Progress Report on the WLRS: Getting ready for GGOS, LLR and Time Transfer

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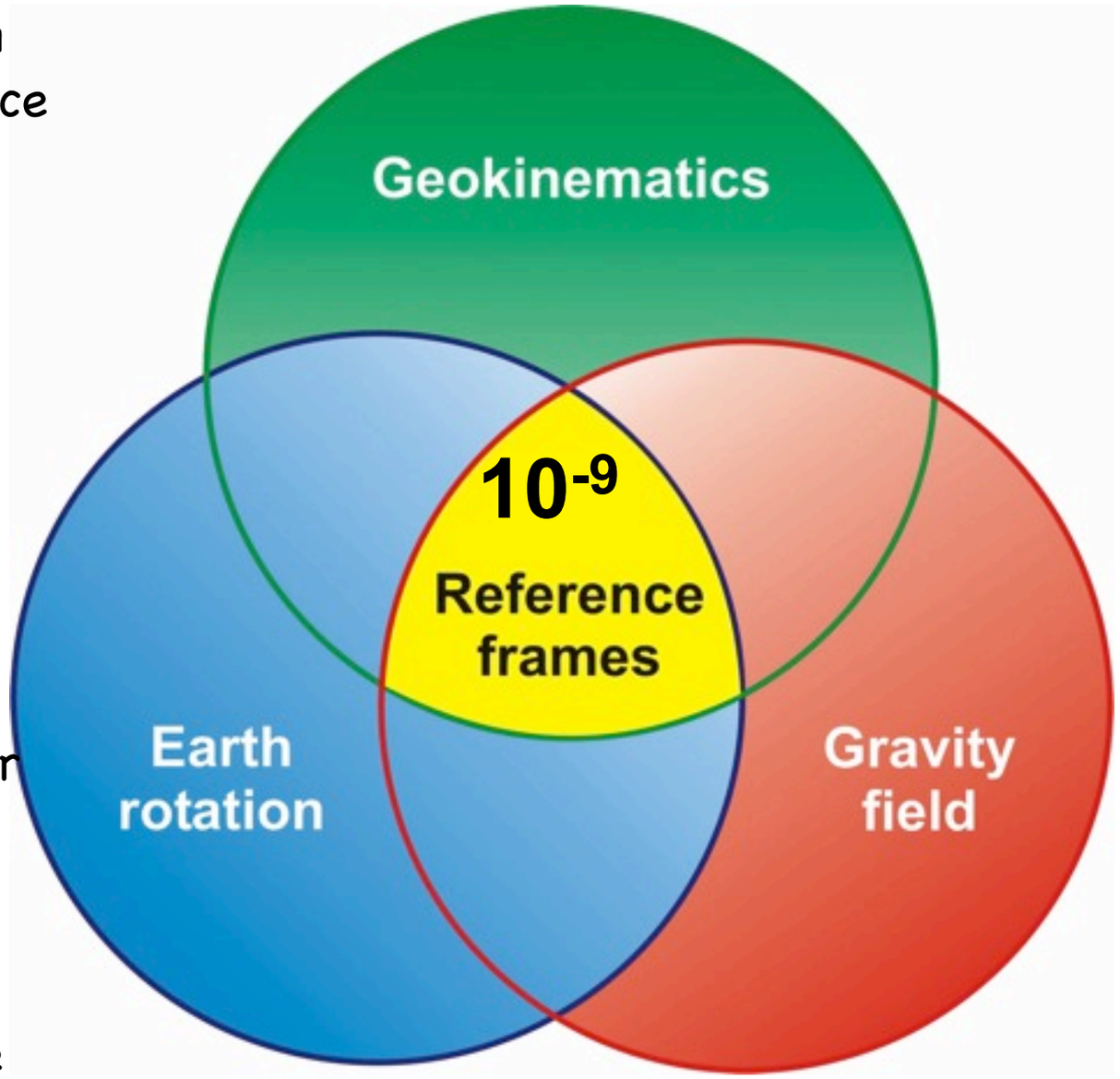
The goals set forward by the GGOS have stringent implications for the SLR stations. Most prominently this requires a good control over systematic effects reducing the accuracy on the range measurements. At the same time the observation load on the system increases as more satellites are endorsed for tracking by the ILRS. We have taken up the challenges and remodeled the WLRS. A new laser with shorter pulse duration and higher reliability and stability is currently being integrated as well as a new ground target providing higher accuracy. We also concentrated on the support for high altitude satellites in order to get back to LLR observations. Last but not least, we have improved our control system to support satellite interleaving. A lot of effort went into the construction of a calibrated timing link between the WLRS and the master clock of the Geodetic Observatory Wettzell in order to support optical time transfer between T2L2 on Jason 2 and eventually ELT on the ISS.

➢ „Internal" Goal

Evolution of GGOS and the geodetic observation technologies to establish an Earth fixed reference frame with a relative accuracy of at least

10^{-9} = 1 ppb

with high spatial and temporal resolution.



➢ „External" Goal

Integration of GGOS as an important contributor into **Earth System Research** (Modeling of physical, chemical and biological processes).

Contributions: Mass transport, dynamics, surface deformations.

Technical demands for GGOS*

We require an accuracy of 1 mm in geodetic positions and 0.1 mm/year level for velocities

-> better control over systematic biases (intra-technique)

-> better linkage between the techniques (inter-technique)

-> local ties (geometry, system delays)

