Synchronization of distant Laser stations thanks to Time Transfer by Laser Link: Proposal for a dedicated campaign

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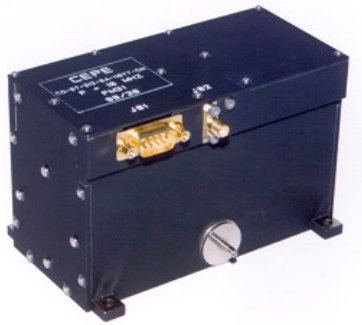
Outline

- The Time Transfer by Laser Link (T2L2) Experiment
  - The Common View (CV) Time Transfer
  - The Non Common View (NCV) Time Transfer issues
- Space Effect on the on-board Oscillator and model
- The NCV Time Transfer
  - Computation principle
  - First Result
- A new Dedicated Campaign

THE TIME TRANSFER BY LASER LINK (T2L2) EXPERIMENT

- Launched in 2008, on-board *Jason-2* at 1335 km
- Synchronized ultra stable clocks using SLR

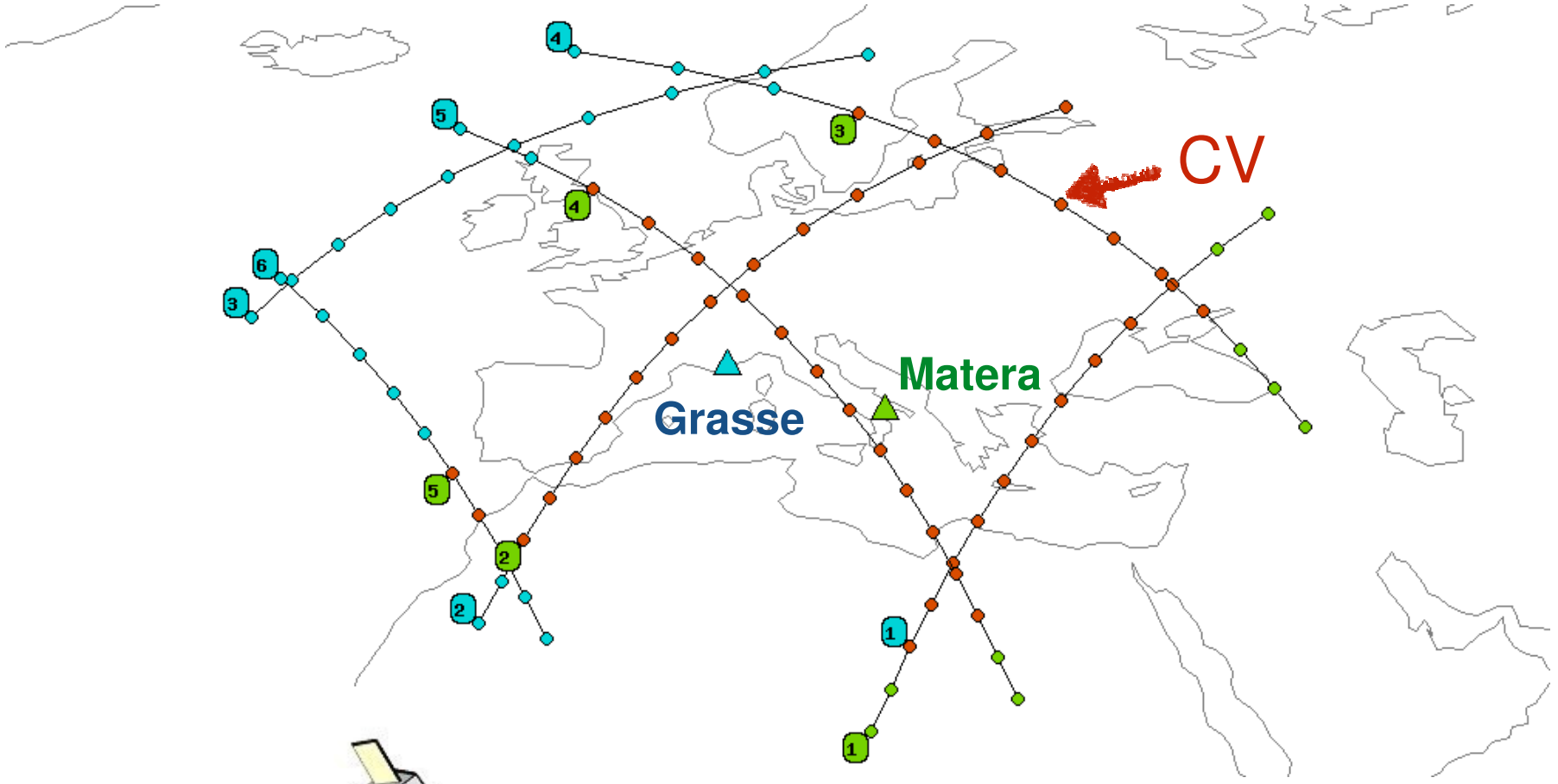
DORIS (Doppler Orbitography and Radiopositioning Integrated on Satellite) USO

