

# TDR Editing

Tuesday CEPC TDR Meeting  
July 29, 2025

Joao Guimaraes

# Outline

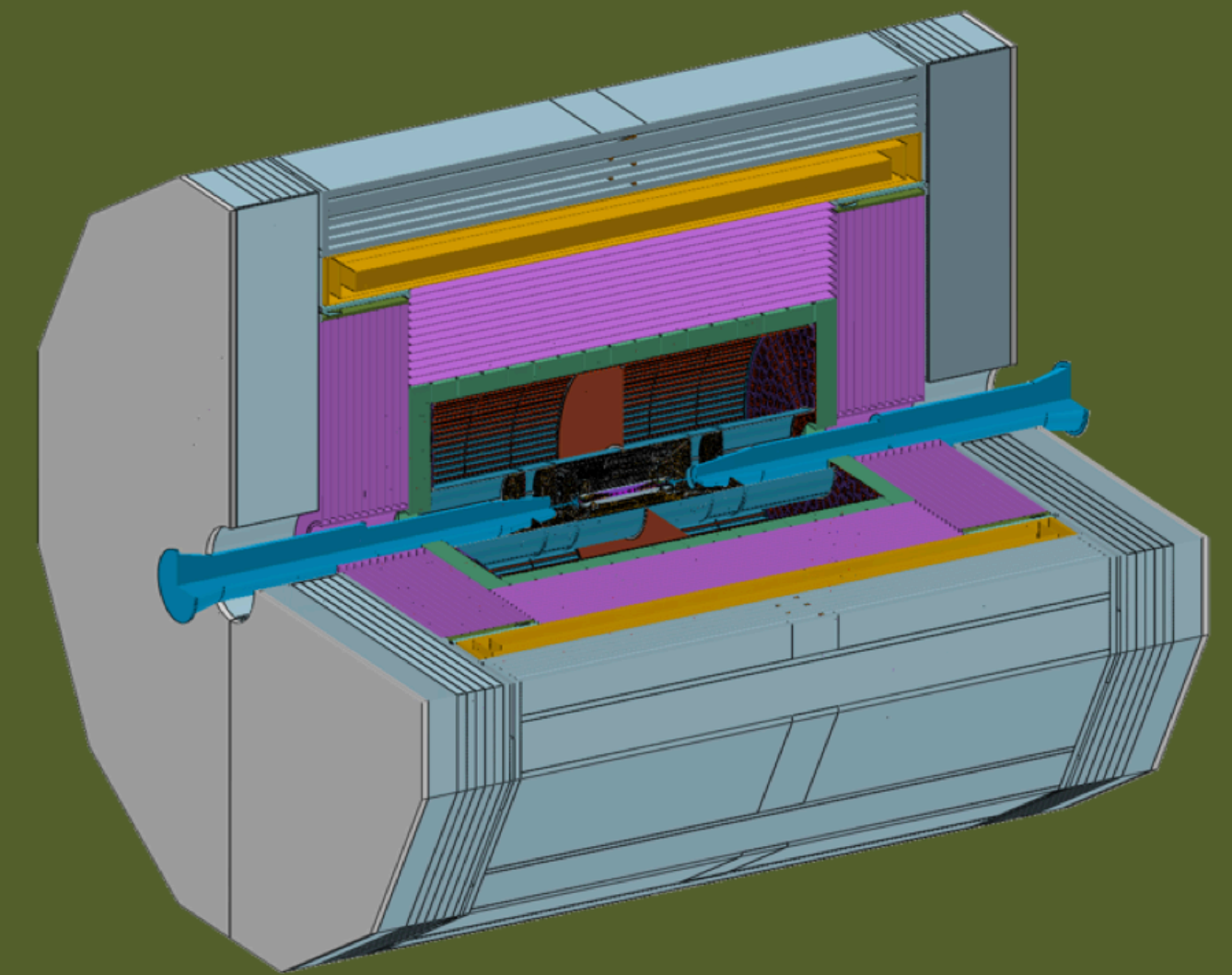
- News from IDRC
- Mechanics issues
- Figures that still need update
- Muon detector - by Xiaolong

# Draft v0.5.0

## CEPC Reference Detector

### Technical Design Report

Version: v0.5.0 build: 2025-07-15 07:37:45+08:00



# Keeping track of modifications

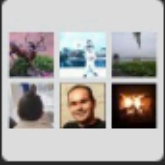
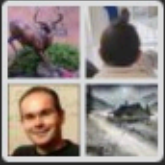
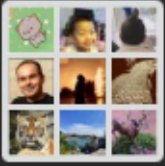
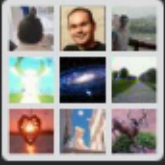
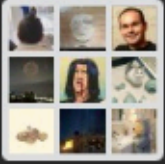

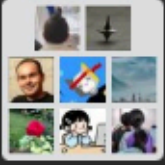

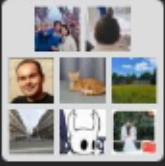
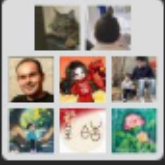

- **Spreadsheet monitoring the status in IHEP docs:**

- <https://docs.ihep.ac.cn/link/ARF4C648FCA57D4CF281A8E821A110229E>
- 文件名: Status of TDR.xlsx
- 文件路径: AnyShare://ZHANG Zhaoru(zhangzr)/CEPC Det TDR/Status of TDR.xlsx

- Please fill in your input now, and **keep it updated** as we move along

- We will try to do the same!

- Provide feedback for improvements

	TDR - Ch02 - Concept(6)
	TDR - Ch09 - Muon(4)
	TDR - Ch12 - TDAQ(9)
	TDR - Ch4 - Vertex(9)
	TDR - Ch7 - ECAL(11)
	TDR - Ch8 - HCAL(6)
	TDR - Ch6 - TPC(8)
	TDR - Ch5 - Tracker(8)
	TDR - Ch10 - Magnet(8)
	TDR - Ch11 - Electronics(8)
	RefTDR_Leaders_Editors(28)



# Keeping track of modifications

**Blue** section of the spreadsheet is for chapter leaders

Chapter	Overall Complete	Chapter structure	Updated date	Tables				Figures		Enlarge the font size	Text		Other remarks
				Unified format	Significant digits	Change to pdf	Unified Macro	Total of not perfect figures	remaining to be updated		Symbols	Glossary	
Executive summary	100%	100%		100%	100%		100%			100%	100%		
1 Introduction	100%	100%		100%	100%		100%	1	0	100%	100%		
2 Concept of CEPC Reference Detector	90%	100%		90%	90%	90%		3	0	90%			
3 MDI and Luminosity Measurement	90%	100%		100%	100%	100%	80%	23	2	90%	100%	100%	
4 Vertex Detector	95%	95%		100%	100%	100%	100%	23	2	100%	100%	100%	figure 22 to be u
5 Silicon Trackers	100%	100%		100%	100%	100%	100%	21	0	100%	100%	100%	
6 Pixelated Time Projection Chamber	95%	100%	25-Jun	100%	100%	100%				80%	95%	95%	
7 Electromagnetic calorimeter	95%	98%	21-Jul	95%	95%	98%	100%			95%	95%	98%	Changes to add
8 Hadronic calorimeter	90%	90%	4-Jul	100%	100%	100%	100%			100%	90%		rewrite some pa
9 Muon Detector	95%	100%	2-Jul	100%	100%	100%	100%	4	4	95%	100%	100%	
10 Detector magnet system	100%	100%	19-Jul	100%	100%	100%	100%	33	2	100%	100%	100%	
11 Readout Electronics	100%	100%		100%	100%	100%		6	1	100%	100%	100%	-
12 Trigger and Data Acquisition	100%	100%	26-Jul	100%	100%	100%	100%	3	0	100%	100%	100%	
13 Offline software and computing	100%	100%	28-Jul	100%	100%	100%	100%	1	0	100%	100%	100%	
14 Mechanics and integration	95%	95%	30-Jul	100%	100%	100%	100%	32	32	100%	100%	100%	Adding the secti
15 Detector and physics performance	95%	100%	21-Jul	100%	95%	100%	100%			100%	100%		Debug JOI confi

**Update status using “blue” color so that we can know it is up to date**

# News from IDRC

- Barcelona-version comments from IDRC:
  - Previously feedback for: Tracker, Calorimeter, Muon Detector, Mechanics, (TPC from Paul communicated earlier), Electronics, Trigger/DAQ, Magnet
- **Received this week:**
  - Software (Cristinel)
  - TPC (Titov)
  - HCAL extra information (Roman)

**From  
Last Week**

**New**

New IDRC	Started implementingg	Date plan to finish
Si-Tracker		
TPC	Y	today
ECAL	Y	1 week
HCAL	Y	3-days — 1 week
Muon	Y	2 days
Mechanics	Y	1 week, cabling
Electronics	Y	Done
Trigger/DAQ		3 days
Magnet		Done, today
Software		
TPC (Titov)		

