Cryo-pumping for "Tower Vacuum"

Gargiulo, Pasqualetti, Zelenova for the WPIV.1

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Abstract

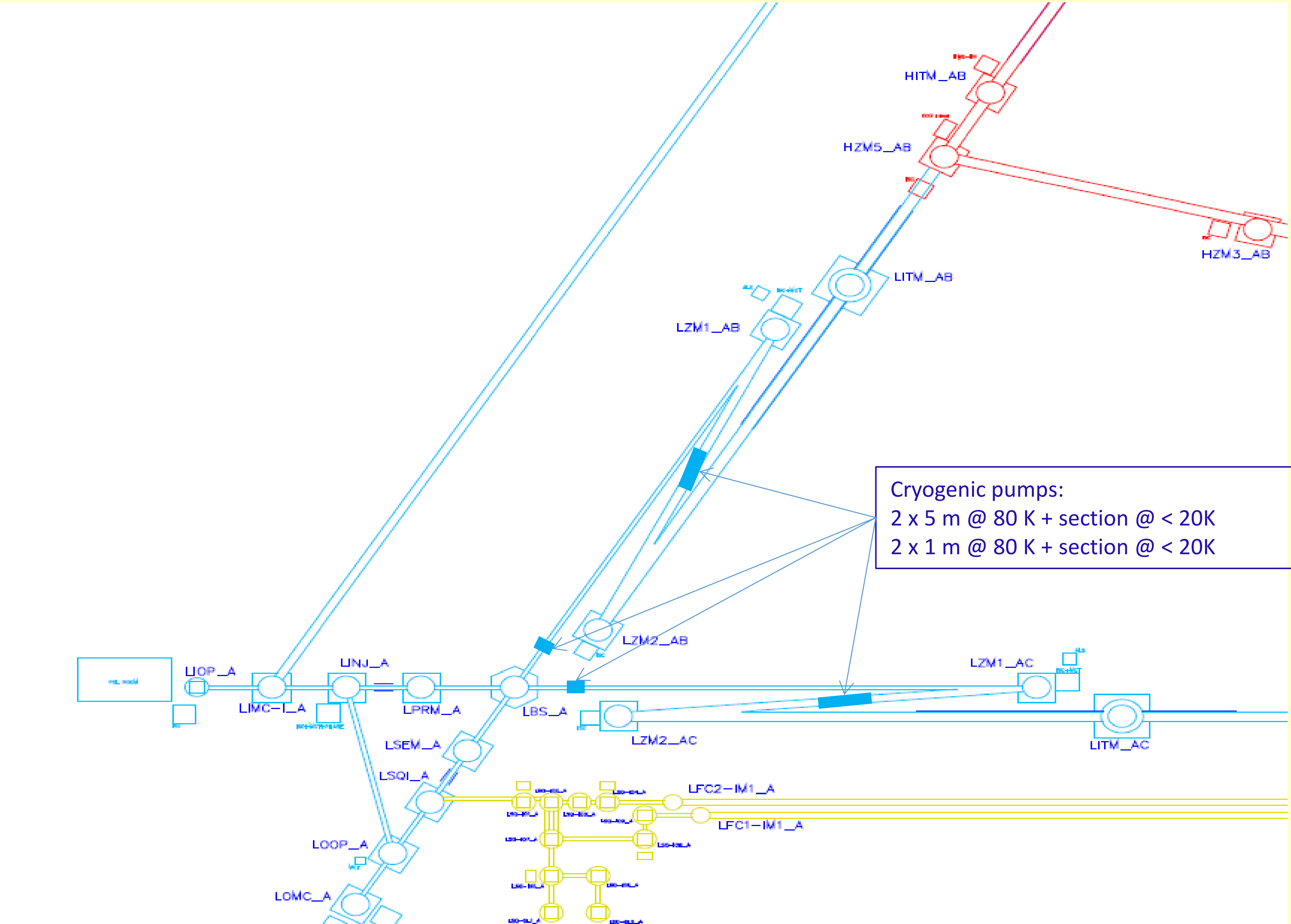
- *We propose cryogenics as the most effective and potentially the only solution to manage the pumping of towers, also for HF. A first feasibility step has been evaluated, corresponding to an ideal gas load scenario = minimal polymeric materials, very low-outgassing maerials and strict compartmental separation. Here we account a not-ideal case, including for leaks, high gas load corresponding commissioning phases, and also more tolerant compromise for selecting in-vacuum materials.*
- *Additionally, a general safety margin is recommended to be included in the design.*
- the purpose is to provide an estimate of the total cryogenic pumping surface for sizing the cryogenic plant. The position of the cryopumps and more precise calculations shall be done in a later phase..

