Improving support for GNSS and other challenging missions

Tracking Many GNSS: Introduction

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Introduction

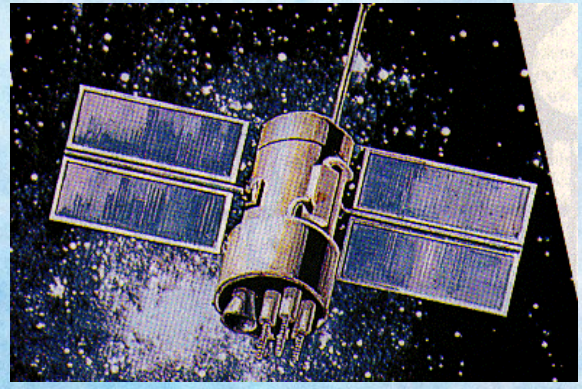
GNSS has evolved to become the most widely available positioning technique used by both civilians and scientists.

GPS became operational in 1994 and the GLONASS system was developed over a similar time and continues to take shape.

Many future GNSS missions are around the corner, placing an increased demand on SLR tracking

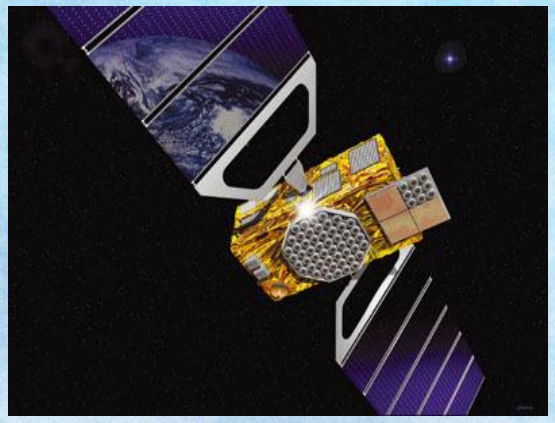
- Overview to the *"Improving support for GNSS and other challenging missions"* session
- Experience of the Herstmonceux station

Future GNSS requiring ILRS support



GLONASS

- Near full constellation
- 27 satellites orbiting, 24 operational



Galileo

- Satellites to begin launch in August 2011
- Total number of Satellites is 27 + 3 reserve

GPS

- Future GPS satellites could carry retro-reflectors

Compass/BeiDou

- *Inside GNSS* reports an 8th satellite was launched on 10th April 2011.
- 3rd geosynchronous and 4 geostationary and 1 middle orbit (Compass-M1)

QZSS

- QZS-1 launched, 2 more satellites planned

Benefits of SLR to GNSS

Conference in Metsovo in 2009 on *"SLR tracking of GNSS Constellations"*

Messages from Metsovo

- SLR has been demonstrated to be viable, valuable and unique technique for independent analysis of GPS orbits through
  - evaluation of GPS error budget
    - provides radial orbit accuracy
    - detection of systematic errors (inter-system biases)

- **SLR can provide a unique tool to validate gravity field solutions from microwave m independently assess their quality**

Galileo SLR Scenario

- **Support to Galileo for early phases**
  - With low number of GSS and few IGS Galileo stations GNSS based orbits of Galileo will be of medium accuracy
  - Addition of SLR observation will offer a significant accuracy improvement
- **Calibration of Spacecraft Dynamics**
  - The Y-bias as present on most GNSS satellites has rm effect on the satellite position.
  - urate determination of the Y-bias for each satellite will be of prime importance to fulfill e in a lifetime" station keeping manoeuvre ent
  - RF to ITRF

Main goals for SLR data processing in GLONASS:

- ✓ **Improving of the geodetic base for GLONASS on the way to ITRF**
- ✓ **Studying and improving of the SC motion model etc.**
- ✓ **Calibration and validation of the microwave means**
- ✓ **Testing and validation of the software and analysis results**
- ✓ **Monitoring of the real on-board ephemeris and clock**

Messages from Metsovo

- SLR is insensitive to the ionosphere, with a very small dependence on atmospheric water vapour
- SLR observations can assist in modelling the onboard clocks
- SLR provides useful tracking support in the initial phases of

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- SLR can link and support the interoperability of the different GNSS systems through a common, independent measurement technique.
- Combination of GNSS observations and SLR measurements with accurate space ties could strengthen the determination of the ITRF.

