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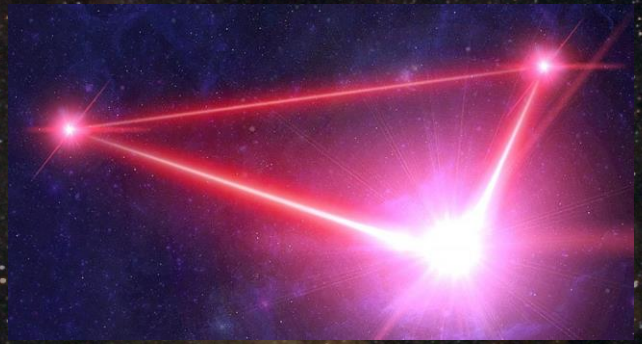

UHH – DESY MSK

02.12.2020

A LISA PHASEMETER BASED ON MICROTCA AS GROUND-SUPPORT EQUIPMENT

O. GERBERDING, J. MARJANOVIC, S. CHAOUCH-BOURAOUI, S. FARINA, J. ZINK, A. BRUNZEL, H. SCHLARB

CREDIT: THE MILKY WAY GALAXY BY DEREK ROWLEY

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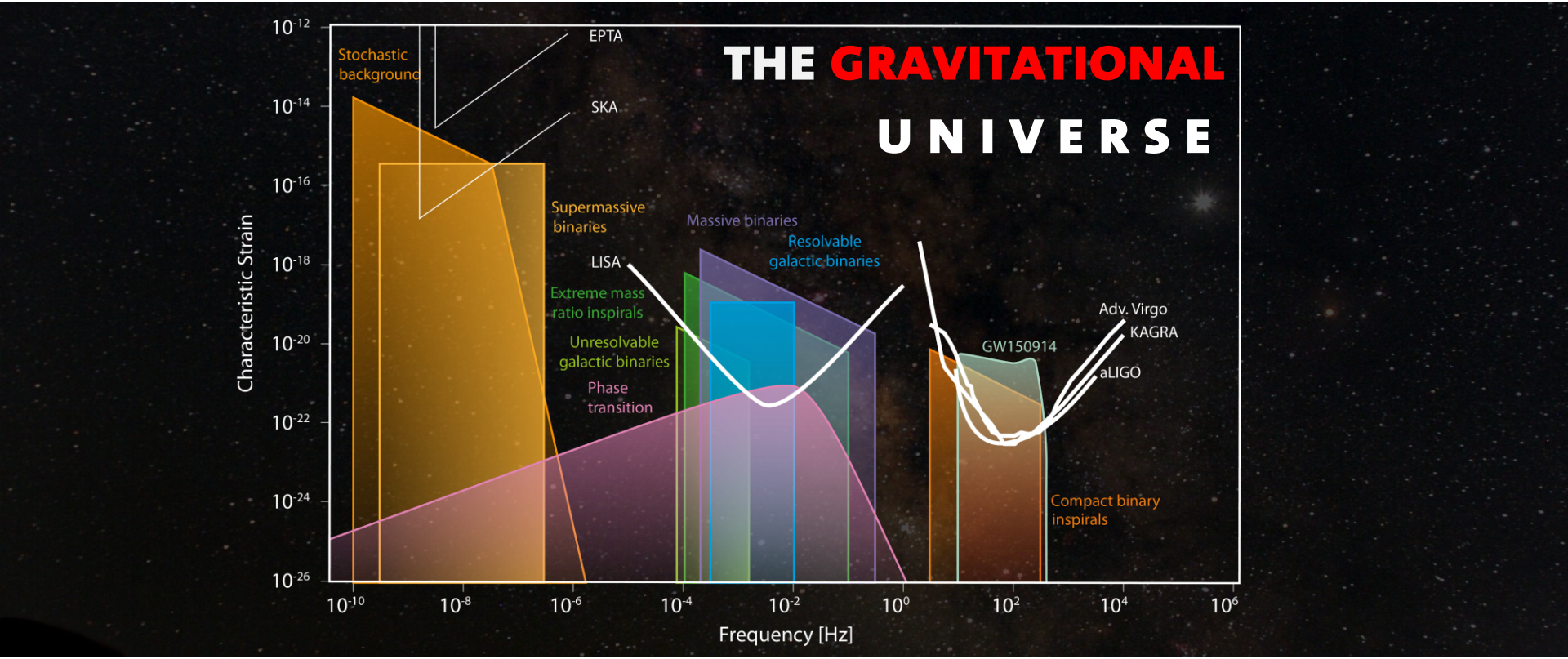

CREDIT: GWPLOTTER.COM, MOORE, CHRISTOPHER J., ROBERT H. COLE, AND CHRISTOPHER PL BERRY.

