GRAZ LIGHT CURVES MEASUREMENTS SINCE 2015

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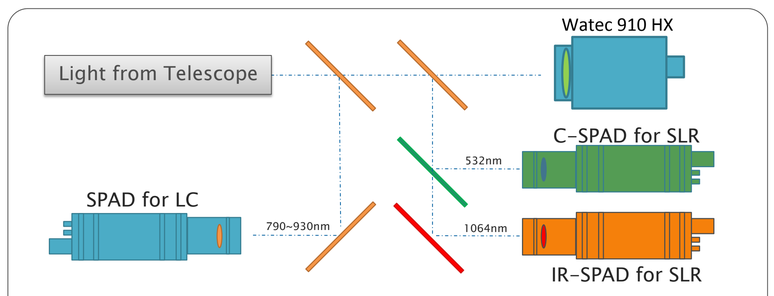
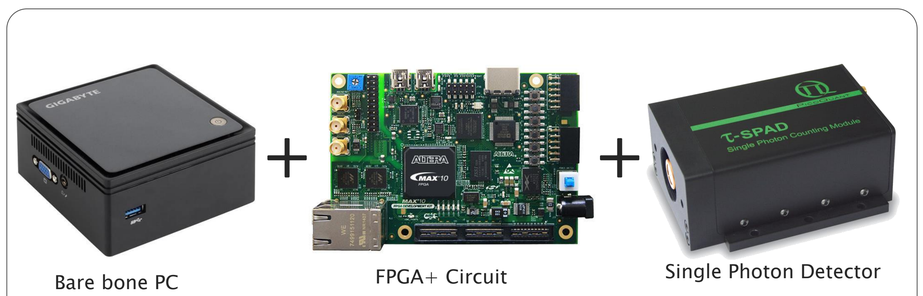
Light Curves (Photometry) as a function of time illustrate the average intensity of reflected sunlight by the observed targets. Graz SLR station established such a low cost measurement system since 2015 with single photon detector and FPGA circuit, concentrating on the wavelength band of 780~930nm, allowing simultaneous operation with SLR. Only the number of photons per bin (adjustable from 20μs ~ 1s) are stored into PC, which extremely compacts the data with an overwhelming advantage at this point compared with imaging techniques. Several kinds of targets - from low earth orbit up to geostationary satellites, including debris – have been measured in Graz, e.g. Ajisai, TOPEX/Poseidon, Envisat, more than 40 defunct Glonass, COSMOS, Compass GEO, R/B, etc. It turns out that the shape, the current status and the variation along time of spin rate or attitude can be yielded out of light curves.

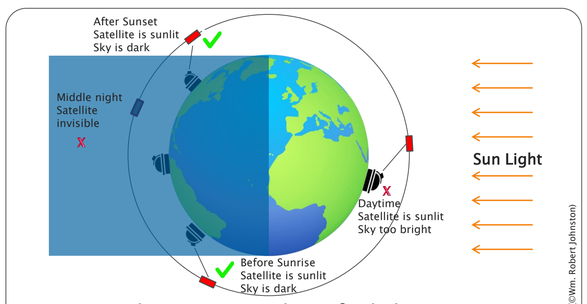


Graz optical setup principle/Simultaneously light curves measurement



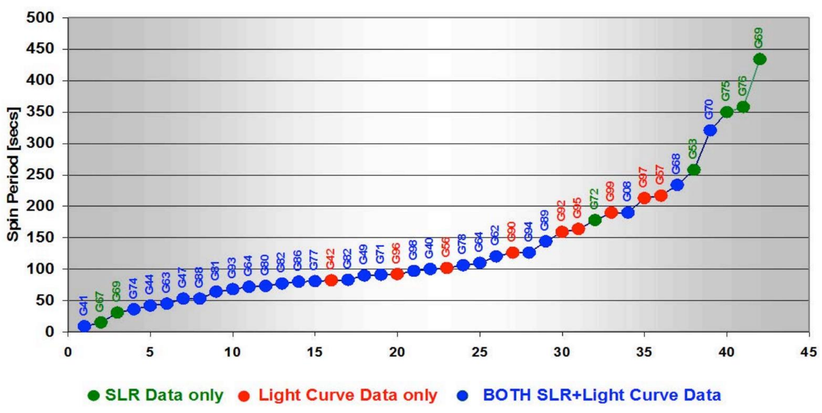
Bare bone PC + FPGA+ Circuit + Single Photon Detector

