Graz kHz SLR Station

Measuring Atmospheric Seeing with kHz SLR

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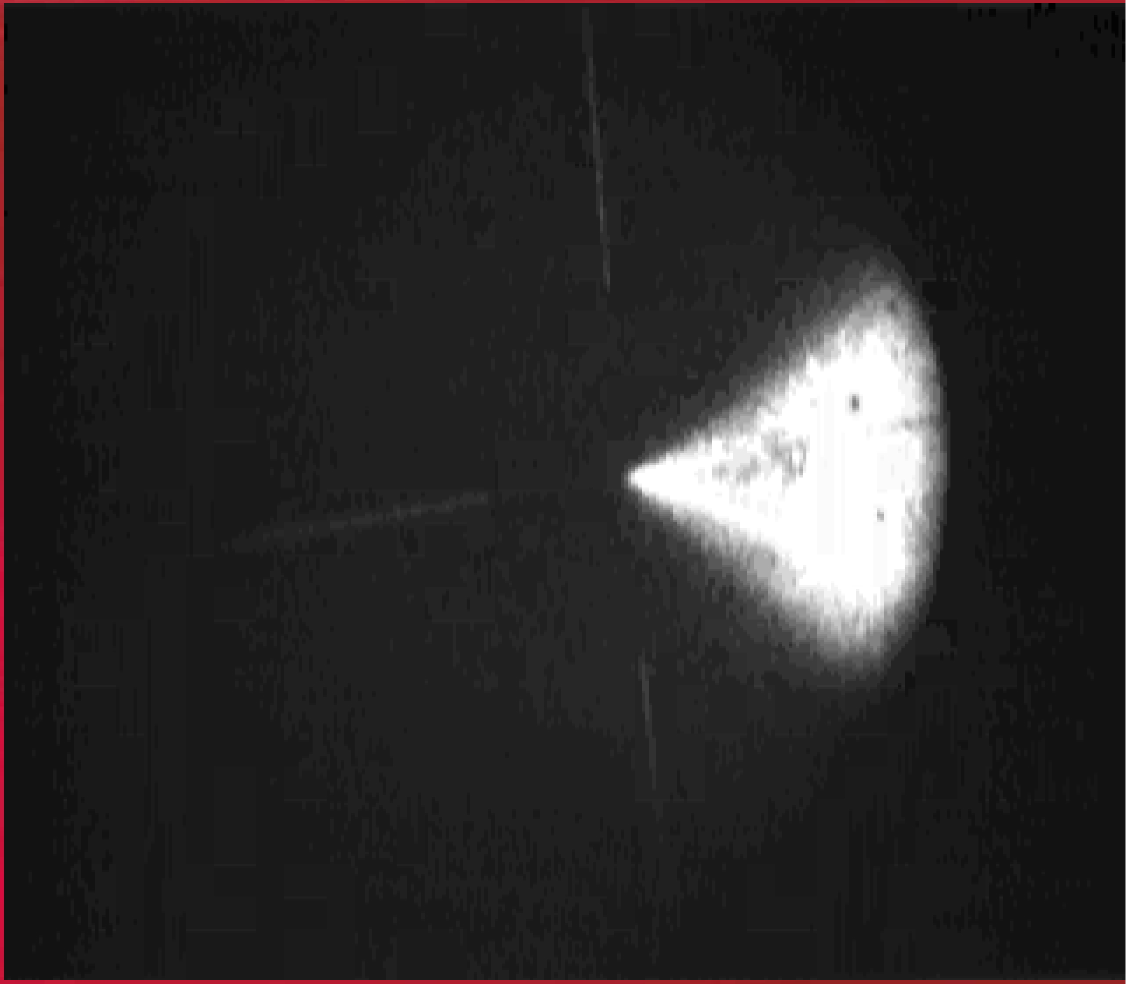
Canberra, Oct. 2006

