Preliminary design of CEPC detector installation scheme

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Outline

1. Overview
2. Preliminary mechanical design
3. Preliminary design of installation scheme
4. Summary

1. Overview

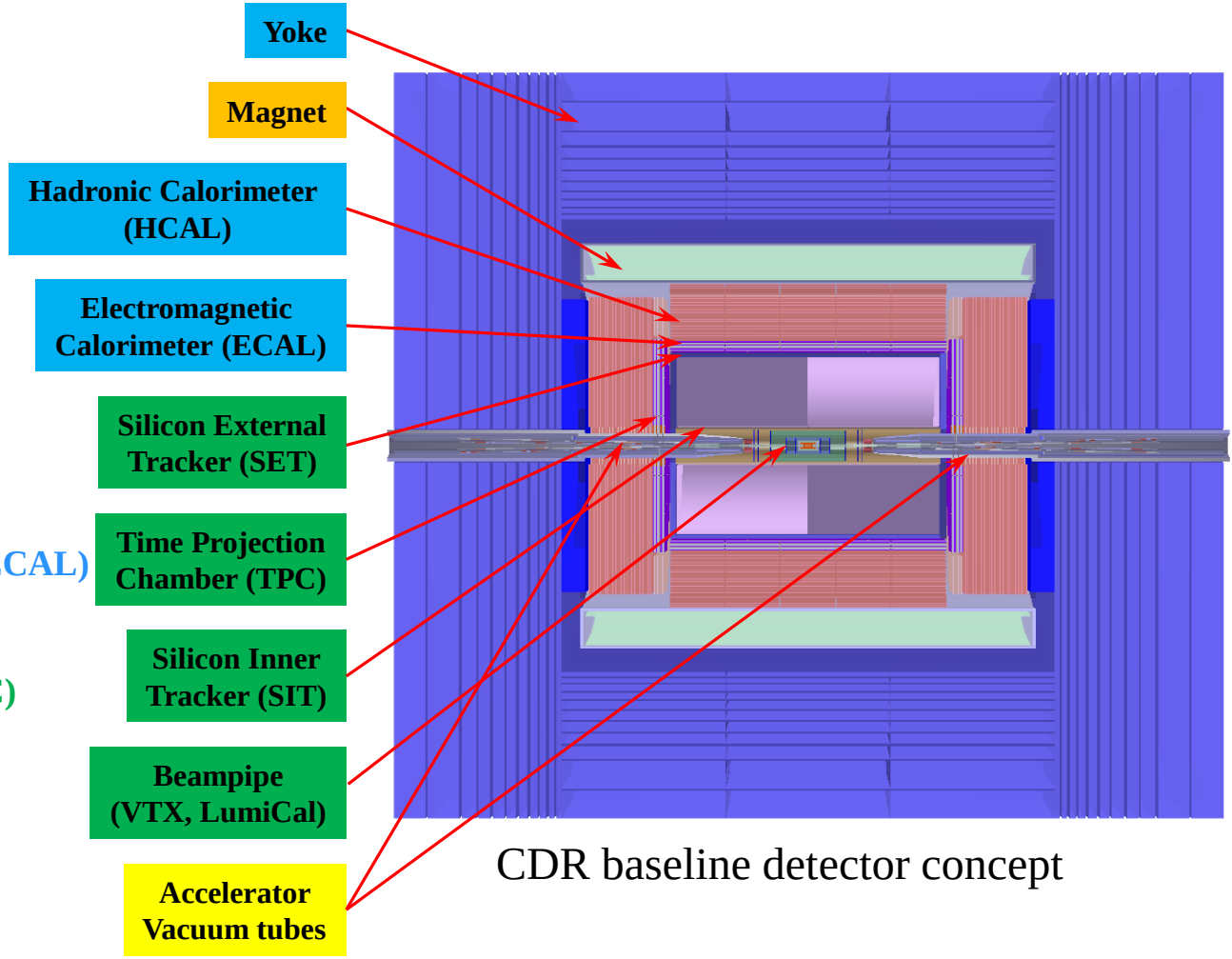
From outermost to innermost:

--Yoke

--Magnet

--**Detectors:**

- Muon detector (in yoke)
- Hadronic Calorimeter (HCAL)
- Electromagnetic Calorimeter (ECAL)
- Silicon External Tracker (SET)
- Time Projection Chamber (TPC)
- Silicon Inner Tracker (SIT)
- Beampipe (VTX, LumiCal)

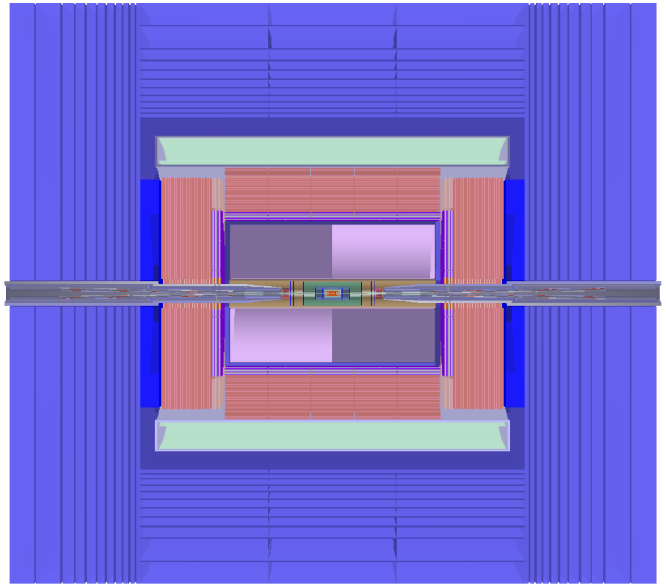


CDR baseline detector concept

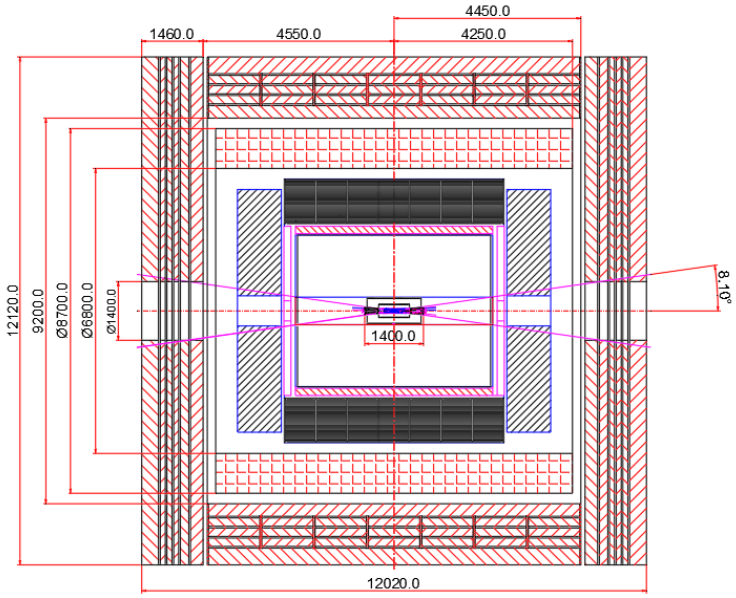
1. Overview

The objective of next step is to accomplish the preliminary engineering design for TDR.

CDR
Oct. 2018



Present



TDR
2022?

• • •

Scope -

1. to present a very preliminary mechanical design of detectors, focusing on dimension and connection structure of yoke, magnet, HCAL, ECAL, etc. .
2. to present the concept of detectors installation scheme.

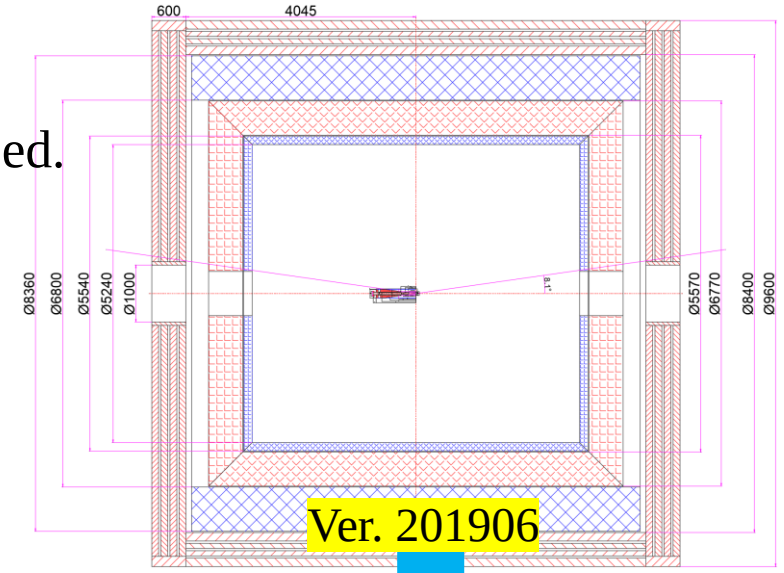
Outline

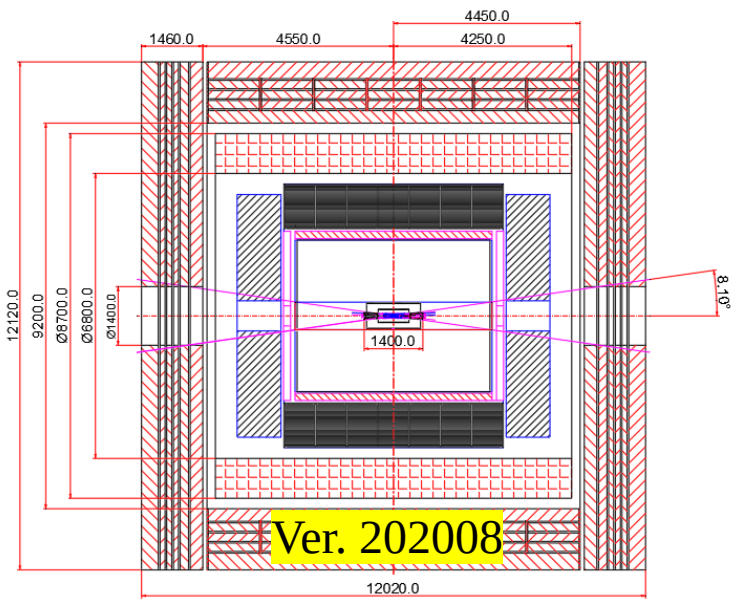
1. Overview
2. **Preliminary mechanical design**
3. Preliminary design of installation scheme
4. Summary

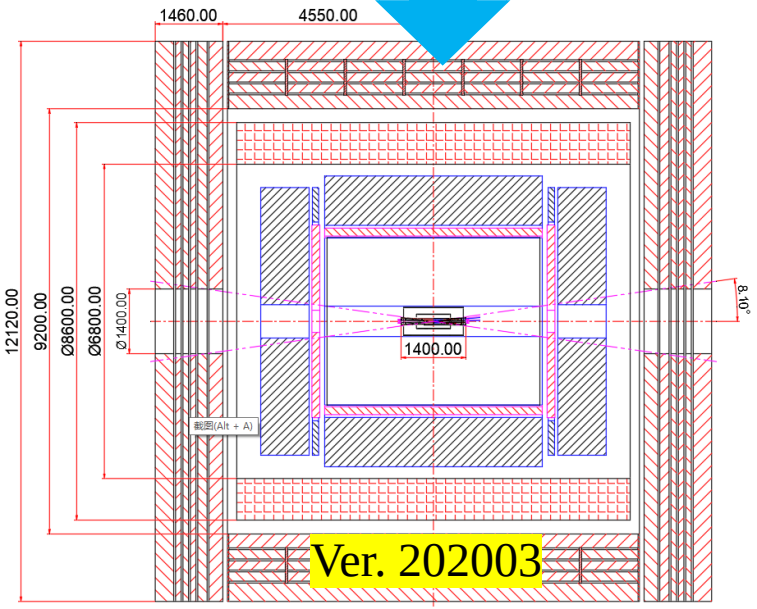
2. Preliminary mechanical design

Optimization for the dimension and structure of detectors has been done after CDR was proposed.

