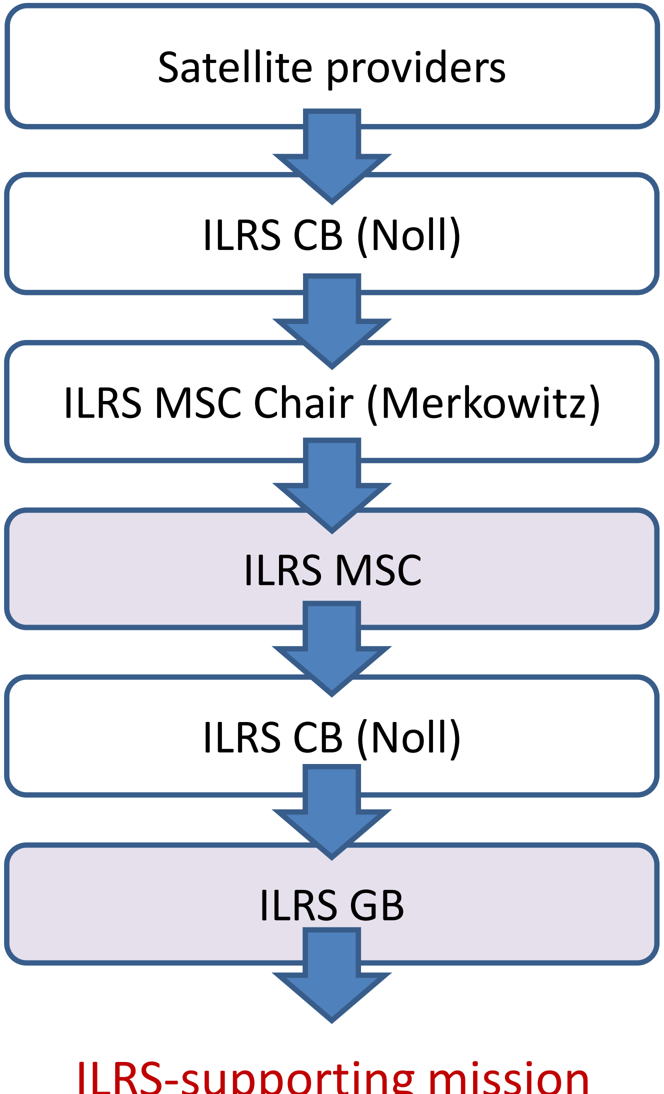
MSRF flow


Satellite providers
ILRS CB (Noll)
ILRS MSC Chair (Merkowitz)
ILRS MSC
ILRS CB (Noll)
ILRS GB
ILRS-supporting mission

Reviewing mission approval procedure: background

- **Triggered by ILRS CB**

  Our stations are getting busier monotonically. We should not ask them impossible missions.

  We sometimes see CCR+LRA not well designed for SLR observations, or the value of our (ILRS) tracking data is doubtful or seemingly not very significant.

⬇ Discussions via email & MSC meeting in Canberra

- **New procedure already effective**

  Updated the ILRS webpages in February 2019.

New guideline for future mission approvals

International Laser Ranging Service
A service of the International Association of Geodesy

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IAG | GGOS

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Missions

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  - Mission Support Request Form
  - 7 Day Groundtrack of Geodetic Sat Data
  - Mission News
  - SLR Satellite Support History
- Mission Operations
- Missions Standing Committee

Quick Links

New Mission Support

Request for ILRS laser ranging tracking support of new missions must be formally submitted to the ILRS Central Bureau (CB), reviewed by the Missions Standing Committee (MSC) and approved by the ILRS Governing Board (GB).

The ILRS was established to support applications and programs in geodesy, geodynamics, and space science; the service's primary emphasis is placed on tasks that support the IAG's Global Geodetic Observing System (GGOS). As of 2018, the ILRS network ranges to more than 100 satellites and missions continue to submit additional requests for tracking support. The ILRS reviews new Mission Support Requests (MSRs) on the basis of laser tracking need and the likelihood of mission success. Although the ILRS tries to accommodate all new tracking requests, the submission of a request does not guarantee ILRS support.

New missions requesting ILRS tracking support should review the following **Guidelines for Submitting an ILRS New Mission Support Request** to ensure the ILRS can support the upcoming mission. Following this review, the mission must then complete an ILRS SLR Mission Support Request Form. The ILRS will consider the following points when reviewing the submitted MSR form:

1. Does SLR provide a unique capability that other tracking systems cannot? Is SLR the primary or secondary tracking technique? Can the tracking requirement be met by another technique?
2. What added value will SLR data provide to the data products?
3. Has the mission sufficiently quantified its tracking requirement (accuracy, data volume, coverage, etc.)? A request for "Everything you can get" and "do the best you can do" would result in a **very low priority** for the ILRS.
4. Does the mission have a vulnerable payload aboard that will require special tracking procedures?
5. What is the procurement source of the retroreflector array(s)? Does the design include accommodation for the velocity aberration? See https://ilrs.cddis.eosdis.nasa.gov/technology/spaceSegment/ for more information.

https://ilrs.cddis.eosdis.nasa.gov/missions/mission_support/new_mission_support.htr

New guideline for future mission approvals

- **MSRF has to be submitted 6 mo in advance (was 3-6 mo)**
- **Questioned issues clarified**

  1. Does SLR provide a unique capability that other tracking systems cannot? Is SLR the primary or secondary tracking technique? Can the tracking requirement be met by another technique?
  2. What added value will SLR data provide to the data products?
  3. Has the mission sufficiently quantified its tracking requirement (accuracy, data volume, coverage, etc.)? A request for "Everything you can get" and "do the best you can do" would result in a very low priority for the ILRS.
  4. Does the mission have a vulnerable payload aboard that will require special tracking procedures?
  5. What is the procurement source of the retroreflector array(s)? Does the design include accommodation for the velocity aberration?
  6. Has the signal link budget been estimated either through comparison with spacecraft already tracked by SLR or through the link equation?
  7. Have provisions been made to provide reliable predictions in CPF format? Has this source tested their CPF files or are there plans to do such testing?

Coherent Time and Frequency Distribution System for a Fundamental Station

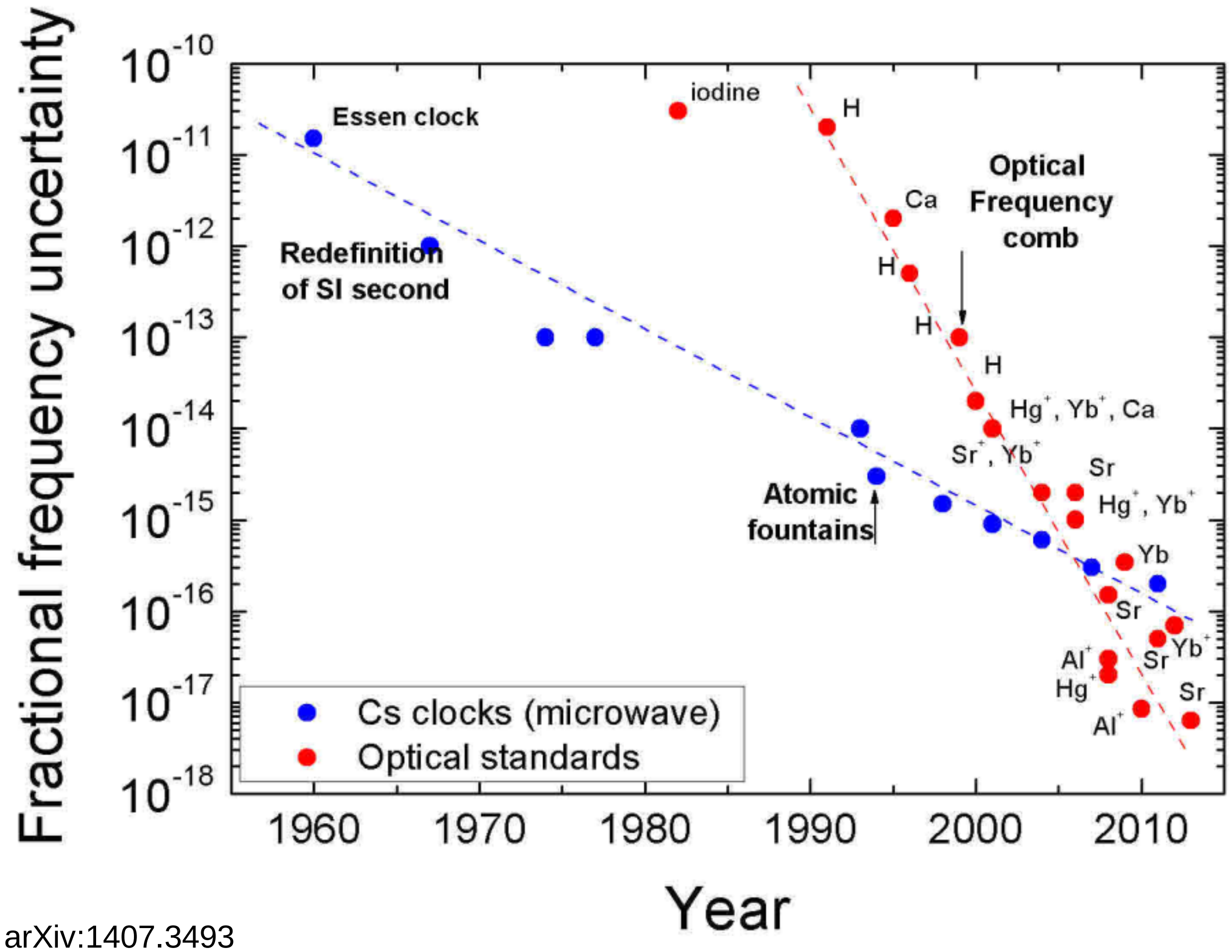
Jan Kodet, K. Ulrich Schreibe
Technische Universität München, GO- Wettzell

Torben Schüler
Bundesamt fuer Kartographie und Geodaesie, GO- Wettzell

TECHNISCHE UNIVERSITÄT MÜNCHEN

Federal Agency for Cartography and Geodesy

Optical Clocks in Space Geodesy



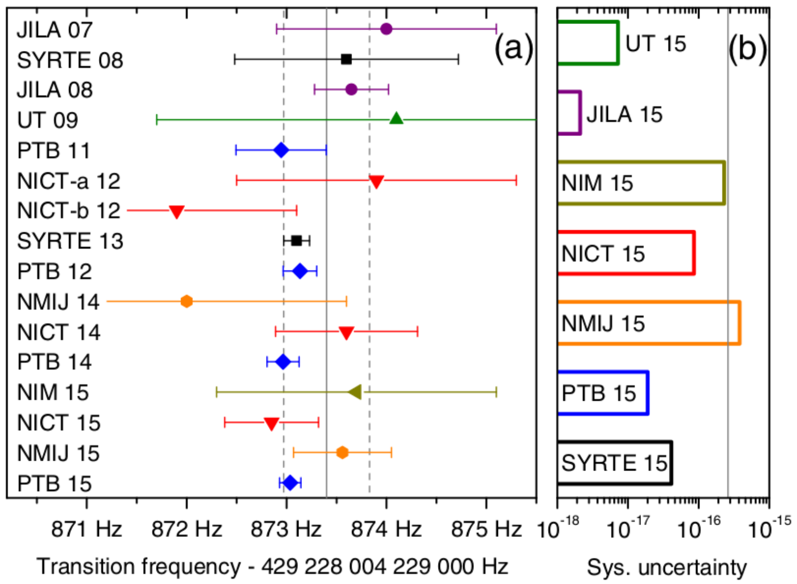
arXiv:1407.3493

Optical clocks has extremely good accuracy and stability. Both properties we would like to transfer into space geodesy.

