UNDERSTANDING AND ADDRESSING SLR STATION SYSTEMATICS

20TH INTERNATIONAL WORKSHOP ON LASER RANGING

SYSTEMATICS AT THE SGF, HERSTMONCEUX

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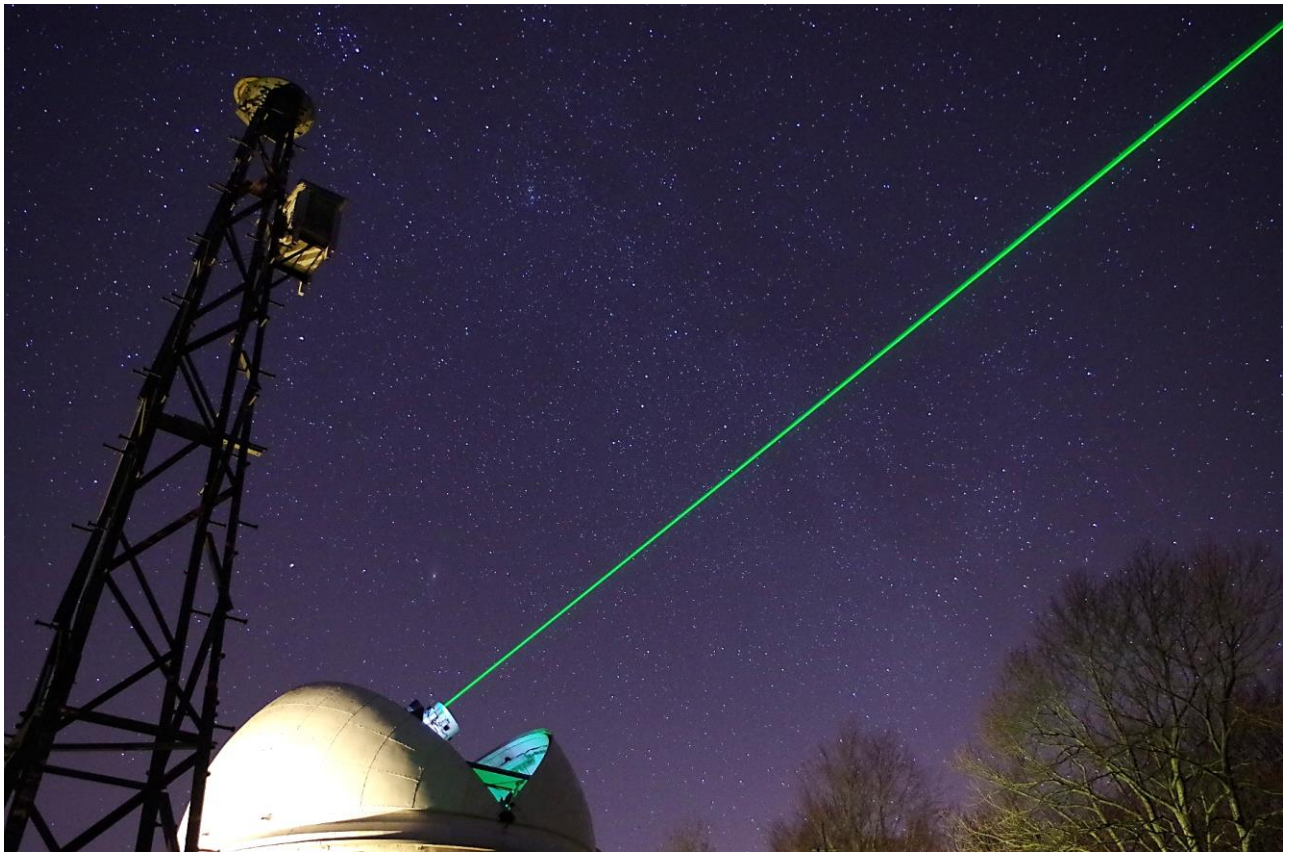
INTRODUCTION

How can a SLR station be better?

- Increase number of satellites tracked and NP yield
- Decrease the uncertainty in the normal point ranges by making many measurements (kHz SLR).
- Identify potential sources of systematic error.
- Operate in a way to minimise the impact of systematics on the range data.
- Monitor, using available tools, for any occurring systematics.

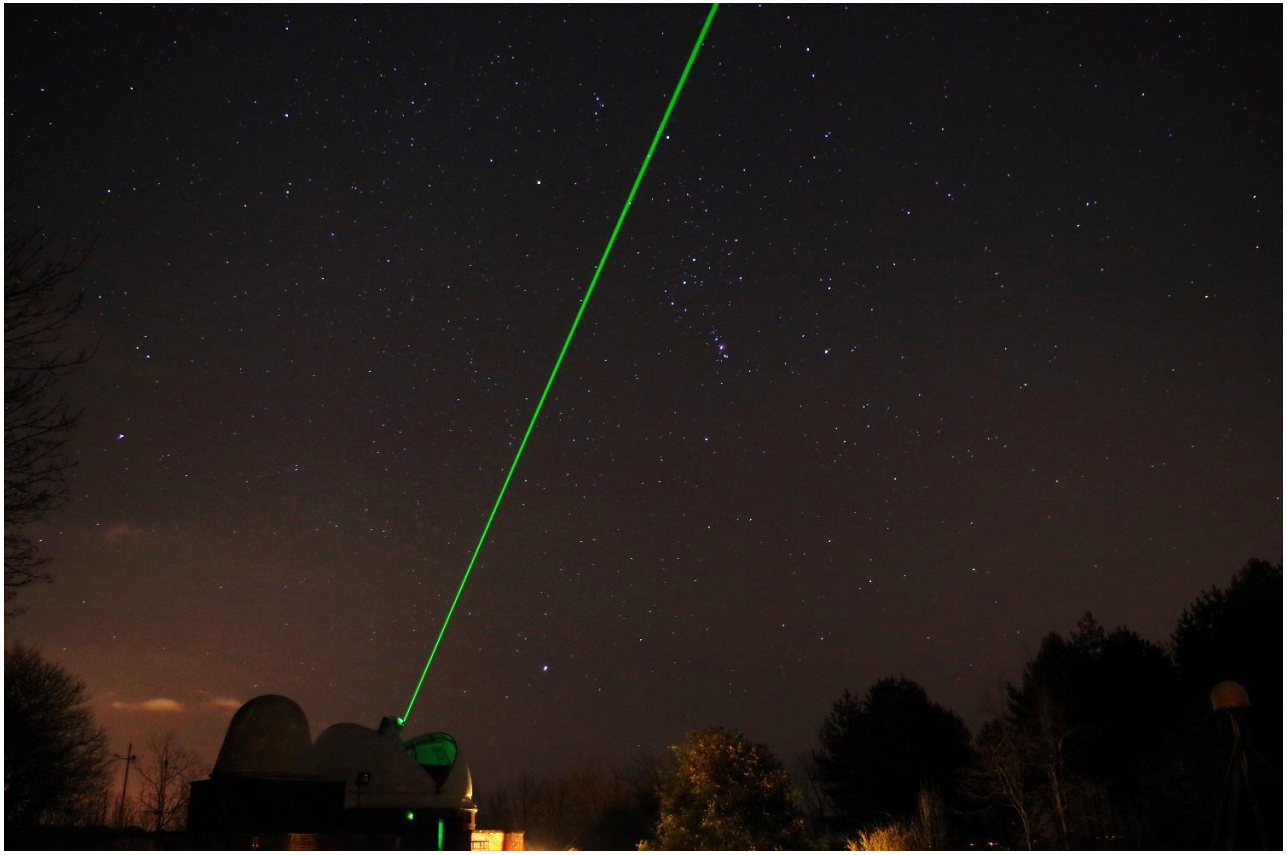
OVERVIEW

- Systematics @ the SGF
  - Single photon SLR
  - Timers
  - Calibration jumps
  - Levelling
  - New calibration target
  - Range bias trend with NP RMS (plotted by T. Otsubo)



OVERVIEW

- ILRS activities in response to systematics at stations
  - ILRS Quality Control Board
  - Analysis feedback
  - ILRS Networks and Engineering SC Forum



SINGLE PHOTON SLR @ SGF, HERSTMONCEUX

Single photon SLR is long practiced at the SGF, Herstmonceux

It avoids systematics in range measurements by:

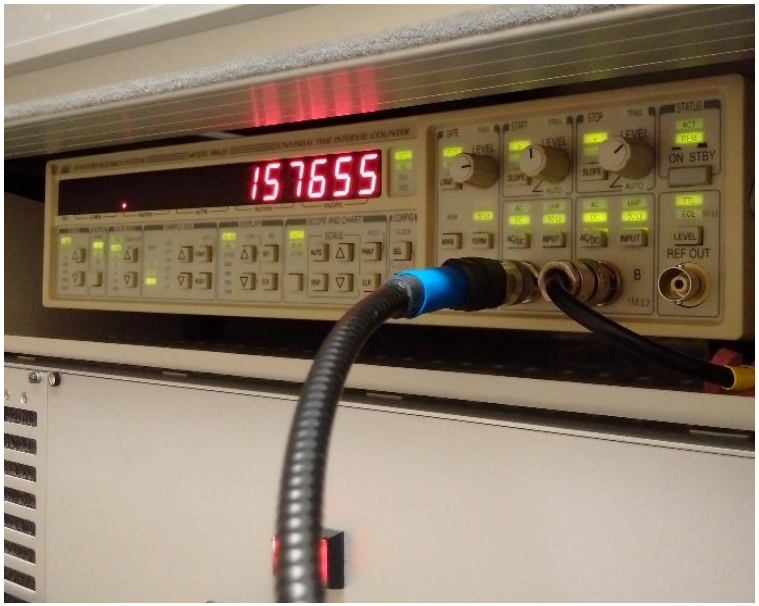
- Making consistent observations across retro-reflector targets.
- Avoiding return signal dependent time walk on detectors.

This is achieved by:

- Real-time reactive adjustment of a graded neutral density wheel on the return optical path.
- Filtering of high return rate range data in post-processing. (Rodriguez: *"Assessing and enforcing single-photon returns: Poisson filtering"*)

TIMERS @ SGF, HERSTMONCEUX

- In 2006, the SGF upgraded from using Stanford SR620 interval timers to the HxET event timer, built in-house from 2 Thales Systems timing modules and a clock module.
- This provided the opportunity to compare and calibrate the linearity of the timers, which confirmed earlier calibration work (Appleby *et al*, 1999 and Gibbs *et al*, 2002).



