



**American Nuclear Society
Fusion Energy Division
January 2019 Newsletter**

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Lumsdaine

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Letter from FED Chair, Arnold Lumsdaine, Oak Ridge National Laboratory, Oak Ridge, TN

The TOFE meeting has come and gone for the 23rd time – each one that I have attended has its own character, and the 2018 TOFE was no exception, not only because of the pleasant November weather in Orlando, FL. TOFE is the ANS Fusion Energy Division’s topical meeting on the Technology of Fusion Energy, and it meets every two years, alternating between being “stand alone” and being embedded in the larger, biannual ANS meeting. This year’s TOFE was embedded with the 2018 Winter ANS Meeting, which allowed us the opportunity to rub shoulders with the larger nuclear society and discuss issues that overlap between different parts of the society. For this meeting, a concerted effort led to new topics for sessions that we hadn’t tried before:

- Privately funded fusion ventures (organized by Ales Necas of TAE Technologies);
- Licensing and safety for advanced fission and fusion reactors (organized by Yican Wu and Zhibin Chen of INEST, with help from ANS President John Kelly);
- Four sessions related to the “Transformative Enabling Capabilities” that were identified as areas that could shorten the path to realizing fusion power in a FESAC report earlier this year:
 - High temperature superconductors (organized by Robert Duckworth)
 - Advanced Materials and Manufacturing (organized by Juergen Rapp)
 - Tritium fuel cycle control (organized by myself)
 - Liquid metal plasma facing components (organized by Chuck Kessel).



View of the opening TOFE plenary (left) and the beautiful weather in Orlando.

Highlights of the meeting are given below, but I want to take some space in this part of the newsletter to thank Trey Gebhart (ORNL) for all of the time and effort that he put into making this meeting happen as technical program co-chair, and so much more. Of course, other members of the organizing committee (Leigh Winfrey—general chair, John Gilligan-technical co-chair, Greg Staack and myself—publications chairs, and Lauren Garrison—student paper competition chair) and the technical program committee contributed tremendously to a successful conference. But Trey was the glue that held the meeting together, and it is worth taking a little extra space to acknowledge it.

At every TOFE, three awards are presented, Best Student Paper, Technical Accomplishment, and Outstanding Achievement. A few comments on these standing awards (and one additional honor):

The **best student paper award** was handled a little differently this year. Typically, we have the students submit a paper several weeks prior to the meeting. In addition to the paper, students were invited to be a part of a special evening session where each of the finalists gave a 15 minute presentation of their work. Those of us who attended were impressed by the quality of the research and the presentation of that research by each of the students. Given the outstanding content, we decided to give three places this year instead of just one. The top three papers were:

1. Eric Lang, University of Illinois at Urbana-Champaign, “Pre-irradiation comparison of W-based alloys for the PHENIX campaign: microstructure, composition, and mechanical properties”
2. Deep Patel, University of New Mexico, “High temperature creep properties of SiC fibers with different compositions”
3. Jonah David Duran, University of Tennessee, Knoxville, “Multiple analytical approach to isotopic transport analysis in magnetic fusion devices”

The future of our profession is bright with the talent being displayed by students in the field!



Student Best Paper Awardees (from left to right): Eric Lang, Deep Patel, & Jonah David Duran with ANS FED Student Paper Competition Chair Lauren Garrison.

The **Technical Accomplishment Award** was given to J.P. Allain at University of Illinois at Urbana-Champaign received this award “for pioneering work on in-situ plasma-material interaction diagnostics and surface chemistry in nuclear fusion devices.” The **Outstanding Achievement Award** was given to Yican Wu as the Institute for Nuclear Energy Safety Technology in Hefei, China “in recognition of his pioneering contributions to the field of Fusion Nuclear Science and Technology, including neutronics, blankets, materials, and safety, and his exemplary leadership in establishing a world-class program.”

One more recognition that was given at TOFE – to Laila El-Guebaly, who published this newsletter for decades. We honored her with a plaque “In gratitude for your many years of effective and dedicated service to the American Nuclear Society, the Fusion Energy Division, and the international effort to develop fusion energy, as editor of Fusion Science and Technology newsletter.” It was a small token – much too small for all of the work that Laila has done for many years, but an inadequate gesture is better than none.

Mark your calendars. The 24th TOFE will be at (. . . drumroll, please . . .) Charleston, South Carolina from April 19-24, 2020, organized by Greg Staack and Gregg Morgan (general chairs) and Paul Korinko (technical chair), all from Savannah River National Lab. Note that it is a different time of year than the past several TOFEs. This is in part in order to hit a good season for the location, but, even more, to provide more calendar distinction from the SOFT meeting, which meets in the fall (September or October) in Europe on the same biannual schedule as TOFE.

Membership of the ANS FED should take note of the important United States DOE fusion planning effort that will take place this year – there is an article about this later in the newsletter. Lauren Garrison (the FED Secretary-Treasurer) is one of the seven national organizers of the process, representing the fusion technology community. I hope that many FED members make effort to participate in this process, as the technology and engineering issues become more critical as the US moves in the direction of focusing on a fusion energy mission.

