American Nuclear Society
Fusion Energy Division
June 2012 Newsletter

Letter from the Chair, Lee Cadwallader, Fusion Safety Program, Idaho National Laboratory, Idaho Falls, ID.

I have two items to discuss for this letter. The first item is a few highlights from the US Fusion Energy Sciences Advisory Committee (FESAC) meeting that was held on February 28-29, 2012. There is a summary of the meeting in this newsletter and the meeting video has been archived at http://doe.granicus.com, so these are brief points. Two reports were prepared, one on International Collaboration (DOE/SC-0150) and one on Materials Science and Technology (DOE/SC-0149). These are excellent reports that were well thought out and are certainly worth the time to read. They are available for download at http://science.doe.gov. Other FESAC news of interest for our Division is that the DOE Office of Fusion Energy Sciences has found itself in a position of being forced to reduce the fusion program budget to provide funding to meet the US ITER commitment. The President's budget did not provide enough funding to meet the ITER commitment. There have been a number of protestations to Congress and the Administration about this issue. The House budget has included additional funds for the ITER commitment. The Senate has not. Difficult budget choices included a plan to close the Alcator C-Mod tokamak at MIT and displace those students and staff. At this writing, it is not clear what the final FY-2013 budget will contain.

The second item is to repeat the Fusion Energy Division Statement that was sent to key members of Congress on April 10, 2012:

Dear Chairman Inouye, Vice Chairman Cochran, Chairman Feinstein and Ranking Member Alexander:

The Fusion Energy Division of the American Nuclear Society has a Statement on the proposed Department of Energy budget and its adverse effect upon the future of fusion energy research and development:

Research in nuclear fusion represents one of very few options for a long-term effort to provide a major source of energy to replace climate-changing fossil fuels and ensure America's energy security. Fusion is one of the fundamental energy sources of the universe. Providing energy from fusion is a major scientific and technological challenge–in fact, it is one of the National Academy of Engineering's Grand Challenges for Engineering–but the rewards of fusion power and the benefits of a sustainable domestic source of energy make it a challenge worth taking.

The FY-2013 budget request by the Administration endangers the United States' domestic fusion program as well as our country's scientific contributions to the ITER international project. If implemented, the FY-2013 budget reductions will deal a major blow to the U.S. fusion research program and further erode its leadership position. After years of operating on minimal budgets and essentially level funding, the U.S. fusion program cannot withstand the proposed reductions without significant negative impacts.

U.S. fusion researchers were told a few years ago that there would be some "belt tightening" to divert fusion research funds to ITER construction. Without any quantitative guidance from the DOE on belt-tightening, there was speculation that it might be 1% or perhaps even as much as a 5% budget reduction for a few years. The FY-2013 budget, however, proposes a 16% reduction ($45 million) of fusion research funds, and DOE officials have given warnings that reductions of up to $100 million more will be needed in the coming years. If the Administration's FY-2013 budget is implemented, the DOE will close a unique fusion experiment, the Alcator machine at MIT, and the students and staff there will be dispersed. Deeper cuts in the future will disperse even more staff and students at institutions around the country who would use the ITER results, and greatly reduce the number of American engineers and scientists who will be educated and trained in fusion.

We urge the U.S. to consistently and adequately support the fusion research program as outlined in the Energy Policy Act of 2005 (PL 109-58, sec 971-972) and reverse this position, restoring funds to the domestic fusion program budget and, separately, fully funding this nation's promised annual ITER contribution.

The path to discover commercially viable fusion energy is one of the grand scientific challenges of our time. With ITER under construction to explore the science of burning plasmas, the world fusion program is poised to enter its final era of research. Other nations, including China, the European Union, Japan, Russia, and South Korea, are forging ahead rapidly, investing heavily in their domestic fusion programs and in educating the next generation of fusion researchers. They are fully supporting ITER as well. The U.S. has consistently led the fusion field and should continue to do so. American leadership in fusion energy would be in the best interests of the U.S. and science itself.

Sincerely,

Lee Cadwallader
Chair, Fusion Energy Division

Minami Yoda
Vice-Chair, Fusion Energy Division

cc: The Honorable Dr. Steven Chu, Secretary of Energy
The Honorable Dr. William Brinkman, Director, Office of Science, DOE
Dr. Edmund Synakowski, Associate Director, Office of Fusion Energy Sciences

This FED statement was also posted to the ANS Nuclear Café (http/:www.ansnuclearcafe.org) on April 18, 2012.

I am privileged to have served as the FED Chair for our Division's first 2-year term of office. I shall become Past Chair, and Dr. Minami Yoda will become Chair, at the ANS National Meeting in June 2012. Minami will lead the FED quite capably.

New ANS Fusion Fellows – June 2012, Nermin A. Uckan, FS&T Editor, Oak Ridge National Laboratory, Oak Ridge, TN.

The election to the rank of Fellow within the ANS recognizes the contributions that individuals have made to the advancement of nuclear science and technology through the years. Selection comes as a result of nomination by peers, careful review by the Honors and Awards Committee, and election by the Society's Board of Directors. The list of current fellows, nomination steps, guidelines, and nomination forms can be found at http://www.ans.org/honors/va-fellow.

It is a pleasure to report that we have a new ANS Fusion Fellow added to the honors rank: Prof. Ahmed Hassanein. Congratulations for a well-deserved honor.

Ahmed Hassanein is the Paul L. Wattelet Professor and Head of Nuclear Engineering, Purdue University, West Lafayette, IN. Hassanein's research interests include plasma material interactions, magnetic and inertial fusion research radiation damage in materials, computational physics and hydrodynamics, materials under extreme conditions, advanced numerical methods, extreme ultraviolet lithography, laser and discharge-produced plasma, nuclear radiation detection, and high power targets for accelerators.

Ahmed Hassanein will be recognized as a Fellow of the American Nuclear Society during the ANS Annual Meeting, held in Chicago, IL, June 24-28, 2012. Hassanein earned the highest grade of ANS membership for *"his significant development of comprehensive models and computer simulation packages for plasma material interactions for fusion energy applications in both magnetic and inertial confinement as well as other plasma science applications*."

Ahmed Hassanein is also a Fellow of SPIE, International Society for Optics and Photonics, a Fellow of AAAS, the American Association for the Advancement of Science, and a Fellow of IEEE, the Institute of Electrical and Electronics Engineers.

