The AEI 10m Prototype Facility

Tobin Fricke
AEI Hannover
for the 10m Prototype team

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LIGO-G1400991

Max-Planck-Institut
für Gravitationsphysik
(Albert-Einstein-Institut)

What is it?

An Experiment

A suspended in-vacuum Fabry-Perot Michelson interferometer designed to reach the **Standard Quantum Limit** at 200 Hz with 100g mirrors.

A Facility

A **general-purpose environment** for experiments requiring ultra-low-displacement noise, highly stabilized laser light, high vacuum, controlled displacements, up to ~11m beams.

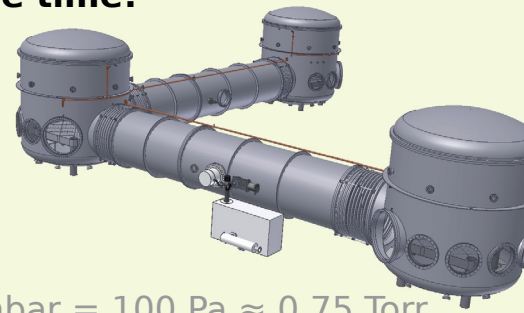
Examples: coating thermal noise measurements,
GRACE-like spacecraft testing.

Vacuum system

Volume: 100 m^3 - **Luxuriously large tanks!**

Pumpdown to 1e-6 mbar in 6 hours - **Fast cycle time!**

Best pressure ~1e-7 mbar

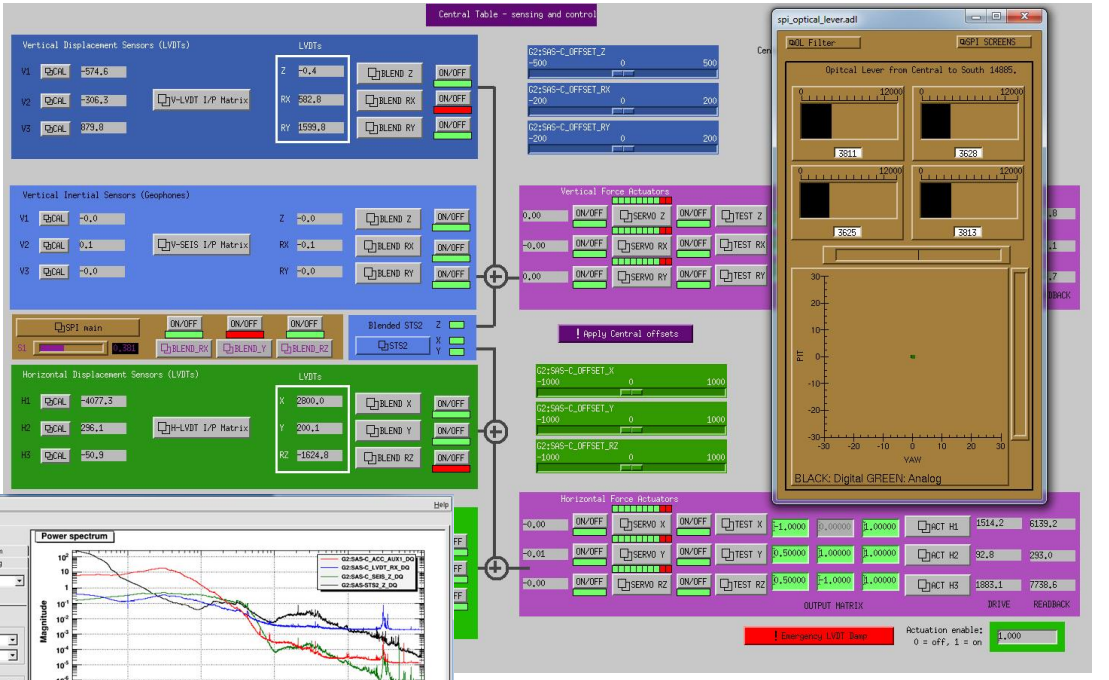


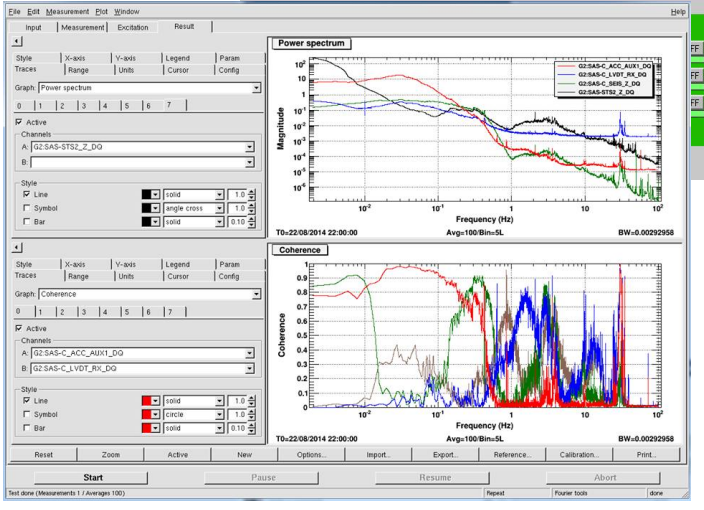
1 mbar = 100 Pa ≈ 0.75 Torr

aLIGO CDS

all-digital controls!

