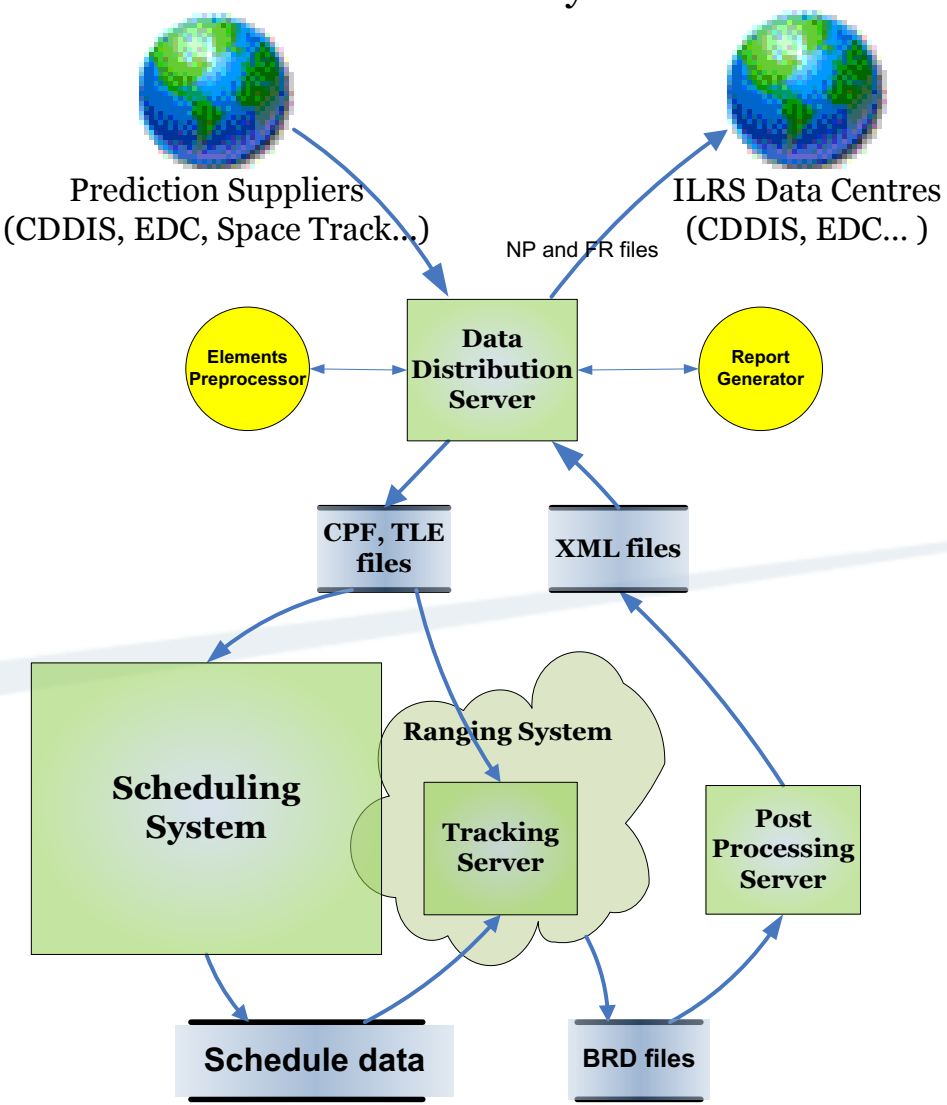
Automated Scheduling

Mt Stromlo SLR System
Schematic of Primary
Automation Systems



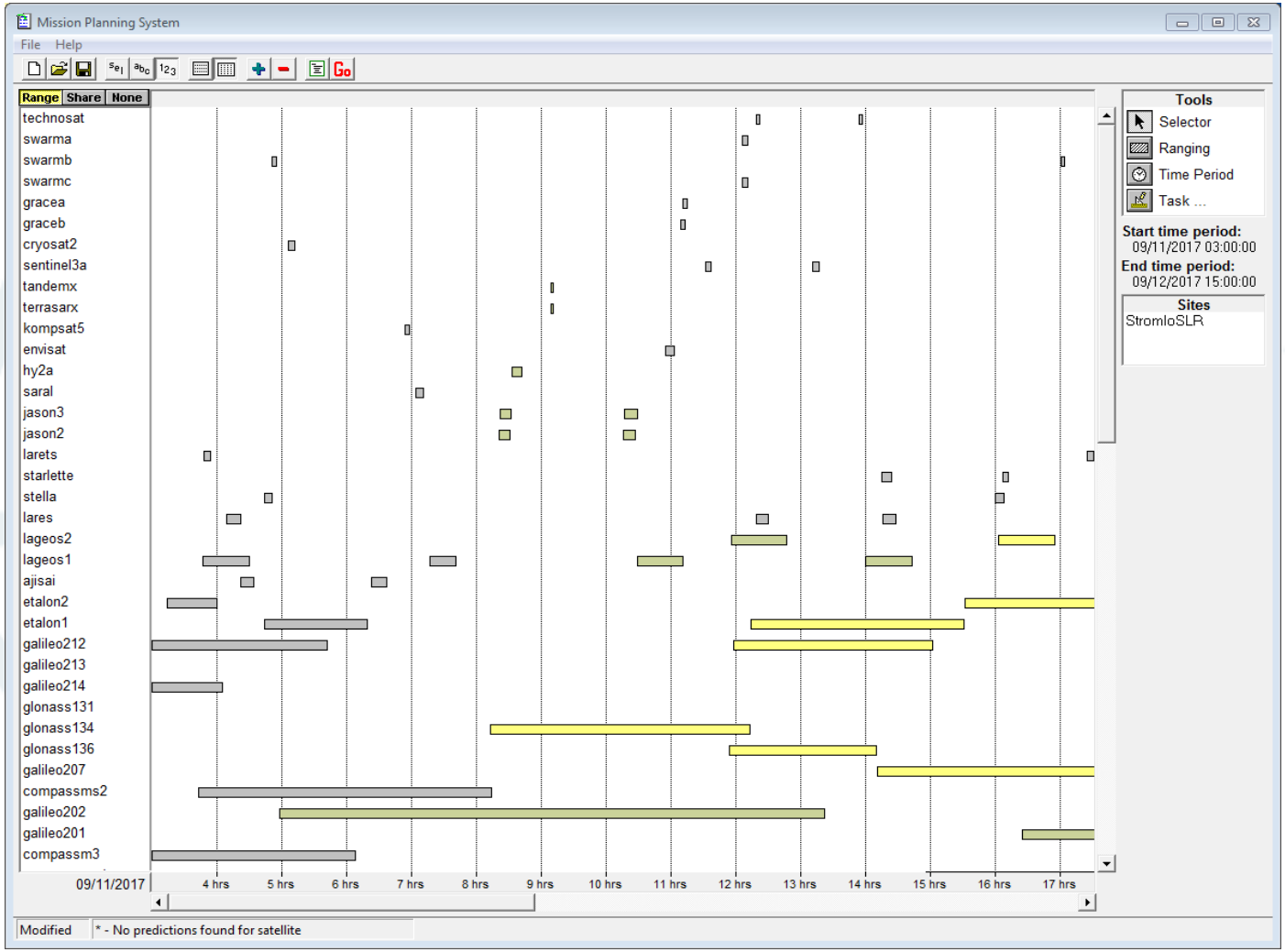
Automated Scheduling

Mission Planning System (MPS)

- Current MPS in use over 18 years at Mt Stromlo (see Matera Workshop 2000).
- MPS allows automatic operations over a defined period (many days, depending on available predictions).
- MPS requires manual creation. The longer the period, the more effort.
- With increasing (GNSS) targets, schedule creation is more tedious.
- Need autonomous scheduling system.

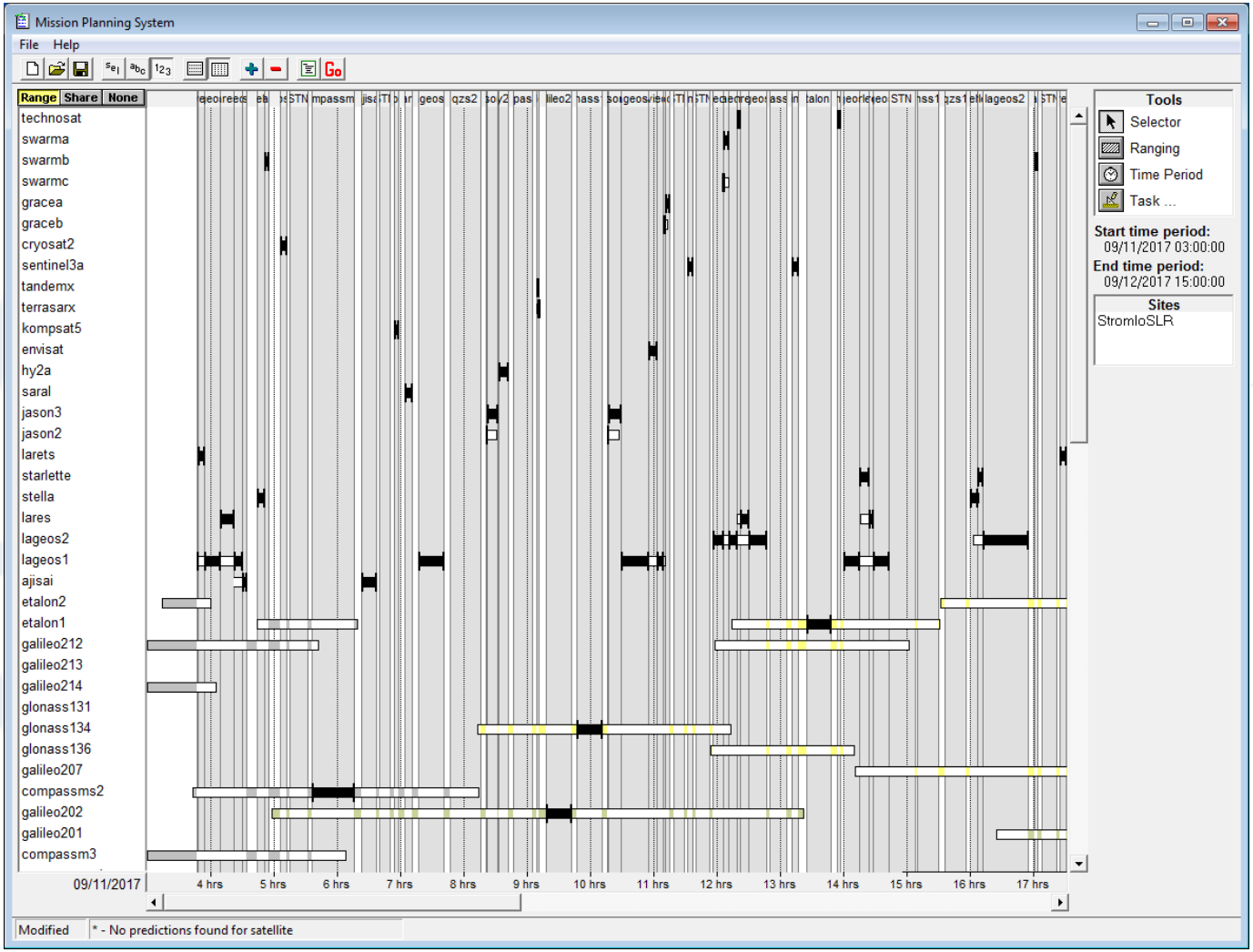
Automated Scheduling
Mission Planning System (MPS)

Generates passes for all specified targets over a specified period.



