LAGEOS-1 spin determination, using comparisons between Graz kHz SLR data and simulations

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LAGEOS-1

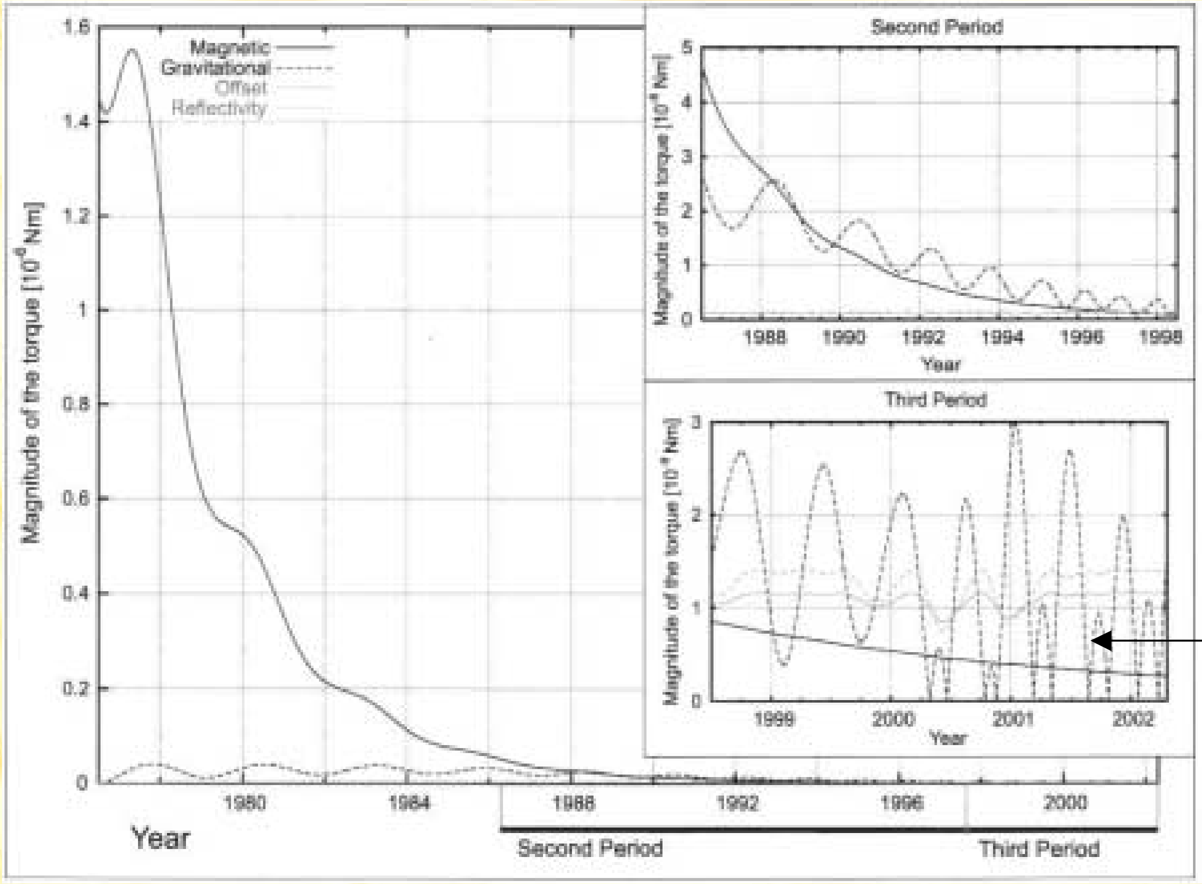
Sphere diameter: 60 cm

426 corner cube reflectors

Orbit perigee: 5,860 km

Launch Date:May 4, 1976

Time history of the magnitude of the different torques acting on LAGEOS-1 : LOSSAM model



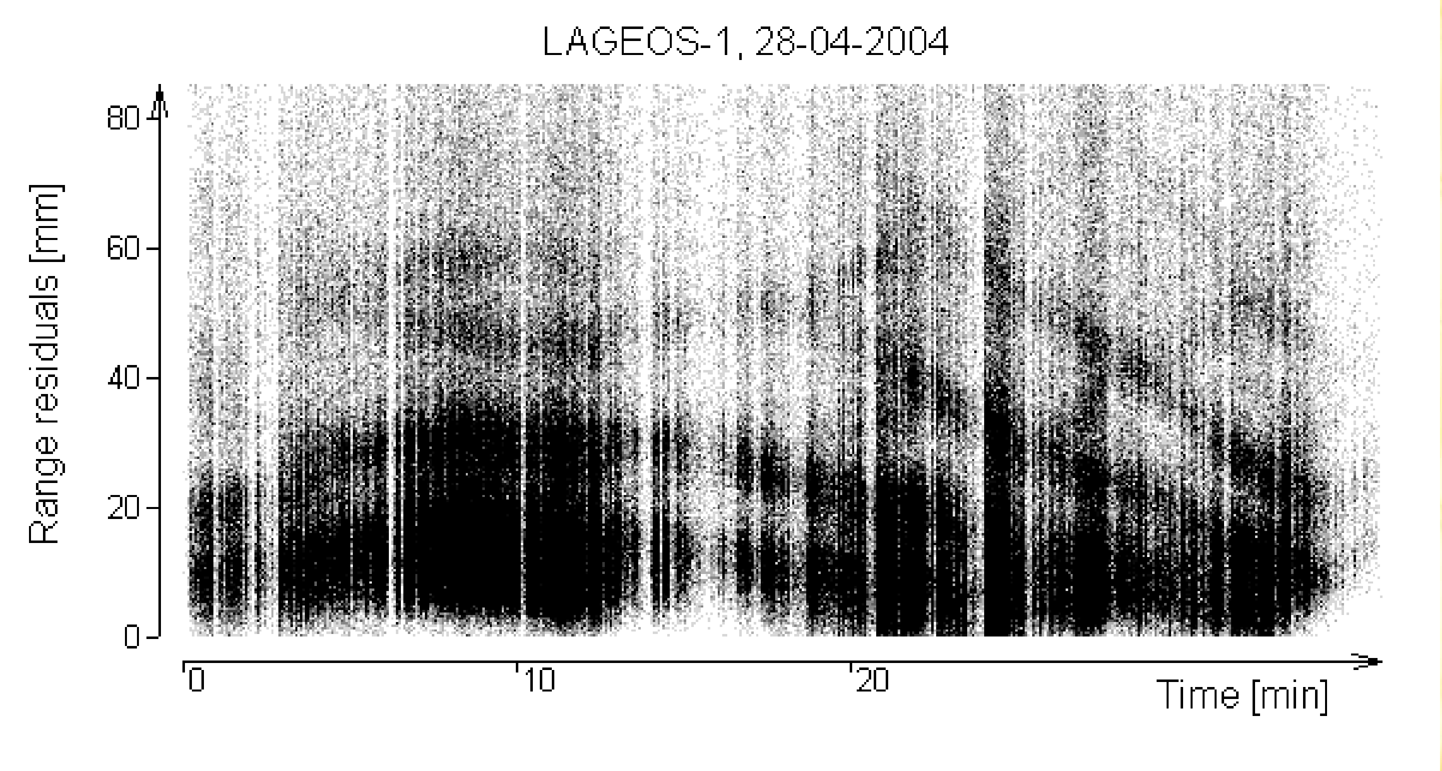
L1 is now in the third period

All torques have the same order of magnitude (10^{-9} Nm)

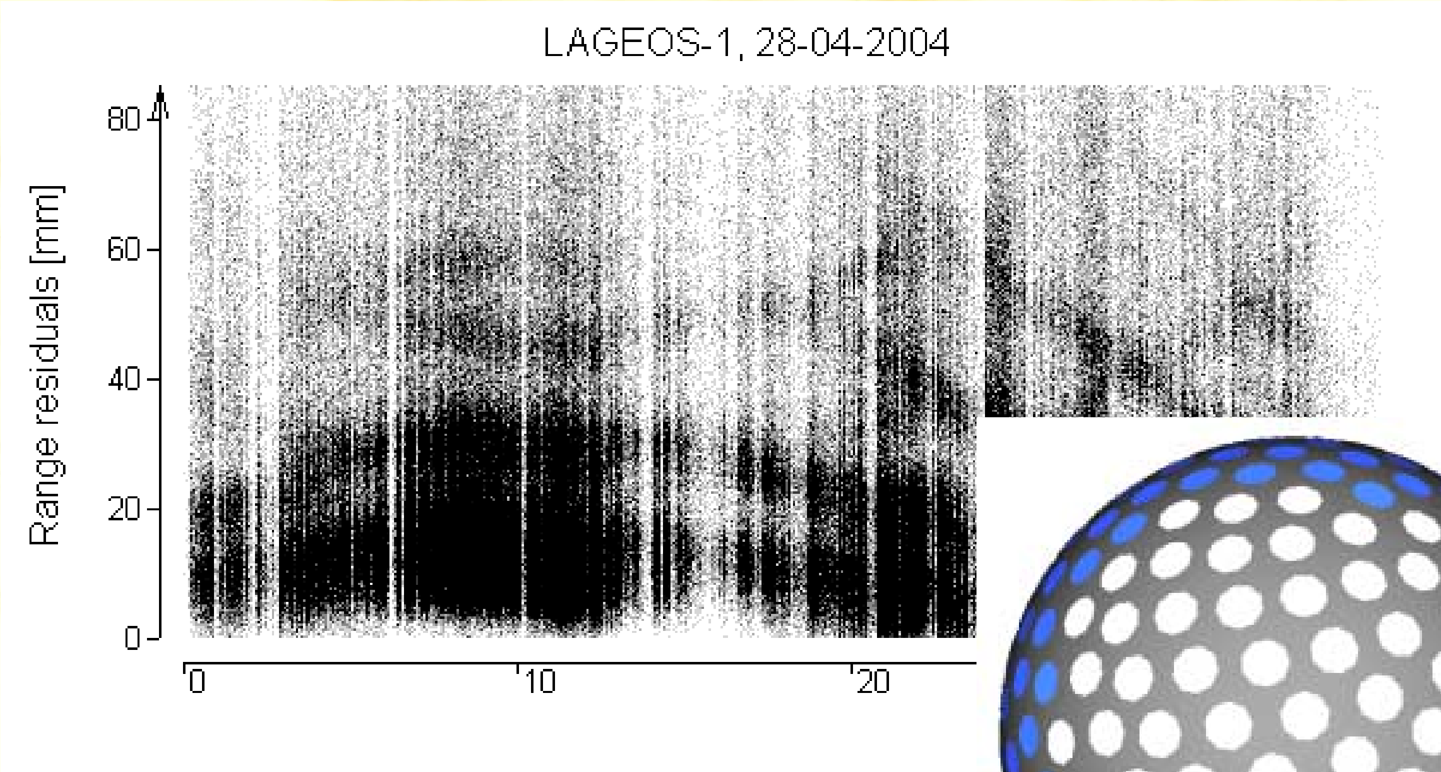
Andres, J. I., R. Noomen, G. Bianco, D. G. Currie, T. Otsubo (2004), Spin axis behavior of the LAGEOS satellites J. Geophys. Res., 109, B06403

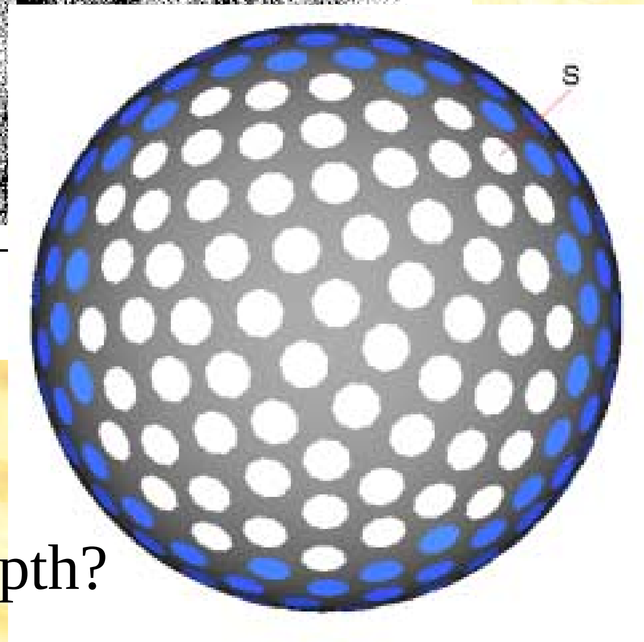
Graz kHz SLR

~40 min pass, > 500,000 returns



Spin tracks – how they can be created... ?

