The phase reference distribution system for the TESLA technology based projects

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OUTLINE

- Design requirements
- Main design challenges
- System concept
- Subsystem description - system status
- Experimental results
- Future plans

OUR TEAM

PHASE REFERENCE DISTRIBUTION SYSTEM

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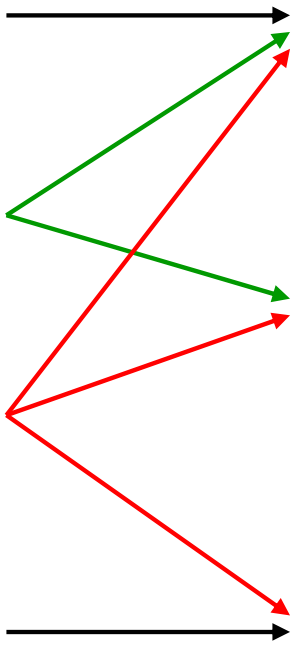


MASTER OSCILLATOR

COAX CABLE DISTRIBUTION

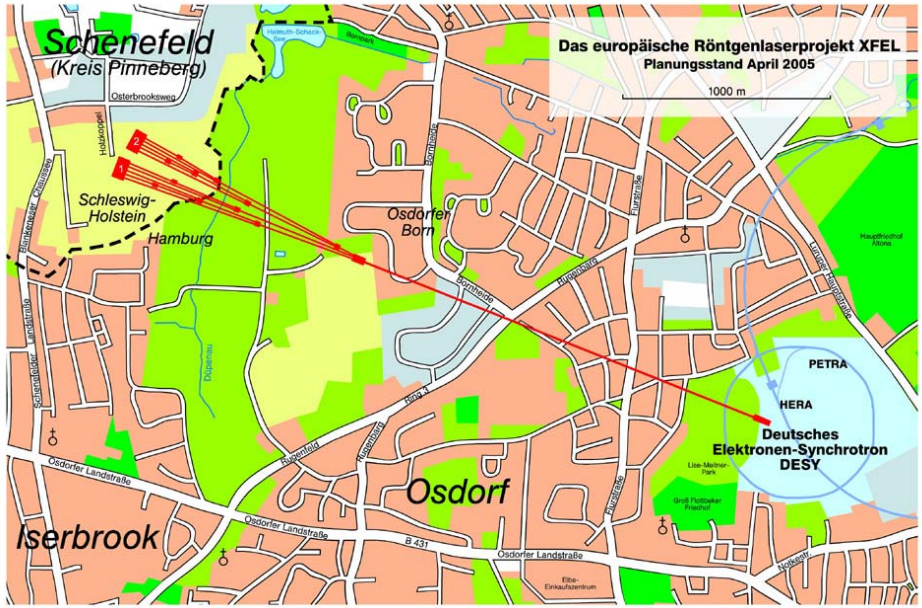
FIBER OPTIC DISTRIBUTION

DESIGN REQUIREMENTS

Synchronize RF devices located along the accelerator with timing jitter (phase) error << 1 ps*

Distribution distance:

- 300 m UVFEL
- 3.1 km XFEL
- 30 km ILC



Distributed RF signal frequency range:

1 MHz to 2.856 GHz (10 frequencies)

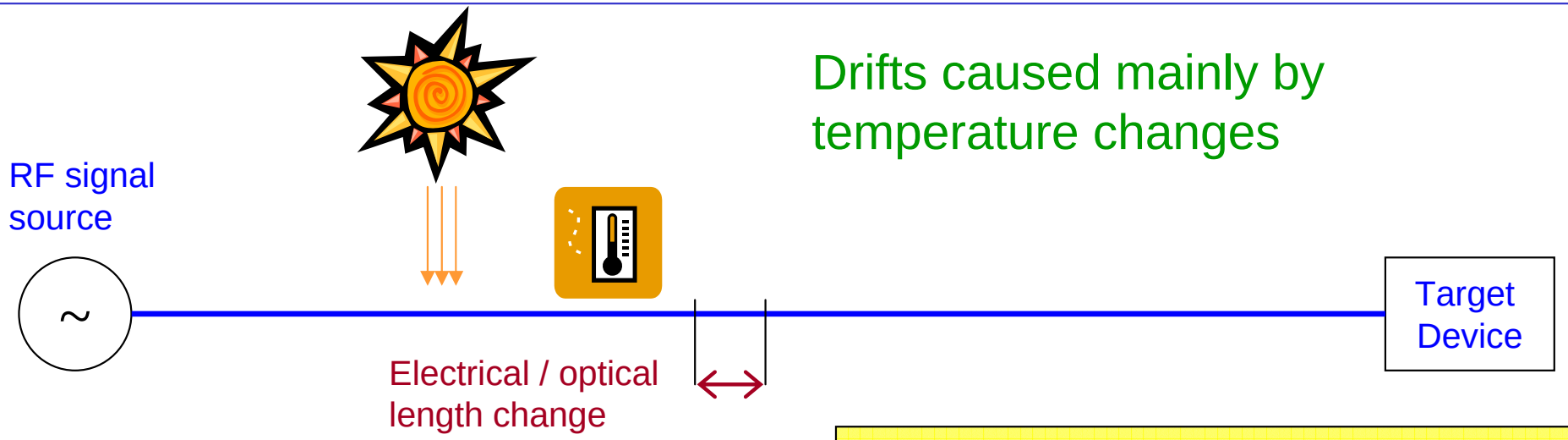
1.3 GHz – main distribution frequency

*) 10 fs synchronization required at several locations in the XFEL

PROBLEMS TO BE SOLVED (1)

- Master Oscillator (MO) design
- Distribution system layout:
  - Which distribution frequencies?
  - Generate all frequencies at MO and distribute or generate locally from one distribution frequency? Which type of frequency multiplier/divider…
- Distribution media: coaxial cable or optical fiber?
- Phase noise: which level is allowable, PLL optimization, degradation in the distribution line, quality of local oscillators…
- Signal power level: amplification necessary for long distribution distances but amplifier noise …
- …

PROBLEMS (2): LONG TERM PHASE DRIFTS



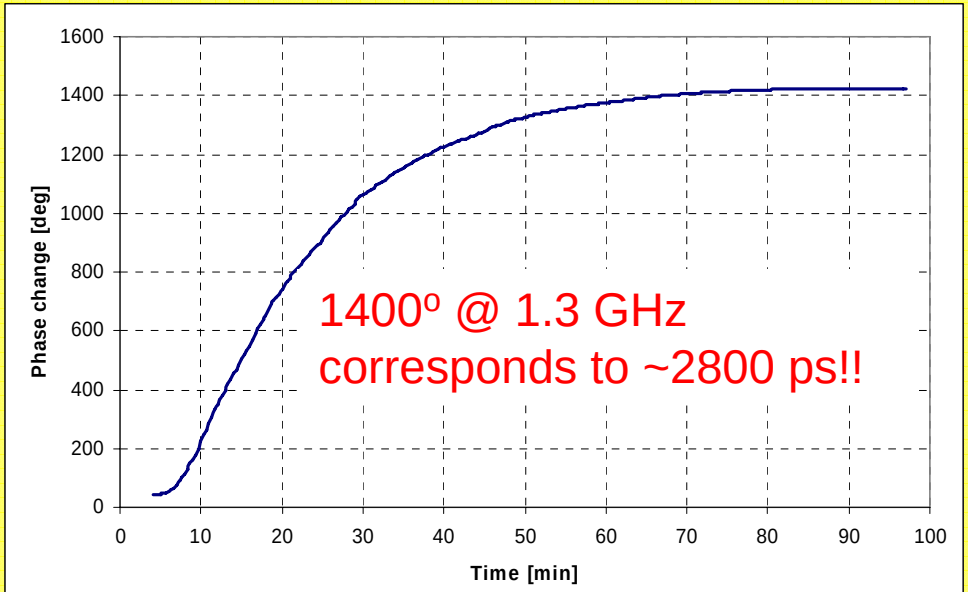
Drifts caused mainly by temperature changes

Reason of drifts:

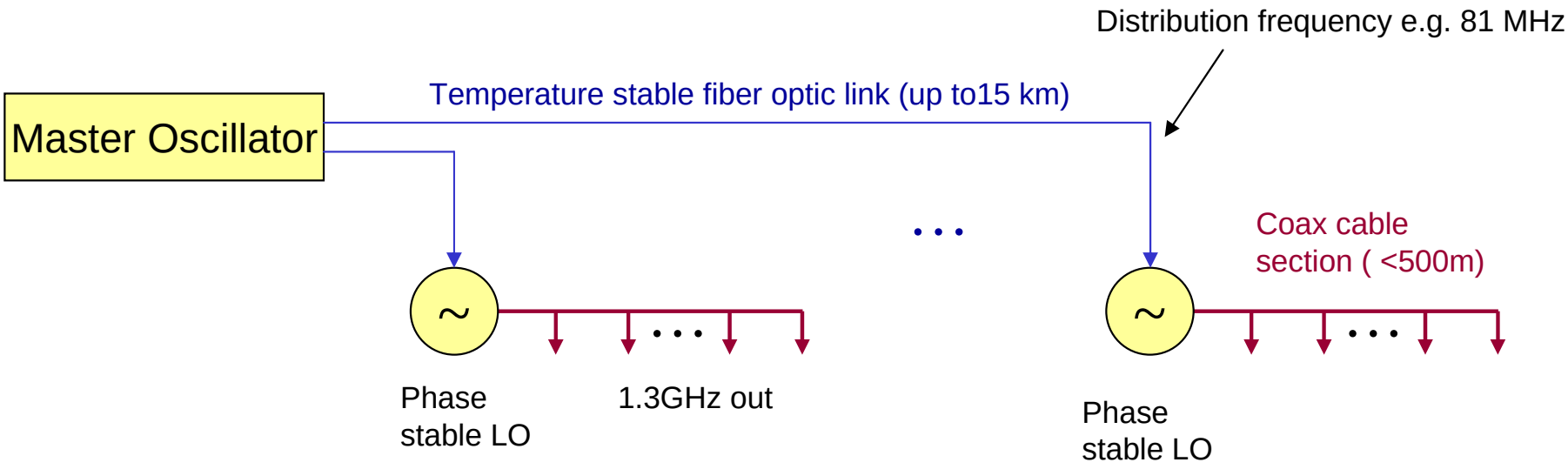
- In fiber: n_{eff} change
- In cable: physical dimension and dielectric properties change

