FUTURE CIRCULAR COLLIDER

How the FCC-ee could look like?

FCC-ee Arc Half-Cell 1:1 Mock-up project

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Outlines

1. What is an arc half-cell? And why this demonstrator?
2. Details concerning the 1:1 mock-up
3. A short functional demonstrator
4. Conclusion

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Towards approval of the FCC

→ **2013 Update of European Strategy for Particle Physics:**

- *"CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines."*
- ***FCC Conceptual Design Reports (2018/19)***

→ **2020 Update of European Strategy for Particle Physics:**

- *"Europe, together with its international partners, should investigate technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage."*
- ***FCC Feasibility Study leading to Final Report (2021/25)***

→ **2026/28 Next process of Update of European Strategy for Particle Physics:**

- Importance of Feasibility Study documentation and **demonstrators!**

Which demonstrators?

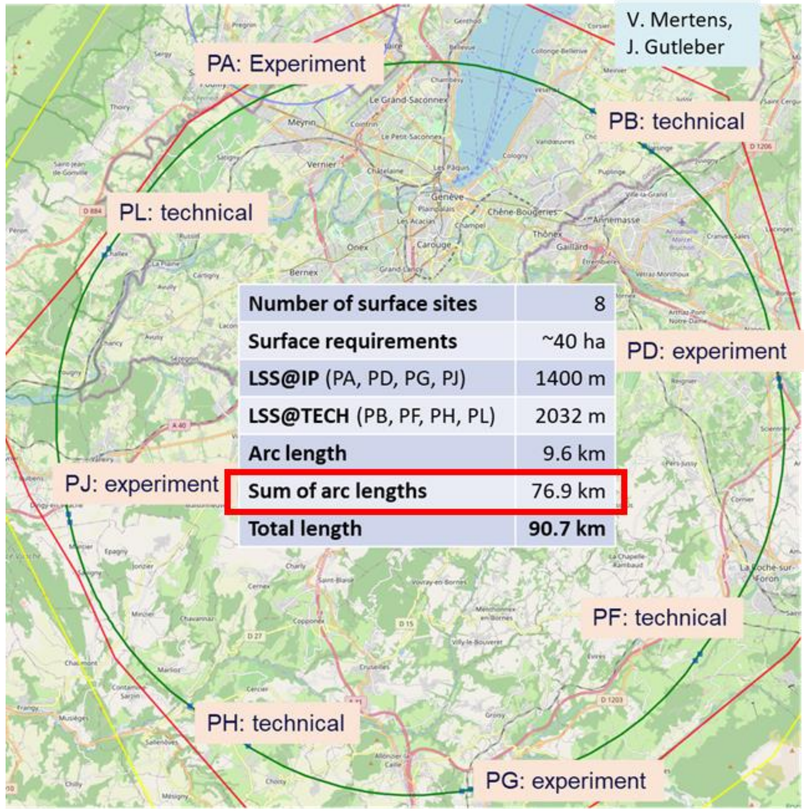
Arc half-cell = most recurrent assembly of mechanical hardware in the accelerator → **77 km** over **90 km** are arc cells (about **85 %**)

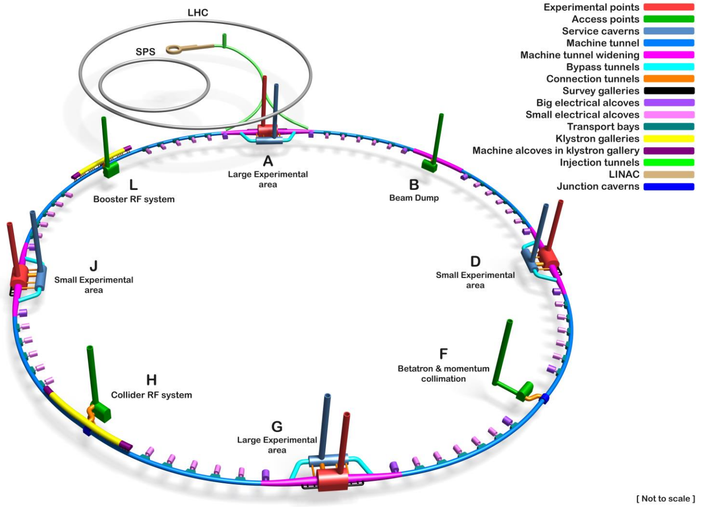
Objectives:

→ **Test aspects** related to:

- Cost
- Integration
- Assembly
- Stability inspection
- Security / Safety
- Transport
- Installation
- Alignment
- Maintenance
- Safety
- Fabrication, machining capabilities for critical components

→**"Visual" driver** for FCC stakeholders, visitors and collaborating researchers





