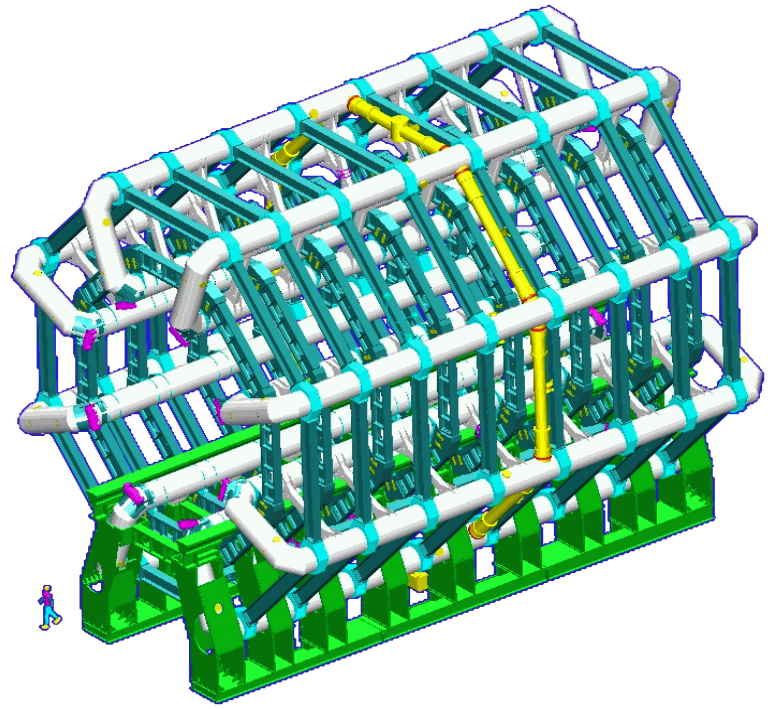
Support Structure (Level III, IV)

Level II	Level III	Level IV
11 Main Components	111. Magnet system	
		111.1 Solenoid
		111.2 Toroid
	112. Inner Detector	
		112.1 Pixel
		112.2 SCT
		112.3 TRT
	113. Calorimetry	
		113.1 Lar
		113.2 Tile
	114. Muon Spetrometer	
		114.1 Barrel
		114.2 Endcap
	115. Shilding	
		115.1 Disk shilding
		115.2 Forward shilding
		115.3 Moderate shilding
		115.4 Lar cal shilding plugs
		115.5 Toroid shilding
		115.6 Nose shilding
	116. Beam Pipe	

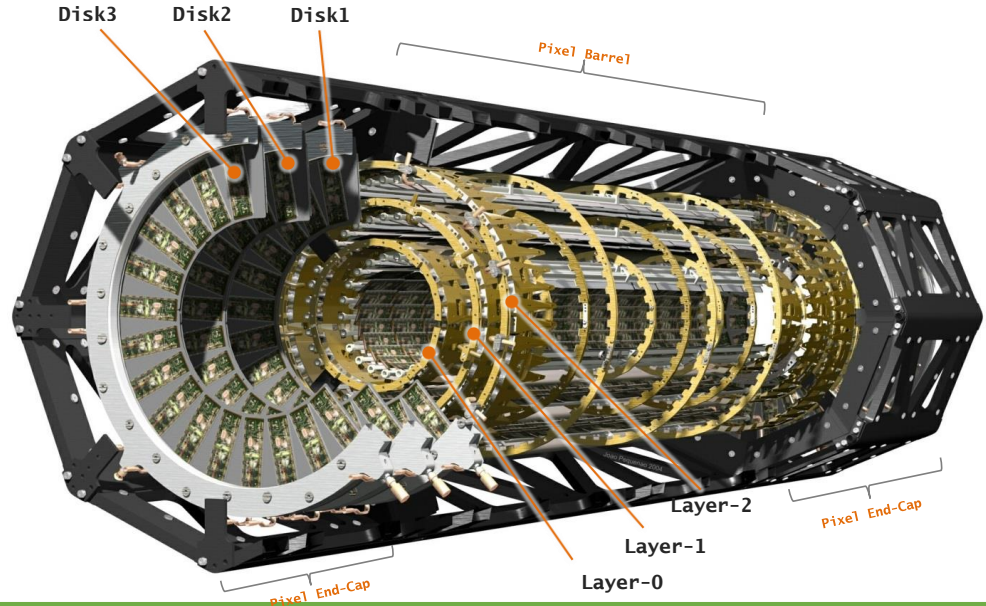
Level II	Level III	Level IV
12 Support Structure	121. Mechanical Structure	
		121.01 Feet and Rails
		121.02 Pixel Supports
		121.03 SCT
		121.04 TRT
		121.05 LAr
		121.06 Tile
		121.07 Muon
		121.08 BT Warm Structure
		121.09 Shielding
		121.10 Beam Pipe Supports
	122. MB Access platforms	
	123. Muon Alignment	
		123.1 Barrel Alignment
		123.12 Endcap Alignment