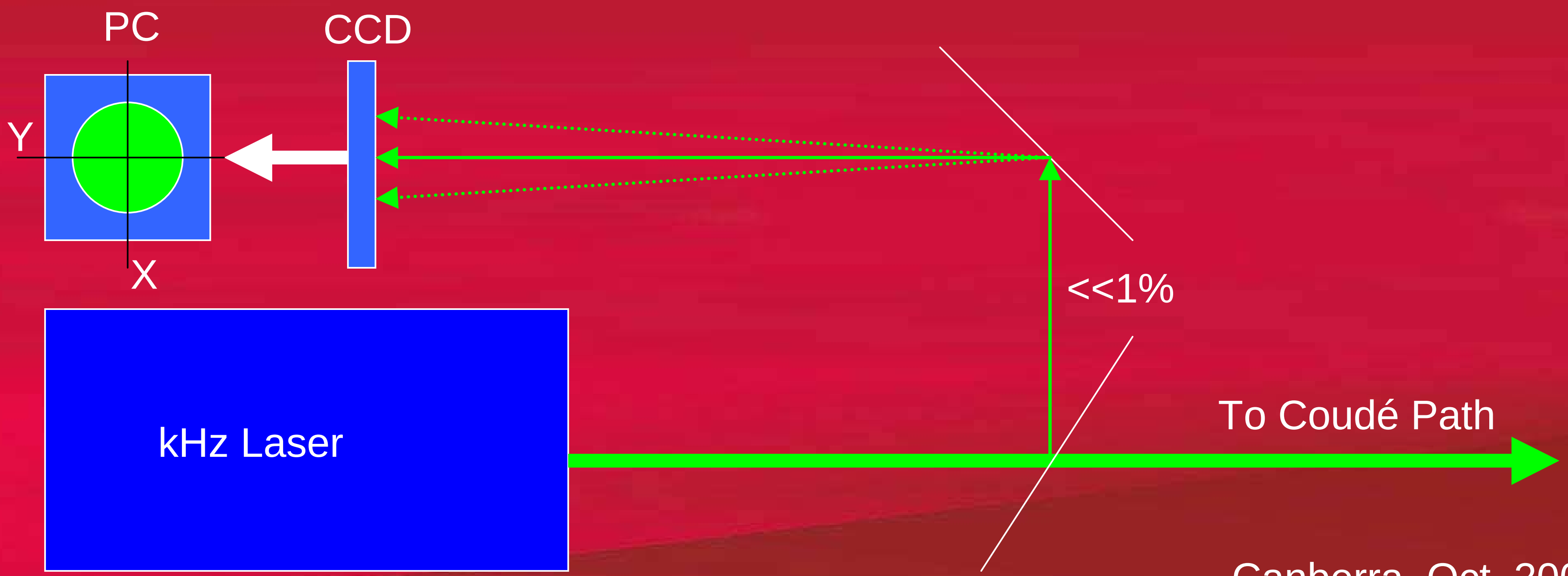
Beam Pointing: Not always stable ...

- Laser Beam, night time
- Backscatter, seen by ISIT
- 25 Frames per second
- Pointing is NOT stable
- Pointing Jitter: up to 50 µrad
- Frequency of this wobbling: Few Hz up to few 10 Hz



Possible Reason: Laser Beam Pointing ?

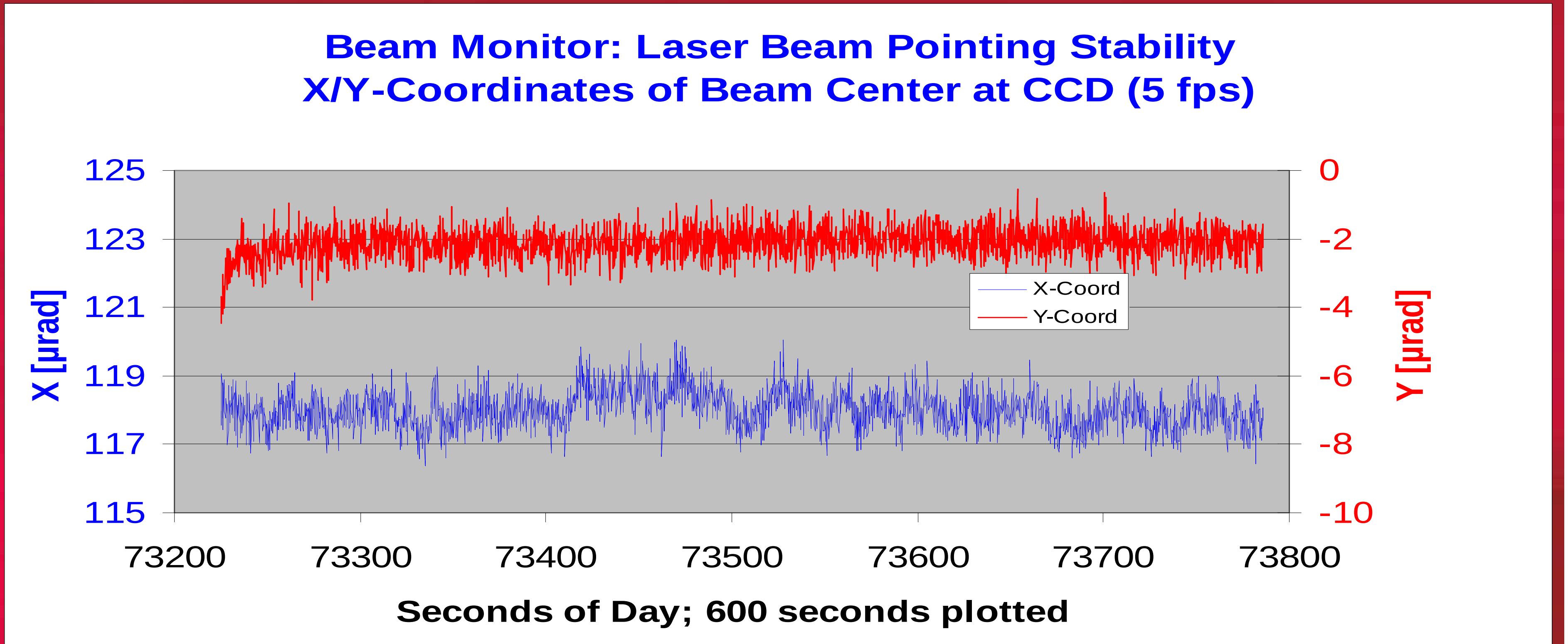
- We installed a **Laser Beam Monitor** at the laser box beam exit:
  - A mirror reflects a small portion (<< 1%) of the laser on a CCD chip;
  - CCD Image: Monitored by a PC, with up to 30 fps;
  - Center Coordinates of Beam (X / Y) calculated, and stored.