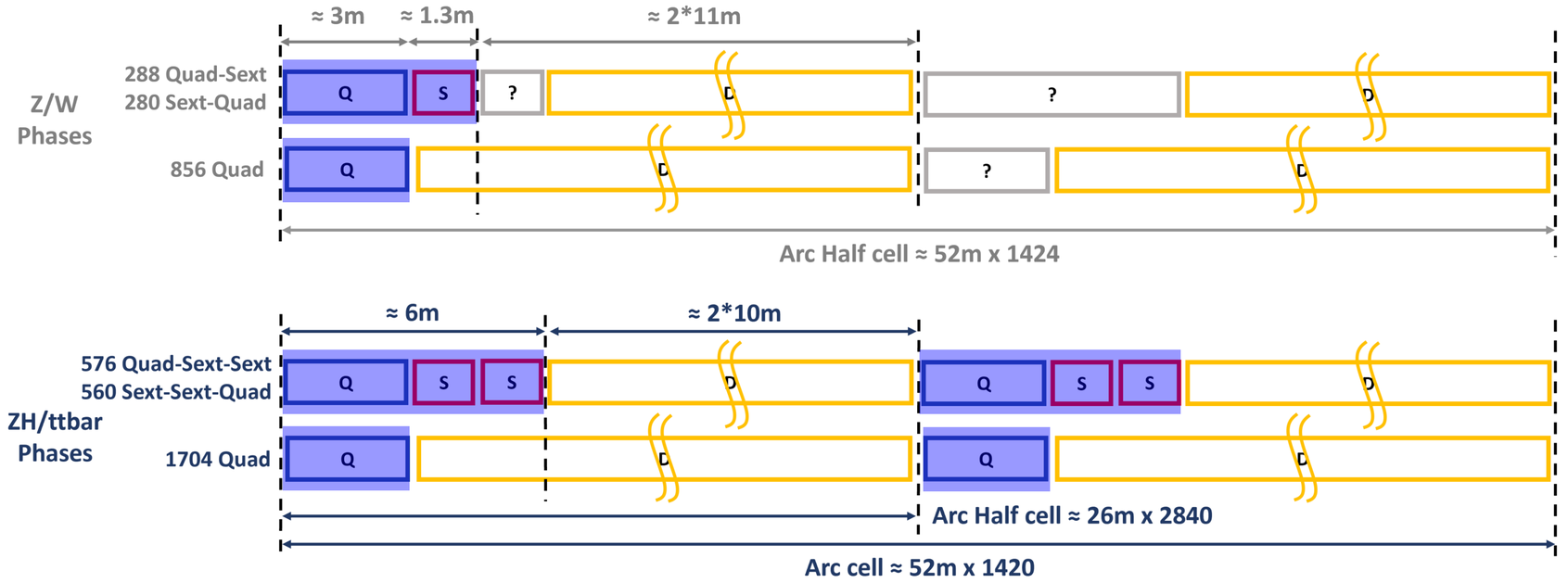
What is an arc half-cell?

For the **current optics baseline** of the collier (GHC optics), the cells are **different** for the **Z/W phases** and the **ZH/ttbar phases**.

An arc half-cell =

+ **Short Straight Section (SSS):** 1 Quadrupole + (0, 1, 2 Sextupoles) + … (correctors, BPM, etc.) → elements standing on a common girder, pre-aligned on the surface. *Length 3 to 6 m*
+ **Dipole region:** obtained by a sequence of dipole. *Length 20 to 46 m*

