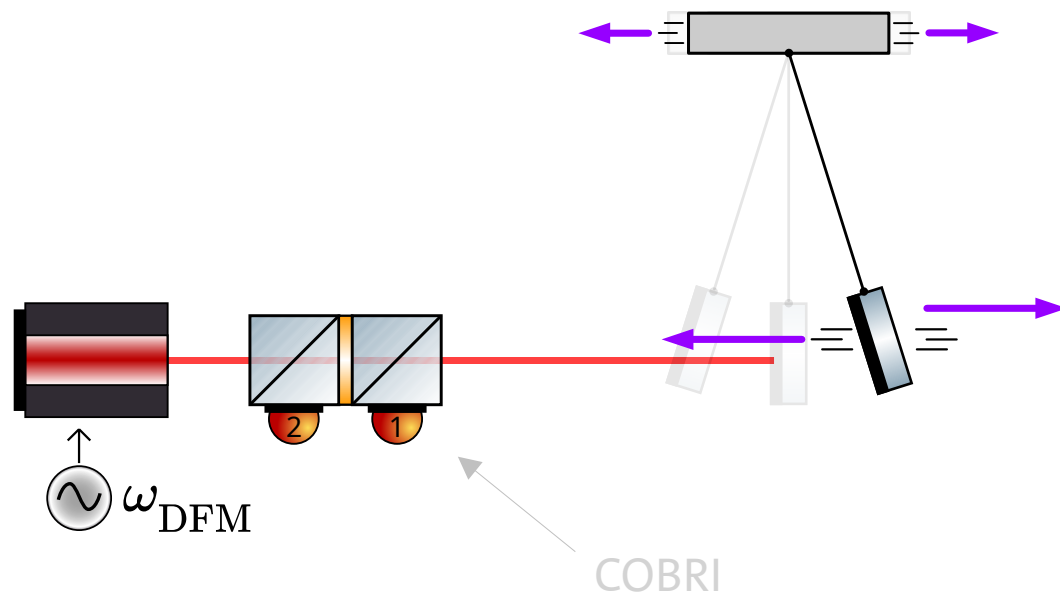
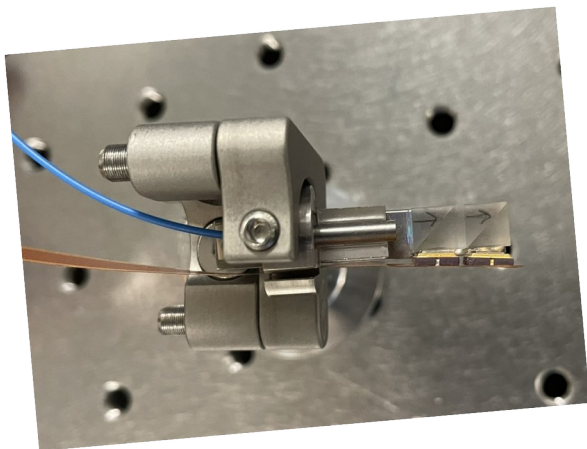


By
Leander Weickhardt,
Jan-Niklas Feldhusen,
Meenakshi Mahesh,
Charlotta Hugel,
Tobias Eckhardt,
& Oliver Gerberding

