Track Finding at the Herstmonceux Space Geodesy Facility

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Reasons for automatic track finding

It helps to search for and maintain a satellite signal

It frees the observer to concentrate on other duties, such as looking for aeroplanes

It allows real time return signal feedback and track determination criteria to be set.

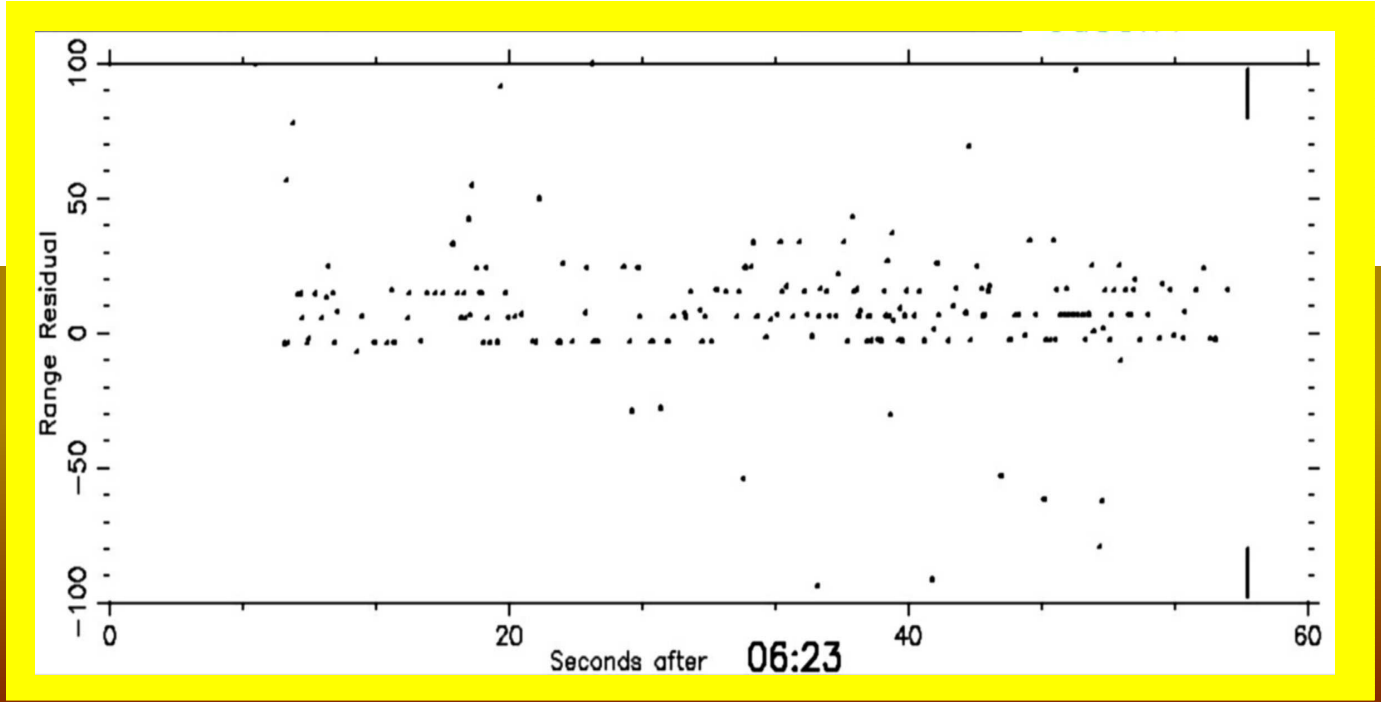
It can search for track that might not be obvious the observer

It speeds up post-processing

Techniques used for track finding

Satellite track stands out clearly in a small enough range gate window.

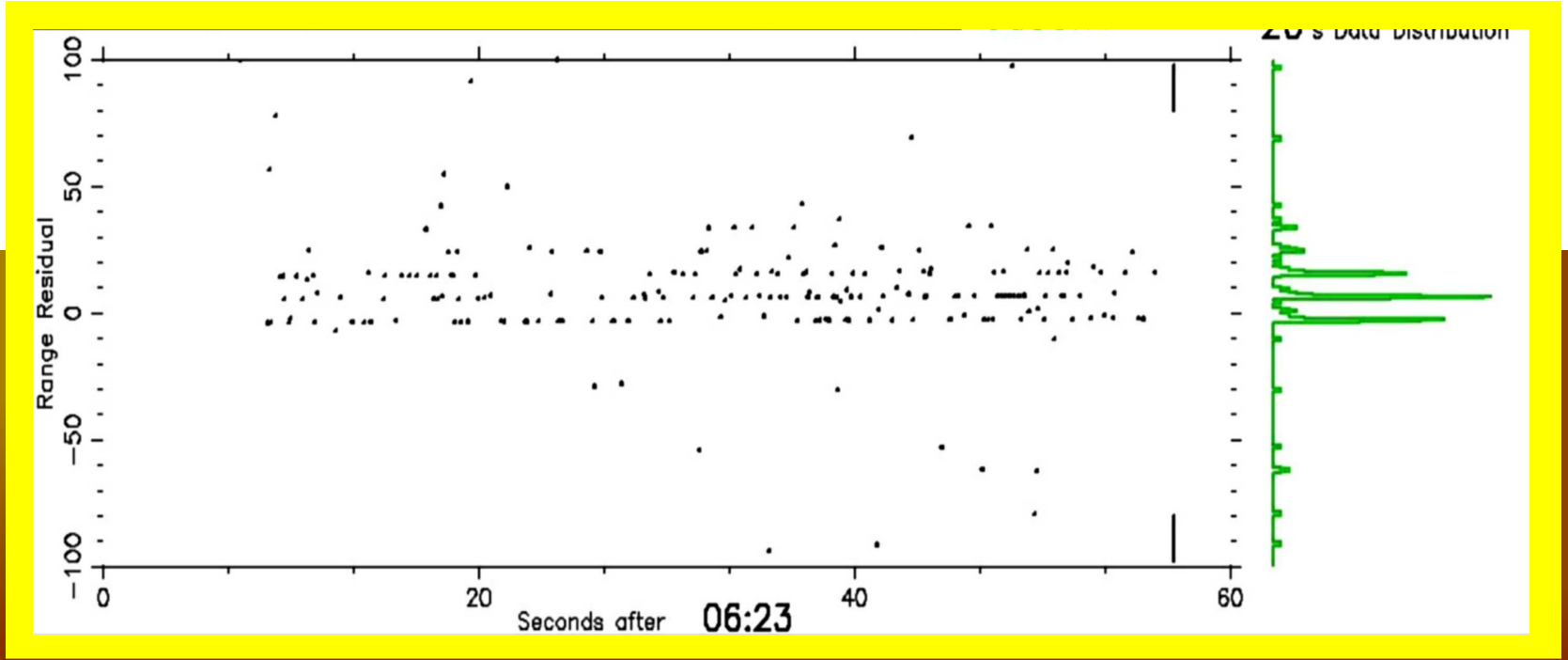
But how to translate this visual identification of track to a measurable quantity?



Techniques used for track finding

Using a histogram clearly displays the peaks from the return signal.

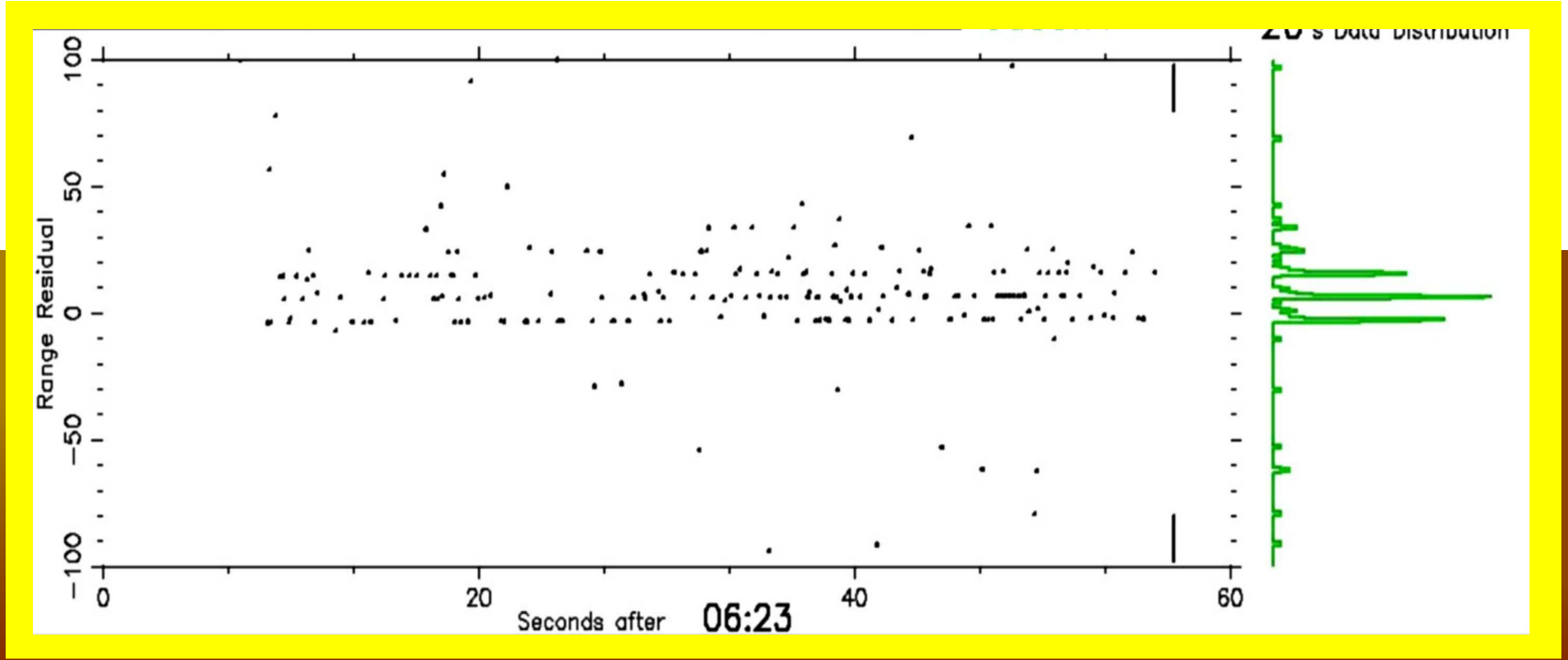
These peaks can then be identified computationally



