

Beampipes for GW Telescopes 2023



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CERN, 27th-29th March 2023

Commissioning of the vacuum system

- Rough pumping (from atmospheric pressure to 10^{-1} mbar)
- HV pumping (from HV to UHV range)
- UHV pumping at RT

Possible ZAO[®] NEG-based pumping approaches for ET

HV Pumping during bakeout

UHV Pumping after bakeout

ZAO «HV» version - HV + UHV pumping solution

- This ZAO version can be used while the outgassing is larger (process pump)
- The same pump can be used to deliver large pumping speed at regime to meet the pressure target
- Compared to «Z», «HV» version of ZAO has more capacity and less pumping speed within the same dimension

ZAO «Z» version – UHV pumping solution

- This ZAO version can be used to release the maximum pumping speed after the baking
- Compared to «HV», «Z» version of ZAO has more pumping speed and less capacity within the same dimension



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NEG cartridge based pumps

Pressure requirements for ET (TBD)

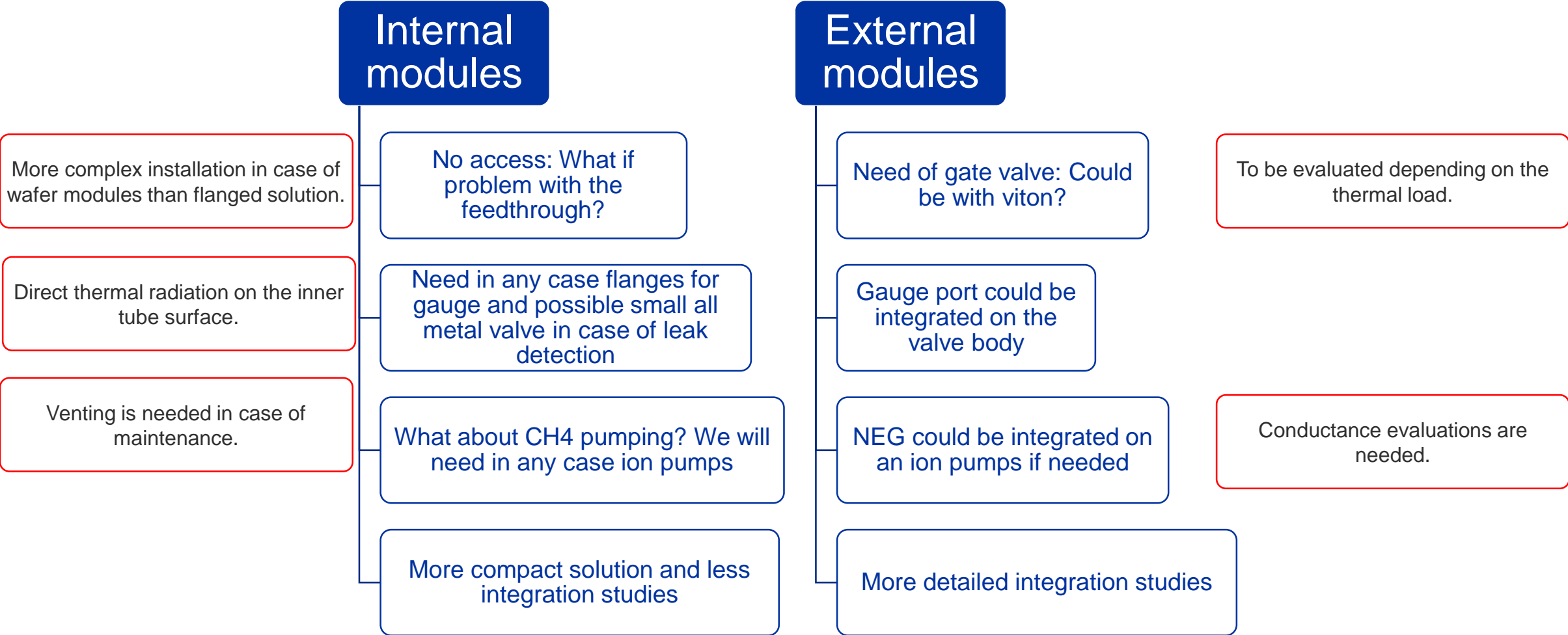
Gas	Goal P _{ET} [mbar]
H ₂	1 x 10 ⁻¹⁰
CH ₄	1.6 x 10 ⁻¹²
CO	1.9 x 10 ⁻¹²
CO ₂	2 x 10 ⁻¹²
H ₂ O	2 x 10 ⁻¹¹ (Final after bakeout cycle)

Example of outgassing rate per cm²

Material	H ₂	CH ₄	CO	CO ₂
SS (vacuum fired – Baked 24h@250C)	1.0·10 ⁻¹⁴	2.0·10 ⁻¹⁷	3.5·10 ⁻¹⁷	2.0·10 ⁻¹⁷
Mild steel (Baked @ <100C for 20d)	7.5·10 ⁻¹⁶	< 1.0·10 ⁻¹⁷	< 1.0·10 ⁻¹⁶	< 5·10 ⁻¹⁷

NEG cartridges based pump

Best integration strategy?