TIMERS @ SGF, HERSTMONCEUX

- A calibration dependent error was also investigated. This was caused by the SR620 timer non-linearity for short intervals.
- A correction was published in 2006 to all SGF SR620 measurements for this error in the calibration ranges.
- This correction was later re-determined by solving for a bias in weekly laser solutions (V. Luceri).

TIMERS @ SGF, HERSTMONCEUX

- An A033-ET Riga event timer was installed in 2014 to simultaneously collect laser ranges.
- A comparison of the two event timers show good agreement and linear behaviour.
- However, more jitter was seen in the results than should be expected, approximately 10ps.
- By feeding timer channels a start pulse, this was attributed to the HxET timer.

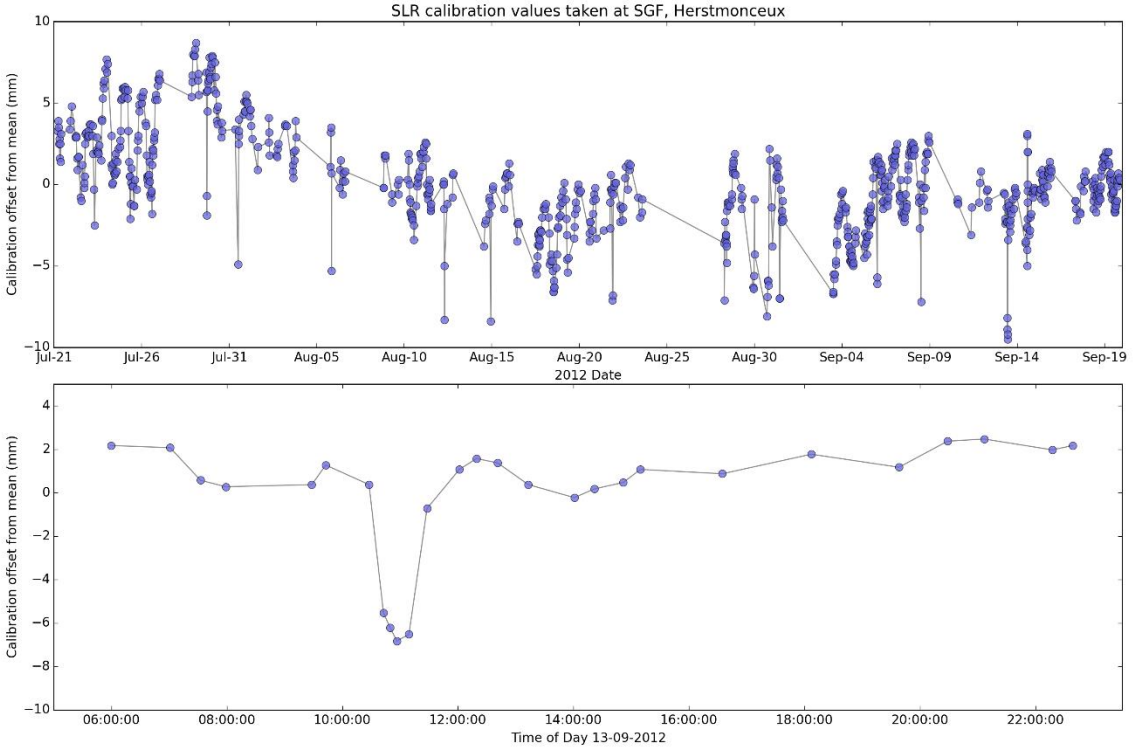
CALIBRATIONS @ SGF, HERSTMONCEUX

- Regular calibrations are made to a terrestrial target approximately 120 metres away.
- Results are compared visually in a time-series by the observer after each calibration.

CALIBRATION JUMPS

- Over the years 2010 to 2012, calibration 'jumps', **8mm** in magnitude, were spotted in the time series plot.

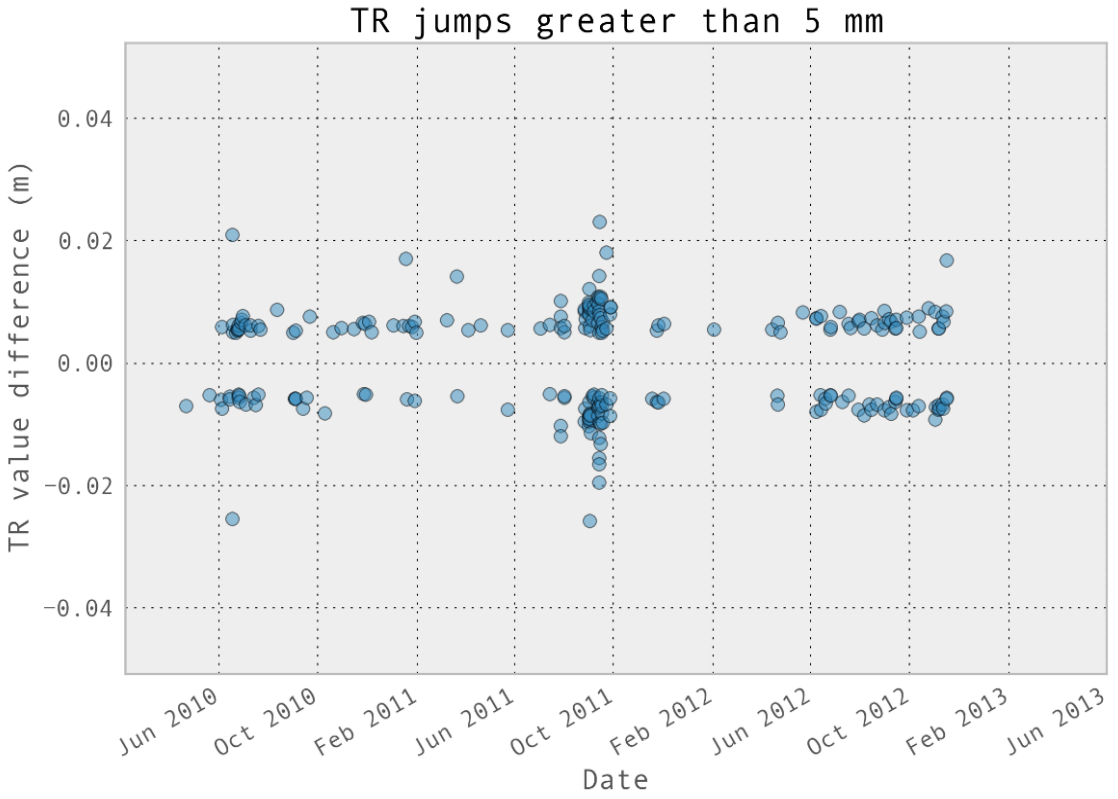
- SLR continued in this period with repeat calibrations taken or data discarded when necessary.



CALIBRATION JUMPS

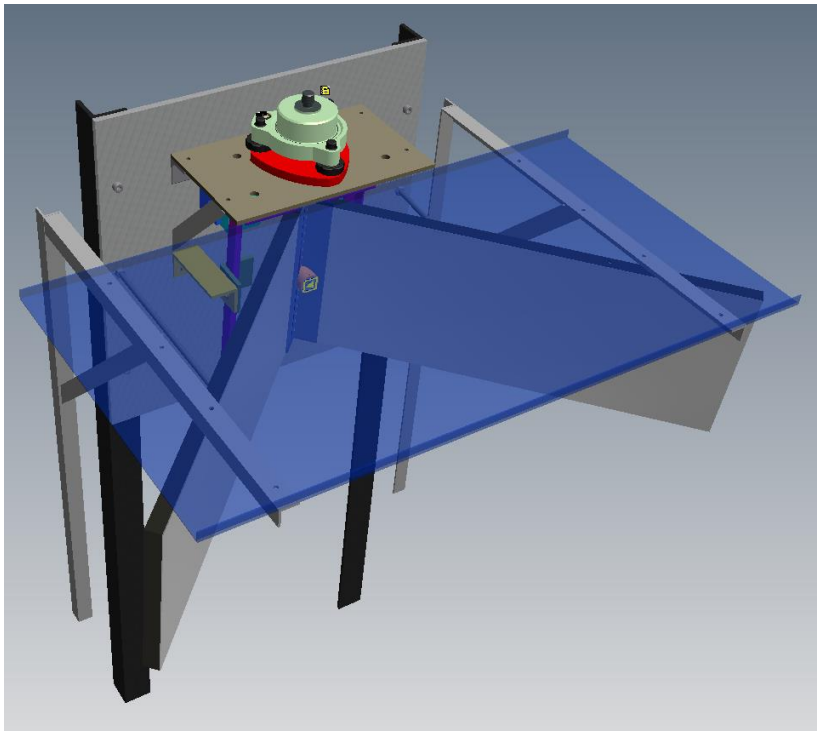
- Finally, the cause of the jumps was found to be a faulty Ortec rack power supply for discriminators and signal splitters.

- This a systematic at a level that would be difficult for the current analysis feedback to detect. Yet it was detectable given the right tool at the station.
- The larger problem, however, was **finding the source** of the systematic.



CALIBRATIONS @ SGF, HERSTMONCEUX

- A possible bias in SLR measurements from Herstmonceux is due to the calibration target.
- The target was surveyed in 2008, with difficulty in determining the target reference point.
- A new and improved target was designed and built at the SGF and is now installed alongside the primary calibration target.



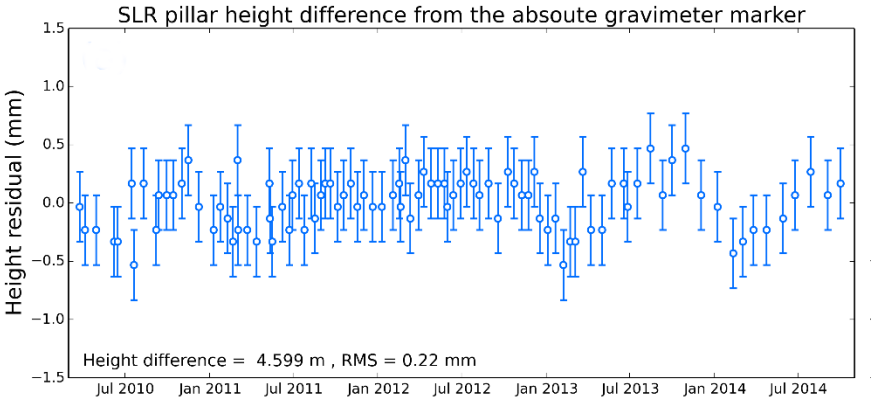
POSTER: *A new laser ranging target suited for accurate surveying at the SGF, Herstmonceux.* T Shoobridge

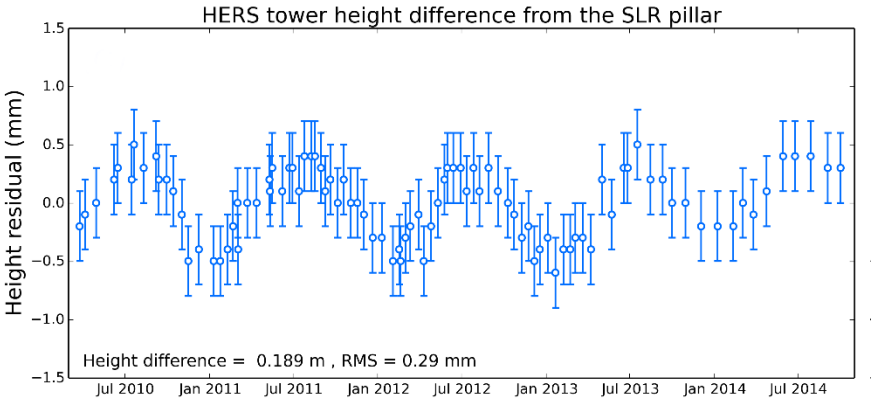
LEVELLING @ SGF, HERSTMONCEUX

- The SGF is a multi-technique facility and in order to monitor the local site for instability a regular campaign of levelling began in 2010.
- A levelling run uses a Leica DNA03, instrumental accuracy of 0.3mm, to measure step height change over a total of 22 monuments across the site.

