kHz SLR Graz

Millimeter Accuracy from Centimeter Targets

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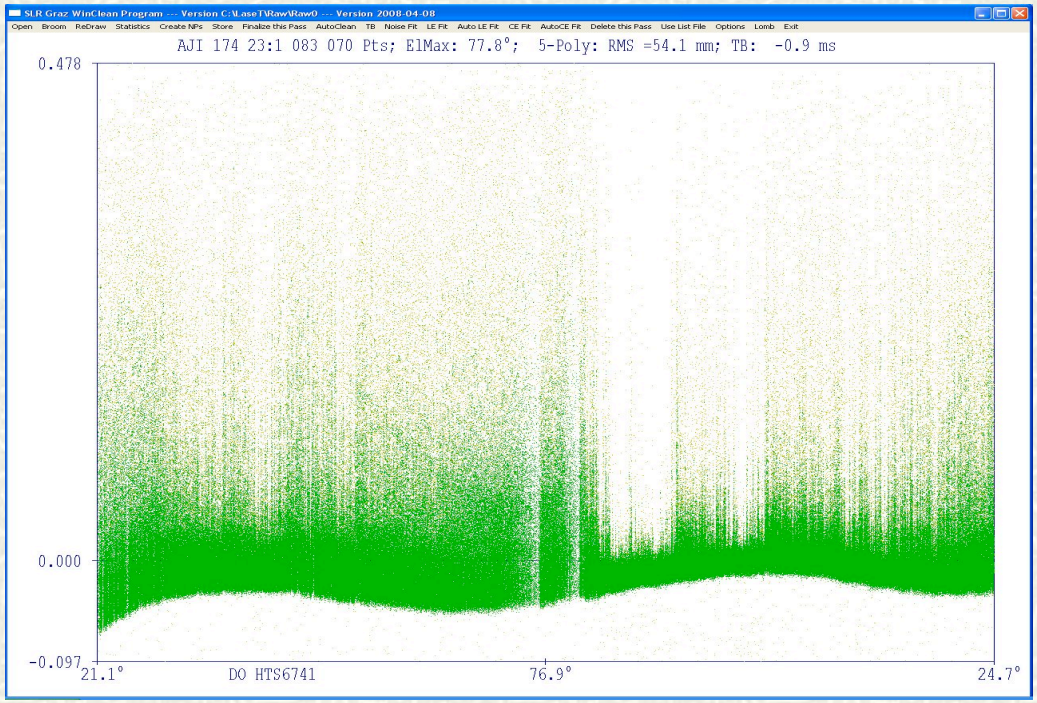
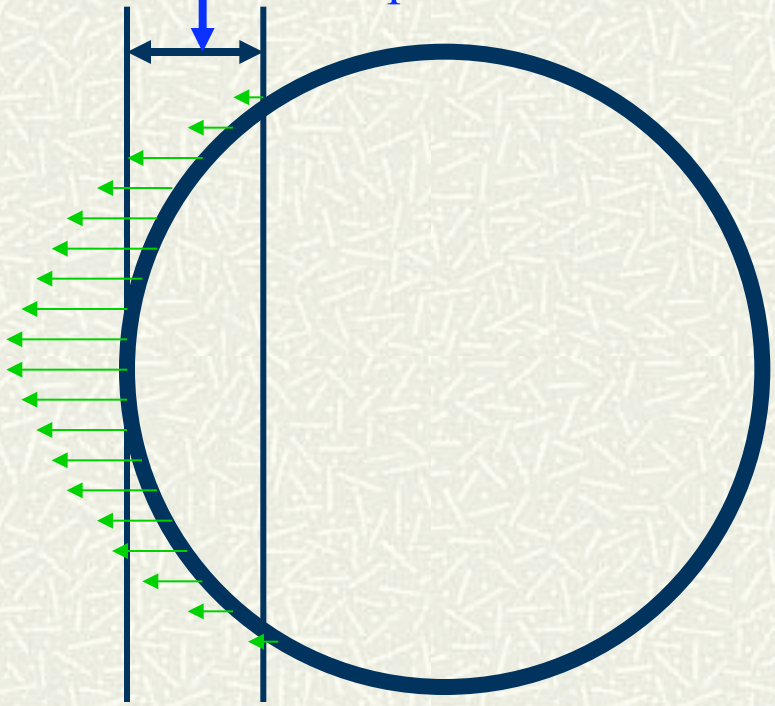
*What we **HAVE**: Centimeter Targets*

- LAGEOS-1, LAGEOS-2, AJISAI, ...
- **Reflective Depth: Satellite Signature**
- **For AJISAI: > 300 mm**
- **For LAGEOS: > 80 mm**
- TRUE „CM“ Targets ☺

