

The ILD - Barrel, End Cap integration

- current design with 9 meters beam height -
- Transport in Japan below 25 tones per part -
 - alternative design of yoke modules -

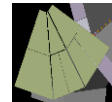
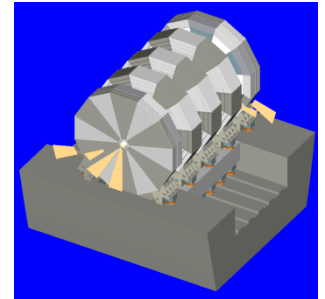
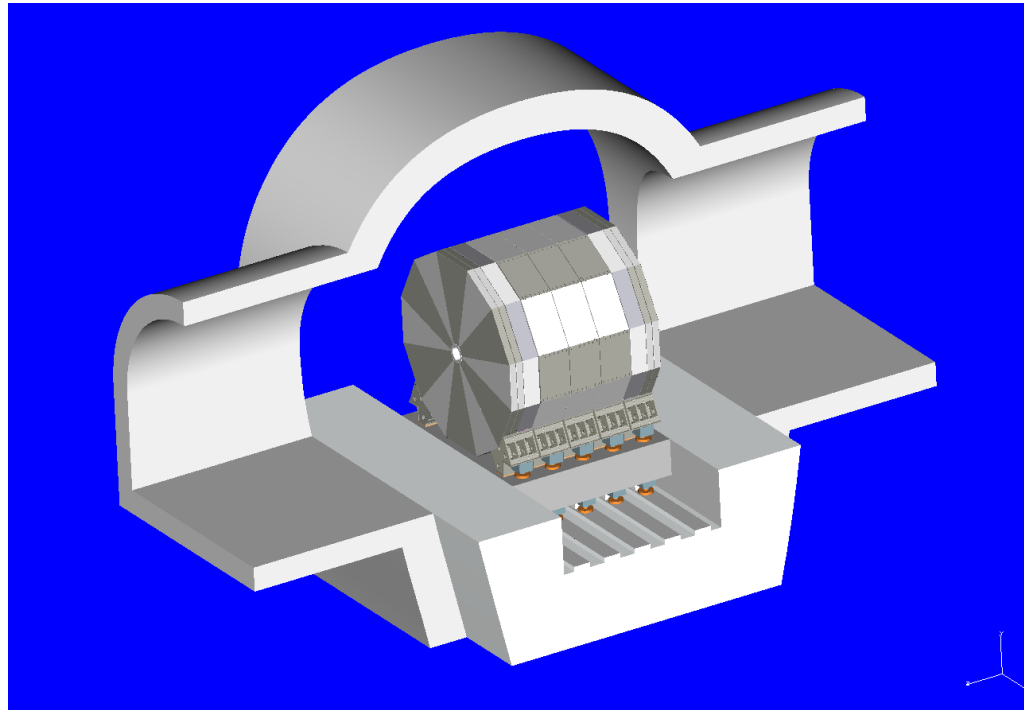
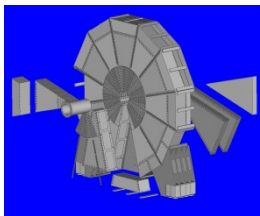
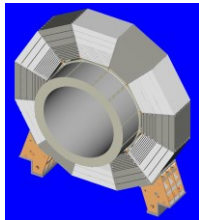
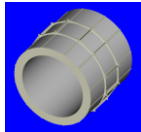


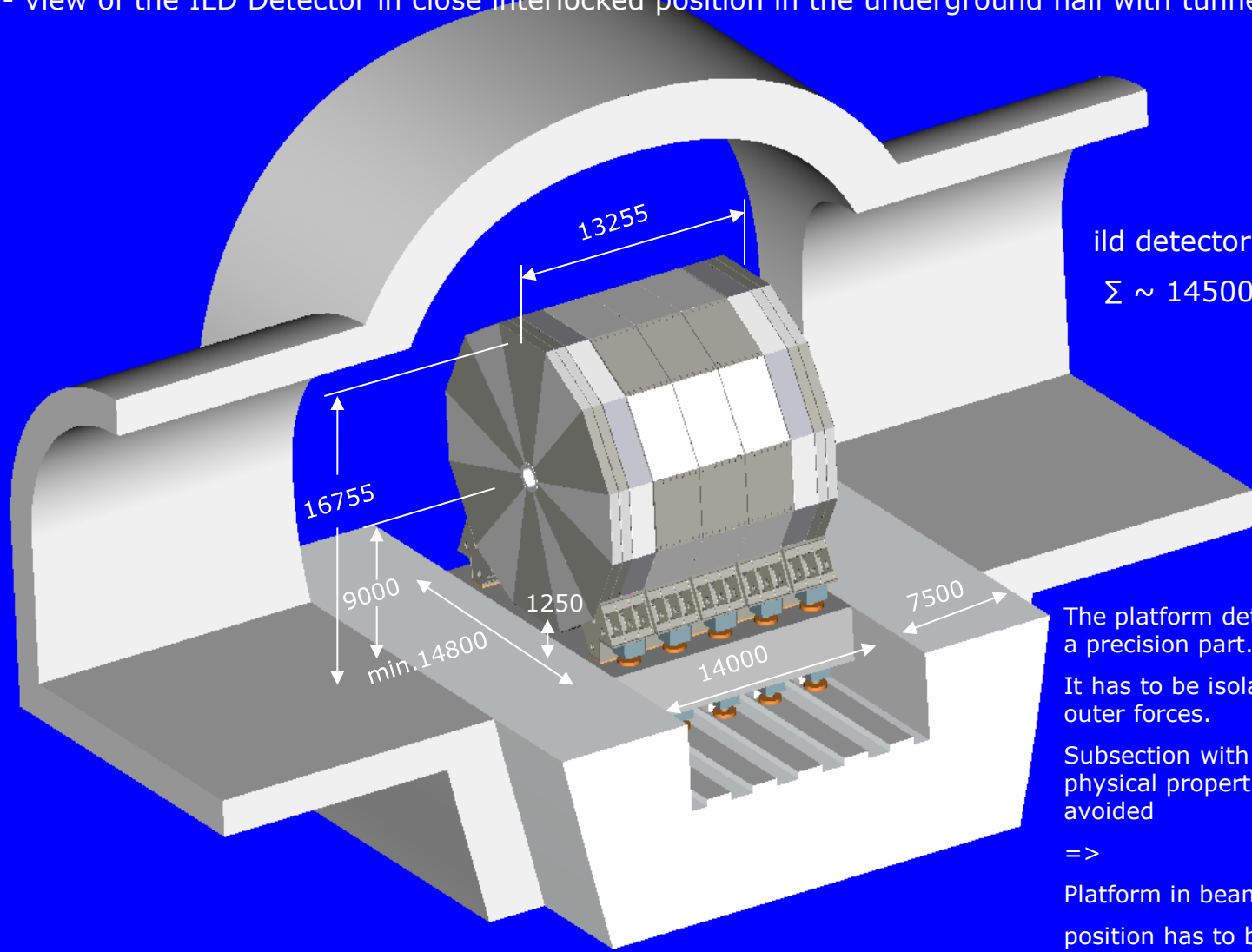
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- view of the ILD Detector in close interlocked position in the underground hall with tunnel



ild detector weight
 $\Sigma \sim 14500$ tons

The platform detector unit is a precision part.

It has to be isolated from outer forces.

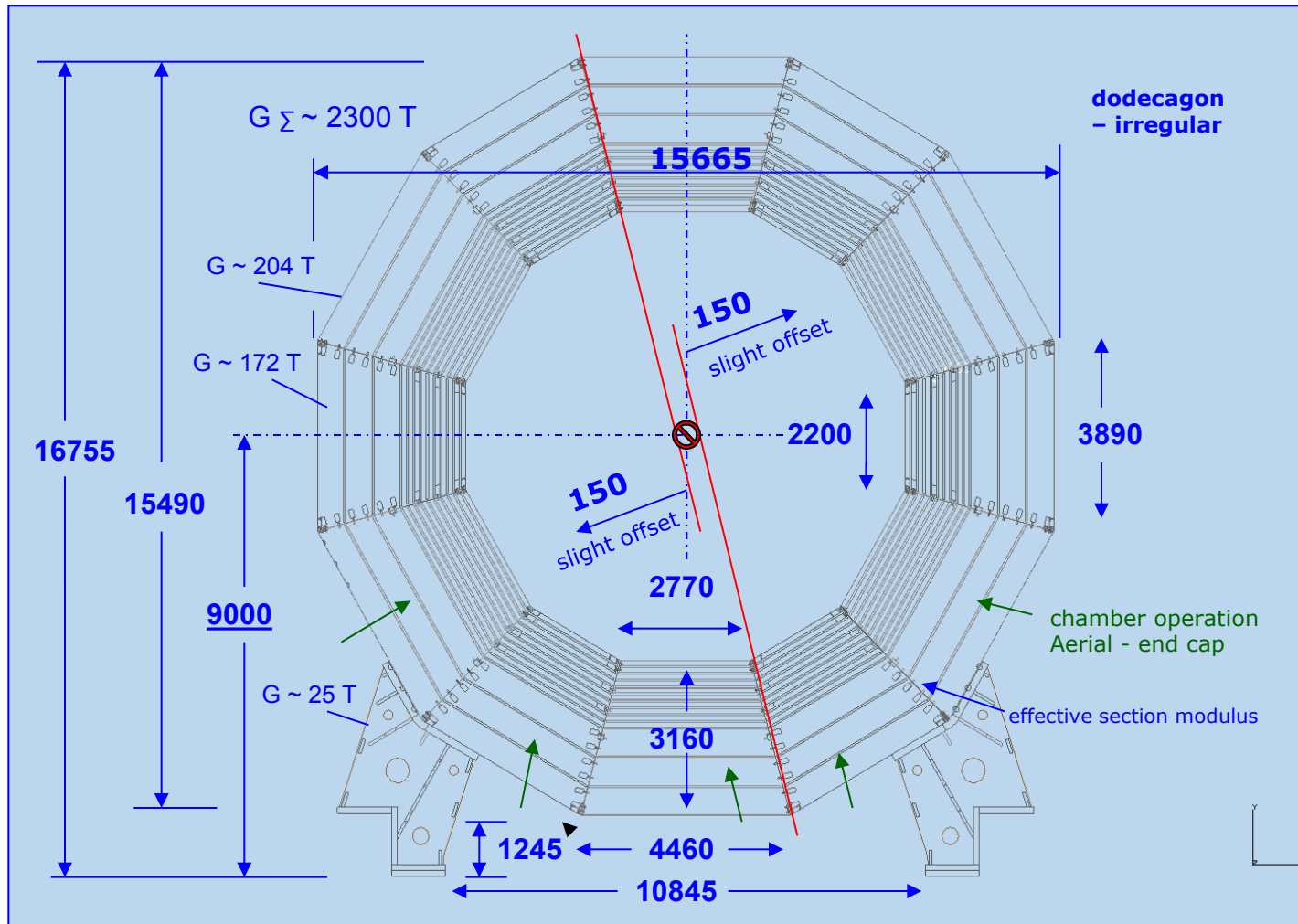
Subsection with different physical properties are to be avoided