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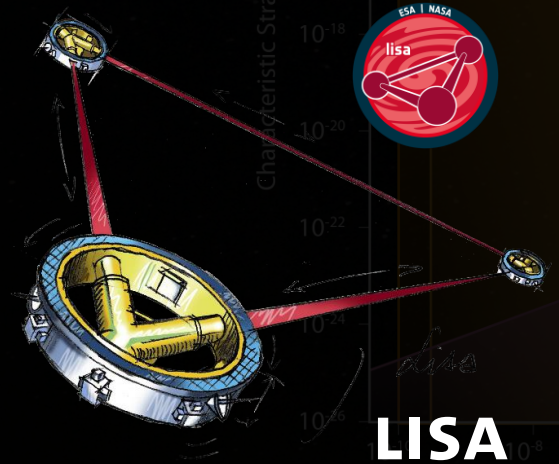
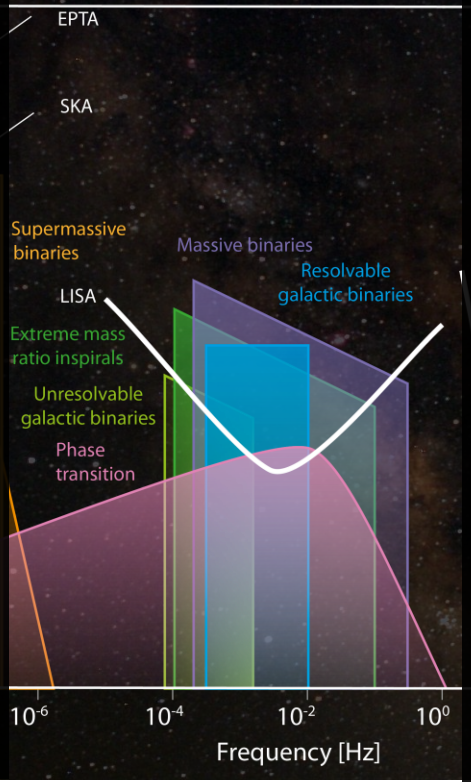
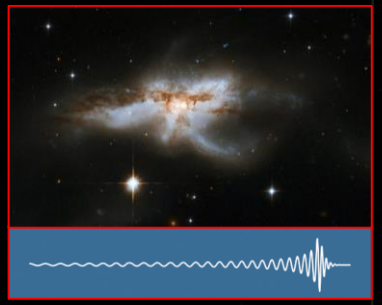
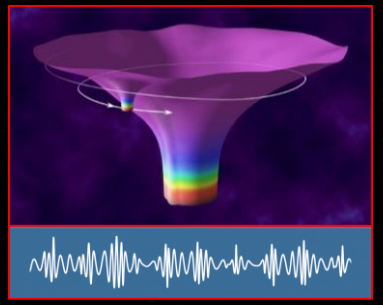
SPACE-BASED DETECTORS

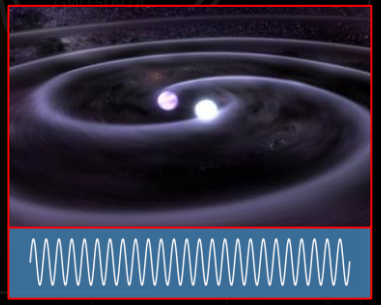


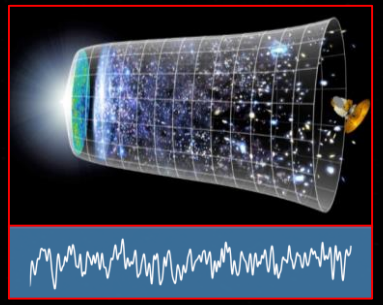
LISA











CREDIT: GWPLOTTER.COM, MOORE, CHRISTOPHER J., ROBERT H. COLE, AND CHRISTOPHER PL BERRY.

