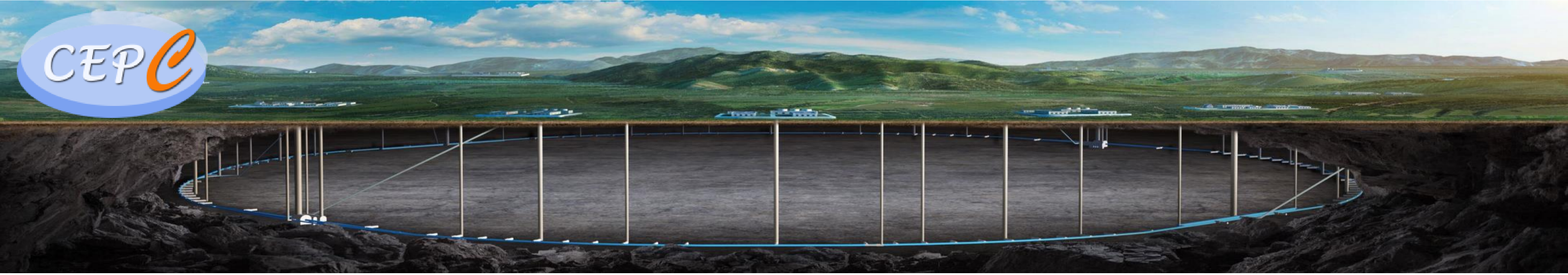


Overall design and installation of the CEPC detector machinery

Ji Quan

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

Aug. 7th, 2024, CEPC Detector Ref-TDR Review

Content

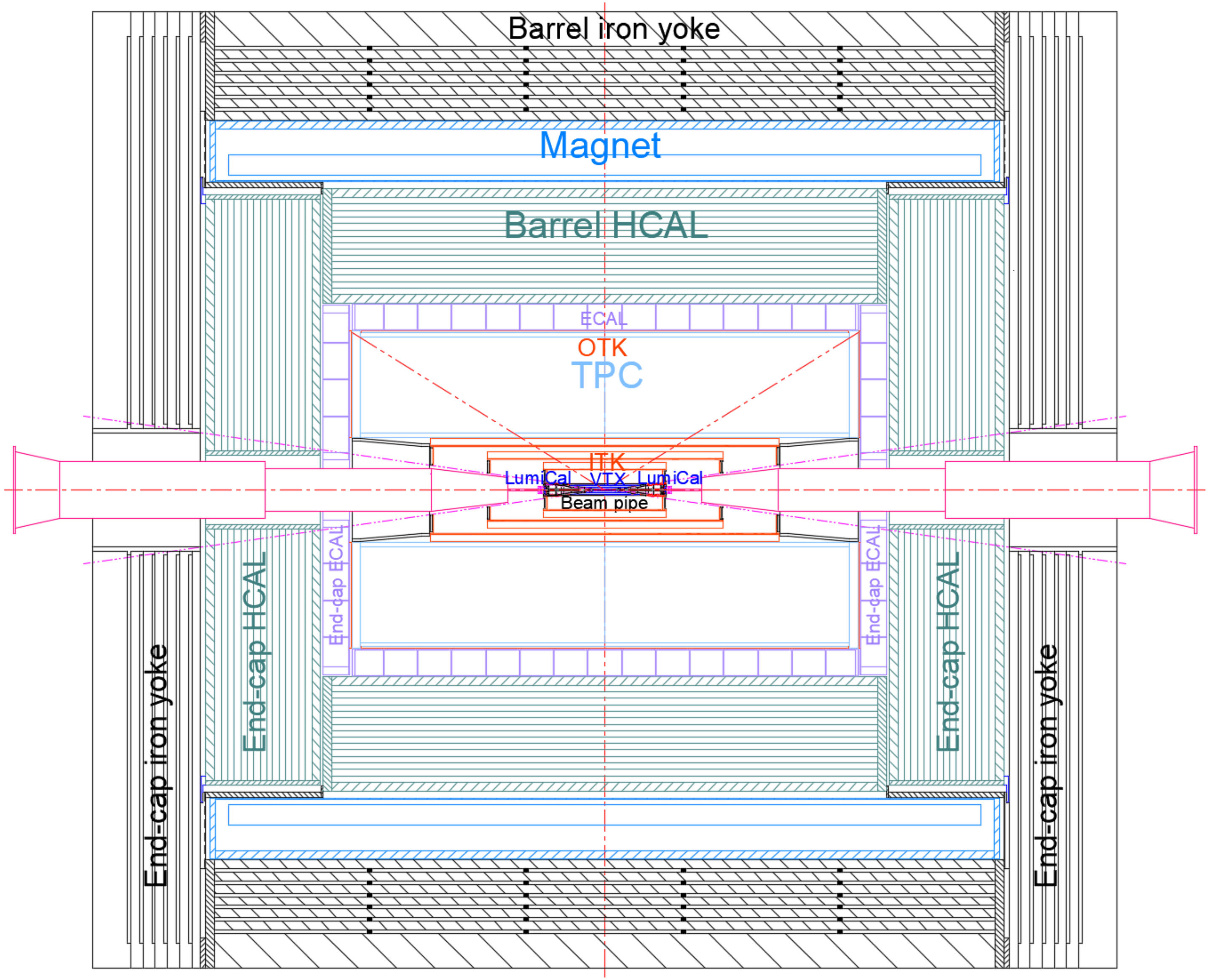
- Introduction
- Requirements
- **Technical challenges**
- **Overall progress of the installation design**
- Research team
- Summary and working plan

Introduction

Overall layout

ACC MDI Component

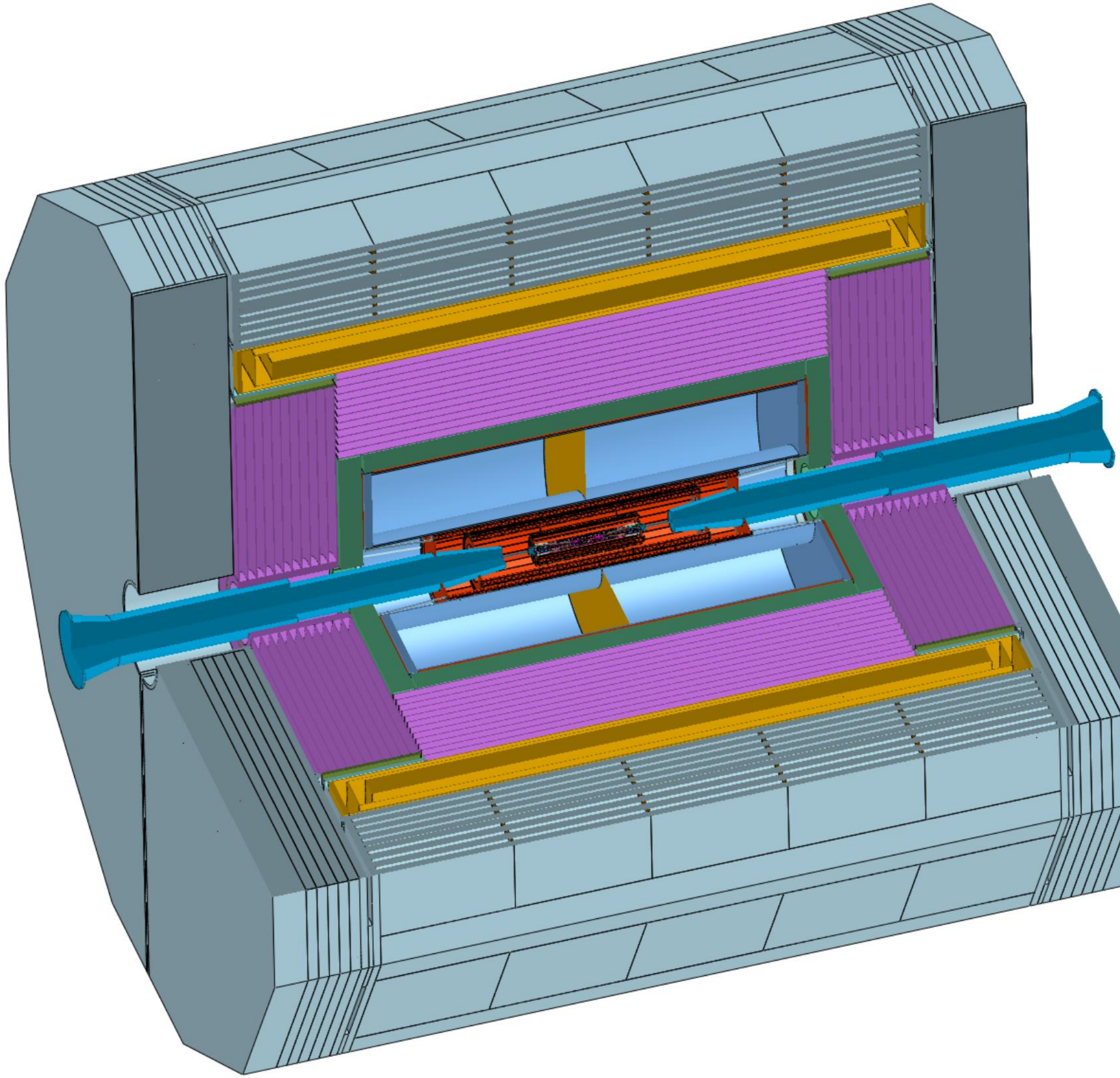
Others are detector components



Introduction

Total weight :

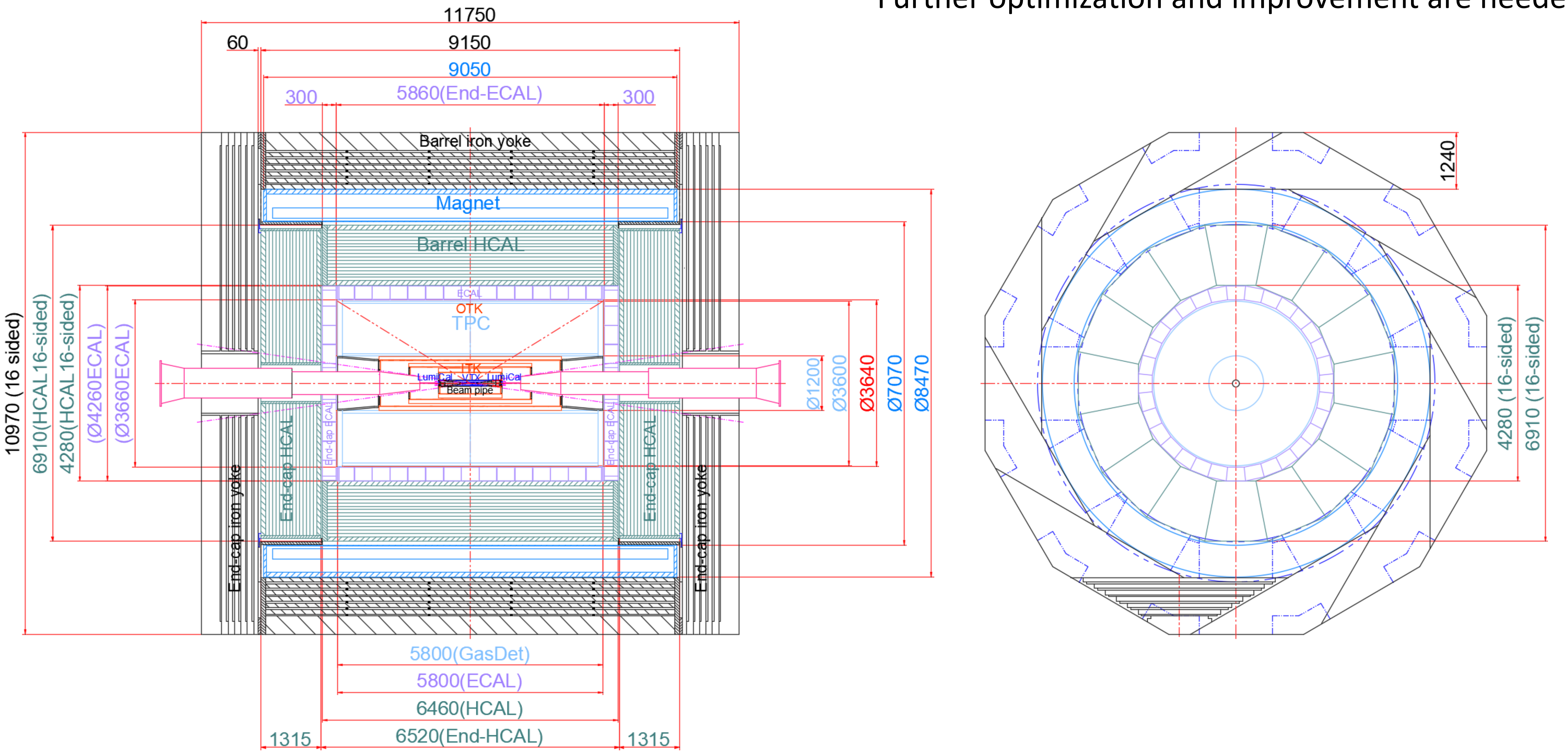
≈ 6000 t



Introduction

Size distribution

Further optimization and improvement are needed



Introduction

MDI boundary

Consists of 4 segments channels

Detection angle :   8.1 ° (arccos0.99)

(Before ECAL)

