Technology Collaboration Programme on the Stellarator-Heliotron Concept

(SH-TCP)

Annual Report 2017
(Full Report)

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1 Preface

Established in 1985, the Stellarator-Heliotron Technology Collaboration programmes objective is to improve the physics base of the Stellarator concept and to enhance the effectiveness and productivity of research and development efforts related to the Stellarator concept by strengthening co-operation among member countries. All collaborative activities of the worldwide stellarator and heliotron research are combined under the umbrella of this programme, which continues to promote the exchange of information among the partners, the assignment of specialists to facilities and research groups of the contracting parties, joint planning and coordination of experimental programmes in selected areas, joint experiments, workshops, seminars and symposia, joint theoretical and design and system studies, and the exchange of computer codes. The research activities within the TCP are organized via the Coordinated Working Group Meetings (CWGM). The bi-annual "International Stellarator-Heliotron Workshop" (ISHW) serves as an important forum for the scientific exchange within the scientific community.

While the main development line in fusion research is the tokamak line, stellarators and heliotrons constitute a promising alternative with advantageous properties, such as steady-state confinement with the prospect of developing a more economic power plant concept. A major strategic objective is the development of the physics and technology basis for a fusion demonstration power plant. Based on the enhancement of physics understandings and accumulated experimental database, conceptual reactor designs have progressed, based on Stellarator-Heliotron concepts.

However, it has also become evident that the understanding of the more complex three-dimensional confinement properties of stellarators and heliotrons is indispensable for the further development of tokamaks. The promotion of the synergies between tokamaks and stellarators and heliotrons is therefore a central part of the strategic direction of the TCP. An important mechanism to foster such synergies is the participation of a representative of the Stellarator-Heliotron TCP in each topical group of the International Tokamak Physics Activity (ITPA).

In 2017 major achievements were the deuterium plasma campaign in the Large Helical Device (LHD) and start of the second experimental campaign of the optimized stellarator Wendelstein 7-X (W7-X). First results of LHD deuterium plasmas were shown at the ISHW in Kyoto including record heating powers, extremely high ion temperatures and intriguing transport properties. The first half of the second experimental campaign was just completed with success. With an uncooled divertor the injected energy could be extended to 80 MJ which is one of the major milestones on the way to steady-state plasmas.

2 Chair's Report

2.1 Main events

2.1.1 21st International Stellarator-Heliotron Workshop (ISHW)

The 21^2t International Stellarator – Heliotron Workshop, hosted by the Institute of Advanced Energy at Kyoto University, was held at the Kyoto University from October 2nd to October 6th 2017.

The conference was locally organized by the team from Kyoto University coordinated by Prof. Tohru Mizuuchi (chair) and Prof. Kazunobu Nagasaki (secretary). The conference attracted nearly 200 delegates coming from the whole stellarator- Heliotron community as well as invited speakers from the tokamak community. Our Japanese hosts provided an excellent and unique atmosphere for the conference.

The international scientific programme committee, chaired by Carlos Hidalgo, played a key role in the development of the scientific programme (http://www.center.iae.kyoto-u.ac.jp/ishw2017/program.html). The objective of the conference was to assemble contributions with depth and high quality from the entire stellarator-heliotron community, including a special session on the physics of decoupling transport channels to promote synergies between tokamaks and stellarators.

2.1.2 16th Coordinated Working Group Meeting (CWGM)

The 16th Coordinated Working Group Meeting (CWGM16) was held 18–20 January 2017 in Madrid, Spain. The meeting implements the world-wide cooperation in the field of stellarators and heliotrons. On-site workshop participants, represented CIEMAT (Madrid), IPP Greifswald and IPP Garching (Germany), IPPLM (Poland), IPT Kharkov (Ukraine), Kyoto University and NIFS (Japan), and ORNL, PPPL, and the University of Wisconsin-Madison (USA). Staff from the host institution, CIEMAT, attended many of the sessions, which brought the total number of those engaging in the meeting to about 30.

This was the largest CWGM participation in recent years, and it may have resulted from the great interest generated by the then imminent operational phase OP 1.2 campaign at Wendelstein 7-X (W7-X) and the first deuterium plasma campaign at the Large Helical Device (LHD). Discussion of physics problems that could be addressed by these new experiments had a prominent place in all the sessions.

2.2 Milestones achieved

2.2.1 Deuterium Campaign at LHD

In 2017, the 19th experimental campaign of the Large Helical Device (LHD) commenced on February 7 with a prominently attended commemorative ceremony. The Director General of NIFS, Prof. Yasuhiko Takeiri, delivered the ceremonial address, followed by the start of the sequence to successfully produce the first deuterium plasma heated by Electron Cyclotron Resonance Heating (ECRH). The campaign continued for 100 days until it was successfully concluded on August 3, 2017. More than 13.000 individual plasma experiments were carried out with support and interaction from national and international collaborators working on many highly contemporary research topics.

After several years of preparation for device upgrades and improved administrative procedures, After several years of preparation for device upgrades and improved administrative procedures, this new phase was highly anticipated, since it was the first time that the hydrogen isotope deuterium was employed as plasma species in a large non-axisymmetric fusion device. Full deuterium plasma operation started on March, 7 after the complete machine conditioning in hydrogen and the test as well as confirmation of the safety systems. One of the major goals was to investigate the well-known “isotope-effect” from tokamak experiments where it is generally observed in both L- and H-mode that the plasma performance and confinement is enhanced with increasing isotope mass.

To date, statistically relevant evidence of an isotope-effect in helical devices was lacking, but recent large-scale gyrokinetic simulations predicted an improved confinement with isotope mass using turbulence reduction. During the course of the campaign it was found that in plasmas generated with Neutral beam injection (NBI) heating as well as in ECRH plasmas, the performance favorably increased with deuterium, therefore giving clues for an isotope-effect in helical devices. The ion temperature could be extended to a new LHD record value of 120 million degrees, marking a milestone for helical systems research by demonstrating its capability to satisfy one of the conditions for fusion. Beyond that, an important discovery has been the expelling of impurities through microwave heating, i.e. a plasma with deliberately injected impurities could be cleaned through an immediate injection of microwaves. A further highlight of this campaign was the achievement of detached divertor conditions with vanishing divertor heat load by imposing an external perturbed magnetic field through auxiliary coils.

During the last month of the campaign additional experiments were undertaken with hydrogen as working gas in order to establish a reference database to enable a detailed comparison between hydrogen and deuterium plasmas. With the conclusion of this highly successful experimental campaign with many novel results and highlights, the main focus is now set on detailed data evaluation and analysis while simultaneously preparing the next operation cycle which is to continue in fall 2018.

Research highlights of the first deuterium campaign were presented at the 17th International Stellarator-Heliotron Workshop (Oct. 2017 in Kyoto) and will be reviewed at other international events, such as in the upcoming 27th IAEA Fusion Energy Conference.

Milestones from TJ-II

Operation of the dual Heavy Ion Beam Probe system and GK validation in TJ-II [Collaboration with Ukraine/Russia]

Dual operation of pellet injector using cryogenic and TESPEL pellets IN TJ-II [Collaboration with NIFS]

Wendelstein 7-X Campaign OP 1.2a

During the second experimental campaign of Wendelstein 7-X in the period August - December 2017, more than 1400 plasma discharges were successfully achieved. The experiments were conducted in Helium and Hydrogen using ECRH as the only plasma heating system with a maximum power of 7.2MW delivered by 10 gyrotrons. Most of the envisaged diagnostic systems were operational and in routine operation. The scientific program focused on the demonstration of stationary, high performance discharges and the characterization of the inertially cooled test divertor units in preparation for operation of the high heat-flux divertor in the later campaign.

It was demonstrated that high plasma densities exceeding the X2 cut-off at $1.2 \cdot 10^{20} 20m^{-3}$ can be reached with a transition of the microwave heating power from X2 to full power O2 polarization. Discharge lengths could be considerably improved compared to the previous campaign reaching a maximum of 25s with stationary conditions, allowing studying bootstrap current saturation. Alternatively, toroidal plasma currents exceeding 10kA could be generated via electron cyclotron current drive.

Heat load patterns on the test divertor modules could by symmetrized using the magnetic trim coils. Even for long high-power discharges approaching the specified maximum energy input of 80MJ and peak diamagnetic energies of 1MJ, divertor temperatures remained well within the specifications. Strongly reduced heat loads on the divertor were observed in high-density hydrogen operation with and without pellet fueling, suggesting that detachment was achieved. For high-density discharges, a remarkable triple product approaching $6 \cdot 10^{19} m^{-3}$ was reached.

2.3 Future Plans

2.3.1 W7-X

The schedule for W7-X foresees two more completion phases (CP 1.2b, CP 2) and one operations phase with 15 weeks of plasma experiments (OP 1.2b), until the machine will have reached steady state capability at the end of the year 2020.

After conclusion of OP 1.2a, W7-X will be warmed up, vented and reopened for the installation of two so called “Scraper Elements” which serve as extensions of the Test Divertor Unit (TDU) and are designed to protect the main divertor target edges against possible overheating in certain magnetic configurations. In addition, six new diagnostics systems will be integrated and the available heating systems will be extended: The first injector of the Neutral Beam Injection (NBI) system will be installed and commissioned with two sources, and a first antenna for the Ion Cyclotron Resonance Heating (ICRH) system is planned to be installed. Plasma experiments are scheduled to resume in June 2018. The main objectives of this operations phase OP 1.2b are:

(a) Achieve controllable (symmetric) power loads on the divertor plates; (b) achieve plasma density control and examine elements of appropriate fuelling schemes; (c) qualify techniques and tools for configuration control and determine whether scraper elements could and should be used in OP 2; (d) qualify heating schemes in view of high-density discharges (transition from 2nd harmonic X-mode to 2nd harmonic O-mode ECRH); (e) develop concepts for the avoidance of impurity sources and accumulation and for controlled PWI; (f) explore operation parameters and control actuators for the safe operation of the island divertor; (g) achieve high separatrix (upstream) density scenarios with the island divertor; (h) develop techniques for highly radiating and high-recycling divertor scenarios; (i) examine turbulent transport in 3D fields with the interplay of neoclassical electric field shear, zonal-flows and configuration effects on micro-instabilities.

The subsequent completion phase CP 2, which is planned to last from October 2018 until November 2020, will consist of the removal of the TDU and the installation of several major components that are essential for achieving steady state capability. The four main component groups are: (I) The actively water cooled High-Heat-Flux-Divertor, (II) the cryo pumps with their external cryo supply, (III) the 80 HHF-port liners, which protect the ports and their diagnostics from ECRH stray radiation, and (IV) the complex cooling water supply for the port liners, divertor, wall elements and baffles.

Additionally, the NBI and ICRH-heating systems will be extended to their full capability, the set of diagnostics will be expanded with additional diagnostics and many diagnostics will receive additional hardening for long pulse operations. Substantial efforts will also go into the extension of the control systems (cSS and cOPM) and the upgrade of the data acquisition for diagnostics.

The operations phase OP 2 itself will follow a staged approach, consisting of several energy steps from 1 GJ to 18 GJ. The creation of long-pulse, high performance plasmas with 30 minute pulse length and 10 MW heating power is intended to be achieved during the operations phase OP 2.3 in the years 2023/2024.