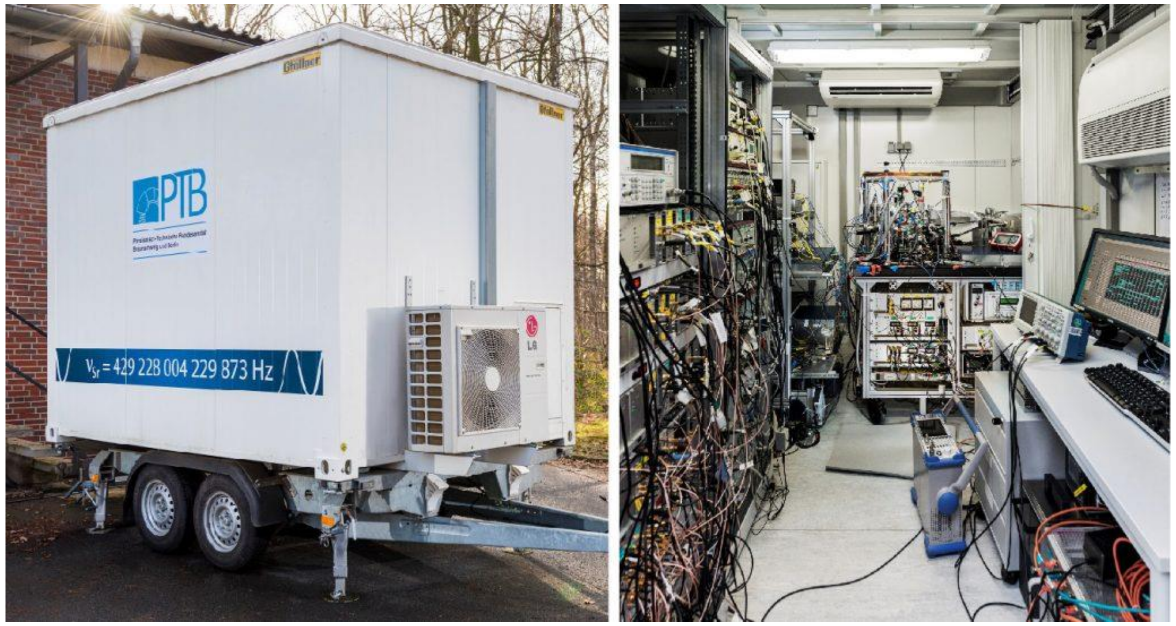
Space Geodesy measures signal delays, therefore we require high accuracy and stability to track phase.

Highly accurate clocks allow to exploit GR for a height system.

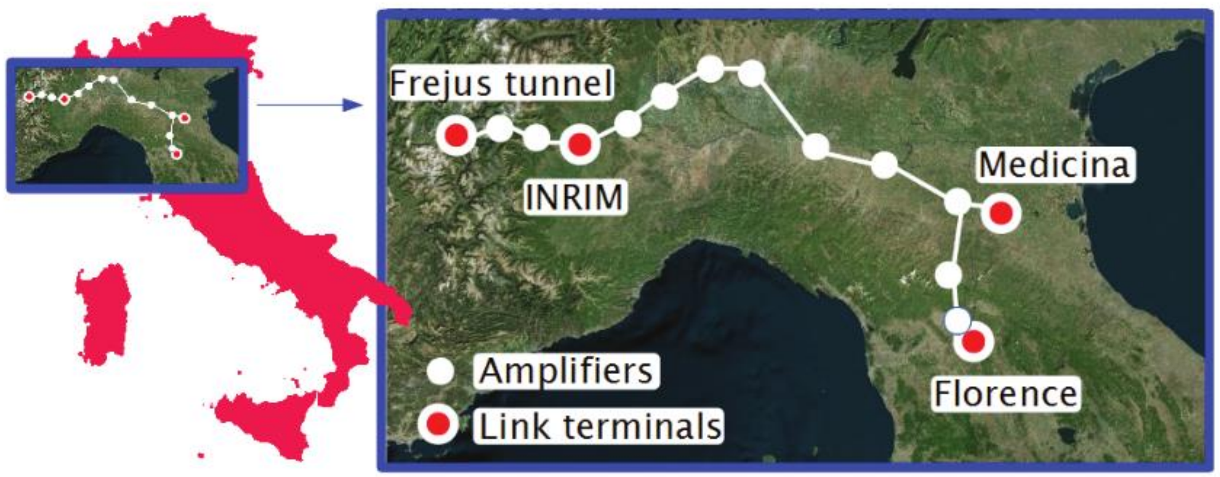
Optical Clocks in Space Geodesy



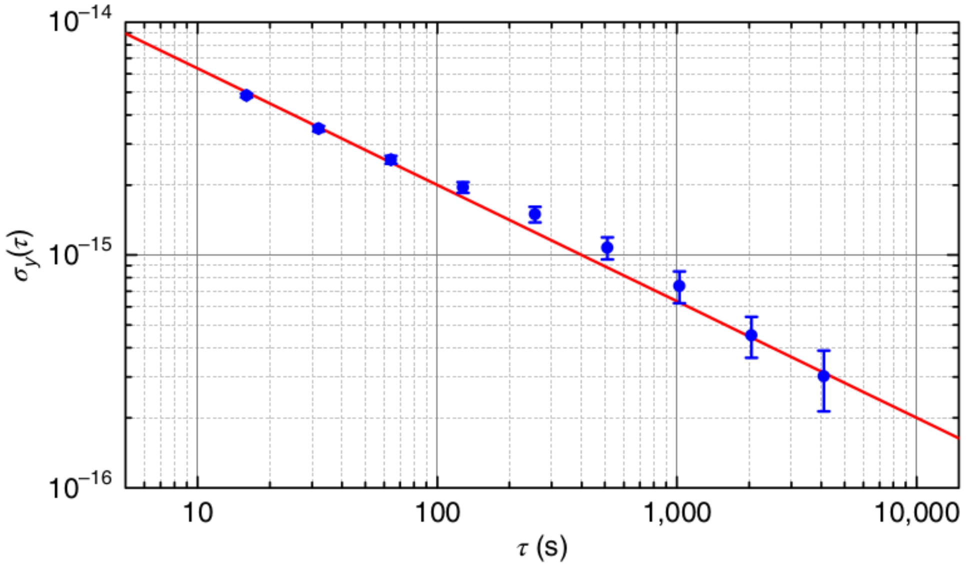
C. Grebing et al., „Realization of a timescale with an accurate optical lattice clock", Optica, č. 6, s. 563–569, erven 2016.



Pictures taken from the publication arXiv:1609.06183

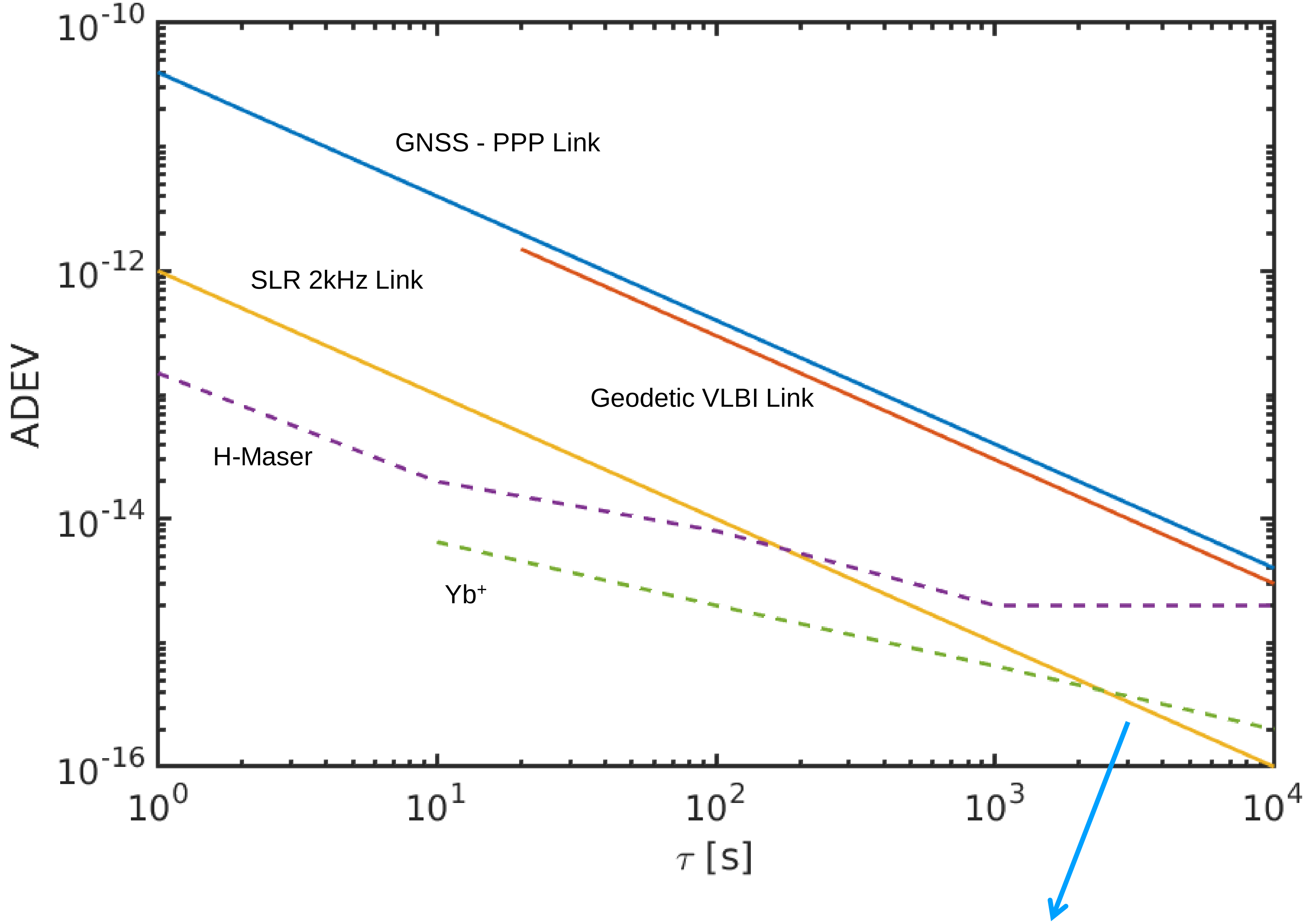


C. Clivati et al., "A coherent fiber link for very long baseline interferometry," IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 62, no. 11, pp. 1907–1912, Nov. 2015.



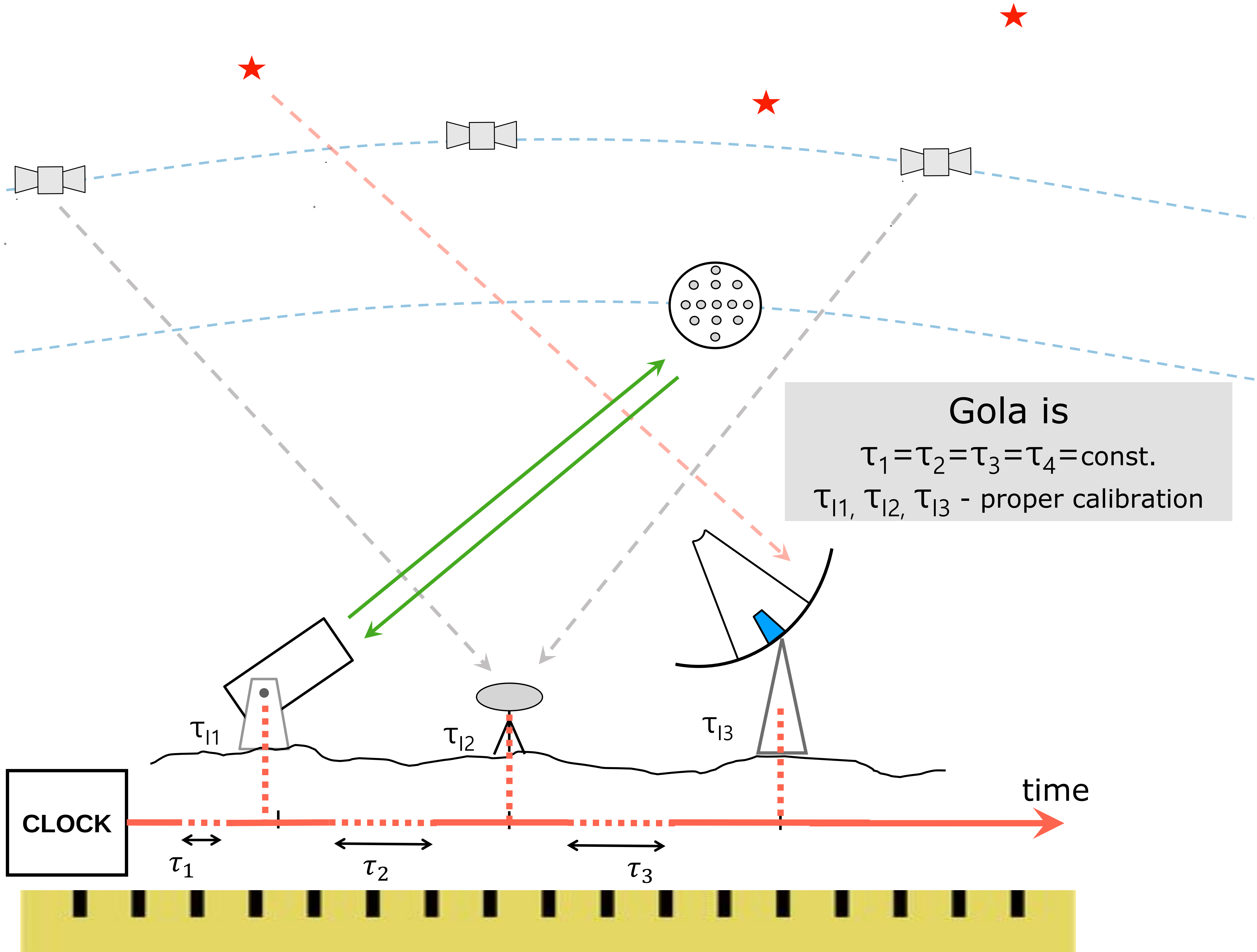
J. Grotti et al., "Geodesy and metrology with a transportable optical clock," Nature Phys, vol. 14, no. 5, pp. 437–441, May 2018.

