U.S. DEPARTMENT OF ENERGY | Office of Science

Fusion Technology Program Overview

3/2/2022

FES Program Manager

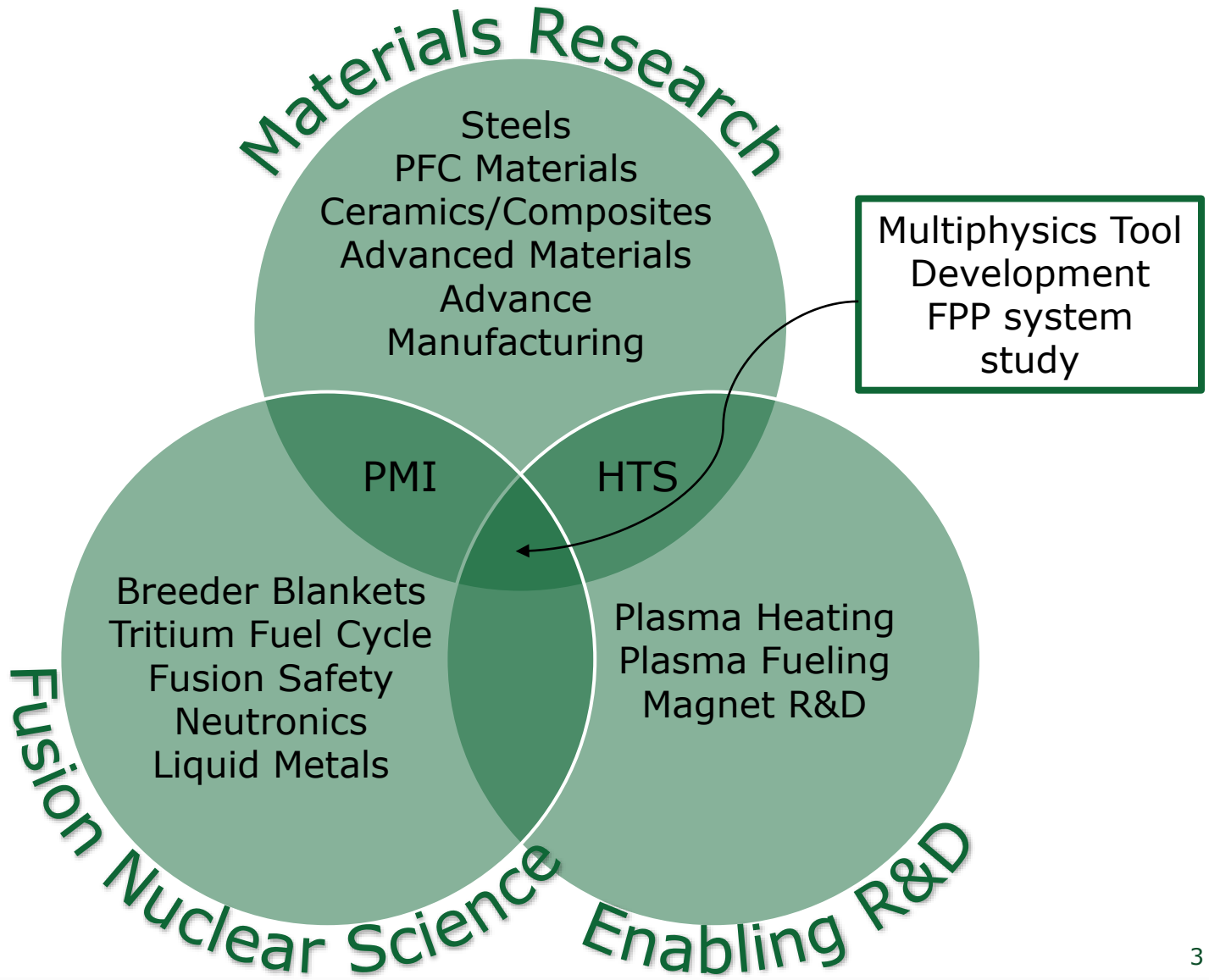
Dr. Guinevere Shaw

About me?