2.3.2 LHD

LHD is now preparing further deuterium campaigns. The 20th experimental campaign of LHD is foreseen to start in October 2018 and last until February 2019. A LHD deuterium workshop is planned for February 7-8, 2018. For participation in the 20th LHD campaign, proposals by international collaborators are requested until July 1, 2018.

2.3.3 China

China is extending its fusion activities towards stellarator research. This includes the start of the joint project to construct Chinese First Quasi-axisymmetric Stellarator (CFQS) by the joint project between NIFS and Southwest Jiaotong University, and the move of the Heliac H1 from the Australian National University to the University of South China. In preparation, an international workshop will be held on March 26-28, 2018 in Hangzhou, China.

3 Membership

3.1 Contracting Parties and ExCo Members

Contracting party	Country	Name	Affiliation
ANU	Australia	B. Blackwell	The Australian National University
		J.H. Harris	The Australian National University
EURATOM	EU	L.-G Eriksson	European Commission
	Germany	R. Wolf (Chair) T. Klinger (alternate)	Max-Planck-Institute for Plasma Physics
	Spain	J. Sanchez (alternate)	CIEMAT
NIFS	Japan	Y. Takeiri (Vice Chair)	National Institute for Fusion Science
		T. Morisaki	National Institute for Fusion Science
ROSATOM	Russia	B. Kuteev	National Research Center, Kurchatov Institute
		V. Ivanov	Prokhorov General Physics Institute of Russian Academy of Sciences
NSC	Ukraine	I.E. Garkusha	Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology"
		V.S. Voitsenya	Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology"
US DOE	USA	D.T. Anderson	Wisconsin University
		D. Gates	Princeton Plasma Physics Laboratory
Observers		C. Pottinger	IEA
		C. Hidalgo	CIEMAT
		S. Kubo	National Institute for Fusion Science
		I. Vargas Blanco	Costa Rica Institute of Technology
		M. Yokoyama	National Institute for Fusion Science
		P. Kurz (Secretary)	Max-Planck-Institute for Plasma Physics

3.2 Countries targeted to join

Costa Rica has declared its intention to join the SH-TCP as a contracting party.

Several entities from China have expressed their interest in participation. First discussions are expected to start in the beginning of 2018.

4 Meetings

4.1 International Stellarator-Heliotron Workshop (ISHW)

The 21^{2t} International Stellarator – Heliotron Workshop, hosted by the Institute of Advanced Energy at Kyoto University, was held at the Kyoto University from October 2nd to October 6^{th} 2017 (cf. also section 2.1.1). A report will be published in an early issue of the Stellarator News 2018.

4.2 Coordinated Working Group Meetings (CWGM)

The 16th Coordinated Working Group Meeting (CWGM16) was held 18–20 January 2017 in Madrid, Spain. The meeting implements the world-wide cooperation in the field of stellarators and heliotrons. On-site workshop participants, represented CIEMAT (Madrid), IPP Greifswald and IPP Garching (Germany), IPPLM (Poland), IPT Kharkov (Ukraine), Kyoto University and NIFS (Japan), and ORNL, PPPL, and the University of Wisconsin-Madison (USA). Staff from the host institution, CIEMAT, attended many of the sessions, which brought the total number of those engaging in the meeting to about 30.

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As in previous editions, a group of coordinators (Ascasíbar, Dinklage, Gates, and Yokoyama) prepared the meeting by identifying topics for international cooperations. Colleagues from CIEMAT (Velasco, García-Regaña, Ascasíbar) took care of local organization. The list of topics and session coordinators was:

- Core electron root plasmas (Felix Warmer).
- Fueling; pellet injection (Kieran J. McCarthy).
- Impurity transport (Novimir Pablant).
- Turbulence, isotope effect (Teresa Estrada).
- Divertor physics (Jeremy Lore).
- Plasma wall interaction (Suguru Masuzaki / Ana Belén Martín-Rojo).

The materials presented at the 16th CWGM are available at http://fusionsites.ciemat.es/cwgm16/ and http://ish- cdb.nifs.ac.jp/. A summary report is available in issue 158 of the Stellarator News (https://stelnews.info/pdf/issue_158).

The 17th Coordinated Working Group Meeting (CWGM17) will be held 6 October 2017 in Kyoto, Japan, in the margins of the 21st ISHW (report under https://stelnews.info/pdf/issue_159). A further meeting (CWGM18) is planned April 10-12, 2018 and will take place in Princeton, USA.

4.3 Executive Committee (ExCo) meetings

The Executive Committee met on October 3, 2017 at the venue of the International Stellarator-Heliotron Workshop in Kyoto, Japan. The meeting was attended by nine representatives from five out of six contracting parties, as well as observers from Costa Rica, Japan, the coordinated working group and Europe. Two presentations were given by contenders for the 18^{th} ISHW, and the ExCo voted for Madison, Wisconsin as the venue for 2018. The ExCo also voted unanimously to invite Costa Rica as a participant to the TCP and to seek discussions with Chinese entities with the prospect of joining.

5 Communication Efforts

5.1 Communication Efforts within the Fusion Community

5.1.1 Japan

At the occasion of the initiation of LHD deuterium experiment, reviews on LHD hydrogen experiment phase (along with the cutting-edge engineering and technological aspects) and first highlights in deuterium experiment were reported as the plenary talks in international conferences, highlighted as follows:

- Y. Takeiri, “Prospect towards steady-state helical fusion reactor based on progress of LHD project entering the deuterium experiment phase”, 27th IEEE Symposium on Fusion Engineering, Shanghai, June 4-8, 2017. (submitted to IEEE Transactions on Plasma Science)
- Y. Takeiri, “Deuterium Experiment in Large Helical Device towards Steady-State Helical Fusion Reactor”, 16th Latin American Workshop on Plasma Physics (LAWPP), Mexico city, September 4-8, 2017. (to be submitted to IEEE Transactions on Plasma Science)
- T. Morisaki et al., “First Deuterium Plasmas on LHD”, International Conference on Research and Application of Plasmas, Warsaw, September 18-22, 2017.
- M. Osakabe et al., “Initial result from LHD deuterium experiment and its future plan”, 1st Asia-Pacific Conference on Plasma Physics, Chengdu, September 18-20, 2017.

5.1.2 Spain

- Jose Luis Velasco et al., “Temperature screening and moderation of neoclassical impurity accumulation in high-temperature plasmas of non-axisymmetric devices “ Invited talk 44th EPS (Belfast, 2017)

5.1.3 United States

- “Needs for Stellarator Research in Fusion Energy Development”, Presented by D. A. Gates, representing the National Stellarator Coordinating Committee - USBPO webinar
  April 27, 2017
- “Needs for Stellarator Research in Fusion Energy Development”, Presented by D. A. Gates, representing the National Stellarator Coordinating Committee - University of Wisconsin-Madison, May 1, 2017
- “Needs for Stellarator Research in Fusion Energy Development”, Presented by D. A. Gates, representing the National Stellarator Coordinating Committee – Columbia University, June 16, 2017
- “Needs for Stellarator Research in Fusion Energy Development”, Presented by D. A. Gates, representing the National Stellarator Coordinating Committee - University of Wisconsin-Madison, September 12, 2017
- “The Rationale for a Strong Stellarator Component in the US FES Strategic Plan”, Presented by D. T. Anderson, representing the National Stellarator Coordinating Committee - USMFRD Workshop University of Wisconsin-Madison, July 26, 2017
- “Stellarator Research: Challenges and Opportunities”, Presented by C. C. Hegna, representing the National Stellarator Coordinating Committee - USMFRD Workshop, University of Wisconsin-Madison, July 26, 2017

- “An invigorated US domestic stellarator program based on quasi-symmetry”, Presented by D. A. Gates, representing the National Stellarator Coordinating Committee - USMFRD Workshop, University of Wisconsin-Madison, July 26, 2017

5.2 Outreach to non-specialist communities

- Carlos Hidalgo “Nuclear Fusion at the energy crossroads”, Ramón Areces Foundation, Madrid, October 9th, 2017
- D. A. Spong, “Stellarators,” Oak Ridge Institute for Continued Learning (ORICL), Roane State Community College, public lecture, February 22, 2017
- On March 6, 2017, Thomas Klinger presented a talk on “New Machines for Fusion Research” at the TEDx Brussels. A video was published on YouTube in May 2017 (https://www.youtube.com/watch?v=cQ3PWXoYIoE) and has since then received 9100 hits.
- Wendelstein 7-X was present with an exhibit at the EXPO 2017 in Astana. Also, T. Klinger presented a talk during the Fusion Energy Day on July 25, 2017.
- An info graphic about Wendelstein 7-X for the magazin „Gaswinner“ received a Red Dot-Award for „Communication Design“ (https://red-dot.de/cd/de/online-exhibition/work/?code=08-01211&y=2017)
- Since November 2017, a virtual tour through Wendelstein 7-X is online at www.ipp.mpg.de/panoramaw7x (english version: www.ipp.mpg.de/panoramaw7xeng)

6 Activities and Outcomes

6.1 Australia

6.1.1 Domestic Report

The decommissioning of the H-1 Heliac in May 2017 marked the completion of the transition of experimental fusion science in Australian into the plasma materials field – the study of plasma material interaction and fusion/extreme materials. This recognises a growing domestic interest in these fields and builds the success of the prototype materials interaction device, MAGPIE. After 25 years of operation in Australia producing more than 160 publications, negotiations for the H-1 Heliac to be relocated to the University of South China (USC) are being finalized. Various personnel exchange visits of 17 staff over a total of more than 30 man weeks have enabled training in H-1 operational procedures, assistance in the disassembly of diagnostics, power supplies and other infrastructure, and progress in finalizing the details of the agreement. Experimental stellarator research will continue via international collaborations such as those in this report and with China. The substantial infrastructure of H-1 will be redeployed on a new materials and basic plasma physics linear device based on the MAGPIE prototype, together with several key power and vacuum components to be supplied as part of the agreement with USC. Construction of the first stage of this device, the 40kW continuous helicon plasma source, is advanced, with commissioning to begin in the next few months.

6.1.2 Collaborations

The main international experimental collaborations this year were with LHD (fast ion instability studies using phase contrast imaging of mm wave scattering), Heliotron J (MHD datamining) and Wendelstein 7-X (limiter probe array and test divertor probe array) and the Kharkov group. The collaboration with Dr. Moiseenko resulted in the design and installation of a 'compact Alfven antenna', which underwent further commissioning this year, using two frequencies, one optimized to produce a target plasma (7MHz) using the original plasma, and a lower frequency (~5MHz) to launch Alfven waves below the

Ion Cyclotron frequency. Initial findings were that cleaner plasma conditions were needed, and RF discharge cleaning was employed for ~50 hours resulting in some improvement.

A datamining collaboration with the Heliotron J and LHD groups has been extended to include W7-X limiter and divertor Langmuir probe data, and beam emission spectroscopy data from Heliotron J. This provided edge plasma data for several investigations, including density limit studies (IPP) and edge plasma modelling (IPP, Wisconsin). The LHD collaboration resulted in a paper on the effect of varying helium/hydrogen ratios on fast ion instabilities and micro-turbulence and ion temperature. Coherence imaging techniques developed at ANU are being applied to divertor imaging on W7-X by Auburn University.

