Prediction and refinement of magnetic equilibrium and Heavy Ion Beam trajectories in MST

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Abstract

The application of heavy ions beam on the MST plasma source presents a unique fundamental challenge in accurate prediction of beam trajectory and sample volume. The magnetic field, generated by a conducting shell of MST introduces magnetic field errors that affect the beam trajectory and sample volume.

1. Magnetic equilibrium reconstruction

- The effect of magnetic equilibria in MST is significant on the accuracy of the beam trajectory and sample volume.
- Equilibrium reconstruction is done iteratively with trajectory computation to improve the accuracy of both the trajectory and sample volume.
- The resulting magnetic field vector is used to compute the beam trajectory and sample volume.

2. MST port magnetic field errors

- The MST magnetic equilibrium for a discharge or ensemble of discharges at times of interest is reconstructed.
- Perturbations to the magnetic equilibrium are modeled using measurements where possible, analytic models if measurements are unavailable.
- The MST magnetic equilibrium is modeled using MSTFit, a 2D Grad-Shafranov equilibrium reconstruction code developed at UW-Madison.

3. HIBP beamline electric and magnetic fields

- Both beamlines are equipped with vacuum electrostatic steering plates.
- Primary beamline with reconstructed electric fields.
- The MST port magnetic field errors are modeled using a finite element method simulation, interpolated to 3-D grids.
- The beamline electric fields are calculated with a finite element method simulation, interpolated to 3-D grids.

4. Beam trajectory computation

- The computed beam trajectory and sample volume are compared with experimental data and magnetic field models.
- The magnetic field errors can significantly affect the accuracy of the beam trajectory and sample volume.
- The model is validated using a subset of experimental data.

5. Sample volume motion

- The equilibrium reconstruction is done using a subset of experimental data.
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- The displacement of sample volumes is on the order of sample volume size.
- The beamline electric fields are calculated with a finite element method simulation, interpolated to 3-D grids.

Future work

- Studying the effect of magnetic equilibria on the beam trajectory and sample volume.
- Developing models of electric and magnetic field errors to allow extraction of HIBP measurement errors.
- Developing a full-fledged beamline model to allow in-line extraction of HIBP measurement errors.

Conclusions

- The MST-Magnetic equilibrium and Heavy Ion Beam trajectories research has led to significant improvements in the accuracy of beam trajectory and sample volume prediction.
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