Two more items that should be of general interest to FED members. First, FED decided to make a new position – “social media liaison” in order to communicate division news and successes in a more timely fashion, and perhaps in a way that will reach a broader audience than a newsletter. Jon Echols (University of Florida) volunteered for this position. Since this is new, Jon will be spending some time just figuring it out. He will likely need some support, and content fed to him, which is a call to each of us to be ready to help him, echolsster@gmail.com. Second, FED decided to give a \$2500 gift to the ANS Center for Nuclear Science and Technology Information. The center just started a new initiative – “Navigating Nuclear” which has put science content into fully half of the middle schools in the United States (see <http://www.ans.org/pi/navigatingnuclear/> for details). This is a critical function for putting good information in the hands of the next generation. But it is not revenue generating. The Center has done a good job of soliciting outside funds, but had a little bit more that was needed, and a number of ANS divisions chipped in. FYI, the Center does other valuable advocacy work (such as supporting a full-time Washington, DC representative of the society to conduct federal outreach activities).

I wish all the membership of ANS FED a prosperous New Year!

News from *Fusion Science and Technology Journal*, Leigh Winfrey, FS&T Editor, Penn State University, State College, PA

During the period of January 1, 2018 to October 15, 2018, FS&T received 239 manuscripts. Of the 239 manuscripts received in 2018, 116 were from North America, 44 from Europe (including Russia), 76 from Asia, and 3 from Others, with the following breakdown: 22 were accepted, 13 were withdrawn/rejected, and 204 are under review/revision.

As a reference, during the period January 1, to December 31, 2017, FS&T received a total of 130 manuscripts. Of the 130 manuscripts received in 2017, 63 were from North America, 14 from Europe (including Russia), 46 from Asia, and 7 from Others, with the following breakdown: 98 were accepted, 31 were withdrawn/rejected, and 1 is under review/revision.

Following dedicated issues were published during the period 1/1/17 to 5/15/18:

- APS Special issue on Plasma Material Interactions – FS&T (Jan 2017)
- Selected papers from Tritium 2016 – FS&T (Apr. & May 2017)
- Selected papers from TOFE2016 – FS&T (Oct. & Nov. 2017)
- Selected papers from the 22nd Target Fabrication Meeting (Mar. & Apr. 2018)
- Selected papers from the 2nd IAEA Technical Meeting on Fusion Data Processing, Validation, and Analysis (Jul. & Aug. 2018)

Following issues are scheduled/planned for November 2018 and beyond

- Special issue on Fusion Neutronics (Nov. 2018)
- Special issue on New Fusion Concepts (Apr. 2019)
- Selected papers from TOFE2018 – FS&T (Jul. & Aug. 2019)

Call for Papers

Fusion Science and Technology is the journal of the ANS Fusion Energy Division—it belongs to us and needs us to thrive. I highly encourage all engineers, technologists, academics, and scientists working in fusion research to submit to **your** journal. With several improvements in recent years—including a new publishing partner, rising impact factor, speedy online publication, and the availability of open access publication—FS&T is a vibrant platform for fusion research. I welcome your contributions to our prestigious journal. See these websites for calls for new special issues, author information, and submission instructions:

<http://www.ans.org/pubs/journals/fst/>

<https://www.tandfonline.com/toc/ufst20/current>

<http://www.ans.org/pubs/journals/fst/authors/>

<http://www.editorialmanager.com/fst/default.aspx>.

Awards and Honors, Robert Duckworth, Oak Ridge National Laboratory

Fusion awards have been established to formally recognize outstanding contributions to fusion development made by members of the fusion community. The following awards

(listed in alphabetical order) were available to the newsletter editor at the time of publishing this newsletter. We encourage all members of the fusion community to submit information on future honorees to the editor to be included in future issues. The ANS FED officers and executive committee members congratulate the honored recipients of the 2018 fusion awards on this well-deserved recognition and our kudos to all of them. Please email future awards and recognitions to duckworthrc@ornl.gov for inclusion in our newsletter.

American Physical Society (APS)

2018 John Dawson Award for Excellence in Plasma Physics Research

Fusion physicists **Max Fenstermacher (LLNL)**, **Todd Evans (General Atomics)** and **Richard Moyer (UCSD)** have been awarded the 2018 John Dawson Award for Excellence in Plasma Physics Research from the American Physical Society.

The Dawson award recognizes a particular recent outstanding achievement in plasma physics research. The award consists of \$5,000 to be divided equally in the case of multiple recipients, and includes a certificate citing the contributions made by the recipient or recipients to be presented at an award ceremony at the Division of Plasma Physics annual meeting banquet.

The team was cited “for the first experimental demonstration of the stabilization of edge localized modes in high-confinement diverted discharges, by application of very small edge-resonant magnetic perturbations, leading to the adoption of suppression coils in the ITER design.”

Fenstermacher, Evans and Moyer performed experiments that proved edge magnetic plasma instabilities in toroidally confined fusion plasmas, known as Edge Localized Modes or “ELMs,” can be stabilized by applying small 3D magnetic perturbation fields. ELM stabilization was predicted and confirmed experimentally by an international team of physicists in the DIII-D tokamak at General Atomics and published in a 2004 issue of *Physical Review Letters* and a 2006 issue of *Nature Physics*. Analysis of DIII-D data showed a correlation between the effectiveness of ELM mitigation and the width of the region in the plasma edge where the induced magnetic islands overlapped. The analysis suggested a threshold width of island overlap to achieve full ELM stabilization.

2018 Landau-Spitzer

Yevgen Kazakov, Laboratory for Plasma Physics of the Royal Military Academy (LPP-ERM/KMS), Brussels, Belgium, **Jozef Ongena**, Laboratory for Plasma Physics of the Royal Military Academy (LPP-ERM/KMS), Brussels, Belgium, **John. C. Wright** and **Stephen J. Wukitch**, MIT Plasma Science and Fusion Center, USA were selected "for experimental verification, through collaborative experiments, of a novel and highly efficient ion cyclotron resonance heating (ICRH) scenario for plasma heating and generation of energetic ions in magnetic fusion devices."