COBRI Sensor development for seismic isolation and control

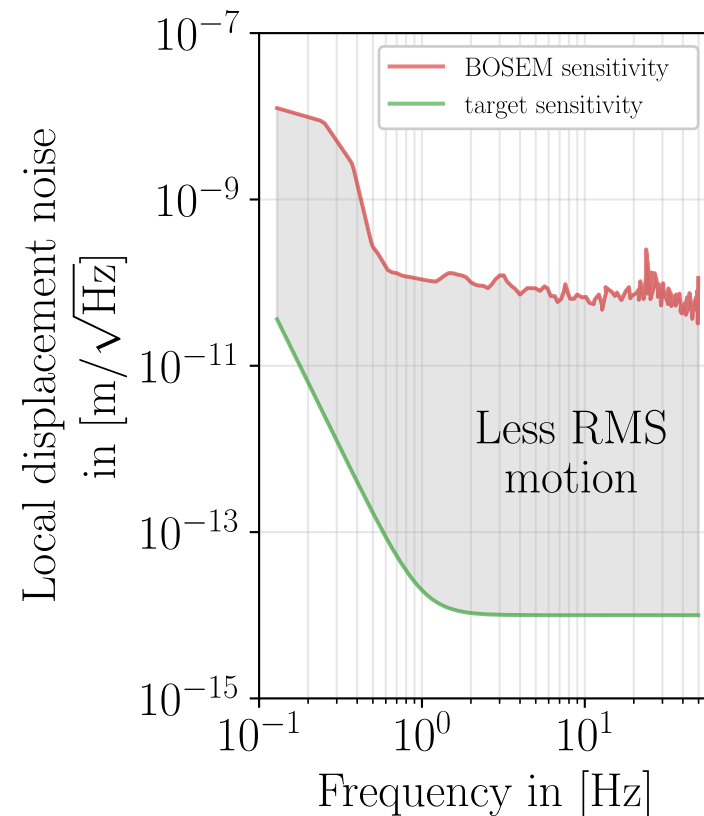
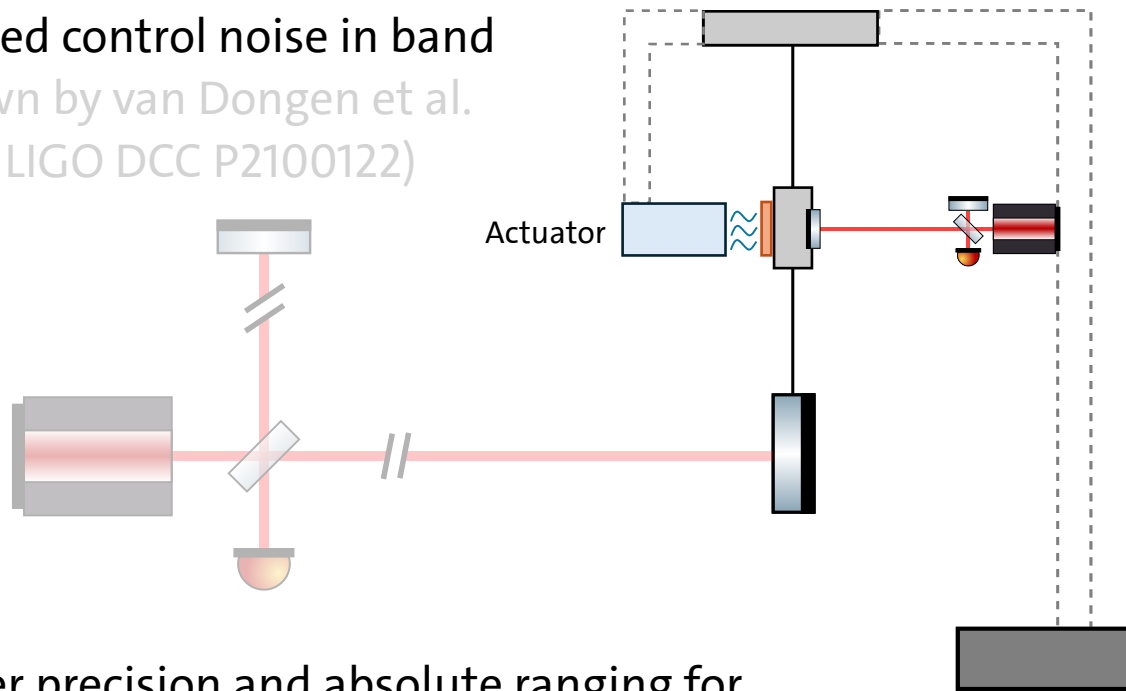


Goal: Improving the seismic isolation and (optic) alignment

► Motivation:

