

Progress on the Los Alamos High-Density Field Reversed Configuration Experiment

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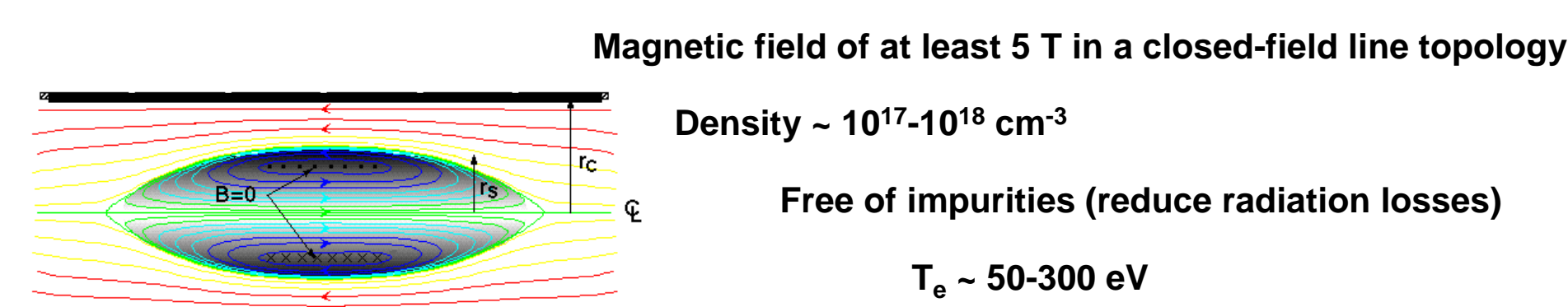
National Aeronautics and Space Administration

Introduction

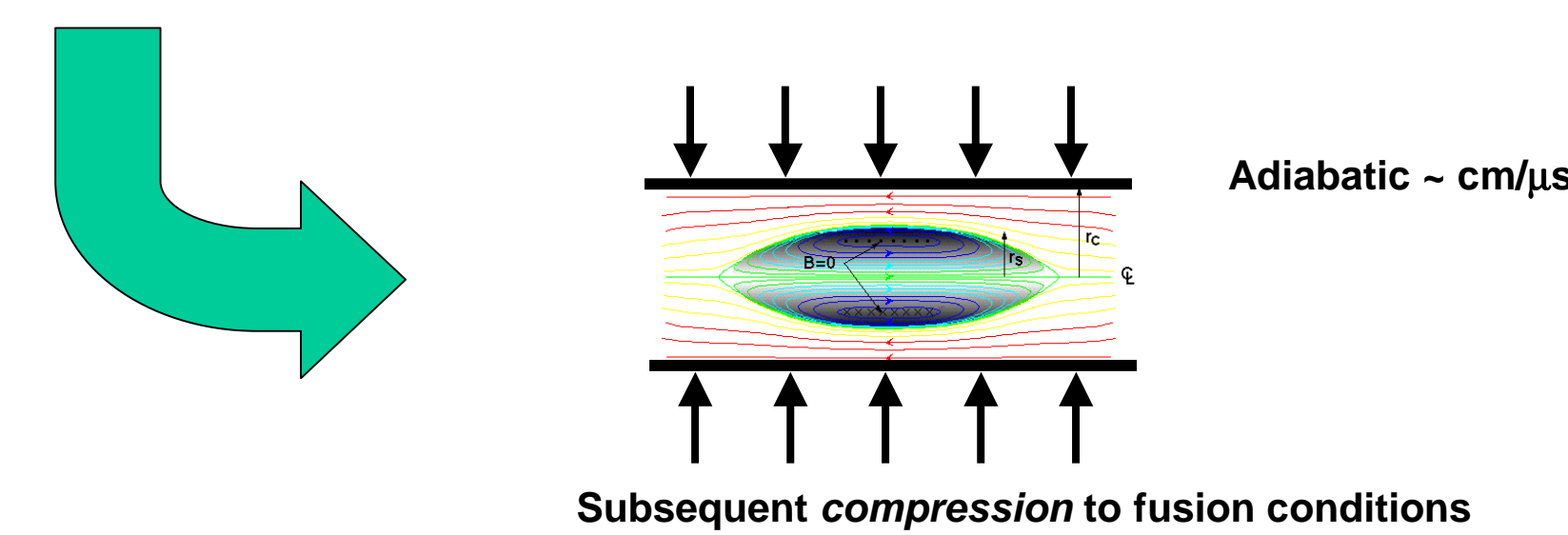
Abstract

We present the status of the LANL high-density Field Reversed Configuration (FRC). This FRC will be the target plasma for *Magnetized Target Fusion* (MTF) experiments; heating it by compressing it inside an imploding flux conserver should allow access to fusion conditions. We present our current experimental setup to study the pre-ionization, formation, and translation phases of the FRC. Diagnosing this plasma is challenging due to the short timescales, high energy densities, high magnetic fields, and restricted access. Our goal is an FRC with $n \sim 10^{17} \text{ cm}^{-3}$, $T \sim 100\text{-}300 \text{ eV}$, $B \sim 5 \text{ T}$, and a lifetime of $10\text{-}20 \mu\text{s}$. According to previous experience, the pre-ionization (PI) process is crucial for good FRC formation. We will ionize the gas in the initial pre-ionization experiments by impressing a rapidly oscillating ($\sim 300 \text{ kHz}$) axial magnetic field over a slower-timescale magnetic bias field of comparable magnitude. This occurs just prior to the theta pinch coil magnetic field reversal. This is a much (10 x) larger field that radially contracts and forms the closed field lines for the FRC.

