



Statistical Evaluation of simulated Normal Points calculated with a Wiener Filter

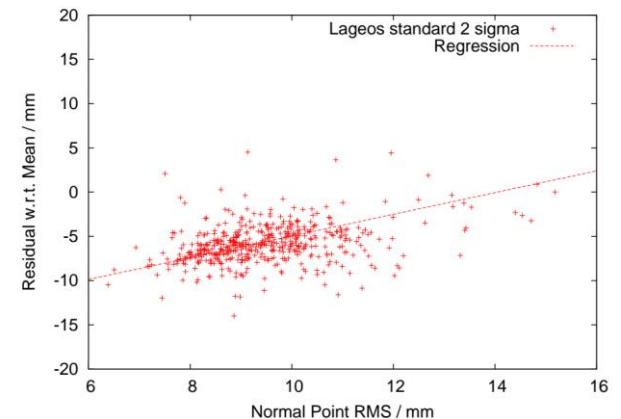
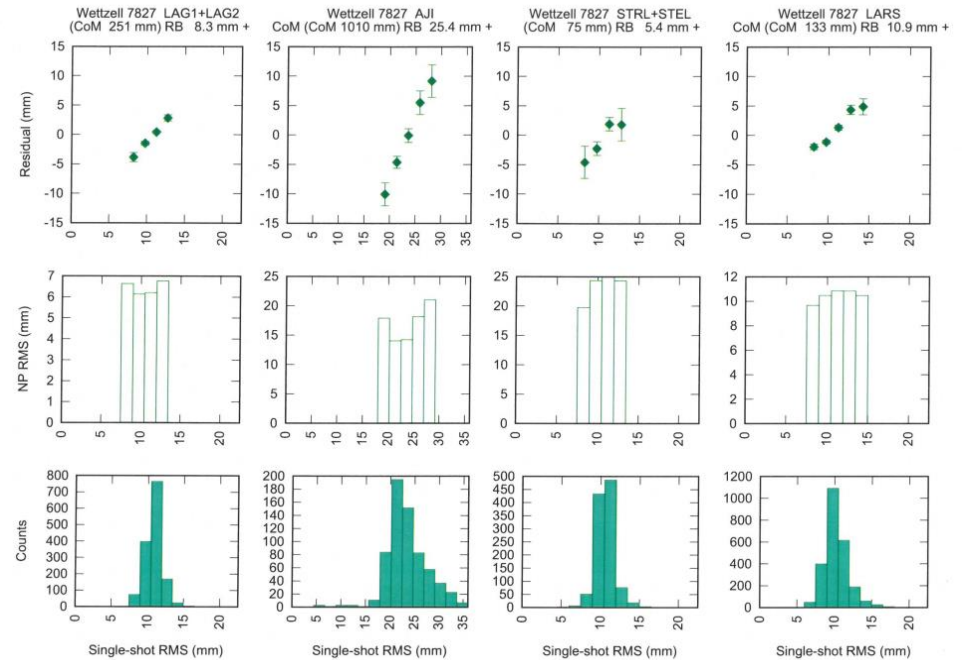
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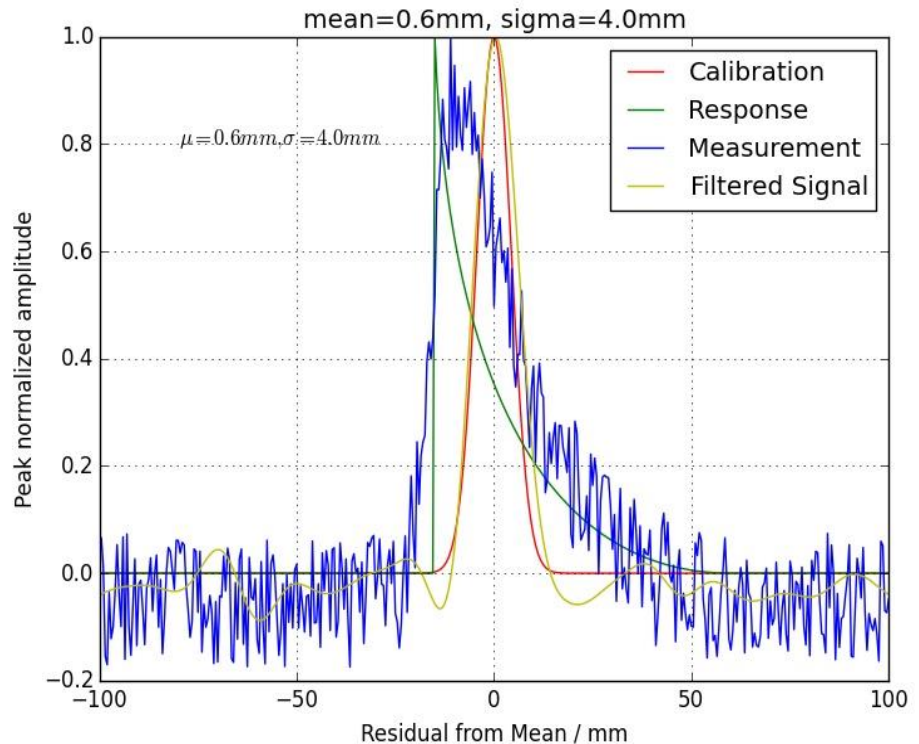


