Overview of the Levitated Dipole Experiment

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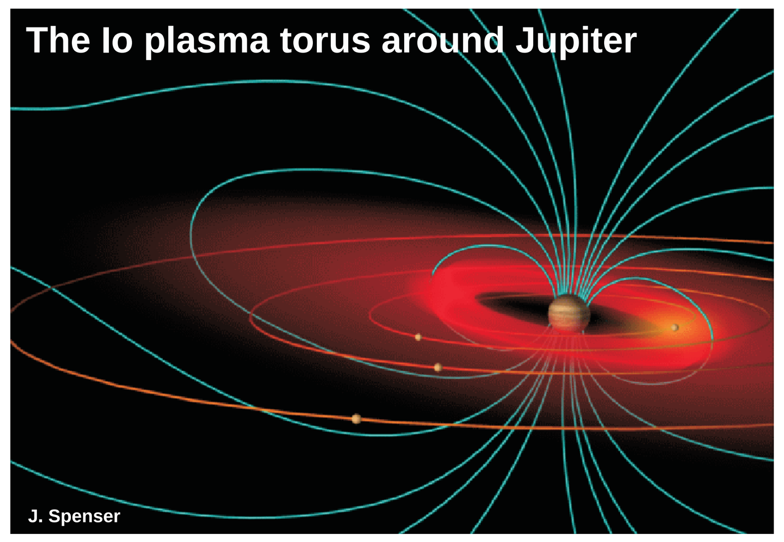
Abstract

The Levitated Dipole Experiment (LDX) will be the first experiment able to study high-beta plasma confined by a magnetic dipole with near classical energy confinement. LDX consists of three superconducting magnets and illustrates the role of innovative magnetic technology that makes possible explorations of entirely new confinement concepts. We describe the LDX machine design and detail the fabrication status of the superconducting floating-coil, charging-coil, and levitation-coil. In addition, we summarize (1) our procedure to cool, to inductively charge, and to levitate the 1.3 MA floating coil, (2) our initial diagnostic set, and (3) our experimental and physics plans that answer the key questions of high-beta stability and confinement in the dipole fusion concept.

The Dipole Concept Originated by Seeking to Capture in the Laboratory the Physics of Nature's High-Beta Plasma



- High-beta confinement occurs naturally in magnetospheres
- β ~ 2 in Jupiter
- Most common "confining magnetic field" in the universe
- Plasma compressibility allows finite pressure gradients—stabilizing both MHD and drift instabilities.
- When field errors are small, "classical confinement" may be possible.

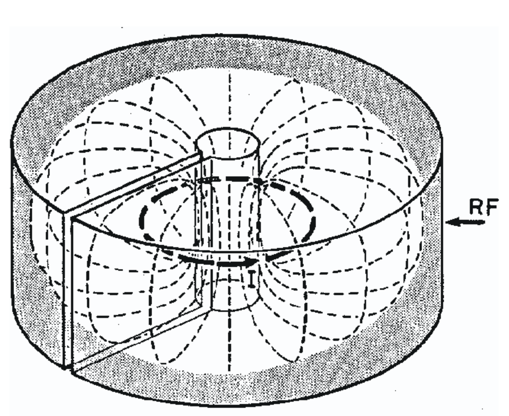
The LDX Team is a Partnership of Plasma Scientists and Magnet Technology Experts

LDX required innovative engineering and design:

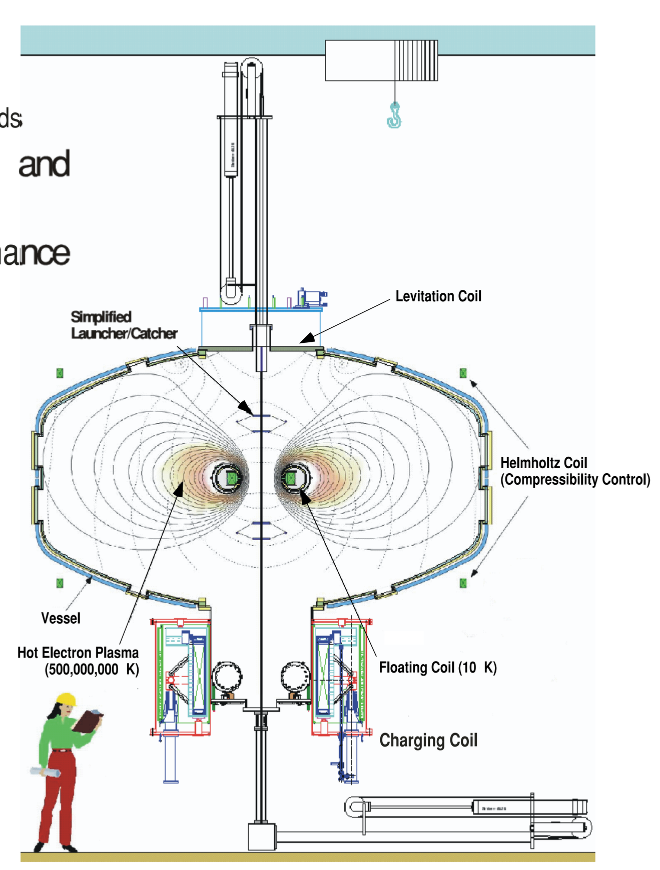
- High-field persistent Nb_3Sn coil with low mass and small size
- Innovative, light-weight cryostat with distributed supports having low-thermal conductivity
- Safe, relatively easy-to-operate cyrogenics
- Large, inductive charging system designed for thousands of high-field cycling during daily charging and discharging
- Fusion's first high-temperature superconducting magnet
- Levitation and stabilization system with distant, upper levitation coil

Factors in the LDX Design

- Overall size sufficiently large to allow for large magnetic flux expansion
- Highest possible field consistent with low-weight:
  - Use ECRH start-up to create high-beta plasma (β ~ 30%)
  - Reduce effects from field-errors and levitation fields
- Use experience from previous levitron and spherator experiments
- Optimize cyrogenics to simplify maintenance and operations

