



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Fusion Energy Sciences Perspective

John Mandrekas
Director, Research Division
Fusion Energy Sciences

43rd Fusion Power Associates Annual Meeting

December 7-8, 2022

Outline

- ▶ Budget Status
- ▶ Office Developments
- ▶ Facilities and Projects
- ▶ Other Program Updates
- ▶ Strategic Planning
- ▶ Other updates



Budget status

- ▶ Budget requests continue to be guided by the FESAC Long-Range Plan, recent NASEM reports, and the Administration's Bold Decadal Vision for commercial fusion development

▶ **FY 2023**

- ▶ Currently, operating under a Continuing Resolution until December 16
 - ▶ FY 2023 Request: \$723,222K
 - ▶ House Mark: \$768,222K
 - ▶ Senate Mark: \$743,222K

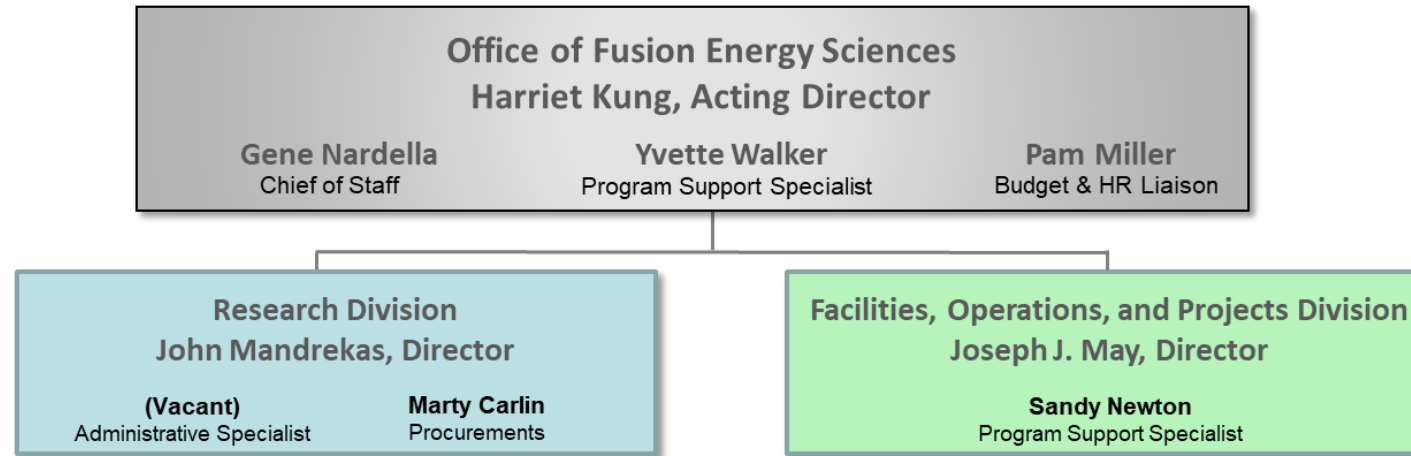
▶ **FY 2024**

- ▶ The FY 2024 Budget Request is under preparation

- ▶ Budget Status
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FES during the search for a new AD

The SC Deputy Director for Science Programs, Dr. **Harriet Kung**, is serving as the Acting AD for FES



We also work very closely with:



Dr. **Scott Hsu** is the DOE Lead Fusion Coordinator in the Office of the Under Secretary for Science and Innovation



Dr. **Rich Hawryluk** joined DOE/SC as Senior Technical Advisor to Dr. Kung. He also represents FES as the co-chair of the Fusion Crosscut Team during the interim period

Other people updates



- Dr. **Asmeret Asefaw Berhe** was sworn in as the Director of the DOE Office of Science on May 19, 2022
- Dr. Berhe was most recently a Professor of Soil Biogeochemistry; the Ted and Jan Falasco Chair in Earth Sciences and Geology; and Interim Associate Dean for Graduate Education at the University of California, Merced



- Dr. **Colleen Nehl** is the new FES Program Manager for Public-Private Partnerships, including the new milestone development program and INFUSE
- Most recently at Booz Allen, supporting ARPA-E



- Dr. **Michael Halfmoon** is the new FES Program Manager for Theory and Simulation
- Most recently at the IFS, U Texas

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DIII-D National Program

▶ **DIII-D completed 20.4 weeks of operations in FY22 and is executing another 20-week campaign in FY23**

