ELT: Multiple reflector identification and real-time time bias correction

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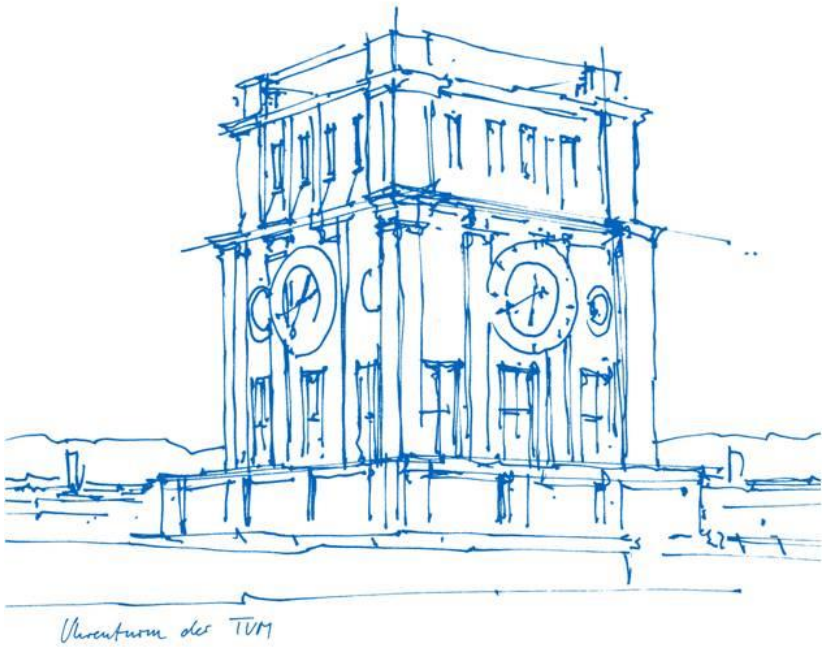
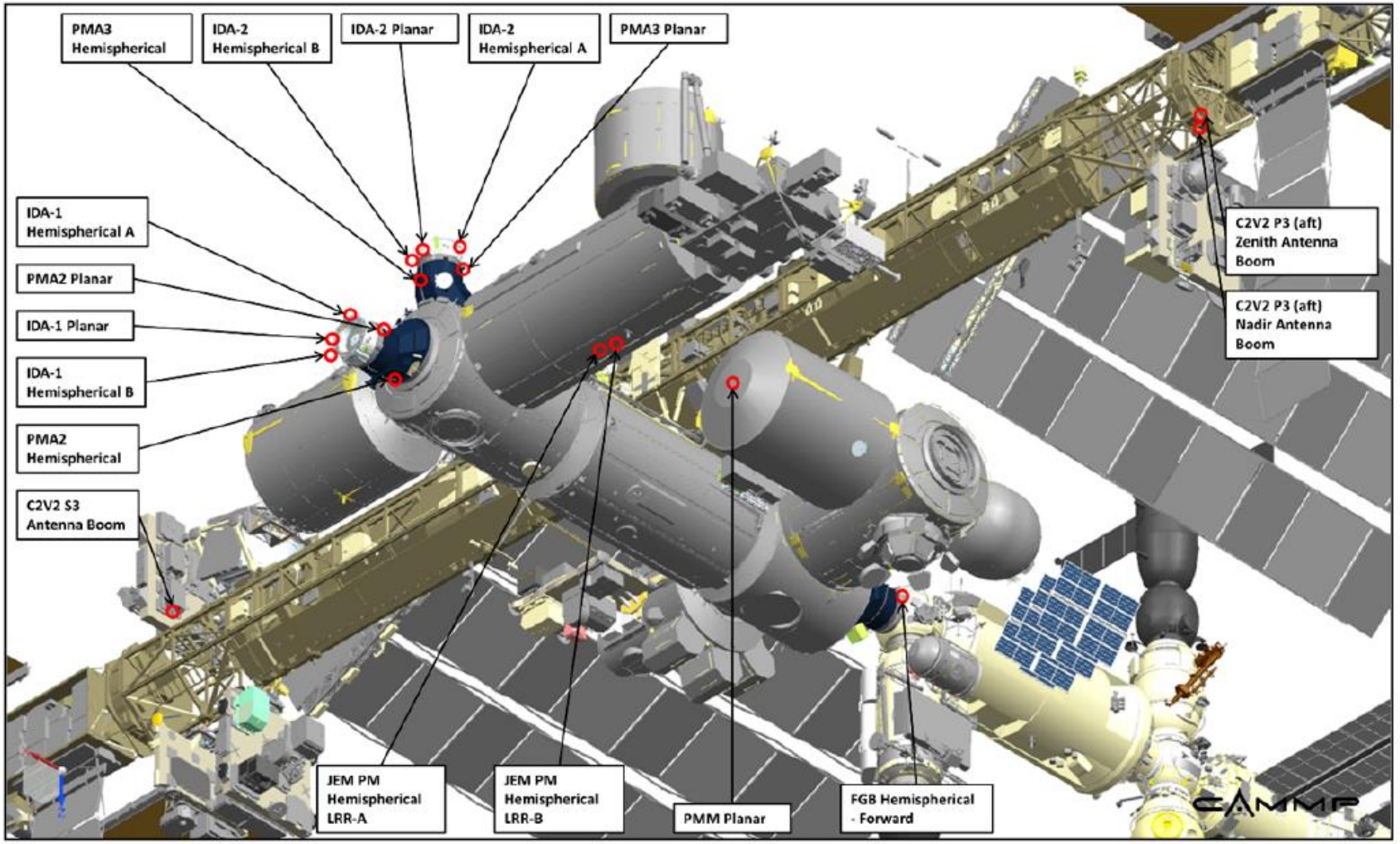
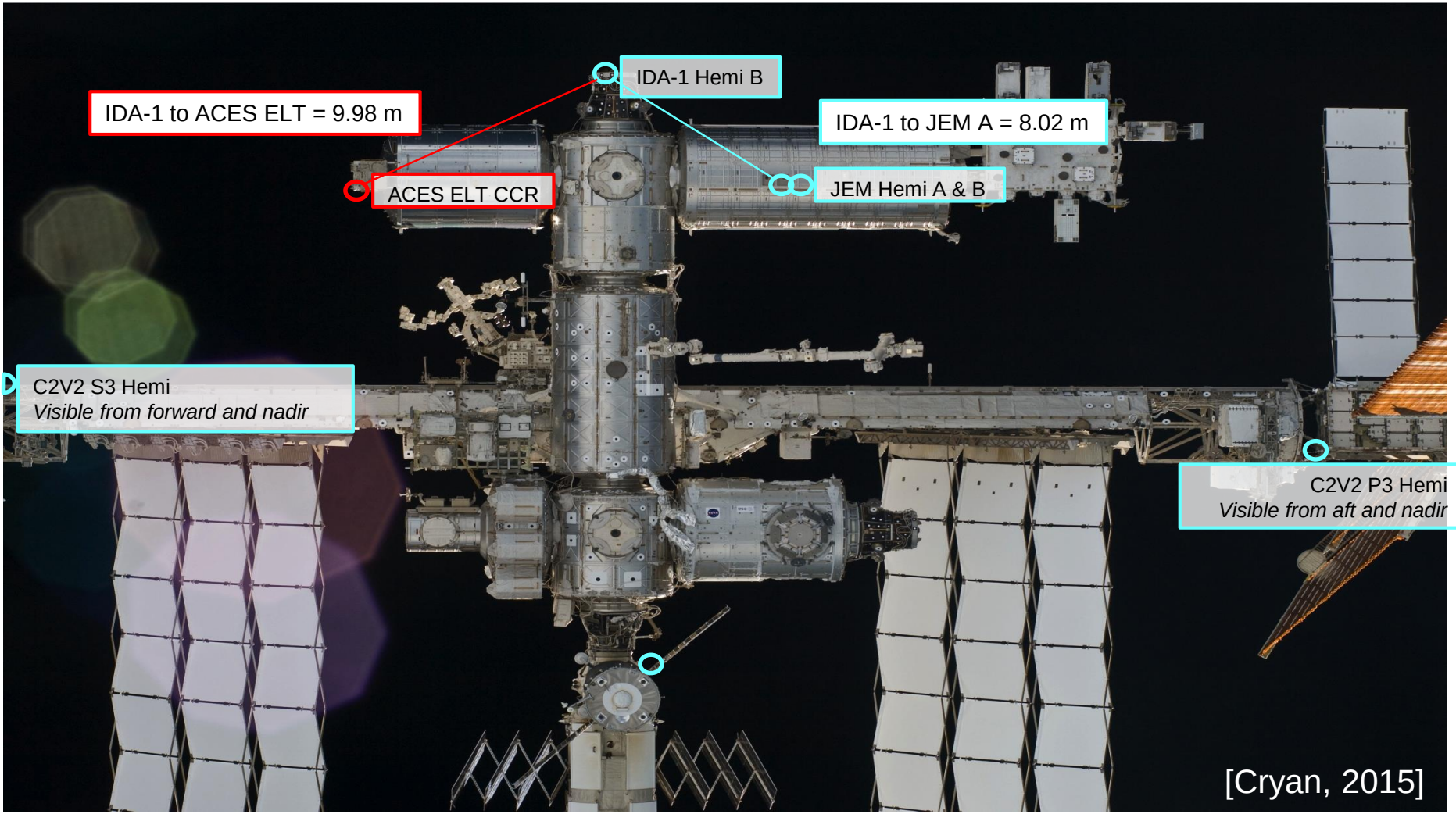