Automated Scheduling
Mission Planning System (MPS)

Tools to prioritize/select required passes or pass segments and then initiate an automated session.



Automated Scheduling

Autonomous Systems

- Autonomous scheduling systems are being developed as an alternative to MPS.
- Include support for debris tracking (many targets, optimization needed).
- Also include support for multi-sensor sites that have different scheduling requirements.
- A “default” scheduler has been developed based on simple business rules.

Automated Scheduling

Example of Business Rules Logic
(as used in the initial version of the Default Scheduler)

Here LEO Targets include Lageos and lower targets; HEO Targets have orbits above Lageos.

For LEO targets, shorter passes have higher priority.

If two LEO target passes overlap and are of similar length, then the one that was ranged to longest ago has higher priority.

HEO targets with highest elevation (excluding any keyhole) have higher priority.

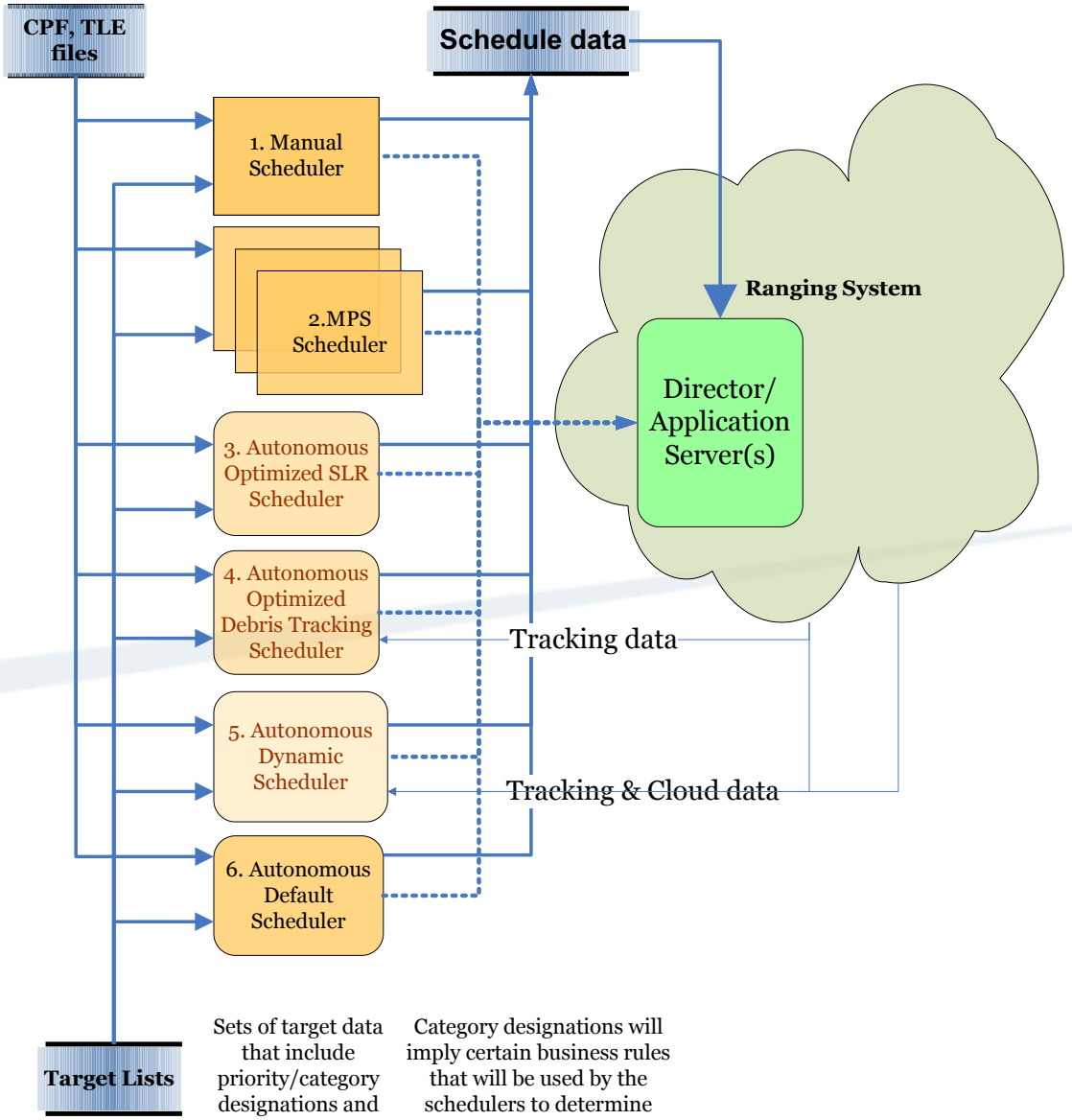
If two HEO target passes overlap and are similar in elevation the one that was ranged to longest ago has higher priority.

Calibration targets that have just been ranged to will have lowest priority, but after two hours their priority is set higher than HEO but lower than LEO targets.

Automated Scheduling

Schematic of Scheduling System under development.

Currently supports direct manual control, existing MPS and default scheduler.

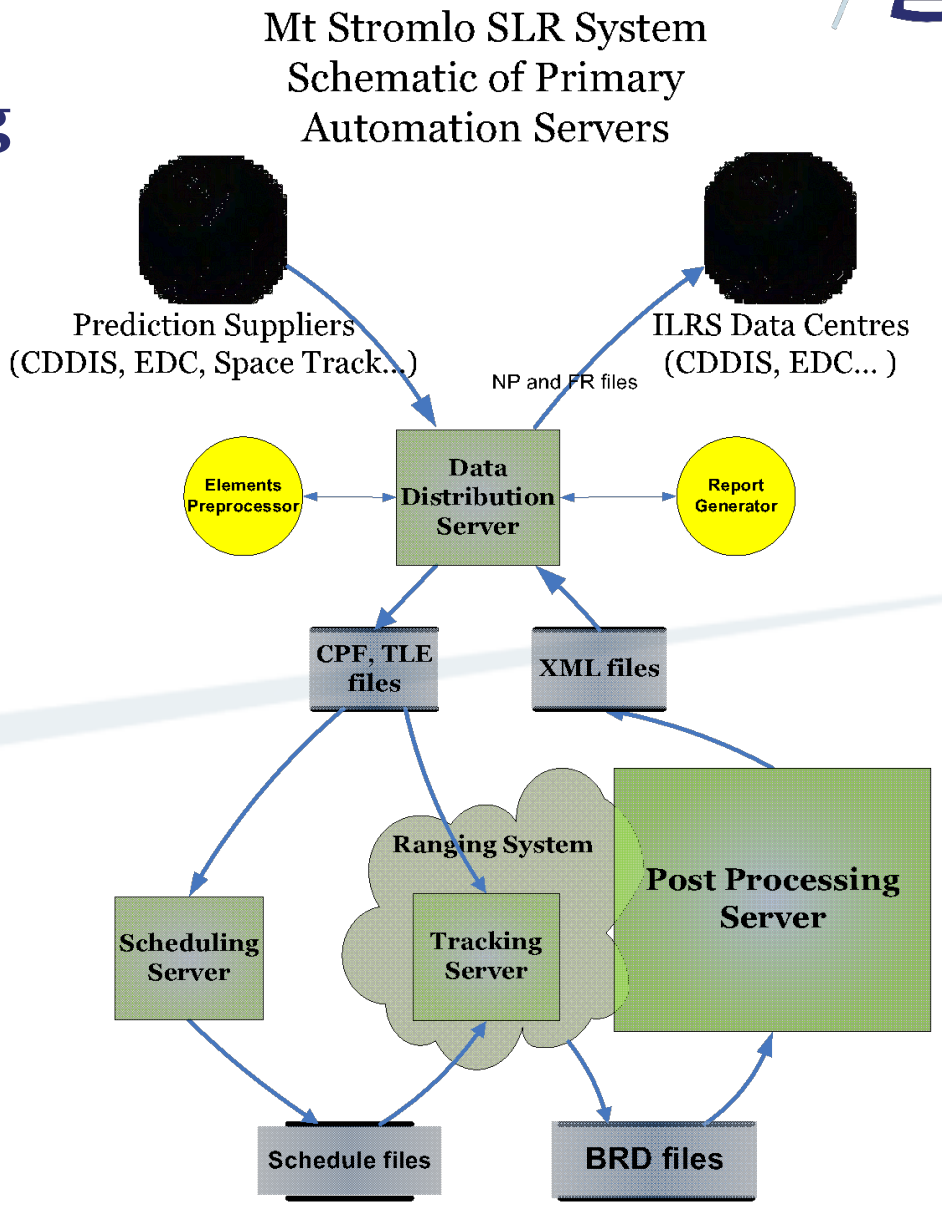


Automated Scheduling

Summary

- Scheduling system with multiple schedulers.
- Allows incremental development to construct, test and refine schedulers with increasing functionality.
- Supports systems with multiple requirements from manual to fully automated dynamic multi-system scheduling.
- Existing MPS scheduler continues to be used (with refinements).
- Initial “default” autonomous scheduler available.
- Optimized schedulers being developed by SERC and EOSSS(in time for the ILRS workshop in 2018).
- Developing improved link budget and visual models to support business rules.

Autonomous Post Processing



Binary Range Data files (*.BRD)

- Captures raw data from the ranging system, including;
  - Pass metadata
  - Shot Events
  - Mets, Cloud data
  - Telescope Pointing
  - Prediction Element(s)
  - System State/Interlocks
  - Current site database
  - Current Target characteristics
- Stored as serialized files using Google's Protocol Buffers.
- Input to post-processing stream.

Binary Range Data files (*.BRD)

Protocol Buffers is used to serialize Ranging data into *.BRD files.

- BRD files <50% size of binary files and much smaller than XML etc.
- Support fast processing.
- Supports backward compatibility.
- Schema based. Maybe support sharing data.

