TEST SATELLITE FOR CALIBRATION OF LARGE-SIZE OPTICAL IMAGING SYSTEMS

N.N. Parkhomenko, V.D. Shargorodsky, V.P. Vasiliev - IPIE, Russia

D.G. Voelz, New Mexico State University, USA

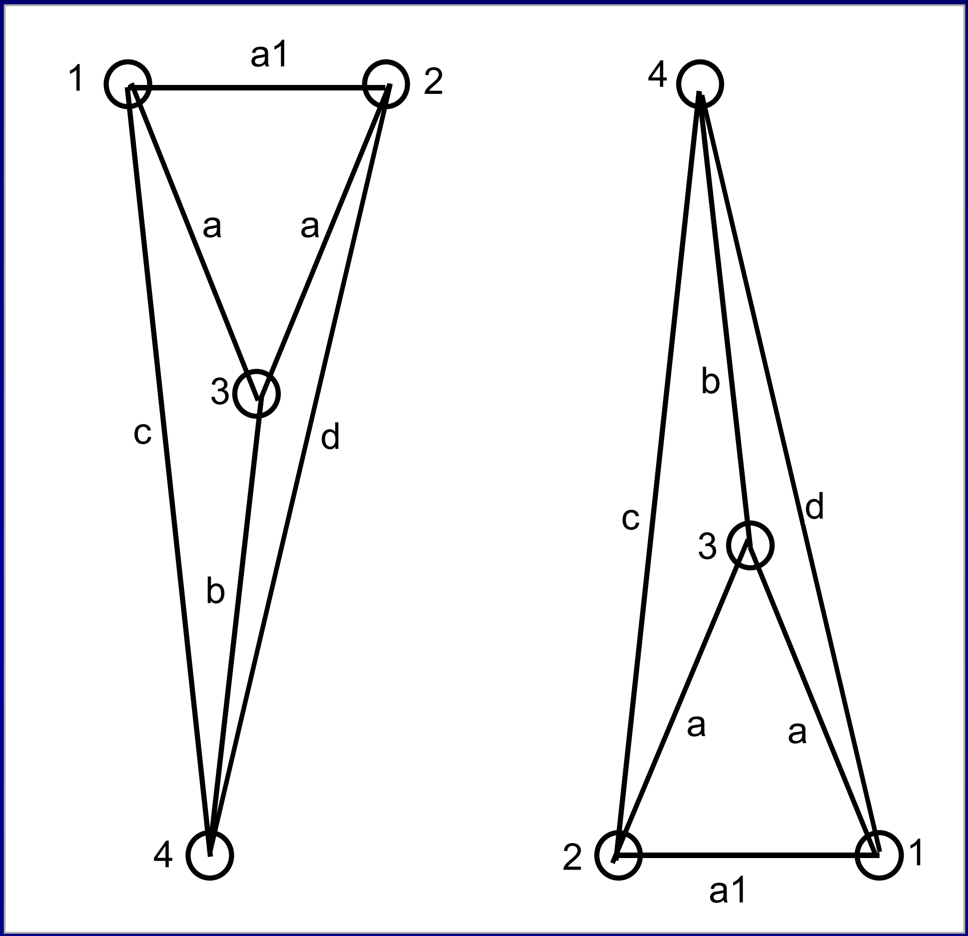
V.L. Gamiz, AFRL, USA

- The REFLECTOR microsatellite has been launched December 10, 2001, into a quasi-circular orbit with a mean height 1018.5 km, as a piggyback load on board of the METEOR-3M(1) satellite.

- REFLECTOR: **R**etroreflector **E**nsemble **F**or **L**aser **E**xperiments, **C**alibration, **T**esting and **O**ptical **R**esearch.

- Basically, the REFLECTOR microsatellite is a test target for calibration of active high-resolution optical systems (combination of laser target illumination means and high-efficiency return signal collectors).

Figure 1. REFLECTOR test image geometry



a_1 = 0.07 arc. sec.*	b/a = 1.37
a = 0.09 arc. sec.*	∠1-3-4 = 150.6°
b = 0.12 arc. sec.*	c/a = 2.294
c = 0.20 arc. sec.*	d/a = 2.345
d = 0.21 arc sec.*	

* For mean observation conditions: elevation 45°

- The REFLECTOR microsatellite carries 32 retroreflectors (cube corner prisms) arranged so that return signals can be obtained from any side when the microsatellite is stabilized along the vertical direction, forming a test image shown in Figure 1.