Theoretical collaborations between the Plasma Theory and Modelling group and the IPP Theory Group focussed on continuum damping and mode drive mechanisms in stellarators. The collaboration with IPP resulted in publication of an article “Global Alfven eigenmodes in the H-1 heliac”, and presentation of this work at the IAEA Technical Meeting on Energetic Particles in PPPL, September 2017. The ongoing collaboration with Princeton Plasma Physics Laboratory on further development of the new 3-D equilibrium code ‘SPEC’ produced several other papers not included in the scope of this report. This collaboration continued in 2017 with the award of a 3 year research grant to extend the multi-region relaxed MHD approach, used in SPEC, from equilibrium to dynamical calculations.

6.2 European Union: Germany

6.2.1 W7-X Completion Phase CP 1.2a

The first operation phase OP 1.1 was followed by a 15 month completion phase (CP 1.2a), during which the machine was upgraded to its next stage. The major change was the installation of over 8500 graphite tiles to cover the copper-chrome-zirconium heat sinks on the plasma vessel, and the integration of 10 so-called Test Divertor Units (TDU). The TDU is an inertially cooled version of the island divertor concept of Wendelstein 7-X designed for 8 s plasma operation at 10 MW heating power, thereby increasing the power handling capability considerably (from 4 MJ injected energy to 80 MJ). The number of gyrotrons was increased from six to ten, raising the heating power to 9 MW. More than 25 new or significantly improved diagnostics systems were installed, raising the number of diagnostics for OP 1.2 to 40. The operation campaign OP 1.2a is scheduled to last until mid December, followed by another 34 week shutdown for the installation of the scraper elements.

6.2.2 W7-X Operations Phase OP 1.2a

After 16 weeks of commissioning (cf. again the report from OP), plasma operations were resumed on August 29, 2017. The operations phase OP 1.2a comprised 40 operation days in 15 weeks. The program was organized in four topical task forces: Plasma heating, fuelling and current drive, Plasma edge and divertor physics, plasma stability and transport, and scenario integration. For each task force, two task force leaders (one from IPP, one from the cooperation partners) were appointed by the International Programme Committee (IPC). The task forces are in charge of the program formation, weekly coordination and daily execution. Together with the session leader and the engineer in charge, the task force leaders manage the work in the control room, where roughly 100 physicists, engineers and technicians must work together in a coordinated way. The team formation process is an important part of the operation phase OP 1.2a, and Wendelstein 7-X has chosen the “one team approach” to integrate all cooperation partners in the home team with a join scientific program.

The first experience with the island divertor was entirely positive. The conditioning of the machine has much improved, the impurity content is lower than before, hot spots or other overloaded areas have not been observed even at high performance discharges. Consequently, the heating energy throughput (ECRH only) could be quickly increased from initially 8 MJ to currently 60 MJ (already 75% of the design limit). Plasma fuelling turns out to be a challenge and intense programs are conducted to find efficient fuelling schemes that are compatible with divertor operation. First indications for detachment have been recently observed.

The best plasma performance is achieved with helium as filling gas. With 3.3 MW ECRH X2-mode heating, plasma with $5 \cdot 10^{19} m^{-3}$ density and 5 keV central electron temperature could be maintained for 20 s duration. Combined with hydrogen pellet injection, $1 \cdot 10^{20} m^{-3}$ plasma density at 2.5 keV ion and electron temperature where achieved with ECRH O2-mode heating. Energy confinement times between 200 and 300 ms are found, which is in the upper range of scaling expectation. The bootstrap current was always observed to be < 10 kA, which is already a first confirmation of the optimization of the Wendelstein 7-X magnetic configuration.

It was demonstrated that high plasma densities exceeding the X2 cut-off at $\mathbf{1.2 \cdot 10^{20} 20 m^{-3}}$ can be reached with a transition of the microwave heating power from X2 to full power O2 polarization. Discharge lengths could be considerably improved compared to the previous campaign reaching a maximum of 25s with stationary conditions, allowing studying bootstrap current saturation. Alternatively, toroidal plasma currents exceeding 10kA could be generated via electron cyclotron current drive.

Heat load patterns on the test divertor modules could by symmetrized using the magnetic trim coils. Even for long high-power discharges approaching the specified maximum energy input of 80MJ and peak diamagnetic energies of 1MJ, divertor temperatures remained well within the specifications. Strongly reduced heat loads on the divertor were observed in high-density hydrogen operation with and without pellet fueling, suggesting that detachment was achieved. For high-density discharges, a remarkable triple product approaching $\mathbf{6 \cdot 10^{19} m^{-3}}$ was reached.

After OP 1.2, another major intervention is planned for the installation of an actively cooled high heat-flux divertor which is capable of handling steady-state heat-flux up to 10 MW/m^2. Thus, following the successive completion of the in-vessel components, high performance steady-state plasma operation is approached.

6.3 European Union: Spain

6.3.1 Experimental radial electric field studies for gyro-kinetic code validation in TJ-II.

Theory validation process requires the development of plasma diagnostics to show that a model faithfully represent physics reality, including quantitative assessments of discrepancies between theoretical and experimental results. From this perspective the direct experimental characterization of Zonal Flows dynamics is a great challenge confronting the fusion community.

Expectations from linear gyrokinetic simulations could be confirm by measurements of zonal flow relaxation in the TJ-II stellarator. A sudden perturbation of the plasma equilibrium was induced by the injection of a cryogenic hydrogen pellet, which is observed to be followed by a damped oscillation in the electrostatic potential, measured by a dual Heavy Ion Beam Probe diagnostic, consistent with computations of zonal flow relaxation.

References: A. Alonso et al., PRL-2017 / E. Sánchez et al., ISHW-2017].

6.3.2 Towards understanding impurity transport in fusion plasmas

Achieving impurity control is a crucial issue in the path towards fusion-grade magnetic confinement devices. This is particularly the case of helical reactors, whose low-collisionality ion-root operation scenarios usually display a negative radial electric field which is expected to cause inwards impurity pinch.

For low collisionality plasmas, the variations of the electrostatic potential on flux surfaces have been predicted to be a strong drive of radial transport of impurities. We have investigated the potential asymmetries in the magnetic flux surfaces in the NBI plasmas in the TJ-II stellarator using edge electrode biasing and dual-Langmuir probe measurements. Expermental findings have shown that the difference between floating potentials at two probe locations increases with Te reaching value up to 20 V. The experimental results were compared with Neoclassical Monte Carlo simulations. The agreement is good in the order of magnitude and remarkable in the phase difference between probe positions. These findings are complementary with previous results obtained in the proximity of the electron-ion root transition in ECRH plasmas and provide the first direct experimental evidence of the potential asymmetry in ion-root regimes.

Furthermore, it has been shown that achievement of high ion temperature in the core of helical devices is not fundamentally incompatible with low core impurity content: due to the very low collisionality of plasmas such as those displaying impurity hole, the radial electric field is negative but small, and its contribution to the impurity flux can be overcome by the ion temperature gradient. In these situations, due to the small radial electric field, the contribution of the superbanana-plateau regime to the transport of the bulk ions has to be taken into account when calculating the electrostatic potential on the flux surface: its variations will become larger than previously predicted, and this can have a strong impact on impurity transport even in optimized devices.

References: J.M. García-Regaña et al., NF 57 (2017) 056004 and ISHW-2017, B. Liu et al. to be published (2017,; J.L. Velasco et al., Nucl. Fusion 57 (2017) 016016 **and ISHW-2017; I. Calvo et al., PPCF 59 (2017) 055014.**

6.3.3 Pellet fuelling studies in the TJ-II stellarator

Core plasma fuelling is a central element for the development of credible steady-state scenarios. In stellarators the temperature gradient causes outward neoclassical particle flux and thus tends to create a hollow density profile. As a consequence central particle fuelling would be needed in a reactor.

A cryogenic pellet injector and tracer encapsulated solid pellet (TESPEL) injector system has been operated in combination on the stellarator TJ-II. The combined injector provides a powerful new tool for comparing ablation of polystyrene TESPEL pellets and solid hydrogen pellets, as well as for contrasting subsequent pellet particle deposition and plasma perturbation under analogous plasma conditions. In particular, a significantly larger increase in plasma line-averaged electron density, and electron content, is observed after a TESPEL pellet injection compared with an equivalent cryogenic pellet injection. Moreover, for these injections from the low-magnetic-field side of the plasma cross-section, TESPEL pellets deposit electrons deeper into the plasma core that cryogenic pellets.

References: K. McCarthy, N. Tamura et al., to be submitted 2017; N. Panadero et al., ISHW-2017

6.3.4 Isotope effect and L-H transition studies in the TJ-II stellarator

Synergies between stellarators and the main-line tokamak seem particularly meaningful to address fundamental open questions like: Are there different paths to reach the L-H transition?, Why does ion mass affect confinement?.

The role of the isotope mass has been studied both in ECH and NBI plasmas, in L-mode and during the L-H transition in TJ-II. Mean radial electric fields as well as low frequency Zonal Flow-like global oscillations in radial electric field have been identified during the Low to High (L-H) transition in Hydrogen and Deuterium plasmas in the stellarator TJ-II. No evidence of isotope effect on the L-H transition dynamics was observed. These observations emphasize the critical role of both zero frequency (equilibrium) and low frequency varying large-scale flows for stabilizing turbulence during the triggering of the L-H transition in magnetically confined toroidal plasmas and show that there are different paths to reach the L-H transition with impact on the conditions to access the H- mode regime.

References: U. Losada et al., to be submitted (2017) and ISHW-2017

6.3.5 The effect of tangential drifts on stellarator neoclassical transport

In a generic stellarator, when the collisionality is below the $1/\nu$ regime the drift-kinetic equation becomes radially non-local. However, it has been shown that, if the stellarator is sufficiently well optimized, one can rigorously derive a radially local, bounce-averaged drift kinetic equation that however includes the component of the drifts tangent to the flux surface [1]. Below the $1/\nu$ regime, and precisely due to the effect of the tangential drifts, radial neoclassical transport is determined by two small layers on phase space; one of them corresponds to the $\sqrt{\nu}$ regime and the other one to the superbanana-plateau regime. An expression for the radial neoclassical fluxes in these regimes is given.

References: I. Calvo, F. I. Parra, J. L Velasco and J. A. Alonso, "The effect of tangential drifts on neoclassical transport in stellarators close to omnigeneity", Plasma Physics and Controlled Fusion 59 (2017) 055014.

6.3.6 Testing Liquid Metal/Capillary Porous System Concepts as alternative solution for the Divertor target design of a Fusion Reactor in TJ-II

The use of liquid metals as plasma facing components (PFCs) in a future fusion reactor has been proposed as an alternative to solid metals, such as tungsten and molybdenum among others. The expected advantages for the power exhaust issues, mainly arising at the divertor target at power densities of 10–20 MW m^{-2}, relay on the self-healing properties of liquid surfaces as well as the ability to in situ replacement of the surfaces exposed to the plasma by the effect of capillary forces (CPS design). Among the possible liquid metals (LM) presently considered as candidates for the development of an alternative solution to the Power Exhaust Handling in a future Fusion Reactor (Li, Sn, Ga), tin lithium alloys offer unique properties in terms of evaporation, fuel retention and plasma compatibility.

