NATURAL ENVIRONMENT RESEARCH COUNCIL

BNSC

New Internal Calibration Target at SGF Herstmonceux: Design and Results

David Benham, Philip Gibbs, Victoria Smith (NERC SGF)

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Overview

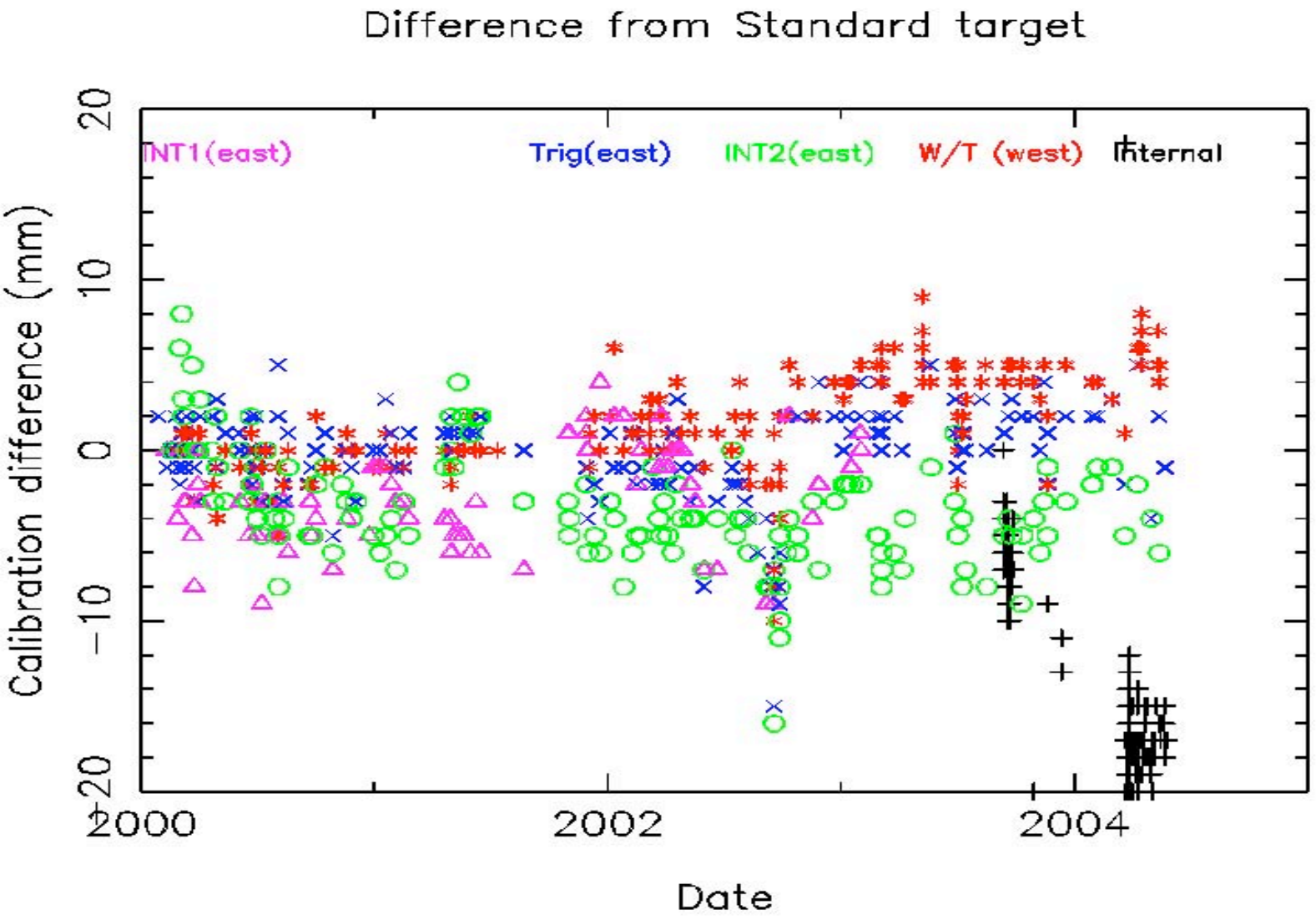
- Existing Targets – Position and Verification
- New Target – Design and Position
- C-SPAD – Arming
- Timers – Non-Linearities
- Results – Comparisons, Problems and Conclusions

