Experience with kHz SLR at Herstmonceux

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Event Timer

An upgrade from the Stanford Counters to an Event Timer was the first step toward high rate SLR.

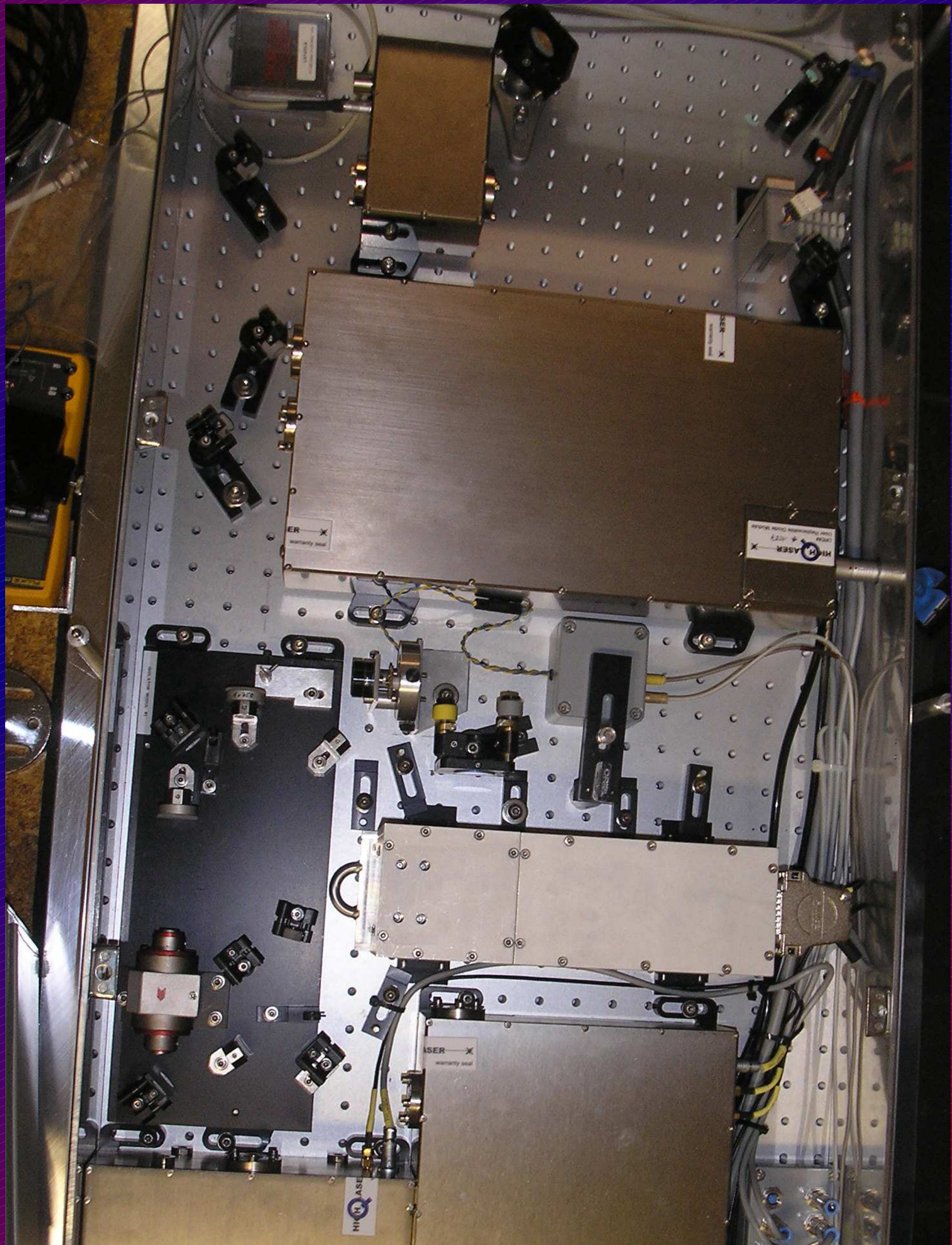
Our Event Timer (HxET) uses 3 Thales modules (One clock and two timing). C. Potter designed and built a power supply, circuitry for the input signals and an input board for interfacing.

As well as improved accuracy, this **Start-Stop** system allows many shots in-flight, immediately giving us an advantage in allowing HEOs to be observed at 10Hz instead of 5Hz.

kHz Laser

The kHz laser fires at a repetition rate of up to 2kHz. Each pulse is 0.4 mJ with a width of 10ps.

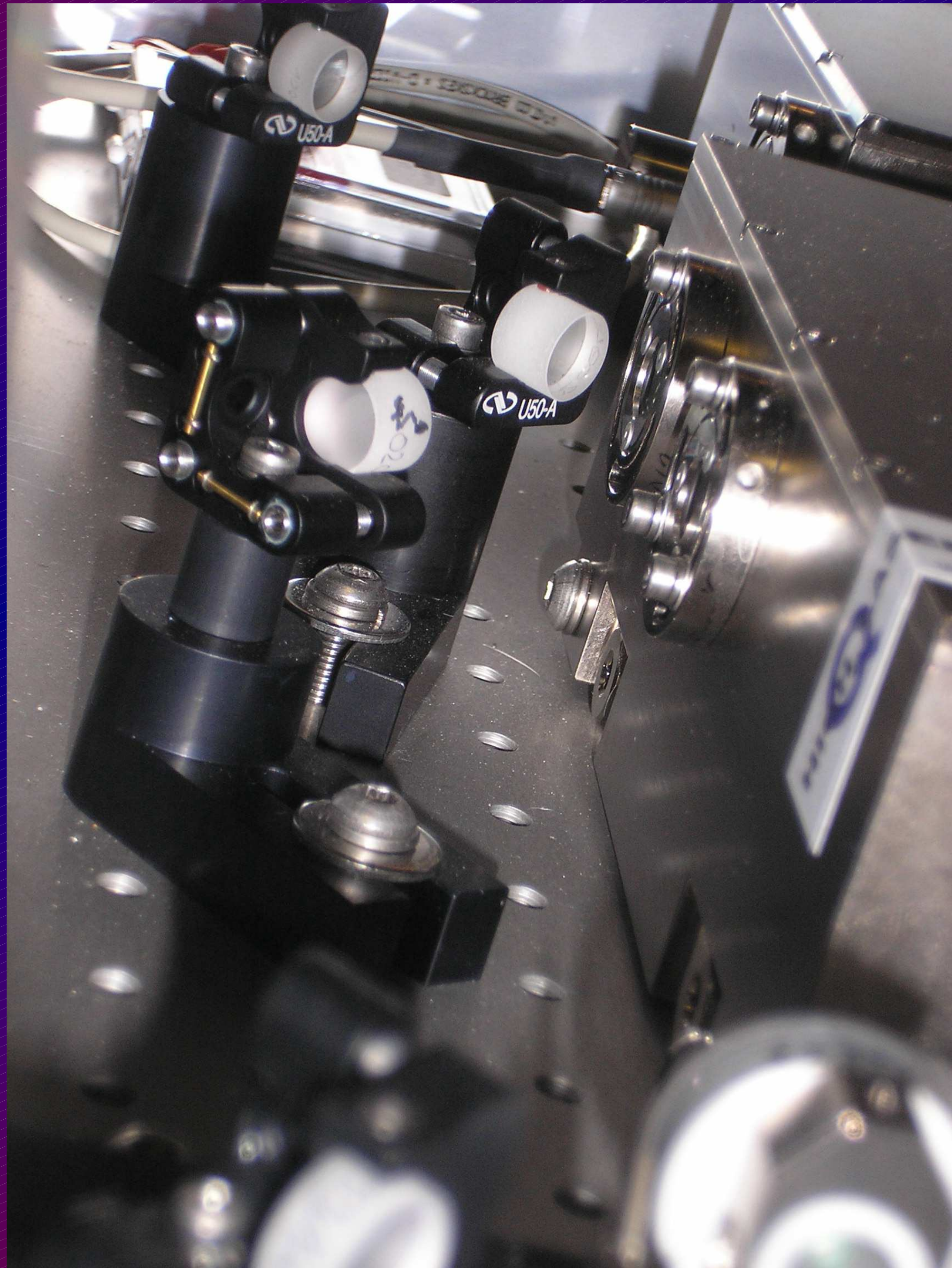
It gives and improved RMS and better statistics.



