Session 2

Daylight Ranging

Werner Gurtner, Ulrich Schreiber

Daylight Tracking

Werner Gurtner

Ulrich Schreiber

ILRS Workshop
28-31 October 2003
Kötzting

Topics to Discuss

- Why is daylight ranging so important?
- Why is the daylight ranging so poor?
- What is the experience at the most successful stations?
- How do we improve it?
- What are the hardware issues?
- What are the software issues?
- Would better predictions help?
- What are the current limitations?

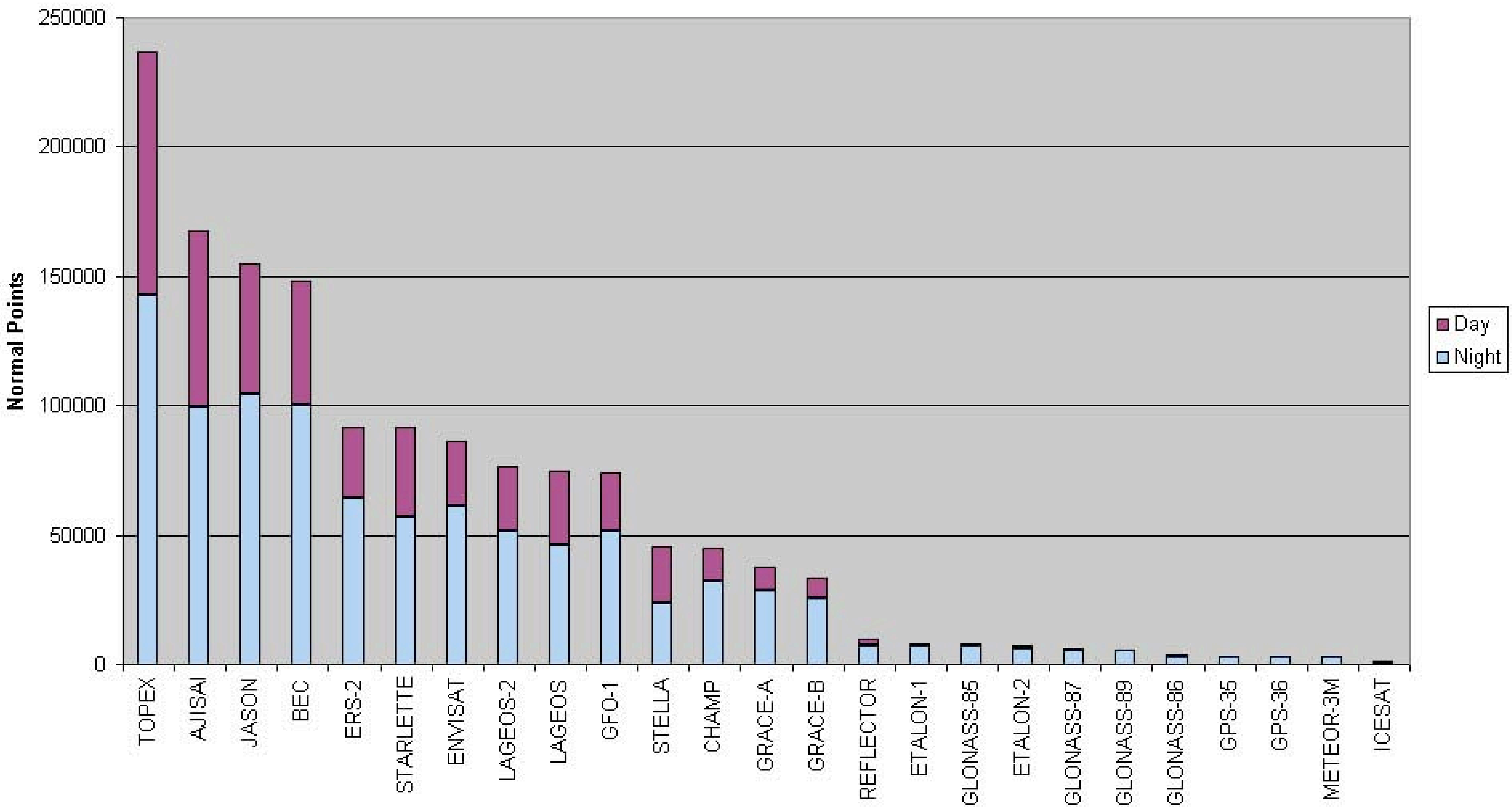
Why is daylight ranging so important?