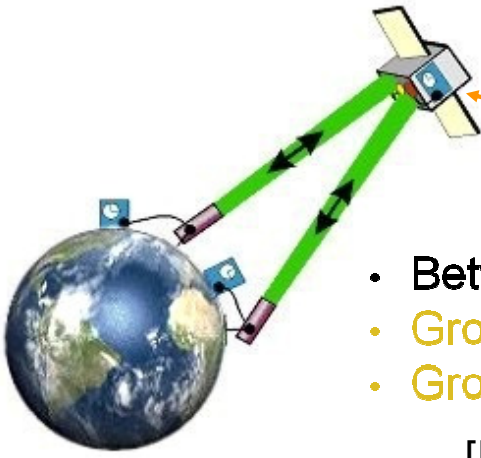


T2L2

- pass over station 10 to 15 min ($T_{orbital}$ ~ 110 min)
- 5 to 6 per day,
- dates optical events at the picosecond resolution from laser stations (ILRS)

Common View (CV) Time Transfer



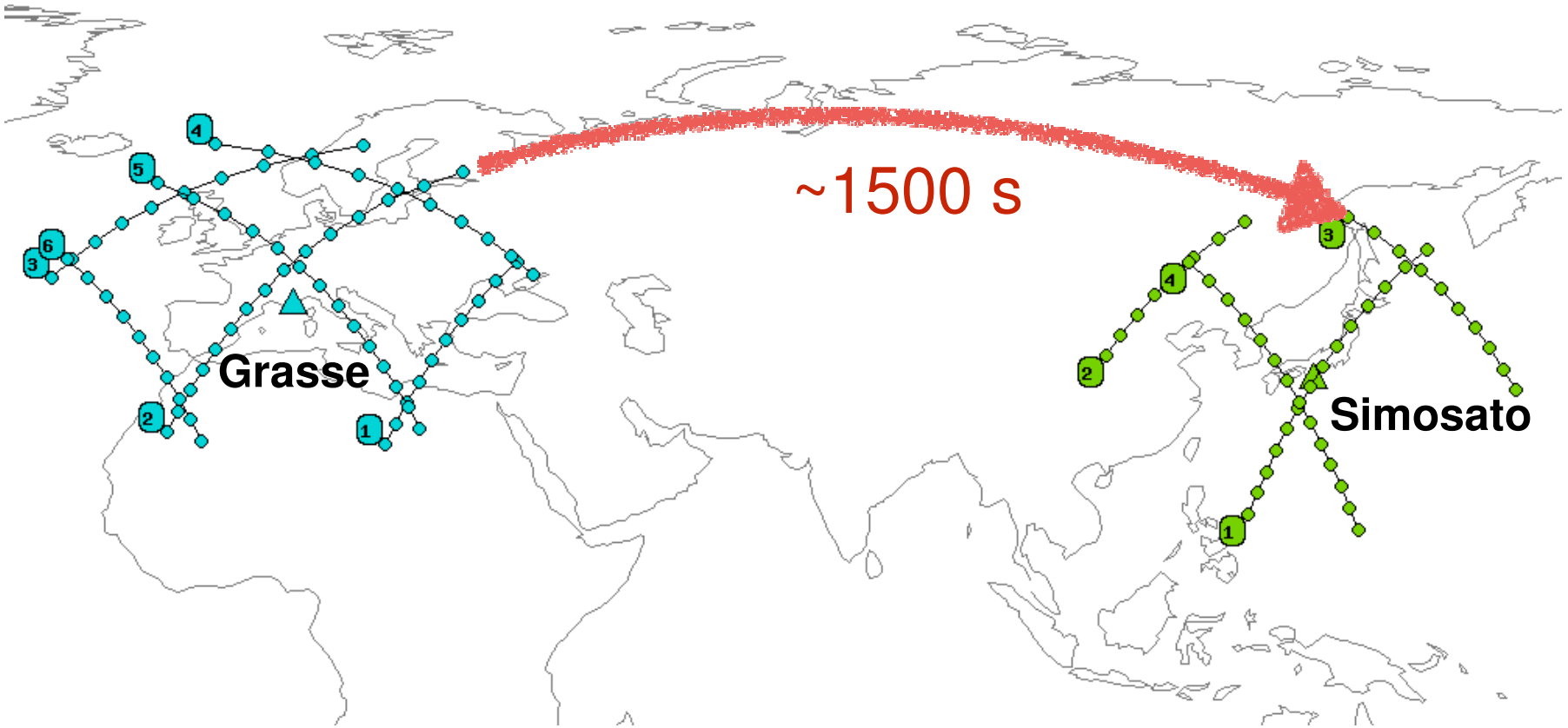


The instability of the oscillator is removed