Introduction: Reflectors on the ISS



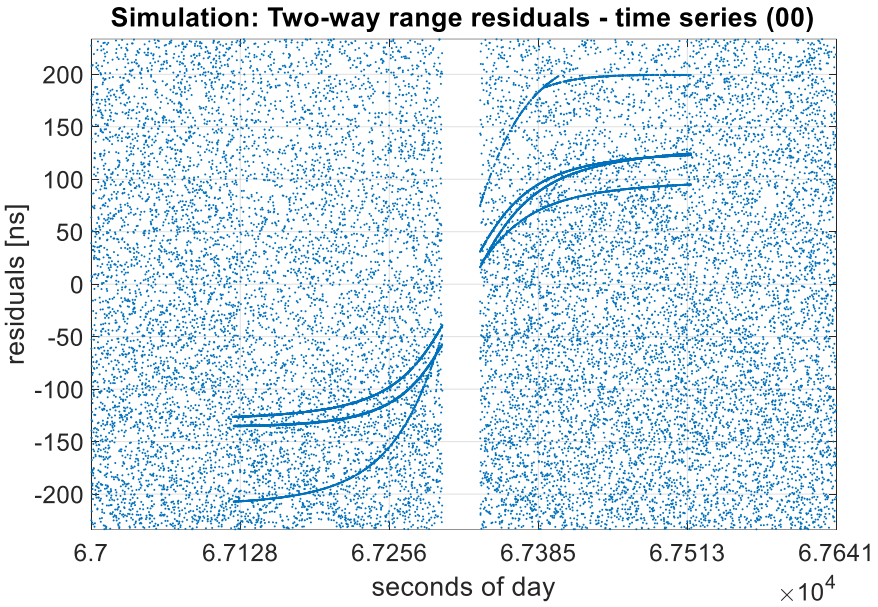
[SSP 50949 Revision A, 2015]

