

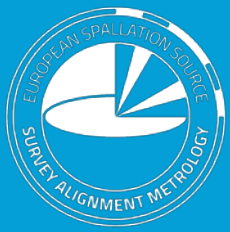


Survey Alignment Metrology

European Spallation Source

Fabien REY





---- Outline ----



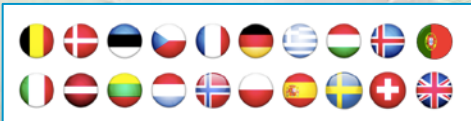
- ESS project
- Alignment challenges at ESS
- Where we are now...



European Spallation Source

Mission:

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



A collaboration across Europe

Partner institutions responsible for delivering the design & construction of ESS

- Aarhus University
- Atomik - Institute for Nuclear Research
- Agder University
- Bergen University
- CEA Saclay, Paris
- Centre for Energy Research, Budapest
- Centre for Nuclear Research, Helsinki, Finland
- CERN, Geneva
- CNR, Rome
- CNRS Orsay, Paris
- Cockcroft Institute, Darlington
- DESY, Hamburg
- Delft University of Technology
- Edinburgh University
- Elettra - Sincrotrone Trieste
- ESS Bilbao
- Forschungszentrum Jülich
- Heimholtz-Zentrum für Materialien und Energie
- IFJ PAN, Krakow
- INFN, Catania
- INFN, Legnaro
- INFN, Milan

- ESS European Spallation Source
- Institute for Energy Efficient Systems, Durham University
- Institut für Experimentelle Physik, Universität Wien
- Rutherford Appleton Laboratory, Oxford
- ISIS Particle Accelerator, Rutherford Appleton Laboratory
- Konkani University

User Program in 2023

€1.843 billion for construction

Construction investment

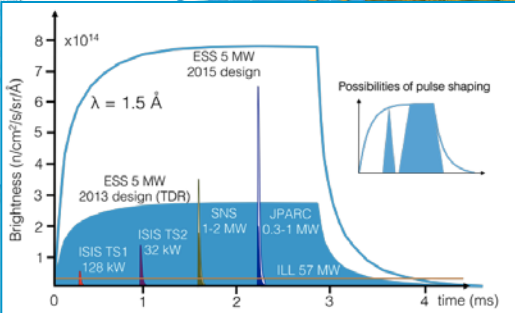
In-Kind Contribution

Country	Contribution (%)
Sweden (member)	35.0 %
Denmark (member)*	12.5 %
Germany (member)	11.0 %
United Kingdom (member)	To be determined
France (member)	To be determined
Italy (member)	To be determined
Spain (member)	To be determined
Norway (member)	To be determined
Poland (member)	To be determined
Czech Republic (member)	To be determined

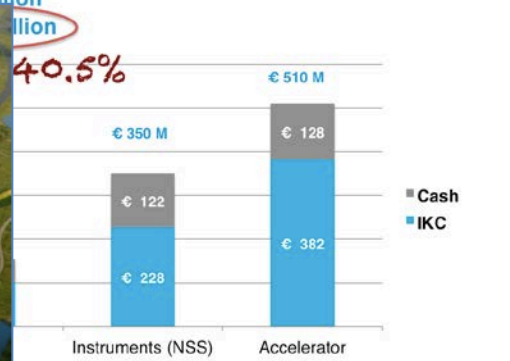
ESS In-kind goals

Construction cost: € 1.84 Billion

Spallation : 5 MW

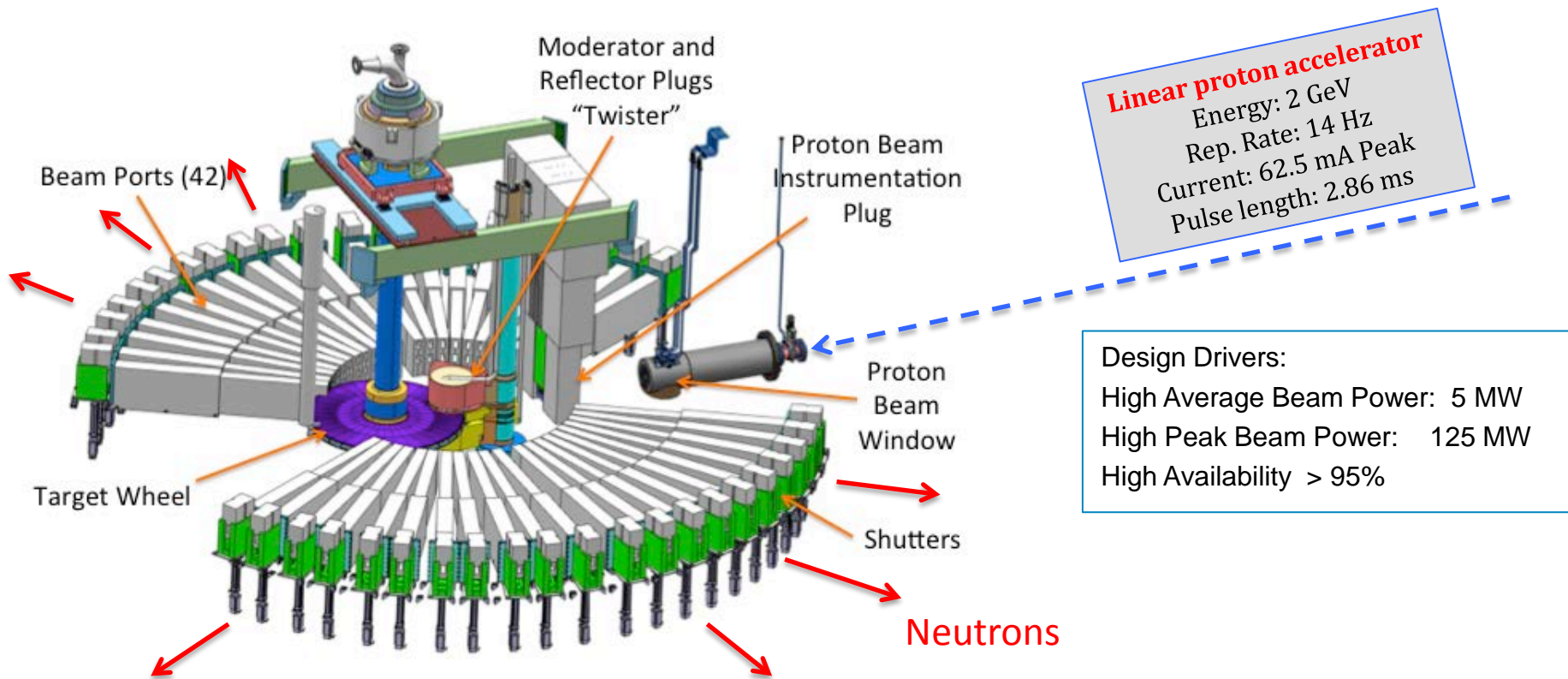


2025 ESS construction complete



---- Spallation ----

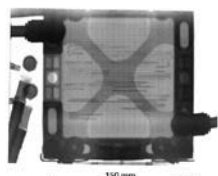
Process in which a **heavy nucleus** emits a large number of **nucleons** as a result of being hit by a **high-energy particle**. (WIKIPEDIA)