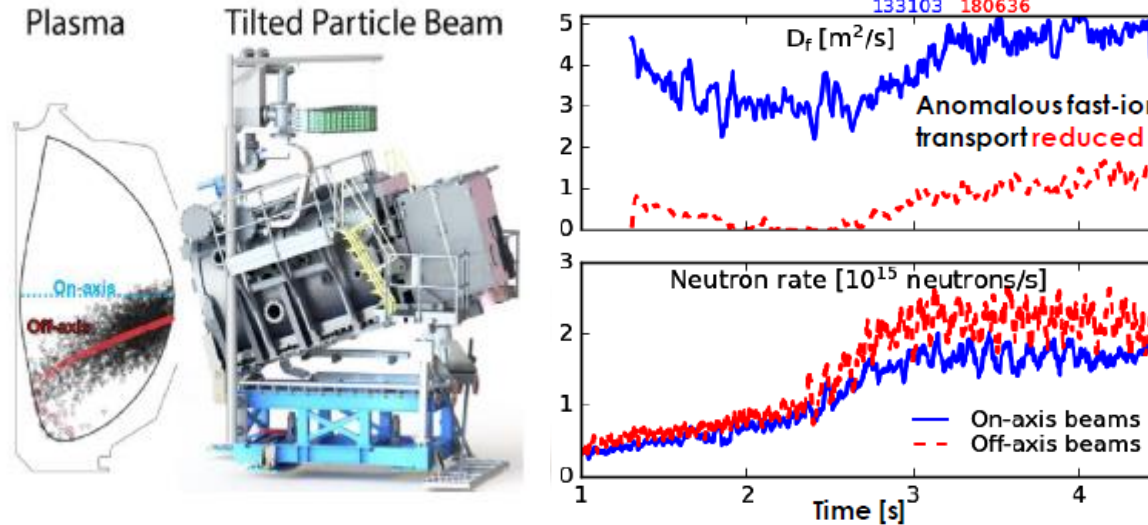
▶ **Consultation document is available on the next five-year plan (2024-2029)**

– Prospective users can preview the proposed topics here:

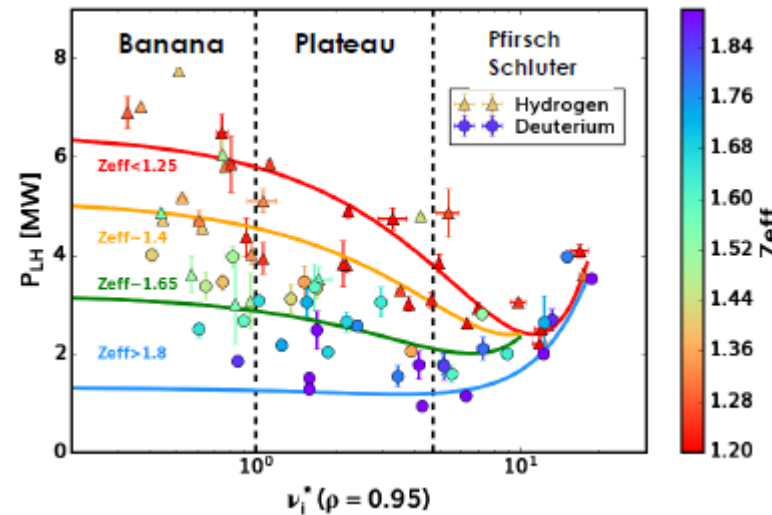
https://fusion.gat.com/global/_media/diii-d/d3d-5yp-consult.pdf

▶ **FY 2023: FES solicitation for collaborative research on DIII-D and innovative technology development for advanced tokamaks is anticipated**

– Technical Contact: Matthew Lanctot
matthew.Lanctot@science.doe.gov



Off-axis NBI broadens current profile, decreases fast-ion transport
(Thome, APS-DPP 2022)



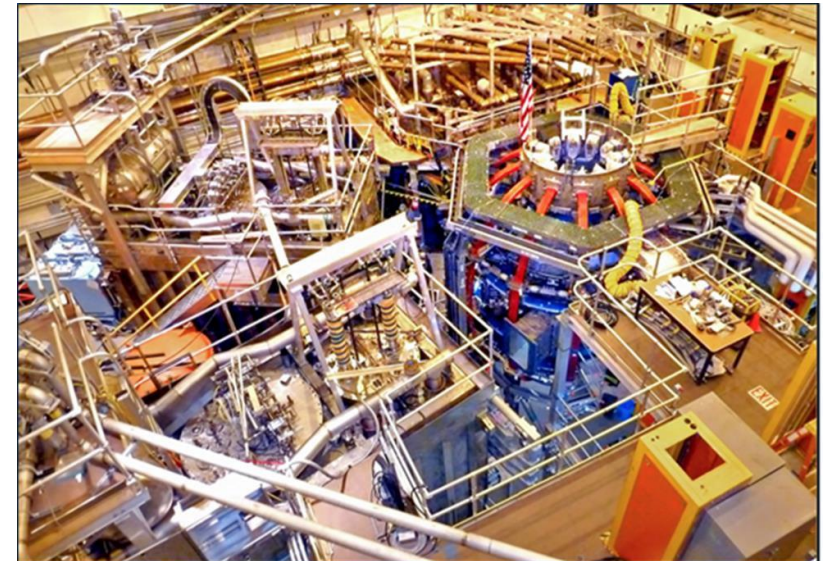
L-H power threshold decreases with increased Z_{eff} at low collisionality; it may be possible to reduce threshold in ITER H+He plasmas by 50% at $Z_{\text{eff}} \sim 1.7$ (Callahan, APS-DPP 2022)