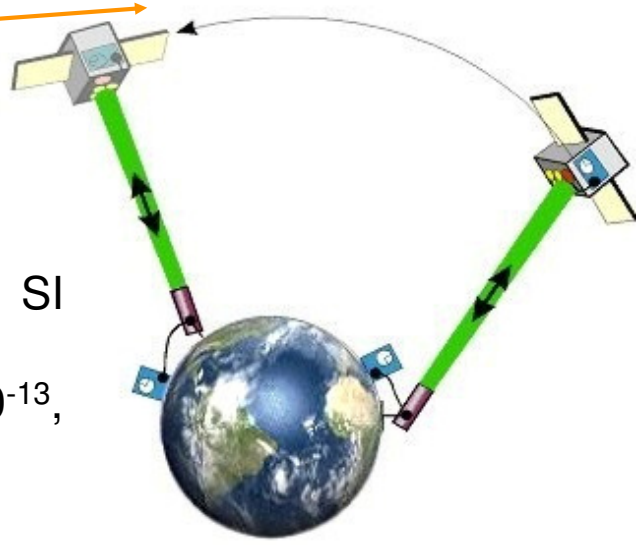
- Between ground stations (< 3000 km)
- Ground to Space time transfer : - Stability 5-6 ps @ 75 s
- Ground to Ground time transfer : - Stability 15 ps @ 1000 s
  - Accuracy 120 ps

[Exertier et al., ASR 54(11), 2014]

Non Common View Time Transfer (NCV)