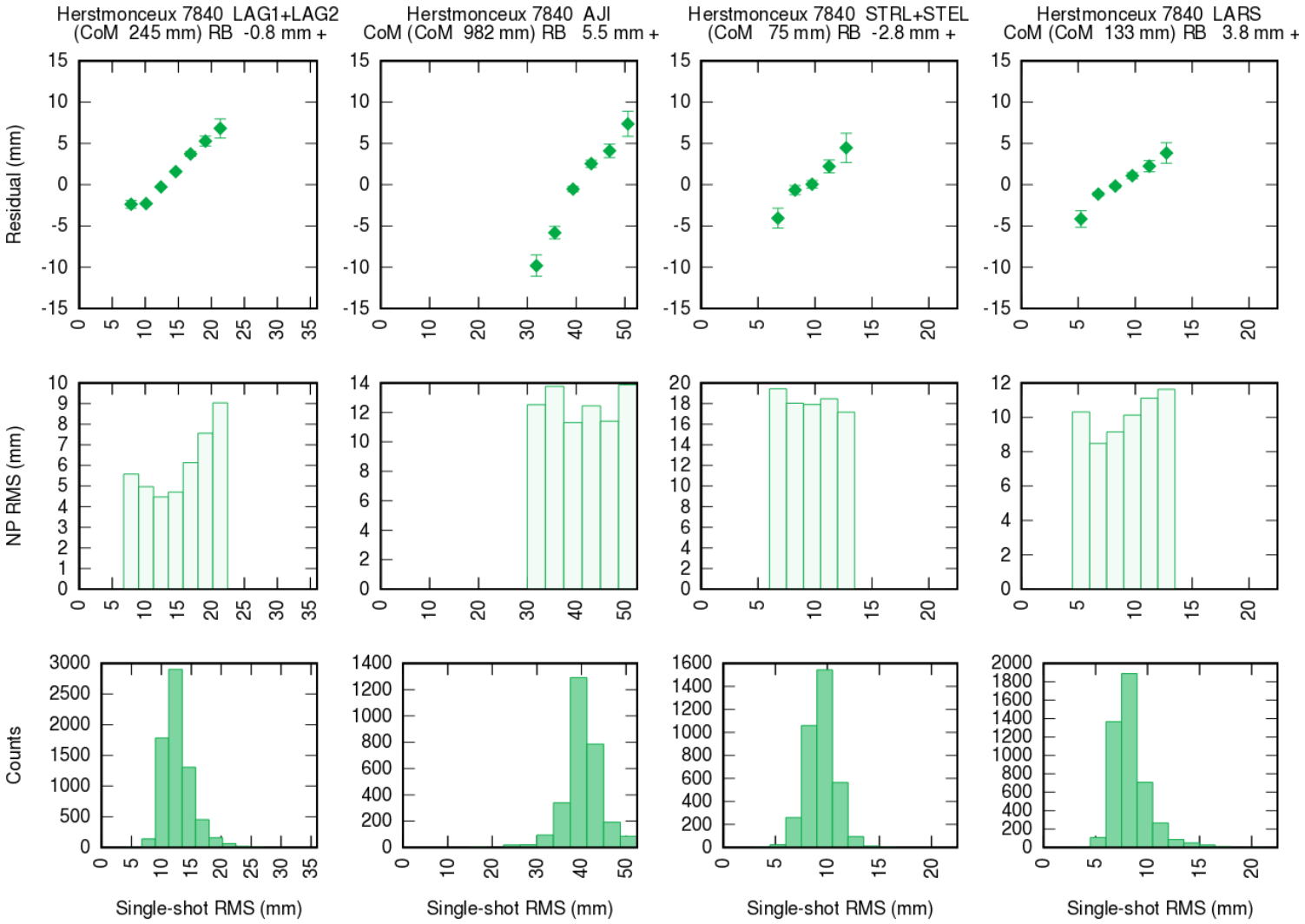
LEVELLING @ SGF, HERSTMONCEUX

- The time series between the SLR pillar and absolute gravimetry markers show little variation over time.
- The time- series between the SLR pillar and the base of the HERS GNSS monument contains an annual variation of magnitude ±0.5mm.





OTSUBO PLOTS

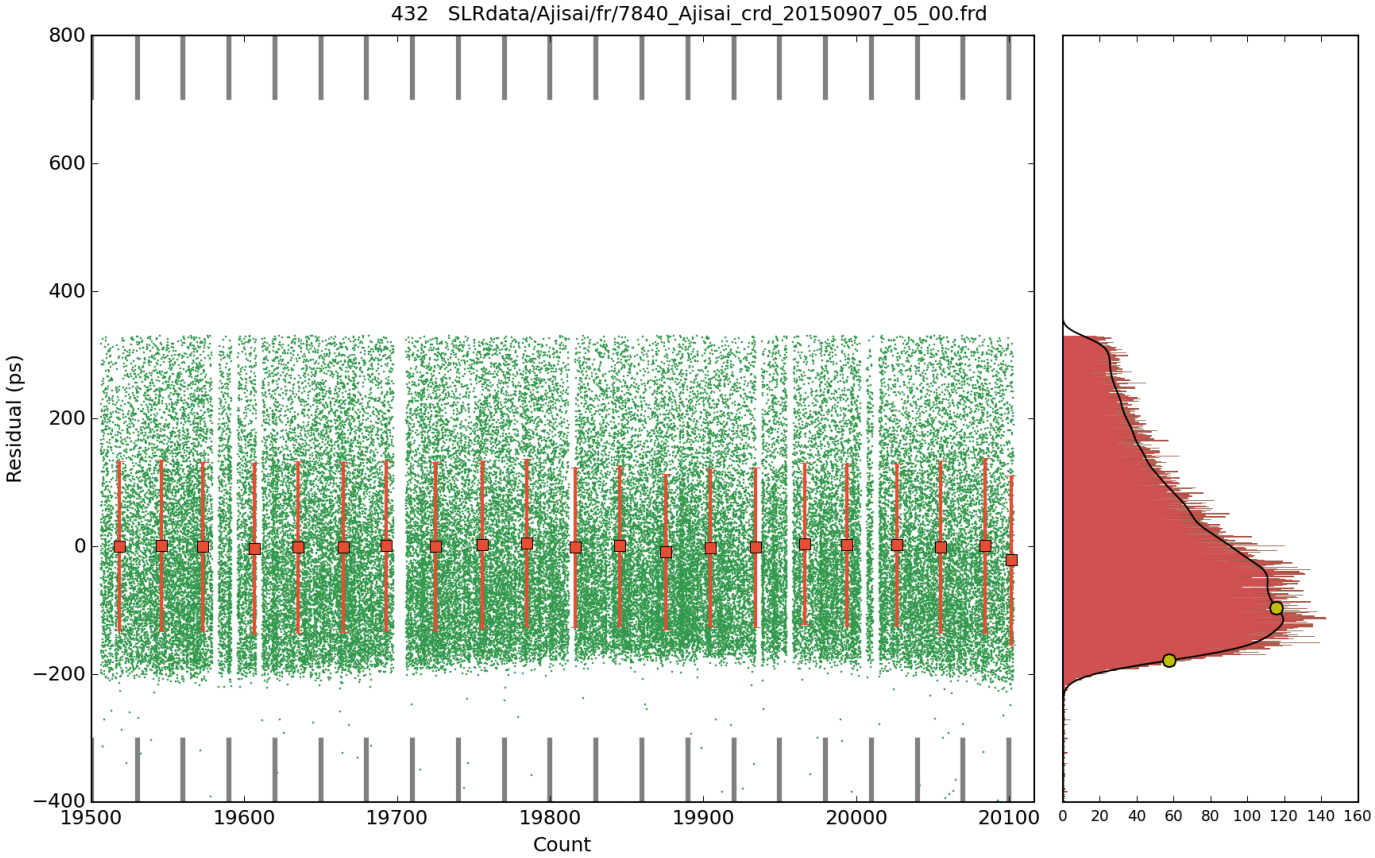


OTSUBO PLOTS

- Toshi visited the SGF, Herstmonceux for 3 months over the summer of 2016 and we were able to discuss the possible causes of these trends.
- The clipping of data at Herstmonceux is made at 3*sigma from the Gaussian fit centre. This was investigated as a possible cause of the observed trend.