Existing Target Layout

- We have 5 targets at Herstmonceux
- Two stainless steel retroreflectors to the west at a distance of 120 metres
- Two retroreflectors to the East at a distance of 600 metres
- One flat board target at 600 metres to the East – this was our original target but is not now used

Survey and monitoring

- Three of the targets (1 east, 1 west and the flat board target) were originally surveyed along with the telescope
- We regularly range to all the targets
- We had all 5 targets surveyed in 2003 and the measured ranges agreed at the 2mm level


Difference from Standard target
INT1(east)
Trig(east)
INT2(east)
W/T (west)
Internal
Calibration difference (mm)
20
10
0
−10
−20
2000
2002
2004
Date

New internal target

Arming problems

- In normal use C-SPAD arming is timed relative to the Start Diode
- The minimum time for our arming route is ~400ns
- But the distance to the new target is ~110 ns
- Therefore cannot use the Start Diode for arming

- However the uncertainty in firing the laser is 10 microseconds

Arming solution

- By always arming the C-SPAD 10 microseconds before firing the laser we guarantee it is ready to receive a return
- However early arming can result in noise detection which can lead to problems controlling single photon returns.
- We believe we have overcome this problem

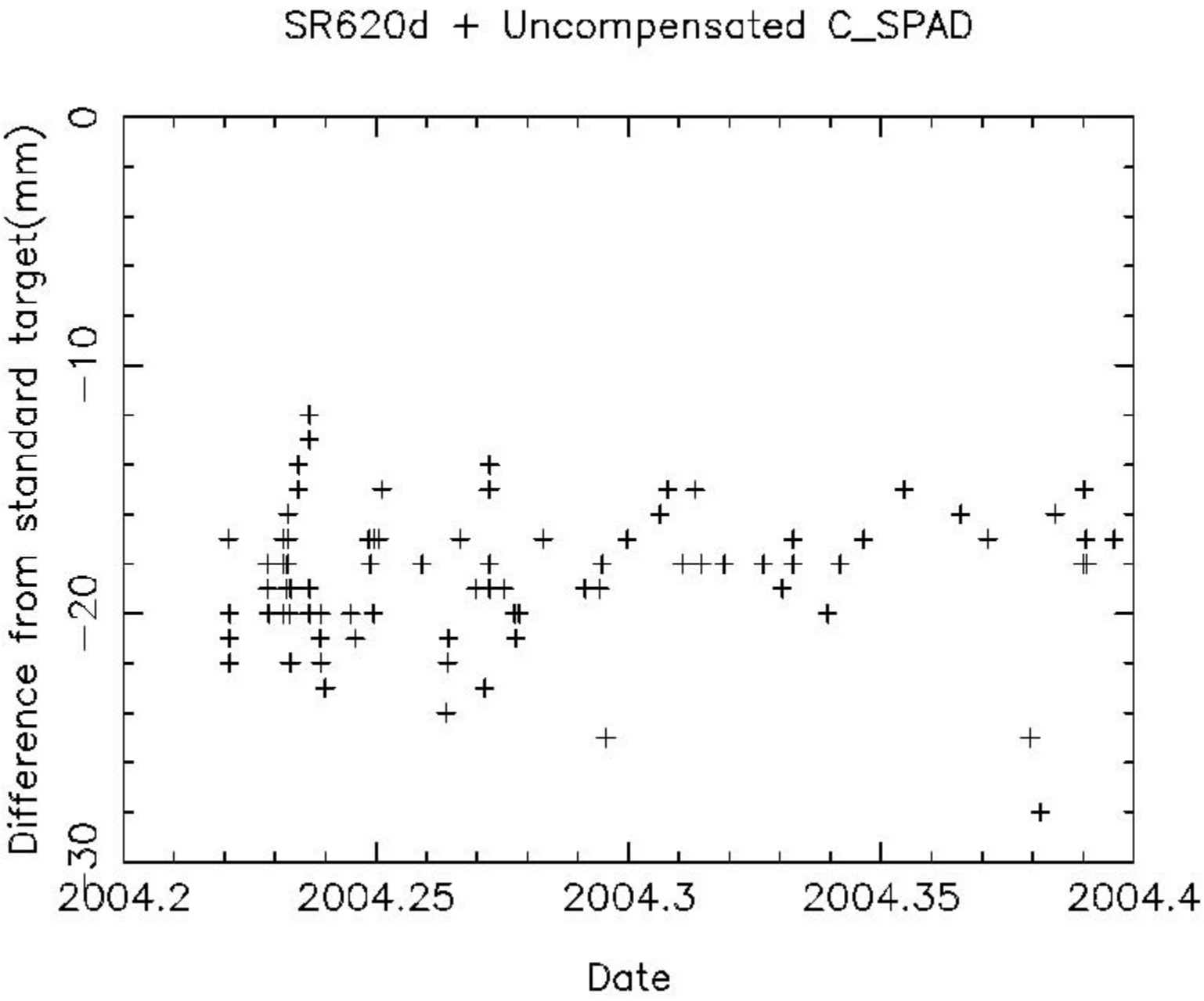
First results

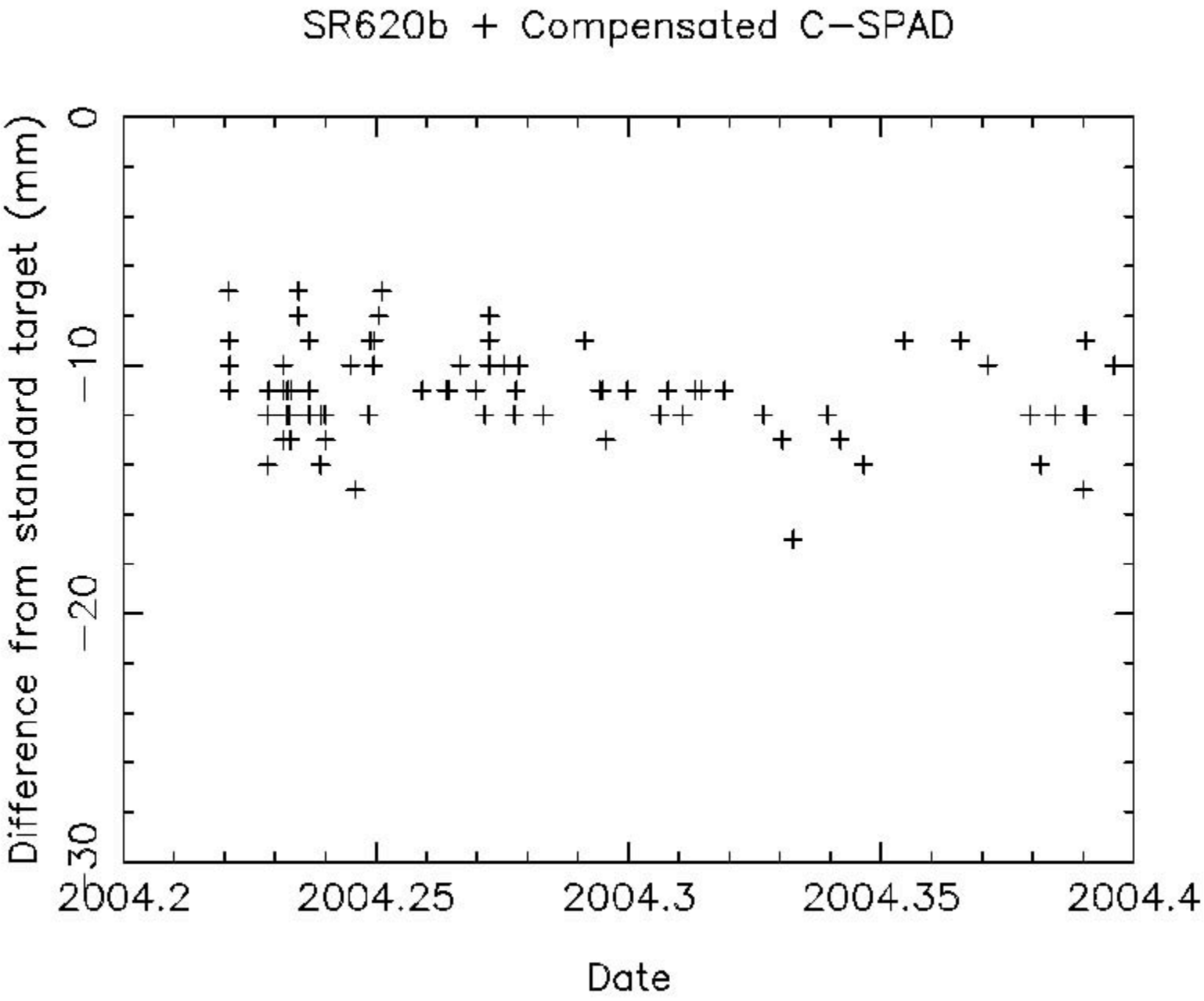
- We know the distance from the target to the telescope axis; we can control C-SPAD arming; and control the return rate.
- We would therefore expect good agreement between the new target and existing targets