# Mechanics Details and Integration

- Prior agreement to split mechanics information into two parts:
  - Sub-detector chapters
    - → details on the mechanics of each sub-detector
  - Chapter 14 on Mechanics and Integration
    - → Overall mechanics issues, integration of each sub-detector (interconnects) and installation
- Currently, the **mechanics information in the TDR is unbalanced** and not detailed enough.
  - Different sub-detectors have different levels of detail
  - FEA simulations results for sub-detectors integration and connections mostly missing
  - Chapter 14 is very detailed on some aspects (e.g. installation and yoke) but lacks technical depth on other critical aspects (e.g. interconnections and sub-detectors deformations and stress)

**Not a problem of one single chapter but of the TDR as a whole**

**Need to define today how better to correct this**



# Mechanics Details and Integration

Based on version from 2025-07-29 07:37:35

133	<b>Chapter 7 Electromagnetic Calorimeter</b>	<b>213</b>
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137	7.2.2 Design with orthogonal long crystals . . . . .	219
138	7.2.3 Detector components . . . . .	220
139	7.2.4 Electronics . . . . .	222
140	7.2.5 Mechanics and cooling . . . . .	224
141	7.2.6 Calibration and monitoring . . . . .	229
142	7.3 Optimization and key performance . . . . .	233
143	7.3.1 Module optimization . . . . .	233
144	7.3.2 Granularity optimisations . . . . .	234
145	7.3.3 Simulation: digitization . . . . .	236
146	7.3.4 Linearity and energy resolution . . . . .	237
147	7.3.5 Temperature effect studies . . . . .	239
148	7.4 ECAL R&D . . . . .	240
149	7.4.1 Crystals . . . . .	241
150	7.4.2 SiPM . . . . .	242
151	7.4.3 Timing performance . . . . .	244
152	7.4.4 Prototype and beam tests . . . . .	245
153	7.4.5 Beam-induced backgrounds . . . . .	247

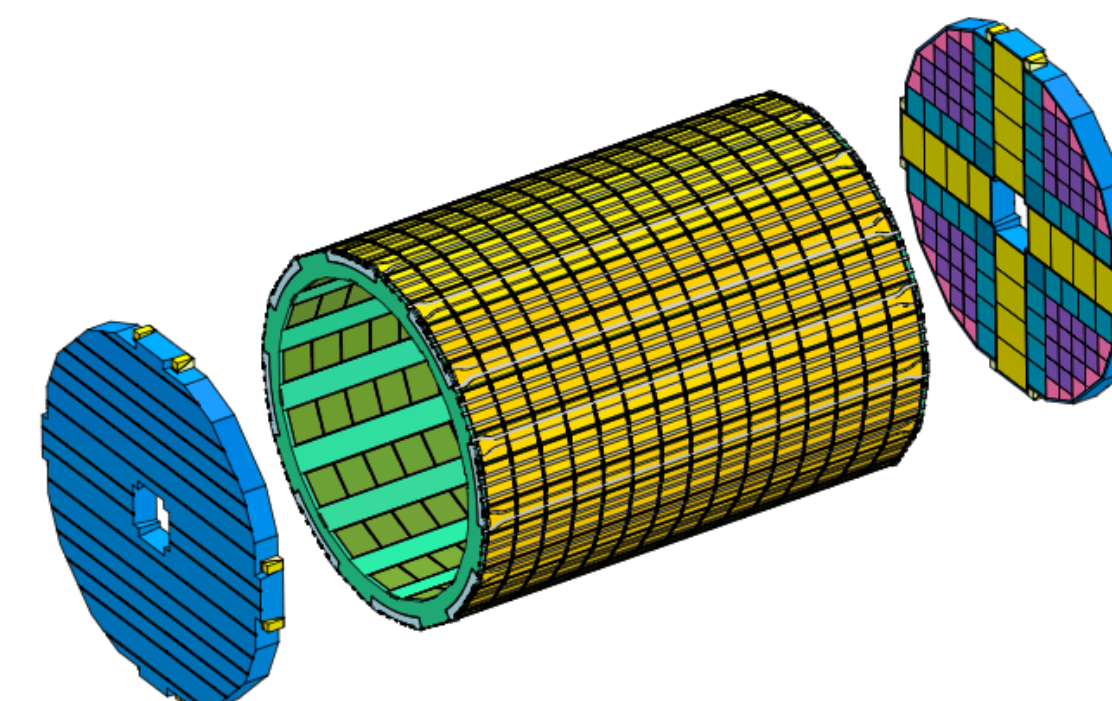
164	<b>Chapter 8 Hadronic Calorimeter</b>	<b>261</b>
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187	8.6 Alternative HCAL Option . . . . .	297
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190	8.7 Summary and Future Plan . . . . .	303
191	References . . . . .	304



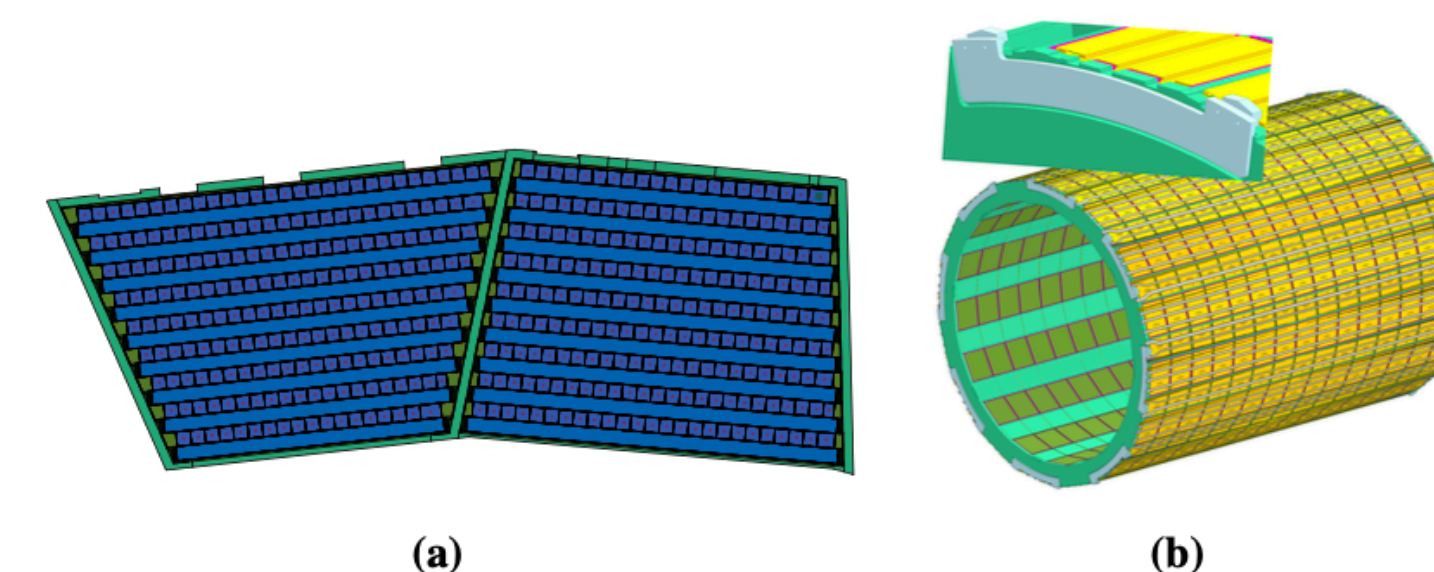
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**Figure 7.10:** The ECAL mechanical design with one barrel and two endcaps. The barrel ECAL has 480 modules, which are integrated into a carbon-fiber frame (in lighter green), and is affixed to the barrel HCAL via 8 interconnection points. Cooling plates and cooling pipes are colored in light yellow. Two ECAL endcap discs along with endcap OTK layers are mounted onto the HCAL from each side. Endcap ECAL modules, indicated in various colors for different dimensions and designs, are integrated into one of the discs of a carbon-fiber frame, indicated in blue.



**Figure 7.11:** The side view of two types of barrel ECAL modules (a); the stainless steel structure for inter-connecting the ECAL barrel to the barrel HCAL, which are embedded in the main carbon-fiber frame (b).