Feedback on phase required!!

1.3 GHz signal phase change in 5km of fiber. 10 °C temperature change

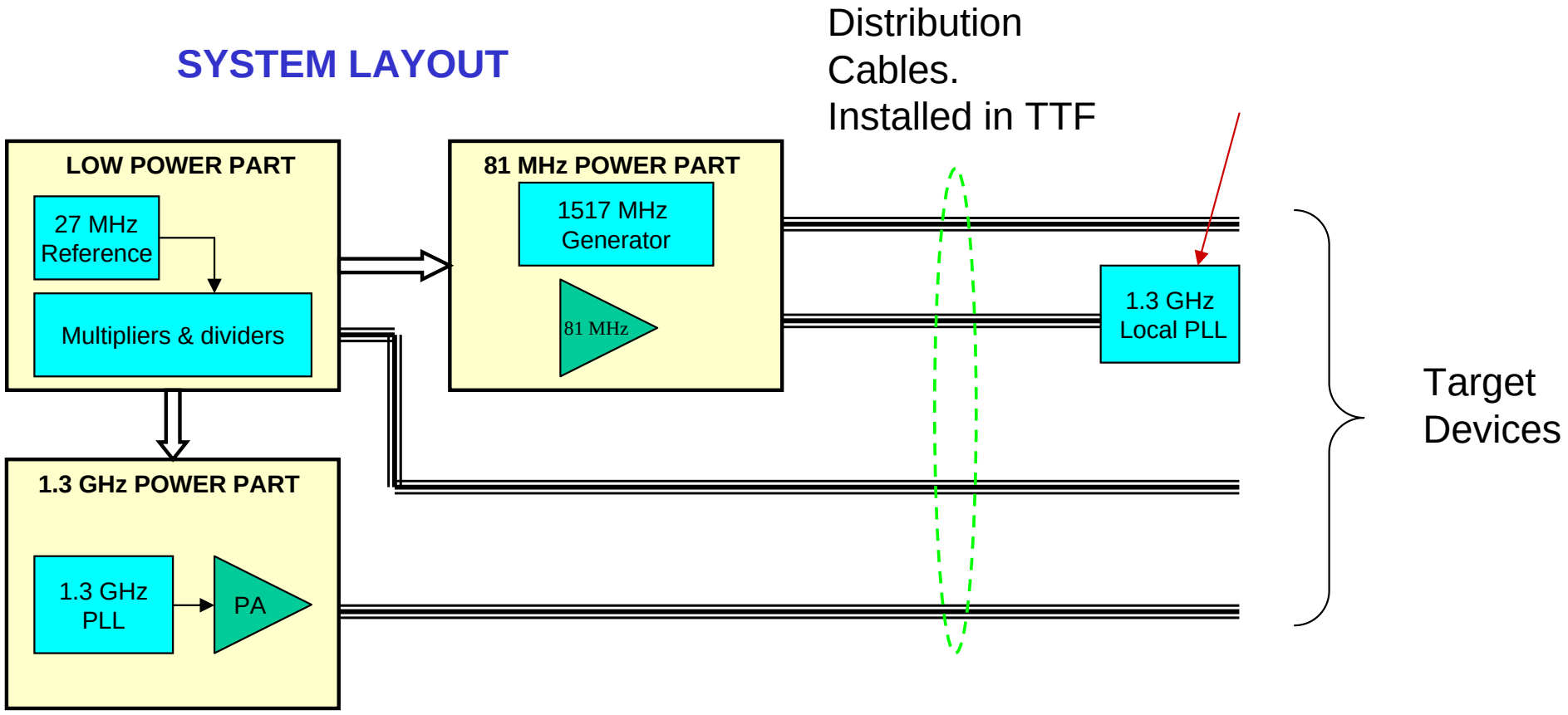


DISTRIBUTION SYSTEM CONCEPT (PROPOSAL)



