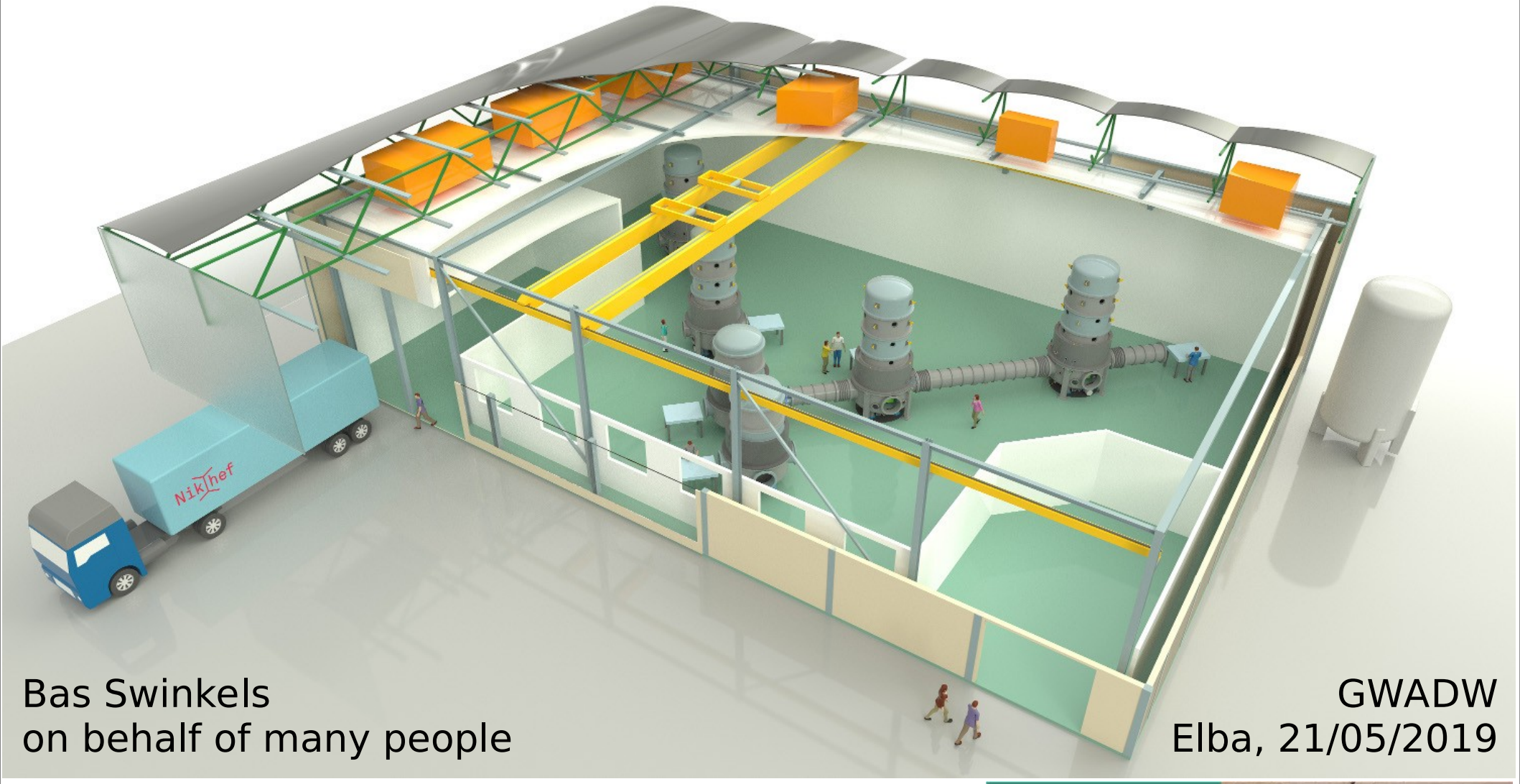
ET Pathfinder in Maastricht



Bas Swinkels
on behalf of many people

GWADW
Elba, 21/05/2019

Nikhef

ET EINSTEIN TELESCOPE

R&D needed for ET

Table 1. Summary of the most important parameters of the ET-D high- and low-frequency interferometers as shown in figure 5. SA = superattenuator, freq. dep. squeez. = squeezing with frequency-dependent angle.