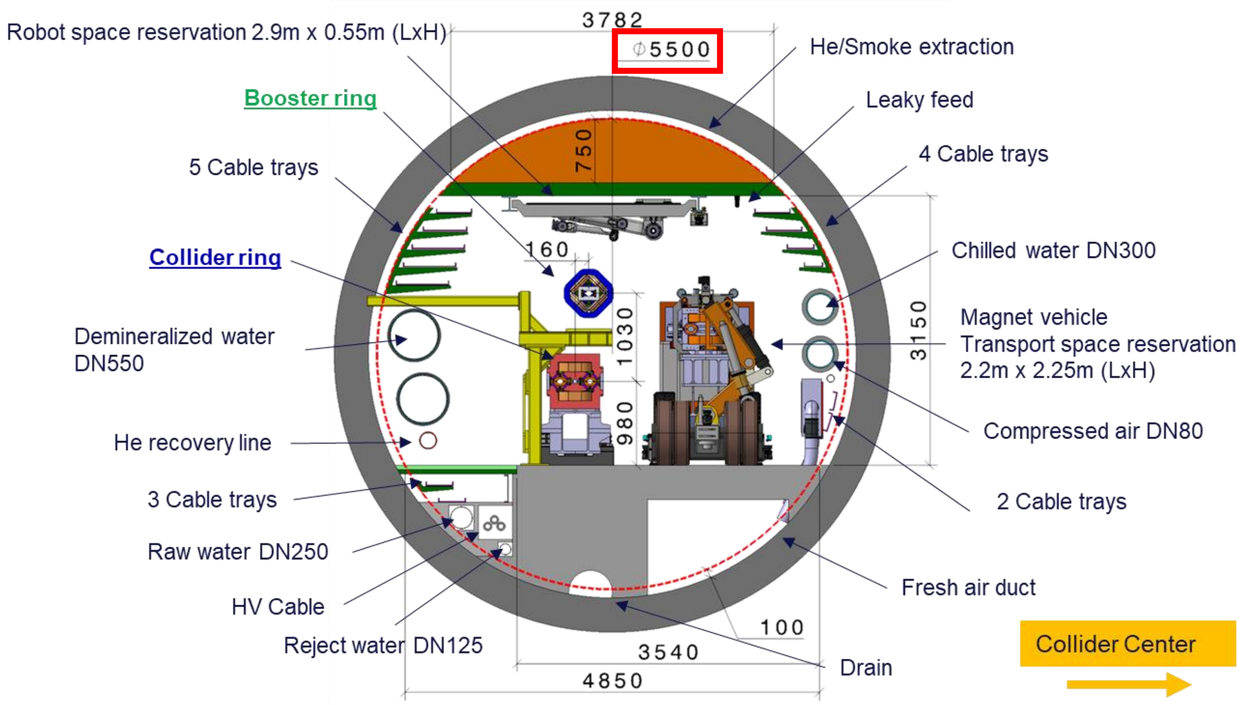
COLLIDER OPTICS

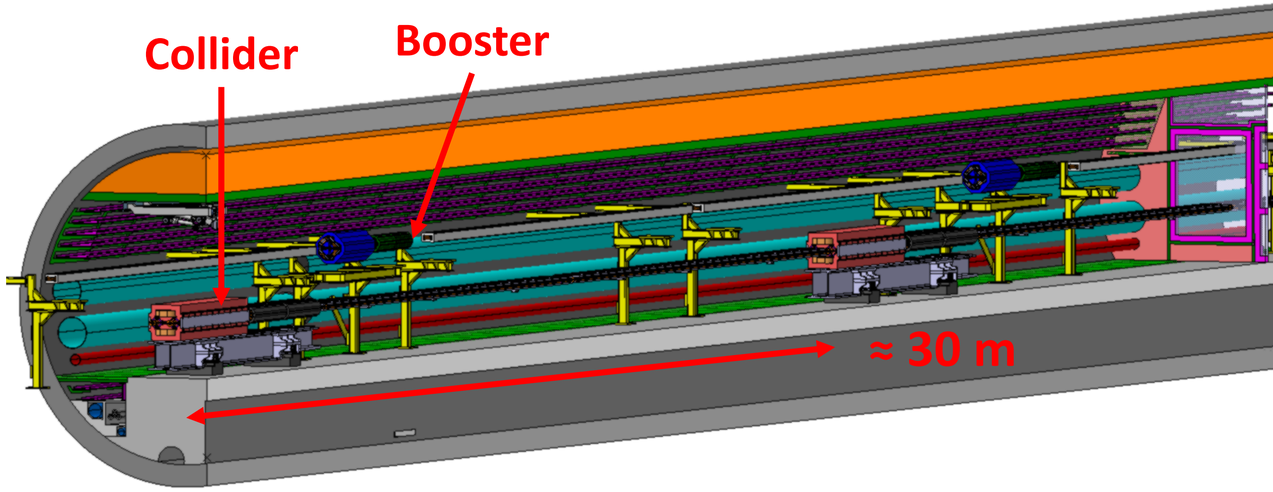


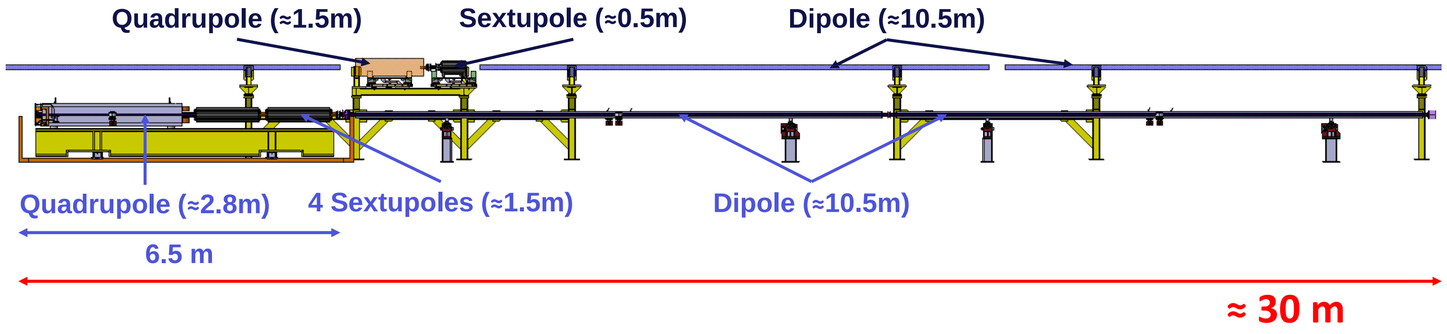
Z/W Phases
Arc half-cell length = 52 m
Unit = about 1500

ZH/ttbar Phases
Arc half-cell length = 26 m
Unit = about 3000

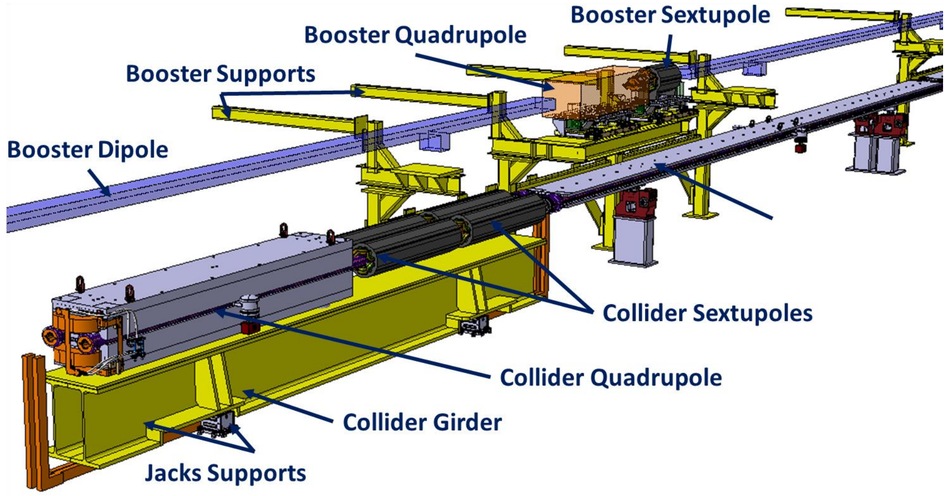
How does an arc half-cell look like?







Short Straight Section = SSS



Courtesy F. Valchkova-Georgieva, M. Timmins, E. Bernard

What about the 1:1 Mock-up?

WHEN?

