

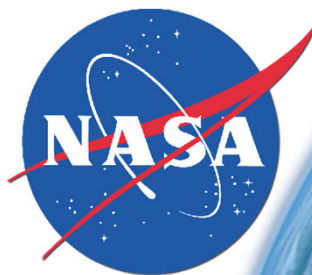
WLRS ranging to LRO



Application of one-way laser ranging data to LRO into orbit determination

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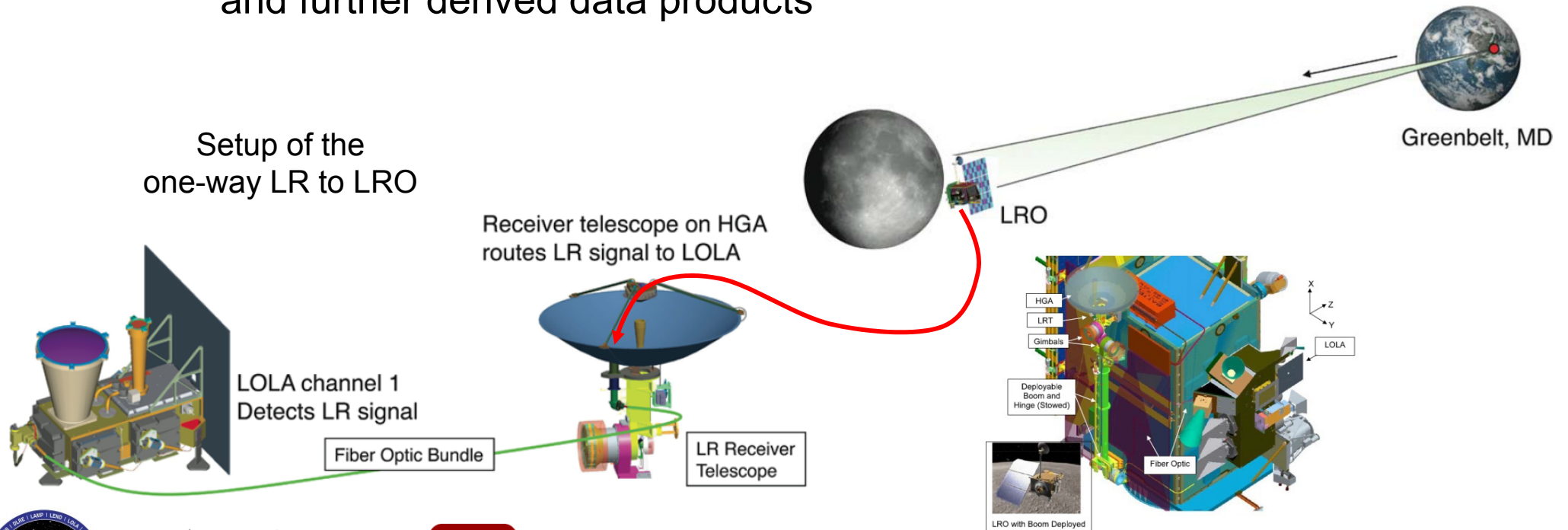


Knowledge for Tomorrow

LR to LRO

Motivation and experiment

- Promising approach
 - LR to LRO provides 15 cm precise pseudo ranges (full data)
 - Setup on SC is simple since LOLA is used and mode is passive
- Goal: analysis of an application into OD for improvement of positioning and further derived data products



