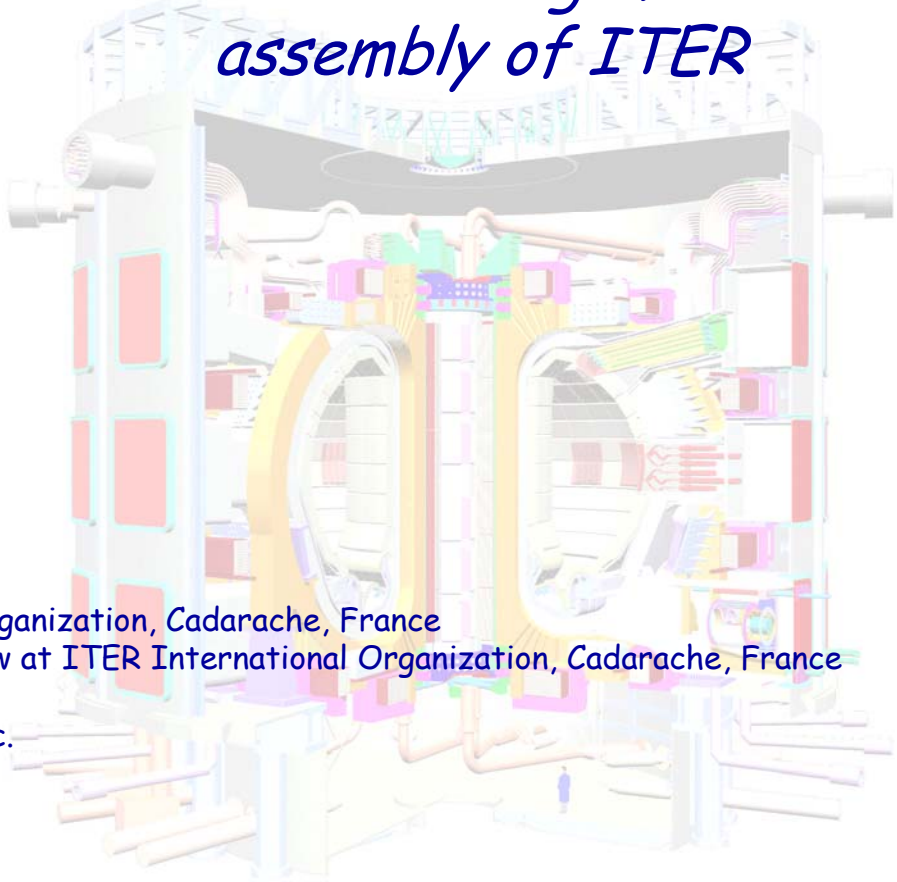
FOGALE nanotech Inc.

The use of simulation to optimise the integration of 3D optical metrology techniques and stability monitoring with capacitive sensors into an alignment concept for the assembly of ITER



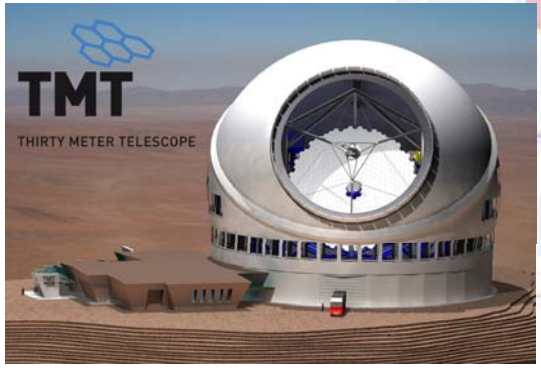
Brian Macklin (1)
Robert Shaw (1)
Bruno Levesy (2)
Malak Senhadji (3)
Arnauld Dumont (4)

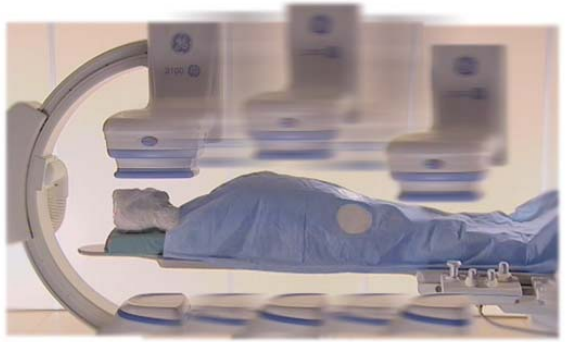
(1) ITER International Organization, Cadarache, France
(2) Formerly at EFDA, now at ITER International Organization, Cadarache, France
(3) ASTRIUM,
(4) FOGALE Nanotech Inc.

A few words about FOGALE nanotech

Active Measurement of small dimensions with very high accuracy

Particle Accelerators Alignment (HLS/WPS)
Telescopes Alignment (Edge Position Sensors and Photogrammetry)
Blade Tip Clearance for aircraft engines (High Temperature Capacitive Sensors)
Intelligent Anti-Collision Sensors (customized sensors for robots)
Glass and other material thickness measurements (Low Coherence Interferometry Lasers)
3d Profilers