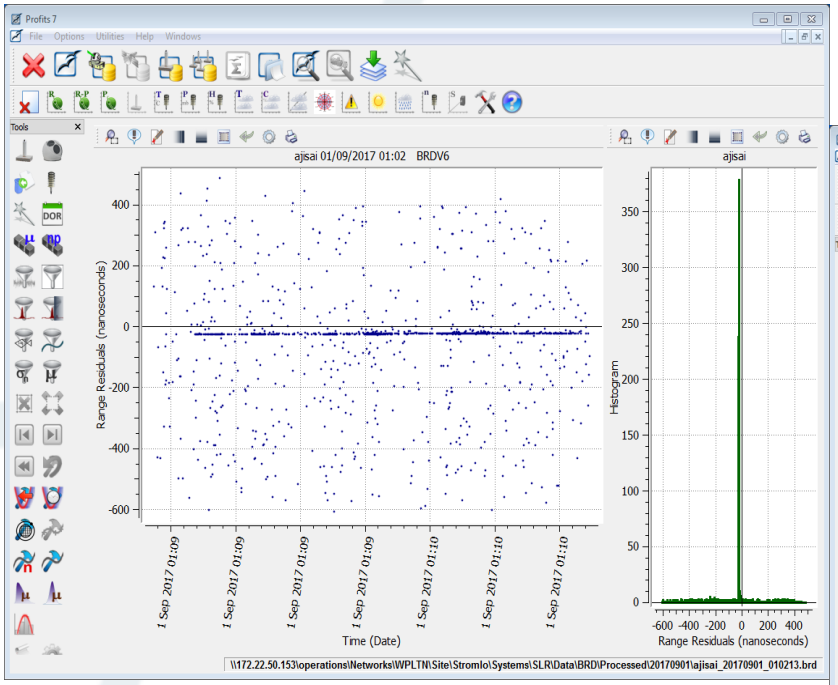
Autonomous Post Processing

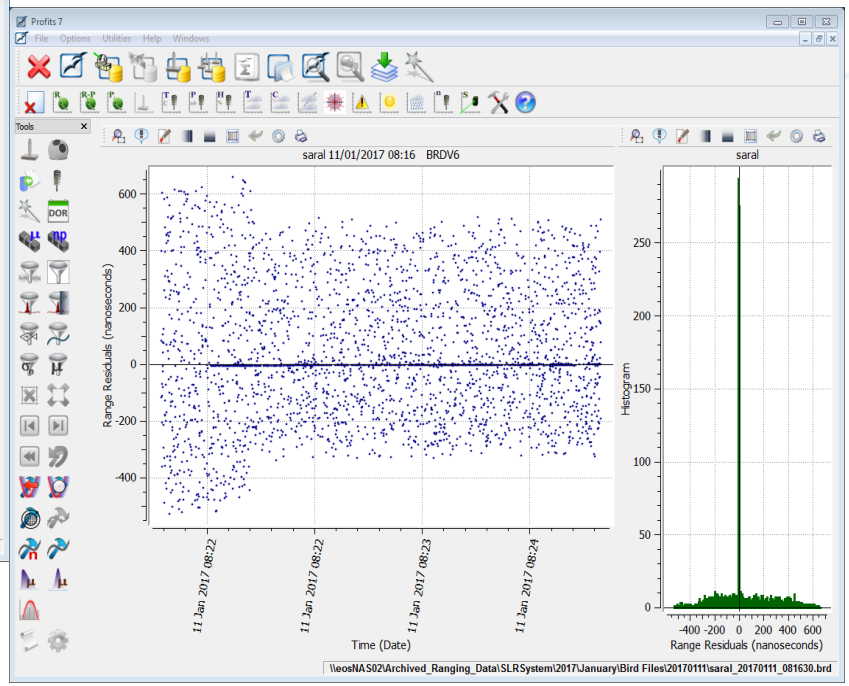
- Characteristics of Mt Stromlo System SLR ranging data;
  - Timing event epochs (using CSPAD).
  - Data collected in BRD files and processed when pre- and post-cals are available
  - Cal data is also collected in BRD files and processed as another target.

- What are the challenges?
  - Managing and applying calibration data
  - Identifying returns from satellites vs noise

Autonomous Post Processing

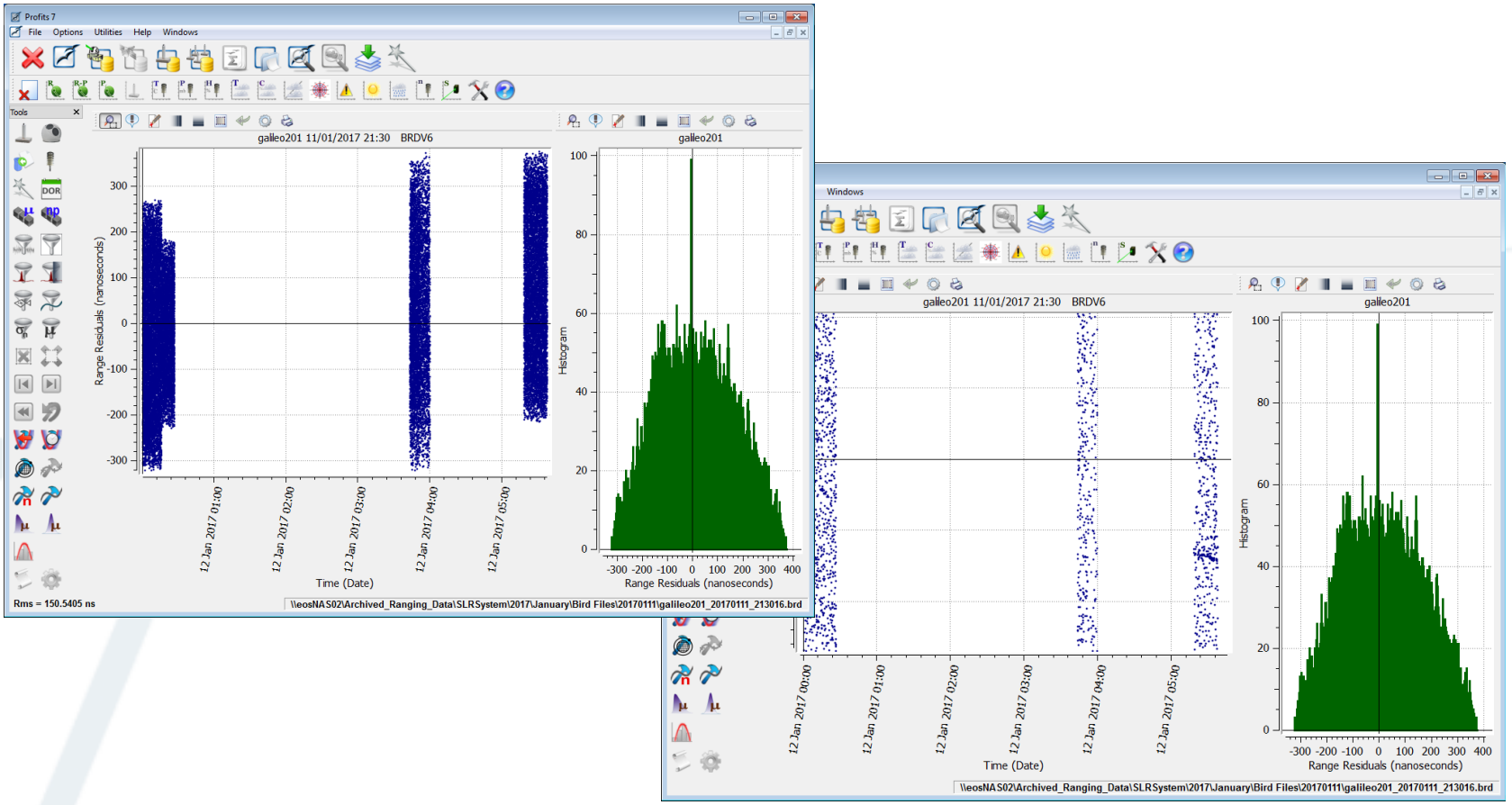
Examples of reasonably strong, flat signals in moderate noise. Easy to identify and extract the required signal.





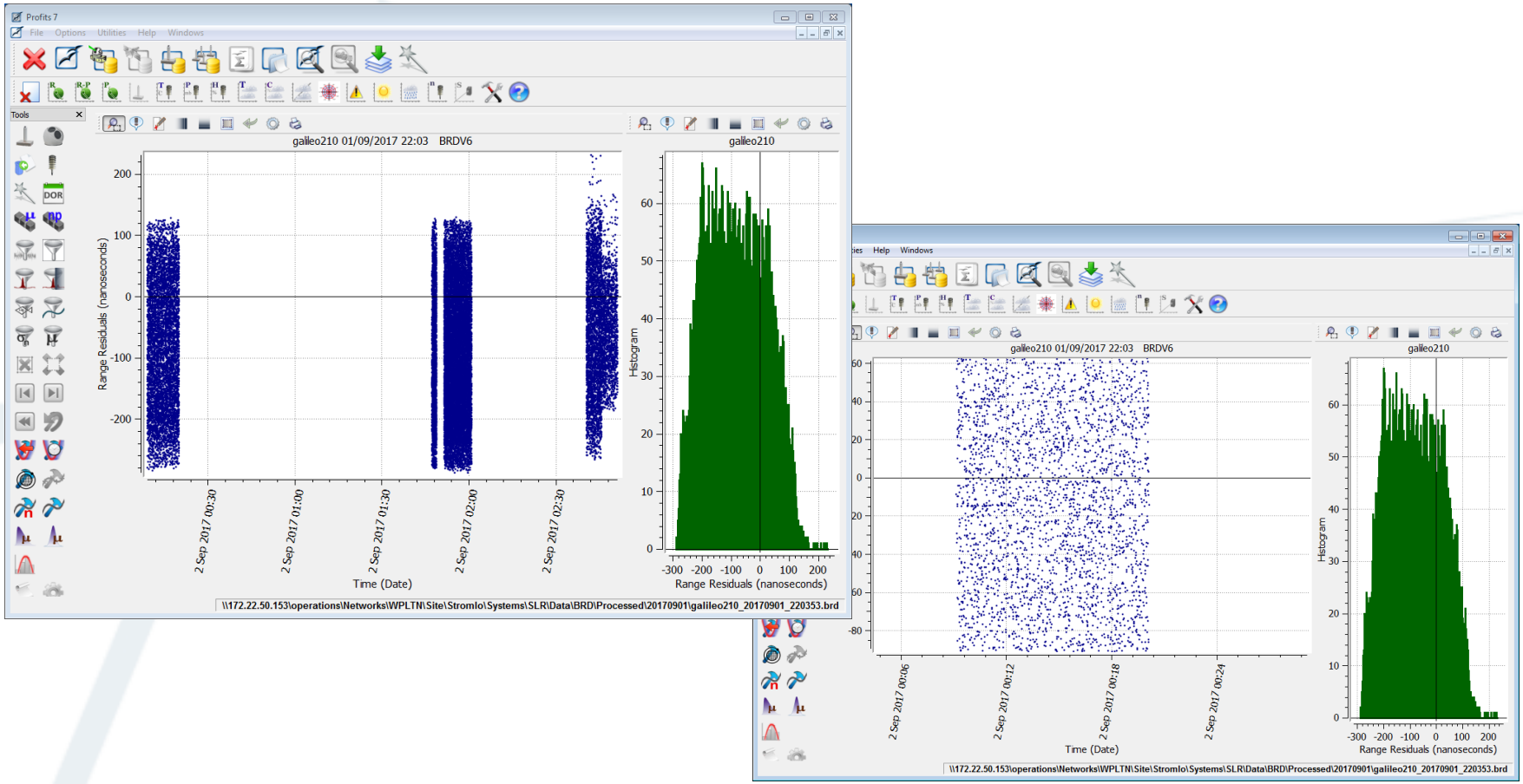
Autonomous Post Processing

Example of a reasonable strong signal in strong noise. Still able to identify and extract the required signal.



