Federal Agency for
Cartography and Geodesy

Time Transfer and System Stability

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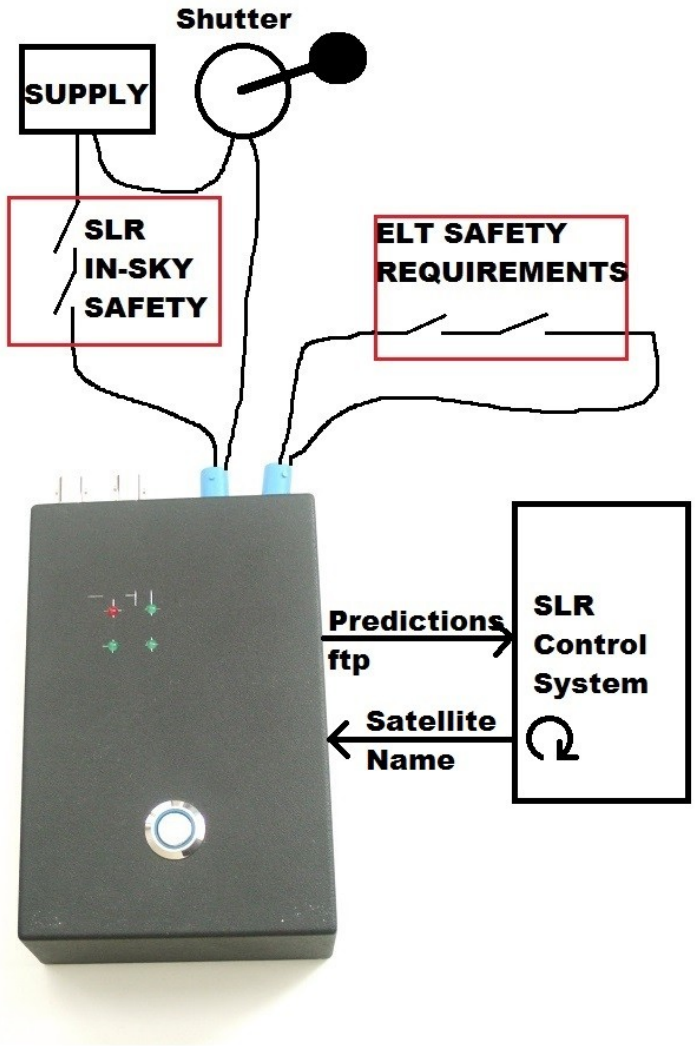
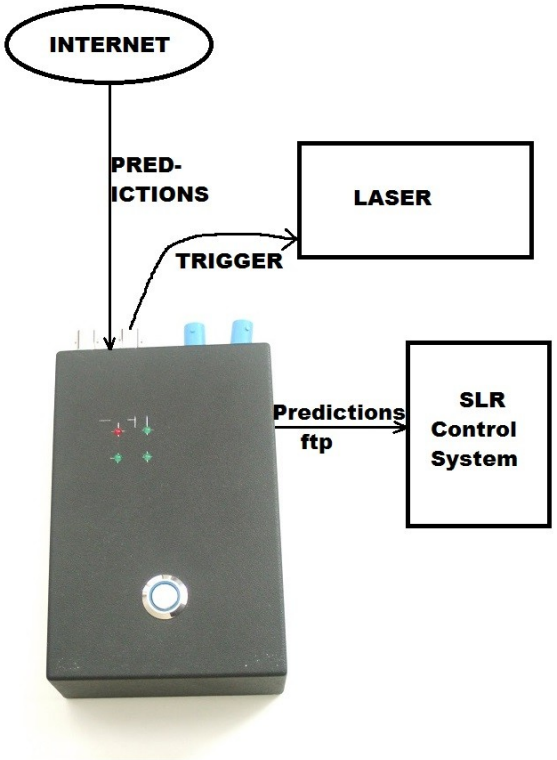
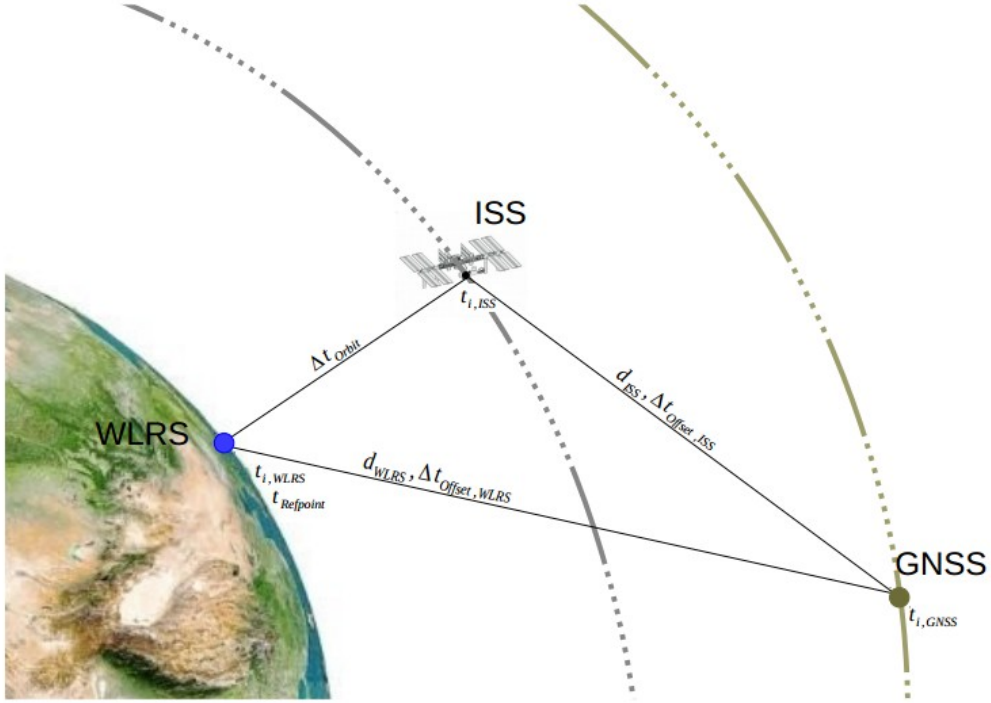
ELT BOX
- safety -

- Safe switching between std. SLR- and ELT-mode
- Impemented in series to std.-SLR In-Sky-Safety system
- Prediction provider via ftp



ELT BOX
- laser trigger -



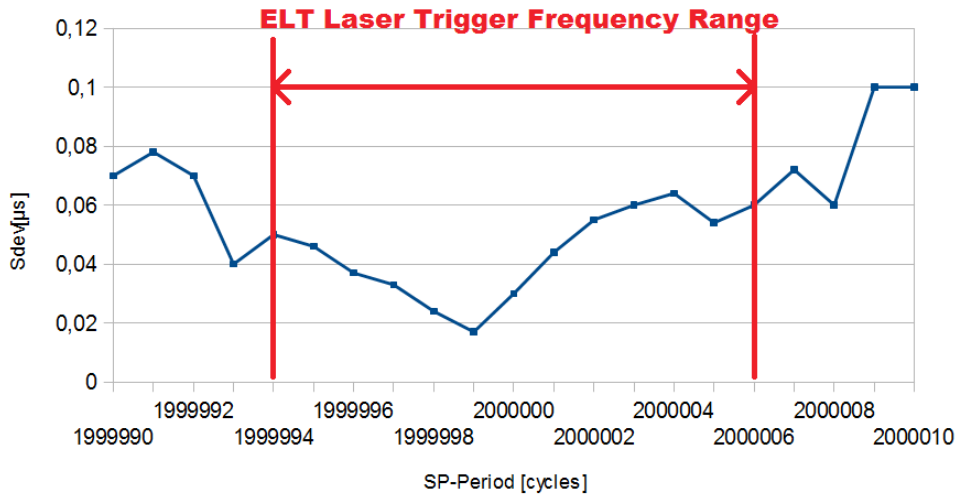


$$t_{i,WLRS} = t_{i,ISS} - \Delta t_{Orbit} + \left(d_{ISS} * t_{i,GNSS} + \Delta t_{Offset,ISS}\right) + \left(d_{WLRS} * t_{i,GNSS} + \Delta t_{Offset,WLRS}\right) + \Delta t_{Refpoint} + \Delta t_{Rest}$$