Recently, LiSn (20-30:80-70 at.%) alloys have been exposed in TJ-II and very promising results on D retention and surface segregation of Li were obtained . Solid and liquid samples have been exposed and a negligible perturbation of the plasma has been recorded in the Li and LiSn cases. The surface temperature of the liquid metal/CPS samples (made of a Tungsten mesh impregnated in SnLi, Sn or Li) has been measured during the plasma pulse with ms resolution by pyrometry and the thermal balance during heating and cooling has been used to obtain the thermal parameters of the LM/CPS arrangements as well as to calculate the thickness of the film interacting with the plasma. Temperatures as high as 1100K during TJ-II plasma exposure were observed for the LiSn case, and hints of sputtering-enhanced evaporation were deduced from the temperature dependence of the lithium fluxes entering the plasma.

References: F. Tabarés et al., 27th IEEE Symposium On Fusion Engineering (2017)

6.3.7 Fast Particle physics: Impact of ECRH & ECCD on Alfvén Eigenmodes (AE’s)

The experiments studying the impact of ECRH/ECCD on the AE’s properties that have been (and are being) carried out in several large tokamaks (DIII-D, ASDEX-U, KSTAR) and stellarators (LHD, H-J, TJ-II) aim at determining the effect of ECRH as a possible candidate for AE’s control in ITER and future devices, thus contributing to the one of the priority goals of the ITPA-Energetic Particles group. A new Joint Experiment (EP-12), focused on determining all possible AE’s actuators, was launched during the 2016 ITPA-EP autumn meeting and initial reports were presented in the ITPA-EP meetings held during 2017.

TJ-II plasmas heated by Neutral Beam Injection show a very wide variety of MHD activity, depending on which of the beams (co or counter) we use, on the levels of current (OH or ECCD), on the injection parameters of the ECRH and on the magnetic configuration of the device. The activities in this field were resumed in the last quarter of 2016, after a full realignment of the ECRH transmission lines that was accomplished during the summer period. A careful control of the ECRH injection parameters is mandatory due to the high sensitivity of the Shear Alfvén Eigenmodes Spectrum on the local values of iota and plasma density. Experiments using on-axis ECCD were performed at the beginning 2017 demonstrating the strong impact that a small variation of the injection parameters has on the AE’s behavior.

The global picture that slowly emerges from the experiments carried out in the involved devices shows that ECRH has indeed a noticeable impact on the AE’s activity, being however very dependent on the plasma conditions its impact as an enhancing or moderating tool of the MHD activity.

Outcomes of these experiments are one of the key issues of the Enabling Research 2017 projects CFP-AWP17-ENR-CIEMAT-03 “Active control of the fast ion distribution and associated Alfvénic activity in 3D configurations”. The goal is to provide an experimental assessment of the operational window for which active control of AE’s is achieved in the TJ-II stellarator.

Two contributions to the ITPA-EP meetings held during 2017 were presented summarizing the status of the EP-12 Joint Experiment: Cappa A. et al, “Status of EP-12: Identification of AE control actuators and preliminary assessment for ITER”, 18th ITPA-EP Meeting, 26th-28th April, Spain /19th ITPA-EP meeting, 11th-12th September, USA.

6.3.8 Magnetic Topology and configuration studies

The effect of magnetic topology on stability and confinement is being studied. The effect of magnetic resonances on the plasma edge and centre is explored performing experiments on LHD and TJ-II stellarators. The magnetic configurations and topology has impact on Alfvén modes: the resonances open new gaps that allow new modes to exist and the reduction of magnetic well provokes a reduction of the frequency of the Alfvén modes. The influence of ECCD on island dynamics is explored, comparing when this is imposed in the O-point whith the case when current is driven in the X-point. Preliminary observations show that the island tend to recover the vacuum topology when the current is driven in the O-point, oppositely to what happen close to the X-point. New experiments and simulations are performed to study the behavior of the island in the edge, in order to explore the behavior of an island based divertor.

References: F. Castejón et al. “Influence of magnetic well on electromagnetic turbulence in the TJ-II stellarator”. Plasma Physics and Controlled Fusion 58 (2016) 094001

6.3.9 Collaborations in Europe

Germany. OP 1.1. / OP 1.2 research programmes. The Ciemat team is involved in the development of the Doppler reflectometry system installed in W7-X (OP1.2 / 2017). A dual reflectometry system is under development in view of the on-going OP1.2 experimental campaign. The Ciemat team will participate on different OP1.2 / 2017 task force areas, including Plasma Heating, Fuelling and Current Drive / Transport and Stability (Arturo Alonso TF) / Scenario Integration. Ciemat will participate in the support structure design, installation and operation of TESPEL on W7-X, currently planned for OP1.2b.

GK simulations and model validation. GK studies (EUTERPE), linear and non-linear simulations, physics of zonal flows and impurity dynamics.

Poland. Impurity transport. Collaboration on impurity transport studies in TJ-II supporting W7-X programme. Collaboration with IPPLM on X-ray pulse height analysis diagnostic for core impurity studies in W7-X.

Participation in S1 and S2 EUROFUSION work packages.

6.3.10 Collaborations with Ukraine and Russia

Electric fields and plasma fluctuations. Application of heavy ion beam probe diagnostics (HIBP) for investigation of plasma characteristics from the plasma edge to the plasma core in the TJ-II stellarator. The Kharkov / Kurchatov teams were involved in the installation and alignment of the second HIBP line in TJ-II. Experiments with the dual HIBP system with combined NBI and ECR heating have given direct experimental evidence of the influence of plasma heating on neoclassical radial electric fields, fluctuation levels and on the magnitude of the Long-Range-Correlations as proxy of Zonal Flows.

6.3.11 Collaborations with USA

Impurity transport. Collaboration on impurity transport studies in TJ-II (USCD).

Plasma-wall. Collaboration on plasma-wall studies (liquid metals) (USCD)

Stability. Collaboration on plasma stability and operational limits (PPPL).

Plasma fuelling. Pellet injector developed by ORNL is in full operation in TJ-II. ORNL has continued to support upgrades of this system.

Stellarator optimization. Collaboration with ORNL

6.3.12 Collaborations with Costa Rica

Collaboration with ITCR (Instituto Técnico de Costa Rica) on stellarator development.

6.3.13 Collaboration with Japan

Experiments were carried out in collaboration with NIFS and with the Institute of Advanced Energy Studies of the Kyoto University in March 2017. The effect that different NBI deposition locations (more or less centered) has on the AE's activity was studied in combination with the injection of ECRH power. Several configurations using different NBI's and different launching parameters were tested at half field magnetic field. The influence of ion mass on Long Range Correlations (as proxy of Zonal Flows) has been investigated in TJ-II.

6.4 Japan

6.4.1 NIFS

The 19th LHD campaign started on February 8, 2017, and then entered deuterium experiment phase on March 7. It ended on April 3, after almost one-month hydrogen experiment. In total, 100 days of experiment, counted to shot numbers more than 13,000.

Active participation of international and domestic collaborators is highly appreciated. Discussions and information sharing among LHD_IPC (International Program Committee) members were so effective to facilitate international collaborations. We received programmatic participation of colleagues supported by EUROfusion as well.

The experimental analyses have been on-going, and those will be presented in the forthcoming conferences and journal publications. Continuous collaborations are highly appreciated to make the maximum outcome.

The NIFS and Southwest Jiaotong University (SWJTU, China) concluded the cooperation agreement on Jul. 3, 2017, to promote stellarator-heliotron research in China, such as by building Chinese First Quasi-axisymmetric Stellarator (CFQS), based on CHS-qa design previously considered in NIFS. Director-General of NIFS, Prof. Y. Takeiri and the vice president (resesrch) of SWJTU, Prof. Zhang Wengui, signed the agreement documents. Director of ASIPP (Institute of Plasma Physics, Chinese Academy of Sciences), Prof. Wan Baonian, and the vice Director of SWIP, Dr. Duan Xuru, also attended the signing ceremony. Both parties will promote joint projects such as for plasma heating, diagnostics, theory and simulations to design and construct CFQS through mutual exchanges of researchers and students.

6.4.2 Kyoto University (Heliotron J)

Improved confinement at high-density plasmas, fast ion confinement, bulk thermal confinement, MHD stability and edge fluctuation have been investigated in a flexible helical-axis heliotron, Heliotron J, with special regard to the optimization study of helical systems with spatial magnetic-axis and vacuum magnetic well. The main subjects are configuration effect on confinement and transport, high-density H-mode produced by high intense gas puffing and pellet injection, electron internal transport barrier (eITB), toroidal and poloidal rotation, isotope effect on plasma turbulence, stabilization of energetic particle driven MHD instabilities by ECH/ECCD and confinement of high energetic particles produced by ICRF, impurity transport and edge plasma.

6.5 Russia

6.5.1 Russian Academy of Sciences – Prokhorov Institute

Analyzing the experimental data from L-2M stellarator and performing appropriate theoretical analysis, it is definitely shown that MHD (magnetohydrodynamic) instability can definitely trigger a transition into improved confinement mode of operation. The external peeling mode is proposed as the instability triggering the transition. Peeling mode stability in magnetic-hill Mercier-stable plasmas is analyzed analytically. It is shown that correctly taking into account vacuum region forbids internal peeling modes, while the external peeling mode has a threshold with respect to the plasma pressure gradient. This instability has definite threshold in plasma density and pressure, i.e. $n(0) > 1.0\times10^{13}$ cm^{-3} и $<\beta> > 0.08\%$, where $n(0)$ – is the line averaged with respect to central chord density, $<\beta>$ - is the volume-averaged ratio of the plasma pressure to the magnetic field pressure. Calculations and experimental data are in reasonable agreement.

S. V. Shchepetov and D. G. Vasilkov "Is it possible that MHD Instability Triggers a Transition into the Improved Confinement Regime of Toroidal Plasmas?" Plasma Physics Reports **43** 720 (2017)

A study is made of the microwave beam evolution due to passing through the stagnation zone, where the group velocity vanishes, thus making the paraxial approximation for the wave field inappropriate. An extension to the standard beam tracing technique is suggested that allows one to calculate the microwave beam parameters on either branch of its path apart from the stagnation zone, omitting the calculation of the wave field inside it. Application examples of the extended technique are presented for the case of microwave reflection from the upper hybrid resonance layer in a tokamak plasma.

M.A. Tereshchenko "Propagation of microwave beams through the stagnation zone in an inhomogeneous plasma" Plasma Physics Reports **43** 18 (2017)

During zero net current experiments on stellarator L-2M two-temperature spectra of soft X-ray emission were found. These spectra bear similarities to typical tokamak spectra (see, e.g., spectra from T-10, TCV, RTP tokamaks). Needless to say that one of the possible reasons to form two-temperature spectra of soft X-ray emission in tokamaks is the electric field that is used for net current production. In order to clarify the origin of two-temperature spectra in zero net current stellarator, spectra in different stellarators modes of operation were analyzed with the help of scanning spectrometer. It is shown that super thermal parts of spectra are formed by the emission from peripheral magnetic surfaces.