Reduction of RMS motion and
reduced control noise in band

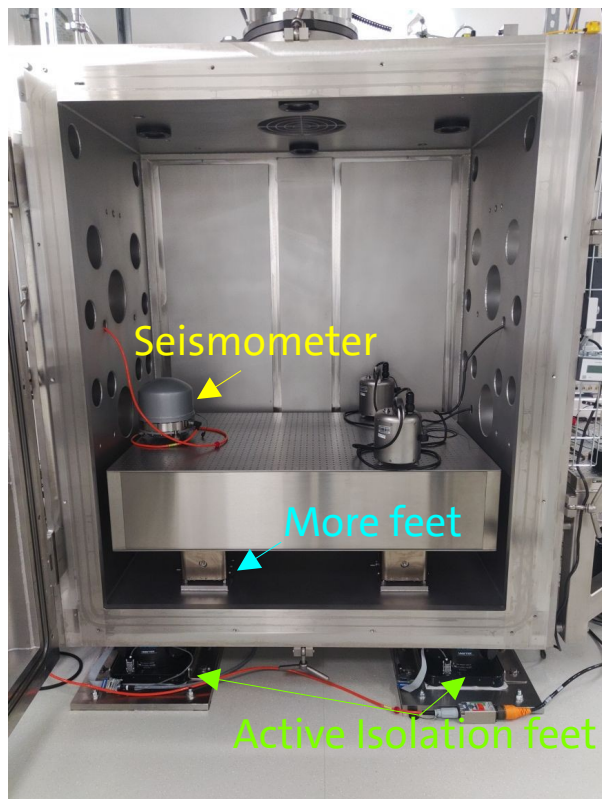
(Shown by van Dongen et al.
2022, LIGO DCC P2100122)



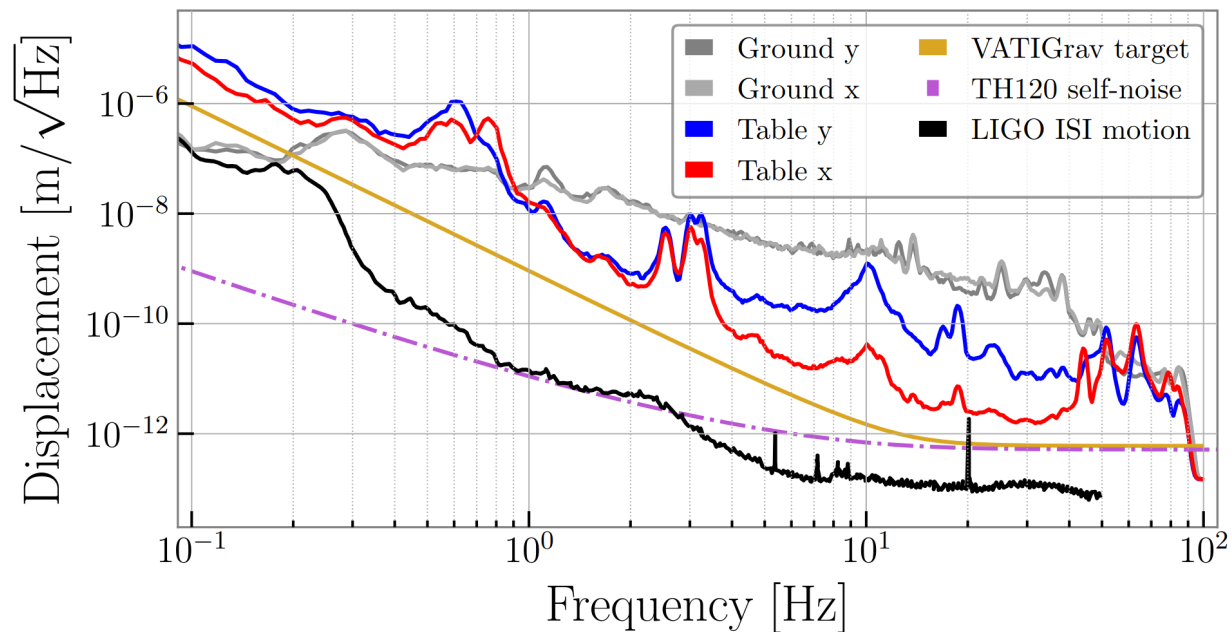
► Higher precision and absolute ranging for local displacement readout