- Number of observed passes
- Number of observations
- Longer gaps in orbit coverage
- Systematic errors in products

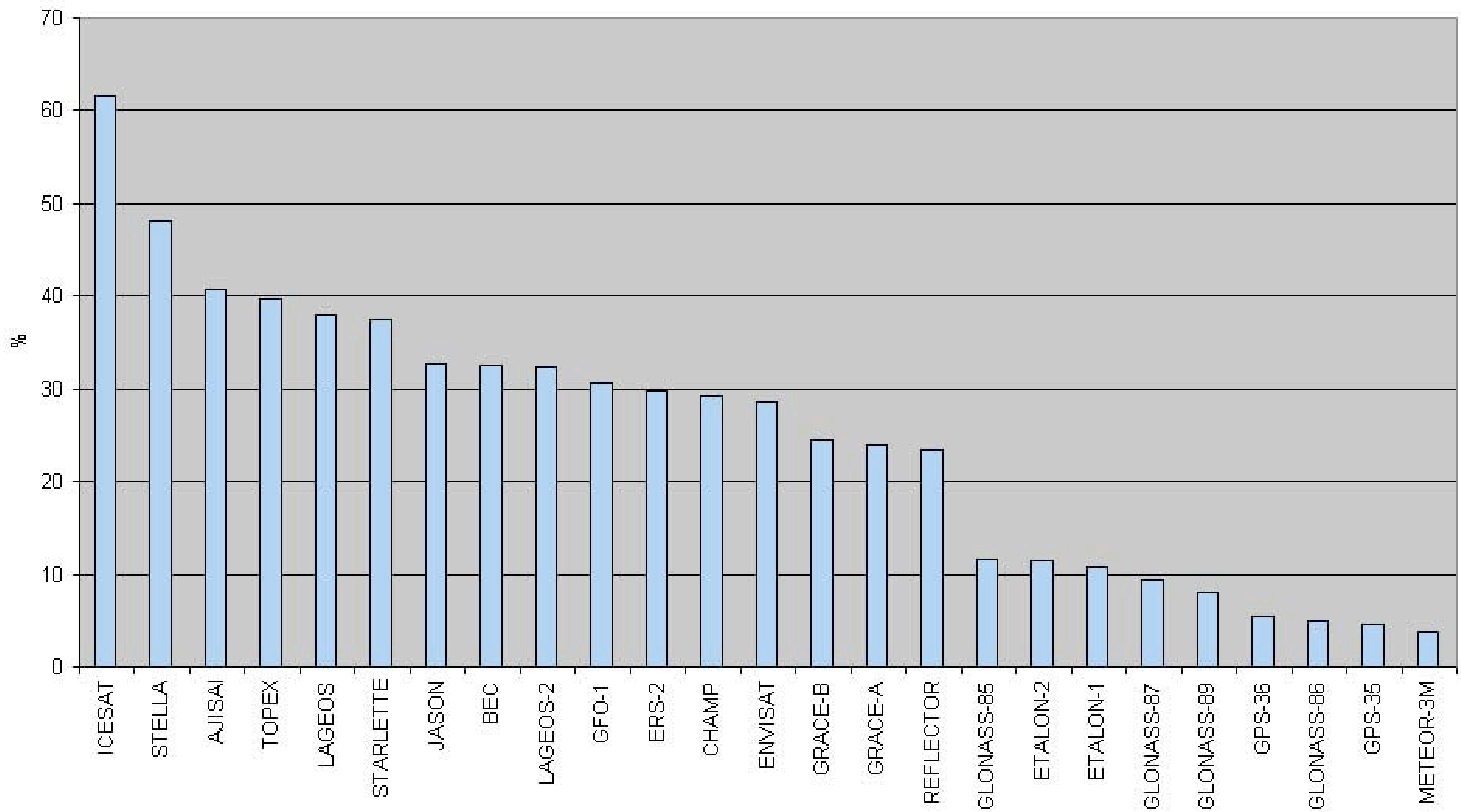
Percentage of Day Time Passes

Stella, Starlette, Lageos-1, Topex, Ajisai	40 %
Jason, BE-C, GFO-1, Lageos-2, ERS-2, Envisat, Champ	30 %
Grace A/B	25 %
Glonass, Etalon	10 %
GPS	5 %