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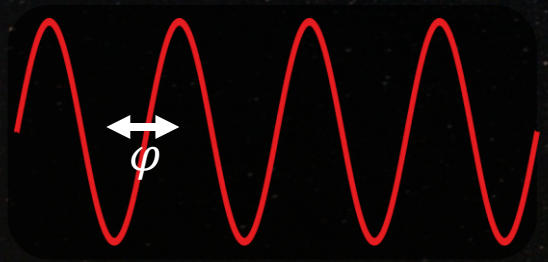
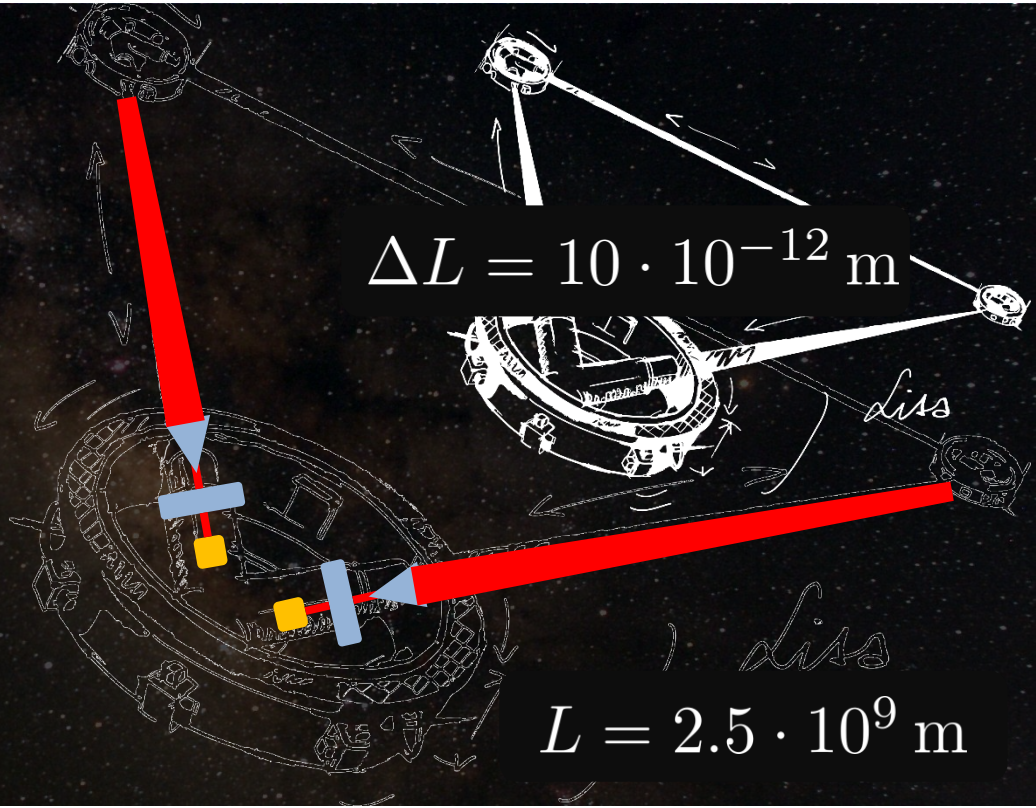
LISA METROLOGY