VATIGrav

- “Pre-isolated” Vacuum chamber for seismic isolation experiments

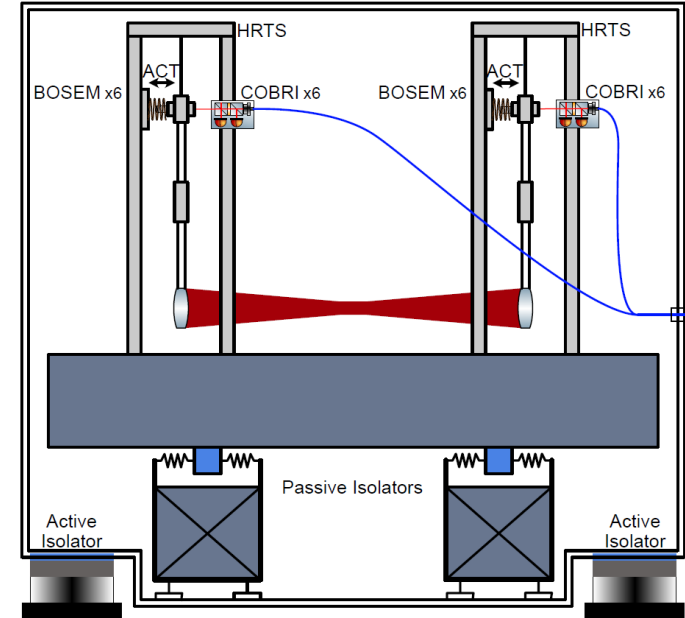
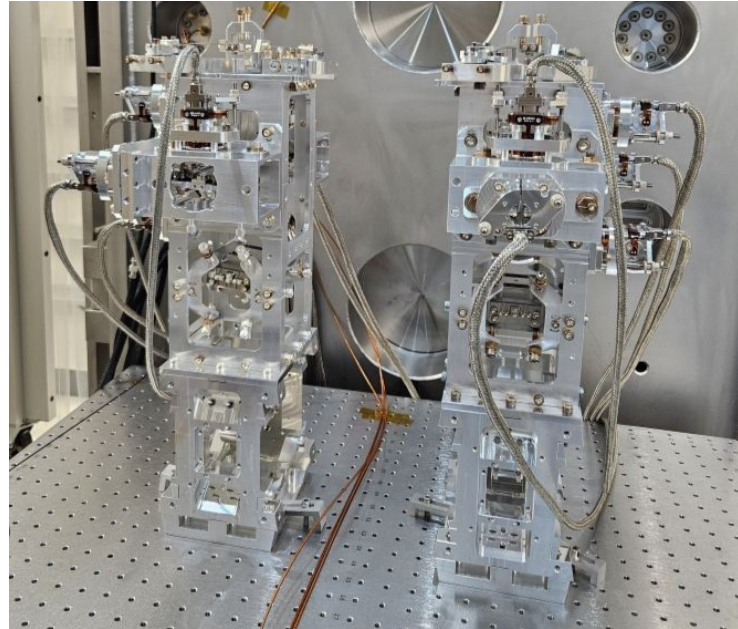


Source: Leander Weickhardt (UHH)



HRTS – HAM Relay Triple Suspension

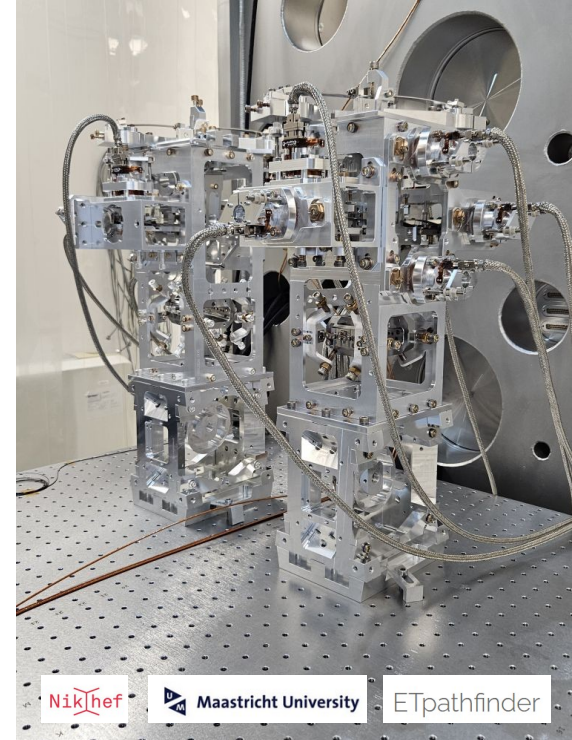
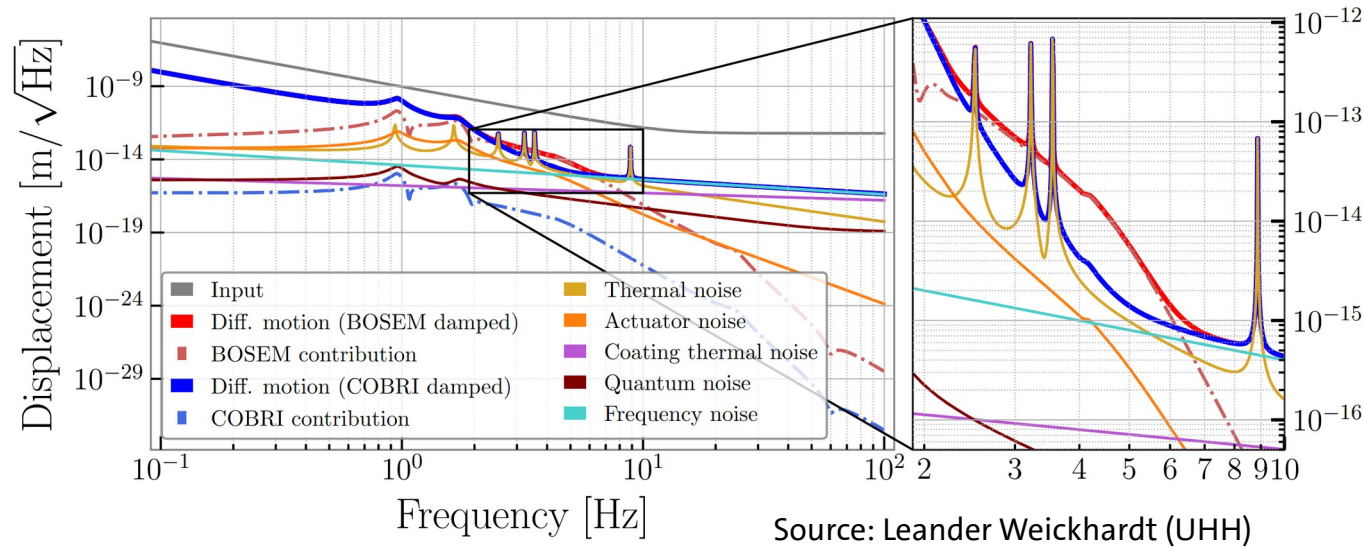
Source: Leander Weickhardt (UHH) & Jan-Niklas Feldhusen(UHH)



