MSK collaboration workshop for the European XFEL

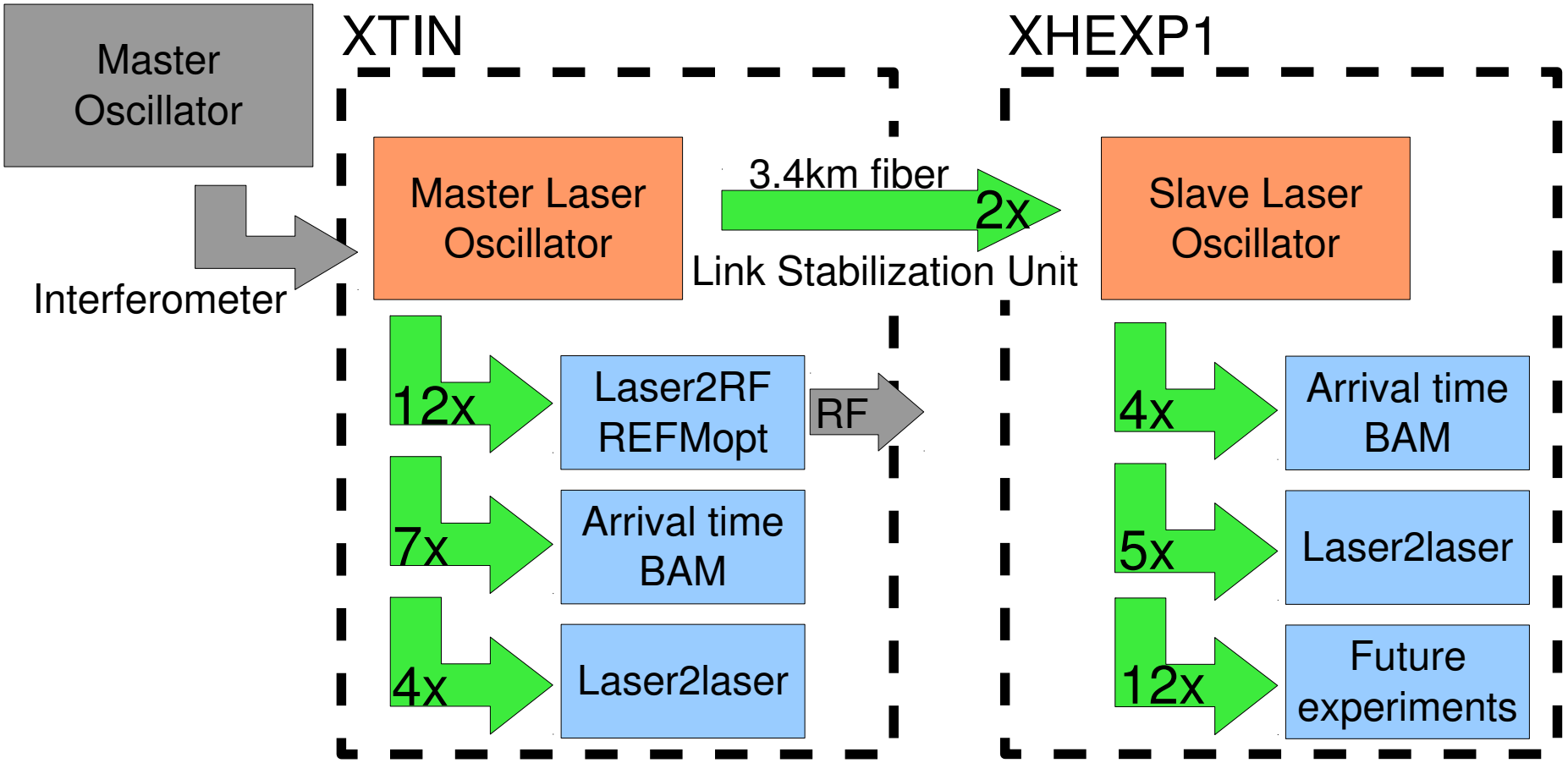
Optical Synchronization at the European X-FEL

Cezary Sydlo
on behalf of the LbSyn Team

12th May 2014
DESY, Hamburg, Germany

HELMHOLTZ ASSOCIATION | TUHH Technische Universität Hamburg-Harburg | POLITECHNIKA WARSZAWSKA WARSAW UNIVERSITY OF TECHNOLOGY | UH | European XFEL | DESY