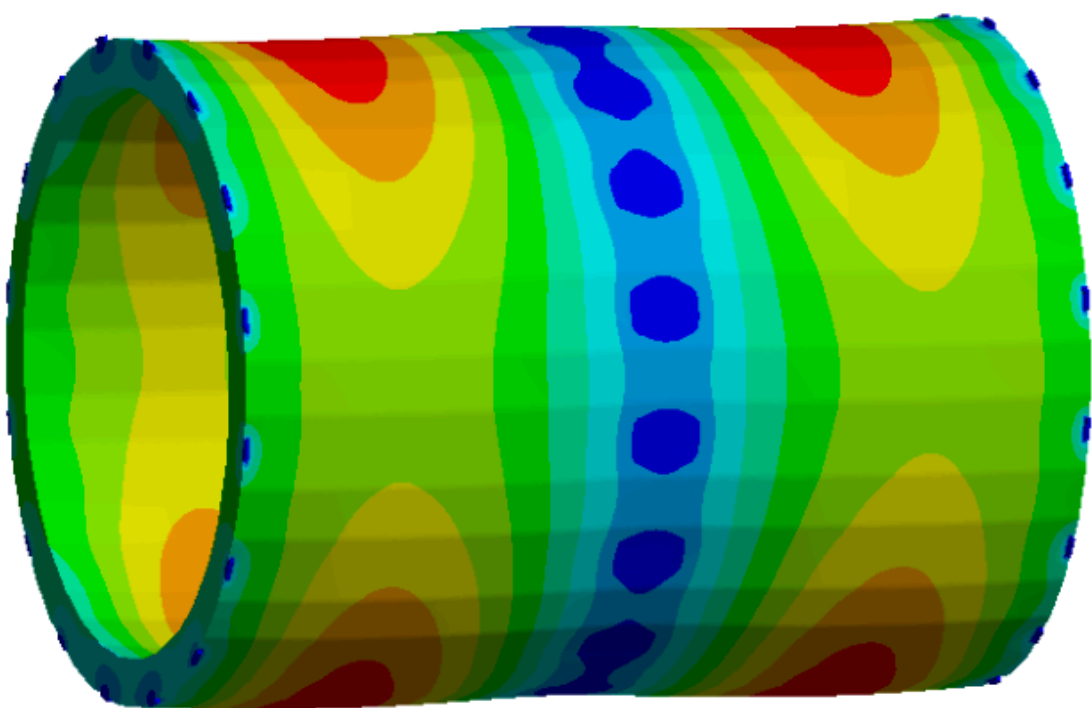
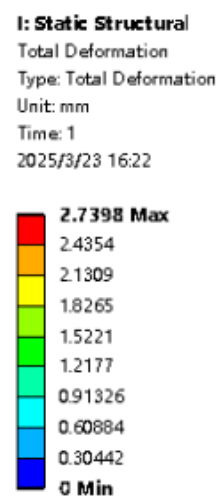


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5730 **Barrel structure FEA results** FEA has been performed to assess the structural stability  
5731 of the carbon-fiber frame and evaluate mechanical stress to crystal bars. The structural  
5732 response was simulated under conditions with a total self-weight of 130 t. The stress  
5733 distributions in three different directions (i.e. the stress in parallel to the carbon-fiber  
5734 direction, the stress perpendicular to the carbon-fiber direction and the in-plane shear  
5735 stress) show that they stay well within the specifications of the cost-effective CFRP option  
5736 named "T700". Additional 16 fixation points fixing points have been included to the barrel  
5737 frame cylinder to reinforce structural stability and reduce deformation. The maximum  
5738 deformation is 2.7 mm, as shown in Figure 7.13, and can meet the design requirement.  
5739 Since the design of barrel modules is similar to that of endcaps, FEA results under  
5740 load are presented in Section 7.2.5.2.



Needs updating

**Figure 7.13:** Deformation distribution of the ECAL barrel frame with the updated mechanical design by adding extra fixation points in the central cylinder, further reinforcing interconnections with the barrel HCAL.

# Mechanics Details and Integration

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356	14.1.2 Design requirements . . . . .	509
357	14.2 Sub-detector connections . . . . .	513
358	14.2.1 Yoke design . . . . .	513
359	14.2.2 Superconducting solenoid magnet . . . . .	516
360	14.2.3 Barrel HCAL . . . . .	517
361	14.2.4 Barrel ECAL . . . . .	519
362	14.2.5 TPC (barrel OTK) . . . . .	520
363	14.2.6 ITK . . . . .	522
364	14.2.7 Beam pipe (VTX and LumiCal) . . . . .	523
365	14.2.8 Endcap ECAL (endcap OTK) . . . . .	524
366	14.2.9 Endcap HCAL . . . . .	526
367	14.2.10 Reliability and safety assessment . . . . .	527
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371	14.4 Layout of the underground hall . . . . .	542
372	14.4.1 Configuration of the experimental hall . . . . .	542
373	14.4.2 Auxiliary hall . . . . .	543
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Detector connections

Chapter organized in order of the installation, which is unnatural

Separated barrel and endcap description

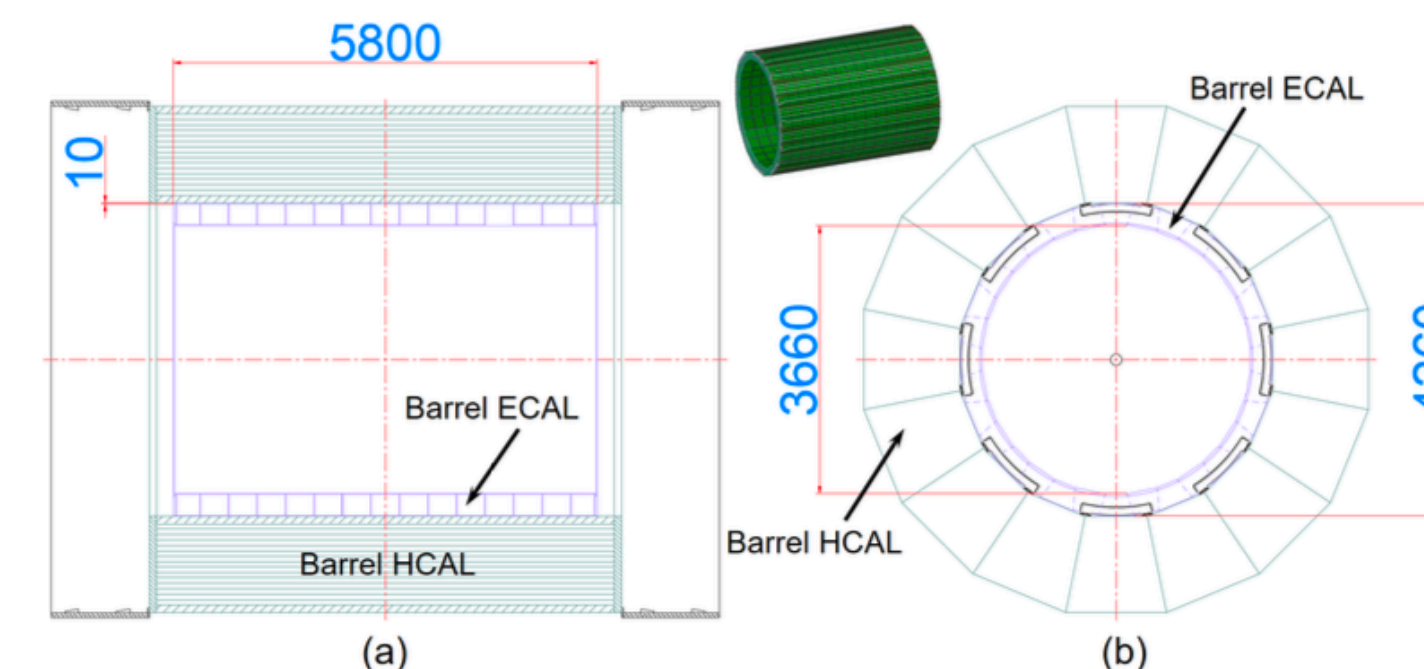
Detector Installation



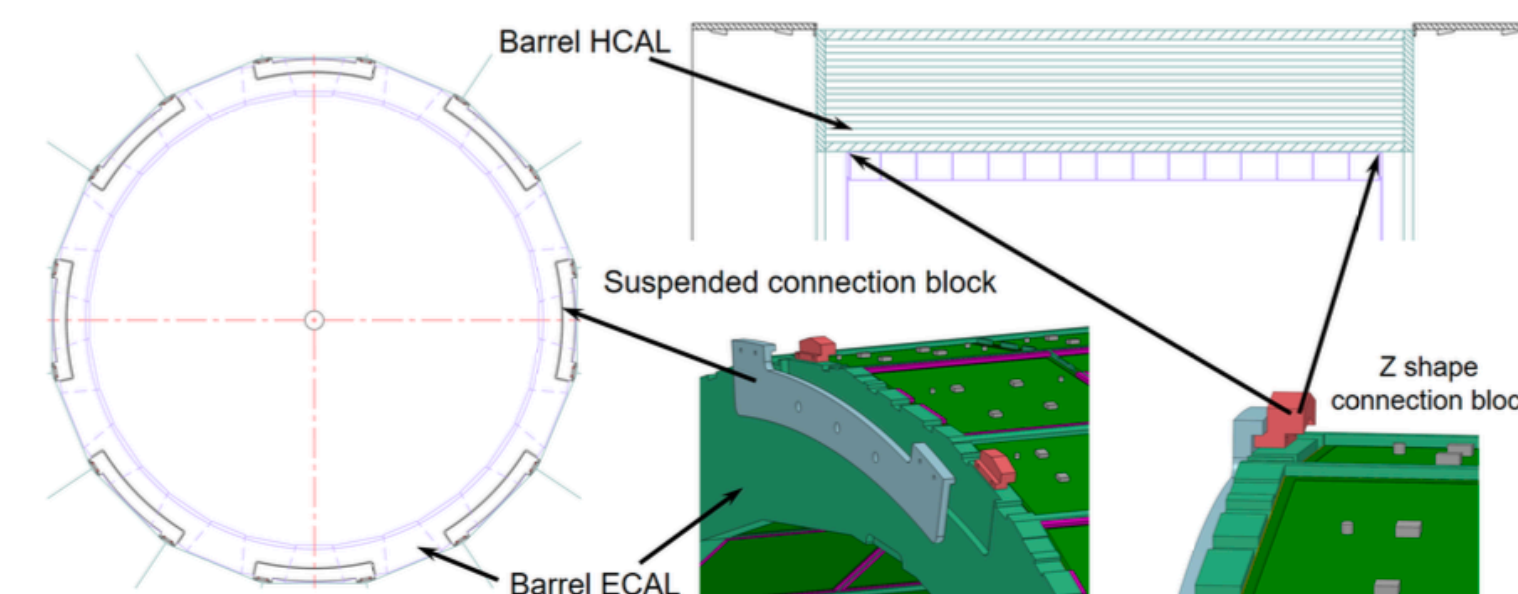
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364	14.2.7 Beam pipe (VTX and LumiCal)	523
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**Figure 14.13:** Boundary dimensions and location of the barrel ECAL. It is installed inside the barrel HCAL, with a minimum clearance of 10 mm. Units are in millimeters.