- HIT-U analysis reveals systematic trend in Normal Point Residuals
- Effect is caused by partial sampling of Retroreflector Array, which is not accounted for in standard reduction method (see J. Rodriguez, Variability of LAGEOS normal point sampling, Riga (2017))
- Trend of HIT-U analysis is reproduced by on site normal point algorithm
- Is there a better way to calculate Normal Points than using iterative data clipping techniques ?



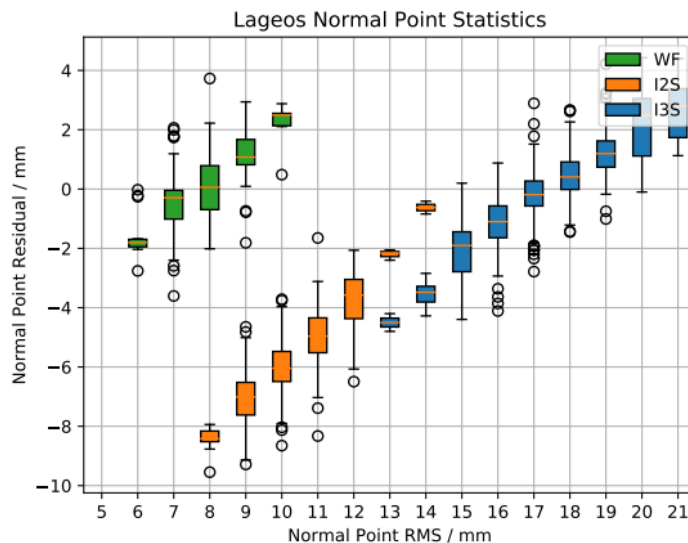
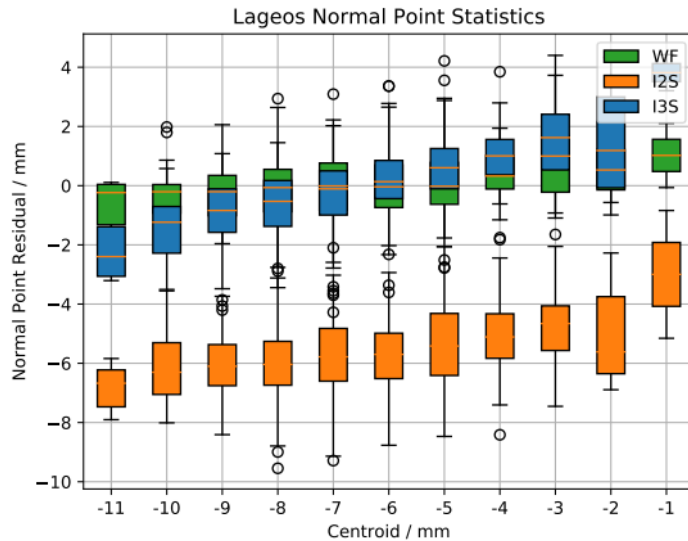