European XFEL optical synchronization scheme



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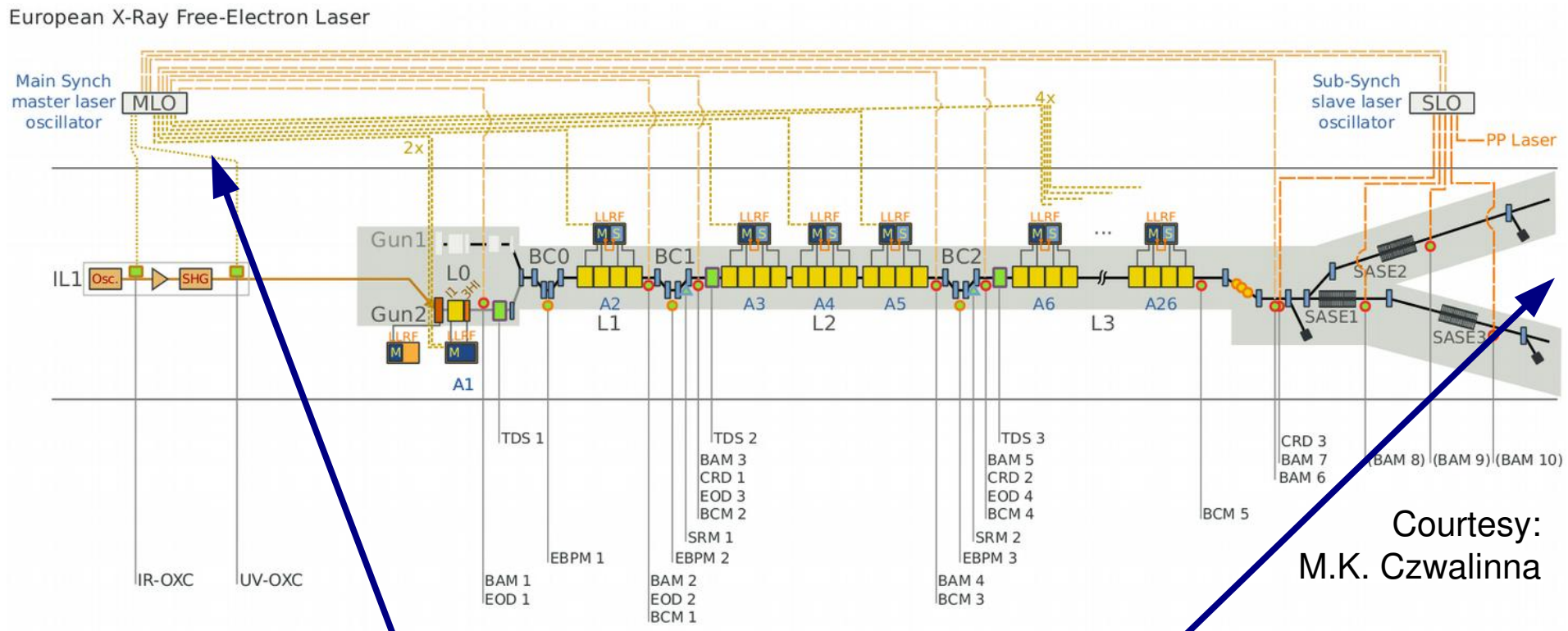
European XFEL Synchronization Overview



Courtesy:
M.K. Czwalinna

- XTIN: 25 link stabilization units at injector site
- XHEXP1: 2nd synchronization room in the experimental hall
  - Slave laser oscillator
  - 9 link stabilization units (space for up to 21)

Characteristics of the Optical Synchronization at XFEL

- 46 Link Stabilization Units to be deployed (largest stage of expansion)
- About 20km of PM fibers needed only for optical synchronization
  - Quite expensive, but ...
  - No timing error due to Polarization Mode Dispersion!
  - No polarization correction necessary
- 2 links from the Master Laser Oscillator to the Slave Laser Oscillator
  - Redundancy => avoiding a single point of failure
  - Continuous out-of-loop measurement for the longest length (3.4km)
- Two Bunch Arrival Time Monitors side by side, after LINAC section, before SASE
  - Important FEL diagnostic tool and used in control-loops
  - One is served from the MLO and the other from the SLO
  - Continuous out-of-loop measurement

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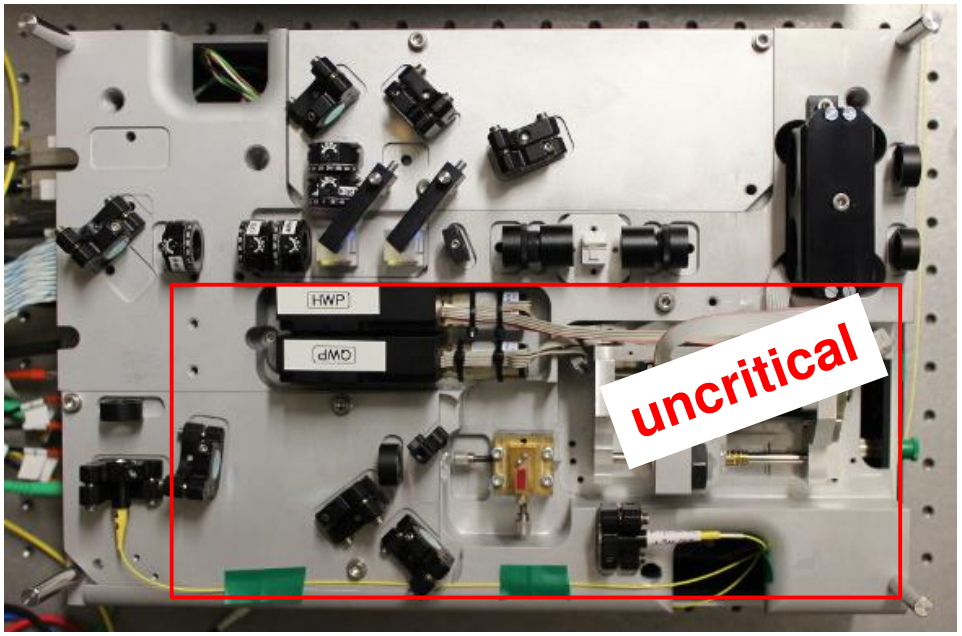
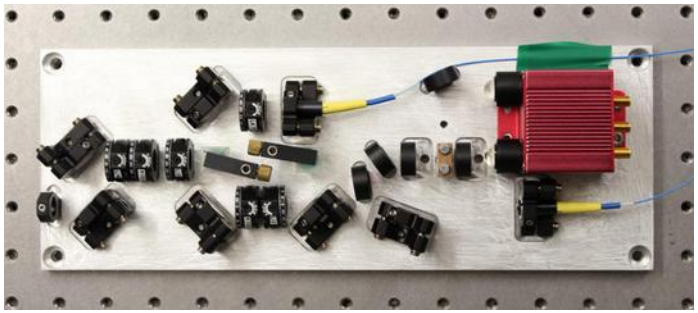
Link Stabilization Unit: New Version V4