A.I. Meshcheryakov, I.Yu. Vafin, I.A. Grishina, A.A. Letunov, and M.A. Tereshchenko "Two-slope soft X-ray spectra observed in experiments on electron cyclotron resonance plasma heating in the L-2M stellarator" Plasma Physics Reports **43** 599(2017)

6.6 Ukraine

6.6.1 Study of RF conditioning at Uragan-2M without magnetic field.

In spring of this year, there was an experimental campaign on Uragan-2M device. A new T-shaped antenna for wall conditioning in continuous regime was installed and tested. The discharge **without magnetic field** is arranged with the frequency 140 MHz. This discharge spreads 1 m far from the antenna. Small magnetic field (100-500 Oe) provides conditions for a volumetric discharge with plasma density 10^{10}-10^{11} cm^{-3}. This discharge was tried in different gases and gas mixtures. A pronounced wall conditioning effect exists for every gas content.

6.6.2 RF plasma production in Uragan-2M by the three half turn antenna.

The three half turn antenna was installed into Uragan-2M for Alfven/ion-cyclotron heating. It was also tried for plasma production. Plasma build up was observed at conditions when the cyclotron zone is present in the plasma column. Two stages can be separated in plasma production: slow low density plasma ramp-up and rapid dense plasma creation at the end of the process.

Alfven plasma heating with three half turn antenna is used with preionisation made by frame antenna. The two foil soft X-ray emission and C-lines that indicate "hot" plasma lasted for no longer than 3 ms. After this the discharge turned to a "fade" stage with domination of low ionized impurities OII and CIII emission. Meanwhile the generation of high energy 1 keV hydrogen atoms was registered at this stage. That has no explanation yet.

6.6.3 Test of a small movable limiter made of boron carbide.

A small movable limiter made of boron carbide was tested. Insertion of it 10 cm in depth from the plasma edge resulted in increase of central electron temperature, which indicates a positive effect of separating plasma from the wall. To achieve more clear effect, a wider limiter is necessary.

6.6.4 New diagnostics.

Two new diagnostic tools are implemented this campaign (Collaboration with LPP-Brussels).

The first one is aimed for operative estimation of impurity level, outgassing rate and molecules layers number, of high vacuum chamber surfaces. It is based on the thermal desorption of gases into a vacuum from the surface of a special metal probe during fast its heating up to temperature ~300ºC. The probe gives a possibility to register low flows of gases desorbed from stainless steel probe during its pulsed heating. Decrease of impurity amount on the surface of the probe by more than two orders of magnitude was registered after Uragan-2M (U-2M) vacuum chamber was subjected to VHF/RF discharge cleaning in various regimes and pumping.

In the small diagnostic cryogenic trap, the gas pumped from the vacuum chamber was condensed on the liquid nitrogen trap inner surface during the RF wall conditioning. Afterwards, the trap was cut off from the vacuum chamber by two vacuum valves and defrosted. The closed volume around the trap was filled with the gas evaporated from the trap surface. In this campaign to the volume surrounding the trap a mass-spectrometer was attached which allows to analyze the pumped gas content.

6.6.5 Uragan-2M is dissembled.

Now Uragan-2M device is disassembled and vacuum chamber is washed. The big amount of depositions inside it was removed by scratching. The plan is to refurbish the device and put into operation next March.

Next stage to the vacuum stage of refurbishment is aimed to increase the confining magnetic field maximum from 0.5 to 1 T. It mainly consists of the construction of a system which supplies oil to the gears of the flywheel in case of fail of the AC network. It also includes a number of small repairs in the machine hall and in the building and some work on attachment of the new power supply to Uragan-2M device.

6.6.6 Estimation of plasma potential and density by the heavy ion beam probing diagnostic (HIBP) on the URAGAN-2M torsatron.

First estimations of plasma electric potential and density in URAGAN -2M torsatron were done by means of the Heavy Ion Beam Probing Diagnostic (HIBP). The plasma potential estimation gives the negative potential value of -80…-195 V. The experimental values of the secondary ion beam current are correlated with average plasma density measured by radio-interferometer $(1.25\ldots 2.5)\times10^{12}$ cm^{-3}. The oscillations of the secondary beam current were observed. These oscillations were caused by fluctuations of the torsatron magnetic field.

6.6.7 A new control unit for probing ion beam in HIBP diagnostic systems.

A new improved unit was developed, manufactured, installed and tested on HIBP system for Uragan-2M torsatron. Some new schematic solutions that are implemented in this unit were created as the result of long-term work with various types of injector power supplies and their control systems, installed on HIBP diagnostics for different fusion devices. The new advanced and highly efficient electronic control block has been constructed.

6.6.8 Microprocessor-based digitizers combined with preamplifiers and detectors as a solution for EMI suppression in U-3M.

Set of new optical diagnostics (20-channels SXR and bolometers, 12- channels H_α) with a temporal resolution of up to 4 microseconds has been designed and is successfully used in the noisy RF plasma conditions in studies of the breakdown plasma and plasma fluctuations in Kharkov torsatrons. This temporal resolution is sufficient for studying of short discharge of the QSPA Kh-50 plasma accelerator too.

The results were presented at the 11th IAEA Technical Meeting on Control, Data Acquisition and Remote Participation for Fusion Research 8-12 May 2017, Greifswald, Germany.

6.6.9 Characterization of the 20 kHz transient burst at the fast modification stage of U-3M plasma parameters.

The spatial structure of the 20–30 kHz burst was studied in last experiments in vicinity of the RF antenna and in opposite toroidal cross-section. Two new multichannel bolometric cameras was designed, manufactured and used for this purpose.

The results will be presented at the 21st International Stellarator/Heliotron Workshop, October 2-6, 2017, Kyoto, Japan.

6.6.10 Draft plan of works at IPP KIPT within WPS1 during year 2018

The W7-X ICRH antenna mock-up will be designed maximum similar to the original one and manufactured with a scaling factor 2/3. The mock-up antenna will also include a Faraday screen, which is planned to make removable and should come in second phase. The tasks of this mock-up are:

To develop scenarios for wall conditioning for W7-X;
To develop plasma start-up scenario for W7-X;
To study a role of Faraday shield during wall conditioning discharges and plasma start-up.

6.6.11 Other works:

Further developing of the thermo-desorption diagnostics that provides information on wall conditions in the device (January-December).
Further development and usage of plasma start-up numerical model for U-2M and W7-X start-up and wall conditioning scenarios (in collaboration with LPP-Brussels) (January-December).
Further developing the cryo-trap diagnostics that give the information on the pumped amount of impurities (January-December).
Modifying the interferometer for pulse to-pulse multi-chord measurements (January-December).
Manufacturing and installation of wider movable limiter that decreases size of the scrape-off layer and can withstand longer pulses (January-March).
Developing a design of a new highly efficient cryo-pump that could substantially increase pumping speed (January-December).
Repairing and putting to operation the gettering pump (June).

6.7 USA

6.7.1 General funding situation

The USDoE Fusion Energy Sciences expanded funding for international collaboration on stellarators substantially in 2017. In addition to the $3.4 million in base funding for collaborations a one-time supplement of $1.8 million dollars was granted to help support operations on W7-X during the OP 1.2 operations phase. The additional funds were divided amongst the funded collaborators according a prioritization of scientific tasks. These additional funds were primarily aimed at placing staff onsite at W7-X. As of September there are 12 US personnel stationed at W7-X supporting the run. More staff are expected to be on site during the course of OP 1.2.

6.7.2 Lab collaboration expansion includes LHD

In addition to funding the W7-X collaboration, FES relaxed the specific requirement that the national lab part of the international collaboration be for activities on W7-X. The focus is still on W7-X, but experiments on LHD are now supported where they make sense in the context of comparative experiments. As a result there have been several new interactions with LHD and more are planned for the near future.

6.7.3 PPPL collaborations with W7-X and LHD

During 2017 PPPL delivered the completed TDU scraper elements to IPP for installation during the break between OP1.2a and 1.2b. PPPL engineers made a site visit to IPP-Greifswald and a test installation of the scraper elements into the W7-X vacuum vessel mock-up was performed. The XICS diagnostic was upgraded with a second Pilatus detector that expands the operating temperature range of the diagnostic and which views several impurity lines. A novel absolute calibration technique is currently under design review for the XICS in collaboration with Auburn University. Novimir Pablant and Sam Lazerson are onsite at IPP for two-year assignments. Both Sam Lazerson and Novimir Pablant have proposed several experiments for the OP 1.2 run period. Sam Lazerson is the Task Force Leader for the scenario development group. Dr. Lazerson has been working closely with Dr. Marcin Jakubowski, Dr. Joachim Geiger, and Dr. Sergey Bozhenkov to symmetrize divertor heat loads using the U.S. supplied trim coil system. He has led multiple experiments on this campaign which are key to accessing long pulse, high beta operation.

Novimir Pablant visited NIFS for a month and developed data analysis software for the existing XICS data from LHD. David Gates visited NIFS and attended the ceremonies marking the start of the deuterium campaign.

6.7.4 ORNL collaboration with W7-X

Dr. Jeremy Lore from ORNL leads the Scraper Element physics group, part of the W7-X task force on divertor and edge physics. An experimental proposal was accepted and allocated time to establish the baseline conditions in special configurations which mimic the overload scenario the scraper element is designed to mitigate in W7-X operational phase two. The experiments are designed to test the key aspects of scraper element physics, including validation of heat and particle flux patterns and magnitudes, and an assessment of the impact of scraper elements on pumping efficiency and impurity transport. These aspects have been modeled using various codes, including the 3D fluid plasma and kinetic neutral transport code EMC3-EIRENE. ORNL contributed to the design of the W7X pellet guide tubes being used in exploratory pellet fueling experiments in OP 1.2, and also provided two microwave cavity mass/speed detectors that are essential to the experiments. ORNL has expanded the W7X filterscope system from 24 to 72 channels.

D. A. Spong and J. Varela-Rodriquez visited NIFS for ~3 weeks earlier in 2017 to participate in fast partial/MHD experiments and analysis. Varela-Rodriquez is returning for a second ~2 week visit in October 2017.

6.7.5 LANL collaborations with W7-X

LANL is involved with infrared and visible imaging systems, both with diagnostic design, construction, and operations. For 2017, the focus has been development of a test divertor unit observation system (reentrant optics for IR and visible to go into port AEK51 prior to OP1.2b), and redesign of the OP2 water-cooled endoscopes for machine protection. Also in 2017, during OP1.2a, we are testing IR observation using modulated ECRH power loading of divertor components to monitor the development of surface layers. Data analysis and software development after OP1.1 also continues. Dr. Glen Wurden has been onsite since Nov. 13, 2016, and has just extended his one-year change-of-station assignment to two years (through Nov. 2018).

6.7.6 MIT collaboration with W7-X

Work done in 2017 as part of the MIT-W7X collaboration on Gas-Puff-Imaging has involved 1) installing and operating a fast-framing camera with a view of the W7X cross-section during OP 1.2, and 2) continued work on the design a Gas-Puff-Imaging diagnostic proposed for use during OP 2. The fast-camera work will contribute to the study of fluctuations and plasma structure in the plasma edge and in the island-divertor regions. A Gas-Puff-Imaging diagnostic will enable detailed study of edge turbulence. Four different MIT staff have been involved with this task.