The Landau-Spitzer Award on the Physics of Plasmas for "outstanding contributions to plasma physics" is jointly sponsored by the Plasma Physics Divisions of the [American Physical Society](#) (APS) and the [European Physical Society](#) (EPS). The Award is given to an individual or group of researchers for outstanding theoretical, experimental or technical contribution(s) in plasma physics and for advancing the collaboration and unity between Europe and the USA by joint research or research that advances knowledge which benefits the two communities in a unique way. The award may be given to a team or collaboration of up to four persons affiliated with either the European or US institutions.

For more detail on the winners and their work please see the [APS announcement](#), the [LPP-ERM/KMS website](#), and [MIT News](#).

IEEE Nuclear and Plasma Sciences Society

Charles K. Birdsall Award

LLNL retiree Bruce Cohen was selected as the recipient of the 2018 IEEE Nuclear and Plasma Sciences Society's Charles K. Birdsall Award for "contributions to the numerical simulation of plasmas, particularly multiple time-scale methods and to their application to diverse plasma physics problems, from laser-plasma interactions to tokamaks."

The Birdsall Award recognizes outstanding contributions in computational nuclear and plasma science, with preference given to areas within the broadest scope of plasma physics encompassing the interaction of charged particles and electromagnetic fields.

"I am elated to receive the IEEE NPSS Birdsall Award," Cohen said. "It is very gratifying to have one's research career in physics recognized with this award. I am very thankful to my supervisors and colleagues at LLNL and DOE for creating a great environment and supporting my work for the past 42 years. I have a special connection to Ned Birdsall as he was one of my professors at UC Berkeley and on my Ph.D. thesis committee, and I worked with him on a number of projects at Berkeley and later at LLNL."

DOE Early Career Awards – Office of Fusion Energy Sciences

This year, the Office of Science of the Department of Energy awarded funding to 84 scientists from across the nation as part of its DOE's 2018 Early Career Research Program. The program, now in its ninth year, supports the development of individual research programs of outstanding scientists early in their careers and stimulates research careers in the disciplines supported by the DOE Office of Science. Under the program, university-based researchers receive at least \$150,000 per year to cover summer salary and research expenses. For researchers based at DOE national laboratories, where DOE typically covers full salary and expenses of laboratory employees, grants will be at least \$500,000 per year to cover year-round salary plus research expenses. The research grants are planned for five years. Scientists that were awarded funding supported by the DOE Office of Fusion Energy Sciences include:

- **Dr. David Donovan**, University of Tennessee-Knoxville - *Understanding Impurity Transport in Magnetically Confined Fusion using Interpretive Modeling and High-Sensitivity Material Characterization Techniques*,
- **Dr. Nathaniel M. Ferraro**, Princeton Plasma Physics Laboratory - *Integrated Predictive Modeling of ELM Suppression and Mitigation*,
- **Dr. Kentaro Hara**, Texas A&M University - *Kinetic effects on self-organization in low-temperature magnetized plasmas*,
- **Dr. Samuel Aaron Lazerson**, Princeton Plasma Physics Laboratory – *Exploration of Energetic Particle Confinement in Stellarators*,
- **Dr. Tammy Ma**, Lawrence Livermore National Laboratory – *Multi-ps Short-Pulse Laser-Driven Particle Acceleration for Novel HED and ICF Applications*
- **Dr. Alex Zylstra**, Los Alamos National Laboratory – *Studying Nuclear Astrophysics with Internal Fusion Implosions*

Fusion Power Associates

Fusion Power Associates recognized outstanding contributions to the field of fusion energy during the 39th Annual Meeting and Symposium, December 4-5 in Washington, DC.

FPA Special Awards

Fusion Power Associates (FPA) Board of Directors has voted to present FPA Special Awards to longtime Department of Energy Office of Fusion Energy managers **Steve Eckstrand** and **Mark Foster** for their contributions to fusion development. FPA Special Awards have been presented periodically since 1980 to persons who have made special contributions to the cause of fusion power development.

In selecting **Stephen Eckstrand**, the FPA Board of Directors recognizes and expresses its appreciation for his managerial and programmatic contributions to the magnetic fusion program through his leadership in managing the Alcator C-Mod experiment; the Tokamak Fusion Test Reactor program when it achieved 10 MW of deuterium-tritium fusion power; the National Spherical Torus Experiment program; and initiating and managing international collaboration teams on superconducting tokamaks. He also supported the management of the theory and SciDAC programs, the U.S. Burning Plasma Organization, U.S. participation in the International Tokamak Project Activities, and shaped overseas research agreements through the International Fusion Research Council.

In selecting **Mark Foster**, the FPA Board of Directors recognizes and expresses its appreciation for managerial and programmatic contributions he has made to advancing magnetic confinement fusion through his effective oversight of the DIII-D National Fusion Program spanning three decades, while more recently providing oversight of the C-Mod Program at MIT, the NSTX-U ST Program at PPPL, and the Measurement Innovations Program. During his tenure, Dr. Foster has been instrumental in growing the number of university participants engaged in research on the major facilities through new

awards. During his more than 24 year career at the U.S. Department of Energy, the programs managed by Dr. Foster made significant advances in Fusion Energy development across a number of areas, leading to increased confidence that ITER will meet its objectives for fusion energy development, and provided the scientific infrastructure that trained many of the current and the next generation of fusion research leaders.

