Reaching ultra-high vacuum for a large vacuum vessel in an underground environment

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FOR THE MIGA CONSORTIUM

MIGA

MATTER WAVE LASER - BASED INTERFEROMETER

LAPHIA Laser & Photonics in Aquitaine

université de BORDEAUX

Outline

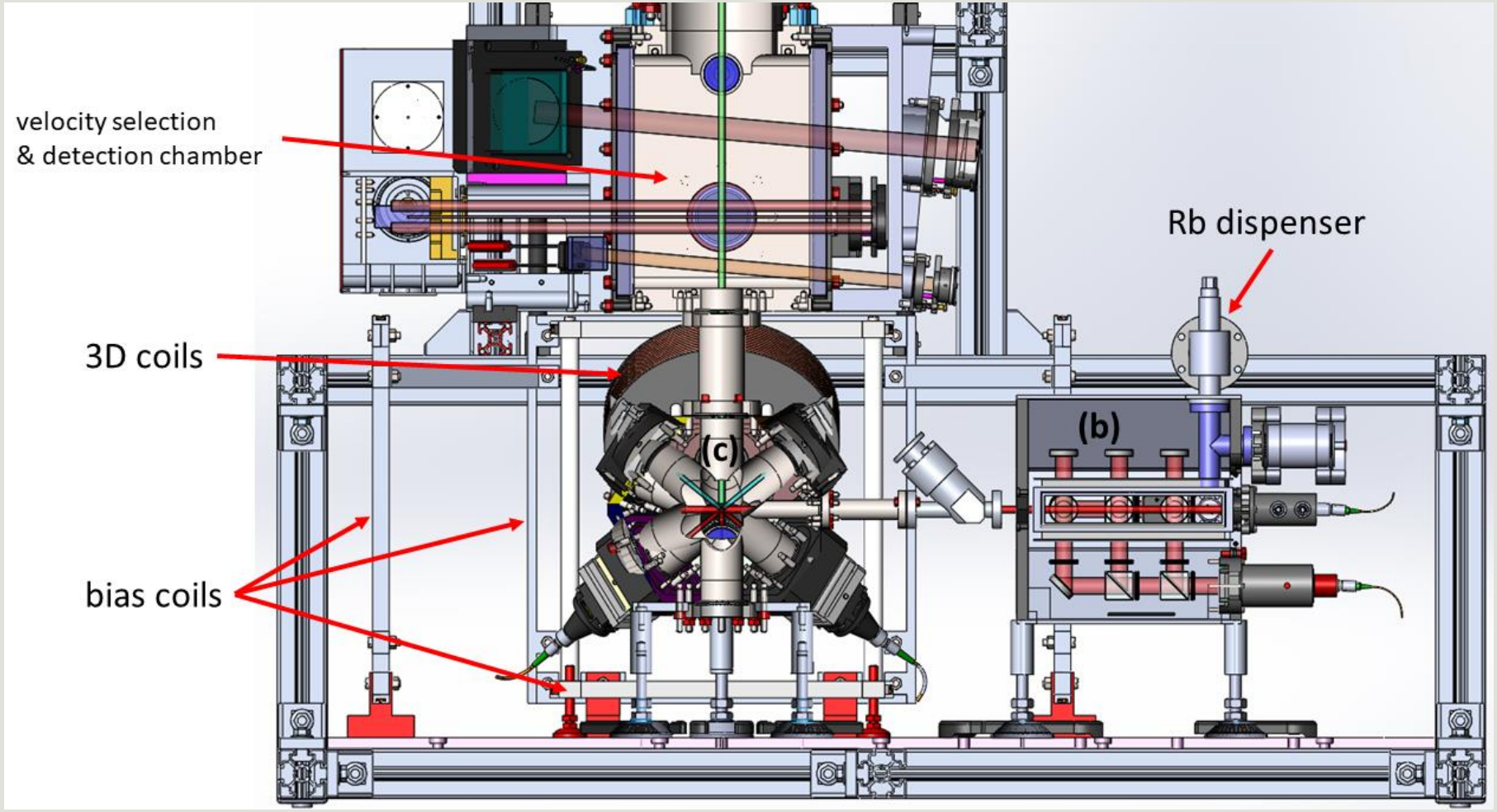
- MIGA @ LSBB – the various subsystems

- Generating Ultra-high vacuum (UHV) in a large volume system

- Moving forward with MIGA @ LSBB

MIGA @ LSBB – the various subsystems

BRIEF COVERAGE OF MAJOR SUBSYSTEMS



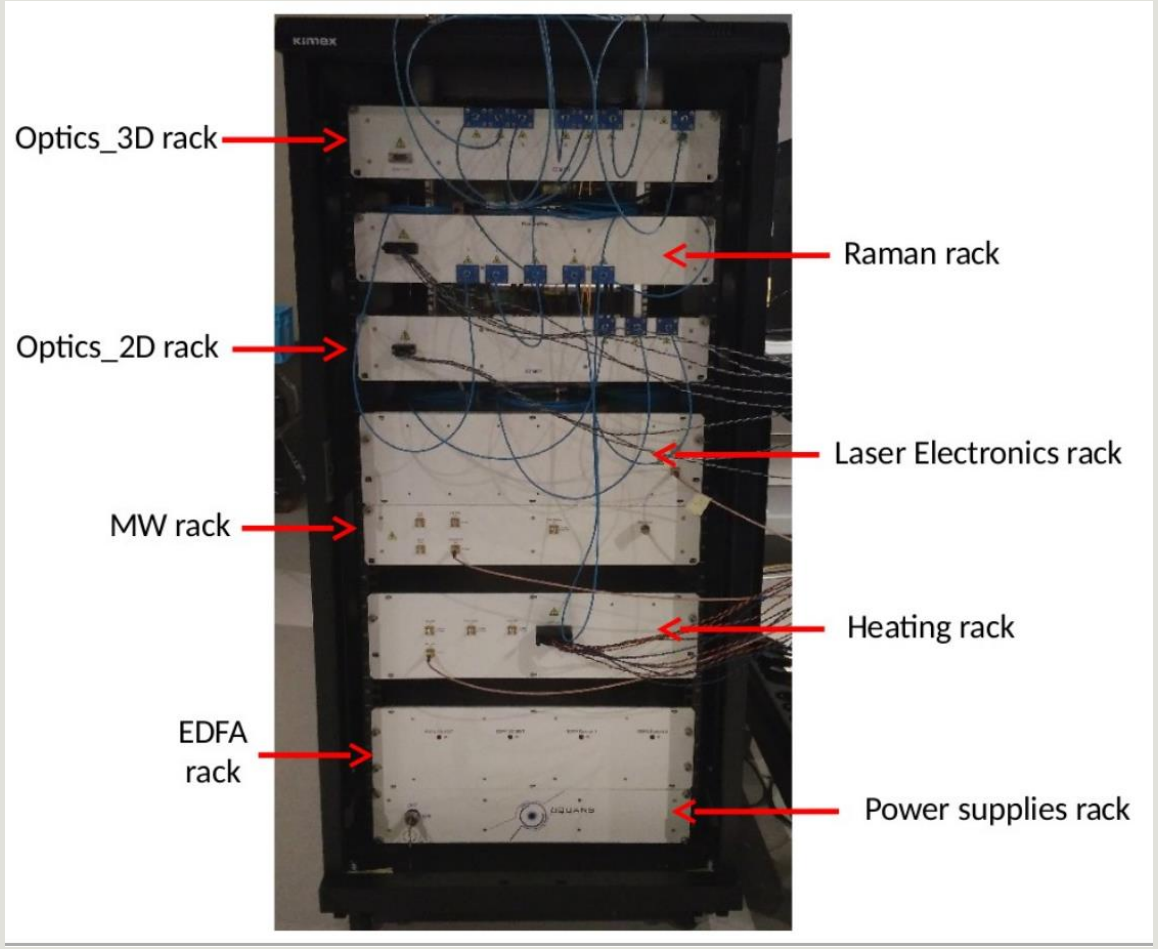
Atomic Source – Rb87 cold atom production and detection