----- Neutron Sciences -----

Properties of neutrons – Unique tool

Charge neutral
deeply penetrating

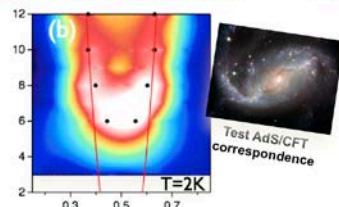


Li motion in fuel cells



Help build electric cars

S=1/2 spin
probe directly magnetism

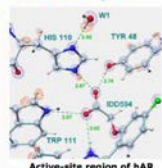


Solve the puzzle of High-Tc superconductivity

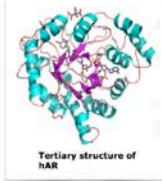


Efficient high speed trains

Nuclear scattering
sensitive to light elements and isotopes

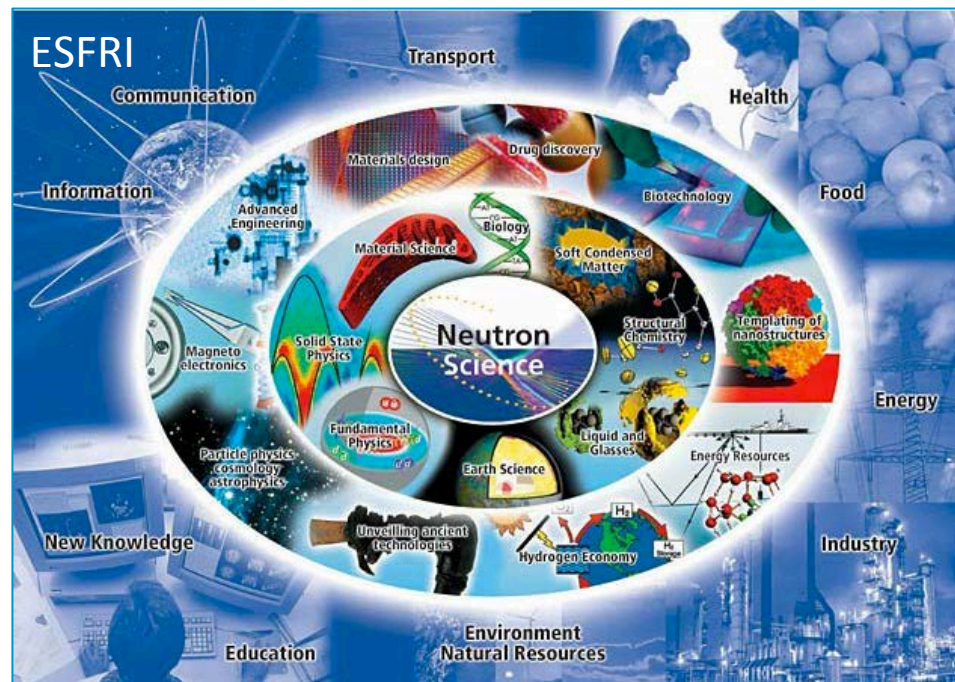


Active sites in proteins

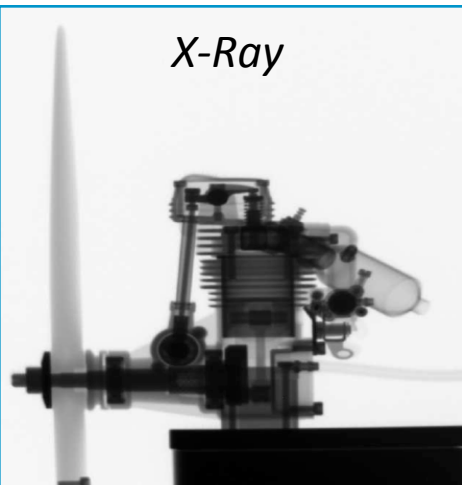


Tertiary structure of hAR

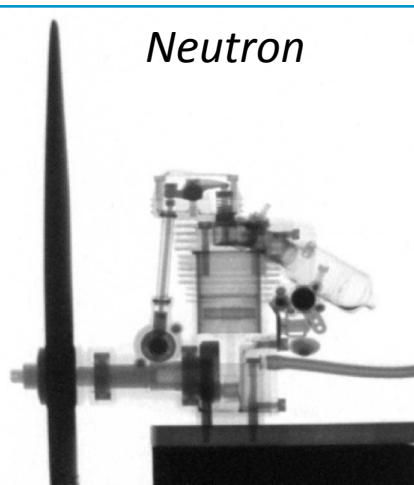
Better drugs



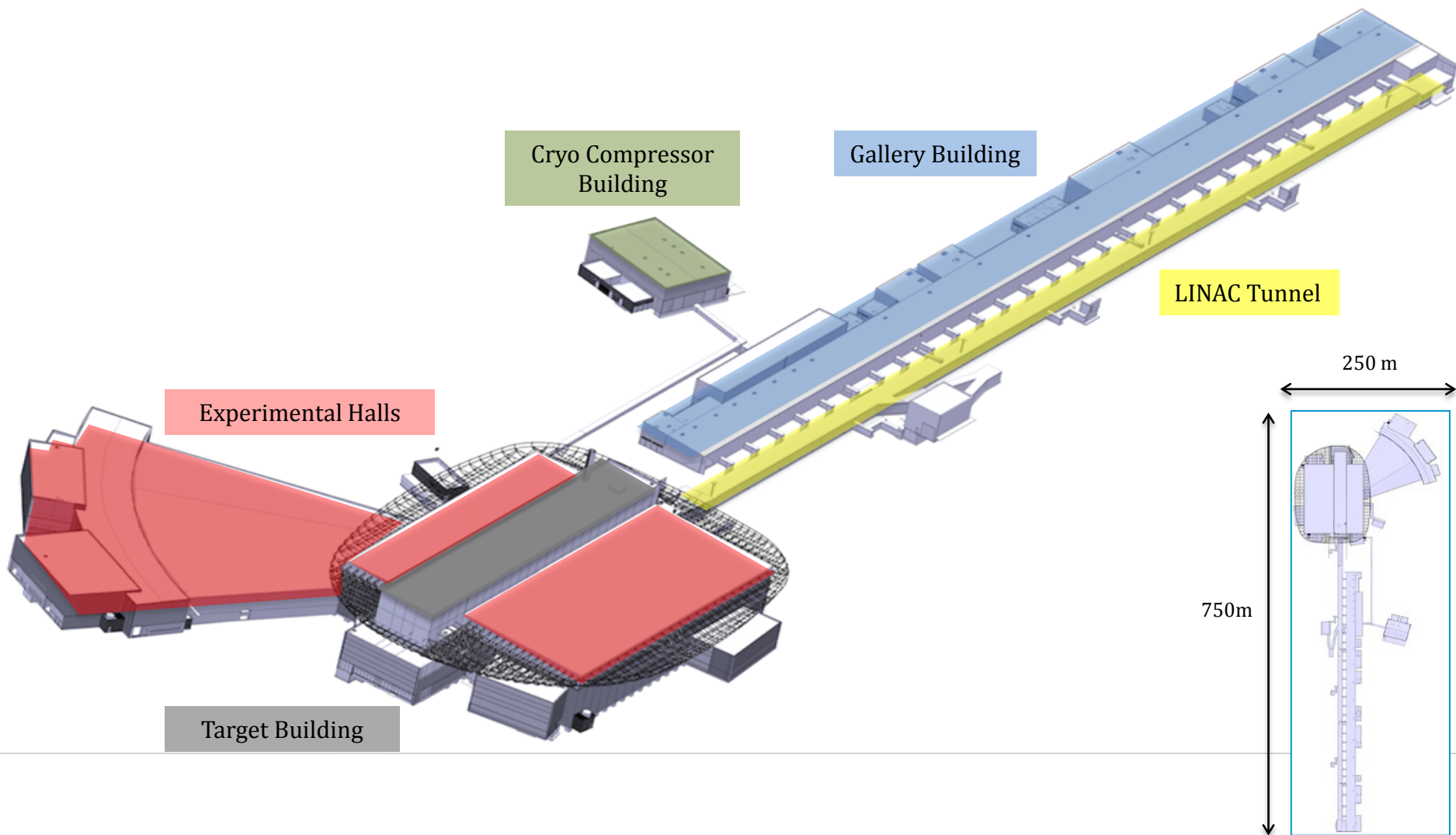
X-Ray



Neutron

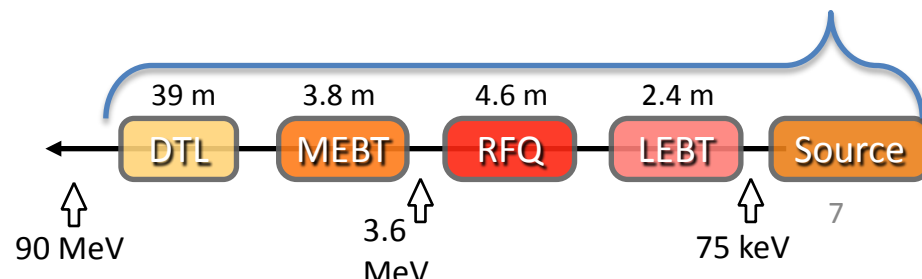
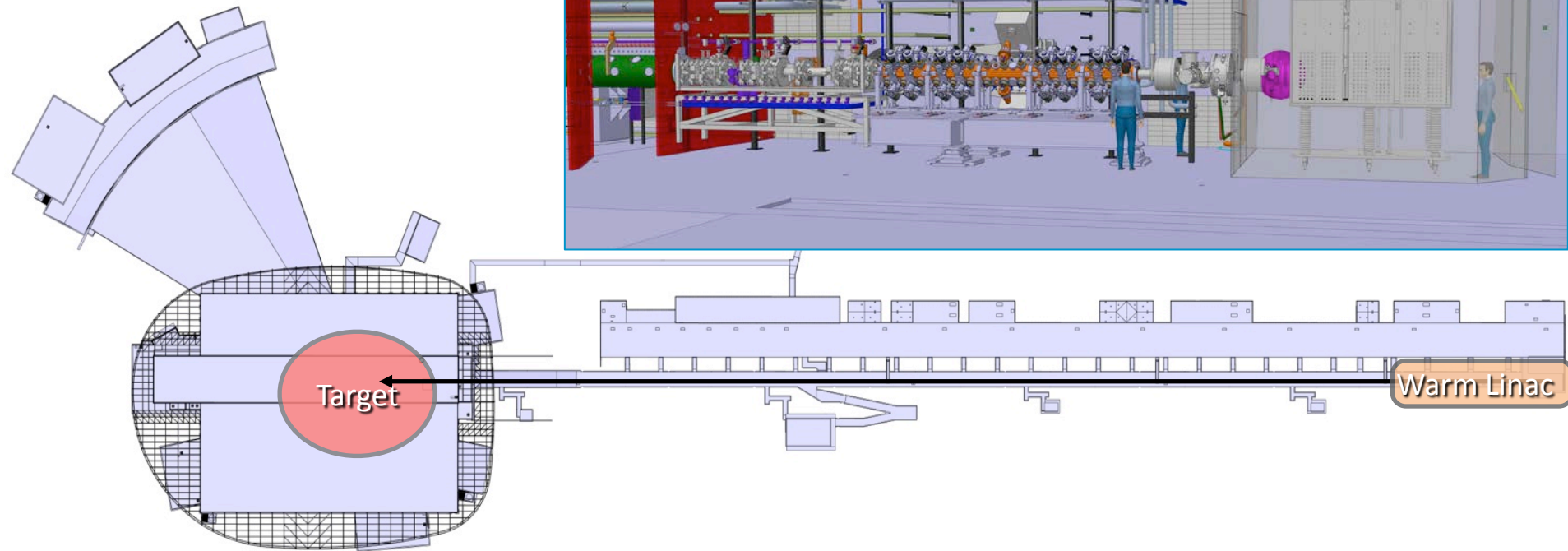
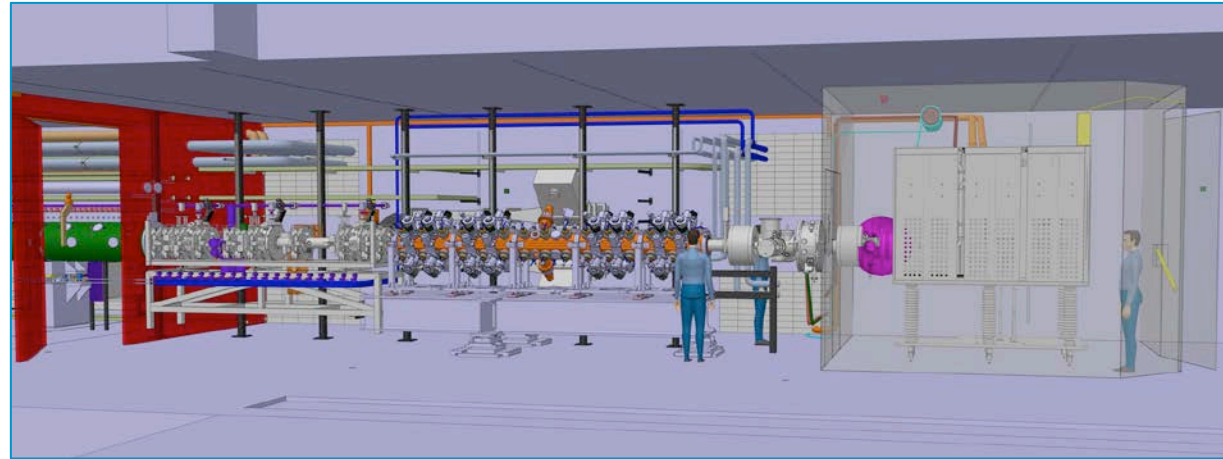