FED has two dozen or so Fellows and the FED Officers/Executive Committee have been encouraging all FED members to actively engage in nominating deserving colleagues to the fellowship grade. During the past couple of years, FED members have been working diligently to add one-to-two well-deserving colleagues a year to the FED Fellows roster. We need to continue this positive trend and keep nominating our colleagues. Please remember that one cannot get recognized and elevated to Fellow status, unless nominated. The FED "red-team" Fellows will be happy to provide guidance and help review nomination packages. Feel free to contact uckanna@ornl.gov for questions.

List of Officers and Executive Committee Members, Lance Snead, Oak Ridge National Laboratory, Oak Ridge, TN.

The election of Fusion Energy Division executive committee members was completed in May. Minami Yoda, the Vice-Chair/Chair-Elect will become Chair for her two-year term at the end of the June meeting. Susana Reyes was elected as the new Vice-Chair/Chair-Elect. Stephen Combs was elected Secretary/Treasurer; he will replace Mark Anderson who served an additional year to synchronize the terms of the officers.

Three new members were needed to fill the seats of those members whose terms are ending. The three elected committee members are Prof. Satoshi Konishi (Kyoto U.), Dr. Jacob Leachman (WSU), and Dr. Juergen Rapp (ORNL). We thank the outgoing committee members Lucille Dauffy, Rick Kurtz, and Shahram Sharafat for their service to the FED. The new Committee will be:

Chair:
Minami Yoda (GIT) (12-14) minami@gatech.edu
Vice-Chair/Chair-Elect:
Susana Reyes (LLNL) (12-14) reyessuarez1@llnl.gov
Secretary/Treasurer:
Stephen Combs (ORNL) (12-14) combssk@ornl.gov

Executive committee members:

Paul Humrickhouse (INL)	(10-13)	paul.humrickhouse@inl.gov
Yutai Katoh (ORNL)	(11-14)	katohy@ornl.gov
Satoshi Konishi (Kyoto U.)	(12-15)	s-konishi@iae.kyoto-u.ac.jp
Jacob Leachman (WSU)	(12-15)	jacob.leachman@wsu.edu
Arnie Lumsdaine (ORNL)	(11-14)	lumsdainea@ornl.gov
Rene Raffray (ITER)	(11-14)	rene.raffray@iter.org
Juergen Rapp (ORNL)	(12-15)	rappj@ornl.gov
Keith Rule (PPPL)	(10-13)	krule@pppl.gov
Mark Tillack (UCSD)	(10-13)	mtillack@ucsd.edu

Past Chair:
Lee Cadwallader (INL) (12-14) lee.cadwallader@inl.gov

FED Standing Committee Chairs:
Nominating: Lee Cadwallader (INL)
Honors and Awards: Farrokh Najmabadi (UCSD)
Program Committee: position open

FED representatives on National Committees:
ANS Public Policy: Lee Cadwallader (INL)
ANS Publications: position open
ANS Program Committee: Lance Snead (ORNL)/Lee Cadwallader (INL)

Editors:

Newsletter: Laila El-Guebaly (UW), Dennis Bruggink (UW)
Fusion Science and Technology journal: Nermin Uckan (ORNL)

Liaisons to other organizations and ANS divisions:

ANS Board of Directors: Ken Schultz (GA)
MS&T: Lance Snead (ORNL)
IEEE: George Miley (UIUC)
RPS: Paul Wilson (UW)

FED Webmasters:

Mark Tillack (UCSD) – FED website
Dennis Bruggink (UW) – UW website.

Fusion Award Recipients,

Laila El-Guebaly, Fusion Technology Institute, University of Wisconsin-Madison, Madison, WI.

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 (elguebaly@engr.wisc.edu) to be included in future issues. The ANS-FED officers and executive committee members congratulate the honored recipients of the 2012 fusion awards on this well-deserved recognition and our kudos to all of them.

ANS Award

Lance Snead (ORNL, Materials S&T Division) has received the 2012 Mishima Award from the American Nuclear Society. The award honors the late Yoshitsugu Mishima, professor at the University of Tokyo, and recognizes outstanding R&D contributions to nuclear fuels and materials.

News from Fusion Science and Technology (FS&T) Journal,

Nermin A. Uckan, FS&T Editor, Oak Ridge National Laboratory, Oak Ridge, TN.

During the past 12 months (from May 1, 2011 to April 30, 2012), FS&T received a total of 247 manuscripts for FS&T regular issues and 125 camera-ready papers for FS&T Transactions. Of the 247 regular manuscripts, 33 were from North America, 116 from Asia, 83 from Europe (including Russia), and 9 from others. The breakdown for 125 camera-ready papers for FS&T Transactions is as follows:

- 45 papers/lectures from the 10th Carolus Magnus Summer School (CMSS2011), held in Weert, The Netherlands, September 4-16, 2011.

- 80 papers from the 15th International Conference on Emerging Nuclear Energy Systems (ICENES), held in San Francisco, CA, May 15-19, 2011.

The following dedicated issues were published during the period 5/1/11 to 4/30/12:

- Selected papers from 2010 EC-16 – FS&T May 2011
- IAEA 1st Int. Fusion Youth Conference – FS&T Trans. (July 2011)
- 19th TOFE 2010 Proceedings – FS&T Jul. & Aug. 2011
- 9th Tritium 2010 Proceedings – FS&T Oct. & Nov. 2011
- ICENES 2011 Proceedings – FS&T Transactions (Jan. 2012)
- 10th Carolus Magnus Summer School (CMSS2011) – FS&T Trans. (Feb. 2012)
- Selected papers from 1st IAEA-ITER Materials 2010 – FS&T Feb. 2012.

For the first time, a new focus for FS&T was the decision to publish manuscripts dealing with fusion materials technology issues from the 15th Int. Conference on Fusion Reactor Materials (ICFRM-l5) that was held 16-22 October 2011, in Charleston, South Carolina. Those ICFRM-15 manuscripts that focus on materials science and properties were continued to be submitted to the Journal of Nuclear Materials, which has traditionally been the journal associated with ICFRM conference series.

