Design Philosophy of the CMS Experiment

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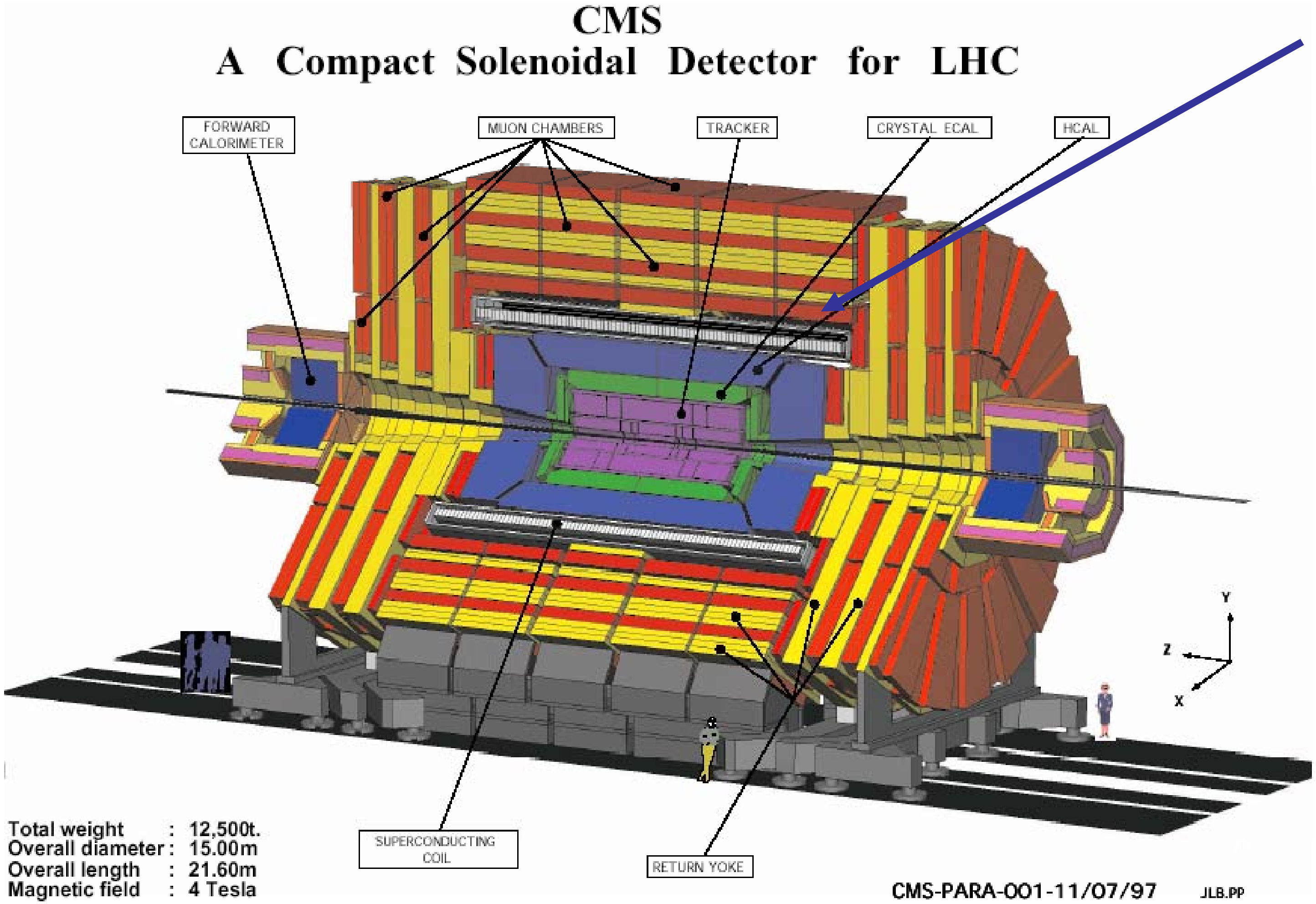
CMS Experiment

Logistics not so different than ILD



Based on Large SC Solenoid

6 m diameter

13 m long

Strong Field 4T

10'000-ton Instrumented Return Yoke

Guarantee Accessibility for Maintenance

– ***Sub-detectors must be maintainable, that is detector can be opened in a reasonable time to give access to every one of them, including access to the main flanges of Tracker, ECAL and HCAL.***

– ***This opening scenario must be possible without decabling or removing services of any sub-detector, to allow fast re-commissioning before closing again the detector.***

– ***The goal is to maximize useful maintenance time to get all sub-detectors operating at their optimum.***

Request Assembly and Test on Surface

- *As seen at LEP, installation work takes 50% more time in a deep underground area for questions of access, limited space, superposed work areas and related safety precautions*
- *CMS has from the start requested an assembly on the surface followed by transfer of FULLY COMMISSIONED large detector elements (up to 2000 tons) by heavy lifting means.*
- *It was also argued, and I think this has been demonstrated, that the length of the underground cavern would be insufficient to carry out such a construction work in a reasonable time.*
- *Another important argument was that all delicate or risky operations, coil test, HB insertion, EB insertion, Tracker insertion, closing of detector etc. can be carried at least once on the surface and corrections made before final operations underground.*

Start the Integration Project Early on

- ***Select a good integration coordinator.***
- ***Assemble an integration and design office.***
- ***Generate and maintain a “central parameter drawing” defining absolute boxes for subdetectors separated by no-go zones.***
- ***Each absolute box must contain the subdetector, its electronics, cables, cooling screens and pipes, deformations, and all associated tolerances.***
- ***Select compatible CAD systems, and maintain a central “up-to-date 3D model”.***

Tackle Fire-Safety Early on

- ***The inside of the cryostat is inaccessible, although it contains the heart of the experiment in terms of investment in time and cost. It must be protected against fire by maintaining an inert atmosphere (enriched in nitrogen) to quench any source of fire ignition***

- ***Thus, inside cryostat, gas cooling can only be natural convection. Associated cold sources must be provided by stabilizing in temperature the Vacuum Tank itself or the HCAL absorber (for example) to prevent inner temperature drifting***

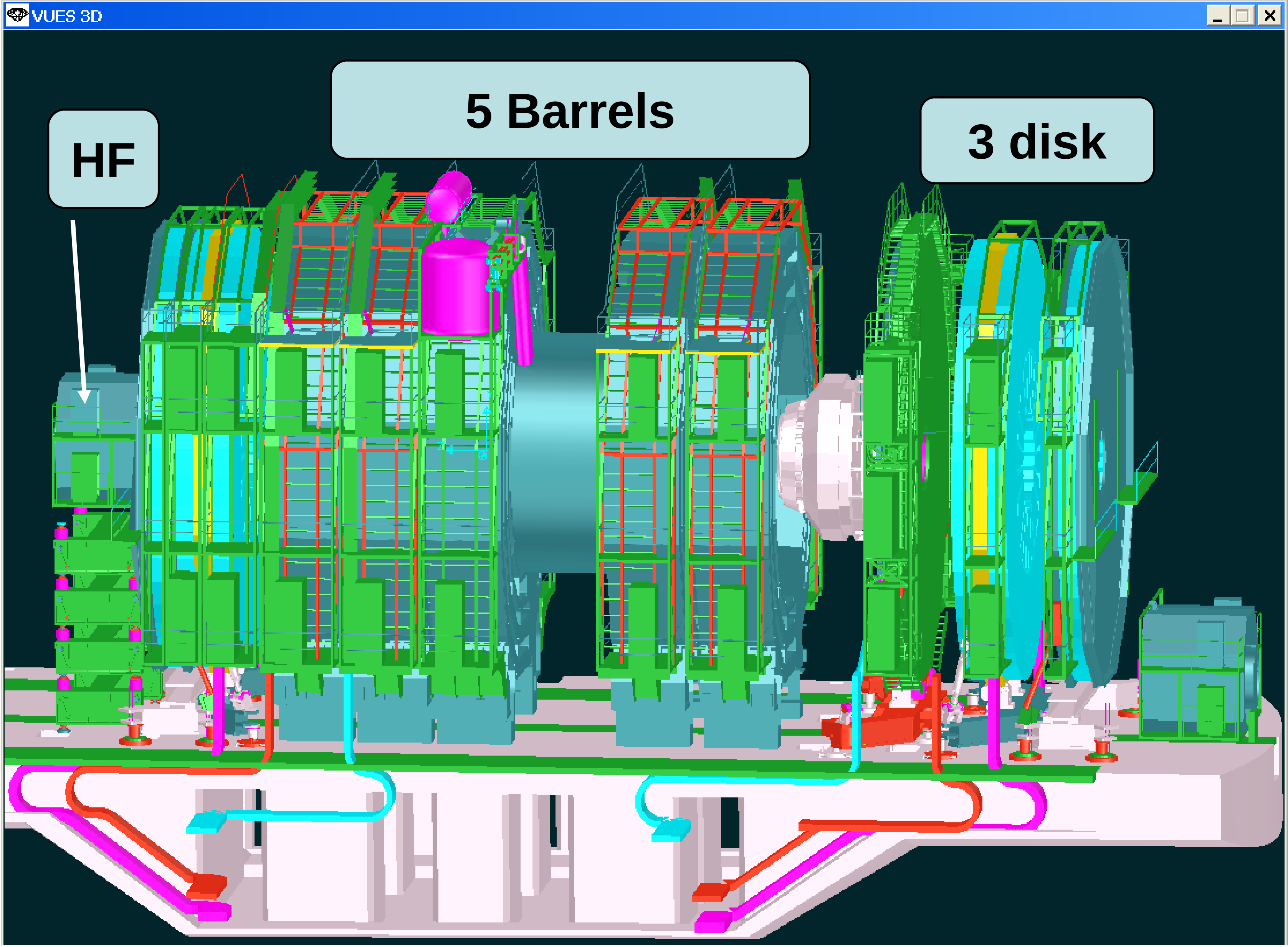
- ***Liquid cooling is thus mandatory to extract main part of the heat as near as possible from where it is created***

Foresee Active Cooling from the Start

- *Active cooling of front-end electronics is a must especially in confined areas like Cryostat which is under nitrogen atmosphere for fire safety*
- *Temperature stabilization is needed as temperature dependence of sub-detectors is often neglected or known quite late, light detectors, RPCs, ….*
- *It is good practice that each sub-detector can be considered as an adiabatic, or isothermal enclosure wrt. its neighbors, that is each one is responsible for removing its own thermal flux*
- *Air (or gas) cooling is very inefficient, it can be used at best to remove residual heat, water is still the best*

Some pictures of CMS construction
to draw attention
to some applicable points

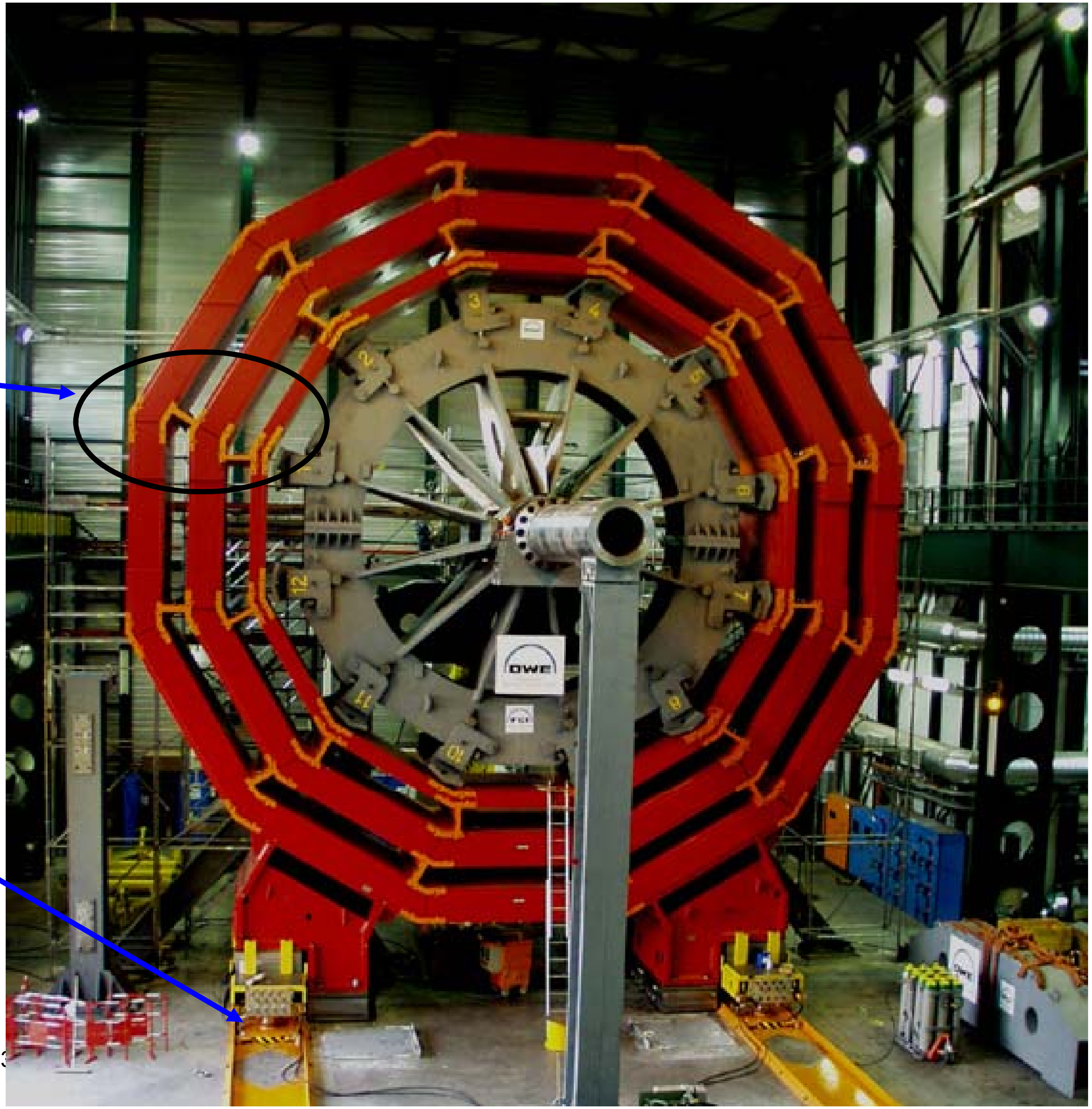
Large elements must be able to moved Connected by large cable chains