----- Buildings -----



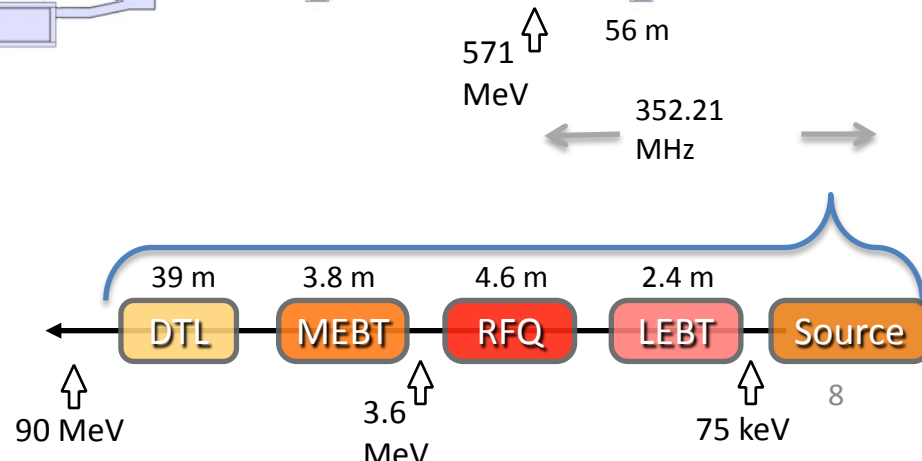
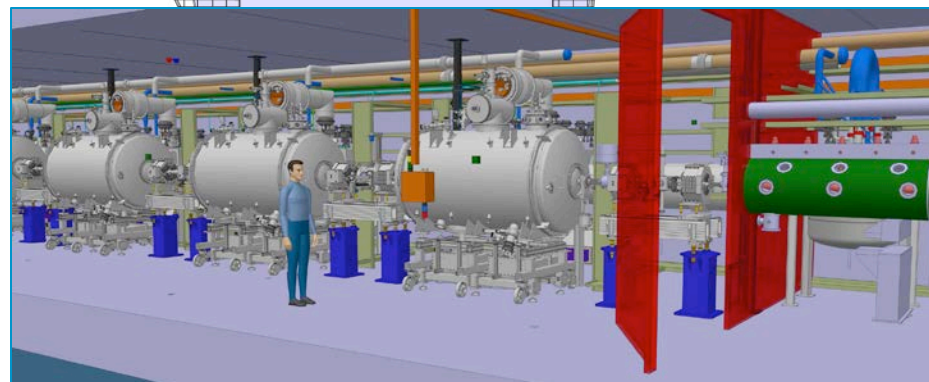
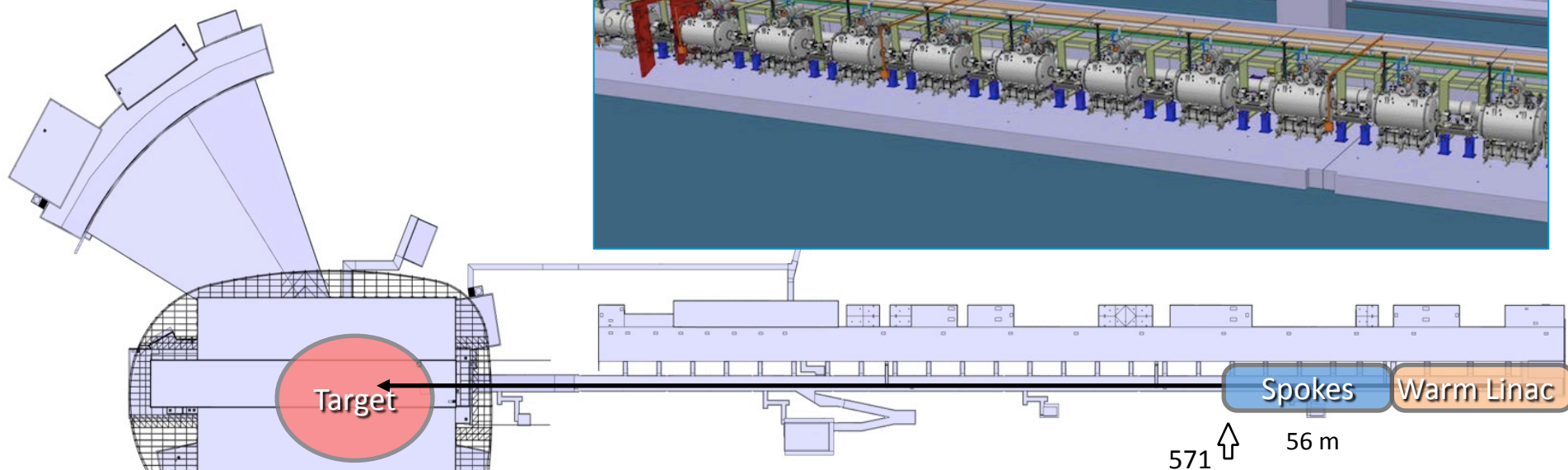
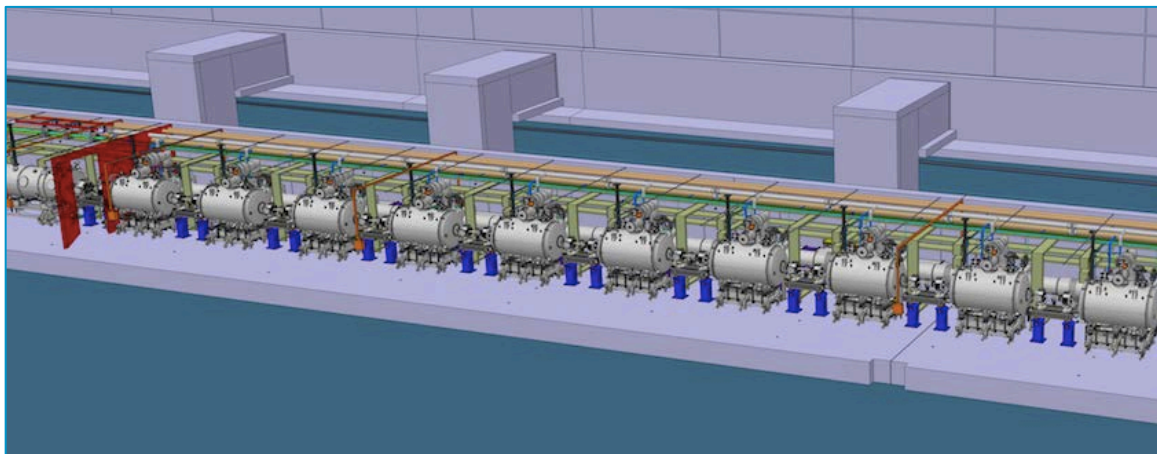
----- Proton LINAC -----

Warm LINAC



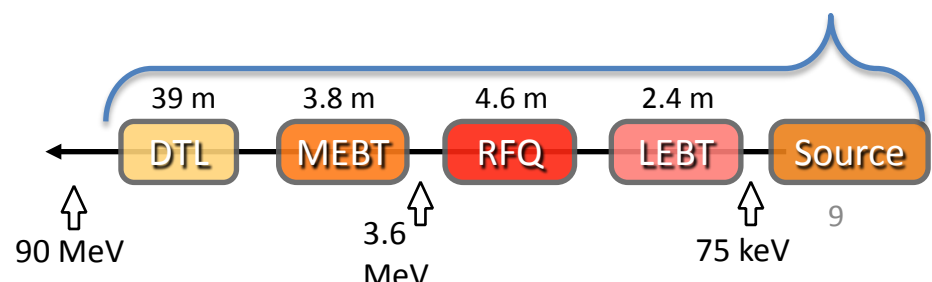
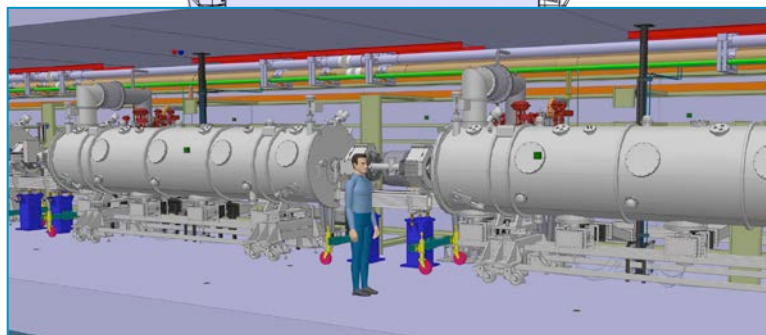
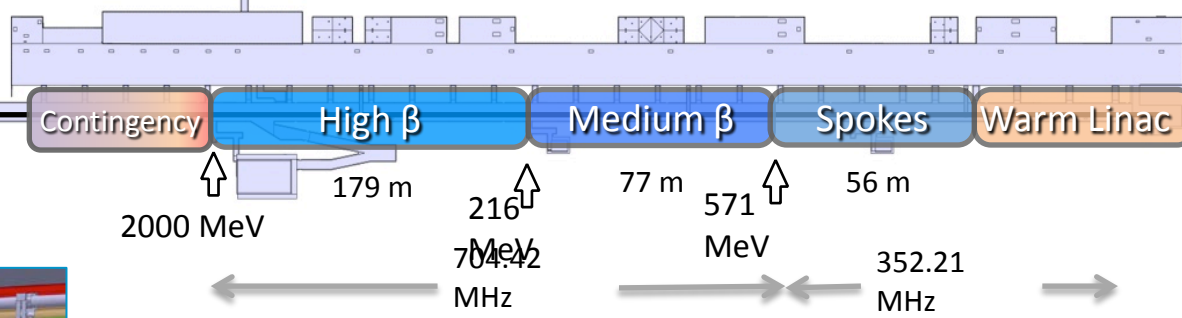
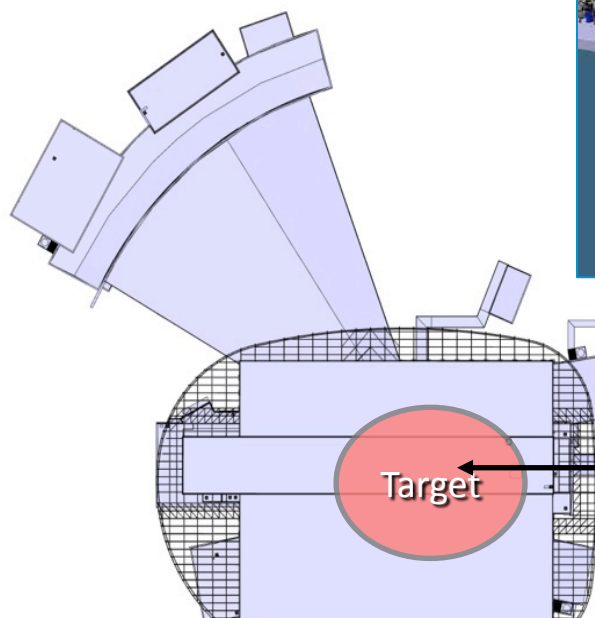
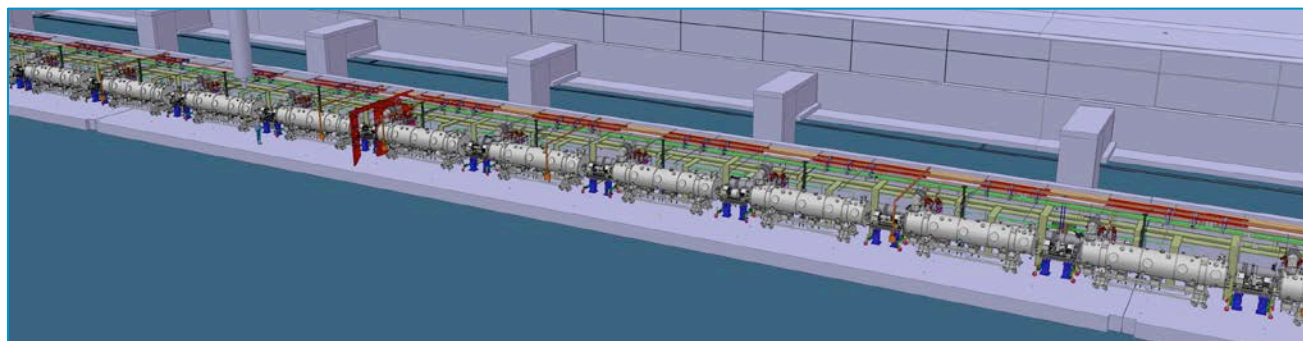
----- Proton LINAC -----

