A CONCEPTUAL DESIGN OF A HEAVY ION BEAM PROBE FOR W7-X

P.J. Fimognari, T.P. Crowley, D.R. Demers
Xantheno Technologies, Madison, WI
O. Grulke, R. Laube, and the W7-X Team
Max-Planck-Institute for Plasma Physics, Greifswald, Germany

ABSTRACT

The TOCCATA project proposes a HIBP insert for W7-X, potentially enabling access to local particle and energy transport measurements in NBI-heated, high confinement plasmas. We have begun a proof of concept phase investigating HIBP feasibility, with a focus on the design, electronics, and steering requirements. A HIBP for W7-X must coordinate with the tokamak’s existing infrastructure, account for the presence of divertor baffle blocks and anion beam extraction, and interface with plasma and diagnostic systems.

CONCEPTUAL DESIGN OF A HEAVY ION BEAM PROBE FOR W7-X

Beam trajectory simulations use the 3-D magnetic fields of W7-X to identify suitable beam energies, injection locations, and focusing requirements. These simulations show that a HIBP design must integrate into W7-X’s existing infrastructure, account for the presence of divertor baffles, and interface with plasma and diagnostic systems.

IONIZATION AND DEFLECTION OF CHARGED PARTICLES RESULTS IN SPATIALLY LOCALIZED MEASUREMENTS

- Secondary electron multiplication will increase signal sensitivity
- No secondary electron multiplication at detector

SIMULATIONS SHOWN HERE

- Simulated magnetic configurations (~2.7 m west) of W7-X CAD files integrated into Xantho models
- 4.5 mm radius electron beam at 45° angle

A HEAVY ION BEAM PROBE IS ALREADY AT W7-X

W7-X UTILIZES A HIBP INSERTION

SUMMARY

- In a preliminary design, the beam enters through K11, injects a focused beam into the plasma, and exits through N11.
- Simulations show that the beam can be focused into the plasma using existing tokamak infrastructure, accounting for divertor baffles, and interface with plasma and diagnostic systems.
- The design must account for the presence of divertor baffle blocks and anion beam extraction.

ADVANTAGES

- Simulate local particle and energy transport measurements in NBI-heated, high confinement plasmas.
- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate potential for density and temperature from the plasma interior.

CHALLENGES

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.

SUMMARY OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp (primary current), Jc (secondary current), and Jp/Jc (current ratio) in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

FUTURE WORK GOALS

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.
- Investigate location of HIBP system components.

DETECTION GEOMETRY

- Beam trajectories study the beam deflection elements system including ion beam and electrostatic steering.
- Simulated sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.

 ESTIMATES OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

ADVANTAGES

- Simulate local particle and energy transport measurements in NBI-heated, high confinement plasmas.
- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate potential for density and temperature from the plasma interior.

CHALLENGES

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.

SUMMARY OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp (primary current), Jc (secondary current), and Jp/Jc (current ratio) in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

FUTURE WORK GOALS

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.
- Investigate location of HIBP system components.

DETECTION GEOMETRY

- Beam trajectories study the beam deflection elements system including ion beam and electrostatic steering.
- Simulated sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.

 ESTIMATES OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

ADVANTAGES

- Simulate local particle and energy transport measurements in NBI-heated, high confinement plasmas.
- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate potential for density and temperature from the plasma interior.

CHALLENGES

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.

SUMMARY OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp (primary current), Jc (secondary current), and Jp/Jc (current ratio) in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

FUTURE WORK GOALS

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.
- Investigate location of HIBP system components.

DETECTION GEOMETRY

- Beam trajectories study the beam deflection elements system including ion beam and electrostatic steering.
- Simulated sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.

 ESTIMATES OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

ADVANTAGES

- Simulate local particle and energy transport measurements in NBI-heated, high confinement plasmas.
- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate potential for density and temperature from the plasma interior.

CHALLENGES

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.

SUMMARY OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp (primary current), Jc (secondary current), and Jp/Jc (current ratio) in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

FUTURE WORK GOALS

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.
- Investigate location of HIBP system components.

DETECTION GEOMETRY

- Beam trajectories study the beam deflection elements system including ion beam and electrostatic steering.
- Simulated sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.
- Sample volumes are disc-like shapes.

 ESTIMATES OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.

ADVANTAGES

- Simulate local particle and energy transport measurements in NBI-heated, high confinement plasmas.
- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate potential for density and temperature from the plasma interior.

CHALLENGES

- Investigate location of HIBP system components.
- Estimate limiting cases of density and temperature.
- Investigate location of HIBP system components.

SUMMARY OF DETECTED CURRENT APPEAR SUFFICIENT FOR EDGE MEASUREMENTS

- Simulated measurements of Jp (primary current), Jc (secondary current), and Jp/Jc (current ratio) in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.
- Simulated measurements of Jp, Jc, and Jp/Jc in primary, central, and secondary currents.