Status of the NSTX-U Recovery

Project Progress

- Recovery project is proceeding (~70% complete)
- Technical issue w/TF bundle insulation required the design and manufacture of a new inner TF/OH bundle.
- An Independent Project Review of the new proposed NSTX-U Recovery cost and schedule baseline was completed in November 2022.
- **New Completion Date:** *Dec 2026* (includes 19 months of contingency)
- **New Cost:** *\$363.5M* (includes \$75.1M of contingency)

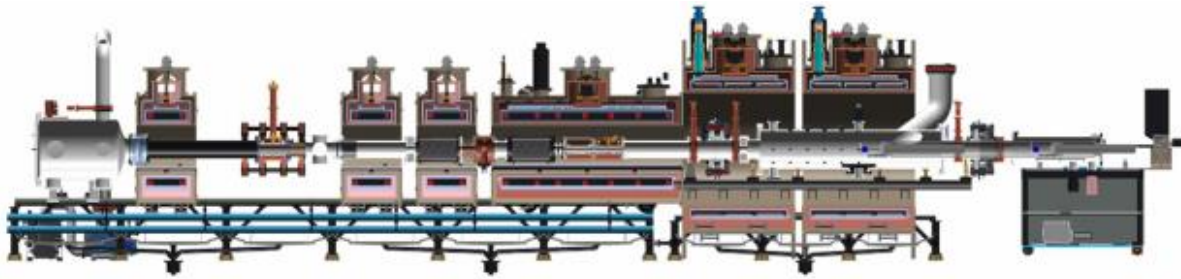
New Centerstack Casing



MPEX and MEC-U

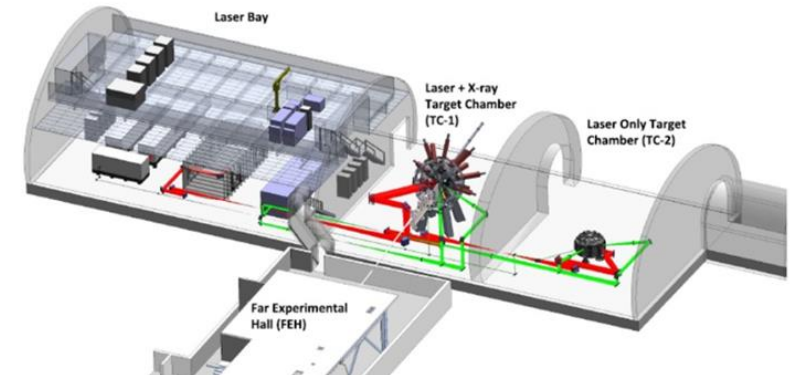
Material Plasma Exposure eXperiment (MPEX)

- ▶ New world-class plasma exposure facility for accelerated testing of fusion materials
- ▶ CD-2 (Approve Performance Baseline) approval achieved August 2022
- ▶ Estimated Completion Date is **January 2028** and estimated cost is **\$201M** (includes \$42.8M of contingency)
- ▶ CD-3 (Start of Construction) approval achieved August 2022
- ▶ Facility Enhancements initiated October 2022



Matter in Extreme Conditions (MEC) Petawatt Laser Upgrade

- ▶ World-leading high-energy-density plasma science instrument
- ▶ Design efforts progressing through Preliminary Design phase. Next milestone CD-2/3 (Baseline / Start Construction) planned for 2024
- ▶ Preliminary completion date: **Q1 of FY 2030**
- ▶ Preliminary Total Project Cost: **\$309.5 M**
- ▶ *Note: MEC-U is in Post-CD-1 preliminary design, project has not been baselined.*



Central Solenoid Modules in ITER Assembly Hall

Module #1 installed on the base



Overhead view of module #1 on the base and module #2 (wrapped in pink plastic)



Third CS Module expected to ship Spring 2023

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Long Pulse Tokamak: Competitive call held in FY22

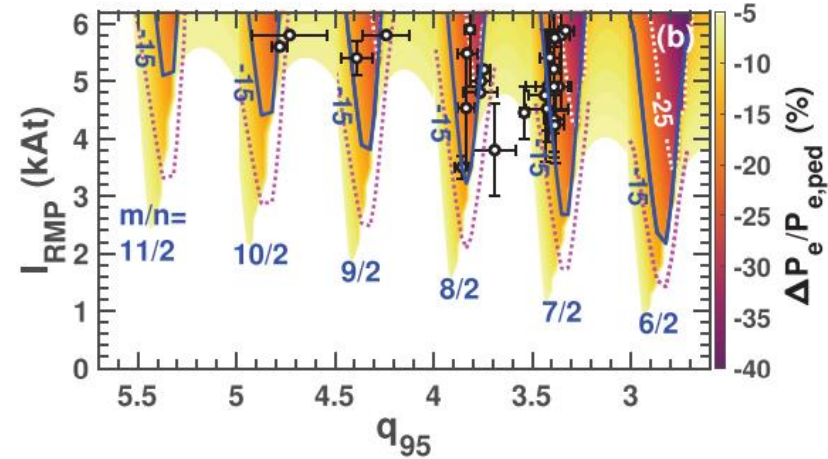
► FY22 solicitation focused on key areas of LRP driver “Sustain a Burning Plasma”