Considered is also coaxial cable based distribution with fiber optic links used for long term phase drift monitoring

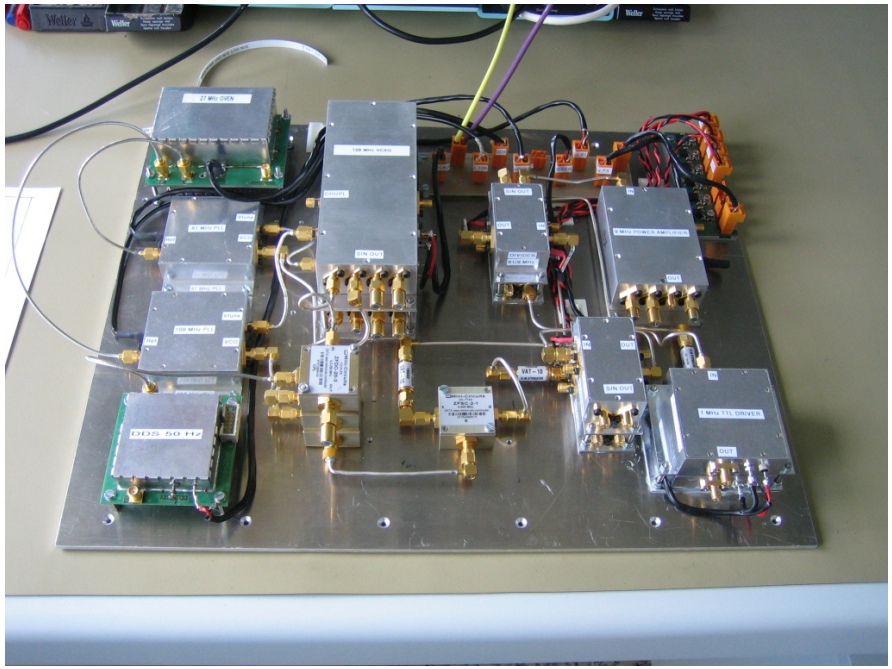
MASTER OSCILLATOR BLOCK DIAGRAM



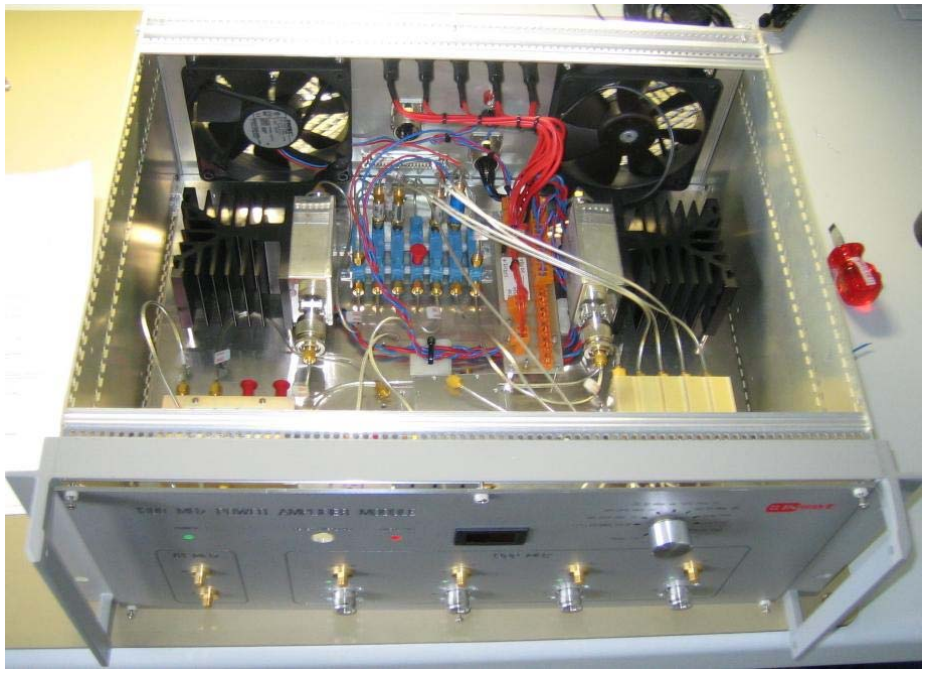
Generated frequencies: 50 Hz, 1 MHz, 9 MHz, 13.5 MHz, 27 MHz, 81 MHz, 108 MHz, 1.3 GHz, 1.517 GHz, 2.856 GHz