Possible Reason: Laser Beam Pointing ?

- Only few µrad (<<1“) wobble (mainly measurement accuracy);
- Even THAT is DEcreased by following beam expander;
- Bigger DRIFTS only at switch-on / warm up (not shown here)

➔ **Conclusion: Wobble is NOT caused by Laser Beam Pointing Instability.**

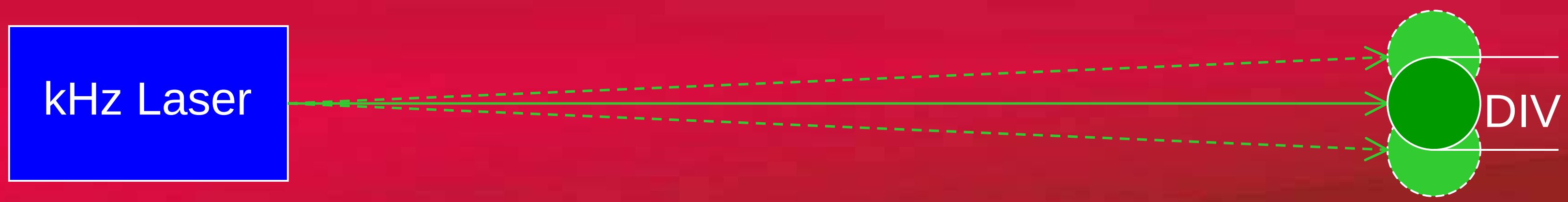


Other possible reason: Atmosphere ...

- Beam Wobble caused by atmospheric micro-turbulences
  => Atmospheric „Seeing“:
- Expected Amplitudes: Some Arcseconds
  - Laser Beam Wobble: Up to 50 µrad (= 10“)
  - Expected Frequencies: From few Hz up to few 10 Hz
  - Can be more than 100 Hz, but at decreasing amplitudes ...
  - Laser Beam Wobble: Up to 10 or 15 Hz visible at ISIT images

Seeing Effects for SLR ???

- Graz Beam Divergence (< 10“) and Seeing (≈ 2“ – 7“):
  - Both with Similar Magnitudes ...
  - Seeing for SLR can be WORSE than Astronomical Seeing:
    => Fast moving telescope, faster changing atmospheric conditions
- Degrades laser pointing accuracy
- May reduce return rates;
- No problem for LEOs, but may have effects for GPS etc.



What worsens „Seeing“ ?

- Seeing Values are influenced by:
  - Actual atmosphere: Wind; layers, gradients etc.
  - Elevation of Satellite: Seeing is worse at lower elevation
  - Temperature differences: Seeing is worse in winter time:
    - Graz Observatory rooms are heated; but isolation is almost ZERO
    - This causes lot of turbulences around station in WINTER time ...
  - Motion of telescope: Seeing is worse at higher speeds !!!

Measuring Seeing: Standard Method

- Hartmann – Shack: 2 Holes at the entrance pupil;
- Observing Polar Star: Gives 2 spots on the CCD sensor;
- Variation of spot distances gives Seeing Value