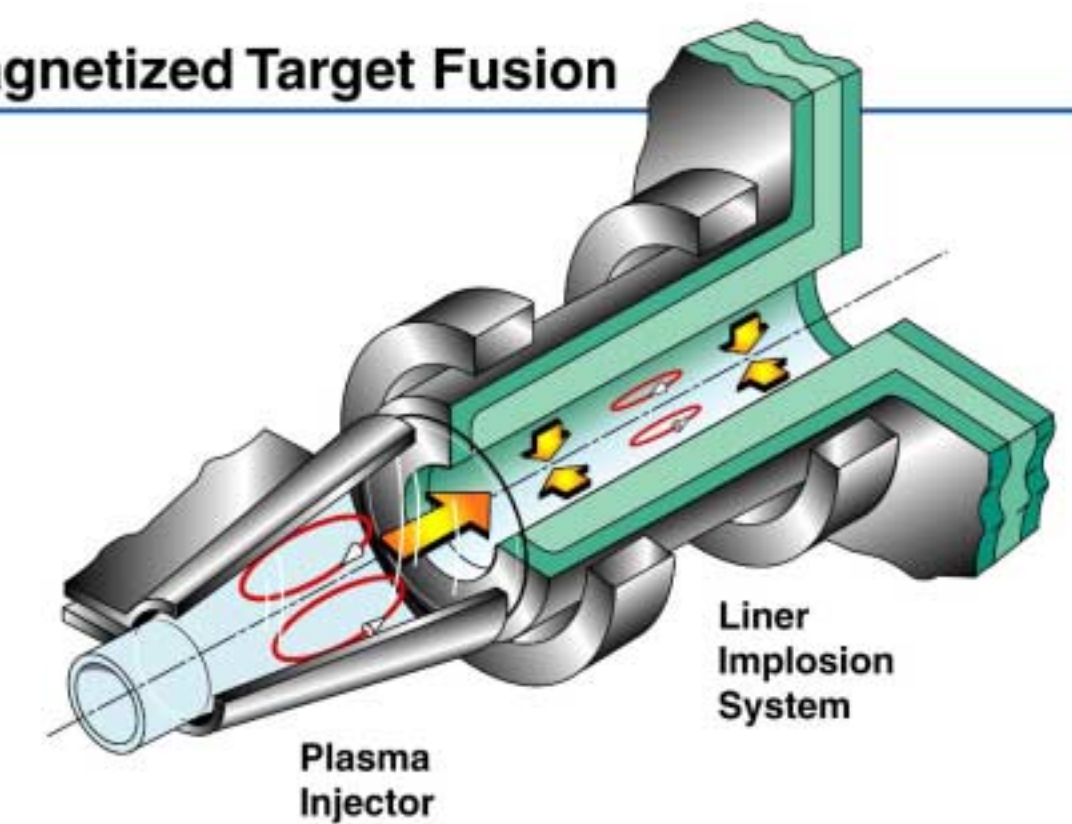
MTF: Magnetized Target Fusion



Initial target: preheated & magnetized

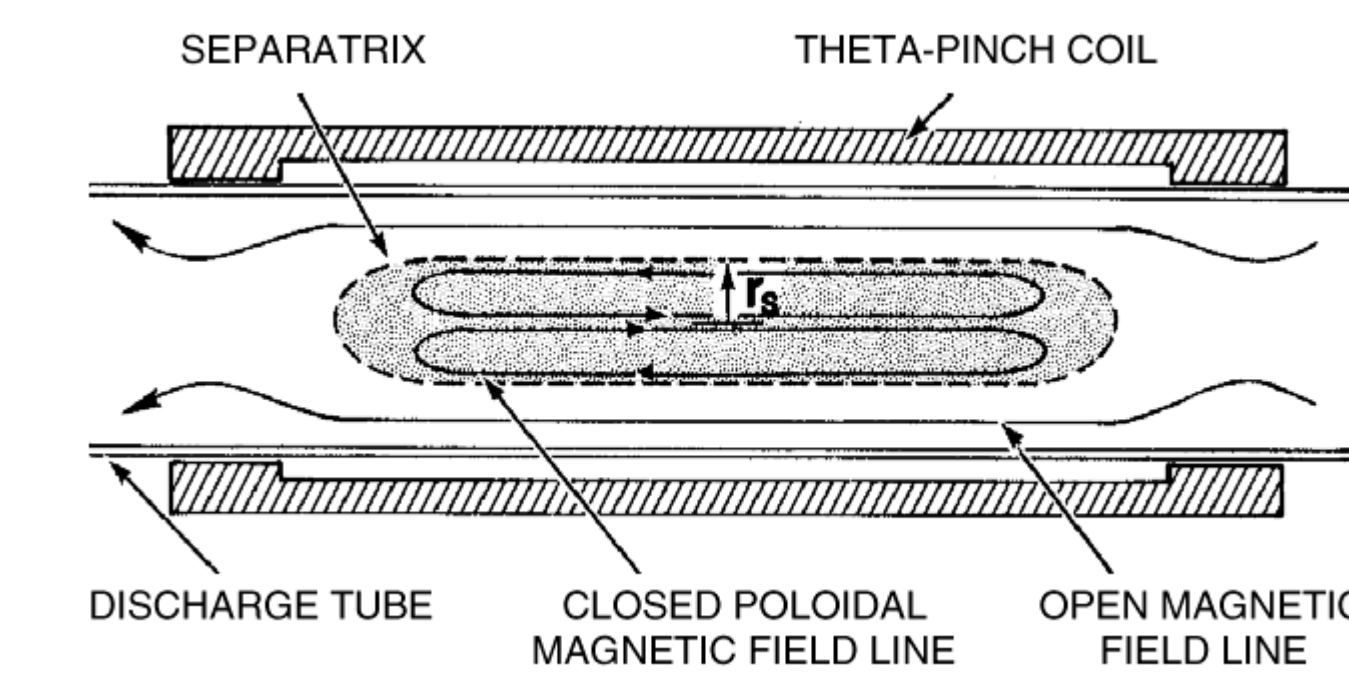


Magnetized Target Fusion



Field Reversed Configuration

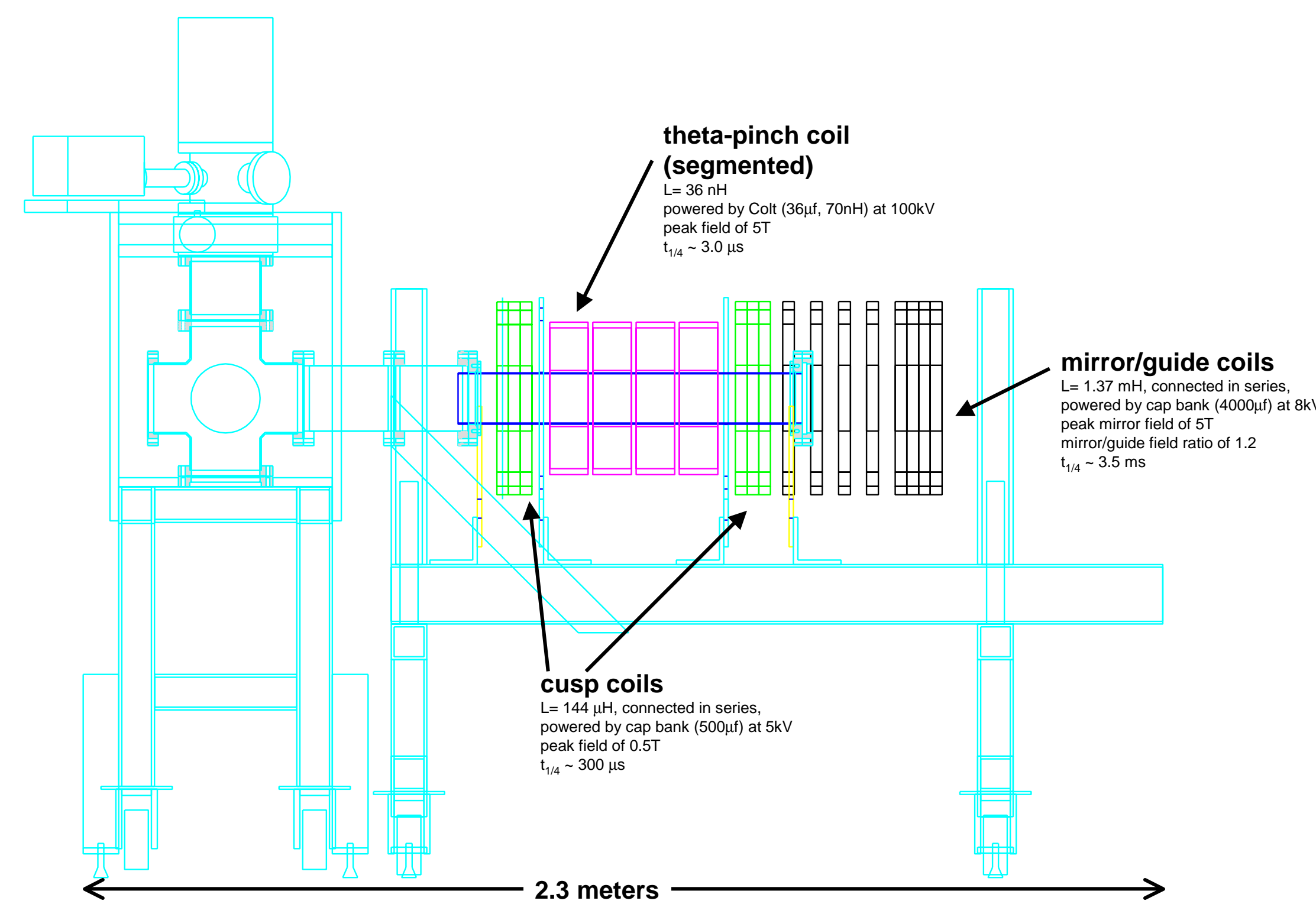
The FRC is an elongated compact toroid that is formed without toroidal field. The FRC consists of a closed-field-line torus inside a separatrix and an open-field-line sheath outside the separatrix. Equilibrium in a FRC is a balance of magnetic field pressure and plasma pressure in the radial direction,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