XFEL Synchronization:

- More links to stabilize
- But space is constrainted

- New design required
- Also longer delay stage required
- First prototype running in 26a
- Advantages
  - Huge space savings
  - Highly modular
  - Spatial separation of functions



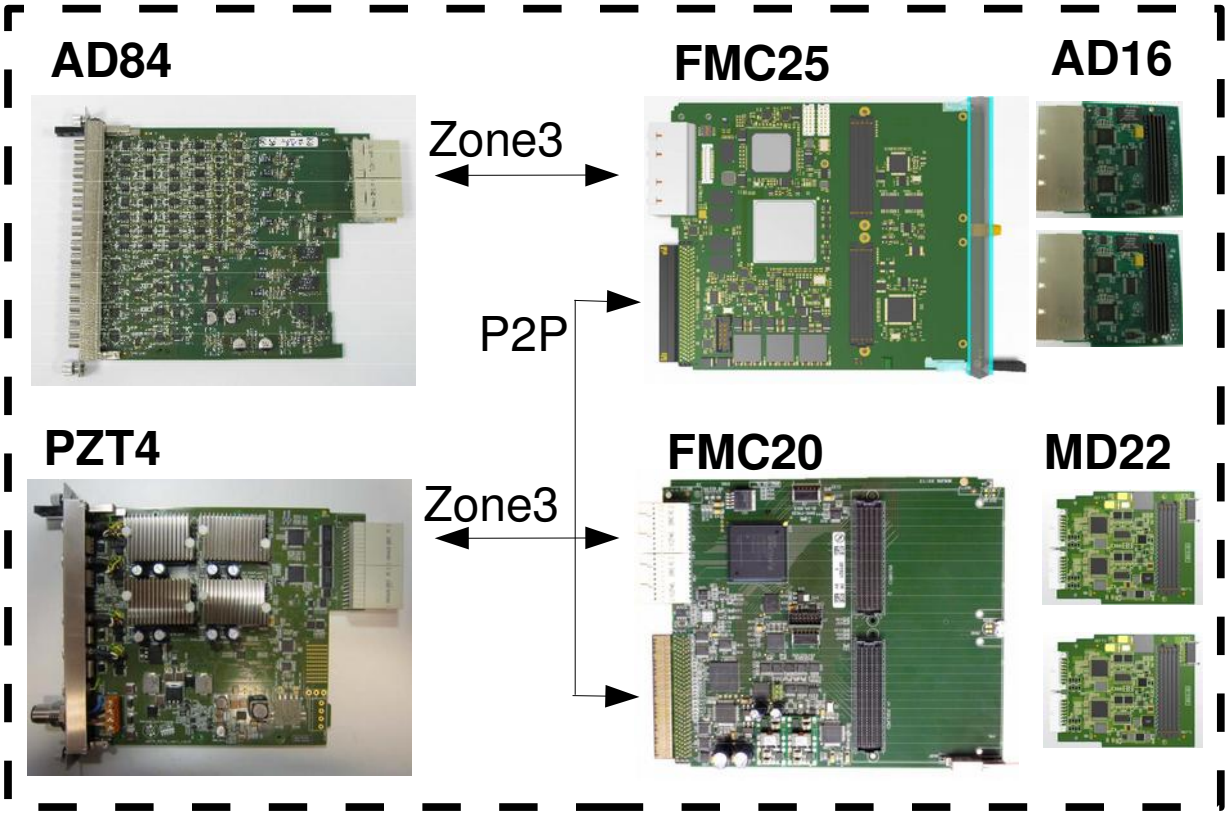


Status: Equipment & Infrastructure

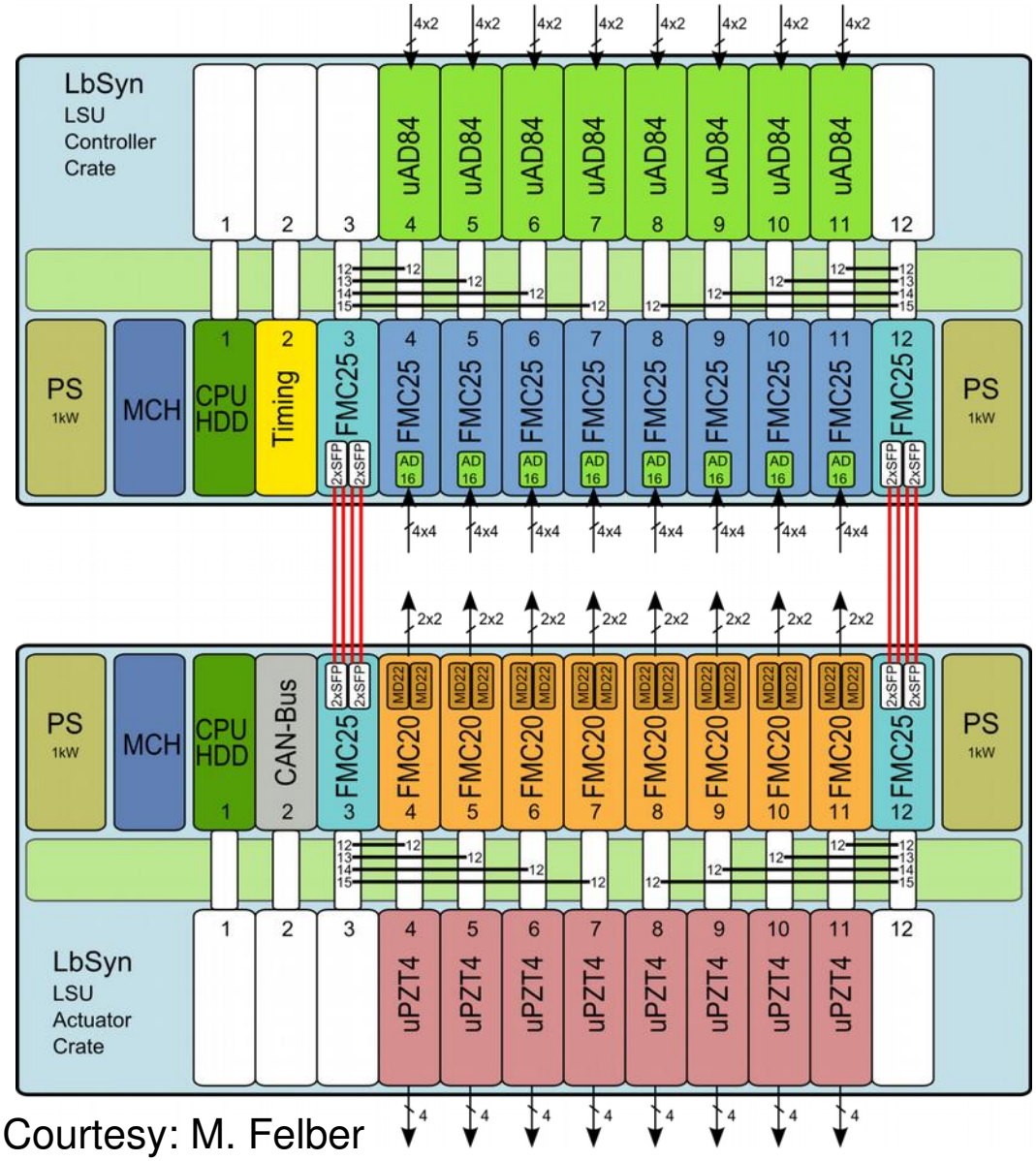
- Room infrastructure in progress
- Optical tables are at their place
- Optics (PBC, lenses, mirrors, etc.)
  - 70% already delivered/available and ready for assembly
  - Remaining optics should arrive within few weeks
- Optomechanics (Mirror mounts, custom mechanics, etc.)
  - Ordered or in-production or at least close. Should arrive within few weeks
- Optoelectronics (balanced detector, link electronics)
  - Should arrive within few weeks

MTCA for optical synchronization

- One Card-Set (8 cards) handles 4 Link Stabilization Units
- 24 LSUs => 6 sets
- 16bit 10MSps
- Virtex 5 FPGA
- Stepper drives
- ±80V Piezo driver
- Monitoring ADCs



