Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept

2012 Executive Committee Annual Report to the Fusion Power Coordination Committee

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EXECUTIVE SUMMARY

The present report overviews the scientific and technical progress achieved in 2012 by the parties to the Stellarator-Heliotron Concept Implementing Agreement, who have greatly benefit from its international collaborative framework. The document reports the collaborations in 2012 and the parties' research plans for 2013, including technical reports on 2012 activities.

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1 JOINT ACTIVITY: COORDINATED WORKING GROUP MEETING (CWGM) FOR STELLARATOR-HELIOTRON STUDIES

The 10th Coordinated Working Group Meeting (CWGM10) was held from 6 to 8, Jun. 2012 at Max-Planck Institut für Plasmaphysik in Greifswald, Germany. More than 50 experts (on record, including through videoconference) participated.

The materials presented in 10th CWGM are available at http://ishcdb.nifs.ac.jp/ (→ CWGM10) for those of you having further interests. Below, you will find the overall summary of the meeting.

This is the memorial 10th meeting of the CWGM. On this occasion, H.Yamada (NIFS) reflected the original ideas, “sharing the goal, and acceleration of the output-outcome wheel”, to launch the working group activity by referring materials from the informal meeting in 2003 (Greifswald) on Stellarator Database, and IEA Stellarator Executive Committee meeting in 2004 (Villamoura). The launched CWGM activity has embodied these ideas by promoting the comprehensive and exact understanding of complex physics, through the database, joint experiment, benchmarking and joint papers. It was also pointed out that the CWGM should become an excellent light house for global/domestic programs such as ITPA and also the power plant design activities. Continuous contribution to the ITPA has already been made through “3D physics”. In addition to that, reactor session was set up in this 10th CWGM to promote joint efforts in this direction as well. To further promote joint experiments among stellarator-heliotron (S-H) devices, recent and upcoming statuses of the devices are introduced from LHD, TJ-II and Heliotron J (H-J). New systems that will become available are: the increase of ECH and ICH heating power, and closed divertor (cryo-pumping at 1 section and baffle/dome installation at the total 8 sections out of 10 sections) in LHD, the pellet injector and 2nd HIBP (in collaboration with ORNL and Kharkov/Kurchatov Institute, respectively) in TJ-II, and plasma profile measurement by means of several diagnostics in H-J. Increase of device capability should increase the range of joint research. One specific request to TJ-II and H-J was to perform deuterium (D) experiment to increase the database (in addition to previous D-experiment in W7-AS) to resolve isotope effect, which should be critical issue to prospect burning S-H plasmas.

The topics discussed are the following: RMP (resonant magnetic perturbation), wall conditioning, 3D equilibrium, flow and viscosity, transport validation (energy transport: on-going, and particle transport: kick-off), Alfvén eigenmode and energetic particles, database issues, and reactor design and system code. Among these sessions, joint papers have been accepted on Alfvén eigenmode (oral, EX/5-2) and transport validation (poster, EX/P3-14) issues for the coming 24th IAEA Fusin Energy Conference (FEC) (at San Diego in Oct. 2012), and database issue (Singularization of data subgroups) for the coming EPS conference (Stockholm, Jul. 2012). One more joint paper originated from CWGM is on the magnetic island dynamics for the EPS, although the session was not set up in the CWGM10.

Brief memo on discussions in each session

RMP

The study on the transport modification due to RMP in LHD has been conducted as the joint experiment with tokamak community. It has been formulated as the task, TC-24 (along with the 3D effects on macro- and micro-structures), in the transport and confinement topical group in the ITPA. Further joint experiment is being planned in the coming 16th experiment campaign of the LHD for investigating how the amplitude of perturbation affects the level of turbulent transport.

Wall conditioning

Summary of recycling and isotope exchange of H, D and He plasmas is reported from TJ-II Li-wall conditioning research. Wall conditioning strategy for W7-X has been considered from the experiences of other devices, such as WEGA, LHD and Tore Supra. Since ECRH is the main heating source for the 1st operation phase of W7-X, ECRH wall conditioning should be developed. For this purpose, joint experiment is proposed in LHD by utilizing its ECRH capability.

