" ET Tower Vacuum " and Highlights from Virgo experience

GWD Vac 2022

La Biodola 29-30 September, 2022

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Summary

- Introduction
- Virgo experience
  - Towers systems
  - Towers highlights
- ET ‘Tower vacuum’
  - Status and preliminary choices
  - Challenges, proposed R&D
  - Development path

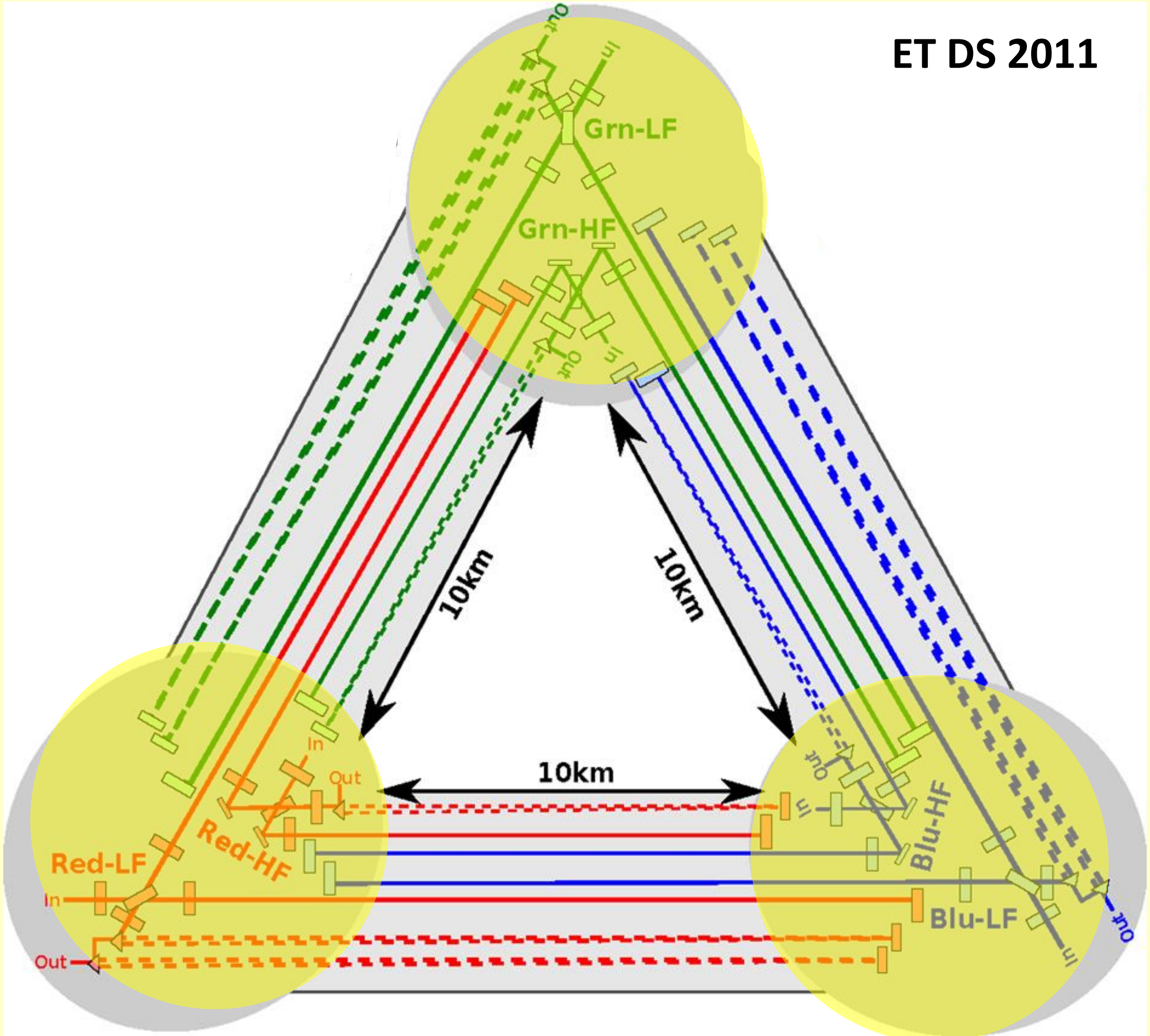
ET project Vacuum Systems

- **4 different vacuum systems**

  Huge **Tubes** and large **Towers**, hosting scientific equipment with different requirements and operativity.

  Combined together by very large cryogenic pumps: **Cryotraps**.

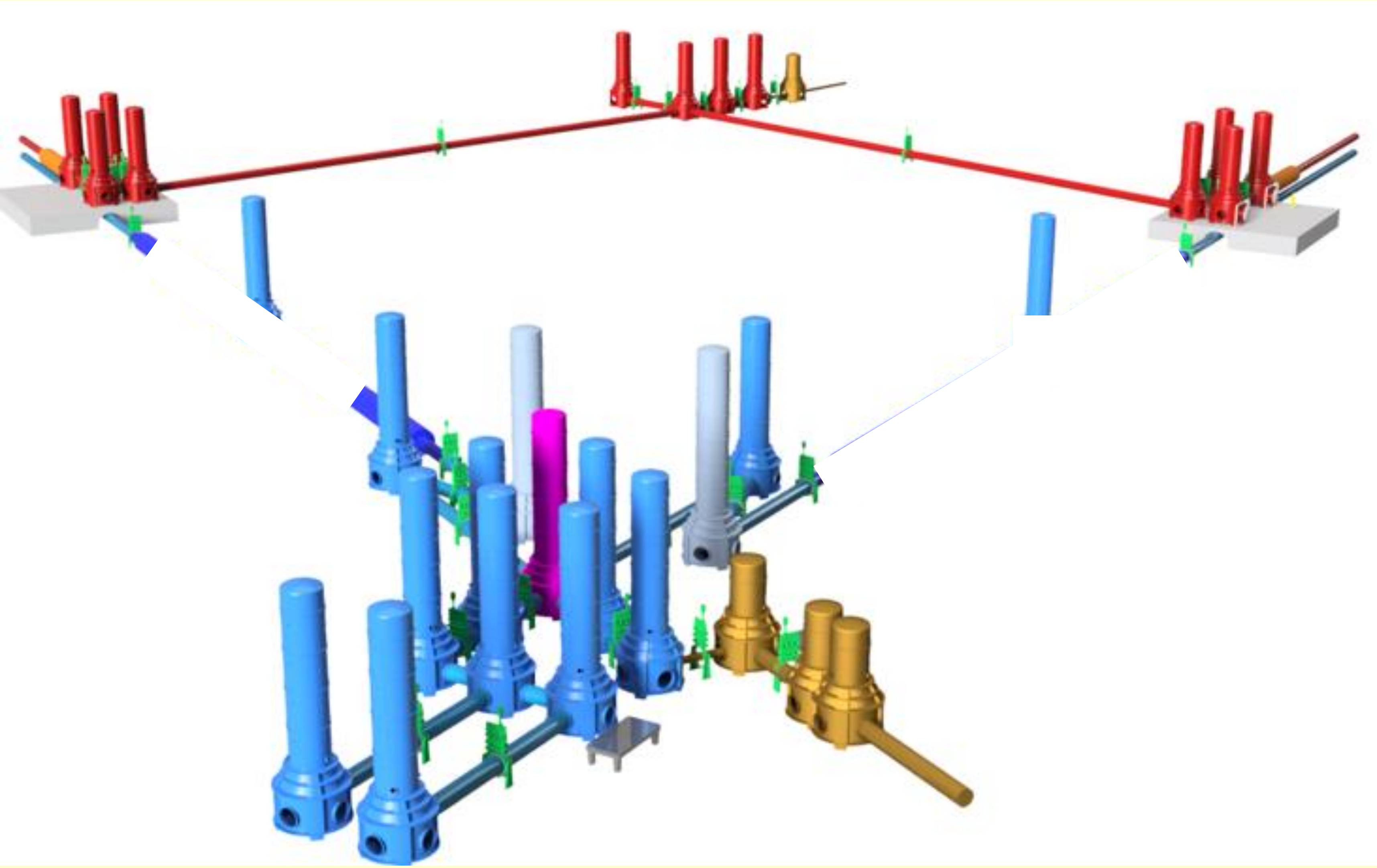
  And **Cryostats** dedicated to the cryogenic payload.



'Towers Vacuum'

- House the **Suspensions** and the **Payloads** (not the cryogenic ones)
- Interfaces with:
  - Civil Infrastructure
  - Optical layout
  - Suspension system
  - TCS system
  - Stray Light Control
  - Interferometer controls
- Different types of 'towers'

1 detector ≈ 42 towers



‘Towers’ statistics

- ***How many tower types? A preliminary study (A.Paoli)***

Idea is to standardize the chambers, identifying a few basic models with some modifications depending on the service

Tower	Base shape	Base dimensions	Basement	Access	Notes	Lower part	Upper part	Beam height	Height from beam	Height from floor	Cavern Type
LF_BS	Hexagonal	circumscribed to a circle Ø5.0m		from below			Ø2.5m	1.5m	17.5m	19.0m	A
LF_PRM	Square	4.0x4.0m		from below			Ø2.5m	1.5m	17.5m	19.0m	A
LF_IMC	Square	4.0x4.0m		from below			Ø2.5m	1.5m	17.5m	19.0m	A
LF_SRM	Square	4.0x4.0m		from below			Ø2.5m	1.5m	17.5m	19.0m	A
LF_OMC	Square	4.0x4.0m		from below			Ø2.5m	1.5m	17.5m	19.0m	A
LF_X_ZM1	Square	4.0x4.0m		lateral???	telescope		Ø2.5m	1.5m	17.5m	19.0m	A
LF_X_ZM2	Square	4.0x4.0m		lateral???	telescope		Ø2.5m	1.5m	17.5m	19.0m	A
LF_X_ITM	Square	5.0x5.0m		from below	cryogenic equipments		Ø2.5m	1.5m	17.5m	19.0m	A
LF_Y_ZM1	Square	4.0x4.0m		lateral???	telescope		Ø2.5m	1.5m	17.5m	19.0m	A
LF_Y_ZM2	Square	4.0x4.0m		lateral???	telescope		Ø2.5m	1.5m	17.5m	19.0m	A
LF_Y_ITM	Square	5.0x5.0m		from below	cryogenic equipments	Ø4m	Ø2.5m	1.5m	17.5m	19.0m	A
LF_FC_I1	Circle	Ø1.5m		lateral			Ø1.5m	1.5m	4.5m	6.0m	A
LF_FC_I2	Circle	Ø1.5m		lateral			Ø1.5m	1.5m	4.5m	6.0m	A
LF_FC_M1	Circle	Ø1.5m		lateral	filter cavity		Ø1.5m	1.5m	4.5m	6.0m	A
LF_FC_M2	Circle	Ø1.5m		lateral	filter cavity		Ø1.5m	1.5m	4.5m	6.0m	A
LF_X_ETM	Square	5.0x5.0m		from below	cryogenic equipments	Ø4m	Ø2.5m	1.5m	17.5m	19.0m	D
LF_X_Cal1	Square	2.5x2.5m		lateral	TBD		Ø1.5m	1.5m	7.5m	9.0m	C
LF_X_Cal2	Square	2.5x2.5m		lateral	TBD		Ø1.5m	1.5m	7.5m	9.0m	C
LF_Y_ETM	Square	5.0x5.0m		from below	cryogenic equipments	Ø4m	Ø2.5m	1.5m	17.5m	19.0m	D
LF_Y_Cal1	Square	2.5x2.5m		lateral	TBD		Ø1.5m	1.5m	7.5m	9.0m	C
LF_Y_Cal2	Square	2.5x2.5m		lateral	TBD		Ø1.5m	1.5m	7.5m	9.0m	C

HF_BS	Sq										
HF_PRM	Sq										
HF_IMC	Sq										
HF_SRM	Sq										
HF_OMC	Sq										
HF_X_ZM	Sq										
HF_X_ZM1	Sq										
HF_X_ZM2	Sq										
HF_X_ITM	Sq										
HF_Y_ZM	Sq										
HF_Y_ZM1	Sq										
HF_Y_ZM2	Sq										
HF_Y_ITM	Sq										
HF_FC_M1	Ci										
HF_FC_M2	Ci										
HF_X_ETM	Sq										
HF_X_Cal1	Sq										
HF_X_Cal2	Sq										
HF_Y_ETM	Sq										
HF_Y_Cal1	Square	2.5x2.5m	H=2.5m	lateral	TBD		Ø1.5m	3.5m	7.5m	11.0m	E
HF_Y_Cal2	Square	2.5x2.5m	H=2.5m	lateral	TBD		Ø1.5m	3.5m	7.5m	11.0m	E

Vacuum levels

- **Preliminary figures**
  - *Likely driven by interfaces compliance! To be finalized, for the different gas species, considering the wanted facility limits, iterating on materials and design options.*
  - *A design margin should be discussed as well*
  - *Extremely low partial pressure of low-volatile organics: a challenging task.*

A. HF towers: low E-9 mbar range, unbaked. *Note: vacuum level in HF tubes is highly demanding;*

B. LF towers: low E-9 mbar range, unbaked. *Note: many gas species are a potential risk for deposition on mirrors;*

C. Upper compartments: E-7 mbar range, unbaked, water prevalent;

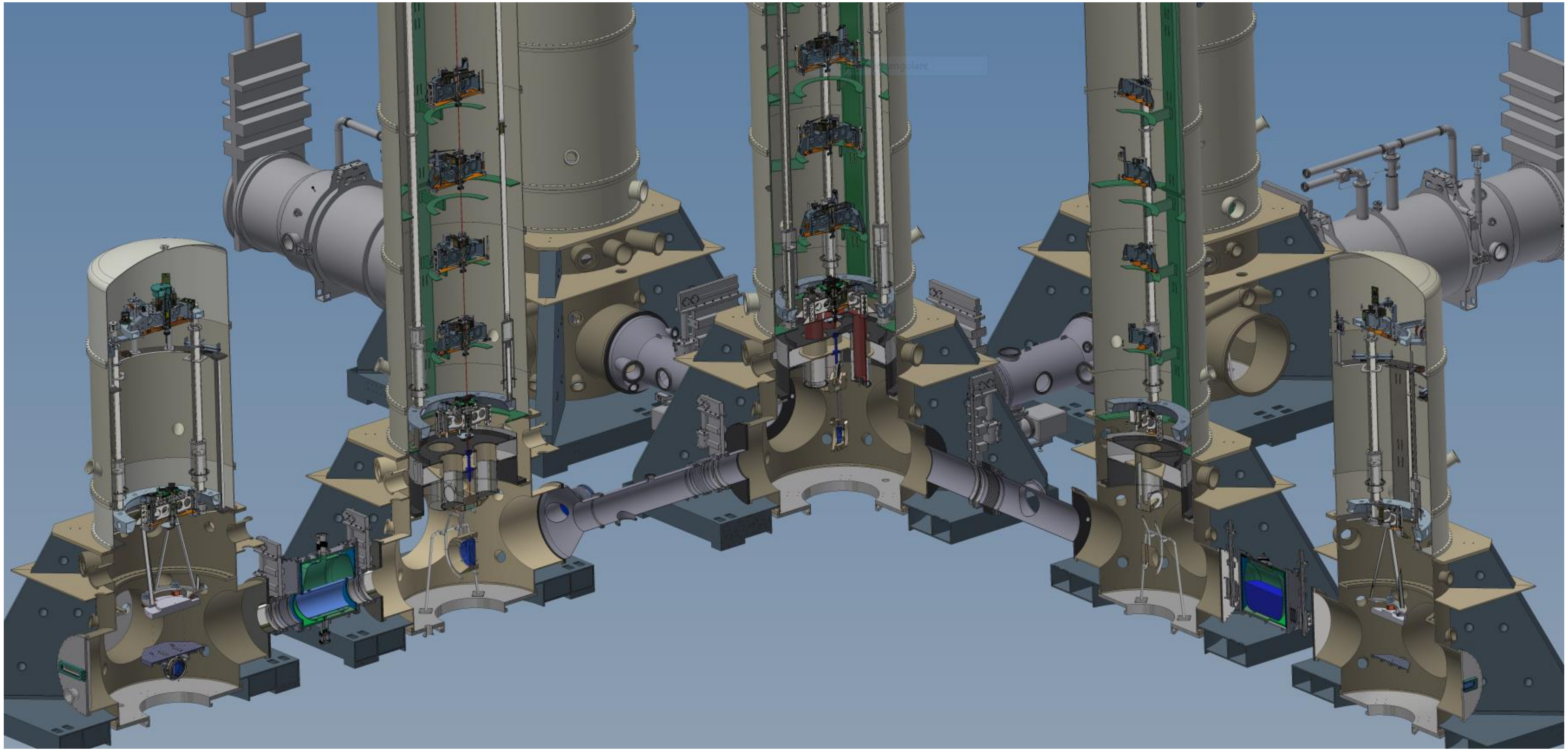
D. Other auxiliary chambers, typically lower-rated concerning residual pressure.

Purpose and Plan

- **Light Technical Design**
  - **Technical Design within 2 years**. *Not yet at construction level, but with closed options with significant impact on budget and civil infrastructure.*
  - **Costs evaluation.**
  - Design choices should be considered whether or not configuration & site dependent .

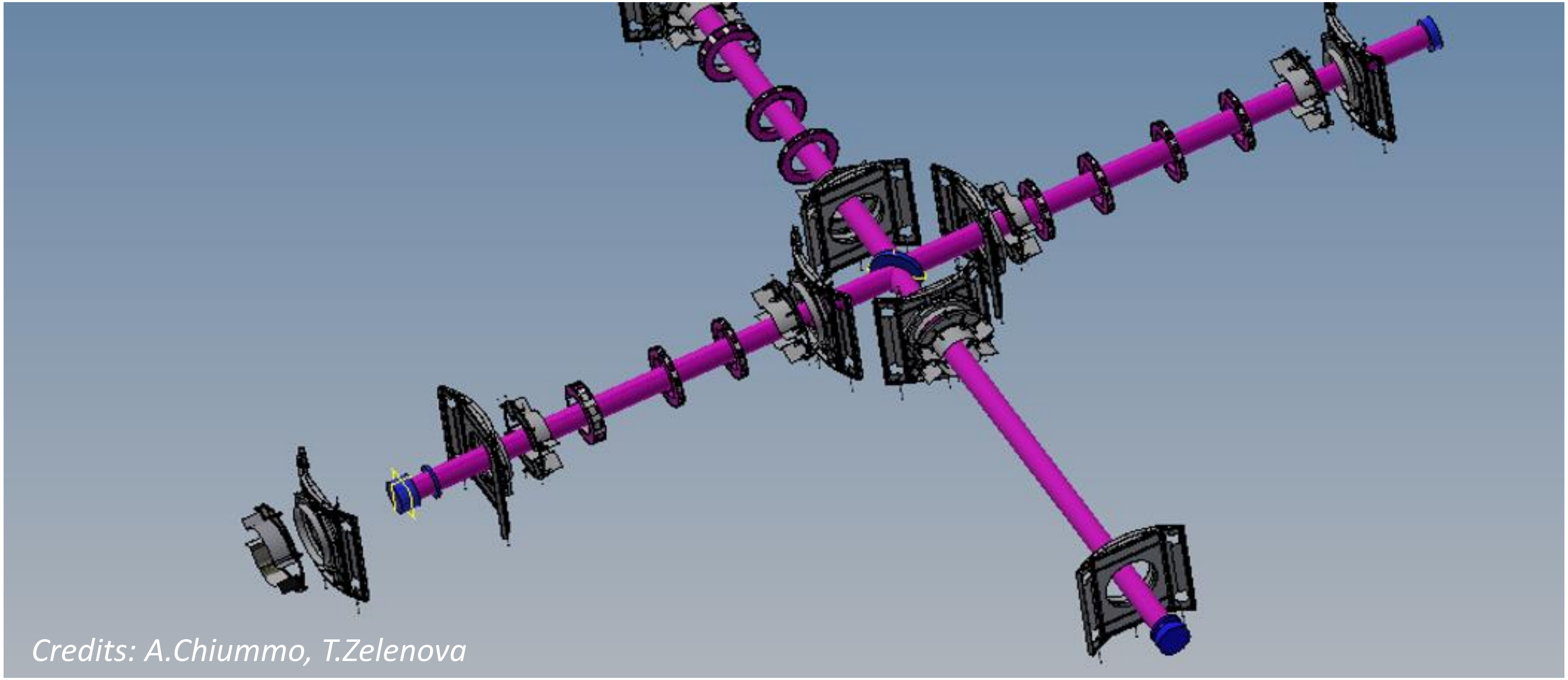
Virgo 'Tower Vacuum'

- View of Central Area (7 + 3 'Towers' in total)



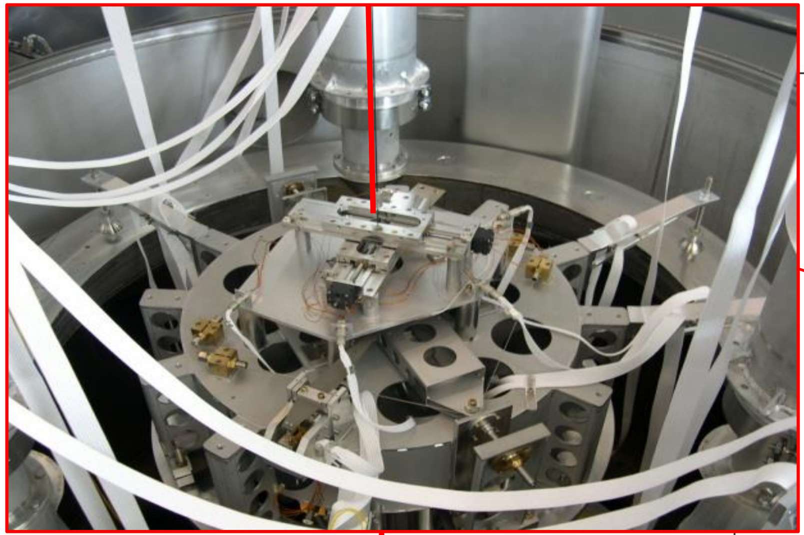
Optical content

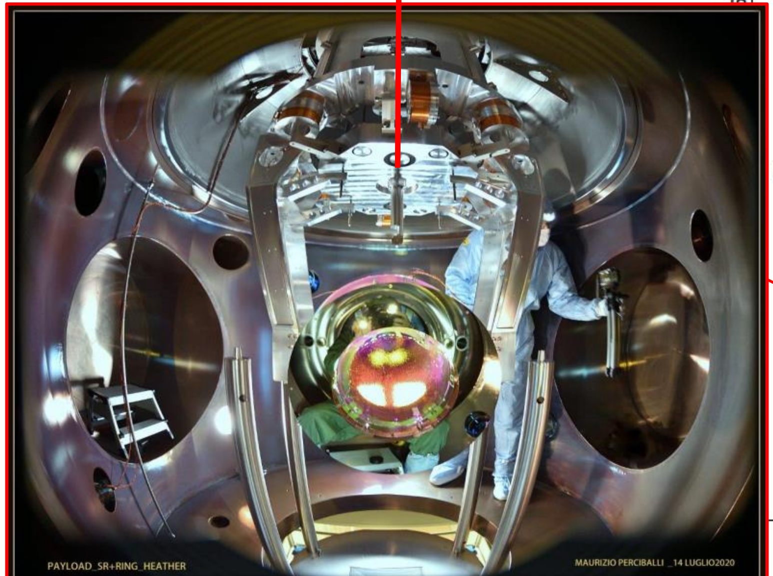
- Main beam and optical 'baffles'

