

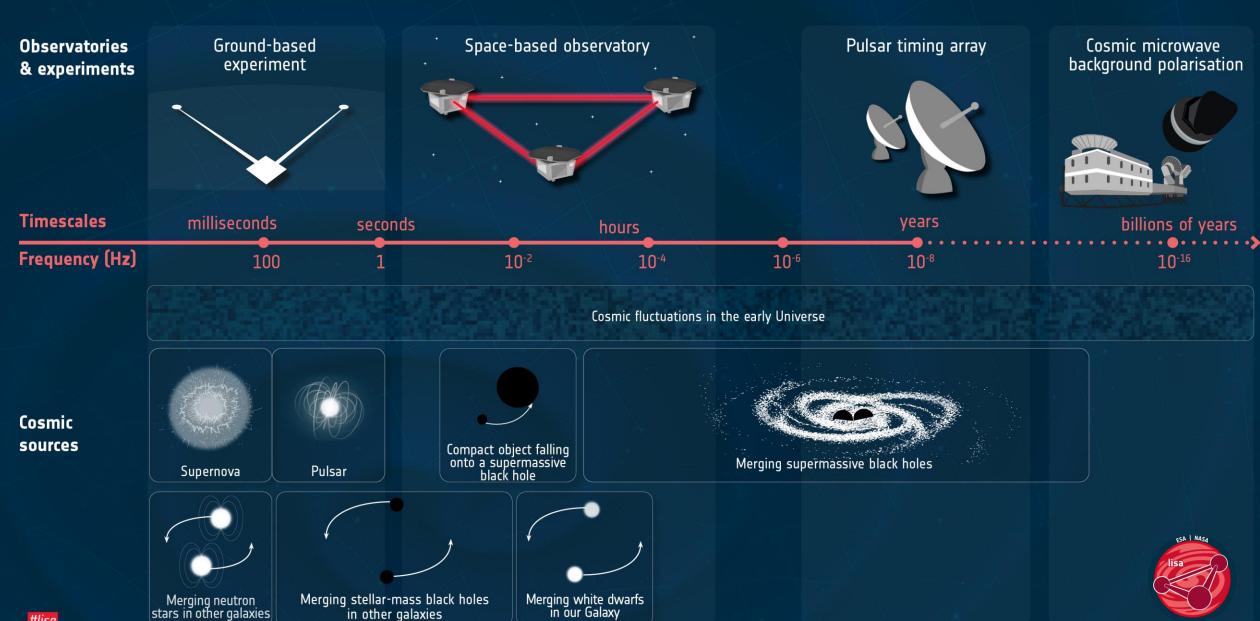
Testbed for Validating Second-Generation TDI and Clock Noise Correction for LISA