Introduction: Reflectors on the ISS



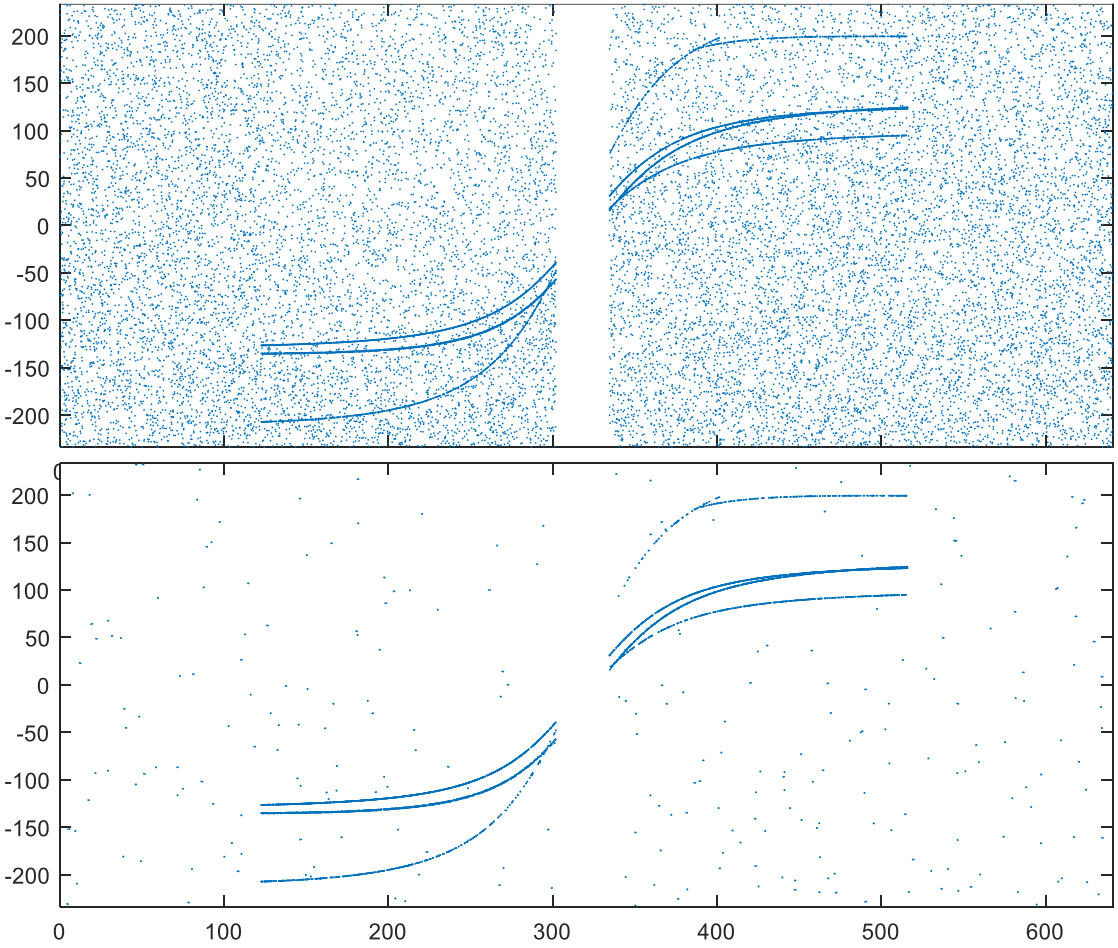
Motivation

Multiple reflectors mounted on the ISS lead to critical problems for the ELT experiment:



- It is not possible to identify the signal returns of the ELT reflector in the two-way residuals
- Without an identification the ELT Data Center can not adjust the two-way residuals by orbit errors
  - ➢ It is neither possible to adjust and filter the one-way residuals, nor can we calculate the data triplets required to compute the actual ground-to-space time transfer!
- It is not possible for the SLR stations to correct the ELT reflector time bias during operation
  - ➢ Without an operational time bias correction it is not possible to strike the ELT detector completely (100 ns gate) in case of an along-track error larger than about 20 meters (predicted orbits)!

Binominal noise filter

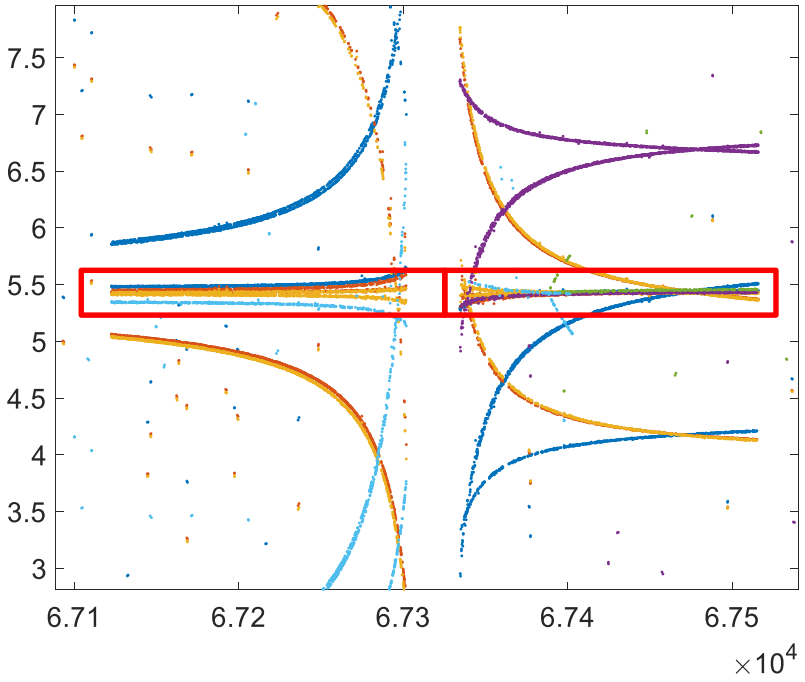


Reflector identification for quicklooks

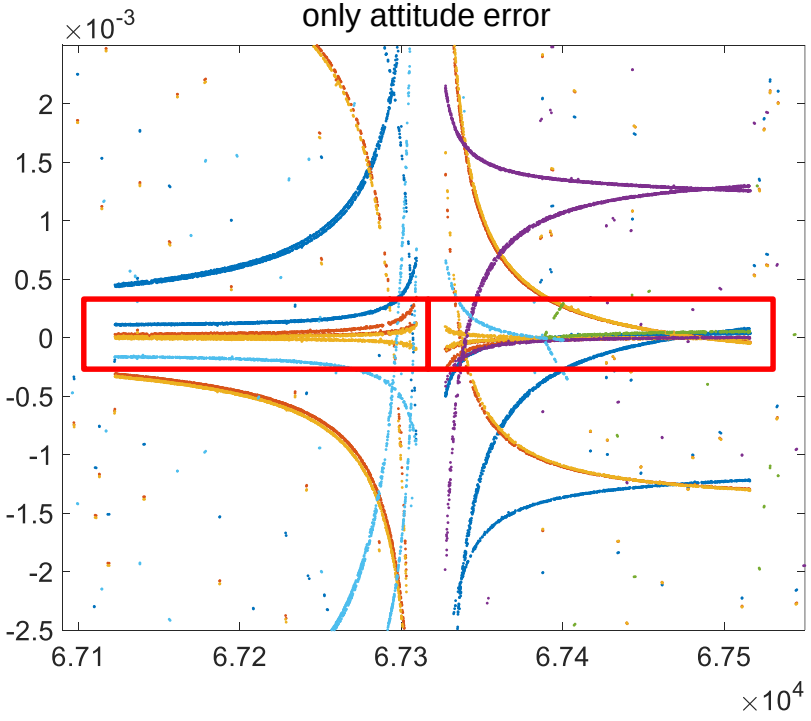
Idea: Calculation of an “ISS time bias” with calculated (two-way) signal time of flights of each reflector (tof_c) from known reflector positions

