Noise Reduction Analysis

# Abstract

Problem: there is too much noise in our data, and previous methods to determine the significance of the noise have left room for uncertainty.

Approach: Use Bayesian analysis to determine the actual noise of the system, and use the results to determine if that noise is statistically significant.

Solution:

Main contributions:

# Introduction

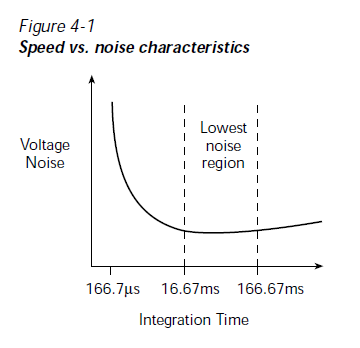
Noise is one of the most difficult problems to diagnose. Continuing effort is committed to improving the signal to noise ratio of a prototype emittance scanner in the hopes of finding an effective way to measure the emittance and thus brightness of a plasma ion-source currently used in electron microscopy. This is a first necessary step to redesigning the extractor geometry in order to improve ion-source performance; if there is not an analytical way to tell if one beam is performing better than another then you cannot analyze the impact of geometry on the beam.

The inspiration for this study into the distribution of noise came on the tail of a signal to noise characterization test using distinct speed settings on the Keithley 6487 picoammeter.[[1]](#footnote-1) The study was designed to determine the most efficient rate at which to measure the current accounting for speed and signal clarity. The results of the test however we inconclusive, as the behavior of the noise did not follow the expected relationship based on the instrument manual. Further observation shows the region around the maximum does not have statistically significant variance, making it difficult to determine with confidence the true area of maximum current. This in itself is not detrimental to the end design as we are looking to find a reliable user-facing tool to find the maximum current, not the region of maximum current. However, we cannot currently move forward on an automated method for aligning our probe in which to take the current until we have an accurate enough measurement device. It is from this data that a Bayesian analytical technique will be applied.

The noise detected in the measurements can arise from several different origins, currently we are attempting to control for vibrations from the surroundings, from the type and length of cable used to connect the source to the picoammeter and the picoammeter resolution itself. All easily implemented noise reduction techniques have been employed in the system, now we must look at the data to confirm if any further noise-reduction is necessary, and check if current ‘advanced’ techniques actually improve the quality of the collection.

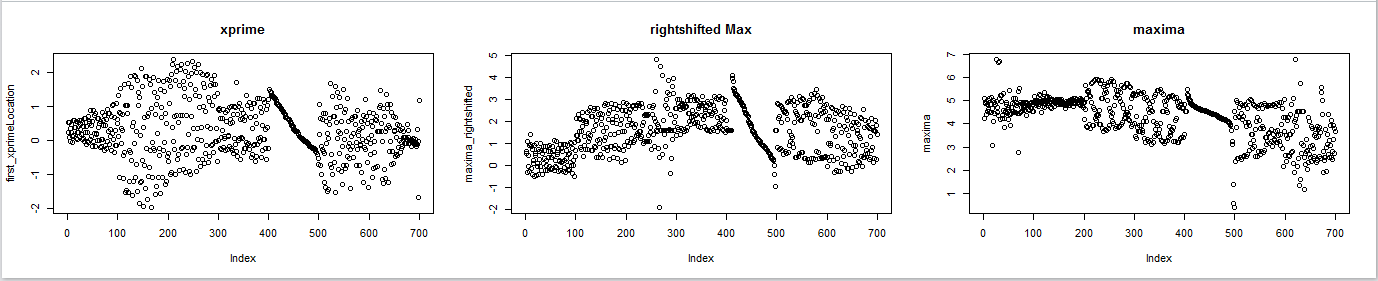
Previous noise analysis focused on end-stage results in the full-width 50, a standard measurement used in emittance collection. The full-width 50’s was generated with a modified boot-strap sampler on the raw data of each collected sample. The variance in the full-width was determined to be the result of noise in the system. This analysis results in a many-times removed look at the raw data, possibly distorting the effects and importance of the noise in the data. Bootstrapping is commonly used when Bayesian analytical techniques are either unavailable or unknown.[[2]](#footnote-2)

# Noise in Emitter Measurements:

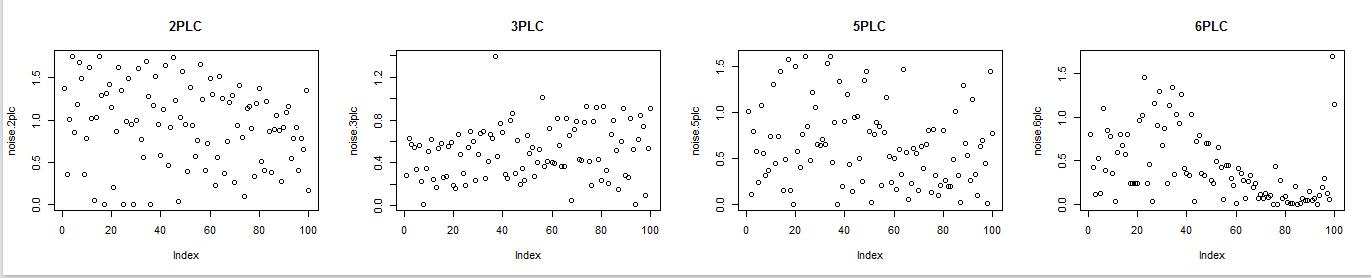
As part of an ongoing project to optimize a new type of emittance scanner for a Plasma Ion Source the rate of sampling was characterized to ensure optimal sampling rate was chosen to ensure minimum time spend during data collection without effecting sample reliability.

The data we will be using comes from 5 different levels of sampling rate starting at 2 powerline cycles (2PLC) which runs for 33.34msec up to 6PLC or 100.2msec (.1second), and a rerunning of 2PLC for a total of 3 2PLC emittance collections. Although increasing PLC results in a longer integration time by the Keithly, there was no difference in data collection times across the samples.

A quick look at the spread of currents across the data showed that there was an odd trend in PLC4, so it was omitted from the analysis, and there were no immediately apparent trends in the noise correlated with the time the sample was taken. There was also some odd behavior in the noise around the maxima data that is undefined.



Looking at the difference between samples around the first point of collection(~ 75 um from maxima location)



# Related work

Previous efforts to look into noise and noise reduction have been primarily focused on the physical system, which was reflectively analyzed though boot-strap analysis.

# Conclusions

# Future Work

# Acknowledgements

Citations

appendices

1. Internal FEI memo Melanie Pierce to FEI Plasma Emitters Group; *Characterization of Keithley Rates for Uncertainty in FW50 values* [↑](#footnote-ref-1)
2. http://www.sumsar.net/blog/2015/04/the-non-parametric-bootstrap-as-a-bayesian-model/ [↑](#footnote-ref-2)