Spokes Cryomodules



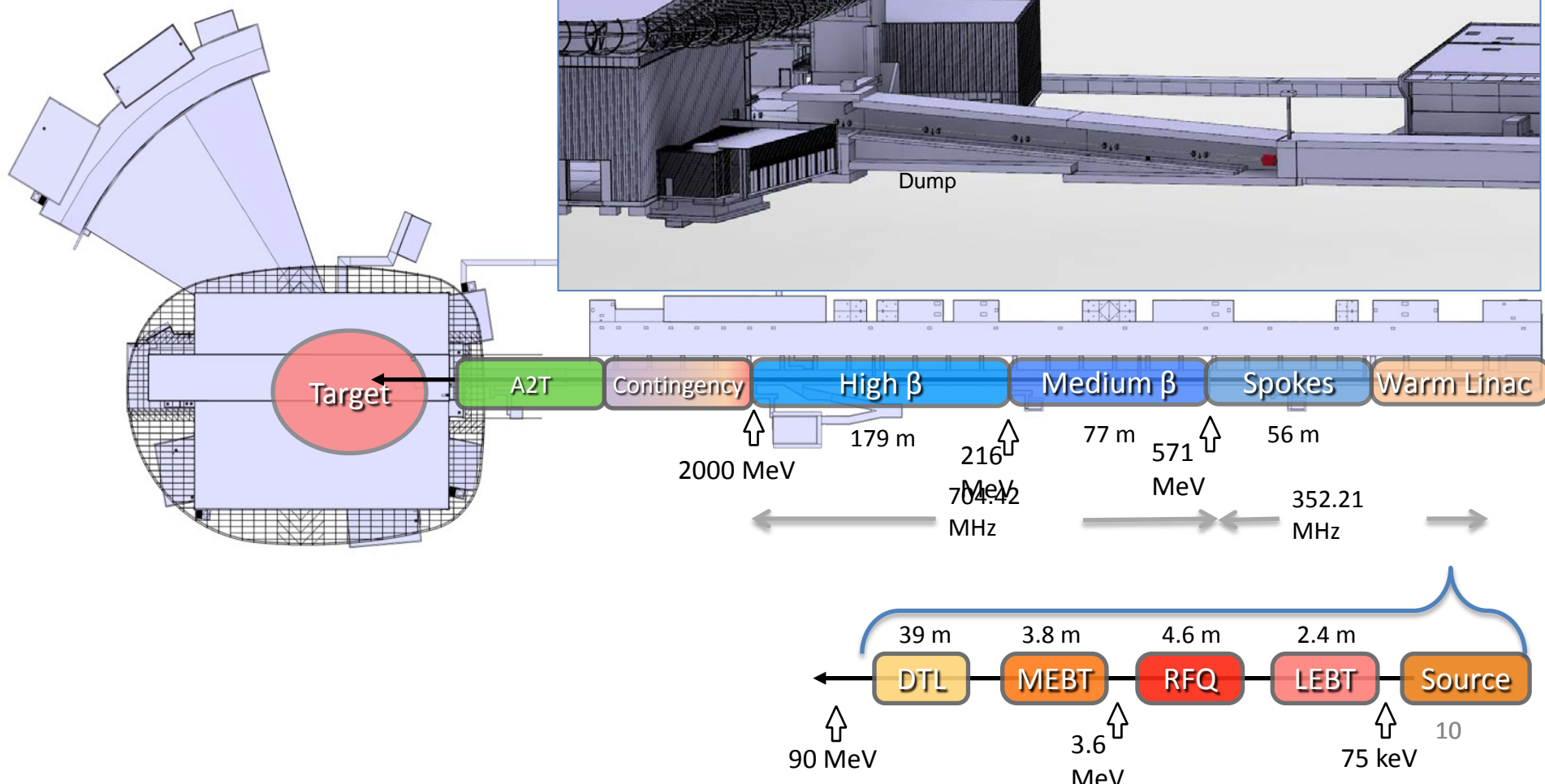
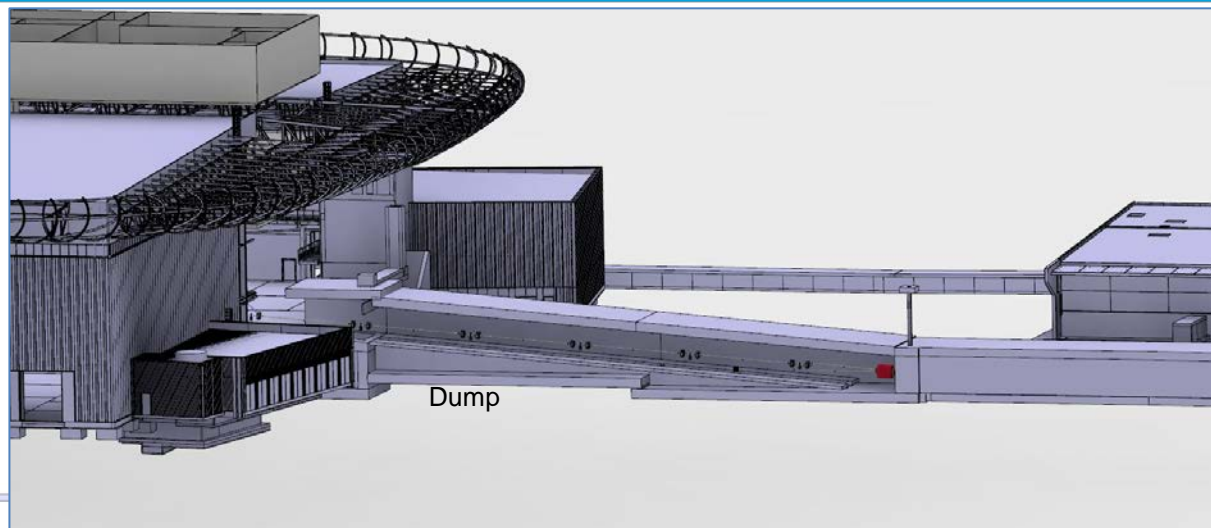
----- Proton LINAC -----

Elliptical Cryomodules

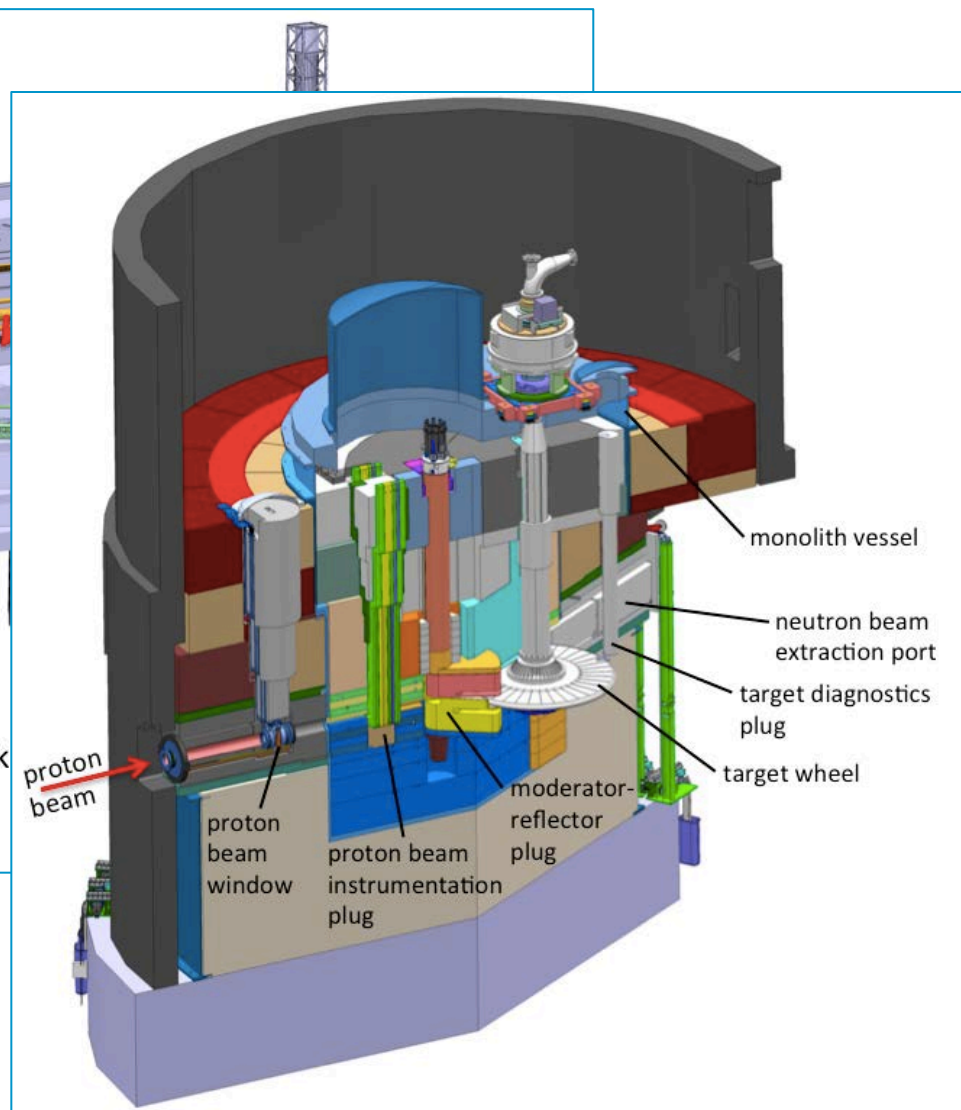
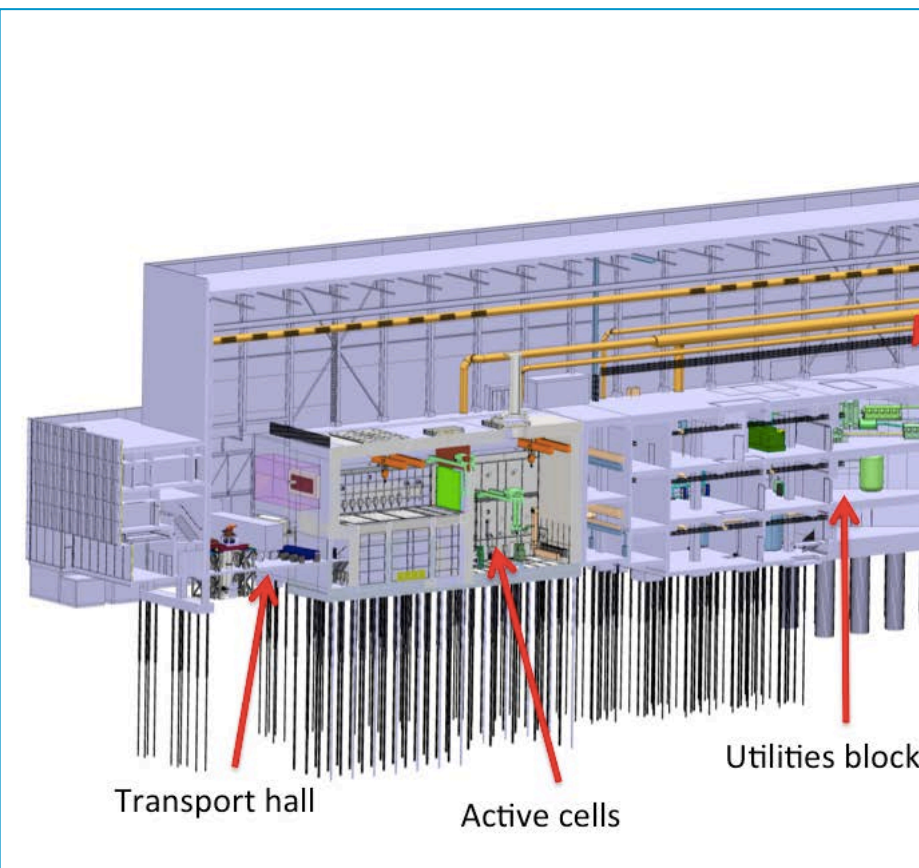