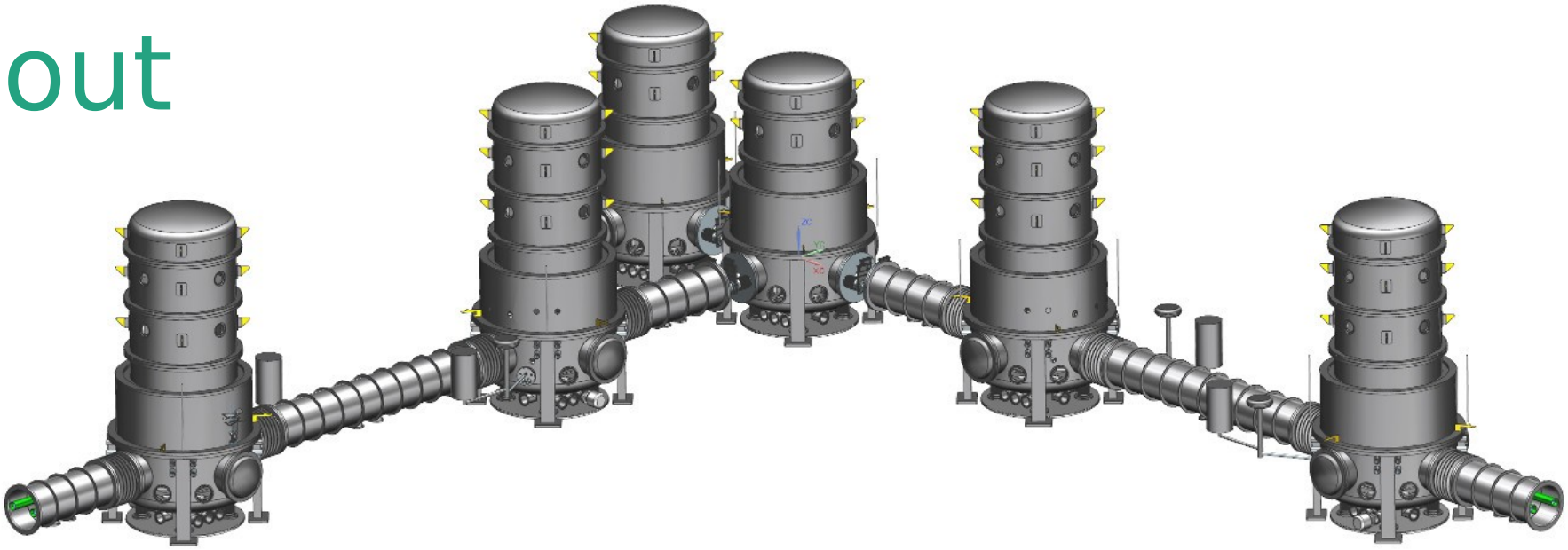
Parameter	ET-D-HF	ET-D-LF
Arm length	10 km	10 km
Input power (after IMC)	500 W	3 W
Arm power	3 MW	18 kW
Temperature	290 K	10 K
Mirror material	Fused silica	Silicon
Mirror diameter/thickness	62 cm/30 cm	min 45 cm/TBD
Mirror masses	200 kg	211 kg
Laser wavelength	1064 nm	1550 nm
SR-phase	tuned (0.0)	detuned (0.6)
SR transmittance	10%	20%
Quantum-noise suppression	freq. dep. squeez.	freq. dep. squeez.
Filter cavities	1×10 km	2×10 km
Squeezing level	10 dB (effective)	10 dB (effective)
Beam shape	LG_{33}	TEM_{00}
Beam radius	7.25 cm	9 cm
Scatter loss per surface	37.5 ppm	37.5 ppm
Partial pressurefor H_2O, H_2, N_2	10^{-8}, 5×10^{-8}, 10^{-9} Pa	10^{-8}, 5×10^{-8}, 10^{-9} Pa
Seismic isolation	SA, 8 m tall	mod SA, 17 m tall
Seismic (for $f > 1$ Hz)	$5 \times 10^{-10}\,\mathrm{m}/f^2$	$5 \times 10^{-10}\,\mathrm{m}/f^2$
Gravity-gradient subtraction	none	none