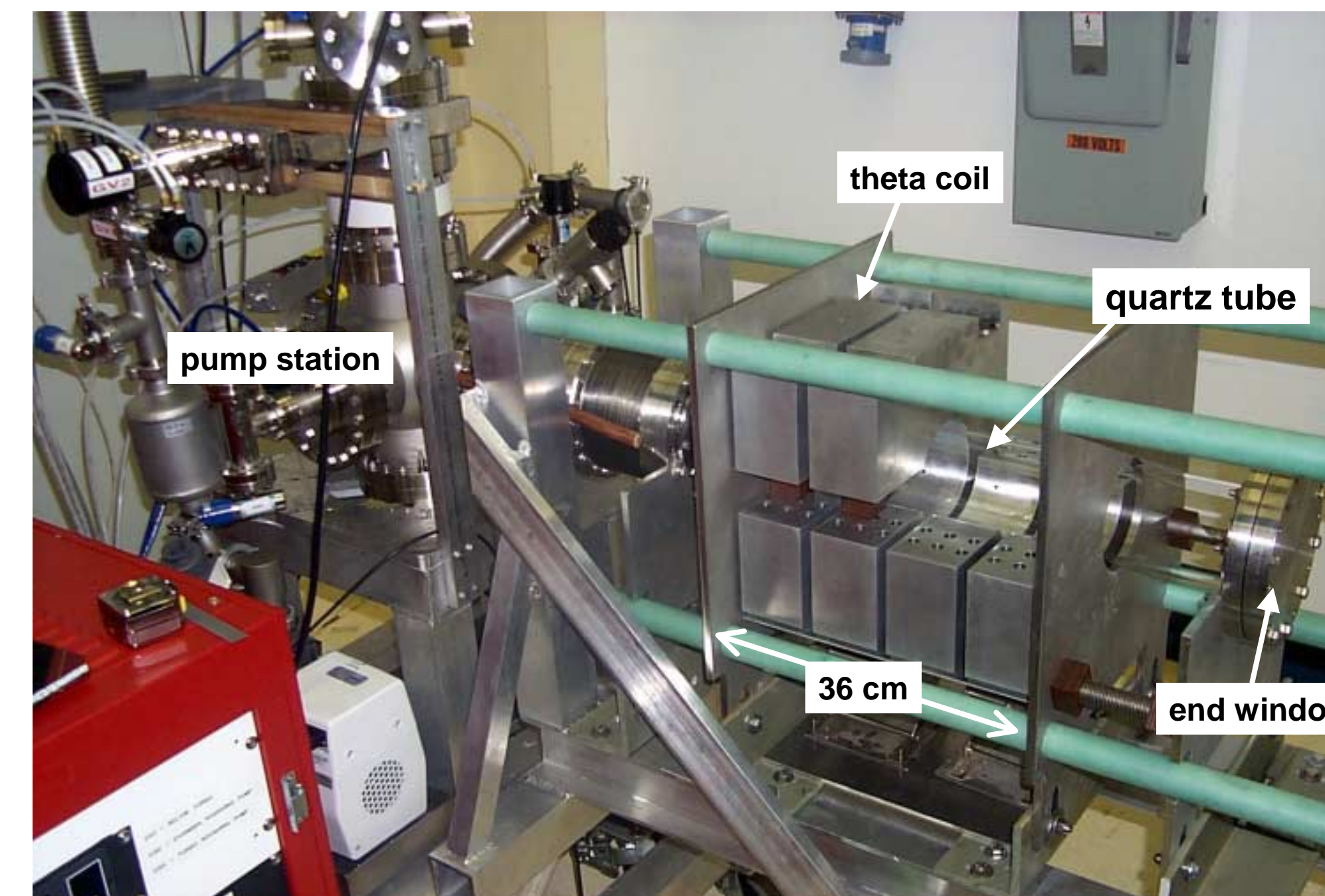
FRC geometry showing separatrix radius and flux-conserving boundary.

