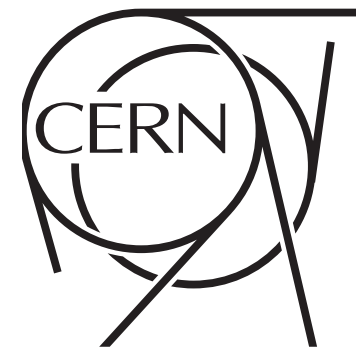


# SBFD Cryostats

Marzio NESSI

Director's Progress Review of SBN

15-17 December 2015



## Who Am I and Where Have I Been?

Leader of the CERN Neutrino Platform.

Liaison between CERN and Fermilab on Neutrino projects.

Member of the WA104 Collaboration.

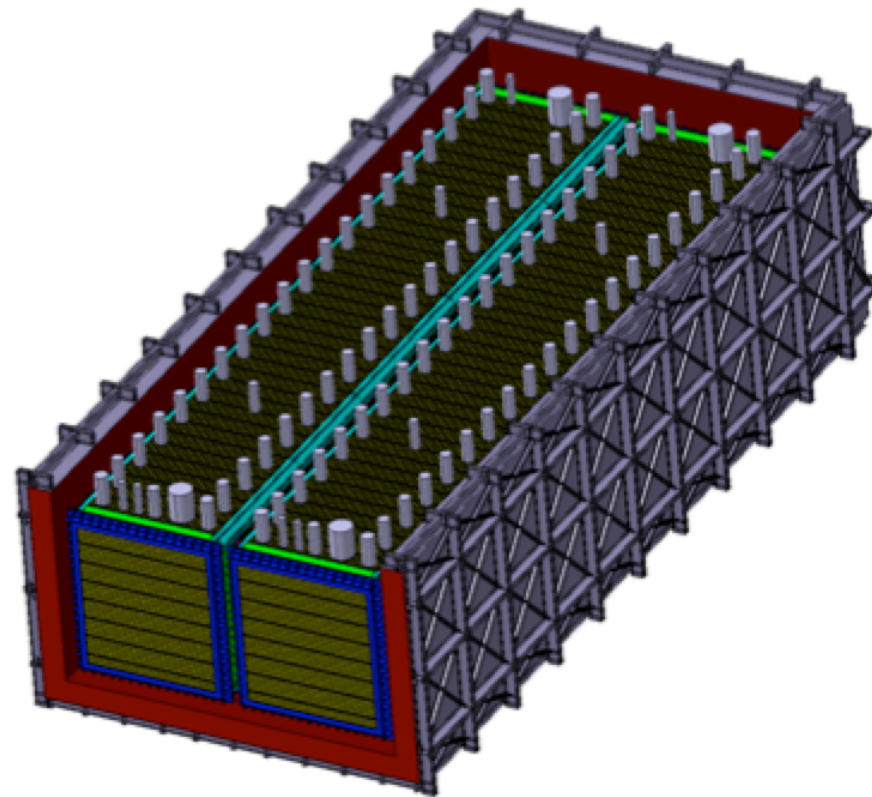
Technical Coordinator of the ATLAS LHC project at CERN during construction and run1 operation.

Experience includes 27 years as a project manager and technical leader of a few very large projects. Large experience on detectors and complex systems.

Education as Particle Physicist (PhD). Physics Professor at the University of Geneva. At CERN, senior staff and leader of the Development and Innovation Unit in the DG-department. JINST director.

# Outline

- Design requirement
- The Warm vessel
- The Insulation
- The Cold vessel
- Logistics issues
- Schedule
- Documentation

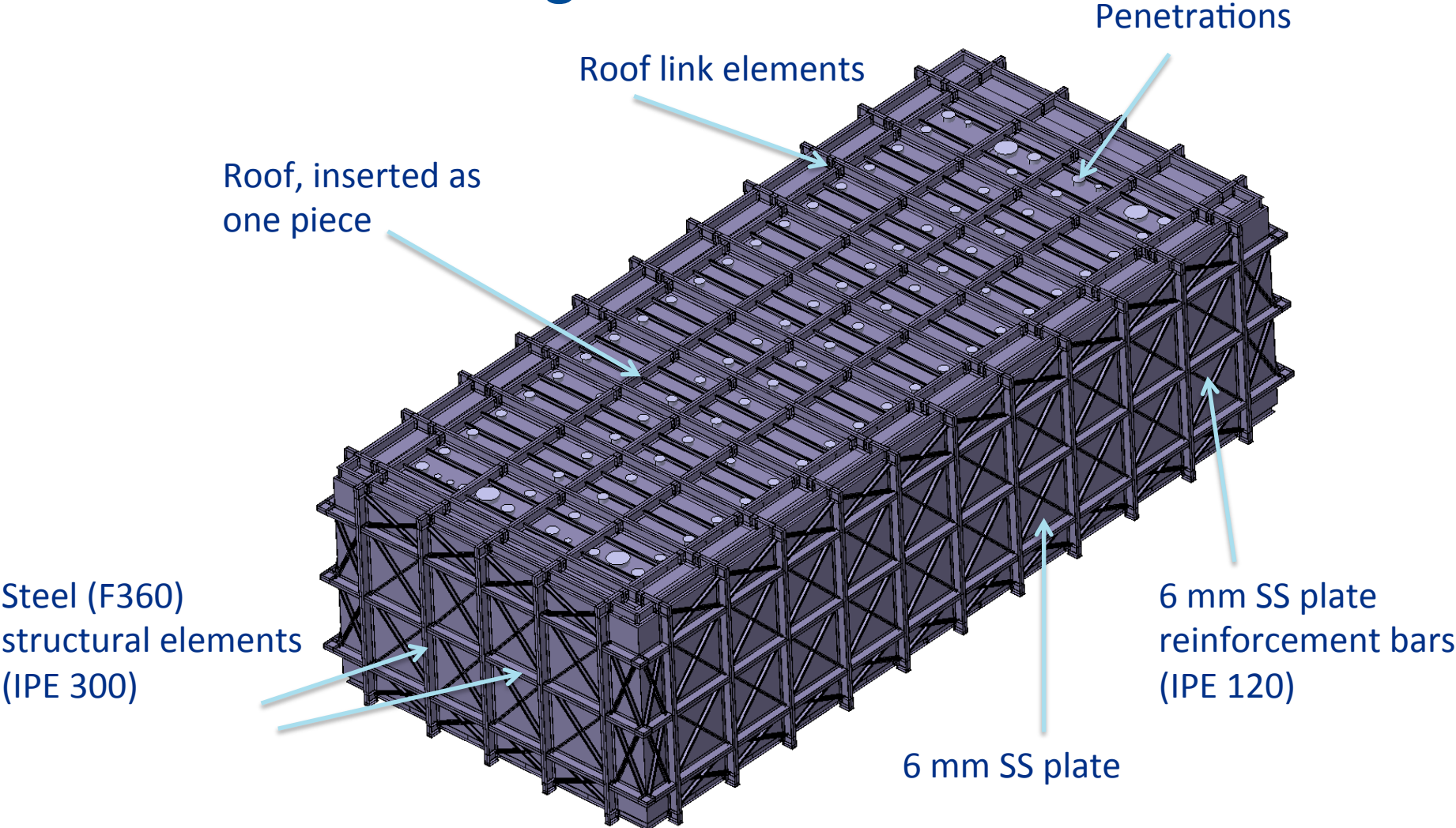


# Design requirements

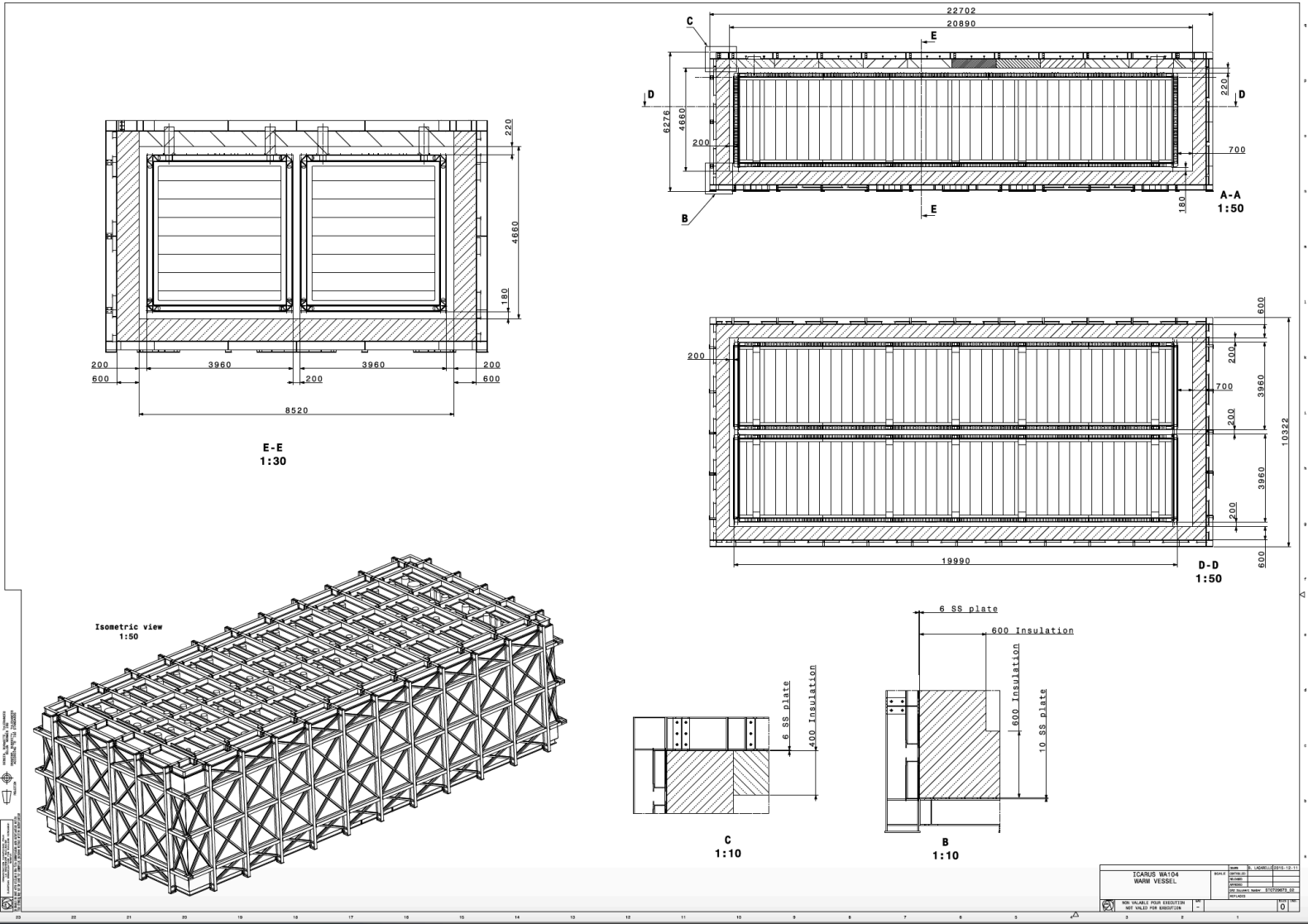
- One single warm vessel hosting the two cold vessels
- Warm vessel gas tight
- Passive thermal insulation (GTT polyurethane foam, 7-13 W/m<sup>2</sup>)
- Active cooling through heat shields
- Cold vessels with vacuum capabilities
- Cold vessels dimensions (19.990 m x 3.960 m x 4.260 m)
- Amount of LAr per vessel ~ 380 tons
- Cold vessels to be shipped to FNAL with the TPC inside
- Cold vessels with an access possibility (manholes)
- Minimize weight (for shipment and installation)
- Minimize costs



# Warm vessel design



# Warm vessel design : <https://edms.cern.ch/document/1566894>



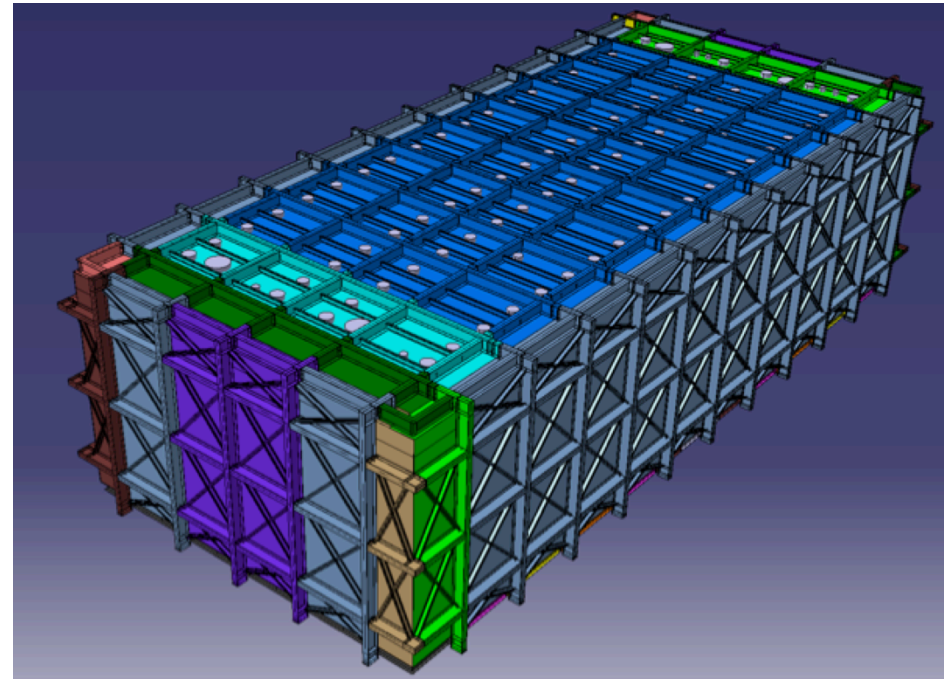
# Warm vessel design

~ 103 tons of steel profiles,  
including SS plates

15 types of modules that will be  
delivered, with SS plates welded,  
to FNAL and produced in EU

