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Time series of SpinSat return intensity: How long can BK7 reflectors survive in space?

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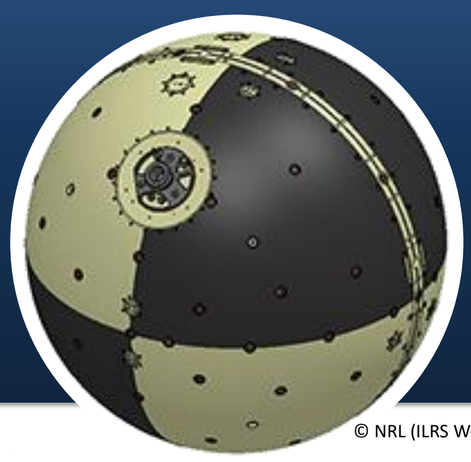

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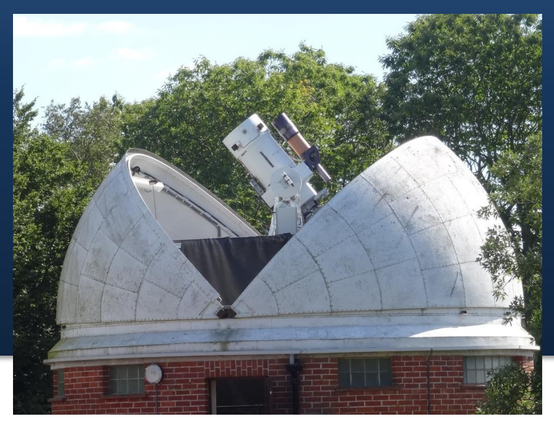


What is SpinSat?

Developed by NRL, following the series of ANDE missions.
Deployed from the ISS on 28 Nov 2014.
Objectives:
- Performance of electrically controlled solid propellant technology.
- Improvement of atmospheric density models.

Spacecraft:
- Alminium sphere.
- Diameter: 558 mm. Mass: 57 kg.

Orbit:
- Initial altitude 425 km.
- Inclination 51.6 deg.

Retroreflectors on SpinSat

68 retroreflectors
Diameter 12.7 mm
No dihedral angle, but 5 arcsec tolerance
Made of BK7
- Fused silica has a long lifetime, but BK7 is not radiation resistant.
- BK7 is much cheaper.
- BK7 reflectors used for ANDE missions (NRL) and LRE (NASDA, Japan).

→ **Do they perform well?**
→ **How long can they survive?**
→ **Possibly useful for future missions?**

Intensity observation at Herstmonceux

Single-photoelectron policy:
- Return rate < 20%.
- 1 kHz repetition (5000 shots per normal point bin = 5 sec)

Intensity information used in this study:
- ILRS Normal Point (CRD):
  - Number of returns per bin
  - Range (intensity inversely proportional to range^4)
- Herstmonceux local data (“status” file):
  - ND wheel rotation
  - Beam divergence