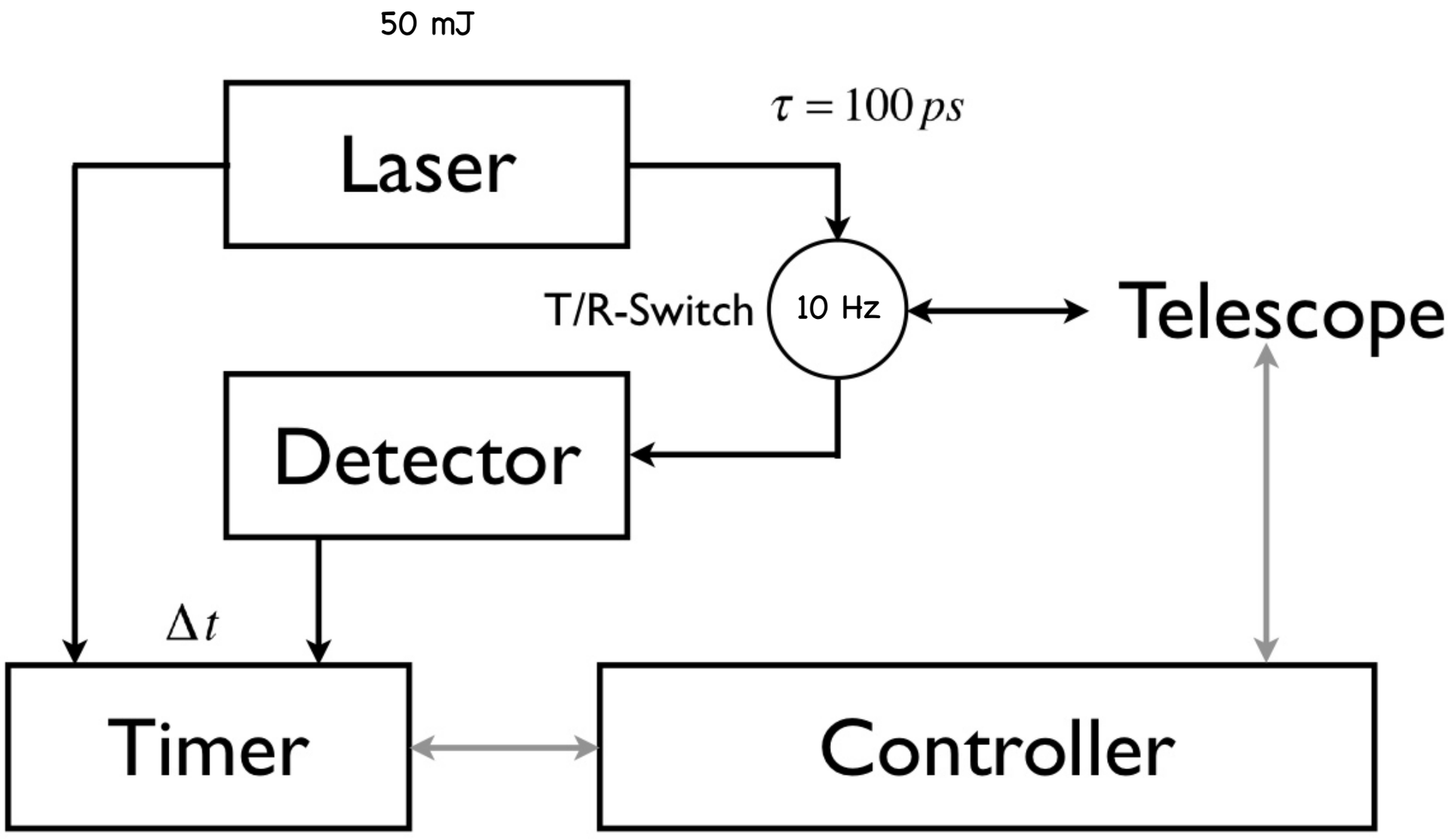
What do we experience at the SLR station level?

- observation load is increasing, while resources are getting sparser

- higher level of automation is required (also for quality control)

- reduced data latency is required

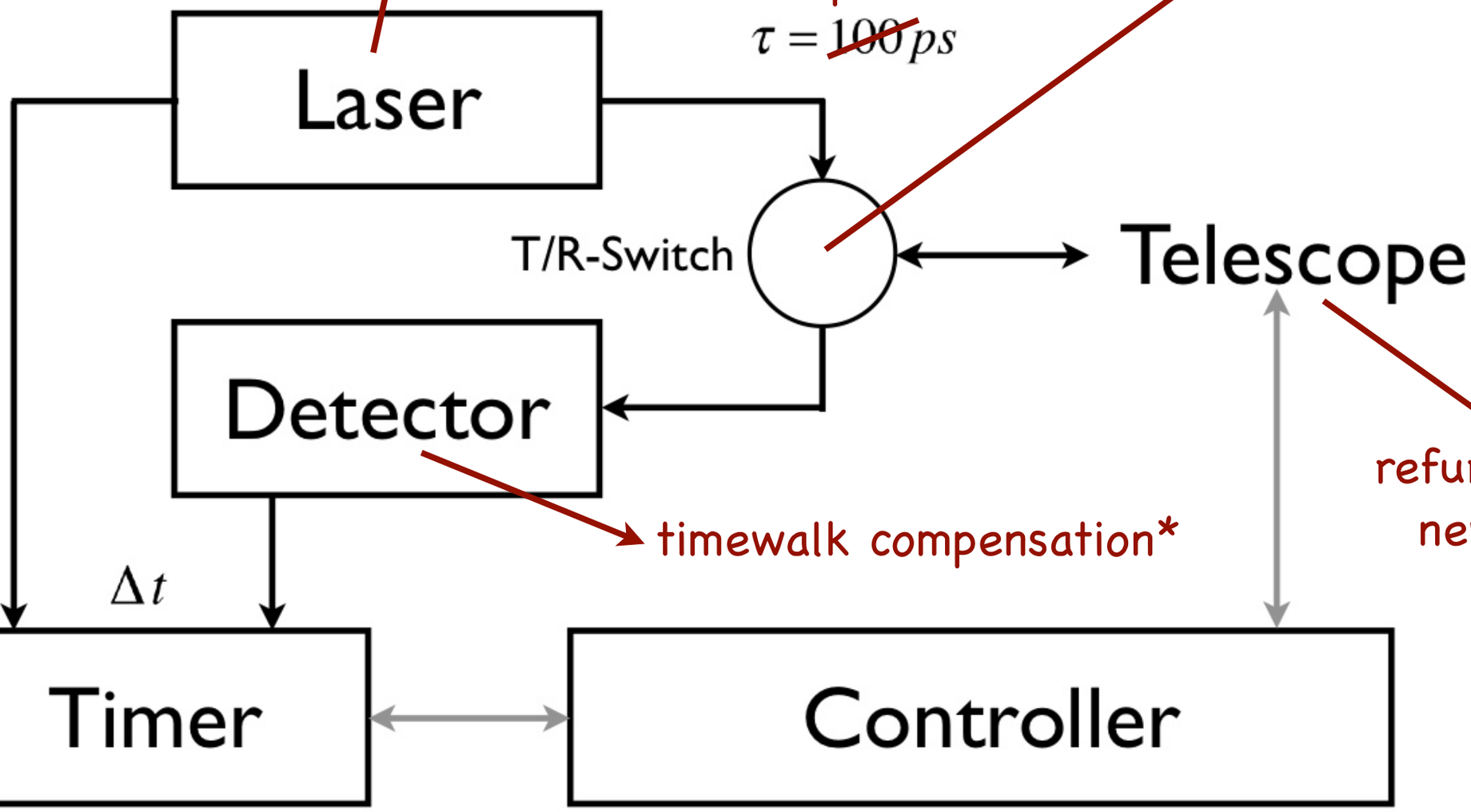
*Plag and Pearlman, (2009)