- PhD from University of Tennessee – Knoxville
  - Dissertation focused on fusion materials and the application of laser-based characterization techniques
- FES Program Manager – 2018
  - Fusion Nuclear Science
  - Enabling R&D
  - Fusion Education, Outreach, and Workforce Development
- New Parent – 2021

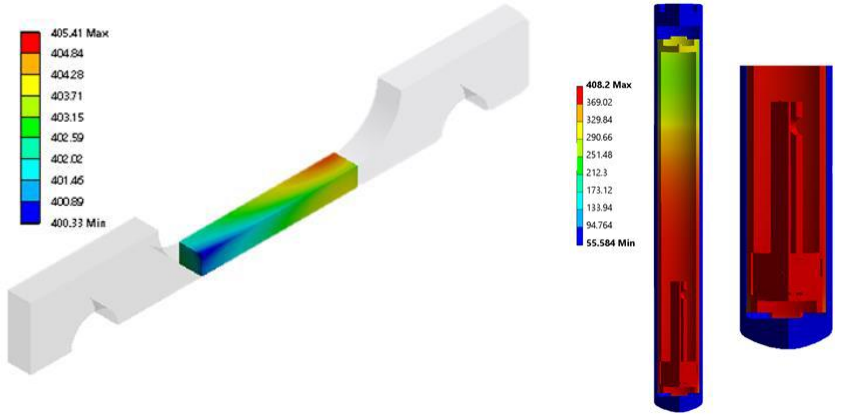
FES Technology Research Overview

- Research in support of fusion energy
- Focused on understanding and meeting material and technology requirements for a fusion power plant
- Research is applicable to all D-T magnetic fusion concepts



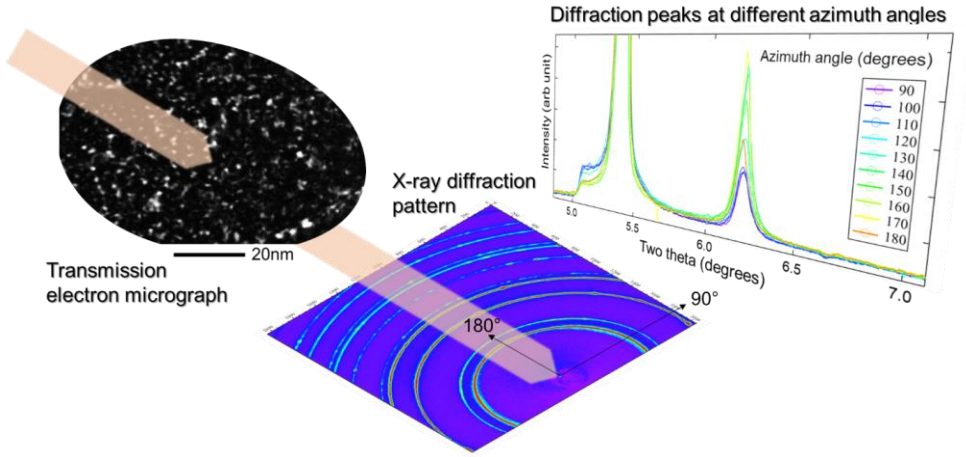
Fusion Materials

- **High Flux Isotope Reactor (HFIR)**
  - Continues to be a workhorse and center of excellence for both the domestic and international fusion materials research programs
  - Nexus for current and proposed international collaborations, including Japan (QST, NIFS), EUROfusion, and the UK
  - Actively developing novel irradiation capabilities to explore fusion relevant regimes, including helium effects studies, hydrogen charging experiments, and in-situ corrosion experiments



Temperature distribution calculations for novel in-situ corrosion experiments in HFIR

