United States
Burning Plasma Organization

The US Burning Plasma Organization

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Fusion Power Associates
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GENERAL ATOMICS

Who is the US Burning Plasma Organization (USBPO)?

- **A community-based organization, supported by DOE FES, with a mission to "*Advance the scientific understanding of burning plasmas and ensure the greatest benefit from a burning plasma experiment by coordinating relevant U.S. fusion research with broad community participation.*"**
  - Includes 10 topical groups that can consider and address science and technology issues
- **You can become a member* or sign up for our e-Newsletter* at https://www.burningplasma.org (look for "Sign Up Forms")**
  - Currently 457 members, mainly US researchers across the fusion enterprise
    - Also includes 41 non-voting associate members from the international community
  - Monthly e-Newsletter and occasional announcements reach 624 readers
- **Disseminating information via e-News, web seminars, oral sessions at APS-DPP**
- **Largest focus has been on preparations for a successful ITER that brings back the results we need to progress toward fusion energy…**

*Membership is free

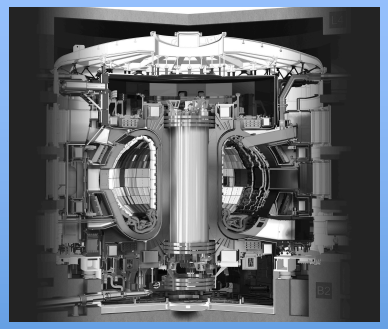
THANK YOU to both Amanda and Oliver!

Congratulations to Amanda on receiving a 2020 Secretary of Energy Appreciation Award!

Amanda Hubbard has stepped down as Deputy Director of the US Burning Plasma Organization in order to devote more time to her research. Amanda was instrumental in the original formation of the USBPO, serving as the first Council Vice Chair and later as Council Chair, briefly as Deputy Leader of the Integrated Scenarios topical group, and finally as Deputy Director since 2011.

Professor Oliver Schmitz of the University of Wisconsin has taken over as the new Deputy Director of the USBPO. Oliver is well known as one of the young leaders of our field, and I am very happy that he has agreed to bring his enthusiasm for and expertise in burning plasma science to this new role. I look forward to working closely with Oliver in the coming years.

The US Fusion Program is developing an ambitious plan for fusion energy



NAS
DPP-CPP
FESAC

EXCITE
FPP
ITER
VNS
SPARC
…

What should be the role of the USBPO moving forward?

Focusing of USBPO activities in the CPP/FESAC LRP landscape

- **The recent series of reports, culminating in the FESAC long-range plan, identified several new facilities – which are potentially within the scope of the USBPO?**
  - Working definition of "burning plasma" has been that most of the plasma heating comes from fusion reactions… Q>5
  - What are the criteria for consideration? Q>5? Anything that contributes to the FPP mission? FES funding?
  - How could the USBPO contribute?
    - Activities for other programs could look a lot like those for ITER in the early days of the USBPO: Participation in scoping, design activities, community outreach, development of physics basis…
- **ITER is real and will be the first magnetically confined high-gain burning plasma at reactor scale**
  It must remain our most immediate focus in the coming years
  - There are well defined needs that the USBPO can help (and is helping) to address…

ITER – What's urgent NOW (1)

- **Participation in facility commissioning**
  - Already underway for several major systems
  - Unrealized (so far) opportunity to gain experience in operating the first large fusion facility
    - Caveat: Opportunities to participate early would require long-term on-site presence
- **Building a culture of collaboration with the ITER Organization and our fellow ITER Members**
  - International Tokamak Physics Activity (ITPA): *Large US participation including one outgoing topical group chair, one incoming chair, and two incoming co-chairs*
  - ITER Science Fellows: *13 from US*
  - ITER Operations Network: *Three from US*
  - ITER Project Associates: *One from US*
  - Monaco Fellows: *One from US (in outgoing group, none in incoming group)*
  - Continued US participation and leadership in ITER advisory committees, design reviews,…

ITER – What's urgent NOW (2)

Issues under discussion in USBPO Research Committee

- **(usually) annual ITER International School**
  - USBPO provides scholarships for US students and post-docs to attend (16 identified in 2020)
  - 2020 school in Aix-en-Provence postponed due to COVID-19
    - USBPO planning to host next instance in the US; now probably in 2021
- **Addressing urgent science topics to prepare for successful ITER operation**
- **Building a centralized US ITER research team that can hit the ground running and bring home an essential knowledge base for proceeding to a Fusion Power Plant is recommended in the DPP-CPP and FESAC LRP reports**

The possibility of the USBPO evolving into a US ITER Research Team has been discussed, but the following is agnostic on that point. Many of us are in agreement that such a Team should be formed sooner rather than later.