WRONG

Single Photon

- Our system has four SR620 timers, 2 connected to the uncompensated channel of the C-SPAD, 2 connected to the compensated channel
- Main Target to Internal Target comparisons
  - Standard setup
    - Uncomp A 16mm D 17mm
    - Comp B 9mm C 10mm
  - Non-standard setup
    - Uncomp A 17mm B 15mm C 14mm D 18mm
    - Comp A 16mm B 12mm C 12mm D 15mm


SR620d + Uncompensated C_SPAD
Difference from standard target(mm)
0
−10
−20
−30
2004.2
2004.25
2004.3
2004.35
2004.4
Date


SR620b + Compensated C-SPAD
Difference from standard target (mm)
0
-10
-20
-30
2004.2
2004.25
2004.3
2004.35
2004.4
Date

Possible explanations

- Survey measurements wrong – we do not believe this is the case due to the site survey of 2003
- Uncontrolled return rate (not single photon)
- Decay in C-SPAD due to early arming
- Timer non-linearity

Single Photon

- The plots shown previously were taken at very close to 0% return rate !
- Any return rate problems should only show in uncompensated channel measurements
- But compensated channel data indicate there is still a discrepancy of order 10-12mm

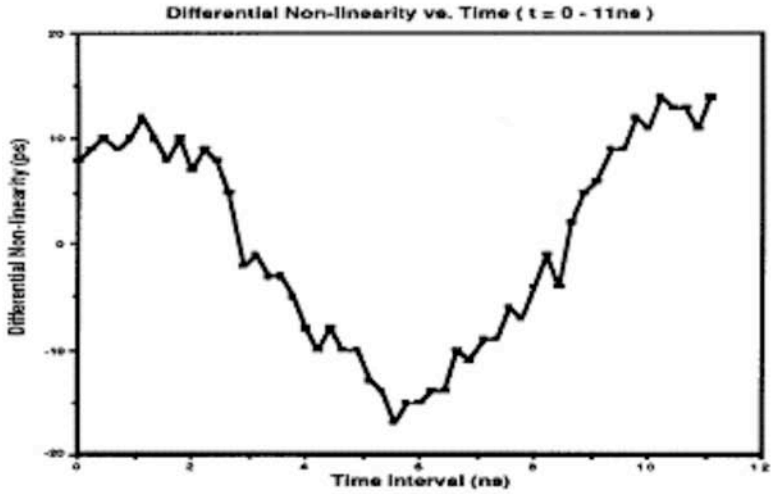
Decay of C-SPAD electronics

- We know there are errors if you do not arm the C-SPAD far enough in advance. The requirements are
  - Uncompensated 50ns - if less, errors can be up to 15mm
  - Compensated 100ns - if less, errors can be up to 40mm
- For the internal target we arm the C-SPAD very early (up to 10microseconds).
  - Can this cause a problem?
    - To check this we ranged to our 600 Metre target and armed C-SPAD between 100ns to 4□s early.
    - The calibration values varied only at the 1mm level.
- We are therefore happy that it is not an arming problem with the C-SPAD.