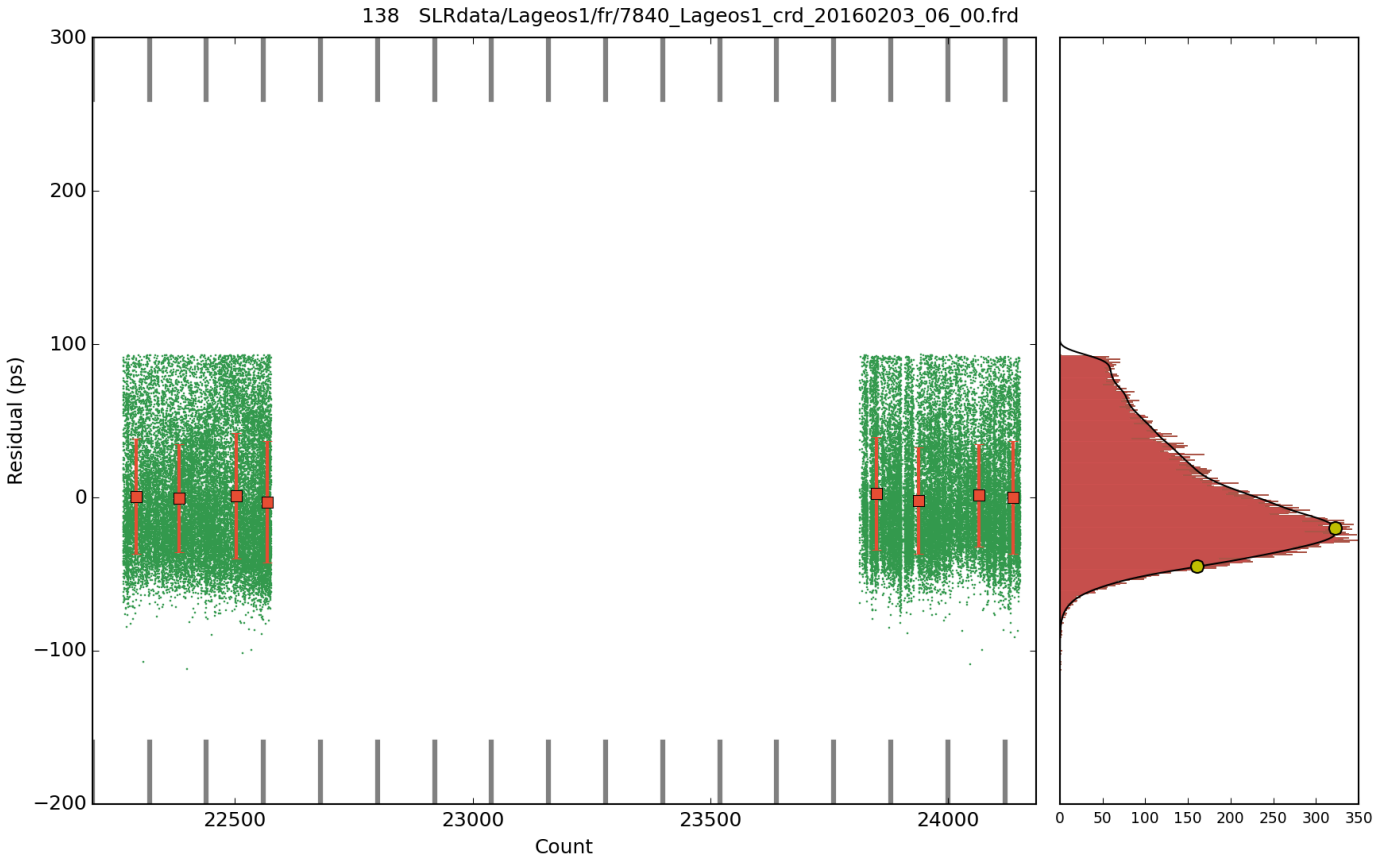
DATA CLIPPING @ SGF, HERSTMONCEUX

- Full rate data residuals distribution –**Ajisai**
- Clipping point varying from pass to pass



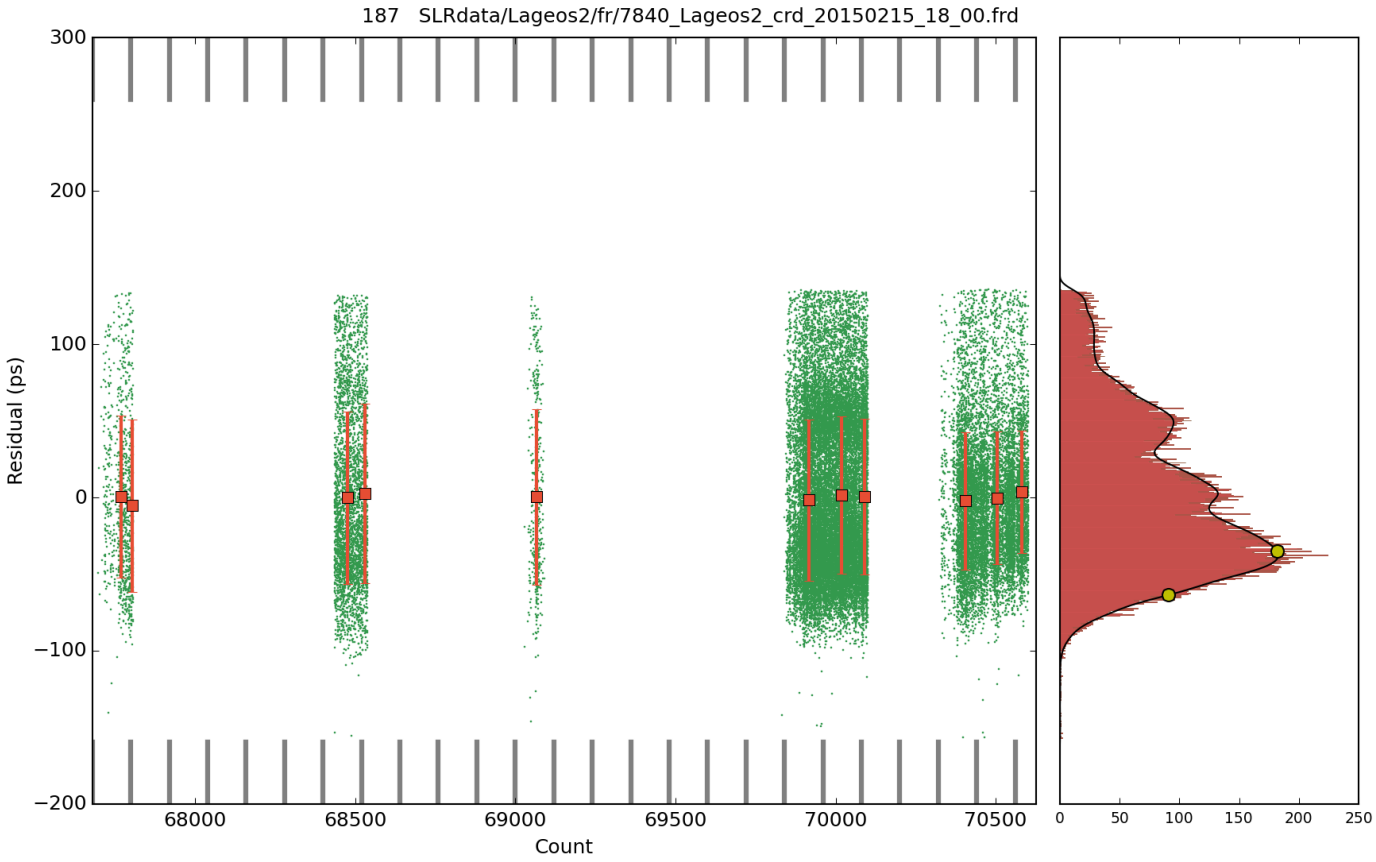
DATA CLIPPING @ SGF, HERSTMONCEUX

- Full rate data residuals distribution – **Lageos1**
- Less visible variation in clipping.



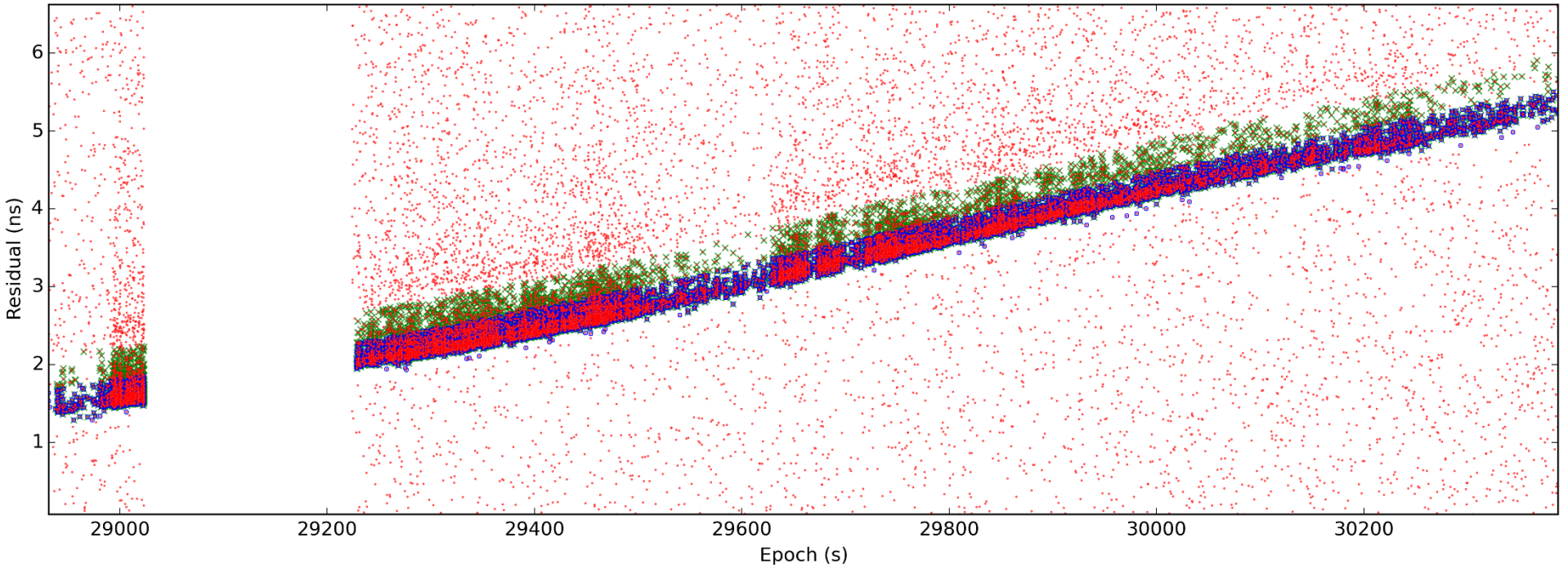
DATA CLIPPING @ SGF, HERSTMONCEUX

- Full rate data residuals distribution – **Lageos2**
- Non-uniform distributions from pass to pass.