Techniques used for track finding

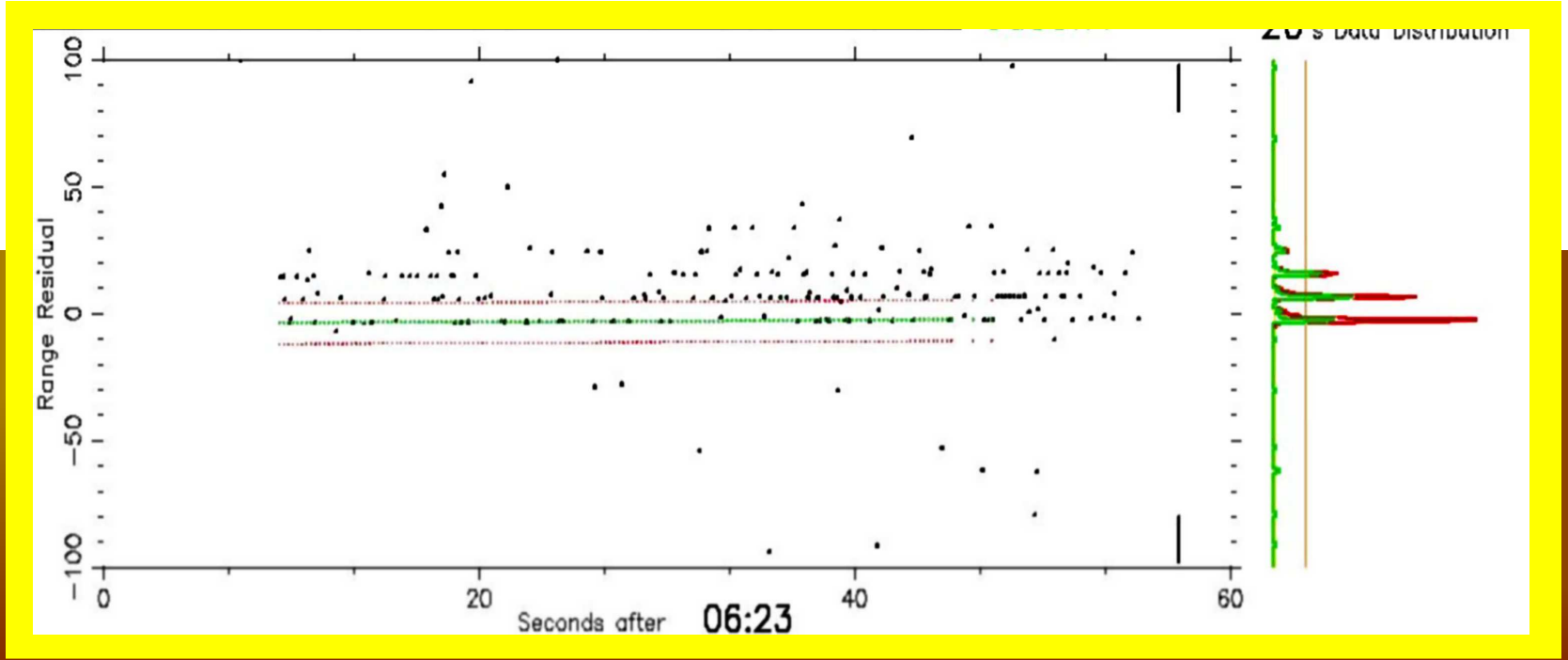
A semi train can make identifying 'pulse 1' difficult, as the second pulse may momentarily have a stronger signal.

By not tracking pulse 1 only, the final selected track would then be less useful for post processing.

