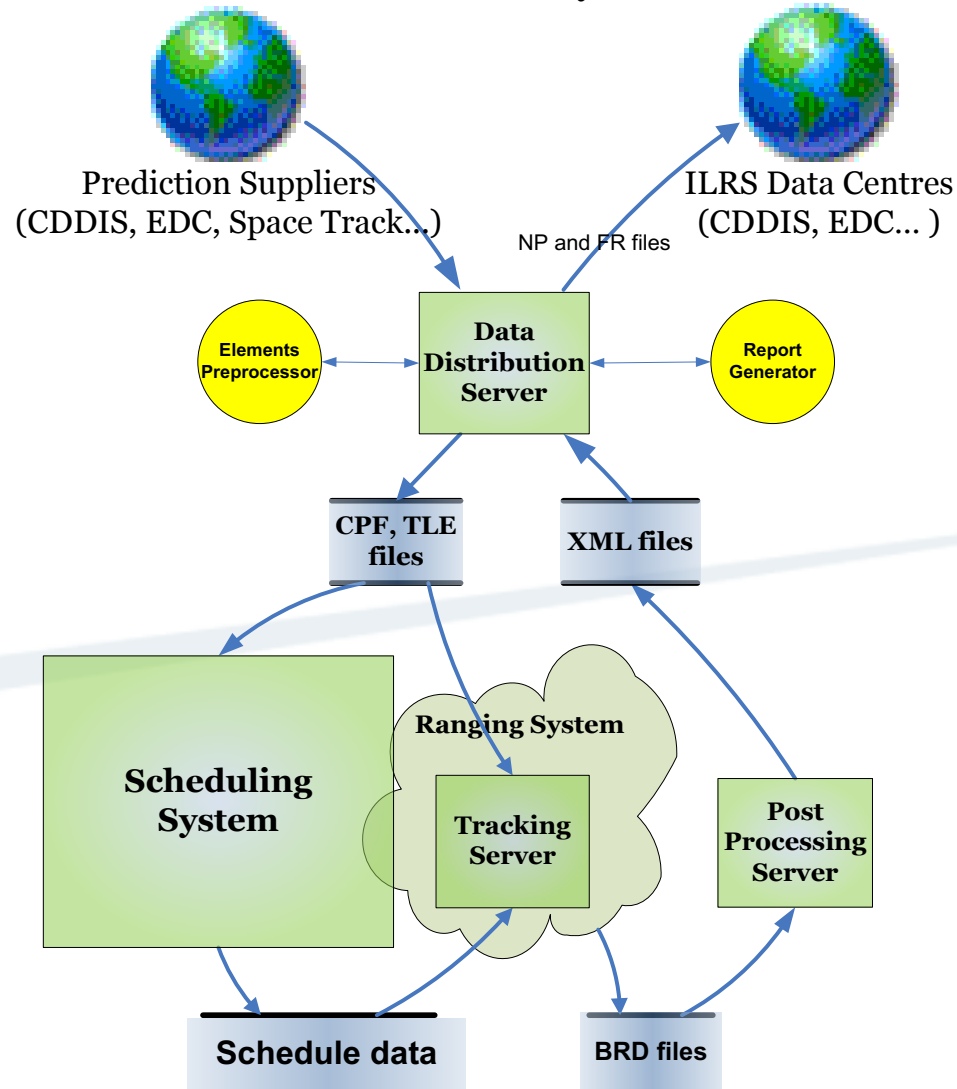


Automated Scheduling

Mt Stromlo SLR System Schematic of Primary Automation Systems



Automated Scheduling



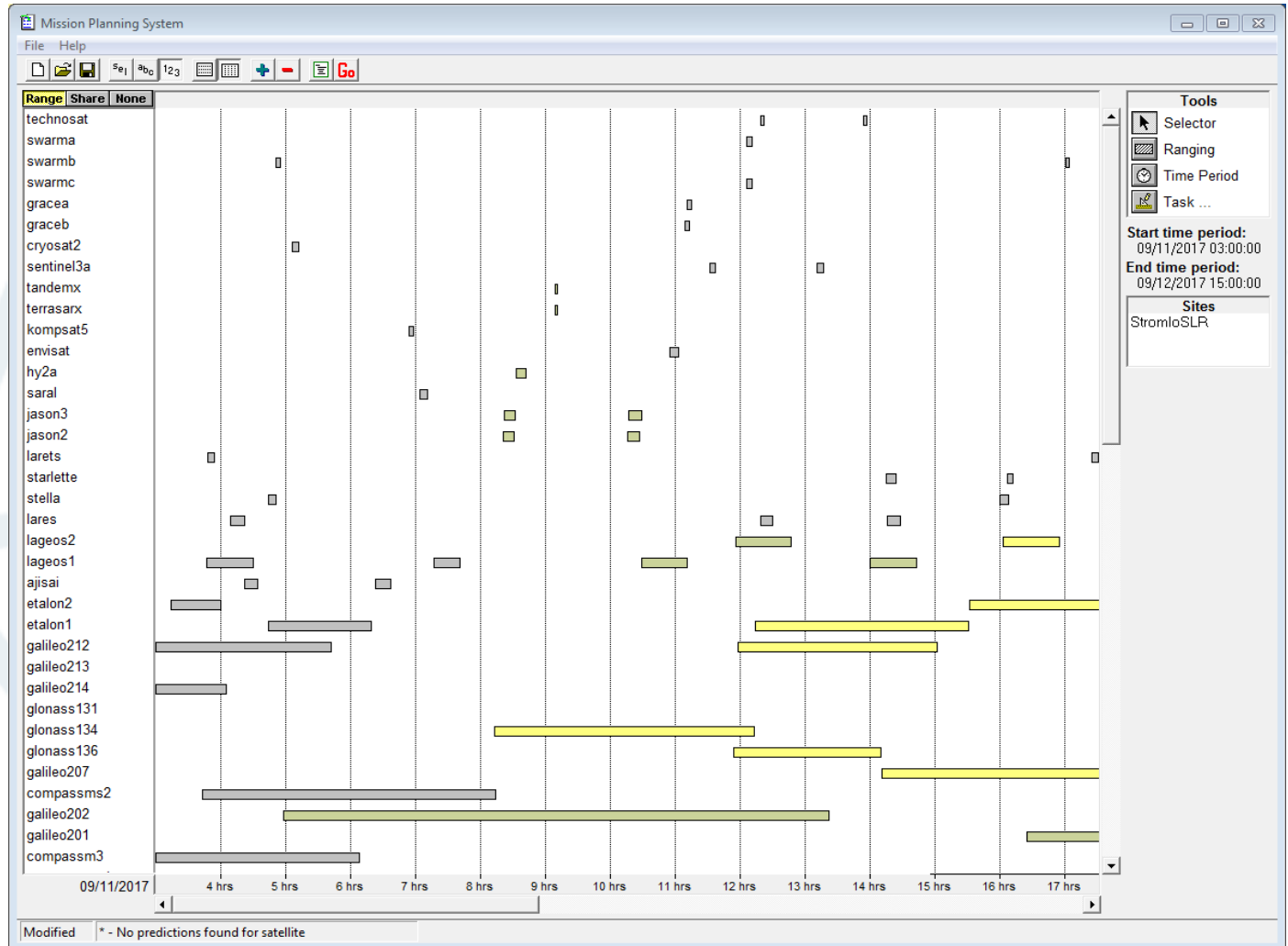
Mission Planning System (MPS)

- 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)



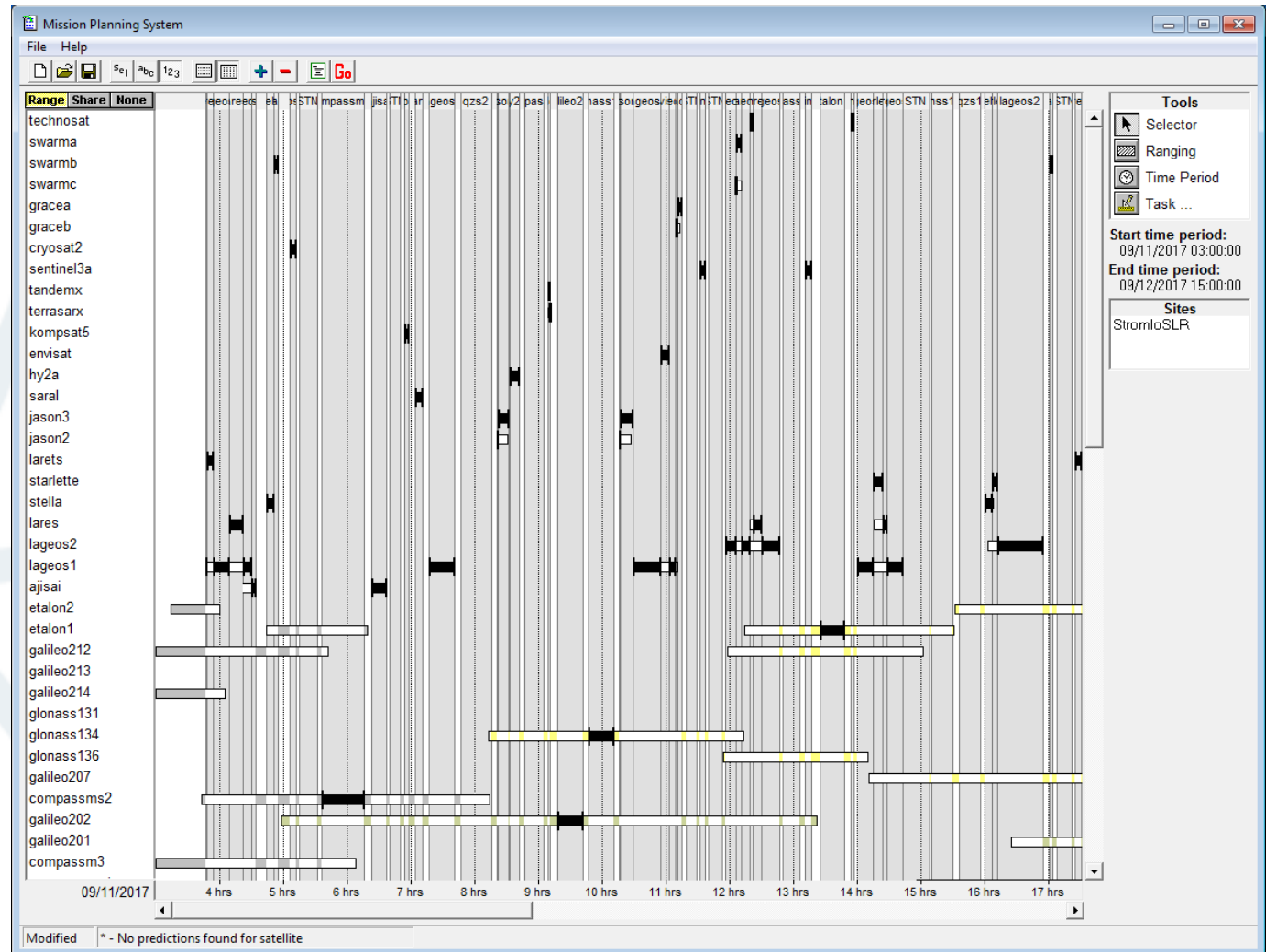
Generates
passes for all
specified targets
over a specified
period.