Beaufils *et al*. Cold-atom sources for the Matter-wave laser Interferometric Gravitation Antenna (MIGA). 2022. ⟨hal-03643088⟩

Joseph Junca. Progress of the MIGA project toward gravity strain measurements with atom interferometry. Université de Bordeaux, 2022. English. ⟨NNT : 2022BORD0150⟩. ⟨tel-03669058⟩

Laser System – Rb87 laser cooling and manipulation

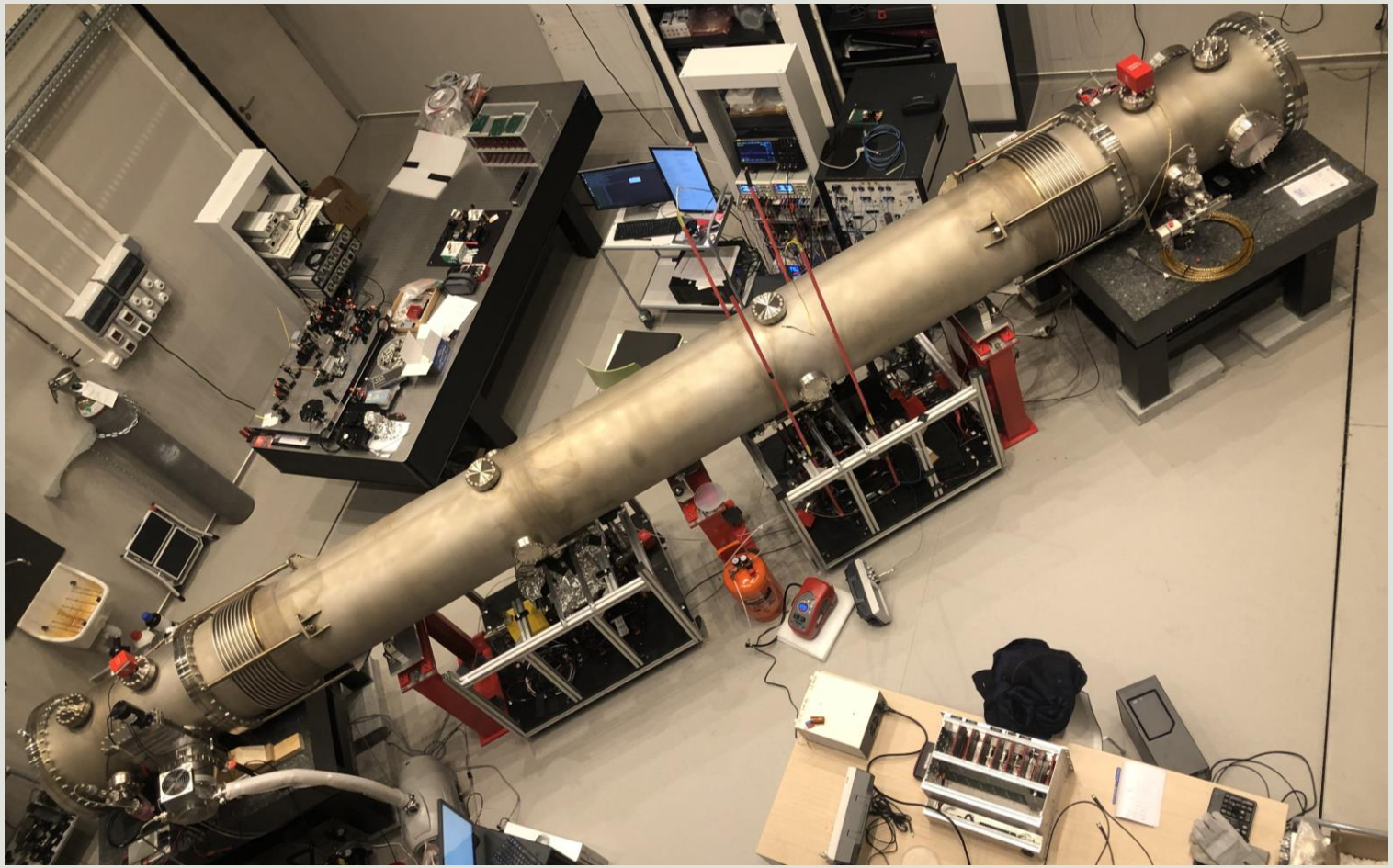
Sabulsky *et al.* A fibered laser system for the MIGA large scale atom interferometer. *Sci Rep* **10,** 3268 (2020).