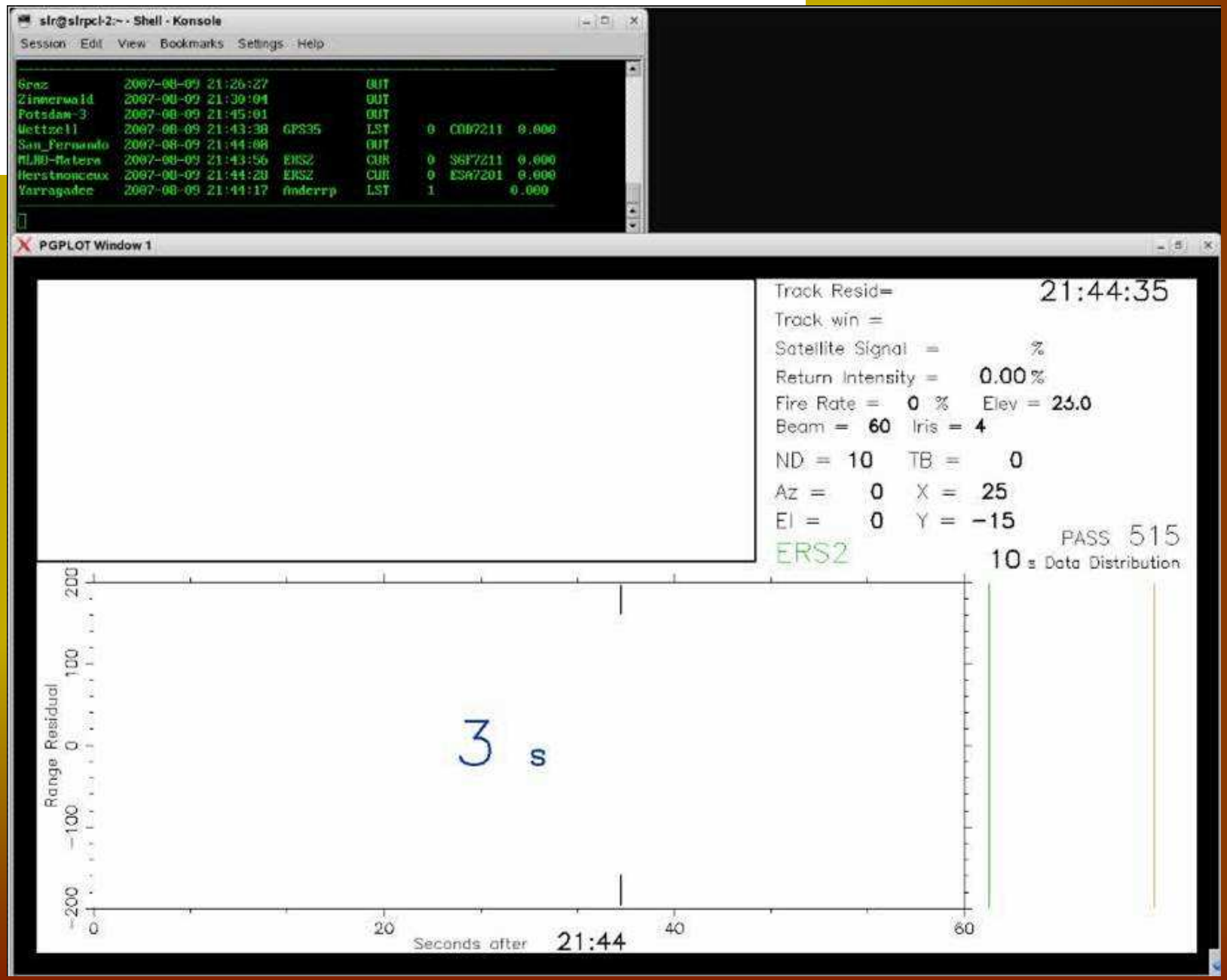


Techniques used for track finding

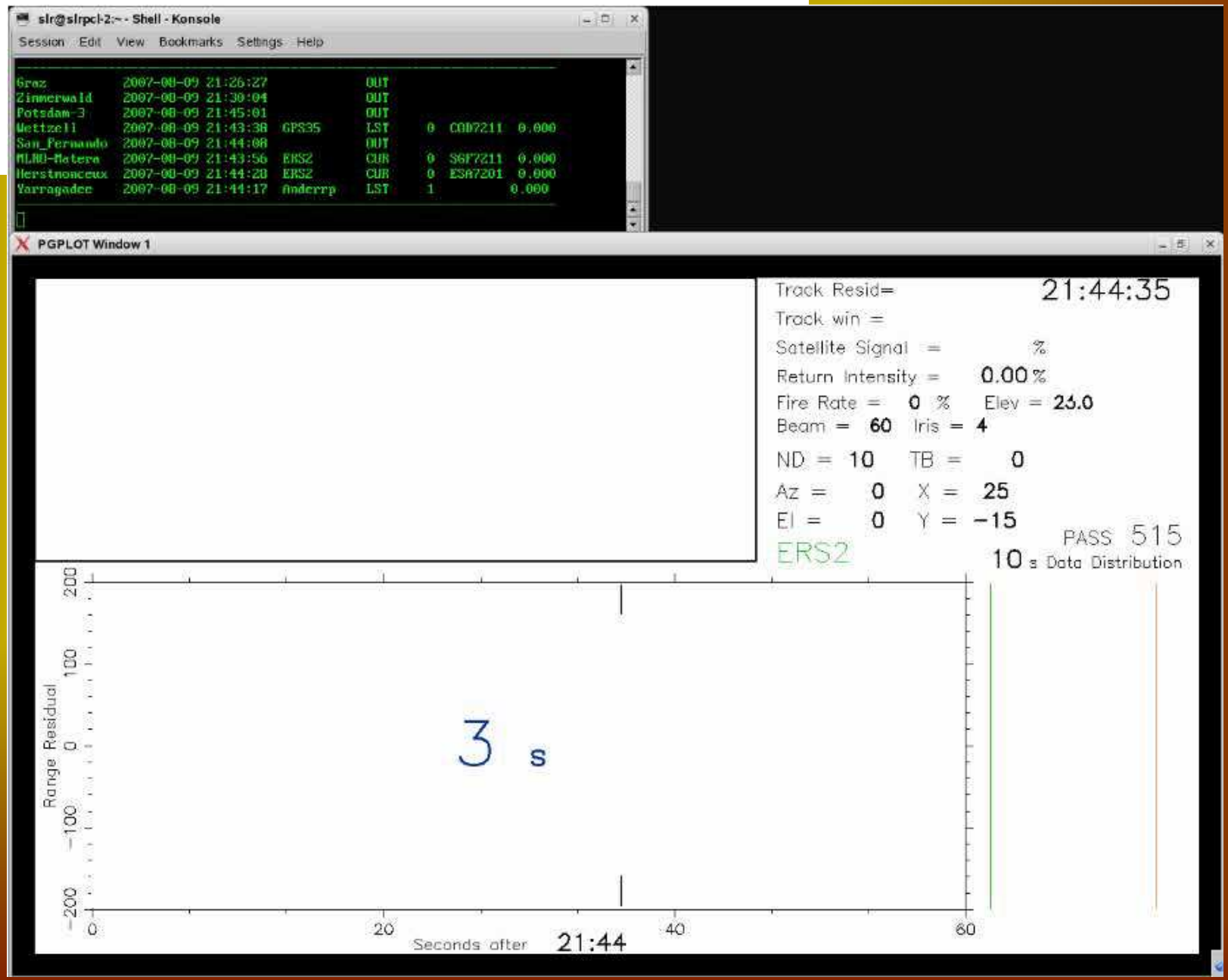
Generating a new histogram by 'folding down' returns if they fit an existing peak can emphasise the first pulses and allows pulse 1 to be selected far more consistently.



Pass video


slr@slrpc1-2:~ - Shell - Konsole
Session Edit View Bookmarks Settings Help
Graz 2007-08-09 21:26:27 OUT
Zimmerwald 2007-08-09 21:39:04 OUT
Potsdam-3 2007-08-09 21:45:01 OUT
Wettzell 2007-08-09 21:43:38 GPS35 LST 0 C00721I 0.000
San_Fernando 2007-08-09 21:44:08 OUT
MLRO-Matera 2007-08-09 21:43:56 ERS2 CUR 0 S0P7211 0.000
Herstmonceux 2007-08-09 21:44:20 ERS2 CUR 0 ESA7201 0.000
Yarragadee 2007-08-09 21:44:17 Anderrp LST 1 0.000
PGPLOT Window 1
Track Resid=
21:44:35
Track win =
Satellite Signal = %
Return Intensity = 0.00 %
Fire Rate = 0 % Elev = 25.0
Beam = 60 Iris = 4
ND = 10 TB = 0
Az = 0 X = 25
El = 0 Y = -15
ERS2
PASS 515
10 s Data Distribution
3 s
Range Residual
200
100
0
-100
-200
0
20
40
60
Seconds after 21:44

Pass video


slr@slrpc1-2:~ - Shell - Konsole
Session Edit View Bookmarks Settings Help
Graz 2007-08-09 21:26:27 OUT
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MLRO-Matera 2007-08-09 21:43:56 ERS2 CUR 0 SGF7211 0.000
Herstmonceux 2007-08-09 21:44:28 ERS2 CUR 0 ESA7201 0.000
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Histogram time lengths

LEOs ~10s

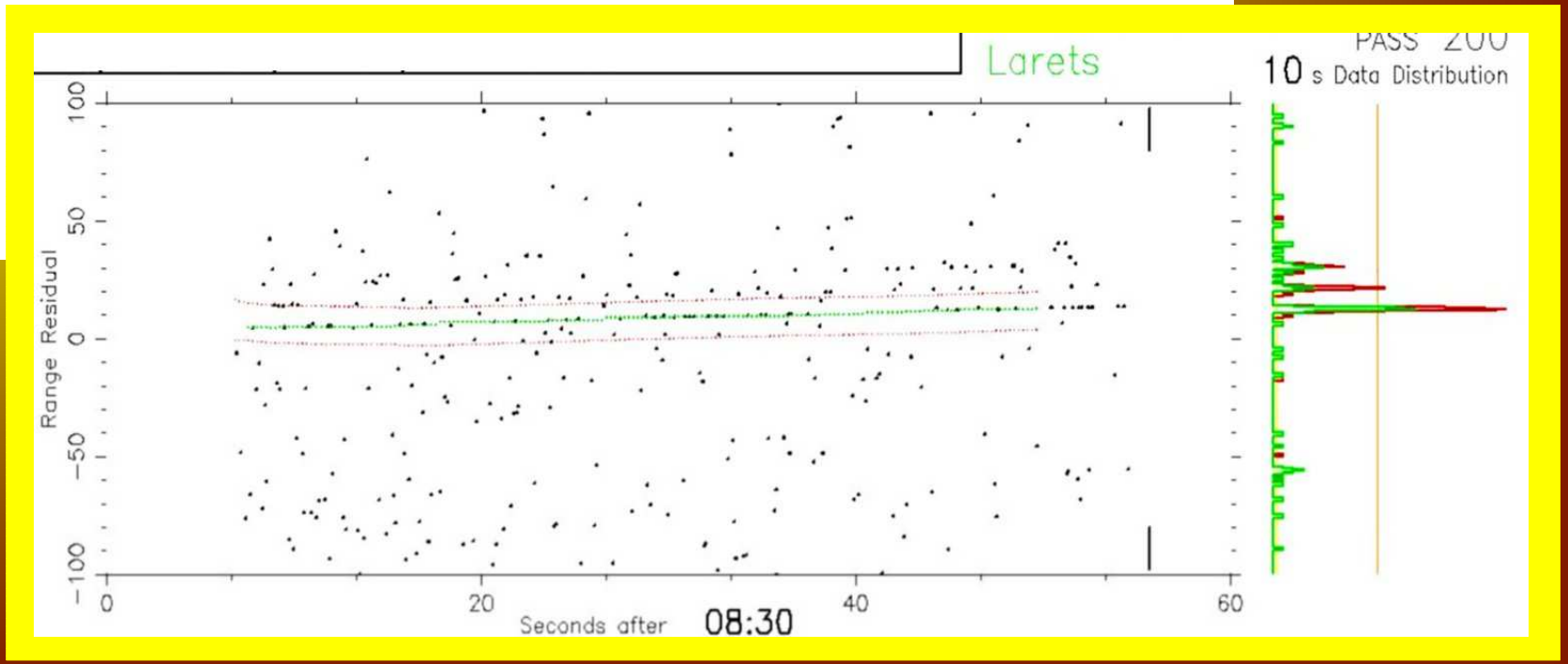
Strong signal and likely to slope in the range gate

Lageos 20s

Could be weak or strong signal with little slope.

HEOS 60s

Weak signal with no slope in the centre of the range gate window.



