**ABSTRACT**

This study investigates the crucial role that an accurate understanding of inter-planar coupling in the transverse plane plays in regulating charged particle dynamics in a high-intensity linear accelerator and minimizing foil/ septum impacts during injection from the linac to a ring. We in-depth analyze the emergence and evolution of transverse inter-planar coupling through multiple active lattice elements, taking into account space charge and field non-linearities in the superconducting section of the PIP-II linac. The article compares various analytical, numerical, and experimental techniques for measuring transverse coupling using beam and lattice matrices and provides insight into effective strategies for its mitigation prior to ring injection.

**SPACE-CHARGE, LINAC ELEMENTS & INTER-PLANAR COUPLING**

\[ \Sigma = \sigma_{13}^2 + \sigma_{14}^2 + \sigma_{23}^2 + \sigma_{24}^2 \]

**MITIGATION STRATEGIES**

- The expressions for \( \sigma_{13}, \sigma_{14}, \sigma_{23}, \) and \( \sigma_{24} \)

\[ \Delta \theta = \Delta \phi \]

**DETERMINATION OF INTER-PLANAR COUPLING**

**CONCLUSION**

- Conducted an in-depth analysis to quantify the influence of nonlinear space charge forces and lattice elements on the occurrence of transverse inter-planar coupling.

- Proposed and compared two viable approaches to fully reconstruct the beam matrix and accurately identify the coupling terms, allowing for a comprehensive characterization of the coupling phenomenon.

- Identified the essential diagnostic requirements necessary for effective measurement and characterization of the coupling effects.

- Demonstrated the effectiveness of strategically positioned skew-quadrupoles in mitigating and compensating for potential instances of transverse coupling within the PIP-II linac.