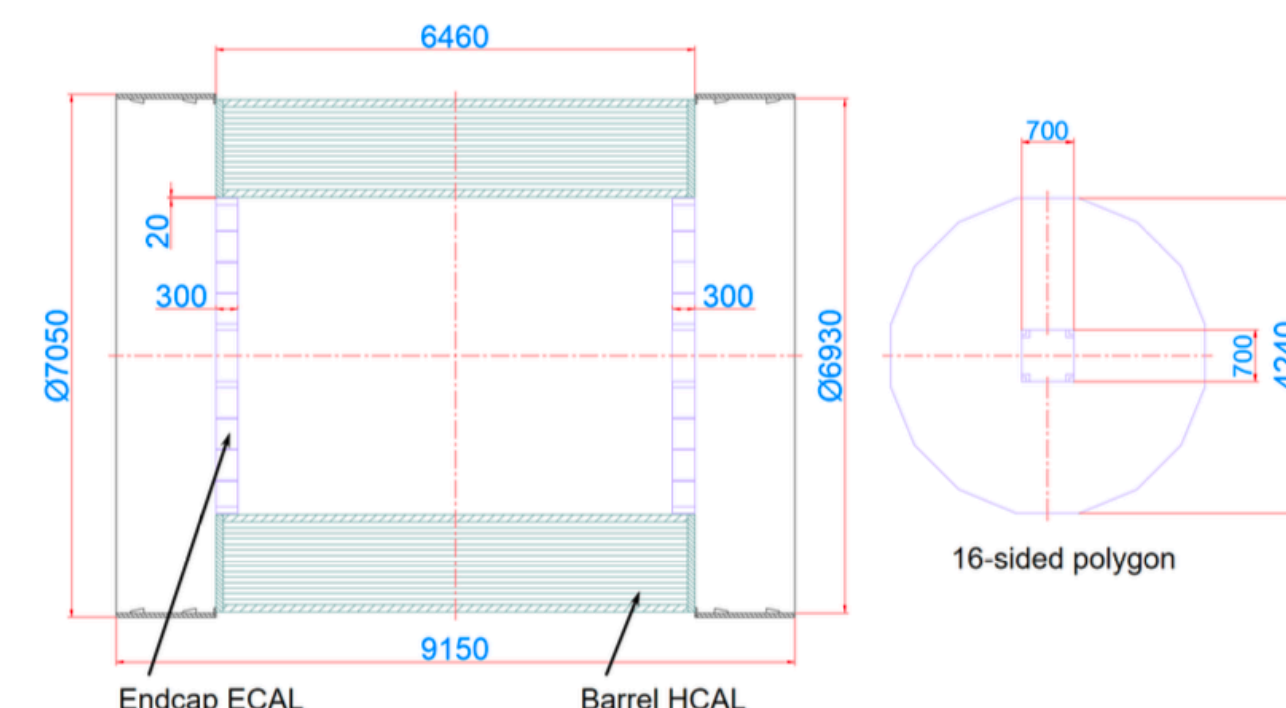
**Figure 14.14:** Connection structure of the barrel ECAL. Eight-point circular suspension structure are adopted to connect the barrel ECAL and the barrel HCAL.

Similar information to the ECAL chapter, but no FEA or analysis of the strength of the connection, stress and deformations



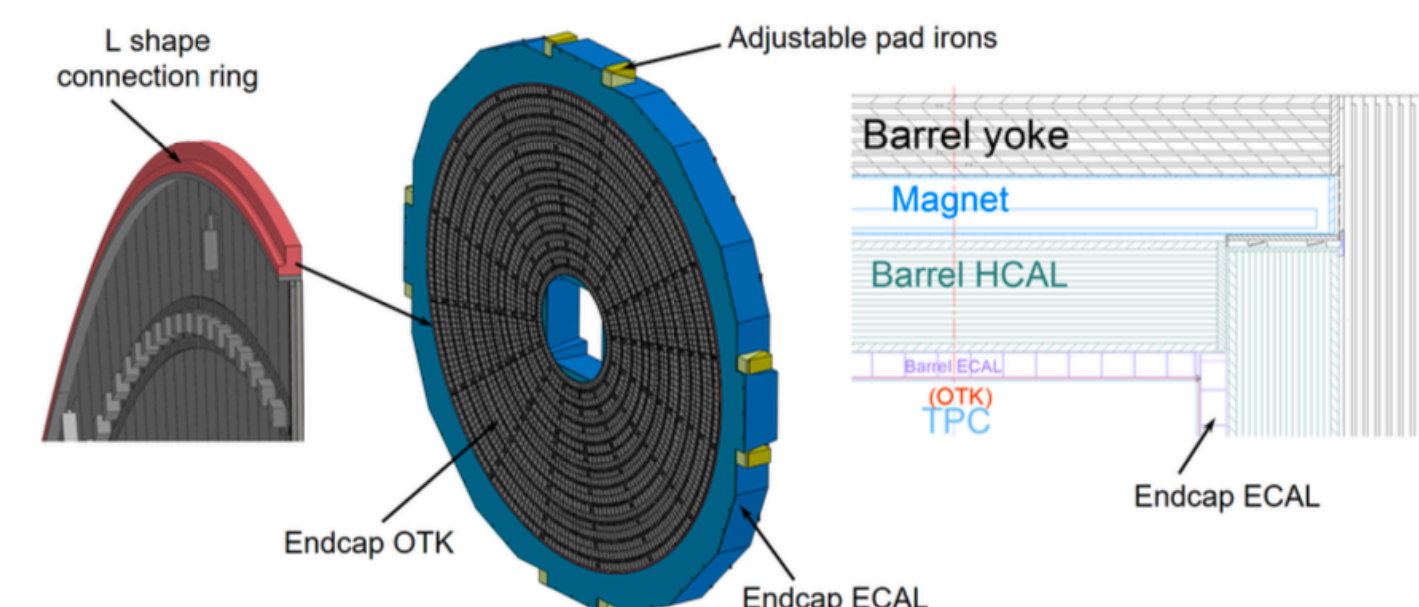
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363	14.2.6 ITK	522
364	14.2.7 Beam pipe (VTX and LumiCal)	523
365	<b>14.2.8 Endcap ECAL (endcap OTK)</b>	<b>524</b>
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**Figure 14.22:** Boundary dimensions and location of the endcap ECAL. It is located at both ends of the barrel ECAL, with the minimum clearance of 20 mm for the routing of cable and pipe. Units are in millimeters.

12932 The endcap ECAL is connected to the barrel HCAL and positioned by the four pairs  
12933 of adjustable pad irons uniformly distributed around the circumference. Due to the 25-ton  
12934 weight of the endcap ECAL, the adjustment operation must rely on hydraulic drive or  
12935 external tooling assistance to support the weight of the endcap ECAL.



**Figure 14.23:** Connection structure of the endcap ECAL and the endcap OTK. They are connected and positioned by four pairs of adjustable pad irons uniformly distributed around the circumference.

No information regarding stress, deformation or strength of connection, no FEA

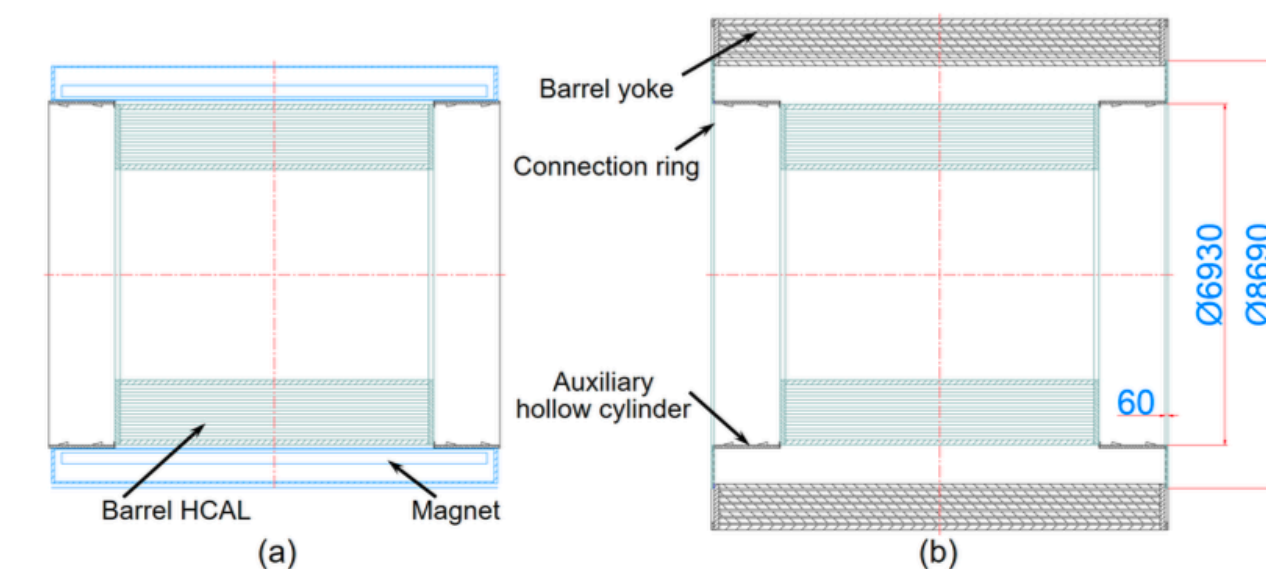
**Suggestion:** analysis of the interconnections and FEA in the mechanics chapter. Possible?