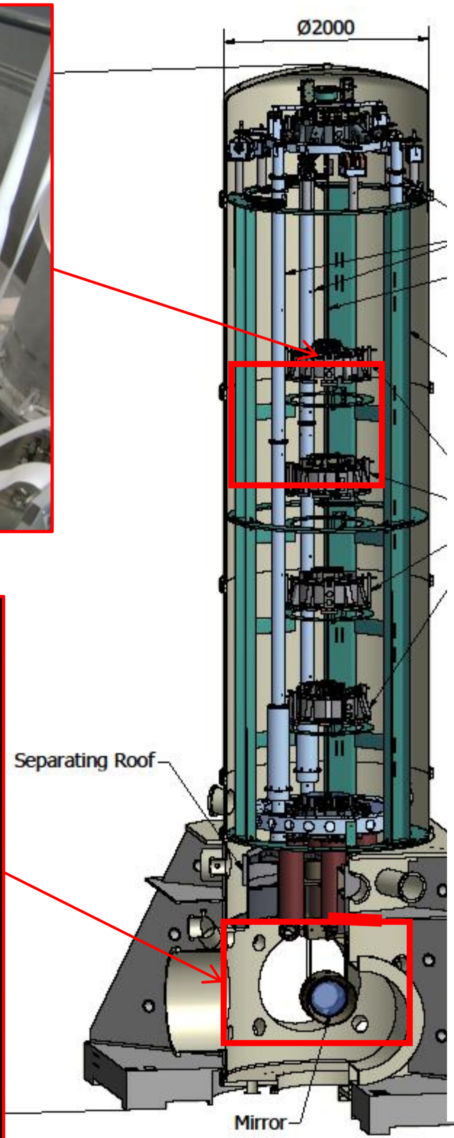


Credits: A.Chiummo, T.Zelenova

Two vacuum compartments







Upper Part

< 10^{-6}

mbar

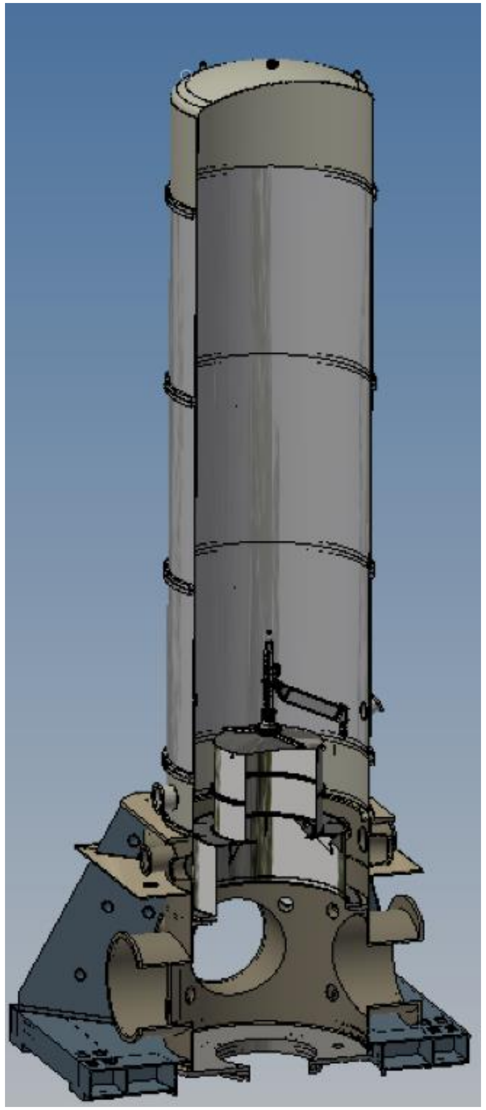
Lower part

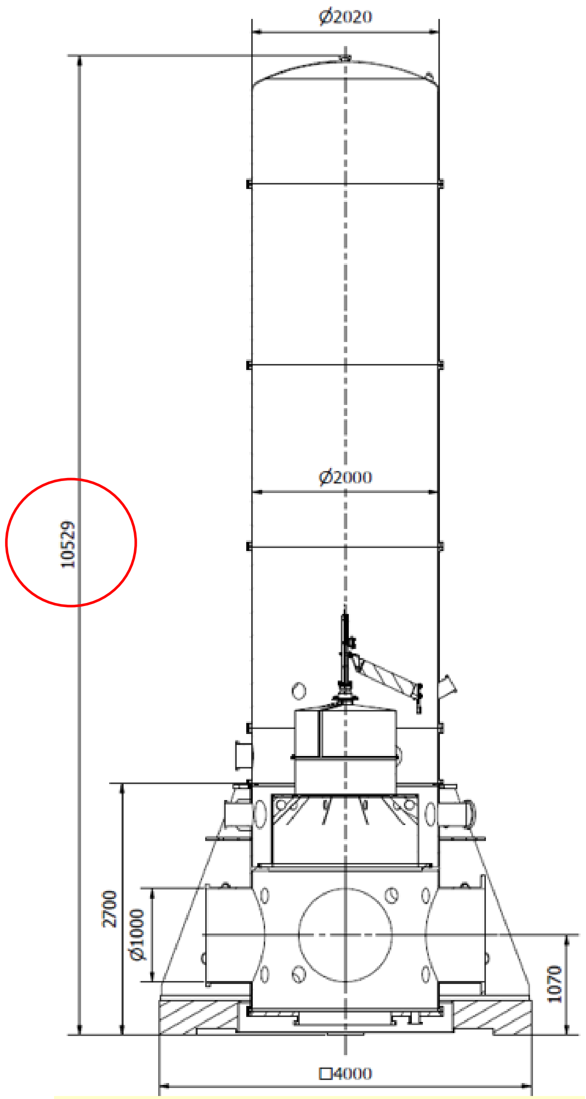
10^{-8} mbar

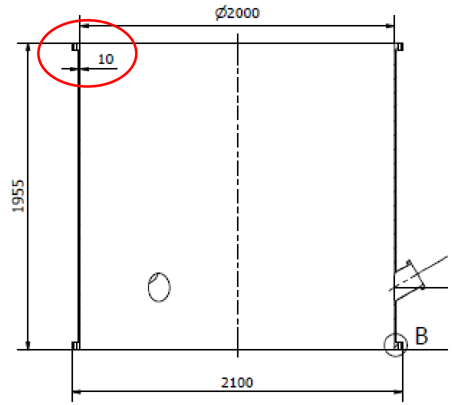
Main features

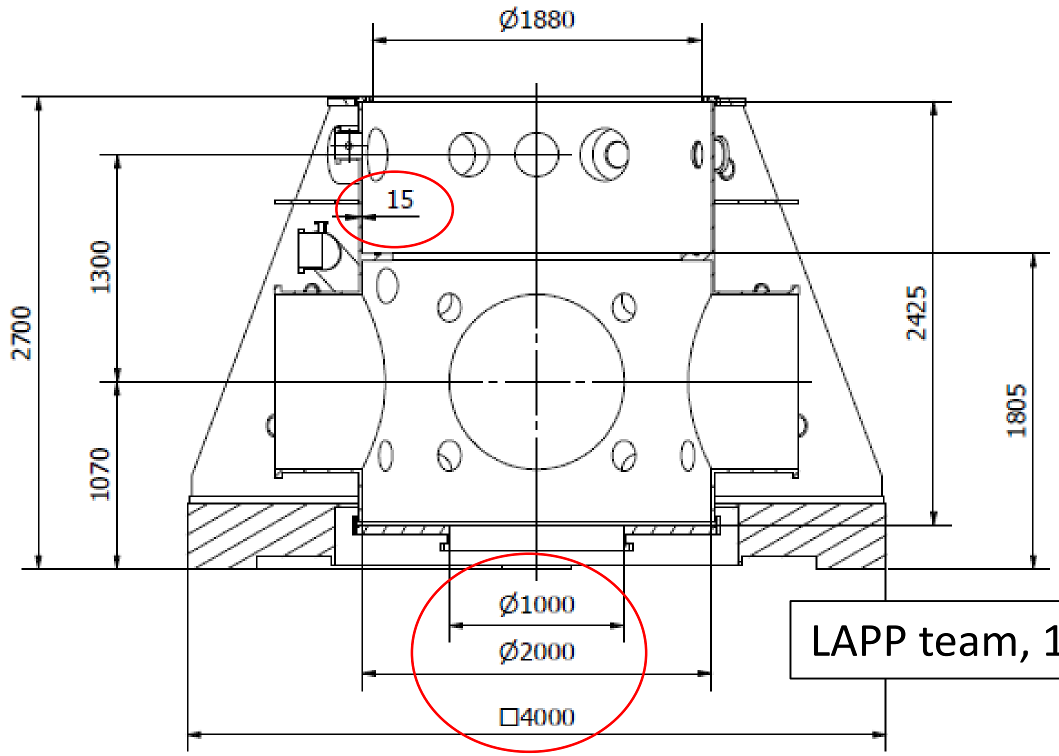
- Ø = 2m, up to 11m high, ≈ 20 ton, Unbaked;
- House crucial optics and complex mechanics (frequencies > 10 Hz, within seismic-attenuator range);
- Allow clean and ‘easy’ access of personnel ;
- Materials policy: screening and pre-baking;
- Cleanroom class 100 (even if w/out strictly laminar flow);
- Electropolished surfaces, baking in situ before optics insertion*:*

Chamber technical design

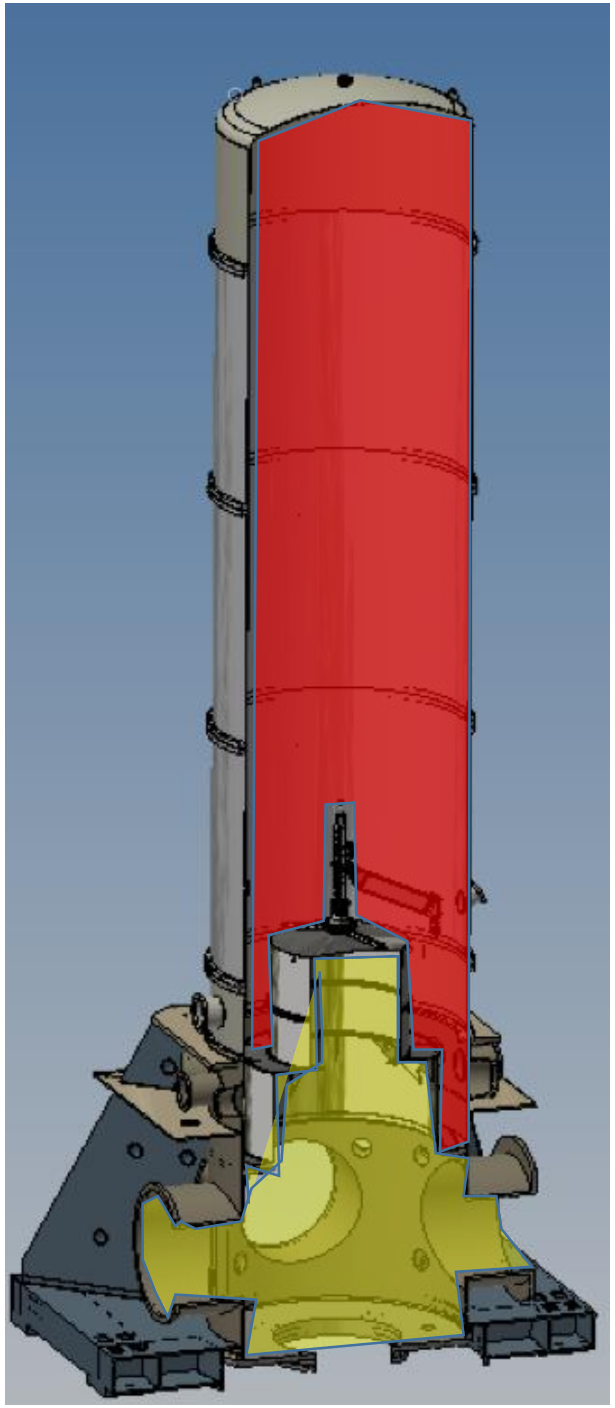






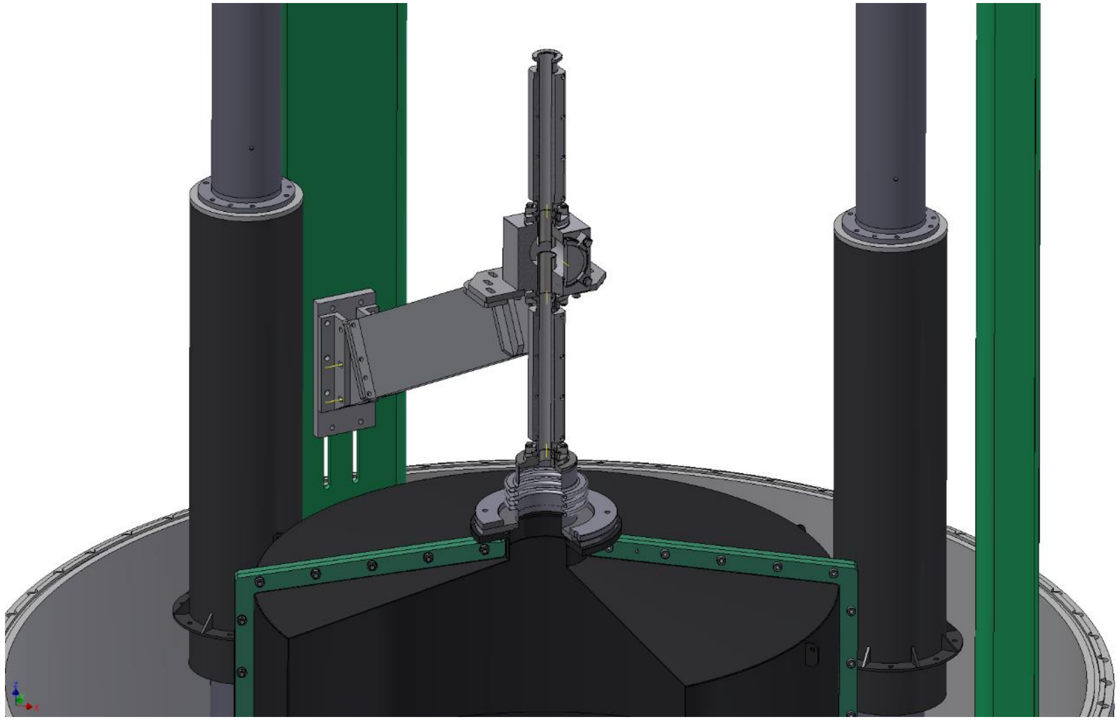


LAPP team, 1997



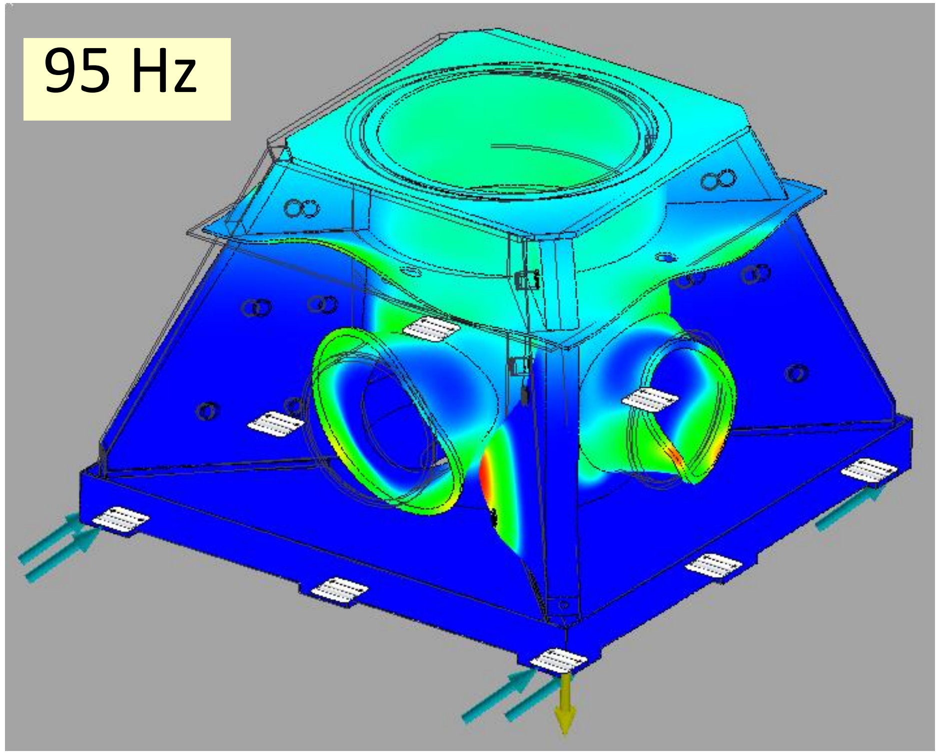
Vacuum transition

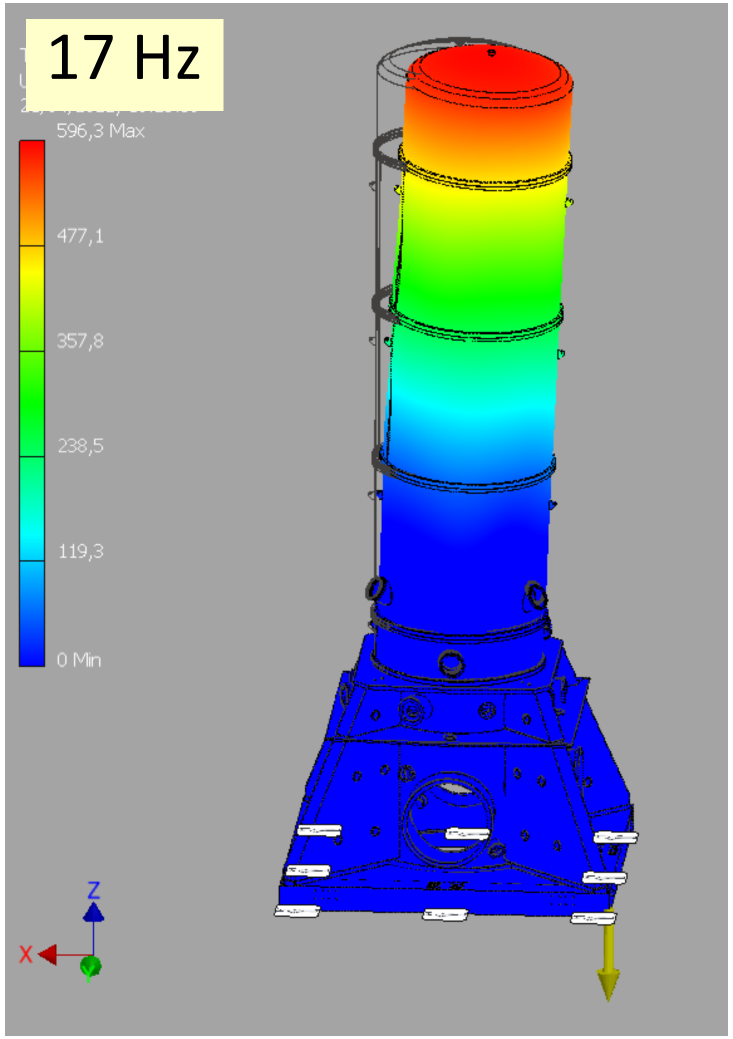
- Lenght ≈ 80 cm, 6 mm clearance, differential pumping not installed. Ceq.: order of 1 l/s N_2 (+ some leaking defects elsewhere ...)
- O-ring (single or double) seals, metal seals (Conflat, Helicoflex)
- Limited maximum delta pressure (order of 10 mbar)



Main chamber structure

- Frequencies of vibrational modes of Virgo towers





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Bake-out and qualification of chambers

- Bake-out of the lower compartment (done once)
- The estimated total outgassing load was: $\leq$1E-6 mbar.l/s N_2eq.@20C *(includes 'links', vacuum equipment and a few glass baffles, - not the scientific equipment -)*
- Low-volatile organics ('Hydrocarbons'): E-13 mbar range (conventional estimate)
- Bake-out of entire tower, originally foreseen, is not performed (just once per test, right plot) and we introduced LN2 cryopumps.