The optimization objective is to:
--minimize the structural deformation
--simplify the installation operation
…







2. Preliminary mechanical design

Design requirements:

--Max. deformation of radius : ±1mm? (yoke)

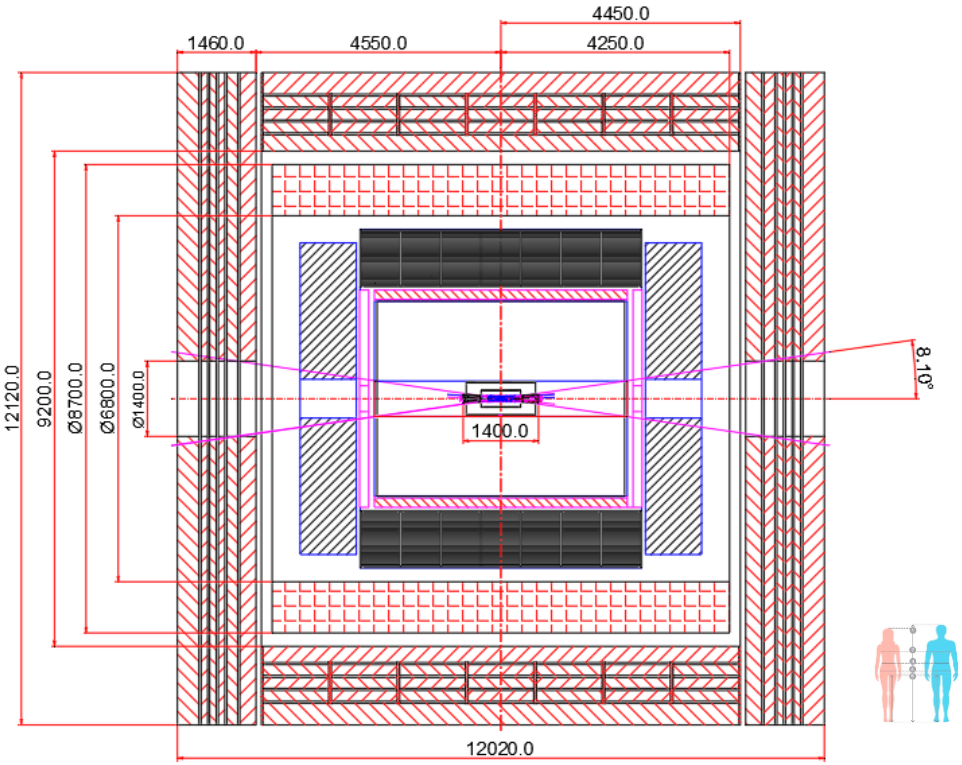
--Concentricity with beam : ±1mm? (yoke…)

--**Modularized design**: each detector can be installed and maintained as integrated module.

--Cooling?

--Vacuum?

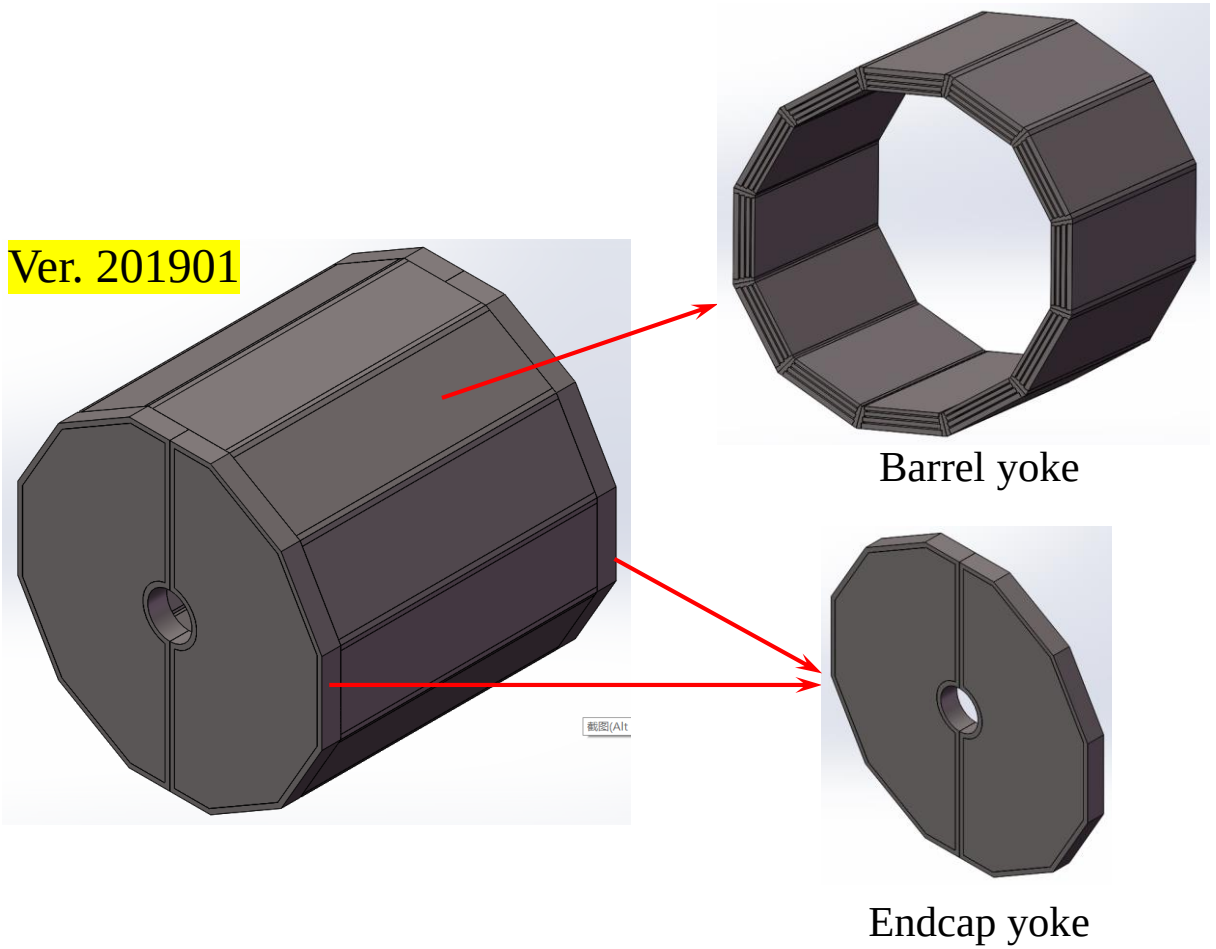
…



2. 1 Yoke—barrel yoke

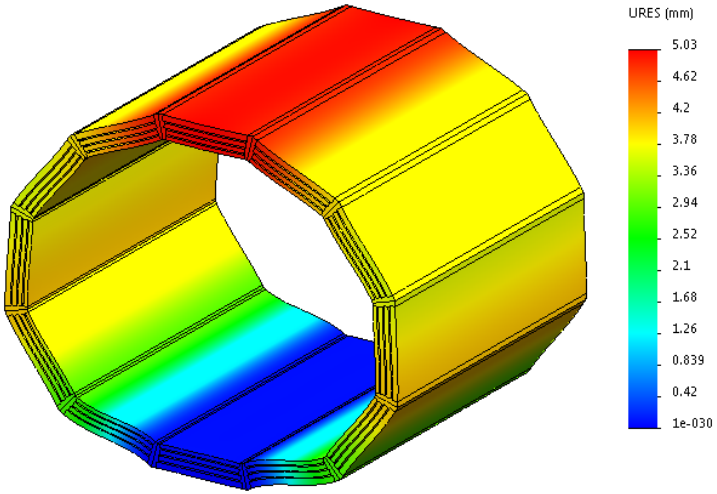
In order to reduce the weight of yoke, a **slimming style** design has been demonstrated.

Dimension:
OD=9600mm
ID=8400mm
Length=8090+600+600
=9290
Material: T10
Weight: 1500 tons

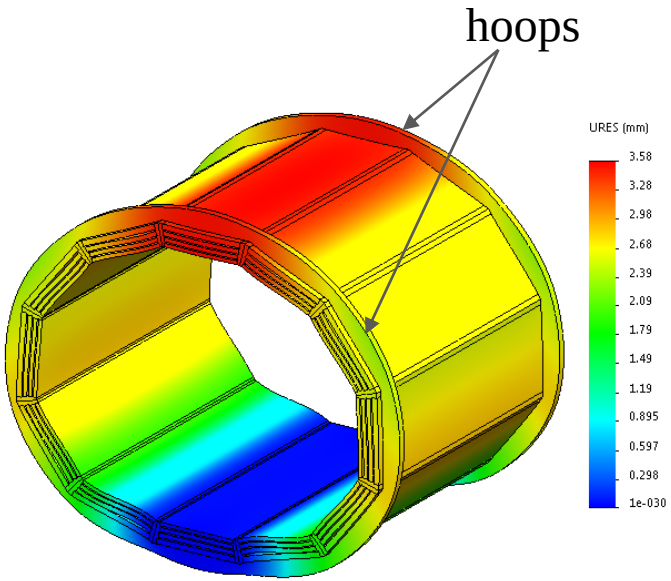


2. 1 Yoke—barrel yoke

Deformation due to gravity:



Max. = 5.03mm



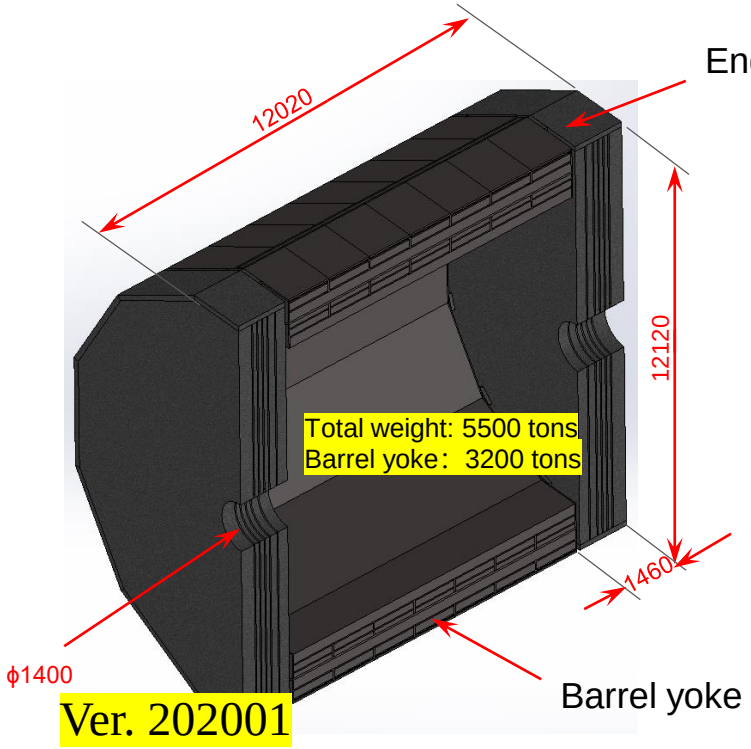
Max. = 3.08mm

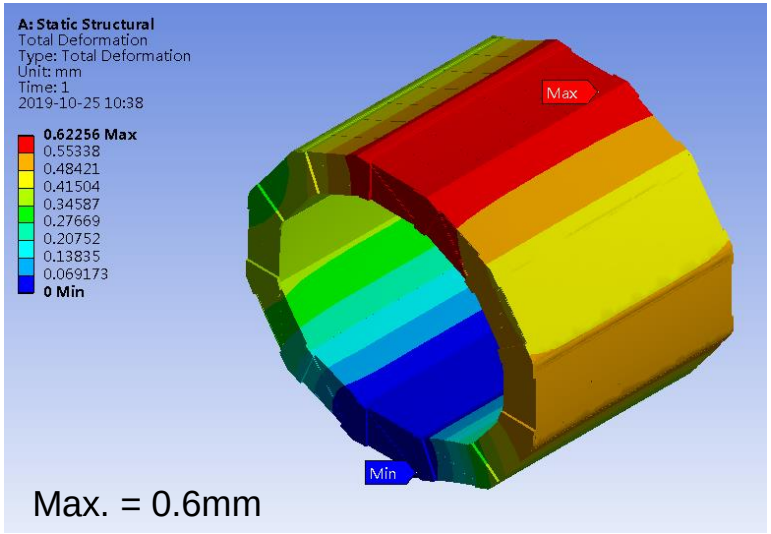
The deformation exceed the design requirement (±1mm).