=>

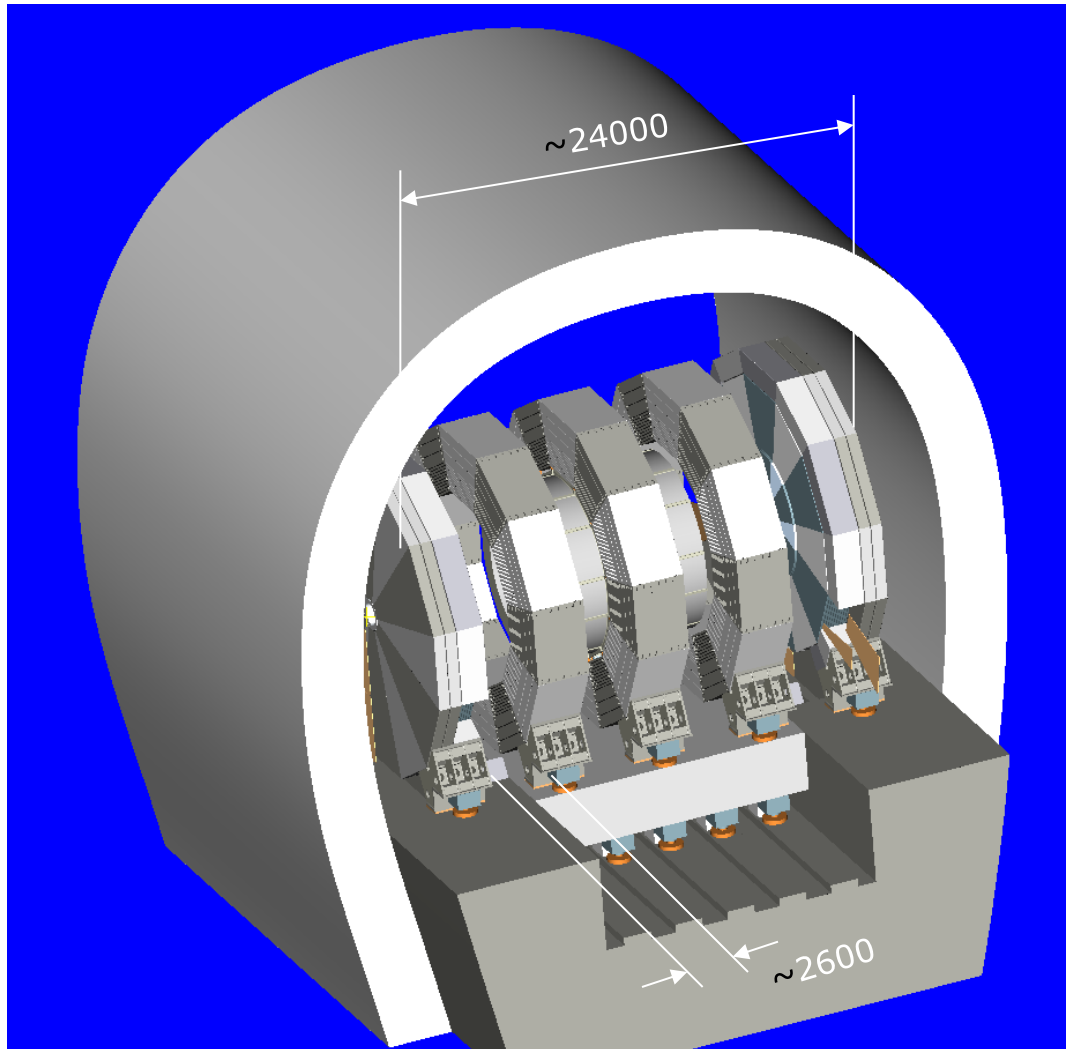
Platform in beam position has to be locked.



- barrel geometry / dodecagon have irregularly geometry -
 slight offset 150 mm



Overview of The Detector / shut-down time in the hall

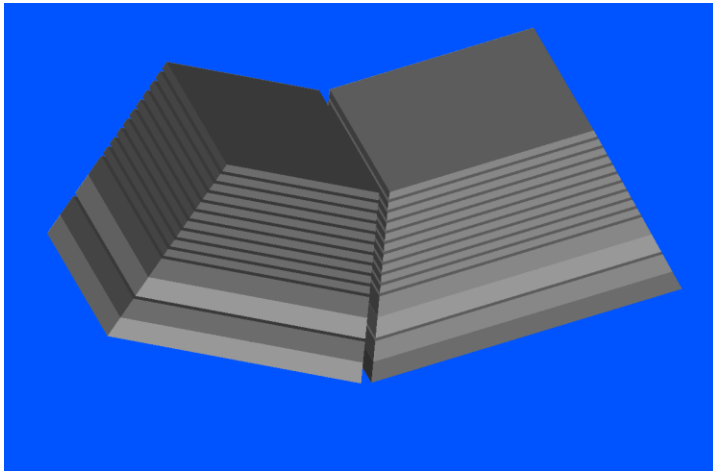


Hall for detector and acquirment required area estimate:

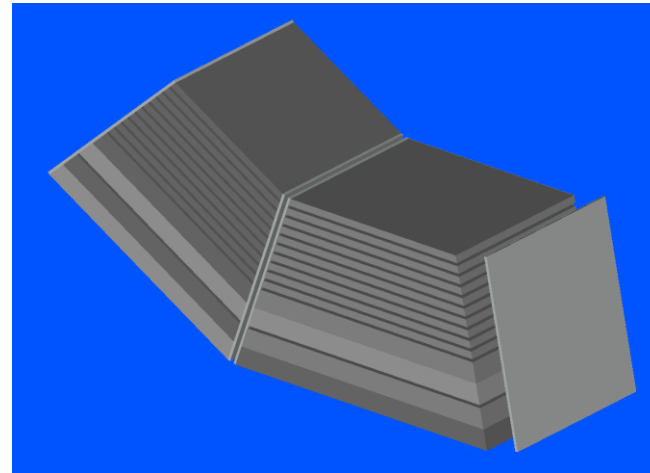
- escape route
- service operation
- scaffolding
- ladder
- cables
- cooling and gas system
- crane and movable device
- distance to crane working aerial
- operation tunnel for the chamber
- platform position locking safety system
- radiation shielding wall
- interlock set system
- general safety system (smoke-, gas detectors, fire fighting service...)
- light and more...

Barrel On-Site Installation

Proposal for all kind of transportation
no more than 25 tonns per transport and part
Barrel and End-Cap consisting of singles board
12 wedge-shaped modules



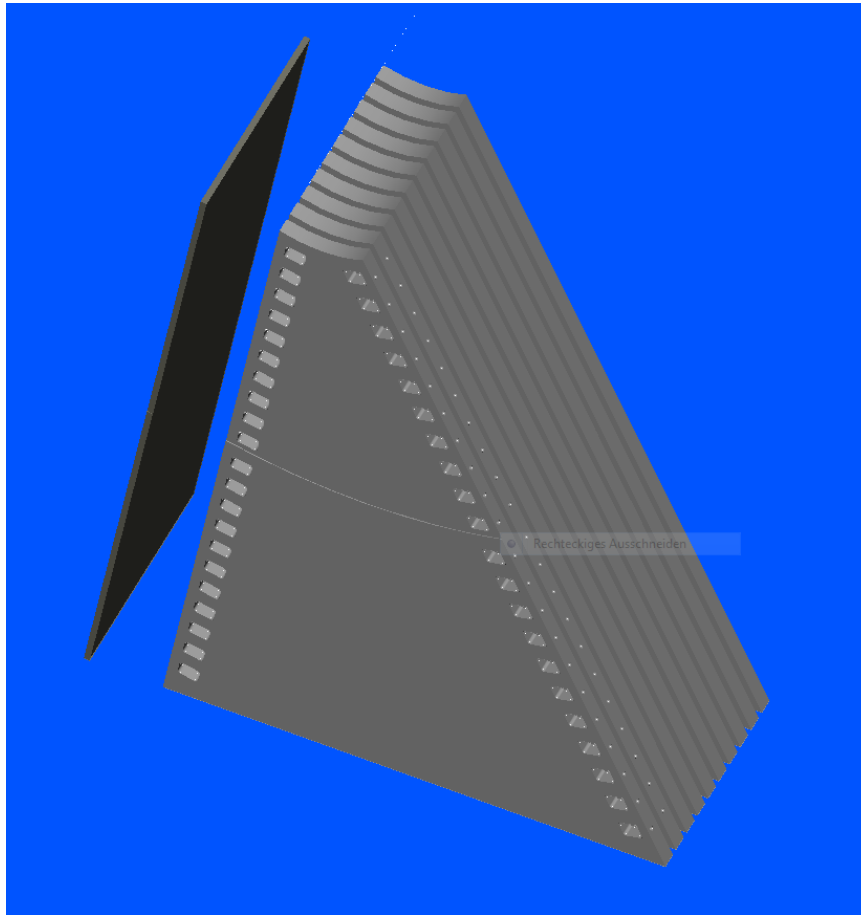
- all assembly and module screwable
- alternative: all assembly welded and machined to module
- module screwable



Production requirements on-site
needed:

- manufacturing machines
- welded activity area
- hall (temporary hall), fundament ...

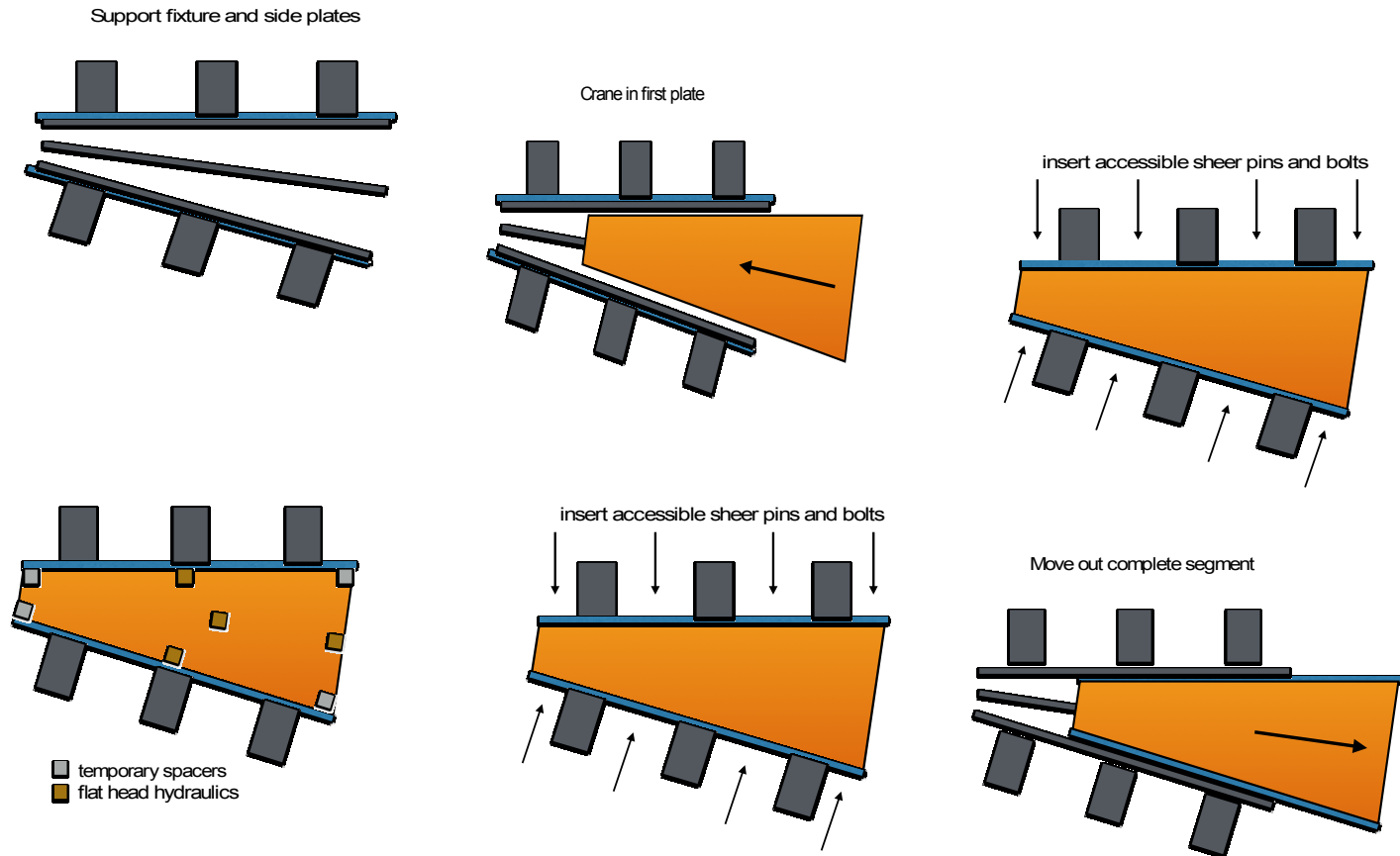
End-Cap On-Site Installation



Inner end-cap
Consisting of 12 wedge-shaped
modules
10 x 100mm thick plates
screwed together,
alternatively
welded together.