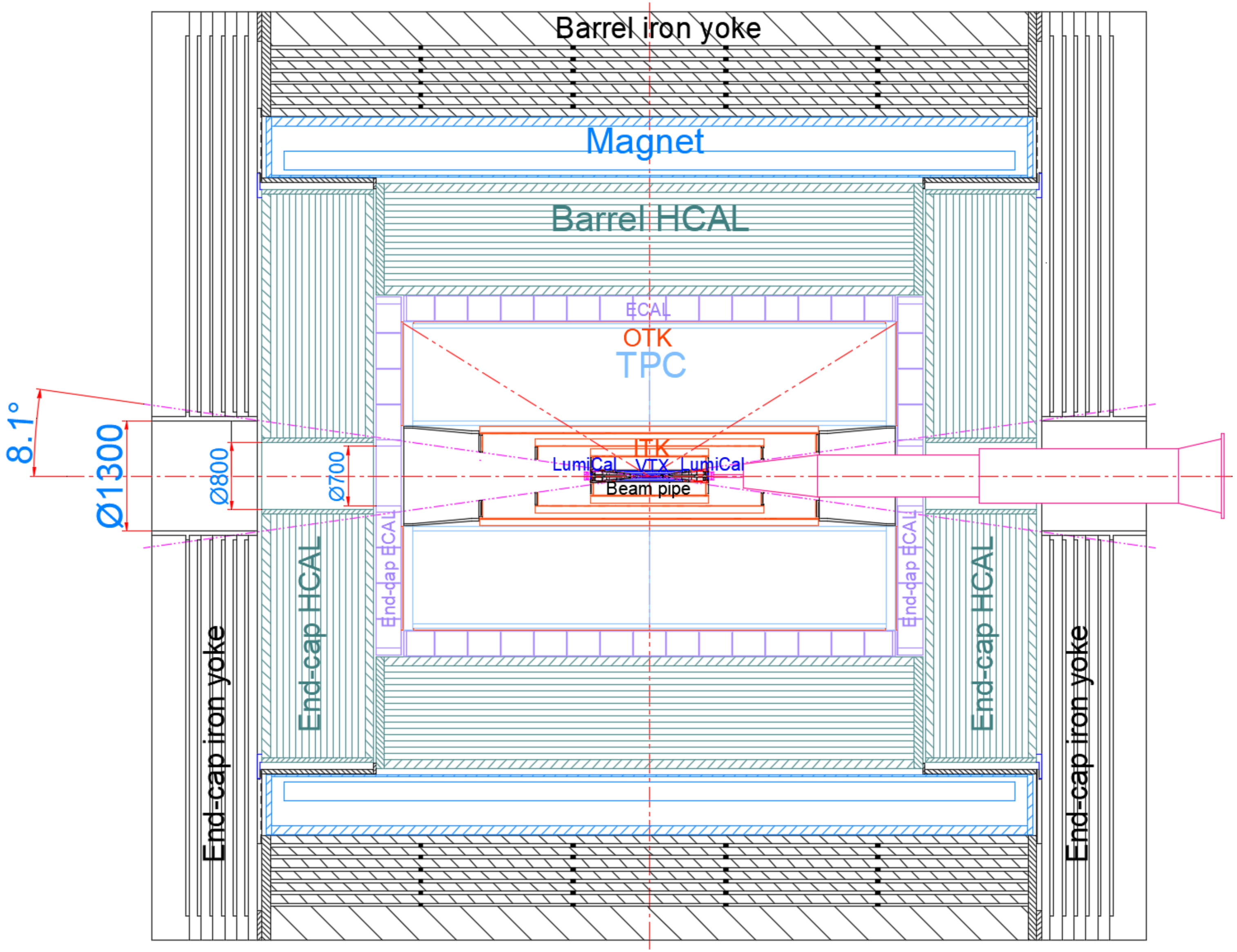
(After ECAL)

ECAL :   Ø700 mm

HCAL : Ø800 mm

Yoke :   Ø1300 mm

Conical and stepped holes are reserved spaces for accelerators



Requirements

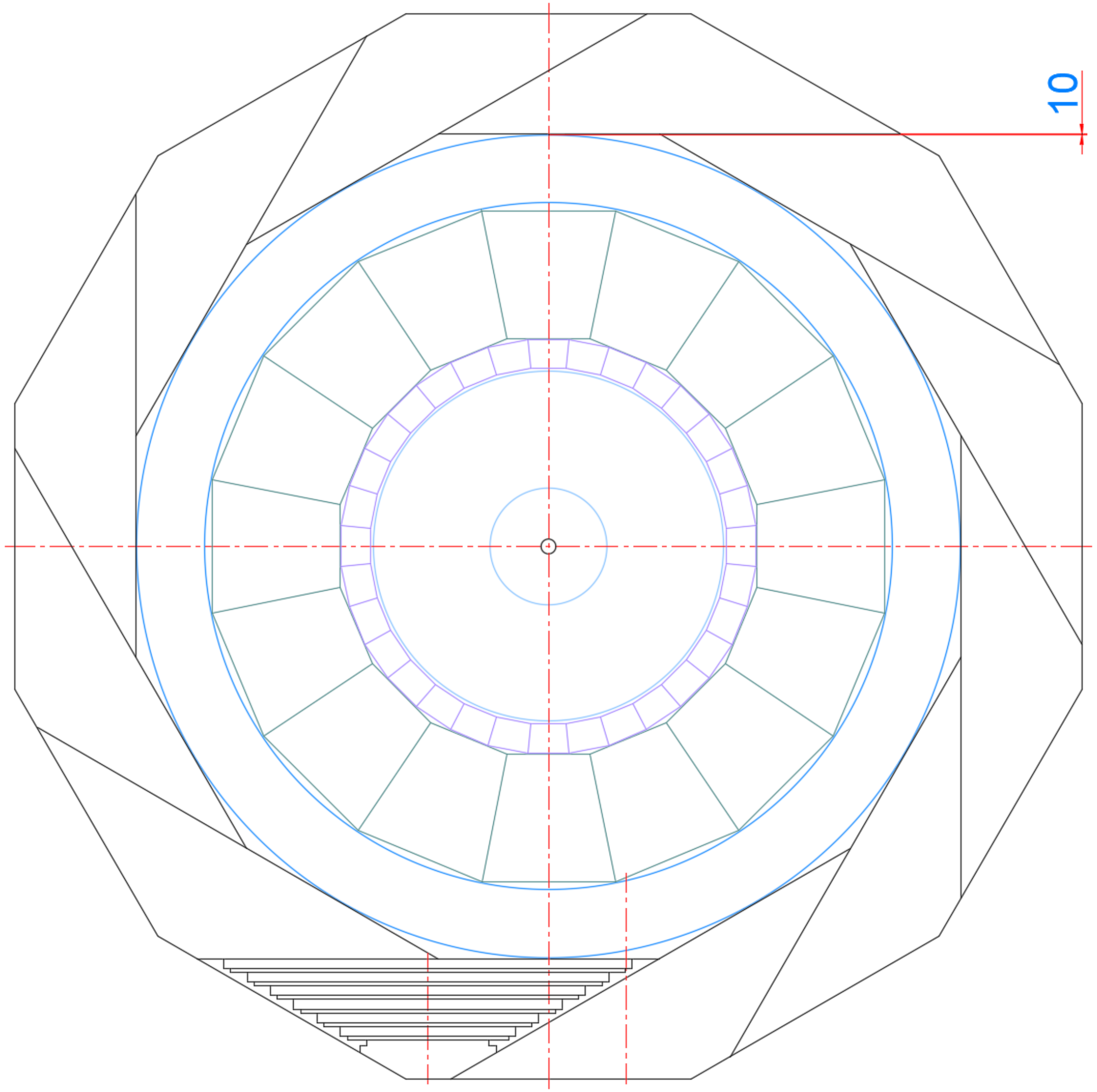
Minimum gap principle :

As small as possible

Gap between sub detectors :

Installation gap : ≤ 10mm

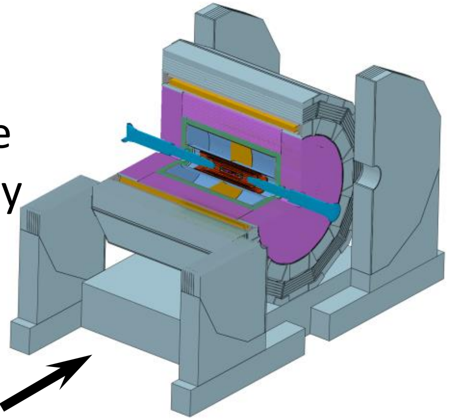
Note: Initial design parameters



Requirements

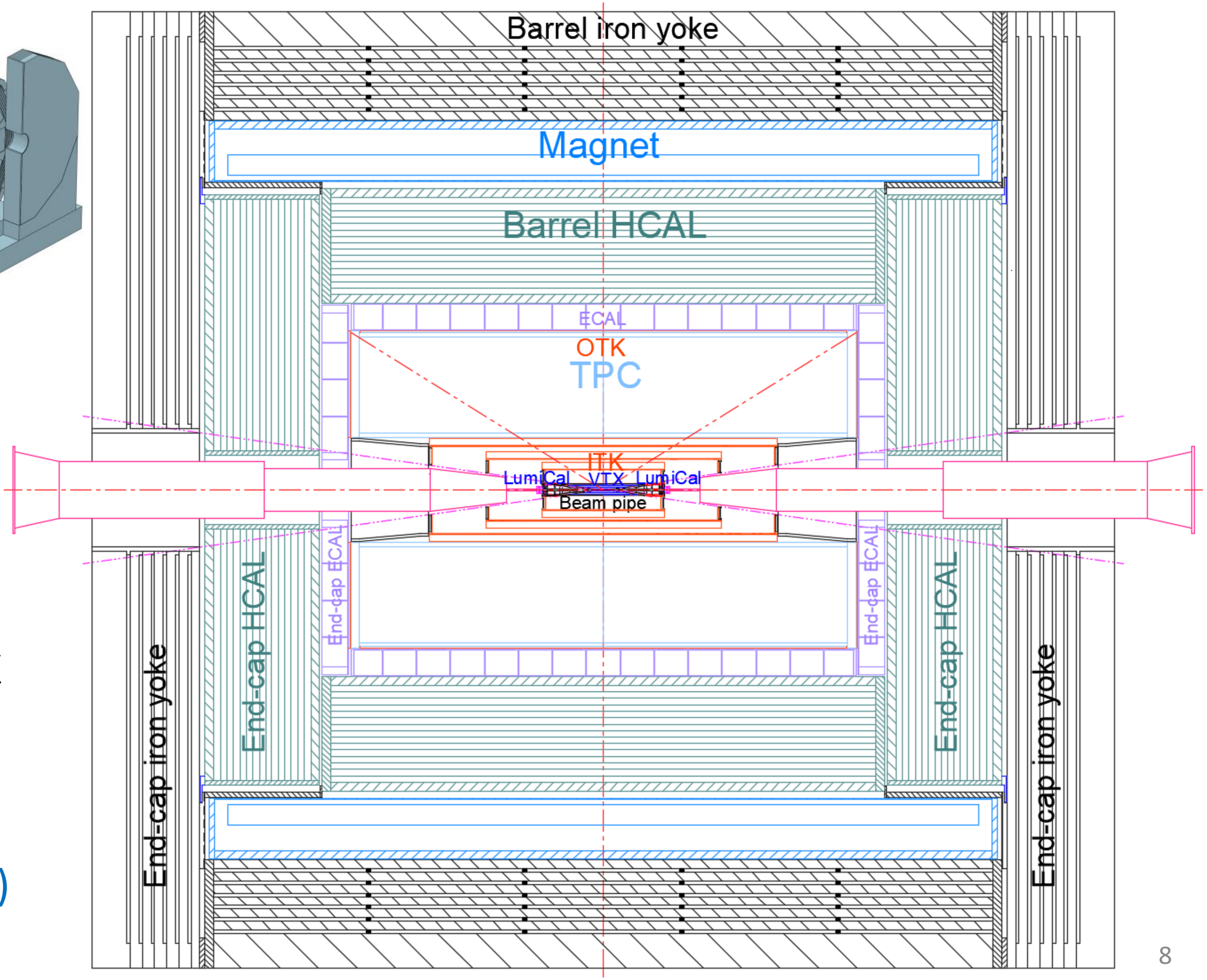
Connection design :

The design of the connection structure should follow the principle of proximity connection



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 : Fixed on the TPC
Beampipe(Vertex and LumiCal) : Fixed on the ITK

End-cap ECAL+OTK : Fixed on the Barrel HCAL
End-cap HCAL : Fixed on the Barrel HCAL
(Auxiliary cylinder or Flange)
End Yoke : Fixed on the Base

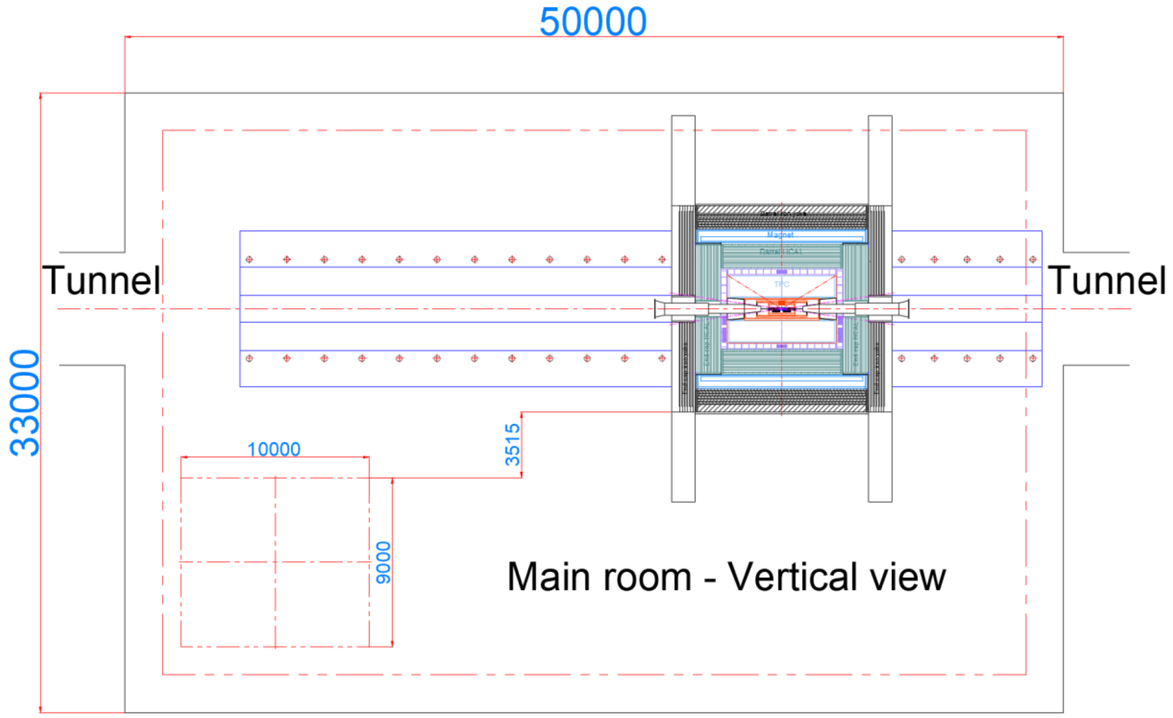


Technical challenges

Due to space limitations in the underground experimental room : **50L X 33W X 30H (m)**

Installation location : **Collision point**

Pre installation location design requires more space



Underground experimental room

Installation design requirements :

Minimal redundant installation tooling
Minimal installation steps
Minimum number of mechanical design engineers

In order to

Reduction of economic, time and personnel costs

How to achieve design goals ?

Breaking through conventional thinking ……
Surpass traditional thoughts ……

The modern remote installation design is the only possibility to install large equipment in a limited small space.