The following issues are planned for July 2012 and beyond:

- Selected papers from ICFRM-15 – FS&T regular issue(s) (Jul./Aug. 2012)
- Selected papers from 20th IFE TFM 2012 – FS&T regular issue (2013)
- 20th TOFE 2012 Proceedings – FS&T regular issues (2013)
- Open Systems 2012 Proceedings – FS&T Transactions (2013)
- Selected papers from 2nd IAEA-ITER Materials 2012 – FS&T regular issue (2013)
- JT-60U (update of JT-60 Tokamak Special 2002) – FS&T regular issue (2013)
- IFE-Fast Ignition (US, EU, JA) – FS&T regular issue (in planning).

Electronic access to FS&T is available from 1997-to-current. ANS has completed plans to start adding pre-1997 back issues within the next few years. Tables of contents and abstracts of papers can be accessed at http://www.ans.org/pubs/journals/fst/. Individual and library subscribers can access the full text articles at http://epubs.ans.org/.

Please send your comments on FS&T contents and coverage as well as suggestions for potential future topical areas that are timely and of interest to fst@ans.org.

ONGOING FUSION RESEARCH

FESAC Activities, Martin Greenwald, FESAC Chair, Massachusetts Institute of Technology, Cambridge, MA.

The Fusion Energy Sciences Advisory Committee (FESAC) is chartered to provide advice to the Department of Energy's Office of Science and to the Office of Fusion Energy Sciences (OFES). Over the past year, FESAC has been given two charges by Undersecretary Brinkman concerning the dissemination of research results, international

collaborations and fusion materials. Three panels were formed to study the issues and report back to the main committee. At meetings in July 2011 and February 2012, the panel reports were discussed, approved and forwarded to Drs. Brinkman and Synakowski (head of OFES). Below is a brief summary of those two meetings. All reports along with minutes and presentations from the meetings are available at http://science.energy.gov/fes/fesac/reports/.

Briefings by Dr. Brinkman and Dr. Synakowski reviewed budgets and plans. Due to general pressures on the Federal budget and the need to significantly increase ITER funding to meet US obligations, the domestic program was cut by almost $50M – down to approximately $250M. DOE is working on plans to accommodate ITER costs in future years. FESAC expressed concerns over the impact this might have on the domestic program in a letter for Dr. Brinkman. The focus of FES planning is on US ITER contributions, opportunities in international collaboration and materials research. ITER construction is moving ahead with more solid funding from the EU, after a period of some uncertainty. The impact of last year's earthquake in Japan on the ITER schedule has also been a matter of concern – currently it is projected to delay ITER operation by about one year. In the US, procurements are proceeding as the program moves into a fabrication phase. Management oversight on the US ITER project office is intense with a target of reaching "CD-2" (Critical Decision-2, a milestone for major projects) by June 2012. With CD-2 would come a detailed cost and schedule.

Other briefings included a report on progress from the Fusion Nuclear Sciences Pathway Assessment by Chuck Kessel of PPPL and on a BPO (Burning Plasma Organization) study of Opportunities for International Collaboration by Mike Zarnstorff of PPPL. These activities led into formal FESAC charges and reports described below. Jiangang Li, a leader of the Chinese fusion program, described current programs and plans, which were ambitious and aggressive, featuring a fast-track plan aimed at a operation of a Chinese burning plasma device operating by 2025. Dr. Li thanked the US for its past help and invited participation on current and future experiments.

In March 2011, FESAC was charged to summarize "the policies and practices that apply to the dissemination of and public access to results of research funded by the US Government". This charge was part of a government wide initiative, driven by Congressional interest. The scope of the charge included documents, presentations and data - whether in paper or digital form. Specific questions asked were:

- The criteria for dissemination and who makes this determination.
- How access is provided and controlled.
- Whether access is limited in any way.
- Whether the access comes with any additional functionality.
- The version of the written material or data provided.
- Whether peer review is a condition of dissemination.

- The institution, DOE user facility, or other body by which the policy is currently upheld.
- Whether, in addition to dissemination, long-term stewardship is accounted for by the existing policy or practice.

A panel, chaired by Bruce Cohen of LLNL, was formed and reported on its findings at the July FESAC meeting. The panel found that DOE and home institutions generally have policies for this set of issues but these are not necessarily complete – especially for digital data and researchers are not always well informed about them. DOE policies in particular were not easy to find. The formality of the policy and its execution are quite non-uniform from institution to institution. The panel found that researchers originating results bear the largest responsibility for screening for quality, applying policy and initiating dissemination. The practices and policies for dissemination in the form of peer-reviewed publications are mature and work well, while those for dissemination of digital data are far less mature. The report found a number of issues that needed resolution. DOE policy, especially on access and retention for digital data, needs more clarity and needs to be communicated to all Principal Investigators. More generally, the issues of access, retention and support for data are complicated and have important resource implications. The panel was also concerned with the impact of "abusive" requests – that is, requests for information that would obstruct by drawing on scarce manpower without adding value to the research. The panel report was accepted unanimously by the full committee and forwarded to DOE.

A charge was issued by Dr. Brinkman at the July 2011 FESAC meeting asking three questions covering two general areas:

1. "What areas of research on new international facilities provide compelling scientific opportunities for US researchers over the next 10-20 years? Look at opportunities in long-pulse, steady-state research on superconducting advanced tokamaks and stellarators; in steady-state plasma confinement and control science and in plasma-wall interactions."
2. "What research modes would best facilitate international research collaborations in plasma and fusion sciences? Consider modes already used by these communities as well as those used by other research communities that have significant international collaborations."
3. "What areas of research in materials science and technology provide compelling opportunities for US researchers in the near term and in the ITER era? Please focus on research needed to fill gaps in order to create the basis for a DEMO and specify technical requirements in greater detail than provided in the MFE ReNeW (Research Needs Workshop) report. Also, your assessment of the risks associated with research paths with different degrees of experimental study vs. computation as a proxy to experiment will be of value."

Two panels were set up to answer this charge. The first, focused on opportunities for international collaborations, that is questions 1 and 2, was led by Dale Meade of PPPL. The second covered materials science and technology and was led by Steve Zinkle of ORNL.

