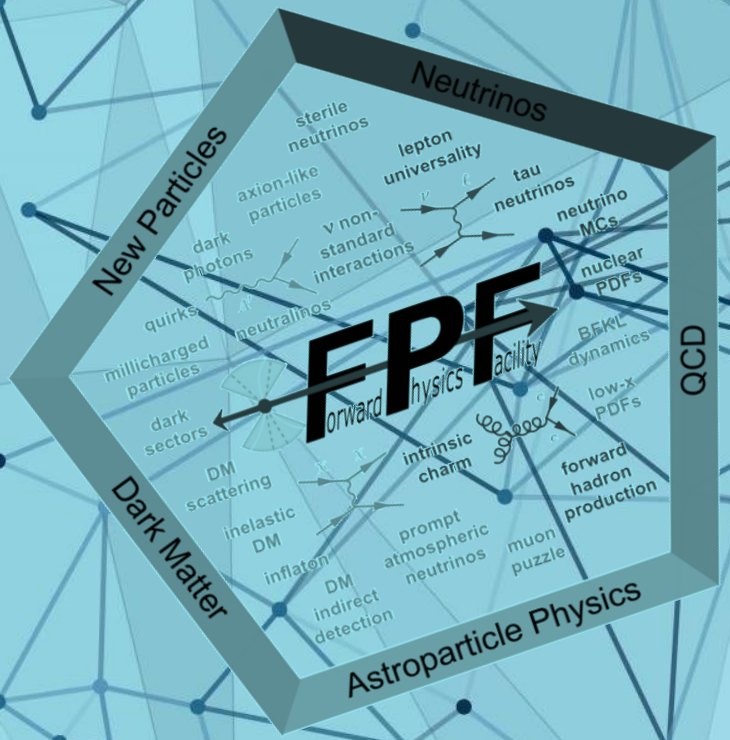
CERN ENGINEERING DEPARTMENT

ACTEMIUM

Forward Physics Facility Integration

7th FPF Meeting

The presentation is the result of the joint work of many experts from CERN and collaborative institutes



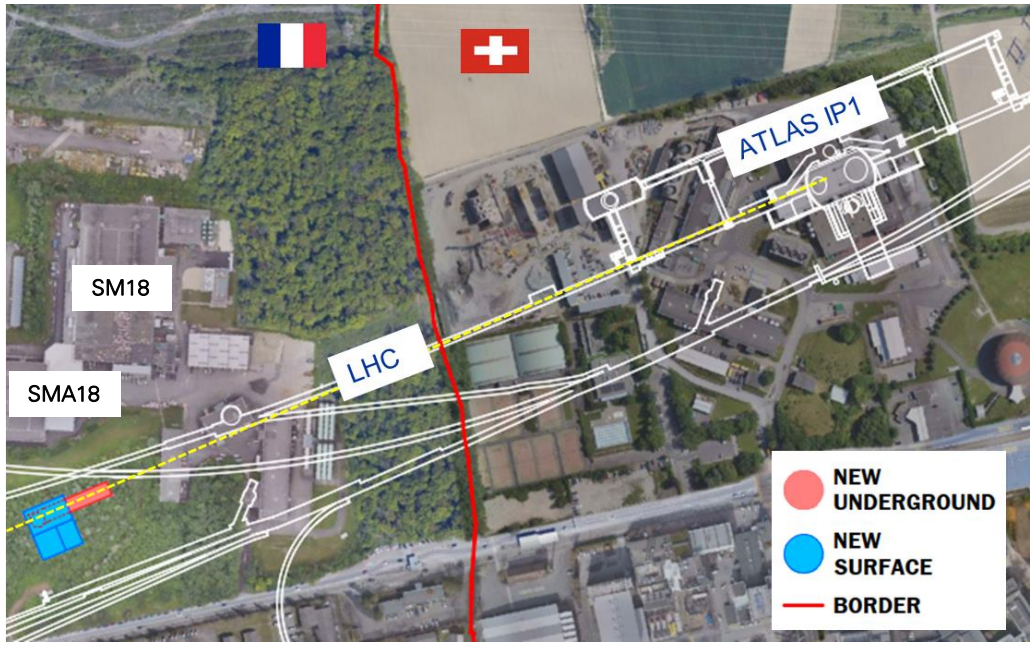
February 29th, 2024

The 3D integration office for the accelerators is responsible for collecting, centralizing, and checking the 3D models provided by CERN design offices such as equipment owners, electrical, civil engineering, metallic structure, transport, handling, cooling, and ventilation services. This office manages 3D space and avoid any interferences before and during the installation phase.

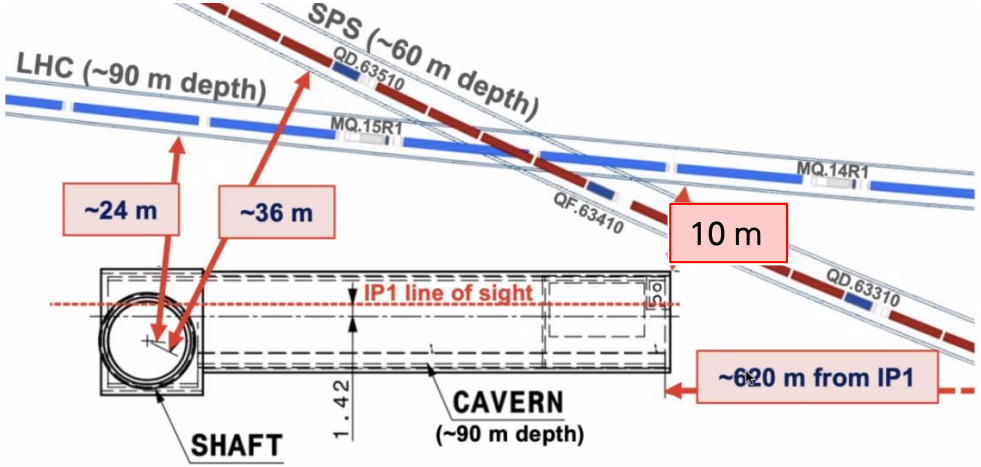
Content

- Overview
  - Location
  - General layout
  - FPF experiments
- Integration Methodology
- Summary
- Next steps

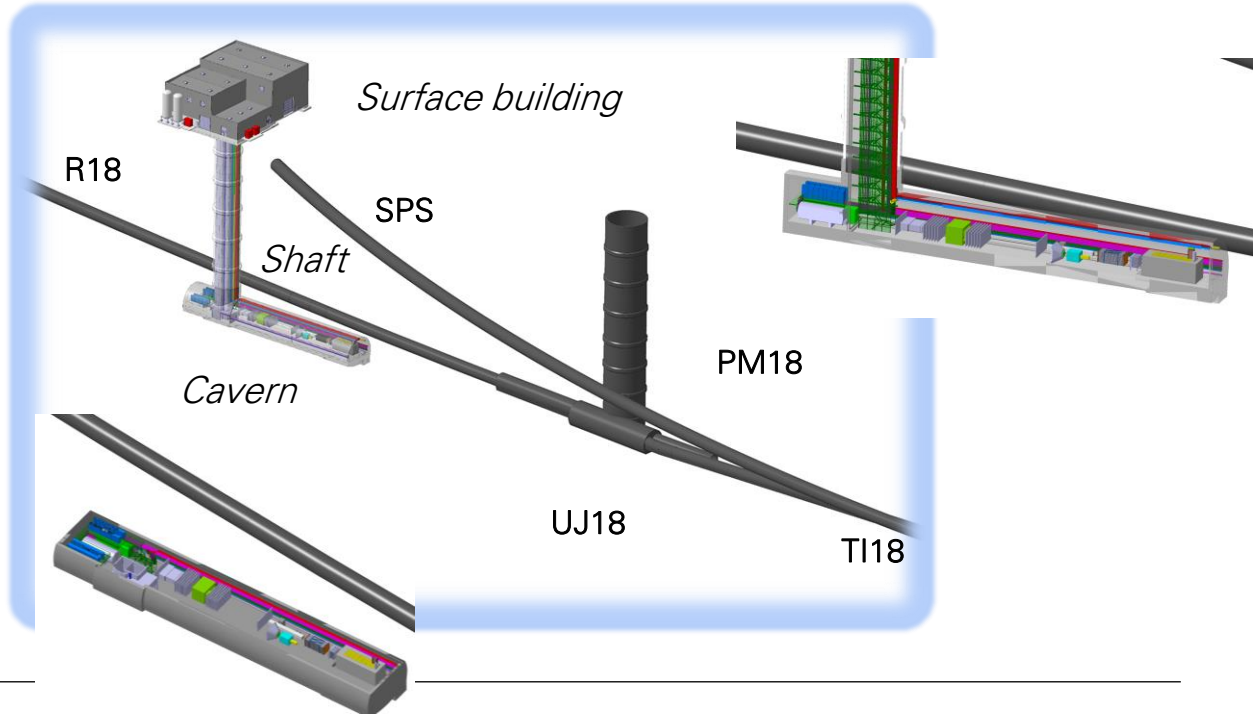
FPF location



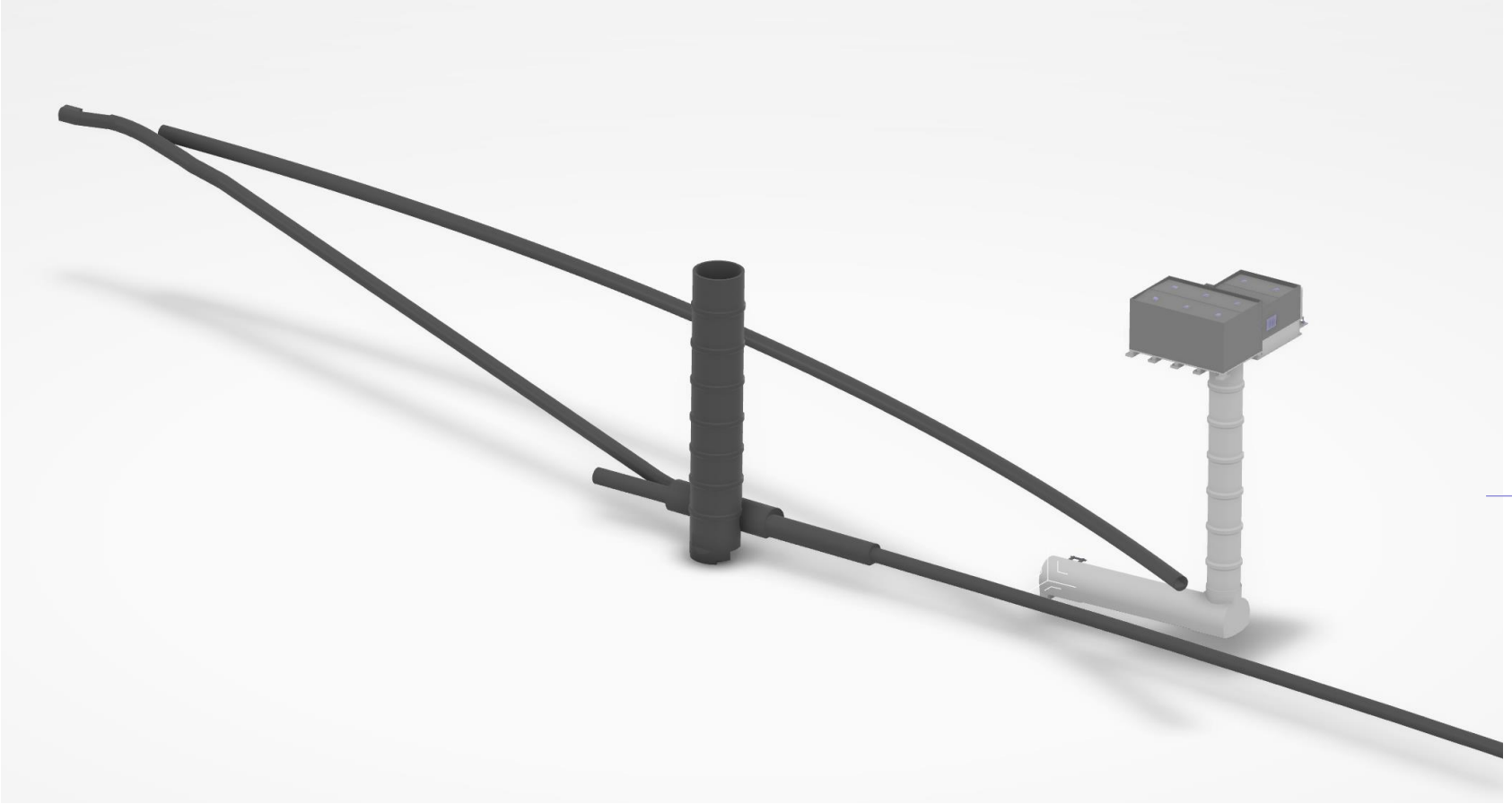
- To build a new facility to test new physics
- Proposed location:
  - ~617 m from ATLAS IP1 on the French side of CERN land,
  - 90 m depth,
  - Min 10 m away from the LHC tunnel (critical from RP and civil engineering point of view)