Karin Kruuse

THE SPECTRUM OF GRAVITATIONAL WAVES

in other galaxies

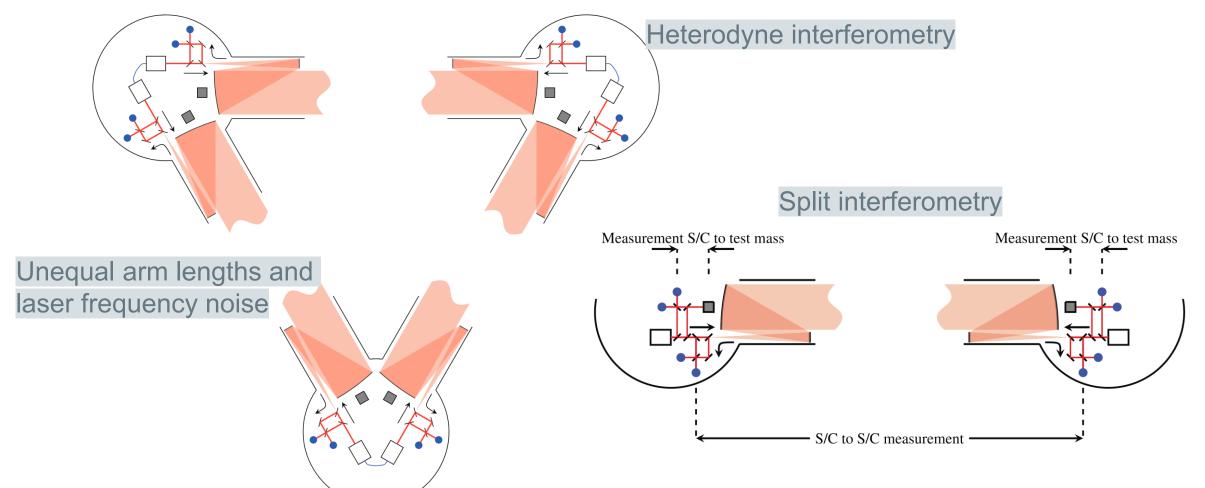






The LISA Satellites

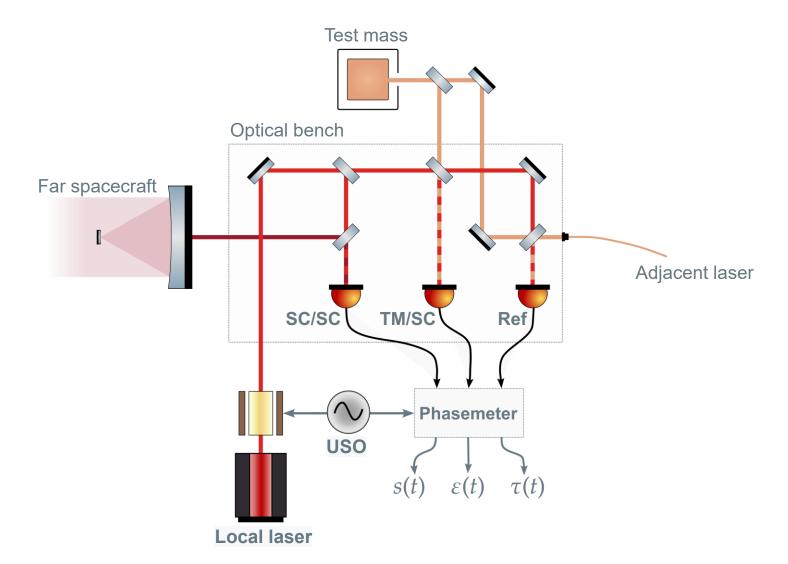




LISA Interferometric Metrology System







USO – Ultra Stable Oscillator

s(t) – science beat note

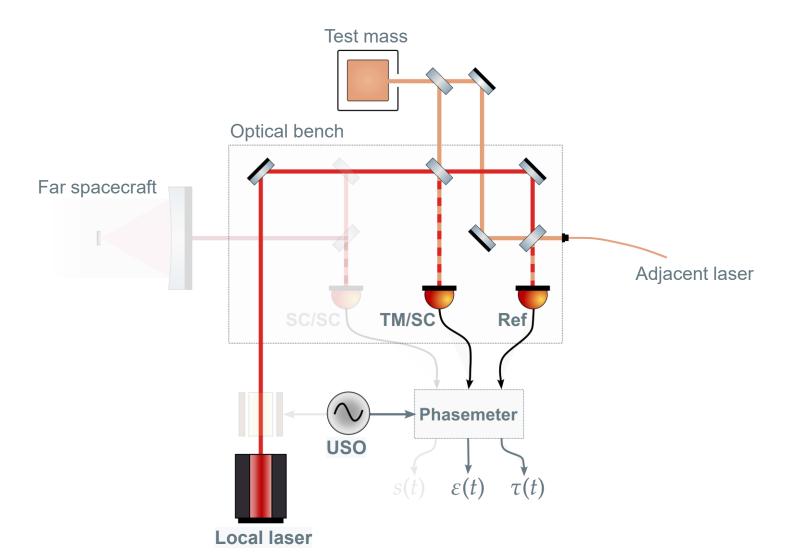
ε(t) − test mass beat note

r(t) – reference beat note

LISA Interferometric Metrology System







USO – Ultra Stable Oscillator

s(t) - science beat note

ε(t) − test mass beat note