→ **During 2025:** Installation of the first version of the Mock-up

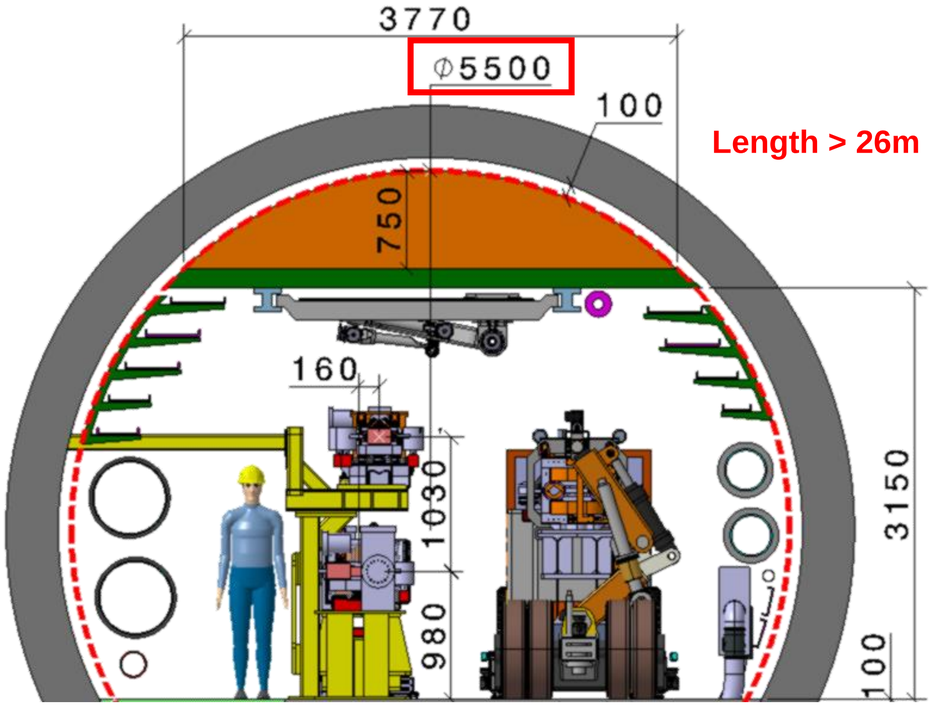
→ **Following years:** Possible evolution of the mock-up

WHY?

Short term objective = A mock-up allowing to test the integration of simplified elements within a short timeframe.

- *Detailed study of the integration of elements*
- *Analysis of access and compatibility with safety requirements*
- *Test of alignment strategy and mechanical stability*

And: outreaching! (“Visual” demonstrator for FCC stakeholders).

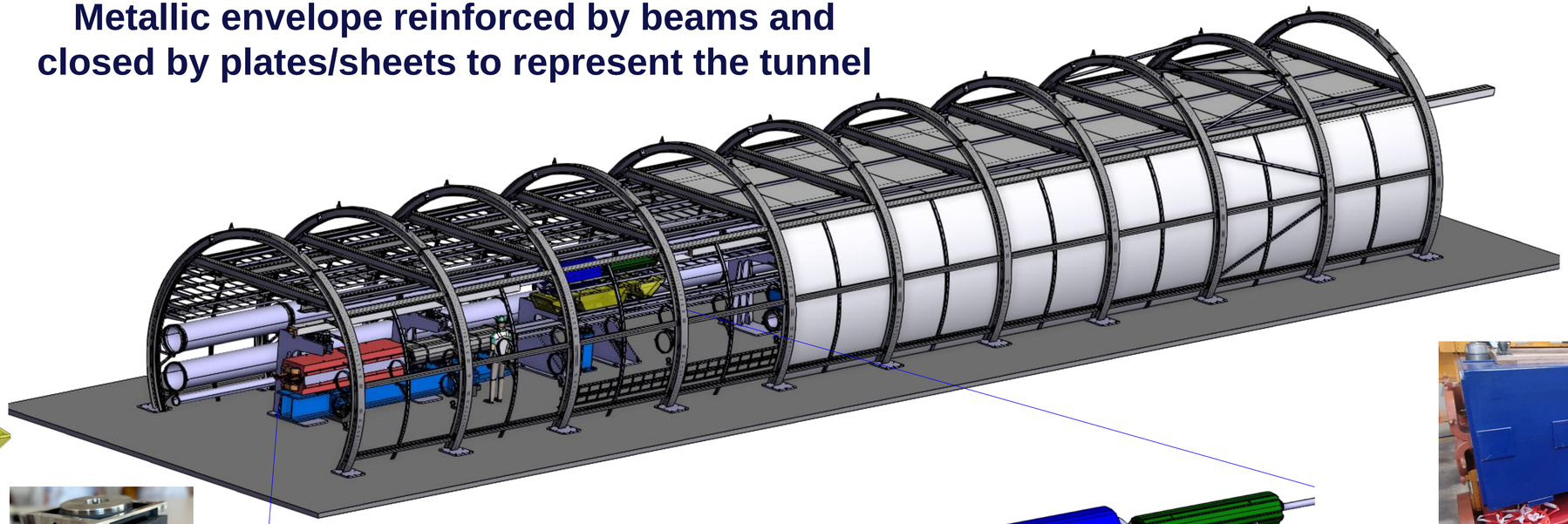


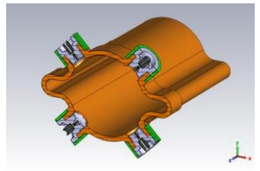
Length > 26m

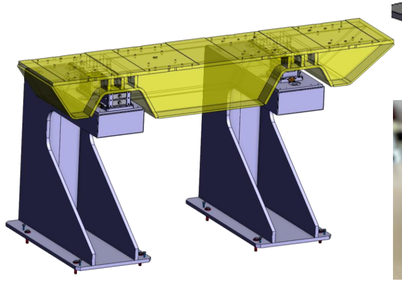
Long term objective = An evolving mock-up allowing **equipment groups to install and test their equipment** → we are designing the envelope and supports to be able to host, in a future, the full-size/weight functional elements

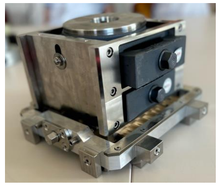
How the 1:1 Mock-up will be built?

