Four Barrel Pellet Injector Upgrade on the Madison Symmetric Torus (MST)

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A two-barrel cryogenic pellet injector, installed in 2002, has recently been upgraded to allow up to four pellets of hydrogenic ice to be injected into a single MST plasma discharge. The injector system, based on a pipe gun configuration, was designed and fabricated by Oak Ridge National Laboratory (ORNL) and installed on an existing MST support structure. The gun, which was previously outfitted with two barrels, has been refitted with its full design complement of four barrels, producing pellets of diameters ranging from 1 mm to 1.6 mm. Pellet speeds are selectable and range from ~200 m/s to over 1000 m/s by the choice of a mechanical punch, a high-pressure propellant gas, or a combination of the two. Additionally, a new short-barrel geometry has been developed to allow reliable pellet speeds in the 500 m/s range, which is critical for MST type plasma parameters. To diagnose the pellets' speed and size, all four barrels share a common microwave mass detector, and each barrel is equipped with a light gate and photography station. The mass detector cavity geometry has also been optimized for MST-sized pellets.

Pellets are radially injected at an angle of 30 degrees from the outboard midplane through a newly installed set of ports on the MST vacuum vessel. Aligned about the plasma center, these new ports allow all four barrels a line-of-sight trajectory to the discharge core. The system uses a closed loop helium gas cryocooler for pellet formation, eliminating the inconvenience, expense and hazards of liquid cryogens. The entire system is self-contained and is controlled through a single, remotely sited instrumentation rack, which contains all of the necessary control and data acquisition electronics, including the control computer.

Initial results from the previous two-barrel gun show that during improved confinement plasmas, increases in line average density of nearly 50 percent persisting for several milliseconds have been achieved, consistent with improved particle confinement. With the full complement of four barrels, more comprehensive studies of edge and core fueling will be conducted, using fast and slow pellets of various sizes.

In addition to the standard complement of MST diagnostics used with pellet injection (fast CCD camera, single-chord CO_2 interferometer, multi-chord far-infrared interferometer and Thomson scattering,) a dedicated high-resolution spectrometer and a bichromator, fabricated by ORNL, will be installed for measurements of the deuterium pellet ablation cloud. High-resolution measurements of the Stark broadening of the D_α line will provide information about the pellet cloud density, while bichromator measurements of the D_α-to-D_β line ratio will yield information on the cloud temperature. These measurements, combined with pellet cloud images, will be crucial in determining if pellet ablation physics in the RFP is similar to that of other toroidal confinement devices.