Design and Fabrication of a High-Density Field Reversed Configuration

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Abstract

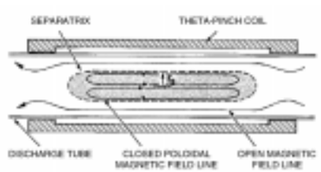
The design of the Field Reversed Configuration (FRC) experiment at Los Alamos National Laboratory takes advantage of our many years of experience with these devices. The physics of attaining a high density and temperature FRC requires magnetic energy that scales with the size of the Green Newton magnetic field. This in turn requires large bias magnetic field (< 0.4 Tesla), large crowbar field (< 5 Tesla), and large theta pinch electric field (< 0.8 kV/cm). The FRC formation region is inside the theta pinch coil, and eventually the FRC will be translated along a guide field into a mirror trapped region inside the liner. The theta pinch coil is a single turn clamshell design with inside diameter approximately 12 cm. Larger bore symmetric cusp coils at each end and guide field and mirror field solenoids for the translation region are designed as modular combinations of a standard magnet pancake unit. The initial design calls for slow but pulsed wave forms for all magnets so they can ring using capacitor banks. Physics and engineering requirements, and drawings along with a progress report will be presented.

Motivation for FRC

The FRC under development will be the target plasma for **Magnetized Target Fusion (MTF)** studies, as put forth in the *MTF Proof-of-Principle Proposal*, LA-UR-98-2413 (5/19/98). MTF is the approach by which deuterium-tritium fuel in a *preheated* and *magnetized* plasma is rapidly compressed to thermonuclear temperatures by pdV heating.

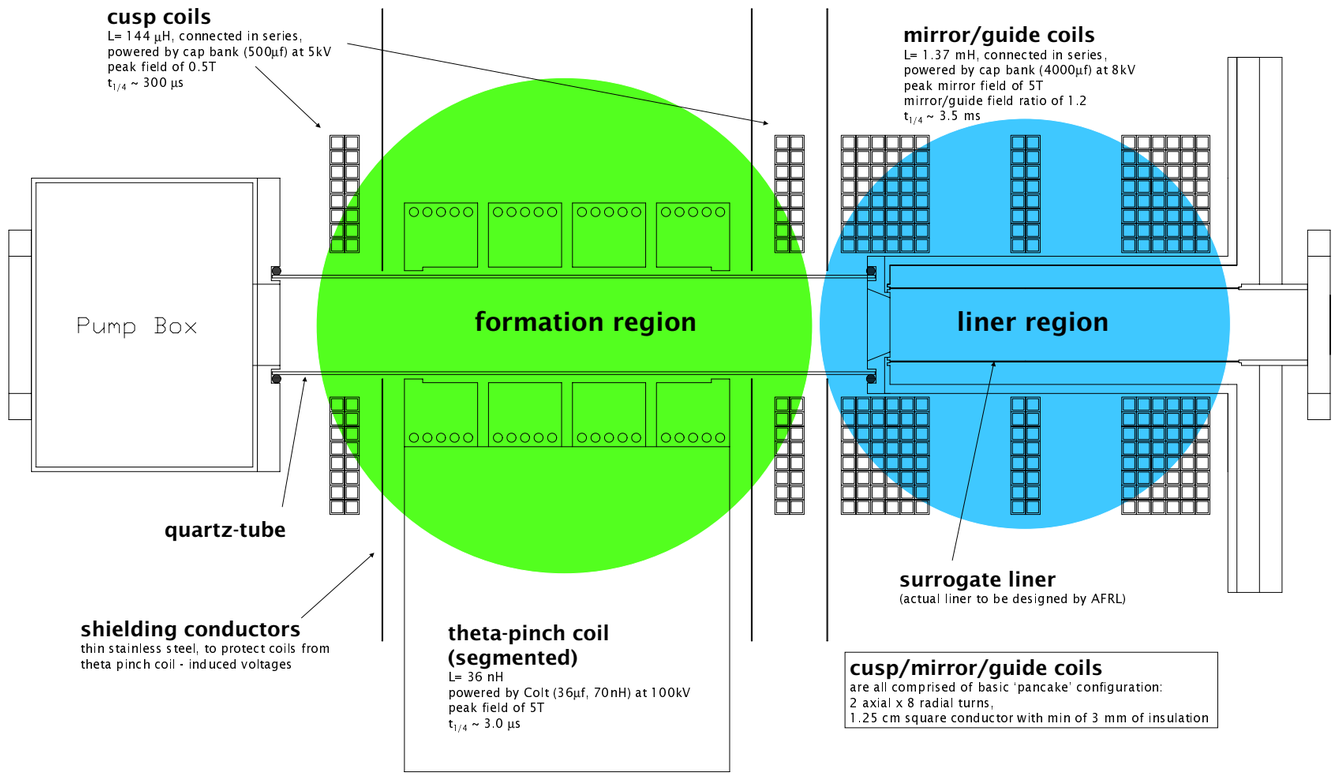
Check http://fusionenergy.lanl.gov/mtf.htm#MTF