LRO OD

Latest activities

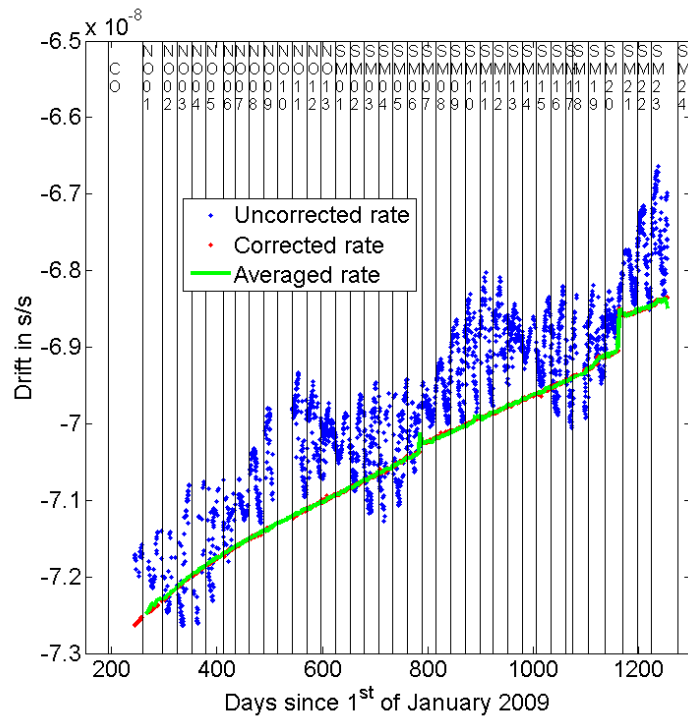
- LRO OD with only one-way LR data
 - Estimation of all timing parameters along with LRO initial state
 - Challenge: high correlations of the timing parameters (LRO & GS clocks) due to the one-way setup
- Using further sources as reference
 - A priori info on state and LRO timing parameters from SPK analysis
 - GS timing parameters from simultaneous pass analysis & literature
 - So providing input to the estimation and do result interpretation
- OD setup used
 - LRO and GS clock estimated to the 2nd order
 - Variation of the length over which the LRO state and the LRO and GS clocks are estimated (state and clock arc length)
 - Gravity field: gggrx_0900c @ D/O180
 - Box model for LRO for the solar radiation pressure
 - A priori total and covariance values for the timing parameters



LRO OD

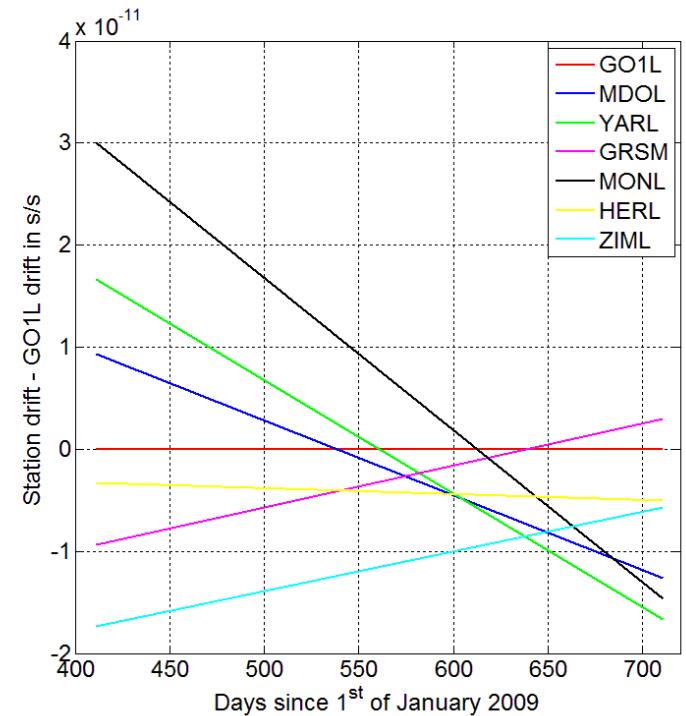
Further references

- LRO clock: offset, drift and aging from SPK analysis
- GS clock: differences between stations on offset, drift and aging from [1] and from analysis of simultaneous passes



Left:
Results on LRO clock drift rate from SPK analysis

Right:
GS clock drifts wrt. GO1L from [1]

