White Paper for Developing an Electromagnetic Particle Injector (EPI) System for ITER on NSTX-U

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This white paper describes our plans for developing a new system for safely terminating discharges in ITER. The system, referred to as an Electromagnetic Particle Injector (EPI) propels a coaxial projectile, containing particulate matter of various sizes and composition, in a coaxial electromagnetic rail gun, then shatters it prior to injecting a dust of particles into the tokamak.

At the recent US Disruption Mitigation Workshop (GA, March 12-13, 2012) it was concluded that although the Massive Gas Injection system is the best understood for safely terminating discharges in ITER, both the time response of this system and the controllability of the amount of gas and impurities injected by this system for variations in the initial plasma current at which a disruption initiates may be inadequate to fully rely on this system. It was decided that other faster acting systems should also be tested and developed. During this meeting, we presented the EPI concept. It was noted that this system was more complex as compared to a conventional gas gun, but no technical flaws were identified. It was also suggested that a proto-type should be built and tested before considering it for ITER.

The proposed system, shown in Figures 1 and 2, is now under design. It has several advantages over other disruption mitigation systems being considered for ITER.

- Well suited for long stand-by mode operation
  - Large particle inventory
  - All particles are delivered at nearly the same time
  - Particles are tailored to contain multiple elements in different fractions and sizes
  - Tailored particles fully ionized only in higher current discharges (to control current quench rates)

- Toroidal nature and conical disperser ensures that,
  - The capsule does not enter the tokamak intact
  - The capsule will fragment symmetrically and deliver a uniform distribution of particles (or via. tapered final section)
  - Particle penetration is not impeded by magnetic fields

- Coaxial Rail Gun is a fully electromagnetic system with no moving parts, so should have high reliability from long stand-by mode to operate on demand
  - Conventional gas guns will inject gas before capsule and trigger pre-mature thermal quench

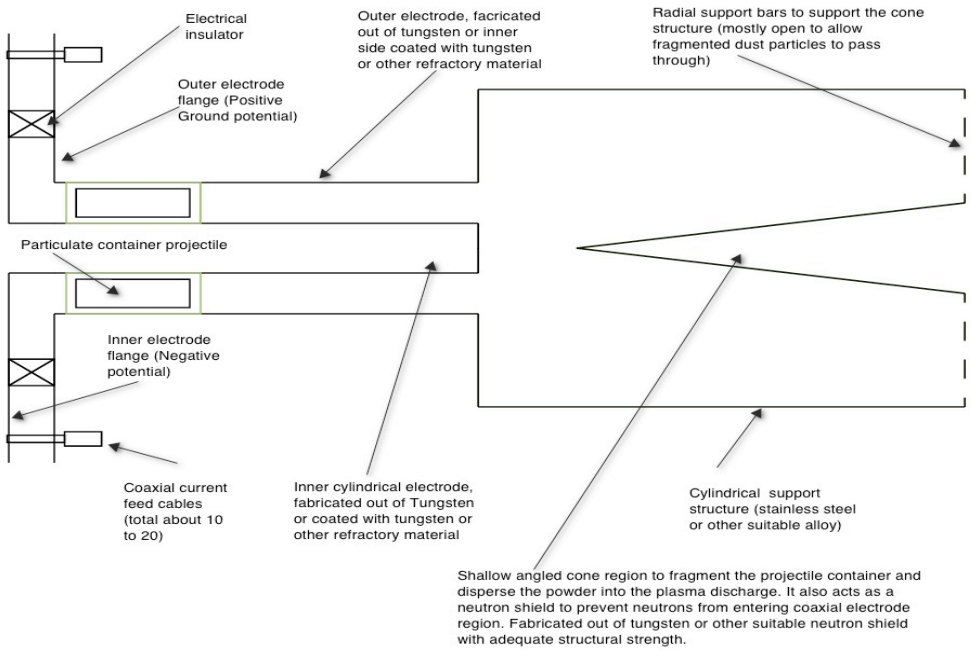

Fig. 1: Electromagnetic Particle Injector (EPI) using a coaxial electromagnetic rail gun

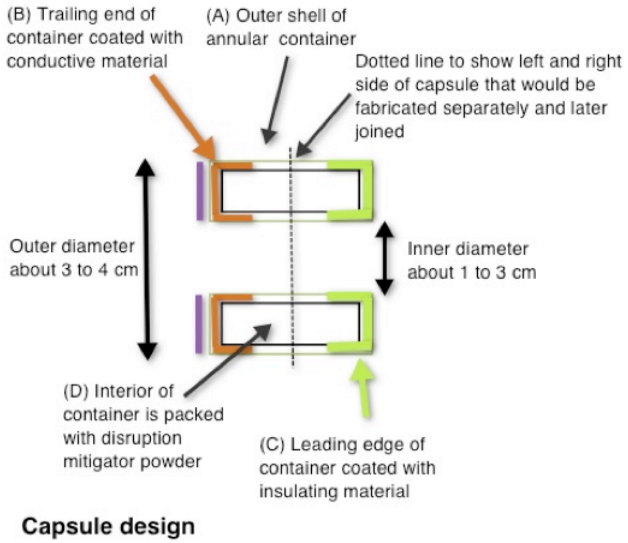

Fig. 2. Shown are the primary elements of the capsule design. The purple ring at the trailing end of the capsule serves two purposes. In an electromagnetic accelerator it is used to increase the inertial strength of the capsule. If the capsule is used in a conventional gas gun it could be fabricated out of a non-conductive material.

We plan to finish the design during 2012 and to build a proto-type during 2013. It will initially undergo several months of off-line testing at the University of Washington and then be ready for a test on NSTX-U soon after NSTX-U begins operation. An intermediate test at another tokamak facility is also being considered.