<<Specifically designed to operate at LSBB>>

Generating Ultra-high vacuum (UHV) in a large volume system

BROUGHT TO YOU BY D. SABULSKY, X.-H. ZOU, B. CANUEL



Assembled atom gradiometer at LP2N

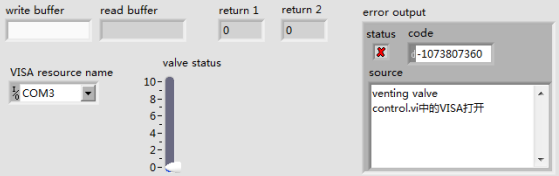
~8 m vacuum system, ~1.6 m^3

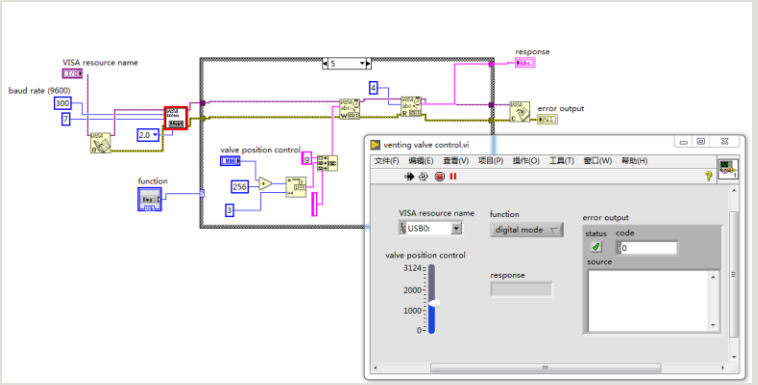
Pumped by Dry scroll (4.3 L/s), turbomolecular pump (920 L/s, 10^6 compression ratio), multiple NEGs (~2150 L/s) and two ion pumps (~20 L/s)

Safe, automated, and clean venting of the vacuum vessel

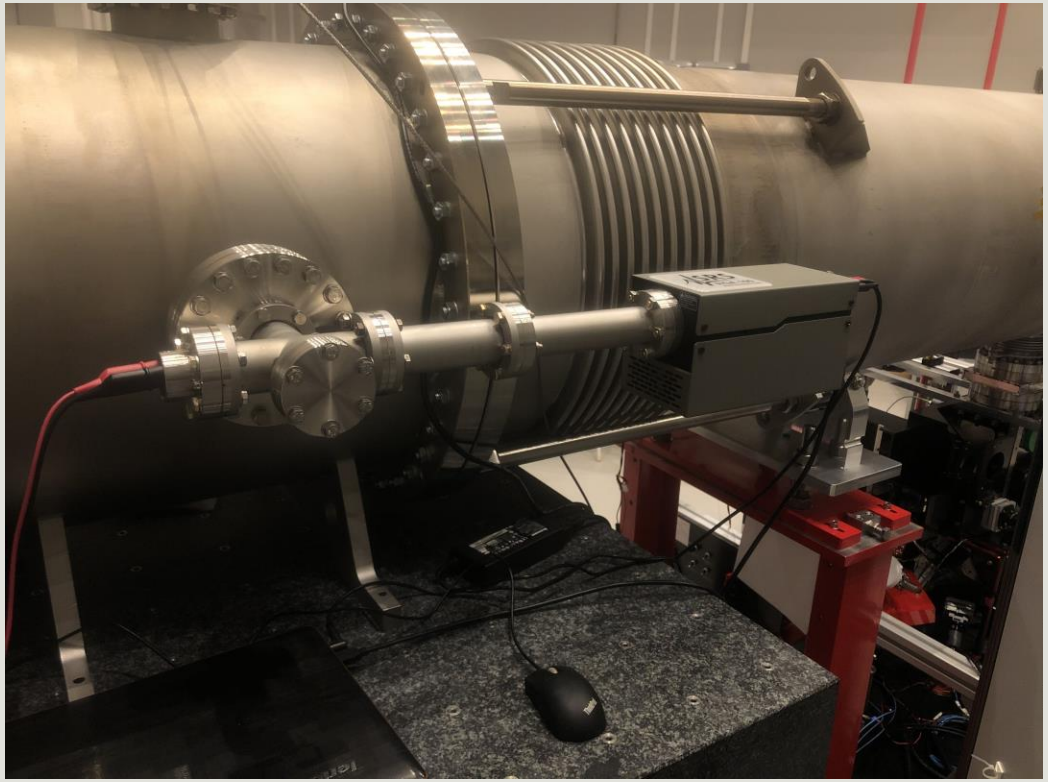
- Venting tests involving a series of valves and filters

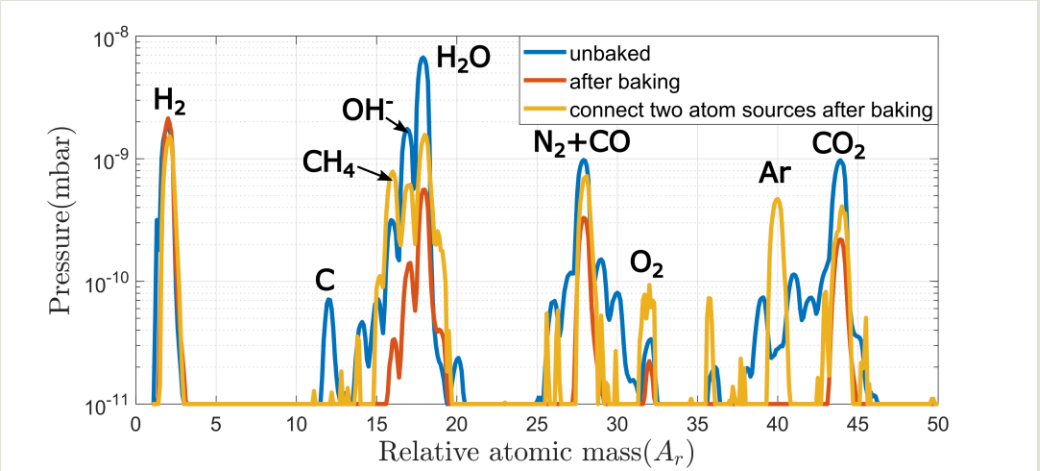
- Successfully prevents infiltration of contaminants





Spotlight on: Residual Gas Analyzer (RGA)



