Survey Alignment Metrology

European Spallation Source

Fabien REY

---- Outline ----

- ESS project
- Alignment challenges at ESS
- Where we are now…

---- ESS Project ----

European Spallation Source

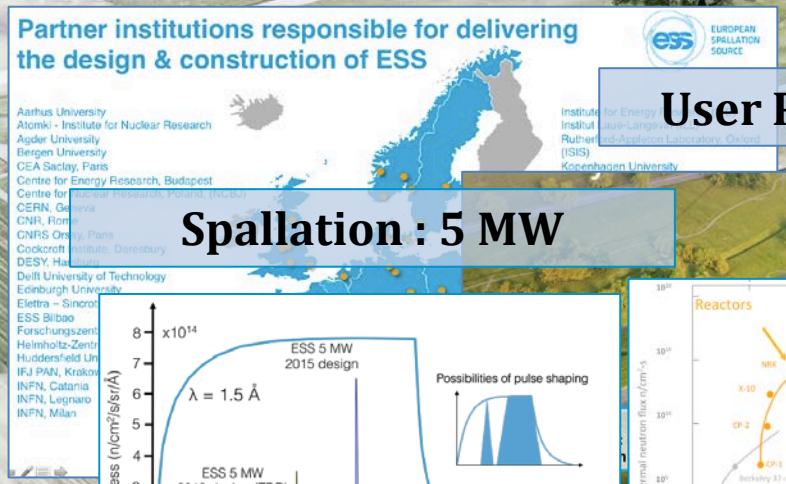
Mission:

Design, Build, and Operate the world's leading research facility using Neutrons.

€1.843 billion for construction

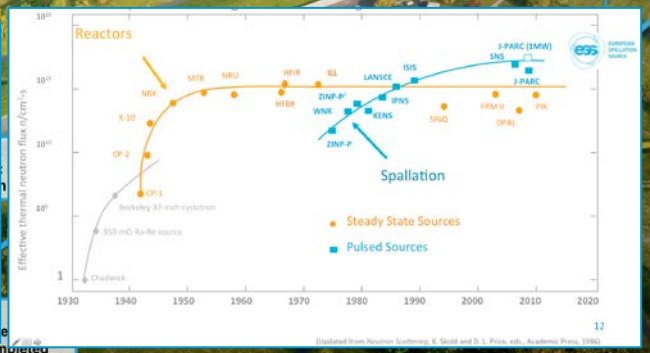
A collaboration across Europe

In-Kind Contribution



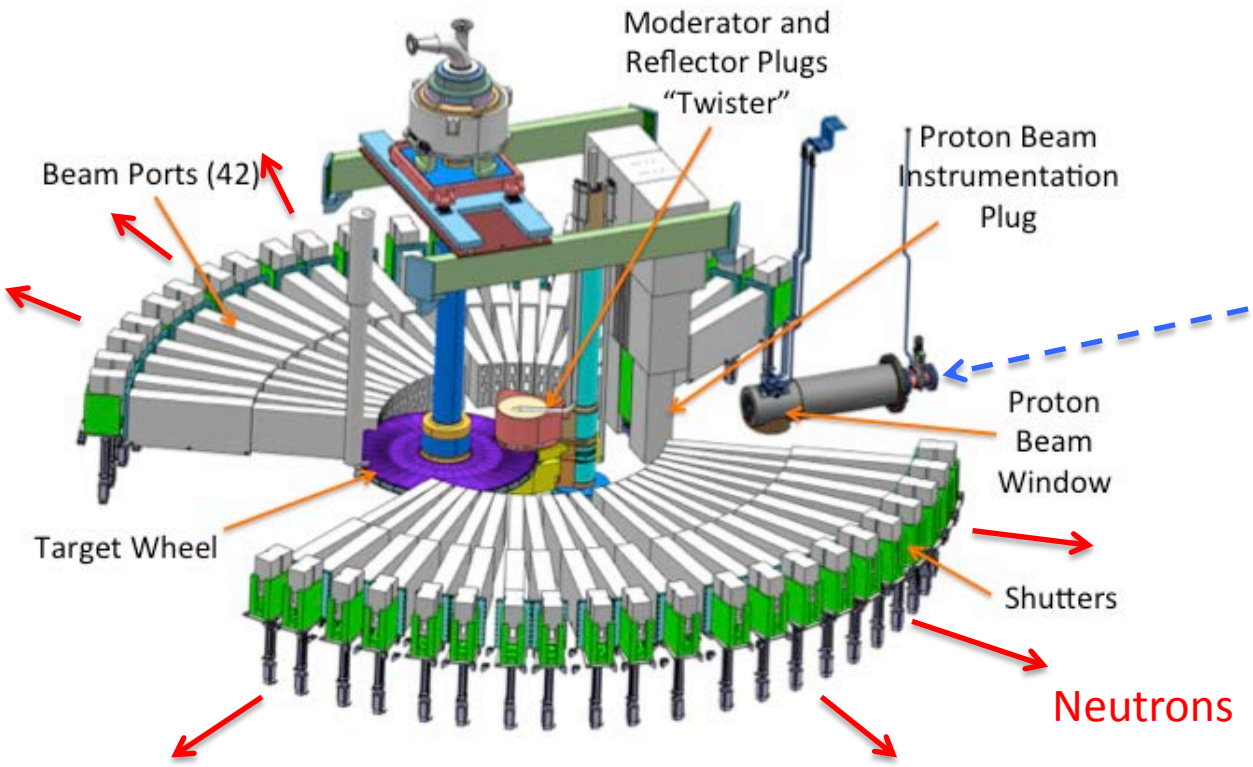
User Program in 2023

Spallation : 5 MW



---- Spallation ----

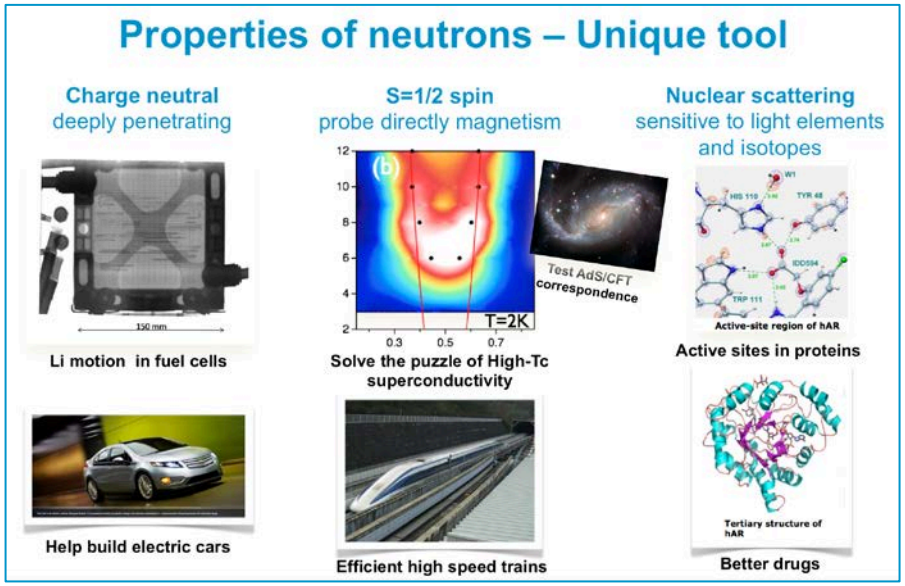
Process in which a **heavy nucleus** emits a large number of **nucleons** as a result of being hit by a **high-energy particle**. (WIKIPEDIA)