kHz Laser

Fire times are very predictable (within 5ns). Internal calibrations can operate by simply pre-predicting the time of the return signal without reading the start diode.

Reliable laser firing means that epoch matching laser fires with detections is straight forward. Important to beware of time bias changes however.



TCP-IP Communication

A dedicated DOS PC receives and matches the starts and stops and communicates with the ISA board.

It then uses TCP-IP to communicate with two secondary Linux PCs to save and display the data.

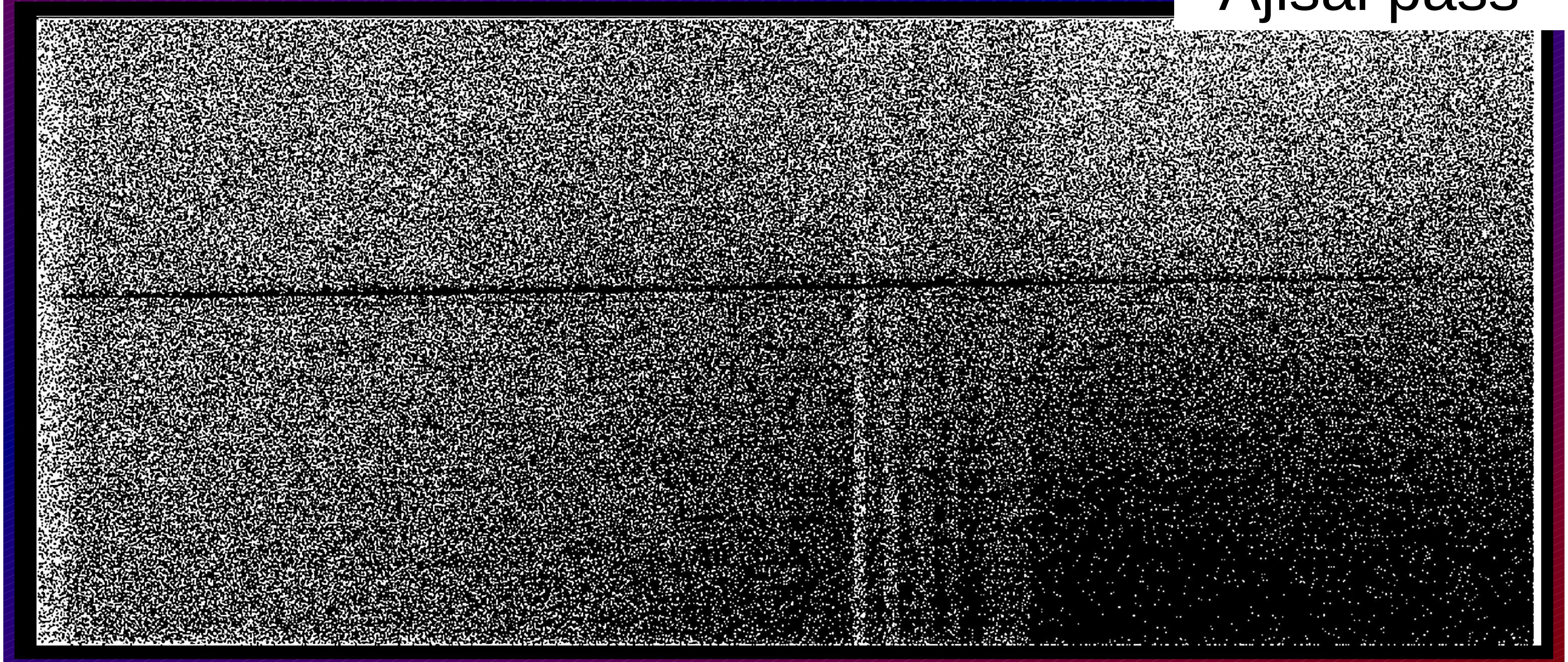
Data Storage

Data files are significantly larger and are written by the downstairs display Linux PC as it displays the data.

Display Changes

kHz data needs to be displayed so that satellite track can be easily seen by the observer.

