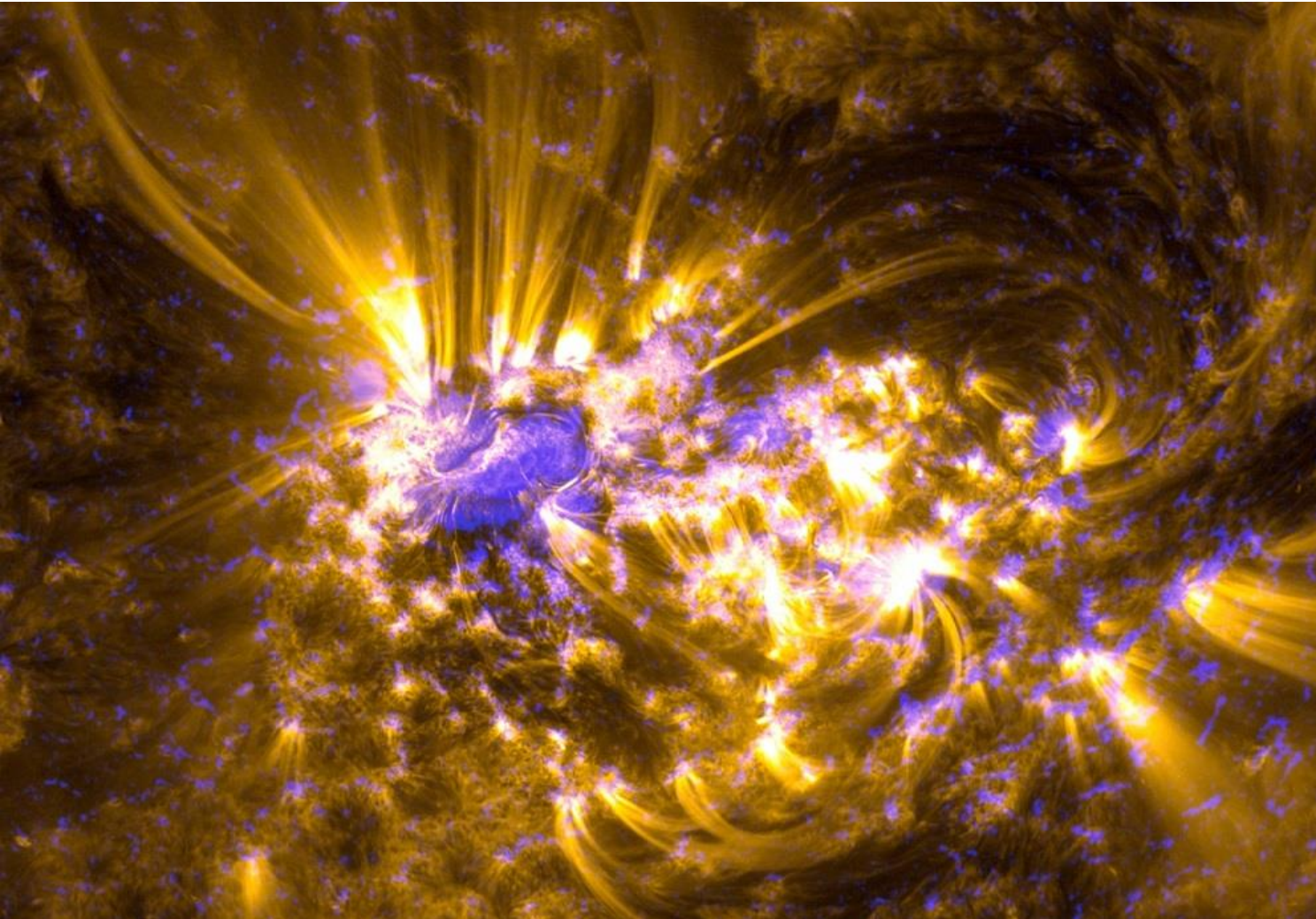


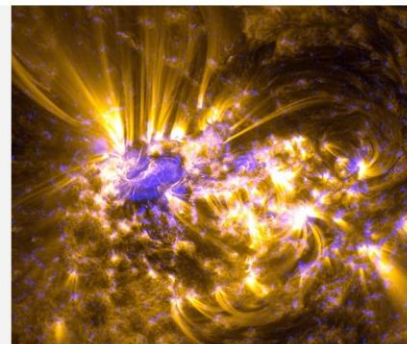
# Public-Private Partnerships



## Innovation Network for Fusion Energy: Past Performance, Future Plans and Lessons Learned

Dennis Youchison and Ahmed Diallo  
infuse@ornl.gov

FESAC Meeting  
August 31, 2021



## 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](#)

Hot Topic: U.S. Department of Energy Office of Fusion Energy Sciences Strengthened