Space Geodesy Instrumentation, where and how we can gain from ultrastable cloks



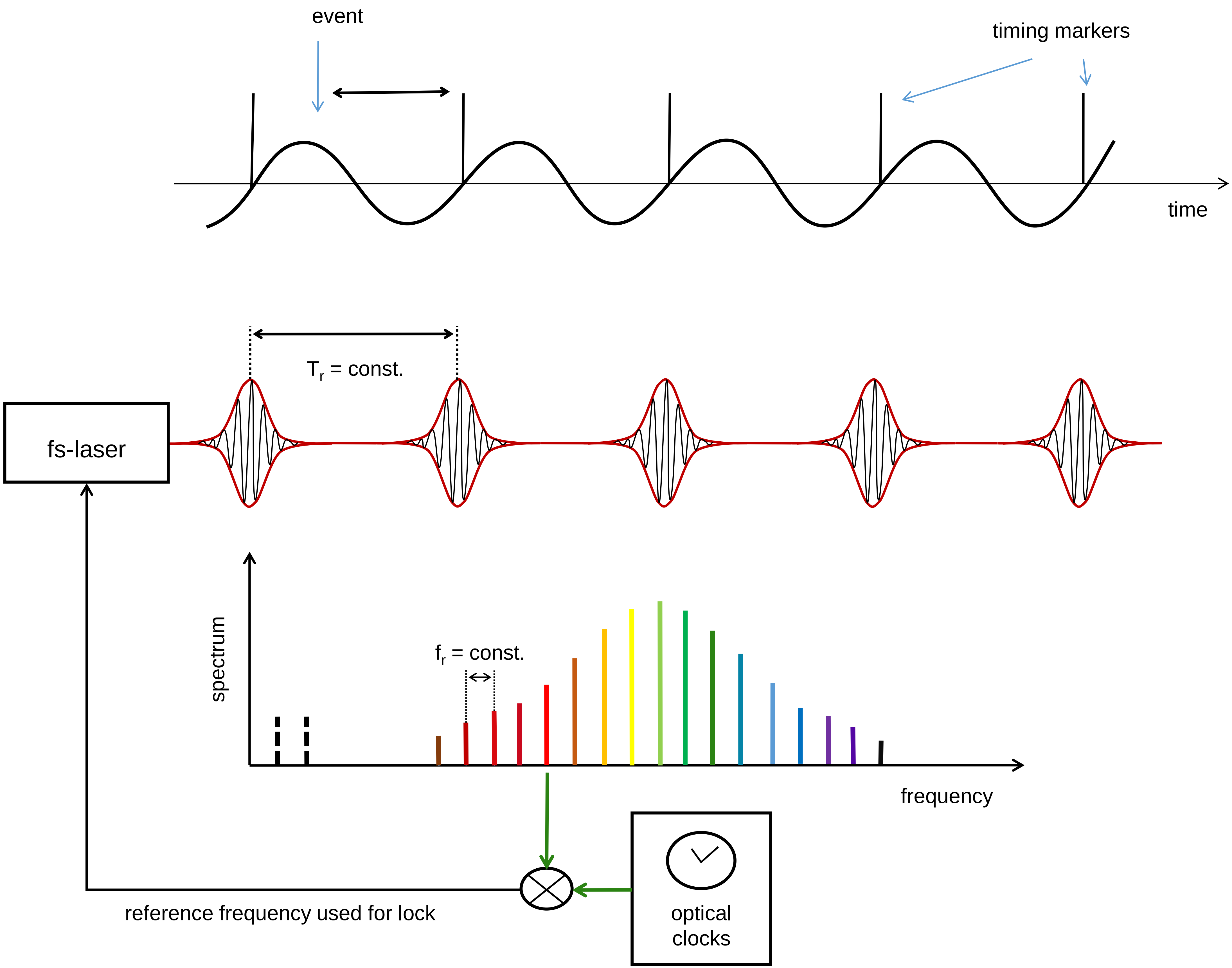
To reach 10^{-16} we must make our measurement stable and accurate.

T. Hobiger, C. Rieck, R. Haas, and Y. Koyama, "Combining GPS and VLBI for inter-continental frequency transfer," Metrologia, vol. 52, no. 2, p. 251, 2015.
J. Leute et al., "Frequency Comparison of ^171text Yb^+ Ion Optical Clocks at PTB and NPL via GPS PPP, Ferroelectrics, and Frequency Control, vol. 63, no. 7, pp. 981–985, Jul. 2016.

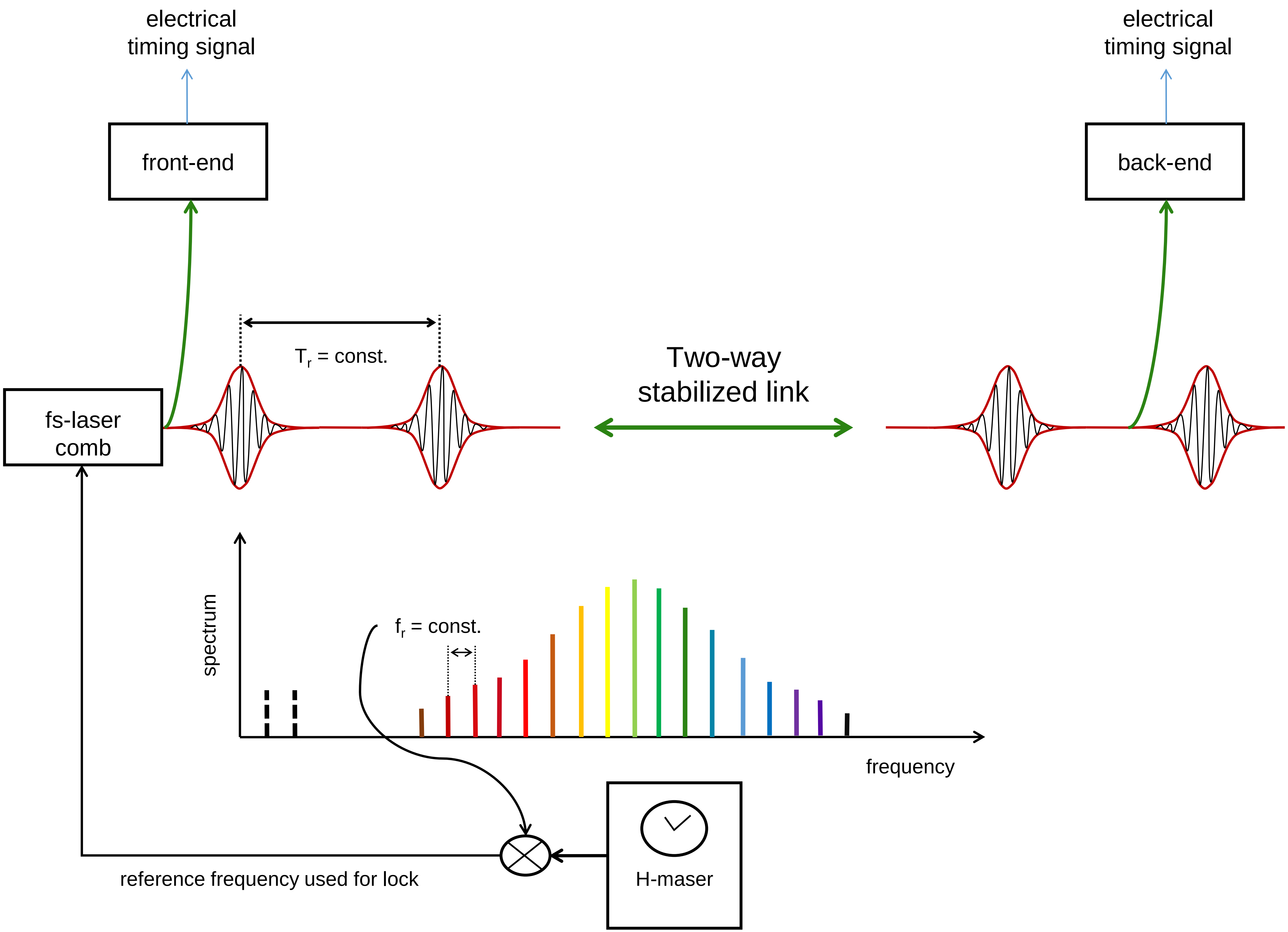


Gola is
$\tau_1=\tau_2=\tau_3=\tau_4$=const.
τ_{l1}, τ_{l2}, τ_{l3} - proper calibration
τ_{l1}
τ_{l2}
τ_{l3}
time
CLOCK
τ_1
τ_2
τ_3