- Proposed by N.Wiener (1949)
- Statistical Filter based on least squares method
- Application to SPE-SLR straightforward
- Eliminates skewness of data distribution
- Data clipping systematics don't exist
- Removes noise
- Procedure:
 - → Calculate histogram for every normal point window
 - → Deconvolve Transfer function and do statistics on filtered signal

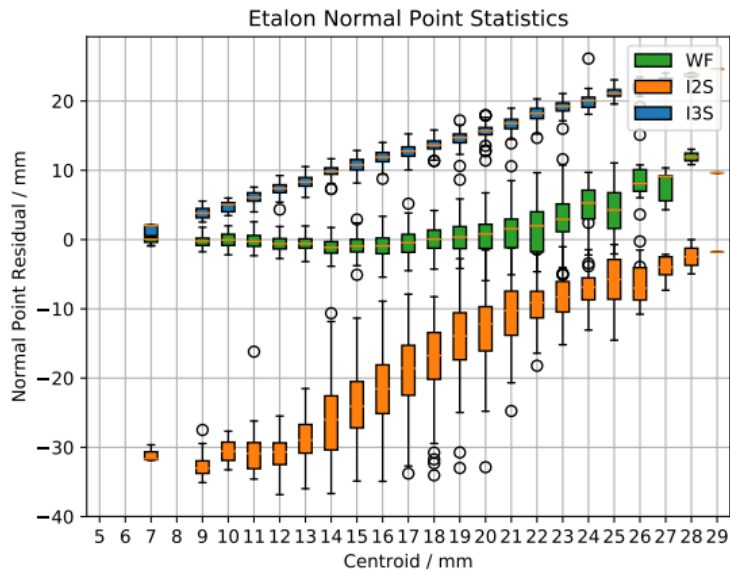




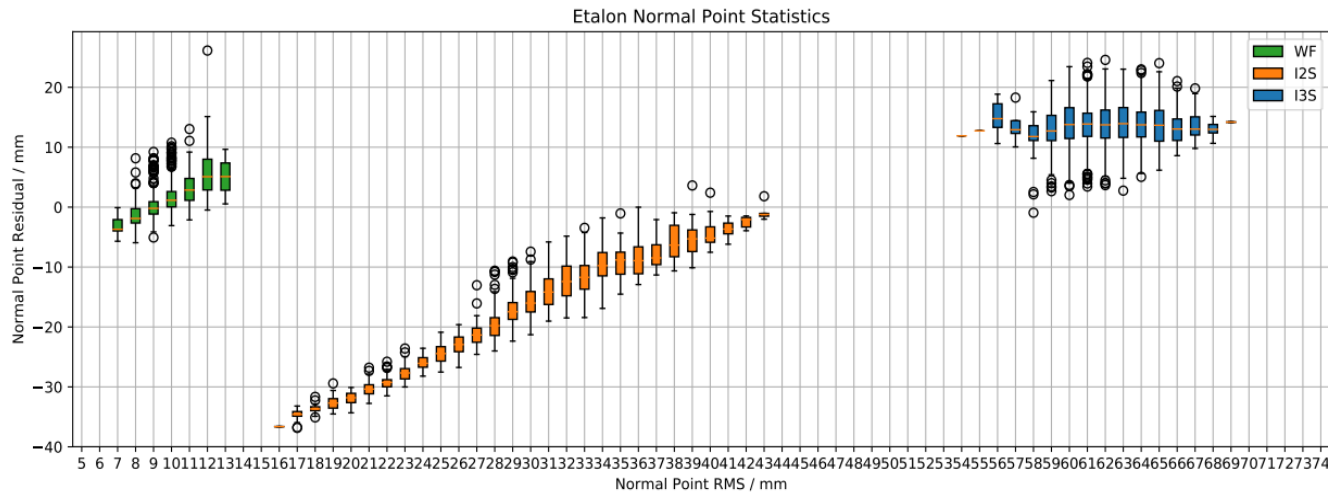
- Evaluation for LAGEOS, Etalon, Ajisai, Lares, Starlette/Stella
- Array specific Transfer Function (850nm) averaged over all orientations
- Residual Simulation for known mean value (see see J. Rodriguez, Variability of LAGEOS normal point sampling, Riga (2017)) calculated for 5% return rate and SOS-W Instrument Function (Calibration Data)
- Calculate Standard Normal Points for 2 and 3 Sigma iterative Clipping as well as with Wiener Filter algorithm
- Compare Results in terms of Normal Point RMS, Centroid and Normal Point Residual