2018 Excellence in Fusion Engineering Award

FPA Excellence in Fusion Engineering Awards have been given annually since 1987, in memory of MIT Professor David J. Rose, to recognize persons in the relatively early part of their careers who have shown both technical accomplishment and potential to become exceptionally influential leaders in the fusion field.

Chad Parish (ORNL) is recognized for "your many scientific contributions to advance microstructural characteristics of materials for fusion energy applications, including the surface morphology evolution of tungsten, and the productive collaborations you have established with other institutions in this important field of research".

Wayne Solomon (General Atomics) is recognized for "your development of unique diagnostic capabilities and pioneering contributions towards the understanding of momentum transport and intrinsic rotation generation, and discovery of experimental access to the super H-mode regime, and for your leadership as the Deputy Director of the DIII-D National Fusion Program".

2018 Distinguished Career Awards

Nathaniel Fisch is recognized "for your many years of dedication to plasma science and its applications in many fields and to advancing the prospects for fusion power, and especially for your decades of career contributions as a scientist and your role as an educator of a generation of younger scientists, upon whose shoulders the future of plasma science and fusion depends".

David Hammer is recognized "for your many years of dedication to plasma science and its applications in many fields and to advancing the prospects for fusion power, and especially for your decades of outstanding career contributions to the fields of pulsed power, the science of high energy density plasma and its applications, and your role as an educator of a generation of younger scientists, upon whose shoulders the future of plasma science and fusion depends".

FPA Leadership Awards

Dennis Whyte (MIT) is recognized for "the leadership you are providing to the worldwide quest for fusion power, especially by emphasizing the importance of seeking

continued improvements in both scientific and engineering foundations that will improve the prospects for fusion's commercial success".

Sean Regan (U. Rochester) is recognized for "the leadership you are providing to the inertial confinement fusion effort, and especially for the scientific contributions you have been providing to the experimental program on the OMEGA laser facility and the leadership you are providing to the national program in your role as co-chair of the National Implosion Stagnation Physics Working Group"

A list of previous recipients is posted on the FPA website: <http://fusionpower.org> and click on Awards.

2018 Chinese Government Friendship Award

Mohamed Abdou, Distinguished Professor of the University of California –Los Angeles (UCLA), has received the 2018 Chinese Government Friendship Award, which is China's highest award for foreign experts who have made outstanding contributions to the country's economic and social progress. He received the Award from Vice Premier Liu He in a ceremony on September 29th in the Great Hall of the People. The Chinese Government also held a grand award ceremony in the Great Hall on September 30th to honor the winners of the 2018 Friendship Award. In this ceremony, Premier Li Keqiang expressed his very warm congratulations to the honored experts, fully appreciating their efforts to boost China's development and to promote China's friendship with other countries. The recipients of the 2018 Friendship Award were 50 foreign experts from 21 countries working in various fields that include industry, agriculture, energy, environmental protection, education, science and technology, medical care and public health, culture and sports. Professor Abdou is also the recipient of Fusion Power Associates Leadership Award (1996) and Distinguished Career Award (2016) and is a current member of Fusion Power Associates Board of Directors.

Congratulations to these award recipients who we are proud to have representing our field, our division, and the society. Please forward recognitions of our fusion community to our newsletter editor, Robert Duckworth, duckworthrc@ornl.gov.

Awards within the ANS FED are given every two years, and nominations can be made by anyone at anytime to the Honors and Awards Committee Chair of the Fusion Energy Division of the American Nuclear Society. (currently Susana Reyes at SLAC National Accelerator Laboratory). For more information, go to the Honors & Awards page at the FED web site (<http://fed.ans.org/awards/>).

ONGOING FUSION RESEARCH AND NEWS

On the Path to Clean Fusion Energy TAE Technologies – Private Fusion Ventures, Ales Necas, TAE Technologies

Introduction

For nearly one million years, the level of carbon dioxide (CO₂) in our atmosphere has varied between 180 – 280 ppm. The most dramatic rise in CO₂ coincides with the Industrial Revolution in 1750; from then on, CO₂ levels rose from 280 ppm to the current 405 ppm and it has continued to accelerate. CO₂ is a greenhouse gas that, along with methane, is causing the heating of our planet. CO₂ is also responsible for the acidification of our oceans, causing coral destruction and shelled animals to have difficulty building protective shells. The solution to this catastrophic problem seems simple: Stop using fossil fuels, whose by-products are greenhouse gases, and switch to clean energy. However, this may be easier said than done, as implementation can be difficult due to powerful economic and political forces. Let us for a moment assume we live in a world driven by sustainability and care for the air we breathe. In such a world, the “bang-for-the-buck” solution is fusion, as it delivers more energy per nucleon than fission without radioactive waste. TAE Technologies is pursuing aneutronic fusion $p+^{11}\text{B}\rightarrow 3\alpha+8.3\text{ MeV}$ energy as a cornerstone of our research. Due to the absence of neutrons, the $p(^{11}\text{B},\alpha)\alpha$ reaction causes neither wall activation nor wall damage.