Day and Night Time NP per Satellite

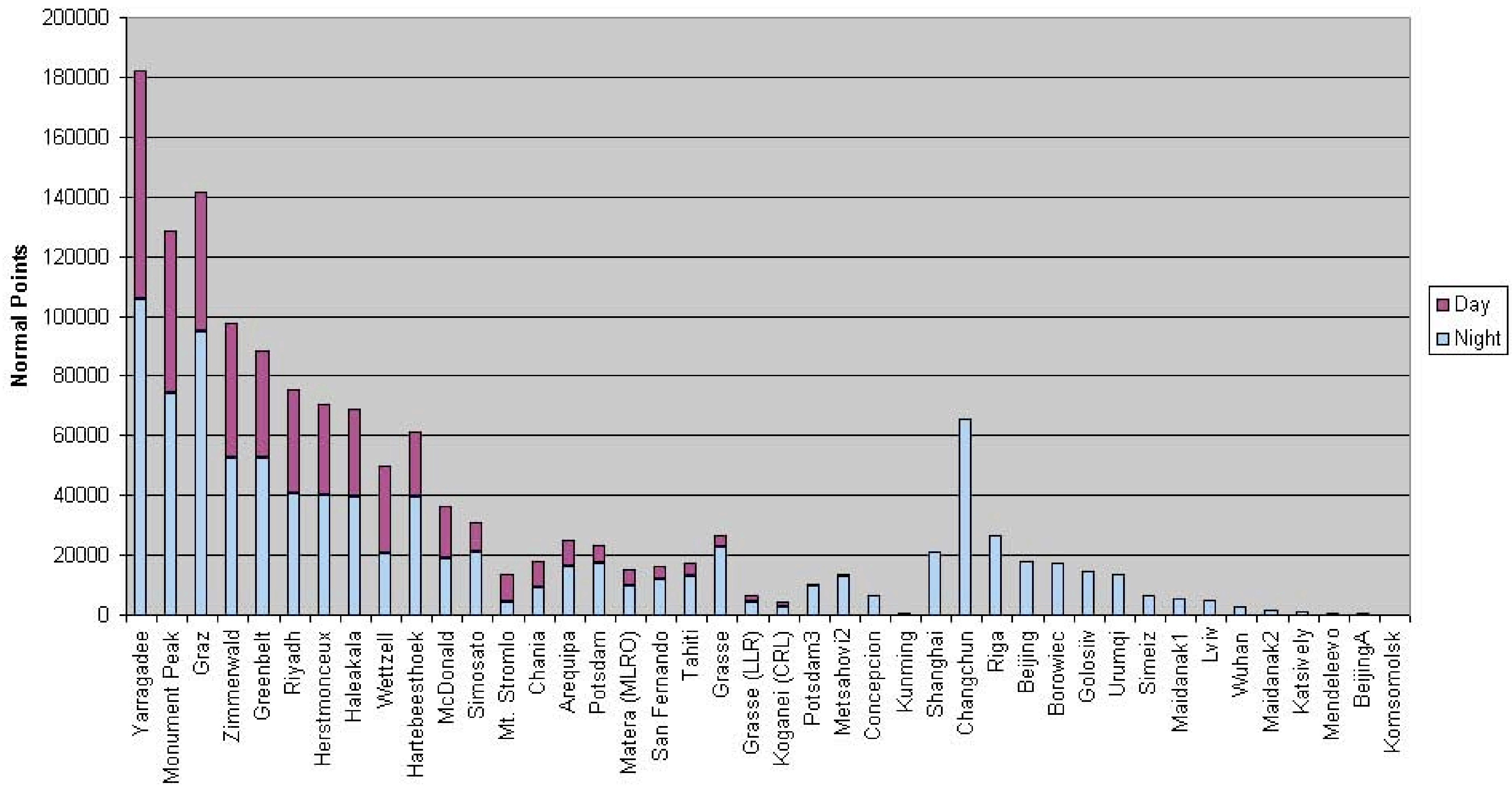