- Real-Time Time-Bias calculation neccessary (Stefan Marz)

$t_{i,WLRS}$: *Epoche Wettzell*
$t_{i,ISS}$: *Epoche ISS*
Δt_{Orbit}: *Delay aus Weglänge*
$t_{i,GNSS}$: *Epoche GNSS*
$(d_{i,ISS} * t_{i,GNSS} + \Delta t_{Offset,ISS})$: *Uhrenoffset und –drift der ISS*
$(d_{i,WLRS} * t_{i,GNSS} + \Delta t_{Offset,WLRS})$: *Uhrenoffset und –drift des WLRS*
Δt_{Rest}: *Weitere zu berücksichtigende Parameter*

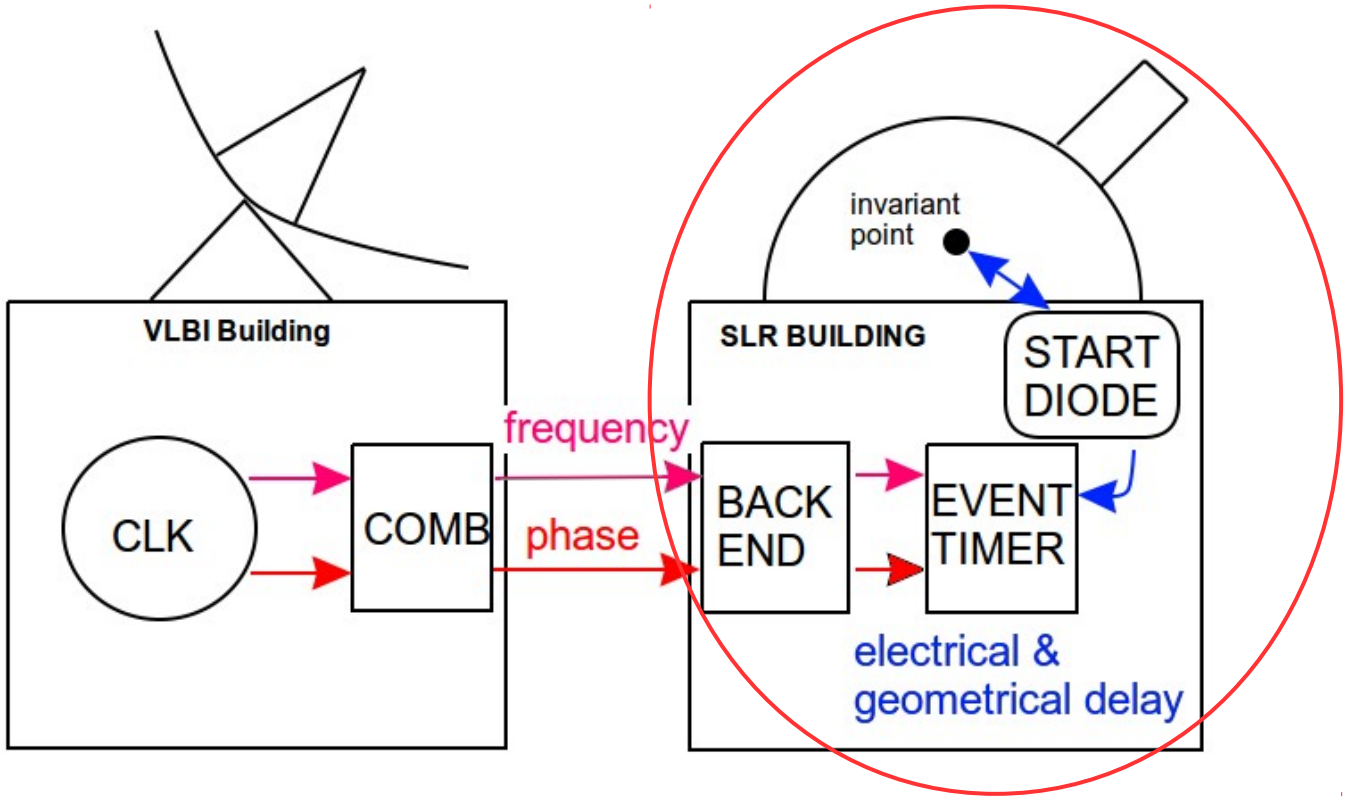
ELT BOX
- timing support -



- Possibility of operating an additional Event-Timer, optimised for Time Transfer

Situation

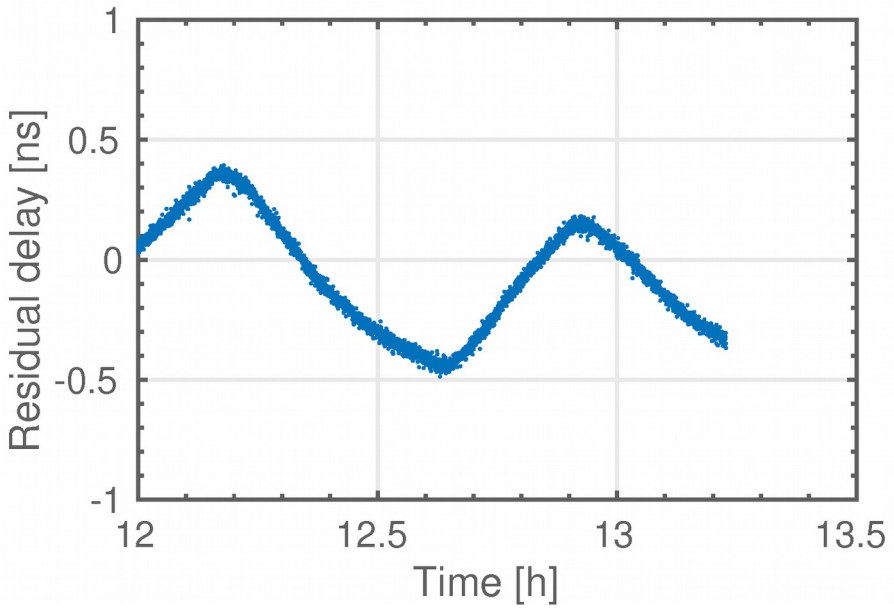
- T&F distribution from Clock module / Backend (future) of interest here