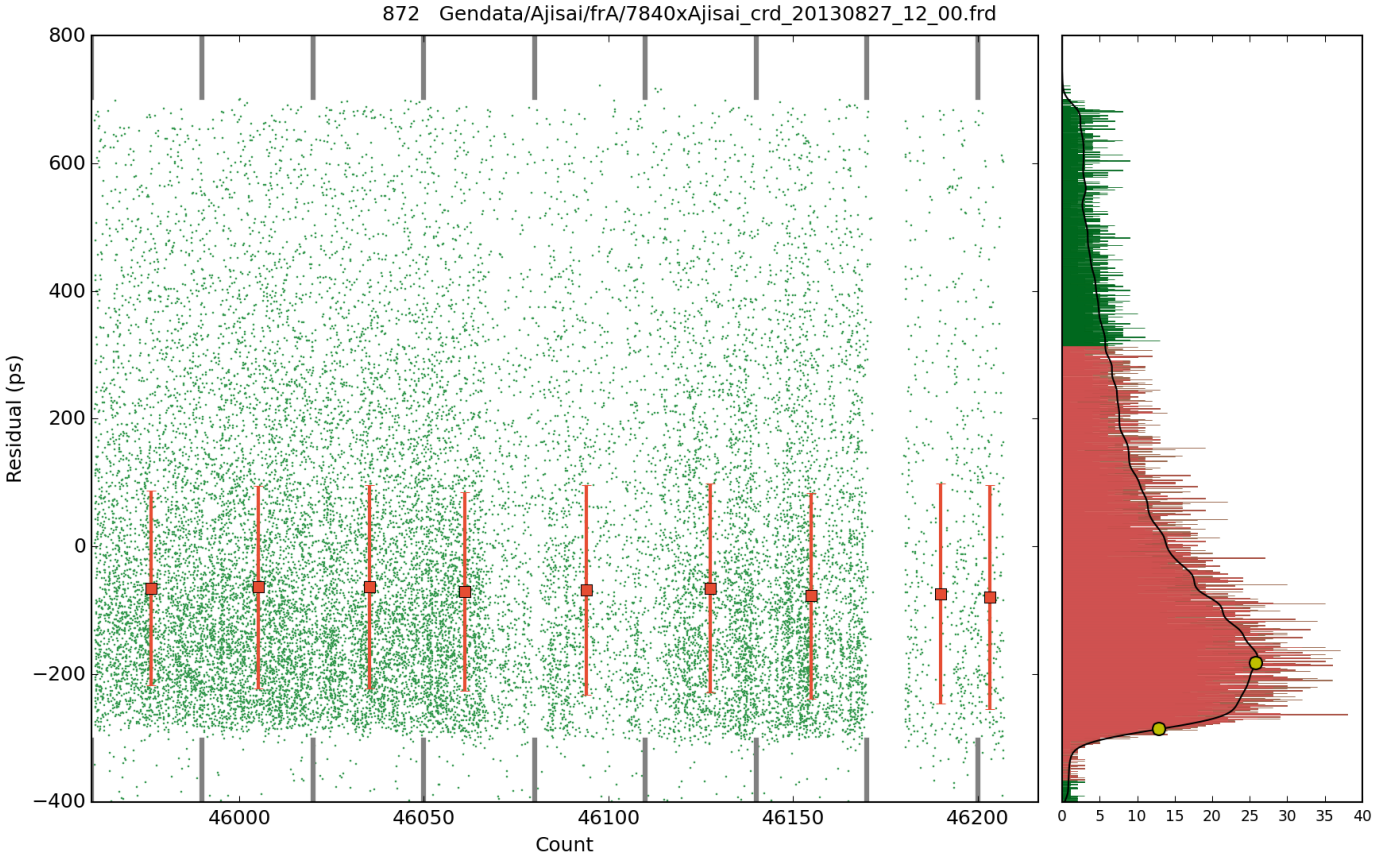
DATA CLIPPING @ SGF, HERSTMONCEUX

- To change the clipping point in a distribution it was necessary to go back to the **raw data** file.
- Using the **full rate data** file it was possible to identify the track in the raw data and **reselect the track** data.



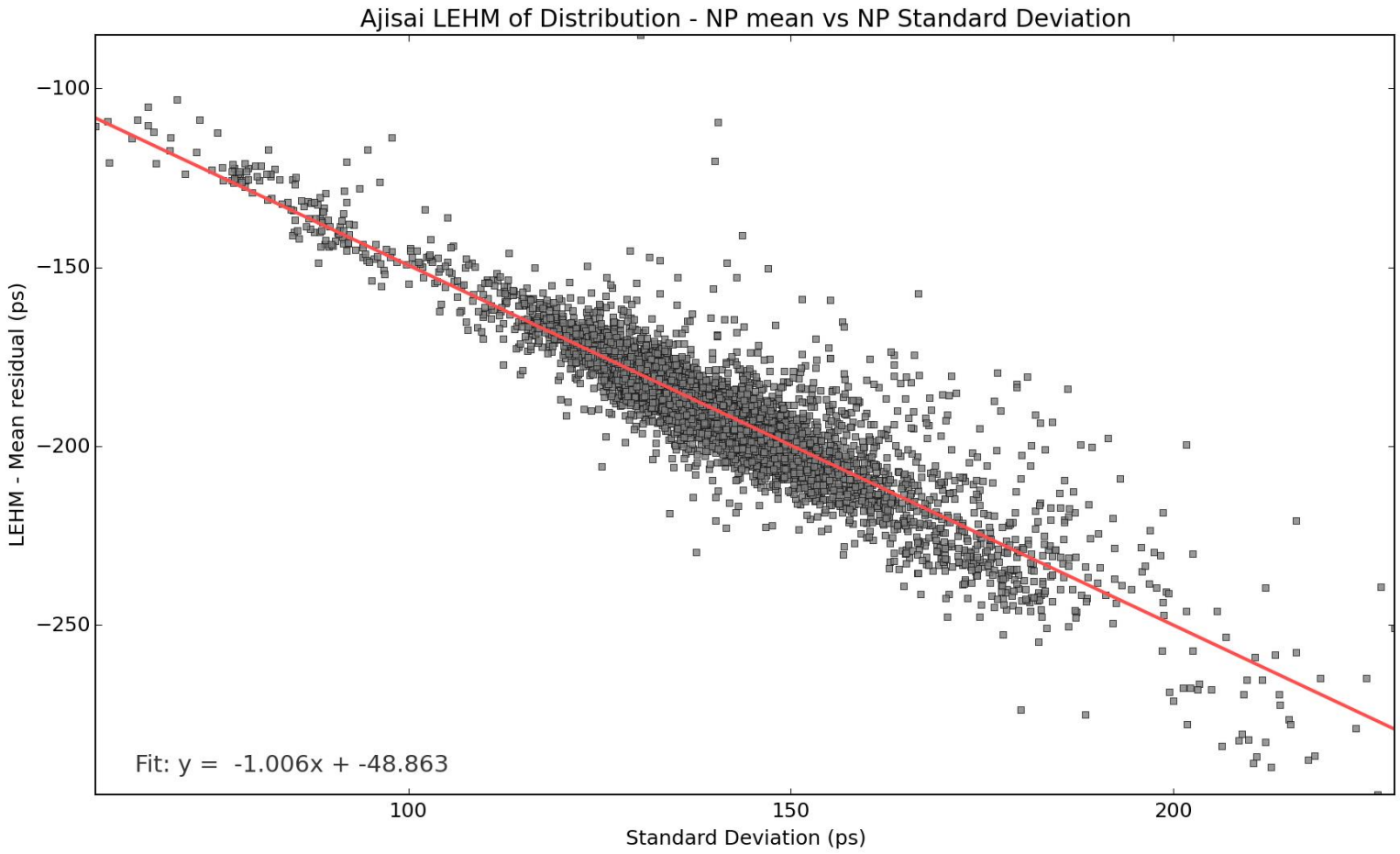
DATA CLIPPING @ SGF, HERSTMONCEUX

- Peak of distribution determined b fitting a tangent and finding minimum slope.
- The LEHM was found using this peak point.
- A new clipping point set for Ajisai of 600ps behind the LEHM.



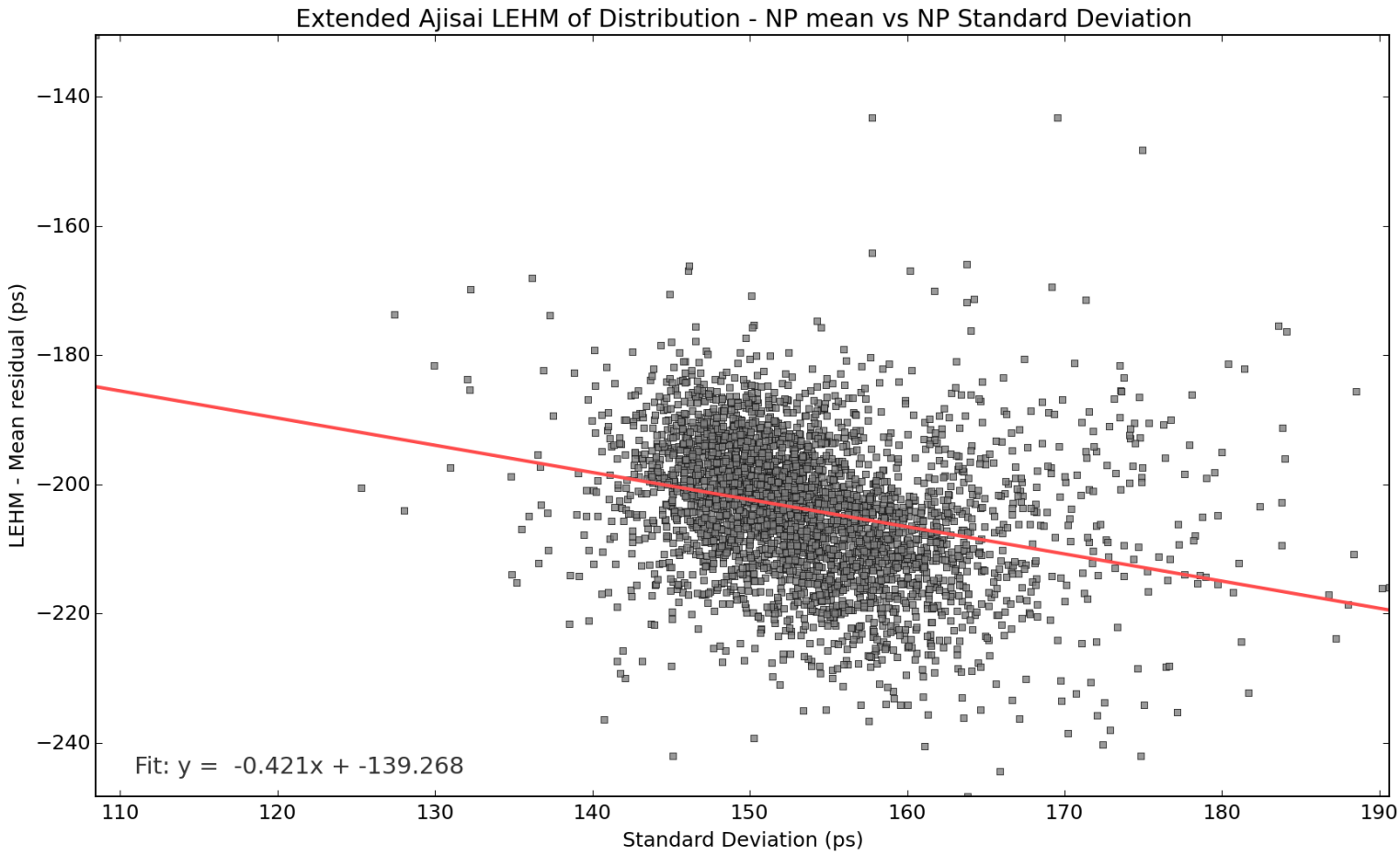
DATA CLIPPING @ SGF, HERSTMONCEUX

- Ajisai LEHM– Mean residual vs Standard Deviation **– original clipping**
- Data from years 2012-2015