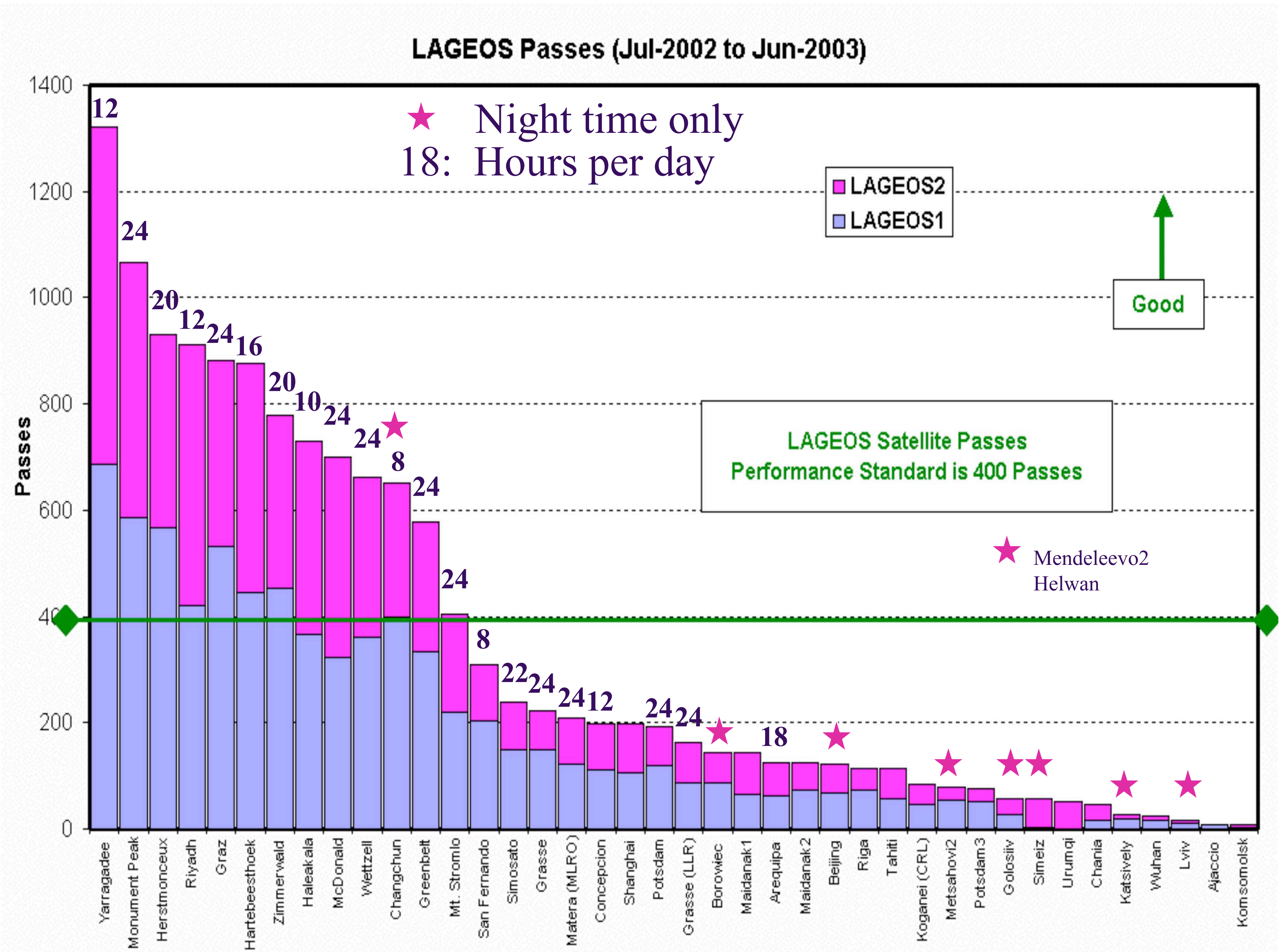
Percentage of Day Time Data (NP)