The background for the report on Opportunities in International Research Collaborations is the construction, outside of the US, of $1B class superconducting experiment (EAST, KSTAR, W7-X, JT60-SA). The report placed collaboration opportunities into a strategic context, aimed at developing a more systematic approach to these activities and looking for specific benefits that would accrue to the U.S. fusion program. It took cognizance of ITER as a major collaborative program that would come to dominate our field and focused on collaborations needed to support ITER and US fusion development after ITER. The panel developed a set of criteria for evaluating international opportunities:

- The importance of the scientific issue to be resolved.
- The significance and distinctiveness of US contributions and potential of the collaboration for success.
- The extent to which the collaboration positions the US to obtain optimum benefit from ITER participation and builds a foundation for a potential future US development path in fusion energy.
- The ability to strengthen, extend and regenerate the US scientific workforce.
- The resource requirements required and the impact and relative value compared with other program elements.

With these criteria, the report identified three themes ripe for exploitation. Achieving high performance core plasma regimes suitable for long pulse; developing and integrating long pulse plasma-wall solutions; and understanding the dynamics and stability of the burning plasma state.

The panel addressing the question on Opportunities in Fusion Materials aimed to address a set of critical gaps on the road to practical fusion energy. In addition to more general findings and recommendations, the report contains a great deal of detailed technical information and will be a valuable resource for some years to come. The panel looked at the full range of fusion materials including those needed for structures, tritium breeding components, plasma facing components, launchers and antennas, diagnostics and magnets. The report has three main findings:

1. There are inherent inefficiencies and costs associated with exploring multiple materials or concept options once the technological maturity has grown beyond the concept exploration stage.
2. Most existing US fusion technology test stands are no longer unique or world-leading. However, numerous compelling opportunities for high-impact fusion research may be achievable by making modifications to existing facilities and/or moderate investment in new medium-scale facilities.

3. Computational modeling for fusion nuclear sciences is not yet sufficiently robust to enable truly predictive results to be obtained, but considerable reductions in risk, cost and schedule can be achieved by integration of experiment and modeling.

The report also made three main recommendations that can be paraphrased as:

1. As fusion nuclear science matures, it is appropriate to focus R&D on front-runner concepts.
2. Numerous fusion nuclear science feasibility issues can be effectively investigated during the next 5 to 10 years by efficient use of medium-scale facilities.
3. The key mission of the next step US device should be to explore the integrated response of tritium fuel, materials and components in the extreme fusion environment.

Both reports formulated to address the charge questions were approved unanimously by the whole FESAC committee at the February meeting and forwarded to DOE.

Plasma Diagnostics for Measurement and Control of Next Generation Fusion Devices

, Alan E. Costley, EURATOM/CCFE Fusion Association, Culham Science Centre, Abingdon, Oxfordshire, United Kingdom, and Kenneth M. Young, Princeton Scientific Instruments, Monmouth Jct., NJ.

Next generation fusion devices – fusion neutron sources, pilot plants and DEMOs – that will follow or even overlap with ITER, will explore and utilize plasmas generating copious fusion neutrons and will operate close to operational limits. Measurement systems (diagnostics) will be needed for plasma control and device protection but the environment in the vacuum vessel, where traditionally some diagnostic components have been installed, will be much harsher: for example, neutron radiation fluxes at the diagnostic components will be typically 3 – 20 times higher than on ITER and the integrated fluence could be 50 times higher [1]. Relatively high thermal and mechanical loads can also be expected. In addition, access through ports, a common access route for diagnostics, will be limited because of the need to preserve as much as possible of the first wall for tritium breeding, and the engineering requirements for reliability and robustness in the measurements will be enhanced [2]. Taken together these aspects mean that the implementation of diagnostics on the fusion devices that follow ITER will be a major challenge. Significant dedicated R&D will be needed to meet it and, quite possibly, the designs of the fusion devices will have to be adjusted in order to achieve a credible integrated system design that includes diagnostics [3,4].

In ITER, most radiation-induced deficiencies can be minimized by design, but the higher radiation fluxes in next generation devices will be more difficult to ameliorate. Effects such as radiation-induced conductivity (RIC) in ceramic insulation, which creates

electronic noise in magnetic diagnostics, electrical damage in gauges (radiation-induced electrical deterioration (RIED), radiation-induced noise and damage of detectors and optical components, must all be considered in the design and placing of diagnostic components [5]. Adding in the high, and varying, temperature ranges, and the impacts of sputtering and deposition for components close to the plasma-facing wall, and the constraints that those apply to diagnostic component design, it is apparent that the implementation of the measurement system will be a difficult engineering challenge. If, as in ITER, diagnostic components are incorporated into shielding port plugs (for ITER each plug is the size of a small bus and weighs ~ 50 tons), there will be major detraction from the space available for tritium breeding. An approach that makes less demand for first wall space is needed.

Integration of Measurement and Control Requirements into Fusion Device Design

The control requirements for next generation devices, both the measurements and the responding actuators for fuelling, heating, current drive and disruption prevention, will probably not be fully defined until ITER has achieved full-power operation. But, in order to keep the momentum in the program, the design of follow-on devices including their measurement systems must start earlier and will no doubt undergo many iterations as the ITER program progresses. Many of the measurements will be involved in the device protection, especially of parts of the first wall and so the measurement system constitutes a critical device system and must achieve very high levels of reliability and availability.

The selection and design of the measurement system must be fully integrated into the design of the fusion devices. Figure 1 shows a possible plan for the evolution of the design of the diagnostic instrumentation for a DEMO. At an early stage in the design process, an initial determination of the measurement requirements would be made, bearing in mind the responding control actuation. Diagnostic systems to provide the measurements would then be selected for a rather detailed conceptual design to be integrated into the vacuum vessel, shielding and blanket arrangements for the DEMO device. At that point an assessment of the quality of the measurement, relative to expectations, would be made. If the quality were insufficient, a new attempt at providing this measurement would be required (loop A). It is quite possible that this iterative loop cannot be closed because of such things as the requirements being too demanding, or inadequate space allowed for a shielding labyrinth, or radiation impact on components, at which point the basic design of the device would have to be reconsidered (loop B) and possibly adjustments made.