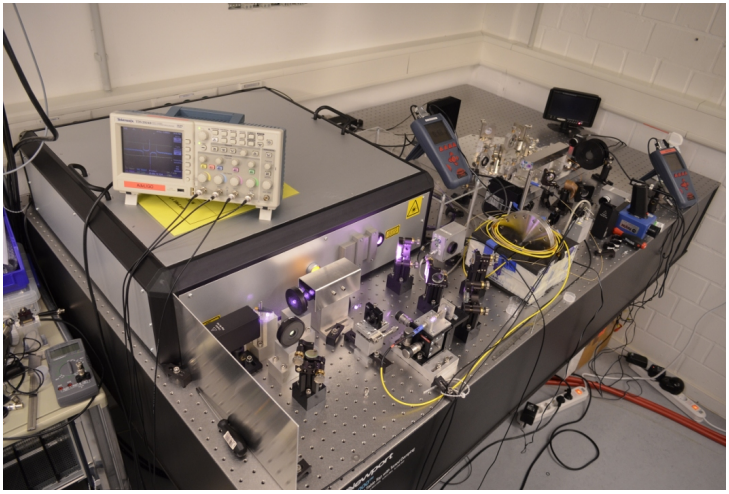
very flexible.

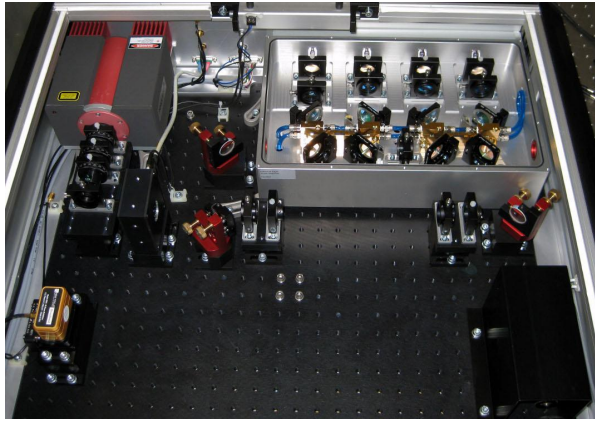




Supported locally by
Gerrit Kühn and Michael Born

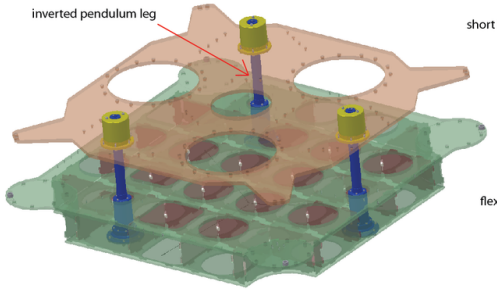
Advanced LIGO 35W Laser





- Coupled into vacuum by photonic crystal fiber
- In-vacuum pre-mode-cleaner (PMC)
- We'll use 8 Watts for initial experiments

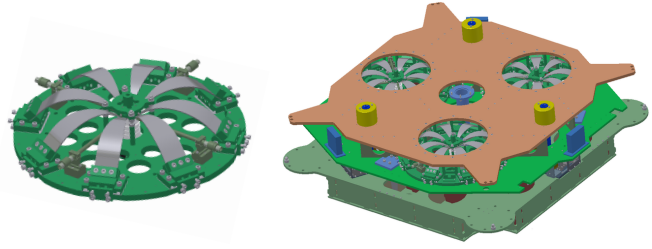
AEI SAS



Soft passive plant...

- 1 stage vertical, 1 stage horizontal

- 100 mHz horizontal resonance
- 270 mHz vertical resonance
- 400 mHz tilt resonance

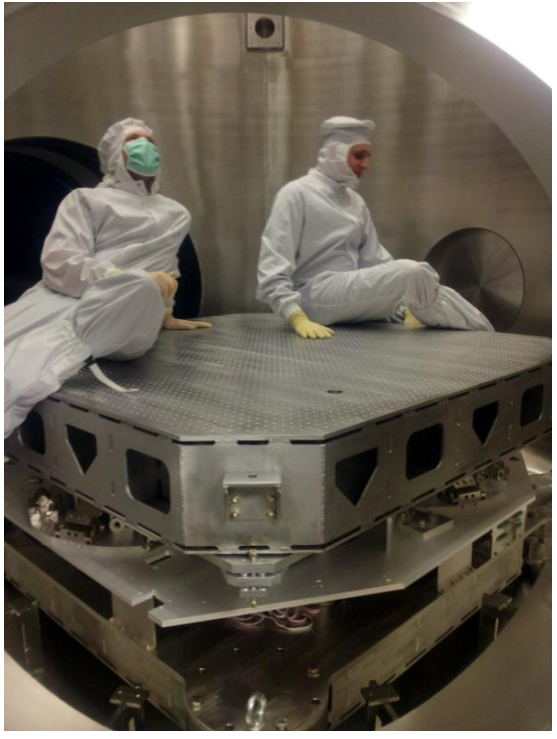


...but with the usual complement of sensors and actuators

- 6X **inertial sensors**: monolithic accelerometers (Horiz); geophones (Vert)
- 6X **displacement sensors**: LVDTs
- **feed-forward** from ground motion (STS2 seismometer)
- 6X **voice-coil actuators**