Day and Night Time Data per Station

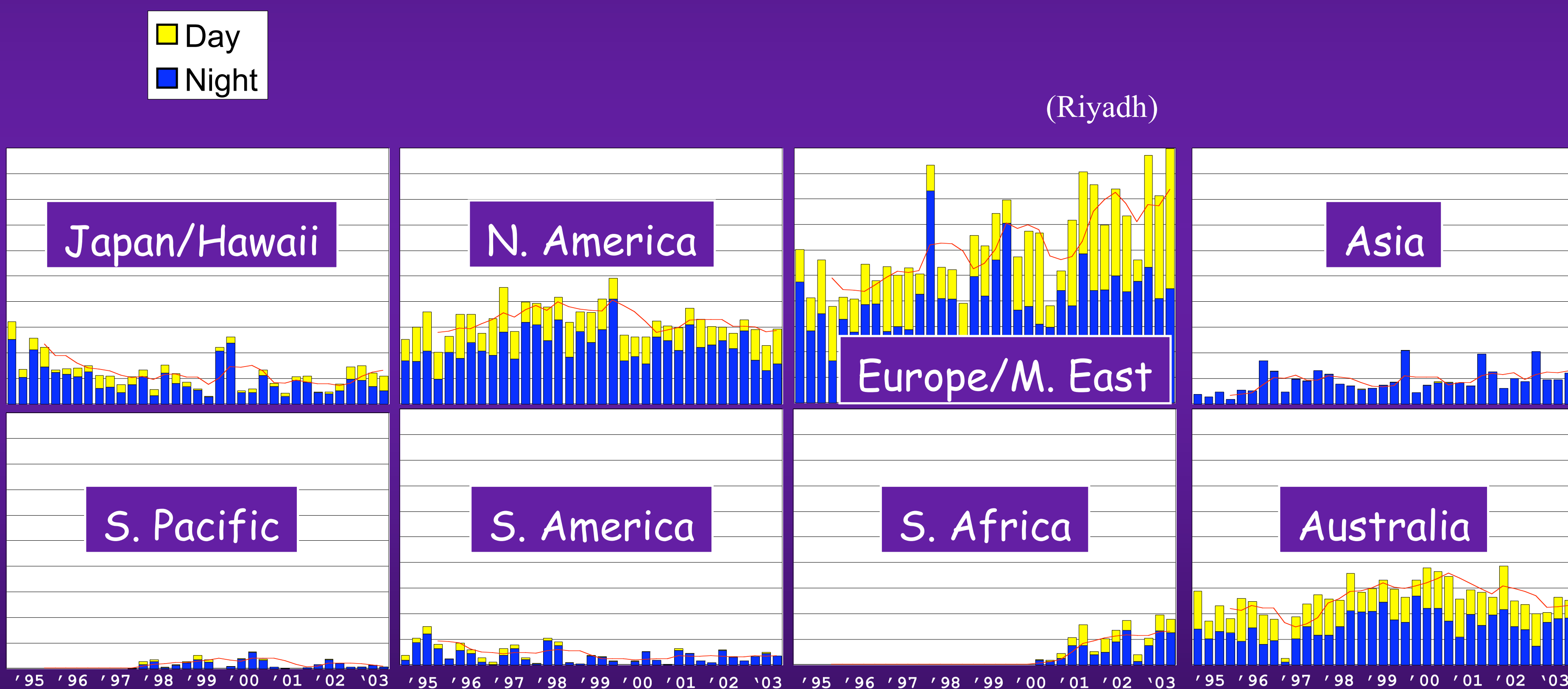
(Oct 2002 - Sep 2003)



