Fusion Power Program at LANL

John Kline
Fusion Energy Science program manager

Fusion Energy Materials Workshop

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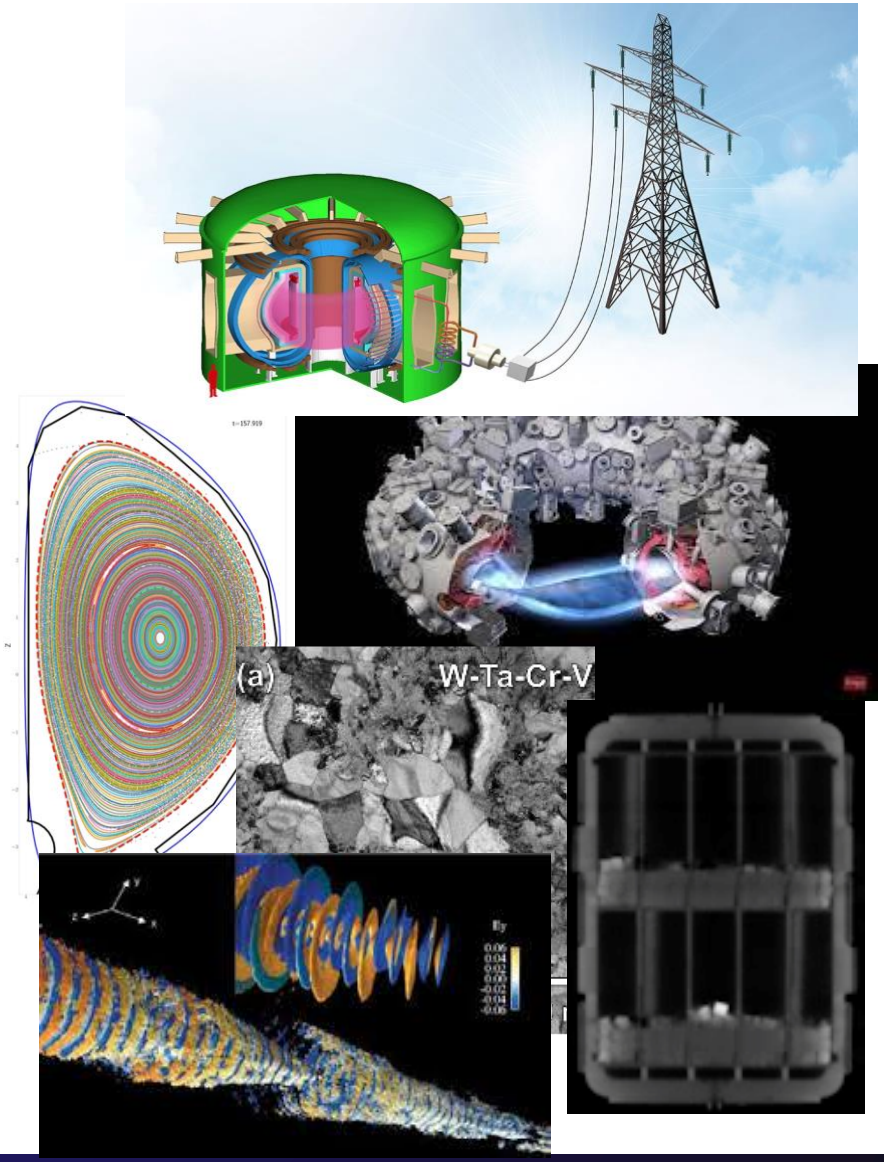
LANL's program focuses on plasma theory/diagnostics, fusion materials, and tritium processing tapping into the lab's vast resources

- **LANL's core companies are:**
  - Fusion Theory and modeling: Whole device modeling, MHD, PIC, and Vlasov code
  - Diagnostics: Nuclear, particle, and optical diagnostics for wide range of Magnetized and Inertial fusion plasmas
  - Materials: theory & modeling, Full development of High Entropy Alloys
  - Tritium: TSTA historical data, Hydrogen processing lab, tritium system design
  - Inertial Fusion Energy target design: Full direct and indirect drive design unique capabilities, Kinetic particle acceleration capabilities for fast ignition