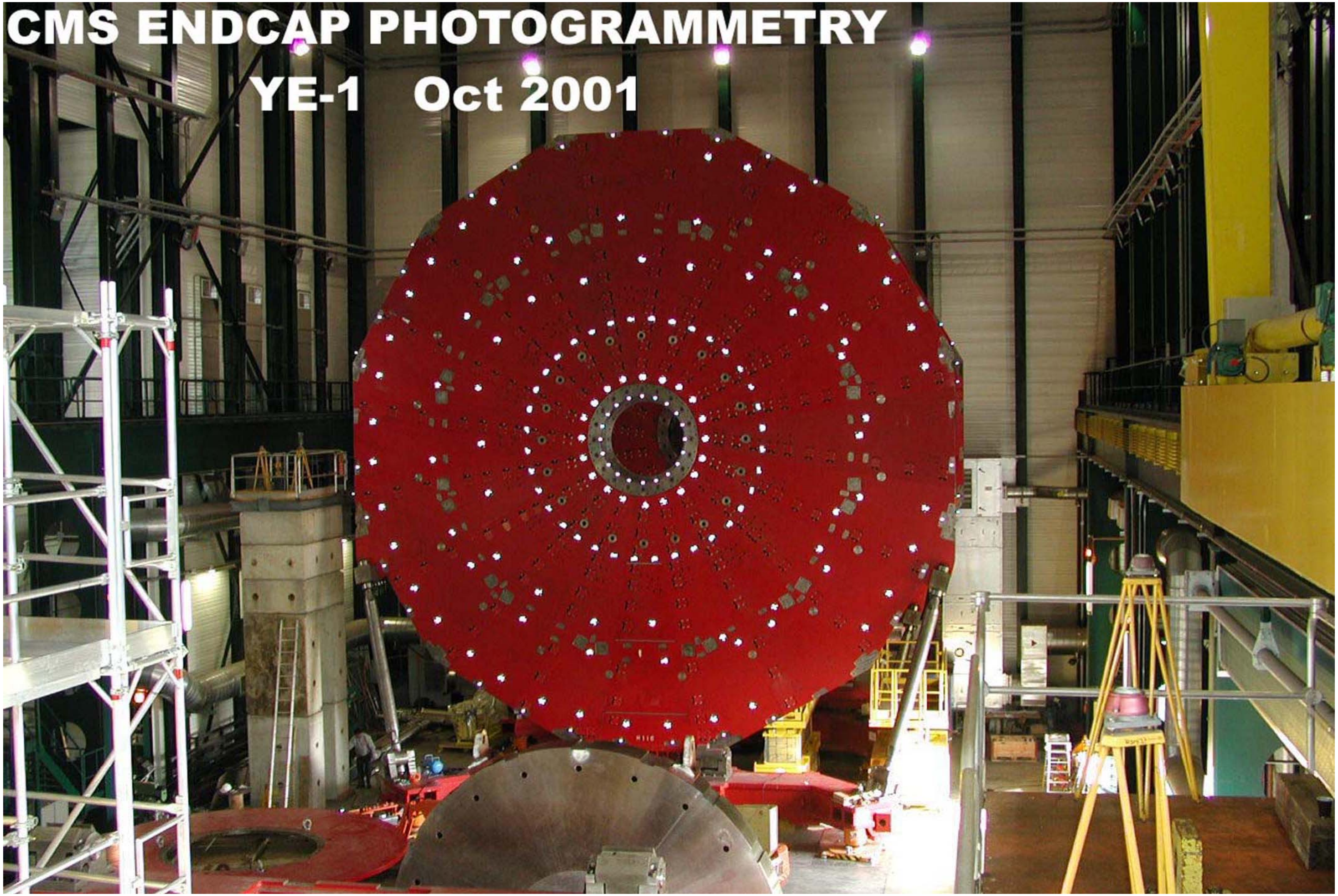
Construction of yoke used precise Jig and Keys to minimize Tolerances and allow fast re-Assembly

Effort has been made not to align dead zones

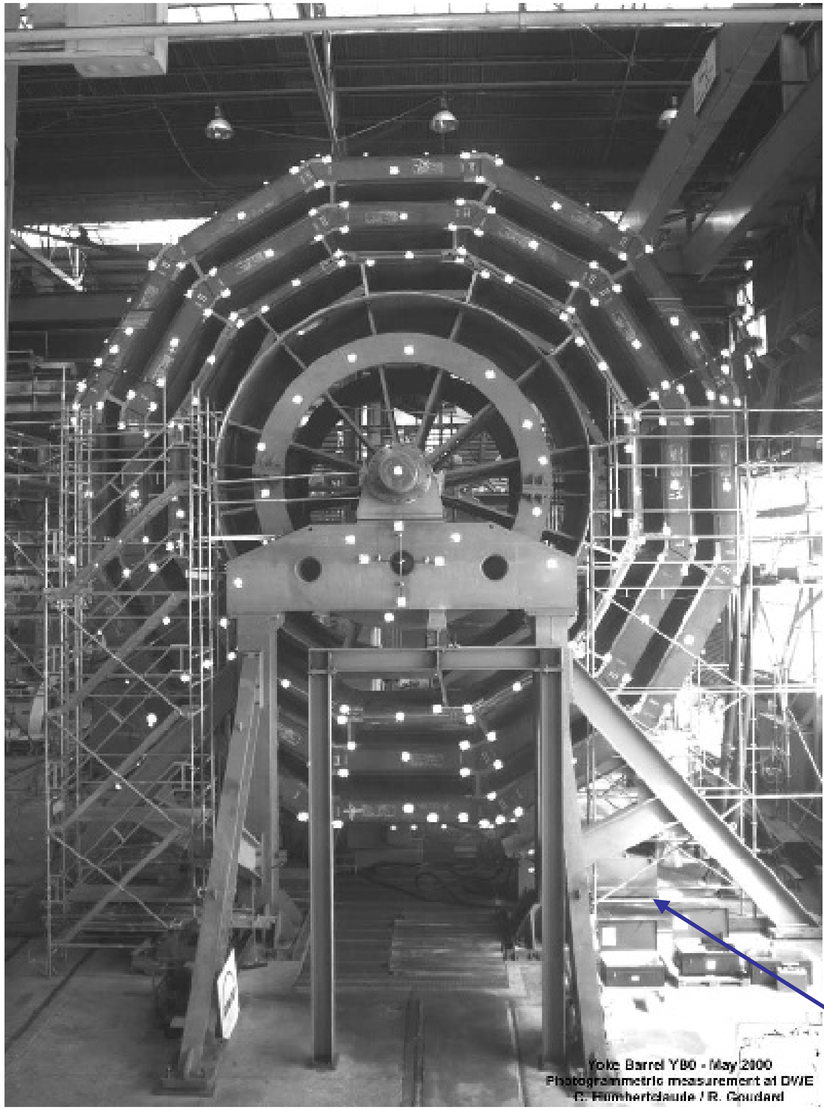
Air pads



All Pieces have been carefully Surveyed



Also during Blank assy at Manufacturers



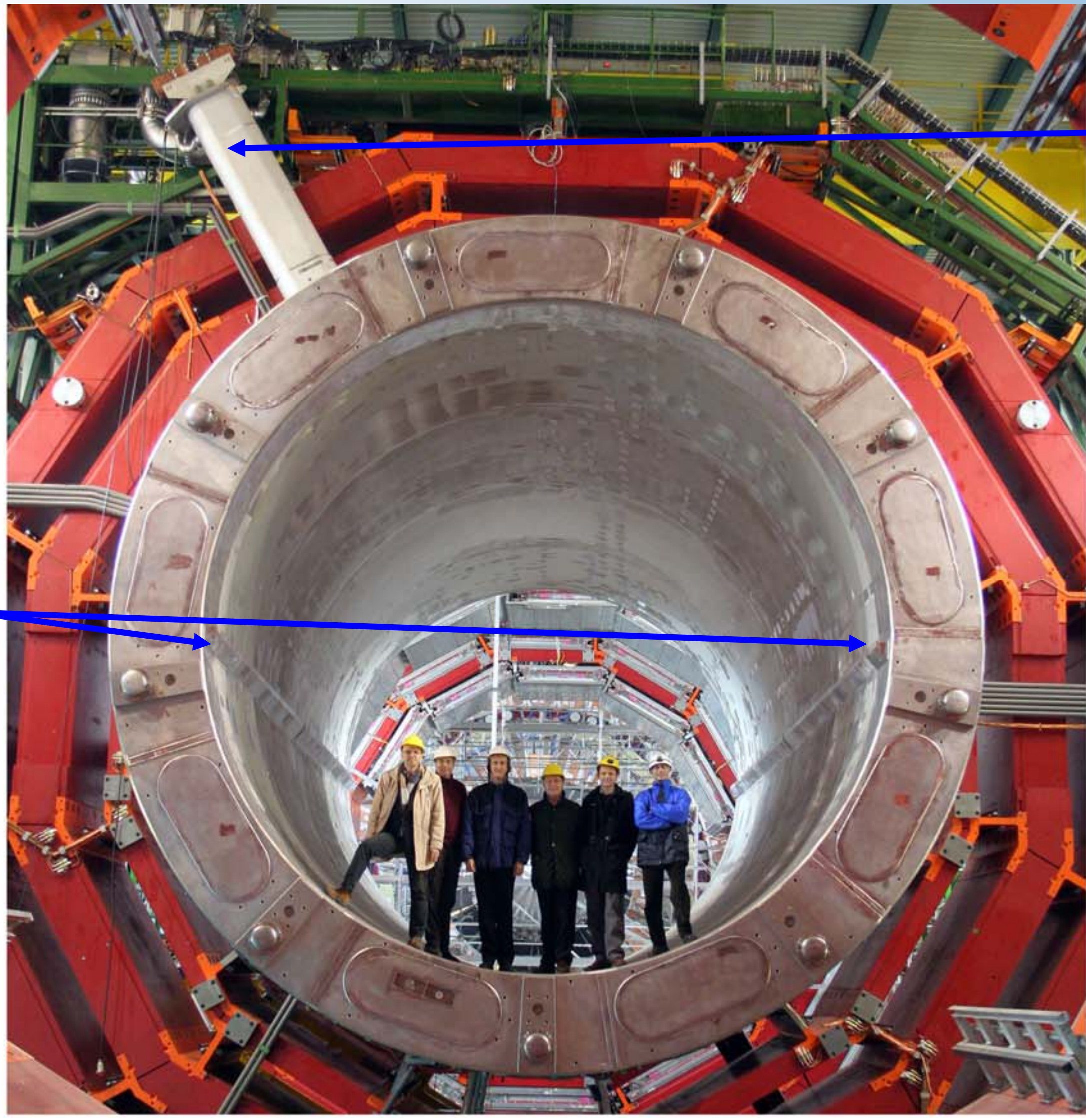
In Germany

In Japan

Construction of Outer Cryostat imbedded in Central Wheel to transmit Load of HB to Ground

Supporting the Inner Detectors from Cryostat

Inner vactank supports the 1000-tonne Hadronic Barrel and 200-ton Electromagnetic barrel on 2 rails imbedded in the shell



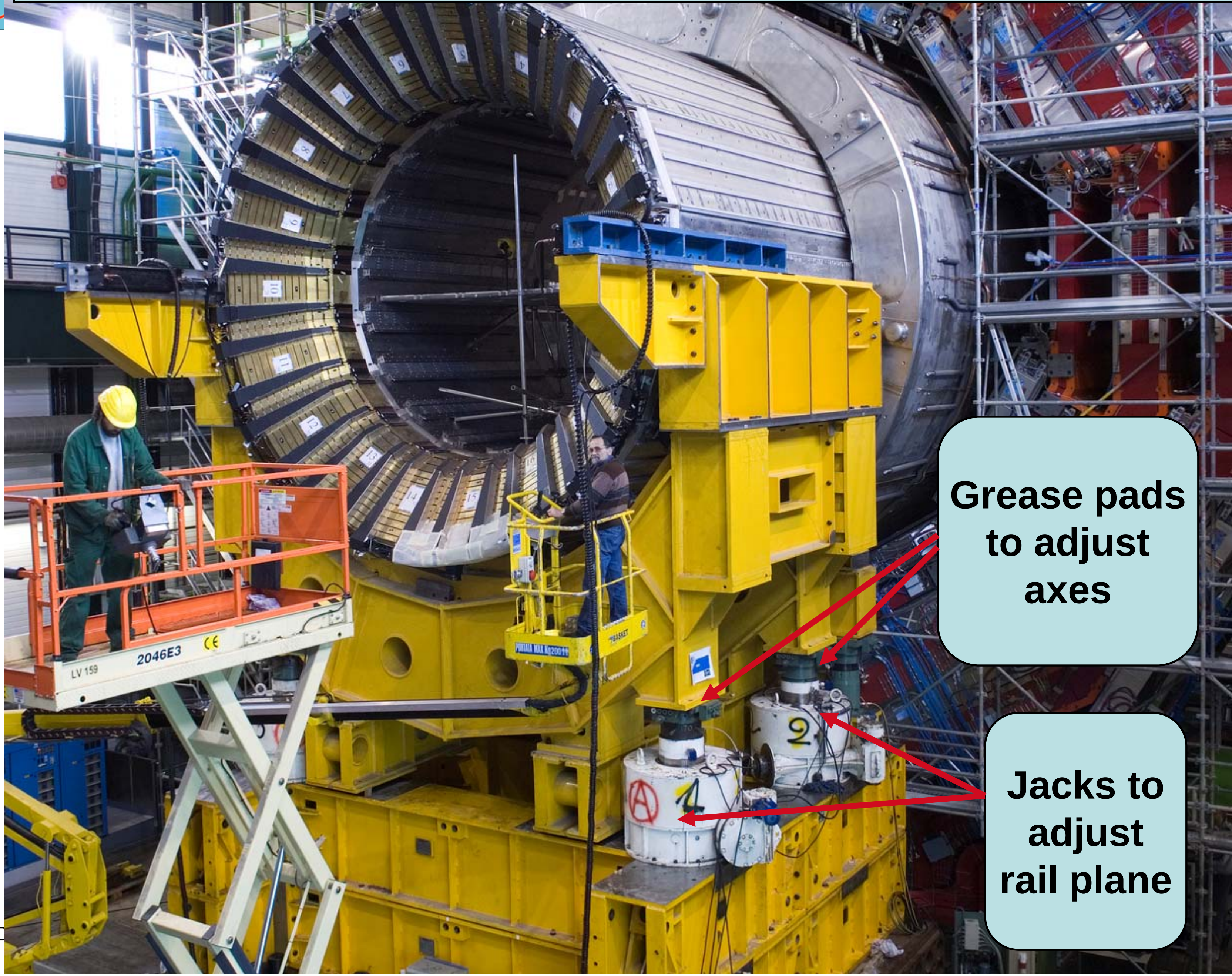
Penetration for current leads and pumping

