

Progress in mechanical design of CEPC detector TDR

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June 27, 2024

Content:

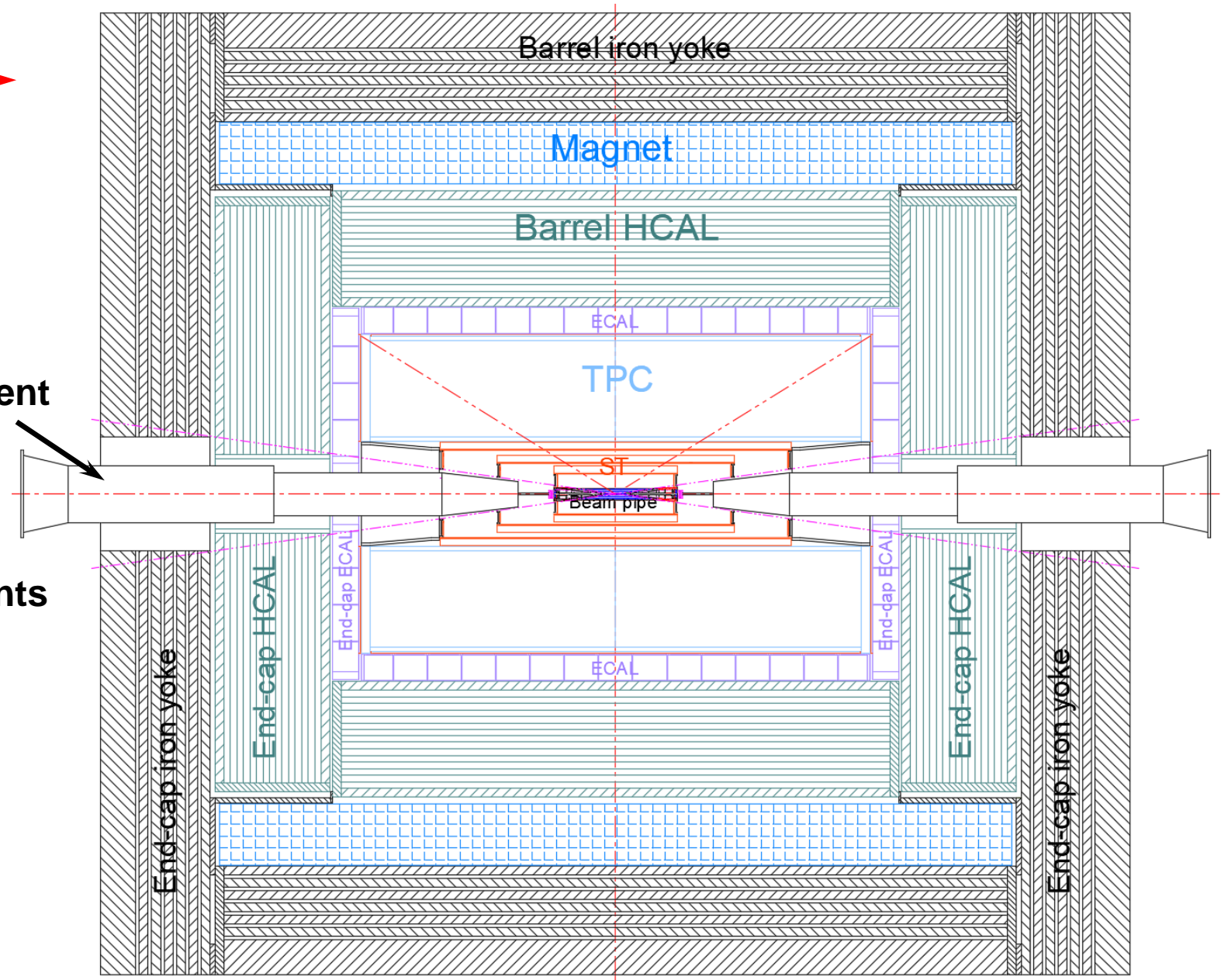
1. Overall layout and Size distribution
2. Installation and Connection Concept design of Sub detectors
3. Summary

1. Overall layout and Size distribution

Overall layout →

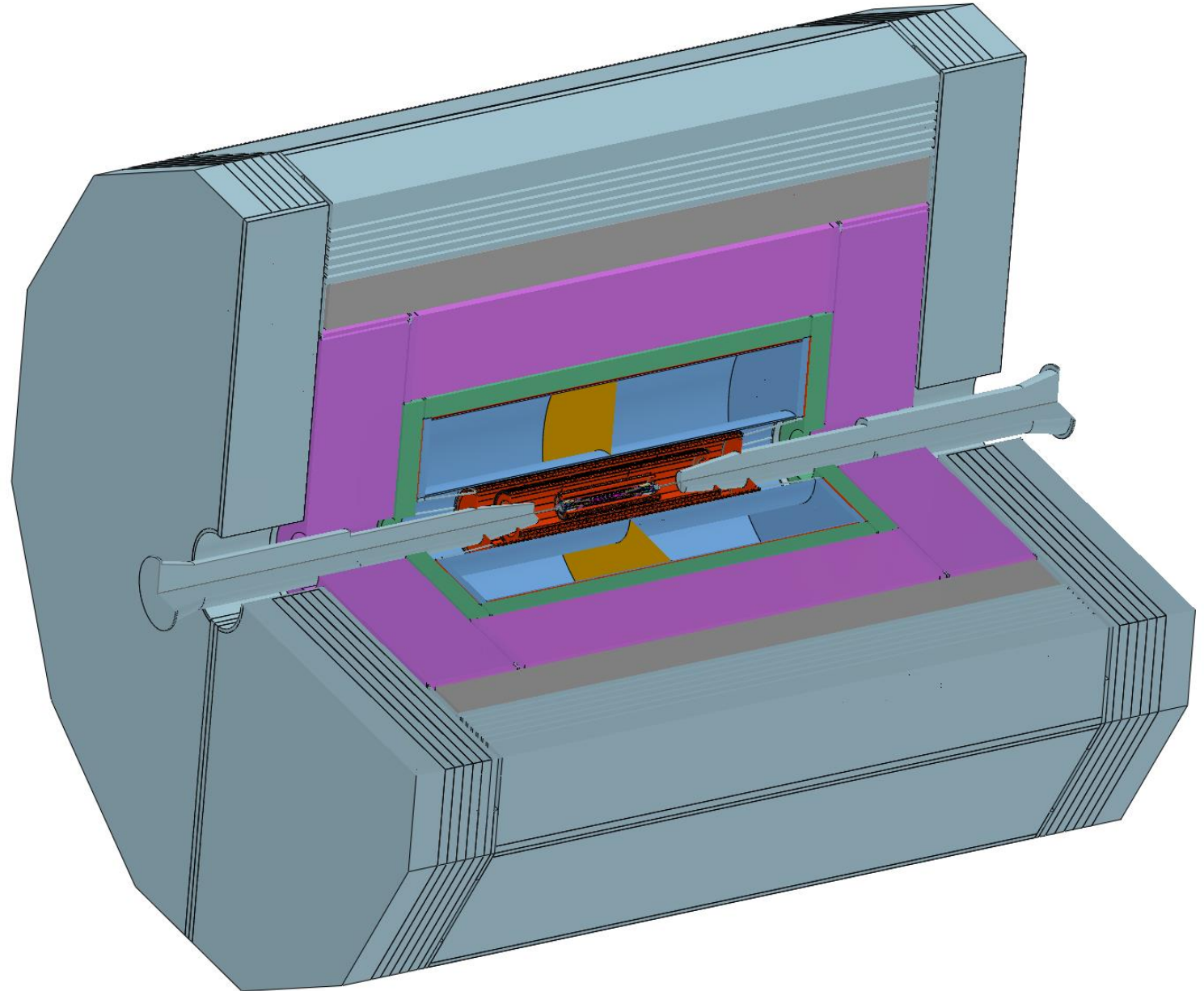
ACC MDI Component

Others are detector components



1. Overall layout and Size distribution

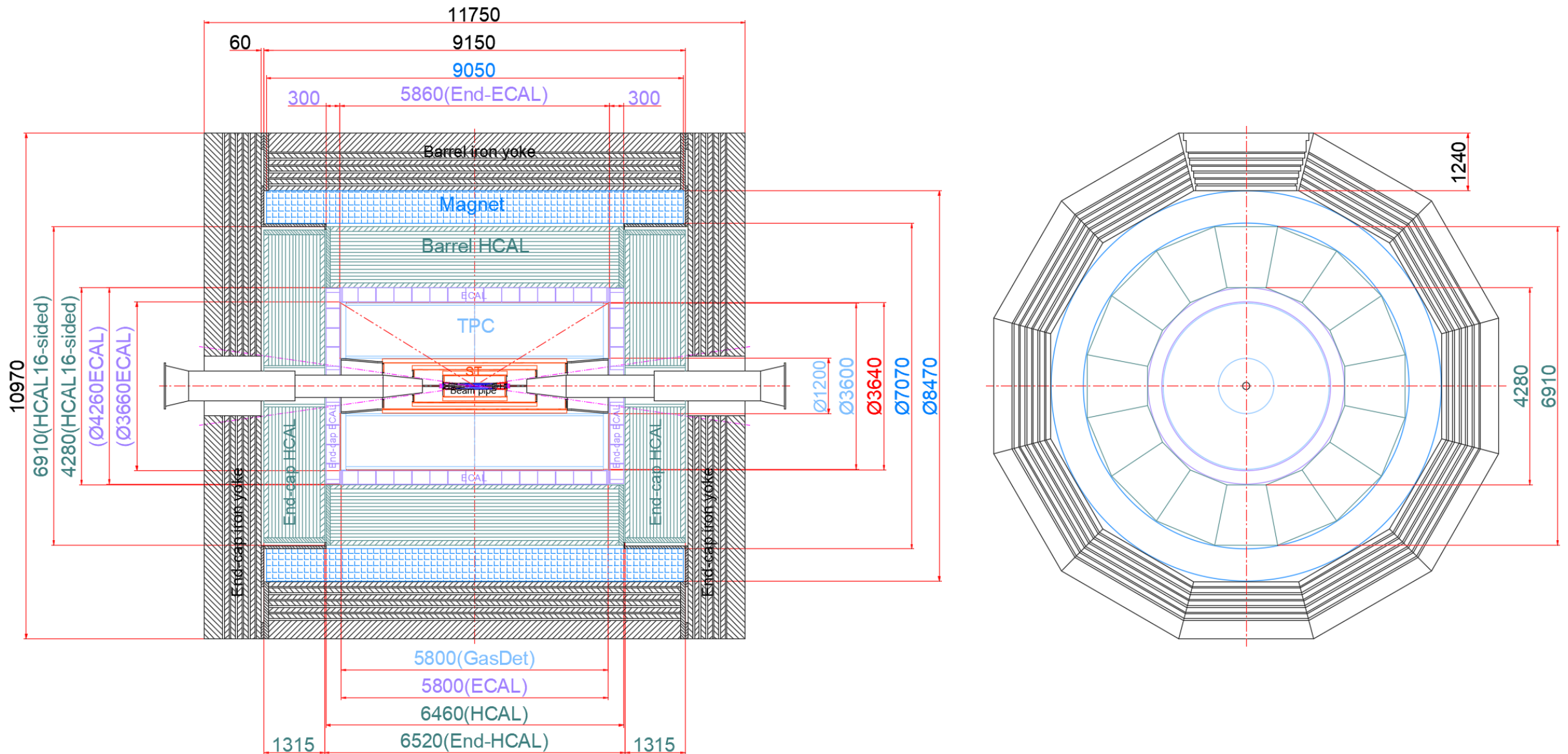
Overall layout



Total weight :
≈ 6000 t

1. Overall layout and Size distribution

Size distribution --- Detector boundary



1. Overall layout and Size distribution

Size distribution --- MDI boundary

consists of 4 segments of channels:

Detection angle : 8.1° ($\arccos 0.99$)
(Before ECAL)

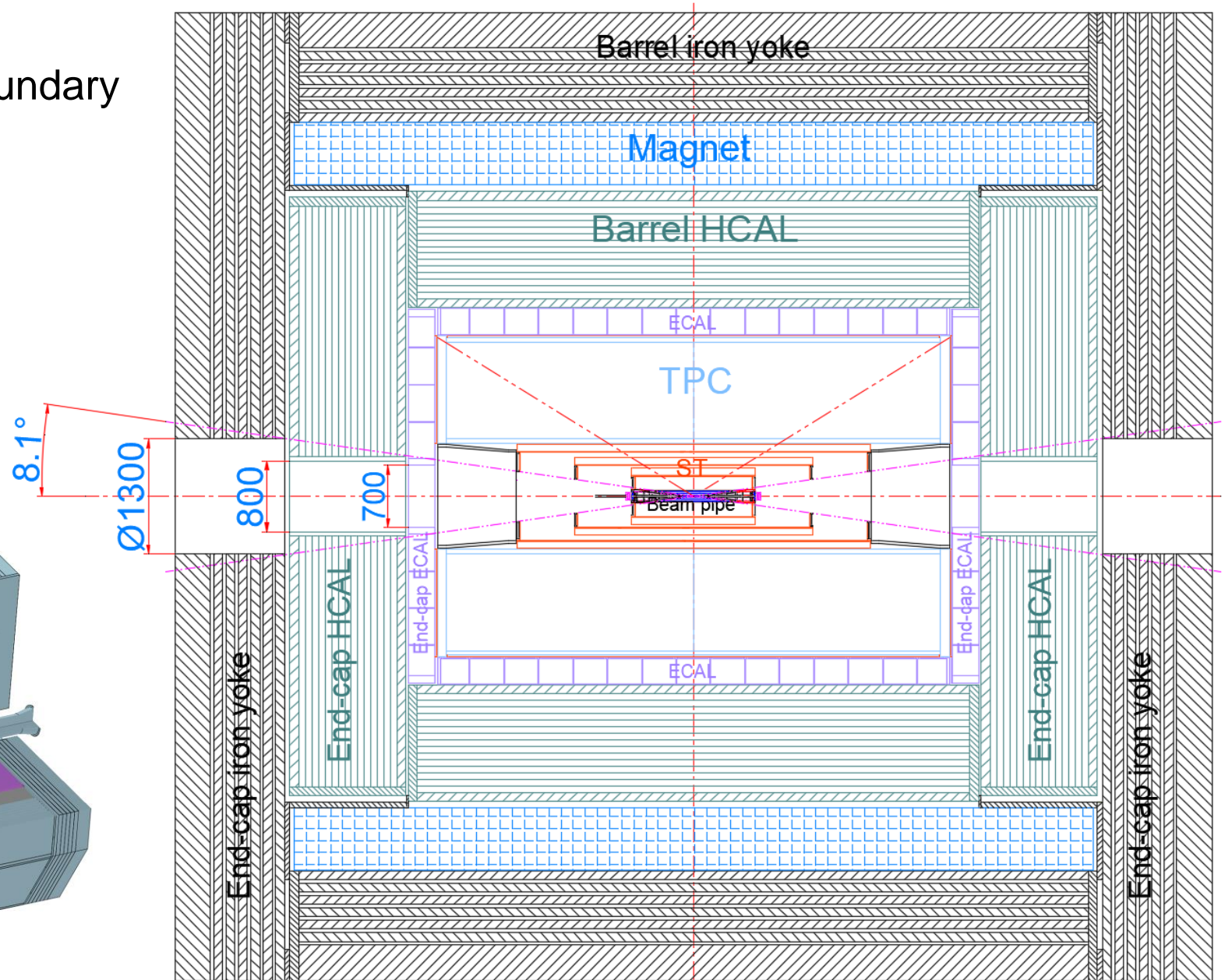
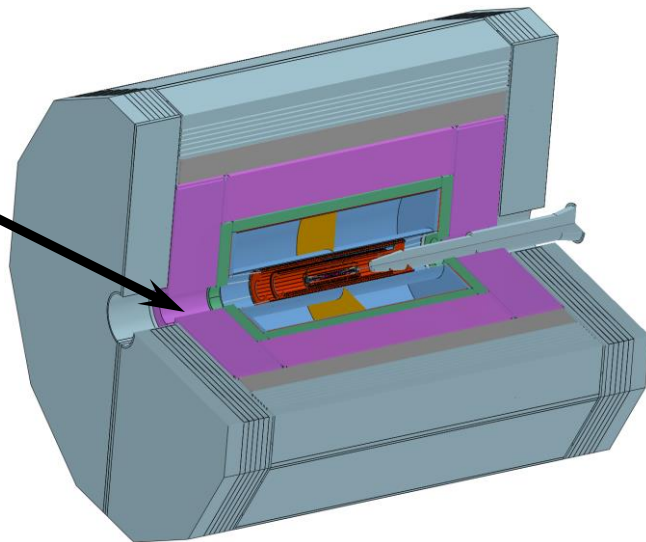
(After ECAL)

ECAL : 700 mm

HCAL : 800 mm

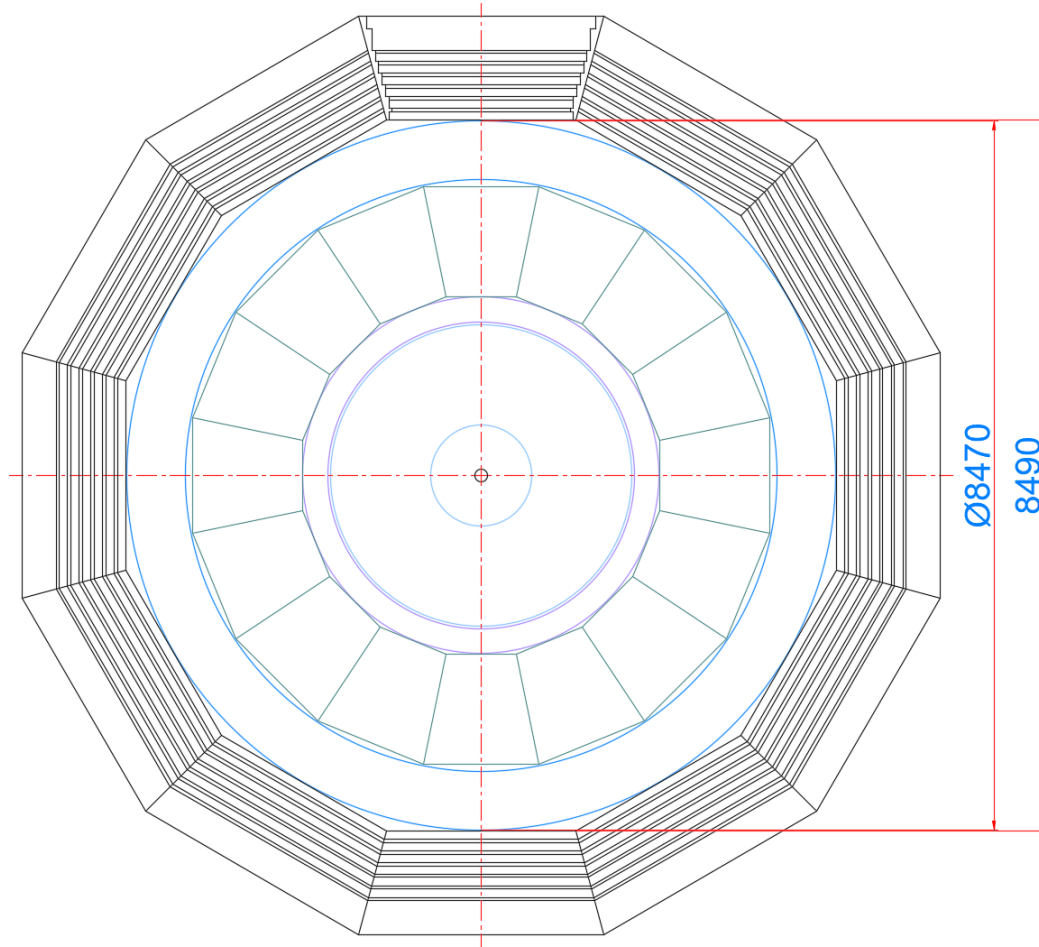
Yoke : $\varnothing 1300$ mm

MDI Channels



1. Overall layout and Size distribution

Size distribution --- Gap between sub detectors



Example for GAP between the Yoke and Magnet

Minimum gap principle:

Designed installation gap: 10mm

Factors: Guide rail accuracy
Collimation accuracy

Dimensional tolerance: (example)

