FUTURE CIRCULAR COLLIDER

Integration work for the 1:1 Mock-up

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

M. Rouchouse

With F. Carra, A. Piccini, A. Manios, M. Timmins, E. Bernard, P. Catherine, Y. Grislain, J. Coupard, J. Bossy

ACTEMIUM

Friday 6th December 2024

EDMS : 3204871

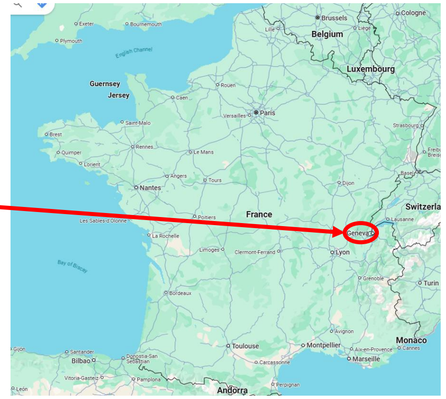
Who am I ?

Melvyn Rouchouse

25 years

French

From Geneva



2017 - 2020

Bachelor’s degree as mechanical designer in Annecy

2021 - 2023

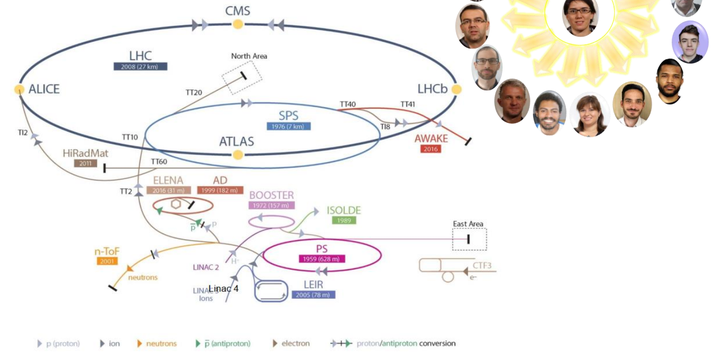
3 years at CERN in Septa section (**SY-ABT-SE**) as mechanical designer for electrostatic magnets

Since January 2024

Working for the integration of FCC Mock-Up and SPS

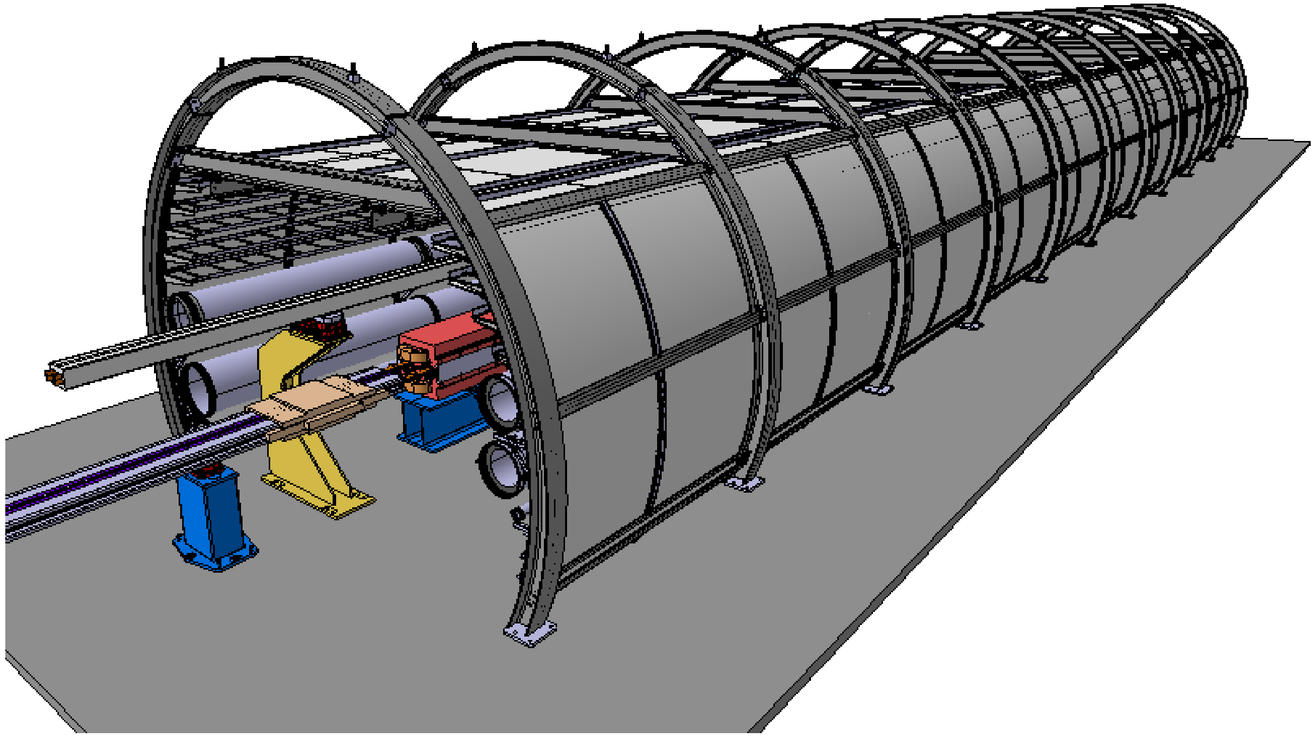
Integration Office

CERN's Accelerator Complex

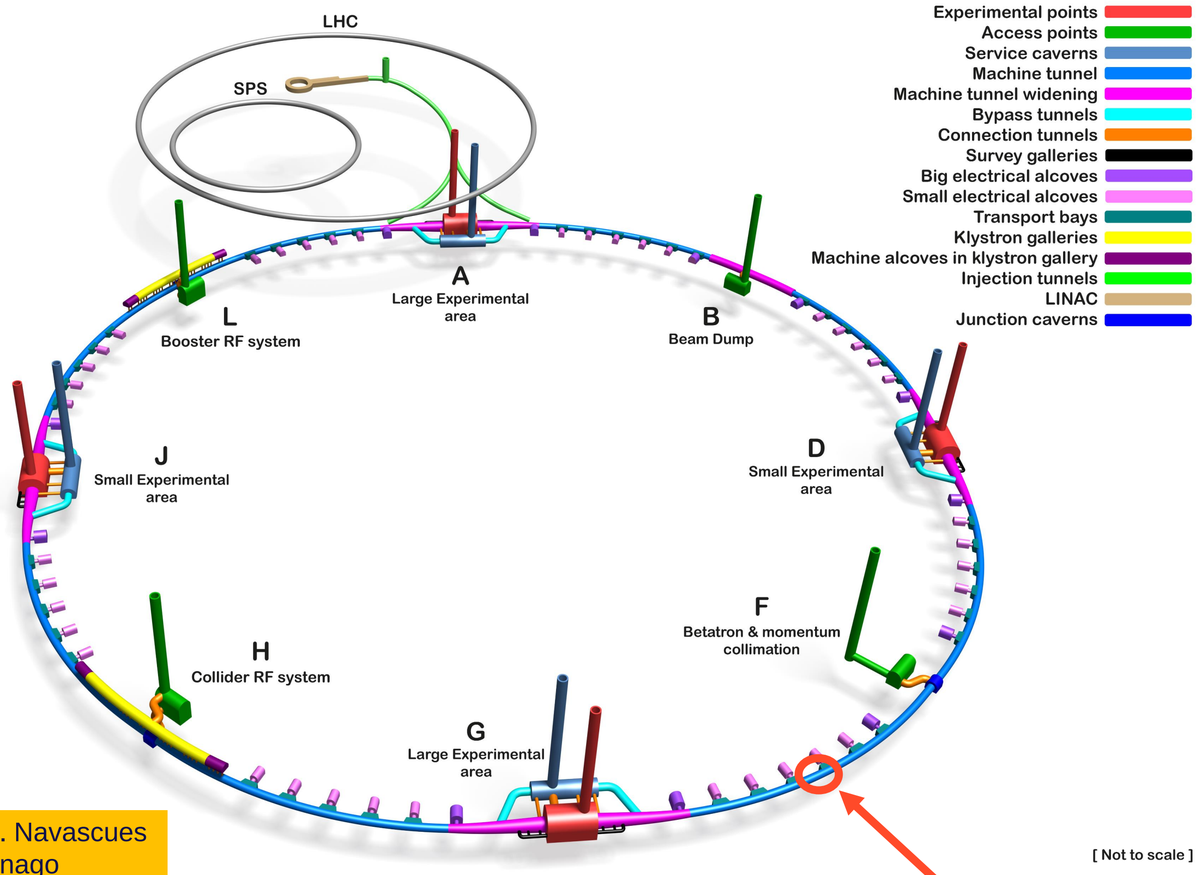


Outline

- FCC – Arc Half-Cell
- Mock-up dimensions
- Mock-up Structure + Collider / Booster
- Mock-up : Fire door
- Integration in building 355-358
- Future : Mixed reality
- Conclusion



FCC – Arc Half-Cell



Courtesy A. Navascues Cornago

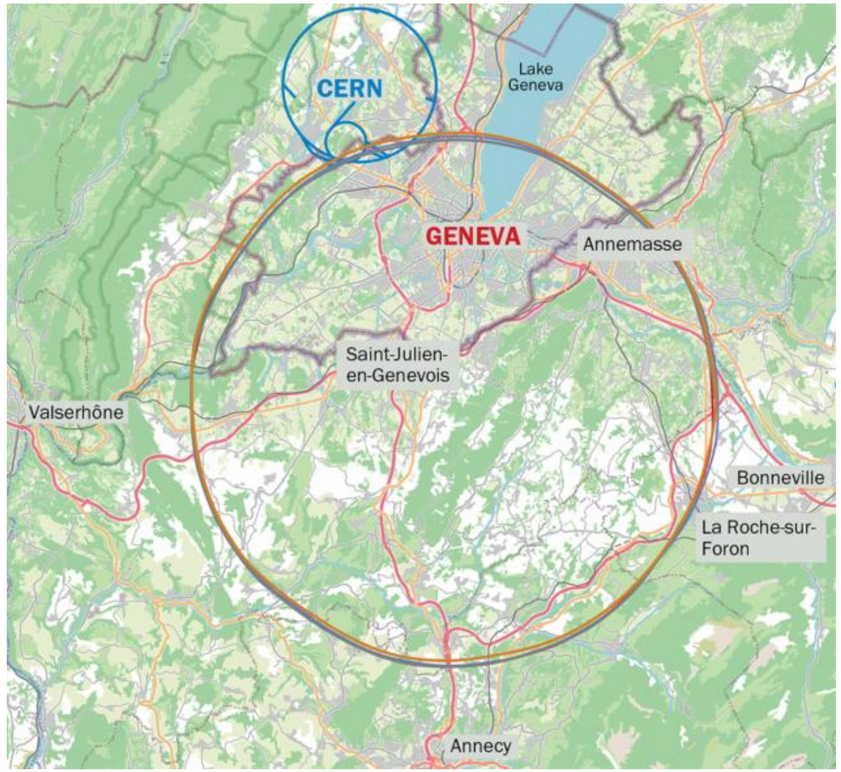
Only schematic, and not to scale.

https://www.youtube.com/watch?v=Uvq8vF5LKzM

https://home.cern/science/accelerators/future-circular-collider

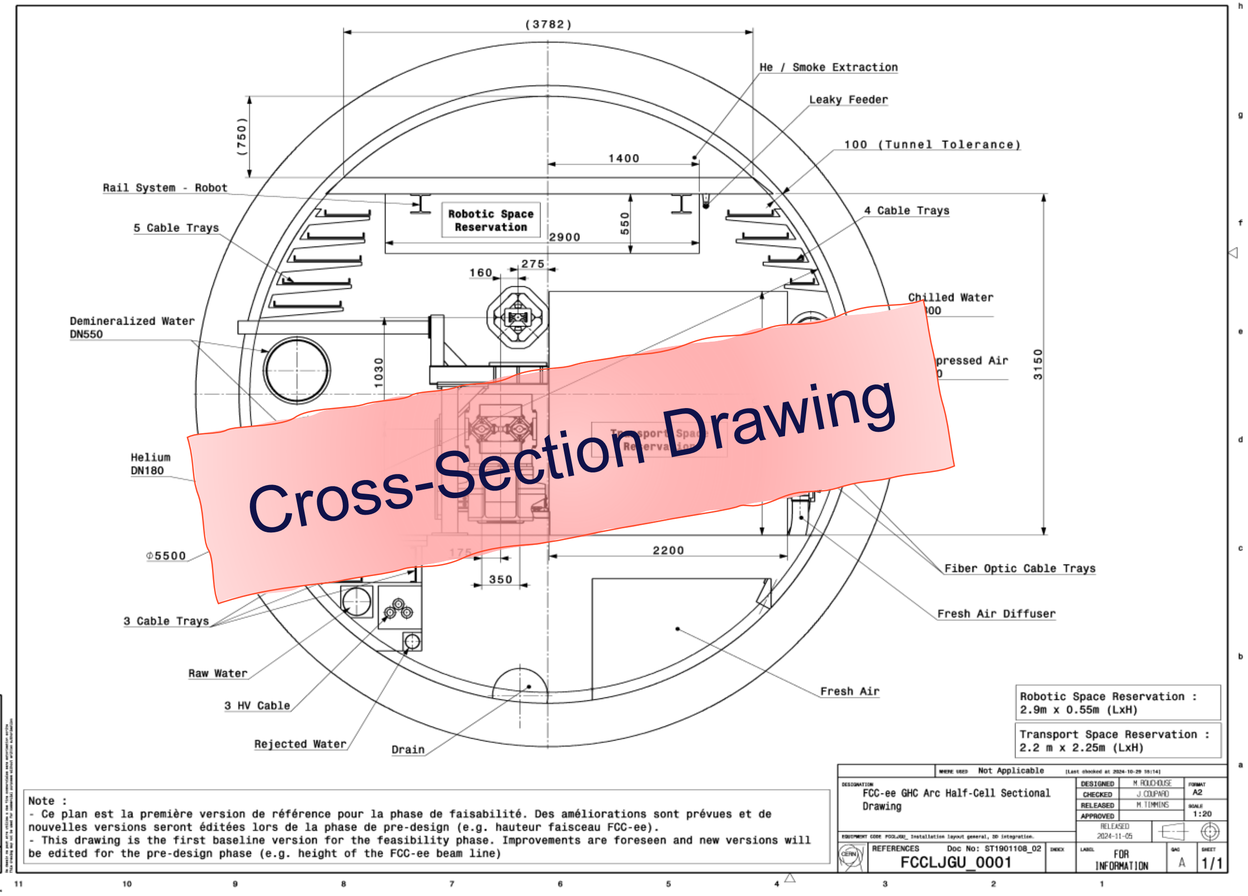
Focusing on only 30 m of the accelerator

