TDR Editing

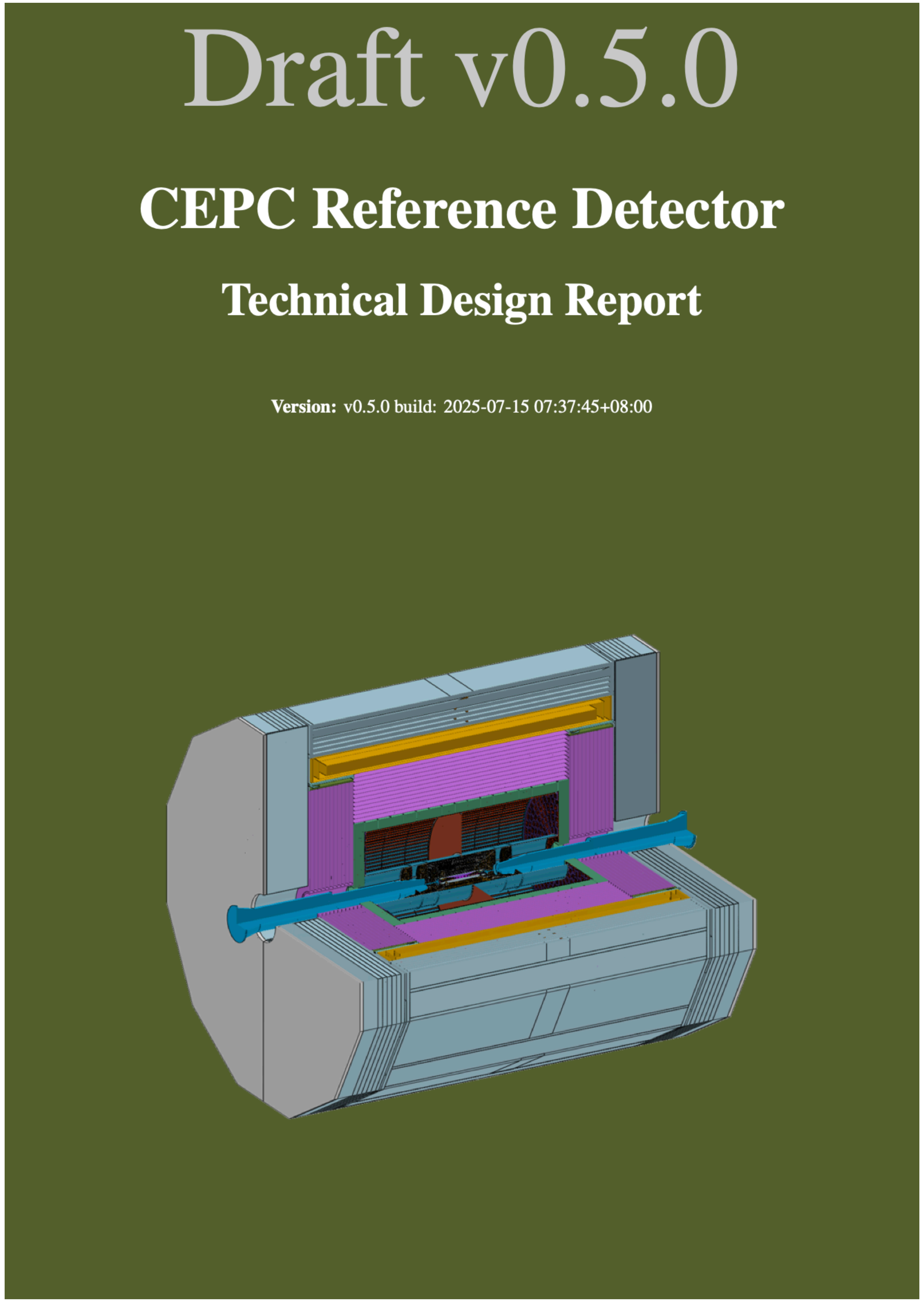
Tuesday CEPC TDR Meeting
July 29, 2025

Joao Guimaraes

Outline

- News from IDRC
- Mechanics issues

- Figures that still need update
- Muon detector - by Xiaolong



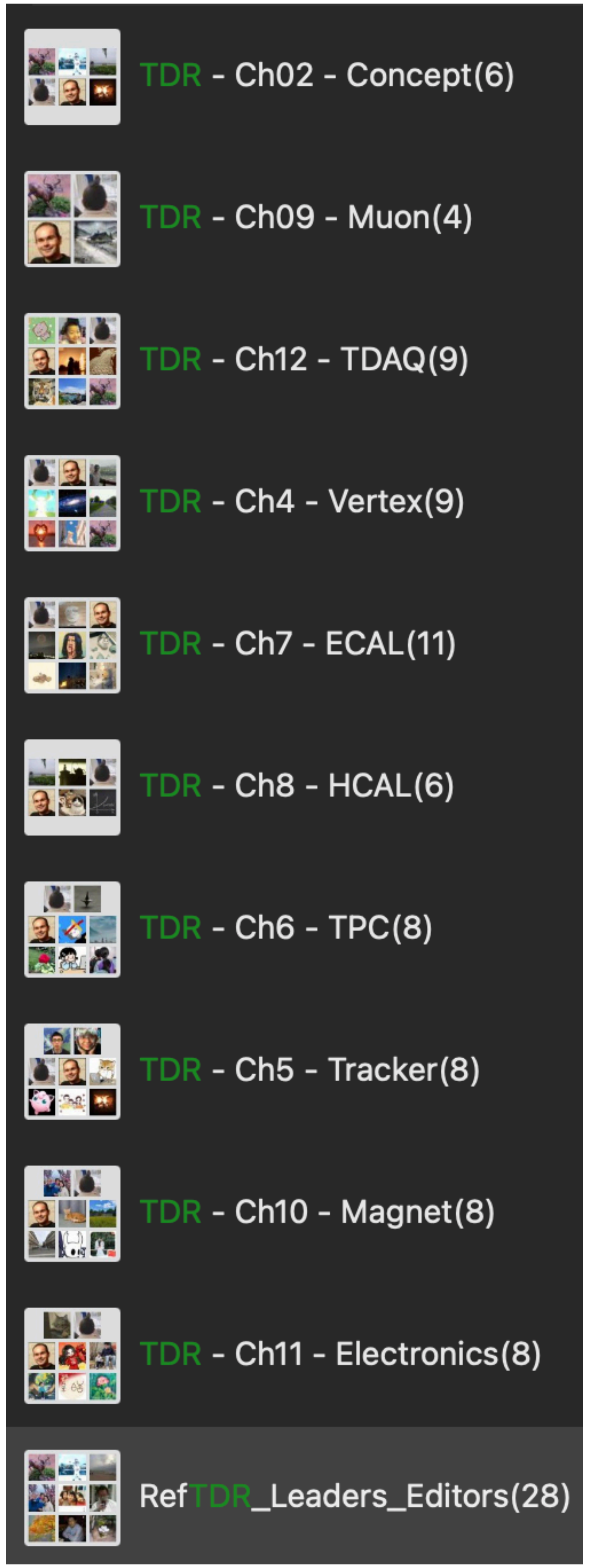
Keeping track of modifications

- **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



Keeping track of modifications

Blue section of the spreadsheet is for chapter leaders

Chapter	Overall Complete	Chapter structure	Updated date	Tables				Figures			Text		Other r
			Ready for check	Unified format	Significant digits	Change to pdf	Unified Macro	Total of not perfect figures	remaining to be updated	Enlarge the font size	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 conf

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)

	New IDRC	Started implementingg	Date plan to finish
From Last Week	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
New	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

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No mechanics, only simple design