The USBPO Research Committee has already laid the groundwork for identifying high priority physics tasks

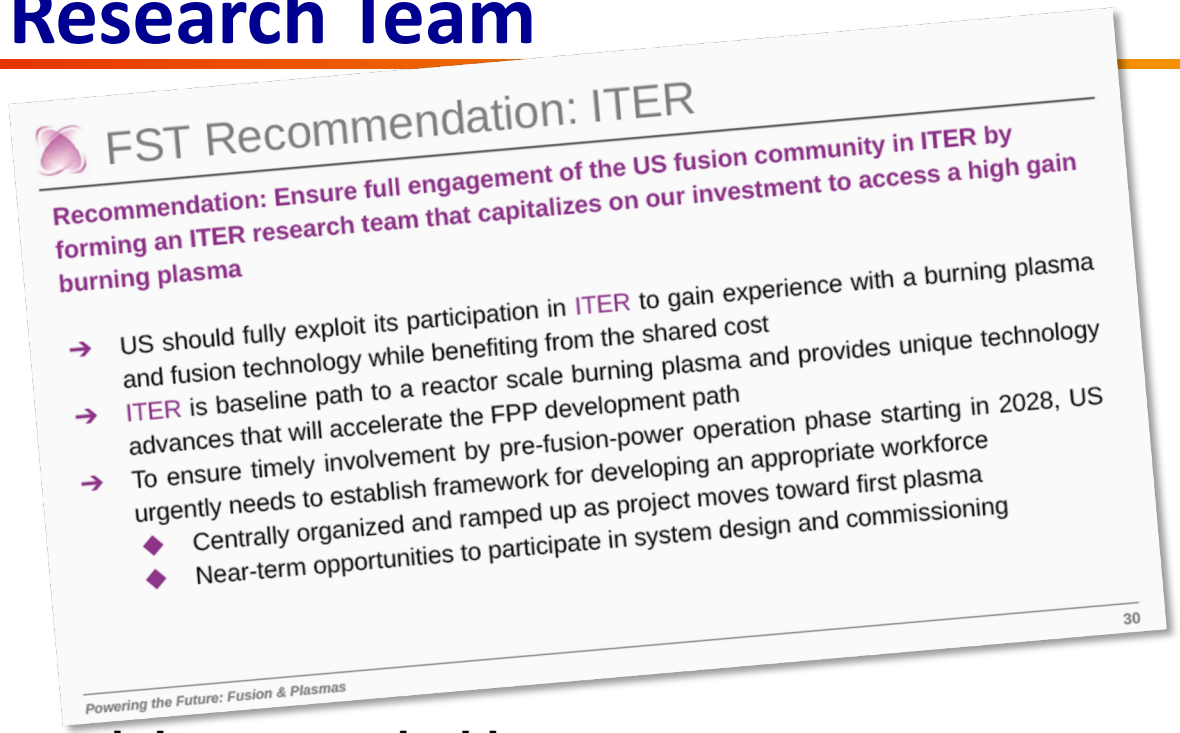
Ref.	System/ Issue	Required R&D	Category*	Required experimental facilities	Comment	Phase when system required/	US contribution	US collab opportunity	US notes
A. R&D for design completion									
A.1	SPI-single injector. Pellet injection optimization for RE avoidance (incl. TQ and CQ mitigation)	Optimization of shard size, velocity, amount, gas vs. shard fraction, composition (D + impurity) to achieve RE avoidance with optimum TQ, CQ (incl. wall loads)	1	Range of tokamaks with different sizes and plasma parameters to allow extrapolation to ITER (including high l_i tokamak) and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-1	US1	C1	D3D leads on this. JET SPI
A.2	SPI-single injector demonstration for runaway mitigation	Determination of feasibility to dissipate the energy of formed runaway beams (amount, assimilation) and to improve scheme	1	Range of tokamaks with different sizes and plasma parameters to allow extrapolation to ITER and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-1	US1	C1	D3D leads on this. JET SPI
A.3	SPI-multiple injections	Determination of effectiveness of multiple injections to achieve RE avoidance with optimum TQ, CQ (incl. wall loads) compared to single injections (incl. timing requirements)	1	Range of tokamaks with different sizes and plasma parameters to allow extrapolation to ITER with at least two injectors from the same/similar locations (toroidal separation not required) and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-1	US1	C1	D3D leads on this. KSTAR will have multiple SPI in 2020. Jet possibly in extension.
A.4	SPI-multiple injectors	Determination of effectiveness of multiple injection from different spatial locations to achieve RE avoidance with optimum TQ, CQ (incl. wall loads)	1	Range of tokamaks with different sizes and plasma parameters to allow extrapolation to ITER with at least two injectors toroidally well separated and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-1	US1	C1	D3D leads on this. See above re multiple SPI.
A.5	DMS – alternative injections techniques	Demonstration of the feasibility of the technique to inject material in a tokamak and comparison of mitigation efficiency with SPI	1	Single tokamak demonstration and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-1	US1-2		Other US ideas exist. Already leading with Shell Pellet on D3D. NSTX could do something new. Ideas (eg CPP input) include Electromagnetic Particle Injection, Marshall gun, Linear Induction Motor injection. Potential opportunity to expand efforts and world leadership.