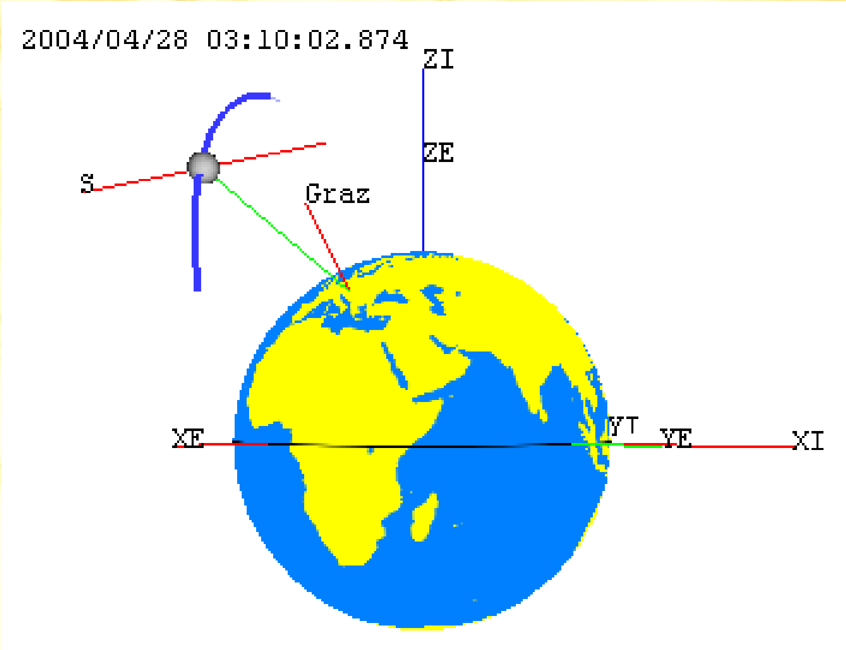




...if there are ~64 CCRs on ~80mm depth?

Spin tracks – modeling the effect

Macro - model

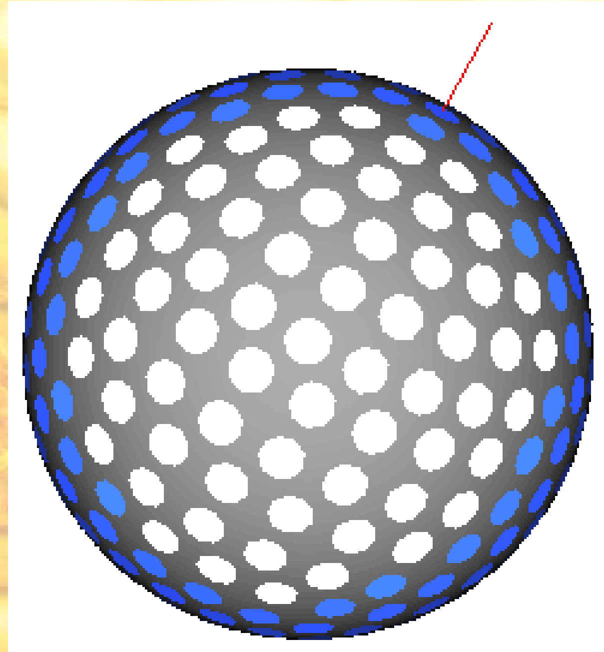


-Earth rotation

-Site position ITRF2000

-Orbital motion (J2000)

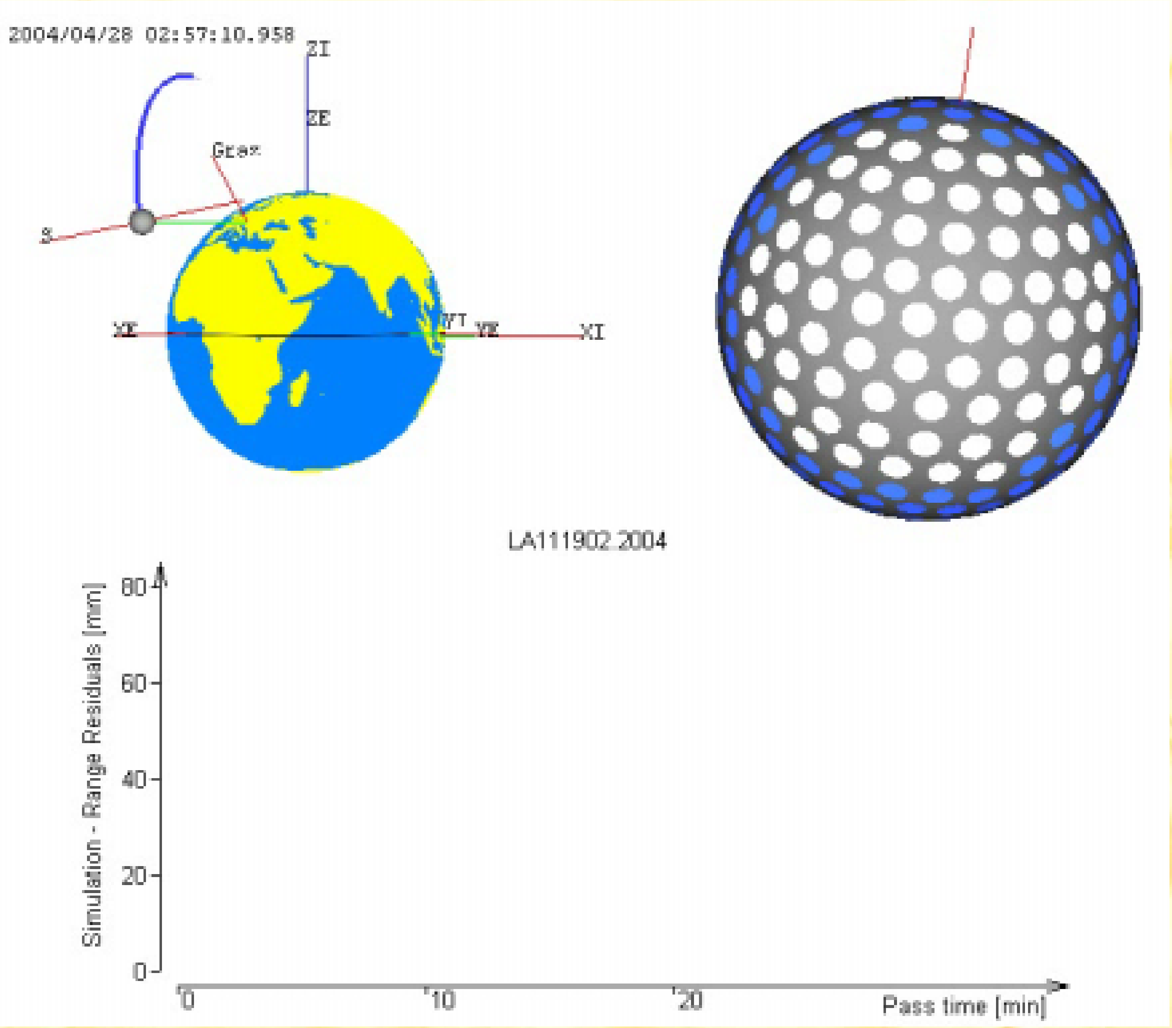
Micro - model



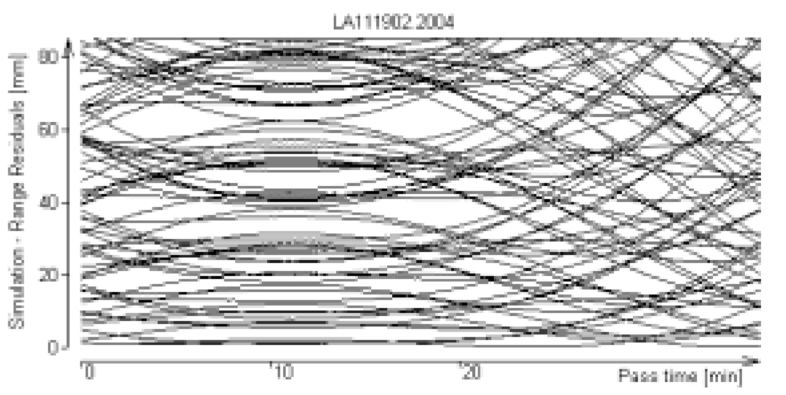
-CCR array

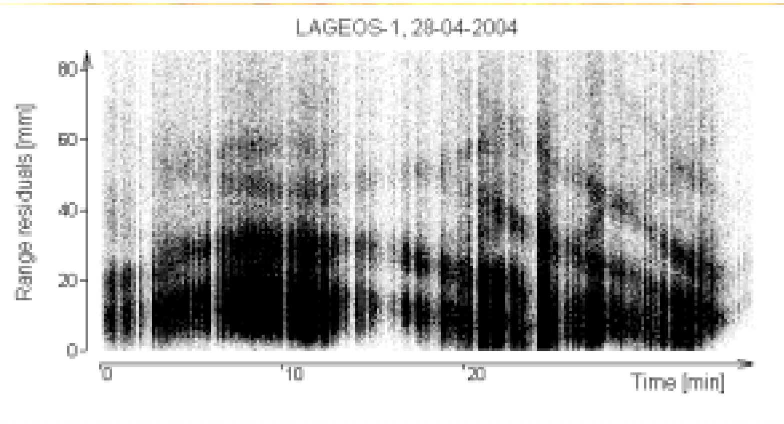
-Range correction
(photons going thru CCR)

Simulation: range residuals



It is possible that groups of CCRs give range residuals on the same way (track)

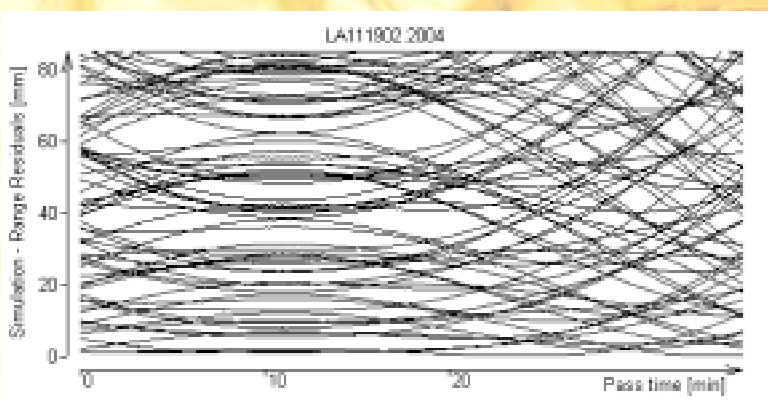


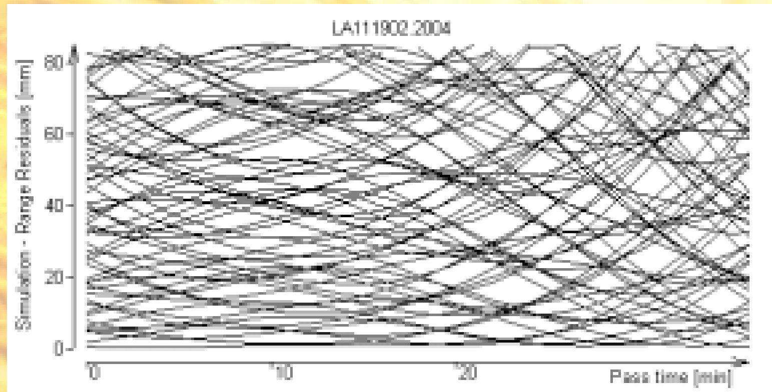


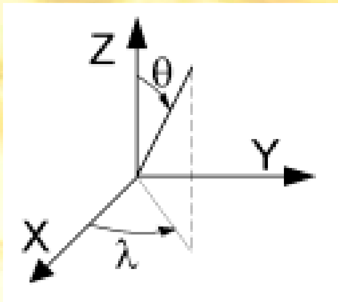
Geometry of the spin tracks depends on spin parameters of the satellite...