- Power Handling and Core-edge Integration
- Plasma-Material Interaction
- Long Pulse Plasma Sustainment and Control
- Actuators and Diagnostic Systems
- Validation of Burning Plasma Models and Design Tools

► Eight teams selected for 3-years of funding

- 4 renewals; 4 new awards; [Full Awards list](#) is on FES web site
- Activities funded on long pulse facilities KSTAR, EAST, & WEST
- Previously funded activities continue at JET, AUG, and JT-60SA

Science Highlight from KSTAR



Nonlinear MHD (TM1) predicts n=2 ELM suppression windows in KSTAR; good agreement found also for other fields and in DIII-D (Qu, PoP, 2021)

FY 2022 Awards – Lead Institutions Only

Proposal Topic	Lead PI	Lead Institution
Real Time Disruption Prediction and Avoidance on KSTAR	Sabbagh, Steven	Columbia
Divertor Plasma Detachment Control Systems on KSTAR	Eldon, David	General Atomics
Fusion Pilot Plant and ITER Scenarios and Control on EAST	Garofalo, Andrea	General Atomics
Long Pulse ITER Scenarios and Control on KSTAR	Eidietis, Nicholas	General Atomics
Lower hybrid current drive efficiency on WEST	Lau, Cornwall	ORNL
Plasma-material Interaction Analysis on WEST	Unterberg, Ezekial	ORNL
Integrated 3D-edge Long-pulse Tokamak Scenarios on KSTAR	Park, Jong-Kyu	PPPL
Transport and Confinement in WEST	Delgado-Aparicio, Luis	PPPL

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Frontier at ORNL Launches Exascale Era

Office of Science

At the Frontier: DOE Supercomputing Launches the Exascale Era

JUNE 7, 2022



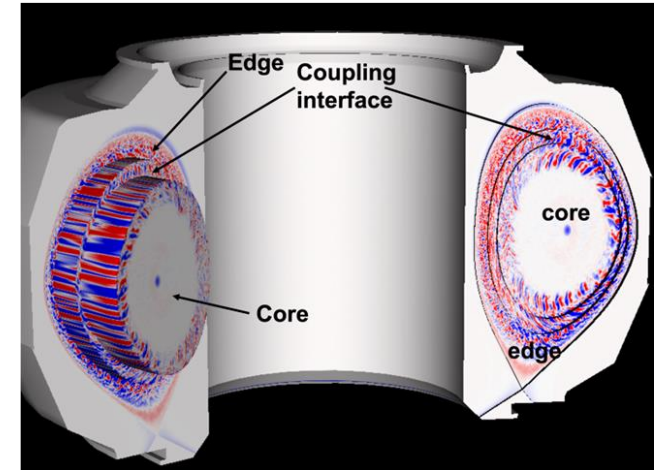
Office of Science » At the Frontier: DOE Supercomputing Launches the Exascale Era



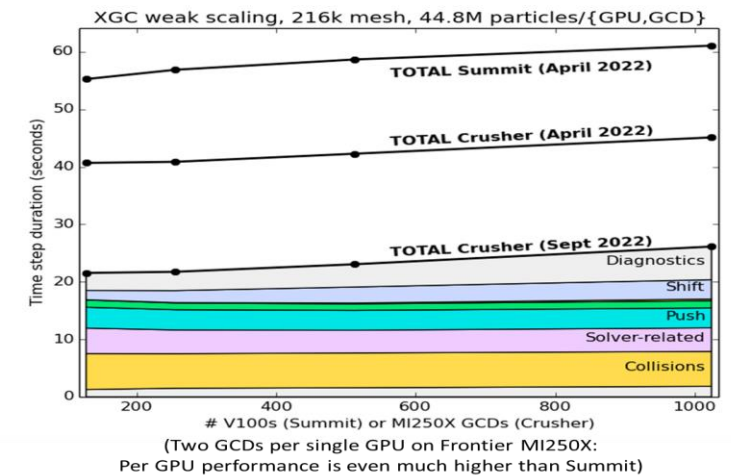
Frontier is a DOE Office of Science exascale supercomputer that was ranked the fastest in the world on the Top500 list released May 30, 2022.

Image courtesy of Oak Ridge National Laboratory

ECP WDMApp



Core (GENE or GEM) and edge (XGC) coupled kinetic simulation, showing continuation of turbulence across the coupling interface.



FY 2023 ECRP FOA Issued

Office of Science

Department of Energy Announces Early Career Research Program for FY 2023

NOVEMBER 16, 2022



[Office of Science](#) » Department of Energy Announces Early Career Research Program for FY 2023

Awards Will Support Outstanding Early Career Scientists at Universities, National Laboratories, and Office of Science User Facilities

WASHINGTON, D.C. - Today, the U.S. Department of Energy (DOE) announced it is accepting applications for the 2023 DOE Office of Science Early Career Research Program to support the research of outstanding scientists early in their careers. The program will support over 80 early career researchers for five years at U.S. academic institutions, DOE national laboratories, and Office of Science user facilities.