LANL has an extensive fusion research legacy

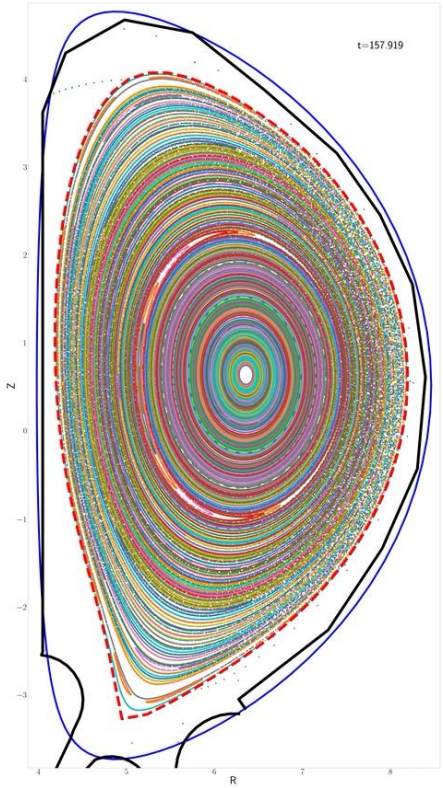


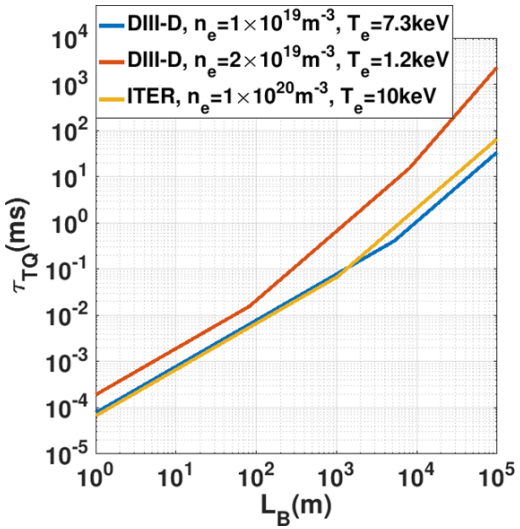
LANL deploys state-of-the-art extended MHD, Particle-in-Cell, and Vlasov to advance our full device modeling of Tokamaks

- Integrate runaway electron dynamics into self consistent electric field evolution to follow the macro-dynamics of a disrupting plasma.
- Account for the full toroidal geometry plus 3D magnetic fields. All known runaway seeding mechanisms

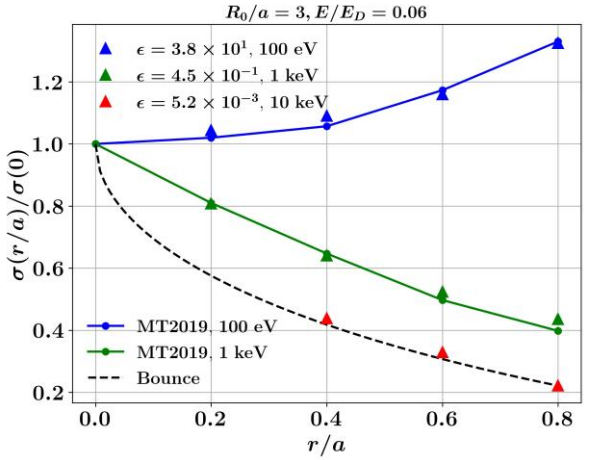
- **Current Capabilities:**
  - Fusion Plasma Theory
  - Computational capabilities
    - *Gyrokinetic codes*
    - *MHD codes*
    - *Particle in Cell codes*
    - *Fokker-Planck codes*
  - Large scale computing

Impact of 3D B-field evolution on Quench





Run Away Electrons



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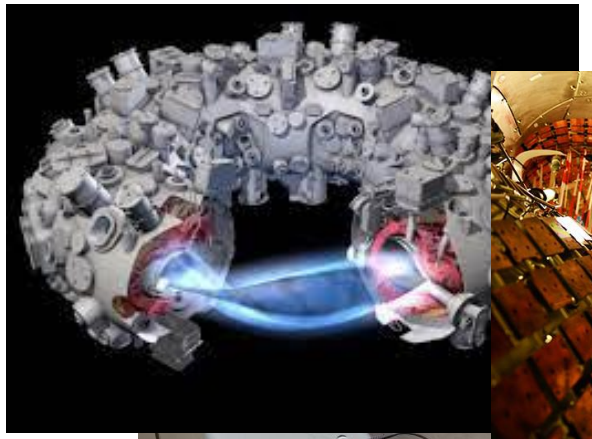
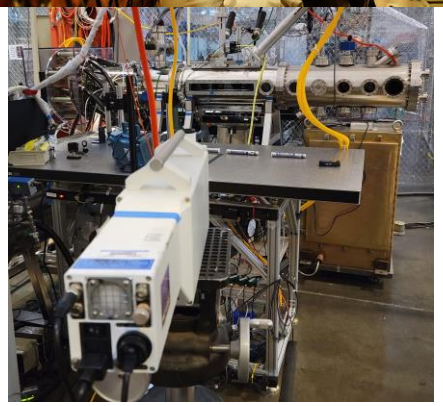
LANL contributes novel diagnostics for fusion experiments around the world