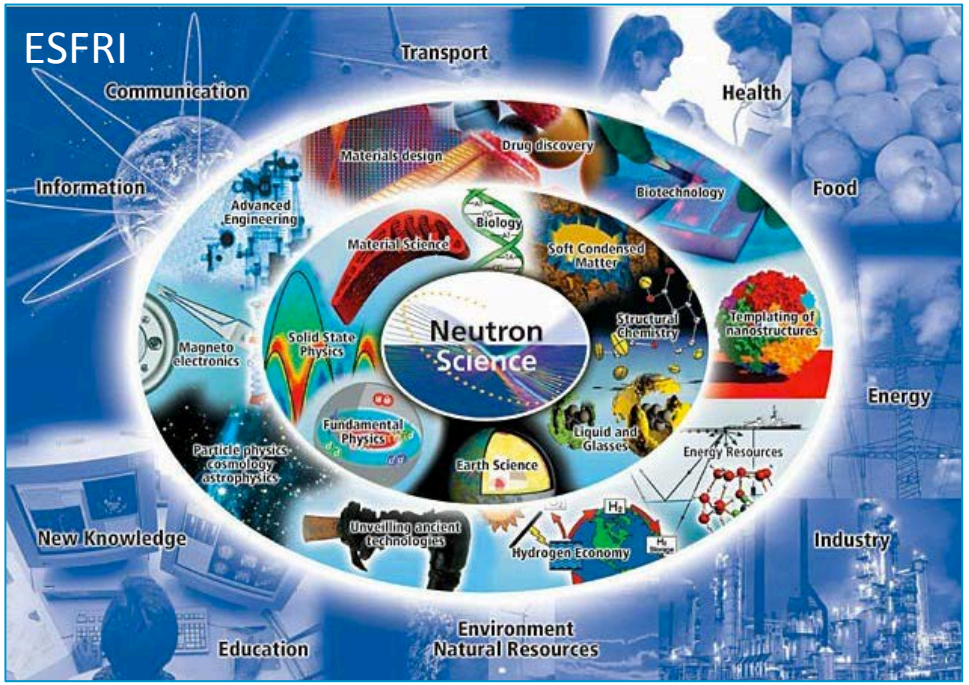


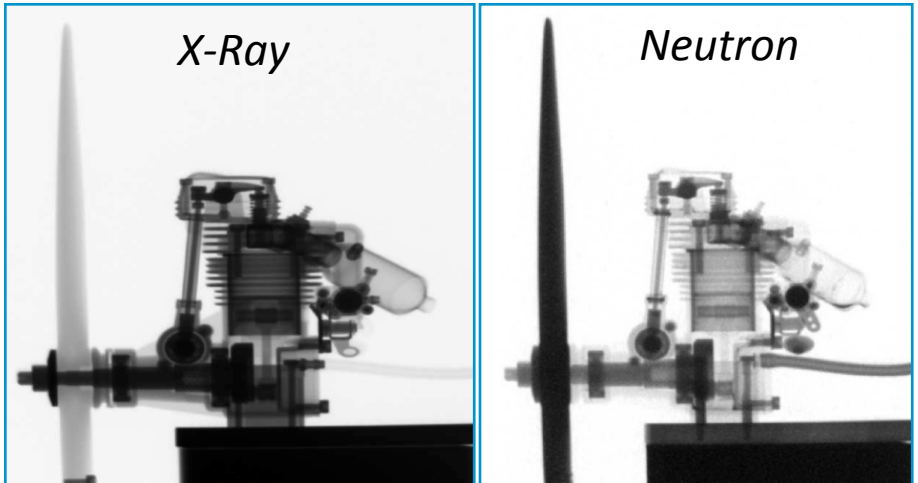
Linear proton accelerator
Energy: 2 GeV
Rep. Rate: 14 Hz
Current: 62.5 mA Peak
Pulse length: 2.86 ms

Design Drivers:
High Average Beam Power: 5 MW
High Peak Beam Power: 125 MW
High Availability > 95%

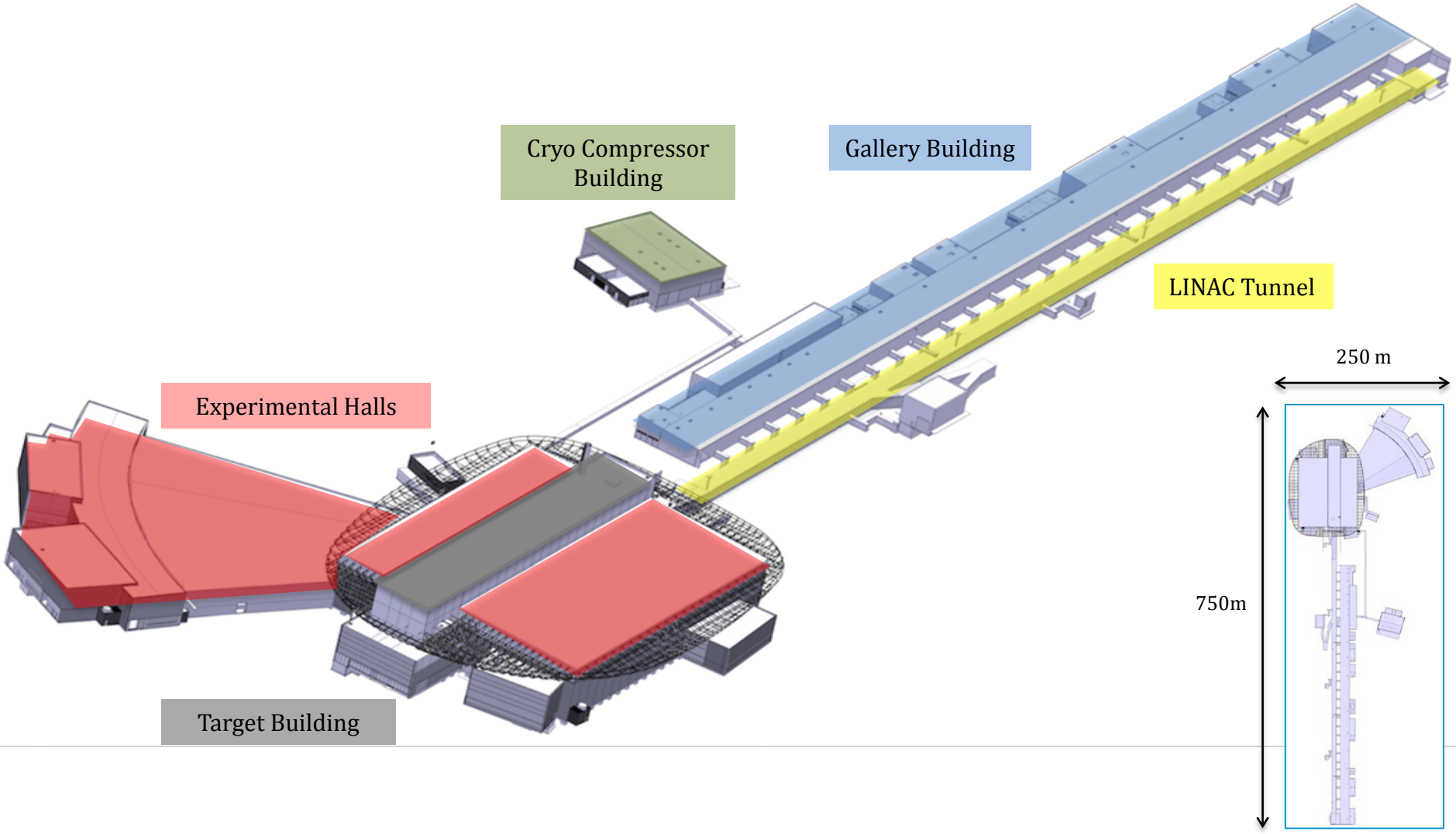
---- Neutron Sciences ----





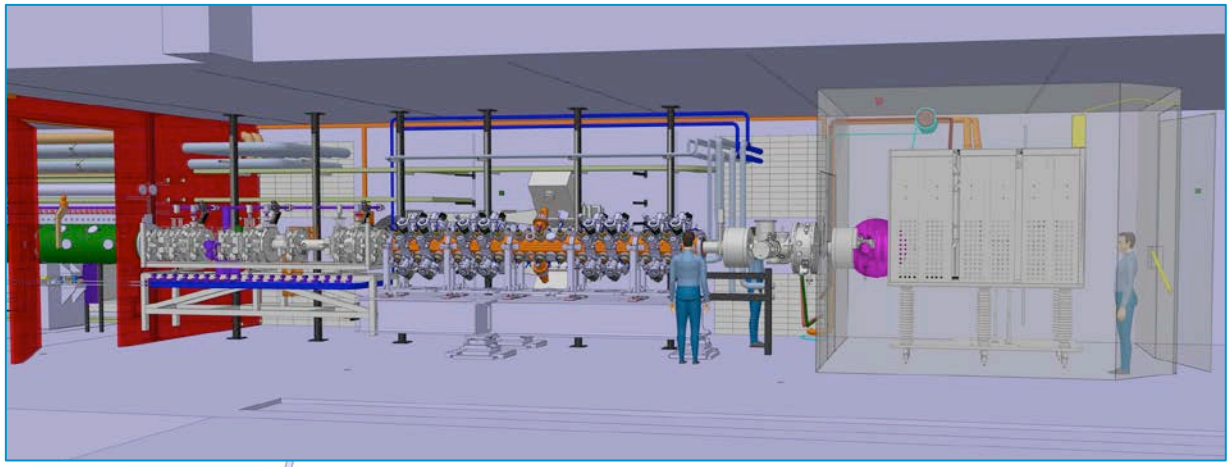


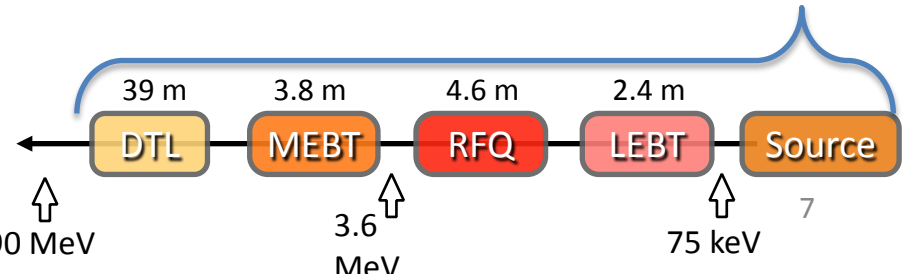
---- Buildings ----


Cryo Compressor Building
Gallery Building
LINAC Tunnel
Experimental Halls
Target Building
250 m
750m