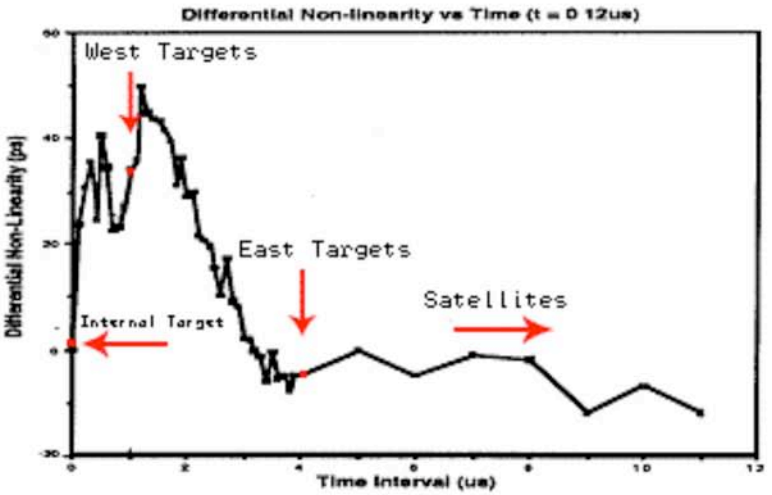
Timer non-linearity

- The SR620 manual describes 2 differential non-linearities

Specification Guide



Graph 1: Differential Non-linearity for time differences of 0 to 11 ns. This shows the residual non-linearity of the time-to-amplitude converters.