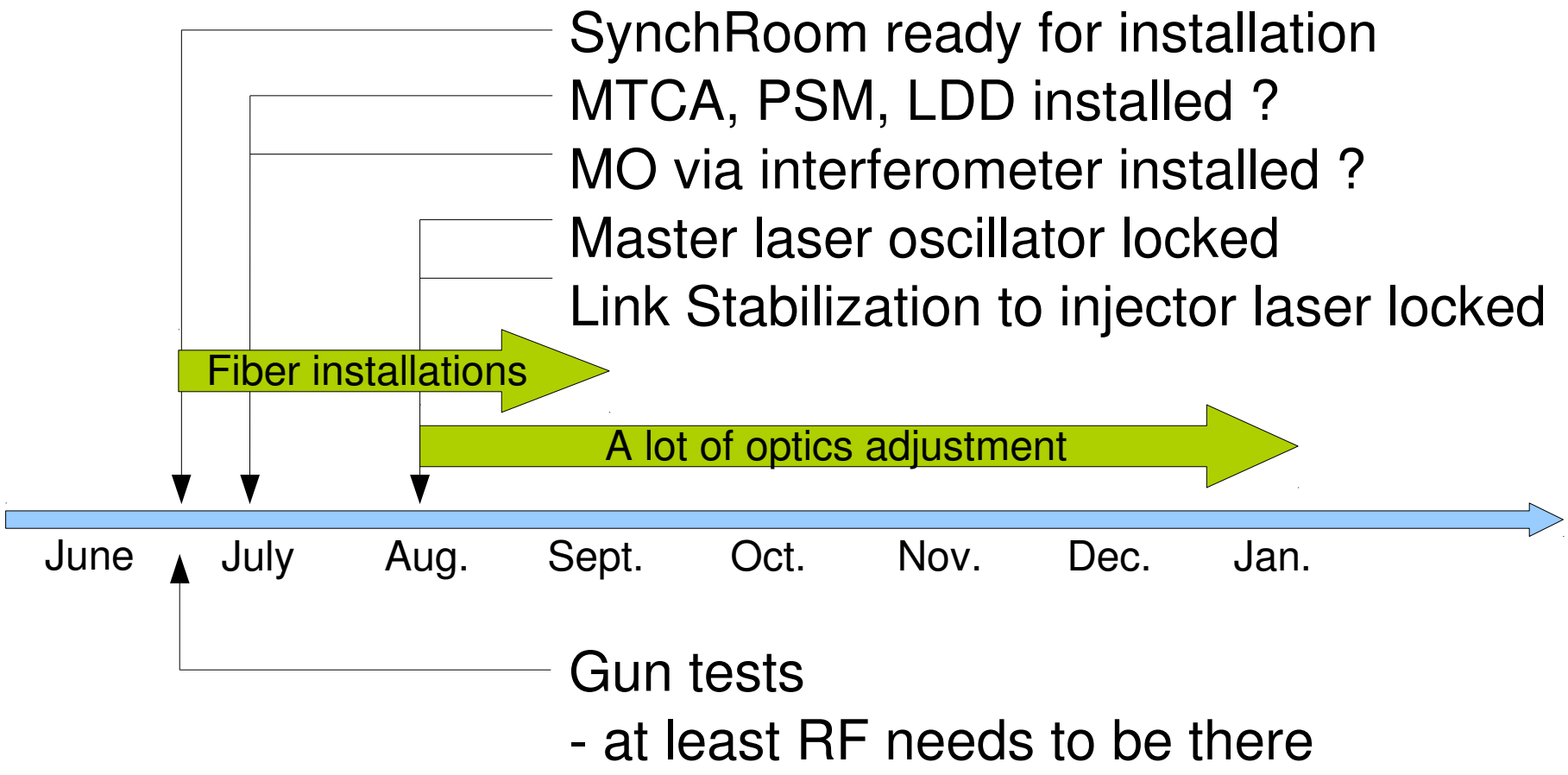
Two Crate Configuration serves up to 32 Links



Courtesy: M. Felber

- “Sensitive” Crate
  - Balanced detectors
  - Monitoring ADCs
  - Number crunching
- Optical data connection
  - No EMI
- “Dirty” Crate
  - Stepper motors
  - Piezo signals

Timeline bottleneck



Still some way to go ...

Thank you
for your attention

XTIN Synchronization room, UG5/R25
“Laserraum1”, 5 May 2014

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How to measure a femtosecond?

Long-Term Femtosecond Timing Link Stabilization Using a Single-Crystal Balanced Cross-Correlator

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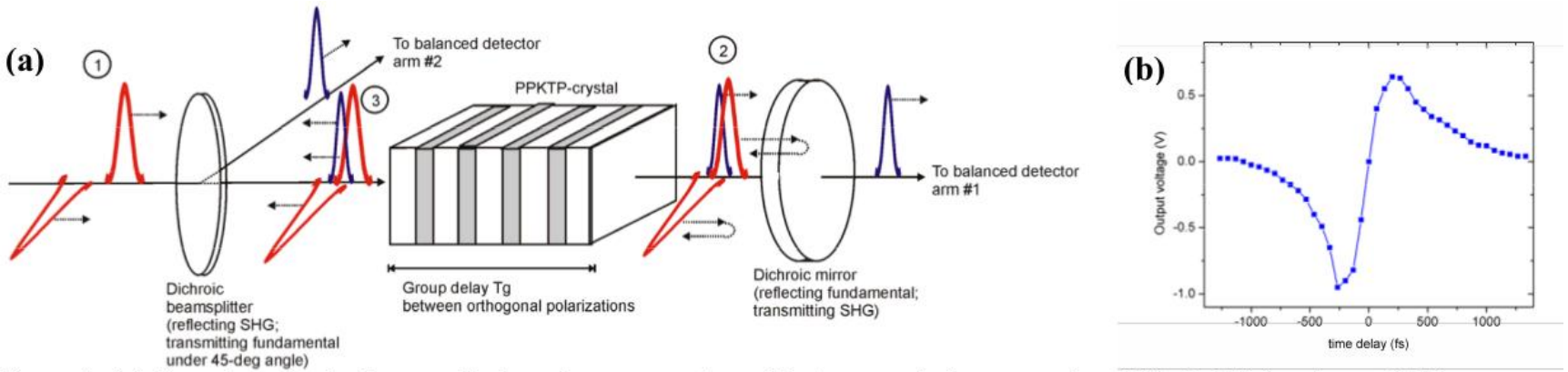

Figure 1: (a) Operation of a single-crystal balanced cross-correlator. **(b)** Autocorrelation trace using 0.34 nJ, 170-fs pulses at 1550 nm.