Mechanics Details and Integration

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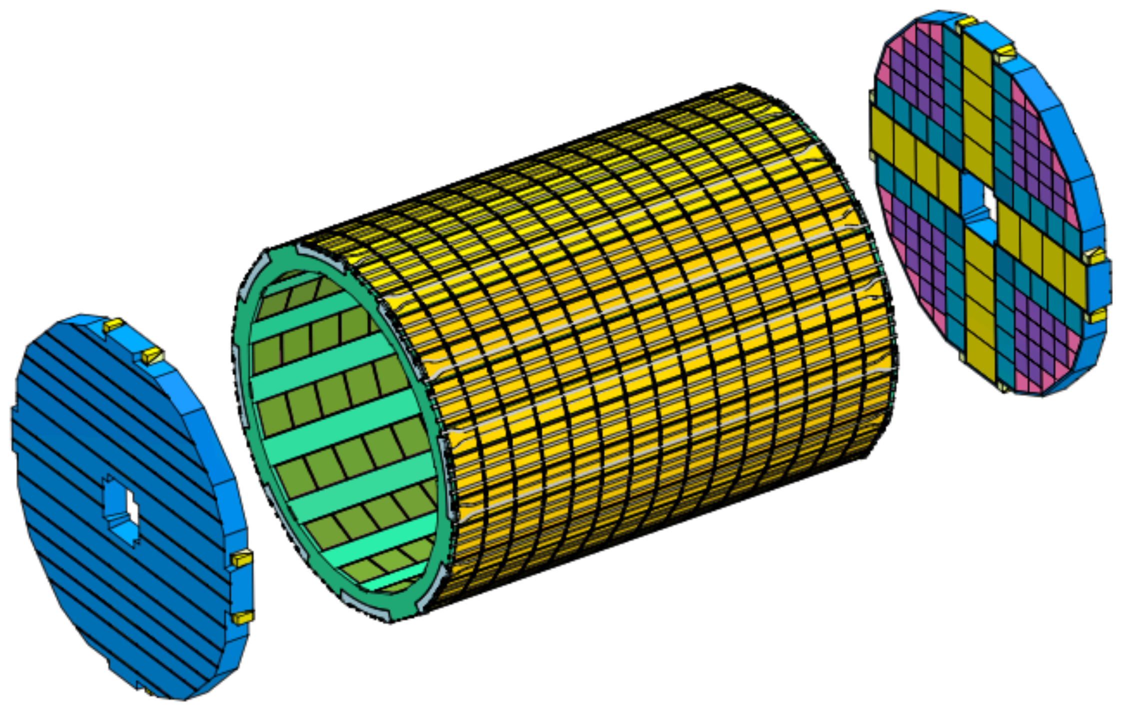
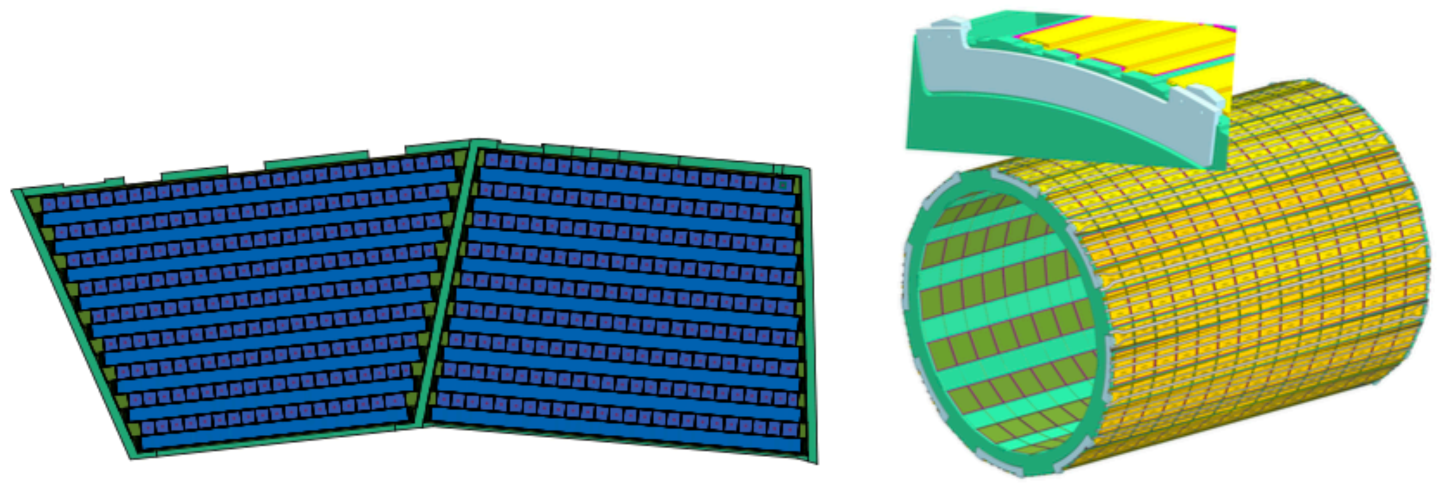


Figure 7.10: The ECAL mechanical design with one barrel and two endcaps. The barrel ECAL has 480 modules, which are integrated into a carbon-fiber frame (in lighter green), and is affixed to the barrel HCAL via 8 interconnection points. Cooling plates and cooling pipes are colored in light yellow. Two 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.



(a) **(b)**

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).

Mechanics Details and Integration

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Barrel structure FEA results FEA has been performed to assess the structural stability of the carbon-fiber frame and evaluate mechanical stress to crystal bars. The structural response was simulated under conditions with a total self-weight of 130 t. The stress distributions in three different directions (i.e. the stress in parallel to the carbon-fiber direction, the stress perpendicular to the carbon-fiber direction and the in-plane shear stress) show that they stay well within the specifications of the cost-effective CFRP option named ”T700”. Additional 16 fixation points fixing points have been included to the barrel frame cylinder to reinforce structural stability and reduce deformation. The maximum deformation is 2.7 mm, as shown in Figure 7.13, and can meet the design requirement.

Since the design of barrel modules is similar to that of endcaps, FEA results under load are presented in Section 7.2.5.2.

Needs updating

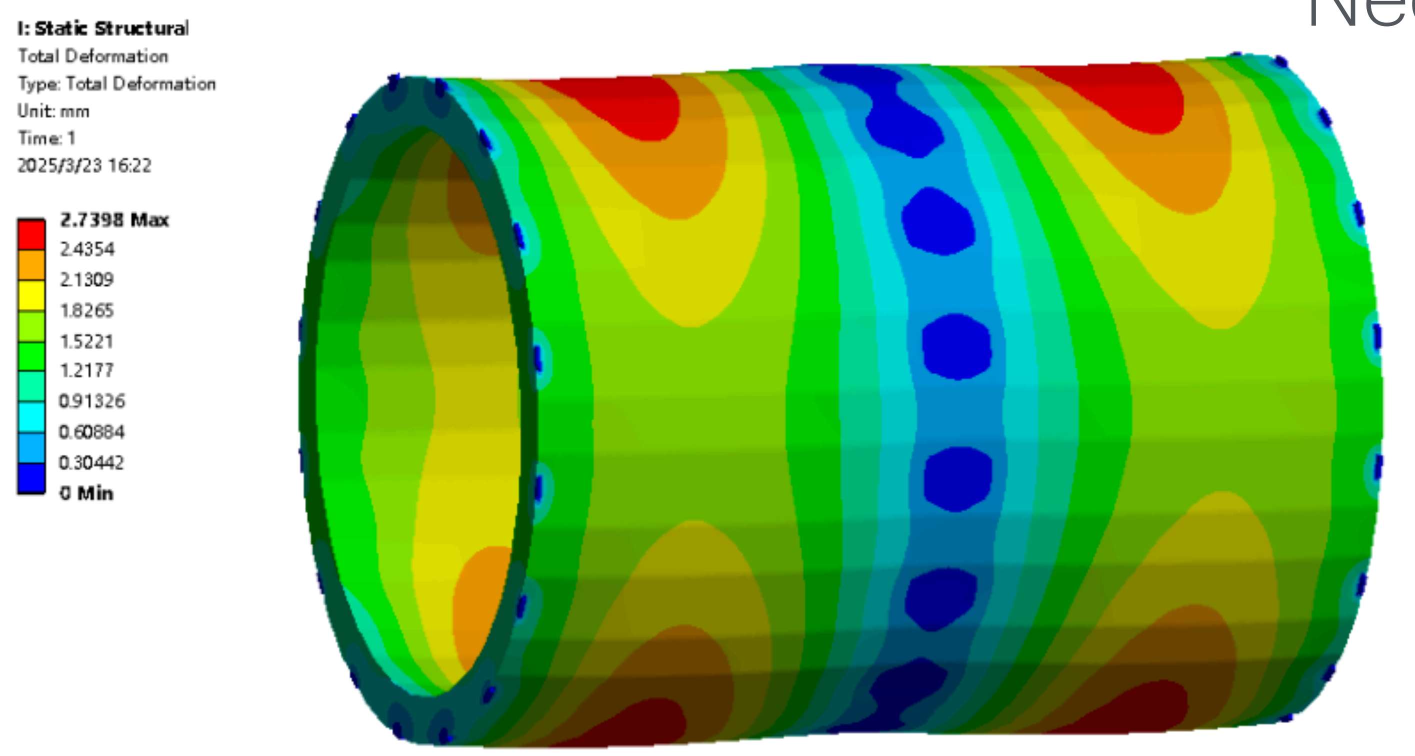

Figure 7.13: Deformation distribution of the ECAL barrel frame with the updated mechanical design by adding extra fixation points in the central cylinder, further reinforcing interconnections with the barrel HCAL.