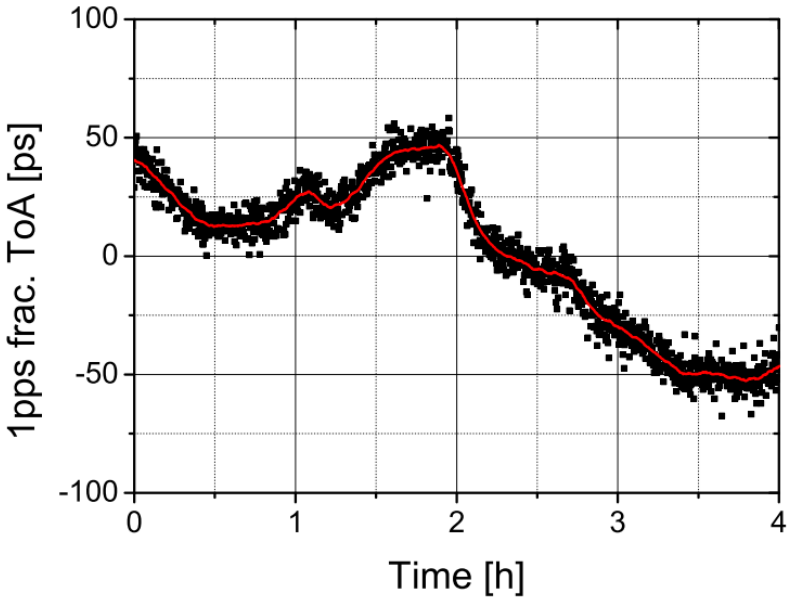
Maser Connection
- stability -

- Typical SLR Clock Module
- No cable delay variation included

high temperature coefficient

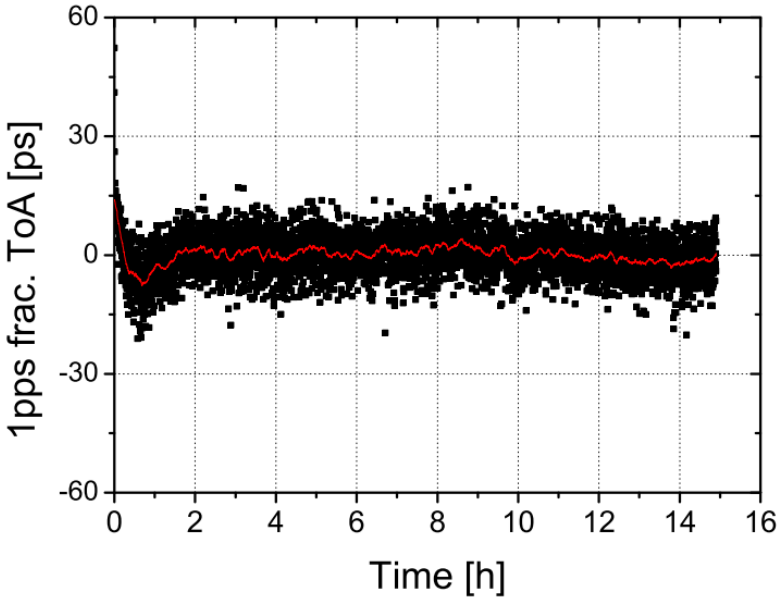


no temperature control

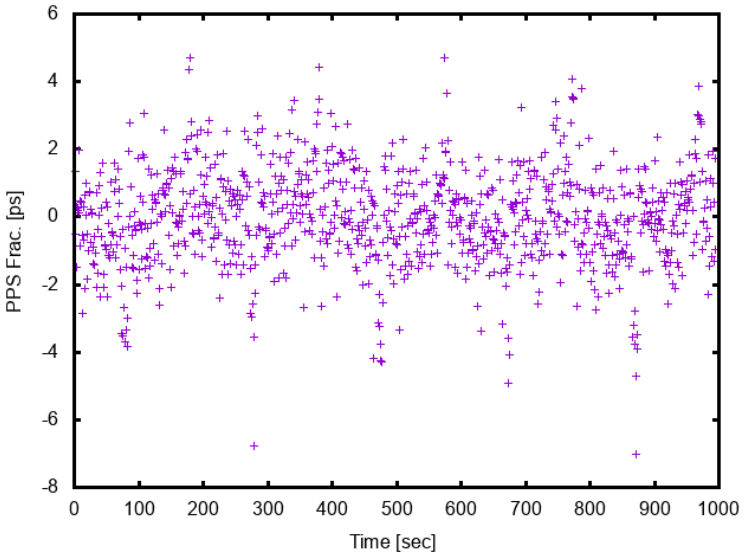


Maser Connection
- temperature stabilised -

electrical shorttime



optical shorttime



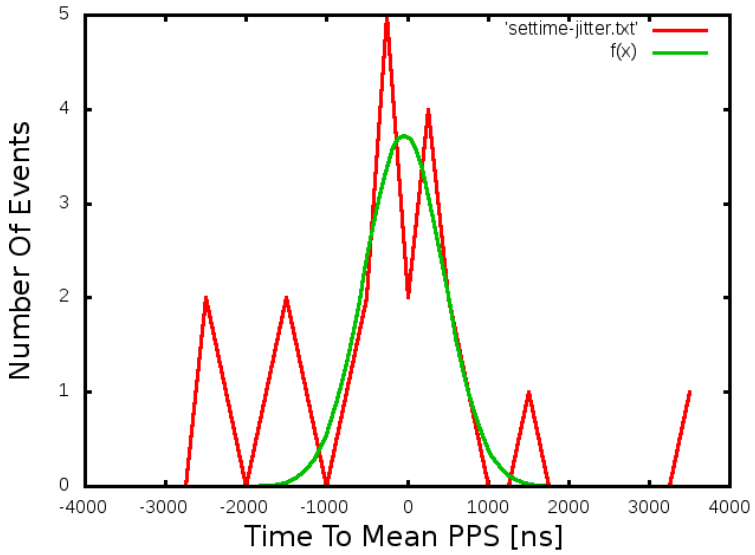
Optical: no cable delay!