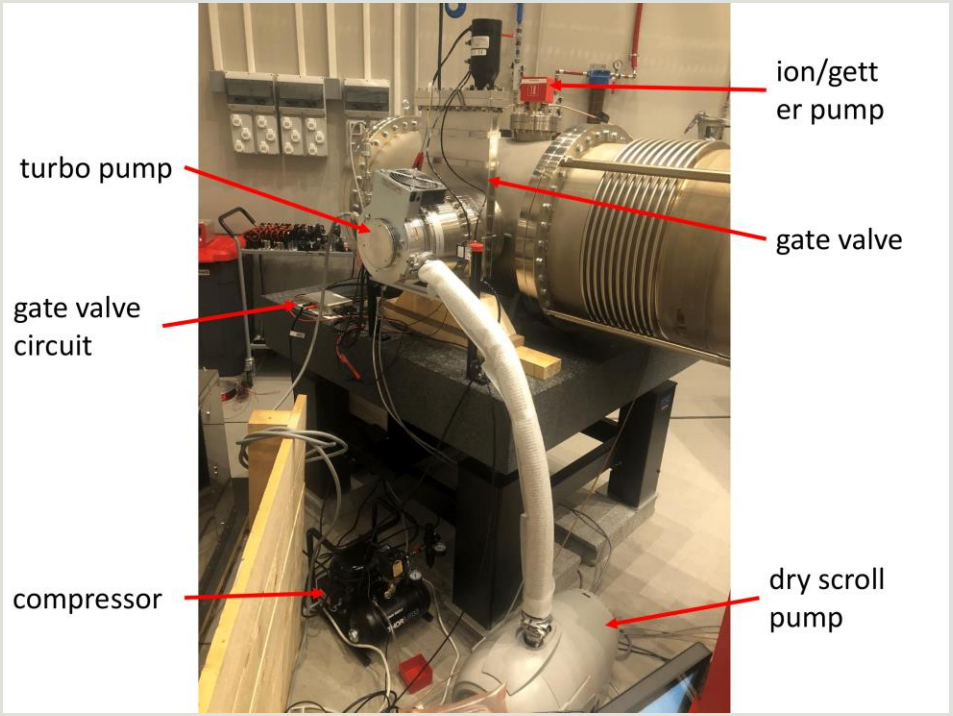


- Permanent installation of a mass spectrometer working as a residual gas analyzer for monitoring and trouble shooting

