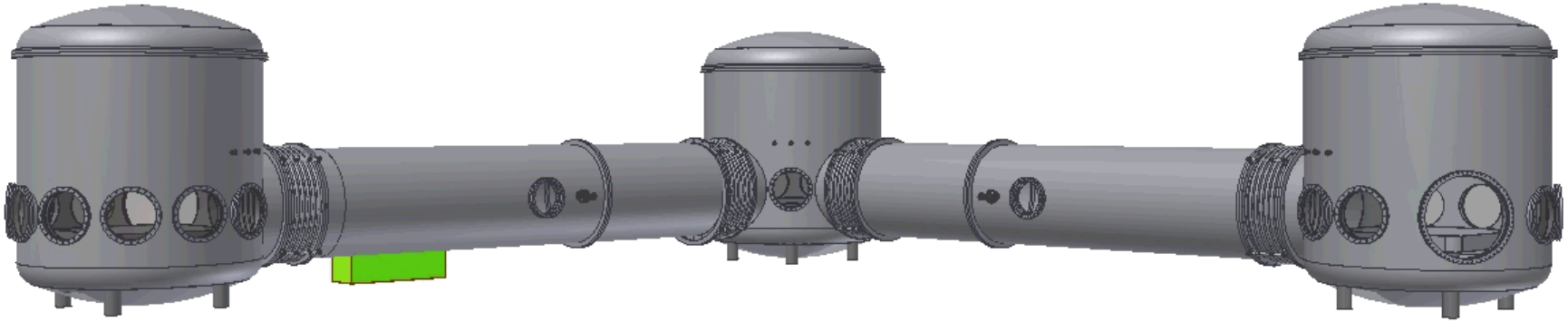
Centre for Quantum Engineering and Space-Time Research

Leibniz Universität Hannover

The AEI 10 m prototype interferometer



Stefan Goßler for the 10 m prototype team

Purpose of our prototype

- **Maximal overlap with GEO-HF subsystems**
  - develop and prove as many of the techniques needed for GEO 600 upgrades as possible (e.g. laser, digital control infrastructure)
  - provide training for people who will install and run GEO-HF

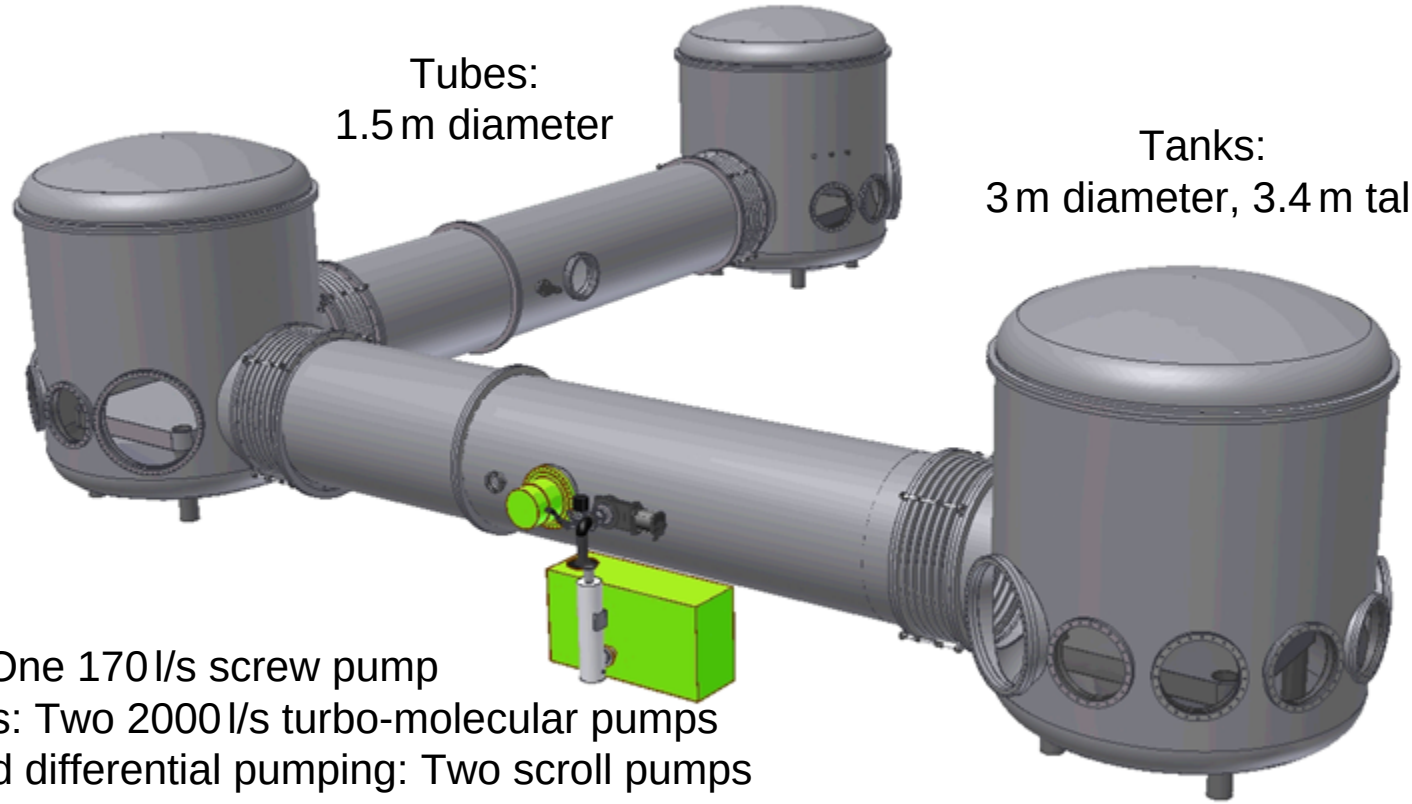
- **Ultra-low displacement noise test environment**
  - to probe at and beyond the *Standard Quantum Limit* (**SQL**) for of order 100 g to kilogram scale masses
  - Entanglement of macroscopic test masses