50 mJ
$\tau = 100\,ps$
Laser
T/R-Switch
10 Hz
Telescope
Detector
Δt
Timer
Controller

after 16 years of operation:
new laser (HighQ + Innolas)

new T/R: 20 Hz
(reduces blind region)

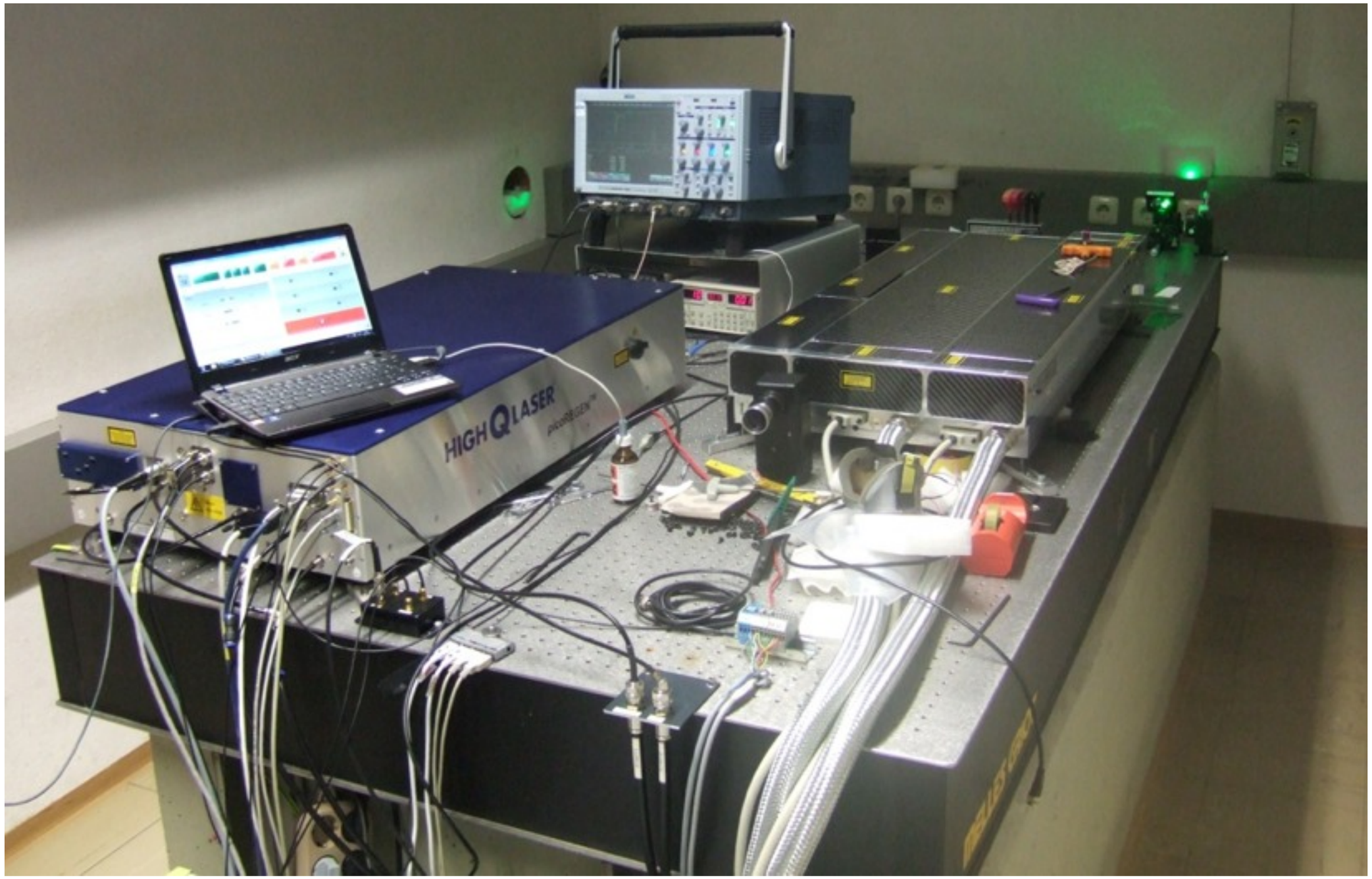
12 ps
$\tau = \cancel{100}\, ps$



new control system: more autonomous functions, satellite interleaving, improved timer