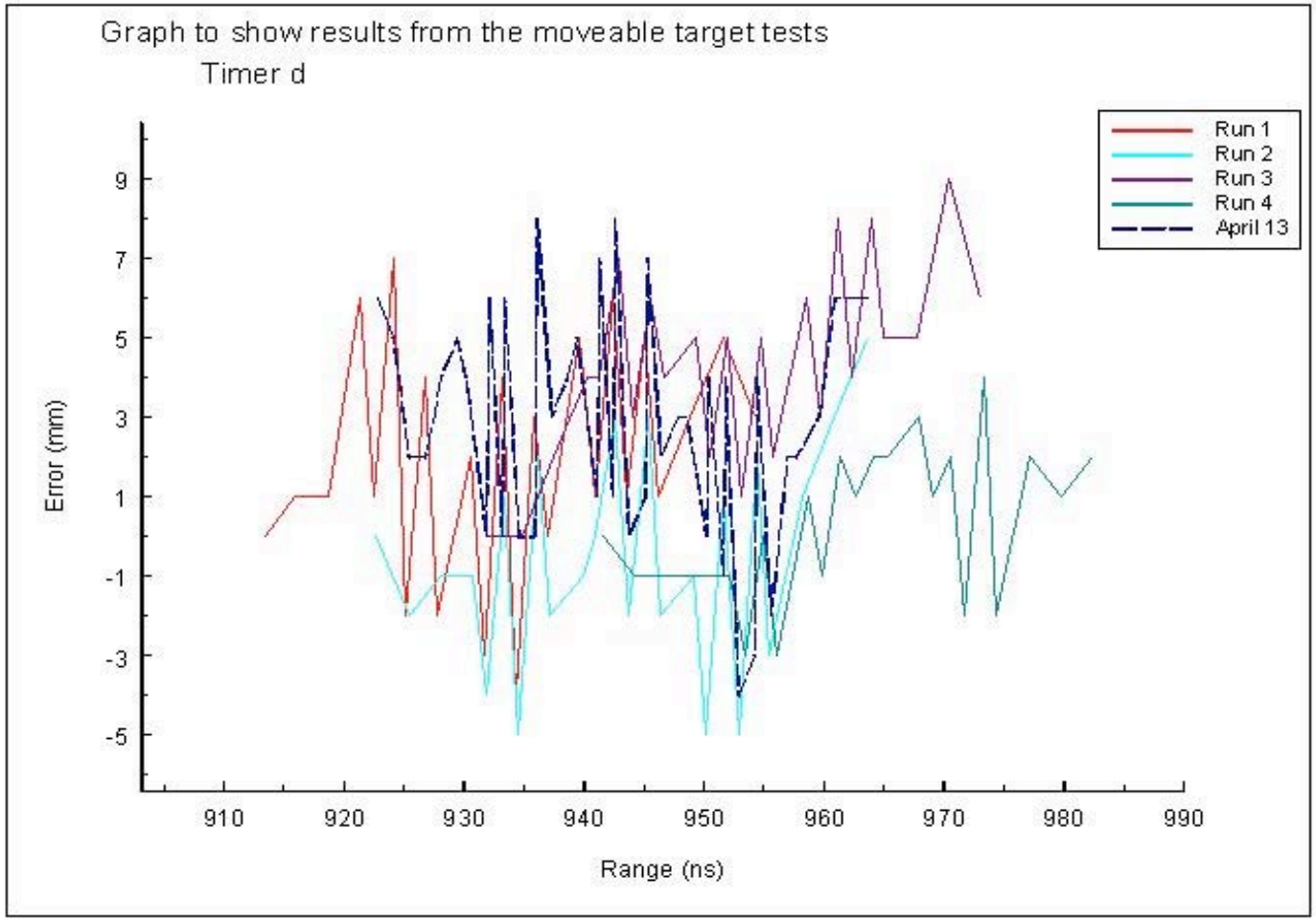


Graph 2: Differential Non-linearity for time differences of 0 to 11μs.