Poster by
Gerald Bergmann

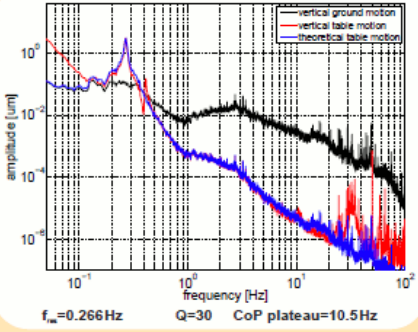
Seismic Isolation



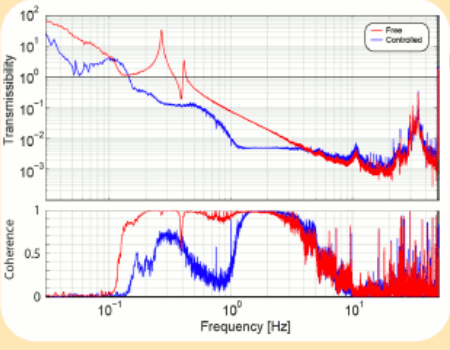
Poster by Gerald Bergmann

Vertical passive table performance

In-vacuum table inertial motion is compared with ground motion. The predicted motion is calculated using only one fitted parameter, the center of percussion plateau. Geophone noise dominates below 0.07 Hz and above 30 Hz.