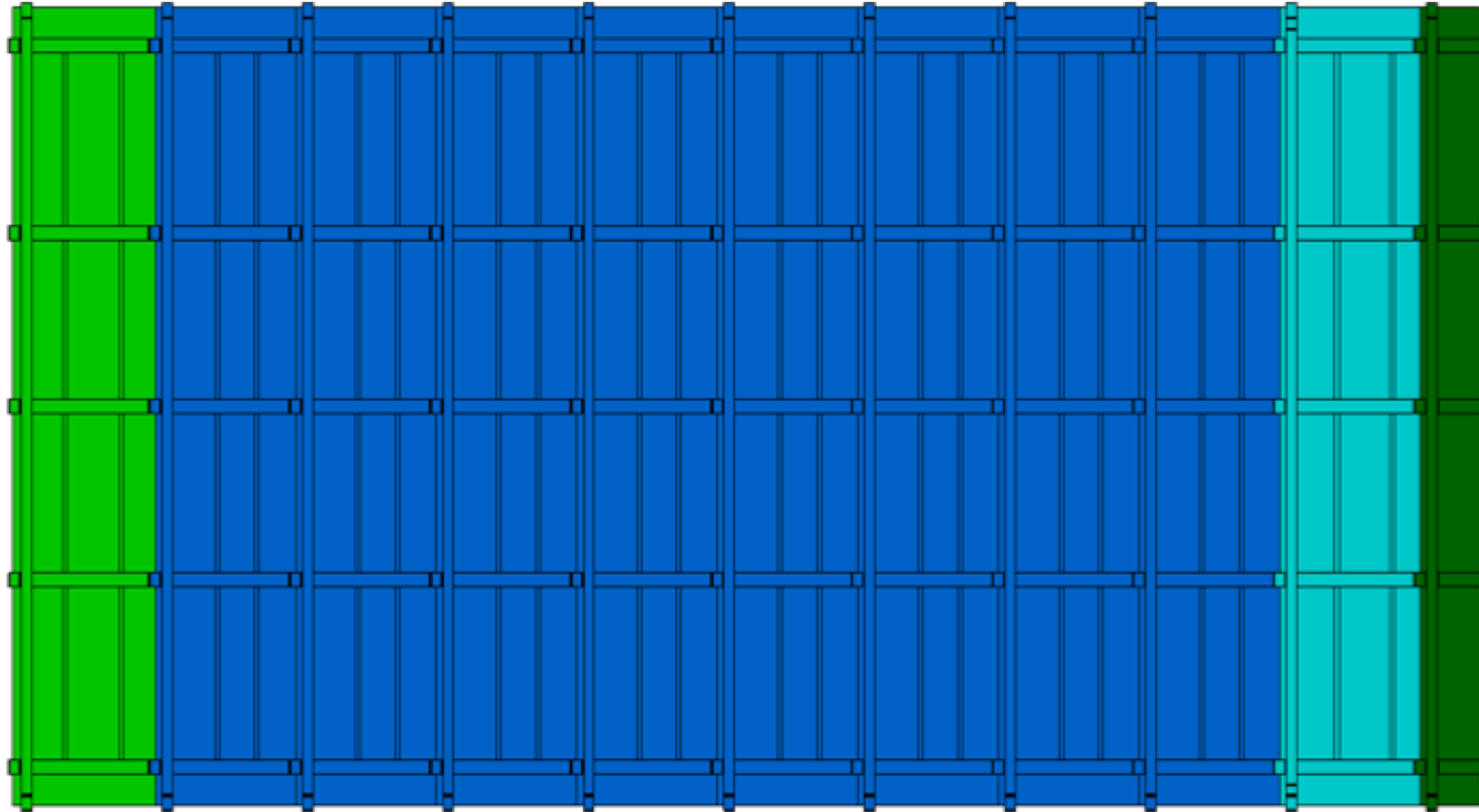
All modules will be just bolted in  
place at FNAL (no welding)

SS adjacent plates will be tig  
welded at FNAL



The 60 modules will be delivered  
to FNAL in ship containers (40"),  
with SS plates welded

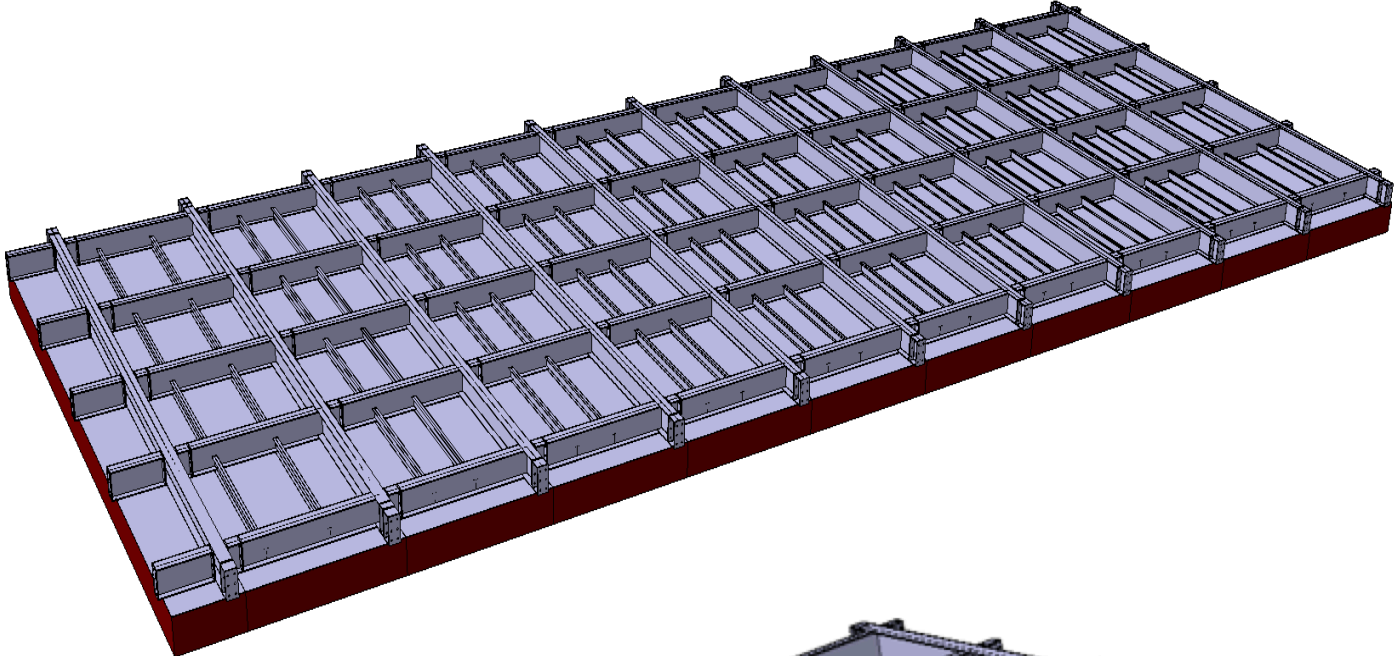
# Roof



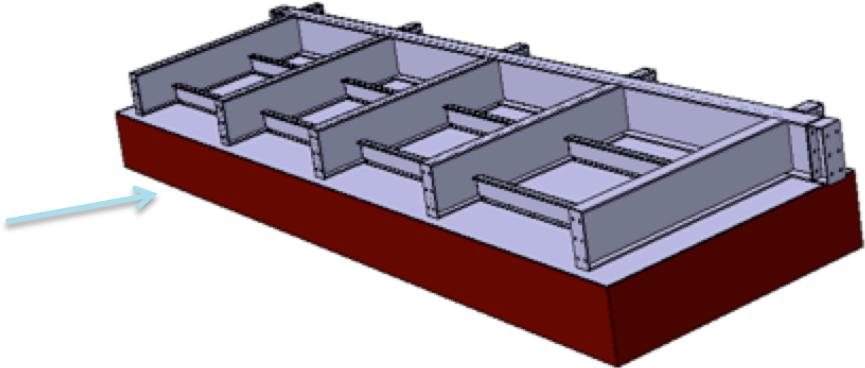
In total 4 different modules

Wall weight around 20 tons, stainless steel included but not the insulation

# Roof

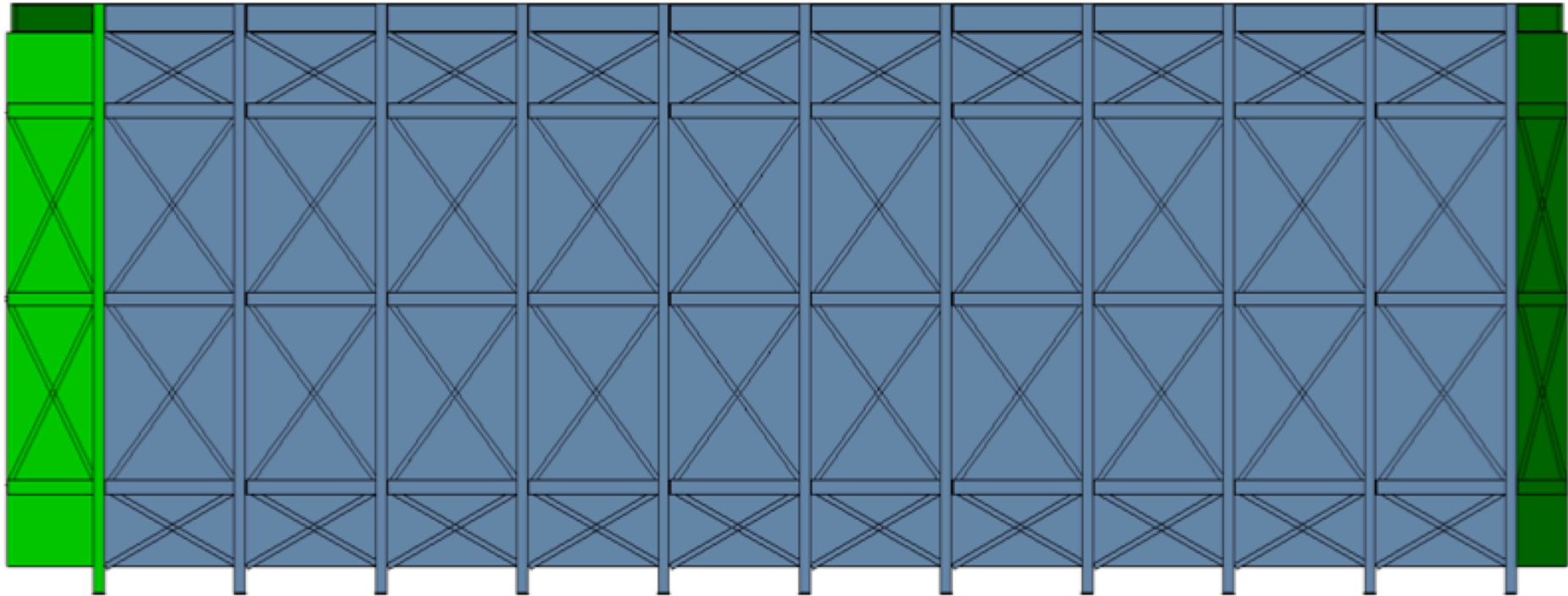


Individual modules with SS plate and insulation



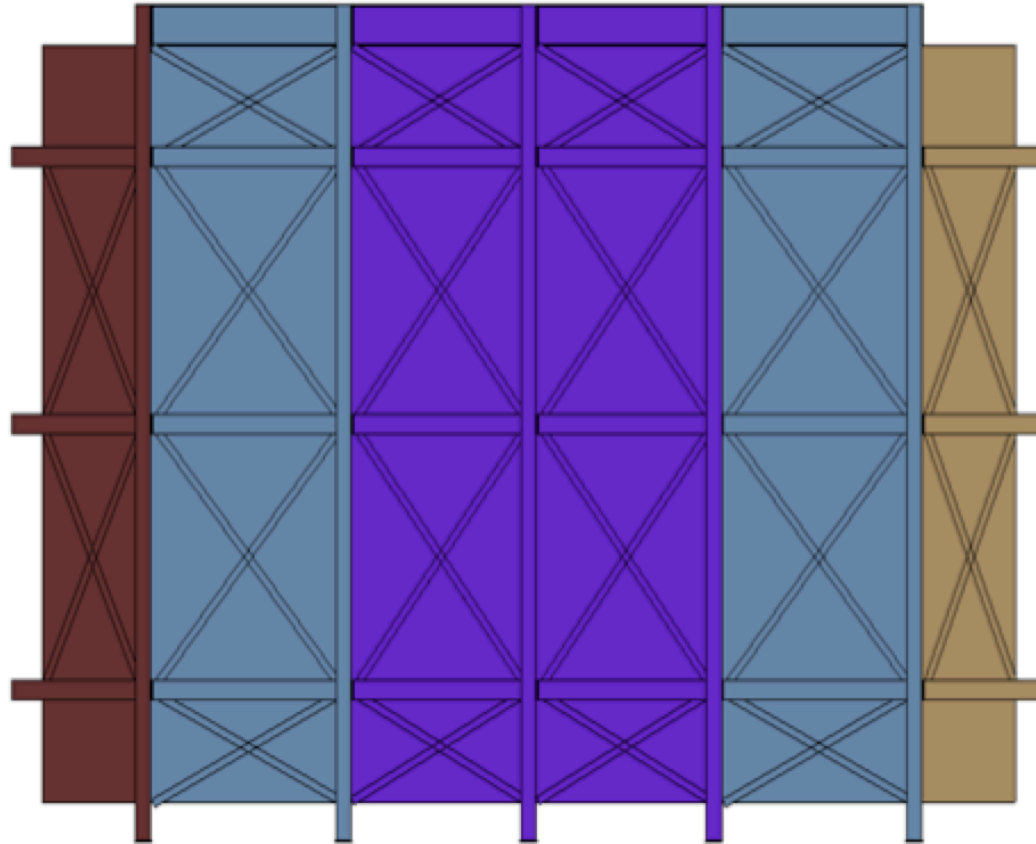


# Long side walls



In total 3 different modules  
Wall weight around, 16 tons stainless steel included