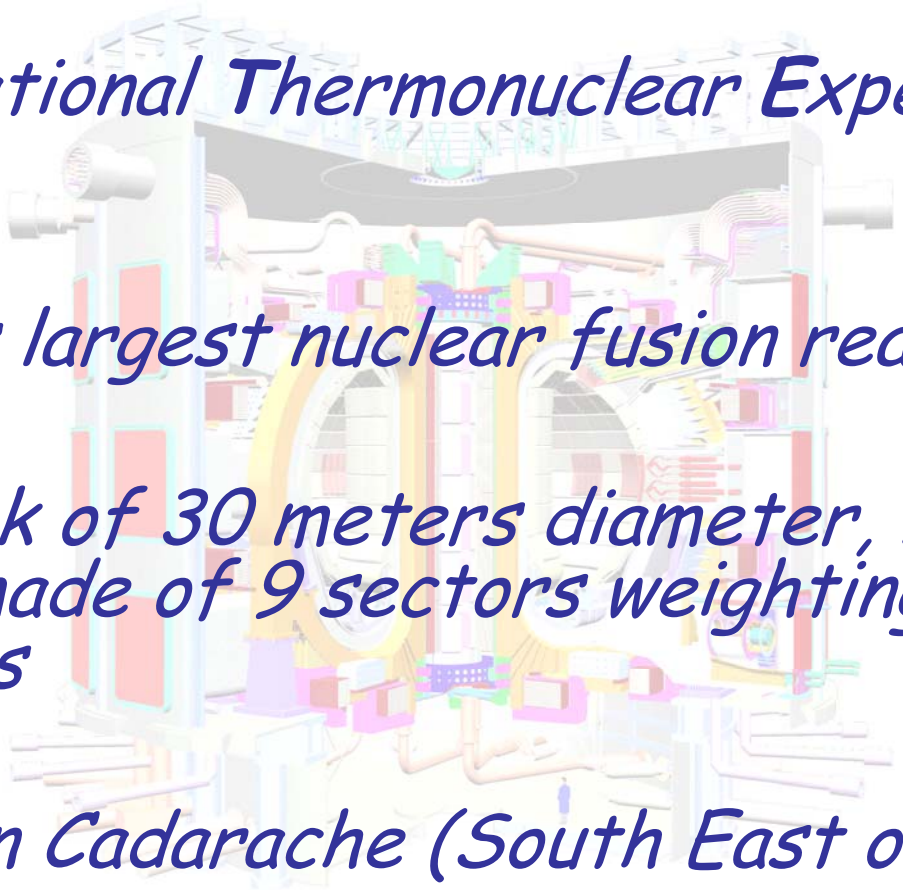




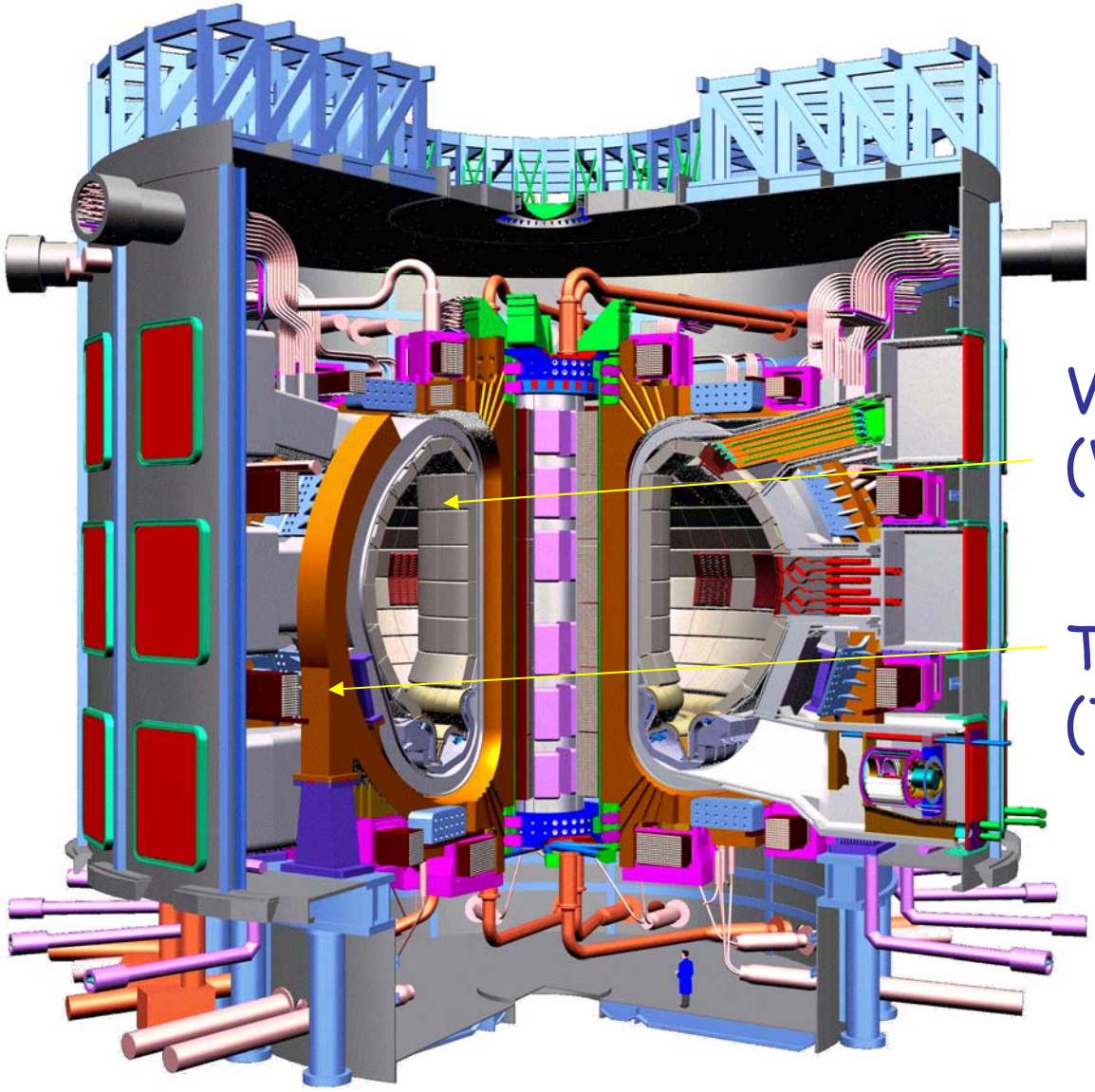
Contents

- The ITER project
- The Final Alignment Goal
- Metrology for Assembly
- CAD Simulation
- The Future

The ITER project



- International Thermonuclear Experimental Reactor
- World's largest nuclear fusion reactor
- Tokamak of 30 meters diameter, 12 meters height, made of 9 sectors weighting at least 1500 tons
- Based in Cadarache (South East of France)



Vacuum Vessel (VV)

Toroidal Field Coil (TFC)