DATA CLIPPING @ SGF, HERSTMONCEUX

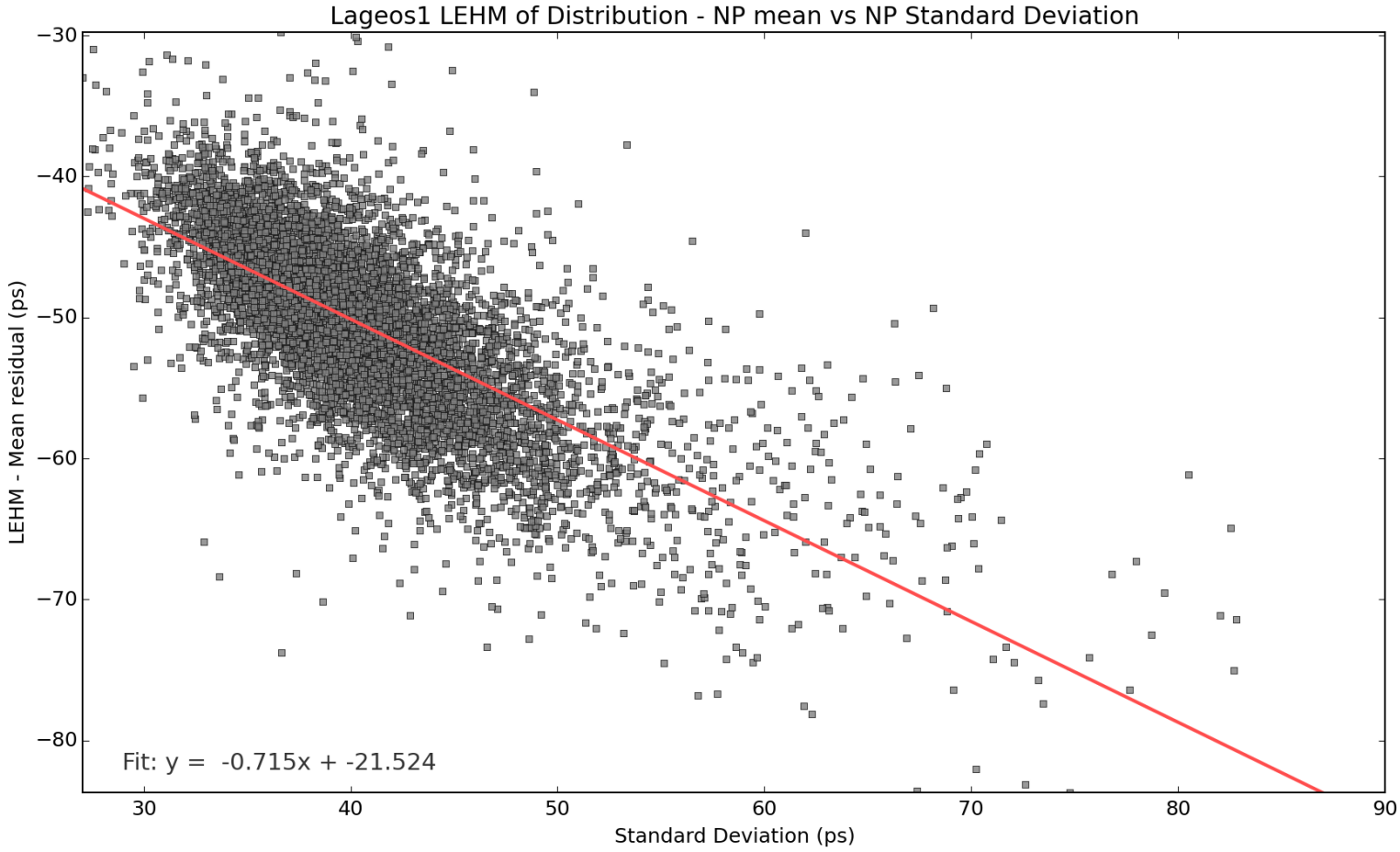
- Ajisai LEHM– Mean residual vs Standard Deviation **– new clipping**
- Data from years 2012-2015