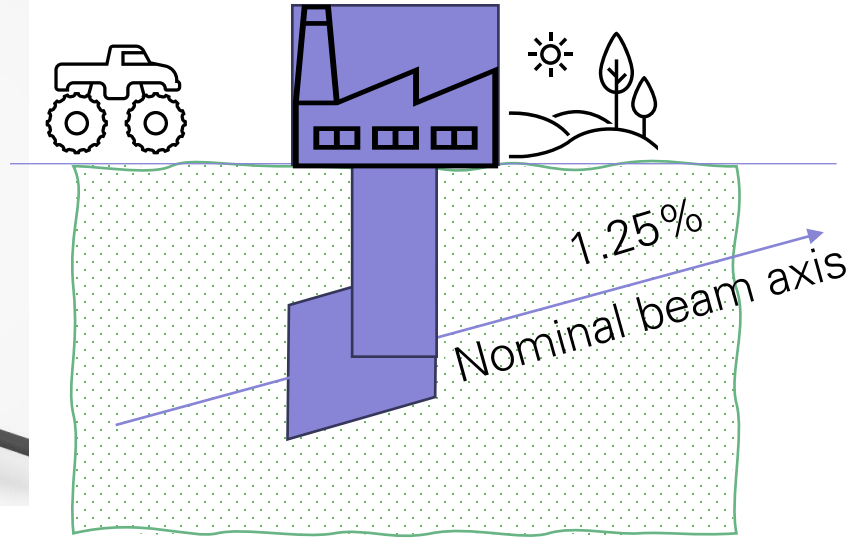
Integration model



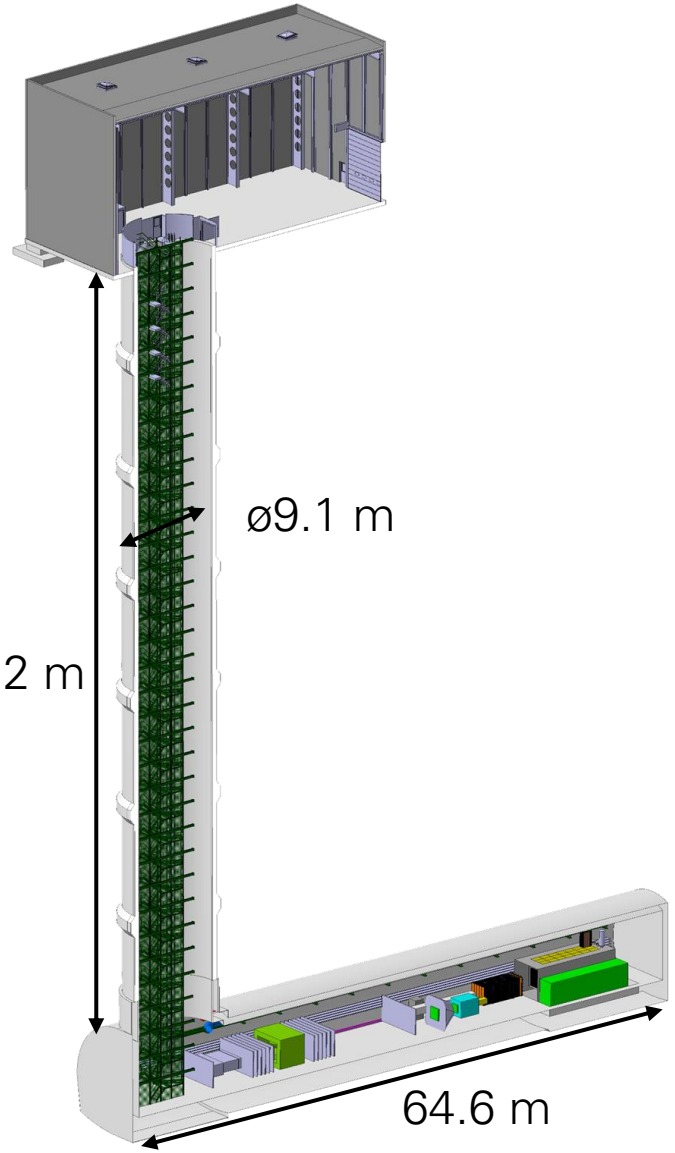
General layout



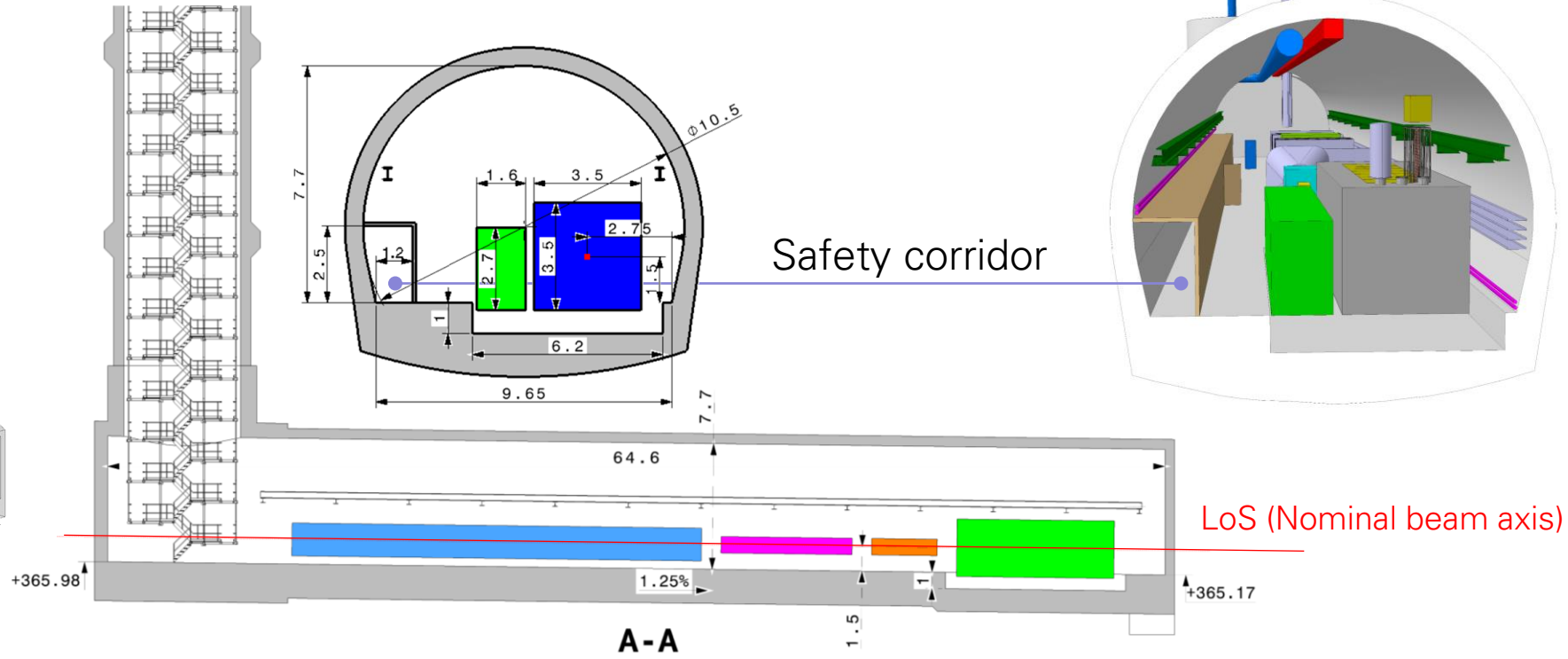
- Surface building
- Shaft - vertical
- Cavern - // to the LoS (Nominal Beam Axis - NBA)



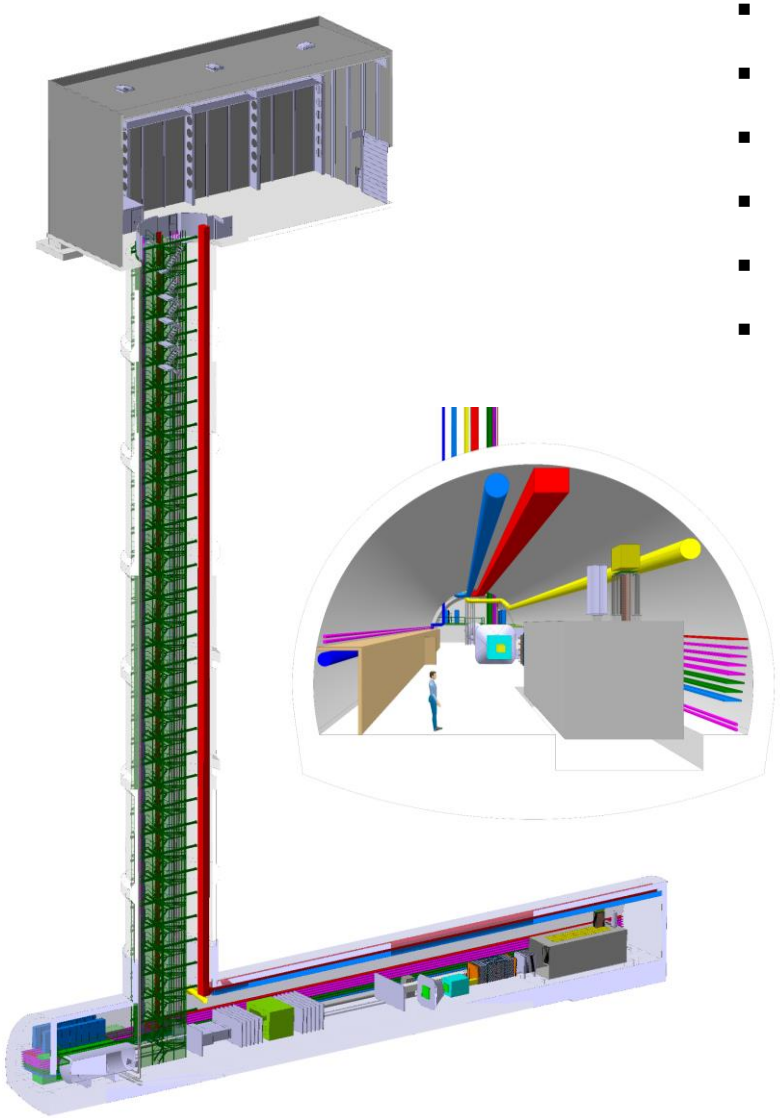
General layout (12.2023)



- A 64.6 m long experimental cavern
- An 87.2 m deep access shaft with a 9.1m internal diameter
- Floor is parallel to Line of Sight, NBA, 1.25% fall
- A cavern with a diameter of 10.5 m, a height 7.7 m
- Safety corridor used as an emergency escape route
- The shaft/cavern design is based on CERN experience with recent underground projects (as the new HL-LHC underground works at point-1/5)

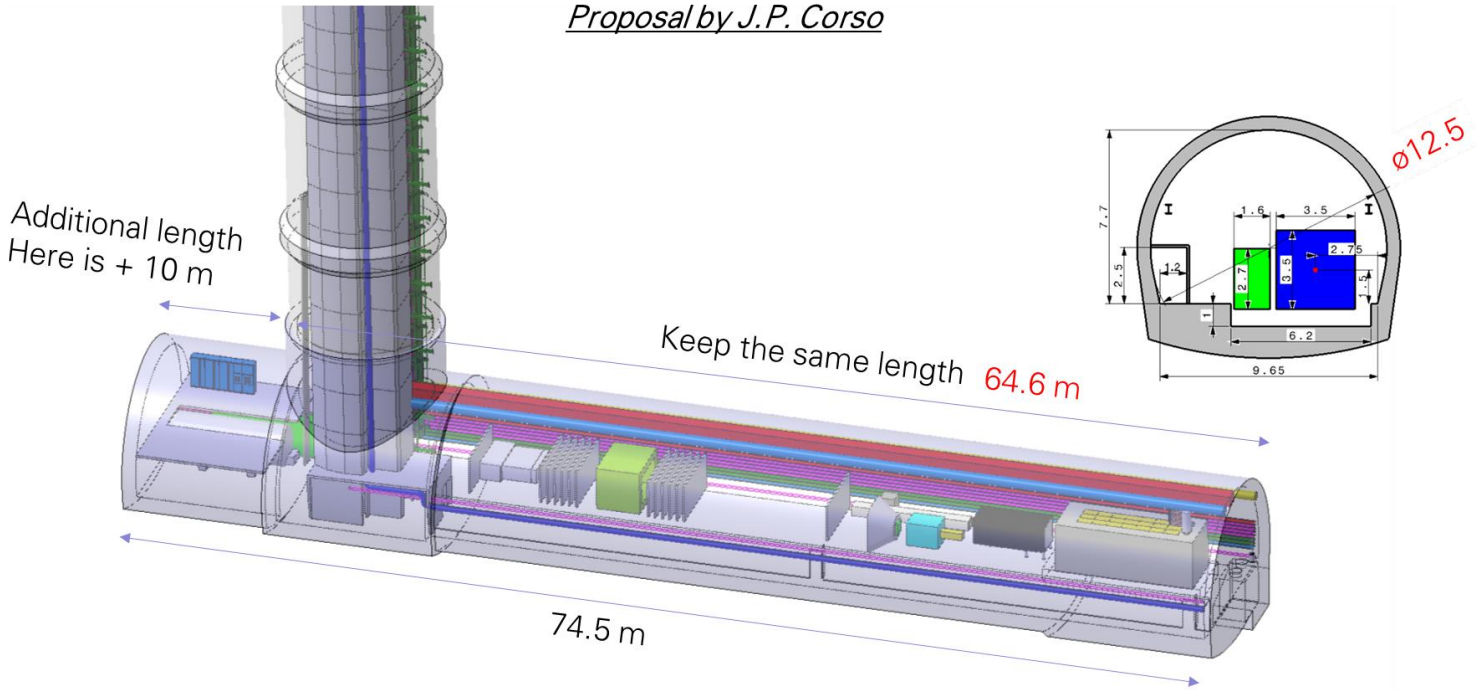


General layout (02.2024)



- A 64.6 m long experimental cavern + 10 m extension
- An 87.2 m deep access shaft with a 9.1m internal diameter
- Floor is parallel to Line of Sight, NBA, 1.25% fall
- A cavern with a diameter of 12.5 m, a height 7.7 m
- Safety corridor used as an emergency escape route
- The shaft/cavern design is based on CERN experience with recent underground projects (as the new HL-LHC underground works at point-1/5)

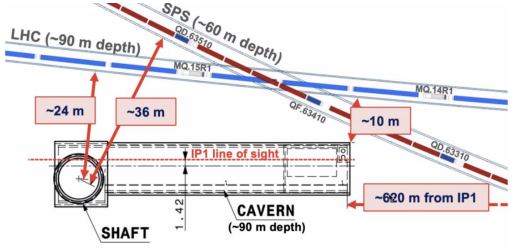
Proposal by J.P. Corso

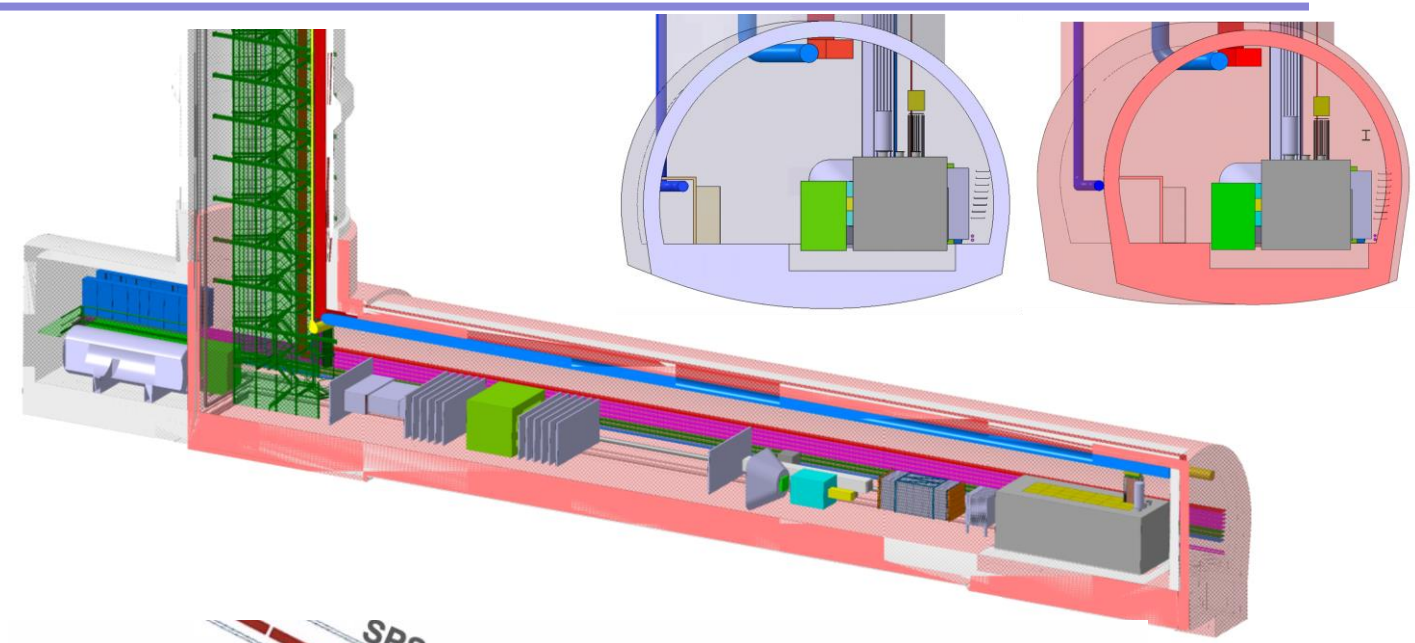


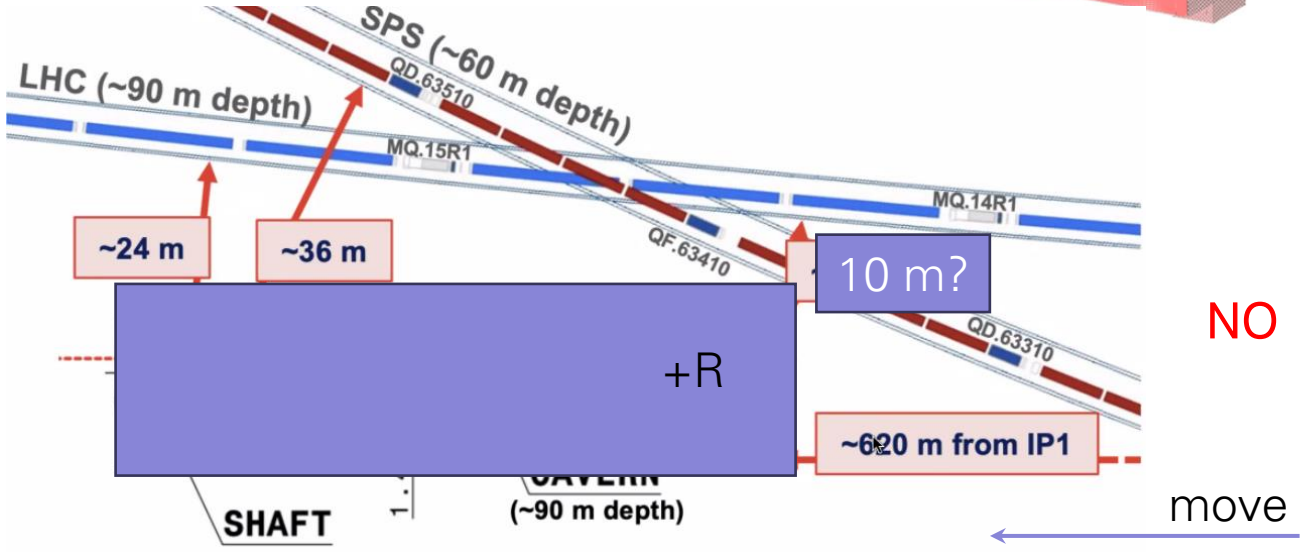
General layout (02.2024)