The FRC is an elongated compact toroid that is formed without toroidal field. The FRC consists of a closed-field-line torus inside a separatrix and an open-field-line *sheath* outside the separatrix. Equilibrium in a FRC is a balance of magnetic field pressure and plasma pressure in the radial direction, and field-line tension and plasma pressure in the axial direction.



FRC geometry showing separatrix radius and flux-conserving boundary.

Mockup of FRC and transmission lines on existing Colt Experimental Setup



Schematic of Experiment -- Scale 1:2

Phase 1: FRC formation suitable for compression -- in situ characterization

FRC Goal Parameters:	Principal diagnostics planned:
- density $n \sim 10^{17}\ \mathrm{cm}^{-3}$	Excluded flux B-probe array
- temperature $T \sim 300$ eV	Interferometry
- lifetime $\tau_E > 10\ \mu\mathrm{s}$	Thomson scattering
	Bolometry
	Optical Spectroscopy

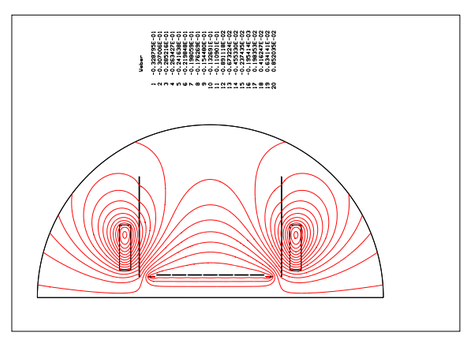
Phase 2: FRC Translation into liner via conical theta pinch

FRC inside liner:	Principal diagnostics planned:
- liner $r_{wall} = 5$ cm	B probe array
- plasma $r_s \sim 3$ cm	Bolometry
- plasma $l_s = 30$ cm	Interferometry
	Spectroscopy

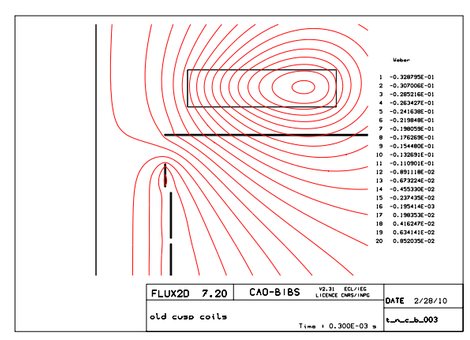
Time-Dependent Effects

The theta-pinch, cusp, mirror, and guide field coils are all pulsed due to the high fields required for the experiment. Flux2D (Magsoft) is used to model the time-dependent effects.

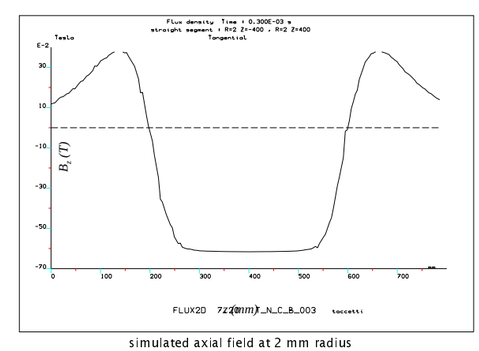
Some results showing the null field region between the cusp and theta-pinch are shown in the figures to the right.



flux contours from simulation running theta pinch and cusp coils together



flux contours - closeup of a null point



simulated axial field at 2 mm radius
(theta pinch coil center is at 400 mm)