There is another one for cryogenics vertical on opposite side of YB0

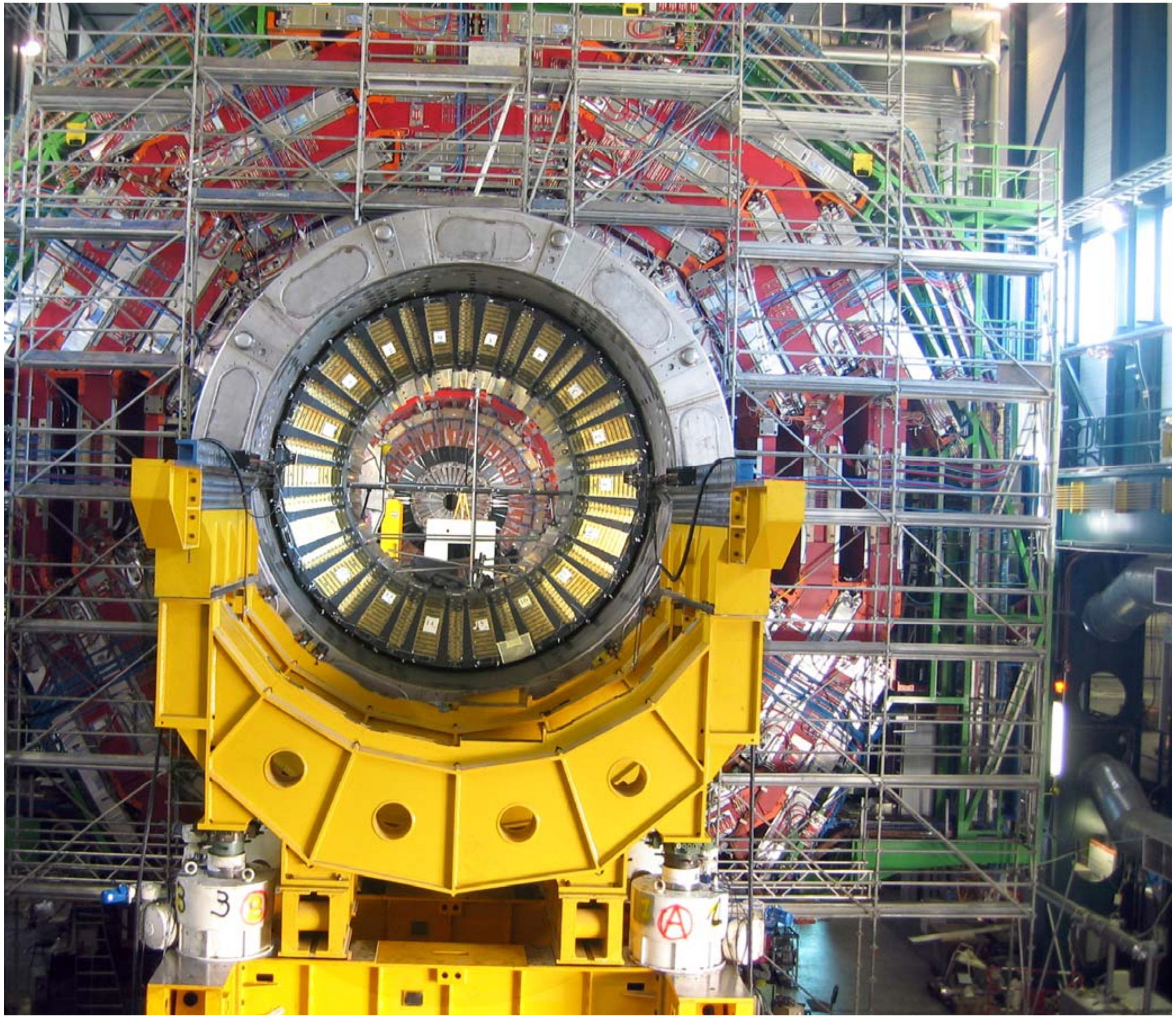
January 2006: End of the CMS Magnet Manufacturing

The two 500-ton HBs have been assembled on Surface directly at Beam Height

HB Insertion inside inner Cryostat on Surface



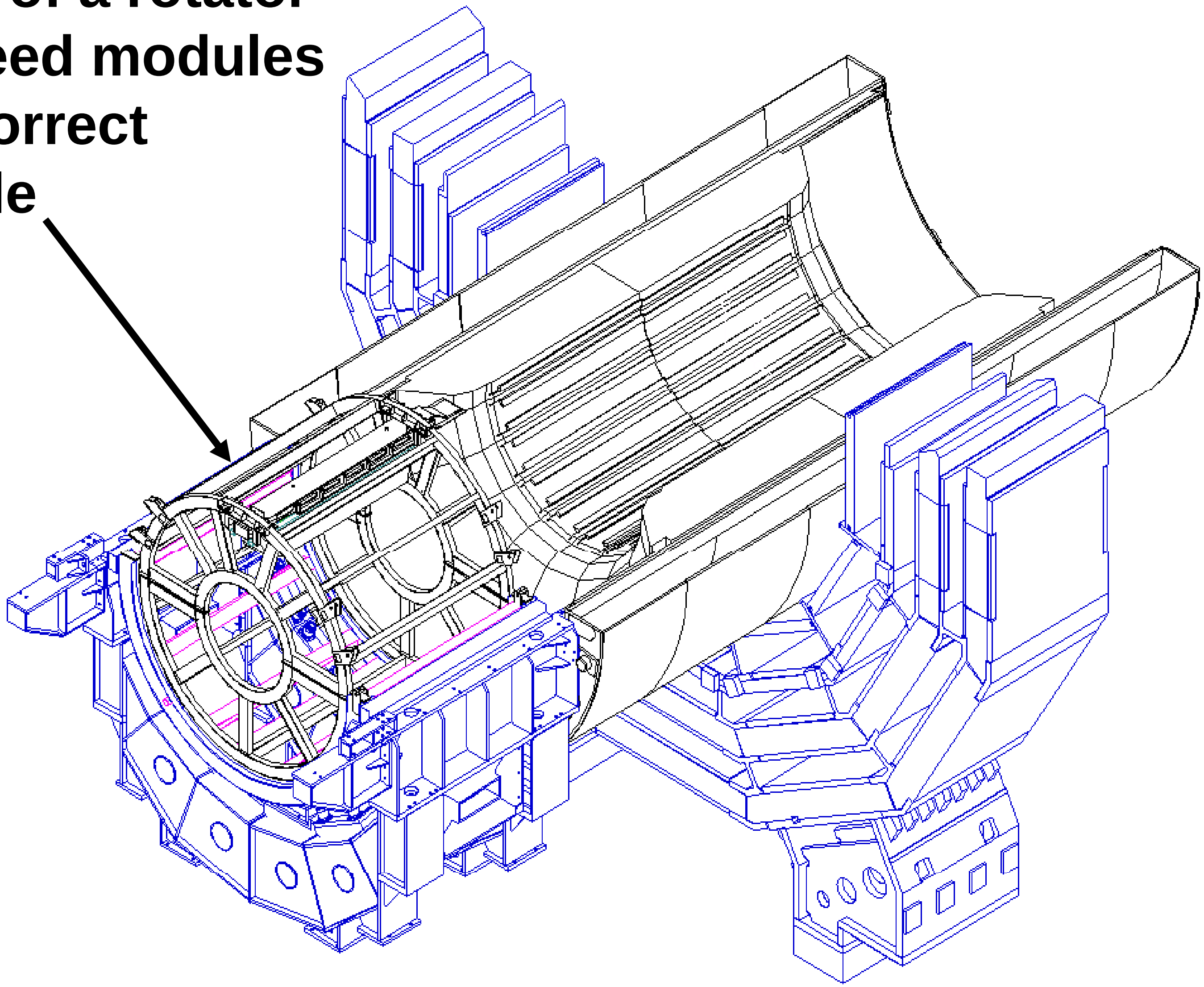
HCAL Barrel inserted to load Cryostat



Precise survey to determine **shimming and corrections** to be applied for **final installation underground** and mitigate cryostat deformation

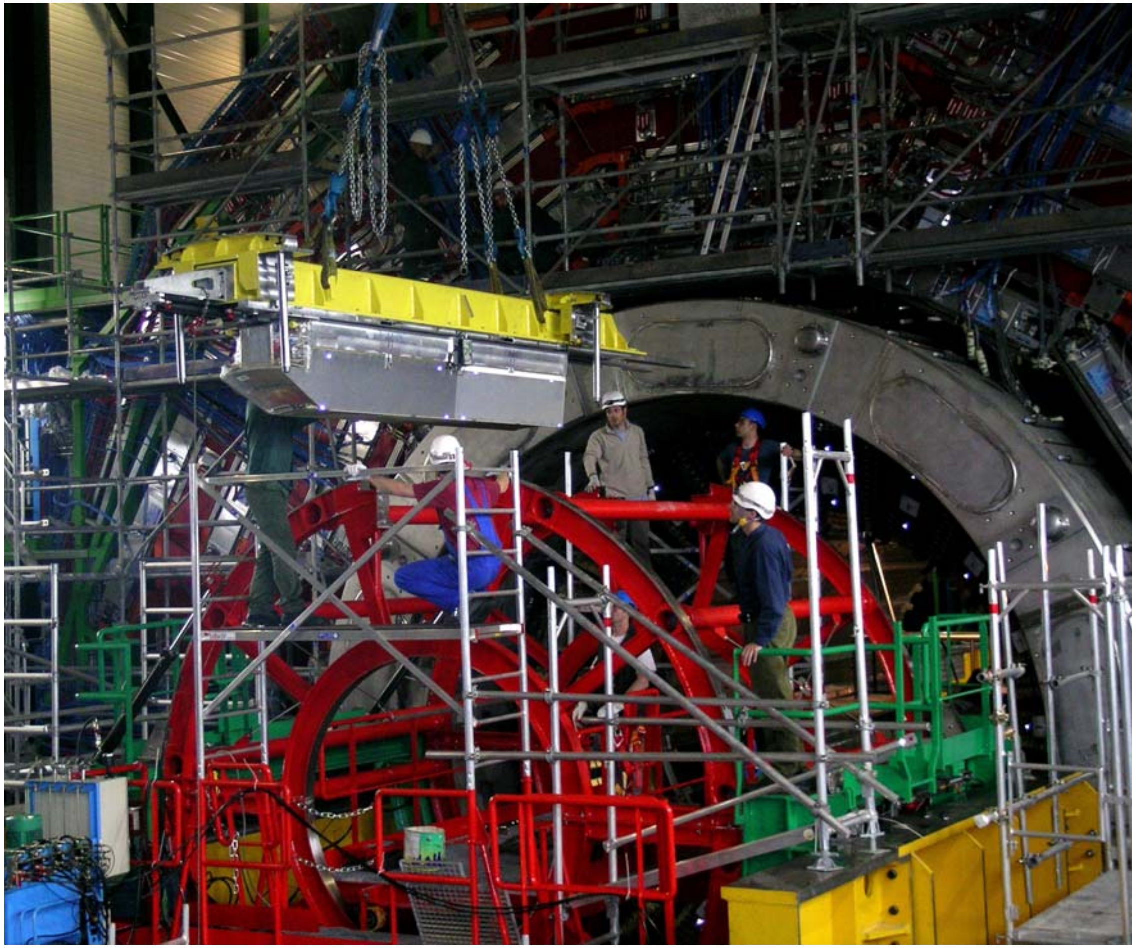
Installation of EB modules inside HB
Compatible with maintenance scenario