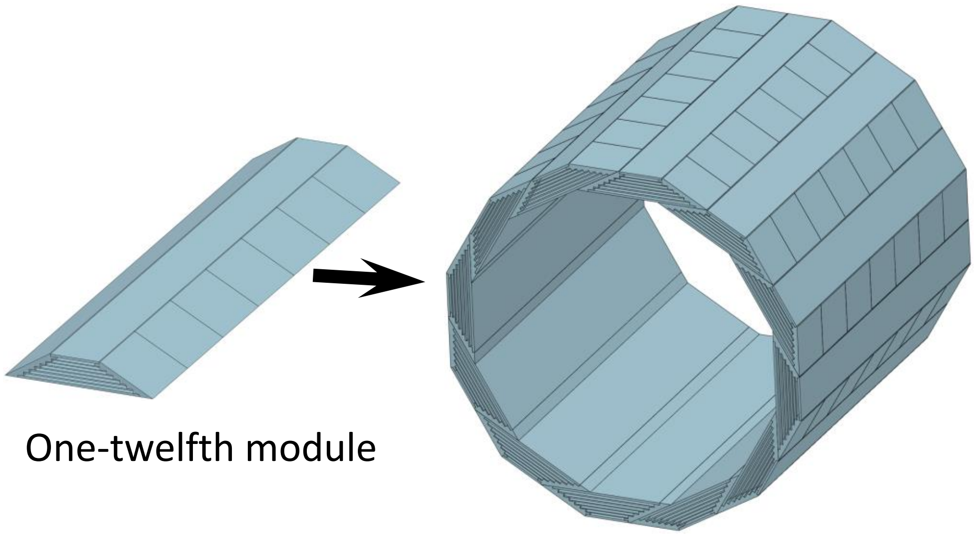
Technical challenges

New design concepts 1 : Self supporting structural design

I think that no one has proposed such a design concept before

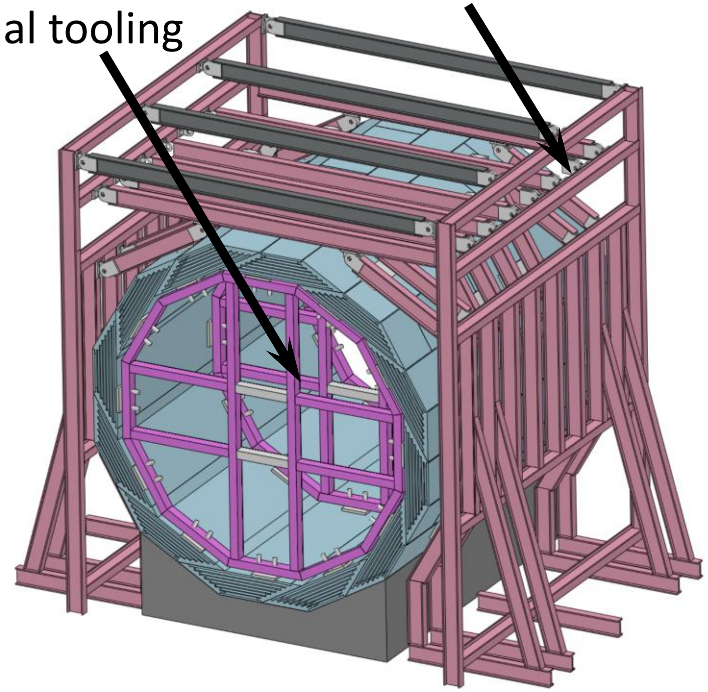
We believe that self-supporting structural design replaces conventional structural design, making it possible to reduce redundant tooling during installation.

What is conventional structural design?



Shortcomings :

1. Installation steps are complex
   Assembly must be possible with the help of the auxiliary tooling
2. Every step of the installation requires collimation
3. Installation process requires more space and time
4. **Uncontrollable installing accuracy**



Conclusion :

Conventional structure design is not fit the small space requirements of the CEPC

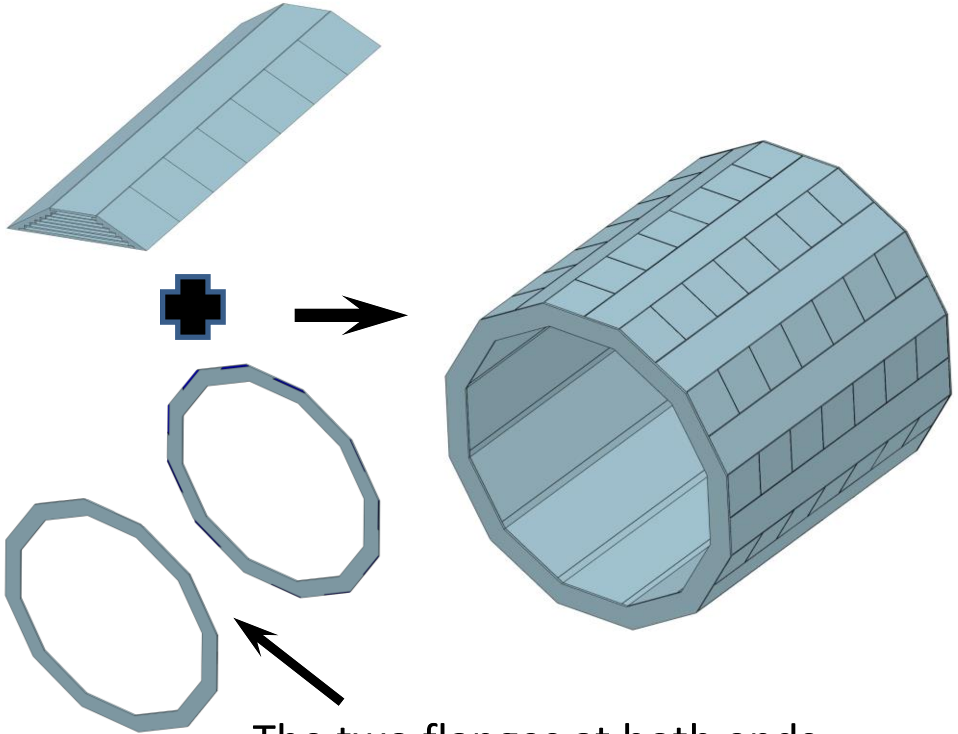
Technical challenges

New design concepts 1 : Self supporting structural design

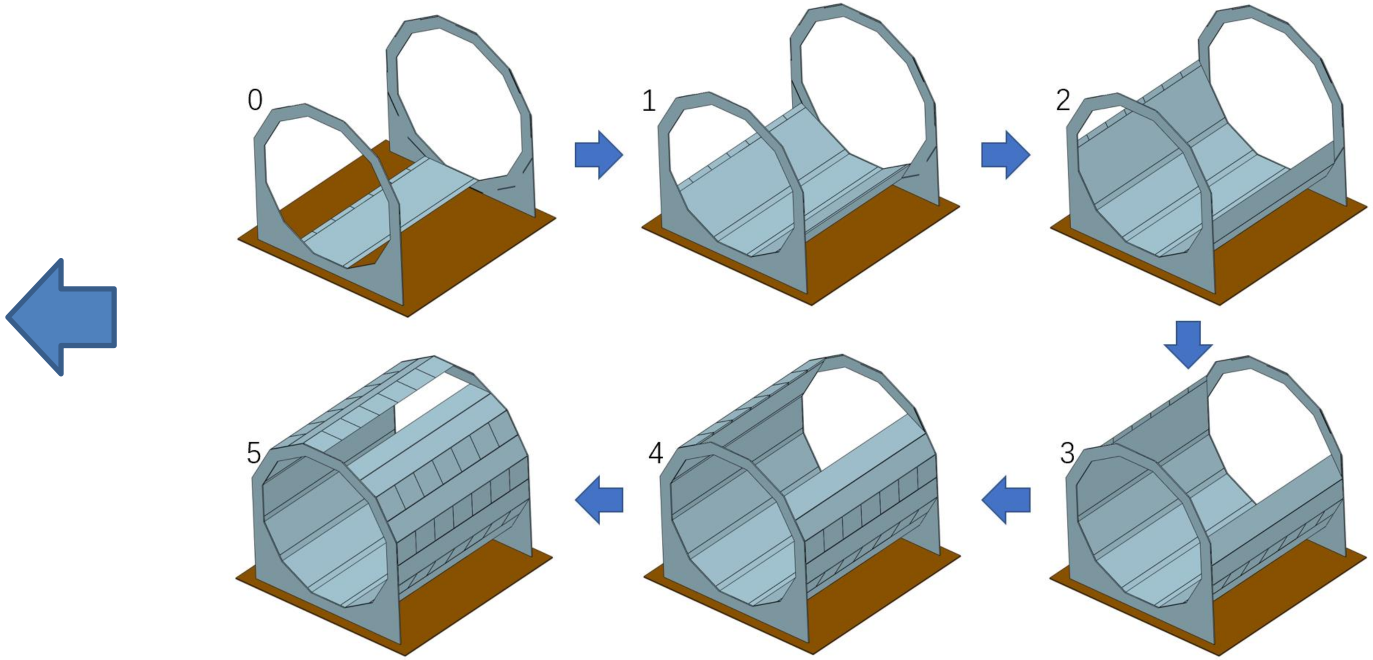
We believe that self-supporting structural design replaces conventional structural design, making it possible to reduce redundant tooling during installation.

Highly efficient Installation design

What is self supporting structural design?



The two flanges at both ends are the installation tooling

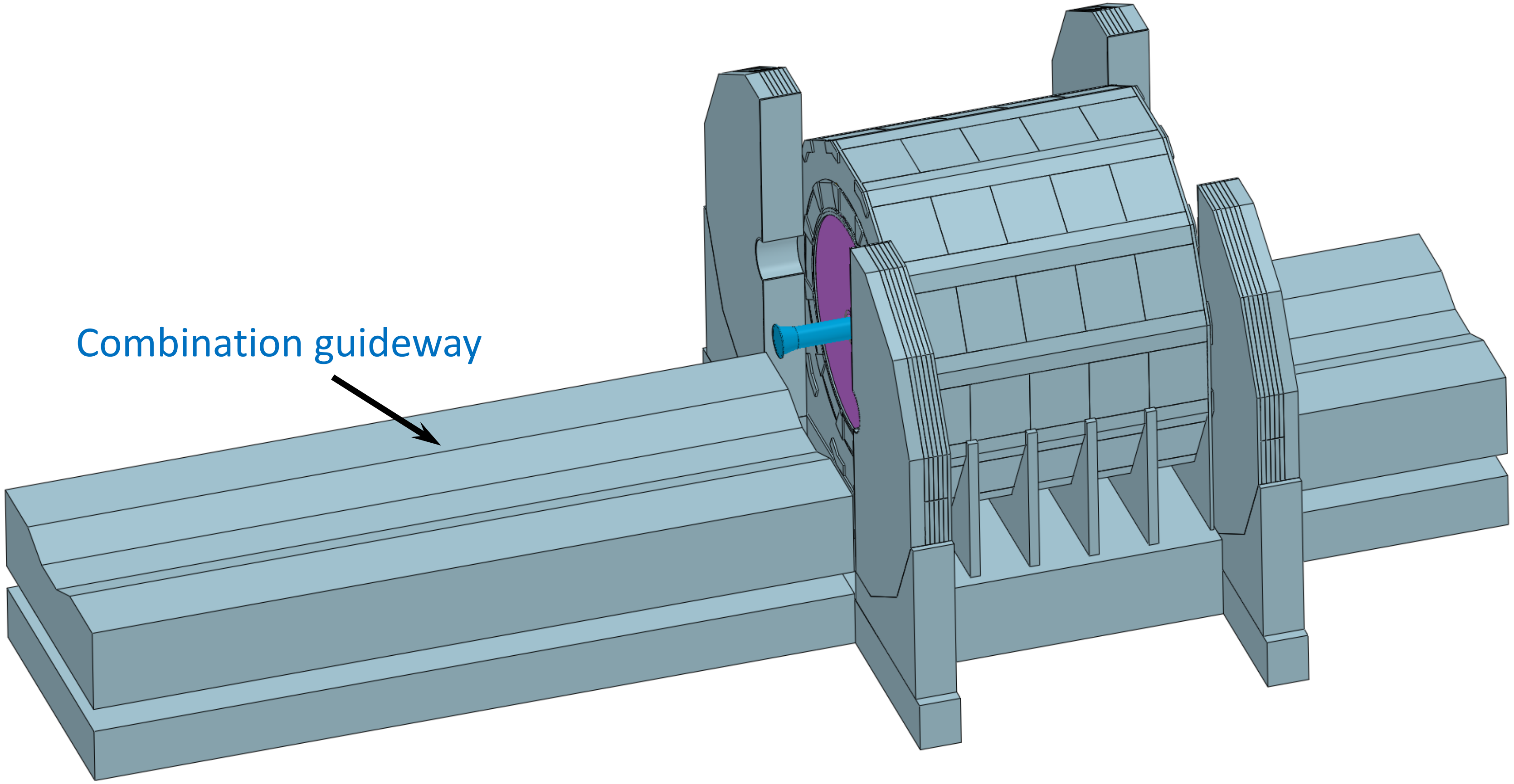


The whole installation process, without any additional auxiliary tools.