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.

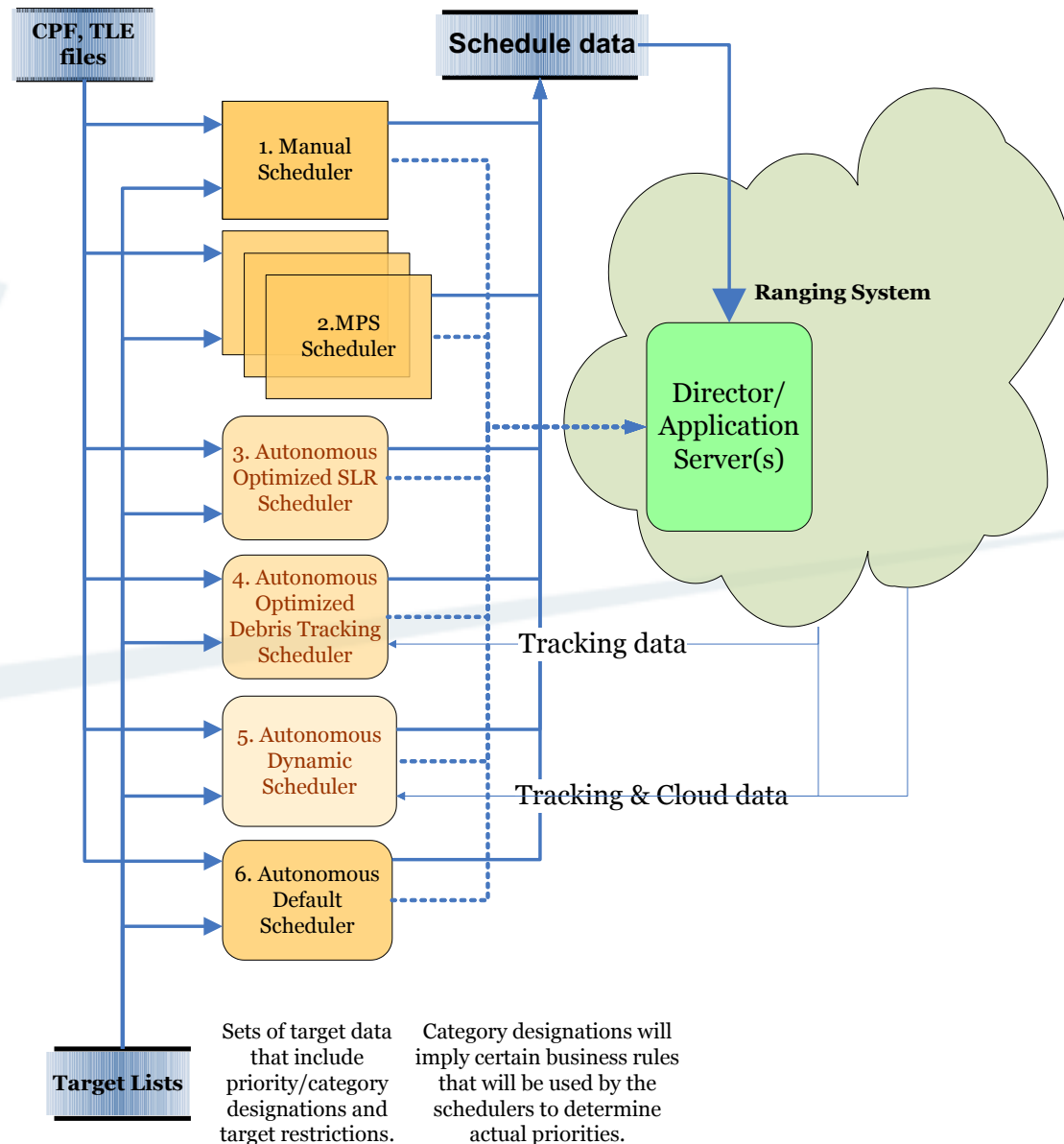
If two HEO target passes overlap and are similar in elevation the one that was ranged to longest ago has higher priority.

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

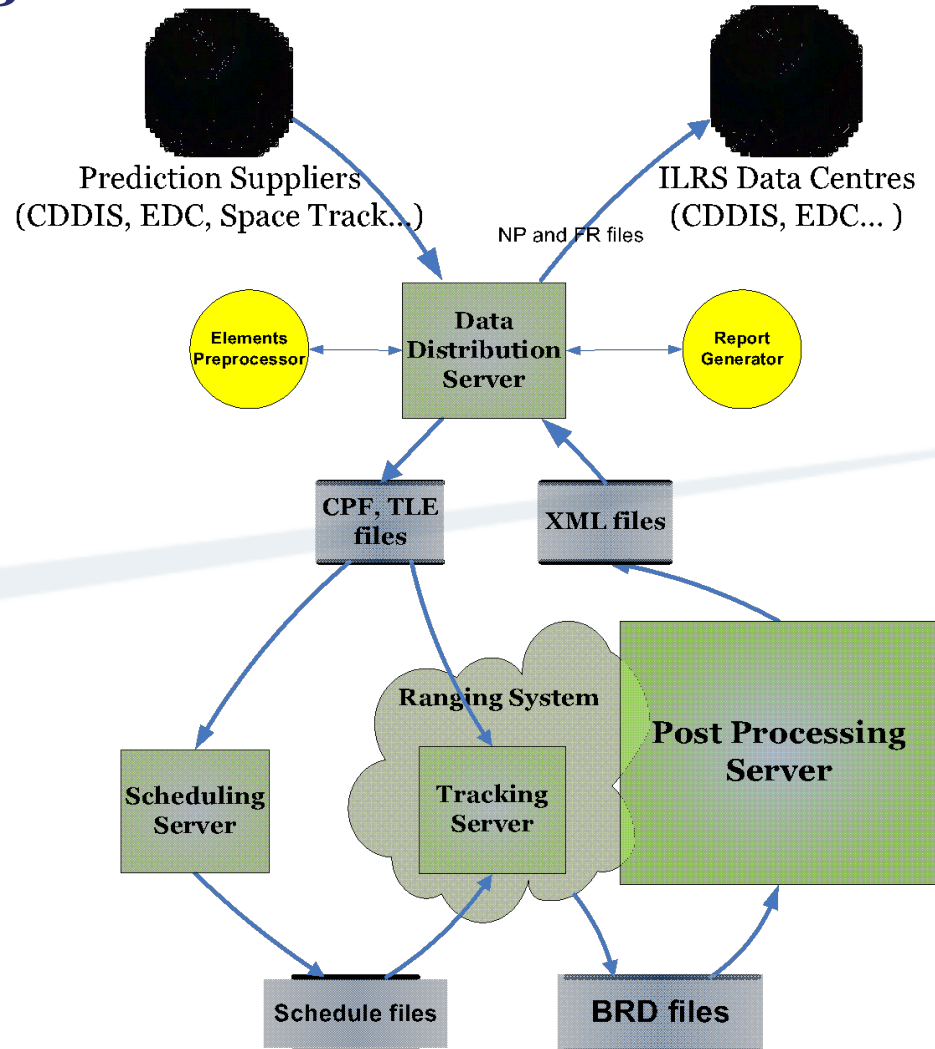


Summary

- 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

Mt Stromlo SLR System Schematic of Primary Automation Servers



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.

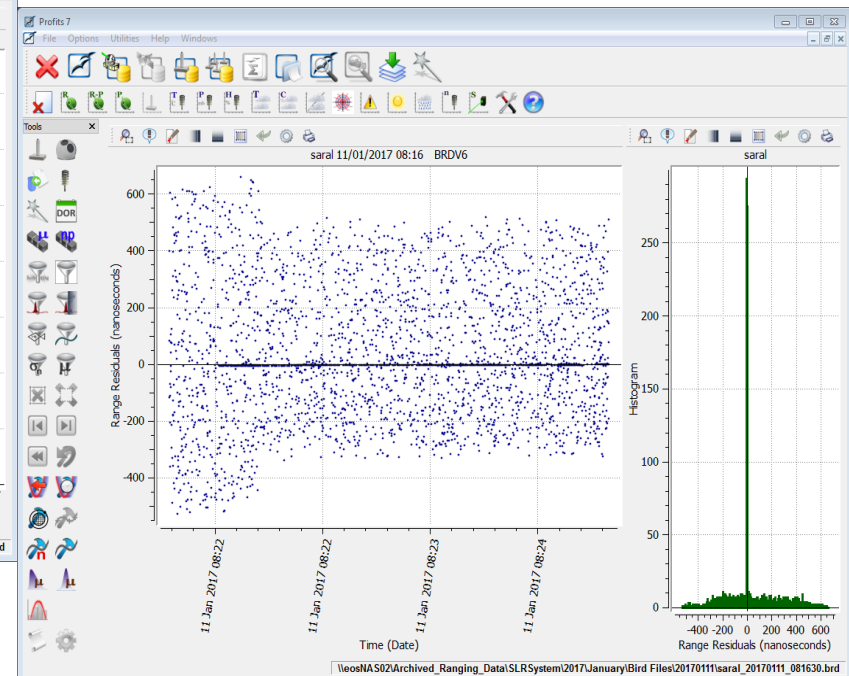
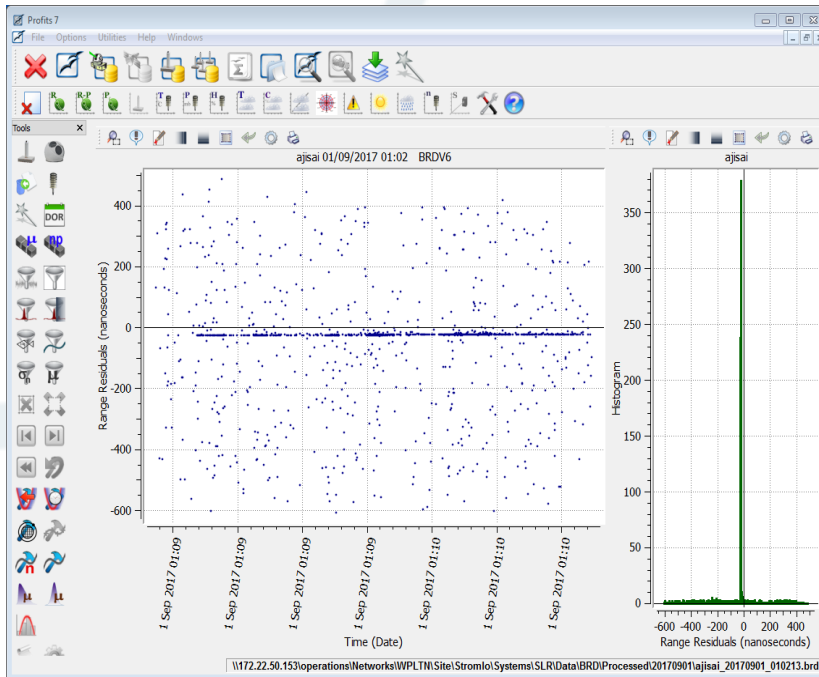
Autonomous Post Processing