GNSS SLR - My Experience

Tracking **sunlit** GNSS satellites **at night** needs:

- Good skies
- Narrow beam
- Camera to centre laser beam and satellite

Tracking **in-shadow** GNSS satellites **at night** also needs:

- Good telescope pointing
- Azimuth and elevation search patterns
- Some patience and luck

Tracking GNSS satellites **during the day** also needs:

- Small iris
- Very good skies
- Daylight filter
- Close gating of detector
- Daytime camera to align laser beam
- Excellent telescope pointing
- More patience and luck!

GNSS tracking at Herstmonceux

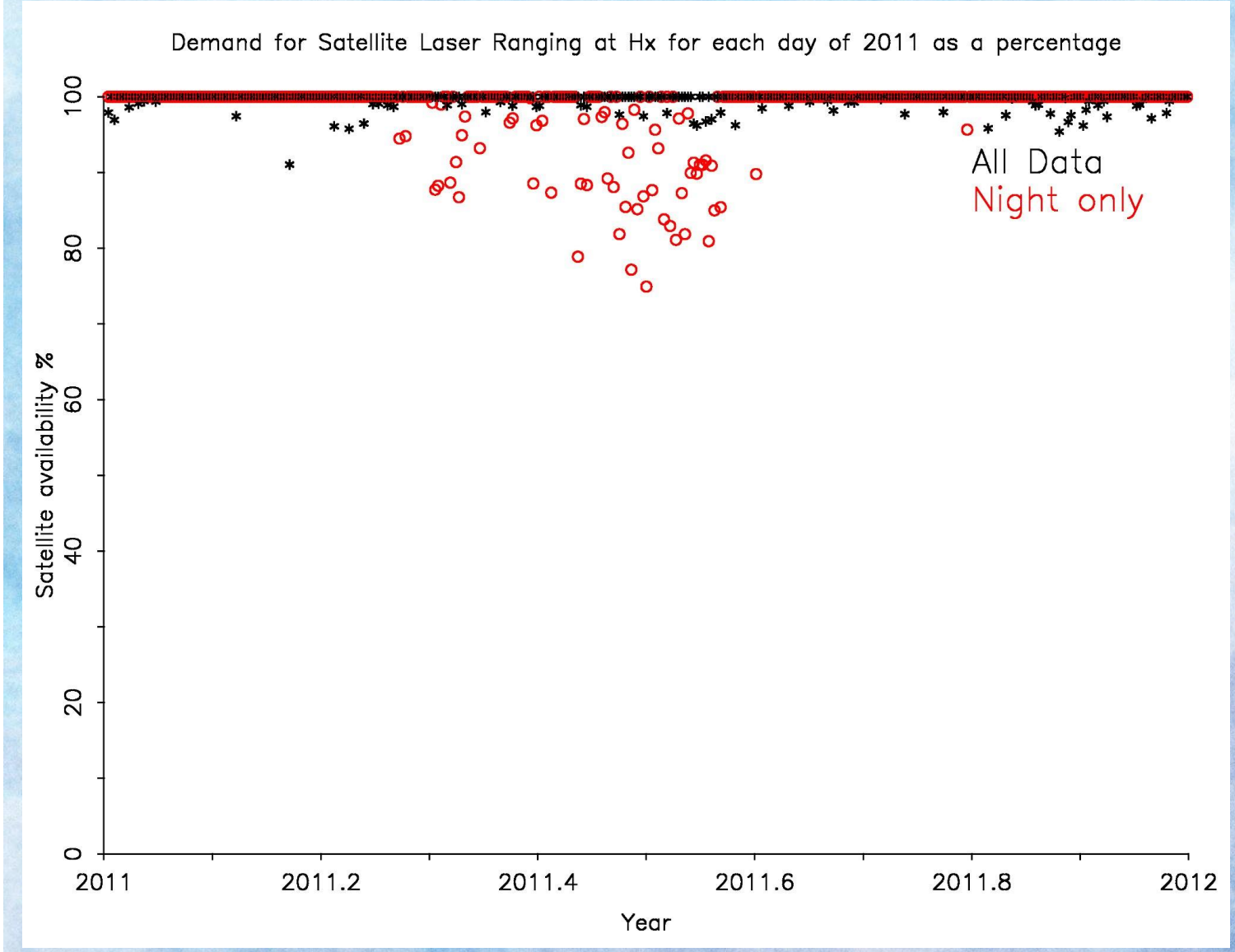
Herstmonceux tracks all ILRS GNSS and Etalon missions and in addition now tracks **all** GLONASS.