$$\Delta v_{\max} \approx 15\,\frac{\mathrm{m}}{\mathrm{s}}$$

$$\Delta f_{\mathrm{D}} \approx 15\,\mathrm{MHz}$$



$$\Delta\varphi < 6 \cdot 10^{-6}\,\mathrm{rad}\,@\,\mathrm{mHz}$$



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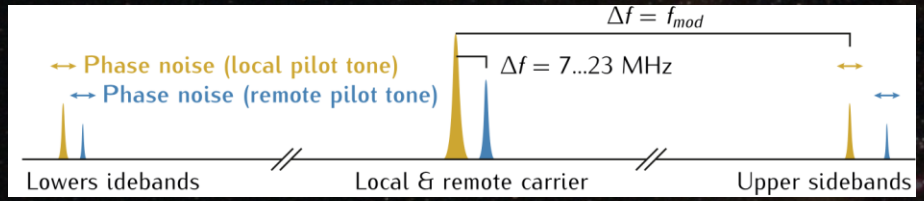
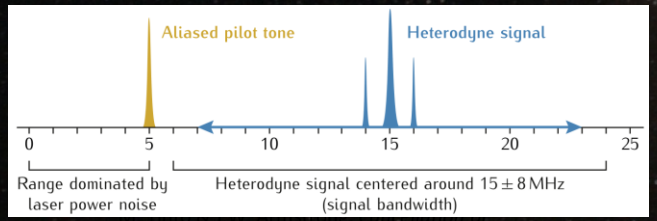
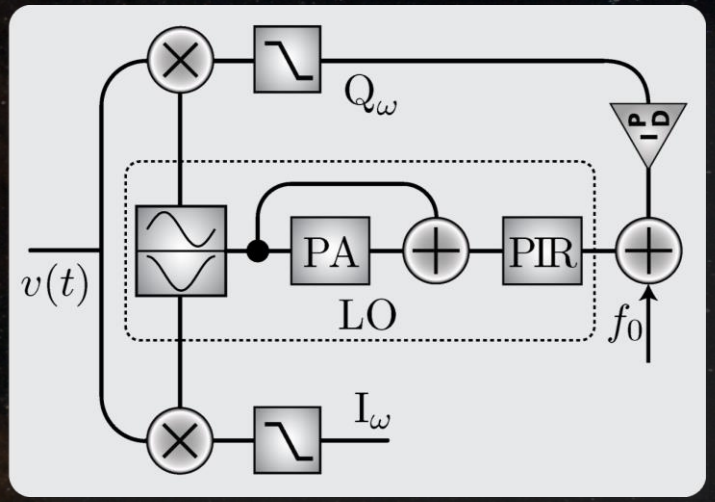
LISA PHOTODETECTOR SIGNALS



OPTICAL



ELECTRICAL



ALL-DIGITAL PHASE-LOCKED LOOP

O. Gerberding et al. CQG 30, 23 (2013)

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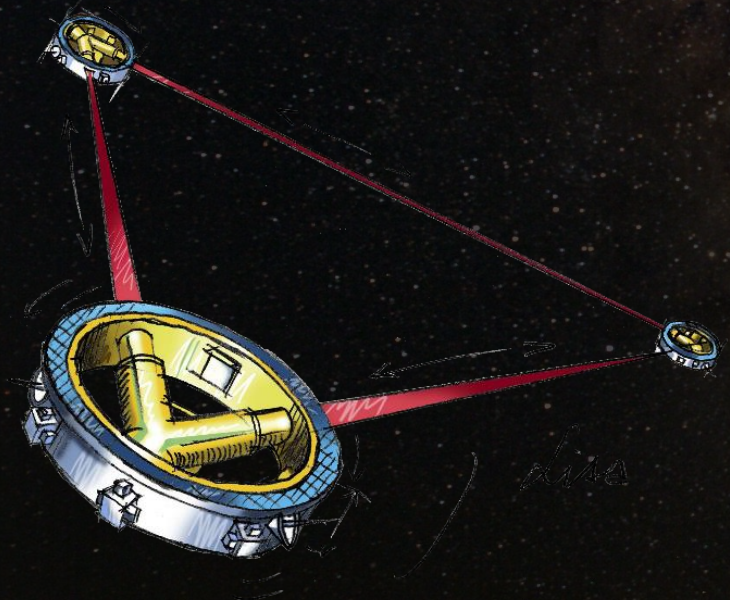
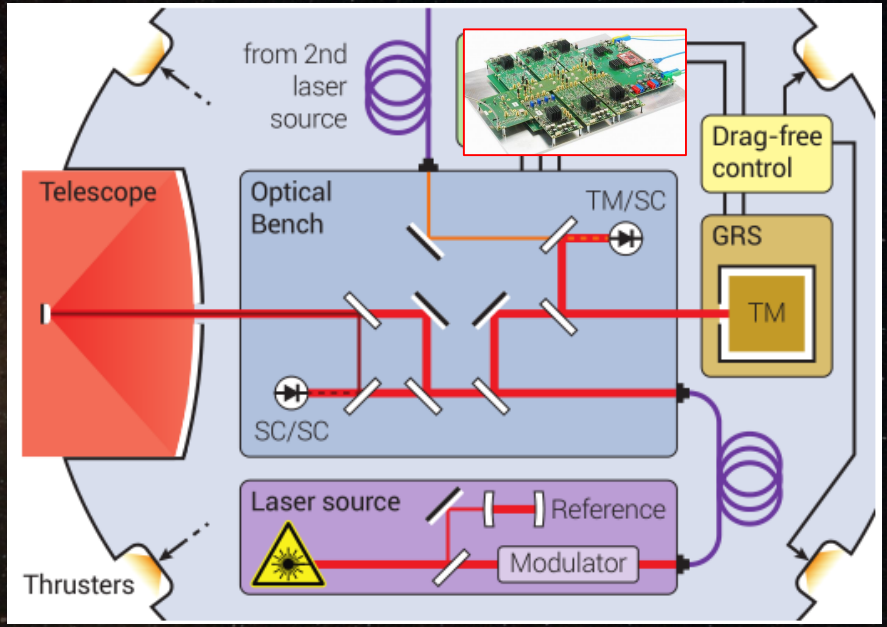
LISA INSTRUMENT