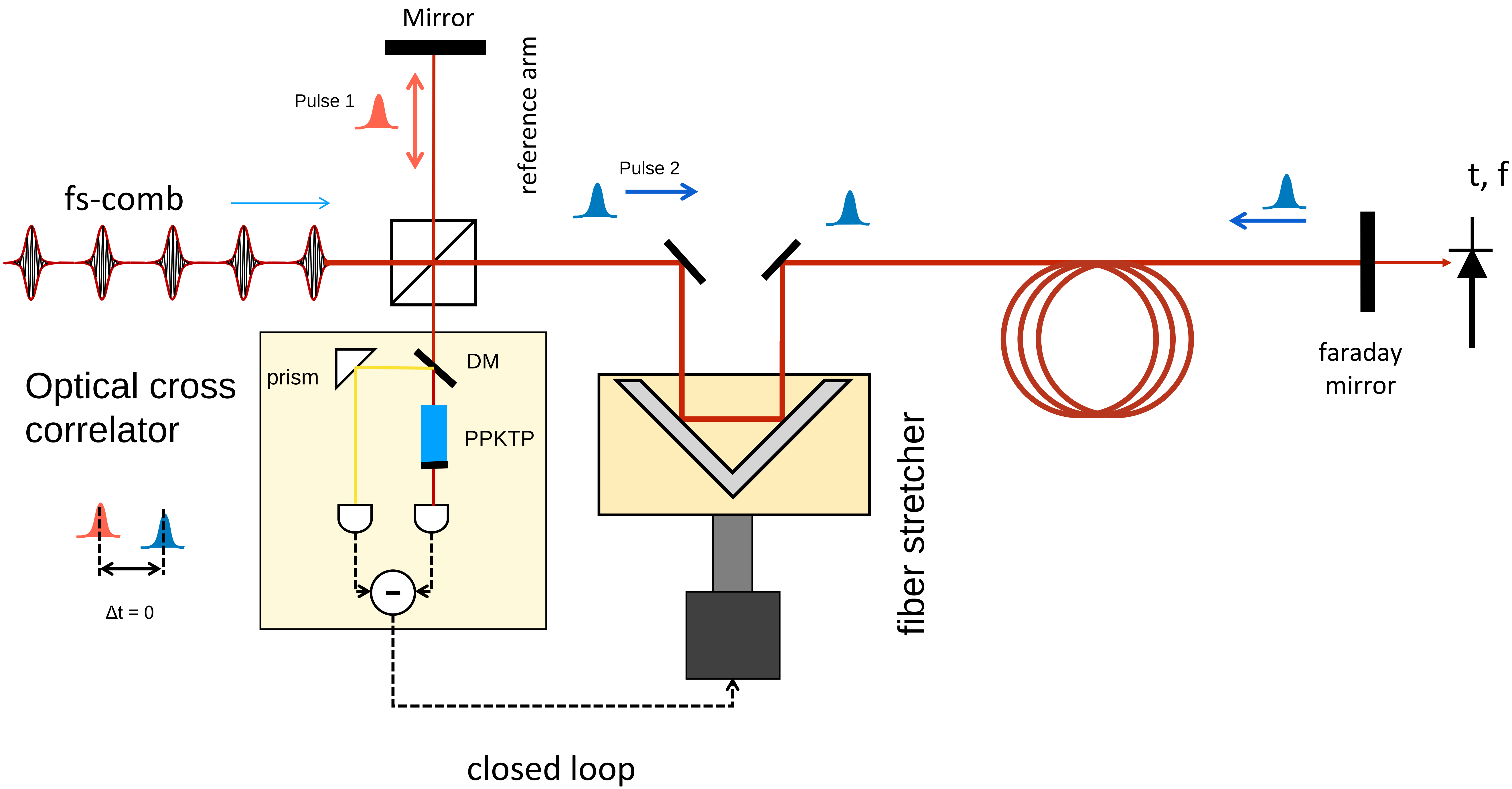
Optical Frequency Comb as an Ruler



Optical Frequency Comb as an Ruler



Drift-free timing synchronization of remote space geodetic instruments

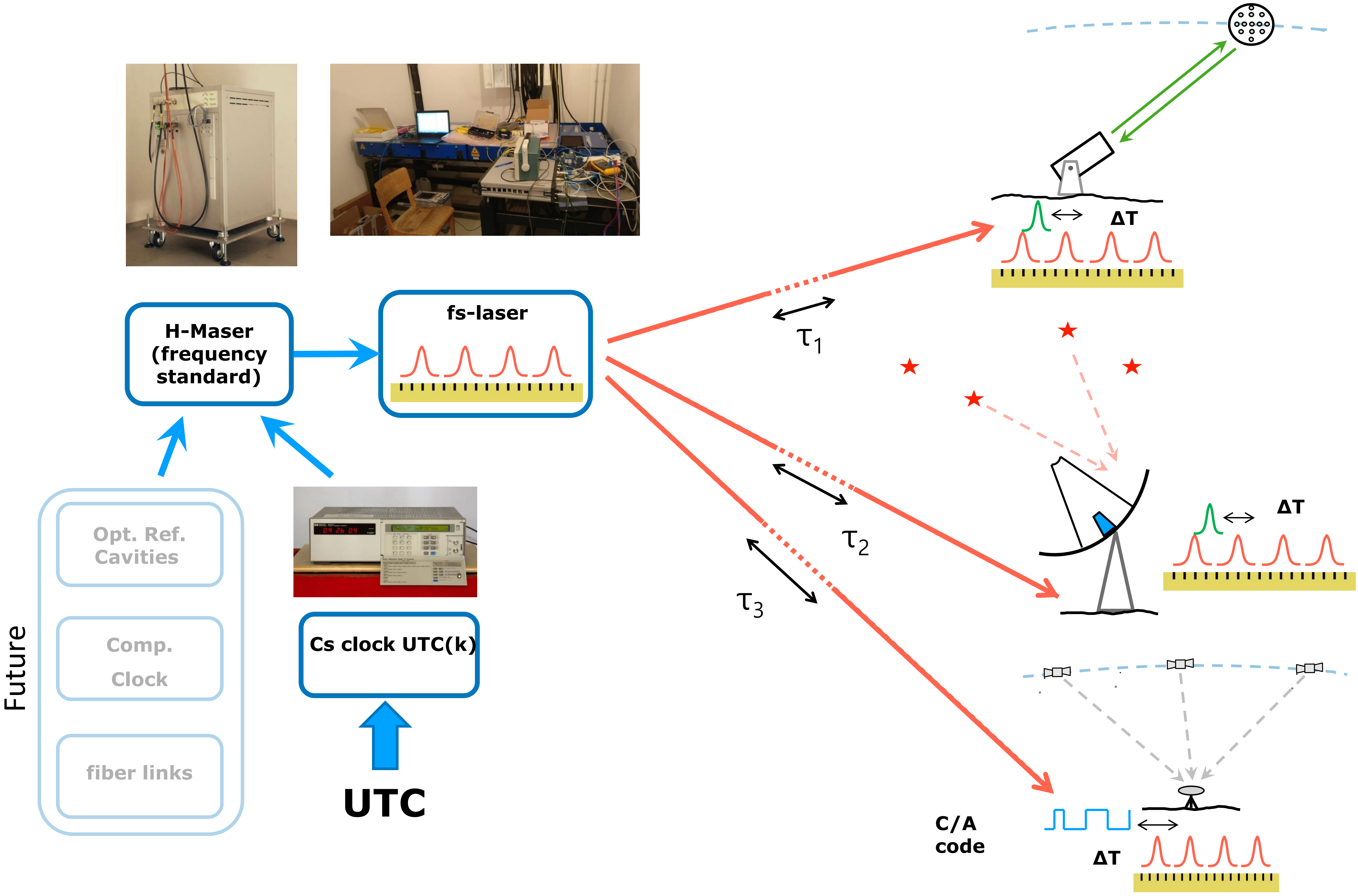


MenloSystems

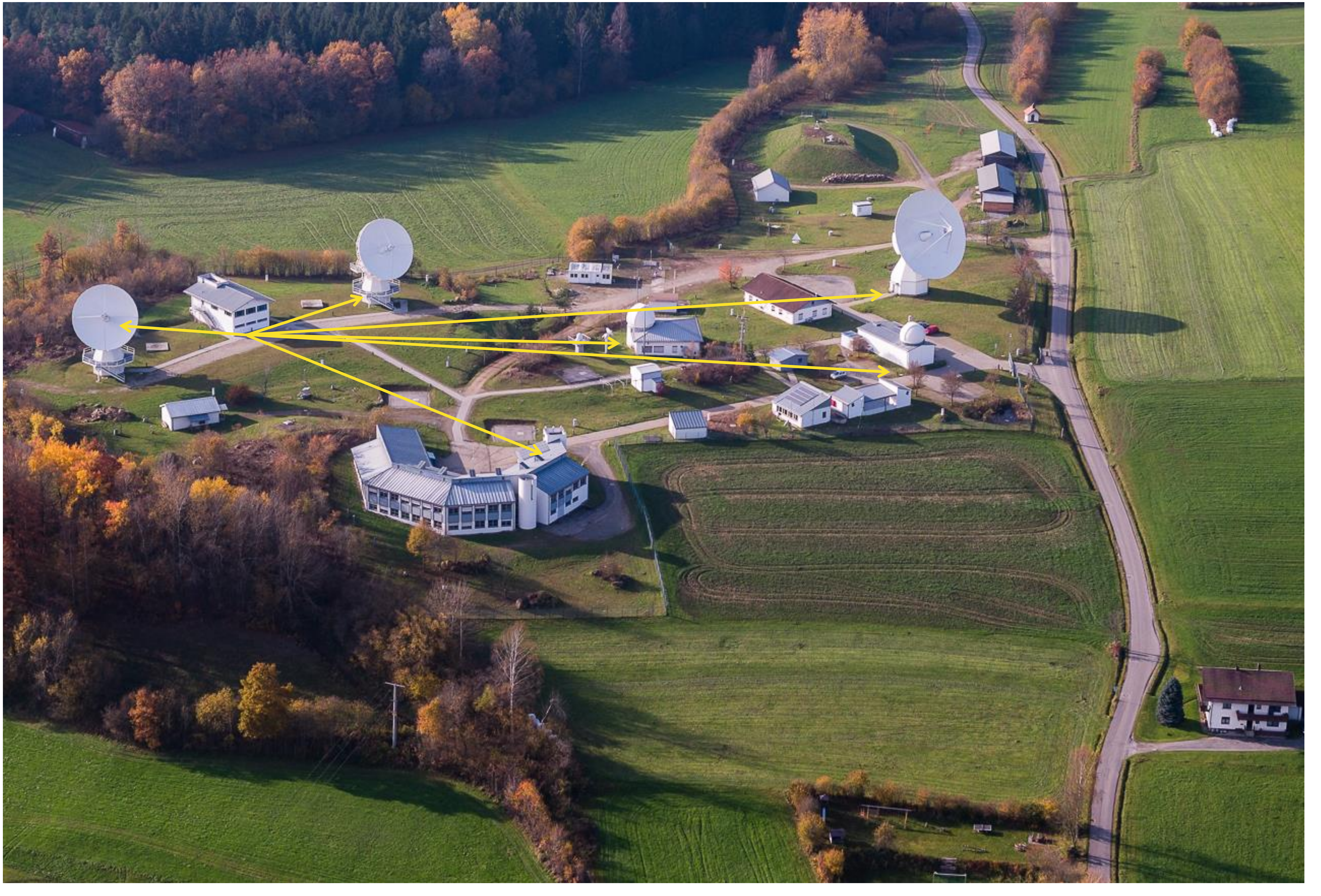
Example: FEL in Trieste

Schreiber et al.: Space Science Reviews, **214 (**1), p. 1371, (2017)

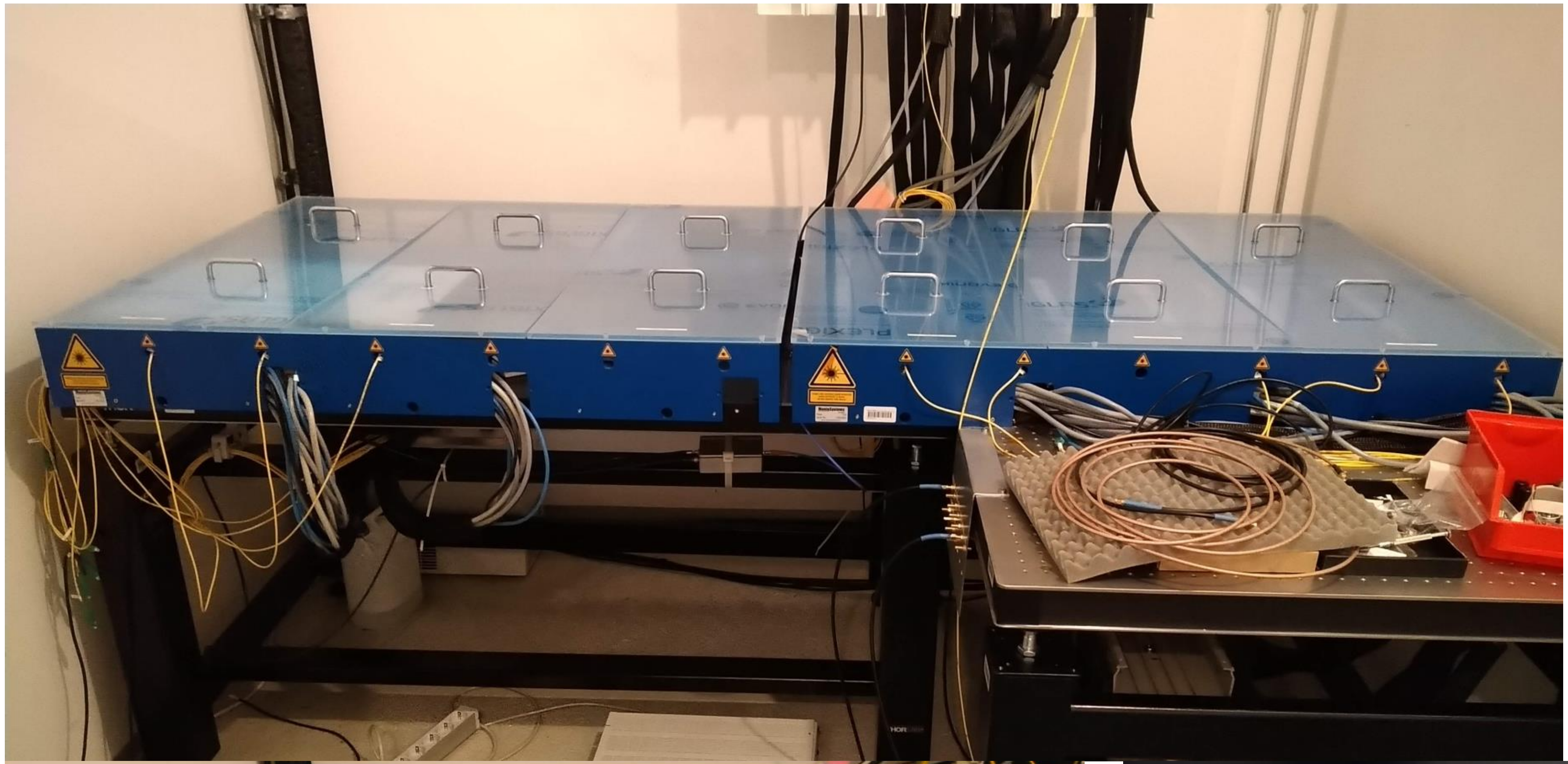
Optical Time Distribution system at Geodetic Observatory Wettzell