80 – 300 mm depth

Spherical Satellite

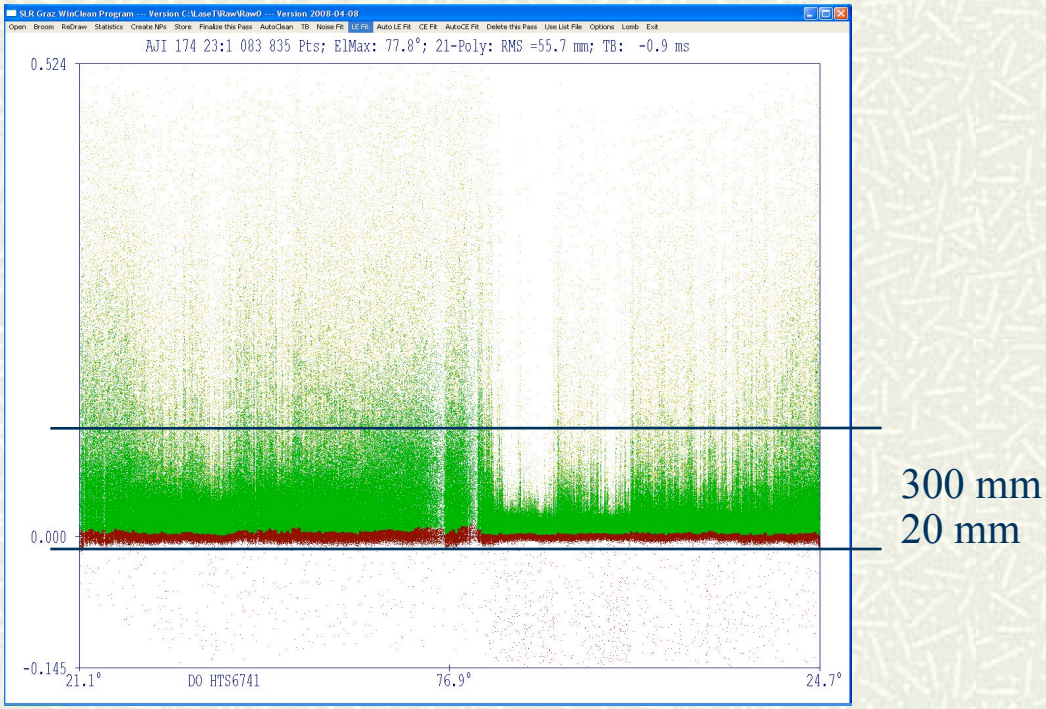


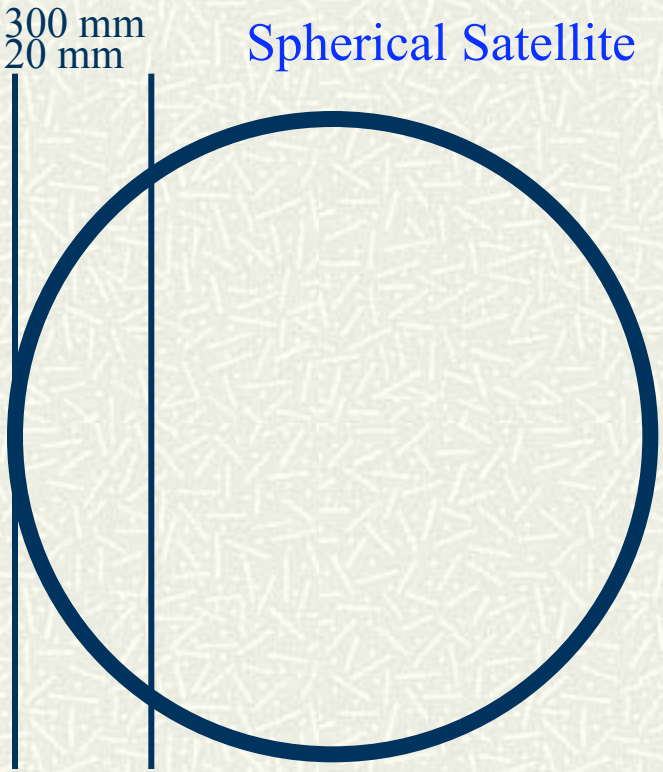


What we **NEED**: *Millimeter Results*

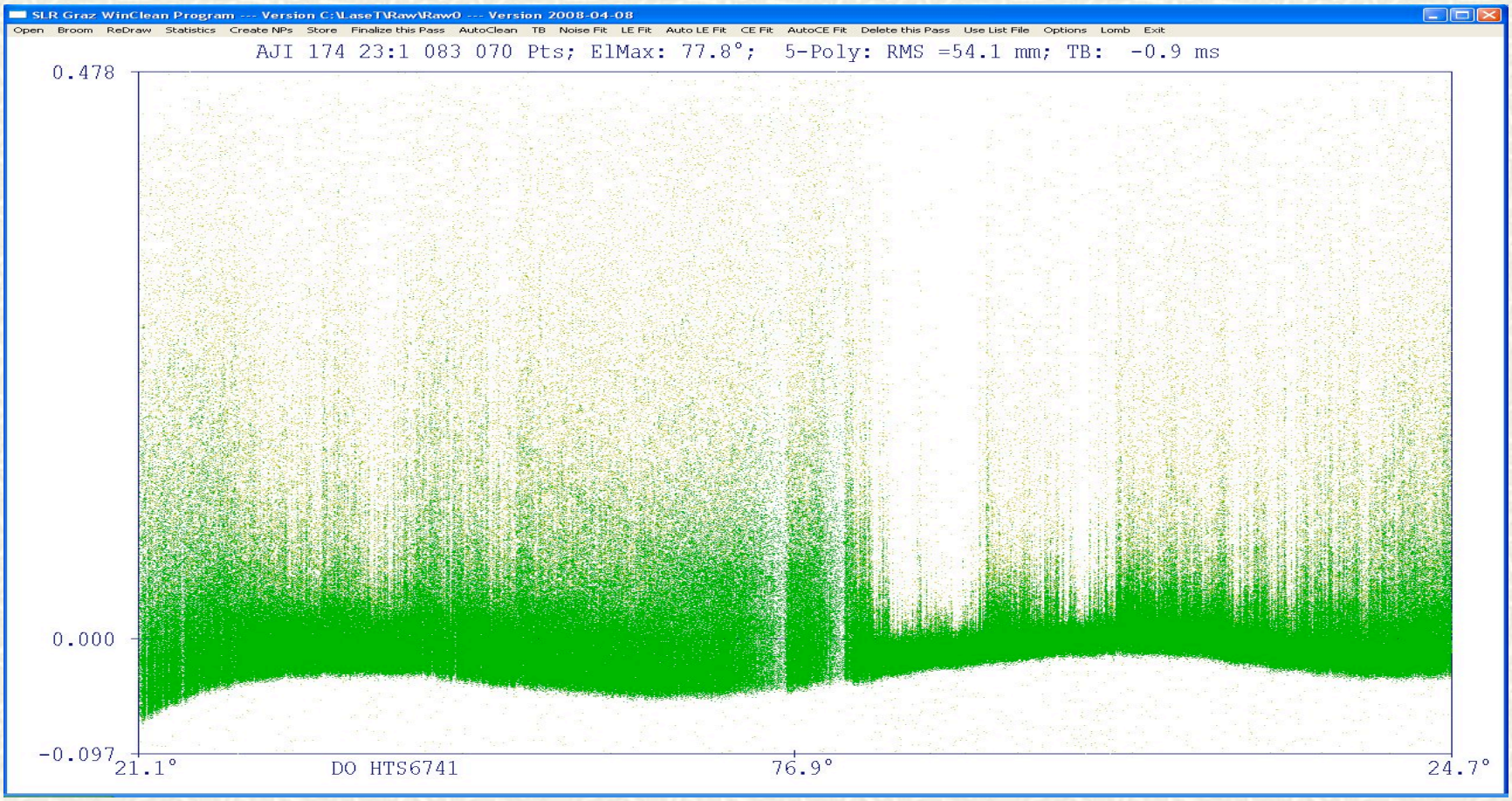
A possible solution, used in Graz / kHz SLR:

- We accept **ONLY** returns from **NEAREST** Retros
- Reflective Depth is reduced to **20 mm only**
- All returns behind that are rejected (~ 30%)



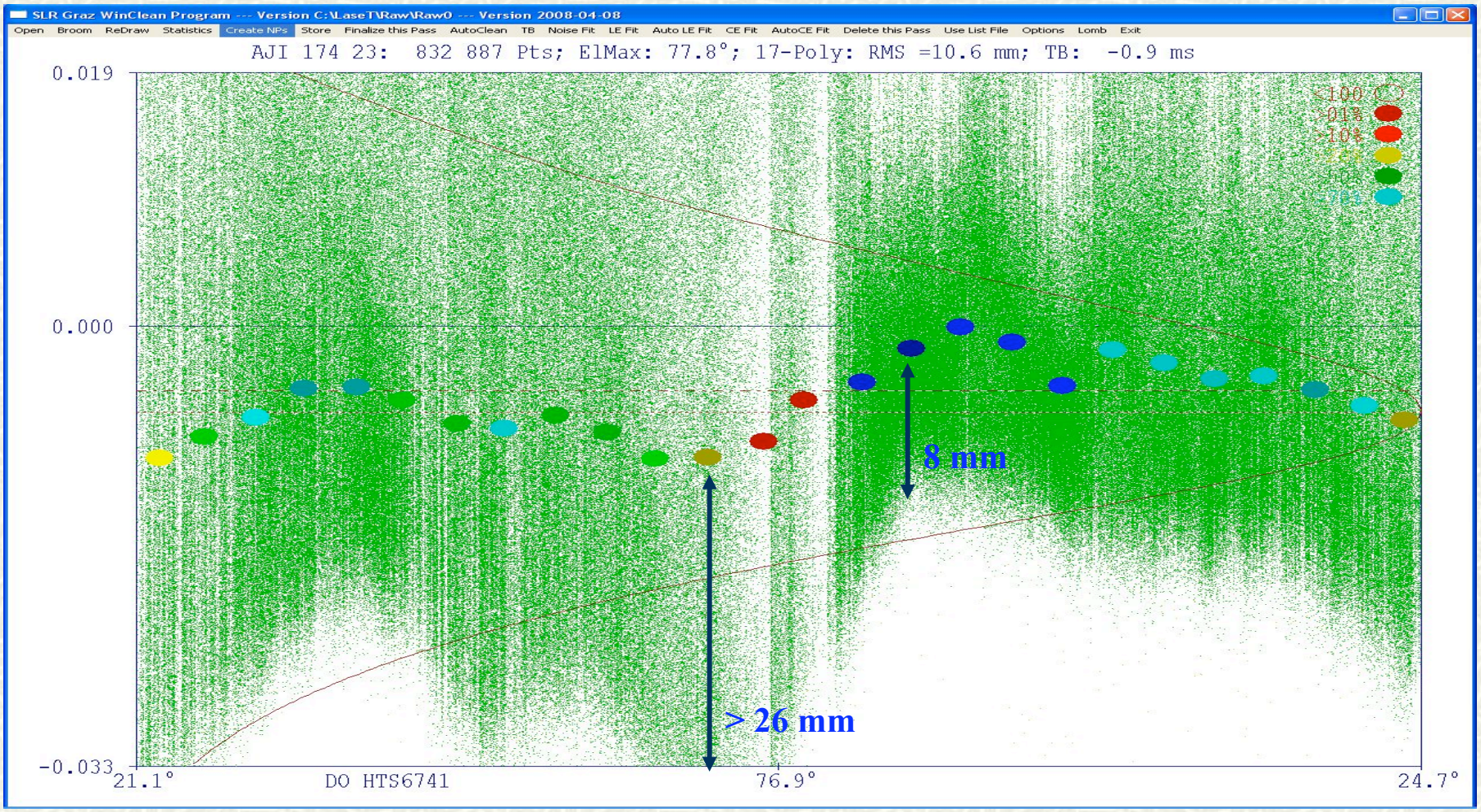


Example: AJISAI



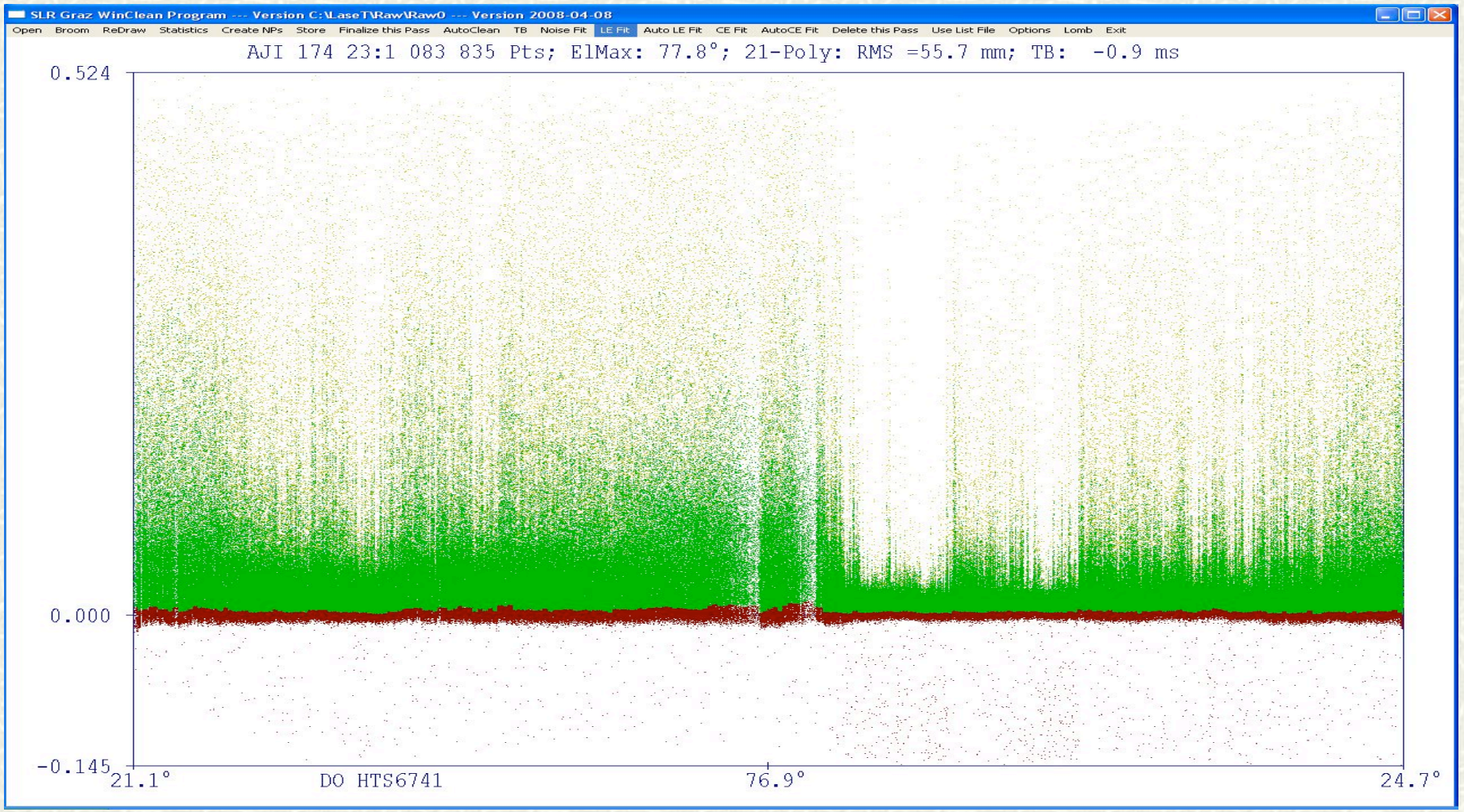
- Raw Data: > 1 Million points, with big variations of return energy;