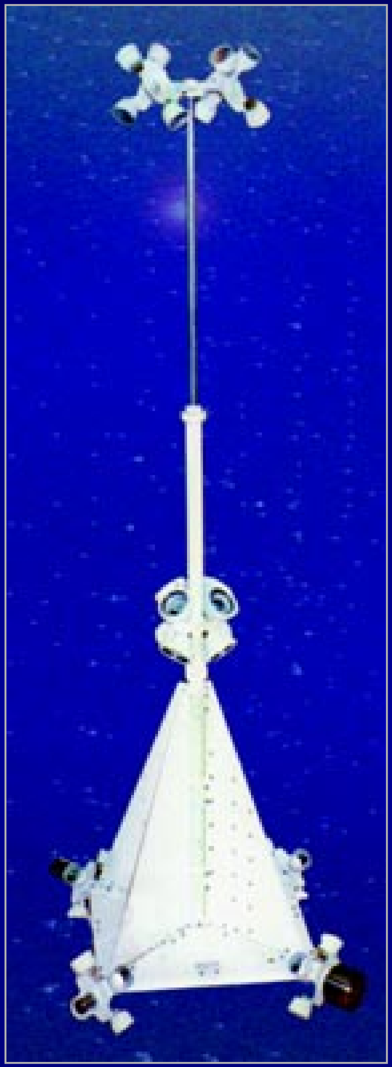


Figure 2 a. REFLECTOR microsatellite (outlook)

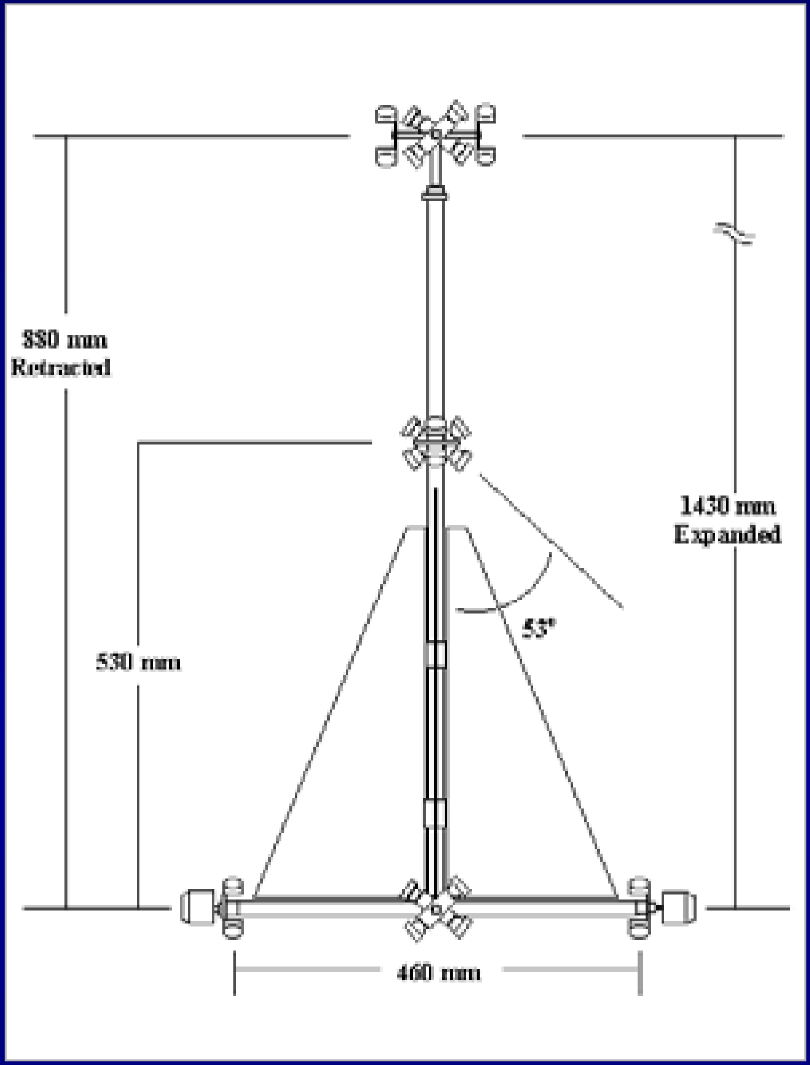


Figure 2 b. REFLECTOR microsatellite (drawing)

- After separation from the carrier satellite and extension of the boom carrying 8 cube corner prisms, the microsatellite attitude is controlled by a passive stabilization/damping system. The oscillation damping duration may be as long as several months. After final stabilization, the extendable boom should be pointed towards the Zenith or Nadir.

- Gravitational stabilization is achieved due to different moments of inertia along the three orthogonal directions.

- Oscillation damping is achieved due to interaction between the Earth magnetic field and built-in rods of magnetically soft material with a wide hysteresis loop.