Use of a rotator to feed modules at correct angle

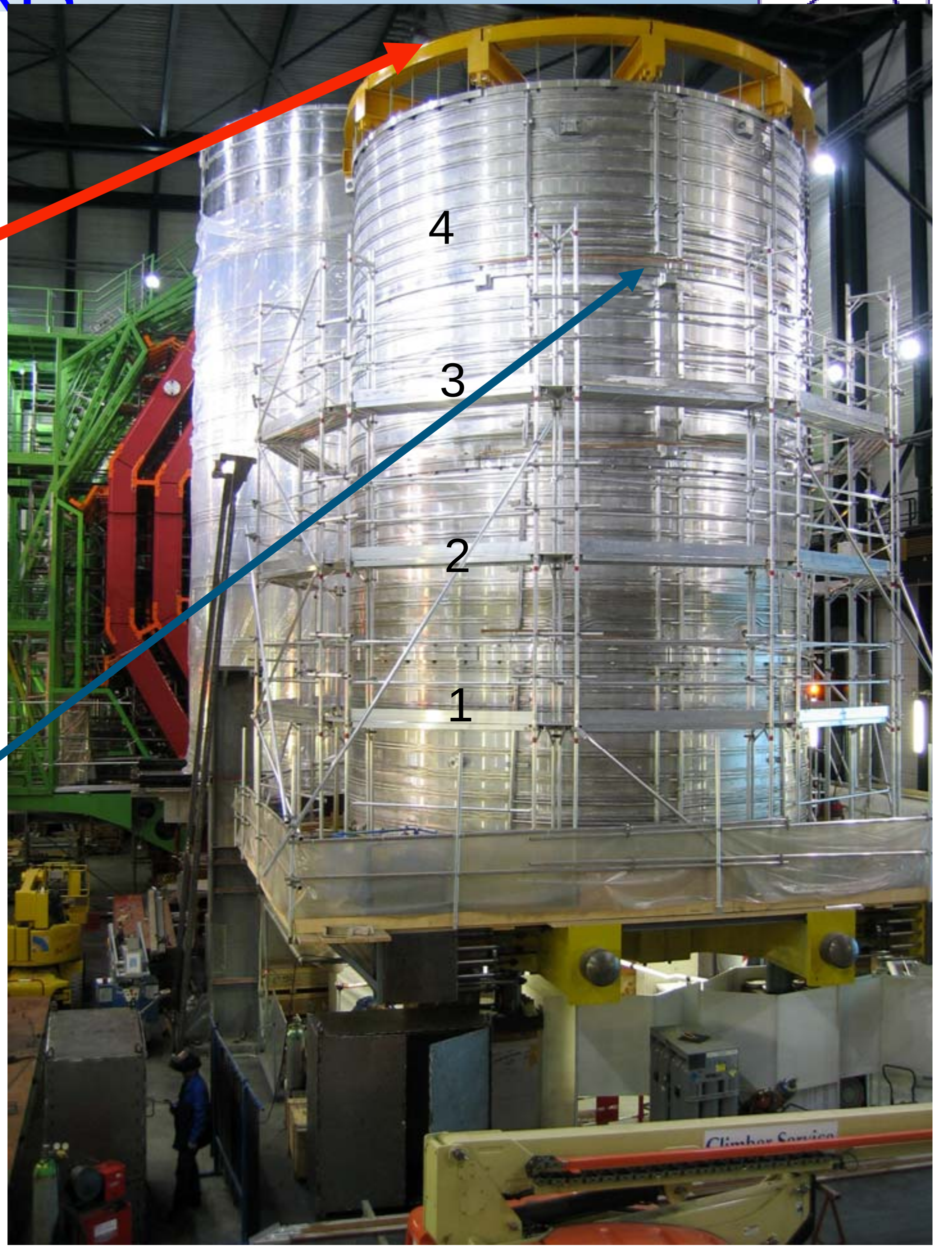


Installation of two EB modules inside HB

For testing on the surface



The coil has been assembled with Vertical Axis



This allows a very precise coupling

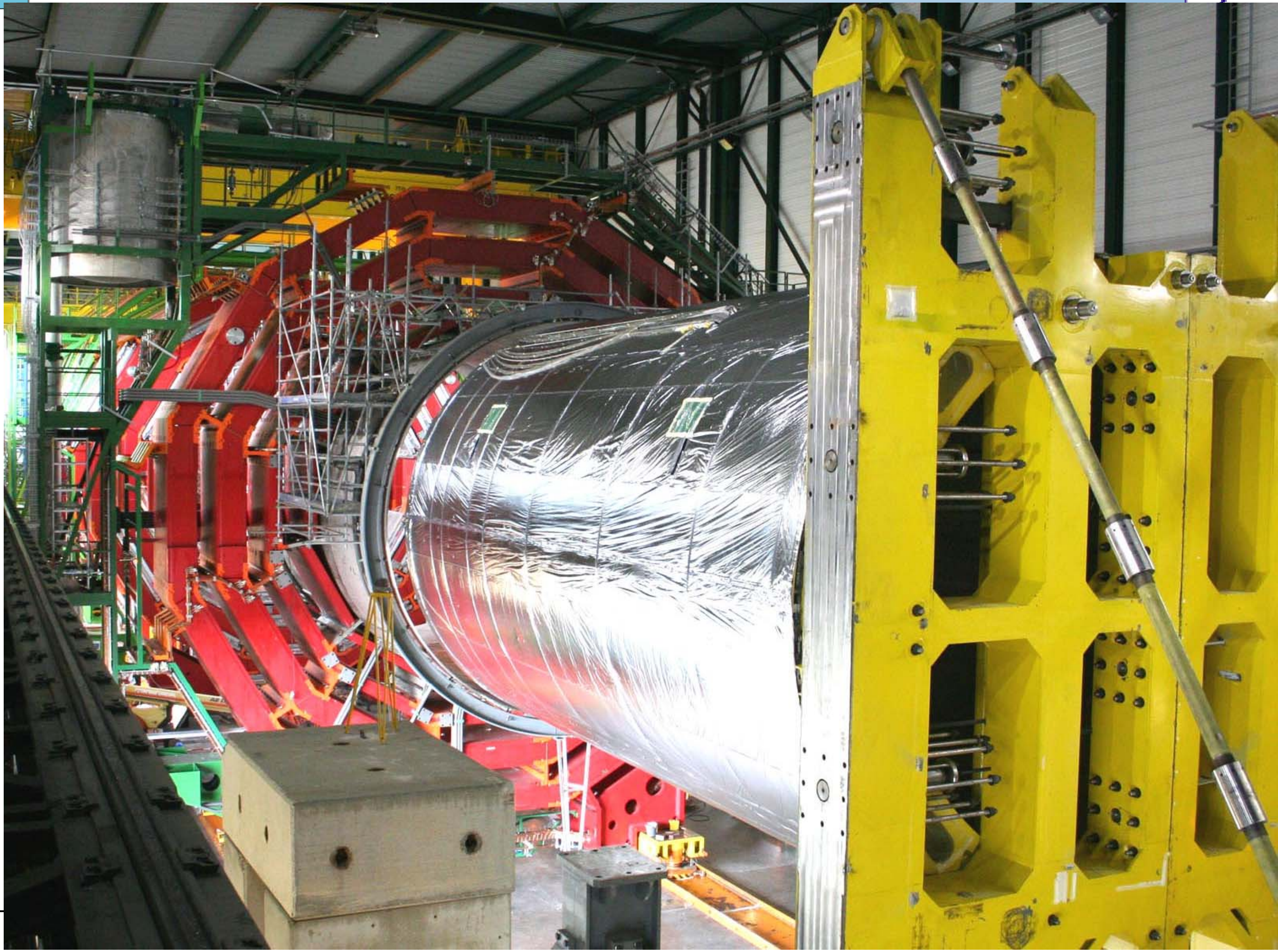
But the 220-ton coil has to be inserted inside the Cryostat with horizontal axis!

Coil swiveling requests large tooling

The 220 ton cold mass was rotated in 15 min

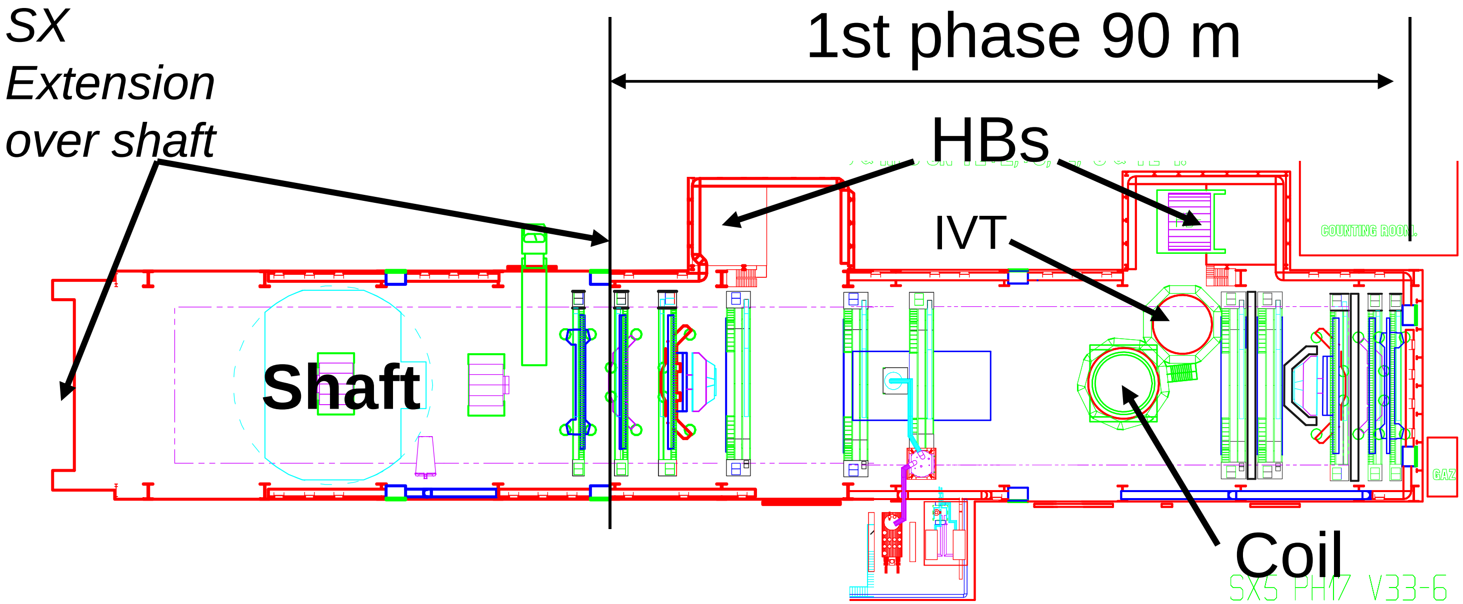
The coil is maneuvered cantilevered from one end

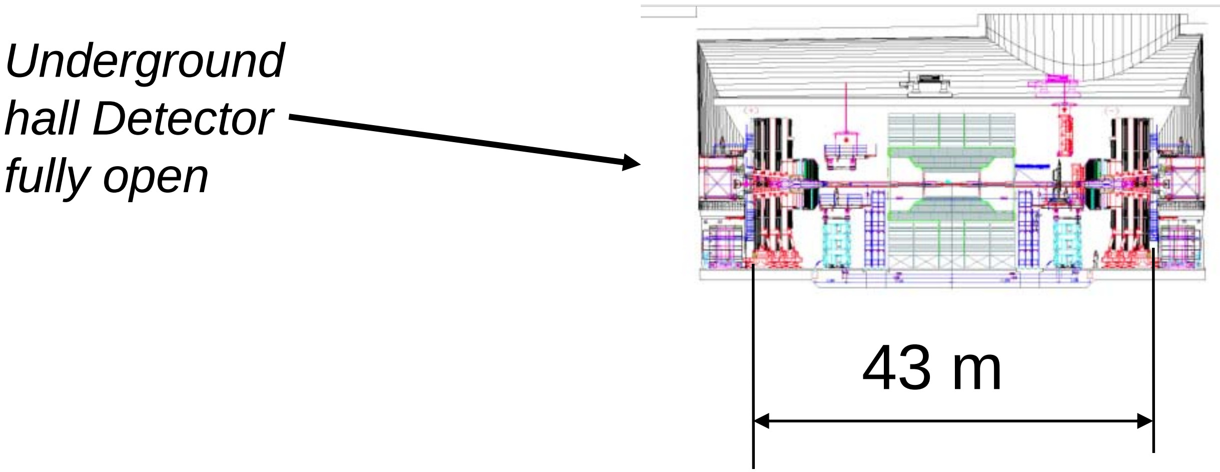
Sept. 2005: ready to insert!



ILD-

Coil swiveling in Surface Hall August 05





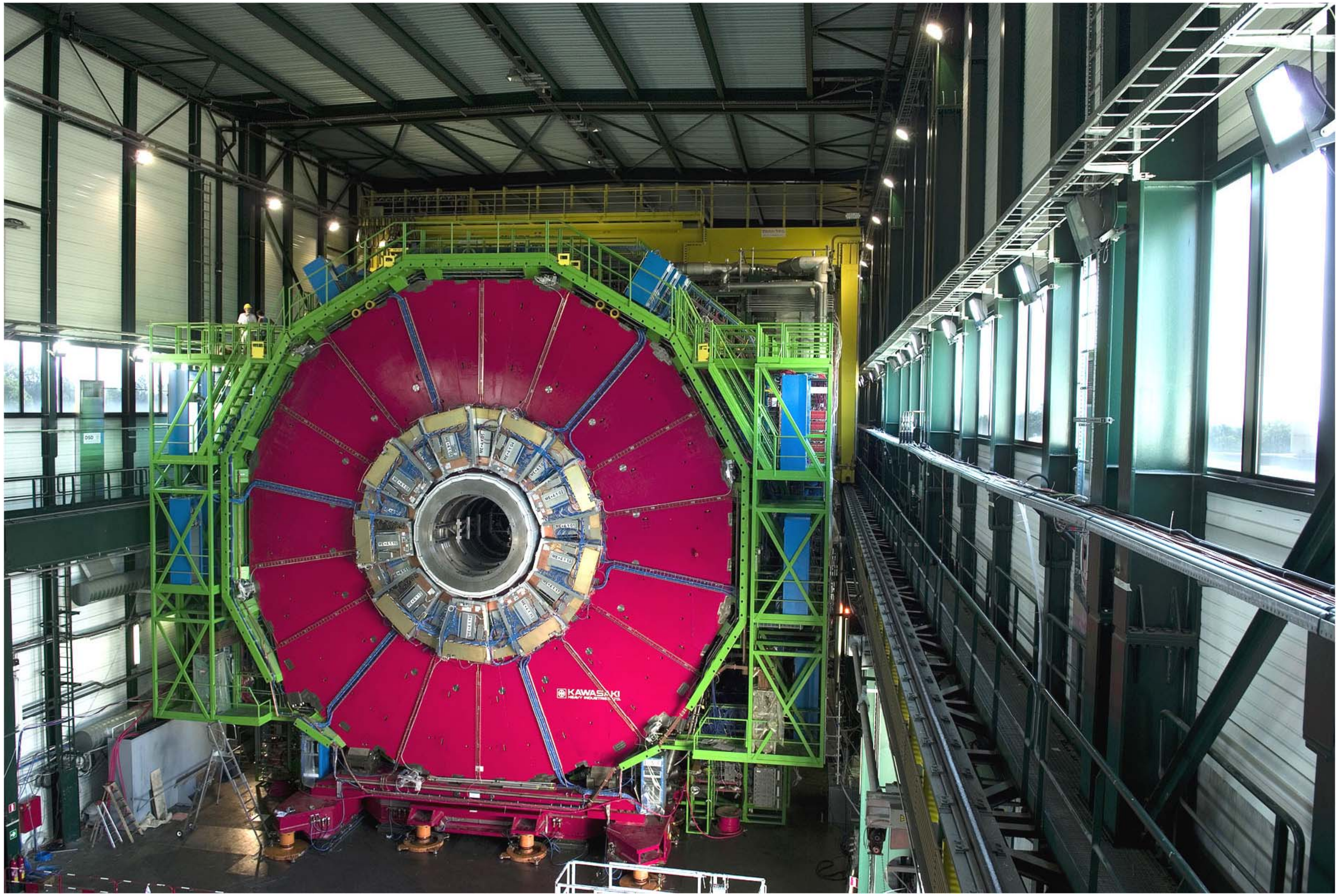
Same scale!