- A 10 m extension allows an additional space for the services (cryogenics, electrical)
- The services do not clash with the transport path
- The services are kept separately from the rest of the cavern
- A radius increase enlarges the transport path and give room for the services inside the cavern (cable trays, pipes etc.)
- A radius increase enlarges the crane movement rate

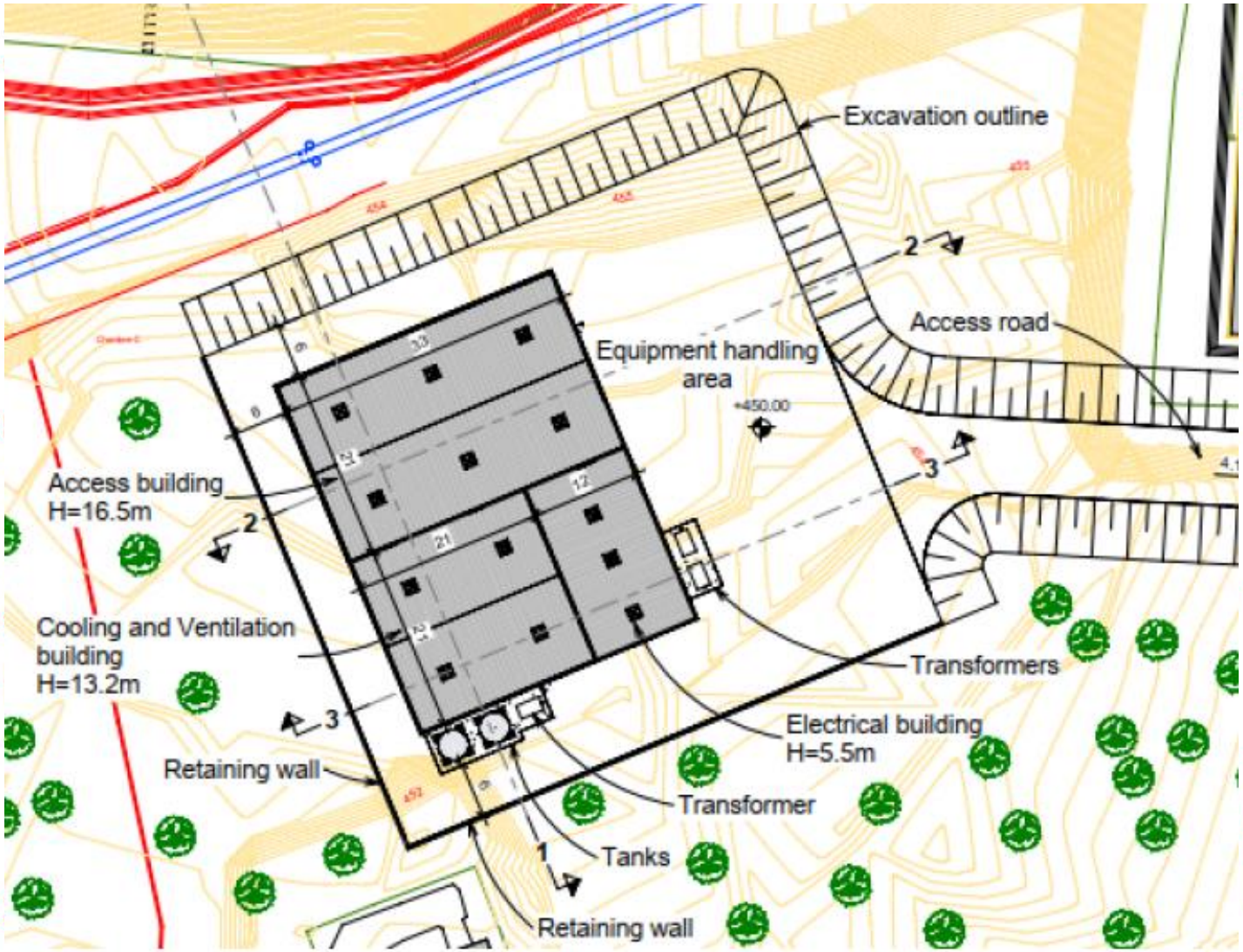
- *Need to understand effect for cavern placement (keeping minimum distance from LHC tunnel, and effect of LOS in cavern)*

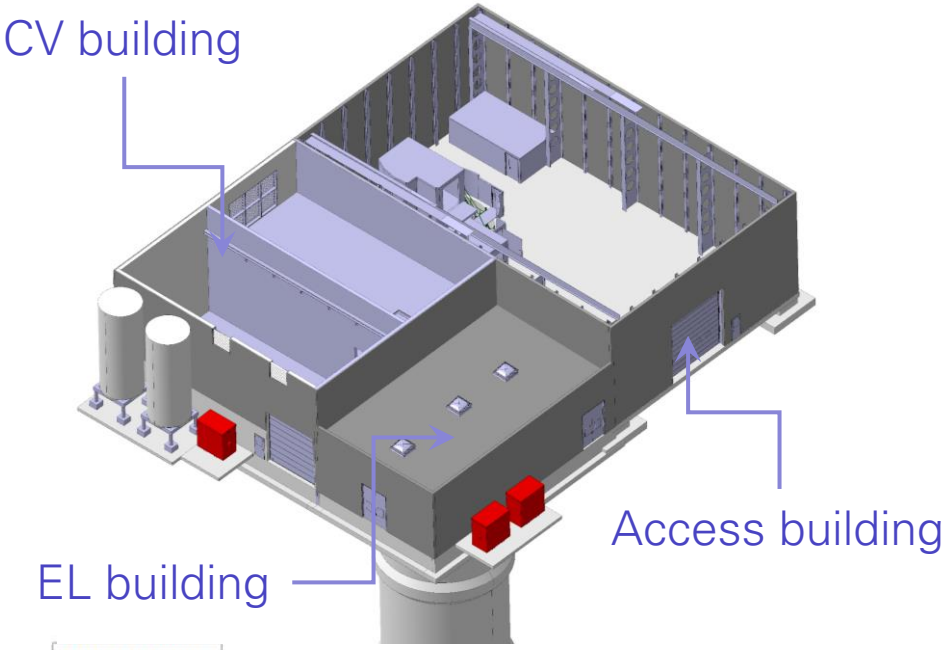






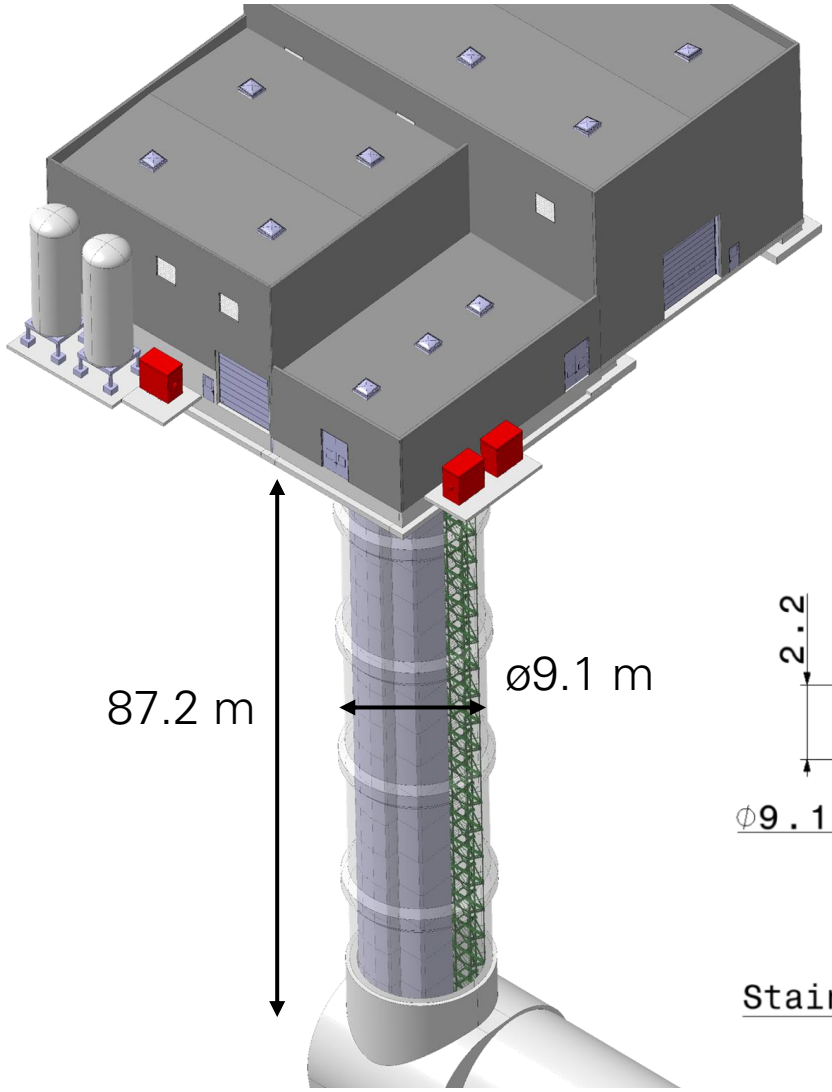
Surface building



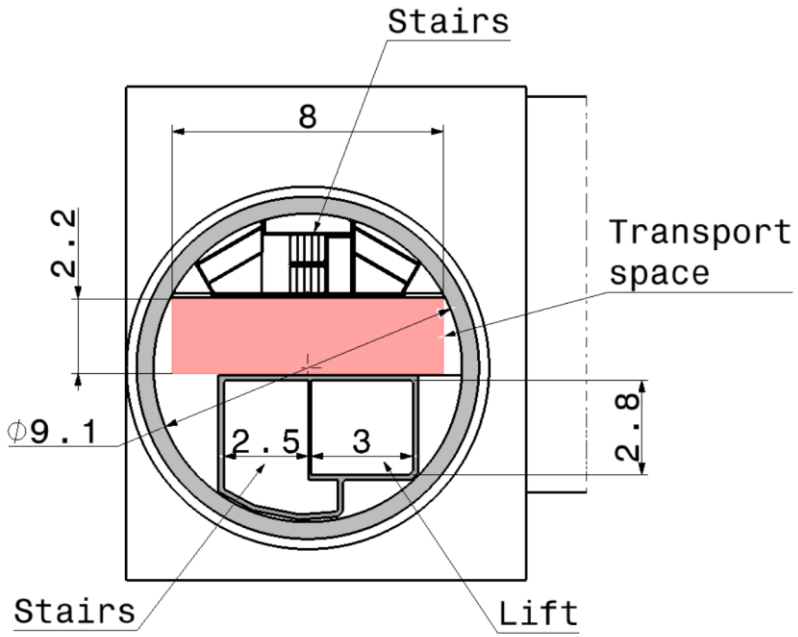


Both service buildings have a 1.2 m deep false floor to allow the services to be distributed into the shaft

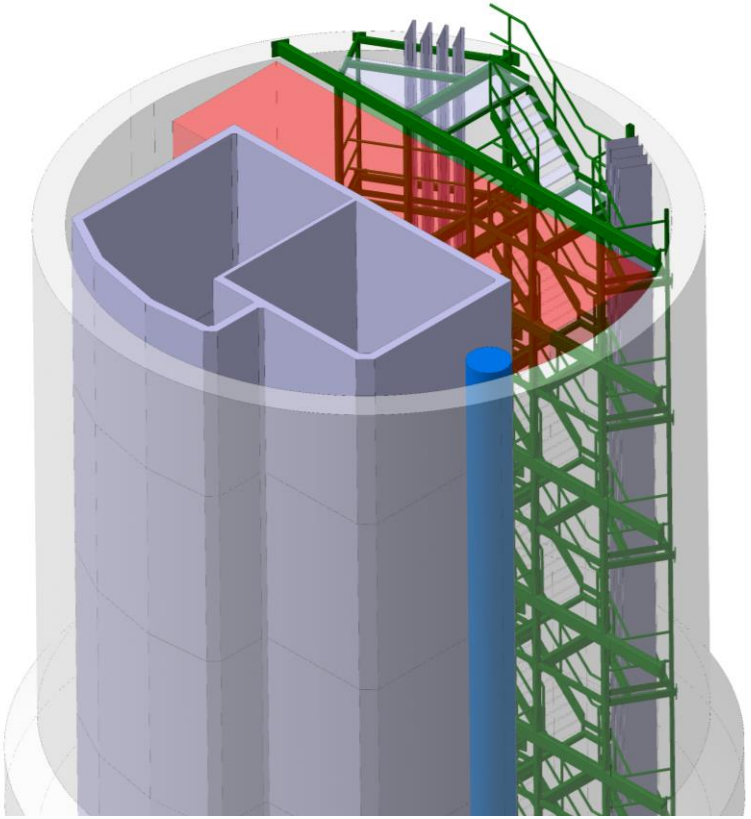
SHAFT



- ✓ Transport volume
- ✓ Stairs
- ✓ Pressurized lift and stairs in the concrete module
- ✓ The remaining volume for the services