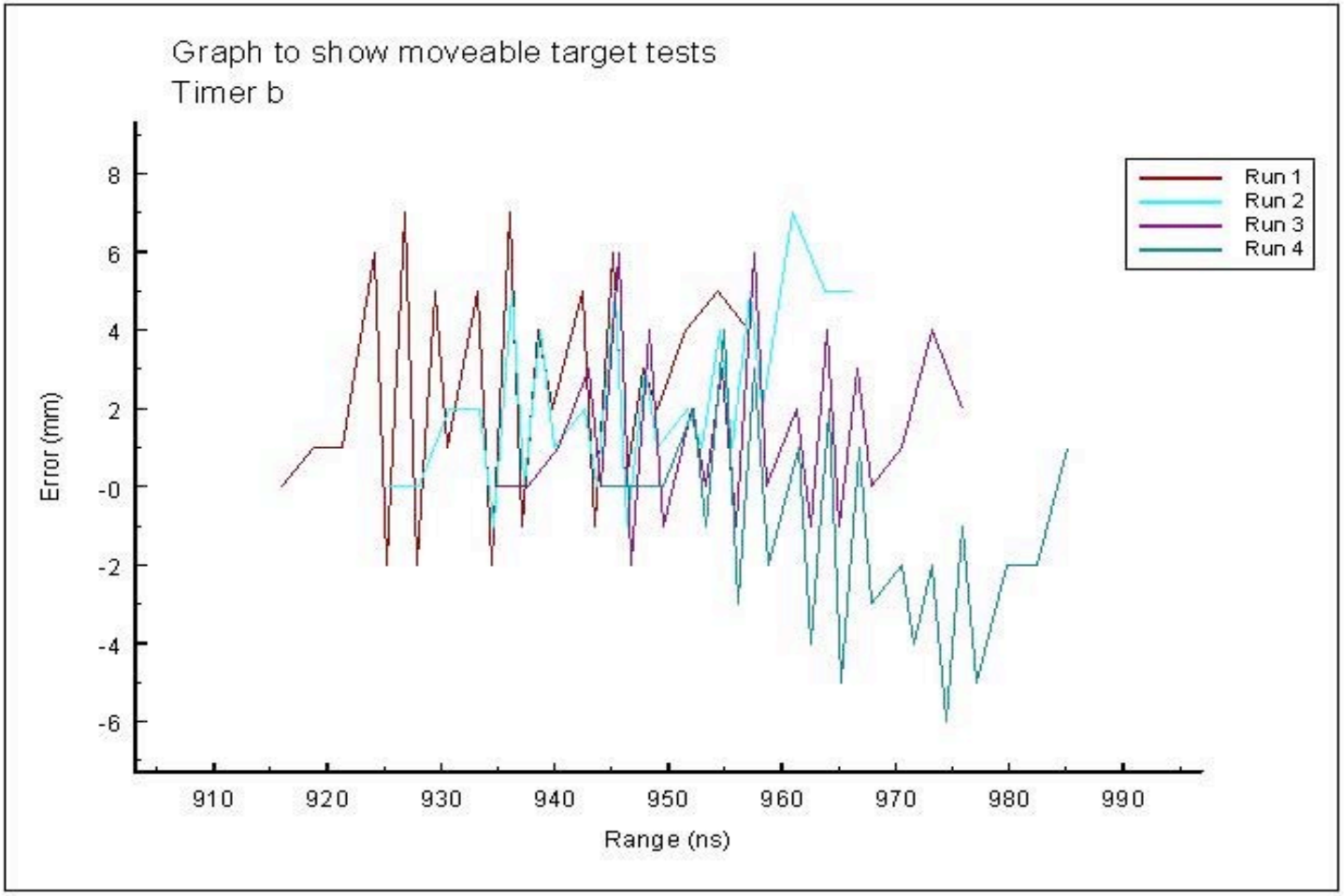
Moveable Target

- A moveable target was built to sample the SR620 behaviour over the 11ns non linearity
- The target was mounted on a rail allowing movement of 2 metres (>11ns) along the line of sight, therefore 4 metre range difference.
- Calibration measurements were taken every 20 cm along the rail
- For a truly linear system we would expect any change in calibration to equal the movement of the target
- Using the semi-train enables data sets of some 40ns for our tests
- Adding cables to the start/stop train can also shorten or lengthen the measured range

Results for SRd



Results from SRb



Conclusions from SRd & b data

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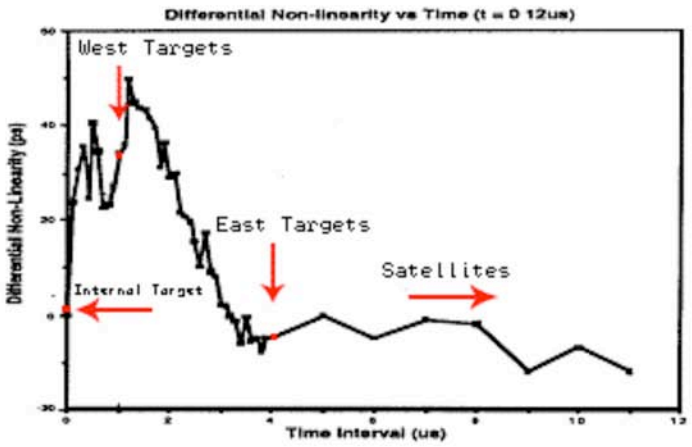
Specification Guide

Graph 1: Differential Non-linearity for time differences of 0 to 11 ns. This shows the residual non-linearity of the time-to-amplitude converters.