This cycle would have to be followed concurrently for a whole set of diagnostics, in the range of perhaps 20 complex instruments. This number is a substantial reduction from the 50 or so that will be implemented on ITER. ITER will have a much wider range of plasma scenarios to support the physics research leading up to its engineering phase of operation and so requires an extensive diagnostic system. The expectation is that the smaller number of operating regimes expected in a DEMO will lead to a requirement for a smaller number of diagnostic systems. Obviously reaching the final determination for any one diagnostic itself would involve development and testing, hopefully on an operating device and possibly on ITER.

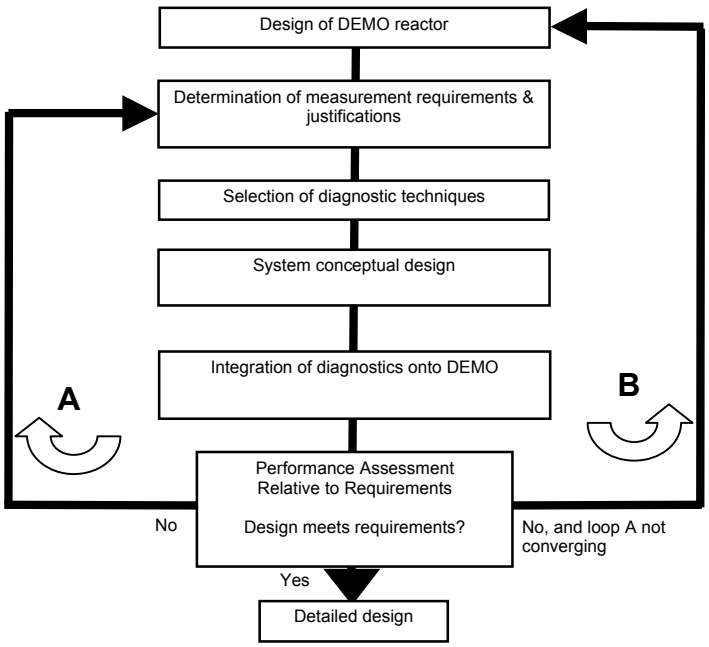

Figure 1. Scheme of integration of measurement and control requirements into a DEMO device design [4].

Necessary Research and Development

An initial step to defining the instrumentation set is the choice of the plasma's operational scenario and for a DEMO the operational scenario will have to be fully validated on ITER [6]. Since necessarily the device will have to operate very close to its operational limits (for example, the β-limit), control requirements will be very demanding. Hence, the required quantity and quality of all the measurements of individual plasma parameters should be defined by experimental studies. Operating present-day tokamaks with reduced numbers of diagnostics and with reduced quality of measurement, for example reduced spatial resolution, as a development path for operating with reduced diagnostics will be essential. Potentially the diagnostic engineering challenge could be reduced by using enhanced predictive modeling tools for the real-time feedback of data for a control system that could operate with a lower quality of diagnostic measurements. But such an approach would need development on today's devices and on ITER. Innovative real-time techniques for device protection, for example for measuring wall erosion, and/or deposition will also have to be applied.

Most of the diagnostics being designed for ITER have evolved from the diagnostics developed for TFTR, JET and JT-60U. However, some techniques used on these devices may not be possible for next generation devices: for example, magnetic diagnostics with fast response may not be possible close to the plasma because of RIC [5], and alternative methods for determining the plasma position may be necessary. New ideas for measurement of the ion temperature, plasma rotation, and driven current distribution will probably be needed. ITER operation will show whether any measurement of the alpha

particles will be necessary; if so, a technique suitable for implementing on a DEMO will be a challenge.

For ITER, the diagnostic components close to the plasma that will be installed inside the port plugs, are being designed to have a long lifetime and give good operation in the high radiation, thermal and magnetic field (including disruption-generated currents) environment. Similar components will have to be developed to operate in the harsher active DEMO environment and with probably reduced access. They should also include capability for environment mitigating measures such as shutter control, built in calibration sources and first mirror protection, all able to function during the plasma pulses.

Specific engineering aspects brought on by fusion's evolution to reactor-grade devices will also have to be considered. For example, in order to achieve the required reliability, redundancy in the measurements will be needed and this tends to go in the opposite direction of reducing space for diagnostics. High reliability and robustness of the instrumentation, while preserving its precision and sensitivity, must be built in. Being able to view the whole first wall in real time, to provide the necessary protection, will require many strategically located optical systems. Background noise on the signals, whether electrical from the large power systems close-by, or unwanted emissions from the plasma or the vessel wall will have to be ameliorated. These factors, and others, will have to be taken into account in an integrated manner during the device design process.

Summary

Plasma measurements on next generation fusion devices will be critical for protecting the device and controlling the plasma. Some of the diagnostic components will have to survive, maintain calibration and operate with high reliability in an environment much harsher than any experienced previously, including that on ITER. It is already clear that some diagnostic techniques currently widely used to provide quite basic measurements will not be applicable and new approaches are required. The solution to the challenge requires two main thrusts. Consideration of diagnostic requirements and designs needs to be brought into the design of next generation devices at a very early stage in the device design process. In addition, dedicated R&D is needed to find and develop diagnostic approaches and techniques that are better suited to the demanding fusion environment of next generation devices. These techniques will have to be developed and validated on existing devices including ITER.

References:

[1] Alan E Costley, "Towards Diagnostics for a Fusion Reactor," IEEE Trans. on Plasma Science, vol. **38**, no. 10, 2934-2943 (2010).

[2] Kenneth M. Young, "An Assessment of the Penetrations in the First Wall Required for Plasma Measurements for Control of an Advanced Tokamak Plasma Demo," Fusion Sci. Technol., **57**, 298 (2010).

[3] Kenneth M. Young, Réjean Boivin, David Johnson and Jim Terry, "Research and Development Activities for Fusion Energy: Issues for Integration of Measurements into FNSF," Chapter 9 in "Fusion Nuclear Pathways Assessment," C.E. Kessel et al.,

PPPL Report, PPPL-4736 (2012).
[4] A.J.H. Donné, A.E. Costley and A.W. Morris, "Diagnostics for Plasma Control on DEMO: Challenges of Implementation," to be published in Nucl. Fusion, July 2012.
[5] G. Vayakis, E.R. Hodgson, V. Voitsenya and C.I. Walker, "Generic Diagnostic Issues for a Burning Plasma Experiment," Fus. Sci. & Tech., **53**, 699 (2008).
[6] Report of the Research Needs Workshop (ReNeW), September 2009. Available at http://burningplasma.org/web/renew.html.