T&F stable @ Clock Module, but Time is read from Event-Timer

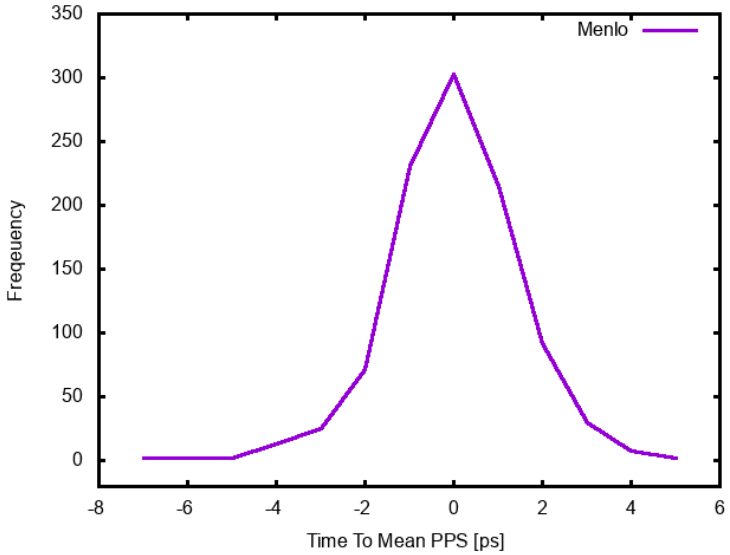
Maser Connection
- Eventtimer -

- Event-Timer set time

std. SLR-ET

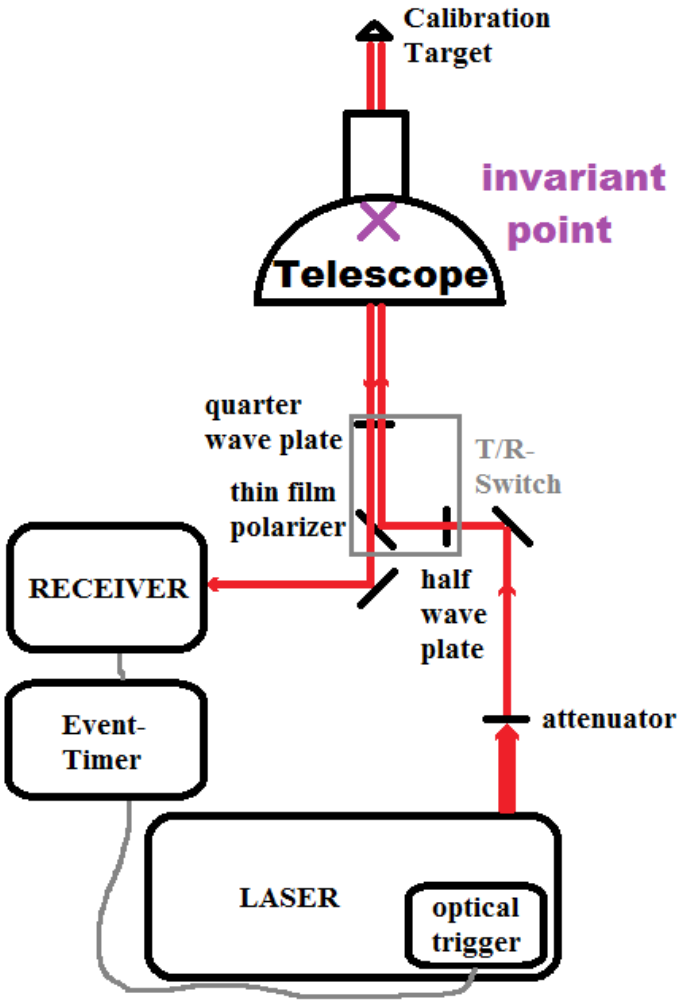


Menlo T&F distribution & ET upgrade



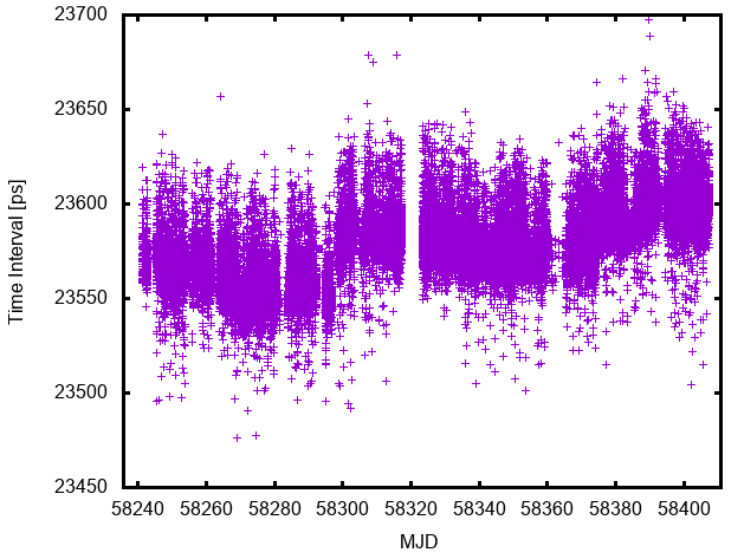
Situation
- SLR calibration -

- Ranging a „well known distance“ with all devices involved in SLR measurements
- Verification of „well known distance“ by local tie measurements

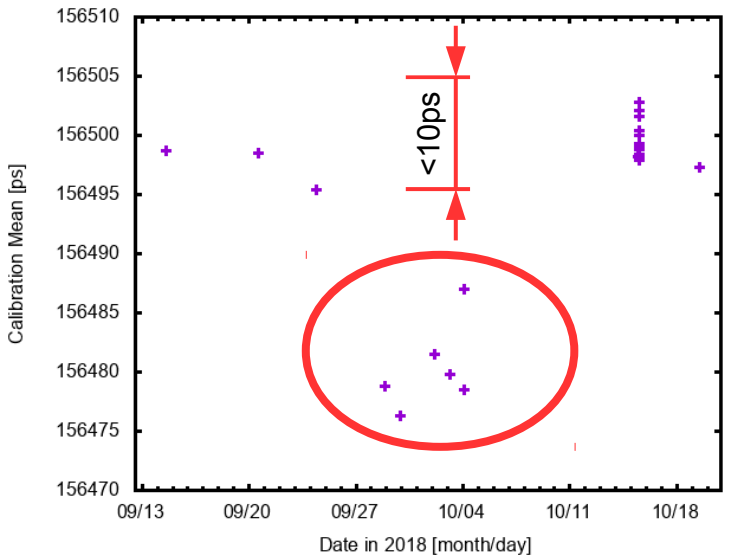


SLR Calibration
- electrical stability -

Std. SLR Calibration
6 month



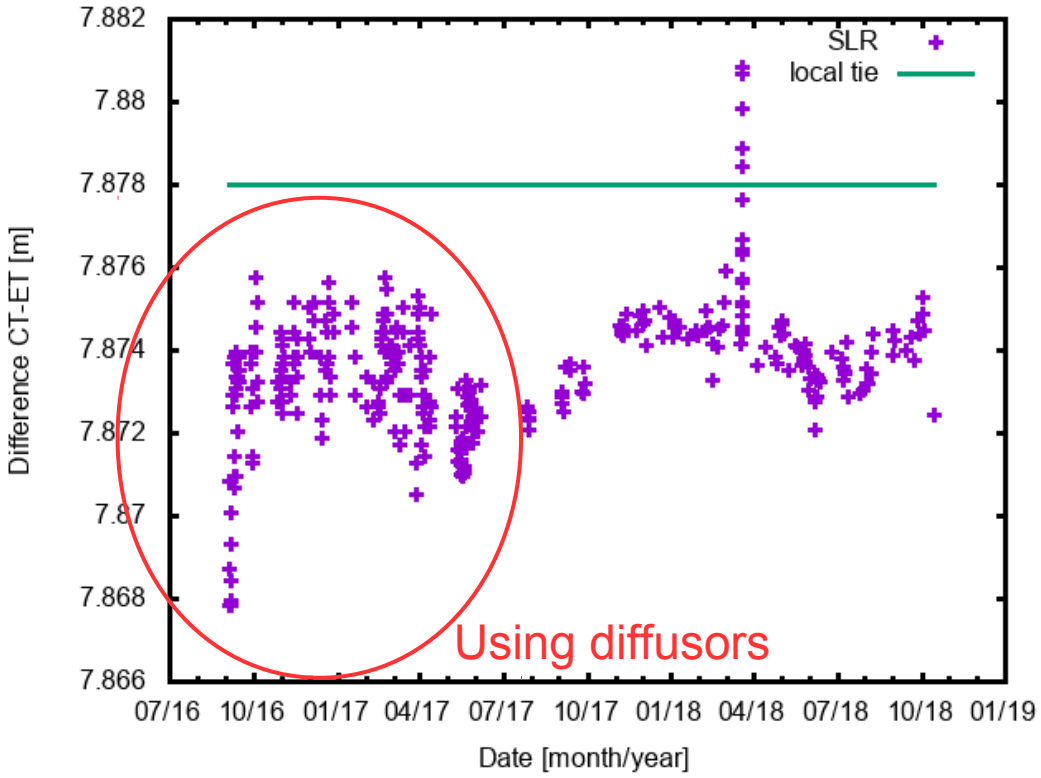
optimsed electronics
1 month



→ once installation finished, system should not be touched, carefull planning required!