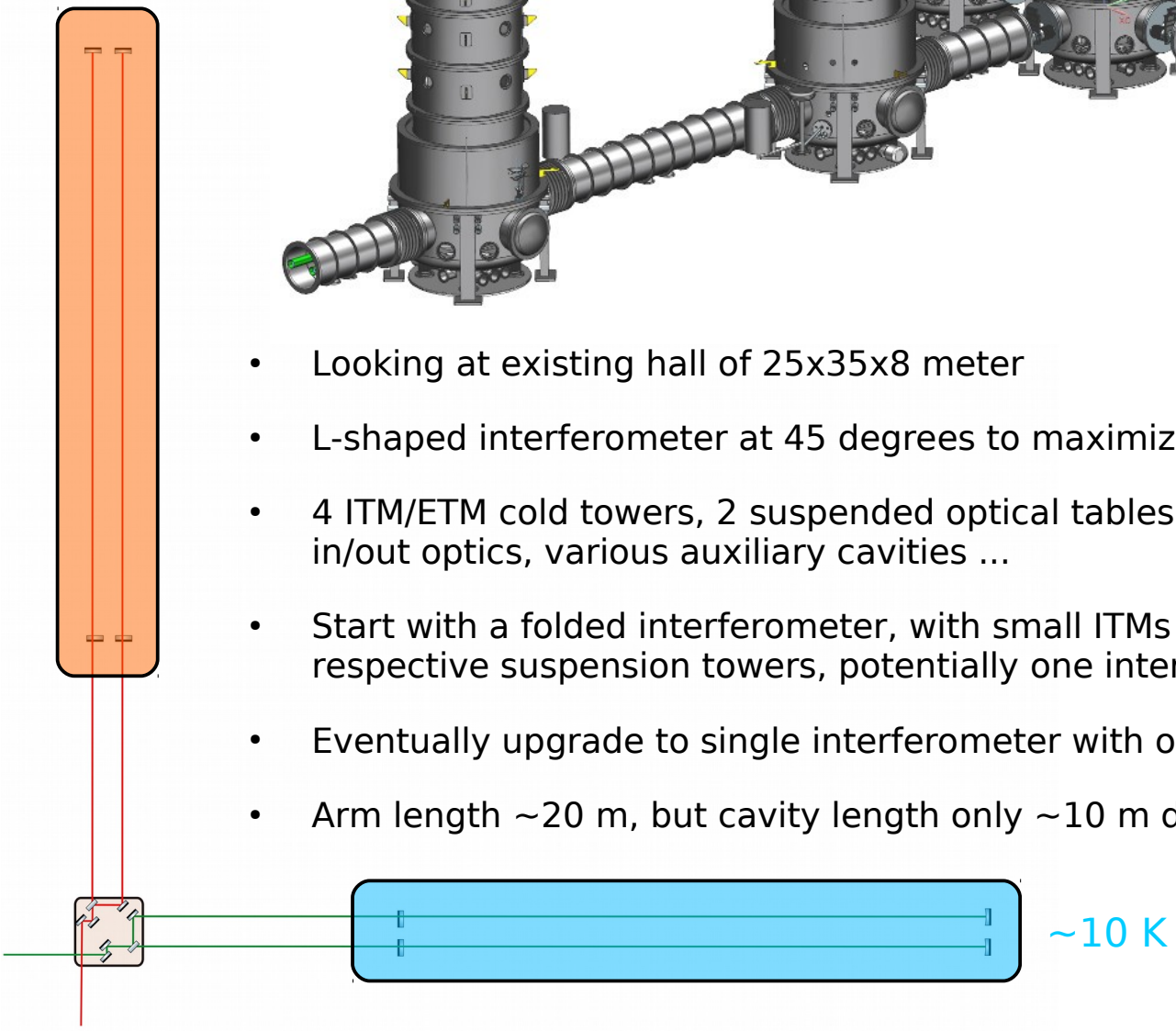
- Many existing prototypes already, but none targeted at core ET technology
- Aspects that are better tested at A+ detectors or are not accessible to a prototype.
- Aspects could be tested in prototype but might be easier tested elsewhere
- Cryogenic, Silicon optics at 1550nm are key technologies that need testing at scale for ET:
  Main aim of Maastricht Prototype