Tokamak Assembly in Pit

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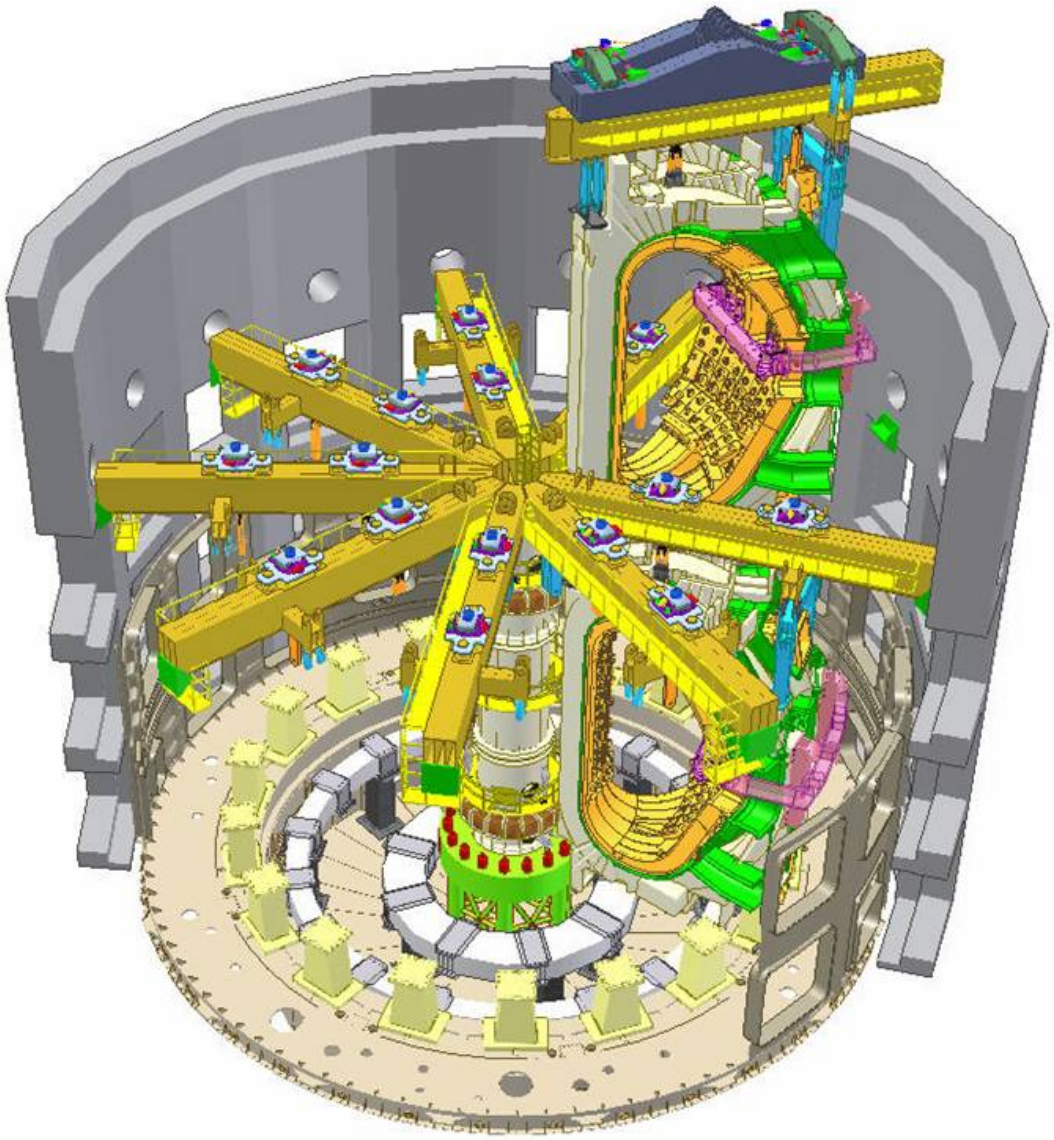

JET : Joint European Torus

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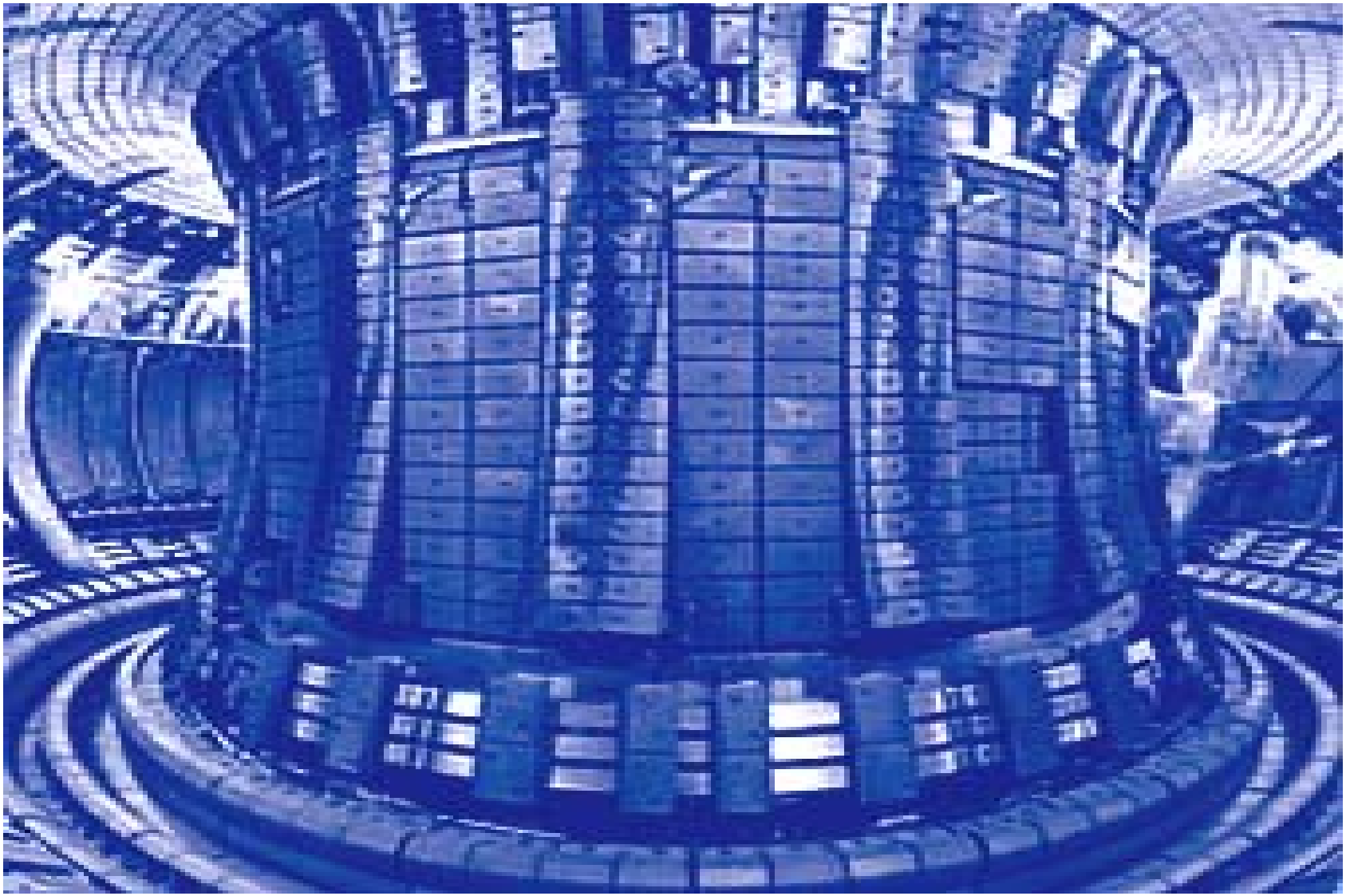