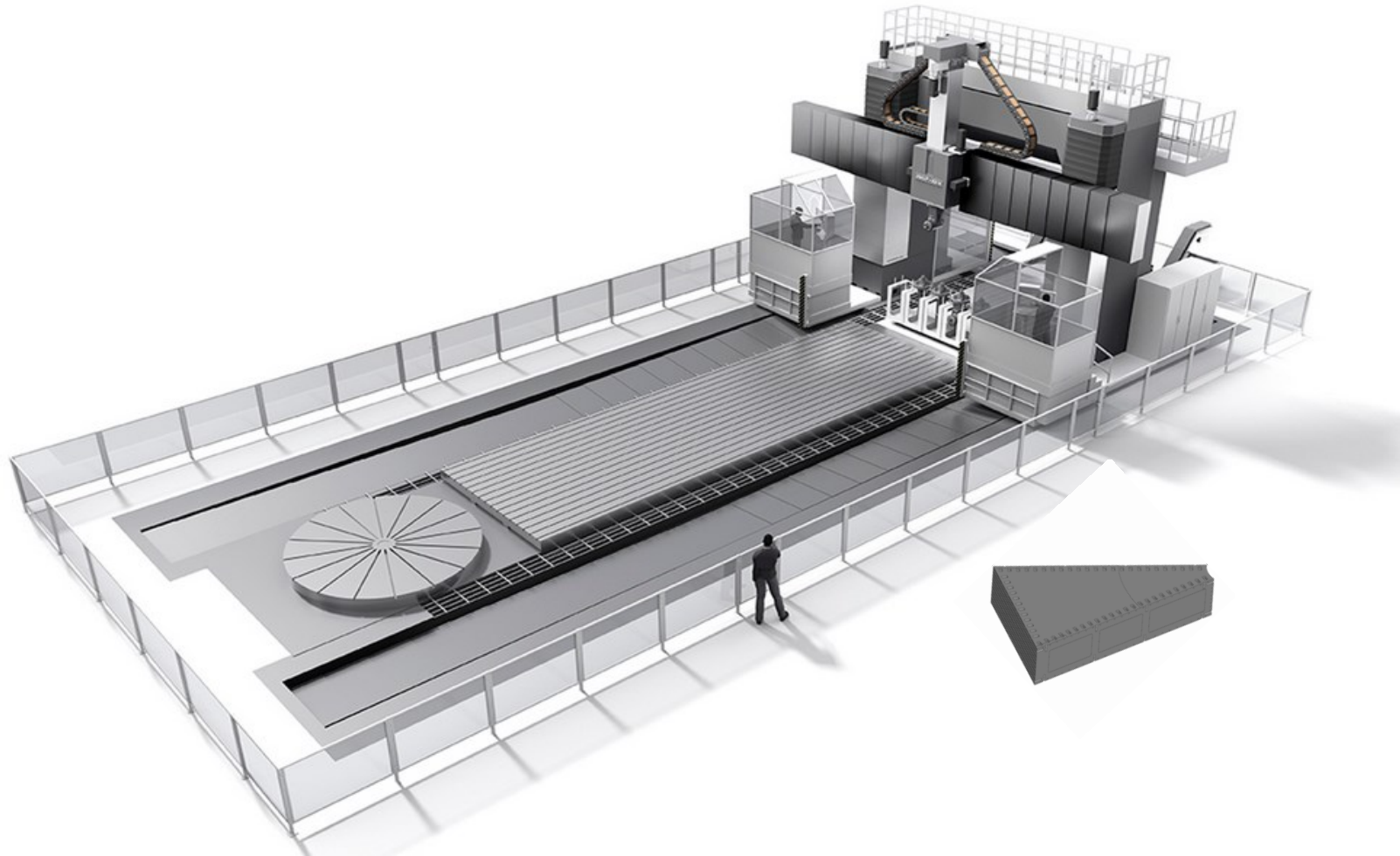
Modules bolted
together using M36 screws.

Proposal: fixture construction for End-Cap and Barrel welding or to bolt



Assembly line need 10 x 10 meters

Locally manufacturing need's mobile machining or/and welding center



Module Assembly – Rough Schedule



Inner End-Cap

- Quality control per module: 4 hours (1/2 day)
- jig manufacturing for setting of 10 plates, screw, bolt: 24 h.
- to tighten the screws with a torque wrench and lift from the device: 8 h.
- quality inspection / final acceptance: 4 h.

Total Area Time: 40 hours

- by End-Cap segment
24 pieces modules = 120 days (24 weeks)
- Man-power : chief engineer, 4 x mechanic technician operator, 3x crane operator,
2x survey technician



Module Assembly – Rough Schedule

Outer End-Caps

- Single modules too heavy for transport, should be divided into 3 pieces: 32 h per modules
- Total 48 modules → 192 days
- Outer radial pieces (to be completed)
- End-caps: total 312 days (without outer radial pieces)

Barrel wheels

- Inner barrel 10 plates
- Outer barrel 3 thick plates, each to be divide into 2 pieces: 6 thick plates
- 9 days per module
- 36 modules → 324 days
- Man-power : chief engineer, 4 x mechanic technician operator, 3x crane operator,
2x survey technician

Module Assembly – Rough Schedule

- Preliminary schedule
 - End-Caps: 312 days (without outer radial pieces)
 - Barrel wheels: 324 days (without support feet),
 - In total about 2 years, ~1 year in case of two assembly lines
- Module assembly hall
 - Storage area for 1 end-cap
 - ~1400m² (with 40t crane) without space for moving plates and assembled modules alternative
 - ~900m² with 250t crane
 - Assuming plates are delivered in containers,
 - have to be store incoming containers on outside “parking lot” to reduce required hall space
 - Assembly area 20m x 10m → 200m², 2 assembly lines → 400m²
 - Need 2 ~40t cranes + moving system for assembled modules (or ~250t crane)
- Work to be done at fabrication site
 - Module assembly, barrel and end-cap assembly, complete disassembly of yoke and modules
- Assuming max. shipping load of 25t → at least 540 truck transports

Module Assembly – Rough Schedule

Module assembly very time consuming due to trial assembly at company

- Assuming two assembly lines, ~ 1½ year additional time for yoke fabrication and assembly

Alternatives

- Yoke fabrication will be done by company on ILC site, not at company
 - Set up heavy fabrication workshop on site
 - Welded option preferred, costs are less expensive
 - Need floor space for welding, machining, surface preparation, painting, quality assurance and storage in one hall (if possible)
 - increase the possibility by companies / suppliers in Japan
- Yoke fabrication will be done at company on ILC site, but without trial assembly
 - Rely on quality assurance
 - Might require machining of top modules. Could be made slightly smaller, use shim plates if necessary

Module Assembly – Rough Schedule

Start looking at alternative yoke module design under 25 tons per part.

Bolted instead of welded plates (more expensive).

Barrel and End-cap plates should be straightforward.

End- Cap front plate (200 mm thickness) due large magnetic forces +++.
Front plate need to be higher steel strength class.

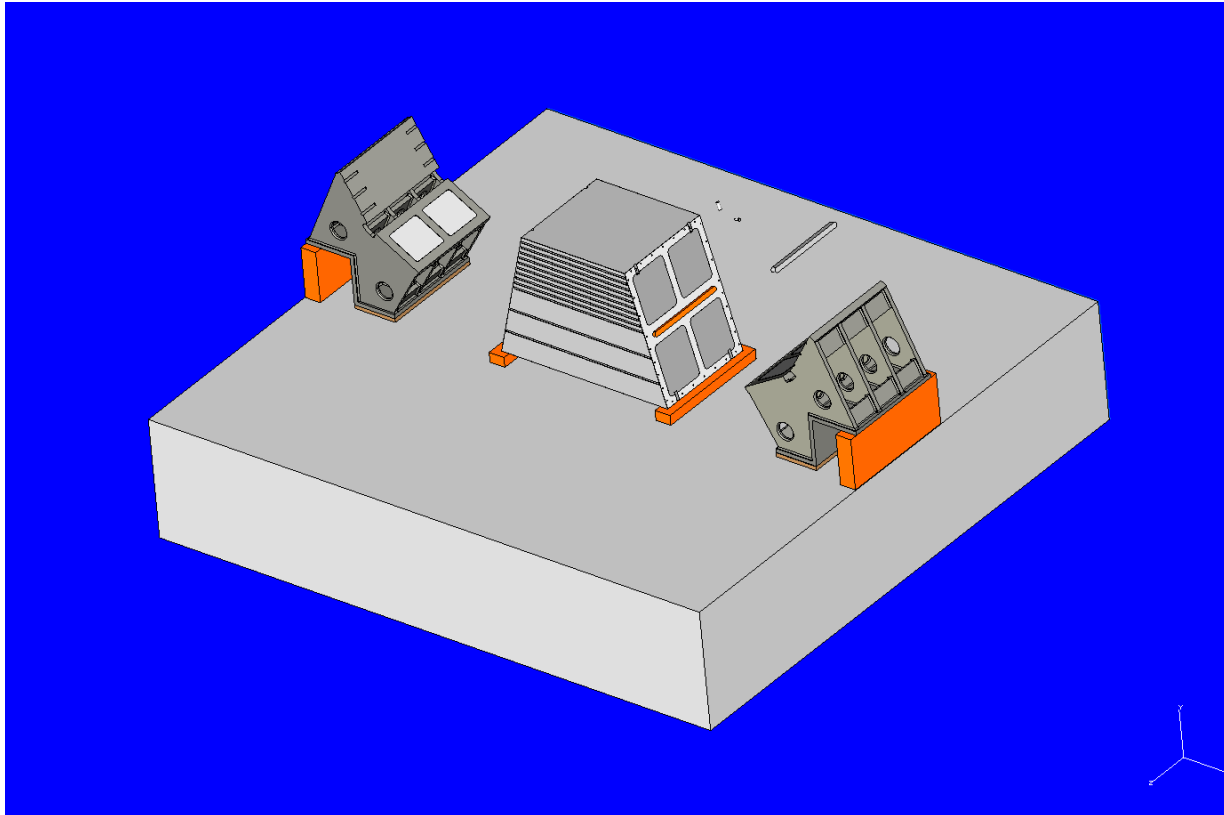
Assuming two assembly lines, ~ 1½ year additional time for yoke
fabrication and assembly.

Storage of 1 End-Cap requires ~1300m² (~250t crane) or ~2300m²
(~40t crane) module assembly hall with cranes and moving systems,
less if containers are stored outside

No trial assembly at fabrication site
Fabrication near ILC exp. Hall,
welded - option preferred.

Preparations for the Final Assembly

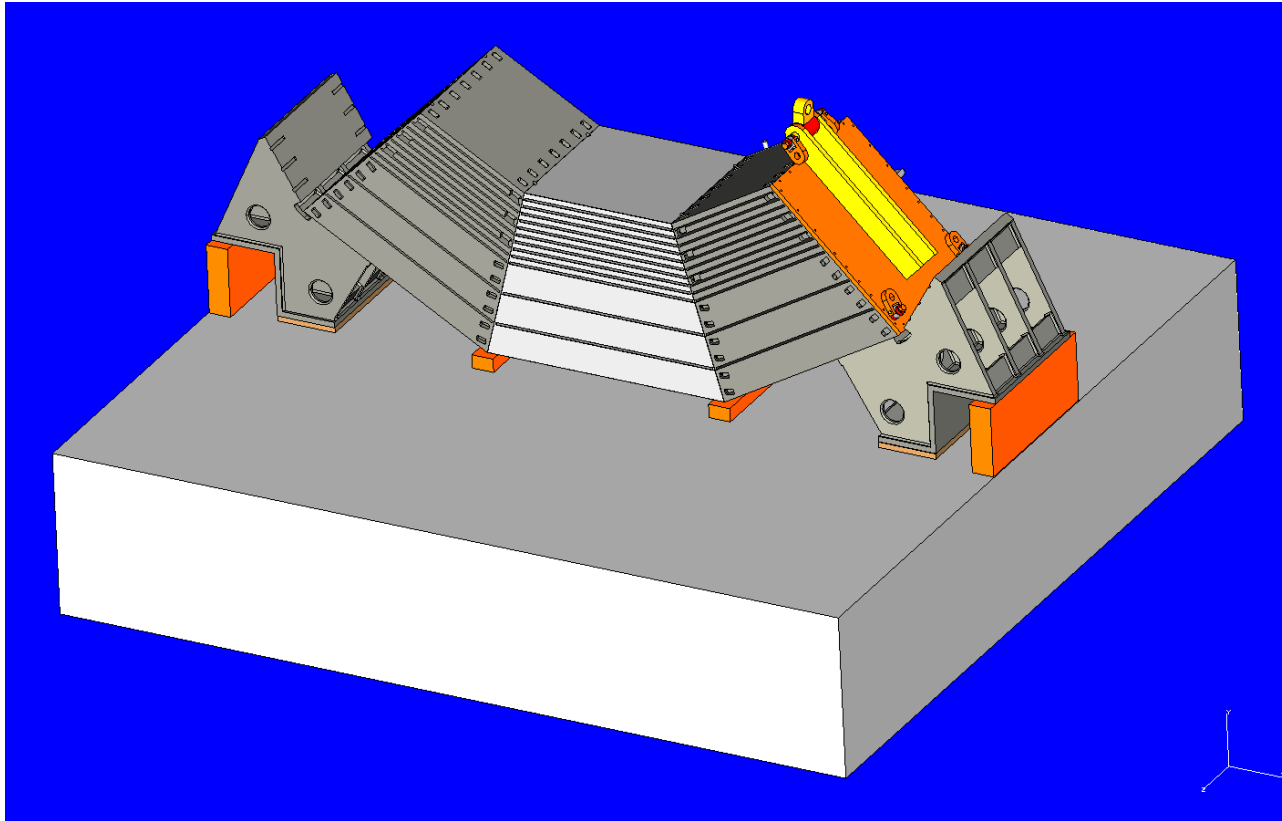
Preparations for final assembly, support gear coloured orange



The footing and the barrel centre section are lined up and anchored to the foundation of the hall, safely held in position. The keys are then inserted and screwed on.