M.O. COMPONENTS

LOW POWER PART



81 MHz POWER PART



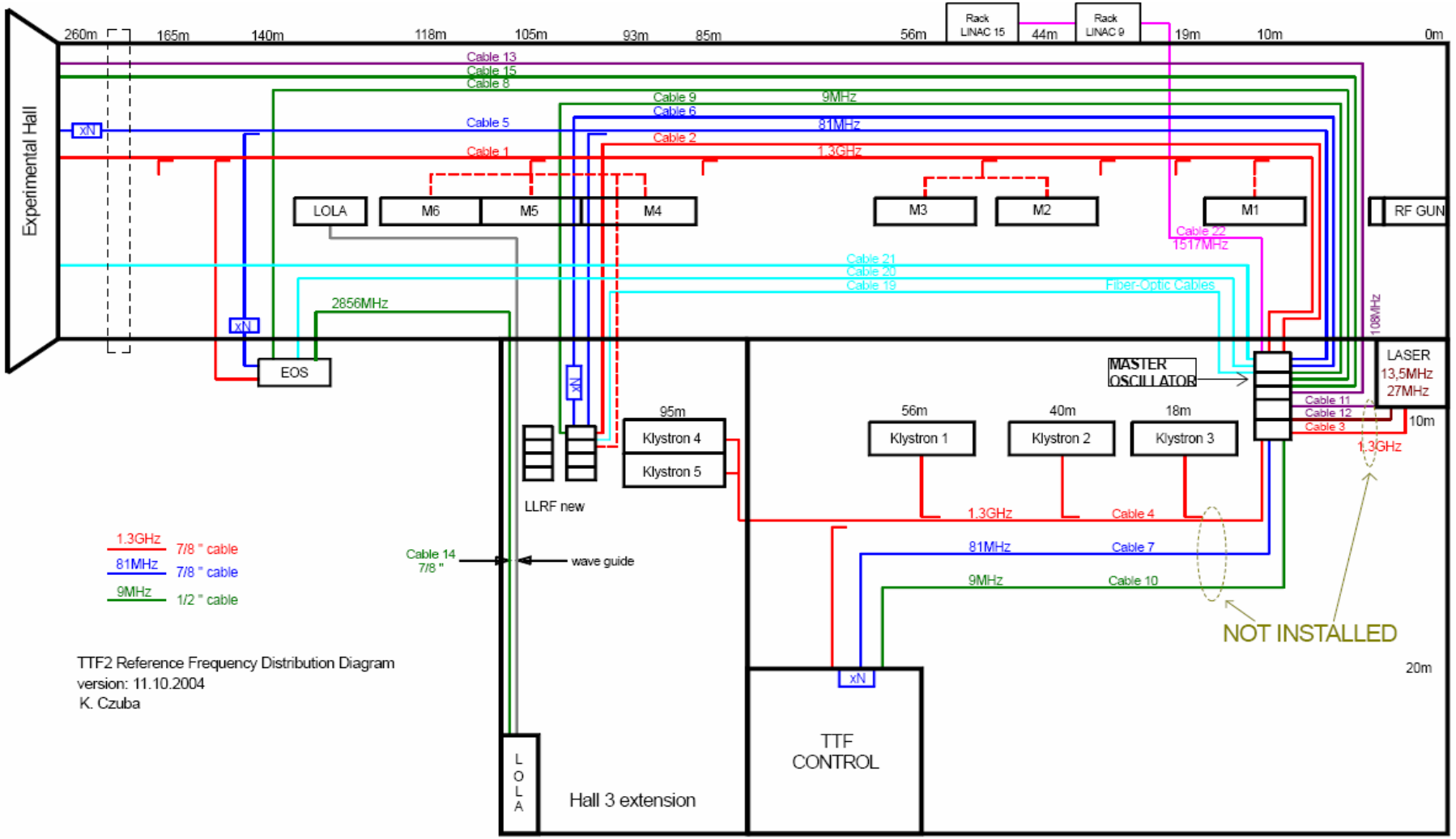
M.O. components provided by the Inwave company

Two copies of each module assembled in DESY

Special, low noise, battery based power supply provided

Tests in progress

COAXIAL CABLE DISTRIBUTION



Coaxial and fiber optic cables installed in the UVFEL. Temperature control system applied