* see contribution: J. Eckl

Laser Integration: 22. 10. 2013

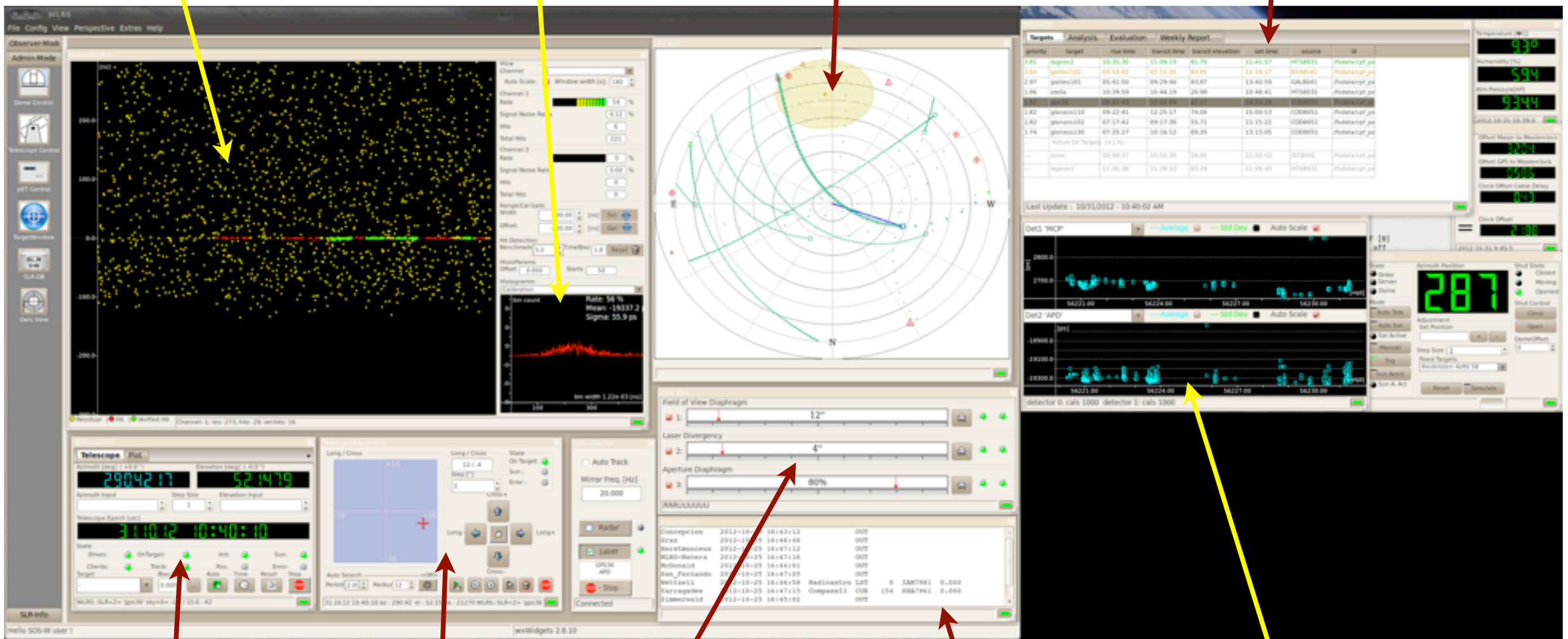


Residual Window

Internal Calibration

Sky Plot
Target Selection

Tracking Priority List



Telescope Status

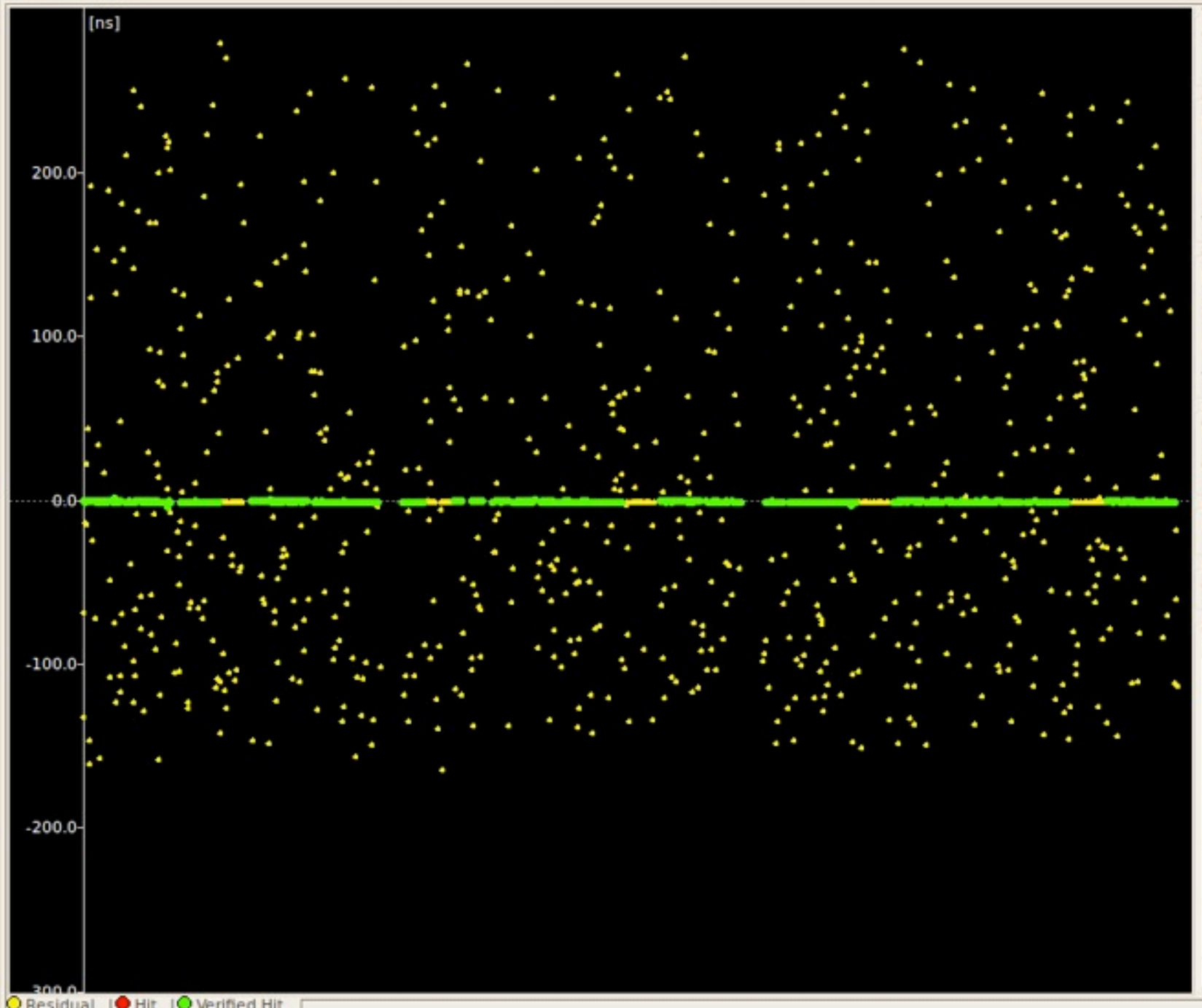
Offset Pointing

Filter Settings

Eurolas Status

Calibration History

ReturnWindow



Residual | Hit | Verified Hit

View