Layout vacuum system

Volume ca. 100 m^3
22 t stainless steel

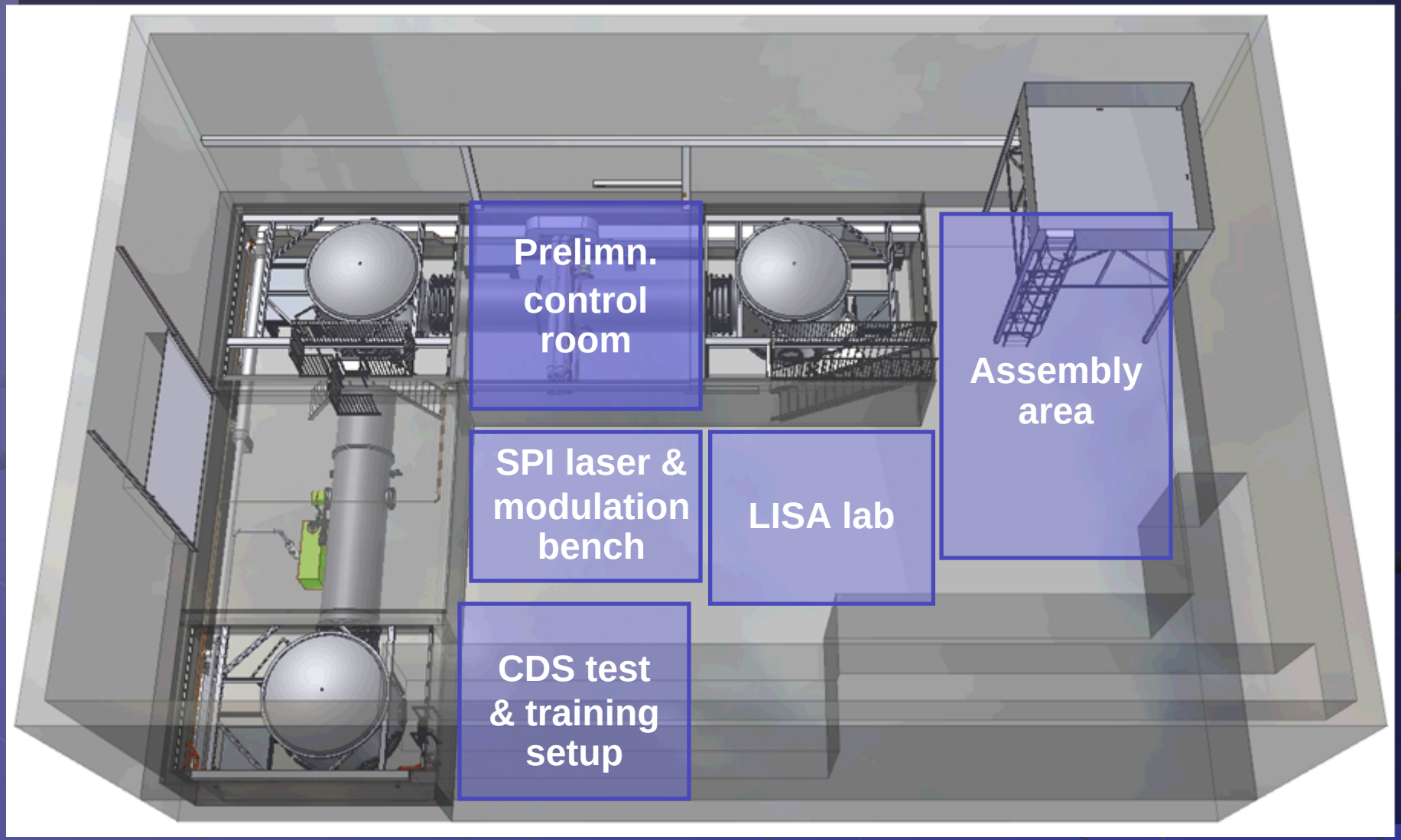
Tubes:
1.5 m diameter

Tanks:
3 m diameter, 3.4 m tall

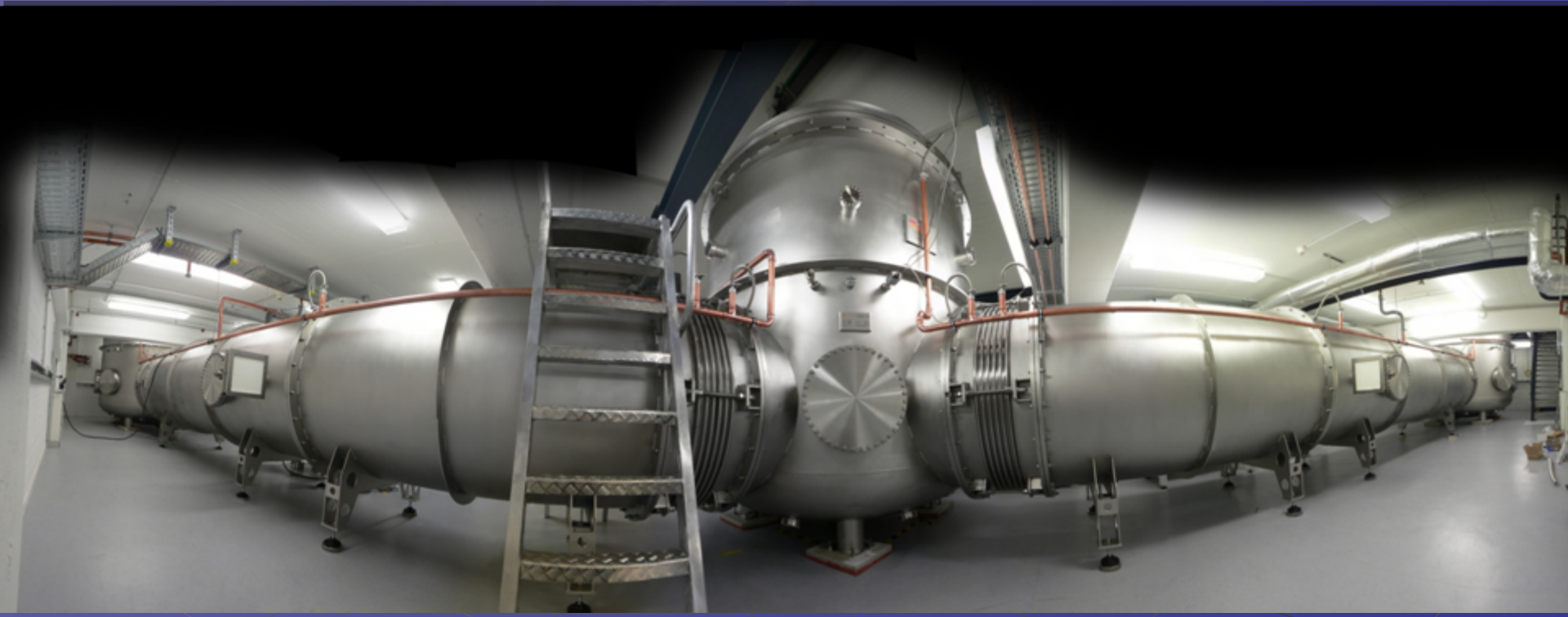


Roughing: One 170 l/s screw pump
Main pumps: Two 2000 l/s turbo-molecular pumps
Backing and differential pumping: Two scroll pumps
All-metal gaskets for flanges up to 600 mm
Differential pumping system with viton O-rings at all bigger flanges
10^{-6} mbar after about 12 hours

