
GWADW2021
Summary Session

Summary of
Low-Frequency Workshop

Masaki Ando (Univ. of Tokyo)
Conor Mow-Lowry (University of Birmingham)

Low-Frequency Workshop 1

Low frequency workshop #1 (Tuesday, 18 May)

Newtonian Noise Mitigation and Related Topics

- Newtonian-noise cancellation

Jan Harms (GSGC)

- Development Update for the TorPeDO Experiment
 - A Newtonian Noise Sensor for 3G Observatories

Nathan Holland (The Australian National University)

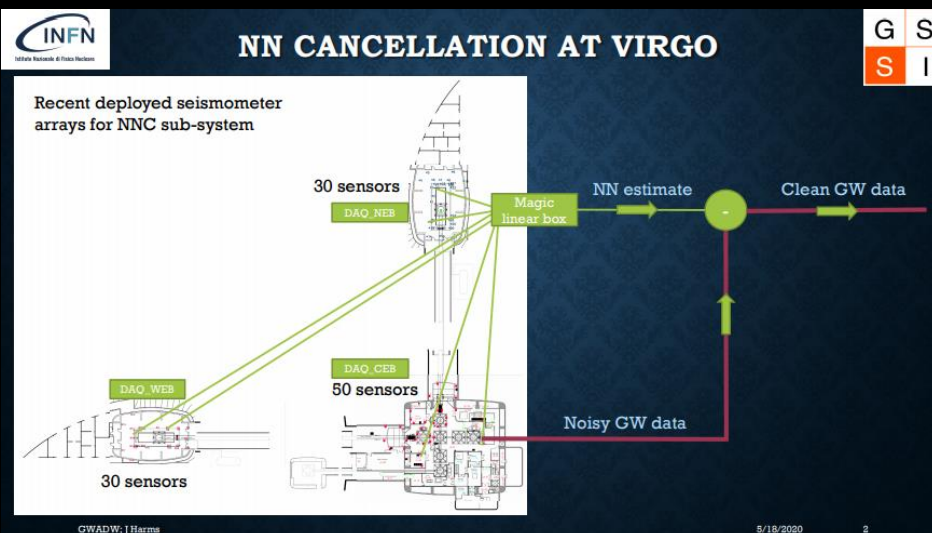
- The Current Status of TOBA

Satoru Takano (The University of Tokyo)

- Low-frequency ground deformation observed by the geophysics interferometer (GIF) in the KAGRA tunnel
 - Akito Araya (Earthquake Research Institute, U-Tokyo)

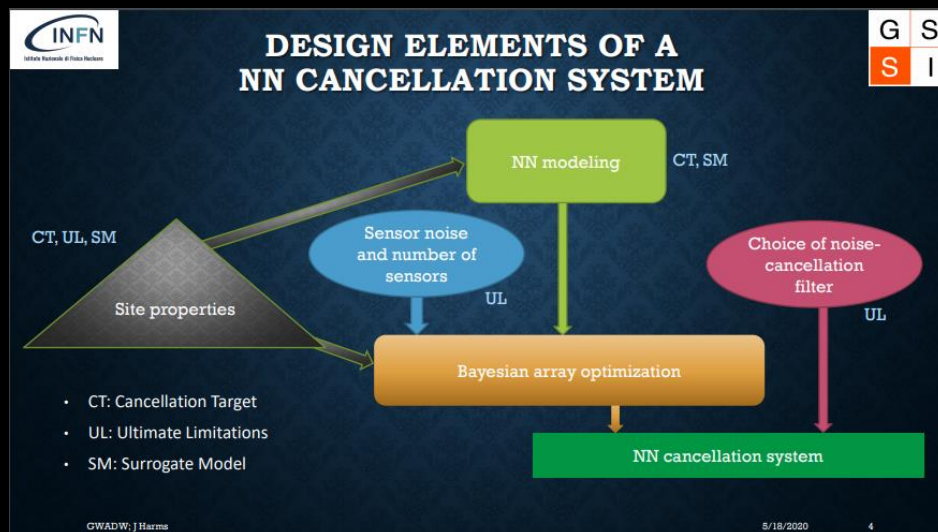
- Update on Cryogenic Silicon Suspension Activities at Glasgow
 - Graeme Eddolls (University of Glasgow)

Newtonian-Noise Cancellation [Jan Harms]



Concept and results of **Newtonian noise cancellation** using seismometer array were presented.