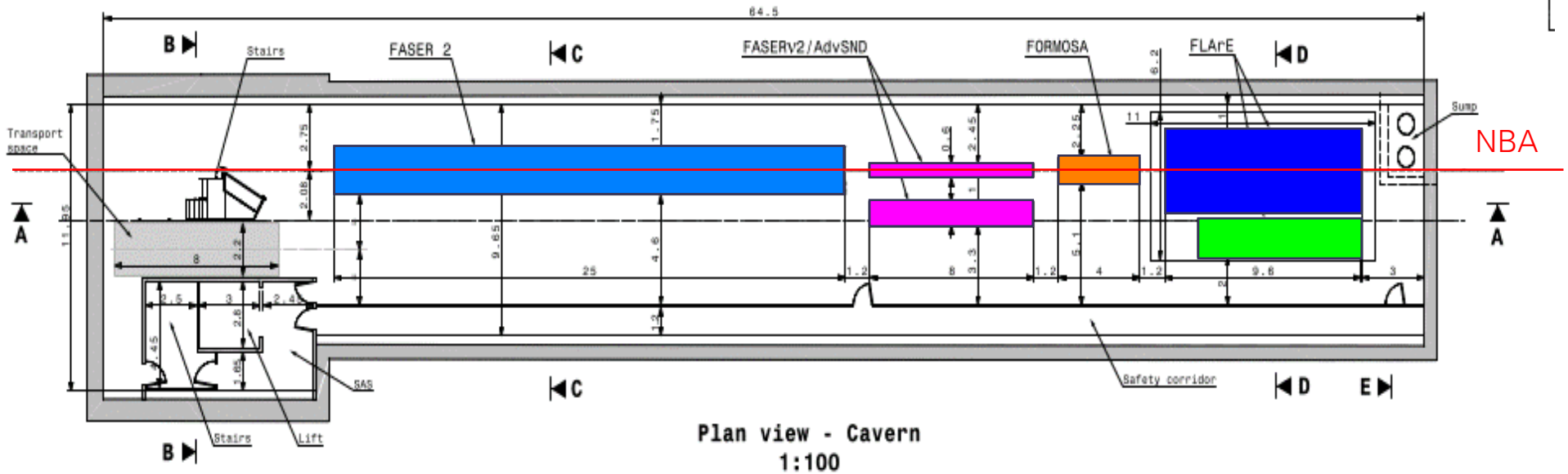
Plan view - Shaft



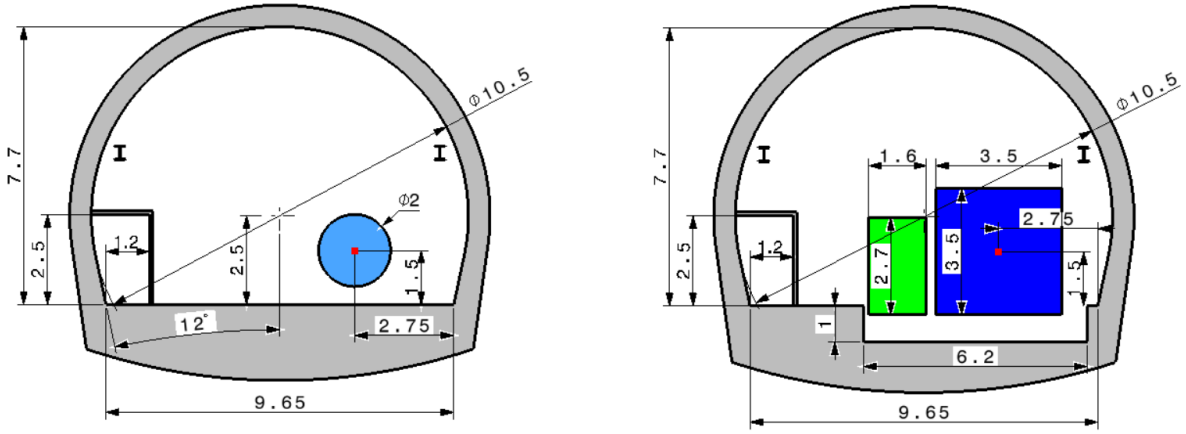
FPF Experiments

5 proposed FPF experiments, diverse detectors for a broad physics program

- FASER2
- FASERv2
- Advanced SND
- FLArE
- FORMOSA

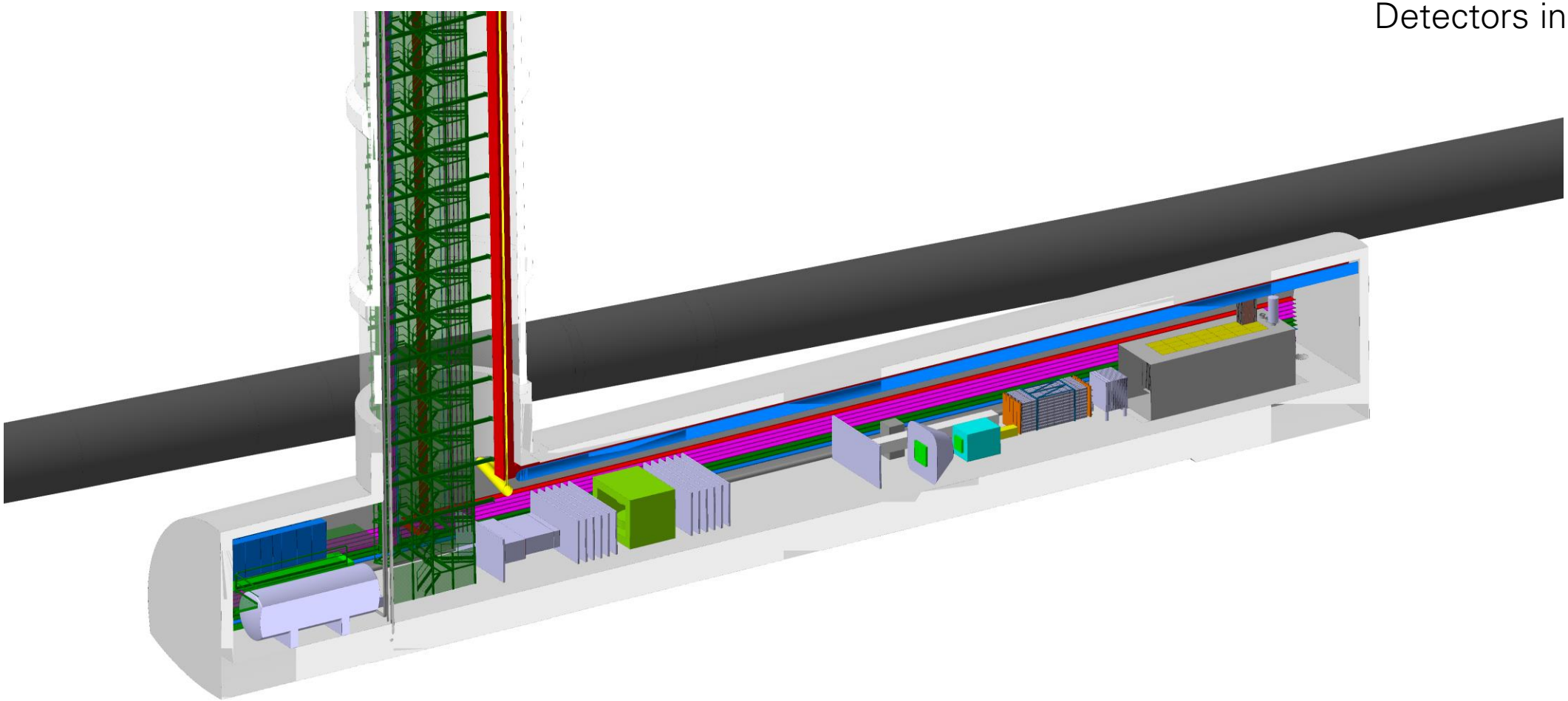


- Experiments centered on the line of sight (except AdvSND), <u>1.5 m from the cavern floor.</u>
- Trench under the LAr detector to catch any escaped cold gas.

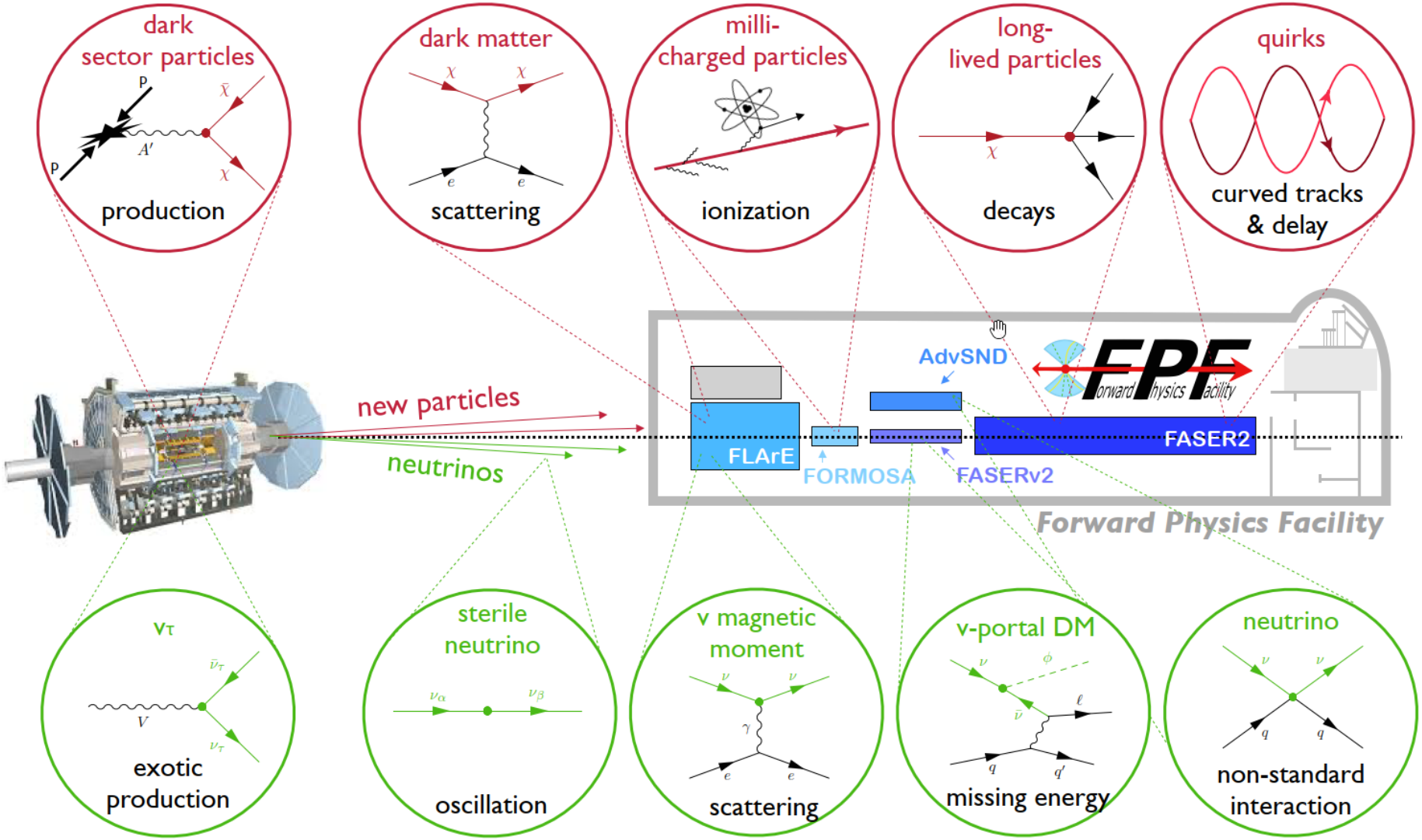


FPF Experiments

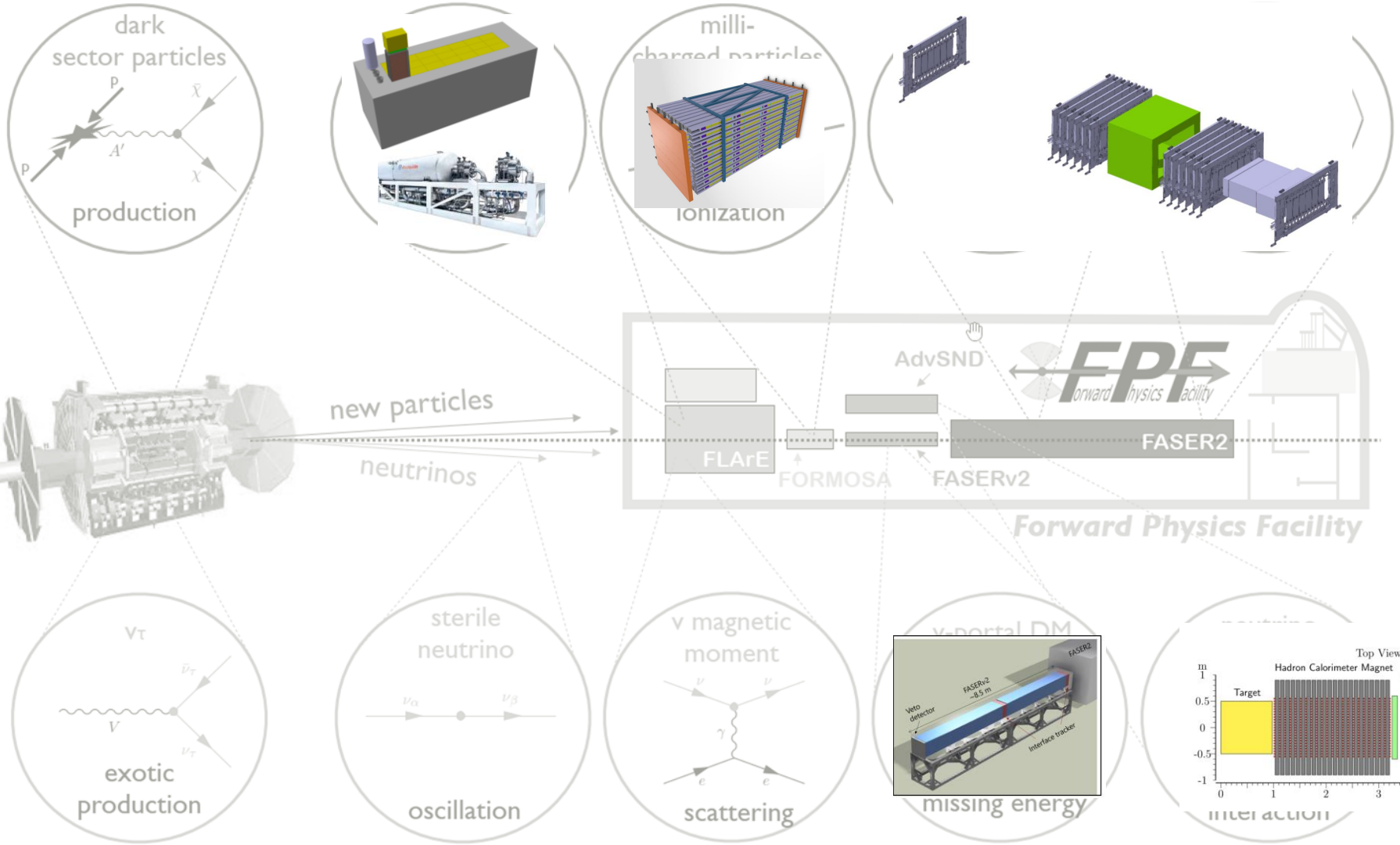
Detectors in progress



FPF Experiments

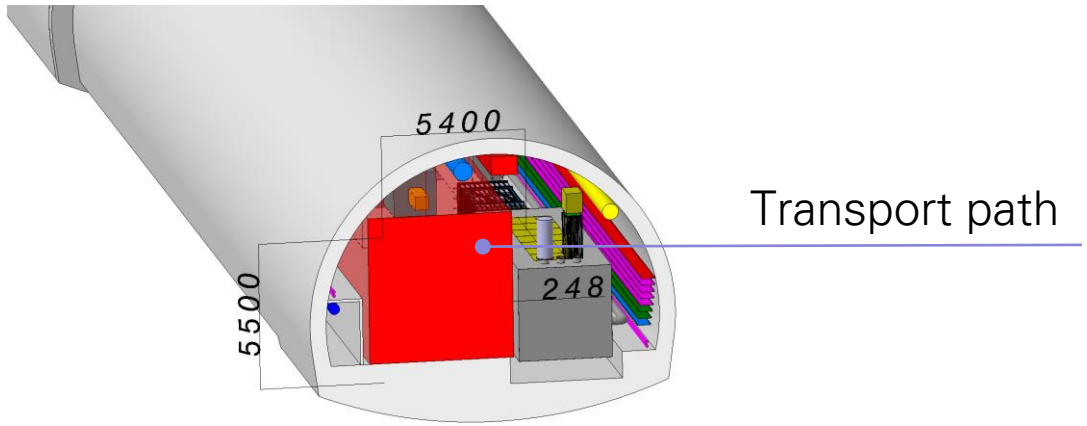


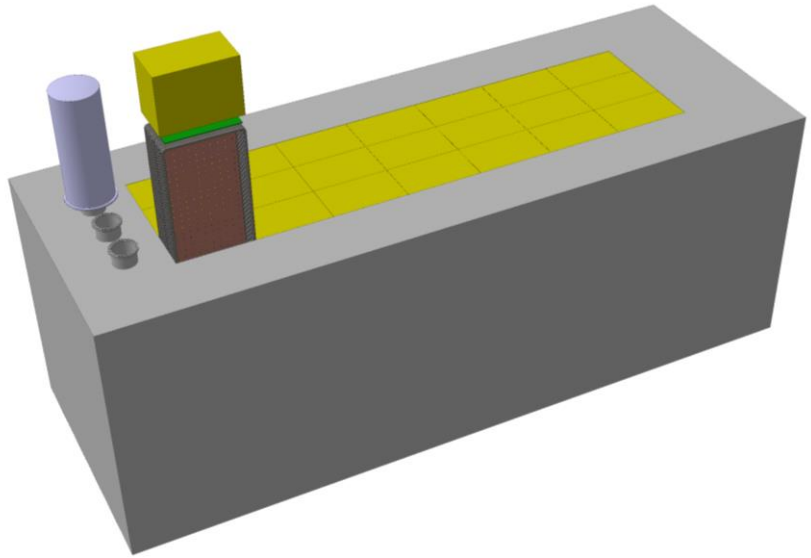
FPF Experiments



FLArE (Forward Liquid Argon based neutrino detector)

- Neutrinos
- Time projection detector (TPC)





Challenges

✓ *To find a compact solution to bring Ar in the cavern*

✓ *For alignment with NBA, cryostat need to be raised from the trench floor*

✓ *Safety:*

- Position of the cryostat and cryogenics away from the main egress and escape route
- Trench needed under cryostat to catch any argon leaks