The prototype hall



Vacuum system 180° view



100 m^3 volume @10^{-7}mbar after about 2 weeks of pumping

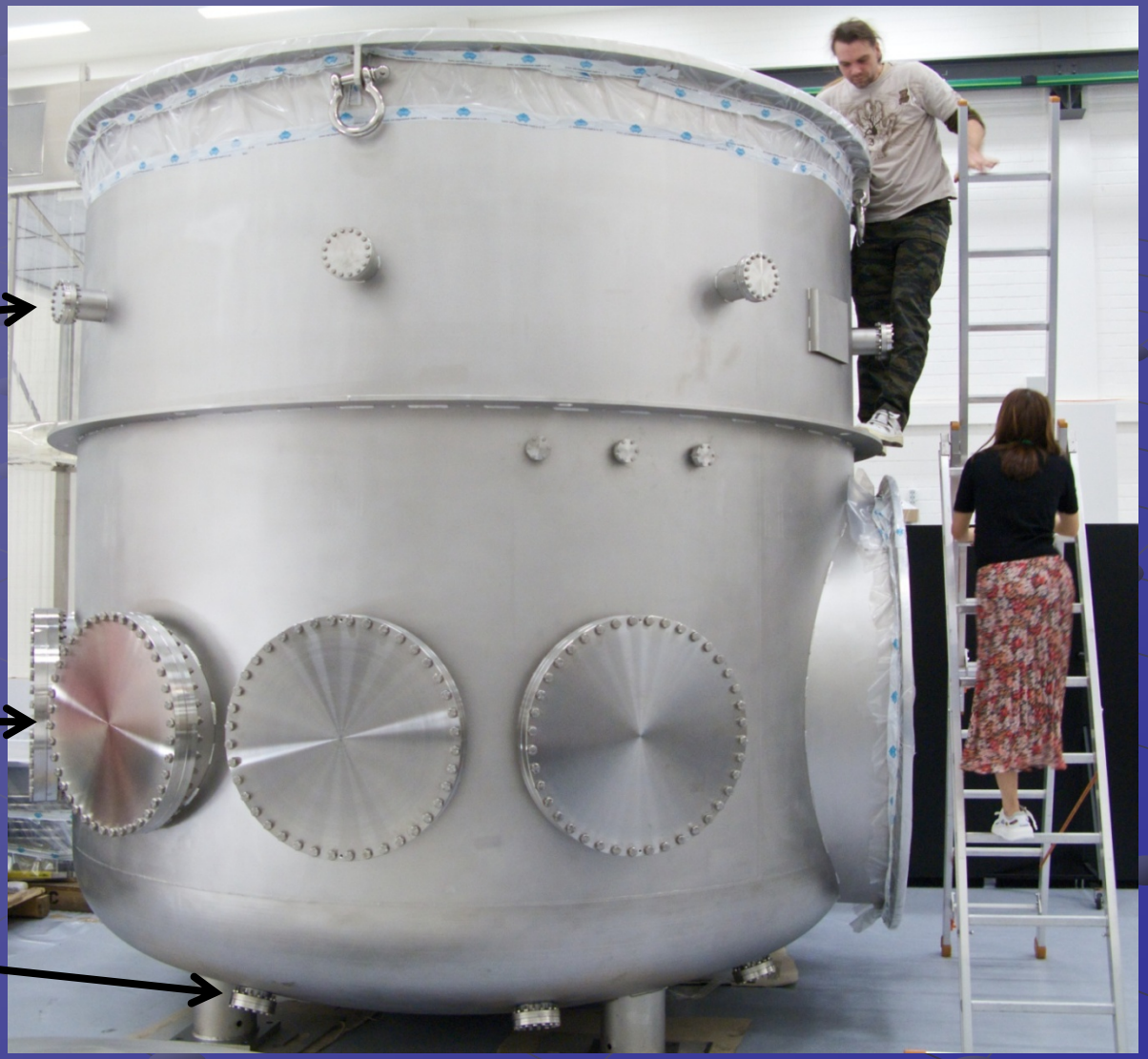
He leak check: 1500 mm flanges are leaky, thicker O-rings are installed as we speak