Channel 1
Auto Scale: Window width [s]: 180

Channel 1
Rate 44 %
Signal Noise Ratio 1.20 %
Hits 24
Total Hits 1083

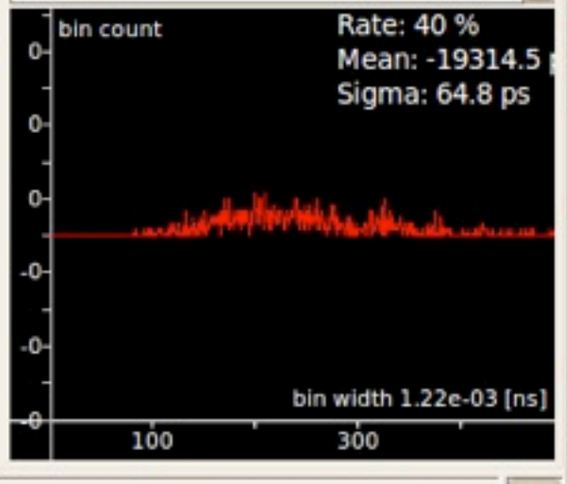
Channel 2
Rate 0 %
Signal Noise Ratio 0.00 %
Hits 0
Total Hits 0

Range/Cal Gate
Width 600.00 [ns] Set
Offset -260.00 [ns] Get

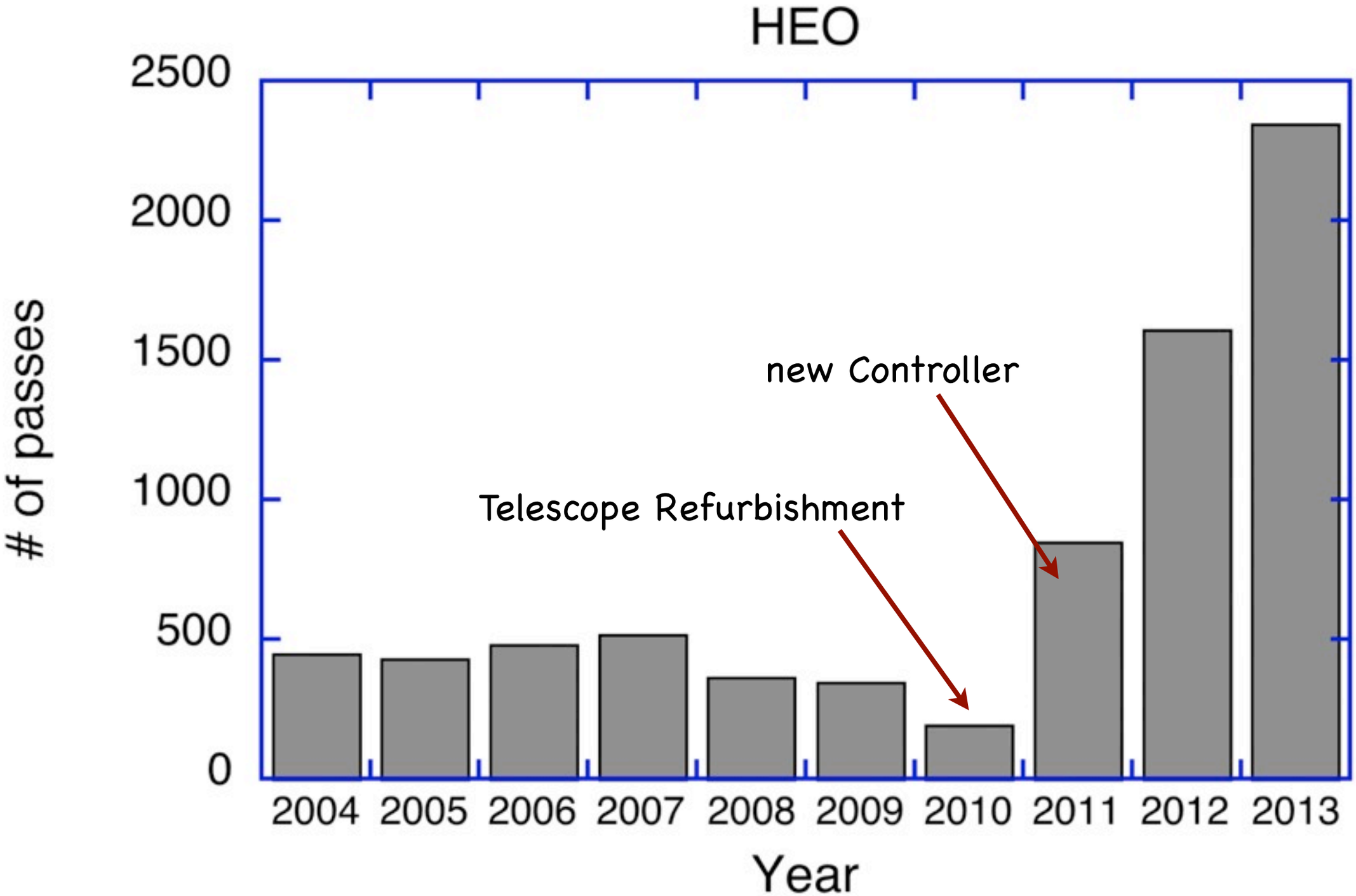
Hit Detection
Benchmark 6.0 TimeBias 25.0 Reset