Mechanics Details and Integration

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Detector connections

Chapter organized in order of the installation, which is unnatural

Separated barrel and endcap description

Detector Installation

Mechanics Details and Integration

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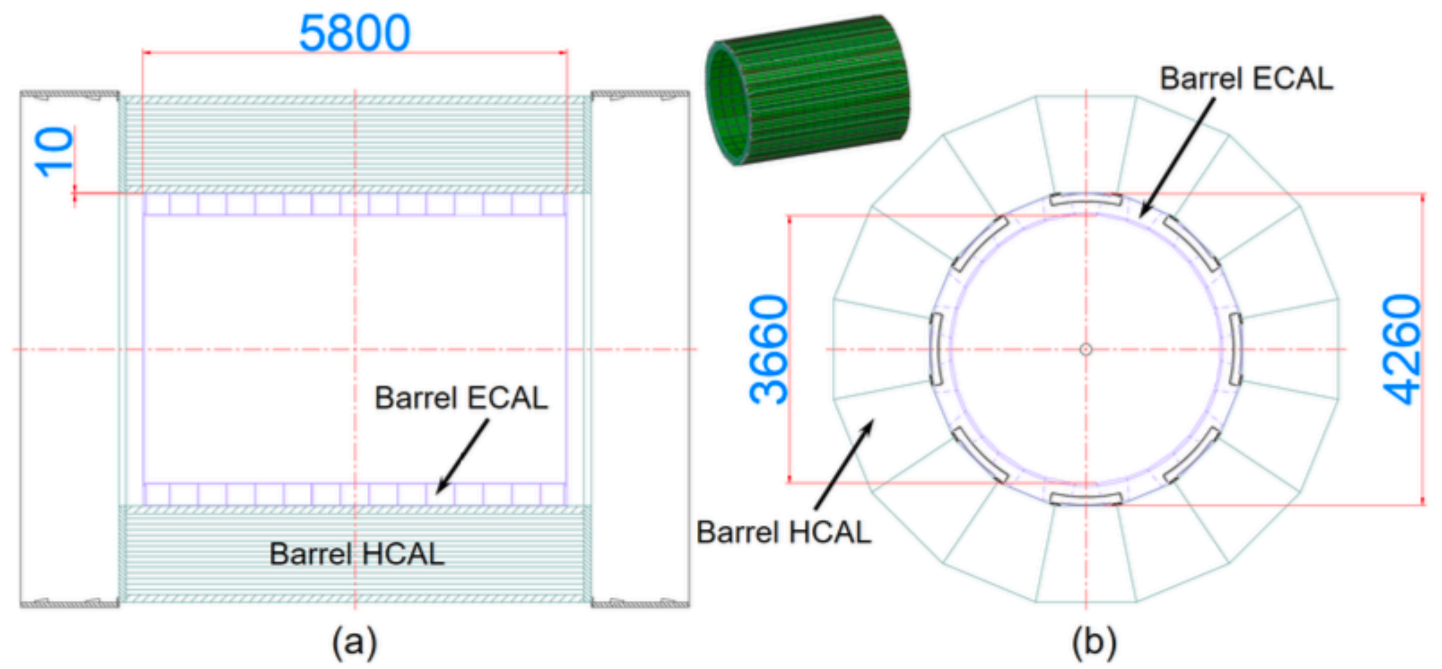

Figure 14.13: Boundary dimensions and location of the barrel ECAL. It is installed inside the barrel HCAL, with a minimum clearance of 10 mm. Units are in millimeters.

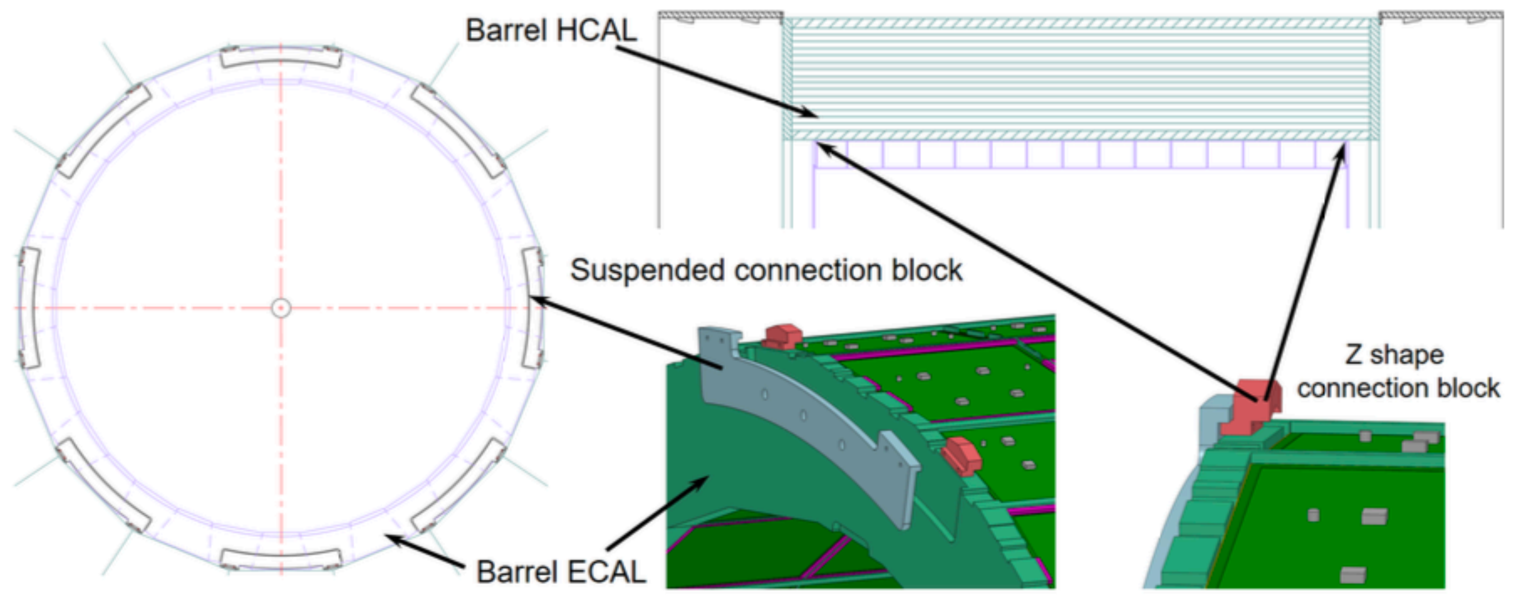

Figure 14.14: Connection structure of the barrel ECAL. Eight-point circular suspension structure are adopted to connect the barrel ECAL and the barrel HCAL.