Structure of barrel yoke should be strengthened!

2. 1 Yoke—barrel yoke

The deformation of barrel yoke with optimized dimension has been simulated:



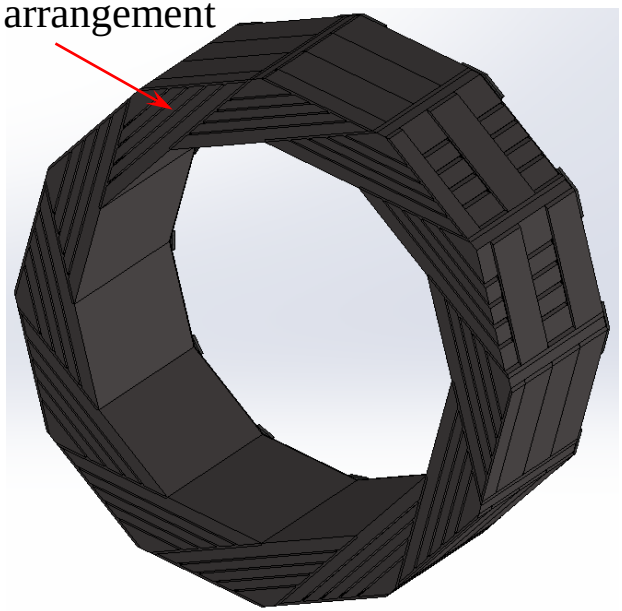


Meet design requirement!

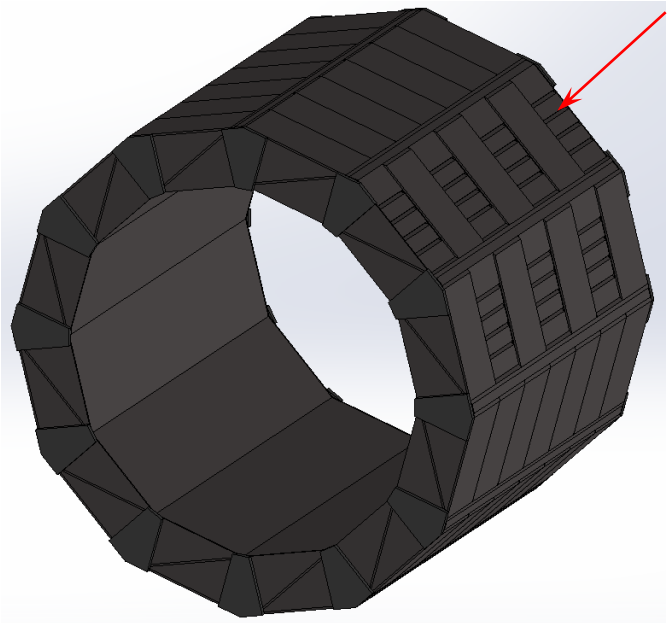
2. 1 Yoke—barrel yoke

Structural design:
--full range detection: helical arrangement
--installation/maintenance of muon detector: the outer surface can be removed to insert detector

Helical arrangement



Removed and insert detector

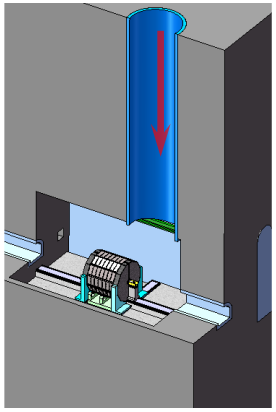


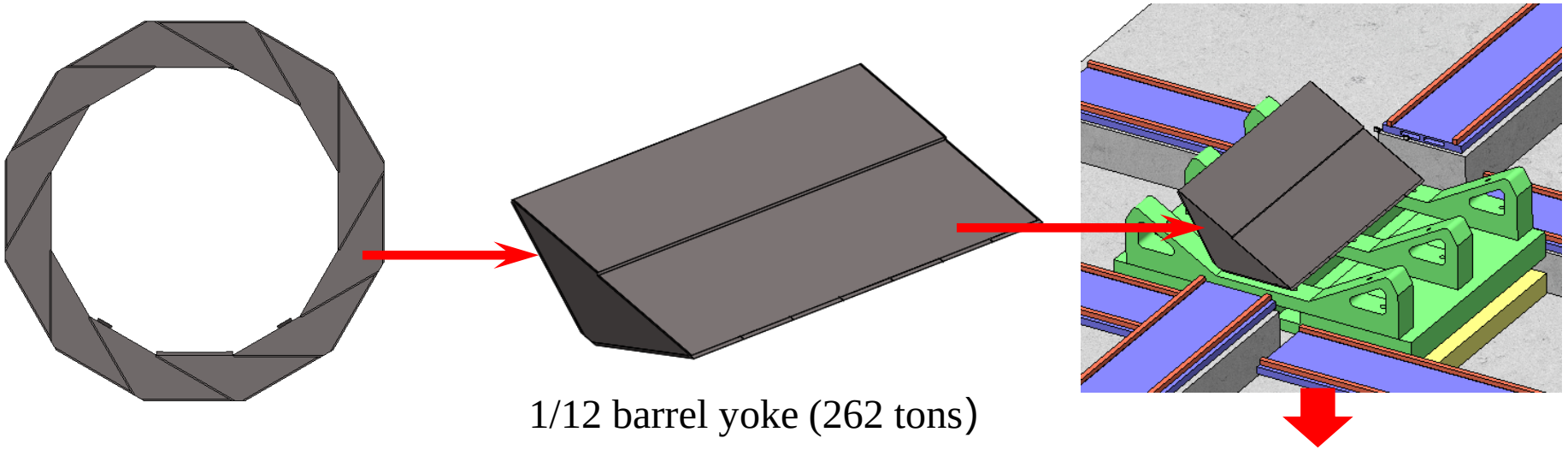
Full range detection and easy maintenance.

2. 1 Yoke—barrel yoke

Structural design:

--installation: every 1/12 yoke is designed to be a sub-assembly, which will be assembled on ground and hoisted down to main cavern.

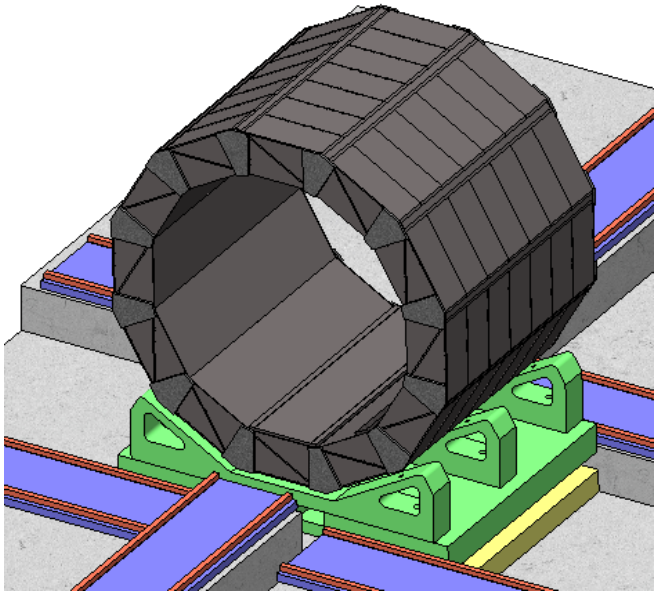


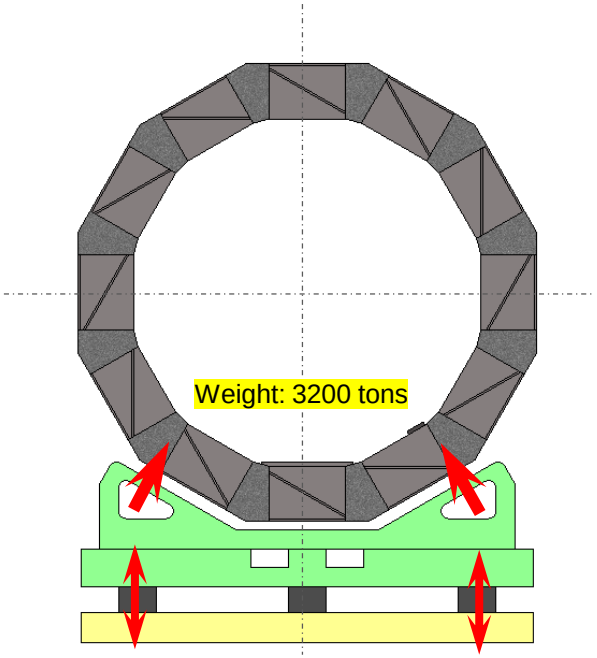


1/12 barrel yoke (262 tons)

2. 1 Yoke—barrel yoke

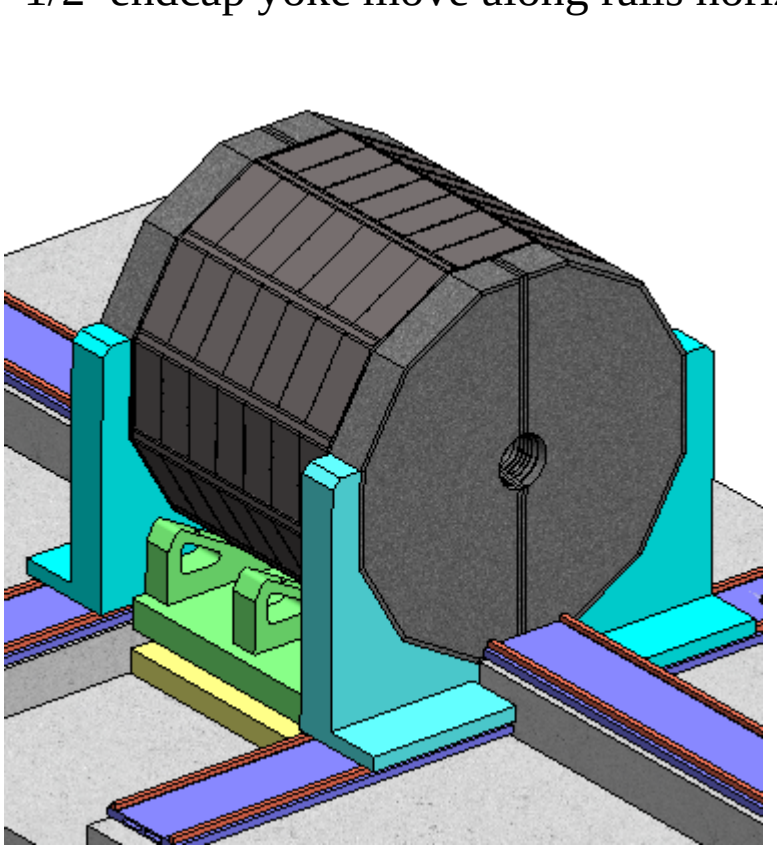
Supporting and position adjustment structure of barrel yoke:

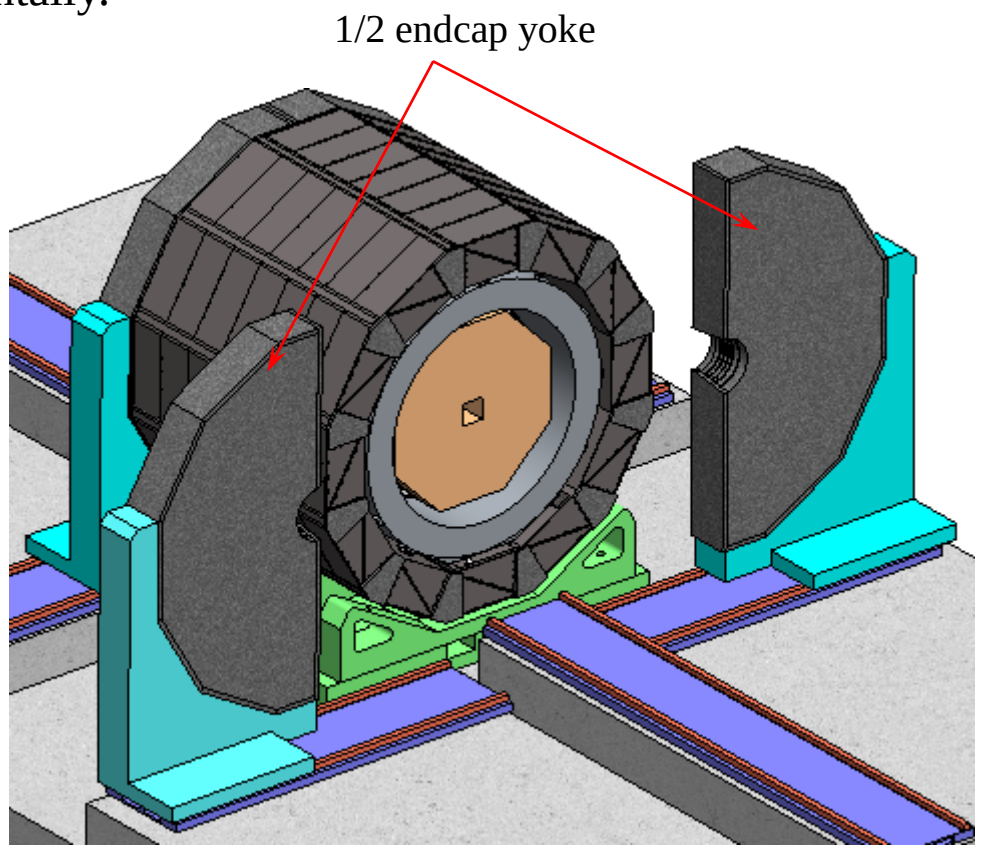




2. 1 Yoke—endcap yoke

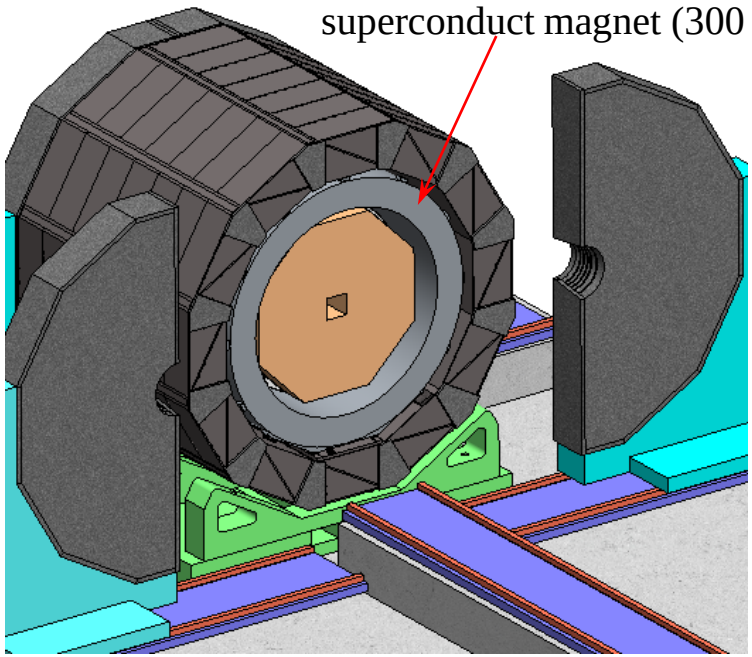
Unfolding mechanism:
1/2 endcap yoke move along rails horizontally.

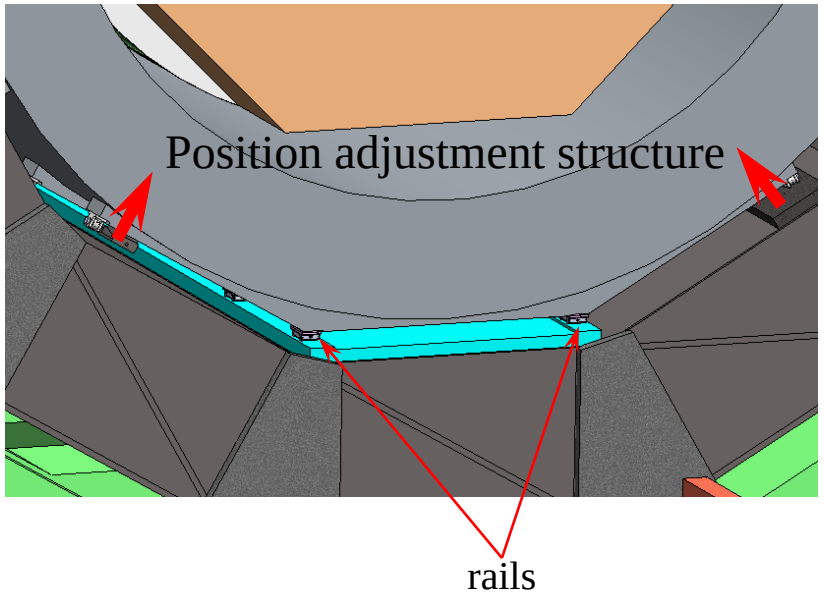




2. 2 Magnet

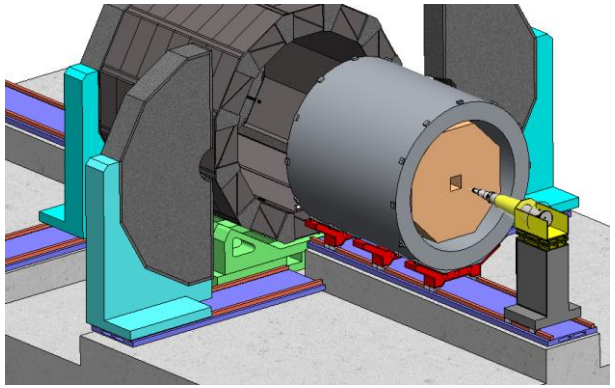
Supporting and adjustment structure:

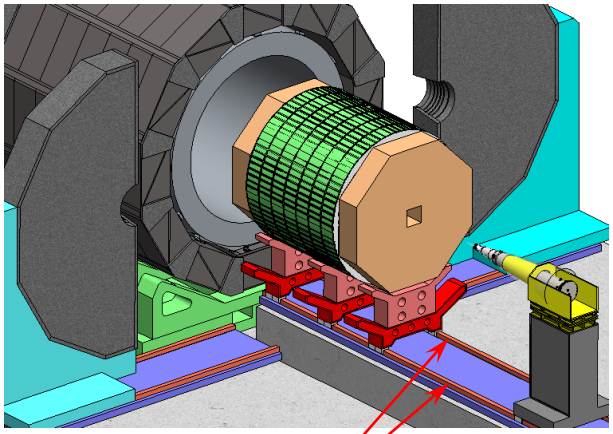


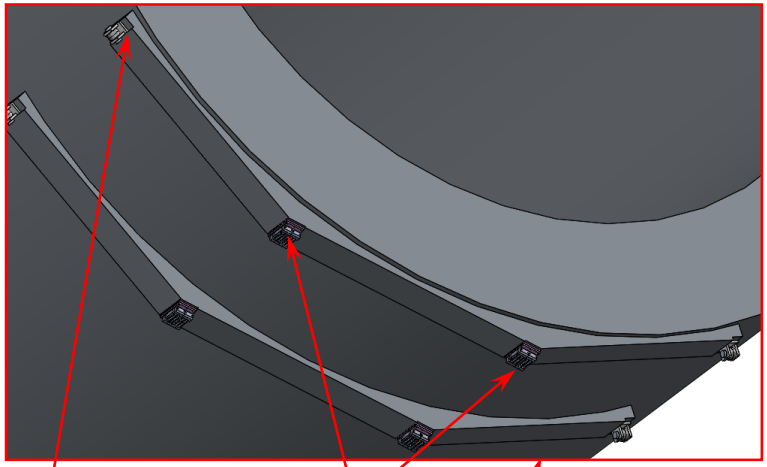


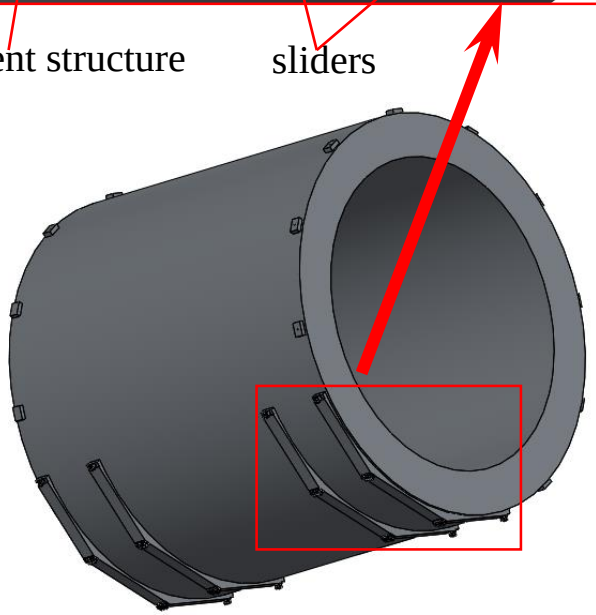
2. 2 Magnet

Magnet and each detector can be retracted and moved along the rails as a module, and share the same moving and position adjustment structure.



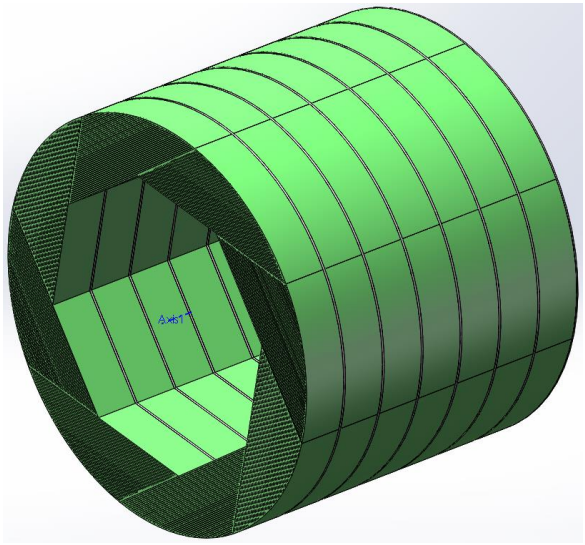


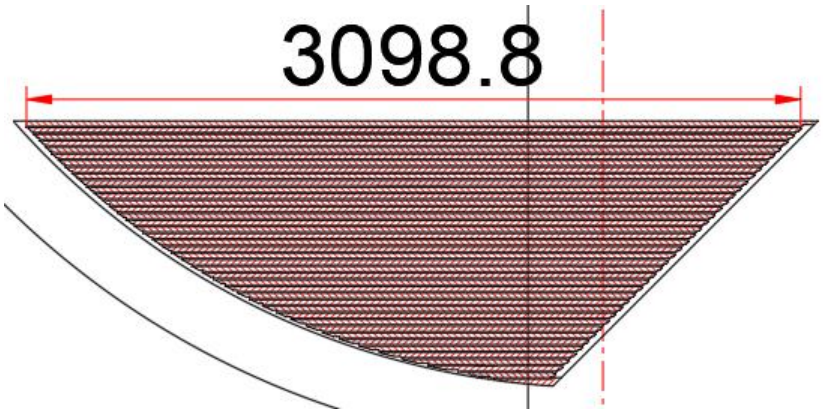


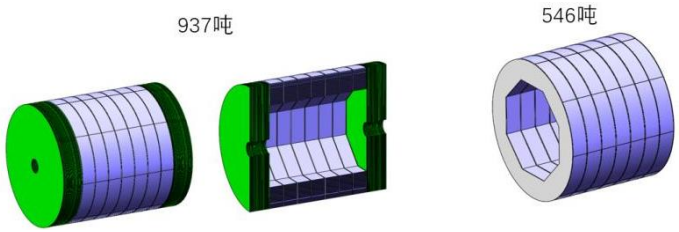


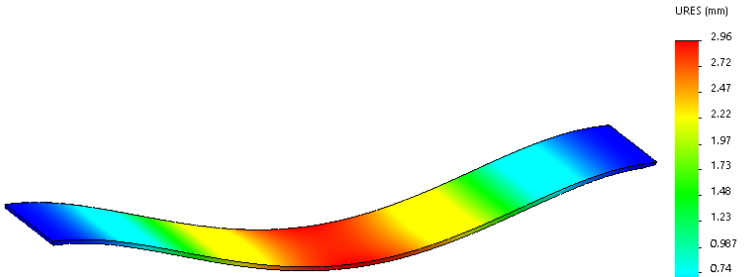
2. 3 Calorimetry

A conceptual mechanical design of HCAL:









Max. deformation = 3 mm

Gap for detector： 11.5mm

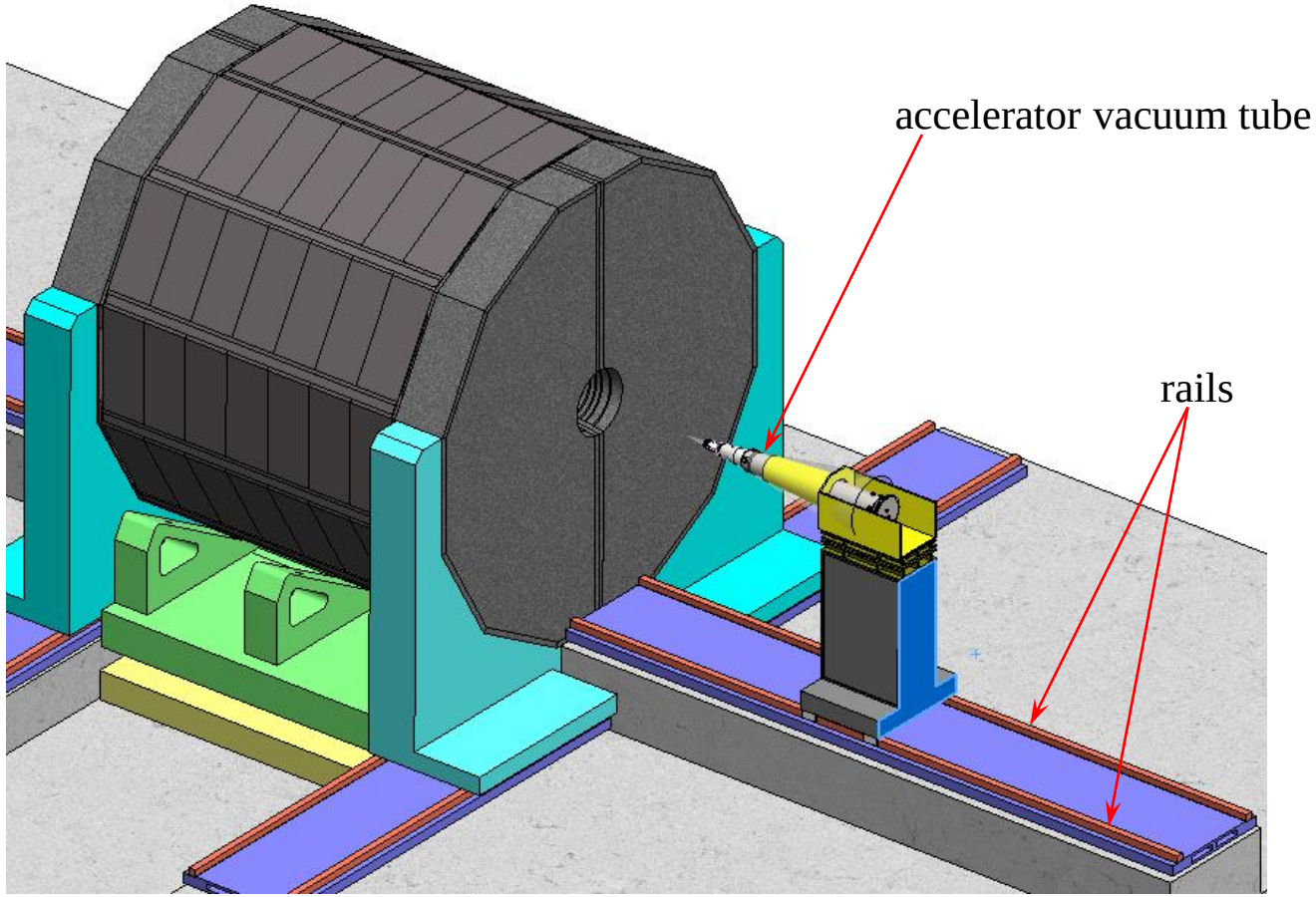
Need further optimization!

ECAL? Need more detailed requirements.

2.4 Interface with accelerator vacuum tube

(1) Rails

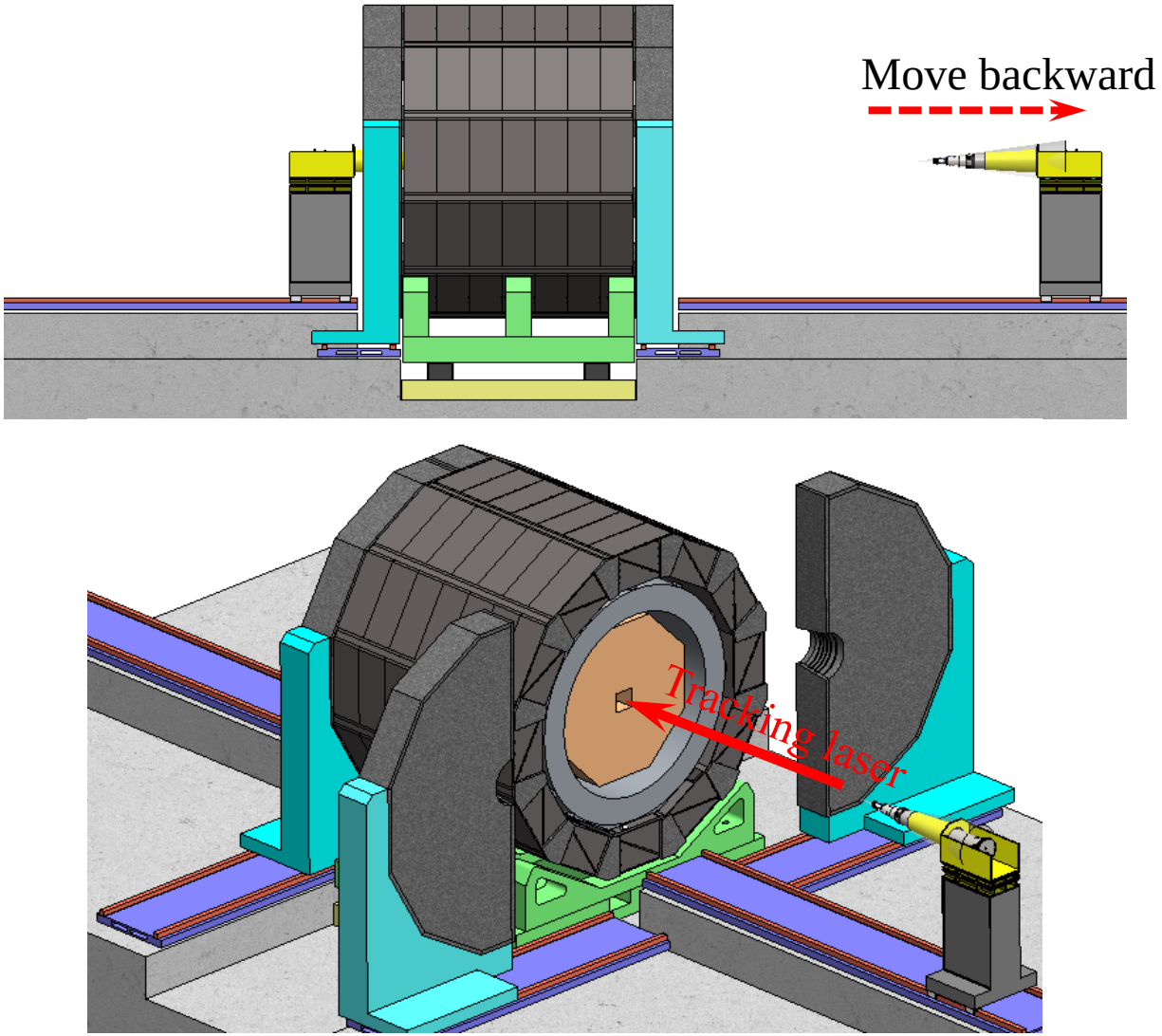
Share the same rail with detectors installation.



2.4 Interface with accelerator vacuum tube

(2) Position alignment tracking

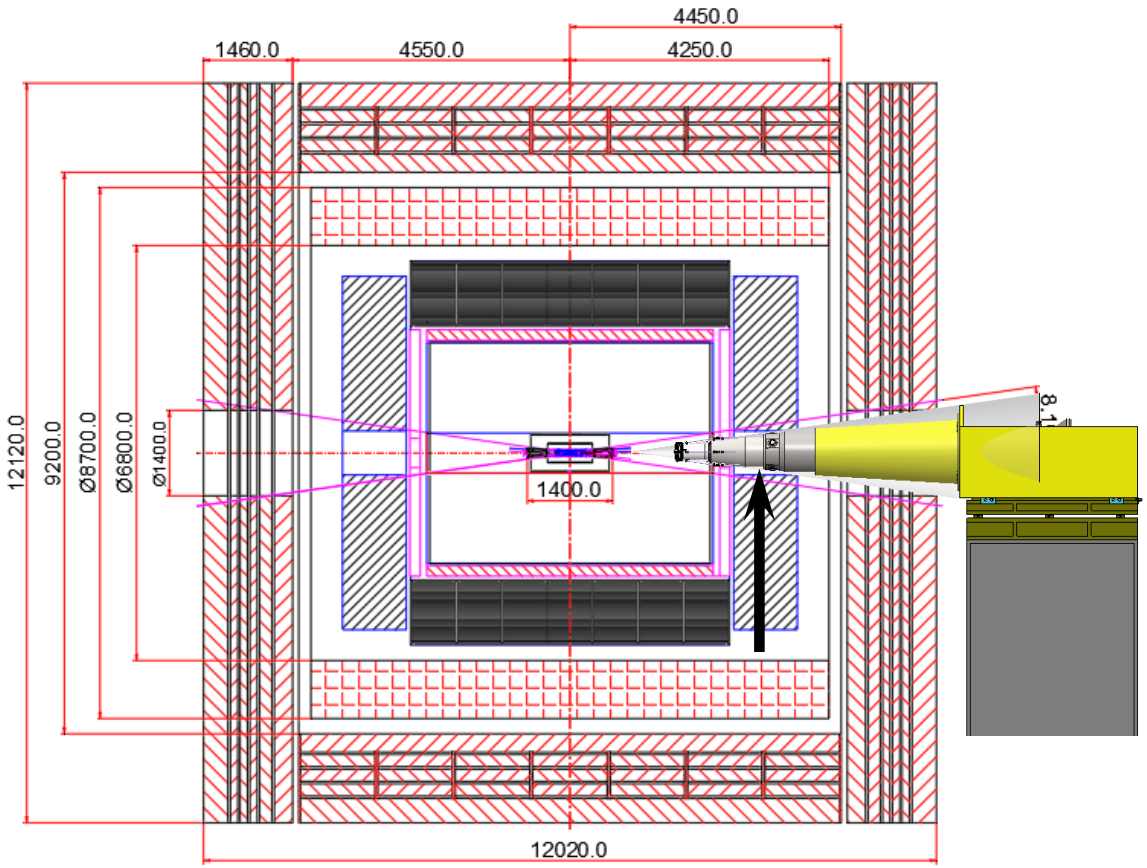
The alignment tracking laser go through the center of detector.