Time bias: $TB = \frac{(tof_m - tof_c)}{\dot{R}}$ with $\dot{R} = \frac{d\frac{tof_c}{2}}{dT}$

only along-track orbit error

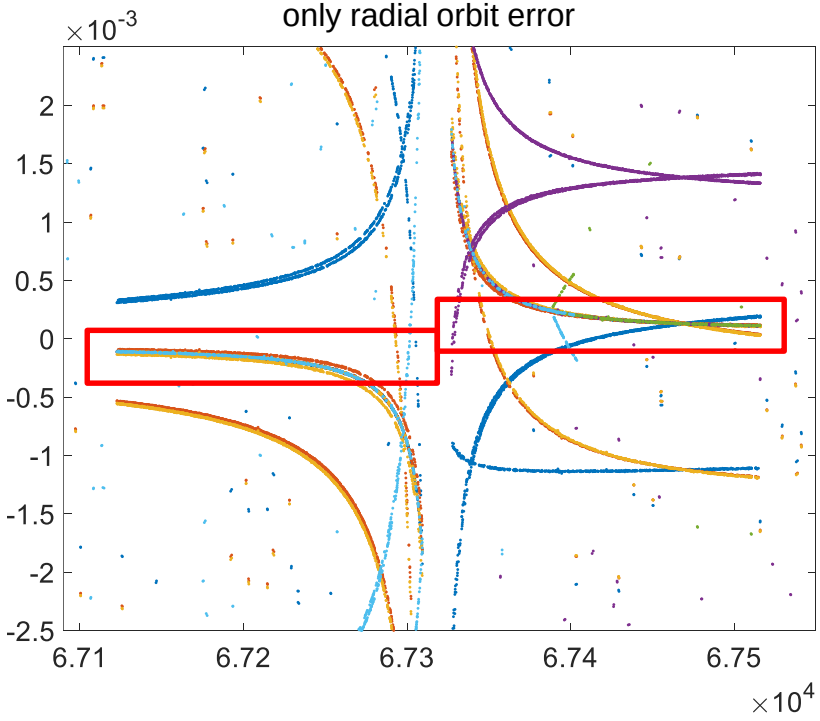


only attitude error

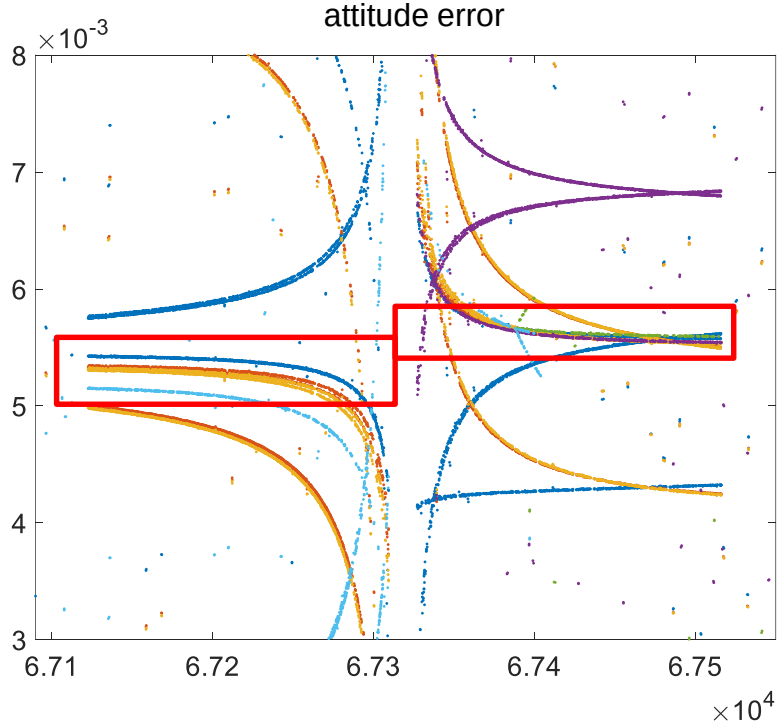


Reflector identification for quicklooks

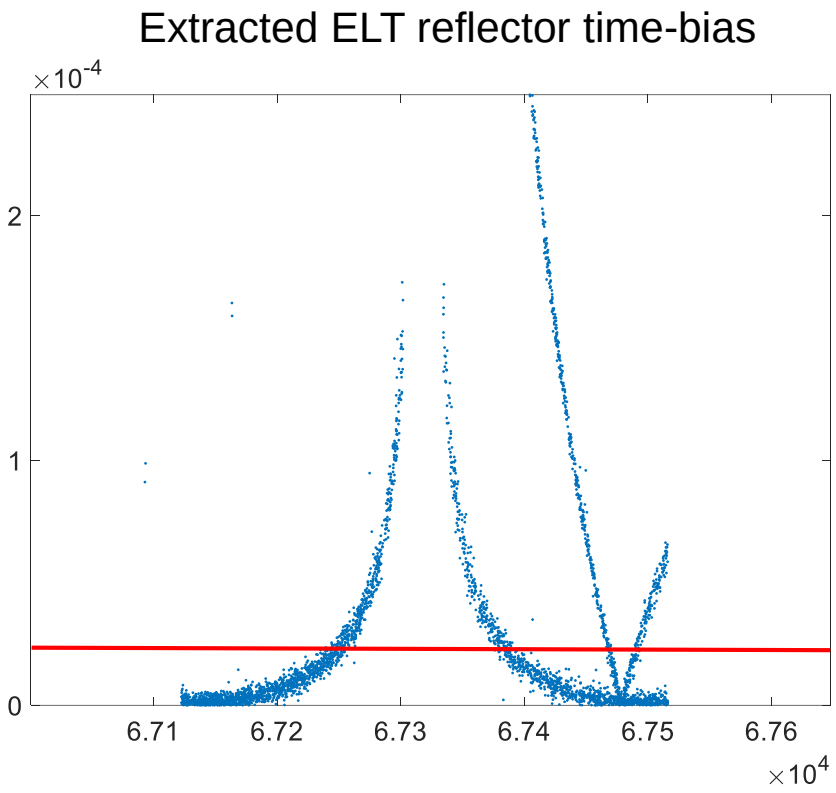
only radial orbit error

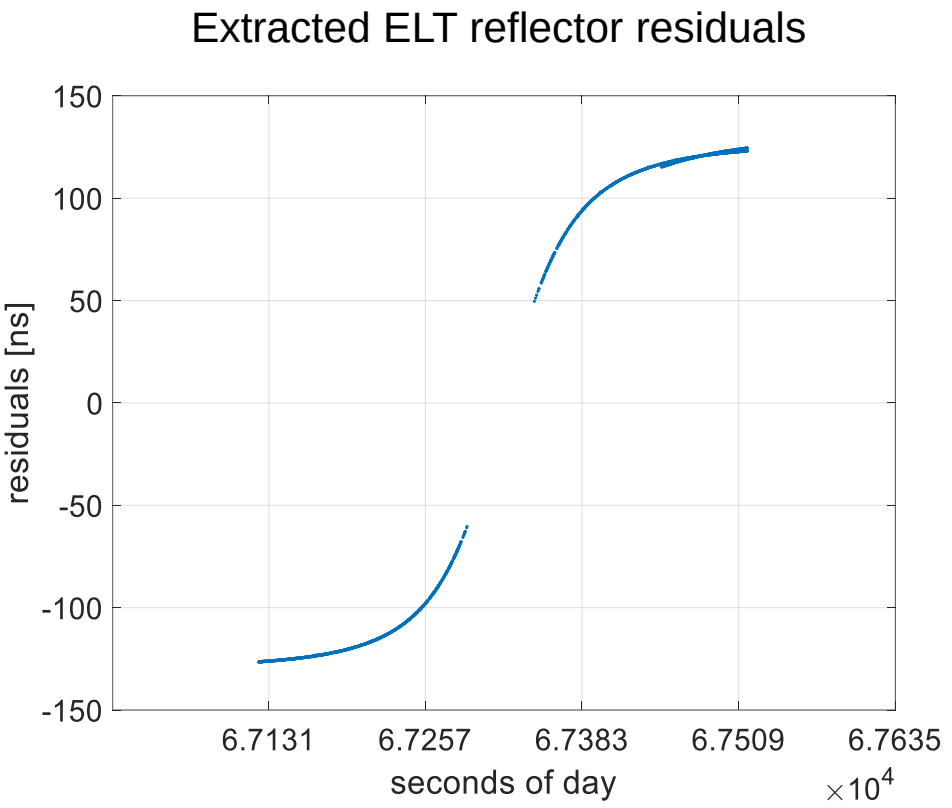