Metallic envelope reinforced by beams and closed by plates/sheets to represent the tunnel

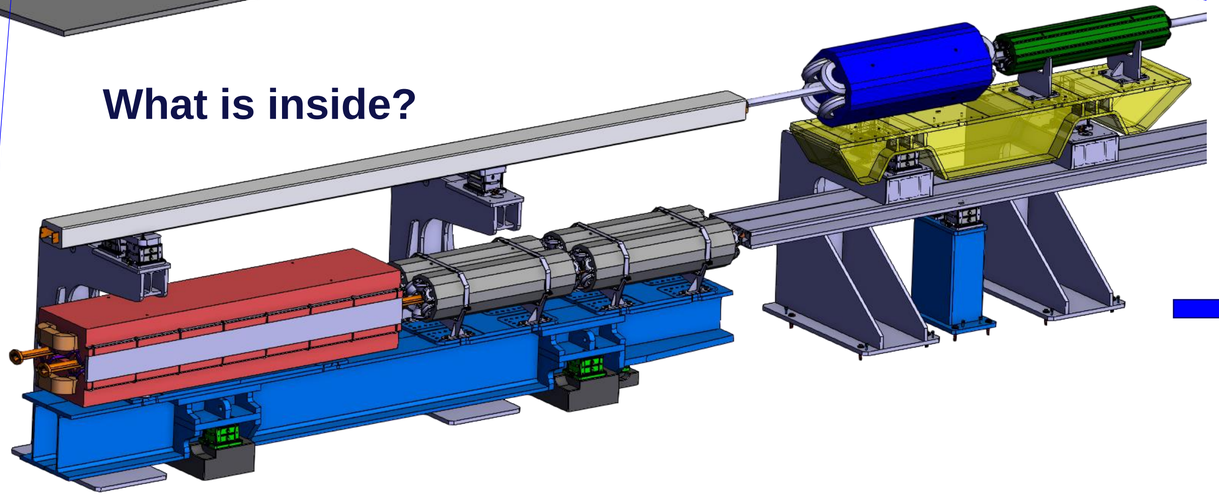




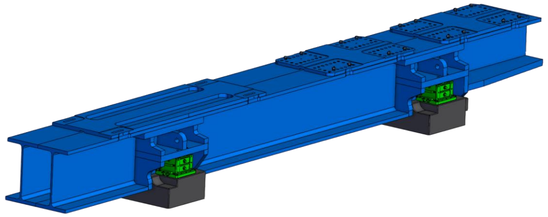


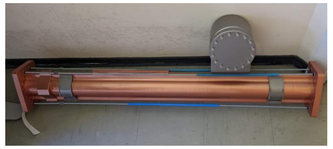


What is inside?



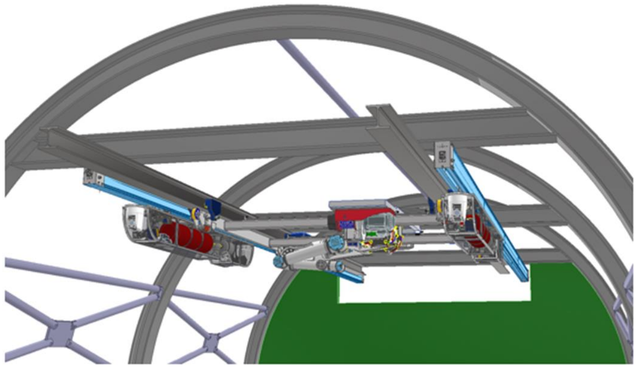
Real supporting systems

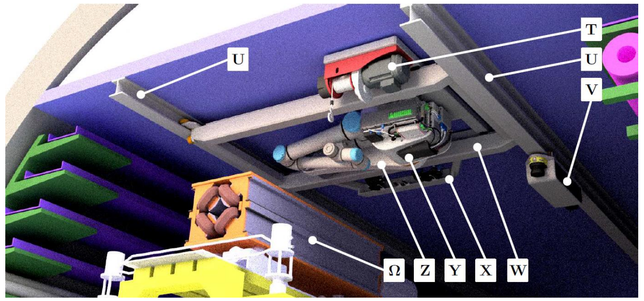




Representative dummy systems that can evolve into prototypes

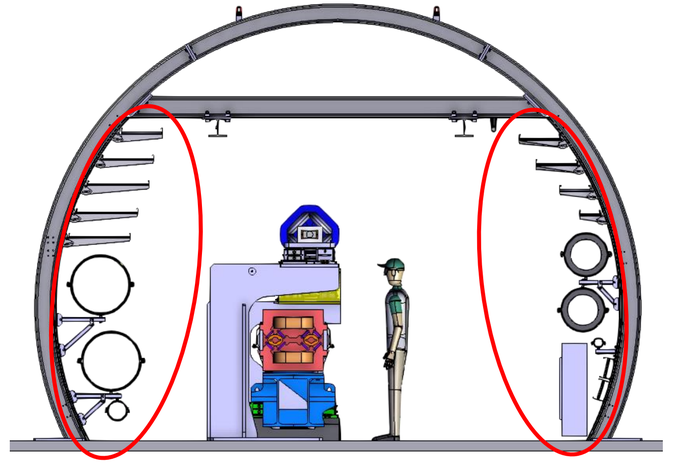
How the 1:1 Mock-up will be built?



