ETpathfinder
Overview and Status
Jan-Simon Hennig for the ETpathfinder Team
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Challenges for 3G Detectors

On the example of ET

- At mid and high frequencies we aim for a sensitivity improvement by a factor of \( \sim 10 \)
- 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

300K
Fused silica
1064nm
“Cheat” Heisenberg @ 1064nm

3rd Gen. detectors
ET, CE2

10K / 20K / 120K
Silicon
1550nm / ~2100nm
Can we do the same @ 1550nm, ~2100nm?

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)

**WP3: Cleanroom**
Lead: Paul Kuijer (Nikhef)
Deputy: Marieke Hopman (Nikhef)

**WP4: Vacuum and Cryogenics**
Lead: Henk-Jan Bulten (Nikhef)
Deputy: Dirk Ryckbosch (Gent)

**WP5: Seismic Isolation**
Lead: Alessandro Bertolini (Nikhef)
Deputy: Joris van Heijningen (Louvain)

**WP6: Optics**
Lead: Jean Pierre Loquet (Leuven)
Deputy: Sebastian Steinlechner (Maastricht)

**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 130m³
- 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
**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)