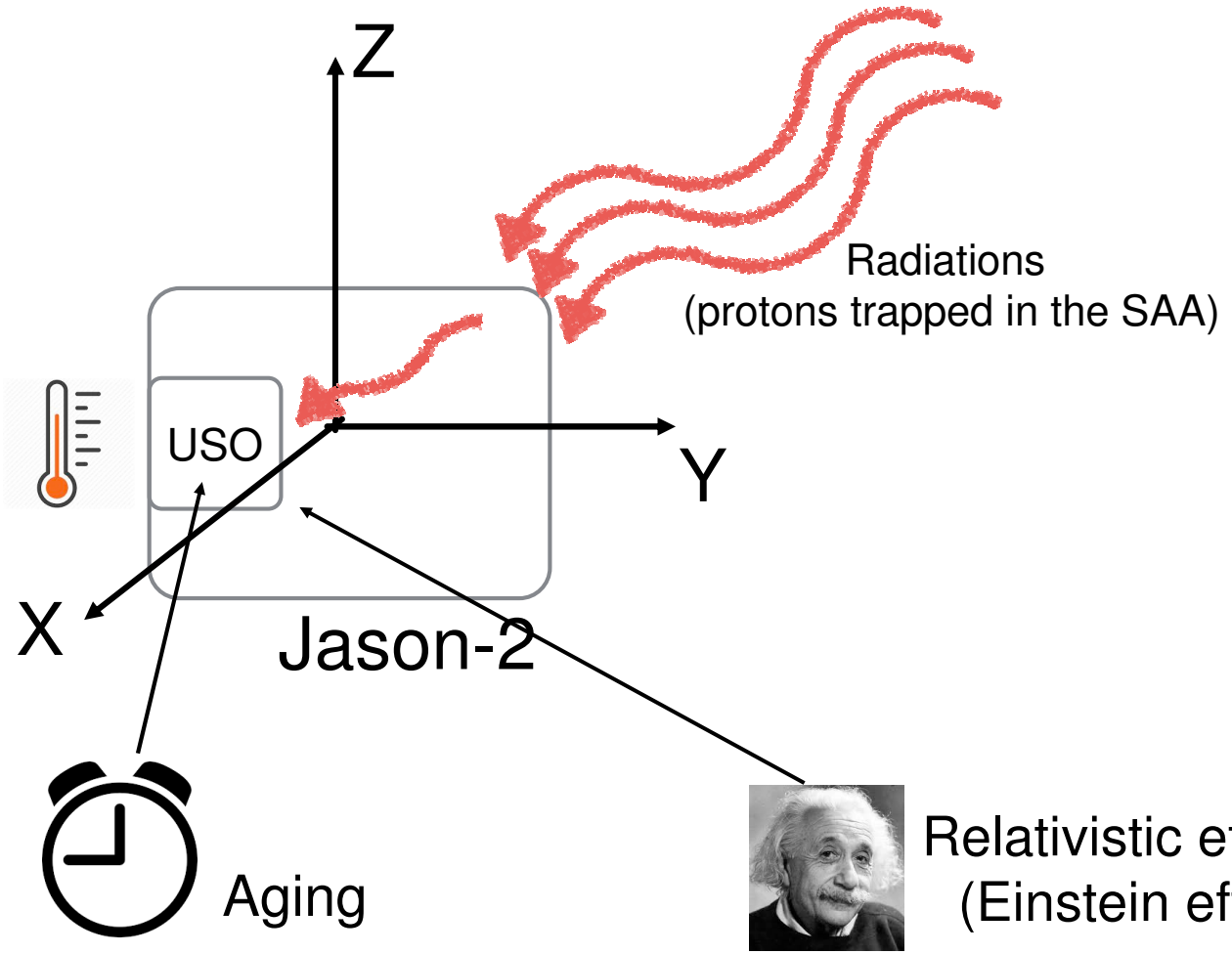


Rely on the stability of the oscillator

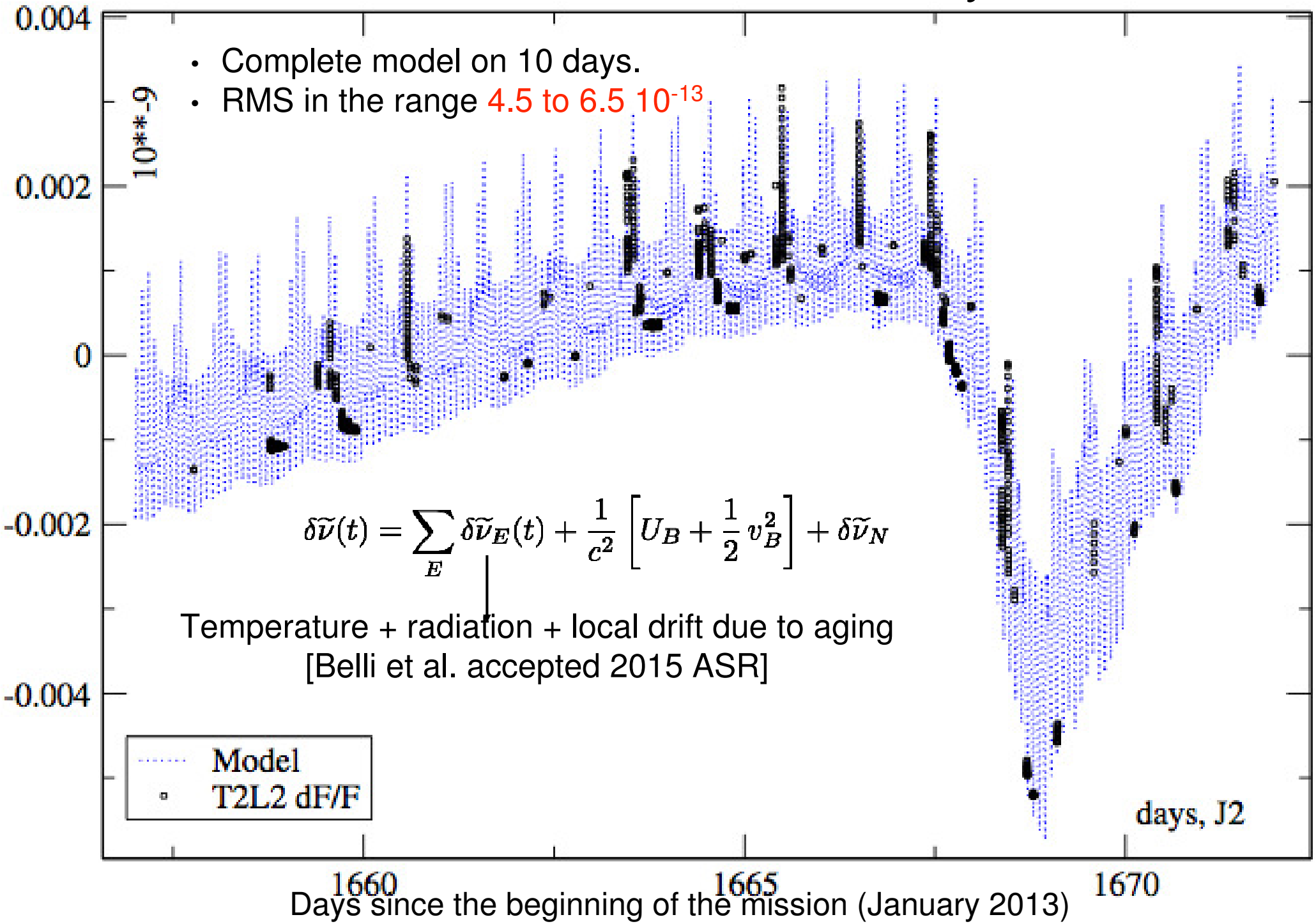


- Between ground stations (> 3000 km)
- A model to explain the frequency variations (see Belli et al., ASR SI Doris, 2015)
  - the frequency accuracy of the model was estimated at ~5.10^{-13}, which roughly corresponds to a stability of 5 ns @ 10,000 s
  - NB: Orbital period of *Jason-2* : 6700 s

From the space environment effect on the USO, to a frequency model



Oscillator model on 10-day



The NCV computation Principle

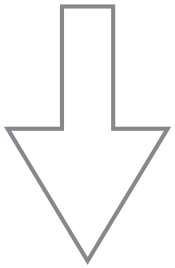
1

Selecting a Master Station (A reference Station)

Fitted to UTC(OP) by a calibrated GPS link

2

Integration of the frequency model

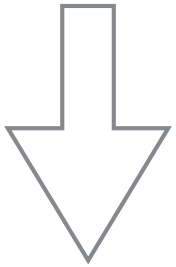


Synthetic Coordinate Time Scale fitted to Grasse local time

The NCV computation Principle

3

control on every pass over Grasse
(integrated phase - observed phase)