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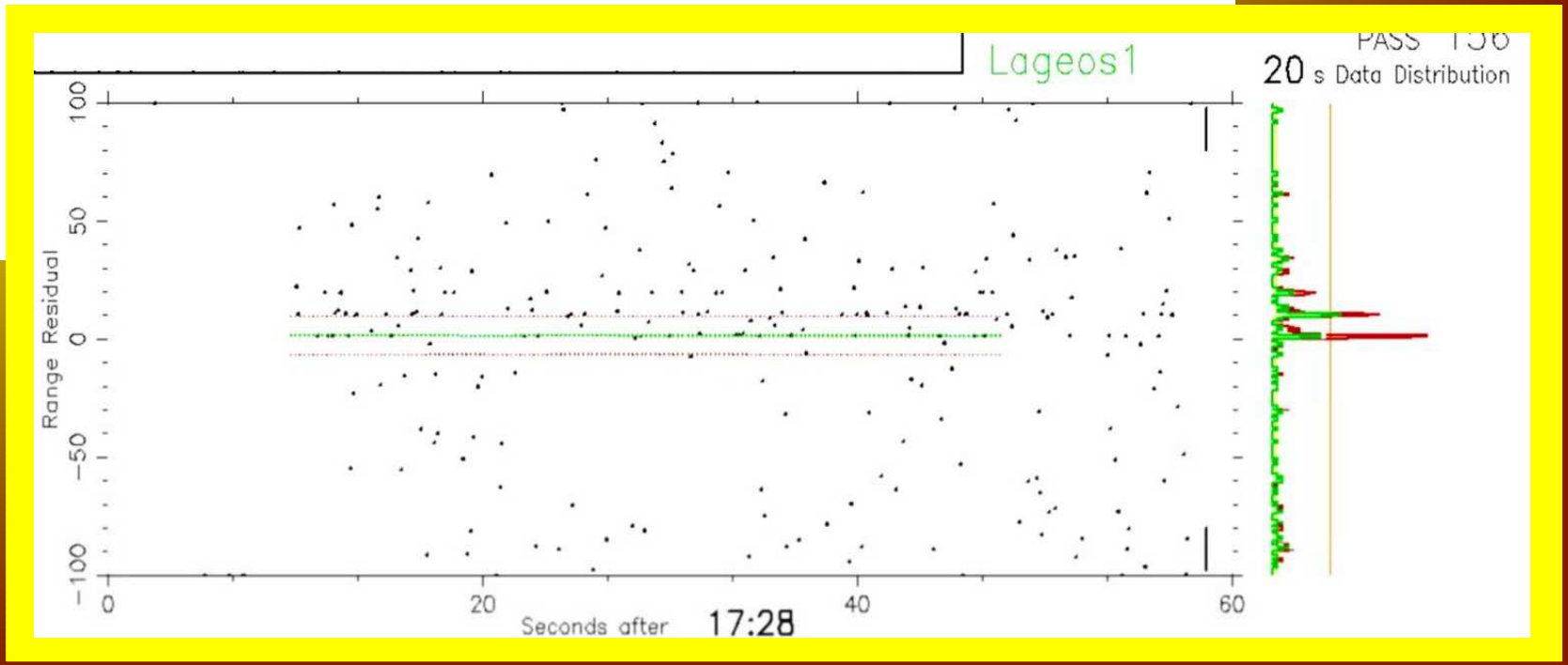

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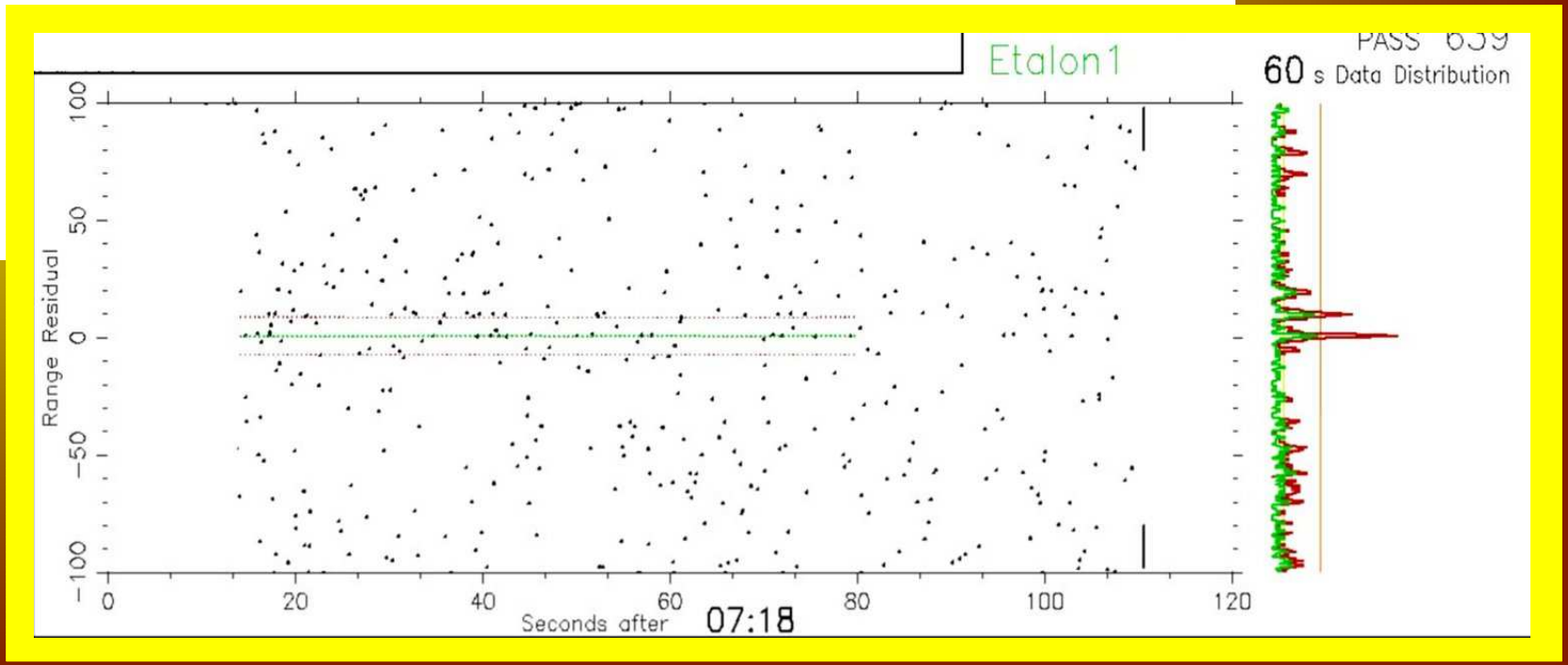
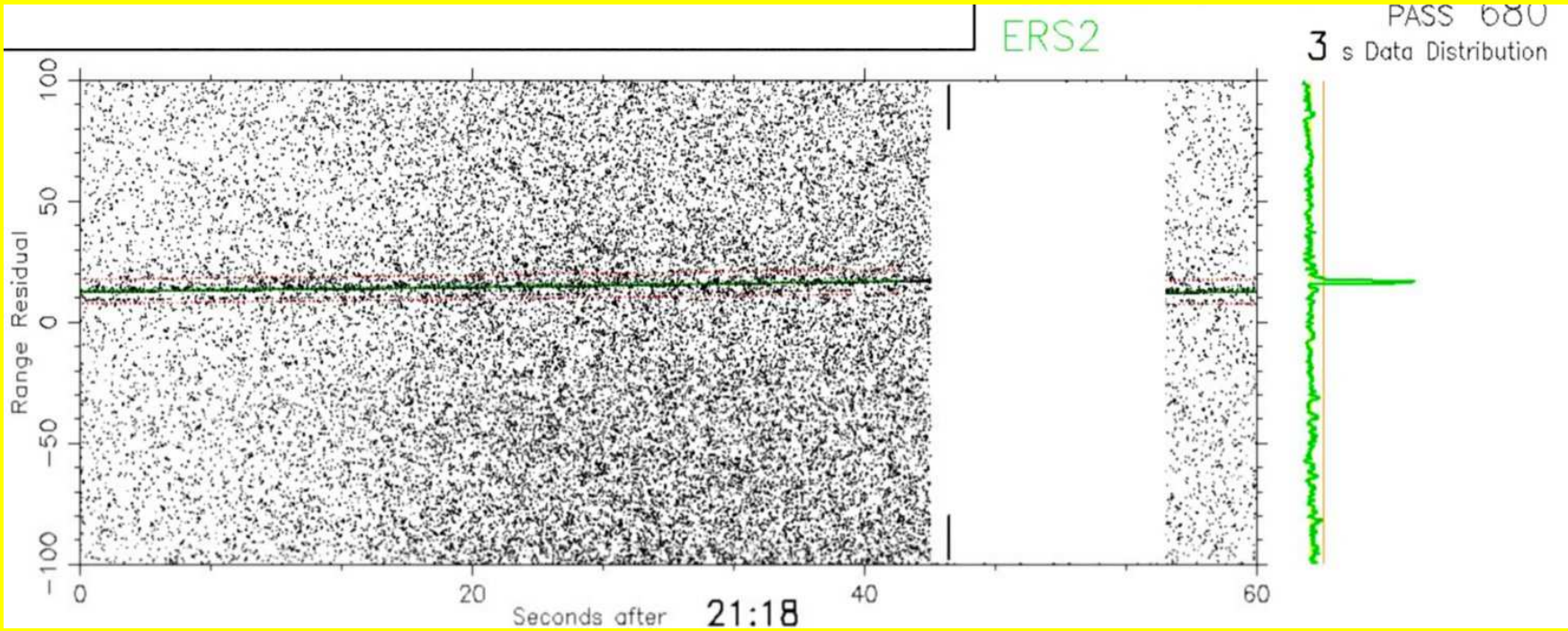