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

Mechanics Details and Integration

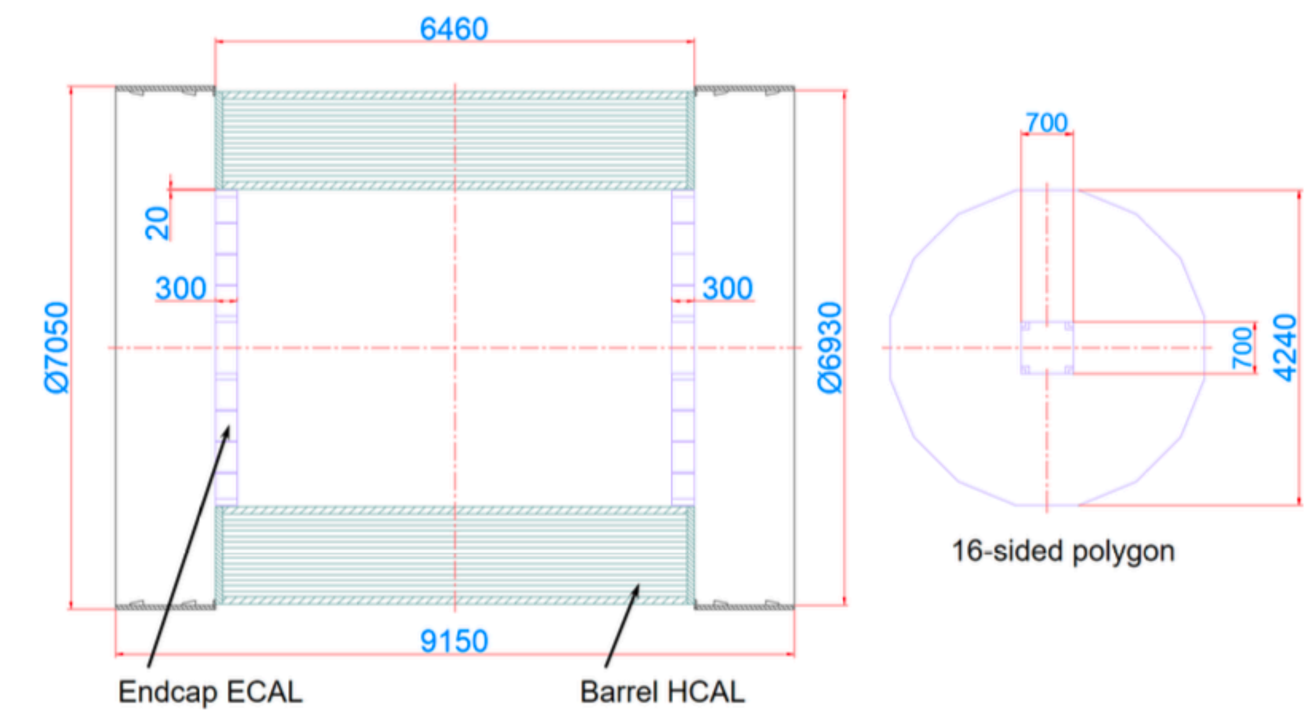

Figure 14.22: Boundary dimensions and location of the endcap ECAL. It is located at both ends of the barrel ECAL , with the minimum clearance of 20 mm for the routing of cable and pipe. Units are in millimeters.

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

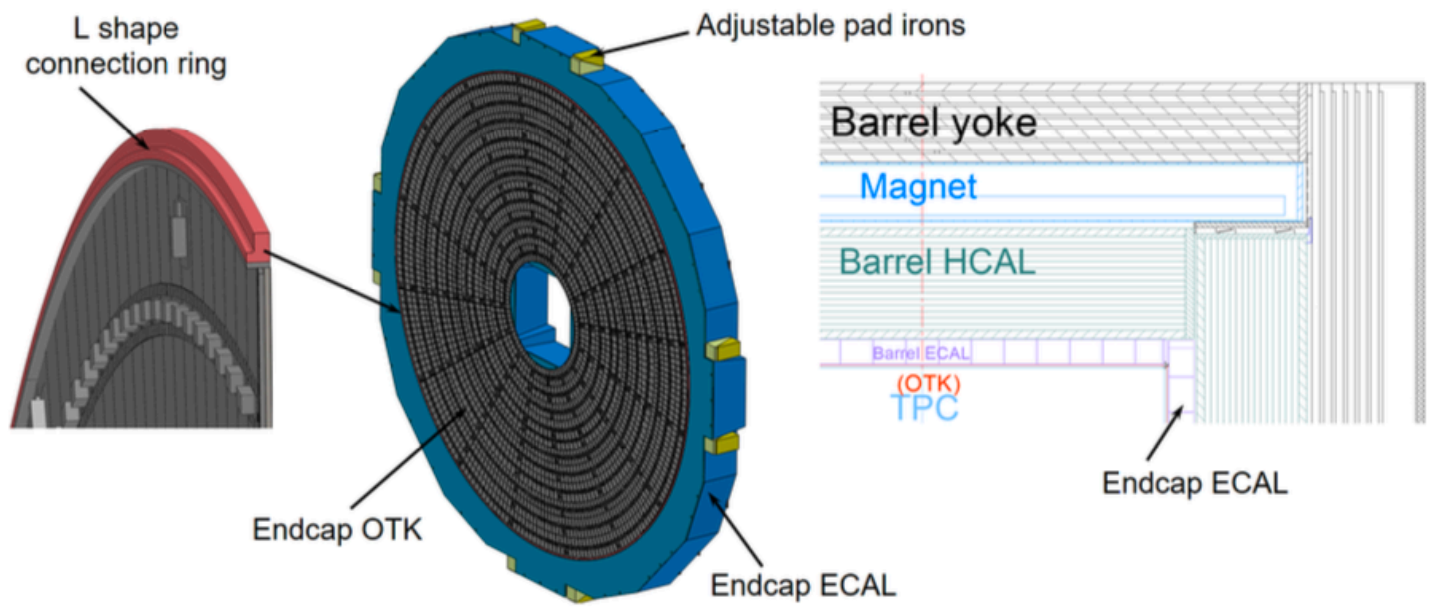

Figure 14.23: Connection structure of the endcap ECAL and the endcap OTK. They are connected and positioned by four pairs of adjustable pad irons uniformly distributed around the circumference.

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

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

Mechanics Details and Integration

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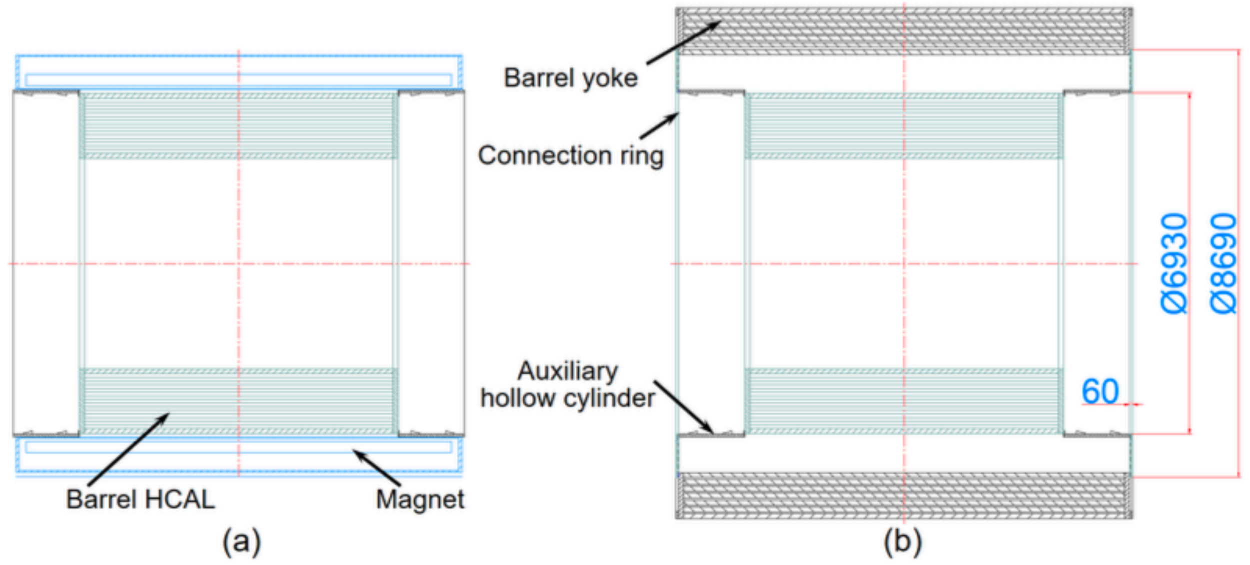

Figure 14.10: Location of the barrel HCAL. It is directly connected to the barrel yoke using the rings. Units are in millimeters.