combination along-track, radial orbit error and attitude error



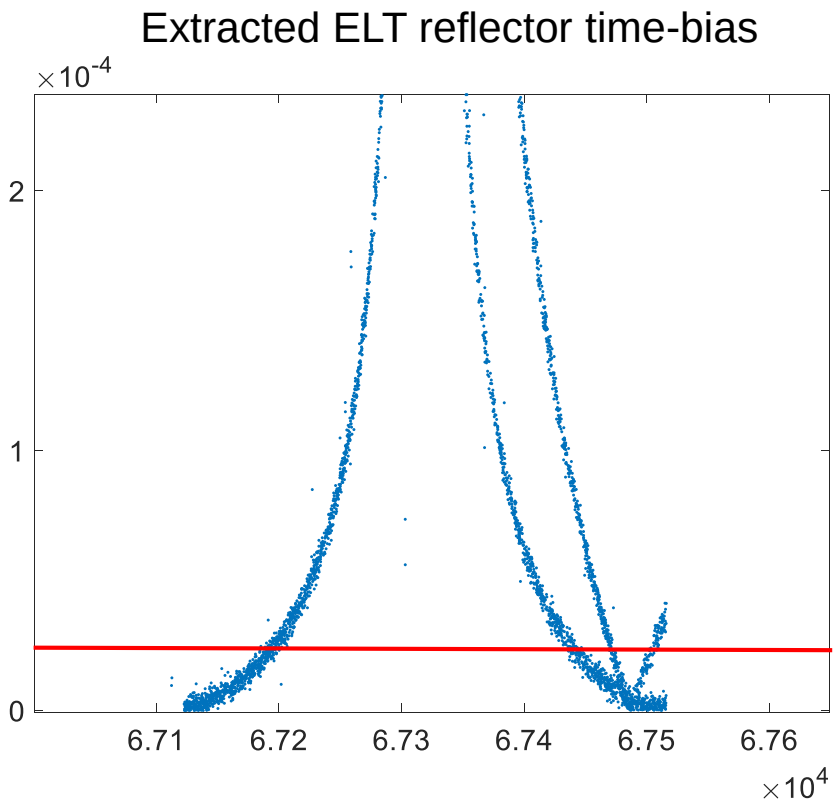
Reflector identification for quicklooks

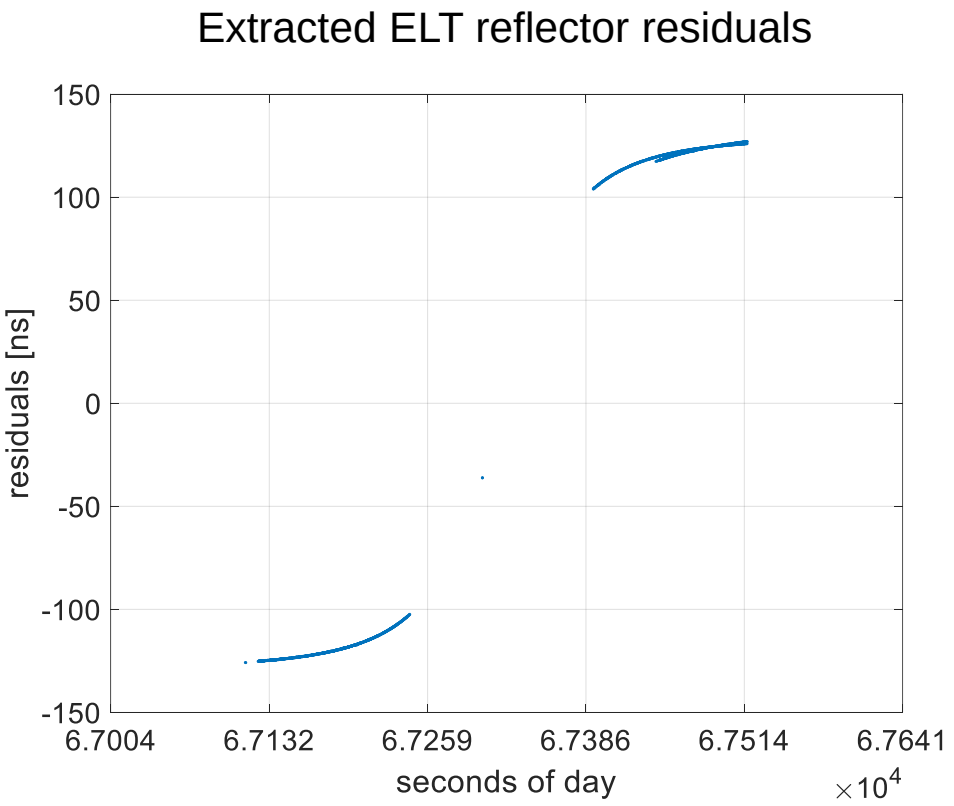




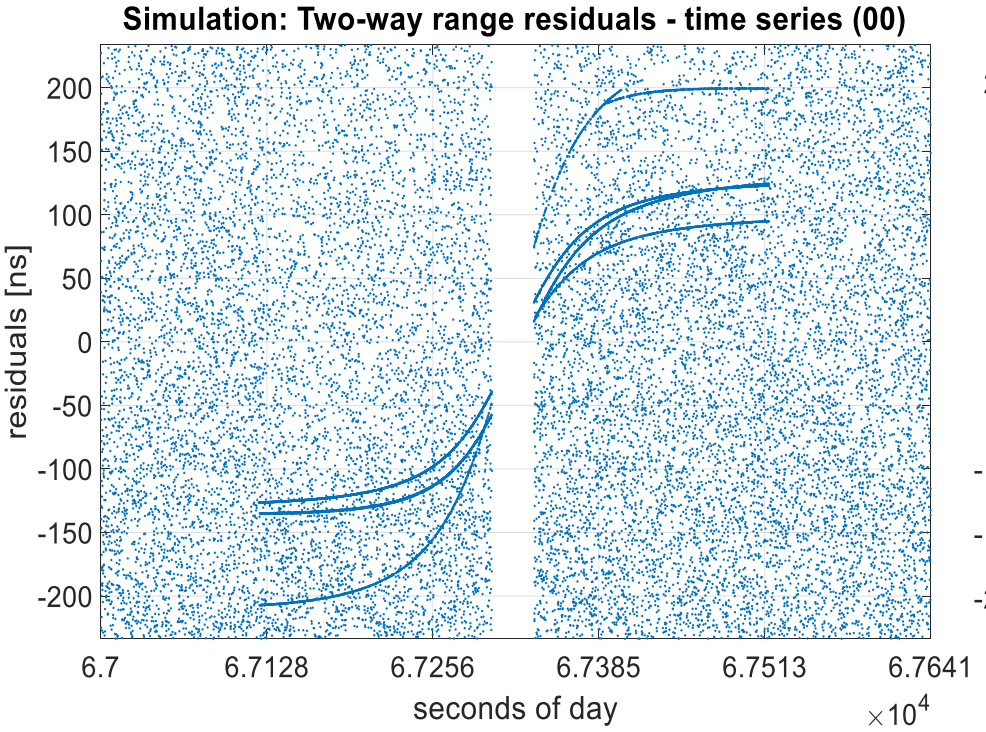
Reflector identification for quicklooks

With 1 m radial orbit error

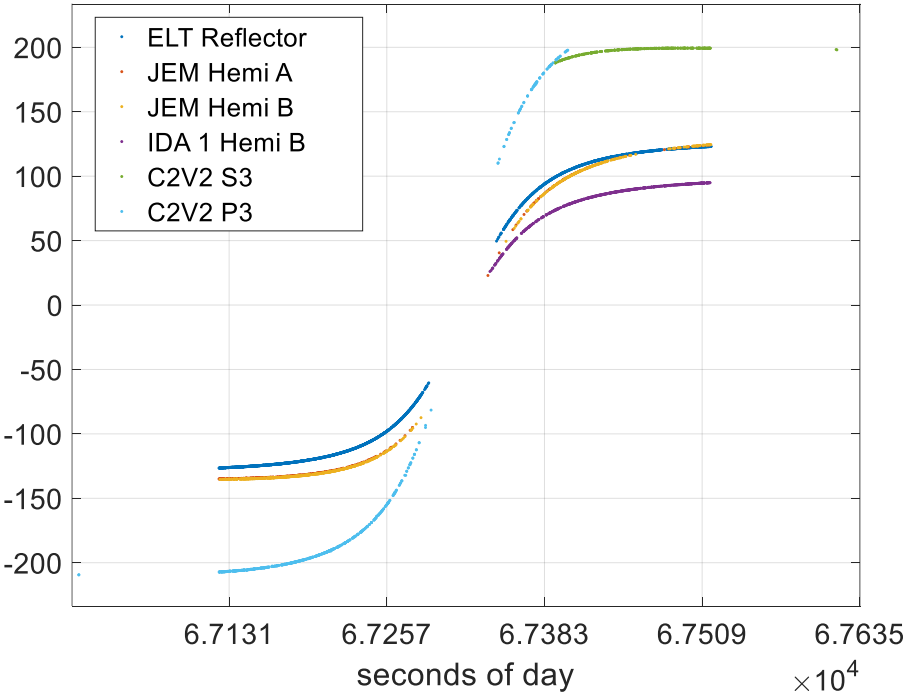




Reflector identification for quicklooks