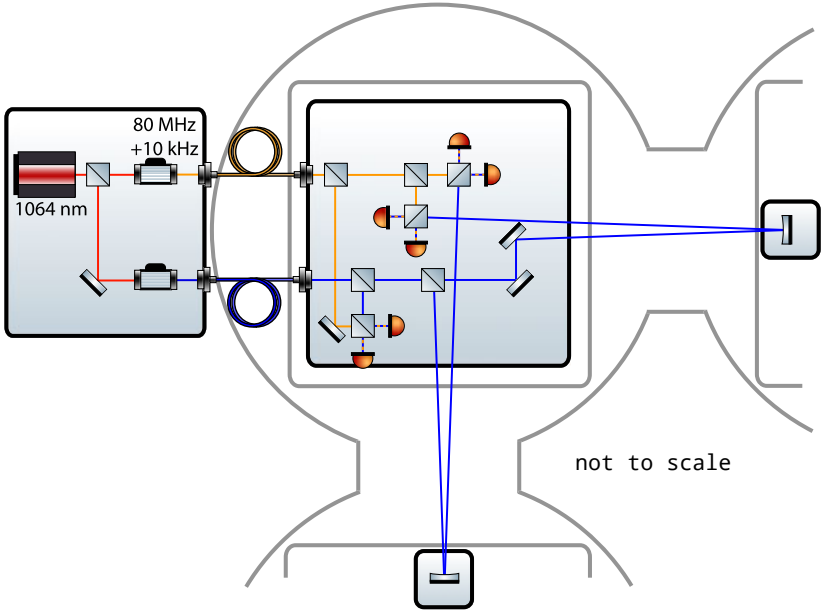
Low frequency active control



Vertical blending at 0.01 and 0.30 Hz
Horizontal blending at 0.04 and 0.15 Hz

U.G frequencies:
Vertical: ~5-15 Hz
Horizontal: ~0.5-2 Hz

Suspension Platform Interferometer (SPI) - design



Idea: link the table platforms via sensing and feedback

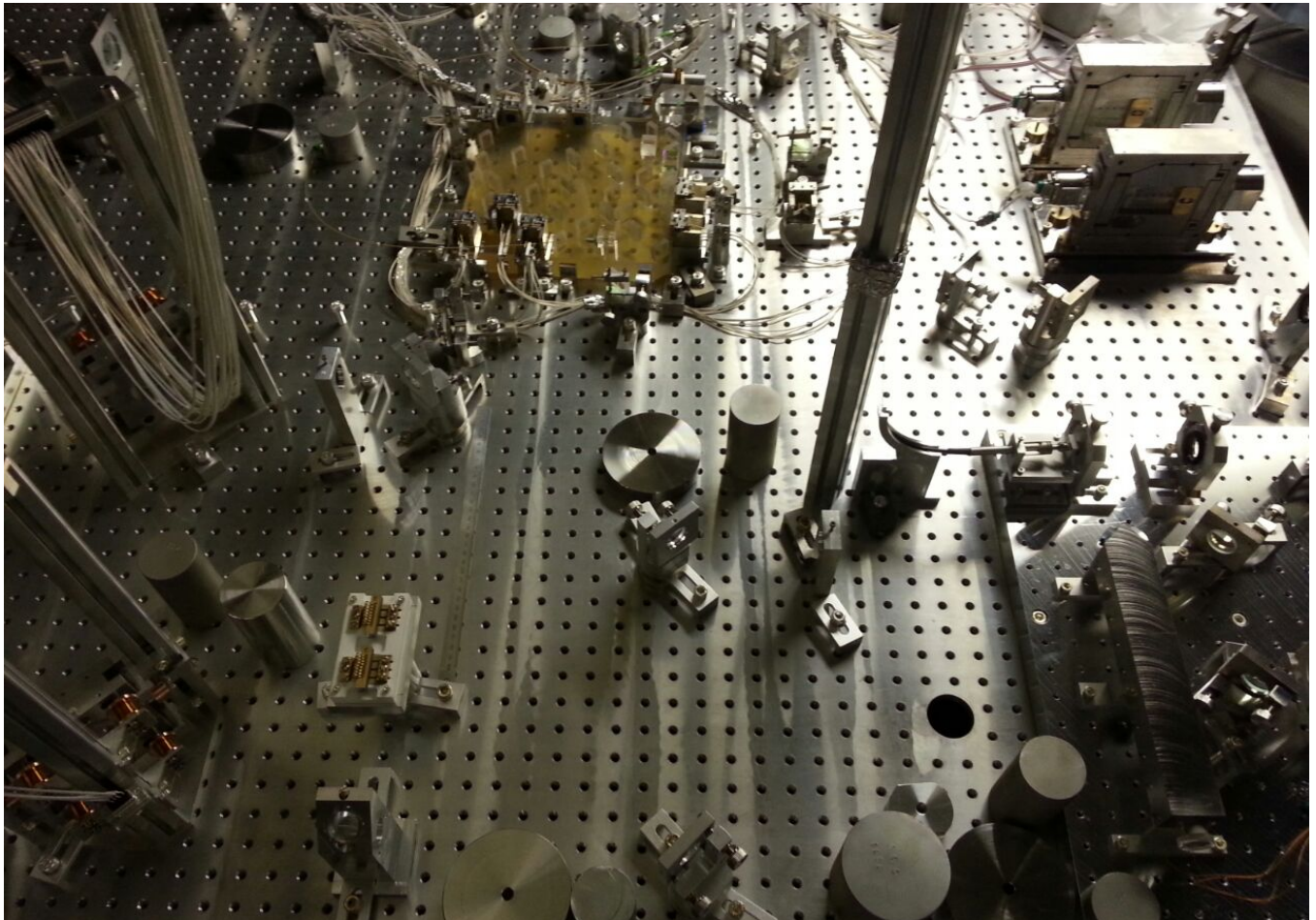
Mach-Zender for high dynamic range.

Uses **LISA phasemeter** and monolithic construction.

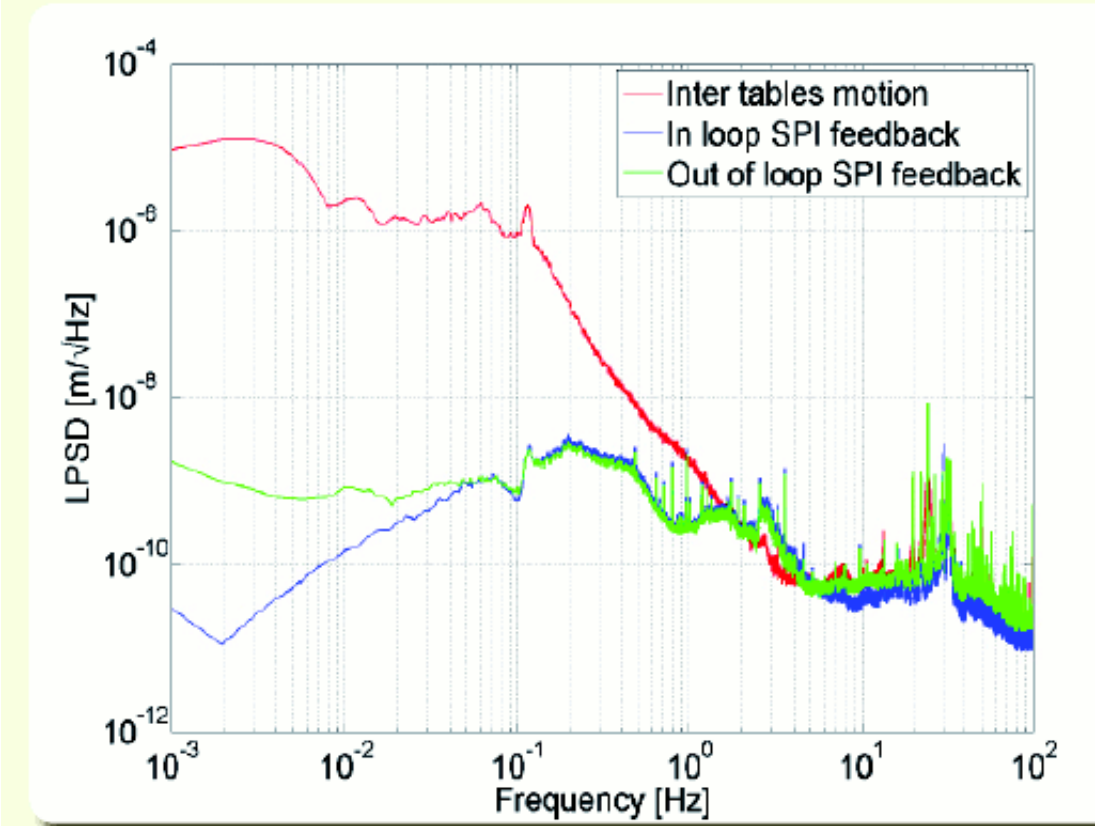
Achieved sensing noise:
10 nm/√Hz below 10 mHz
10 pm/√Hz above 1 Hz
+ frequency noise?