- Suspension used for i.e. input modecleaner optics
- Used to test local sensors for active seismic isolation

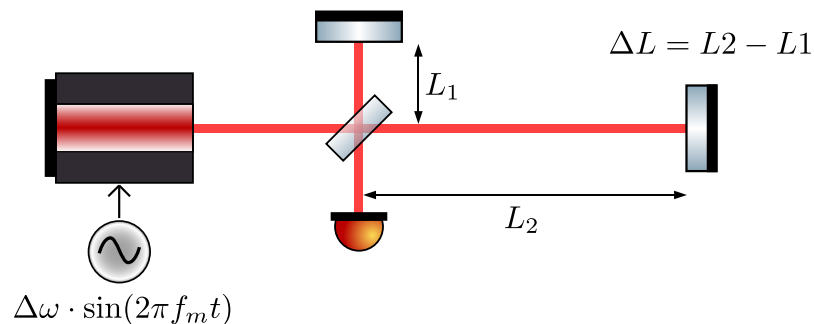
HRTS – HAM Relay Triple Suspension

- ▶ LIGO Noise estimation for improved local sensors



- ▶ Noise estimation for improved local sensors
- ▶ Currently writing paper (reserved DCC Nr: P2500323)

Deep-Frequency Modulation Interferometry (DFMI) for local displacement sensing



Measured signal:

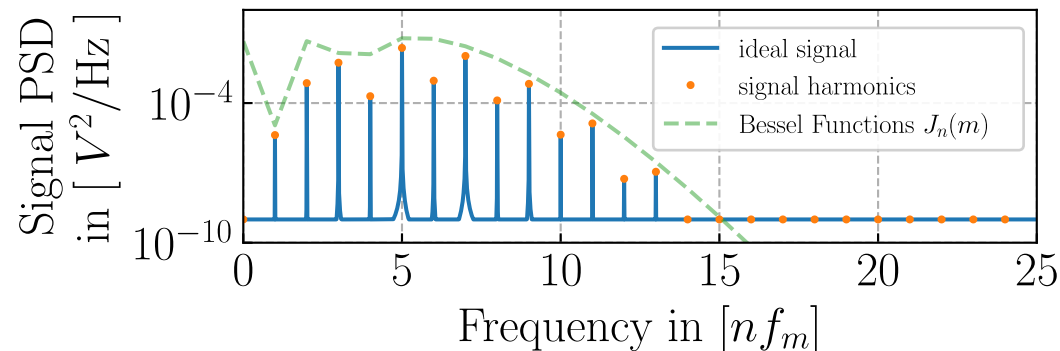
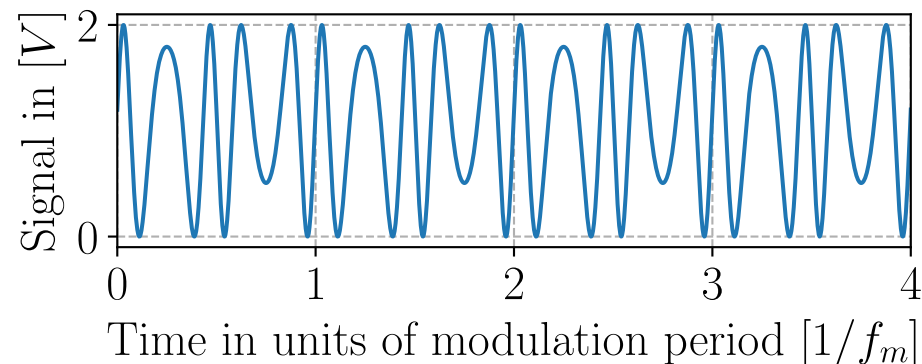
$$s(t) = B + A \cos(\varphi + m \cdot \sin(\omega_m t + \psi))$$

$$\varphi := \omega_0 \cdot \frac{\Delta L}{c_0}$$

Microscopic / precise
displacement information

$$m := \Delta\omega \cdot \frac{\Delta L}{c_0}$$

Macroscopic / absolute
distance information



Readout algorithm: Eckhardt & Gerberding 2023
(<https://www.nature.com/articles/s41598-024-70392-9>)

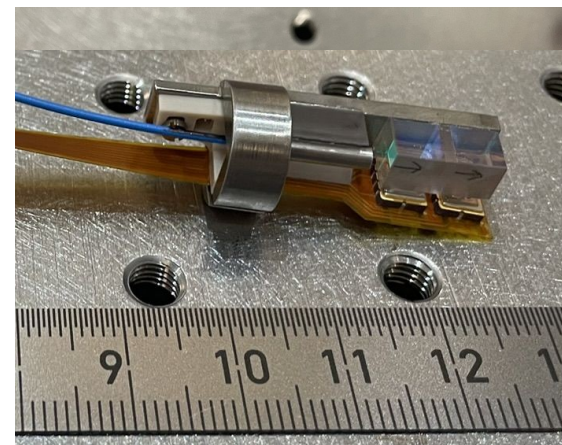
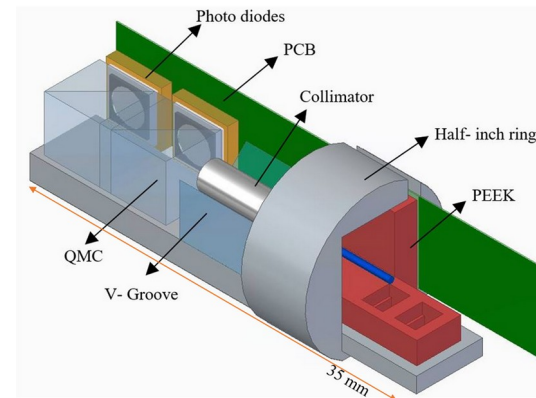
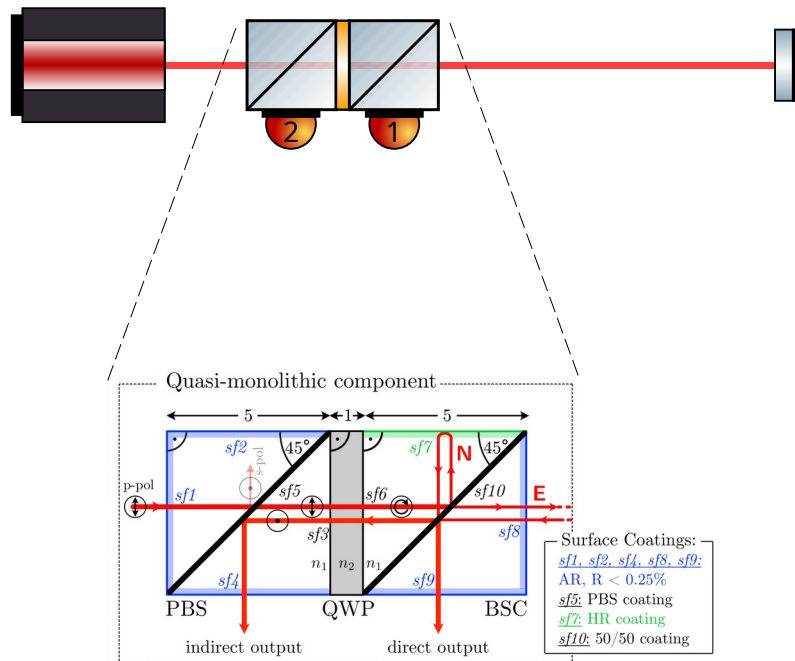
The COBRI