"The Department of Energy is committed to supporting rising stars in science - researchers who show great promise and a bright future," said **Asmeret Asefaw Berhe, Director of the DOE Office of Science**. "These individuals will be instrumental in meeting the big scientific challenges we face as a nation with innovation and passion."

Changes for FY 2023:

- Eligibility extended to **12** years since receiving a PhD for FY23 and FY24 to address COVID-19 impacts
- Minimum funding for universities increased to **\$875K** over five years to encourage increases in graduate student stipends
- Researchers at all SC Scientific User Facilities are eligible (permanent staff, not postdocs)
- Submission deadlines:
 - Pre-applications: January 5, 2023
 - Applications: March 23, 2023
- For more information and links to the FOA, FAQ, and Webinar: <https://science.osti.gov/early-career>



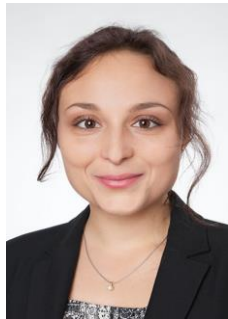
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Fusion Power Associates Meeting, December 7-8, 2022

FY 2022 FES Early Career Research Awards

FES made five university and four lab awards in FY 2022



Prof. Yuanyuan Zhu
Univ Connecticut
Understanding Thermal Oxidation of Tungsten and the Impact of Radiation under Fusion Extremes

Prof. Lorenzo Sironi
Columbia Univ
The interplay of reconnection and turbulence in relativistic plasmas: the case of black hole accretion flows and coronae

Prof. Livia Casali
Univ Tennessee
Innovative Core-Edge Solutions for Tokamaks

Prof. Benjamin Jorns
Univ Michigan
Understanding the Spatiotemporal Spectra of Transport-Inducing Instabilities in Low Temperature Plasmas

Prof. David Cereceda Senas
Villanova Univ
Unraveling transmutation effects in tungsten-based plasma-facing materials: a computational approach that integrates nuclear transmutation, first-principles calculations, and Machine Learning

Dr. Trey Gebhart III
ORNL
Solutions For a More Efficient and Economical Fusion Fuel Cycle

Dr. Kenneth Hammond
PPPL
Pellet fueling and profile control in Wendelstein 7-X

Dr. Shaun Haskey
PPPL
Main Ion Transport and Fueling in the DIII-D Pedestal: From Formation to Sustainment

Dr. Timofey Frolov
LLNL
Grain Boundary Structure Engineering of Resilient Tungsten Alloys for Fusion Applications

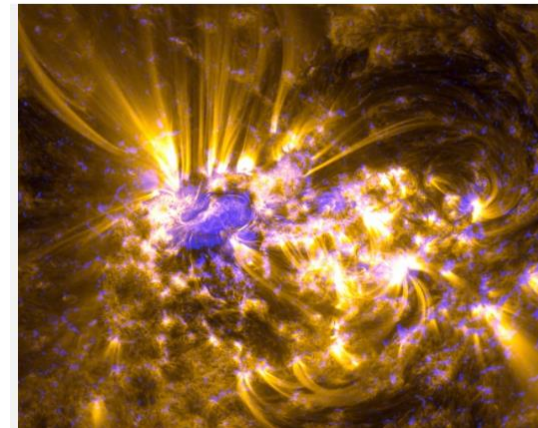


Innovation Network for Fusion Energy (INFUSE)

- As of FY 23, **INFUSE** is now in its fifth year
- A pilot program for **university** participation was launched in FY 2022
- To date, **62 awards** totaling **\$12.5M** have been made, enabling **9 DOE national labs** and **8 universities** to collaborate with **19 private fusion companies**
- The 4th Annual **INFUSE Workshop** was held on Oct. 19th as part of the APS-DPP **Mini-conference on Public-Private Partnerships**
- The FY 2022 Second Round Request for Assistance Call has closed, and selections announcement will be coming in late CY 2022
- Thanks to Dennis Youchison and Ahmed Diallo for managing the program the last few years



What Is INFUSE? Topic Areas ▾ Meetings ▾ Library Submission ▾



Innovation Network for Fusion Energy

The INFUSE program will accelerate fusion energy development in the private sector by reducing impediments to collaboration involving the expertise and unique resources available at DOE laboratories. This will ensure the nation's energy, environmental and security needs by resolving technical, cost, and safety issues for industry.

[Read More](#)



Arnold Lumsdaine,
Director



Walter Guttenfelder,
Deputy Director




Milestone-Based Fusion Development Program

Purpose: Support the development of a U.S.-based fusion power industry through the RD&D of technologies that will enable the construction of new full-scale **fusion systems capable of demonstrating significant improvements** in the performance of such systems.

- Full applications are due **December 15 @ 11:59 PM ET**
- We expect to select 3-5 applications for award negotiations (*likely more than one Tier 1 application*)
- DOE anticipates that the Federal share of the total value of awards over the first 18 months of this program will be \$50M, subject to the availability of FY23 appropriations.
- Additional funding for up to five years will be contingent upon awardees meeting early milestones and the availability of appropriated funding to continue this program in FY24 and beyond.