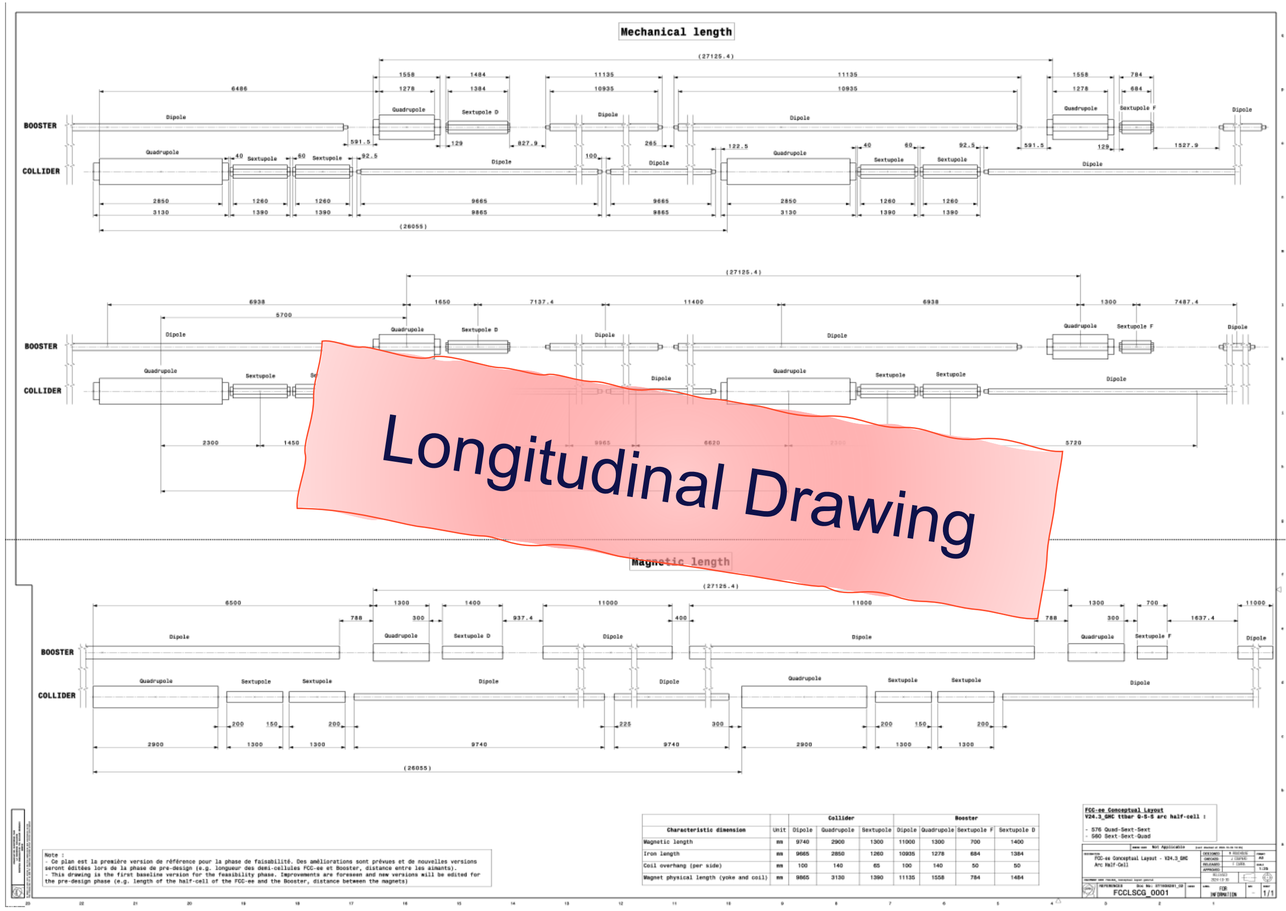
- **F**uture **C**ircular **C**ollider : A CERN project to build a **91km** circular accelerator to explore much higher energies than the LHC



Dimensions of the Mock-up

→ Release of the two drawings: **baseline definition for the arc**, approved by FCC management





FCC-ee GHC Arc Half-Cell Sectional Drawing | Document FCCLJGU_0001 (v.0) (cern.ch)

FCC-ee Conceptual Layout - V24.3_GHC Arc Half-Cell | Document FCCLSCG_0001 (v.0) (cern.ch)

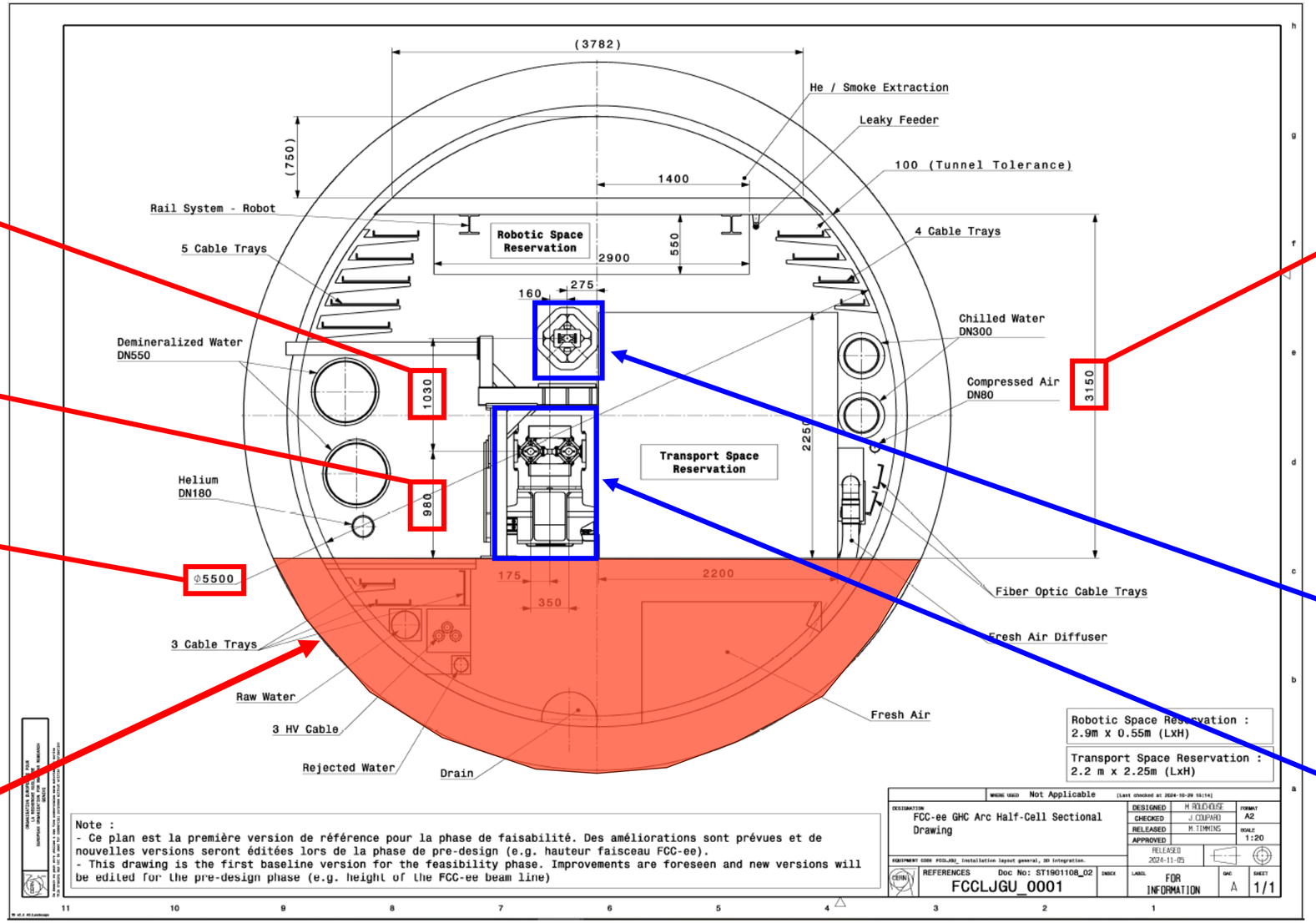
FCC-ee GHC Arc Half-Cell Sectional Drawing