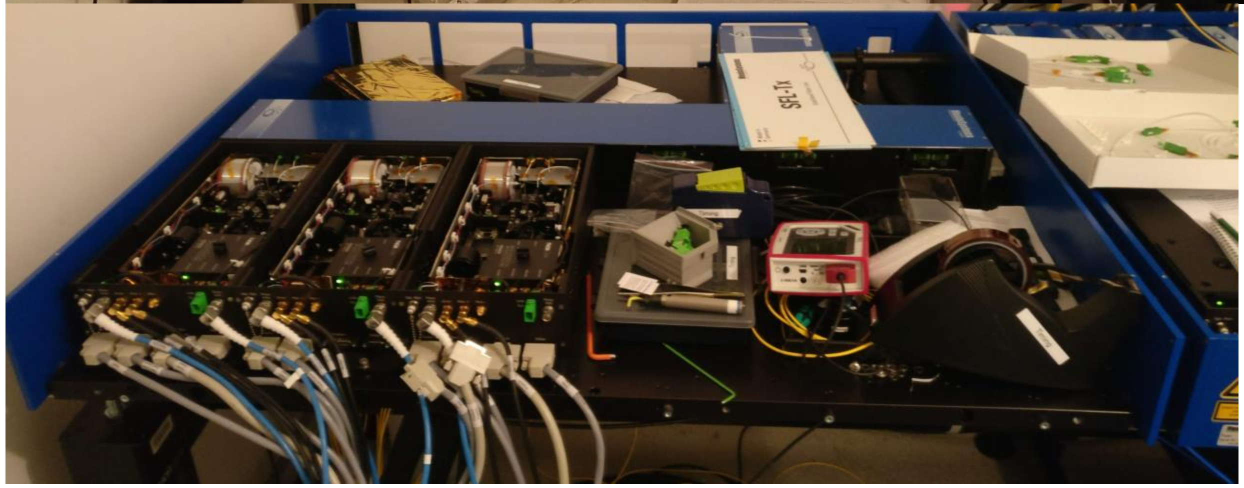
Geodetic Observatory Wettzell

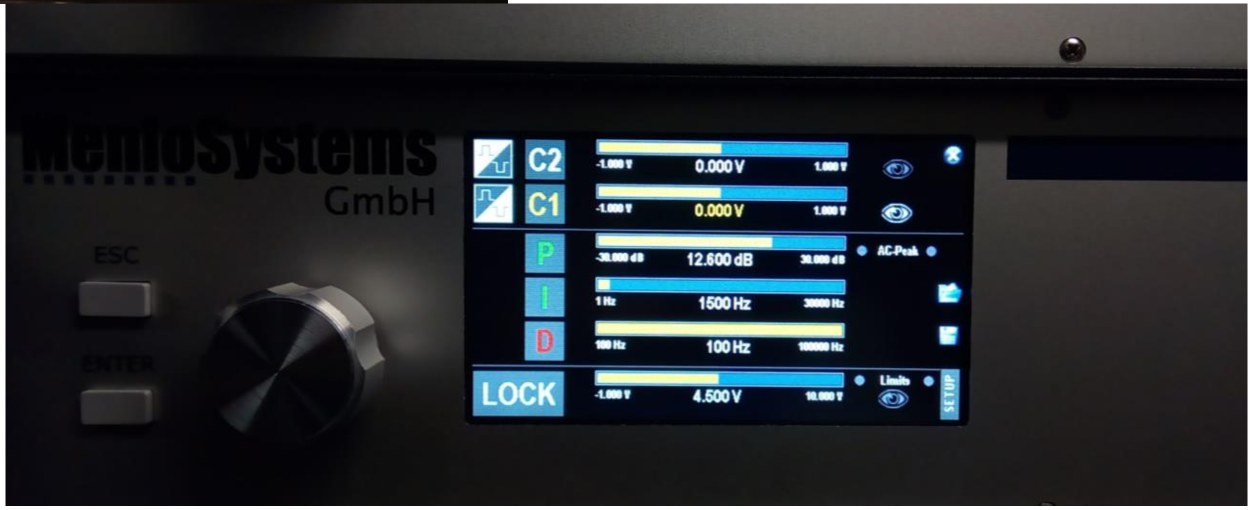


Campus Distribution for accurate Time



- laser - 1560nm
- laser lock unit
- 2x optical amplifier
- 10 links in operation