Executive summary

PROPOSED ADDITIONAL TOTAL CRYOPUMPING LENGHT

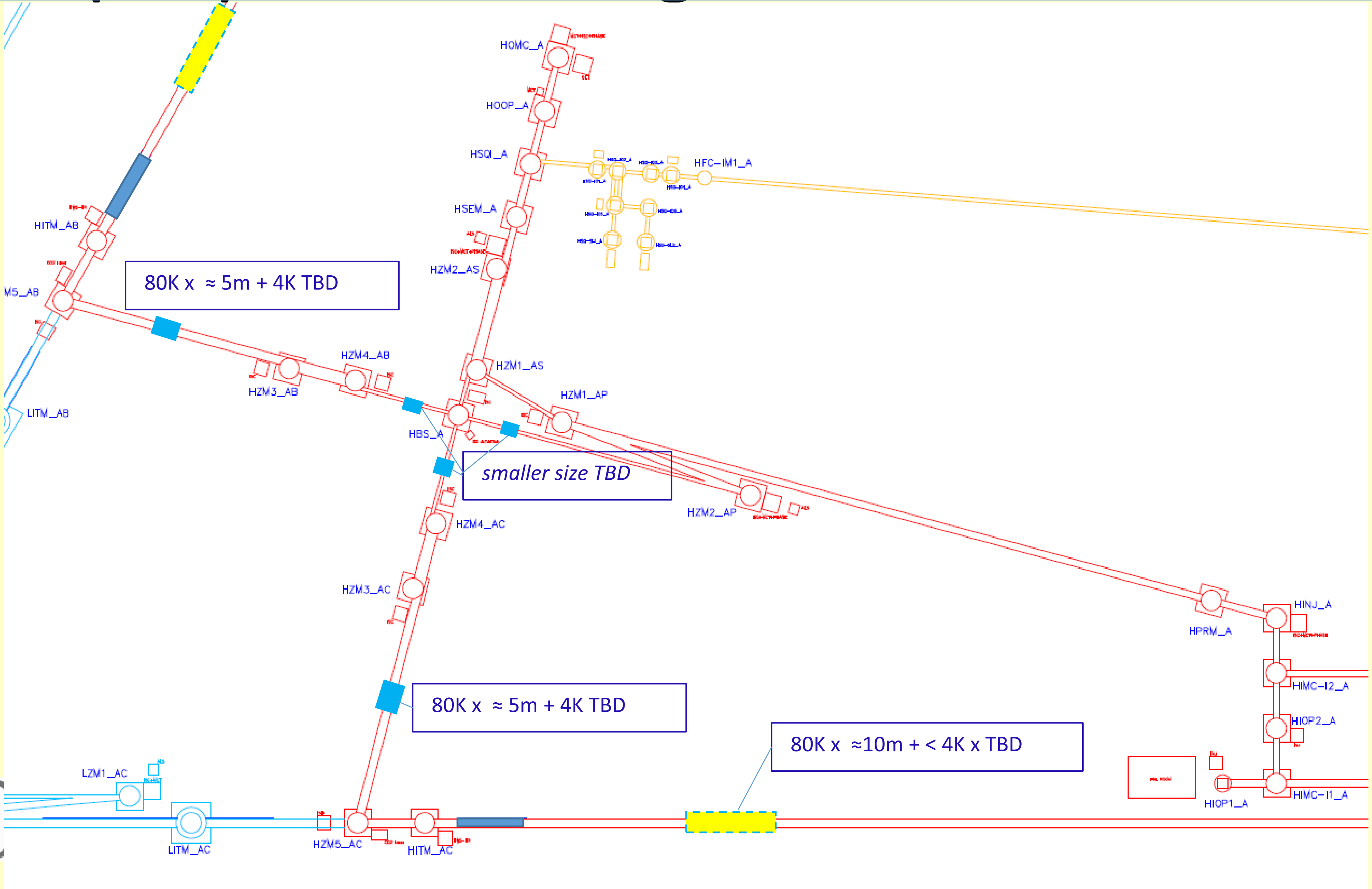
LF		HF	
80 K	L = 12 m x Ø ≤ 0.8 m	80 K	L = (13 + 10 TBC) m x Ø ≤ 1 m
< 10 K	L << 12 m x Ø ≤ 0.8 m	< 10 K	L << 13 m x Ø ≤ 1 m

