Gaussian Kernel Density Estimation in MICE

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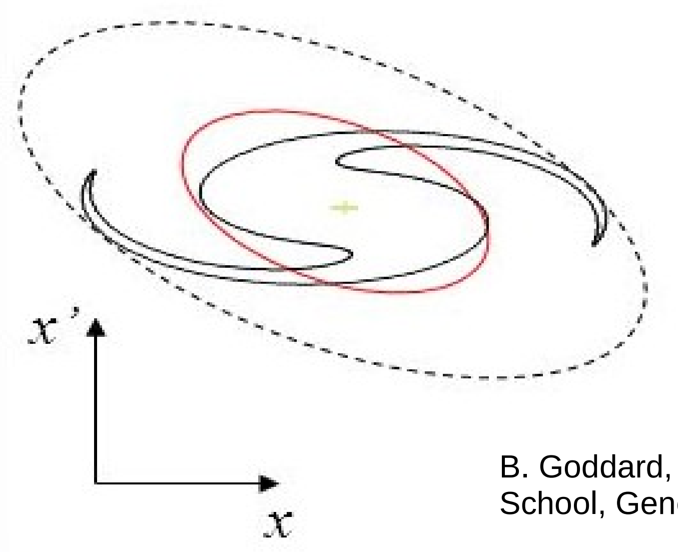
Motivation

- Solenoid beam optics in MICE prone to filamentation and other non-linear effects.



B. Goddard, “Injection and Extraction”, CERN Accelerator School, General Accelerator Physics

- Non-linearities cause the beam's distorted shape to fill larger ellipse → “apparent” emittance growth.
- Necessary to develop algorithms that can work around these non-linearities.
- Kernel density estimation (KDE) is one option. could also be one of the many measures of cooling performance in MICE.

KDE and Procedure

- KDE estimates PDF using a pre-defined kernel.
- General KDE definition,

$$\rho(y) = \sum_{j=1}^{N} K\left(\frac{y - x_i}{b}\right) \qquad (1)$$

- MICE has ~gaussian beam→ PDF estimation using guassian kernel ,

$$G_{ND}(\vec{x}, \sigma) = \frac{1}{(\sqrt{2\pi}\sigma)^N} e^{-\frac{|\vec{x^2}|}{2\sigma^2}} \qquad (2)$$

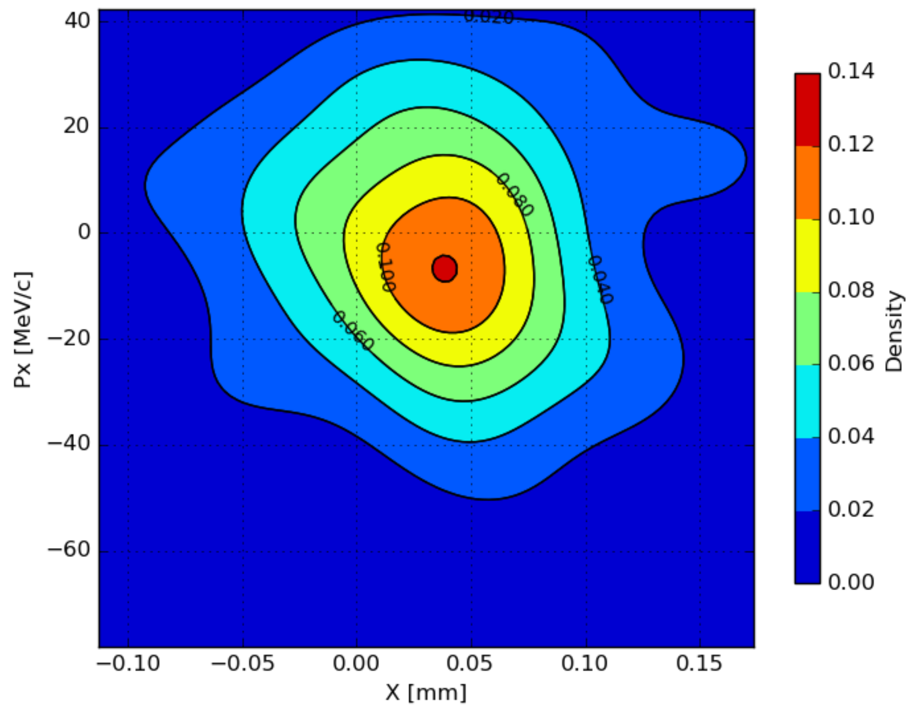
- stats.gaussian_kde() module in scipy which is used for both univariate and multi-variate data.
- Bandwidth → scotts factor:

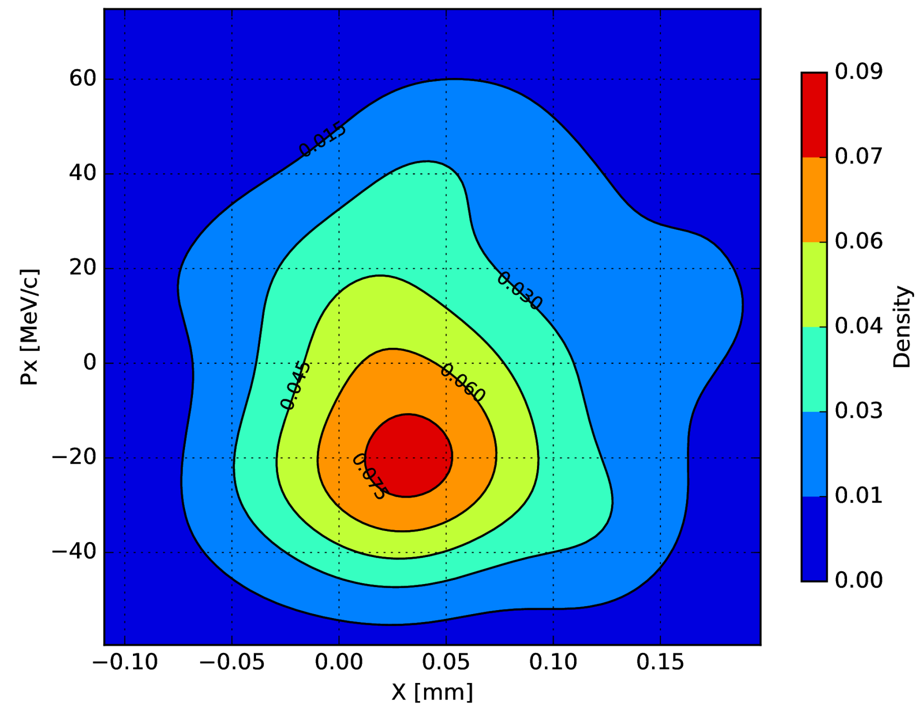
$$n^{\frac{-1}{d+4}} \qquad (3)$$

- Data point's shape → (# of dimensions, # of points) array.

Preliminary (x,x') Plot

- Single g4bl simulated data set using MAUS 1.4.0
- small sample of data → on the order of 70 muons upstream and downstream of the absorber.
- 6π 200 MeV/c positive beam with 5E11 protons at target.
- Absorber → LiH disk from geometry ID 74.
- MC truth data points immediately upstream (right) and downstream (left) of LiH disk.





Preliminary (y,y') Plot