

Compact sensors for test mass readout using deep frequency modulation interferometry

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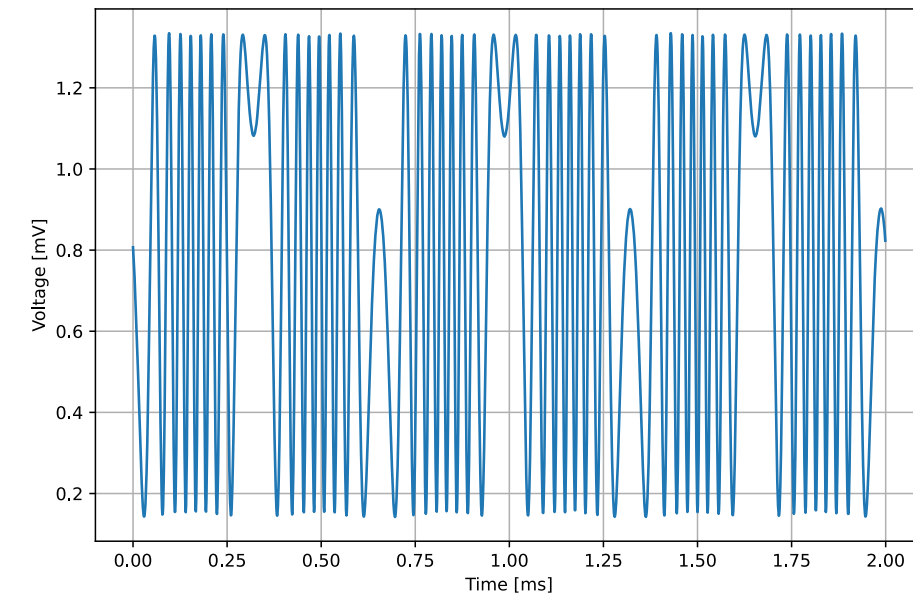
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What is Deep Frequency Modulation Interferometry (DFMI)?

In DFMI the laser frequency is modulated. If this laser is then used in an interferometer setup. The photodiode shows a modulated output signal as can be seen in the figure.

In this complex signal phase and distance information are encoded. Using an analytic readout algorithm, it is possible to extract these signal parameters.

Through this approach we are able to achieve precise displacement readout as well as absolute ranging with reduced complexity and compact sensing heads.