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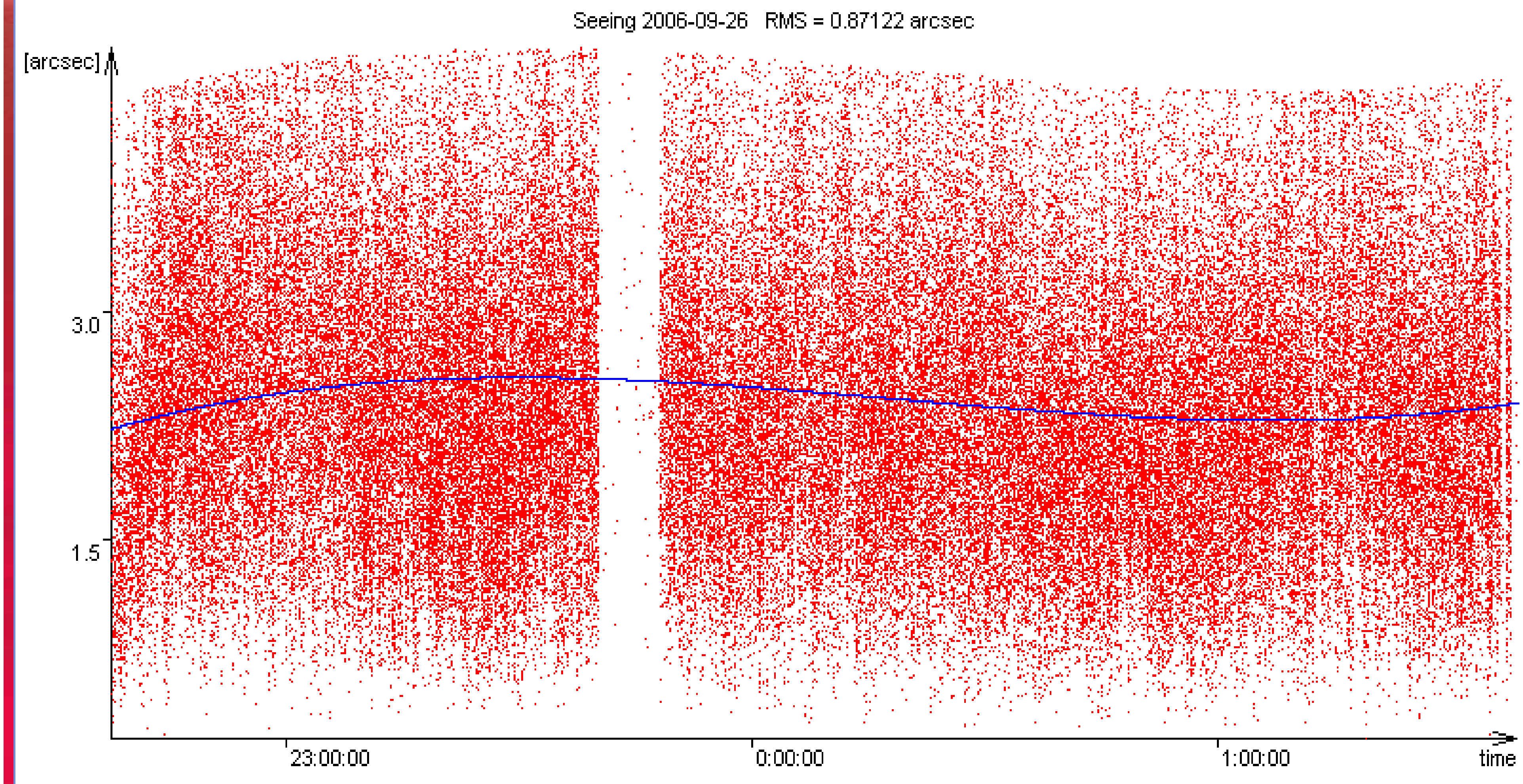
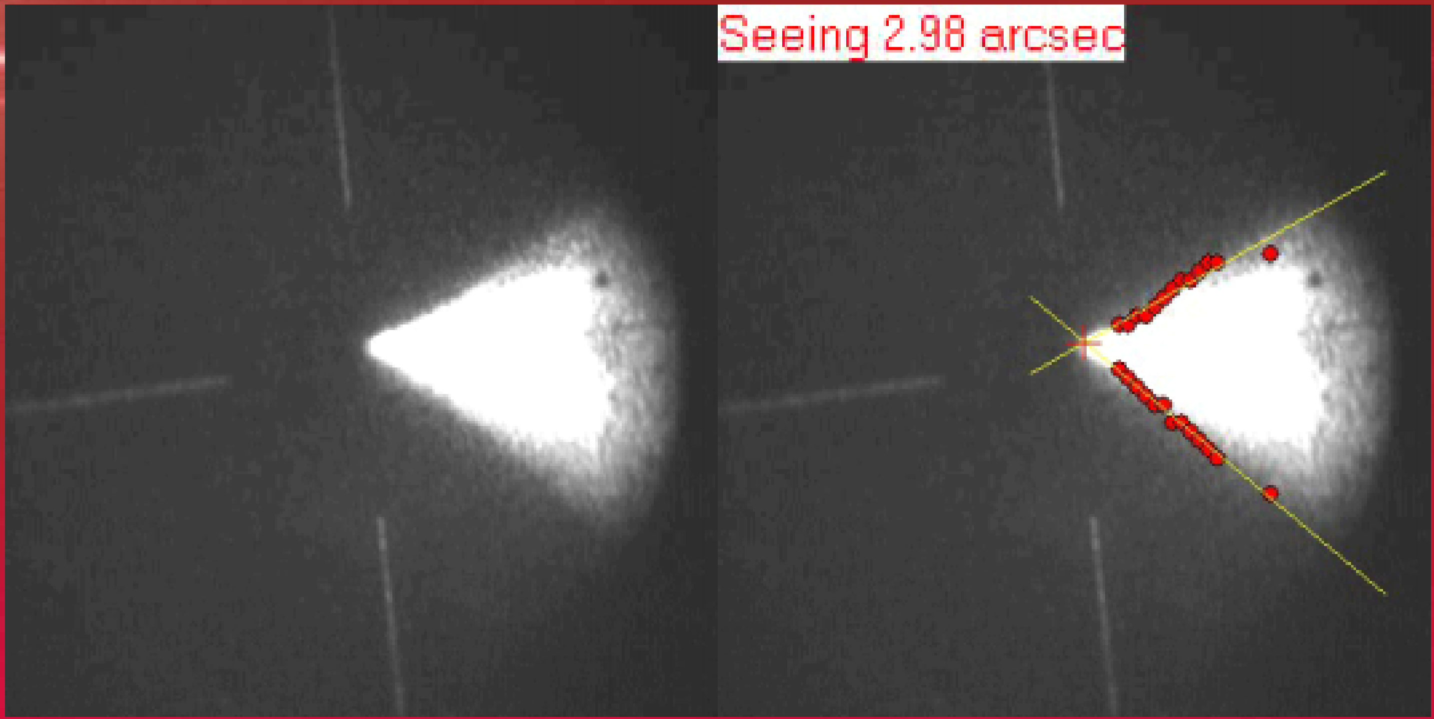
Seeing Values with Hartmann-Shack