LF proposed configuration



Cryogenic pumps:
2 x 5 m @ 80 K + section @ < 20K
2 x 1 m @ 80 K + section @ < 20K

HF proposed configuration



Summary

- Design scenario (Gas loads)
- Proposed solutions for HF and LF
- Sizing criteria (Requirements for LF => cryo-tower and for HF => arm tube)
- Plan for design finalization

Design scenario

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- Not-ideal gas load case
- Detector duty cycle: the gas load from towers is not constant, depending on frequence of in-tower intervention, significantly higher during commissioning phases, taking years after first installations. With so many towers, there is a risk of significantly affecting operations during commissioning. C*ommissioning periods are years long, and the detector is practically always in this condition. Additionally, having large pumping = short recovery times is vital to avoid disrupting the experiment duty cycle. Also, the experience shows that the in-vacuum materials load tends to increase with future developments, and it seems not feasible to reduce the 2G gas loads although not optimized.*
- The impact on detector operation is also related to the tolerance to leaks.
- For the moment the gas scenario is an educated guess based on 2G experience. In a next phase the gas load shall be estimated using the outgassing database tool.
- Vacuum requirements for 3G are (much) more stringent: water vapor, air traces, hydrogen need to be pumped more effectively than 2G.
- Constraint: Cryogenic pumps are to be positioned not ‘too far’ from main cryotraps.