Low cost light curves package

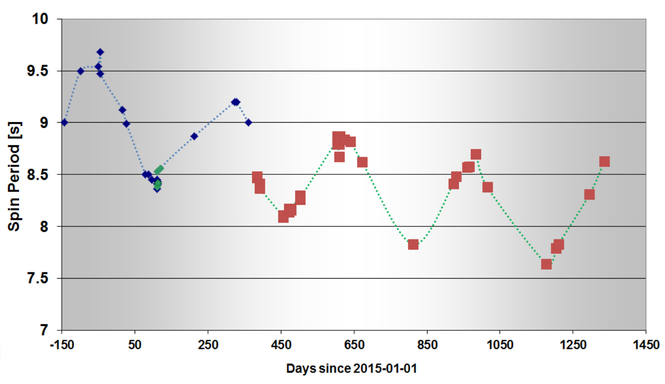


Observation condition for light curves

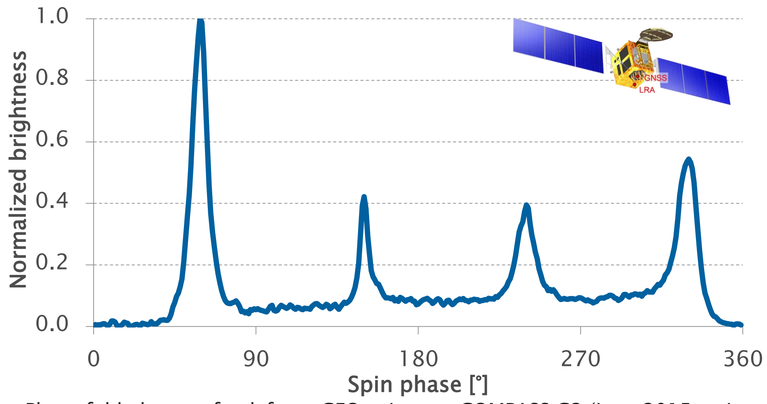
1. Defunct Satellites



Spin periods for 42 Glonass satellites determined by SLR only (green), light curves only (red) or SLR and light curves simultaneously (blue).

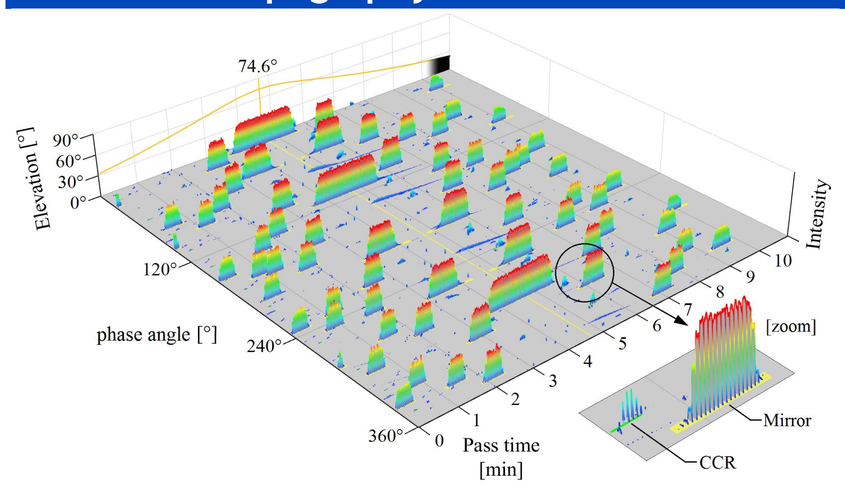


Defunct Glonass41: Spin duration derived from kHz SLR AND Light Curves: Spin is accelerating, and shows clear yearly variations.

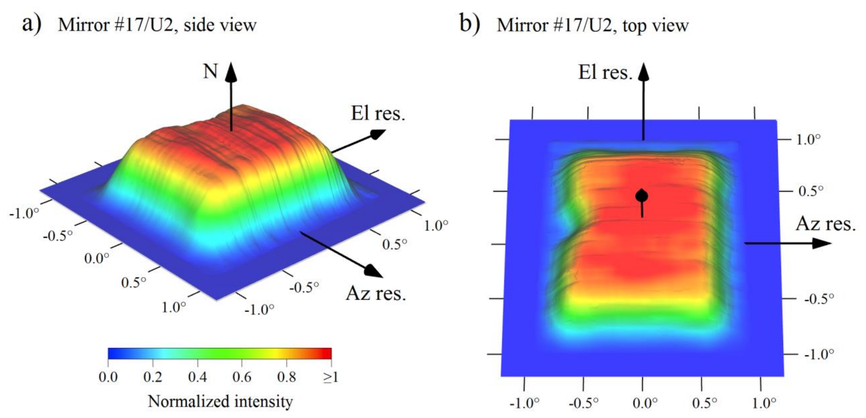


Phase folded pass of a defunct GEO spinner - COMPASS G2 (June 2015, spin period 7.2 s). The high signal-to-noise ratio can be achieved in spite of the distance of 36200 km.