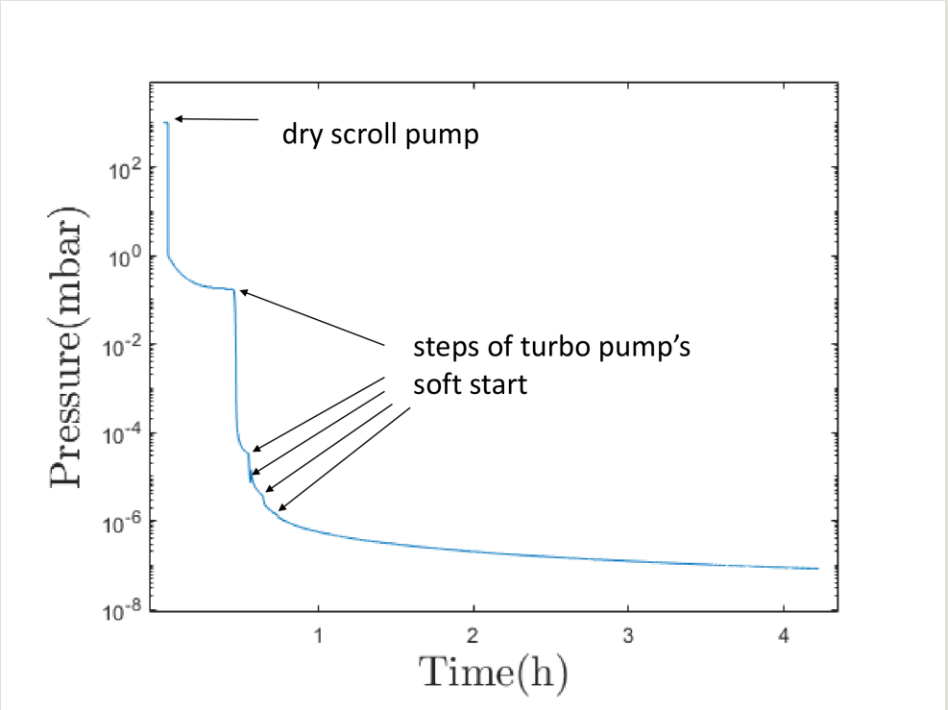
- Present at LP2N and LSBB

Spotlight on: turbo group

Single pumping group; ~900 L/s



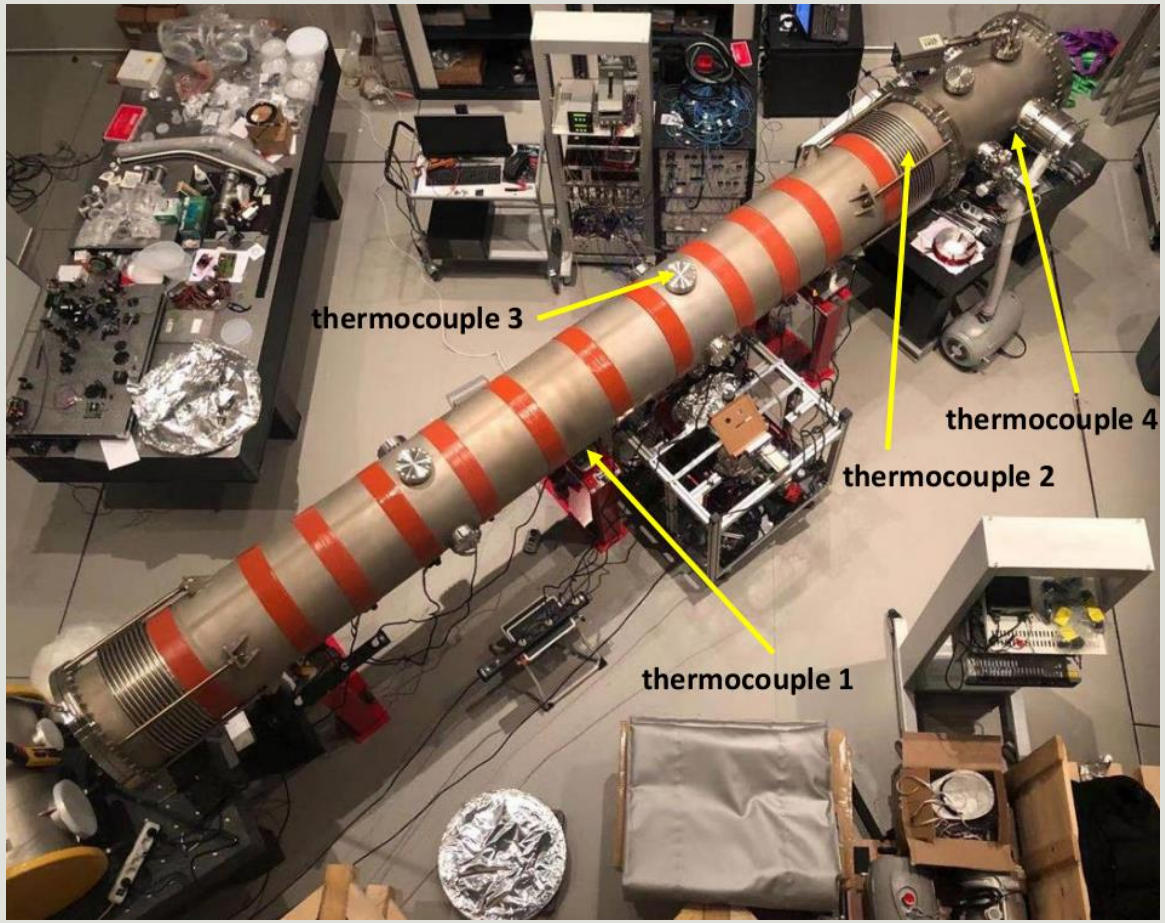
Analysis; typical pump cycle



Reaching target pressure; forced evolution by direct heating

- Colloquially known as "baking"

- Multiple, coupled, band heaters in conjunction with monitoring and fume removed

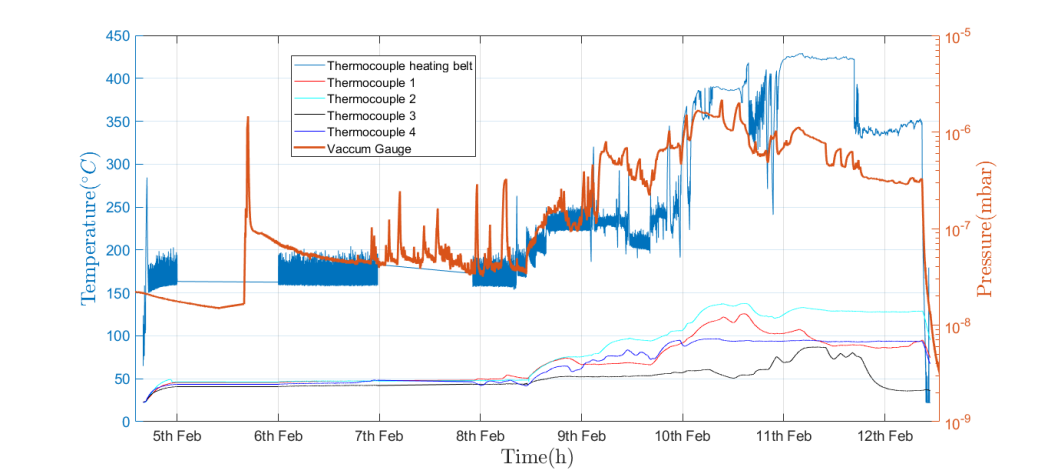


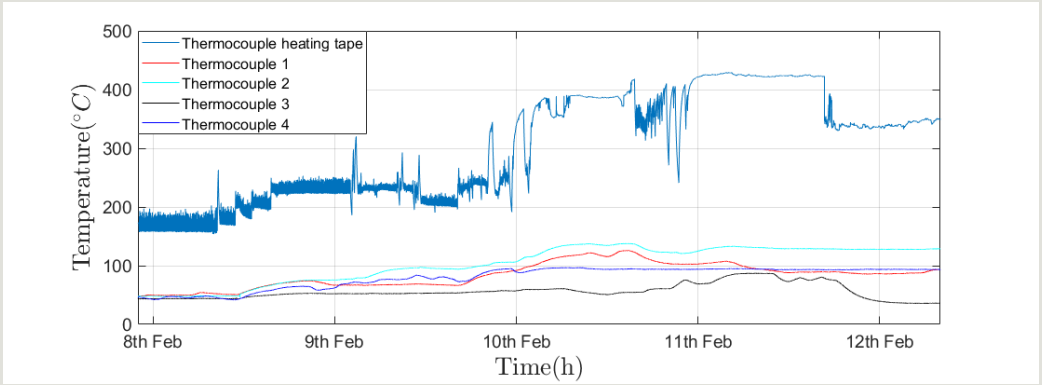
Temperature readings...

- Spurious readings in first two tests...

- Temperature readings exceed target by over a factor 2...

We perform lab tests for this reason...

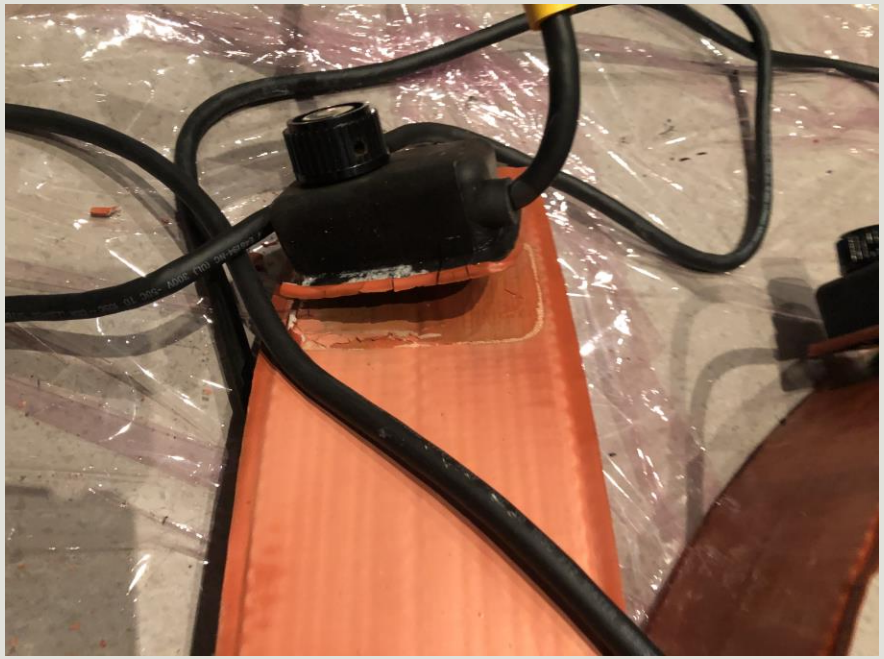




We reached 10^{-10} mbar in the tube (without internal optics or atom sources), despite the following...

Coupled Heating Bands – disastrous!