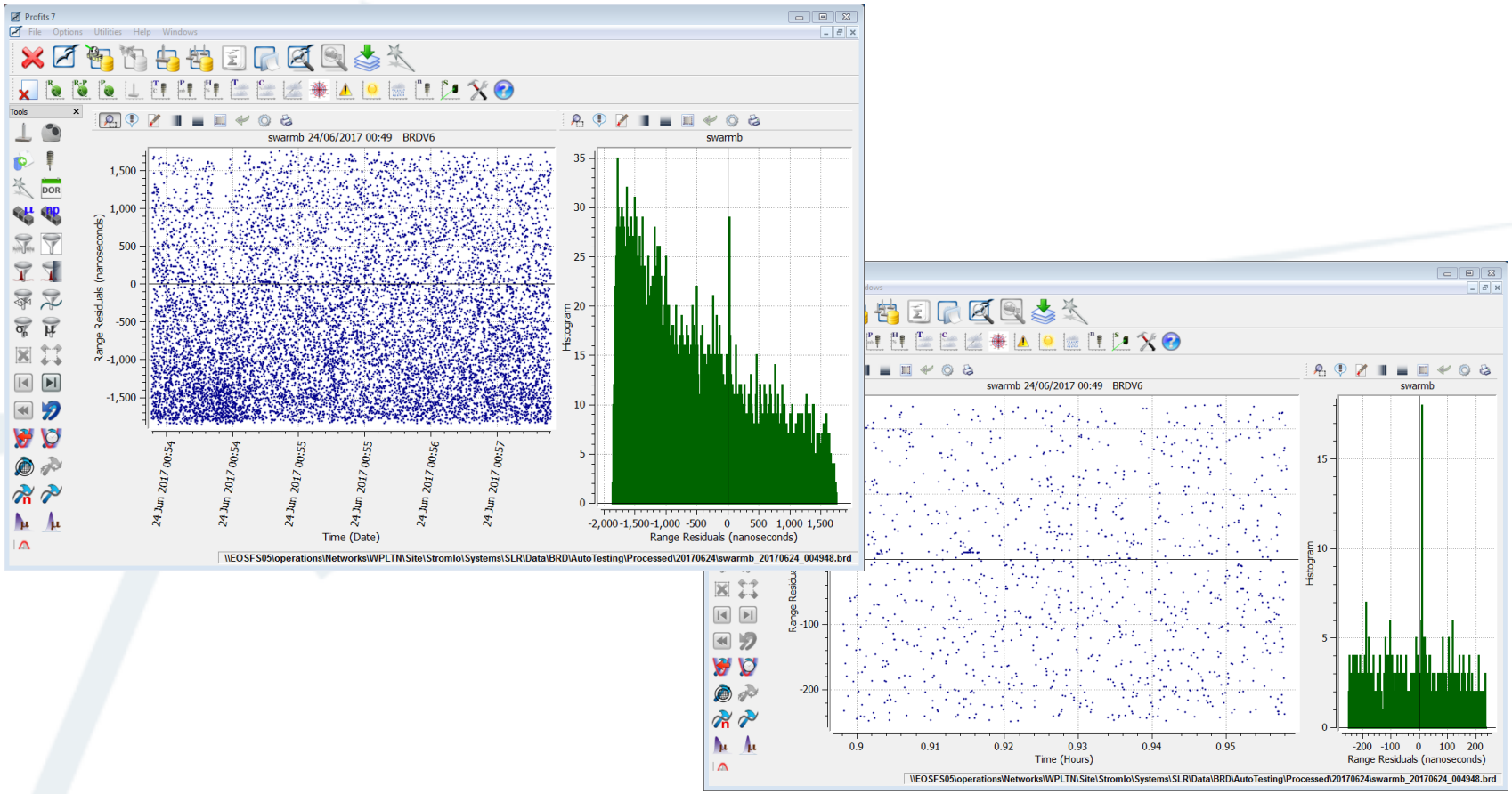
Autonomous Post Processing

Example of a weak signal in strong noise. Identification and extraction of the required signal is very difficult.

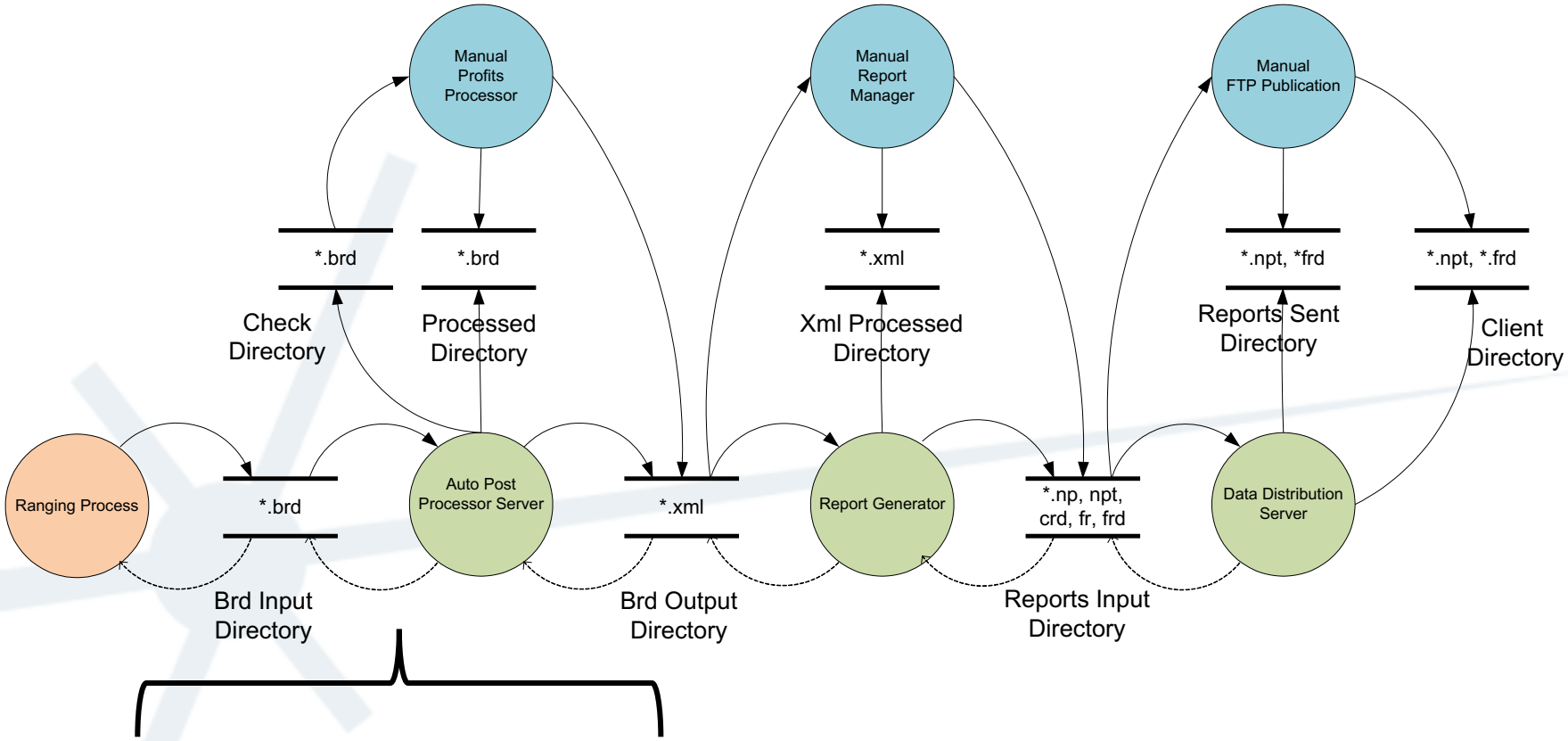


Autonomous Post Processing

Examples of a weak signal in cloud noise. Very difficult to identify and extract the required signal.