Support Structure - Feet and Rails, Pixel Supports

121. Mechanical Structure			
	121.01 Feet and Rails		
		121.01.1	Feet
		121.01.2	Rails

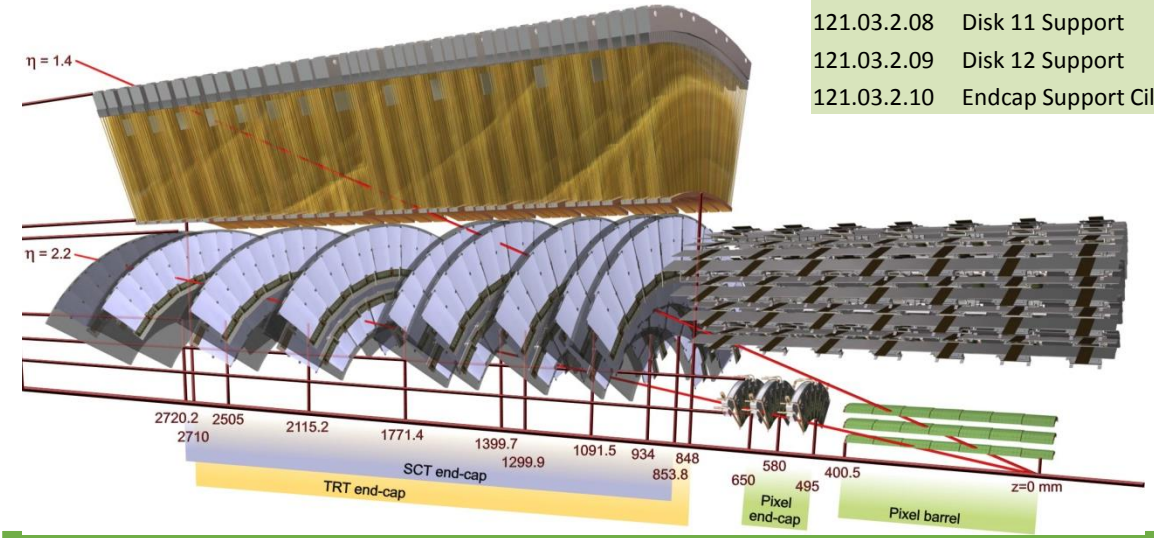


121.02 Pixel Supports			
	121.02.1 Pixel Barrel Supp		
		121.02.11	Layer 0 Support
		121.02.12	Layer 1 Support
		121.02.13	Layer 2 Support
		121.02.14	Pixel Barrel Frame
	121.02.2 Pixel Endcap Supp		
		121.02.21	Disk 1 Support
		121.02.22	Disk 2 Support
		121.02.23	Disk 3 Support
		121.02.24	Pixel Endcap Frame

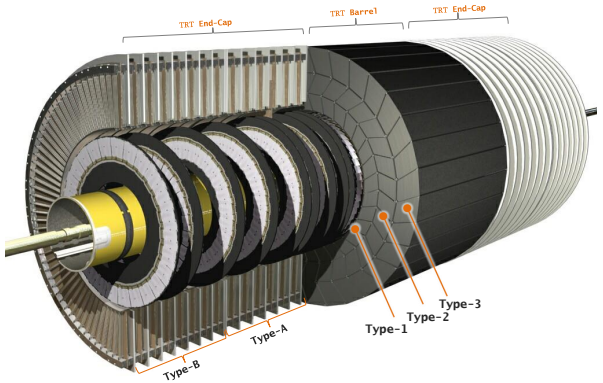


Support Structure – SCT, TRT Supports

121.03 SCT		
121.03.1 SCT Barrel Supp		
	121.03.11	Layer 4 Support
	121.03.12	Layerv5 Support
	121.03.13	Layer 6 Support
	121.03.14	Layer 7 Support
	121.03.15	Barrel Support Cilindre
121.03.2 SCT Endcap Supp		
	121.03.2.01	Disk 4 Support
	121.03.2.02	Disk 5 Support
	121.03.2.03	Disk 6 Support
	121.03.2.04	Disk 7 Support
	121.03.2.05	Disk 8 Support
	121.03.2.06	Disk 9 Support
	121.03.2.07	Disk 10 Support
	121.03.2.08	Disk 11 Support
	121.03.2.09	Disk 12 Support
	121.03.2.10	Endcap Support Cilindre