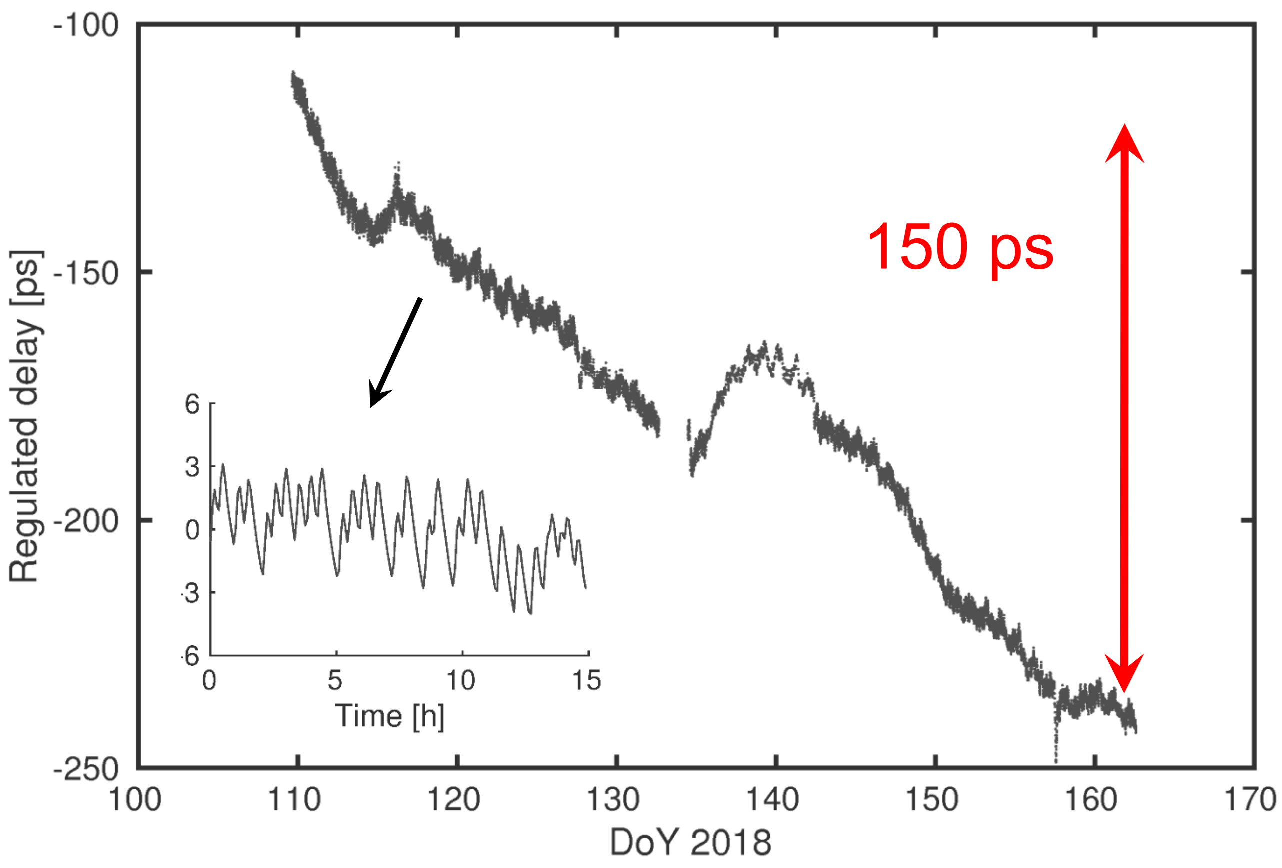




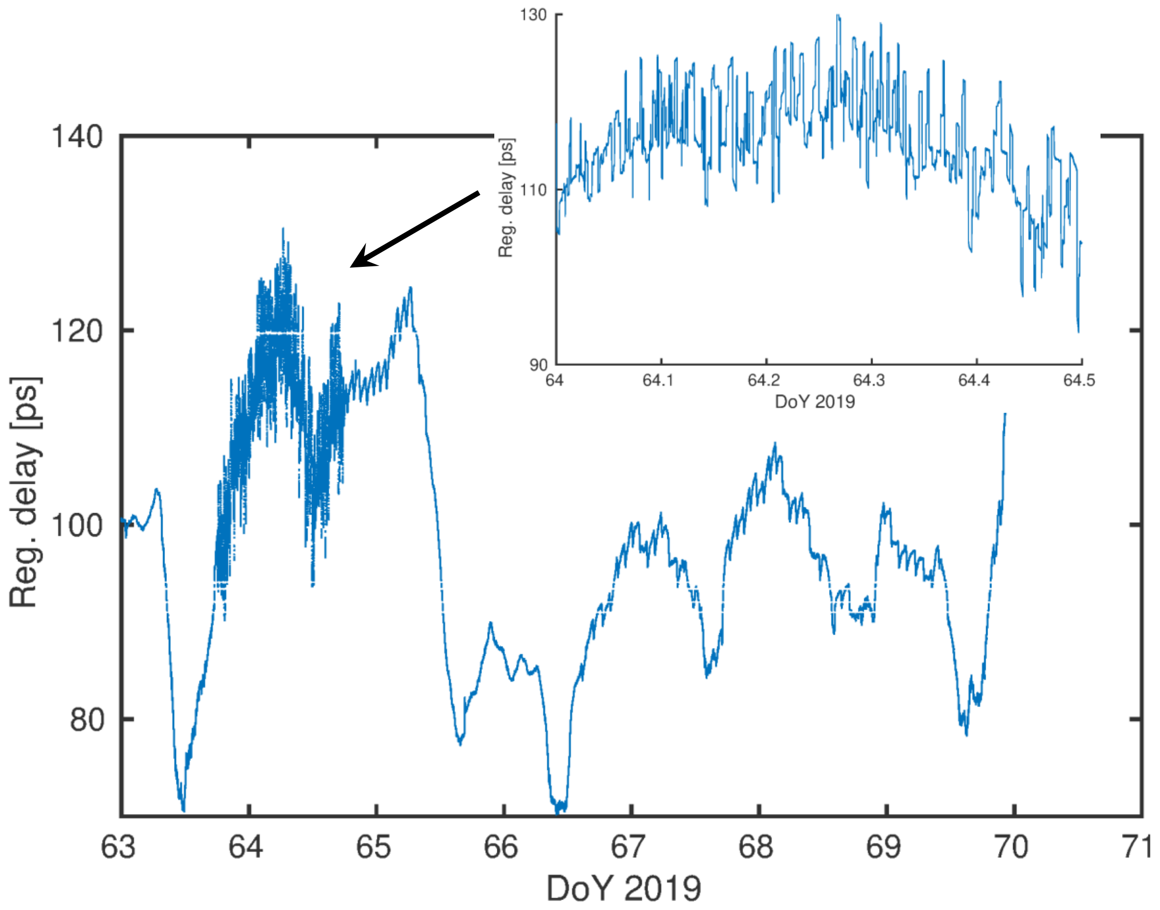
MenloSystems

Error signal for the closed loop fiber stretcher

Stationary link length ~300 m

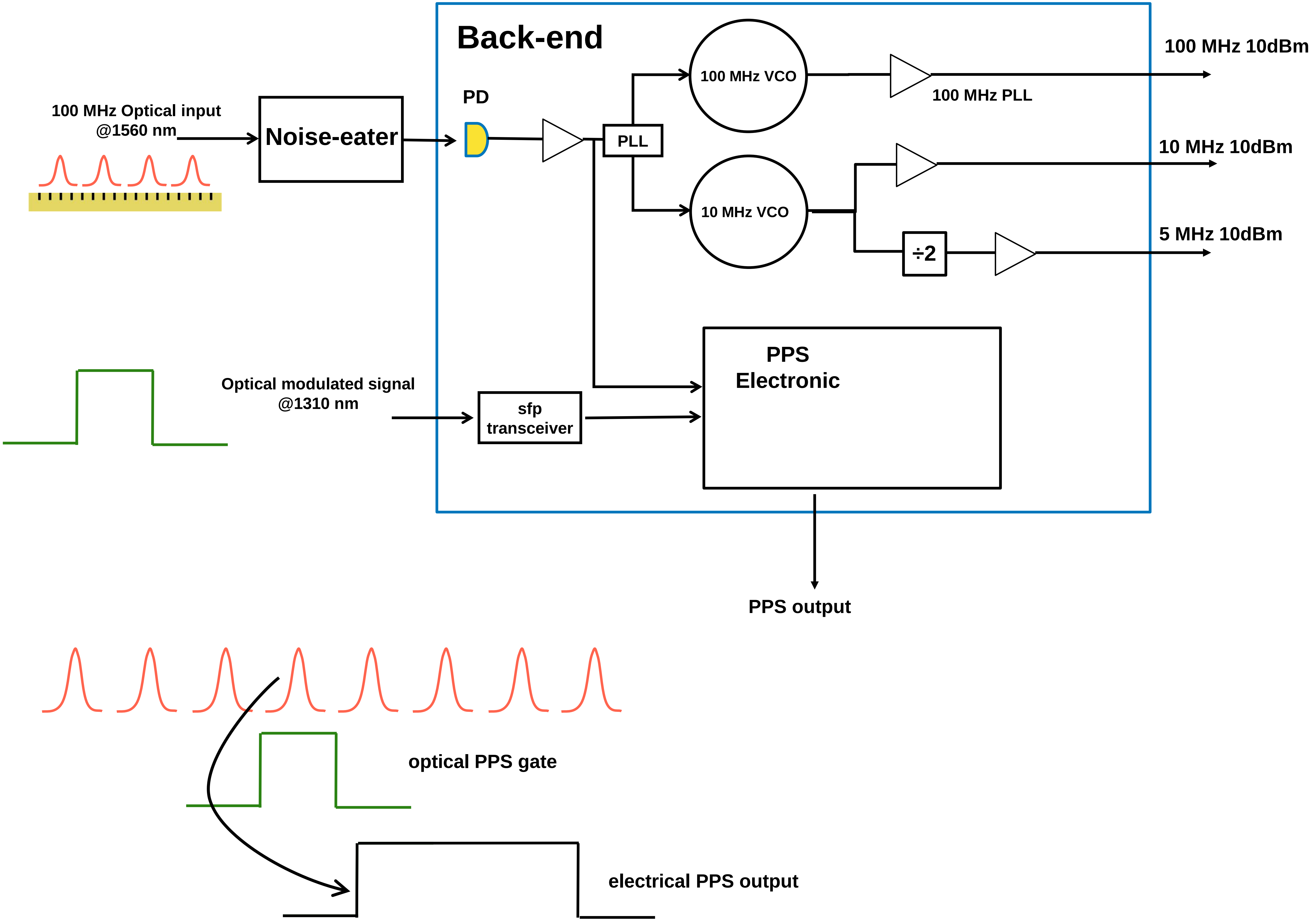


Moving link TTW2

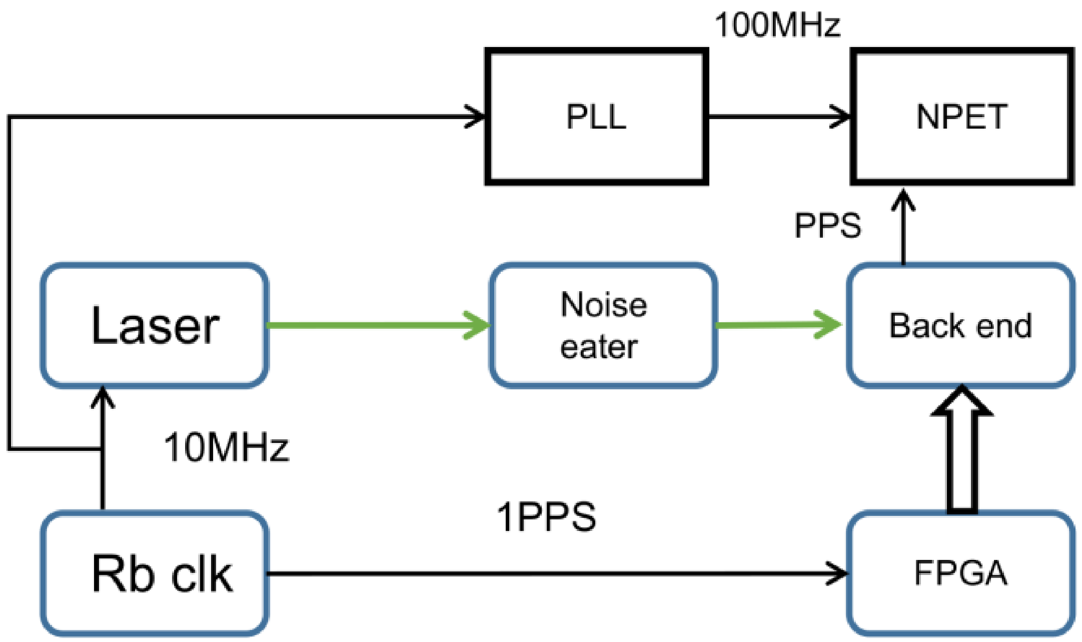


Most of the excursions appear to be caused by the air conditioning and movement of the radioteleskop.

Back-end diagram



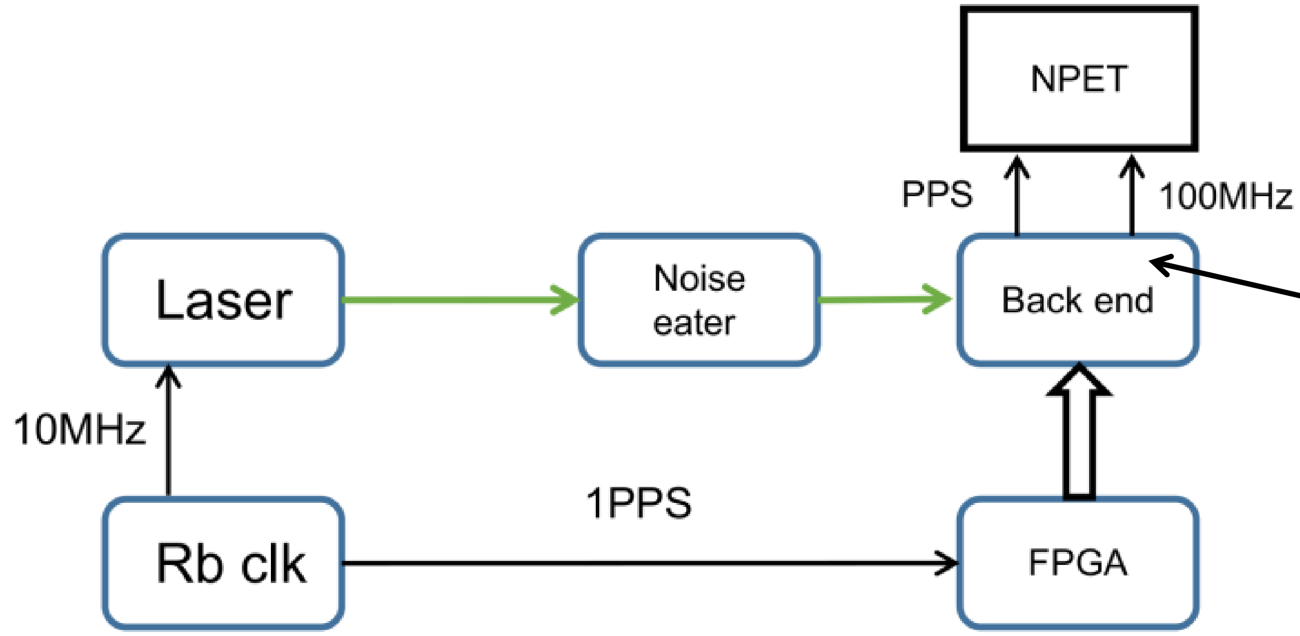
Timing properties of the timing signals



Additive jitter by Back-end electronic

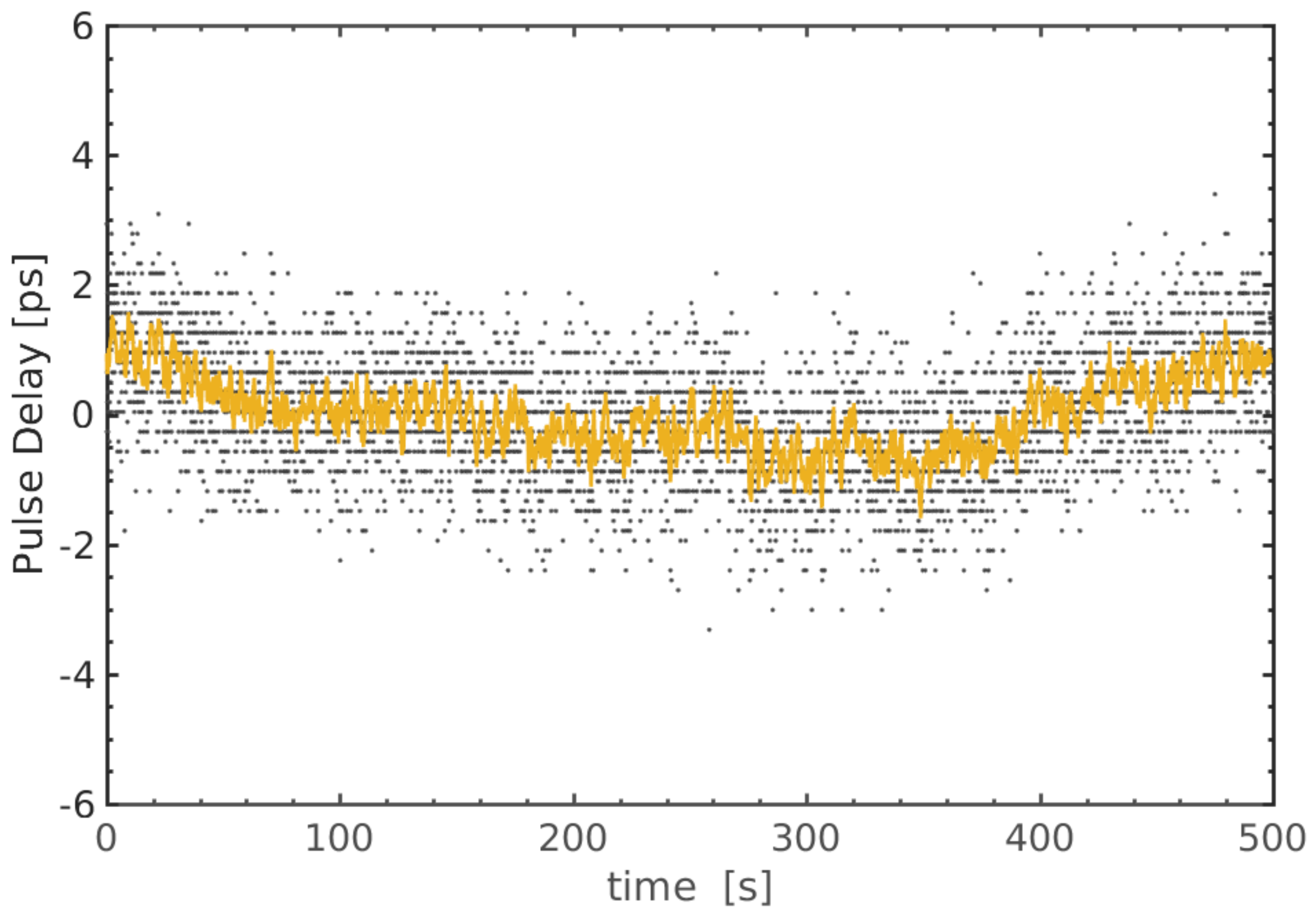
Signal Name	RMS Jitter	Temp. Coef.
Electrical PPS 1	0.43 ps	0.84 ps/°C
Electrical PPS 2	0.43 ps	0.83 ps/°C
CMOS PPS	1.26 ps	2.2 ps/°C