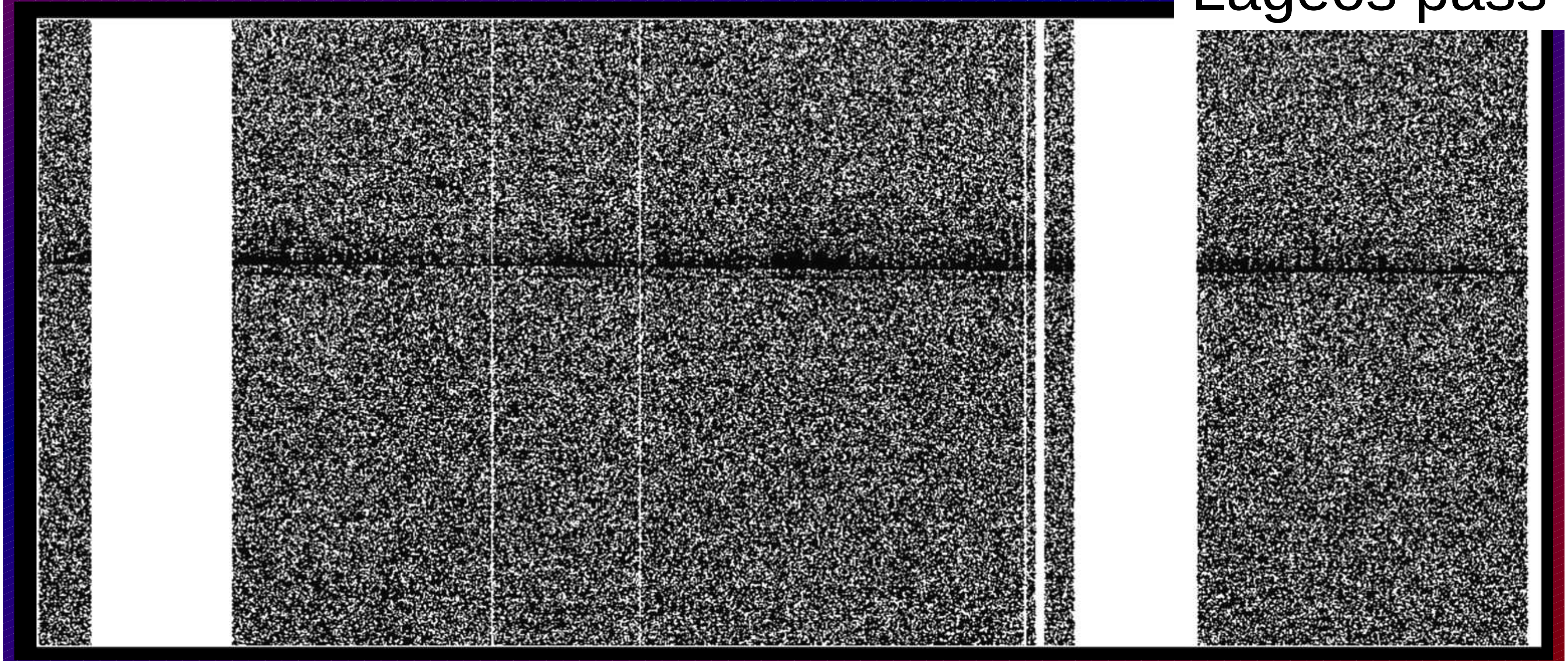
Ajisai pass



Display Changes

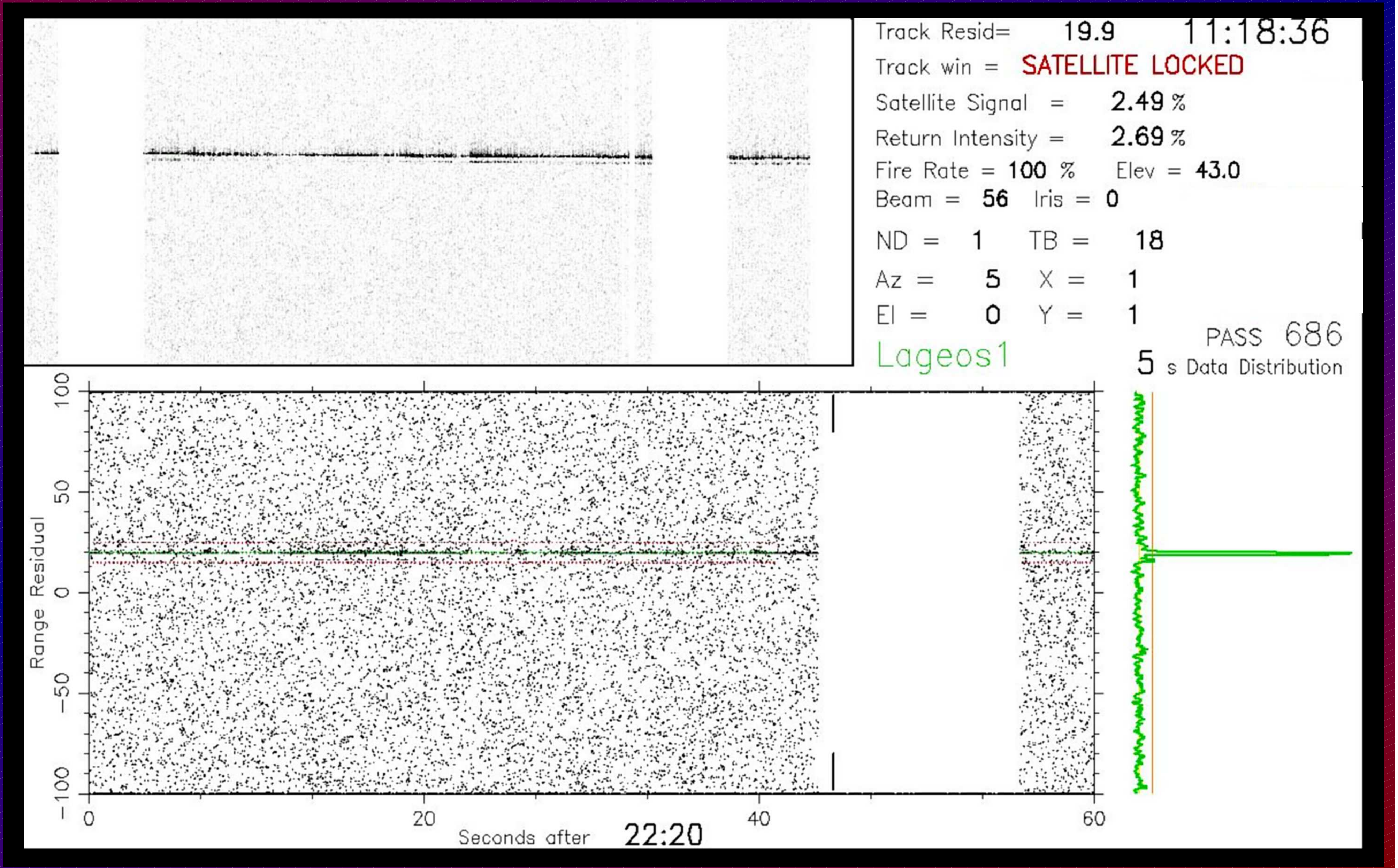
kHz data needs to be displayed so that satellite track can be easily seen by the observer.