HistoParams
Offset 0.000 Starts 0

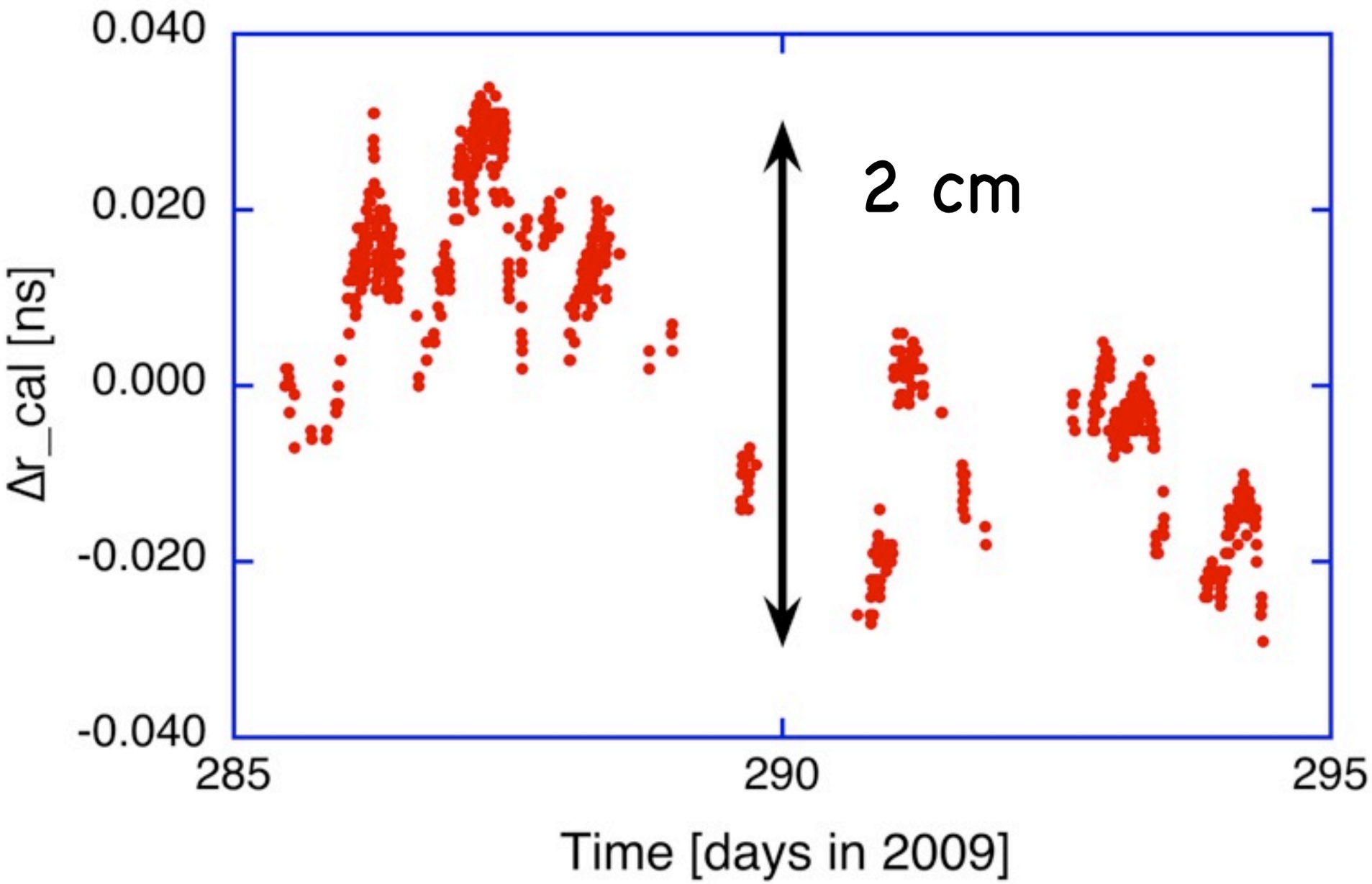
Histogramm
Calibration



The additional Ground Target


HEO
# of passes
2500
2000
1500
1000
500
0
new Controller
Telescope Refurbishment
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year