2. Satellite Topography

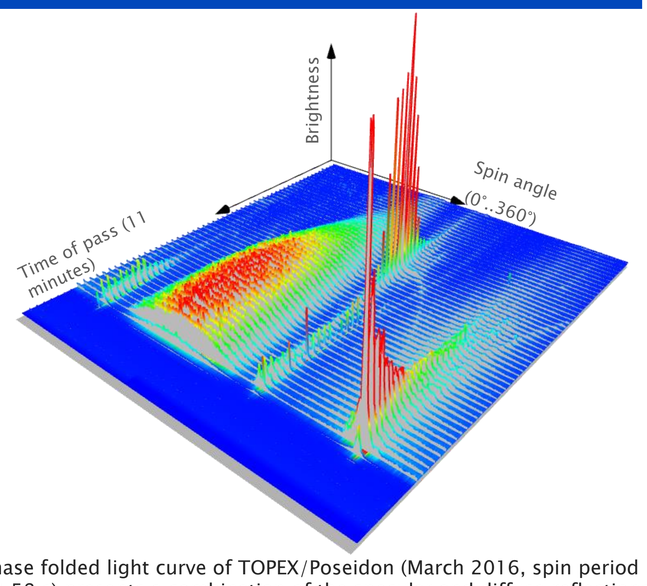


Phase folded pass of Ajisai (April 2016, spin period 2.3s). The bursts of the solar flashes produced by the single mirrors can be distinguished. The maximum satellite elevation above the horizon during the pass is 74.6° and the satellite eclipse is indicated by the black end of the elevation chart. The zoom panel shows a burst of the solar flashes given by a single mirror and a set of weaker flashes from the glassy CCRs - the yellow and green rectangles indicate the burst prediction area.



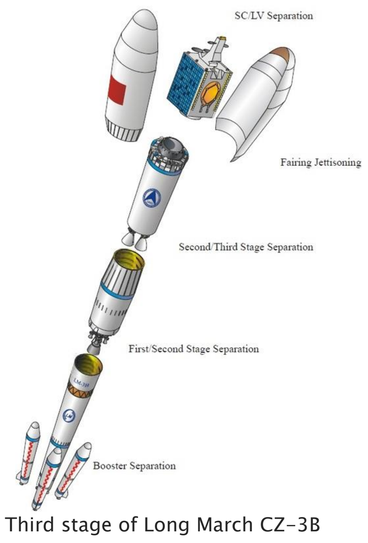
AJISAI: 3D reflectivity profile visualization of mirror #17/U2.

a) side view: the RMS of the plateau area is 5.1%,
b) top view - the reflection anomaly is visible around the coordinates Az.res=-0.5°, El.res=0°.



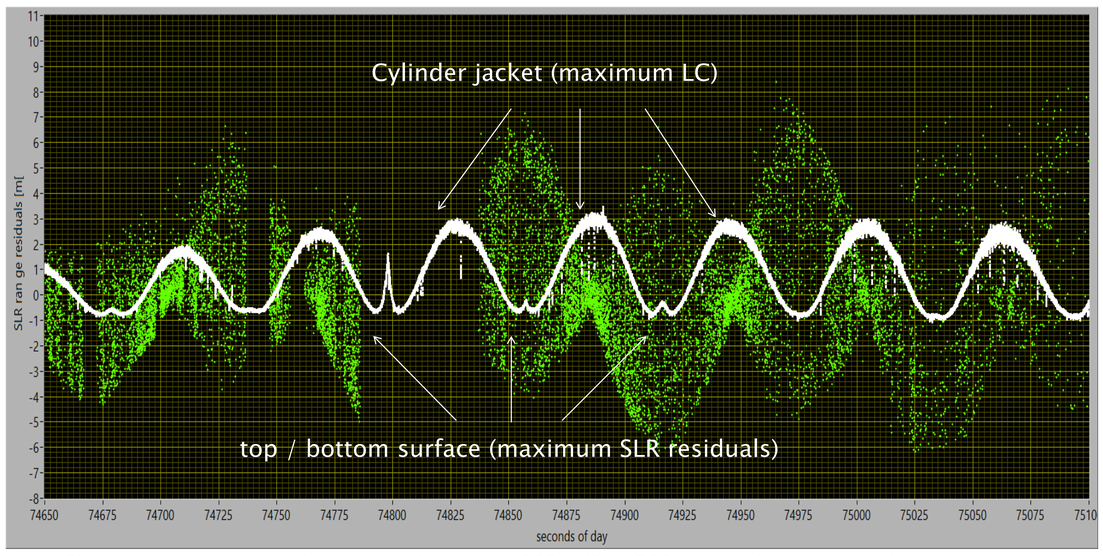
Phase folded light curve of TOPEX/Poseidon (March 2016, spin period 11.58 s) presents a combination of the specular and diffuse reflections from the satellite surface elements.

3. Debris Targets



Third stage of Long March CZ-3B
Norad:38253, Reentry: 2017.08.18
ϕ3m, 12m

- ❑ Maximum SLR residuals <-> Small light curve peaks
- ❑ Minimum SLR residuals <-> Large light curve peaks
- ❑ Maximum SLR offset: approx. 13 meters
  - Cylinder axis roughly parallel to line of sight
  - Sunlight reflection from top/bottom cylinder surface
- ❑ Large LC peaks: Sunlight reflection from cylinder jacket (SLR Minimum)
- ❑ Small LC peaks: Sunlight reflection from top/bottom surface
- ❑ Periodical offset SLR -> rotation about center of mass



Simultaneous space debris laser ranging (green 100hz/3ns/200mJ) and light curve (white) measurements

Reference

1) http://www.johnstonsarchive.net/astro/satview.html
2) Steindorfer, M.A., Kirchner, G., Koidl, F., Wang, P., 2015. Light Curve Measurements with Single Photon Counters at Graz SLR. 2015 ILRS Tech. Workshop