What's New



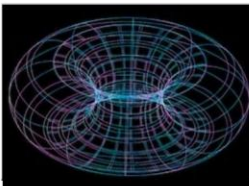
Contact Us



Activities & Events

### Newsroom

<https://infuse.ornl.gov/>



#### FES supports fusion science research

New funding opportunities announced for fusion science research

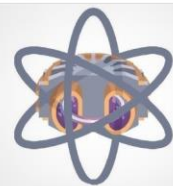
[Read More](#)



#### FES launches new website for the INFUSE program

A new website hosted at ORNL will facilitate news and announcements concerning the INFUSE program and act as a proposal submission and review site.

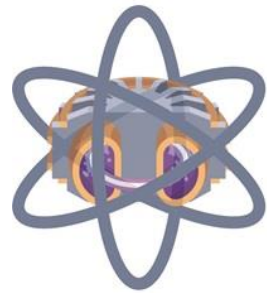
[Read More](#)



#### INFUSE announces initial round of proposal solicitation

The Innovation Network for Fusion Energy program announced its first proposal solicitation for the private/public partnership.

[Read More](#)

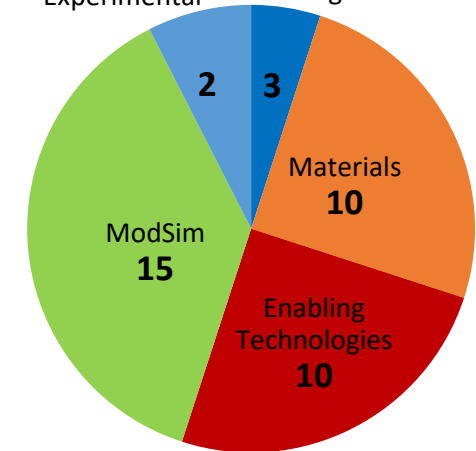


# INFUSE Innovation Network for Fusion Energy

## AWARDS

- 40 projects funded to date with a total value of \$9.93 M (\$7.77 M DOE)
- The 40 awards went to 17 U.S. companies in 9 states involving 8 national labs
- Detailed list: [https://infuse.ornl.gov/wp-content/uploads/2021/01/Cumulative\\_AwardList.pdf](https://infuse.ornl.gov/wp-content/uploads/2021/01/Cumulative_AwardList.pdf)

Awarded Topical Areas  
Experimental      Diagnostics



10 Participating laboratories:

Topical areas:

- 1) Enabling Technologies including magnets
- 2) Materials Science
- 3) Plasma Diagnostics
- 4) Theory and Simulation
- 5) Magnetic Fusion Experimental Capabilities





# Program Overview

- **INFUSE program is a Public-Private Partnership (P3) Program started by FES with a Pilot Program in FY 2019**
  - *This is first of a kind P3 program within the Office of Science*
- **Initiated due to the recent surge in private sector investment in fusion energy - Leverages the many unique and important capabilities are located at DOE National Laboratories**
- **Focused on providing a quick, streamlined approach for companies to access DOE Laboratory Capabilities. *“Time is of the essence”***
- **The INFUSE Program is modeled after other successful DOE P3 programs, most notably the Gateway for Accelerated Innovation in Nuclear (GAIN) Nuclear Energy Voucher program established by the DOE Office of Nuclear Energy (NE), which has been very successful in providing the nuclear fission industrial community with access to the resources available across the DOE complex.**
- **The Request for Assistance (RFA) Calls are managed by a consortium of FES funded laboratories, led by ORNL and PPPL.**

# Program Organization

INFUSE is implemented by the “Point-of-Contacts” POC panel whose members come from each of the participating laboratories. They provide program oversight and facilitate the P3 program at their laboratory.