Autonomous Post Processing

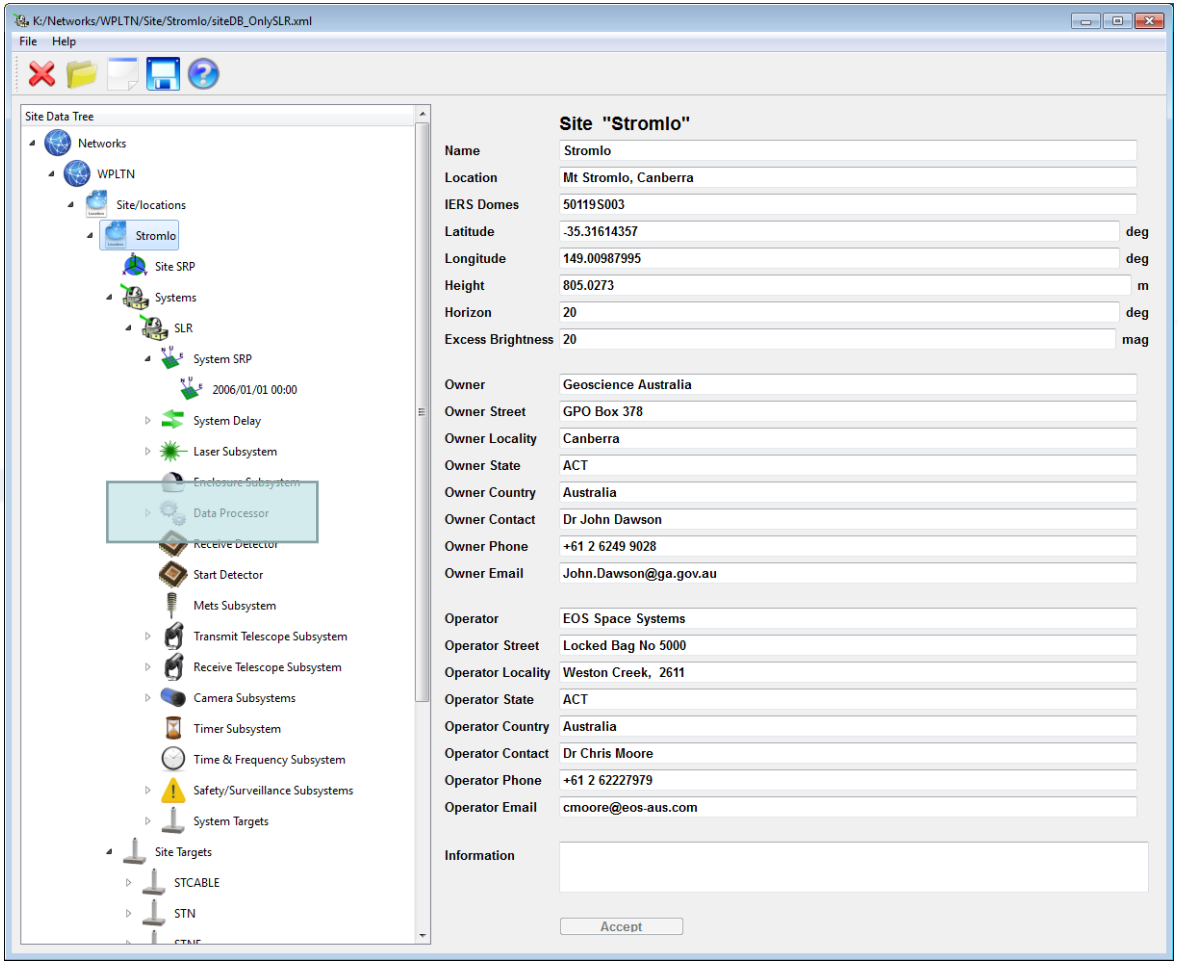


BRD file post processing stream

Autonomous Post Processing

Site Database

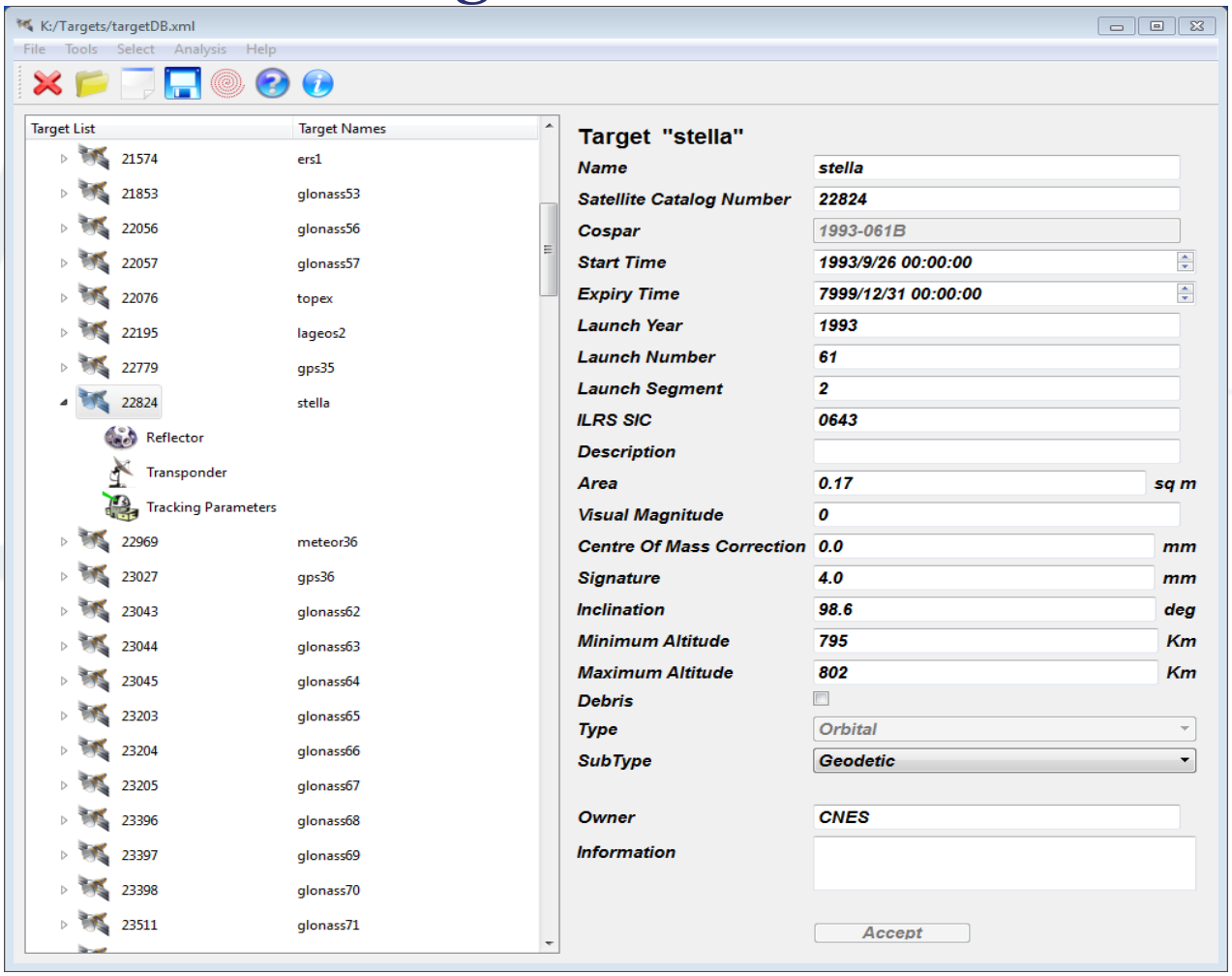
Site based parameterization for post processor



Autonomous Post Processing

Target Database

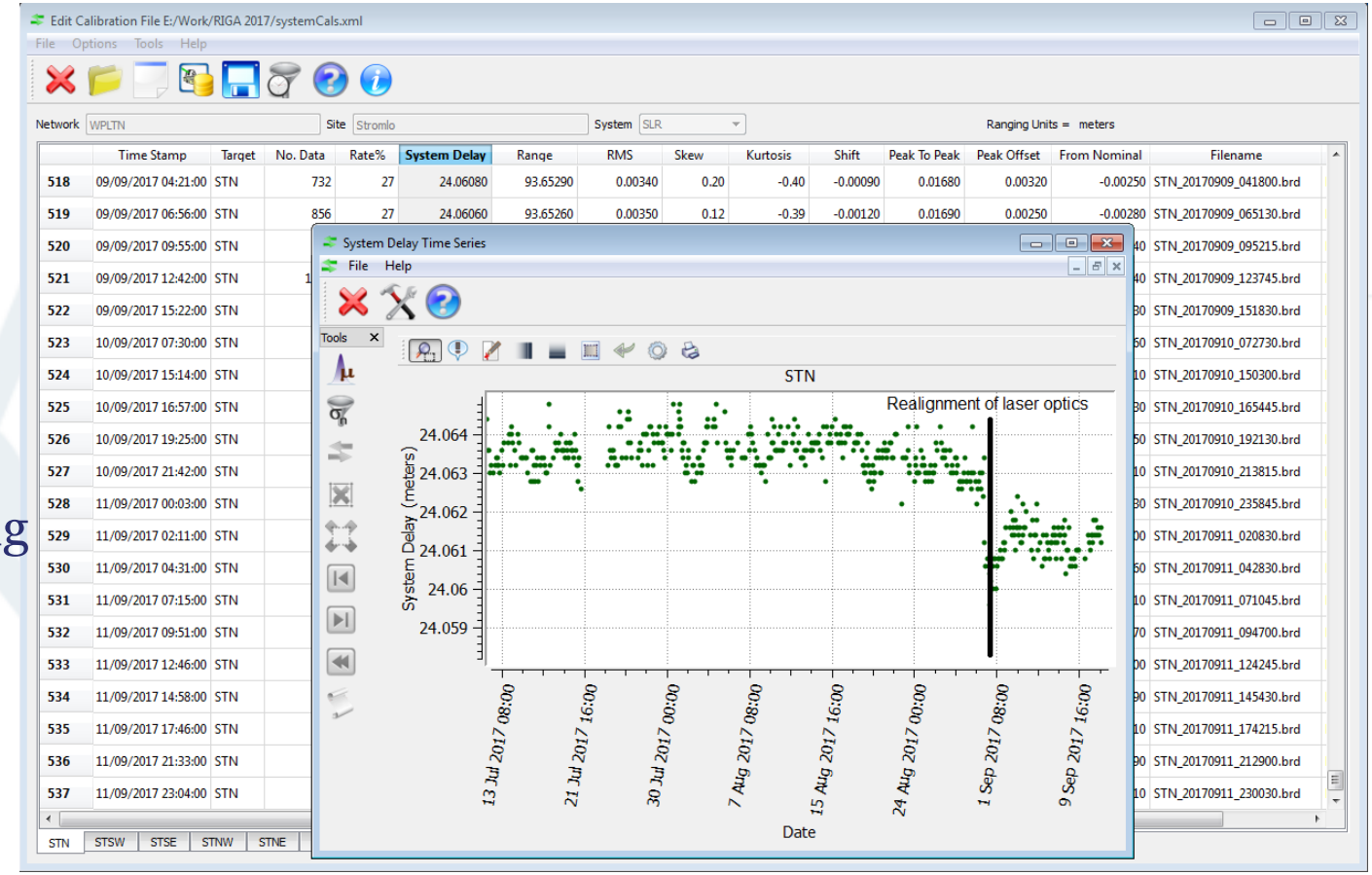
Target parameterization also used for post processing