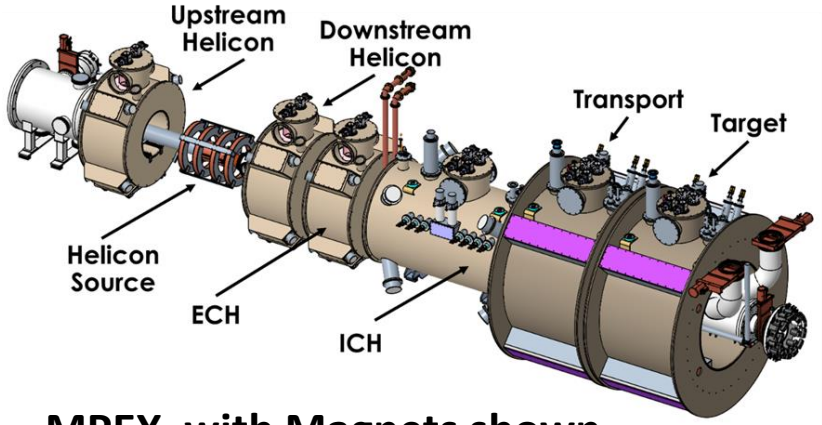
- **National Synchrotron Light Source II (NSLS-II)**
  - Synchrotron-based microstructural characterization techniques are increasingly powerful for application to fusion materials research
  - Increased domestic and international interest in these synchrotron methods, which complement traditional characterization approaches
  - New funding for direct collaborative experiments provide enhanced facility access through researchers at Stony Brook University



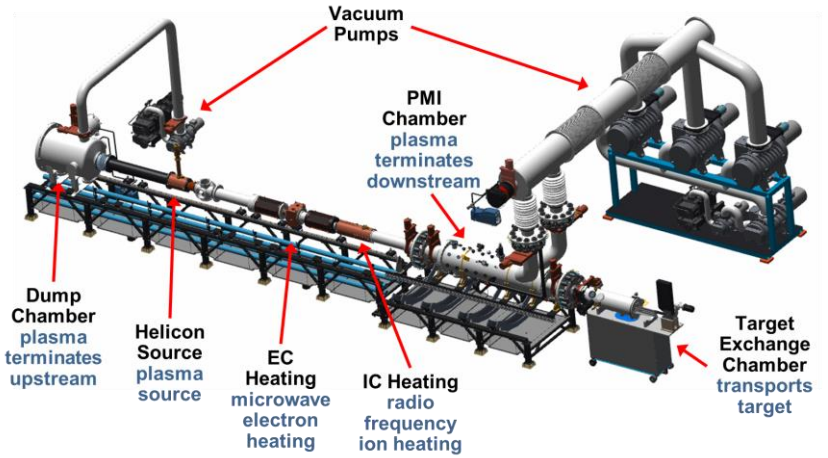
X-ray diffraction analysis at NSLS-II

Material Plasma Exposure eXperiment (MPEX)

- The MPEX project (TPC estimate -$120M) is currently on schedule and on budget for the baselined scope
- To date, the project has:
  - Completed Critical Decision - 1, Approval of Alternative Selection and Cost Range, on February 3, 2020
  - Completed Critical Decision - 3A (CD-3A), Approval of Long-Lead Procurements, on October 29, 2020
  - Awarded contracts for the Magnet system, Gyrotrons, High Voltage Power Supply (HVPS), and building reconfiguration
  - Completed all 29 milestones on or ahead of schedule
- Coming in FY22
  - Critical Decision – 2/3, Approve Performance Baseline and Start of Execution