Extracted reflector residuals



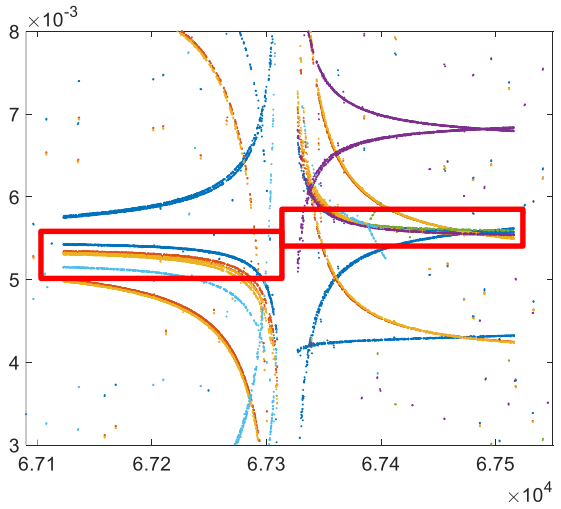
Real-time time bias (TB) correction

Aim:

- Calculate a TB value regarding the ELT reflector as soon as possible, without accurate knowledge of the attitude in real-time
- TB correction has to be accurate enough to be able to strike the ELT detector gate (100 ns ELT detector gate ⇨ two-way residuals within 200 ns gate)