Barrel yoke : 4245 Tolerance: +5
0

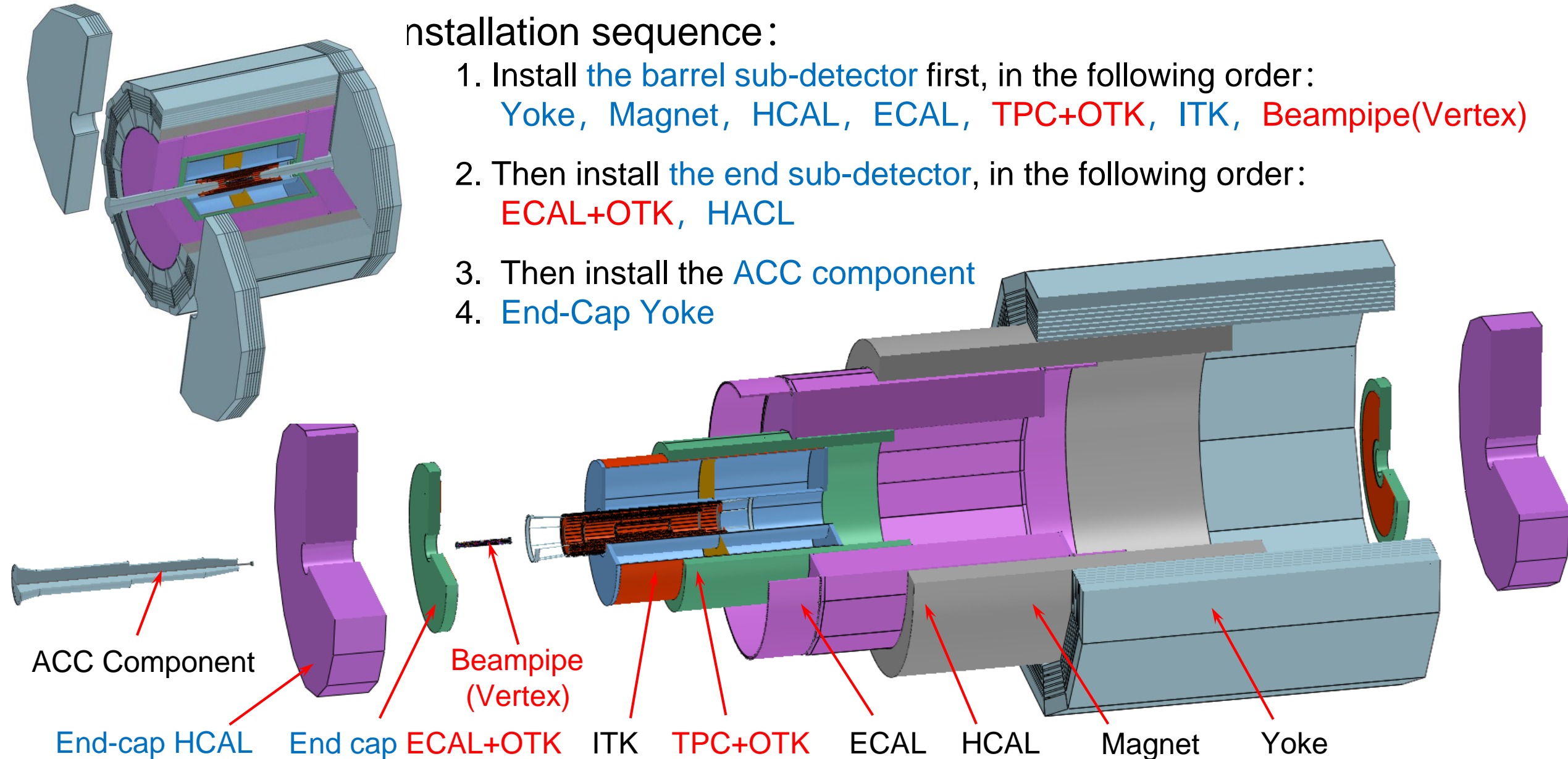
Magnet: R4235 Tolerance: -5

Actual installation gap:
10~20 mm

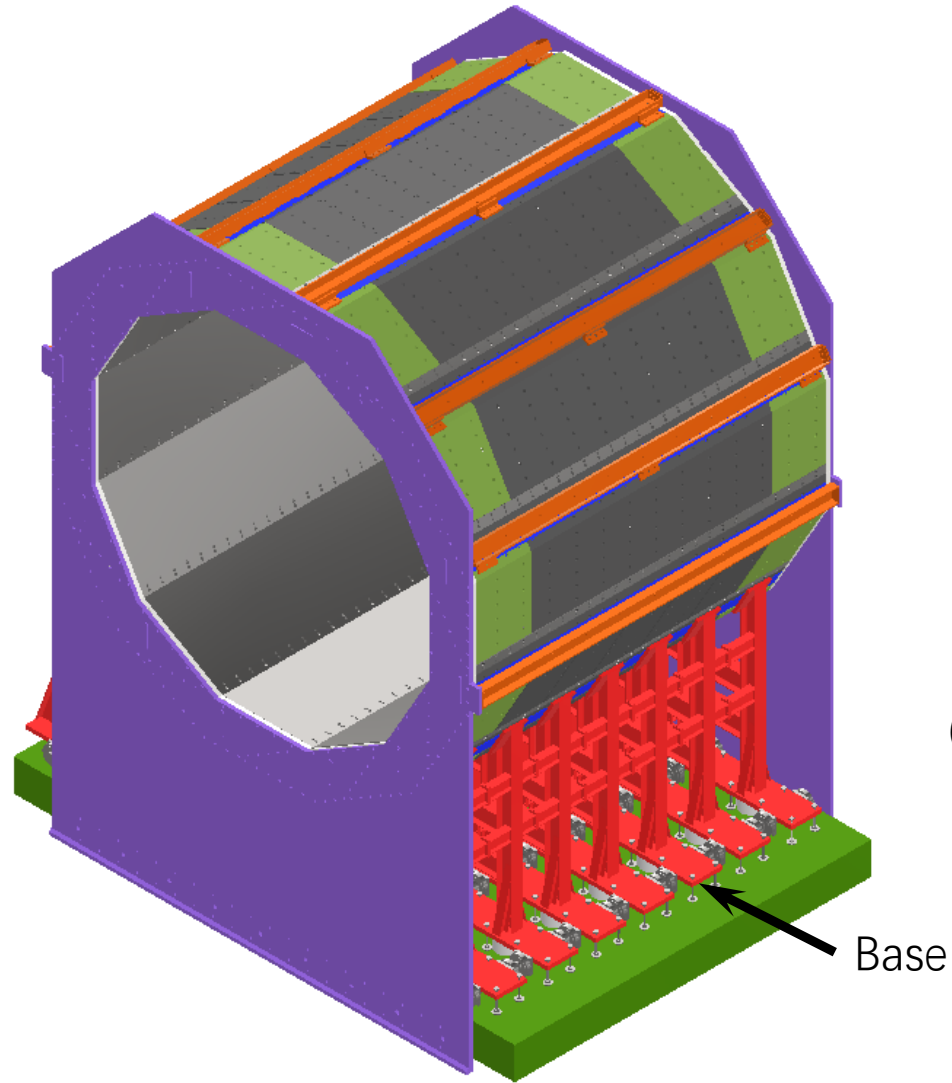
2. Installation and Connection Concept of Sub detectors

Installation sequence:

1. Install the barrel sub-detector first, in the following order:
Yoke, Magnet, HCAL, ECAL, TPC+OTK, ITK, Beampipe(Vertex)
2. Then install the end sub-detector, in the following order:
ECAL+OTK, HACL
3. Then install the ACC component
4. End-Cap Yoke



2. Installation and Connection Concept of Sub detectors



洛矿的工程设计图
(3月8日-6月6日)

Step 1:
Install Yoke iron

Realized the installation design
of zero-assist Tools

(说明: 没有探测器及超导以及电子学等干扰情况下的机械设计)

Total weight :
 $\approx 3900 + 700(\text{base}) \text{ t}$

2. Installation and Connection Concept of Sub detectors

Collaboration with 洛矿 will be the best choice for the High Energy Institute

关于成立 CEPC 项目预研攻关小组的通知

院属各有关单位：

CEPC 项目为中国科学院高能物理研究所研发的环形正负电子对撞机项目，该项目属于科技最前沿的大科学装置。目前项目处于研发阶段，高能物理研究所拟与我公司开展合作研发，该项目的合作能够有效提升公司在高端装备制造领域的影响力，筑牢公司国之重器地位。为确保项目合作研发的顺利推进，经公司批准，决定成立 CEPC 项目预研攻关小组。

一、小组成员

组长：石如星

副组长：周洁

组员：张雁、苗军克、徐侠剑、李利霞、林健、杜宙彬

技术顾问：王智敬

二、工作任务

- 对轱铁的結構进行工艺性优化。通过对轱铁的应用场景和关键指标进行充分分析，结合公司生产制造能力及现场安装条件，通过 CAE 分析等手段，对轱铁的结构进行工艺性优化。牵头完成人：苗军克，完成时间：2024 年 4 月 15 日。
- 制定轱铁的制造及装配工艺方案。根据优化后的轱铁结构制定原材料的供应方案及各零件的制造方案。结合产品的结构特

点和现场安装条件，制定各零件进入试验大厅后的详细装配方案。装配方案需要充分体现零安装工装的设计理念。牵头完成人：张

日。

术方案，形成轱铁制造技术预研汇报交流。牵头完成人：徐侠剑，完

工作进行总结，由徐侠剑汇总形

专题会议，对阶段性工作进行总结，

且所有成员共同完成，所有项目组

牵头完成人开展工作。

项目节点工作完成情况进行监督

矿研院

2024 年 3 月 11 日

3月8日，纪全夏商
去洛矿交流，谈合作

定期召开例会

3月11日，成立
CEPC项目预研
攻关小组

CEPC 项目预研攻关工作例会会议纪要

2024 年 04 月 19 日，CEPC 项目预研攻关小组召开了项目预研

CEPC 项目预研攻关工作例会会议纪要

2024 年 3 月 29 日，CEPC 项目预研攻关小组召开了项目预研进展工作例会。纪要如下：

一、已开展工作汇报

- 根据高能物理研究所提供的资料完成了轱筒及其支座的初步三维结构设计。
- 完成了轱筒螺旋段内部结构及连接方式的初步设计。
- 开展了本项目所需 10#钢板的初步询价工作，目前已与舞钢进行了沟通，舞钢目前不具备轧制本项目所需最大规格的能力，其他厂家尚未回复。

二、会议讨论事项

- 会议对现有三维结构进行了分析讨论，目前的结构不利于后续轱筒螺旋段的组装，建议将整体高度方向隔板改为层间隔板，层间隔板与层板利用螺栓连接，增加强度。
- 为保证轱筒螺旋段组装后的精度，各段配合部位外形尺寸需要进行加工，加工面上的螺栓采用沉头螺栓结构。
- 考虑到装配过程中的定位要求，轱筒螺旋段配合部位需增加定位止口。
- 为保证轱筒螺旋段的整体刚性和安装需求，轱筒螺旋段两端面保留堵板结构。