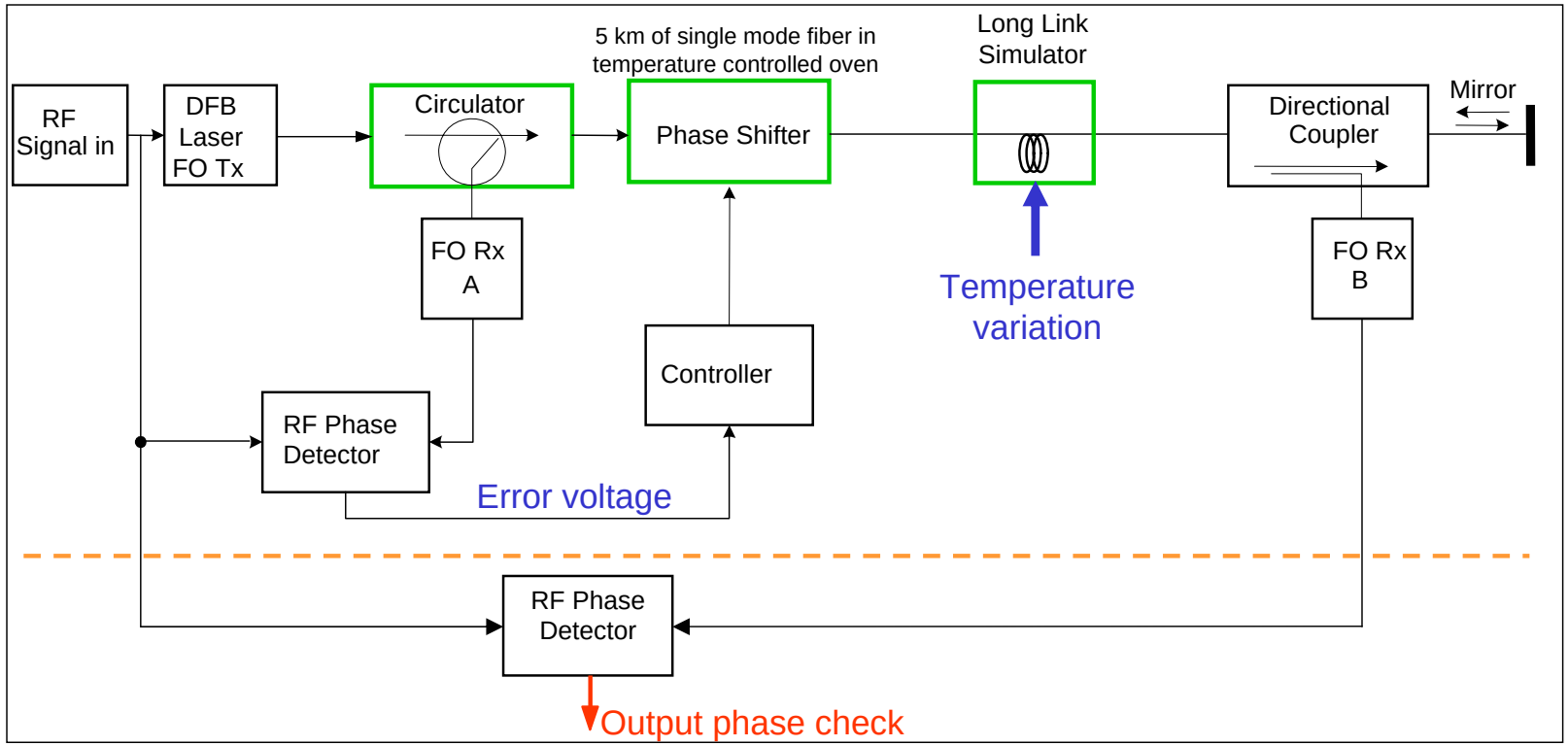
FIBER OPTIC DISTRIBUTION SYSTEM CONCEPT

Phase stable signal distribution over long distances (up to 20 km)

Feedback on phase suppressing long term drifts

Main application of this system is long term phase drifts monitoring / compensation

Test system block diagram



FIRST EXPERIMENTS

Spool with fiber as a phase shifter

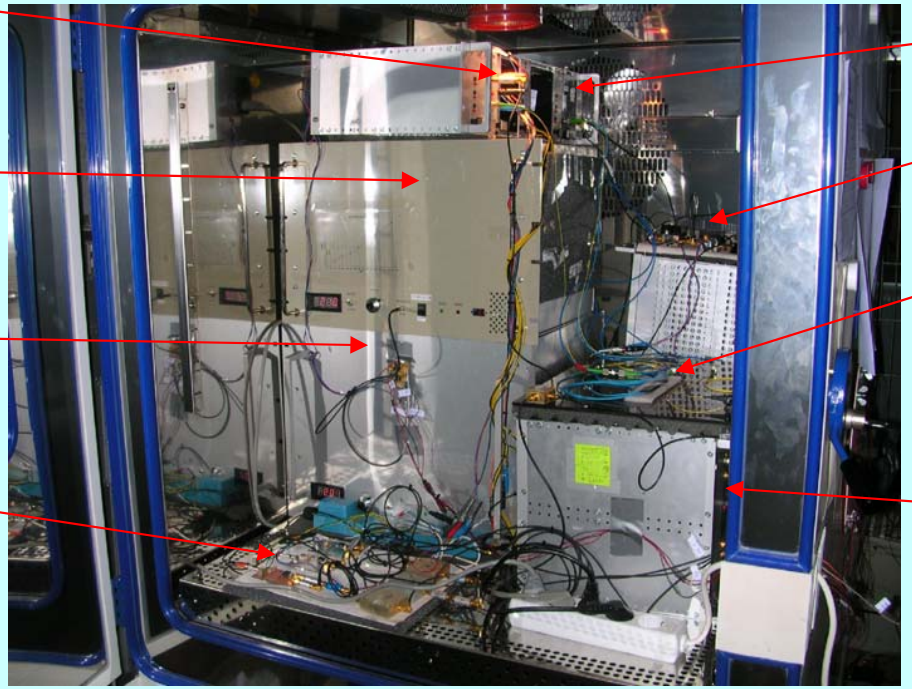
FIRST SYSTEM TEST IN A CLIMATE CHAMBER

DFB laser

Optical phase shifter (oven with 5km of fiber)