---- Proton LINAC ----

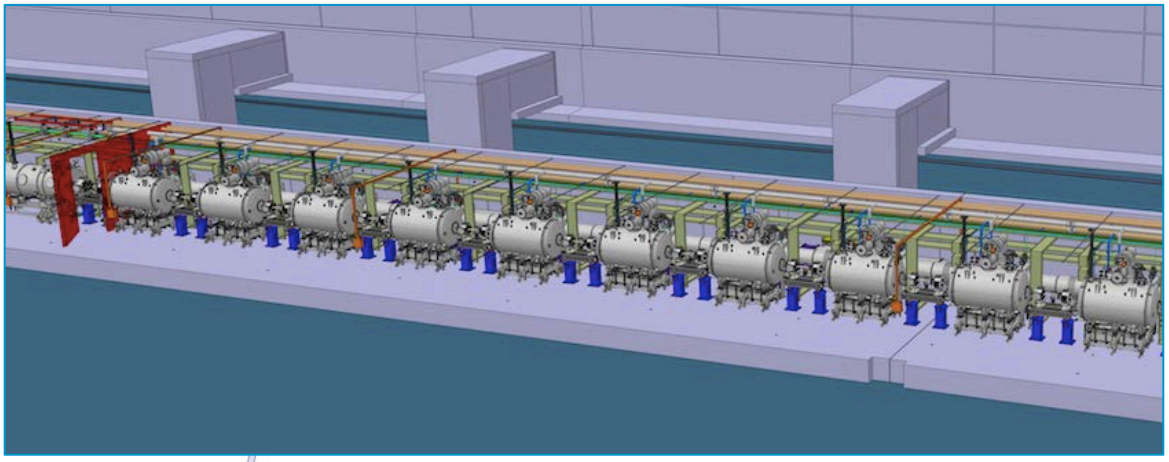
Warm LINAC

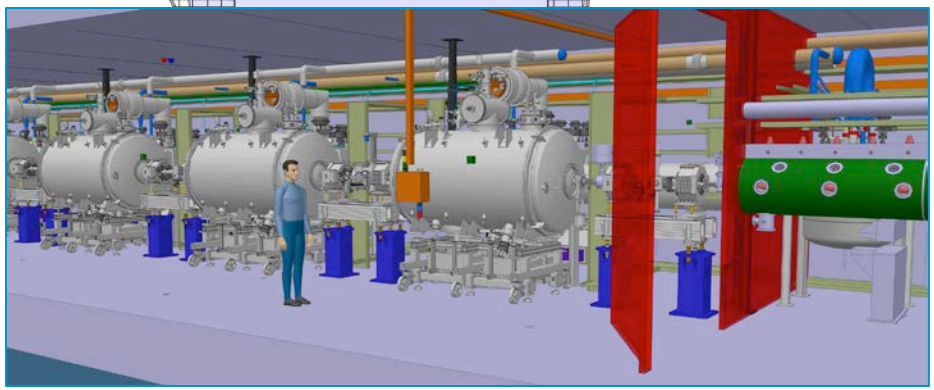


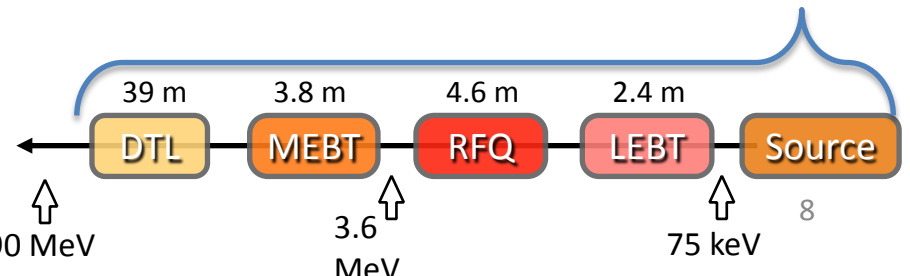


---- Proton LINAC ----

Spokes Cryomodules

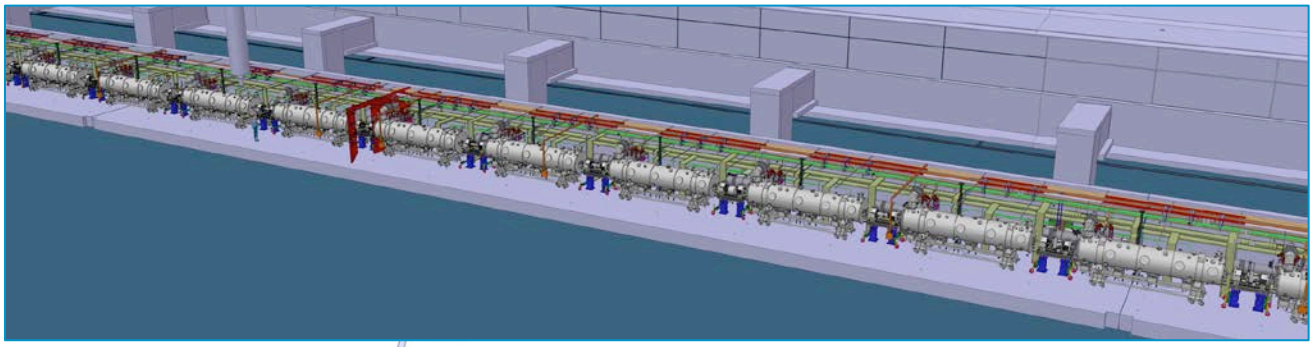


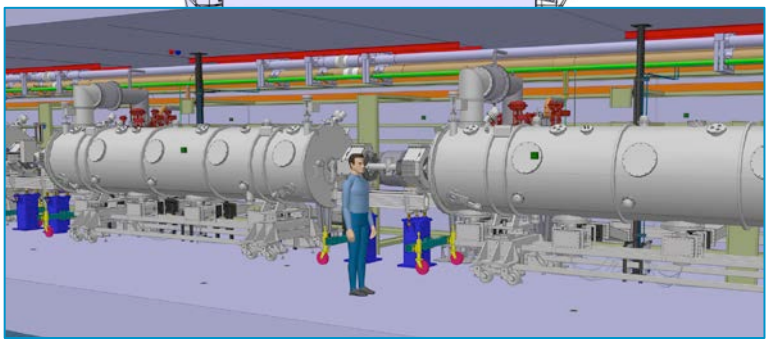


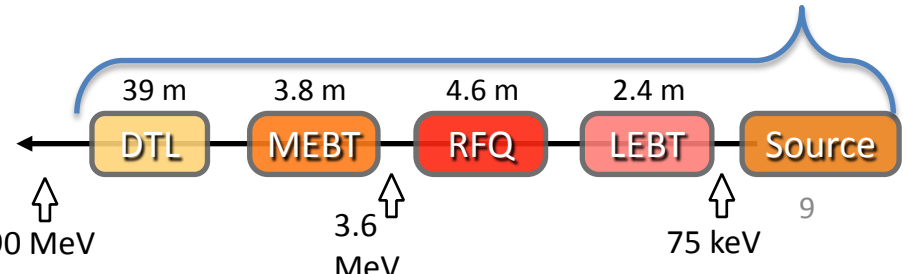


---- Proton LINAC ----

Elliptical Cryomodules

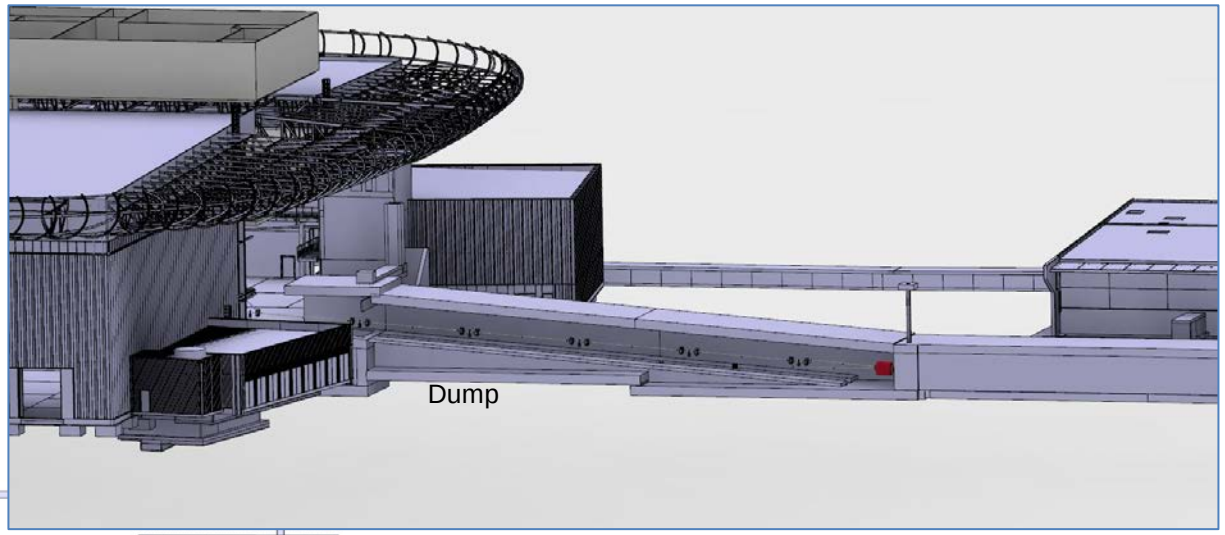


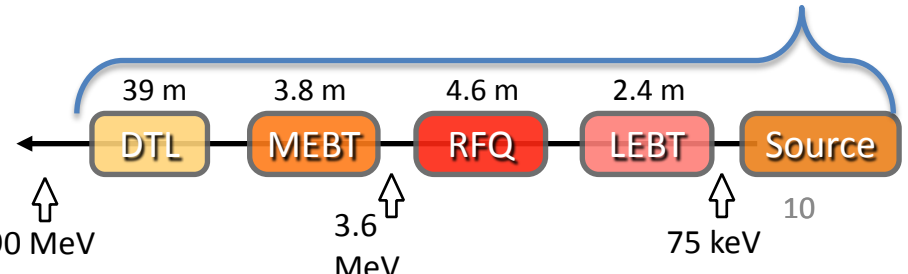