INTERNATIONAL ACTIVITIES

US ITER Report, Ned Sauthoff, US ITER Project Office, Oak Ridge National Laboratory, Oak Ridge, TN.

The international ITER collaboration continues to maintain design and early fabrication momentum, while also making significant construction progress. In Cadarache, France, the ITER headquarters building will be completed in August and the largest non-nuclear facility at the site, the Poloidal Field Coils Winding Facility, was completed in January 2012. The ground support structure for the tokamak complex was in place by April 2012; progress continues with framework and reinforcement of the complex basement. Work has also begun on the ground investigation drilling for the assembly hall, next to the tokamak complex.

By June 2012, US ITER will have completed the preliminary design (or beyond) for the following US contributions: central solenoid, toroidal field conductor, tokamak cooling water system, early delivery vacuum auxiliary components, steady state electrical network, and electron cyclotron transmission lines.

Team members continue to work closely with the ITER Organization (IO) and French nuclear regulatory bodies to assure that system designs will meet requirements. The tokamak cooling water system, the largest US system, completed a successful independent preliminary design review in March 2012.

In US long-lead fabrication efforts, more than 85% of superconducting wire strand production for the US contribution to the toroidal field magnets has been completed by Luvata Waterbury and Oxford Superconducting Technologies. New England Wire Technologies has begun activities for fabricating a copper dummy cable, which is a key step in qualifying their production process.

To address new US scope, a workshop on disruption mitigation was held at General Atomics in March 2012 to assist US ITER and the IO in defining candidate technologies and techniques.

The US ITER project remains on schedule to complete design work necessary to support early US hardware deliverables in FY13 and FY14. The project is planning to establish a cost and schedule baseline in 2012.

As of March 2012, over $767M (in total value with options) has been awarded to US industry and universities and obligated to DOE national laboratories in 38 states plus the District of Columbia.

The US is looking forward to hosting its first ITER Council meeting June 20–21, 2012 in Washington, DC.

ANS Topical Meeting on the Technology of Fusion Energy (TOFE-2012) August 27- 31, 2012, Nashville, TN, USA

, David Rasmussen, Brad Nelson, Arnie Lumsdaine, Oak Ridge National Laboratory, Oak Ridge, TN.

TOFE Program

The Topical Meeting is a forum for sharing progress in fusion research and advancement of fusion technology as well as presenting plans for national and worldwide fusion programs. The meeting scope spans the scientific, technological and engineering issues of fusion energy research. The meeting will feature a mixture of oral presentations and poster sessions allowing for extensive interactions among the participants.

The keynote presentation will be given by Dr. Steve Zinkle of Oak Ridge National Laboratory: "Challenges of Developing Materials for Fusion Technology – Past, Present, and Future." Plenary presentations will showcase leaders of some of the premier fusion experiments around the world (such as ITER, NIF, IFMIF, W7X, K-STAR, EAST, DIII-D and NSTX). The meeting will include 14 oral sessions:

- ITER Session I
- ITER Session II
- DEMO and Next Step Facilities
- Technologies Towards Fusion Power
- Alternative Concepts
- Inertial Fusion Energy
- Materials Development
- Safety, Environment, and Tritium Handling
- Divertor and High Heat Flux Components
- Nuclear Systems: Analysis and Experiments
- Plasma-Material Interactions
- Test Blankets, Fuel Cycle, and Breeding
- Fusion Technologies: Heating and Fueling
- ARIES Session.

Sponsors

The meeting is sponsored by the ANS Fusion Energy Division and the ANS Oak Ridge/Knoxville Local Section which includes the Vanderbilt University Student Section, Knoxville Student Section. Co-sponsors include the Atomic Energy Society of Japan (AESJ) and the Canadian Nuclear Society (CNS).

Oak Ridge National Laboratory Tour August 31

The meeting also features an optional day tour on August 31, of Oak Ridge National Laboratory's neutron and materials science facilities, including the Spallation Neutron Source and the High Flux Isotope Reactor (Figure 1).

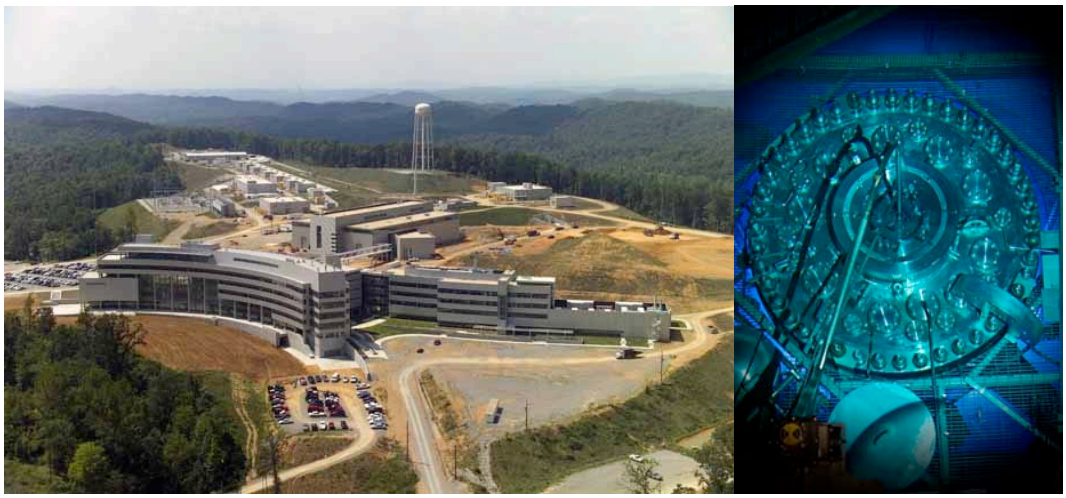

Figure 1. Spallation Neutron Source and High Flux Isotope Reactor at Oak Ridge National Laboratory.

Social Program

The first evening of the conference (Monday, August 27) includes a reception followed by a Town Hall Meeting – "From ITER to DEMO: Technology Towards Fusion Power" moderated by Hutch Neilson, with panelists Stan Milora, Chuck Kessel, Tom Todd, Hiroshi Matsumoto, Farrokh Najmabadi.

Tuesday evening includes an evening at the historic Grand Ole Opry.