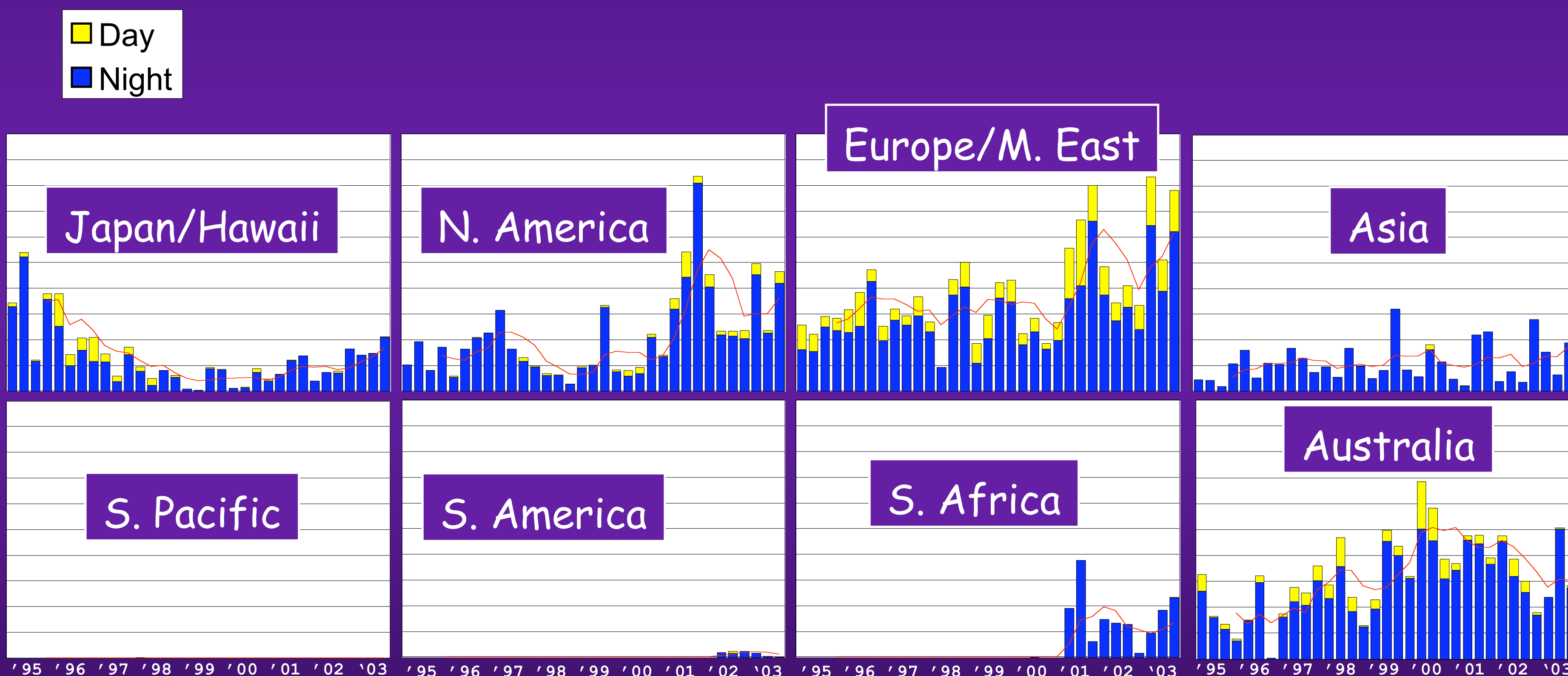


LAGEOS Passes (Jul-2002 to Jun-2003)
★ Night time only
18: Hours per day
LAGEOS2
LAGEOS1
Good
LAGEOS Satellite Passes
Performance Standard is 400 Passes
★ Mendeleevo2
Helwan
Passes
1400
1200
1000
800
600
400
200
0
Yarragadee
Monument Peak
Herstmonceux
Riyadh
Graz
Hartebeesthoek
Zimmerwald
Haleakala
McDonald
Wettzell
Changchun
Greenbelt
Mt. Stromlo
San Fernando
Simosato
Grasse
Matera (MLRO)
Concepcion
Shanghai
Potsdam
Grasse (LLR)
Borowiec
Maidanak1
Arequipa
Maidanak2
Beijing
Riga
Tahiti
Koganei (CRL)
Metsahovi2
Potsdam3
Golosiiv
Simeiz
Urumqi
Chania
Katsively
Wuhan
Lviv
Ajaccio
Komsomolsk
12
24
20
12
24
16
20
10
24
24
8
24
24
8
22
24
24
12
24
24
18

LAGEOS NP Data Yield



Etalon NP Data Yield



Problem: Bad Pointing

- Problem: Bad pointing accuracy, misalignments
  - Inherent precision of the telescope or the alignment procedures
  - Daytime degradation due to direct sun radiation → tens of arc seconds
- Impact
  - large field of view necessary
  - too much noise
- Possible actions
  - Protection/insulation → Herstmonceux, Potsdam, Zimmerwald
  - Daytime mount model (bright stars, red filters)

Problem: Sun Interference

- Problem: Possible damage by focussed sun light
- Solution:
  - Evasion routines: Maintain minimum distance to sun (e.g. 25 deg)
  - Emergency shutters
- Loss of a certain percentage of possible tracking coverage
  (e.g., 15 % when ranging down to 20 deg elevation)