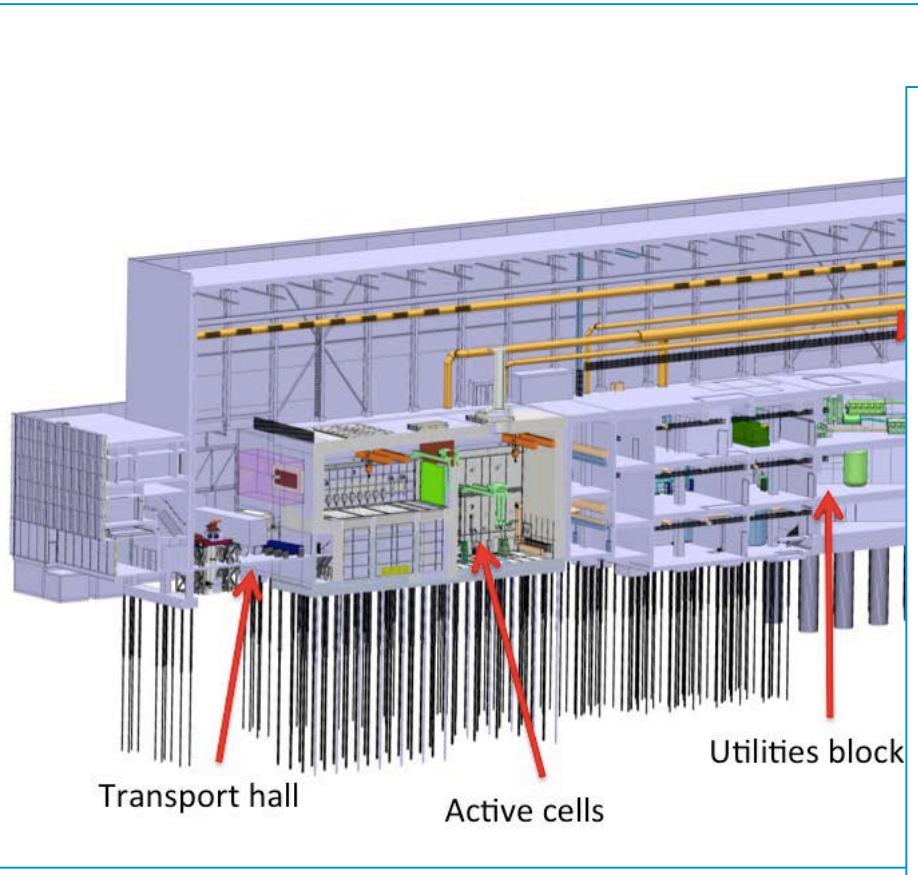
---- Proton LINAC ----

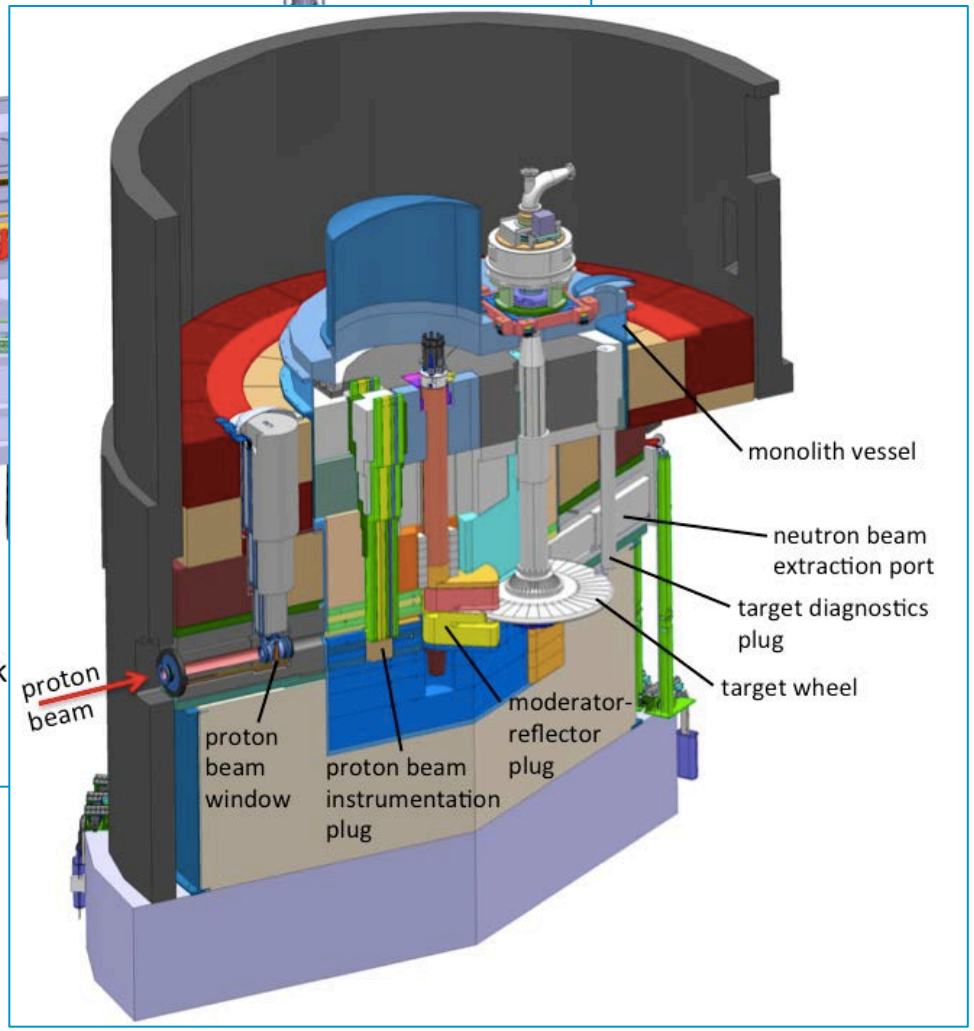
A2T : Accelerator to Target



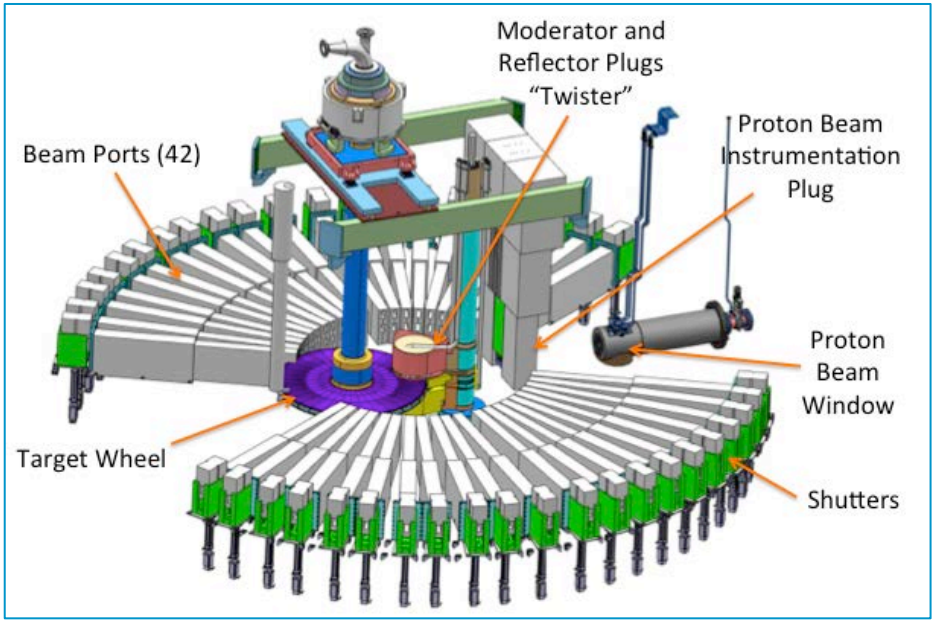


---- Target ----

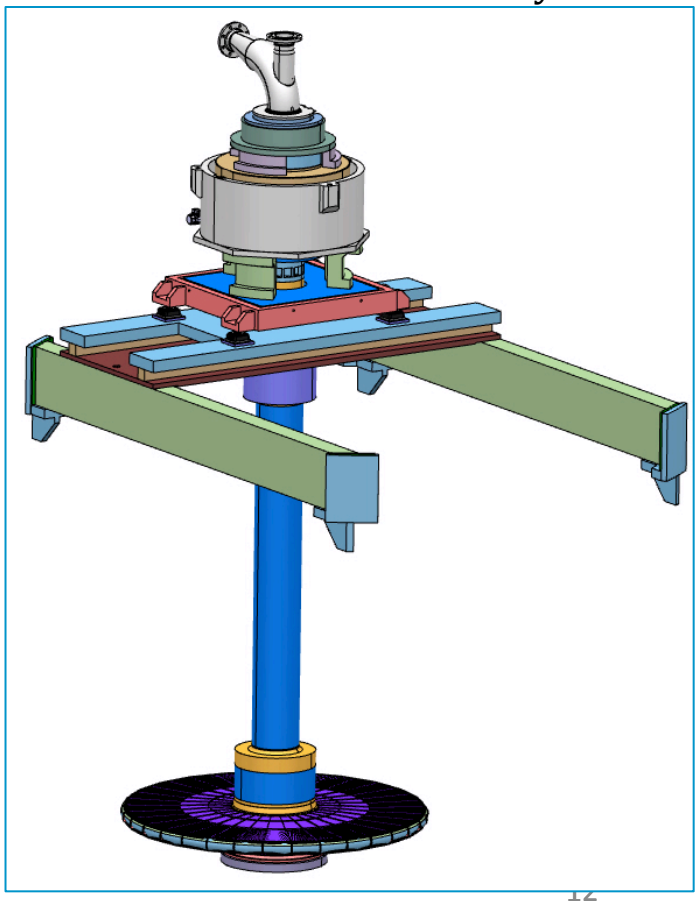

Transport hall
Active cells
Utilities block

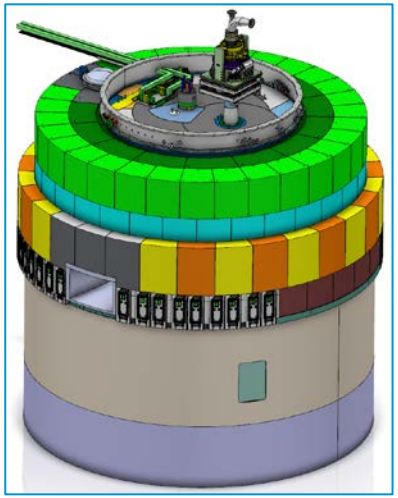

monolith vessel
neutron beam extraction port
target diagnostics plug
target wheel
proton beam
proton beam window
proton beam instrumentation plug
moderator-reflector plug