Lageos pass

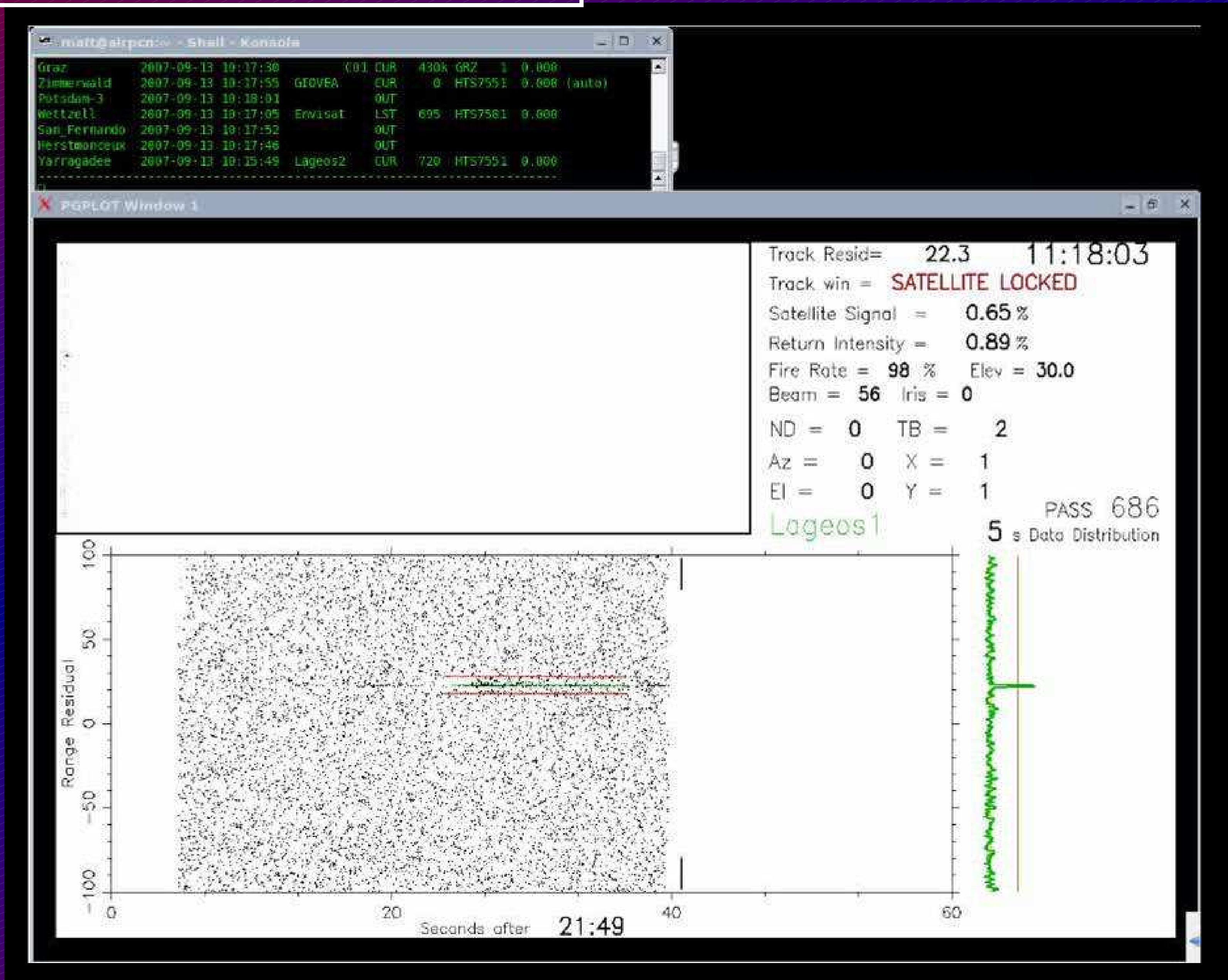


Display Changes

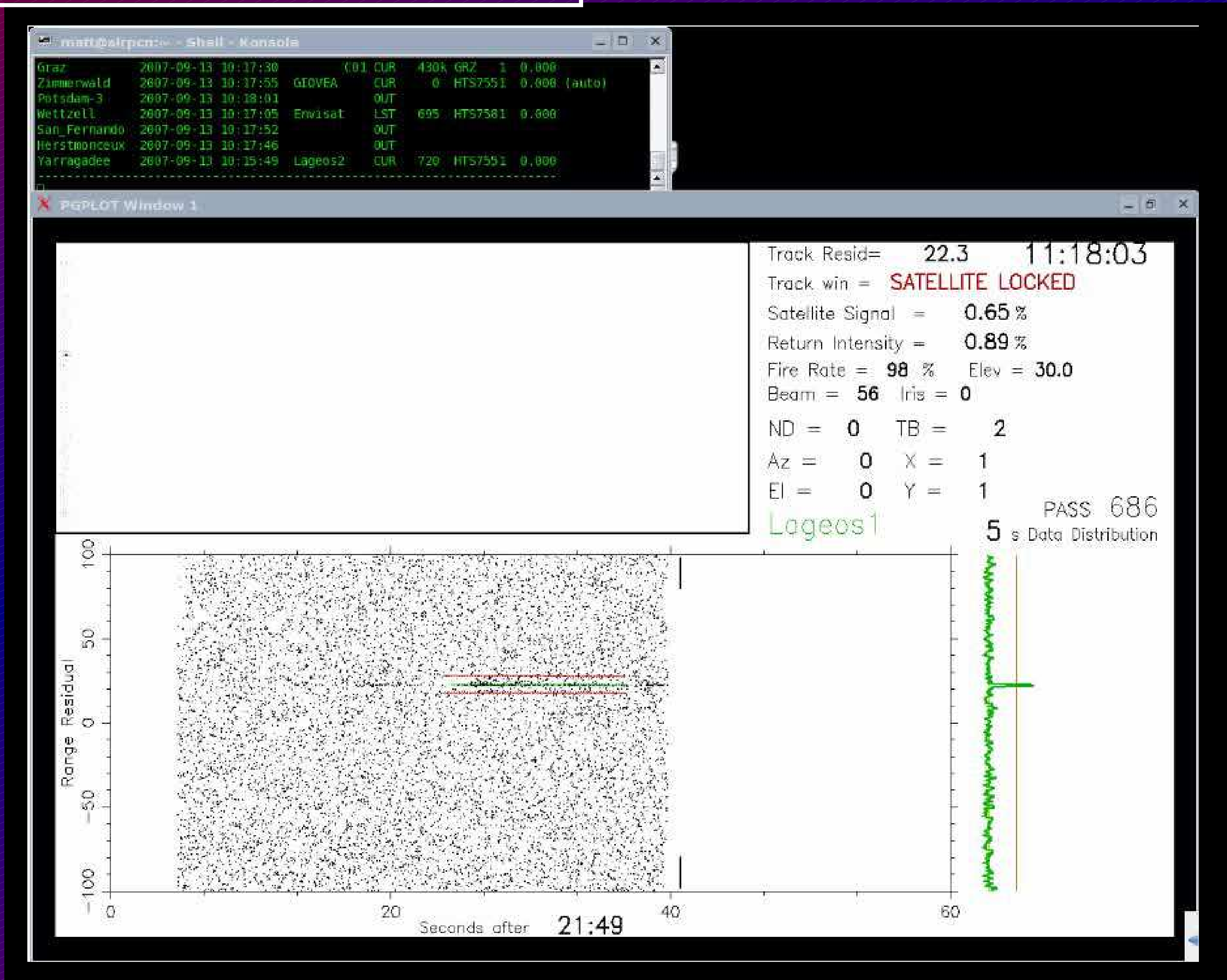
Redesigned kHz display



kHz pass video



kHz pass video



Observer Technique

Satellite search patterns can be stepped through more quickly due to the feedback from many shots.

However neutral density filters have to be controlled smoothly despite the quick measurement of return energy

Range Gate Generator

We looked into using a software based range gate generator but the speed at which we could read the internal clock meant that such a method could not match the speeds necessary to control the gating.