Wednesday evening is the conference banquet, which will also include an awards ceremony, honoring both student and professional achievements.

Conference Venue

The meeting venue is the Hutton Hotel (Figure 2) located in Nashville's West End. There is easy access to restaurants, attractions, nightlife and the Vanderbuilt University campus.

Figure 2. Hutton Hotel, Nashville, TN.

Nashville Attractions

Nashville's most famous attractions are directly music-related. Music is the ribbon that weaves the city together, intertwining history, arts, culture and sports into one dynamic cultural package. From gospel spirituals and bluegrass to modern pop and blues, Nashville is "Music City." The downtown area of Nashville features a diverse assortment of entertainment, dining, cultural and architectural attractions. The Broadway and 2nd Avenue areas feature entertainment venues, nightclubs and a variety of restaurants. Nashville's attractions (Figure 3) include Music Row, Honky Tonk Highway, Ryman Auditorium, Opryland, Sommet Center, Bluebird Cafe and more. They can be reached by public transportation or short taxi rides from the Hutton Hotel. The Hutton Hotel also provides a shuttle service to downtown locations on request.

Figure 3. Nashville "Music City" attractions.

Nashville is also known for its dedication to higher education with more than 17 colleges and universities in the Middle Tennessee region, including Vanderbilt University and Fisk University.

TOFE-2012 and Hutton Hotel Websites

For more information, please visit the TOFE-2012 web site at http://tofe2012.org/ and the Hutton Hotel web site http://www.hutton.com.

27th Symposium on Fusion Technology (SOFT-2012), September 24-28, 2012, Liège, Belgium, Vincent Massaut, Belgian Nuclear Research Center, Mol, Belgium.

SOFT is the largest fusion conference in Europe and probably even in the world. It brings together more than 800 scientists and engineers working on the development of this new source of energy for future generations. Fusion is intrinsically safe, carbon-free, uses an almost unlimited fuel source, and produces only short-lived radioactive waste, which decays rapidly and can then be recycled for other uses. Belgium has been participating in this development for over 40 years through a dedicated European fusion program.

This symposium is jointly organized by the SCK•CEN (the Belgian Nuclear Research Center) and the TEC, the Trilateral Euregio Cluster, involving the Dutch FOM, the German FZJ and the Belgian ERM/KMS and SCK•CEN.[1]

SOFT-2012 (http://www.soft2012.eu/) will comprise technical talks, poster sessions, an extended industrial exhibition, as well as thematic roundtables, where we will provide as much information as possible on the opportunities that fusion development can bring to the industry. Moreover, a strong collaboration with Industry Liaison Officers and the Fusion Industrial Forum is foreseen within and concurrently to the conference. A general public exhibition, called the Fusion Expo, will also attract the attention of the general public to this important event in the former capital of the Principality.

Topics

SOFT-2012 will include contributions on the following topics:

- Experimental Fusion Devices and Supporting Facilities
- Plasma Heating and Current Drive
- Plasma Engineering and Control
- Diagnostics, Data Acquisition and Remote Participation
- Magnets and Power Supplies
- Plasma Facing Components
- Vessel/In-Vessel Engineering and Remote Handling
- Fuel Cycle and Breeding Blankets
- Materials Technology
- Power Plant Safety and Environment, Socio-Economics and Technology Transfer
- Laser and Accelerator Technologies.

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[1] The Trilateral Euregio Cluster (so-called TEC) is an agreement between FZJ (Jülich, Germany), FOM (Nieuwegein, the Netherlands), ERM/KMS and SCK•CEN (Brussels and Mol, Belgian Association), coordinating the research on fusion energy in the NorthWest EUREGIO of Nordrhein-Westfalen, the Netherlands and Belgium. The current program of collaborative research is mostly oriented towards Plasma-Wall Interaction (PWI) studies, based on complementary experimental devices situated in the three laboratories. This collaborative agreement allows gathering the largest group in Europe (and maybe in the world) studying PWI for controlled thermonuclear fusion.

Participation

The abstract submission process was closed in mid-April. More than 820 abstracts were submitted, which makes SOFT, by far, the largest conference on the topic of fusion technology. Authors are coming from all over the world, reflecting the international aspect of the common next facility ITER. ITER Internal Organization will be well represented, having a special booth at the exhibition, and with the Director General, Prof. H. Motojima, giving an invited talk on "ITER on the move". Other European, American, Russian, Japanese, Chinese, and Korean high-level speakers are giving invited or oral talks on the situation of several large fusion facilities and progress in key technologies.

Panel Discussion

SOFT 2012 will feature a panel discussion on the topic "Toward a Fusion Power Plant - Fusion in the Context of Future Energy Alternatives", with major players and stakeholders in the field of power production and energy forecast: high level representatives of the industry, ITER-IO, EFDA, a specialist on energy storage, and probably the Minister of Energy.

Fusion Technology Forum

The Fusion Technology Forum provides industry, research laboratories and institutions that are active in fusion technology the opportunity to exhibit their products and latest developments, and interact in B2B meetings. See http://www.soft2012.eu/fusion-technology-forum-0.

R&D exhibition

A specific area has been reserved for labs and research institutions. (Please consult the website if you would like to take advantage of this opportunity.)

Venue

Conference site: Located in the heart of the Boverie Park, the Convention Centre of Liège offers pleasant surroundings. Just recently renovated, the complex has three levels, and over twenty variable halls. The largest auditorium is able to comfortably receive up to one thousand people. Its two enormous floors, favorite spots for cocktail parties and exhibitions, offer a panoramic view of the river.

Hospitality in a unique atmosphere: Rich from its past as a principality, Liège enjoys a history which offers visitors incalculable treasures. Liège is proud of its reputation as a warm and welcoming city. Neither too small nor too large, it offers all the advantages of a real city, but remains on a human scale. A tourist city, a city of hospitality, a passageway at the intersection of three borders, Liège is a cosmopolitan metropolis, a land of meeting, a "must" for business tourism. Taking advantage of its favorable situation, Liège has built up a top-level transportation infrastructure incorporating the most advanced facilities for road, water, air and rail transport.