---- Target ----

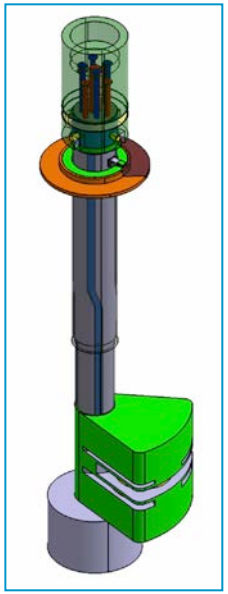


Wheel assembly





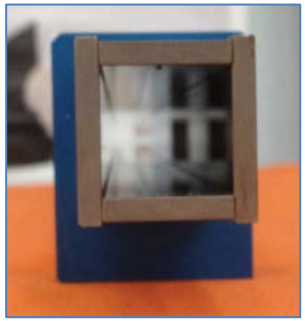
Target monolith



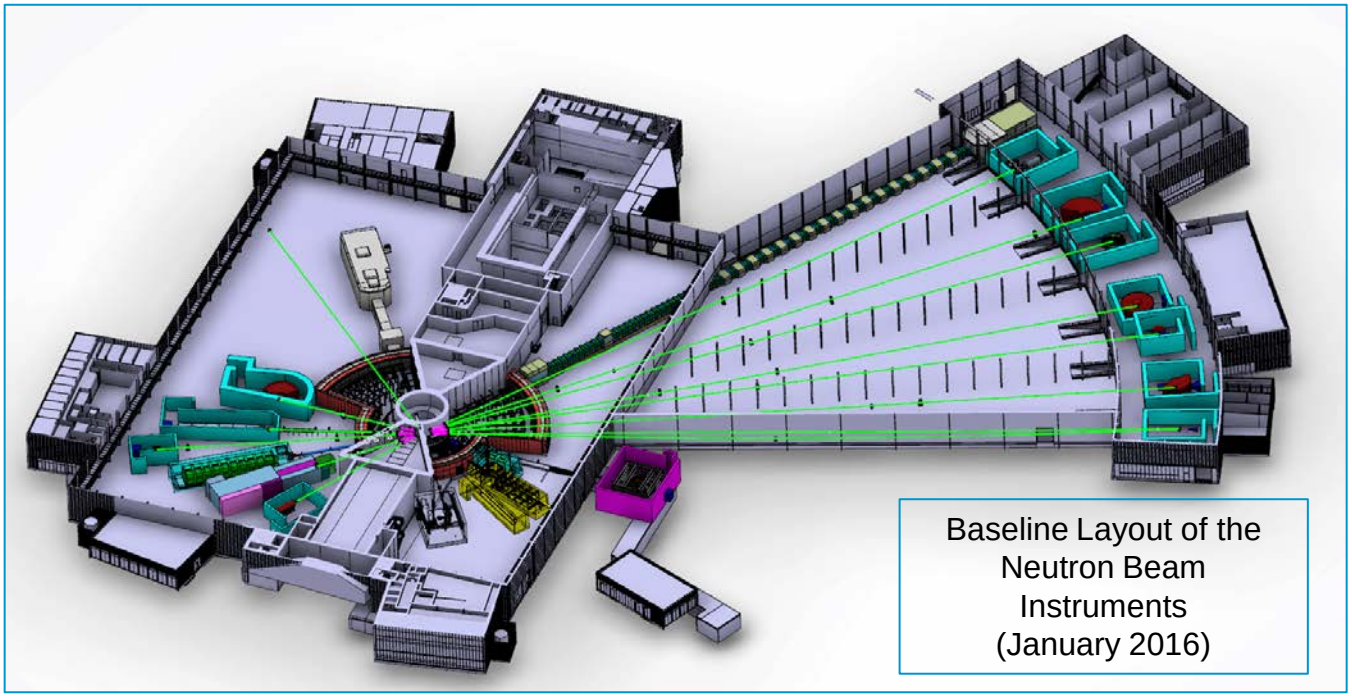
Moderator Reflector

---- Instruments ----

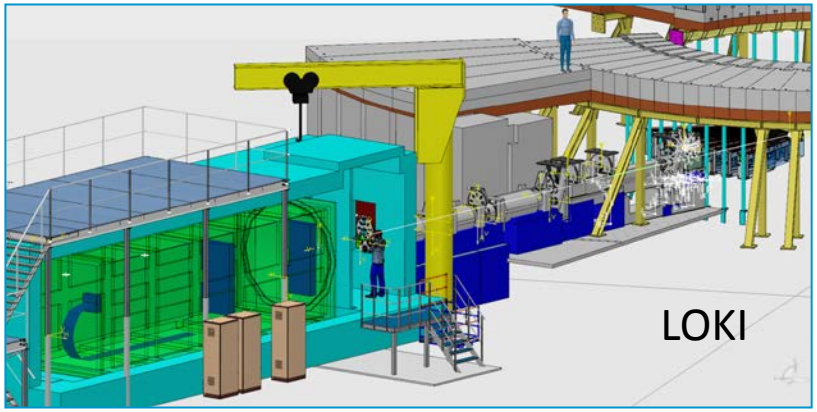
Instruments :

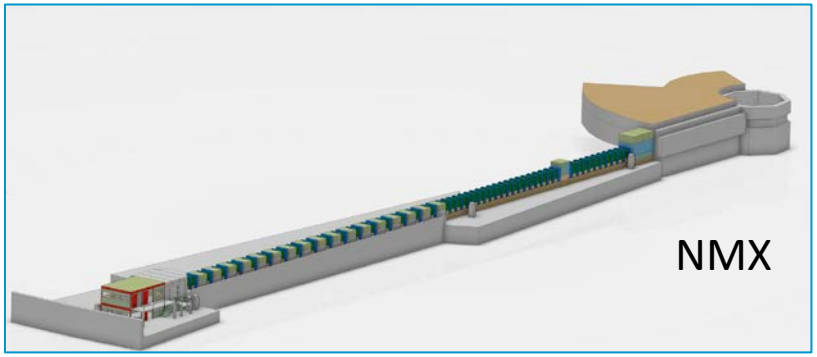


Neutron guide inside view



Baseline Layout of the Neutron Beam Instruments (January 2016)

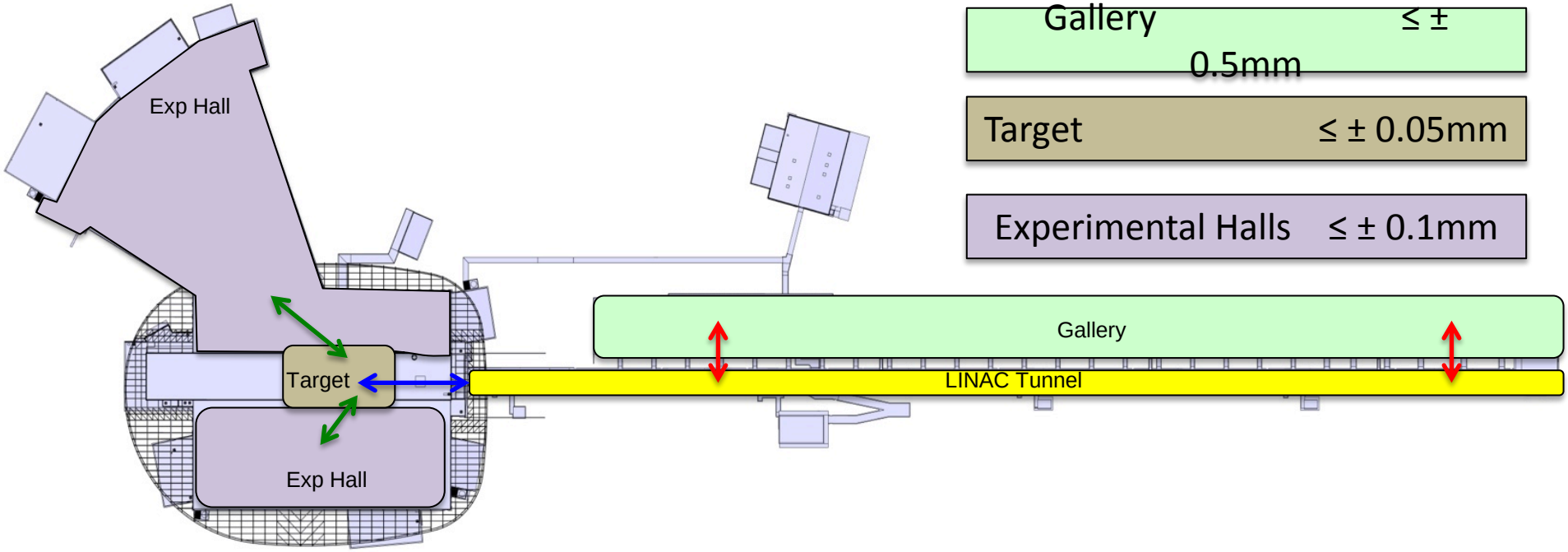




---- Needs for Alignment ----

Internal Alignment budget:

LINAC Tunnel	≤ ± 0.1mm
Gallery	≤ ± 0.5mm
Target	≤ ± 0.05mm
Experimental Halls	≤ ± 0.1mm



Relative Alignment budget:

LINAC Tunnel ≤ ± 1mm Gallery

LINAC Tunnel ≤ ± 1mm Target

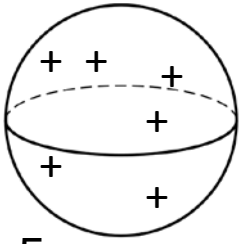
Target ≤ ± 1mm Experimental Halls

---- Alignment Strategy ----

3d free stationing technique with least squares adjustment calculus

Dense 3D network of reference points + Laser Tracker Total Station Digital Level + Adjustment Software

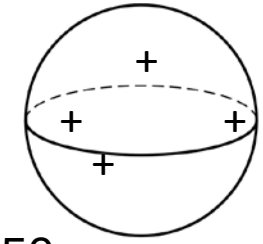
Inside



R=5m

6 points

Outside



R=50m

4 points

SpatialAnalyzer

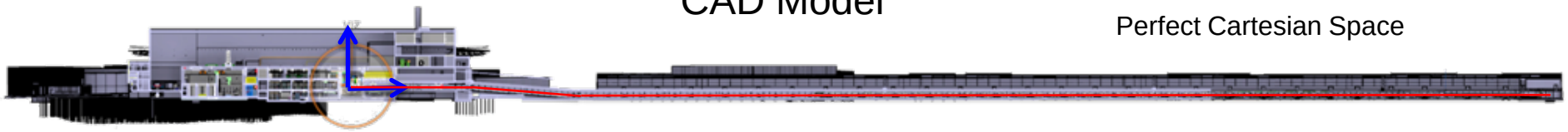
Describe **machine geometry** and **CAD models** in Cartesian system including **geodetics aspects!!!**

---- Alignment Strategy ----

750m

CAD Model

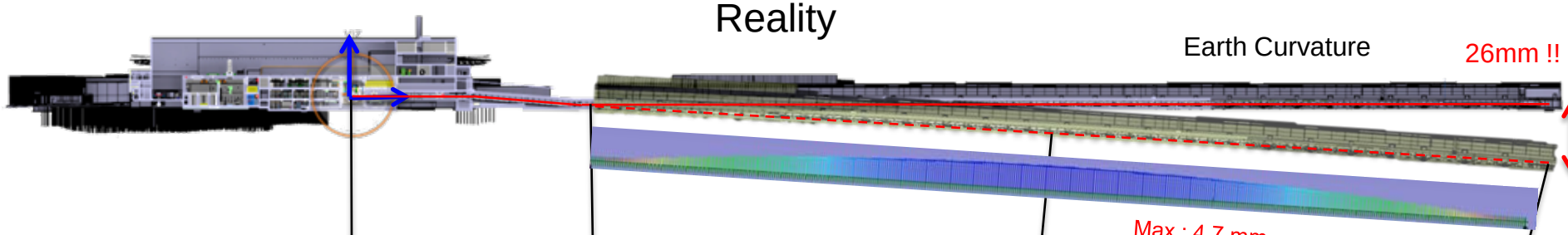
Perfect Cartesian Space



Reality

Earth Curvature

26mm !!

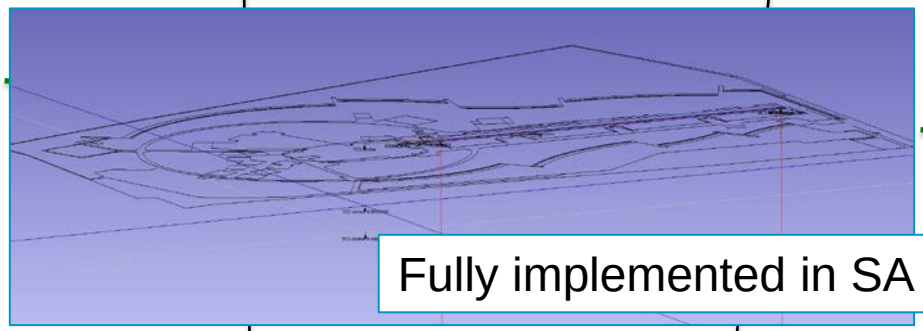


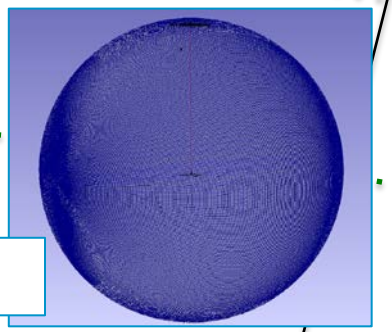
Max : 4.7 mm
Less than Construction Tolerance of the Tunnel floor : Good !!