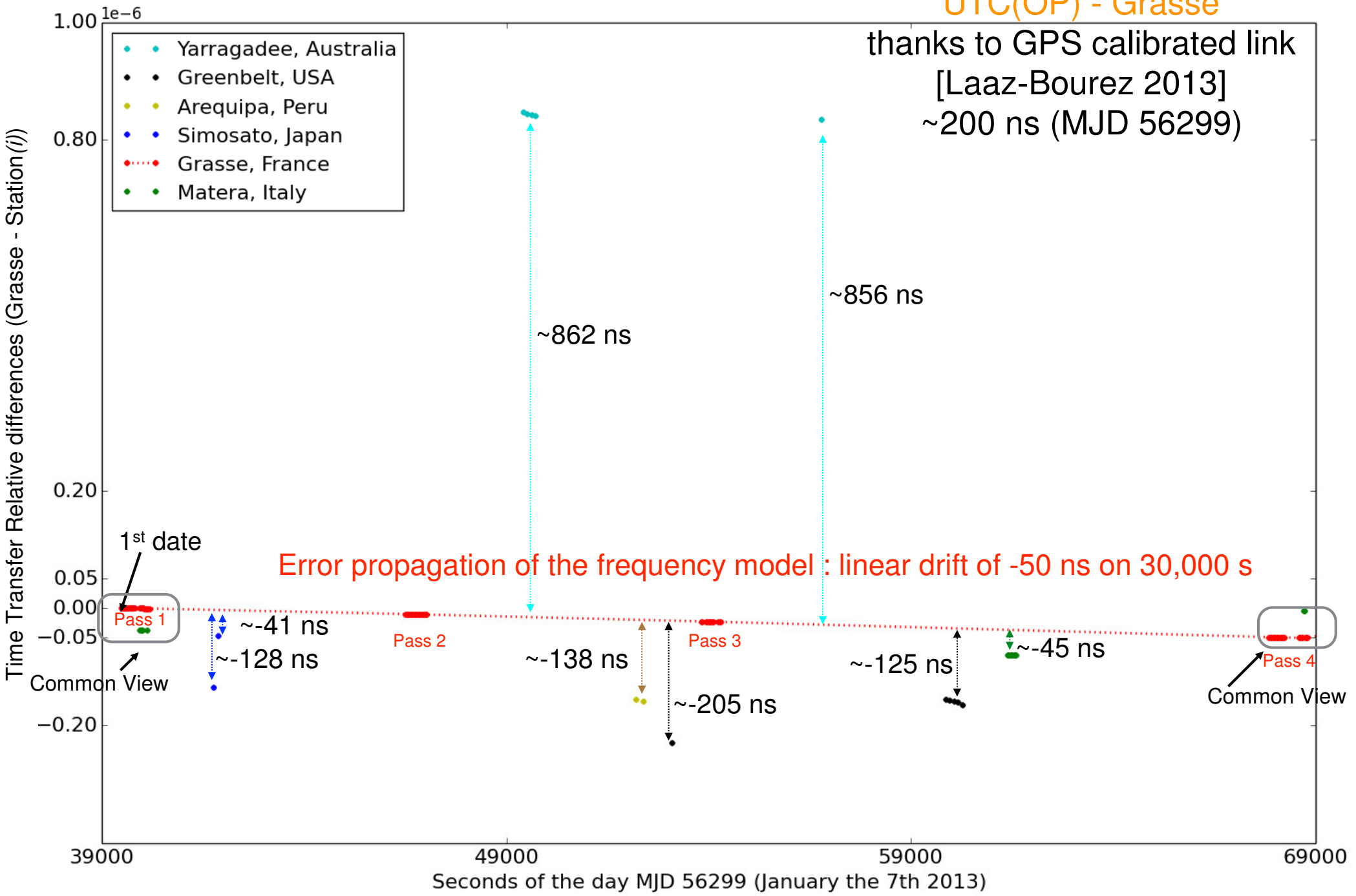


This operation give the error propagation of the integrated model

4

Time Transfer Relative differences (Grasse - Station*(i)*)

First Results (Global Network)

