Demonstration of Tokamak Ohmic Flux Saving by Transient Coaxial Helicity Injection on NSTX (R. Raman, et al.,)

- **Experiments in NSTX have now unambiguously demonstrated the coupling of Transient CHI started discharges to induction from the central solenoid.**
- **The coupled discharges have ramped up to high current and transitioned to an H-mode demonstrating the compatibility of this method with high-performance plasma operation.**
- **Peak currents of up to 300kA have been generated and when coupled to induction, it has produced 200 kA additional current over inductive-only operation.**
- **Further improvements to last year's results can be expected due to the outer electrode being metallic, and due to higher currents in the CHI absorber coils, which should further reduce low-Z impurities.**
- **TSC simulations show current multiplication to increase with BT with factors up to 100 as seen experimentally.**
- **These results in conjunction with experimental work on HIT-II and NSTX, two machines with different sizes, indicate that the amount of injector current required to pull the injector flux into the vessel increases with the injector flux but decreases with the toroidal field and the current multiplication increases with toroidal flux, indicating that the scaling to future machines with stronger toroidal field and larger vessel volume is favorable.**

Demonstration of Tokamak Ohmic Flux Saving by Transient Coaxial Helicity Injection on NSTX (Abstract)

Experiments in NSTX have now demonstrated the savings of 200kA of solenoid flux after coupling of toroidal plasmas produced by the technique of Transient Coaxial Helicity Injection (CHI) to inductive sustainment and ramp-up of the toroidal plasma current. This is a record for non-inductive plasma startup, and an essential step for developing a fusion reactor based on the spherical torus concept. The method could also reduce the cost of a tokamak reactor. CHI–initiated discharges with an injector current of only 4kA (total power supply energy of only 21kJ) generated a start-up current of 250kA that were coupled to 0.11Vs of induction ramped up to 525kA without using any auxiliary heating, while identical OH only discharge ramps to only 325kA. A flux saving was realized by reducing the influx of low-Z impurities during the plasma start-up phase. This was achieved through the use of long-pulse CHI discharges to ablate low-Z surface impurities from the lower divertor electrodes, followed by Lithium evaporative coatings and an effort to reduce spurious arcs in the upper divertor region by controlling the magnetic field there with two new poloidal field coils. As a result of these improvements, and for the first time in NSTX, the electron temperature during the CHI phase continually increased with input energy, indicating that the additional injected energy was contributing to heating the plasma instead of being lost as low-Z impurity line radiation. NSTX CHI simulations with the Tokamak Simulation Code (TSC) show that CHI start-up current scaling with toroidal field is consistent with present understanding of CHI theory, and this suggests that potential use of CHI on larger machines is quite attractive. These exciting new results from NSTX demonstrate that CHI is a viable solenoid-free plasma startup method for future STs and Tokamaks.