Optical parameters of the REFLECTOR microsatellite

Table 1

Parameter	Value
Operating wavelenght, μm	0.532
Total number of cube corner prisms	32
Number of cube corner prisms with λ/4-plates at the face	8
Cube corner prism aperture size, mm	28.2
Cube corner prism height, mm	18.9
Fused silica refraction index	1.4607
Retroreflector transparency at normal incidence	0.57
Reflection pattern angular width (FWHM) along the microsatellite velocity vector, arc. sec.	5.7
Retroreflector axis tilt relative to the microsatellite vertical axis, deg.	45

• The global SLR network is regularly tracking the REFLECTOR microsatellite.

REFLECTOR passes observed by SLR stations till September, 2002

Table 2

Station number	Station name	Number of passes
7090	Yarragadee	259
7839	Graz	132
7110	Monument Peak	132
7840	Herstmonceux	121
7501	Hartebeesthoek	108
7105	Greenbelt	92
-	Shelkovo	84
7824	San Fernando	78
7835	Grasse	72
7237	Changchun	67
7080	McDonald	65
7832	Ryiadh	49
7810	Zimmerwald	48
7210	Haleakala	41
7403	Arequipa	38
7124	Papeete	35

Station number	Station name	Number of passes
8834	Wettzell	27
1873	Simeiz	19
7837	Shanghai	19
7838	Simosato	18
7849	Mount Stromlo	15
7836	Potsdam	13
1870	Mendeleevo	12
1864	Maidanak	11
7249	Beijing	8
1863	Maidanak	7
1884	Riga	5
1868	Komsomolsk	4
7405	Concepcion	4
7806	Metsahovi	2
1893	Katzively	1
7820	Kunming	1

Total 1587

• The precision orbit determination (POD) is provided by the Mission Control Center (MCC-M, Russia)

• SLR stations with multistop time-of-flight counters (first of all, Herstmonceux) provided data from which the REFLECTOR microsatellite attitude in space may be determined, as well as the period of its oscillation (or tumbling)

• Based on the Herstmonceux station data, the REFLECTOR microsatellite oscillation period duration has been plotted versus time from December 23, 2001 to February 6, 2002 (Figure 3).