Autonomous Post Processing

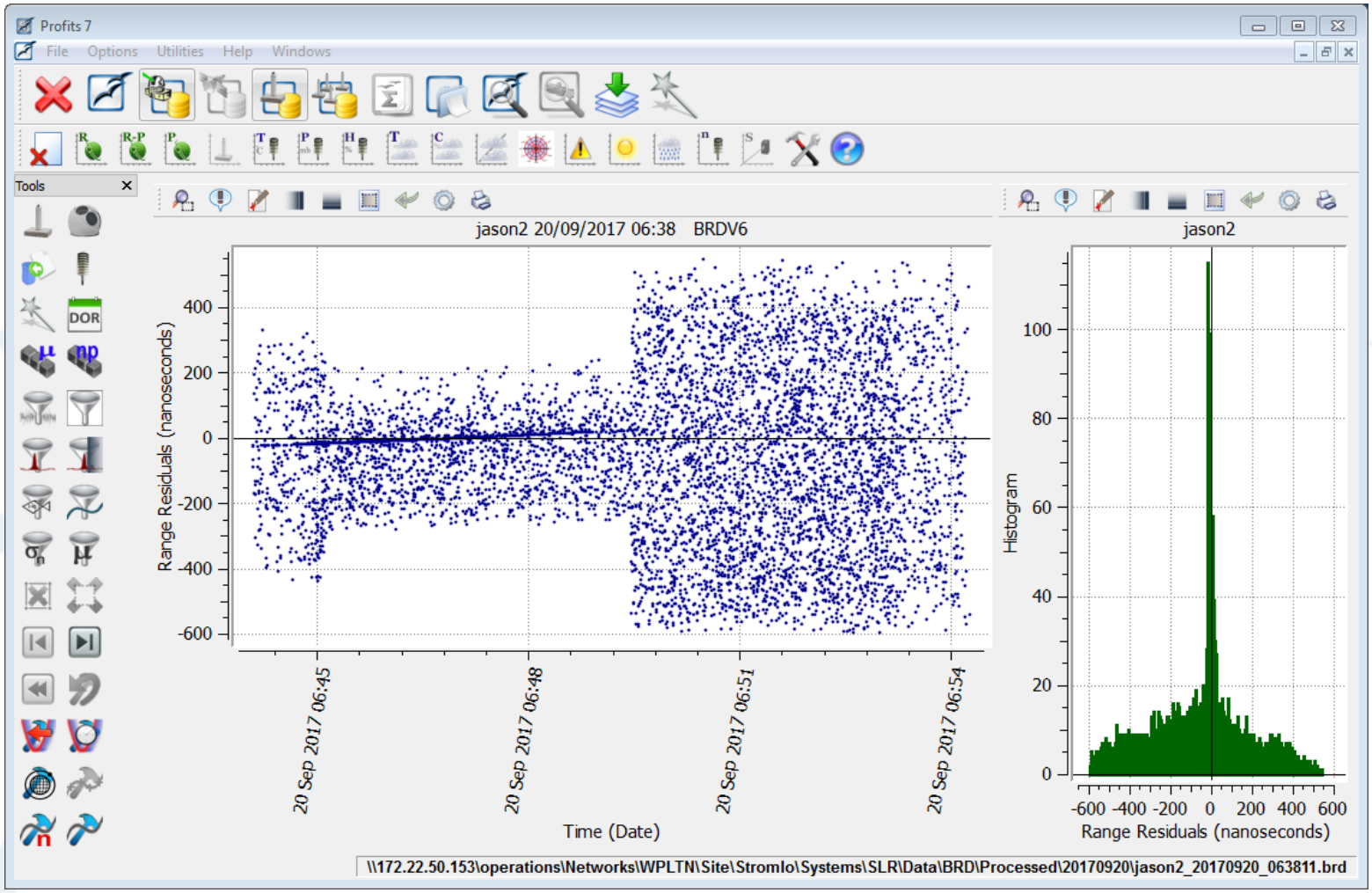
System Calibration Database

Pre and post system calibrations required for post processing



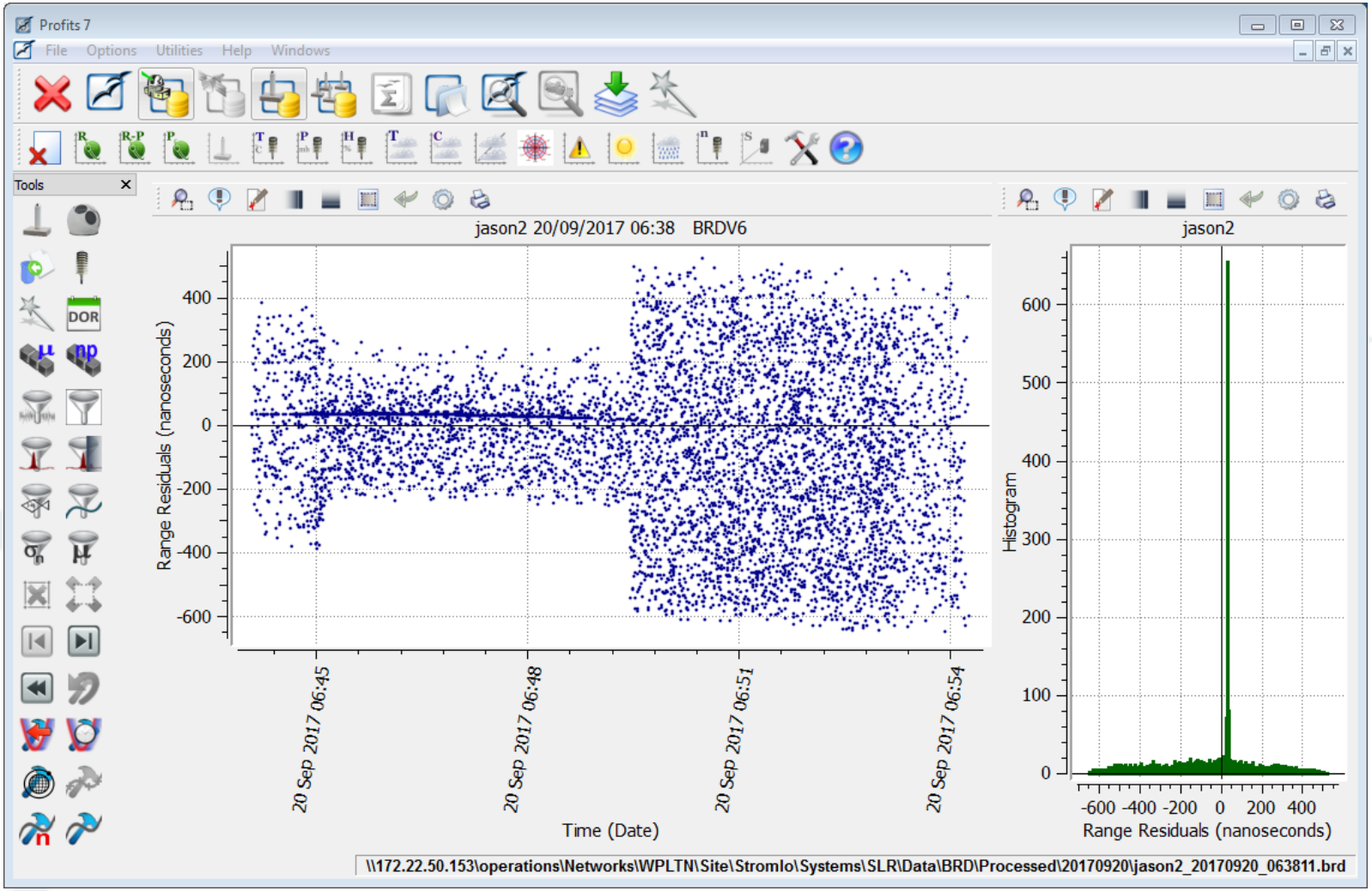
Autonomous Post Processing

Post Processing Steps – input range data



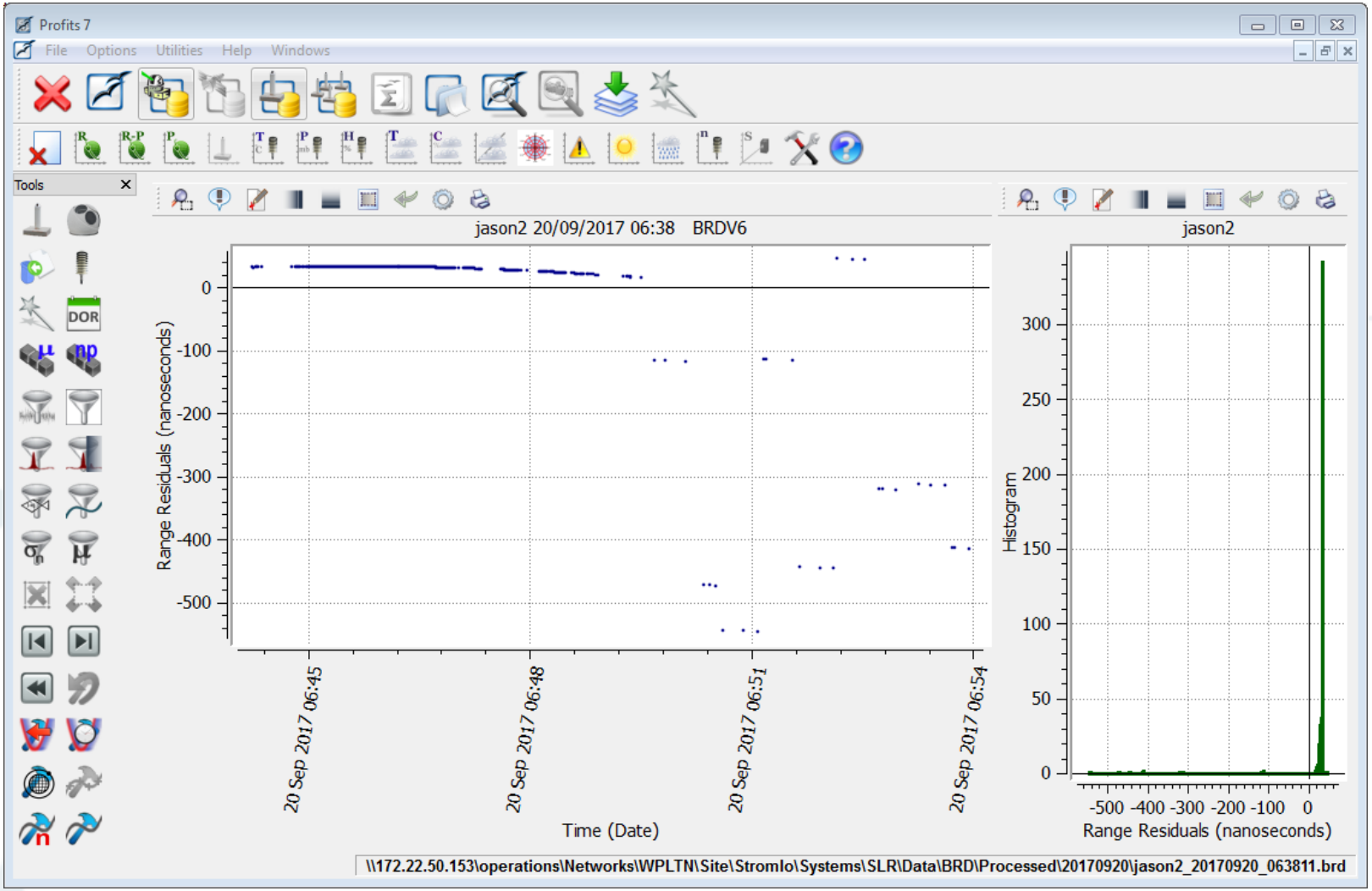
Autonomous Post Processing

Post Processing Steps – after time bias sweep



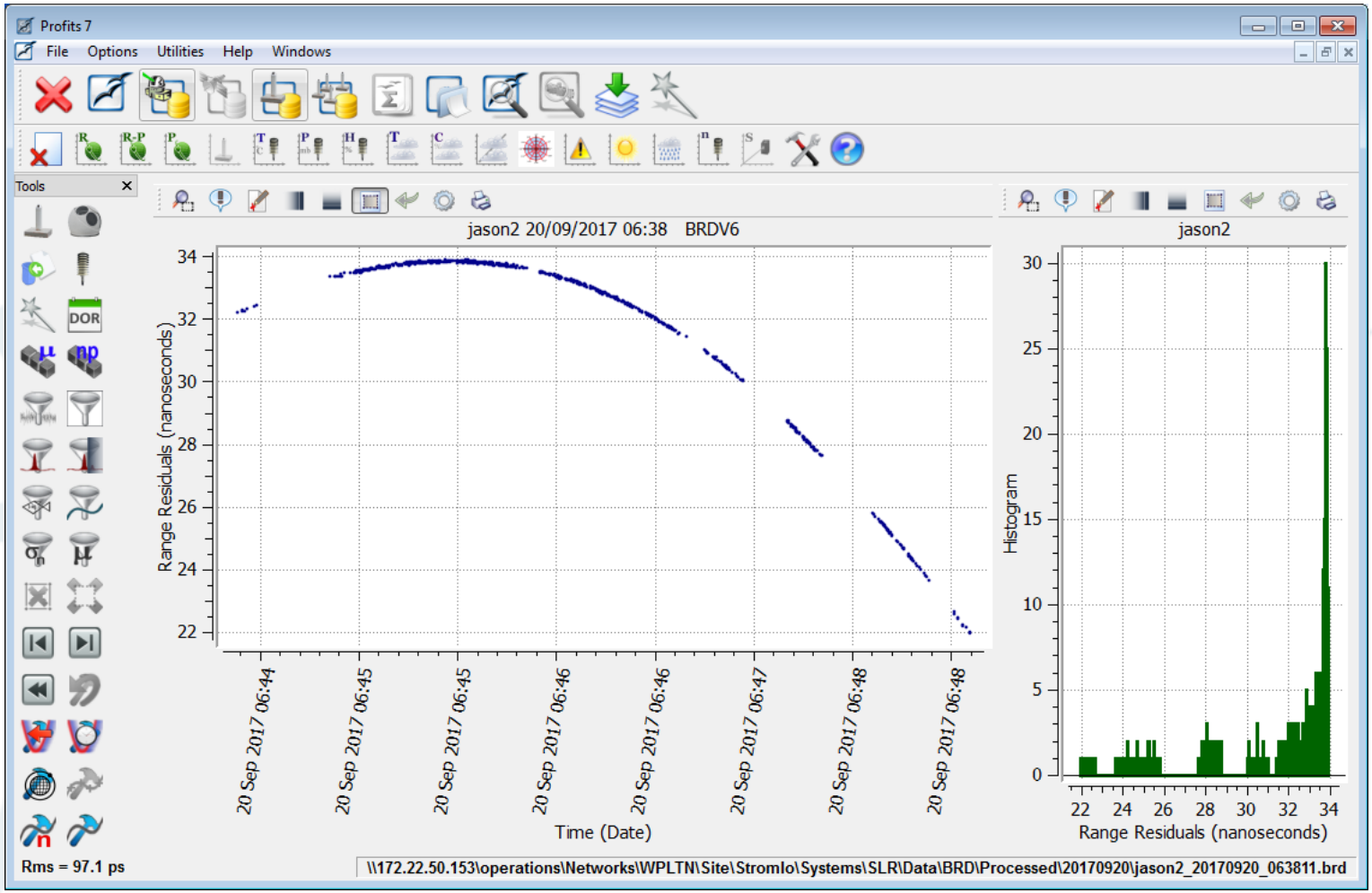