Finding kHz track

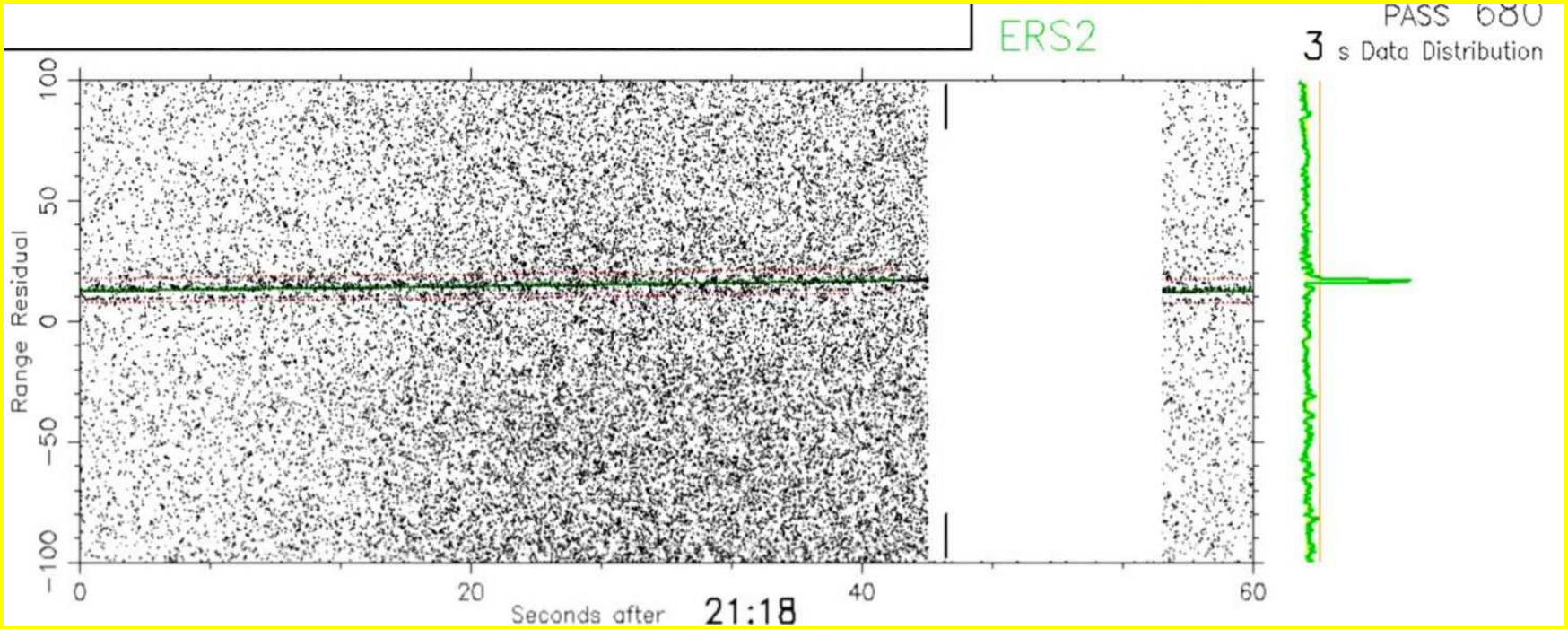
kHz track finding is distinctly different because there is no semi-train, the return signal is weaker, the number of data points is much larger and consequently the **signal to noise ratio** is significantly reduced.



Finding kHz track

Track can be determined more quickly than with 10Hz tracking.

Tracking using a histogram becomes more useful to identify track.



kHz Histogram time lengths

LEOs < 3s

Strong signal and likely to slope in the range gate

Lageos ~5s

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HEOS 10-20s

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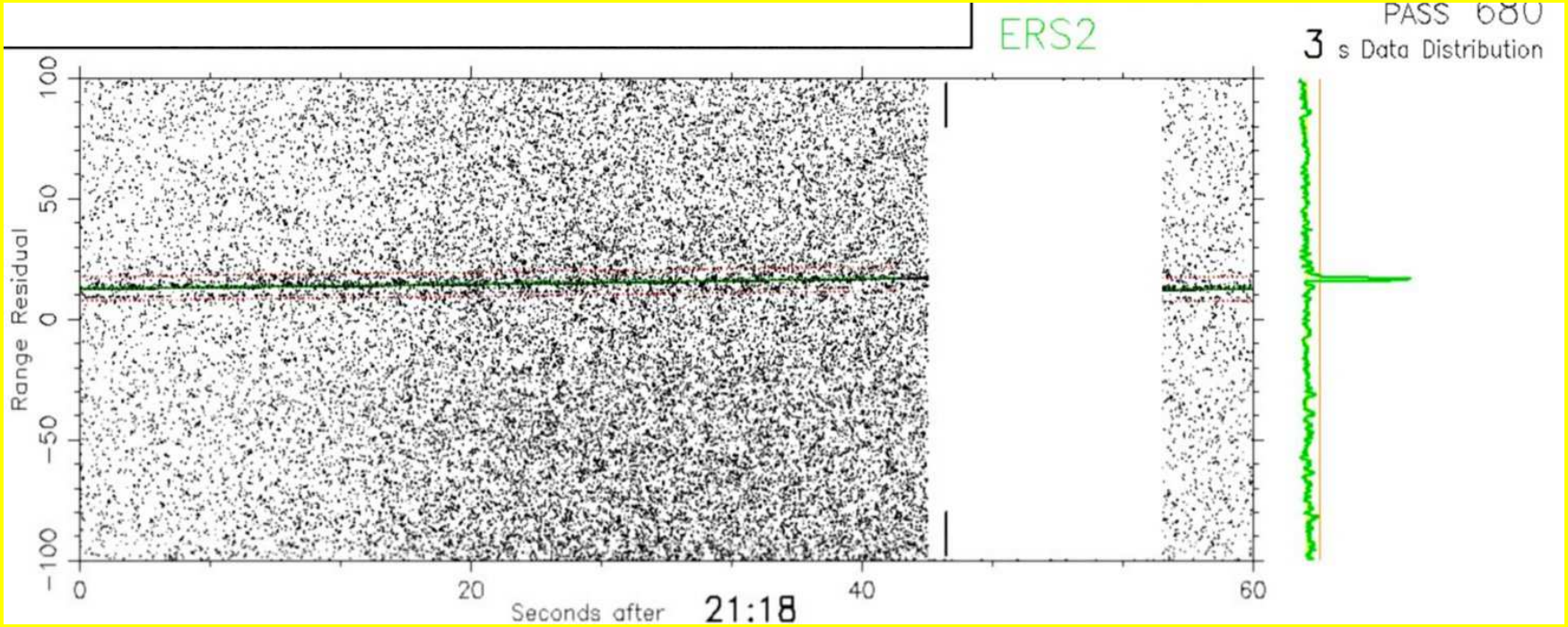

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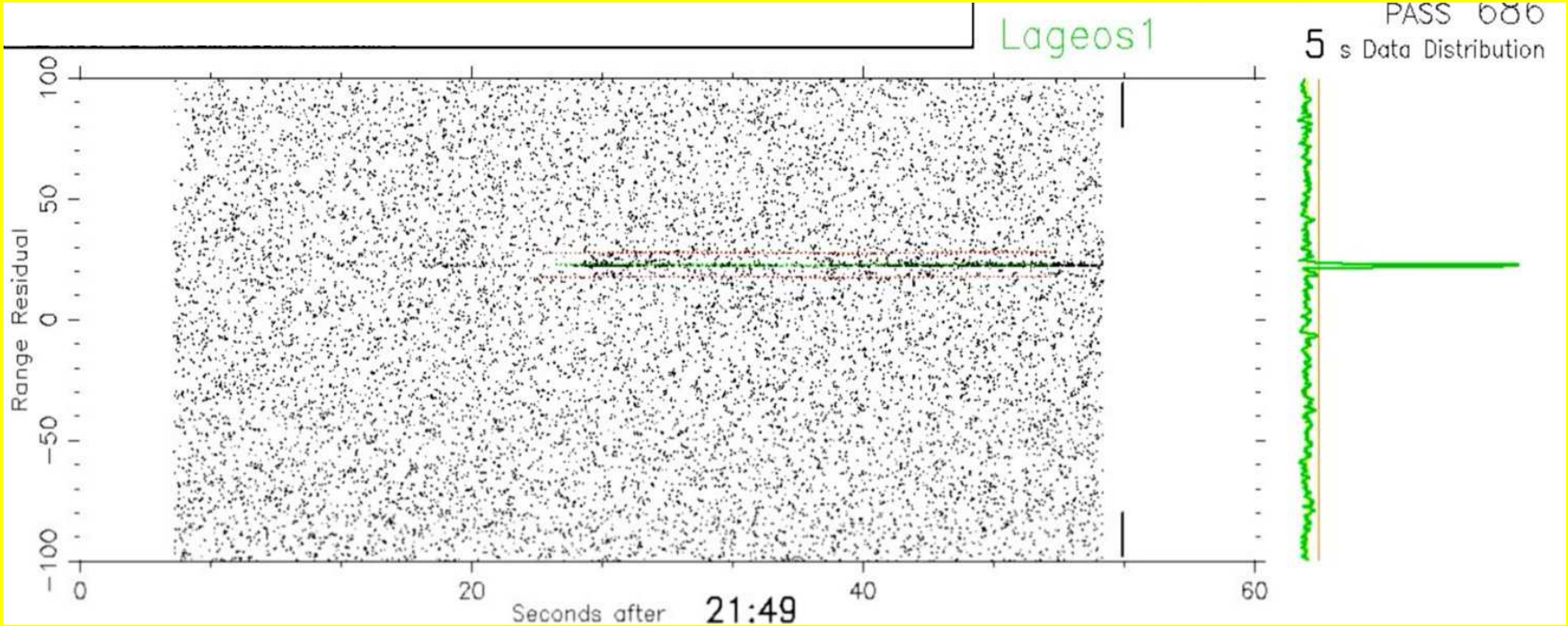