Spin axis orientation:

θ , λ θ+10° , λ+10°

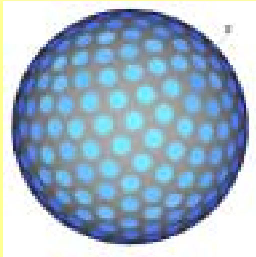






The simulation method

Unknown:



-Spin axis orientation (two angles)

-Spin period

Known from kHz SLR observation:

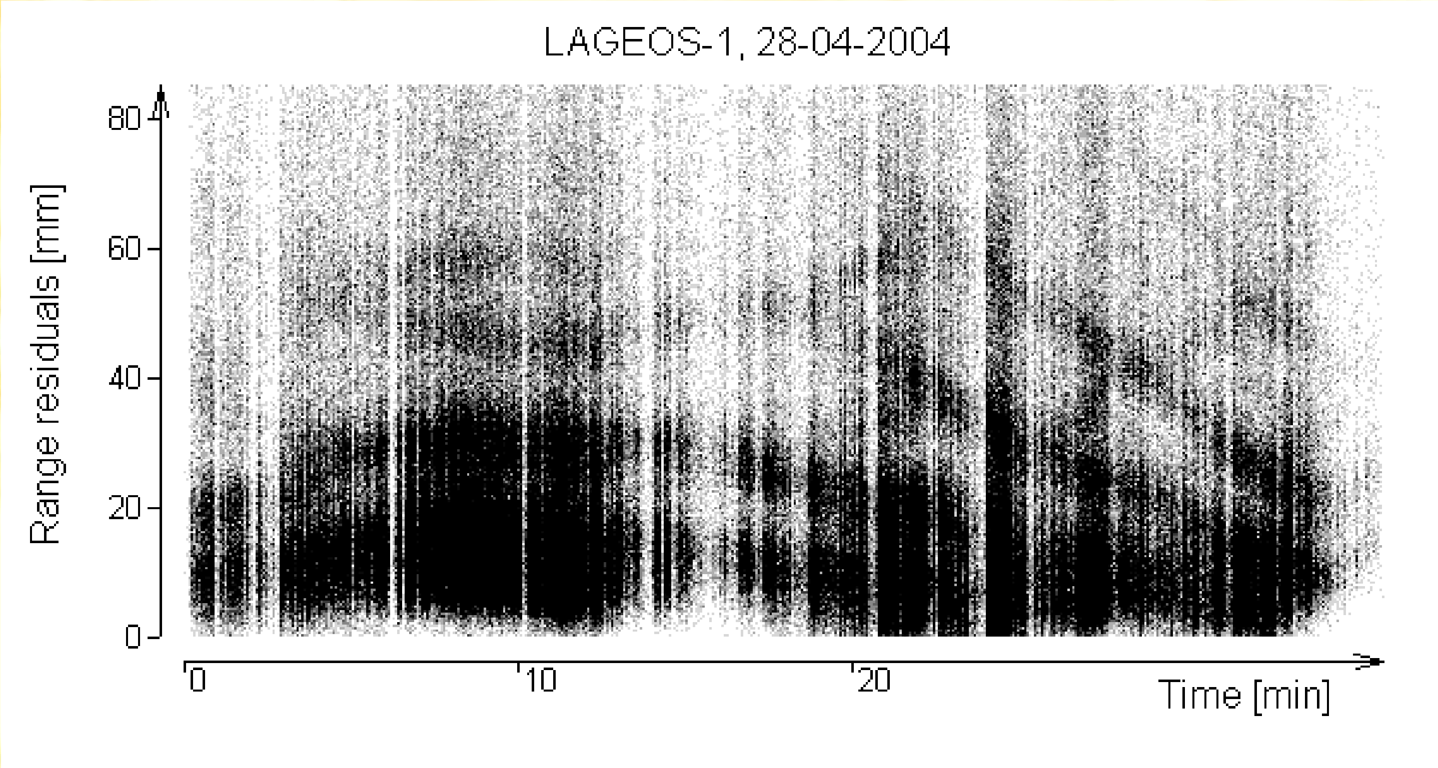
-Spin tracks geometry

Method:

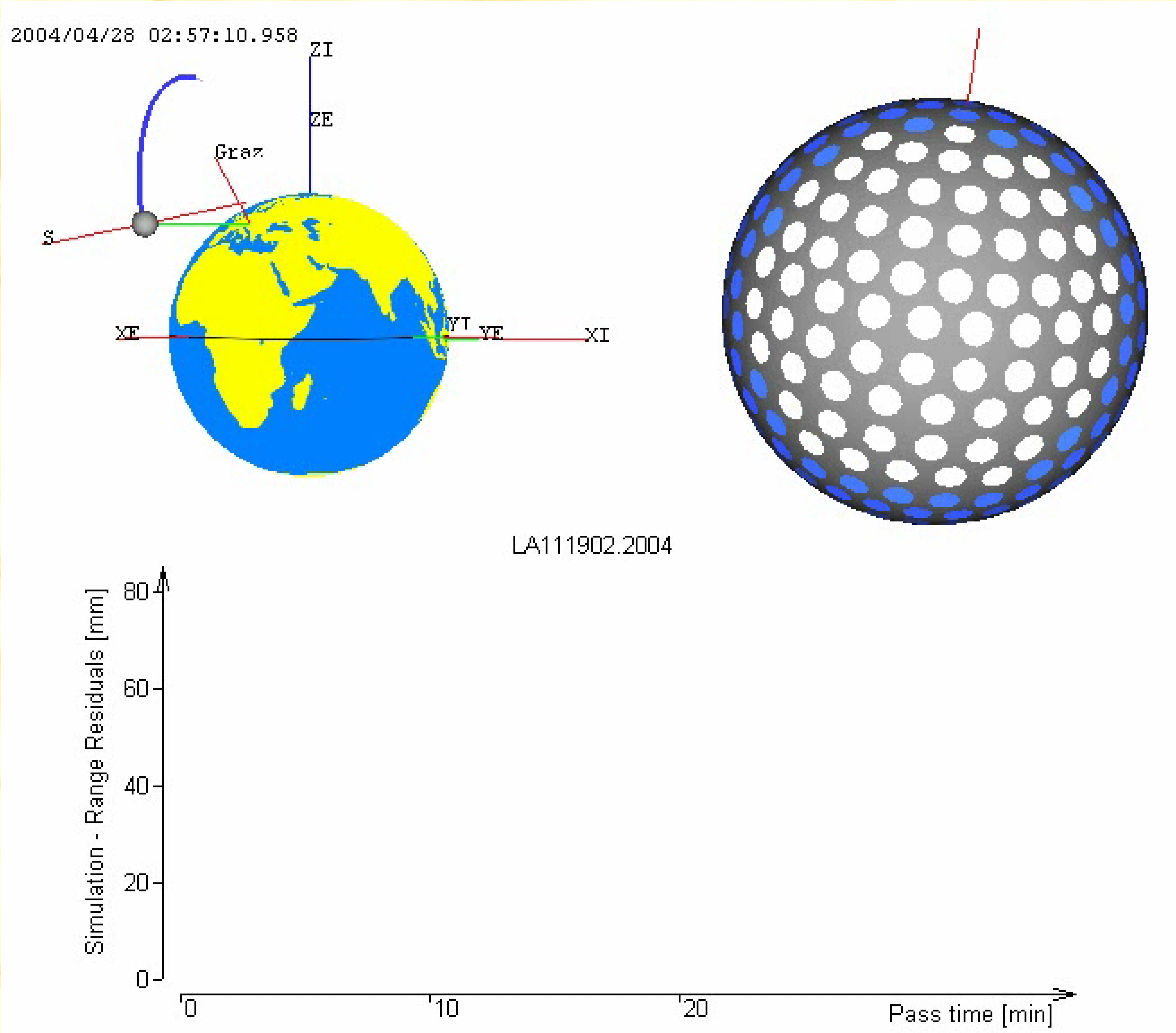
For single pass simulate range residuals for various spin parameters and check geometry agreement with the observation.