Fusion Approach at TAE

TAE Technologies (TAE) is a private company conceived and founded at the University of California-Irvine by a large and diverse group of individuals, including Prof. Norman Rostoker and Glenn Seaborg. TAE is concentrating its efforts on a combination of plasma physics and accelerator physics by confining hot plasmas through its proprietary Field-Reversed Configuration (FRC) shown in Figure 1. [1] [2] Such plasma is a high beta compact toroid, which translates into having a very high-power density in addition to being compact. Closed field lines allow for a good confinement; open field lines facilitate the

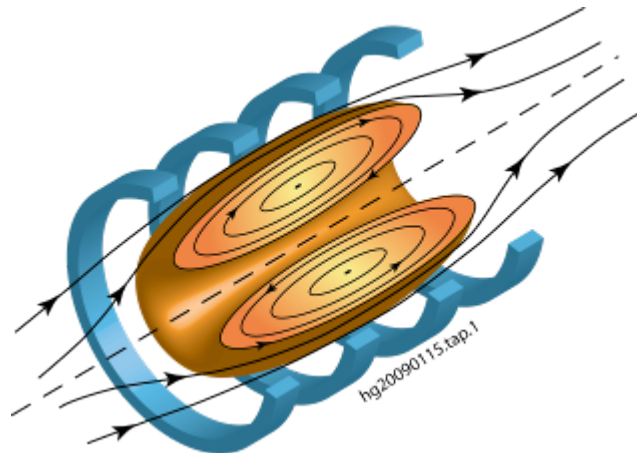


Figure 1: Geometry of the FRC showing open and closed field lines with plasma confined within the closed field lines. Magnetic coils in blue provide an external magnetic field.

the

removal of spent fuel into linear and unrestricted diverters. The diverter size is not dictated by the size of magnetic coils. The last closed line is the separatrix, or FRC plasma radius. Such design allows for easier design and maintenance. In addition, FRCs may allow to burn the advanced, aneutronic fuels such as D-He³ or p-B¹¹.

The history of TAE's progress [1], [2], [3] can be measured by the FRC radius as shown in Figure 2.

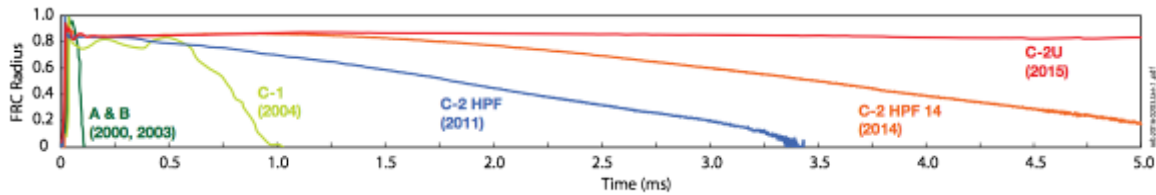


Figure 2: TAE's progress of improved normalized FRC plasma radius.

Simulations by fluid codes (e.g. NIMROD) [4] and hybrid code (HYM) [5] have shown that FRC is subject to instabilities on the order of 100s μ s (Alfven time) [6], thus plasma lasting 5+ ms is a testament of the intrinsic stability of TAE's FRC. Indeed, it had been postulated by Prof. Rostoker [7] that high energy particles (and more kinetic plasmas) will average out over turbulent flows, allowing for a quiescent core. This result is shown in Figure 3, both experimentally [left] and computationally [right] [8].

In order to achieve long plasma sustainment, a high current advanced neutral beam injection was implemented with up to 21 MW in the present machine – Norman aka C-2W. TAE iterated through many cycles of learning with initial table top machines made from sewer pipes. Through innovation and the application of the “fast to fail” mindset, TAE has built ever more sophisticated machines to probe the physics of high beta plasmas, culminating in the construction of the Norman experiment, a \$100MM National Laboratory-scale device that was constructed from the ground up in just one year, including first plasma commissioning. The design of its successor experiment will begin soon. None of this could be achieved without high performance computing (HPC). HPC accelerates scientific understanding, which helps to predict the most optimal design parameters, and mitigates business risk by identifying high priority project-critical components.

TAE is driven by innovation and the delivery of value to its shareholders. To satisfy these goals, TAE has begun applying its in-house technology to its TAE Life Sciences subsidiary, which leverages our flexible, compact, and cost-effective neutron source for Boron Neutron Capture Therapy (BNCT) to treat cancer.

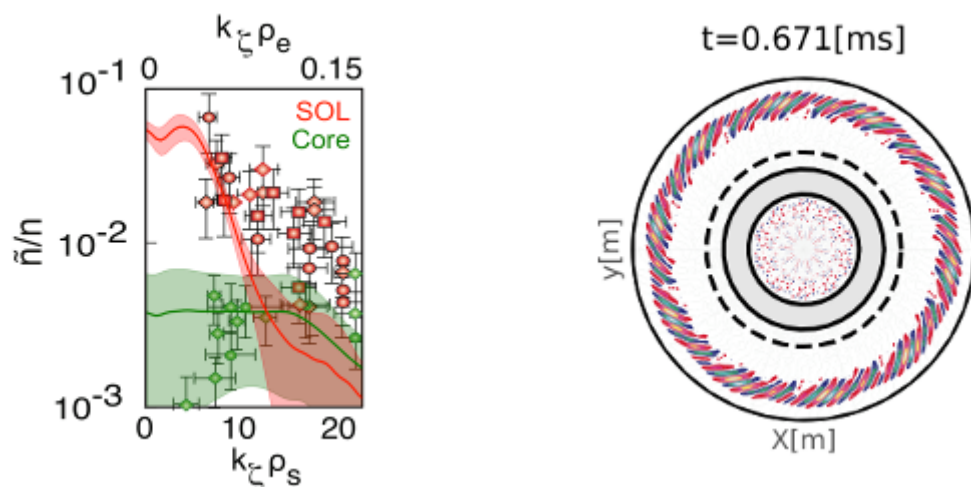


Figure 3: [Left] Experimental measurements (symbols with error bars), by Doppler Backscattering, of density fluctuations in the previous C-2/C-2U experiments as a function of normalized wave number [8]; overlaid with simulation results (lines with shaded uncertainty regions) of density fluctuations obtained with the ANC turbulence code [9]. [Right] Snapshot of ANC simulation before the inverse energy cascade with equilibrium from Lamy Ridge code [10].