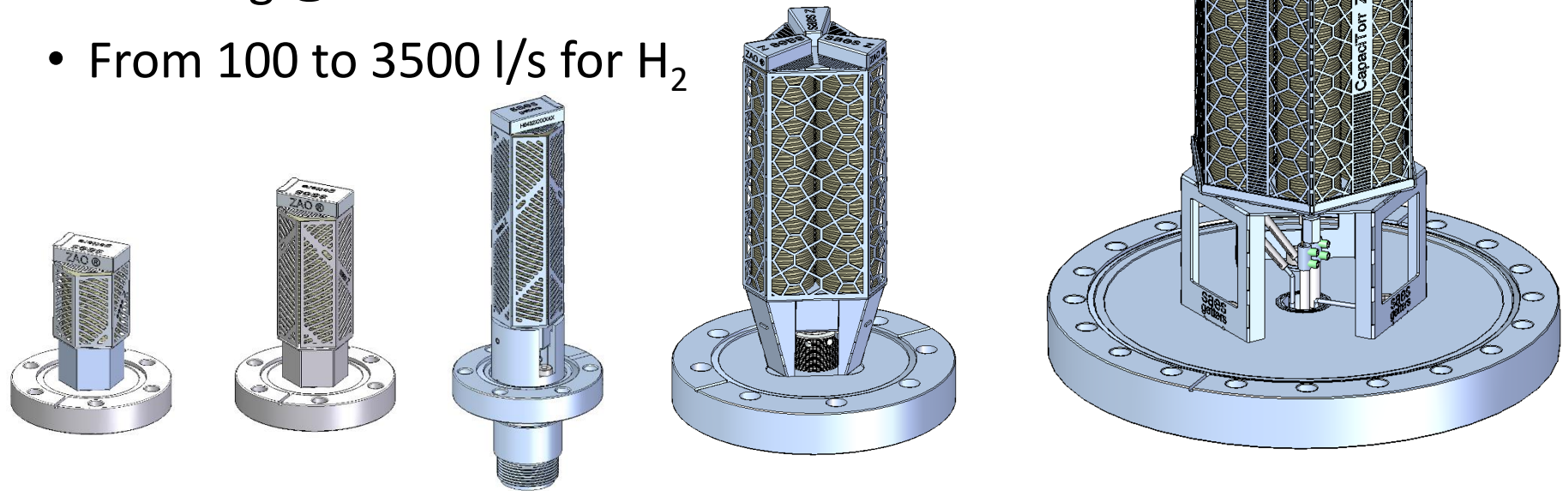
STANDARD PUMPS

- CapaciTorr
- Wafer Module

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CapaciTorr

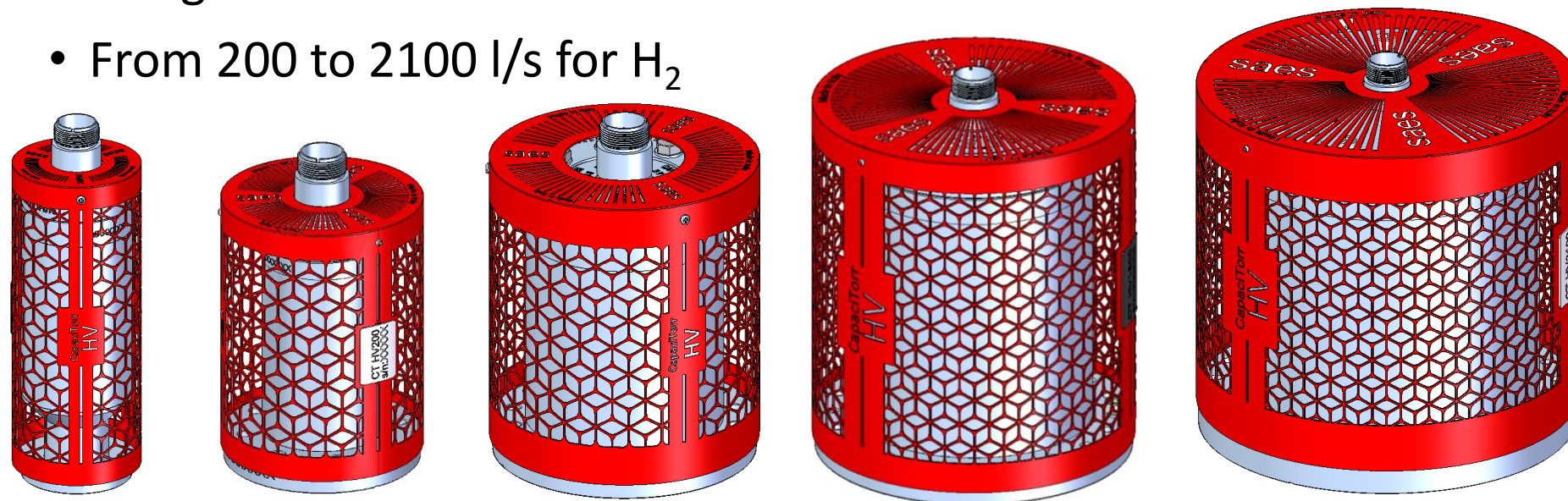
- NEG Pump only
- CapaciTorr «Z» family → **UHV application**
- Getter alloy: ZAO - **UHV** (sintered)
- Flange from CF40 to CF200
- Nude configuration
- Working @RT
- From 100 to 3500 l/s for H₂



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CapaciTorr

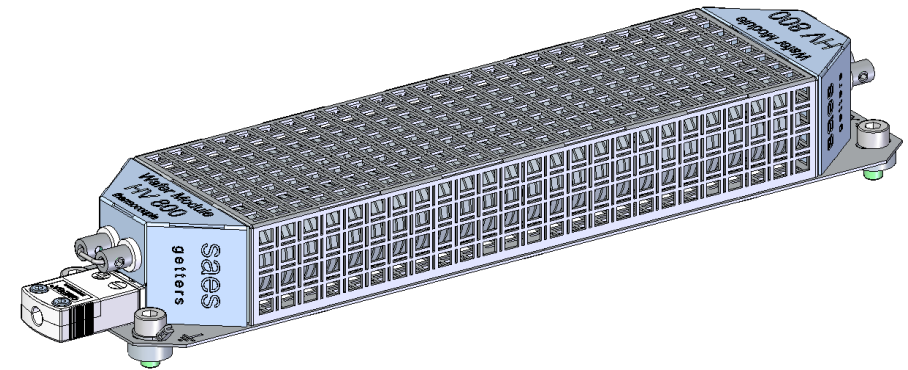
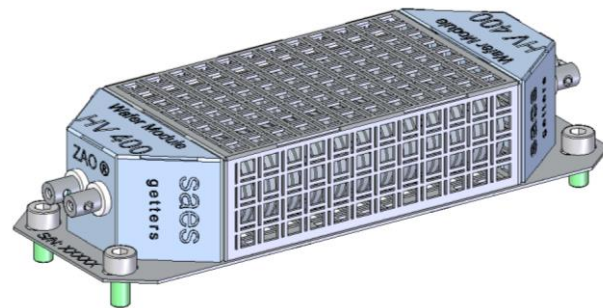
- CapaciTorr «HV» family → for **HV application**
 - Higher capacity;
 - In-body (or nude) solution
 - Working @ 200°C (or RT)
- Getter alloy: ZAO - **HV** (sintered)
- Flange from CF40 to CF200
- From 200 to 2100 l/s for H₂



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Wafer Module

- NEG Pump without flange
- HV/UHV application (ZAO **HV/UHV** sintered getter alloy)
- Feedthrough flange and in-vacuum cabling available
- Models with thermocouple available
- From 400 to 1400 l/s for H₂