Technical challenges

New design concepts 2: Reversible installation design

Key point : Retain installation benchmarks (Never dismantle forever)

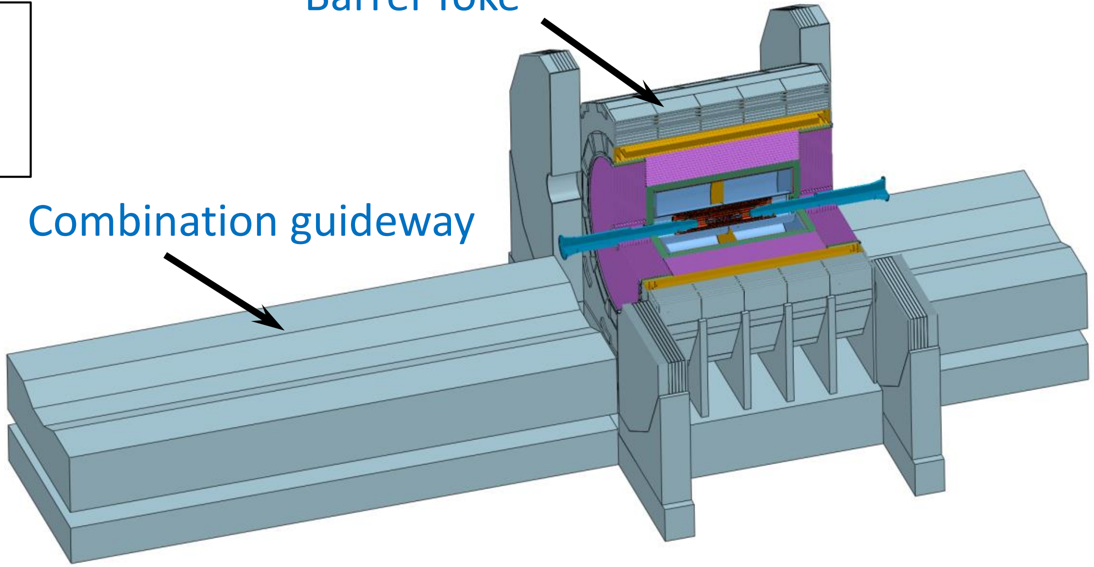


Optimization design of connection structure and wiring (as much as possible)

Overall progress of the installation design

General installation drawing of detectors in the underground experimental room

Combination guideway is the installation reference, and is pre-aligned with the yoke



Overall installation steps :

1. On the ground assembly room
   Complete the assembly work of each sub detector , including electronics, etc.

2. Each subdetector is lifted into the underground experimental room through vertical shafts in sequence

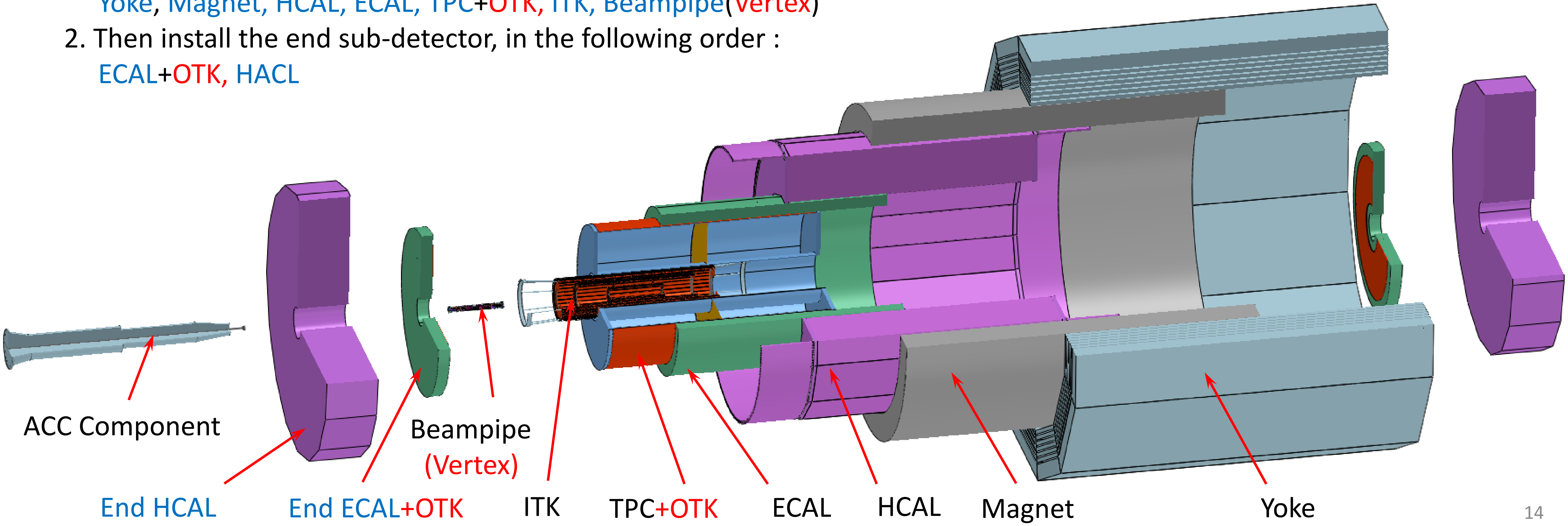
3. In the underground experimental room
   Assemble the sub-detectors on the combination guideway and push them into the yoke in sequence

Overall progress of the installation design

Detectors installation steps (As shown in the exploded view)

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



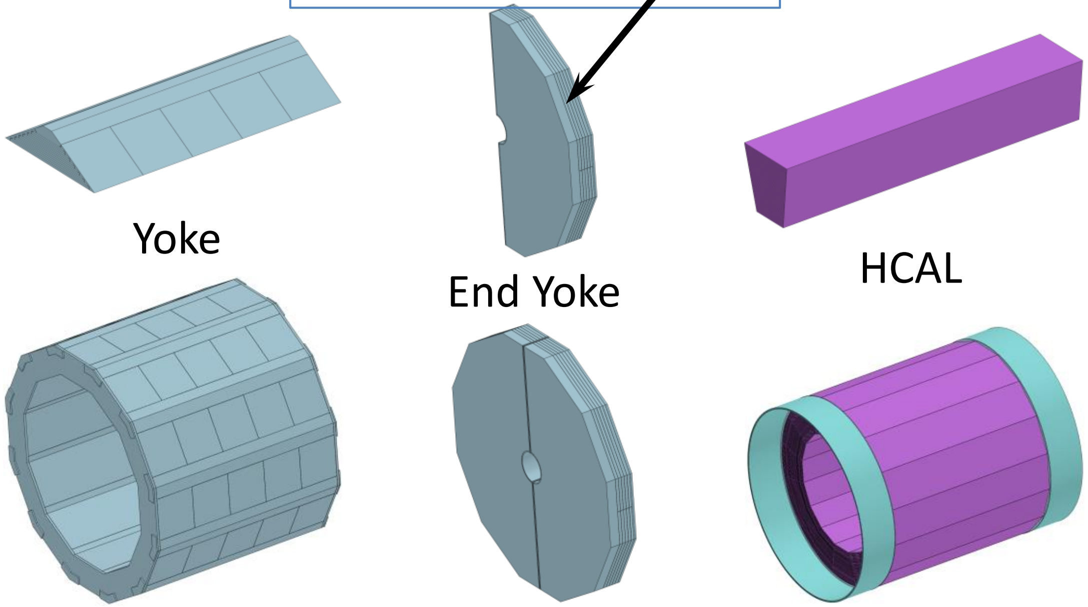
Overall progress of the installation design

Consideration of vertical shaft hoist

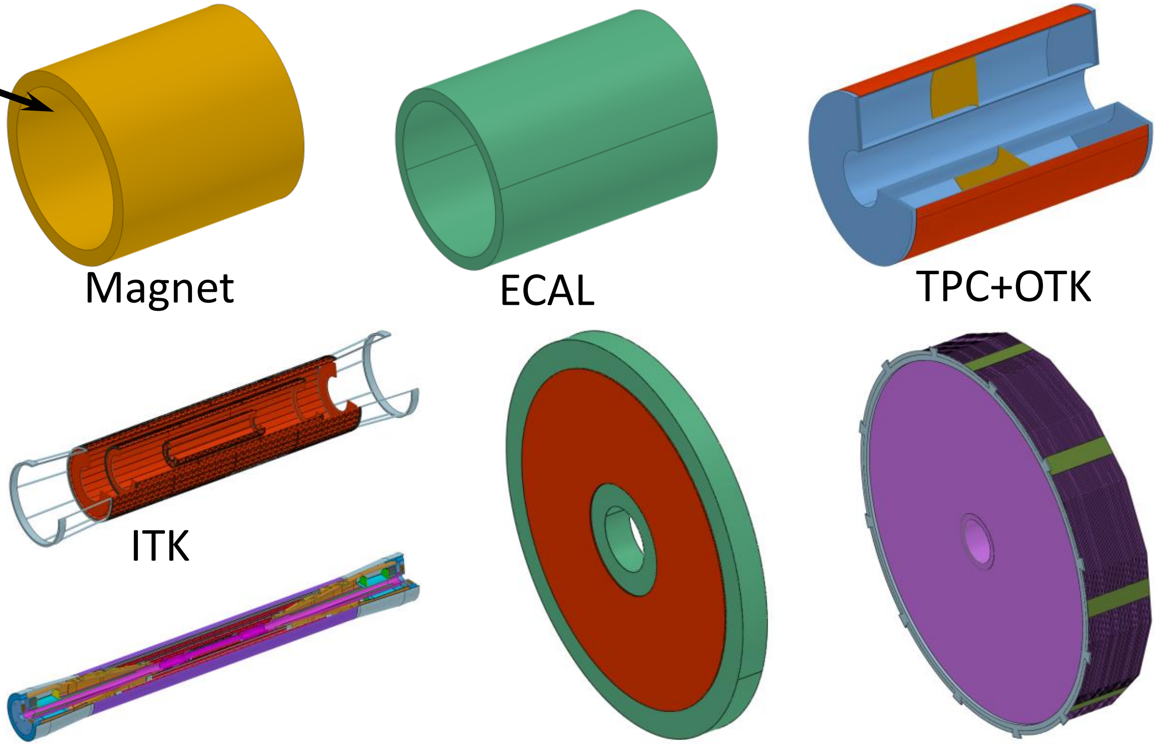
Lifted in Separate

heaviest single module
≈ **400 T**

Largest single size
9050 L X Φ 8470



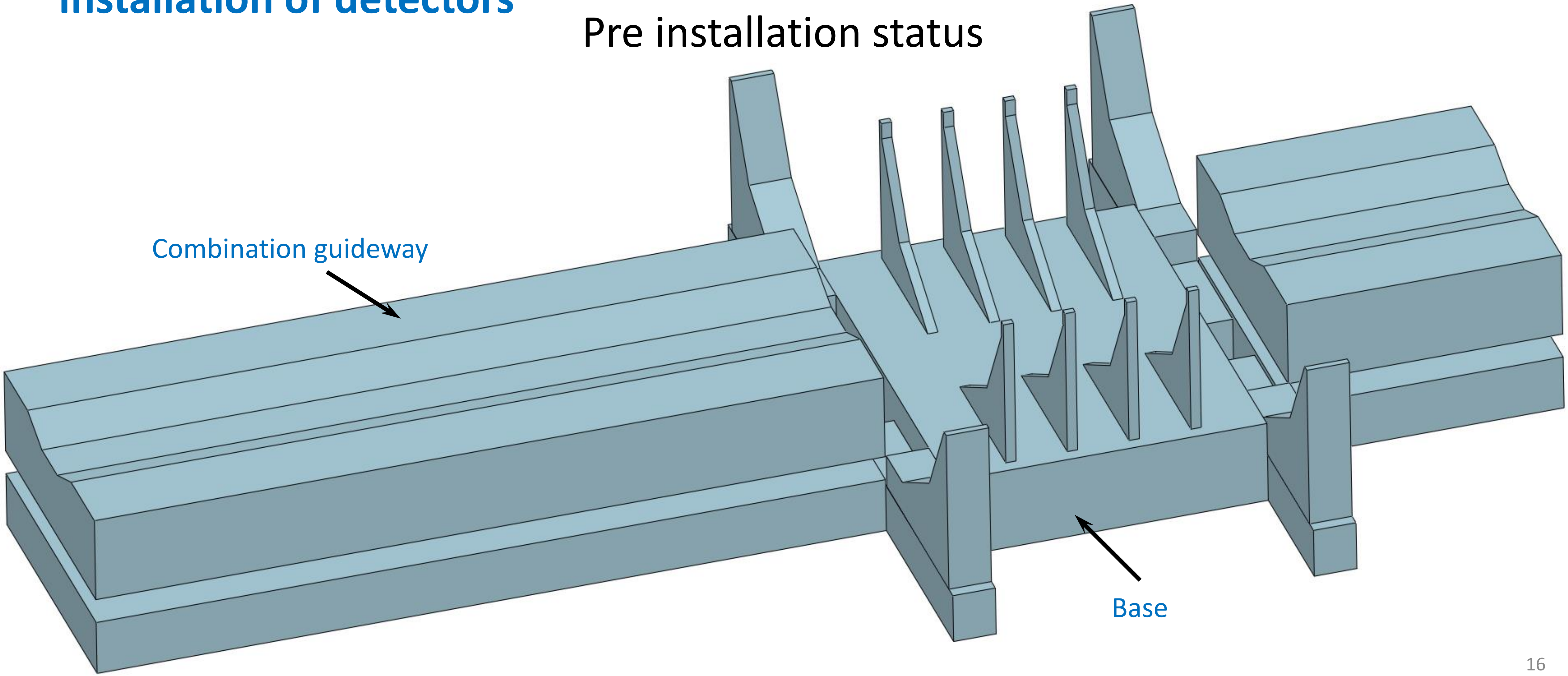
Lifted as a whole



Overall progress of the installation design

Installation of detectors

Pre installation status

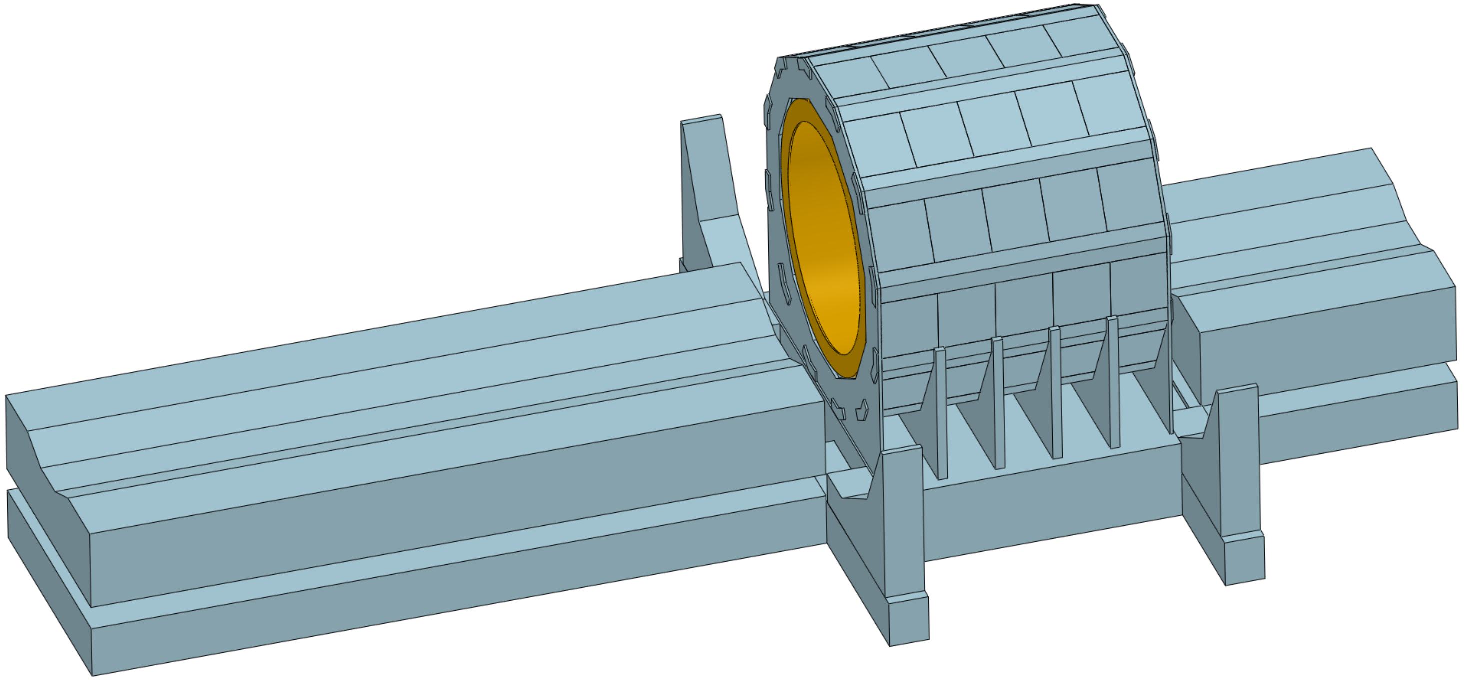


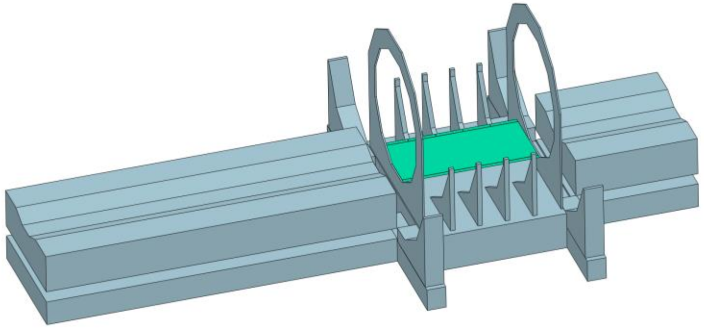
Overall progress of the installation design