- Reflection Depth: > 300 mm (Single Photons);
- Strong Returns from Nearest Retros

Not a good post-processing ....



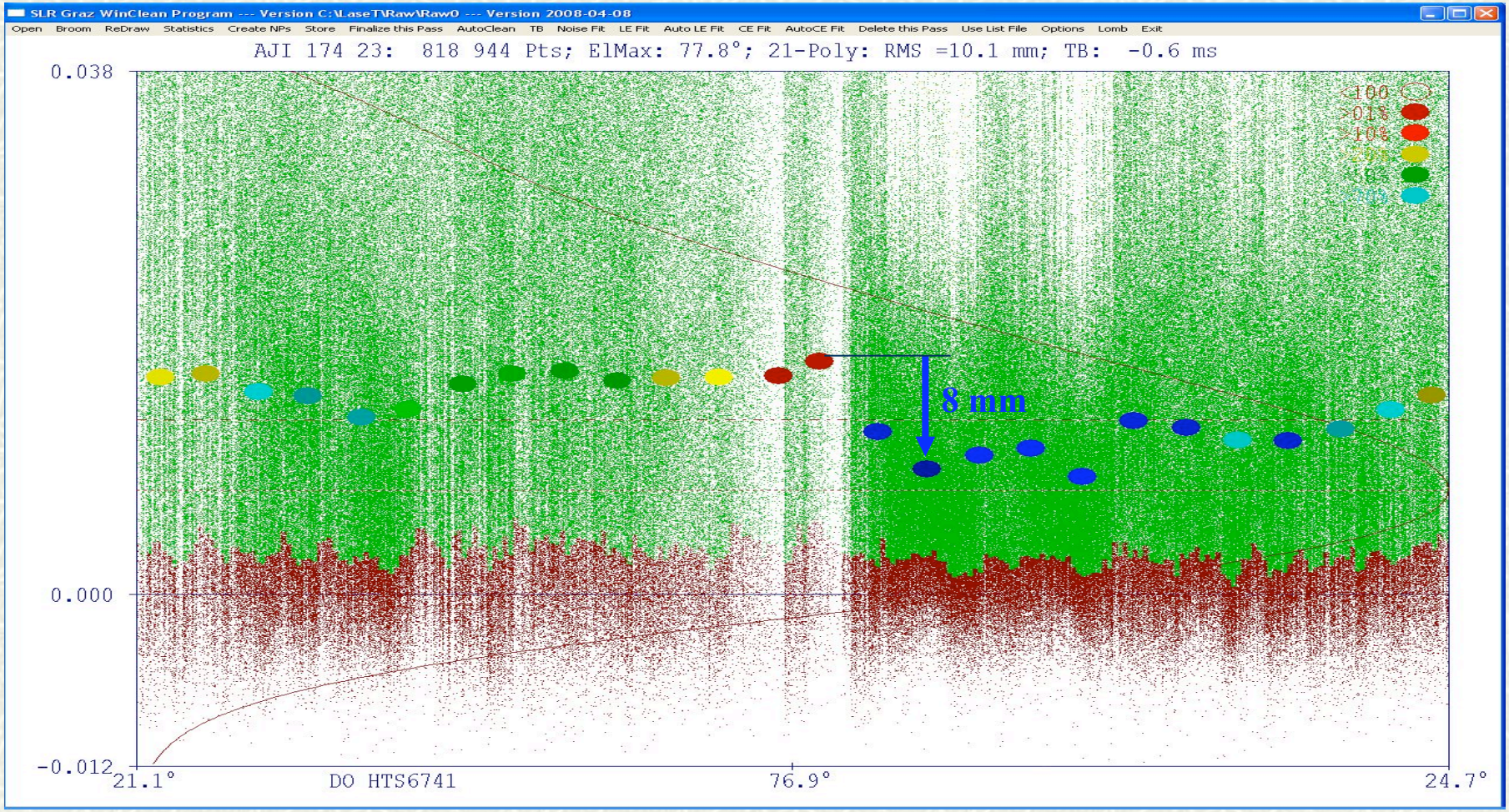
- Big variations of reflection points / NP distances to Leading Edge
- 2.5 Sigma: > 10 mm RMS; 0.282 Skew; NPs: big variations...