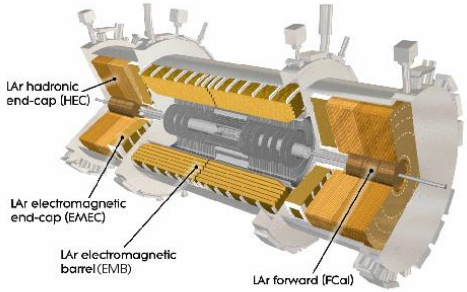


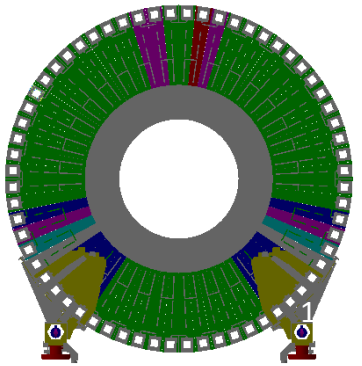
121.04 TRT		
121.04.1 TRT Barrel Supp		
121.04.2 TRT Endcap Supp		
	121.04.21	TRT Type-A Supp
	121.04.22	TRT Type-B Supp



121.05 LAr		
	121.05.1	LAr Barrel Cryostat
	121.05.2	LAr Endcap Cryostat

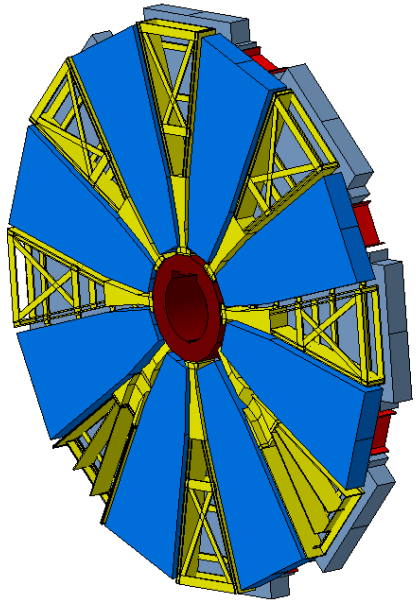
121.06 Tile		
	121.06.1	Tile Barrel Feet
	121.06.2	Tile Barrel Extended Feet