Walk-in tanks

100 mm flanges
to fit feed throughs

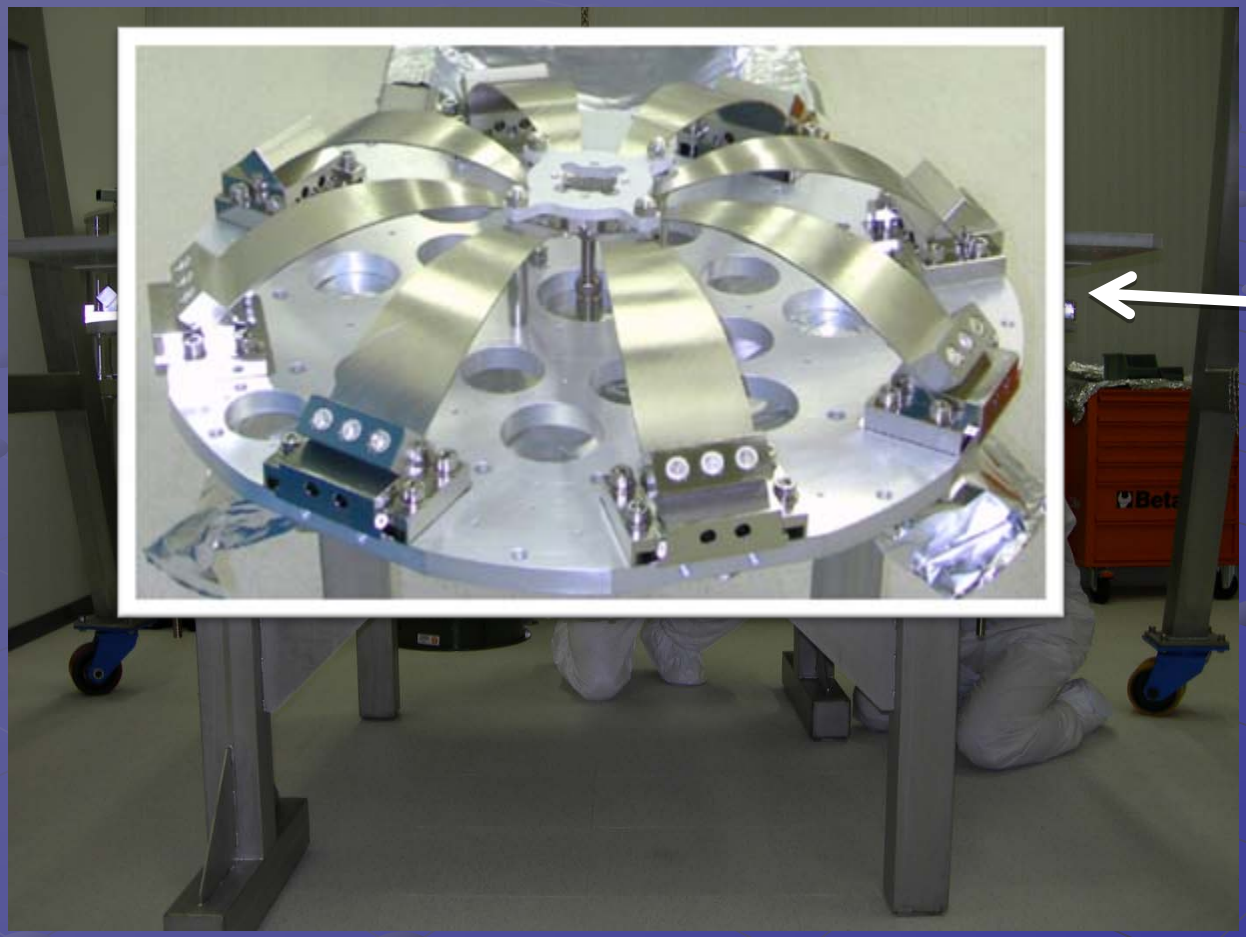
600 mm flanges
to fit viewports

100 mm flanges
to fit feed throughs



G0900626-v1

Soft isolation tables

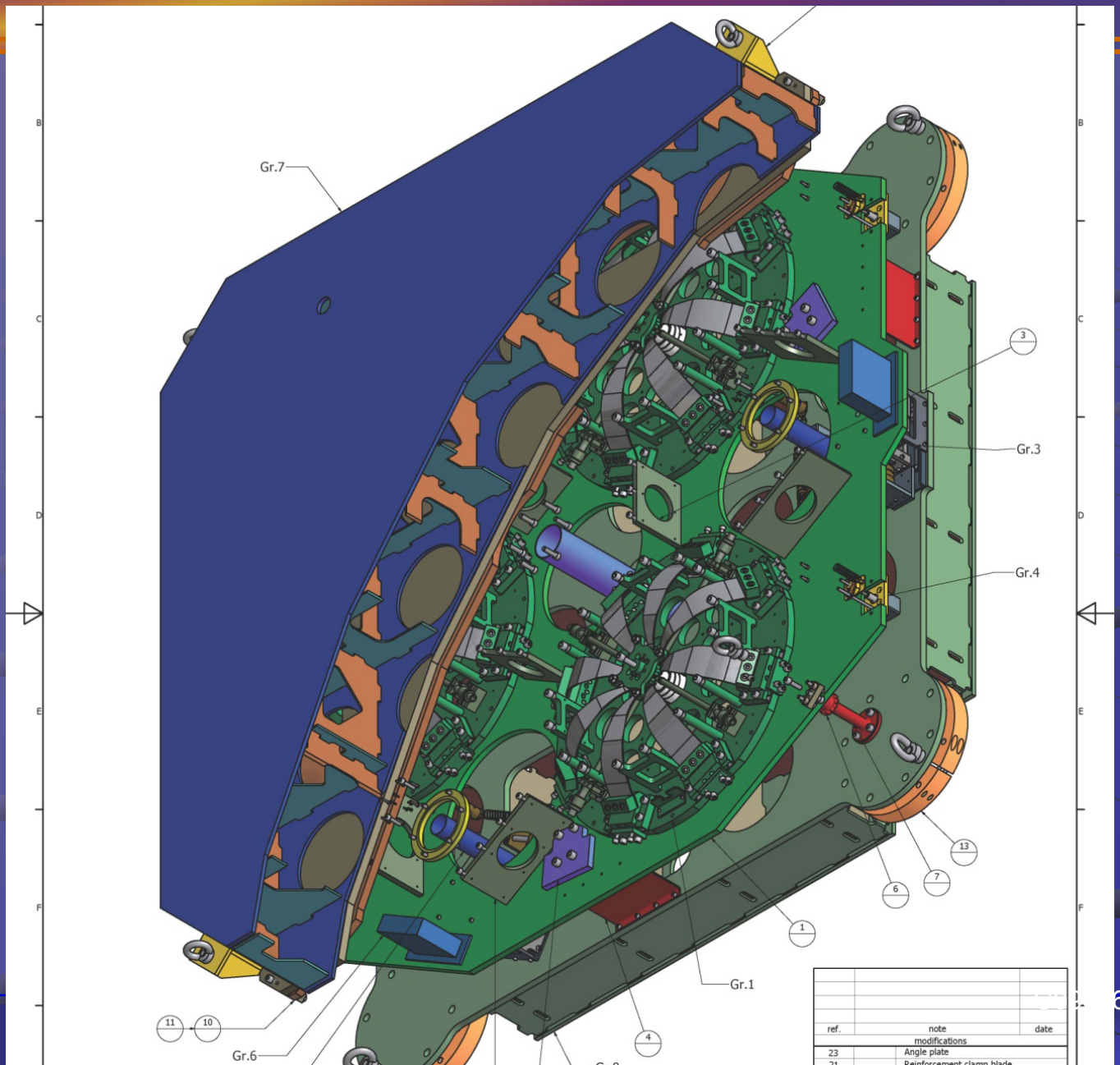


Experimental platform

GAS Filters

Inverted pendulum legs

Table assembly



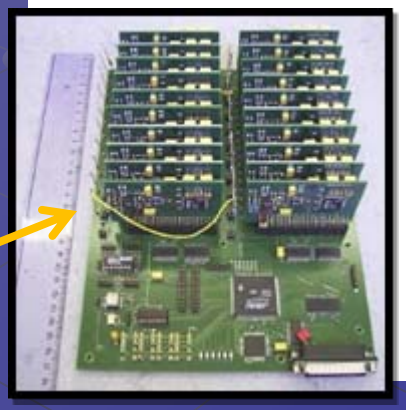
Interferometric link between tables: SPI