- ❑ 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

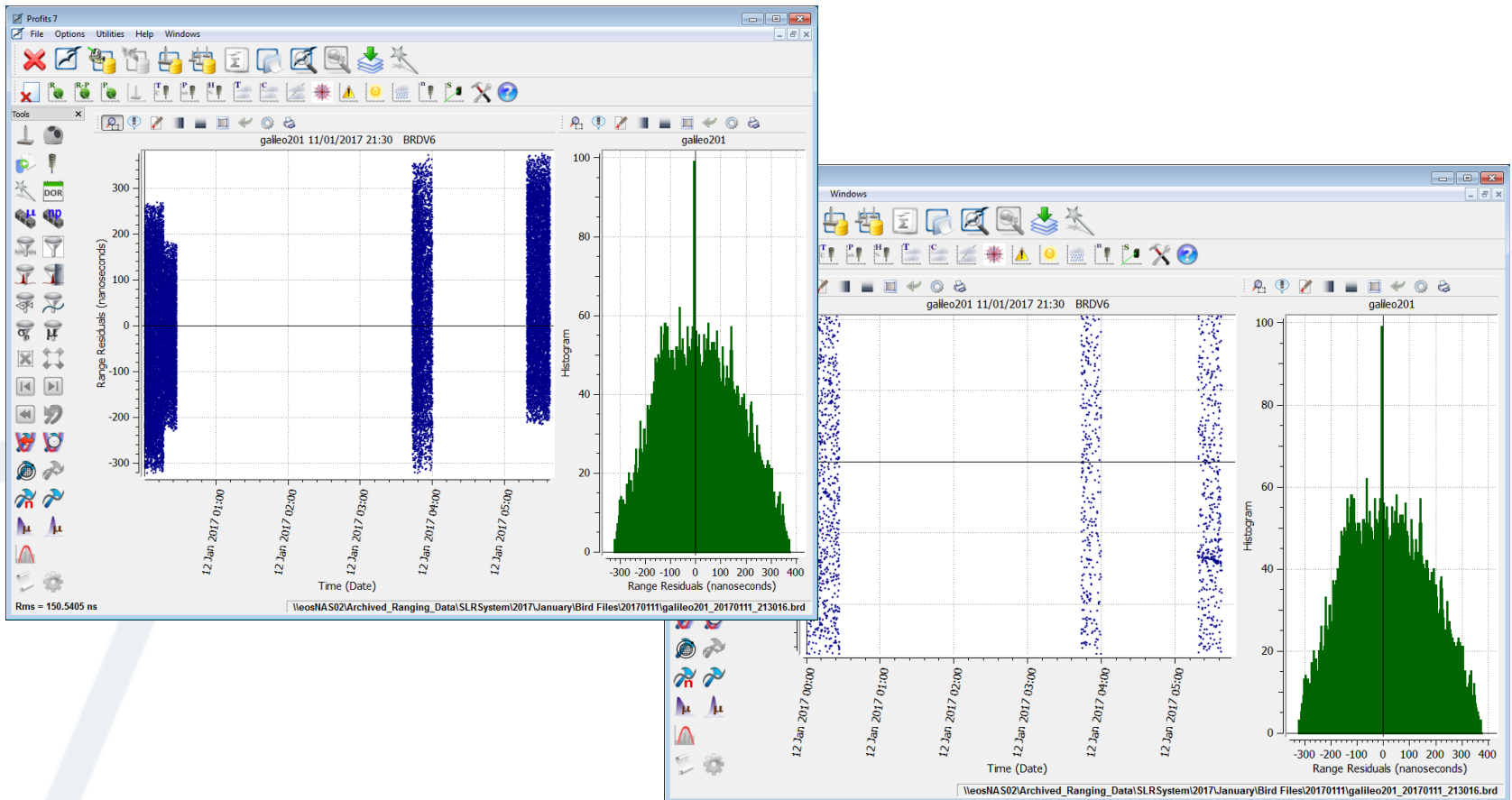
Autonomous Post Processing

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



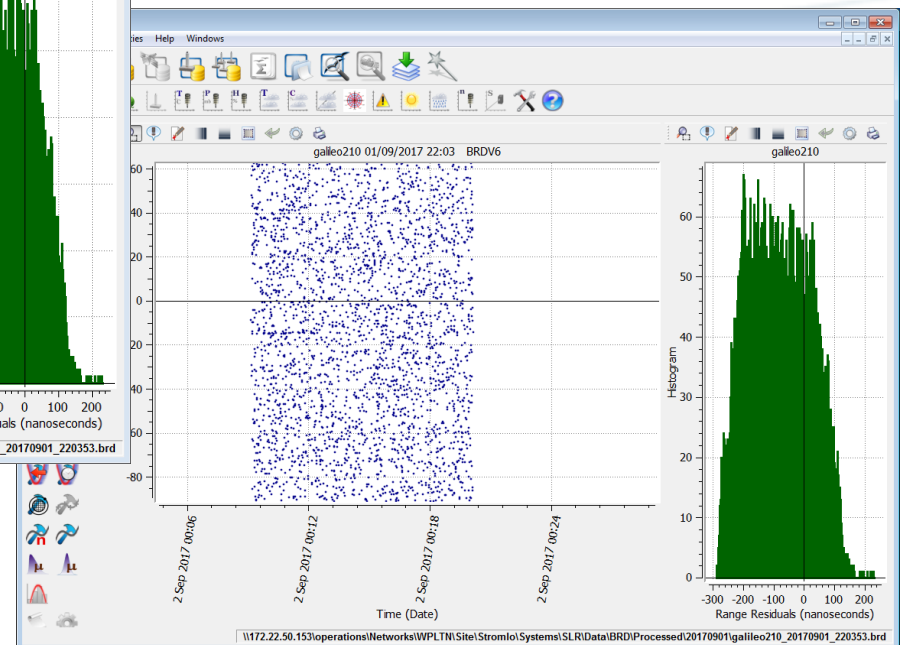
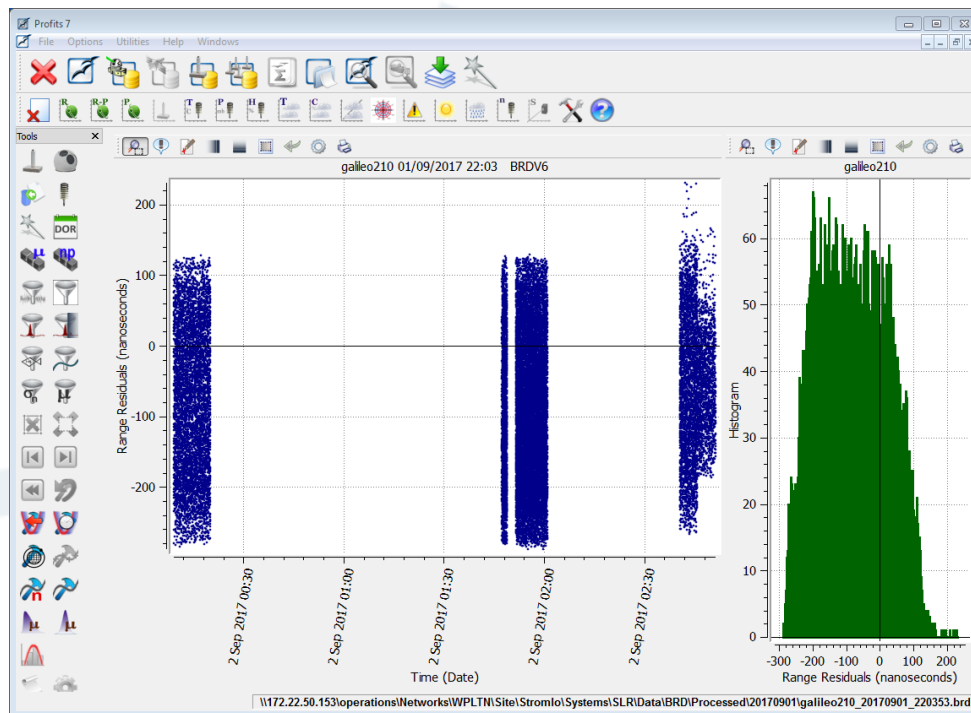
Autonomous Post Processing

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



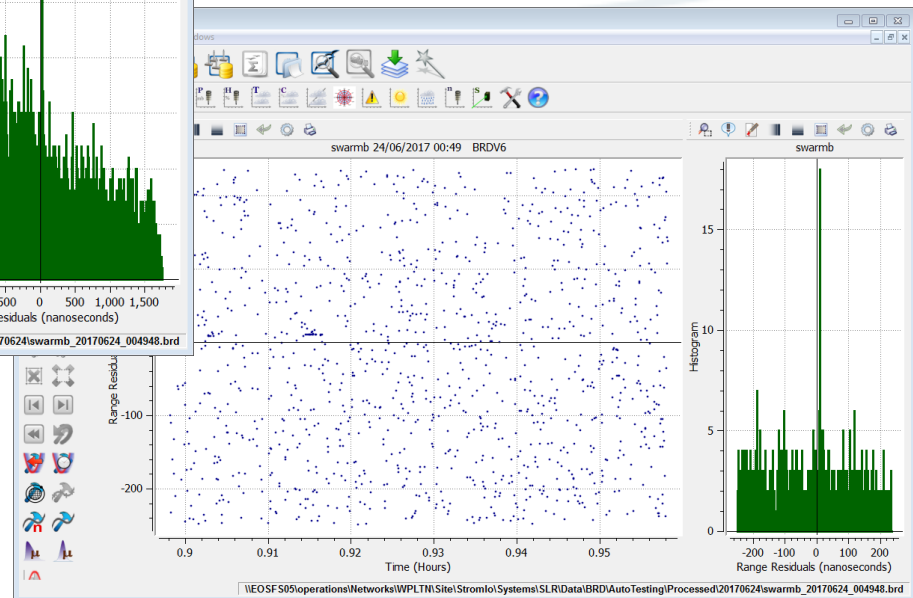
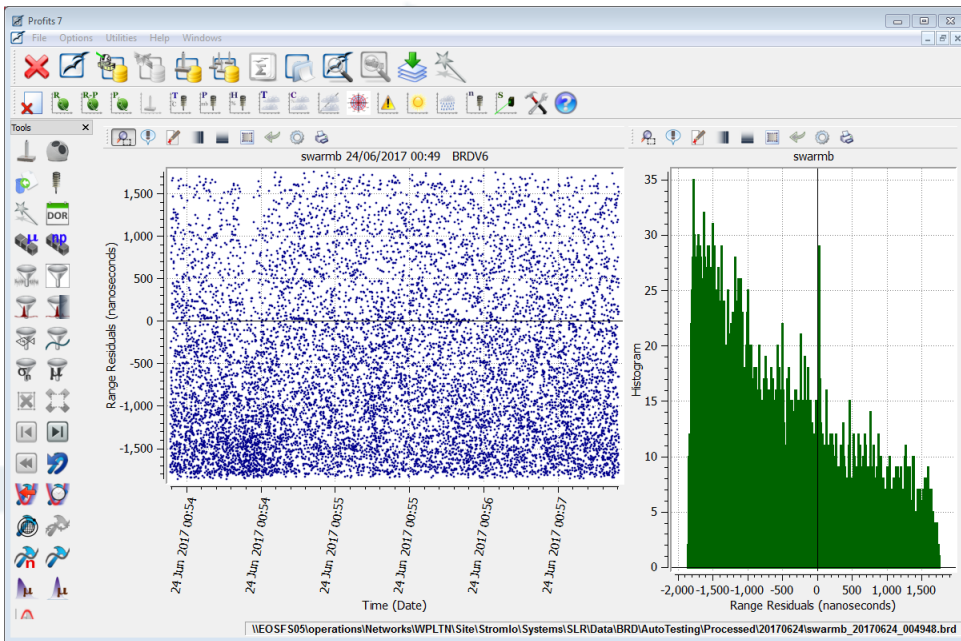
Autonomous Post Processing