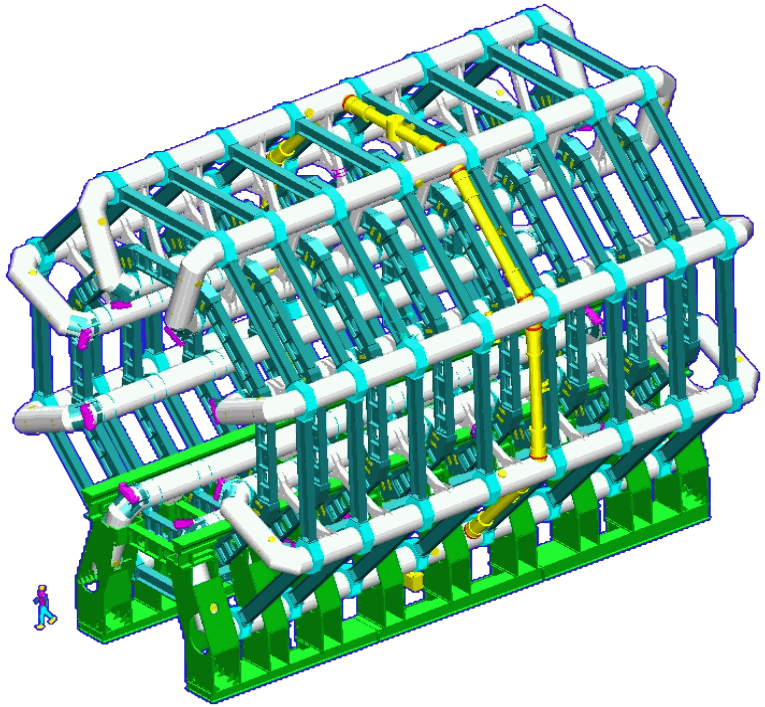


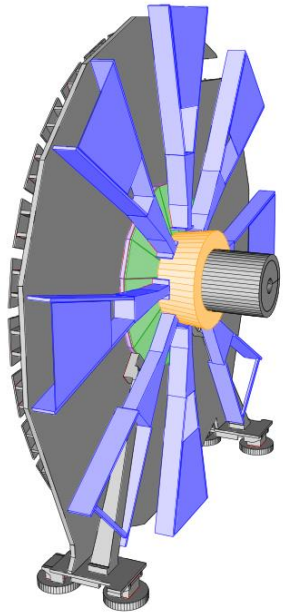
Muon Support Structures

121.07 Muon			
	121.07.1 Muon Barrel		
		121.07.11	BI Bracket
		121.07.12	BM Bracket
		121.07.13	BO Bracket
	121.07.2 Muon Endcap		
		121.07.21	EI supports
		121.07.22	EE supports
		121.07.23	EM supports
		121.07.24	EO supports



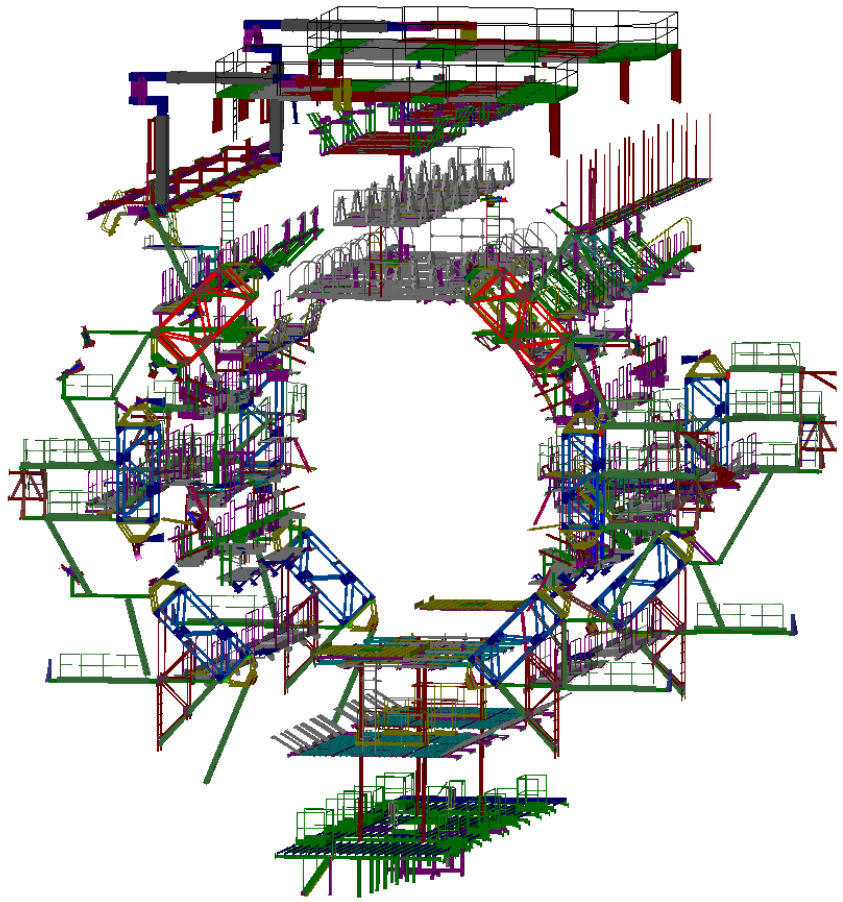
121.08 BT Warm Structure			
121.09 Shielding			
	121.09.1 Disk Shielding		
	121.09.2 Forward Shielding		
		121.09.21	Supports Frame
		121.09.22	HF Truck
	121.09.3 Nose Shielding		
121.10 Beam Pipe Supports			