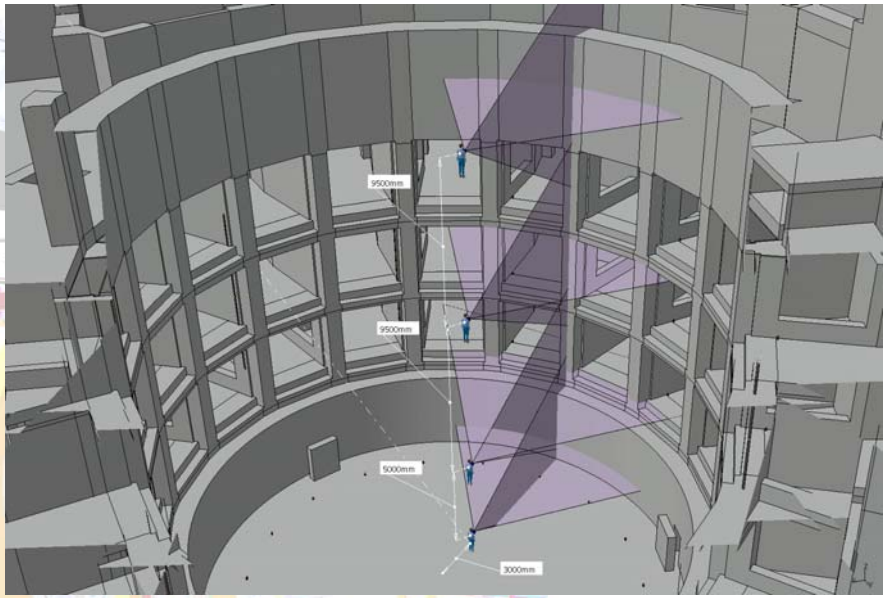
The Final Alignment Goal

- 2 mm Alignment between the magnetic center (with respect to Toroidal Field Coils) and the Vacuum Vessel center,
  - The first System Axis is fixed by the Pit Cylinder Best-Fit,
  - The final one is fixed by the As-Built position of the TFC,
- Measurement Accuracy close to 0.2 mm,
- The Method should take into account :
  - Visibility problems,
  - Stability Issues.