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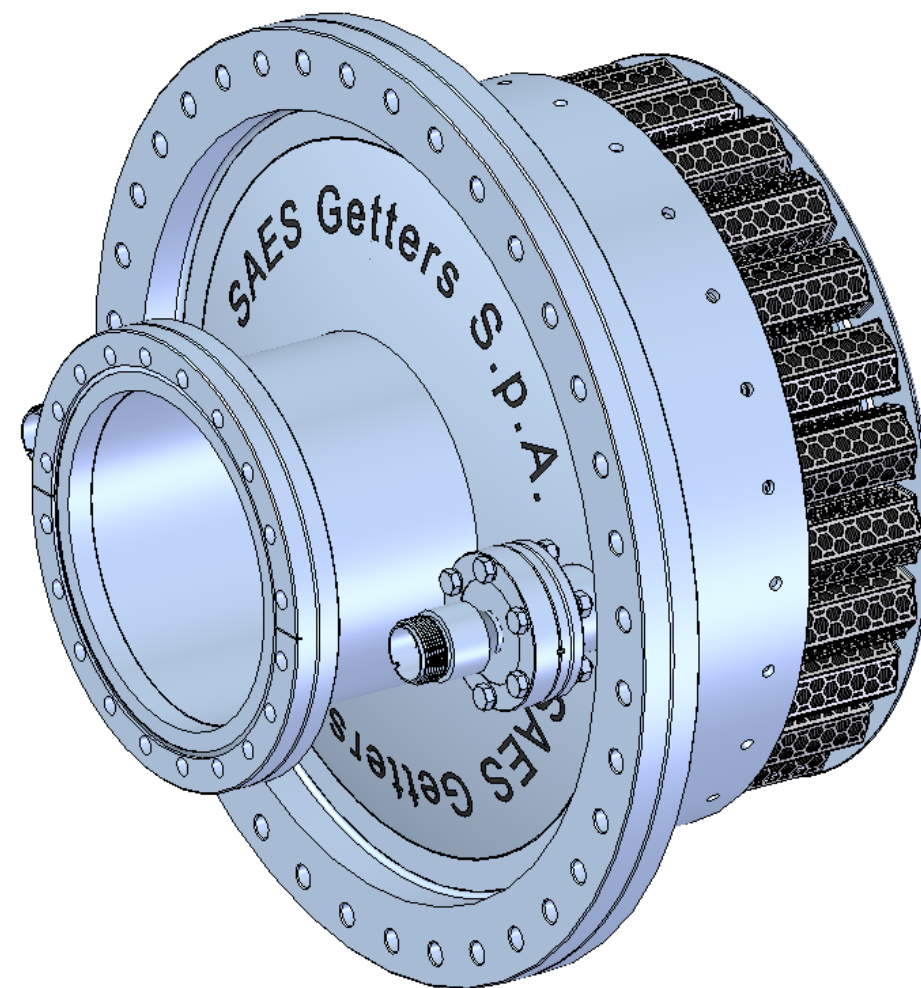
CUSTOM PUMPS

- Examples

The logo for 'saes' is displayed in white lowercase letters on a solid red square background.

40 x CapaciTorr Z 200 Cartridge/CF350

- Pumping speed target 7500 l/s for H₂
- Customer's CF350 special body design;
- n. 40 cartridge CapaciTorr Z 200
- n. 2 feedthroughs 4 pin 10 A

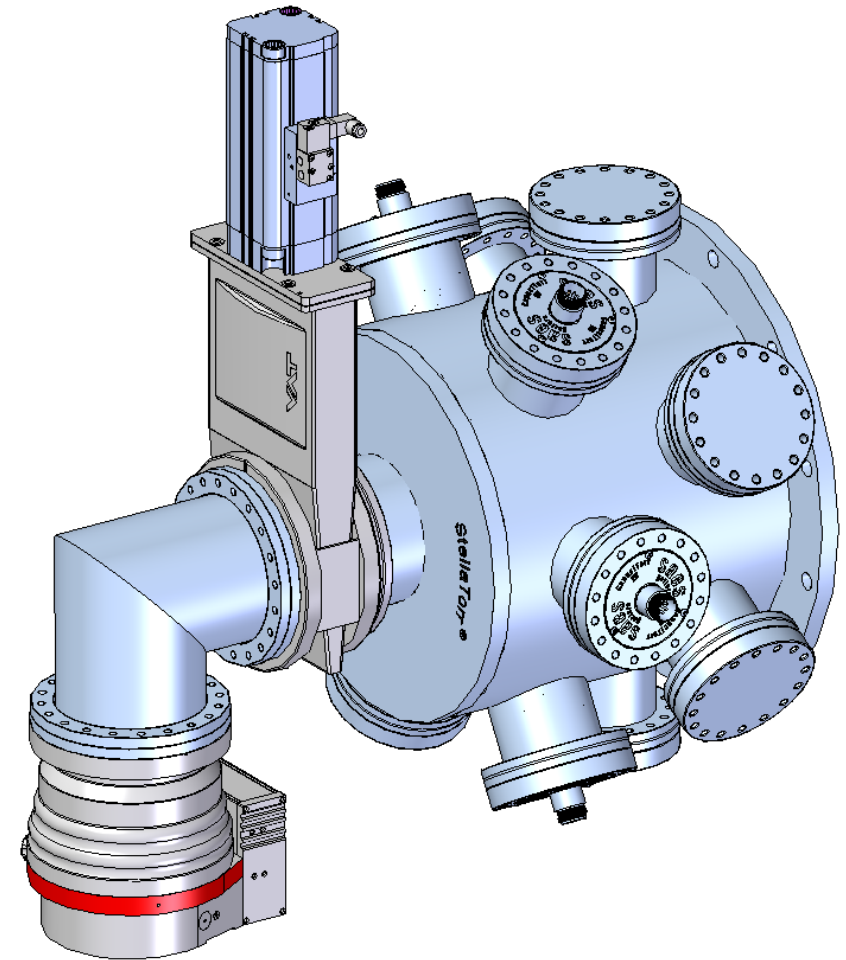


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StellaTorr 2x6xC2100HV/DN400

- The solution allows the installation of 6 or 12 C 2100 HV o CT HV NBI cartridges.
- Body geometry discussed with the customer
- Gate valve, TMP e accessories could have been supplied by SAES or not.