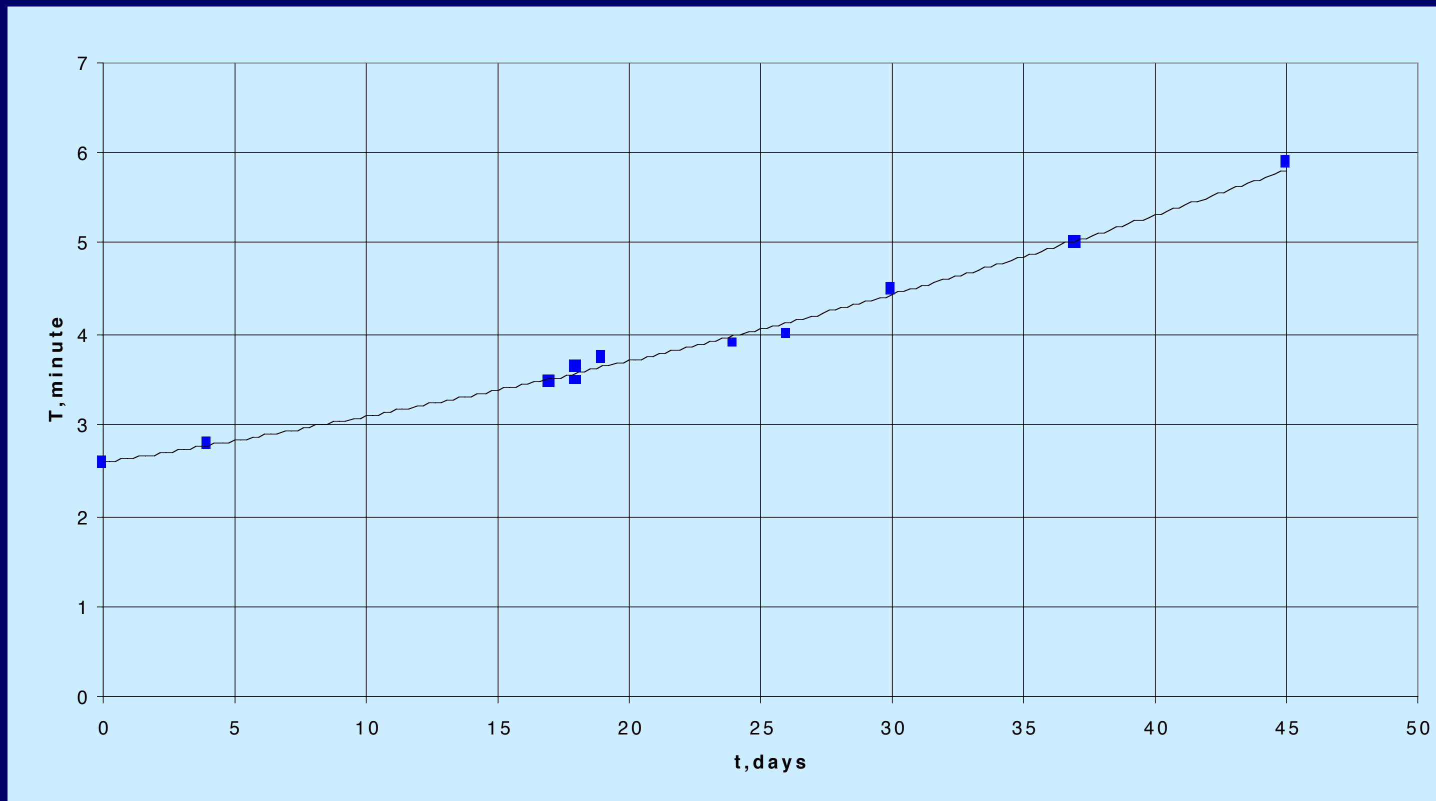
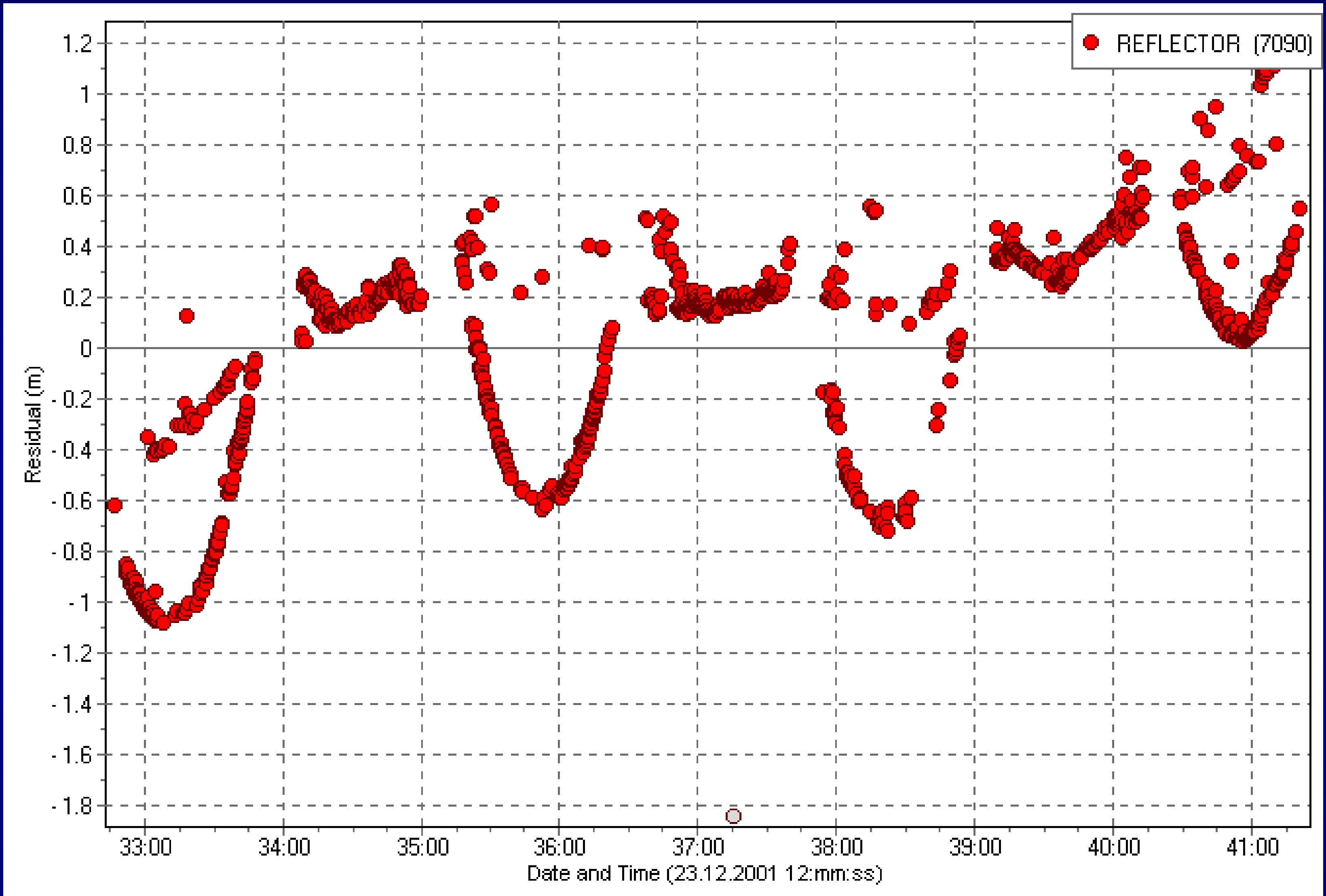