- Optimization study of the sensor array at VIRGO site.
- Optimal liner filtering.
- Experimental results at the LIGO Hanford site.
- ET Newtonian noise model, cancellation concept, and Numerical simulation.



TorPeDO [Nathan Holland]

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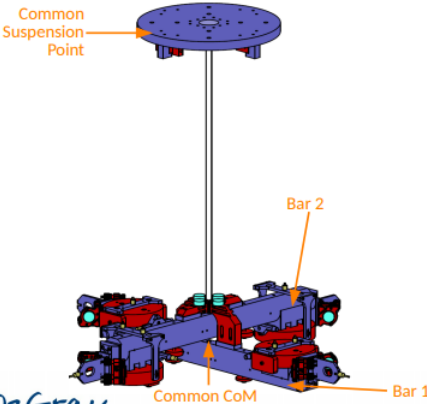
TorPeDO Mechanical Design

Designed as a direct Newtonian noise sensor for 3G facilities.

Torsion Pendulum Dual Oscillator

- 2x Torsion pendula, with 25 mHz torsion frequency.
- Common centre of mass & rotation, reduce the sensitivity to common motion.
- 2 wires per pendulum - easier to use but more cross coupling.

Soft in all 6 degrees of freedom.



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Recent update of **TorPeDO** development was presented.

- Motivation of Newtonian noise mitigation using gravity gradiometer.
- Mechanical, Interferometer sensors, control design.
- Current sensitivity.
- Upgrade activities:
 - Seismic isolation chain,
 - Local sensors, quadrupole
 - Newtonian noise generator.

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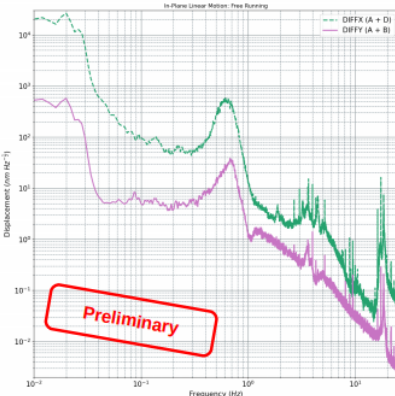
DIFFX and DIFFY

Again using idealised diagonalisation matrix.

DIFFX is dominated by cavity D motion.

DIFFY shows good cancellation.

- Less common motion at ≈ 20 Hz.
- Only 1 of the roll modes is clearly visible - somewhat expected.
- Less intrusion of DRZ.



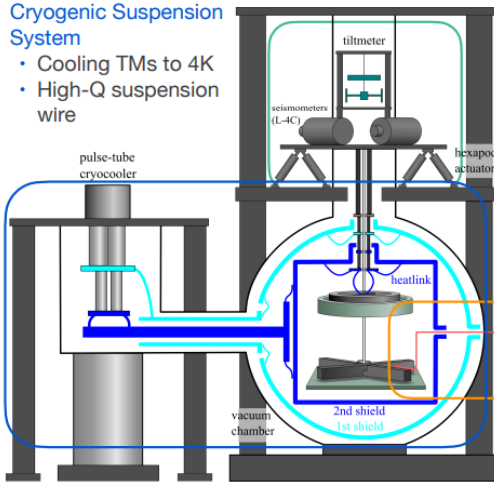
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TOBA [Satoru Takano]