In January of 2017, installation and testing of the hardware commenced at the IPP in Greifswald, Germany. Testing of the optics and laser system was conducted in a laser room. The testing process was completed in April, 2017. During this time, Adrian von Stechow (IPP) developed a control system for interfacing with the electrical components that are integrated in the diagnostic. In May, all equipment was transferred to the W7-X Torus Hall. Alignment of the optics was completed in August. The project has been successful and is producing measurements of plasma fluctuations. The PCI system has collected data on most experiments conducted so far. The on-site team is analyzing the measurements and will be looking for changes in the turbulent spectra with magnetic configuration and heating power.

6.7.7 UW Madison collaborations with W7-X and LHD

UW Madison (group of PI O. Schmitz) collaborative research with both large superconducting stellarator devices W7-X and LHD. On both devices, effort focus on plasma edge and divertor physics including the coupling to the plasma-material interface. Four graduate students, one post-doctoral researcher, a numerical scientist and PI Oliver Schmitz are involved in this effort. Three students are on-site for the entire OP1.2 campaign.

At W7-X, experimentally, a new neutral gas characterization system based on the Penning discharge principle (called Penning gauges from now on) was developed and implemented. Measurements of the eroded carbon source are being prepared by students in the group working with the enhanced filter scope system of the Oak Ridge National Laboratory ORNL. The system has been installed, activated and calibrated by students from UW Madison. An undergraduate student from the group was awarded a RISE fellowship of the DAAD for an internship at IPP Greifswald in summer 2017. He worked on analysis of the Bremsstahlung signal obtained with the filters cope system in the MINERVA framework to extract a Zeff value for OP1.1 plasmas. Also, one student is working with Dr. G. Wurden from LANL on a visible camera observation of the scarper element. UW Madison post-doc Dr. T. Barbui is responsible for setup of a high-resolution spectrometer system in the upper and lower divertor of HM31 and HM50.

A mock-up experiment for the Laser Blow-Off (LBO) system at W7-X has been installed and commissioned at UW Madison. An undergraduate student at UW Madison is responsible for these local tests.

At LHD, studies were continued to assess helium exhaust with the closed helical divertor concept. Experiments have been performed in the inward shifted configuration. O. Schmitz has also participated in first experiments of the exhaust properties with the pumped CHD at LHD. The results of the helium transport studies are presented as a poster on the 2017 ISHW conference in Kyoto, Japan and a paper has been submitted as letter to Nuclear Fusion. EMC3-EIRENe modeling for the helium exhaust experiments is being performed by UW Madison Scientist Dr. A. Bader.

6.7.8 Auburn collaboration with W7-X

Auburn University is involved with 3D equilibrium reconstruction of the plasmas using available diagnostics including magnetics, Thomson scattering, ECE, soft x-ray, and interferometry. Auburn is also involved with the modeling and measurement of the time evolution of the net toroidal currents, including the self-driven bootstrap current and ECCD (electron cyclotron current drive). In the OP1.2a, Auburn has used the V3FIT equilibrium reconstruction code to help analyze the pressure and current profiles in the W7-X plasmas with magnetic diagnostic signals, in the absence of Thomson profiles.

Software development continues for the analysis and expansion of the V3FIT codebase. (see John's email for details as to his stay on-site)

Auburn University is also involved in day-to-day operations and data analysis of the X-ray Imaging Crystal Spectrometer (XICS) in conjunction with Dr. Novimir Pablant of PPPL during OP1.2. A graduate student will be on-site for the entire duration of OP.2a. A second Auburn graduate student is also in the process of developing and designing an in-situ absolute x-ray calibration system in collaboration with Dr. Pablant for the XICS with tentative planned installation prior to OP1.2b.

In addition to the equilibrium reconstruction and XICS activities, Auburn University has made a one time contribution of €110,000 to IPP for the purchase of a calibration laser system for the W7-X Coherence Imaging System being developed for OP1.2. Dr. David Ennis spent 1 week this summer on-site at IPP and is participating in the development of the CIS diagnostic with IPP. Dr. Ennis will be leading this portion of the Auburn collaboration.

6.7.9 Xantho Technologies collaboration with W7-X

The long-term aim of this program is detailed study of the Wendelstein 7-X plasma interior using a Heavy Ion Beam Probe (HIBP) diagnostic to measure key quantities such as fluctuations of density and potential, equilibrium potential, and radial electric field. Efforts during the past year, as part of the Xantho-W7X collaboration, include the first steps toward HIBP hardware engineering and implementation. They have involved 1) beam simulation & modeling (including evaluation of port options, assessment of plasma region that can be measured, and estimation of signal strength and resolution) and 2) system & hardware characterization (including study of electrostatic beam-steering system requirements, and estimation of plasma loads). Results indicate that implementation of an HIBP on W7-X looks promising; within all eight of the W7-X reference magnetic configurations (assuming B_{tor} is in the $-\varphi$ direction), $\phi(r)$ measurements will be possible from plasma core to edge, and fluctuation measurements will be possible in the outer region.

6.7.10 University of Maryland

Matt Landreman from the University of Maryland carried out neoclassical calculations using OP 1.1 data, with results appearing in several journal publications.

6.8 Names of personnel participating in experiments

Country	Institution	Experiment	Name
Australia	ANU	Heliotron J	Boyd Blackwell
Australia	ANU	LHD	Clive Michael
Australia	ANU	W7-X	Boyd Blackwell
EU: Belgium	LPP-ERM-KMS	W7-X	Tom Wauters
EU: Germany	FZJ	W7-X	Andreas Krämer-Flecken
EU: Germany	FZJ	W7-X	Dirk Nicolai
EU: Germany	FZJ	W7-X	Erhui Wang
EU: Germany	FZJ	W7-X	Michael Rack
EU: Germany	FZJ	W7-X	Philipp Drews
EU: Germany	FZJ	W7-X	Satheeswaran Guruparan
EU: Germany	FZJ	W7-X	Sebastijan Brezinsek
EU: Germany	FZJ	W7-X	Shaocheng Liu
EU: Germany	FZJ	W7-X	Xiang Han
EU: Germany	FZJ	W7-X	Yanling Wei
EU: Germany	FZJ	W7-X	Yu Gao
EU: Germany	IPP	LHD	Andreas Dinklage
EU: Germany	IPP	LHD	Dmitry Moseev
EU: Germany	IPP	LHD	Georg Schlisio
EU: Germany	IPP	LHD	Hannes Damm
EU: Germany	IPP	LHD	Jürgen Baldzuhn
EU: Germany	IPP	LHD	Uwe Wenzel
EU: Hungary	RCP Wigner	W7-X	Domonkos Nagy
EU: Hungary	RCP Wigner	W7-X	Gabor Anda
EU: Hungary	RCP Wigner	W7-X	Gabor Cseh
EU: Hungary	RCP Wigner	W7-X	Gabor Kocsis
EU: Hungary	RCP Wigner	W7-X	Sandor Zoletnik
EU: Hungary	RCP Wigner	W7-X	Tamas Szepesi
EU: Hungary	RCP Wigner	W7-X	Tibor Krizsanóczi
EU: Italy	ENEA	W7-X	Barbara Cannas
EU: Italy	ENEA	W7-X	Guiliana Sias
EU: Italy	Univ. Cagliari	W7-X	Fabio Pisano
EU: Poland	IPPLM	W7-X	Agata Czarnecka
EU: Poland	IPPLM	W7-X	Jacek Kaczmarczyk

EU: Poland	IPPLM	W7-X	Marta Gruca
EU: Poland	IPPLM	W7-X	Monika Kubkowska
EU: Poland	IPPLM	W7-X	Natalia Krawczyk
EU: Poland	IPPLM	W7-X	Slawomir Jablonski
EU: Poland	IPPLM	W7-X	Tomasz Fornal
EU: Poland	University of Szczecin	W7-X	Marcin Slecka
EU: Spain	CIEMAT	Heliotron J	Bing Liu
EU: Spain	CIEMAT	LHD	José-Luis Velasco
EU: Spain	CIEMAT	W7-X	Arturo Alonso
EU: Spain	CIEMAT	W7-X	Daniel Carralero
EU: Spain	CIEMAT	W7-X	José Luis Velasco
EU: Spain	CIEMAT	W7-X	Kieran McCarthy
EU: Spain	CIEMAT	W7-X	Nerea Panadero
EU: Spain	CIEMAT	W7-X	Teresa Estrada
EU: Spain	CIEMAT	W7-X	Ulises Losada
Japan	IAE Kyoto	HSX	Shiji Kobayashi
Japan	IAE Kyoto	HSX	Shinsuke Ohshima
Japan	IAE Kyoto	TJ-II	Shinsuke Ohshima
Japan	NIFS	TJ-II	K. Nagaoka
Japan	NIFS	TJ-II	S. Yamamoto
Japan	NIFS	TJ-II	Yoshiro Narushima
Japan	NIFS	W7-X	G. Motojima
Japan	NIFS	W7-X	H. Tsuchiya
Japan	NIFS	W7-X	K. Tanaka
Japan	NIFS	W7-X	M. Kobayashi
Japan	NIFS	W7-X	M. Tokitani
Japan	NIFS	W7-X	N. Ashikawa
Japan	NIFS	W7-X	N. Tamura
Japan	NIFS	W7-X	S. Satake
Russia	NRC Kurchatov Institute	TJ-II	A. Melnikov
Russia	NRC Kurchatov Institute	TJ-II	L G Eliseev
Russia	NRC Kurchatov Institute	TJ-II	P O Khabanov
Ukraine	IPP NSC KIPT	TJ-II	A. Chmyga
Ukraine	IPP NSC KIPT	TJ-II	A. Kozachek
Ukraine	IPP NSC KIPT	TJ-II	A. Zhezhera

Ukraine	IPP NSC KIPT	TJ-II	G. Deshko
Ukraine	IPP NSC KIPT	TJ-II	Liudmyla Krupnik
Ukraine	IPP NSC KIPT	W7-X	Vladimir Moiseenko
USA	Auburn University	W7-X	David Ennis
USA	Auburn University	W7-X	David Maurer
USA	Auburn University	W7-X	James Kring
USA	Auburn University	W7-X	John Schmitt
USA	Auburn University	W7-X	Peter Traverso
USA	LANL	W7-X	Glen Wurden
USA	MIT	W7-X	Eric Edlund
USA	MIT	W7-X	Jim Terry
USA	MIT	W7-X	K. Tang
USA	MIT	W7-X	Miklos Porkolab
USA	MIT	W7-X	S. Ballinger
USA	MIT	W7-X	S.G. Baek
USA	ORNL	LHD	Donald Spong
USA	ORNL	LHD	J. Varela-Rodriquez
USA	ORNL	W7-X	Jeffrey Harris
USA	ORNL	W7-X	Jeremy Lore
USA	ORNL	W7-X	L. Baylor
USA	PPPL	LHD	David Gates
USA	PPPL	LHD	Hutch Neilson
USA	PPPL	LHD	Novimir Pablant
USA	PPPL	W7-X	David Gates
USA	PPPL	W7-X	Hutch Neilson
USA	PPPL	W7-X	Novimir Pablant
USA	PPPL	W7-X	Samuel Lazerson
USA	Princeton University	W7-X	Alexandra LeViness
USA	UCSD	TJ-II	Eric M Hollmann
USA	University of Maryland	W7-X	Matt Landreman
USA	UW Madison	LHD	Aaron Bader
USA	UW Madison	W7-X	Florain Effenberg
USA	UW Madison	W7-X	Patrick Leonard
USA	UW Madison	W7-X	Thierry Kreymeyer
USA	UW Madison	W7-X	Tullio Barbui