O. Gerberding & K.-S. Isleif, Sensors, 21(5), (2021)

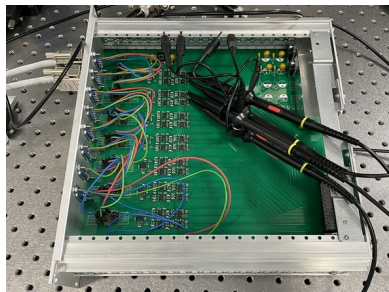
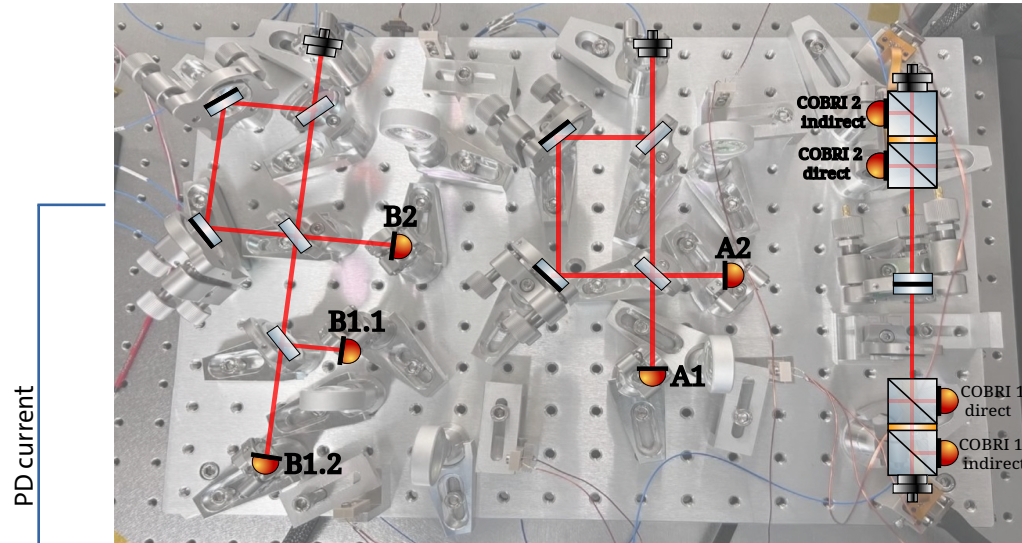
<https://dcc.ligo.org/LIGO-G2401825> , <https://apps.et-gw.eu/tds/ql/?c=17295>

Compact Balanced Readout Interferometer

- ▶ Compact DFMI sensor named COBRI
- ▶ Designed to be used in vacuum setup
- ▶ Currently in production / testing phase