MPEX with Magnets shown

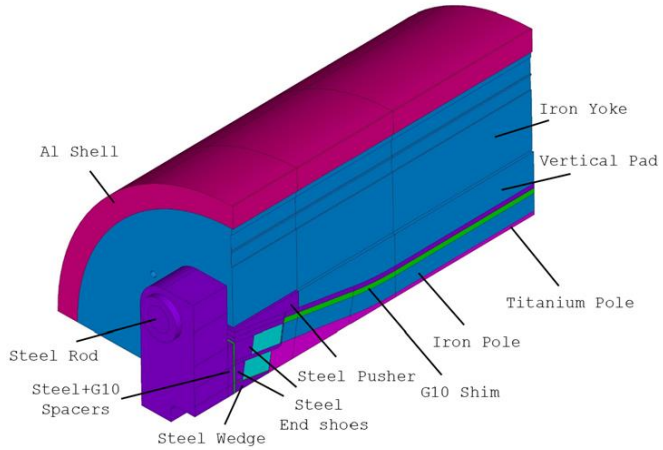


MPEX Heating and Support Systems without Magnets

Enabling R&D

High-Field Vertical Test Stand

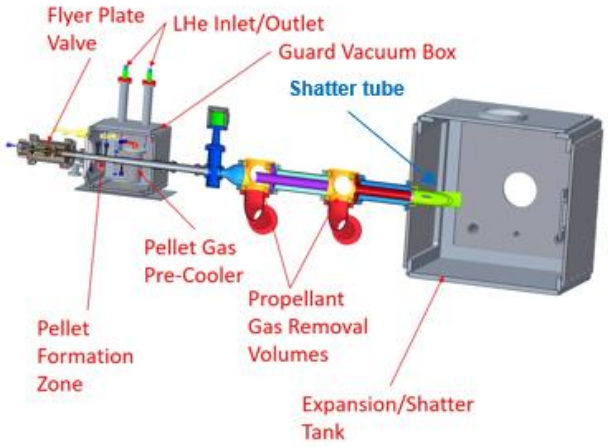
- FES and HEP have joined forces to support the development of a unique world-class High-Field Vertical Test Stand.
- First External Oversight Committee (EOC) meeting held in Jan. 2021 to solicit input on the magnet design and fabrication approach
- Coil fabrication by LBNL to start in early 2022
- Estimated completion by June 2025



High-Field Dipole 3D Design

Shattered Pellet Injector R&D

- ORNL has constructed an ITER-like SPI testbed and conducted experiments to inform the design of the ITER SPI system
- This is the first step in determining the optimal fragment size distribution and shatter tube design needed for the ITER shattered pellet injection system



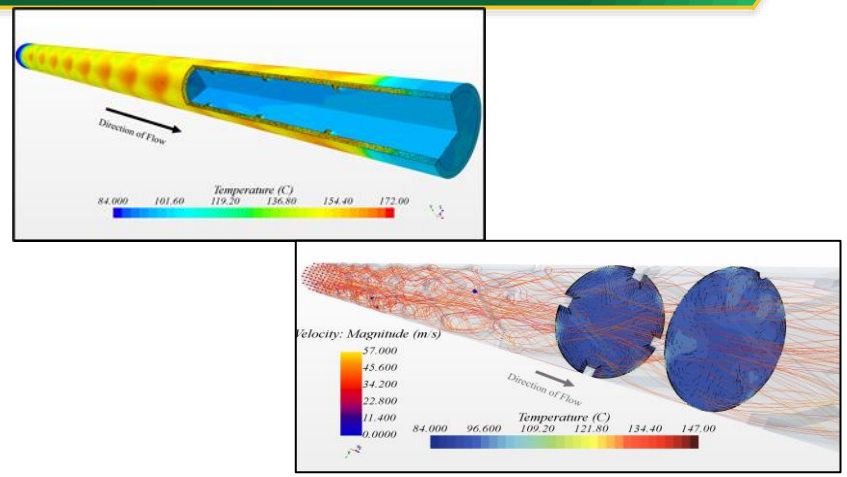
ITER SPI Testbed

Fusion Nuclear Science

US Blanket and Fuel Cycle Program

A multi-institutional domestic program focused on helium cooled, PbLi liquid breeder and solid breeder with RAFM and advanced RAFM structure