Gas load – practical case

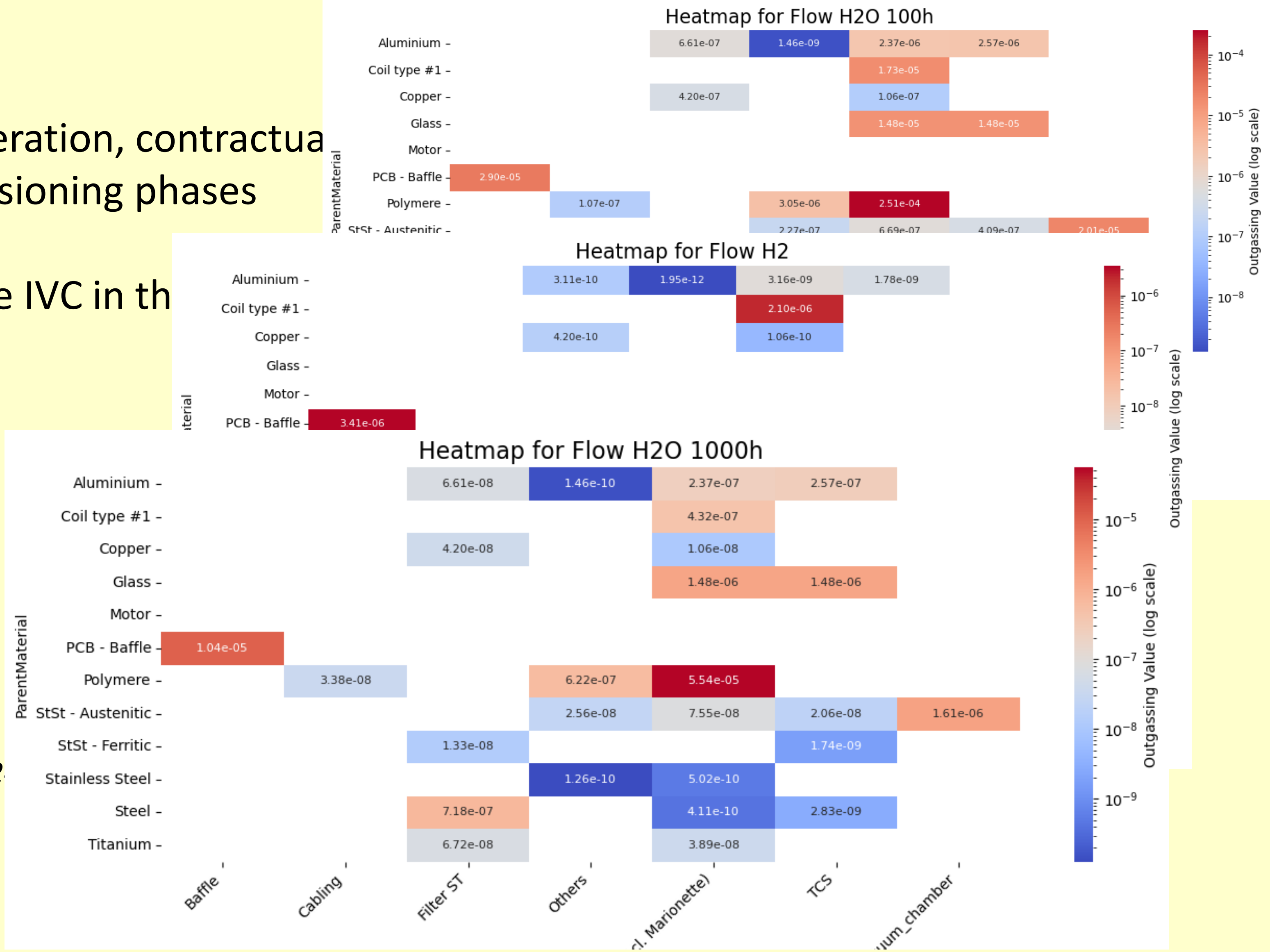
It is all about the gas load scenario

Not-ideal design needs to include:

- leaks (tolerable one during operation, contractua
- higher gas load during commissioning phases
- not-ideal materials
- parts of suspension beyond the IVC in th

H20@100h	H20@1000h	H2
2.12E-04	4.07E-05	7.31E-06
4.48E-04	8.91E-05	1.59E-05
5.00E-04	**1.00E-04**	**2.00E-05**

Case of warm 'mirror tower' lower compartment – Jul2

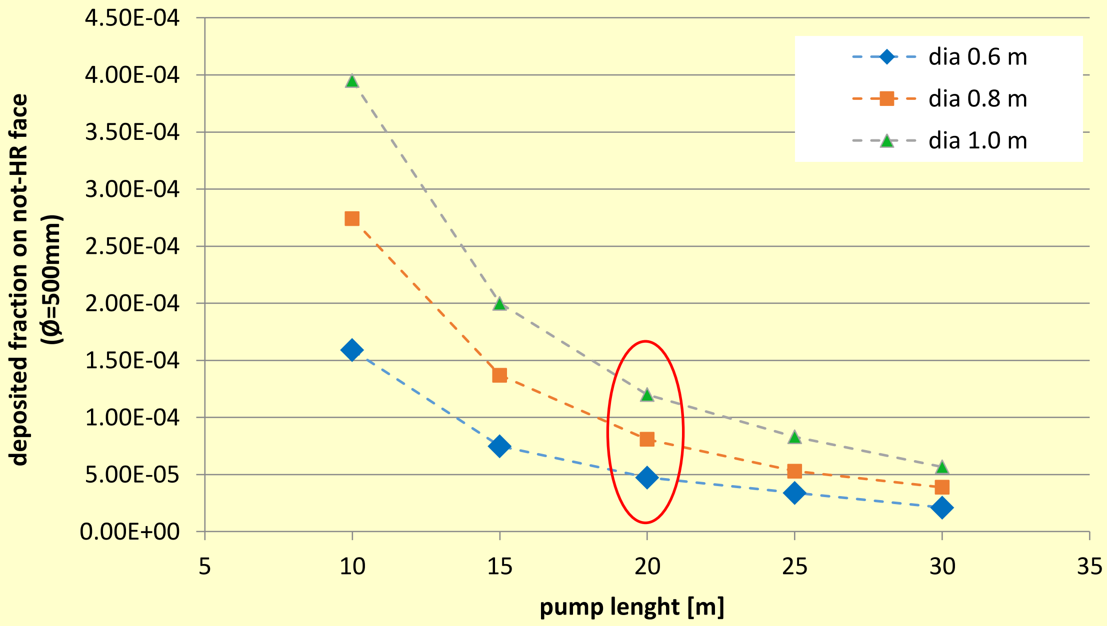


LF case

- **Growth rate on TM drives the residual gas requirements for LF warm towers (for all species except for H_2) => "maximum acceptable condensed build-up on not-HR TM face"**
- Indications to be derived for the not-HR case: absorption and heating req.ts are expected as quite different (e.g. 10kW for HR side, 20W not-HR side) and optical constraints to be considered too …