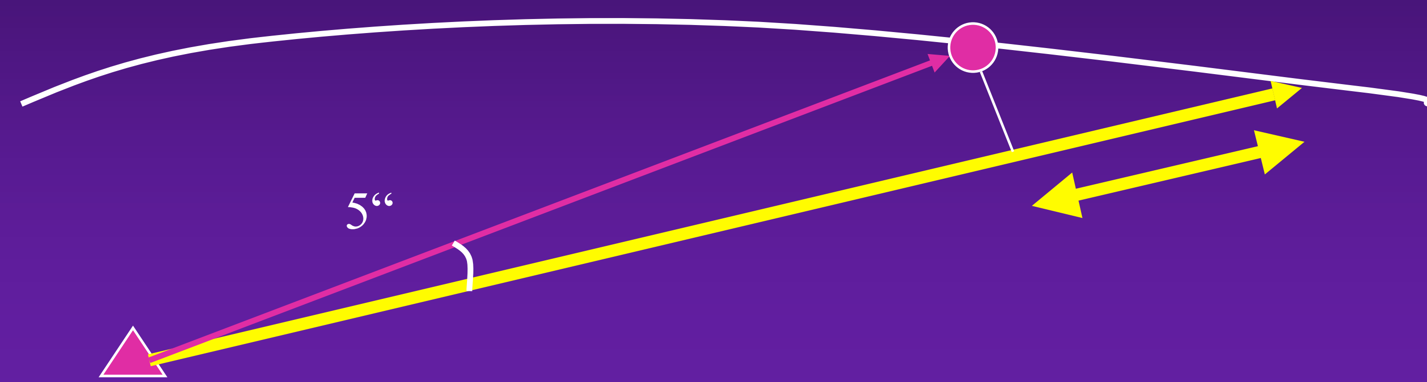
Problem: Background Noise

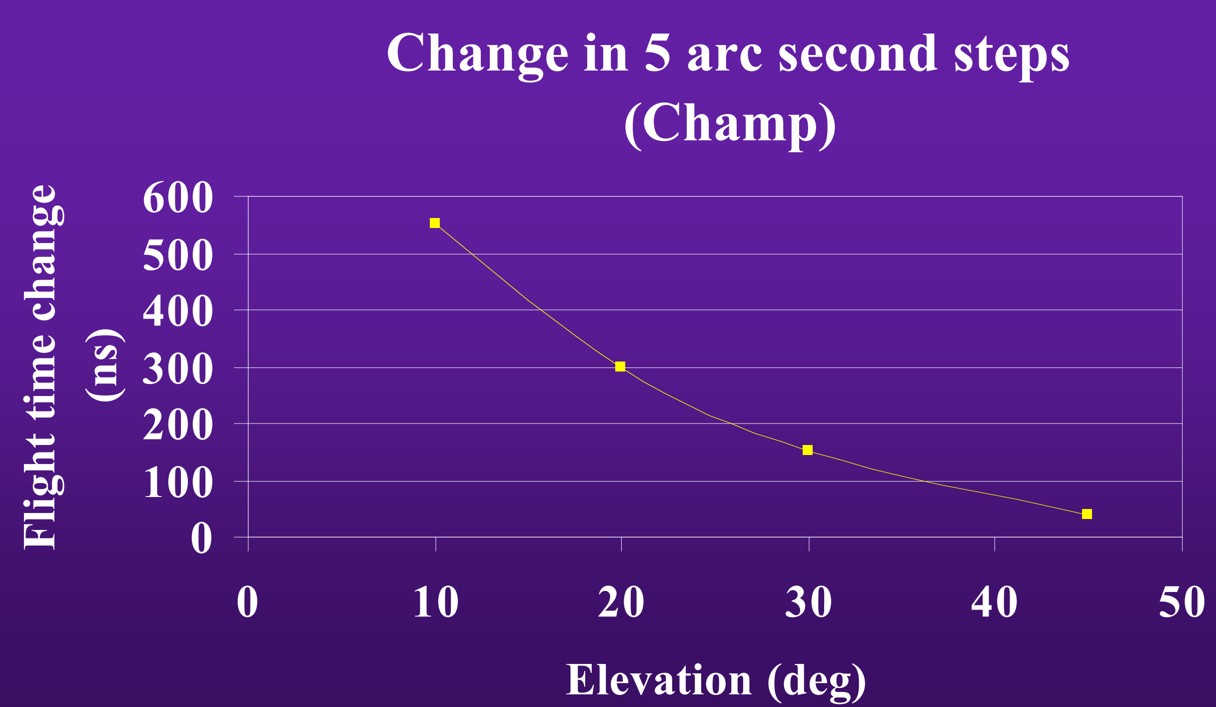
- Problem: Too much background noise
- Absolut Limit: 100 percent noise returns before laser return arrives at the sensor
- Solutions
  - Narrower spectral filter
  - Smaller window ←→ prediction
  - Smaller field of view ←→ prediction, pointing
  - Neutral density filter for strong satellites
  - Window swaying