----- Proton LINAC -----

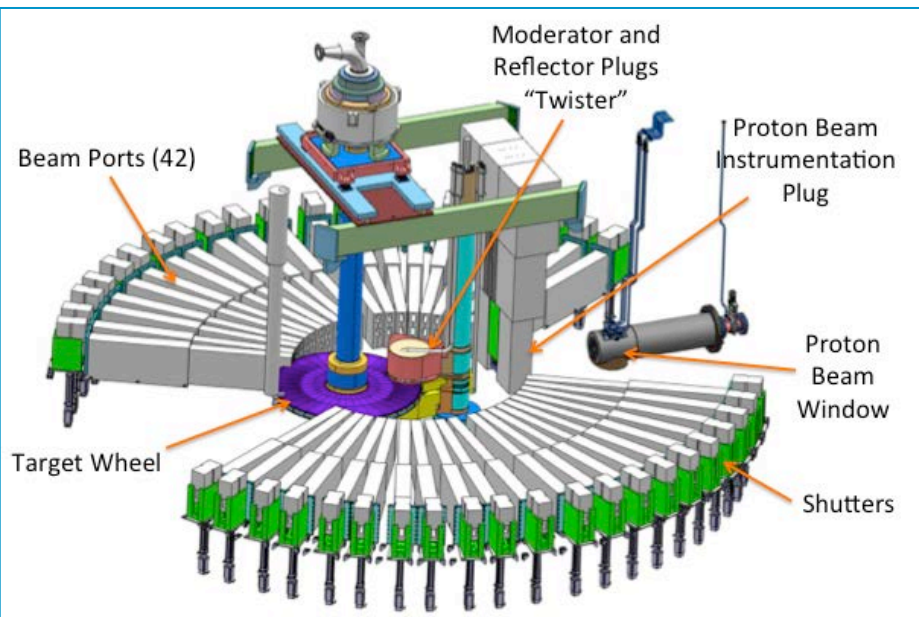
A2T : Accelerator to Target



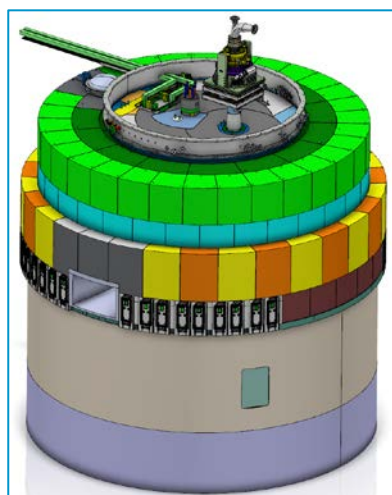
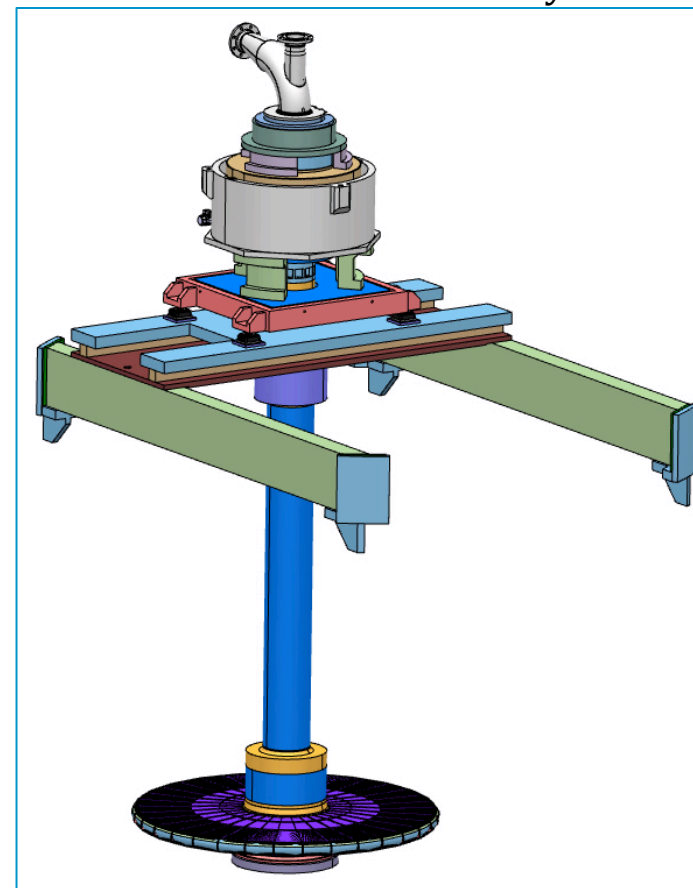
----- Target -----



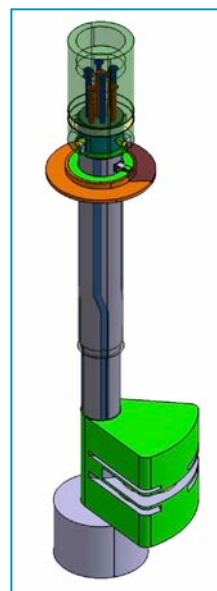
----- Target -----



Wheel assembly



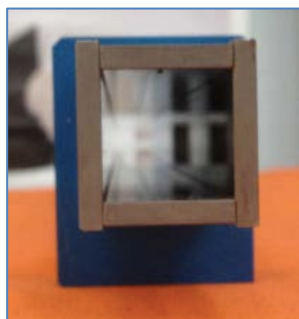
Target monolith



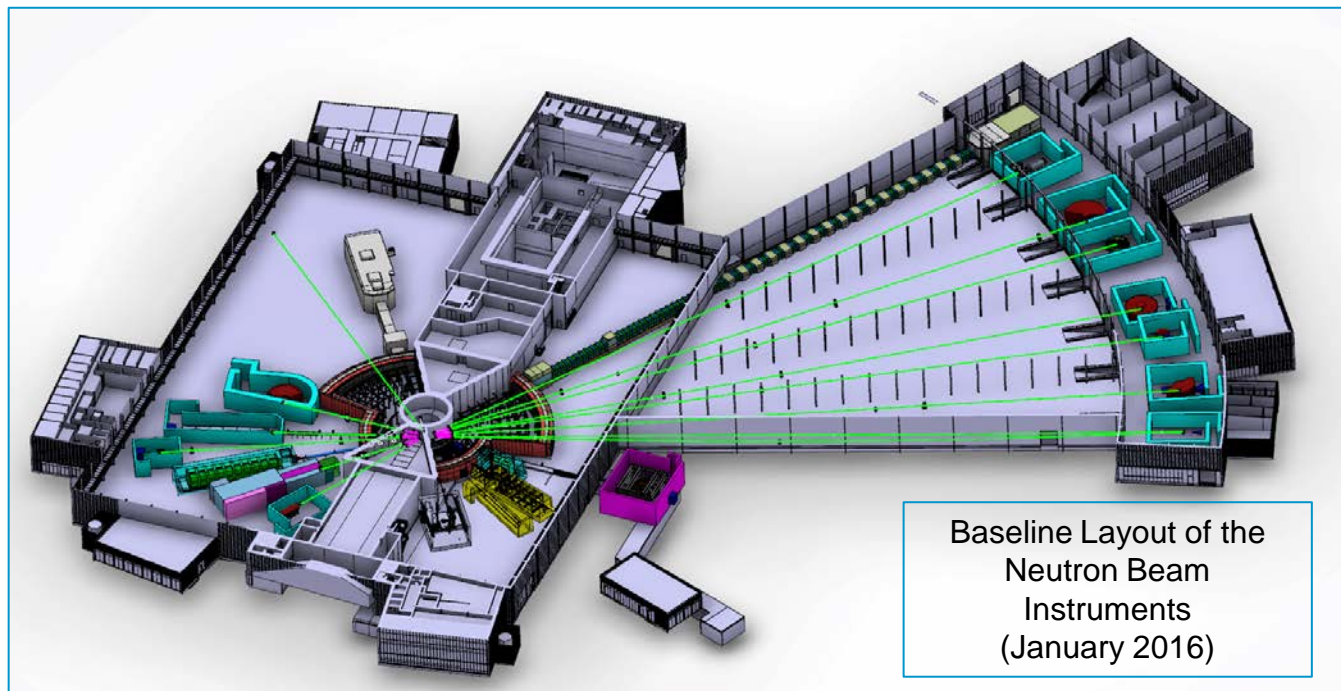
Moderator Reflector

---- Instruments ----

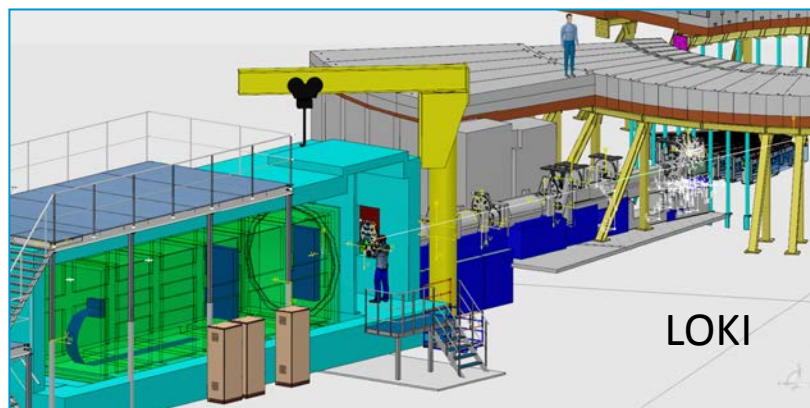
Instruments :



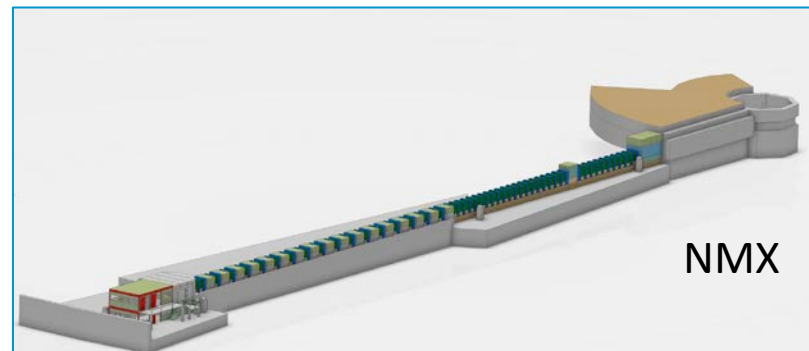
Neutron guide inside view



Baseline Layout of the Neutron Beam Instruments (January 2016)