We now use a **Graz built ISA board** to control the arming of the detector through hardware.

The ISA board is straightforward to install and control and takes care of the difficulty of range gate setting.

Clock Consistency

The clocks used to set the Event Timer and the Range gate generator need to be the same.

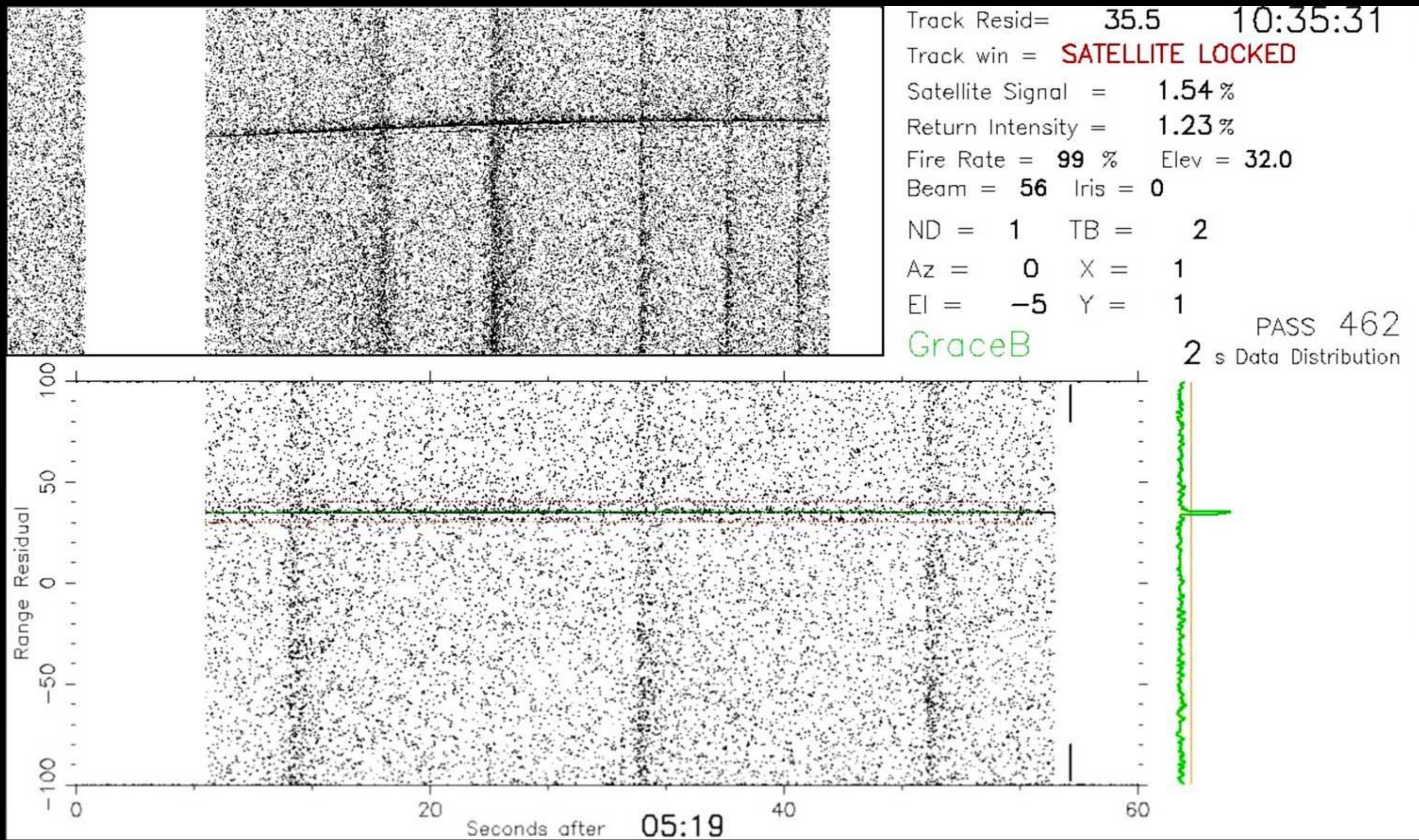
We initially used GPS time to set HxET and a smoothed GPS time to set the ISA card.

As GPS was steered these times drifted apart and the gating could change by about 100ns.

Using only raw GPS time, we no longer see this problem.