3D equilibrium

Recent progresses on 3D equilibrium studies in LHD high-beta plasmas were reviewed, focusing on how to identify 3D magnetic field structure. Identification approach by means of position of radial electric field (E_r) =0 or maximum gradient of E_r, originated to the positive E_r generation due to opening magnetic field lines. This has been also observed in DIII-D. Identification of stochastization in plasma edge has been also tried with the heat pulse propagation technique. Necessity of rigorous numerical treatment outside the last closed flux surface (LCFS) is also pointed out for relating measurement at different Scrape Off Layer (SOL) positions and performing simulations on edge physics such as EMC3. An open question raised is how to validate the numerical modeling. As a follow-up discussion, divertor heat flux measurements in LHD was introduced, stating that the positions of measured heat flux peaks fit to those predicted from HINT2 numerical results. Such a validation study, including the identification of LCFS, was discussed to be formulated as joint experiments.

Flow and Viscosity

There have been recognized that range of research on plasma flow and viscosity issues has been conducted in S-H devices. Based on individual discussions made in the last 18th International Stellarator-Heliotron Workshop (Australia, 2012), it was agreed to launch the flow and viscosity session in CWGM. The possible joint actions discussed so far between NIFS and CIEMAT were introduced, such as the numerical code verification/validation and joint experiments on plasma biasing. The HSX also joined discussions with their Reynolds stress and E_r measurement, and comparisons to PENTA code calculations. The proposed joint actions will be transferred to HSX group to formulate further programmatic joint actions and to set a specific goal. The topics-oriented joint actions such as on the trigger and dynamics of the L-H transition, 3D effects on zonal flow, and the impact of self-regulation mechanisms in transport and stability were also proposed in close link to “3D physics” session in ITPA.

Transport validation (energy transport)

Transport in S-H plasmas consists of neoclassical and turbulent contribution. To perform studies of transport model validation, impact of neoclassical transport has been investigated in ion-root plasmas (medium to high density with comparable electron and ion temperature under sufficient ion heating power) of W7-AS (previous documentation), LHD and TJ-II (new joint experiment). This is a natural consequent extension of joint efforts on CERC (Core Electron-Root Confinement) plasmas, and successfully documented international benchmarking activities of neoclassical transport codes. Towards joint paper in the coming IAEA-FEC, progress of energy balance analysis was shared and the formats of materials were discussed along with "homework" assignments. It was also followed up by showing examples of non-local neoclassical transport code, FORTEC-3D, to provide quantitatively different prediction of the neoclassical ambipolar E_r at some cases. Certainly, it would be valuable to examine discharges of joint experiments by several other codes for validation points of view. The progress on XICS (X-ray Imaging Crystal Spectrometer, under collaboration between PPPL and NIFS) measurement of ion and electron temperatures was also reported, to provide profile information for the energy transport analysis. The request to perform also particle transport study was raised, and this became a natural introduction to the following session.

Particle transport

Density control is one of key issues to be comprehensively understood for considering operation in large S-H plasmas and reactors. The summary on particle transport from observations in LHD is as follows: the density profile becomes more hollow in outwardly shifted configuration/the lower the collisionality, density profile is determined not by particle fueling (NBI fueling and wall source) but from transport, neoclassical contribution is larger (smaller) for convection (diffusion), respectively, and gyro-kinetic quasi-linear analysis shows qualitative agreements of zero flux condition, indicating anomalous feature plays a role on transport. It was pointed out that the separation of core and peripheral region by investigating the penetration depth of neutral particles would be one approach to be considered for particle transport. Joint experiment in LHD was proposed to further investigate particle transport by decoupling heating and particle sources such as by ECRH and/or pellet injection. A summary of methods and results for particle transport studies in TJ-II contributed to this new topic. A poor particle confinement regime is identified in low density plasmas considerably affected by kinetic effects from the ECRH. This identification must be discerned in order to plan a joint contribution. NBI plasma studies are ongoing, but the analysis done so far point to a linear dependence of particle confinement time with density. There seems to be, however, a strong degradation with heating power. There is improvement of particle confinement when the L-H transition occurs, but no steady state H-mode is available to make a quantitative description.