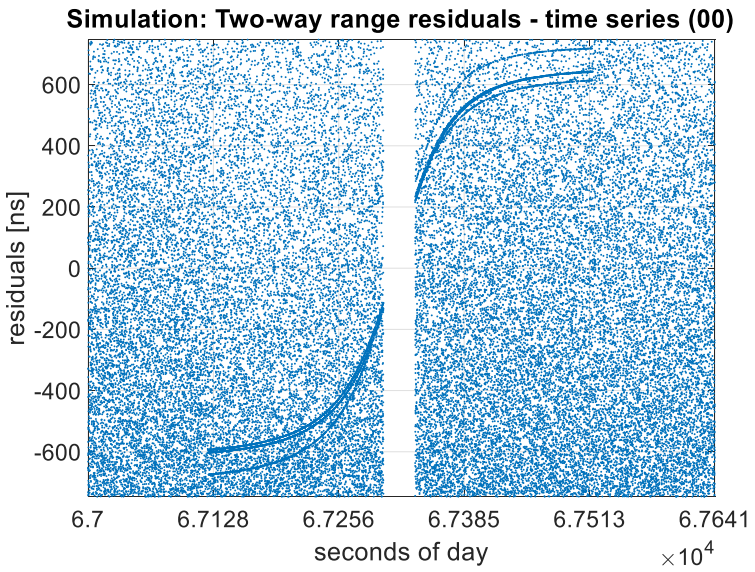
Difficulties:

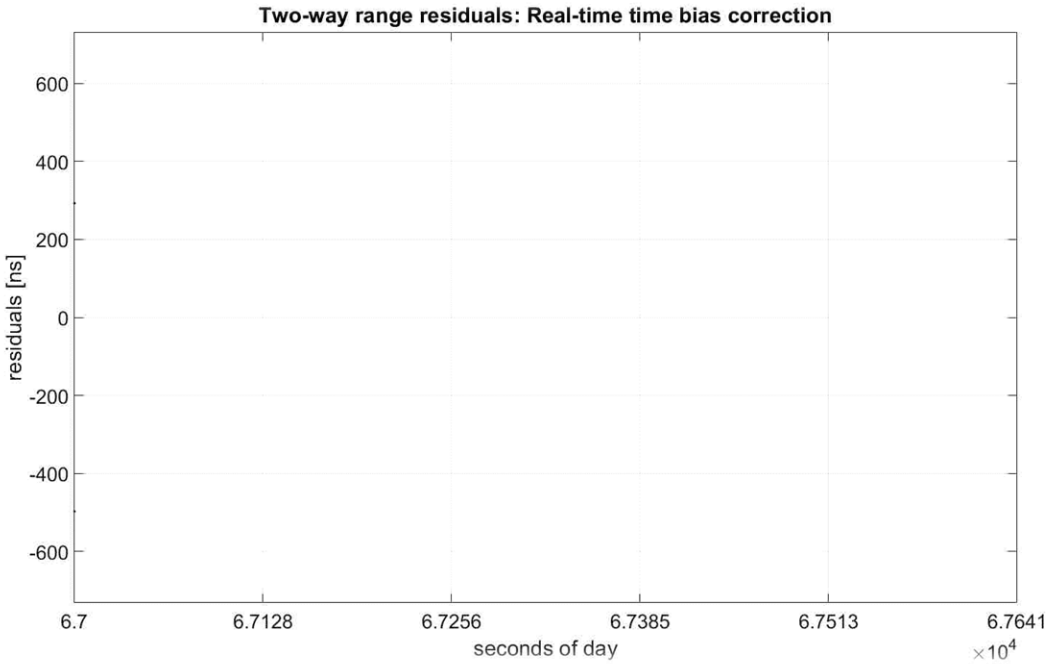
- No binominal noise filtering is possible due to calculation time
- “ISS time bias“ peak has to be calculated with just a few signal data ⇨ interval method
- If there are only returns from one reflector
  - ➢ A reflector allocation is not possible
  - ➢ Most returns are expected from the ELT reflector



Real-time TB correction

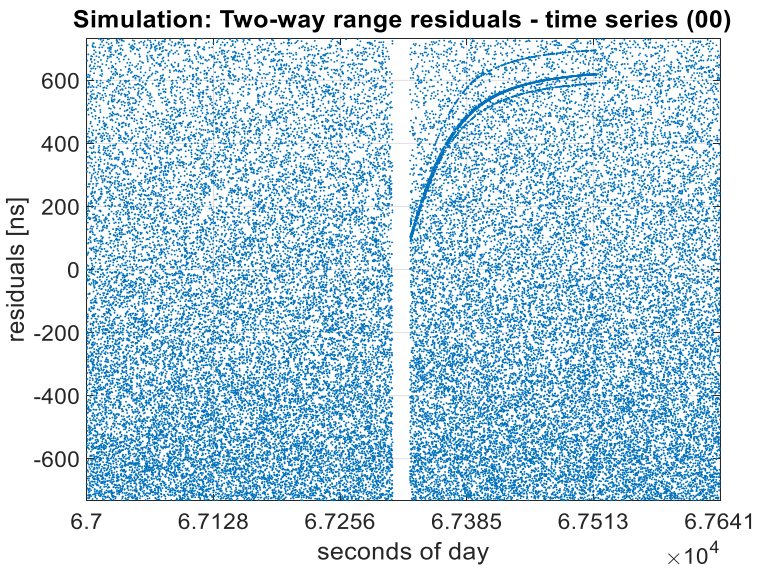
100 m along-track orbit error, 1 m radial orbit error, constant 0.5° attitude error