三、近期工作计划

立及零件毛

分析在自重

径向增长

月牙形工装

态。

单元与底部支

块、螺栓连接

制定位槽加工

孔，层板加工

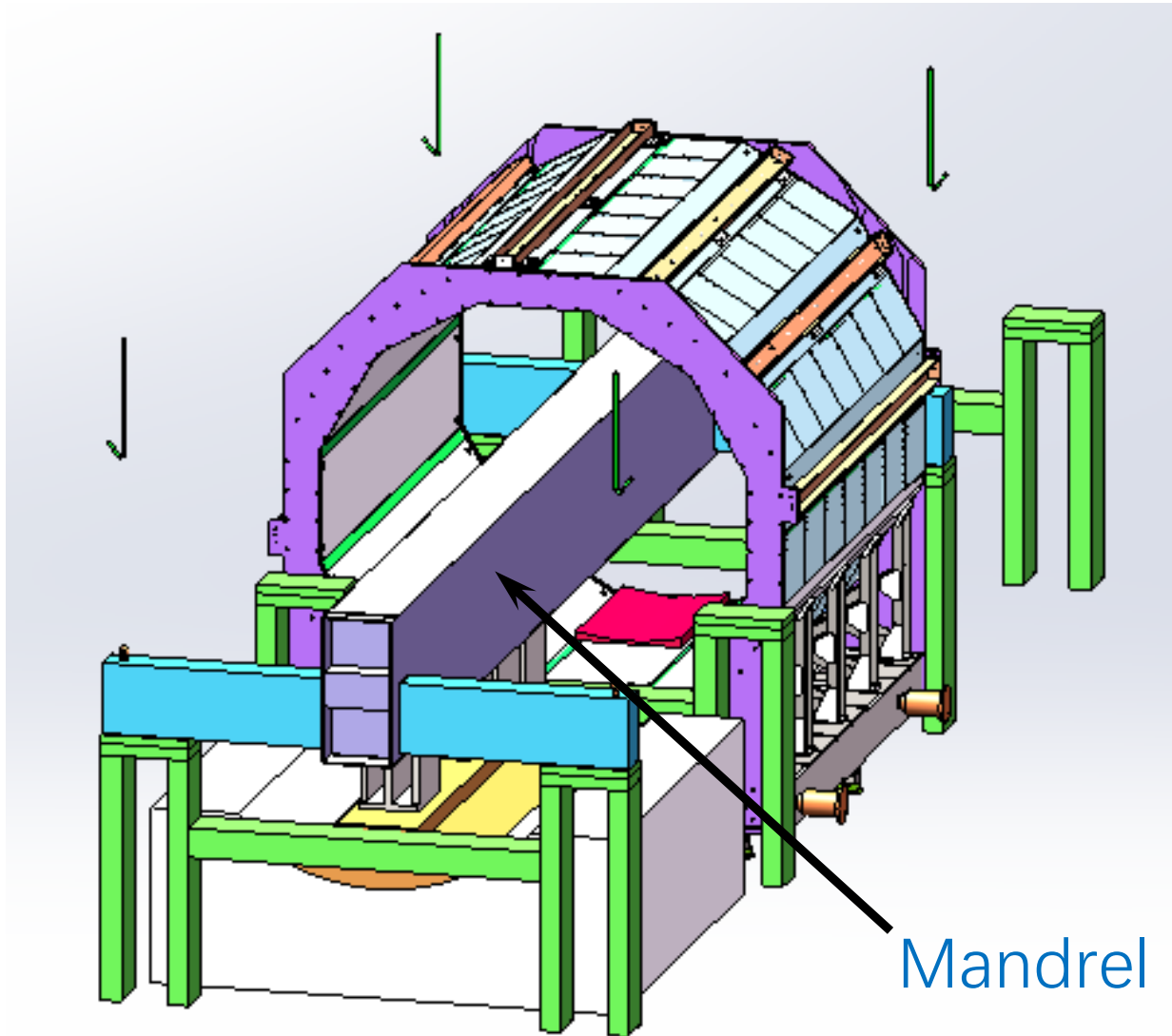
工。

干涉，建议将

方便安装。

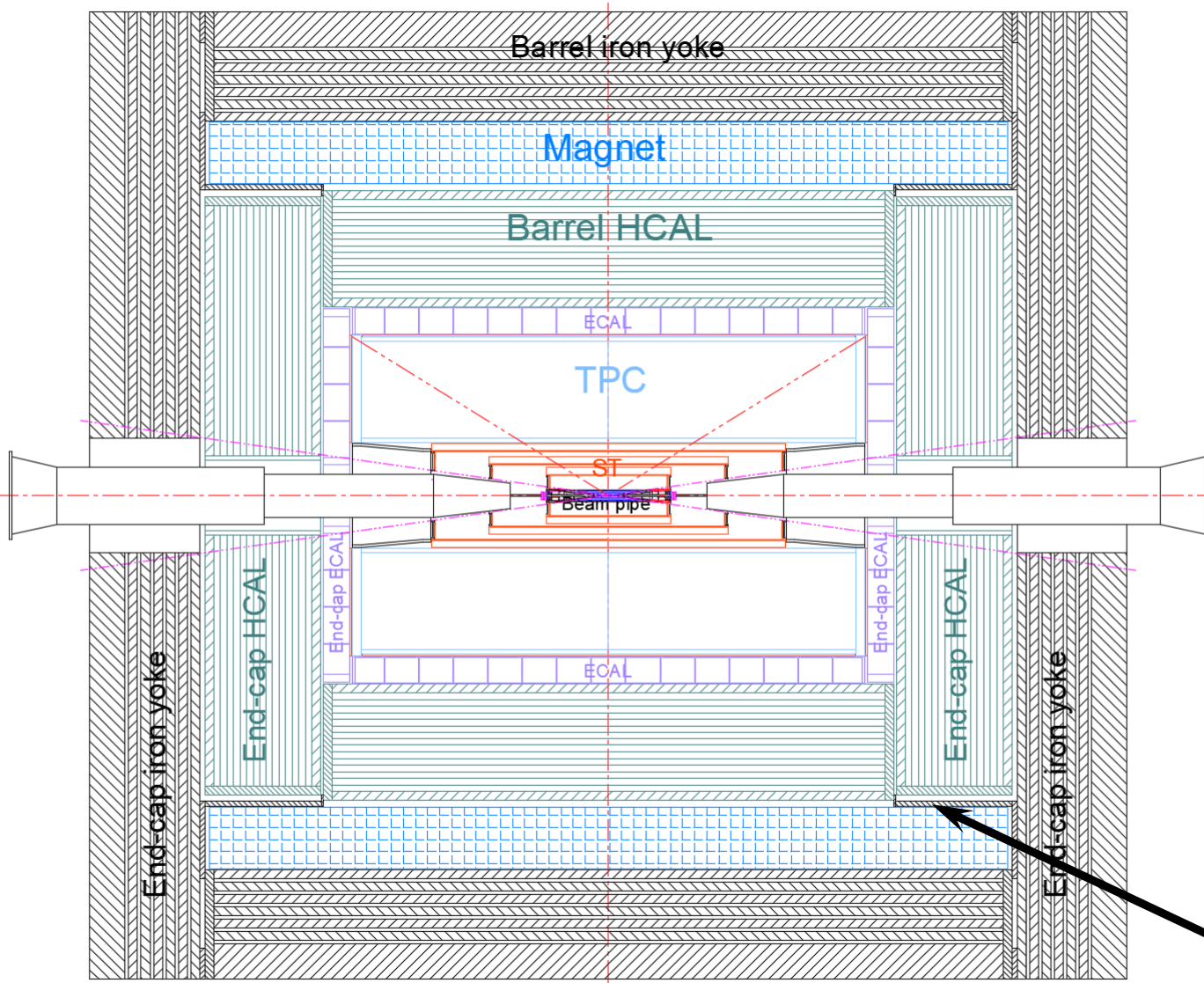
以在轱筒两端

2. Installation and Connection Concept of Sub detectors



Installation:
Mandrel method

2. Installation and Connection Concept of Sub detectors

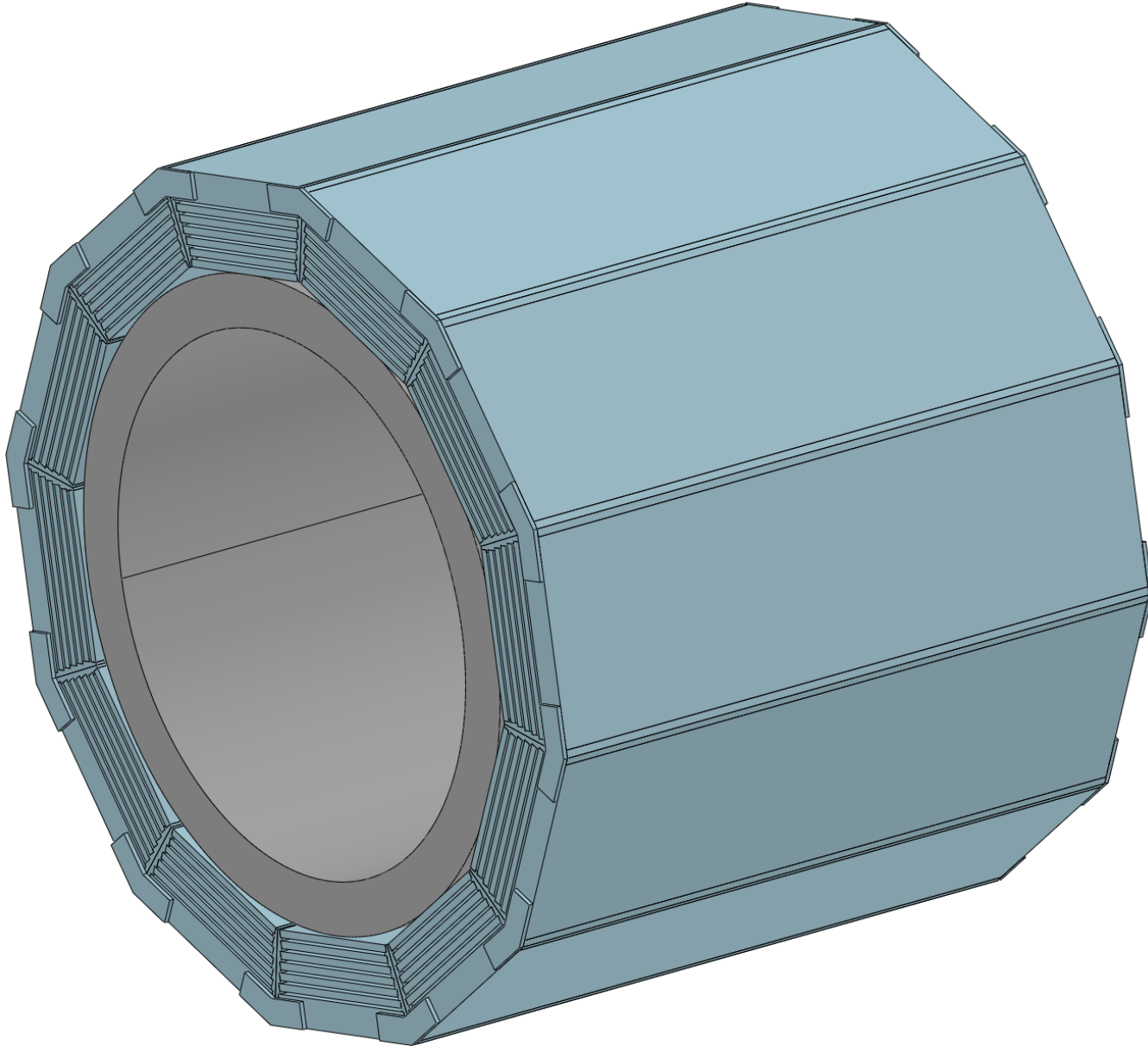


Connection design: Principle of proximity

- Barrel Yoke : Fixed on the base
- Magnet : Fixed on the Barrel Yoke
- Barrel HCAL : Fixed on the Barrel Yoke
- Barrel ECAL : Fixed on the Barrel HCAL
- TPC+OTK : Fixed on the Barrel ECAL
- ITK(ST) : Fixed on the TPC
- Beampipe(Vertex) : Fixed on the ITK
- End-cap ECAL+OTK : Fixed on the Barrel HCAL
- End-cap HCAL : Fixed on the Barrel HCAL
(Auxiliary cylinder)