Alfvén eigenmodes, energetic particles

This is the 3rd sessions on this topic, after the launch at 8th CWGM (NIFS, Mar. 2011). Joint experiment has been successfully evolved between H-J (low rotational transform, ı) and TJ-II (high-ı) to commonly understand Alfvén eigenmodes in low-shear S-H plasmas, to be reported as the joint paper in the coming IAEA-FEC. Comparative study will be expanded to LHD. So far, independent database in each device has been utilized for numerical code validation, along with the on-going code verification among several codes. It was pointed out that the accuracy of equilibrium, especially the ι-profile, should be carefully considered such as for ι-scan experiments and those interpretations by numerical codes. The Bernstein-wave heated plasmas in WEGA stellarator was also reported to show the existence of supra-thermal electrons in keV-range, and also to show the direct momentum transfer with a combination of 2.45 GHz ECRH.

Database issues

ISS04 has been established based on the International Stellarator-Heliotron Confinement Database (ISH-CDB) from existing devices. As the next step, the assessment of energy confinement for the future devices has been tried with utilizing the dimensionless variables following the principles of similarity and scale invariance. Clustering of database by using several sets of dimensionless variables has been going on, and still a lot of efforts will be required at this moment. Extension of CDB with new data was requested to increase the capability for discriminating dataset. The progress of Profile Database (ISH-PDB) was also reported. Equilibrium information corresponding to registered discharges, such as wout and input files of VMEC2000, has been registered (requiring authentication as joint analysis). The reading routine will be provided to cover possible different version of VMEC2000 (currently, equilibria from version 6.90 and 8.00 coexist in the database). This “de facto standard” platform should enhance the validation activity of numerical codes/modeling by easing the possible difficulties for their applications to experimental data.

Reactor, system code

One of long-term goal of the CWGM activity is to define data basis for S-H reactor studies. Thus, it is meaningful for CWGM activity to share the current status and future prospects of S-H reactor scenario and system code development to consider the research direction. In the 4th CWGM (CIEMAT, Oct. 2008), the reactor session was held, focusing on engineering issues. At this time in 10th CWGM, reactor system code application to reactor design is also emphasized. European fusion roadmap being discussed was introduced with identifying required steps towards DEMO and commercial fusion power plant (“step ladder” consideration). Design status of HELIAS 5-B (a 5-period HELIAS reactor) was reported with emphasis on engineering issues. Predictive simulation using 1D transport models (including neoclassical database and anomalous modeling) has been performed for a “up-scaled” W7-X, to particularly find the renormalization factor (in ISS04 scaling) tends to decrease with size of the plasma. This finding provides impact for taking the confinement scaling law into the system code The application of reactor system code, HELIOSCOPE, and the current status/future prospects of FFHR-d1 (heliotron reactor in the design study) was also reported. The HELIOSCOPE has been utilized to specify design window with several engineering and physics (basically scaling law, right now) conditions. Fast-time and accurate employment such as of 3D equilibrium and physics models into the system code are to be pursued to obtain more robust design. It was discussed that the interaction between system code development/application and CWGM activity in this regard should be enhanced. The optimization research of TJ-II configuration has been conducted utilizing DAB (Distributed Asynchronous Bees” algorithm on the grid computers (http://fusion.bifi.unizar.es/).

Figure 1 shows a slide prepared for the final concluding session, summarizing work plans for 2012/2013 (and towards future). Programmatic joint experiments/activities were formulated based on discussions made in the meeting.