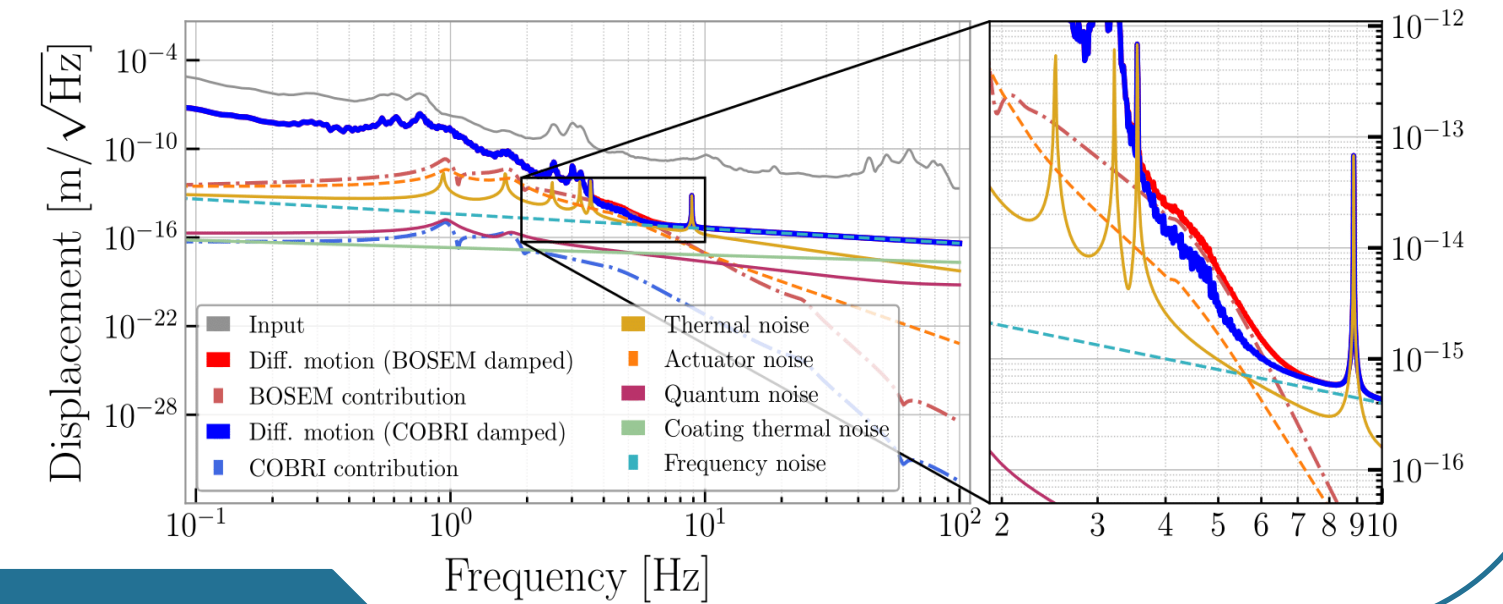


We plan to test the COBRI in our Interferometer Displacement Sensor Testbed (IDIST), consisting of two HRTS suspensions monitored with our local sensors and compare them to the currently used BOSEM. The experiment will be located inside our VAcuum system for ThIrd generation GRAVitational wave-detector prototyping (VATIGrav) in Hamburg.

Currently we are working on the laser preparation and stabilization. Additionally, we are installing an in-vacuum seismometer for a better active seismic isolation.

Want to know more?

Weickhardt et al, DOI: [10.1088/1361-6382/ae1a2d](https://doi.org/10.1088/1361-6382/ae1a2d)



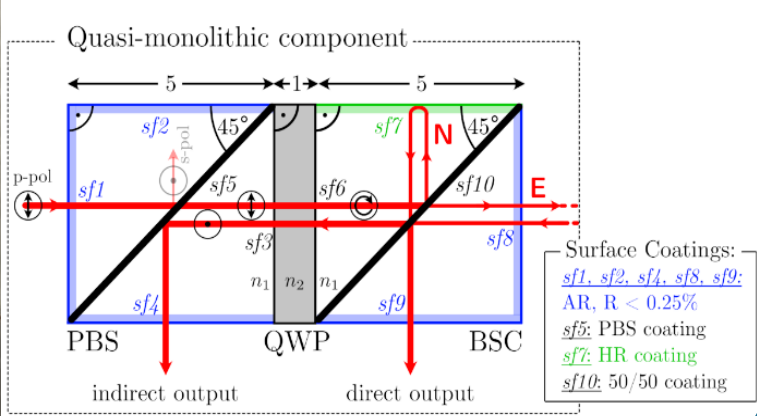
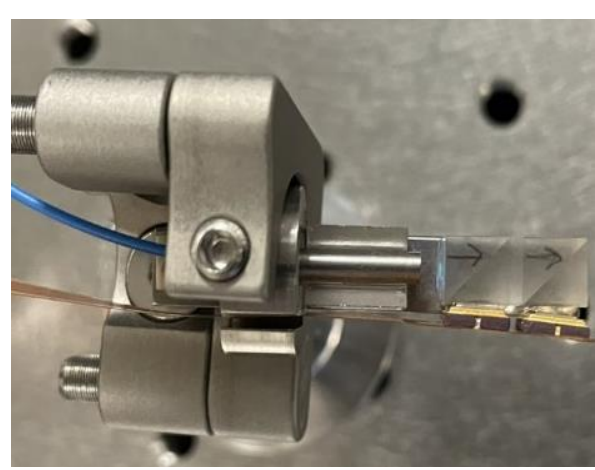
How do we plan to prove the sensor's performance?