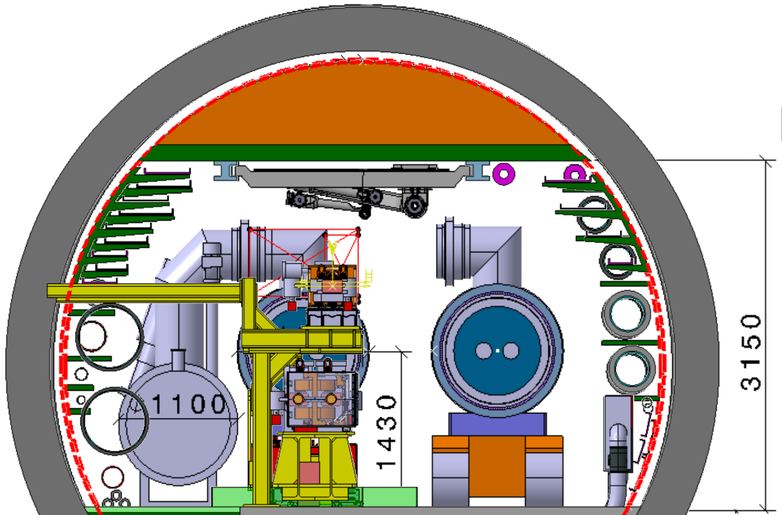


The FCC robot prototype will be installed and will move on two rails (BE/CEM)

Install a fire door to test safety aspects (HSE)



Services like pipes, cable trays will be fixed on the envelope



Use mixed reality to visualise the evolution of FCC-ee from low to high energy phase → FCC-hh

Courtesy M. Rouchouse, H. Gamper, F. Valchkova-Georgieva, F. Carra

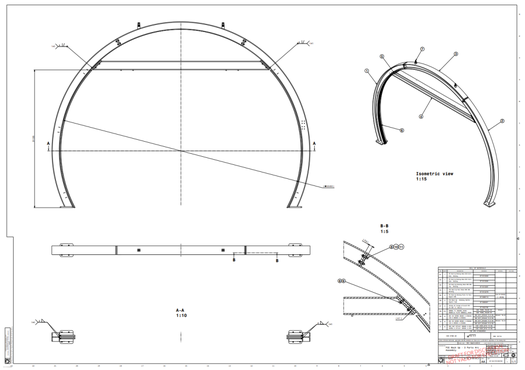
What studies does this 1:1 Mock-up involve?

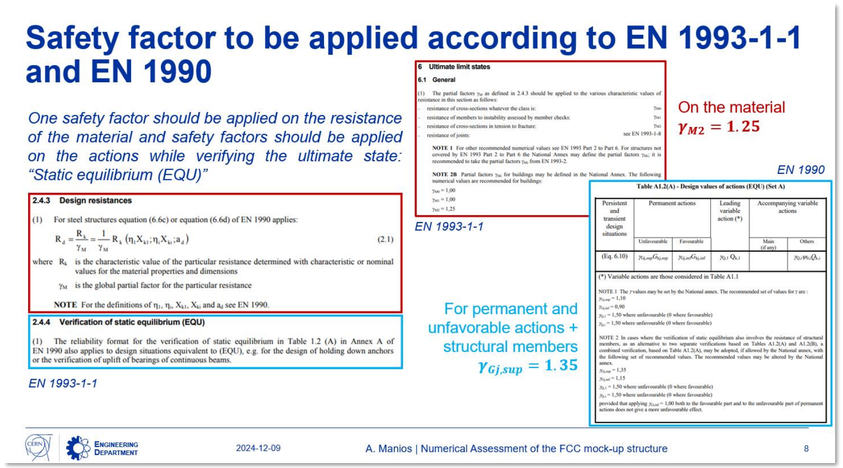
→ **Integration** of the mock-up inside a specific building in Meyrin site
- *Considering the needs of transport and neighbouring building stakeholders is essential.*

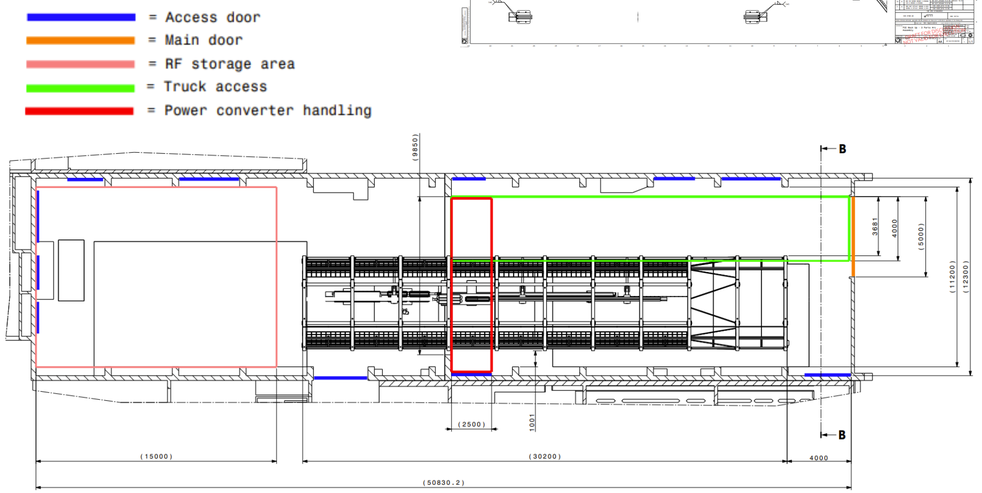
→ **Preparation and renovation works** on the building: *asbestos presence, lead paint, work on slabs, etc.*

→ The whole project is conducted in **collaboration with HSE***
- *Hazard identification (mechanical safety, fire safety, structural safety, working conditions etc.).*
- *Steel structure assessment according to European standards.*

→ Preparation of the **drawings** of the structure and performing all the **orders**.