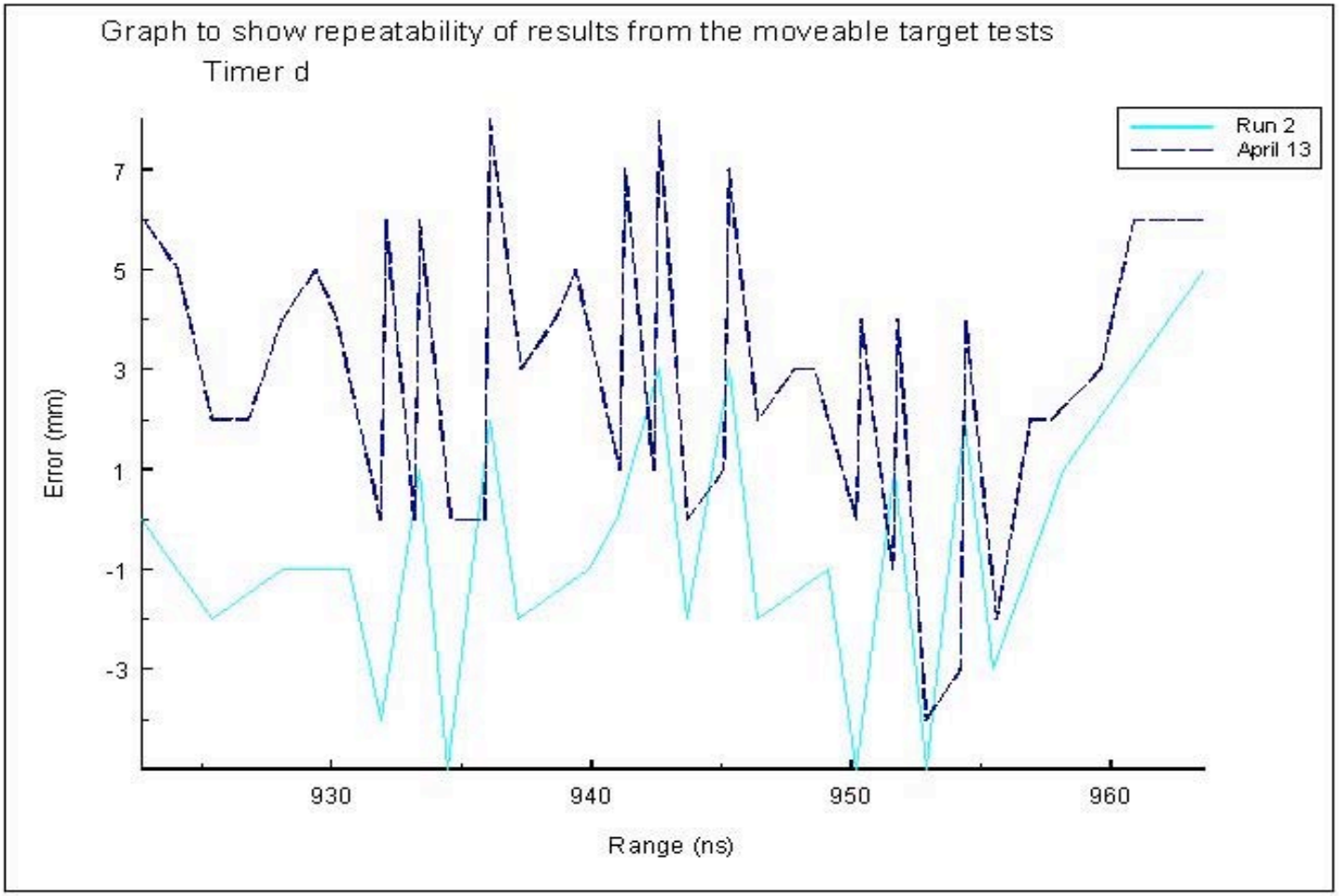
Graph 2: Differential Non-linearity for time differences of 0 to 11µs.

- The remainder is currently unaccounted for – but may be due to the differential non-linearity between 0-1 microsecond as shown on the second Stanford plot from the manual

Repeatability

- During moveable target tests standard calibration measurements were made at the start and finish, and sometimes in the middle of the runs
- These standard measurements did not vary more than 2mm. This is in keeping with all of our standard calibration measurements
- When tests were repeated over the same ranges on different days the behaviour appears to be similar

Repeatability



The Zero point for each run is arbitrary but similar behaviour is apparent

Future

- This is an ongoing investigation, the differences may only be explained when we have
  - built and installed the Herstmonceux ET and can measure the non-linearity of the Stanfords
  - installed a more precisely controllable KHz laser to eliminate C-SPAD arming problems and thus problems of maintaining single photon returns

Watch this Space