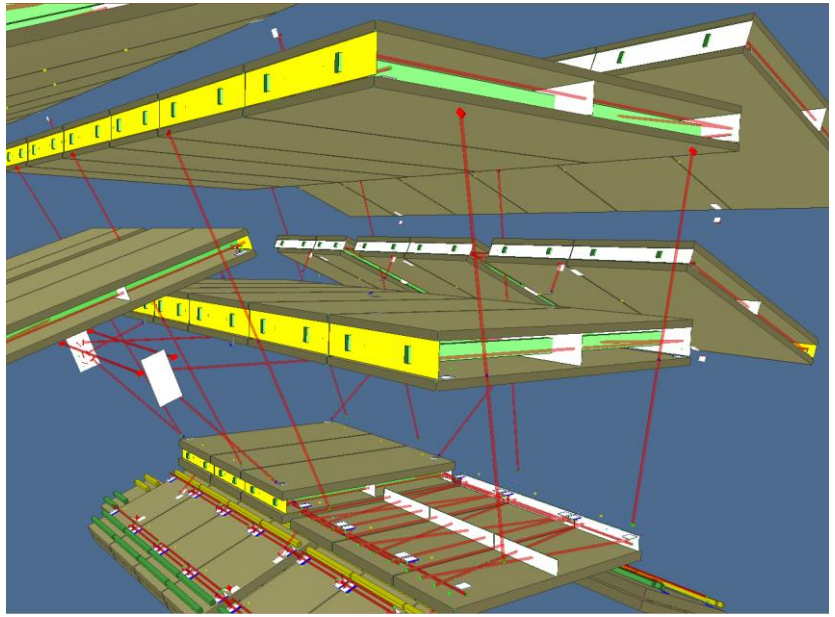




Support Structure

122.	MB Access platforms



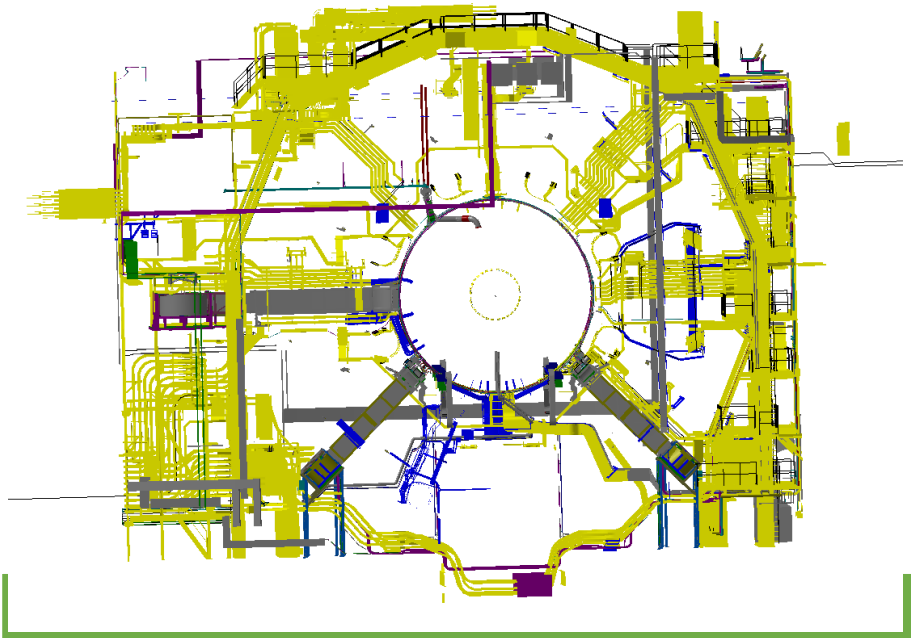


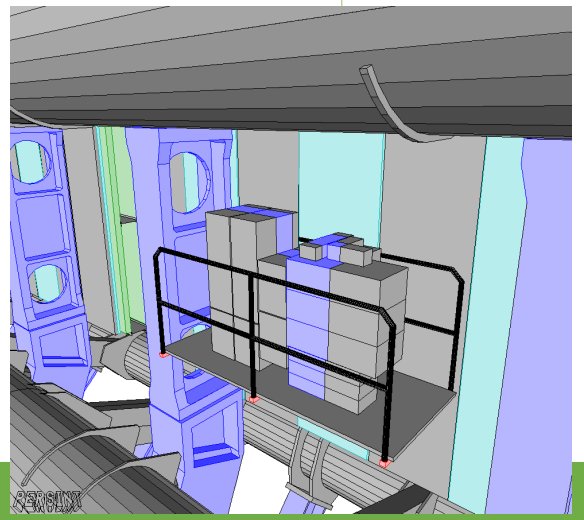
123.	Muon Alignment	
123.1	Barrel Alignment	
123.11	In-plane	
		123.111 BI In-plane
		123.112 BM In-plane
		123.113 BO In-plane
123.12	Praxial	
		123.121 BI Praxial
		123.122 BM Praxial
		123.123 BO Praxial
123.13	Axial	
123.14	Projective	
123.15	Reference	
		123.151 BI Reference
		123.152 BM Reference
		123.153 BO Reference
123.16	CCC	
		123.161 BI CCC
		123.162 BM CCC
		123.163 BO CCC
123.17	BIR-BIM	
123.12	Endcap Alignment	
123.21	In-plate	
		123.211 EI In-plate
		123.212 EE In-plate
		123.213 EM In-plate
		123.214 EO In-plate
123.22	In-Bar	
		123.221 EI In-Bar
		123.222 EE In-Bar