USA	UW Madison	W7-X	Victoria Winters
USA	UW Madison	W7-X, LHD	Oliver Schmitz
USA	UW-Madison	LHD	Chris Hegna
USA	Xantho Technologies	W7-X	Diane Demers
USA	Xantho Technologies	W7-X	P.J. Fimognari
USA	Xantho Technologies	W7-X	TP Crowley

6.9 List of scientist exchanges

Country	Institution	Name	Dates	Location
EU: Austria	TU Vienna	Paul Szabo	03/27/2017 - 04/22/2017	IPP, Greifswald, Germany
EU: Czech Republic	Prague University	Jakub Hromadka	02/01/2017 - 03/31/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Frank Leipold	07/24/2017 - 07/28/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Martin Jessen	09/11/2017 - 09/15/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Morten Stejner Pedersen	08/21/2017 - 08/25/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Morten Stejner Pedersen	09/11/2017 - 09/15/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Morten Stejner Pedersen	09/19/2017 - 09/22/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Stefan Kragh Nielsen	09/11/2017 - 09/15/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Thomas Jensen	08/21/2017 - 08/25/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Thomas Jensen	09/11/2017 - 09/15/2017	IPP, Greifswald, Germany
EU: Denmark	DTU	Thomas Jensen	09/19/2017 - 09/22/2017	IPP, Greifswald, Germany
EU: France	CEA	Tran Thanh Ngo	06/12/2017 - 06/15/2017	IPP, Greifswald, Germany
EU: Germany	IPP Greifswald	Albert Mollen	10/15/2017 - 11/10/2017	University of Maryland
EU: Germany	IPP Greifswald	Albert Mollén	04/28/2017 - 05/06/2017	Chalmers University Göteborg, Sweden
EU: Germany	IPP Greifswald	Alessandro Zocco	07/04/2017 - 07/15/2017	University Oxford/GB
EU: Germany	Würzburg University	Alexander Herbst	06/26/2017 - 09/01/2017	IPP, Greifswald, Germany
EU: Germany	IPP Greifswald	Brendan Shanahan	01/15/2017 - 01/21/2017	University of York, UK
EU: Germany	IPP Greifswald	Brendan Shanahan	06/11/2017 - 06/17/2017	University of York/GB
EU: Germany	IPP Greifswald	Joaquim Loizu	03/11/2017 - 03/17/2017	University Barcelona, Spain
EU: Germany	FZJ	Jörg Cosfeld	01/13/2017 - 01/19/2017	IPP, Greifswald, Germany

EU: Germany	FZJ	Klaus-Peter Hollfeld	05/08/2017 - 05/12/2017	IPP, Greifswald, Germany
EU: Germany	University Heidelberg	Martin Stein	04/23/2017 - 07/15/2017	IPP, Greifswald, Germany
EU: Germany	FZJ	Michael Rack	01/16/2017 - 01/20/2017	IPP, Greifswald, Germany
EU: Germany	FZJ	Oleksandr Marchuk	07/06/2017 - 07/14/2017	IPP, Greifswald, Germany
EU: Germany	IPP Greifswald	Per Helander	06/10/2017 - 06/13/2017	Chalmers University Göteborg/Sweden
EU: Germany	IPP Greifswald	Per Helander	01/18/2017 - 01/20/2017	KTH Stockholm, Sweden
EU: Germany	IPP Greifswald	Per Helander	04/03/2017 - 04/11/2017	Oxford University, UK
EU: Germany	IPP Greifswald	Per Helander	07/11/2017 - 07/13/2017	TU Graz/Austria
EU: Germany	FZJ	Philipp Drews	09/01/2017 - 12/06/2017	IPP, Greifswald, Germany
EU: Germany	IPP Greifswald	Ralf Kleiber	03/28/2017 - 04/02/2017	Colonia de Sant Jordi, Spain
EU: Germany	FZJ	Satheeswaran Guruparan	05/08/2017 - 05/12/2017	IPP, Greifswald, Germany
EU: Germany	FZJ	Wladimir Zholobenko	10/09/2017 - 11/11/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Domonkos Nagy	05/29/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Gábor Anda	01/31/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Gábor Anda	03/27/2017 - 03/31/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Gábor Anda	05/29/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Gábor Kocsis	03/27/2017 - 03/31/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Gábor Kocsis	08/14/2017 - 08/25/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Mátyás Tóth	08/14/2017 - 08/25/2017	IPP, Greifswald, Germany
EU: Hungary	University of Technology and Economics	Peter Pölöskei	10/17/2017 - 10/19/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Sandor Hegedus	06/12/2017 - 06/16/2017	IPP, Greifswald, Germany

EU: Hungary	Wigner RCP	Tamás Szabolics	07/03/2017 - 07/14/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Tamás Szabolics	08/14/2017 - 08/18/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Tamás Szepesi	03/27/2017 - 03/31/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Tamás Szepesi	08/14/2017 - 08/25/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Tibor Krizsanóczi	05/29/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Hungary	Wigner RCP	Tibor Krizsanóczi	07/24/2017 - 08/15/2017	IPP, Greifswald, Germany
EU: Italy	Politecnico die Milano	Andrea Tancetti	01/01/2017 - 08/20/2017	IPP, Greifswald, Germany
EU: Italy	University of Cagliari	Fabio Pisano	06/12/2017 - 07/21/2017	IPP, Greifswald, Germany
EU: Italy	University of Milan	Francesco Vannini	01/09/2017 - 09/30/2017	IPP, Greifswald, Germany
EU: Italy	University of Milan	Massimiliano Rome	05/23/2017 - 05/31/2017	IPP, Greifswald, Germany
EU: Netherlands	Eindhoven University of Technology	Jonathan van den Berg	06/04/2017 - 06/24/2017	IPP, Greifswald, Germany
EU: Netherlands	Eindhoven University of Technology	Jonathan van den Berg	08/21/2017 - 09/23/2017	IPP, Greifswald, Germany
EU: Netherlands	Eindhoven University of Technology	Josefine Proll	06/06/2017 - 09/16/2017	IPP, Greifswald, Germany
EU: Netherlands	DIFFER	Matthijs van Berkel	08/02/2017 - 08/02/2017	IPP, Greifswald, Germany
EU: Netherlands	Eindhoven University of Technology	Nishith Chennakeshava	10/18/2017 - 10/20/2017	IPP, Greifswald, Germany
EU: Netherlands	Eindhoven University of Technology	Timo van Overveld	11/12/2017 - 02/02/2018	IPP, Greifswald, Germany
EU: Poland	University of Opole	Ireneusz Książek	06/27/2017 - 06/30/2017	IPP, Greifswald, Germany
EU: Poland	IPPLM	Jacek Kaczmarczyk	01/16/2017 - 01/27/2017	IPP, Greifswald, Germany
EU: Poland	IPPLM	Jacek Kaczmarczyk	04/24/2017 - 04/27/2017	IPP, Greifswald, Germany
EU: Poland	IPPLM	Sławomir Jabłoński	01/23/2017 - 01/27/2017	IPP, Greifswald, Germany
EU: Poland	IPPLM	Tomasz Fornal	01/16/2017 - 01/27/2017	IPP, Greifswald, Germany

EU: Poland	IPPLM	Tomasz Fornal	04/24/2017 - 04/27/2017	IPP, Greifswald, Germany
EU: Poland	IPPLM	Tomasz Fornal	06/27/2017 - 06/30/2017	IPP, Greifswald, Germany
EU: Portugal	IST	Bernardo Carvalho	02/27/2017 - 03/03/2017	IPP, Greifswald, Germany
EU: Spain	University Carlos III	Alena Gogoleva	01/01/2017 - 02/17/2017	IPP, Greifswald, Germany
EU: Spain	University Carlos III	Alena Gogoleva	09/04/2017 - 12/15/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Álvaro Cappa	03/01/2017 - 03/31/2017	NIFS, Toki, Japan
EU: Spain	CIEMAT	Angel de la Pena	06/12/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Arturo Alonso	01/01/2017 - 12/31/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Bing Liu	11/17/2016 - 01/16/2017	Kyoto University, Japan
EU: Spain	CIEMAT	Boudewijn van Milligen	06/12/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Daniel Carralero	06/2017 - 12/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Iván Calvo	10/23/2017 - 11/12/2017	Oxford Univesity, UK
EU: Spain	University Madrid	Jorge Alberto Alcuson Belloso	04/24/2017 - 04/29/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Jose L. Velasco	06/2017 - 12/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	José L. Velasco	09/18/2017 - 11/18/2017	NIFS, Toki, Japan
EU: Spain	CIEMAT	Kieran McCarthy	03/27/2017 - 03/31/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Kieran McCarthy	06/2017 - 12/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Luis Pacios	06/12/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Spain	Barcelona Supercomputing Center	Nathan de Oliveira Lopes	07/14/2017 - 08/12/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Nerea Panadero	06/2017 - 12/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Teresa Estrada	03/27/2017 - 03/31/2017	IPP, Greifswald, Germany

EU: Spain	CIEMAT	Teresa Estrada	06/12/2017 - 06/16/2017	IPP, Greifswald, Germany
EU: Spain	CIEMAT	Ulises Losada	06/02/2017 - 08.05.2017	IPP, Greifswald, Germany
EU: Sweden	Chalmers University	Aylwin Iantchenko	07/27/2017 - 07/29/2017	IPP, Greifswald, Germany
EU: Sweden	Chalmers University	Stefan Buller	10/15/2017 - 12/16/2017	IPP, Greifswald, Germany
EU: UK	University of York	Christopher Bowman	05/02/2017 - 05/12/2017	IPP, Greifswald, Germany
EU: UK	Oxford University	Daniel Kennedy	01/02/2017 - 01/04/2017	IPP, Greifswald, Germany
Japan	NIFS	H. Kasahara	03/25/2017 - 04/02/2017	IPP, Greifswald, Germany
Japan	NIFS	H. Nuga	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	H. Yamada	01/15/2017 - 01/20/2017	IPP, Greifswald, Germany
Japan	NIFS	H. Yamada	11/13/2017 - 11/16/2017	IPP, Greifswald, Germany
Japan	NIFS	K. Ichiguchi	06/19/2017 - 06/23/2017	CIEMAT, Madrid, Spain
Japan	NIFS	K. Ida	10/22/2017 - 10/29/2017	UW Madison, USA
Japan	NIFS	K. Matsuoka	03/26/2017 - 03/31/2017	IPP, Greifswald, Germany
Japan	NIFS	K. Nagaoka	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	M. Isobe	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	M. Kobayashi	05/29/2017 - 06/03/2017	ORNL, Oak Ridge, USA
Japan	NIFS	M. Kobayashi	01/22/2017 - 01/27/2017	UW Madison, USA
Japan	NIFS	M. Nakata	01/17/2017 - 01/22/2017	CIEMAT, Madrid, Spain
Japan	NIFS	M. Nakata	03/26/2017 - 03/31/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Nakata	03/27/2017 - 03/29/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Nunami	02/19/2017 - 03/05/2017	IPP, Greifswald, Germany