- Wiener Filter (WF) NP Residuals show almost no correlation with Centroid
- Iterative 2 Sigma (I2S) NP Residuals show slope in terms of Centroid
- WF NP RMS in same range as calibration, NP Residual spread is tighter than I2S
- WF NP Residuals located around mean
- I2S slope in terms of NP RMS
- reproduces HIT-U analysis
- I3S NP RMS unacceptable high

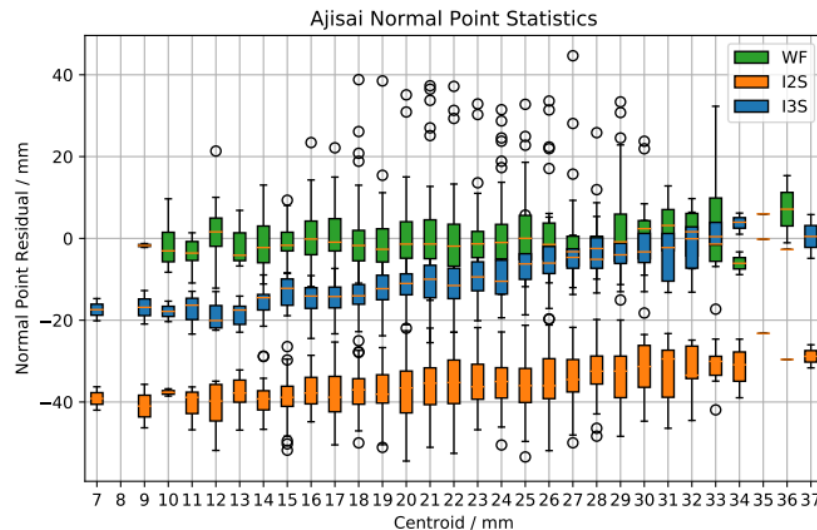


- I2S, I3S NP Residuals show vast dependence on centroid, WF NP Residual variation with Centroid is subcentimeter
- I3S NP RMS unacceptable high
- WF NP RMS in same range as calibration, NP Residual spread is much tighter than I2S
- WF NP Residuals located around mean