During the entire operation the position is continuously checked via laser, the tolerance is to be better than 1.6mm at all times.

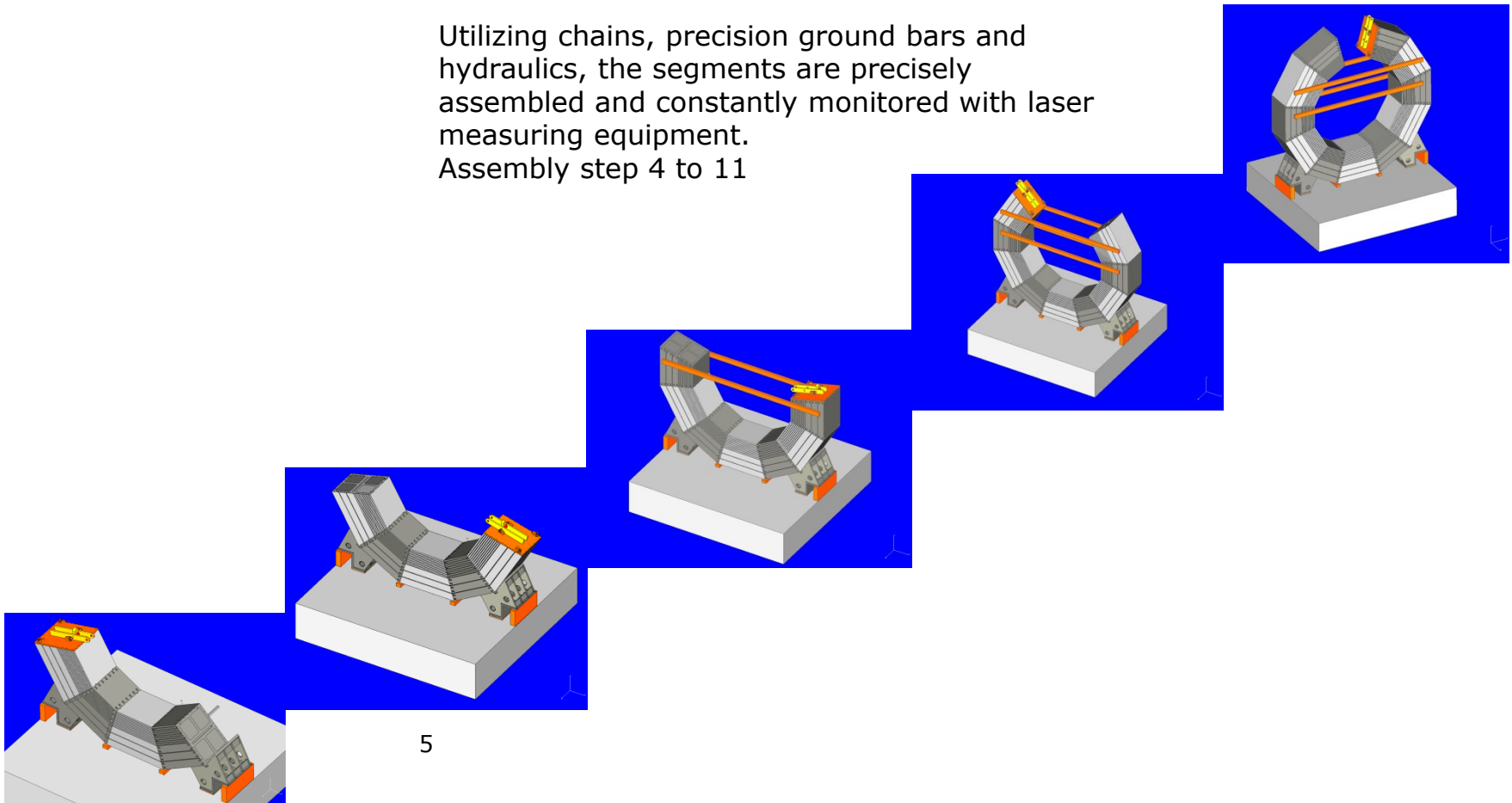
Preparations for No. 3 segment assembly



The barrel segments are handled only with special equipment and are suspended at precisely the correct angle from an adjustable jig.

Assembly with chains and hydraulics (indicated by orange bars)

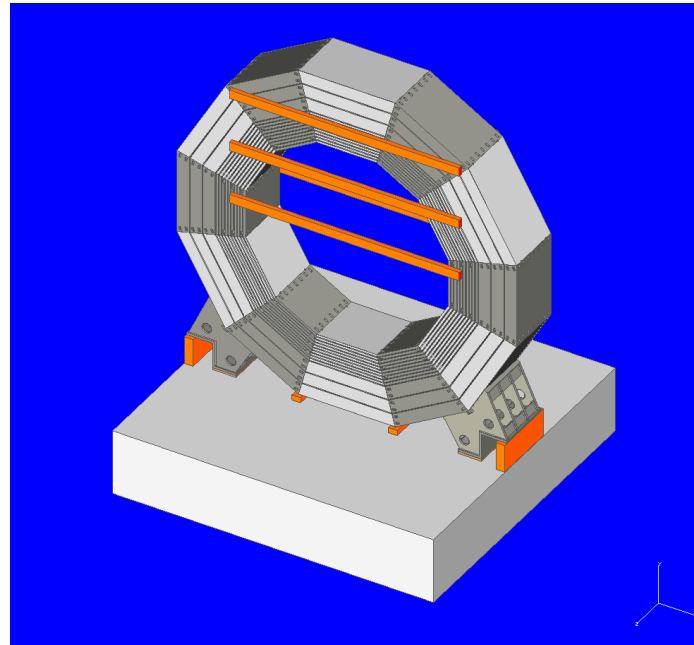
Utilizing chains, precision ground bars and hydraulics, the segments are precisely assembled and constantly monitored with laser measuring equipment.
Assembly step 4 to 11



4

5

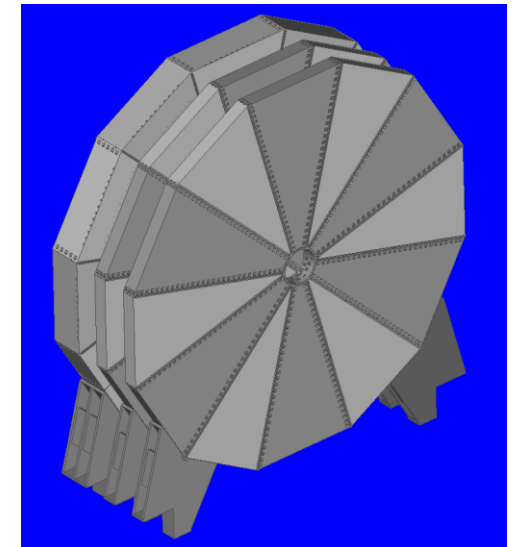
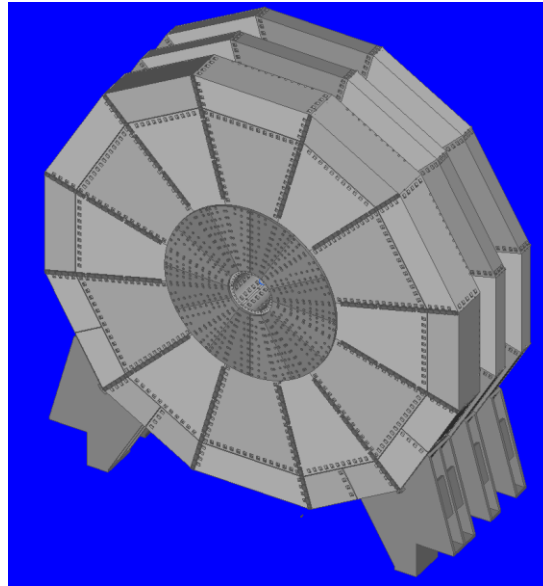
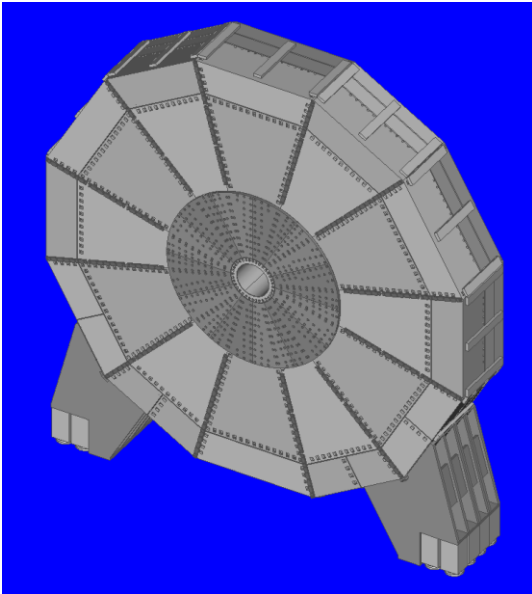
Insertion of the closing section



Positioning of the final element requires a positive tolerance on the open angle to allow the insertion of the closing section. To achieve a flush connection of the mounting surfaces, the section has to be inserted under pressure, alternatively the frame has to have an inbuilt elasticity. Further options are compensating with shims or relying on the manufacturer's expertise who would pre-assemble the frame and guaranty the precise fit.

The ILD End Cap other version

The End Cape 3 parts disc in the closed and open position, are moving individual

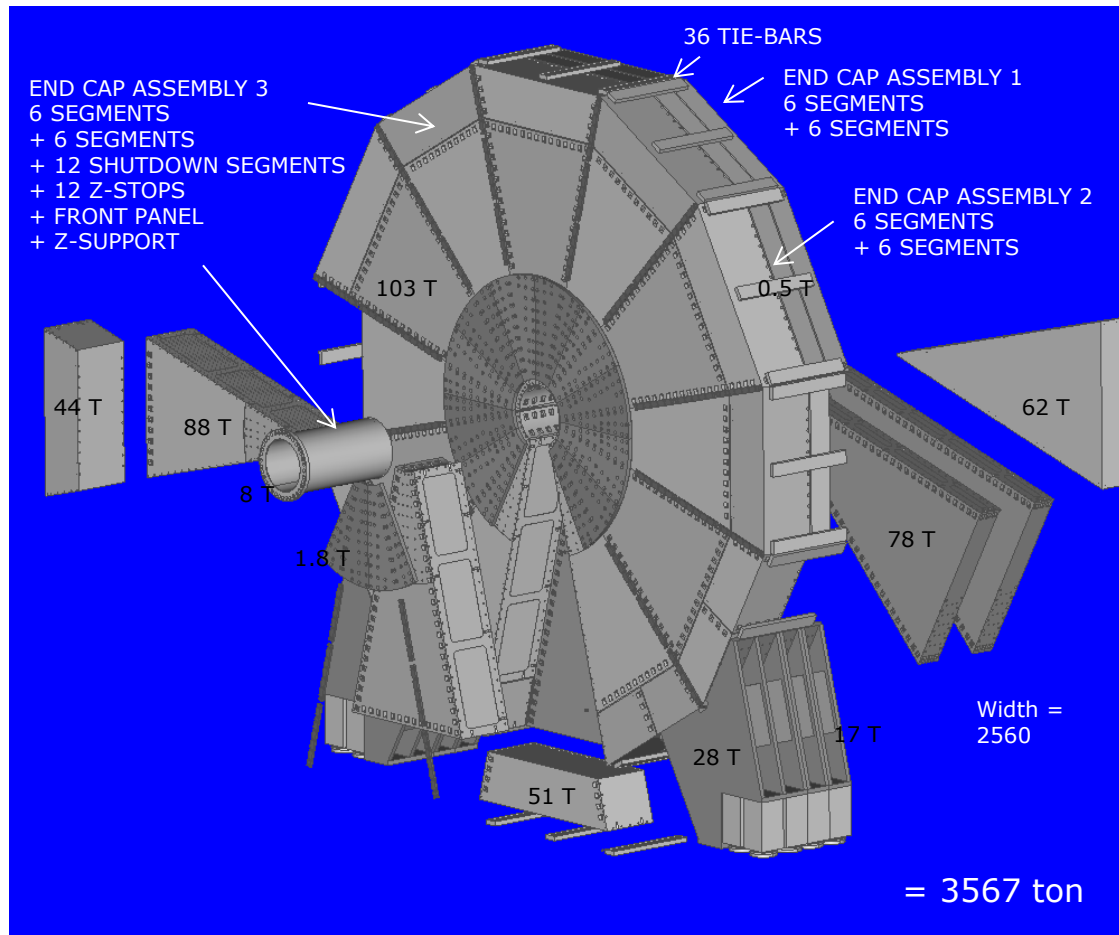


back view

End Cap could be moved by means of hydraulic, guide rails and transportation Beam.
The distance between the individual modules End Cap is 1000 mm.
Between the end cap assembly need to be more place for scaffolding and safety related devices.

