Maastricht 3G Prototype (aka ETpathfinder*)

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* Working title of the project so far and used in the corresponding funding applications.

** Wavefunction of team not yet collapsed. If you want to contribute please get in contact!
Prototypes: Past and Presence

- Prototype interferometers have been vital to develop GW detectors over the past decades.
- Garching 30m, Glasgow 10m, Caltech 40m, MIT, Gingin, Stanford, CLIO, AEI...

• Why building yet another one?
What R&D is needed for ET?

Let’s start from the ET-D top-level design parameters.

Which parameters we have already achieved?

Which ones might be easiest tested in Advanced + detectors?
What R&D is needed for ET?

- Aspects that are better tested at A+ detectors or are not accessible to a prototype.
- Aspects could be tested in prototype but might be easier tested elsewhere.
- Cryogenic, Silicon optics at 1550nm are key technologies that need testing at scale for ET.

=> Main aim of Maastricht Prototype Interferometer
Main idea

- Starting of with a cryogenic payload volume of about 1x1x2m.
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• Then if you want to test low phase noise performance you need 4 of these cryogenic payload volumes.
• 4 ITM/ETM tanks (2.8m diameter, 6.5m height)
• 2 ‘warm’ tanks with suspended benches for BS, input and output optics + fancy QND in long run
• Total armlength about 20m, but due to heat shields in front of ITMs and behind ETMs the cavity length will only be 9.34m.
• Tube diameter 80cm (but heat shields will have much smaller clear aperture)
• System designed to be able to test silicon mirrors of 100kg or more at 10K in the long run.

• For scale this 45cm by 22.5cm (~82kg).

• Problem: could we buy silicon mirrors of such dimensions and with the right properties right now? – probably not yet ...
In the initial phase (Phase 1) we will hang 2 small mirrors in each cryostat.

- Small mirrors = 15cm diameter and 3kg.
- That way we can operate 2 independent FPMI interferometers with a total of 8 cryogenic test masses.
Footprint – Phase 1

• Can arrange these 2 interferometers as 2 ‘L’.

• However if we use each arm of the vacuum system for one interferometer we can operate the two arms and hence interferometers at **different temperatures**: one at 120K and one at 10K.

• In principle this also allows to run the two interferometers at **different wavelength**: one at 1550nm and one more towards 2um.

• **Potentially allows to explore test the full matrix of temperatures and wavelengths currently discussed.**

• For example on could operate one interferometer as in ET-D-LF config (10K, 1550nm, low power) and one in Voyager/CE config (120K, 2um, high power).
Science Goals

- Low phase noise interferometry with cryogenic silicon mirrors of up to ~100kg;
- Providing a flexible testbed to explore the full matrix of cryogenic temperatures and laser wavelength;
- Investigating the interplay of thermal noise, quantum noise and control noises in the sub 10Hz region;
- Various tests of cryogenic plants (liquids vs cryo-coolers; stable control of mirror temperature; contamination handling of mirror surfaces; low power actuators etc)
- Loads of other interesting topics (Thermal compensation; adaptive modematching; Parameteric Instabilities; etc)
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What would you like seen being test or investigated in this prototype? --- Please let us know!
## Partners & Funding

1. **Nikhef**
2. **Maastricht University**
3. **Technische Universiteit Eindhoven**
4. **University of Leuven**
5. **Ghent University**
6. **University of Antwerp**
7. **University of Hasselt**
8. **University of Liege**
9. **Vrije Universiteit Brussel**
10. **Fraunhofer Institute for Laser Technology (ILT)**
11. **Rheinisch-Westfälische Technische Hochschule (RWTH, Aachen)**
12. **University of Twente**
13. **Flemish Institute for Technological Research (VITO), Mol**
14. **Netherlands Organisation for Applied Scientific Research (TNO), Delft**

**Location:** Maastricht

- Maastricht University to become a Nikhef member and starting new GW instrumentation group
- 14.5 MEuro capital investment (Interreg, Institutions, Governments & Provinces)
- Committed manpower of 100+ man years (staff scientists and engineers) over the next 5 years

Also input from Glasgow, AEI, Perugia...

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S.Hild  
KAGRA-VIRGO 3G, Perugia 2019  
Slide 13
Current State
Seismic Isolation

1150[mm]
20[kg] D520[mm]
1030[mm]
20[kg] D520[mm]
1030[mm]
+/-10[kg] D400[mm]
In work Diameter smaller!

Fishing Rod
Wire Rotator

KAGRA-VIRGO 3G, Perugia 2019
Cooling the Testmasses

- 4.2k cooling
- Filter with flat copper beryllium blades
- 2 adjustable masses, 2 motorized masses
- Recoil mass
- Marionette
- 2 adjustable masses, 2 motorized masses
- Recoil mass
- Coils
Next steps

• Weekly ETpathfinder call since Nov 2018
• Continue design effort and expand to remaining subsystems. Build up noise budget.
• Define exact science targets for Phase 1 (first 3-5 years)
• Official project start: June 2019
• Establish Strategic Advisory Board
• In parallel start planning for Phase 2 (~100kg testmasses)

Opportunity bigger than what current partners can do on their own.

We welcome any kind of contribution (ideas, collaboration, contribution to subsystems, exchange of expertise + skills) from within the ET collaboration, KAGRA, LSC and beyond.

We try where ever possible to adopt a ‘platform’ design strategy, so that it will be possible to integrate test the community or individual groups/institutions are interested to carry out in ETpathfinder.

You are welcome to join and contribute. Please do not hesitate if you have spare bandwidth!
We all hope there will be many generations of detectors being operated in the ET infrastructure over the next ~40 years. Our ambition for Maastricht Prototype is to serve over the next decade(s) as one of testbeds for developing and qualifying many ET technologies on a systems level.

Thank you for your attention!