*Occupational Health & Safety and Environmental Protection

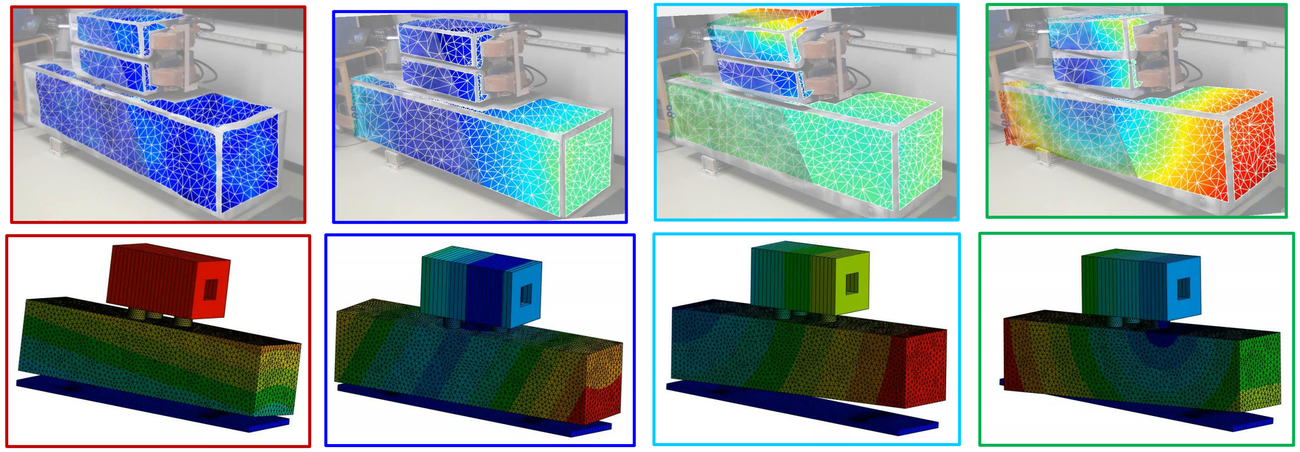
In parallel: a short functional demonstrator

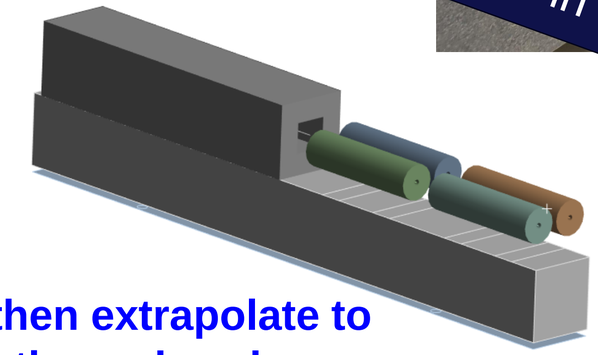
→ **WHY?** To know how the different elements of the SSS affect stability.
Do we have a fundamental problem of **dynamic stability**?
To obtain **first and fast feedback** for the design and at low-cost.

Simulations *can predict the accelerator movement generated by ground motion,*
BUT Experimental benchmarking *is needed to tune simulations (many uncertainties / assumptions!).*

YES, considerable work is required to optimize systems in terms of stability

Validation of the short model (experimental vs numerical results)





To then extrapolate to the real scale

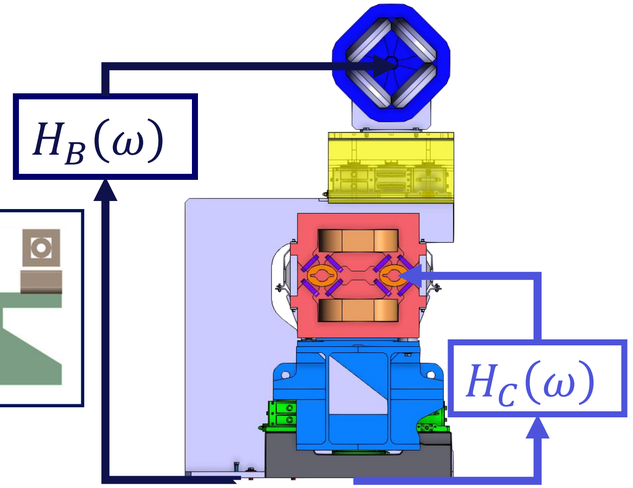
To help optimizing the supporting structures

BOOSTER support

→ *Test / compare different:*

- *Geometries,*
- *Fixations,*
- *Etc.*
- *Height,*
- *Shift,*

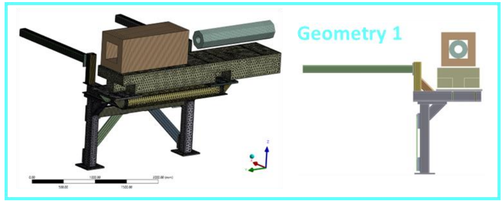
→ **Structural and stability analysis of supports**

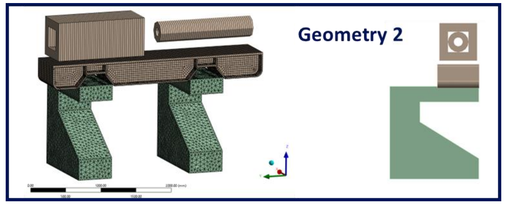


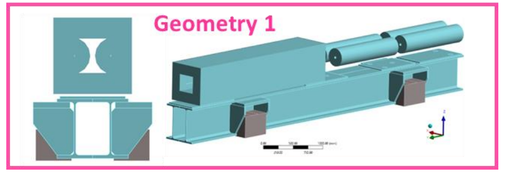
COLLIDER girder

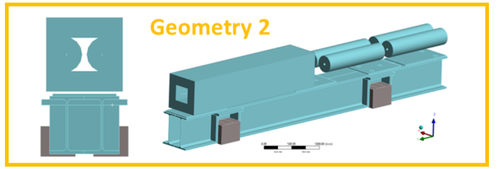
→ *Test / compare different:*

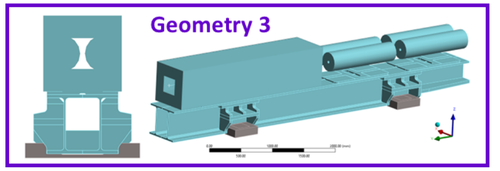
- *Geometries,*
- *Material,*
- *Etc.*
- *Position of jacks,*
- *Number/position of jacks,*