Better Post-Processing ....



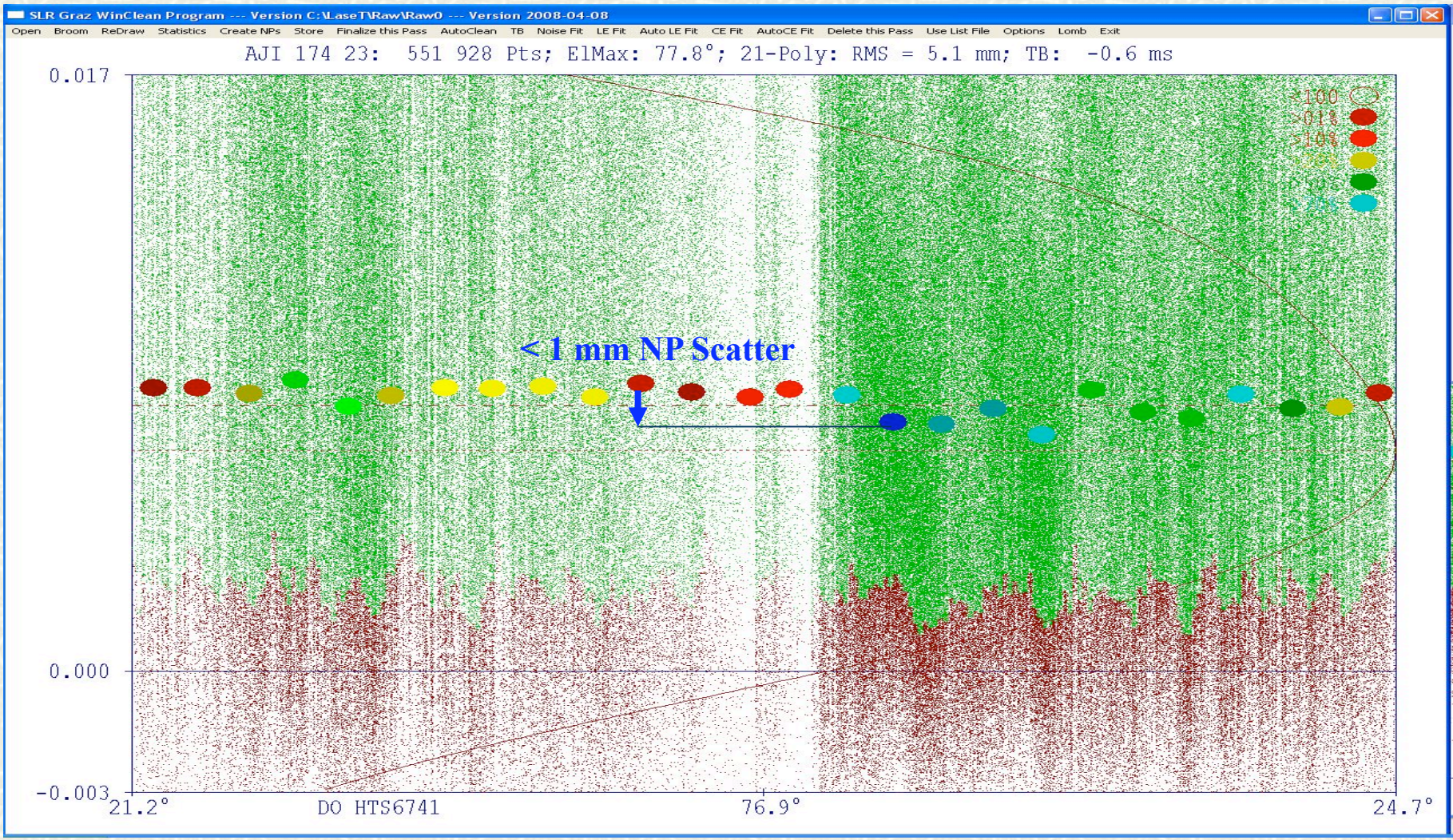
- Poly-Fit to „Leading Edge“ (Returns marked ‘RED‘)

Leading Edge Fit, 2.5σ : Better...



- LE, 2.5 σ, 10 mm RMS, NPs: Still 8 mm diff ...