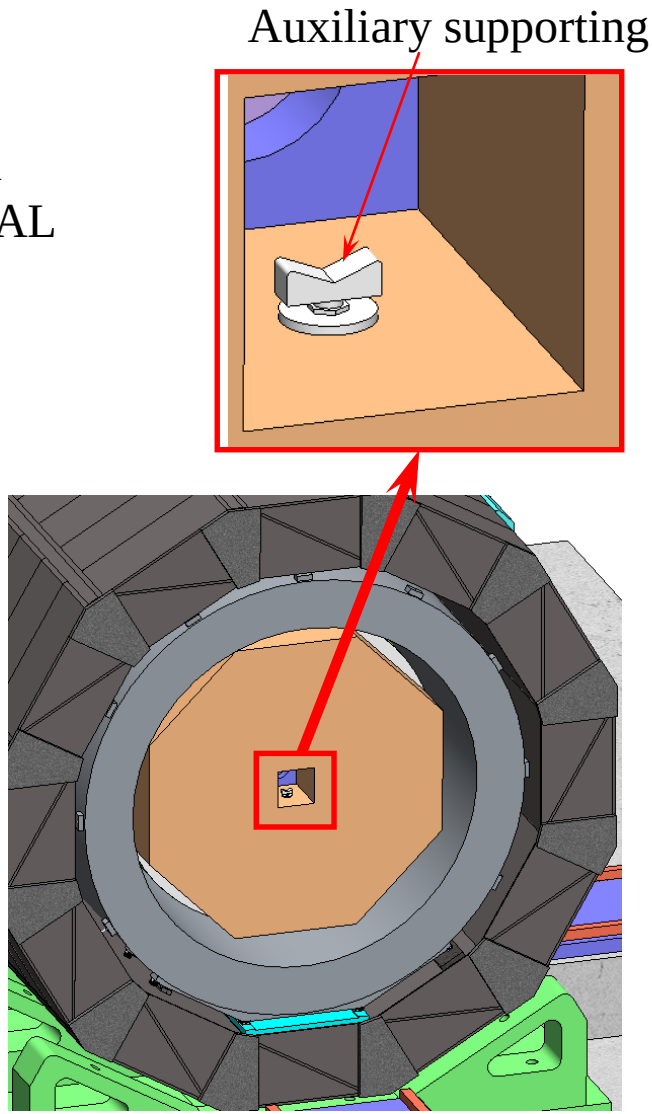


2.4 Interface with accelerator vacuum tube

(3) Auxiliary supporting

An auxiliary supporting point for cantileveredly mounted accelerator vacuum tube is set in the entrance port of HCAL endcap, to mitigate the deformation and vibration.





2. 4 Summary of the present design

(1) Preliminary mechanical design of yoke is presented, and further optimization and detailed design is needed.

(2) The engineering design of calorimetry is in a very early stage, more detailed requirements is needed.

(3) All of the detectors can be installed and maintained as an integrated assembly and share the same moving and position adjustment structure.

Outline

1. Overview
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4. Summary

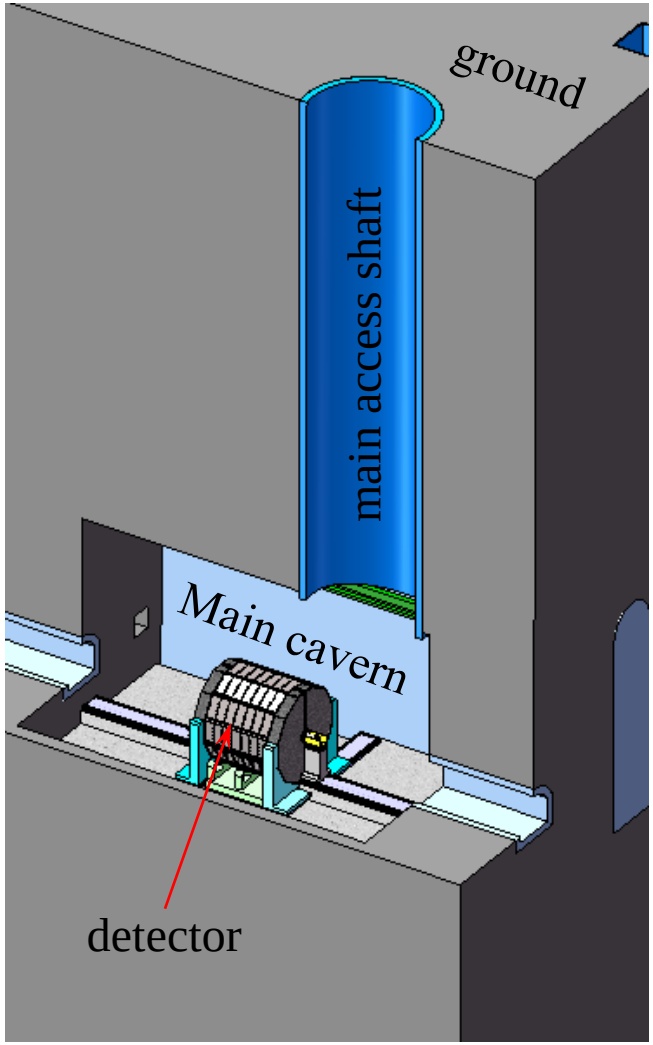
3. Preliminary design of installation scheme

Principles:

(1) Less operation in cavern: In order to reduce operation inside the main cavern, most of the components (within the crane capacity) should be assembled on ground;

(2) **Modularized concept:** Magnet and each detector can be withdraw and moved along the rails as a module for installation and maintenance.

(3) **Multifunctional,** rather than single-use, tools for installation and maintenance, save cost.



3.1 Size of main cavern and crane

(Zhu Zian，CEPC Detector Hall Issues，2020.3.25)

Main cavern:

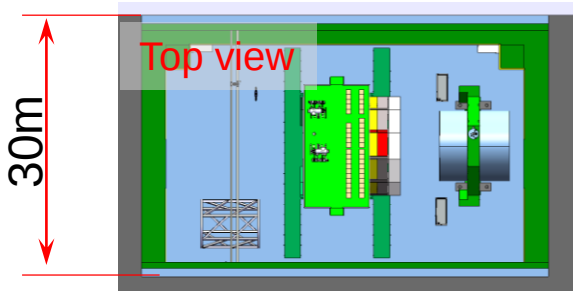
30x30x40m (HxWxL)

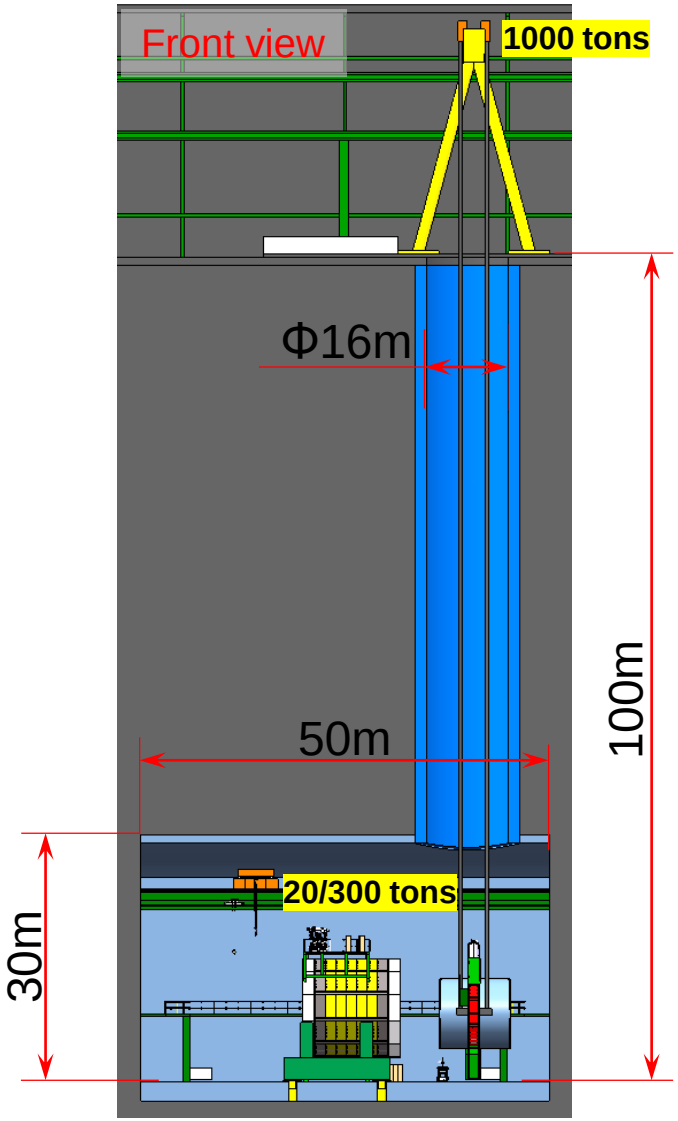
One main access shaft, Φ16m

2 Cranes:

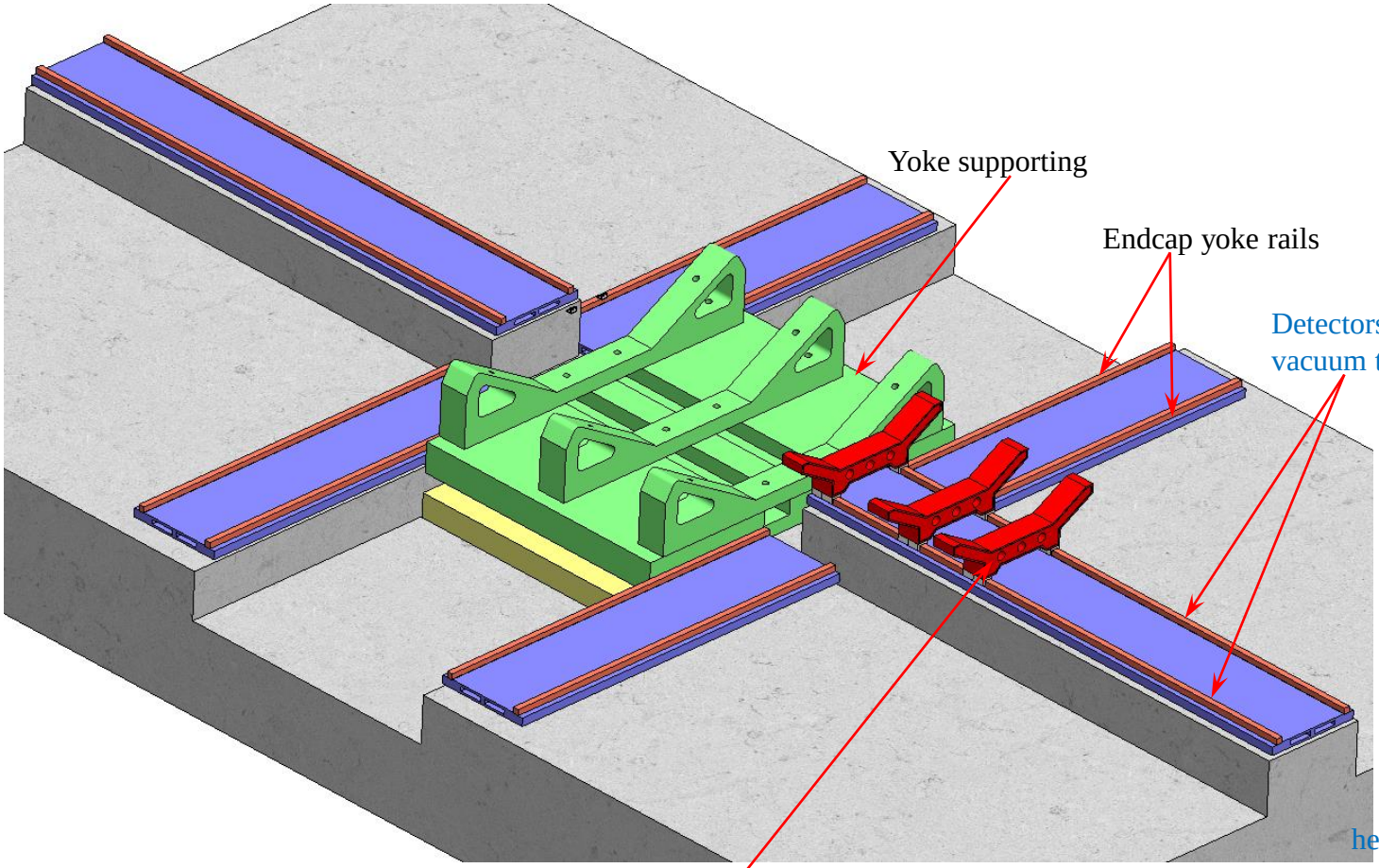
20/300 tons in main cavern

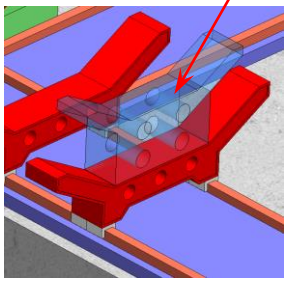
1000 tons on the ground access of the Φ16m shaft