Summary

TAE Technologies has substantially contributed to the high-beta approach to fusion research: what started as a simple tabletop experiment has grown to over \$100MM National Laboratory-scale device with the building of the present machine -- Norman aka C-2W. The C-2 program demonstrated an impressive list of scientific and engineering breakthrough achievements: (1) successful operation and study of advanced beam-driven FRCs; (2) discovery of the high performance FRC regime; (3) synergetic combination of neutral beam injection with edge biasing and gettering; (4) FRC macro-stability and improved confinement; (5) record >11 ms FRC lifetimes due to the superior confinement scaling and coupled core-SOL transport barriers; such performance is limited only by hardware and stored energy constraints. The operation of C-2W will explore real-time monitoring and control as well as probe the open field-line plasma. Lastly, TAE has formed a Life Sciences subsidiary to enable an effective, highly targeted cancer treatment called Boron Neutron Capture Therapy (BNCT) to be administered in hospitals and clinical settings for the first time.

References:

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U.S. to Launch Major Fusion Planning Effort, Robert Duckworth, Oak Ridge National Laboratory

Jim Van Dam, Acting Associate Director for Fusion Energy Sciences at the U.S. Department of Energy, has announced that a major "new long-range strategic planning activity for the Fusion Energy Sciences (FES) program" will soon begin. He asks for extensive community involvement, with a report by December 2020. The effort is intended to provide "a holistic, integrated perspective". The American Physical Society (APS) Division of Plasma Physics (DPP) has been asked to form a committee to lead the process. They sought ANS FED input, and selected Lauren Garrison, FED Secretary-Treasurer to be a member of this committee. All FED members should be ready to participate in coming workshops, and to support Lauren in her work representing the fusion technology community in this process.

Jim Van Dam's announcement, in full is appended below:

Dear Colleagues:

I write to inform you about the launch of a new long-range strategic planning activity for the Fusion Energy Sciences (FES) program, in which both the U.S. fusion plasma science community and the Fusion Energy Sciences Advisory Committee (FESAC) will be involved.

First, let me take the opportunity to thank the community for all of its efforts to provide information for the National Academy of Sciences (NAS) Burning Plasma Study. The community's efforts included organizing the town hall meetings that were held in Madison, WI, and Austin, TX, during 2017. I am sure that all of this information was extremely helpful to the NAS study, which is now moving toward completion of its final report. These two town halls also provided an excellent venue for the community to discuss the directions of the magnetic confinement part of the FES program.

In addition to this activity, over the last several years the community has come together and, through a series of workshops, has provided to our office valuable information on possible research directions across the FES program. The initial set of 2015 workshops helped us immensely in developing and implementing the FES program plan Fusion Energy Sciences: A Ten-Year Perspective (2015-2025) (1). These initial workshops, as well as subsequent workshops that the community has organized in recent years, have helped to guide us in our decision-making across the program to address the most pressing scientific challenges as well as to start new initiatives. Again, let me convey our thanks to the community for your time and effort to make all of these workshops a success.

(1) https://science.energy.gov/~media/fes/pdf/program-documents/FES_A_Ten-Year_Perspective_2015-2025.pdf

In the budget allocations appropriated for the last two fiscal years (FY 2018 and 2019), the FES program received significant funding increases and support from Congress. These increases have allowed the FES program to accomplish a number of important programmatic activities, including enhancing the DIII-D facility capabilities; accelerating the NSTX-U recovery; expanding our theory/simulation, international collaboration, and discovery science programs; and initiating construction of a new, world-leading materials experimental testing facility (MPEX), to name a few. We also made our first in-cash contribution to the ITER Organization since FY 2015. All of this has strengthened the FES program across many scientific frontiers and formed the basis for a stronger program going forward.

Given this Congressional support and all of these recent efforts by the community and given that the NAS Burning Plasma Study report is on the verge of completion, we believe that the time is right to initiate an activity with the community and with FESAC to develop a new long-range strategic plan for the FES program. Several years ago FESAC worked hard, twice, to try to accomplish this very difficult task. Unfortunately, the plans thus developed lacked broad consensus. Now, at the present time, we believe that the community's efforts described above have built momentum and helped all of us to gain confidence

that our community, together with FESAC, can successfully develop a long-range plan, having broad consensus, for the FES program.

Two program offices within the DOE Office of Science-the High Energy Physics program (HEP) and the Nuclear Physics (NP) program-have noteworthy experience in strategic planning. Our office has engaged with both of these offices to understand the processes that they used, how these processes were organized and led, and what challenges were encountered. We are grateful for these discussions and their advice to us. I encourage you to take a look at their reports: Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context-Report of the Particle Physics Project Prioritization Panel (P5) (May 2014) (2) and Reaching for the Horizon: The 2015 Long Range Plan for Nuclear Science (3).

(2) https://science.energy.gov/~media/hep/hepap/pdf/May-2014/FINAL_P5_Report_053014.pdf

(3) https://science.energy.gov/~media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf

The HEP and NP program offices both used their respective American Physical Society (APS) divisions to organize community-led activities, which involved town halls, workshops, white papers, and-in the case of HEP-a final integrated get-together called "Snowmass on the Mississippi." All of the community input was then turned over to their respective federal advisory committees for final prioritization and the writing of the resultant report.

