

The Role of the Theory Department within PPPL and within the Fusion Energy Sciences Program

**Rob Goldston, Director
DOE Princeton University Plasma Physics Laboratory**

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Theory Plays a Critical Role in PPPL's Mission

- **Mission Statement:**

The DOE Princeton Plasma Physics Laboratory is *a Collaborative National Center* for plasma and fusion science. Its primary mission is to develop *the scientific understanding and the key innovations* which will lead to an attractive energy source.

Associated missions include conducting *world-class research* along the broad frontier of plasma science and technology, and providing the highest quality of *scientific education*.

- **Vision:**

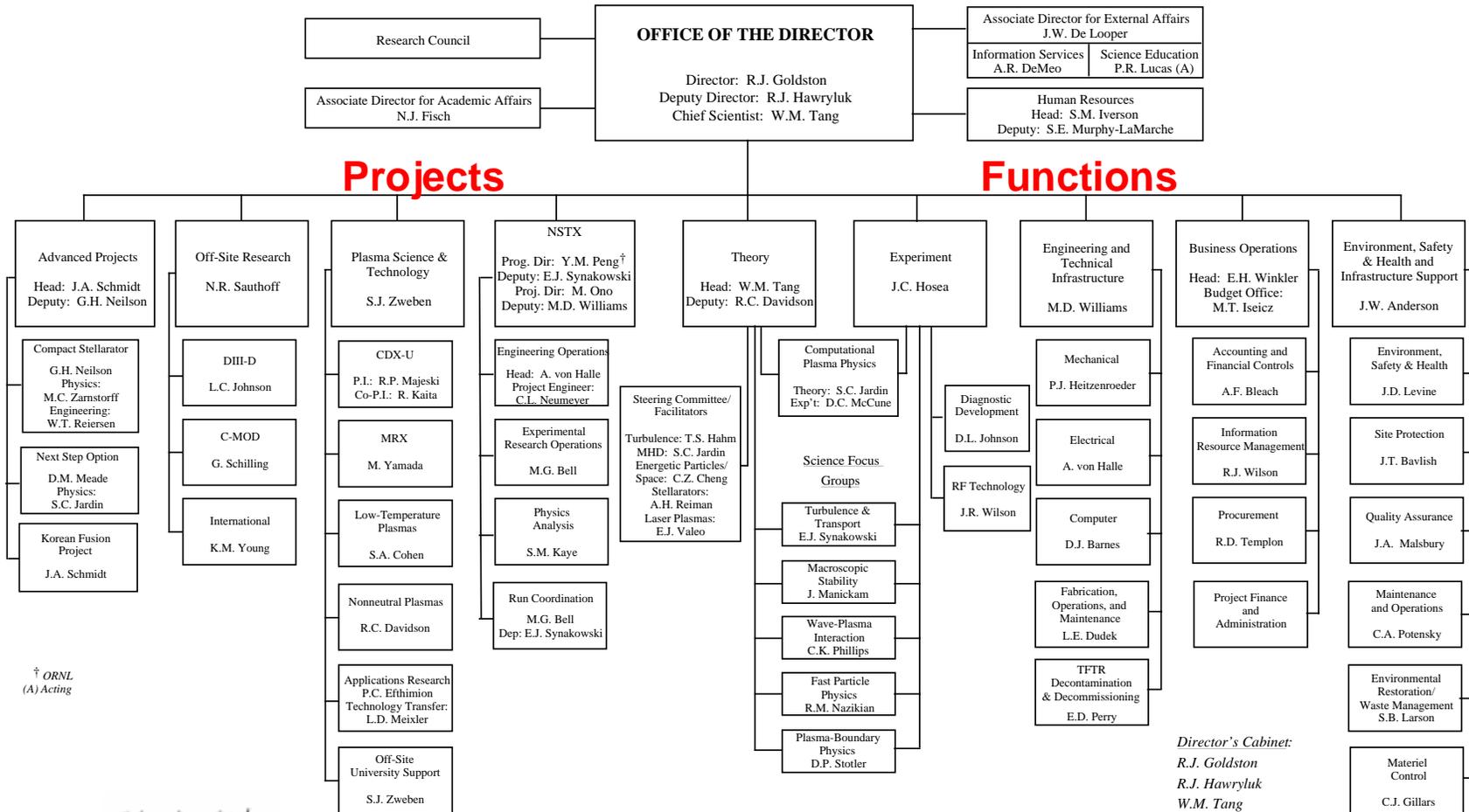
Creating innovations to make fusion power a practical reality.