End Cap Assembler in the close position

The segments can be manufactured with a geometric positional tolerance of +/- 1.0mm and 0.3mm plan. A full assembly at the manufacturers site prior to delivery is recommended.



240 SHEAR PIN

1600 M36 x 140 / 10.9 ISO4014

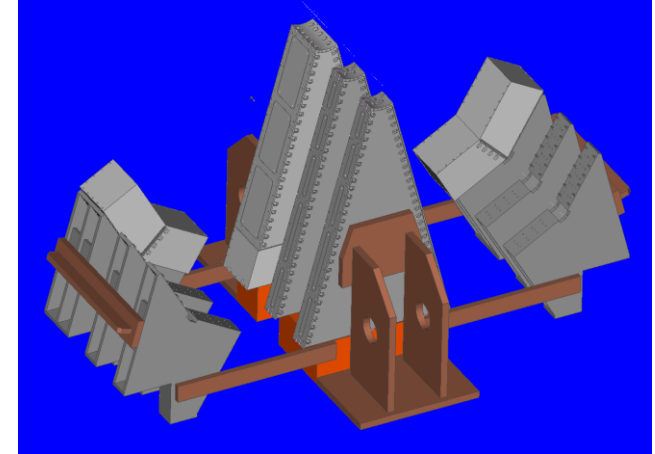
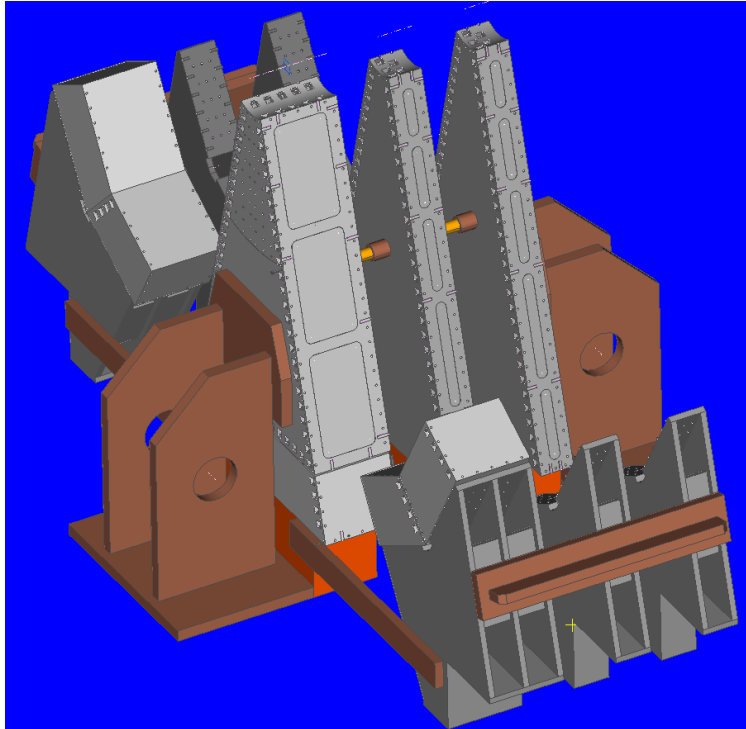
650 M36 x 140 / 10.9 DIN609

300 M24 x 100 / 8.8 DIN 609

32 REINFORCEMENT ASSEMBLY PIN

Preparations for the End Cap Final Assembly

support gear coloured orange

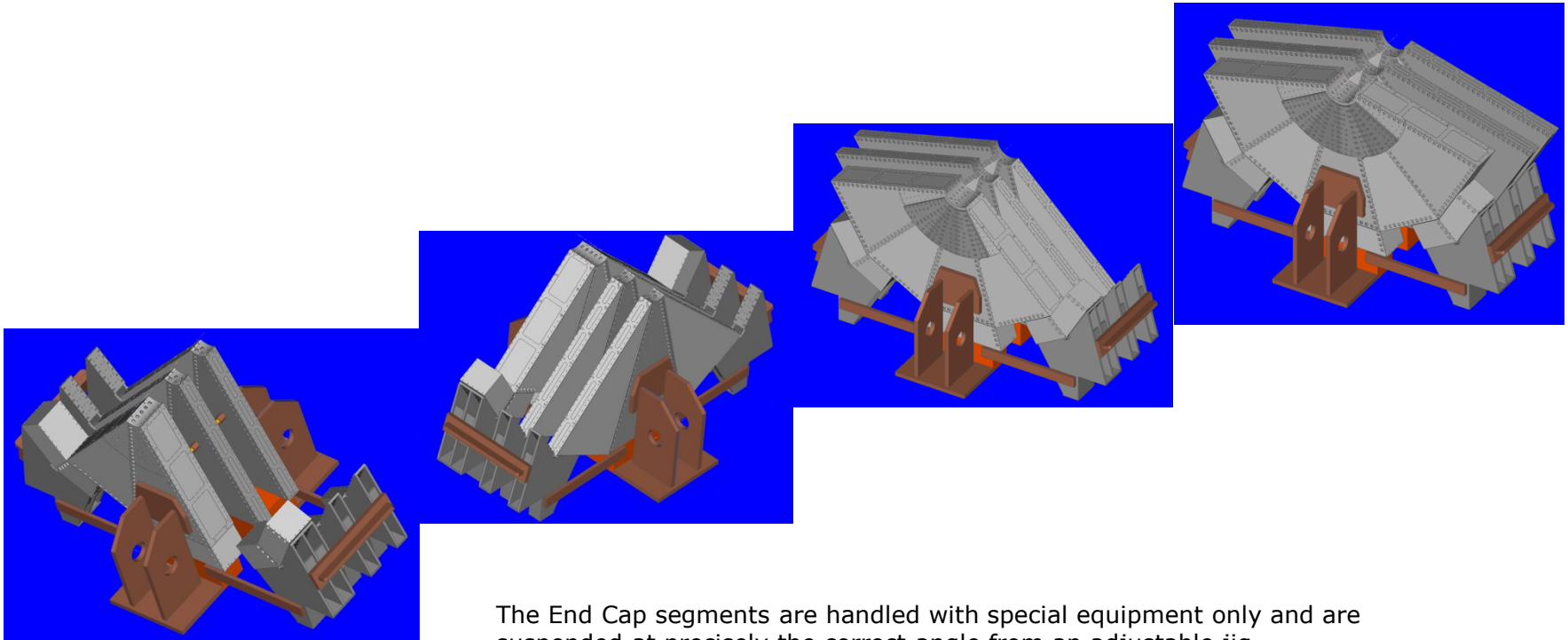


The footing and the End Cap centre section are lined up and anchored to the foundation of the hall, safely held in position.

The keys are then inserted and screwed on.

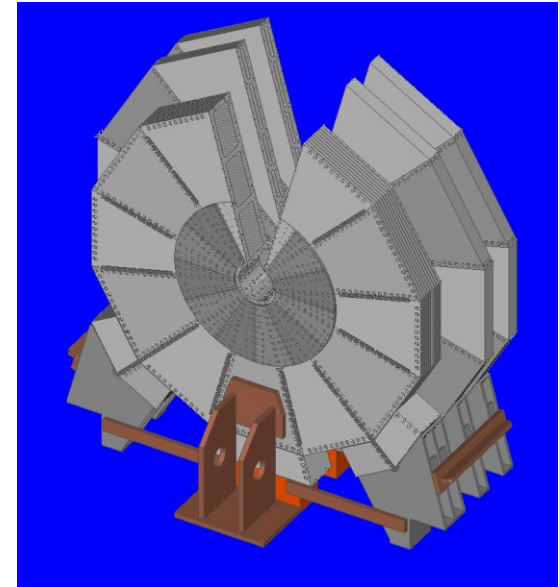
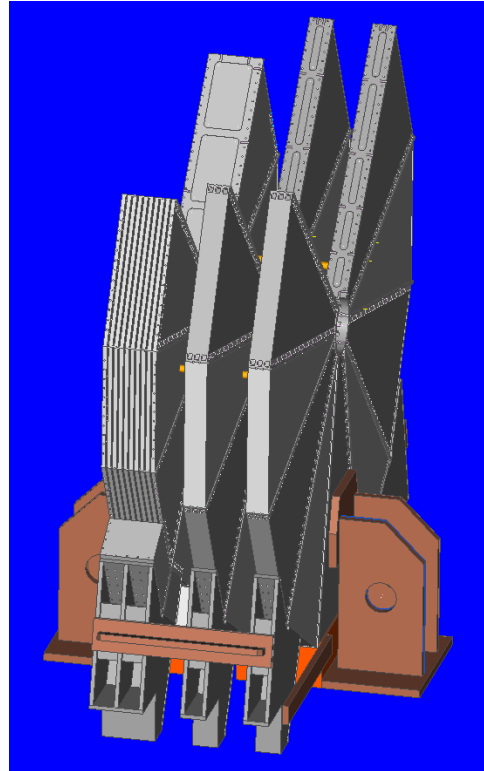
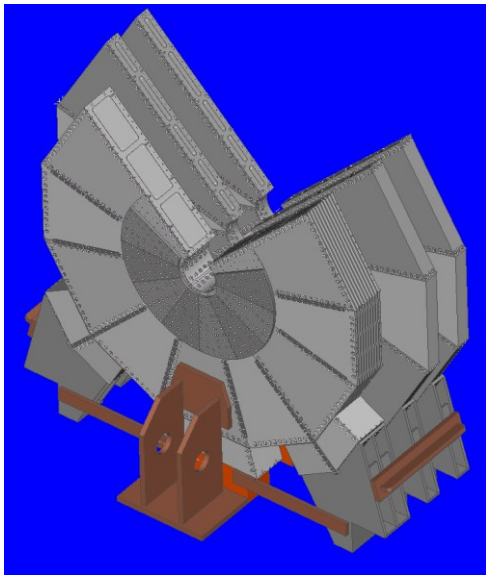
During the entire operation the position is continuously checked via laser, the tolerance is to be better than 1.6mm an all times.

End Cap Segment Assembly next step's



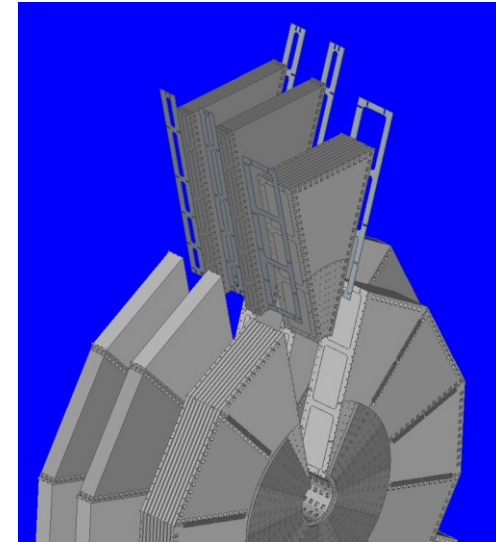
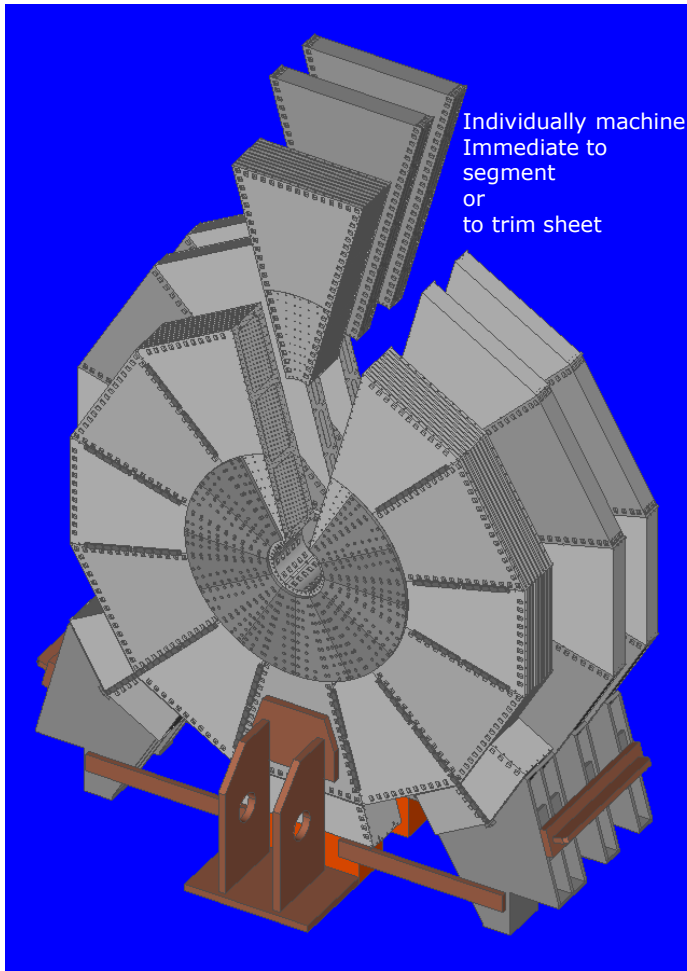
The End Cap segments are handled with special equipment only and are suspended at precisely the correct angle from an adjustable jig. All during the entire operation the position is continuously checked via laser.