LE Fit, 2.2σ, 20 mm Max Depth …

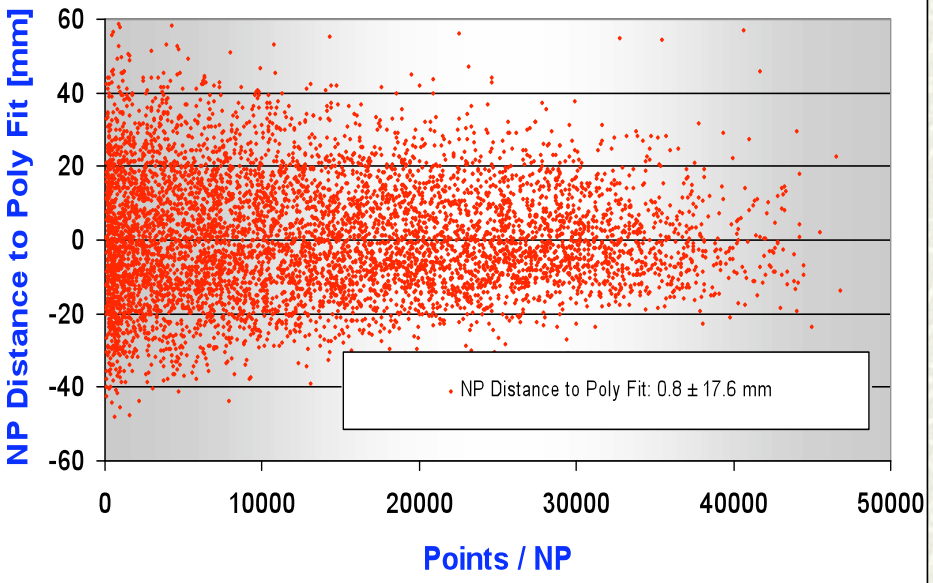


- Only first 20 mm of Reflective Depth accepted: **NP Scatter: < 1 mm**

AJISAI: Big improvement …

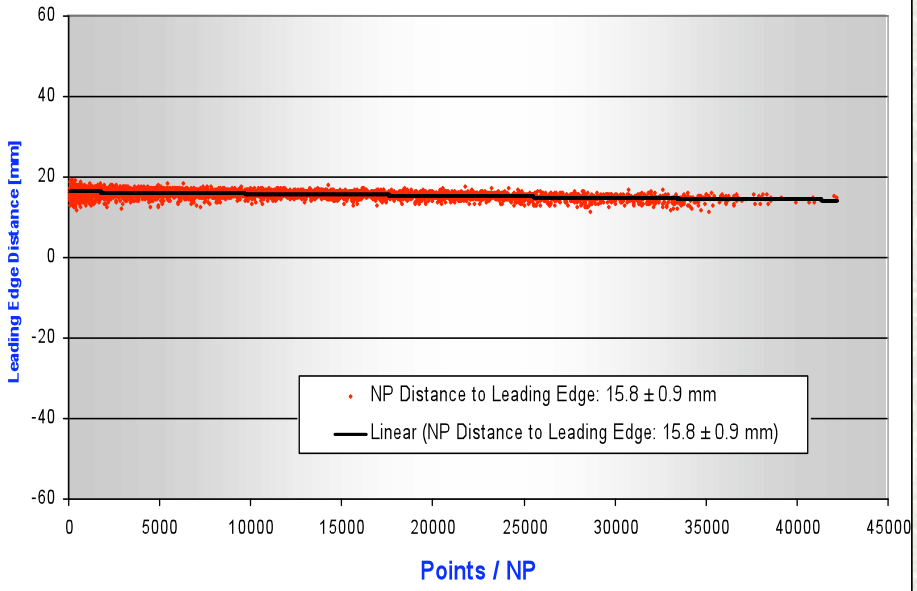
AJISAI 2007: Standard Post-Processing:

Distance of each NP to Poly Fit: 0.8 ± 17.6 mm



AJISAI 2008: Leading Edge Post-Processing:

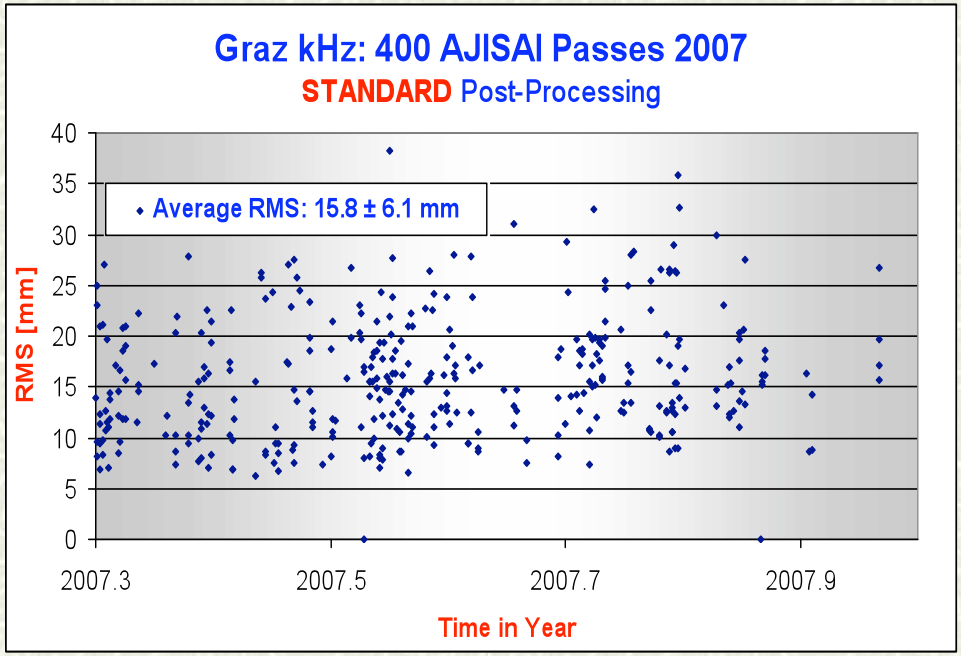
Distance of each NP to Leading Edge: 15.8 ± 0.9 mm