Auxiliary cylinder

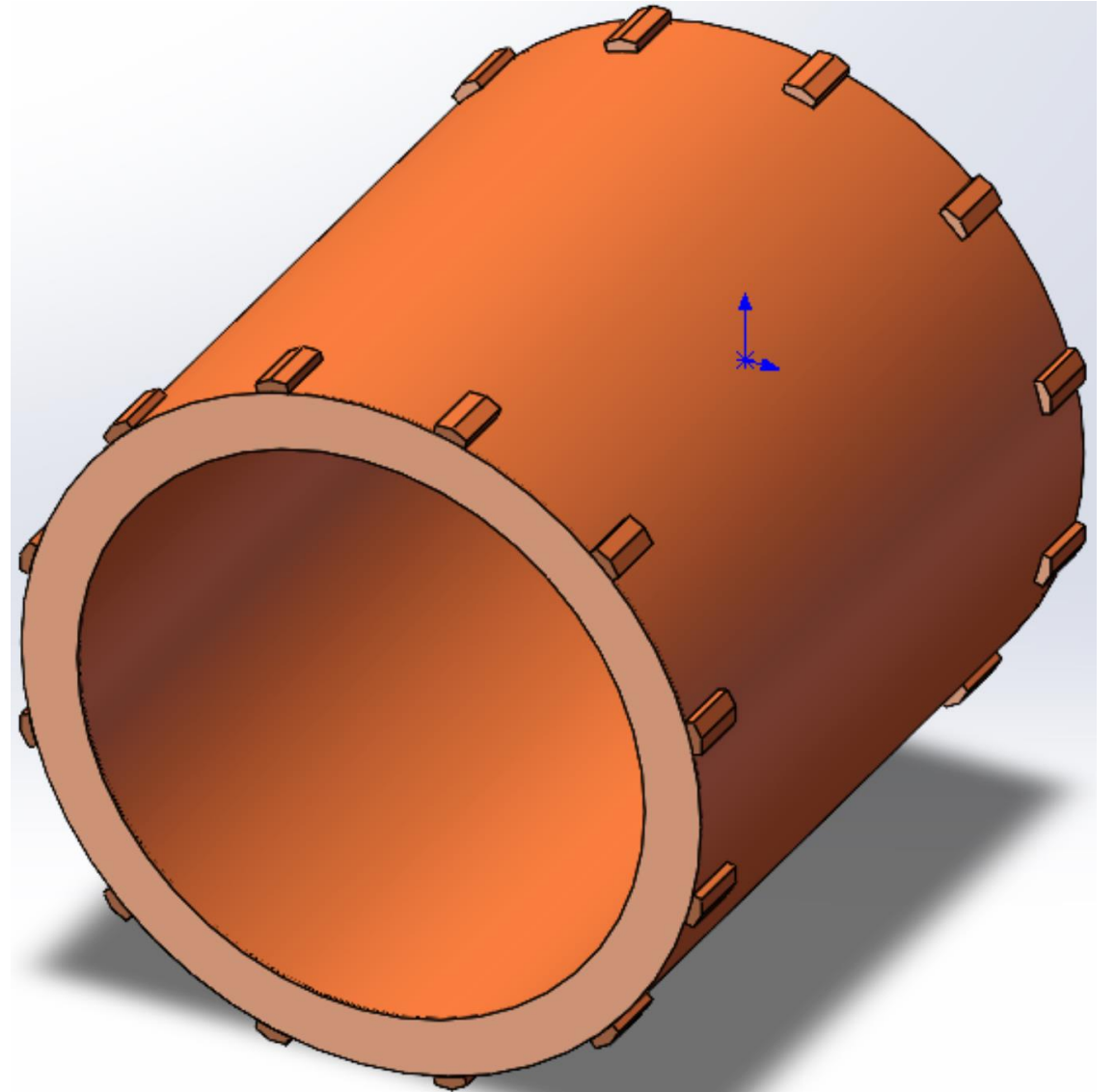
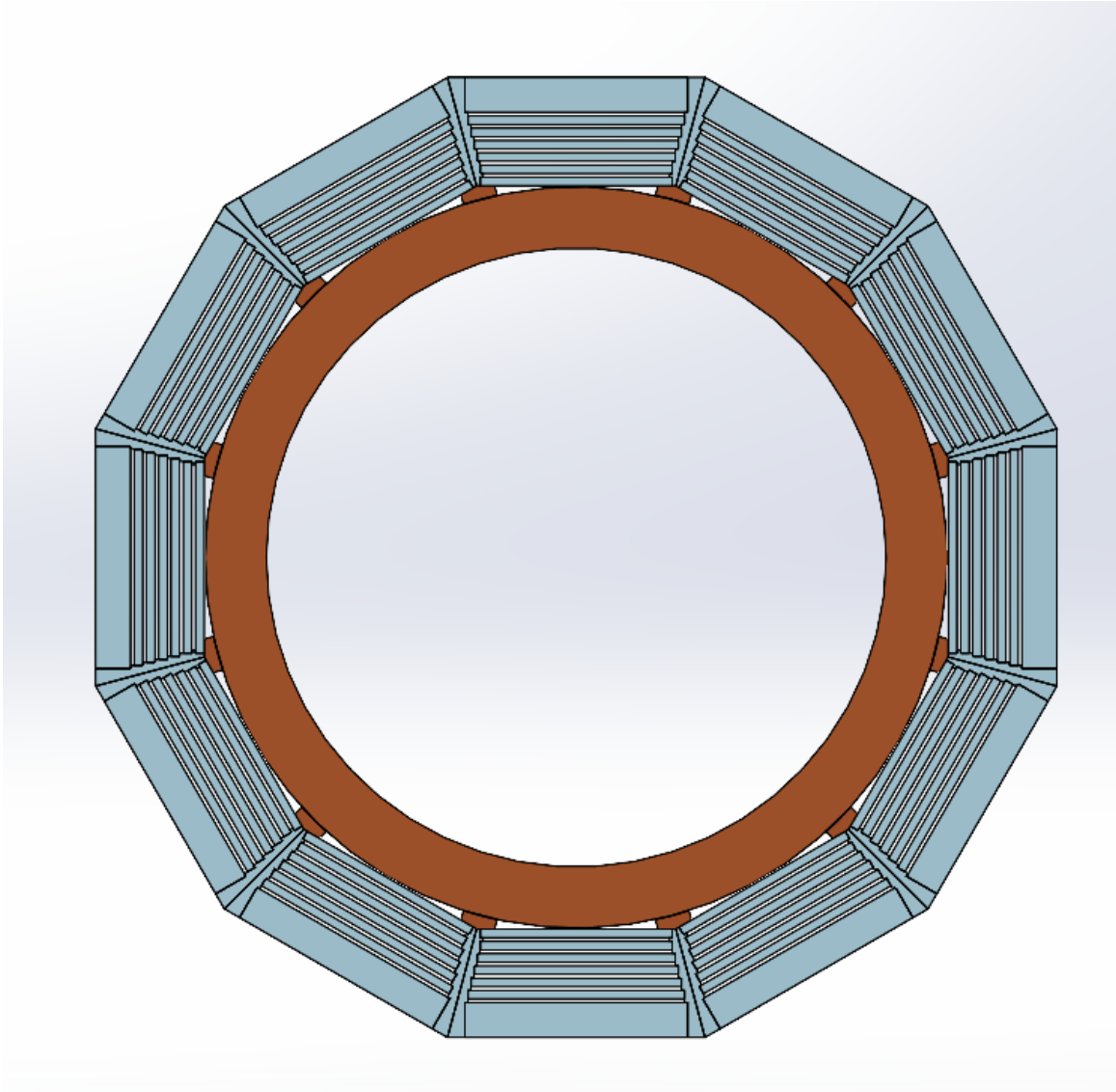
Step 2: Installation and connection of magnet



Connection:
Fixed on the Yoke

Weight :
 ≈ 265 t

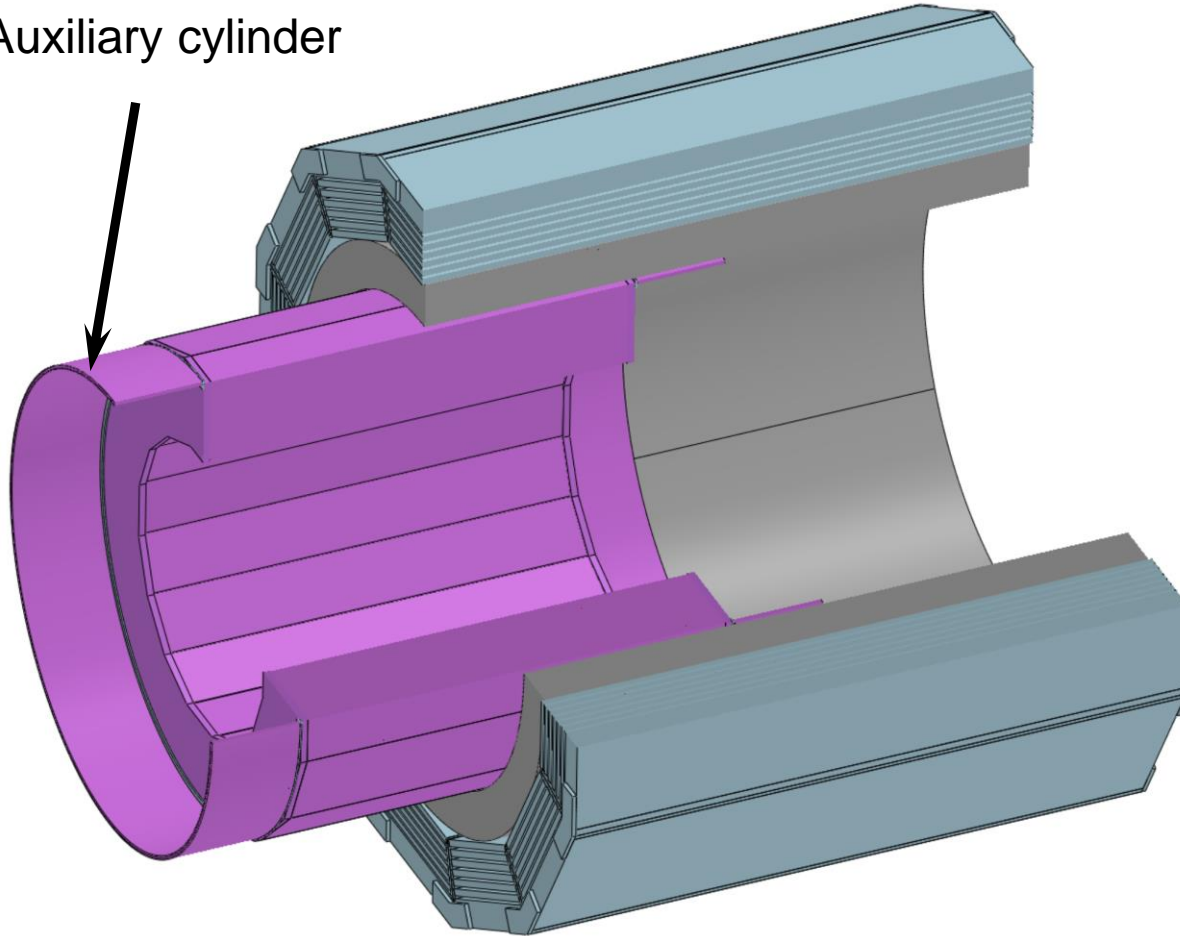
Connection of the magnet: (裴亚田)



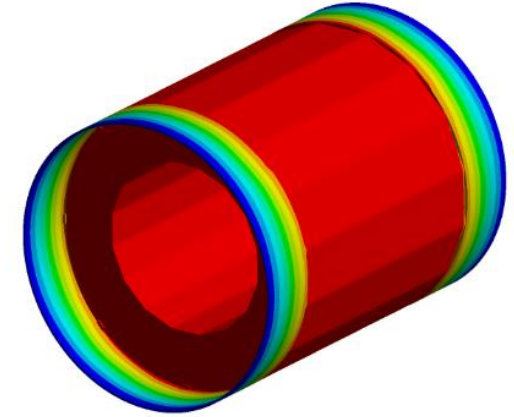
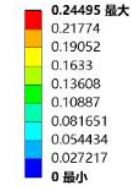
Step 3: Installation and connection of Barrel HCAL

Install the Barrel HCAL :