Experimental Setup

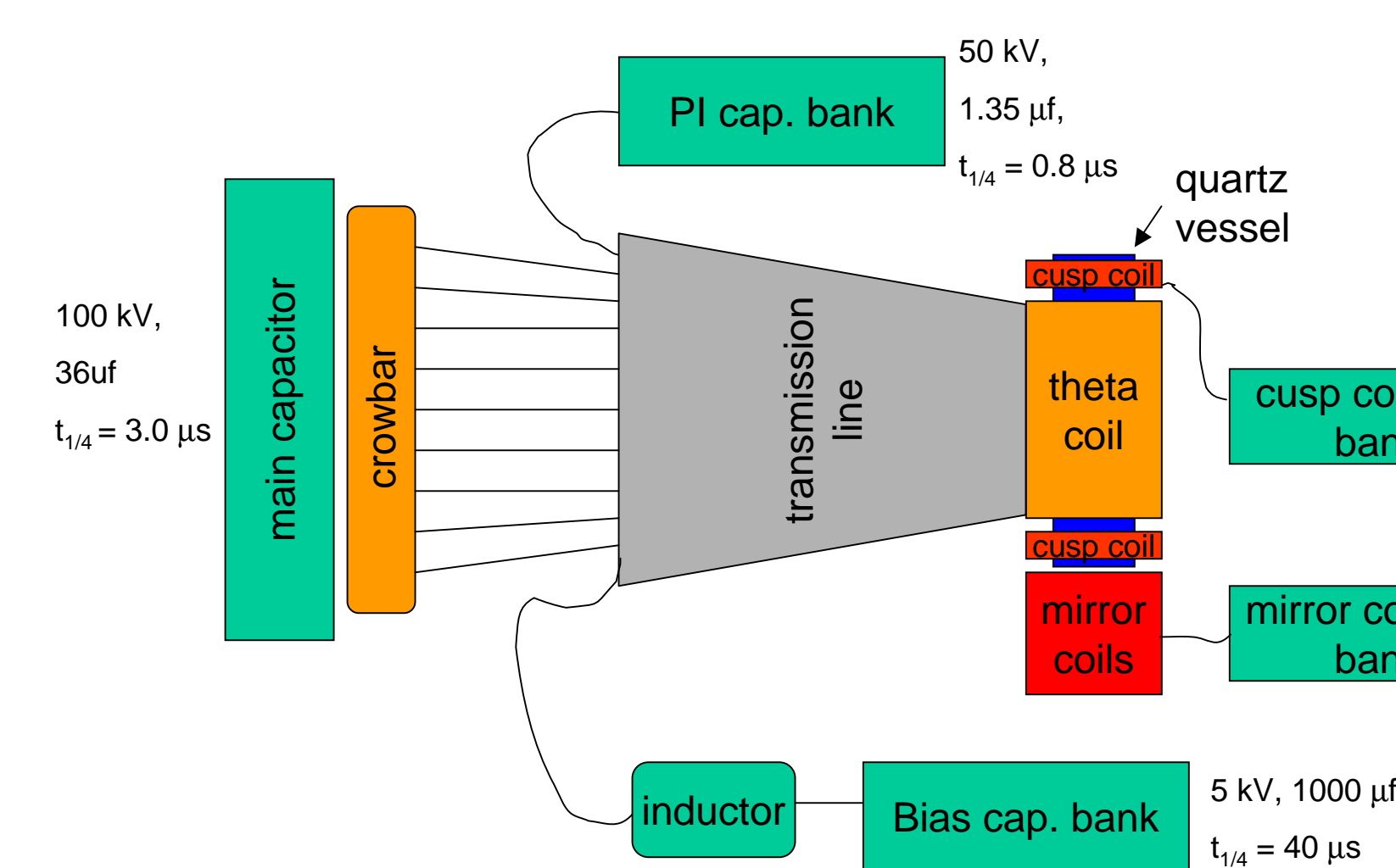
Experimental Setup - Side View



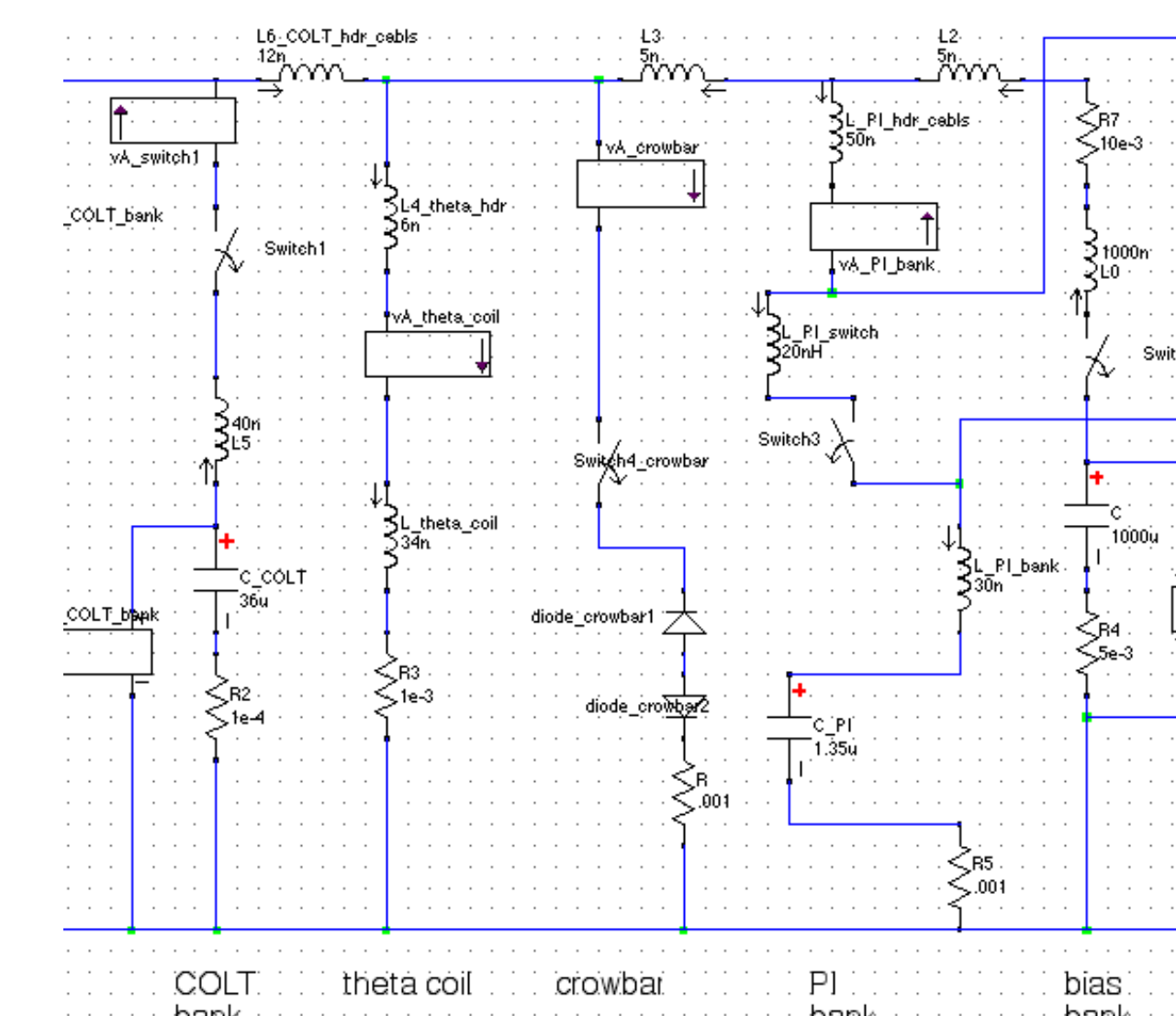
Assembly of Experiment



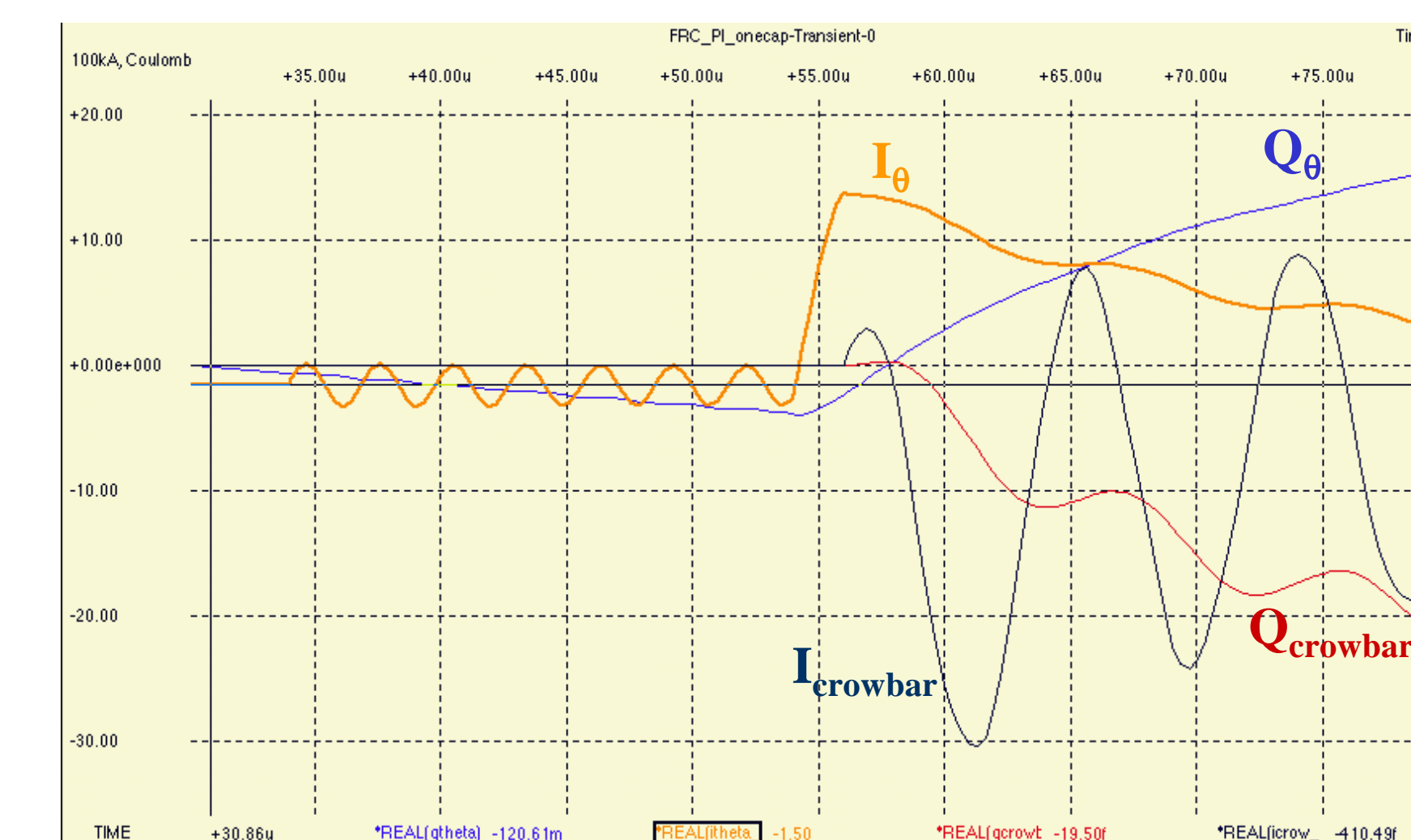
Block Diagram



Electrical Circuit



Current vs t



Pre-ionization Experiment

Method

- ring theta-pinch coil ringing
- overlap bias field
- frequency: $\sim 300 \text{ kHz}$