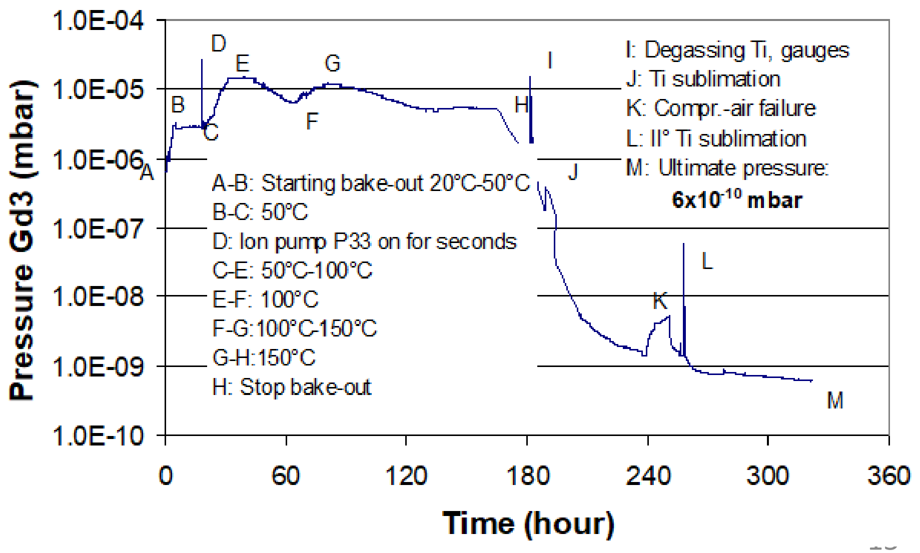
COMPLIANCE REPORT TOWER:**PR**

SHEET **2 of 3**

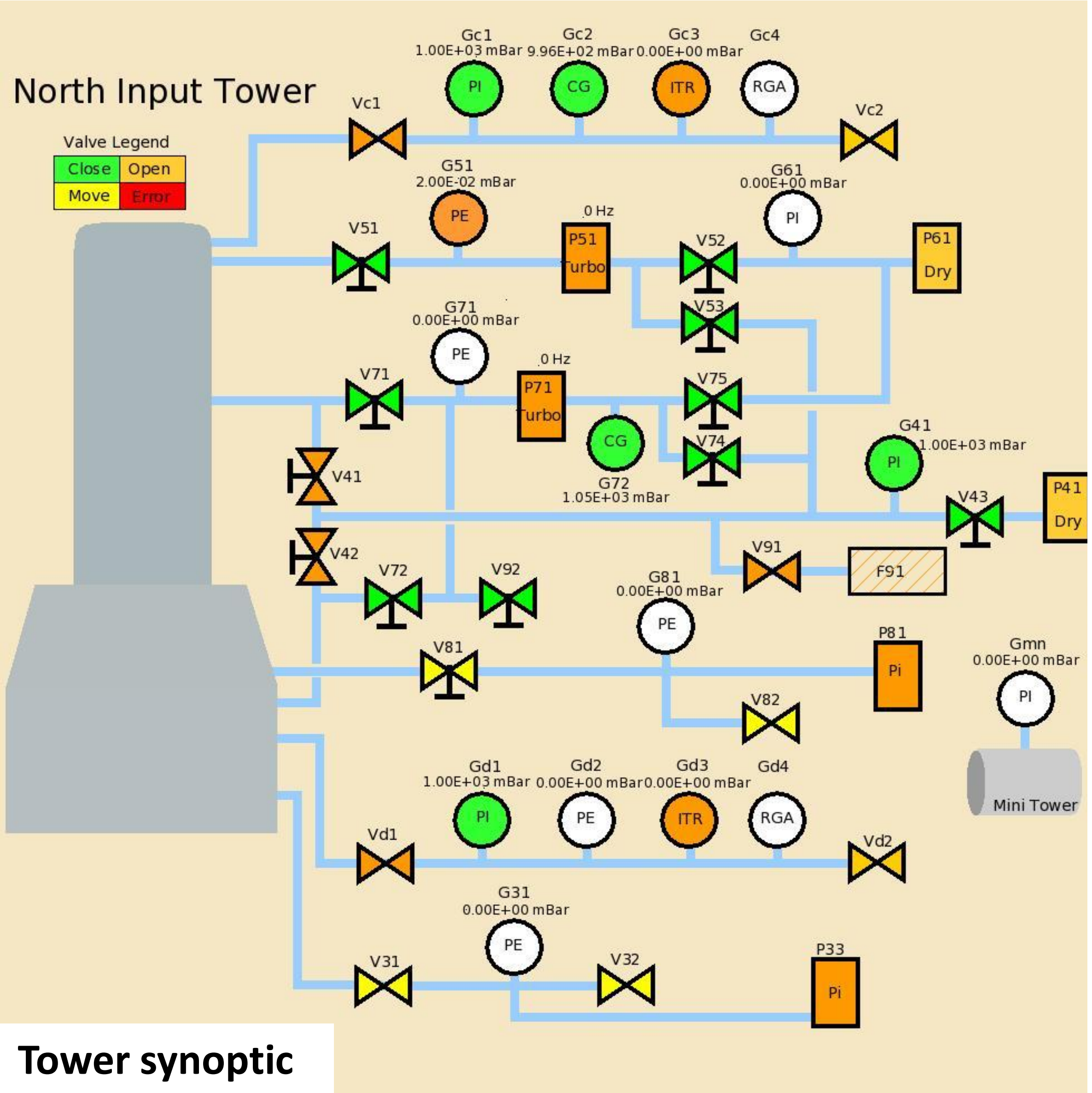
DATE: 30.09.99

II. **SYSTEM PERFORMANCE**

Item	Requirement	Ref.Doc	Result	Compl.	Remark/notes
Leak tightness	10^{-8} mbar l s^{-1} (for base tower)	8)	<10^{-10} mbar l s^{-1} (detection limit)	A	He test of each flange before baking, RGA analysis after baking
H_2 pressure*	$\leq 10^{-9}$ mbar N_2 @20°C	1)	8.10^{-10} mbar N_2	A	Not measured at same time than below spectrum
H_2O *,**	$\leq 10^{-10}$ mbar N_2@20°C	1)	9.10^{-11} mbar@35°C	A	Higher then expected maybe due to the "low" (100°C) cupola baking temp.
Others*,**	$\leq 10^{-10}$ mbar N_2@20°C	1)	Fulfilled	A	Air signature N_2, O_2, Ar maybe from viton (same for all towers)
HC cleanliness*,**	$\leq 10^{-14}$ mbar N_2@20°C	1)	4.10^{-13} mbar@35°C	A	Ref. to amu 55; as for the water about the removal efficiency. Expected order of 10^{-14} mbar @20°C
Total outgassing	_	1)	5.10^{-7} mbarls^{-1}N_2	C	Roughly estimated by "accumulation" method "Apparent" outg. rate ~1.4 10^{-12} mbar l s^{-1} cm^{-2} N_2 4 glass baffles are present inside the chamber.
Baking temp. cycle	150°C 4 days controlled cool down 24 hr warmup	1), 7)	2 days cooldown	AR	Slow cooldown of the tower bottom: it is necessary to open the lower insulation panel to speed up the cooldown
Tower displacement after baking	0 mm in all directions	6) appendix	N arm~ -0.3 mm W arm~ +2.9 mm	C AR	See attacched doc 6), pag.5 and appended datasheet Tower initial position has to be recovered. See app.2.
Max baking pressure	5.10^{-5} mbar @150°C	1)	3.10^{-5} mbar	A	Oven at 120°C
Local control HW				A/AR	Some problems to be corrected when ENEL power fail
Local control SW				A/AR	The following tests have to be done: pumping sequences; security on rough pump; 12 RGA heads in same time; local supervisor with 8 towers in same time

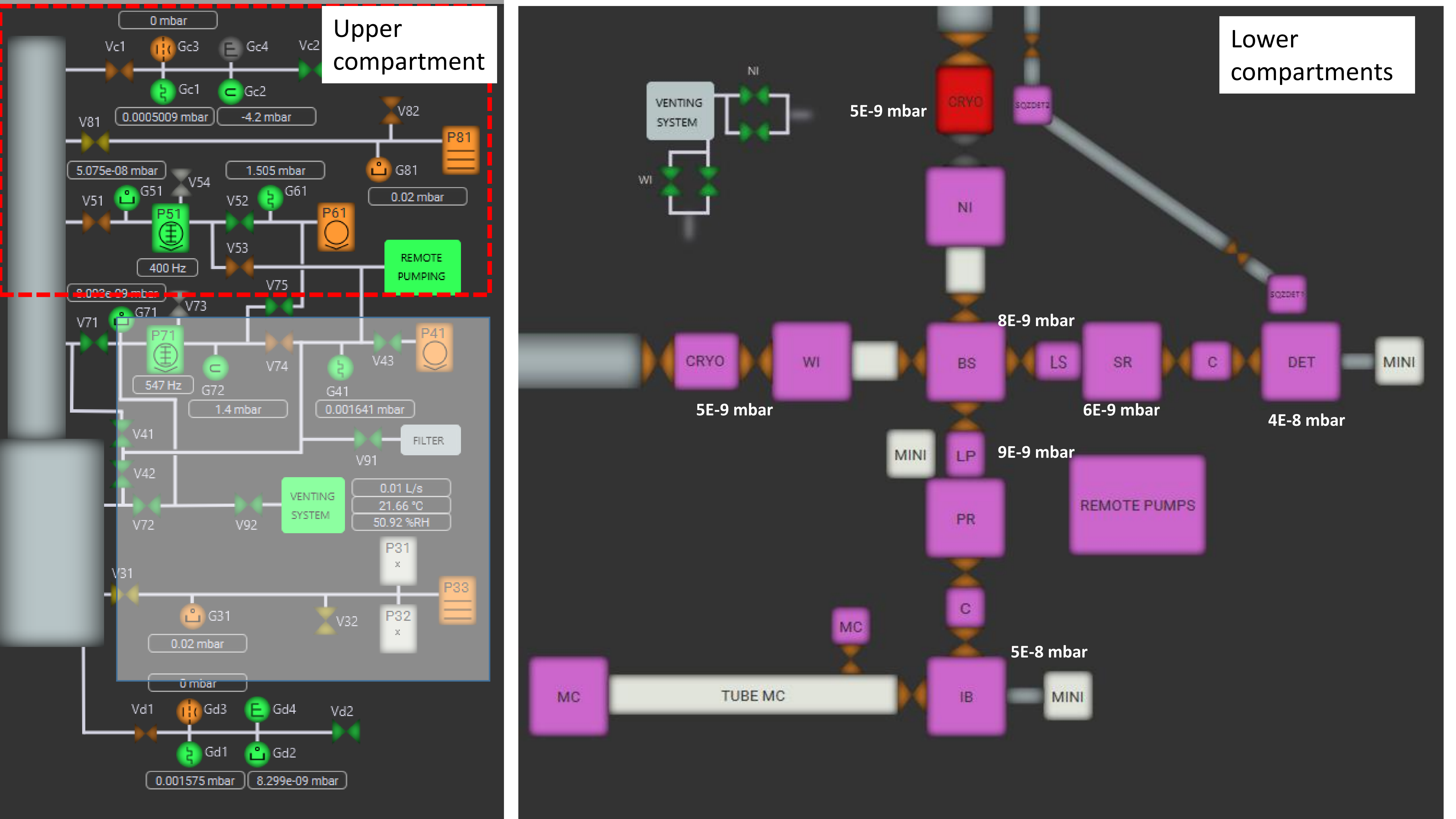


Pumping System

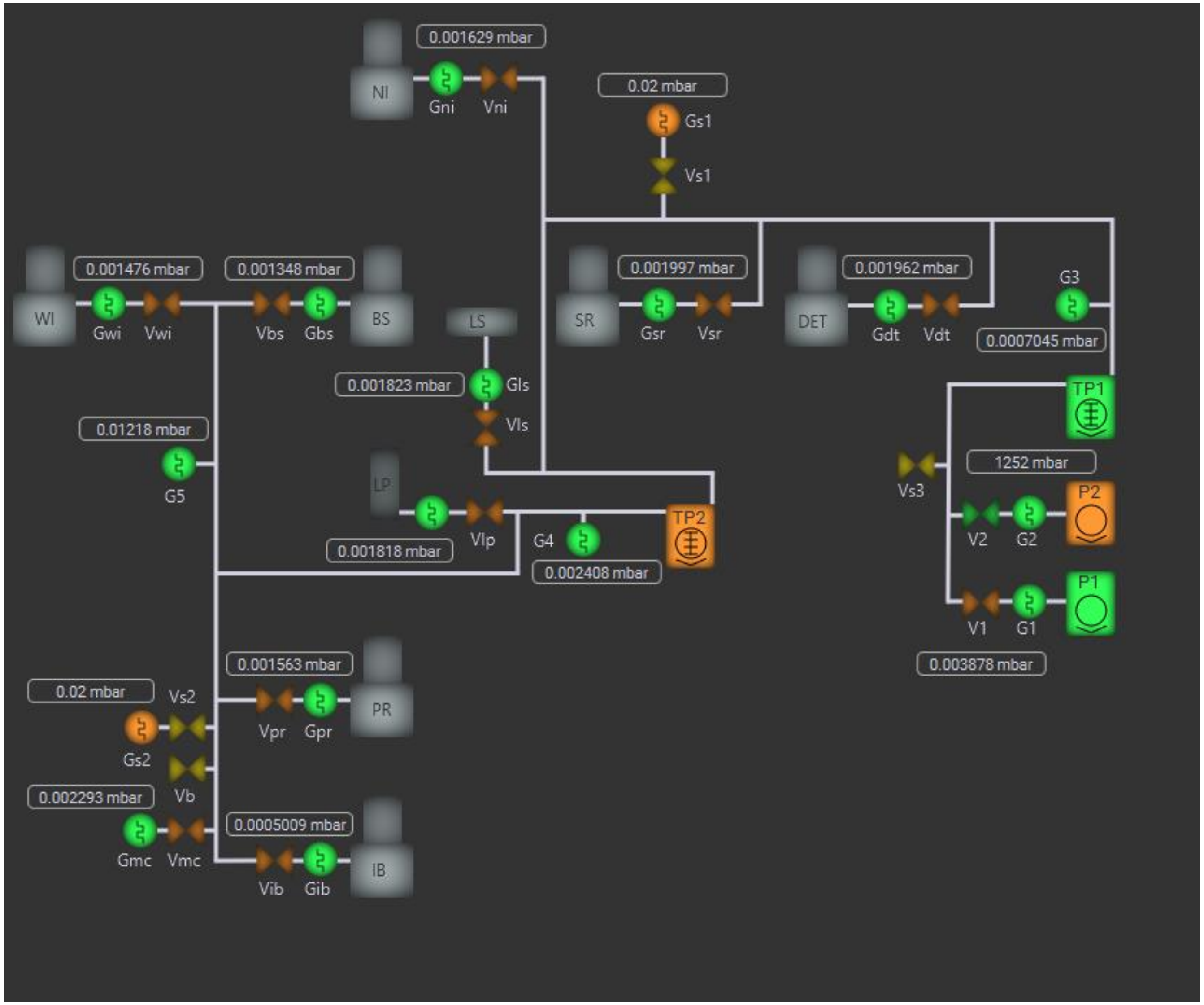


Tower synoptic

- All stages from 1 bar to UHV
  - Rough (about 24h)
  - Intermediate (days)
  - Permanent
- Emergency pumps
- Safety interlocks
- No automatic pumping sequences
- Oil-free, low-acoustic / seismic / magnetic emissions, long maintenance intervals

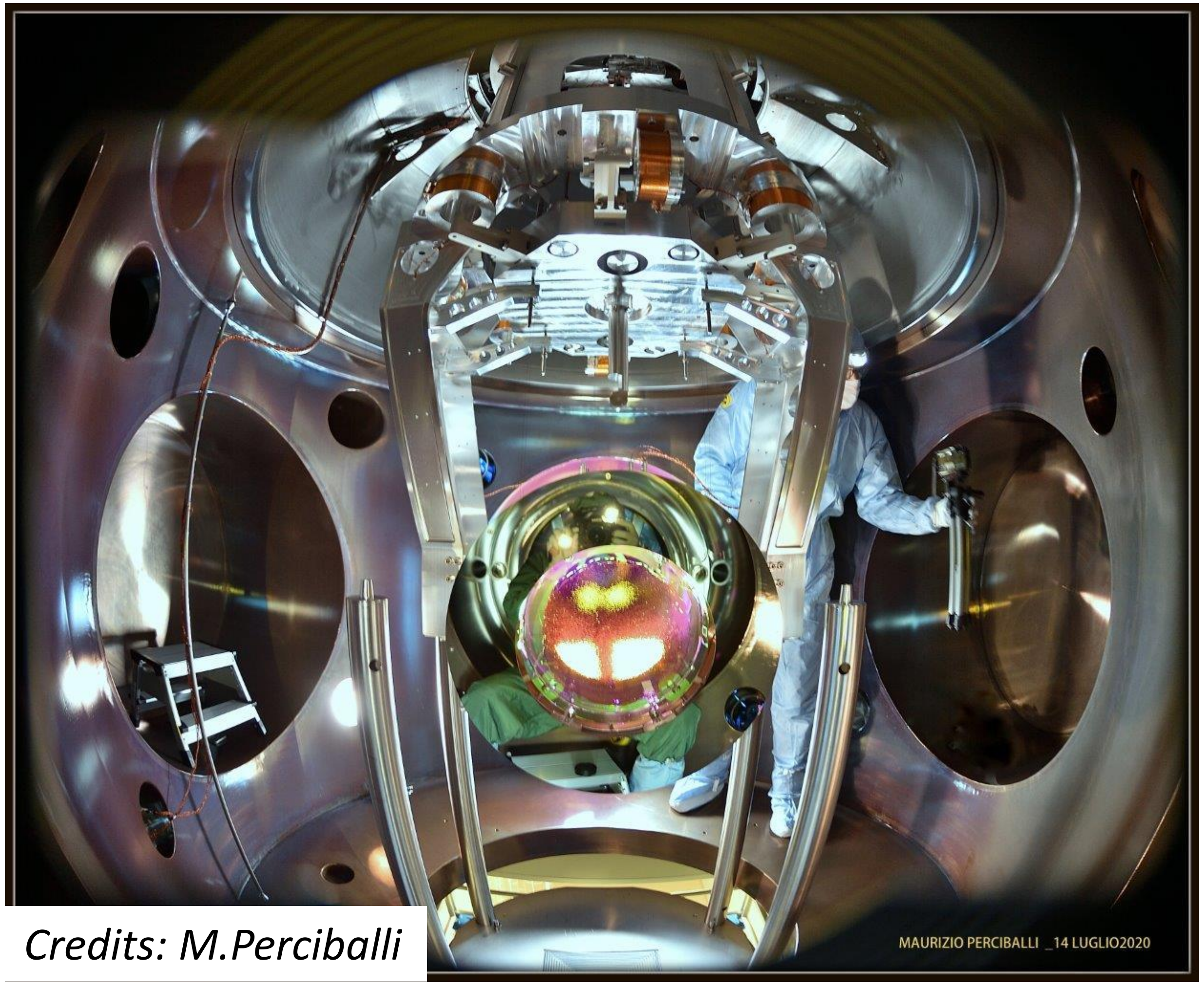

Upper compartment
0 mbar
Vc1
Gc3
Gc4
Vc2
Gc1
Gc2
0.0005009 mbar
-4.2 mbar
V82
V81
P81
5.075e-08 mbar
V54
1.505 mbar
G81
V51
G51
P51
V52
G61
P61
0.02 mbar
V53
400 Hz
REMOTE PUMPING
V75
V71
G71
V73
P71
P41
G72
V74
V43
547 Hz
G41
1.4 mbar
0.001641 mbar
V41
FILTER
V91
V42
VENTING SYSTEM
0.01 L/s
21.66 °C
50.92 %RH
V72
V92
P31
V31
P33
G31
V32
P32
0.02 mbar
0 mbar
Vd1
Gd3
Gd4
Vd2
Gd1
Gd2
0.001575 mbar
8.299e-09 mbar
Lower compartments
NI
VENTING SYSTEM
WI
5E-9 mbar
CRYO
NI
8E-9 mbar
CRYO
WI
BS
LS
SR
C
DET
MINI
5E-9 mbar
6E-9 mbar
4E-8 mbar
MINI
LP
9E-9 mbar
PR
REMOTE PUMPS
C
MC
5E-8 mbar
MC
TUBE MC
IB
MINI

Primary and backing pumps



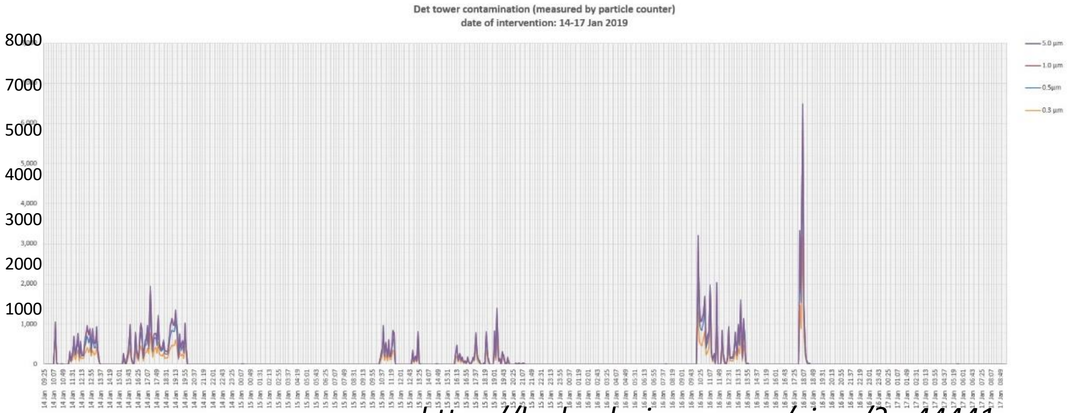
Turbo-molecular pumps are permanently running onn each tower upper compartment (typical size 1000 l/s) : they are backed remotely
or with baking pumps operated discontinuously (not optimal for Hydrogen)

Cleanroom service



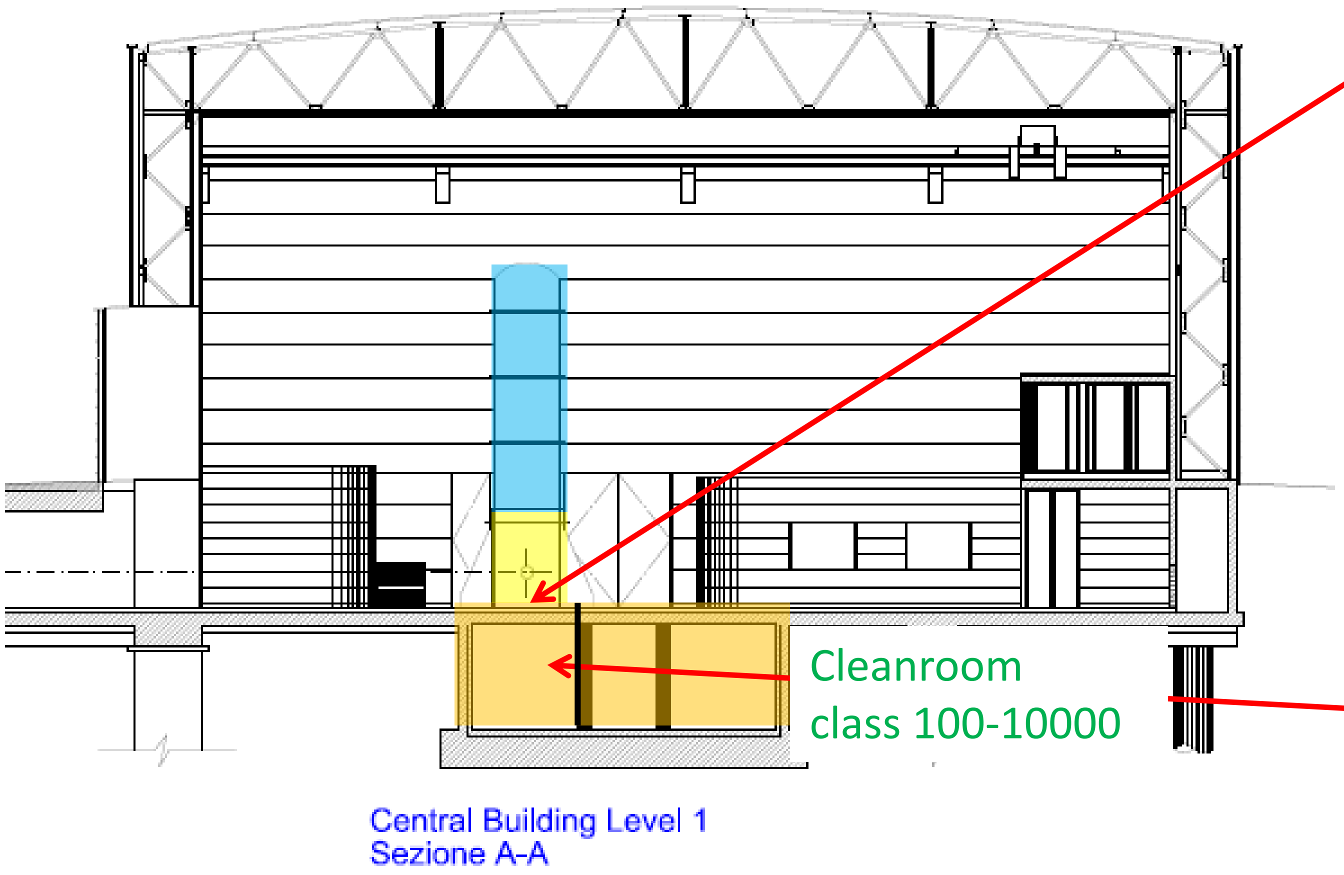
Credits: M.Perciballi

- *Towers lower compartments are a 'classified' environment for dust particles concentration (airborne)*
- *Flushed with HEPA filtered air and kept monitored wrt dust particle contamination*