We wish to use a similar approach, namely, that of requesting the APS Division of Plasma Physics (DPP) Executive Committee to help with the organization of the community-led activities. We want the community to be truly involved in this long-term planning process. We are grateful that the DPP leadership are willing to provide this valuable sponsorship of the community-driven first phase.

The second phase of the process involves a charge to FESAC. This charge will be provided at or before the next FESAC meeting, scheduled for December 6 and 7, 2018, in North Bethesda, MD. (Location details are posted on the FES web site.) Details of the FESAC charge, which will include guidance budget scenarios (as did the HEP and NP charges to their advisory committees), are still being developed. This charge, unlike the two previous program prioritization charges to FESAC several years ago that focused only on magnetic confinement fusion, will encompass the entire FES portfolio so that all parts of the FES program are integrated into one long-range plan.

Although this charge will be discussed at the December FESAC meeting, no FESAC subcommittee to address the charge will be formed at that time. Our wish is that the community, under the sponsorship of the DPP, will organize itself and hold discussions, town halls, workshops, and any other forums it chooses. Toward the end of the community's process to develop its important input for planning, a FESAC subcommittee will be formed to carry out its work of developing the final long-range plan. The full FESAC, as the official federal advisory body for the FES program, will be responsible to review, edit, and decide whether to approve the report.

The excellent reports from the recent workshops, as well as the findings and recommendations in the soon-to-be-released NAS Burning Plasma Study, will be

very useful to the community in its phase one activities and to FESAC in phase two.

With all of the recent significant efforts by the community across the FES program portfolio, we believe that a solid initial foundation has been formed upon which to launch and build this long-range planning process. Utilizing that foundation should allow some acceleration of the process, so we are asking that both the community and FESAC activities be completed, if possible, by December 2020. We ask that the community, working with APS/DPP, now begin its part of the long-range planning process.

Sincere thanks,
James W. Van Dam
Acting Associate Director of the Office of Science
For Fusion Energy Science

National Academy Final Report released, Robert Duckworth, Oak Ridge National Laboratory

The U.S. National Academies of Sciences (NAS) has completed a 2-year study of the U.S. fusion program and recommended "[the United States should start a national program of accompanying research and technology leading to the construction of a compact pilot plant that produces electricity from fusion at the lowest possible capital cost](#)". A webinar was held on December 13, 2018 to discuss key findings and recommendations. This webinar was recorded and can be viewed [here](#). A copy of the report is available from the [NAS](#). The Executive Summary from their report is provided below:

Executive Summary

Fusion energy offers the prospect of virtually unlimited energy, and the United States and many nations around the world have made enormous progress toward achieving fusion energy. Many of the complex physical processes of magnetically confined plasma are now understood, and the first construction phase of the international ITER fusion reactor is more than half complete. With the initial operation of ITER scheduled to begin within a decade and with the expectation, 10 years later, that controlled fusion will be demonstrated, now is the right time for the United States to develop plans to benefit from its investment in burning plasma research and take steps towards the development of fusion electricity for the nation's future energy needs.

This report of the Committee on a Strategic Plan for U.S. Burning Plasma Research describes a strategic plan for fusion research to guide implementation of the committee's two main recommendations:

- First, the United States should remain an ITER partner as the most cost-effective way to gain experience with a burning plasma at the scale of a power plant.

- Second, the United States should start a national program of accompanying research and technology leading to the construction of a compact pilot plant that produces electricity from fusion at the lowest possible capital cost.

ITER is a burning plasma experiment and the critical next step in the development of fusion energy. It is a large and ambitious project that integrates multiple advanced technologies and combines the scientific and engineering expertise, industrial capacity, and financial resources of many nations. As a partner, the United States receives full benefit from the technology developed for ITER while providing only a fraction of the financial resources. Methods to control the plasma and extract the electricity producing heat will be tested and developed. U.S. industry is building major systems for ITER and thereby gaining expertise in fusion engineering science and building industrial capabilities.

Although the United States provides only part of the cost of ITER, if the United States is to profit from its share of the ITER investment, the nation's strategic plan for fusion should combine its ITER experience with the additional science and engineering research needed to realize reliable and economical fusion electricity. Without this additional research, the United States risks being overtaken as other nations advance the science and technology required to deliver a new and important source of energy.

Recent advances motivate a new national research program leading to the construction of a compact fusion pilot plant. Significant progress in predicting and creating the high-pressure plasma required for such a reactor has been made. Opportunities to develop technologies for fusion, such as high temperature superconducting magnets and advanced materials, now make a compact device possible. A focus on a compact device will accelerate the fusion development path, making it affordable and attractive for industrial participation. Finally, by starting now, a national research program toward a compact pilot plant and critical science and technology research can be ready in time to use the knowledge learned from ITER operation to demonstrate electricity production by mid-century.

The committee envisions a U.S. pilot plant producing power similar to that expected in ITER but in a device much smaller in size and cost and employing design improvements that would allow net electricity production. This compact burning plasma fusion pilot plant would be a pre-commercial research facility. In addition to the production of fusion electricity, it would ultimately be capable of uninterrupted operation for weeks and produce tritium, the heavy isotope of hydrogen in fusion fuel. As a pilot plant, its purpose will be learning, but the knowledge obtained would be sufficient to design the first commercial fusion power systems.

A new national focus on developing a compact pilot plant in the long term will help set priorities for the near and mid-term fusion program. Research needs to show how to increase the fusion power density beyond that obtainable in ITER. Uninterrupted operation should be demonstrated while researchers learn how to handle reliably the high levels of escaping heat from the plasma. New program elements should begin

immediately to develop the materials and technologies needed to extract the heat and recirculate tritium and, also, to promote the industrial development of very-high-field superconducting magnets for fusion. Finally, technology innovations should be encouraged and developed to simplify maintenance and lower construction cost.