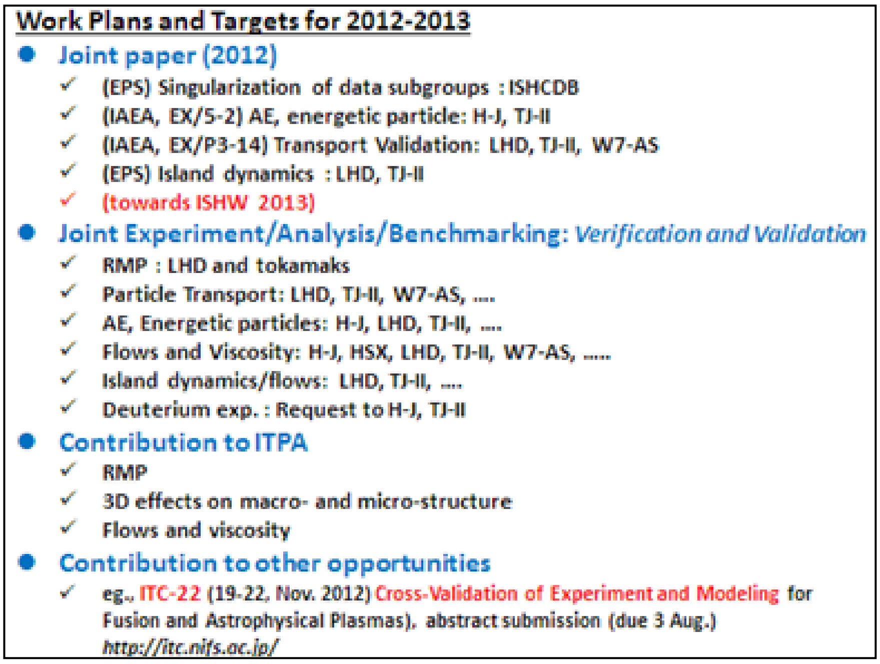

Fig.1 A slide prepared for concluding session of 10th CWGM.

Finally, it should be mentioned that the next 11th CWGM was agreed to be hosted by CIEMAT. The details will be announced once they become available.

The presented materials in previous CWGMs (except the 1st one, unfortunately) can be reachable through either IPP or NIFS CWGM website (designated at the top of this manuscript). Looking back contents discussed in previous CWGMs should be instructive to consider future direction for this activity.

Acknowledgements

Prof. R.Wolf, Dr. A.Dinklage and Ms. M.Radau (IPP-Greifswald) are greatly appreciated for their extensive efforts for hosting the 10th CWGM. Mr. R.Klatt (IPP-Greifswald) and Dr. T.Akiyama (NIFS) are also appreciated for their kind supports to make the video-conference smoothly run. The 10th CWGM is partly supported by NIFS (National Institute for Fusion Science)/NINS (National Institutes of Natural Sciences) under the project, “Promotion of the International Collaborative Research Network Formation”.

2 AUSTRALIA

2.1 International collaborations in 2012

The Australian Plasma Fusion Research Facility at the Australian National University houses the H-1 heliac and the MAGPIE linear device. H-1 is a three-period helical axis stellarator with a flexible magnetic topology that allows fundamental studies in plasma confinement and stability, turbulence and flows, and confinement transitions at moderate heating power. Because of its coil-in-tank construction, the device is an ideal test bed for the development of advanced active and passive imaging diagnostic technologies from microwave through to optical frequencies.

In 2012, the new 2x200kW 4-20MHz RF heating system, including a cooled antenna was commissioned and began regular operation, as a major part of the ~US$7M upgrade under the Australian Government's Super Science Scheme. Enhancements to the Facility will enable future growth of Australian capability in fusion science and engineering, and as a focus for collaboration within the Australian community, will support the development of world-class diagnostic systems for application to international facilities in preparation for ITER.

Diagnostic upgrades completed this year included the first 7 channels of a sensitive imaging multichannel interferometer, and an imaging optical impurity monitor. This interferometer and the rf upgrades enabled magnetic field scans with minimal variation to the rf heating mechanism to investigate the scaling of the dispersion properties of the observed MHD modes.

Vacuum enhancements installed this year include the first set of three glow discharge cleaning electrodes, a new coiling cool for the high capacity cryopump, and a residual gas analyser capable of monitoring both higher pressure glow discharge cleaning, and lower pressure plasma operations.

As part of a longer term strategy that aims for an Australian involvement with ITER, upgrade funding is supporting the development of a small linear, high power-density satellite device "MAGPIE", utilizing the H-1 heating, power and diagnostic systems. This is the first device in the Materials Diagnostic Facility, led by Dr. Cormac Corr and was developed in collaboration with Oak Ridge and the Australian Nuclear Science and Technology Organisation (ANSTO), to facilitate development of diagnostics for plasma wall interactions and for characterizing advanced high temperature materials. In 2012, operation up to $10^{19}m^{-3}$ in helium and hydrogen was achieved, and some tungsten and carbon materials were exposed to the plasma.