How can DFMI be used in a sensor?

Our small sensor is called **Compact Balanced Readout Interferometer (COBRI)**. It is an unequal arm Michelson-Interferometer, consisting of a polarizing beamsplitter, quarter-waveplate and a beamsplitter. Glued together to a single glass piece, called **Quasi-Monolithic Component (QMC)**.

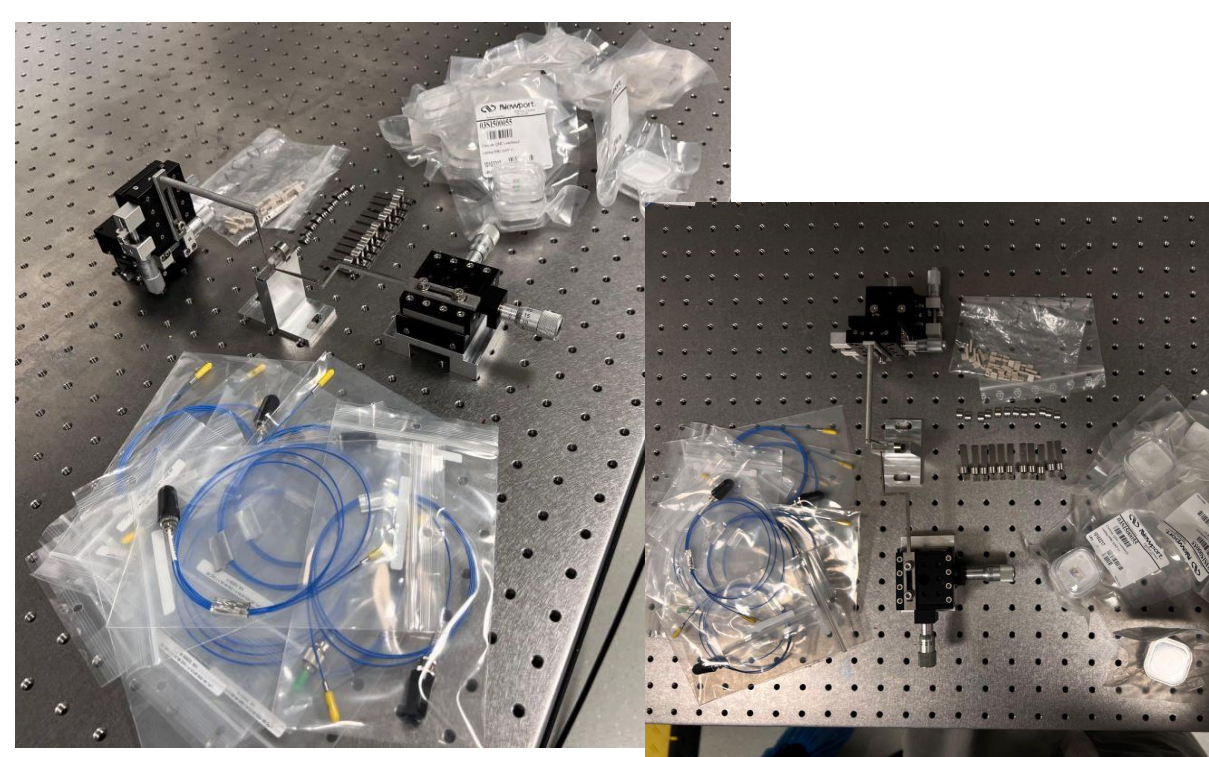
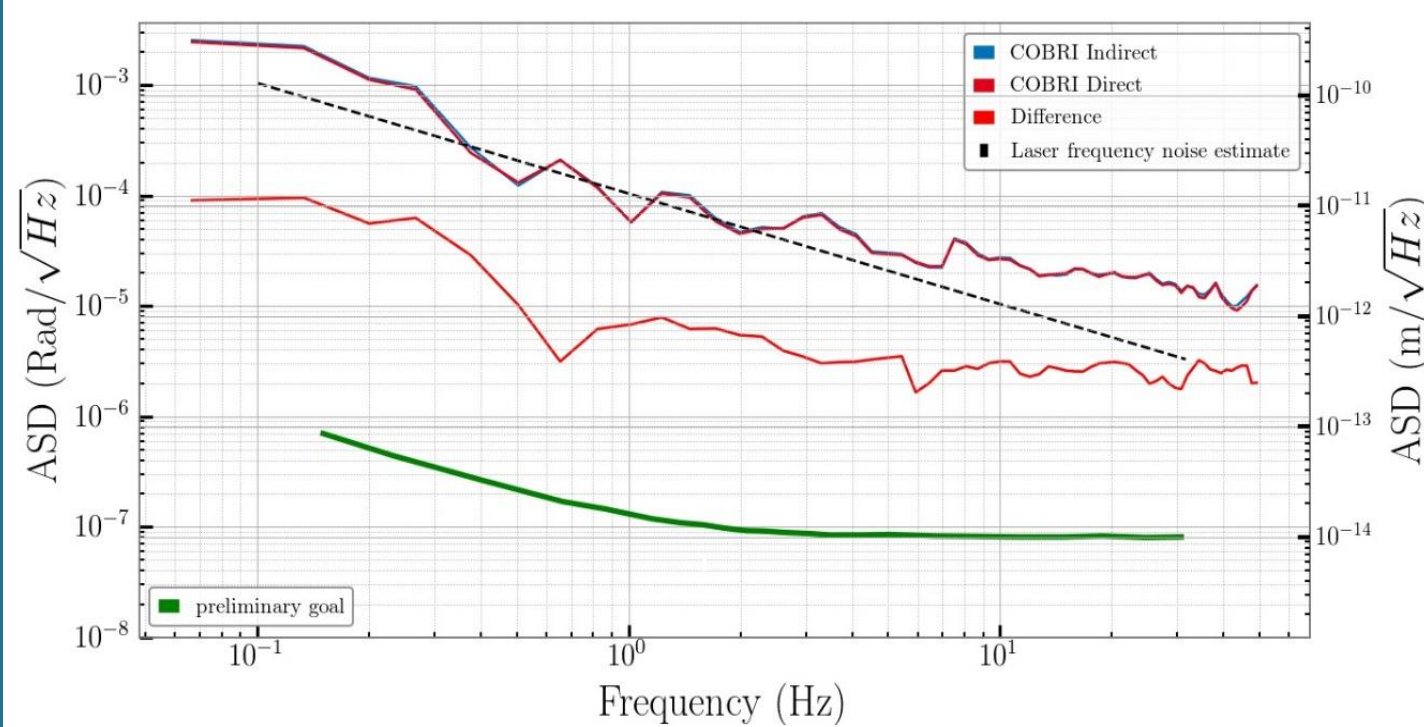
We utilize two photodiodes for a balanced readout.