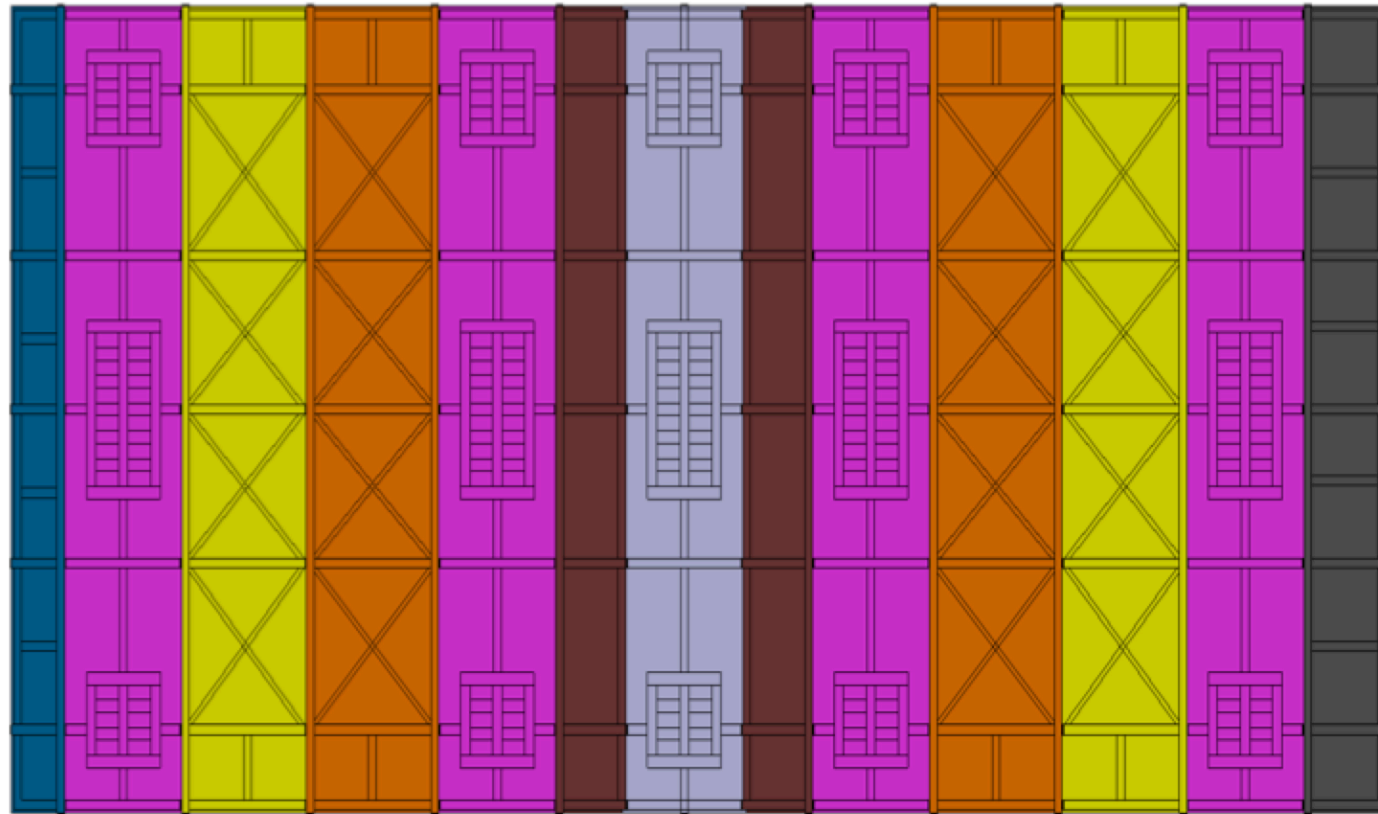
# Short side walls



In total 4 different modules

Wall weight around 8 tons stainless steel included

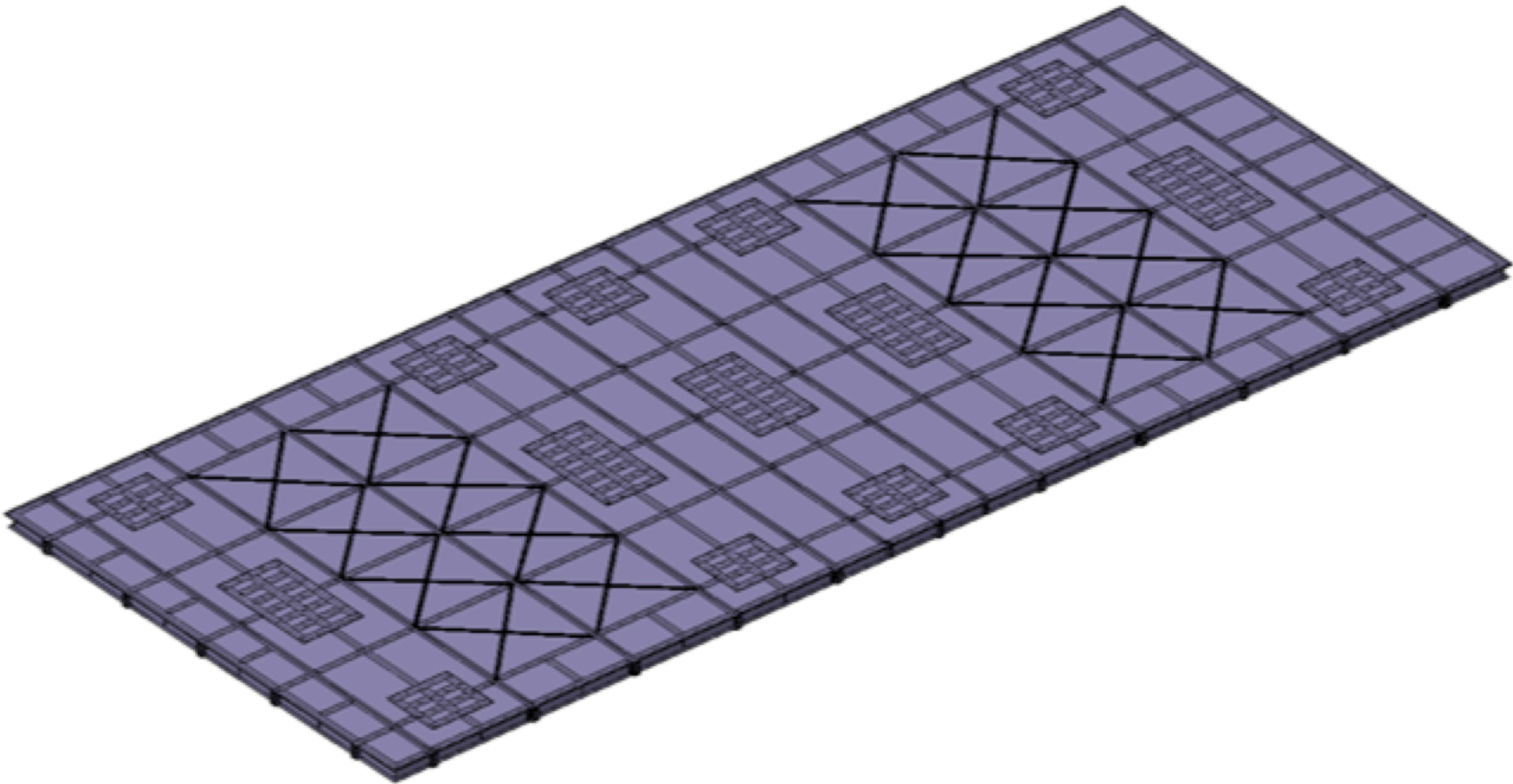
# Floor



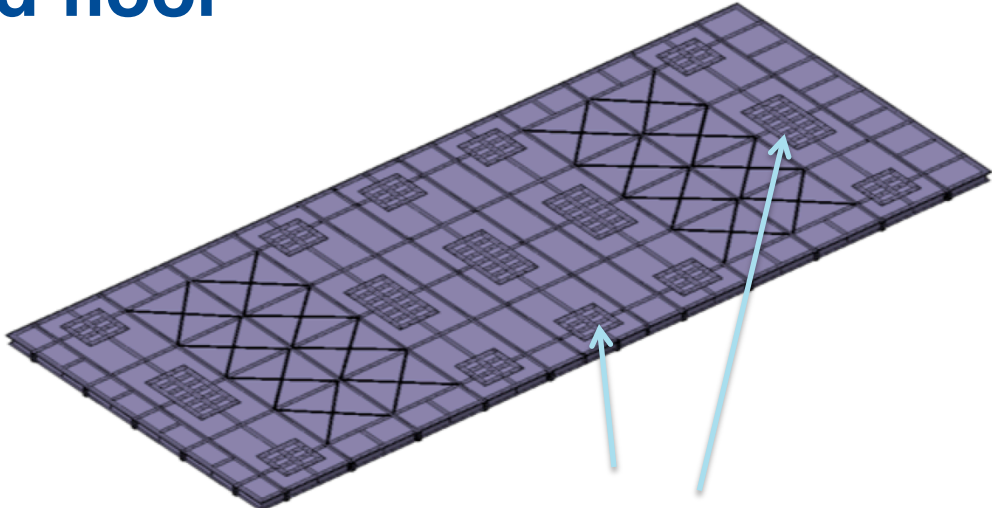
In total 7 different modules

Wall weight around 35 tons stainless steel included

# Floor layout

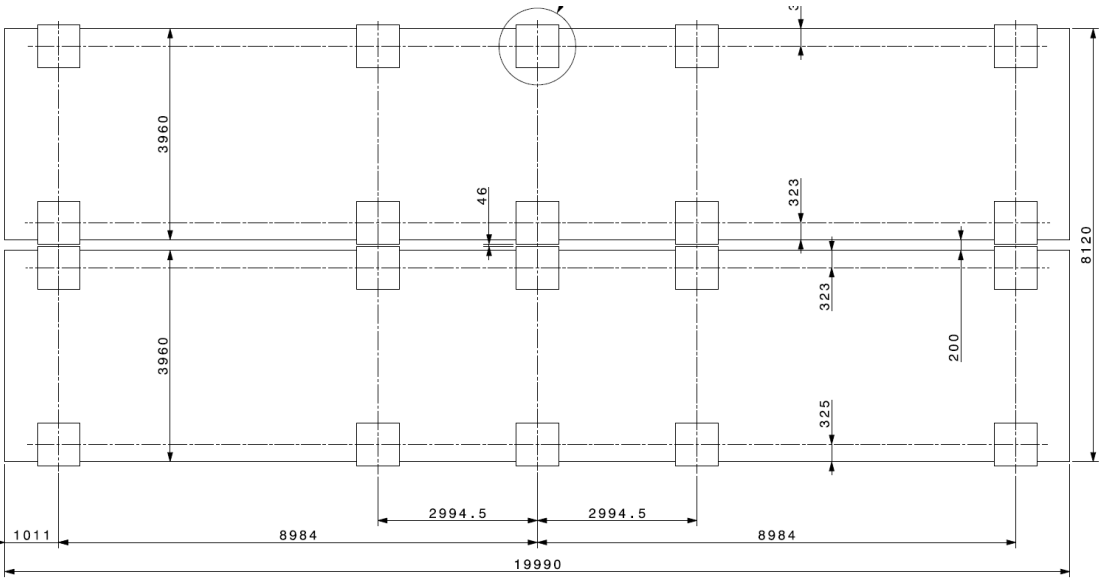


# Cold vessels inprint and floor



Warm supports

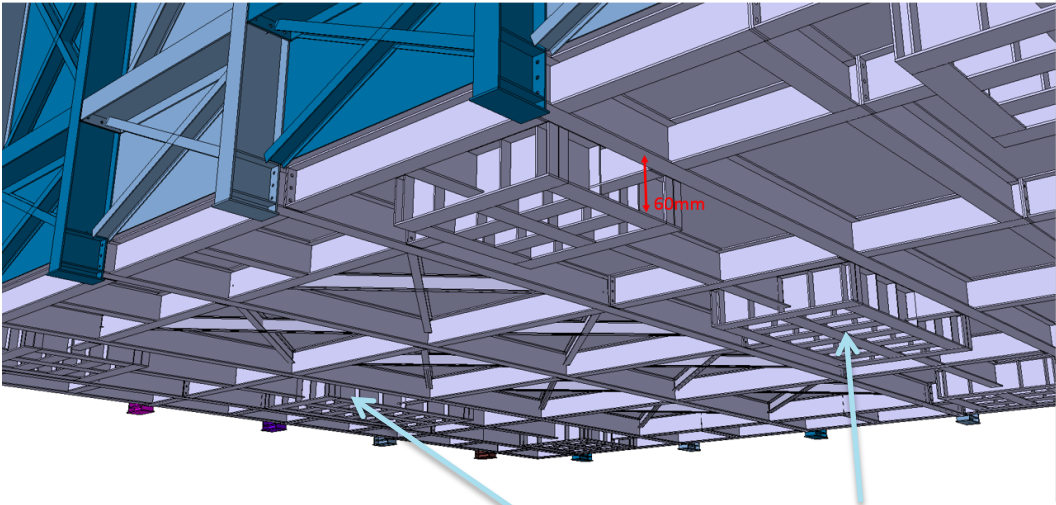
### Cold vessels



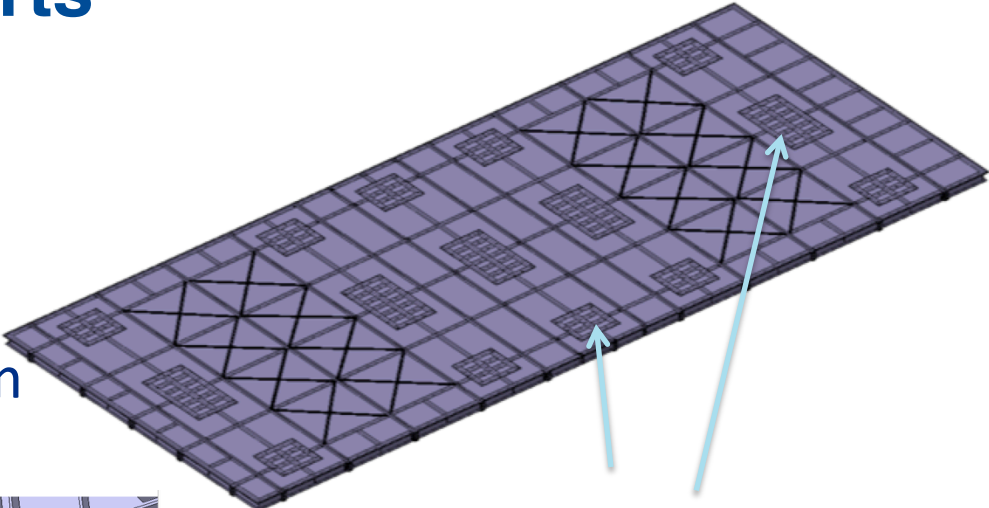


# Floor layout and supports

In between warm supports, 60mm vertical space



Warm supports



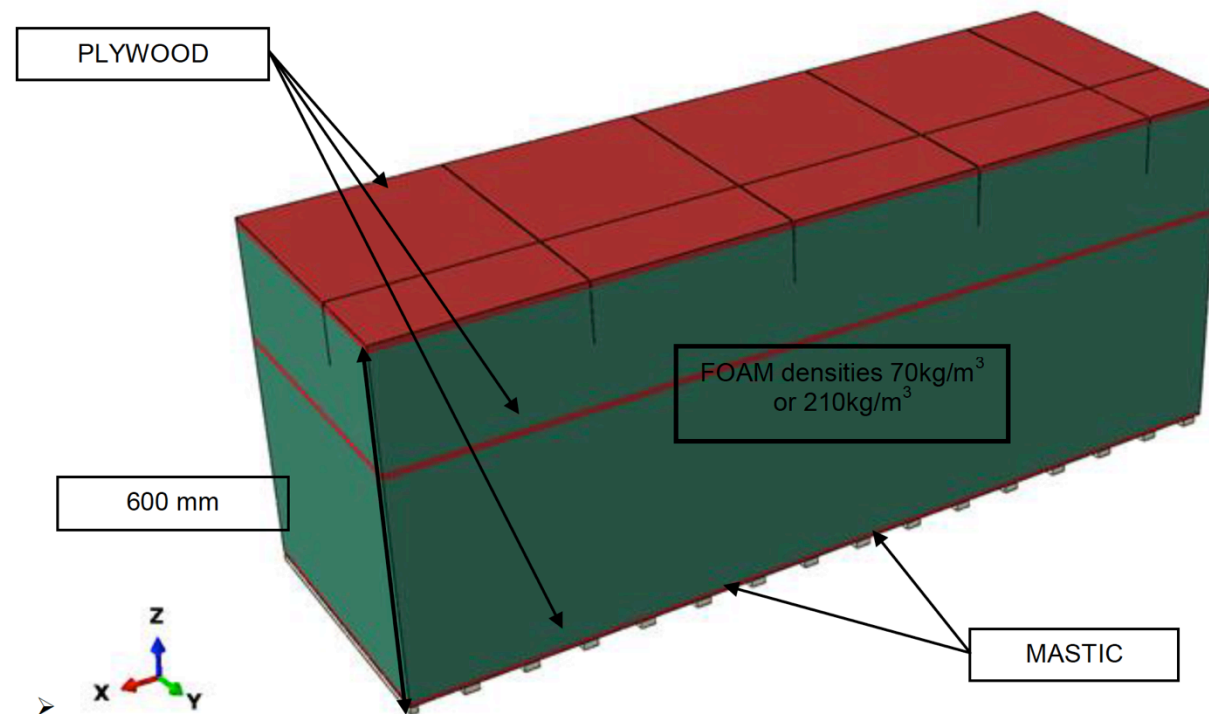
Warm supports

# Procurement and Installation plans

- Final drawings by February 2016
- Structural analysis done, but report not yet finalized
- Once final it will be analyzed by CERN HSE for green light
- Standard IP beams will be ordered by CERN store
- Modules assemblies will be subcontracted to EU firms via a CERN tendering process by March 2016
- Preassembled modules delivery to FNAL in containers
  
- *Final mechanical assembly ~1 month by a WA104 team at FNAL (not roof), including SS plates tig welding*
- *Check QA of SS welds with die penetrants and sniffer system: goal  $10^{-6}$  mbar/l/s*
- *Roof assembled and installed (+SS welding) after cold vessels in place (~ 2 weeks) + final leaks test*
- *To clarify survey and crane manpower availability at FNAL + aerial platforms and/or scaffolding*