- **Fielding IR imaging bolometer on W7-X to evaluate heat loading**
- **Provide key diagnostic measurements to the FuZE stabilized z-pinch experiment at Zap Energy.**
  - Electromagnetic and Particle Diagnostics for Transformative Fusion Energy Concepts
  - Portable Soft X-Ray Diagnostics for Transformative Fusion-Energy Concepts
- **NNSA: Fusion diagnostics, fast imaging, spectroscopy capabilities that may be useful for MFE**





Capabilities:

- Diagnostic design, assembly, calibration, and fielding
- Engineering support

Wendelstein 7-X

Los Alamos NATIONAL LABORATORY

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IPP Max-Planck-Institut für Plasmaphysik

ZAP ENERGY

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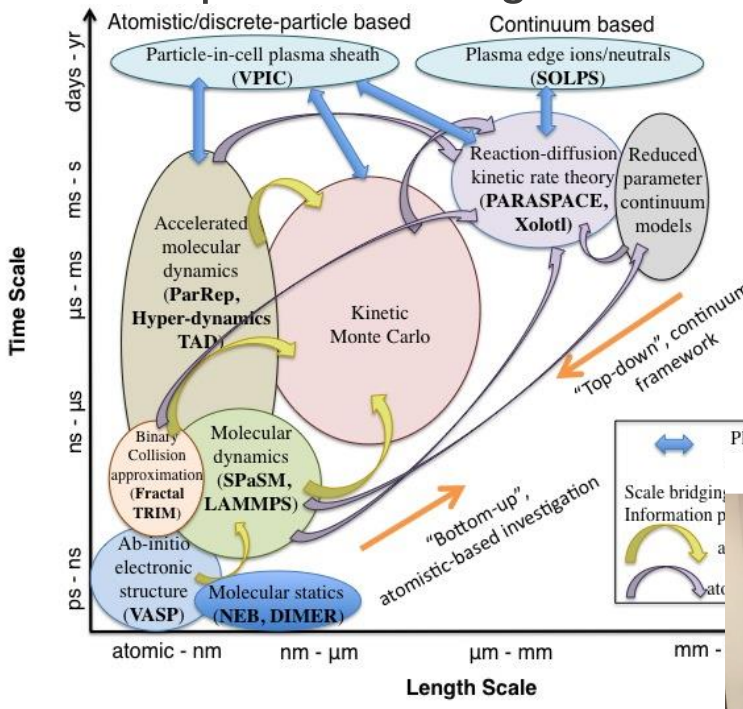
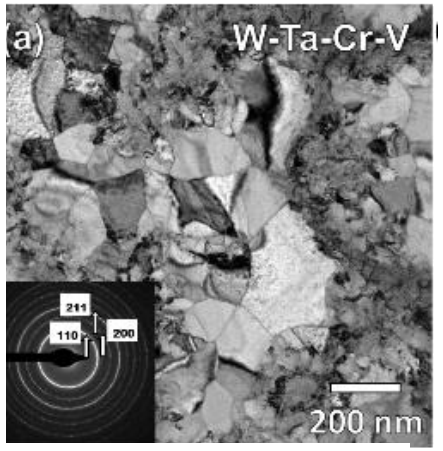
LANL's materials capabilities are leading to designer materials for instance High Entropy Alloys (HEA) or metal hydrides

- Examining HEAs which may maintain strength under extreme radiation conditions
- Plasma surface interaction science is part of a team developing a multiscale paradigm where atomistic insight informs larger-scale models to reach experimental time scales – *PI Brian Wirth*
- **INFUSE:** Fabrication and Characterization of Transition Metal Hydrides for Radiation Shielding in Tokamak Devices in collaboration with **Tokamak Energy** (Caitlin Taylor: LANL Principal investigator)
- **LANL capabilities:**
  - Manufacturing facilities for samples.
  - Local ion beam test facilities
  - Theory/computational codes