Design ideas

- Aim far large (half-size?) cryogenic mirrors
- Allow for suspended cold payloads of ~2x1x1 m in size
- Need at least 4 mirrors to test low-noise operation
- Try to stay as flexible as possible, to allow for 10+ years of tests and upgrades

Layout



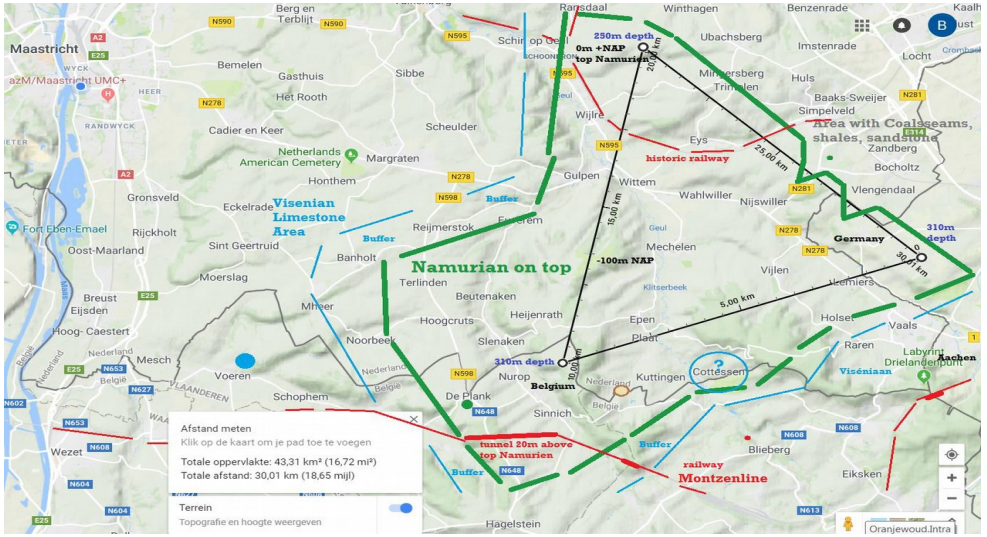


- Looking at existing hall of 25x35x8 meter
- L-shaped interferometer at 45 degrees to maximize use of space
- 4 ITM/ETM cold towers, 2 suspended optical tables at room temperature for beam-splitter, in/out optics, various auxiliary cavities ...
- Start with a folded interferometer, with small ITMs and ETMs mounted side-by-side in the respective suspension towers, potentially one interferometer at 120 K, one at 10 K
- Eventually upgrade to single interferometer with one large mirror per suspension
- Arm length ~20 m, but cavity length only ~10 m due to heat shields

Science goals

- Low phase noise interferometry with cryogenic silicon mirrors of up to ~100kg
- Providing a flexible testbed to explore various combinations 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 issues (liquids vs cryo-coolers; stable control of mirror temperature; contamination handling of mirror surfaces; low power actuators ...)
- Testbed for new control techniques and sensors

Why in Maastricht?

