High pressure Field Reversed Configuration plasmas in FRX-L for Magnetized Target Fusion IC

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We are developing a field reversed configuration (FRC) plasma for application as the target plasma to demonstrate the physics of magnetized target fusion (MTF) [1]. The FRX-L experiment at Los Alamos has the goal of demonstrating plasma parameters good enough to warrant moving toward translation and implosion experiments [2,3]. The FRC experimental parameters (density, temperature, and cleanliness) obtained in the past several years are sufficient, but we still have two remaining issues. These are: a relatively short lifetime ~10 µsec, and low probability (~10%) of forming an FRC that would remain static, centered around the central region Θ-coils, where our primary diagnostics are located. Consequently, the focus of our recent experimental campaigns has been to enhance performance in these two areas, which has resulted in the following accomplishments:

- improved reproducibility of good FRC's via PI/main bank timing experiments
- improved FRC performance due to upgraded crowbar switch which has minimized magnetic field ringing and premature deterioration of FRC's
- increased n_e, $<T_e+T_i>$, & plasma pressure, including 0.7 mWb trapped flux during formation
- modeled time-dependent cusps and field penetration of flux-excluder plates to optimize formation and flux trapping, designed add-on mirror coils, and are using an analytic model and MOQUI simulations [4] to design the FRC translation experiment

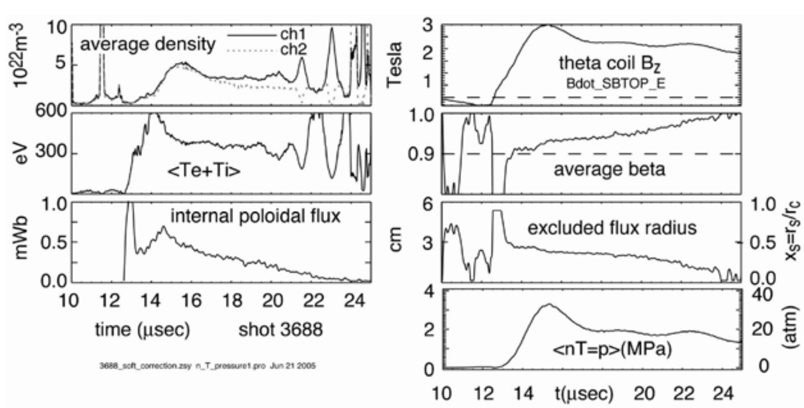

Figure 1: High pressure FRC parameters in FRX-L, following installation of improved high-current crowbar system. The plasma pressure is 2-3 MegaPascals, or 20-30 bars; higher than even the largest tokamak plasmas. An n=2 rotational instability develops by t=20 µsec.

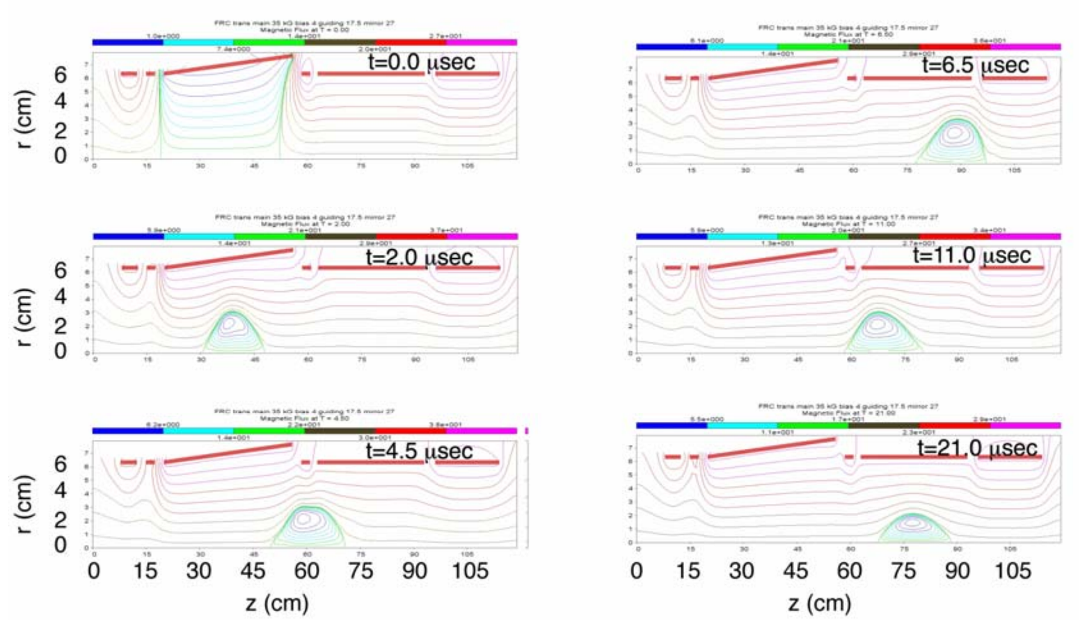

Figure 2: Six frames of a MOQUI code simulation for typical experimental parameters and the planned conical Θ-coil design for FRC translation experiments. The expected liner implosion time will be ~22 μsec, so one timing option is to begin the liner implosion first, before forming and injecting the FRC on Shiva Star.

The MOQUI simulation frames in Figure 2 start with formation in the conical Θ-coil at t=0 μs with a 3.5 Tesla main field, acceleration by t = 2 μs, expulsion at t = 4.5 μs, and translation by t = 6.5 μs through a guide field region, after which it collides with a 2.7 Tesla mirror field on the right hand side. A subsequent bounce leads to leftward motion at t=11 μs and final stagnation and dissipation are shown after t= 21 μs. The expected translation speed is ~15 cm/μs (which asymptotes to the source ion acoustic speed), and the elapsed time of 21 μsec is consistent with demonstrated liner implosion times of 22 μsec [5]. A movie can be viewed on the web, at http://wsx.lanl.gov/moqui.htm

The accomplishments of the past two years include an engineering design for translation and implosion experimental phases. In addition, we have (Jan 2006) installed new passive mirror coils which lengthen the FRC Θ-coil region slightly, while providing a 1.05 mirror ratio to improve position control at all times during FRC formation. The present experimental campaign is focused on achieving further increases in flux trapping, lifetime, and reproducibility of well-formed FRC's.

References

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