Current experimental setup



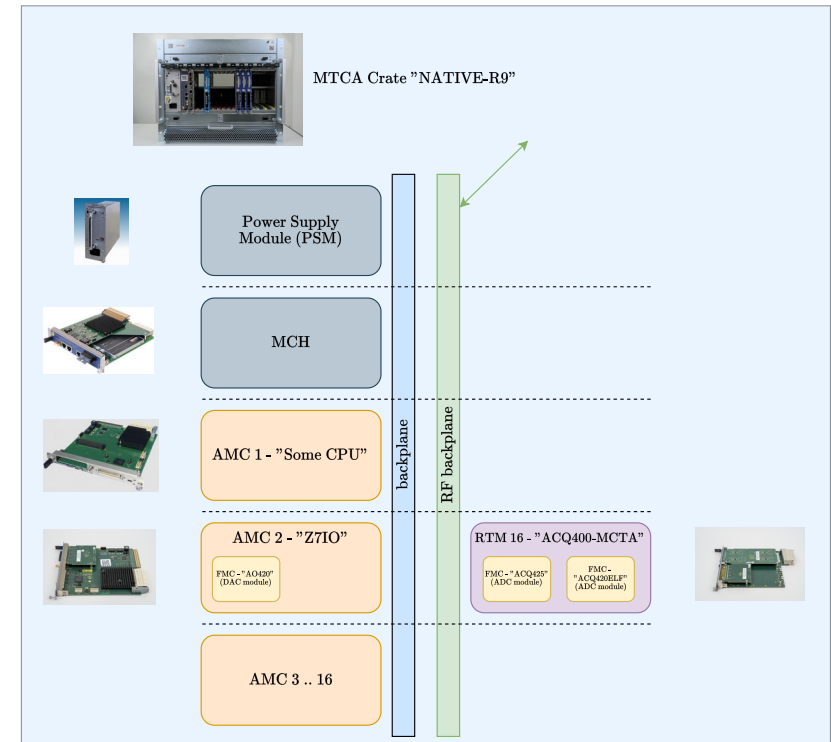
Trans-impedance amplifier

(voltage)
signal

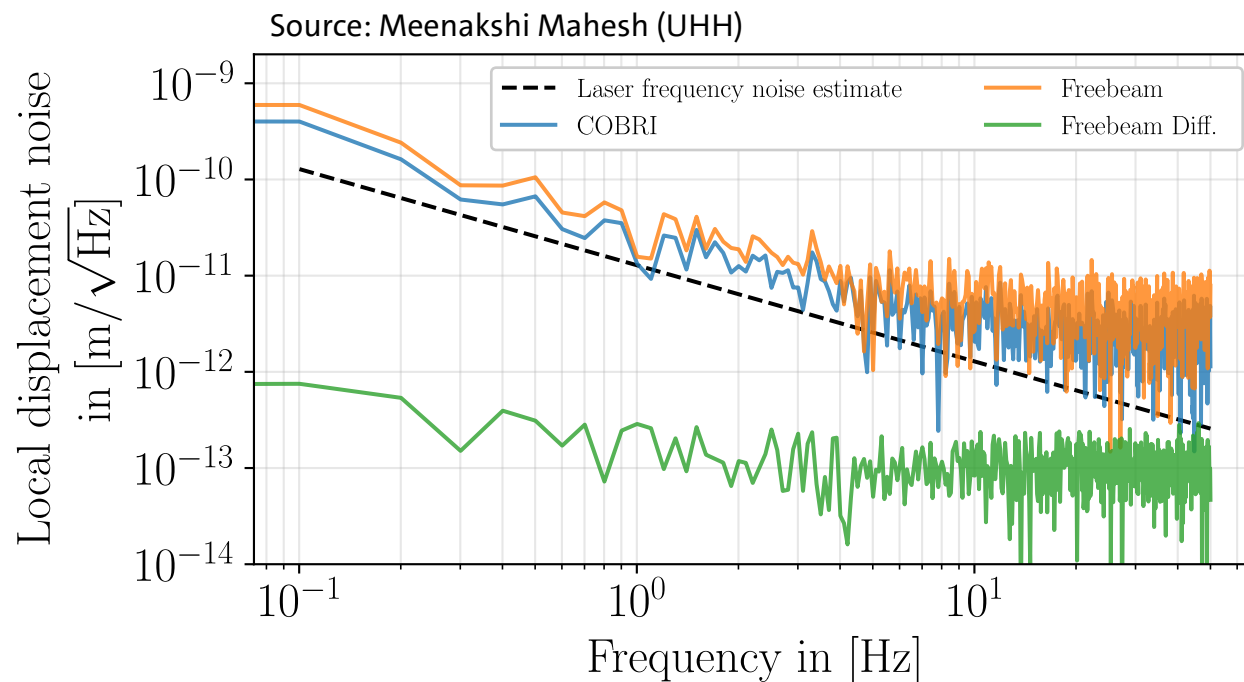


ADCs (and CPU+FPGA)

- Currently using MTCA based infrastructure (incl. ADCs, DACs, FPGA and CPUs)



Current performance and Outlook



- ▶ Current (best) performance around ~ 0.1 pm
- ▶ Working on implementing LIGO CDS (Control and Data System) in MTCA (incl. DFMI readout)
- ▶ Working on stabilizing laser frequency and amplitude for DFMI