Long link simulator (oven with 20km of fiber)

RF phase detectors



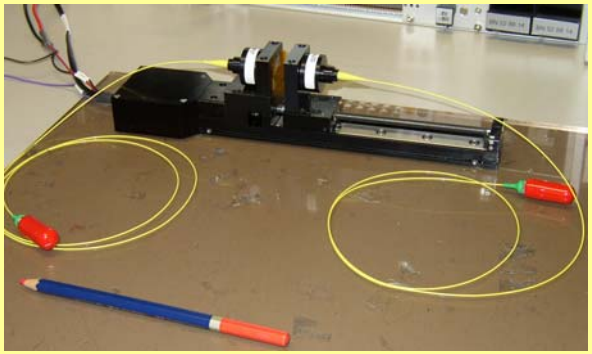
F.O. receivers

RF amplifiers

F.O. components (circulator, coupler and other)

1.3 GHz signal source

Motorized Optical Delay Line as a phase shifter



RF components and laser crate

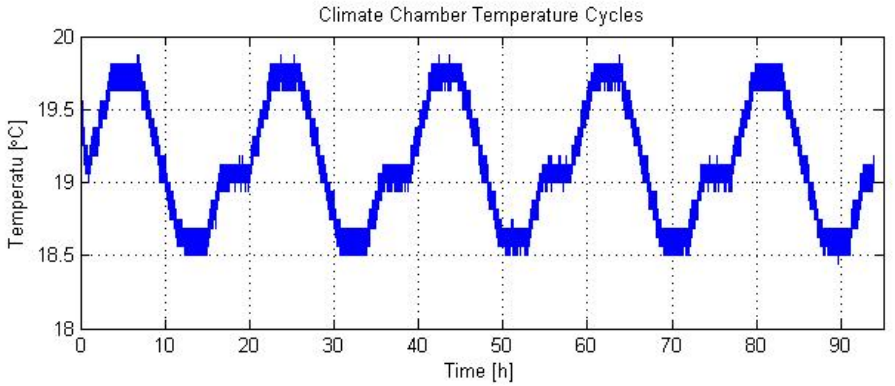
Fiber optic bread-board

F.O. LINK – LABORATORY MEASUREMENT RESULTS

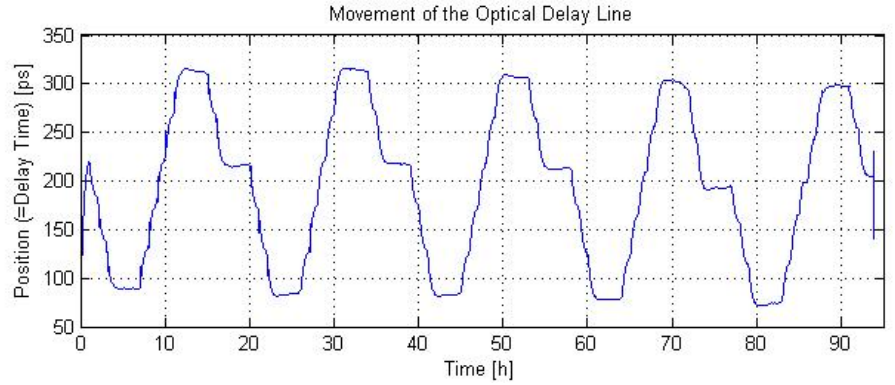
Measurement performed inside of the climate chamber