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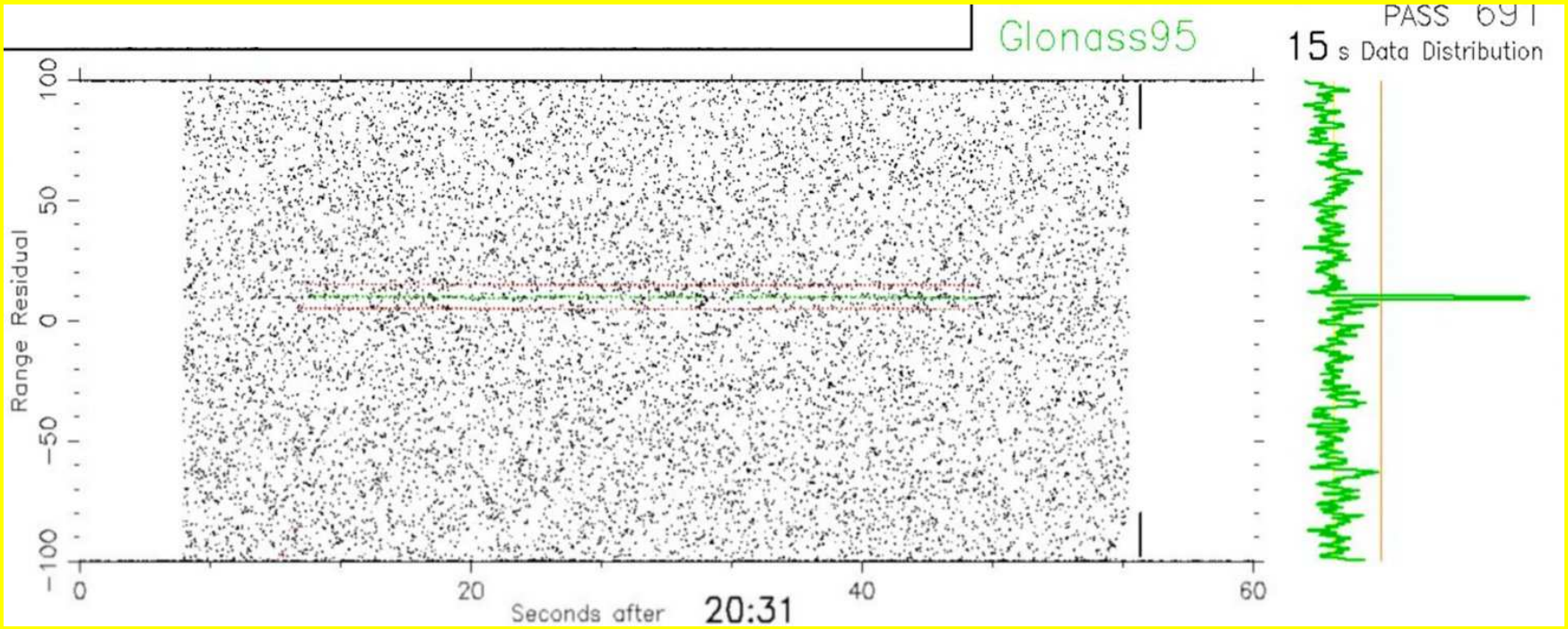
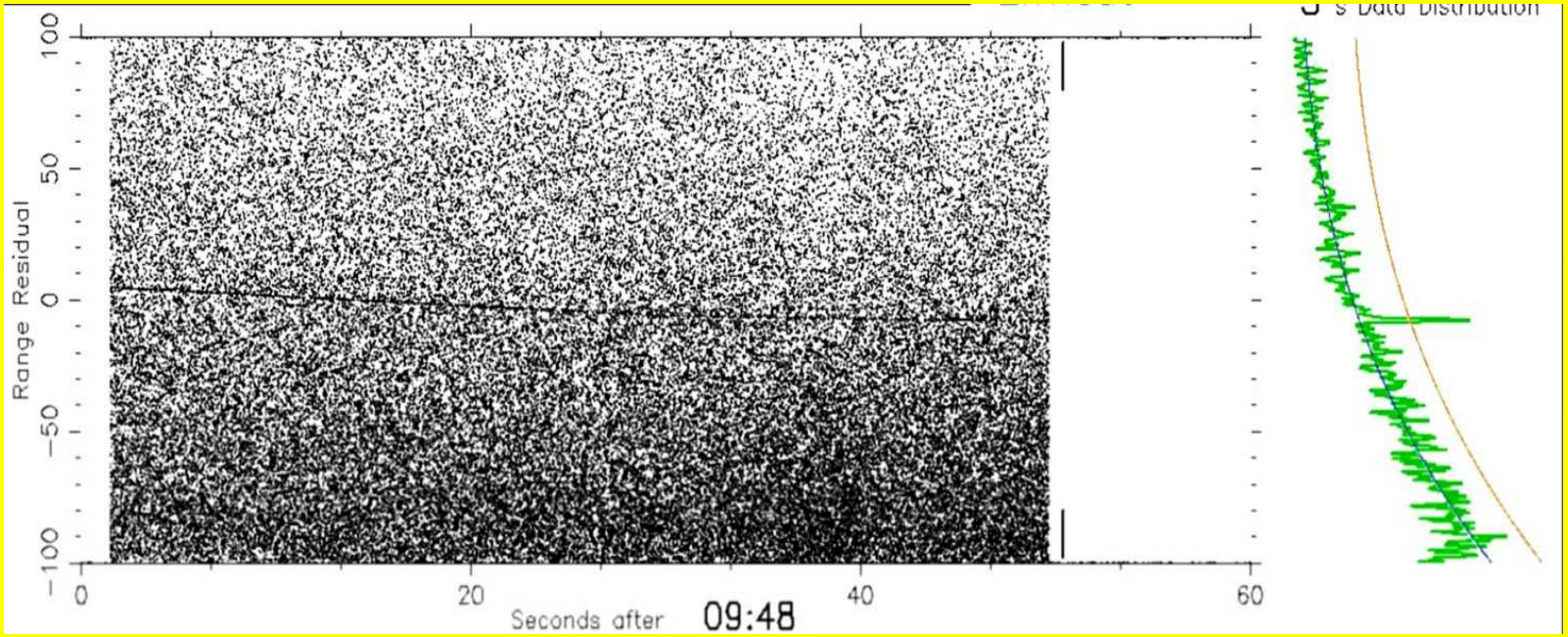


Daytime noise

Daytime noise can be a restricting factor to kHz observing.

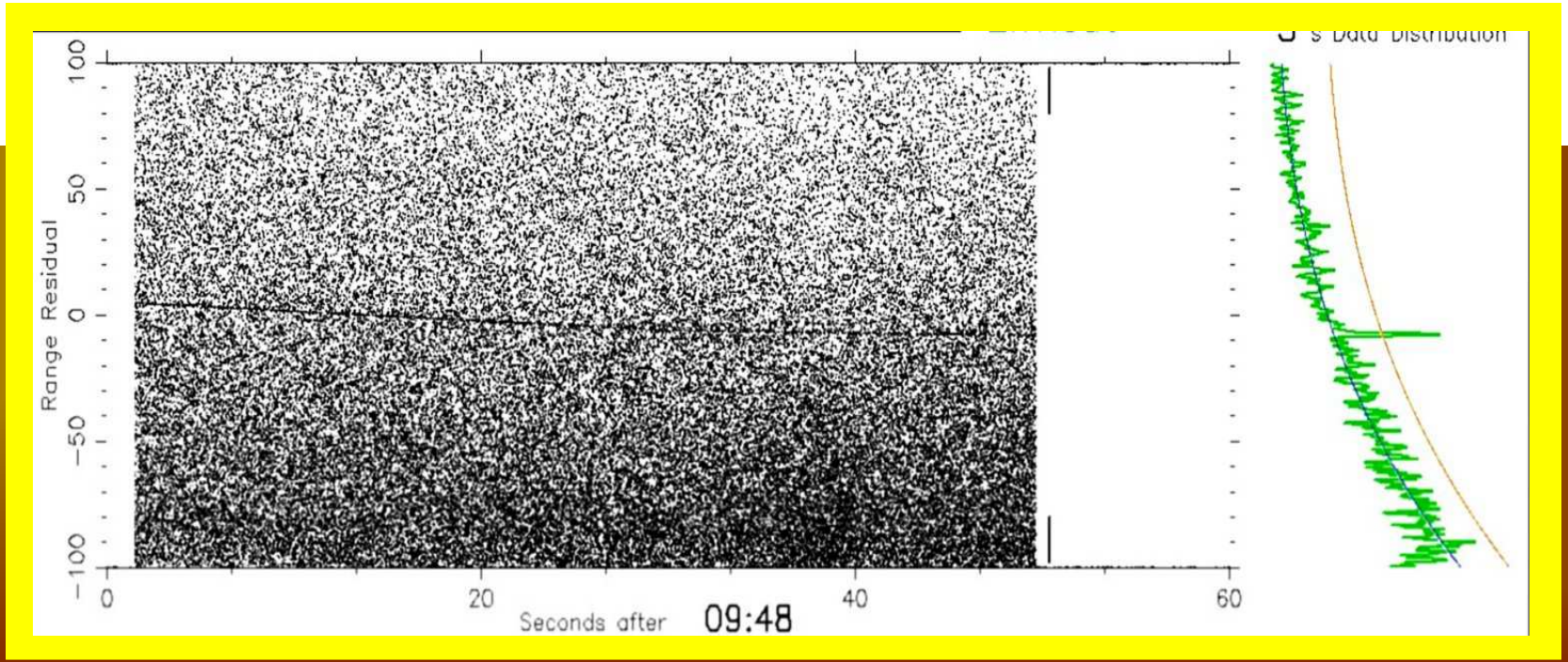
The noise floods the range gate, making it difficult to see the track and distorting the histogram.