Japan	NIFS	M. Nunami	02/21/2017 - 03/03/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Nunami	09/19/2017 - 09/29/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Nunami	09/20/2017 - 09/27/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Yokoyama	10/23/2017 - 10/25/2017	IPP, Greifswald, Germany
Japan	NIFS	M. Yokoyama	09/03/2017 - 09/08/2017	PPPL, Princeton, USA
Japan	NIFS	N. Tamura	09/19/2017 - 09/24/2017	IPP, Greifswald, Germany
Japan	NIFS	R. Seki	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	S. Ohdachi	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	IAE Kyoto Univ.	Shinsuke Ohshima	02/23/2017 - 03/16/2017	CIEMAT, Madrid, Spain
Japan	IAE Kyoto Univ.	Shinsuke Ohshima	03/23/2017 - 03/31/2017	CIEMAT, Madrid, Spain
Japan	IAE Kyoto Univ.	Shinsuke Ohshima	07/28/2017 - 09/07/2017	UW Madison, USA
Japan	NIFS	T. Akiyama	10/16/2017 - 10/20/2017	IPP, Greifswald, Germany
Japan	NIFS	T. Kobayashi	09/18/2017 - 09/21/2017	IPP, Greifswald, Germany
Japan	NIFS	T. Naoki	09/18/2017 - 09/22/2017	IPP, Greifswald, Germany
Japan	NIFS	W. Hao	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	Y. Hishinuma	03/16/2017 - 03/19/2017	ORNL, Oak Ridge, USA
Japan	NIFS	Y. Narushima	07/03/2017 - 07/09/2017	CIEMAT, Madrid, Spain
Japan	NIFS	Y. Suzuki	03/27/2017 - 04/02/2017	IPP, Greifswald, Germany
Japan	NIFS	Y. Suzuki	03/22/2017 - 03/27/2017	PPPL, Princeton, USA
Japan	NIFS	Y. Suzuki	09/03/2017 - 09/10/2017	PPPL, Princeton, USA
Japan	NIFS	Y. Todo	09/17/2017 - 09/24/2017	IPP, Greifswald, Germany

Japan	NIFS	Y. Todo	09/04/2017 - 09/10/2017	PPPL, Princeton, USA
Russia	Kurchatov Institute	Mikhail Mikhailov	02/27/2017 - 03/31/2017	IPP, Greifswald, Germany
Russia	Kurchatov Institute	Mikhail Mikhailov	11/06/2017 - 12/08/2017	IPP, Greifswald, Germany
Ukraine	NSC-KIPT	Alexandr Chmyga	04/23/2017 - 06/30/2018	CIEMAT, Madrid, Spain
Ukraine	NSC-KIPT	Alexandr Kozachek	04/23/2017 - 06/29/2017	CIEMAT, Madrid, Spain
Ukraine	NSC-KIPT	Alexandr Zhezhera	04/23/2017 - 06/30/2017	CIEMAT, Madrid, Spain
Ukraine	NSC-KIPT	Galina Deshko	06/12/2017 - 06/29/2018	CIEMAT, Madrid, Spain
Ukraine	NSC-KIPT	Lyudmila Krupnik	06/12/2017 - 06/29/2017	CIEMAT, Madrid, Spain
Ukraine	NSC-KIPT	Sergei Kasilov	End of 2017	IPP, Greifswald, Germany
Ukraine	NSC-KIPT	Sergei Kasilov	02/06/2017 - 03/31/2017	TU Graz, Austria
Ukraine	NSC-KIPT	Sergei Kasilov	06/06/2017 - 08/31/2017	TU Graz, Austria
Ukraine	NSC-KIPT	Vladimir Moiseenko	12/04/2017 - 12/15/2017	ERM/KMS, Brussels, Belgium
Ukraine	NSC-KIPT	Vladimir Moiseenko	09/04/2017 - 09/16/2017	IPP, Greifswald, Germany
USA	UW Madison	Aaron Bader	10/05/2017 - 10/10/2017	NIFS, Toki, Japan
USA	Saint Michael´s College	Alain Brizard	06/13/2017 - 06/24/2017	IPP, Greifswald, Germany
USA	Princeton University	Alexandra LeViness	09/22/2017 - 08/25/2018	IPP, Greifswald, Germany
USA	General Atomics	Cameron Samuell	04/23/2017 - 04/27/2017	IPP, Greifswald, Germany
USA	Princeton University	Camille Liotine	06/29/2017 - 08/18/2017	IPP, Greifswald, Germany
USA	Auburn University	David Ennis	07/02/2017 - 07/07/2017	IPP, Greifswald, Germany
USA	PPPL	David Gates	01/23/2017 - 01/27/2017	IPP, Greifswald, Germany
USA	PPPL	David Gates	09/16/2017 - 09/23/2017	IPP, Greifswald, Germany

USA	PPPL	David Gates	03/04/2017 - 03/11/2017	NIFS, Toki, Japan
USA	ORNL	Donald Spong	03/15/2017	Kyoto University, Japan
USA	ORNL	Donald Spong	02/27/2017 - 03/31/2017	NIFS, Toki, Japan
USA	PPPL	Doug Loesser	03/19/2017 - 03/23/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	01/10/2017 - 01/28/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	02/26/2017 - 03/10/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	03/26/2017 - 04/27/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	04/01/2017 - 05/12/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	05/09/2017 - 06/22/2017	IPP, Greifswald, Germany
USA	MIT	Eric Edlund	08/25/2017 - 12/23/2017	IPP, Greifswald, Germany
USA	UCSD	Eric M Hollmann	06/01/2017 - 06/15/2017	CIEMAT, Madrid, Spain
USA	UW Madison	Florian Effenberg	02/18/2017 - 03/12/2017	IPP, Greifswald, Germany
USA	UW Madison	Florian Effenberg	03/19/2017 - 04/08/2017	IPP, Greifswald, Germany
USA	UW Madison	Florian Effenberg	05/06/2017 - 06/16/2017	IPP, Greifswald, Germany
USA	UW Madison	Florian Effenberg	09/18/2017 - 11/25/2017	IPP, Greifswald, Germany
USA	LANL	Glen Wurden	11/13/2016 - 11/13/2018	IPP, Greifswald, Germany
USA	New York University	Harold Weitzner	06/12/2017 - 06/24/2017	IPP, Greifswald, Germany
USA	PPPL	Hutch Neilson	10/15/2017 - 10/18/2017	IPP, Greifswald, Germany
USA	ORNL	J. Varela-Rodriquez	02/27/2017 - 03/31/2017	NIFS, Toki, Japan
USA	ORNL	J. Varela-Rodriquez	10/10/2017 - 10/20/2017	NIFS, Toki, Japan
USA	UW Madison	Jason Smoniewski	11/08/2017 - 12/20/2017	IPP, Greifswald, Germany

USA	MIT	Jeanette Maisano-Brown	01/10/2017 - 01/20/2017	IPP, Greifswald, Germany
USA	ORNL	Jeffery Harris	10/01/2017 - 12/31/2017	IPP, Greifswald, Germany
USA	ORNL	Jeffrey Harris	08/14/2017 - 08/18/2017	IPP, Greifswald, Germany
USA	ORNL	Jeremy Lore	11/21/2017 - 11/24/2017	IPP, Greifswald, Germany
USA	MIT	Jim Terry	05/21/2107 - 06/03/2017	IPP, Greifswald, Germany
USA	MIT	Jim Terry	07/10/2017 - 07/23/2017	IPP, Greifswald, Germany
USA	MIT	Jim Terry	09/23/2017 - 10/06/2017	IPP, Greifswald, Germany
USA	Auburn University	John Schmitt	03/20/2017 - 04/01/2017	IPP, Greifswald, Germany
USA	Auburn University	John Schmitt	05/15/2017 - 05/28/2017	IPP, Greifswald, Germany
USA	Auburn University	John Schmitt	08/02/2017 - 10/01/2017	IPP, Greifswald, Germany
USA	Auburn University	John Schmitt	09/09/2017 - 10/13/2017	IPP, Greifswald, Germany
USA	Auburn University	John Schmitt	10/08/2017 - 12/16/2017	IPP, Greifswald, Germany
USA	New York University	Joshua Burby	08/28/2017 - 08/30/2017	IPP, Greifswald, Germany
USA	MIT	Kevin Tang	06/13/2017 - 20/08/2017	IPP, Greifswald, Germany
USA	University of Maryland	Mike Martin	11/06/2017 - 11/17/2017	IPP, Greifswald, Germany
USA	MIT	Miklos Porkolab	01/11/2017 - 01/13/2017	IPP, Greifswald, Germany
USA	MIT	Miklos Prokolab	11/01/2017 - 11/03/2017	IPP, Greifswald, Germany
USA	PPPL	Novimir Pablant	03/26/2017 - 04/08/2017	IPP, Greifswald, Germany
USA	PPPL	Novimir Pablant	08/07/2017 - 08/07/2019	IPP, Greifswald, Germany
USA	PPPL	Novimir Pablant	02/23/2017 - 03/24/2017	NIFS, Toki, Japan
USA	UW Madison	Oliver Schmitz	09/16/2017 - 09/18/2017	FZ Jülich, Germany

USA	UW Madison	Oliver Schmitz	02/11/2017 - 02/18/2017	IPP, Greifswald, Germany
USA	UW Madison	Oliver Schmitz	03/22/2017 - 04/08/2017	IPP, Greifswald, Germany
USA	UW Madison	Oliver Schmitz	09/18/2017 - 09/23/2017	IPP, Greifswald, Germany
USA	UW Madison	Patrick Leonard	06/01/2017 - 08/31/2017	NIFS, Toki, Japan
USA	Auburn University	Peter Traverso	08/22/2017 - 12/15/2017	IPP, Greifswald, Germany
USA	PPPL	Rob Miller	03/19/2017 - 03/31/2017	IPP, Greifswald, Germany
USA	PPPL	Robert Lunsford	09/17/2017 - 09/22/2017	IPP, Greifswald, Germany
USA	PPPL	Samuel Lazerson	03/19/2017 - 04/01/2017	IPP, Greifswald, Germany
USA	PPPL	Samuel Lazerson	05/14/2017 - 06/02/2017	IPP, Greifswald, Germany
USA	PPPL	Samuel Lazerson	06/19/2017 - 06/19/2019	IPP, Greifswald, Germany
USA	MIT	Sean Ballinger	06/05/2017 - 09/04/2017	IPP, Greifswald, Germany
USA	UW Madison	Thierry Kremeyer	03/18/2017 - 04/15/2017	IPP, Greifswald, Germany
USA	UW Madison	Thierry Kremeyer	07/01/2017 - indefinite	IPP, Greifswald, Germany
USA	UW Madison	Thulio Barbui	08/01/2014 - indefinite	IPP, Greifswald, Germany
USA	UW Madison	Victoria Winters	01/12/2017 - 02/22/2017	FZ Jülich, Germany
USA	UW Madison	Victoria Winters	05/06/2017 - 05/20/2017	IPP, Greifswald, Germany
USA	UW Madison	Victoria Winters	07/01/2017 - indefinite	IPP, Greifswald, Germany
USA	UW Madison	Victoria Winters	08/01/2017 - 12/31/2018	IPP, Greifswald, Germany

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