Laboratory	Point of Contact	Email
<a href="#">Brookhaven National Laboratory (BNL)</a>	Ramesh Gupta	<a href="mailto:gupta@bnl.gov">gupta@bnl.gov</a>
<a href="#">Idaho National Laboratory (INL)</a>	Paul Humrickhouse	<a href="mailto:paul.humrickhouse@inl.gov">paul.humrickhouse@inl.gov</a>
<a href="#">Lawrence Berkeley National Laboratory (LBNL)</a>	Steve Gourlay	<a href="mailto:sagourlay@lbl.gov">sagourlay@lbl.gov</a>
<a href="#">Lawrence Livermore National Laboratory (LLNL)</a>	Andris Dimits	<a href="mailto:dimits1@llnl.gov">dimits1@llnl.gov</a>
<a href="#">Los Alamos National Laboratory (LANL)</a>	John Kline	<a href="mailto:jkline@lanl.gov">jkline@lanl.gov</a>
<a href="#">Oak Ridge National Laboratory (ORNL)</a>	Dennis Youchison*	<a href="mailto:youchisondl@ornl.gov">youchisondl@ornl.gov</a>
<a href="#">Pacific Northwest National Laboratory (PNNL)</a>	Wahyu Setyawan	<a href="mailto:wahyu.setyawan@pnnl.gov">wahyu.setyawan@pnnl.gov</a>
<a href="#">Princeton Plasma Physics Laboratory (PPPL)</a>	Ahmed Diallo**	<a href="mailto:adiallo@pppl.gov">adiallo@pppl.gov</a>
<a href="#">Sandia National Laboratories (SNL)</a>	Rob Kolasinski	<a href="mailto:rkolasi@sandia.gov">rkolasi@sandia.gov</a>
<a href="#">Savannah River National Laboratory (SRNL)</a>	Jim Klein	<a href="mailto:james.klein@srnl.doe.gov">james.klein@srnl.doe.gov</a>

### Interfaces:

- SC FES
- Lab SPP office
- DOE site office
- Company PIs and CEOs
- Lab capabilities and PIs

\*INFUSE Director



\*\*INFUSE Deputy Director



# Request for Assistance (RFA) Details

## Scope

- Work is performed in support of the requesting company using expertise at a DOE national lab to conduct research necessary to attain the company's fusion goals, not further commercialization
- Focused on unique capabilities at DOE laboratories, not items readily available elsewhere
- A single institution may submit up to five RFA's to a single RFA call

## Budget and Schedule

2 RFA cycles per yr, ~\$4M /yr

- Majority of requests are for single year awards with a value of between \$50k - \$250k
- In special cases, applicants may request up to \$500k in total value with a duration of up to two years. A 20 percent cost share is required, which can be cash, equipment, or in-kind contributions

## Company Certification

- Requestors must certify that they will accept one of the two standardized Cooperative Research and Development Agreements (CRADAs)
- Requestors must certify that they will provide the required 20 percent cost share upon selection for a partnership award

# Request for Assistance (RFA) Details

## Eligible Requester

- U.S. based private entity with U.S. ownership
- U.S. based private entity with foreign ownership so long as that entity's participation is in the economic interest of the U.S.

## RFA Execution Requirements

- Most\* work under an INFUSE award must be performed in the U.S.
- Products embodying intellectual property developed under the assistance must be substantially manufactured in the U.S.
- The transfer of technology and data resulting from INFUSE awards are subject to U.S. export control laws.

## Merit Review

- The Review Process is organized by the INFUSE POC panel, with input provided to FES for final selection
- RFA applications are evaluated and competitively selected in accordance with the Office of Science Review Criteria
- 3 reviewers are asked to comment on the value of the RFA and impact to fusion overall