Suspension Platform Interferometer based on LISA Pathfinder phasemeter

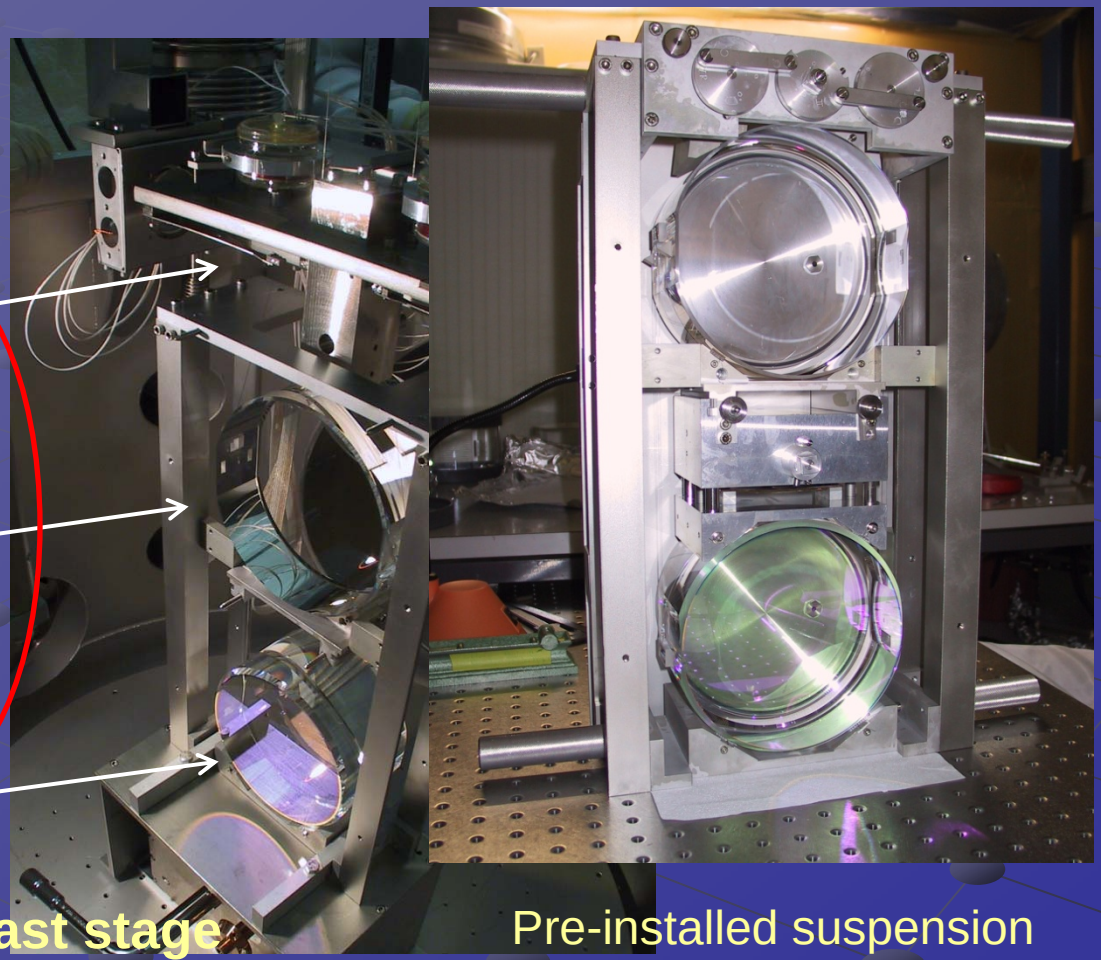
Mach-Zehnder interferometer with unequal arm length (by 20 m), requires stable laser to reach design sensitivity of 100 pm/sqrt(Hz) @ 10 mHz: Iodine-stabilised Nd:YAG

Thermal drift requires components to be bonded onto plate with low CTE

Designed custom interface between **FPGA based phasemeter** and digital control system



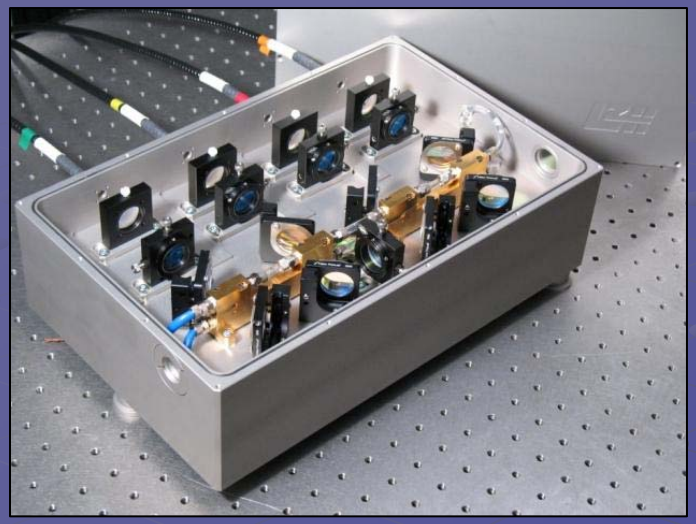
Mirror suspensions

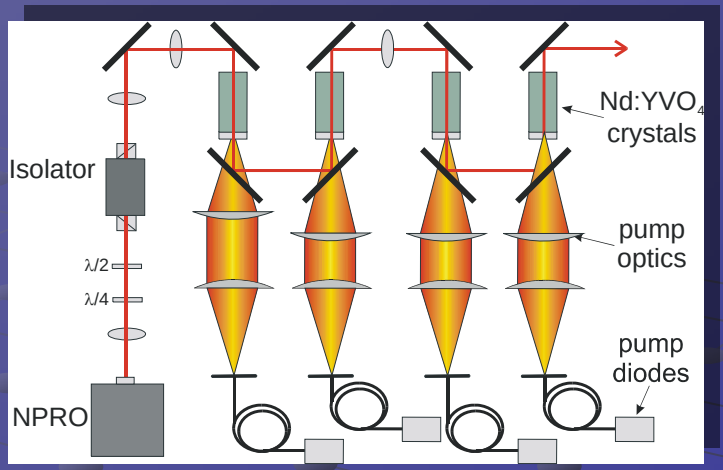


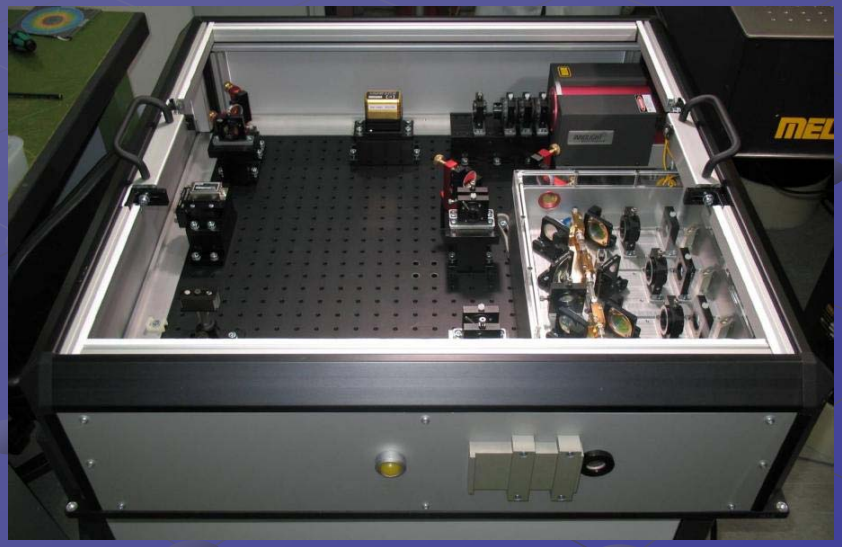
Monolithic last stage
100 g mirror, four 28 µm silica fibres

