Tracking up to Geostationary Satellite with 15μJ Laser and 70cm Astronomy Telescope

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OUTLINE

- Concept of SP–DART
- Experiment Setup
- ASA Telescope
- Results
- Conclusions and Outlook
Single-Photon Detection, Alignment and Reference Tool

SP-DART

SP-DART is a tiny SLR station, but uses a host mount/telescope

- Transmitting module (15μJ/1ns/2kHz)
- Detection package
- FPGA-based Control Unit
- Riga ET-A033
- Laptop
- Real-Time programs
- GNSS T&F Receiver
- P/T/H Device

TRANSMITTING MODULE

- Laser Start Detector
- 2nd Beam Expander 4X
- 1st Beam Expander 40X
- 15μJ Laser

DETECTION AND CONTROL MODULE

- Iris
- Filter
- Watec Camera
- 532nm ø500μm Gated Detector
- 532nm ø500μm Non-Gated Detector for Light Curves

- 19’’ Rack Box
  -- FPGA for laser and RG
  -- GPS Time & Freq. Unit
  -- Latvia ET
  -- P/T/H

- Laptop
Telescope was remotely controlled by Dr. Martin Ploner in Switzerland
THE SANDL TELESCOPE

- Altazimuth Ritchey Chretien
- Aperture: 70 cm
- Focal length: 6.3 m
- Two hyperbolic mirrors -> aberration correction
- Nazmyth style  Outcoupling in Elevation axis  Rotatable 45° mirror
Unfair, I am only 0.03w !!! But........
• In total, 17 passes from LEO up to GEO
• Only 6 hours setup, the first pass was tracked successfully

<table>
<thead>
<tr>
<th></th>
<th>Passes</th>
<th>Max. Return Rate</th>
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<tbody>
<tr>
<td>GEO (Compass I5) Elevation: ~40°</td>
<td>1</td>
<td>~0.2%</td>
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<tr>
<td>GNSS</td>
<td>6</td>
<td>~2.6%</td>
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<tr>
<td>Lageos</td>
<td>3</td>
<td>~12.5%</td>
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<tr>
<td>LEO</td>
<td>7</td>
<td>&gt;30%</td>
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<table>
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<tr>
<th>Date</th>
<th>Days of Year</th>
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<tr>
<td>2016-08-22</td>
<td>235</td>
<td>3</td>
</tr>
<tr>
<td>2016-08-23</td>
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<td>2016-08-24</td>
<td>237</td>
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An non-gated un-gated detector was installed for parallel light curves

GLONASS041, $T_{\text{spin}} = 8.84$ s, 4 sides of satellites visible

CONCLUSIONS AND OUTLOOK

• **TINY, Transportable, Easy, Efficient**
  -- Tiny: <10 kg mounted on telescope; <30kg in total
  -- Transportable: easily loaded into a car
  -- Easy: 6 hours setup time, then get ready
  -- Efficient: up to GEO target with 15 μJ laser

• **SP–DART could be used for**
  -- Calibrate/Evaluate system
  -- Upgrade astronomical telescope to bi/multi–static ranging
  -- Full automatic HEOs ranging system
    (4 cm single–shot RMS, sufficient for EOP calculated by Toshimichi Otsubo )

• This project is supported ESA (4000112211/14/D/SR)
• Thanks for colleagues from ASA and remote operator from CH
A problem has been detected and windows has been shutdown to prevent damage to your computer.

If this is the first time you've seen this stop error screen, restart your computer. If this screen appears again, follow these steps:

Check to hardware

If problem is caching, press F8

Technical

*** gv3.s

Beginning

Physical

Contact y...