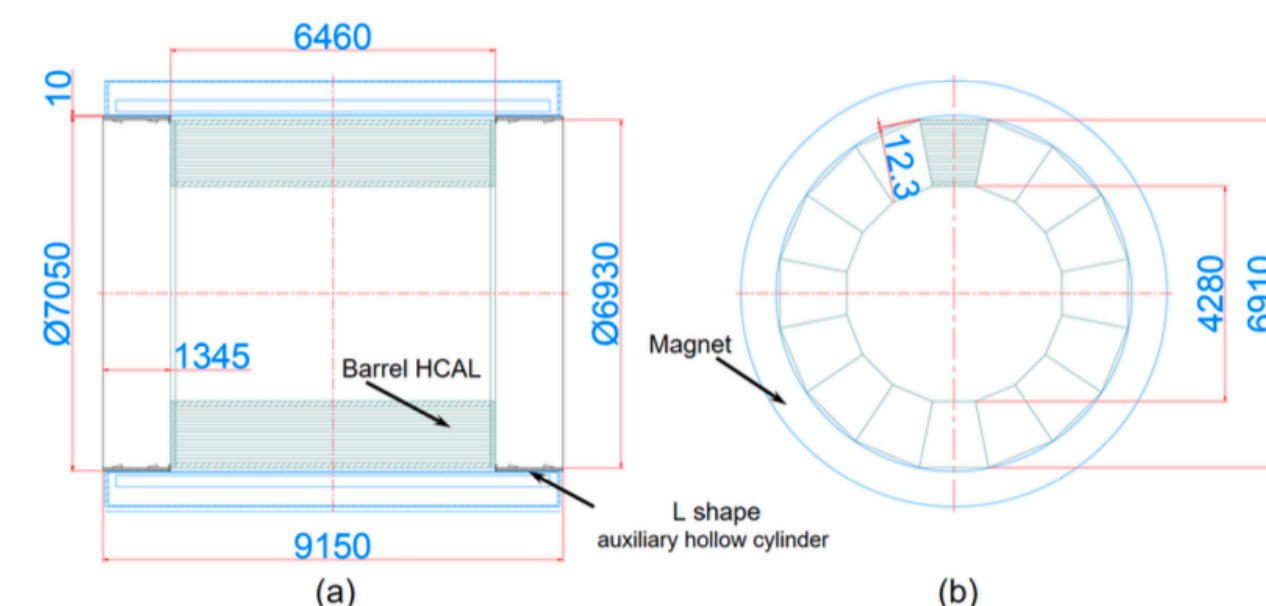
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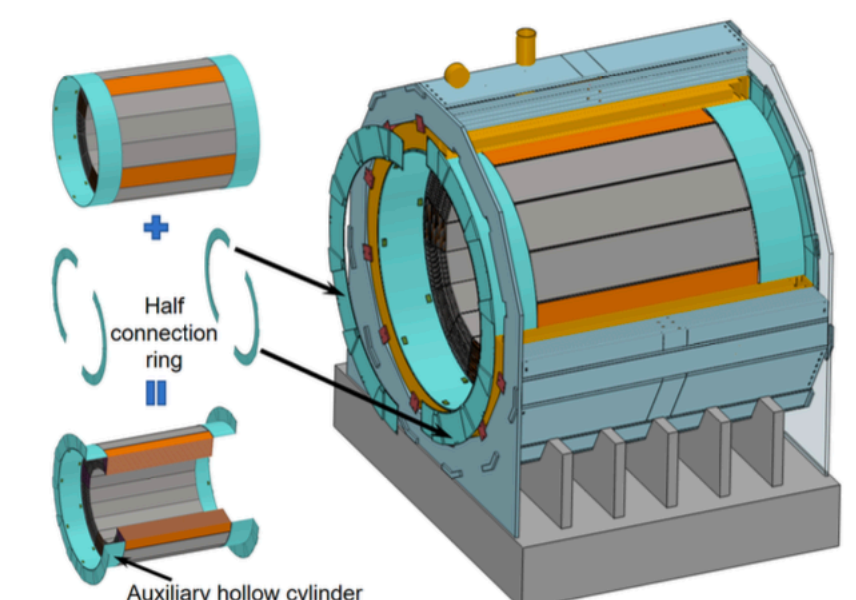


**Figure 14.10:** Location of the barrel HCAL. It is directly connected to the barrel yoke using the rings. Units are in millimeters.



**Figure 14.11:** Boundary dimensions of the barrel HCAL. The L-shaped auxiliary hollow cylinders serve as both assembly fixture and the key connection interface, with 10 mm clearance between to the magnet. Units are in millimeters.

Many simple drawings with design, but no FEA results on stress, deformation, etc



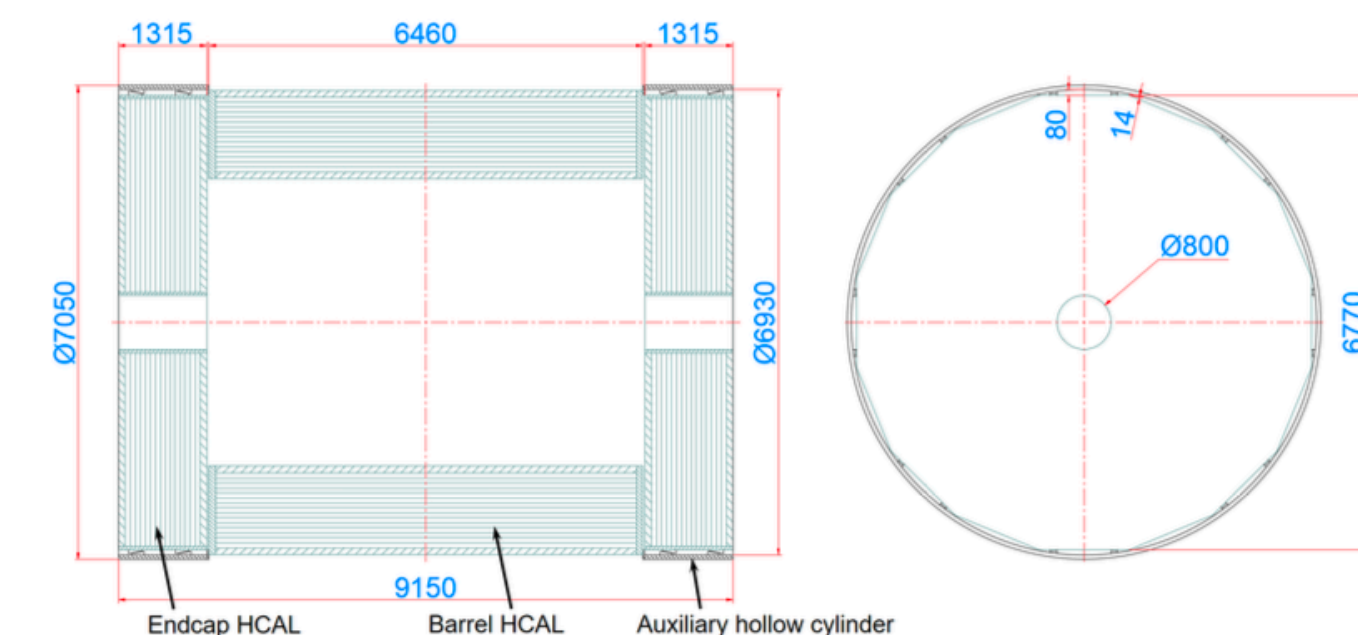
**Figure 14.12:** Connection structure of the barrel HCAL. Split rings with wire slots connect the HCAL auxiliary cylinder to the barrel yoke flange.