End Cap Segment Assembly next step's



The positioning of the final segments

- custom made during operation -

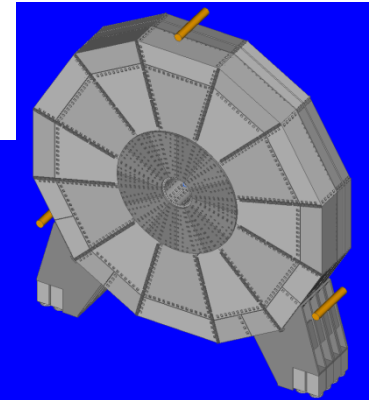


The positioning of the final segments requires a positive tolerance on the open angle to allow the insertion of the closing section.

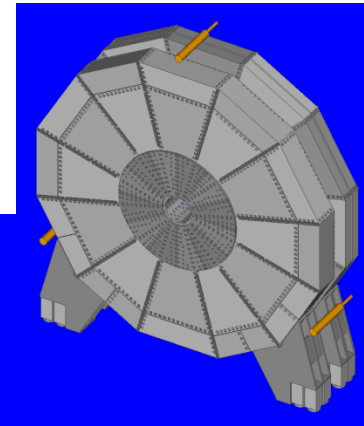
Further options are compensating with shims or relying on the manufacturer's expertise who would pre-assemble the frame and guaranty the precise fit.

Base Position before End Cap installation

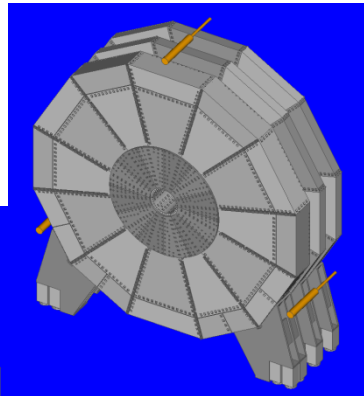
close with hydraulic



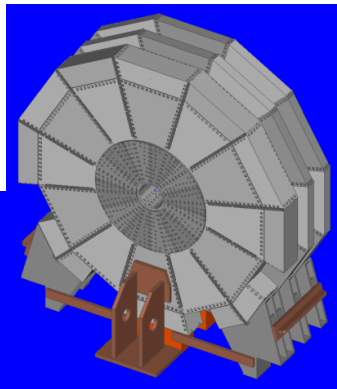
move the middle
End Cap Assembly,
prepart to fixing



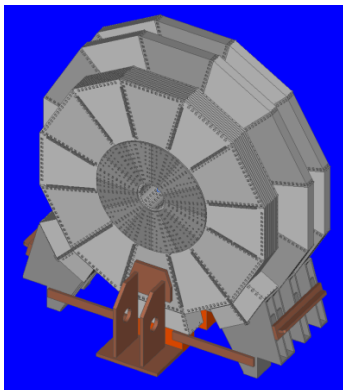
move the last End Cap Assembly
with hydraulic and
the transport beam



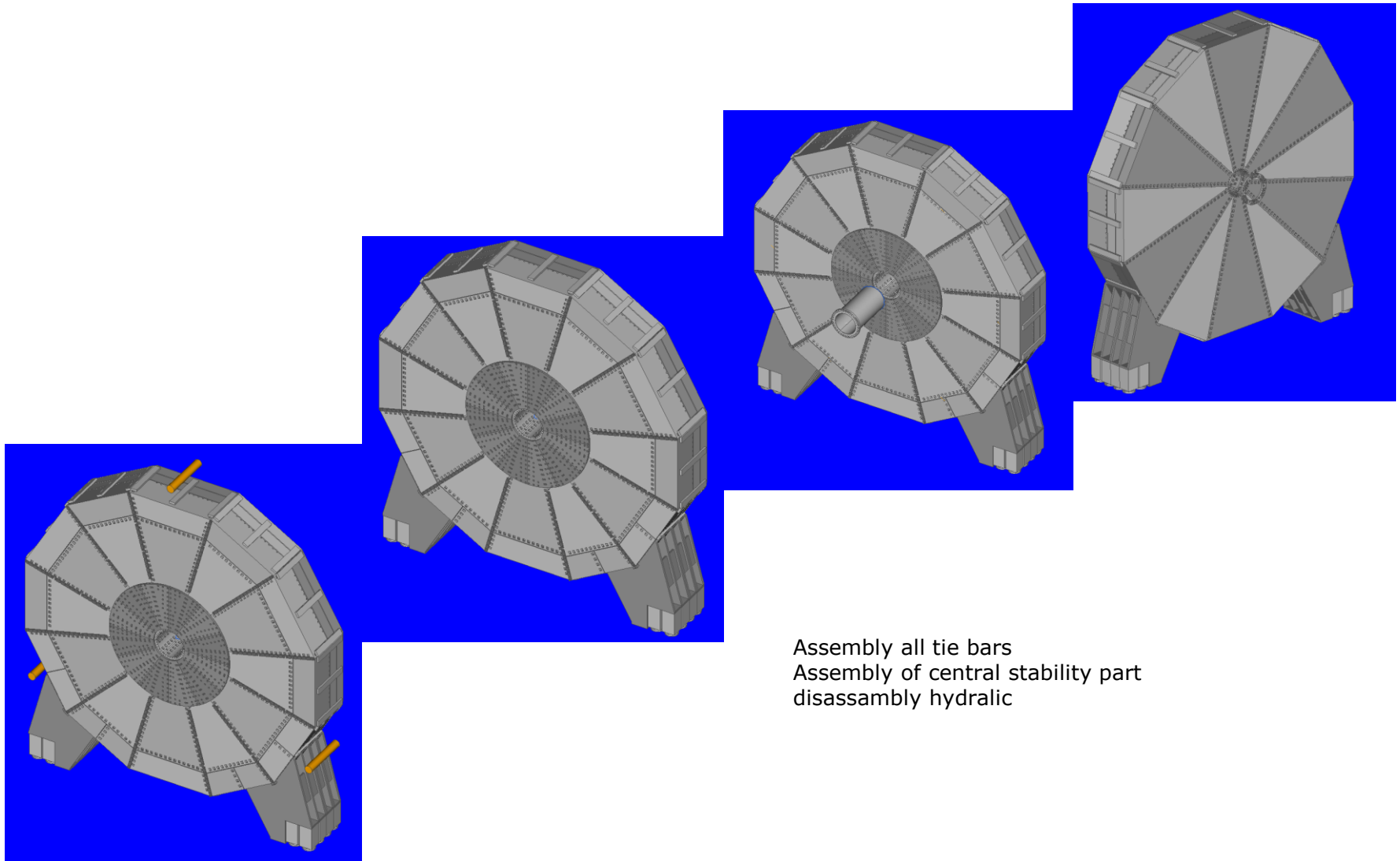
close with hydraulic
to dislodge fixture, at the same time -
to maunting from hydraulic cylinder arragament (3~6 cylinder)
and transport beam



basic position
chamber assembly

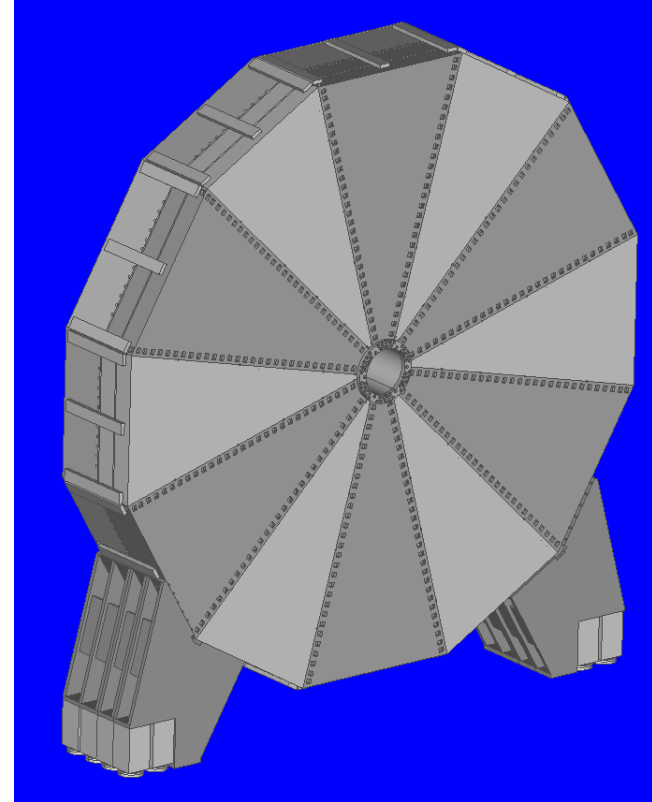
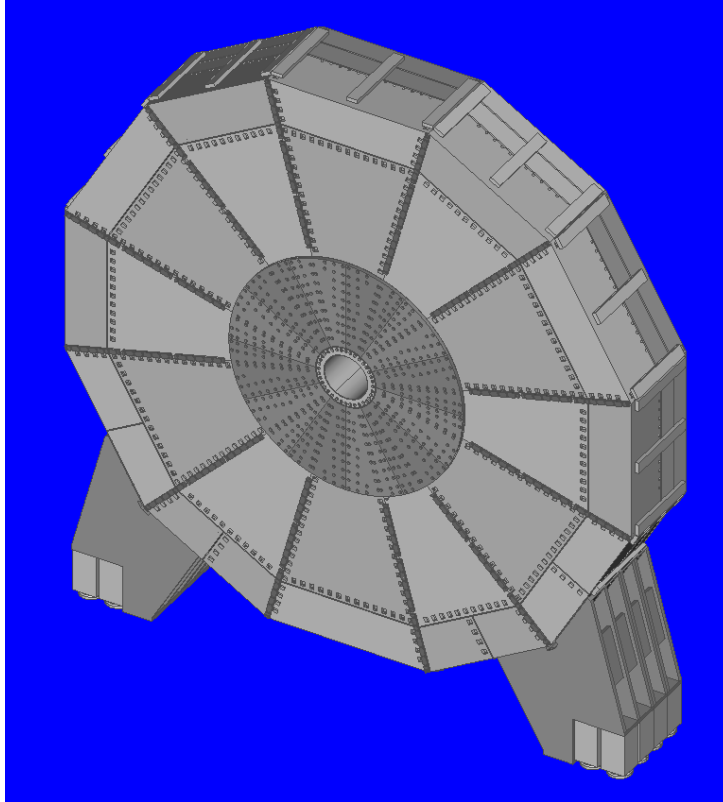