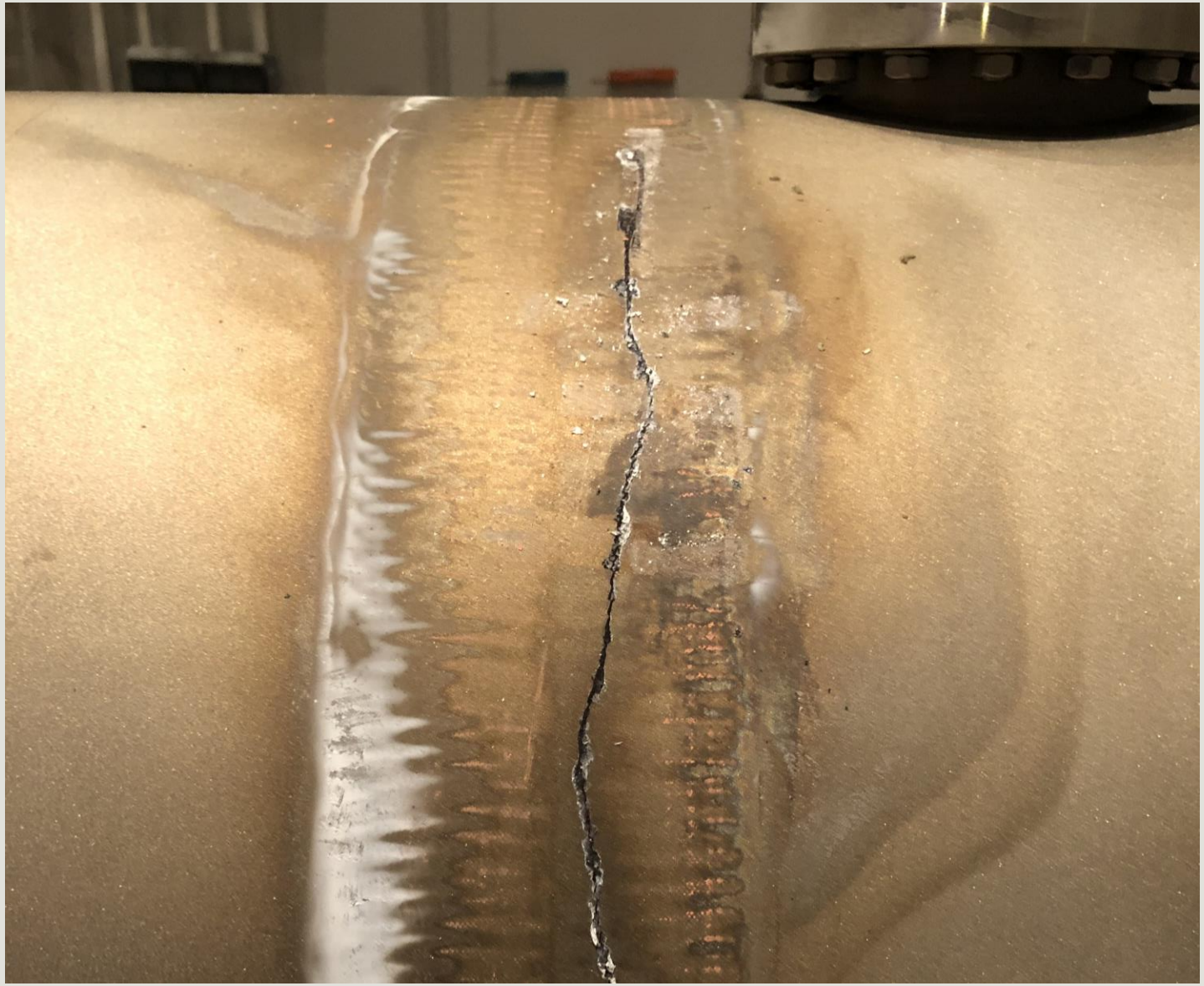
- Coupled bands with separate controllers and an 'empty' vessel led to failure



- We also fumigated the entire lab...

Surface damage from extreme heating and failure of bands

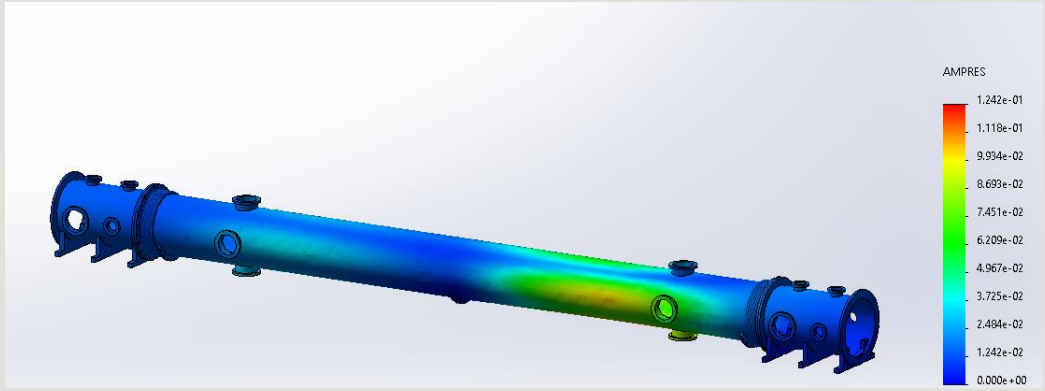
- Nothing a bit of acetone couldn't fix...