Auxiliary cylinder



A: Static Structural
Total Deformation
类型: 总变形
单位: mm
时间: 1
2024/4/29 16:15



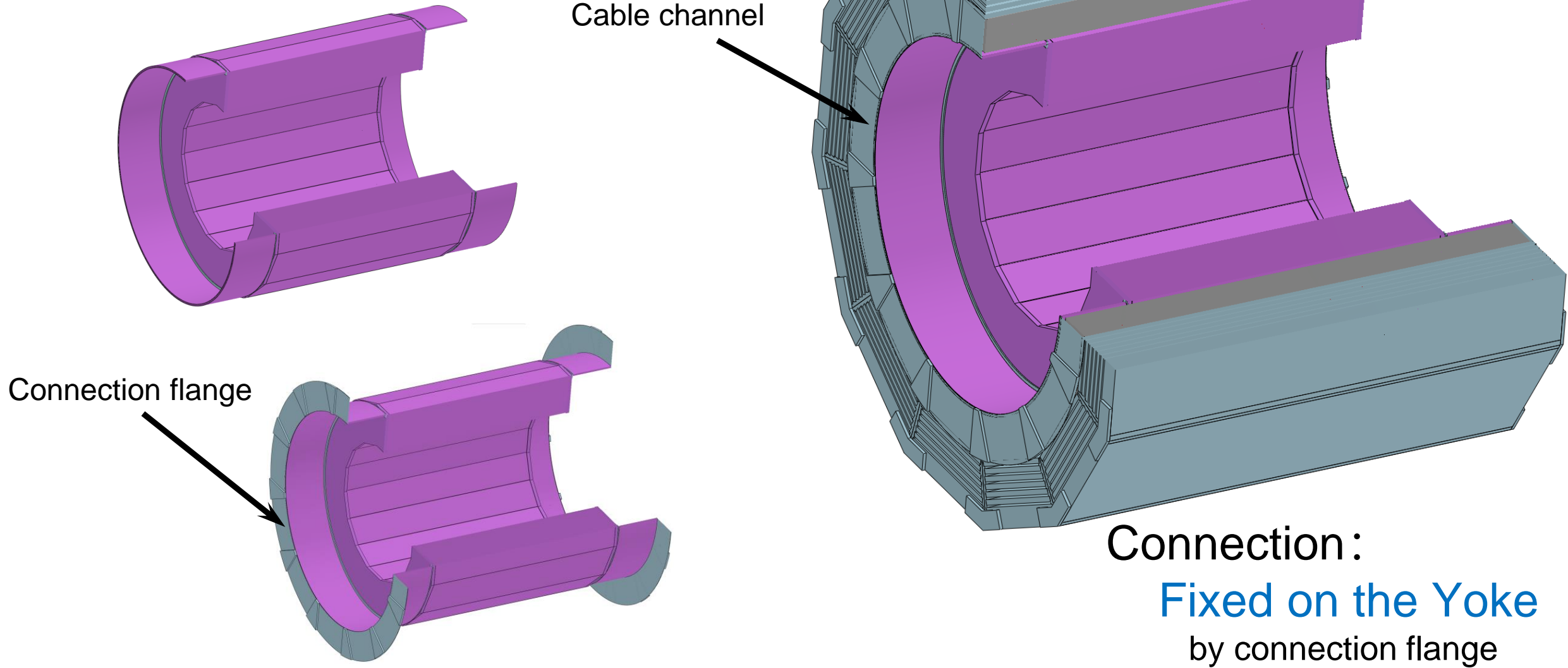
Thickness of cylinder:
60 mm

Max deformation:
~ 0.25

Weight :
≈ 1000 t

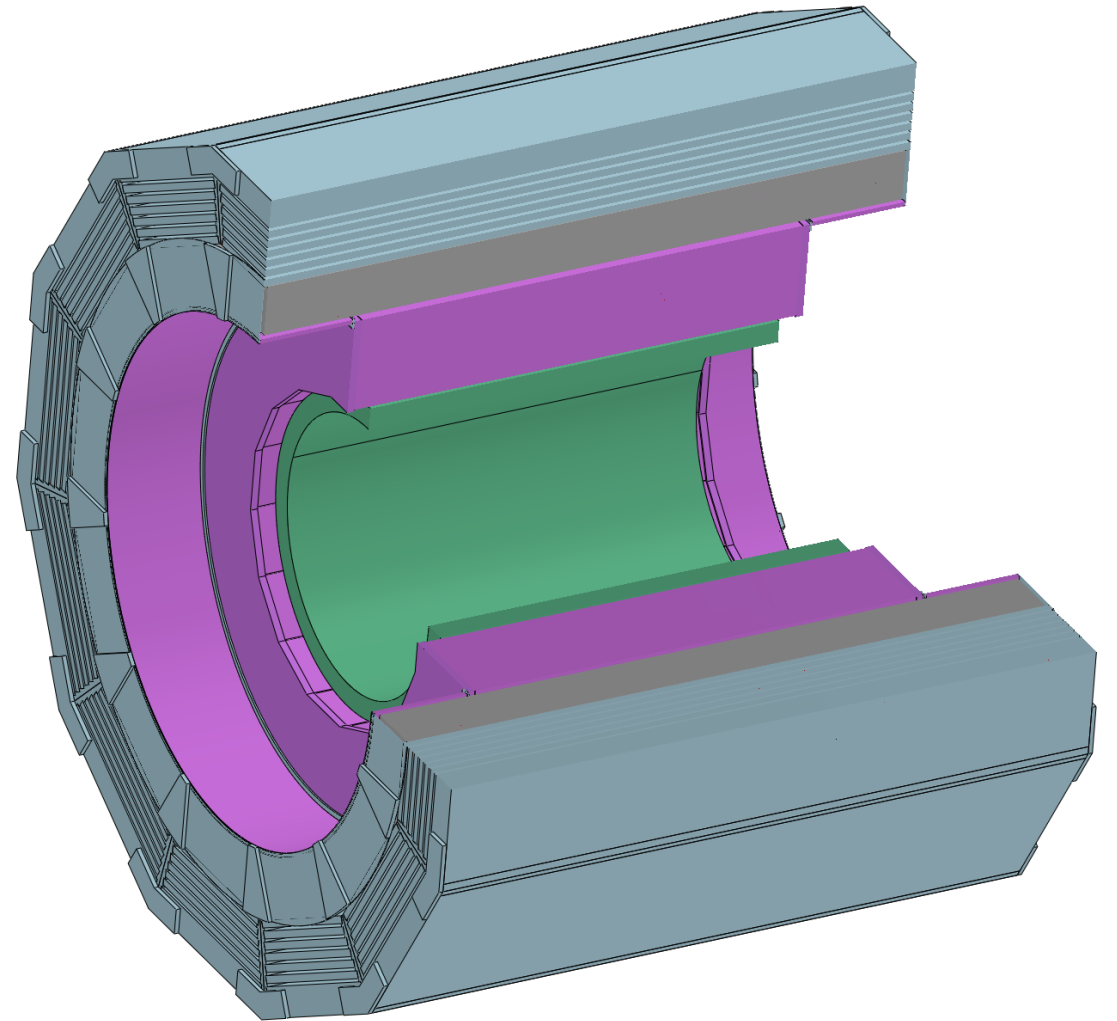
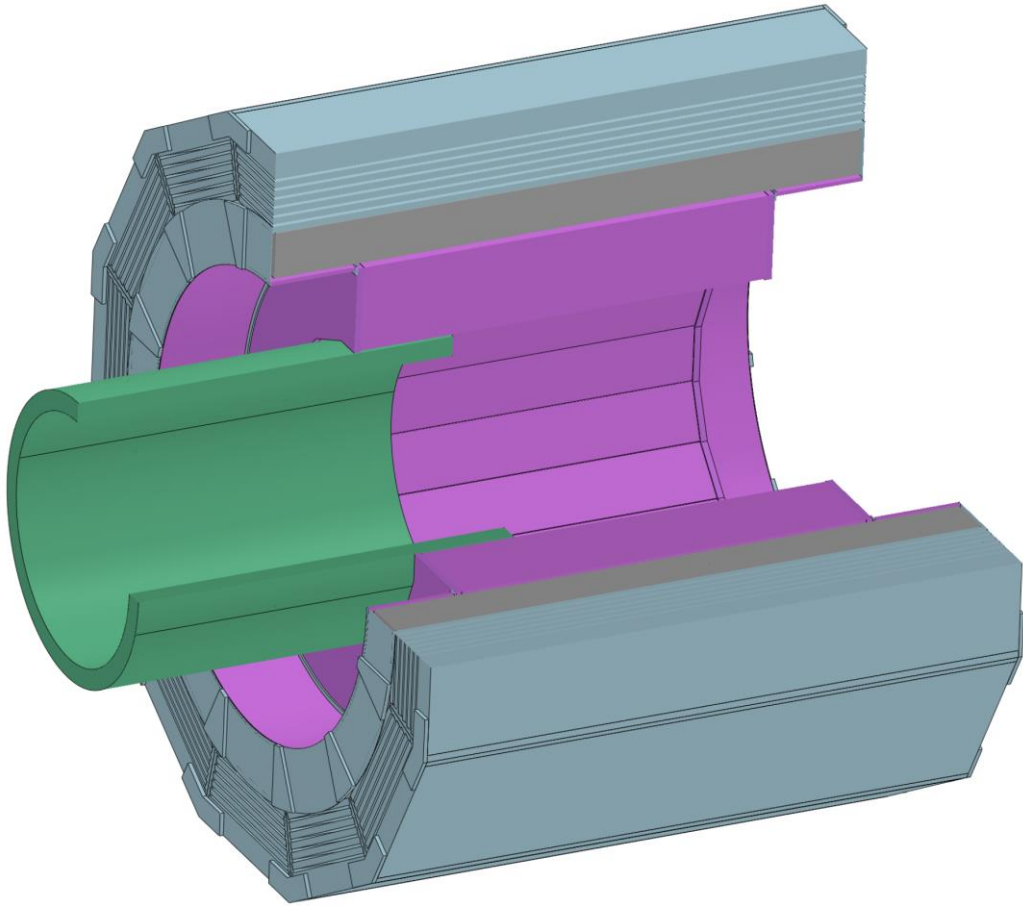
Step 3: Installation and connection of Barrel HCAL

Connection of the barrel HCAL:



Step 4: Installation and connection of Barrel ECAL

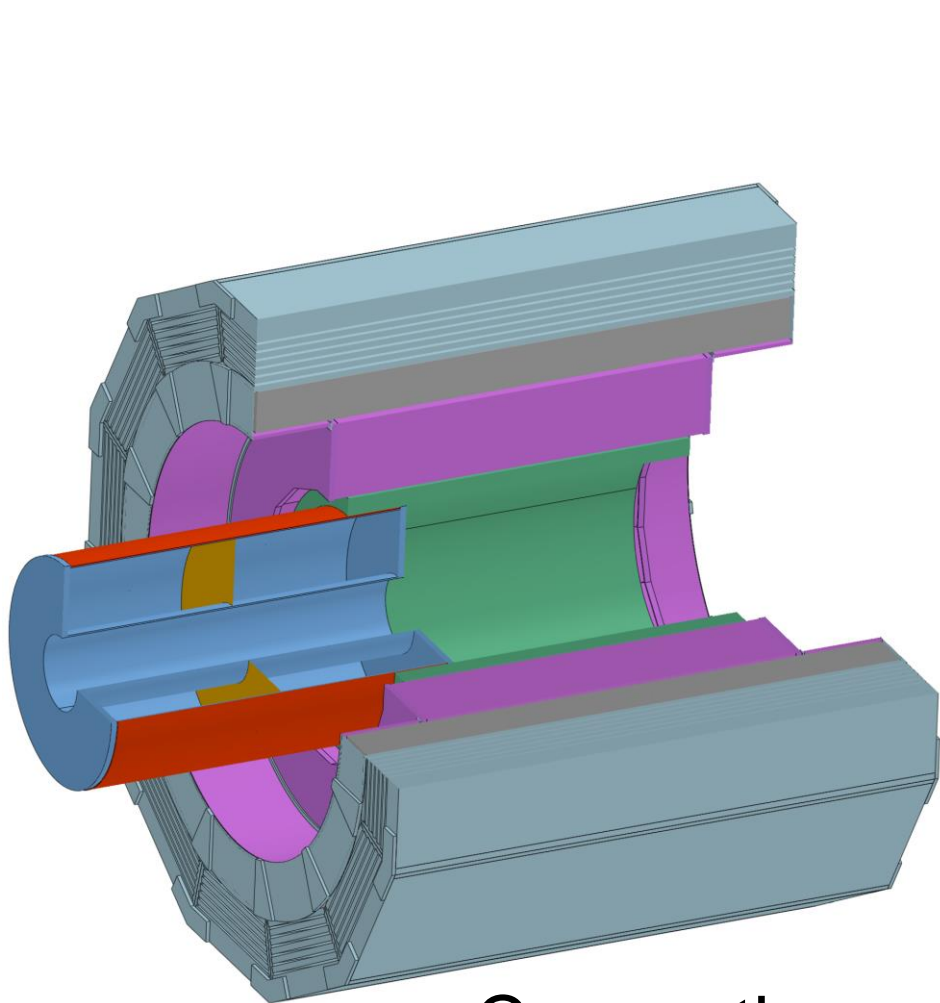
Install the Barrel ECAL :