Poster by
Sina Köhlenbeck

Suspension Platform Interferometer (SPI) - photo



Suspension Platform Interferometer (SPI) - plot



Frequency Reference Cavity (RefCav)

Triangular cavity, F=3000, L=21m

Uses heavier mirrors (850g) to reduce radiation pressure noise

Triple suspensions

G = 10^6 at 100 Hz

LIGO TTFSS

Fine alignment/locking when we get back to Hannover!

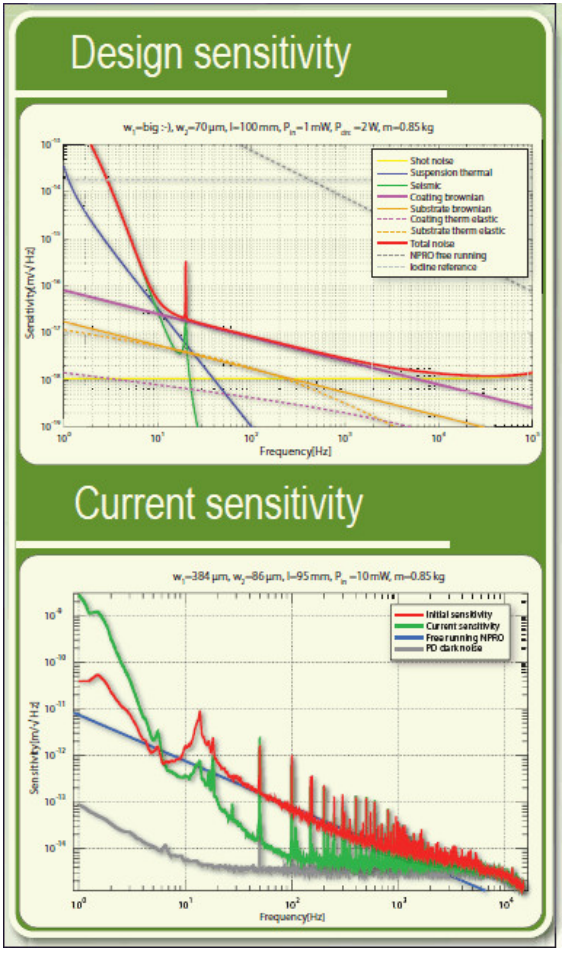
Poster by Manuela Hanke

Thermal Noise Interferometer

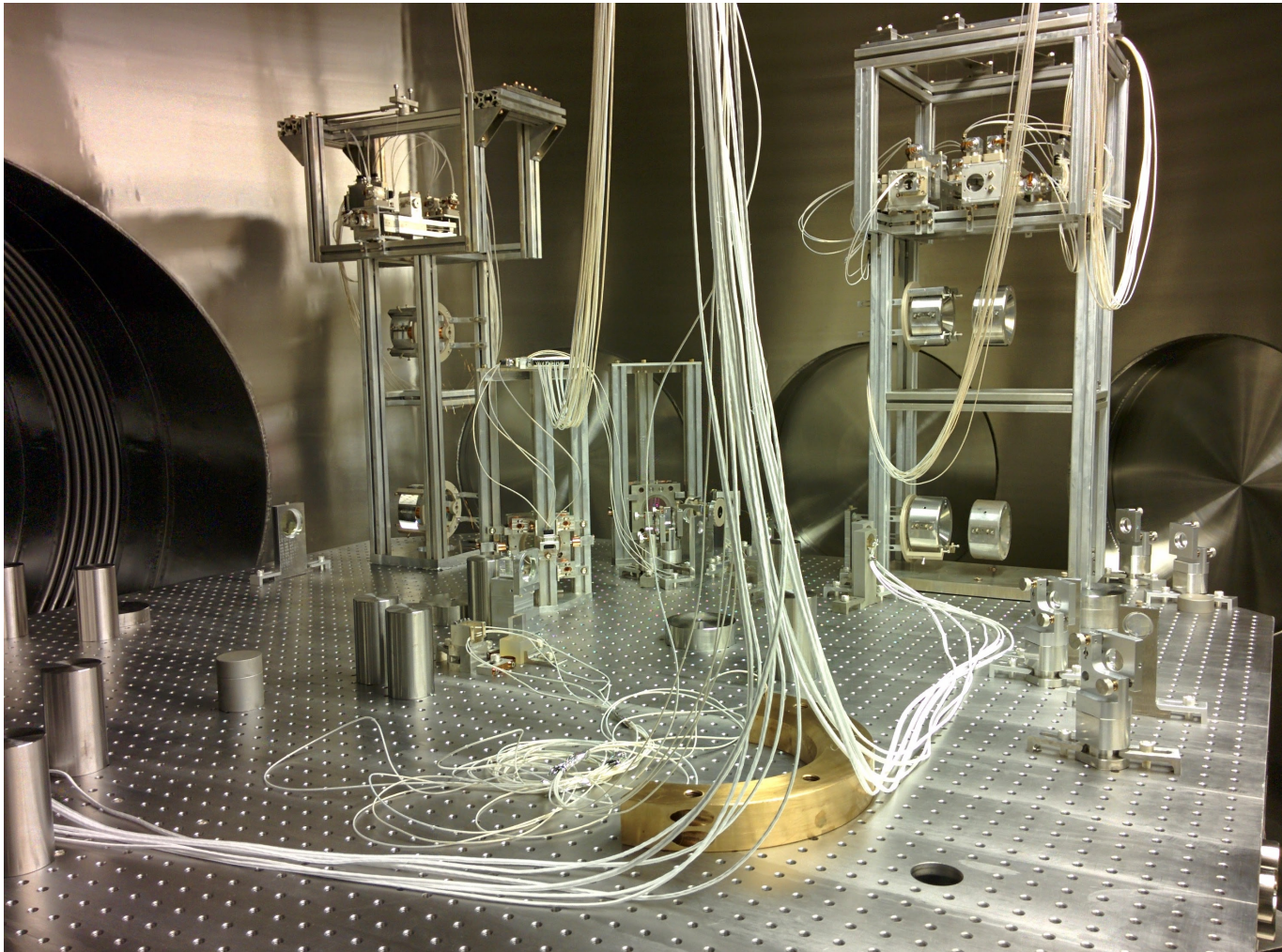
Two-mirror short suspended cavity with tunable cavity length.