End Cap Ground Connection



Assembly all tie bars
Assembly of central stability part
disassembly hydraulic

The ILD End Cap Proposal for Solution



To be under examination

- axial dynamic and torsion stiffness
- magnetic rigidity

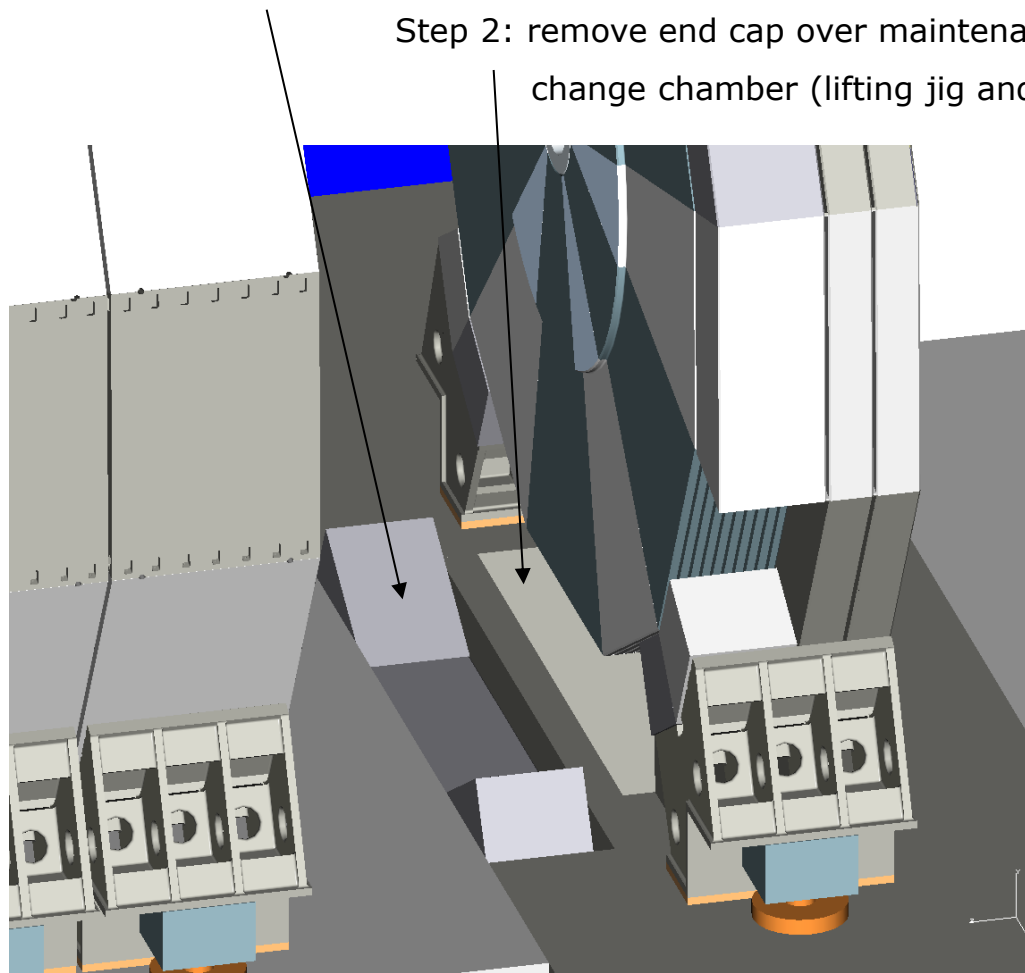
Chamber dismantling at shut down

Step 1: remove end cap over maintenance pit 1

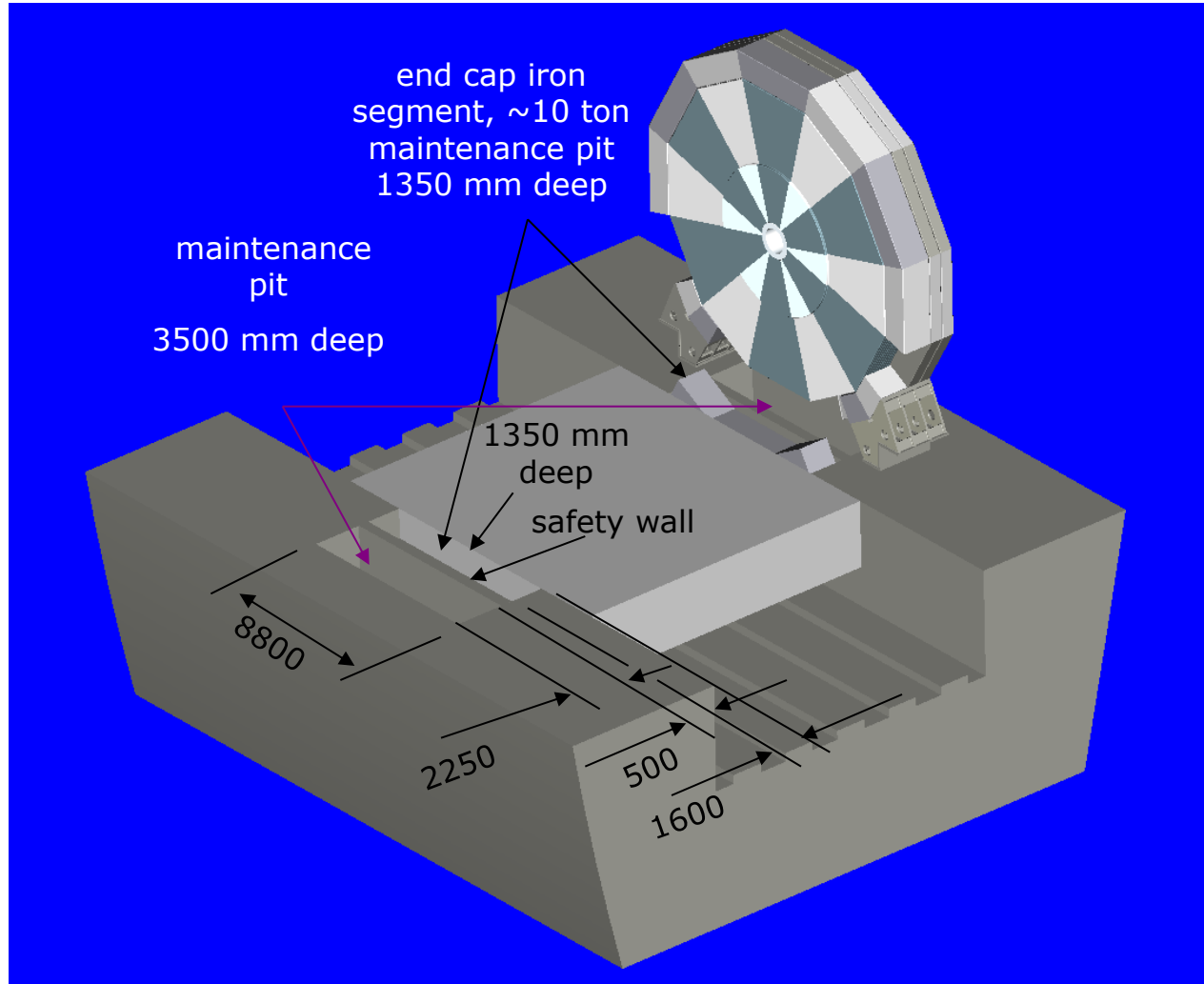
lower iron (automatic with stroke jig)

Step 2: remove end cap over maintenance pit 2

change chamber (lifting jig and manual)



ILD platform and hall fundament



End Cap iron segment in low-angle shot:

automation operating by hydraulic cylinder, electric motor or lifting jack

All other segments positioning with hall crane

chamber pit:

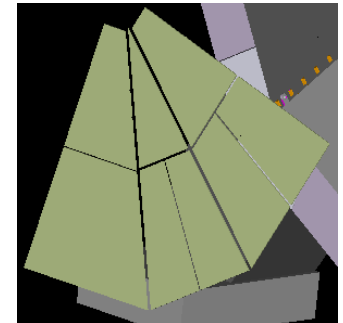
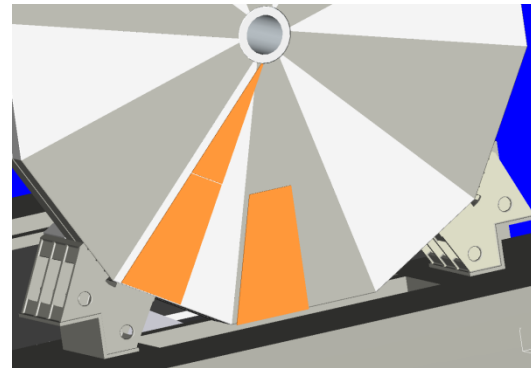
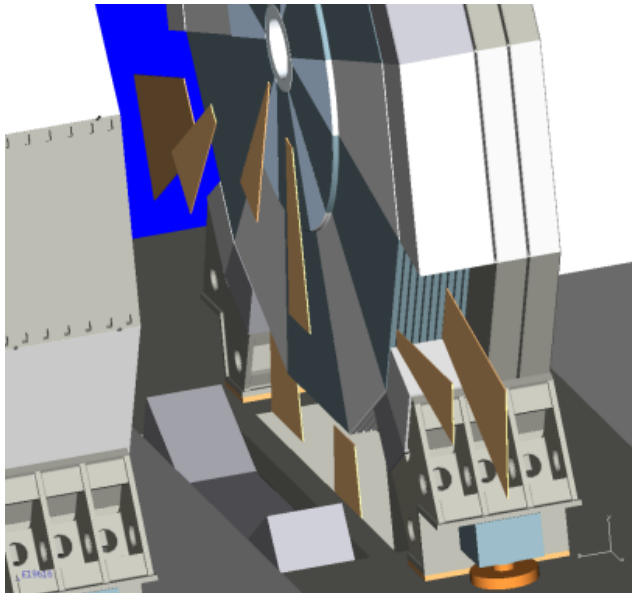
manual with scaffold and leader