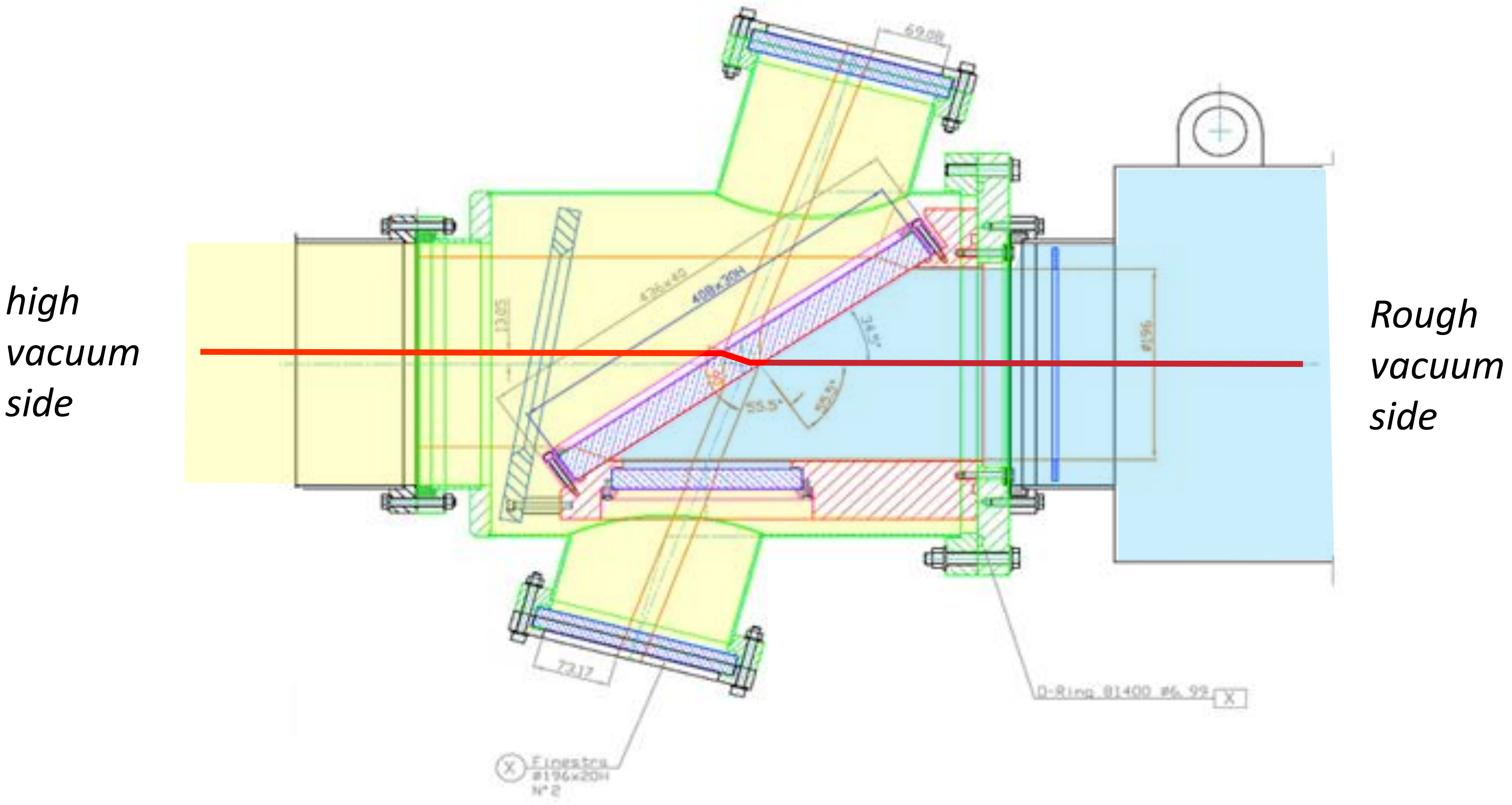
https://logbook.virgo-gw.eu/virgo/?r=44441

Tower bottom access



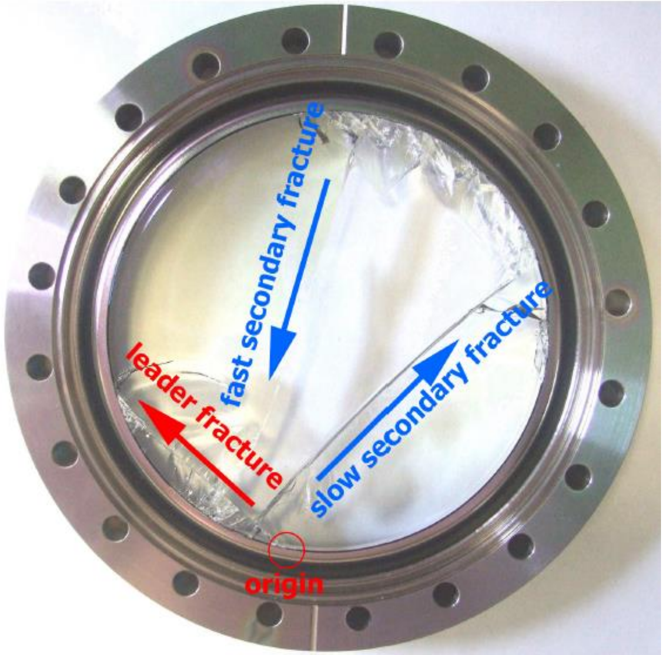
‘WINDOW’ SEPARATIONS

- Vacuum tight glass separation are in use to allow beam passage between chambers at much different vacuum levels. May become a disturbance for the experiment (or for vacuum if removed). Not a valid solution for critical areas / beams.



VIEWPORT RISKS

Order of 70 viewports installed, mostly standard ones. Dedicated policy against breaking risks in force.



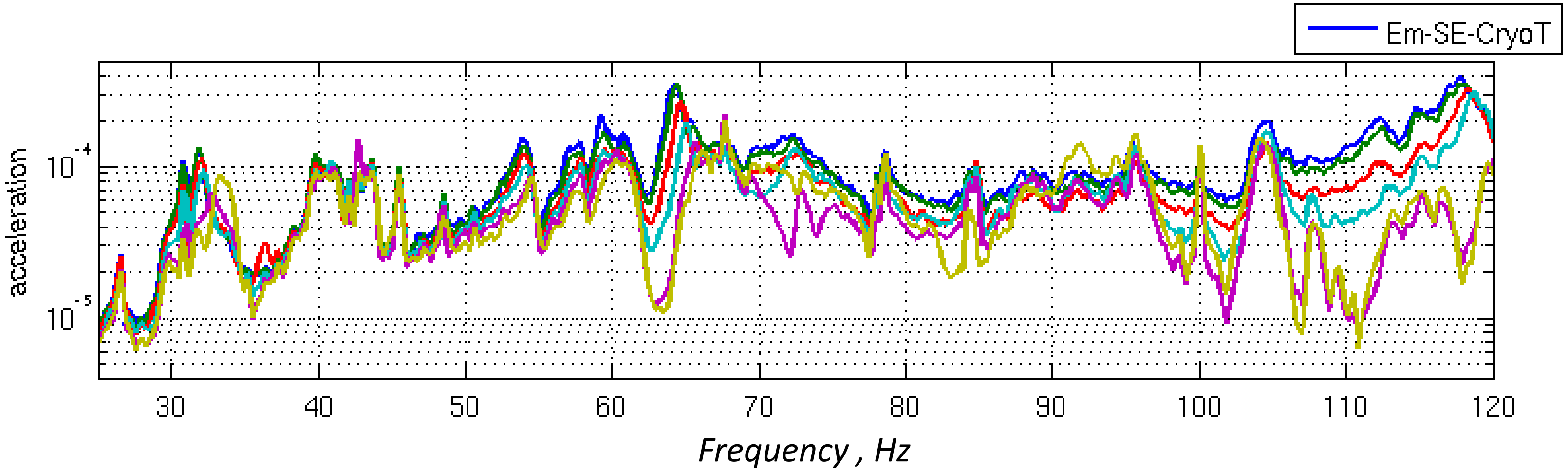
Breaking event of a viewport, 2008

Risk = defect + stress x time

Glass/KOVAR joint design was the origin of the stress (SSV et al.)

LN2 BUBBLING

LN2 boiling inside cryostats is a possible source of noise (mechanical vibrations): *accurate design to avoid 'heat concentration spots' , seismic isolation of the cryostat, large walls opening.*

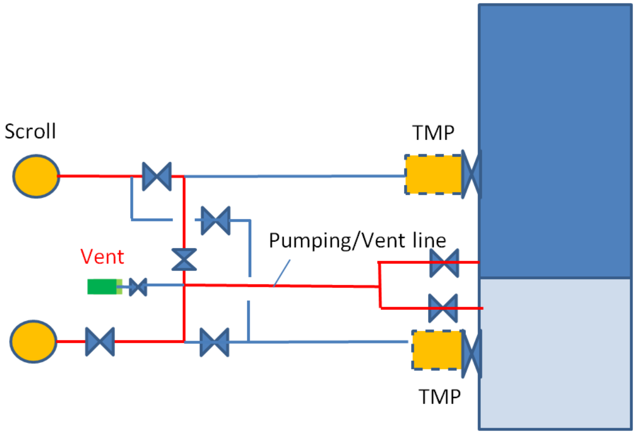


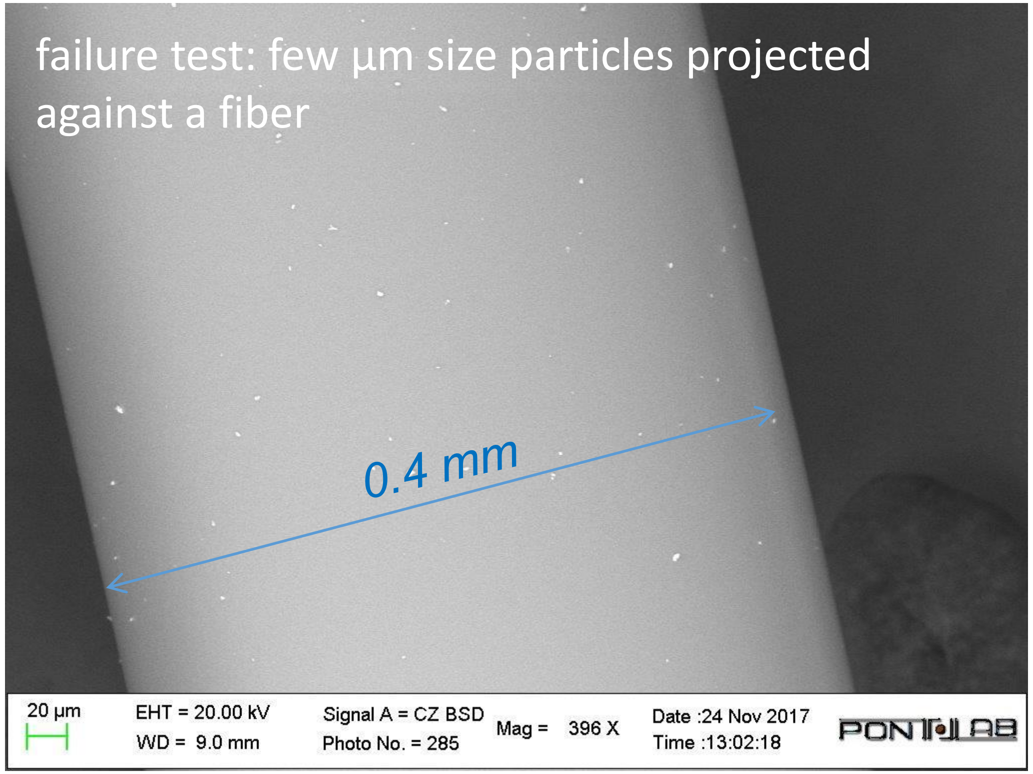
Increase of the eismic vibrations of cryostat walls due to LN2 bubbling

DUST PARTICLES vs QUARTZ FIBERS

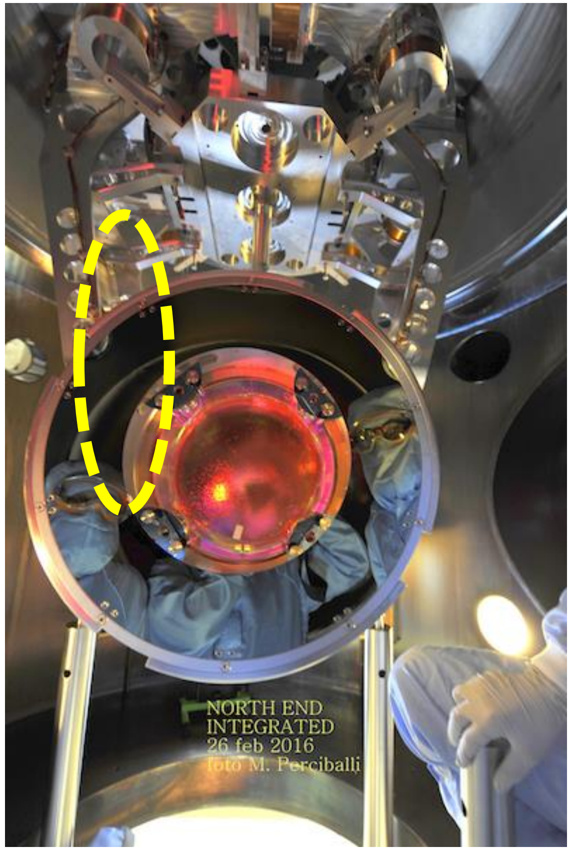
Dust particles of a few µm travelling at some m/s inside chambers has been recognized as the main cause of failure of quartz fibers

- Venting circuit re-designed
- Primary pumps (scroll type) replaced
- Guards added to fibers

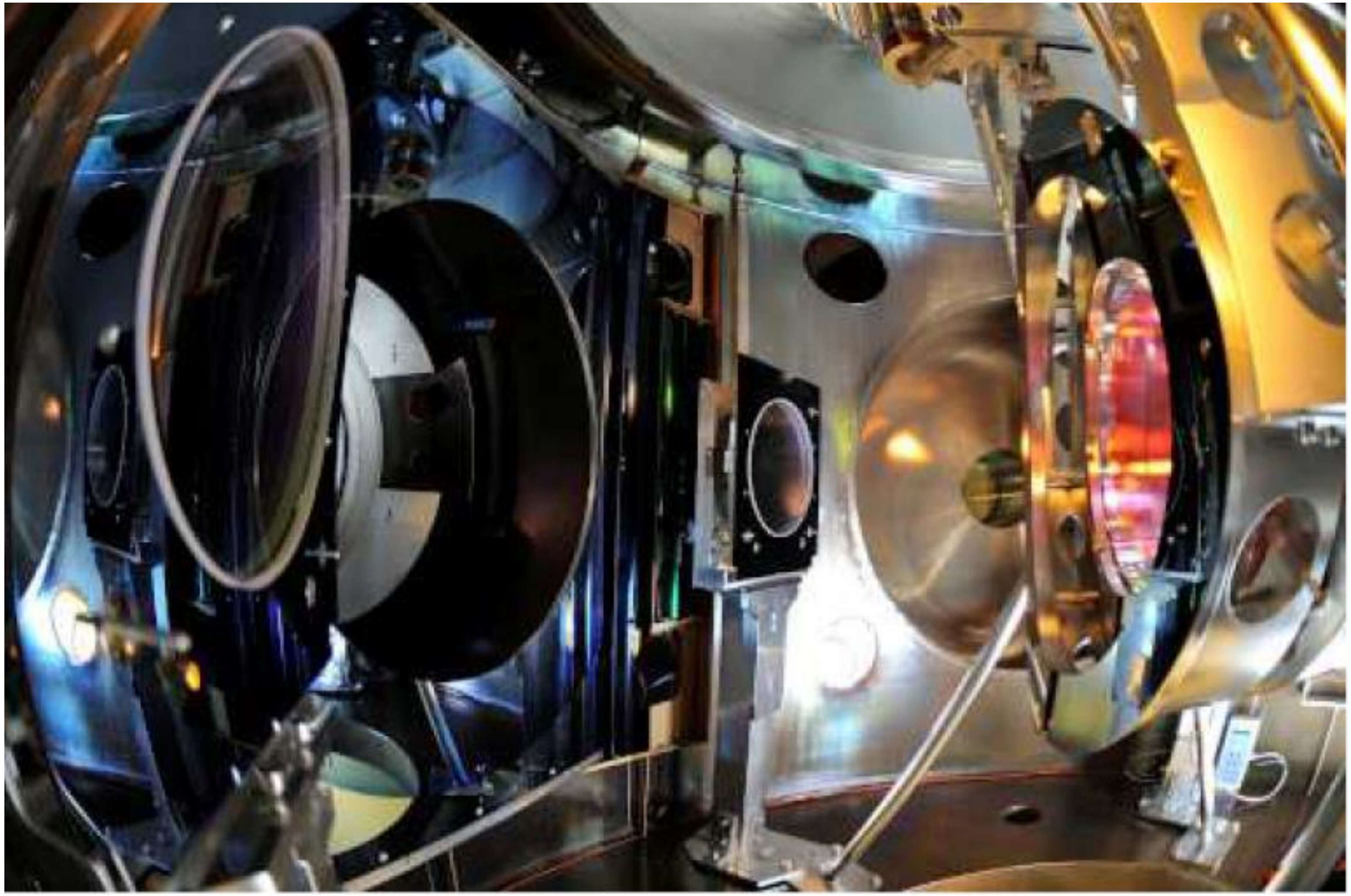




Electrostatic forces may play a role…



Static charge



Static charge on TMs estimated at level of E-9 C, not uniform in magnitude and sign.

A related noise effects emerged during the commissioning phase in 2018 , then disappeared with a modification of the coils driving board.

May come back after future sensitivity improvements: a charge neutralization method is needed

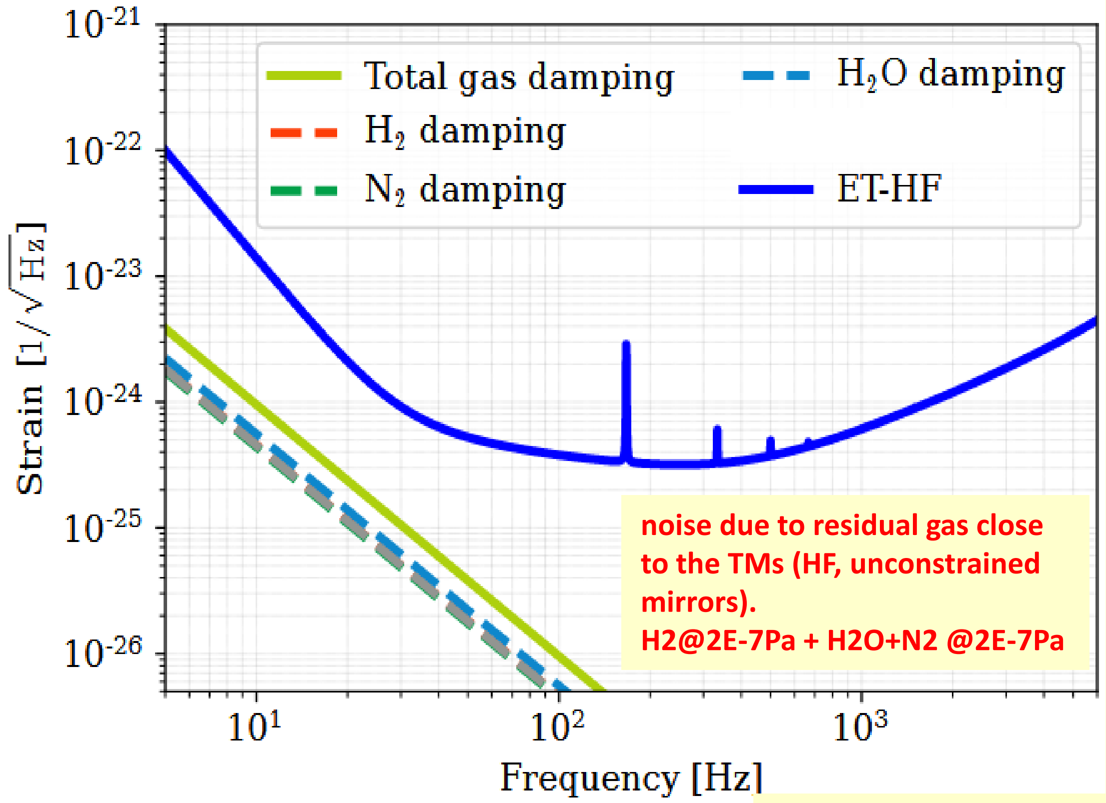
ET 'Tower Vacuum'

Outline of the presentation:

- *Requirements*
- *Focus on the design of the main vacuum chamber*
- *Interfaces*
- *Selected challenges*
  - *Gas load*
  - *In-vacuum contamination*
  - *dust control*
  - *Raw-material*

Requirements setting

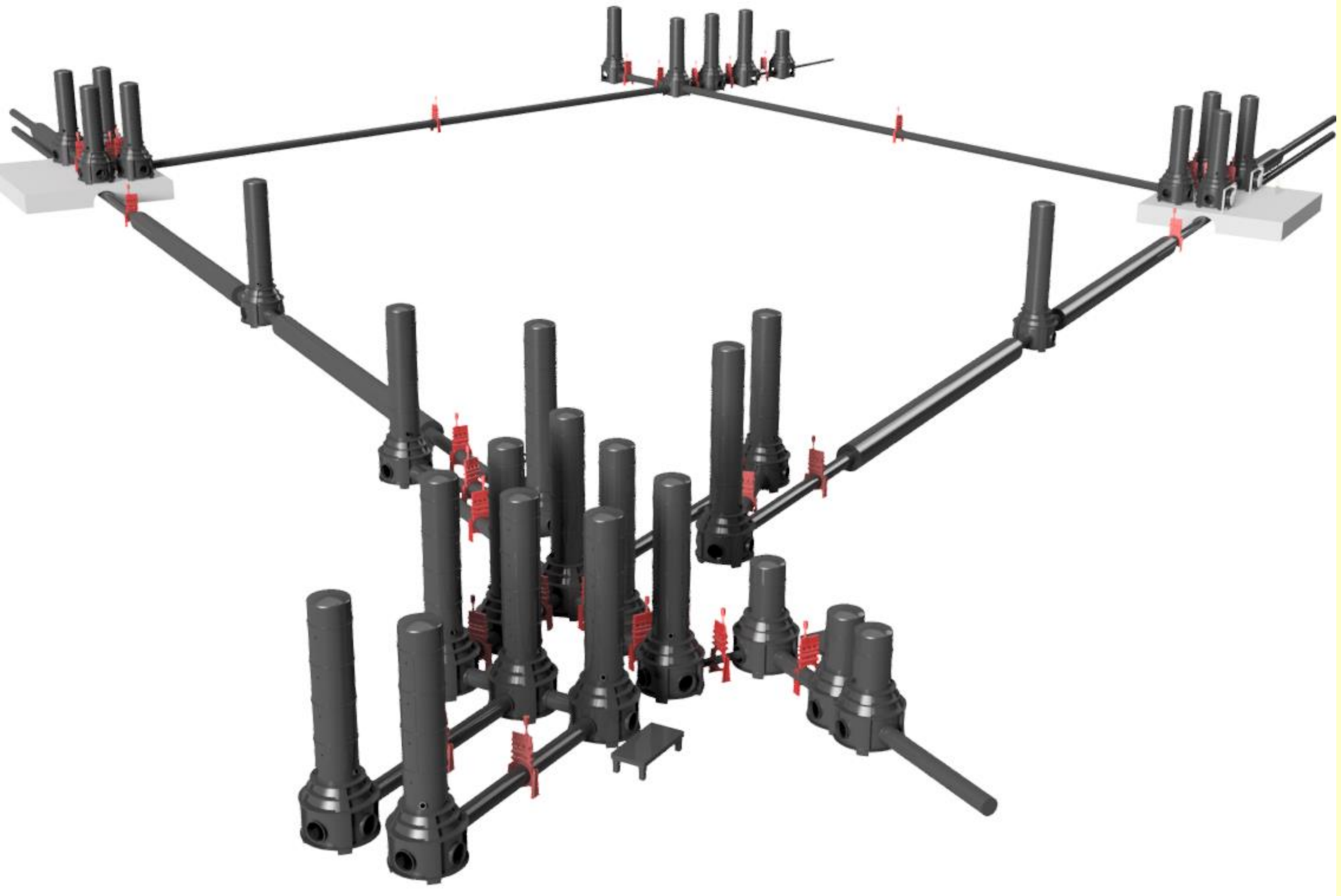
- **It is the principal ongoing process:**
  - Direct scientific needs (e.g. gas damping effect);
  - Interfaces (size, mechanical structure ...);
  - Cleanliness class of chambers (dust particles class, low-volatile compounds);
  - Noise mitigation features (risk reduction approach);
- **Warning: TOWER VACUUM CHAMBERS are part of the 'facility' difficult to modify (especially underground...). REQUIREMENTS are to be set for the LONG-TERM (ULTIMATE) DETECTOR CONFIGURATION**