1030 mm

980 mm

Ø5500 mm

Will not be part of the mock-up



3150 mm

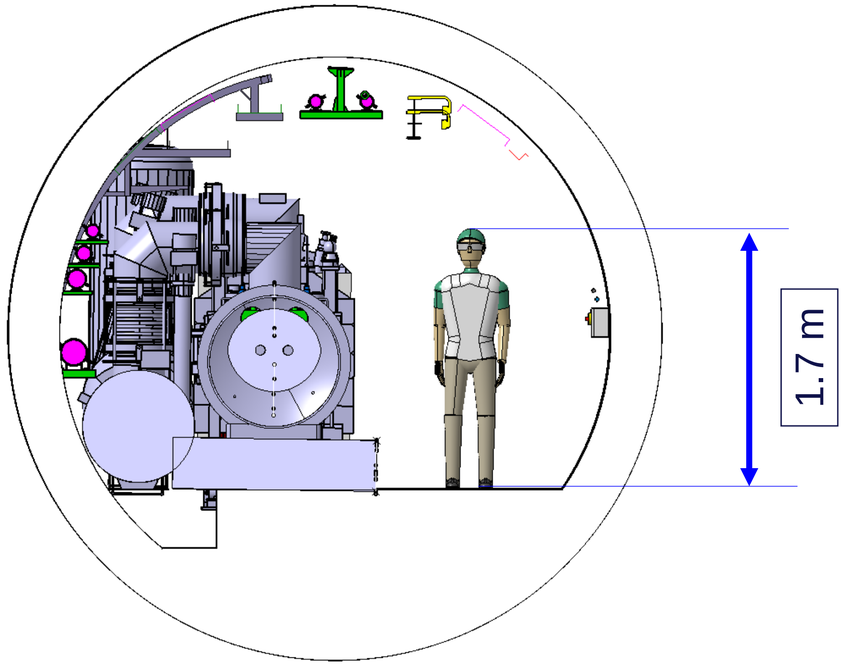
Baseline approved 05-11-2024

Booster line

Collider line

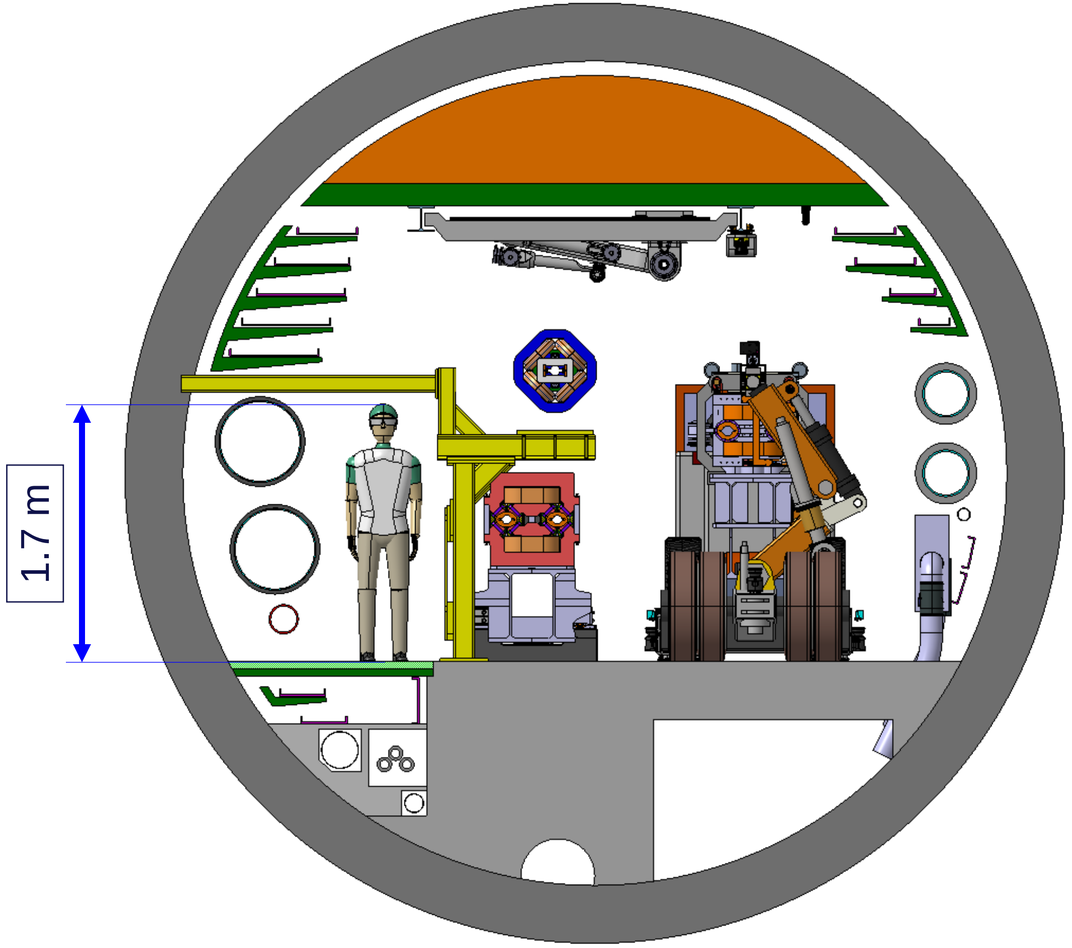
Comparison between LHC and FCC

LHC



Diameter 3.8m

FCC



Diameter 5.5m

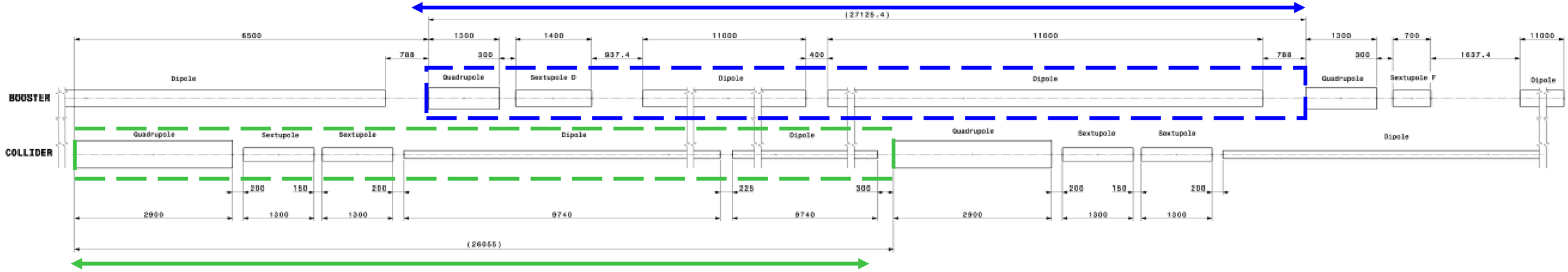
Longitudinal Drawing

Based on FCCLSCG_0001 (v.0)

Magnetic length

Half-Cell **Booster**

27125 mm



26055 mm

Half-Cell **Collider**

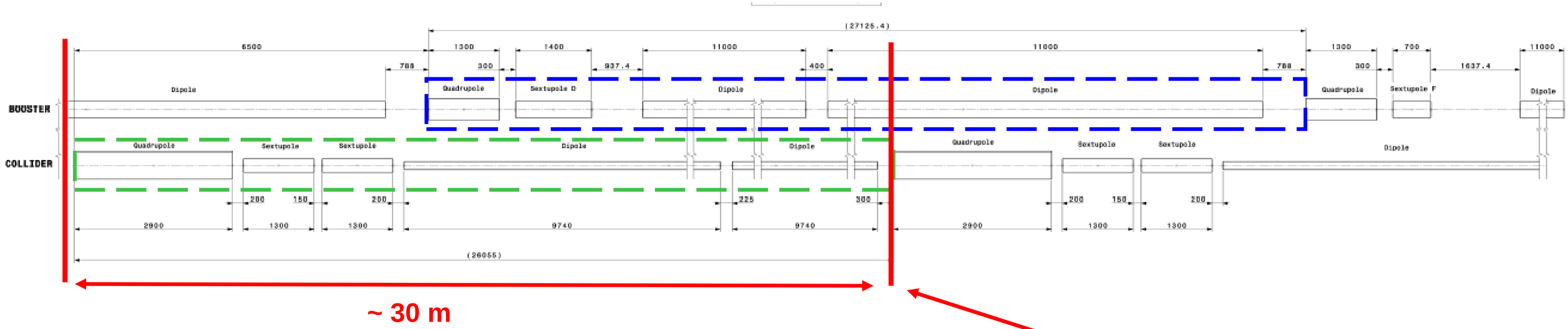
Both length have to be similar for a perfect repetition

Still under study with Optic team

Longitudinal Drawing

Based on FCCLSCG_0001 (v.0)

Magnetic length

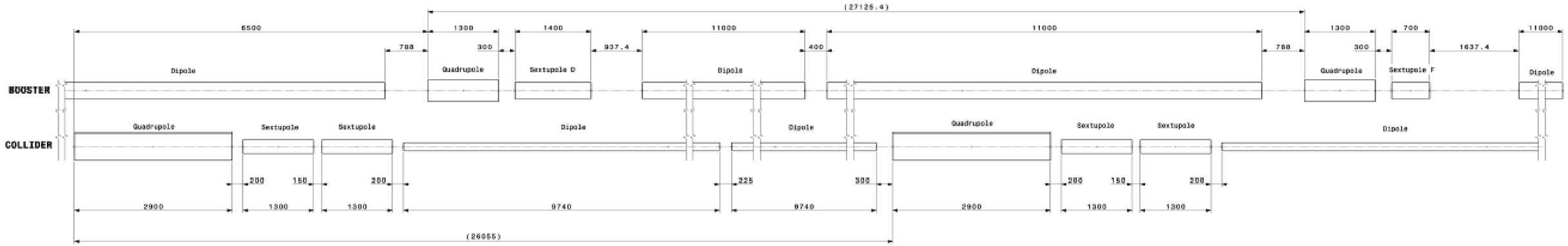


~ 30 m

To be included in the mock-up

Longitudinal Drawing

Magnetic length from optic



name	type	dcum	length	dcum_rel
start		12400.95009		
			0.3000	
U.QD1.1	quadrupole	12401.25009		0.30000
D.QD1.1	quadrupole	12404.15009	2.9000	3.20000
			0.2000	
U.SD38.1	sextupole	12404.35009		3.40000
D.SD38.1	sextupole	12405.65009	1.3000	4.70000
			0.1500	
U.SD38.2	sextupole	12405.80009		4.85000
D.SD38.2	sextupole	12407.10009	1.3000	6.15000
			0.2000	
U.B1S.140	rbend	12407.30010		6.35001
D.B1S.140	rbend	12427.00547	19.7054	26.05538
			0.3000	
U.QF2.1	quadrupole	12427.30547		26.35538
D.QF2.1	quadrupole	12430.20547	2.9000	29.25538
			1.7000	
U.B1L.36	rbend	12431.90547		30.95538
D.B1L.36	rbend	12453.06084	21.1554	52.11075

Collider Magnetic Lengths

Will be used to define mechanical length and position

Cell 336	NAME	KEYWORD	S	S_relatif	L
	Start		89019.48314	0	
		drift			0.788
QD2	U.MQD2.A8.336	quadrupole	89020.27084	0.7877	
	D.MQD2.A8.336	quadrupole	89021.57084	2.0877	1.3
		drift			0.3
SD1	U.MSD1.A8.336	sextupole	89021.87084	2.3877	
	D.MSD1.A8.336	sextupole	89023.27084	3.7877	1.4
		drift			0.93769
	U.MB.A8.336A	sbend	89024.20853	4.72539	
	D.MB.A8.336A	sbend	89035.20853	15.72539	11
		drift			0.4
	U.MB.A8.336B	sbend	89035.60853	16.12539	
	D.MB.A8.336B	sbend	89046.60853	27.12539	11

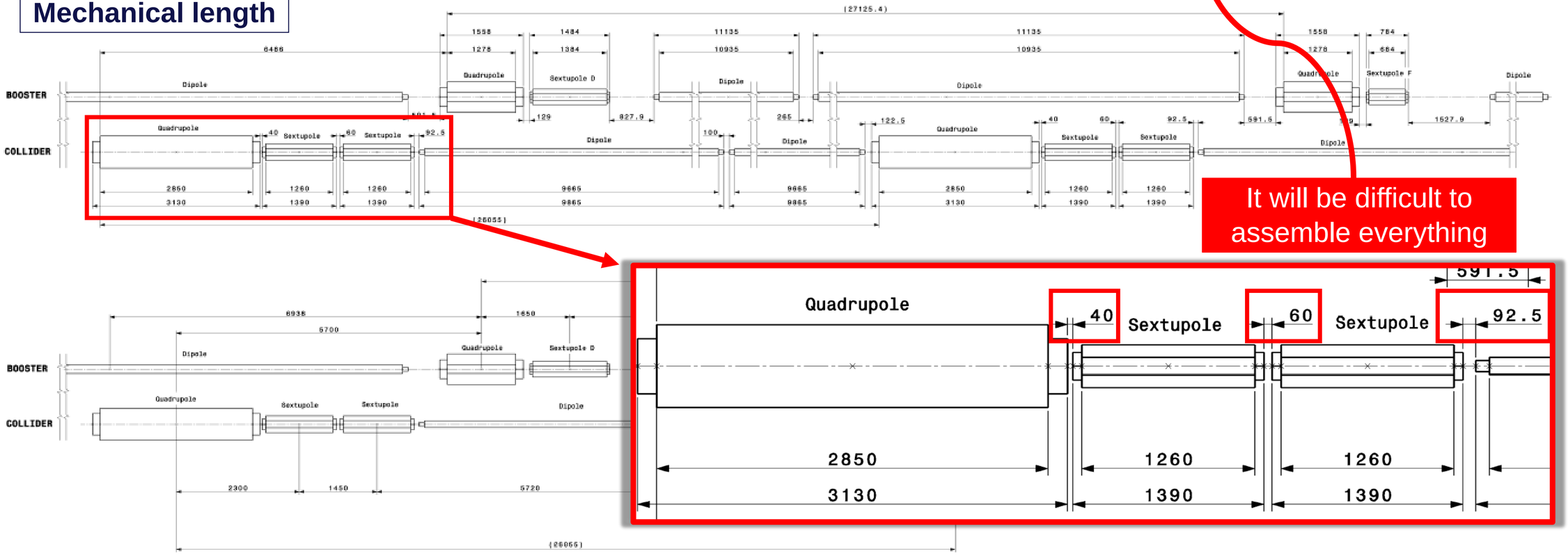
Booster Magnetic Lengths

Longitudinal Drawing

Magnetic length used to create the mechanical length

To be defined between optic and magnetic teams

Mechanical length

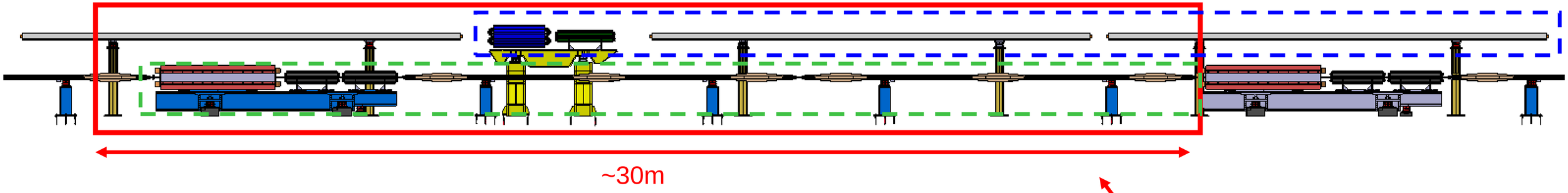


Longitudinal Drawing

Based on FCCLSCG_0001 (v.0)

Half-Cell Booster

Half-cell Collider



~30m

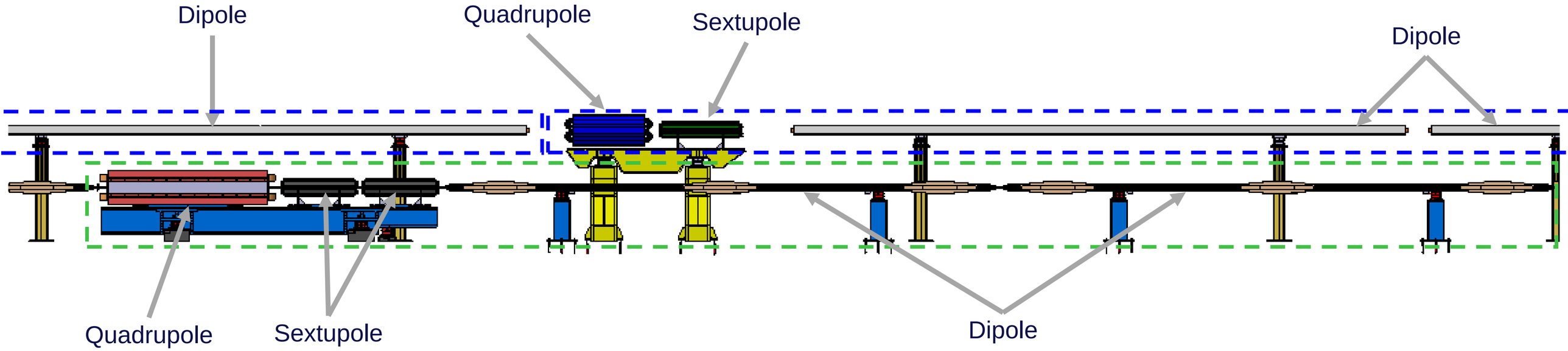
To be included in the mock-up

Longitudinal Drawing

Based on FCCLSCG_0001 (v.0)

Half-Cell Booster

Half-cell Collider



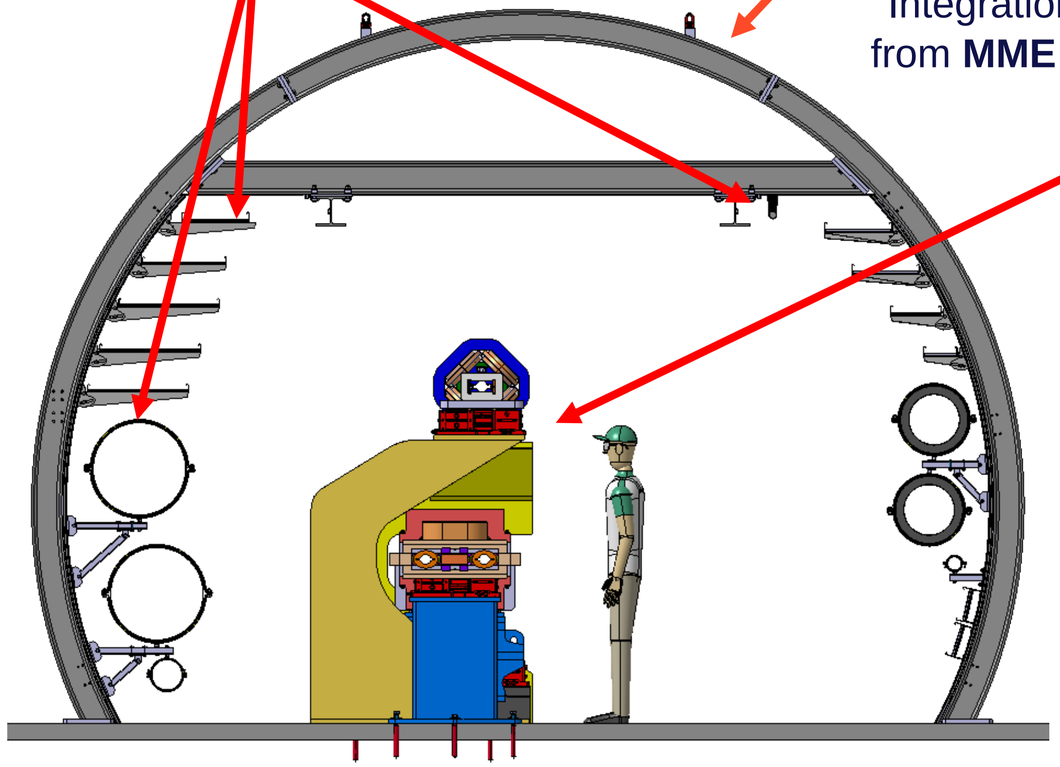
~ 30m

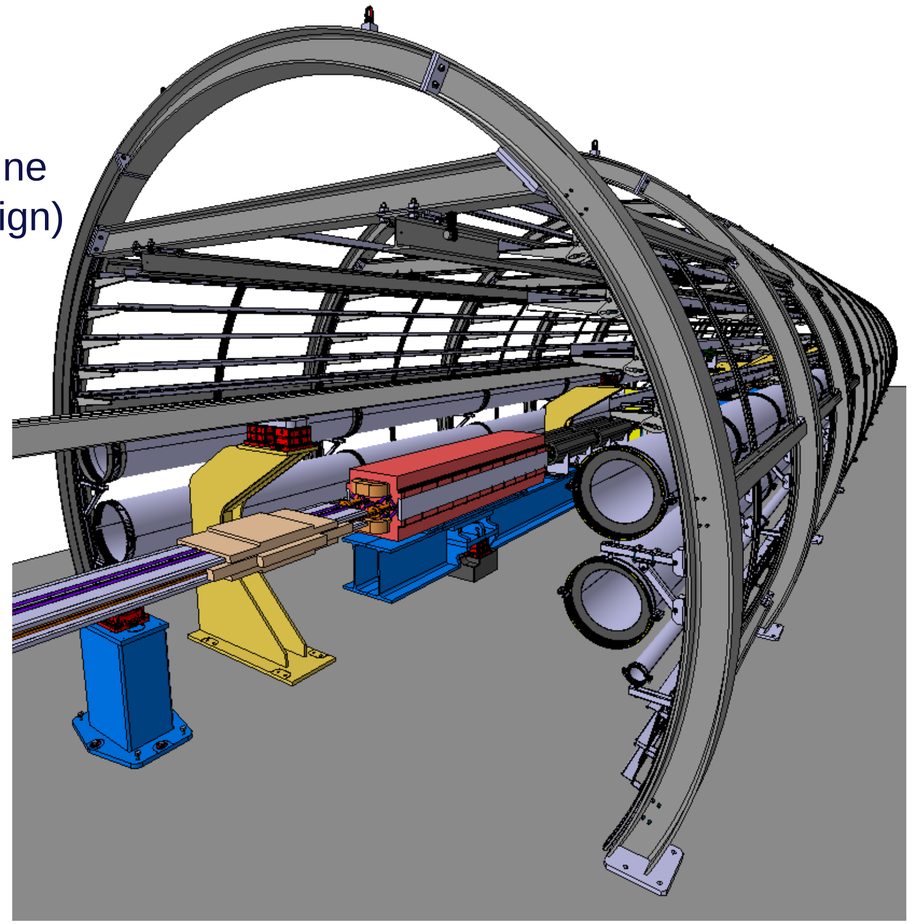
Mock-Up Structure + Collider/ Booster

Integration of cable trays and cooling system (services)

Design of the mechanical structure

Integration of the Collider and Booster line from **MME design study** (still under design)





Latest design

Other Mock-up Ideas

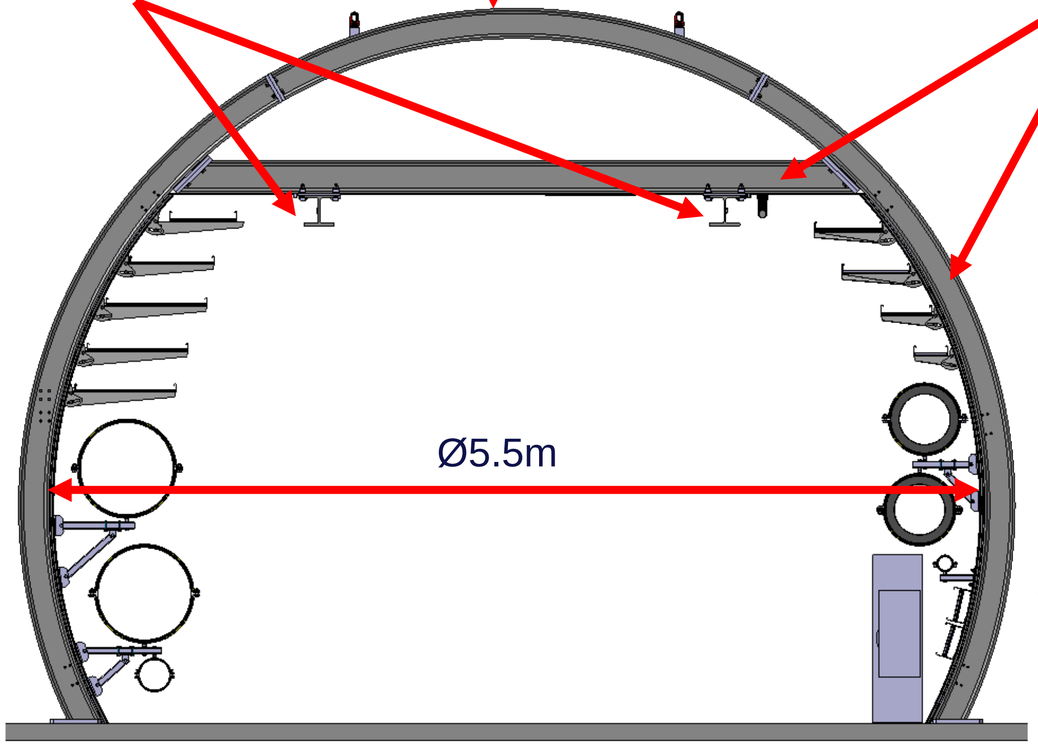
BE-CEM LHC Mock-up (Building 927)

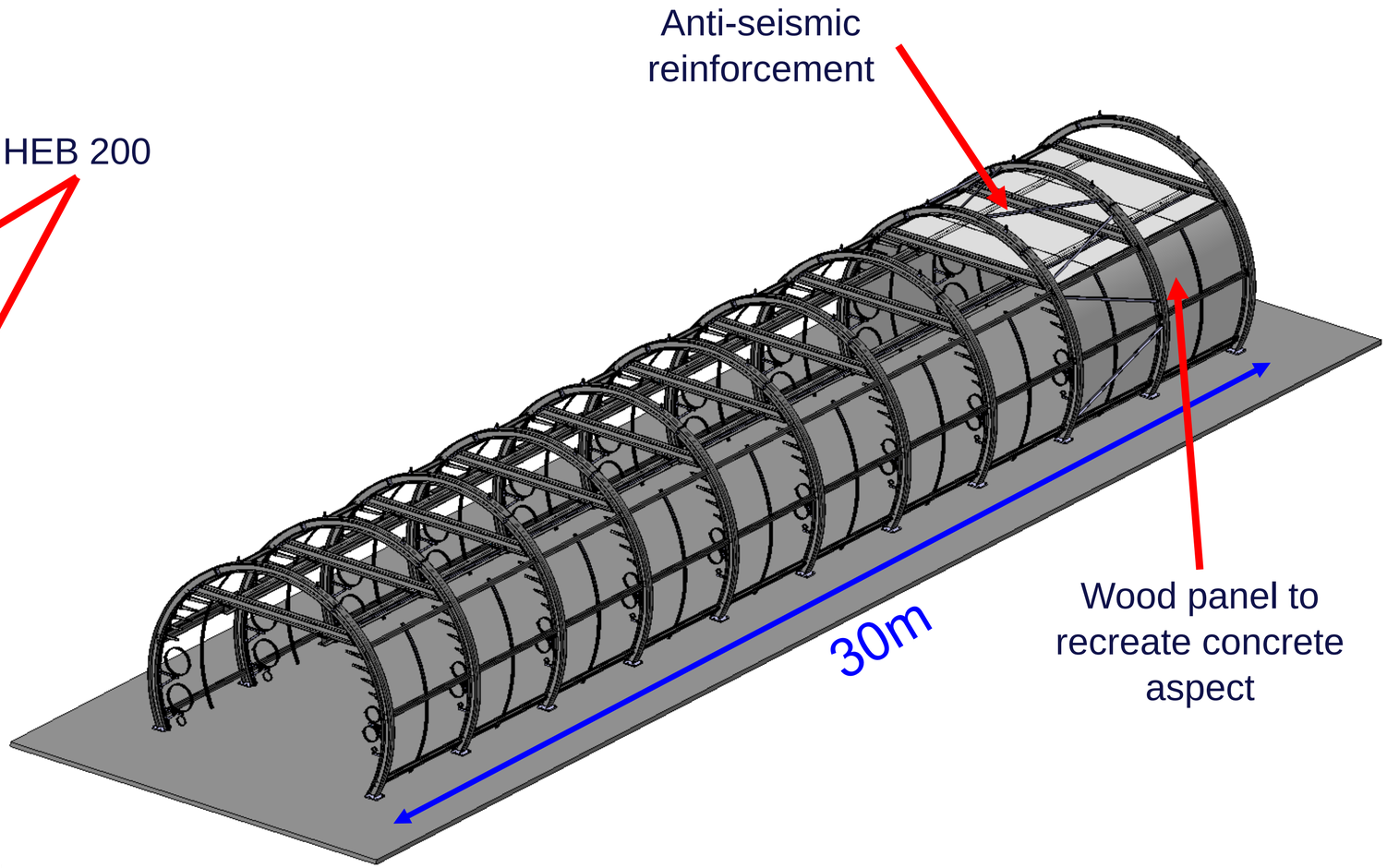
Similarities with our mock-up

Diameter (~4m) and length

ELISA – Science Gateway

Mock-Up Structure

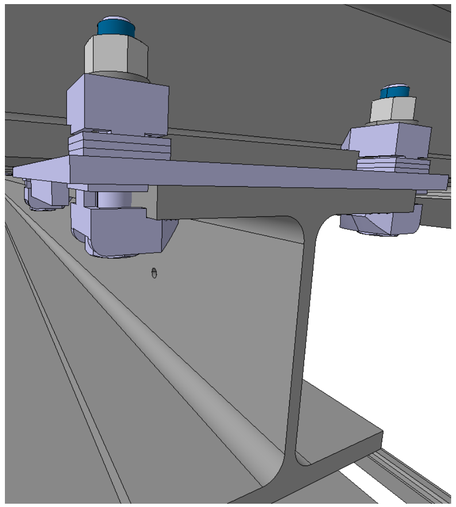




Work done with Audrey Piccini / Alexandros Manios (EN-MME) and Pascal Catherine / Yannick Grislain (EN-ACE)

Mock-Up Structure

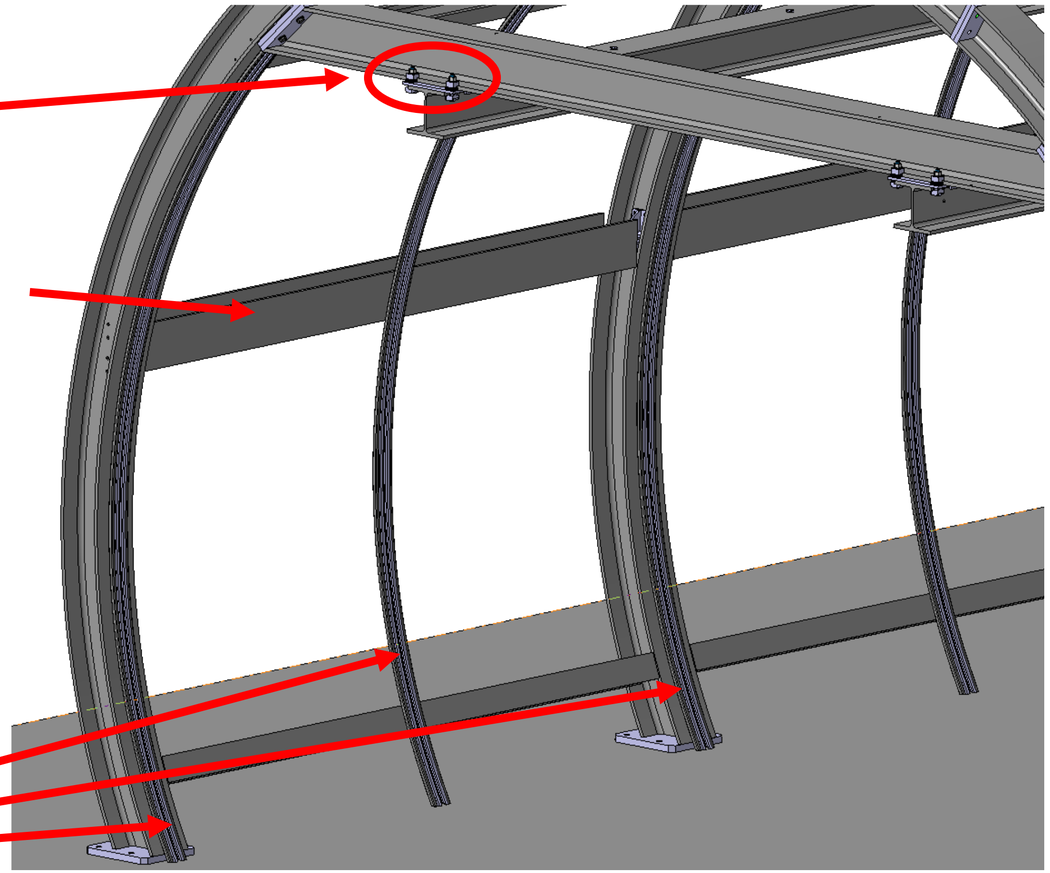
Clamping system

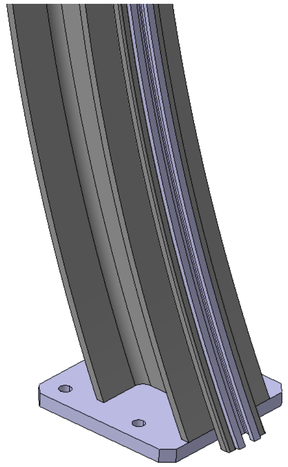


Allows modularity

HEB 140 for booster support fixation, between every arc

Allows modularity

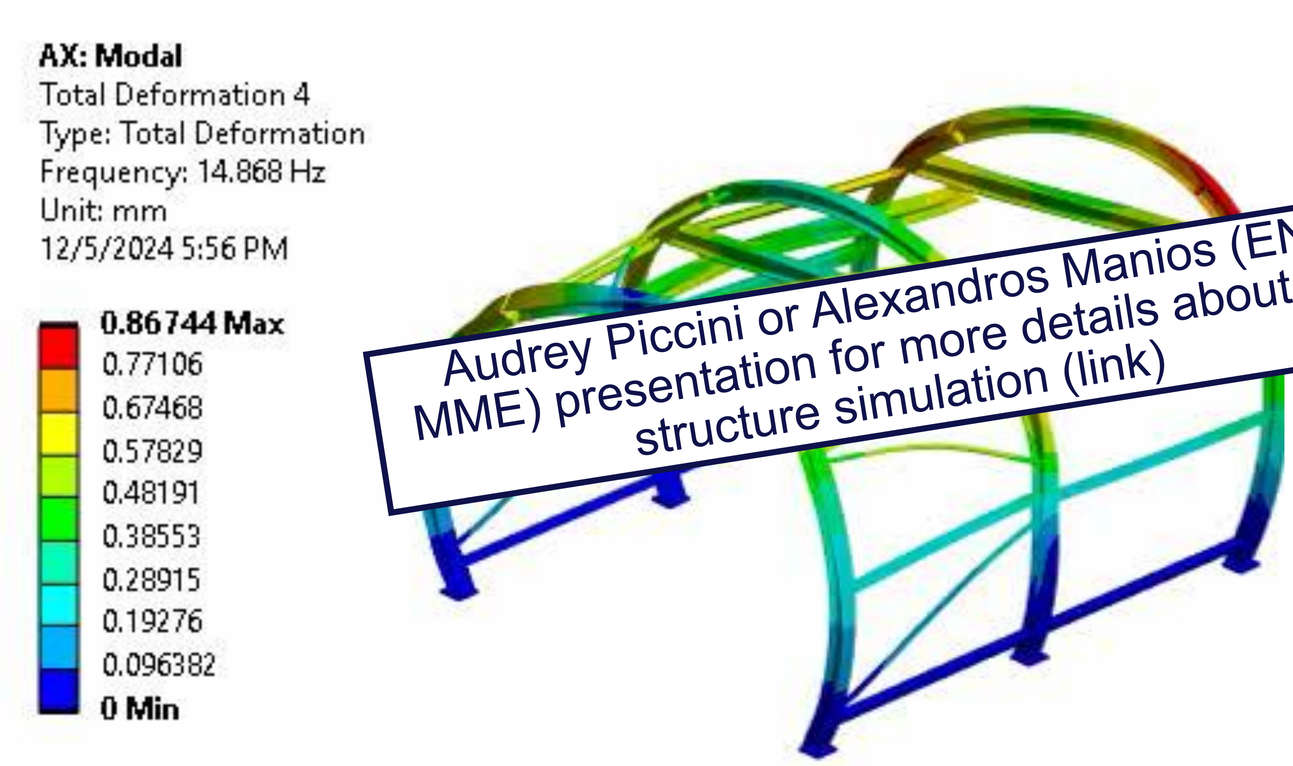




Halfen rail every 1.5m → Allows modularity

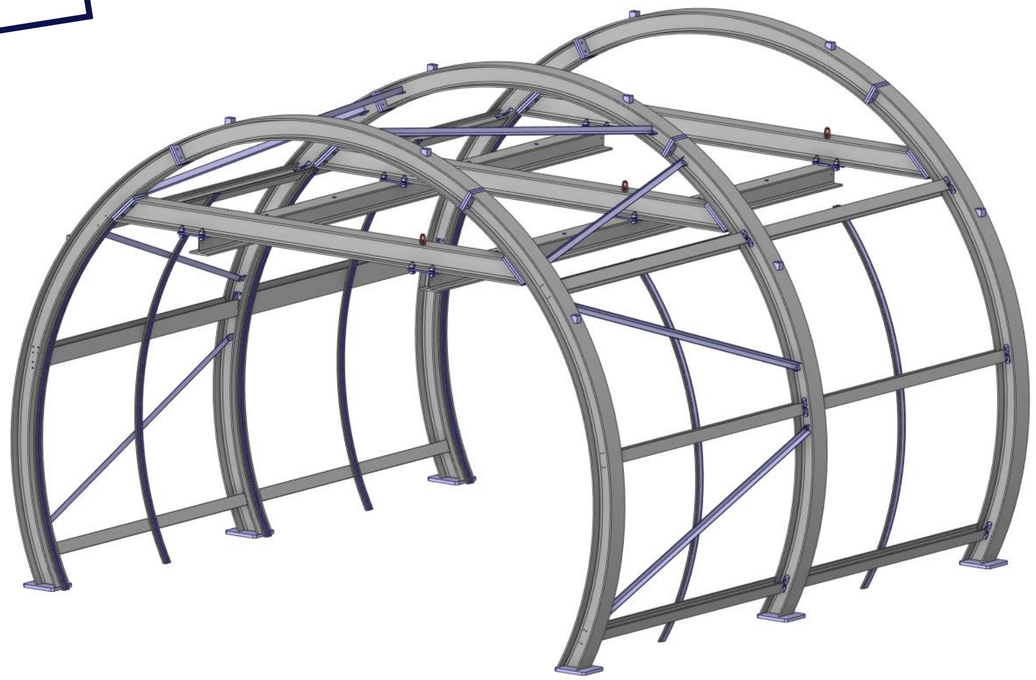
Modularity to anticipate future evolution

Example of the mock-up structure simulation



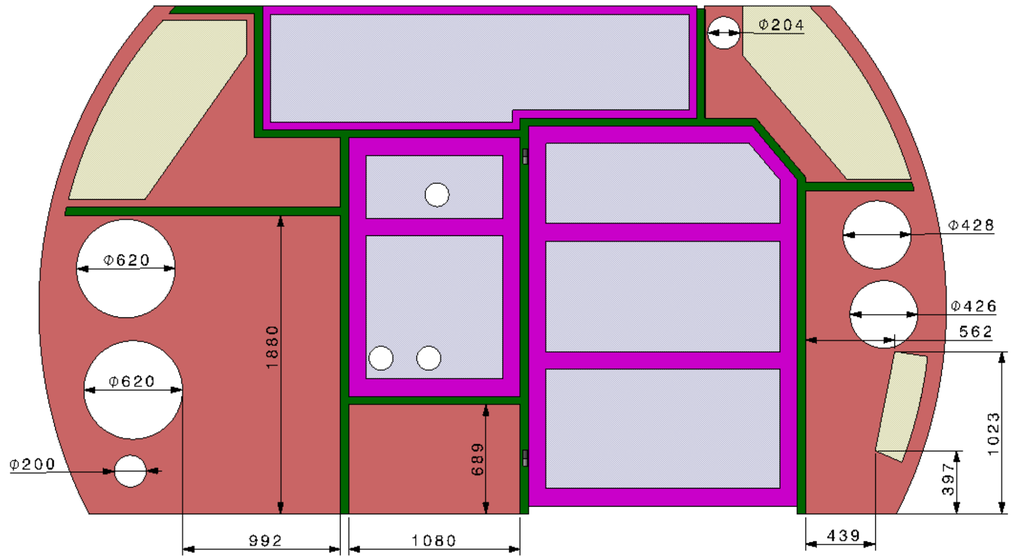
Audrey Piccini or Alexandros Manios (EN-MME) presentation for more details about the structure simulation (link)

Mechanical simulation to validate my structure design

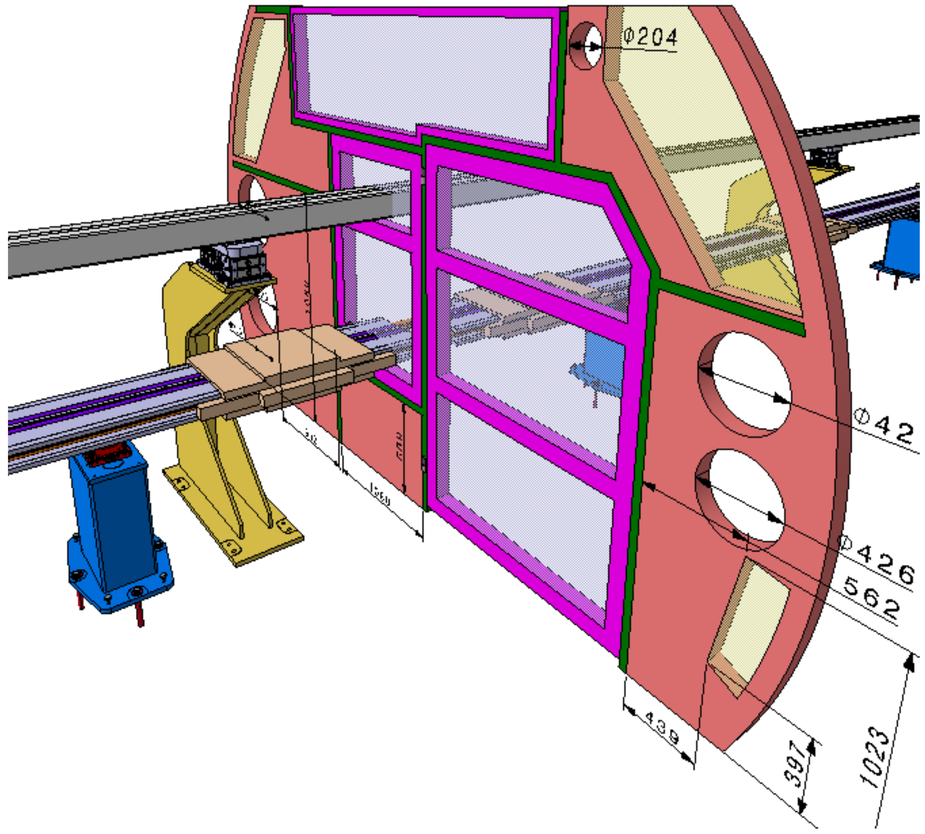


Mock-up : Fire door study

First design made by Fani (FCC Week 2024)



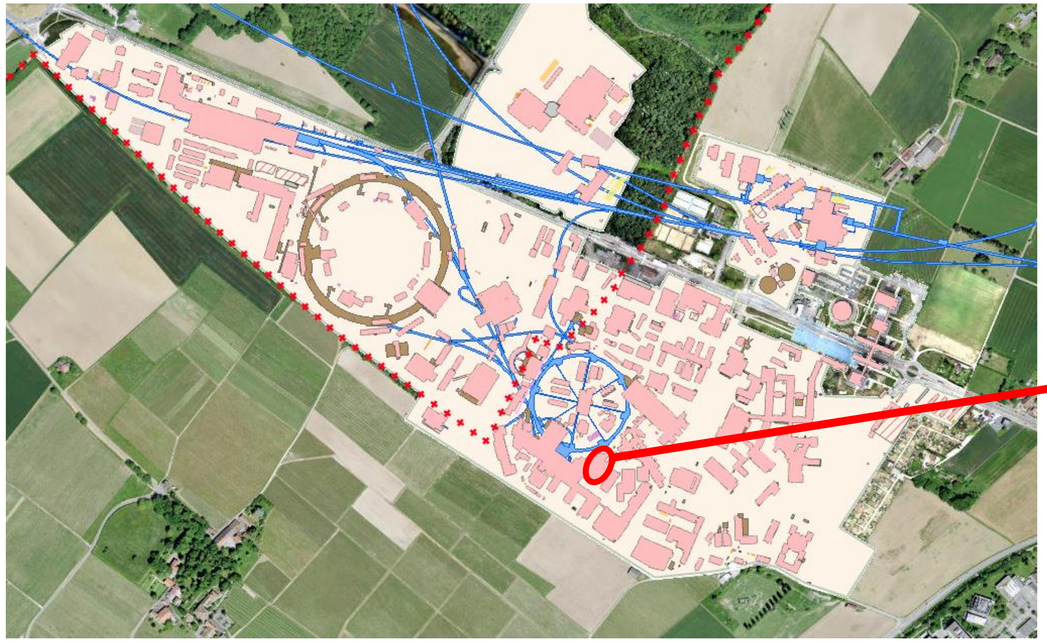
Integration and design : **in study with HSE**



- Ideally, the fire door should be placed where we have both dipoles for the collider and booster.
- A fire door every ~400m.

Mock-up installation building 355-358

CERN Meyrin site



Mock-up installation building 355-358

Was previously used by the **PS - Generator**

Mock-up installation building 355-358

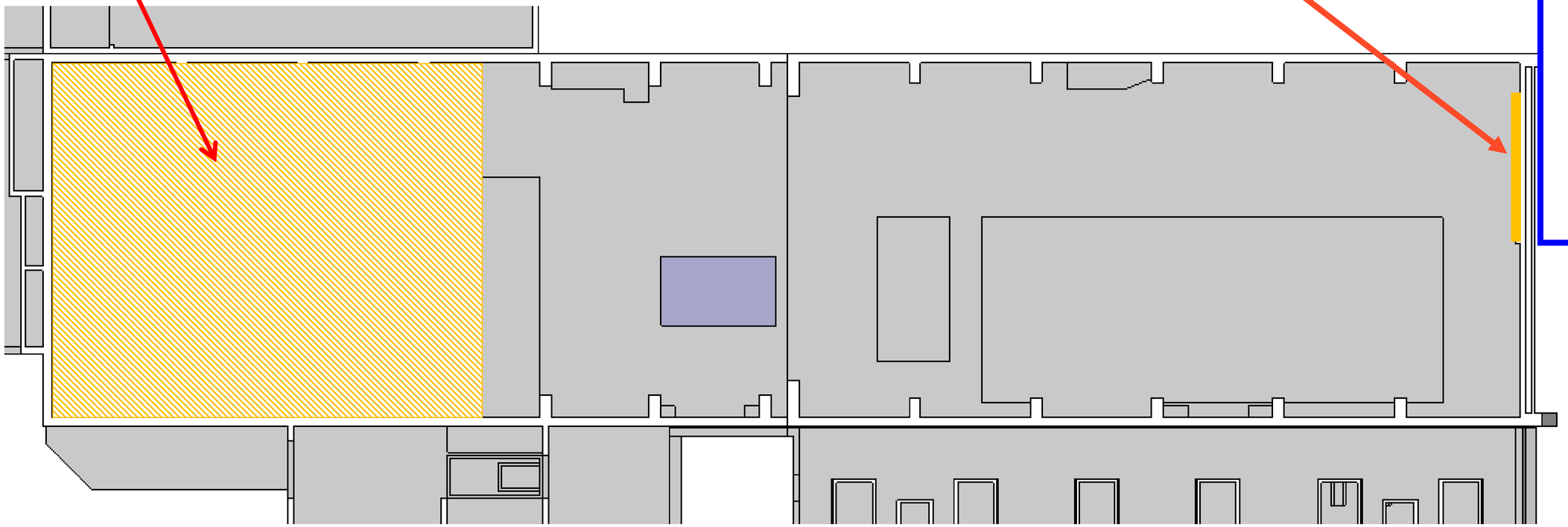
Now, the building is empty

Building 355-358

RF Storage Area (Klystron)

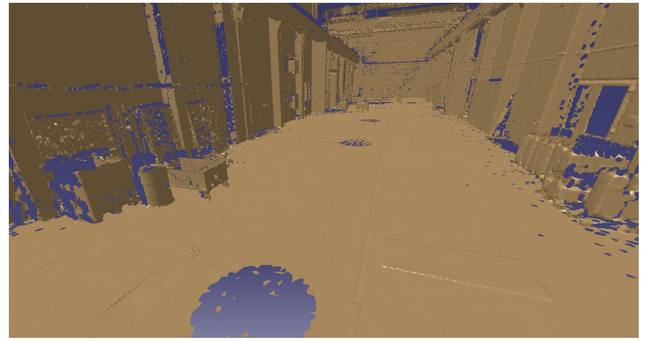
Main access door

PARKING



Building split between FCC Mock-up and RF

3D scan performed on September 11th 2024

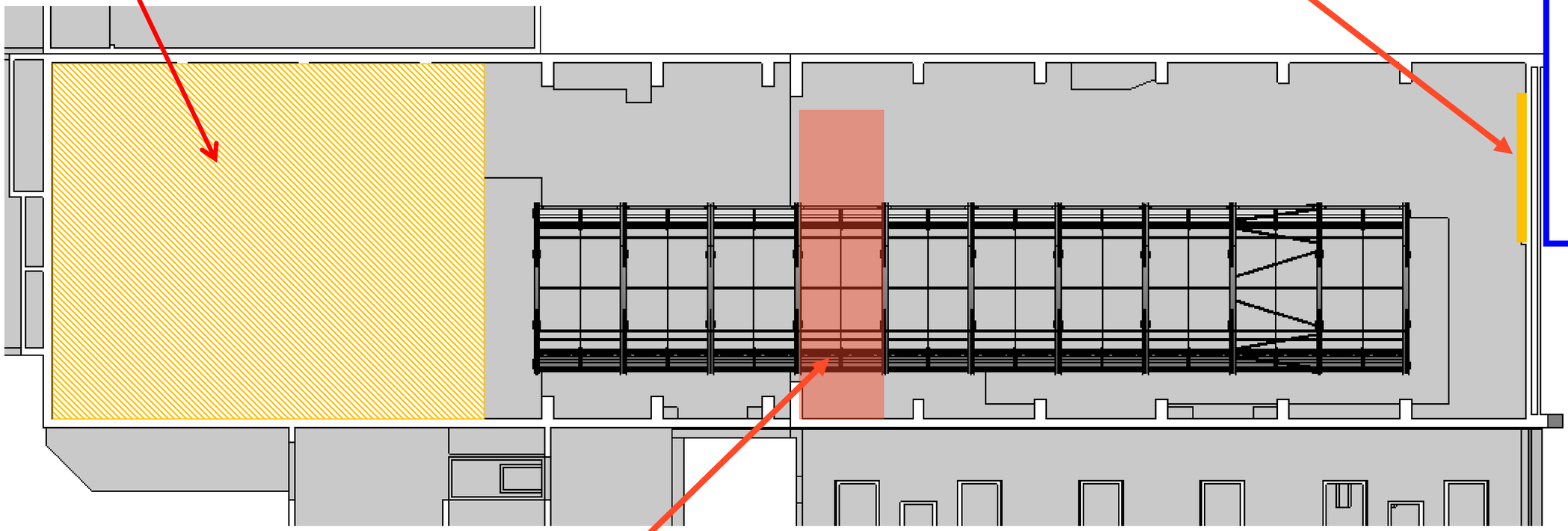


Building 355-358

RF Storage Area (Klystron)

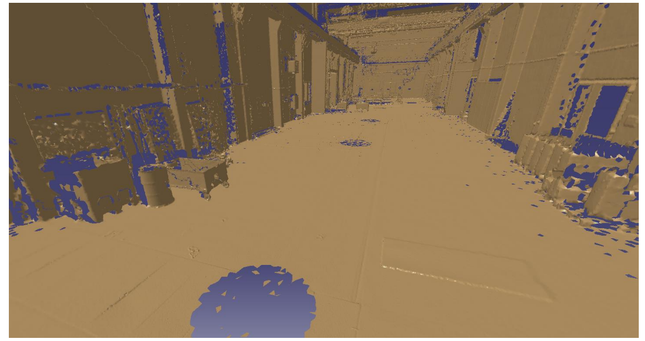
Main access door

PARKING



Critical zone, has to be easily dismantled for handling

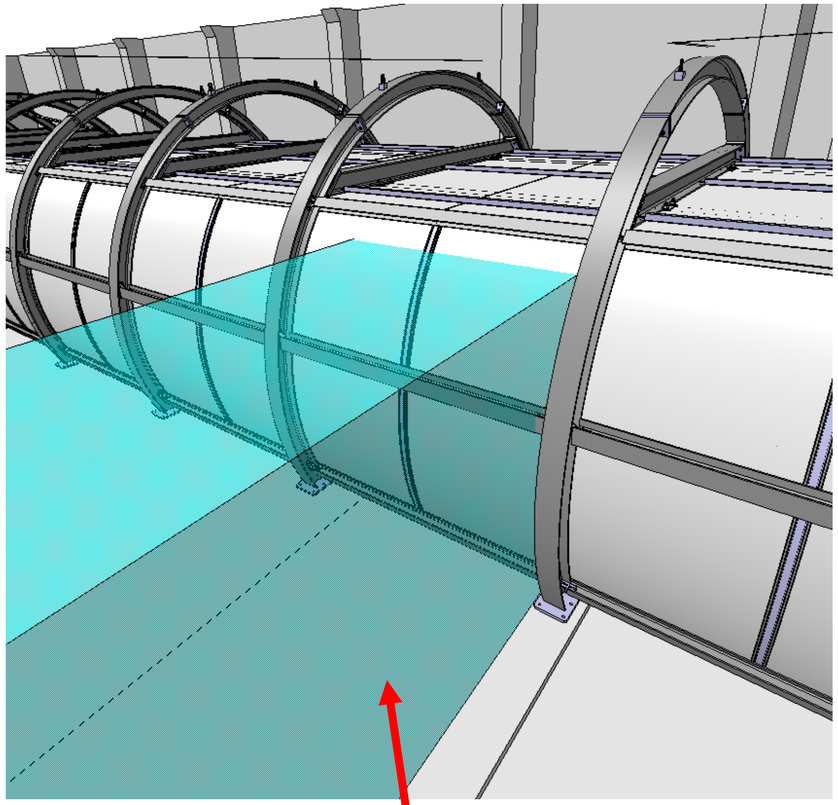
3D scan performed on September 11th 2024



Building split between FCC Mock-up and RF

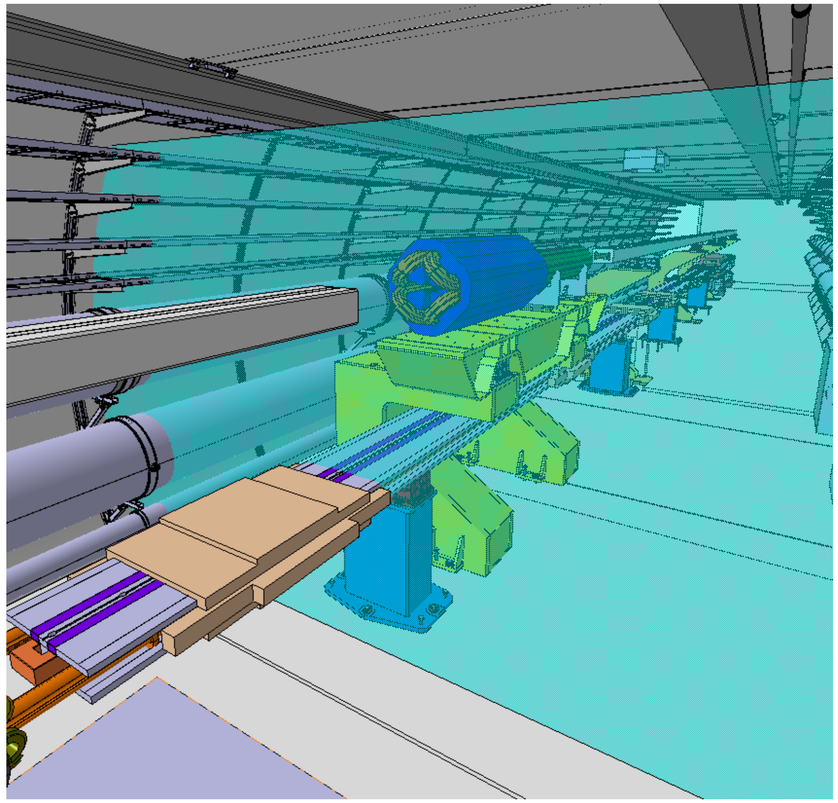
Building 355-358

Keep the possibility to dismantle easily between each arc



Transport zone in case of failure of an electrical transformer

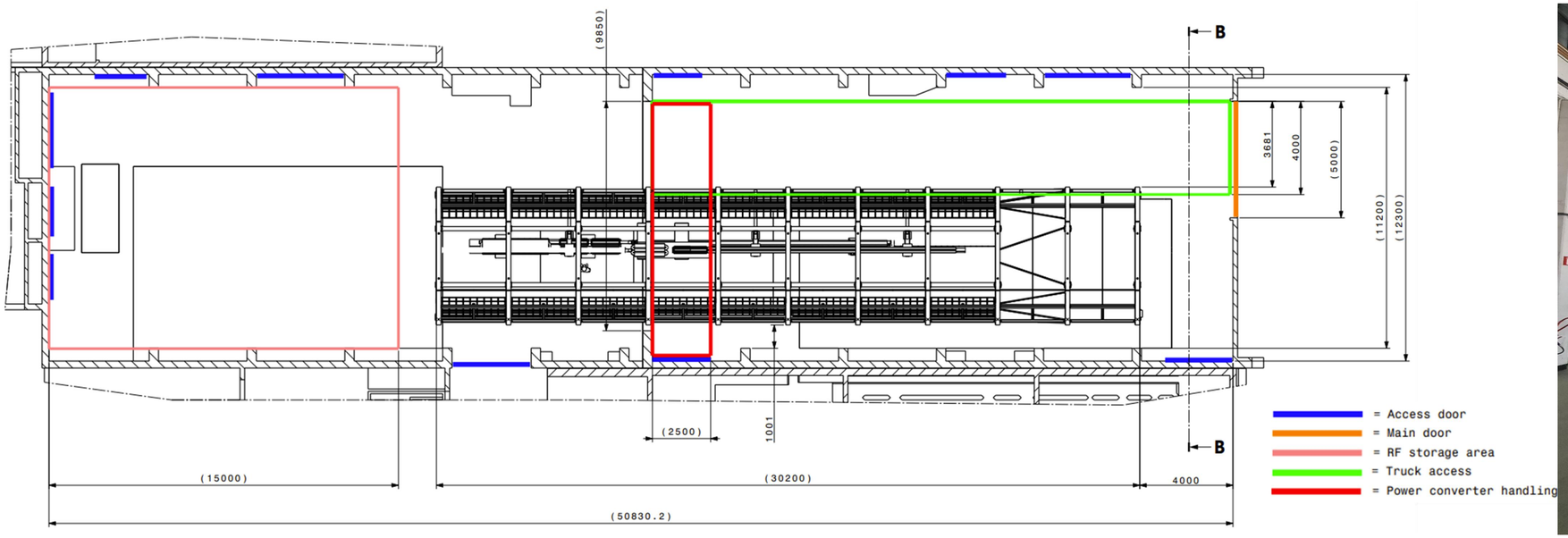
But we'll still have to dismantle what is inside



Building 355-358

→ Integration work in building 355-358 is still ongoing. Discussion with the EN-HE team.

→Preparation work on building (asbestos, lead painting removal, …) may be launched soon.

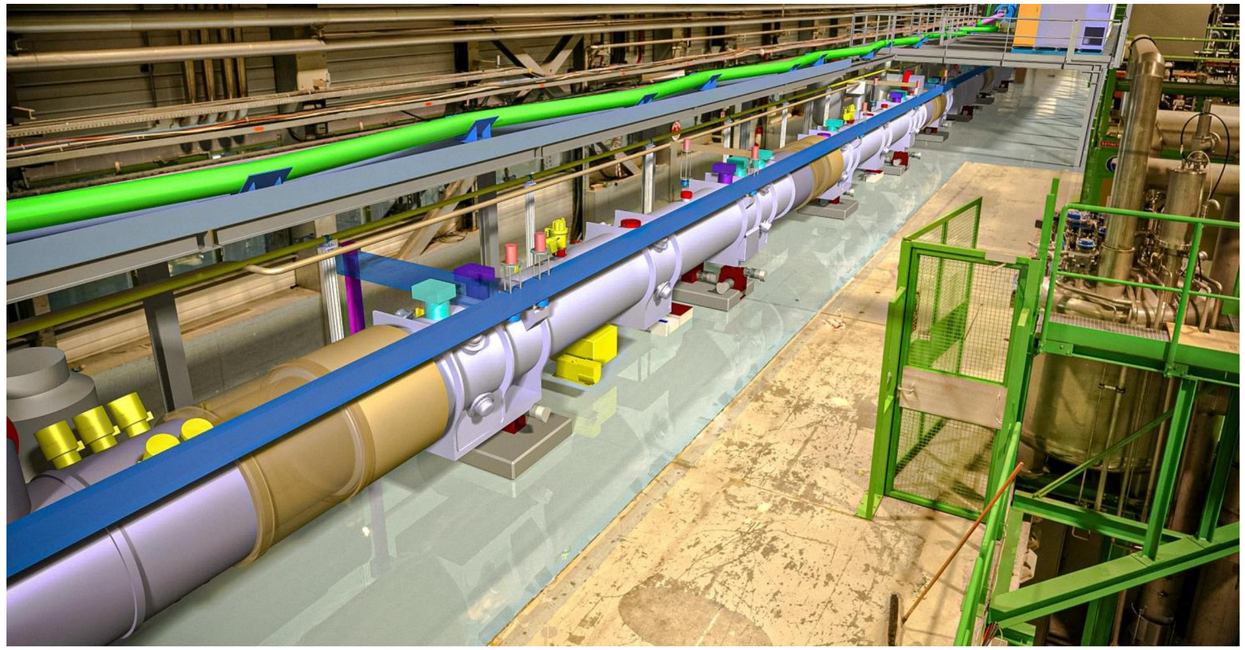


Future : Mixed reality

Microsoft Hololens 2

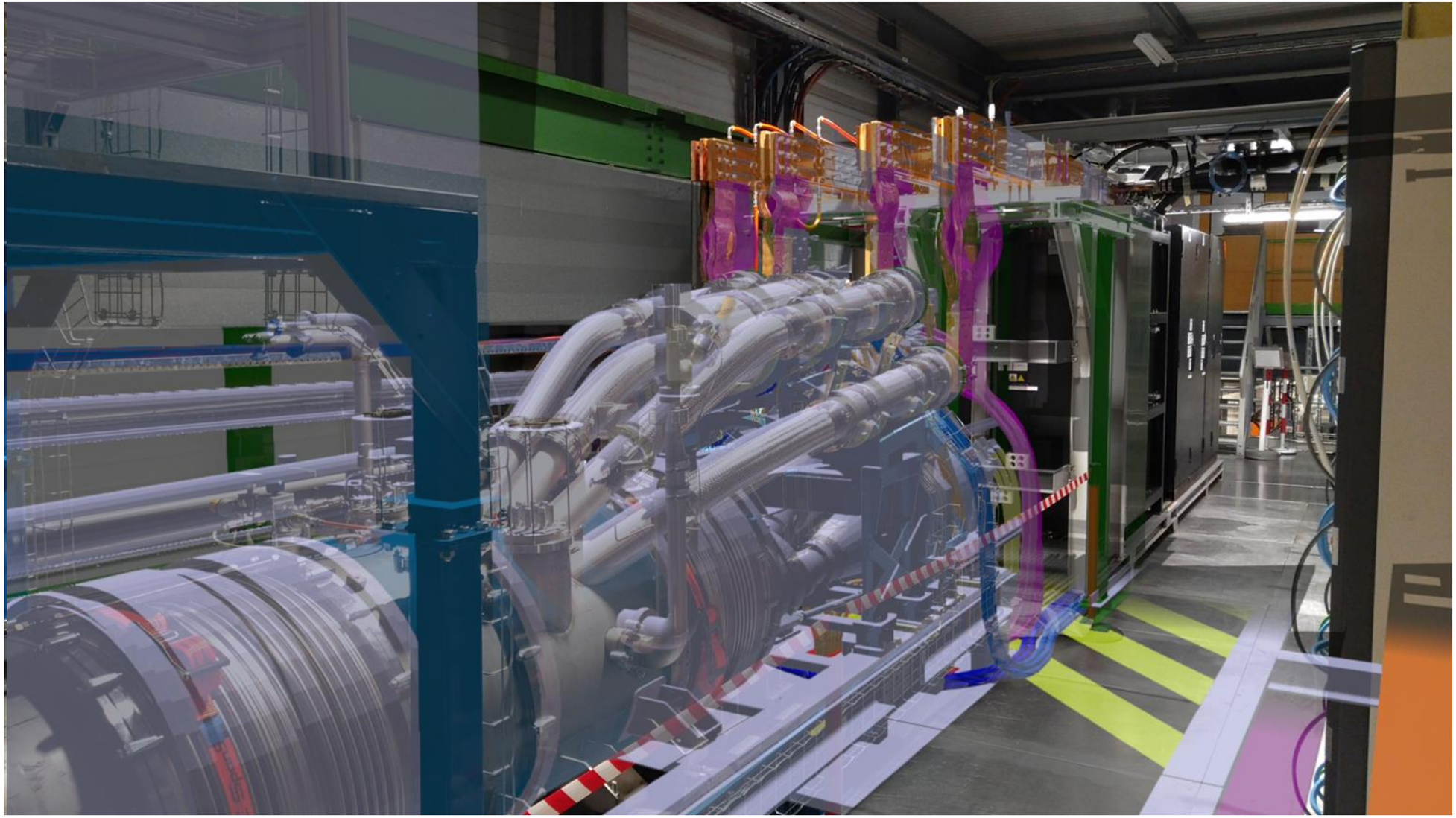
Mixed reality blends the real and virtual worlds, enabling real-time interaction between both environments.

The mixed reality system will be used here to incorporate future developments of the mock-up (e.g., FCC-hh) into our real environment.



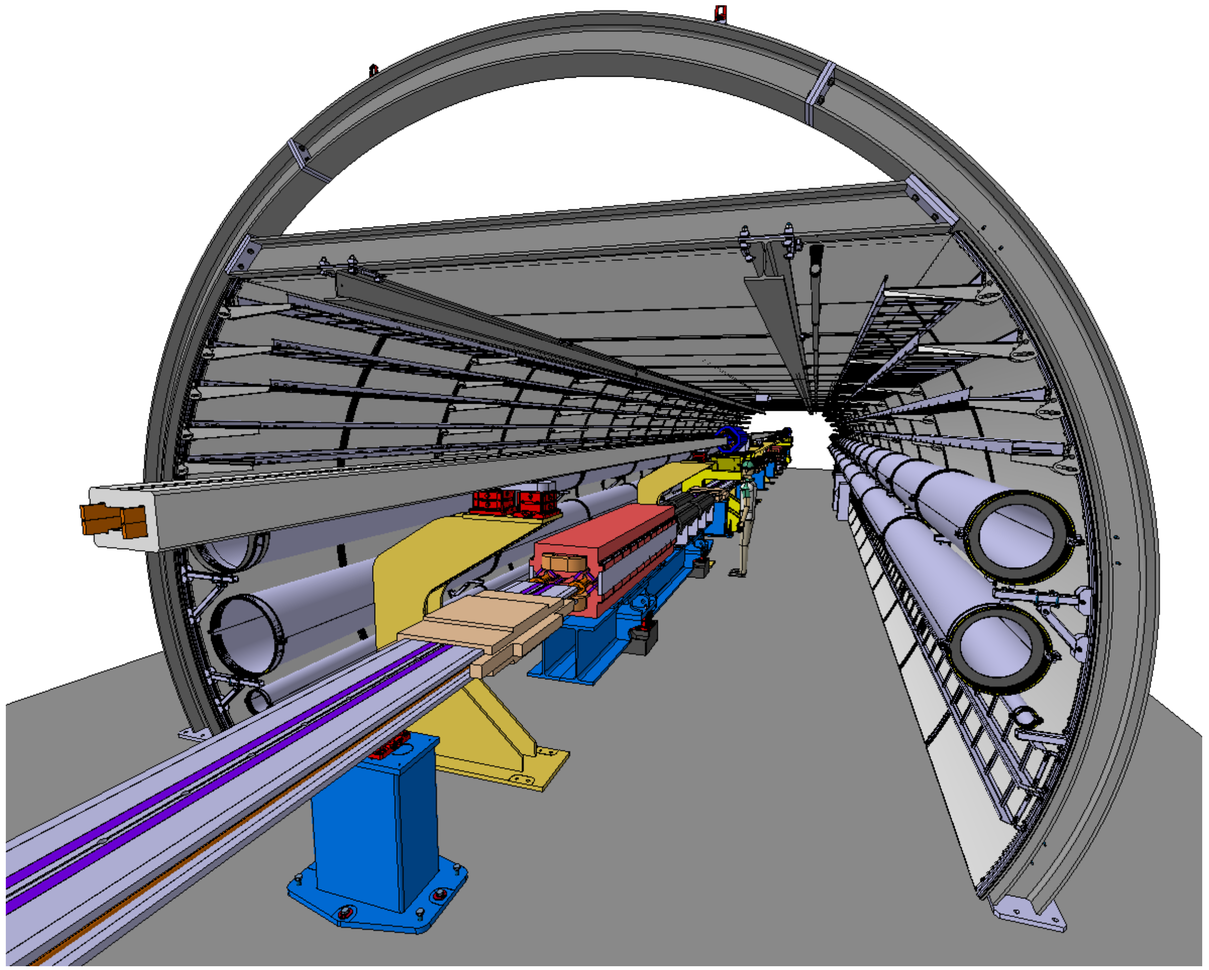
The use of the mixed reality for integration purpose proof of principle (cern.ch)

Example of mixed reality in SM18



Summary

- **Achievement** :
  - Layout baseline approved (cross-section layout and longitudinal layout)
- **Next steps :**
  - Design a modulable structure for the next design iteration of the mock-up
  - Integration studies of the mock-up in building 355-358
  - Production for manufacturing and assembly of the structure
  - Installation of the mock-up in building 355-358 (first semester 2025)
  - Test of the mixed reality to visualise the FCC-hh configuration within the mock-up



THANK YOU FOR YOUR ATTENTION

CERN

BACK-UP SLIDE

CERN

Magnetic values

Collider Magnetic Lengths

name	type	dcum	length	dcum_rel
start		12400.95009		
			0.3000	
U.QD1.1	quadrupole	12401.25009		0.30000
D.QD1.1	quadrupole	12404.15009	2.9000	3.20000
			0.2000	
U.SD38.1	sextupole	12404.35009		3.40000
D.SD38.1	sextupole	12405.65009	1.3000	4.70000
			0.1500	
U.SD38.2	sextupole	12405.80009		4.85000
D.SD38.2	sextupole	12407.10009	1.3000	6.15000
			0.2000	
U.B1S.140	rbend	12407.30010		6.35001
D.B1S.140	rbend	12427.00547	19.7054	26.05538
			0.3000	
U.QF2.1	quadrupole	12427.30547		26.35538
D.QF2.1	quadrupole	12430.20547	2.9000	29.25538
			1.7000	
U.B1L.36	rbend	12431.90547		30.95538
D.B1L.36	rbend	12453.06084	21.1554	52.11075

Booster Magnetic Lengths

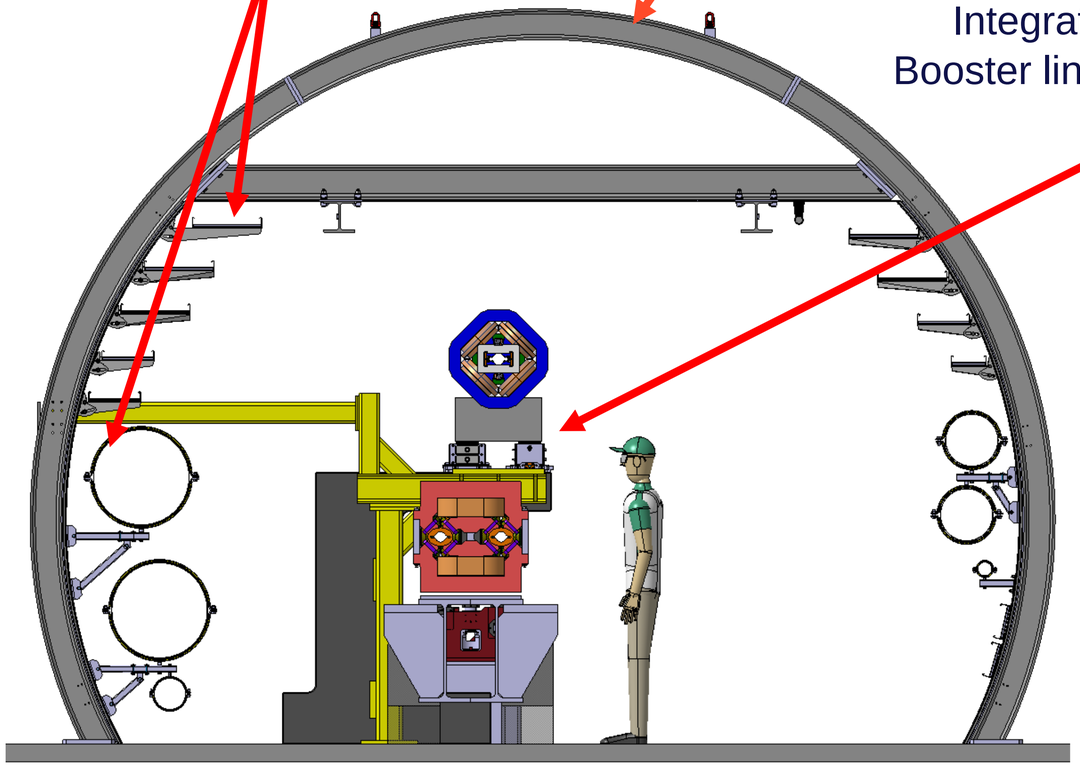
Cell 336	NAME	KEYWORD	S	S_relatif	L
	Start		89019.48314	0	
		drift			0.788
QD2	U.MQD2.A8.336	quadrupole	89020.27084	0.7877	
	D.MQD2.A8.336	quadrupole	89021.57084	2.0877	1.3
		drift			0.3
SD1	U.MSD1.A8.336	sextupole	89021.87084	2.3877	
	D.MSD1.A8.336	sextupole	89023.27084	3.7877	1.4
		drift			0.93769
	U.MB.A8.336A	sbend	89024.20853	4.72539	
	D.MB.A8.336A	sbend	89035.20853	15.72539	11
		drift			0.4
	U.MB.A8.336B	sbend	89035.60853	16.12539	
	D.MB.A8.336B	sbend	89046.60853	27.12539	11

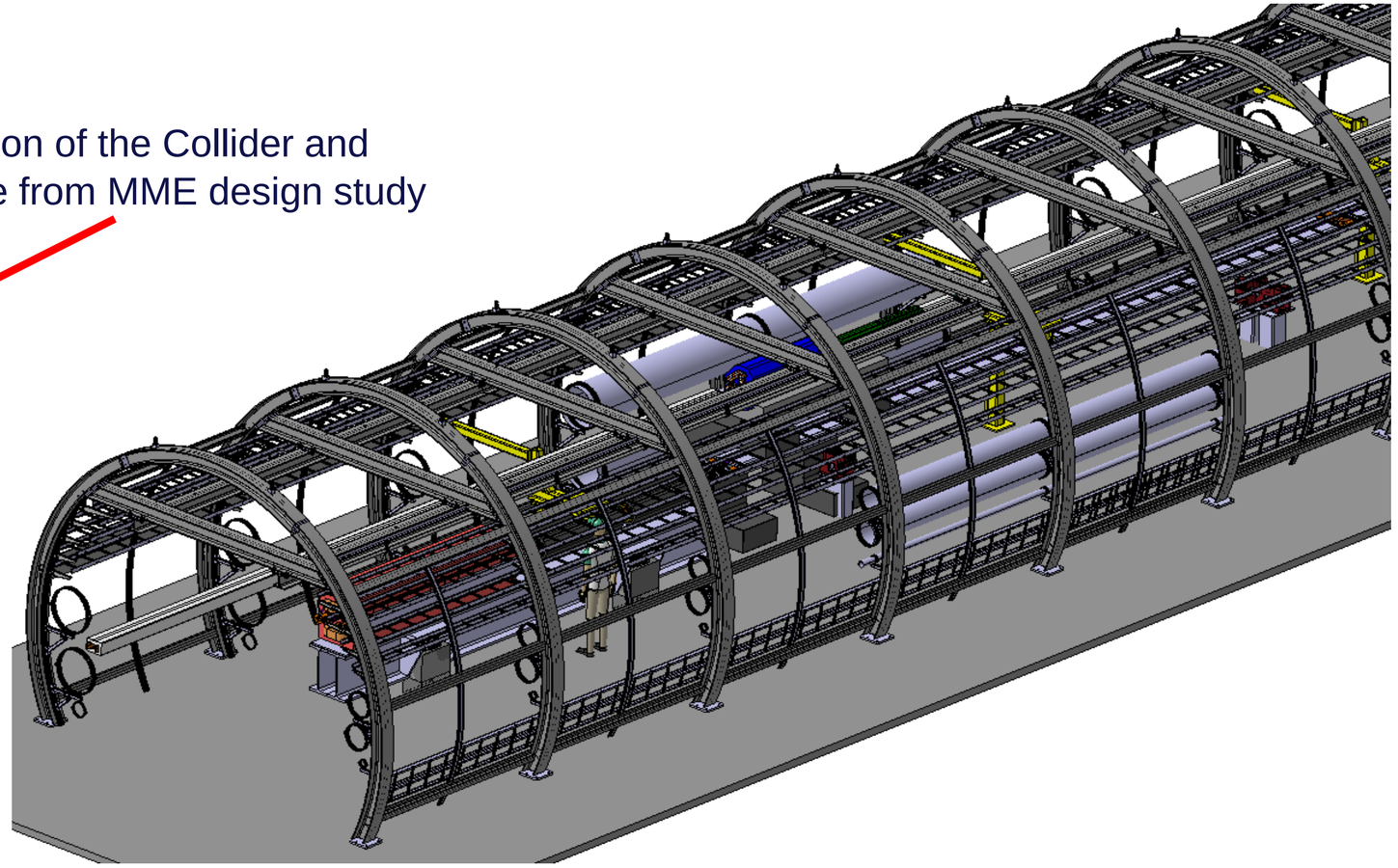
Previous design from September

Integration of cable tray and cooling system

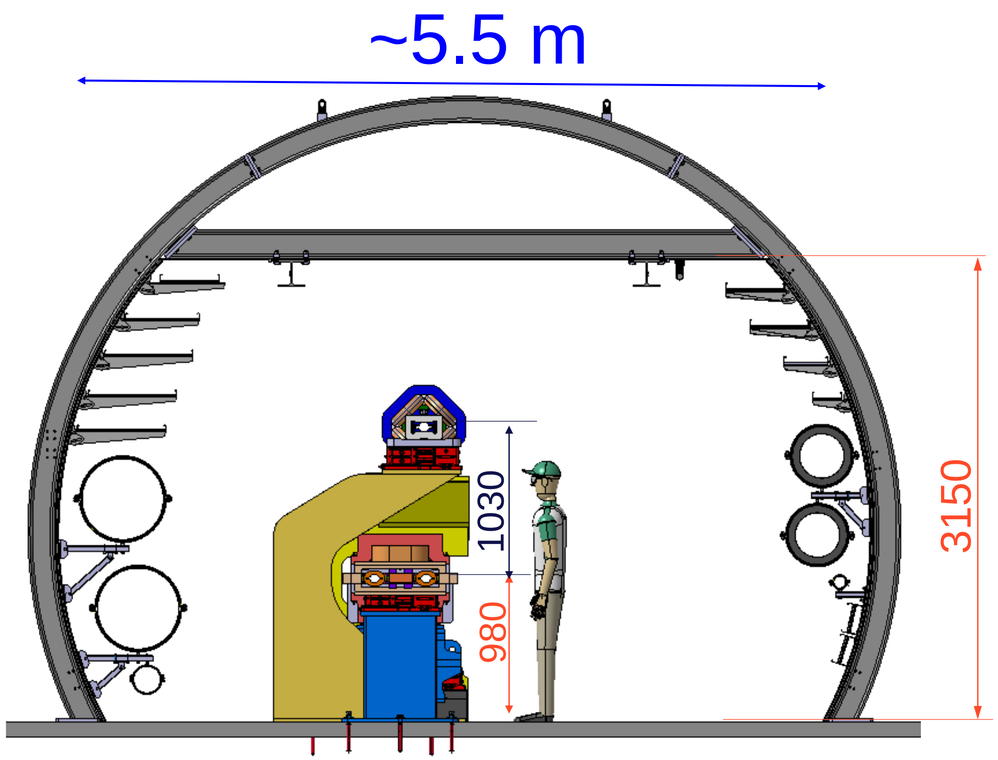
Design of the structure

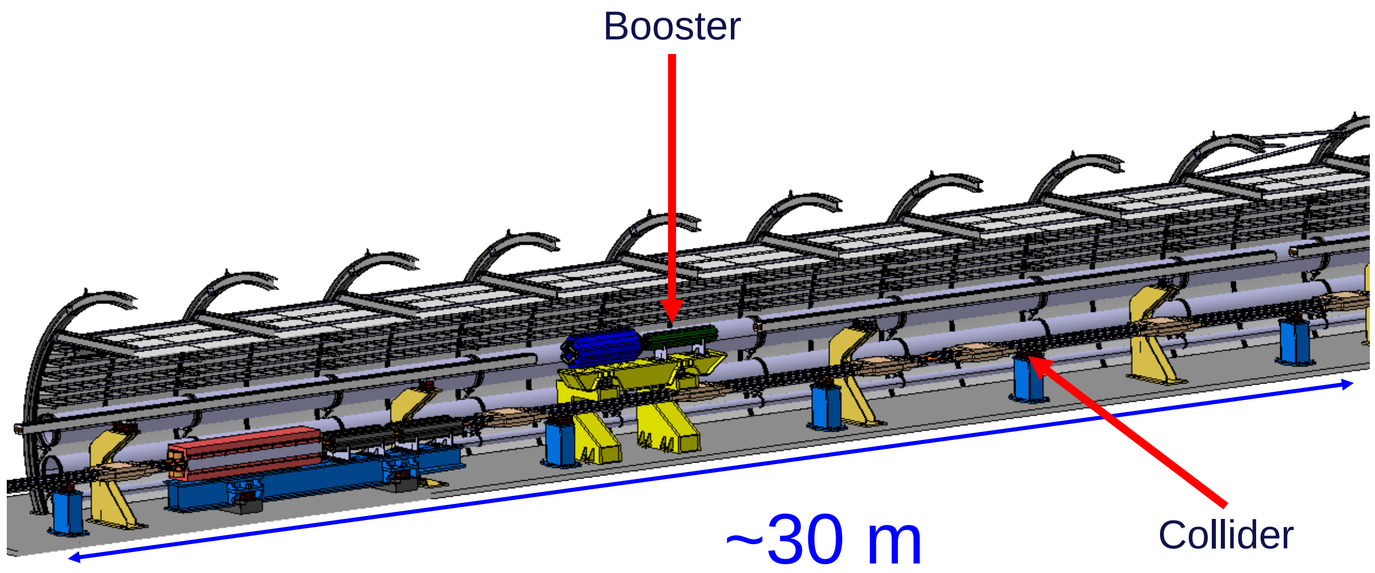
Integration of the Collider and Booster line from MME design study

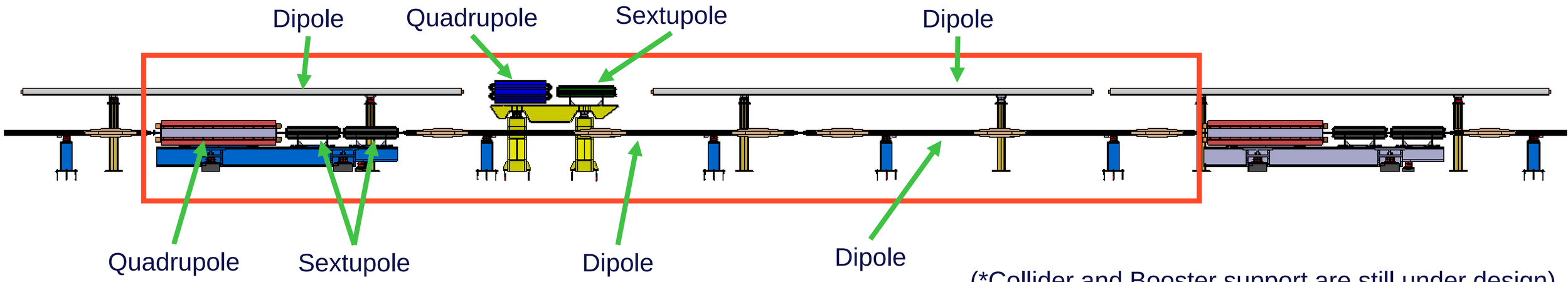




Mock-up cross section







(*Collider and Booster support are still under design)