In Recent Years U.S. Fusion Theory has Resolved Many Mysteries

- **Transport**
 - Thermal diffusivity increasing with radius
 - Importance of edge temperature
 - Unknown mechanism of barrier formation
- **Stability**
 - Short-pulse stability consistent with ideal wall
 - Long-pulse stability limited by mode locking
 - Long-pulse stability limited by mid-m tearing-like modes
- **Fast Particles**
 - Zoology and stability of *AE modes
 - Detailed understanding of nonaxisymmetric effects
- **Boundary**
 - Physics of divertor detachment

PPPL is Organized by Projects and Functions



R.J. Goldston
 Approved: _____
 R.J. Goldston
 Director

Director's Cabinet:
 R.J. Goldston
 R.J. Hawryluk
 W.M. Tang
 W. Happer

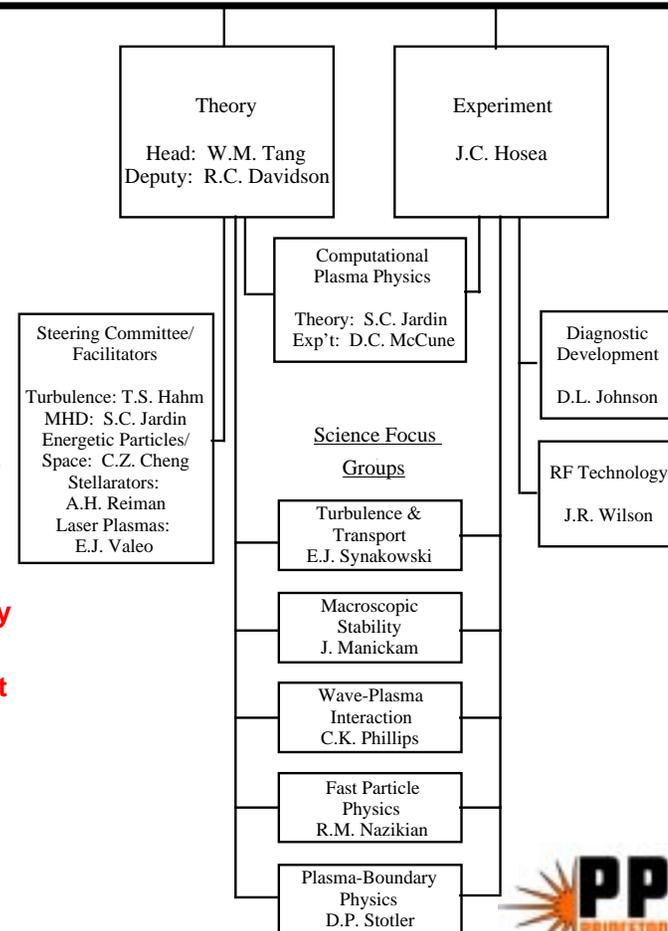
Theory Organization has Evolved at PPPL

- **Theory has been upgraded from a division of Plasma Science & Technology to its own Department**
 - Recognizes increasing importance of theory team
 - Theory Department Head, Bill Tang, also Chief Scientist
 - Outreach is key - Fusion community, DOE (PSACI), Scientific Community
- **Steering Committee (Facilitators) Recognized**
 - Responsible for steering theory activities
 - Facilitate communication and efficiency within theory
- **Science Focus Groups link Theory & Experiment**
 - Organize communication between multiple projects, theory
 - Participated, along with Projects, in development of 5-year Plan
- **Computational Plasma Physics Group**
 - Recognizes the critical role of advanced computation
 - Provides support to both theorists and experimentalists