Credits: T.Zhang

Links – independent Towers

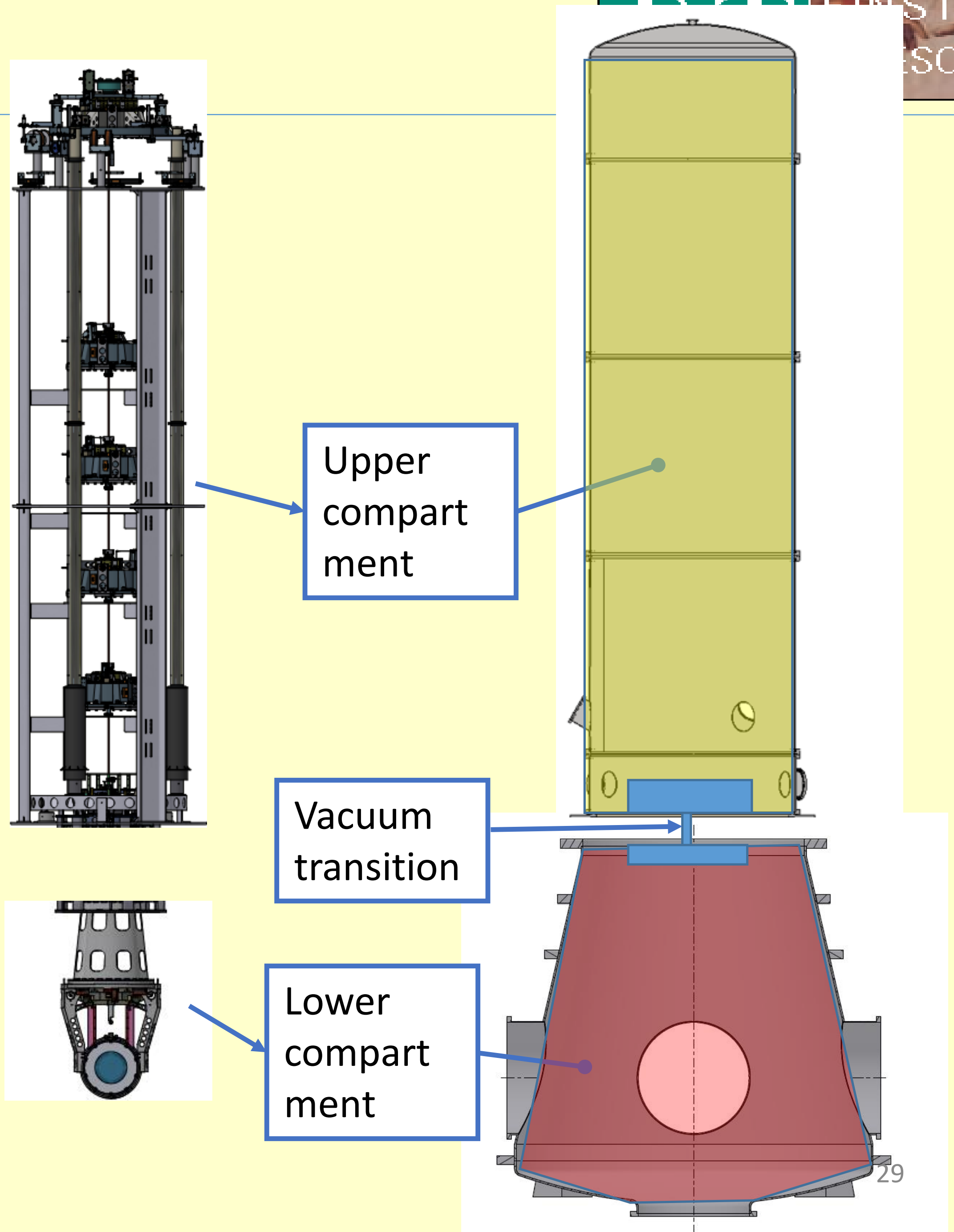
- **Separable towers ?** Requires large valves (viewports on gates where needed) and pumps.
- ***Large Valves*** *(size likely 800-1000 mm) will be a significant cost, but towers independence seems desirable, especially in 3G complex configuration (and for safety too).*



2 compartments

Separation seems advantaging for: dust cleanliness, gas load management, allowing compromises on materials choices

- Transition ‘differentially pumped’. <u>Maximum delta pressure few mbar !</u>
- Different seals type, surface treatments, dust cleanliness class <u>and materials prescriptions</u>.
  - lower compartments: metal seals for both ‘permanently’ closed and ordinary joints;
  - lower compartments: Viton on ‘selected valve gates’ only;
  - upper compartment: Viton o-rings (double):
  - welds (lip joints) considered for ‘links’
  - (lower compartment: pre-baked)



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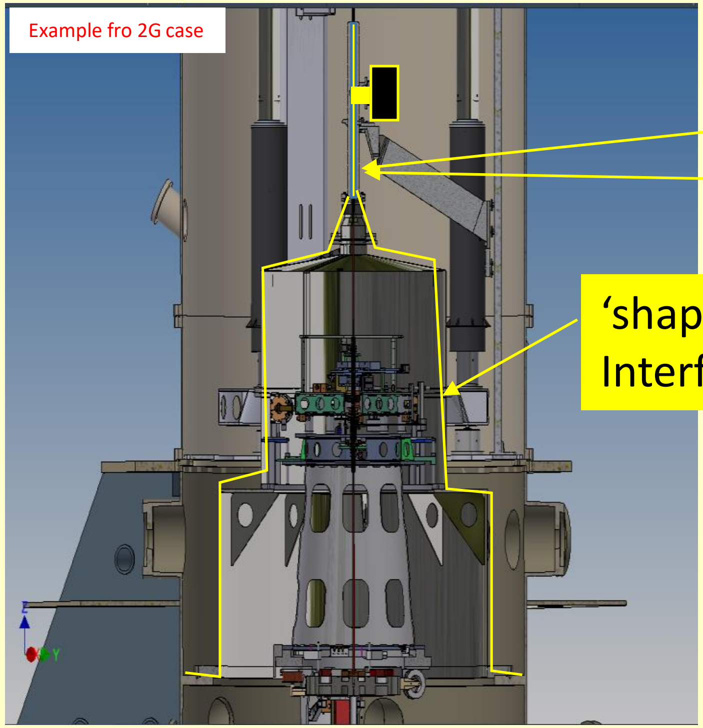
2 compartments

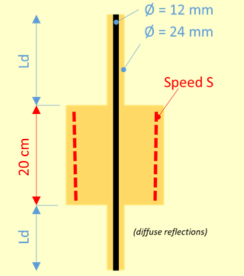
Vacuum separation to be defined fo HF case (impact on cost and general design)

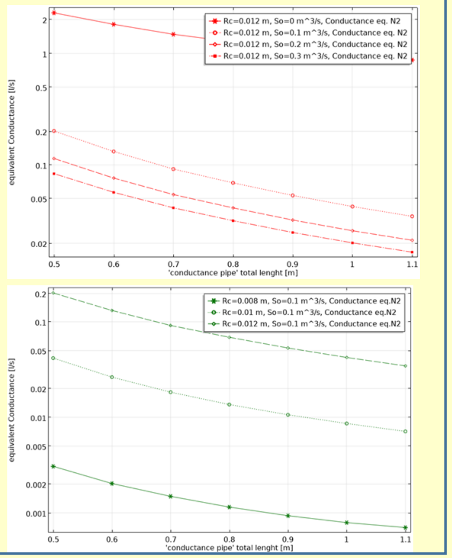


New ideas ?

‘shape’ to be redesigned
Interface SUSP/PAY .

REVISED 2G design





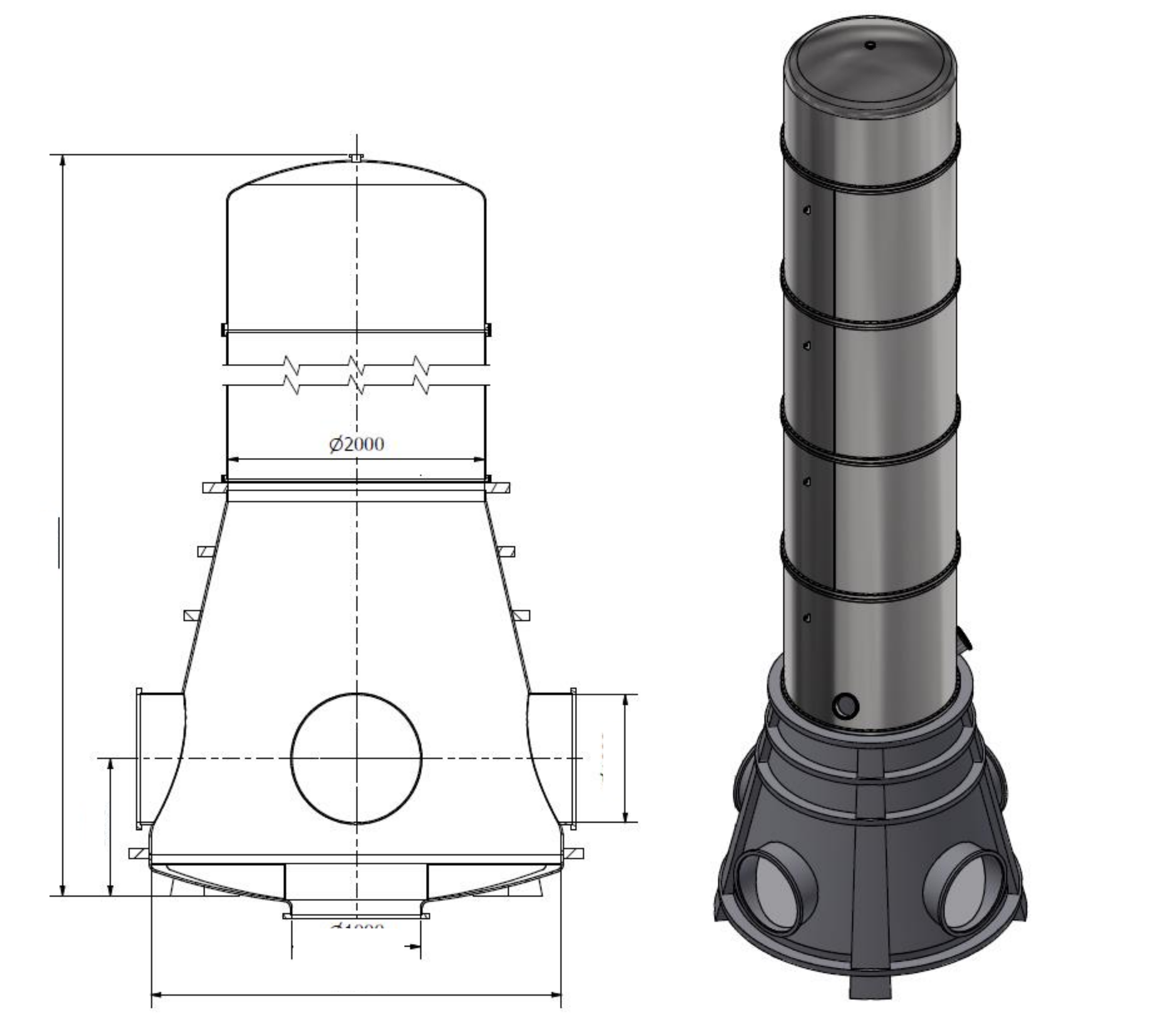
Ceq << 1 l/s N_2

Ion pump could be inside the tower

Tower chamber dimensions

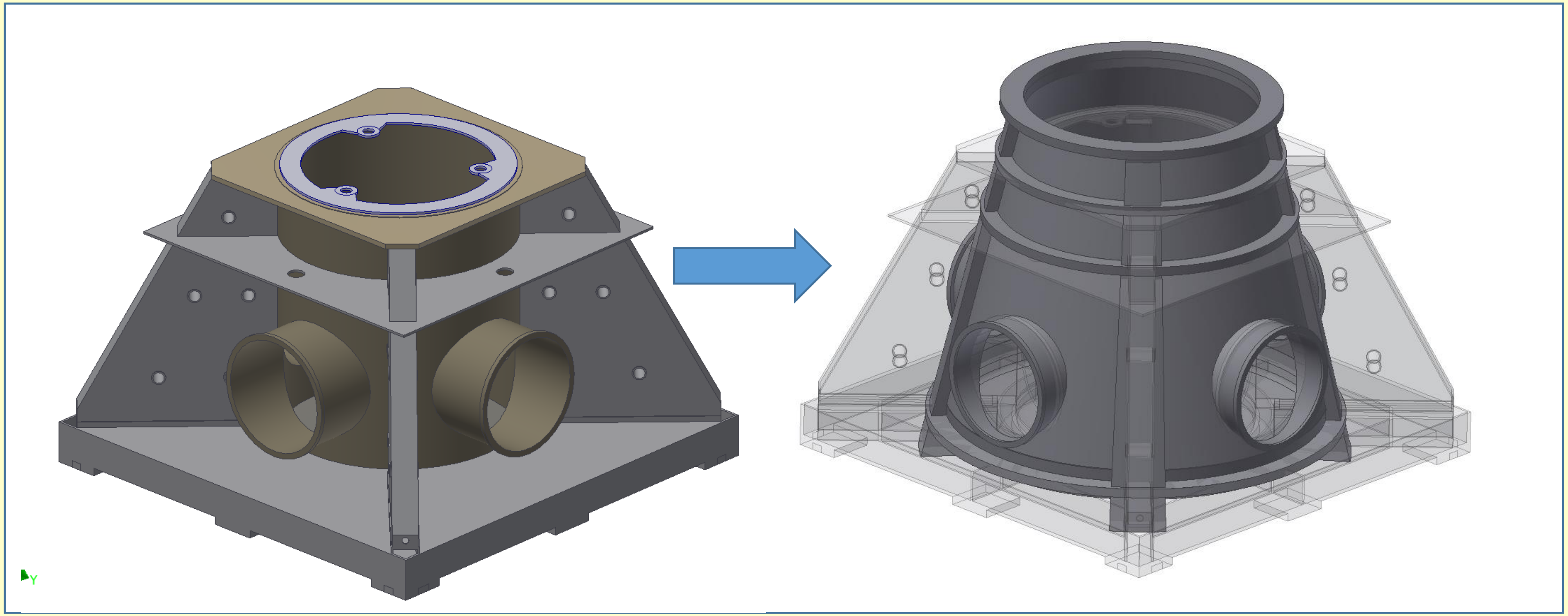
- 'Base tower' design drives the whole design

- Tower upper part height /diameter is not an urgent requirement for us, it should be easy to adapt the design at later stage



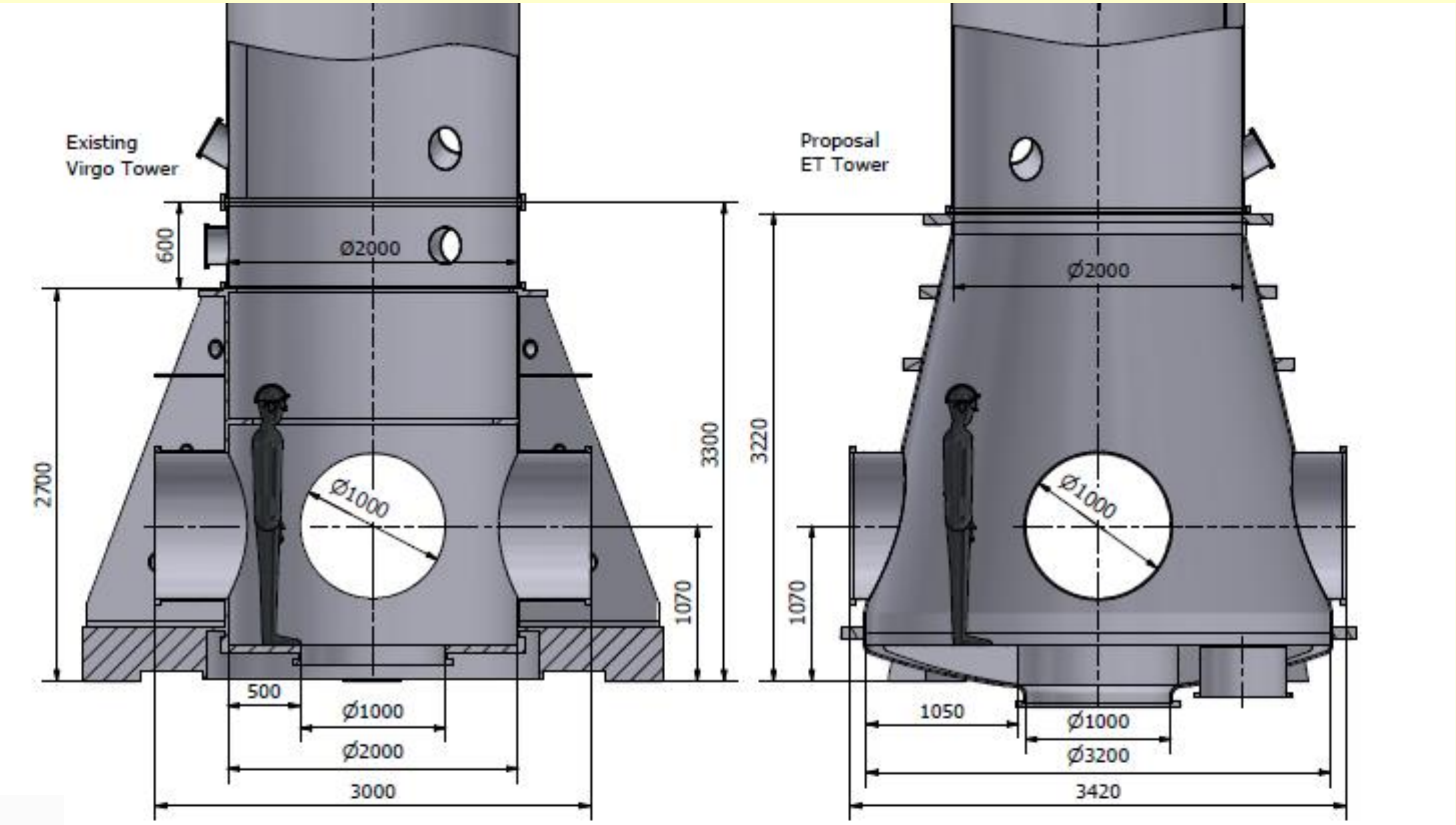
Main chamber: lower compartment

- **Evolution with respect to Virgo design: size to be enlarged while not increasing the room occupancy (underground limitations) and retaining stiffness.**



Main chamber: lower compartment

with the **same footprint, the conical geometry allows a larger inner work space:** **<u>example only.</u>**



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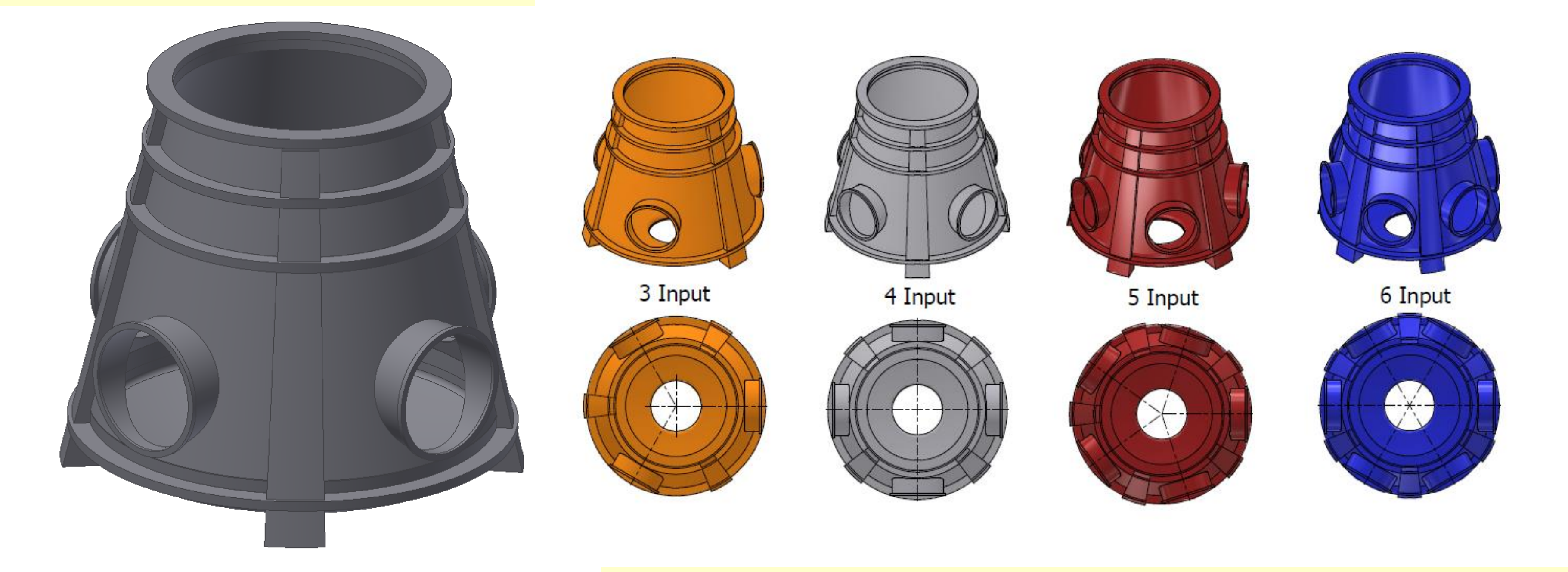
Towers standardization