		123.223 EM In-Bar
		123.224 EO In-Bar
123.23	Radial	
		123.231 EI Radial
		123.232 EE Radial
		123.233 EM Radial
		123.234 EO Radial
123.24	Polar	
123.25	Azimuthal	
		123.251 EI Azimuthal
		123.252 EE Azimuthal
		123.253 EM Azimuthal
		123.254 EO Azimuthal
123.26	Proximity	
123.27	Saloon Door	
		123.271 EI Saloon Door
		123.272 EE Saloon Door
		123.273 EM Saloon Door
		123.274 EO Saloon Door
123.28	3D Sensor	

Services

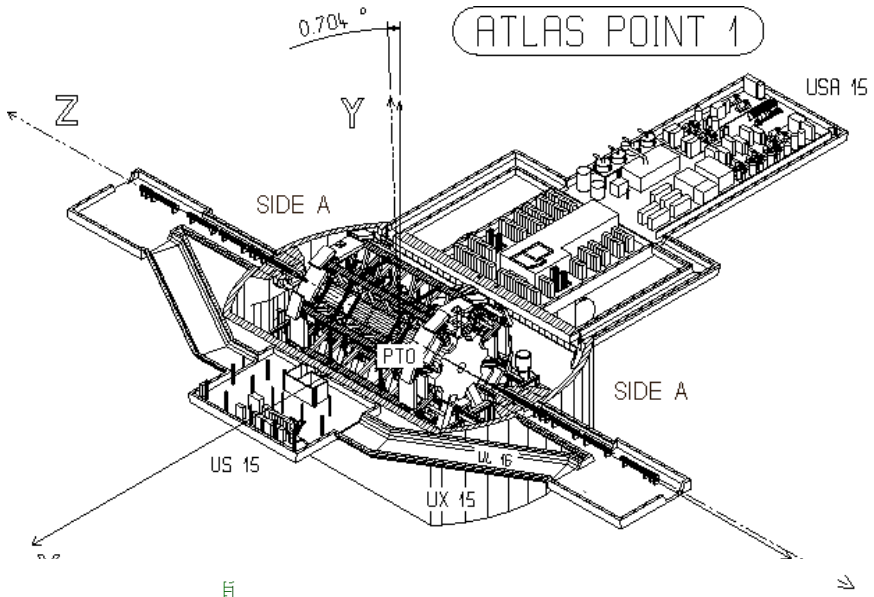
Level II	Level III		Level IV	
13 Services	131.	Cables		
			131.1	Power Supply Cable
			131.2	Data Transmission Cable
	132.	Patch Panels		
			132.1	Patch Panels 0/1
			132.2	Patch Panels 2
	133.	Tubes ans Pipes		
			133.1	Cooling system
			133.2	Gas Distribution
			133.3	Cryogenic System
	134.	Service Supports		