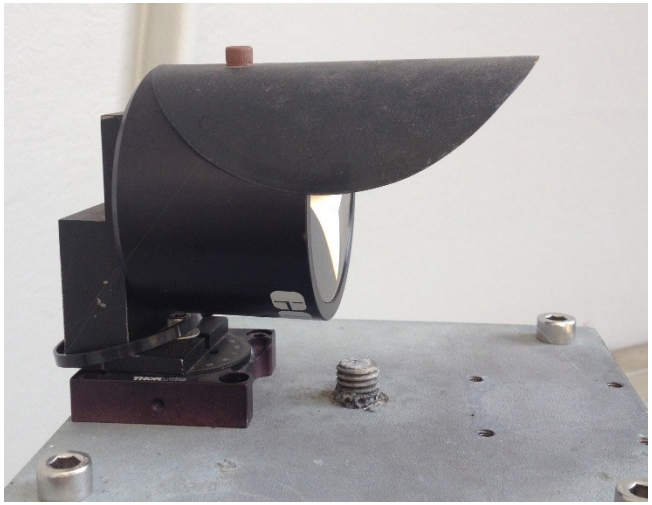
SLR Calibration
- stability geometry -

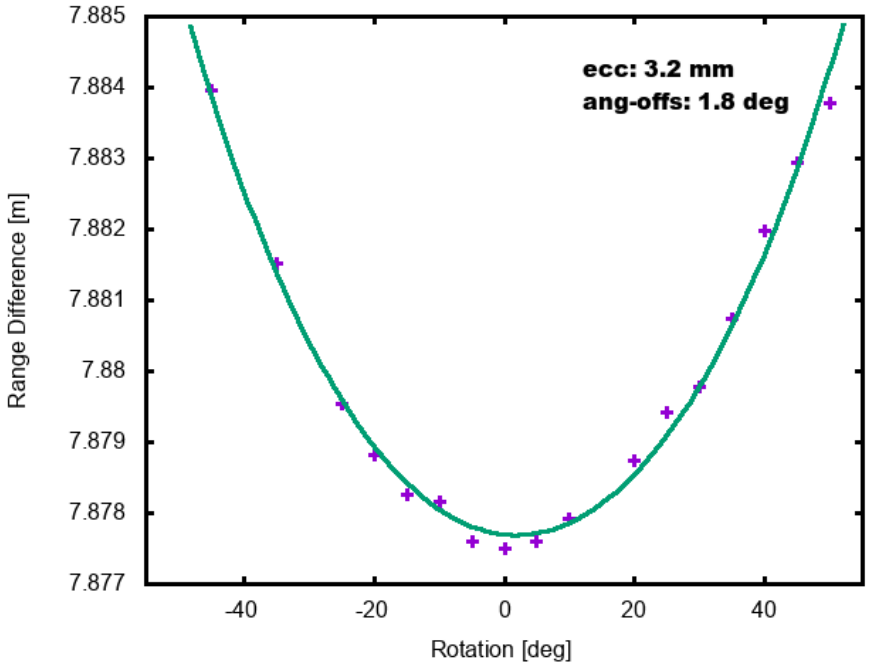
- Ranging two local reflectors and calculating the difference



SLR Calibration
- systematics geometry -

- Reflector center of rotation, needed for reflector constant



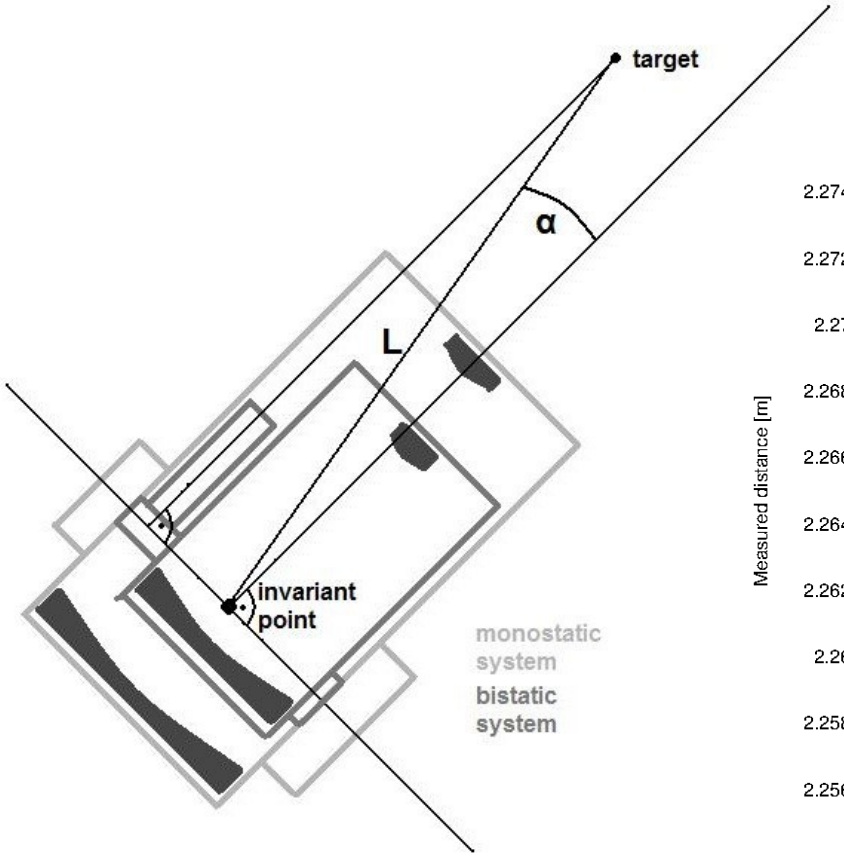


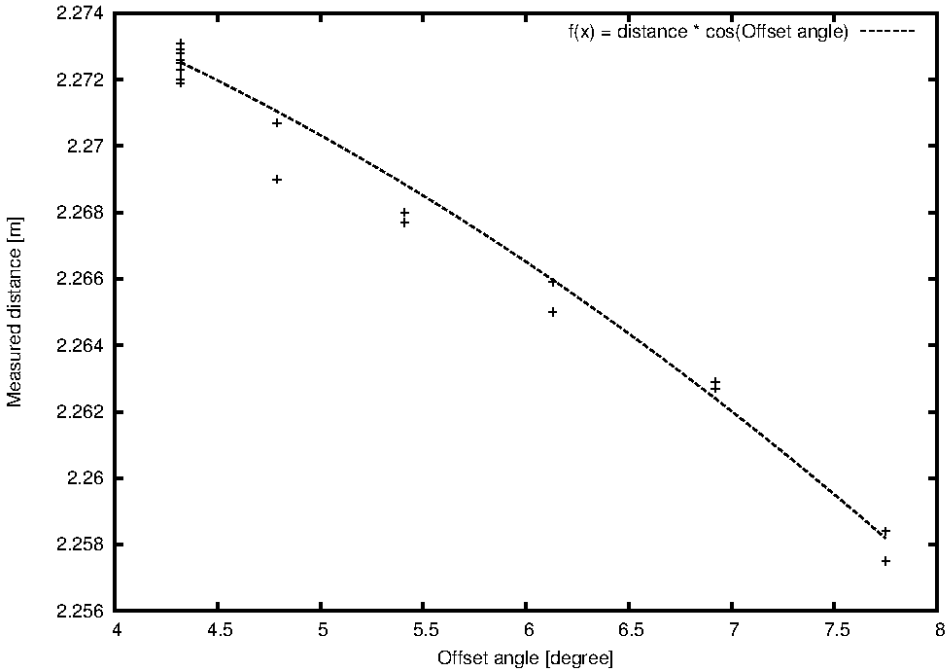
→ found deviation in reflector constant for one reflector