Autonomous Post Processing

Post Processing Steps – after Poisson filtering



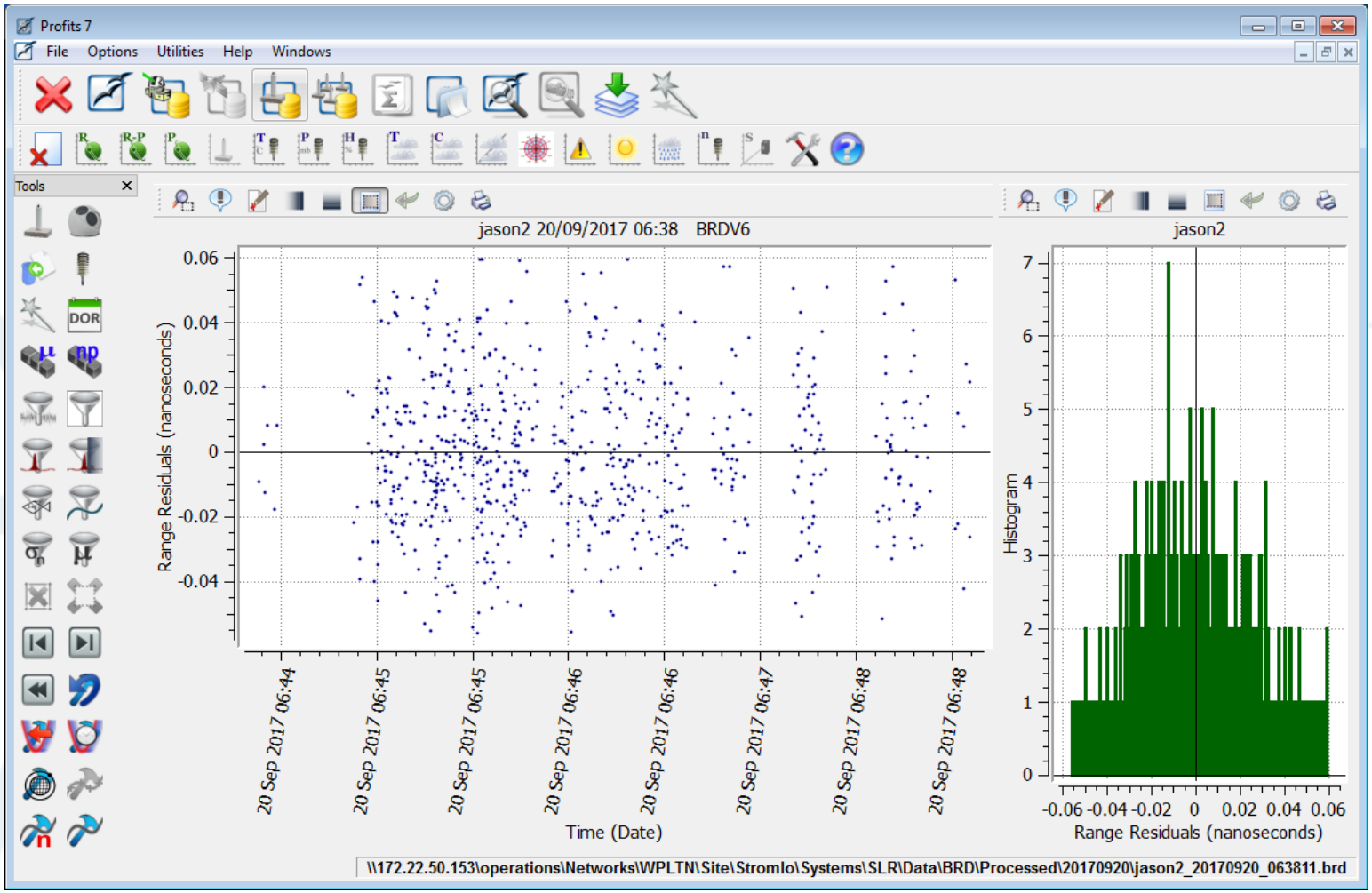
Autonomous Post Processing

Post Processing Steps – after polynomial filtering



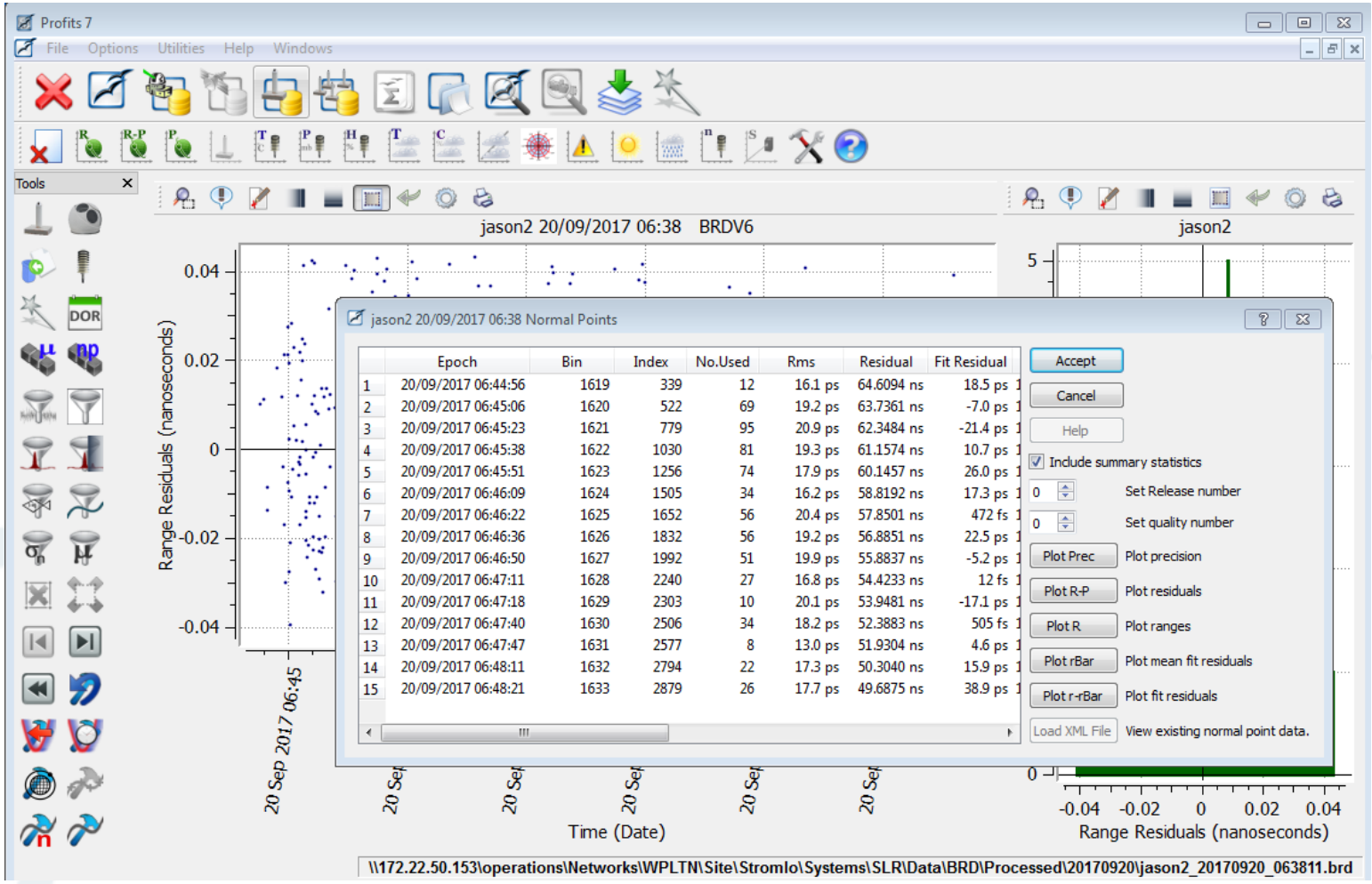
Autonomous Post Processing

Post Processing Steps – after polynomial fitting



Autonomous Post Processing

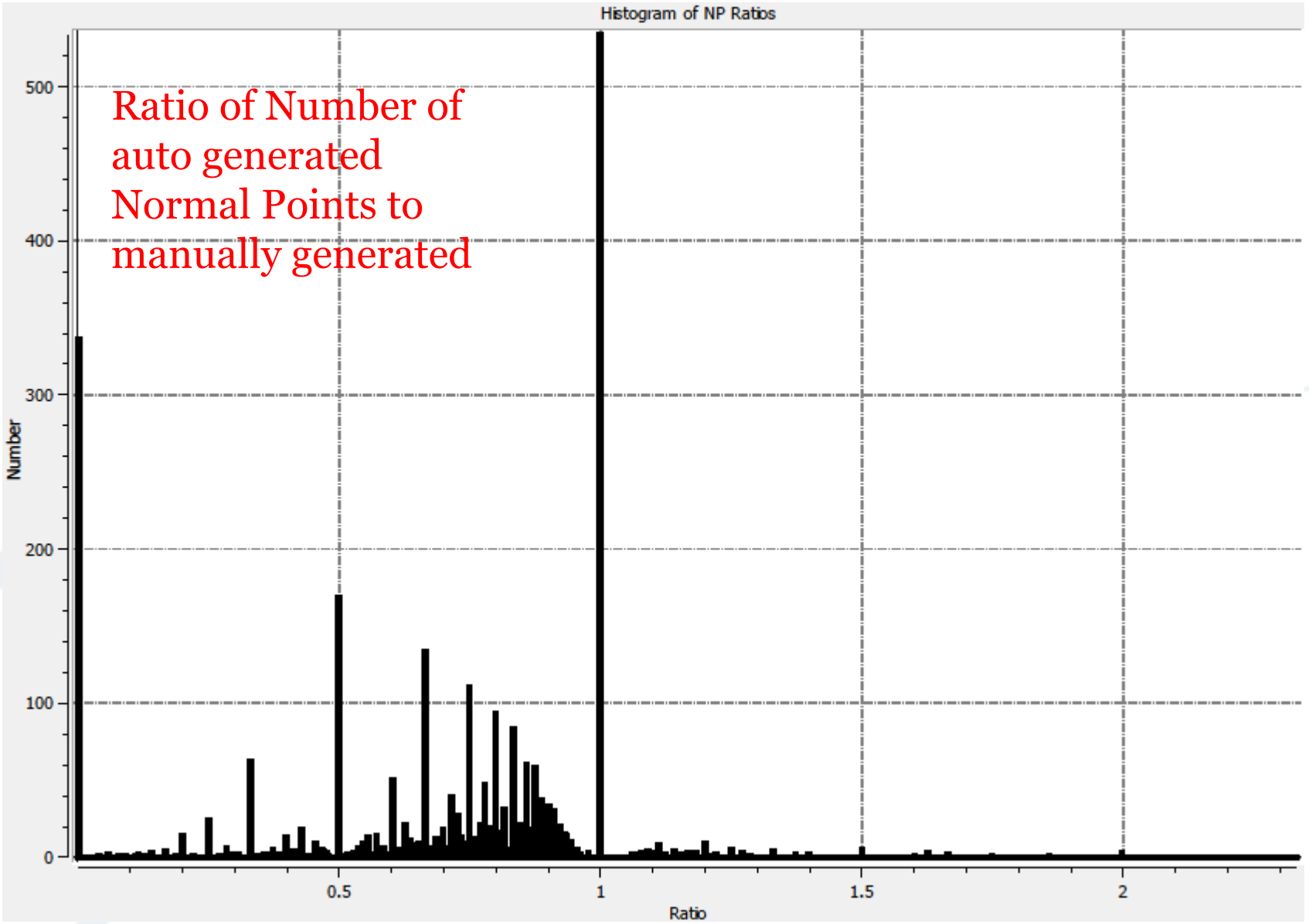
Post Processing Steps – Normal Point Generation