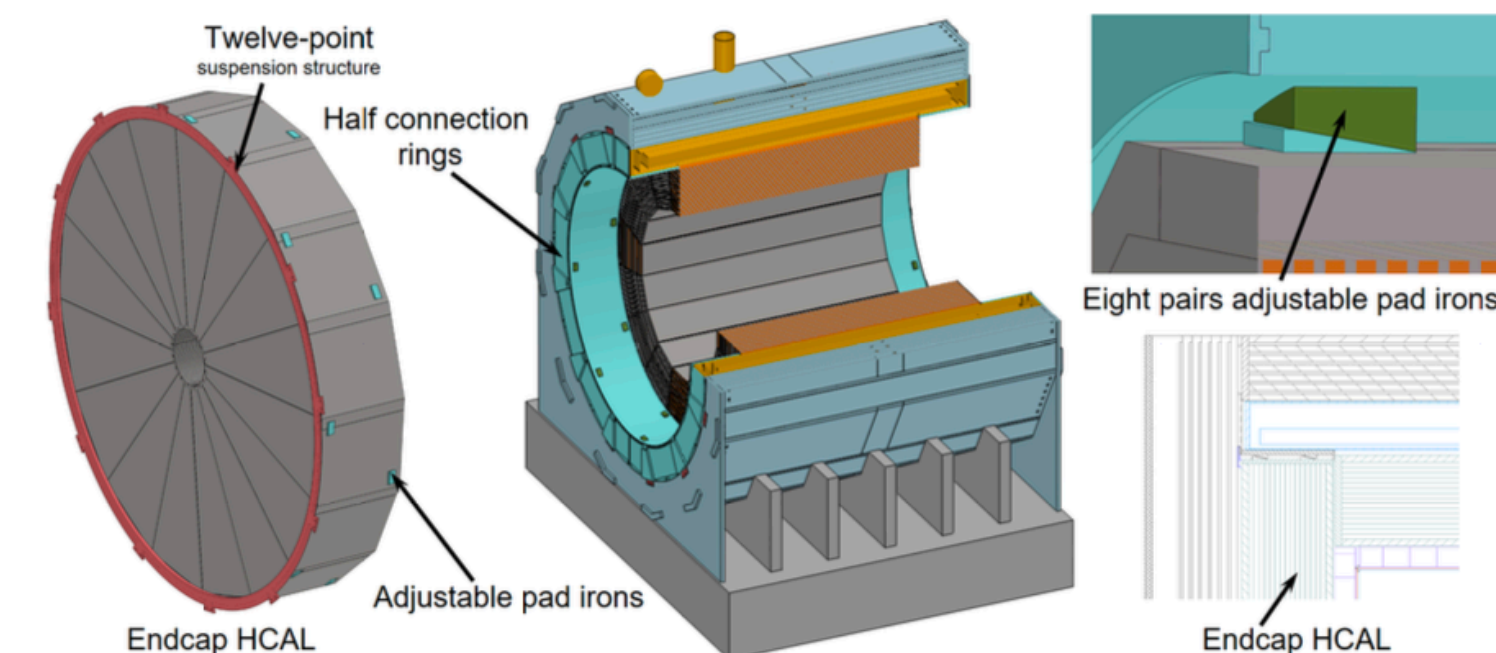
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**Figure 14.24:** Boundary dimensions and location of the endcap HCAL. It is installed in the auxiliary hollow cylinder of the barrel HCAL, the clearance between them is ranged from 14 mm to 80 mm for routing space. Units are in millimeters.



**Figure 14.25:** Connection structure of the endcap HCAL. The endcap HCAL is rigidly connected to the barrel yoke through eight pairs of adjustable pad irons, two pairs of axial pads, and a twelve-tooth flange, ensuring stable support for the superconducting magnet.

Many simple drawings with design, but no FEA results on stress, deformation, etc

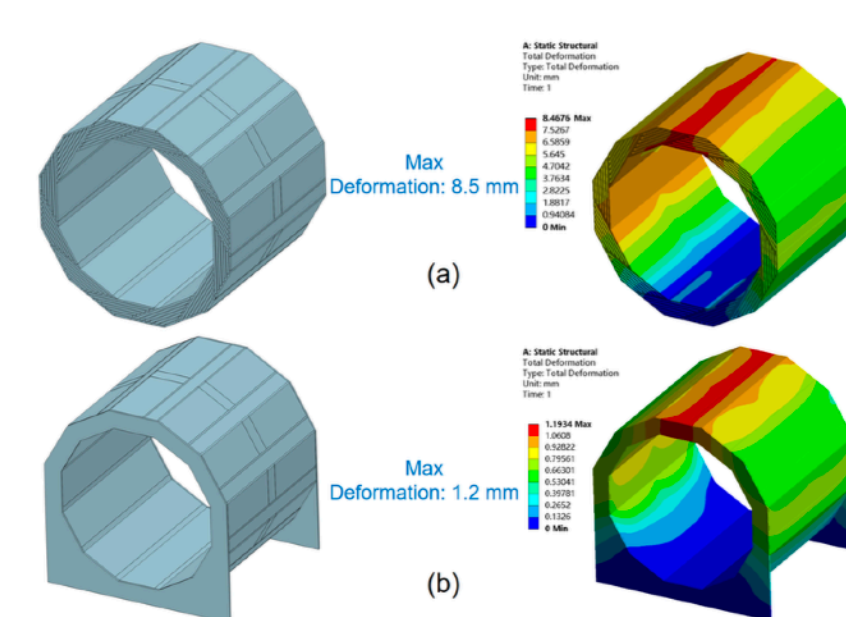
**Suggestion:** analysis of the interconnections and FEA in the mechanics chapter. Possible?



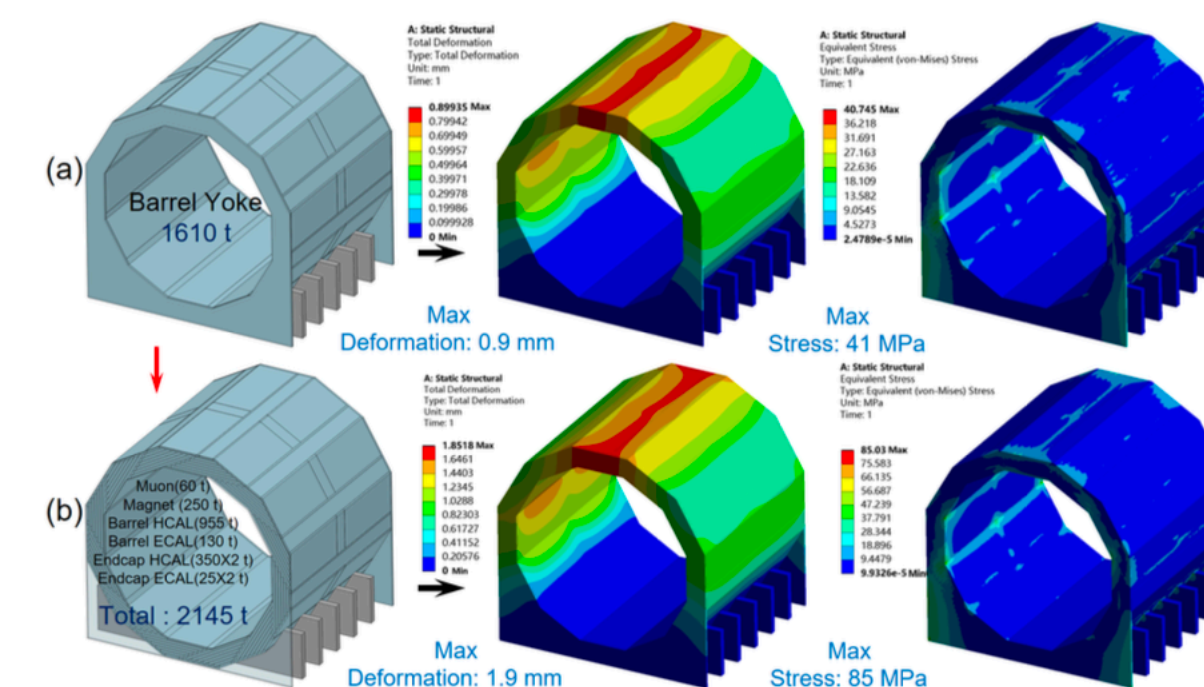
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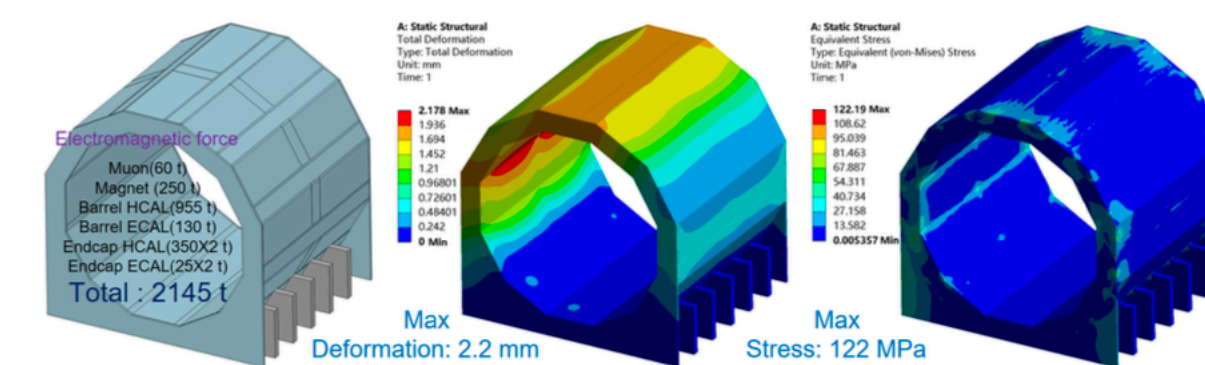
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**Figure 14.6:** Overall deformation comparison of FEA results for the barrel yoke without and with the end flanges. (a) Maximum deformation is 8.5 mm without the end flanges; (b) Maximum deformation is 1.2 mm with the end flanges.