- Focused research on tritium extraction, hydrogen isolation for direct internal recycle, solid breeder material characterization and exploration., PbLi liquid metal compatibility and simulations, and advanced helium cooling



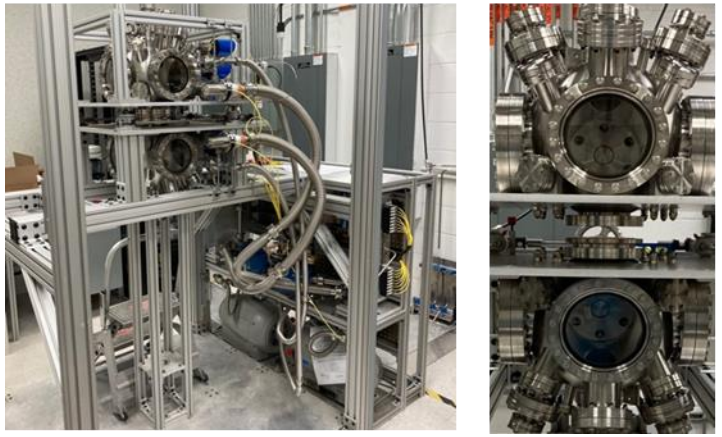
Shimada & Fuerst

US Fusion Safety Program

The INL's Fusion Safety Program (FSP) is the Office of Fusion Energy Science's (OFES's) Lead Laboratory for Magnetic Fusion Energy (MFE) Safety.

- Focused research on Tritium retention and permeation in fusion plasma facing component (PFC) and blanket materials, fusion safety code development, dust and radiological source characterization, dust collection, and material oxidation, and material safety research at the Safety and Tritium Applied Research (STAR) facility

Permeation Experiment for Asymmetric Surfaces (PEAS)

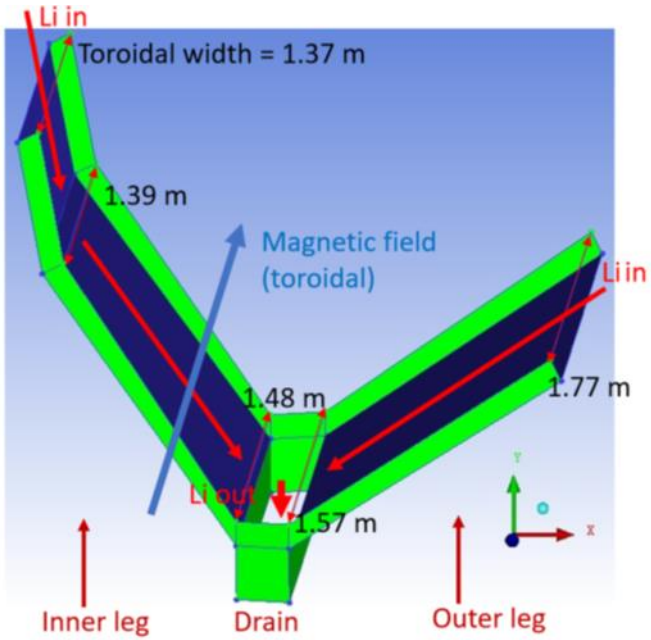


Fusion Nuclear Science

Liquid Metal Research

A domestic liquid metal plasma-facing component (PFC) design program was initiated by Fusion Energy Sciences (FES) in the fall of 2019. Progress has been made on three sets of coupled activities:

- Design calculations of heat transfer and liquid metal (LM) flow for candidate PFC designs for a well-characterized base case, the fusion nuclear science facility (FNSF)
- Experimental activities in test stands to close LM technology and science gaps
- Experimental activities in prototypical flow geometry, e.g. in a linear configuration with applied magnetic fields