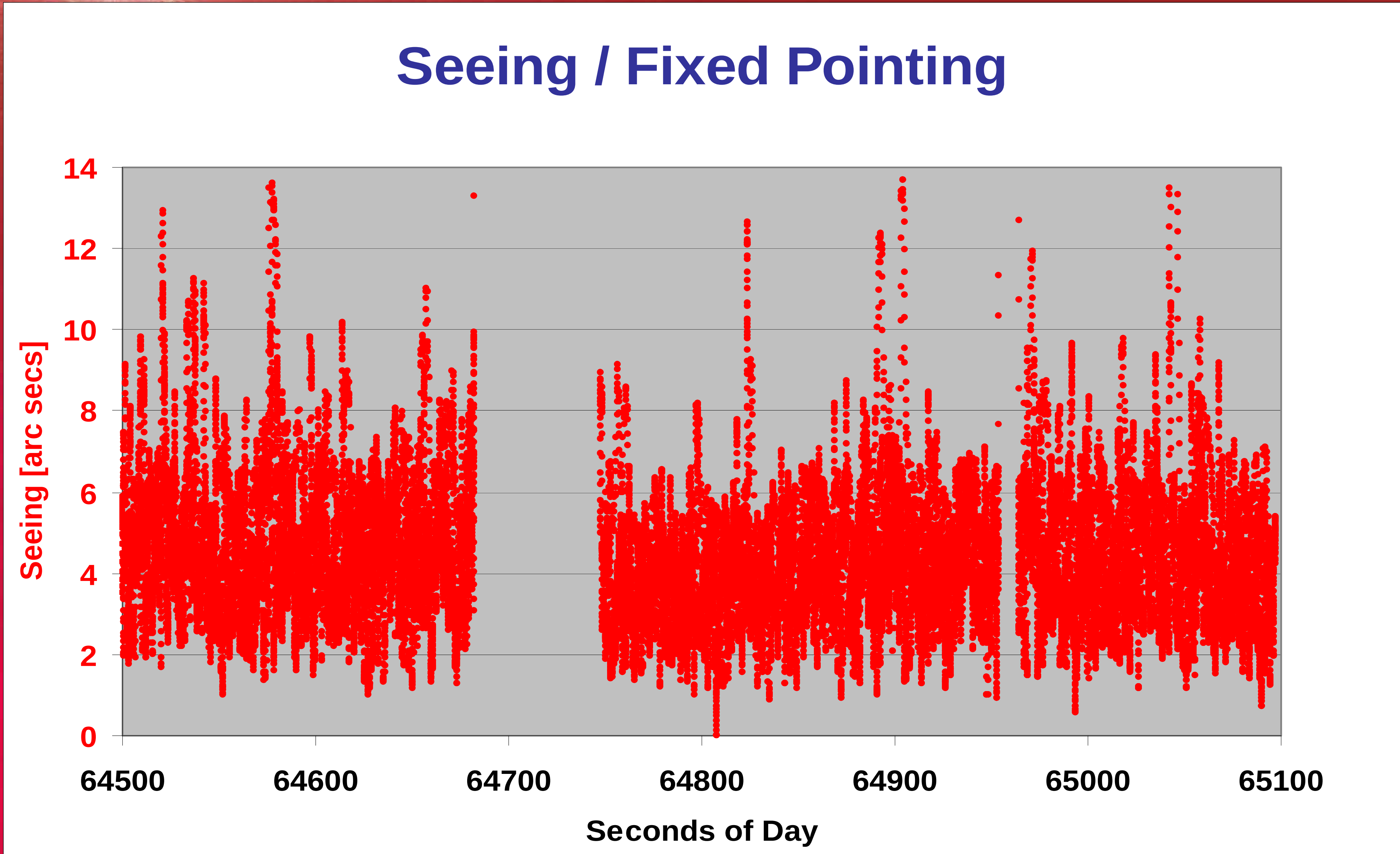
- Our „Best“ Seeing ever measured: Below 3“ during 3 hours