Metrology for Assembly
Pit Network : Photogrammetry

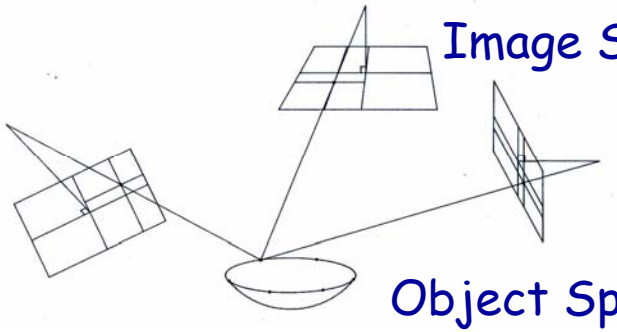
GSI

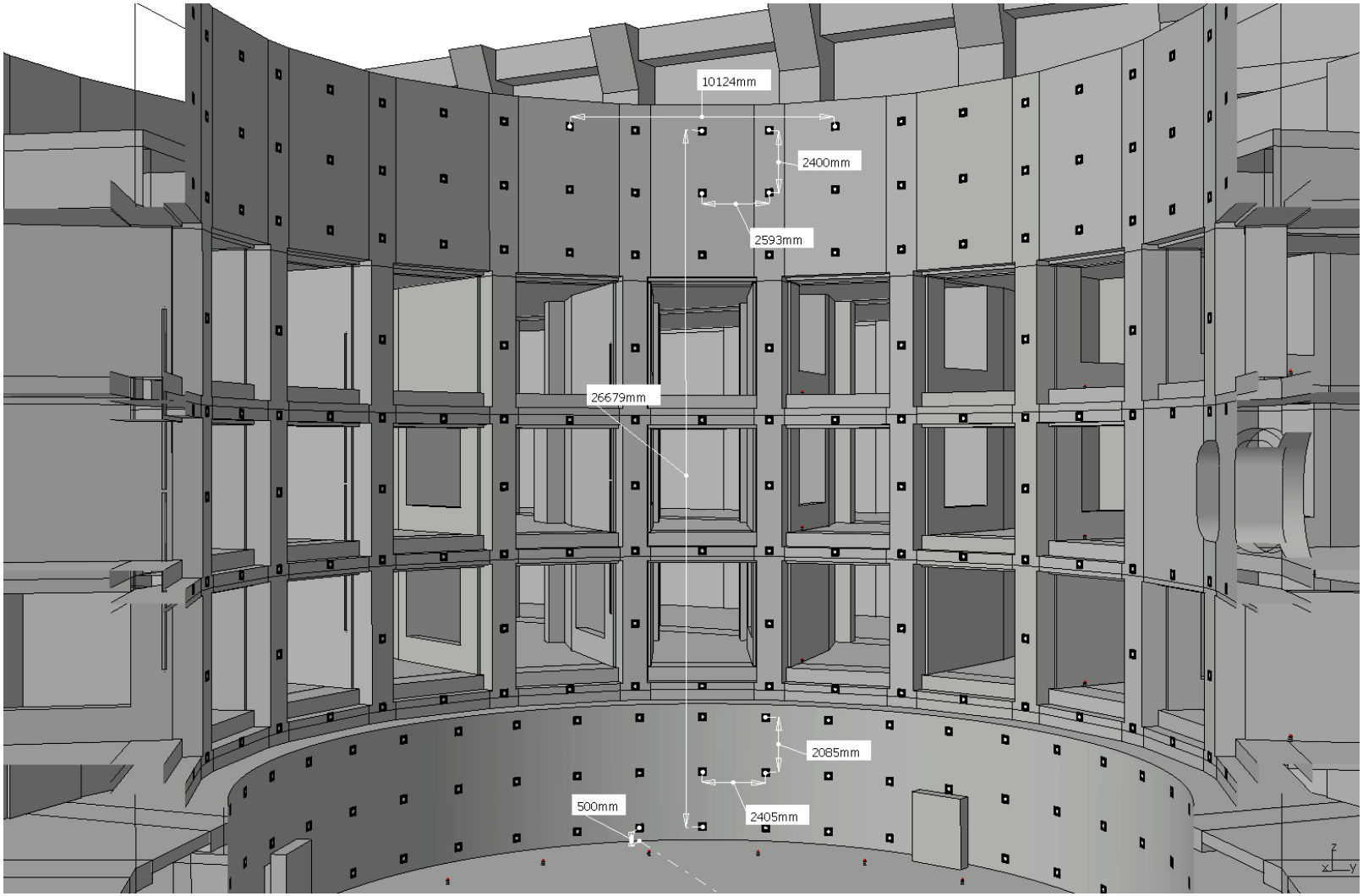
INCA3
Digital Camera



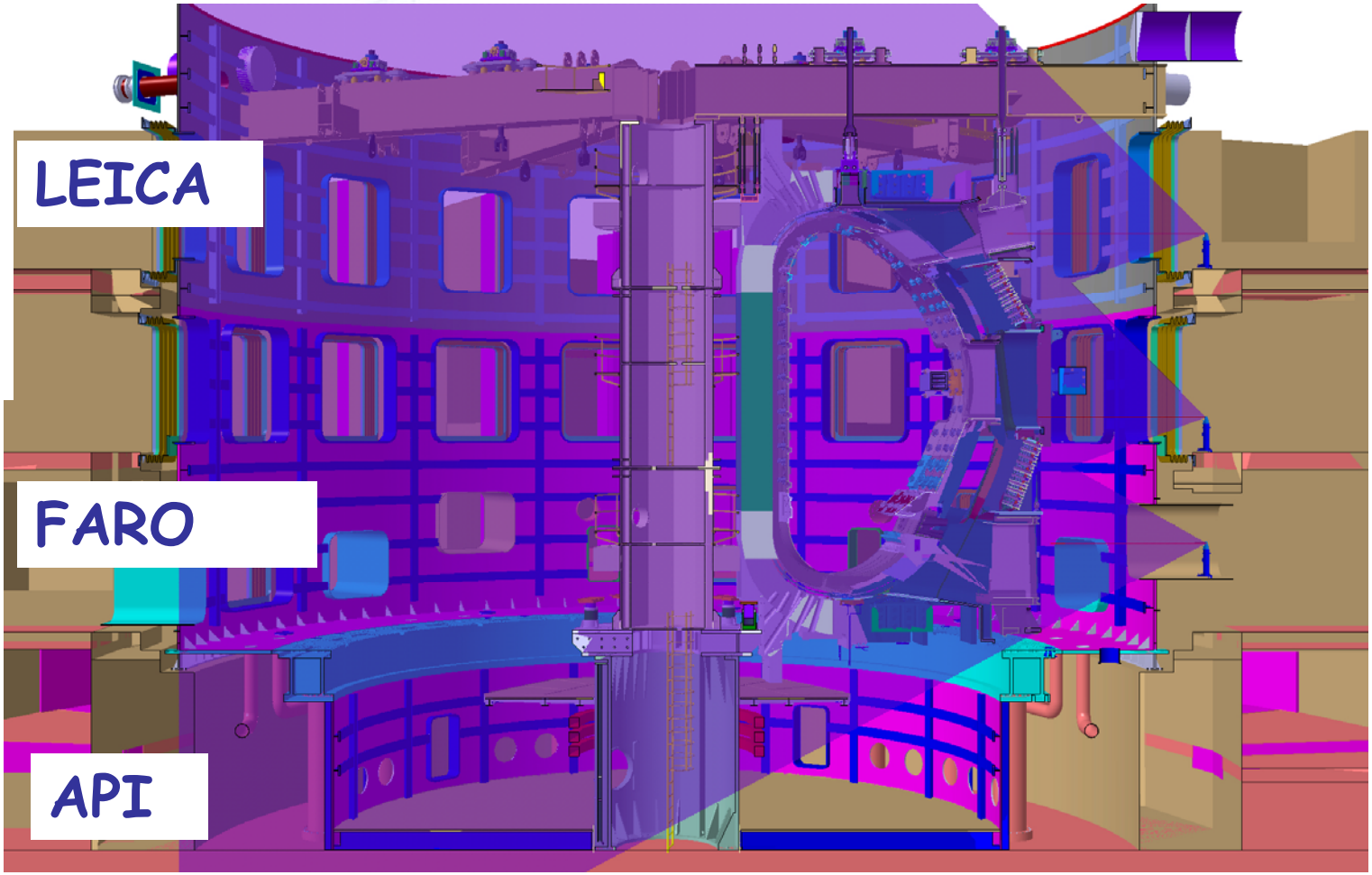
GSI

CRC2 and CRC1