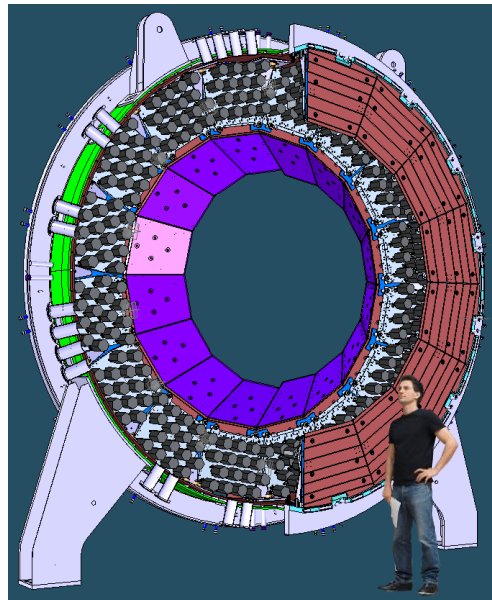


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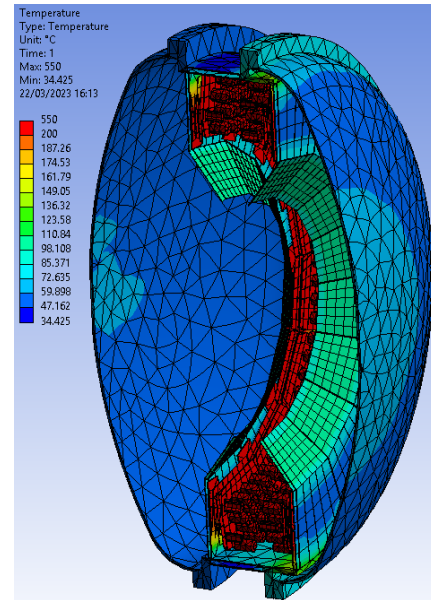
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SPIDER

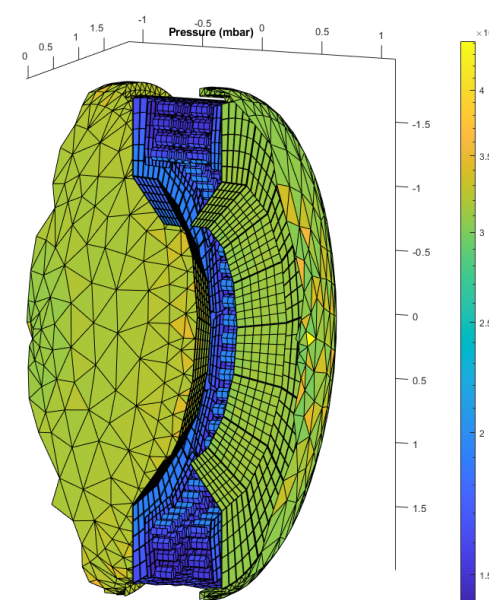
- Pumping system for SPIDER Neutral Beam Injector experiment at RFX for ITER
- Up to 512 NEG cartridges installed → pumping up to 330 m³/s for H₂ @e-4 mbar
- Largest NEG pumping system in the world
- Several studies to determine optimal positioning of the pumps
- Thermal and vacuum studies closely linked
- Power supply, electronics and SW integrated within the overall experiment control system



CAD model



Thermal analysis



Vacuum analysis



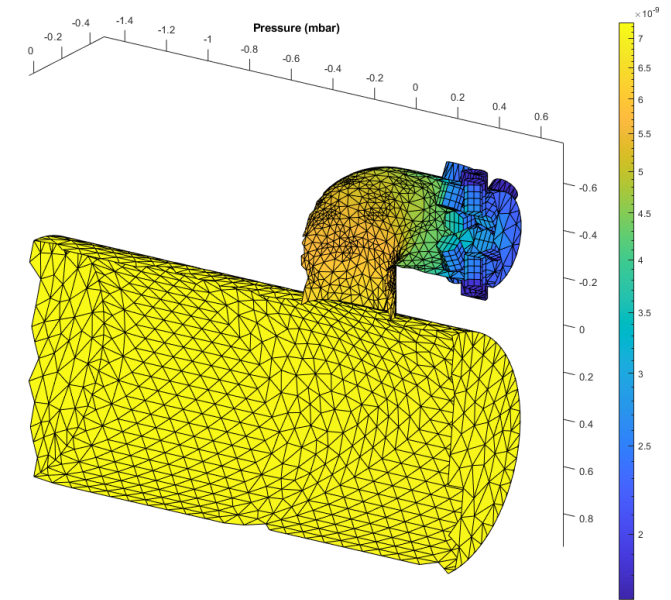
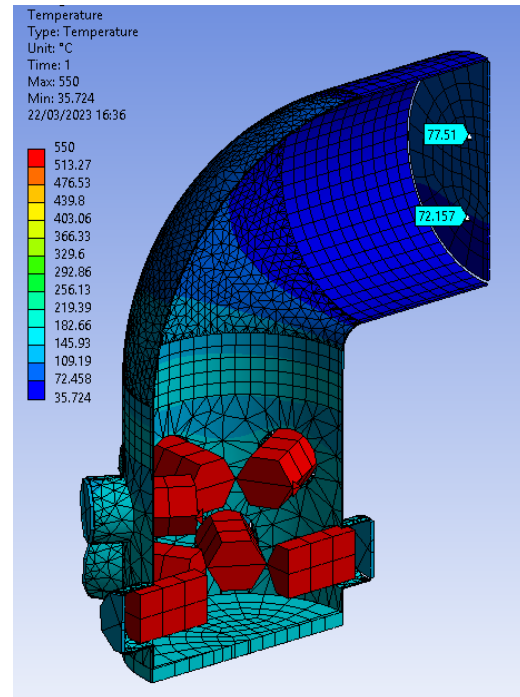
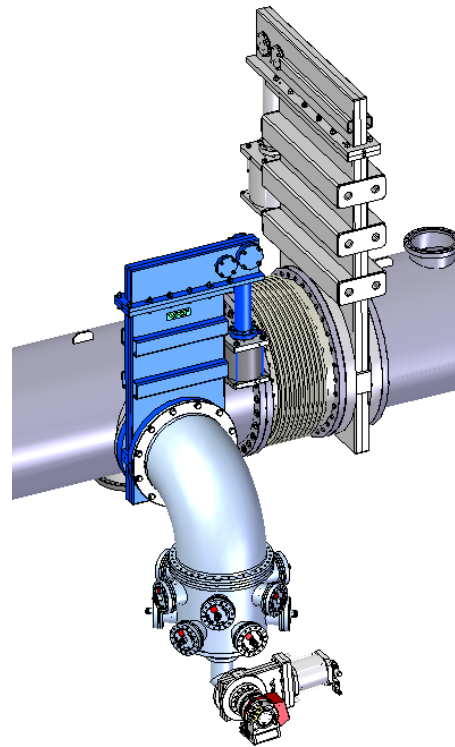
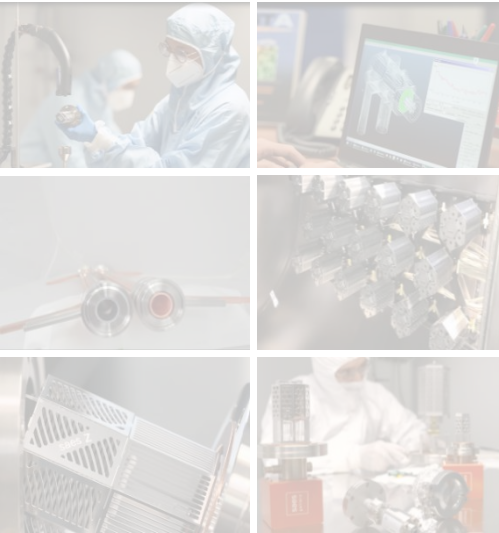
Lab Validation Tests on a sector