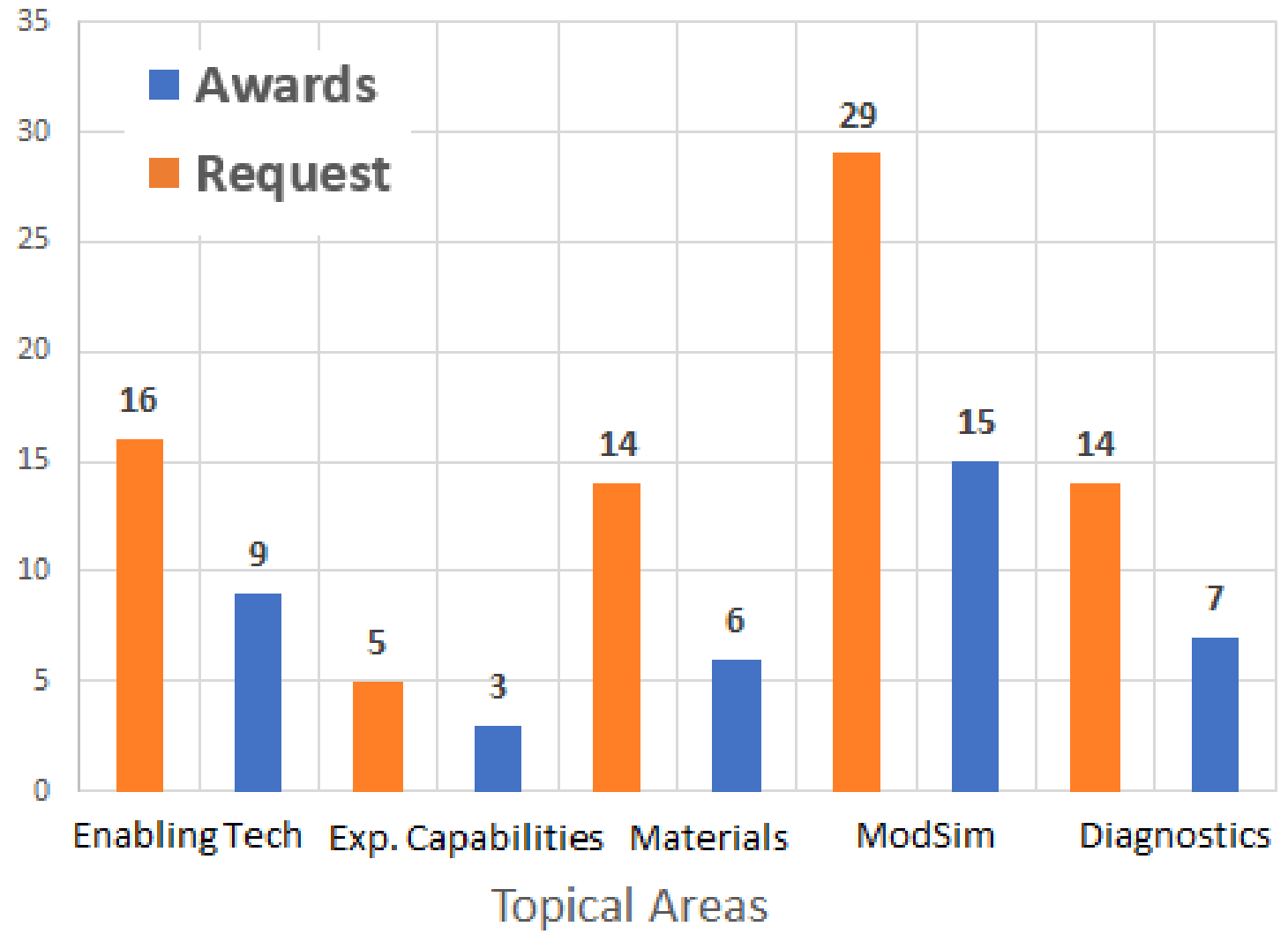
**More details available:** <https://infuse.ornl.gov/rfa-announcement-and-submission/>

**Award Abstracts:** [https://infuse.ornl.gov/wp-content/uploads/2021/07/Cumulative\\_AwardList.pdf](https://infuse.ornl.gov/wp-content/uploads/2021/07/Cumulative_AwardList.pdf)

# Request Details (Continued)

	Requests	Awards	Rate
All RFA's	78	40	51%
FY19	21	11	52%
FY20-A	25	10	40%
FY20-B	16	10	63%
FY21-A	16	9	56%
FY21-B	11		

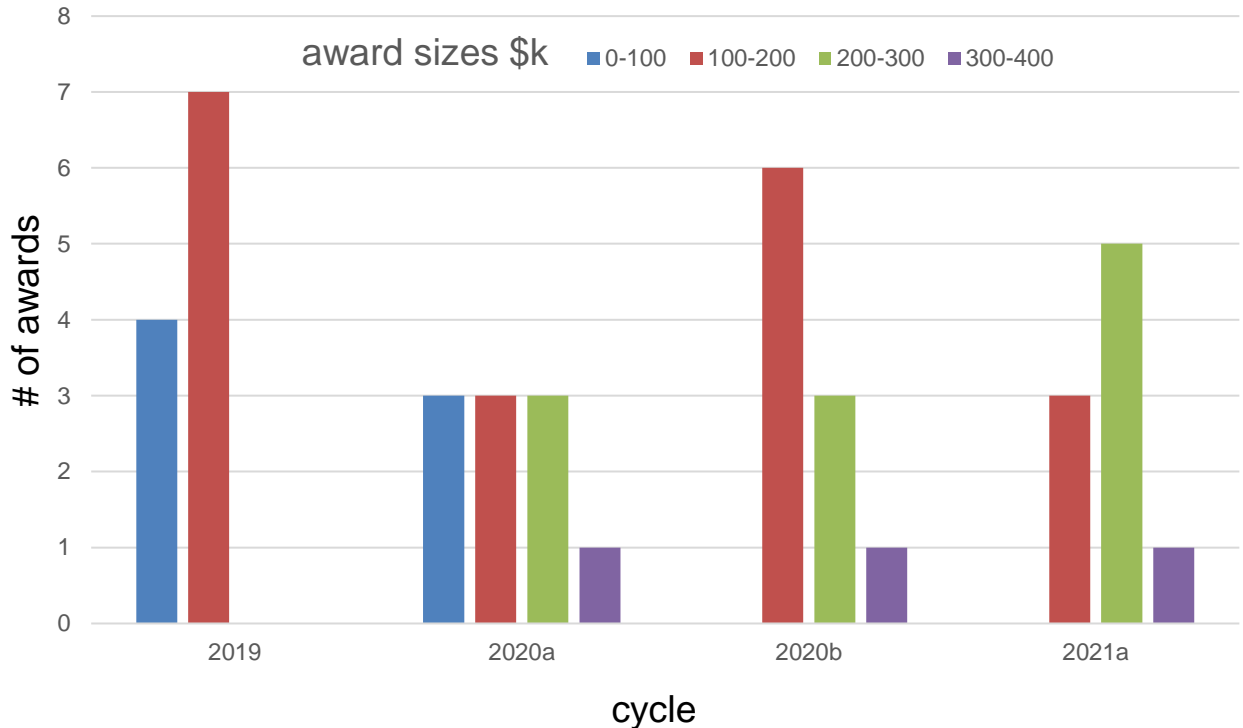
- FY19 RFA Call included restriction of one request per topical area