DATA CLIPPING @ SGF, HERSTMONCEUX

- Lageos1 LEHM– Mean residual vs Standard Deviation **– original clipping**

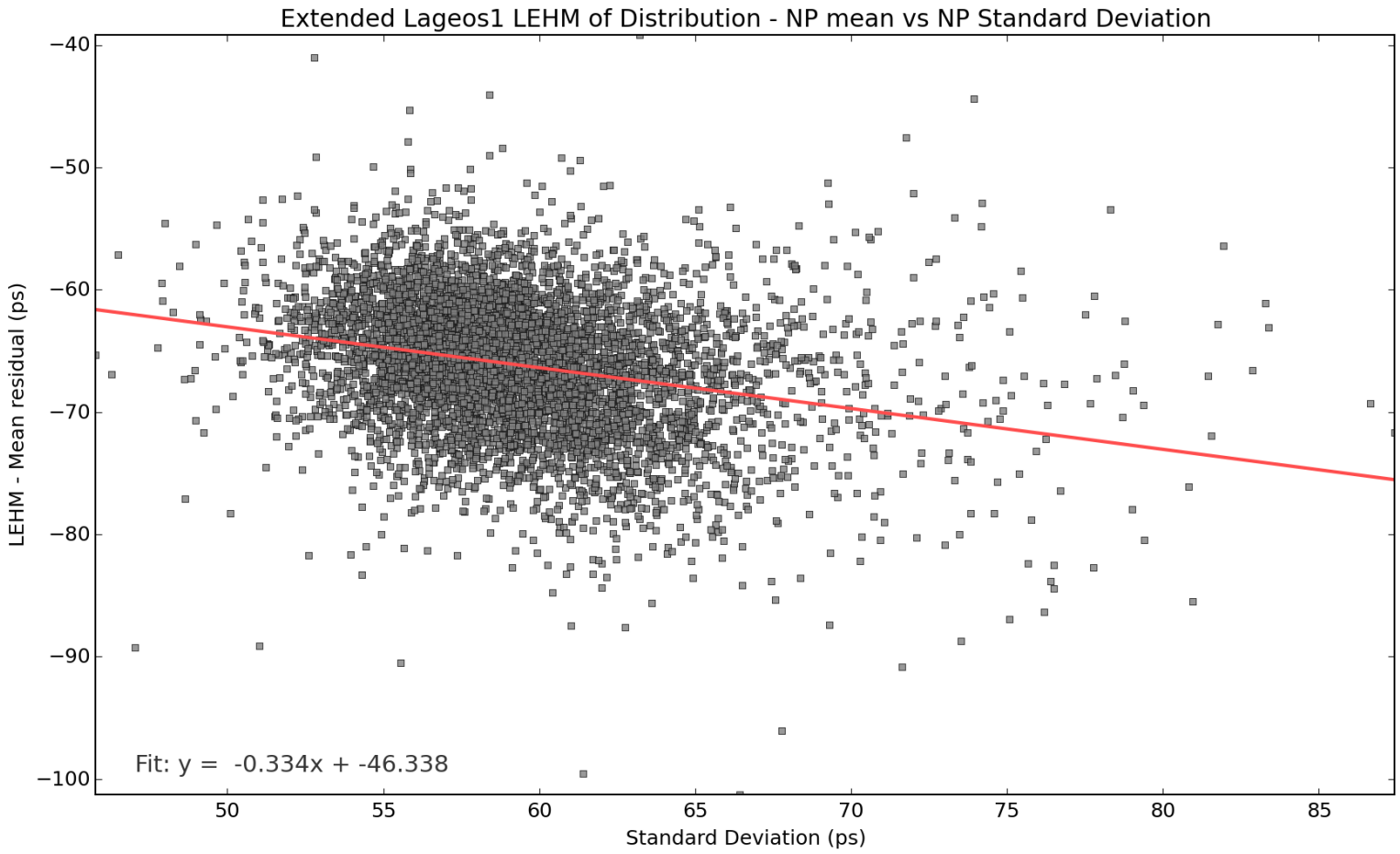
- Data from years 2014-2016



DATA CLIPPING @ SGF, HERSTMONCEUX

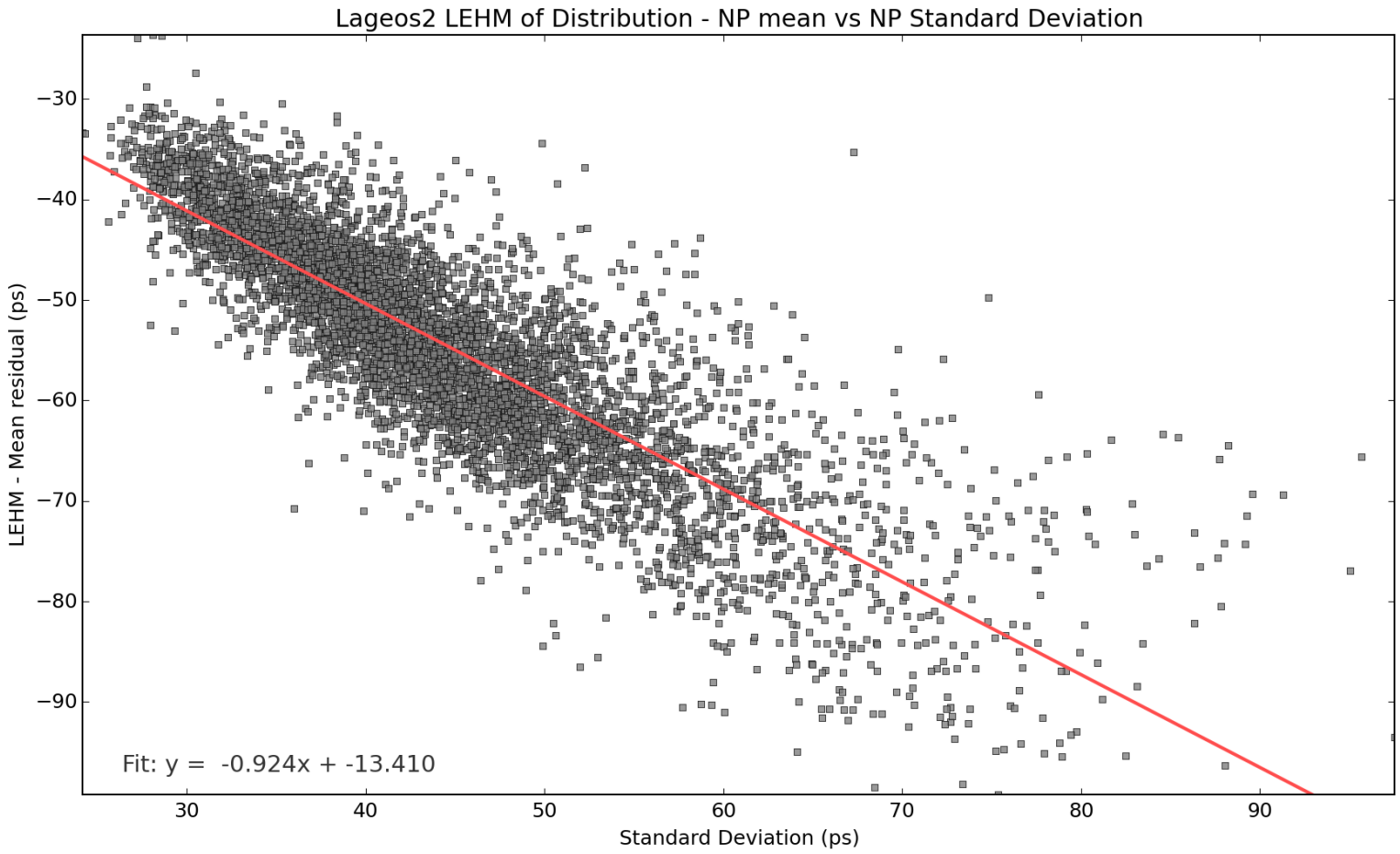
- Lageos1 LEHM– Mean residual vs Standard Deviation **– new clipping**

- Data from years 2014-2016



DATA CLIPPING @ SGF, HERSTMONCEUX

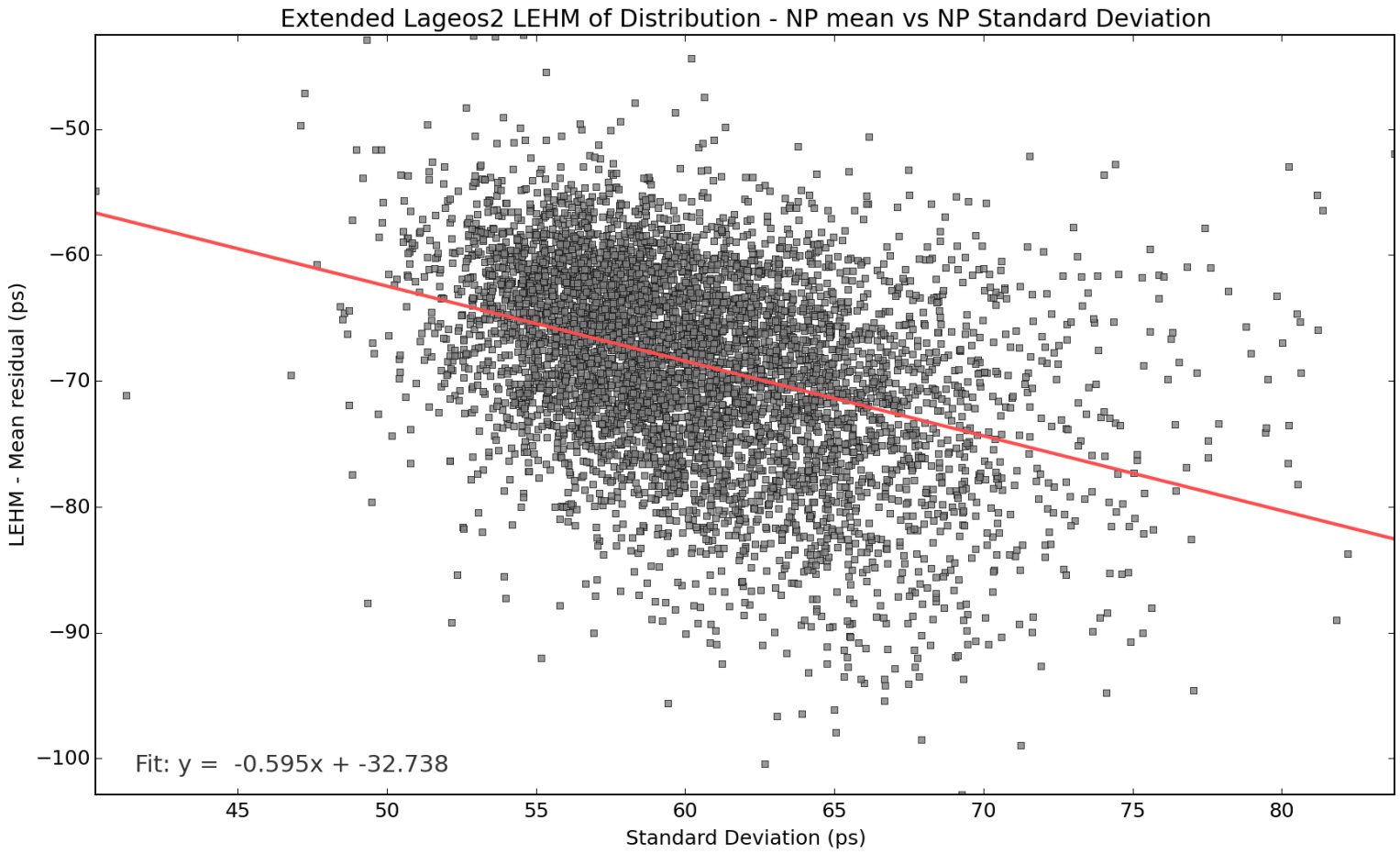
- Lageos2 LEHM– Mean residual vs Standard Deviation **– original clipping**
- Data from years 2014-2016



DATA CLIPPING @ SGF, HERSTMONCEUX

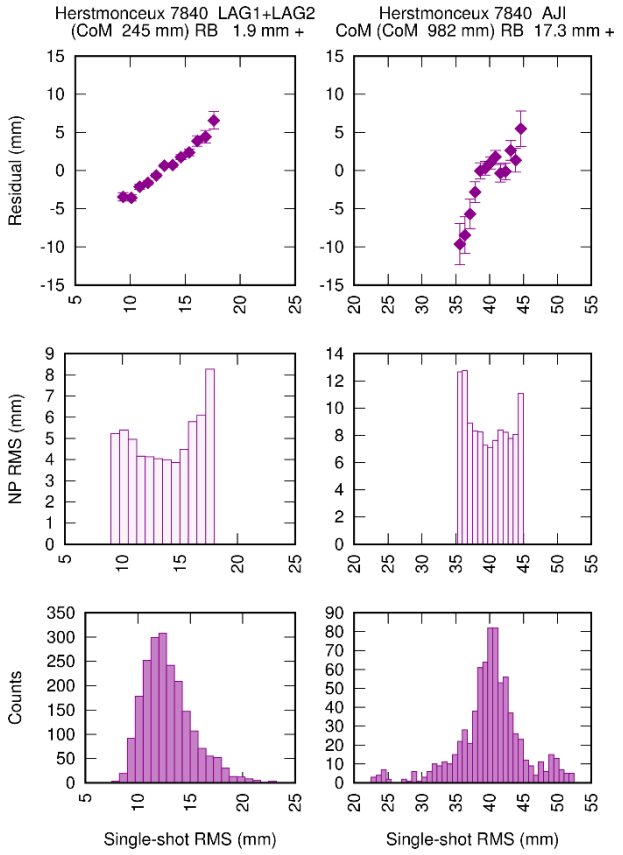
- Lageos2 LEHM– Mean residual vs Standard Deviation **– new clipping**

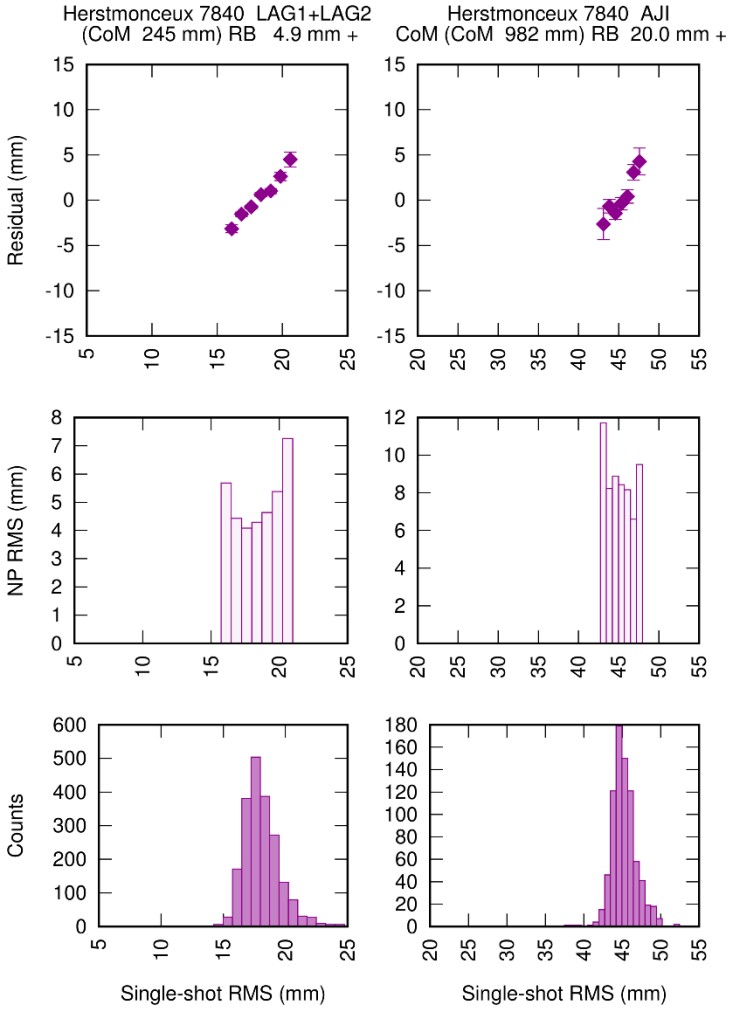
- Data from years 2014-2016



DATA CLIPPING @ SGF, HERSTMONCEUX

- New normal points were formed using the new clipping full rate data for Ajisai, Lageos1, Lageos2.
- Toshi reanalysed the new normal point dataset.
- Reduction in spread of RMS values, but trend still present.