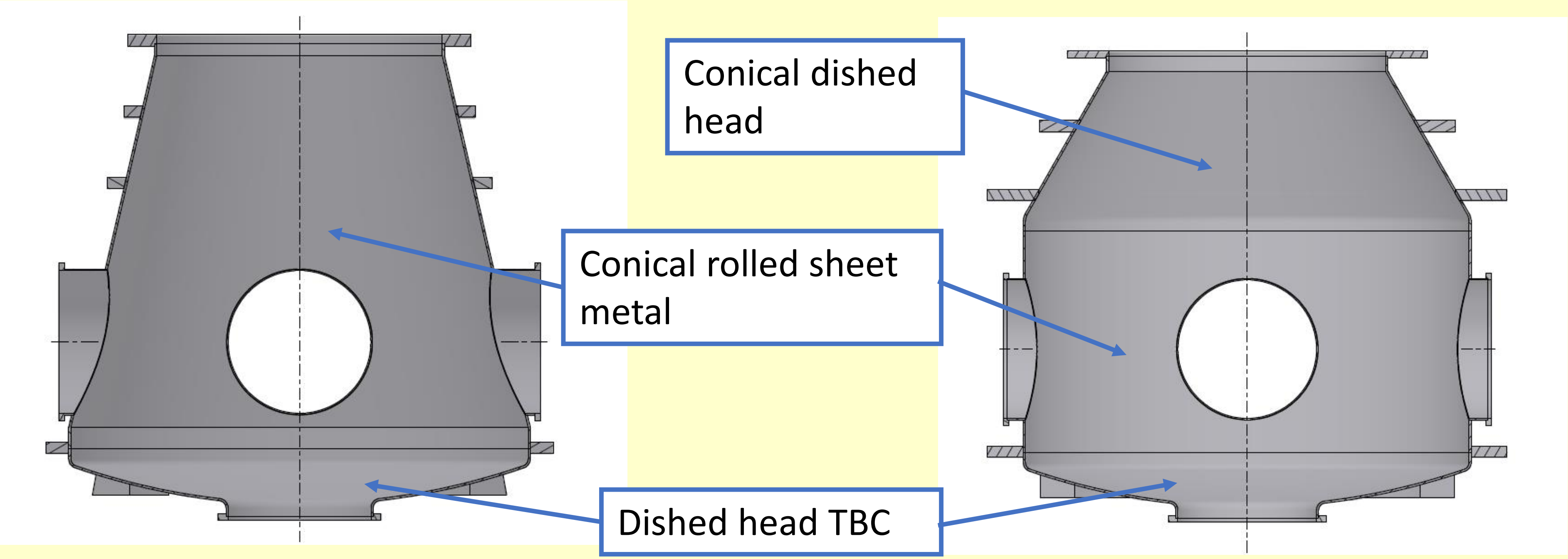
The conical geometry allows to have, with the same overall dimensions and topology, chambers ith similar design but different number of entrances and orientation. Some examples:



Main chamber: lower compartment

EINSTEIN TELESCOPE

The geometry shall be optimized on the basis of the available semi-finished products and also of the wanted surface roughness. Two possible configurations are shown as example:

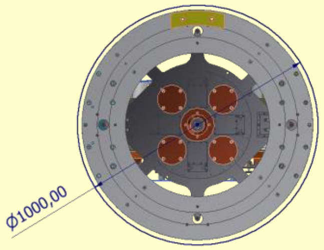


Torre tronco-conica

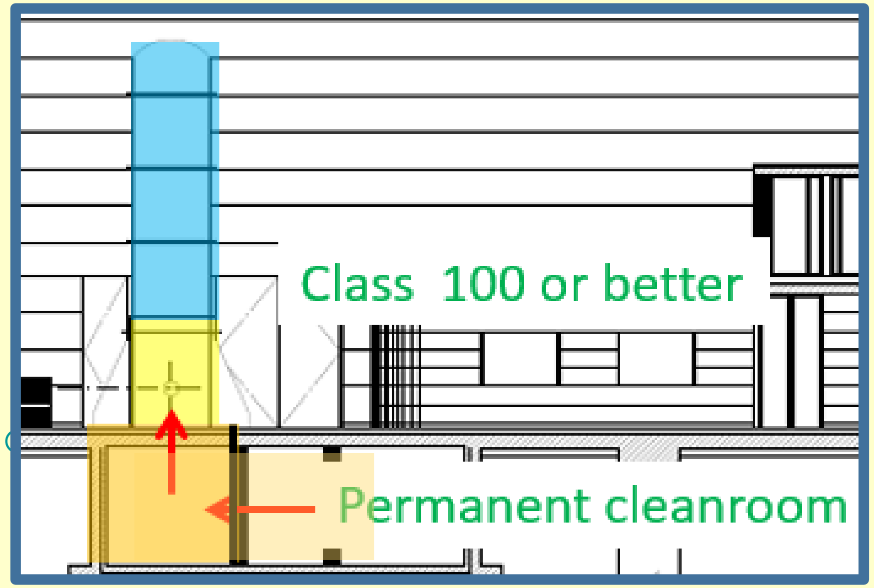
Torre cilindro-conica

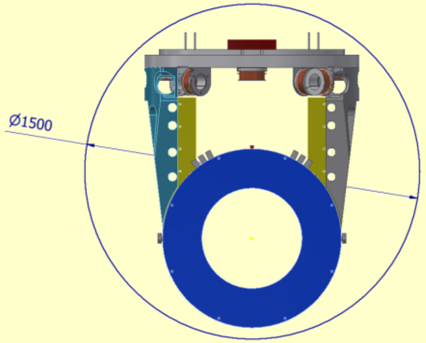
Main chamber: Access

- **Bottom or lateral access?** an <u>impacting</u> feature on the chamber design

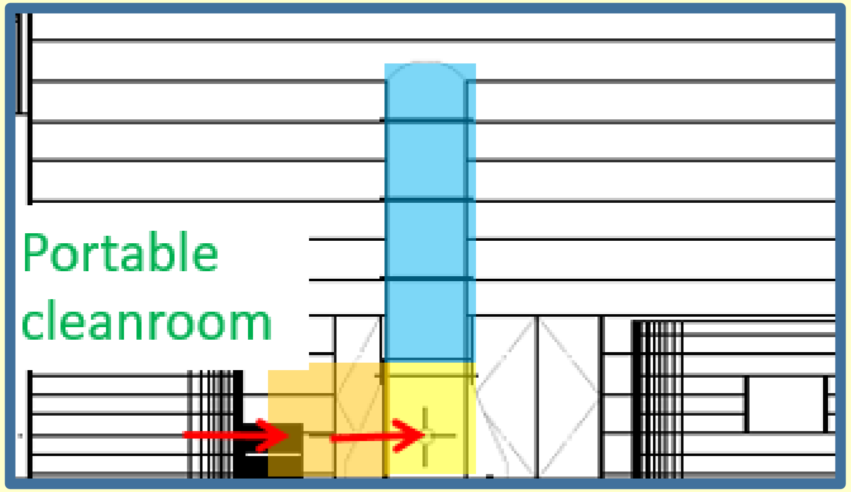


- Need to dig extra rooms
- Likely more efficient for area confinement (to be quantifed)
- Exploit the tower bottom, leave the lateral walls free for other uses



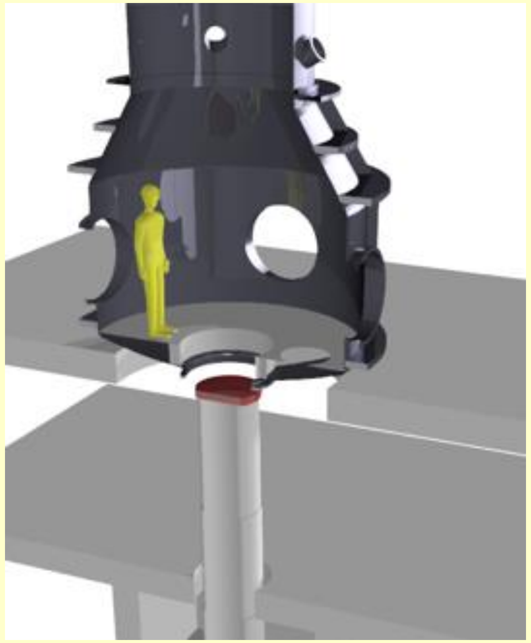


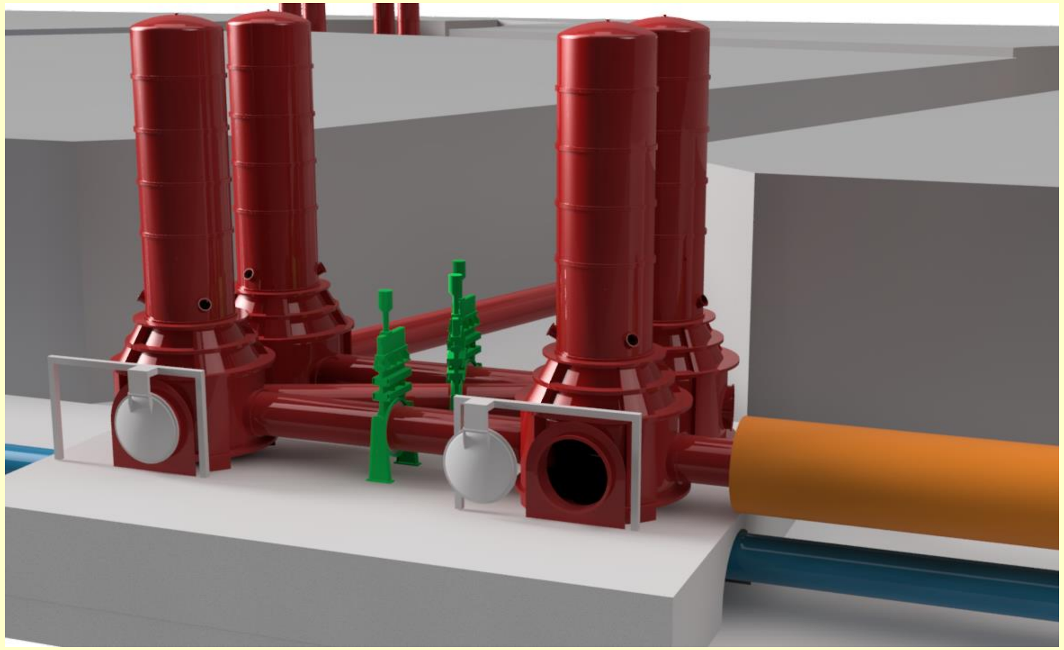
- Extra room in the hall at floor level, even if using portable cleanroom
- Wider aperture <u>could be</u> required for the 'lateral door' configuration
- One side of the tower is 'engaged'



Main chamber: Access

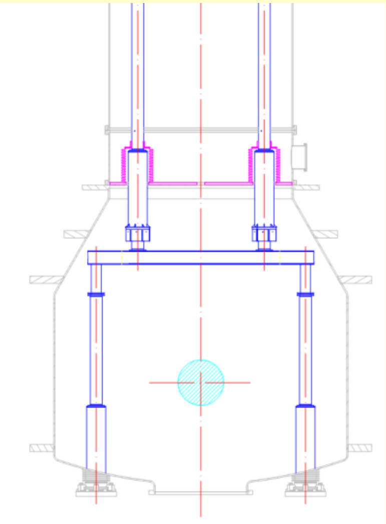
- **Remaks:**
  - Bottom access: seems not possible for all the Towers (ESFRI configuration, due to superposed vacuum tubes. *Rotation of 'tubes' possible?*)
  - Lateral access: seems not possible for all the Towers as well (due to room constraints inside the central hall)



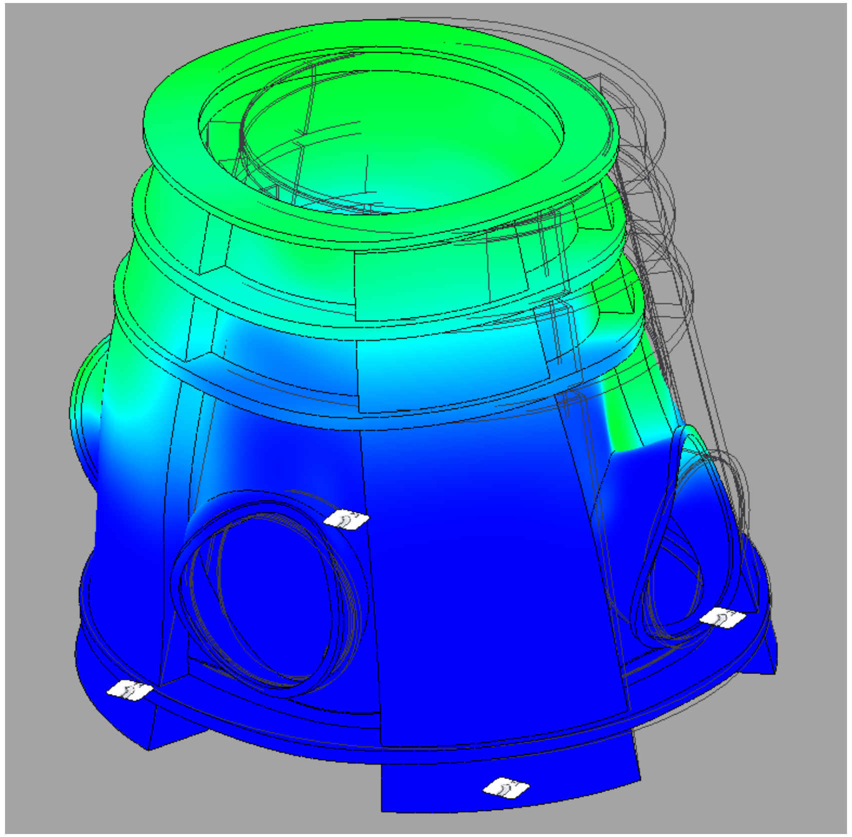


Main chamber structure

- **House the Suspension system**
  - Wanted dynamical response at level of the suspension interface. *The mechanical structure of 2G Virgo towers is considered adequate for ET as well*
  - A redesign can be considered (if useful to save height for instance)
  - Scenario of Suspension ‘filters’ installation and maintenance

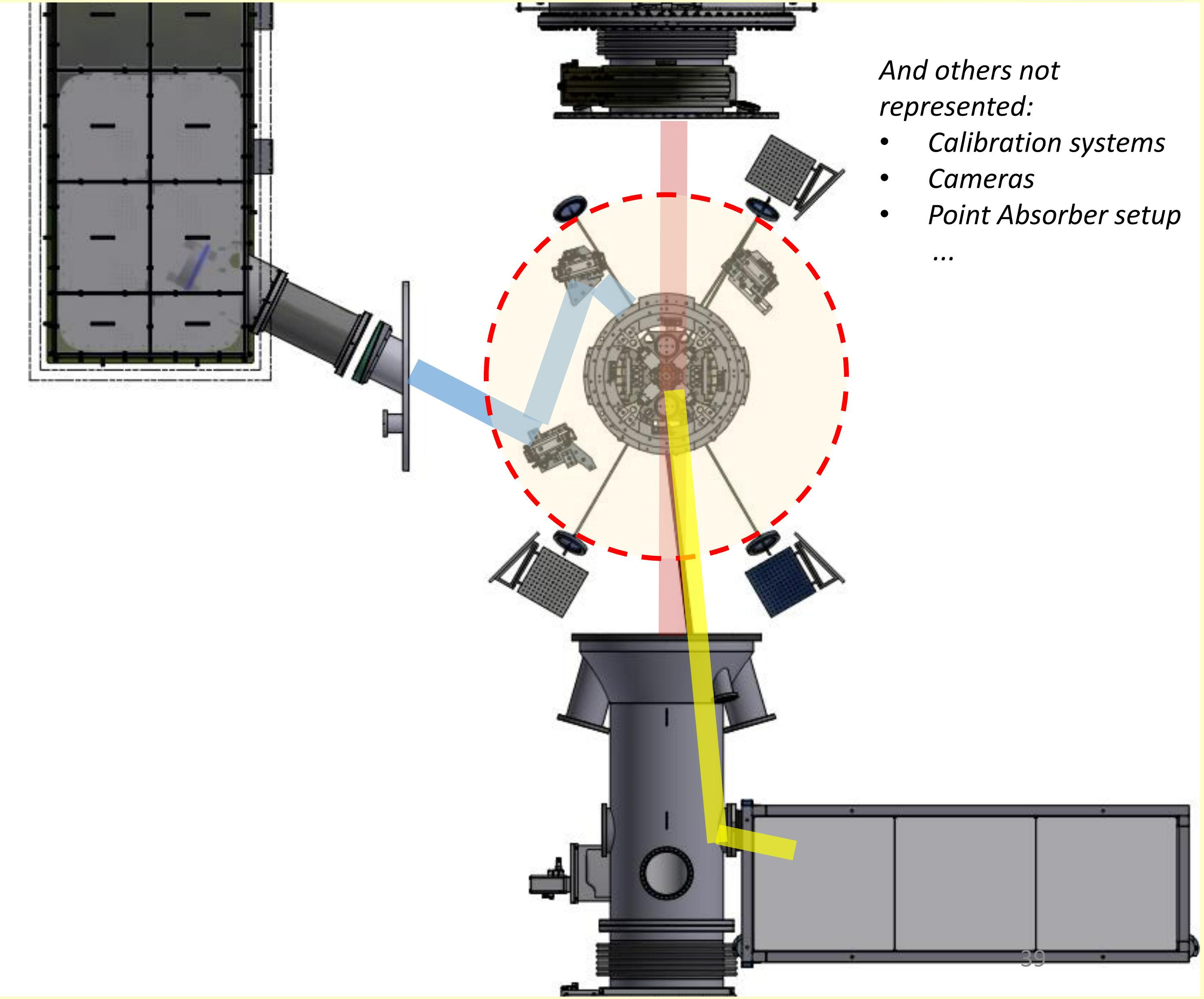


Design for the wanted frequency (and possibly amplitude) of the forced vibration of the anchoring points of the anti-seismic attenuator



Optics 'service'

- **Determination of chambers apertures and of space needs adjacent to towers**
  - Main beam size and position, height to floor, wanted chambers apertures
  - Stray-light baffling strategy and wanted chambers apertures (affect links, main valves…)
  - Optical benches guess sizes and positions – In-vacuum and external ones
  - Estimated types, size and number of viewports. Features of the viewports to be defined as well, related to safety.



And others not represented:
- *Calibration systems*
- *Cameras*
- *Point Absorber setup*

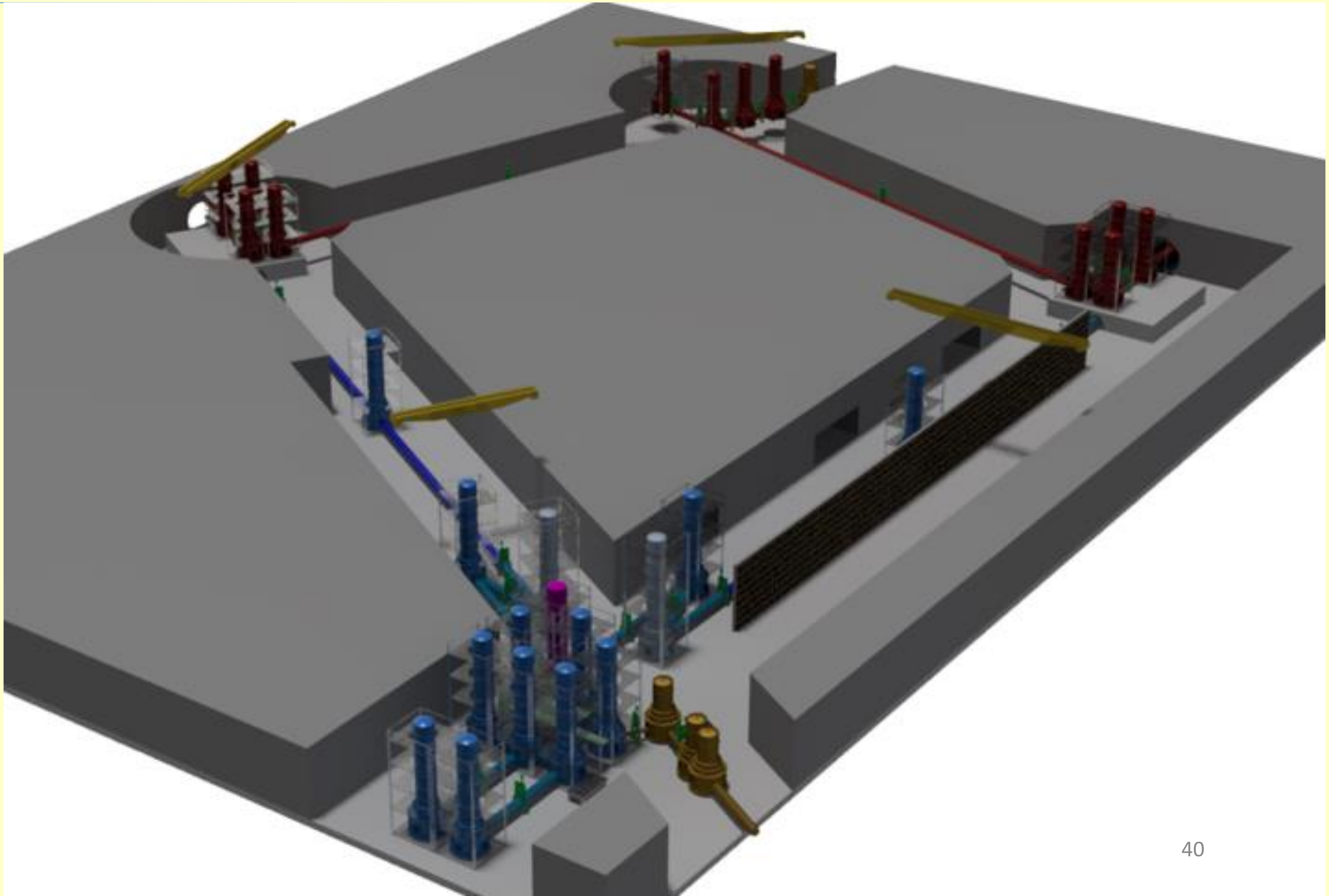
...

Interface with Civil Infrastructure

ET EINSTEIN TELESCOPE

- **Heavy dependencies. non-exhaustive list as a reminder for future iterations**

- Critical points: distance between the arm tube and the side wall of LF-ETM cryostats, height difference HF/LF ('arm tube pattern' adjustable?).