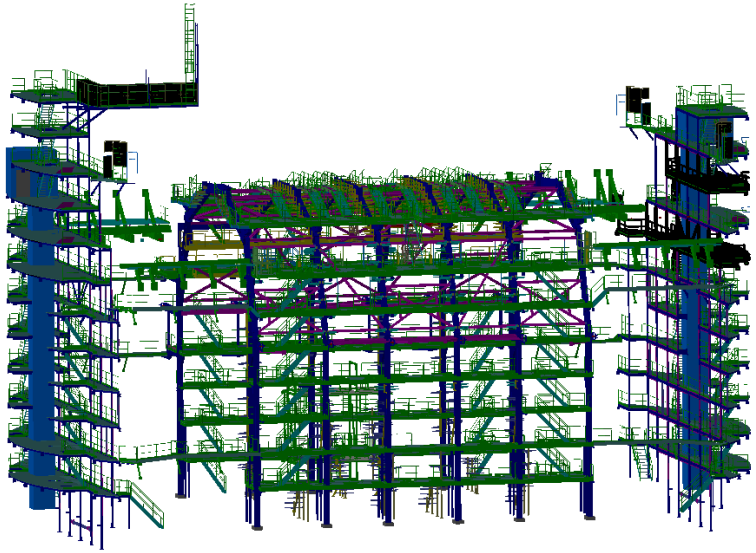
Level II	Level III		Level IV	
14 Control System	141.	Cooling CS		
			141.1	Pixel Cooling CS
			141.2	SCT Cooling CS
			141.3	TRT Cooling CS
	142.	Detector Comp. CS		
			142.1	Magnet Field CS
			142.2	Alignment CS
			142.3	Position, Strain CS
	143.	Power supply CS		
	144.	Temperature CS		
	145.	Gas CS		
			145.1	TRT Gas CS
			145.2	Muon Gas CS
	146.	Cryogenic CS		
			146.1	LAr Cryogenic CS
			146.2	Magent Cryogenic CS





Infrastructure



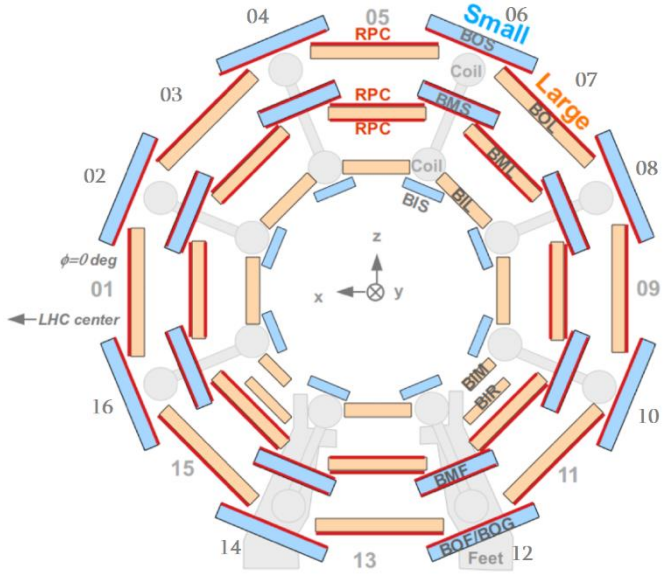


Level I	Level II		Level III	
2	21	Civil Engineering		
			211.	UX15
			212.	US15/USA15
	22	Surrounding Structure		
			221.	HO
			222	HS
	23	Cable and Pipe Distribution		
Infrastructure			231.	Cables/Cable Trays
			232.	Cooling and Gas Pipes
			233.	Racks
			234.	Flaxible Chain
	24	Air-conditioning		
	25	Cooling system		
	26	Gas system		
	27	Cryogenic system		
			271.	Magent Cryogenic System
			272.	LAr Cryogenic System

II Step. Spatial decomposition of ATLAS Detector

Spatial decomposition according to Sector

No.	EA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.1.1.2.1.	Barrel Toroid	-	v	-	v	-	v	-	v	-	v	-	v	-	v	-	v
1.1.3.2.1.	Tile Barrel	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.3.2.2.	Tile Barrel Extended	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.1.1	BI Muon Barrel Inner	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.1.2	BM Muon Barrel Middle	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.1.3	BO Muon Barrel Outer	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.2.1	EI Muon Small wheel	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.2.2	EE Muon Extra wheel	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v
1.1.4.2.3	EM Muon Big wheel	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v	v