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

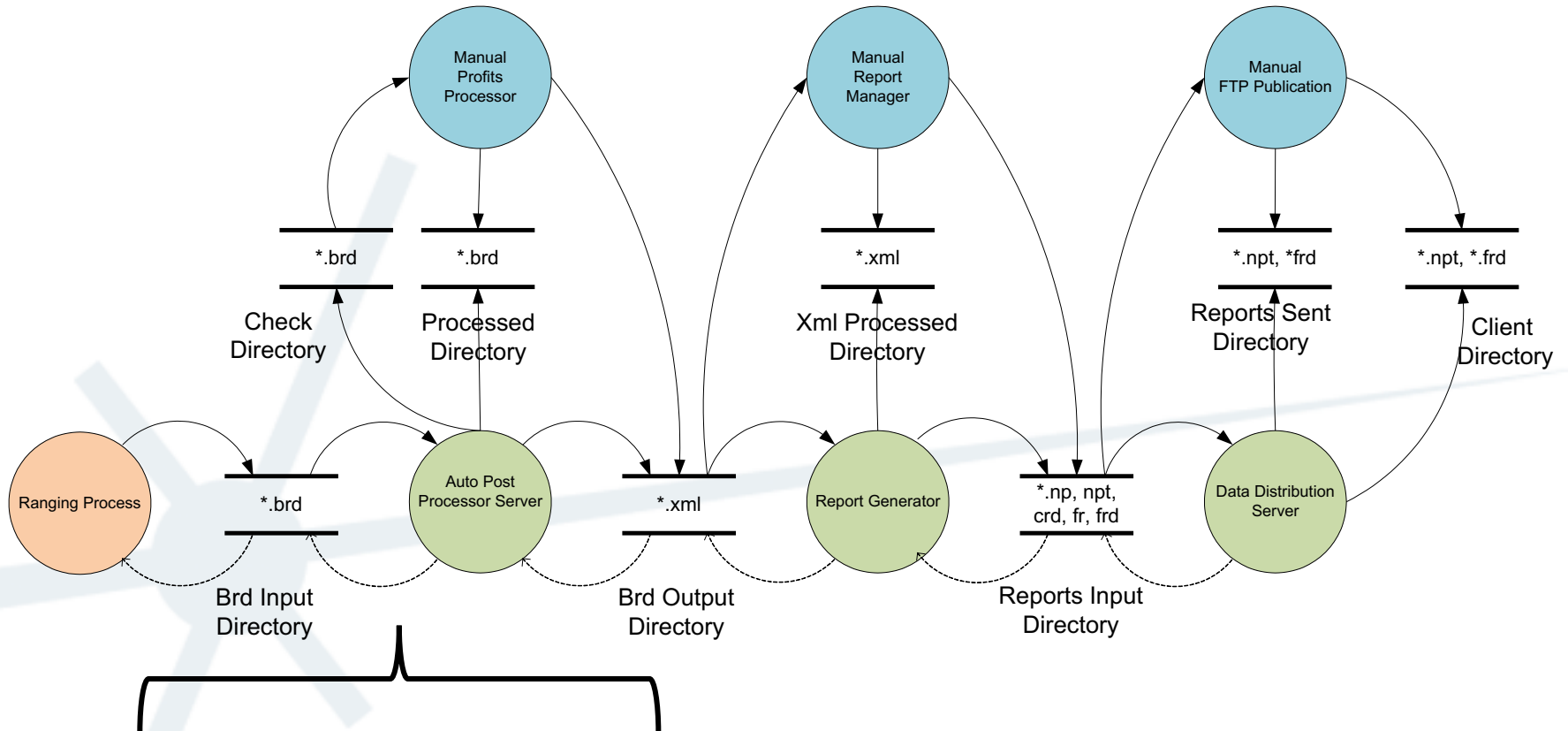


Autonomous Post Processing

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



Autonomous Post Processing

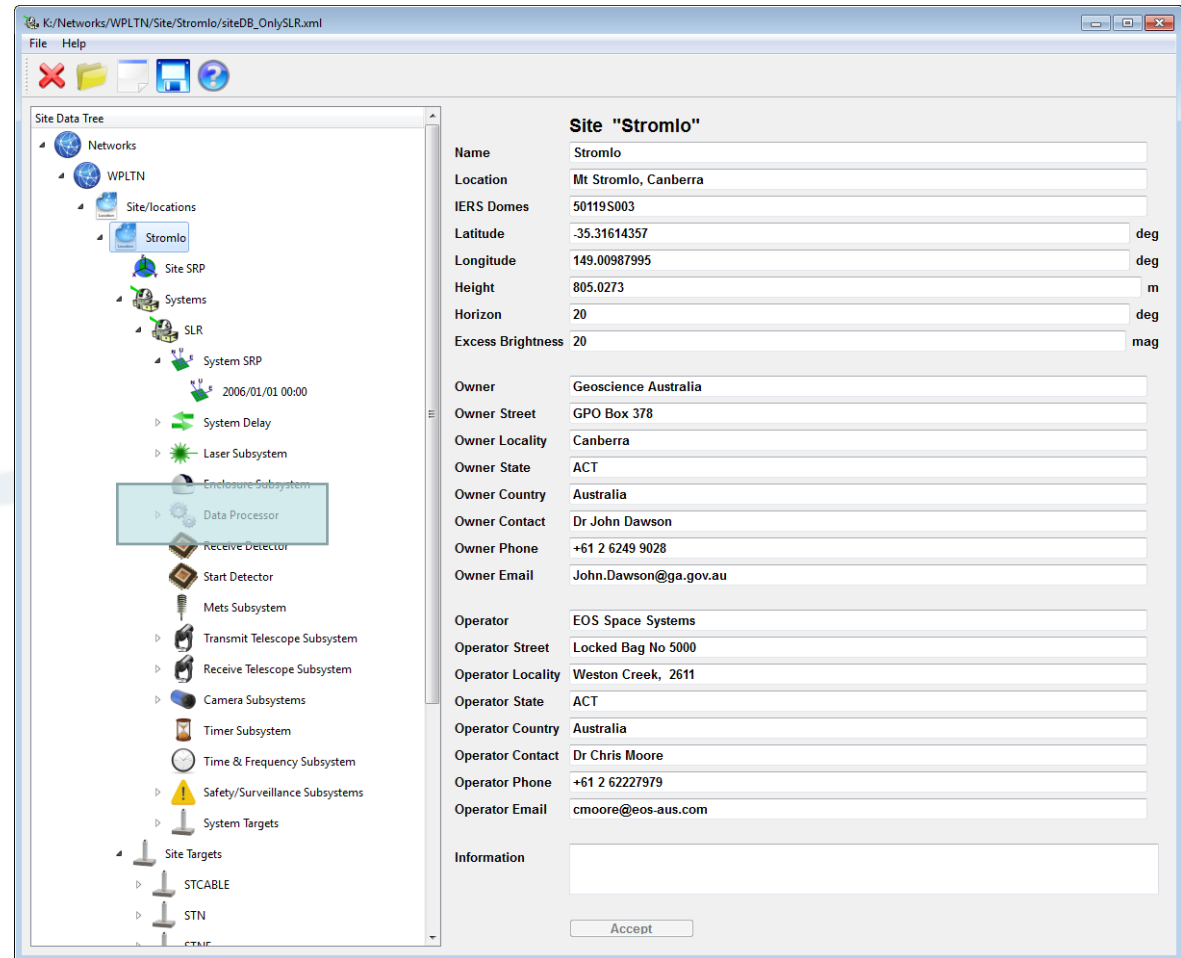


BRD file post processing stream

Autonomous Post Processing

Site Database

Site based
parameterization
for post processor



The screenshot shows a software window titled "K:/Networks/WPLTN/Site/Stromlo/siteDB_OnlySLR.xml". The interface is divided into two main sections: a "Site Data Tree" on the left and a configuration form on the right.

Site Data Tree:

- Networks
 - WPLTN
 - Site/locations
 - Stromlo
 - Site SRP
 - Systems
 - SLR
 - System SRP
 - 2006/01/01 00:00
 - System Delay
 - Laser Subsystem
 - Enclosure Subsystem
 - Data Processor
 - Receive Detector
 - Start Detector
 - Mets Subsystem
 - Transmit Telescope Subsystem
 - Receive Telescope Subsystem
 - Camera Subsystems
 - Timer Subsystem
 - Time & Frequency Subsystem
 - Safety/Surveillance Subsystems
 - System Targets
 - Site Targets
 - STCABLE
 - STN
 - CTAF

Configuration Form for Site "Stromlo":

Name	Stromlo
Location	Mt Stromlo, Canberra
IERS Domes	50119S003
Latitude	-35.31614357 deg
Longitude	149.00987995 deg
Height	805.0273 m
Horizon	20 deg
Excess Brightness	20 mag
Owner	Geoscience Australia
Owner Street	GPO Box 378
Owner Locality	Canberra
Owner State	ACT
Owner Country	Australia
Owner Contact	Dr John Dawson
Owner Phone	+61 2 6249 9028
Owner Email	John.Dawson@ga.gov.au
Operator	EOS Space Systems
Operator Street	Locked Bag No 5000
Operator Locality	Weston Creek, 2611
Operator State	ACT
Operator Country	Australia
Operator Contact	Dr Chris Moore
Operator Phone	+61 2 62227979
Operator Email	cmoore@eos-aus.com
Information	

Accept

Autonomous Post Processing



Target Database

Target
parameterization
also used for post
processing

The screenshot shows a software window titled 'K:/Targets/targetDB.xml' with a menu bar (File, Tools, Select, Analysis, Help) and a toolbar. The main area is divided into three sections:

- Target List:** A table with two columns: 'Target List' (containing icons and IDs) and 'Target Names'. The target '22824' (stella) is selected.
- Target "stella":** A detailed parameterization form for the selected target.
- Accept:** A button at the bottom right of the form.