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VIRGO

- Pumping enhancement module for Virgo
- CAD project, thermal and vacuum simulation closely linked in iterative process
- Various configurations tested (straight tube, angled elbow, continuous, Tee, etc)
- Best solution chosen for ideal compromise between gate valve T and max pumping



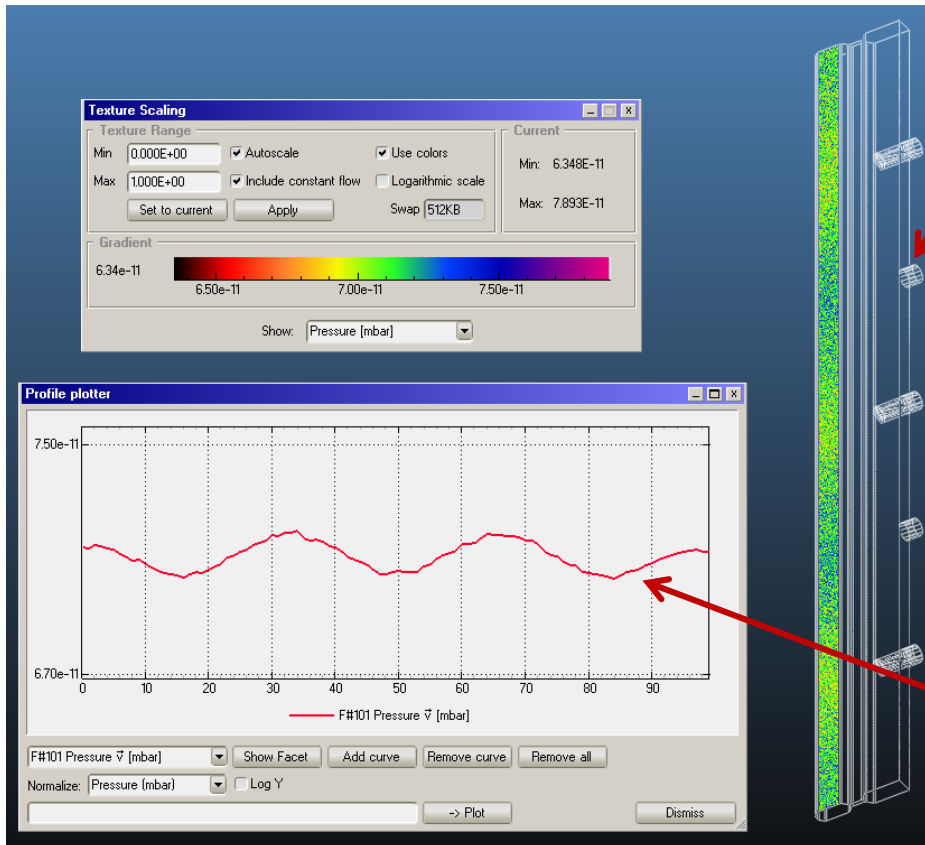
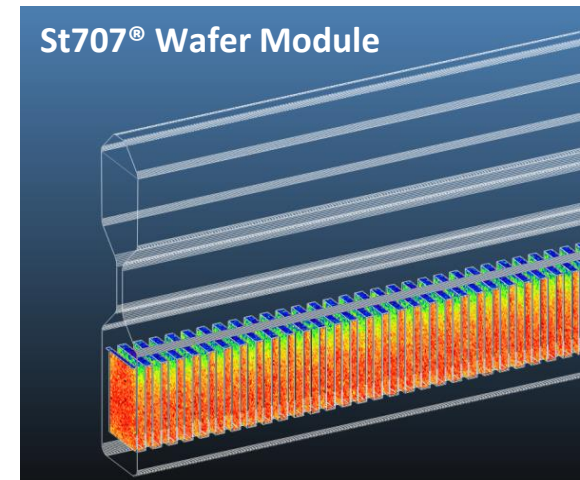
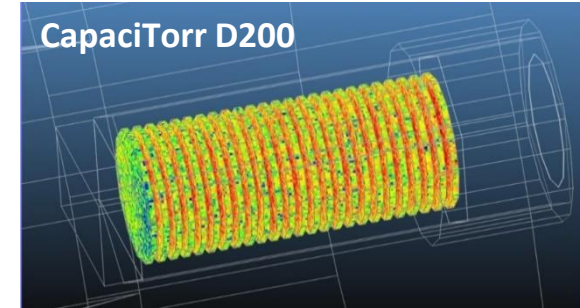
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Monte-Carlo simulations of NEG-based vacuum systems