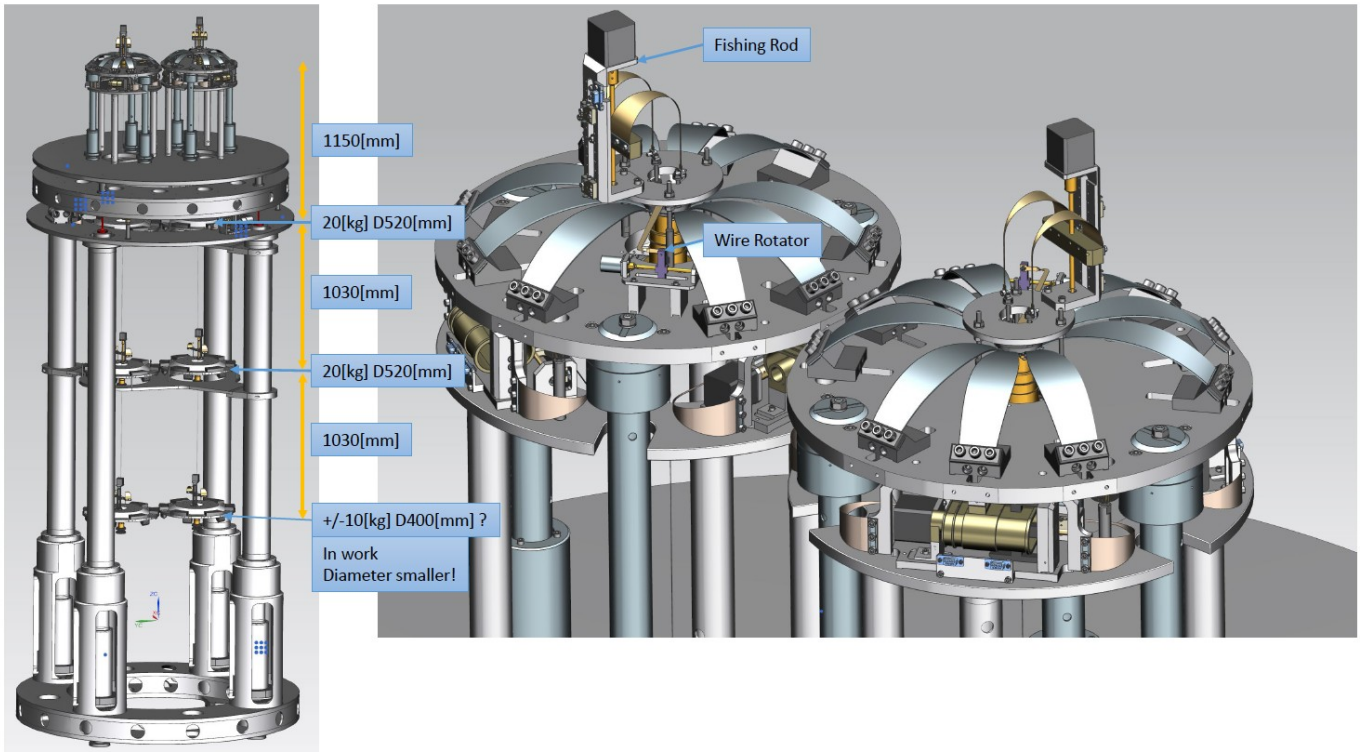


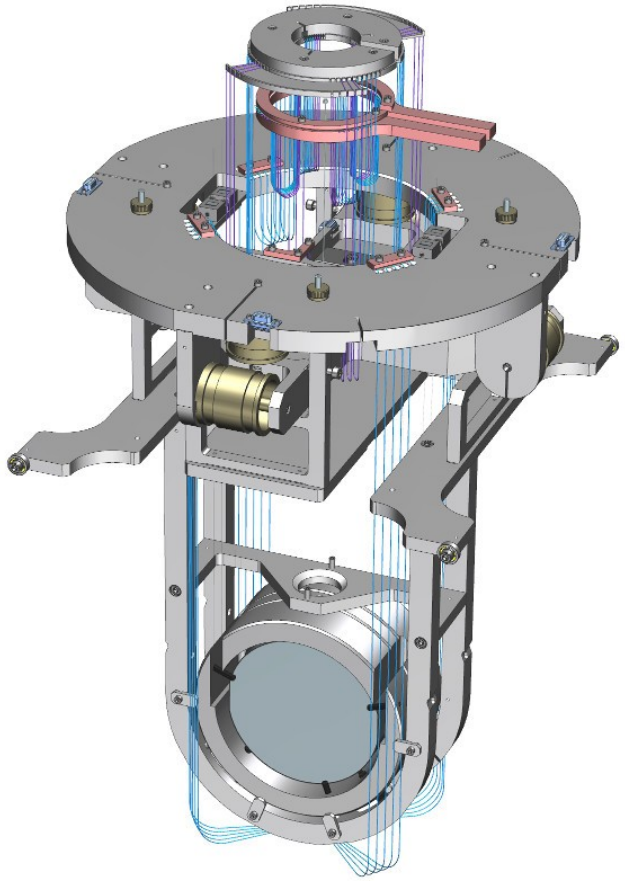
- Aachen-Liege-Maastricht area is one of the candidate sites for hosting ET
- Want to strengthen collaboration and GW knowledge in the region
- Opportunities for local and regional funding
- New GW group at Maastricht University:
  S. Hild, J. Steinlechner, S. Danilishin, S. Steinlechner, G. Koekoek

Funding & partners

- Obtained ~14.5 MEuro funding from unconventional sources:
  - InterReg Flanders-South of NL (European fund for cross-border development)
  - Province of Limburg (NL), Dutch and Belgian national ministries
  - Matched contribution by partners
- Partners: Nikhef, universities of Antwerpen, Eindhoven, Ghent, Hasselt, Leuven, Maastrich
- Satellite partners: Aachen, Brussels, Fraunhofer, Liège, Louvain la Neuve, Twente, TNO
- Additional input from Glasgow, AEI, Perugia ...
- 100+ person-years (staff scientists and engineers) committed over the next 5 years
- New collaborators are welcome