LOKI

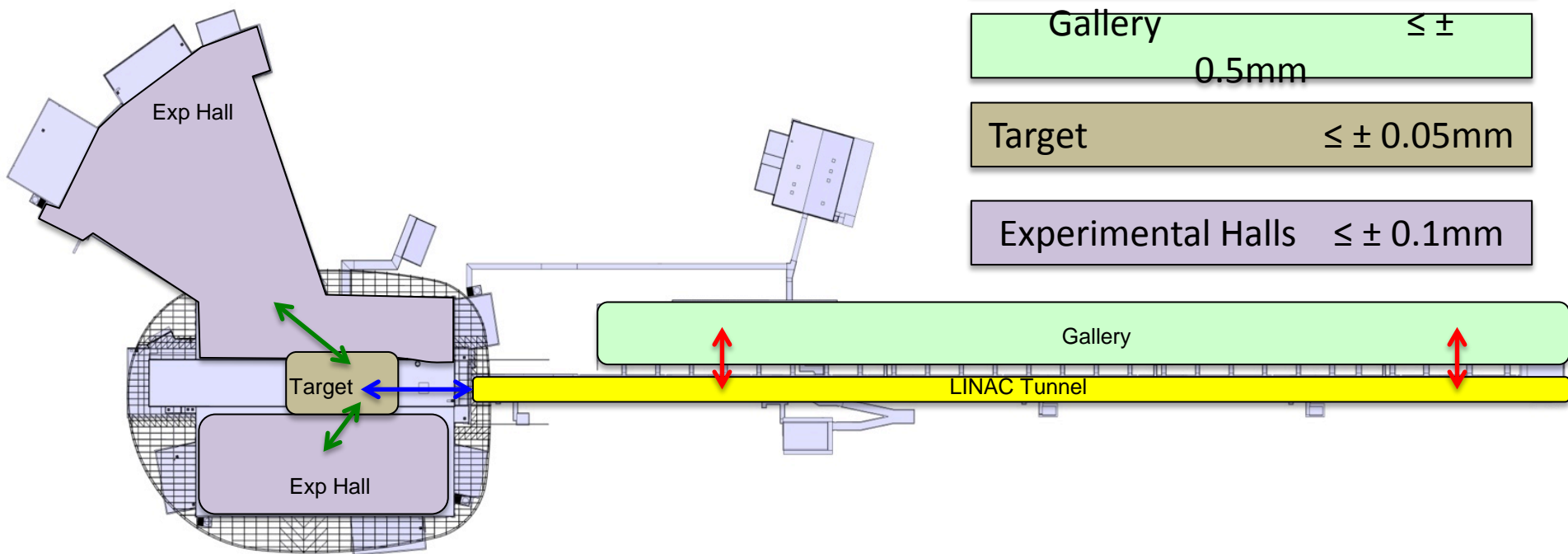


NMX

Needs for Alignment

Internal Alignment budget:

LINAC Tunnel	$\leq \pm 0.1\text{mm}$
Gallery	$\leq \pm 0.5\text{mm}$
Target	$\leq \pm 0.05\text{mm}$
Experimental Halls	$\leq \pm 0.1\text{mm}$



Relative Alignment budget:

LINAC Tunnel $\overset{\leq \pm 1\text{mm}}{\longleftrightarrow}$ Gallery

Target $\overset{\leq \pm 1\text{mm}}{\longleftrightarrow}$ Experimental Halls

LINAC Tunnel $\overset{\leq \pm 1\text{mm}}{\longleftrightarrow}$ Target

3d free stationing technique with least squares adjustment calculus

Dense 3D network of reference points

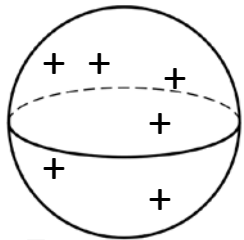


Laser Tracker
Total Station
Digital Level



Adjustment Software

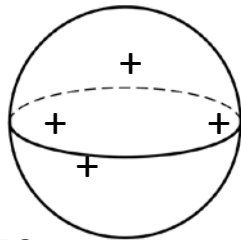
Inside



R=5m

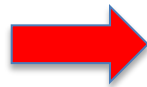
6 points

Outside



R=50m

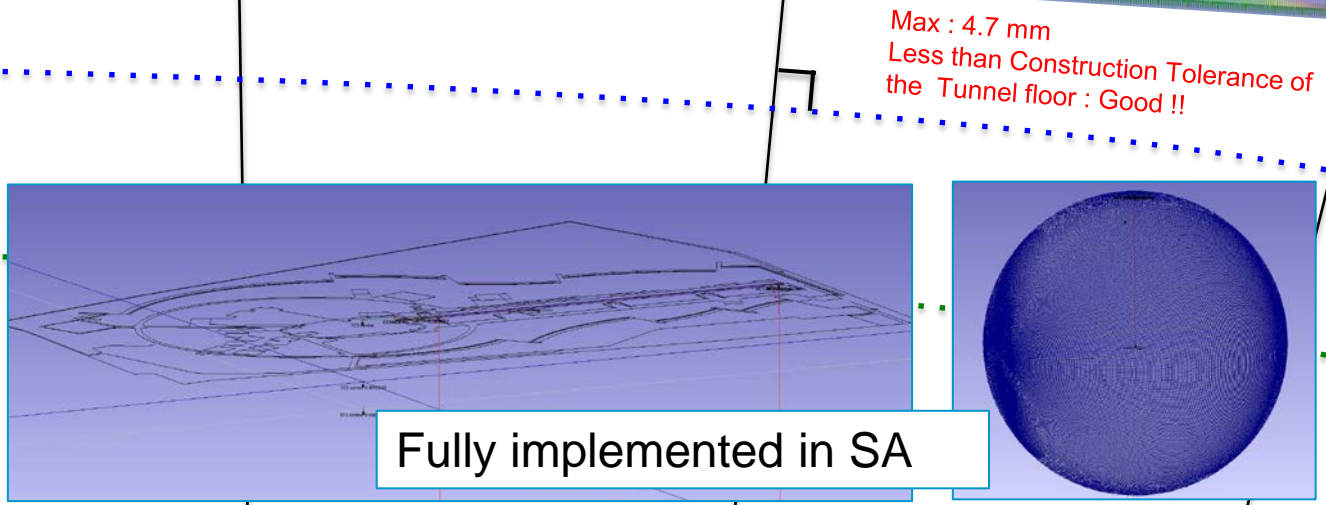
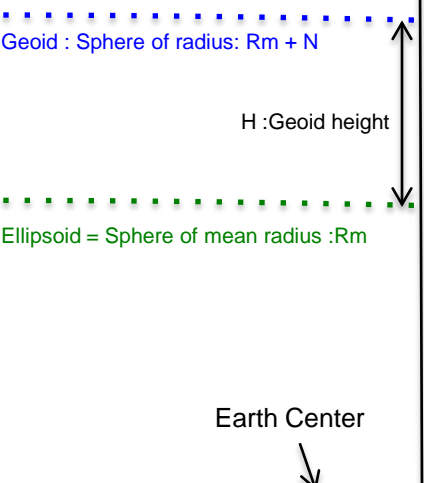
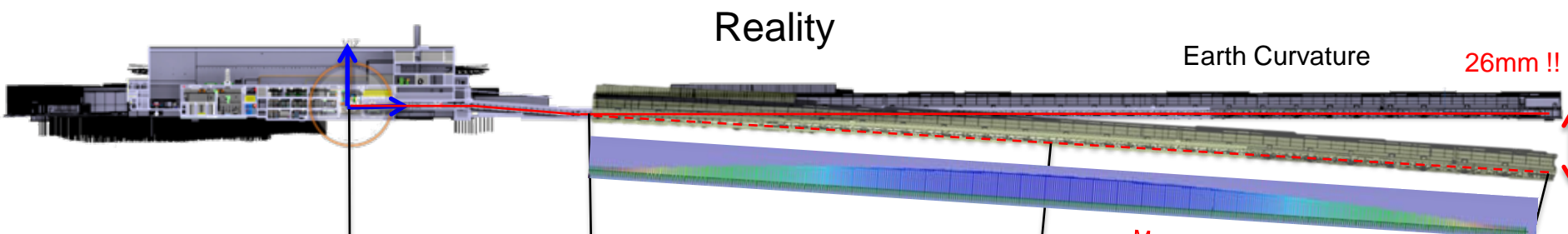
4 points