Typical SLR calibration data over 10 days



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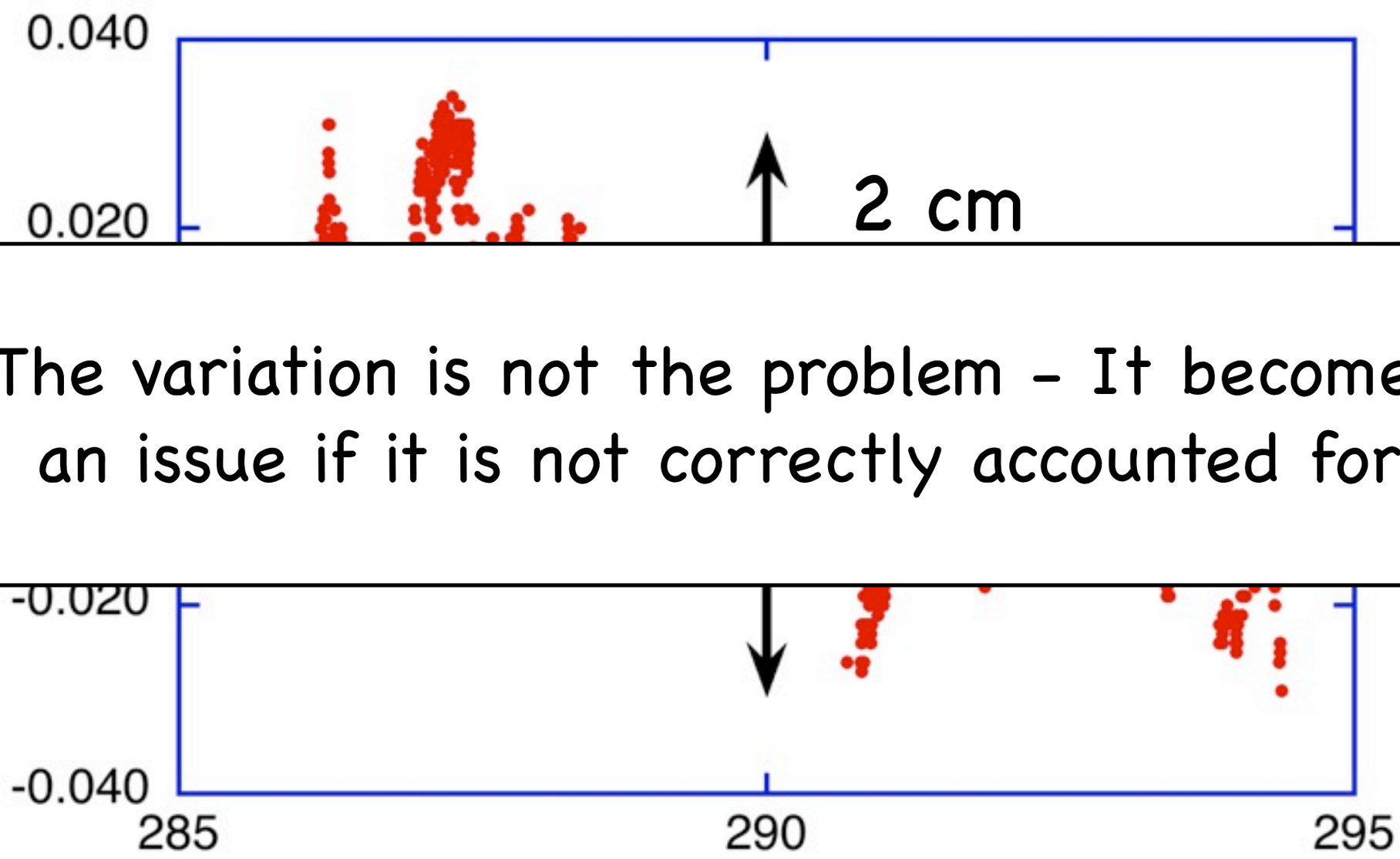
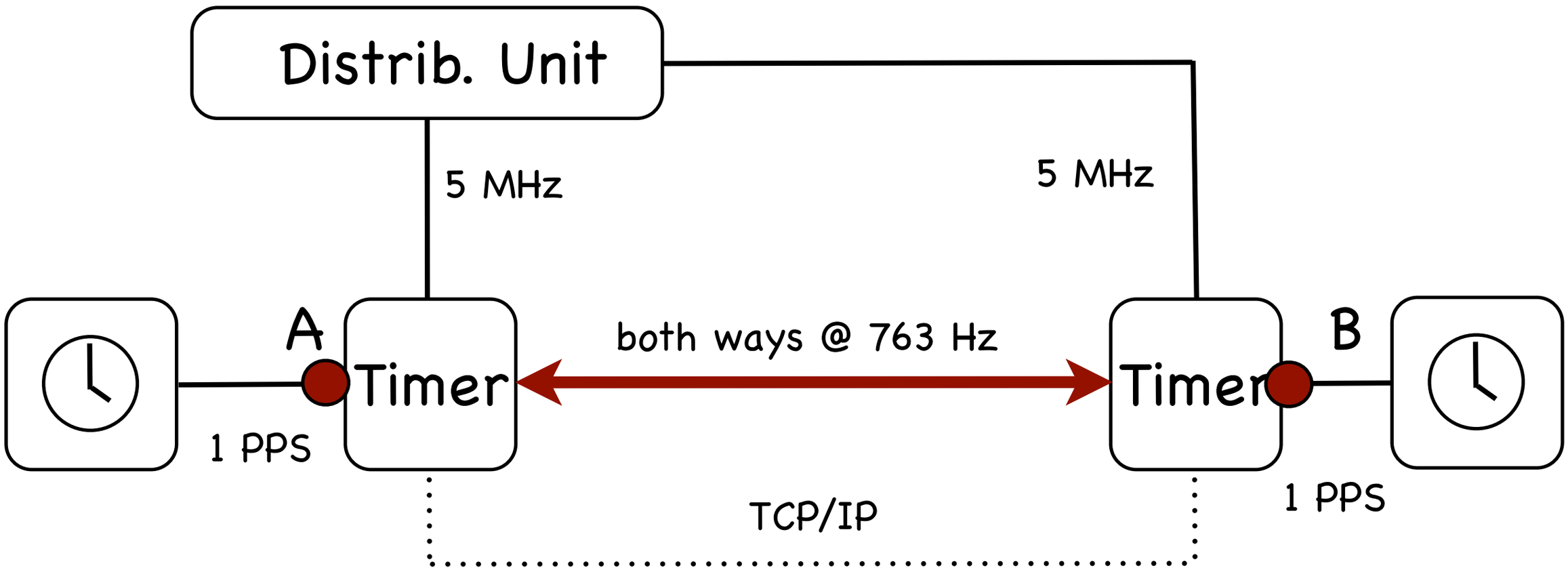


The variation is not the problem - It becomes an issue if it is not correctly accounted for

How to address such potential bias problems?

- Use fast rise-time signals
- Apply 2-way measurement concept
- Avoid measurement asymmetries
  -> satellite signature vs. unperturbed calibration
  -> minimize non-identical electronic signal path
  -> establish system stability between ranging and calibration (or capture variations)