This justifies the surface assembly

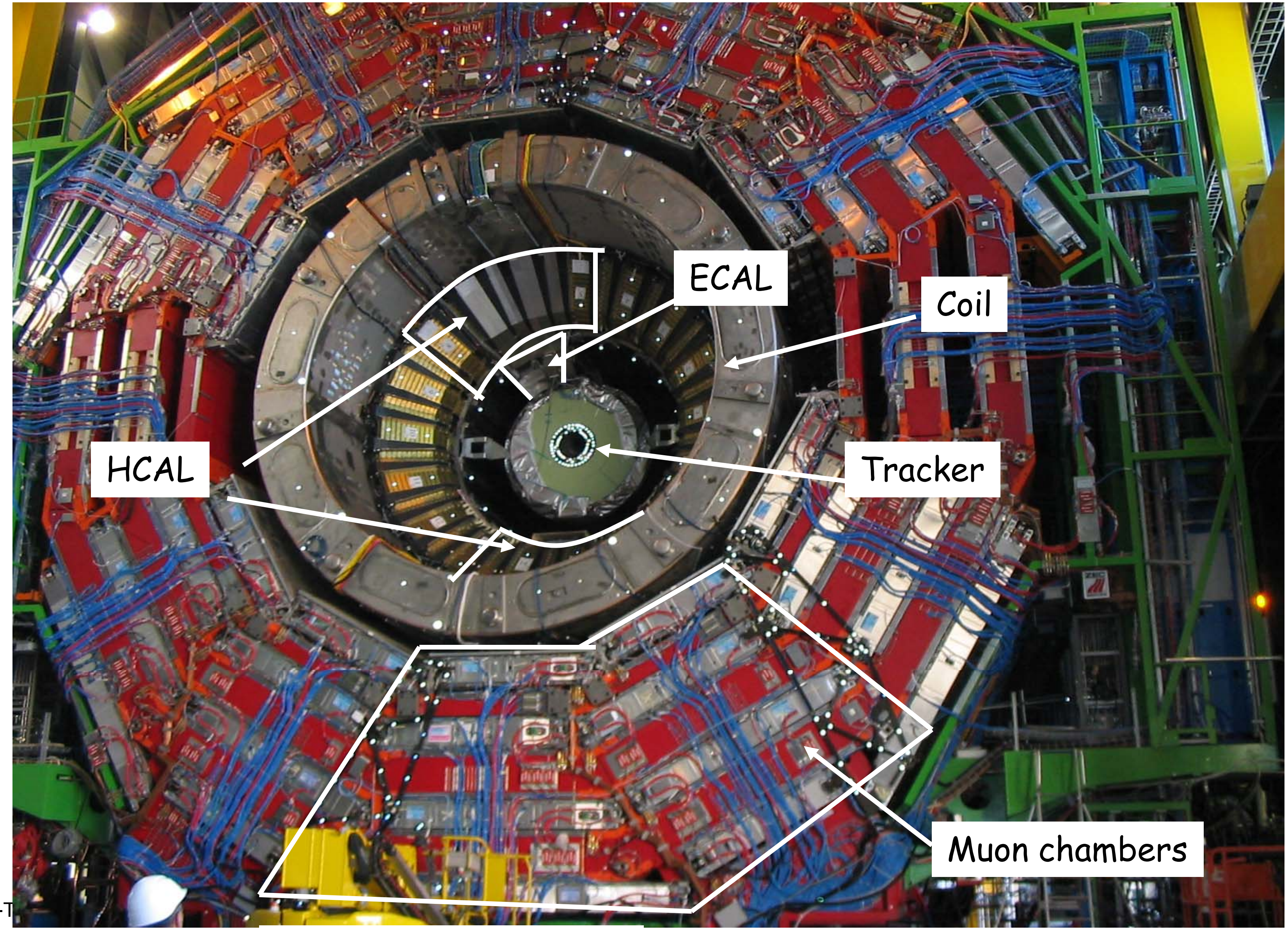
- These heavy construction activities cannot be done in a reasonable time, safely, in the underground hall.

- A much longer and wider underground hall, equipped with two 80-ton cranes, would be needed, and more time….

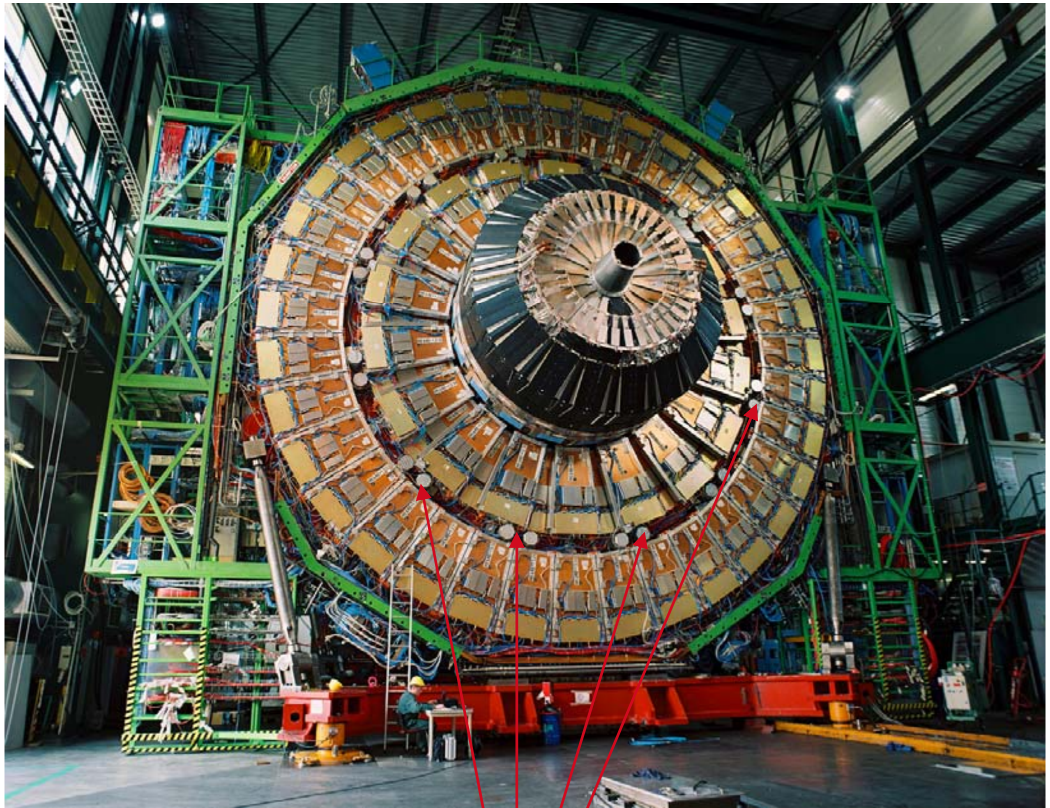
CMS Closed mid-July 2006
4T reached on 22 August 2006



A slice of all sub-detectors has been fully commissioned on surface using cosmics



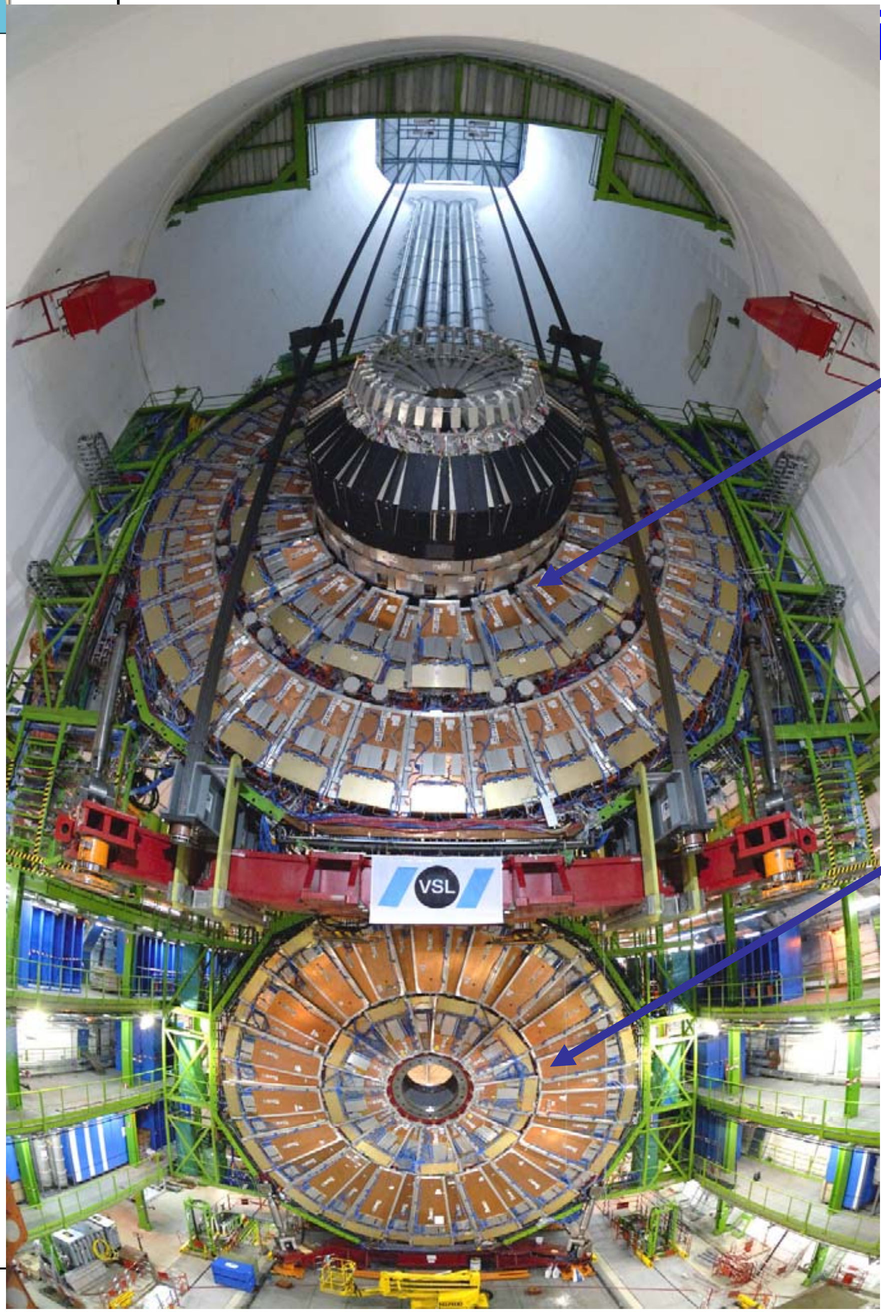
All Elements are fully Commissioned ready to be lowered (for example YE+1)



Z-stops resist the 10’000-ton attraction magnetic force

Elements are fully cabled to local racks.
All services, gas and water cooling pipes are there.
Subdetectors have been commissioned.
Once below they can be connected to the umbilical cables going to the counting rooms through the cable chains.

