The current status of the move to KHz Laser Ranging at Herstmonceux

NERC Space Geodesy Facility, UK

15th Laser Workshop, Canberra 2006
Completed

- Replacement of SR620 timer with an Epoch Timer (July 2006).
- Software/Hardware to read and control ET.
- Verification of Linearity and jitter of ET.
- Purchase and installation of a KHz Laser (2005).
- Software/Hardware to arm C-SPAD at KHz rate.
- Software to collect, plot and archive KHz data, detect track in real-time, control telescope and safety radar, interact with observer and control beam divergence, ND, Iris and beam steering.
Incomplete

• Control of Laser & safety systems for single manning of system.
• Implementation of software control of Laser & overlap control.
• Reduction software.
• Full Software package for KHz ranging.
• Ranging to Champ/Grace
• Daytime Glonass. GPS/Etalon day or night
• Full implementation of monitoring software for ET.
• Viewing laser in daytime – we can see the beam by moving our night-time camera
• Software to pre-arm C-SPAD for the calibration target inside the dome it works but not 100%
Herstmonceux Event Timer

- We have used the commercially available Modules from Thales Systems – 2 timing and 1 clock module.
- Separate power supplies for each module.
- 8-Euro-Cards containing 15 power supply units, all optimised for their specific purpose.
- Forced air cooling to remove heat from these power supplies, and provide good air flow around modules.
- ET can accept either NIM or TTL start pulses from laser and stop pulses from the C-SPAD.
- It accepts a 1-pps pulse from GPS to enable epoch synchronisation of the timing modules.
- It has an on-board 1 KHz pulse on the PCB to determine the timing difference for the two modules.
- It outputs to the modules a standard ECL pulse into 50Ω @ -2Volts.
Herstmonceux Event timer

• We get 5ps jitter for start and stop.
• Comparisons with our SR620s give the same results as identical tests carried out with PPET in 1998.
• Comparisons with SR620s have confirmed the non-linearities in the SR620s and have enabled us to quantify errors in our system calibration back to 1994
Module1

Module2

Clock Module

1 pps from GPSIII
For Epoch Ref

1 KHz Pulses for
Module Offset Cal

START

STOP

Ranging PC

Input Select

Module Read

Module Write

Hx
GPSIII

1 pps

10 MHz

Fig. 2: Principle of Input Board
NSGF 2000 Pico Event Timer

Fig. 1: General Setup Block Diagram
Fully programmable ISA card

This was purchased from Graz along with demo Fortran code. It allows us to

• Read and control ET.
• Send range gate pulses to the C-SPAD.
• Control laser and laser rates and avoid overlap between incoming and outgoing pulses.
• Bring world peace – not yet implemented
**KHz Laser**

- Nd:Vanadate picoREGEN laser from High-Q
- Pulse energy 0.5mJ at 532nm at 1KHz
- 0.4mJ at 532nm at 2KHz
- We have had repetition rates of between 100 and 2000 with no need for re-alignment
- Pulse width is 10ps FWHM at 532nm
Tracking so far

• We have successfully tracked
  – Day
    • Lageos and below except Grace & Champ
  – Night
    • All satellites except
      – GPS/Etalon – no opportunity
      – Champ/Grace – we have some software issues
Problems

• The extra dark noise generated by the C-SPAD has given us a few problems detecting faint tracks in real-time and at the reduction stage.

Picture provided by Graz as a response to our enquiry about the increase in Dark Noise.
Dark Noise counts plotted against Range gate (ns). The losses due to dark noise are ~4% per 100ns from when the C-SPAD is gated.
Problems

- We have had some communication problems with the Linux machine we are archiving the data on.
- We have not yet managed to track Champ/Grace.
- Faint tracks have failed to reduce to our satisfaction using our current software because of the high background noise.
- Different return energies give us different looking data sets.
- When we try to get return energies above 20% for calibrations (and satellites??) the system appears to get swamped and the return rate drops off.
Successes

• The Laser had had no work done on it for 2 months when we turned it on to use it and none during the test period and it worked well for any fire rate we threw at it (100Hz – 2KHz).
• The software to do the initial tracking was cobbled together in a few days and worked almost immediately.
• Tracking Giove to Larets.
• Calibrating to our target inside the dome.
A few pictures

This track was not detected in real-time
This has failed to reduce properly due to the track/noise ratio.
Honestly – there is a track here
Pass 166  Glonass87

- = rejected by NP process

Residual (ns)

-0.4 -0.2 0 0.2 0.4

100 110 120 130 140

2006-10- 4 19 hrs+
Data set after fitting an orbit but before fitting a Gaussian
Extracted Lageos data which goes into the Gaussian fitting routine for ET/KHz and SR/NdYag (scaled)

The shape is very similar as Lageos dominates the shape.
There is still some obvious noise left – but is it any worse than our current system?
The final data set for both KHz and 10Hz system.

At first glance it would appear that our reduction process is producing the same results for both systems for Lageos.
Histogram of Envisat data after orbit fit for ET/KHz and SR/NdYag.

With very little Satellite signature the pulse width and timer come into play a little more.
Pass 164 Envisat.

- = rejected by NP process

Residual (ns)

-0.4  -0.2  0  0.2  0.4

2006-10-4  21 hrs+
Although the shape of the final data looks similar we can see the KHz system gives a smaller jitter but the means look the same.
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<th>Satellite</th>
<th>RMS(mm) (10Hz)</th>
<th>RMS(mm) (KHz)</th>
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Future

• Control laser, add safety systems
• Remove all spurious tracks from laser
• Complete ranging software
  – Control data to single photon
  – Track Champ/Grace
  – Enable time biases
  – Real-time monitoring of ET
• See laser in daylight