Geoid : Sphere of radius: Rm + N

H :Geoid height

Ellipsoid = Sphere of mean radius :Rm



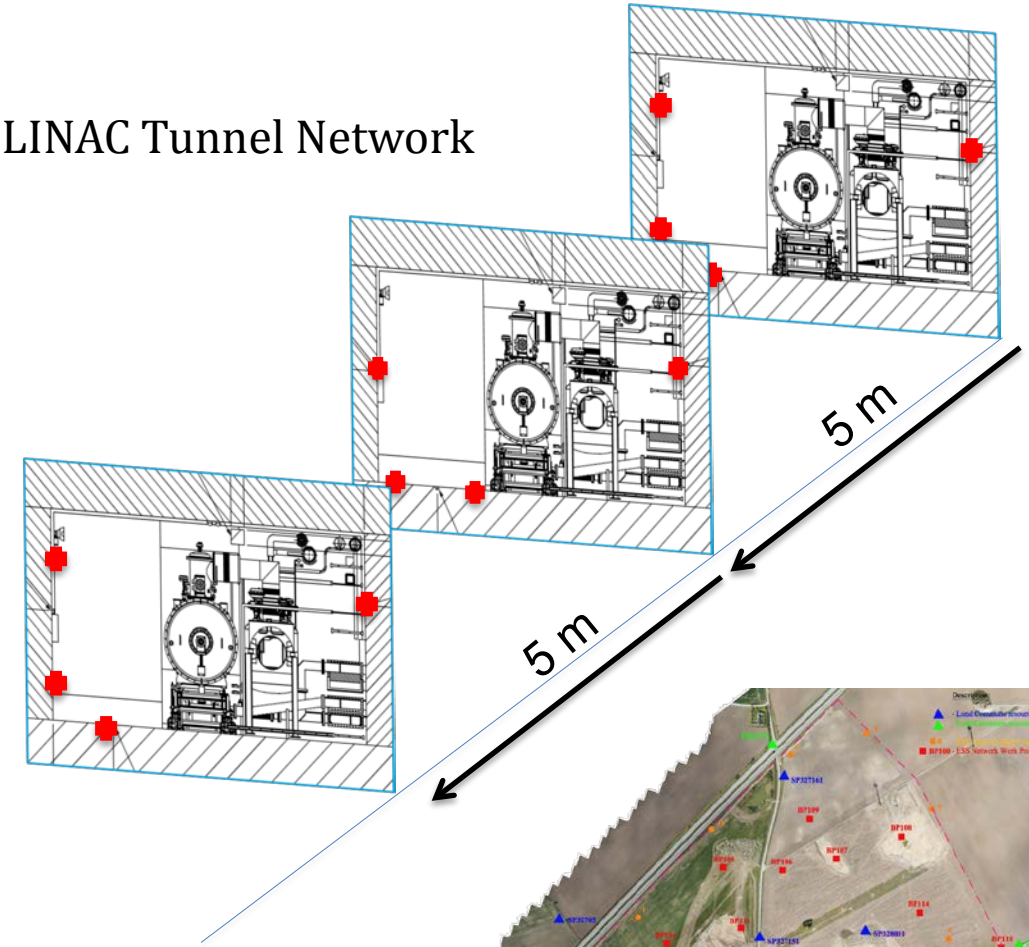


Fully implemented in SA

Earth Center

---- Alignment Strategy ----

LINAC Tunnel Network

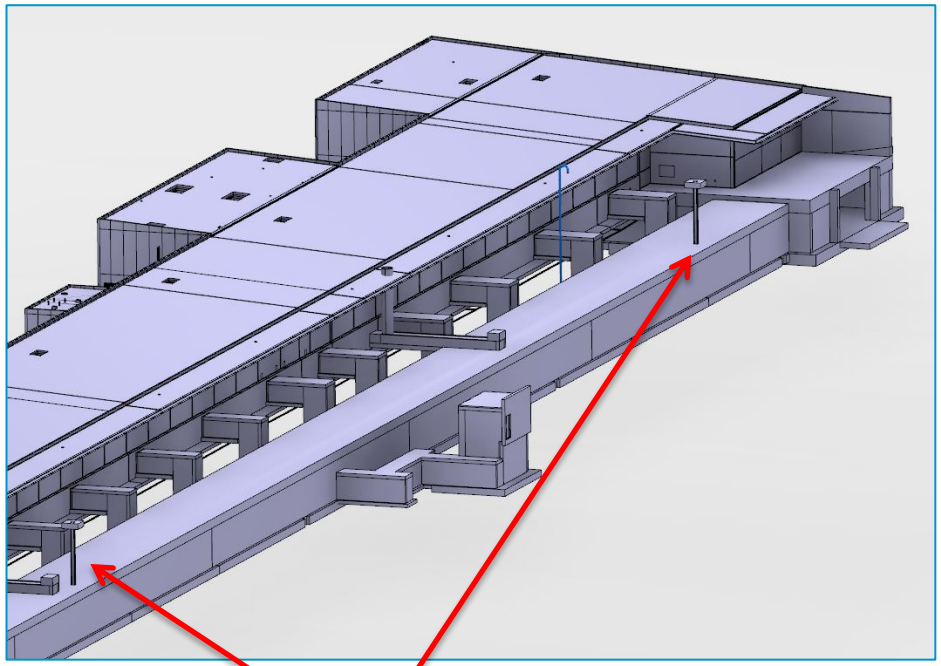


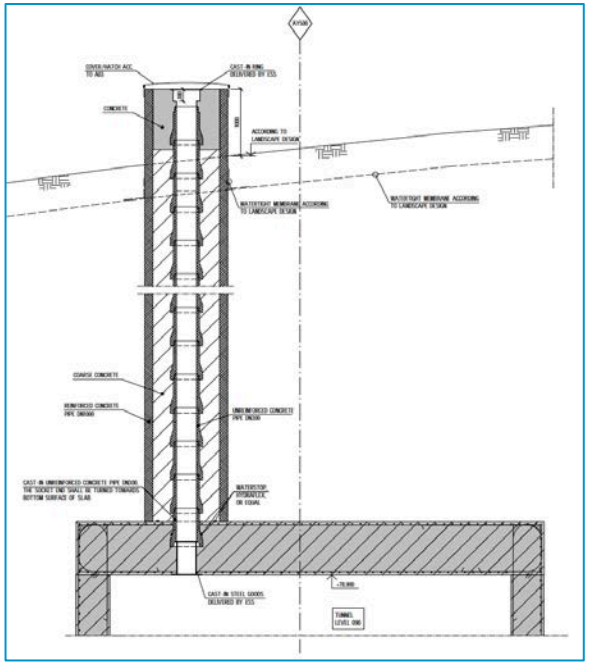
Two reference networks connected:

- <u>outside Geodetic Pillar Network</u> (mm accuracy)
Measurements: GPS, Total Stations, Digital Levels.

- <u>internal reference network</u> (0.1 mm accuracy)
Measurements: Laser Trackers , Total Stations, Digita
Levels

---- Alignment Strategy ----



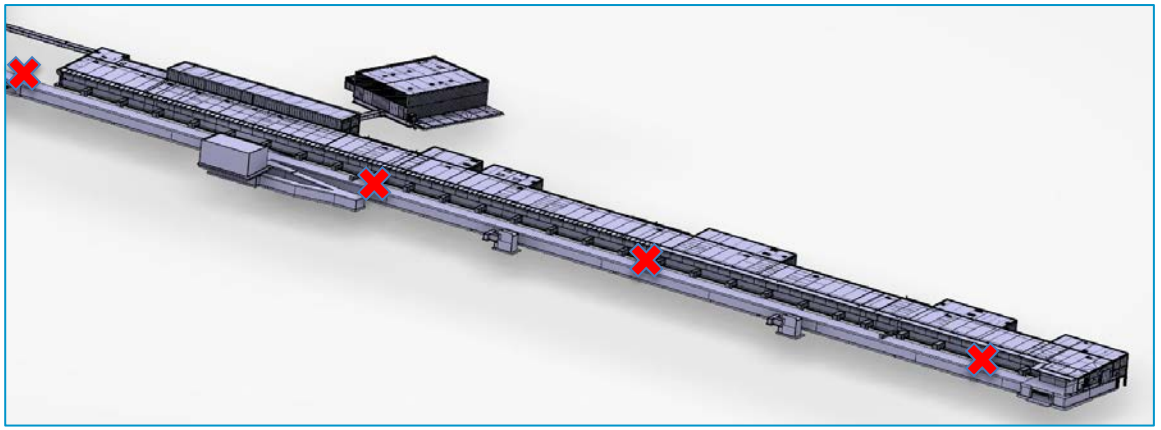


≈ 7 m

Vertical Alignment Shafts

x 4

Connecting Inside tunnel to outside



---- SAM Group ----

Team :

Pawel Garsztka

SAM Engineer

Fabien Rey

Group Leader

Tomasz Zawierucha

SAM Engineer

Instrumentation:

Laser Trackers/ Total Station:

- 1 x AT402
- 1 x AT960 LR
- 1 x TDRA 6000

Levels:

- 1 x DNA 03
- 2 x N3

Laser Scanner:

- 1 x P30

GNSS:

- 1 x GR10 +AR25
- 1 x GS14 + CS15

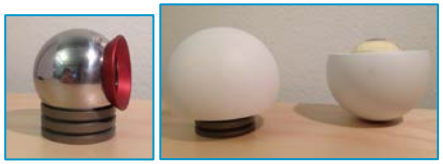
Softwares:

- Spatial Analyser
- PANDA
- Cyclone
- LGO
- Catia V6

---- Laser Scanning ----

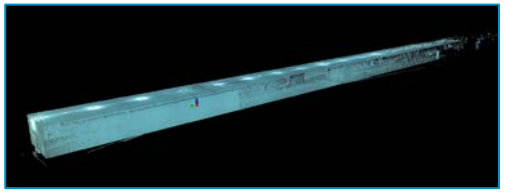
Raw data Acquisition

P30

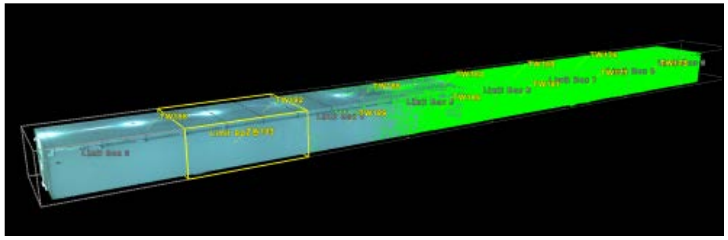


Concentric Spheres

Analysis in Cyclone

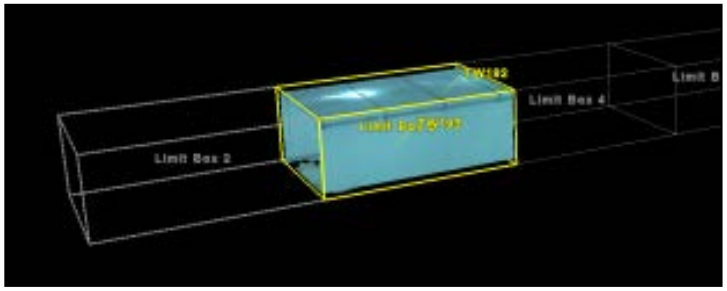


Data Cleaning
Orientation of Scans (registration)
Geometries created on demand

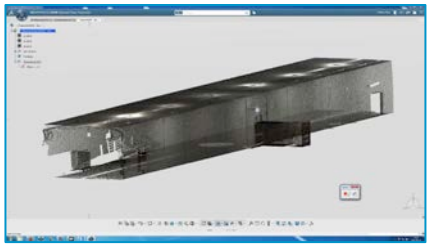


Point cloud splitting according to LBS

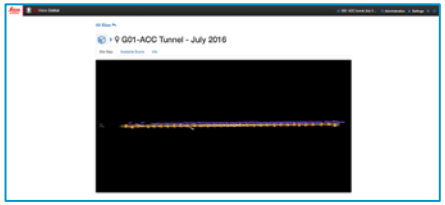
(Location Breakdown Structure)