- Specific feature: we are thinking about using iris-like adjustable baffles to reduce the opening of the traps (non-recessed areas should be tolerable) during periods of high gas load, typically in recovery phases. For example, possibly the diameter could be reduced to 0.5m.

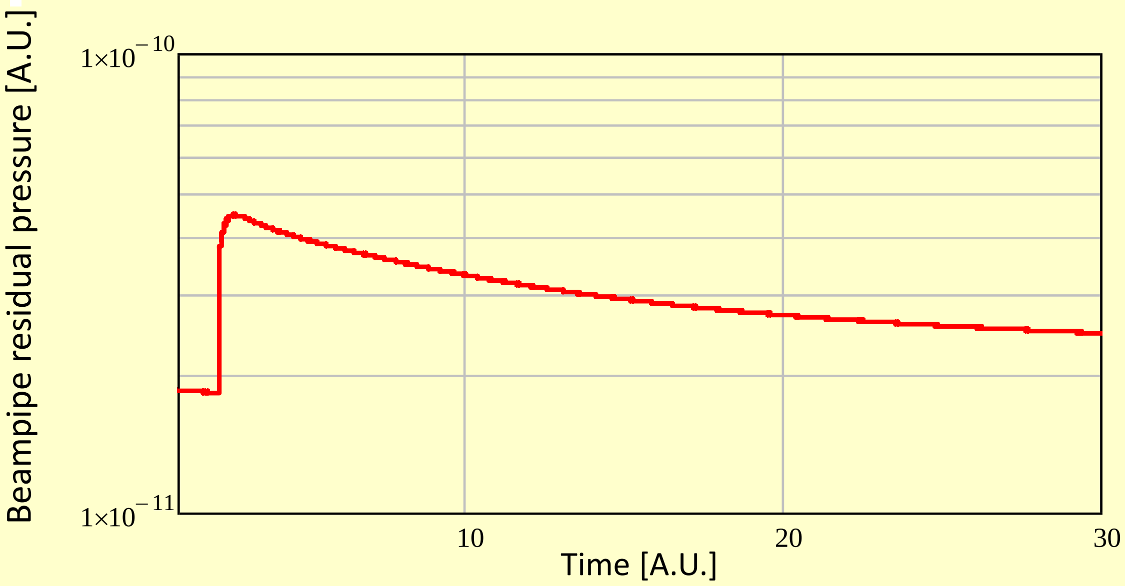
Deposited fraction * $\int_{t1}^{t2} Q(t)dt$ => CML_{ave}
can be up to some monolayers/year