Multiscale theoretical framework for plasma facing materials



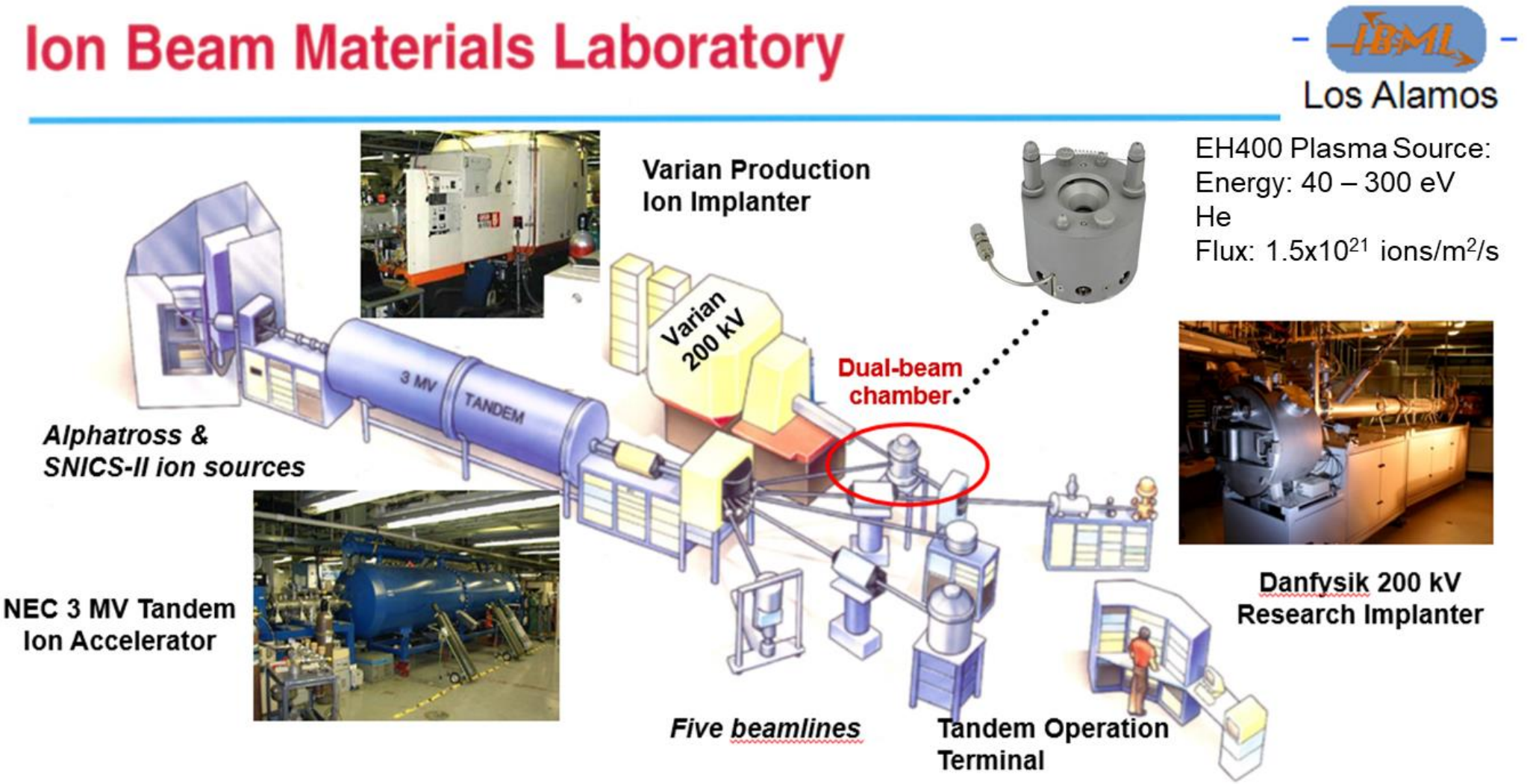
High Entropy Alloys



Synthesis Glovebox in the Hydride Research Lab

LANL's broad materials capabilities that may overlap with fusion energy

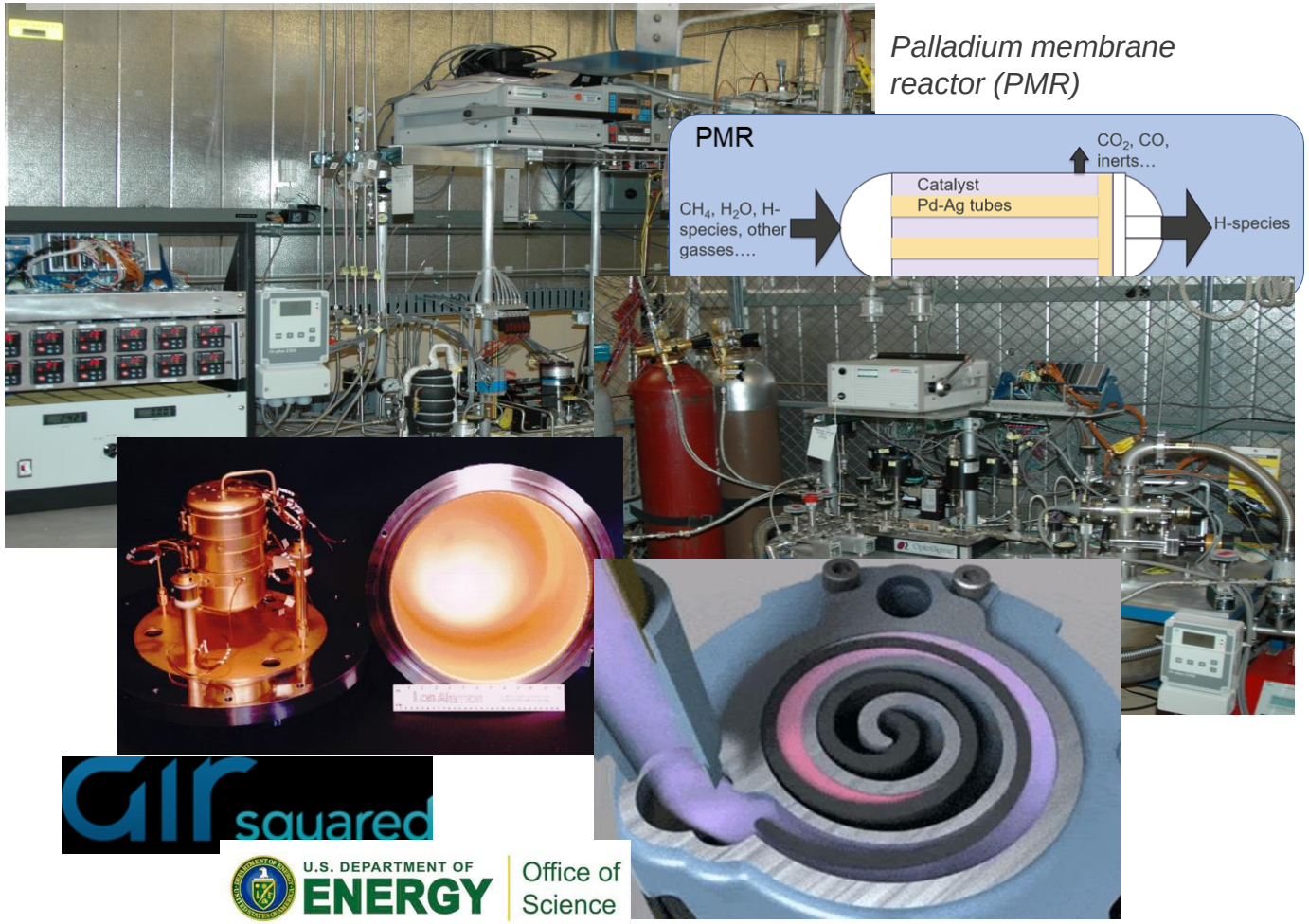
Collaborations with the ion beam materials laboratory provides additional unique fusion materials testing with fission reactor research synergies



LANL continues to understand key aspects for tritium processing often built on empirical models developed in the lab

- **We have Tritium design capability for collection, inventory, etc**
- **We use the Hydrogen Processing Lab to develop and validate models for tritium processing design**
- **We are evaluating scroll pumps for Air Squared for operations in a hydrogen environment**
- **Capabilities:**
  - Component testing with hydrogen/deuterium
  - Development of empirical component models
  - Permeator & separator modeling for chemical processes
  - Tritium pumping and storage
  - Tritium handling system design

Hydrogen Processing Laboratory (HPL)