→ use more than one target

SLR & Time Transfer
- systematics geometry -

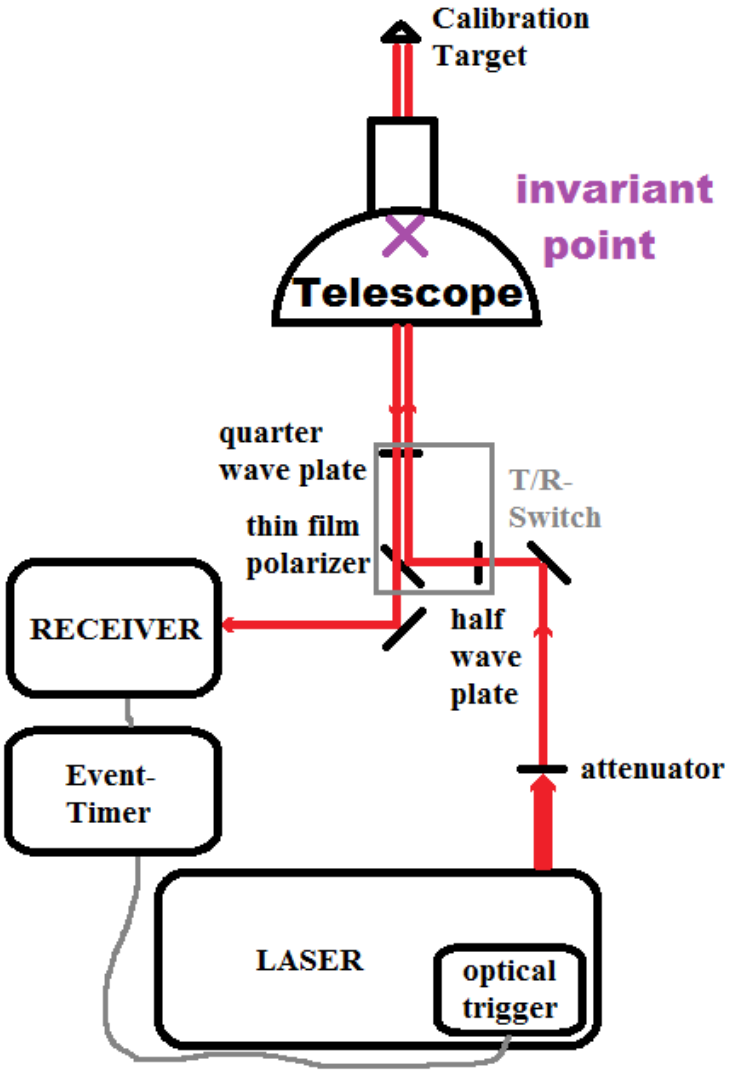
- Found during ELT-calibration campaign





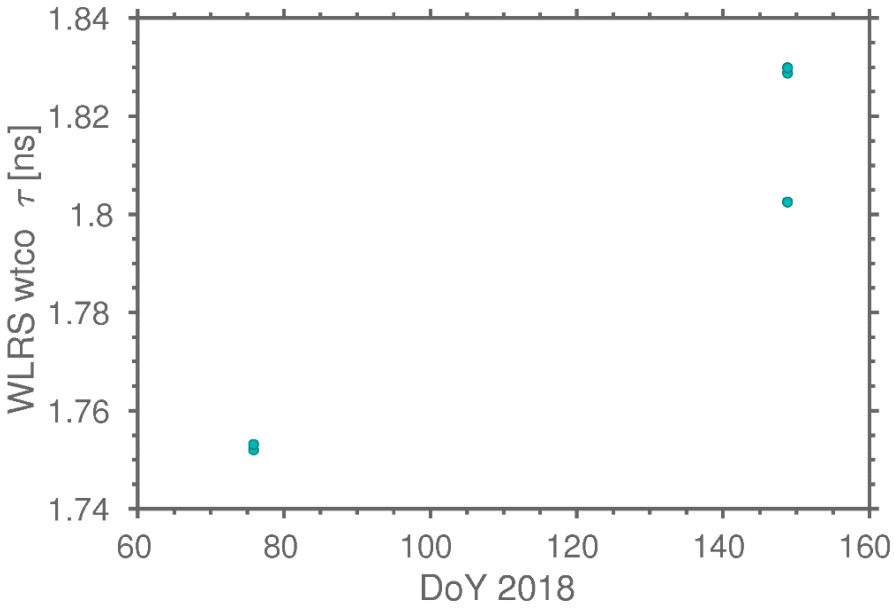
Time Transfer
- transmit & receive -

- Separation of transmit and receive path neccessary
- Solution:
  - „permant ELT calibration standard“
  - Synchronisation of laser repetition rate (planned)