Target List	Target Names
21574	ers1
21853	glonass53
22056	glonass56
22057	glonass57
22076	topex
22195	lageos2
22779	gps35
22824	stella
Reflector	
Transponder	
Tracking Parameters	
22969	meteor36
23027	gps36
23043	glonass62
23044	glonass63
23045	glonass64
23203	glonass65
23204	glonass66
23205	glonass67
23396	glonass68
23397	glonass69
23398	glonass70
23511	glonass71

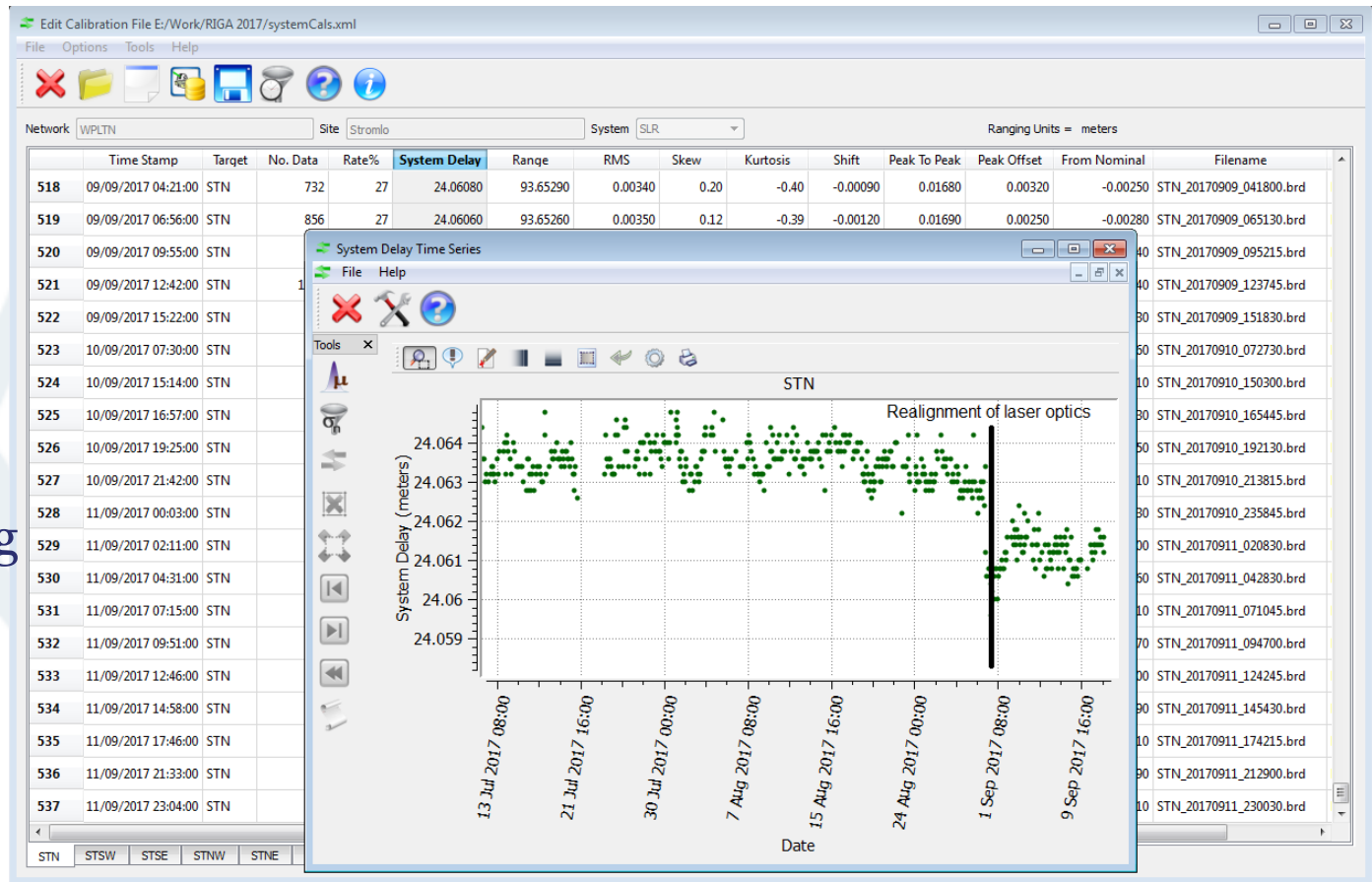
Name	stella
Satellite Catalog Number	22824
Cospar	1993-061B
Start Time	1993/9/26 00:00:00
Expiry Time	7999/12/31 00:00:00
Launch Year	1993
Launch Number	61
Launch Segment	2
ILRS SIC	0643
Description	
Area	0.17 sq m
Visual Magnitude	0
Centre Of Mass Correction	0.0 mm
Signature	4.0 mm
Inclination	98.6 deg
Minimum Altitude	795 Km
Maximum Altitude	802 Km
Debris	<input type="checkbox"/>
Type	Orbital
SubType	Geodetic
Owner	CNES
Information	