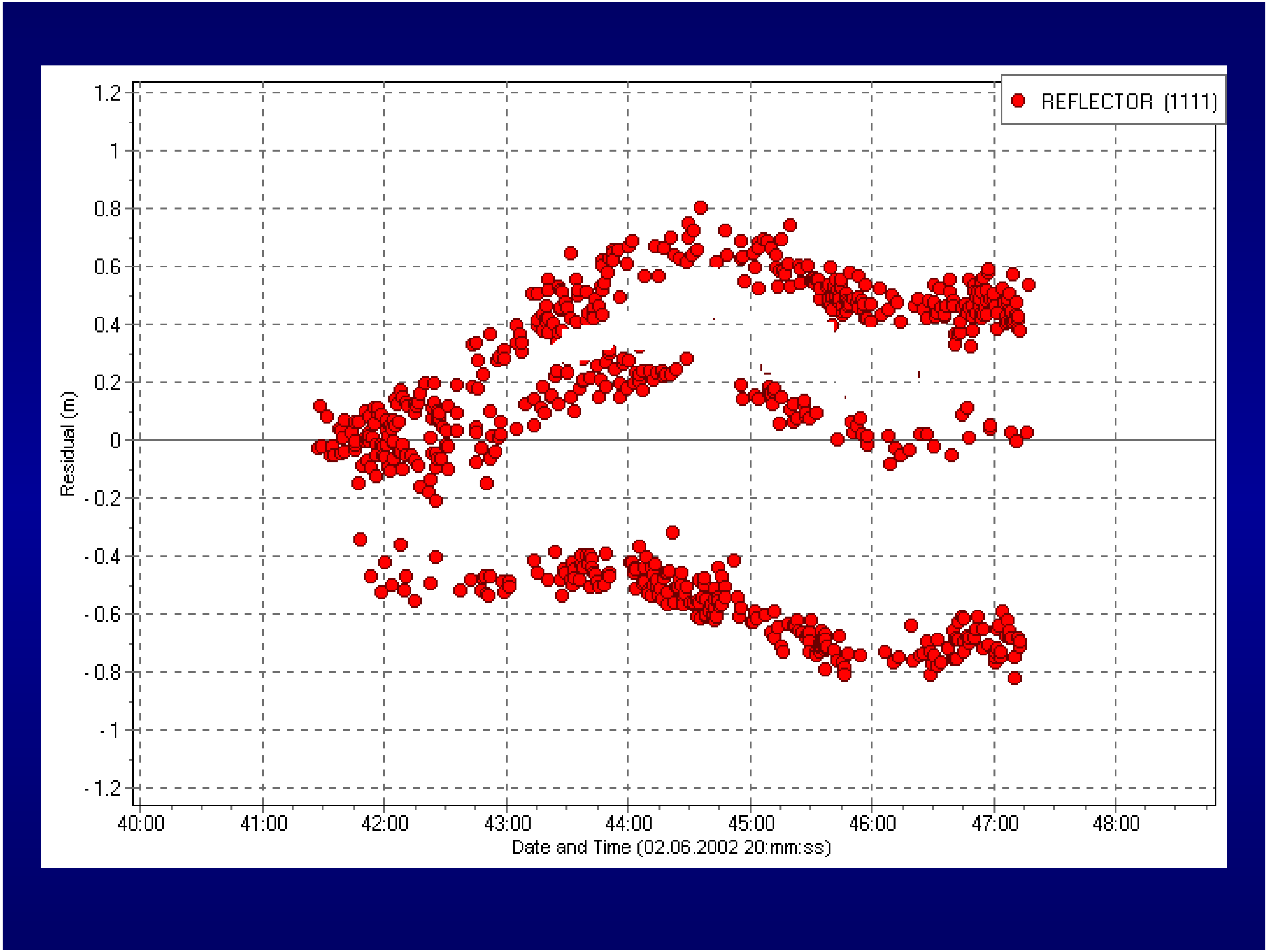