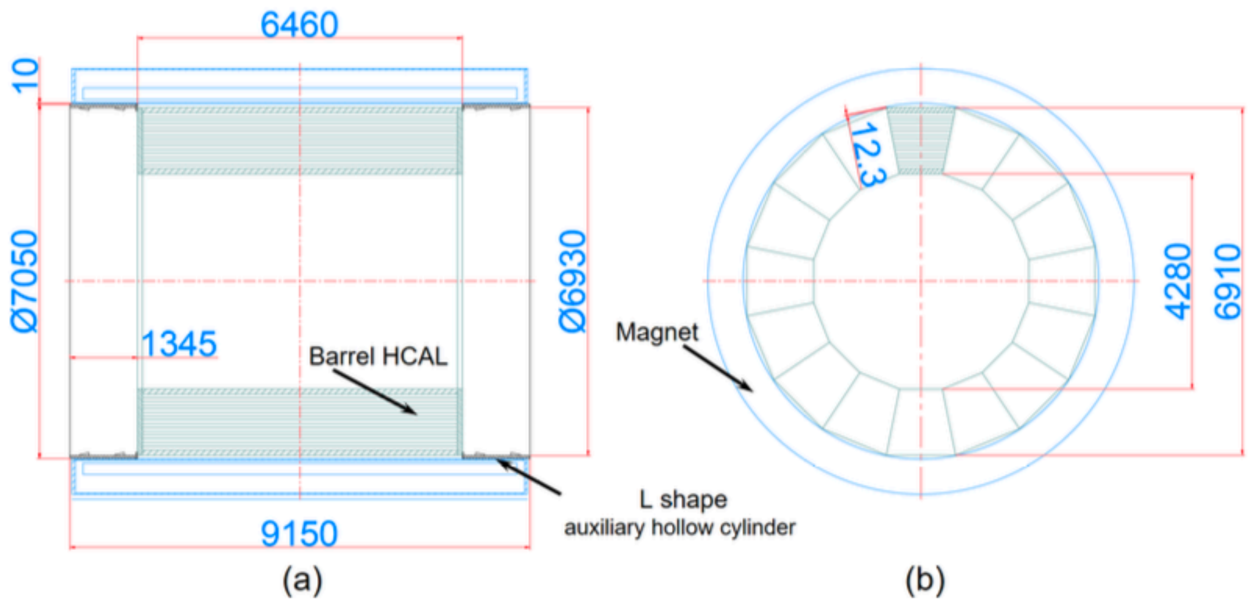

Figure 14.11: Boundary dimensions of the barrel HCAL. The L-shaped auxiliary hollow cylinders serve as both assembly fixture and the key connection interface, with 10 mm clearance between to the magnet. Units are in millimeters.

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

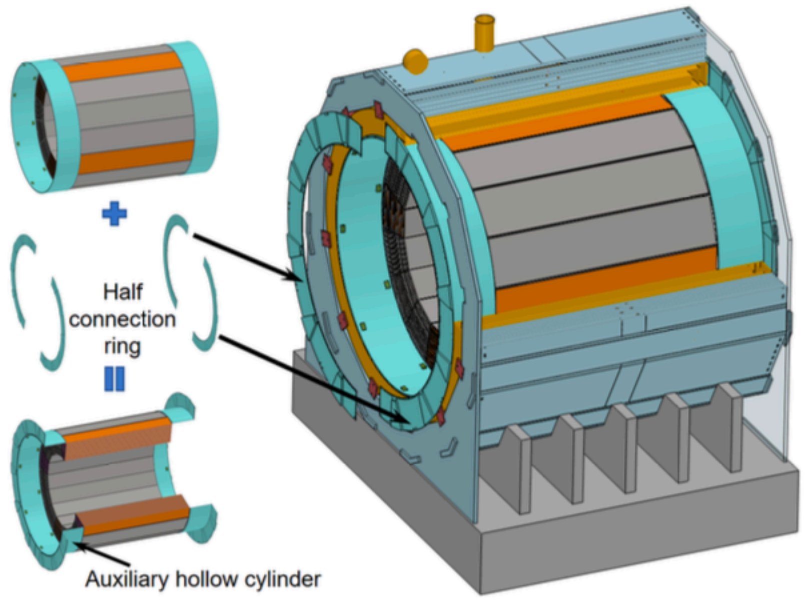

Figure 14.12: Connection structure of the barrel HCAL. Split rings with wire slots connect the HCAL auxiliary cylinder to the barrel yoke flange.

Mechanics Details and Integration

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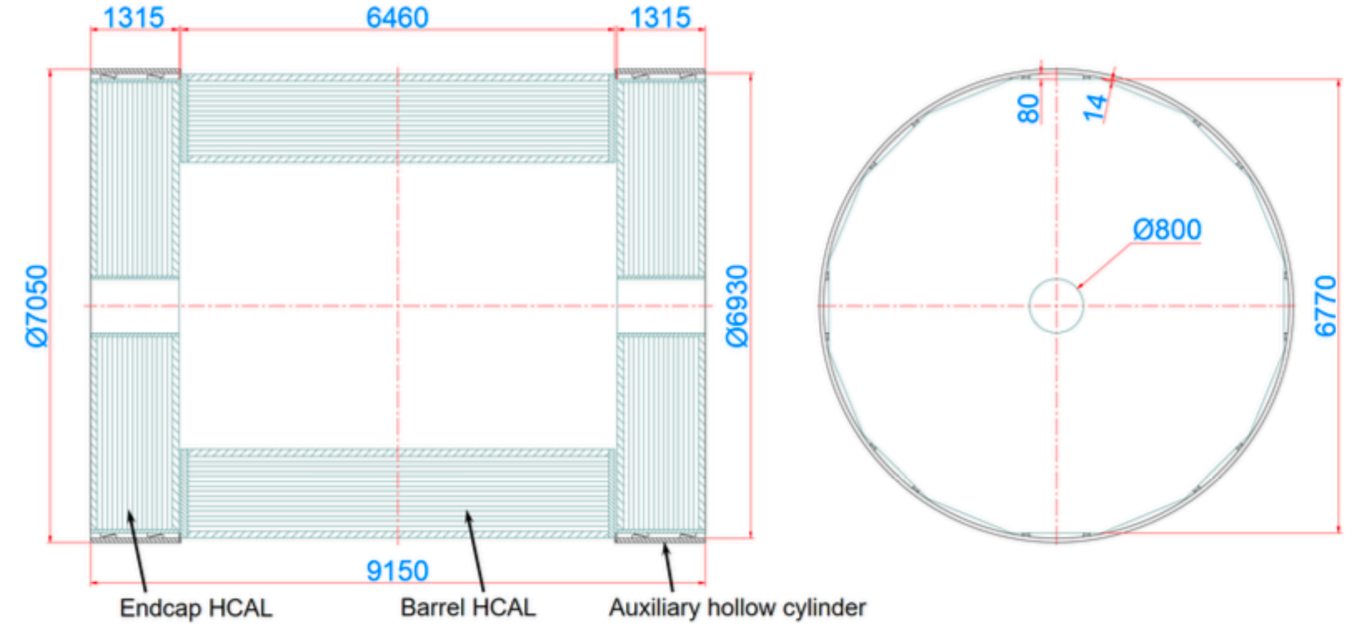

Figure 14.24: Boundary dimensions and location of the endcap HCAL. It is installed in the auxiliary hollow cylinder of the barrel HCAL, the clearance between them is ranged from 14 mm to 80 mm for routing space. Units are in millimeters.