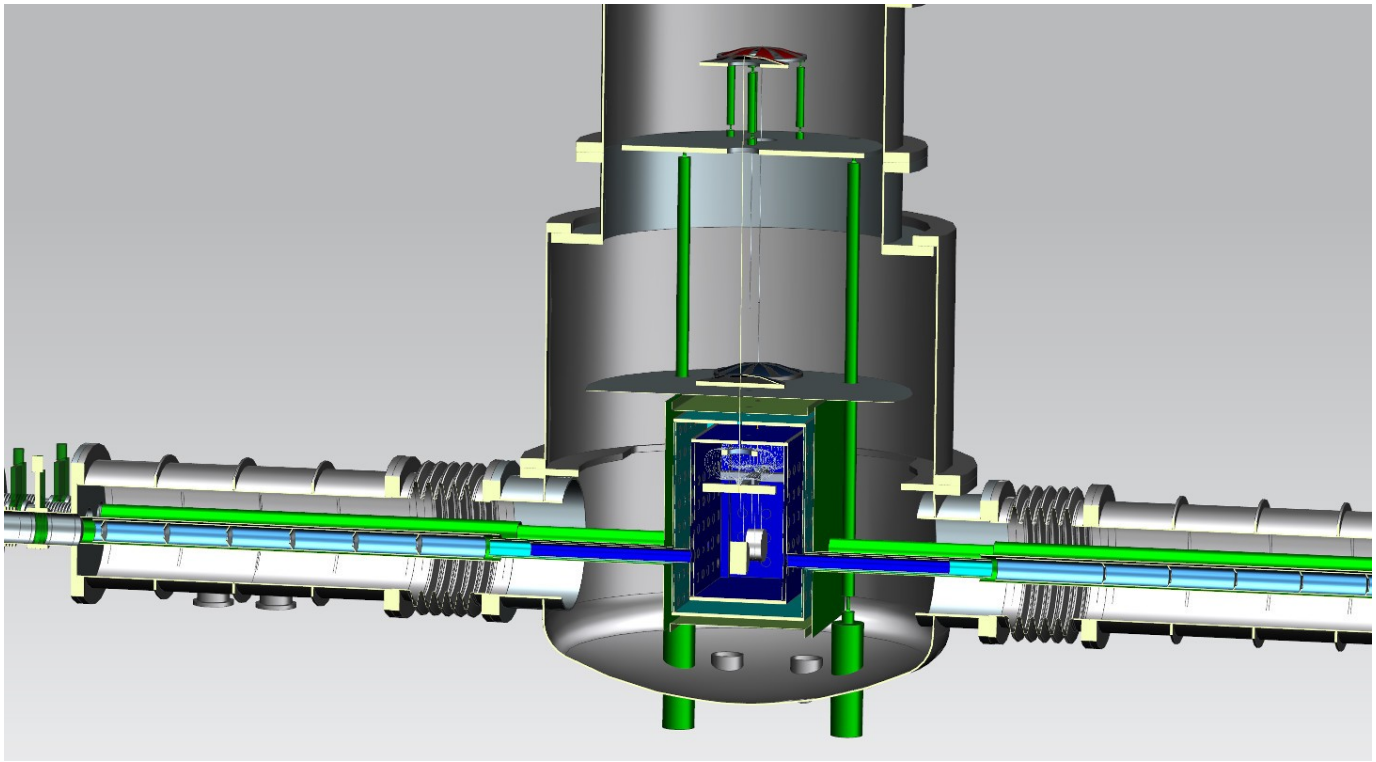
Suspensions

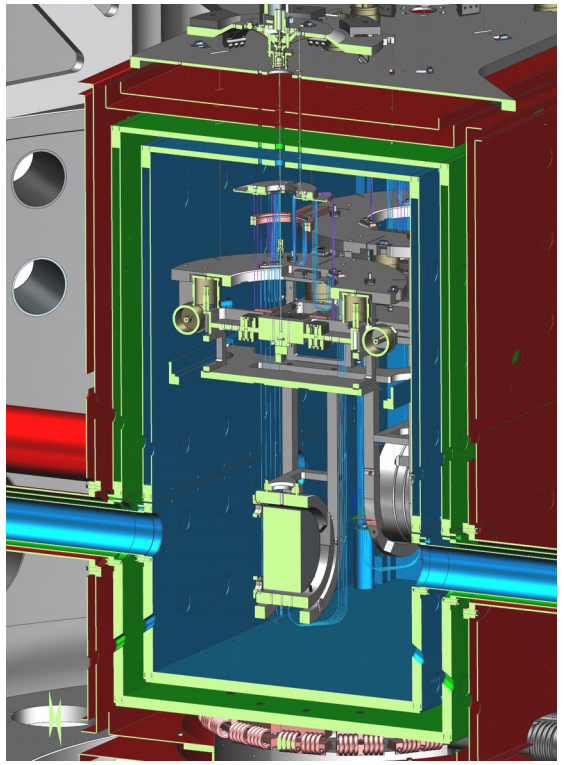




- Scaled up design of Multi-SAS suspended benches used at Virgo
- Suspend 2 mirror payloads on single inverted pendulum in phase 1
- Upgrade to one heavy suspension per inverted pendulum in phase 2