Figure 3. REFLECTOR microsatellite oscillation (tumbling) period duration versus time from December 23, 2001 to February 6, 2002

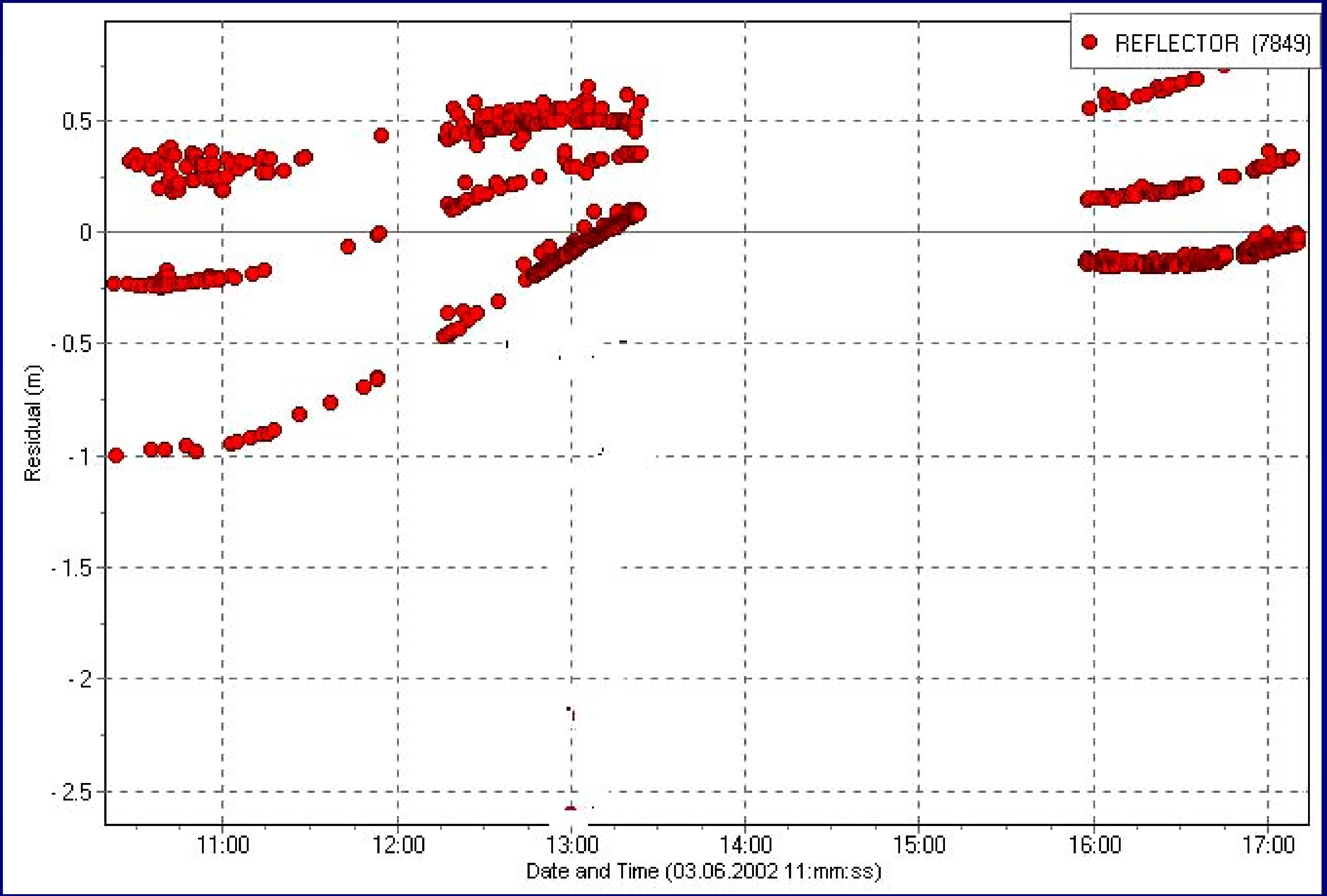
• Observations made March to May 2002 show that the microsatellite oscillation period is much more than 6 min. The pass observation time being only a small fraction of the oscillation period, it is now difficult to estimate the oscillation amplitude from range measurements without a detailed physical or mathematical simulation.