Film-Based Cameras

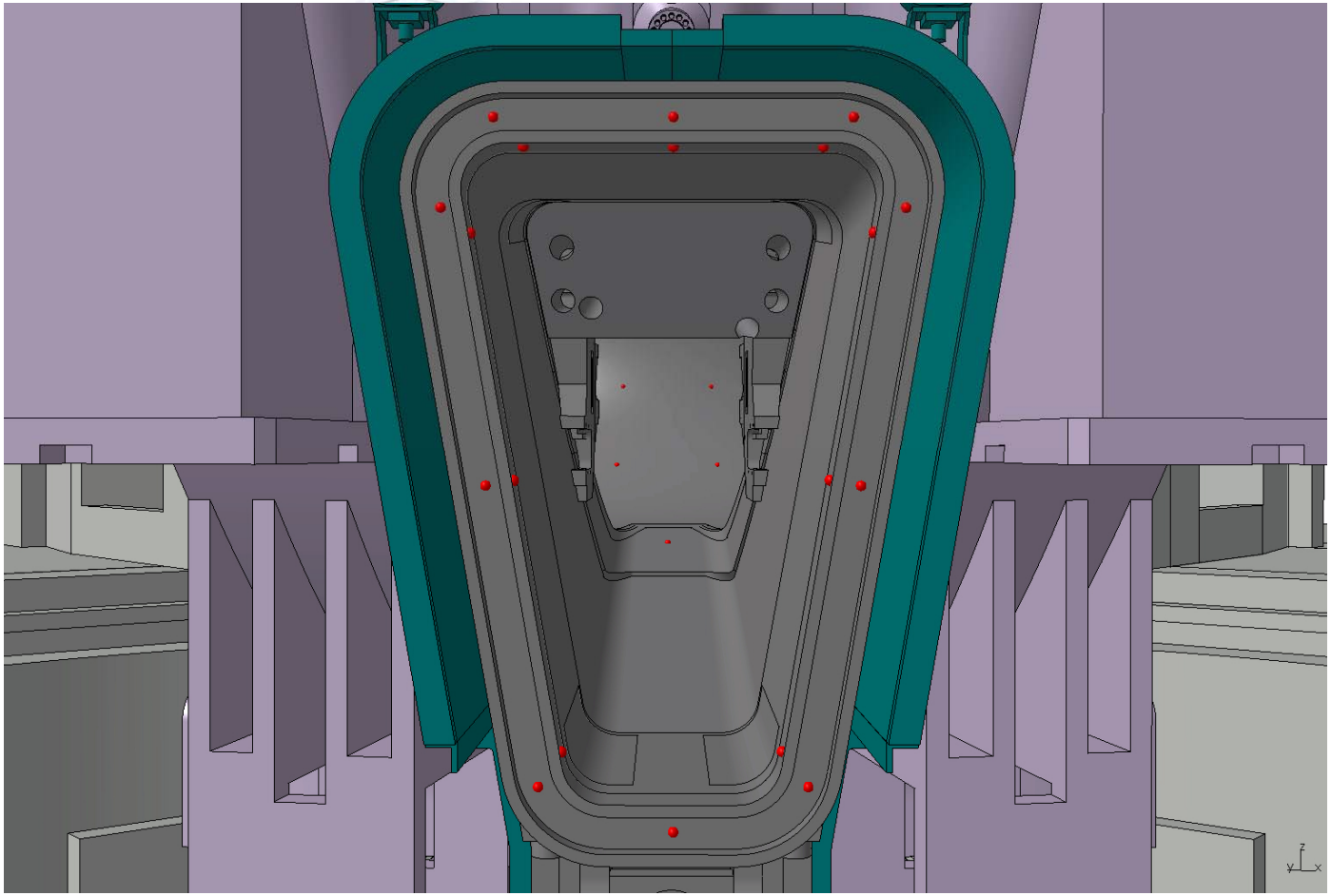



10124mm
2400mm
2593mm
26679mm
2085mm
500mm
2405mm

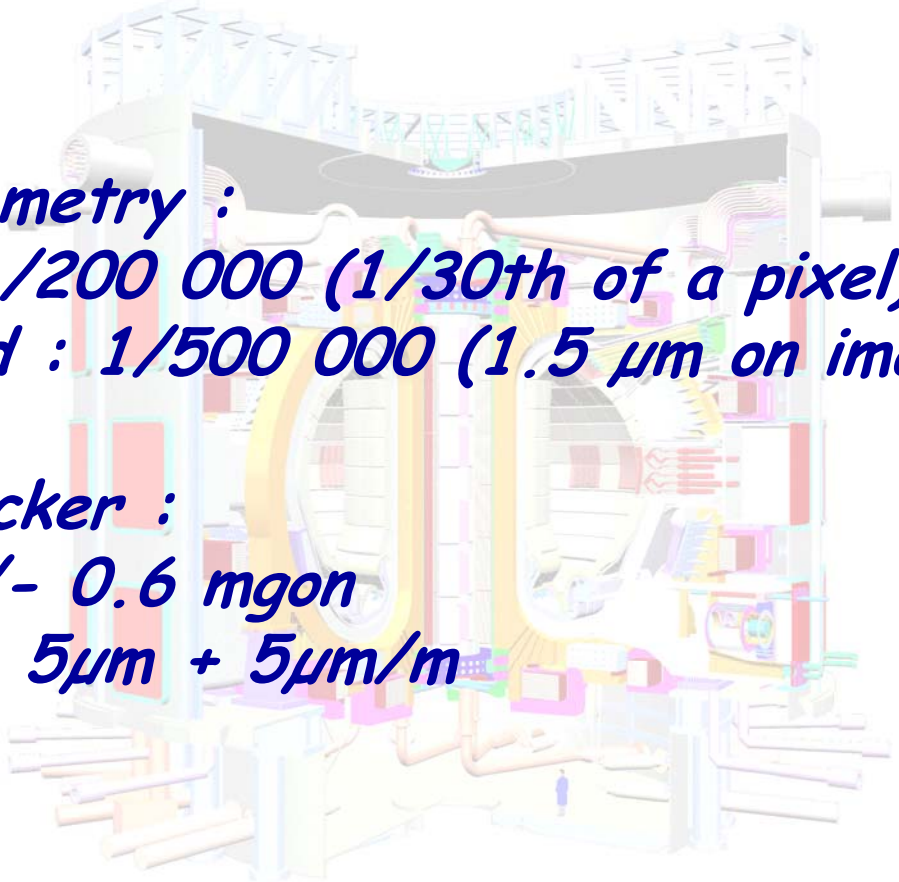
Metrology for Assembly
Sectors Positioning and Assembly : Laser Tracker