# Funding Statistics

Lab funds	Total Requested	Total Awarded	Average Size
All RFA's	\$14,601 k	\$7,773 k	\$177 k
FY19	\$2,870 k	\$1,543 k	\$137 k
FY20-A	\$4,481 k	\$1,949 k	\$179 k
FY20-B	\$3,426 k	\$2,150 k	\$214 k
FY21-A	\$3,824 k	\$2,131 k	\$237 k
FY21-B	\$2,522 k		

- DOE share only – does not include cost share
- FY20 RFA Calls increased the funding level to \$500k total

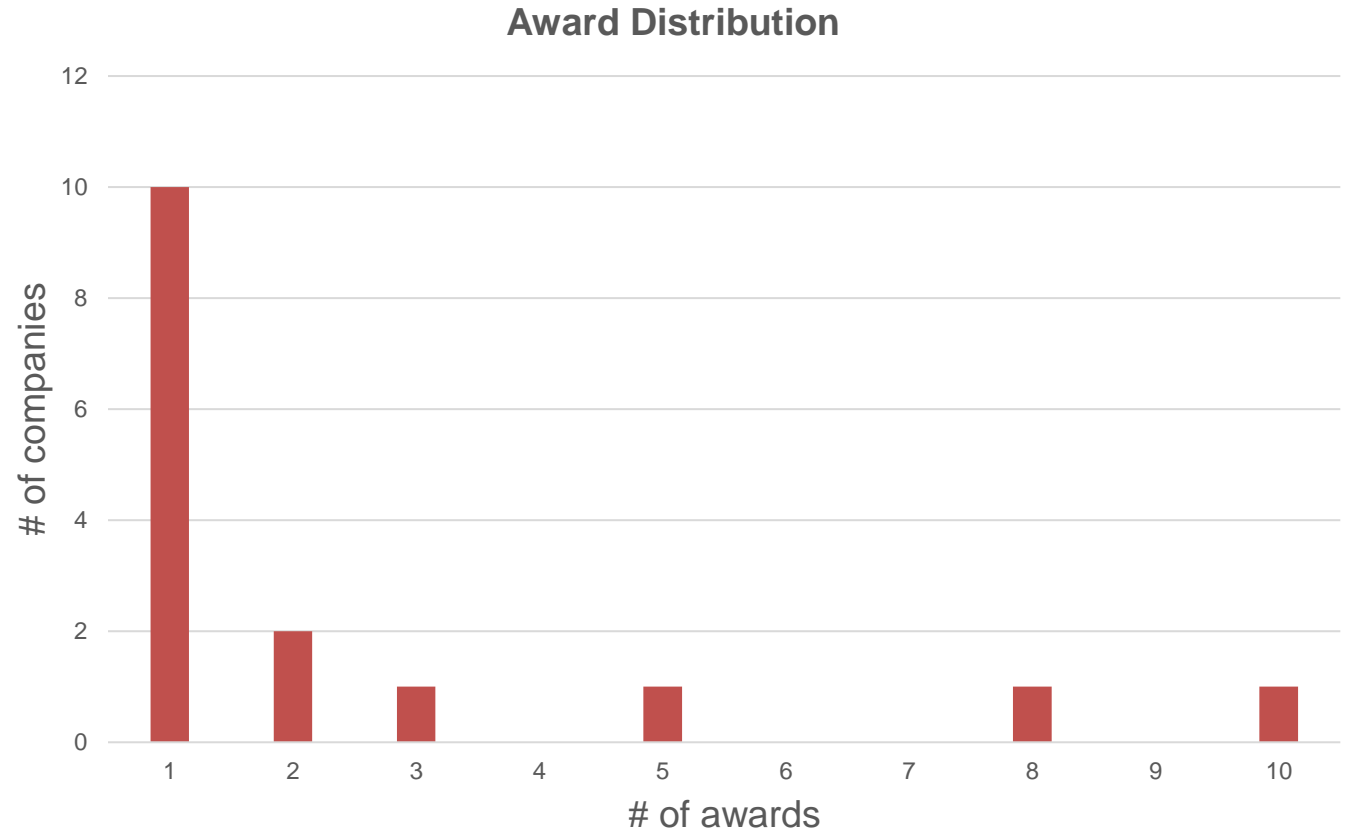




# Company Diversity

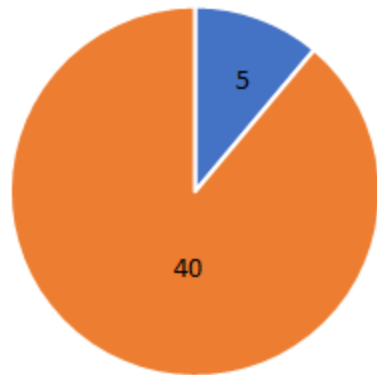
	Total Requests	Unique Requesters	Unique Awardees
All RFA's	78	19	12
FY19	21	11	5
FY20-A	25	13	6
FY20-B	16	10	8
FY21-A	16	9	7
FY21-B	11	8	

- One company selected in FY19 was dropped due to insolvency
- Of the 7 other companies who were unawarded, 5 only submitted once



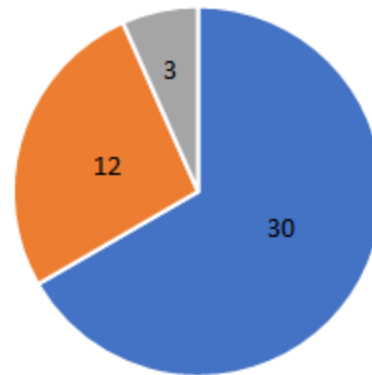
# Reviewer Demographics 2021a – 16 RFAs

reviewer gender



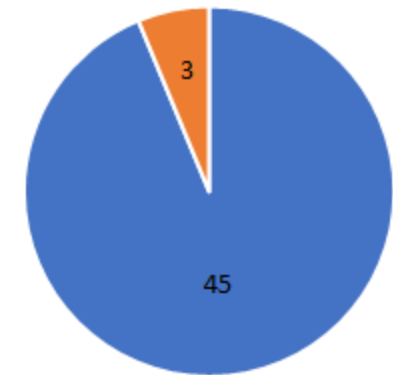
■ female ■ male

reviewer background



■ laboratory ■ university ■ private

reviewer response



■ returned ■ no-response

FES and the INFUSE Team are continuing to evaluate the INFUSE Program moving forward to ensure success

- 2019 pilot projects ended or are near completion - Awardees will submit final reports, including highlight, publications, and other metrics of success
- Two INFUSE Workshops have been held to help bring the labs and private industry together as well as to provide feedback on room for improvement