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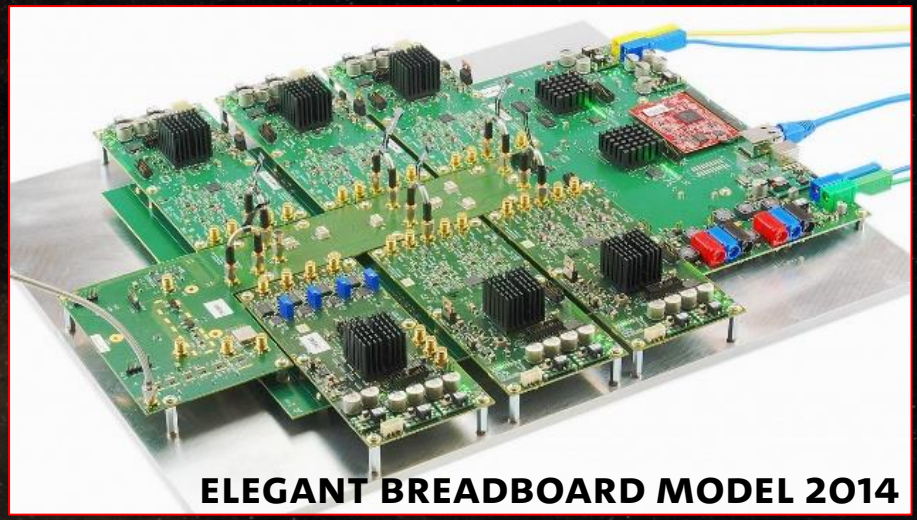
LISA PHASEMETER

O. Gerberding et al., Rev. Sci. Inst. 86, 074501 (2015)
S. Barke et al. Final Report, online (2014)

Functions:

- Phase readout for 48 channels
  - ADC jitter correction
  - Thermal control
  - Readout of clock-tone sidebands
- Generation & distribution of constellation timing signals
- Data transfer and pseudo-ranging via PRN modulation and delay-locked loops
- Beat note acquisition via FFT
- Filtering and data decimation
- Laser frequency control



M. Tinto & J.W. Armstrong, *Cancellation of laser noise in an unequal-arm interferometer detector of gravitational radiation*, PRD 59, 102003 (1999)

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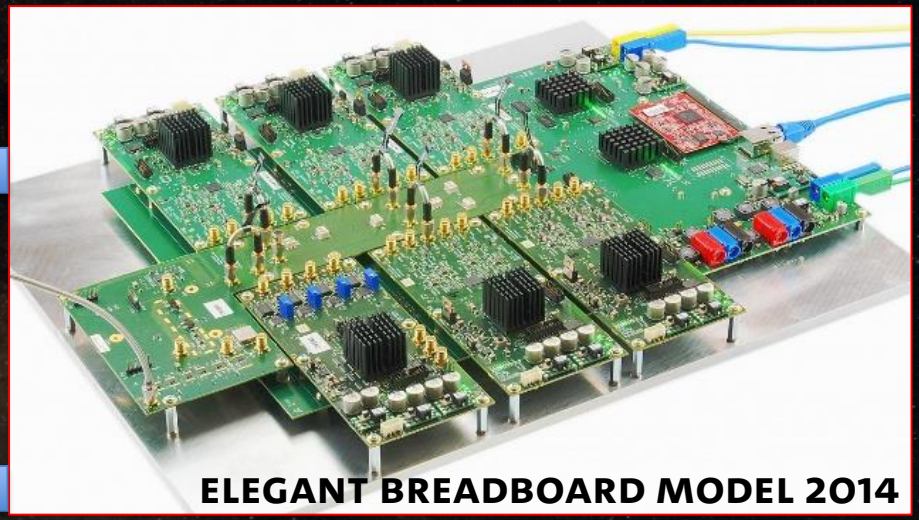
LISA PHASEMETER DEVELOPMENTS