Palladium membrane reactor (PMR)

air squared

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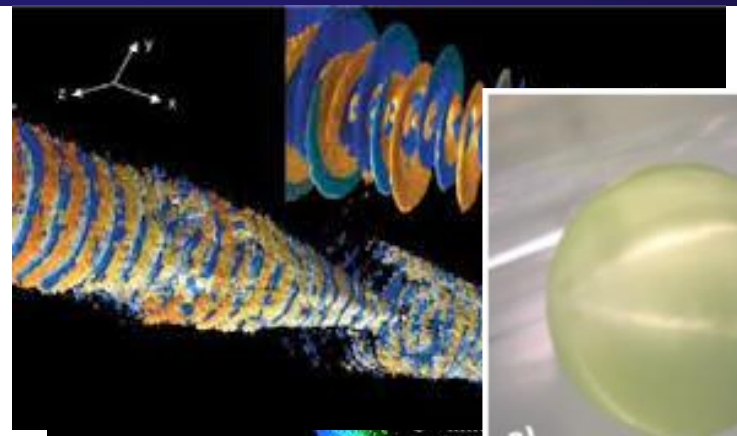
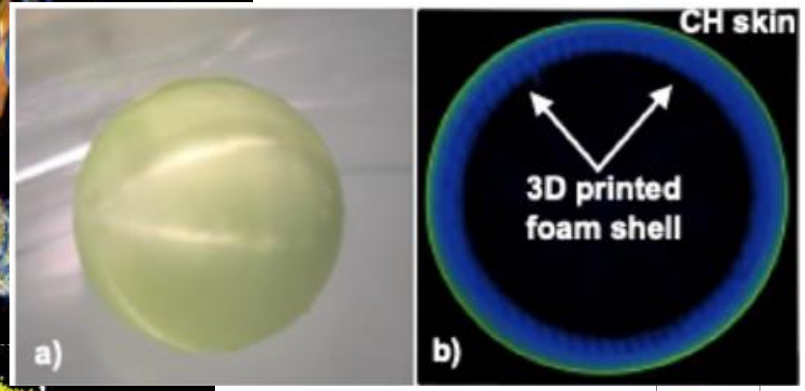
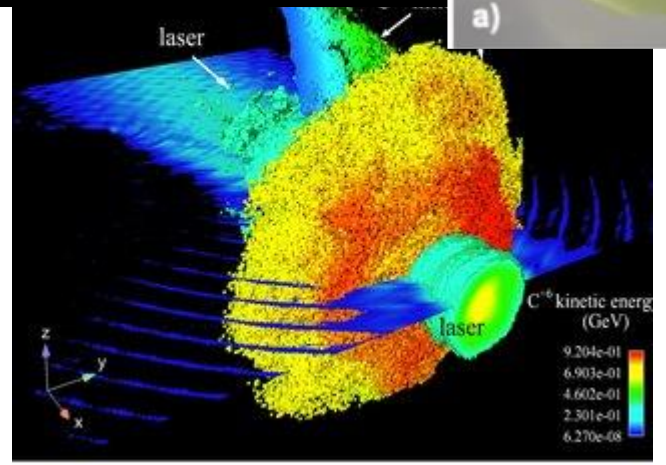
LANL is heavily invested in materials research that may overlap with fusion energy

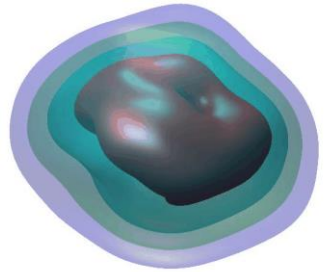
LANL engaging in inertial fusion energy activities as part of a national workshop, as well as looking to team with the private sector

- **Major ICF design lab with computing resources and experimental experience**
- **LANL strengths for IFE include:**
  - *Strong Laser Plasma/Matter Interactions research capabilities for 3D modeling*
  - *Leading the development of liquid layer targets for direct drive after demonstrating them for indirect drive*
  - *Past experience developing particle beam ion sources needed for ion fast ignition*
- **Unique computation capabilities for integrated 3D target simulations**
  - xRage Eulerian code
  - iFP Vlasov-Fokker-Planck code for kinetics
- **Expertise in nuclear fusion diagnostics with novel development to deliver capabilities**









LANL's capabilities extend beyond those shown that may be useful for novel ideas to advance fusion energy