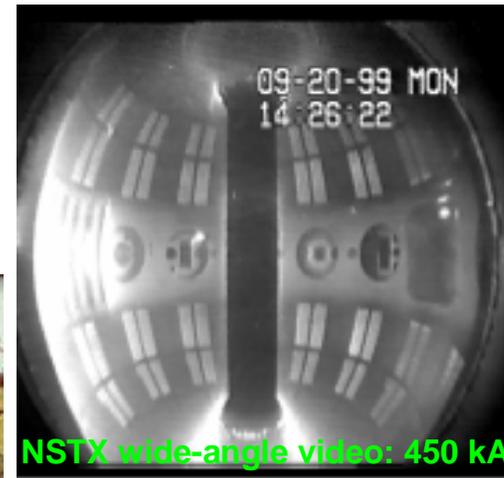


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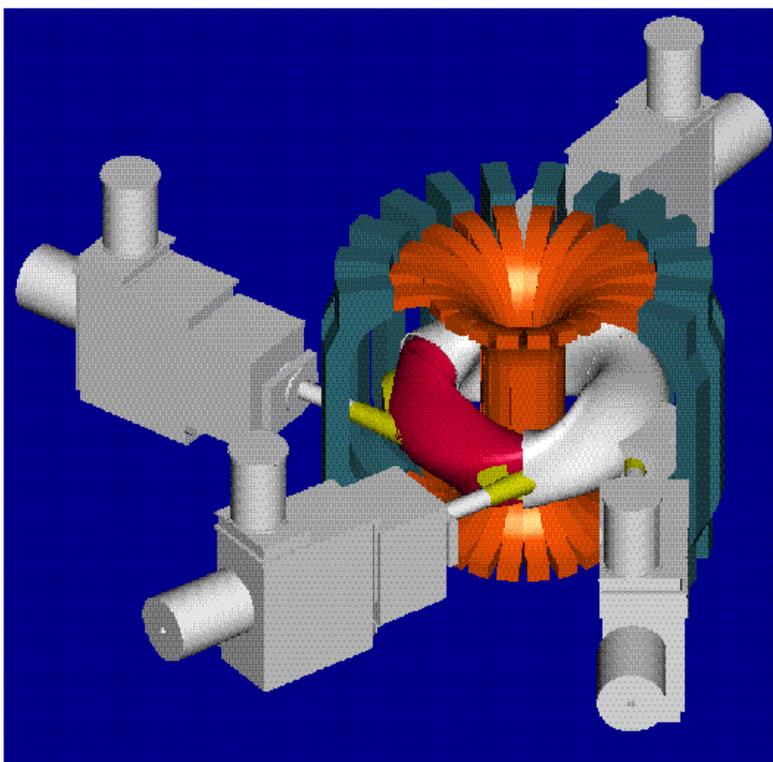
New U.S. Spherical Torus Experiments Came on Line on Budget and Ahead of Schedule



As NSTX begins to bring in detailed data, things will start moving fast. Continuing close involvement of theory will be critical.



NCSX Design is Closely Coupled to Theory



- **Macroscopic Stability:**
 - Stability to kink, ballooning, neoclassical tearing, vertical displacement.
- **Microturbulence and Transport:**
 - Quasi-axisymmetry for ion transport, electric field effects.
- **Wave-particle Interactions:**
 - Non-symmetric fast ion resonances, *AE modes.
- **Plasma-material Interactions:**
 - Effects of magnetic stochasticity.