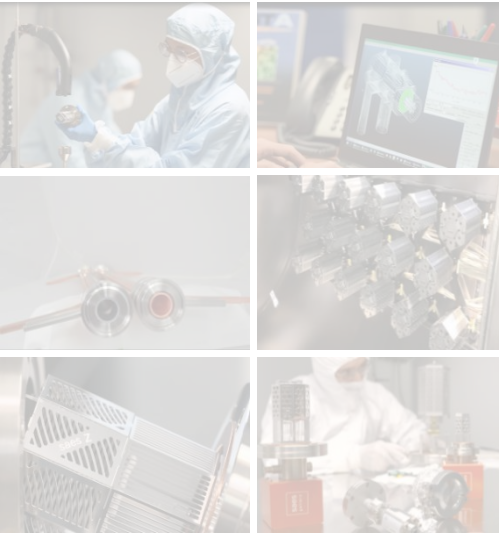
MOLFLOW+

R. Kersevan, J.-L. Pons, J. Vac. Sci. Technol. A 27, 1017 (2009)

Pressure reading by UHV gauge:
6.8E-11 mbar



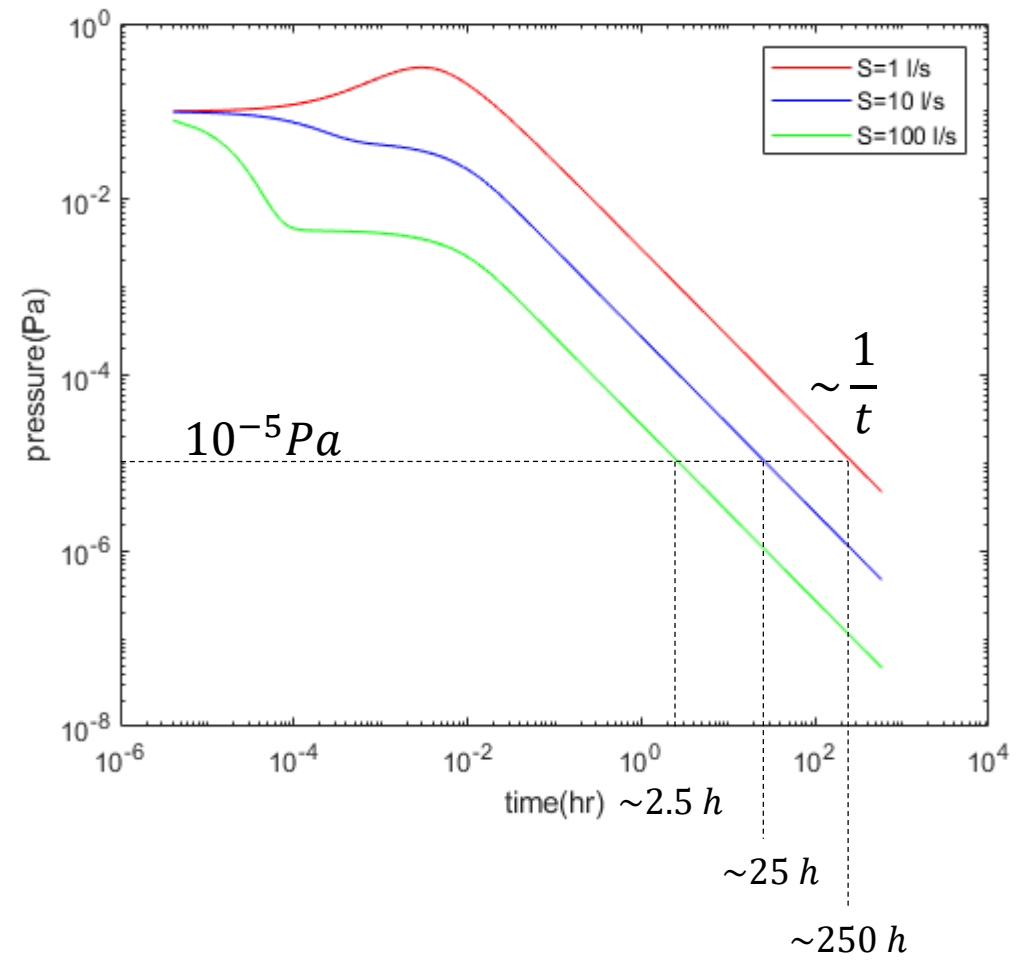
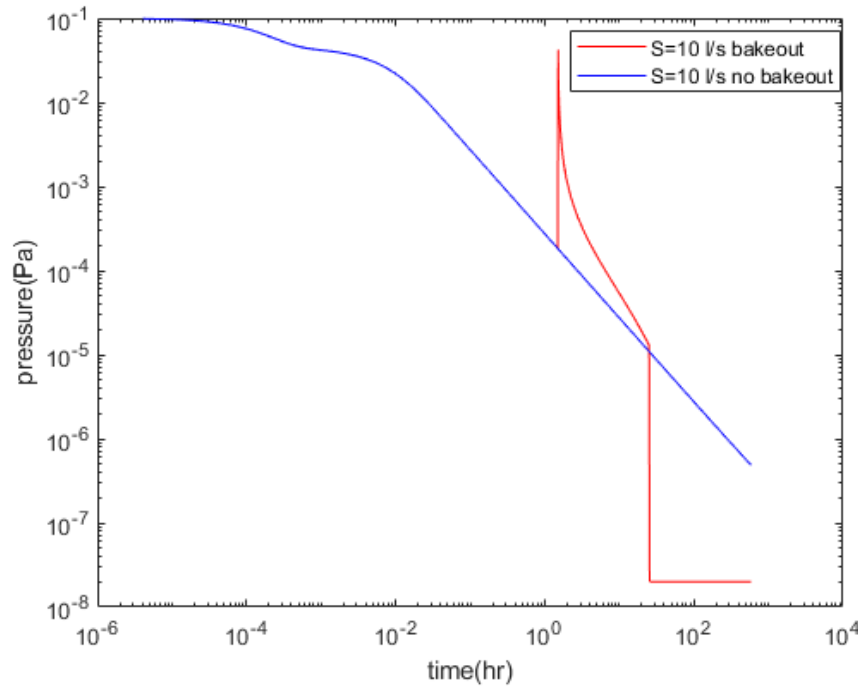
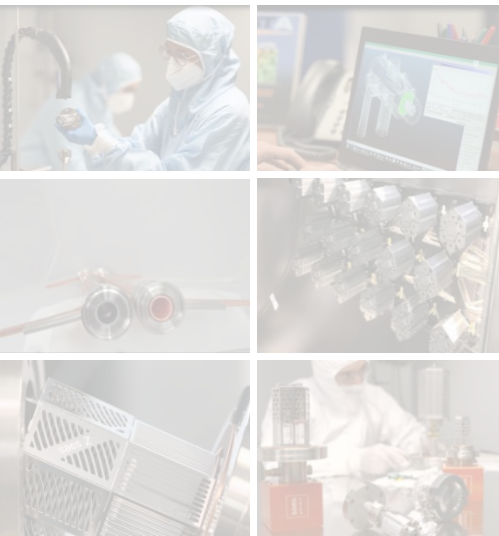
Pressure along the beam channel is quite uniform.