Setup of Phase-III TOBA

Cryogenic Suspension System

- Cooling TMs to 4K
- High-Q suspension wire



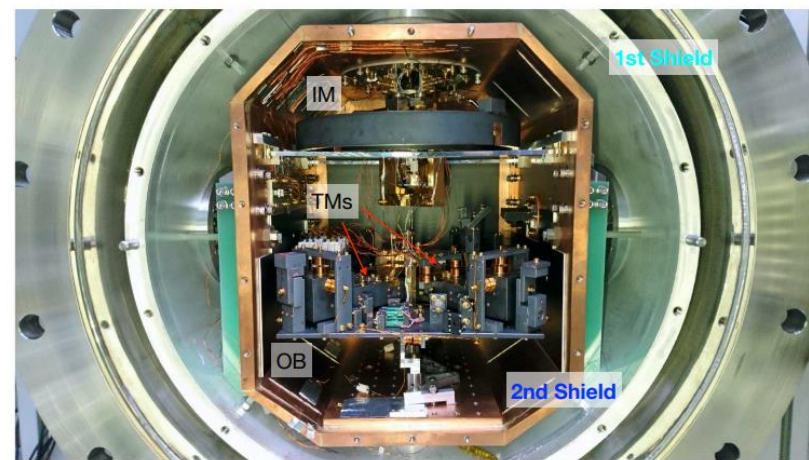
Active Vibration Isolation System

- Reduction of vibration at the suspension point
- Reduction of vibration induced cryocooler

Optical System

- Rotation measurement by high-sensitive wave front sensor
- Beam jitter control in order to follow the incident beam to the optical bench

Current Setup

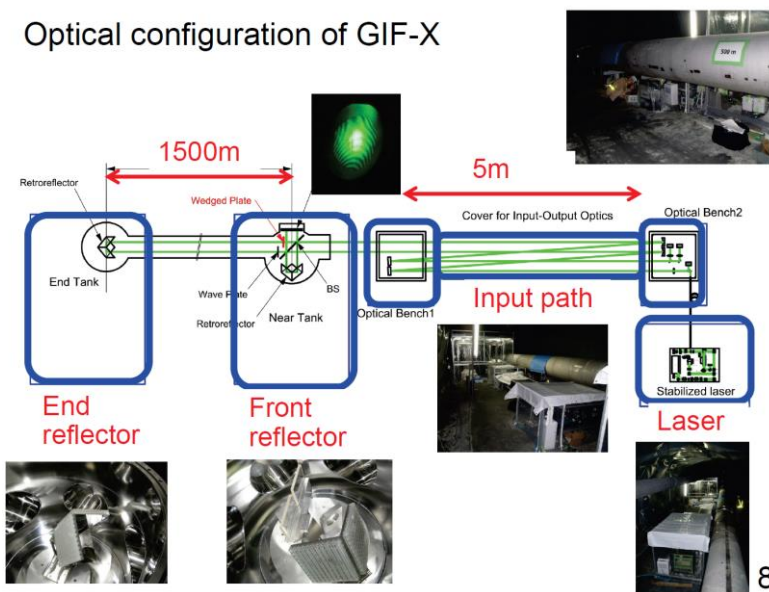


Recent update of **TOBA** development was presented.

- Motivation for development of gravity gradiometer.
- Design, Requirement and target sensitivity.
- Results of cryogenic operation and active vibration isolation system.
- Upgrade activities: Optical sensor, Silicon test mass and monolithic bench

KAGRA Site Results [Akito Araya]

Optical configuration of GIF-X



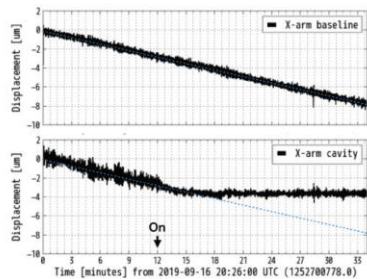
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Results by laser strain meter at the KAGRA site were presented.