DEPARTMENT OF ENERGY (DOE)
OFFICE OF SCIENCE (SC)
FUSION ENERGY SCIENCES (FES)



MILESTONE-BASED FUSION DEVELOPMENT PROGRAM

FUNDING OPPORTUNITY ANNOUNCEMENT (FOA) NUMBER:
DE-FOA-0002809

FOA TYPE: INITIAL
CFDA NUMBER: 81.049

FOA Issue Date:	September 22, 2022
Submission Deadline for Pre-Applications:	October 20, 2022 at 5 PM Eastern Time A Pre-Application is required
Pre-Application Response Date:	November 3, 2022 at 11:59 PM Eastern Time
Submission Deadline for Applications:	December 15, 2022 at 11:59 PM Eastern Time

Year	1	2	3	4	5	6	7	8	9	10	11	12
FOA PoP												



***Deliverables:**
Preconceptual designs, tech roadmaps

https://science.osti.gov/fes/-/media/grants/pdf/foas/2022/SC_FOA_0002809.pdf

Fusion Power Associates Meeting, December 7-8, 2022

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- ▶ **Strategic Planning**
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Accelerate fusion development as a carbon-free, baseload energy source via public-private partnerships

- **White House Fusion Summit:** Stakeholders from government, private sector, universities, energy justice, and non-profit communities (>1,200 live-stream viewers)
- DOE established a fusion crosscutting team with OSTP in S4 office, led by a lead fusion coordinator (Scott Hsu)
- DOE workshop “Fusion Energy Development via Public-Private Partnerships”, held June 1-3, Wash, DC
- Funding Opportunity Announcement for a Fusion Milestone Development Program was issued on Sep 22, 2022



White House “Bold Decadal Vision”

Basic Research Needs workshops

Inertial Fusion Energy (June 21-23, 2022)



Dr. Tammy Ma (LLNL), Chair, and Prof. Riccardo Betti (UR-LLE), Co-Chair

Plasma Science for Microelectronics Fabrication (August 8-9, 2022)



Co-Chairs: Prof. David Graves (PPPL), Dr. Catherine Labelle (Intel), and Prof. Mark Kushner (Michigan)

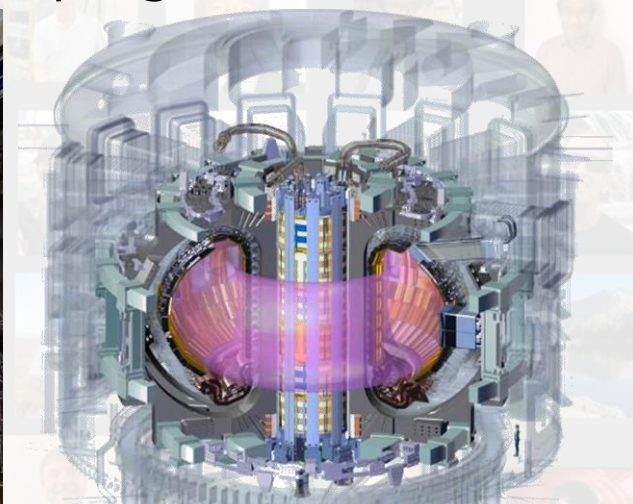
US ITER Research (July 13, 2022)



Dr. Charles Greenfield (GA), Chair, and Dr. Cami Collins (ORNL), Co-Chair

2022 ITER Research Basic Research Needs Workshop

- ▶ ITER is a historic investment for the U.S. and its international partners
- ▶ **FY 2022:** FES sponsored a workshop to discuss a research plan and organizational elements for an ITER research program; Final Report completed on October 7 and is available from <https://www.iterresearch.us/>
- ▶ **FY 2023:** Report recommendations are under consideration by a FES/SC working group and will inform a new research program that has been authorized & funded



SC recognizes Chuck Greenfield (GA) and Cami Collins (ORNL) for their leadership of this momentous planning activity!