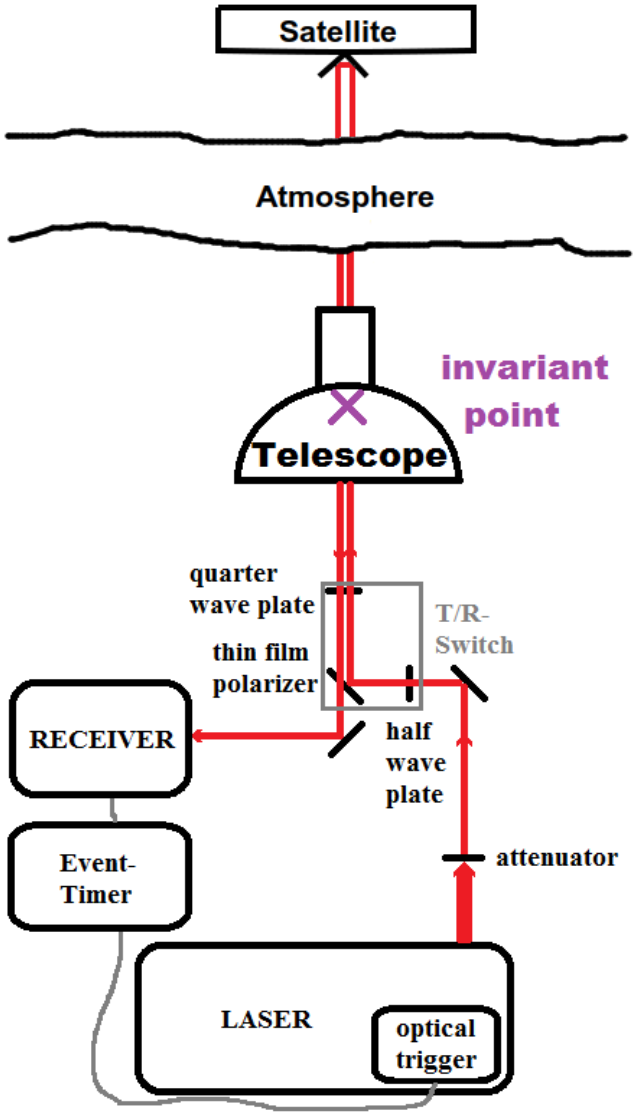
Time Transfer
- Calibration -

- Work of J. Kodet
- Not connected to T&F distribution → preliminary results



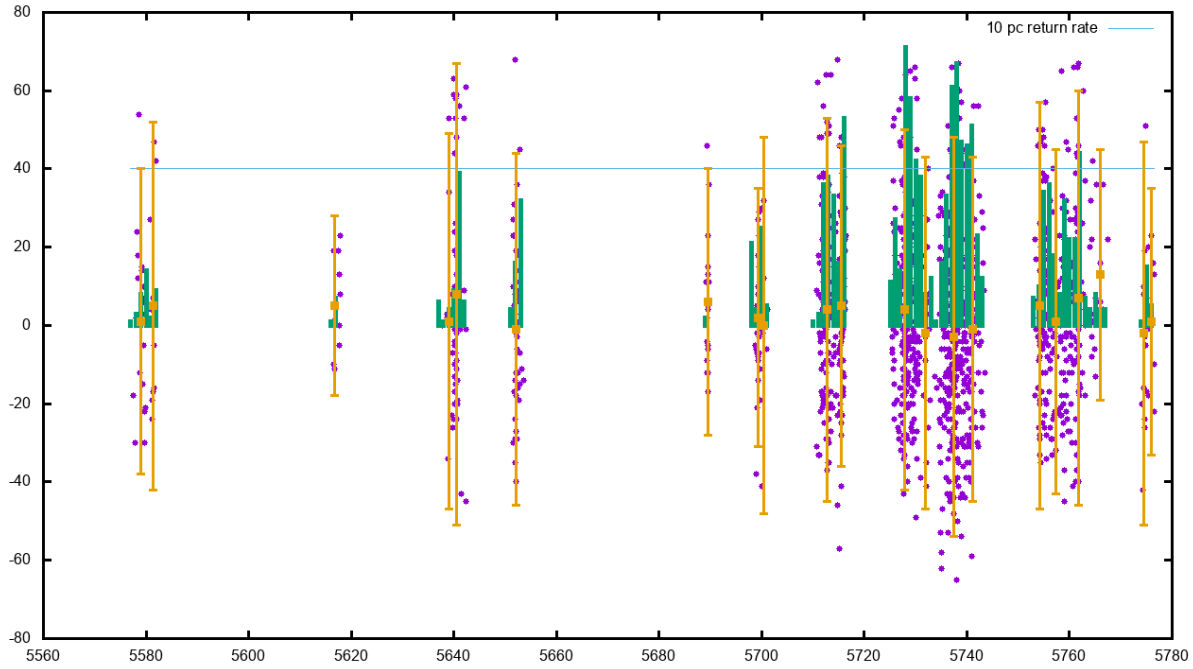
Satellite Ranging

- Einstein-Synchronisation: time-of-flight required
- Difference to calibration: far field, moving target & atmosphere involved



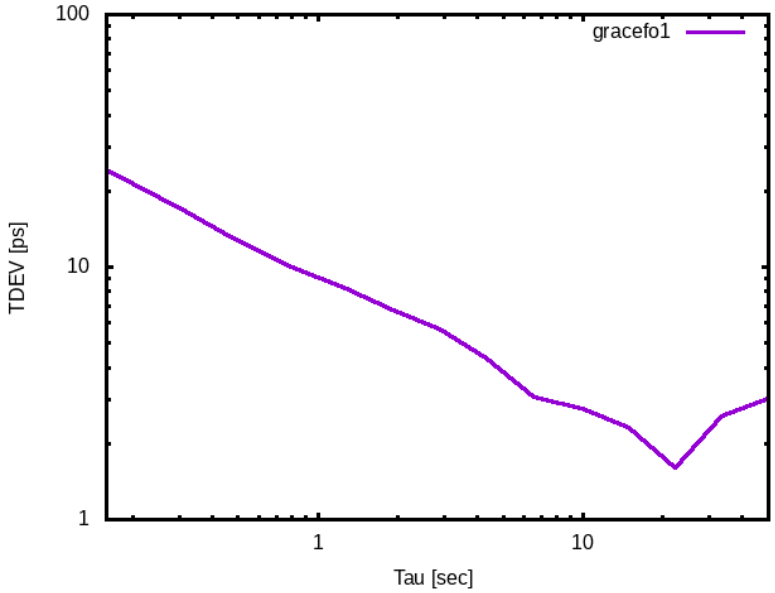
Satellite Ranging
- stability -

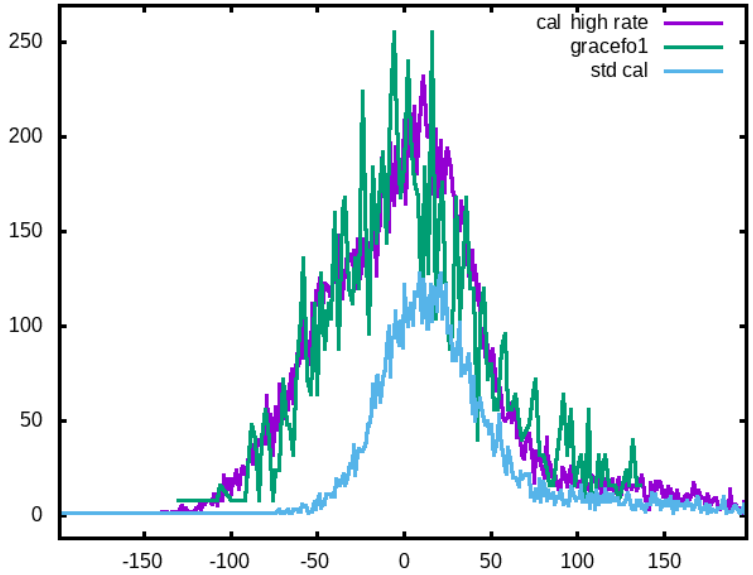
- GraceFo1 ranging with reflector similar to ELT