Goal: investigate new coatings, scaling of thermal noise with spot size, homogeneity, etc.

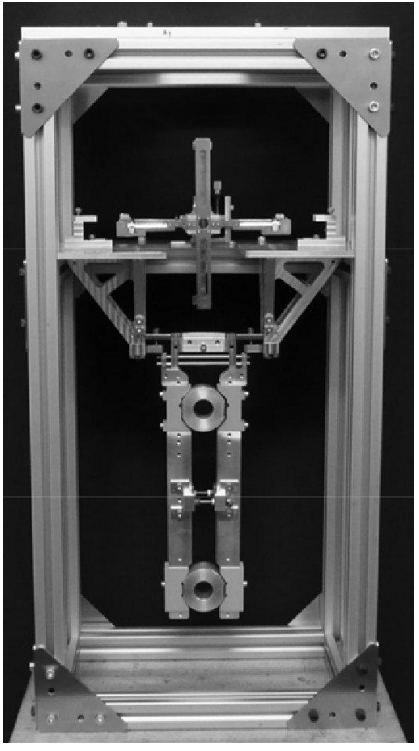
Status: cavity locked for the first time three weeks ago (with feedback to laser)



Poster by
Tobias Westphal ("Fu")



Monolithic Suspensions



University of Glasgow

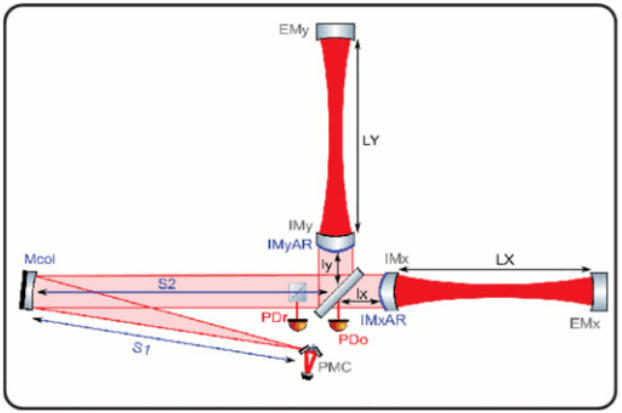
- Three pendulum stages
- Two vertical blade-spring stages
- Lower stage all glass for lower thermal noise

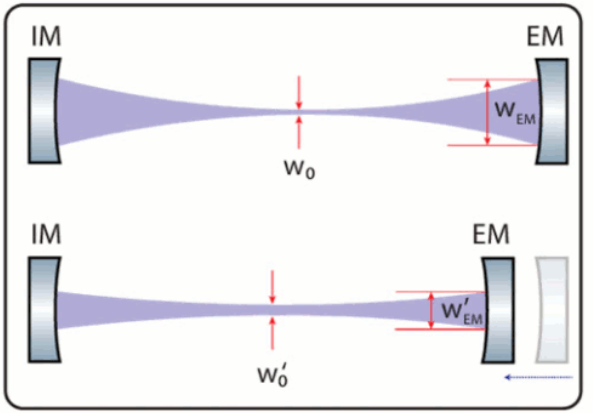
Builds on experience from GEO and aLIGO.