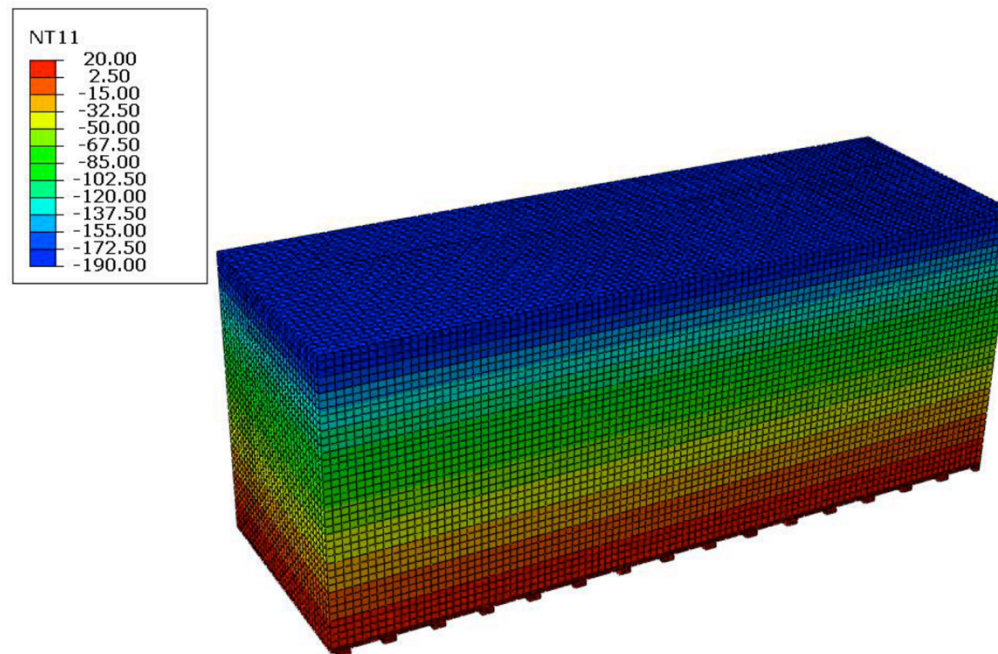
# Warm vessel Insulation : <https://edms.cern.ch/document/1566895>

- First study done by GTT, include dimensions, structural and thermal analysis, installation procedure
- Final study to be issued in Spring 2016, when the design of the warm structure is finished



# Warm vessel Insulation : <https://edms.cern.ch/document/1566895>

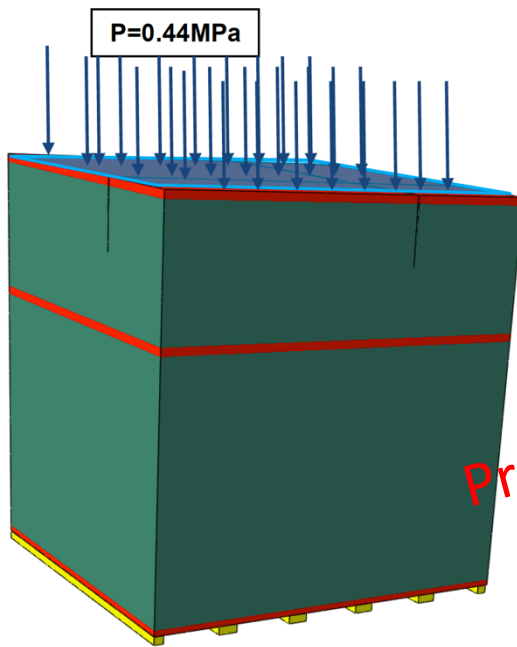
- First study done by GTT, include dimensions, structural and thermal analysis, installation procedure
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Computed thermal gradient in 600mm thick panel

# Warm vessel Insulation : <https://edms.cern.ch/document/1566895>

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Load pressure on top of panel

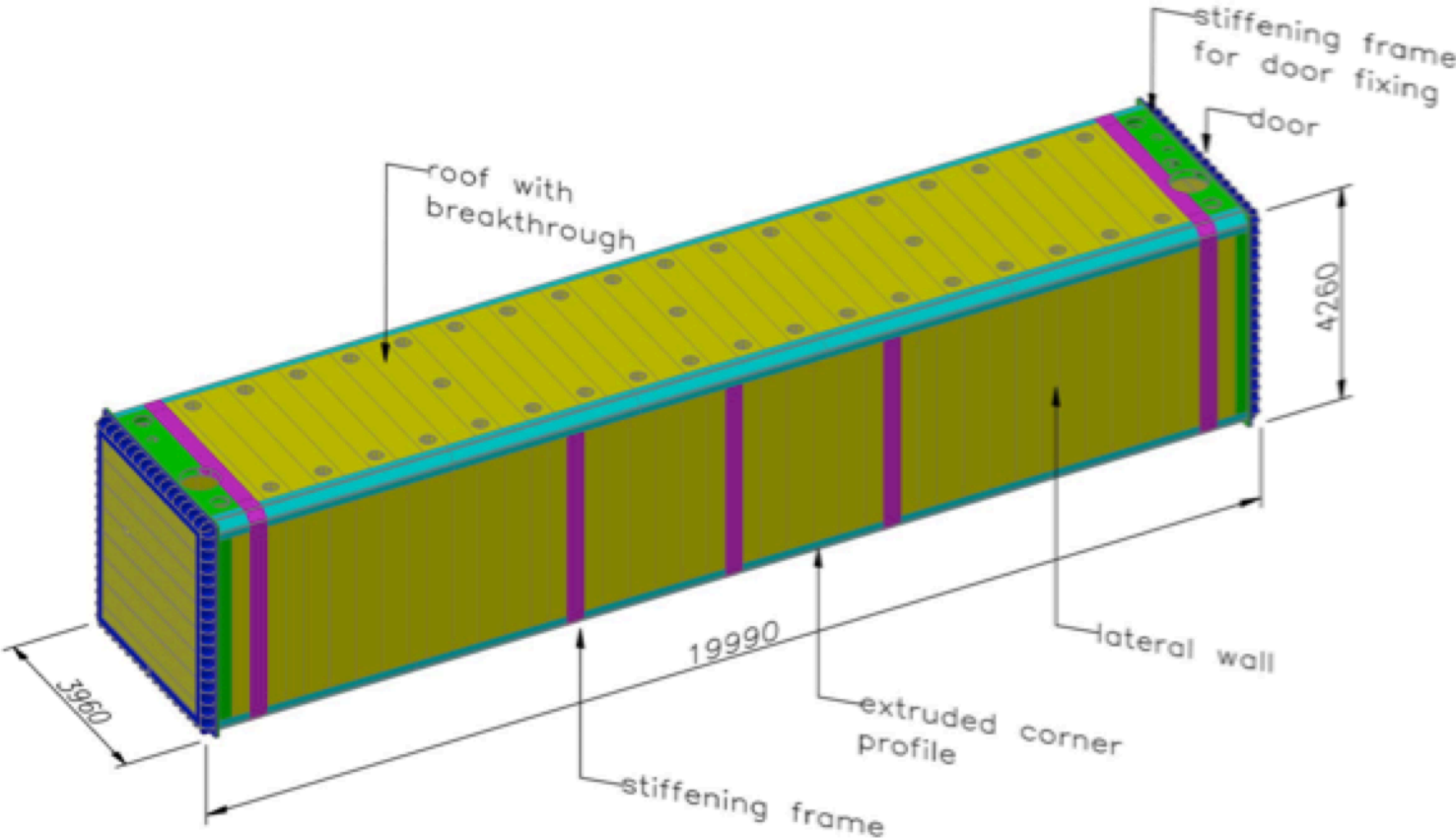
Preliminary values

Stresses in MPa	Stress types	LOAD PRESSURE	VALUE	GTT Specification (strength)	SAFETY COEFF.
Tension (N/mm)					
MASTIC & PRIMER	Hor. Tension	0.88	0.88	15	17.09
	Hor. Compr.	-1.77	1.77	15	8.48
	Vert. Tension	1.99	1.99	10	5.03
	Vert. Compr.	-3.26	3.26	15	4.61
	Max Shearing	2.07	2.07	12	5.80
PLYWOOD	Hor. Tension	2.87	2.87	40	13.94
	Hor. Compr.	-6.94	6.94	40	5.76
	Vert. Tension	0.75	0.75	2	2.67
	Vert. Compr.	-1.64	1.64	4.5	2.74
	Max Shearing	1.32	1.32	3.5	2.65
Reinforced PUF HFC 245 210 Kg/m <sup>3</sup>	Hor. Tension	1.41	1.41	6.1	4.34
	Hor. Compr.	-0.14	0.14	6.1	43.05
	Vert. Tension	0.47	0.47	2.4	5.12
	Vert. Compr.	-1.34	1.34	3.1	2.32
	Max Shearing	0.42	0.42	1.2	2.85

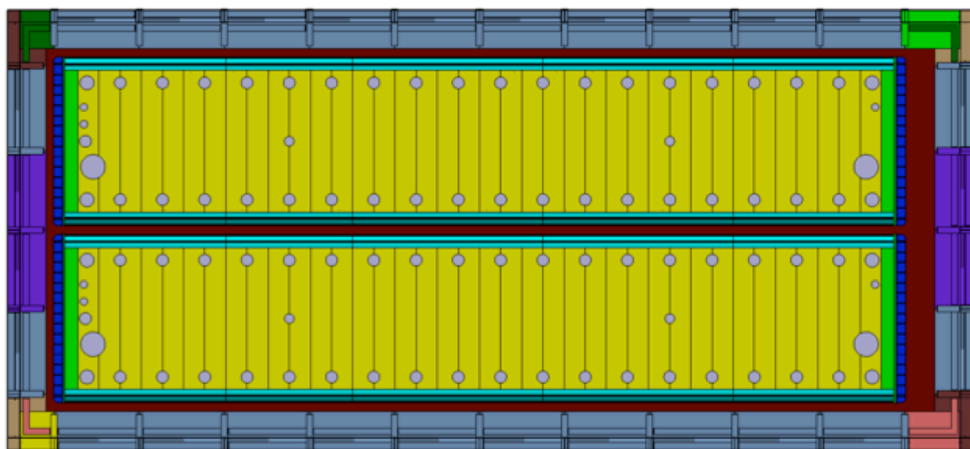
Computed safety factors for 600mm thick panel under pressure load



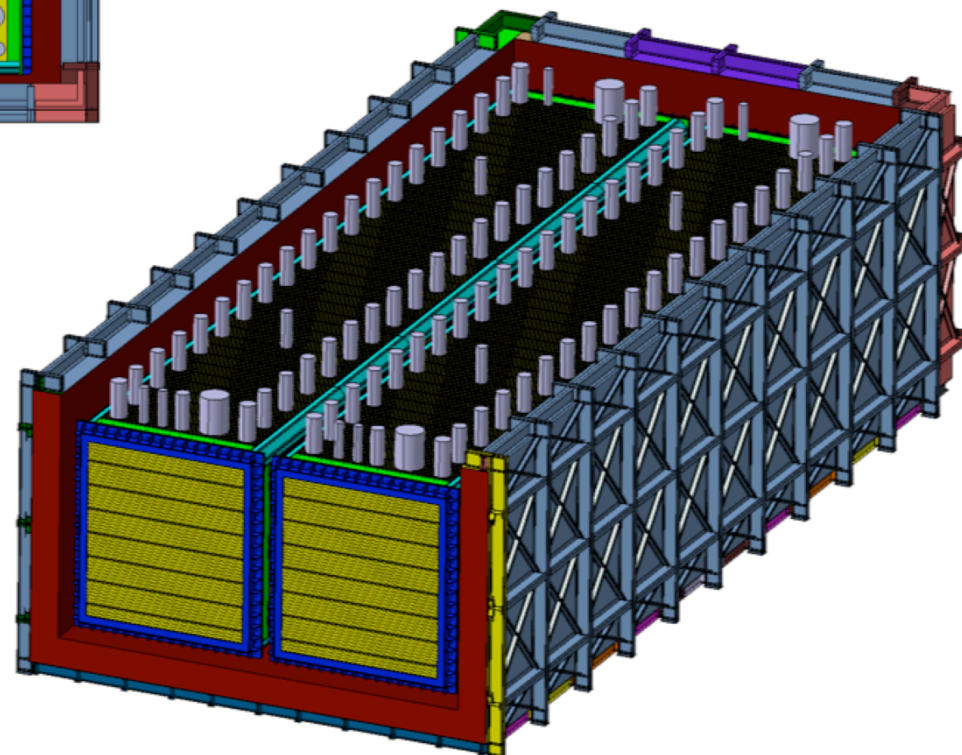
# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



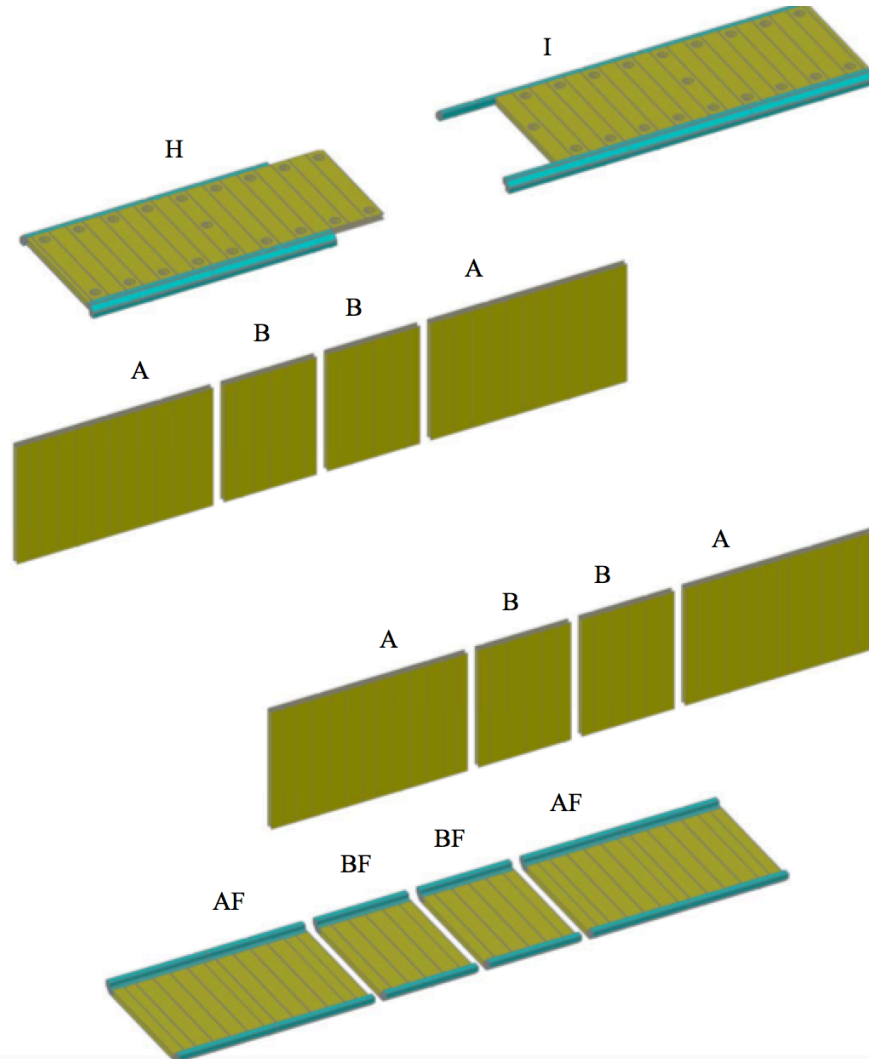
inside the warm vessel  
and the GTT insulation,  
before installing the  
warm roof