Virtual Laboratory for Technology Update 2021

- Updating each topical area
- Re-establish webinars, Jan 2022
- Create regular highlights (quarterly)
- Archiving Historical Workshops
- Institutional links from US Map

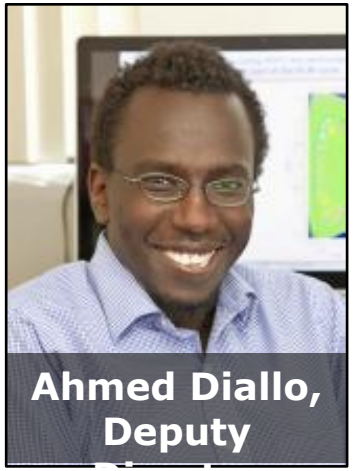
https://vltfusion.org/

Enabling Technologies
Radio-Frequency heating and current drive
Magnet systems
Remote Handling
Measurement and Diagnostics
Materials and High Heat Flux
Fusion materials research
Plasma facing components and plasma material interactions
Blanket, Fuel Cycle and Design
Fueling systems
Blanket research and development
Tritium and Fuel Cycle Research
Fusion safety
Fusion energy systems studies and fusion nuclear facility design

Innovation Network for Fusion Energy (INFUSE)

- **INFUSE** is now in its fourth year
- To date, **39** awards totaling **$7.6M** have been made, enabling **8** DOE national labs to collaborate with **15** fusion companies
- 1st round 2022 RFA call is now closed.
- A pilot program for **University** participation will be launched FY 2022

OAK RIDGE National Laboratory

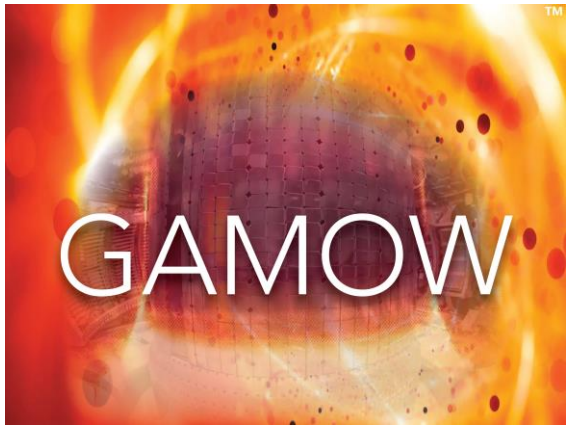


PPPL

https://infuse.ornl.gov/

Galvanizing Advances in Market-aligned fusion for an Overabundance of Watts (GAMOW)

- Bridge 12 Technologies - High Efficiency, Megawatt-Class Gyrotrons for Instability Control of Burning-Plasma Machines
- Colorado School of Mines - Interfacial-Engineered Membranes for Efficient Tritium Extraction
- Oak Ridge National Laboratory (ORNL) - Fusion Energy Reactor Models Integrator (FERMI)
- Oak Ridge National Laboratory (ORNL) - Advance Castable Nanostructured Alloys for First-Wall/Blanket Applications
- Oak Ridge National Laboratory (ORNL) - Plasma-Facing Component Innovations by Advanced Manufacturing and Design
- Pacific Northwest National Laboratory (PNNL) - Microstructure Optimization and Novel Processing Development of ODS Steels for Fusion Environments
- Phoenix - Application of Plasma-Window Technology to Enable an Ultra-High-Flux DT Neutron Source
- Princeton Fusion Systems - Wide-Bandgap Semiconductor Amplifiers for Plasma Heating and Control
- Savannah River National Laboratory - EM-Enhanced HyPOR Loop for Fast Fusion Fuel Cycles
- Savannah River National Laboratory - Process Intensification Scale-Up of Direct LiT Electrolysis
- Stony Brook University - ENHANCED Shield: A Critical Materials Technology Enabling Compact Superconducting Tokamaks
- University of California, Los Angeles (UCLA) - AMPERE - Advanced Materials for Plasma-Exposed Robust Electrodes
- University of California, San Diego (UC San Diego) - Renewable low-Z wall for fusion reactors with built-in tritium recovery
- University of Houston - Advanced HTS Conductors Customized for Fusion