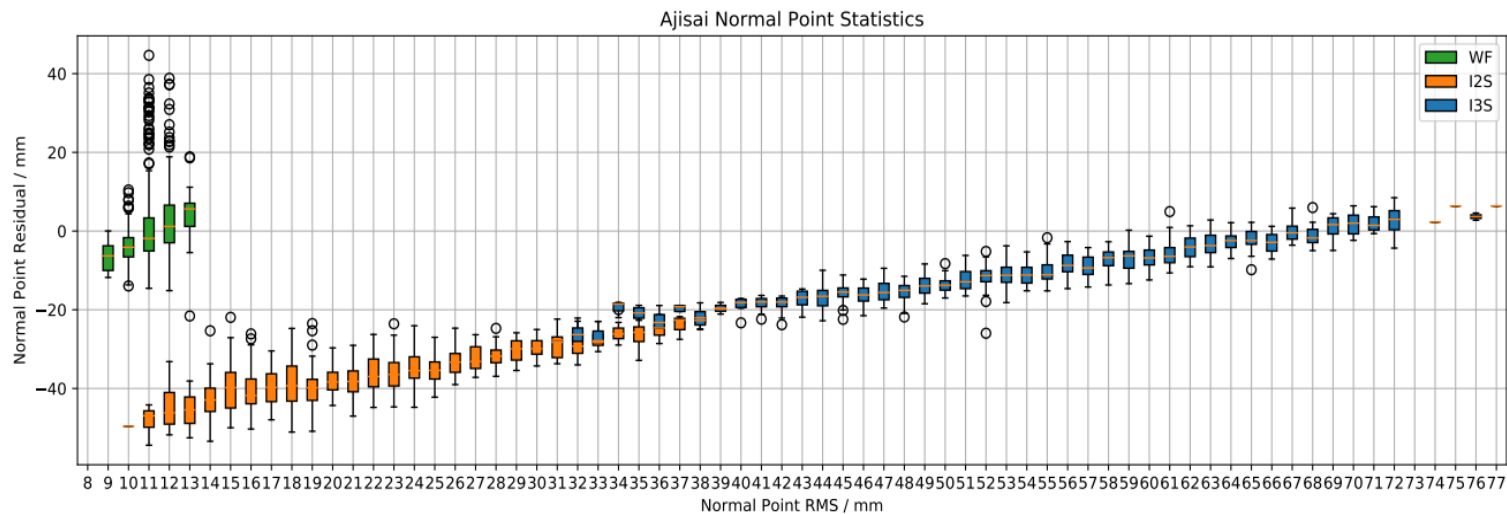


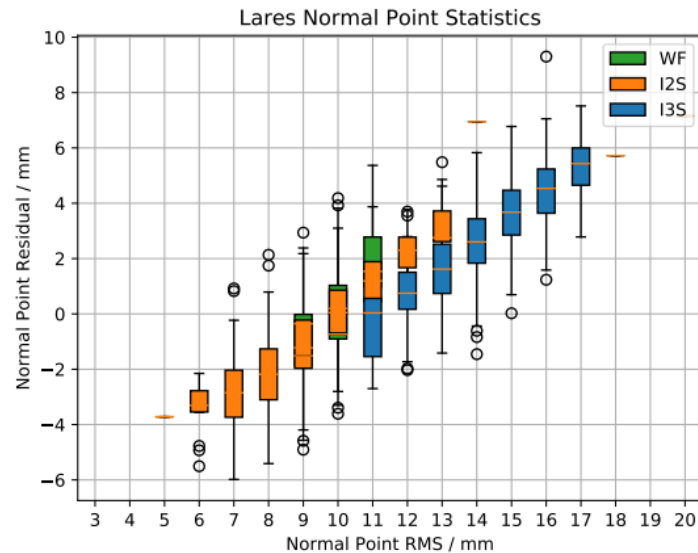
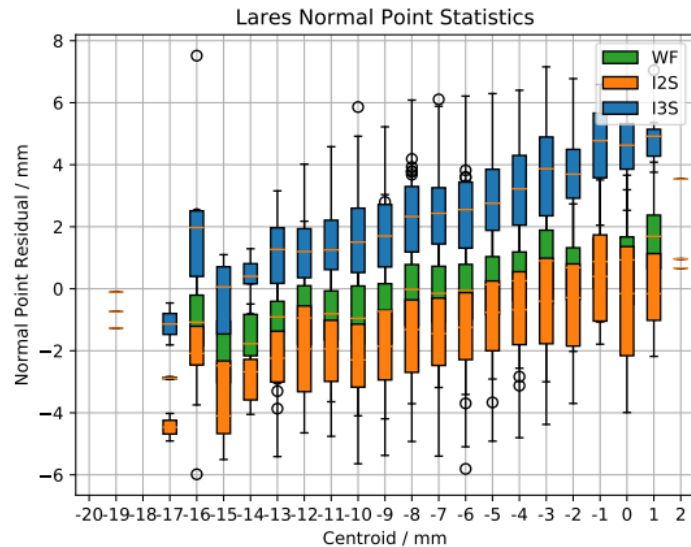


Ajisai Results



- WF NP Residual variation with Centroid is subcentimeter
- I3S NP RMS unacceptable high
- I2S NP Residual vs. NP RMS slope deviates by factor 2 from HIT-U Analysis
- WF NP RMS in same range as calibration, NP Residual spread is much tighter than I2S
- WF NP Residuals located around mean