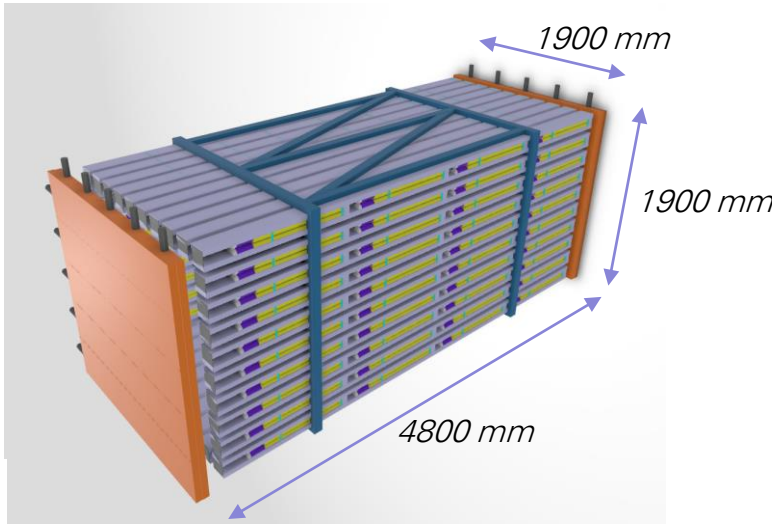
Information required

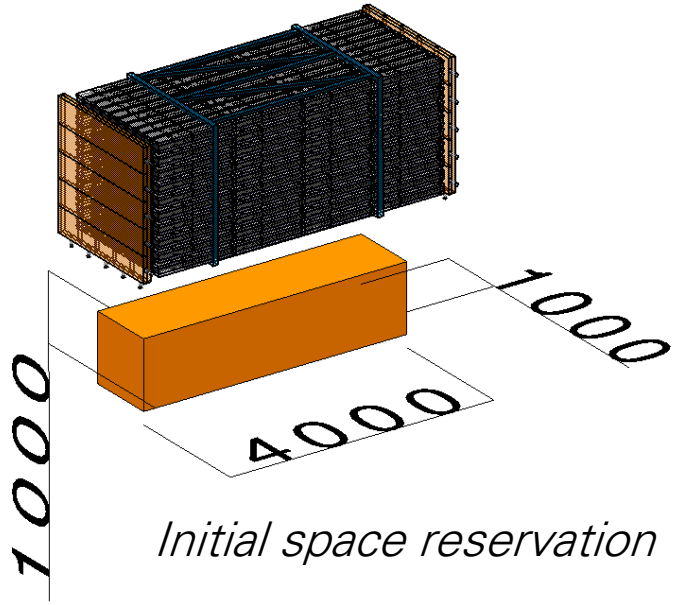
- The latest detector model
- Services (EL, HE, CV etc)
- Weight of Assy
- The heaviest component to transport
- Assembly sequence
- Auxiliary components

FORMOSA

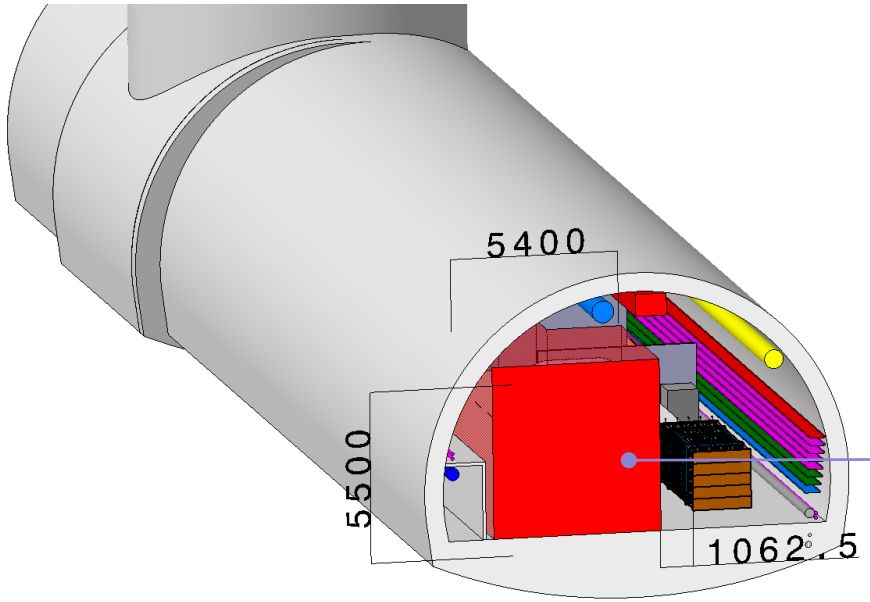
Plastic scintillator array for BSM search

The milliQan demonstrator is installed at LHC Point 5 PX56 for Run 3





Initial space reservation



Transport path

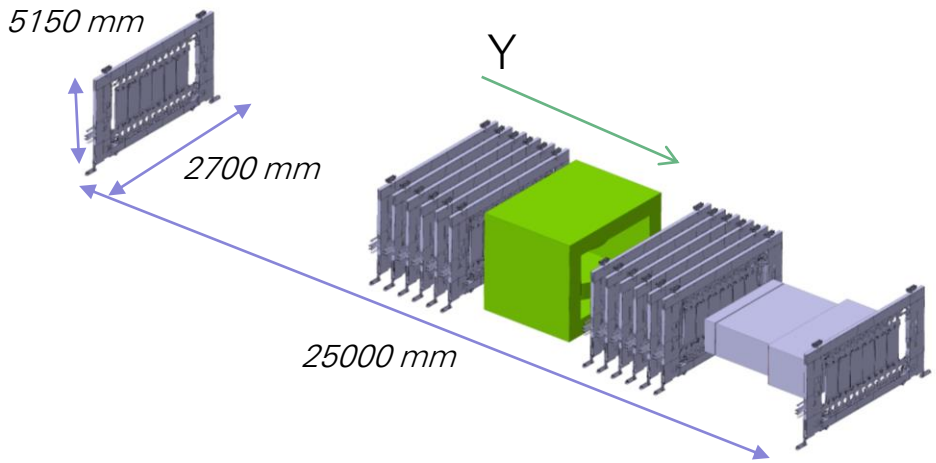
Information required

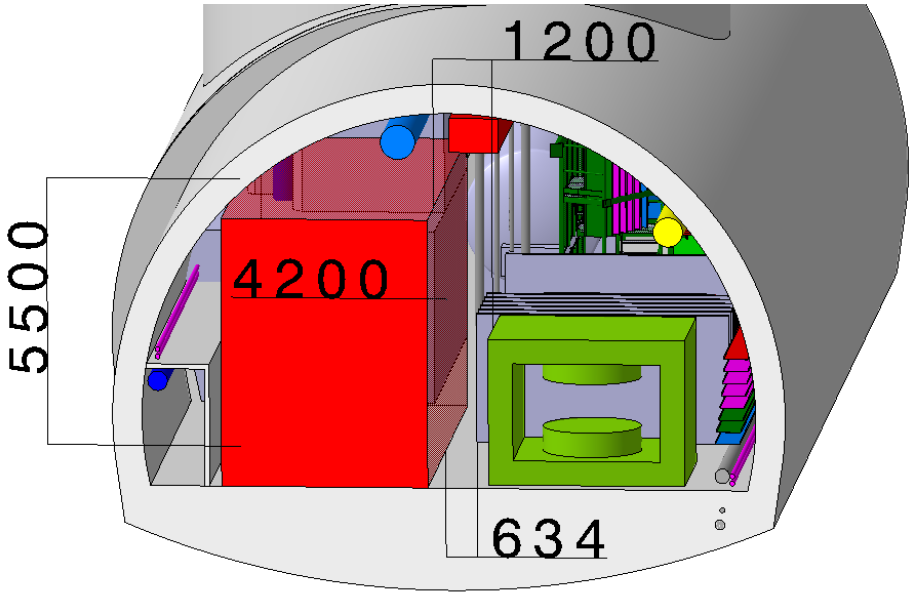
- The latest detector model
- Services (EL, HE, CV etc)
- Weight of Assy
- The heaviest component to transport
- Assembly sequence
- Auxiliary components

FASER2

FASER2 (ForwArd SEaRrch experiment)

- To detect high energy neutrinos
- FASER is already installed in TI12



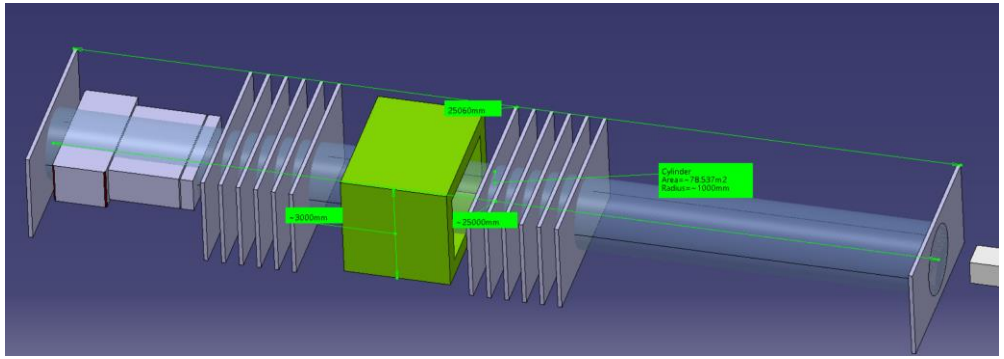


Challenges

- to find a suitable magnet (off shelf)

- to transport the magnet into the cavern

Initial space reservation



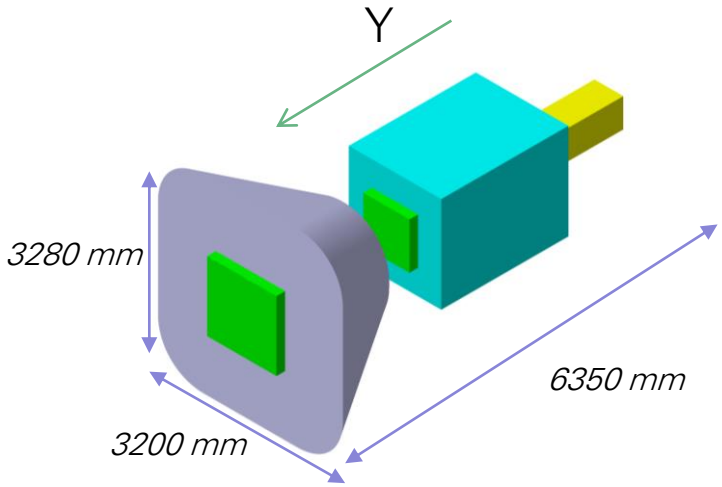
Information required

- The latest detector model
- Services (EL, HE, CV etc)
- Weight of Assy
- The heaviest component to transport
- Assembly sequence
- Auxiliary components

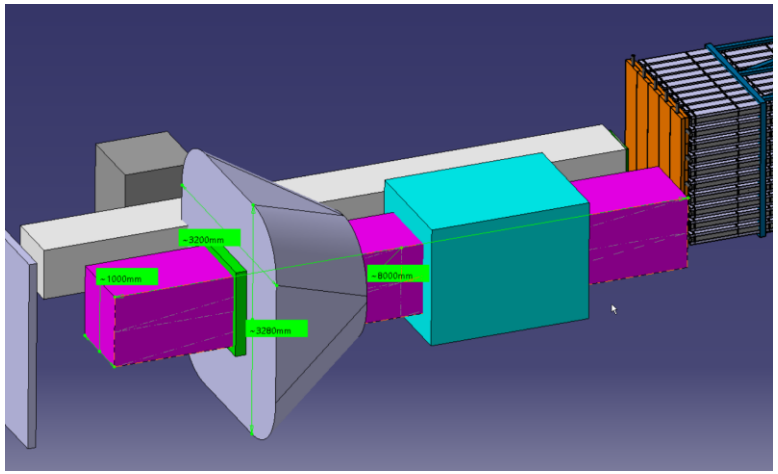
AdvSND

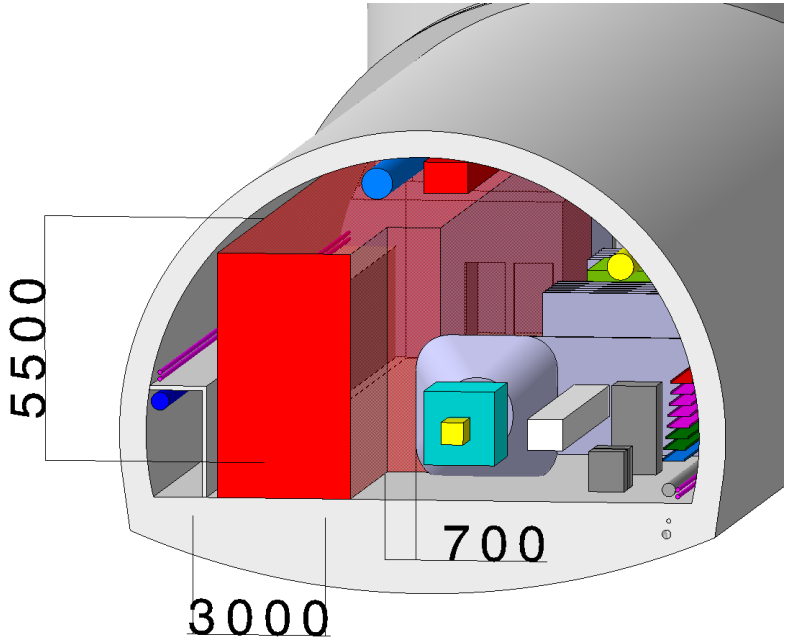
AdvSND (Advanced Scattering Neutrino Detector)

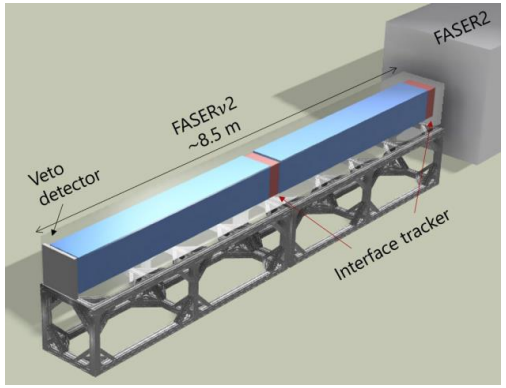
- Consists of two detectors: FAR & NEAR
- Extend the physics case of the SND@LHC
- Electronic neutrino detector



Initial space reservation







FASERν2 (ForwArd SEaRrch experiment)

- To be placed on-axis at the front of FASER2
- Directly detect collider neutrinos
- Emulsion-based neutrino detector
- FASERν is installed for Run 3