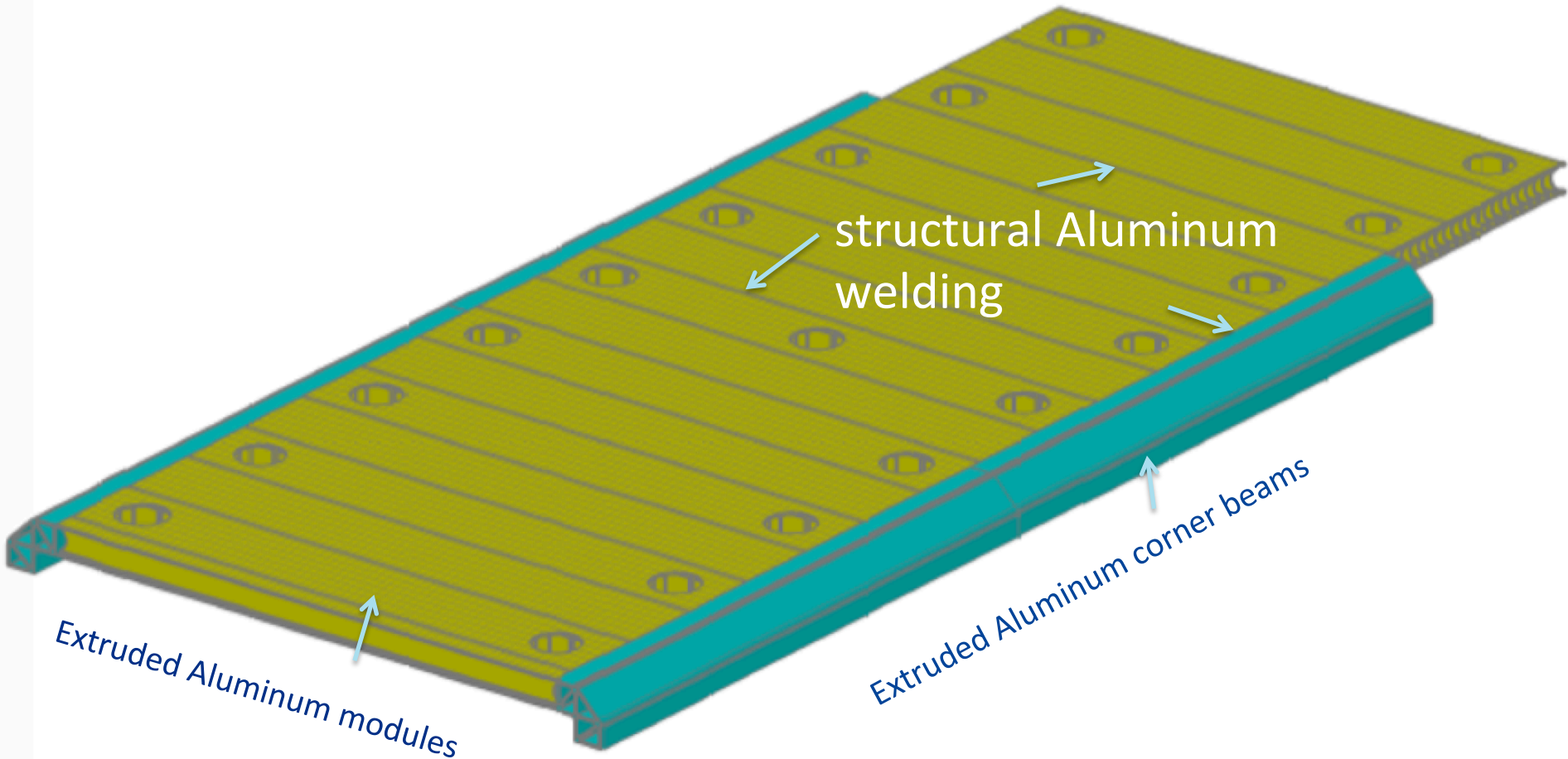
# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>

All pre-assemblies sub contracted to the firm STEP-G in Bonn (D). All contracts actives.

*First delivery to CERN (H+I this week)*



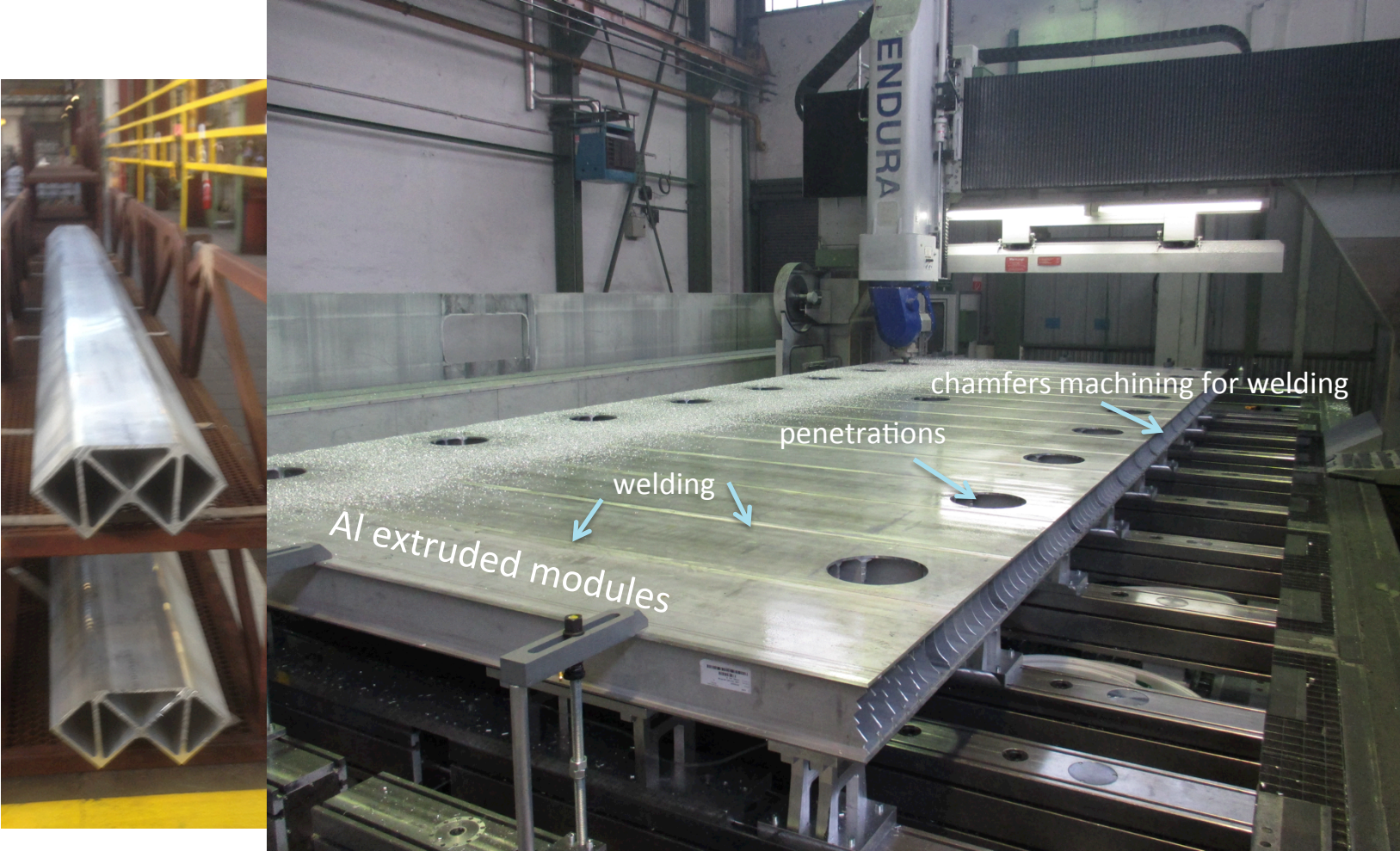
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# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>

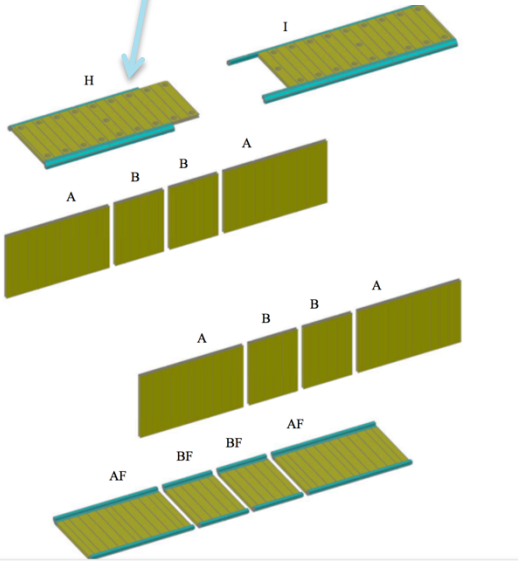


# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



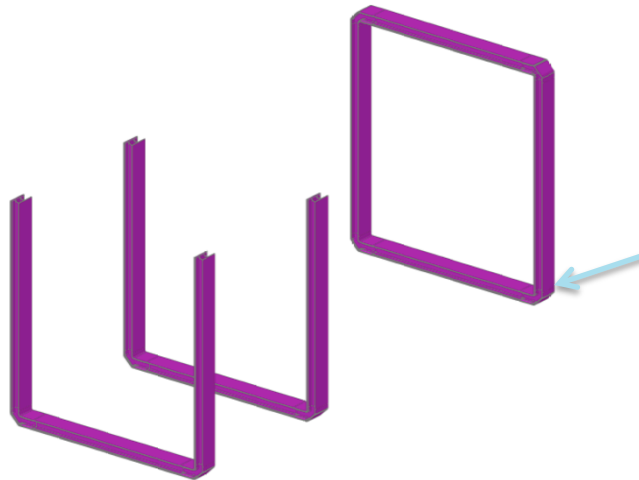
H+I at CERN

All other components for cryostat 1 will be delivered in batches by week 8

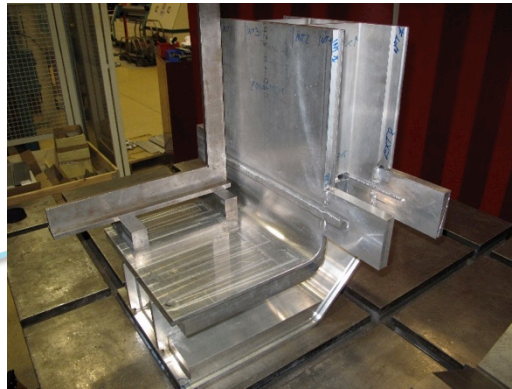




# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



U-frames structural elements



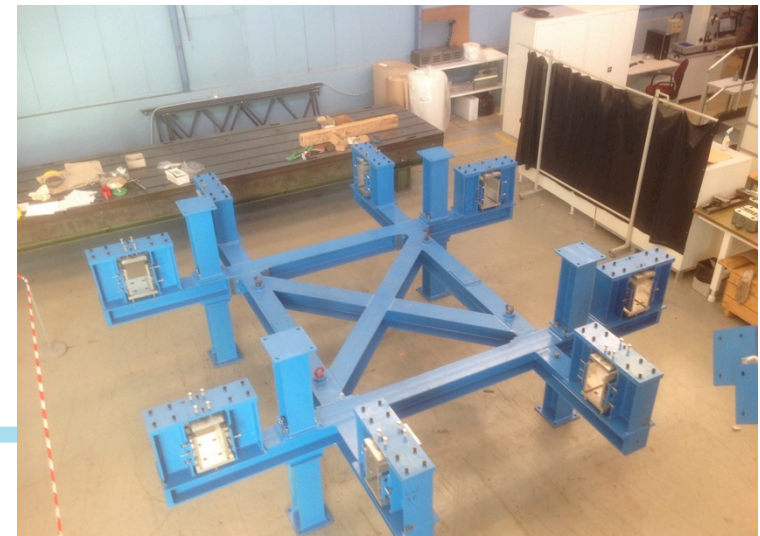
U-frames corner profiles



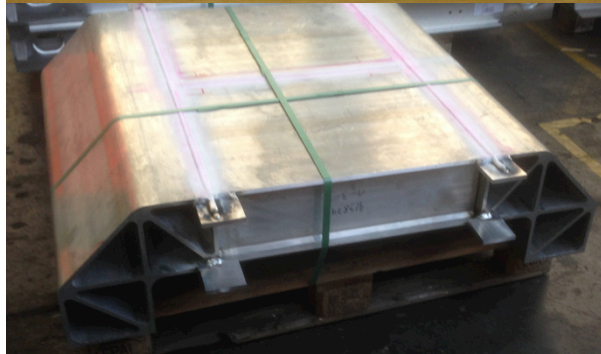
U-frames extruded profiles

- all part available
- welding qualification process done
- welding QA ready
- assembly to be done by CERN using special jig during main assembly (need knowledge of the final dimensions of all components being assembled)