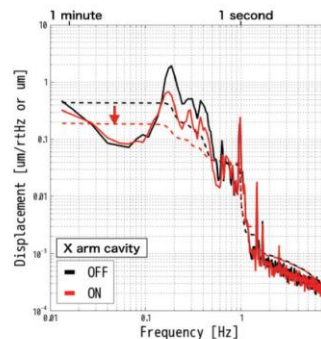
- Overview of 1,500m laser strain meter placed at the KAGRA site.
- Low-frequency strain variations.
- Earth tides and Topographic effects
- Barometric response at the site.
- Long-term strain drifts caused by rain, snow, and tectonic motion.
- Feed forward control of arm-length of the KAGRA interferometer.

Feedforward control of arm length of KAGRA using the strainmeter signal.

T. Akutsu et al., PTEP, 2021



Baseline motions observed by the GIF (top) and the change in length of the KAGRA X-arm cavity (bottom).



RMS of cavity length mainly due to microseisms reduced to ~50 %

Cryogenic Silicon Suspension [Graeme Eddolls]



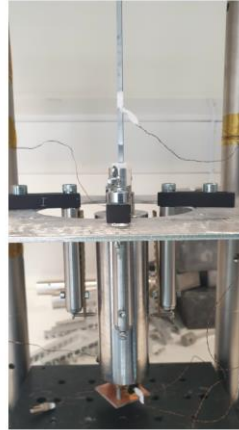
Suspension support structure



Stage 1 build



Ribbon attachment



Stainless steel mass and end stops



THE ROYAL SOCIETY

Recent updates of cryogenic Silicon suspension development were presented.

- Motivation for cryogenic Silicon suspension.
- Design and assemble procedure of the suspension
- Overview of the cryogenic system.
- Hanging results and interpretations.
- Lessons learned and future Prospects.



Results – many iterations

Suspension	Ribbon (775um thick, 0.20-0.25 m long)	Fuse end material	Glue	Result	Comments
1	Offcut, unpolished	Aluminium	Araldite	Failed - unknown	Basic sensor setup, ribbon landed intact
2	Offcut, polished	Aluminium	Eccobond 286	Failed - bottom	Moved sensor, aluminium standoff plate inserts. Turned off over Christmas, failed on warmup.
3	Offcut, polished (re-used from suspension 2)	Aluminium	Eccobond 286	Failed - unknown	Cryo-switch used, ambient sensor fitted, ribbon shattered at bottom of IVC
4	Offcut, polished (re-used from suspension 1)	Aluminium	Eccobond 286	Survived	Ribbon later failed likely due to shock contact with crystal from member of staff. Short circuit in heater system.
5	Offcut, polished (re-used from suspension 1/4)	Aluminium	Eccobond 286	Failed - bottom	Leak valve fitted, 2x sensor fitted to ribbon, sensor reshuffled, ambient sensor removed (capacity)
6	Full, polished	Aluminium	Eccobond 286	Failed - top	New OVC o-ring, vacuum issues
7	Offcut, unpolished	Macor	Eccobond 286	Failed - top	Macor fuse ends, vacuum issues
8	Full, unpolished	Macor	Eccobond 286	Survived	Sensors reshuffled, backing pump seals replaced (fixed), major compressor issues discovered. Compressor died.

Lab shut down

Notes: 'Offcut' ribbons are typically 1.60-1.76 mm in width, 'Full' ribbons are 3.5 mm wide
 'Unpolished' means the ribbon edge was left in it's laser-cut condition, 'polished' ribbons were lapped and super-polished along ends of ribbon inserted into fuse ends



Summary of Session #1

- Newtonian-noise cancellation using **array of seismometers** is tested at the 2G detectors and being considered for the 3rd generation detectors.
- Sensitive **gravity-gradiometers** for direct measurement of Newtonian noise are being developed : **TorPrDO** and **TOBA**.
- Knowledge on environment is also important for long-term stability of the cancellation. Results obtained at the **KAGRA** site results are presented.
- As a related technology, recent results of cryogenic Silicon suspension is also presented in the session.