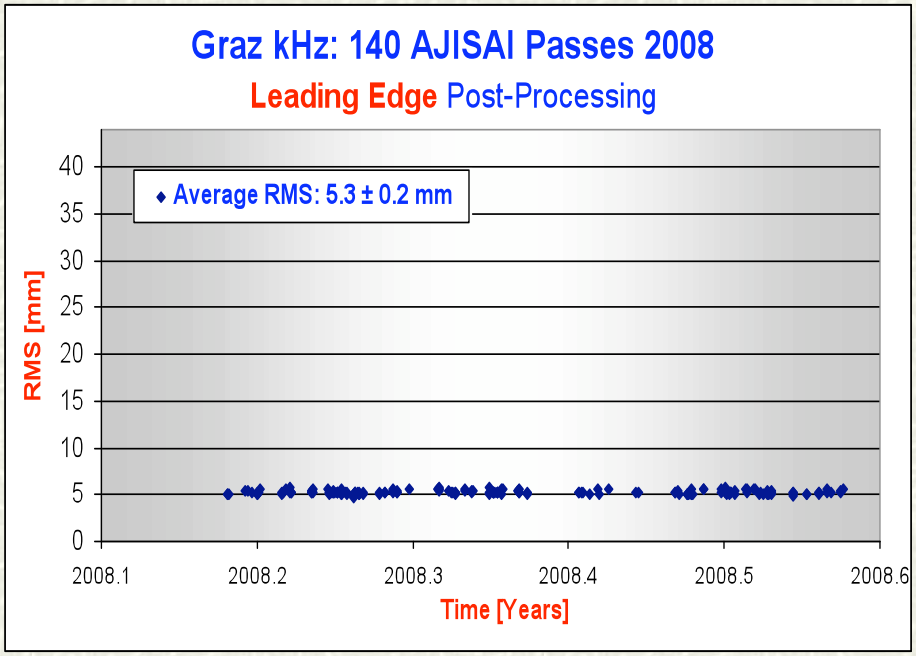


- AJISAI Standard Post-Processing
- NP Distance to Poly Fits: 0.8 ± 17.6 mm
- BIG NP Scattering referred to LE

- AJISAI LE Post-Processing:
- NP Distance to Poly Fits: 15.8 ± 0.9 mm
- STABLE NP Distance to LE

LE Post-Processing: AJISAI passes

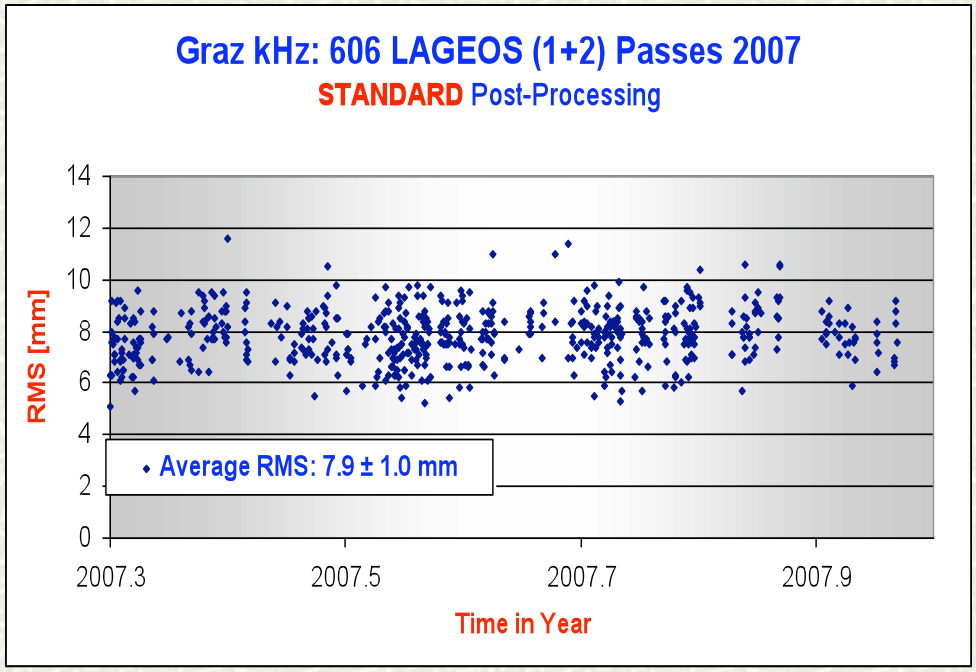


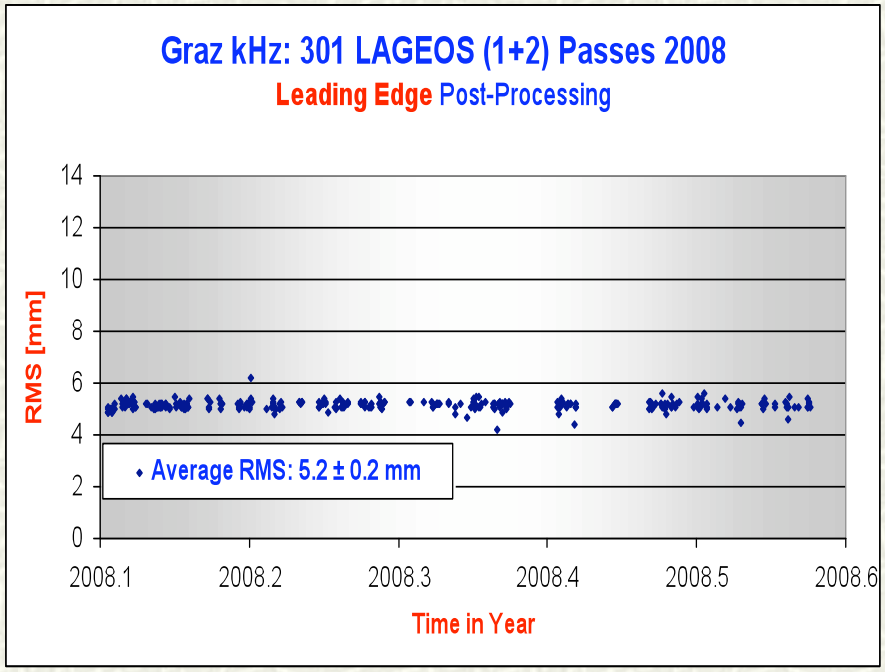


- Standard Post-Processing:
- Until Day 064/2008
- RMS: 15.8 ± 6.1 mm
- NP Scatter: Some CM !!!
- NP: Dist to LE: **cm VARIATIONS**