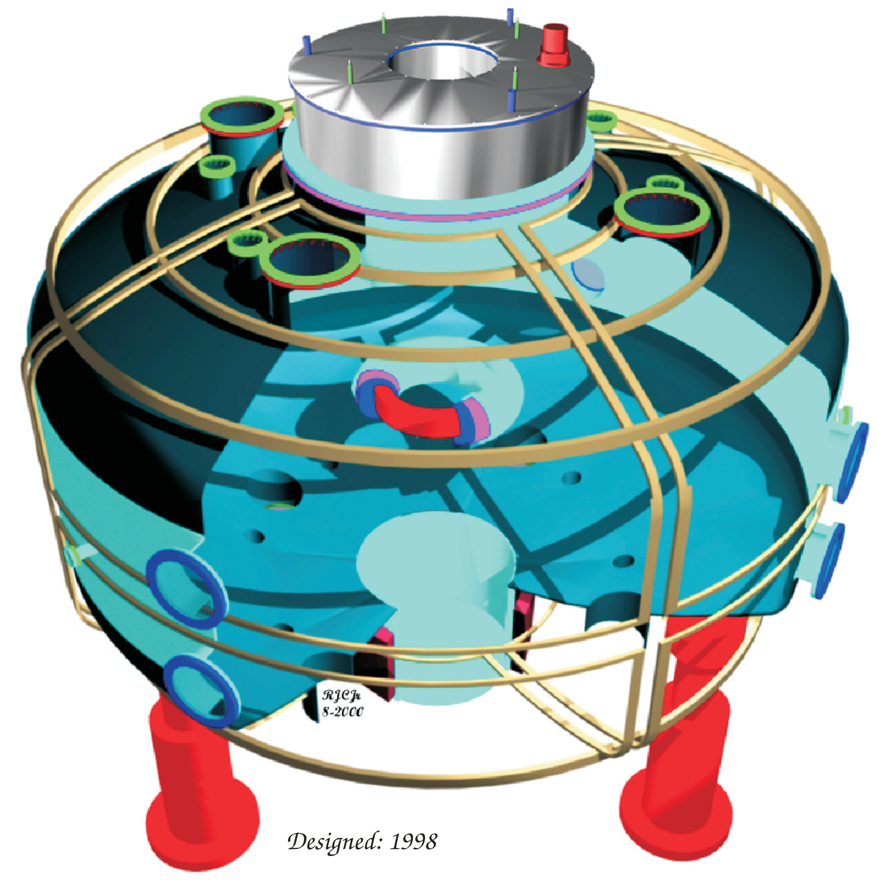


Proposed: 1988



The Levitated Dipole Experiment

The goal of the LDX experimental program is to investigate the possibility of steady-state, high beta dipole confinement with near classical energy confinement ...for the first time!



LDX Superconducting Coil Manufacturing Status:

Floating Coil (714 turns, Nb_3Sn, 5T, 1.3 MA turns)

Ability Engineering (South Holland, IL)

- Floating coil has been completed and tested at full current and encased into high-pressure He vessel
- Final assembly of outer cyrostat is underway

Charging Coil (8000 turns, NbTi, 5T, 4.2 MA turns)

SINTEZ/Science Technology Center (St. Petersburg, Russia)

- Completed R&D tests of conductor, insulation, electromechanical properties
- Coil winding underway
- Manufacturing of cyrostat scheduled

Levitation Coil (1310 turns, High Strength Bi-2223, 0.275 MA turns)

Everson Electric (Allentown, PA)

- Conductor supplied by ASC
- Joint and winding plan complete
- Winding to begin next month

LDX Research Plan

Complete fabrication of the superconducting magnets

- The LDX project required the construction of an entirely new experimental facility that includes three superconducting magnets.

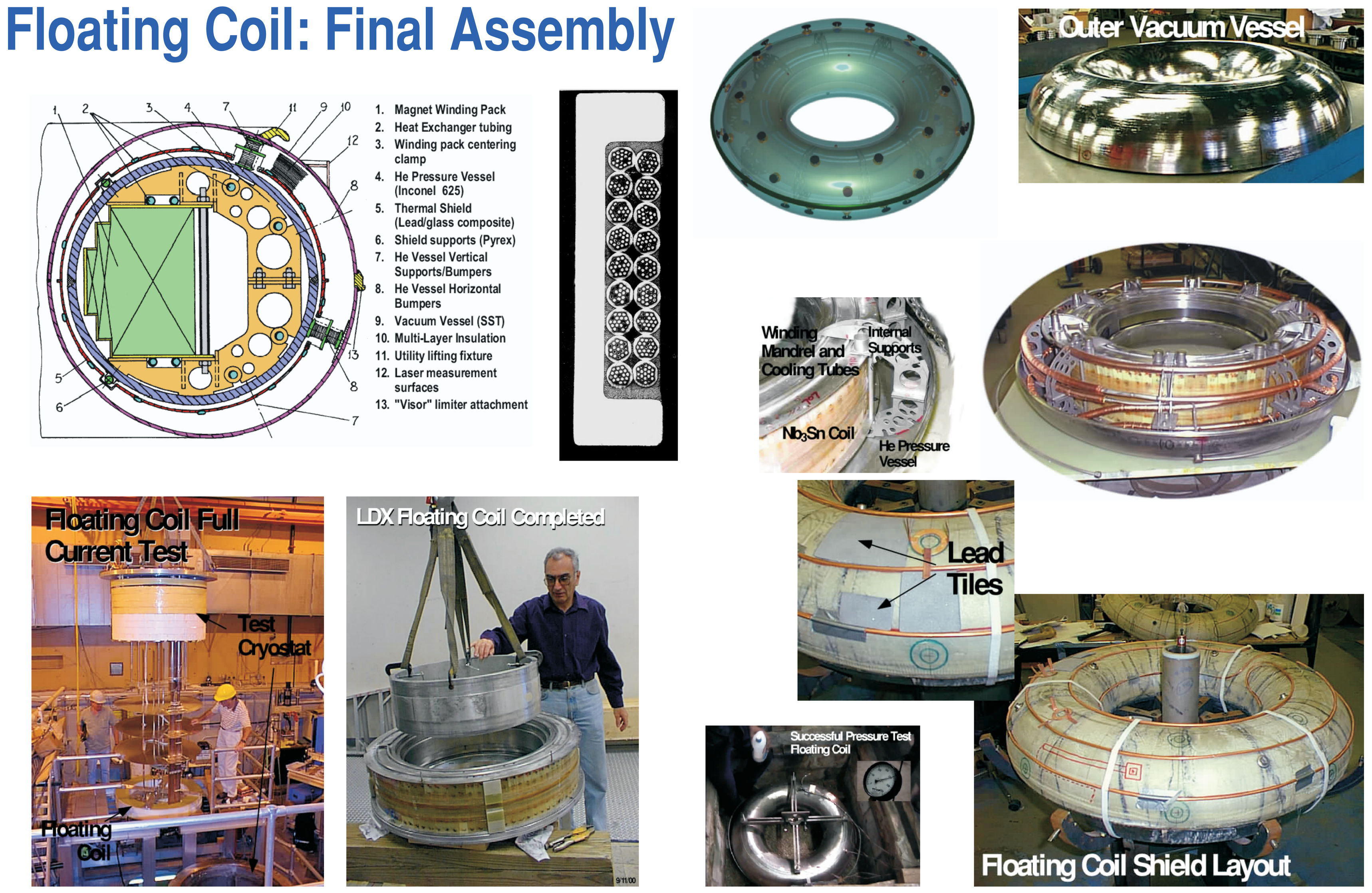
Today, our primary focus is to oversee completion of these magnet systems.