The Social Part of the Conference

As usual SOFT is also a place to meet other people from the fusion development community in a relaxing environment. Several cultural and social events are foreseen

throughout the week. On Sunday, during registration, you will be able to enjoy several of the famous Belgian beers. Monday evening will gather participants to the classical welcome reception in one of the buildings of the Boverie Park. On Tuesday, you will have the opportunity to listen to the choir Scala and the Kolacny Brothers (singers of "Creep" in the Social Network trailer) in a magnificent old gothic style church in the center of the city. Finally, after the classical excursions on Wednesday, you will be invited to the gala dinner in a 13th century building, close to an old crystal factory, the so-called "Val Saint Lambert".

2013 Symposium on Fusion Engineering, Wayne Meier, Lawrence Livermore National Laboratory, Livermore, CA.

The 25th Symposium on Fusion Engineering (SOFE) will be held June 10-14, 2013 in San Francisco, CA, USA. SOFE is organized and sponsored by the Fusion Technology Committee of the IEEE Nuclear and Plasma Sciences Society (NPSS). The venue for SOFE 2013 will be the Stanford Court Renaissance San Francisco Hotel in the heart of the city on Nob Hill.
(http://www.marriott.com/hotels/travel/sfosc-the-stanford-court-renaissance-san-francisco-hotel/). ANS Fusion Energy Division members will remember this as the site of the successful TOFE-2008 meeting.

As in the past, we expect good participation from ANS FED members. Note that ANS members will receive the IEEE member registration rate. SOFE emphasizes fusion technology development and the path to fusion energy. Topics for the 2013 meeting include:

- Experimental Devices
- Fusion Development: R&D Facilities, Next Steps and Power Plants
- Plasma-Material Interactions, First Wall, and Divertors
- Chambers, Blankets, and Shields
- Magnets
- MFE Plasma Heating and Current Drive
- IFE Drivers
- MFE Plasma Fueling
- IFE Target Fabrication and Injection
- Exhaust and Vacuum Systems
- Tritium Processing, Breeding and Containment
- Power Supply Systems
- Diagnostics, Data Acquisition, Control and Protection
- Fabrication, Assembly, Maintenance, and Availability
- Safety and Environmental Engineering
- Systems Engineering and Project Management.

LLNL is the local host and organizer with Dr. Wayne Meier serving as the Conference Chair. The Technical Program Committee is being chaired by Dr. Hutch Neilson of PPPL. Watch for the call for papers in December 2012. To sign up for the mailing list,

please visit the conference website (http://www.sofe2013.org/) and click the mailing list link on the home page. Questions and/or comments can be directed to meier5@llnl.gov.

RECENTLY PUBLISHED FUSION BOOKS

Luigi Di Pace, Laila El-Guebaly, Boris Kolbasov, Vincent Massaut and Massimo Zucchetti, "Radioactive Waste Management of Fusion Power Plants," Chapter 14 in Book: Radioactive Waste. Dr. Rehab Abdel Rahman (Ed.), ISBN: 978-953-51-0551-0, InTech (April 2012). Available at http://www.intechopen.com/books/radioactive-waste/radioactive-waste-management-of-fusion-power-plants.

CALENDAR OF UPCOMING CONFERENCES ON FUSION TECHNOLOGY

2012:

ANS Annual Meeting
June 24-28, 2012, Chicago, Illinois, USA
http://www.ans.org/

ANS 20th Topical Meeting on the Technology of Fusion Energy – TOFE-2012
August 27-31, 2012, Nashville, Tennessee, USA
http://www.tofe2012.org/

27th Symposium on Fusion Technology – SOFT-2012
September 24-28, 2012, Liège, Belgium
http://www.soft2012.eu/

24th IAEA Fusion Energy Conference
8-13 October 2012, San Diego, CA, USA
http://www-naweb.iaea.org/napc/physics/PS/conf.htm

54th American Physical Society - Division of Plasma Physics (APS-DPP) meeting
October 29-November 2, 2012, Providence, Rhode Island, USA
http://www.apsdpp.org

ANS Winter Meeting
November 11-15, 2012, San Diego, CA, USA
http://www.ans.org/

Fusion Power Associates 33rd Annual Meeting and Symposium
December 5-6, 2012, Washington, DC, USA
http://fusionpower.org/

2013:

American Ceramic Society 37th International Conference on Advanced Ceramics and Composites - ICACC'13
January 27 - February 1, 2013, Daytona Beach, FL, USA
http://ceramics.org/meetings/37th-international-conference-and-expo-on-advanced-ceramics-and-composites

4th International Conference on Nuclear & Renewable Energy Resources (NuRER-2013)
May 2013, Turkey
Sümer Şahin: sahin@atilim.edu.tr

16th International Conference on Emerging Nuclear Energy Systems (ICENES-2013)
May 27-31, 2013, Madrid, Spain
Emilio Minguez emilio.minguez@upm.es, mperlado@din.upm.es

25th Symposium on Fusion Engineering – SOFE-2013
June 10-14, 2013, San Francisco, CA, USA
http://SOFE2013.org

ANS Annual Meeting
June 16-20, 2013, Atlanta, GA, USA
http://www.ans.org/

8th International Conference on Inertial Fusion Sciences and Applications – IFSA-2013
September 8-13, 2013, Nara, Japan

11th International Symposium on Fusion Nuclear Technology - ISFNT-11
September 16-20, 2013, Barcelona, Spain
http://www.isfnt-11.org/

16th International Conference on Fusion Reactor Materials - ICFRM-16
October 20-26, 2013, Beijing, China
ccge@mater.ustb.edu.cn

ANS Winter Meeting
November 10-14, 2013, Washington, DC, USA
http://www.ans.org/

55th American Physical Society - Division of Plasma Physics (APS-DPP) meeting
November 11-15, 2013, Denver, Colorado, USA
http://www.apsdpp.org

2014:

ANS Annual Meeting
June 15-19, 2014, Las Vegas, NV, USA
http://www.ans.org/

56th American Physical Society - Division of Plasma Physics (APS-DPP) meeting
October 27-31, 2014, New Orleans, Louisiana, USA
http://www.apsdpp.org

ANS Winter Meeting
November 9-13, 2014, Anaheim, CA, USA
http://www.ans.org/

ANS 21st Topical Meeting on the Technology of Fusion Energy – TOFE-2014
November 9-13, 2014, Anaheim, CA, USA
http://www.ans.org/