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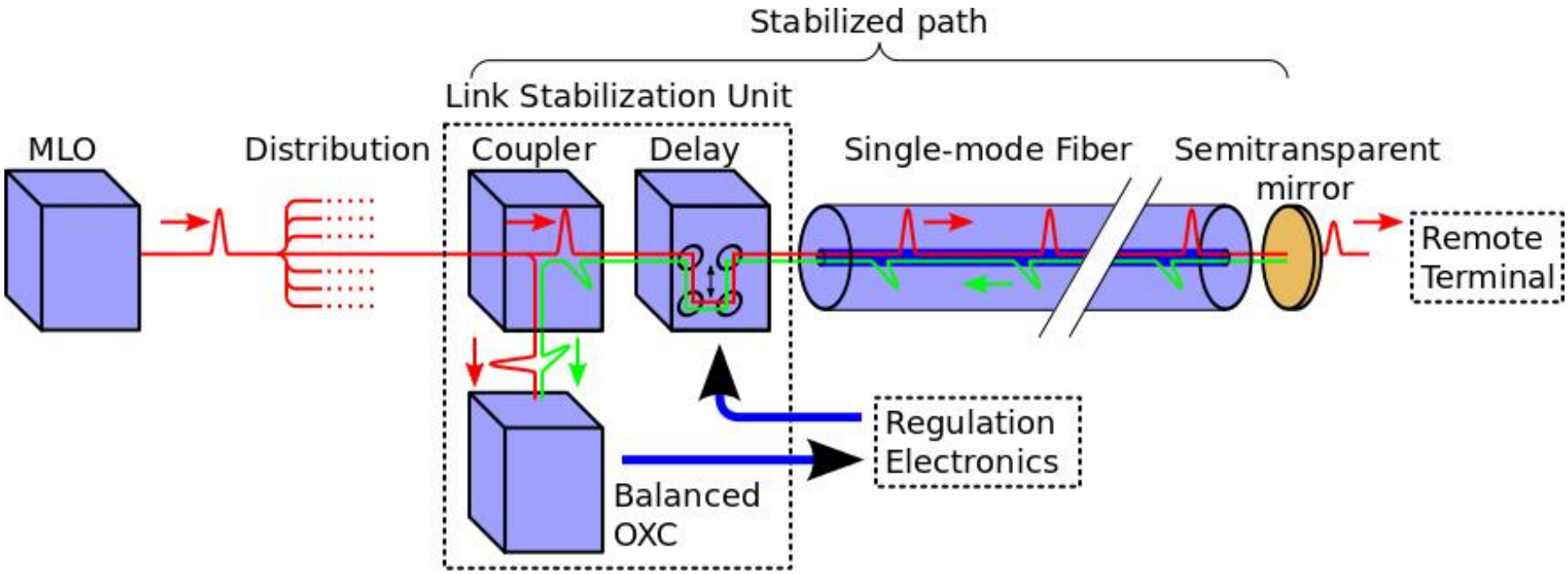
Optical Stabilization Scheme



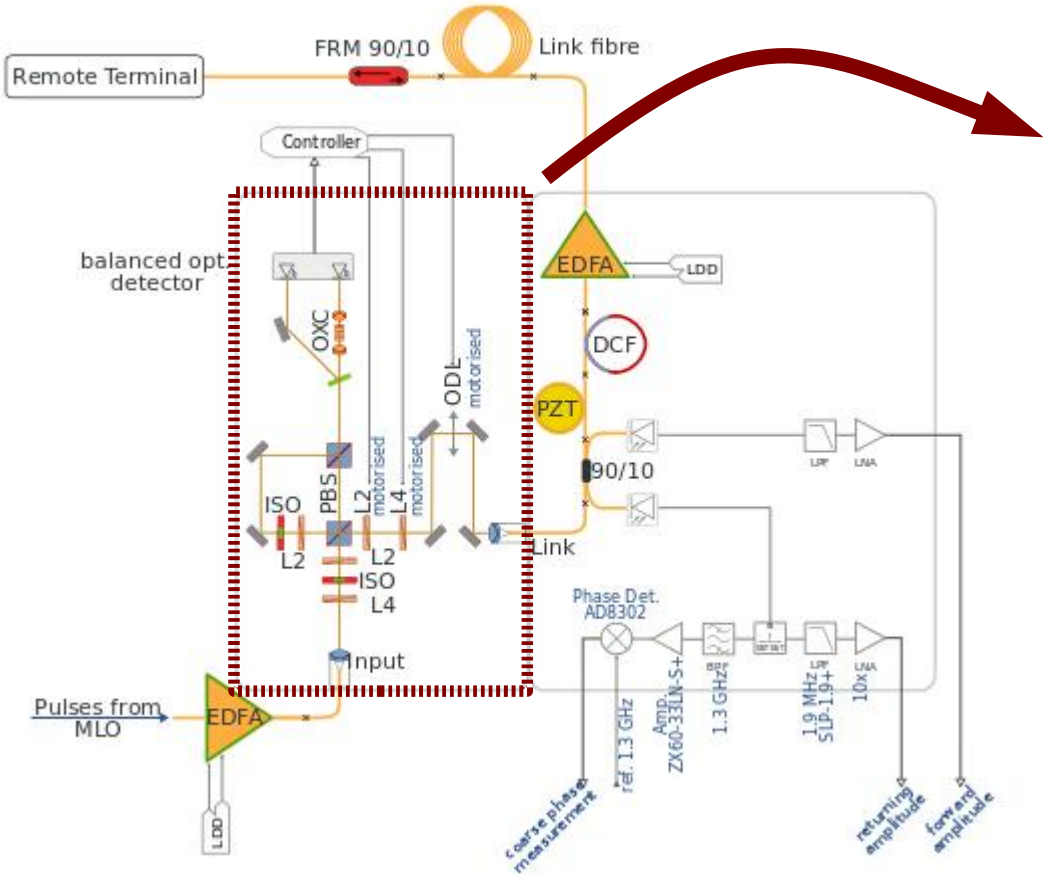
> **M**aster-**L**aser-**O**scillator (217MHz) locked to RF Master-Oscillator (1.3GHz)