Better agreement -> closer to the solution

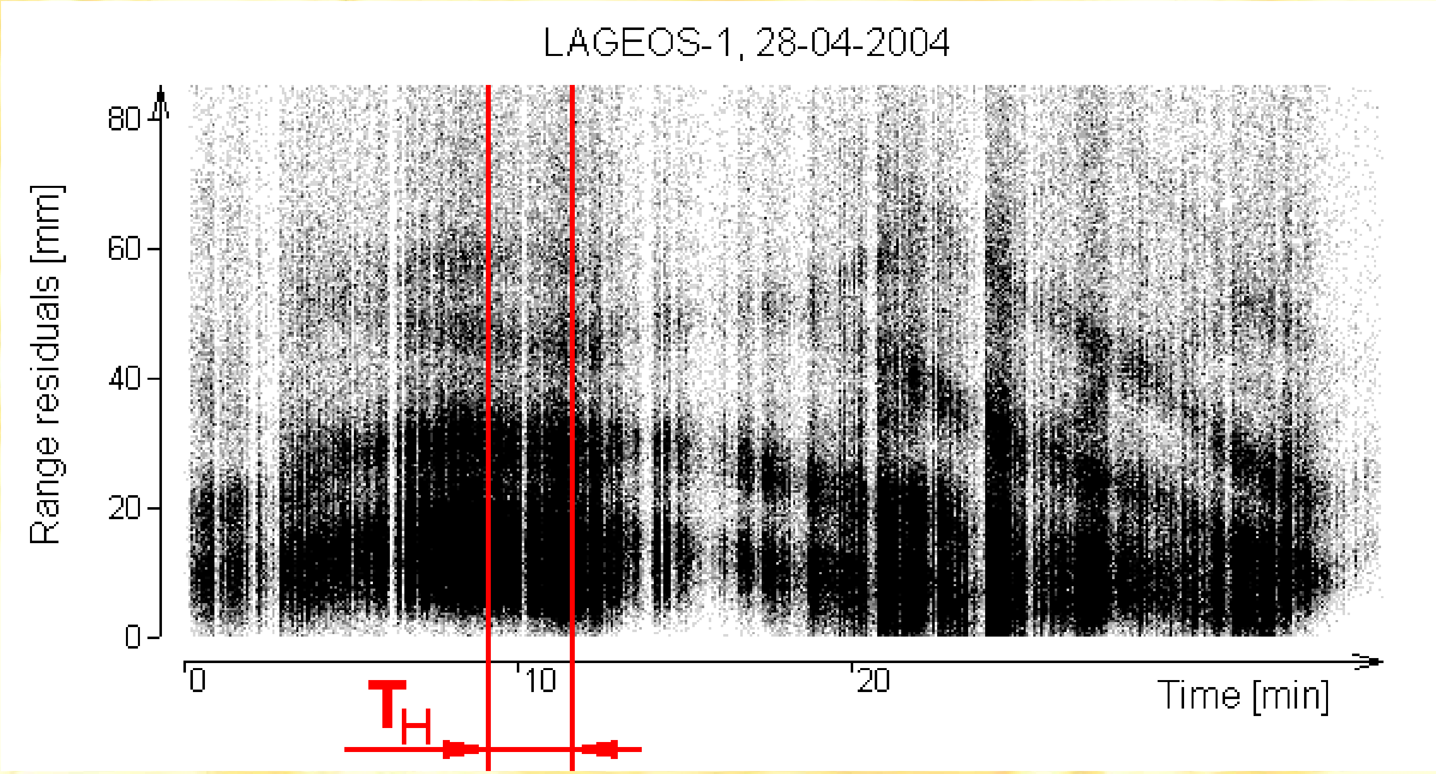
A very special LAGEOS-1 pass



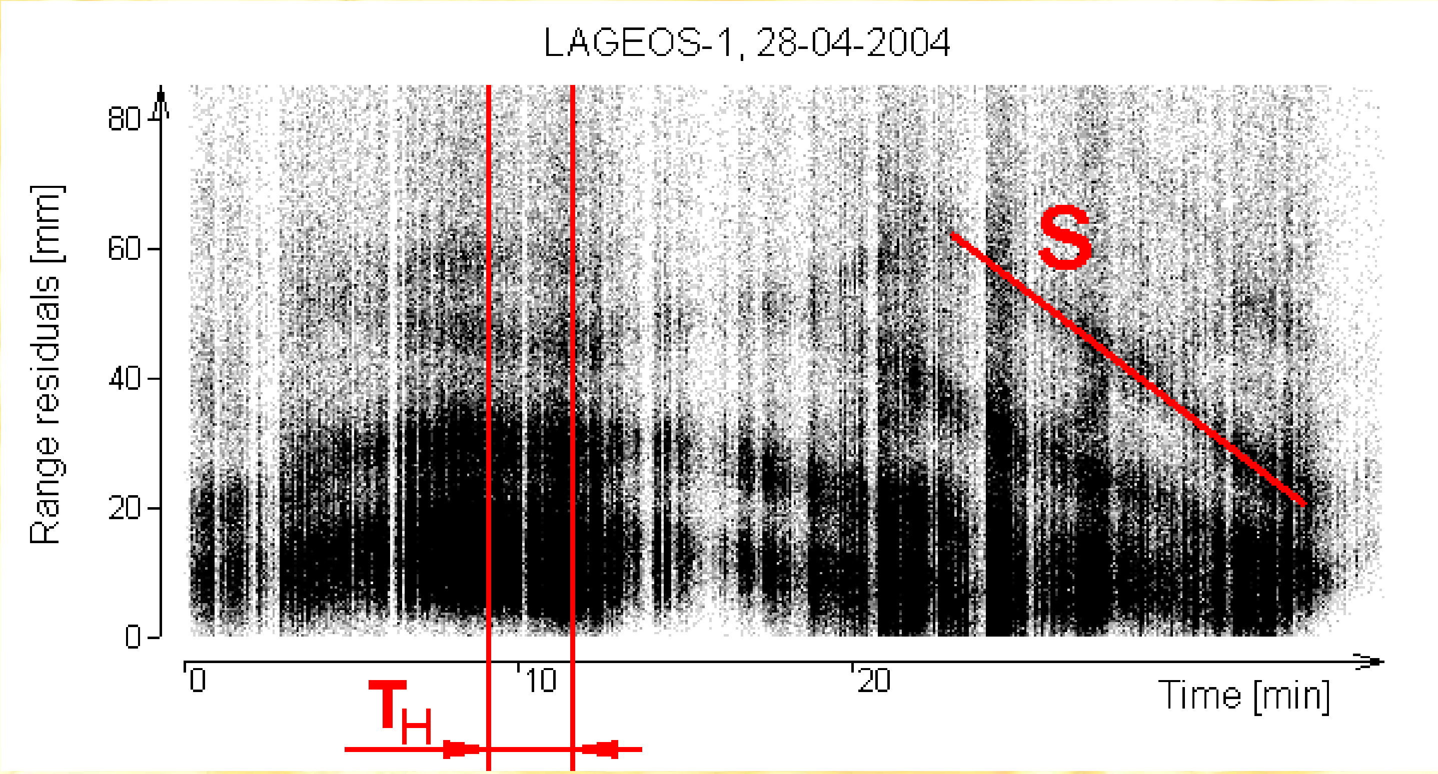
A very special LAGEOS-1 pass, 28-04-2004



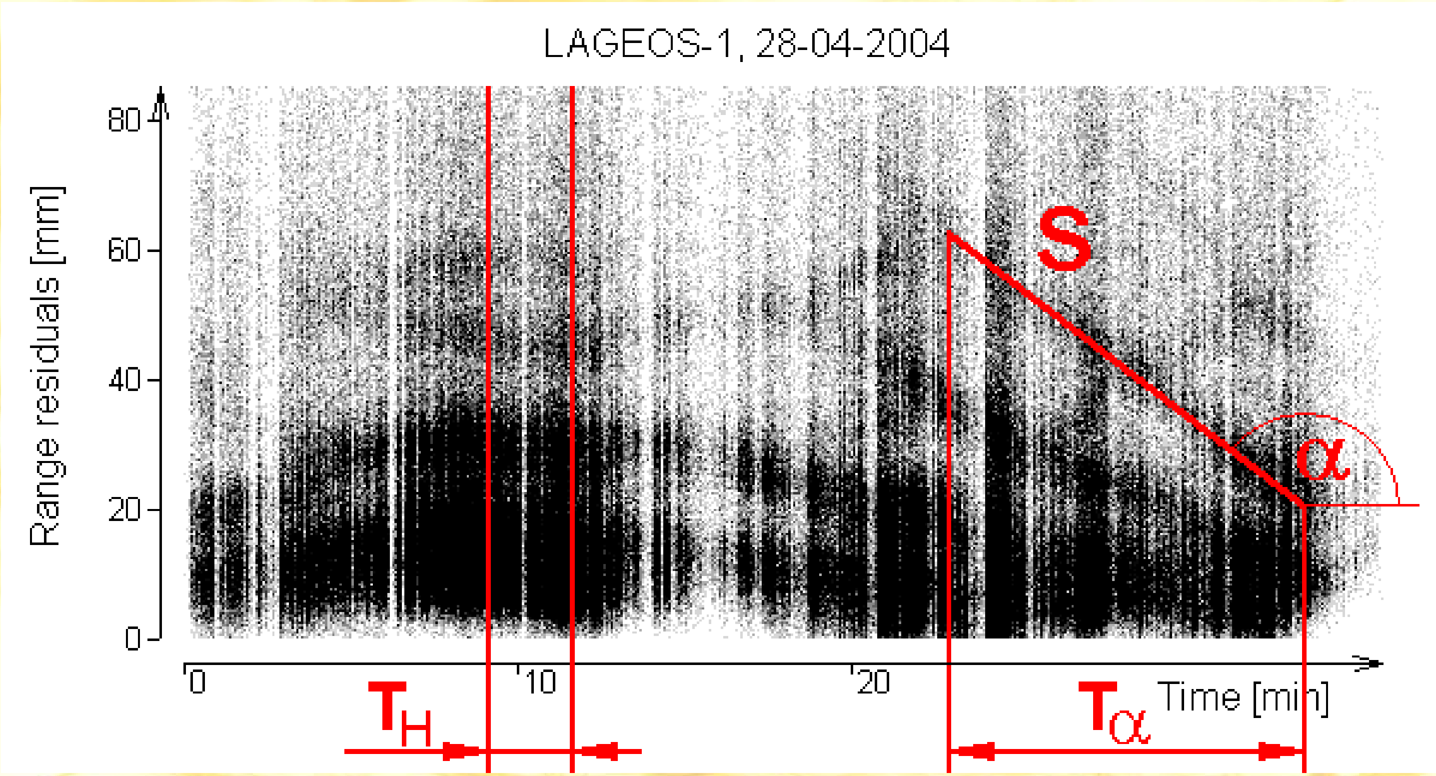
Selecting epoch range for a flat part of the spin tracks