A.6	DMS – alternative disruption mitigation strategies	Exploration of disruption mitigation by schemes other than massive injection of D_2 and high Z impurities	1	Single tokamak demonstration and with appropriate measurement capabilities	More details on R&D work plan for DMS: (https://user.iter.org/?uid=WE6WJR)	PFPO-2	US2		US ideas exist, see eg Transients workshop and CPP input. These include Runaway electron (RE) control using RF-induced kinetic instabilities, controlling the current quench with 3D-field induced islands and passive 3D coil for RE deconfinement
A.7	Laser Induced Desorption for in-situ T retention measurement	Demonstrate LIDS as quantitative in-situ diagnostic measurement for T retention in Be co-deposits at divertor	1	Demonstration in tokamak with Be/W environment	Required to provide in-situ measurements of T retained in divertor Be co-deposits (most likely after each operational day)	FPO	US5	C2	ITER demonstration needs Be/W for which JET uniquely is capable. But more generally, LIDS quantification requires establishing methodology for crater quantification and correlation to mass spectrometry. US does have capabilities on this technique and modelling; needs more effort. Technique can be developed elsewhere, collaborations on WEST and with FZ Juelich, Germany re W7-X and JET
A.8	Single crystal mirror testing	Performance of single crystal mirror with/without active cleaning	1	Demonstration in Be/W environment	Required for evaluation of performance of ITER diagnostics using plasma facing mirrors	PFPO-1	US5	US2	Requested demonstration needs Be PFCs; JET uniquely capable. Again more generally, work is needed and ongoing on the technique. LIBS Quantification is limited by dissimilar laser-induced ablation mechanisms for Be, C and hydrogen isotopes. US has collaborations on WEST and EAST.
A.9	Laser Induced Breakdown Spectroscopy	Demonstrate LIBS as quantitative measurement for T retention in Be co-deposits on main wall	1	Proof of principle demonstration in Be tokamak environment	Can provide an in-situ measurement of T retention in the first wall during shutdown by installation in a robotic arm	FPO	US5	C2	needs Be. Collaborations similar to A.7