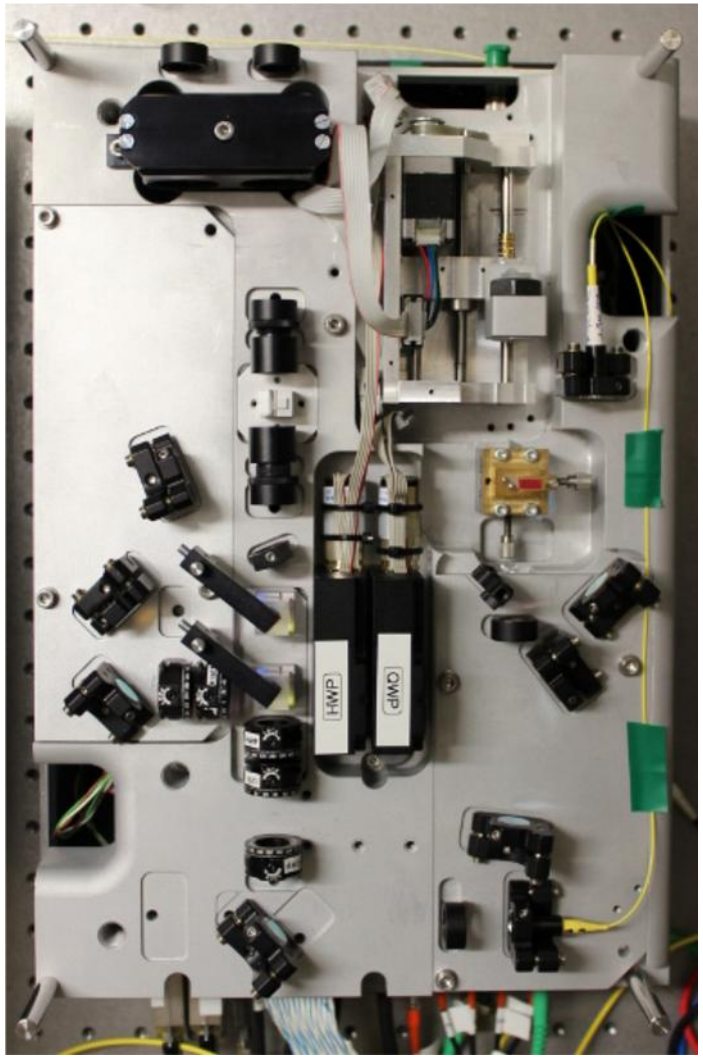
> Optical delay compensates for fiber drifts (temperature, humidity, movement)

> **Balanced O**ptical **Cross**-**C**orrelator detects timing changes (~ 5mV/fs)

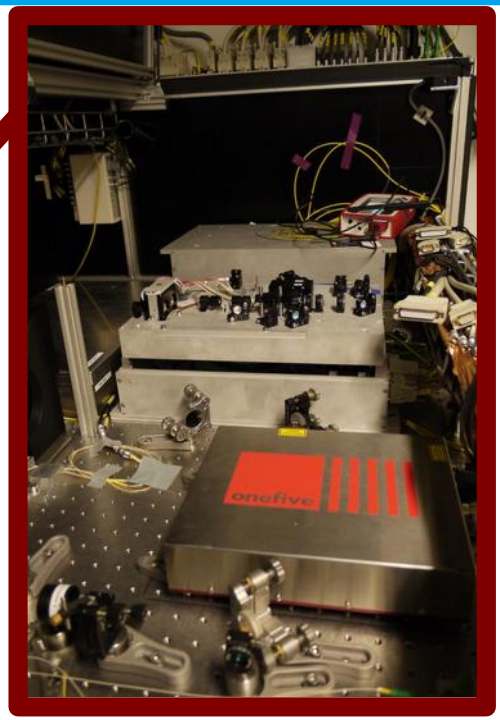
> Endstation uses directly optical pulses or converts to RF

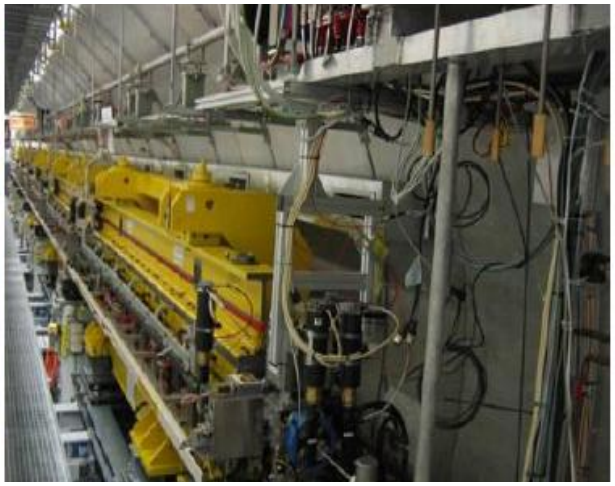
Link Stabilization Unit V3.2 used at FLASH