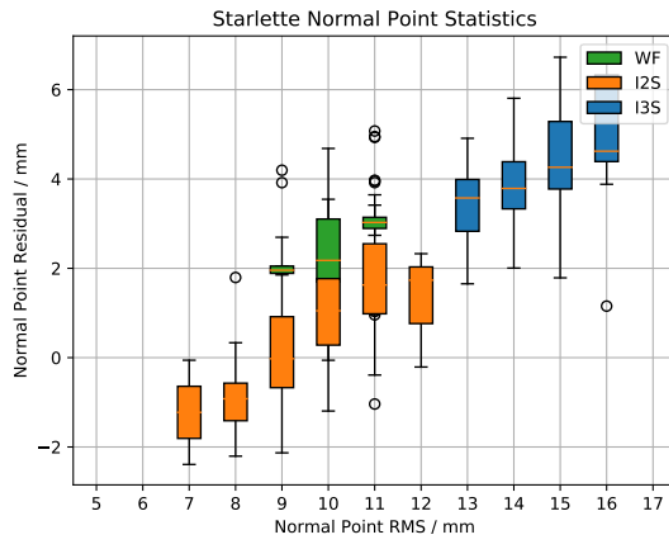
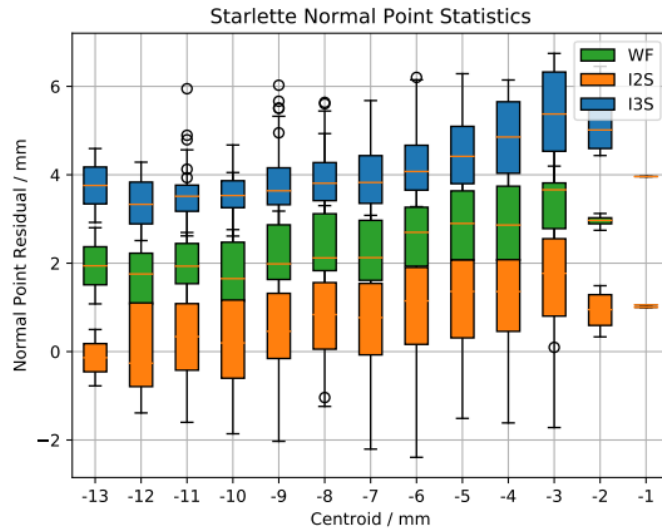




- WF NP Residual show the least variation with Centroid (-2 to +1mm)
- I3S NP RMS unacceptable high
- I2S NP Residuals vs. NP RMS show same slope as HIT-U Analysis
- WF NP RMS in same range as calibration, NP Residual spread is much smaller than I2S
- WF NP Residuals located around mean



Starlette/Stella Results



- WF NP Residual show the least variation with Centroid (+2 to +3mm)
- I3S NP RMS unacceptable high
- I2S NP Residual vs. NP RMS shows similar slope and signature as HIT-U Analysis
- WF NP RMS in same range as calibration, NP Residual spread is much tighter than I2S
- WF NP Residuals located around mean+2mm due to high bandwidth of Starlette response
- Special Tuning of WF causes results to converge against I2S results



- Iterative 3 sigma (I3S) editing is not an option due to high RMS values – it underestimates data quality
- NP-Residual systematics in HIT-U Analysis can be explained to a large extent by the convergence properties of iterative 2 sigma editing
- Wiener Filter NP-Algorithm is able to mitigate these systematics
- Wiener Filter NPs located around mean of Transfer Function for all Satellites under consideration except Starlette(+2mm). With special tuning WF results converge against I2S results
- Wiener Filter NPs show the least correlation with Centroid
- Wiener Filter NPs RMS in the same range as calibration, since satellite signature is removed
- For large diameter Satellites Wiener Filter NPs are of superior quality compared to iterative 2 sigma editing
- Wiener Filter NP procedure is consistent for LAGEOS, Etalon, Ajisai and LARES