As there are 24 operational GLONASS this results in **3 times** as many GNSS altitude satellites being tracked.

This scenario is similar to what could be requested from GNSS missions in the future.

Is there spare capacity to do this?

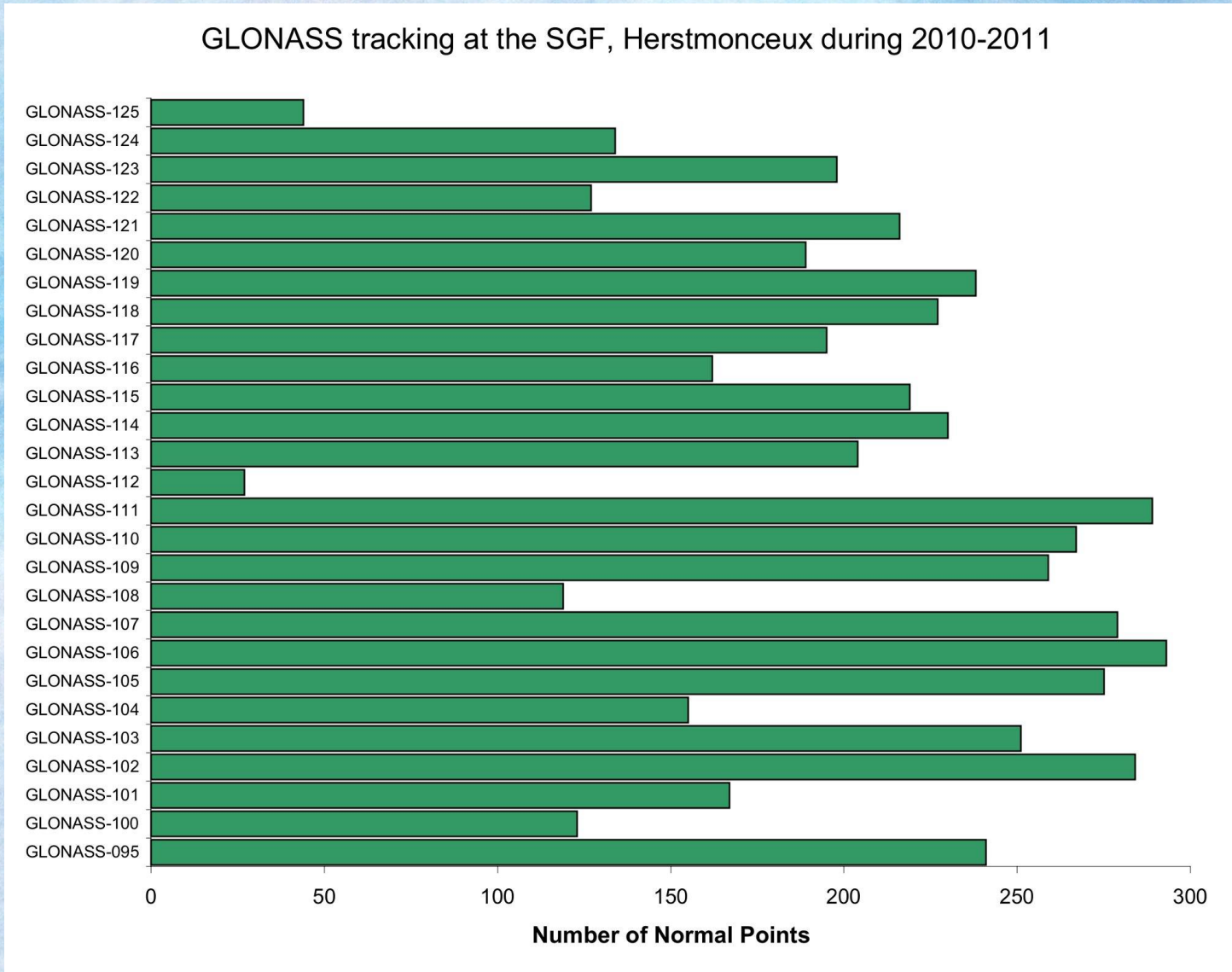
Demands on a SLR Station. E.g. Hx



All LEO Satellites
+
Lageos 1&2
+
Etalon 1&2
+
GIOVE A&B
CompassM-1
GPS 36
+
All GLONASS

GLONASS SLR at Herstmonceux

The SLR of GLONASS satellites is evenly shared, averaging approximately 200 normal points each.