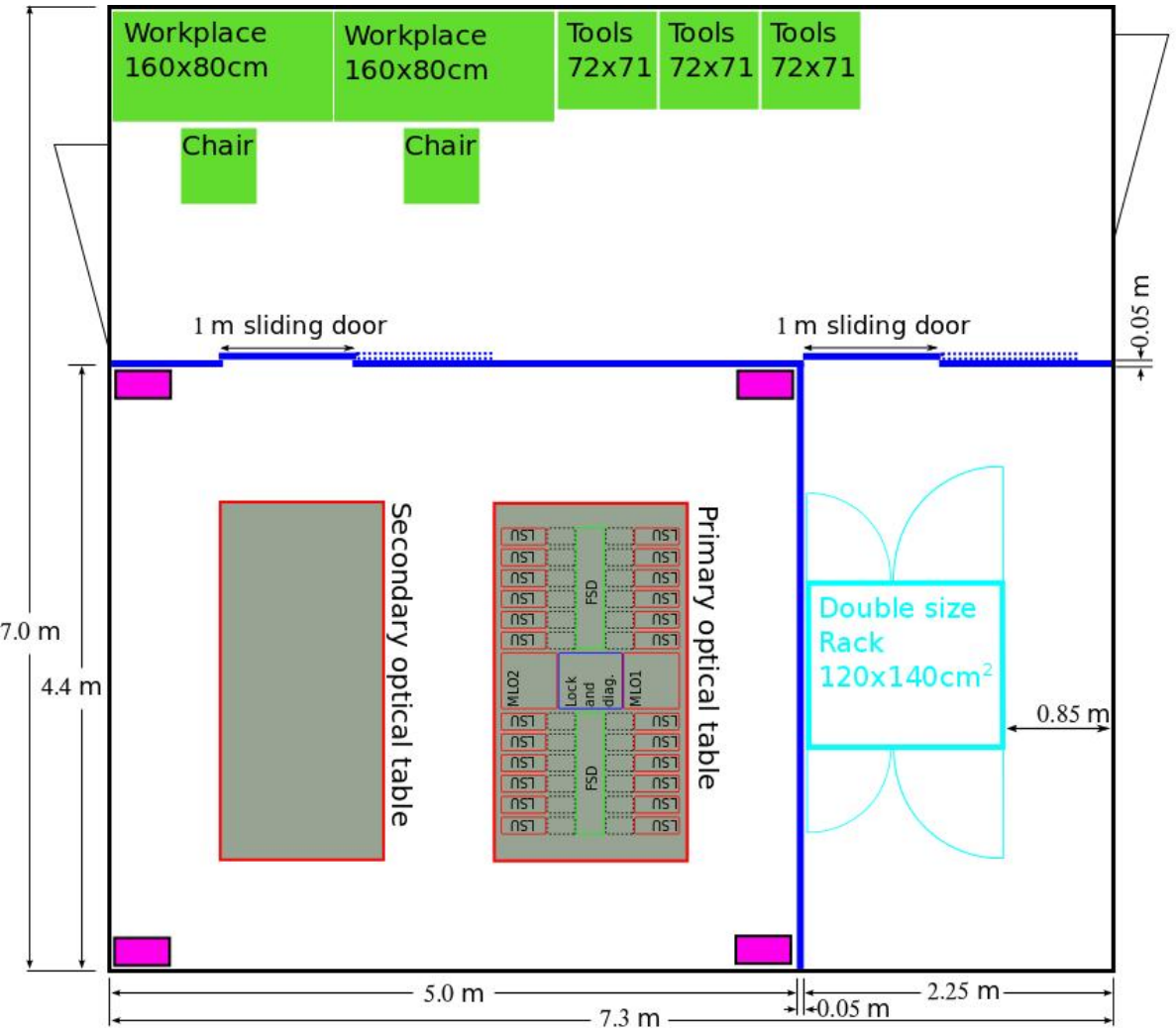


Optical synchronization system at FLASH





Room plan for the optical synchronization at XFEL



Climatisation air outlet
from roof down to 50cm above ground

Dry wall (5cm thick?)
to suppress thermal flow and acoustics

Optical tables standing on concrete ground

Rack standing on concrete ground

Mobile rack

Operating enviroment

Sources of drifts

- Optical fibers
  - Nufern PMF 120 fs/K/m + ? fs/%RH/m
  - Standart SMF 40 fs/K/m + 2.5 fs/%RH/m
  - Furukawa PSOF 18 fs/K/m + 1.2 fs/%RH/m (coated)
  - Linden STFOC 5 fs/K/m + 0.8 fs/%RH/m
  - Furukawa PSOF 3.2 fs/K/m + 0.4 fs/%RH/m
- Free space
  - Aluminum 77 fs/K/m
  - Steel 33 fs/K/m
  - Invar 2-6 fs/K/m
  - Air @ 1550nm 3 fs/K/m + 0.03 fs/%RH/m
  - Superinvar <1 fs/K/m

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