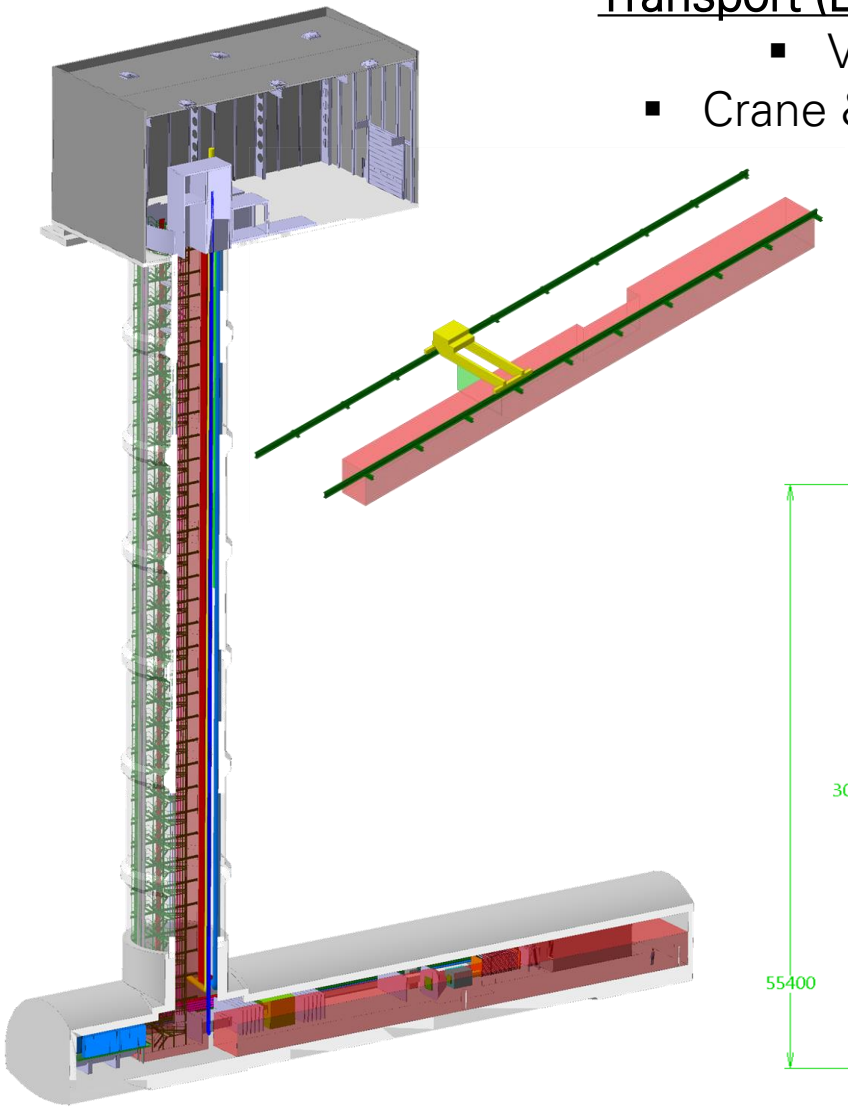
Information required

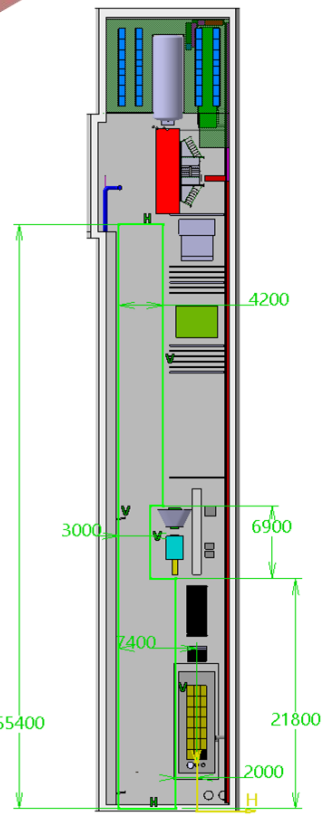
- The latest detector model
- Services (EL, HE, CV etc)
- Weight of Assy
- The heaviest component to transport
- Assembly sequence
- Auxiliary components

FPF Services

Transport (EN-HE)

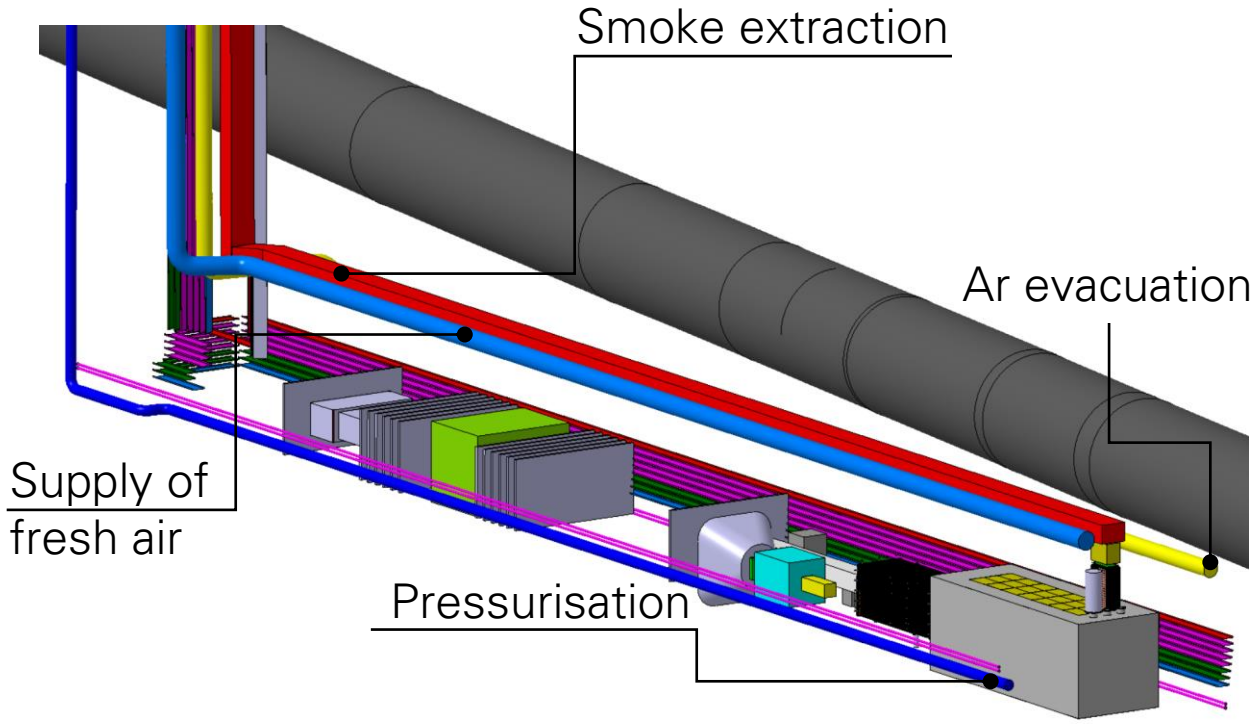
- Volume
- Crane & Rails





EN-CV

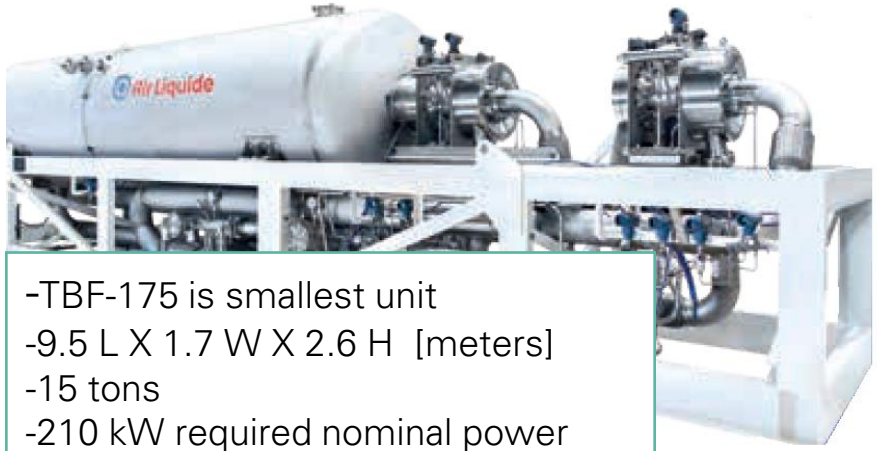
- Smoke extraction
- Ar extraction
- Pressurisation
- Pulsion
- Extraction



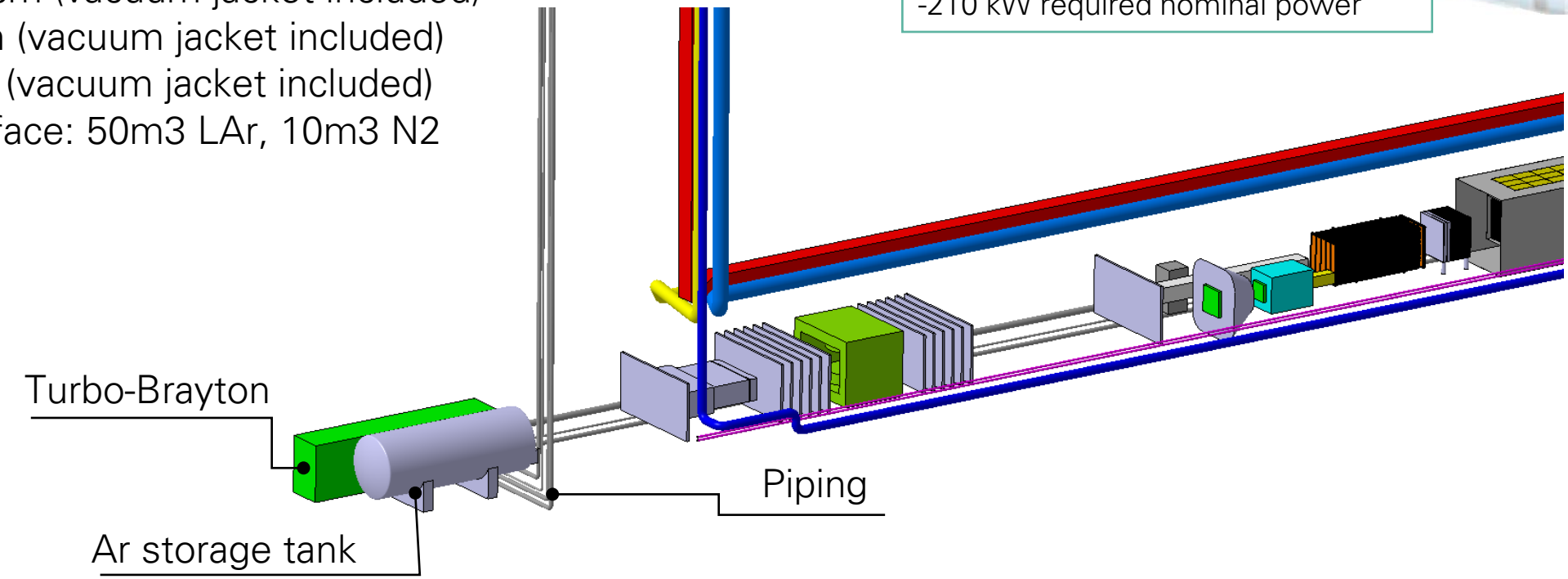
FPF Services

Cryogenics

- Turbo-Brayton cooling unit
- Ar storage tank
- Piping for transporting cryogenic liquid from surface into cavern (N2 and Ar)
  - GAr out 30 cm diameter
  - GAr in 10 cm (vacuum jacket included)
  - LN2 20 cm (vacuum jacket included)
  - LAr 20 cm (vacuum jacket included)
- Dewars on surface: 50m3 LAr, 10m3 N2



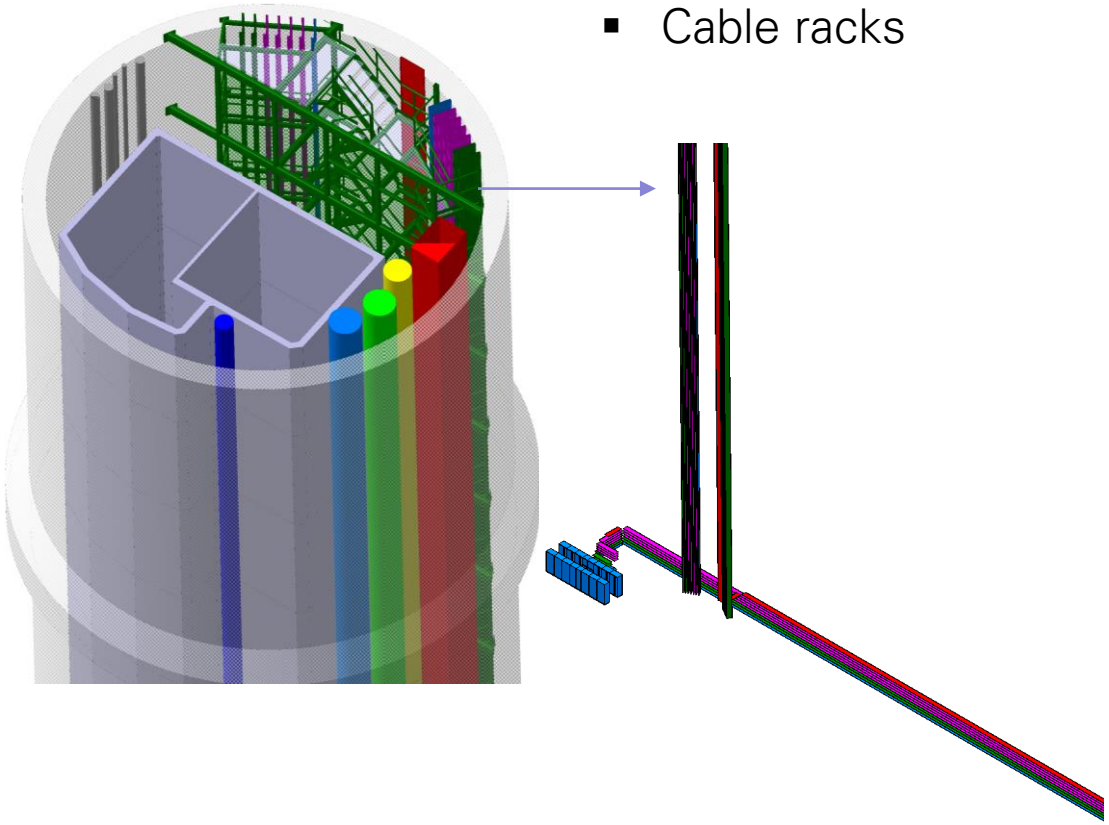
-TBF-175 is smallest unit
-9.5 L X 1.7 W X 2.6 H [meters]
-15 tons
-210 kW required nominal power