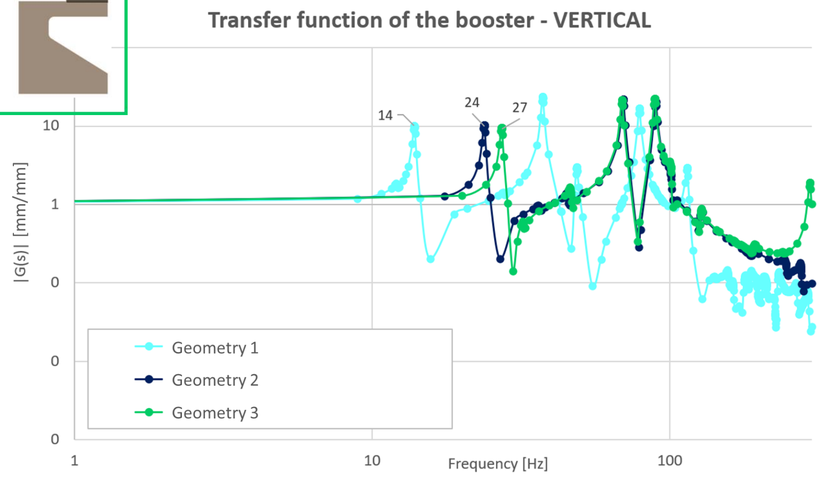


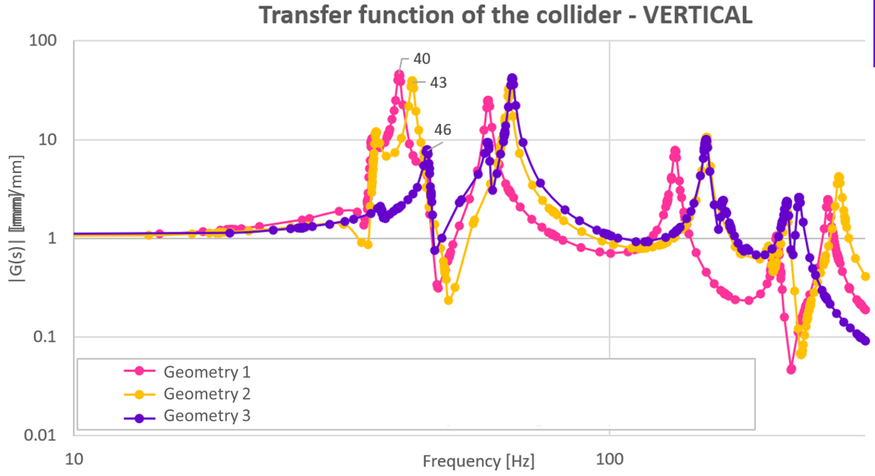












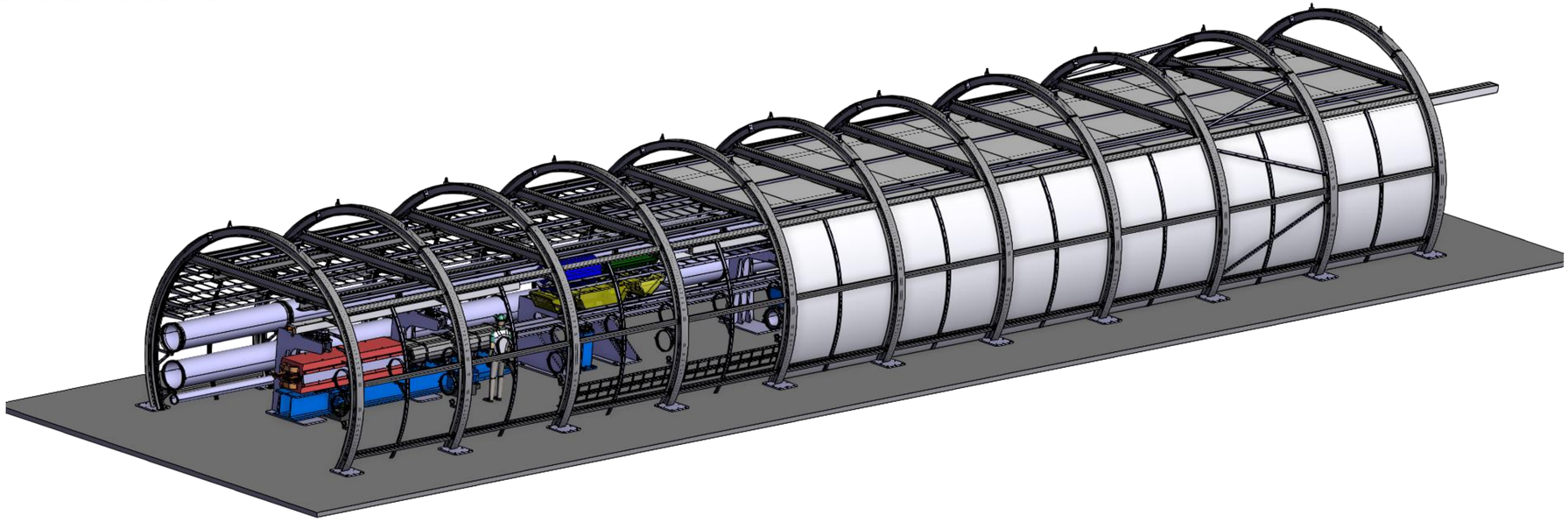
Conclusion

→ One of the important goals of the Feasibility Study is the **Mock-up of the arc half-cell** for FCC-ee.

→ The design of **the mock-up structure** is finalized, and we are now ordering the different part for manufacturing, to prepare its installation.

→ The **optimisation design studies** for the supporting structure account for a significant part of our work.

→ These optimisation studies are completed by the **experimental campaign** allowing us to identify where to invest our efforts.



Thank you for your attention!