In mid 2012 Dr Clive Michael returned to Australia to support international collaborative activities in advanced diagnostic systems and to contribute to the H-1 program, and Dr. Greg von Nessi commenced a joint appointment with the Toroidal and Plasma Theory and Modelling Groups.

- Multilateral Collaborations

Work on the international collaboration on MHD and configuration studies under the IEA agreement focussed on application of the new version of the data mining analysis to recent configuration scans in Heliotron-J and extensive scans in H-1, combining two poloidal arrays and the new 16 element, 3 axis helical arrays. Results were presented at the International Stellarator/Heliotron Workshop, the 22nd International Toki Conference, and the Japan Australia Diagnostic Workshop.

One and two-dimensional coherence imaging (CI) systems developed by Prof Howard at ANU underpin collaborations with the USA, EU members and Korea, which are supported by international agencies and the Australian Government. These include

- (EU) Coherence imaging systems are being installed on the ASDEX-U upgrade for imaging motional Stark effect measurements commencing January 2013. A system is also being deployed on the MAST tokamak for divertor flow and temperature imaging.

- (US) With LLNL and General Atomics, application of Doppler CI systems for imaging flows in the DIII-D divertor and scrape-off-layer. These static systems utilise novel spatial-heterodyne interferometric techniques to capture the 2-D Doppler information.

- (Korea) A 2D spatial heterodyne system installed on KSTAR has produced the first images of the Bz discontinuity arising from narrow edge pedestal currents during H-mode discharges. High resolution CXRS images are also now being analysed.

Collaboration between ANU, MPIPP (J. Svensson), and the Culham Centre for Fusion Energy (L. C. Appel) have complementary stellarator and compact toroidal components. The project, which was supported by an Australian International Science Linkages grant, aims to develop Bayesian techniques for the integration of various diagnostic data, building on pioneering development of the technique on W7-AS. 2012 publications included evidence based cross-validation, to remove rogue diagnostic data, Thomson Scattering and a split-observation Bayesian force balance validation tool developed and implemented on MAST. During a collaborative visit to CCFE, Dr von Nessi installed a stand-alone version of the Bayesian inference code on the MAST scheduler for routine data analysis, as well as making collaborative visits to KSTAR and JT60 to discuss possible uptake. With the addition of Dr Clive Michael to the ANU staff, an expert in fast ion plasma diagnostics, a wider collaboration was initiated between the ANU and CCFE in the modelling of Fast Ion D-alpha diagnostic using a Bayesian model.

In an application to H-1, Dr von Nessi began developing forward models for He line ratios, for application in a Bayesian inference framework.

MRXMHD: Significant progress was demonstrated in a collaboration between the ANU (R. Dewar, M. Hole, B. Blackwell, M. McGann, A. Gibson, G. Von Nessi), Princeton PPL (S. Hudson), RFX-mod (Dr Dominique Escande) and CCFE (Prof. Richard Dendy) on the development of a new variational principle - multi region relaxed MHD (MRXMHD). In 2012 Dr Hudson spent 3 weeks at the ANU guiding numerical studies using the new MRXMHD code SPEC. This included explanation of the spontaneous formation of a second helical axis in the RFP, which is observed at higher plasma current. This plasma is in a lower energy state than the comparable axis-symmetric case. A stability analysis showed that the formation of a second helical axis occurred via tearing modes.

In 2012, seminal “reference” publications will appear for the SPEC code, which was developed for application to stellarators. In addition to the application to RFX-mod, the code has also been applied to DIII-D plasmas with a STELLOPT field reconstruction, demonstrating the appearance of magnetic islands in pressure-flattened regions, as well as ITER with a perturbed plasma boundary. ANU student Ashley Gibson completed a Master’s thesis on the mathematics underpinning MRXMHD, reconciling almost-invariant tori (imperfect magnetic surfaces) produced by the quadratic-flux-minimizing (QFMIN) surface method and the action-gradient-based ghost surface method. Results from these collaborations were presented at the invited talks by S. Hudson, M. J Hole at the ISHW/APPTC 2012 meeting, and by M. J. Hole at contributed oral talk at the Toki 2012 meeting. Finally, with the commencement of PhD student Craig Bowie, the collaboration widened to include the modelling of ELMs as an MRXMHD avalanche.