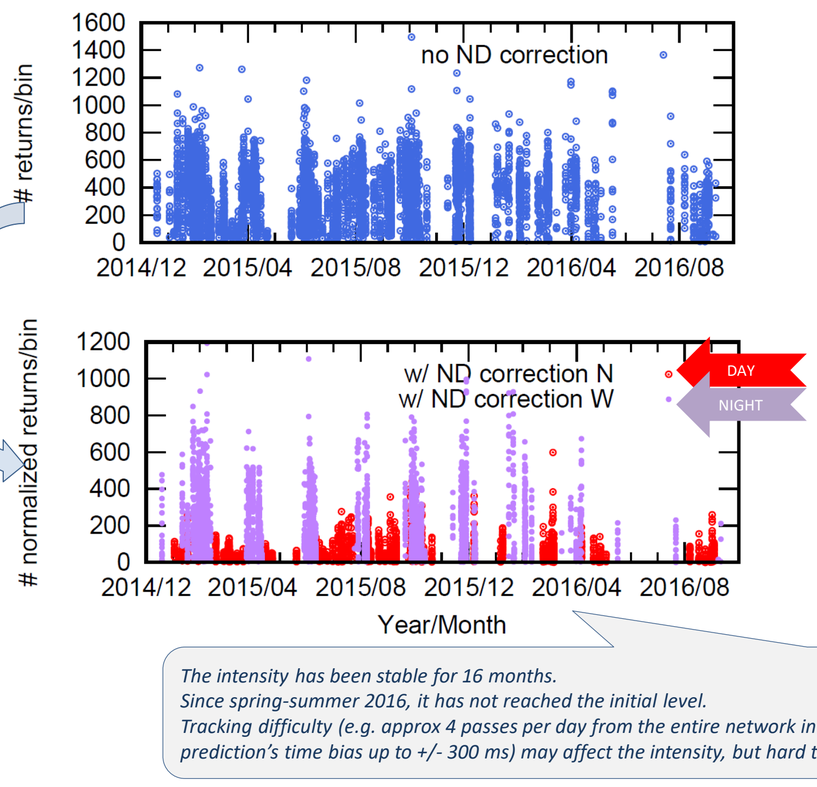
Time series of SpinSat return intensity

[RAW DATA]
Number of returns per NP bin (in CRD)

[CORRECTED/NORMALISED DATA]
Range^4: normalised at 800 km
SpinSat altitude dropped from 420 km to 320 km
ND wheel indicator (locally stored)

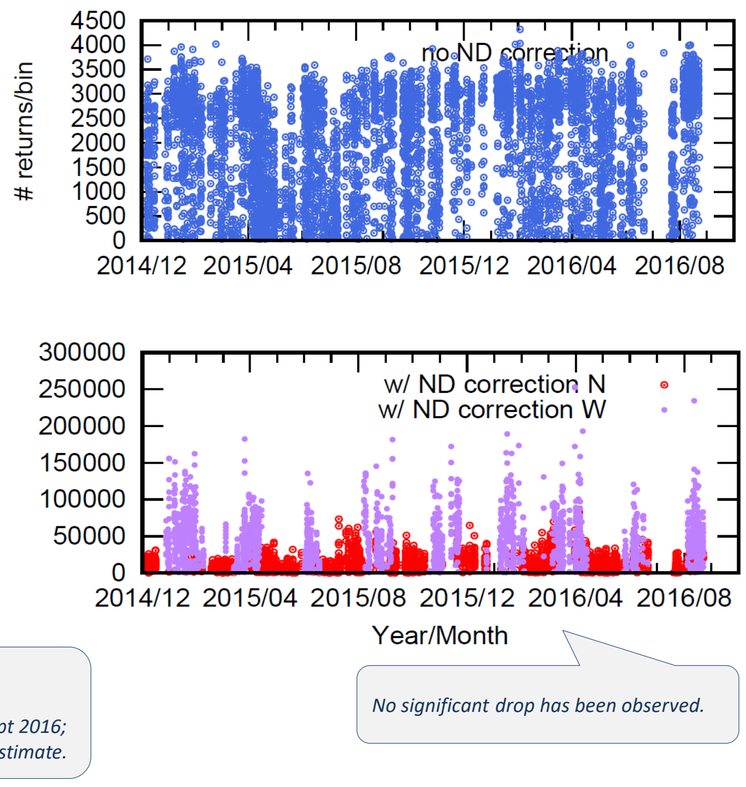
→ Y axis is the number of photoelectrons per NP bin assuming that the target was at a 800 km distance and that no ND filter was applied.

[ADDITIONAL CORRECTION FOR COMPARISON]
NP bin size:
SpinSat 5 sec vs Starlette 30 sec
Beam divergence (standard config.):
SpinSat ~ 24 arcsec vs Starlette ~ 20 arcsec



The intensity has been stable for 16 months.
Since spring-summer 2016, it has not reached the initial level.
Tracking difficulty (e.g. approx 4 passes per day from the entire network in Sept 2016; prediction’s time bias up to +/- 300 ms) may affect the intensity, but hard to estimate.

Starlette case for comparison



No significant drop has been observed.

Summary

- **SpinSat’s BK7 reflectors have performed properly for more than 1 year at the very low orbit.**
- **The effective cross section of SpinSat LRA is about 3-5 % of Starlette.**
- **Possible degradation has been observed since mid-2016, but not conclusive yet.**

This is one of the collaboration researches conducted during Otsubo’s stay at Herstmonceux, May-August 2016.

Future works

- **A few months remains before its re-entry.**
- **Intensity time series from other stations will help.**
  Information we need:
  - Beam divergence (unnecessary if fixed)
  - ND filter attenuation
  - Shot-by-shot intensity records

Contact the authors if these are available.