  - FY21 Workshop was cohosted by FES, the Electric Power Research Institute (EPRI), and the Fusion Industry Association (FIA)
  - Included over 195 Participants from private companies, DOE laboratories, universities, international organizations and utilities
  - FY22 Workshop will again be virtual in December
- FES is considering additional modifications to INFUSE to address company recommendations
  - Include university participation in FY22
  - Access other laboratories?
- FES is actively exploring other P3 programs for engaging private industry directly (larger FOAs, milestones)

## CFS: Alpha Particle Diagnostics Simulation

“This INFUSE program informed the maximum allowable Toroidal Field ripple for SPARC, which in turn affects decisions regarding the number, size and fabrication tolerances of the TF coils. These decisions directly impact the total system cost. The program also compared and improved the ASCOT and SPIRAL codes for fusion alpha particle distribution, directly benefiting the fusion community as a whole. The work led to a publication in the *Journal of Plasma Physics*.”

~Shiyun Ruan

## CFS: Divertor Component Testing

“Travis and Dennis,

I'd like to personally thank you for helping us get to the 30% milestone on time. We held the review all last week and it was a success. SPARC is now ready to construct.

The INFUSE PFC testing is an important part of the SPARC program.

Special thanks in addition to Dennis for his work on the INFUSE program. Onwards to 60%!”