HF case

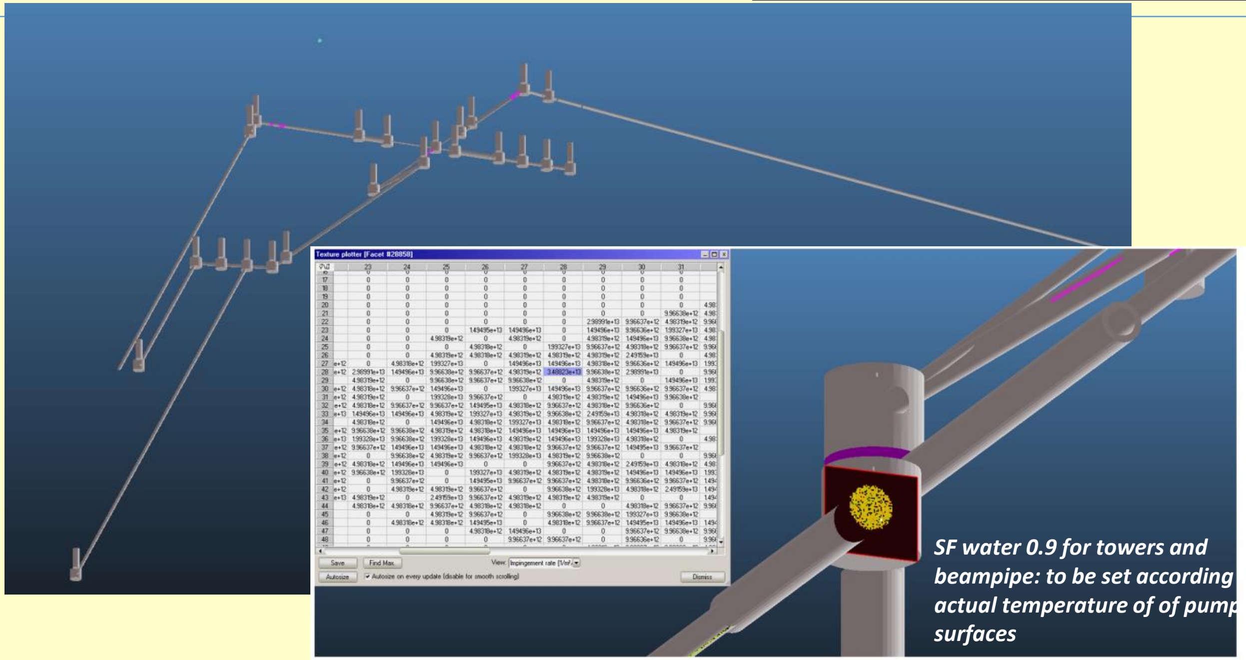
- **The vacuum level requirement for HF warm towers is driven by the wanted residual pressure in the HF beam pipe .**

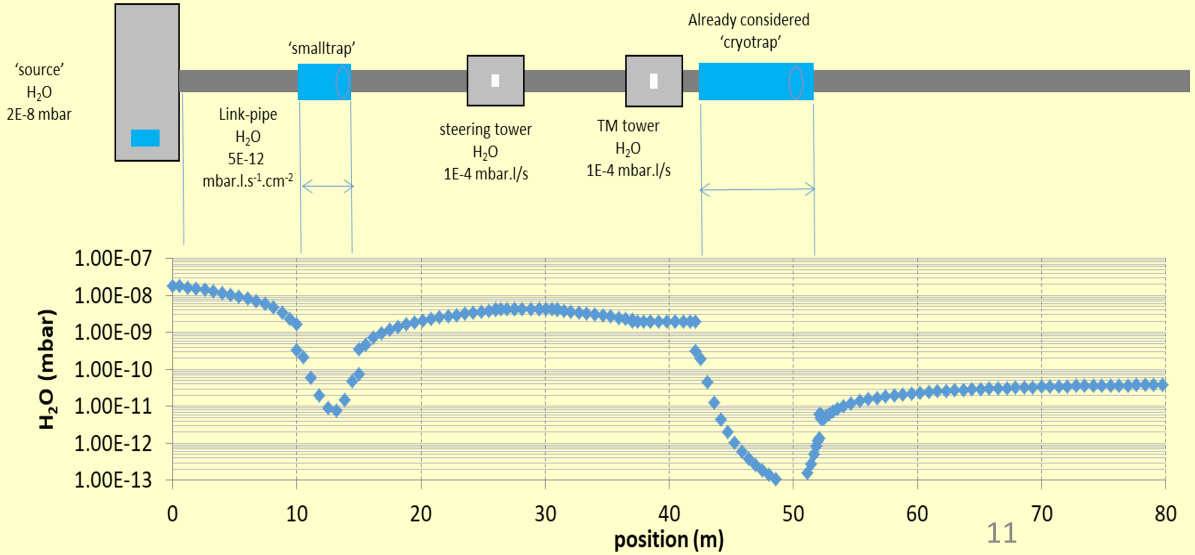
- To be discussed with the 'beampipe' team: the possibility of temporarily increased pressure during the 'commissioning phases' and subsequent recovery



Calculations

- In the model, the geometry can be reproduced to a good detail, and can be updated along progresses, e.g. including baffles , mirrors and special details
- The gas load can be distributed across the different parts according to the various wanted configurations. The gas load figure is based on practical measurements on large-scale components at different pumping times (see the ‘outgassing database’) and summed up in a 'conventional’ way.
- Ray tracing does not directly account for the time evolution of surface conditions (e.g. ignores the re-adsorption of molecules on materials and chambers walls). Dedicated model shall be included in a next step. The conventional approach is generally expected to be conservative, especially when dealing with limited time periods.
- **- everything to be verified by WPIV3 -**





Path to finalization

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- Converge within WPIV , discussing also calculating conditions and possible improvements
- Discuss a general design margin
- Interaction with Beampipe WP about management of high pressure transients (end Nov TBC)

- Iterate with Suspension WP about gas load limitation specific design of in-vacuum parts as well.