CATIA V6
For Reverse Engineering and Integration



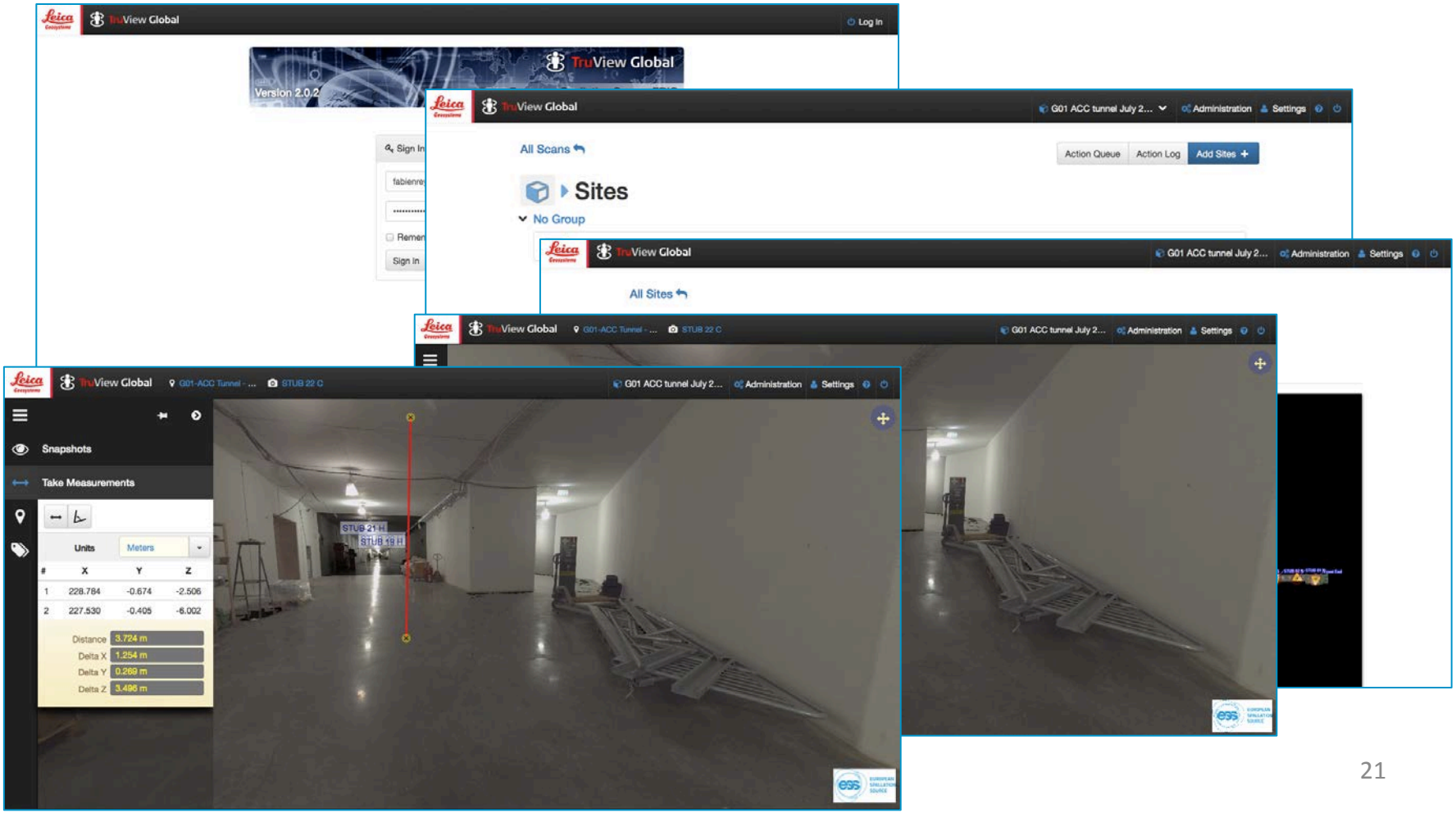
TruView Global



Non CAD users
Visualization/Simple measurments

---- Laser Scanning ----

https://truview.esss.lu.se



---- On site ----

---- On site ----



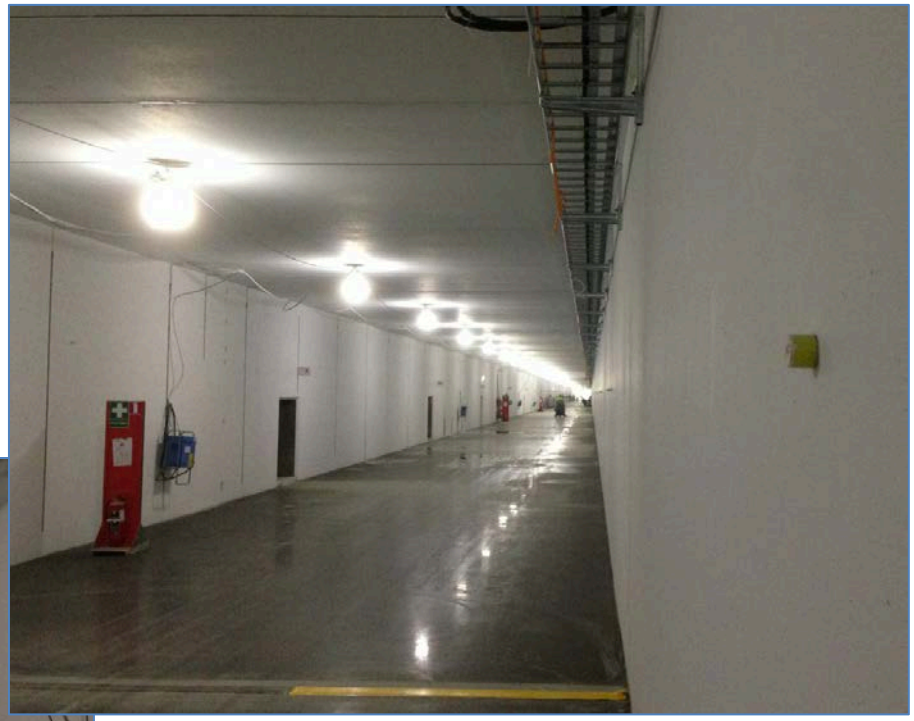



---- On site ----

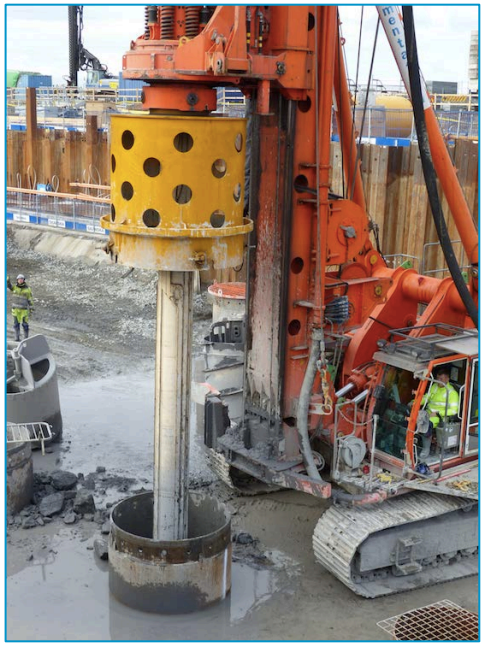
---- On site ----

---- On site ----

---- On site ----



---- On site ----



---- On site ----

---- On site ----

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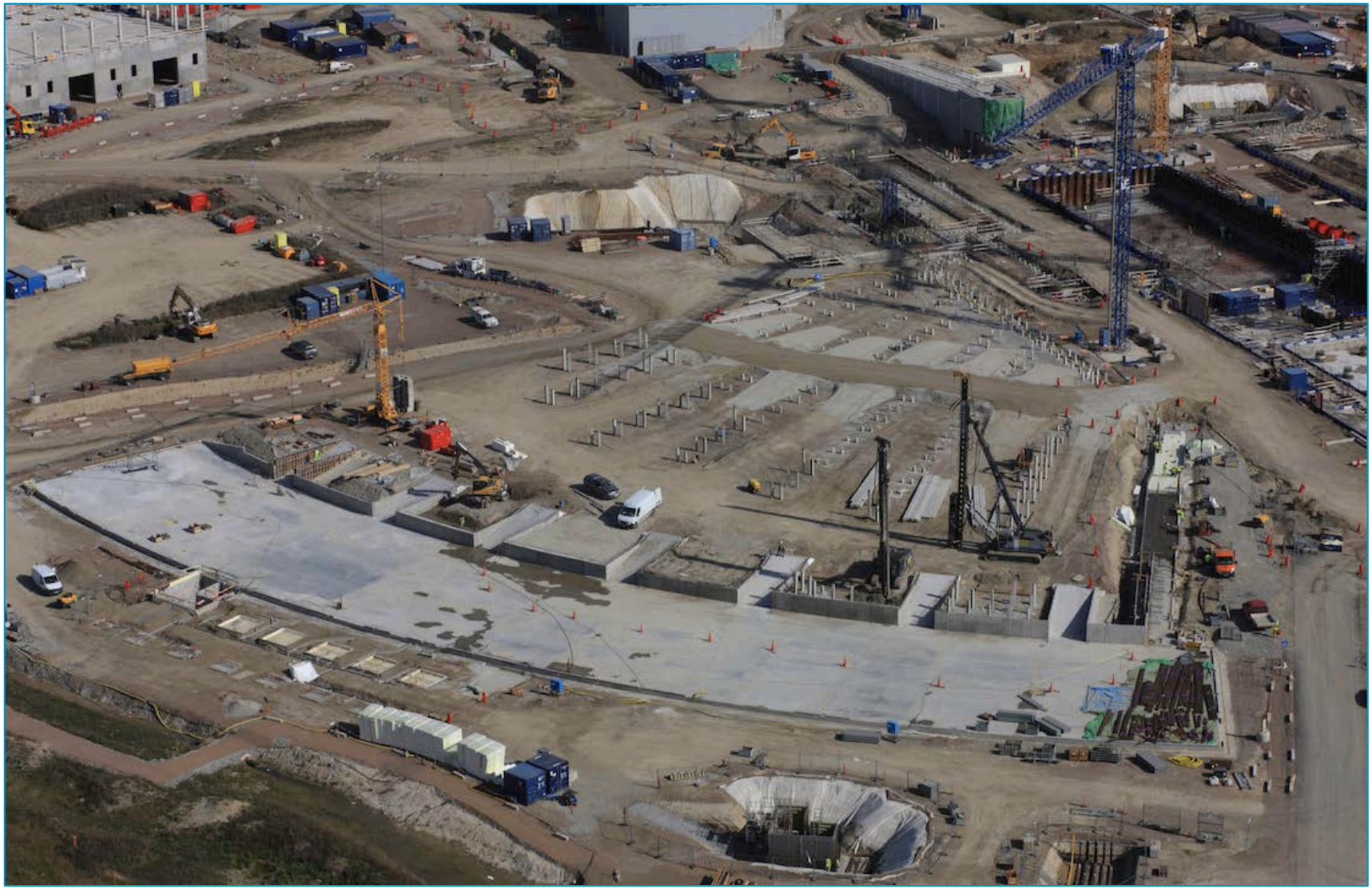

Thanks for your attention !!