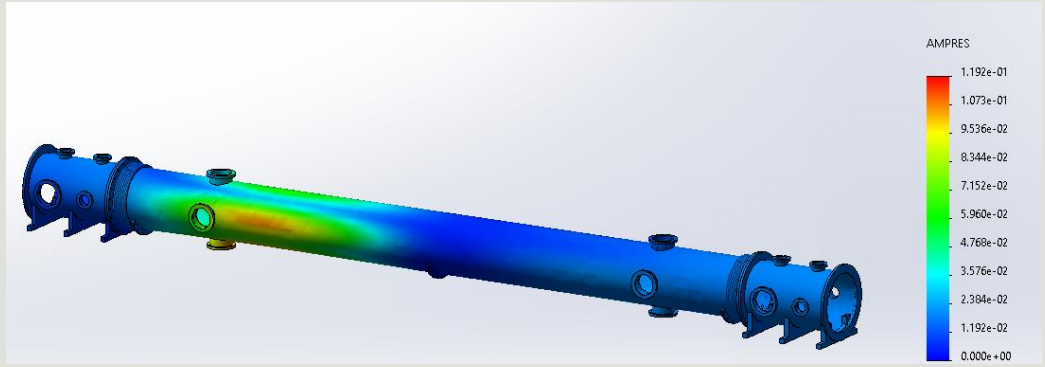


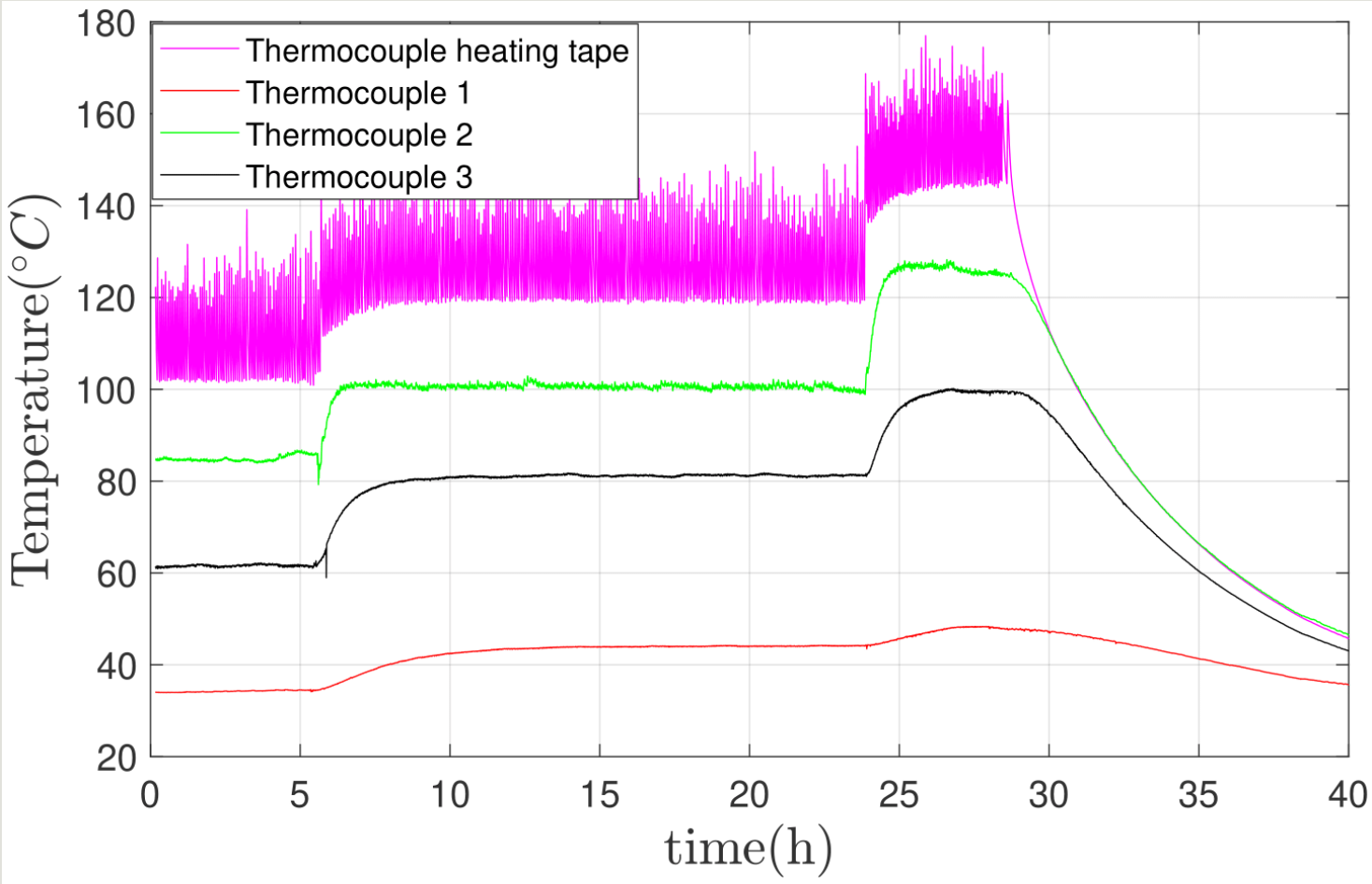
Tube Acoustics

Turbo fan spool up from DC to 650 Hz blows through some tube acoustical resonances around 180 – 200 Hz...

It is an abjectly terrifying sound, eliciting fear of turbopumps from 80s... ie explosions.