Selecting tilted spin track



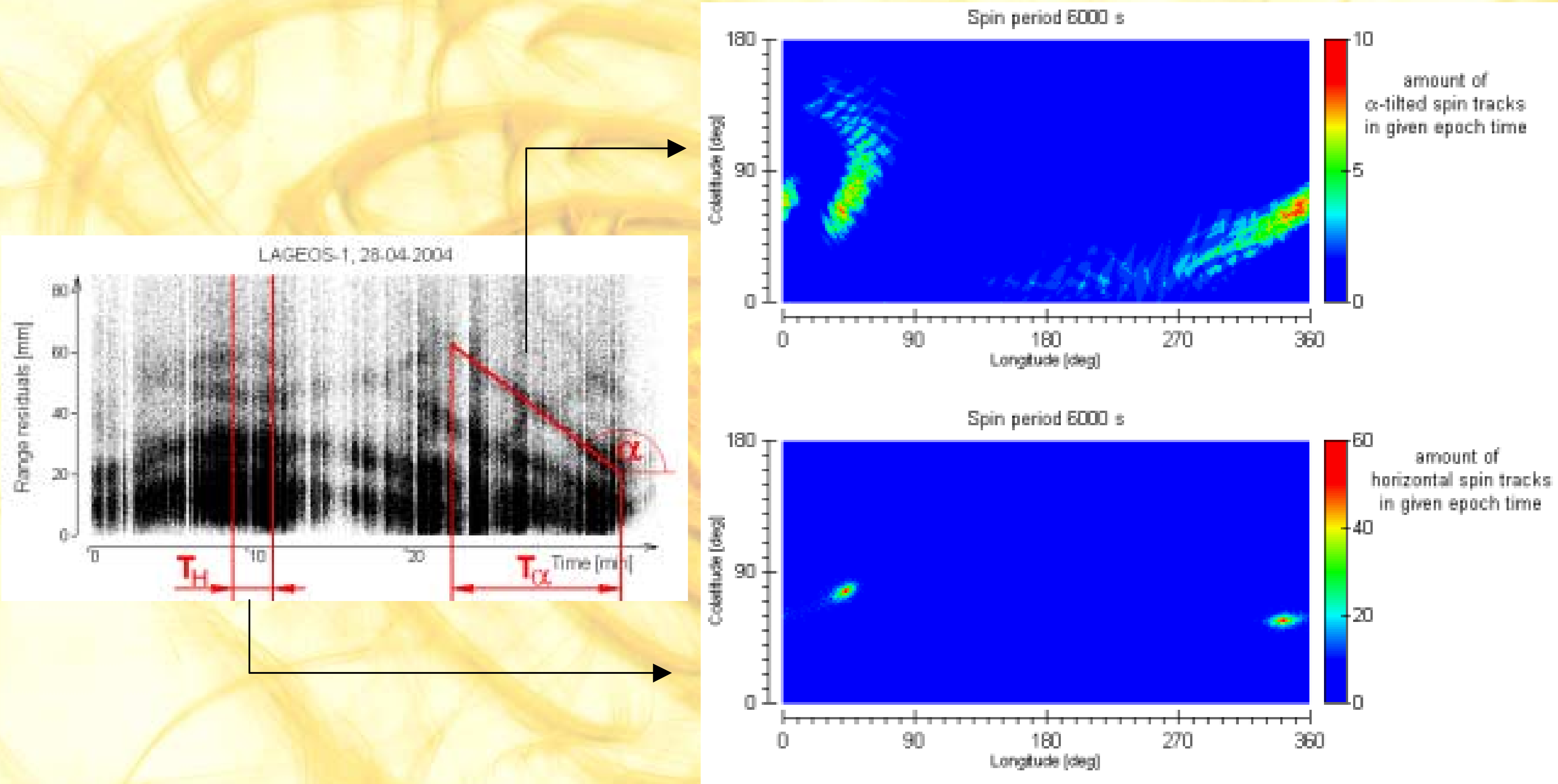
Selecting tilted spin track



-Epoch range of a flat part: T_H

-Epoch range and angle for tilted spin track: T_α, α

Looking for a solution

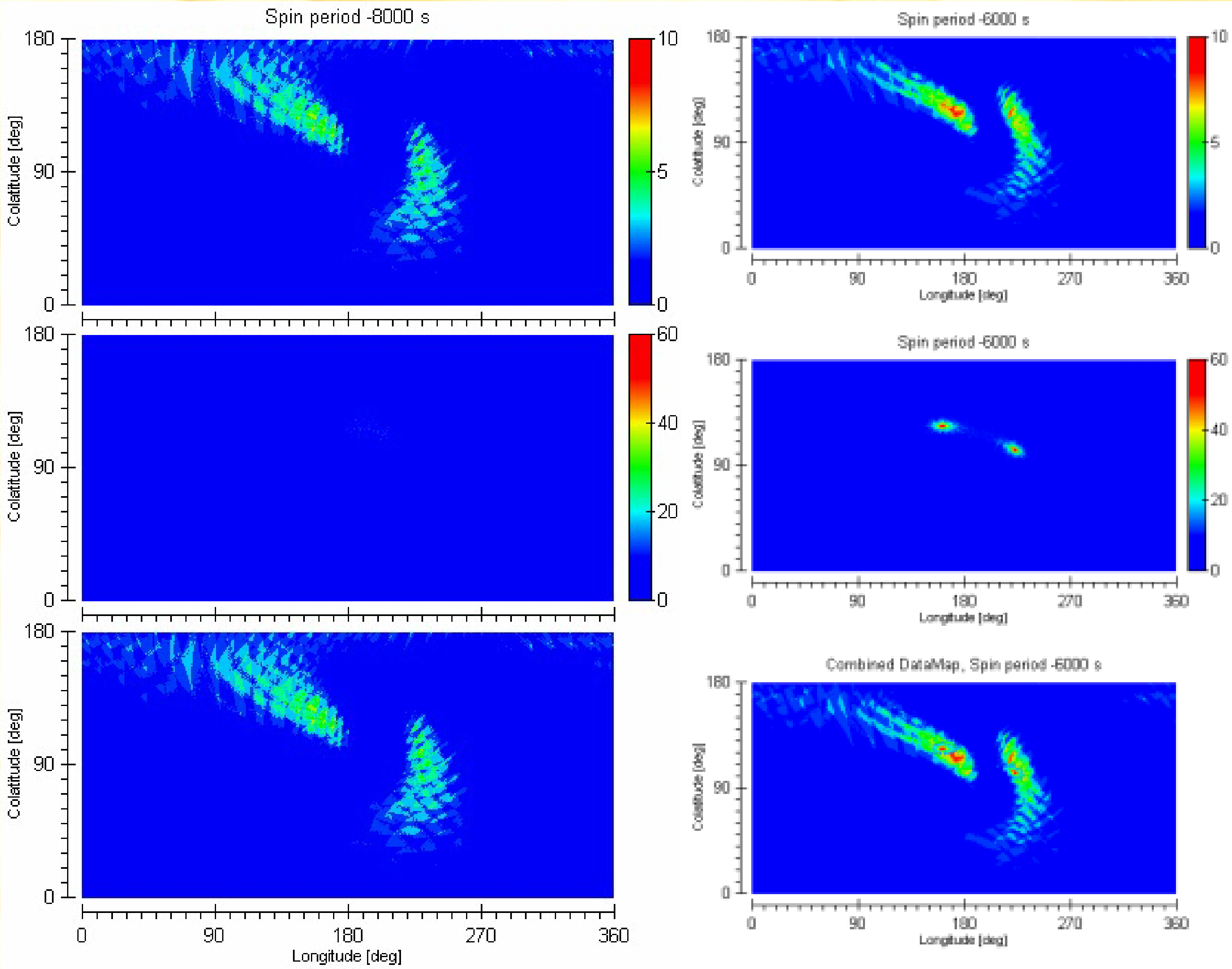


Spin period investigation

1. tilted

2. flat

1+2



Spin period investigation

1. tilted

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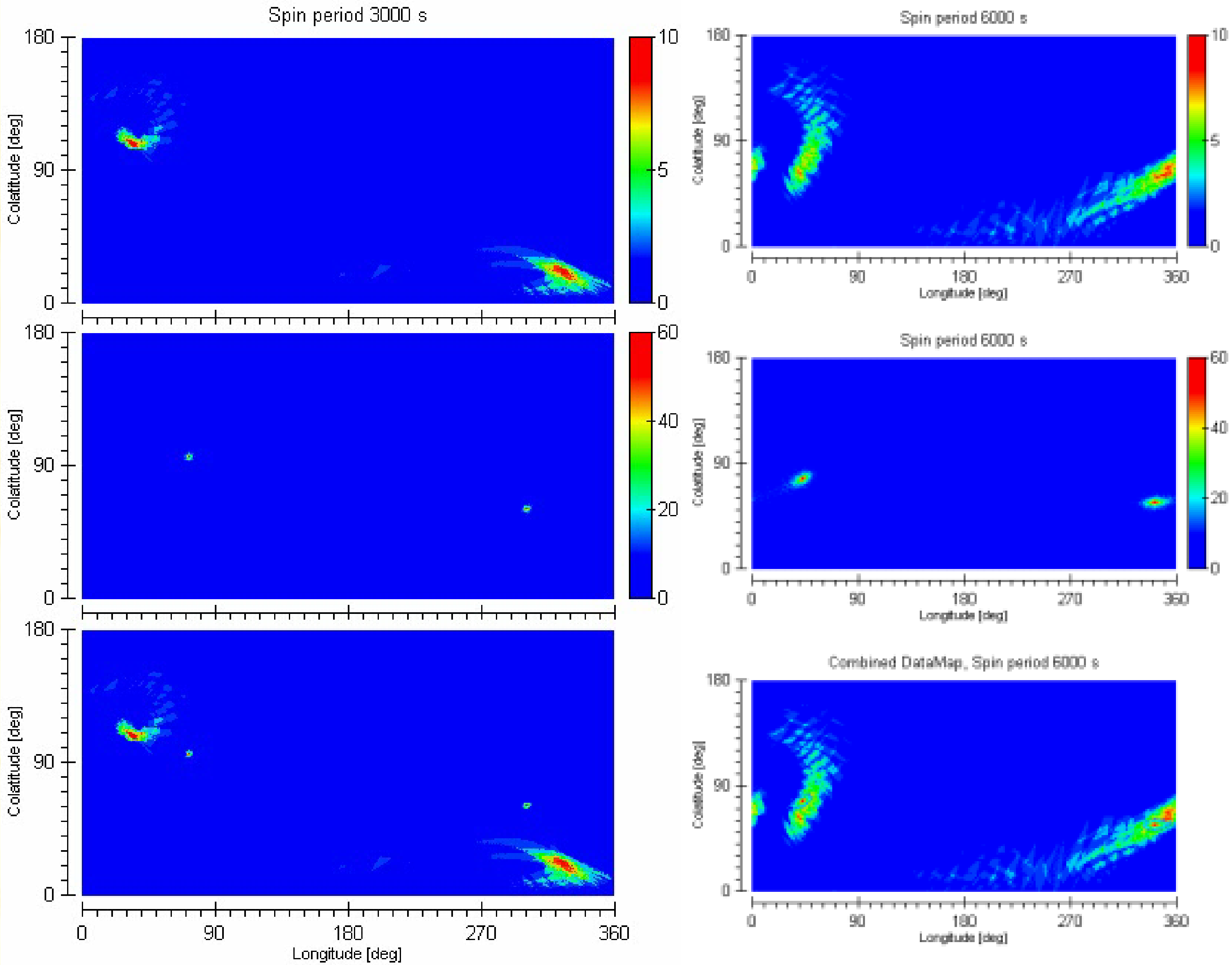


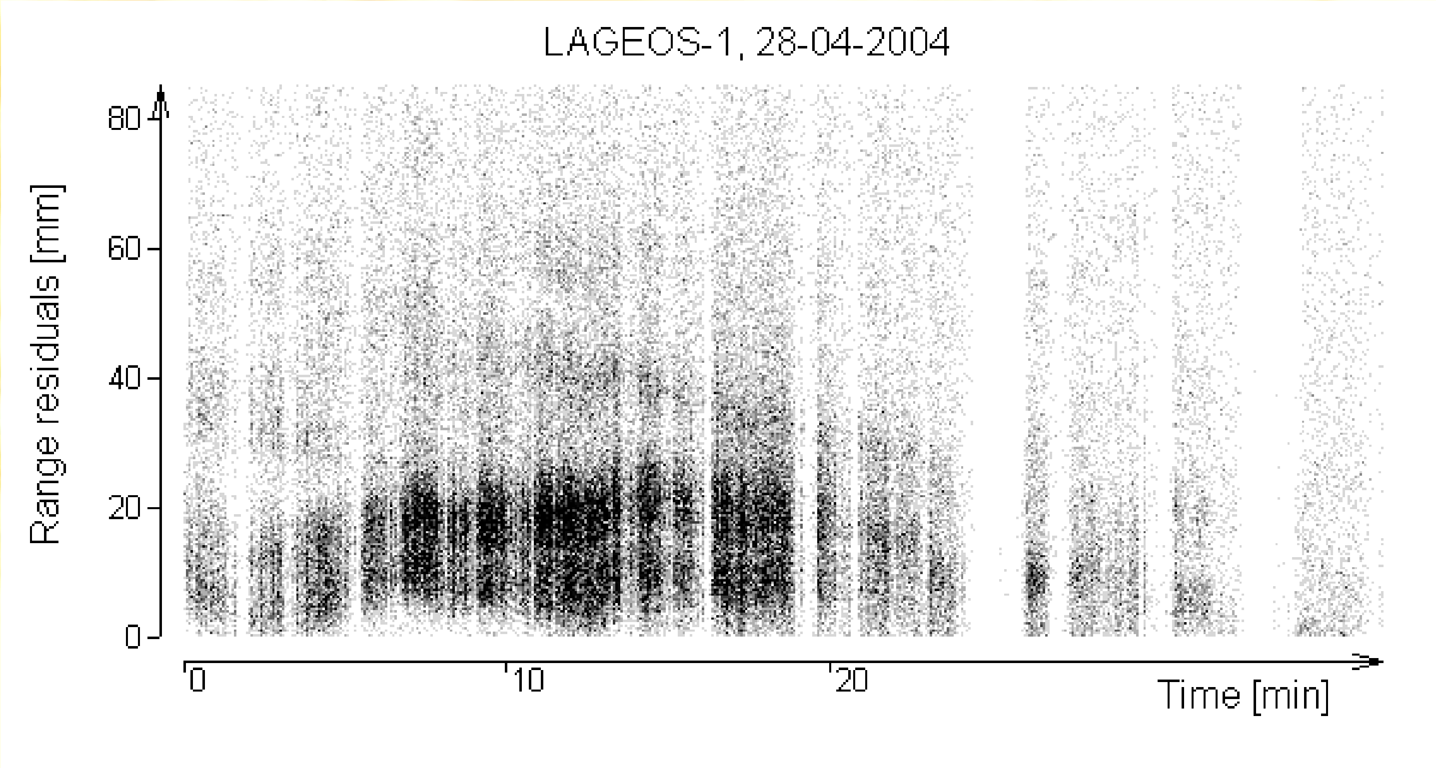
Results : LA111902, 28-04-2004

Spin period	Colatitude	Longitude
[s]	[deg]	[deg]
-6000	123.0	163.2
-6000	103.8	224.2
6000	76.4	44.0
6000	57.1	343.1

Which solution is the real one?