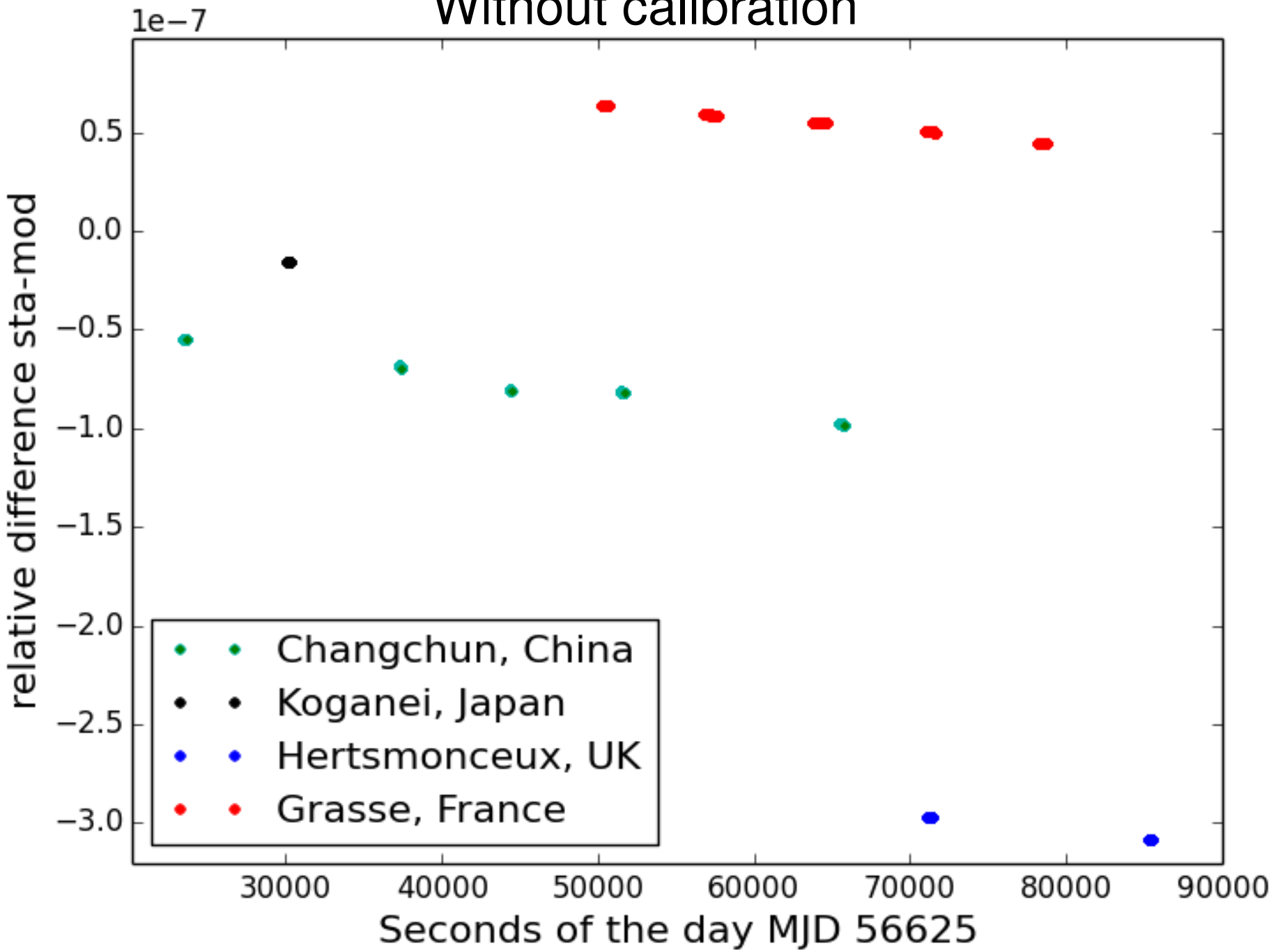


A new Dedicated Campaign:

- 4 stations involved (Grasse, Herstmonceux, Koganei and Changchun)
- Winter to Spring 2016
- 2 by 2 in common view (control)
- Calibration needed
- expected results : Non common view time transfer at the level of several nanoseconds (accuracy)

First results (4 stations)

Without calibration



Conclusions

- Success in the frequency model integration over 30,000 s (around 4 - 5 revolutions of *Jason-2*)
- Synthetic time scale is elaborated each day, which is fitted to Grasse Observatory local time (Grasse - UTC(OP) ~200 ns) permanently measured / GPS
- The laser intercontinental network (ILRS) is currently not synchronized to the 50 - 100 ns level (necessary for the International Terrestrial Reference Frame (ITRF) estimation)
- It is the first space optical time transfer over intercontinental distances !

ACKNOWLEDGMENTS

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- International Laser Ranging Network
- Labex FIRST-TF, Besançon University & Region Franche Comté

Thank you for your attention !

T2L2 website : http://www.geoazur.fr/t2l2/en/data/v4/

Grasse SLR station January 2015