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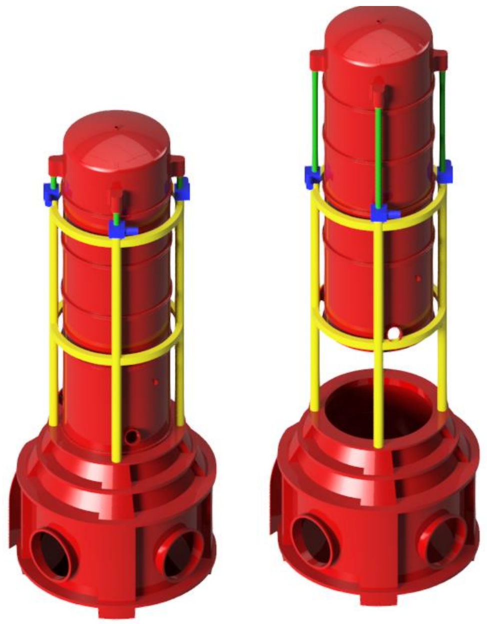
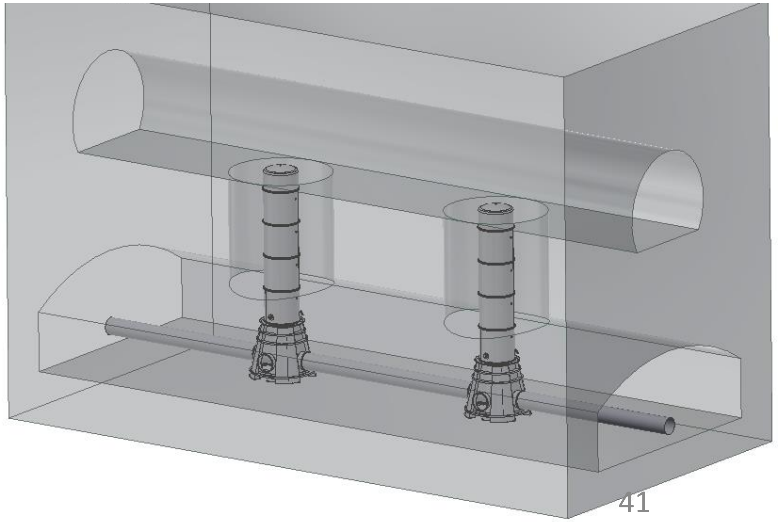
Interface with Civil Infrastructure

- Gallery configuration
- Underground Logistic (access sizes, storage availability for tower rings for example, admissible mass for the ‘base tower’...)
- Phased installations strategy: 1 interferometer under operation (commissioning ...) and the other under construcion ?
- Special safety constraints that could bring to special design features (e.g. welding permit, class of electrical cabling/devices, bake-out of chambers...)
- Cleanroom plants in the experimental halls, physically interfaced with tower chambers;
- Scaffoldings and lifting cranes
- Solutions for environmental noise mitigation (electrical supplies, and acoustically and seismically isolated rooms). Less urgent.
- ...

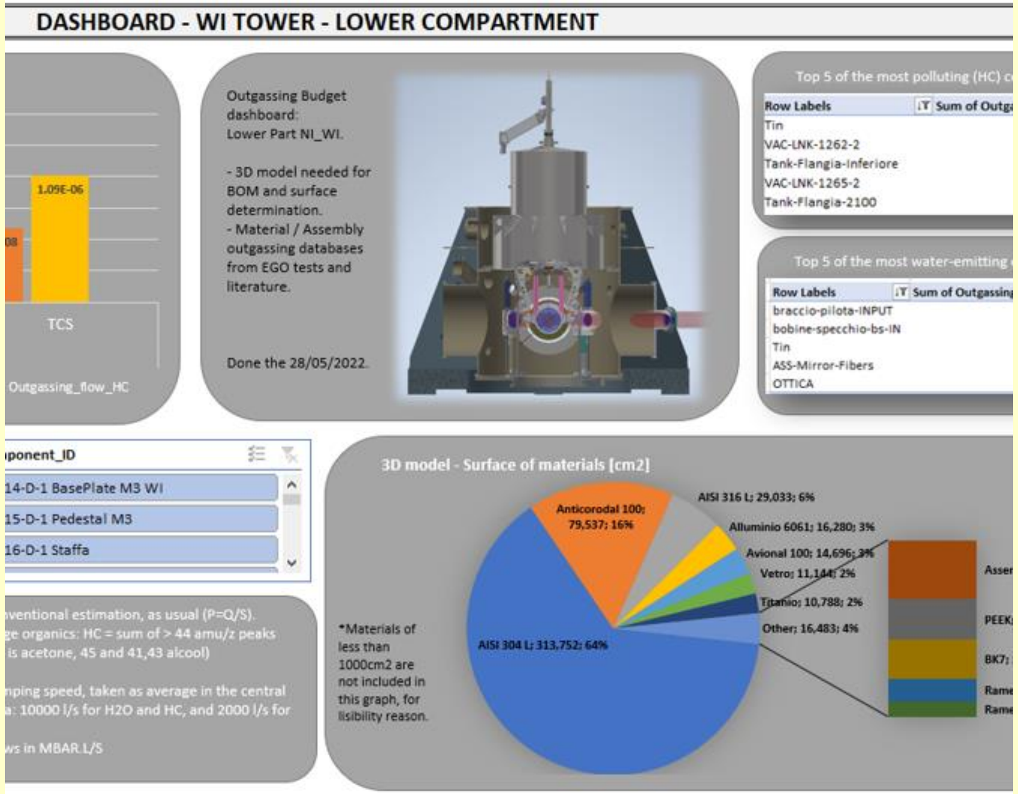




Gas load from Towers

- The gas load is largely due to the added inner materials. Tools:
  - Outgassing database
  - Outgassing budget
- **Material selection = effort at Project level**
  - A procedure is to be defined

Dedicated talk by J. Gargiulo



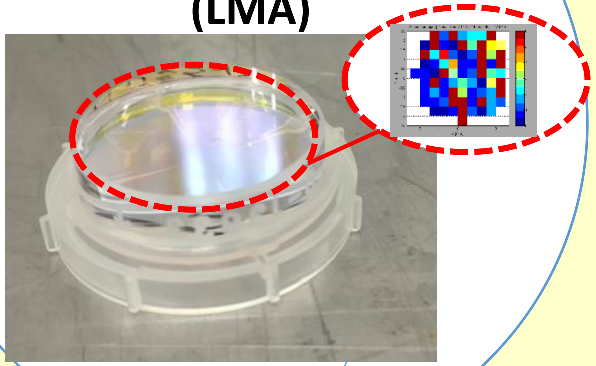
In-vacuum Contamination

- ET's core optics are probably 'the' cutting-edge components of the interferometer, featuring sensitive surfaces and critical optical properties (absorption, scattering). ''Few monolayers of molecules deposited on the surface could affect their performances''.
- A risk to be kept under control

Typically the limit partial pressure of condensable species is calculated under theorethical hypothesis, with the assumption of no re-desorption and that ≈ 1 monolayer of deposit is the acceptable limit.
For ET, we need to better understand the contamination process and quantifying the effects of potential contaminants.

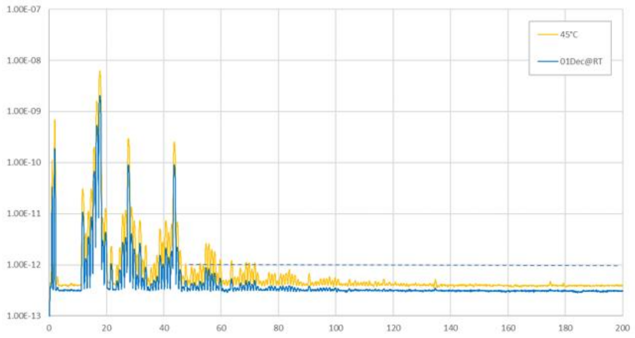
In-vacuum Contamination test

OPTICAL LOSSES MEASUREMENTS (LMA)

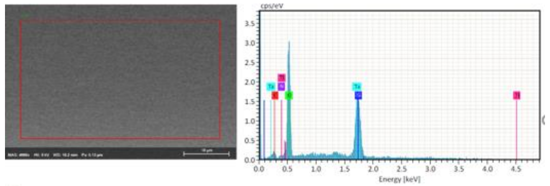


No clear correlation between the detected contaminant level in the gas and the measured optical losses

RESIDUAL GAS ANALYSIS



SEM for GROSS contamination identification



Element	At. No.	Line s.	Netto	Mass [%]	Mass Norm. [%]	Atom [%]	abs. error [%] (1 sigma)	abs. error [%] (2 sigma)	abs. error [%] (3 sigma)	rel. error [%] (1 sigma)	rel. error [%] (2 sigma)
Carbon	6	K-Serie	75	0.87	1.04	2.49	0.51	1.03	1.54	58.93	117.86
Nitrogen	7	K-Serie	0	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00
Oxygen	8	K-Serie	2902	28.69	34.18	61.69	5.02	10.05	15.07	17.51	35.03
Silicon	14	K-Serie	1371	22.23	26.48	27.23	1.36	2.71	4.07	6.10	12.20
Titanium	22	L-Serie	106	4.69	5.59	3.37	2.32	4.64	6.96	49.42	98.84
Tantalum	73	M-Serie	1722	27.46	32.71	5.22	1.61	3.23	4.84	5.88	11.75
			Sum	83.95	100.00	100.00					

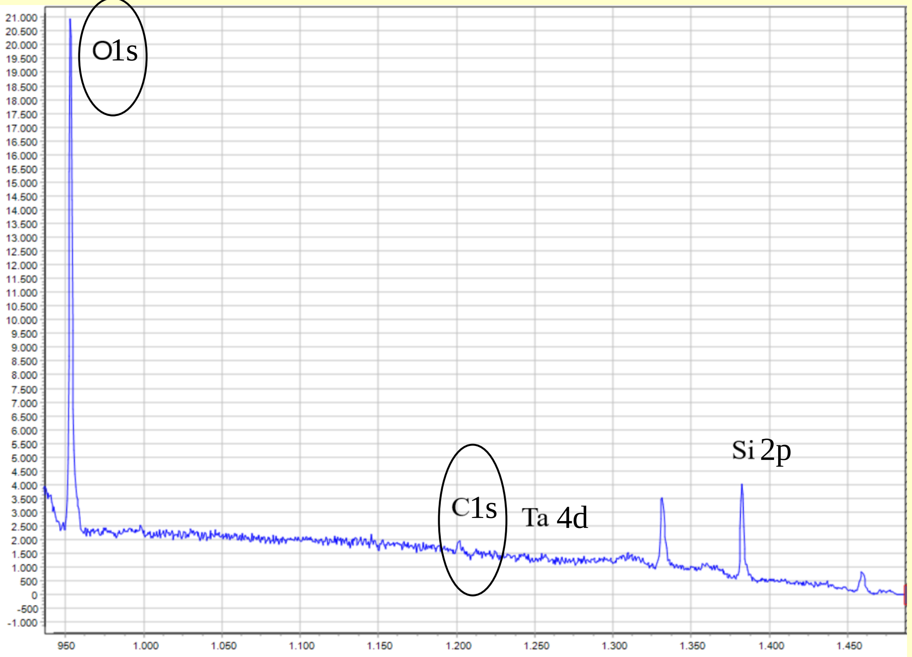
MISSING

1. **Identification of deposited species**
2. **Quantification of deposited quantities**

In-vacuum contamination test

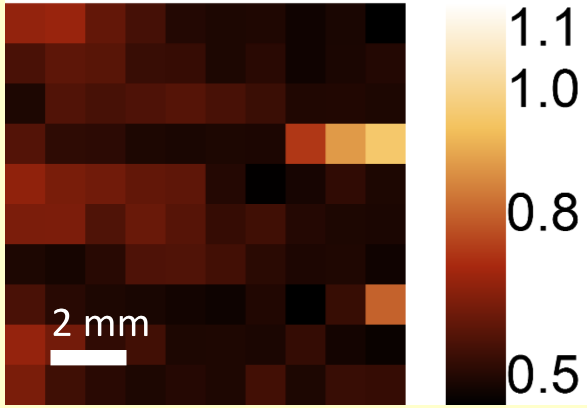
XPS Measurements in Rome Sapienza (Dept. Of Physics)

XPS survey spectra:

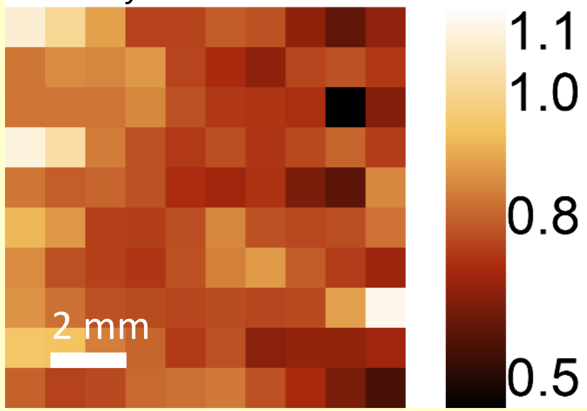


The only detected contaminant component on the surface was Carbon
(H cannot be detected by this technique)

C 1s intensity-map on clean mirror



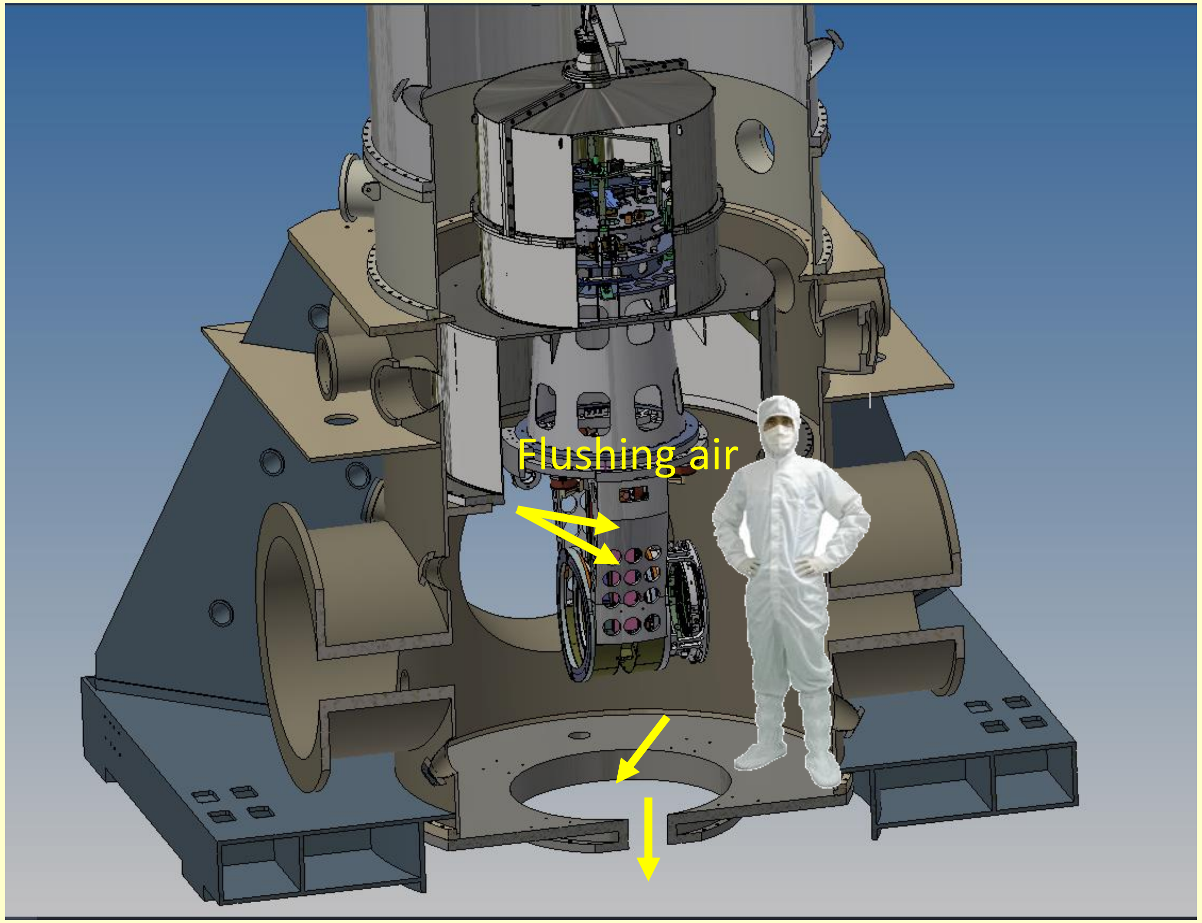
C 1s intensity map on artificially contaminated mirror



The intensity is adimensional and represent the ratio between the C1s peak area and the background intensity in the same area.
In the contaminated mirror such a intensity is around 50% higher in comparison with the same signal on clean mirror.
The same result is obtained if the C1s area is normalized to the O1s peak.

Courtesy of E. Placidi

Dust Particles Control



Towers are also a true cleanroom, often accessed by personnel during integration and tuning phases

A specific design is needed, integrating the UHV needs, including:

- *geometry, materials and surfaces finishing, CFD study of flushing air pattern, dust particles monitoring, ...*

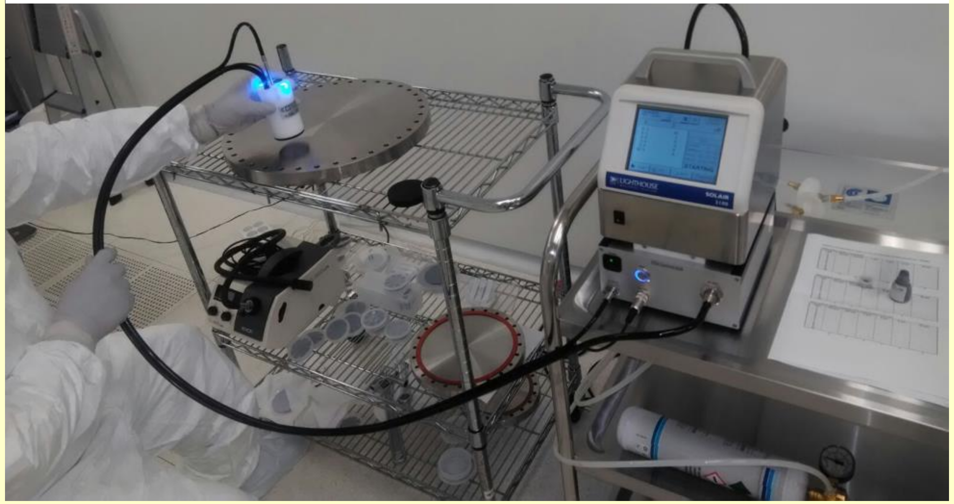
Engineering activity to be started + semiconductor industry methods.

Dust Contamination Control

A new specification for GW vacuum chambers:

- Surface cleanliness for particle concentration shall be included for the 3G vacuum chambers realization:
- Need a standard to refer (e.g. ISO 14644-9:2022)
- Need to define wanted limits !

Concentration of dust particles on the walls of vacuum chambers = *solutions are to be found both to control the fabrication process and to monitor the tower chambers when in service*



Optical feature of chamber walls

EINSTEIN TELESCOPE

Low roughness materials are generally favored for Vacuum and Dust control performances.
What about specific GW stray-light effects ?

TEST ONGOING

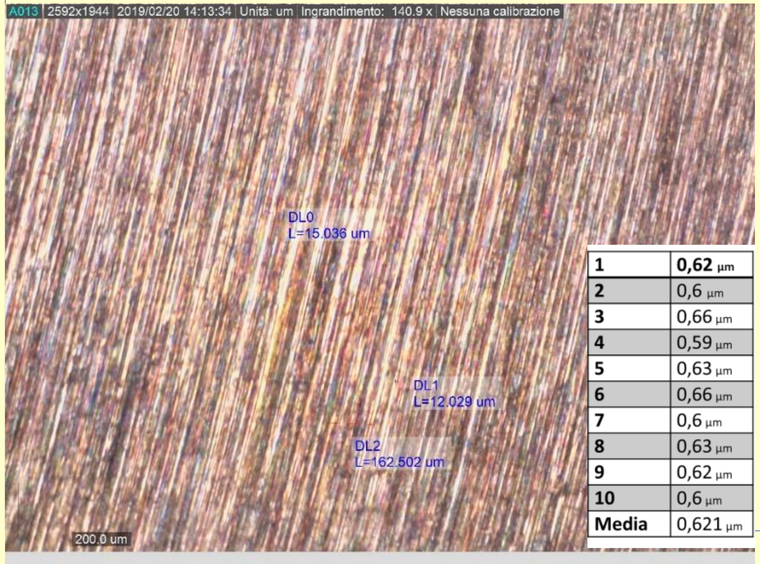
>> Scope: Optimize surface optical reflectance and back- scattering for 1um wavelength laser interferometry.

>> Present situation: Virgo towers surfaces have Ra~0.4um roughness (electrochemically-polished)

>> Question: What is the effect of raw material roughness? Can an ideal optical coating lower significantly vacuum chamber surface reflectance and back-scattering ?