3.2 Devices and tools applied to installation



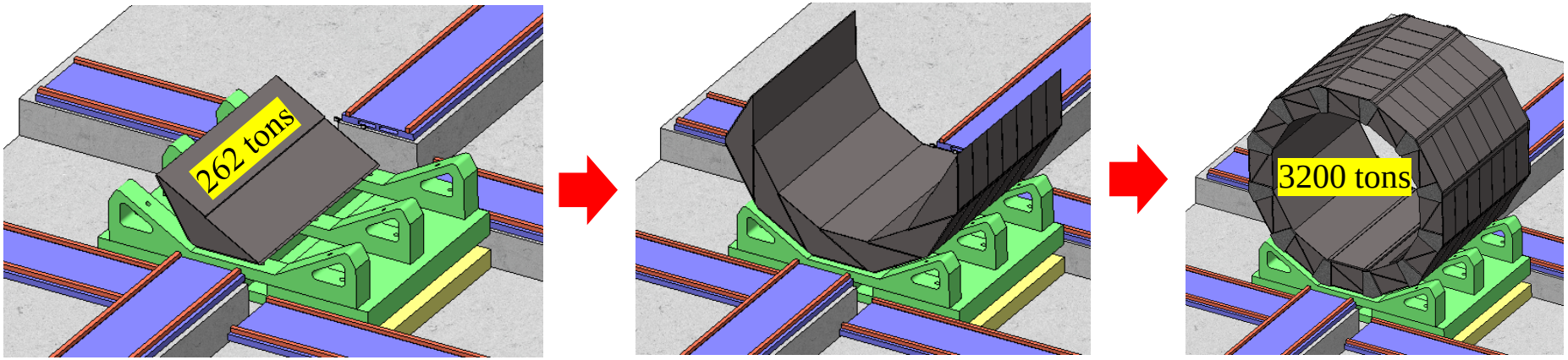


Detectors and accelerator vacuum tube rails and movable units are applied to both installation and maintenance.

3.3 Preliminary design of installation scheme

The following slides show the main flow of installation.

Step 1, barrel yoke
1/12 barrel yoke is assembled on ground, and hoisted down to main cavern for installation.



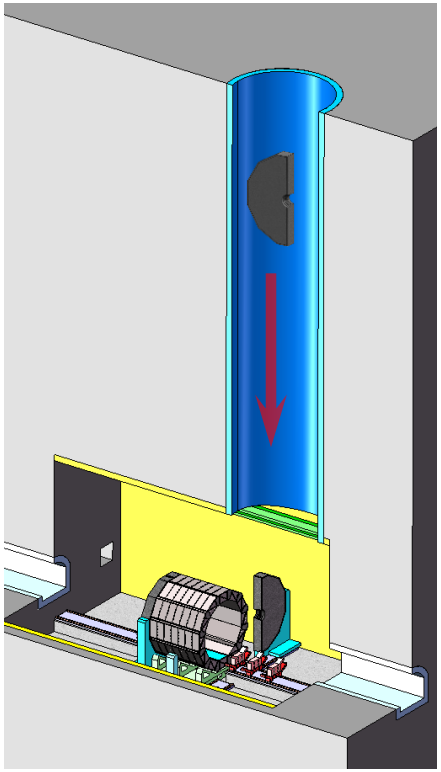
3.3 Preliminary design of installation scheme

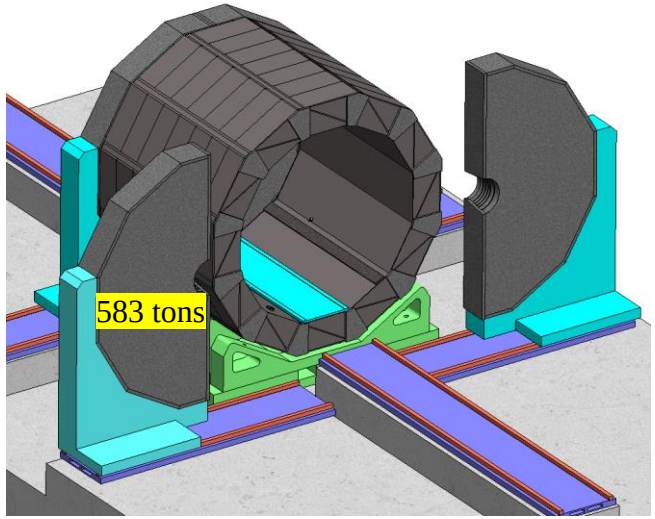
Step 2, endcap yoke

1/2 endcap yoke is assembled on ground, and hoisted down to main cavern for installation.

Weight of 1/2 endcap yoke: 583 tons, >300 tons (capacity of crane),

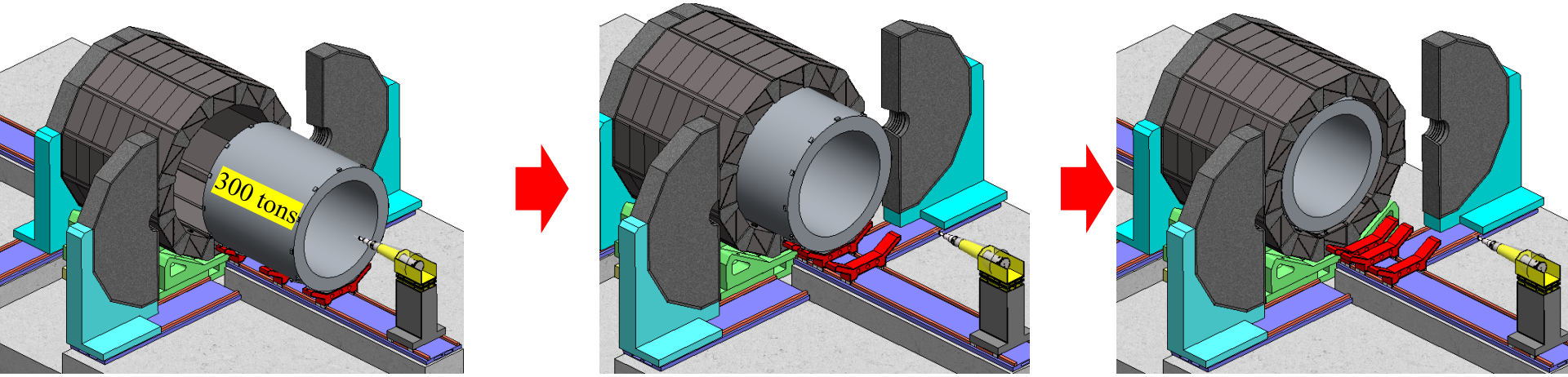
need more segments (1/4?), or increase the capacity of crane.





3.3 Preliminary design of installation scheme

Step 3, magnet
--hoisted down to main cavern; for installation.
--supported and driven into yoke by movable units.

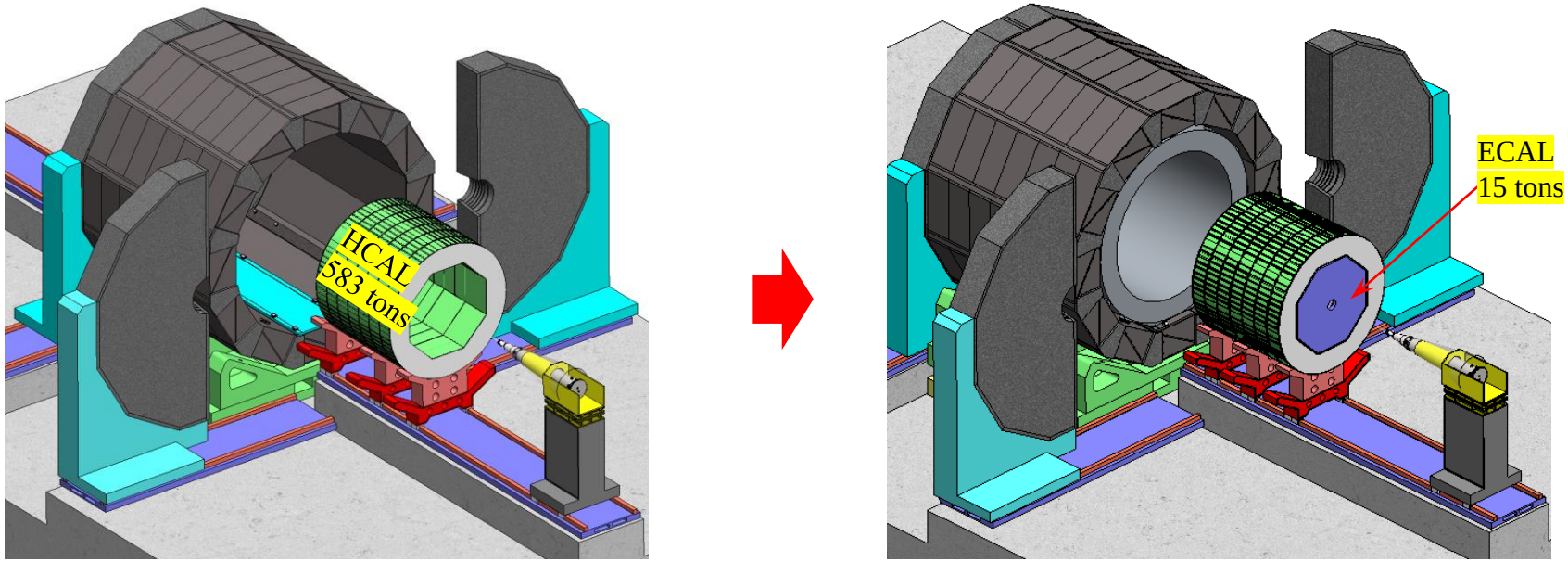


3.3 Preliminary design of installation scheme

Step 4, calorimetry (HCAL and ECAL)

-- HCAL is hoisted as a module down to main cavern and supported by movable units.
(583 tons > 300 tons - capacity of crane, or increase the capacity of crane?)

-- ECAL is hoisted as a module down to main cavern and driven into bore of HCAL.