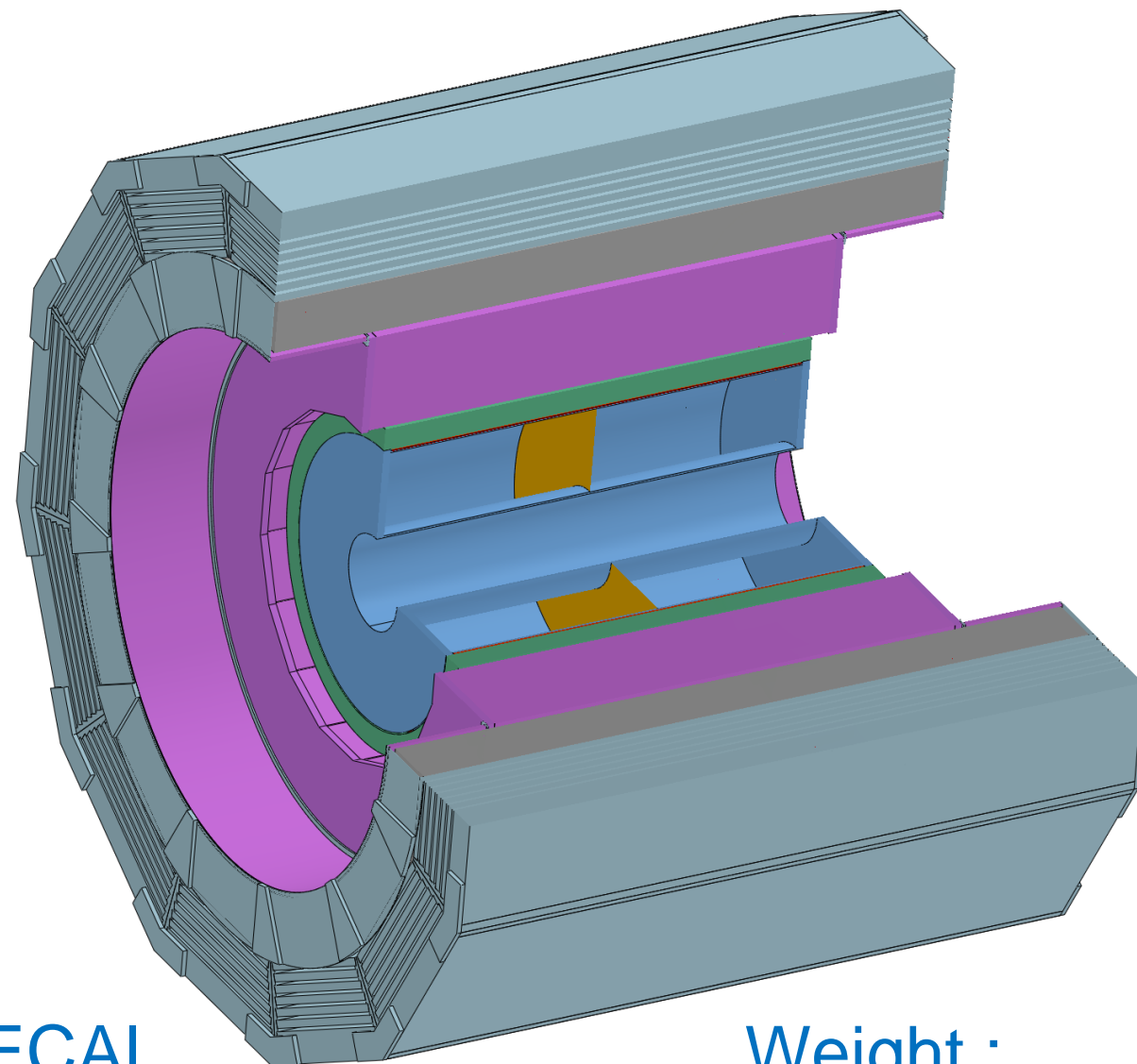
Connection:

Fixed on the Barrel HCAL

Step 5: Installation and connection of TPC(OTK)

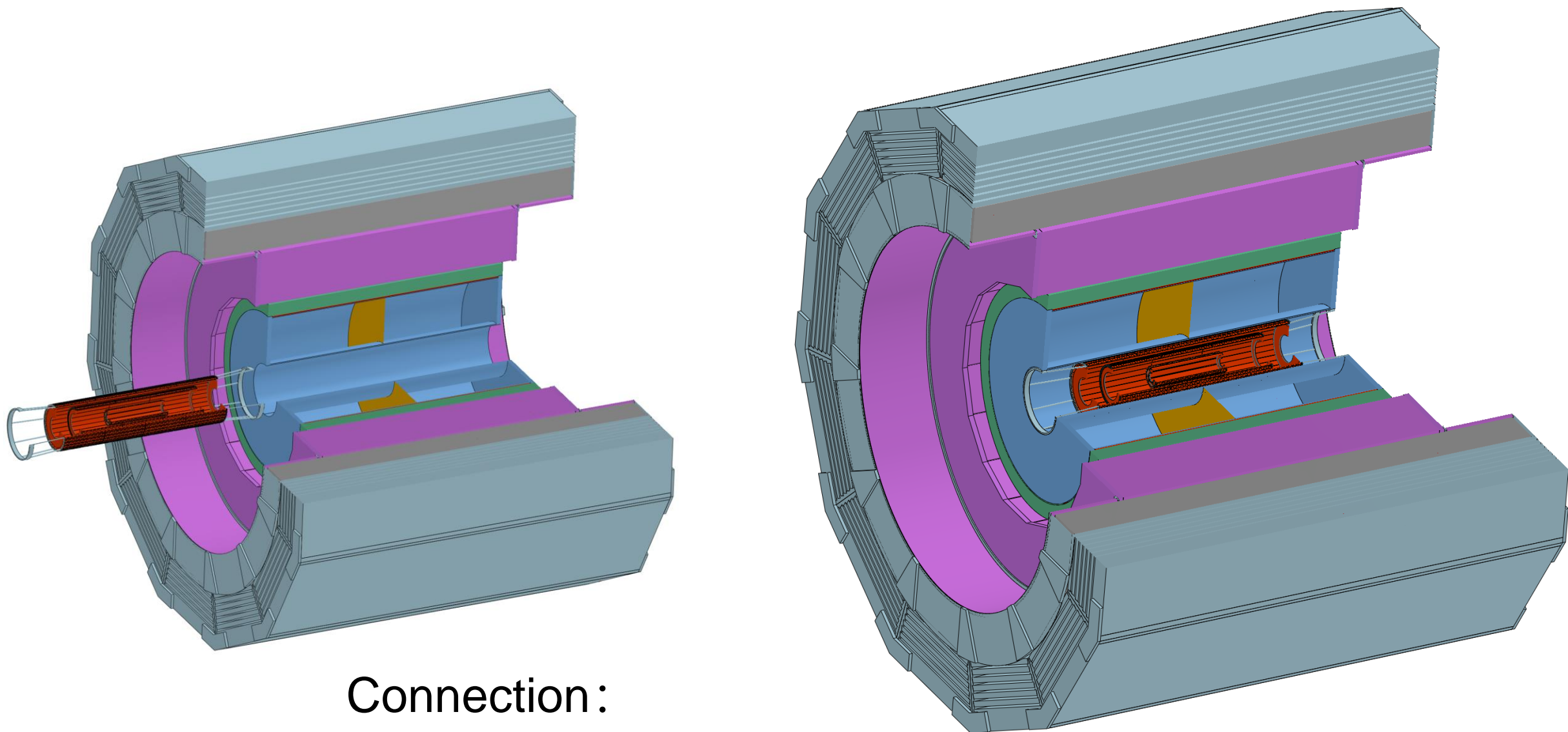


Connection:
Fixed on the Barrel ECAL



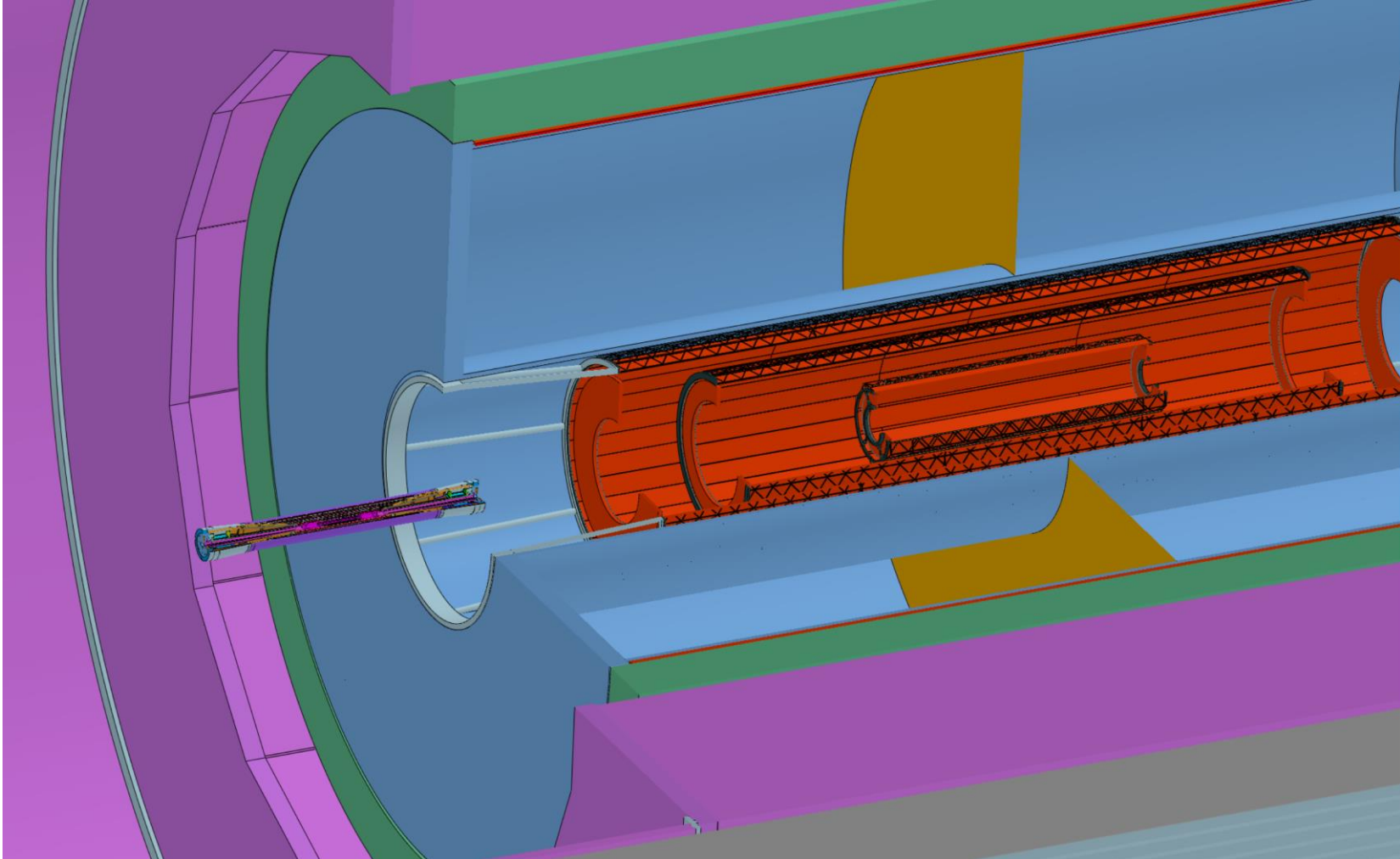
Weight :
 ≈ 1.2 t

Step 6: Installation and connection of ITK



Connection:
Fixed on the TPC

Step 7: Installation and connection of Beampipe(Vertex)