U-frames assembly jigs

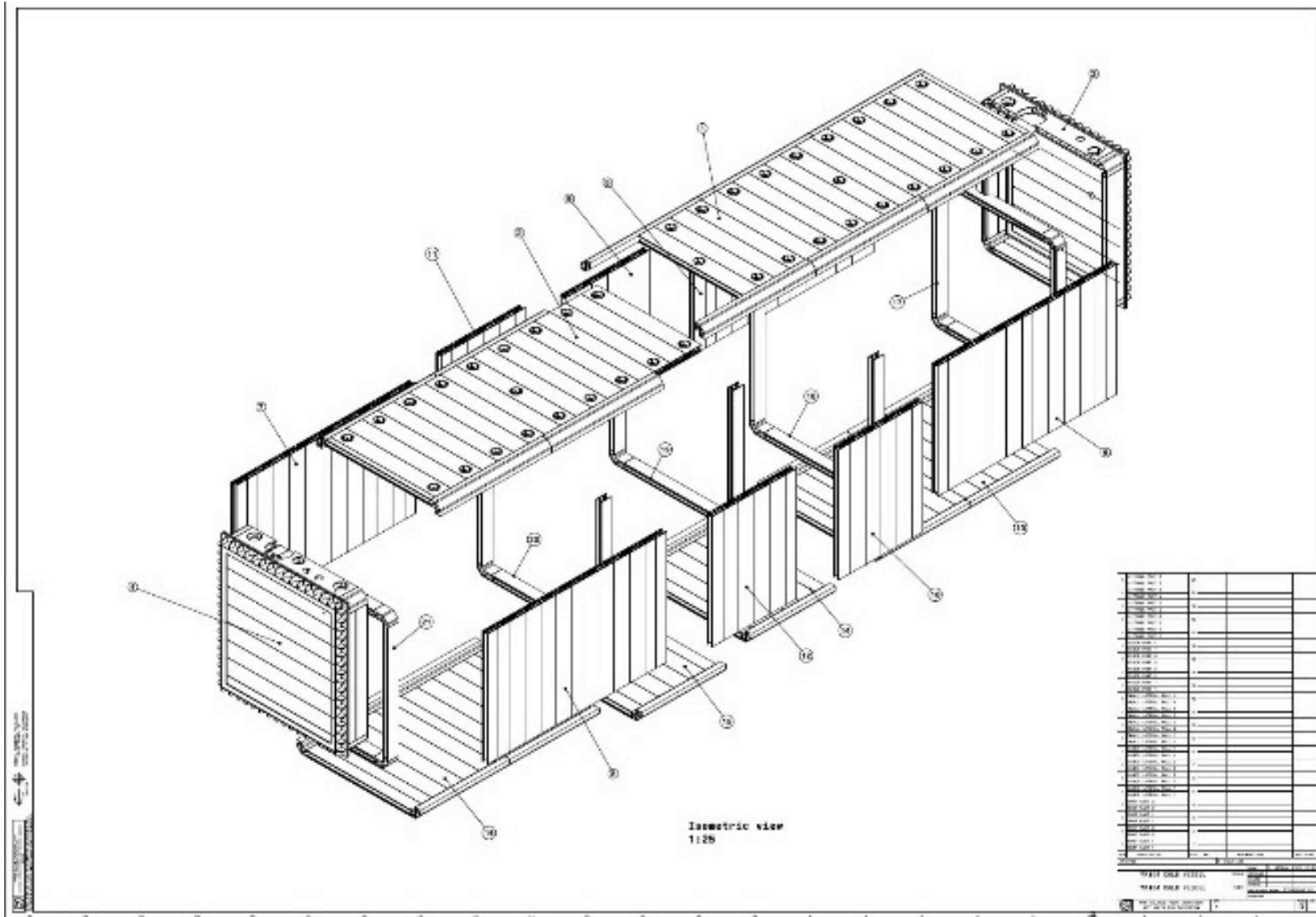


## Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



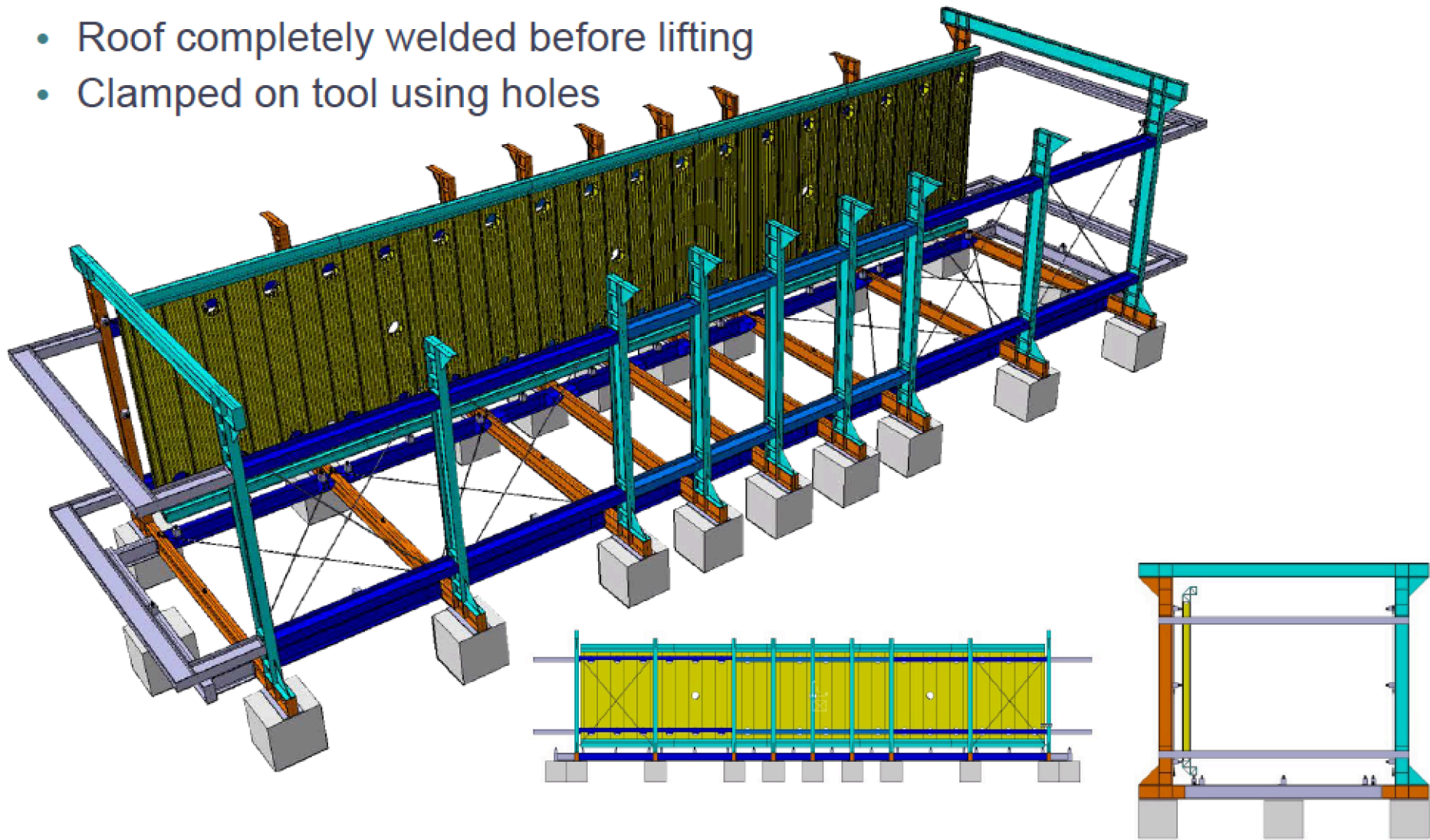
- Welding process qualification done
- QA (material + welding + dimension) plan in place
- Structural analysis done, but need now to updated with all welding and material properties, the CERN HSE (CERN safety) analysis and green light (draft on EDMS)
- Most critical loading conditions : vacuum; which will be qualified at CERN, prior detector insertion and shipment

# Assembly steps simulation →



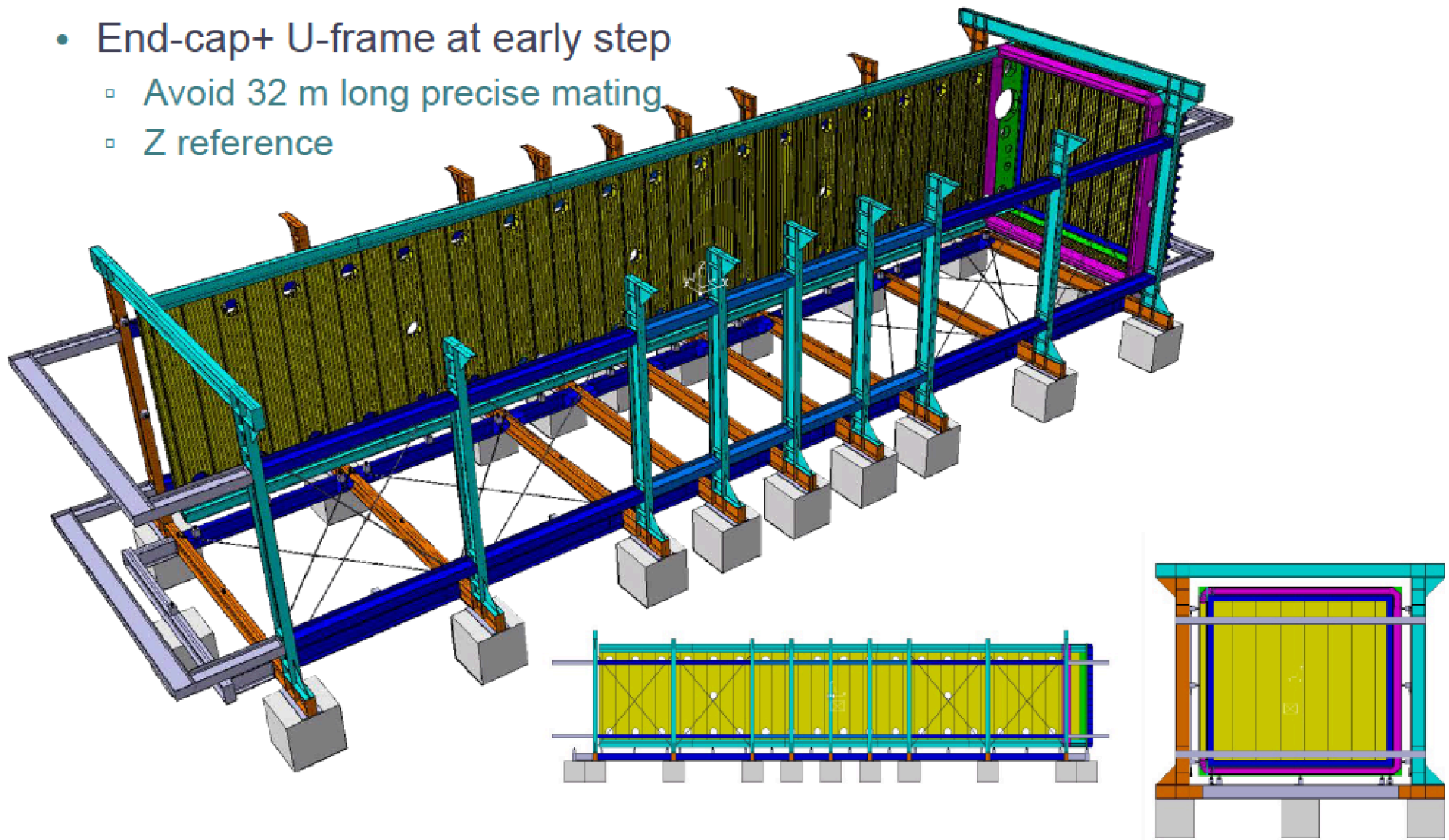


- Roof completely welded before lifting
- Clamped on tool using holes

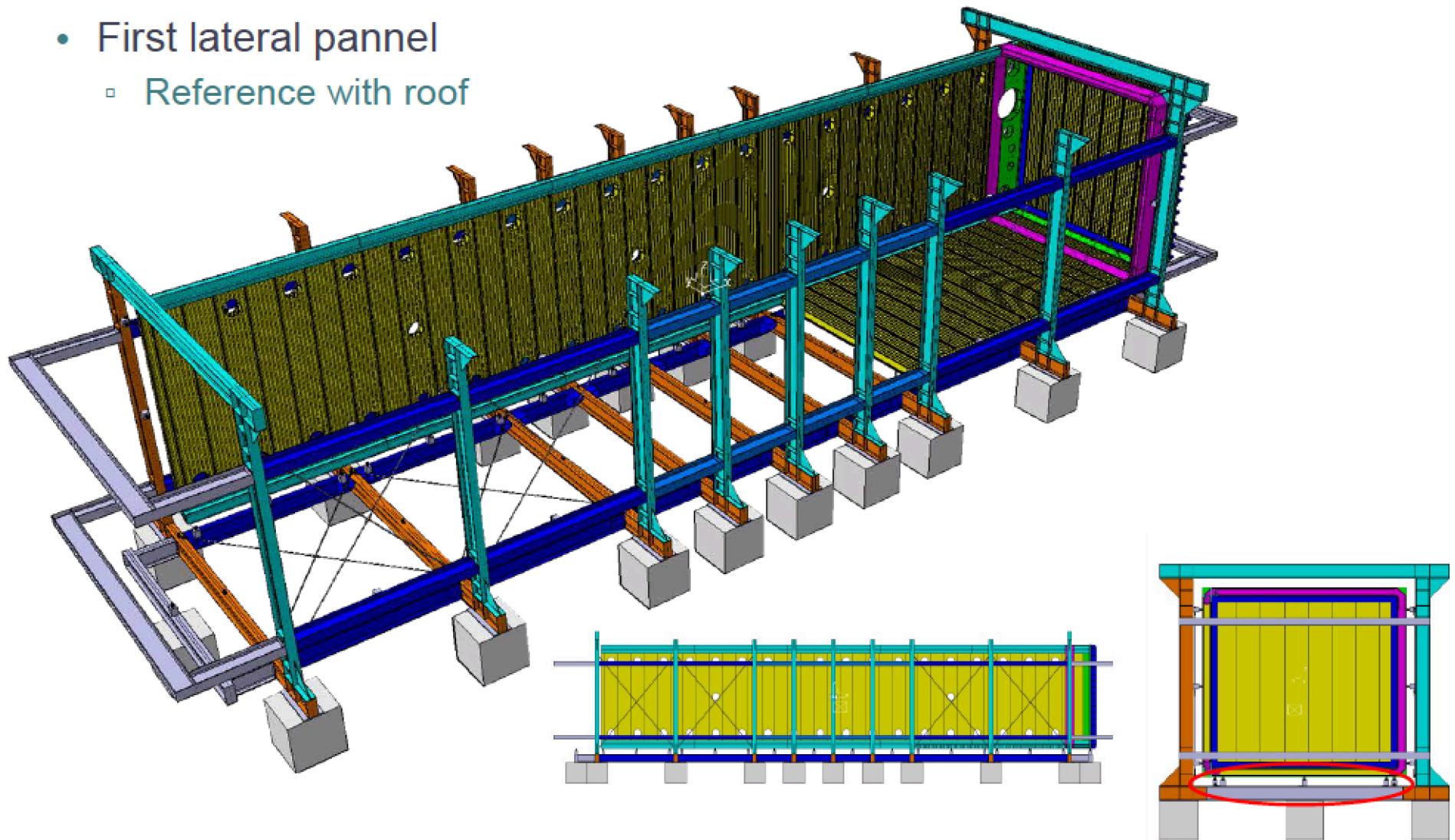




- End-cap+ U-frame at early step
  - Avoid 32 m long precise mating
  - Z reference