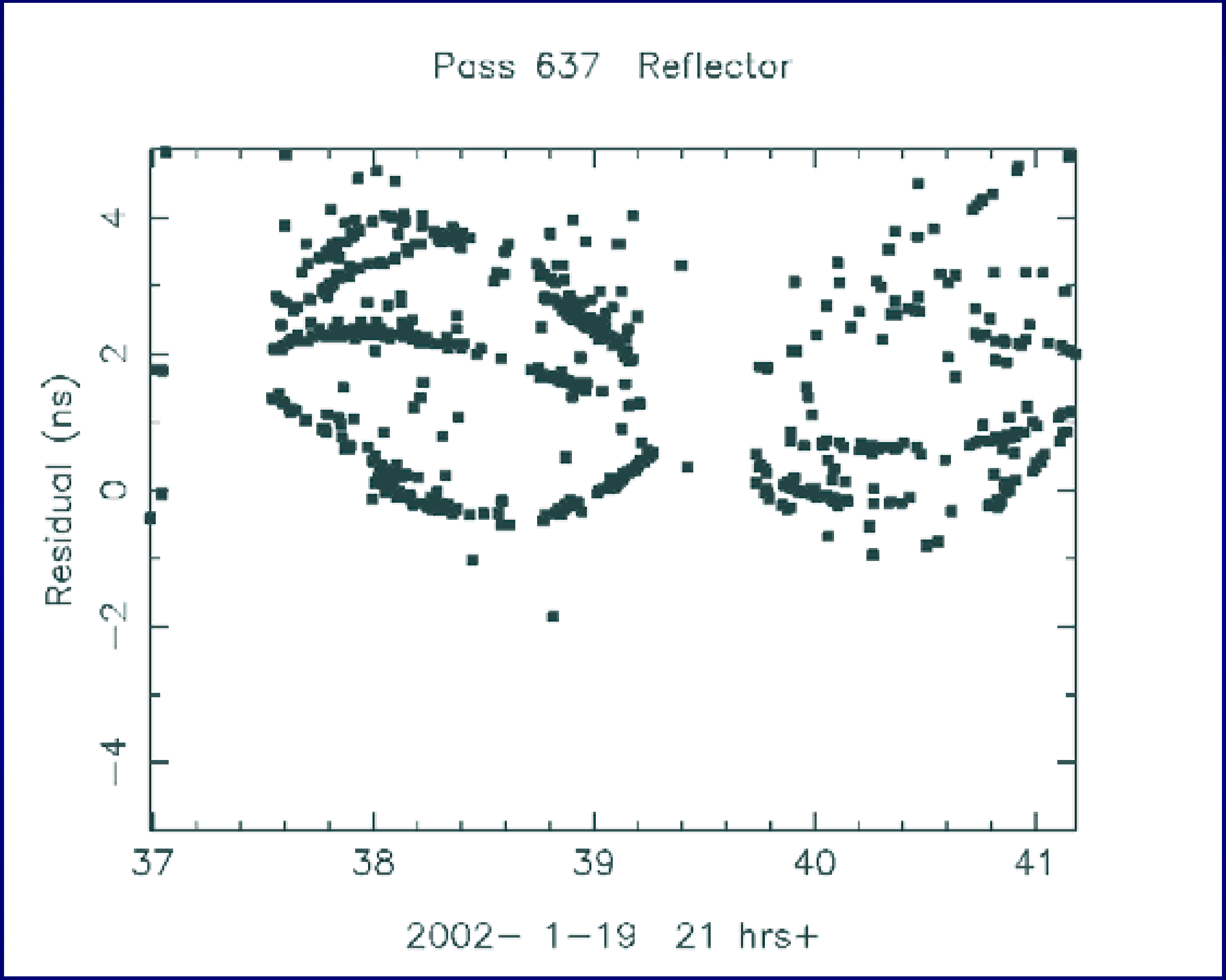
Observations of SLR station Yarragadee (7090)