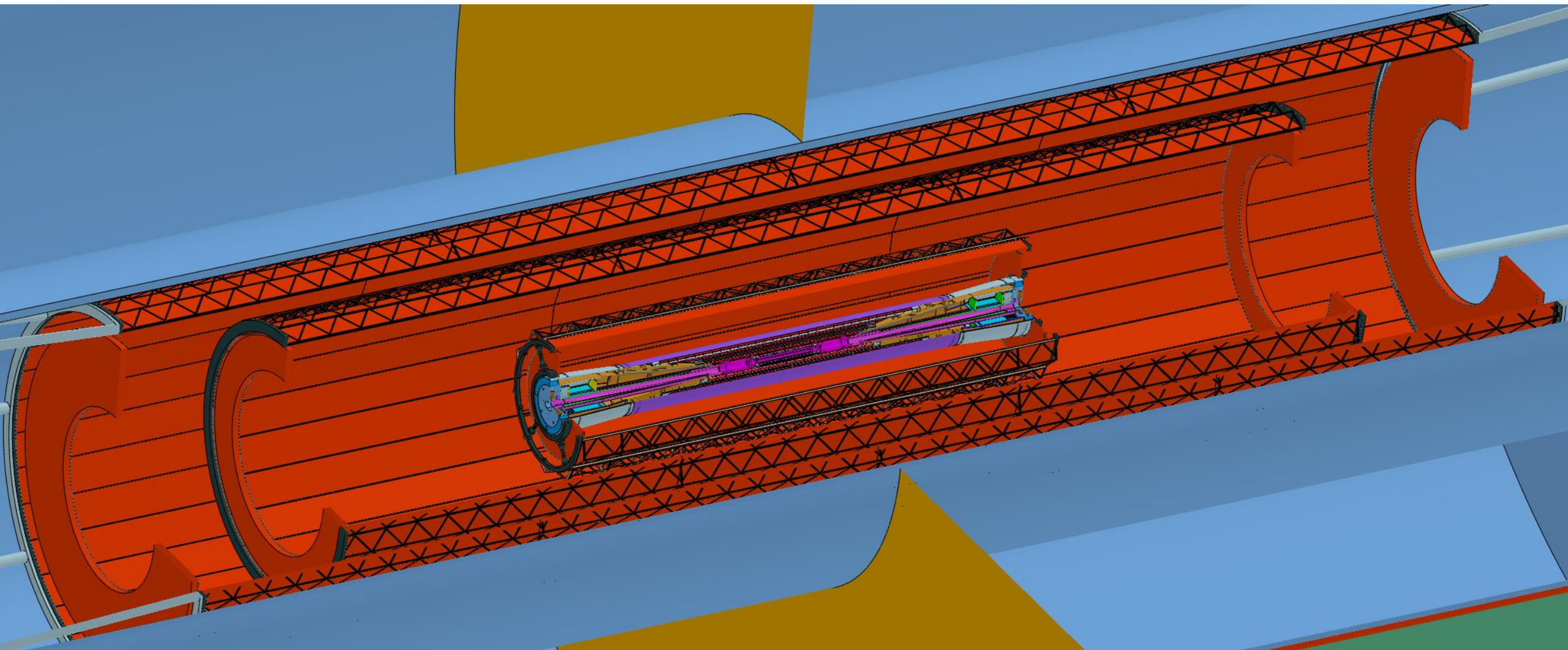


Connection:
Fixed on the ITK

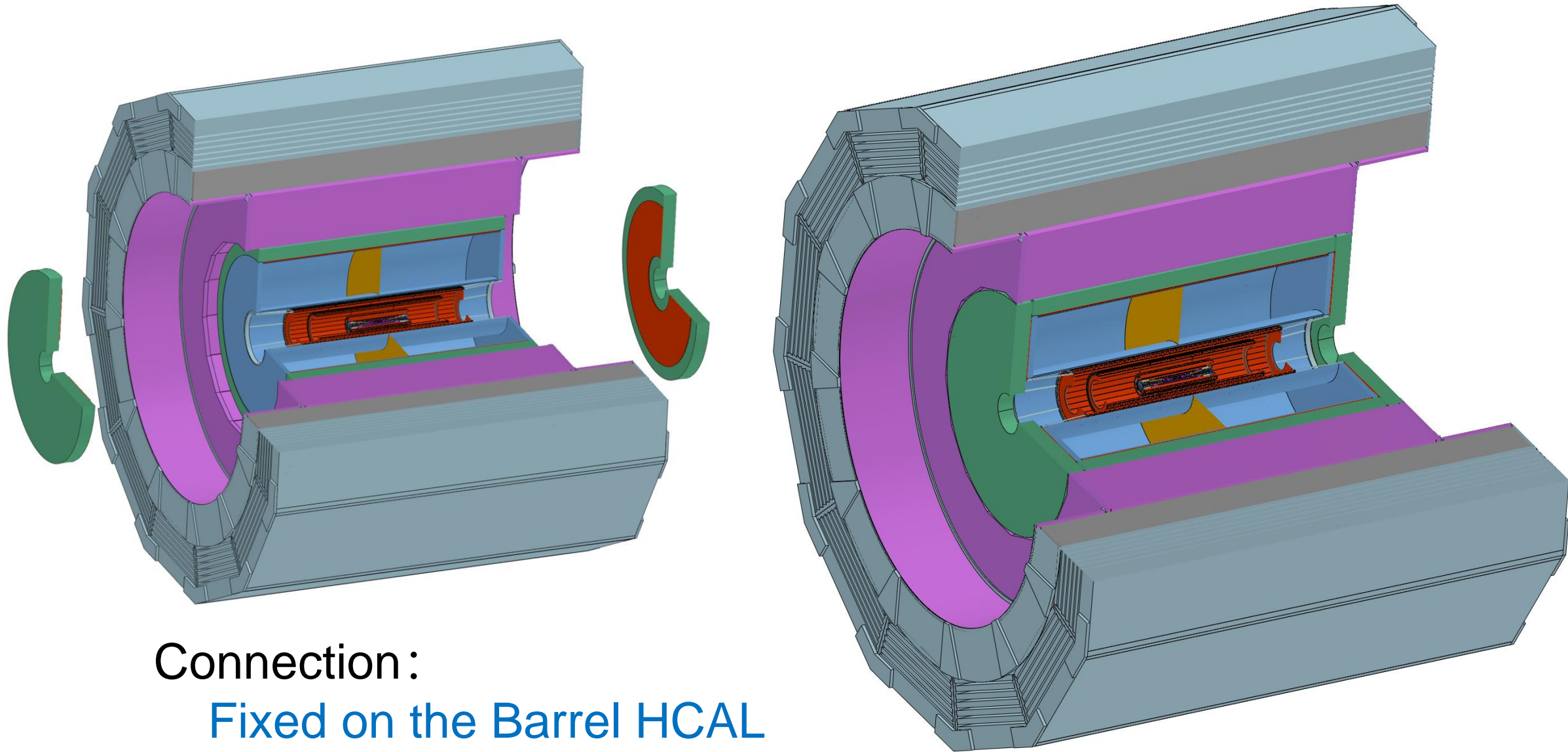
Weight :
 ≈ 10 kg

Step 7: Installation and connection of Beampipe(Vertex)

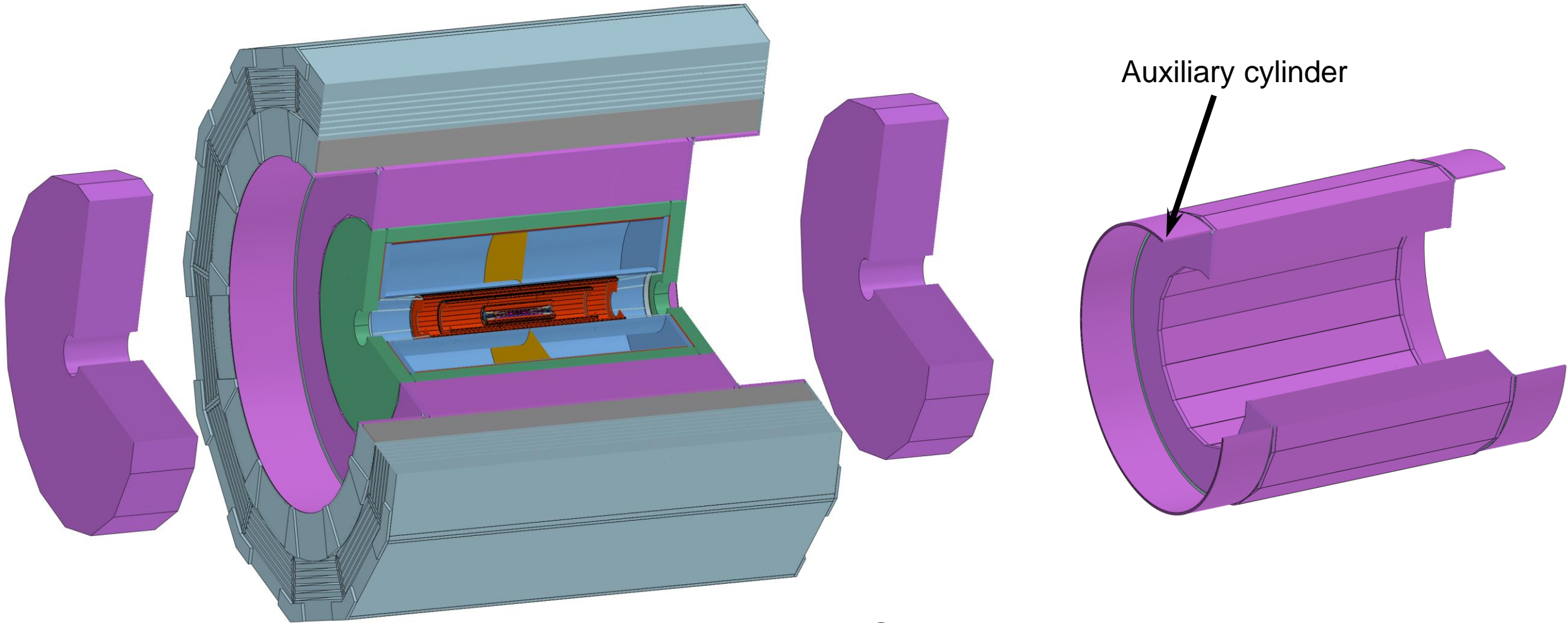
2023年7月, ST的安装模拟图:



Step 8: Installation and connection of End ECAL(OTK)



Step 9: Installation and connection of End HCAL



Weight :
 $\approx 380 \times 2$ t

Connection:
Fixed on the auxiliary cylinder

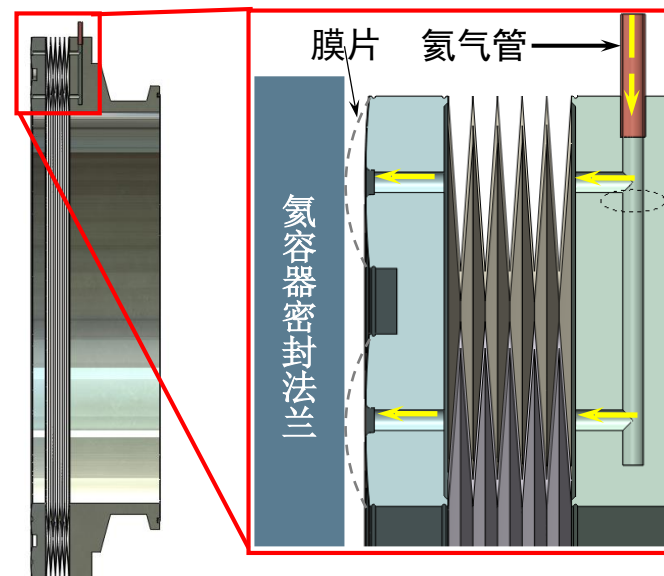
Step 10 : Installation and connection of ACC Component

ACC Component 与 Beampipe 的连接:

Pillow Seal

Pillow Seal密封原理:

表面粗糙度高的金属膜片与刚性金属面在一定气压预应力作用下紧密贴合, 实现密封功能, 如下图所示。



优点:

- ⊙ 实现远程密封
- ⊙ 对配合面的平行度和相对距离要求低

3. Summary

- 1) 大部分分子探测器机械设计停滞在初始阶段
- 2) 探测器、电子学和机械等硬件三方需要加强沟通
- 3) 抓大放小，求大同存小异，尽快给机械工程师明确任务和设计要求等

现状:

机械总图仍处在**第0版**阶段，远没有达到多方自治的程度！

Thanks