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- Backup slides

Air traces, H_2

- Strong pumping needs in HF cryogenic traps / towers !
- … ad specific design of in-vacuum parts as well

HF Towers: gas damping

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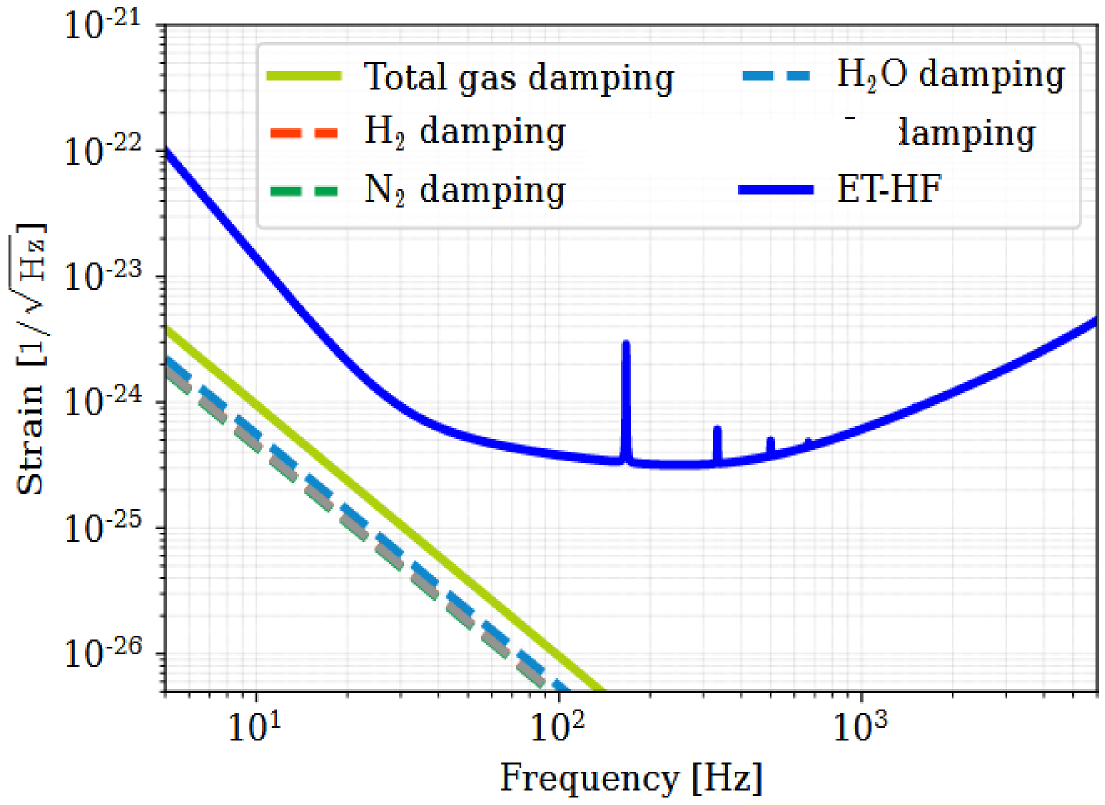
Example:

H_2@2E-7Pa + (H_2O+N_2)@2E-7Pa

Noise due to residual gas in the mid E-9 mbar range (HF towers, unconstrained mirrors) is compatible with ET-HF wanted performances (noise curve @ Sept.2022).



Credits: T.Zhang

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Maximum leak

- Admissible threshold per joint/item/assembly: to be discussed
- Operational side / ITF duty cycle: tolerable leak level of a ‘nearby tower’?
- Example: what happen with a 1E-6 mbar.l/s leak close to TM tower?
- Where/how FKM/Viton o-ring joints?