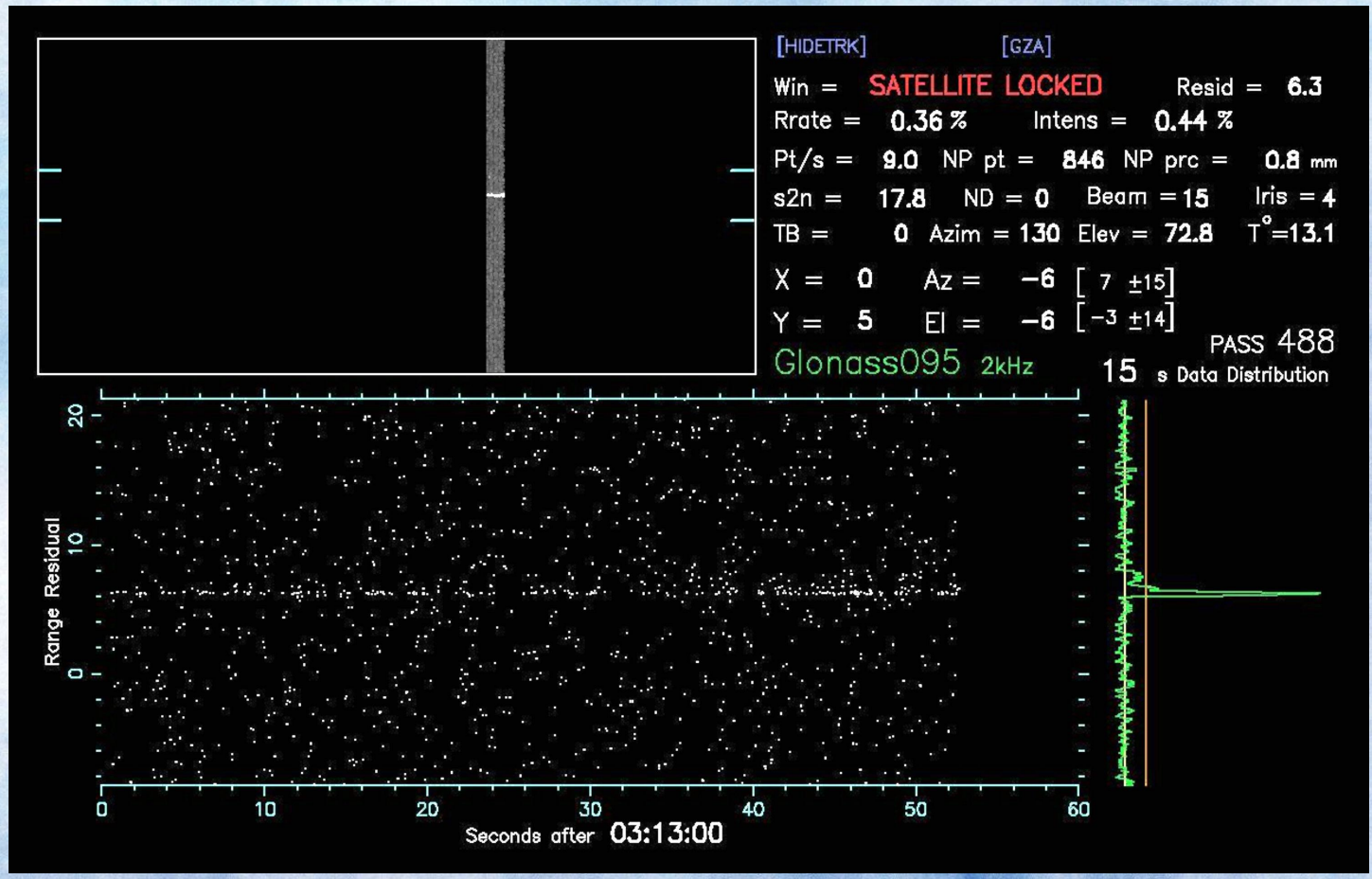
The newer or decommissioned satellites have fewer observations.

Real time precision

Maximising SLR tracking efficiency of many GNSS satellites can be achieved using real-time precision calculations.