Deriving Seeing Values from kHz

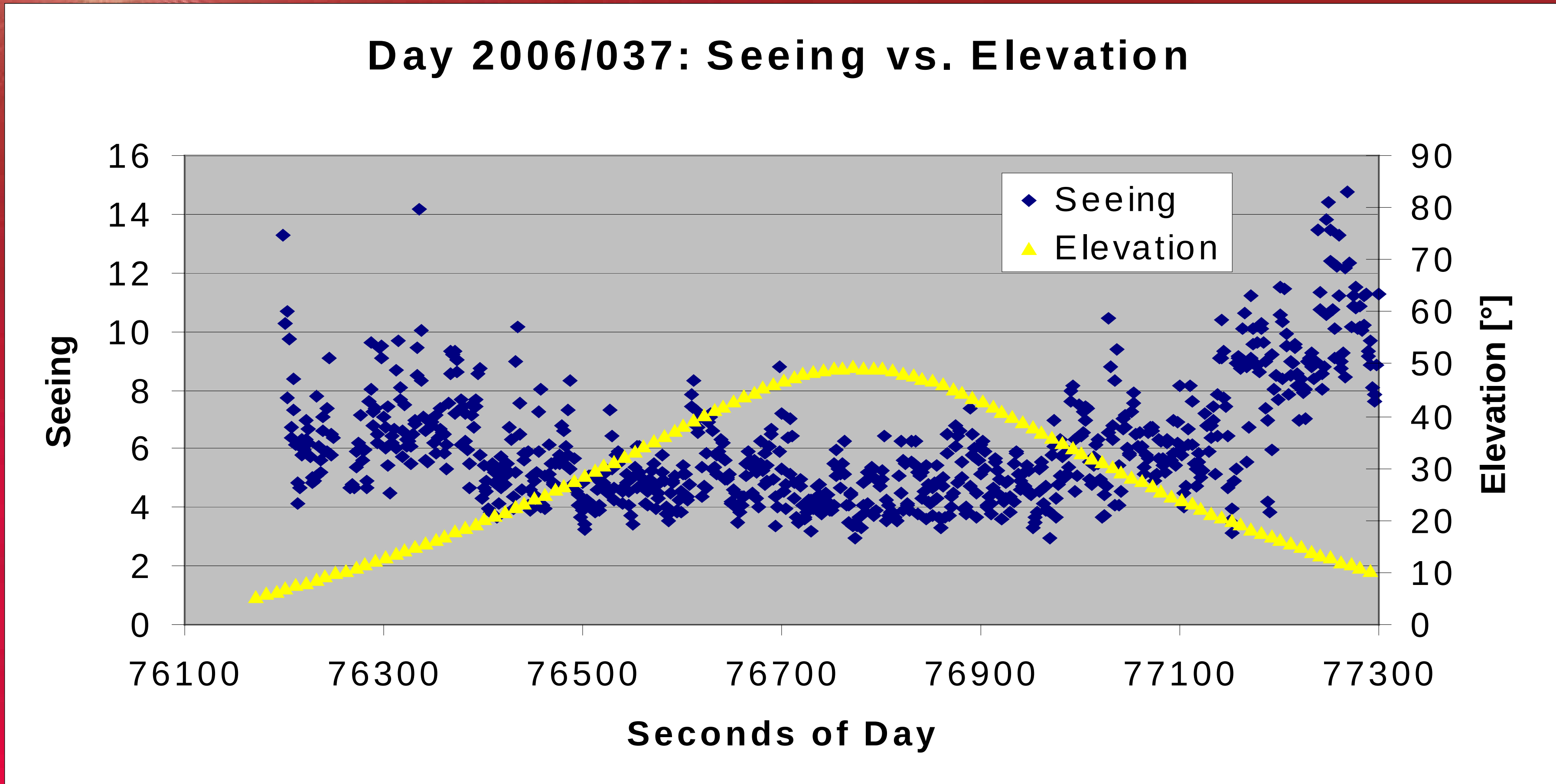


- Laser Beam Backscatter is monitored by ISIT; frames into PC
- Real Time Image Processing: Determine Peak of Laser Beam;
- Coordinates of Peak determine Seeing Area;
- FWHM of this area => Astr. Seeing (arc secs);
- Compare with Hartmann – Shack Results