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

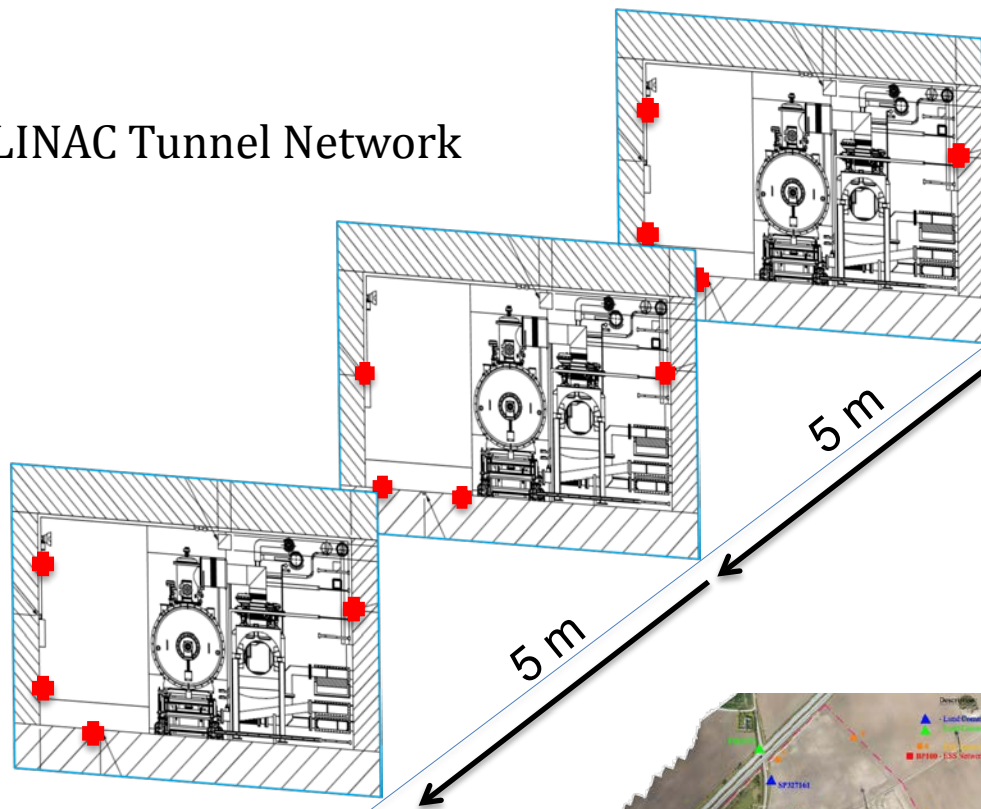
----- Alignment Strategy -----

750m



----- Alignment Strategy -----

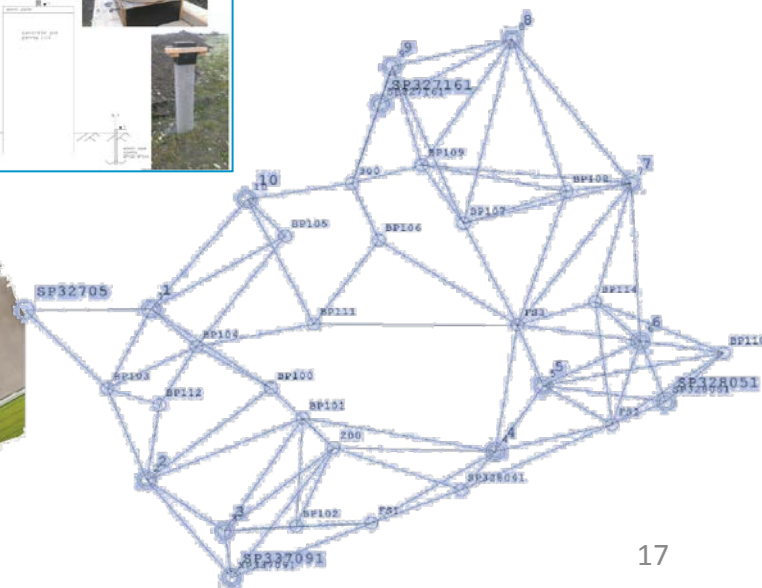
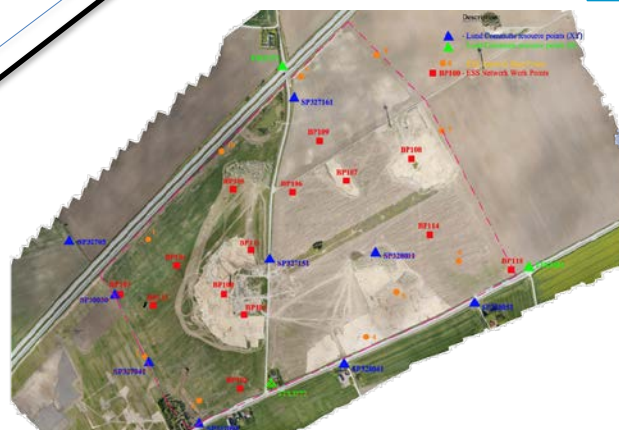
LINAC Tunnel Network



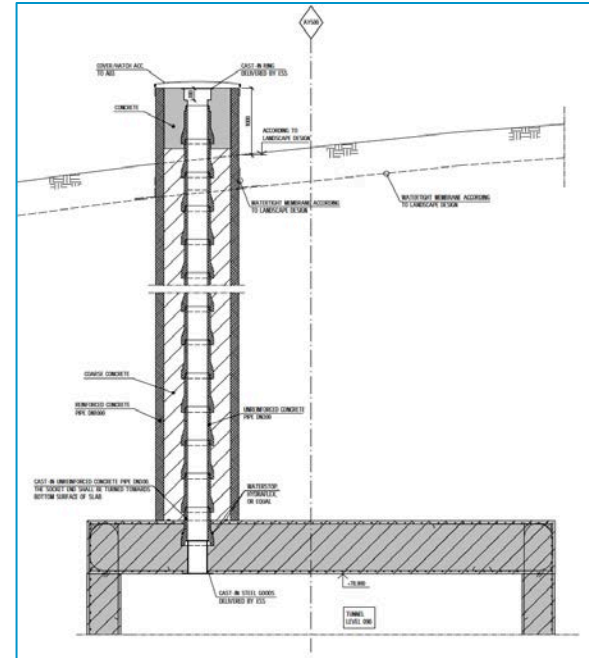
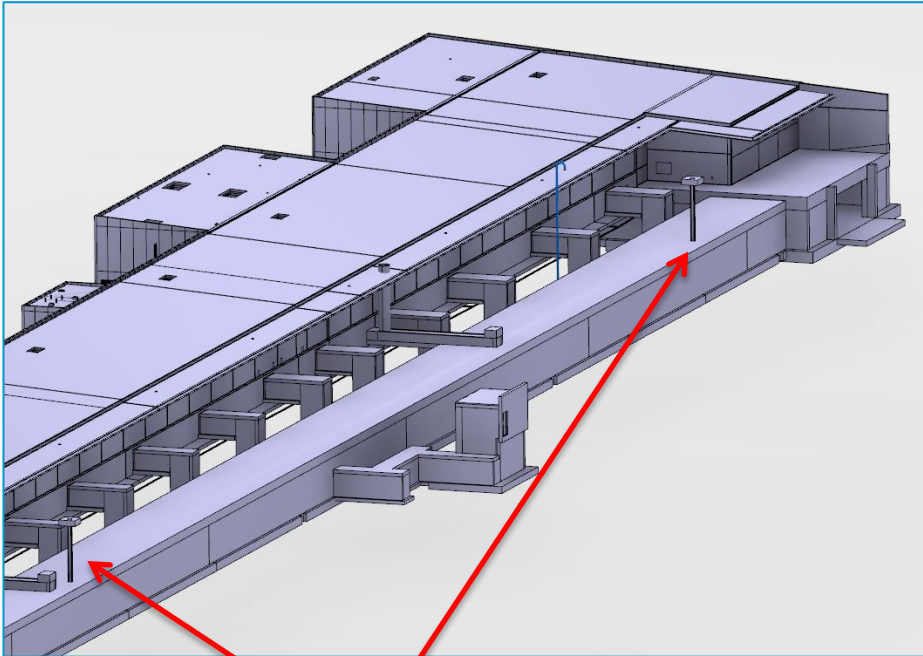
Two reference networks connected:

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

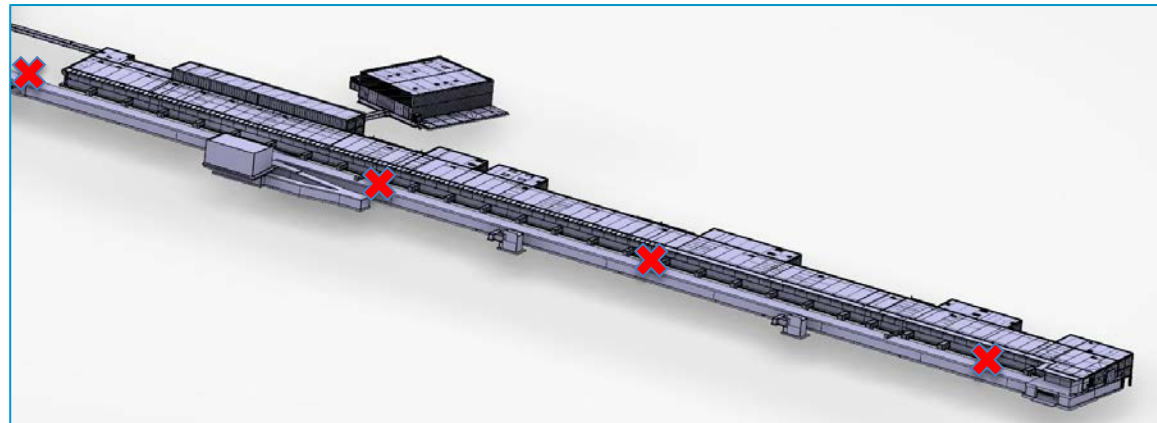
- internal reference network (0.1 mm accuracy)
Measurements: Laser Trackers, Total Stations, Digital Levels



----- Alignment Strategy -----



Vertical Alignment Shafts
x 4
Connecting Inside tunnel to outside



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

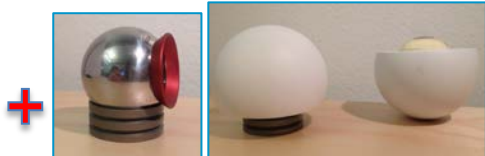
Softwares:

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

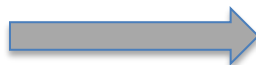
Raw data Acquisition



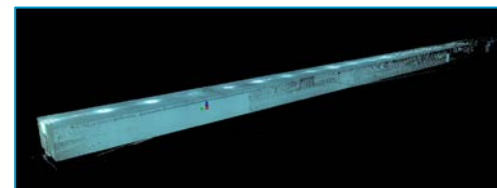
P30



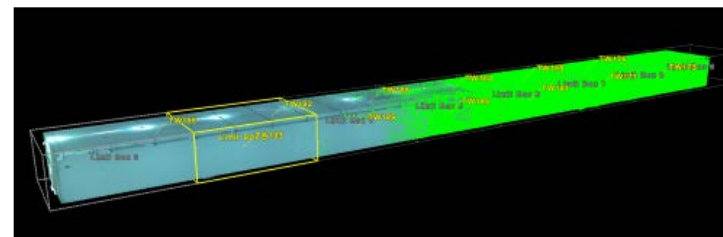
Concentric Spheres



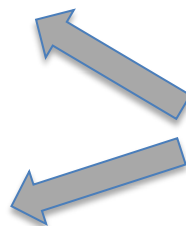
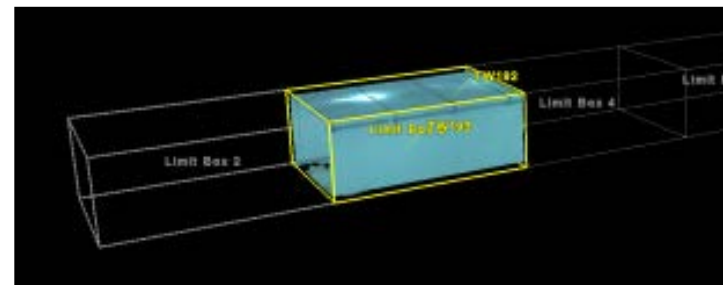
Analysis in Cyclone



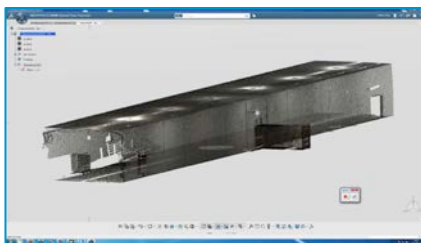
Data Cleaning
Orientation of Scans (registration)
Geometries created on demand



Point cloud splitting according to LBS
(Location Breakdown Structure)