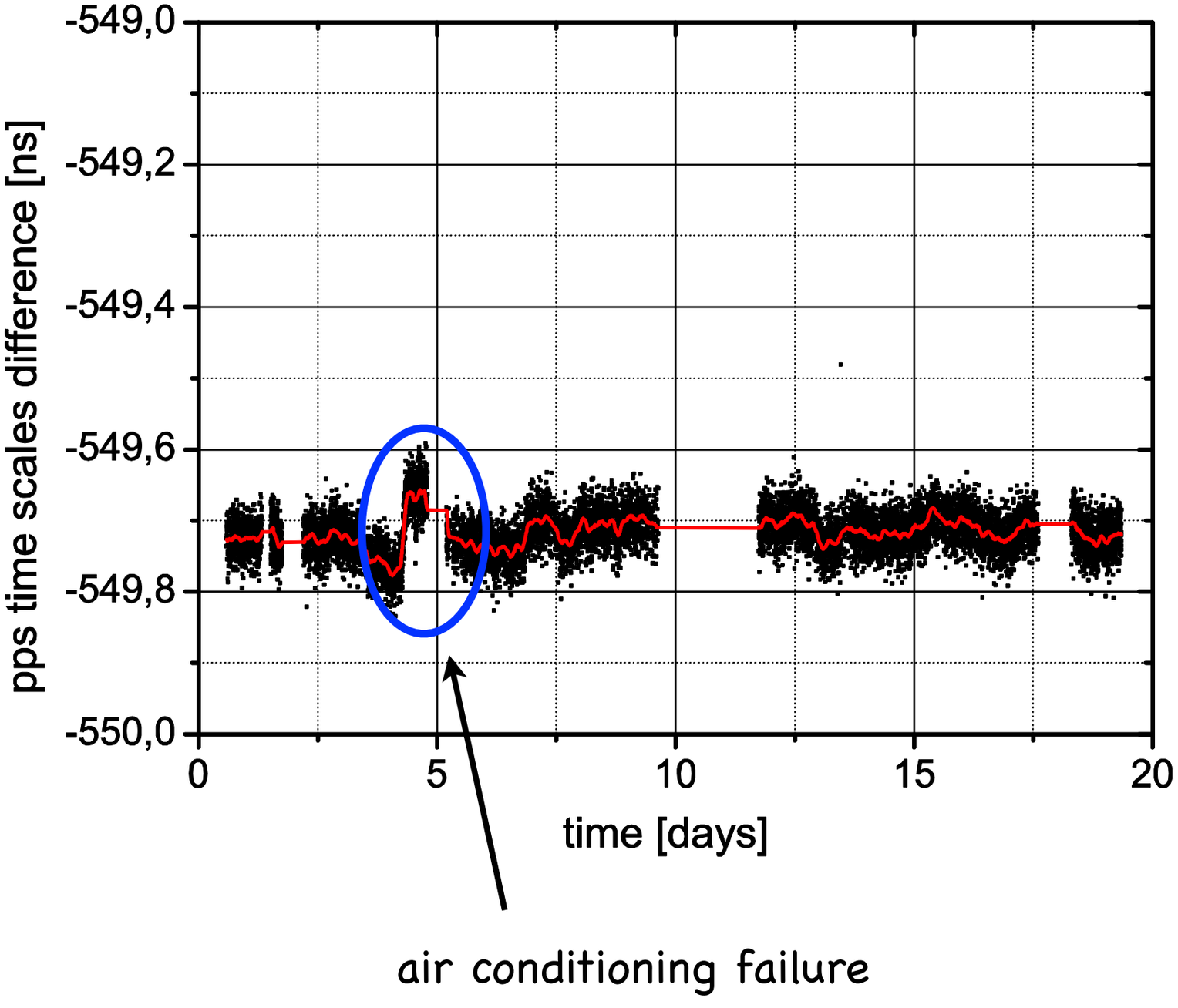
Practical Approach for 2-way eTiming*



Measurement returns Offset between A and B
It also returns the variation in the length of the cable

*see paper J. Kodet

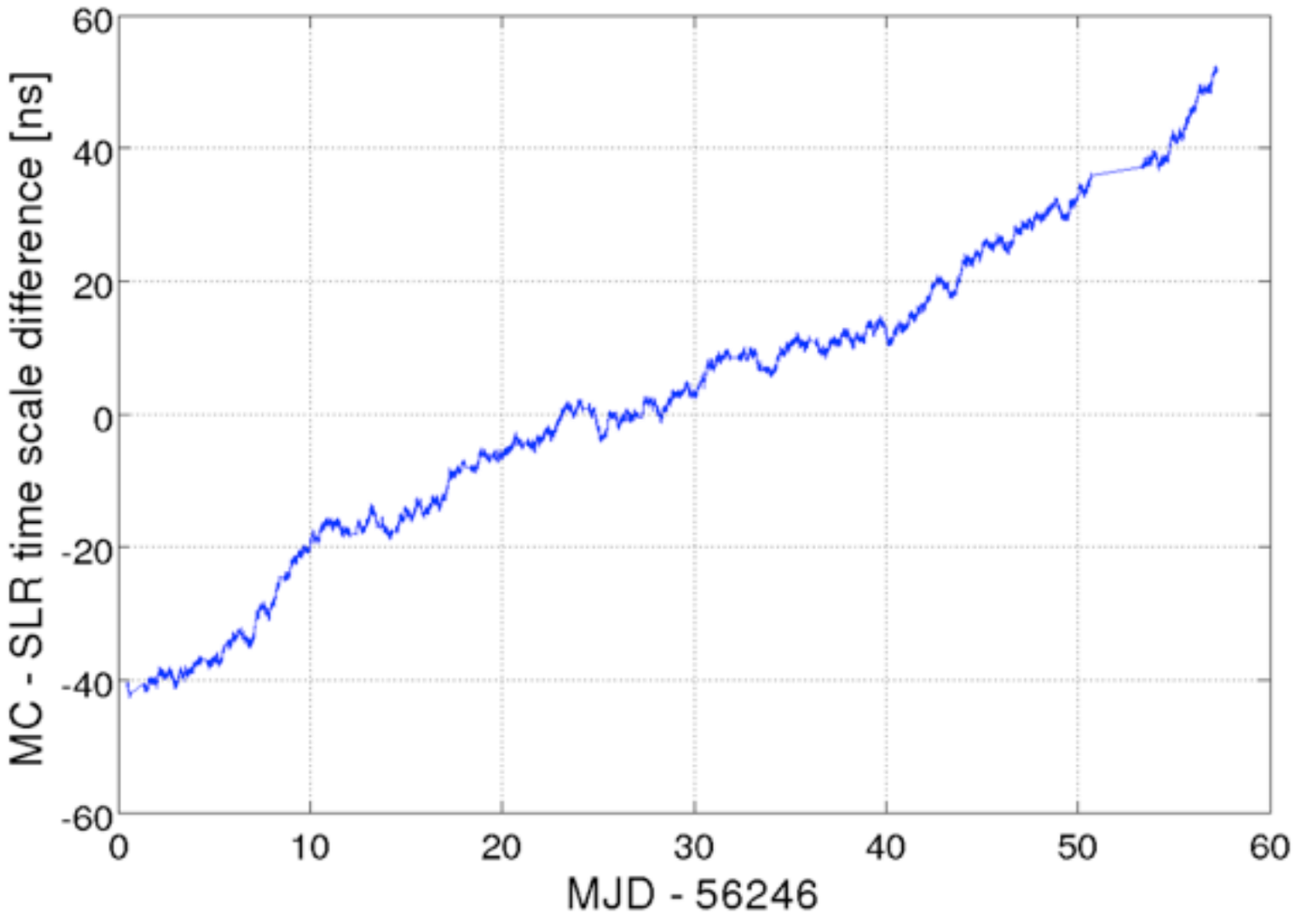
Example for 2-Timer Concept



same frequency source
(cable delay variation)

Measurement resolution
precision < 2 ps
stability < 1 ps

Example for 2-Timer Concept



Maser versus Cs Master Clock
(clock offset variation)

Stability and precision < 2 ps

Summary

- We have improved our system to provide more reliability and to increase "autonomous tracking functionality"
- Data yield on HEO increased noticeably
- In order to approach the GGOS goals, we are concentrating on identifying sources of internal biases