Cryogenics

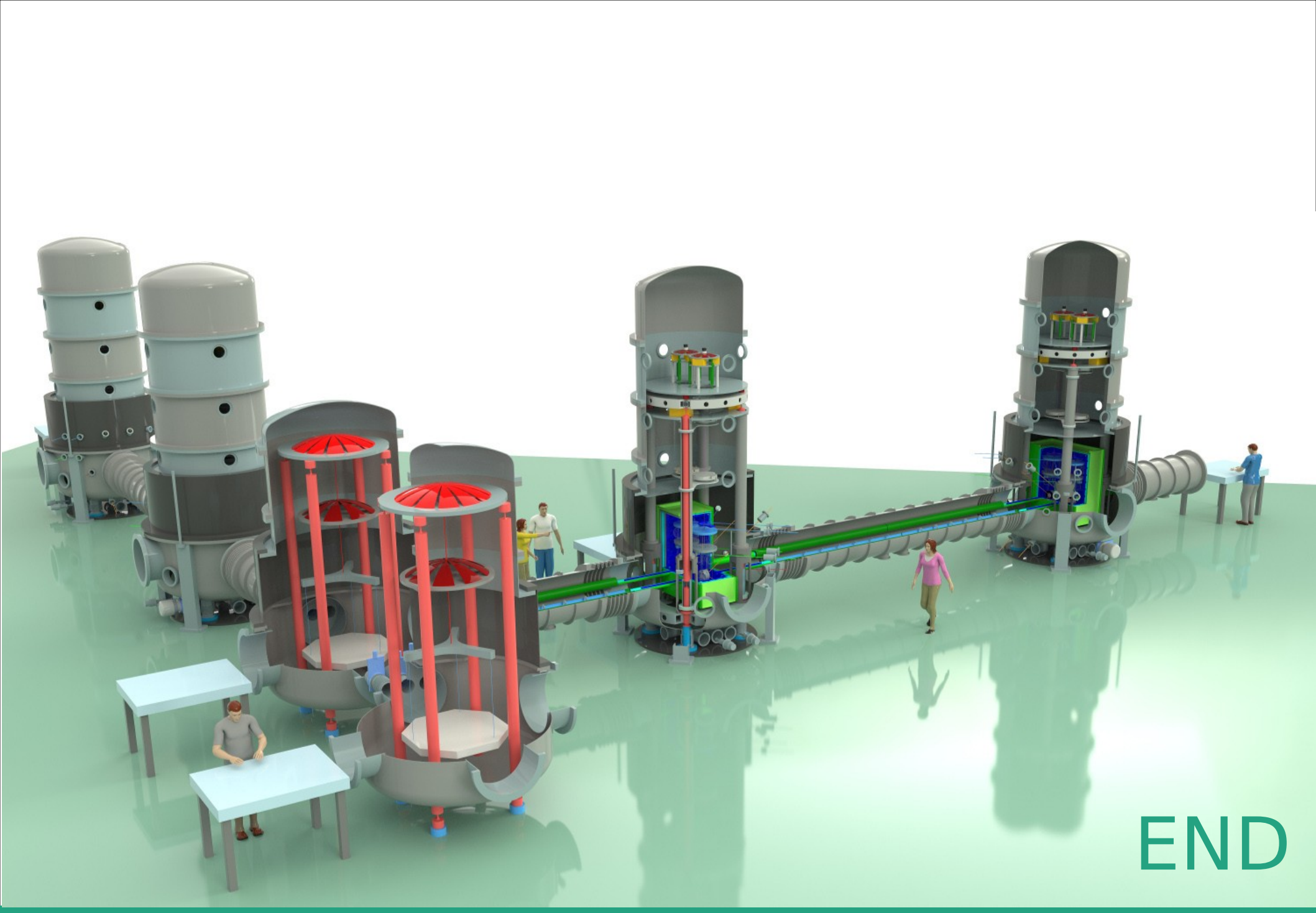




- Allow both ~120 K and ~10 K operation, needs complex thermal shielding
- Aiming to use low-vibration sorption coolers (Univ. of Twente)
- See talk by Henk-Jan Bulten Wednesday afternoon for details

Conclusions

- Obtained funding for a new prototype interferometer in Maastricht, focused on cryogenic payloads
- Good progress on preliminary design of vacuum, cryogenics and suspensions
- In parallel working on infrastructure (building acquisition, cleanroom, beam-crane, power, LN2 supply, ...)
- Need to focus on optical layout, control electronics, coatings next
- Most hardware has to be installed in ~3 years due to funding constraints
- Hope to operate for many years beyond that, apply additional funding as you go
- We are happy to collaborate and prototype other GW technology. Eager to get early feedback now to make this possible


END