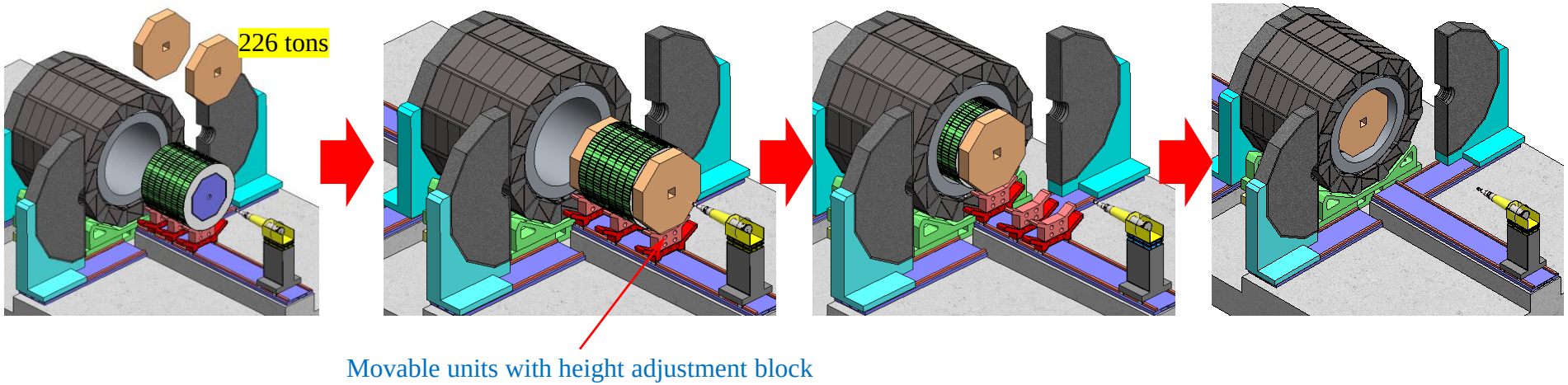


3.3 Preliminary design of installation scheme

Step 4, calorimetry (HCAL and ECAL)

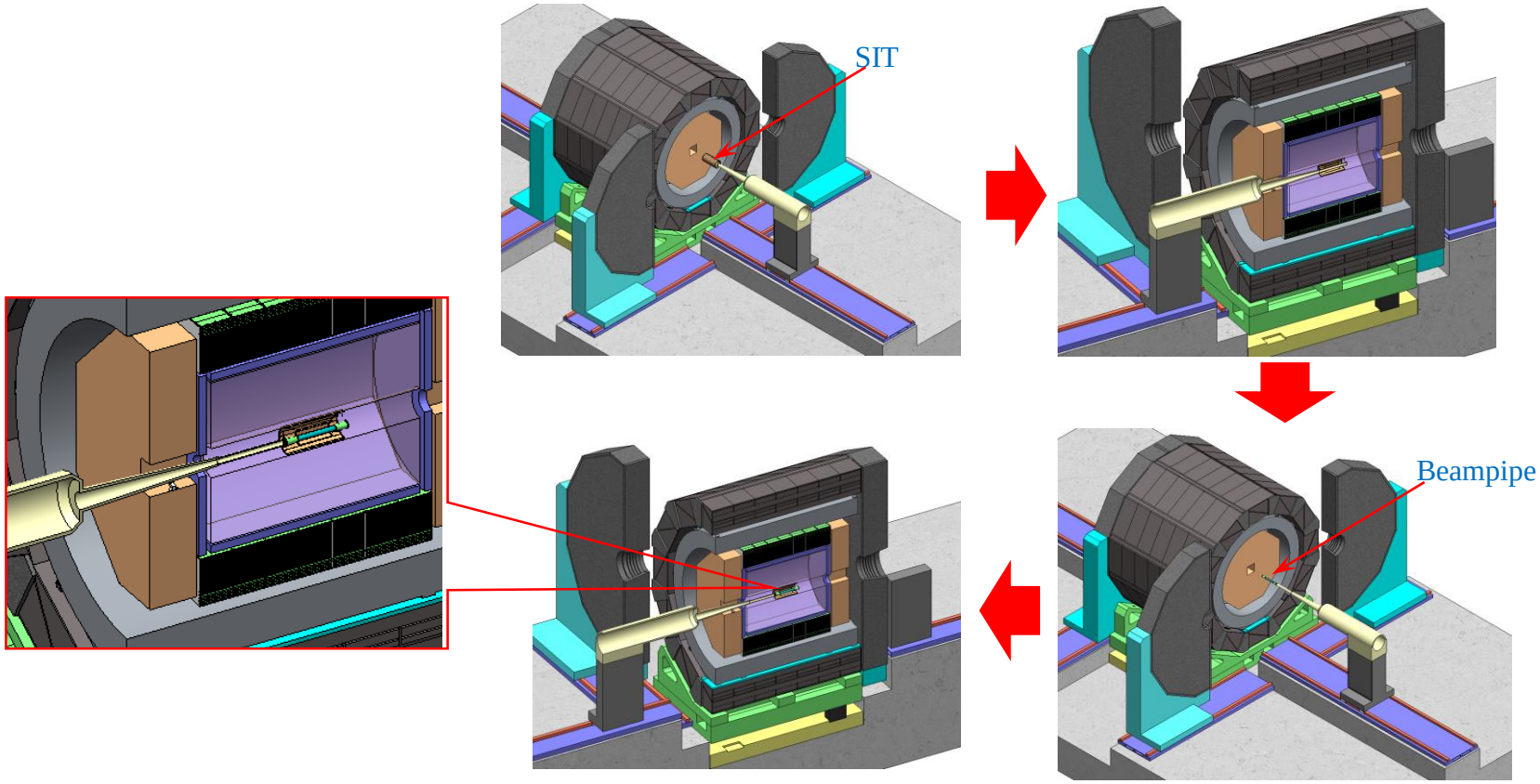
-- Endcap of HCAL is hoisted as a module down to main cavern and supported by movable units.

-- HCAL and ECAL is driven into bore of magnet by movable units.



3.3 Preliminary design of installation scheme

Step 5, beampipe (VTX, SIT)
-- driven by cantileveredly mounted fixture into interaction region.



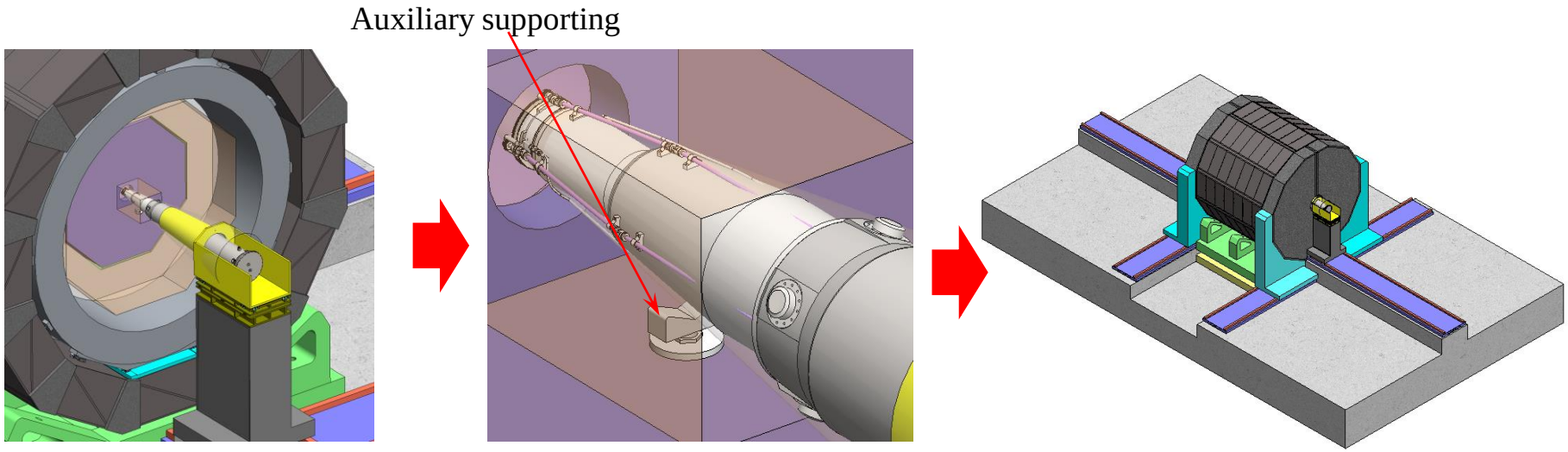
3.3 Preliminary design of installation scheme

Step 5, accelerator vacuum tube

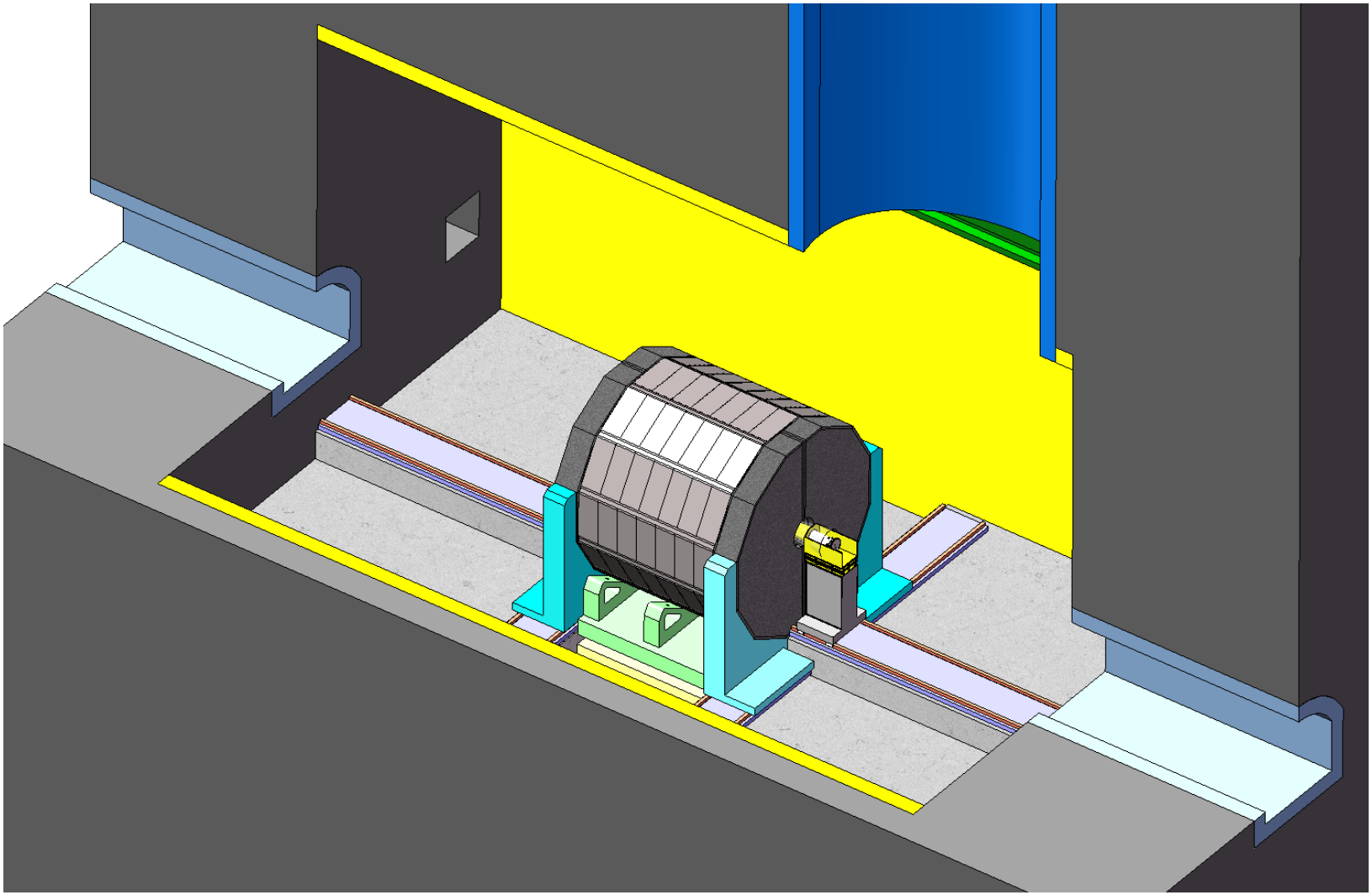
-- drive the accelerator vacuum tube to the operation position and adjust the Auxiliary supporting.

-- connect the sealing structure between accelerator vacuum tube and beampipe.

-- close the endcap yoke.



3.3 Preliminary design of installation scheme



Outline

1. Overview
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4. Summary

4. Summary

(1) Preliminary mechanical design,

*-- structure of **yoke** has been optimized, and the deformation due to gravity meet design requirement. Detailed design is still needed.*

*--The engineering design of **calorimetry** is very preliminary, more detailed requirements is needed.*

*--**Modularized design** concept is adopted. All of the detectors can be installed and maintained as an integrated module and share the same moving and position adjustment structure.*

(2) Preliminary design of installation scheme,

*--A **modularized installation concept** is presented. Most of the components will be assembled on the ground and the magnet and each detector can be retracted and moved along the rails as a module for installation and maintenance.*

*--**Demonstration for installation details** is needed.*

Next step…

Further engineering design of structure and installation scheme under specific design requirement,

--Dimension, material, connection, … , of sensor units for Muon, HCAL, ECAL …

--Cooling

--Vacuum

--Position accuracy

--Maintenance

…

Thanks!