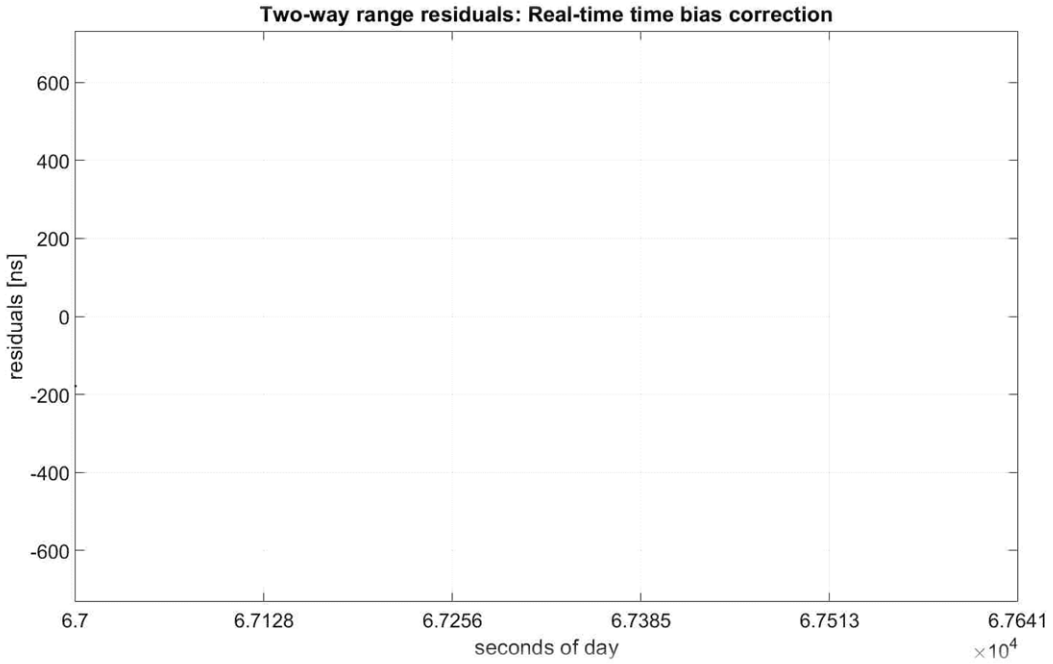




Real-time TB correction

100 m along-track orbit error, 1 m radial orbit error, constant 0.5° attitude error, only second half of the pass visible

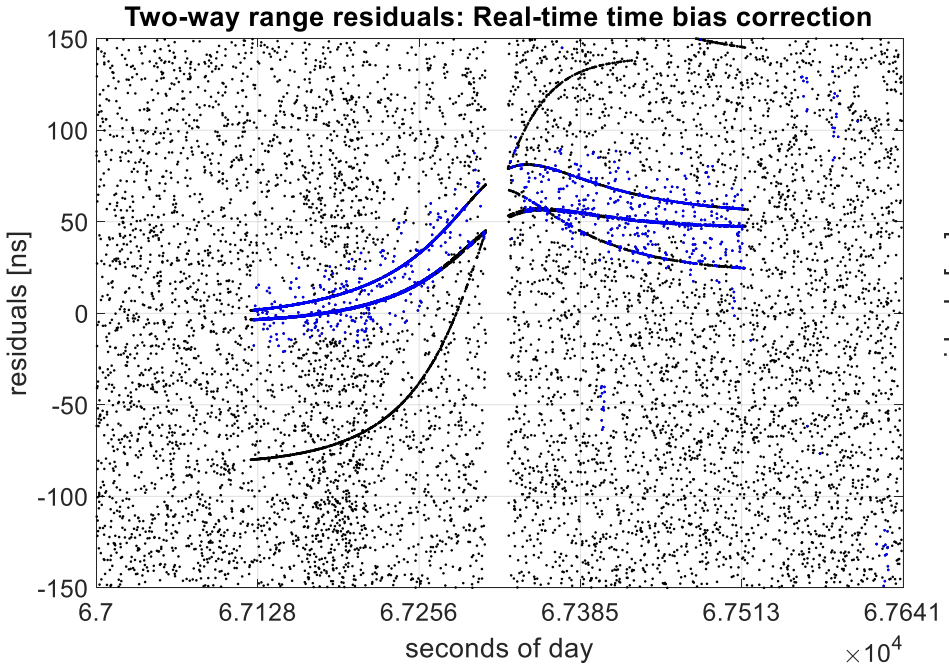




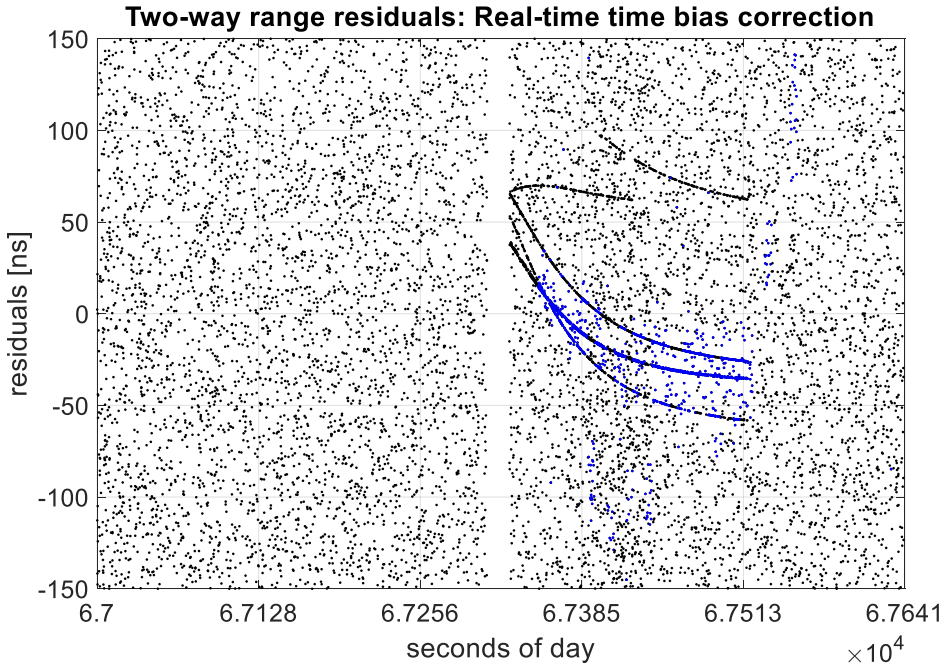
Real-time TB correction

100 m along-track orbit error, 10 m radial orbit error, constant 5.0° attitude error

TB correction in the first half of the pass



only second half of the pass visible



Conclusions

Reflector identification for quicklooks:

- It is possible to identify the reflectors quite precise
- Attitude is known for quicklooks (error: ±0.5°)
- Identification problems in the zenith area in case of a radial orbit error

Real-time TB correction:

- For a successful pass tracking it is necessary to correct the TB in the first half of the pass or shortly after zenith to get enough one-way data for a meaningful evaluation
- It is sufficient to correct the TB regarding the ELT detector gate
  - ➢ All reflectors have a TB which is close enough to the ELT reflector TB
- **Real-time TB correction is indispensable** to get a chance to strike the ELT detector gate!

Outlook

- We want to make the real-time TB correction available for the SLR stations
- More tests in different scenarios have to be done
- **A further tracking campaign** would help:
  - From which reflectors we get returns?
  - Get an idea how many returns we have from the reflectors
  - Compare the data with our simulations
  - Optimize our algorithms

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Thank you for your attention!