FPF services

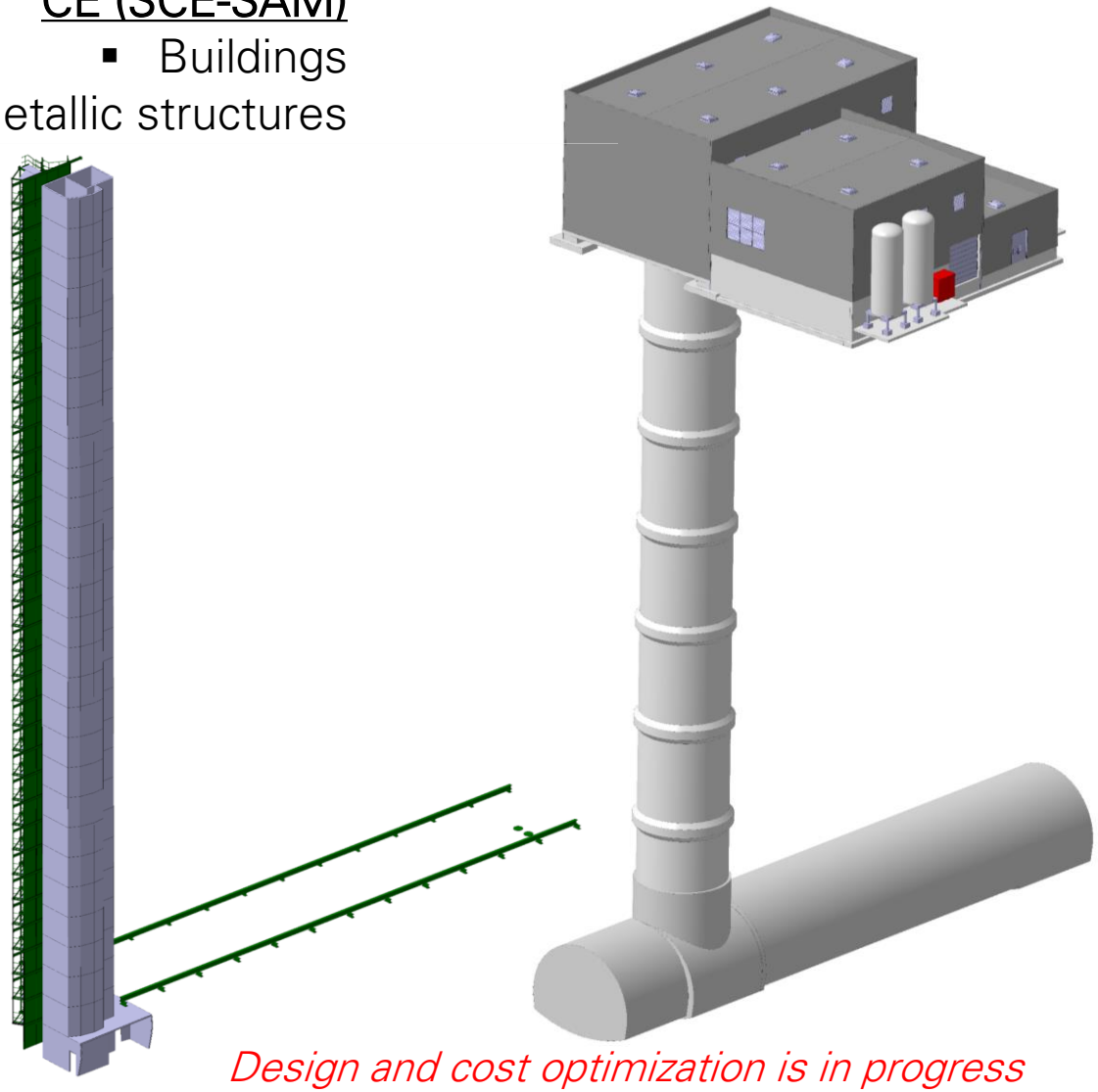
EN-EL

- Cable trays
- Cable racks

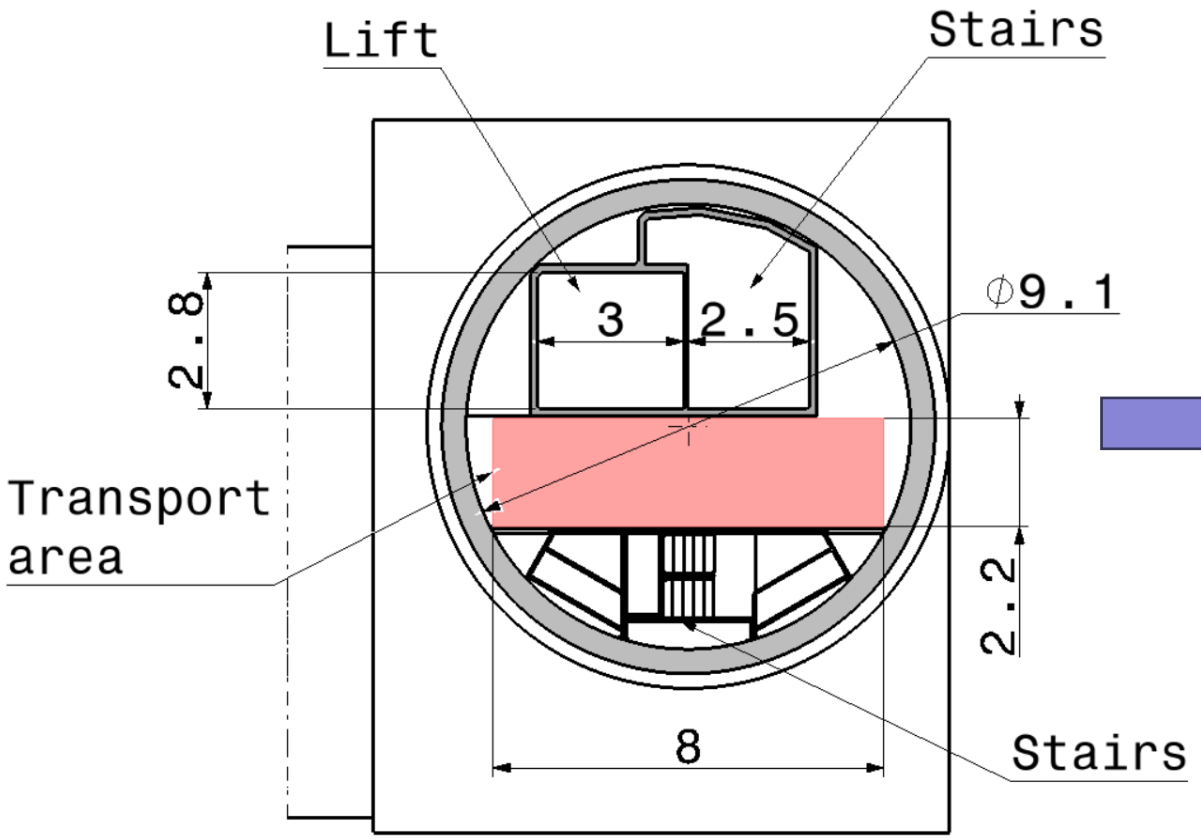


CE (SCE-SAM)

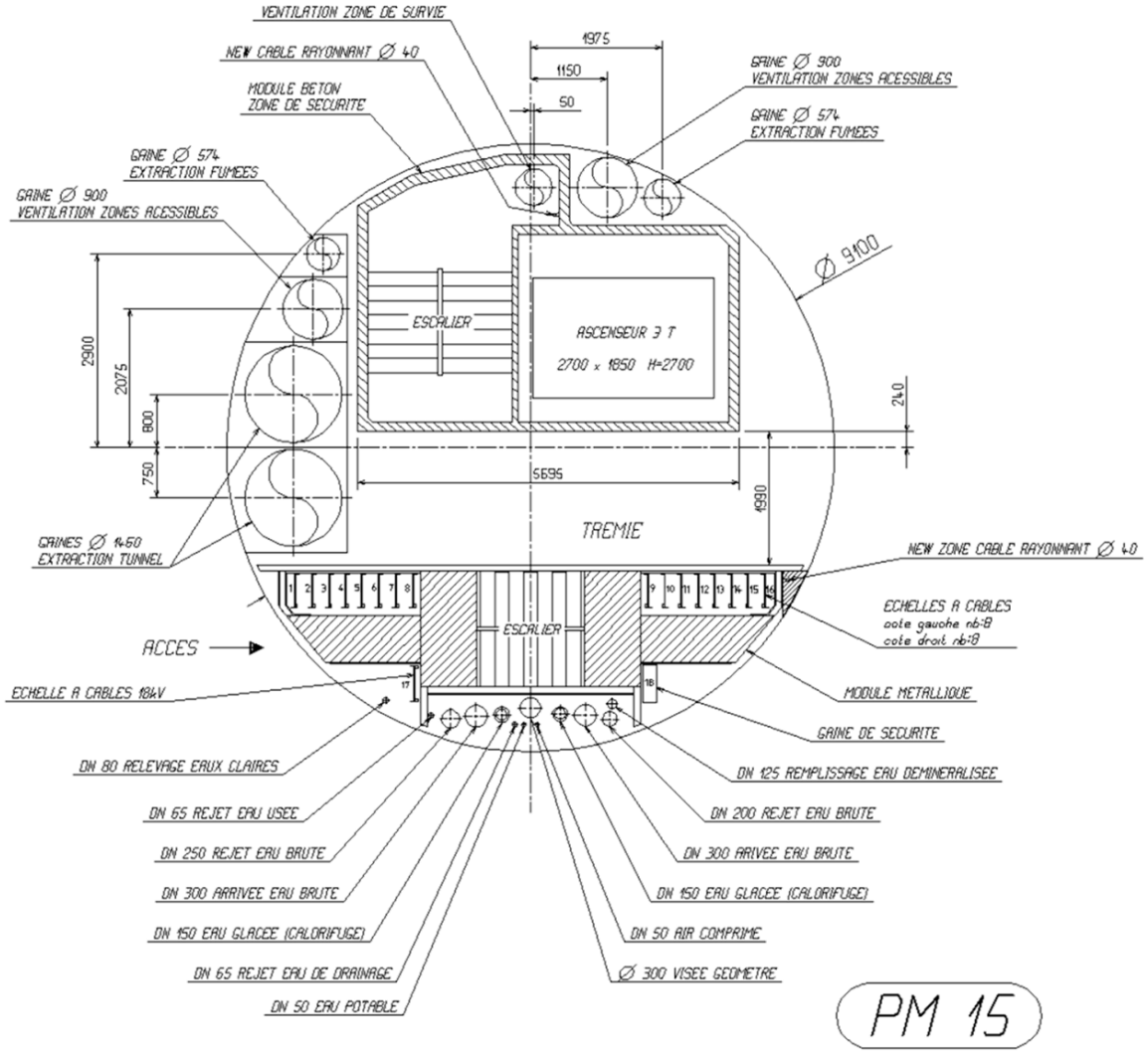
- Buildings
- Metallic structures



Design and cost optimization is in progress



Plan view - Shaft



Safety

CAVERN

- Safety corridor used as an emergency escape route
- Main risks and concerns related to FLArE:
  - Trench needed under cryostat to catch any argon leaks
  - Oxygen deficiency is the main risk associated to the LAr TPC
  - GAr and GN2 exhausts released to the surface
  - Position of the cryostat and cryogenics away from the main egress and escape route
  - More than 10 min to fill with warm argon gas at a flow equivalent to the LAr purification
- ODH alarms in cavern with trigger to ventilation system
- Ventilation (push and extraction)
  - Air extraction in the proximity of the cryostat/cryogenics
  - Constant air circulation with alarms if ventilation not working
- Possibly personal ODH required to access the cavern (or the trench) as well

Integration methodology reminder

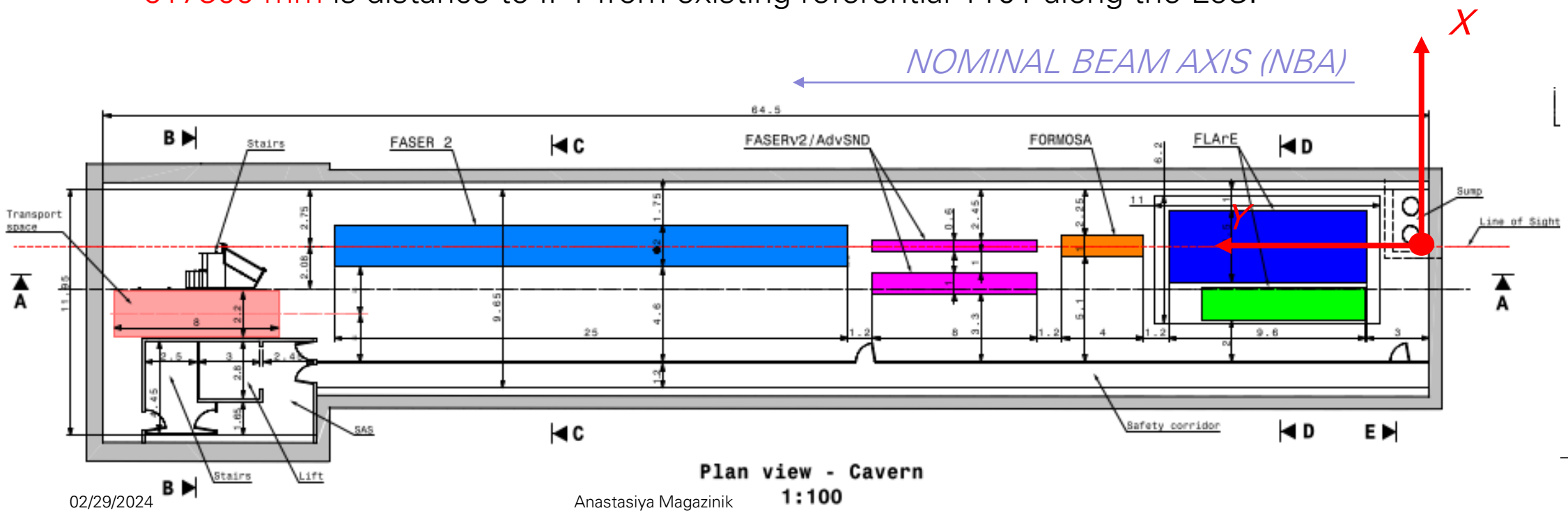
Integration methodology

Applied integration methodology:

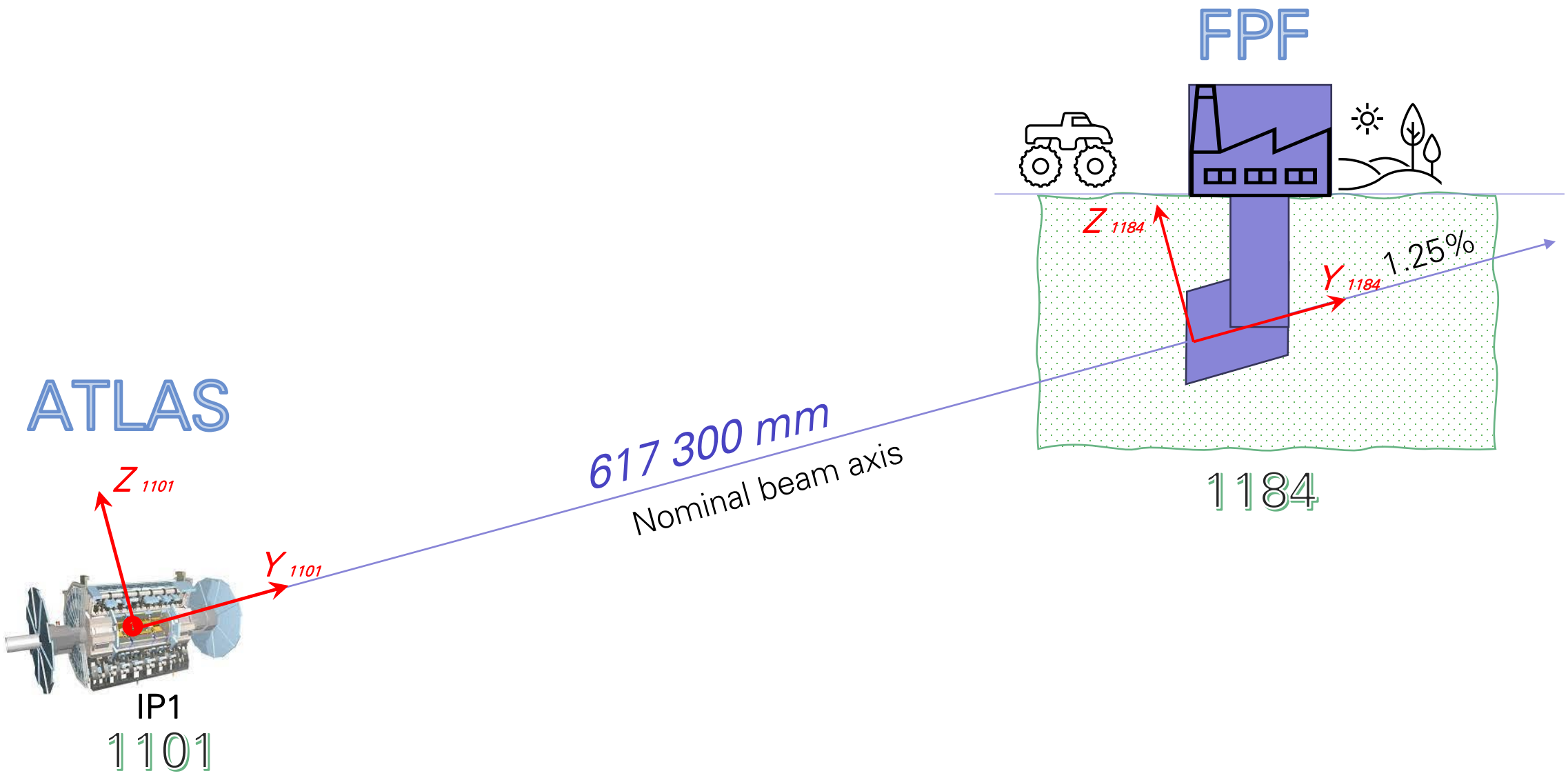
1. New local referential
2. Skeleton
3. Model division & PDM
4. Naming
5. Simplification

New Local referential

- New Local Referential 1184:
  - ‘Y’ is nominal beam line
  - Tunnel floor is parallel to ‘Y’
  - ‘X’ towards to the center ring of the LHC
  - Shaft is vertical
  - 617300 mm is distance to IP1 from existing referential 1101 along the LoS.