- Collaborations with EU

An existing collaboration between C. Nührenberg and Axel Koenies of MPIPP Greifswald, J. Bertram, R. Dewar, B. Blackwell, S. Haskey, J. Howard, M. McGann, G. Von Nessi, M. Fitzgerald and M. Hole of the ANU, which involves comparing the experimental observations of MHD activity with eigenvalue calculations using the CAS3D code and the wave-particle interaction code CAS3D-K, was expanded to commence work on continuum damping in 3D. In 2012, George Bowden commenced a PhD on this topic. A visit from Dr Koenies to the ANU is planned for early 2013, as funded by a successful DAAD grant between the Group of Eight research intensive Australian Universities and German Academic Exchange Service.

Collaboration between CCFE (S. Sharapov, K. M^{C}Clements, S. Pinches, L. C. Appel) and the ANU (M. Hole, R. Dewar) in burning plasma physics, aim to non-perturbatively model the effect of energetic particles such as fusion alpha-particles on the equilibrium, wave-mode structure, and wave-mode induced confinement loss. In 2011-2012 Dr Michael Fitzgerald’s work focussed on the calculation of anisotropy in MAST plasmas, and computing the impact of rotation in high beta plasmas. This new code, EFIT TENSOR, was completed in 2012, and is now being integrated into routine magnetic reconstruction tools for both MAST and JET. The impact of anisotropy-induced q profile corrections to thermal modes of the plasma was also studied. The collaboration with CCFE was also broadened to study the correlation of neutron loss with magnetic activity (Masters student Sebastien Cox), as well as the implementation of anisotropic corrections to MHD stability codes CSCAS and MISHKA (PhD student Zhisong Qu).

- Collaborations with JAPAN

In addition to the multilateral datamining collaboration, the following were active in 2012:

1) Prof R. Dewar (ANU) and Prof. Yoshida (Tokyo) – MHD spectral theory and spheromaks

- Collaborations with USA

In addition to the multilateral MRXMHD collaboration, and the D3D divertor studies the following were active in 2012:

(1) ANU and R. Goulding, J. Harris and P. Krstic of ORNL: development of the Materials Diagnostic Facility Prototype and ANU, and proposals for collaborative grants.

(2) ANU, PPPL and DIIID – The effect of 3D magnetic perturbations on the edge plasma.

(3) ANU and B. Breizman, Univ. of Texas, Austin, and G. Chen of ORNL in helicon waves with the electromagnetic wave code EMS, as well as the formation of gaps and gap modes in a periodic linear machine.

- Workshops and Conferences

The ANU hosted the combined Joint 18th International Stellarator/Heliotron Workshop (Chair: Dr Blackwell) and 10th Asia Pacific Plasma Theory Conference (Chair: Dr Hole) at the Australian National University in Canberra and Murramurang Beachfront Nature Reserve between Jan. 29 – Feb. 3, 2012. The combined meeting (PLASMA2012) was held in cooperation with the International Atomic Energy Agency. The purpose of the combined meetings was to provide a forum for the discussion and dissemination of research in the field of helical fusion magnetic confinement, thereby bridging stellarator and tokamak communities, and foster Asia-Pacific regional collaboration in theory and modelling. The conference, which attracted over 120 abstracts from scientists drawn from 11 nations, was opened by the ANU Vice Chancellor, Prof. Ian Young. Conference topics spanned plasma physics, materials science, and fusion technology development. A dedicated session on Monday was held on materials science, enabling involvement of the wider Australian materials science community. The meeting was supported by Thomson Scientific, which supplied the H-1 transmitter, AINSE, which supported student attendance, ANSTO, which sponsored the conference dinner, the journal Plasma Physics and Controlled Fusion, which provided a student prize, and the IAEA through its technical cooperation program. A number of ABC radio interviews were held in conjunction with the event, featuring Dr Blackwell and Dr Hole.

JAEA, Japan will be host to the 9th Japan-Australia Plasma Diagnostics Workshop.

Dr Hole represented Australia at the 51st IFRC meeting and presented research highlights and summarised progress in upgrade of H-1 and the new materials diagnostic facility of the Australian Plasma Fusion Research Facility.