Goals

- > 50% ionization
- low level of impurities

Diagnosing Pre-ionization

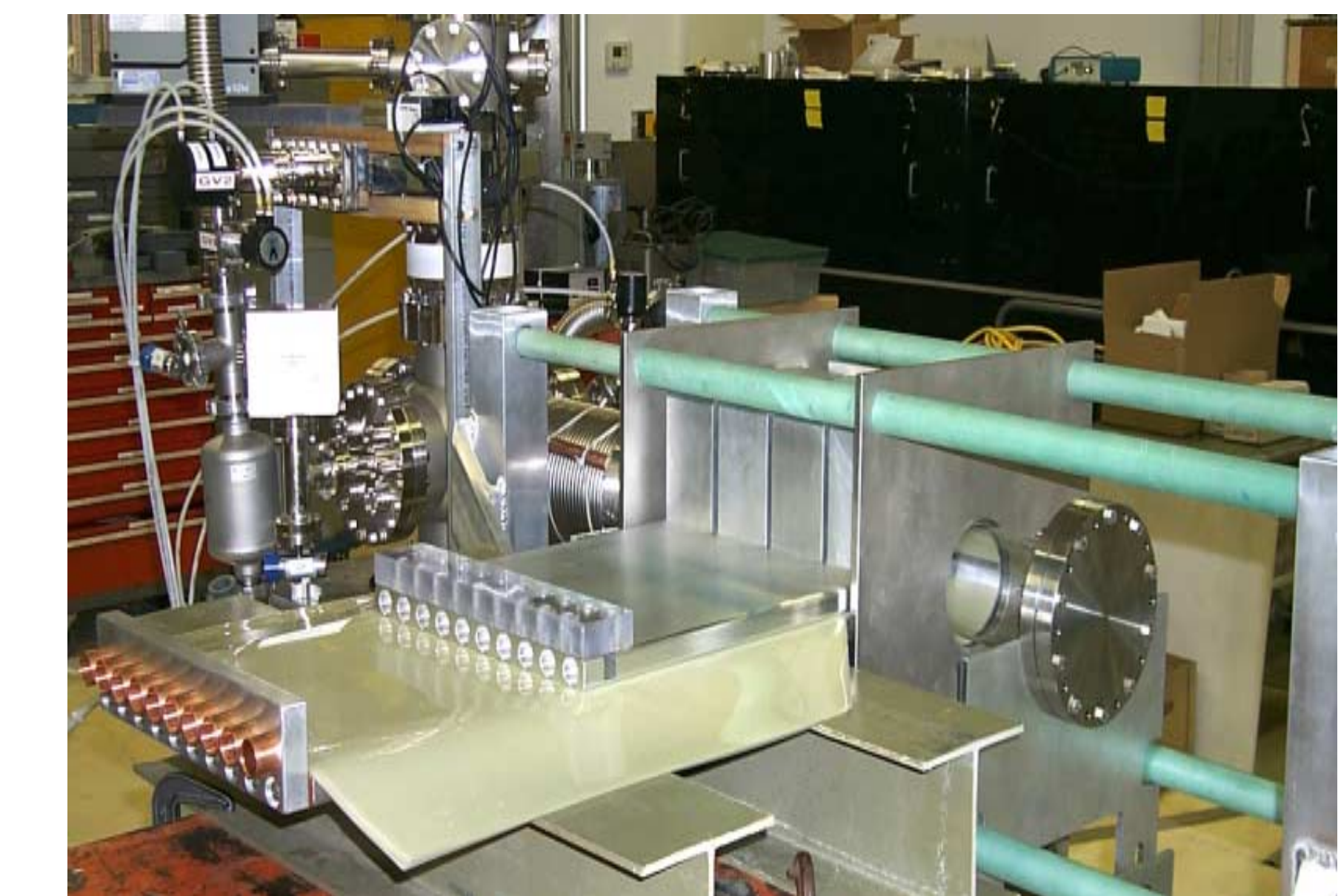
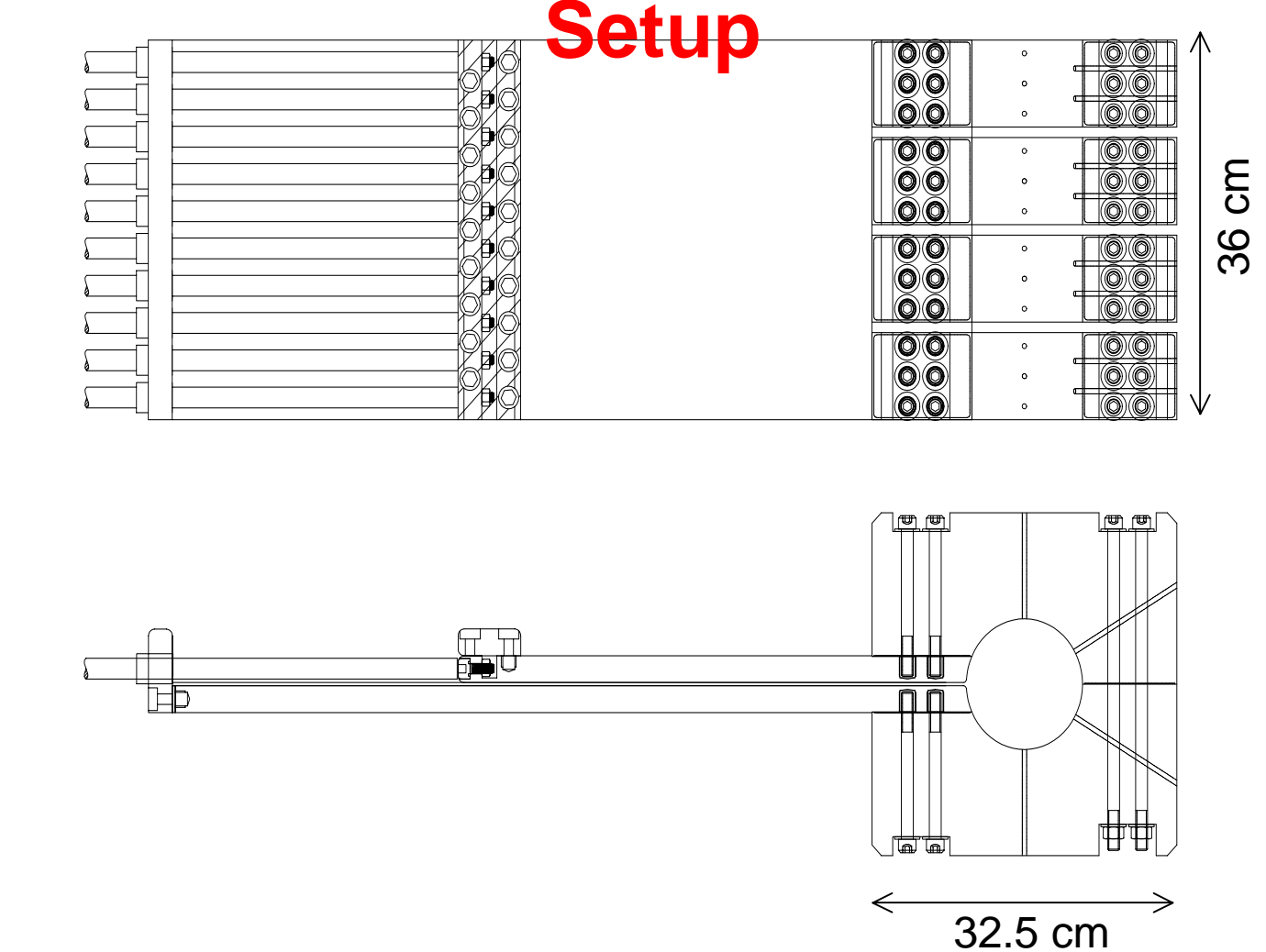
Qualitative diagnostics:

- Watch plasma glow (fast-framing photography)

Quantitative diagnostics:

- Interferometry (side-on and end-on)
- Studying electrical pulse shapes (variation of load inductance)

Pre-ionization Experimental Setup



View of Pre-Ionization Setup



Bias Bank / Inductor



Mirror/Cusp Field Pancake Coil



Summary / Future Directions

After achieving pre-ionization goals, two clearly defined phases will follow

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

- FRC Goal Parameters:
- density $n \sim 10^{17} \text{ cm}^{-3}$
 - temperature $T_e \sim T_i \sim 300 \text{ eV}$
 - lifetime $\tau_e > 10 \mu\text{s}$

- Principal diagnostics planned:
- Excluded flux B-probe array
 - Interferometry
 - Thomson scattering
 - Bolometry
 - Optical Spectroscopy

Phase 2: FRC Translation into liner via conical theta pinch

- FRC inside liner:
- liner $r_{wall} = 5 \text{ cm}$
 - plasma $r_s \sim 3 \text{ cm}$
 - plasma $l_z = 30 \text{ cm}$

- Principal diagnostics planned:
- B probe array
 - Bolometry
 - Interferometry
 - Spectroscopy