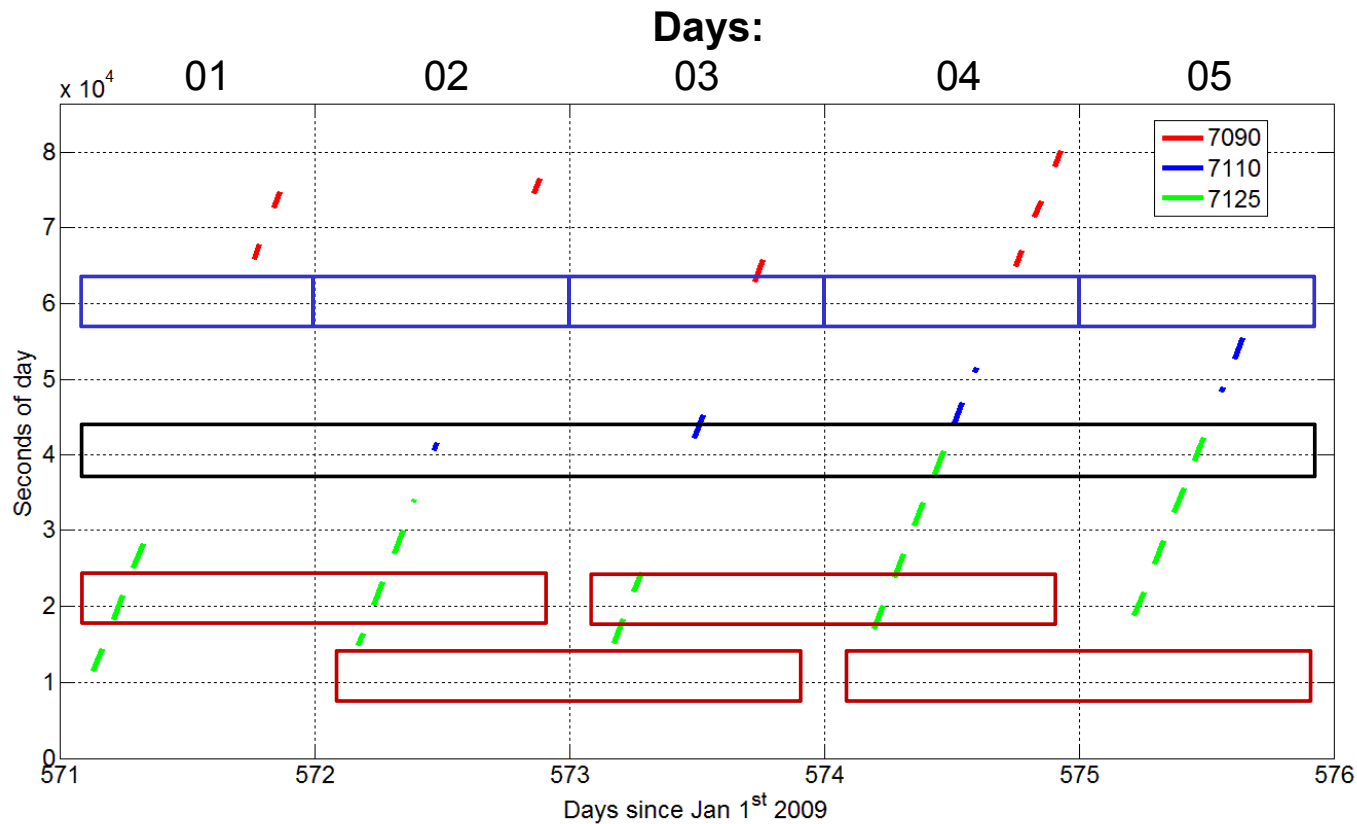


[1] Mao, D., et al.: Laser Ranging Experiment on Lunar Reconnaissance Orbiter: Timing Determination and Orbit Constraints, 17th ILRS workshop



LRO OD

Observation passes & cases



Cases:

Arc length of:

State – clock

05 days – per day

05 days – per full period

02 days – per full period
With arc overlaps

Coverage of 30 LR passes from 3 stations over 5 days, NPT's used for the OD
Timeframe: 26th until 30th July 2010



LRO OD

Results 05 days per day & full period

- Timing parameters for the per day results are averaged over the 05 days
- Comparison to SPK analysis
 - Drift: $-7.1108e-08$ s/s
 - Aging: $4.08e-17$ s/s²

	Per	Day	Full period	
Difference to SPK	Mean in m	40.36	46.50	
Difference in between	Mean in m	6.47		
RMS wrt. trajectory	Mean in m	1.10	2.27	
LRO clock	Offset in s	+1.1222e-03	+2.0678e-04	
	Drift in s/s	-7.1100e-08	-7.1110e-8	
	Aging in s/s ²	-6.7141e-17	-2.9337e-15	
GS clock	Offset in s	7110	-7.7916e-05	2.0507e-04
		7125	-7.7499e-05	2.0528e-04
		7090	-7.3023e-05	2.0365e-04
	Drift in s/s	7110	-4.1653e-12	3.4784e-13
		7125	-7.3567e-12	8.4757e-13
		7090	-4.4276e-11	1.1063e-11
	Aging in s/s ²	7110	-3.0599e-17	-2.9510e-15
		7125	-2.3761e-17	-2.9529e-15
		7090	+4.7019e-17	-2.9704e-15