O. Gerberding et al., Rev. Sci. Inst. 86, 074501 (2015)
S. Barke et al. Final Report, online (2014)



ELEGANT BREADBOARD MODEL 2014

LISA PM FLIGHT HARDWARE

LISA PM SIMULATOR

102003 (1999)

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PROJECT: LISA GROUND-SUPPORT EQUIPMENT: DEVELOPMENT OF A PHASEMETER SIMULATOR AND AN OPTICAL TOOLSET (DLR 50 OQ 2001)

STARTED 10/2020

DURATION OF 3 YEARS

SUBCONTRACTOR

DESY.

MICROTCA TECHNOLOGY LAB

PRIME

UHH

GRAVITATIONAL WAVE DETECTION

FUNDING AGENCY

DLR

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

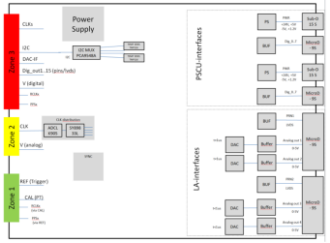
aufgrund eines Beschlusses des Deutschen Bundestages

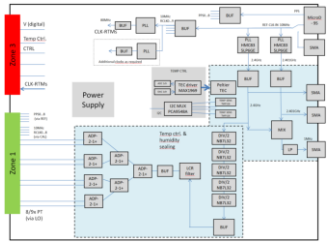
PM SIMULATOR - OVERVIEW

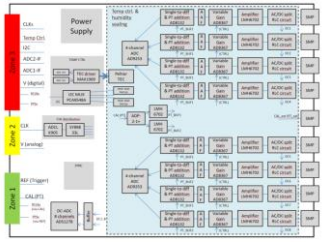
- Electrical ground-support equipment (EGSE) for assembly, integration, verification and testing (8-10 year period for LISA)
- Use available MicroTCA components as much as possible
- Develop three dedicated RTM (eRTM) modules to provide/simulate all PM interfaces and functions
- Transfer and adapt SL and SW to the new architecture
- Test the PM simulator (phase measurement and timing jitter fidelity are the most critical)

Preliminary design

W-Ie-Ne-R MTCA.4 1000W PS	AMC Backplane	RF Backplane	NAT-RPM-AC600?	
NAT-MCH-PHYS80			NAT-MCH-RTM-BM-FPGA-COM	Commerical /availabe
(DAMC-FMC1Z7IO)			DRTM-LISA-ADC	Custom developme
(DAMC-FMC1Z7IO)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	Channel extension
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)			DRTM-LISA-ADC	
DAMC-FMC1Z7IO (DAC) + FMC SpW			DRTM-LISA-DAC	
			DRTM-LISA-FDS	