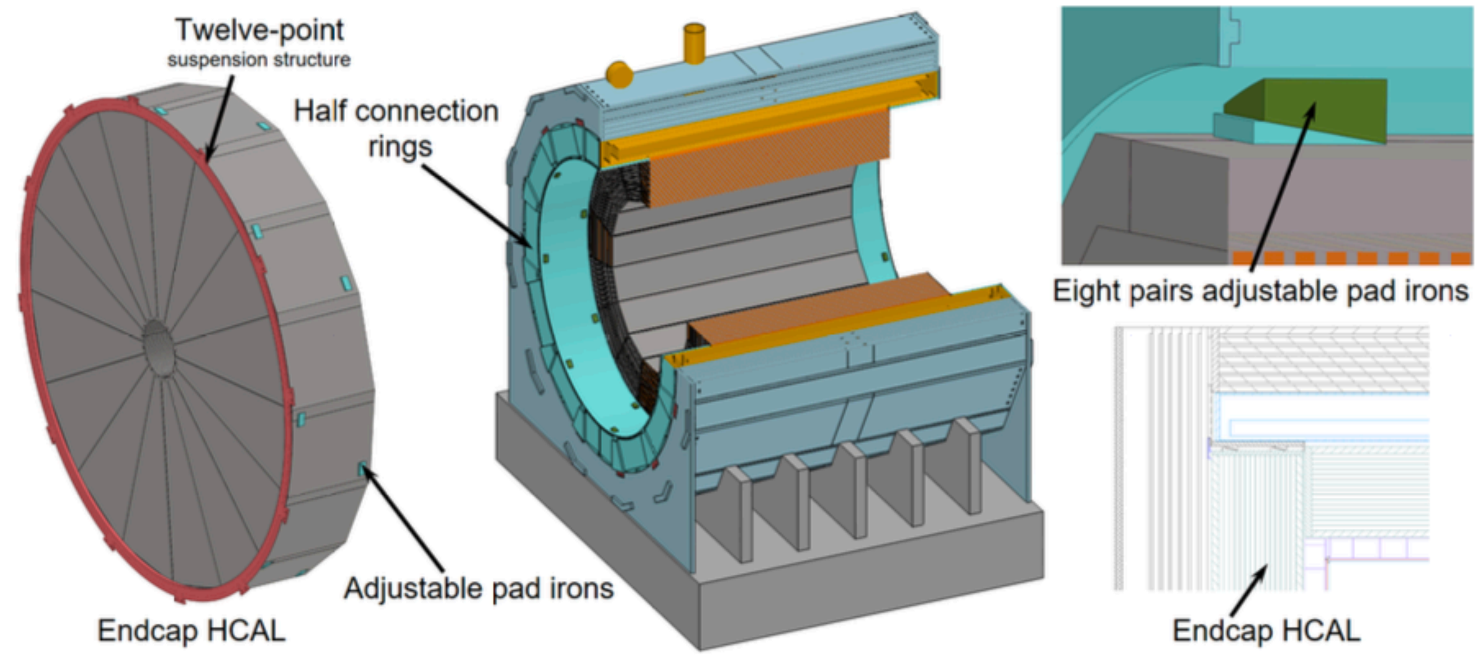

Figure 14.25: Connection structure of the endcap HCAL. The endcap HCAL is rigidly connected to the barrel yoke through eight pairs of adjustable pad irons, two pairs of axial pads, and a twelve-tooth flange, ensuring stable support for the superconducting magnet.

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?

Mechanics Details and Integration

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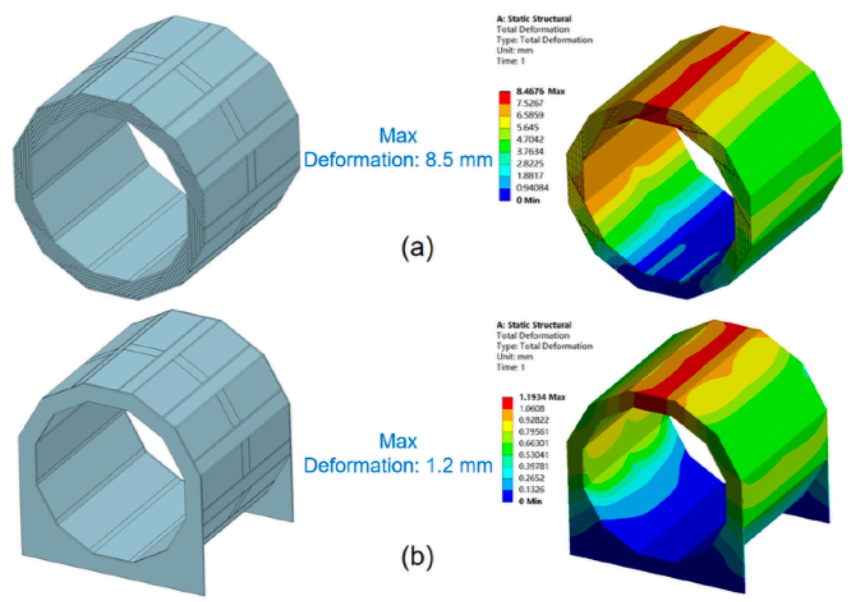

Figure 14.6: Overall deformation comparison of FEA results for the barrel yoke without and with the end flanges. (a) Maximum deformation is 8.5 mm without the end flanges; (b) Maximum deformation is 1.2 mm with the end flanges.

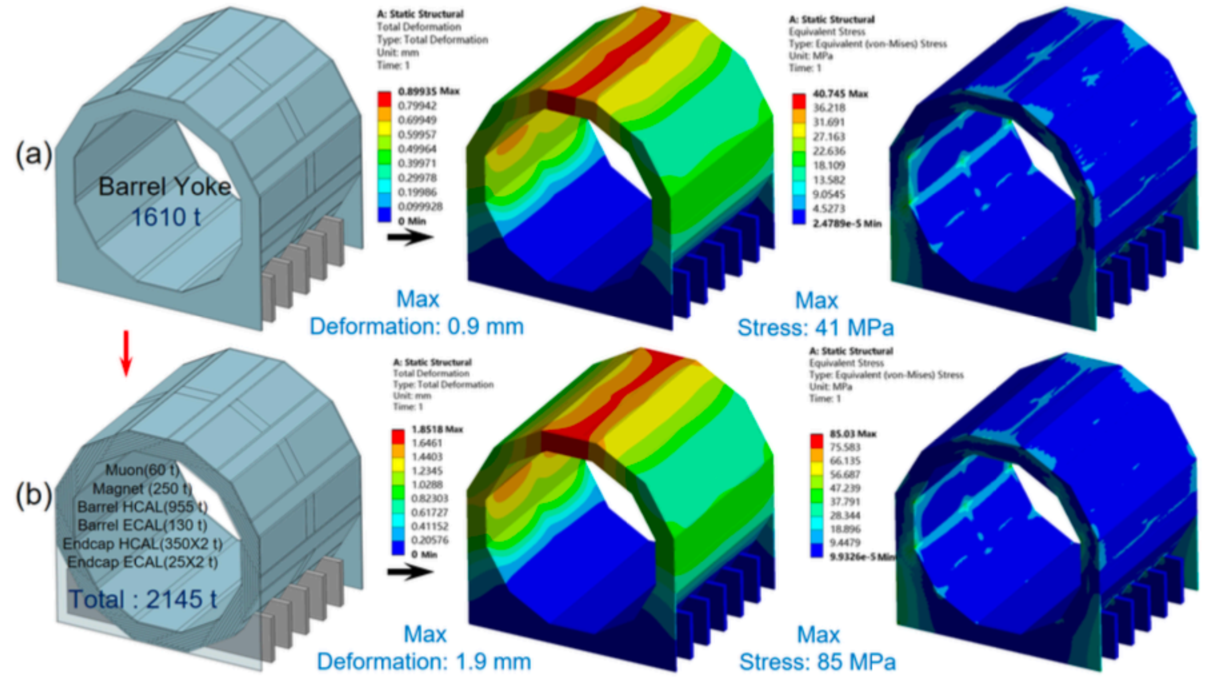

Figure 14.26: FEA results of the barrel yoke deformation and stress under two loading condition. (a) bare yoke condition:load is self-weight of barrel yoke. (b) with sub-detectors condition:load is self-weight of barrel yoke and 2145 tons. (including the superconducting solenoid magnet, the barrel HCAL,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

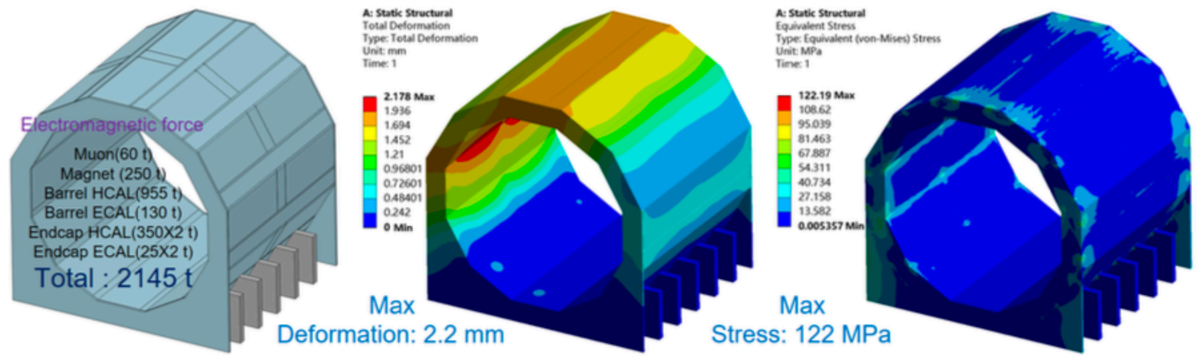

Figure 14.27: Deformation and stress of the barrel yoke under the electromagnetic force load with sub-detectors condition.