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Courtesy of Mr. B. Hippert, DELTA, TU Dortmund, private communication

Temkin isotherm: pump-down predictions w/ or w/o bake-out

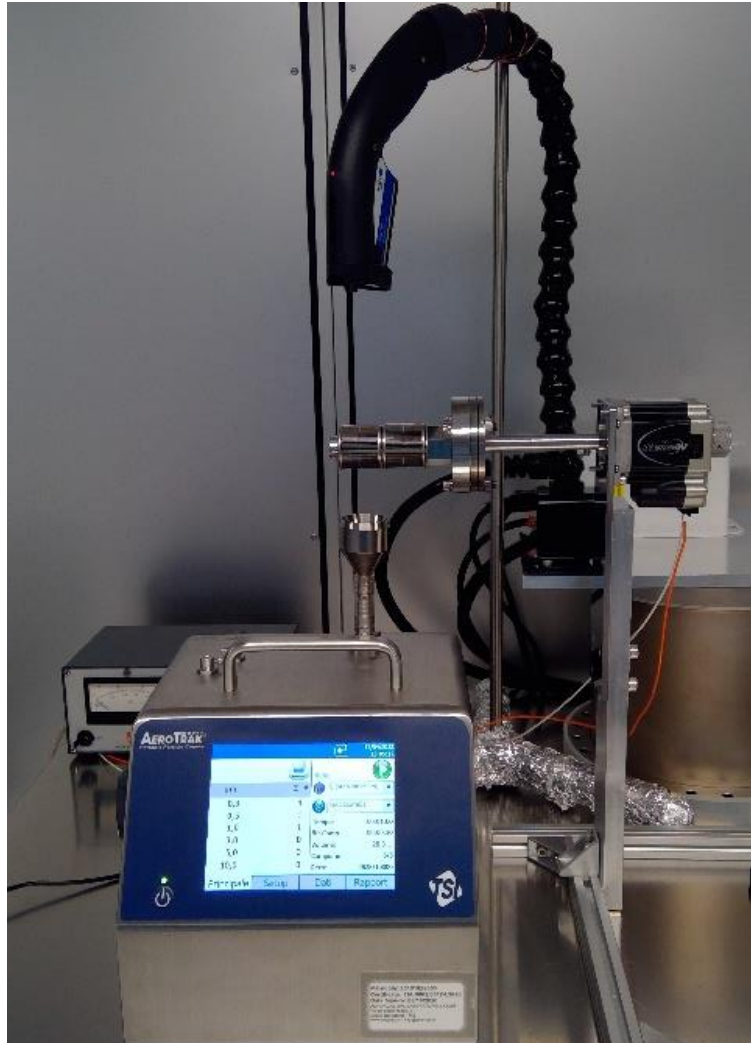
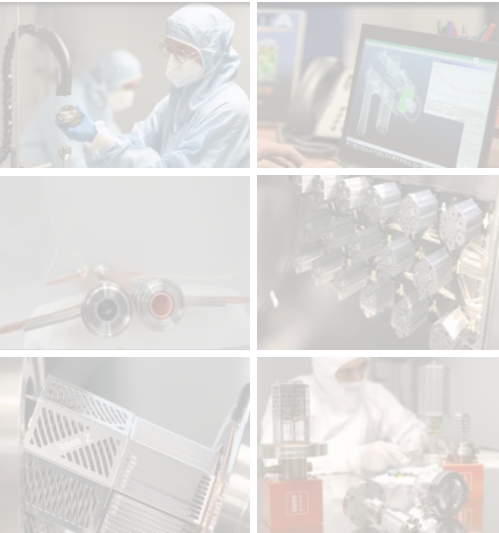


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Particle detection

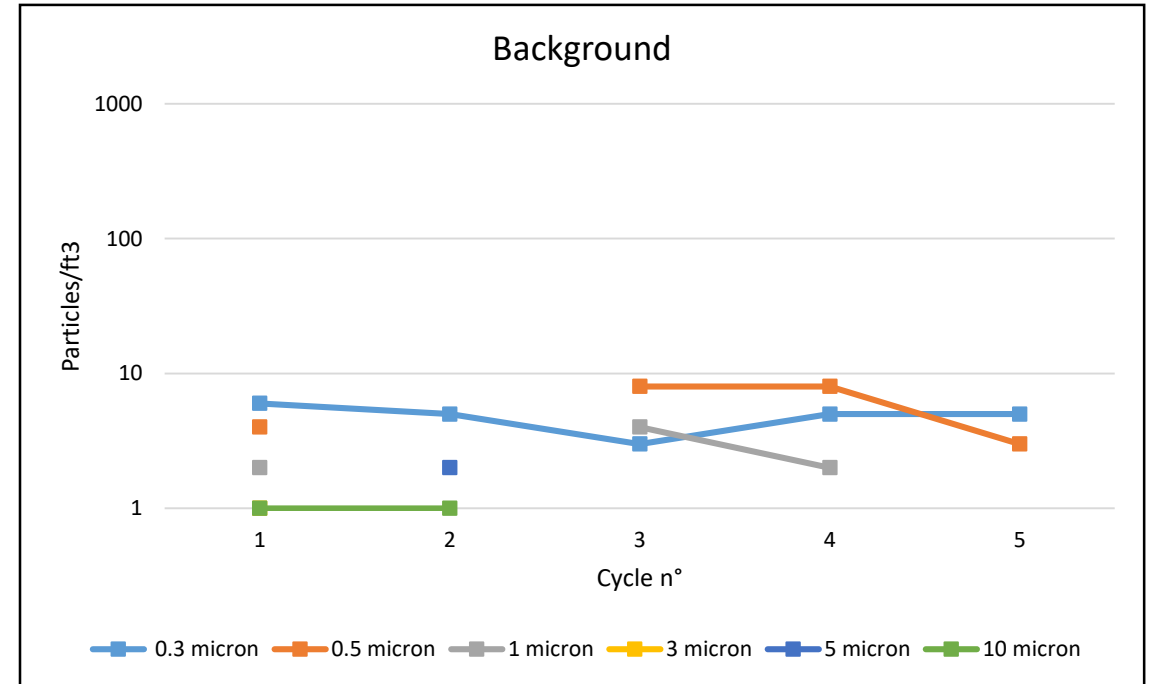
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Particle detection system