**Figure 14.26:** FEA results of the barrel yoke deformation and stress under two loading condition. (a) bare yoke condition:load is self-weight of barrel yoke. (b) with sub-detectors condition:load is self-weight of barrel yoke and 2145 tons. (including the superconducting solenoid magnet, the barrel HCAL, the barrel ECAL, the endcap HCAL, the endcap ECAL and the barrel muon detectors. The weight of the lightweight tracker detector is ignored.)



**Figure 14.27:** Deformation and stress of the barrel yoke under the electromagnetic force load with sub-detectors condition.

Many FEA plots and analysis of the yoke, this gives the impression we only studied the yoke mechanics and nothing else

**Suggestion:** analysis of the interconnections and FEA in the mechanics chapter. Possible?



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**Note:** no detailed FEA analysis of the interconnections in these chapters or in chapter 14

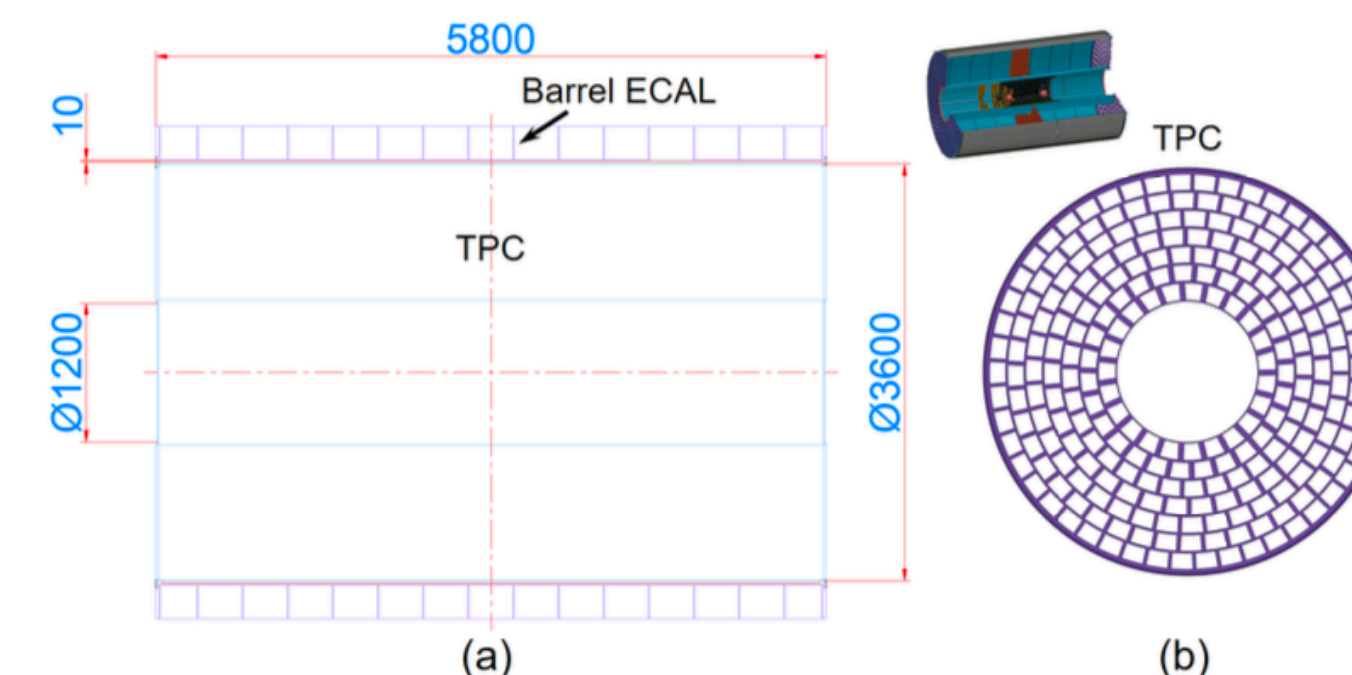
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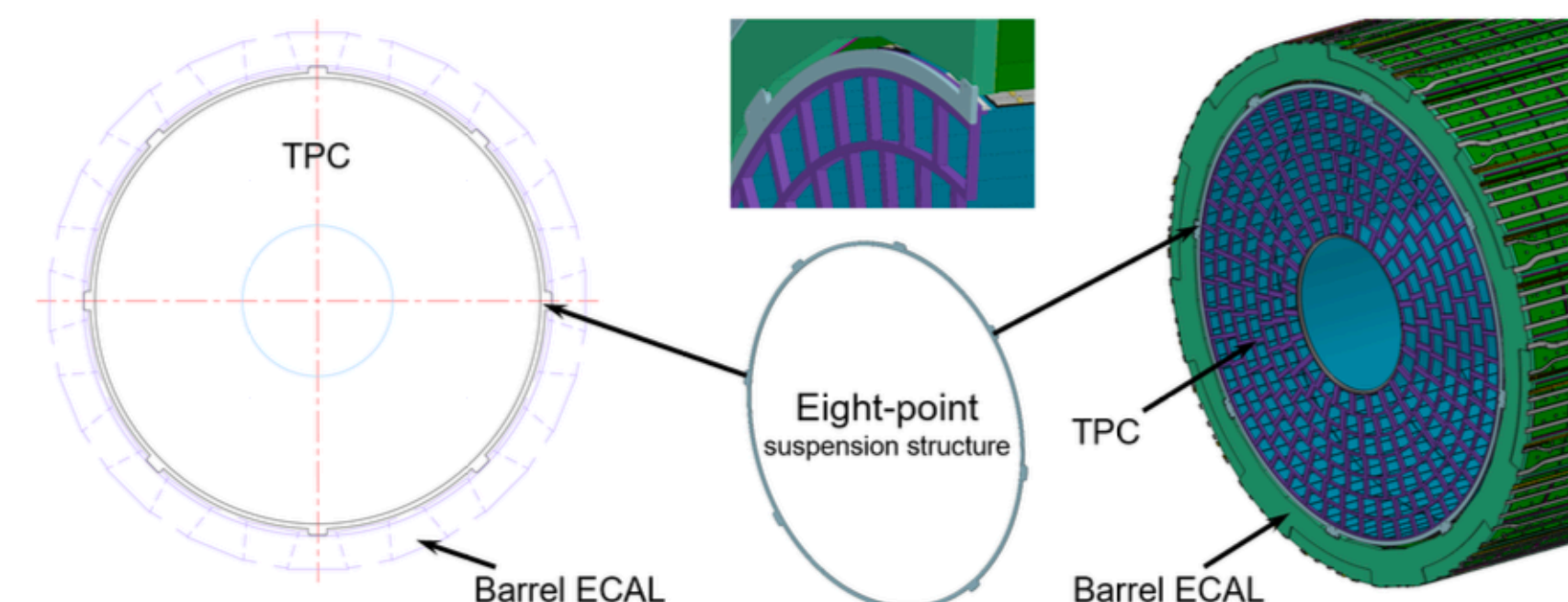
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**Figure 14.15:** Boundary dimensions and location of the TPC. It is mounted inside the barrel ECAL with a minimum clearance of 10 mm. Units are in millimeters.



**Figure 14.16:** Connection structure of the TPC. The TPC is connected to the barrel ECAL by eight-point suspension structure with the slots for cabling and piping.

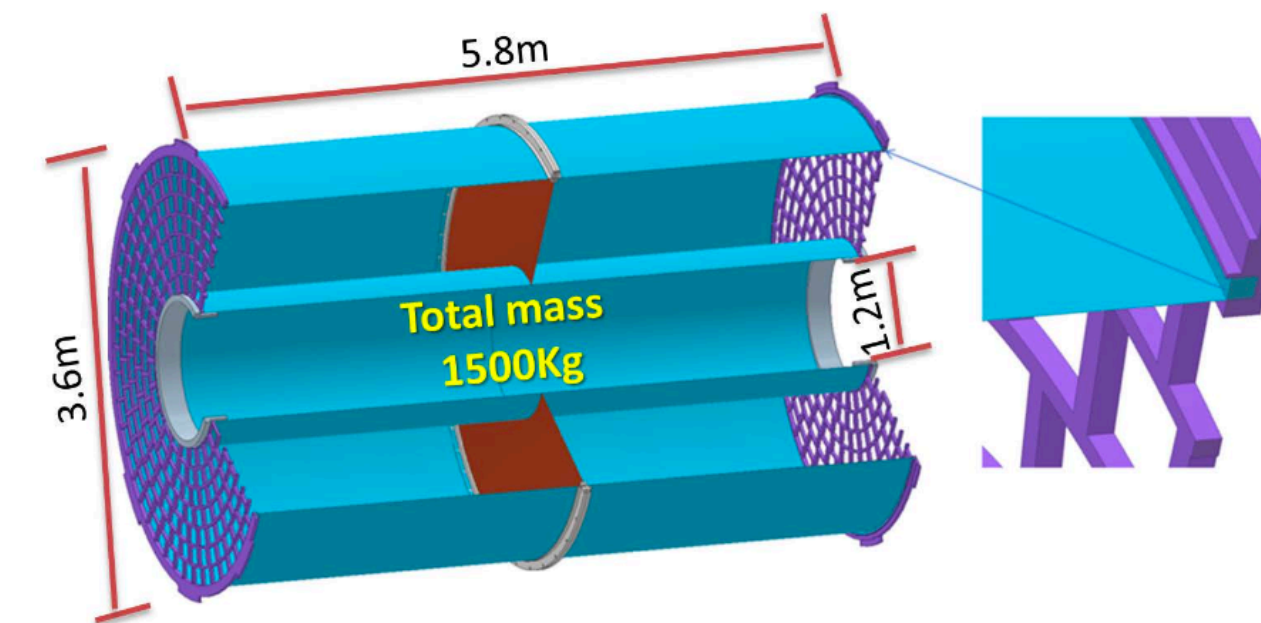
**Note:** no detailed FEA analysis of end plate or interconnection in TPC chapter or chapter 14