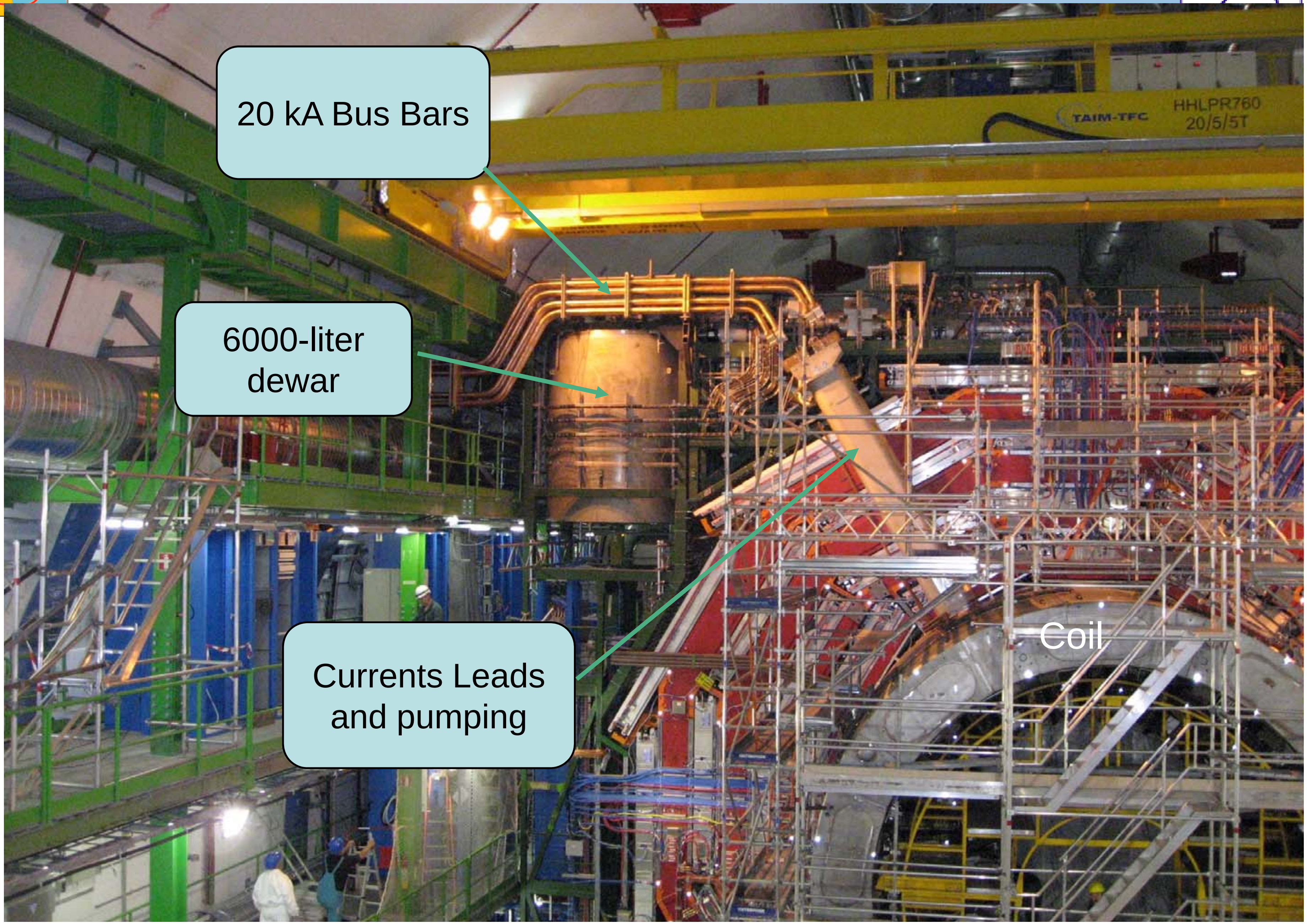
Elements are lowered fully
…ionned



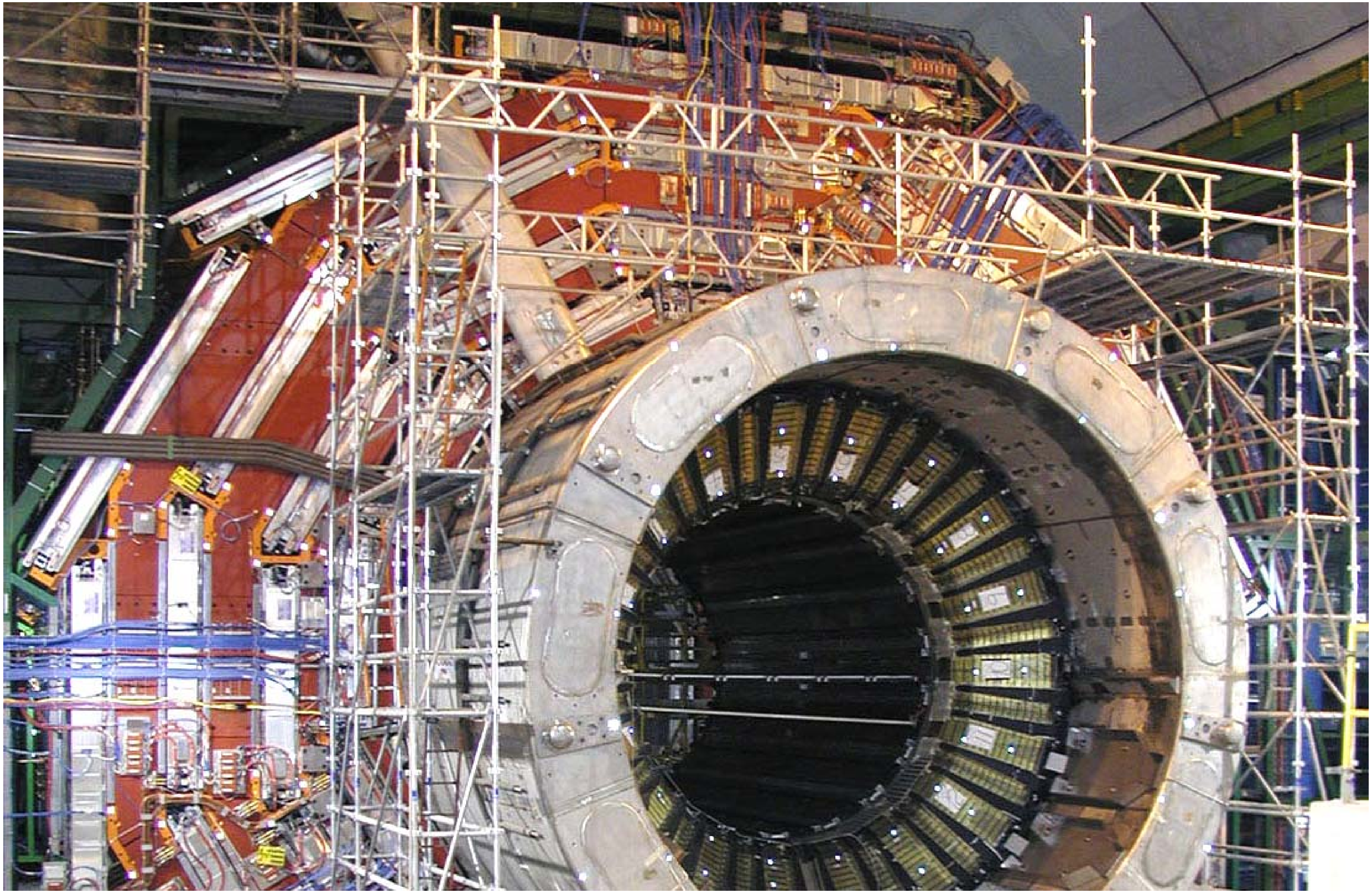
Disk YE+1 arriving in underground hall

Disk YE+2 already in underground hall

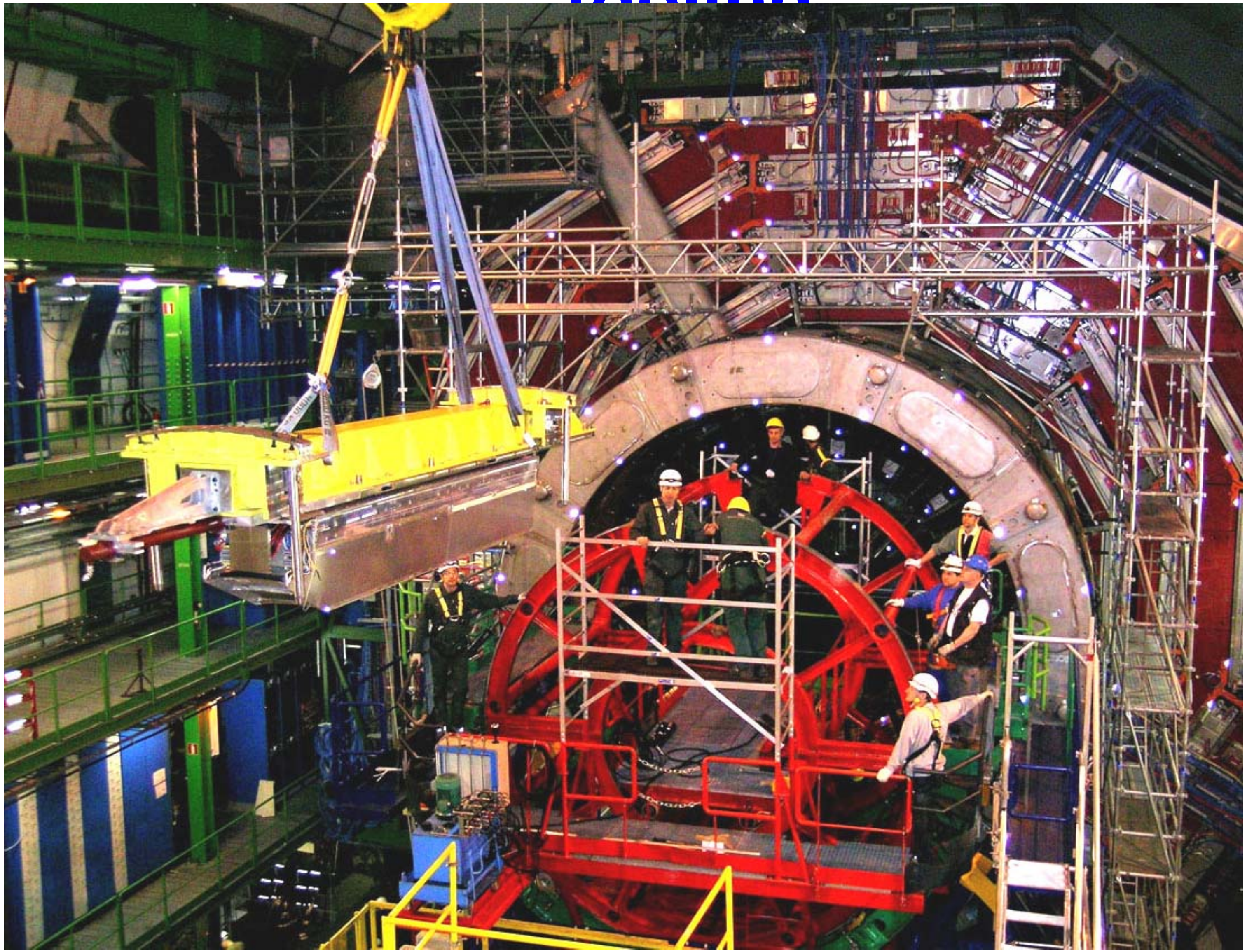
Coil Recommissioned in Spring 08



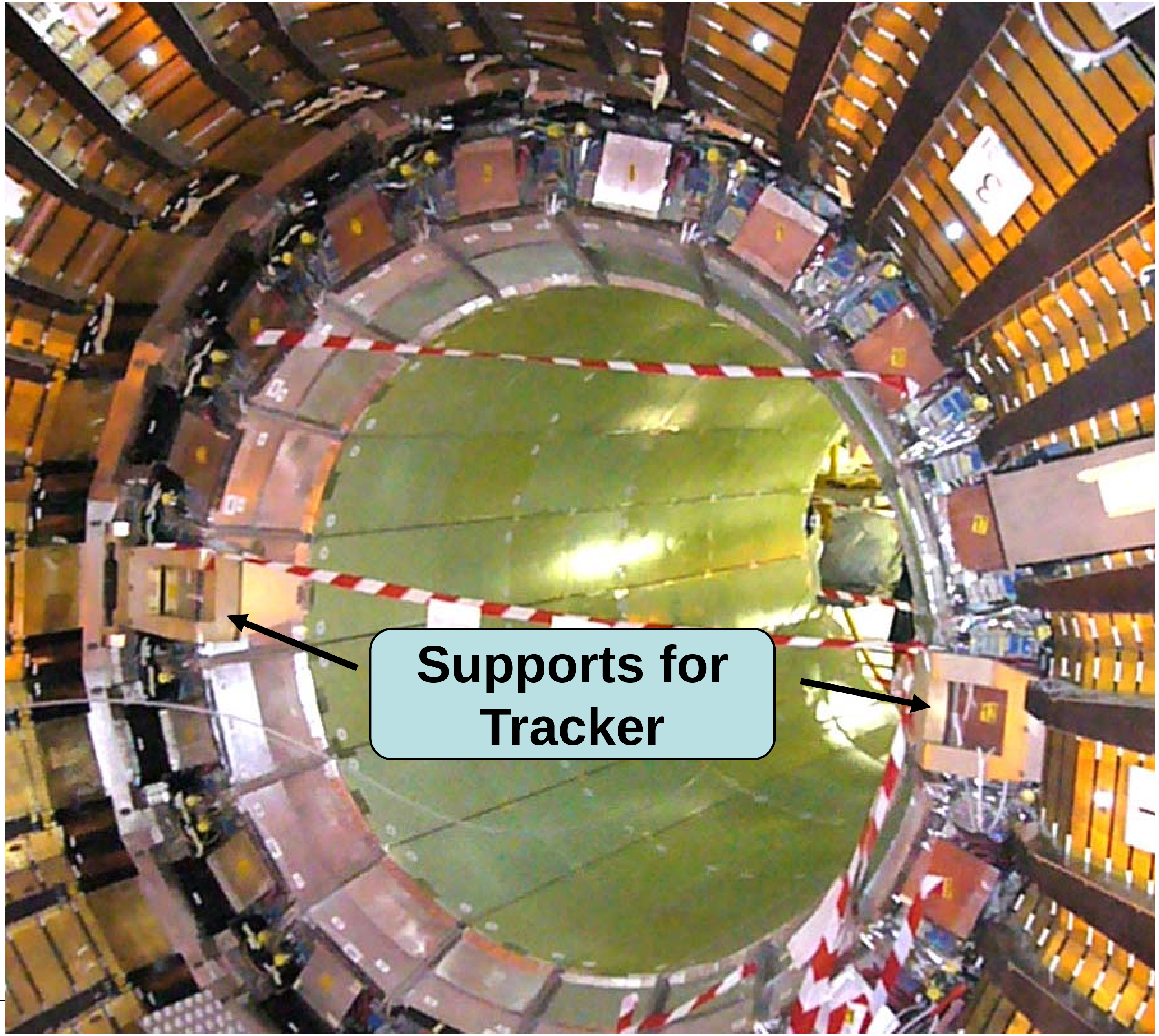
HB inside Cryostat
Perfect fit & alignment wrt. Beam axis!