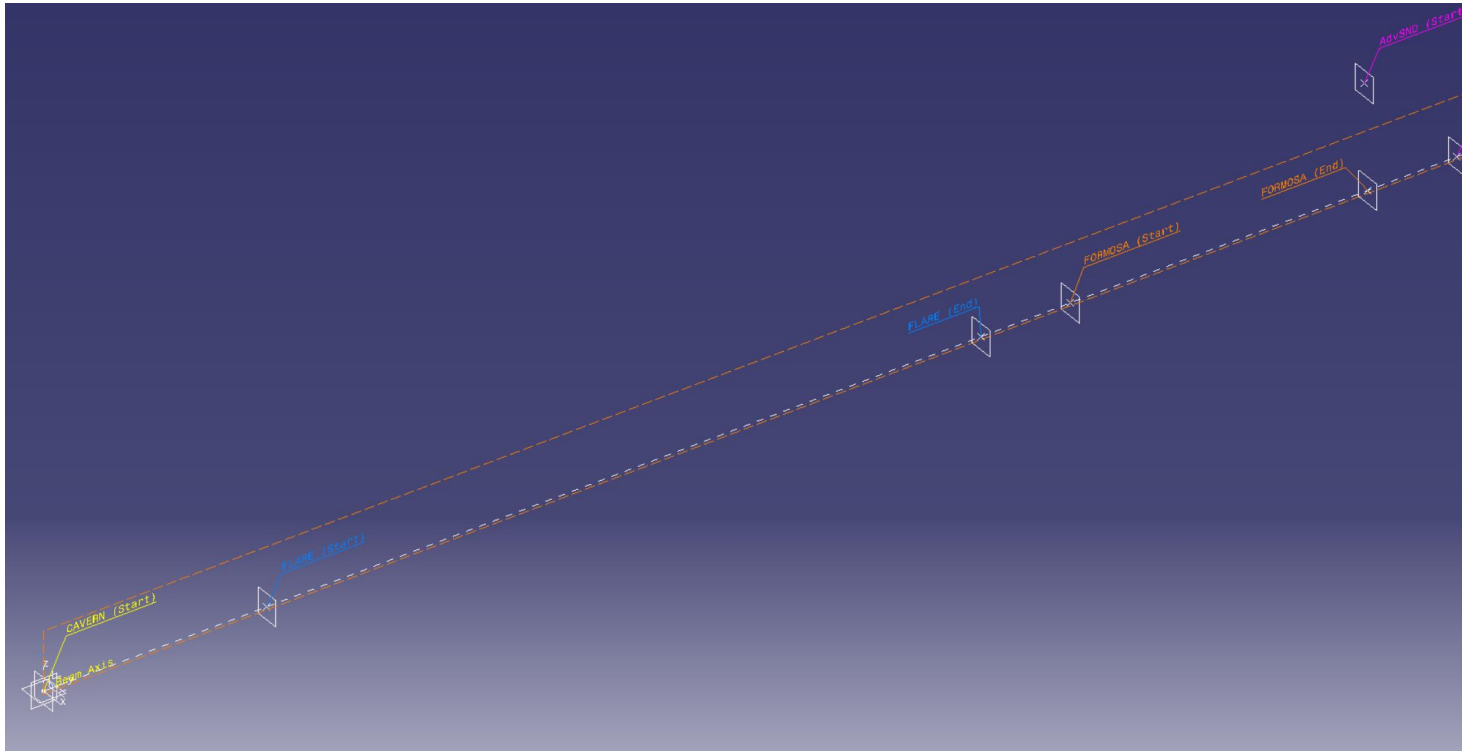
New local referential



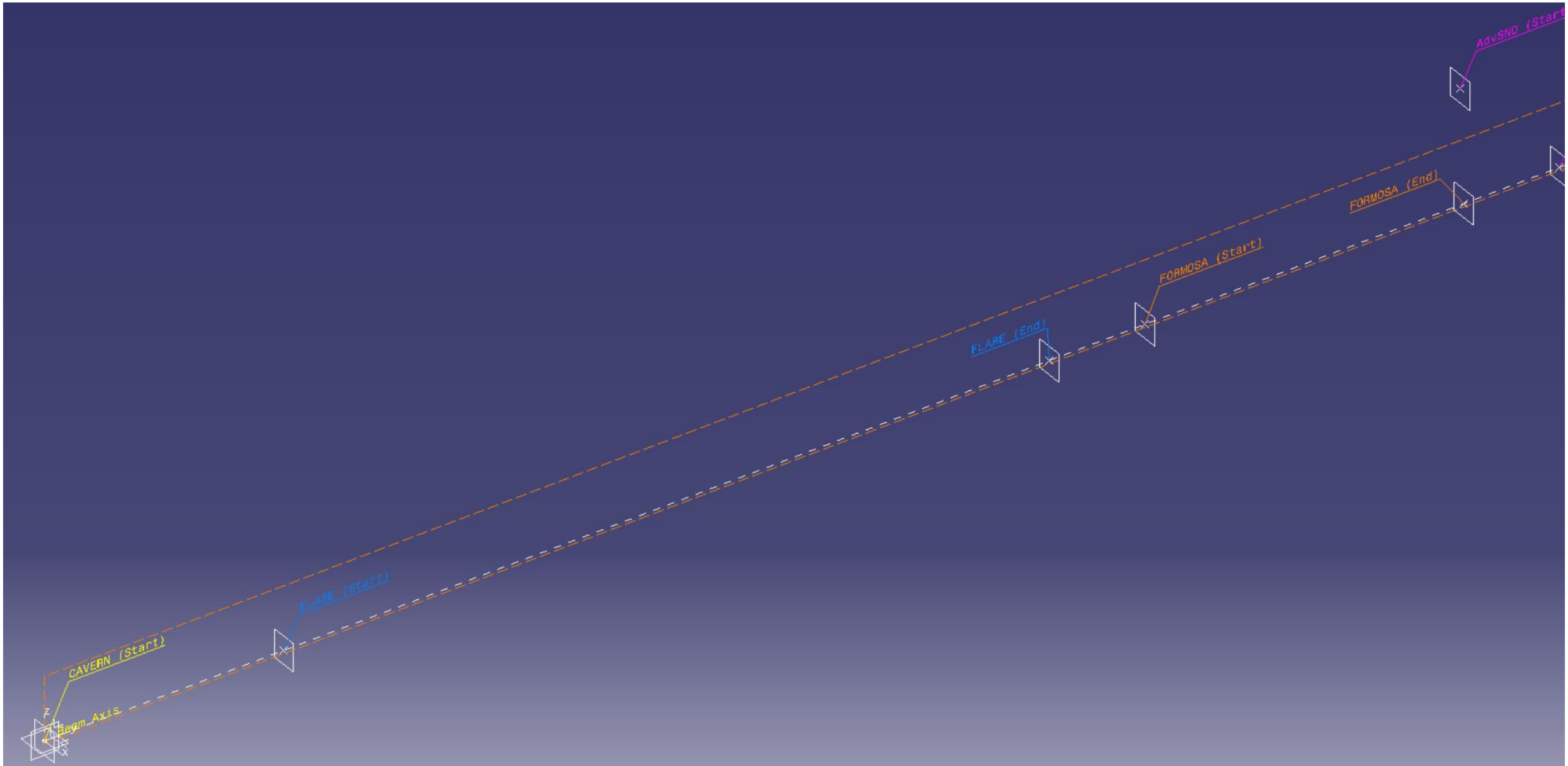
Skeleton

Skeleton is a file with relevant positions for the main components for the integration:

- A new local referential is created 1184 (in CATIA but not yet officialized), it is our ‘0’;
- Points represent Start and End of a components with respect to our ‘0’;
- Points on the nominal beam axis;
- Planes are perpendicular to the NBA.

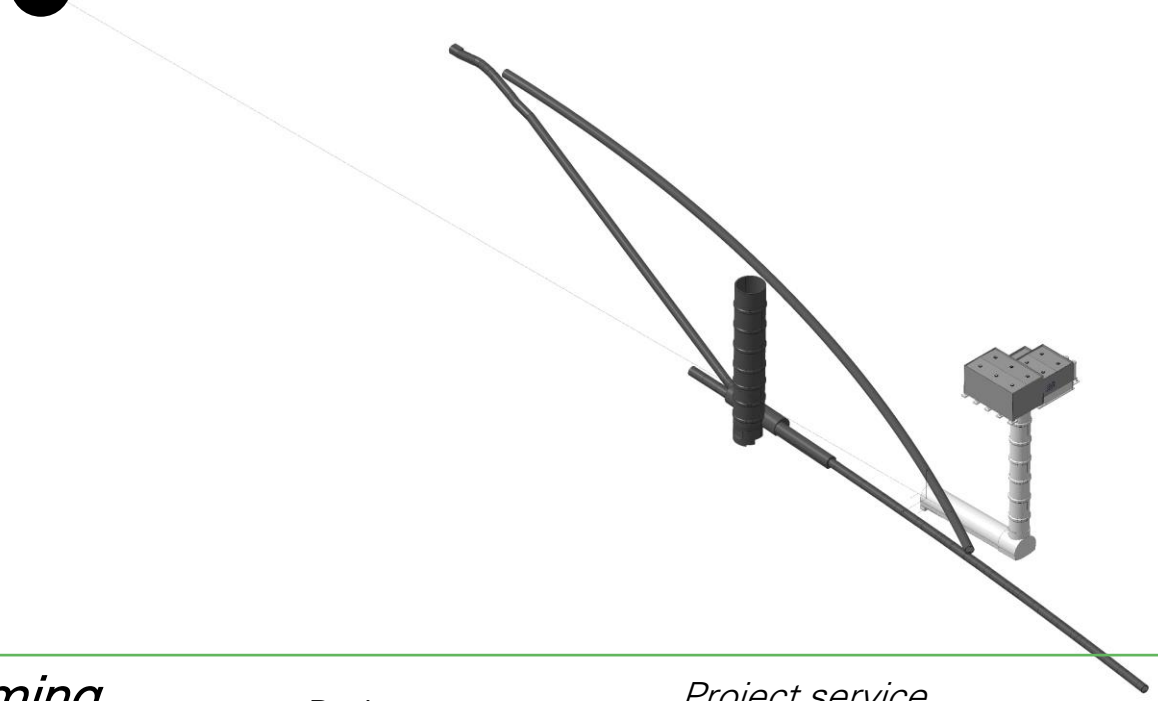


Skeleton

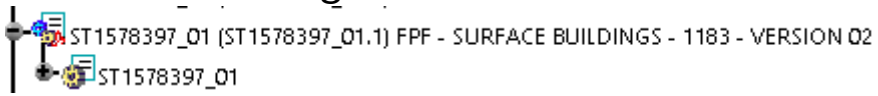

AdvSND (Start
FORMOSA (End)
FORMOSA (Start)
FLARE (End)
FLARE (Start)
CAVERN (Start)
Beam Axis

Model division & Naming& PDM

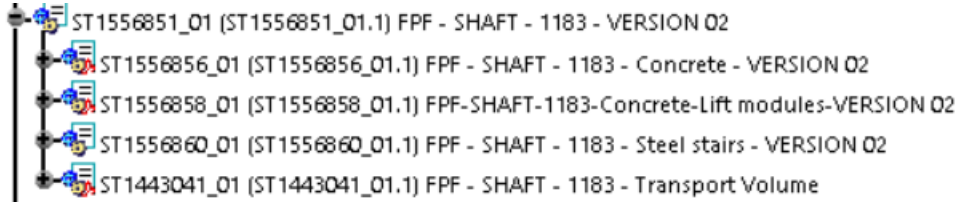
IP1



Surface building



Shaft



Naming

Project name

Project service

Referential

In PDM

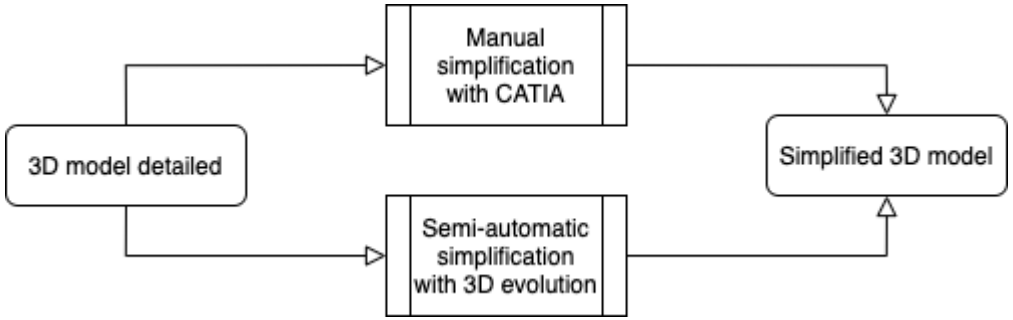
Cavern

Simplification

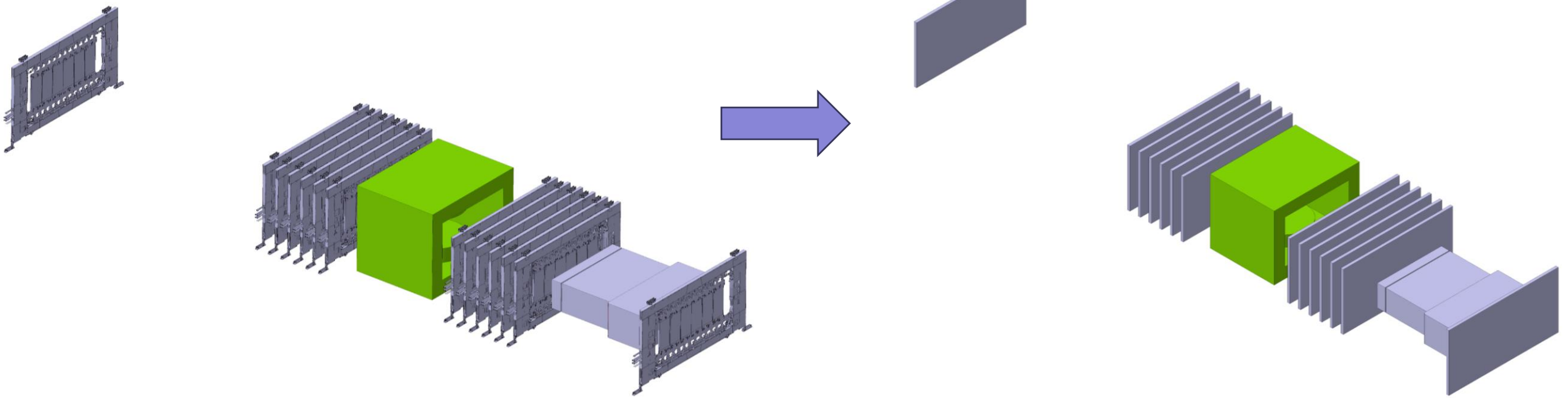
Very simple about simplification

GUCC Working group in progress to define the methods and a common procedure to follow.

Report is in progress



DS CATIA



Summary

- Integration work is covered in the present talk
  - Fitting experiment CAD models into 3D model of cavern.
  - The feedback from collaborators is required:
    - The latest detectors models
    - Services (EL, HE, CV etc)
    - Estimated weight of each detector ant its heaviest component to transport
    - Assembly sequence of each detector (important for the transport study)
    - Auxiliary components for each detector
- Several discussions are in progress
  - Discussion with CE experts cost updates for enlarging cavern
    - Need to understand effect for cavern placement (keeping minimum distance from LHC tunnel, and effect of LOS in cavern)
  - Discussion with CERN cryo expert (J. Bremer), best options for FLArE cryo
- Respecting the Integration methodology prevents/avoids some mistakes and increase the quality of the communication and of the 3D models

Next steps

- Continue optimization of the cavern dimensions and design
  - Challenge: To keep the cavern as small and as compact as possible for the space and the cost optimization reasons
- Integration of the infrastructures/services – *need your feedback*
- Integration of the latest and missing 3D models of the detectors, including auxiliary services (cryo coolers etc..) – *need your feedback*
- Transport study for installation of the largest/most-complicated components into the cavern (FLArE cryostat pieces, FASER2 magnet pieces) – mid May 24 – *need your feedback*

Thank you!

Literature

- FASER Collaboration, Abreu, H., Mansour, E. A., Antel, C., Ariga, A., Ariga, T., Bernlochner, F., Boeckh, T., Boyd, J., Brenner, L., Cadoux, F., Casper, D. W., Cavanagh, C., Chen, X., Coccaro, A., Crespo-Lopez, O., Debieux, S., D'Onofrio, M., Dougherty, L., … Zhang, G. (2022). *The FASER Detector*. http://arxiv.org/abs/2207.11427
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- Presentations of CERN experts

Exchange folders

- DETECTORS & skeleton
  - https://cernbox.cern.ch/s/byQMkFSNBPt9Bnm

- Access to the full model via the new PLM platform
  - CERN Light account is required
  - https://plm.cern.ch/prod/?StartItem=ST_Document:11796331AD5D4FB2CEFEC36143D6E026

- Regular Technical meetings: Technical Meetings · Indico (cern.ch)