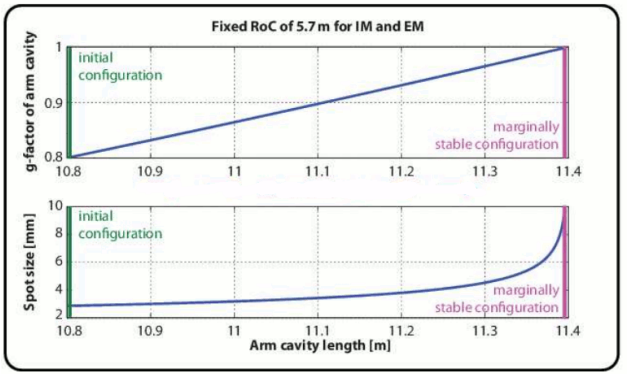
60 mm X 0.3 mm !

First two production builds almost ready for installation.

Tunable configuration

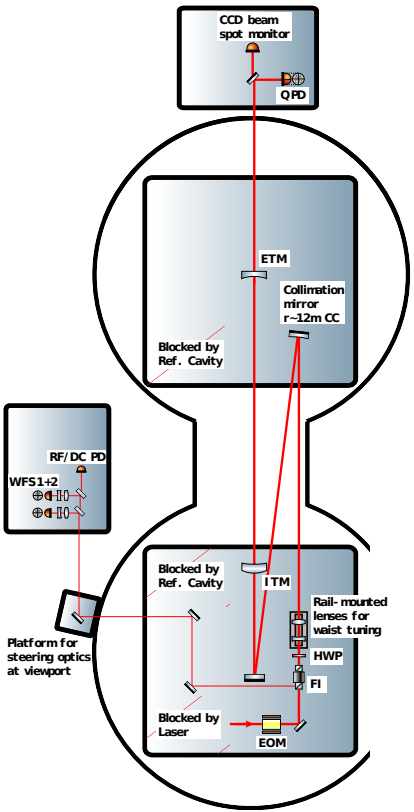




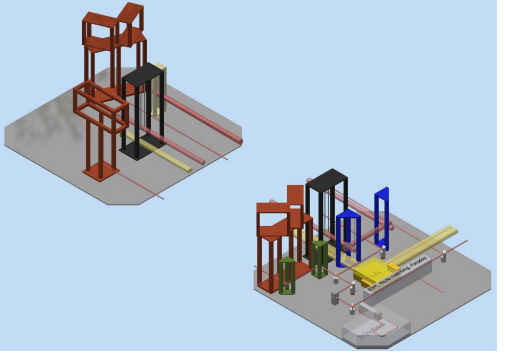


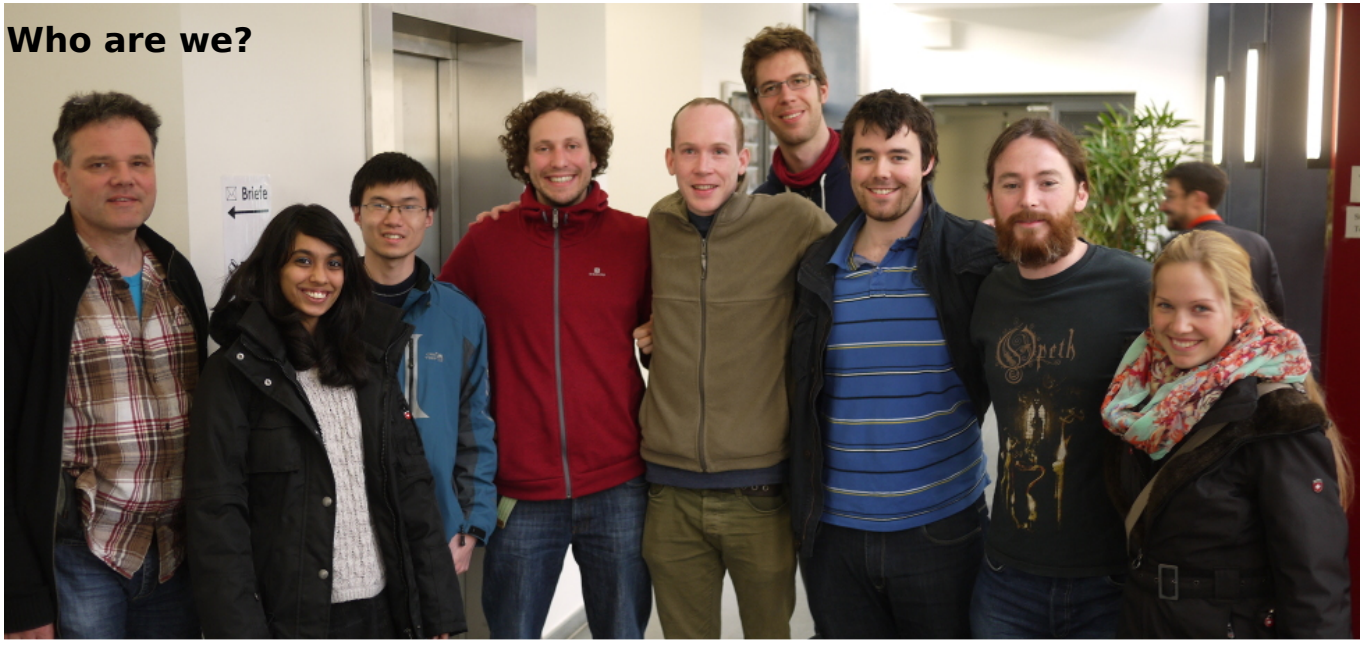
Christian Gräf,
CQG 29 (2012) 075003

Single Arm Test



- Single, impedance-matched cavity
- Tunable stability
- **Goal:** Learn to cope with marginal stability
- then: move to full FP-Michelson