The committee recognizes that there are risks involved in developing a compact fusion pilot plant. Resolving these risks will necessitate the design and operation of new facilities. One of the greatest risks is the control of a continuous high-pressure compact plasma, which will require a design and construction of new intermediate-scale research facility in the United States, or a significant upgrade to an existing facility, to establish its feasibility. Another significant risk is the qualification of the materials and components that surround the plasma and are exposed to fusion irradiation. The committee's proposed strategic plan also includes other recommendations aimed at improving and reducing the cost of fusion as a source of electricity through the development of promising innovations in burning plasma science and fusion engineering science.

The committee expects that the implementation of its recommendations, including both continued participation in ITER and the start of a national research program for a compact pilot plant, will require additional funding, rising to nearly \$200 million beyond the recently enacted annual funding levels. This funding would need be sustained for several decades. Although the funding remains level, the research portfolio evolves over time, and existing research facilities are phased out as new ones are implemented.

The committee was also tasked to recommend strategic guidance if the United States decides to withdraw from the ITER project. This withdrawal would significantly disrupt the national research effort, isolate U.S. researchers from the international effort, and eliminate the benefit of sharing the cost of producing a burning plasma at the power plant scale. Nevertheless, if the United States decides to withdraw from the ITER project, the committee recommends the United States continue research toward the construction of a compact fusion pilot plant. However, without ITER participation, U.S. progress will necessitate a significantly larger commitment of resources for a longer time. Without ITER, the United States would need to design, license, and construct an alternative means to gain experience creating and controlling an energy-producing burning plasma. The scale of research facilities within the United States would become larger, more ambitious, and more expensive. As a result, producing net electricity from fusion in the United States would be delayed.

CALENDAR OF UPCOMING CONFERENCES ON FUSION TECHNOLOGY*

2019:

- 12th International Conference on Tritium Science and Technology (TRITIUM 2019), **April 22-26, 2019**, Busan, S. Korea. See tritium2019.org for current program and conference information. Early Registration Deadline is January 31, 2019.

- 17th International Conference on Plasma-Facing Materials and Components for Fusion Applications (PFMC-17), **May 20-24, 2019**, Eindhoven, The Netherlands. See <https://www.pfmc2019.com/home> for current program and conference information.
- 28th IEEE Symposium on Fusion Engineering (SOFE 2019), **June 2-6, 2019**, Ponte Verda Beach, Florida USA. See <sofe2019.utk.edu> for current program and conference information. Early Registration Deadline is April 15, 2019.
- ANS Annual meeting, **June 9-13, 2019**, Minneapolis, MN, USA. See <http://ansannual.org> for more information.
- 14th International Symposium on Fusion Nuclear Technology (ISFNT), **September 22-27, 2019**, Budapest, Hungary, <http://isfnt-14.org/>. Important Dates to Remember Abstract Submission Deadline – February 28, 2019; Abstract Notification April 30, 2019; June 15, 2019; Early Registration Deadline & Manuscripts due August 31, 2019.
- 11th Inertial Fusion Sciences and Applications (IFSA-2019), **September 22-27, 2019**, Osaka, Japan.
- 19th International Conference on Emerging Nuclear Energy System (ICENES 2019), **October 6-9, 2019**, Bali, Indonesia. See <http://portal.fmipa.itb.ac.id/icenes2019> for more information. Important Dates to Remember Abstract Submission Deadline – April 30, 2019; Abstract Notification May 30, 2019; Early Registration Deadline June 15 2019; Manuscript Submission Deadline September 30, 2019.
- 61st American Physical Society - Division of Plasma Physics (APS-DPP) meeting **October 21-25, 2019**, Ft. Lauderdale, FL, USA. See http://www.apsdpp.org/meetings/upcoming_meetings.php for more information.
- 7th International Workshop on Plasma Material Interaction Facilities for Fusion Research, **October 22-25, 2019** in La Jolla, CA. The workshop will begin exactly one year from today and will last. Details on the workshop can be found at: <https://sites.google.com/ucsd.edu/pmif2019/home>, In order to leave time for those who may need visas to travel to the workshop, the deadline for abstract submission will be May 1st, 2019. Abstract Notifications scheduled for June 17, 2019.
- 19th International Conference on Fusion Reactor Materials (ICFRM), **October 27 – November 1, 2019**, La Jolla, CA, USA, See <https://icfrm-19.com> for more information. Important Dates to Remember Abstract Submission Deadline – February 15, 2019; Abstract Notification March 30, 2019; Early Registration Deadline September 1, 2019.

- ANS Winter Meeting, November 17-21, 2019, Washington, DC, USA
<http://www.ans.org/>

2020:

- 24th ANS Topical Meeting on the Technology of Fusion Energy (TOFE), **April 19-24**, Charleston, SC.
- 31st Symposium on Fusion Technology (SOFT 2020), **September 13 - 17, 2020**, Dubrovnik, Croatia.
- 28th IAEA Fusion Energy Conference (FEC 2020), **October 12 – 17, 2020**, Nice France.

* Calendar of other meetings (of interest to researchers in atomic, molecular and plasma material interaction processes and data relevant to plasma physics and fusion energy research) are posted at: <http://ieee-npps.org/directory-of-plasma-conferences/>, https://www-amdis.iaea.org/w/index.php/Calendar_of_Meetings.

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