Problem: High Orbiting Satellites

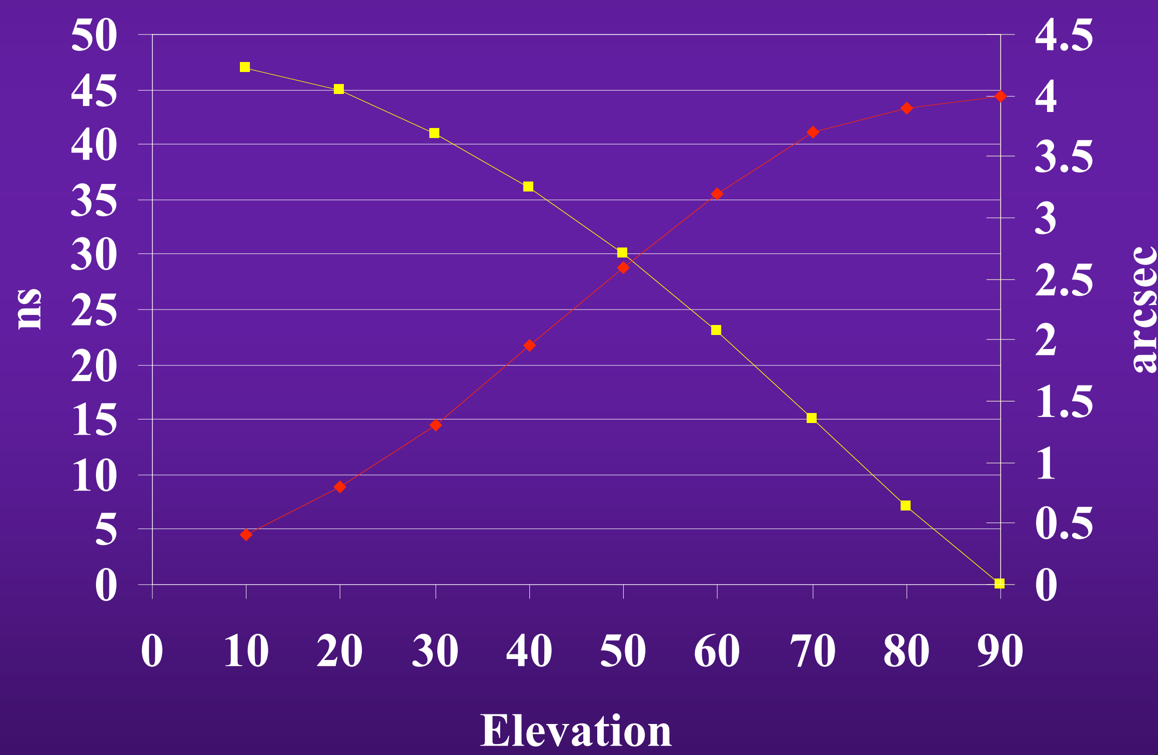
- Low signal to noise ratio
- Acquisition of echoes is difficult in the presence of noise (**one has to wait longer on one spot**)
- Searching for a satellite on a collimated system is difficult in the presence of a small telescope pointing error (**larger spatial segment needs to be scanned**)

Search and Range Gate Width





Delta range and pointing per ms along-track error (Champ)



Maximum Prediction Errors

(Herstmonceux)

- High-orbiting satellites: No problem (?)
- Stella,Starlette,Ajisai,Topex and Jason: < 5 ms
- ERS2,Envisat and GFO : < 30 ms
- Champ and Grace: < 40 ms

- Time bias functions for Champ and Grace: Problem
- Best prediction sets
  - ERS-2: GFZ
  - Envisat: Not ESOC

Prediction Quality

(Grasse)

- Very good on Lageos and Etalon (?)
- Poor predictions on GPS and Etalon (?) for daylight tracking
- Generally sufficient for LEO except Envisat, Grace and Champ

Realtime noise rejection / data identification

- Visual inspection of observed – predicted
- Histogram within window
- Direct comparison of obs-pred
- Convert obs-pred into □t, compare or form histogram (does not work well around C.A) (Grasse, Zimmerwald)

□ Improve predictions with realtime □t

Current limitations

- Pointing precision
- Noise
- Predictions
  - Range (time bias)
  - Position (?)
- Man power
- Schedule (high orbit satellites skipped when LEOs are around)

NASA SLR Daytime Tracking

Successful daytime tracking requires a system design approach concentrating on Signal-to-Noise ratio.

No one component will enable effective daytime operations unless the remaining system, both HW and SW, is capable.

- Experienced, well trained operators
- 10Å daylight filter (~ 65% transmission)
- Triple gated receive signal (+/- 40 nsec around signal)
- 532 nm "Peaked" transmit/receive optics
- Variable receive iris
- Telescope shroud to limit off axis light to 10 degrees
- Variable optical ND filter for receive signal amplitude control

NASA SLR Daytime Tracking

- Precise satellite pointing vectors
- Precision transmit/receive boresight
- Calibrated Constant Fraction Discriminator
- Precision mount pointing performance (+/-2.0 arcsec)
- 30 arcsecond transmit beam divergence
- Precise star calibration
- Daytime to nighttime focus adjustment
- 0.76 meter Receive Telescope
- 100 millijoule, 200ps laser