Pre-installed suspension cartridge

Light source: 35 W @ 1064 nm







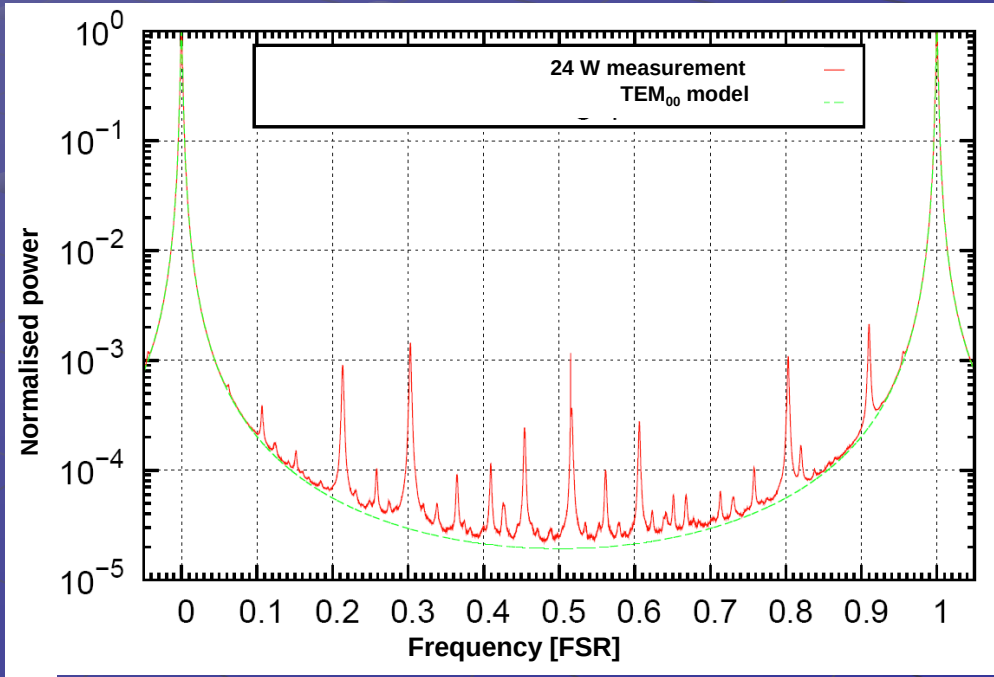
- Crystals:
  3 x 3 x 10 mm³ Nd:YVO_4
  8 mm 0,3 % dot.
  2 mm undoped endcap
- Pump diode:
  808 nm, 45 W
  400 µm fiber diameter
  NA=0,22
- Amplifier:
  38 W for 2 W seed and 150 W pump

Fibre coupling/modecleaning

Conventional single-mode fibre was found to be limited by SBS to about 30 W transmission at a length of 1.7 m

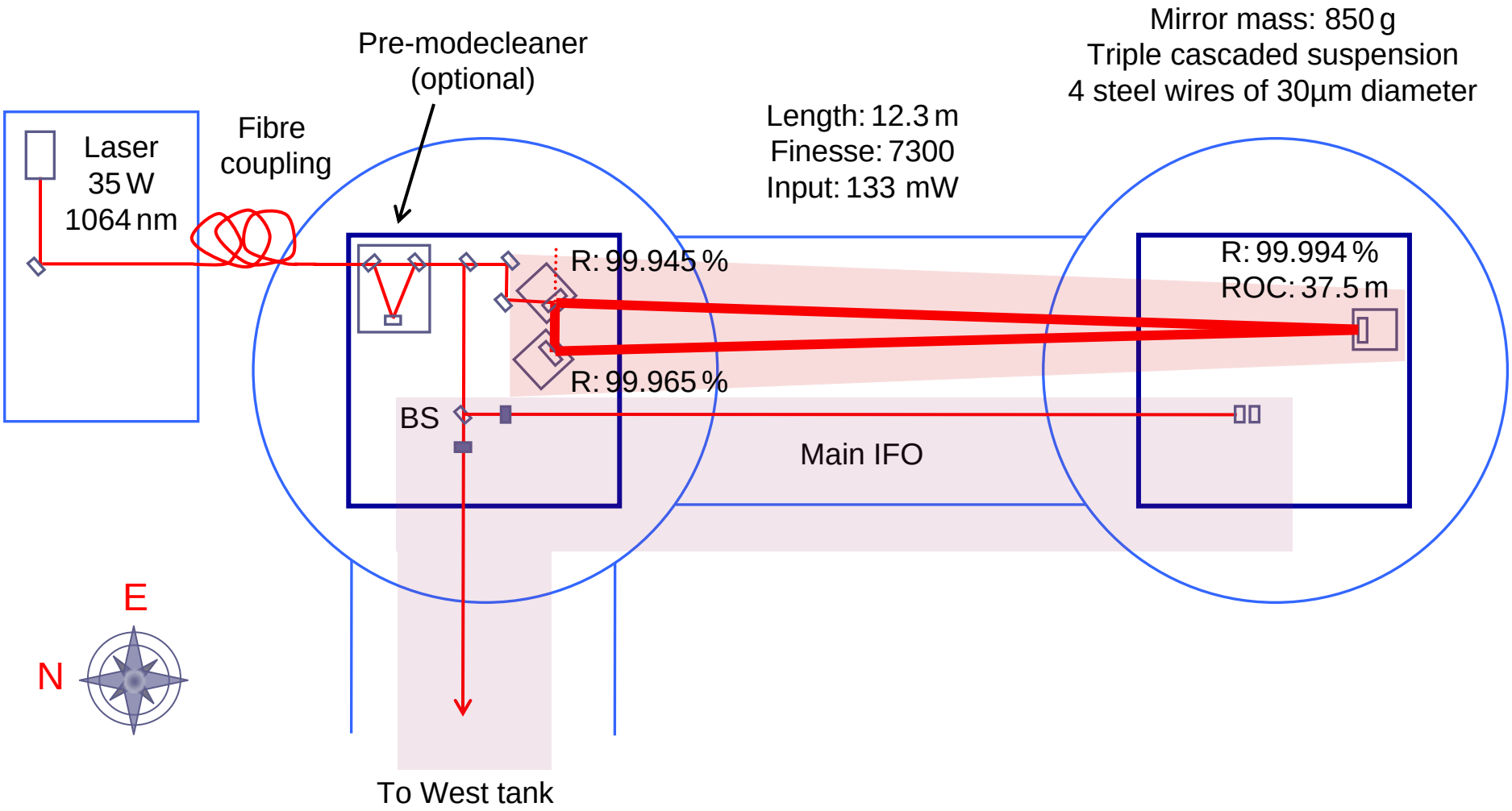
Fibre coupling via **PCF** is promising:

24 W with 3 m fibre
TEM_{00} > 99%
High degree of modecleaning
Well defined polarisation

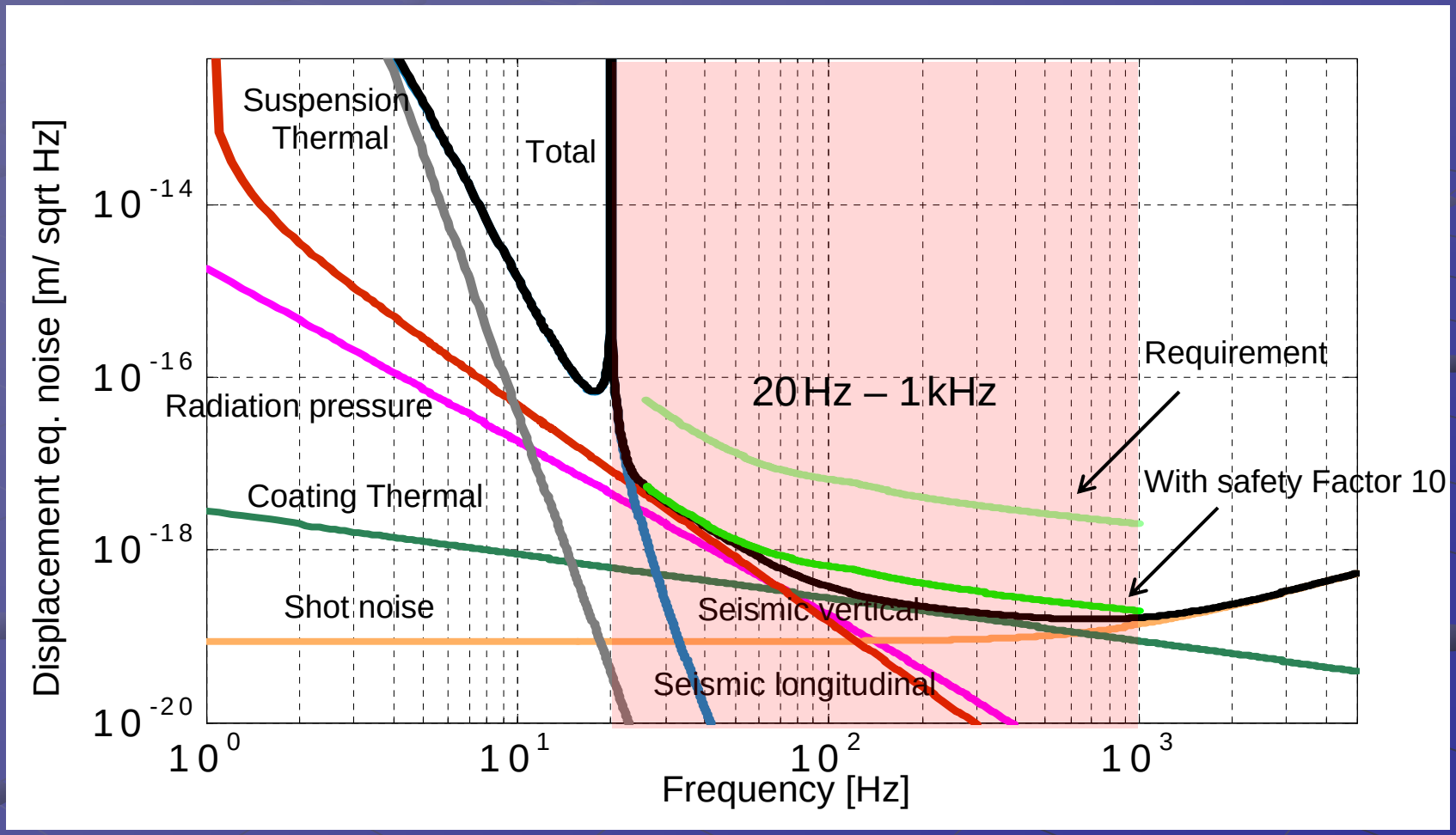


To be solved:
UHV compatible cladding and feed through
Thermal drift at incoupler

Frequency-reference cavity



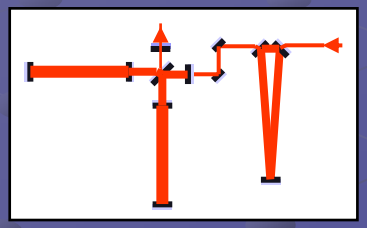
Noise budget ref. cavity



Based on real-time Li

Experiment

sensors
&
actuators



Fiel

Signal c
A

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real-time Linux

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Workstation

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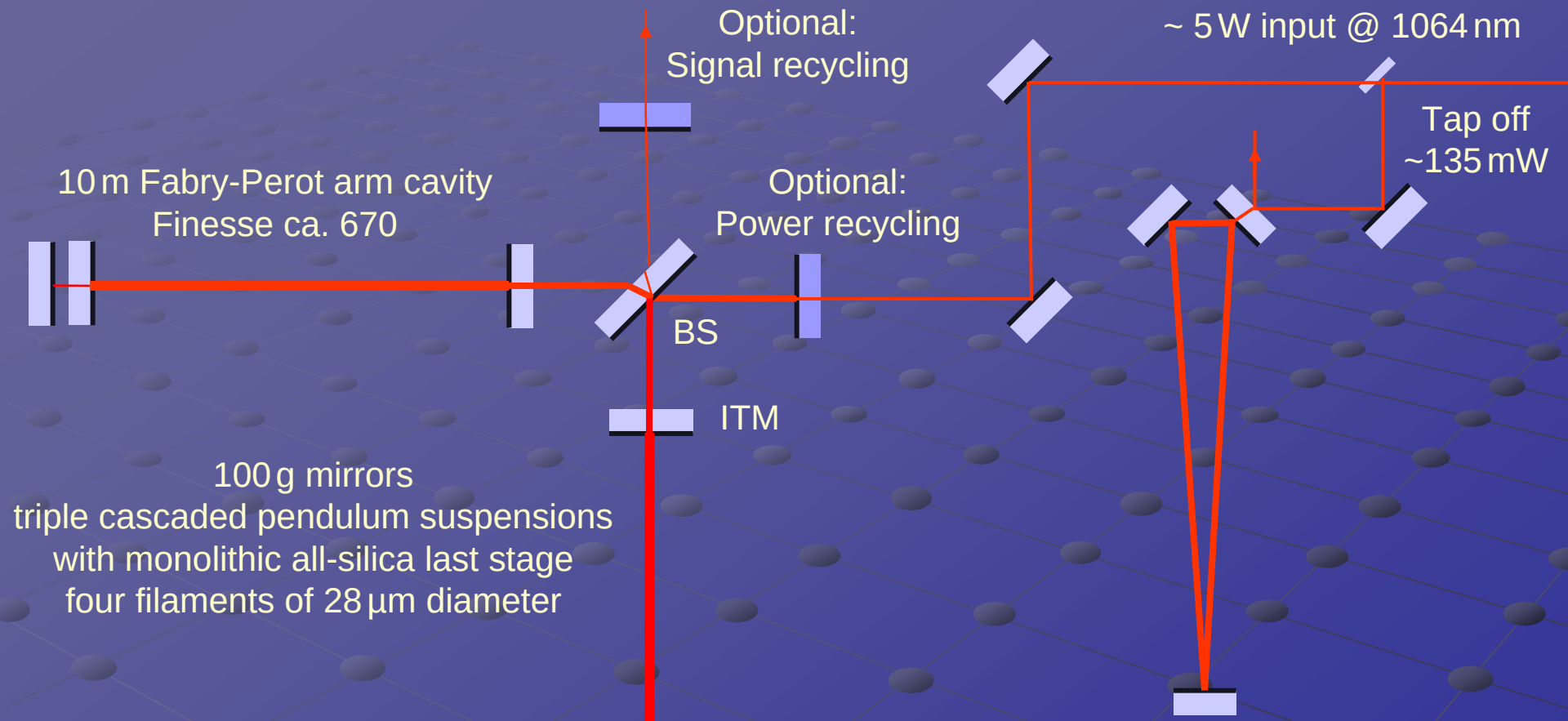
vork