Accept

Autonomous Post Processing



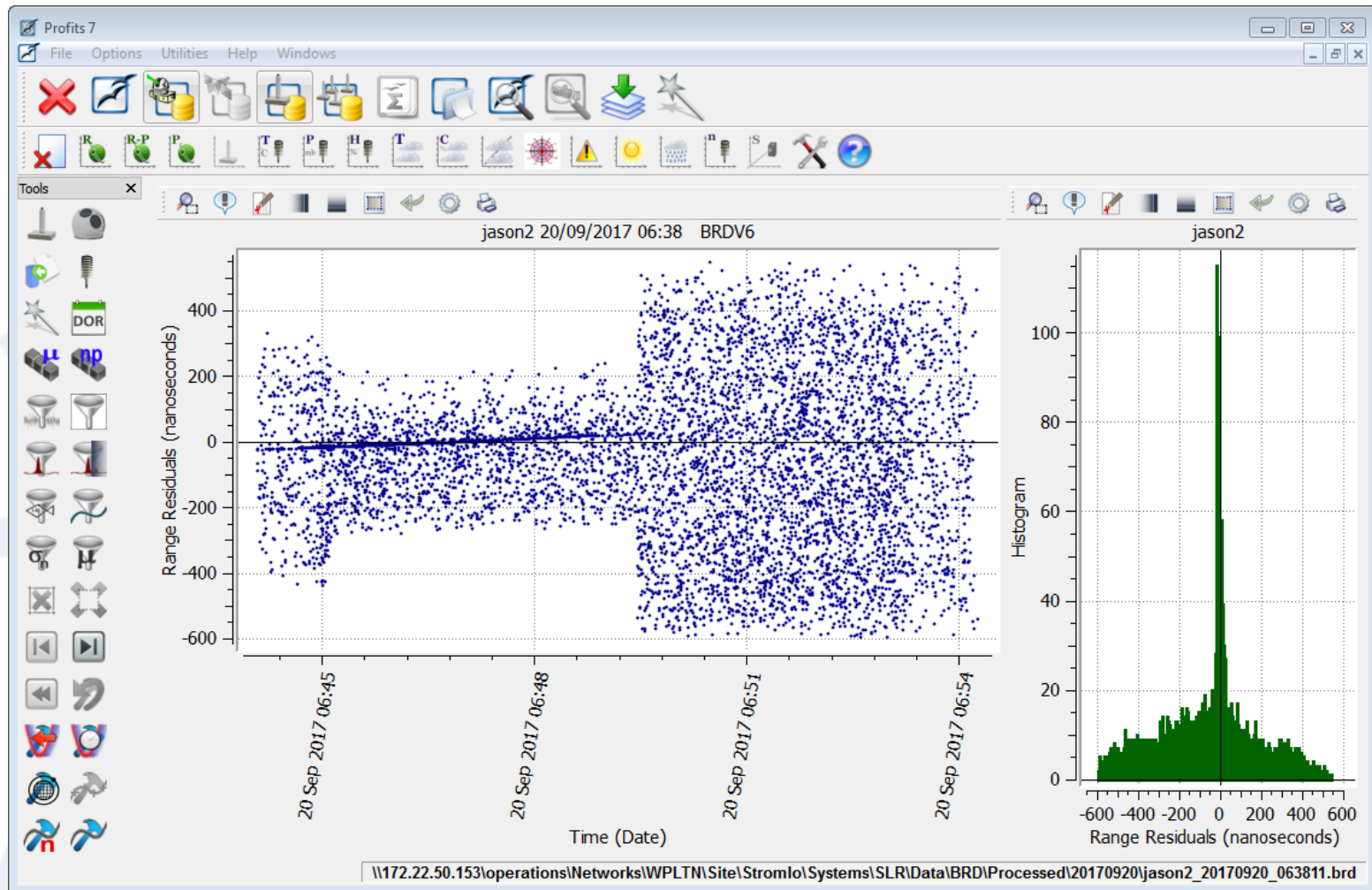
System Calibration Database



Pre and post system calibrations required for post processing

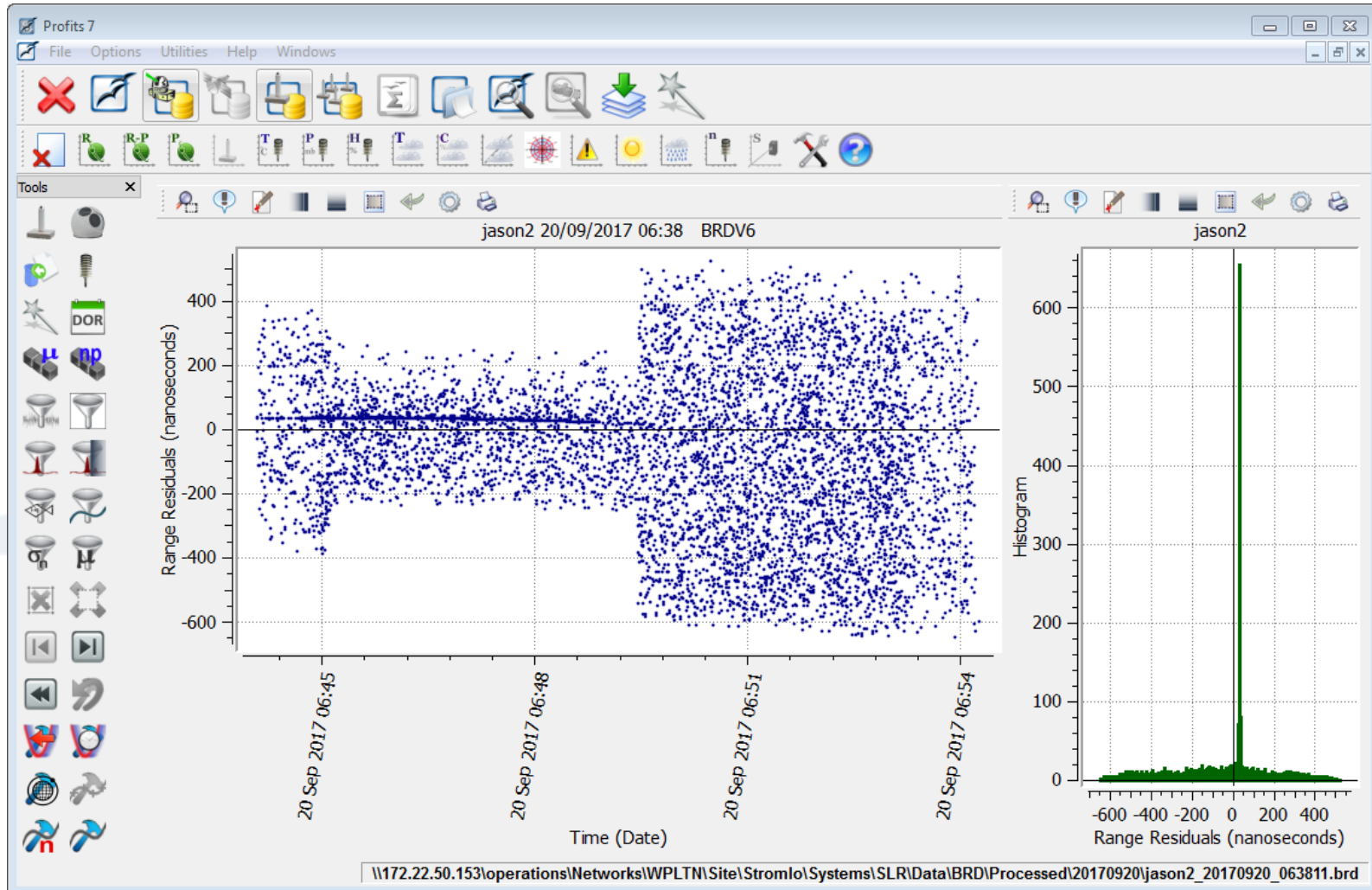
Autonomous Post Processing

Post Processing Steps – input range data



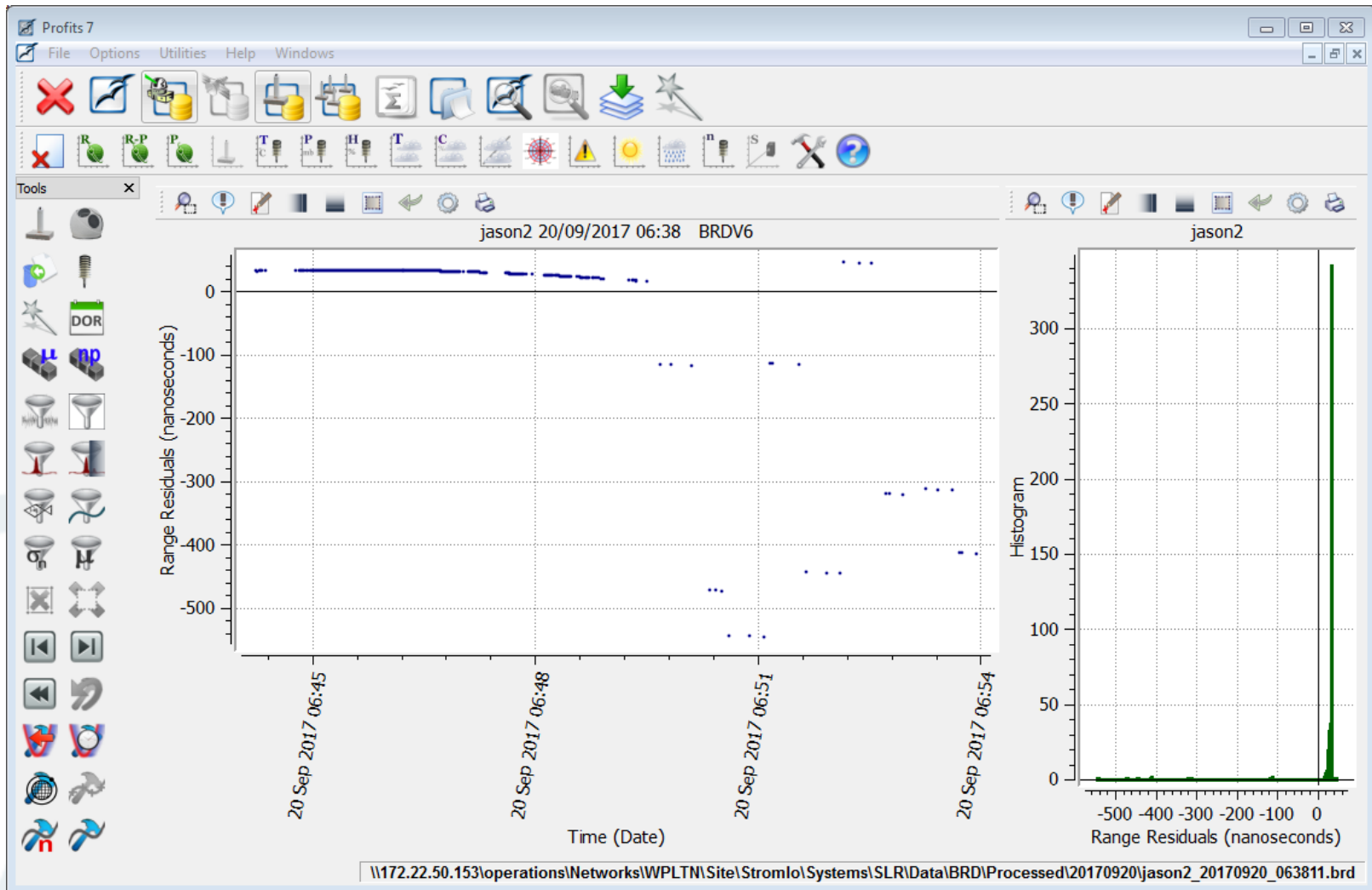
Autonomous Post Processing

Post Processing Steps – after time bias sweep



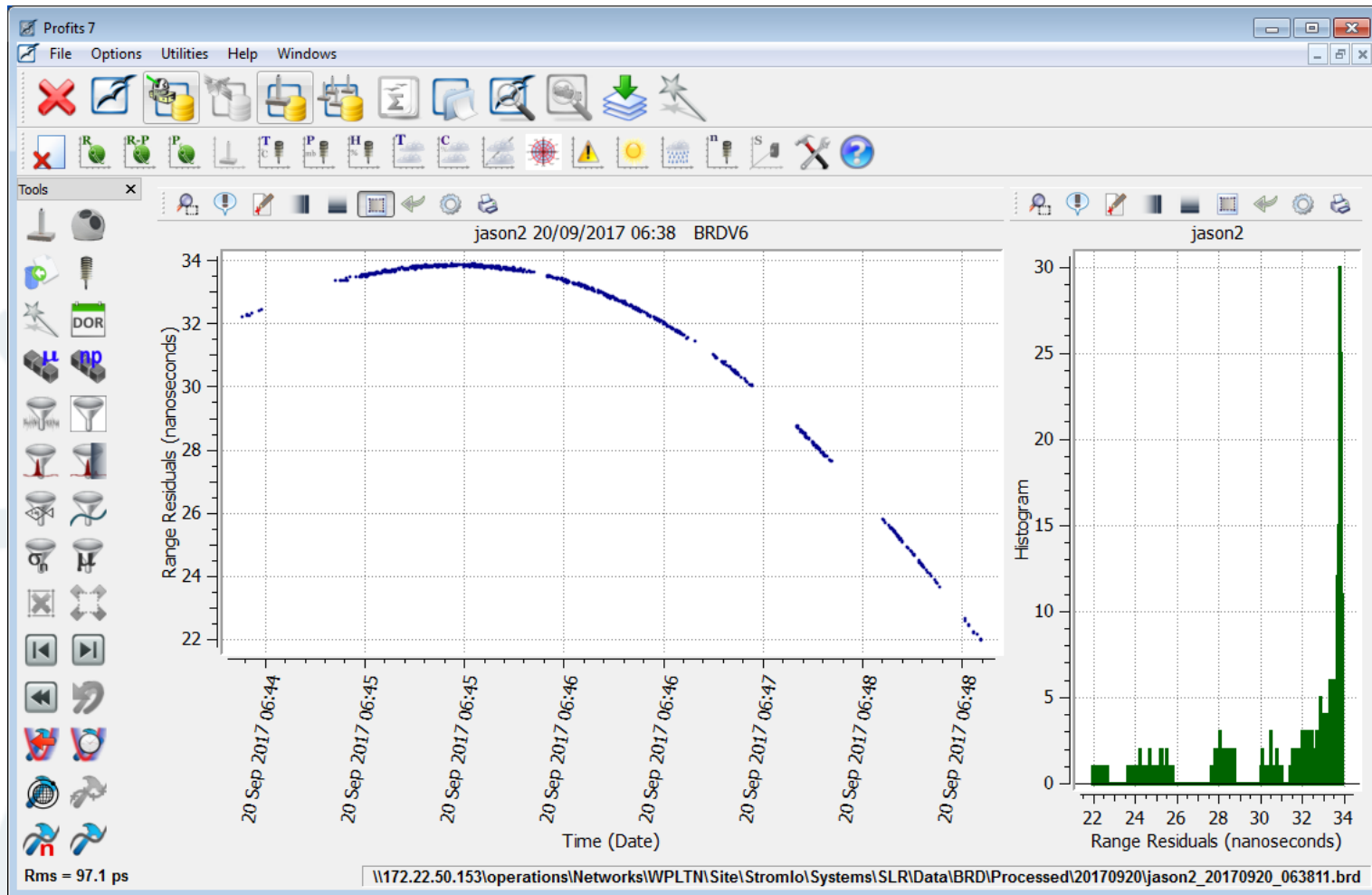
Autonomous Post Processing

Post Processing Steps – after Poisson filtering