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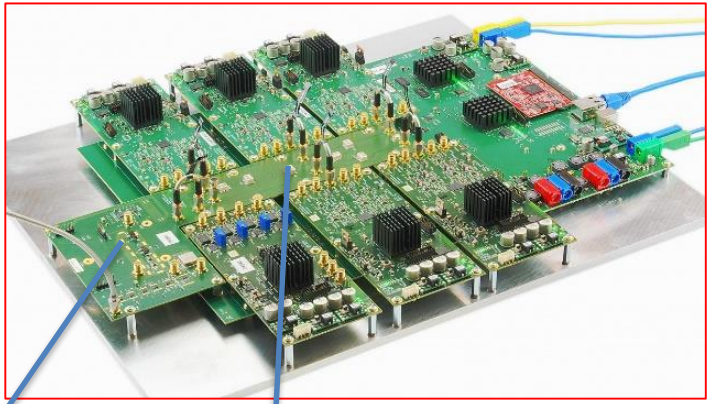
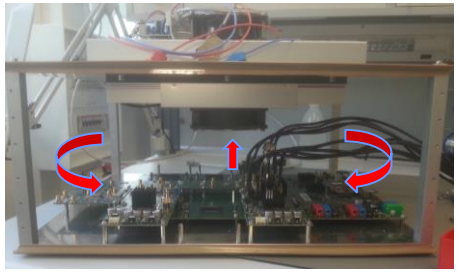
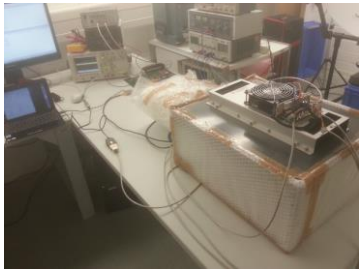
TIMING AND PHASE NOISE

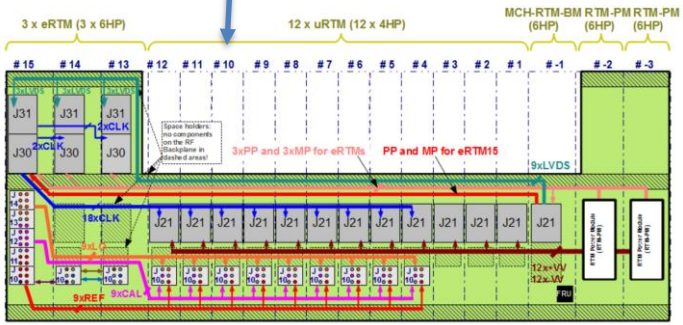
- MicroTCA.4.1 is a perfect fit to implement the distribution of pilot tones for jitter correction
- Modules like DeRTM-LOG1300 can be adapted to simulate a LISA frequency distribution system
- Active temperature stabilization has already been implemented in RTMs

S. Barke et al. Final Report, online (2014)
O. Gerberding et al., Rev. Sci. Inst. 86, 074501 (2015)





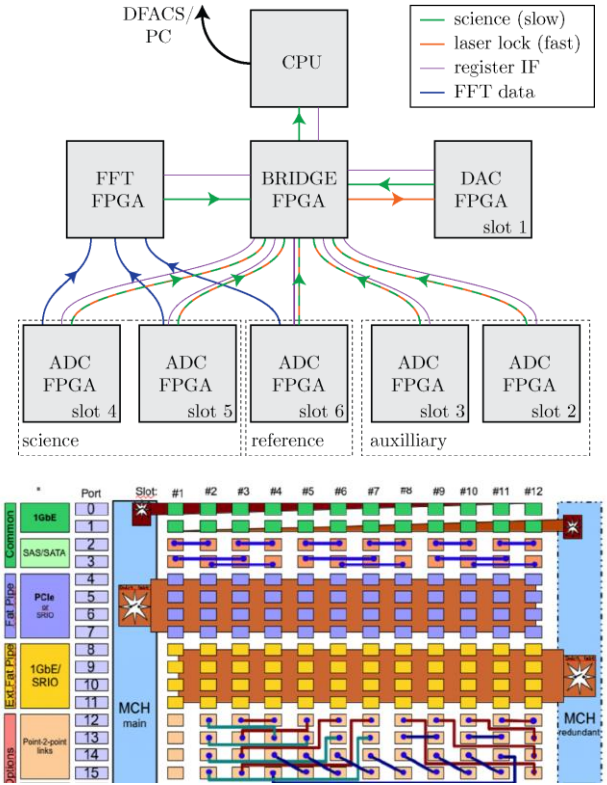




INTERFACES & PROCESSING

- DAMC-FMC1Z7IO is the central AMC module for our algorithms and processing
- We will make use of the various interfaces provided by the backplane
- This includes a high-speed, low latency, direct link between a phase readout AMC and the laser control AMC to implement the laser frequency control loops
- SpaceWire FMC module will provide spacecraft-like interface

O. Gerberding PhD Thesis, LUH (2014)



LISA EBB PM data flow

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GRAVITATIONAL WAVE DETECTION

www.physik.uni-hamburg.de/iexp/gwd

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