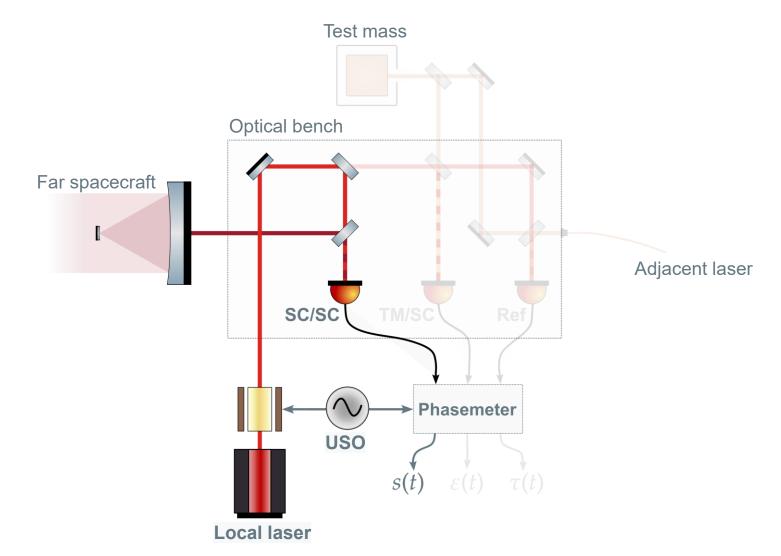
r(t) – reference beat note

LISA Interferometric Metrology System



MAX-PLANCK-INSTITUT FÜR GRAVITATIONSPHYSIK (Albert-Einstein-Institut)





USO – Ultra Stable Oscillator

s(t) - science beat note

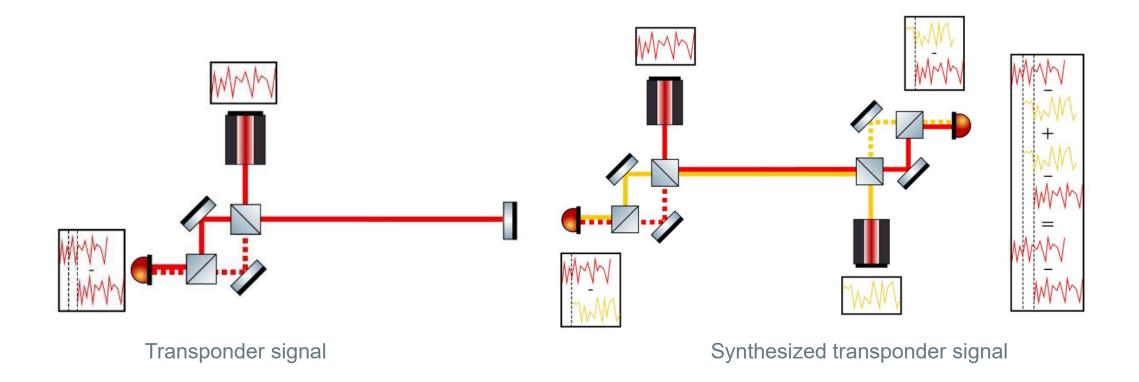
ε(t) − test mass beat note

r(t) – reference beat note

Laser Noise Reduction via TDI

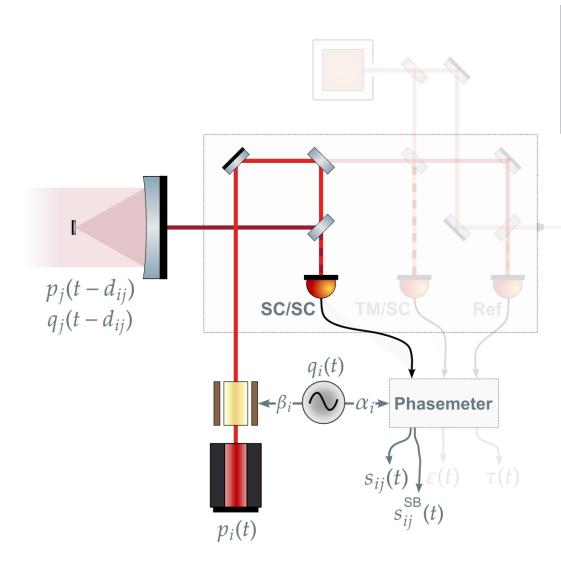


Time Delay Interferometry (TDI) is a cluster of methods to construct virtual equal arms in post-processing.