- ***Metrology for Assembly***
  Fiducials on Components



- *Metrology for Assembly*
  Accuracy considerations

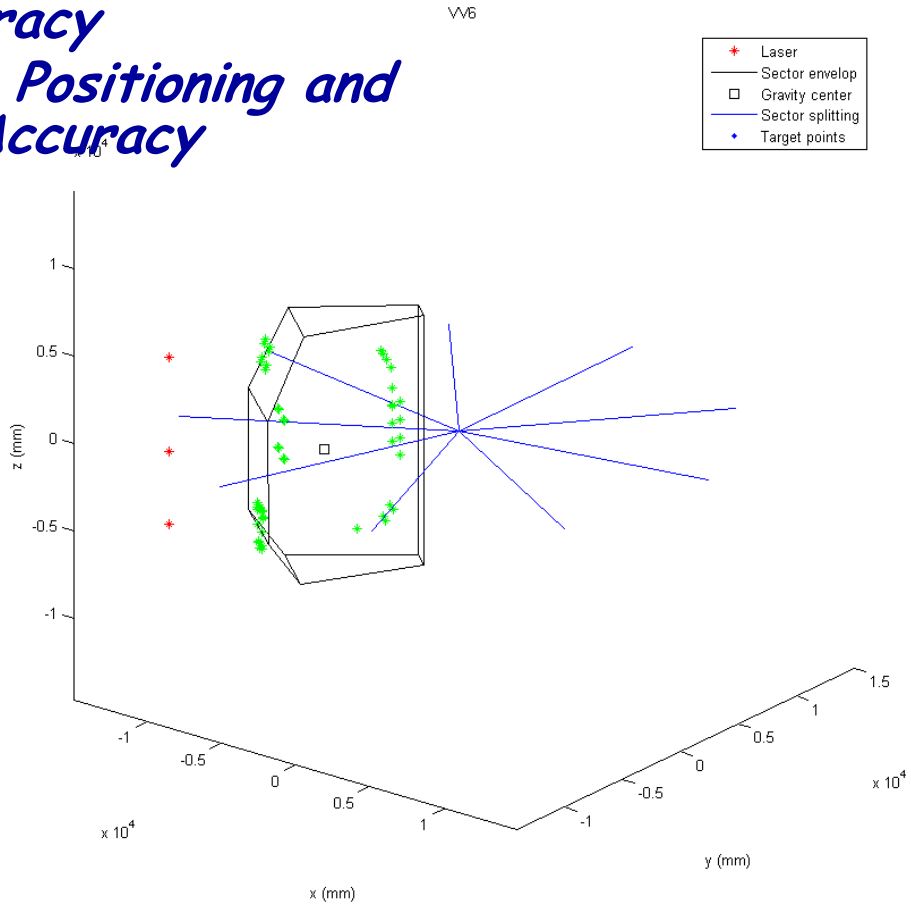


Photogrammetry :
Digital : 1/200 000 (1/30th of a pixel)
Film Based : 1/500 000 (1.5 µm on image)

Laser Tracker :
Angle : +/- 0.6 mgon
Distance : 5µm + 5µm/m

• Metrology for Assembly Accuracy considerations

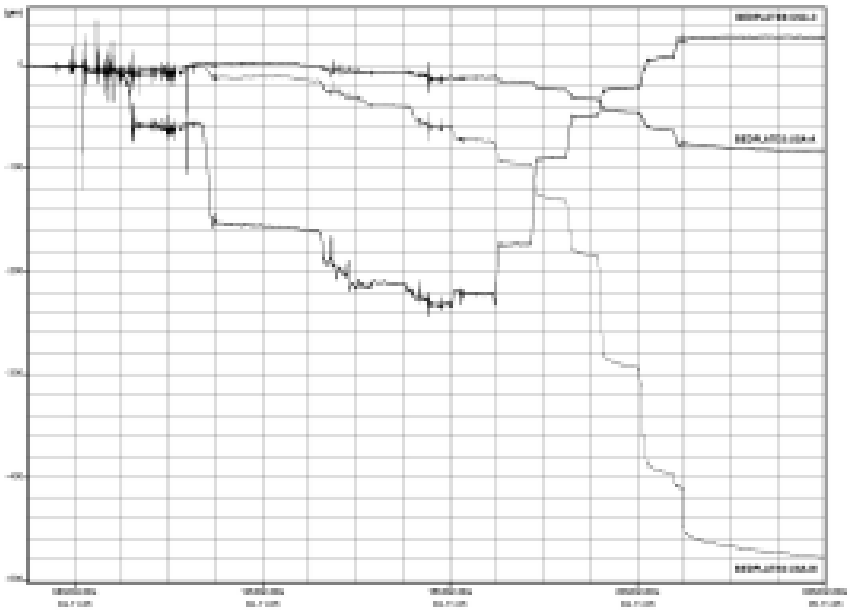
- Network Accuracy
- Laser Tracker Positioning and Measurement Accuracy



+/-0.2 mm in a stable world……..