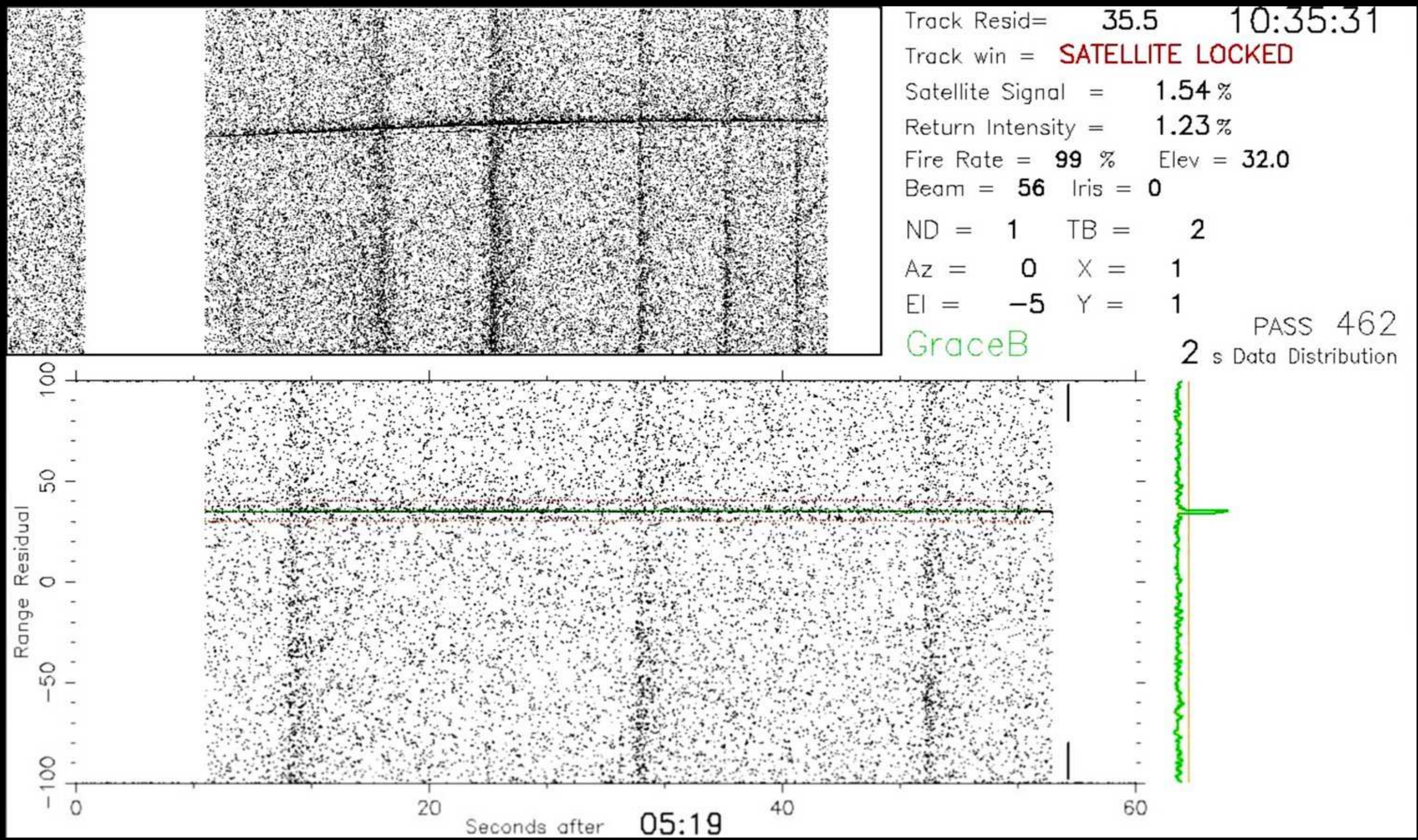
Laser Clashes

Occasionally the gating of the detector will coincide with a laser fire. This results a short period of noise in the observations.



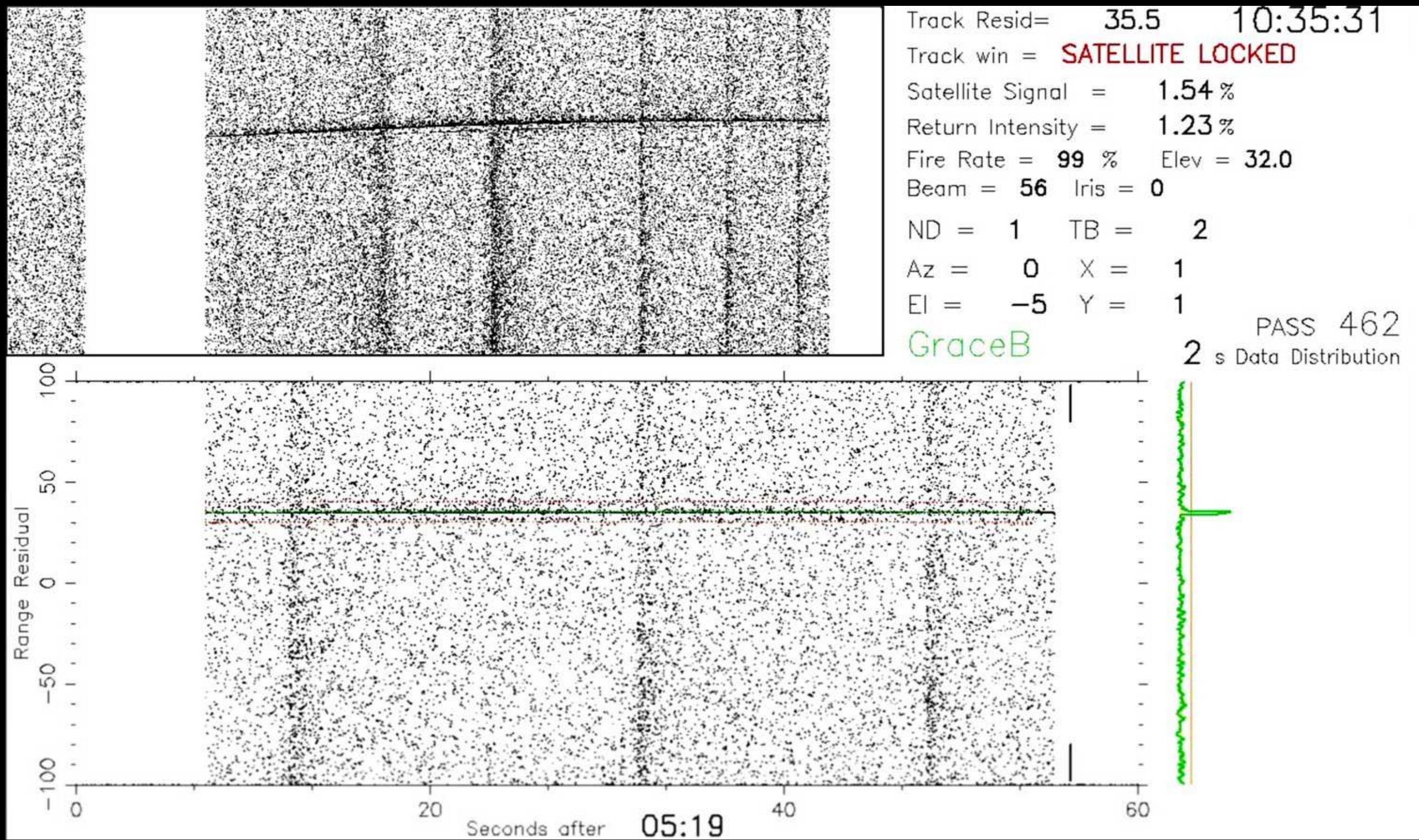
Laser Clashes

The ISA card avoids these clashes automatically by adding a delay to the firing of the laser.