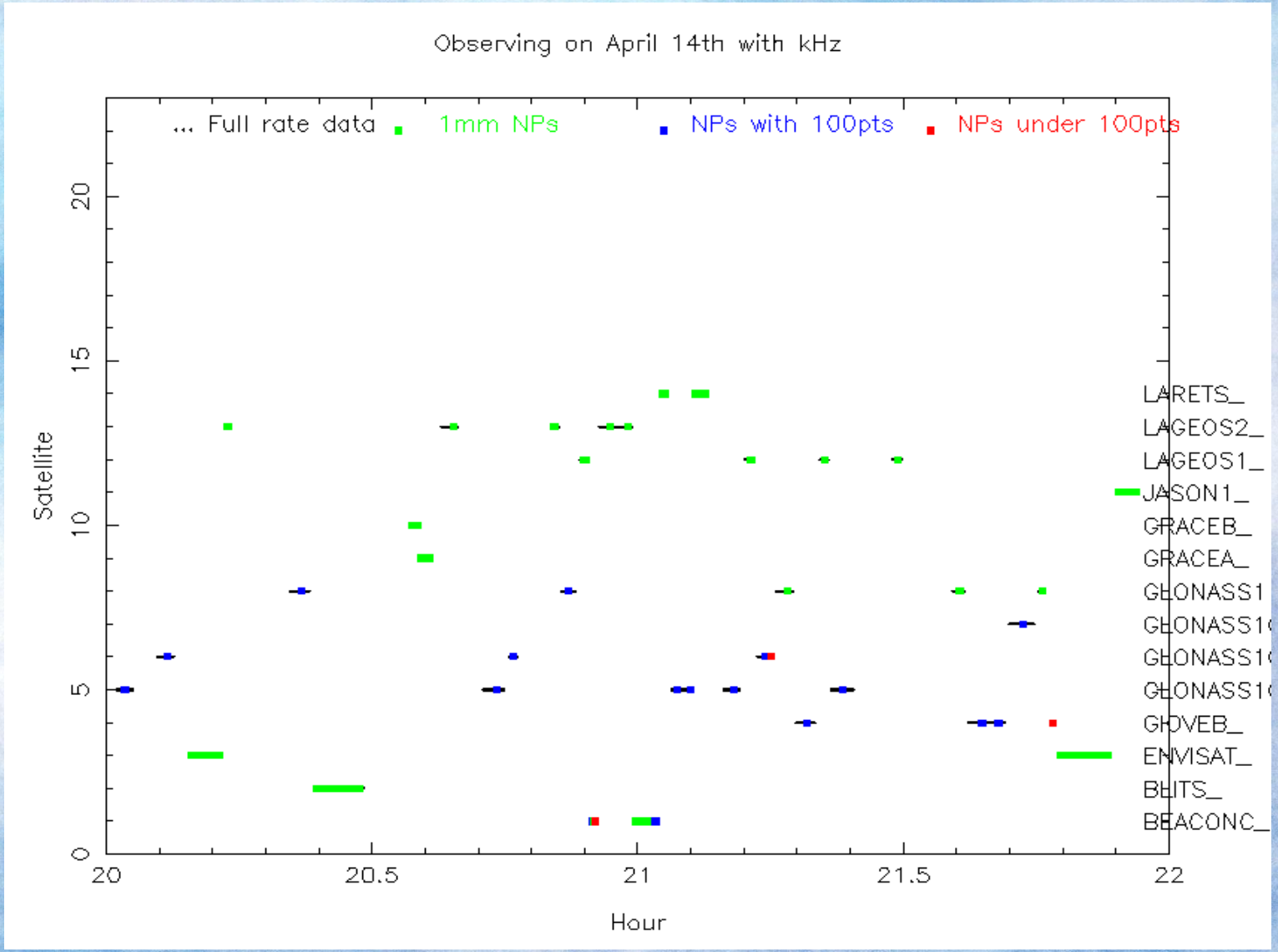
This is best suited for the high rate laser systems which can reach less than 1mm normal point precision quickly.

Need reliable track detection



Efficient satellite switching

Many satellites can be tracked over a short period - but the observer has to work hard!



Conclusions

If the ILRS decides to support all future GNSS satellites this will mean a significant jump in the number of satellites tracked.

However there is spare capacity in the SLR station schedule to observe many GNSS without impacting on the Lageos and LEO tracking.

GNSS satellites are routinely tracked by many stations, including during the day in good sky conditions.

Conclusions

However questions over the 'best practice' for GNSS SLR remain, for example:

- Is it better to provide good support for a few select satellites or is there a benefit to supporting an entire constellation?
- How much SLR and what distribution of observations is needed to best observe a GNSS pass?

Thank You