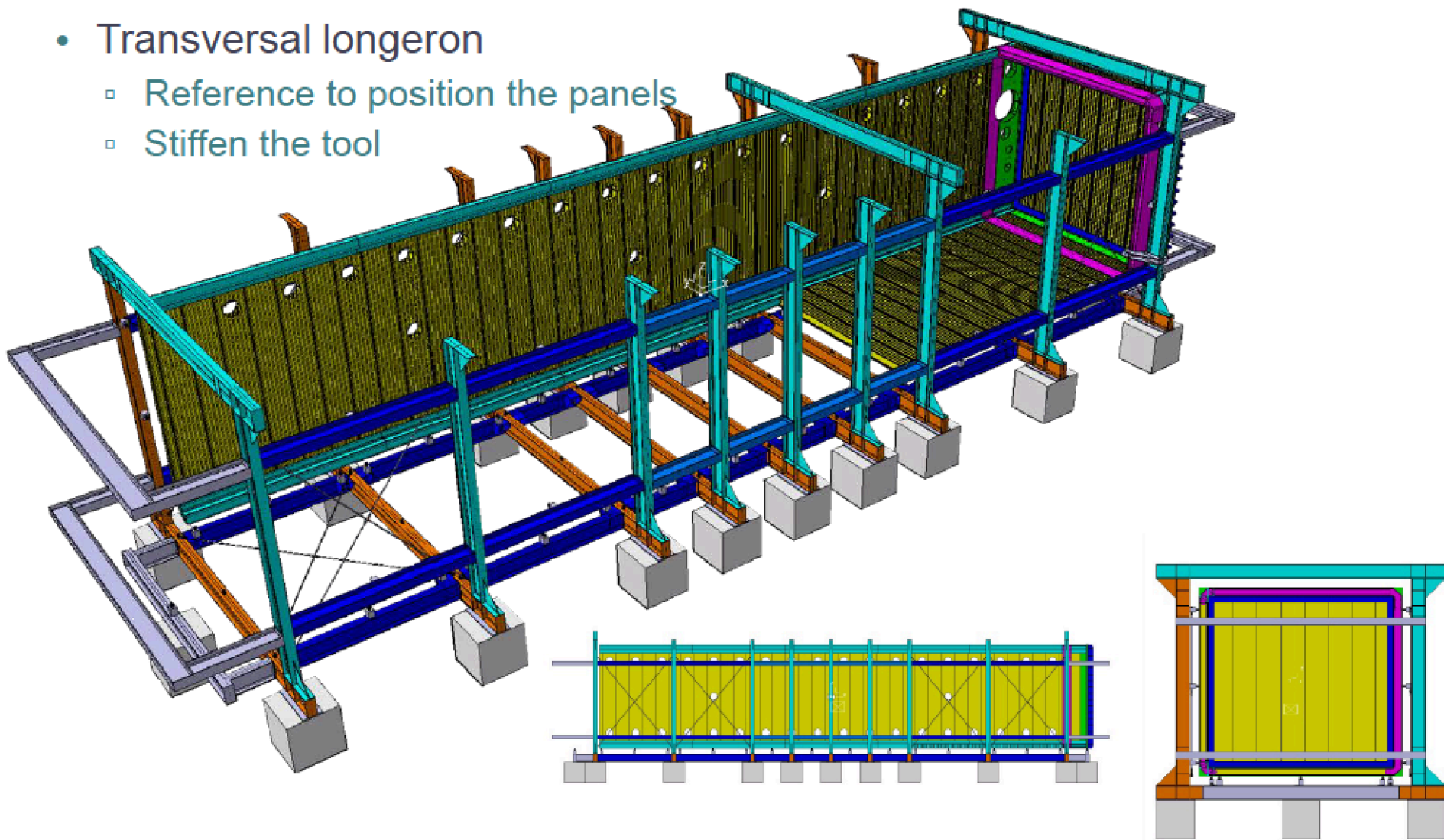


- First lateral pannel
  - Reference with roof

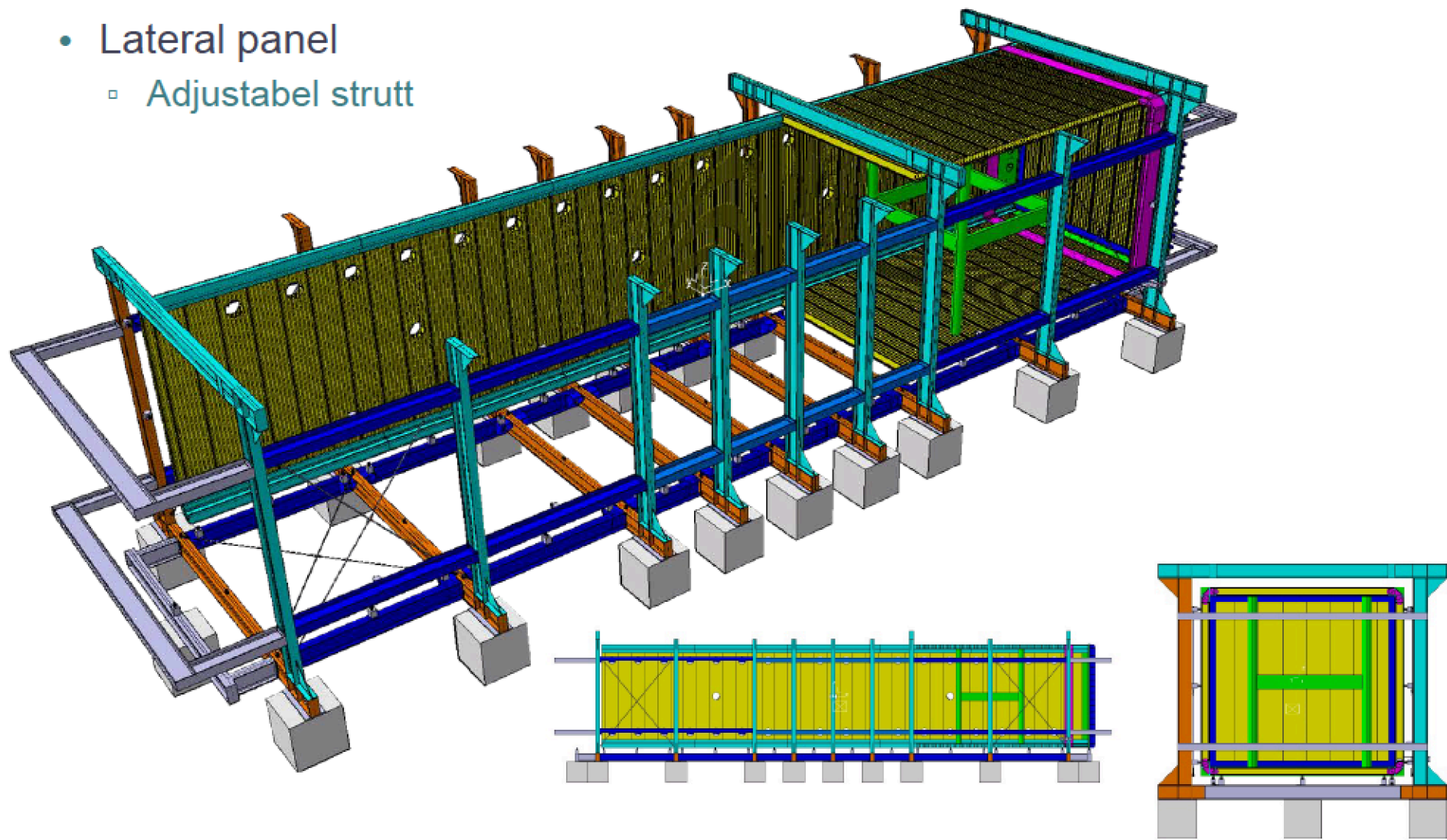




- Transversal longeron
  - Reference to position the panels
  - Stiffen the tool

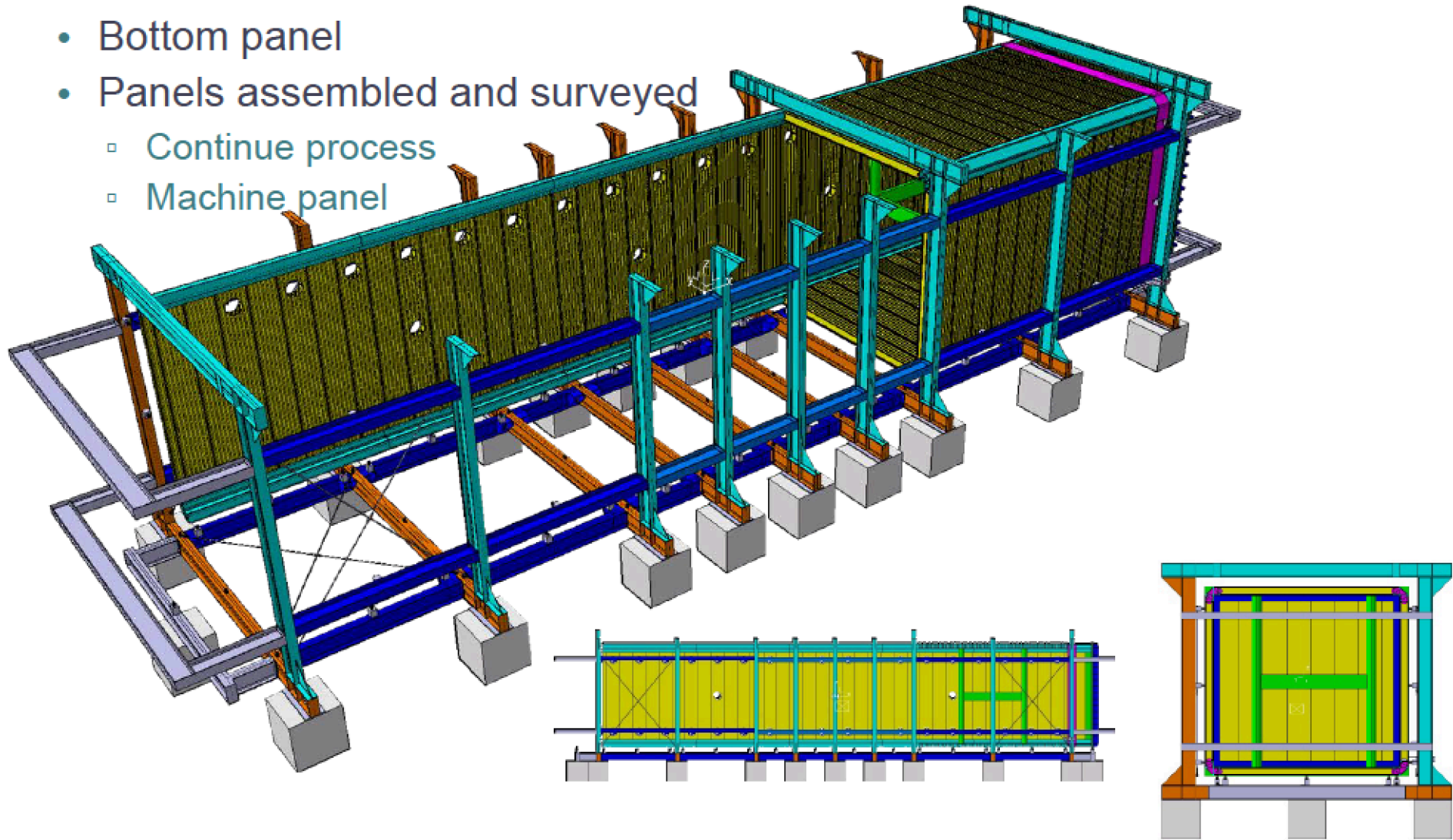


- Lateral panel
  - Adjustabel strutt

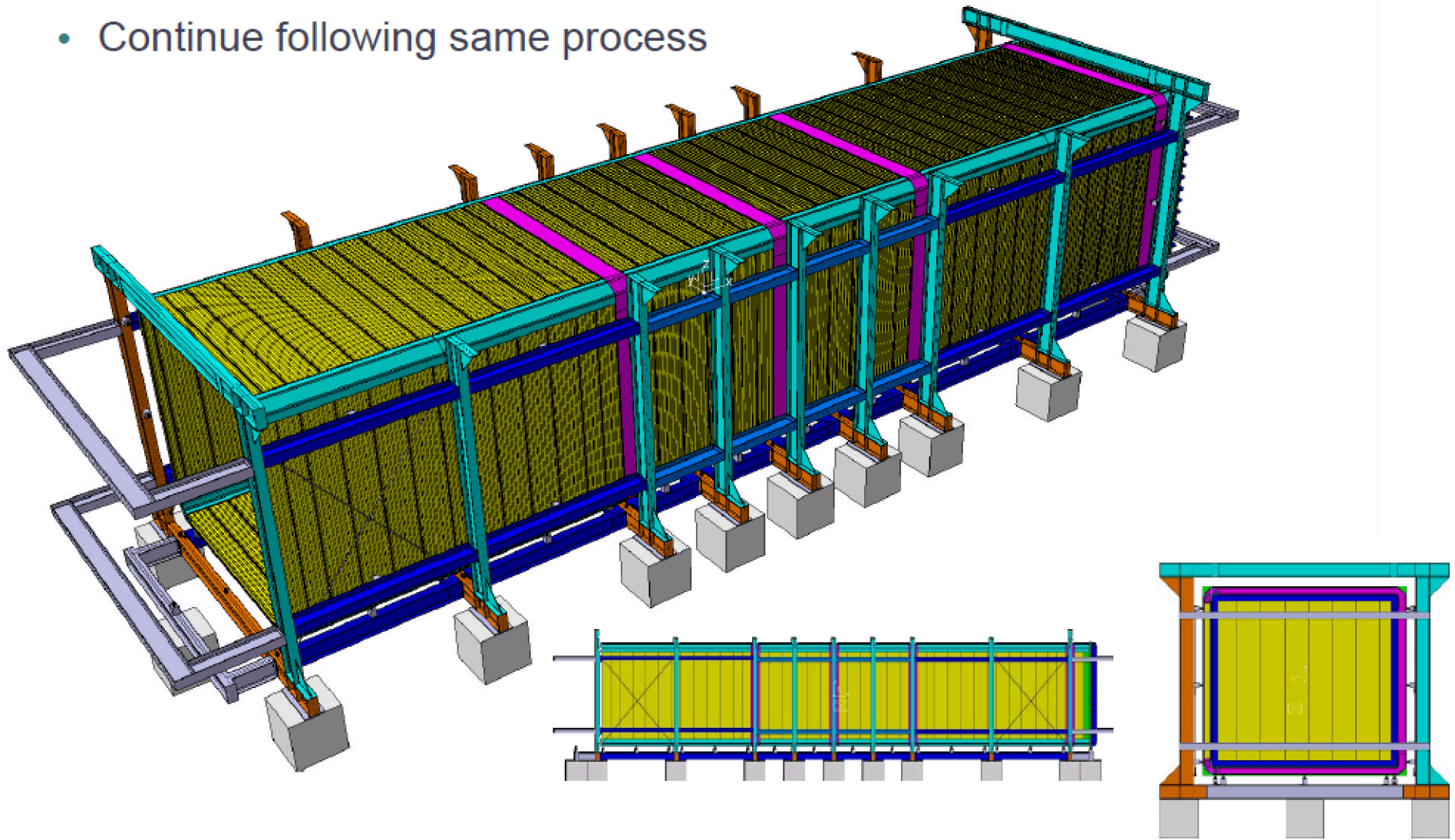




- Bottom panel
- Panels assembled and surveyed
  - Continue process
  - Machine panel