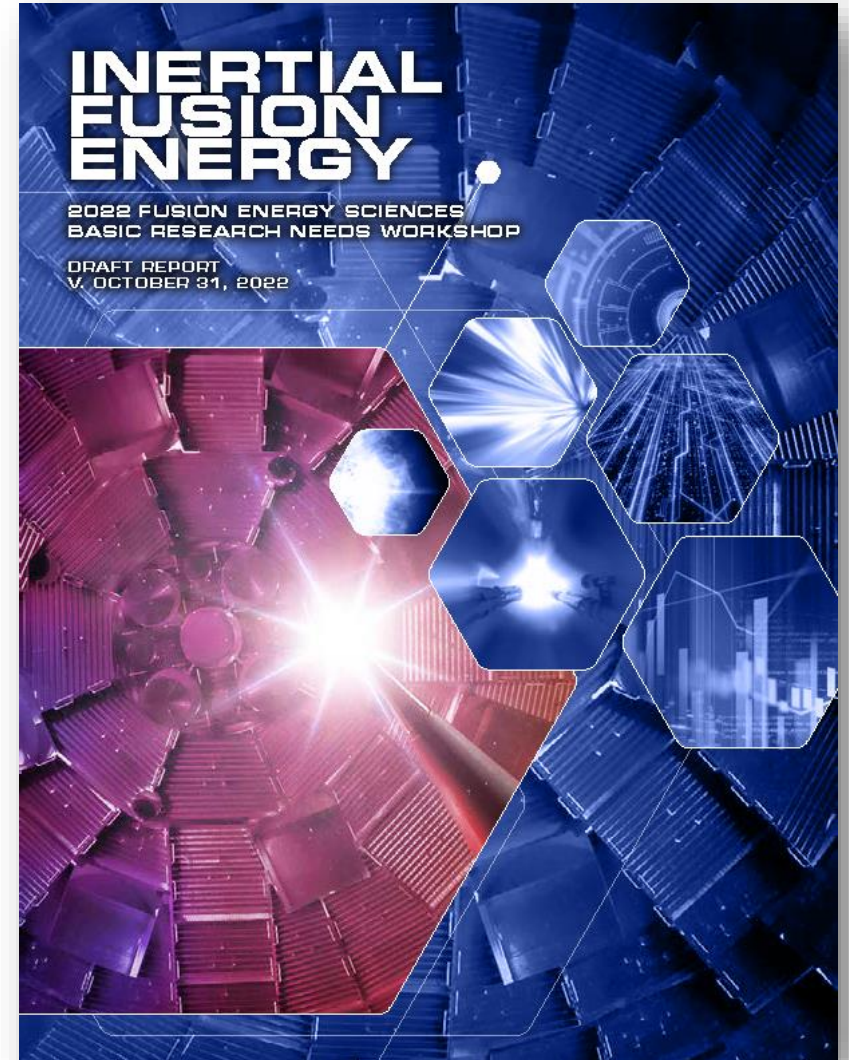


2022 IFE Basic Research Needs Workshop

FESAC Long Range Plan (page 34)

“The enormous progress made with indirect drive at the National Ignition Facility, direct drive, magnetic drive inertial confinement fusion (ICF), and heavy ion fusion underpin the promise of IFE. **An IFE program that leverages US leadership and current investments should be targeted.**”

- ▶ Chaired by Dr. Ma (LLNL) and Prof. Betti (UR)
- ▶ FES point of contact: Kramer Akli
- ▶ <https://events.bizzabo.com/IFEBRN2022>
- ▶ Final Report will be delivered December 15, 2022

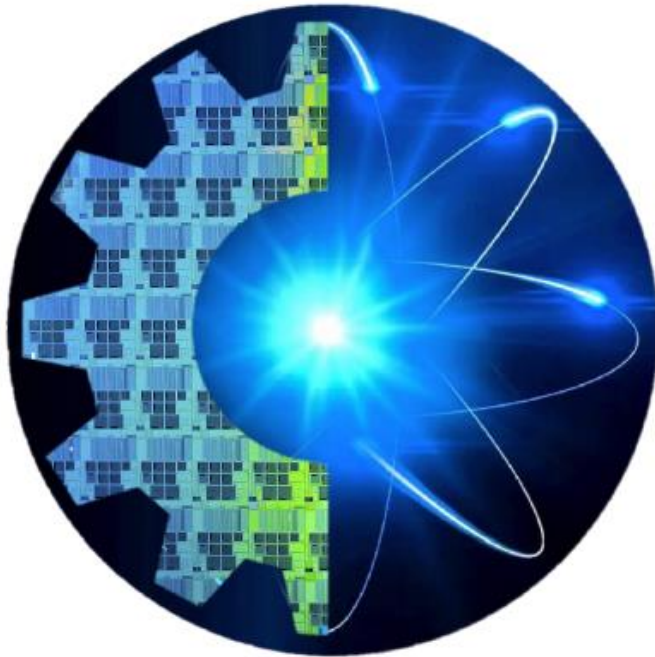


Fusion Power Associates Meeting, December 7-8, 2022

Workshop on Plasma Based Semiconductor Nanofabrication

Fusion Energy Sciences Workshop

Plasma Science for Microelectronics Nanofabrication



Report on Science Challenges and Research Opportunities
for
Plasma Applications in Microelectronics

Plasma Science for **Microelectronics** Fabrication (August 8-9, 2022)



Co-Chairs: Prof. David Graves (PPPL), Dr. Catherine Labelle (Intel), and Prof. Mark Kushner (Michigan)

Draft report:
completed

Public comments period:
November – December

Final edit:
December 2022

Release date:
Late December 2022

FES Workshop on Plasma Science for Microelectronics Nanofabrication

August 8 - 9, 2022

Gaithersburg Marriott Washingtonian Center

[Home](#) [Workshop Charge](#) [Agenda](#) [Relevant White Papers](#) [Useful Information](#) [Attendees](#) [Contacts](#) [Example PROs](#)