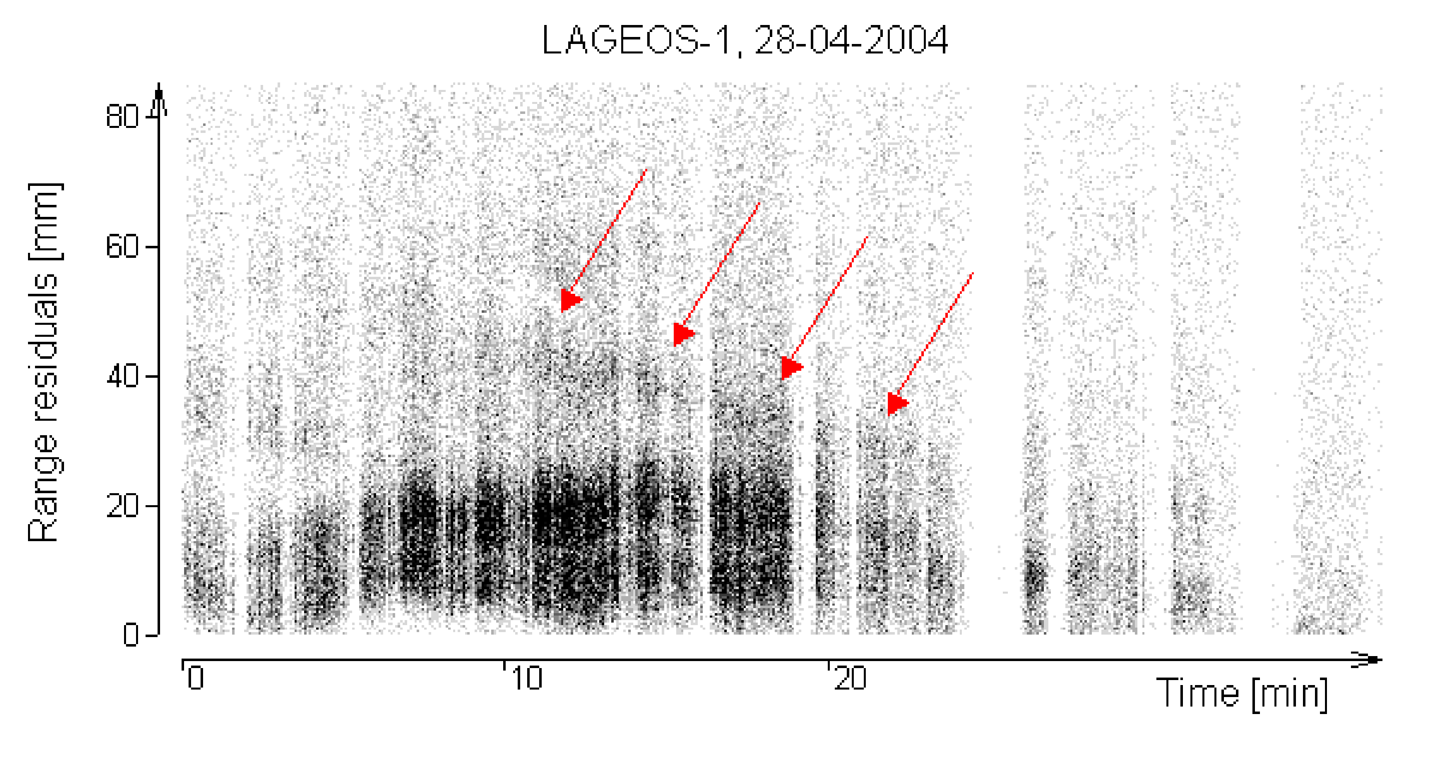
Pass-to-pass method

LAGEOS-1 pass 12 hours later



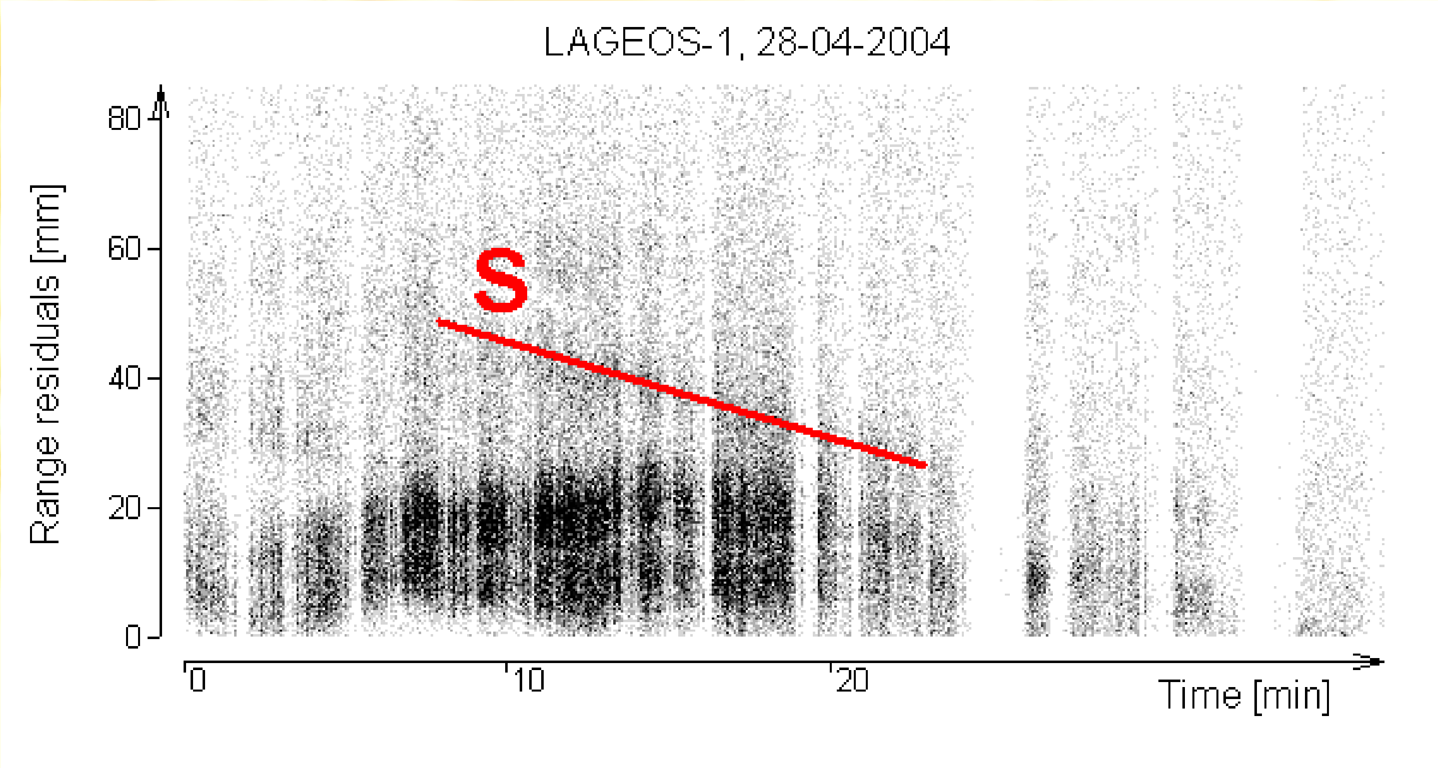
Pass-to-pass method

LAGEOS-1 pass 12 hours later



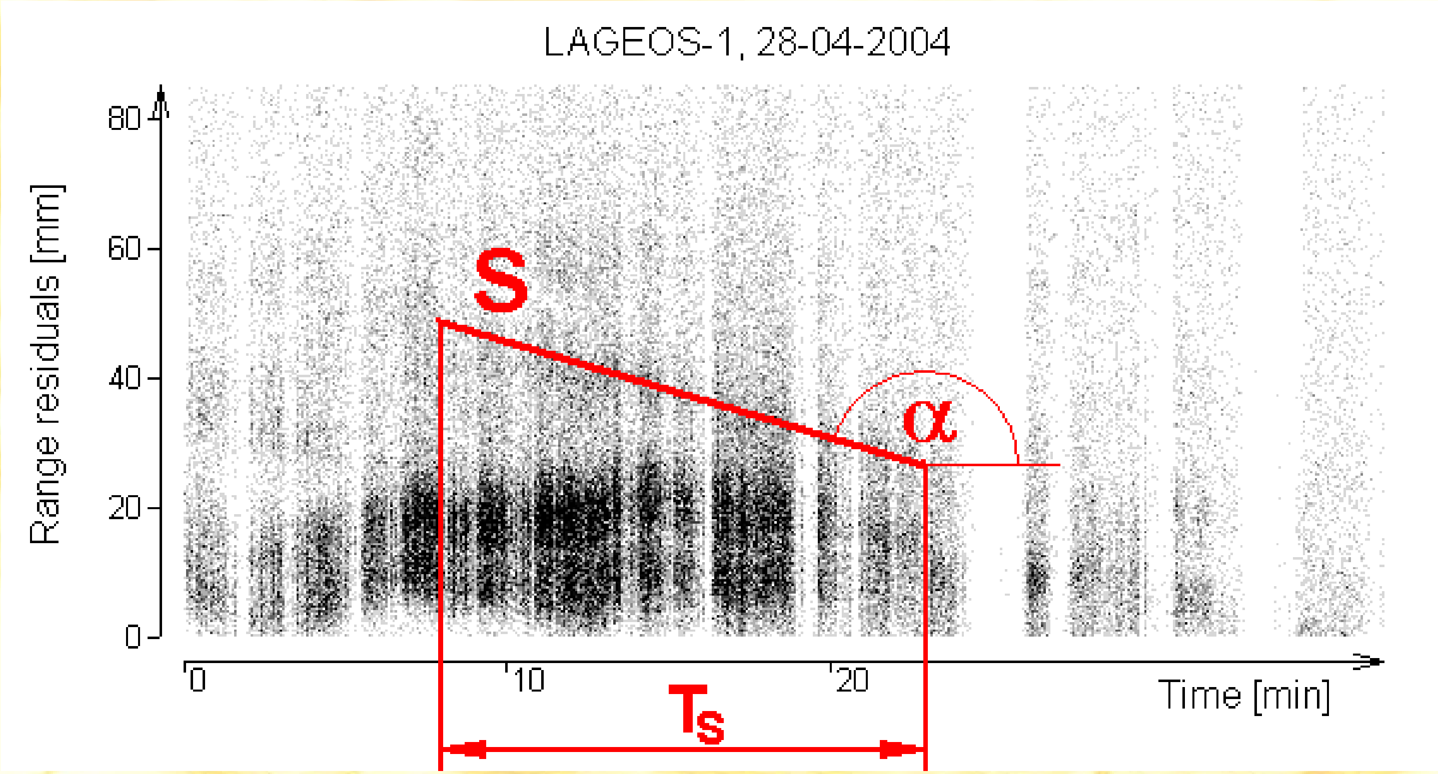
Pass-to-pass method

LAGEOS-1 pass 12 hours later



Pass-to-pass method

LAGEOS-1 pass 12 hours later



Pass-to-pass method

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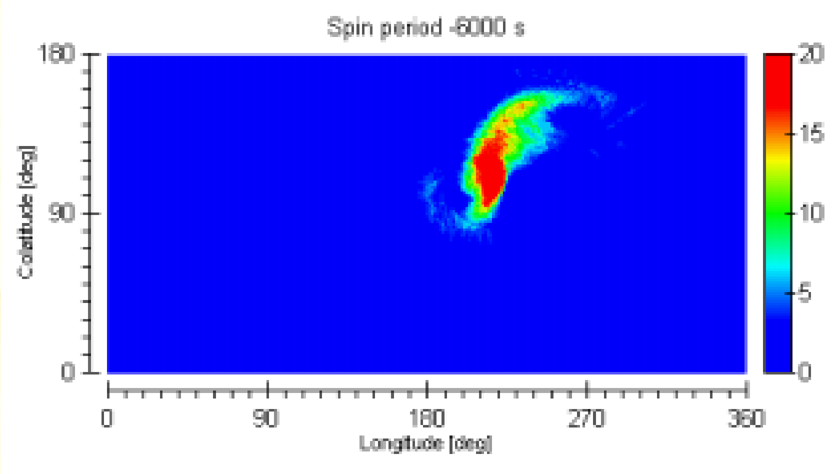
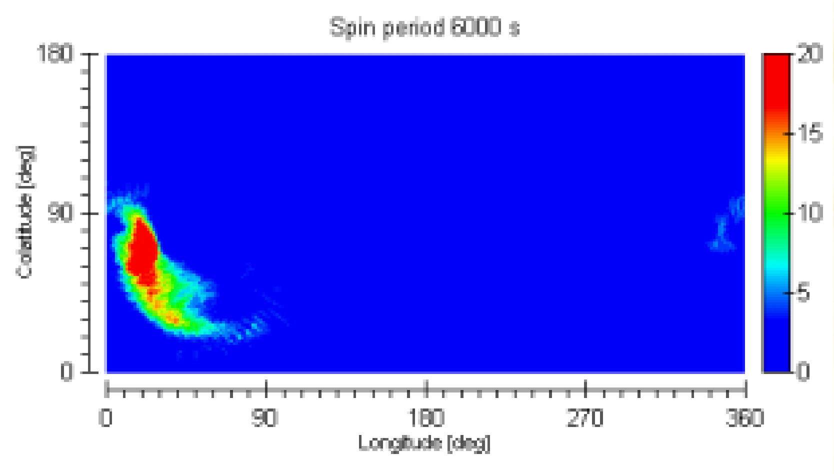




Pass-to-pass method

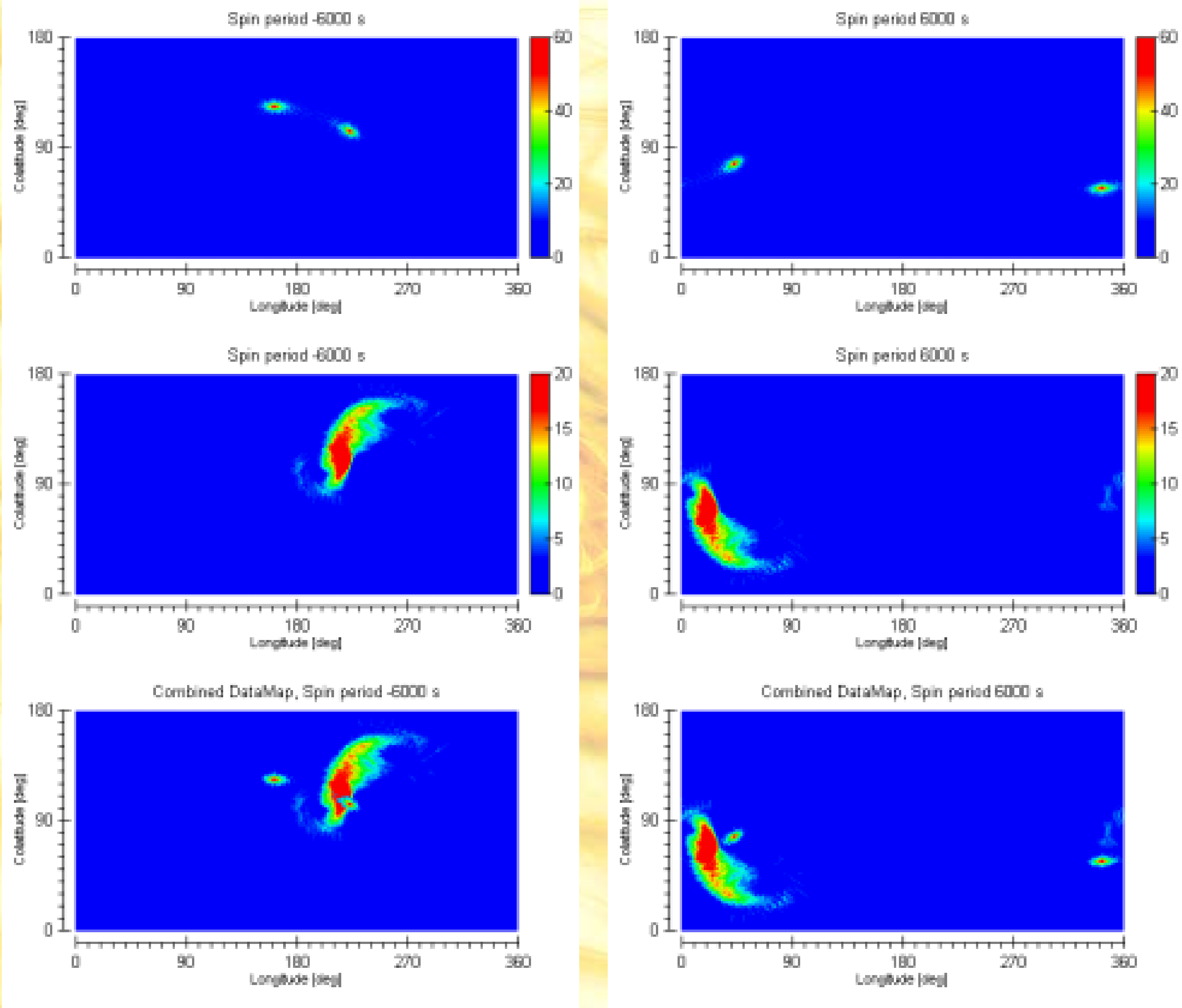
L1 main pass

(**P1**)