Spatial decomposition according to Level

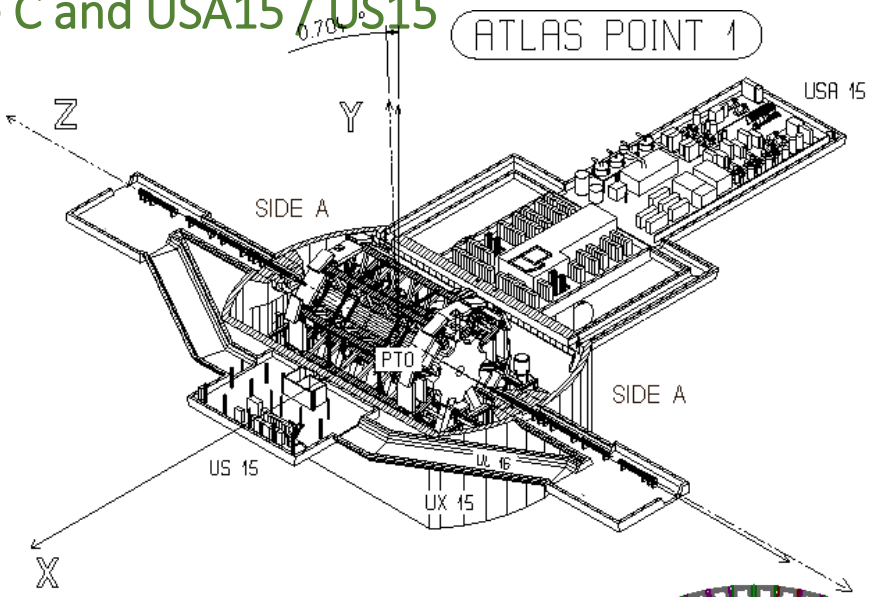
No.	EA	0	1	2	3	4	5	6	7	8	9	10	11	12
221.	Surrounding Structure HO	-	v	v	v	v	v	v	v	v	v	v	v	v
221.	Surrounding Structure HS	v	v	v	v	v	v	v	v	v	-	-	-	-
234.1	Toroid Magnet Flaxible Chain	-	-	-	-	-	-	-	-	v	-	-	-	-
234.2	Muon EI Flexible Chain	-	-	-	-	-	v	-	-	-		-	-	-
234.3	Calorimeter Flexible Chain	-	v	-	-	-	-	-	-	-	-	-	-	-
271.	Magnet Cryogenic System	v	-	-	-	-	-	-	-	-	v	-	-	-
272.	LAr Cryogenic System	v	-	-	-	-	v	-	-	-	v	-	-	-

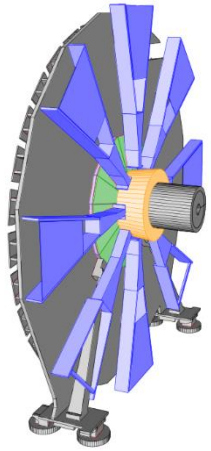
III Step. Symmetrical Decomposition of ATLAS Detector

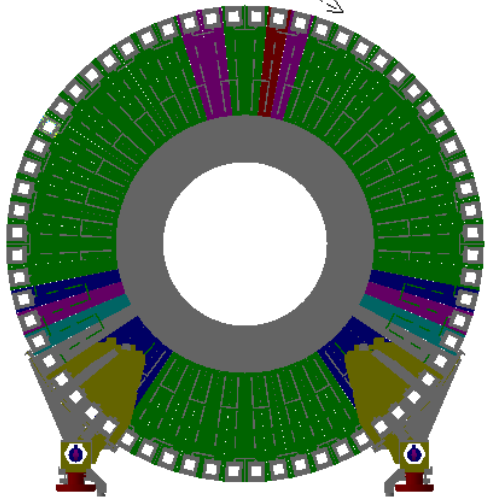
Symmetrical decomposition according to Side A / Side C and USA15 / US15

No.	EA	Side A/C	US15/USA15
1.1.1.2.2.	EndCap Toroid	v	
1.1.2.1.2.1	Pixel Endcap Disk 1	v	
1.1.2.1.2.2	Pixel Endcap Disk 2	v	
1.1.2.1.2.3	Pixel Endcap Disk 3	v	
1.1.2.2.2.1	SCT Endcap Disk 4	v	
1.1.2.2.2.2	SCT Endcap Disk 5	v	
1.1.2.2.2.3	SCT Endcap Disk 6	v	
1.1.2.2.2.4	SCT Endcap Disk 7	v	
1.1.2.2.2.5	SCT Endcap Disk 8	v	
1.1.2.2.2.6	SCT Endcap Disk 9	v	
1.1.2.2.2.7	SCT Endcap Disk 10	v	
1.1.2.2.2.8	SCT Endcap Disk 11	v	
1.1.2.2.2.9	SCT Endcap Disk 12	v	

121.04.21	TRT Type-A Supp	v	
121.04.22	TRT Type-B Supp	v	
121.05.2	LAr Endcap Cryostat	v	
121.06.1	Tile Barrel Feet		v
121.06.2	Tile Barrel Extended Feet	v	v
121.07.11	BI Muon Innel Bracket	v	
121.07.12	BM Muon Middle Bracket	v	
121.07.13	BO Muon Outer Bracket	v	







Structure tree of ATLAS Detector contains 272 Elementary Assemblies (EA)