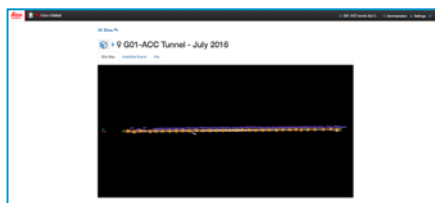


 **CATIA V6**
For Reverse Engineering
and Integration



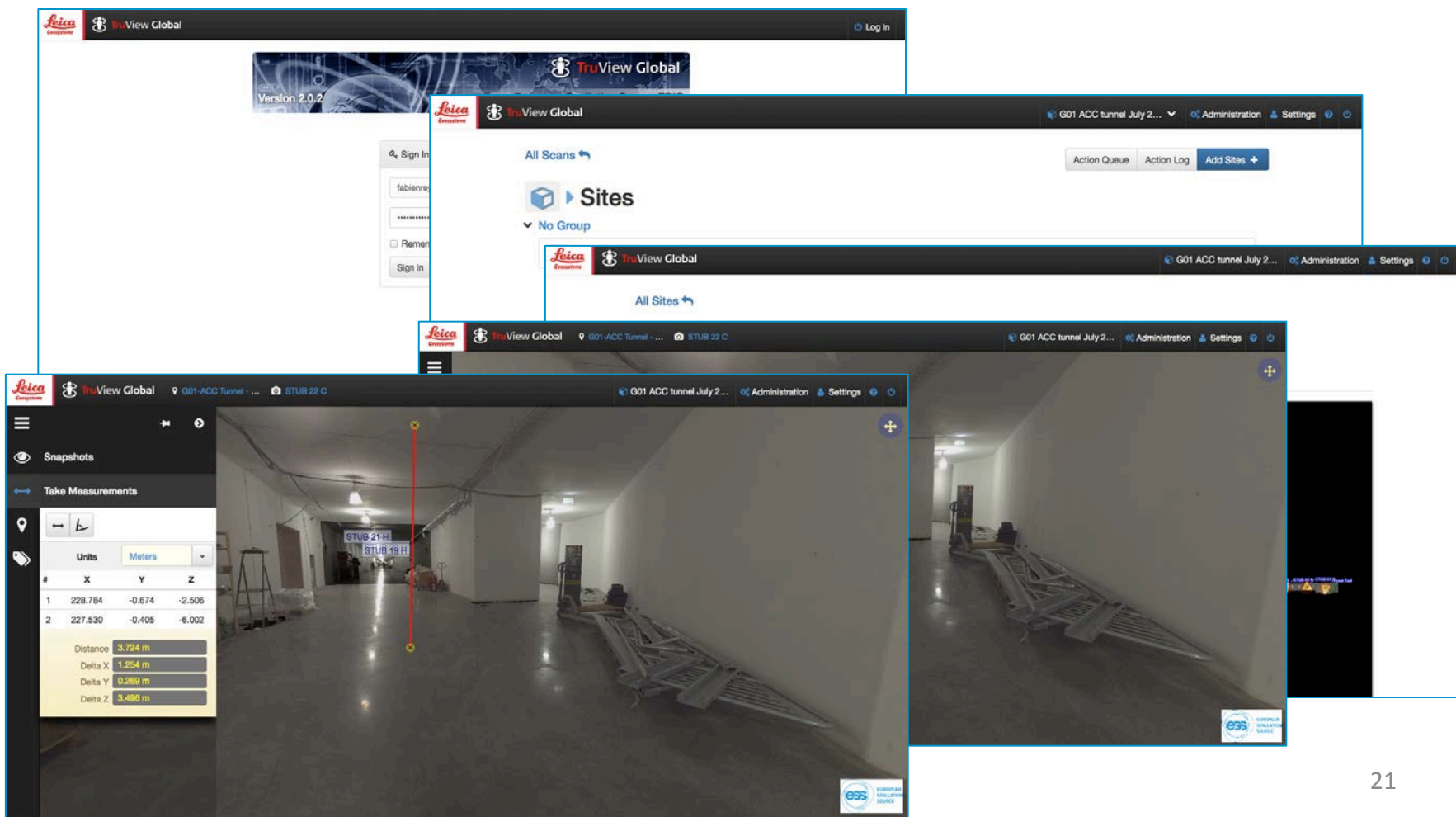
 **TruView Global**

Non CAD users
Visualization/Simple
measurements



---- Laser Scanning ----

<https://truview.esss.lu.se>



The screenshot displays the TruView Global web application interface. The main view shows a 3D laser scan of a tunnel interior. A measurement tool is overlaid on the scan, showing a vertical red line with a yellow dot at the top and bottom. The measurement data is displayed in a table below the scan:

#	X	Y	Z
1	228.784	-0.674	-2.506
2	227.530	-0.405	-6.002

Below the table, the following measurement values are shown:

- Distance: 3.724 m
- Delta X: 1.254 m
- Delta Y: 0.269 m
- Delta Z: 3.496 m

The interface also includes a sidebar with navigation options like 'Sign In', 'fabienne', and 'Remer'. The top navigation bar shows 'G01 ACC tunnel July 2...' and 'Administration Settings'.

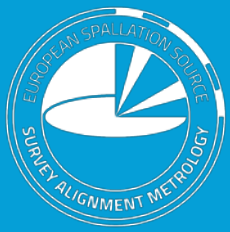


---- On site ----



Back in May 2014



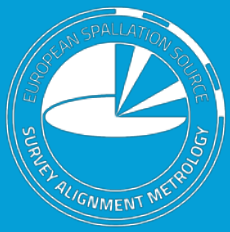


----- On site -----



---- On site ----





---- On site ----



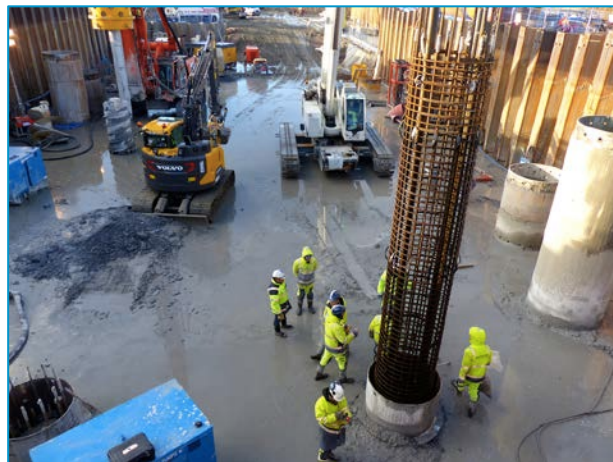
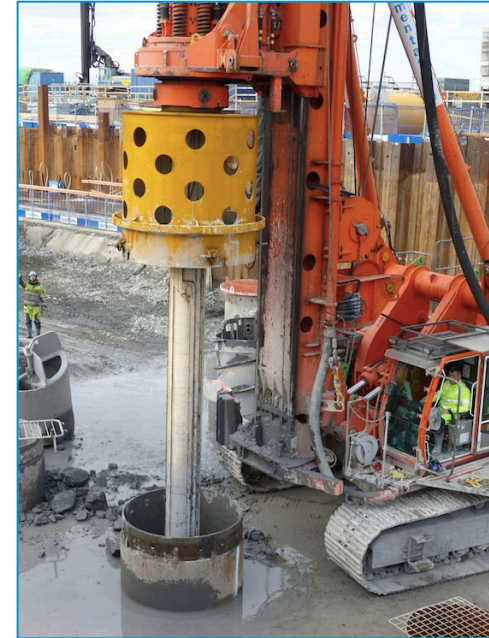
---- On site ----



---- On site ----



---- On site ----



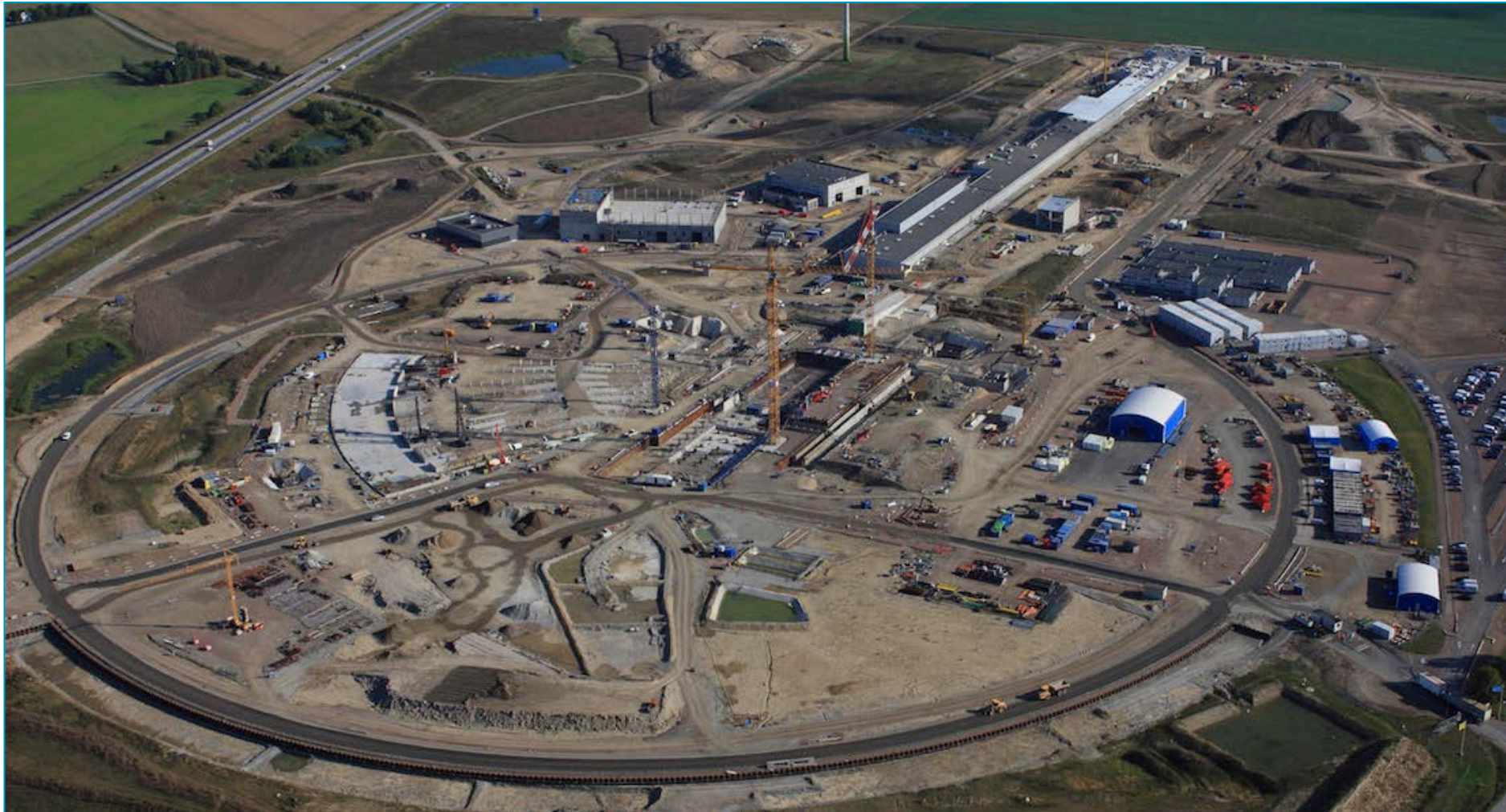


---- On site ----





---- On site ----





----- On site -----





Thanks for your attention !!