https://arpa-e.energy.gov/technologies/programs/gamow

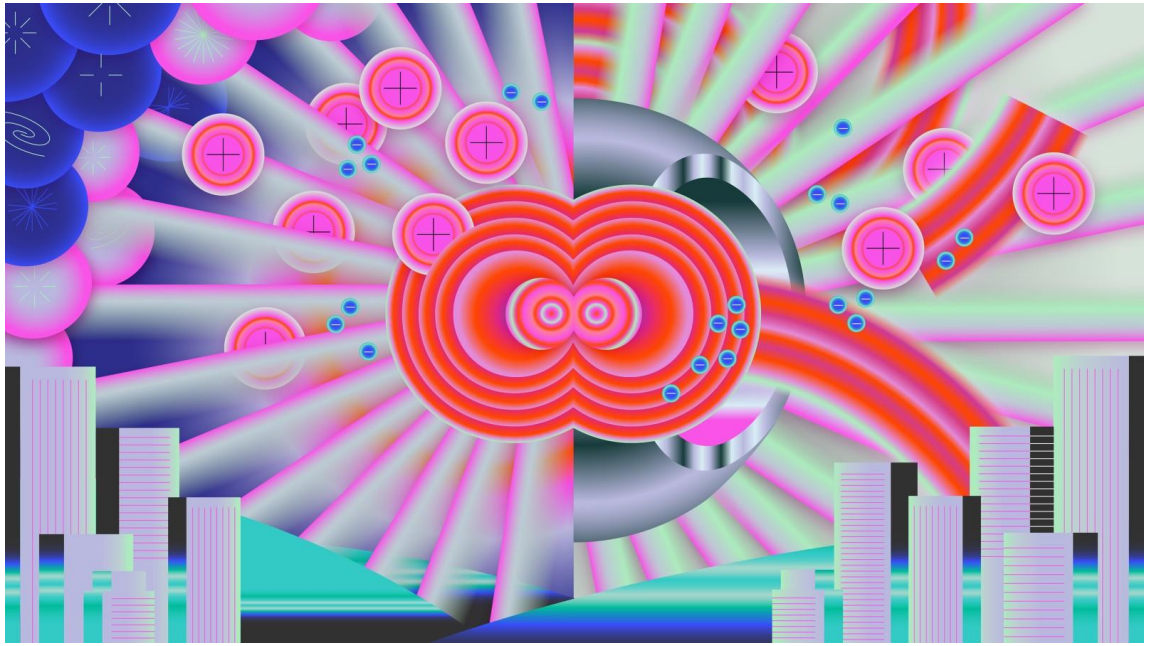
Fusion Outreach and Workforce Development

- Early Career Opportunities
  - Office of Science ECA – https://science.osti.gov/early-career
  - Office of Science Reviewer – TBD (contact me)
  - FES Postdoctoral Fellowship - https://www.orau.gov/doe-fes-postdoc/default.html
- Student Opportunities
  - Office of Science Graduate Research https://science.osti.gov/wdts/scgsr
  - Plasma and Fusion Undergraduate Research Opportunities (PFURO) - https://www.pppl.gov/plasma-and-fusion-undergraduate-research-opportunities-pfuro

And much more…

U.S. Fusion Energy Website

- Organized and designed by the FES community
  - Fusion Outreach Team
- Aligns with the FESAC LRP
- Provides the community and the general public
  - Introduction and general education on Fusion and Plasma Science
  - Current Fusion and Plasma Science News
  - Fusion and Plasma Science Events
  - Fusion and Plasma Science Support in government and industry
  - Student engagement and research opportunities



https://usfusionenergy.org/

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