~Dan Brunner

## TAE: Simulations of Global Stability in the C-2W Device

In collaboration with TAE researchers, Elena Belova (PPPL) performed global stability simulations of FRC plasmas and found a new fast-ion driven compressible mode which, as it saturates at small amplitude, may explain some of the stable low-order fluctuations which have been observed in the C-2W experiment.

~Sean Dettrick

### Simulation of Equilibrium, Stability, and Transport in Advanced FRCs

Show affiliations Show all authors

Dettrick, S. A.; Barnes, D. C.; Belova, E. V.; Ceccherini, F.; Galeotti, L.; Galkin, S. A.; Gupta, S.; Hubbard, K.; Koshkarov, O.; Lau, C. K.; Lin, Z.; Mok, Y.; Necas, A.; Nicks, B. S.; Onofri, M.; Park, J.; Putvinski, S. V.; Steinhauer, L. S.; Tajima, T.; Wang, W.; ...

The Advanced FRC is a Field Reversed Configuration maintained by neutral beam injection and electrode biasing, with scrape-off-layer (SOL) pumping and electron heat confinement provided by expander divertors. This alternate magnetic confinement system has been developed at TAE Technologies, Inc in the C-2, C-2U and C-2W (aka NORMAN) devices. To study this configuration, hybrid fluid/kinetic equilibrium models have been developed which include the effects of fast ion pressure anisotropy. The 3D hybrid PIC codes FPIC and HYM are being used to understand the interplay of beams and biasing in global stability. The 2D hybrid kinetic/MHD/neutral code, Q2D, is being used to study global transport including coupled perpendicular/parallel FRC/SOL transport, neutral gas effects, and field line expansion and electrostatic potential formation in the expander. The 3D electrostatic PIC codes ANC and GTC-X add wave-particle kinetic ion and electron effects to the global transport studies, including shear flows and sheath effects related to biasing. Parallel electron heat transport in the SOL is studied using the KSOL 1d2v continuum code.

Publication: APS Division of Plasma Physics Meeting 2020, abstract id.VP13.016

Pub Date: 2020

Bibcode: 2020APS.DPPV13016D

*J. Plasma Phys.* (2020), vol. 86, 86S860508 © The Author(s), 2020.

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doi:10.1017/S0022377820001087

## Fast-ion physics in SPARC

S. D. Scott<sup>1,†</sup>, G. J. Kramer<sup>2</sup>, E. A. Tolman<sup>3</sup>, A. Snicker<sup>4</sup>, J. Varje<sup>4</sup>, K. Särkimäki<sup>5</sup>, J. C. Wright<sup>3</sup> and P. Rodriguez-Fernandez<sup>3</sup>

<sup>1</sup>Commonwealth Fusion Systems, Cambridge, MA, USA

<sup>2</sup>Princeton Plasma Physics Laboratory, Princeton, NJ, USA

<sup>3</sup>Plasma Science and Fusion Center, MIT, Cambridge, MA, USA

<sup>4</sup>Department of Applied Physics, Aalto University, FI-00076 Espoo, Finland

<sup>5</sup>Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

(Received 27 May 2020; revised 19 August 2020; accepted 20 August 2020)

Potential loss of energetic ions including alphas and radio-frequency tail ions due to classical orbit effects and magnetohydrodynamic instabilities (MHD) are central physics issues in the design and experimental physics programme of the SPARC tokamak. The expected loss of fusion alpha power due to ripple-induced transport is computed for the SPARC tokamak design by the ASCOT and SPIRAL orbit-simulation codes, to assess the expected surface heating of plasma-facing components. We find good agreement between the ASCOT and SPIRAL simulation results not only in integrated quantities (fraction of alpha power loss) but also in the spatial, temporal and pitch-angle dependence of the losses. If the toroidal field (TF) coils are well-aligned, the SPARC edge ripple is small (0.15–0.30%), the computed ripple-induced alpha power loss is small (~0.25%) and the corresponding peak surface power density is acceptable (244 kW m<sup>-2</sup>). However, the ripple and ripple-induced losses increase strongly if the TF coils are assumed to suffer increasing magnitudes of misalignment. Surface heat loads may become problematic if the TF coil misalignment approaches the centimetre level. Ripple-induced losses of the energetic ion tail driven by ion cyclotron range of frequency (ICRF) heating are not expected to generate significant wall or limiter heating in the nominal SPARC plasma scenario. Because the expected classical fast-ion losses are small, SPARC will be able to observe and study fast-ion redistribution due to MHD including sawteeth and Alfvén eigenmodes (AEs). SPARC’s parameter space for AE physics even at moderate  $Q$  is shown to reasonably overlap that of the demonstration power plant ARC (Sorbon *et al.*, *Fusion Engng Des.*, vol. 100, 2015, p. 378), and thus measurements of AE mode amplitude, spectrum and associated fast-ion transport in SPARC would provide relevant guidance about AE behaviour expected in ARC.