Timing properties of the timing signals



100MHz PLL heat up
+10°C

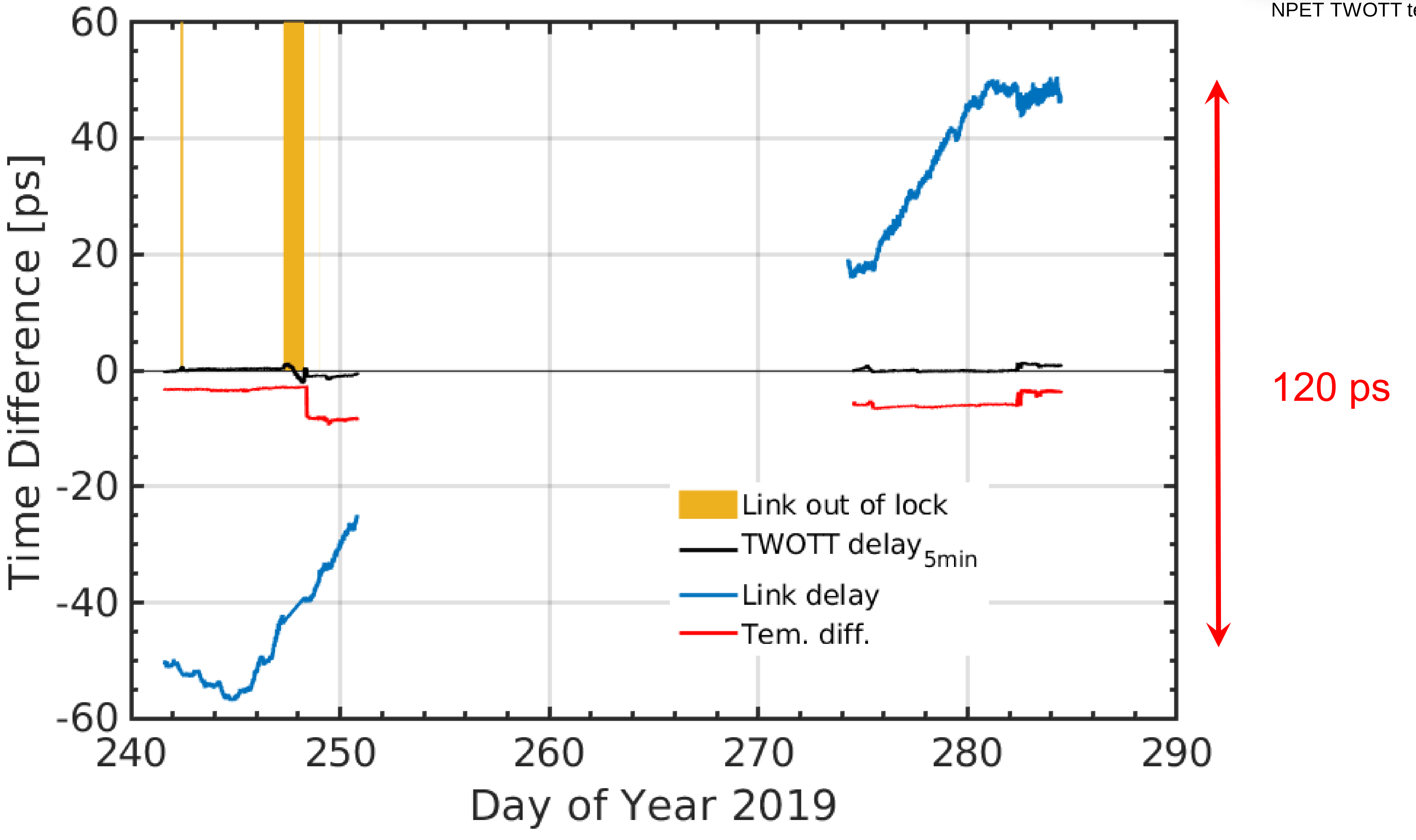
Oscillator output phase



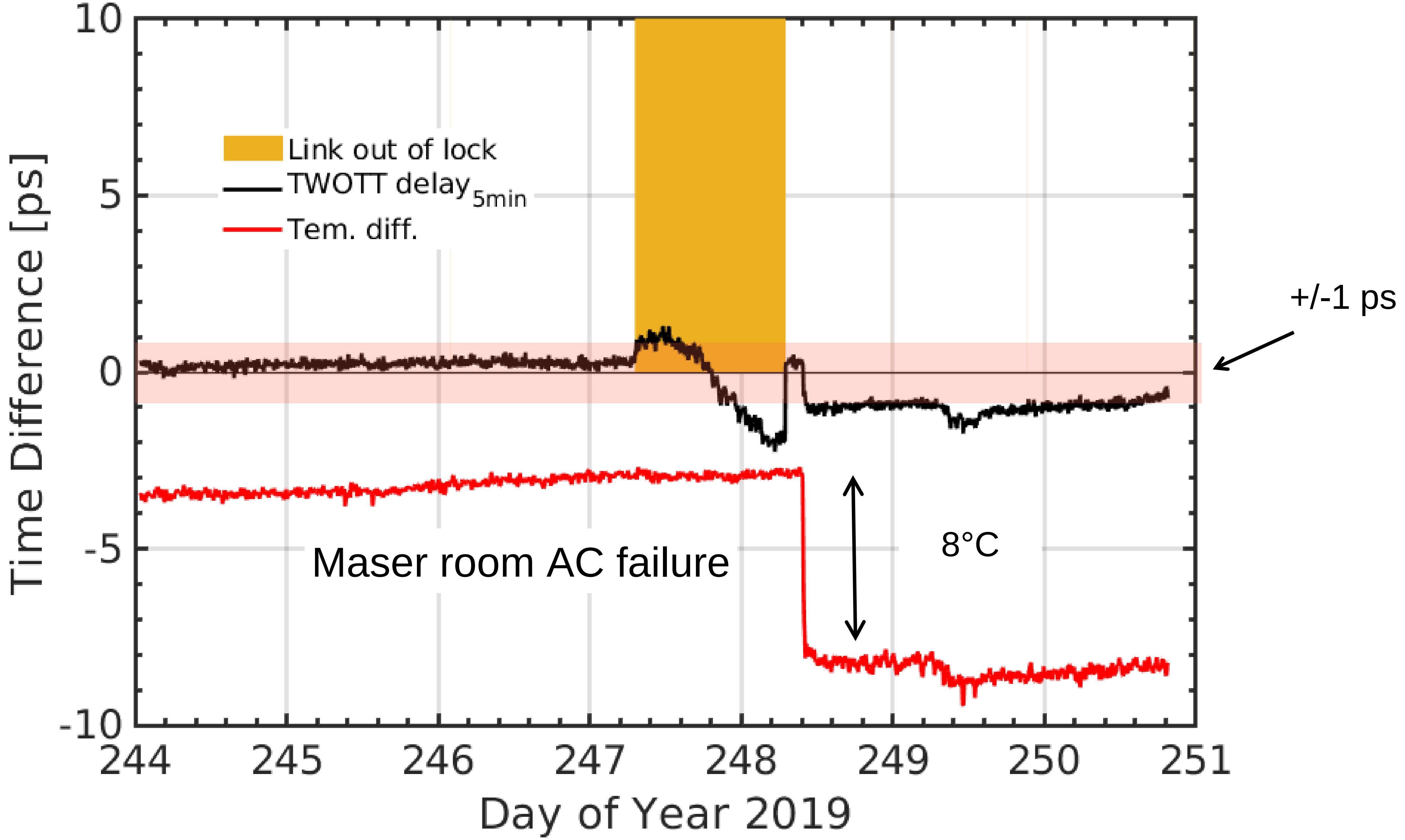
Error signal and time distribution of stationary link

To validate new timing system in terms of stability and absolute delay we developed TWOTT system Event Timer **NPET.** J. Kodet et al., Metrologia, 2016.