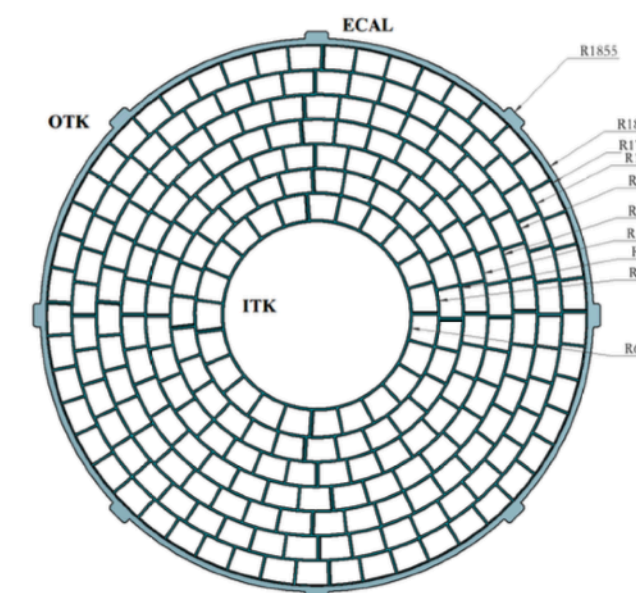
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**Figure 6.1:** The Layout diagram of the TPC fieldcage, the designed boundary connection with ITK, OTK and ECAL sub-detectors



**Figure 6.3:** Two-dimensional layout of the endcap of the TPC detector, with each endcap equipped with 248 individual detector modules. The aluminum endcap offers a combination of lightweight and high strength properties, making it suitable for maintaining structural integrity while minimizing material budget (unit:mm).

**Note:** no detailed FEA analysis of the interconnections in these chapters or in chapter 14

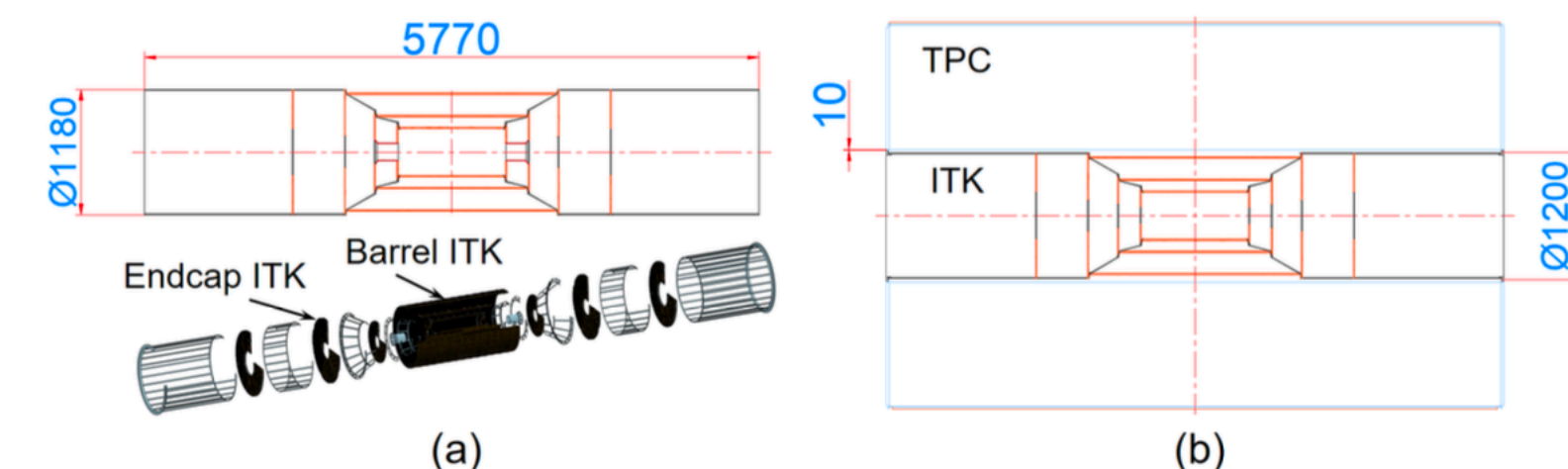
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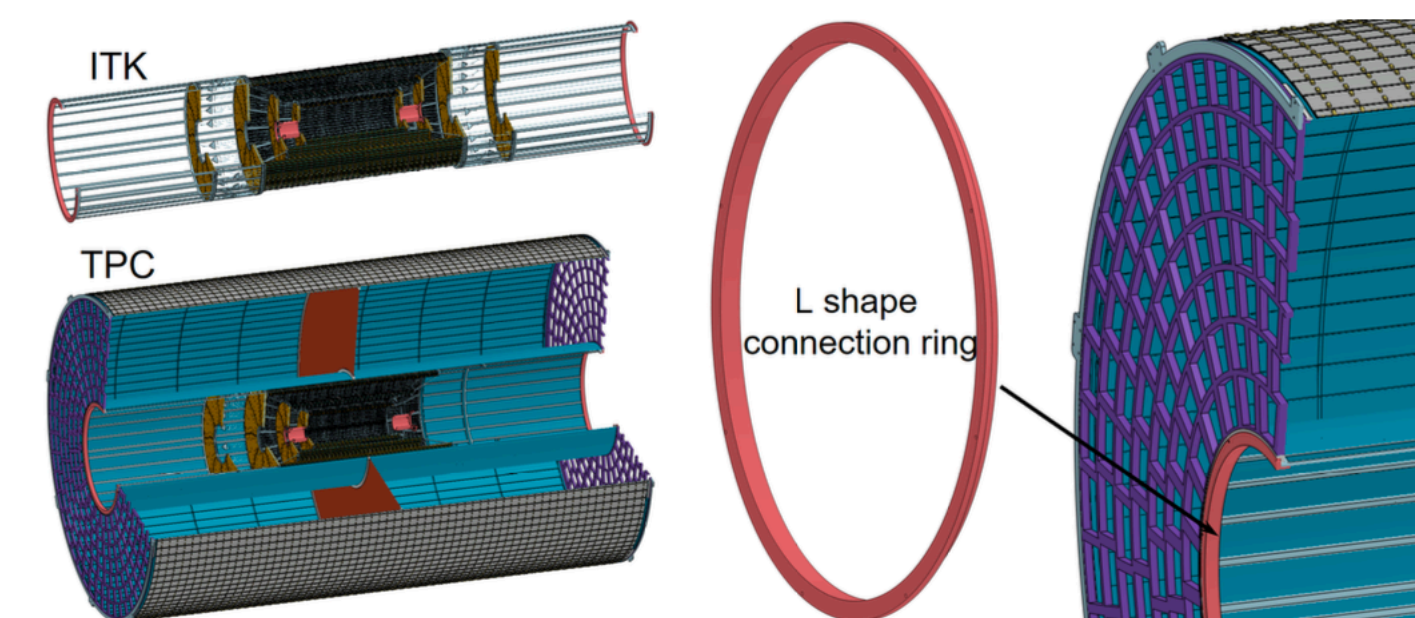
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**Figure 14.18:** Boundary dimensions and location of the ITK. ITK is located inside TPC with a 10 mm clearance, total length of it is 5770 mm and the outer diameter is 1180 mm. Units are in millimeters.



**Figure 14.19:** Connection structure of the ITK. The L shape rings at both ends connect the ITK to the TPC

**Note:** no detailed FEA analysis of support structure

# Chapter Structure

Chapter X:				
X.	1	Overview		What are we going to build? <b>Design</b> , expected performance (“requirements”)
X.	2	Detailed Design		
X.	2.	1	Detailed design	
X.	2.	2	Challenges and critical R&D	
X.	3	Key Technologies to address challenges		
X.	4	R&D and prototypes		
X.	5	Simulation and Performance		
X.	6	Alternative Solutions		Can be either backup or more advanced solution (demonstrate backup solutions are in hand and that their possible selection still meet the requirements)
X.	7	Summary and Future Plan		
X.	8	(Cost table and justification)		Eventually to be moved to a common chapter

- Sections should not have more than 4 numbered subsection levels x.y.z.w
- If using AI, editors need to read the AI output and finalize the text themselves. Cannot blindly use AI output. Also, AI usage should be minimized to correct english, NOT write sections from scratch
- <b>Captions should be long and describe plot, not just a title</b>