- **Engaging the LANL pillars to invest in the strategic plan and partner with the LDRD office**
  - Fusion Plasmas (Nuclear and particles)
  - Materials in Extreme environments (Materials)
- ***Improving coor*dination across Office of Science (Fusion Energy Sciences: INFUSE), Applied Energy (ARPA-E), and Strategic Partnership Programs (Public Private Partnerships).**
- **We are working with the Feynman Center for Innovation to improve processes for working with the public**
  - Technology Transfer
  - CRADA
  - Licensing
  - SBIR

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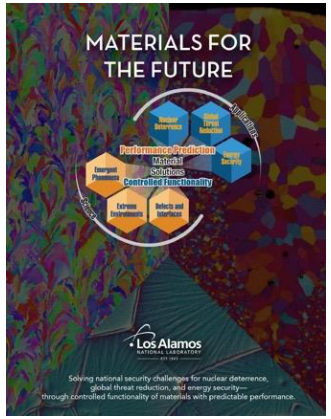
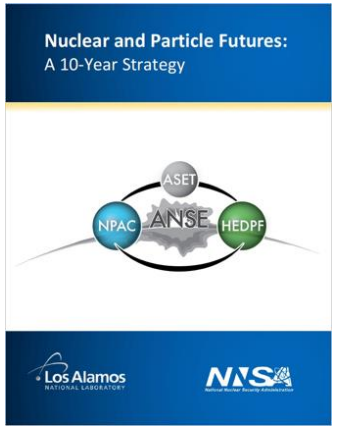
PARTNERSHIPS & PIPELINE OFFICE





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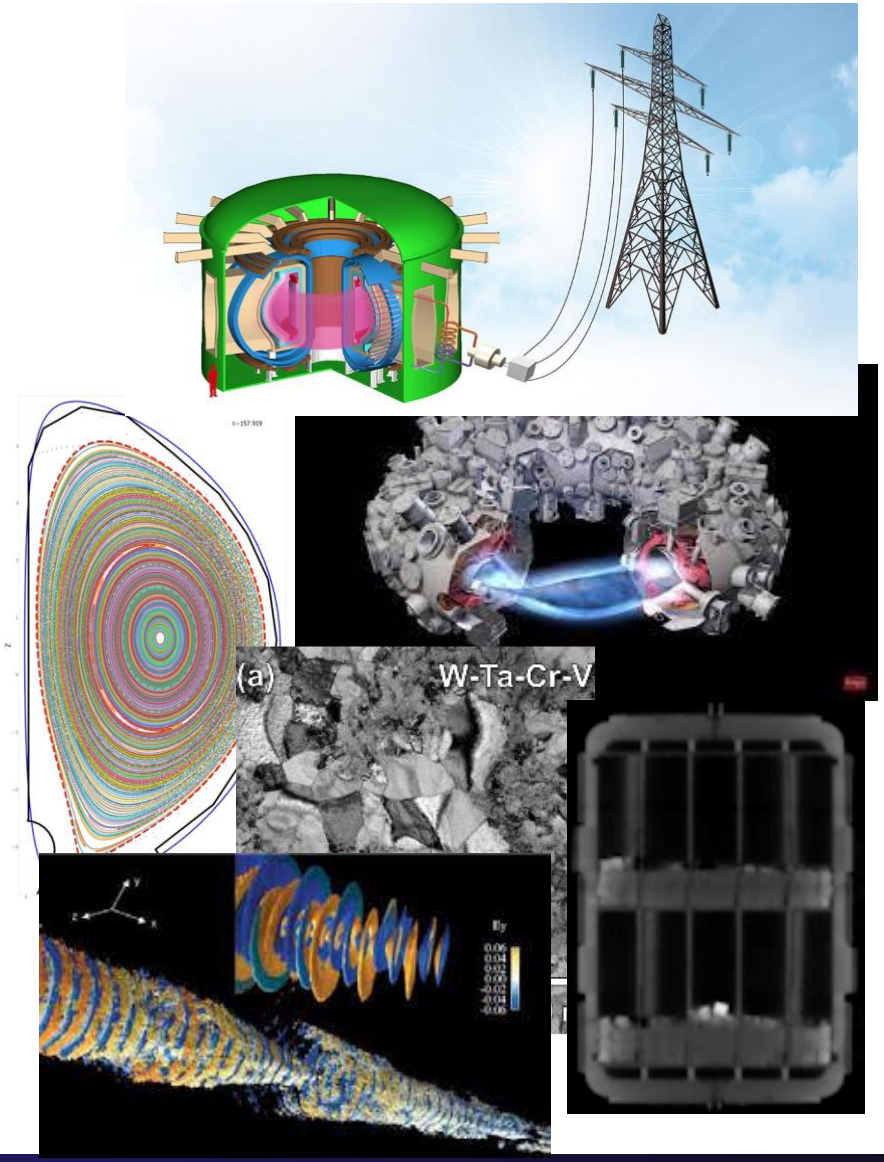
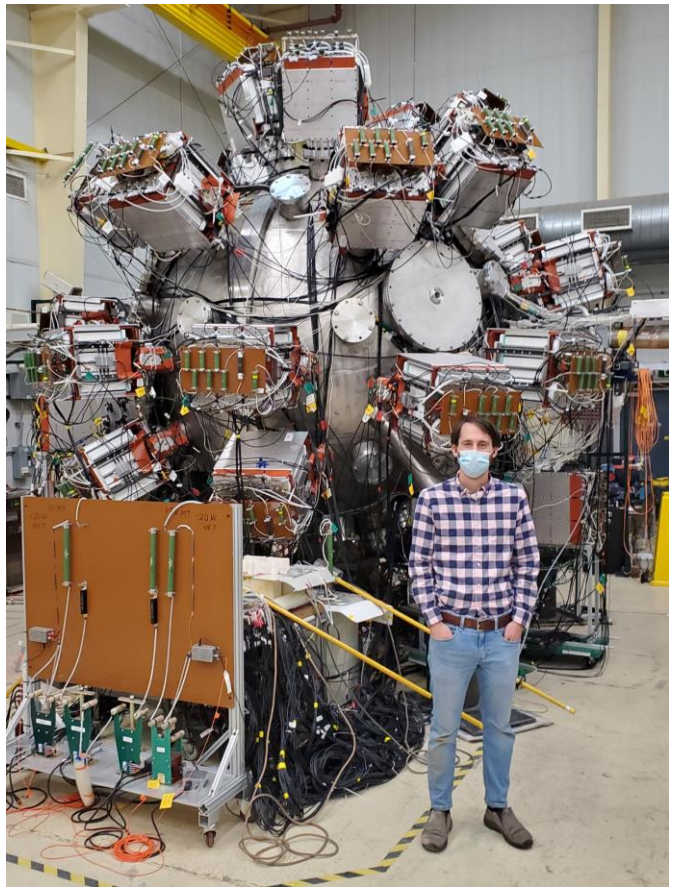