L1, 12 h later

(**P2**)

P1+P2



Pass-to-pass method

L1 main pass

(**P1**)

L1, 12 h later

(**P2**)

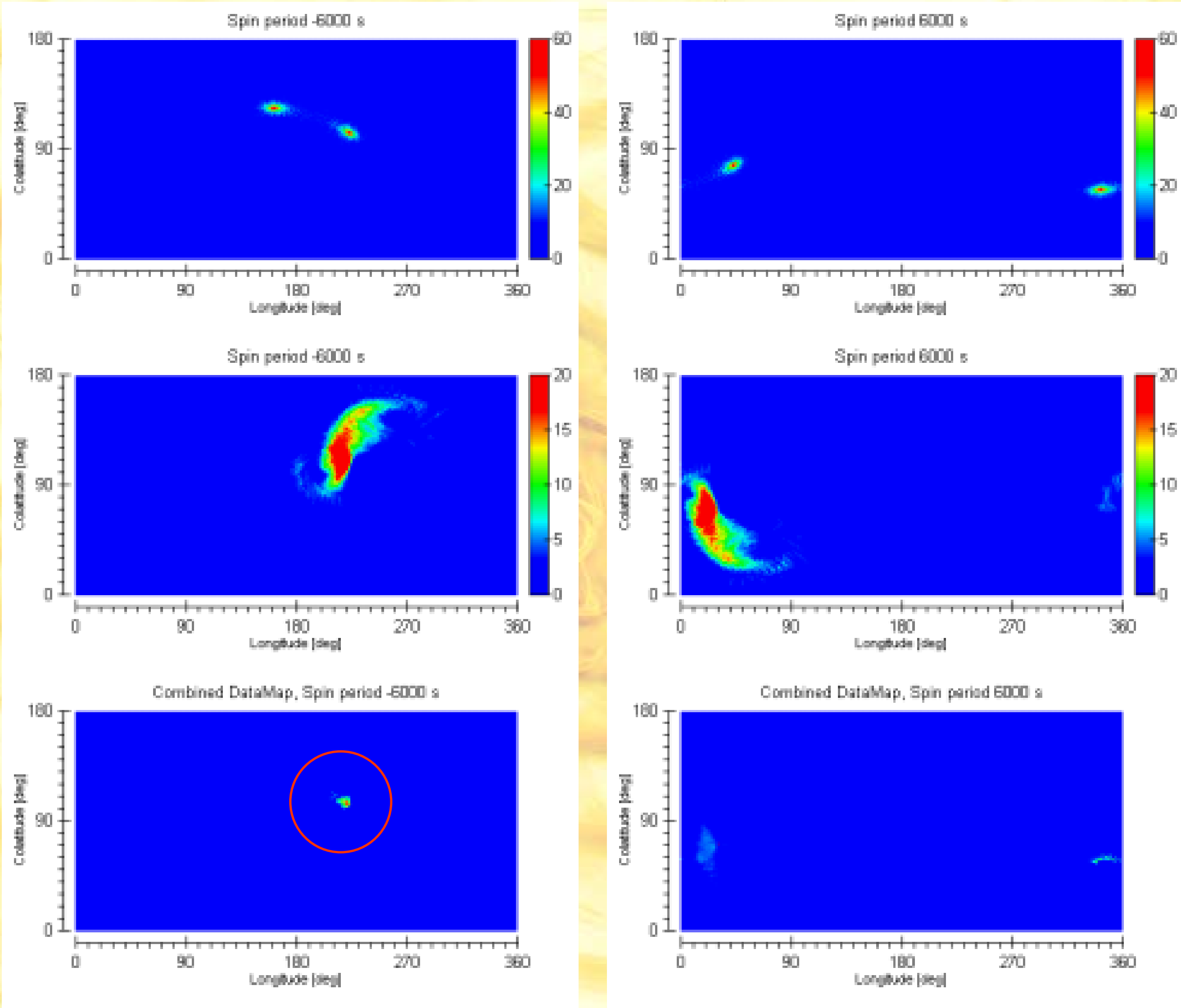
P1 AND **P2** (2.5 σ)

Col = 103.8°

RMS_{Col} = 3.66°

Lon = 224.2°

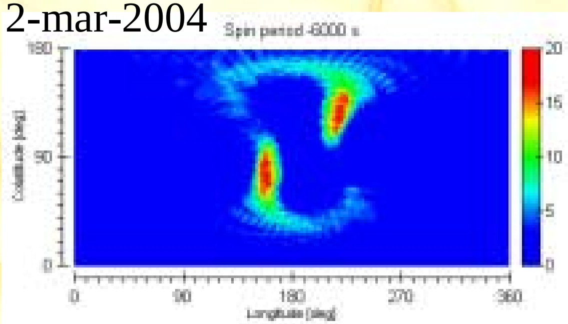
RMS_{Lon} = 3.76°



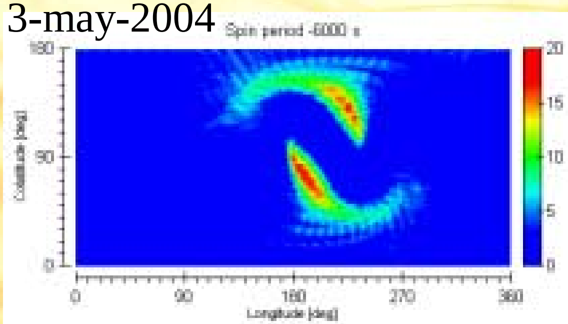
Pass-to-pass method with another passes

P1

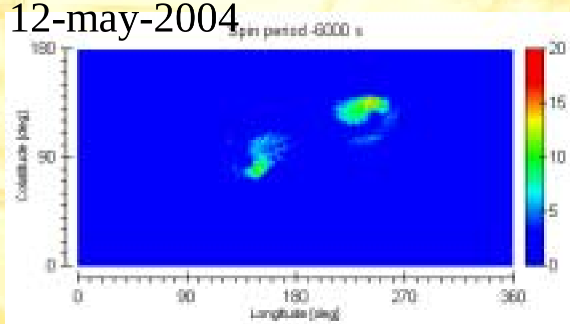
2-mar-2004



3-may-2004

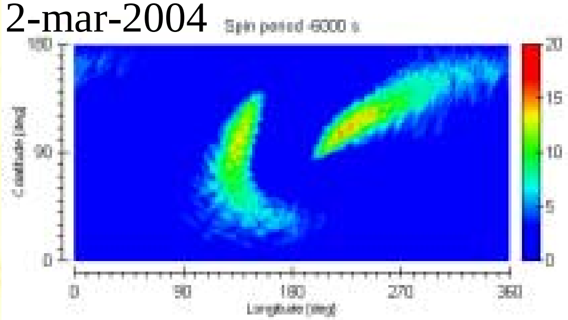


12-may-2004

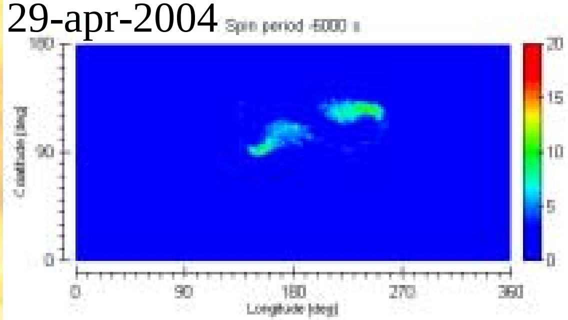


P2

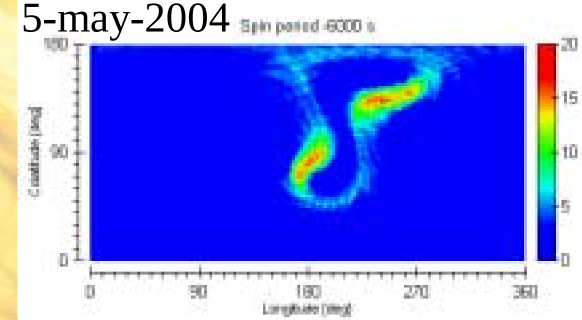
2-mar-2004



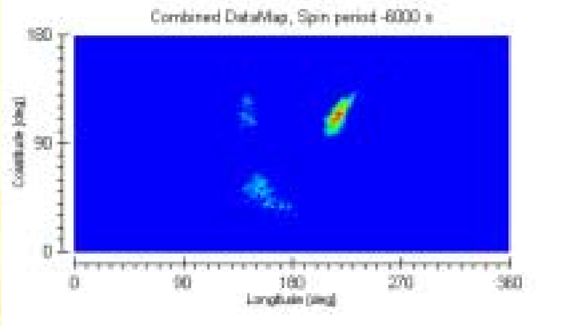
29-apr-2004

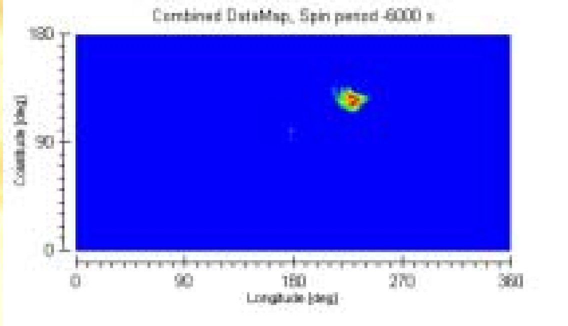


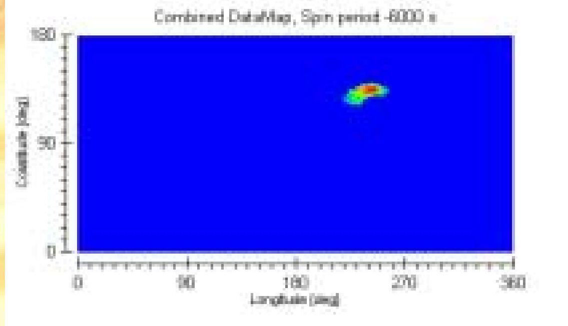
5-may-2004



P1
and
P2







Spin parameters determined from kHz spin tracks analysis

5-feb-2004

-

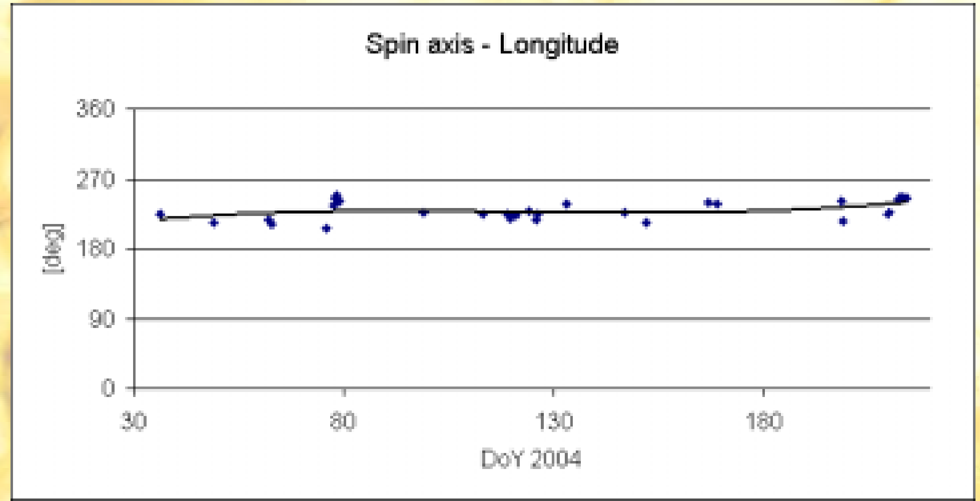
2-aug-2004

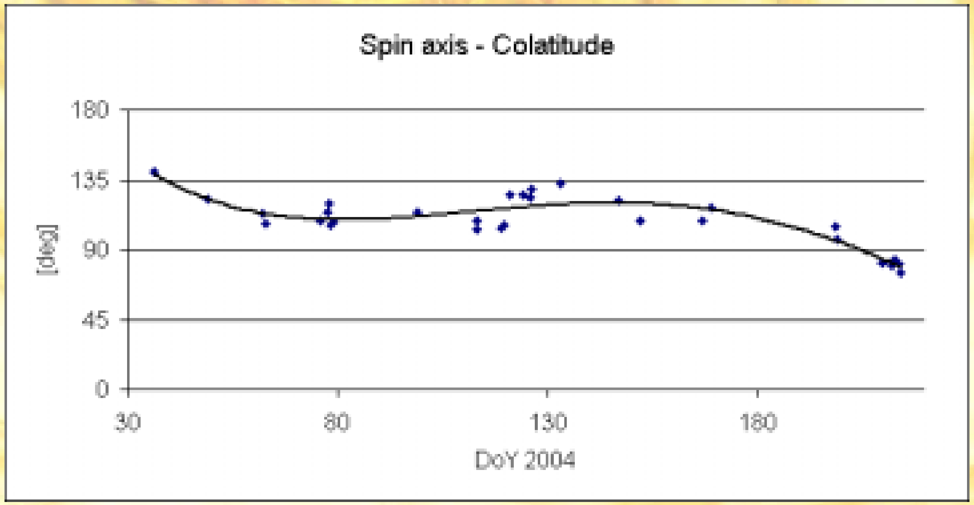
Spin period

-6000 s

CCW

(as the Earth)