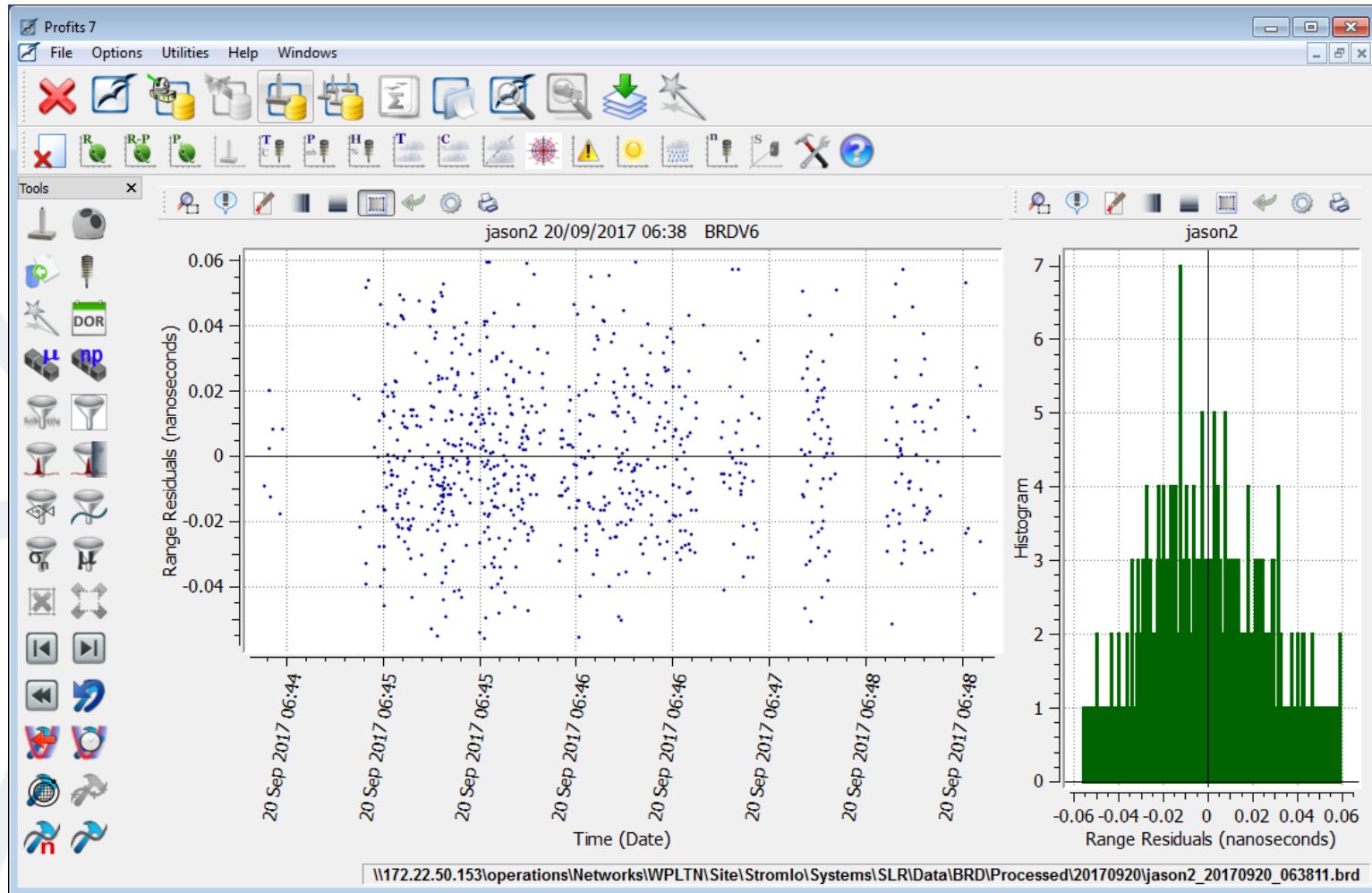
Autonomous Post Processing

Post Processing Steps – after polynomial filtering



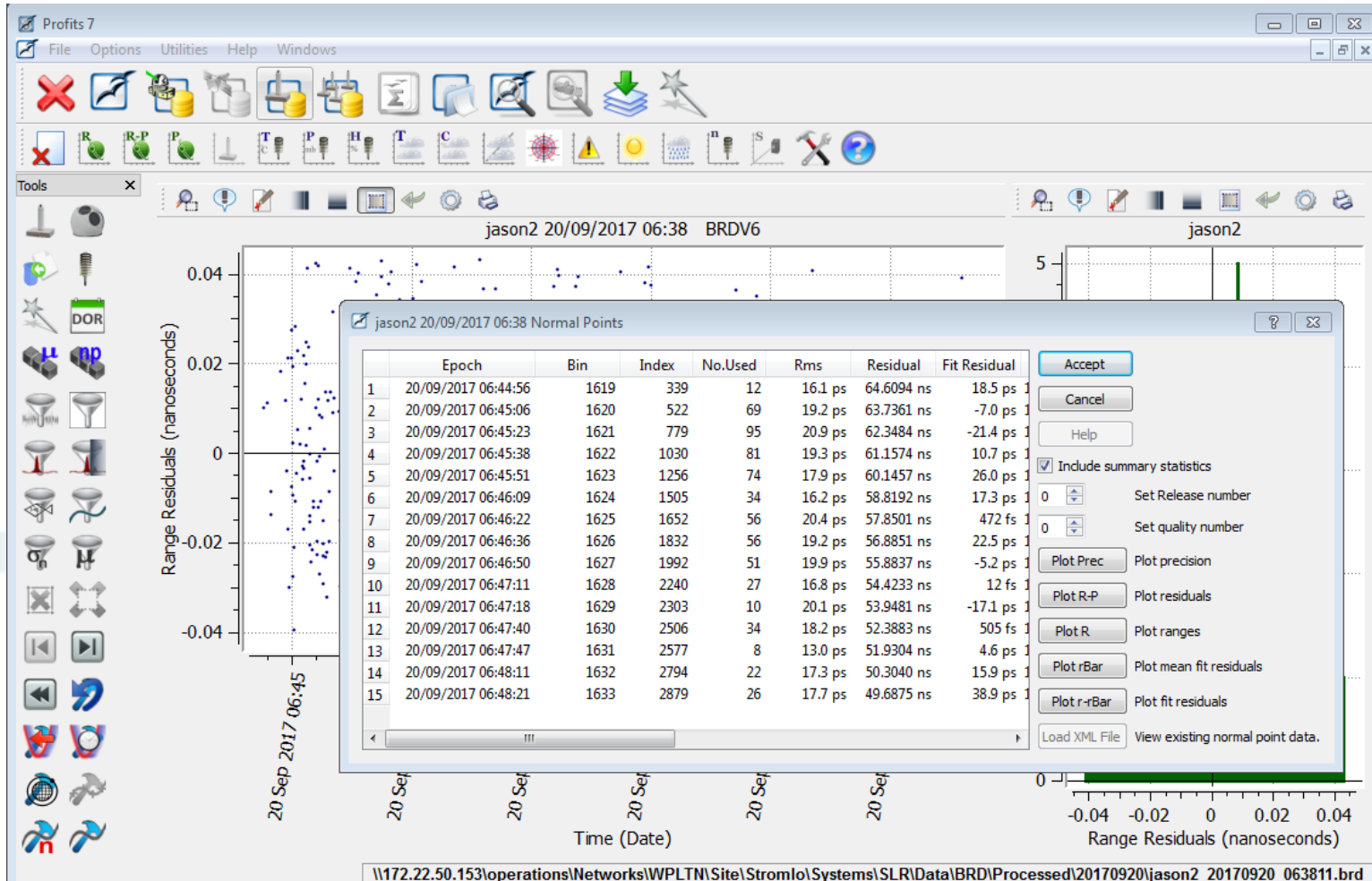
Autonomous Post Processing

Post Processing Steps – after polynomial fitting



Autonomous Post Processing

Post Processing Steps – Normal Point Generation

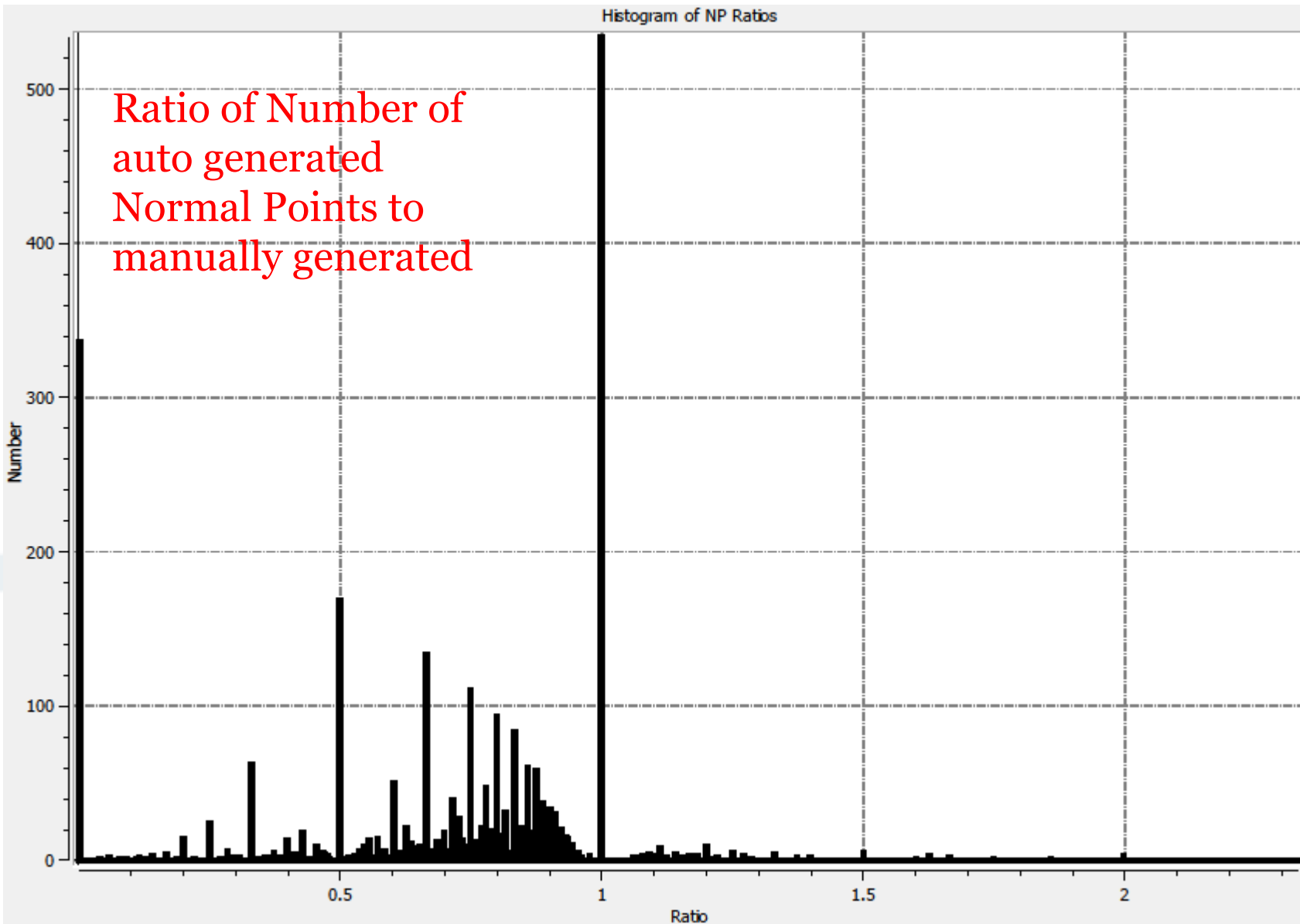


Autonomous Post Processing Analysis

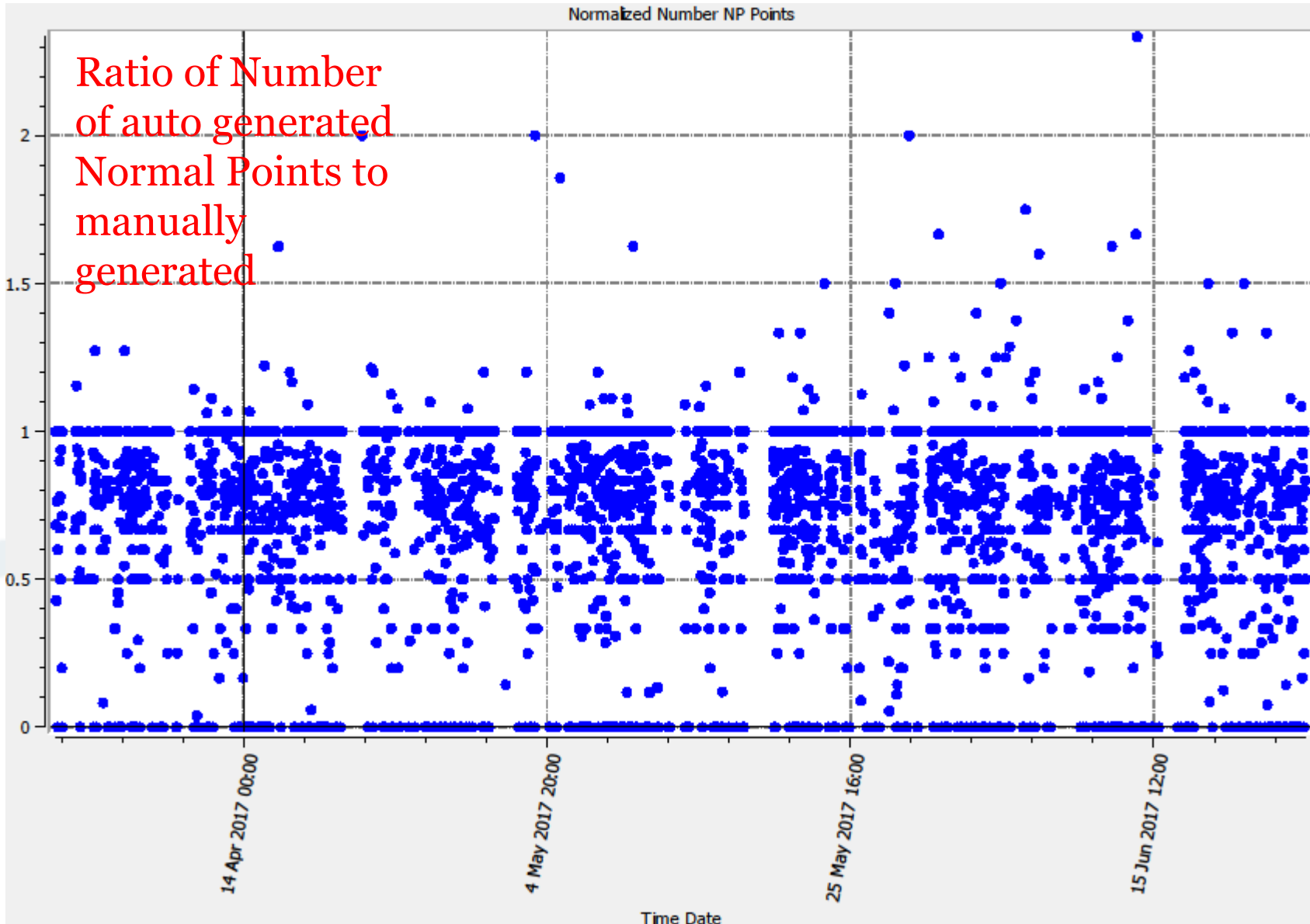


- Analysis of differences between manually and automatically processed BRD files.