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?

Mechanics Details and Integration

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

Do we have these?

Mechanics Details and Integration

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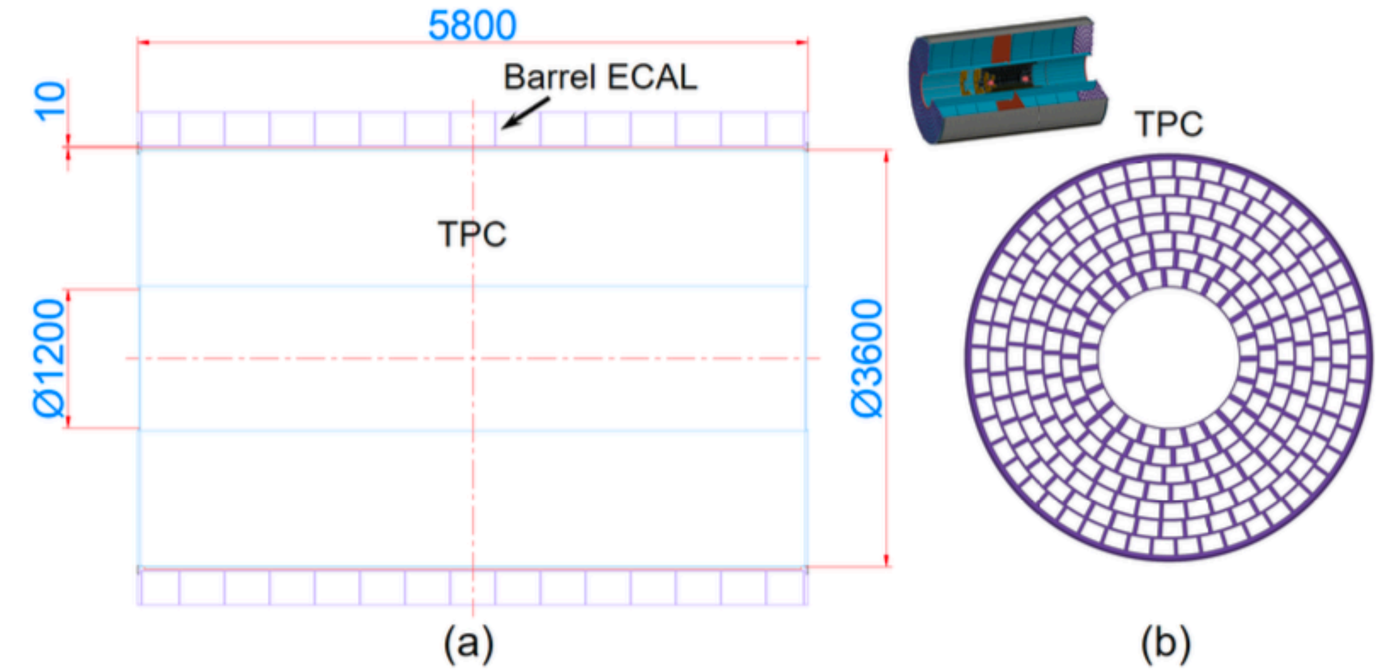

Figure 14.15: Boundary dimensions and location of the TPC. It is mounted inside the barrel ECAL with a minimum clearance of 10 mm. Units are in millimeters.

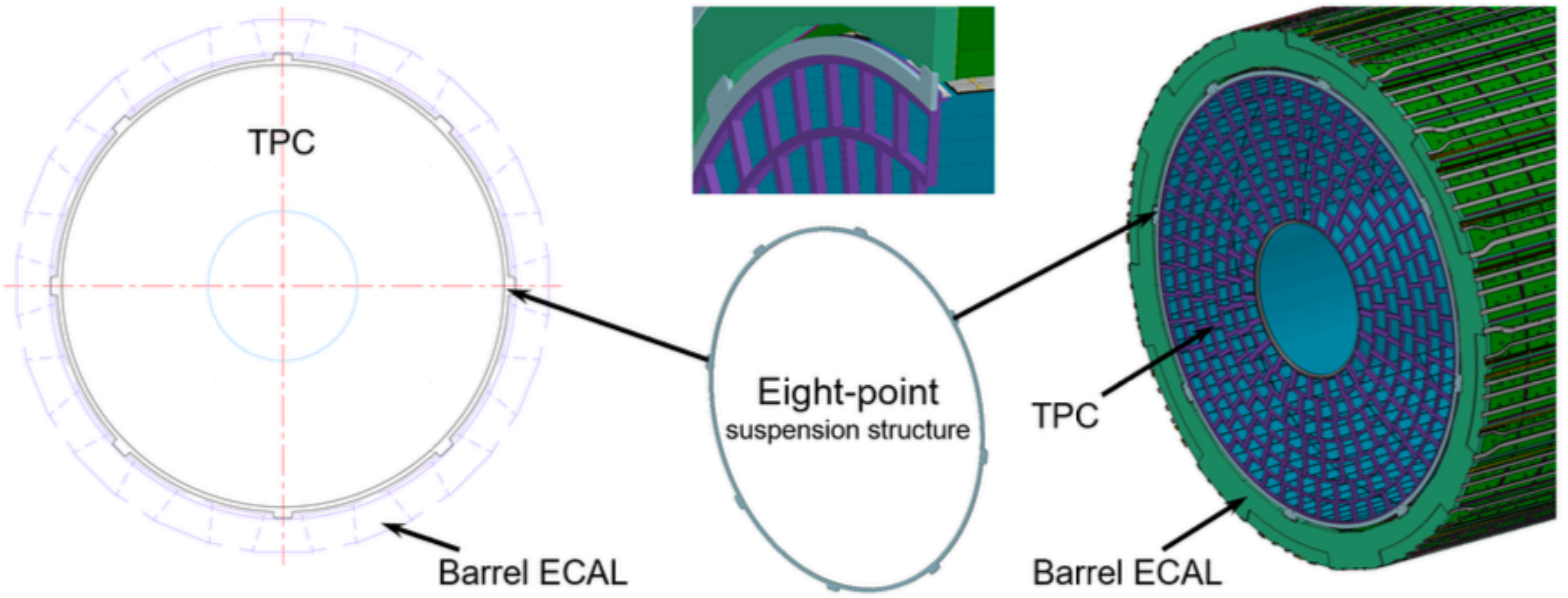

Figure 14.16: Connection structure of the TPC. The TPC is connected to the barrel ECAL by eight-point suspension structure with the slots for cabling and piping.

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

Mechanics Details and Integration

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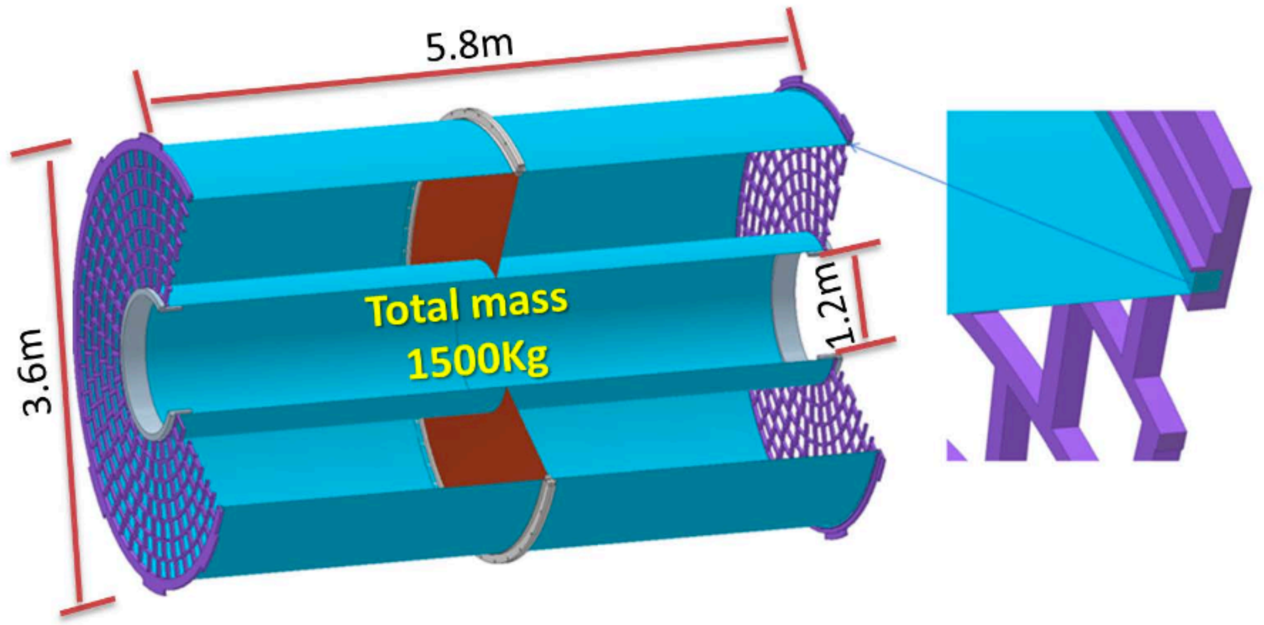