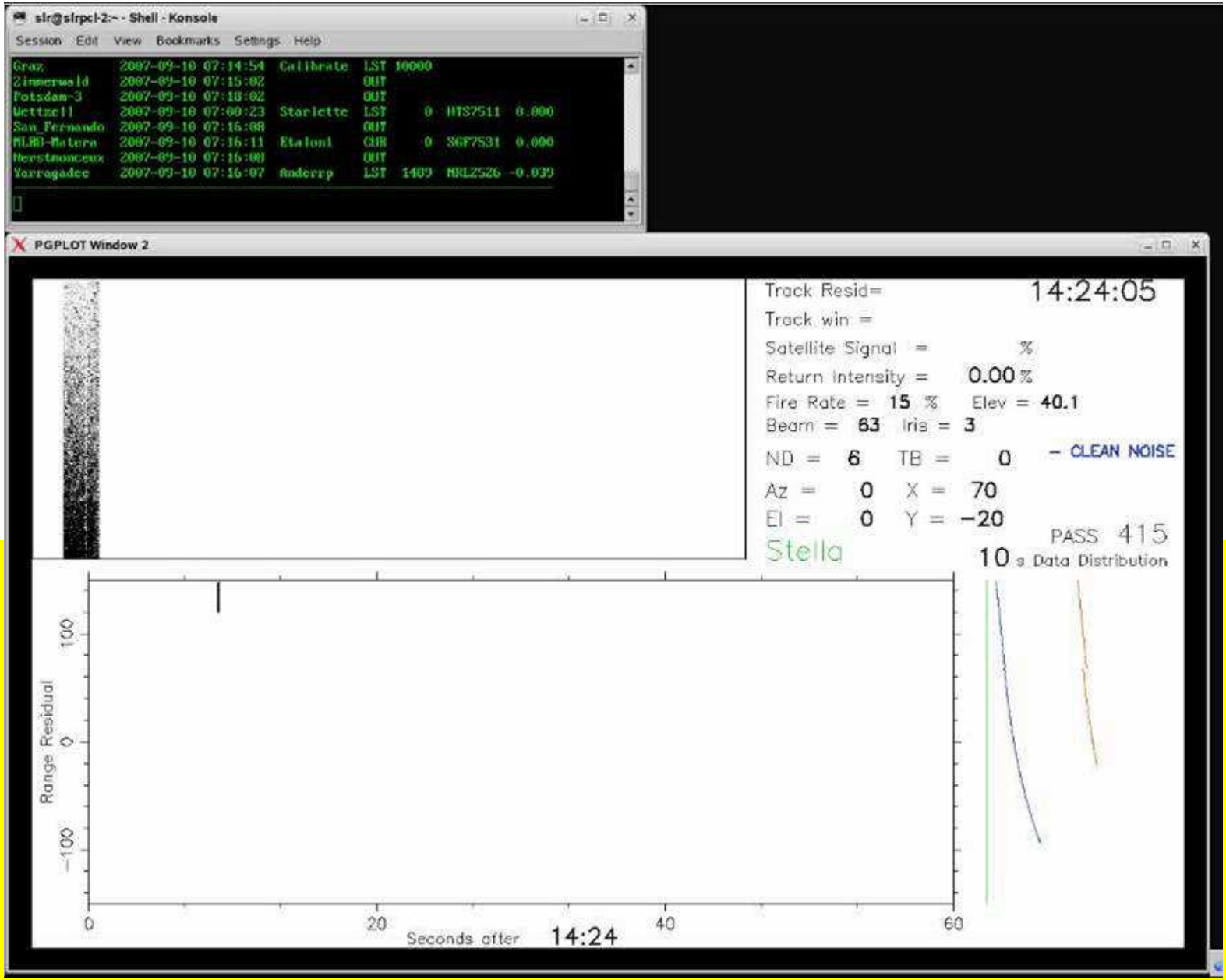
Daytime noise

Despite the satellite peak being visible it is not the peak of the histogram and not selected.

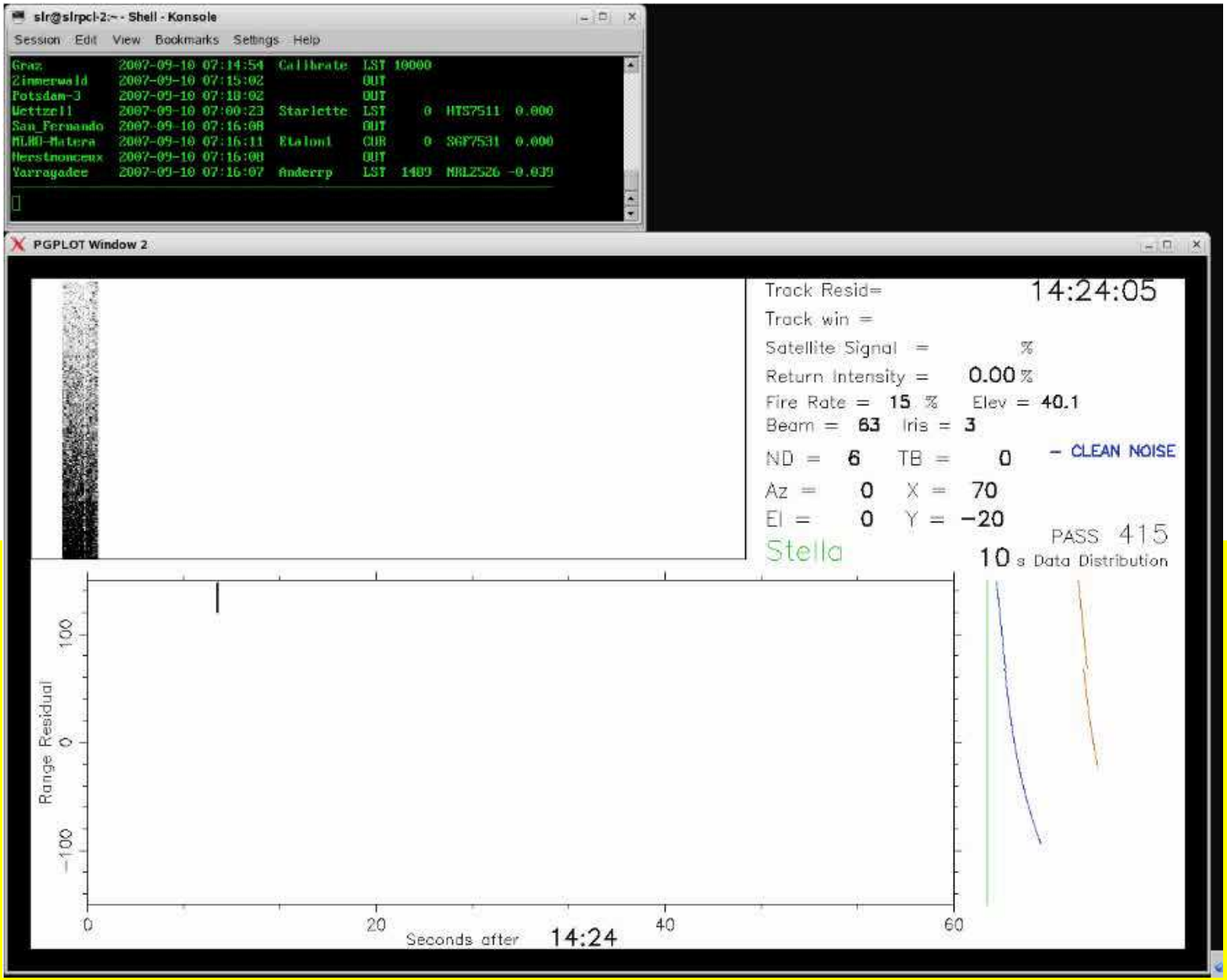
By sampling and removing a polynomial fit to the noise profile in real time the satellite is once again found.