- Post processor server supports repeated re-analysis of BRD files.
- Allows comparison of results from ~20000 BRD files (obtained in 2017).
- Able to identify and focus on outliers.
- Provides average statistics.

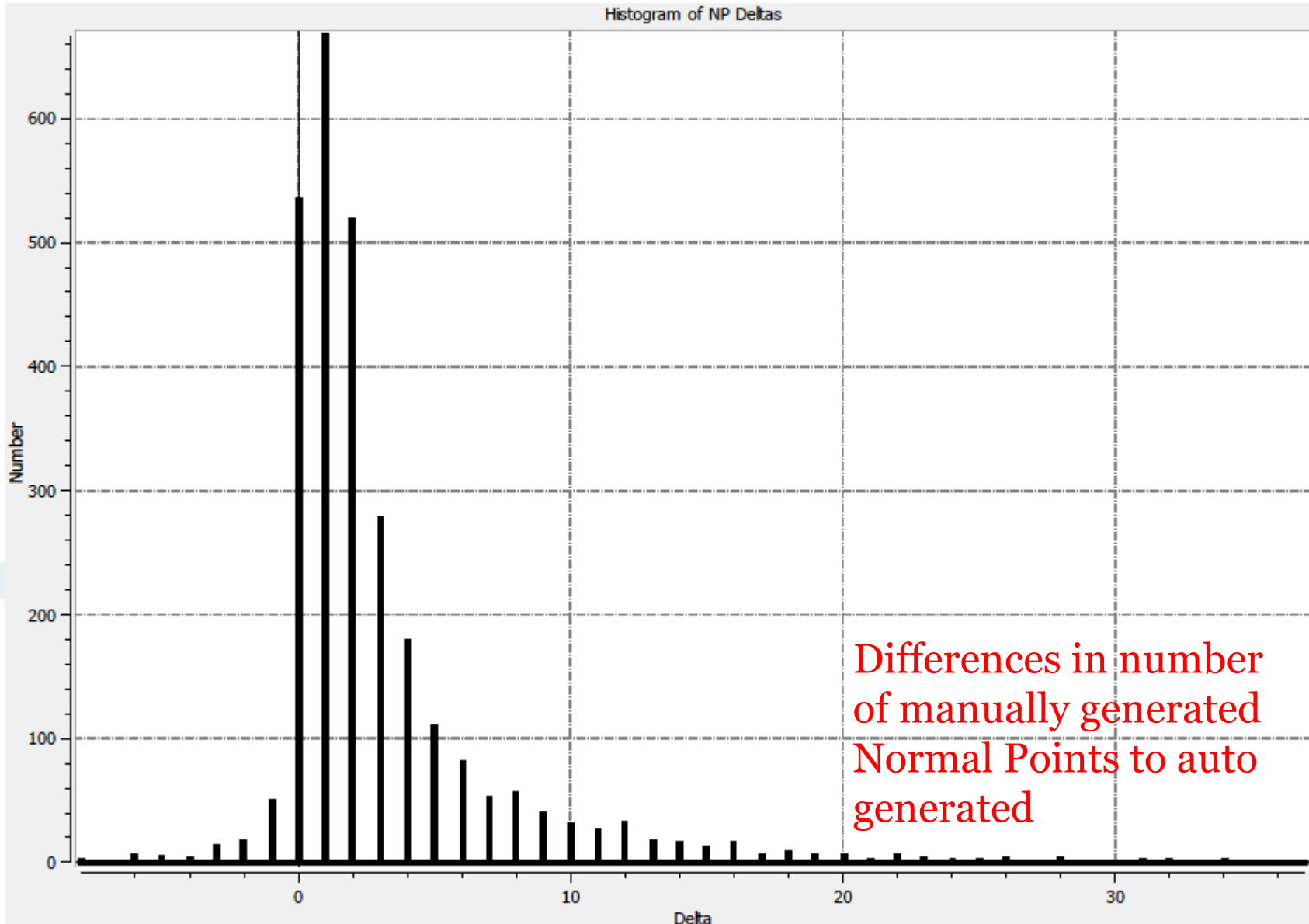
Autonomous Post Processing Analysis



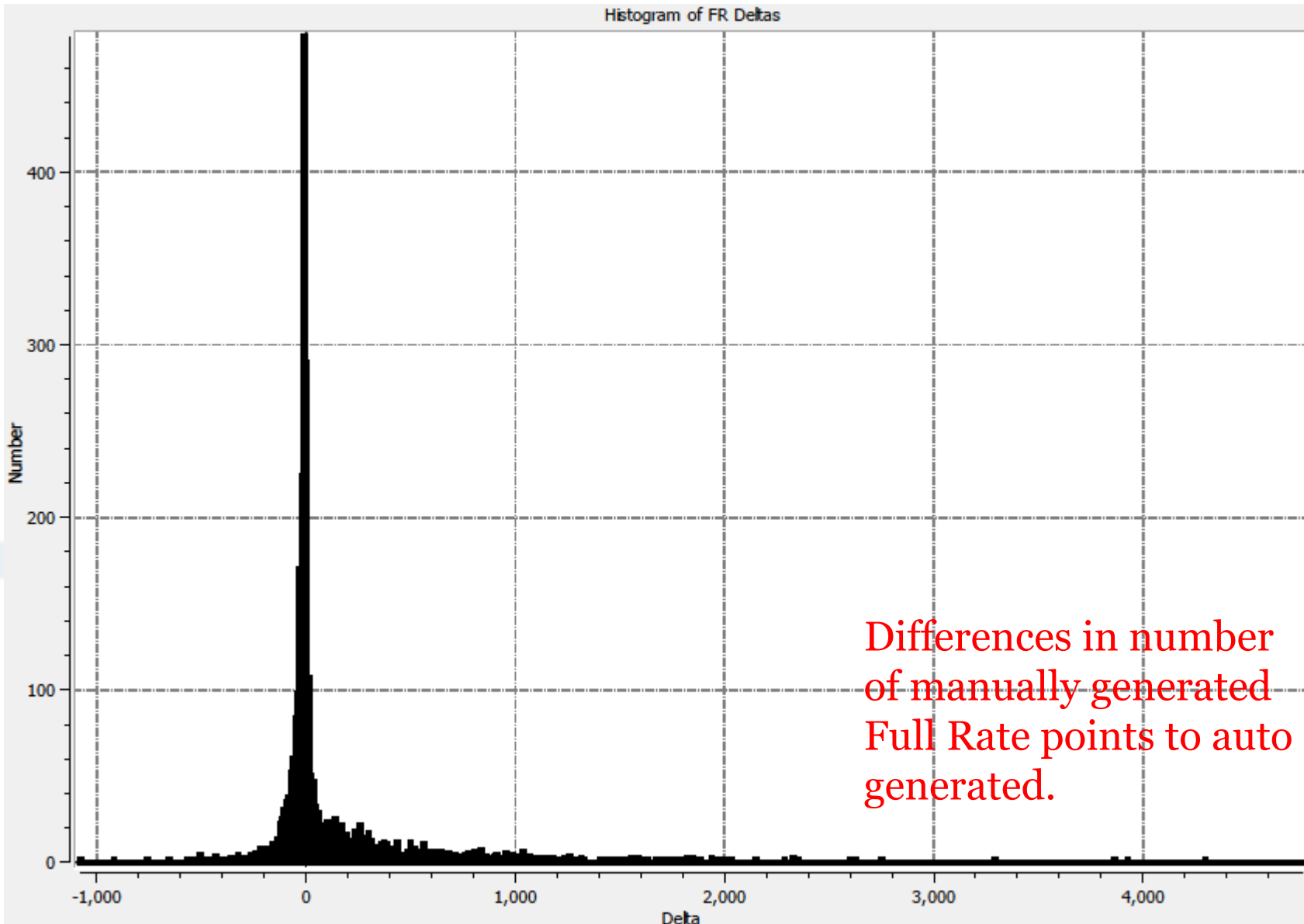
Autonomous Post Processing Analysis



Autonomous Post Processing Analysis



Autonomous Post Processing Analysis



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.