>> Study: - Simulation of an anti-reflective coating on stainless steel with zero roughness (Institut Fresnel)

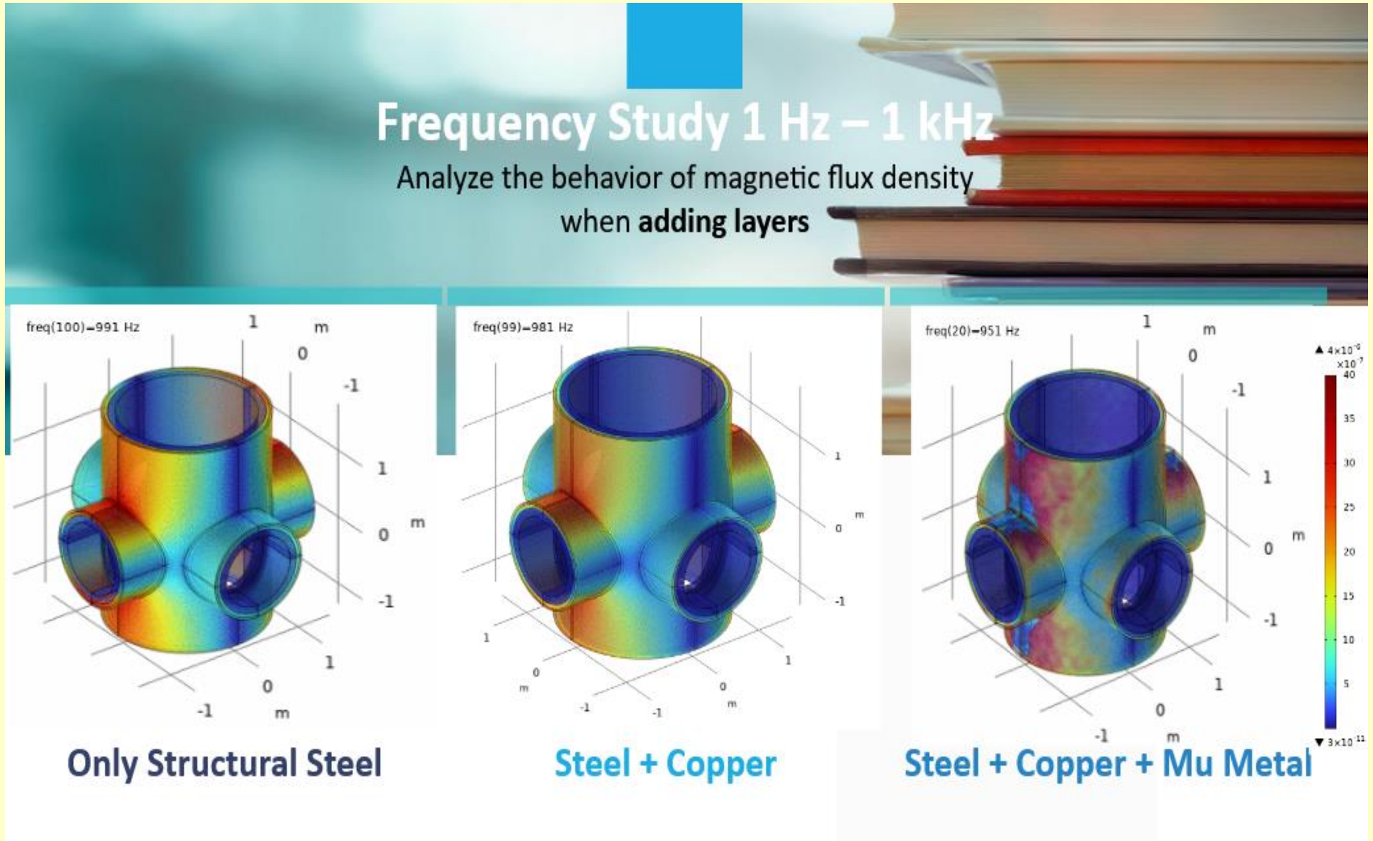
- 15 stainless steel samples have been prepared in a roughness range from 0.1 to 2.5um.
- Apply the optical coating (by plasma ion assisted deposition, CILAS)
- Compare optical reflectance and back-scattering before an after (EGO Optics Group)



1	0,62 µm
2	0,6 µm
3	0,66 µm
4	0,59 µm
5	0,63 µm
6	0,66 µm
7	0,6 µm
8	0,63 µm
9	0,62 µm
10	0,6 µm
Media	0,621 µm

Interfaces: noise mitigation

- **Raw material choice w.r.t. magnetic noise effects**
  - **magnetic noise shielding** effects associated with the chambers raw material are under study by ET-ANM
  - unconventional options can be tested at this stage, to be then evaluated at project level



Credits: B.D'Angelo

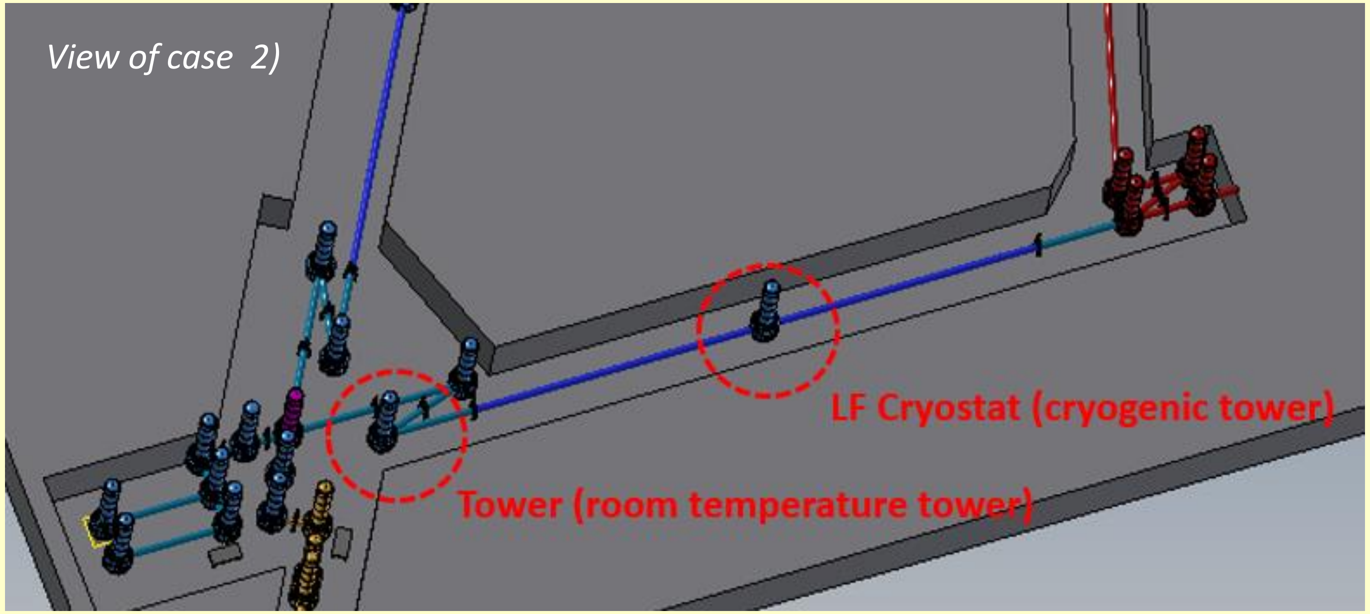
Interface with cryotraps

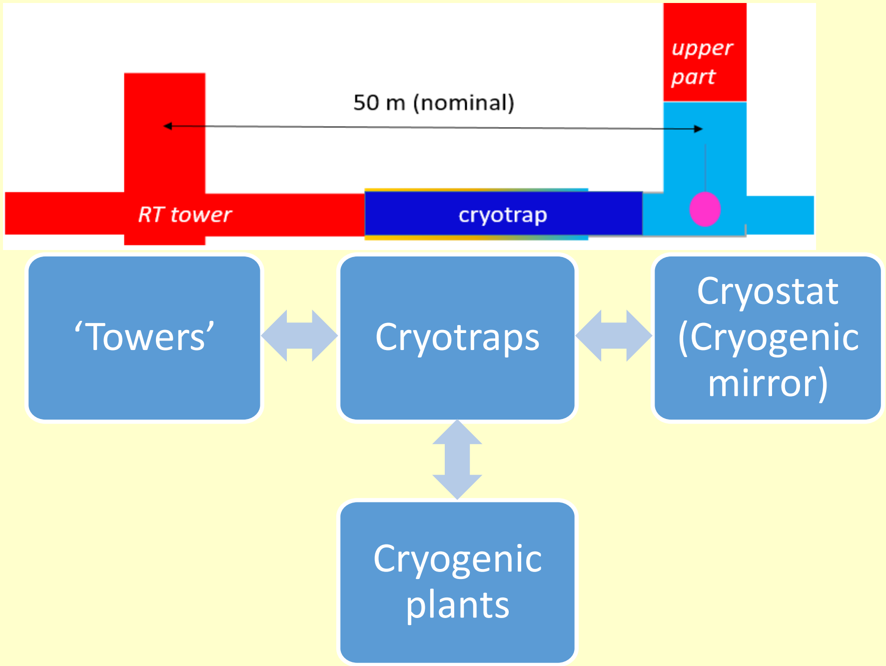
- Towers residual gas affects the vacuum level of the HF Tubes (1) or LF Cryostats (2) via the Cryotraps.
  - **Battery limits defined**

    Type 1) HF Tower to HF Cryotraps (to HF Tube)

    Type 2) LF Tower to LF Cryotraps (to LF Cryostat)

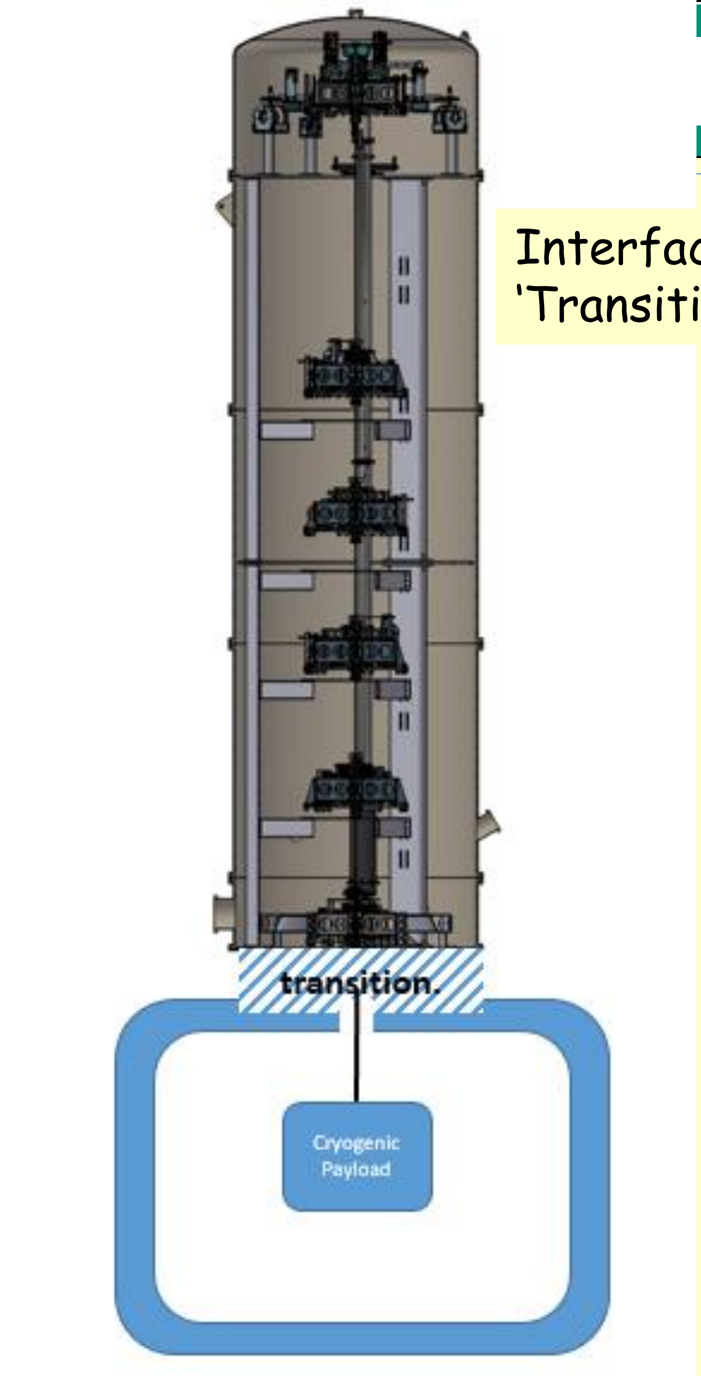
    Type 3) LF Tower (upper compartment) to LF Cryostat
- Large cryogenic pumps (cryotraps) are proposed to manage the large gas loads coming from Towers . *Talk by ET WPIV.3*





Interface with Cryostat

- **Upper tower / cryostat (cryogenic mirror chamber)**
  - Transition design ongoing by WPIV.3 (Vacuum)
  - Thermal transition to be designed as well
  - **1 bar transition possible ? Independent evacuation/venting would be an advantage (or at least preserving vacuum in the cryostat when venting the upper part)**



Interface scenario:
'Transition localization'

Gas load: numbers to get started

- Lower compartment: gas loads

  @ 100 h
  - H_2O = order of E-4 mbar.l/s
  - N_2 + others (condensibles) = at level of 10%

  @ 1000 h 'RT tower' 'Cryotrap/ cryostat'
  - H_2O = order of E-5 mbar.l/s
  - N_2 + others (condensibles) = reduced (normally well below 10%)
  - H_2 = order of E-6 mbar.l/s

- Upper compartment: partial pressures goal
  - H_2 = 1E-8 mbar

  @1000h
  - H_2O = 1E-7 mbar
  - $N_2 + \sum$ others = 1E-8 mbar

- time-dependency: the recovery time ('duty cycle' of ET) is another parameter for the design
- **To be validated at a more mature stage of the project**

Short-term Development plan

We aim at getting a 'first-iteration' design of the tower chamber by the end of 2022

Recap of inputs needed:

- Tower access (baseline hypothesis, likely configuration dependent)
- Reiterate about lower compartment size (Payload) for the typical Towers and mechanical stiffness (Suspensions)
- <u>Wanted production rates</u>

- Start contacting industry

Work Breakdown

- Looking for other teams from various backgrounds to take part in the ‘Vacuum Tower' activities;

Backup slides

R&D plan

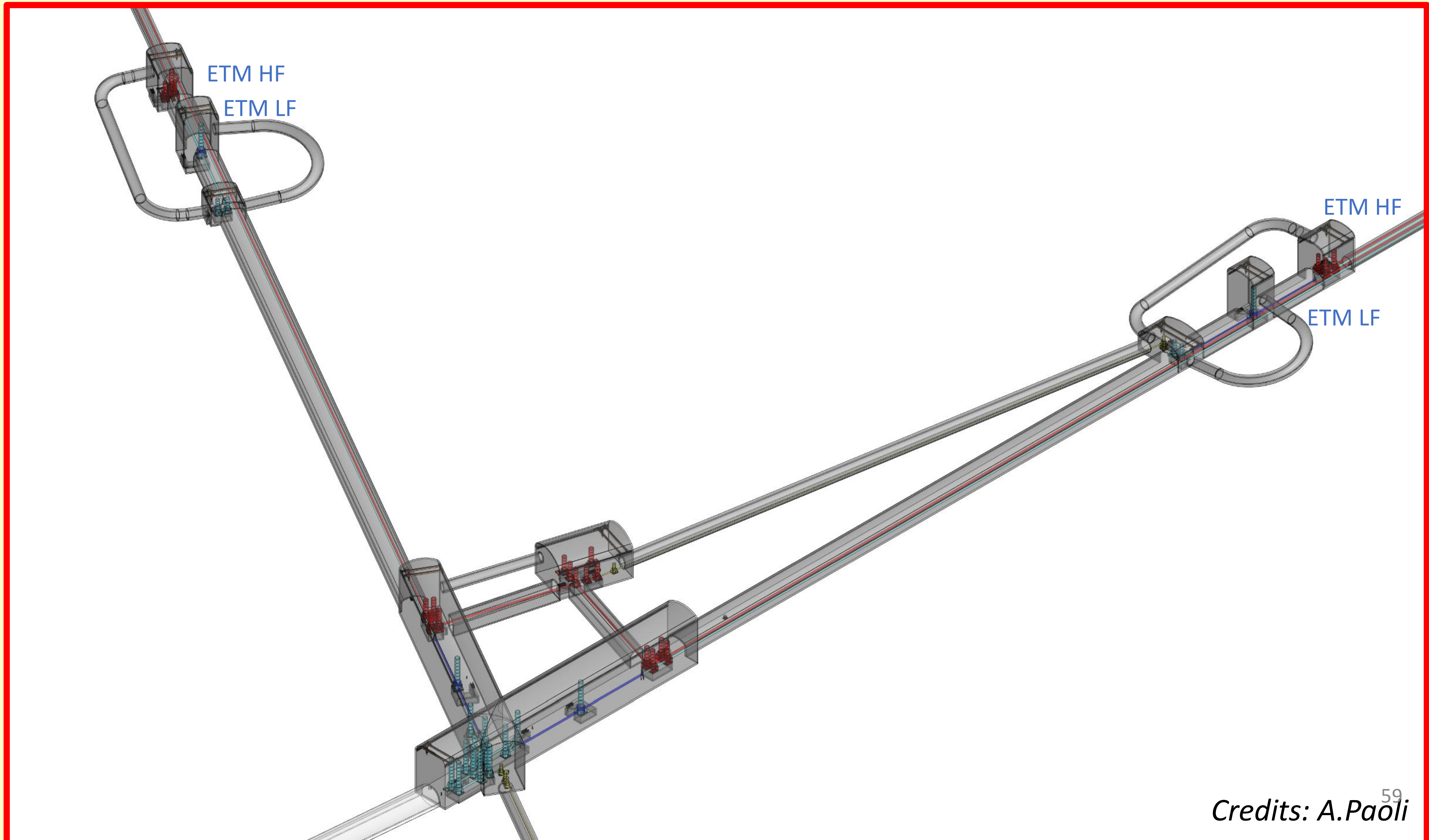
- depending on project and funding evolution

IN-VACUUM CONTAMINANT CONTROL
- Study of the process of pollution of the core optics in vacuum (Room temperature) - Surface analysis (correlation of contaminants in residual gas with optical losses) - Set the requirements for limits for vacuum contaminants in tower chambers - Study of diagnostics to be applied during the production , qualification and operation of tower chambers - Investigation of novel cleaning treatment for tower chambers (plasma processing, ozone)
SPECIALIZED VACUUM TECHNOLOGIES
- Shields for charges dispersed from large Ion pumps - Affordable large metal seals - Large viewports policy and management of 'breaking risks'
VACUUM-COMPLIANT 'BLACK' MATERIALS
- investigation on coatings or conditioning of the inner - large walls - of towers chambers (and of the inter-connecting pipes) - improved performances w.r.t. stray light mitigation - improved performances w.r.t. UHV (research on physical/chemical treatments for water outgassing reduction) - Possibly applied to ET-LF cryostats
CONTROL OF DUST PARTICLES IN VACUUM CHAMBERS
- State-of-the-art methods to measure the concentration of dust particles on the walls of the vacuum chambers - study and design the cleanroom features of tower chambers (general chamber shape, flushing air distribution and devices) - study the possibility to use ultra-dry-ionized air to purge and flush chambers, in order to get faster pump-down and control of static charge

2011 DS costs to be updated

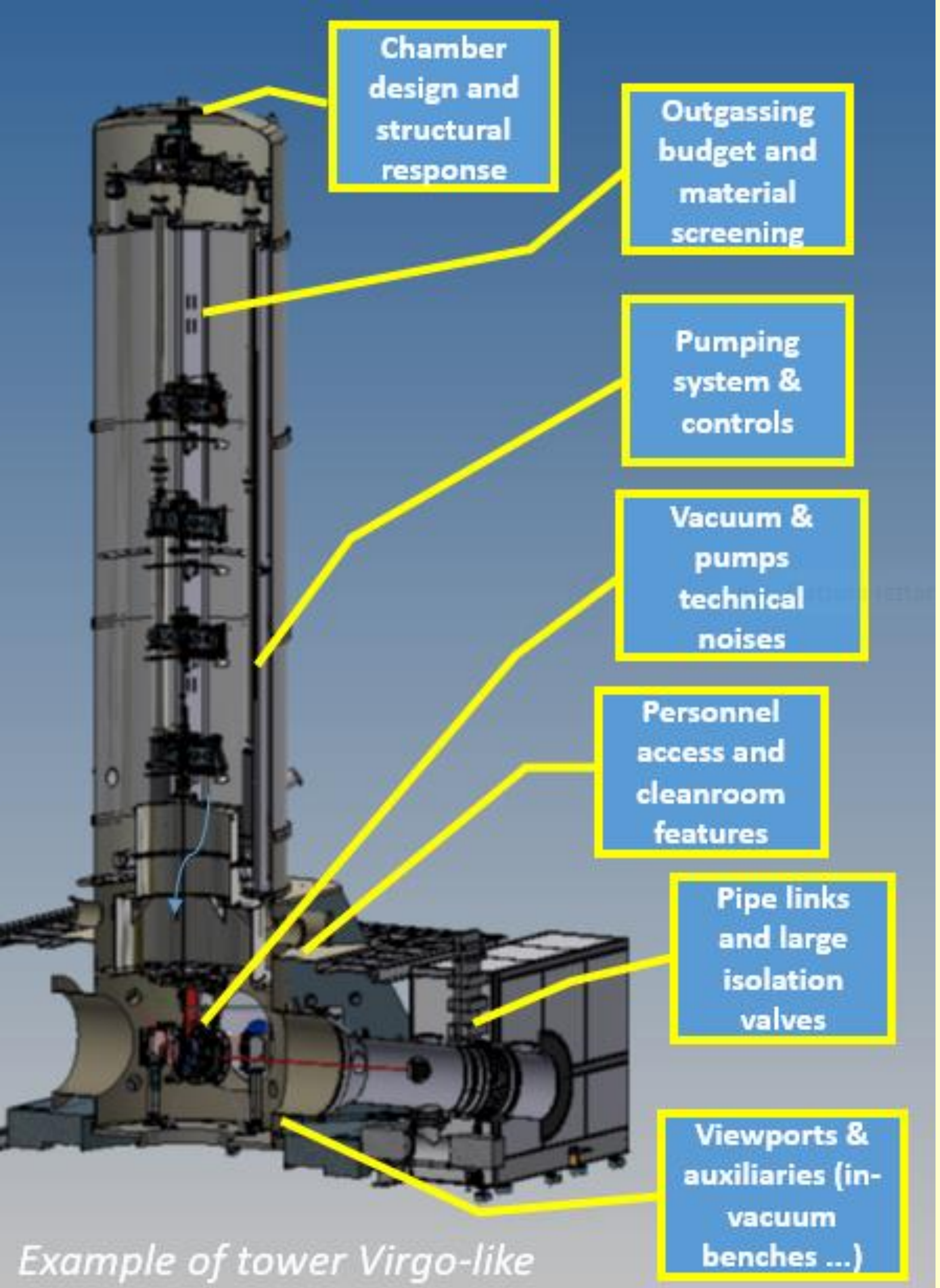
Item Description	Comment	Option	Unitary cost (k€)	Unit	Quantity	SubTotal
HF Vacuum Pipe	ϕ 0,9 m inst + supp + therm insul	Baseline	2070,00	km	20,0	41400,0
LFVacuum Pipe	ϕ 0,75 m inst + supp + therm insul	Baseline	1780,00	km	20,0	35600,0
Filter Cav.Vac. Pipe	ϕ 0,67 m inst + supp + therm insul	Baseline	1630,00	km	20,0	32600,0
Pipe Factory	on site fabrication & 400°C firing	Baseline	1000,00		2,0	2000,0
Baking Supply	15 kV-50 V	Baseline	220,00	km	20,0	4400,0
High Tower	18 m x 2-2.5 m (Figs 196-7)	Baseline	1000,00	#	3,0	3000,0
High Cryo-Tower	18 m x 2 m (cryog. excluded)	Baseline	1100,00		4,0	4400,0
Ancillary Cryo-Tower	6 m x 2 m (cryog. Excluded)	Baseline	300,00		4,0	1200,0
Tower	10 m x 2 m	Baseline	500,00		11,0	5500,0
Filter Tower	8 m x 2.5 m	Baseline	500,00		3,0	1500,0
Cryotrap	6 m x 0.9 m	Baseline	250,00		4,0	1000,0
Large Valve	0,8 m aperture	Baseline	96,00		10,0	960,0
Large Valve	0,65 m aperture	Baseline	40,00		14,0	560,0
Large Valve	0,50 m aperture	Baseline	35,00		12,0	420,0
Pseudo-valve	0,80-0,50 m aperture	Baseline	30,00		10,0	300,0
Tower Link Tubes	0,75-0,9 m diameter	Baseline	40,00		13	520,0
Pipe rough pumping	dry/roots	Baseline	100,00		1	100,0
Pipe evacuation+bake	turbo+scroll+gauges+valves	Baseline	46,00		240	11040,0
Pipe final pumping	Ti evap.+Ion+gauges+valves	Baseline	41,00		360	14760,0
Pipe monitoring	Gauges+RGA	Baseline	100,00		6	600,0
Pipe Vacuum Control	HW+SW+Cabling	Baseline	25,00		60	1500,0
Tower Pumping & Control	scroll+turbo+ion+gauges+valves	Baseline	271,00		24	6504,0

Scaled view of a vertex



Credits: A.Paoli

WPIV.1 @ ET-ISB WORK BREAKDOWN



Activity: realize a 'standard' for the in-vacuum contamination assessment

Surface analysis:

a. - performed under vacuum just after the exposition to the contaminant
b. - sensitive to a single monolayer of deposit
c. - the target media can be chosen as wanted to ease the analysis