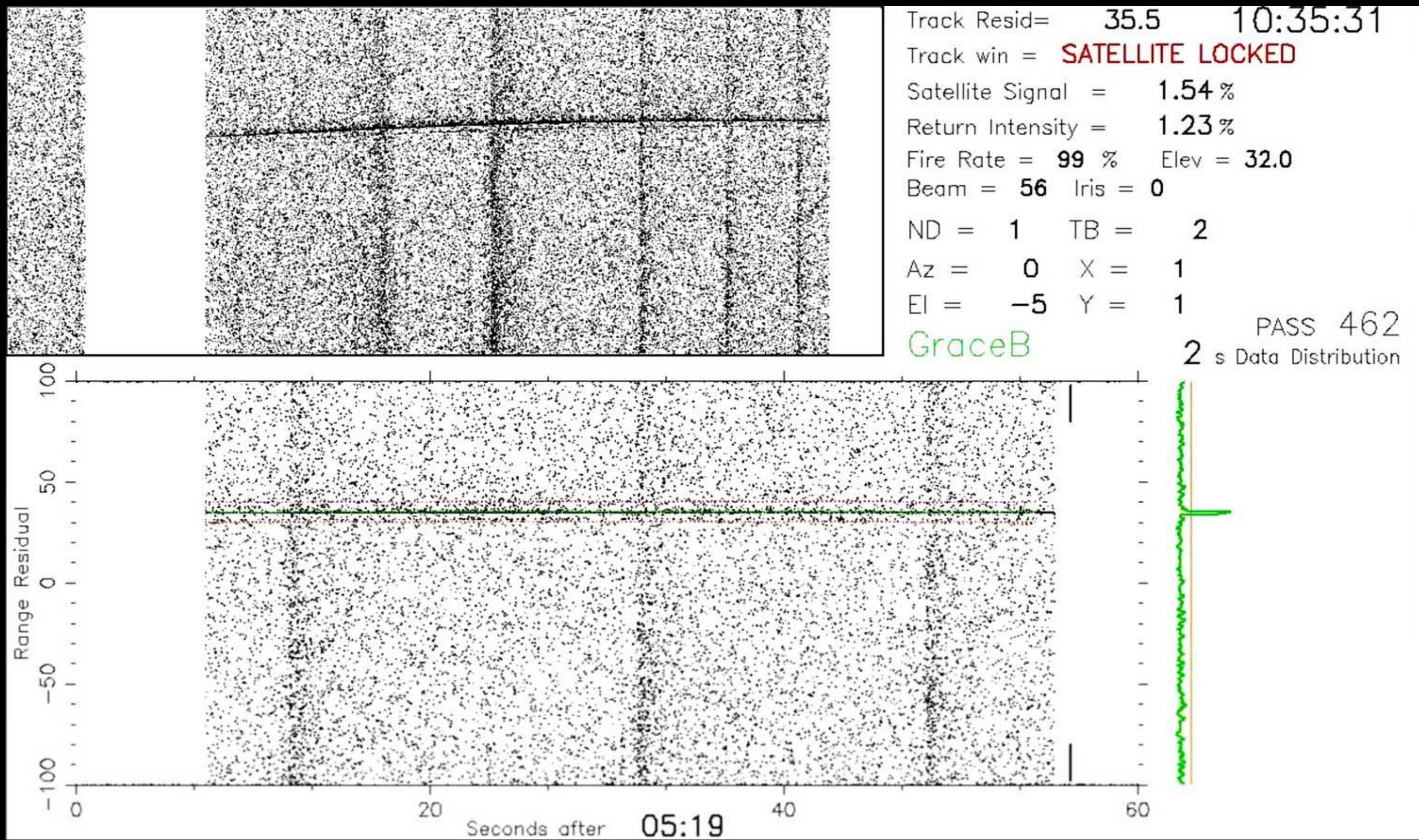
Laser Clashes

However, the ISA card needs feedback from the laser which we are unable to provide so instead we change the firing rate of the laser in real time through software.



Laser Clashes

A clash is easily foreseen because the laser firing is predictable. So the software finds a firing rate without clashes. However this is limited to step changes of 10 Hz on the ISA card.



Link Equation

What return rates to expect from the Link equation and is it still possible to control at single photon?

Link equation predicted ~20% for Lageos at the zenith.

Return rates

What return rates can we get?

LEOs	> 20%
Lageos	~10%
HEOs	< 5%

We are still to align the kHz laser so we expect better.

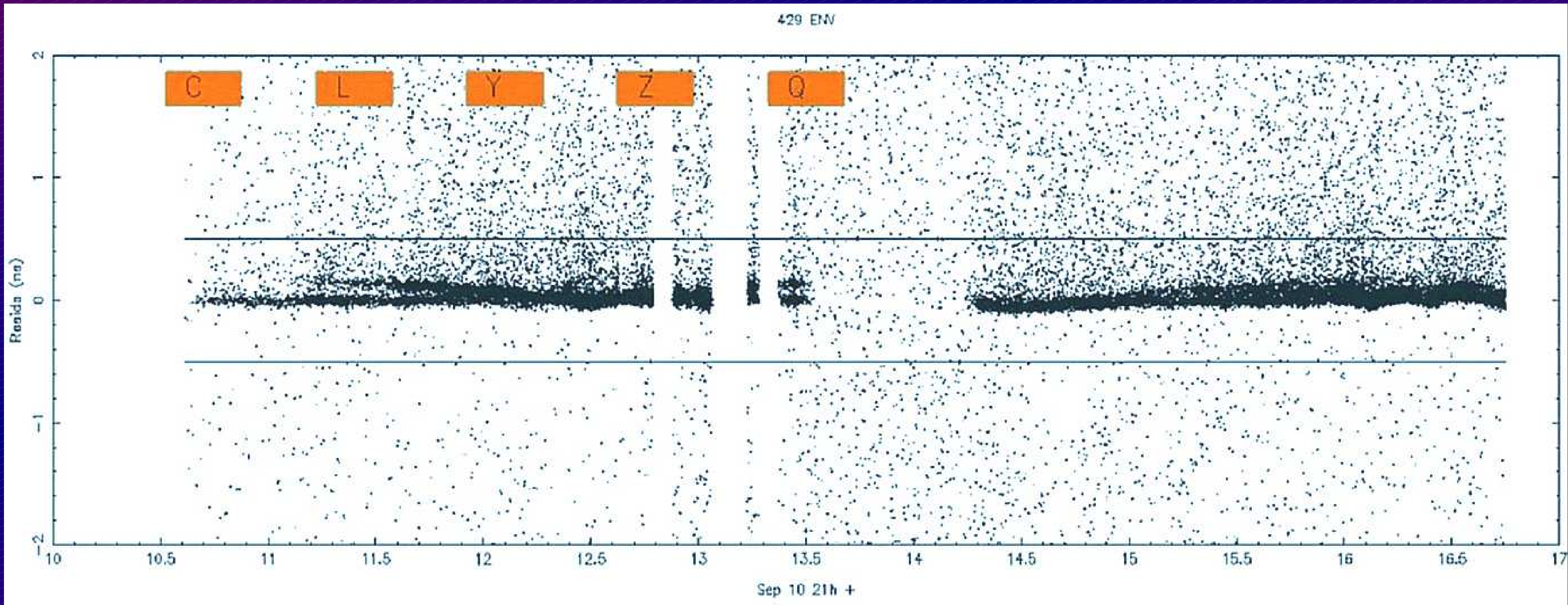
Daytime Camera

We upgraded our daytime camera setup to include an image intensifier that could be gated.

This allows us to see the beam easily during the day so it can then be aligned in the iris using a tip-tilt mirror.