National Nuclear Security Administration
Operated by Los Alamos National Security, LLC for the U.S. Department of Energy's NNSA

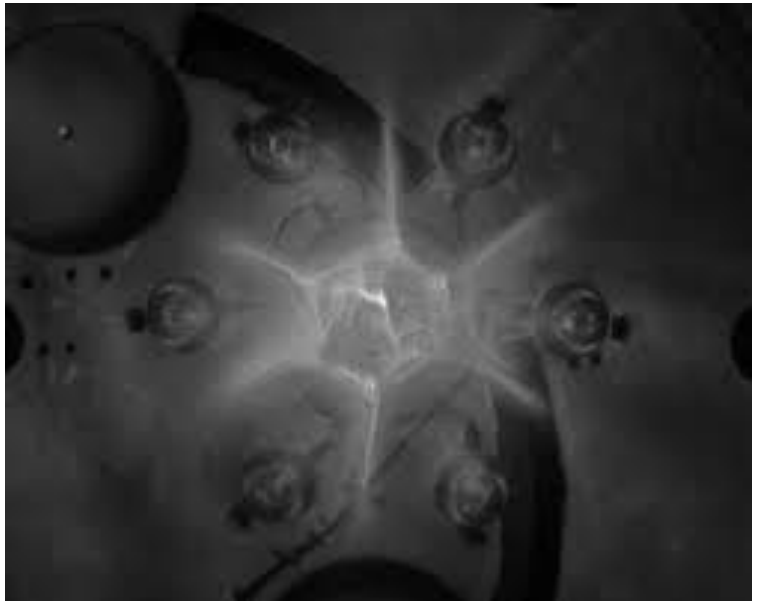
LANL continues to make progress developing Plasma Liner Experiment (PLX) to investigate the efficacy of plasma jet driven magnetized target fusion

PLX with all guns



Schematic for PLX

Plasma Image from multi-jet experiment



Team: S. Langendorf, Feng Chu, T. Byvank* (*now in XTD)