Clock Noise Reduction

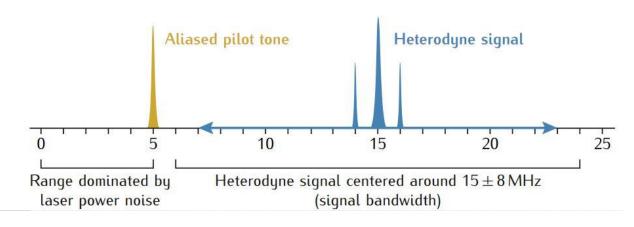




After demodulation, considering laser noise and clock jitter:

$$s_{ij}(t) = p_i(t) - p_j(t - d_{ij}) + \alpha_i q_i(t)$$

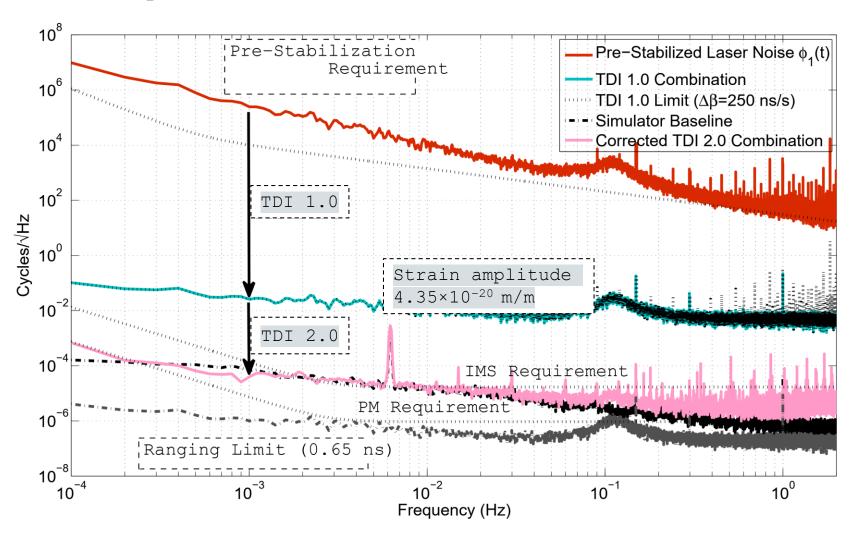
$$s_{ij}^{SB}(t) = p_i(t) - p_j(t - d_{ij}) + \beta_i q_i(t) - \beta_j q_j(t - d_{ij}) + \alpha_i^{SB} q_i(t)$$



Lisa metrology system-final report, 2014

Previous Experiment





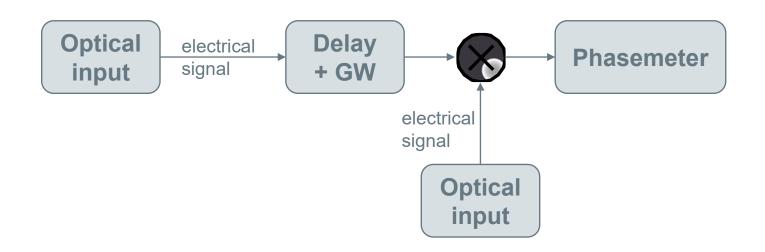
miniLISA



miniLISA is a hardware testbed that aims to simulate LISA's signal chain and test whether we can recover a gravitational wave signal from a realistic, noisy system.

To start with, we want to test the combination of second generation TDI and the clock noise removal post-processing methods on experimental data.

miniLISA could also offer a substitute to modelled noise sources included in current data analysis.