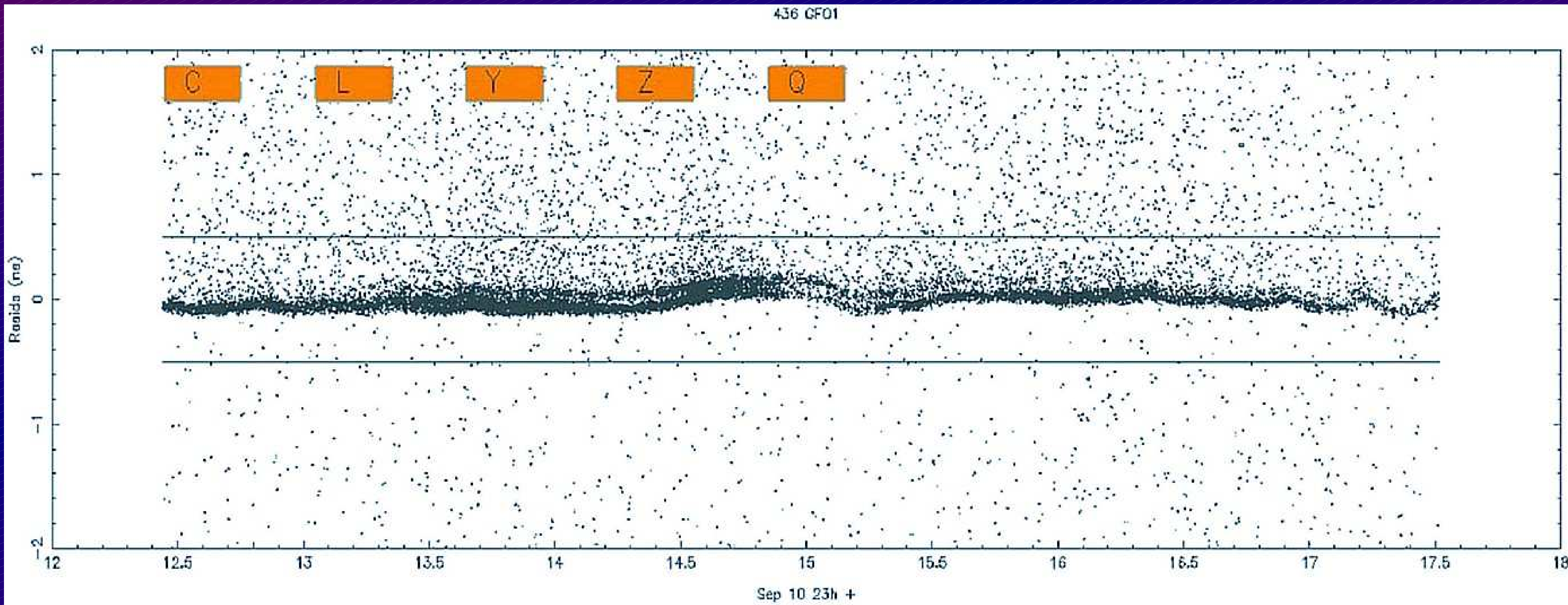
Reductions

Reductions take longer than before but this is overcome by modern computing power.



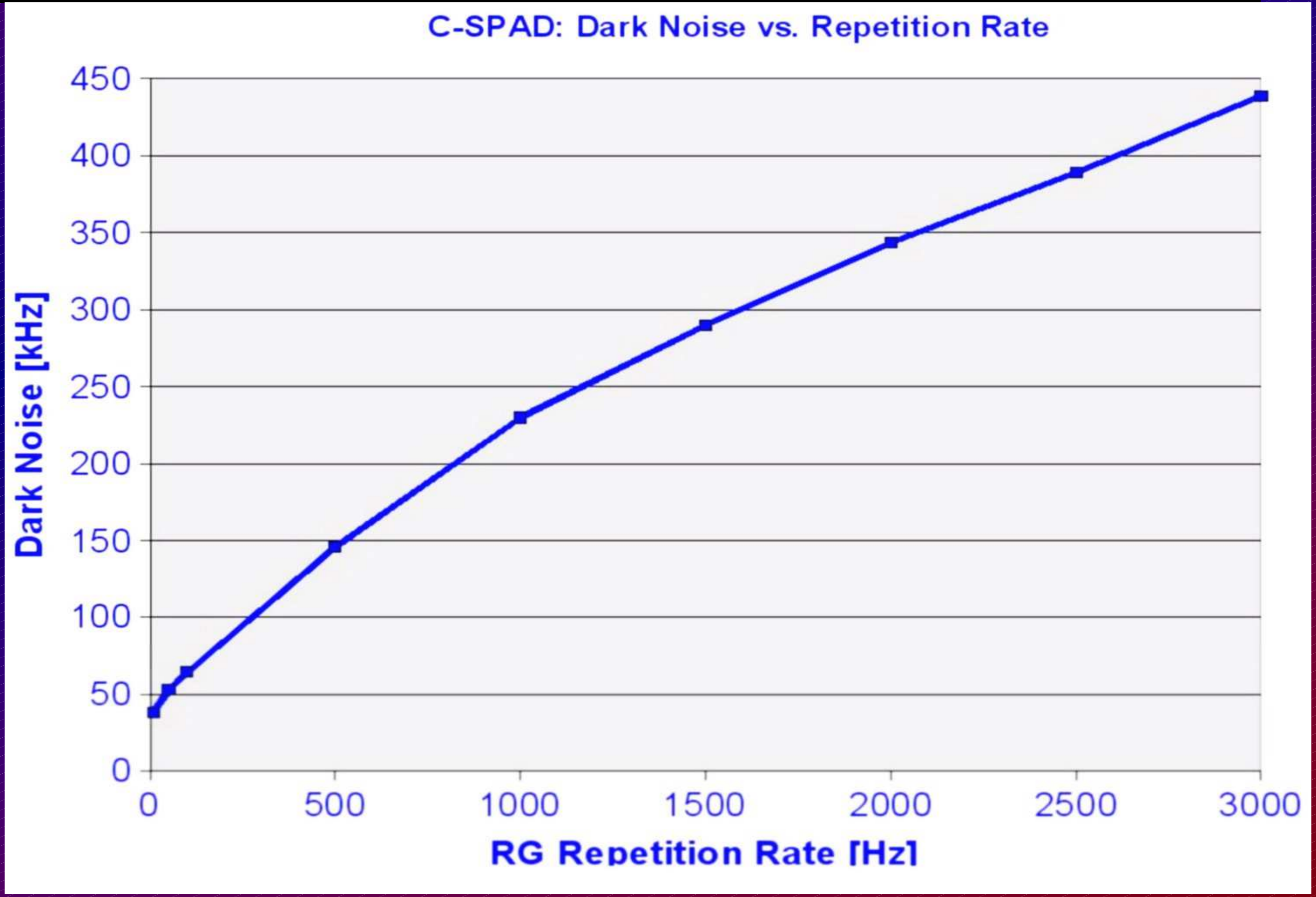
Reductions

Selecting the kHz track so that the criteria used are consistent is difficult.



Detector Noise

The C-SPAD exhibits 'Dark Noise' with high-rate gating speeds.



Two System Switching

The kHz laser is installed to the side of our old 10Hz laser. A sliding mirror controls which laser beam can travel up to the telescope.

This mirror will soon be automated so switching between the high and low rate systems can be done under observer command.

Alignment of the two lasers through the tunnel will be more demanding however.

Summary

Herstmonceux is now ready to operate routinely at kHz repetition rate.

Purchasing the Event Timer, the kHz Laser and the Range Gate Generator gave us our kHz system which we have developed with new communications, a new day time camera system and new display software.

The forthcoming experience we will gain will determine the 'best practice' during observation and for the reduction of data.