Space Segment
- systematics -

- TDEV down to below 2 ps
- Systematics visible

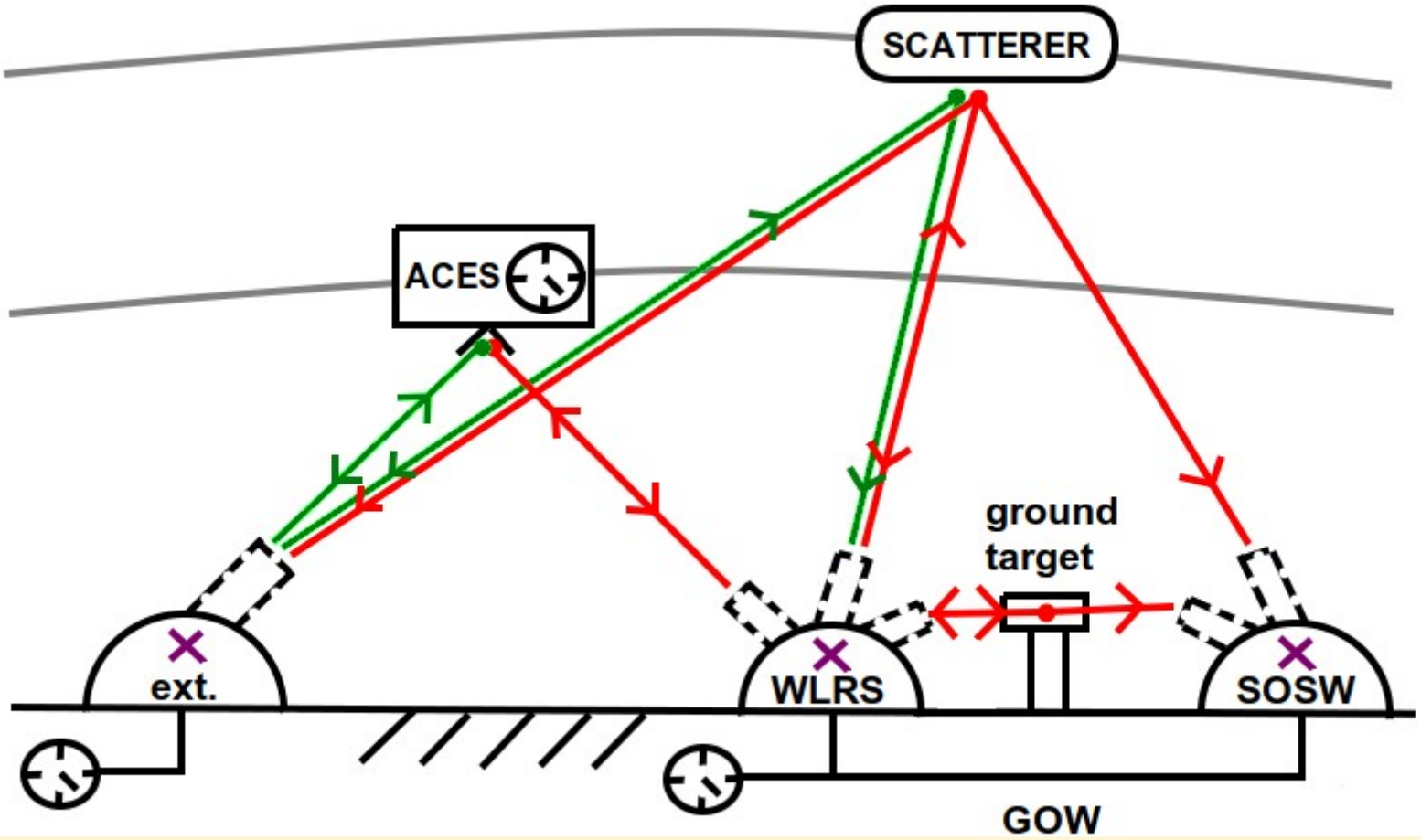




→ Further investigation of atmospheric contribution

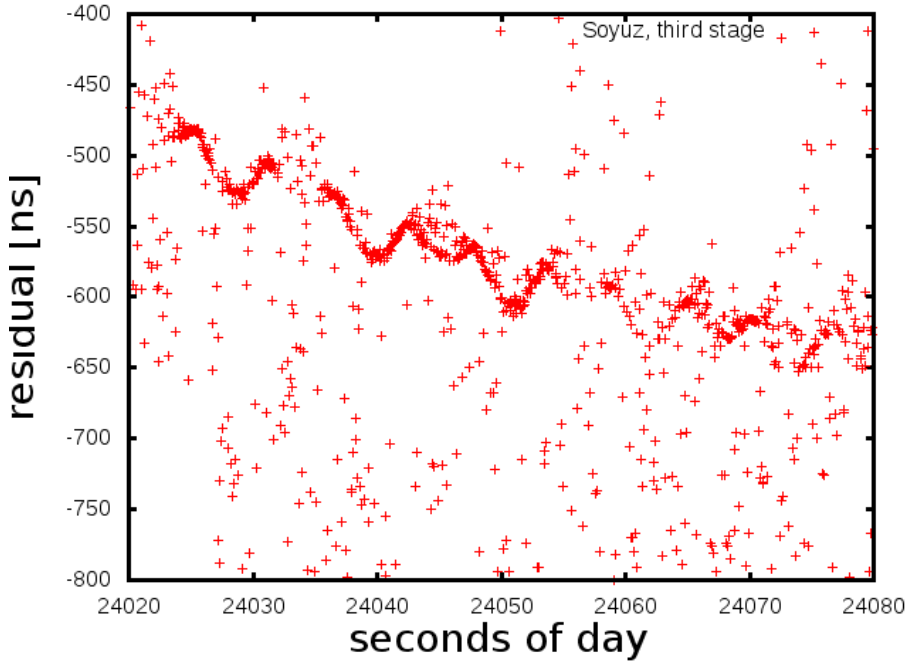
Diffuse Reflection
- independent verification -

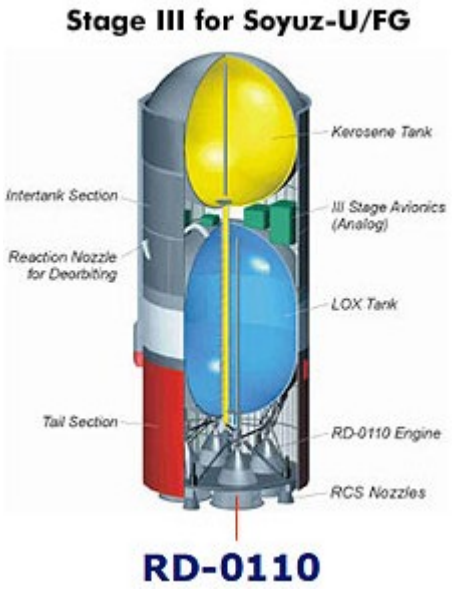
- Low signal strength → pulse energy > ~50 mJ



Diffuse Reflection
- test measurements -

- Ranging Soyuz Third Stage Rocket Body
- During Tests echos from objects <1 m² (<3 ns)

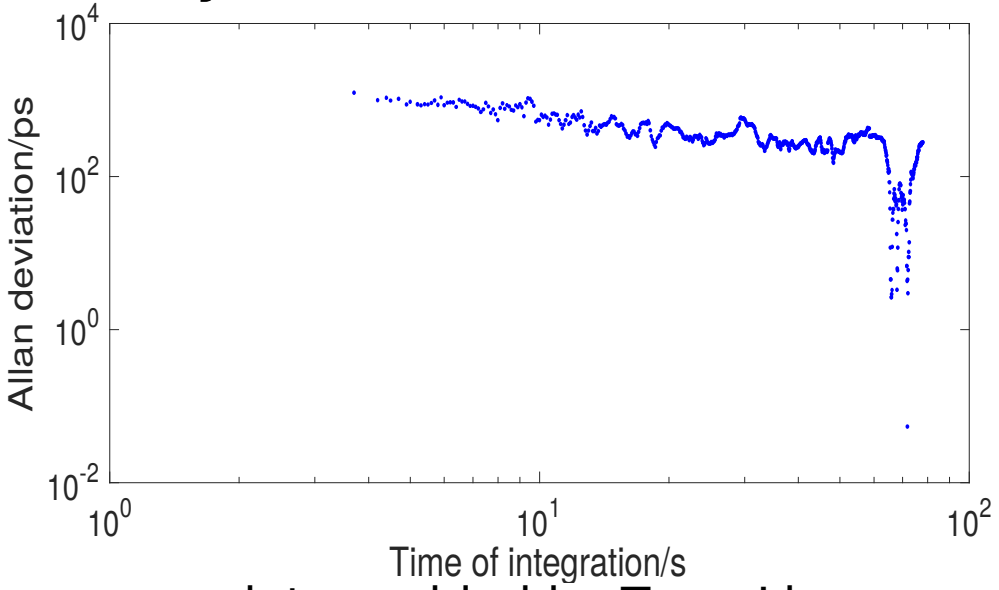




- Time-transfer: tumbling motion model neccessary

Time Transfer via diffuse Reflections - expected precision -

- With appropriate model:
  Precision down to 100 ps possible for large objects
- Advantage: passive space segment → no unknown delays



plot provided by Tong Liu

Conclusion

- Final preparation for ELT till 3rd quartar 2019
- Further ISS ranging tests planned after final laser safety clearance in early 2019
- Major system upgrade in mid 2019 to also improve temperature sensitivity