- Leading Edge Post-Processing:
- Since Day 065/2008
- RMS: 5.3 ± 0.2 mm
- NP Scatter: < 1 mm
- NP Dist to LE: **10.8 ± 0.4 mm**

LE Post-Processing: LAGEOS





- Standard Post-Processing
- Until Day 037/2008
- RMS: 7.9 ± 1.0 mm
- NP Scatter: > 5 mm
- NP: Dist to LE: > 3 mm **VARIATIONS**

- Leading Edge Post-Processing
- Since Day 037/2008
- RMS: 5.2 ± 0.2 mm
- NP Scatter: < 1 mm
- NP Dist to LE: **10.0 ± 0.8 mm**

LE Post-Processing: Consequences

- About 15% to 50% (average 25%) of returns are rejected;
- Still enough returns remaining (much more than with SPE)
- No Change to Hardware Setup necesary:
  - No Real Time adjustments to keep Return Energy constant;
  - No filter wheels, no offset pointing, no observer training etc.
- ALL NPs now at a constant distance from LE: 10 mm ± <1mm
- CoM Correction: Now constant for EVERY NP !!!
  - Regardless of return energy, Single- or Multi-Photon etc.

Conclusions

- FOR SPHERICAL SATELLITES:

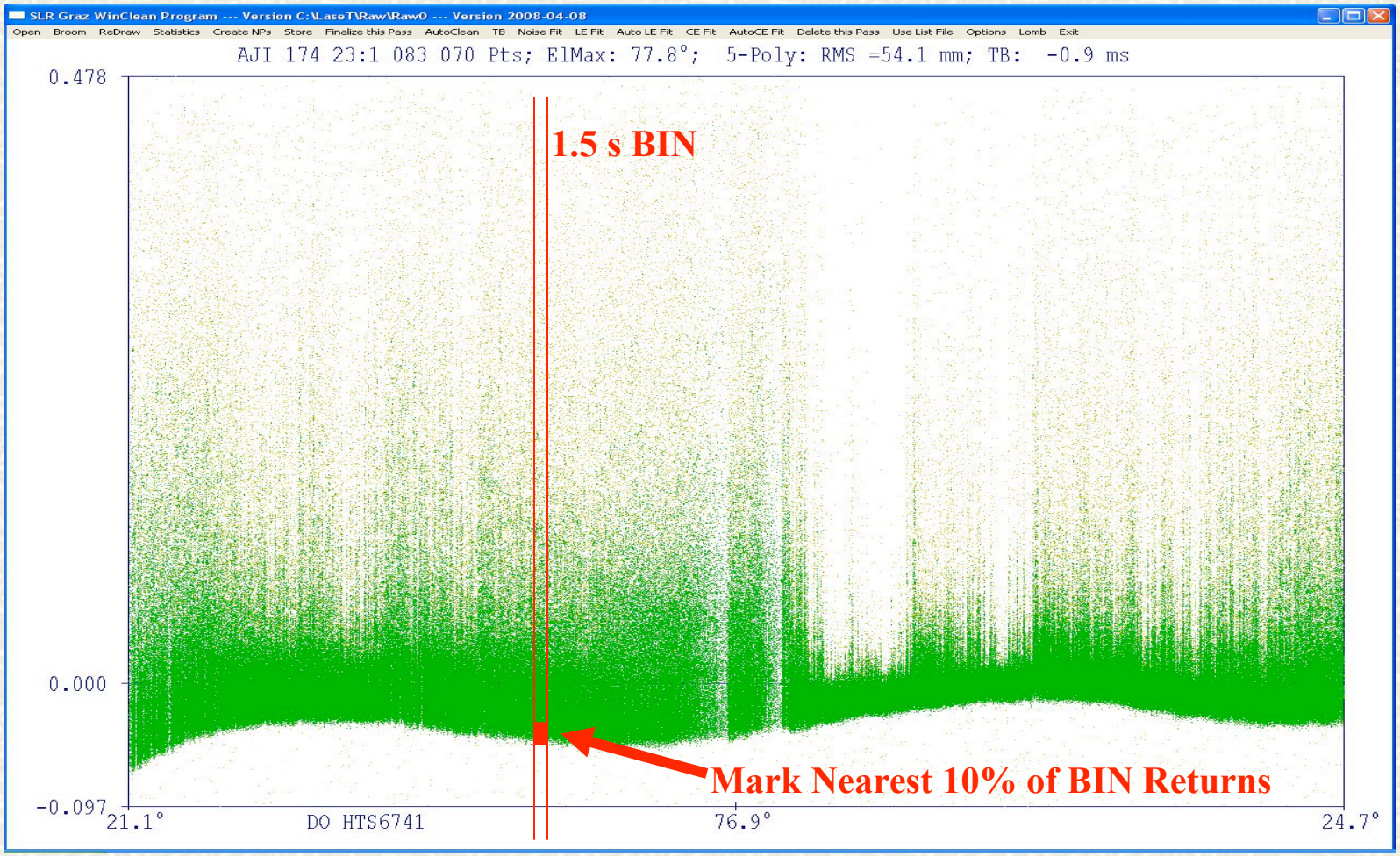
- kHz SLR allows detection of „Leading Edge“ of Returns
- We use this „LE“ as a reference line
- We accept only returns from LE line to 20 mm depth
- This improves NP scatter from CMs to < 1 mm
- Done at the moment for LAGEOS and AJISAI

"Do not look into the laser beam with your remaining eye !"

Thank you ☺

Centimeter Targets: How to do it ...

How to fit to „Leading Edge“



- Divide the pass into BINs; Bin Width eg. 10% of NPW: ie 1.5 s for AJI, 12 s for LAGEOS
- Mark nearest 10% of points in each BIN; fit poly to these marked points ....
- Use these poly coefficients for all points; 2.5/2.2 sigma iteration; apply final limits ...