Figure 6.1: The Layout diagram of the TPC fieldcage, the designed boundary connection with ITK, OTK and ECAL sub-detectors

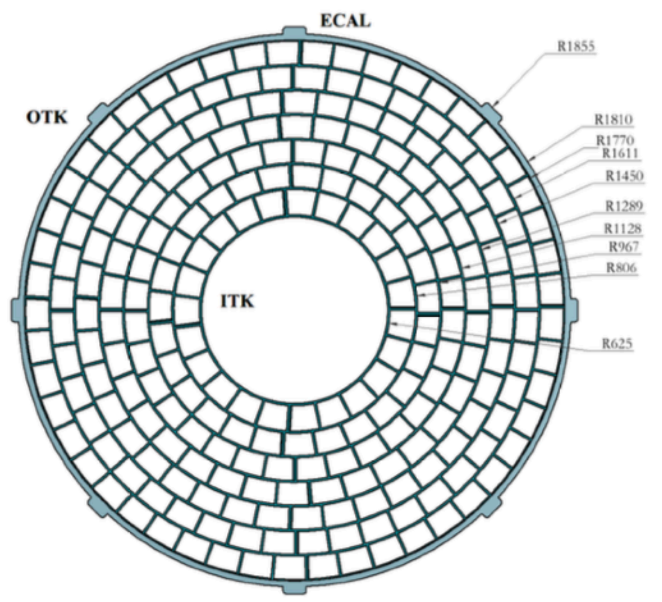

Figure 6.3: Two-dimensional layout of the endcap of the TPC detector, with each endcap equipped with 248 individual detector modules. The aluminum endcap offers a combination of lightweight and high strength properties, making it suitable for maintaining structural integrity while minimizing material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

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

Do we have these?

Mechanics Details and Integration

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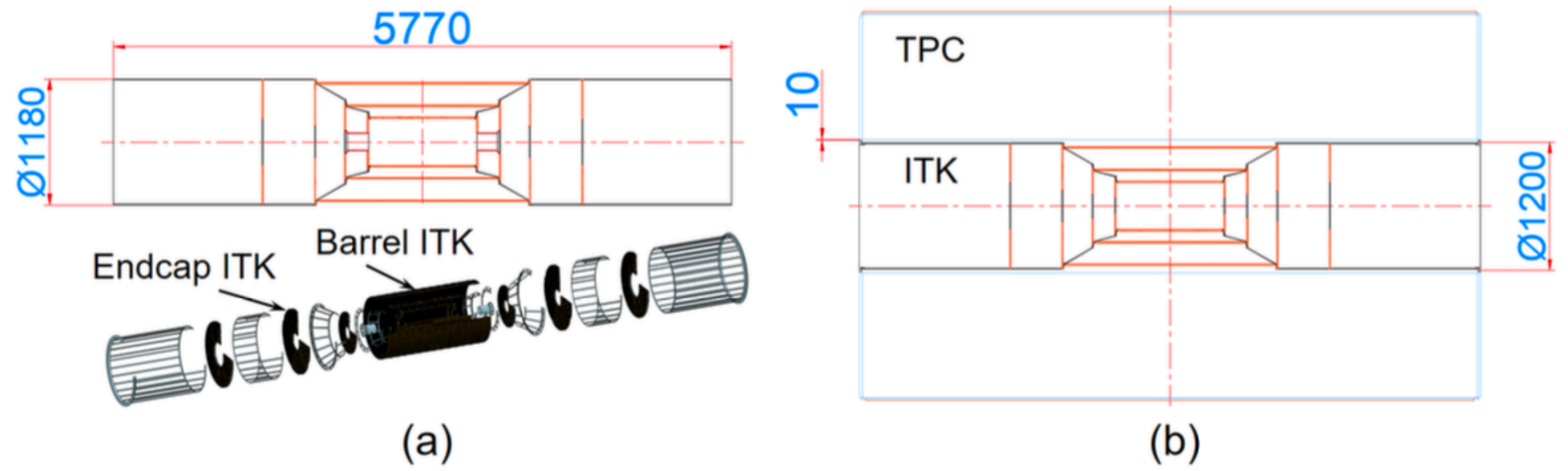

Figure 14.18: Boundary dimensions and location of the ITK. ITK is located inside TPC with a 10 mm clearance, total length of it is 5770 mm and the outer diameter is 1180 mm. Units are in millimeters.

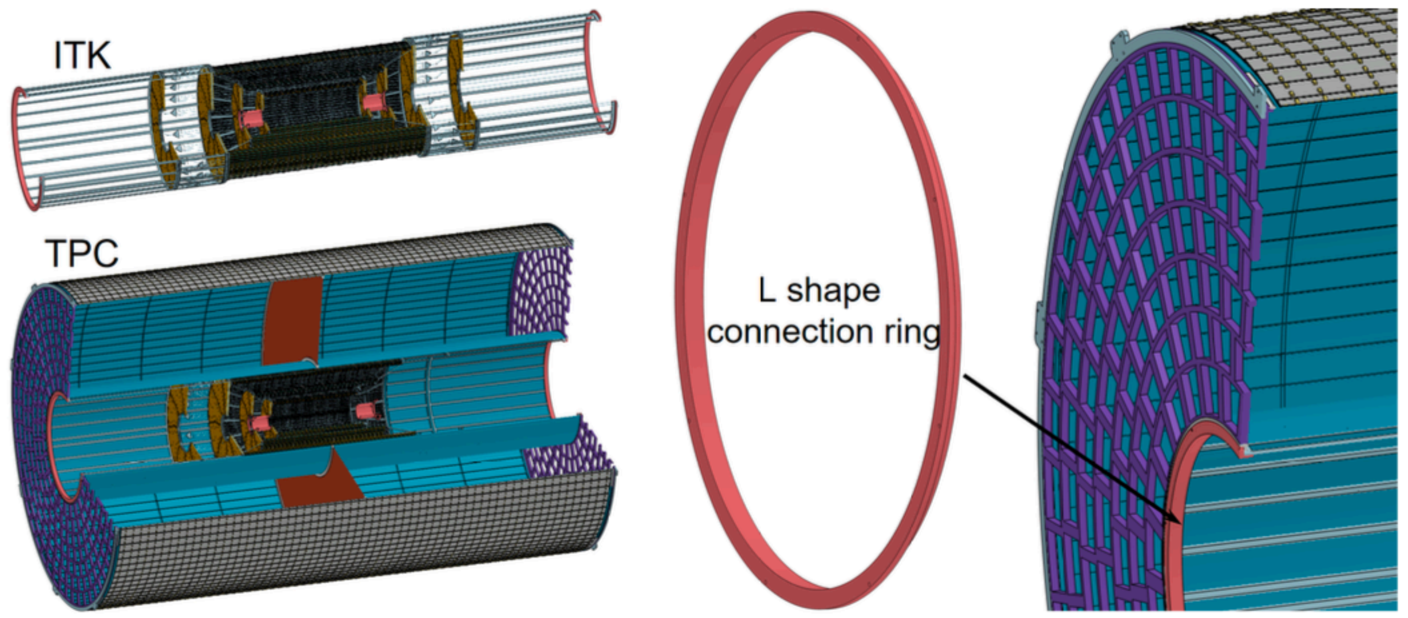

Figure 14.19: Connection structure of the ITK. The L shape rings at both ends connect the ITK to the TPC

Note: no detailed FEA analysis of support structure

Chapter Structure

Chapter X:				
X.	**1**	**Overview**		What are we going to build? **Design**, 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
- Captions should be long and describe plot, not just a title