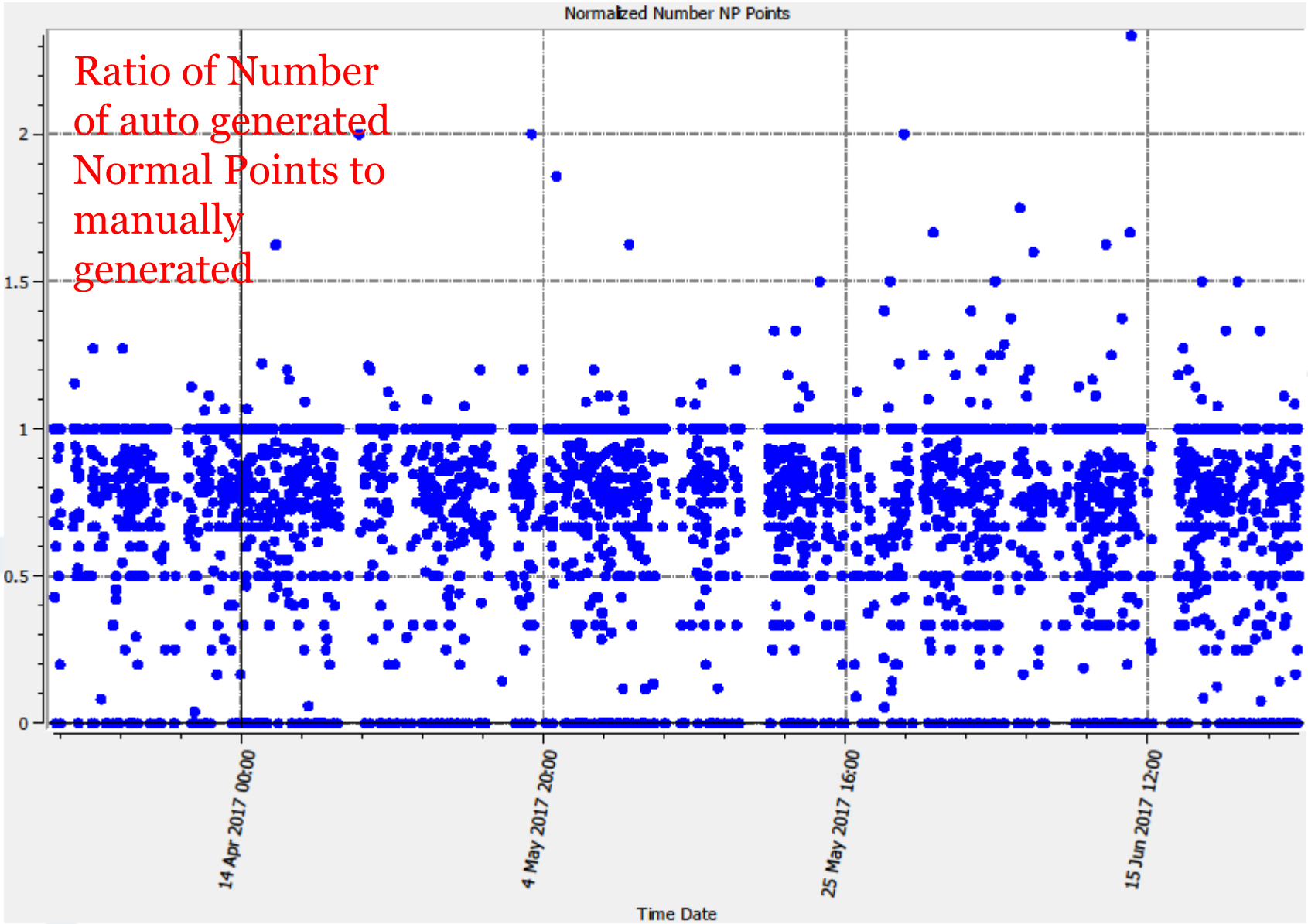
Autonomous Post Processing Analysis

- Analysis of differences between manually and automatically processed BRD files.
- Post processor server supports repeated re-analysis of BRD files.
- Allows comparison of results from ~20000 BRD files (obtained in 2017).
- Able to identify and focus on outliers.
- Provides average statistics.

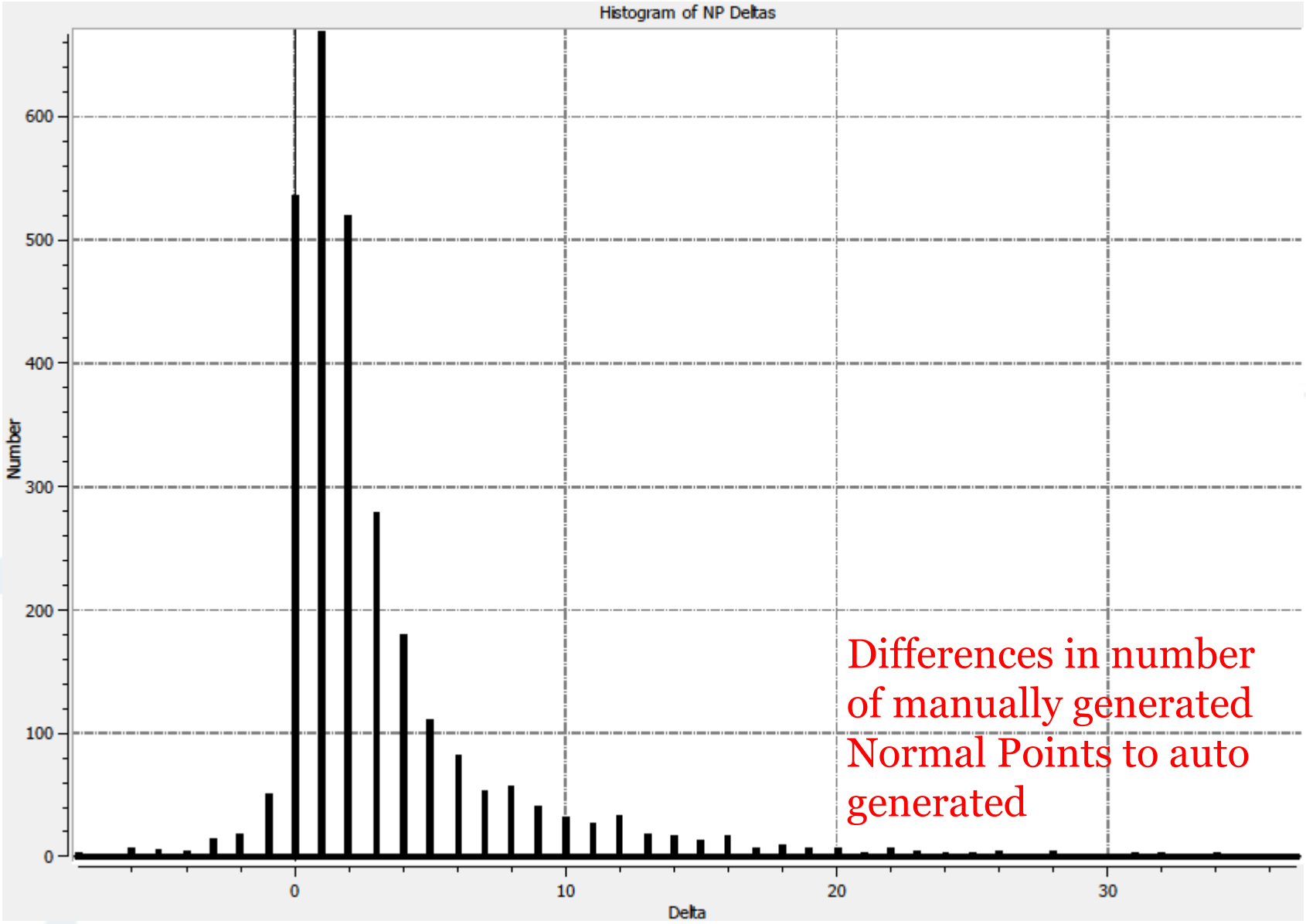
Autonomous Post Processing Analysis



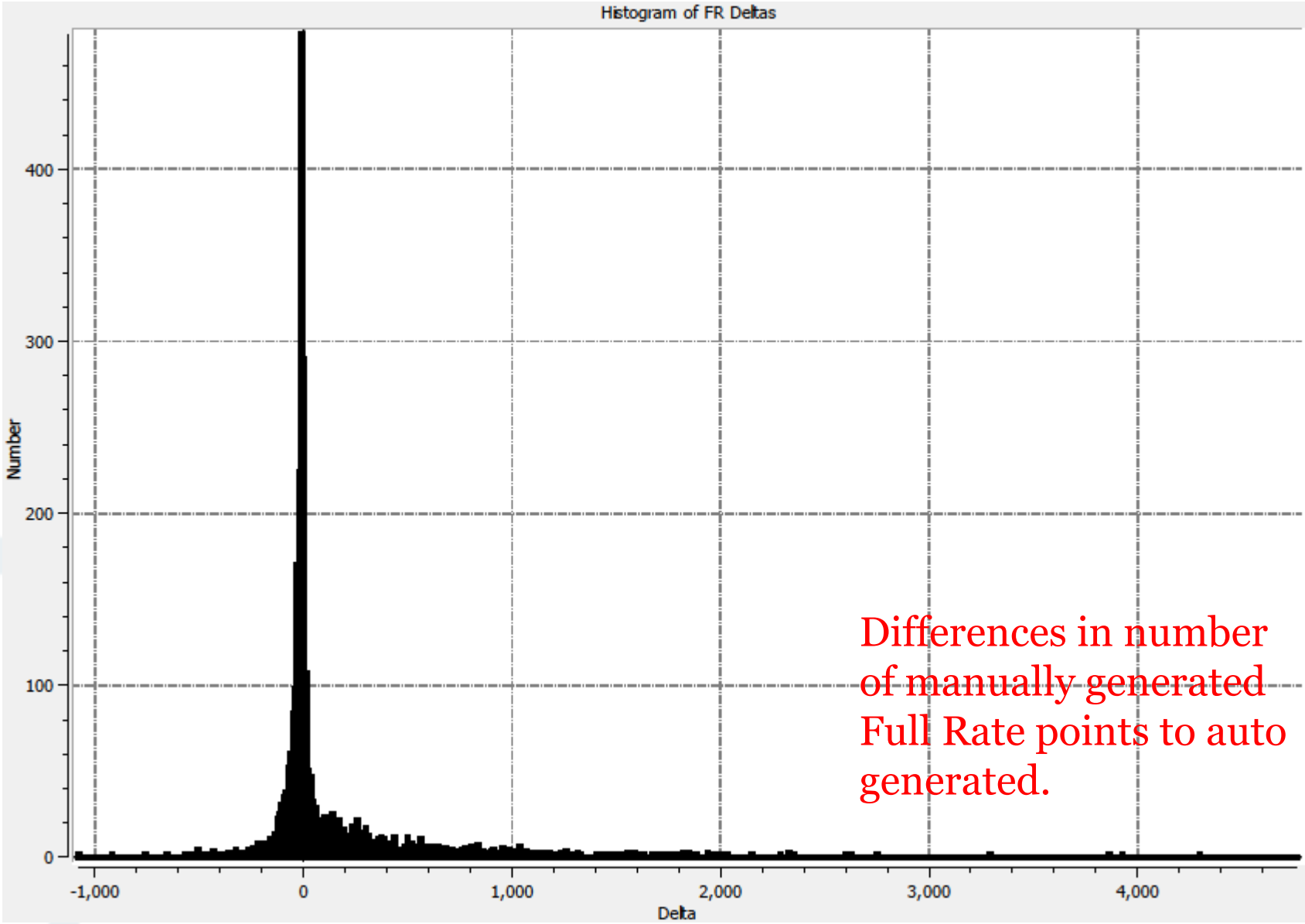
Autonomous Post Processing Analysis



Autonomous Post Processing Analysis



Autonomous Post Processing Analysis



Differences in number of manually generated Full Rate points to auto generated.

EOS SPACE SYSTEMS

Summary & Plans

- Automated processing well developed.
- Refinements to remove spurious points.
- Complete data quality tests.
- Switch publication of results from manually processed to automated.
- Continuous improvement to reduce lost points.