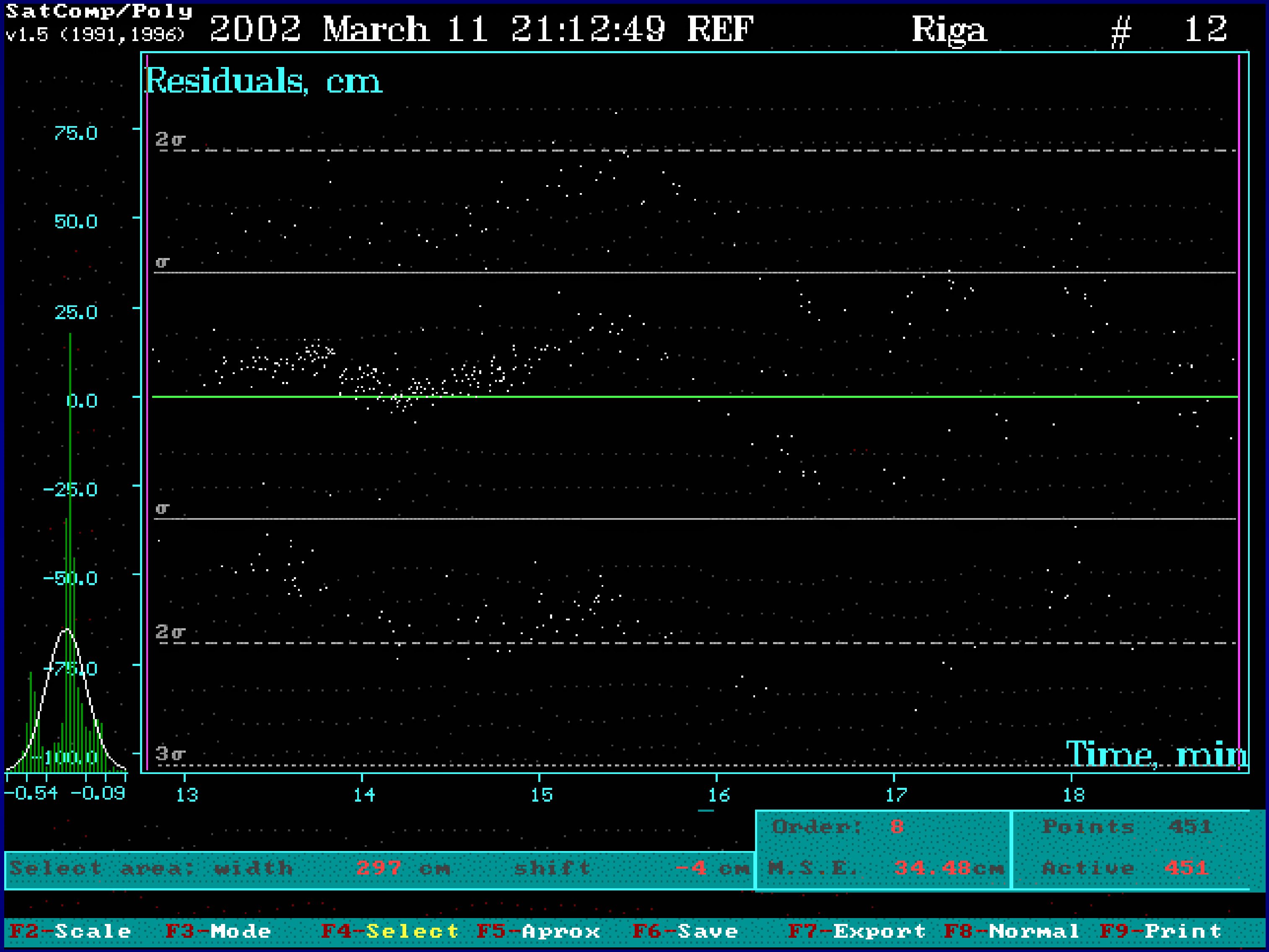
REFLECTOR (1111)
Residual (m)
1.2
1
0.8
0.6
0.4
0.2
0
- 0.2
- 0.4
- 0.6
- 0.8
- 1
- 1.2
40:00
41:00
42:00
43:00
44:00
45:00
46:00
47:00
48:00
Date and Time (02.06.2002 20:mm:ss)



REFLECTOR (7849)
0.5
0
-0.5
-1
-1.5
-2
-2.5
Residual (m)
11:00
12:00
13:00
14:00
15:00
16:00
17:00
Date and Time (03.06.2002 11:mm:ss)



Pass 637 Reflector
Residual (ns)
4
2
0
−2
−4
37
38
39
40
41
2002- 1-19 21 hrs+



Observations of SLR station Riga (1884)

- The REFLECTOR satellite SLR data analysis shows that ranging with multistop time counters is a new and efficient technique for determination of a spacecraft attitude; it can be used if several retroreflectors are mounted in properly selected positions at the spacecraft. The technique may be used to solve various scientific and applied problems (e.g. to determine the value of range correction relative to the spacecraft center of mass, etc.).

- We also call the SLR community to take into account the capability of multistop ranging to provide data for estimation of spacecraft attitude if retroreflectors are installed in several properly selected points of the spacecraft structure. This may be useful for estimation of the spacecraft center of mass position, as well as for solving of some other practical problems (perhaps, in altimeter calibration, etc.).

- For an efficient use of this technique, it is advisable to develop a method of attitude determination from range differences between separate retroreflectors groups, based on mathematical or physical simulation.

- We are very grateful to the International SLR Network, and especially to the most active Yarragadee station, for the REFLECTOR mission support. We are also most grateful to the stations which provided multistop ranging data.

- We ask the ILRS to continue the REFLECTOR observations at a minimum rate of one observation weekly – to retain the microsatellite orbit data till the next active operating phase.

- After separation from the satellite and extension of the boom carrying 8 cube corner prisms, the microsatellite attitude is controlled by a passive stabilization/damping system. The oscillation damping duration may be as long as several months. After final stabilization, the extendable boom should be pointed towards the Zenith or Nadir.

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