…….but the world is not stable……..☺

CERN Results : relative deformation of the ATLAS bedplates during the installation of the Barrel Toroïd System (1600 tons)



"Combined levelling systems for the vertical monitoring of a large physics experiment"

CERN

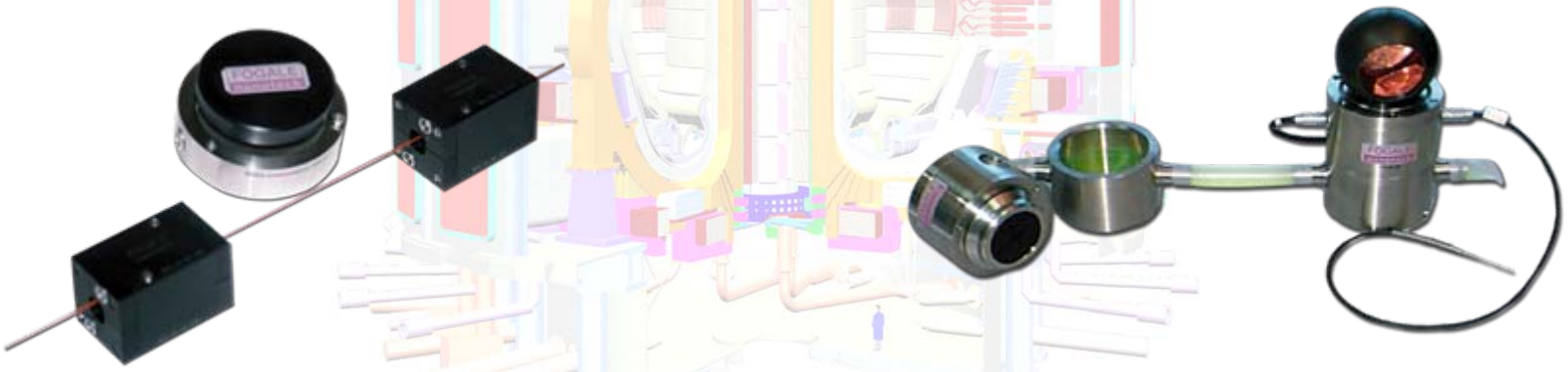
Jean-Christophe Gayde, Andreas Herty, Hélène Mainaud Durand, Christian Lasseur

Metrology for Assembly

Stability Survey with an accuracy of a few µm

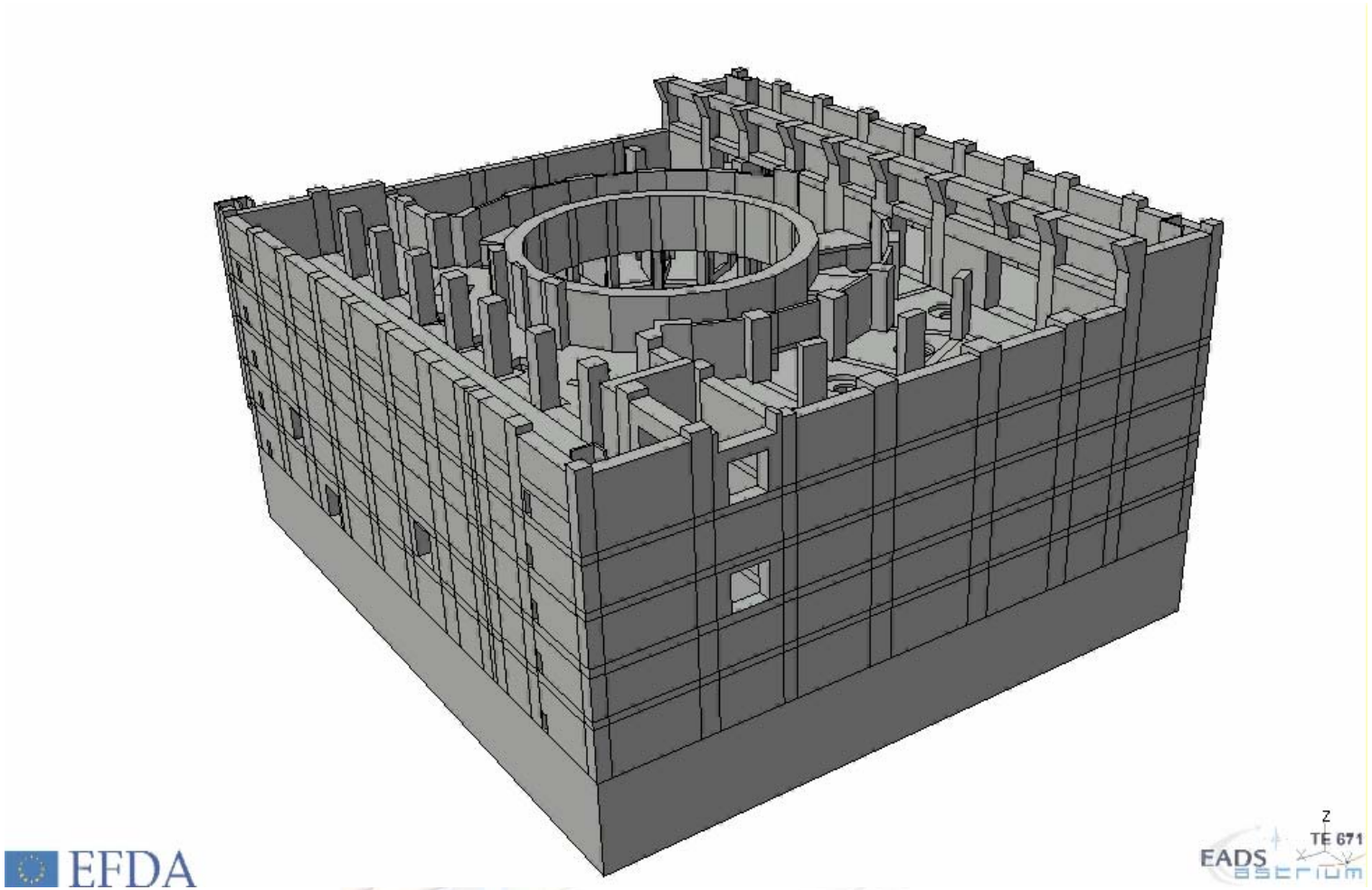
-4 rings of 9+1 HLS : one ring for each level , one sensor for each sector and one far away as a reference

-9+1 vertical references of 4 WPS : one vertical line for each sector and one with the HLS reference sensors



WPS :
Wire Positioning Sensors

HLS :
Hydrostatic Levelling Sensors



CATIA V5

The Future

1. Outside Topography Network
2. Components Manufacturing Control and As-Built Measurements
3. Measurement Automation

But the technology is changing fast with respect to the planning……☺

- Accurate Indoor GPS ?
- Accurate Laser Radar/Scanning?
- ……?

Thanks for your attention

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