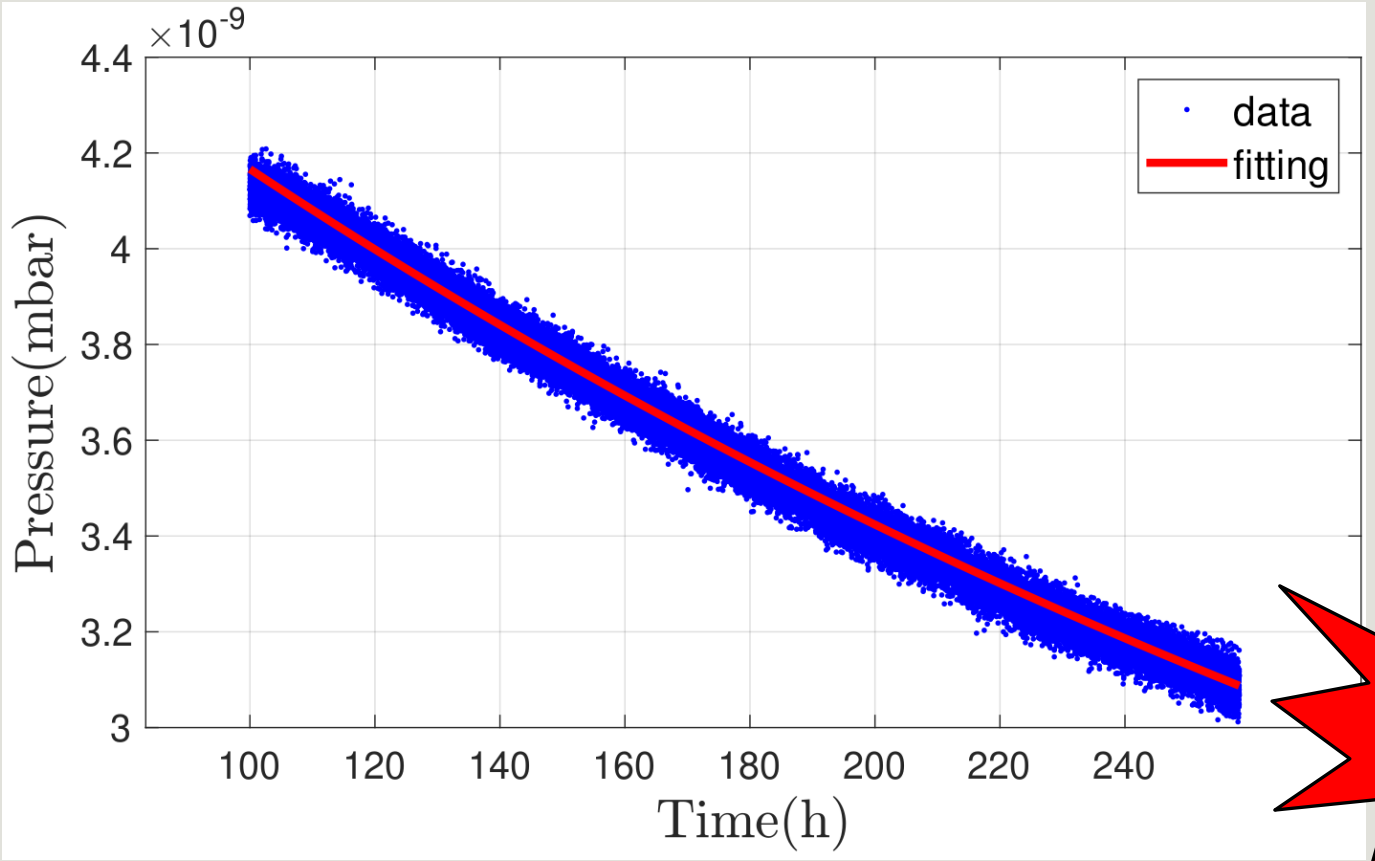






Successful heating test

No fumigation, spot failures, or screeching pumps...



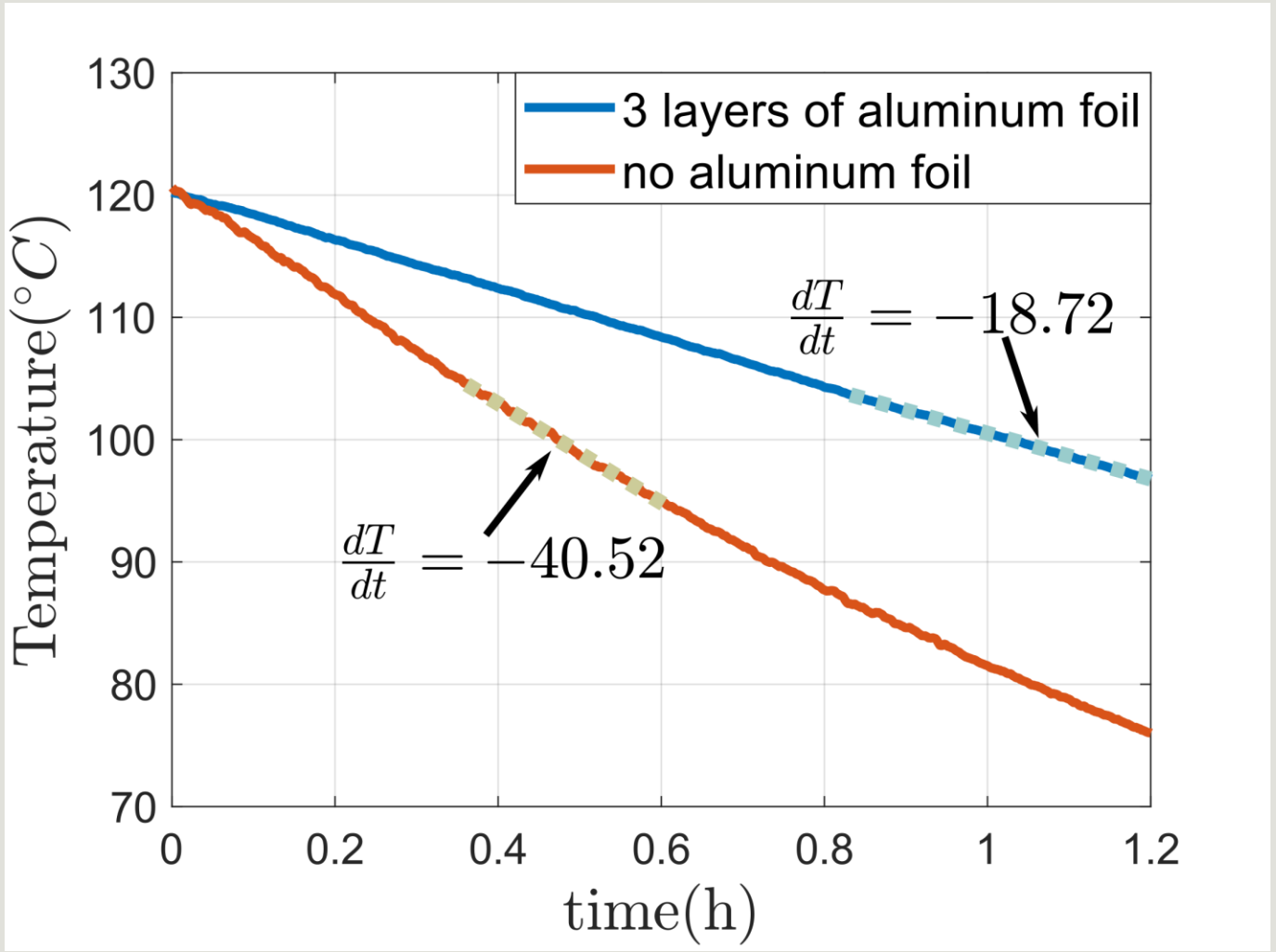
Sweet taste of Success?

Successful tests with all equipment and full installation of subsystems

We reach 2 X 10^{-9} mbar, with internal vacuum optics.

Using our allocated ~100 kW wisely…

- Tests involving layering thick aluminum foil proved instrumental in reaching our target temperature with modest power requirements.



Moving forward with MIGA @ LSBB

10 M TO 150 M SCALABILITY

Installation and alignment work ongoing

Through the summer and autumn 2022, trials and commissioning to commence from now through winter 2022.

Up next: tourelle installation and first vacuum trial @ LSBB

Moving forward with MIGA @ LSBB

To do list, starting Summer 2022:

- Moving pump groups and gauge annexes to LSBB
- Vacuum tests by section, checking worthiness of seals and tube
- Measuring water ingress on tube inner surfaces via RGA
- Installation of heating bands and foil layers, heating tests, power dissipation measurements

Thank you for your attention!