Platform is positioned and safety lock is applied

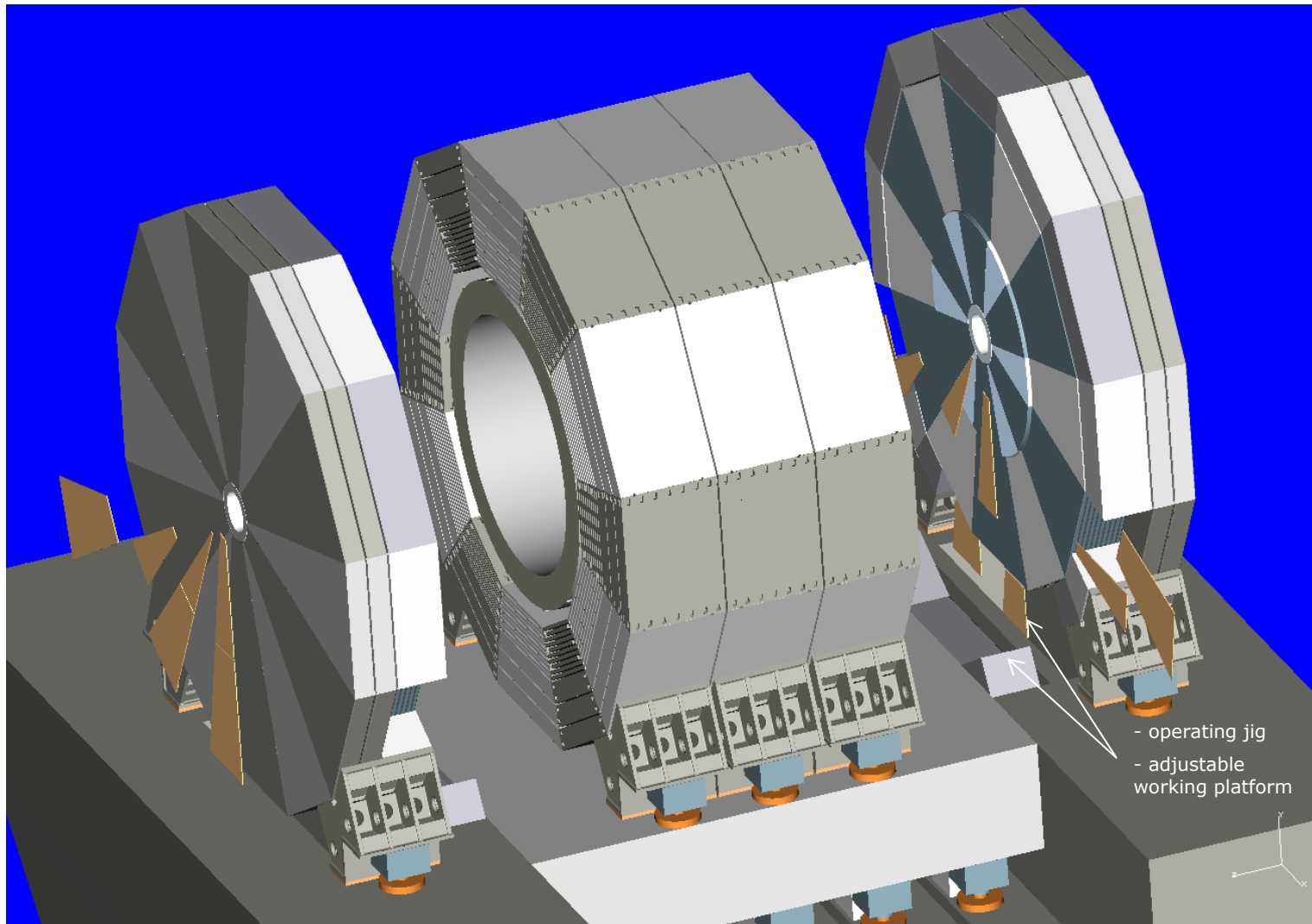
Chamber Assembly End Cap

chamber assembly practical only for 2 or 3 segments

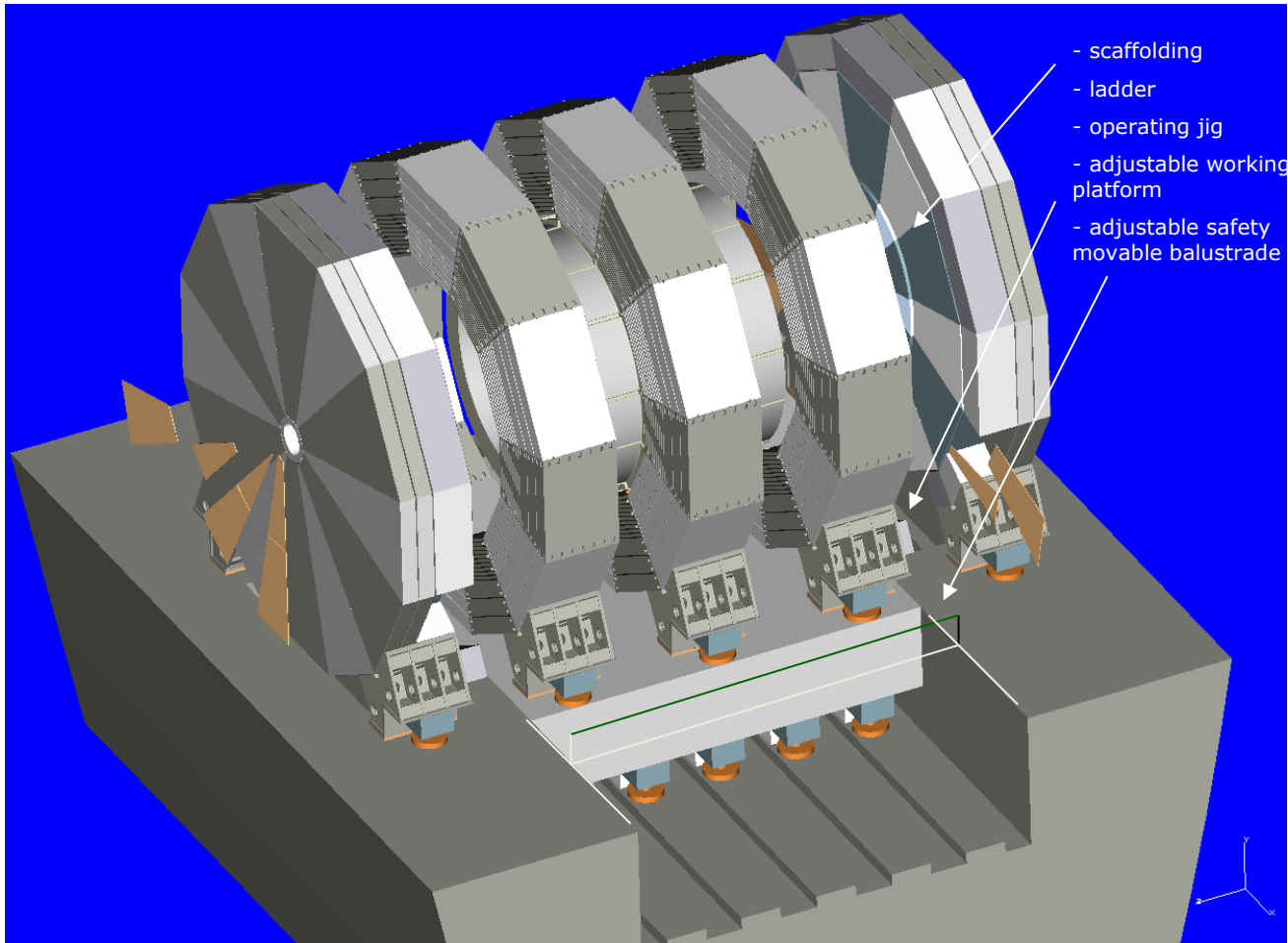
Geometry: $\sim 3400 \times \sim 2200 \times$ thickness between $25 \sim 30$ [mm]



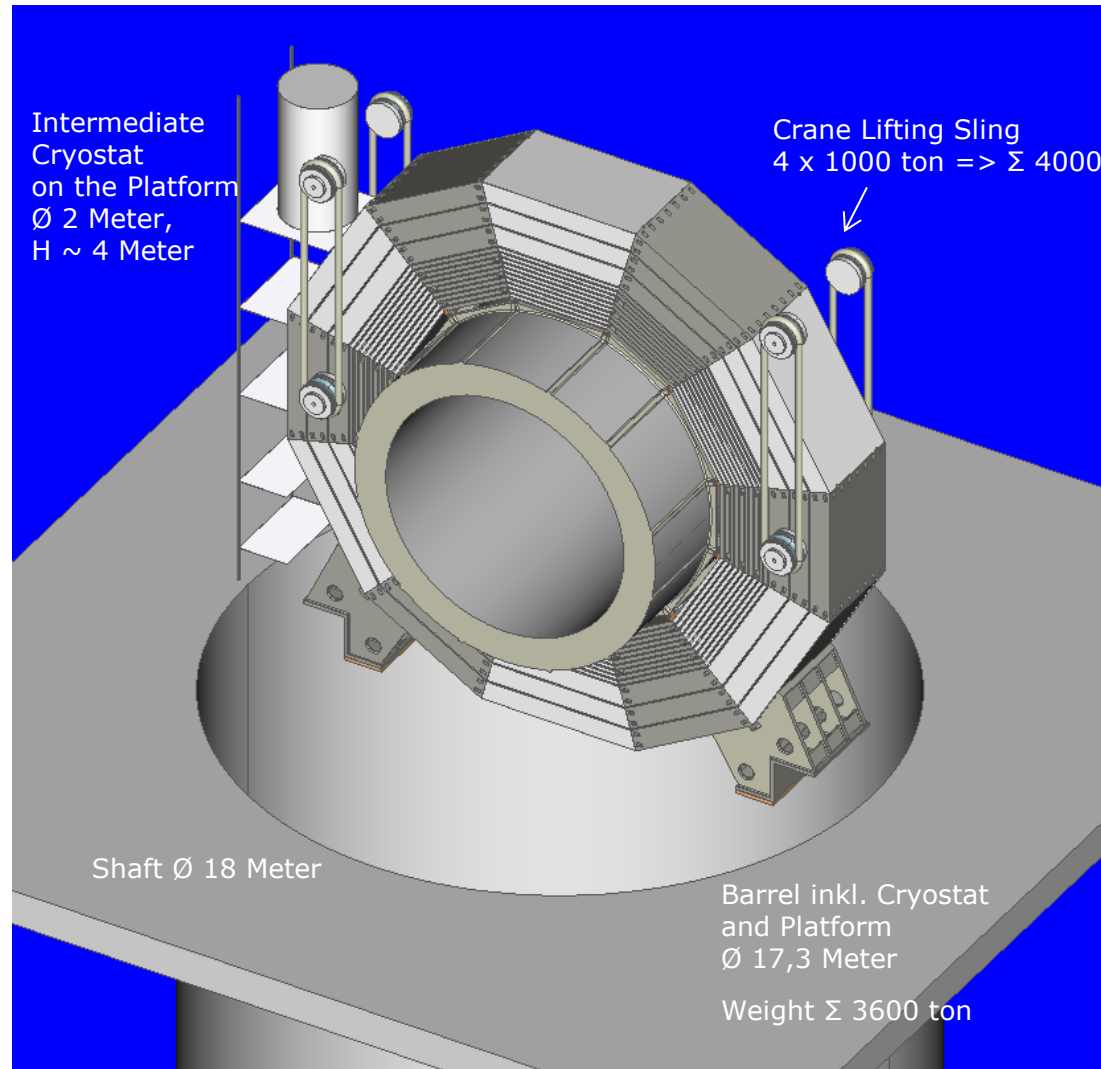
Alternative shut down position / only End Cap moved



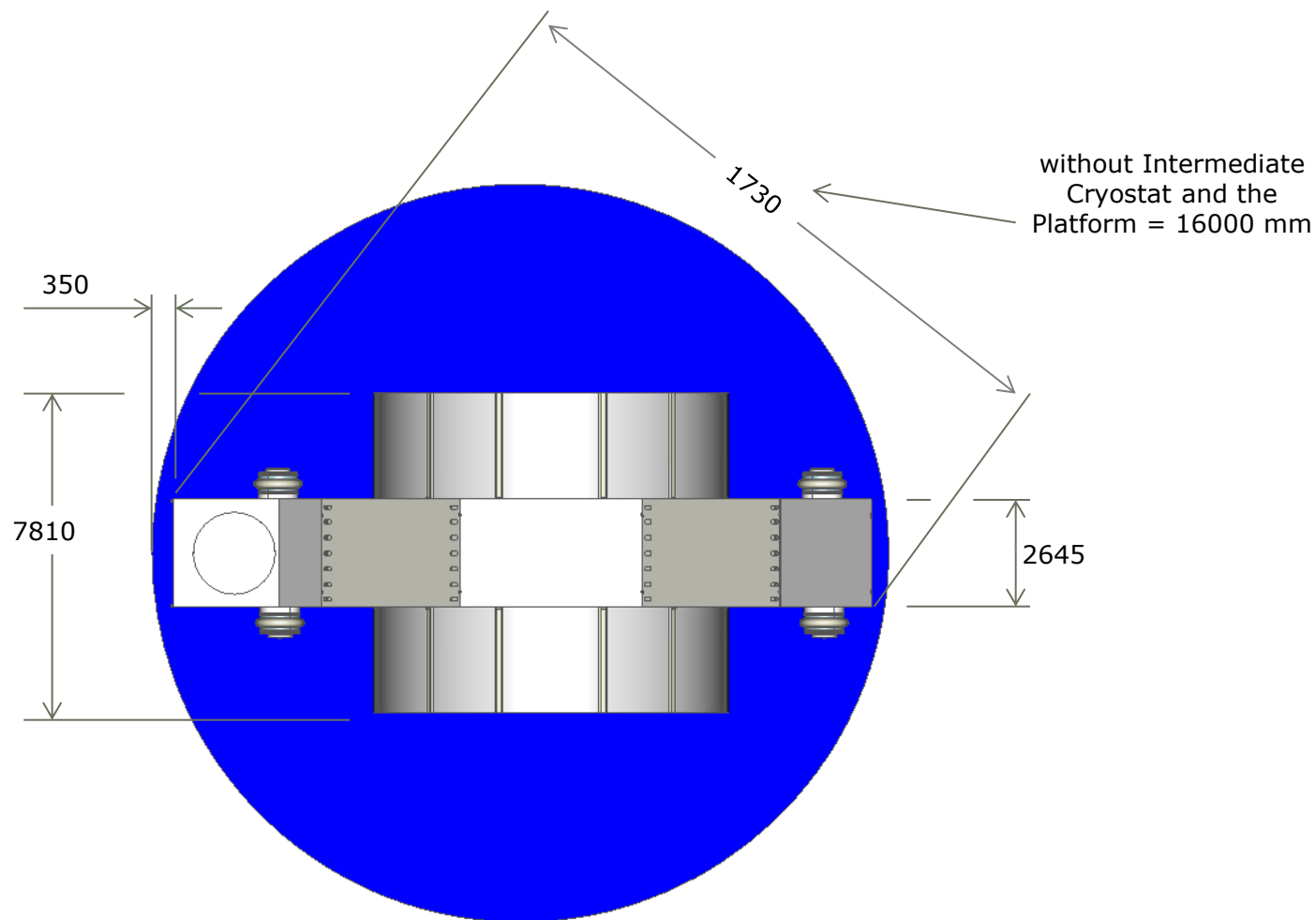
Overview of shut down



Lowering of Central Yoke Wheel into Underground Hall



Lowering of Central Yoke Wheel into Underground Hall Top View



Conclusion



- Detector with end caps and integrated Cryostat make up a contained assembly.
- Platform with detector are assembled as a module with an overall tolerance better than 4 mm, during operation the geometrical changes have to be less than +/- 1.0mm and 0.3mm plan.
- To achieve these tolerances, available manufacturing methods still have to be evaluated.
- Platform with detector have to be isolated from external influences like radiation protection wall, vibration and earth movements.
- Sufficient access has to be provided for, scaffolding, cranes, ladders etc. so that tools and equipment may be easily used during maintenance.
- In case of technical problems, external access to air-pads, sensors, cables and connectors has to be quick and easy.
- Platform should to have an additional locking mechanism also interlock system, for safety reasons during operation.
- Safety issues have to be considered from the outset of the design and enough space has to be reserved for escape routes, fire alarm and fire extinguish devices.
- In agreement with the national safety rules.