HOW CAN A SLR STATION BE BETTER? - SLR ANALYSIS

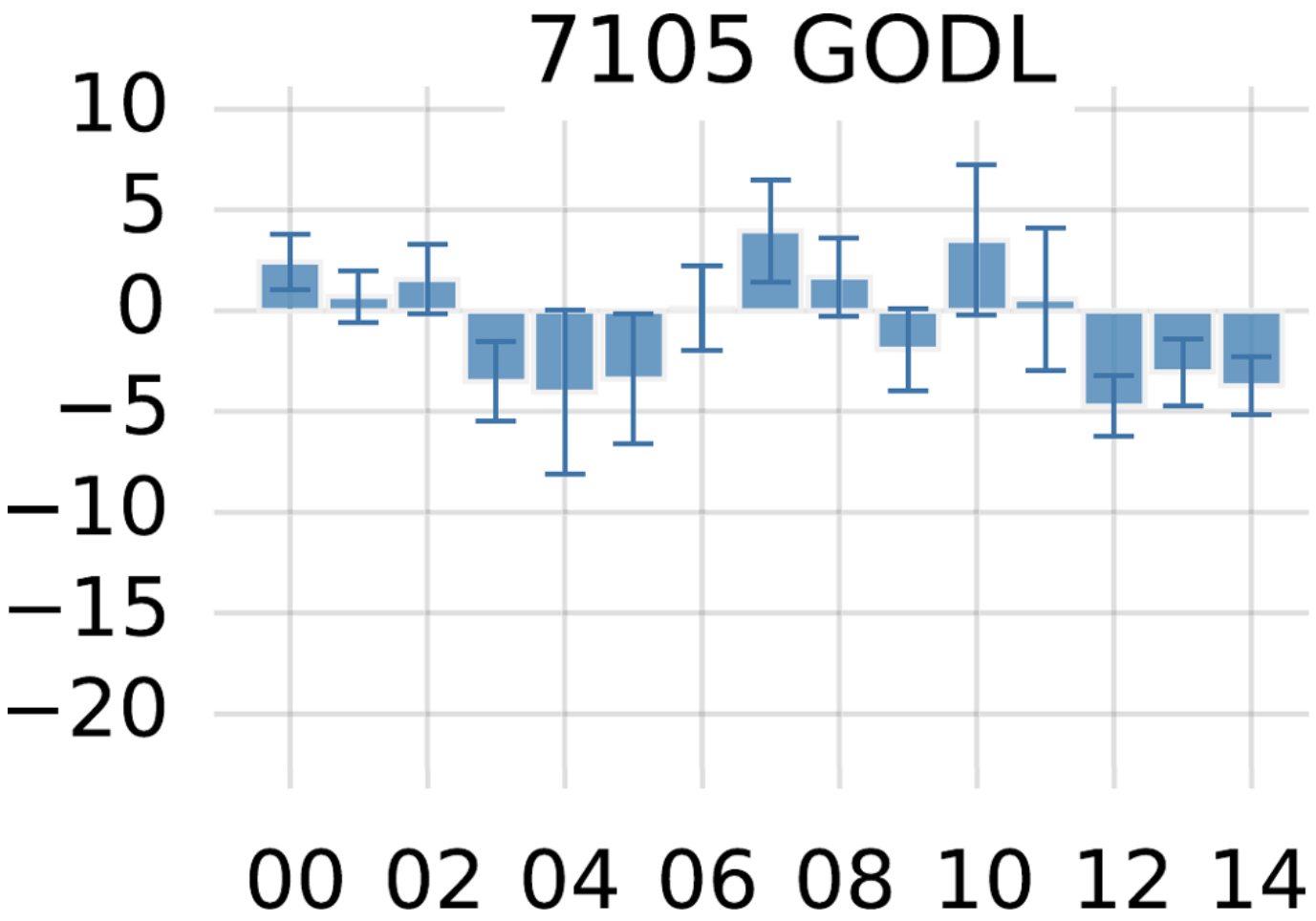
- A SLR station should pay attention to and take on-board the available **feedback from SLR analysis**.
  - Erricos, Horst and Toshi have presentations coming up in this session.
  - In addition, a recent paper was published titled:

"*Assessment of the accuracy of global geodetic satellite laser ranging observations and estimated impact on ITRF scale: estimation of systematic errors in LAGEOS observations 1993–2014*"

Graham Appleby, José Rodríguez, Zuheir Altamimi, Journal of Geodesy

  - This paper estimated systematic bias for all SLR stations, for example…

"ASSESSMENT OF THE ACCURACY OF GLOBAL GEODETIC SATELLITE LASER RANGING OBSERVATIONS AND ESTIMATED IMPACT ON ITRF SCALE: ESTIMATION OF SYSTEMATIC ERRORS IN LAGEOS OBSERVATIONS 1993–2014"
GRAHAM APPLEBY, JOSÉ RODRÍGUEZ, ZUHEIR ALTAMIMI, JOURNAL OF GEODESY



HOW CAN A SLR STATION BE BETTER? - ILRS QUALITY CONTROL BOARD

- The newly formed ILRS '**Quality Control Board**' (QCB) is addressing this question, particularly in relation to systematics.
- The QCB was set up to address systematic bias in the range data and the impact on data products.
- It meets by regular teleconference and available analysis feedback is discussed along with the requirements from stations to have the right diagnostics.
- It is has a new page on the ILRS website http://ilrs.gsfc.nasa.gov/science/qcb/index.html

HOW CAN A SLR STATION BE BETTER? - ILRS NESC FORUM

- Support other stations in the ILRS network.
- Share knowledge and experience
- Learn from other stations in the ILRS network
- Attending ILRS Workshops is one way to do this. This could now also be done online in the **NESC forum**

HOW CAN A SLR STATION BE BETTER? - ILRS NESC FORUM

- The new NESC forum aims to:
  - Strengthen the connection, communication and collaboration between international colleagues.
  - Exploit the wealth of experience and knowledge in the ILRS network to address problems that are common to multiple stations.

http://sgf.rgo.ac.uk/forumNESC

ILRS NESC FORUM

- Online and open to the ILRS community
- Register as a member to:
  - Post topics
  - Post replies
  - Get notifications by email
  - See attachments

http://sgf.rgo.ac.uk/forumNESC

Home Help Search Login Register

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Username

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Networks and Engineering Standing Committee Forum

Welcome

Welcome to the ILRS NESC Forum

This Forum is open to ILRS Networks and Engineering Standing Committee members and to the wider satellite laser ranging community. It is provided so that colleagues can discuss issues, develop ideas, pose questions and ask for or provide advice. Please do what you can to make this an lively and enjoyable forum that proves to be an important tool for the NESC and the ILRS community.

3 Posts
1 Topics

Last post by Matt_SGFHx
in Re: NESC Forum - Please ...
on June 27, 2016, 11:05:05 AM

General Topics

Open a Discussion

Bring up an issue for the attention of the NESC Forum

2 Posts
1 Topics

Last post by jose_sgf
in Re: Anybody know Arnold ...
on July 22, 2016, 09:36:53 AM

Ideas

What bright ideas have you had recently?

4 Posts
1 Topics

Last post by Matt_SGFHx
in Re: Making satellites vi...
on September 21, 2016, 08:17:53 AM

Detecting and Minimising Station Range Bias

Discuss here techniques for detecting sources of range bias at SLR stations and ways to minimise these errors.

0 Posts
0 Topics

Station Performance

Discuss the performance of stations in terms of data quality and quantity.

4 Posts
3 Topics

Last post by Toshimichi Otsubo
in Station performance char...
on September 20, 2016, 04:03:20 PM

Station Updates and News

Let the community know what's happening at your SLR station

1 Posts
1 Topics

Last post by serna_yebes
in Hello from Yebes Observa...
on June 20, 2016, 10:31:57 AM

Author — Topic: Making satellites visible during daylight ranging (Read 308 times)

May 06, 2016, 10:16:32 AM

Georg
Newbie
Posts: 1

Making satellites visible during daylight ranging

« **on:** May 06, 2016, 10:16:32 AM »

Quote | Modify | Remove | Split Topic

Hi everybody from Graz !

During our last visit at Potsdam SLR station in March 2016, Lutz Grunwaldt showed us CCD images of short visible flashes of Envisat during a daylight tracking session - a surprise for us !

We have now installed a proper CCD in our detection package, and have started to visualize at least large targets during daylight tracking; we expect it to be quite useful when tracking e.g. debris using TLE with larger TB values etc....

We have started now to fill a list, which targets we have seen already during daylight... maybe I can report more about, when I am back from a 3 week holiday, which will start tomorrow :-)

Any other experiences with that ?

Georg

Report to moderator 193.170.87.144 (?)

July 05, 2016, 05:14:04 PM — **Reply #1**

Iglg
Newbie
Posts: 1

Re: Making satellites visible during daylight ranging

« **Reply #1 on:** July 05, 2016, 05:14:04 PM »

Quote | Modify | Remove | Split Topic

I, too, once in the daytime saw GLONASS, when the satellite was well illuminated by the sun. I think that should be visible Ajisai.

Networks and Engineering Standing Committee Forum › General Topics › Ideas

Post reply (Re: Making satellites visible during daylight ranging)

Post reply

Subject: Re: Making satellites visible during daylight ranging

Message icon: Standard

Attachments and other options

shortcuts: hit shift+alt+s to submit/post or shift+alt+p to preview

Post Preview

Topic Summary

Posted by: Matt_SGFHx

« **on:** September 21, 2016, 08:17:53 AM »

Insert Quote

Hi Georg

Do you have any more details on how to do this? What equipment do you use? And can you post an image?

Matt

ILRS NESC FORUM

- Manage you Notifications
  - In order to get email notifications of new posts or daily or weekly summaries it is necessary to select 'NOTIFY' on the topics or boards that you want to follow.

ILRS NESC FORUM

- Support the NESC forum by:
  - Registering yourself and inviting your colleagues
  - Support other members by helping to answer questions.
  - Identify yourself (username, location, image)
  - Be a pro-active contributor

http://sgf.rgo.ac.uk/forumNESC