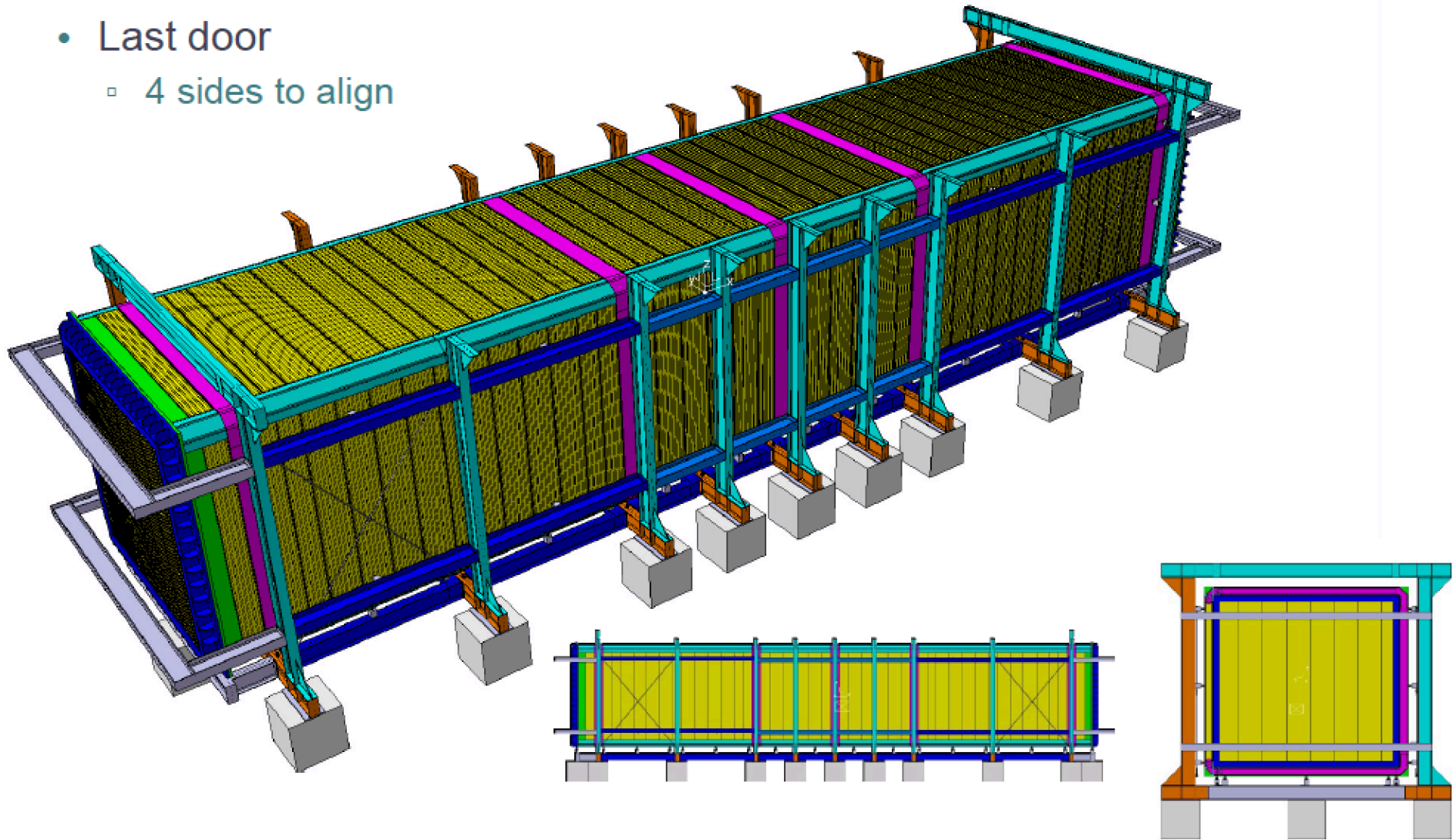


- Continue following same process

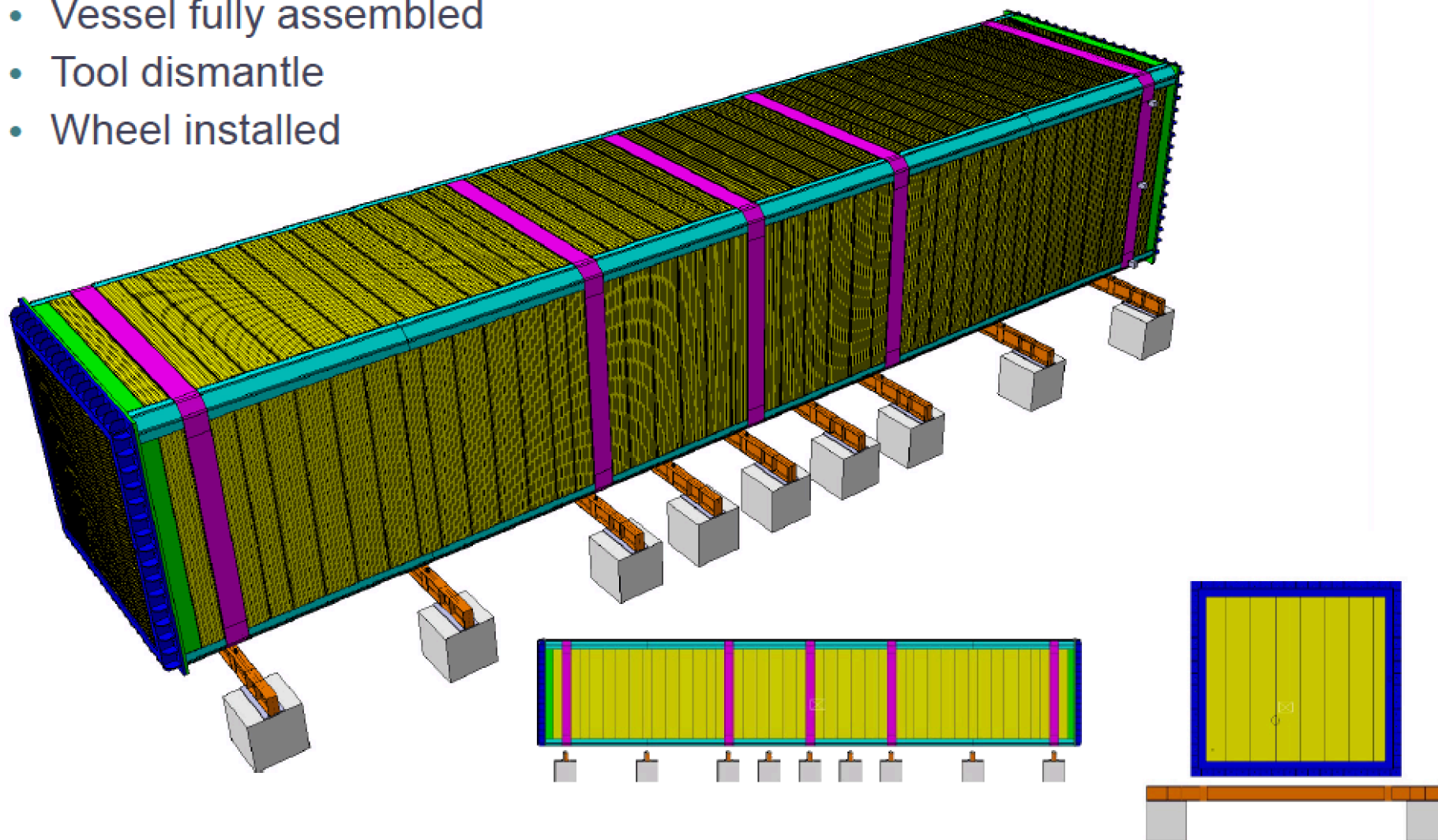




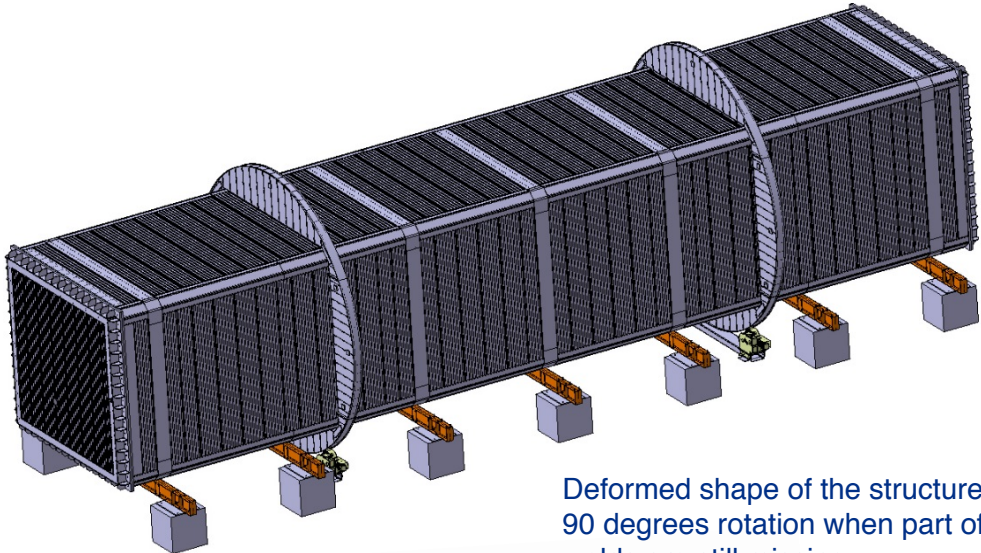
- Last door
  - 4 sides to align



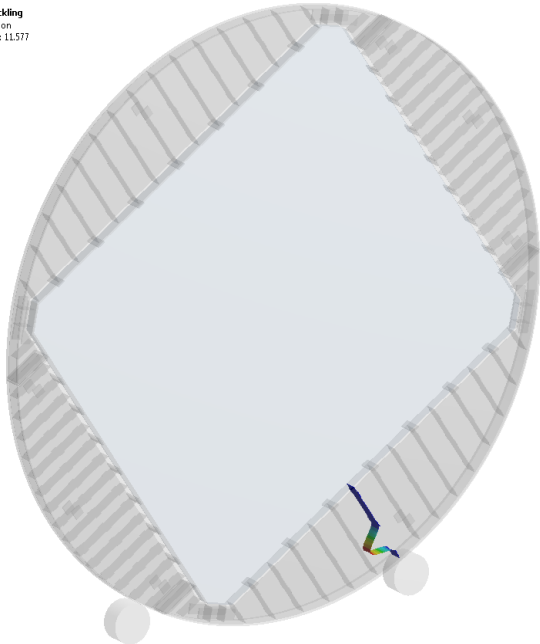
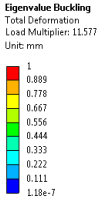
- Vessel fully assembled
- Tool dismantle
- Wheel installed



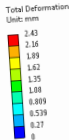
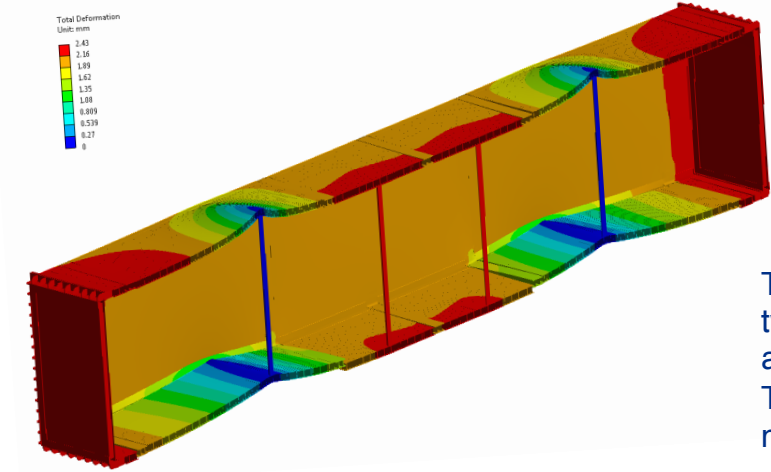
# Then rotation to allow welding in vertical position



Deformed shape of the structure after a 90 degrees rotation when part of the welds are still missing.



First buckling mode of the wheels during rotation. To have this mode one should load the wheel with more than 11 times the real load.



The tool to allow the rotations of the structure consists of two wheels (one motorized, the other free) assembled around the cryostat. The position and size of the wheels have been studied to minimize the deformations and to minimize the weight..







# Cold vessels: <https://edms.cern.ch/project/CERN-0000153072>



~8 months of operations, not continuous: first vessel in b 156, second in b 185

Assembly team in place at CERN:

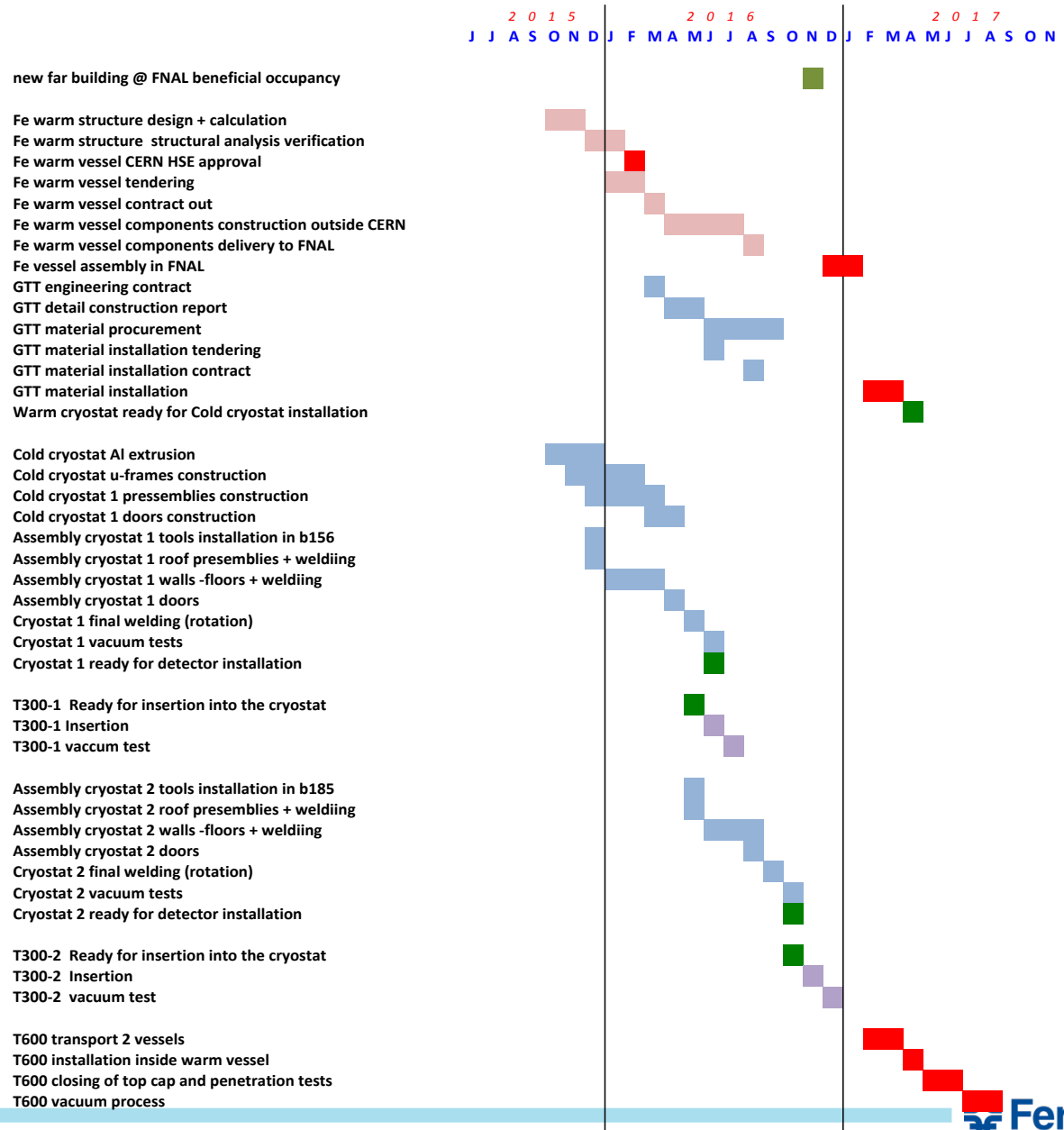
- 1 team leader
- 3 CERN mech. technicians
- 1 CNC operator
- 2 mechanical engineers
- 3 aluminum welders
- 1 welding engineer for QA
- 2 crane drivers
- 2 surveyors
  
- *Welding tools*
- *CNC machines for fast interventions*
- *Aerial platforms for access*
- *Various assembly tools*

# Logistic

- 7 Ship containers (40 ft) via sea transport for the warm structure + installation tools from Europe
- 8 Ship containers (40 ft) via sea transport for the foam insulation from Korea
- 2 Cold vessels with the T300 inside special transport (sea or air, not yet finalized). Road transport to FNAL will be an exceptional transport. Need crane strategy to unload and move it inside the FD surface building
- 2 Final lowering procedures for the cold vessels inside the warm vessel (special tools, dedicated and specialized rigging manpower + survey team)



# Schedule



# Documentation : <https://twiki.cern.ch/twiki/bin/view/CENF/WA104Cryostats>

TWiki > [CENF Web](#) > [RDProjects](#) > [WA104](#) > [WA104Subprojects](#) > [WA104Cryostats \(2015-12-12, MarzioNessi\)](#)

## Welcome to the WA104-Cryostats TWiki Home page

- ↓ [General](#)
- ↓ [Cold vessels](#)
- ↓ [Warm vessel](#)
- ↓ [GTT insulation](#)

### General

- [EDMS link](#)

### Cold vessels

- [Cold vessels EDMS link](#)
- [design, layout and dimensions](#)
- [CAD files](#)
- [assembly plans](#)
- [structural analysis](#)
- [schedule](#)
- [procurement contracts](#)
- [procurement acceptance documents](#)
- [pictures](#)

### Warm vessel

- [Warm vessel EDMS link](#)
- [design, layout and dimensions](#)
- [CAD files](#)
- [schedule](#)
- [procurements](#)
- [pictures](#)

### GTT insulation

- [Insulation EDMS link](#)
- [GTT initial studies](#)
- [schedule](#)
- [procurements](#)
- [pictures](#)

# Working Team in Europe

## Contractors:

- Finzi Associati, Milano : A.Castellani, S.Bonelli, E.Bascialla
- STEP-G, Bonn : K.Funken, Ch.Orth, T.Karsten et al.

## WA104/ICARUS and CERN:

O. Beltramello, F. Bertinelli, F. Cadoux, G.Favre, B. Lacarelle, S. Michal, D. Mladenov, C.Montanari, M. Nessi, D.Perini, J. Poirot, A. Popov, A. Scaramelli, E.Seletskaya, D.Smargianaki, F.Vercellati, A. Zani + EN/SU survey team + EN/MME/FW welding team (4p)

# Summary

- All activities proceeding according to the initial plans
- Critical is the final assembly at CERN of the cold vessels which is technically a very difficult process
- Goal to deliver all material and detectors by early 2017 to FNAL
- All work resources at CERN covered by a WA104 MOU between CERN and INFN
- Activities at FNAL in 2017 not yet finalized in detail
- MOU for all transports and activity at FNAL not yet worked out