LRO OD

Results 05 days per day & full period

- Timing parameters for the per day results are averaged over the 05 days
- Comparison to SPK analysis
 - Drift: $-7.1108e-08$ s/s
 - Aging: $4.08e-17$ s/s²
- Comparison of GS clock parameters to literature

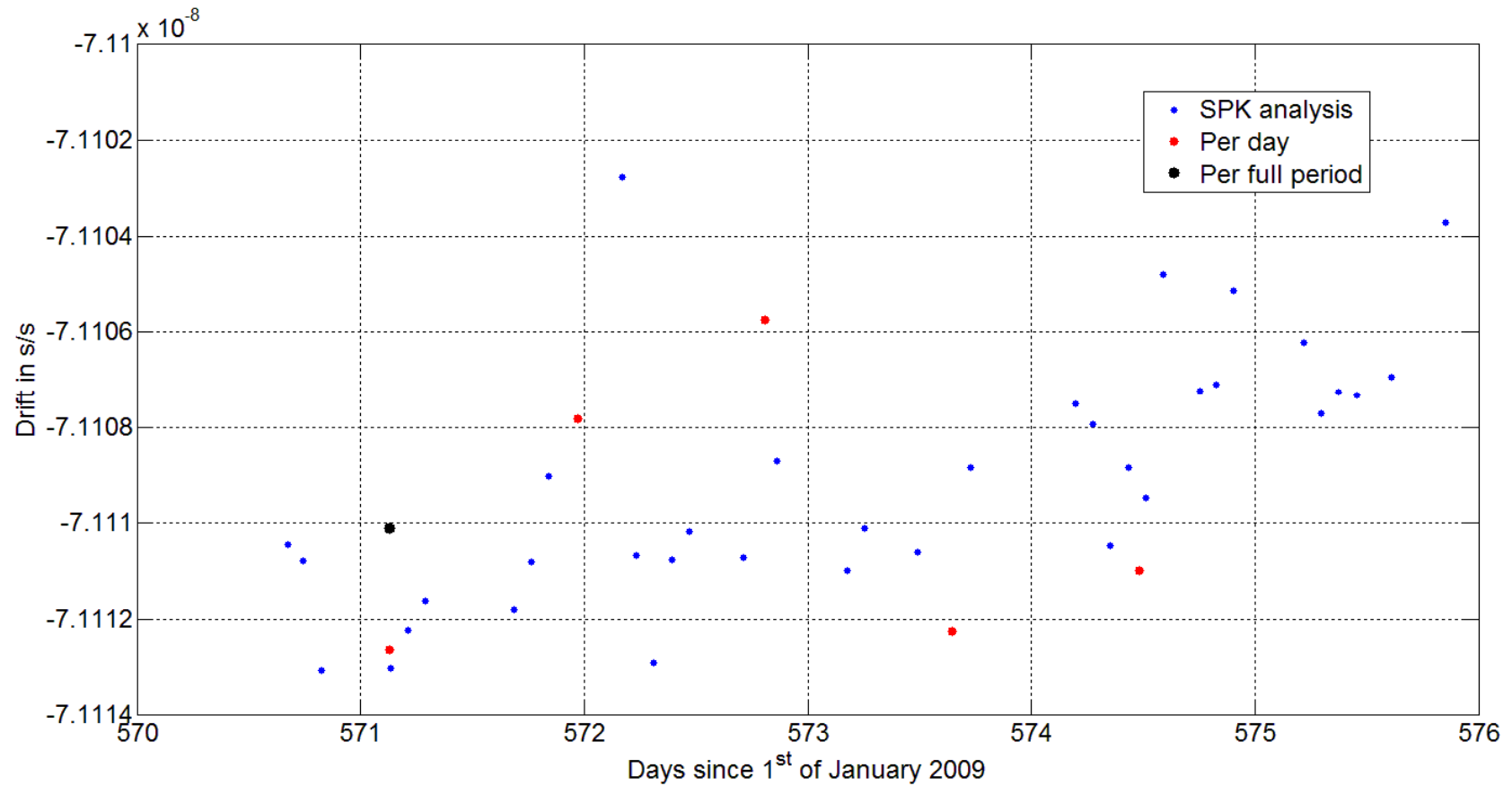
Difference in drift for stations	05 days OD Per day	D. Mao's results From slide 04
7125/GO1L – 7110/MONL	5e-13 s/s	6e-12 s/s
7125/GO1L – 7090/YARL	1e-11 s/s	1e-12 s/s