Establish safe and reliable operation

- Initial operation will include experiments with a supported dipole.
- Our launching apparatus (PPPL, CU, MIT) allows levitation while protecting the floating coil from loss of control or quench.

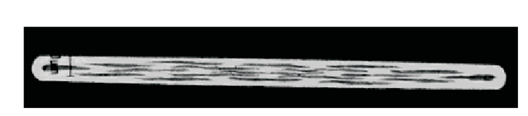
Physics studies include (1) understanding pressure profile effects on MHD stability, (2) electrostatic & magnetic stability, (3) transport and scaling.

Floating Coil: Final Assembly

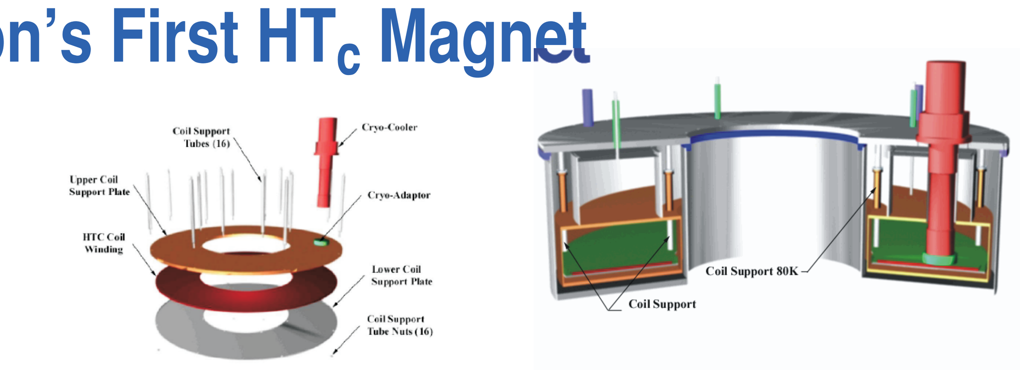


Charging Coil: Winding Underway

Levitation Coil: Fusion's First HT_c Magnet



ASC Bi-2223 "Narrow" Tape



ECRH, Control, Basic Diagnostics On Schedule