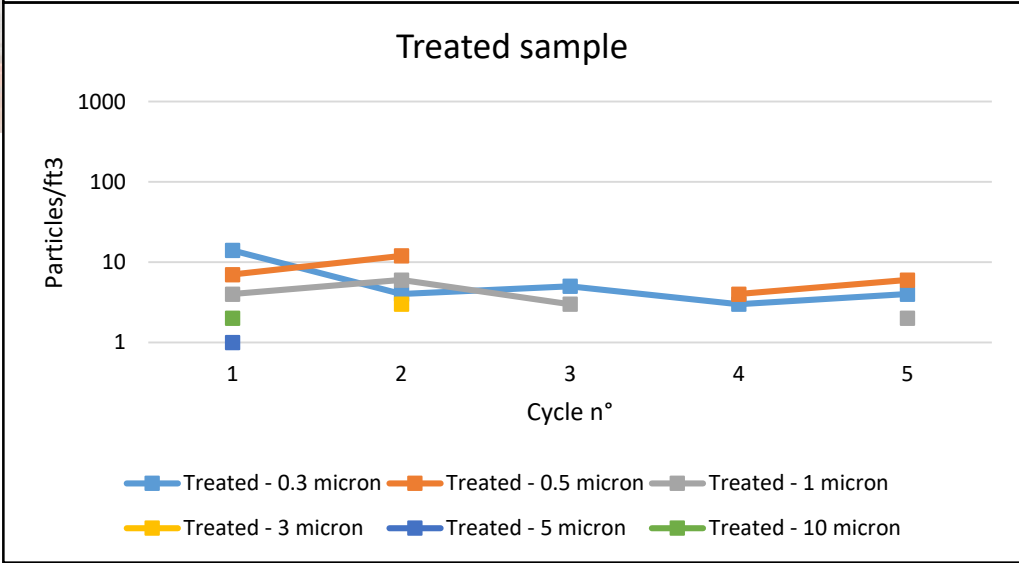
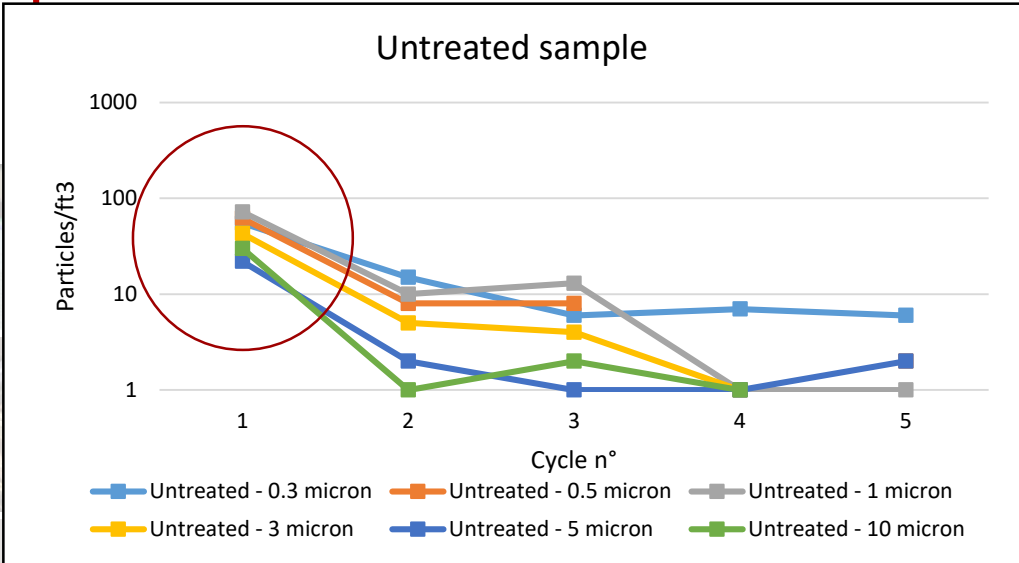
Robust particle detection system:

- Implemented in ISO 6 cleanroom.
- Repeatable measurements.
- Minimization of background effects.
- Capability to check the effectiveness of cleaning treatments developed in our labs.

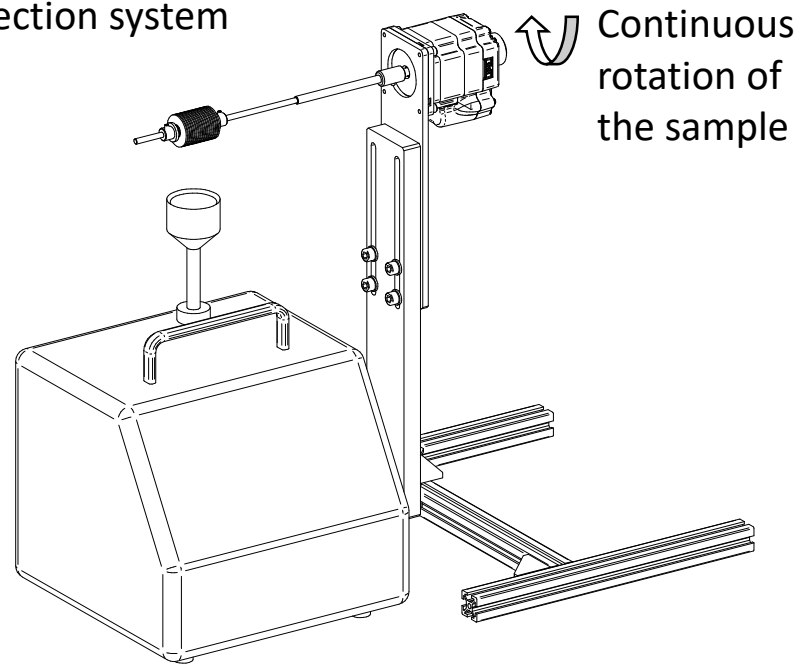


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Checking the effectiveness of cleaning treatments



Detection system



Example of countings for 11 dsk NEG stacks (ZAO UHV):

- **Treated stack: background-comparable;** masses > 5 micron below 2 units at the first minute, then they are not detected anymore.
- **Effectiveness of cleaning treatment.**



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Thank you for your attention

The logo consists of the word "saes" in a white, lowercase, sans-serif font, centered within a solid red square.

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www.saesgroup.com