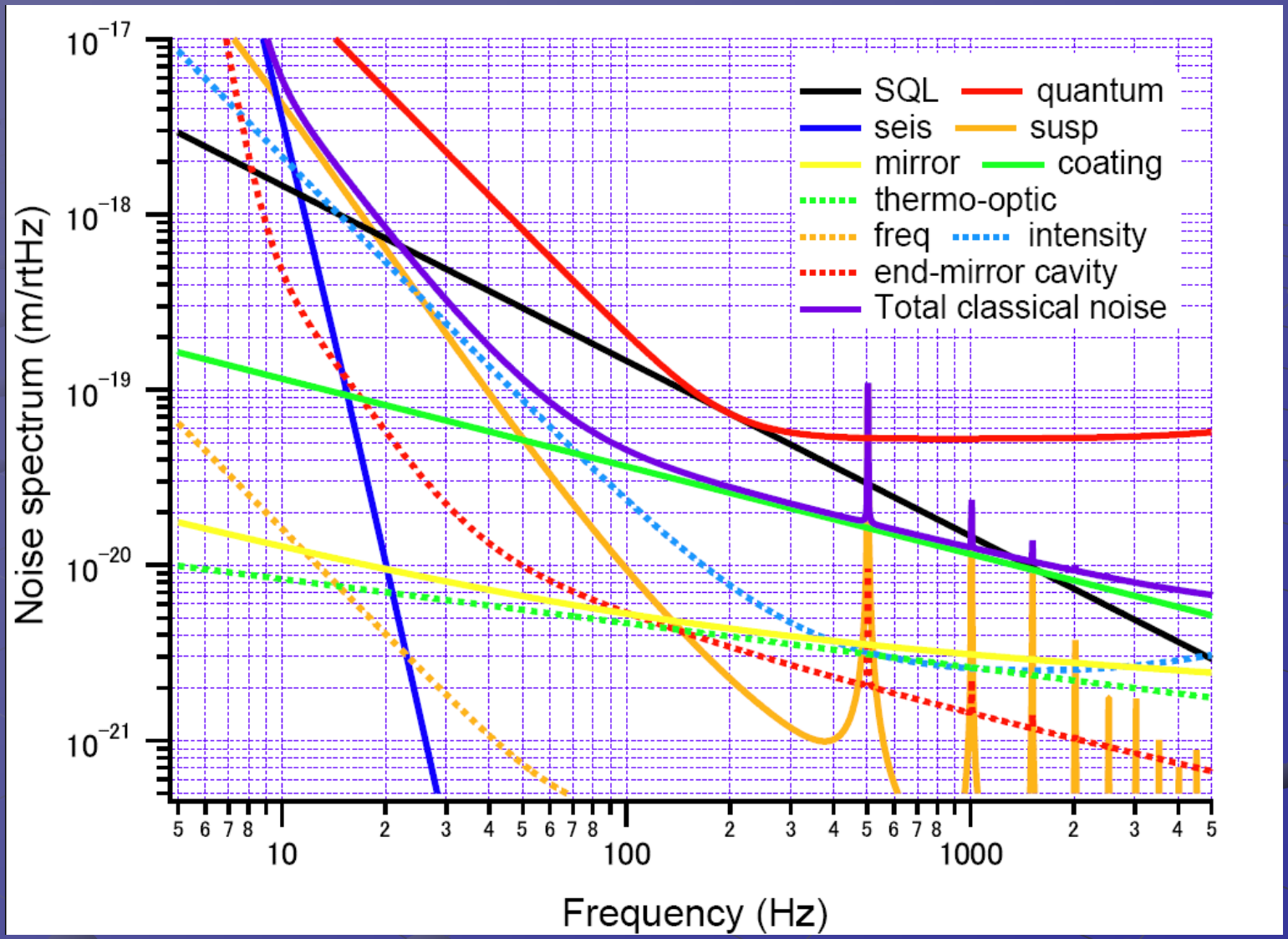
Linux,
Simulink
based input

Frame
builder

Design of sub-SQL IFO



Noise budget



The 10 m team

- Ken Strain: Scientific leader
- Stefan Goßler: Coordinator
- Kasem Mossavi: Vacuum system and pumps control
- Jens Breyer: Mechanical design
- Benno Willke: High power laser
- Gerhard Heinzel: LISA/LPF related experiments
- Yanbei Chen, Kentaro Somiya, Stefan Danilishin, Helge Müller-Ebhardt: Noise analysis, experiment design
- Roman Schnabel: Squeezing and QND experiments
- Harald Lück: Vacuum system and GEO 600 related experiments
- Hartmut Grote: Electronics and GEO 600 related experiments
- Gerrit Kühn, Michael Born, Martin Hewitson: Real time control system
- GEO operators: Filter design and construction, environmental monitoring
- Andreas Weidner: Electronics design
- Henning Ryll: Laser and fibre-modecleaner
- Katrin Dahl (PhD), Oliver Kranz (diploma): Suspension platform interferometer
- Bob Taylor (postdoc): Seismic isolation and control
- Alexander Wanner (PhD): Inertial control
- Fumiko Kawazoe (postdoc): Frequency reference cavity and global control
- Alessandro Bertolini: Seismic isolation
- Tobias Westphal (PhD): Monolithic suspensions
- Christian Gräf (PhD): RT control
- Thomas Brockt (Diploma): DC-Power supplies and voltage distribution
- Daniel Gering (Diploma): Interface SPI - CDS