The purpose of this workshop is to articulate the role of the DOE Office of Science, and Fusion Energy Sciences in particular, in advancing the plasma science required for new plasma-based semiconductor nanofabrication

Fusion Power Associates Meeting, December 7-8, 2022



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Fusion Prototypic Neutron Source (FPNS) 2022 Community Workshop

- ▶ A follow-on workshop to refine initial FPNS requirements set in 2018
- ▶ Goal: Update consensus on the FPNS requirements, including input from:
 - Fusion materials scientists
 - Fusion private sector
 - FPP designers
 - Technology advocates
- ▶ The main recommendation was a **two-part, schedule driven deployment strategy** for an FPNS
 - **Stage 1:** Urgent deployment of an initial capability to support FPP's
 - **Stage 2:** Upgraded capability to support commercial fusion development
 - Final report available at: <https://www.epri.com/research/products/00000003002023917>
- ▶ Additional community workshops in the areas of fuel cycle, blankets, proliferation, and other technology areas are planned for the first quarter of 2023.

Table 1. FPNS performance requirements desired by 2028 or earlier, and 2032 or earlier, as indicated in Columns 2 and 3, respectively.

Parameter	Capability Requirement by 2028 or earlier	Capability Requirement by 2032 or earlier
Damage rate	5 to 11 dpa/calendar year (Fe equivalent)	15 dpa/calendar year (Fe equivalent)
Spectrum	Gaseous and solid transmutant generation rates consistent with 14 MeV fusion neutron	Gaseous and solid transmutant generation rates consistent with 14 MeV fusion neutron
Sample volume in high flux zone	$\geq 50 \text{ cm}^3$	$\geq 300 \text{ cm}^3$
Temperature range	~300 to 1200°C	~300 to 1200°C
Temperature control	3 independently monitored and controlled regions	4 independently monitored and controlled regions
Flux gradient	$\leq 20\%/cm$ in the plane of the sample	$\leq 20\%/cm$ in the plane of the sample



Mary Grace Burke (ORNL)



Mary Alice Cusentino (SNL)



Sara Ferry (MIT)



Kevin Field (Univ. of Michigan)



Andrew Sowder (EPRI), co-chair



Jaime Marian (UCLA)



Wahyu Setyawan (PNNL)



Caroline Sorensen (CFS)



Derek Sutherland (CTFusion)



Brian Wirth (UTK), co-chair

FPNS Workshop Executive Committee

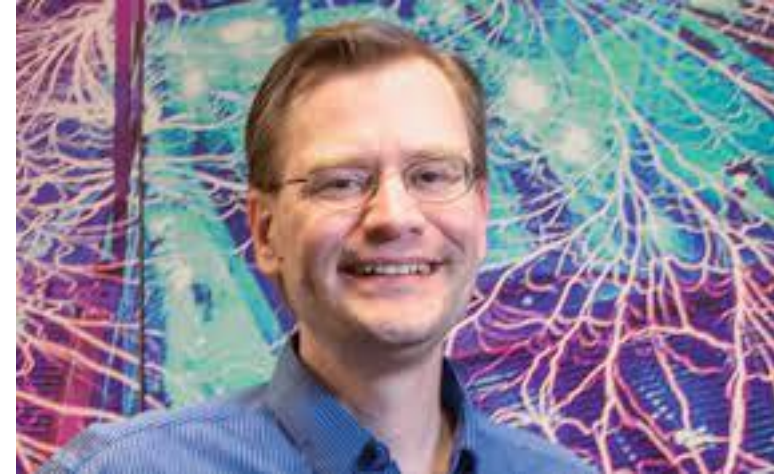
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2021 DOE Ernest O. Lawrence Awards



Luis Chacón (Los Alamos National Laboratory)
Fusion & Plasma Sciences

Honored for his "seminal contributions in multiscale algorithms for fluid, kinetic, and hybrid simulation of plasmas, enabling scientific breakthroughs in fast magnetic reconnection and self-organization in magnetic fusion systems, and in reactivity degradation in inertial fusion systems."



Daniel B. Sinars (Sandia National Laboratories)
National Security and Nonproliferation

Honored for his "pioneering development of seminal X-ray diagnostics and their innovative application to z-pinch implosions that transformed the experimental capabilities on the Z pulsed power facility and enabled novel, record-breaking platforms supporting our nation's nuclear security."

The awards were presented during a ceremony in Washington, DC, on September 22, 2022

29th IAEA Fusion Energy Conference

▶ **FEC 2023**

- ▶ October 16 – 21, 2023
- ▶ London, United Kingdom
- ▶ Meeting Website:

<https://www.iaea.org/events/evt2102340>

▶ **US Paper Selection Committee**

- ▶ Email Synopses to the following address:
- FEC2023.US@science.doe.gov
- ▶ Submission Deadline: January 16, 2023
 - ▶ USPSC meeting: Jan. 31 – Feb. 2, 2023

▶ **FES coordinator for the US program committee**

- ▶ Dr. Josh King
- ▶ For updates, check

<https://science.osti.gov/fes/Community-Resources>