Auburn U., Columbia U., ORNL, PPPL, U. Texas - Austin, U. Wisconsin

Australia, Japan, Germany, Russia, Switzerland



Major PPPL Off-Site Research Programs Benefit from Theory Team



JET, EU



Inside the Joint European Torus (JET) vacuum vessel, JET Joint Undertaking, UK



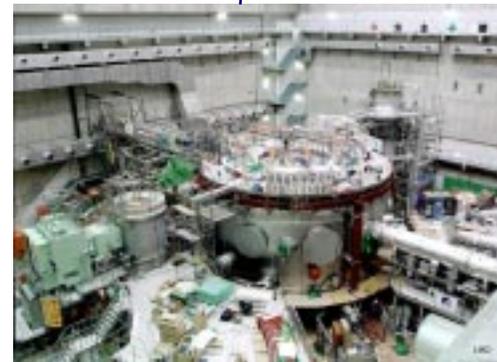
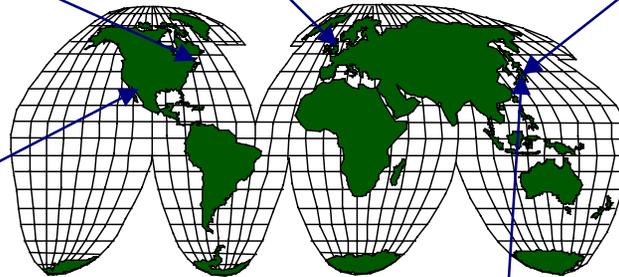
JT-60U, JA

C-MOD, MIT, MA

DIII-D, GA, CA



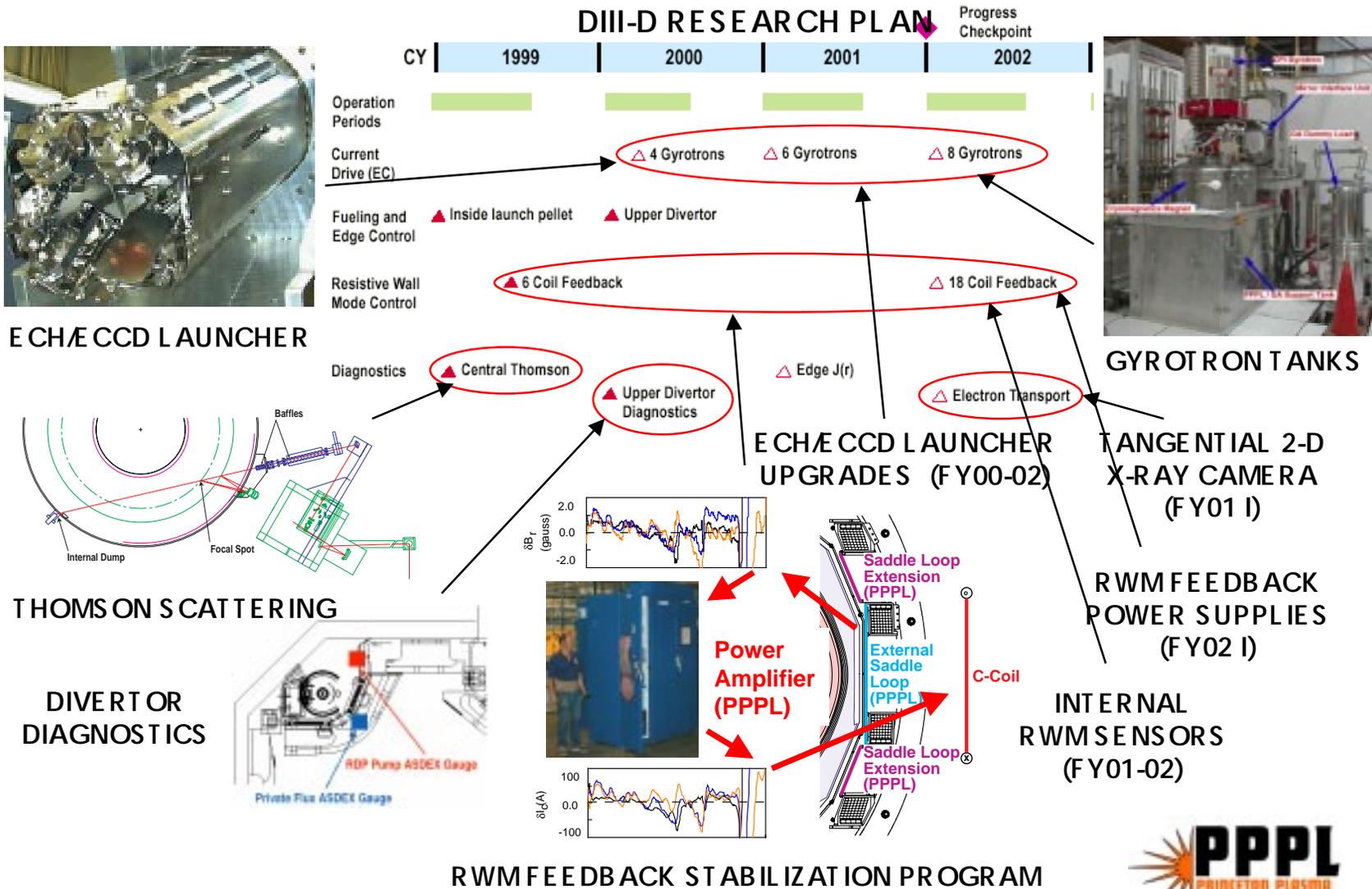
Inside the DIII-D vacuum vessel, General Atomics, USA