Daytime kHz video

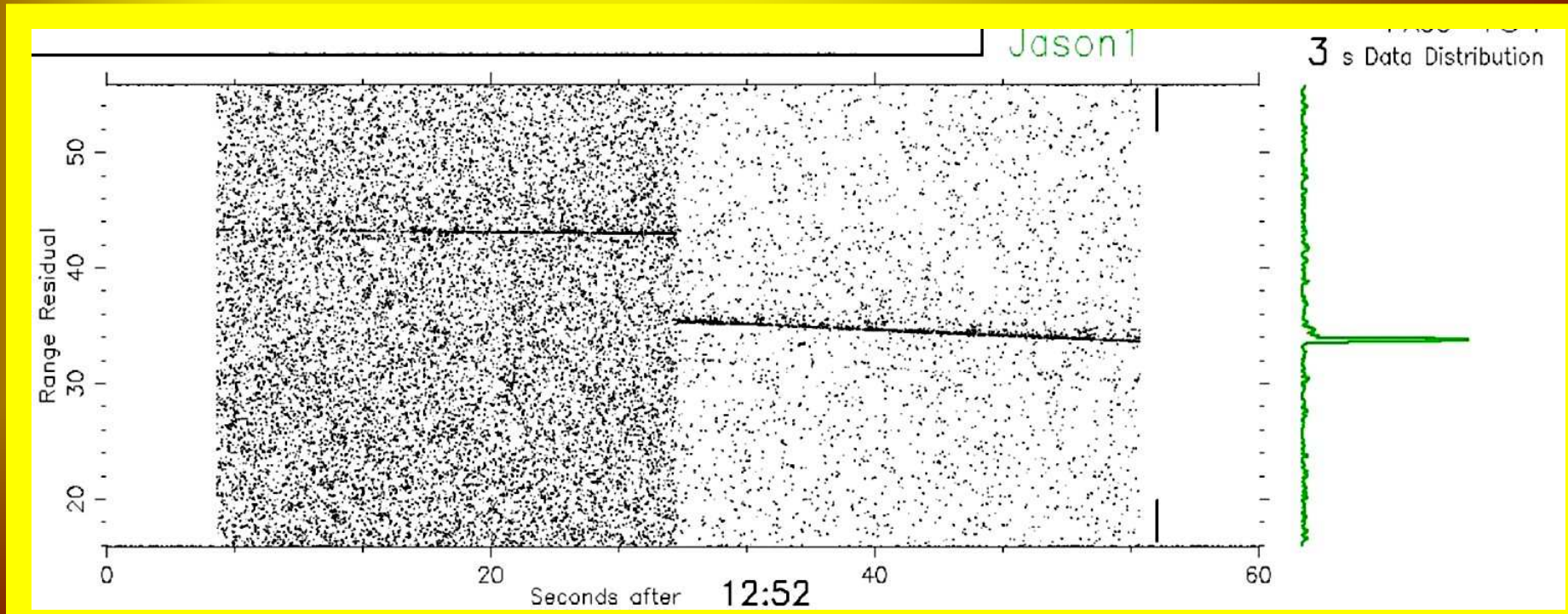


Daytime kHz video



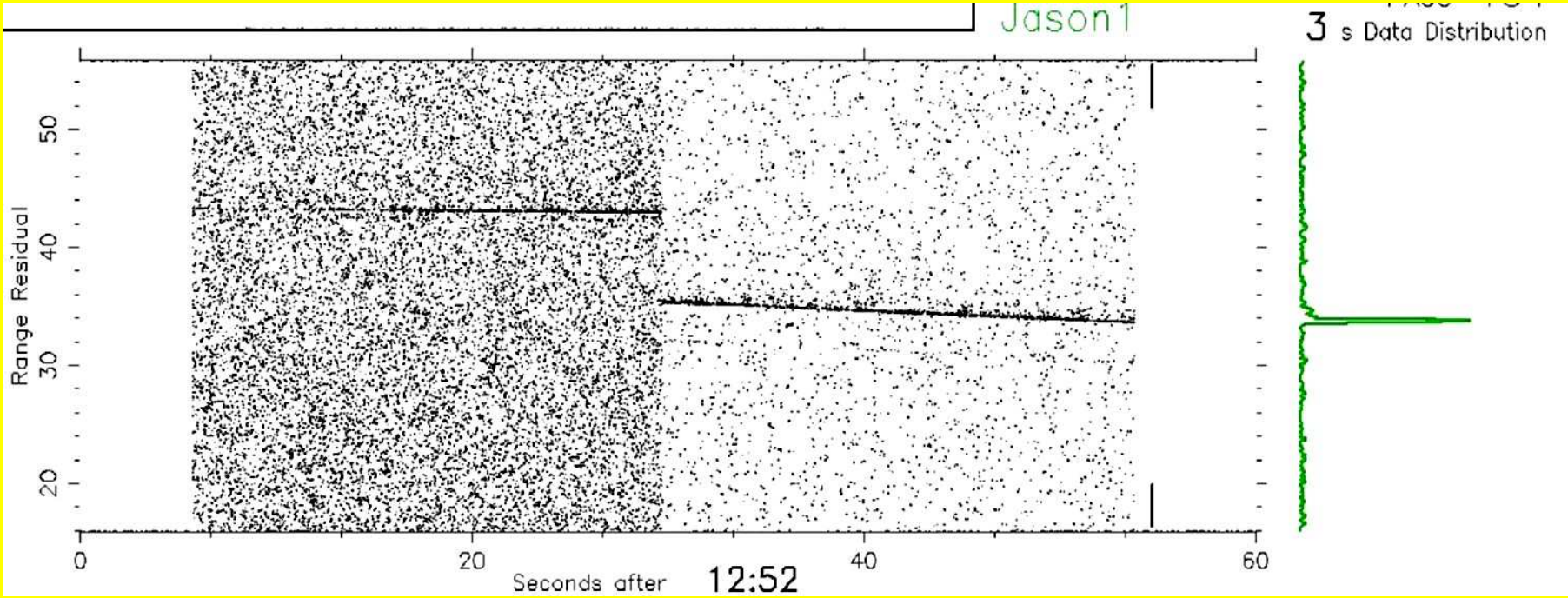
Narrow Range gate

Another way to make the track clearly visible to the observer is to narrow the range gate.



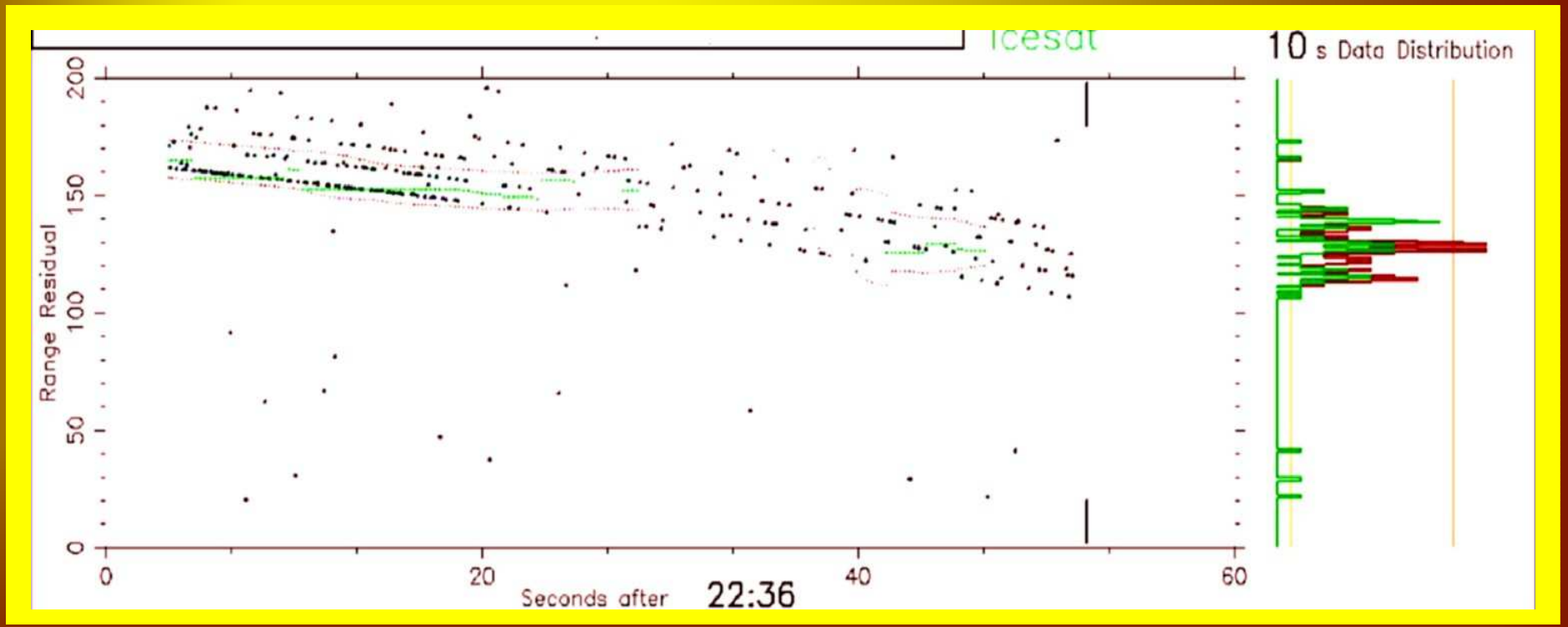
Narrow Range gate

Using a C-SPAD means that we must wait at least 50ns after gating so that no time-walk bias is present in the measurement.



Limitations

Using a histogram to determine track in the range window is limited if the track has a significant time bias and therefore a steep slope in the range gate.



Estimated return rate limits for tracking

	Hz %	**kHz** %
LEOs	1-2	0.6
Lageos	~1	0.4
HEOs	~0.5	0.2

Summary

Automatic real-time track detection is possible but limited by return rate and track slope

A histogram aids the observer to see satellite track and also allows the returns to be quantified and track identified.

kHz track can be automatically found at lower return rates but suffers from daytime noise