US1	US can play a major role and is already making strong contributions.
US2	US can make significant, unique contributions and could do more
US3	US can contribute, along with other parties. May not be unique.
US4	Other parties are better positioned to contribute, and are meeting the research need. Or, US could make a minor contribution.
US5	US lacks needed domestic capabilities to contribute.

- **ITER Organization released a list of 119 high priority tasks supporting the ITER Research Plan in late 2018**
  - Updated as ITER Technical Report in September 2020 (ITR-20-008)
- **USBPO RC analyzed 2018 list and categorized tasks**
  - Identified 30 US1, 1 US1-2, and 42 US-2 tasks
  - Working now to reconcile with updated version (will be publicized to community)

How should research be coordinated to address the highest priority tasks?

Proposal for a community-led US ITER Research Team



- **US ITER research team needed to**
  - Prepare for a successful ITER research program
  - Provide opportunities for US researchers
  - Ensure that we can bring back the intellectual property needed to move expeditiously to an FPP
- **Community-based organization can attract participation from every segment of the community**
  - Need "all hands" on board! Lab, industry, university,…
  - No single institution should have a privileged position

US ITER Research Team Activities:
During construction and assembly (now)

- **Provide information, outreach and advocacy to the US fusion program to ensure broad participation by universities, industry, and laboratories**
- **Provide support for US researchers to become active via ITER Science Fellowships, ITER Project Associates, the ITER Operations Network, and new US-specific programs, e.g. a young scientist secondment program**
- **Provide coordination, starting today and continuing through the end of the ITER research program and decommissioning targeted at bringing back all of the intellectual property we are entitled to and need to move on to an FPP**
- **Organize and train the US ITER Research Team via participation in present-day facility operations and research**
  - Be prepared for US people to participate at all levels of the ITER Research Program, including leadership roles
  - Primarily entails research on DIII-D and NSTX-U, but could extend to related activities on international facilities
- **Building experience and familiarity with working in a remote environment on inter-national devices and through the COVID-19 protocols currently in place for our domestic program**
- **Represent the interests of the US fusion community within the broader group of ITER Members**
  - Although the ITER Research Plan should support our needs, we collectively may have priorities that are different than some of the other Members

US ITER Research Team Activities:
Science Program

- **Starting now (some activities already in progress)**
  - Design and carry out experiments to address open issues for ITER operation
  - Establish activity to serve data and modeling to/from existing devices compatible with ITER's IMAS. Gain necessary experience working with the ITER data model, to bridge existing knowledge to future needs and position the US for success on ITER.
  - To support pulse-design of ITER discharges, the US should adapt existing pulse-simulation workflows to ITER data model and validate against existing devices
- **As ITER operation begins and progresses**
  - US researchers participate both remotely and on-site at ITER
  - Proposal and preparation of experiments on ITER
  - Active participation in all scientific activities during the ITER research phases, including leading and participating in experimental teams, monitoring and operating diagnostic systems, analyzing data, and reporting results via papers and presentations
  - The needs of early career personnel need to be accommodated, as ITER becomes a US research device, with the expectation that they can build a career around ITER
  - Advocate for availability of leadership roles within the ITER research program to US researchers

US ITER Research Team Activities:
Engineering and Technology

- **The first opportunity for US participation may be integrated commissioning of the first power-plant scale fusion nuclear facility, now scheduled to begin in March 2025**
  - Participation in preparation for these activities may be possible as early as 2022 but would likely require participants to be seconded on a long-term basis.
- **The US Team should be tasked to include accessing the knowledge on all systems (radiation hardened electronics, diagnostics, magnets, cryoplant, vacuum pumps, tritium systems, etc.) in ITER.**
- **There is a particular need to involve nuclear licensing and technology specialists, areas where the US fusion community currently has very minimal experience.**

US ITER Research Team formation must not leave the university community behind

Universities are the key source of an innovative workforce that must be included in the ITER research team development

- **Challenges for Universities to work at ITER**
  - Large enterprise appears challenging for academic freedom + visibility
  - Student and early career projects in regulated environment with long time scales and complicated decision making/intellectual ownership, formal challenges
  - Access points to start and sustain participation are unknown to many possible participants
  - Uncertainty in funding acquisition to start and sustain activities
- **Measures to facilitate University involvement**
  - **Entry point:** support involvement in e.g. ITER Science Fellow / IPA roles or membership in OpsNetwork
  - **Sustained research:** support sustained research involvement that allows to conduct thesis projects (5-6 years) in complex international environment
  - **Provide leadership opportunities:** shape ITER research team such that match of opportunities to skills is facilitated and enables to be involved
  - Support with formal aspects of implementation and ownership/IP concerns

The US Burning Plasma Organization
Looking to the future

- **We will continue what we've been able to do well**
  - Informing FES and the community on burning plasma related topics
  - Suggesting priorities for research supporting the ITER Research Plan
- **Consider expanding the focus along with the proposed new initiatives**
- **Current topic of interest: US ITER Research Team**
  - As endorsed by the NAS Burning Plasma Report, the DPP-CPP, and the FESAC long-range plan: "Ensure full engagement of the US fusion community by forming an ITER research team that capitalizes on our investment to access a high-gain plasma"
  - Could grow out of the USBPO, but doesn't have to (but even if it doesn't, the faces will probably look familiar)