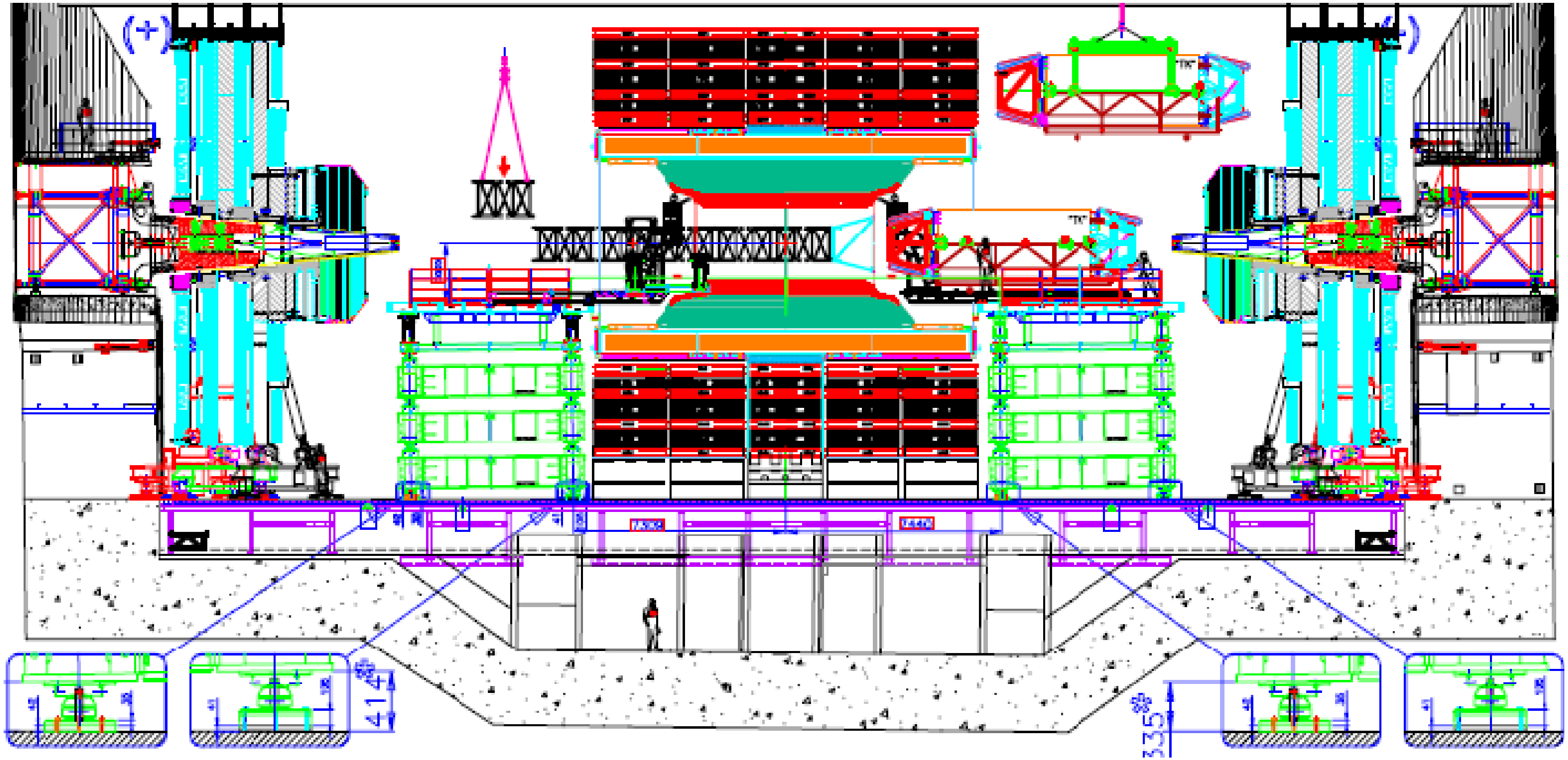
EB module with insertion tooling



Installation of EB Completed



Installation (removal) of Tracker determines the maximum opening in "Garage position"



Conclusions

Conclusions

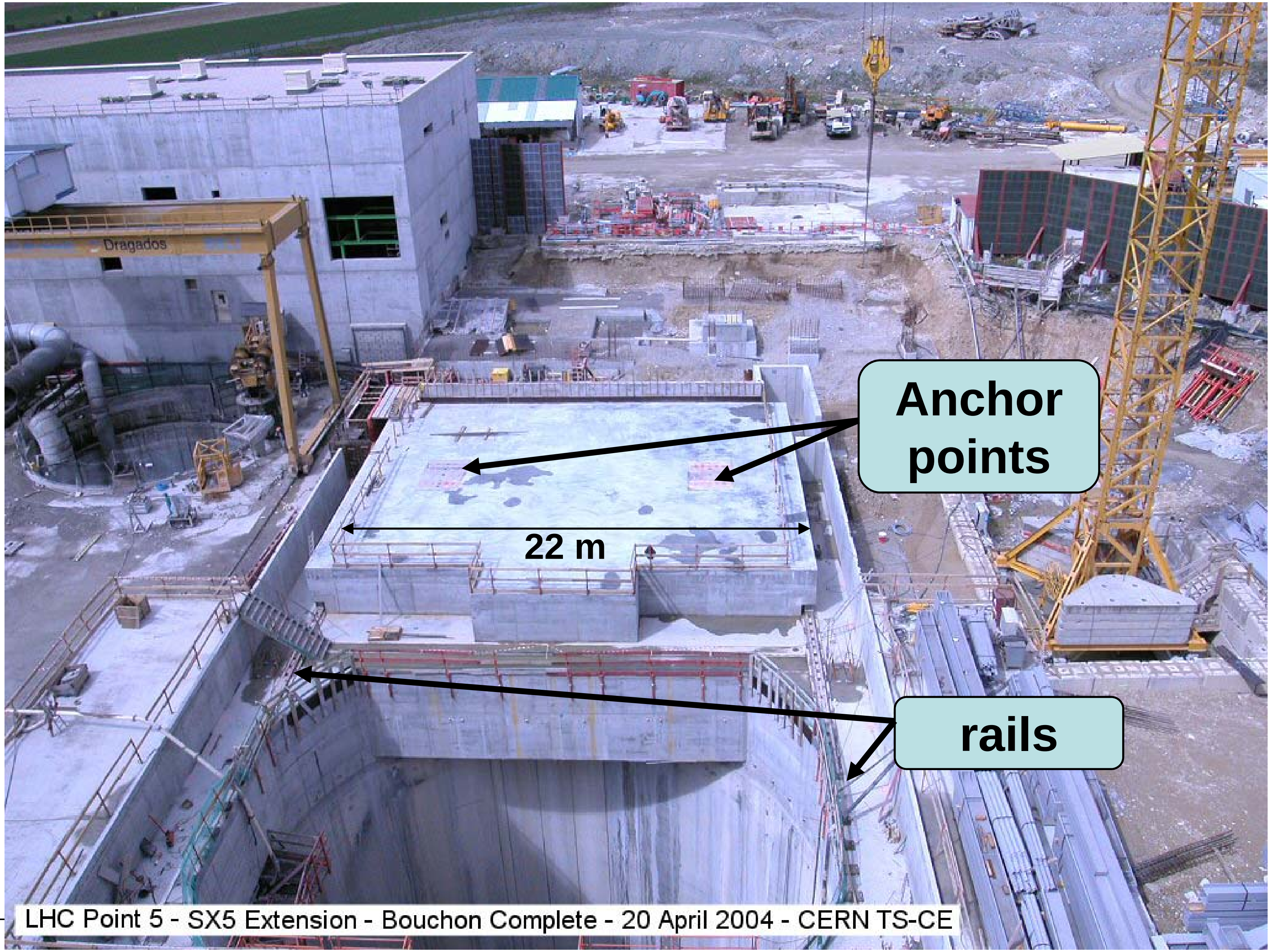
- CMS has been able to maintain the principles adopted in 1991/1992 without any compromising, and it has been fully "built as foreseen".

- This first (imposed) shut-down shows that the general architecture will allow an efficient maintenance as all sub-detectors can be easily accessed during a shut-down.

- Several technical solutions adopted by CMS have shown their validity and I am convinced a large fraction of them may be directly adopted by ILD

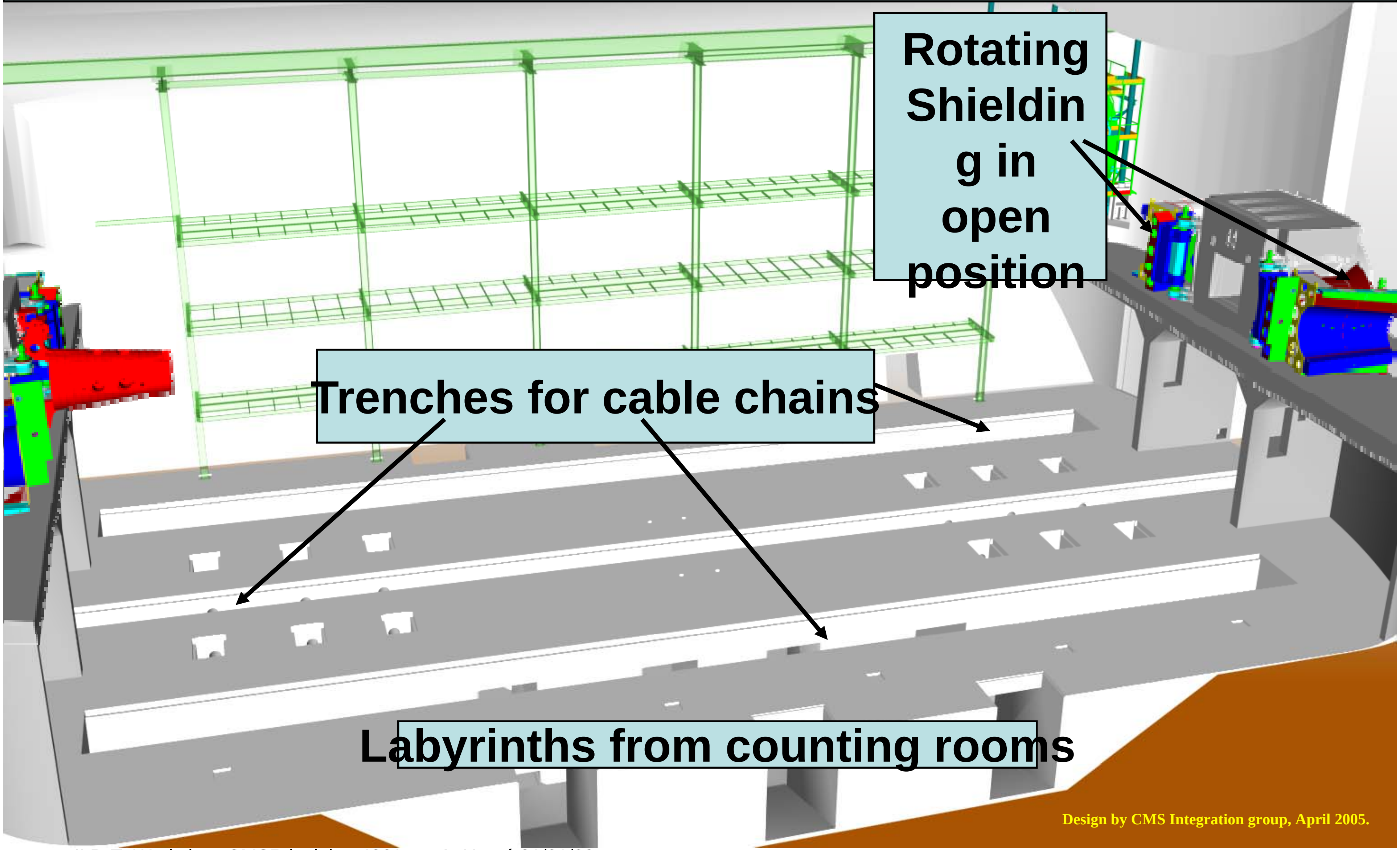
The plug has been tested using a 2500 ton dead load

Construction of Main Plug on side of Shaft Apr. 04
Used as radiation protection and lifting platform