5 km of fiber used as long link

100 h measurement duration

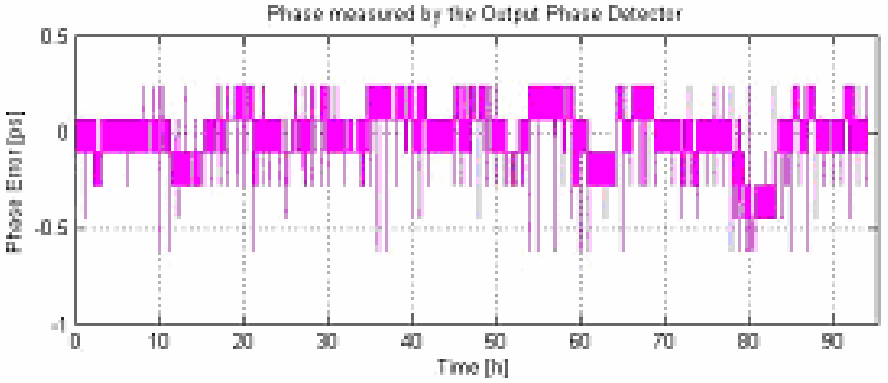


ODL position followed temperature induced phase drifts



RESULTS

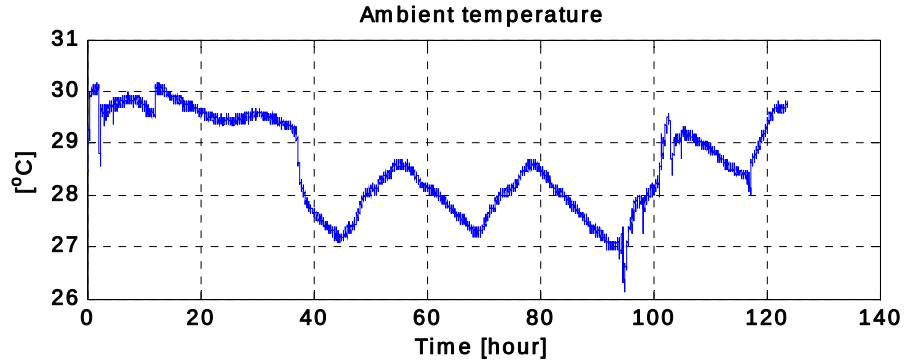
Phase Shifter	Short term stability [ps]	Long term stability [ps]
5 km fiber on spool	0.8	5
ODL	0.3	0.8



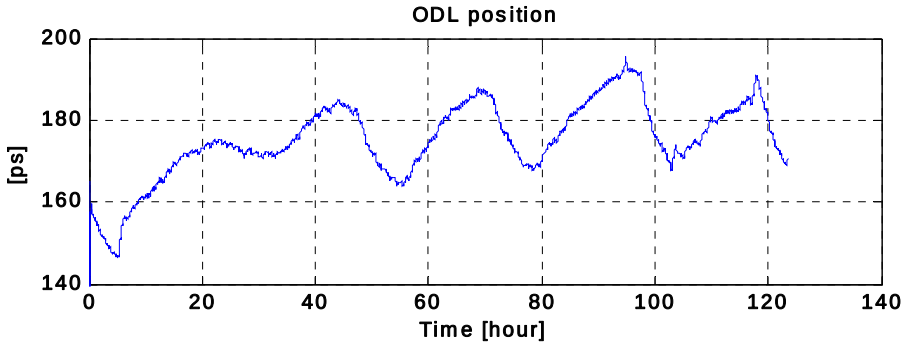
EXPERIMENTS IN THE UVFEL

Measurement performed in the UVFEL tunnel over 125 hours (5 days) – 30.09 to 05.10.2005

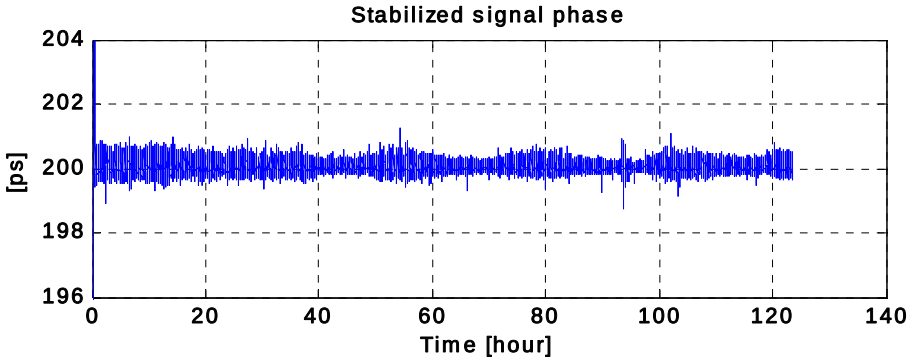
1.3 GHz signal phase was stabilized in 400 m of fiber installed in the UVFEL facility



Notice ODL compensated for ~ 40 ps (p-p) of phase change. Such change would be in the fiber without feedback!



Mean value of the phase remains constant within 0.5ps range. There is large noise observed – most probably EMI problem. Will be investigated soon



FUTURE PLANS

Finish M.O. tests

Install M.O. in the UVFEL

Tests of coaxial against fiber optic signal distribution

Characterization and compensation of long term drifts in PLLs and amplifiers

Low drift (or drift free) phase detector development

SUMMARY

The concept and design issues of the phase reference distribution system were briefly described

Master oscillator modules under development and tests

Coaxial cable distribution system installed in the UVFEL facility

Fiber optic distribution system with feedback on phase drifts successfully tested

Many challenges in front of us …

Thank you for your attention