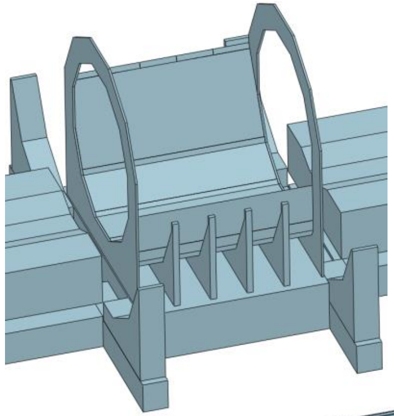
Installation of detectors

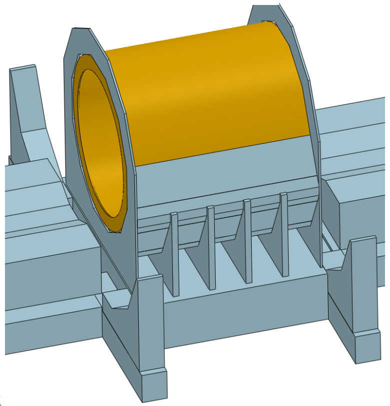
Step 1 :

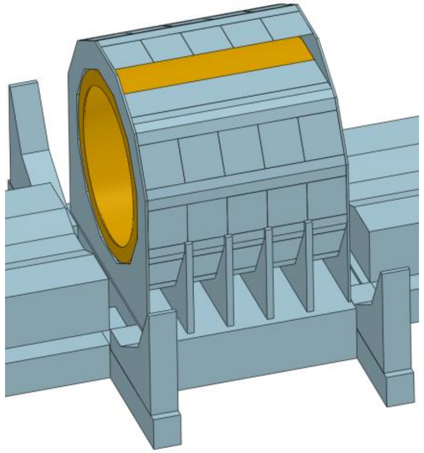
Installing the Yoke and Magnet









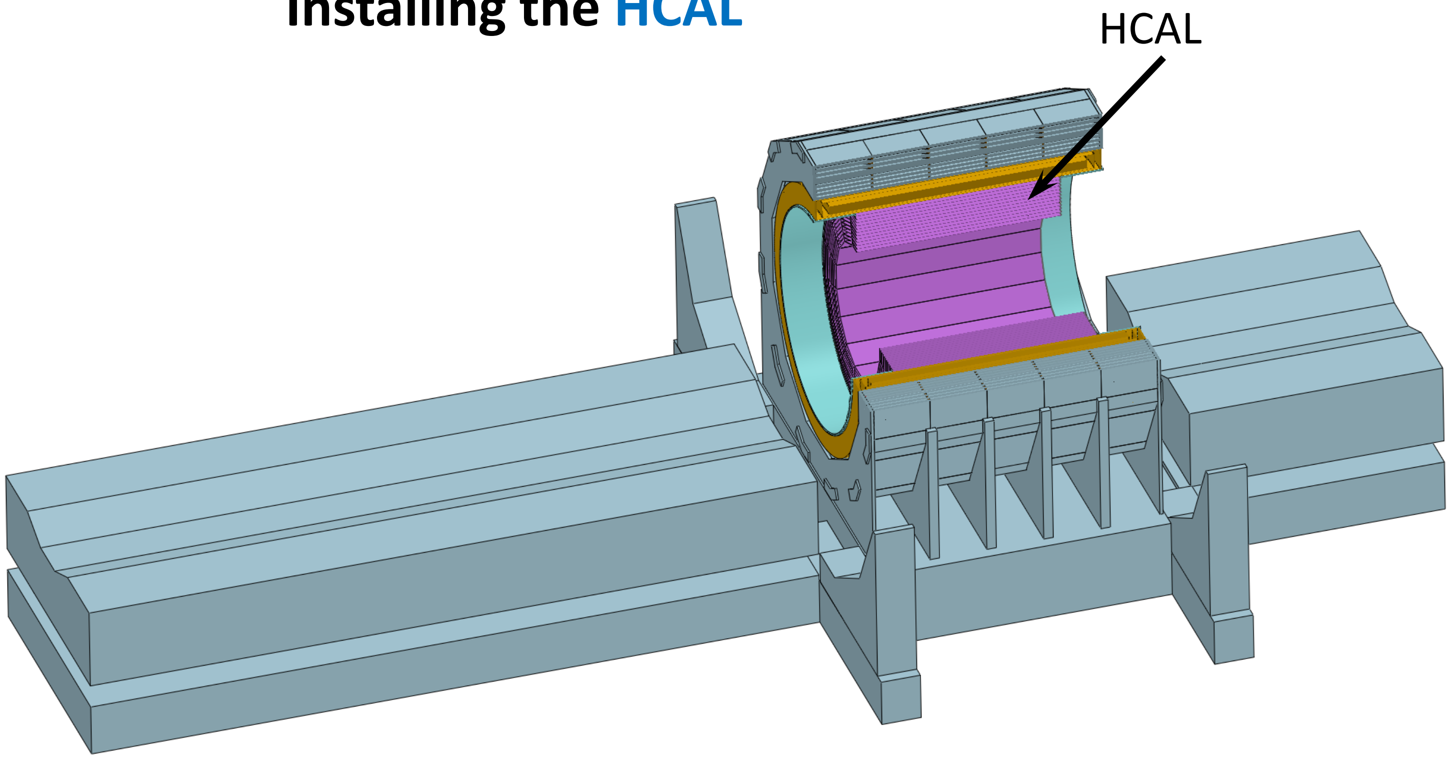


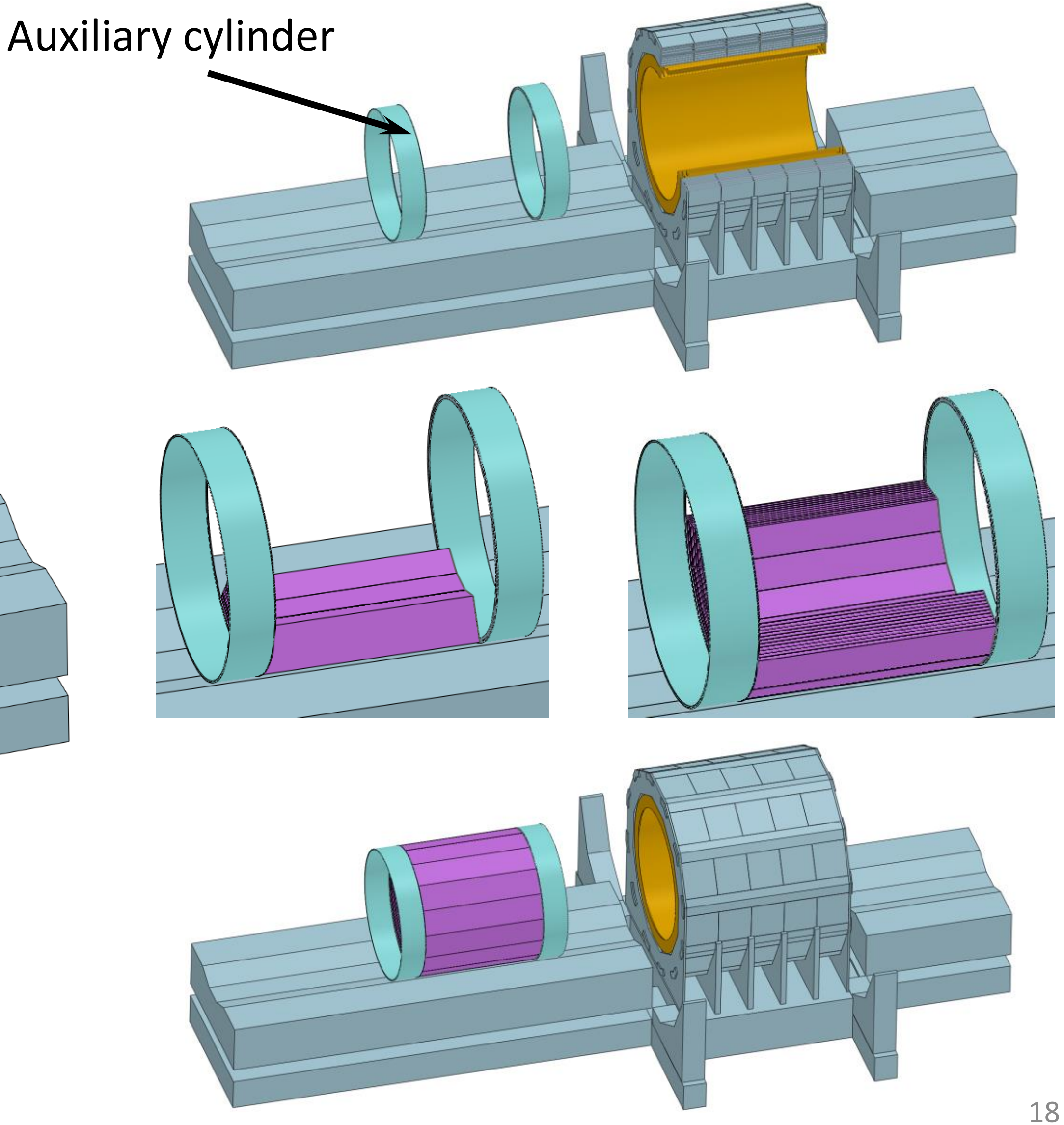
Overall progress of the installation design

Installation of detectors

Step 2 :

Installing the HCAL





Overall progress of the installation design

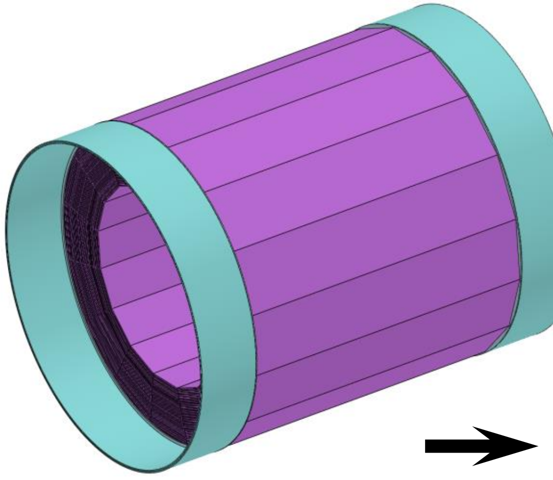
Installation of detectors

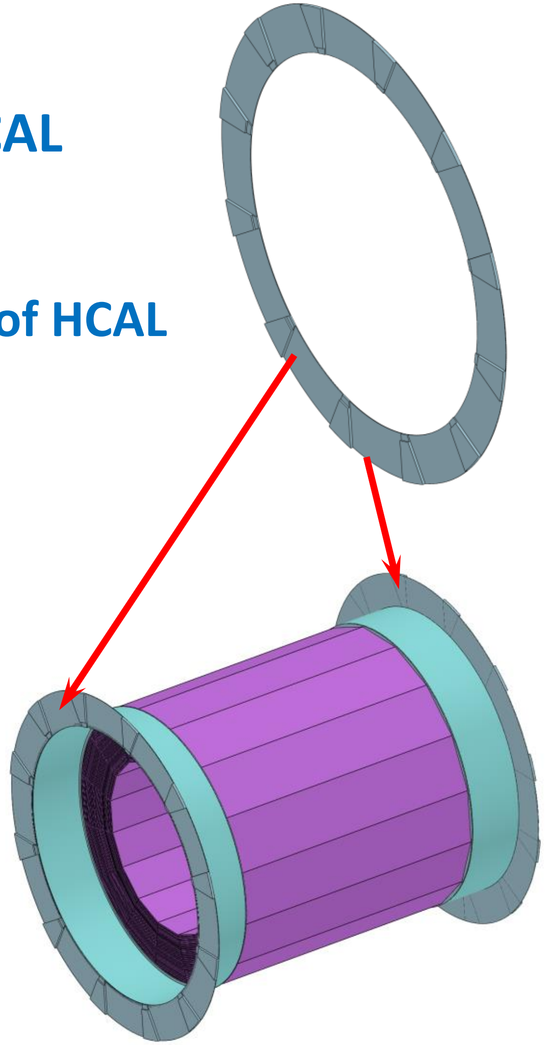
Step 2:

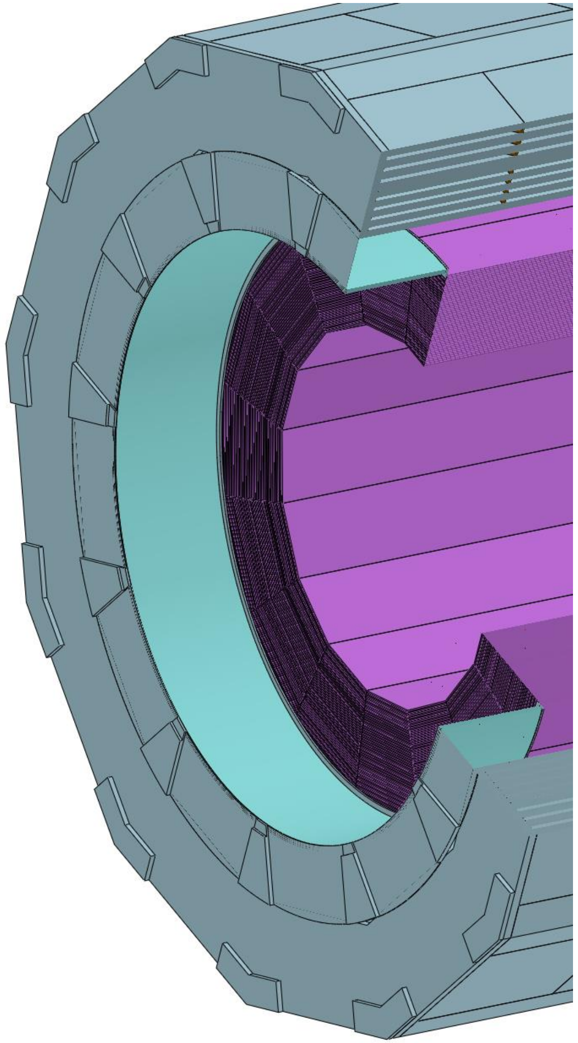
Installing the HCAL

↓

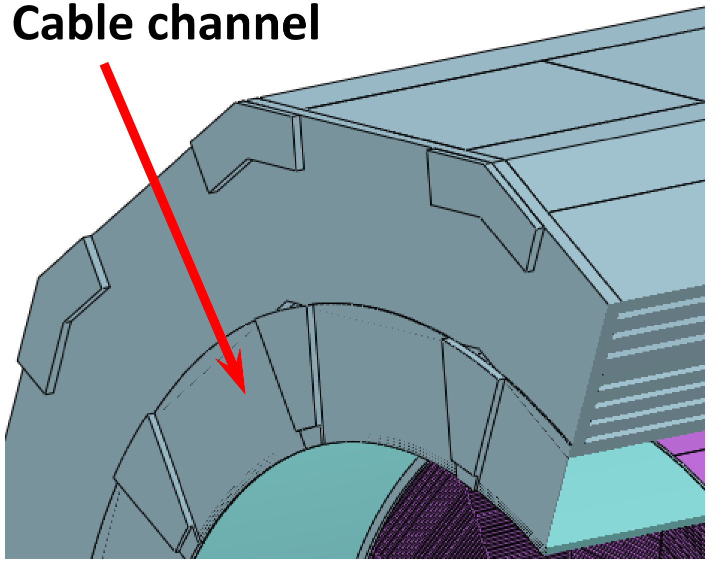
Connection and fixing of HCAL







Cable channel

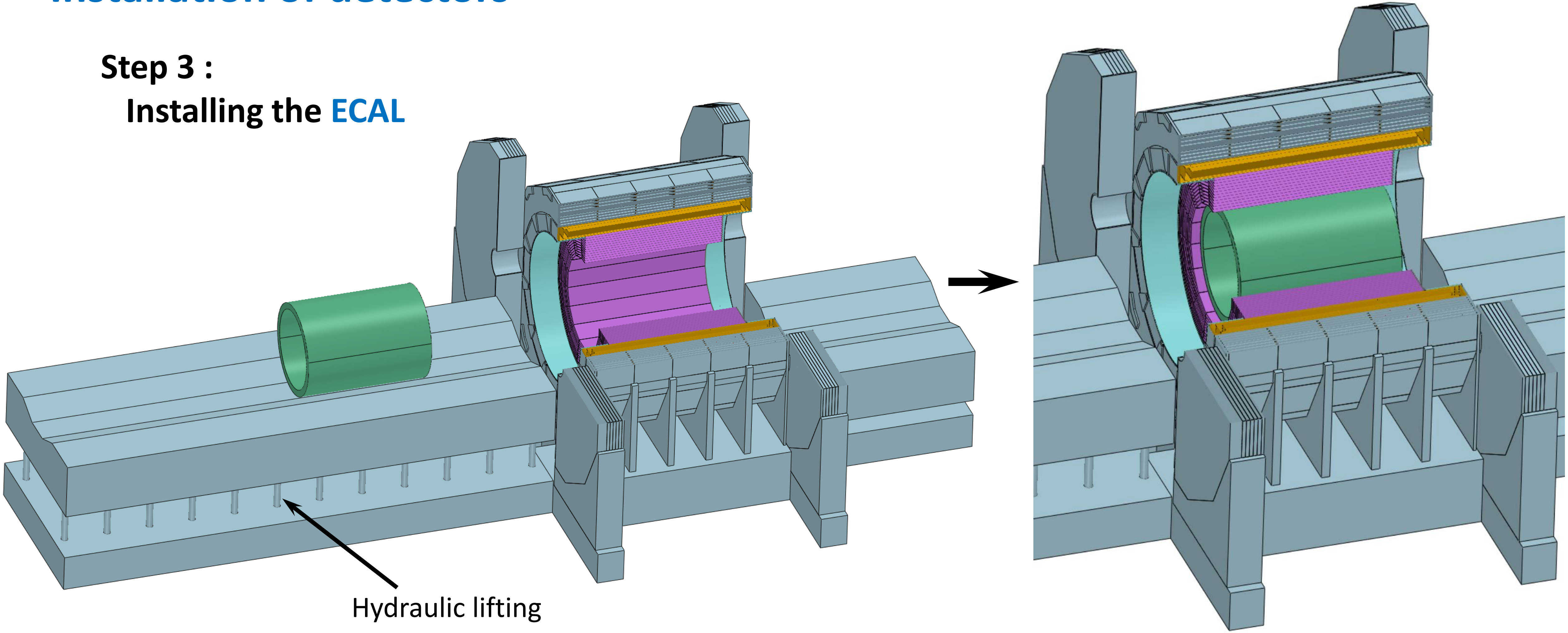


Overall progress of the installation design

Installation of detectors

Step 3 :

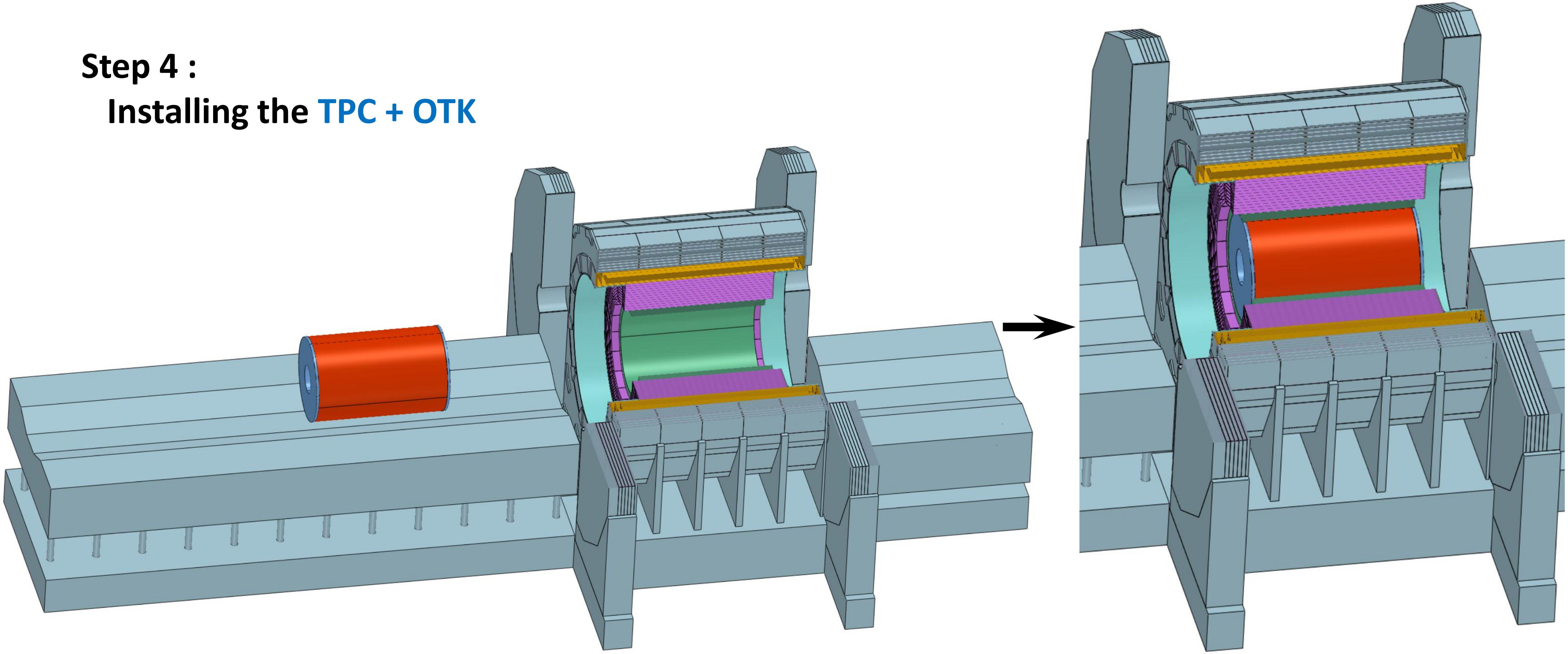
Installing the ECAL



Overall progress of the installation design

Installation of detectors

Step 4 :
Installing the TPC + OTK

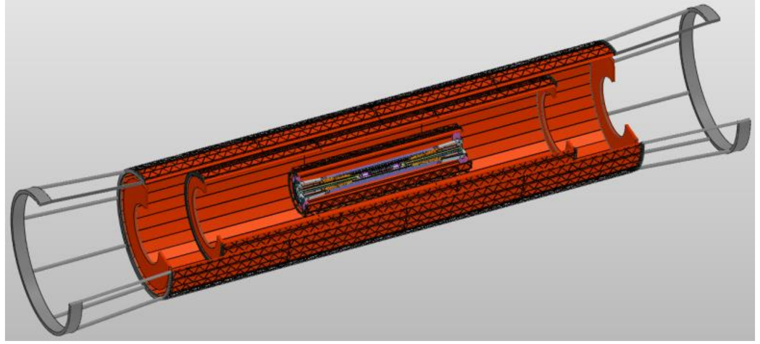


Overall progress of the installation design

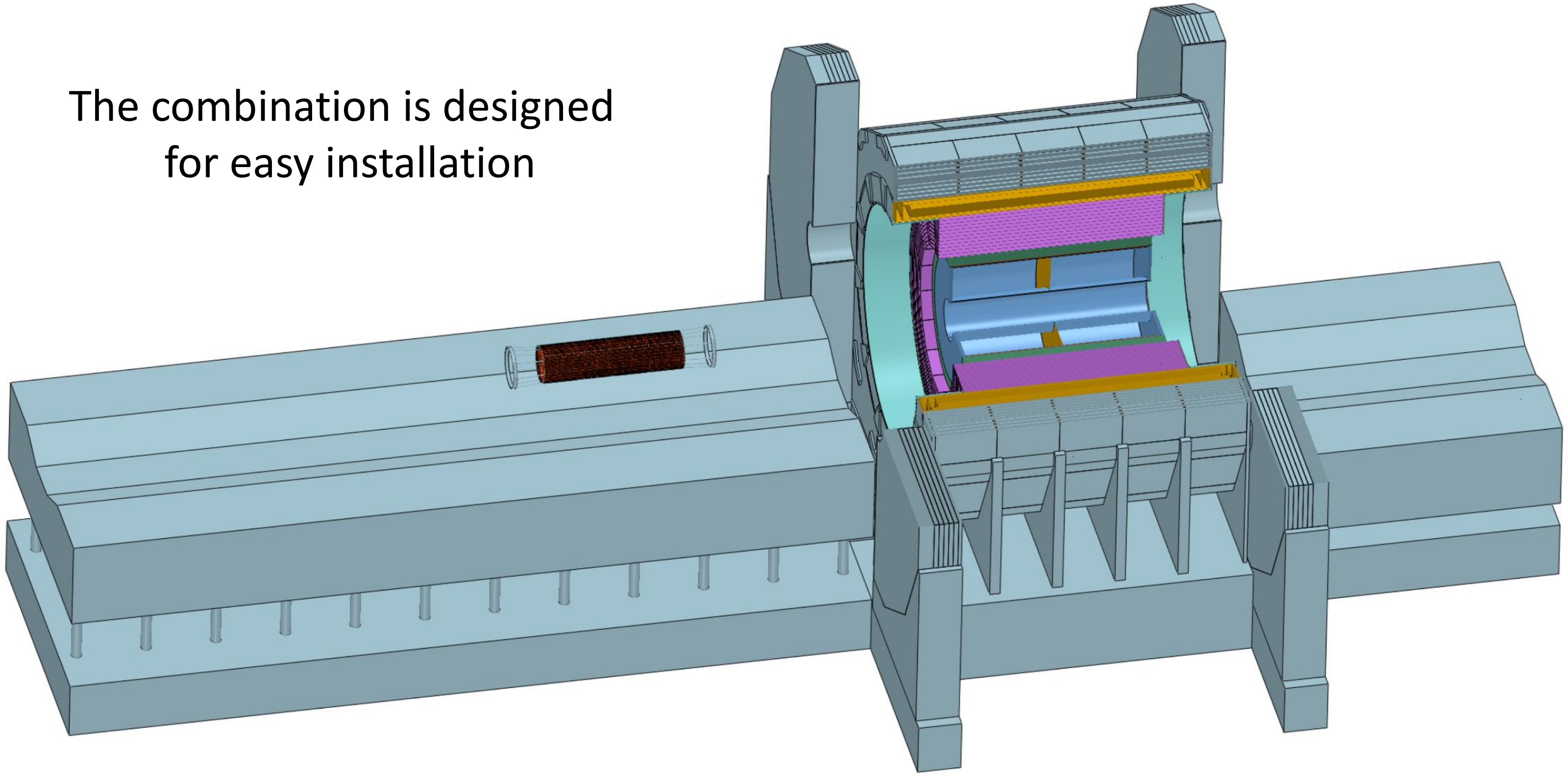
Installation of detectors

Step 5 :