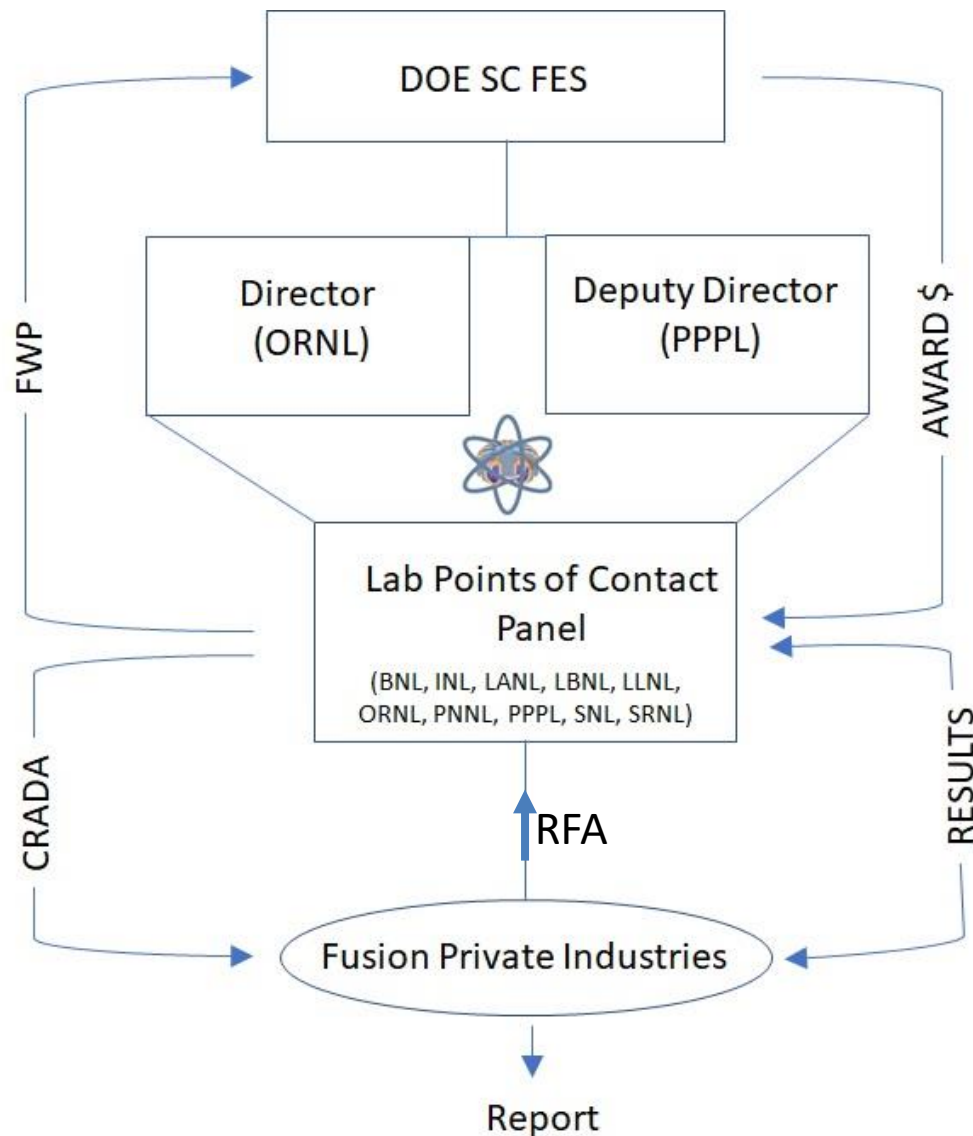
**Key words:** fusion plasma, plasma simulation, plasma confinement

† Email address for correspondence: [sscott@cfs.energy](mailto:sscott@cfs.energy)



# Lessons Learned

- Structure of the US Government
- Eligibility issues and cost share
- Participating labs and sr. bandwidth
- COI mitigations and the INFUSE POCs
- Managing the FWP cycle
- CRADA processing (NDAs, IP and ECI)
- CRADA amendments
- Press releases, cyber security
- INFUSE supplemental requests
- University involvements
- INFUSE workshops – Dec. 2021 (virtual)



# Feedback, please

- What can we improve about INFUSE?
- What is the proper balance between public and private research or investment in fusion energy?
- How is the broader fusion community outside the labs engaged?
- General Q&A