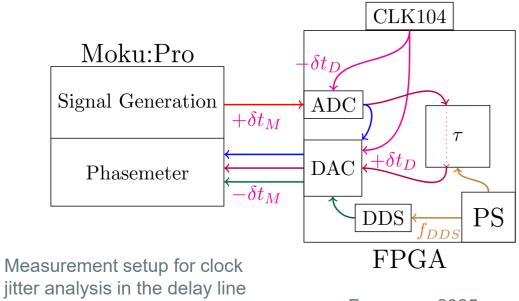


Current Status



A fully electronic implementation of the interferometry system together with a delay and gravitational wave injection has already been developed and is being tested.

- Time varying delays
- Doppler shifts for both the carrier and sidebands
- Gravitational wave injection





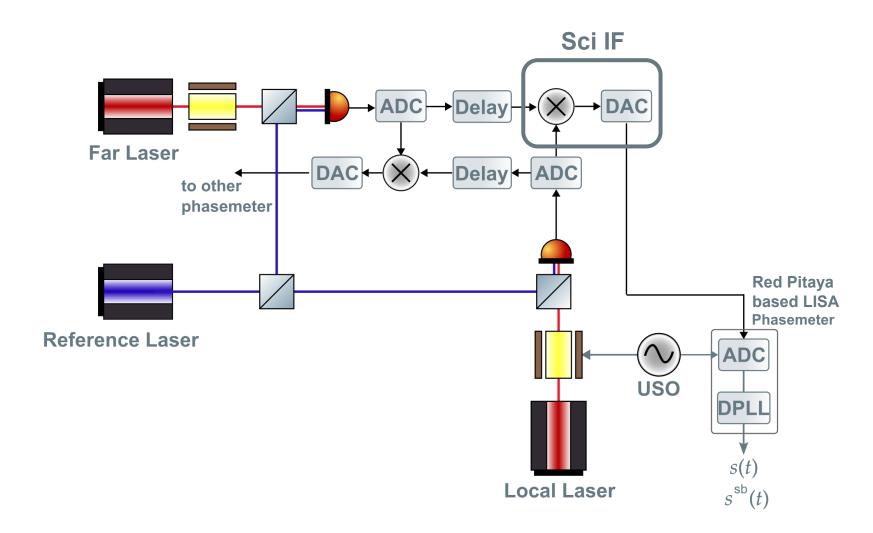
AMD Zynq™ UltraScale+™ RFSoC ZCU208 Evaluation Kit

Ferguson, 2025

One-arm Phase Measurement

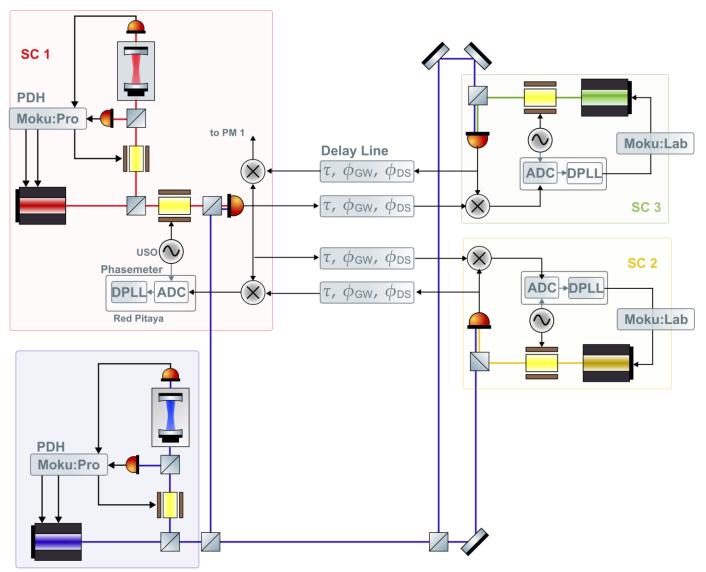


Set up for generating one LISA-like arm link.



Two-arm Testbed





Reference Oscillator

Possible Additions



- Third arm connection
 - for better peremeter estimation and data analysis
- More elaborate clocking system
 - To better replicate the clock noise removal in LISA

