Uniform Irradiation of a Target Using a High-Power Beam
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Abstract
The Accelerator Drive Systems (ADS) require high power beam (> 10 MW) to irradiate the neutron production target. To mitigate the effects of the high power, and high intensity beam on the target, we propose to reduce the intensity of the beam by uniformly irradiating the target. In this poster we present a well-proven method which is being used at the NASA Space Radiation Laboratory (NSRL) facility at BNL for uniform irradiation of material and biological samples.

Mathematical consideration of the method

A change of distribution at the location of a six-dimensional Gaussian distribution can be expressed in terms of a Gaussian field:

\[ f(x, y, z, t, \theta, \phi) = \frac{1}{(2\pi)^2} \exp \left( -\frac{1}{2} \sum_{i=1}^{6} \frac{\left(x_i - x_{i0}\right)^2}{\sigma_i^2} \right) \]

\[ X \sim \mathcal{N} \left( \mu, \Sigma \right) \]

Under linear transformation the beam distribution remains Gaussian.

To modify the beam distribution we must use nonlinear magnetic elements.

Effect of an octupole on an intensive beam

An octupole can alter the distribution of a one-dimensional Gaussian beam to a beam with non-linear magnetic elements.

The equations of motion of a charged particle moving in a quadrupole field

\[ \mathbf{X} (\mathbf{v}) = \mathbf{R} \mathbf{X} (\mathbf{v}) \]

\[ \sigma_{\text{off}} = \mathbf{R} \mathbf{\sigma} \mathbf{R}^T \]

The target on the left/right side of the picture is a circular/rectangular cylinder of lead which is 30 cm in diameter/width by 30 cm long. The beam has a 1 × 0.85 cm diameter spot size. (Gaussian beam)

Converting the shape of the target does change the neutron flux distribution at the corners of the rectangular target. The same results were obtained with a uniform rectangular target.

CONCLUSION
Non-linear elements are necessary to change the Gaussian beam distribution to a non-Gaussian one.

The experiment at NSRL proved that introducing two octupoles at specific locations of the beamline can transform a beam with a Gaussian distribution into a uniform one. The beam size at the target should be adjusted by the first order optics.

This proves to be a major improvement to the target design since it will reduce the intensity of the beam and increase the lifetime of the target. Further studies could be pursued to determine whether the same method can be applied to generate a uniform circular beam.