The laser is added through a collimator resulting in a total sensor length of 35 mm.



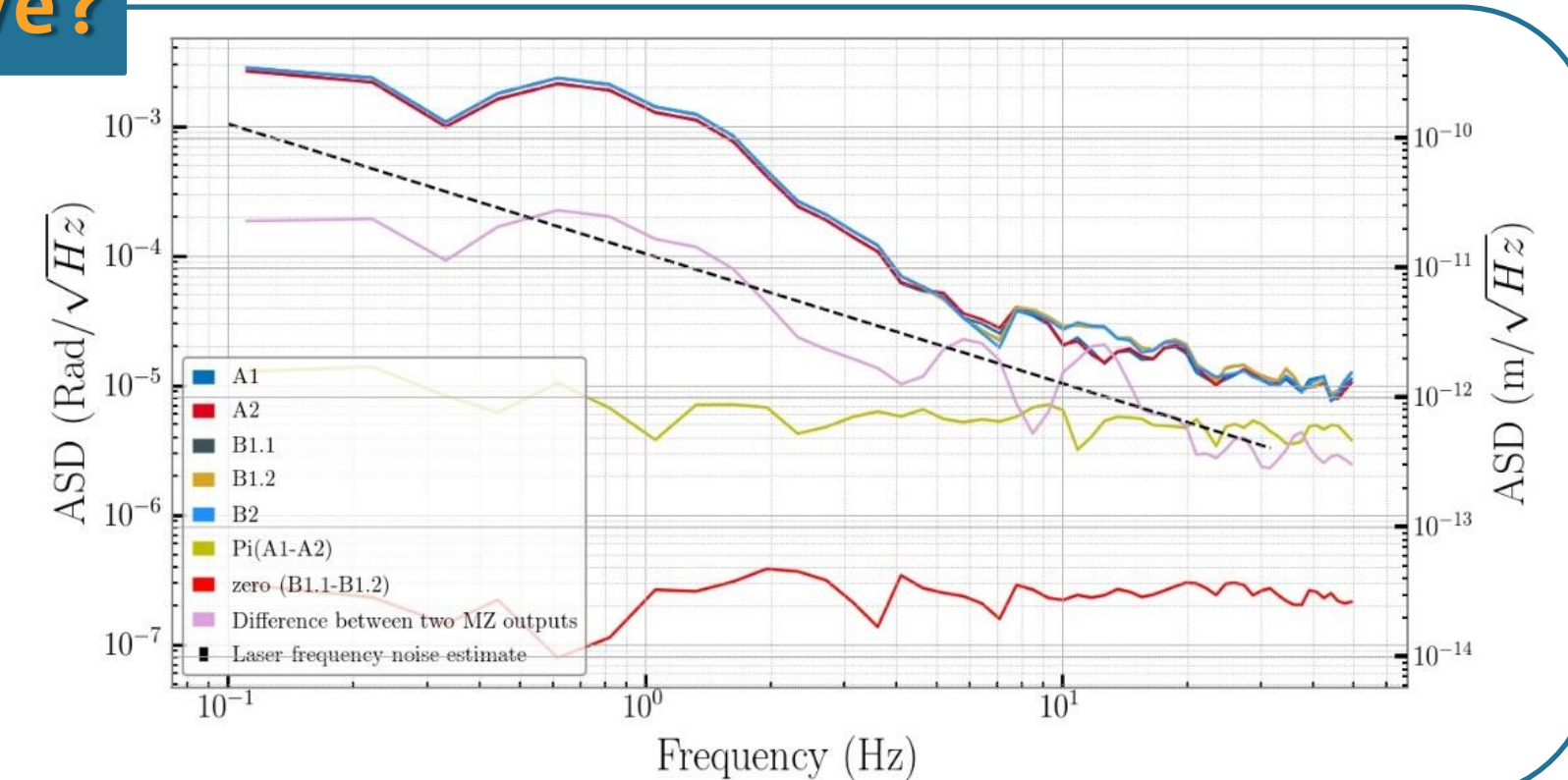
What is the current status?

We received a new QMC manufactured by Newport and are currently focusing our work on characterizing and optimizing the performance of the new prototypes while preparing for the sensor's series production.



What sensitivity level do we plan to achieve?

Our sensitivity goal for the COBRI is 10 fm/√Hz in the 0.1–10 Hz band. To understand what the limitations in the COBRI are we compare it to a free-beam Mach-Zehnder Interferometer setup. Currently we are limited by electronic noise and polarization issues.



Other projects with DFMI/COBRI

Other groups have started to implement DFMI or plan to use the COBRI for their experiments:

- LIGO sensor testing @ LIGO-MIT
 - Comparison of interferometric sensor performance
 - COBRI is one of the candidates
- GEMINI Facility @ GSSI
 - Plans to use the COBRI as displacement sensor in their GEMINI Vibration-Control Platform (GEM-VCP)
- DFMI for SPI @ AEI Hannover
 - Plans to use DFMI for their seismic platform interferometer (SPI) setup



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