	Per	Day	Full period	
Difference to SPK	Mean in m	40.36	46.50	
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LRO OD

Results 05 days LRO clock parameters



Estimated LRO clock drift rate



LRO OD

Results 02 days with arc overlaps

	Unit	01 - 02	02 - 03	03 - 04	04 - 05
Difference to SPK	m	10.96	17.72	28.93	8.64
RMS wrt. trajectory	m	1.27	0.44	1.52	0.85
Overlap at day	day		02	03	04
Arc overlap difference	m		25.68	20.13	17.78

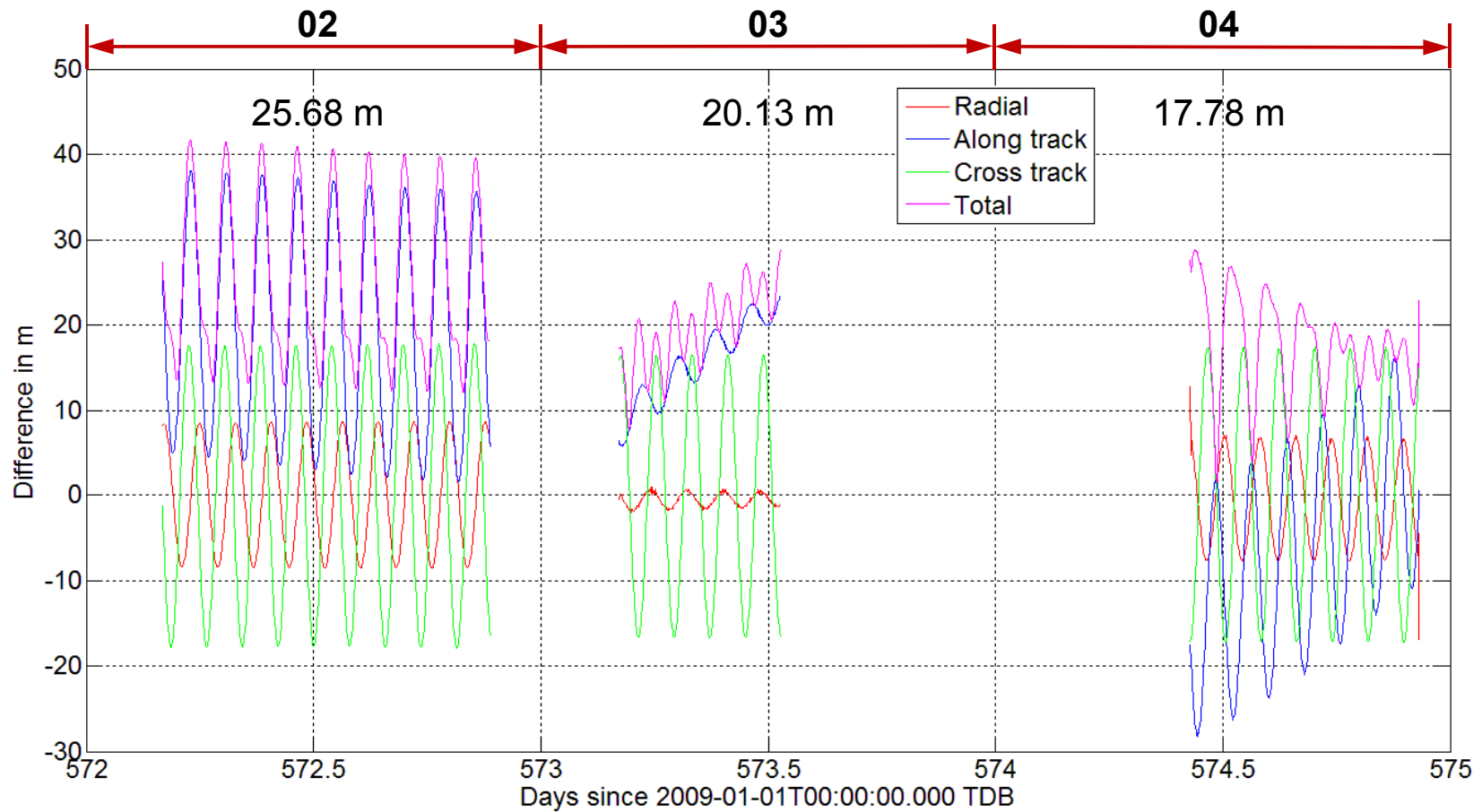
Result of the 02 days OD with arc overlaps