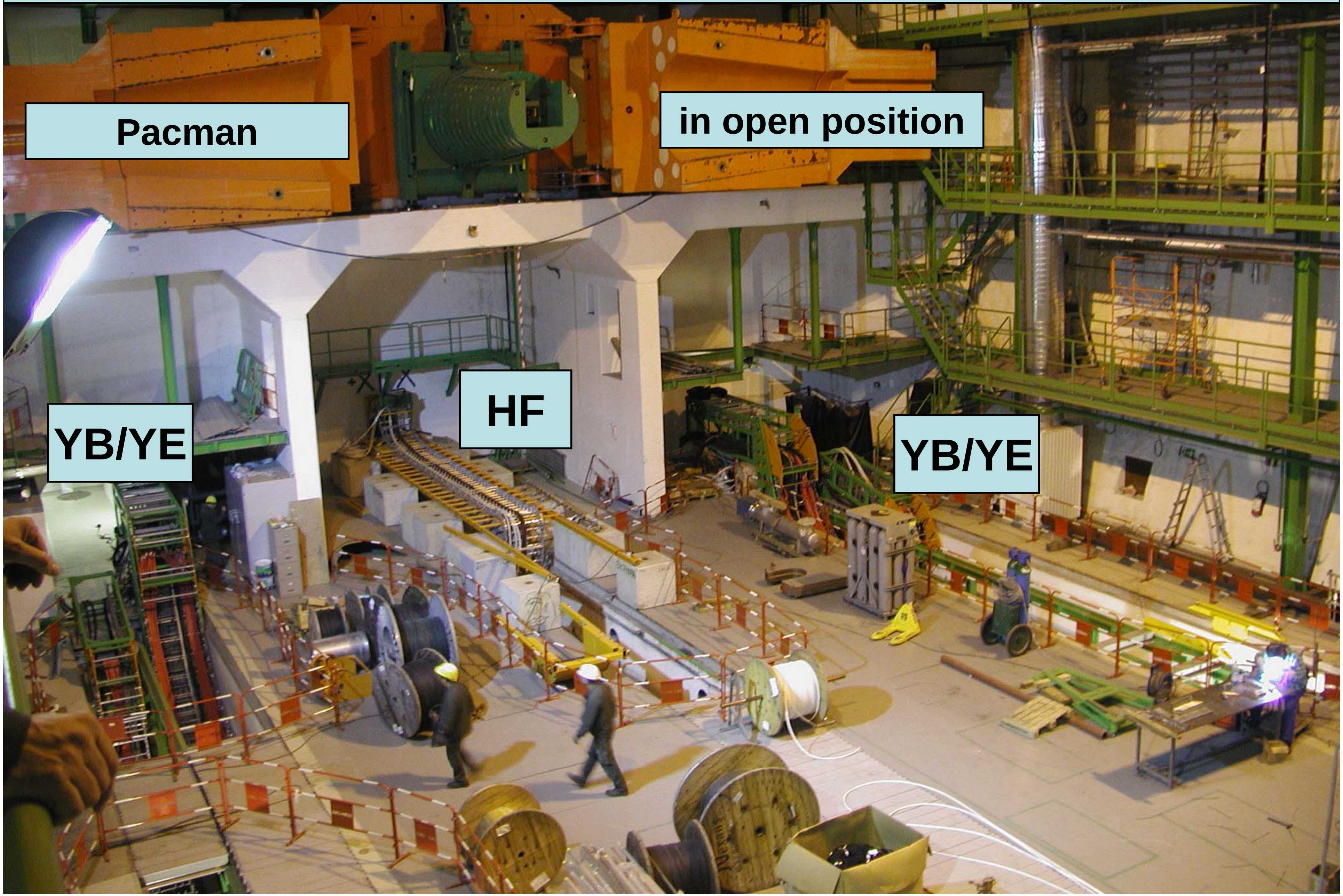


UX5 before receiving Elements

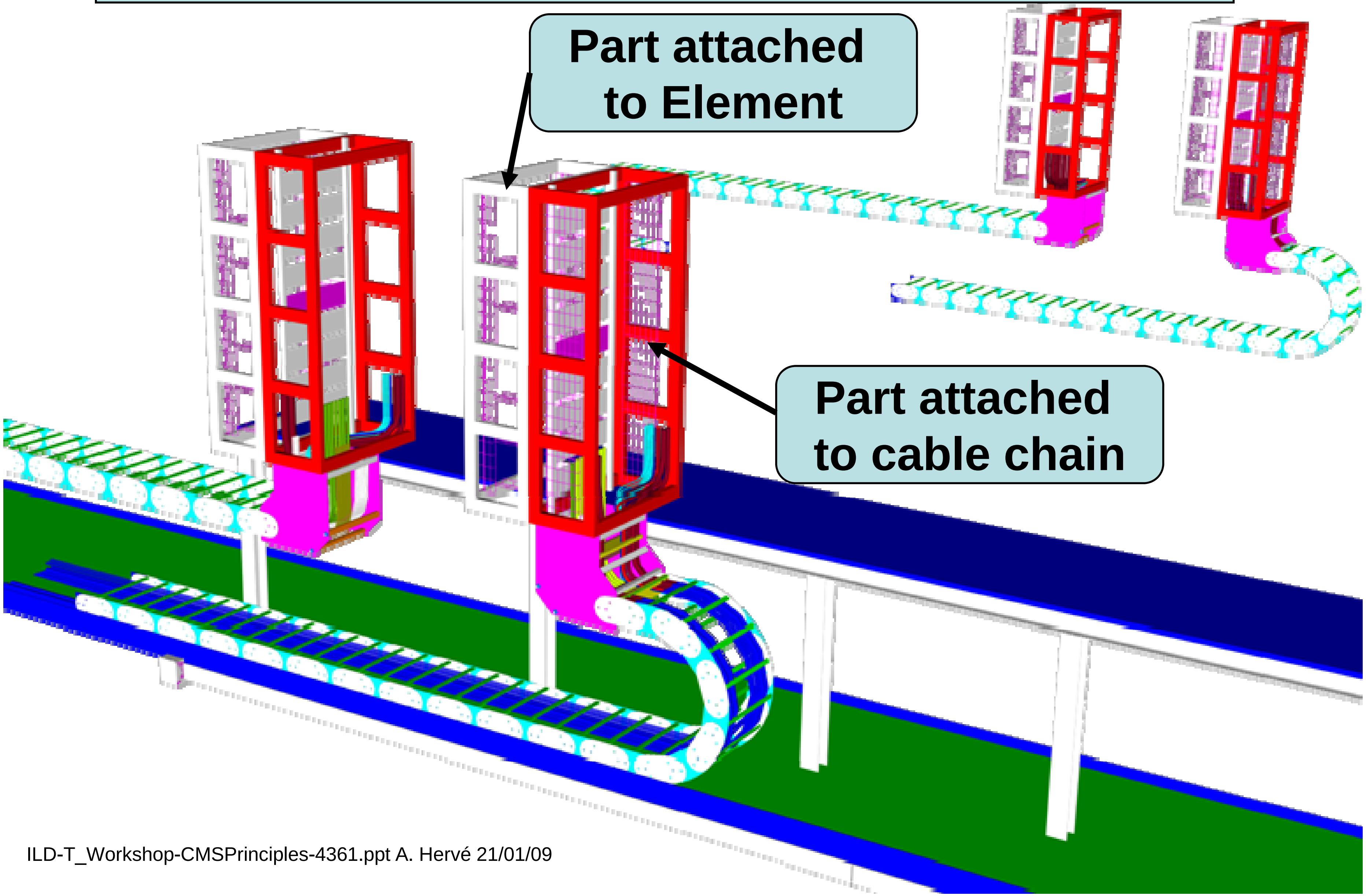
e cave below is used as dispatching center for cabl



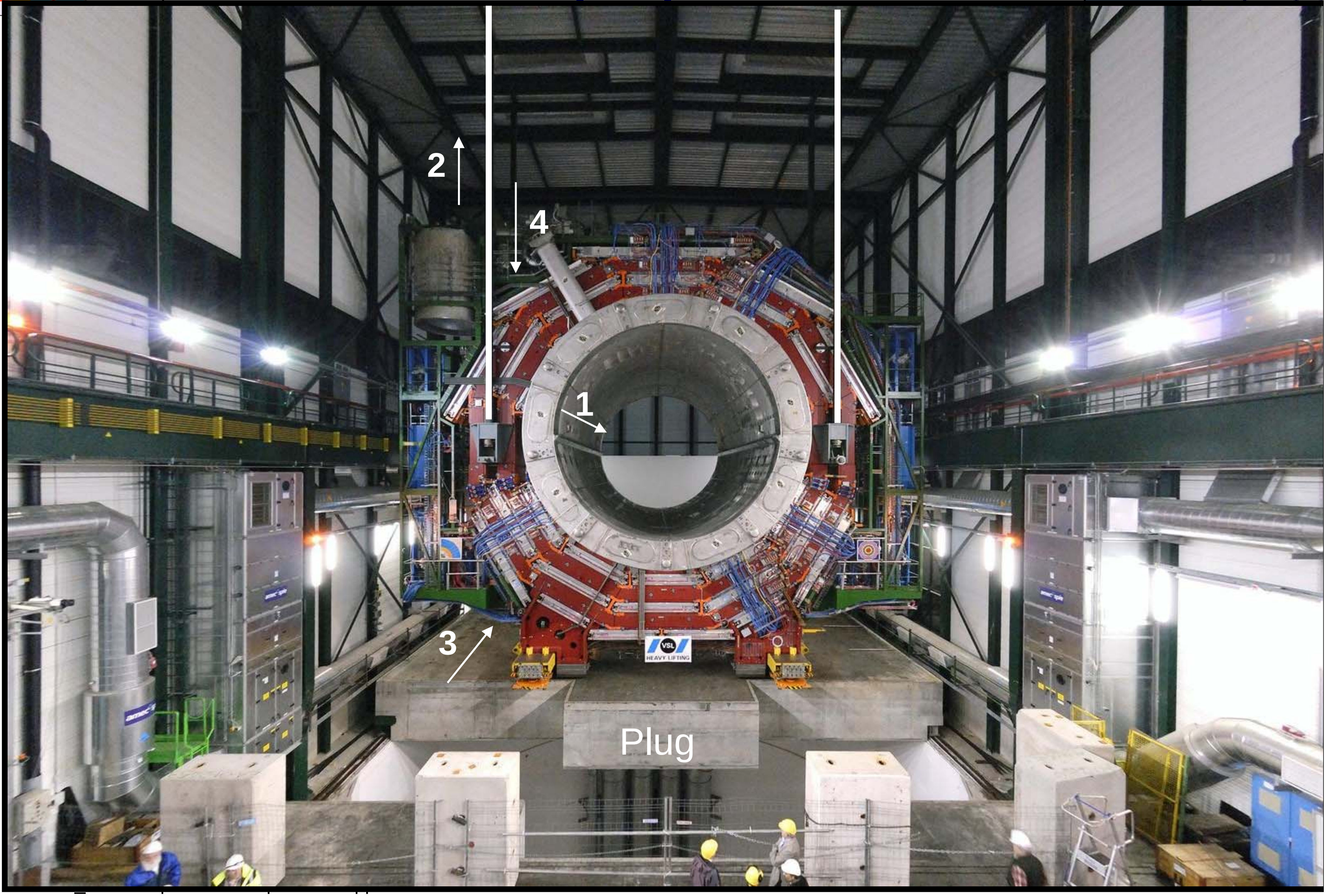
Situation of cable chains before lowering Elements



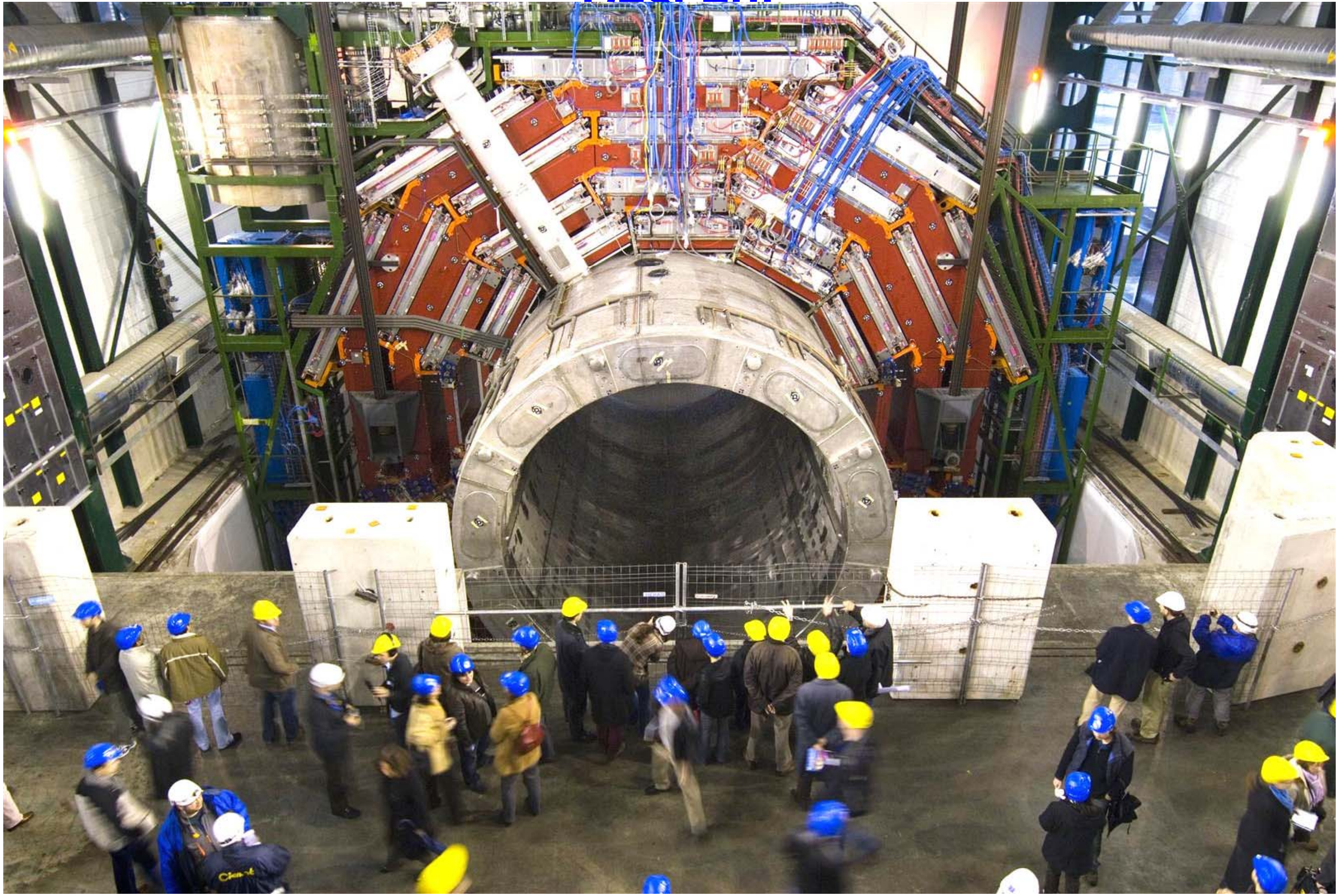
How cable chains are connected to pre-cabled Elements



Opening the plug under the 2000-ton



28 Feb. 07-YB0 at the Beginning of Descent



500-t HB beginning the descent