ETpathfinder Overview and Status

Jan-Simon Hennig for the ETpathfinder Team

Interreg
EUROPESE UNIE
Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

GWADW 2021, May 17th 2021

Nikhef

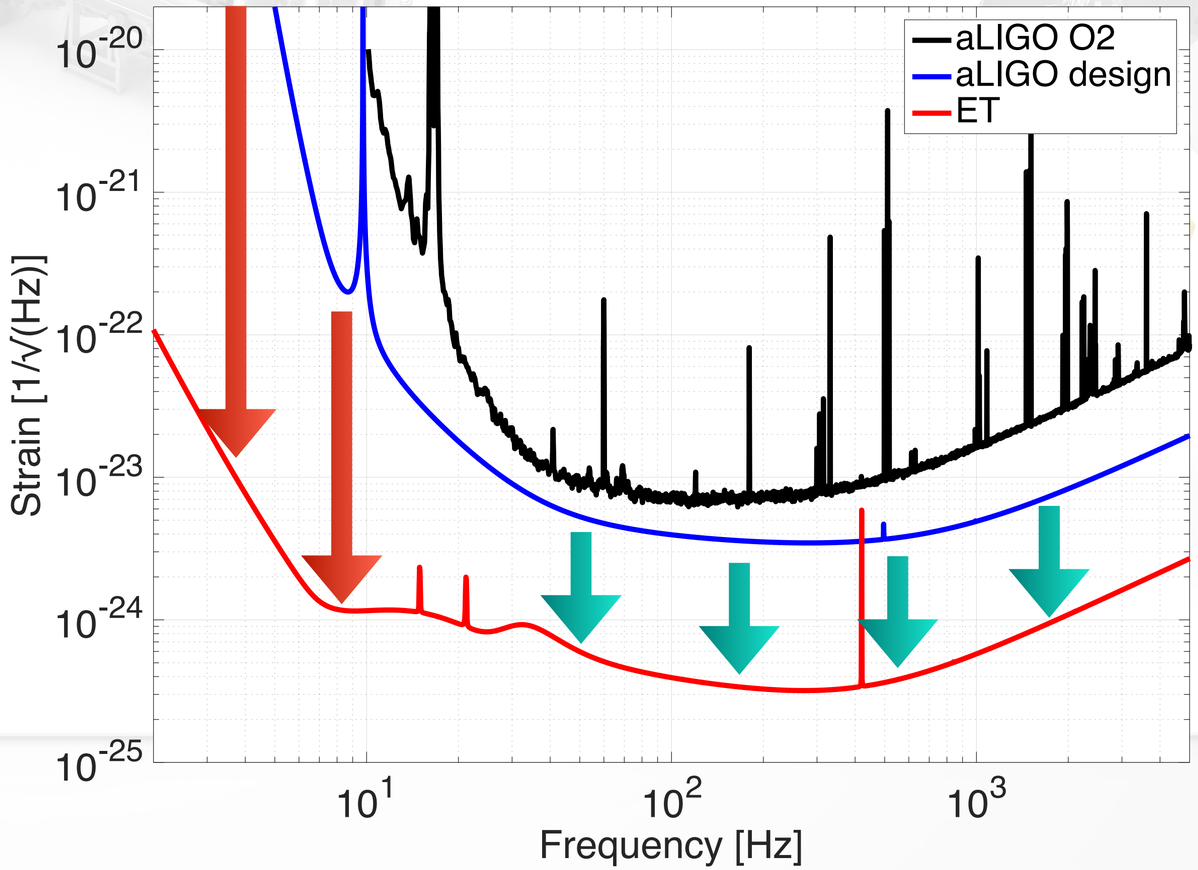
Maastricht University

https://www.nikhef.nl/pub/departments/mt/projects/ETpathfinder/Design/#ETPF_Render5.jpg

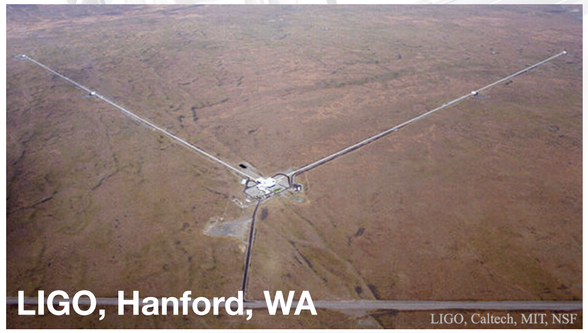
Challenges for 3G Detectors

On the example of ET

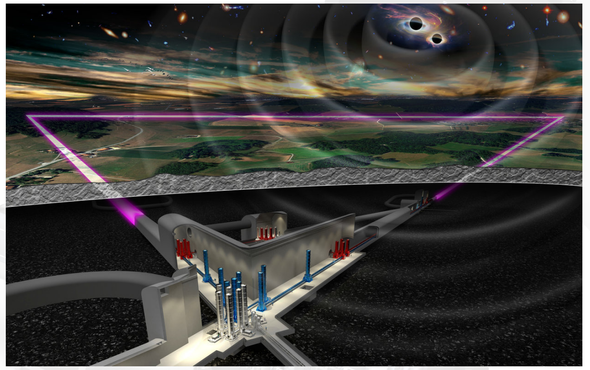
- At mid and high frequencies we aim for a sensitivity improvement by a factor of ~10
- However, at low frequencies, we are looking at a factor of 100 to 1000 and even more
  - This poses a huge challenge
- For this to work we need to do fundamental changes in detector design and there is a need to test, engineer, demonstrate and optimise these changes



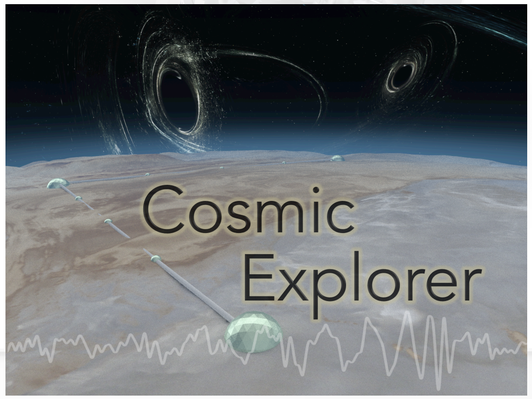
From 2G to 3G Detectors



Current GW detectors aLIGO, aVirgo	3rd Gen. detectors ET, CE2
300K	10K / 20K / 120K
Fused silica	Silicon
1064nm	1550nm / ~2100nm
“Cheat” Heisenberg @ 1064nm	Can we do the same @ 1550nm, ~2100nm?

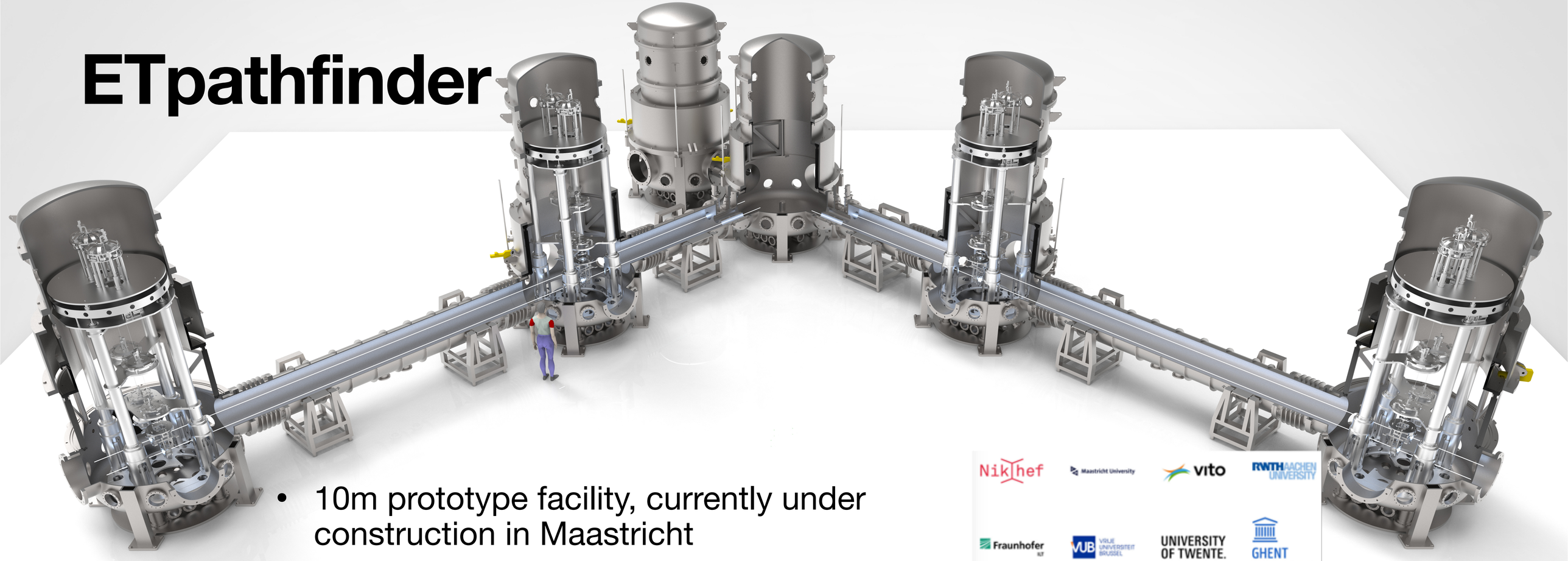


Artist's impression of the Einstein Telescope. © NIKHEF



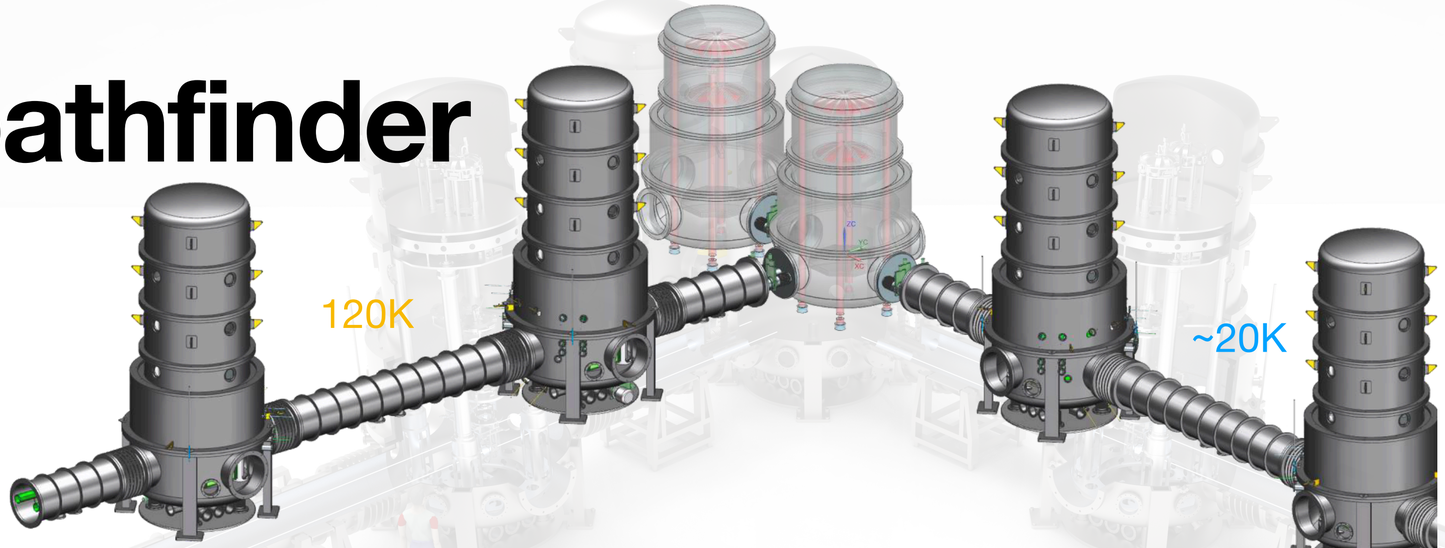
This is where ETpathfinder will be able to help…

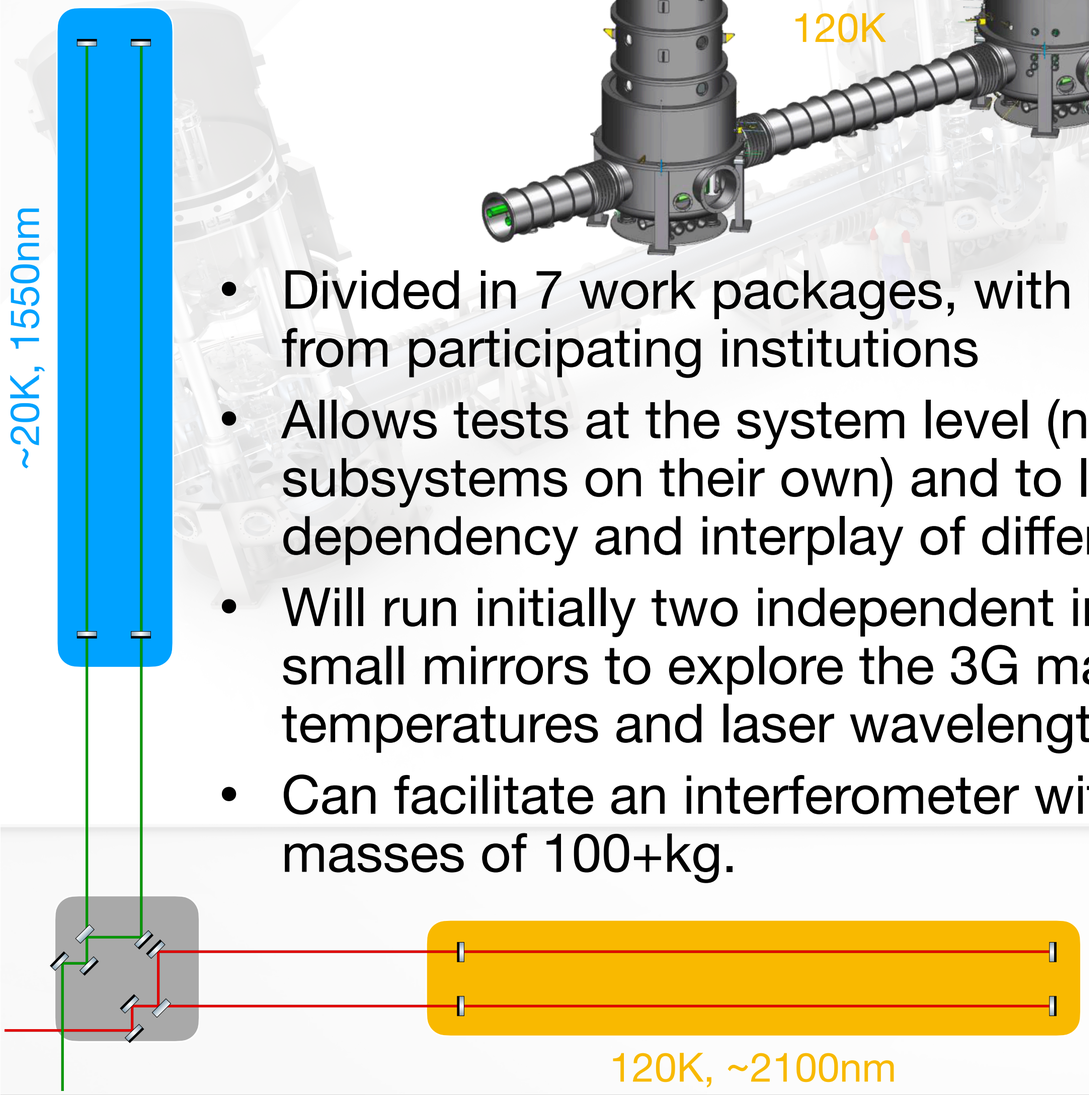
ETpathfinder



- 10m prototype facility, currently under construction in Maastricht
- 14.5M€ investment
- ~20 universities and research institutes from NL/BE/DE/F contribute

ETpathfinder





- Divided in 7 work packages, with leaders and deputies from participating institutions
- Allows tests at the system level (not just individual subsystems on their own) and to learn about dependency and interplay of different subsystems.
- Will run initially two independent interferometers with small mirrors to explore the 3G matrix of cryogenic temperatures and laser wavelengths.
- Can facilitate an interferometer with 4 cryogenic test masses of 100+kg.

Workpackages

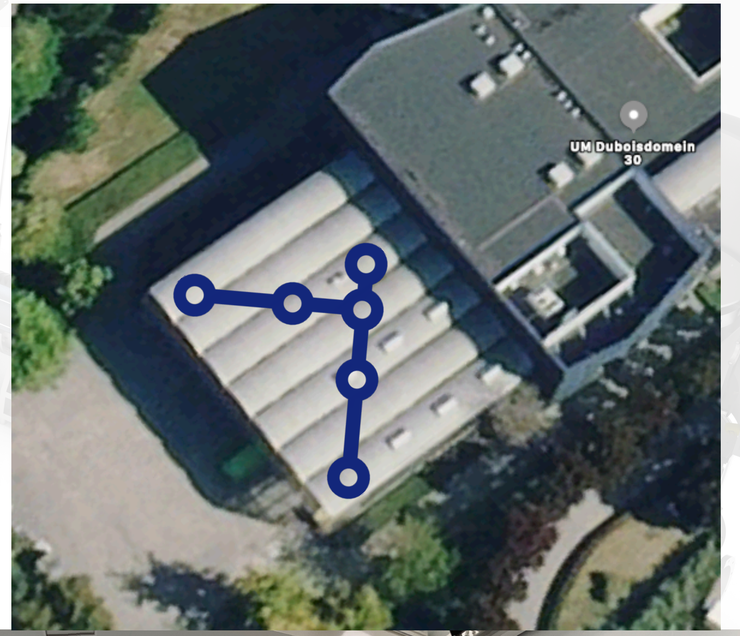
WP1: Organisation
Lead: Stefan Hild (Maastricht)
Deputy: Frank Linde (Nikhef) & Nick van Remortel (Antwerp)

Project Office + System Engineering
Margot Hennig, Jan-Simon Hennig (both Maastricht)

WP2: Communication Lead: Mariette Wennekers (Maastricht) Deputy: Martine Oudenhoven (Nikhef)	**WP5: Seismic Isolation** Lead: Alessandro Bertollini (Nikhef) Deputy: Joris van Heijningen (Louvain)
WP3: Cleanroom Lead: Paul Kuijer (Nikhef) Deputy: Marieke Hopman (Nikhef)	**WP6: Optics** Lead: Jean Pierre Locquet (Leuven) Deputy: Sebastian Steinlechner (Maastricht)
WP4: Vacuum and Cryogenics Lead: Henk-Jan Bulten (Nikhef) Deputy: Dirk Ryckbosch (Gent)	**WP7: Controls** Lead: Bas Swinkels (Nikhef) Deputy: Wim Beaumont (Antwerp)

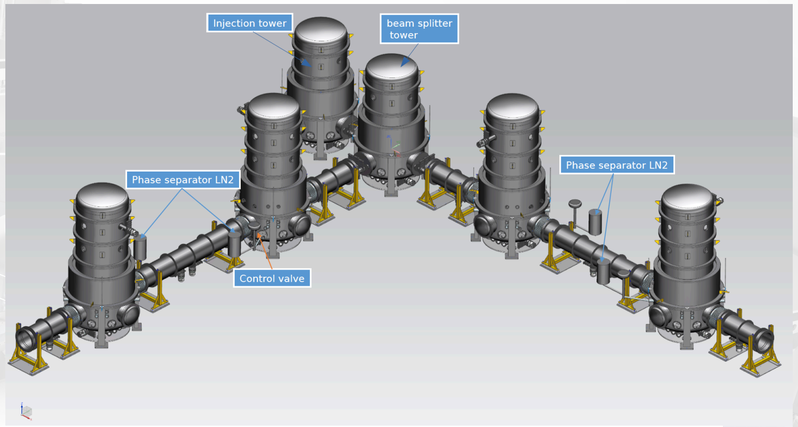
Infrastructure Preparations

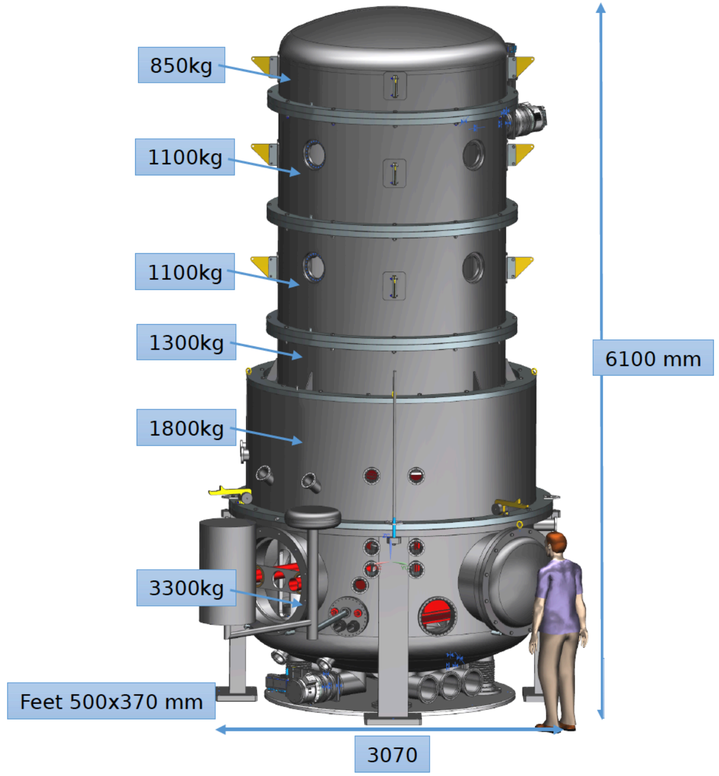
- The facility will be available mid-May 2021 (in the next days):
  - About 22m by 34m total area, 8 m high
  - Separate floor foundations for interferometer and noisy equipment
  - ISO 8 HVAC
  - 2x 2t crane
  - Separate 8m by 8m space for cleaning and preparation
  - Visitor area



Vacuum System

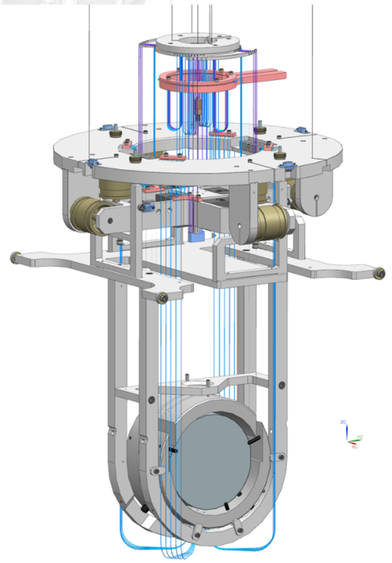
- 6 towers (4 mirror towers and 2 table towers)
- 80cm tubes, 20m arm length
- Total volume about 130m^3
- Target pressure 10^{-9}mbar
- First parts are made; pumping tests at company planned in June/July
- First tower to be delivered early August
- Aiming for fast and easy access





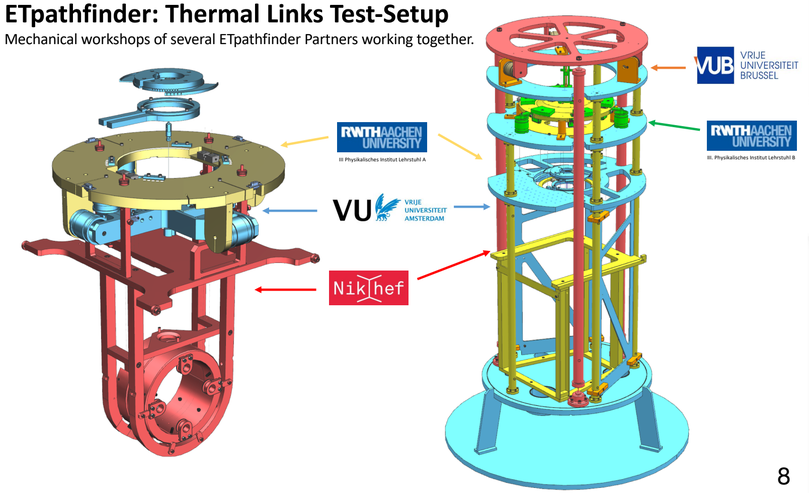
Cryogenic Mirror Suspensions

- Suppression of seismic noise in the detection band via multistage pendulum isolation
  - Inverted-pendulum legs
  - Geometric anti-spring filters
- Conflicting goals & key challenge:
  - Keep mirror as isolated as possible from environment from noise perspective
  - Connect mirror to heat sink (cold finger) for cryogenic cooling
- Cooling via many jellyfish wires running from cold finger to bottom of suspension chain and the mirror
- Low-noise steering of mirrors with coil-magnet actuators



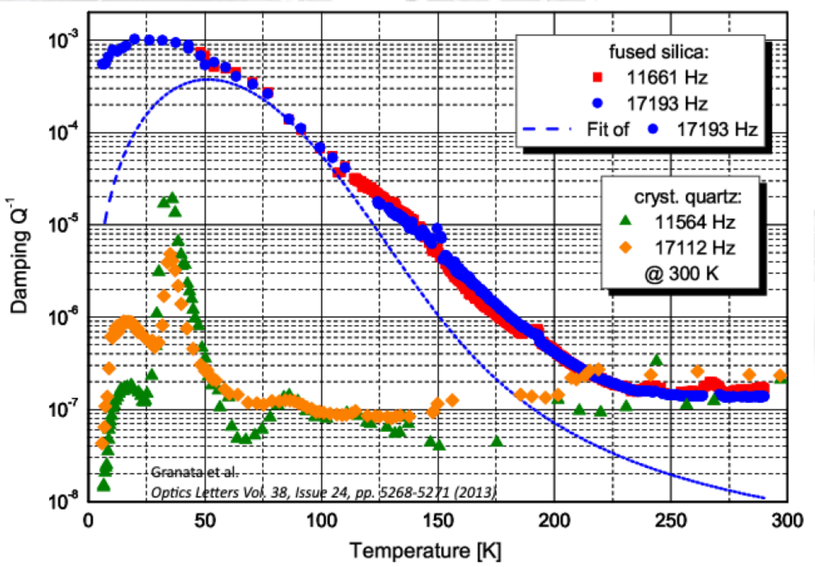
ETpathfinder: Thermal Links Test-Setup

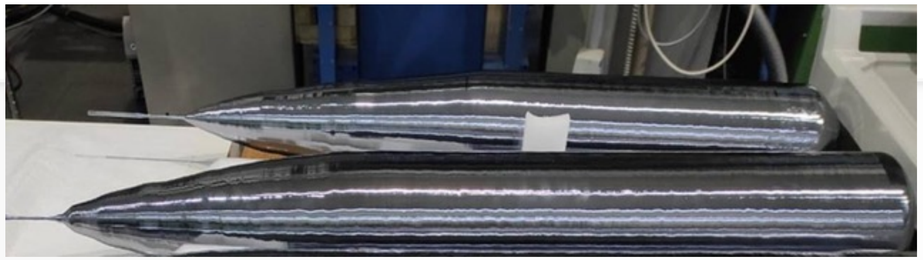
Mechanical workshops of several ETpathfinder Partners working together.

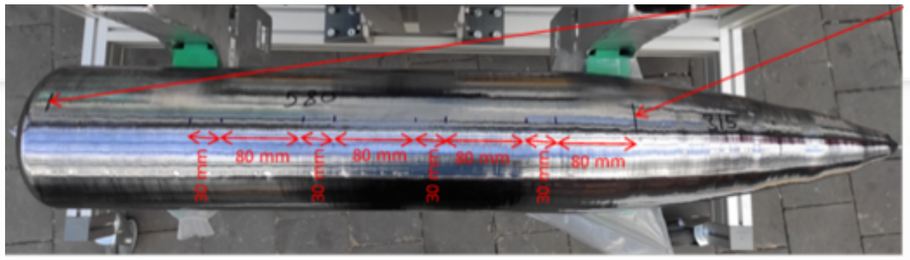


Silicon Optics

- Due to the high mechanical loss at low temperatures, need to move to silicon as mirror material
- Optical absorption in silicon is a challenge, need for high resistivity
- Received moderate resistivity silicon ingots that are now cut into mirror “blanks”
- Surface specifications in final steps before polishing and coating of mirrors







Summary

- ETpathfinder is a technology development and integration platform for the next-generation(s) of gravitational wave detectors
- As such ETpathfinder will provide a low-phase noise, easy access, fast turn-around interferometer testbed
- Good progress on all fronts; infrastructure will be handed over very soon
- Everybody is welcome to join the ETpathfinder team, please get in touch!
- For more information check out the ETpathfinder Design Report (ET-0011A-20)