SELF-CONSISTENT, UNBIASED, EXCLUSION-BASED EMITTANCE ANALYSIS

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The emittance of low-energy, charged particle beams is mostly derived from current signals measured with a double slit device and resulting in locally resolved angular distributions. The small acceptance of such devices reduces these signals to a small fraction of the total beam intensity, which makes the data more susceptible to noise and bias. This is especially evident when measuring pure background that normally dominates the data field. This background can cause a significant problem when calculating the rms-emittance from the raw data, where a bias of 0.01% can change the result by a factor of 5. Such small residual biases are common, even with bias-corrective acquisition systems.

The common practice of thresholding the data yields more consistent results, but the results tend to underestimate the rms-emittance because the threshold removes background as well as the small signals found in the wings of the distribution. Exclusion boundaries, however, can be selected to include all real signals while excluding only pure background. Exclusion boundaries reduce the bias sensitivity, but do not completely eliminate it.

We have developed the Self-Consistent, Unbiased, Elliptical Exclusion Method, SCUBEEx, which uses the data outside an ellipse to estimate the bias. This estimate is subtracted before calculating the rms-emittance from the data within the ellipse. The size of the ellipse is varied to reveal the minimum ellipse that includes all real signals and thus yields the most reliable rms-emittance estimate. Quasi-random background variations encountered during this minimization process lead to variations in the rms-emittance estimate that can be used as an estimate for its uncertainty.

All methods will be illustrated by analyzing measured emittance data.

SNS is a collaboration of six US National Laboratories: Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Los Alamos National Laboratory (LANL), Lawrence Berkeley National Laboratory (LBNL), and Oak Ridge National Laboratory (ORNL). SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.