Abstract
Pellet fueling on MST has previously achieved Greenwald fractions of up to 1.5 in 200 kA improved confinement discharges. Additionally, pellet fueling to densities above the Greenwald limit in 200 kA standard discharges resulted in early termination of the plasma, but pellet size was insufficient to exceed the limit for higher current discharges. To this end, the pellet injector on MST has been upgraded to increase the maximum fueling capability by increasing the size of the pellet guide tubes, which constrain the lateral motion of the pellet in flight, to accommodate pellets of up to 4.0 mm in diameter. These 4.0 mm pellets are capable of triggering density limit terminations for MST’s peak current of 600 kA. An unexpected improvement in the pellet speed and mass control was also observed compared to the smaller diameter pellets. Exploring the effect of increased density on NBI particle and heat deposition shows that for MST’s 1 MW tangential NBI, core deposition of 25 keV neutrals is optimized for densities of 2 - 3 x 10^{20} m^{-3}. This is key for beta limit studies in pellet fueled discharges with improved confinement where maximum NBI heating is desired. An observed toroidal deflection of pellets injected into NBI heated discharges is consistent with asymmetric ablation due to the fast ion population. In 200 kA improved confinement plasmas with NBI heating, pellet fueling has achieved a Greenwald fraction of 2.0. Work supported by US DoE.

Experimental Overview

- MST’s pellet injector is a flexible pipe gun injector built as part of a collaboration with ORNL.
  - Injector hardware provides a customizable fueling capability with 4 injection lines each capable of having a different combination of pellet size and speed including the recently upgraded capability for 4.0 mm diameter pellets.
  - These 4.0 mm pellets have shown an improved control in both velocity and mass compared to the smaller pellets.
- A single large 4.0mm pellet is estimated to be capable of fueling to a density greater than 1 x 10^{20} m^{-3}.

Density Limits Studies

- On MST, the Greenwald limit is n_{GW} = \mu m^2
- By launching high speed pellets that cross the plasma and smash into the far wall, massive edge fueling can trigger a collapse of the plasma in a controllable and reproducible manner for the full range of plasma currents in MST.
  - A small difference is observed in the density limit response for reversed and non-reversed discharges.
  - Edge cooling observed in both edge and core as measured by probes in the edge and Thomson scattering measurements in the core.
  - In cases where the core temperature drops below ~ 50 eV, the plasma does not recover.
  - In PPCD plasmas with NBI heating, the highest densities are obtained without termination of the plasma.
  - 4.0 mm pellets required to reach this density with fueling primarily from a single pellet

Interaction of Pellet and NBI

- MST’s highest β plasmas (β > 20%) obtained via pellet fueling of PPCD discharges
  - Magnetic fluctuations reduced, confinement improved
  - Ion heating observed due to e - i coupling

  - 1 MW NBI provides a unique capability to probe for beta limit by adding controllable heating power
  - Optimizing NBI plasma heating
    - Eliminating shine-through (~20% for n=1 x 10^{20} m^{-3}, < 1 % at n ~ 2-3 x 10^{20} m^{-3})
    - Fast ions born further out radially as density increases

High β (β > 15%) Experiments

- PPCD experiments at 200 and 500 kA with and without NBI heating for β limit studies

  - In a crash heated PPCD discharge with core density exceeding 1 x 10^{20} m^{-3}, T_e is observed to reach 250 eV with a β of ~16%

  - A scaling of the magnetic fluctuations in both the edge and the core is observed as density increases and no impact from NBI is observed

- At both low and high current, there is an apparent saturation of the electron component of beta based on experimental measurements.
  \[ \beta_{sat} = 2 \mu c n_e <T_e> / B(a^2) \]