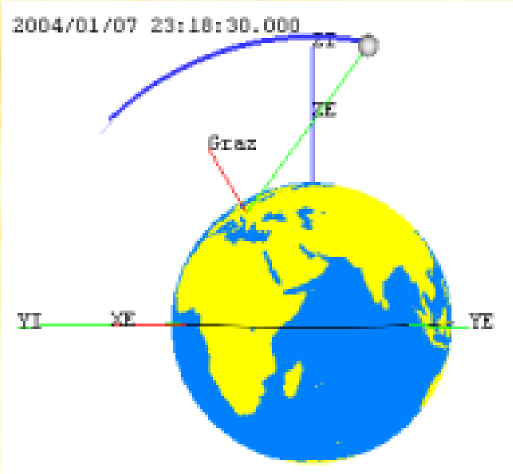


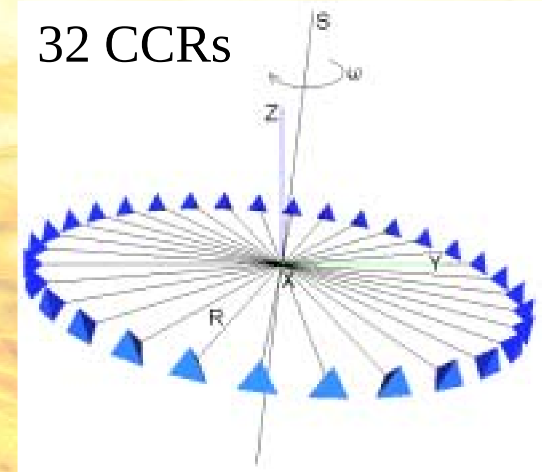
Is it possible that LAGEOS-1 had spin period 1000 s longer (in 2004) than derived from the model based on photometric observations?

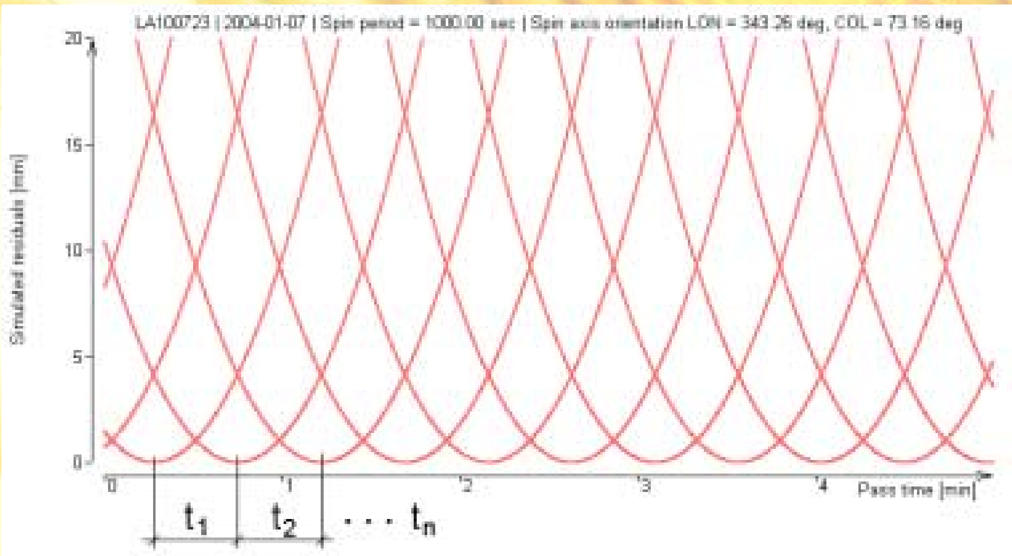
Is it possible that LAGEOS-1 had spin period 1000 s longer (in 2004) than derived from the model based on photometric observations?

Yes, because of apparent spin influence on photometric measurements (orbital motion – passing by of the satellite).

Apparent spin influence on spin period determination by peak-to-peak method (similar to photometry)







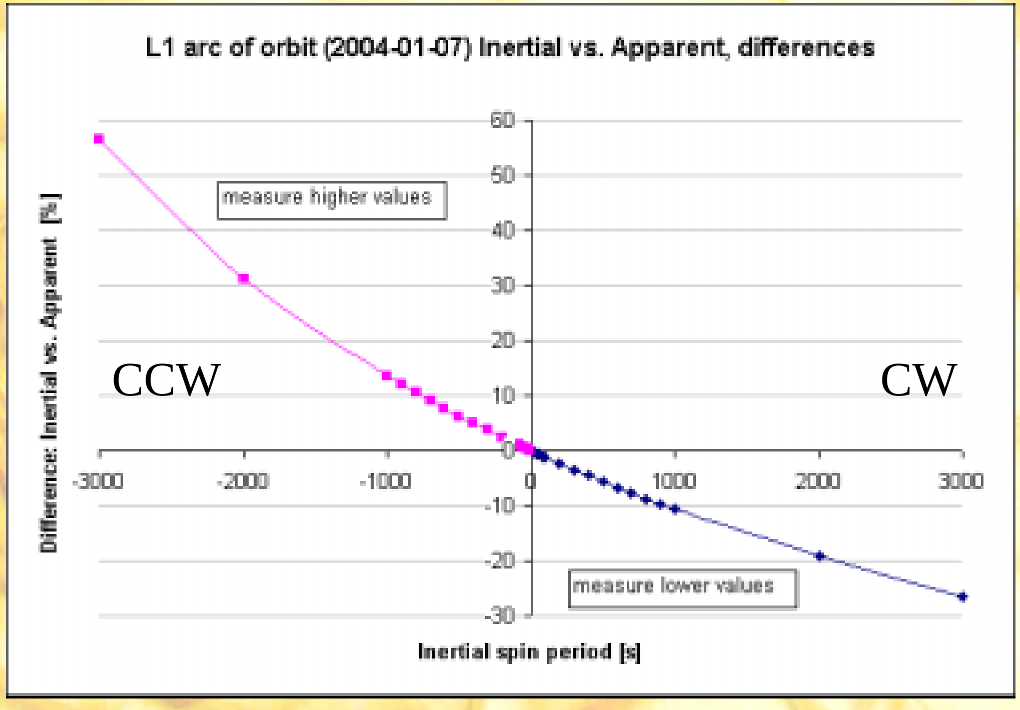
Apparent spin period

(detected from the site)

$$T = \frac{\sum_{i=1}^{n} t_i}{n} \cdot 32$$

Apparent spin influence on spin period determination by peak-to-peak method (similar to photometry)

Inertial spin period CW [s]	Apparent spin period (as seen from the station) [s]	Difference [%]	Inertial spin period CCW [s]	Apparent spin period (as seen from the station) [s]	Difference [%]
10	9.99	-0.12	-10	10.01	0.12
20	19.95	-0.23	-20	20.05	0.23
30	29.89	-0.35	-30	30.11	0.36
40	39.81	-0.47	-40	40.19	0.48
50	49.71	-0.59	-50	50.30	0.59
60	59.58	-0.70	-60	60.43	0.71
70	69.43	-0.82	-70	70.58	0.84
80	79.25	-0.94	-80	80.76	0.95
90	89.05	-1.05	-90	90.97	1.07
100	98.83	-1.17	-100	101.20	1.20
200	195.38	-2.31	-200	204.85	2.43
300	289.71	-3.43	-300	311.09	3.70
400	381.88	-4.53	-400	420.02	5.01
500	471.97	-5.61	-500	531.55	6.31
600	560.27	-6.62	-600	646.12	7.69
700	646.17	-7.69	-700	763.23	9.03
800	730.54	-8.68	-800	883.85	10.48
900	813.09	-9.66	-900	1007.43	11.94
1000	894.11	-10.59	-1000	1134.34	13.43
2000	1615.47	-19.23	-2000	2626.33	31.32
3000	2208.25	-26.39	-3000	4692.27	56.41



Apparent spin influence was prooved with
Ajisai and **GP-B**
spin determination from kHz SLR data.

Apparent spin influence on spin period determination by peak-to-peak method (similar to photometry)

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60	59.58	-0.70	-60	60.43	0.71
70	69.43	-0.82	-70	70.58	0.84
80	79.25	-0.94	-80	80.76	0.95
90	89.05	-1.05	-90	90.97	1.07
100	98.83	-1.17	-100	101.20	1.20
200	195.38	-2.31	-200	204.85	2.43
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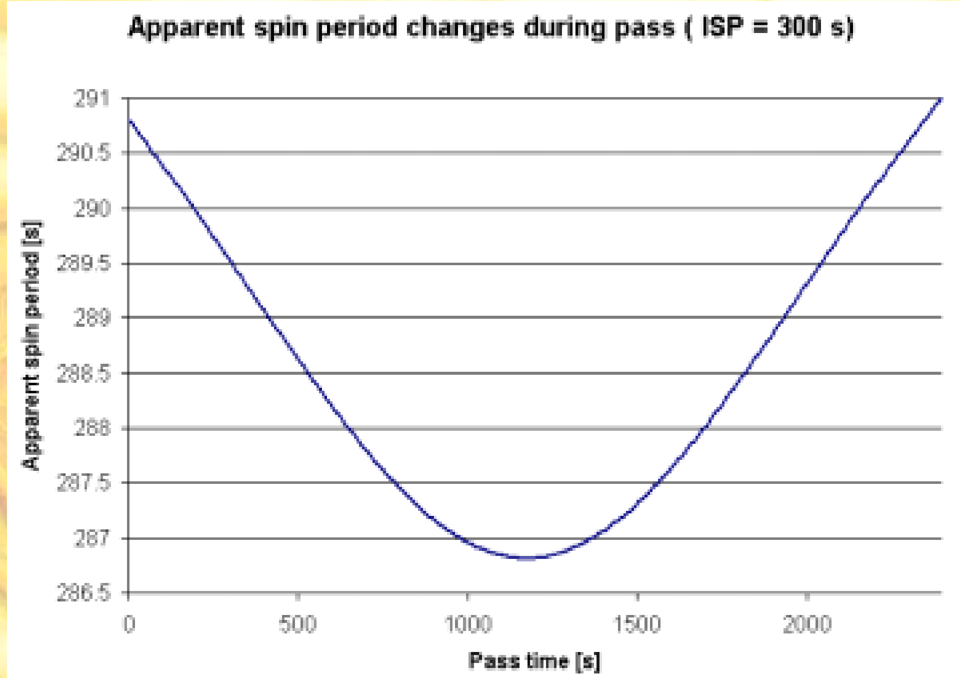

Apparent spin influence was prooved with
Ajisai and **GP-B**
spin determination from kHz SLR data.

Conclusions

-it is possible to determine spin parameters of LAGEOS-1 from spin tracks geometry analysis,

-RMS of spin axis orientation is rather big (~7 deg) for both angles (pass-to-pass method), however the trends are visible,

-during first 200 days of year 2004 only one pass available to determine spin period (flat-and-tilt method)

To increase accuracy:

-more kHz stations (better orbit coverage),

-for maximum accuracy simultaneous kHz ranging is needed.

Thank you