LRO OD

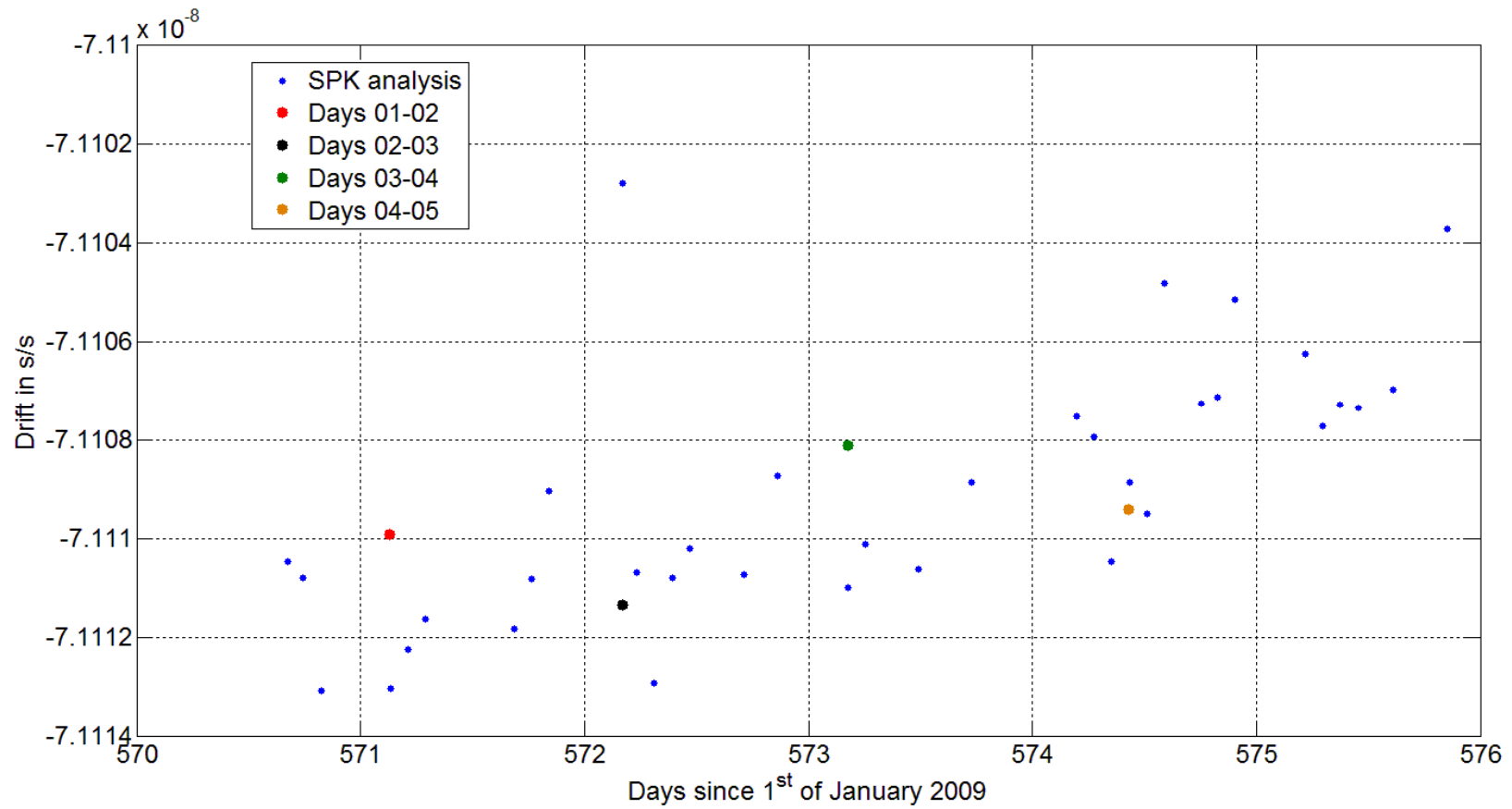
Results 02 days, arc overlaps

Differences of trajectories at the arc overlaps at day



LRO OD

Results 02 days, LRO clock parameters



Estimated LRO clock drift rate



Thank you for your attention! Questions?

The research leading to these results has received funding from the DFG (German Science Foundation) and the European Community's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n° 263466 for the FP7-ESPaCE program.