LHD, JA

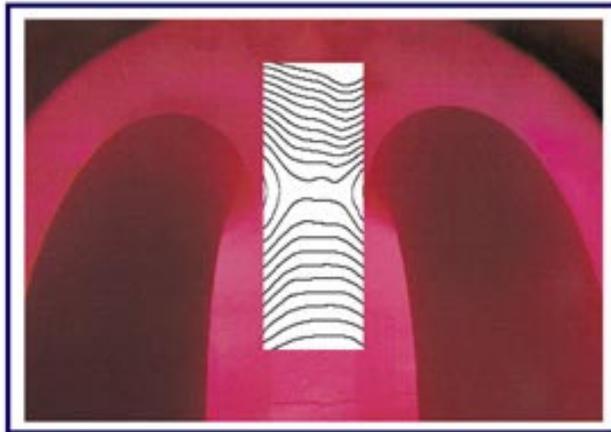


PPPL / DIII-D Progress and Plans

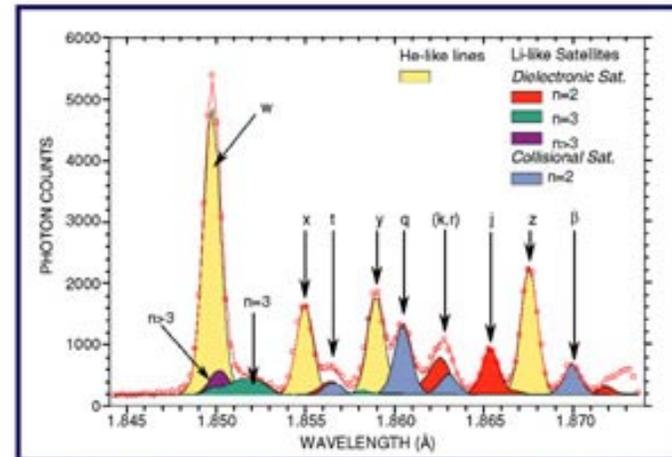


Some Science Benefits of Fusion

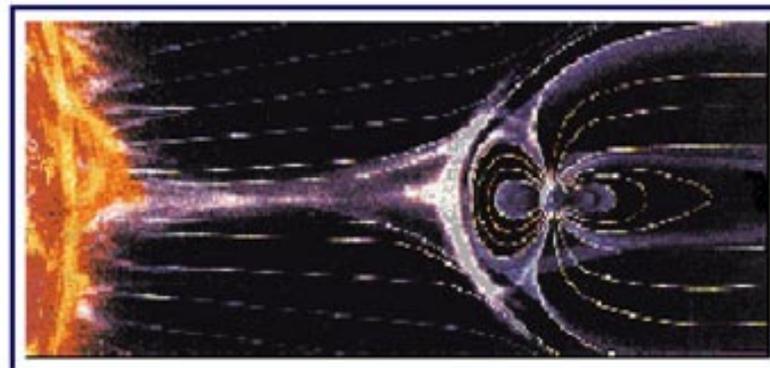
– Space Physics –



MAGNETIC RECONNECTION

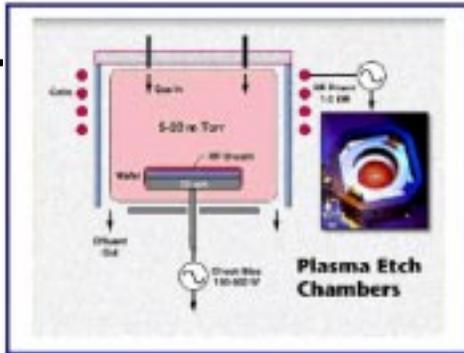


ATOMIC PHYSICS OF LINE RADIATION—IRON SPECTRUM X-RAY CRYSTAL SPECTROMETER



STUDY OF SOLAR WIND EFFECTS

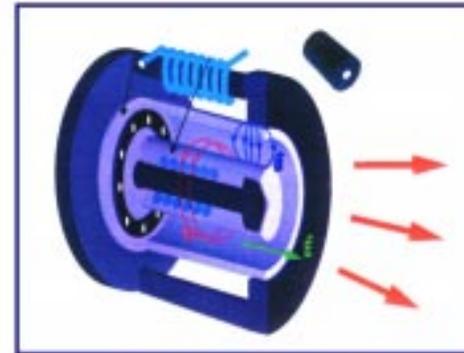
Some Technology Benefits of Fusion



CHIP PROCESSING



USDA PASTEURIZATION
PROCESS



PLASMA THRUSTER



FLAT PANEL DISPLAY



ELECTROSTATIC ATOMIZATION
OF LIQUIDS

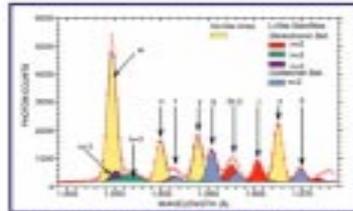


AMTEX PLASMA DIAGNOSTIC

Theory Plays a Key Role in Fusion Outreach



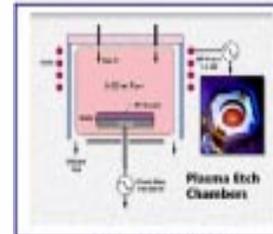
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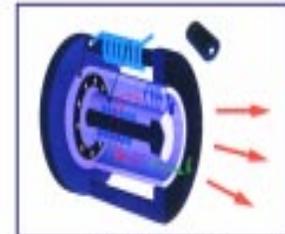
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AMTEX PLASMA DIAGNOSTIC

Science

Technology

Summary

- **Theory and Computation have a growing role at PPPL, and within the OFES program**
 - **PPPL's organization reflects this**
- **PPPL's Theory Department is highly responsive**
 - **To Project needs, both on-site and off-site**
 - **To new ideas in the U.S. and world theory community**
 - **Partnership is key to success**
- **Theory and Computation contribute strongly to outreach**
 - **Within the fusion community, to DOE, to the wider science and technology communities**