Seeing Values derived from kHz Laser

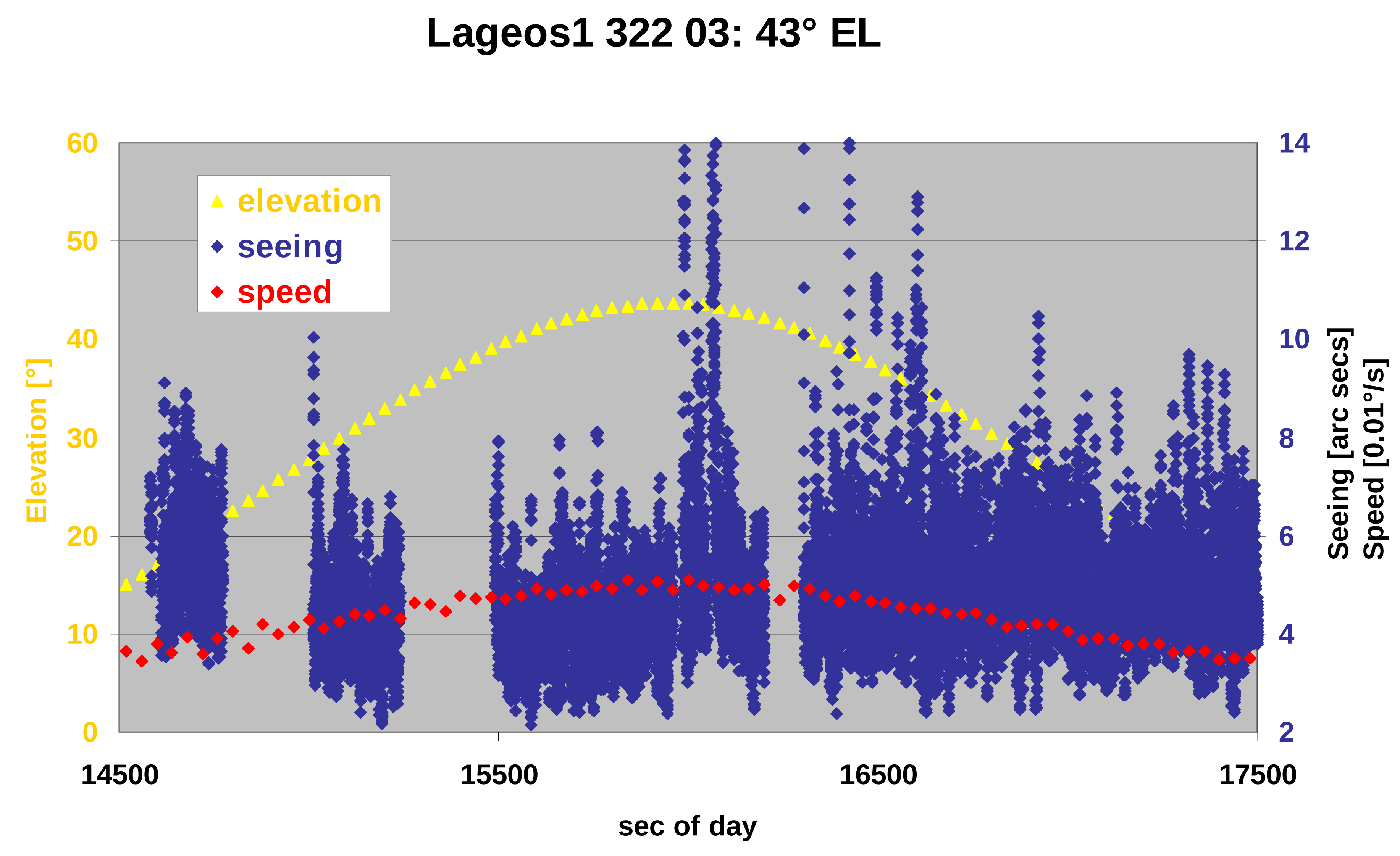


Seeing Values Derived from kHz Laser



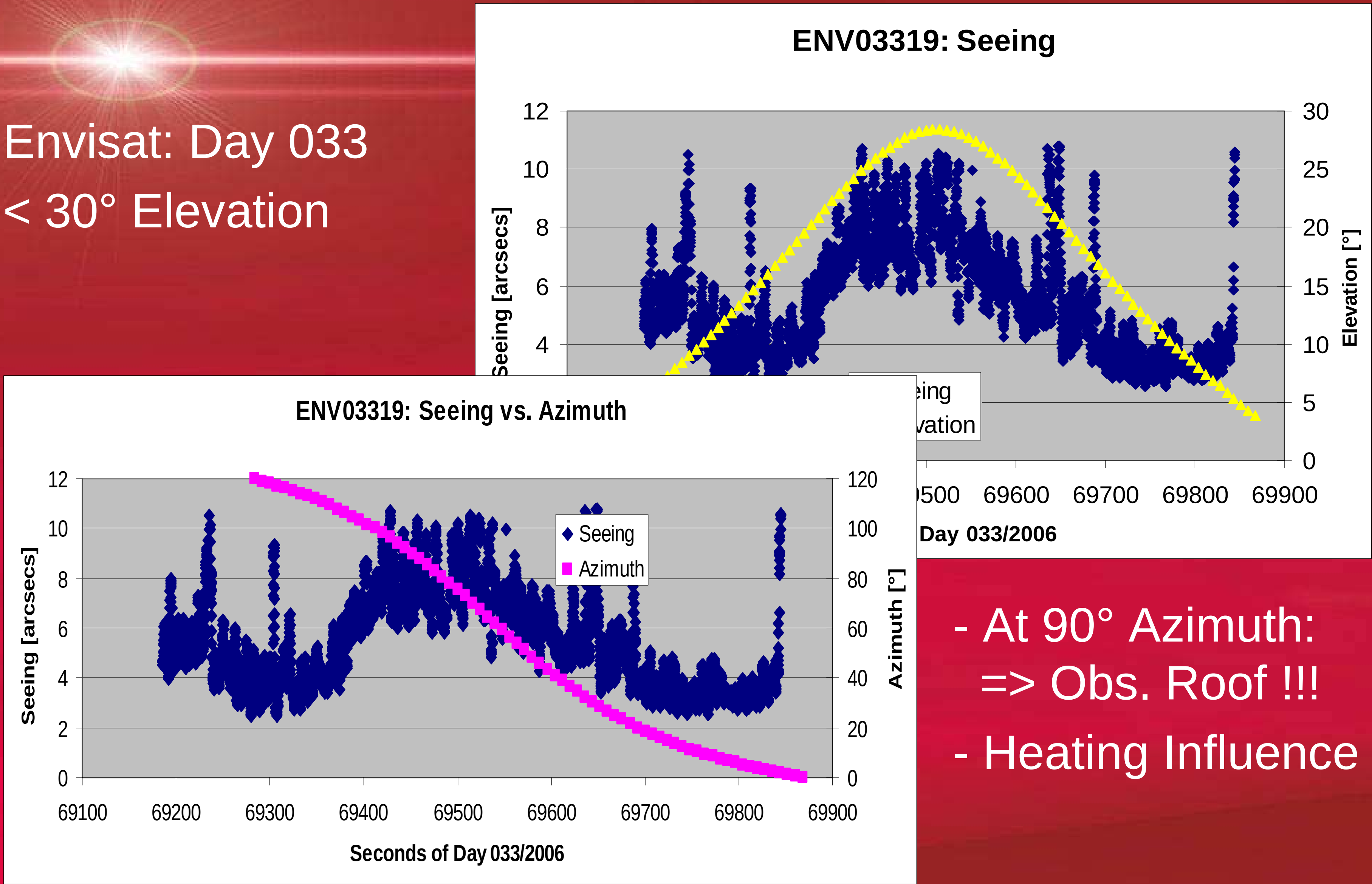
Ajisai / Day 037/2006: Seeing changes with elevation ....

Seeing Values Derived from kHz Laser



Seeing Values Derived from kHz Laser

- Envisat: Day 033
- < 30° Elevation



- At 90° Azimuth:
  => Obs. Roof !!!
- Heating Influence

Conclusions:

- It is possible to derive Seeing Values from a kHz Laser Beam;
- Seeing Influence is BIG enough to spoil Laser Beam Pointing;
- This might reduce Return Rate from High Orbiting Sats;
- Biggest Influence in Graz: Heating of Observatory
    - We have to live with it – or freeze to death ☺
- Plans to reduce effect with a Fast Steering Mirror, controlled by Seeing Offsets derived from kHz Beam (10“ max, 40 Hz max);

Thank You ☺