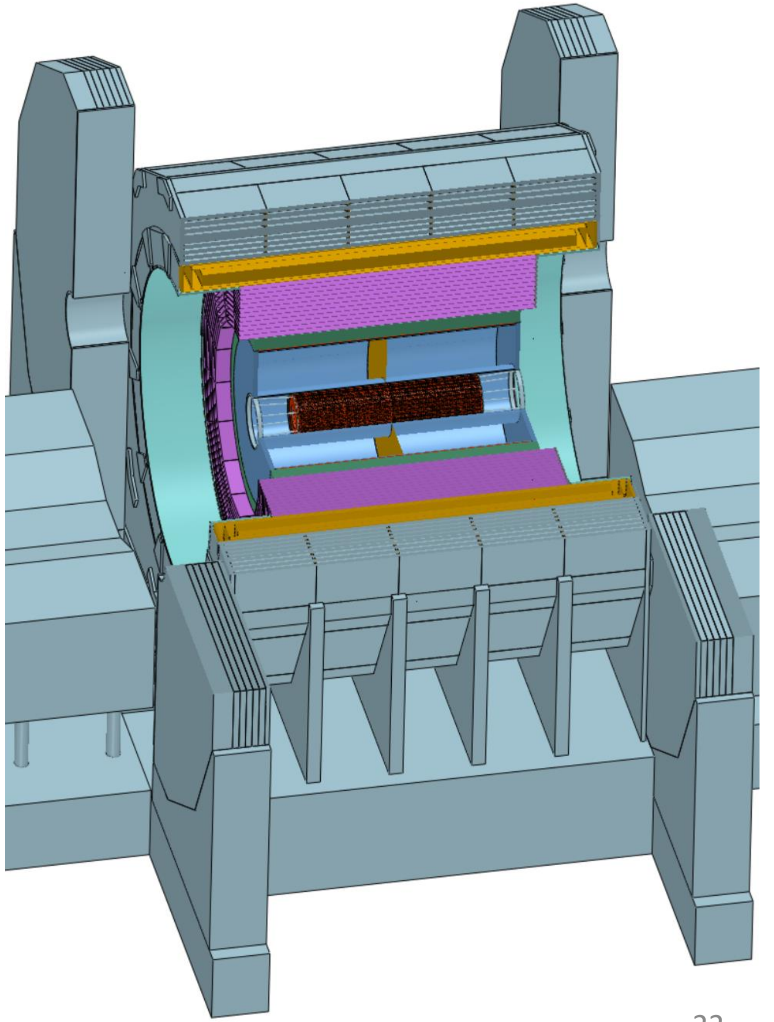
Installing the ITK + Beampipe



The combination is designed for easy installation



→

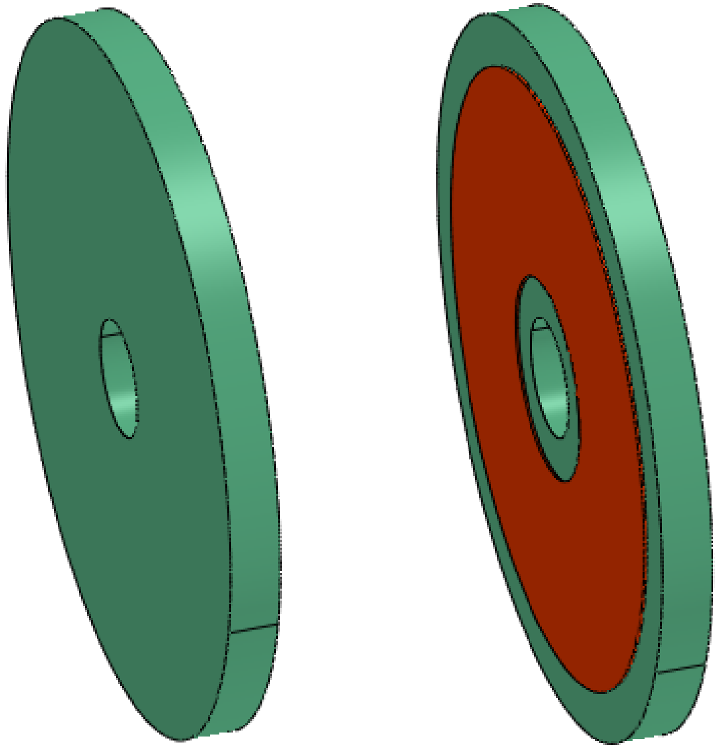


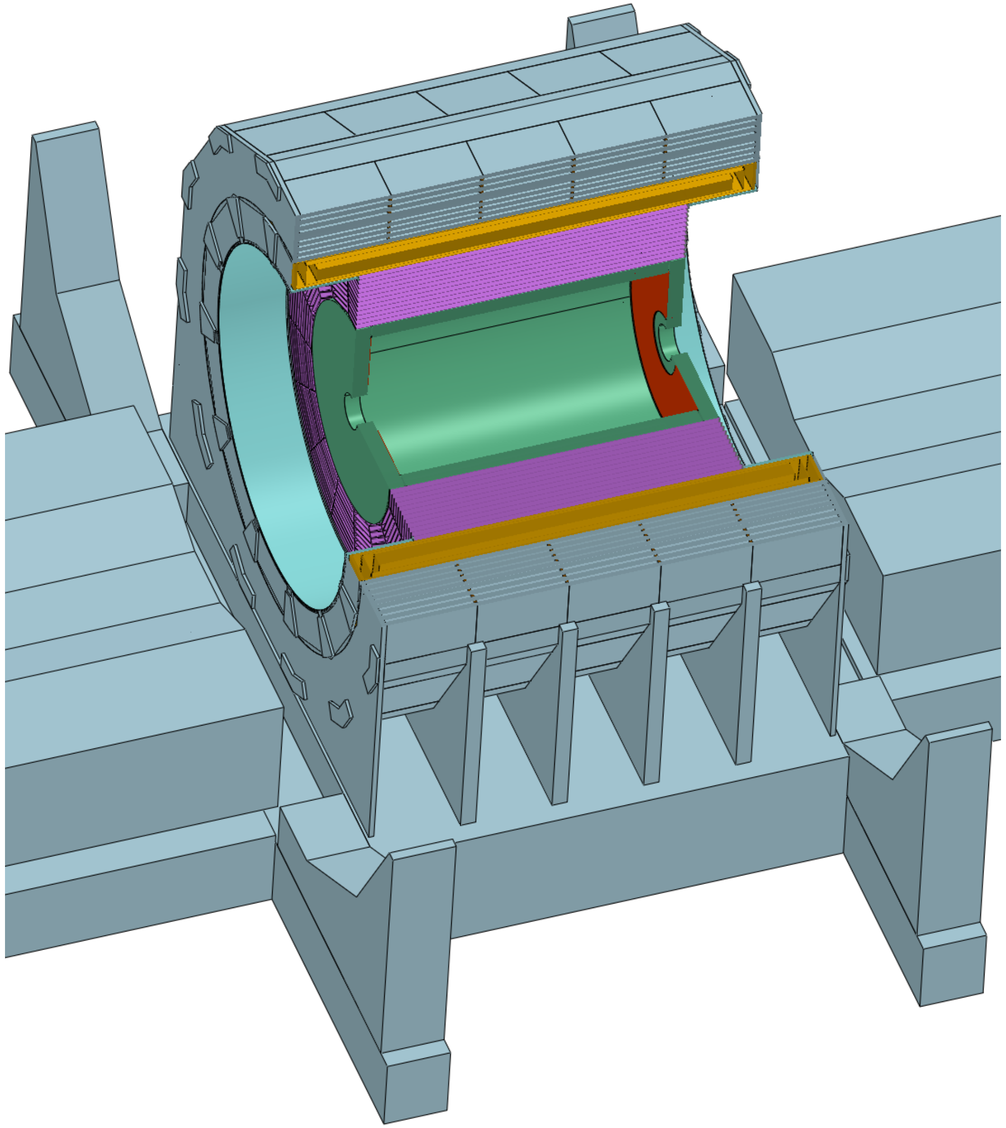
Overall progress of the installation design

Installation of detectors

Step 6 :

Installing the End ECAL



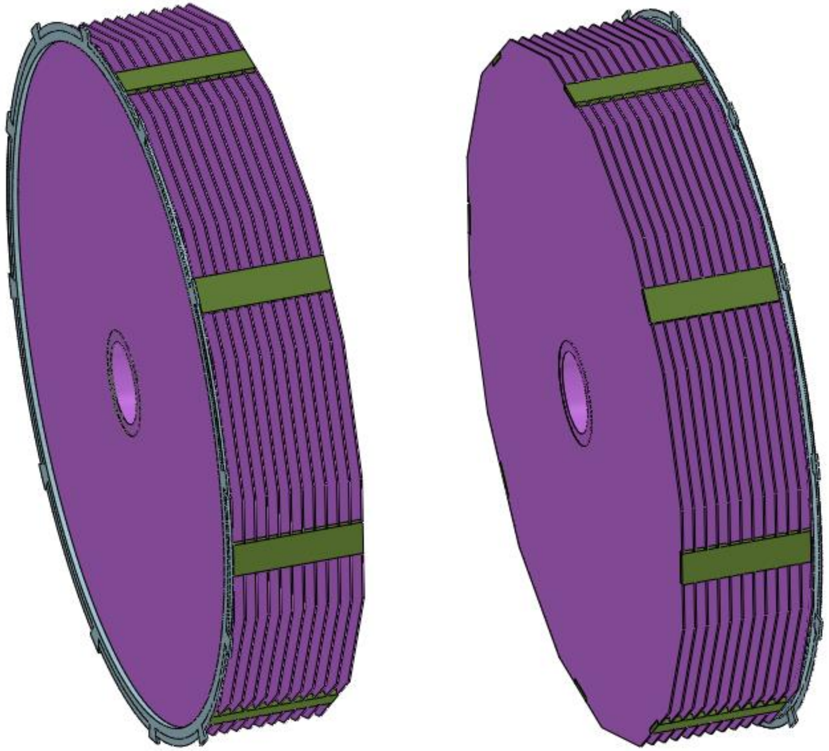


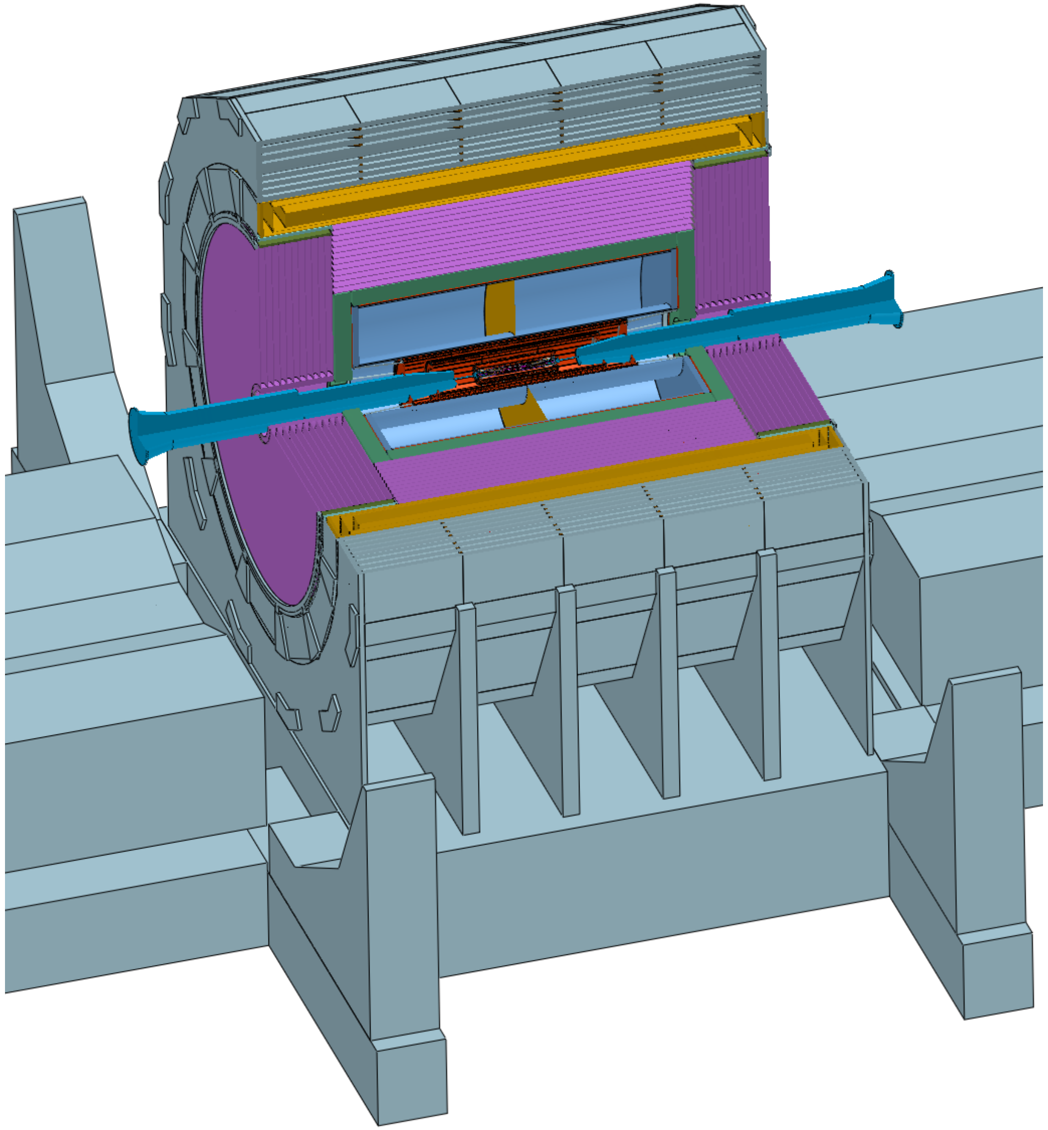
Overall progress of the installation design

Installation of detectors

Step 7 :