PhD Students
Tobias Westphal
Gerald Bergmann
Sina Köhlenbeck
Manuela Hanke
Vaishali Adya
Patrick Oppermann

Postdocs
Conor Mow-Lowry
Tobin Fricke

Group leaders
Harald Lück
Ken Strain

Undergrads
Phillip Koch
Robin Kirchhoff
Johannes Lehmann
Michael Winter
Robin Hothan
REU students

Many others!
Gerrit Kühn
Benno Wilke
AEI Staff
Visitors
Maybe you??

Where are we?


Glasgow
Kirkcaldy
Kilmarnock
Ayr
United Kingdom
Middlesbrough
Isle of Man
Blackpool
Leeds
Hull
Liverpool
Sheffield
Nottingham
Stoke-on-Trent
Derby
Norwich
England
Ipswich
Wales
Swansea
Headington
Bristol
London
Leigh-on-Sea
Cardiff
Reading
Barnstaple
Southampton
Exeter
Portsmouth
Plymouth
Bournemouth
English Channel
Falmouth
Guernsey
Jersey
Le Havre
Caen
Rouen
Amiens
Cambrai
Saint-Quentin
Reims
Lille
Belgium
Brussels
Bruges
Antwerp
Mol
Woensel-Noord
The Hague
Netherlands
Amsterdam
Den Helder
Leeuwarden
Groningen
Bremen
Bremerhaven
Hamburg
Bergedorf
Silkeborg
Horsens
Esbjerg
Denmark
Odense
Flensburg
Kiel
Heide
Neumünster
Helsingborg
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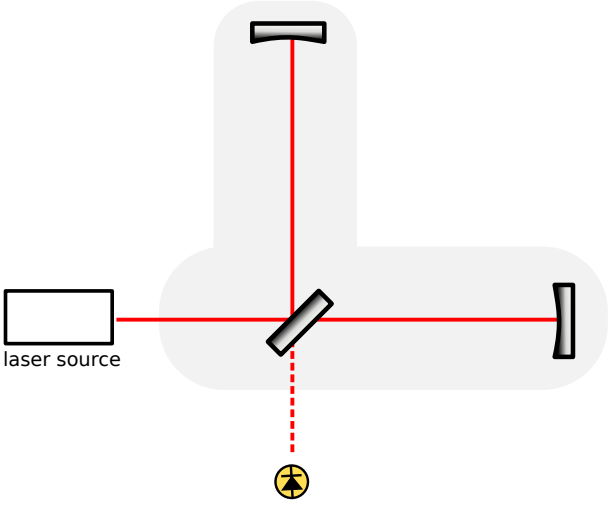
Malmö
Stralsund
Rostock
Schwerin
Neubrandenburg
Hanover
Bielefeld
Brunswick
Münster
Kemstadt
Berlin
Potsdam
Dessau
Leipzig
Dresden
Chemnitz
Gera
Germany
Düsseldorf
Nord
Cologne
Frankfurt
Wiesbaden
Würzburg
Mannheim
Nuremberg
Plzen
Luxembourg
Saarbrücken
Karlsruhe
Regensburg
Google

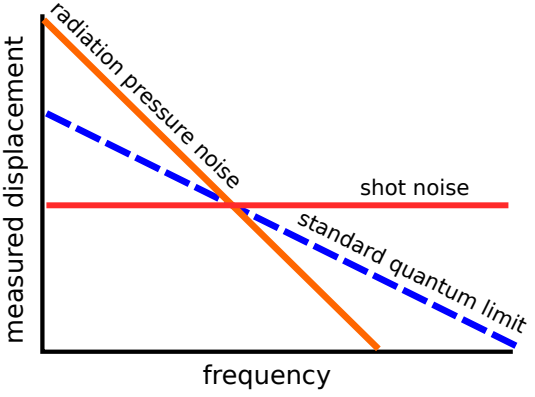
Thanks for listening!

Capabilities

Big vacuum system, fast pumps, fast turn-around time
35W laser source
Three in-vacuum large seismic isolation tables (2 installed)
Intra-table stabilization / control with SPI
Iodine-stabilized laser frequency reference
Full Advanced-LIGO CDS system
Frequency reference cavity (L=~20m, F=3000)
Intensity stabilization (target: RIN 10^(-9)/rtHz)

Outstanding mechanical & electronics support
Local expertise


laser source


radiation pressure noise
shot noise
standard quantum limit
measured displacement
frequency