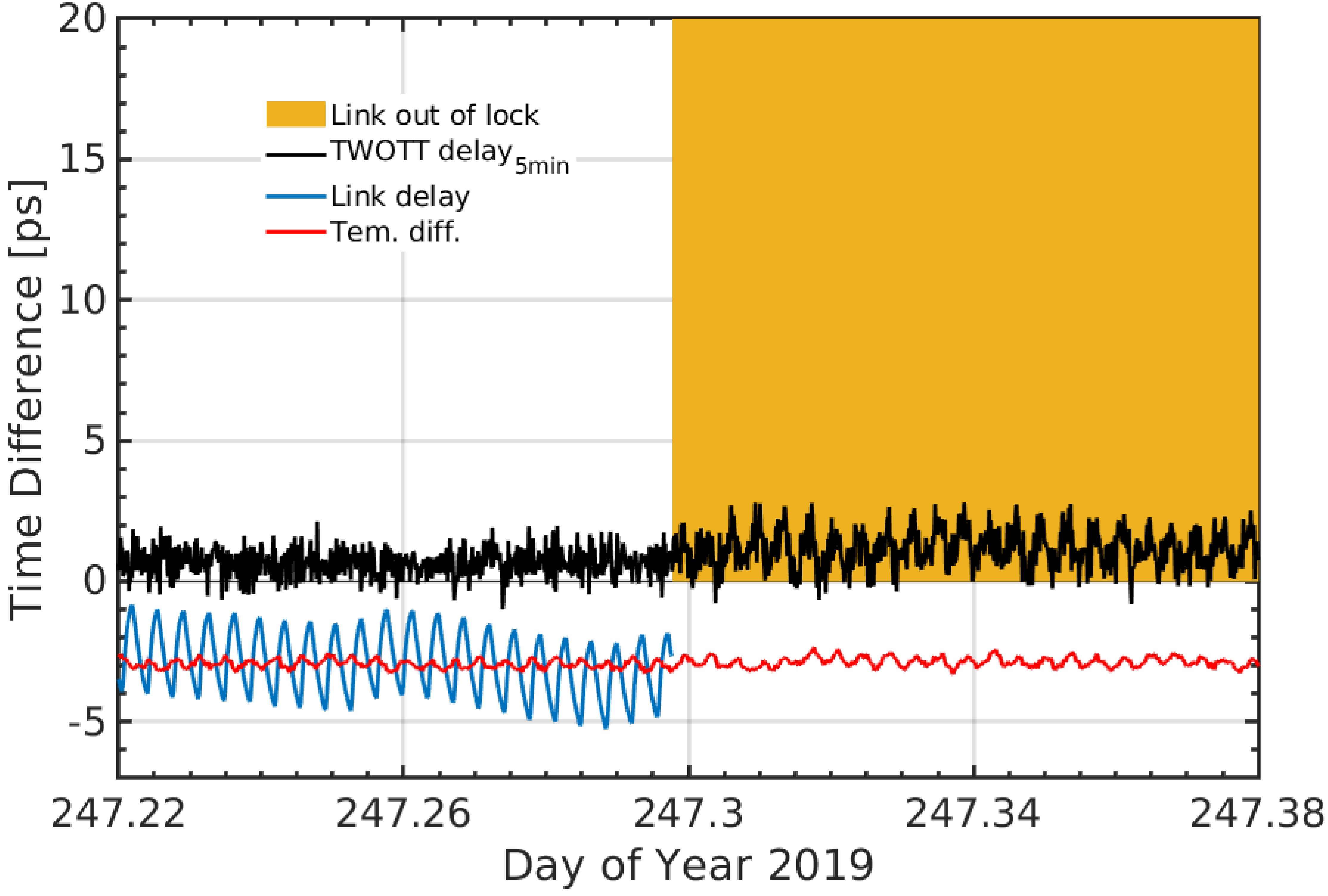
NPET TWOTT terminal



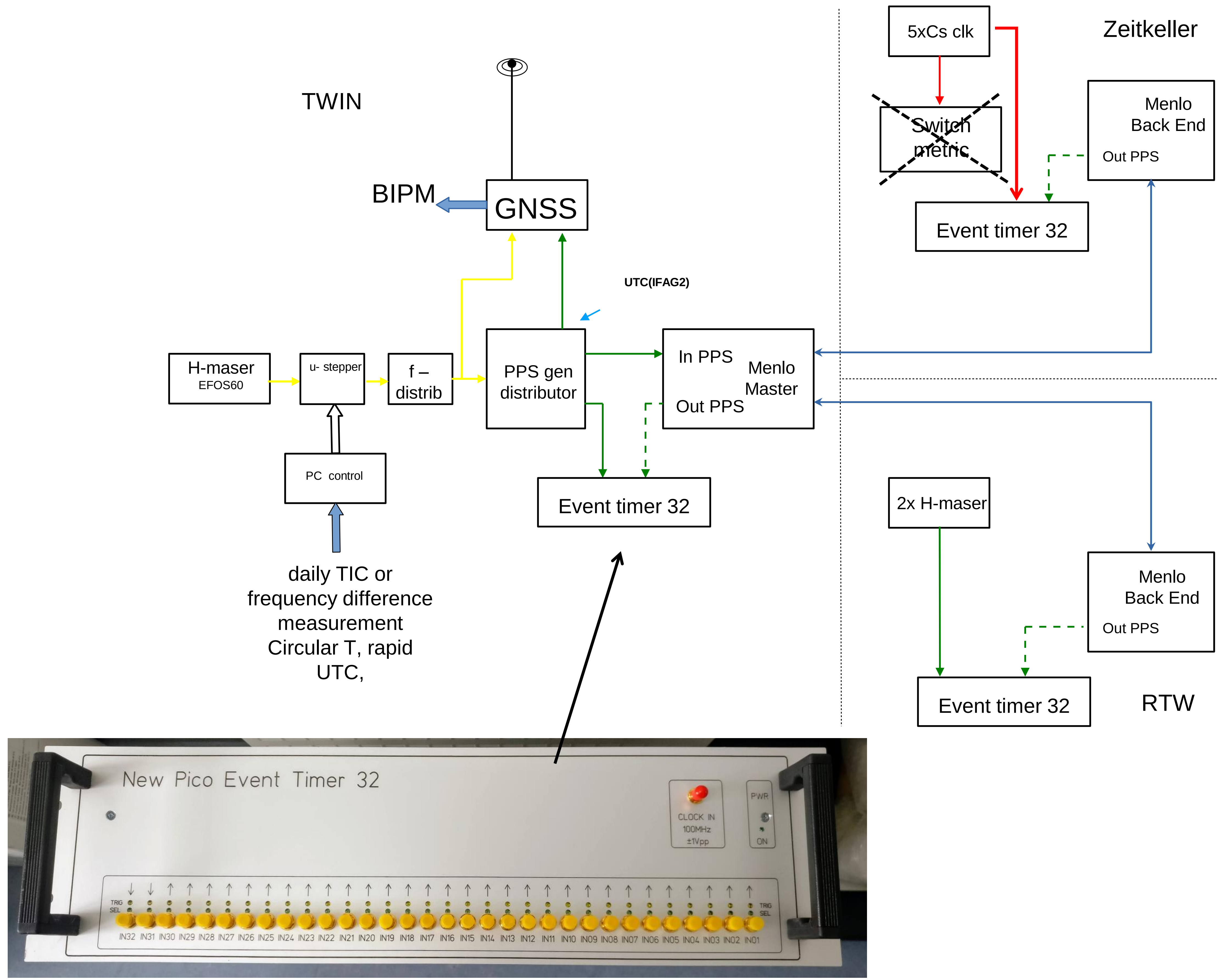
Time distribution of stationary link



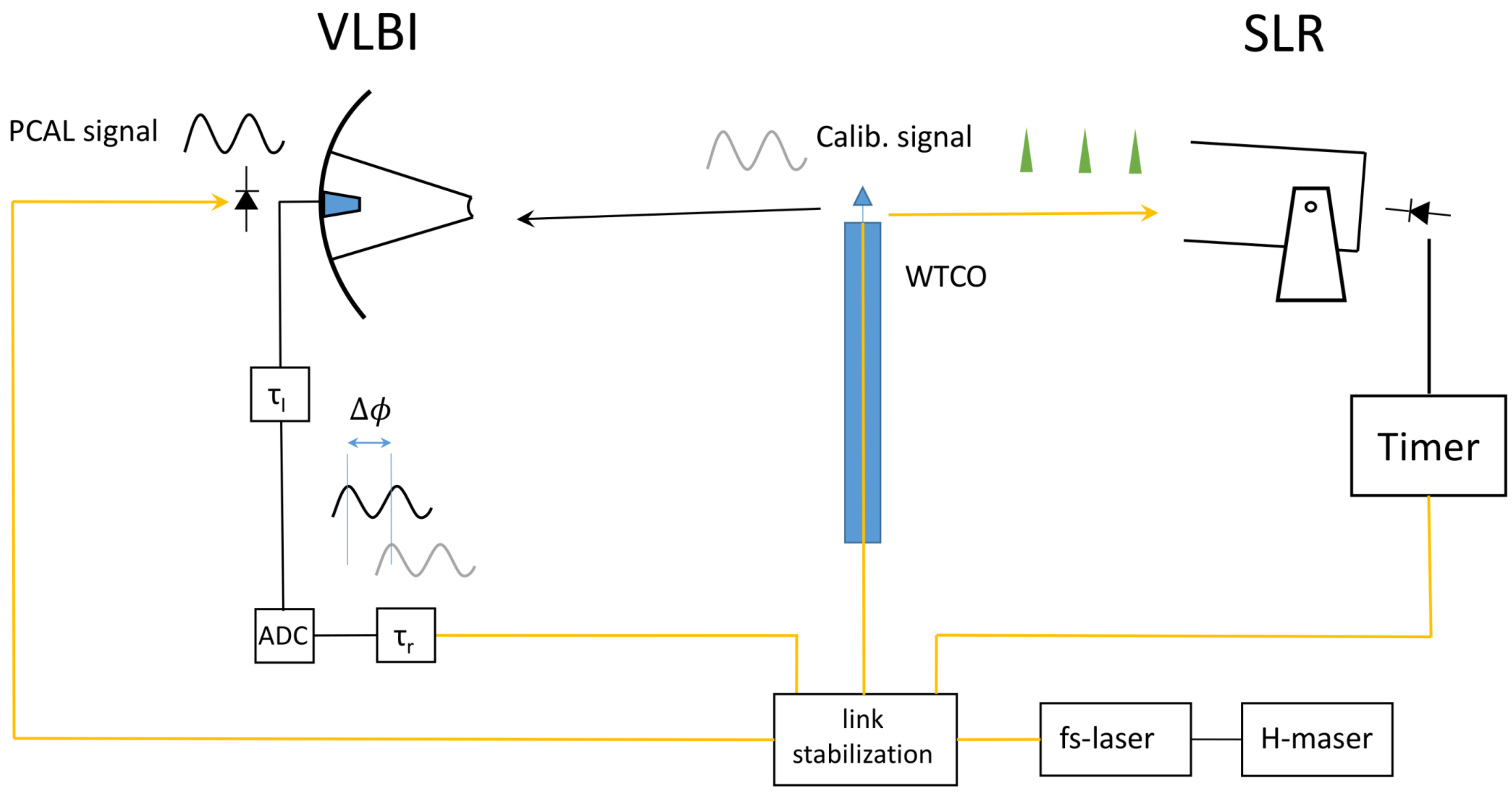
Time distribution of stationary link



Future reorganization of UTC(k)



Accurate Geodetic Ties by Closure Observations in Time



The biases in the geodetic measurement techniques can be quantitatively obtained for the first time in a closure measurement configuration with a resolution of a few ps.


Thank you for your attention

ALOS-4
MISSION OVERVIEW

Kazuhiro Yoshikawa
JAXA

ILRS Mission SC Meeting
22 October 2019

ALOS-4 Overview

Advanced Land Observing Satellite-4

- Observing the Earth's surface using its onboard phased array type L-band synthetic aperture radar (PALSAR-3)
  - Further improved observation performance compared to the predecessor PALSAR-2 aboard the ALOS-2; both higher resolution and broader observation swath
- Monitoring oceans by receiving AIS signals from vessels as well as by acquiring the PALSAR-3 images
  - Effective countermeasures against radio wave interference regions are taken for the SPace based AIS Experiment (SPAISE3) with multiple antennas and groundbased data processing
- Plan to launch in JFY2021

Observation Swath (ALOS-2 / ALOS-4)	
Stripmap mode (Resolution 3 m, 6 m, 10 m)	50 km, 70km / 100km - 200 km
ScanSAR mode (Resolution 25 m)	350 km, 490 km / 700 km
Spotlight mode (Resolution 1 m x 3 m)	25 km x 25 km / 35 km x 35 km

Observation Frequency @Japan (ALOS-2 / ALOS-4)	
Stripmap mode (Resolution 3 m)	Four times a year / Once every two weeks

General Characteristics	
Sensor system	PALSAR-3*, SPAISE-3**
Operational orbit	Sun-synchronous sub-recurrent
Orbit altitude	Approx. 628 km (same as ALOS-2)
Spacecraft size	10.0 m (D) x 20.0 m (W) x 6.4 m (H)
Spacecraft mass	Approx. 3,000 kg
Design life	7 years

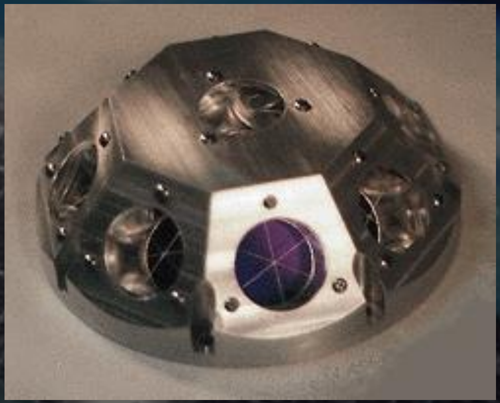
*PALSAR-3:phased array type L-band synthetic aperture radar
**SPAISE-3:Space-based Automatic Identification System Experiment

SLR Tracking

POD is needed

- SAR Interferometry depends on the accuracy of orbits
  - Mission requirement is < 10 cm (RMS)
- The LR onboard will be used for evaluation and calibration of POD
  - The same type LR as ADEOS-2's one
- GPS antennas and receivers will be onboard
  - L1/L2 signal from GPS

LR specification	
Size of LR	ϕ160 mm x 65 mm
Optical Cross Section	5×10^5 m^2
Number of CCR	9 (1 center + 8 surroundings)



LR for ADEOS-2 @HTSI

Mission Support

- Mission Support Request will be submitted in 2021
- Tracking restrictions during maneuvers (Autonomous orbit control)
  - For avoidance of damage to STT
- JAXA asks favor about ILRS Mission Campaigns (including at the IOT phase)
  - ILRS support will be strongly appreciated
  - More detail will be introduced at Kunming meeting