Installing the End HCAL



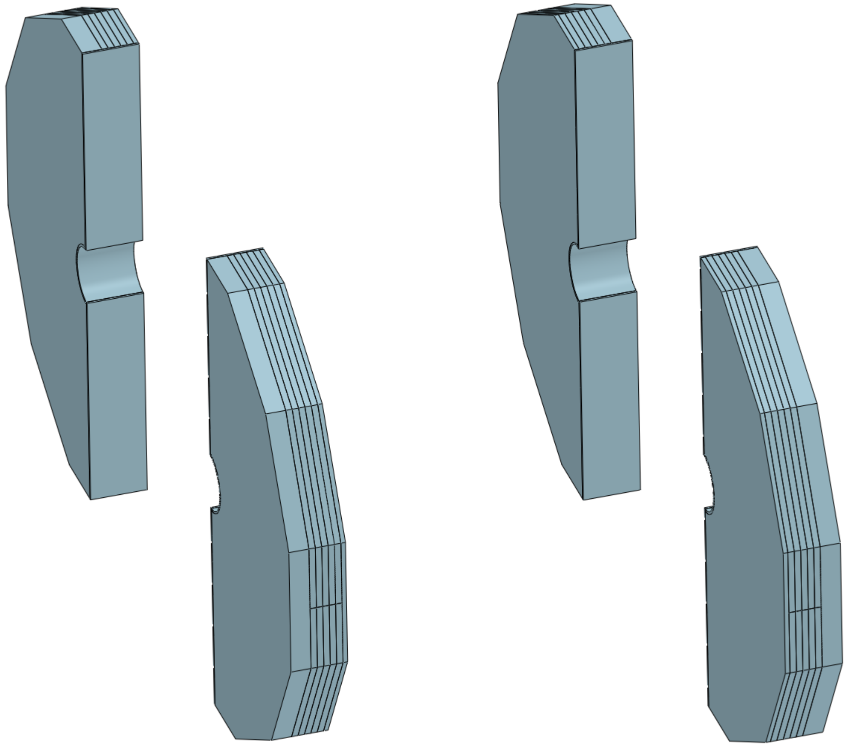


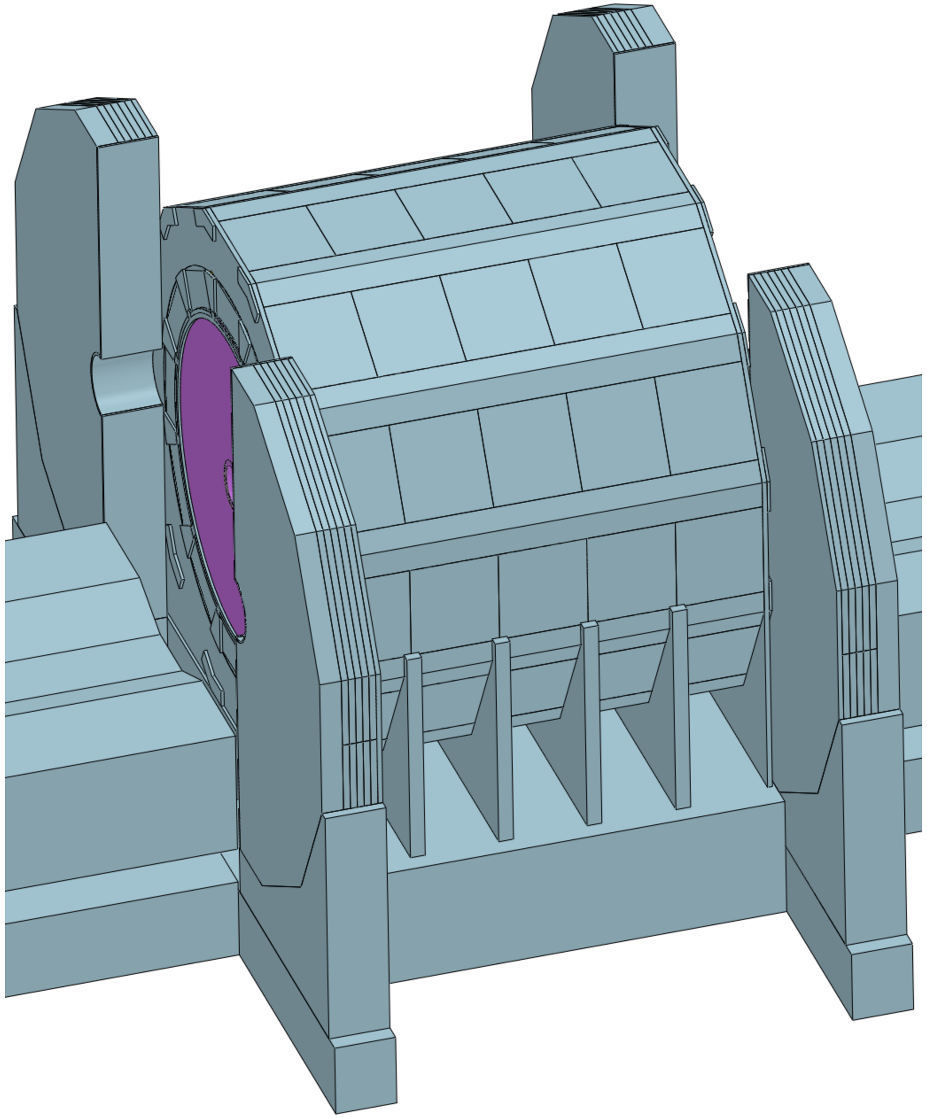
Overall progress of the installation design

Installation of detectors

Step 8 :

Installing the End Yoke



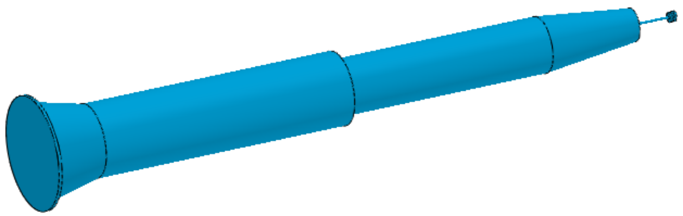


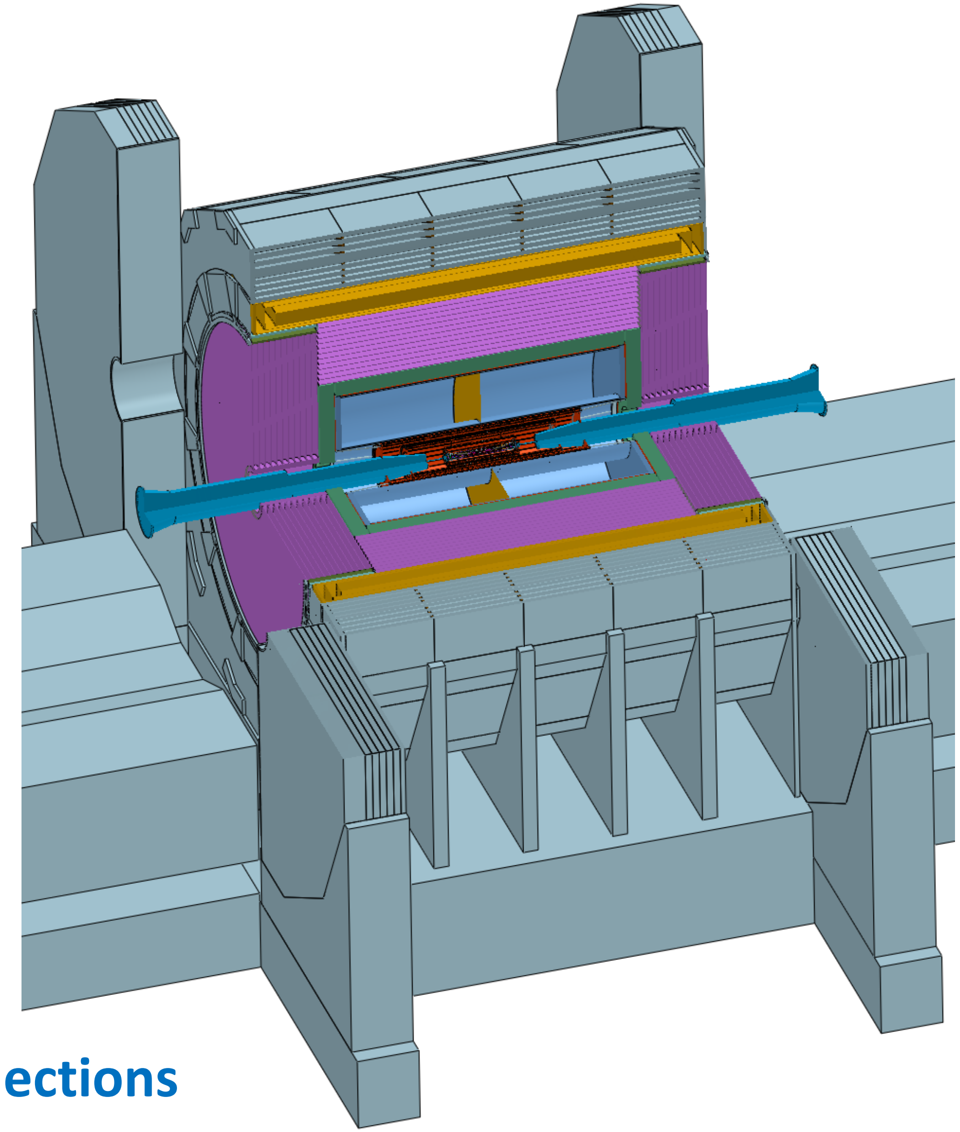
Overall progress of the installation design

Installation of detectors

Step 9 :

Installing the ACC MDI Component





Pillow seal can be used for remote vacuum connections

Research team

Established a multi-disciplinary and multi-level engineering team :

The core is a mechanical engineer from the Institute of High Energy

Calculation team

Students (2)
Xia Shang Doctor
He LongYan Master

IHEP (5)
Ji Quan
Zhang JunSong
Fu JinYu
Pei YaTian
Hou ShaoJing

University (3)
Hunan University
University of South China
Southwest Jiaotong University

Design units (1)
Zhejiang University

Design team

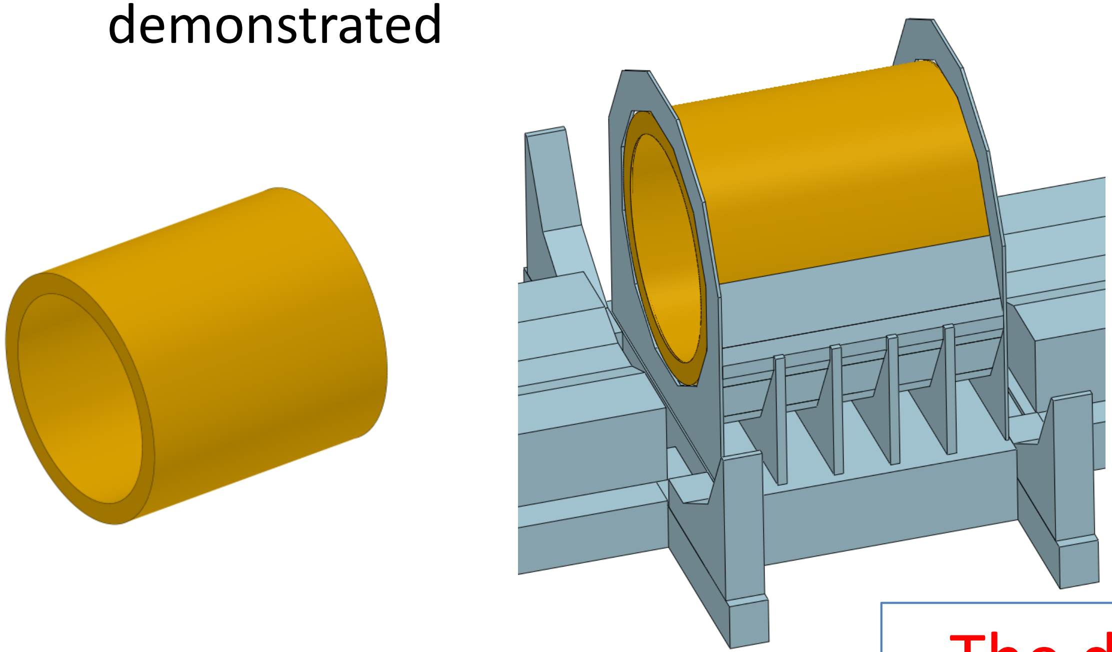
Manufacturing units (1)
CITIC Heavy Industry

Once the design issues are clear in the future,
we will also seek international cooperation

Summary and working plan

Summary

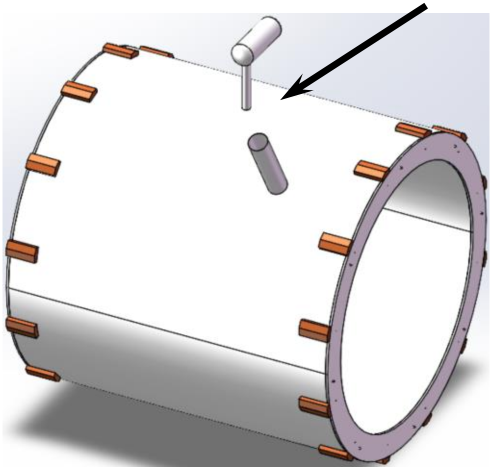
1. The overall design requirements and the design requirements for each sub detector need to be further refined
2. The top-level installation design is basically clear, but further feasibility needs to be demonstrated



Previous installation simulation

The difficulty is obviously different

Two extra valve boxes on the outside of the magnet

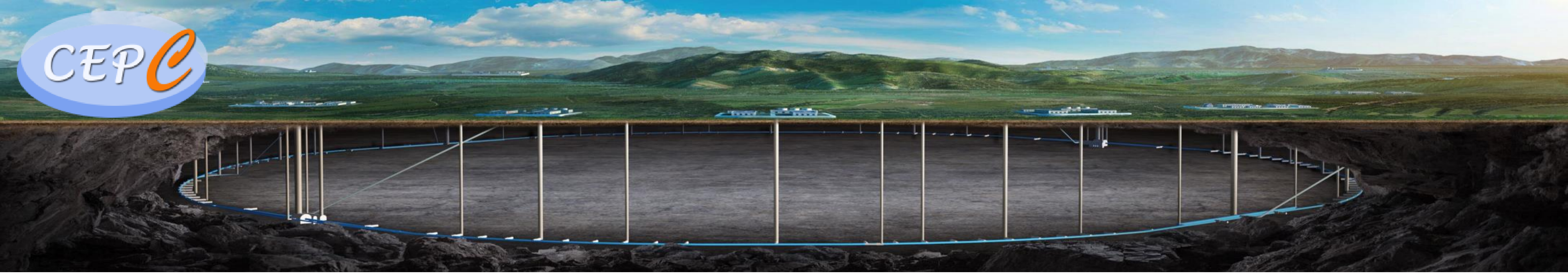


July 22 , 2024 , Magnet

Summary and working plan

Working plan

1. Refine the installation plan and connection design of sub detectors
2. Complete the framework layout of the underground experimental room and its supporting room
3. Complete the layout of the ground assembly room



Thank you for your attention!

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences