Tower Vacuum Implementation

ET-ISB Fall Workshop 2024 on ET-LF TM Tower Integration Concepts

September 19, 2024

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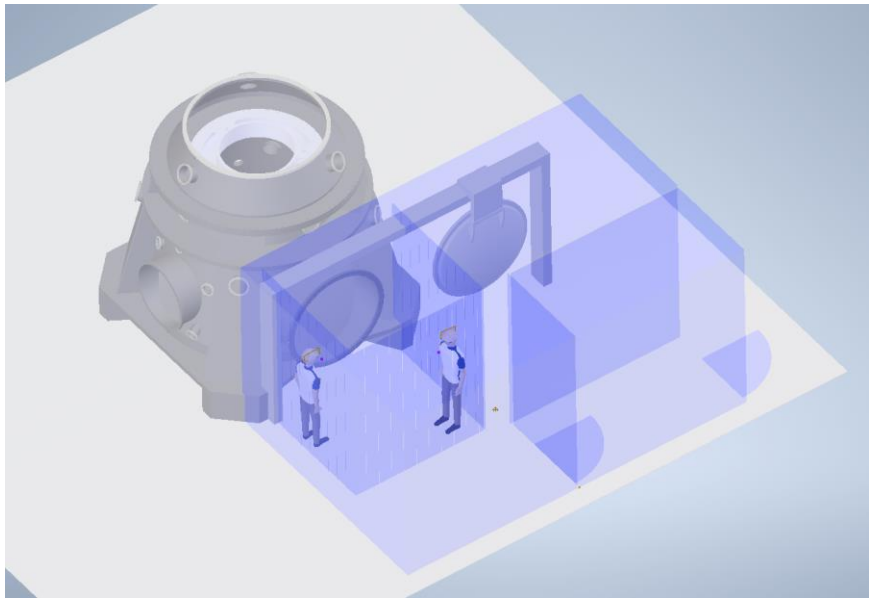
on behalf of the ISB WP-IV.1 Tower Vacuum

Introduction

Summer 2024: Ongoing meetings with ETO to address vacuum system volume requirements and progress on the detector layout.

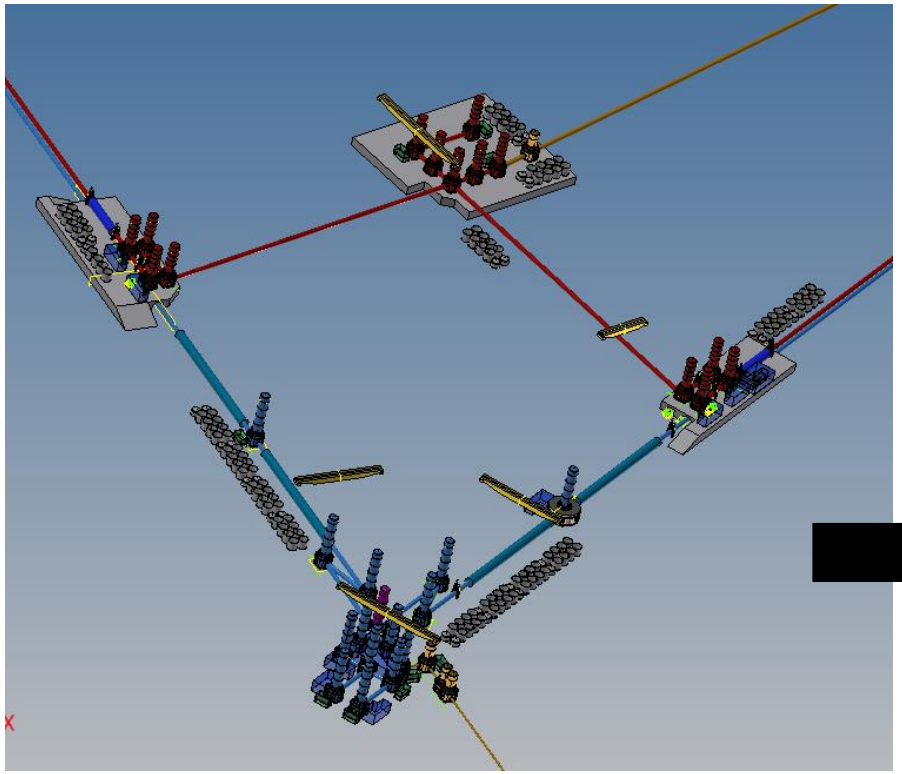


For 1 corner	
Tower HF	31
Filter Cavity «SQZ» Tower HF	12
Auxiliary Bench in Vacuum HF	20
Tower LF	22
Filter Cavity «SQZ» Tower LF	19
Auxiliary Bench in Vacuum LF	12

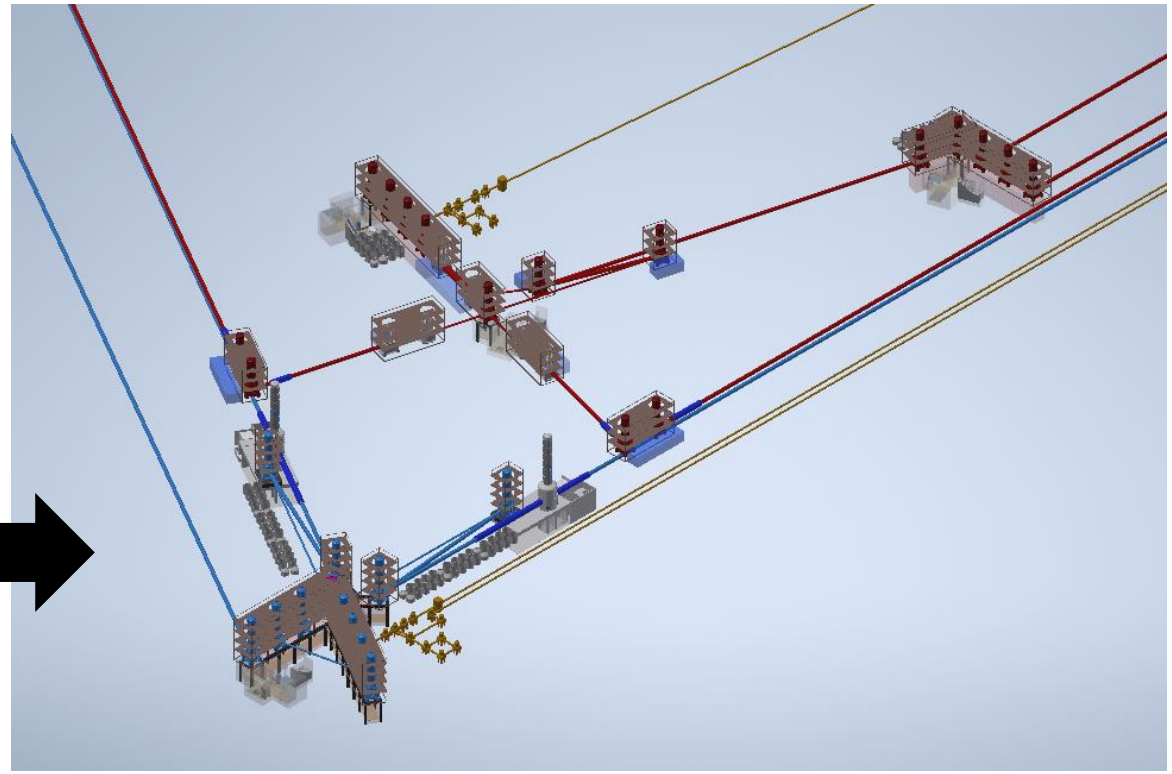
Last status – July 2024:
General ISB Meeting
TDS: ET-0460A-24

General 3D Model

June 2024



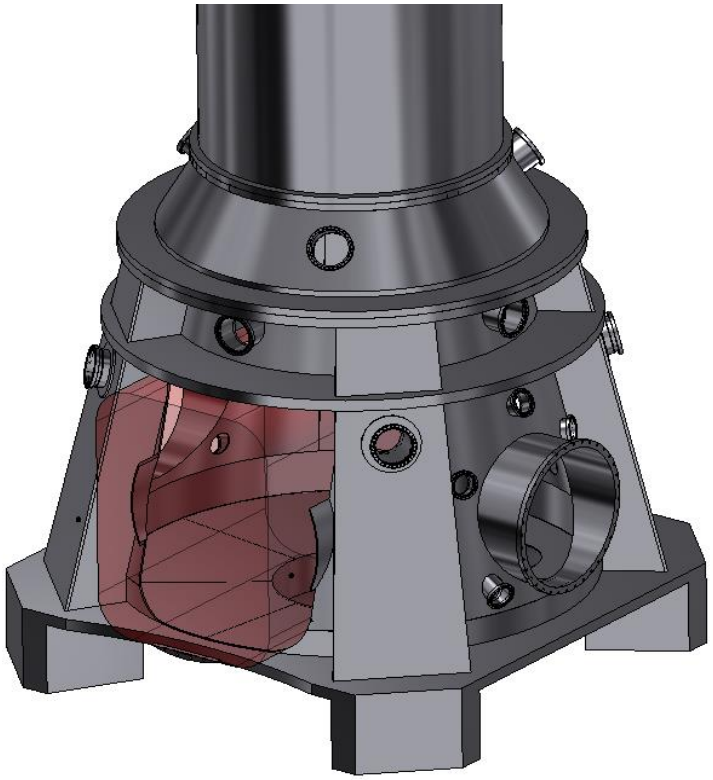
September 2024



Iteration with ETO Revit file for Detector Layout from August

Tower with lateral Access

- 2° Generation Interferometer: Payload with 500mm mirror requires ≥ Ø1800 mm aperture.
- A Ø2000mm circular port is not feasible, with tower footprint of 4m.
- A 'rectangular' port of 1500x2000mm might be possible, with challenging cost, sealing and dust control.



"Light design", for illustration

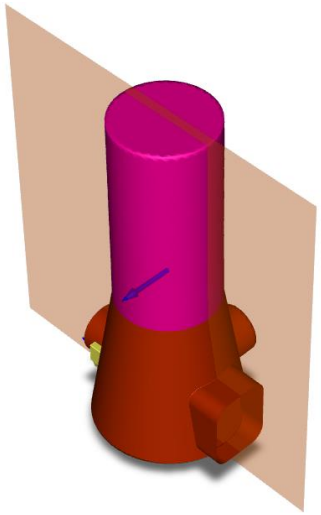
Benefits:

- Proven at LIGO and KAGRA.
- More flexibility if towers are moved from several meters.
- No need for underground room.
- Favourable for «small size» towers (work from outside).

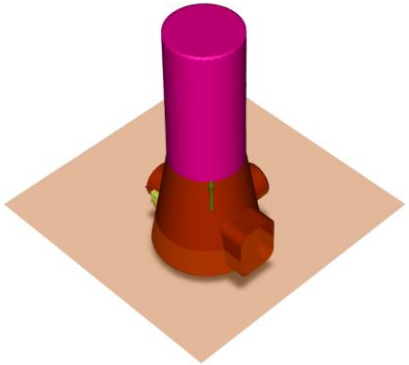
Drawbacks:

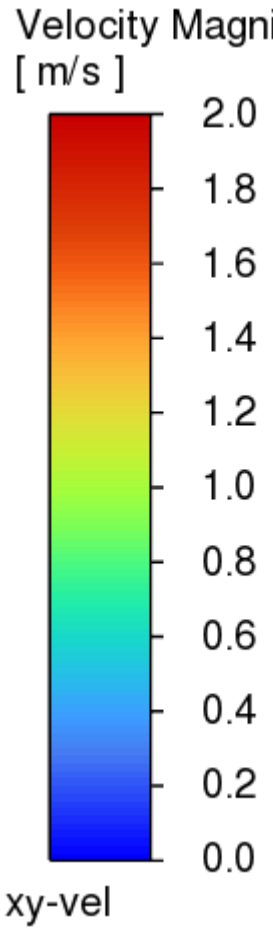
- Very large opening depending on Payload/Bench: Is it compatible with a long-term view?
- Complexity of the chamber + invasive tooling to operate.
- Likely to open the opposite flange to reduce turbulent airflow: need more space for cleanroom to pass below/above the tubes.
- Less space for Auxiliary benches.

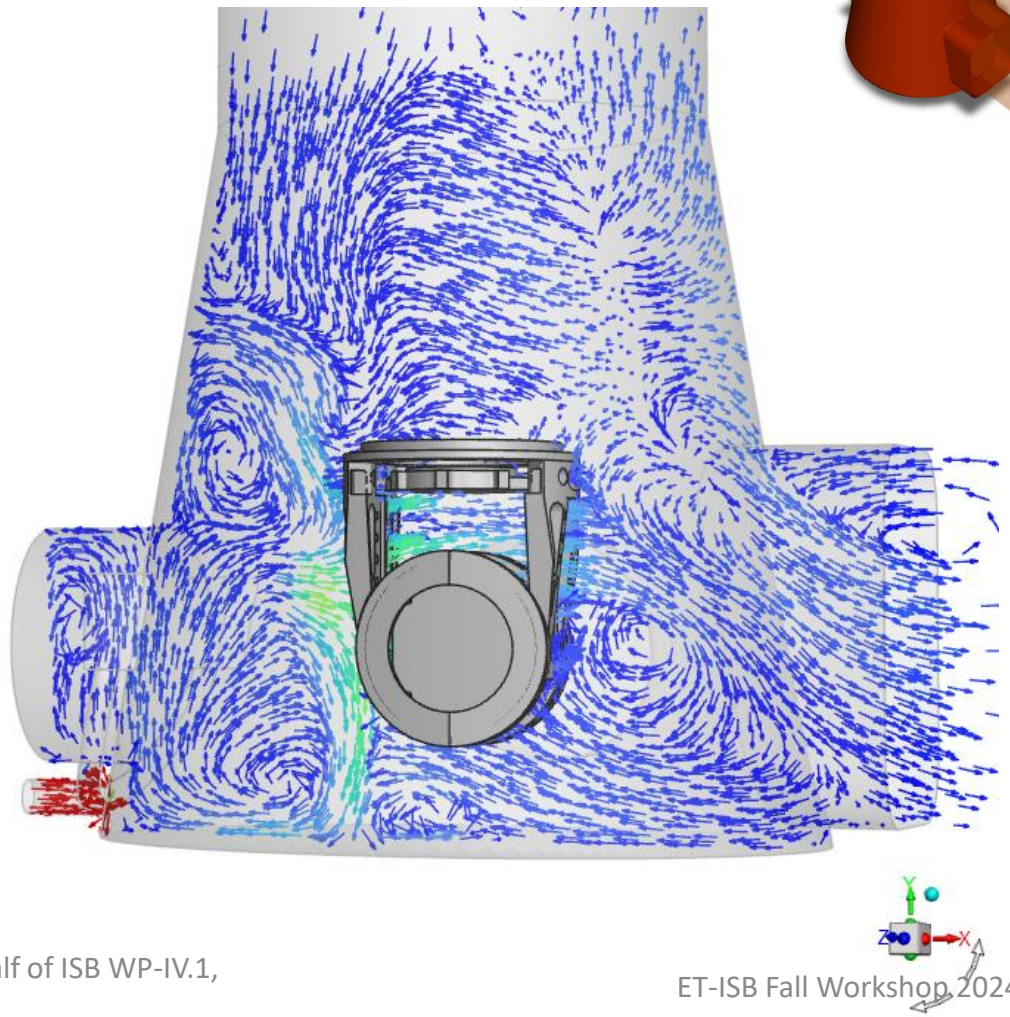
Velocity fields

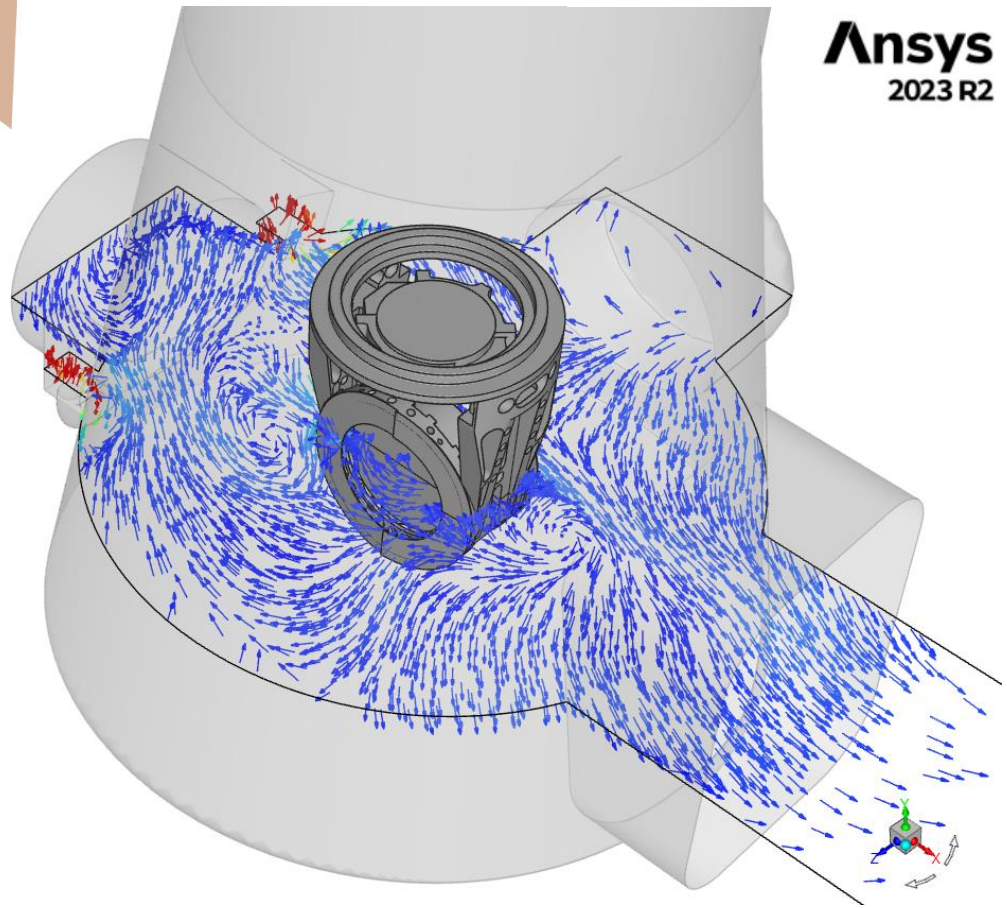


Ongoing study



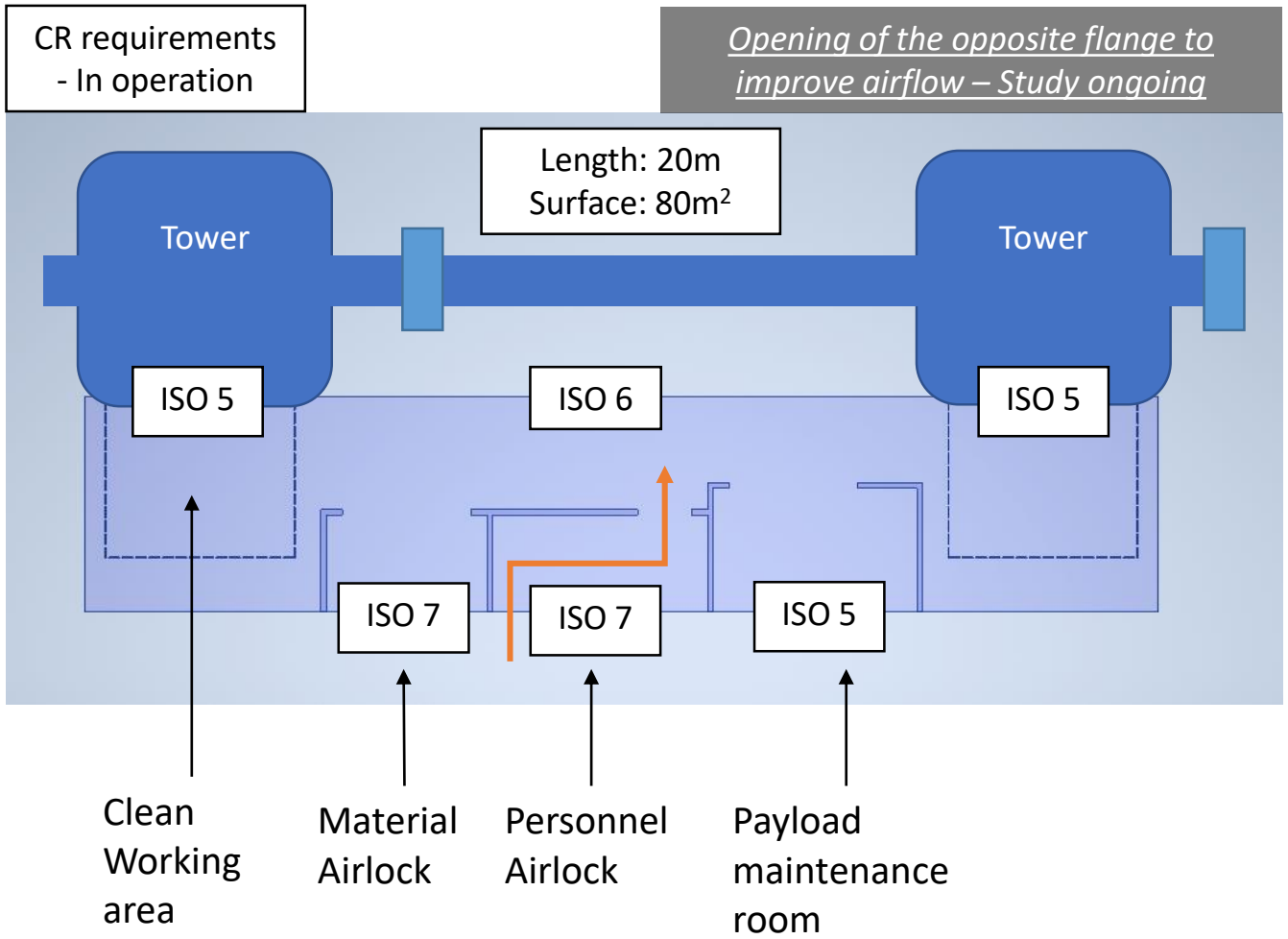






Credits: F. Bianchi

Towers with lateral Access



Required space – Configuration may differ depending on the tower and tunnel available spaces

For several close towers, we can include one large volume for the Clean Room.
Size depending on selected towers.

An ISO5 maintenance room is not mandatory, but preferable, depending on the process of assembly of payloads.

Lateral Access:

- **CR for 1 tower: 9 concerned towers.**
- **CR for several Towers:**
  18 towers → 9 CR
  + 6 CR for Filter Cavities «SQZ».

Auxiliary Benches (in Vacuum or not) attached to a tower can be included in the same CR, requiring an ISO7 class in operation.
Addition to the General 3D model ongoing.

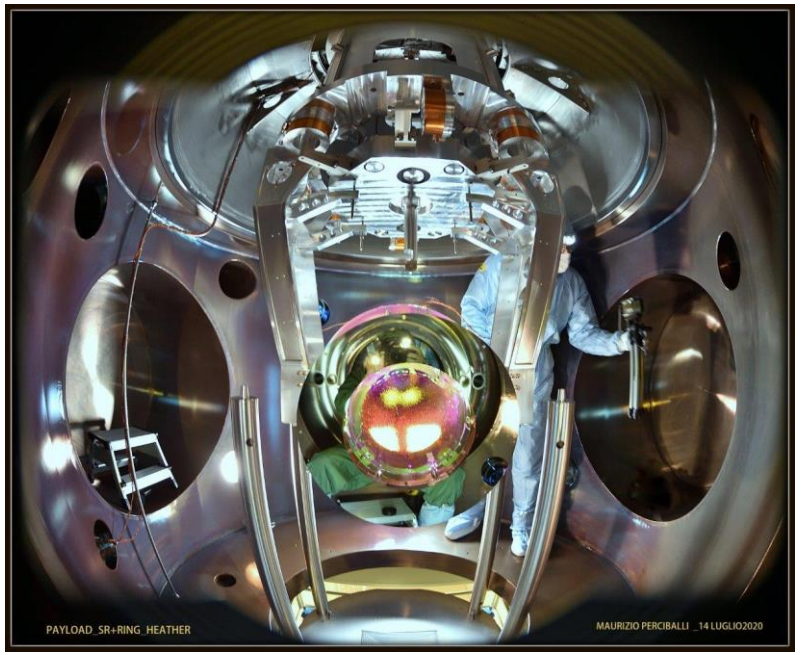
Tower with bottom Access

Benefits:

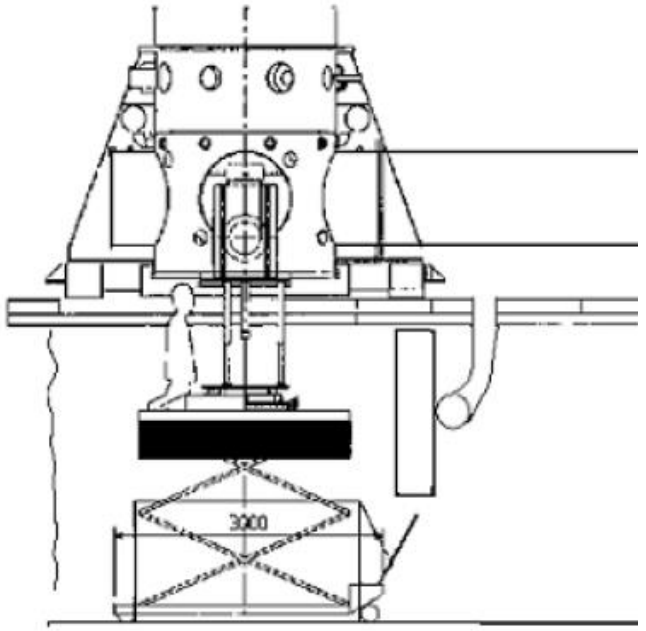
- Proven solution at Virgo.
- Easy access for large Payload.
- No interference on surface, to install benches.
- Clean air flow from top to bottom: less turbulences.

Drawbacks:

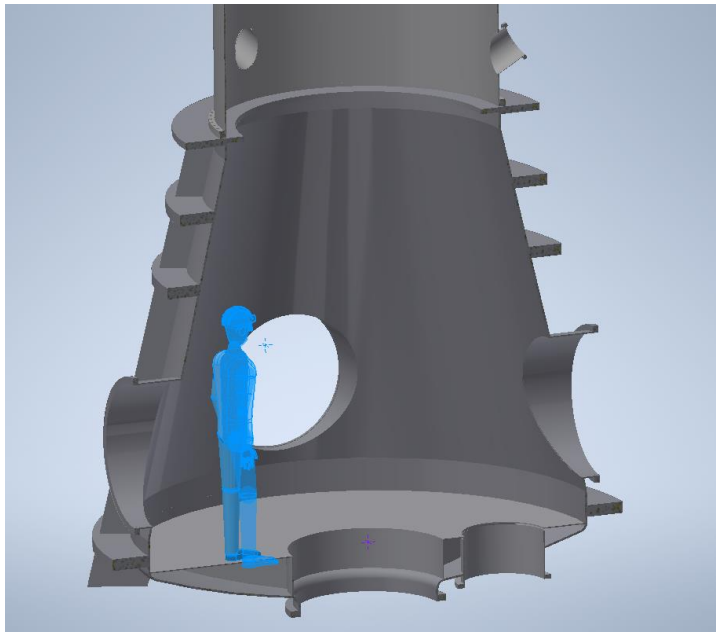
- There is a need to dig deeper and reinforce the underground room and floor.
- Less flexibility in case the towers must be moved several meters.



Virgo Tower with Bottom entrance – SR PAY + Ring Heater

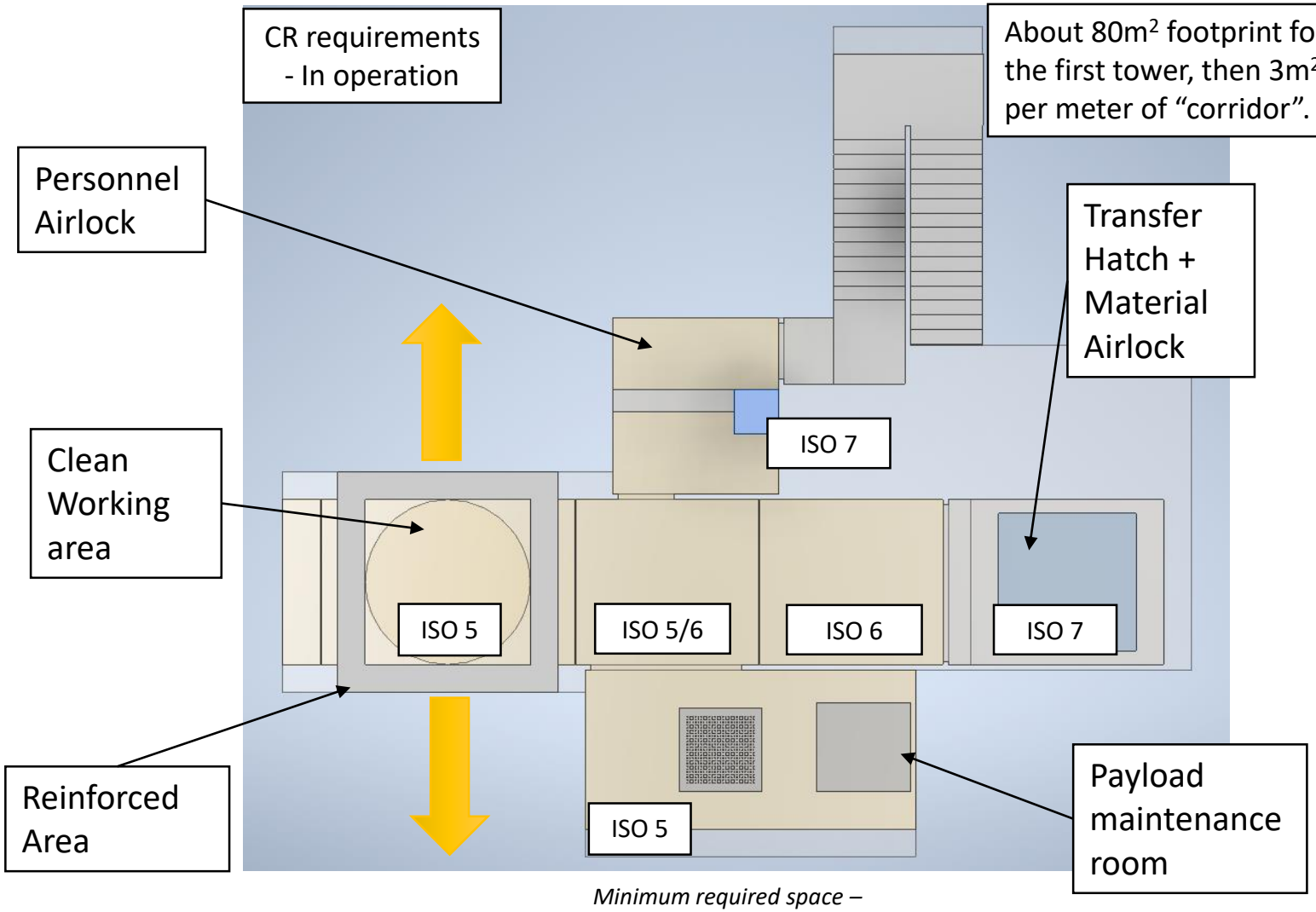


Virgo Tower PAY insertion



"Light design", for illustration

Tower with Bottom Access

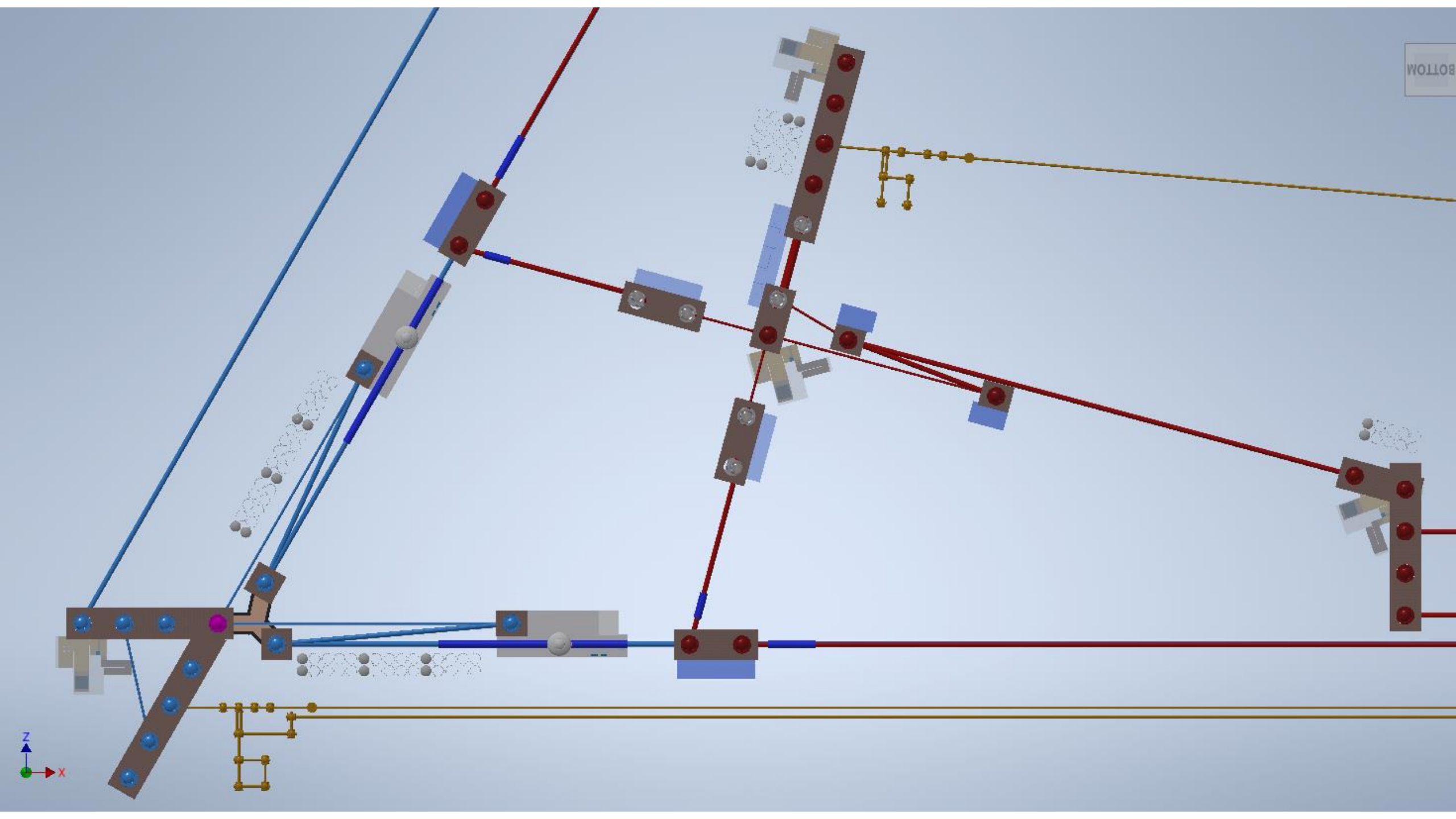


Minimum required space –
Configuration may differ depending on the tower and tunnel available spaces

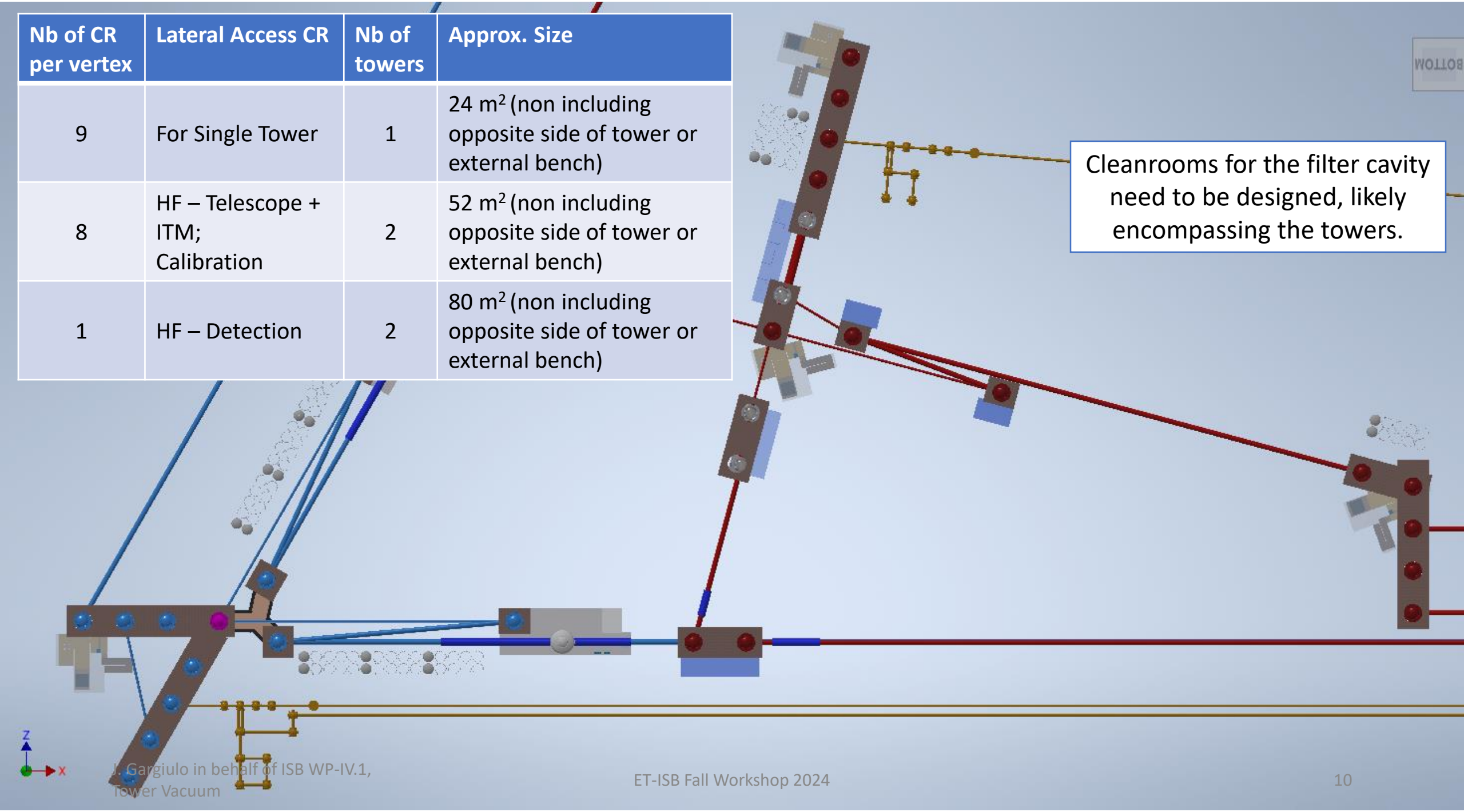
- Airflow needs: Probably centralized, Temperature and Humidity control. Expertise needed for refined calculations
- Geometry and access to optimize depending on the cavern – Revit model on going with ETO.
- Reinforced walls below the tower and on the corridors for structural reasons – Civil Teams.

Bottom Access:

- **CR for 1 tower: HBS.**
- **CR for several Towers: 26 towers → 3 CR + 4 CR for the LF-TM Cryo tower.**

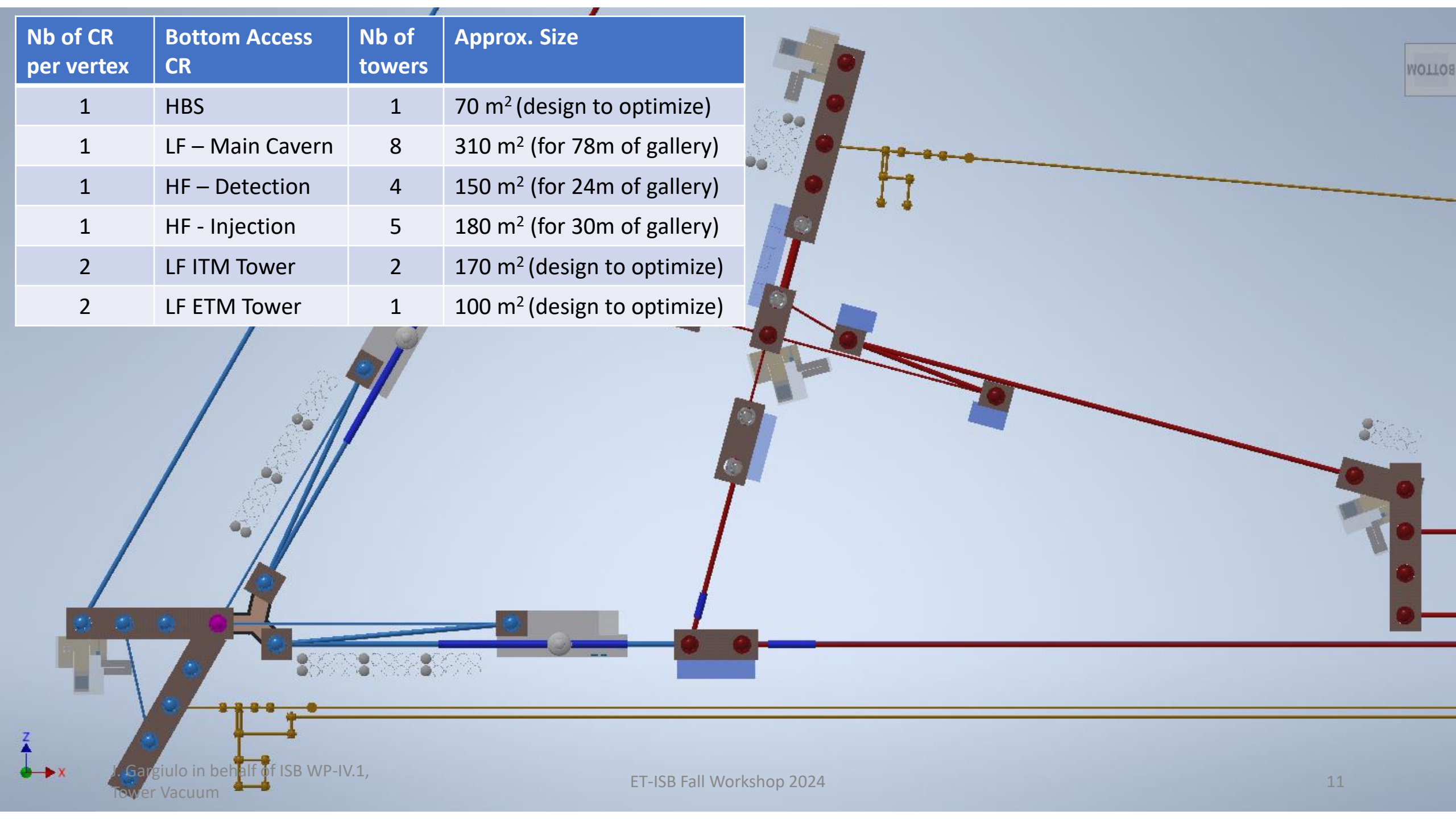

BOTTOM
Z
X

Nb of CR per vertex	Lateral Access CR	Nb of towers	Approx. Size
9	For Single Tower	1	24 m^2 (non including opposite side of tower or external bench)
8	HF – Telescope + ITM; Calibration	2	52 m^2 (non including opposite side of tower or external bench)
1	HF – Detection	2	80 m^2 (non including opposite side of tower or external bench)

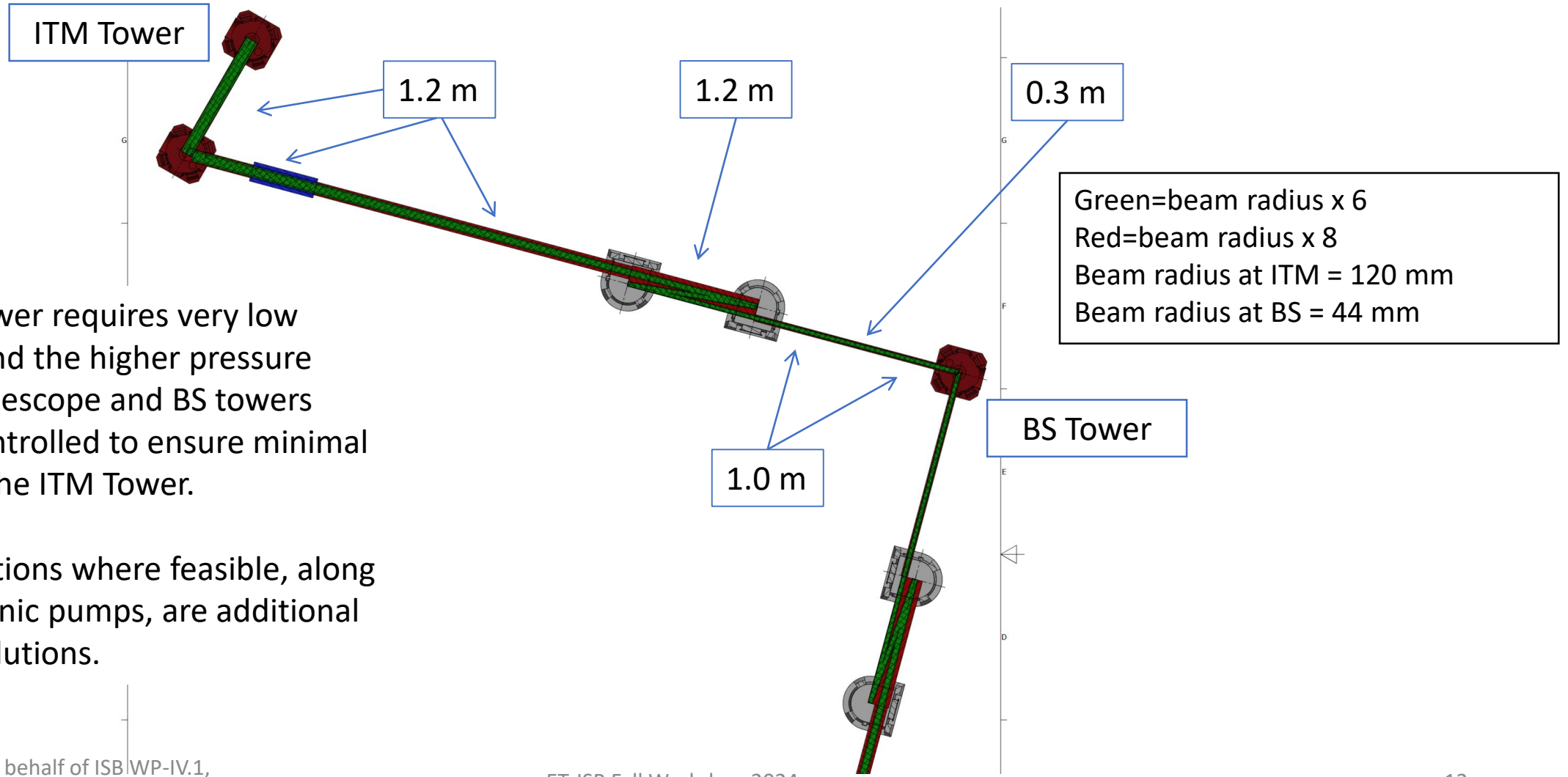


Cleanrooms for the filter cavity need to be designed, likely encompassing the towers.

Nb of CR per vertex	Bottom Access CR	Nb of towers	Approx. Size
1	HBS	1	70 m^2 (design to optimize)
1	LF – Main Cavern	8	310 m^2 (for 78m of gallery)
1	HF – Detection	4	150 m^2 (for 24m of gallery)
1	HF - Injection	5	180 m^2 (for 30m of gallery)
2	LF ITM Tower	2	170 m^2 (design to optimize)
2	LF ETM Tower	1	100 m^2 (design to optimize)



Links Diameter - HF



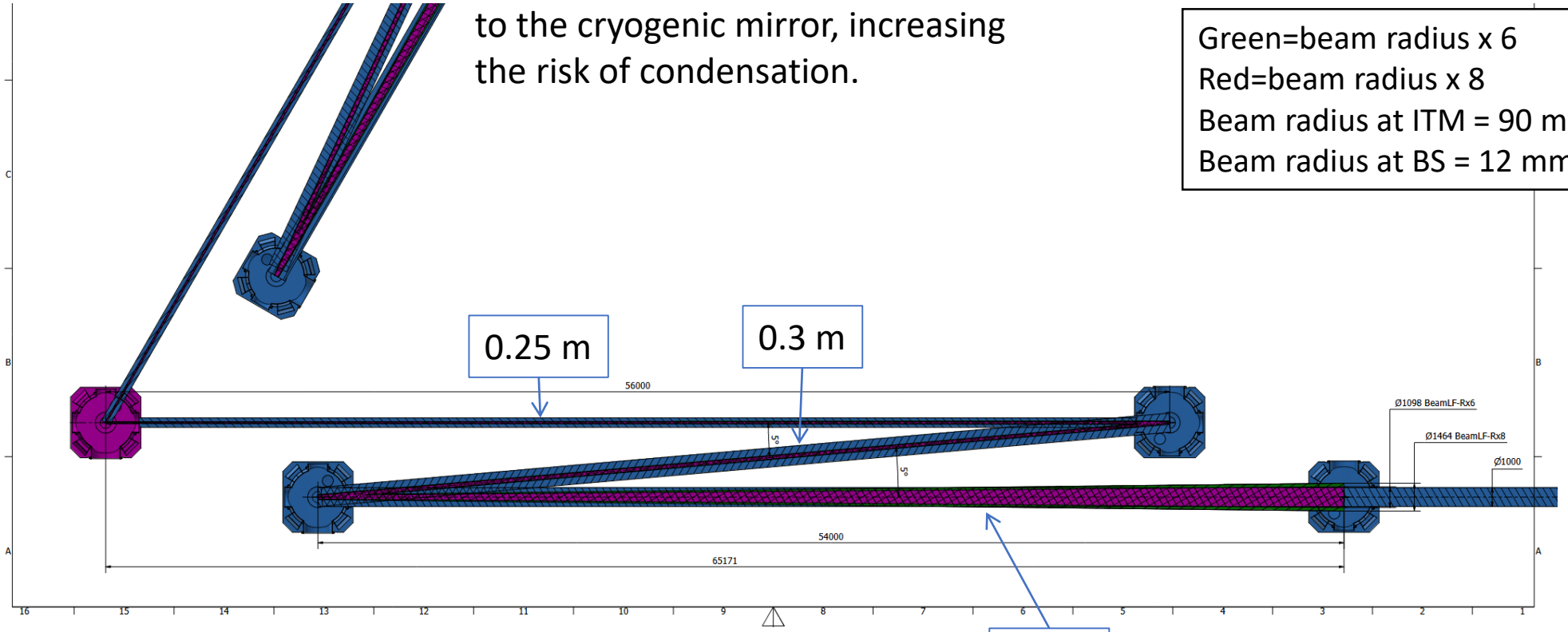
The ITM Tower requires very low pressure, and the higher pressure from the telescope and BS towers must be controlled to ensure minimal impact on the ITM Tower.

Smaller sections where feasible, along with cryogenic pumps, are additional effective solutions.

Links Diameter - LF

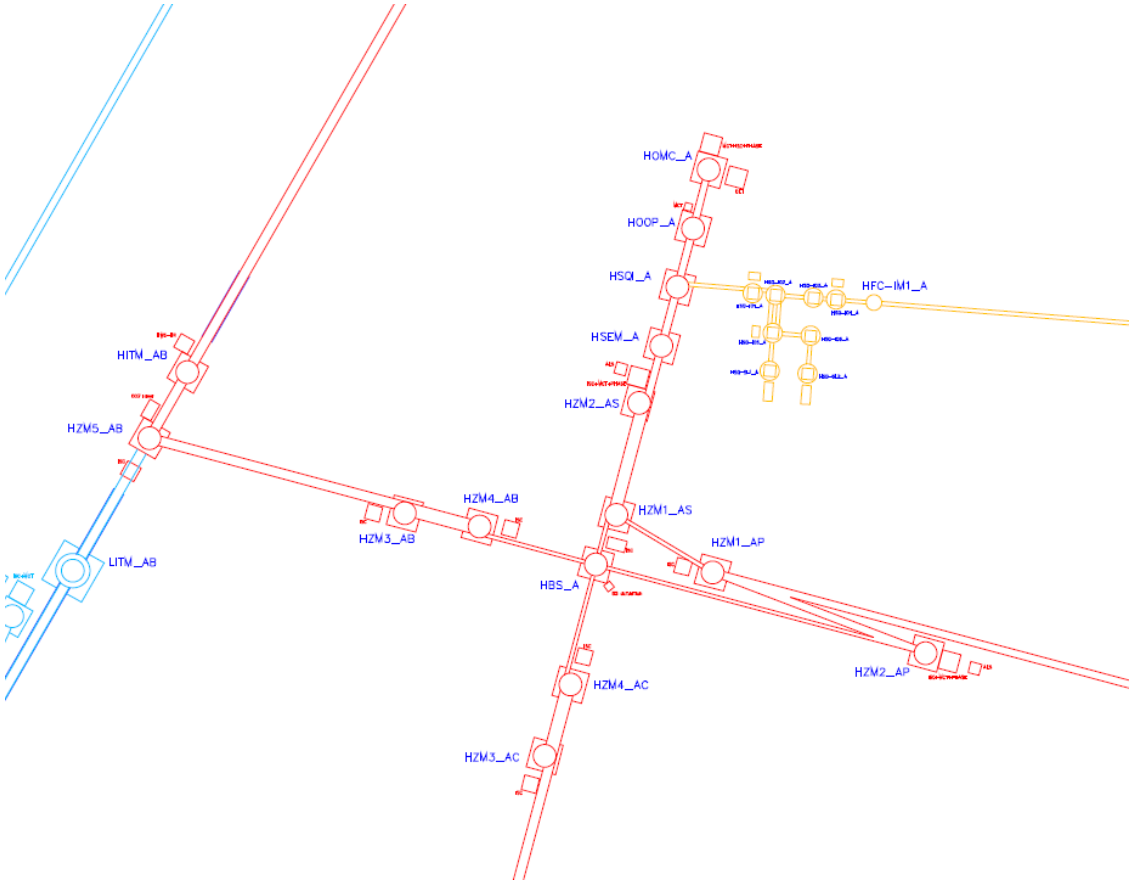
Same issue as with the HF interferometer, but amplified due to the cryogenic mirror, increasing the risk of condensation.

Green=beam radius x 6
Red=beam radius x 8
Beam radius at ITM = 90 mm
Beam radius at BS = 12 mm



Missing elements in the 3D model

- Large Gate Valves – Minor impact
- Cryotraps – Minor impact
- Diameter of links not updated yet.
- Cranes
  - Depending on the Gallery scheme adopted by ETO.
- Additional Clean Areas
  - Probably around / on top each Auxiliary bench – ISO 7 Operational, TBC.
  - Effect on detector Layout: being able to move freely around the Bench.



Next steps

The present 3D model gives a good estimation of the volume claims requested by ETO for the towers + scaffolding + associated clean rooms.

- Adding missing elements in the 3D model.
- Refinement on Clean Room Designs “Volume”.
- Refinement of CFD calculations for Air Flow within the Tower.
- Opening of the upper part – procedure of lifting, preserving cleanliness and storage of rings.
- Progress on the designs of the Towers “Families”.

- Iteration with Working Groups (SUSP, OPT…) for Interfaces.
- Flexibility of towers – Input from Optics group missing.