AbstractID: 3806 Title: A proposed Alternative to phase-space recycling using adaptive kernel density estimator

Purpose: To investigate the adaptive kernel density estimation (AKDE) method as an alternative to recycling phase-space (PS) files or histogram binning during MC accelerator simulation. The AKDE approach has the potential to mitigate statistical "noise" issues (due to latent variance) in the PS data, without the need for an overwhelmingly large number of particles.

Methods and Materials: We have implemented a nonparametric density estimation technique, the AKDE method, to generate additional PS variables in the vicinity of simulated PS points in MC accelerator simulation. The method involves the placement of kernels at simulated PS points, and the window-width is allowed to vary based on the density of the PS points. After successfully testing the method for sampling 1-D and 2-D exponentials we sampled PS files generated from accelerator simulations. The original PS (x, y, u, v, E) was reduced to a rotationally invariant PS (r, θ, α, E) assuming azimuthal symmetry above the collimating jaws. The new PS point $(r', \theta', \alpha', E')$ is generated by sampling in the vicinity of (r, θ, α, E). To test the method we simulated dose profiles for a 10x10cm^2 field using 1x10^6 particles in the PS file as input.

Results: Results indicate that a minimum number of PS points are needed to allow accurate density estimation. Preliminary calculations using a global window-width for each PS variable produce relatively smooth profiles even with as little as 10 million particles in the PS file. However, profiles with the Epanechnikov kernel appear to be smoother and in better agreement with the original PS versus either Gaussian or uniform kernels.

Conclusions: By generating unbiased PS samples "on-the-fly" in the neighborhood of simulated PS points AKDE has been shown to be a promising alternative to PS recycling or histogram-binning (source modeling), where binning effects and propagation of systematic latent uncertainties may pose potential problems.