2.2 Future Research Plans

Enabled by the upgrade, configuration studies will focus on expanded configuration scans and magnetic field scans of Alfvén-driven instabilities. Multi-channel plasma density and polarization interferometers, and multi-channel spectroscopic detectors will provide profile information for configuration studies and mode structure of Alfvénic instabilities. The original H-1 RF antenna will be made available for the excitation of Alfvén modes, and application of perturbation fields.

International collaboration on CI optical systems for spectro-polarimetric imaging will continue in 2012 and beyond. In the coming year, this work will embrace the following activities:

Following successful first data, a second Doppler imaging camera is planned for wide field of view divertor flow and temperature tomography on DIII-D, and a custom designed system will be installed on KSTAR for imaging CXRS and MSE measurements.

Combined with fast, gated CCD cameras, newly developed passive spatial heterodyne CI systems will be deployed for synchronous detection of velocity distribution function perturbations associated with magnetic fluctuations in the H-1 heliac.

In future years we hope to deploy CI imaging systems for edge physics studies in the W7-X stellarator. The recent success of Doppler imaging on the DIII-D tokamak divertor is a valuable guide in future planning.

We are developing multiple-carrier spatial heterodyne CI systems that should allow extended capability for imaging of more complex spectral scenes and exploring Zeeman-assisted Doppler tomography of inhomogeneous magnetized plasma such as the tokamak divertor.

Utilizing the planned linear satellite device, we aim to trial imaging Stark effect and some new concepts in optical radar-based range sensing with the ultimate goal (subject to appropriate funding) to develop a prototype imager for monitoring tile erosion in high power fusion devices.

The expanded collaboration on the MRXMHD project will apply the MRXMHD code SPEC to MAST with an RMP field, and investigate control of magnetic surfaces between different relaxed regions via external coils. In 2012 the burning plasma project will focus on computing the impact of anisotropy on global modes. A reciprocal visit from IPP to Australia is also funded to implement kinetic code CKA/EUTERPE on H1 plasmas, and develop tools to compute continuum damping in 3D.

The Australian Heliac program at the ANU has produced several technological spin-offs that are now attracting support independent of the fusion program. These include technology for long distance, non-line-of-sight VHF digital wireless communications in rural Australia (the BushLAN project), and optical coherence imaging (CI) spectroscopy systems for use in process control in steel production. A demonstration of new wireless communications technology to potential investors is near completion and has attracted interest from several quarters.

Finally, the Australian fusion science community will continue endeavours to secure funding to develop prototype diagnostic concepts using the new capabilities of the H-1 facility for one or more plasma diagnostics for ITER. The Australian fusion science community has revising the 2007 fusion science strategic plan, taking into account funding developments over the last five years and changes to research funding schemes. We anticipate that this will be released in early 2013.

3 EU

3.1 GERMANY

3.1.1 International collaborations in 2012

- Collaborations with EU

1) J. Belloso (CIEMAT) to IPP, 15.01. – 29.02.2012

2) S. Newton (Culham Science Centre) to IPP, 16.01. – 20.01.2012

3) P. Helander (IPP Greifswald) visited Nancy University, 26.01. – 28.01.2012

4) P. Helander (IPP Greifswald) visited Cadarache, 09.02. – 13.02.2012

5) J. Andersson (Chalmers Göteborg) to IPP, 12.02. – 18.02.2012

6) N. Marushchenko (IPP Greifswald) visited Culham Science Centre, 20.02. – 24.02.2012

7) T. Szabolics (KFKI Budapest, Hungary) to IPP, 20.02.-02.03.2012

8) J. Svensson (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 24.02. – 23.04.2012

9) W. Schneider (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 05.03. – 14.03.2012

10) R. Sanchez, V. Tribaldos and L. Garcia (University Carlos 3 Madrid) to IPP, 08.03. – 10.03.2012

11) T. Klinger (IPP Greifswald) to IPPLM-Council-Meeting Warsaw, 12.03. – 16.03.2012

12) A. Rodatos (IPP Greifswald) visited CEA, Cadarache, France, 12.03. - 24.03.2012

13) C. Beidler (IPP Greifswald) with EFDA: PowerPlantPhysics and Technology (Organisational Meeting) , Garching: 20.03.2012

14) I. Ksiazek (Opole University, Opole) to IPP, 27.03. - 30.03.2012

15) I. Ksiazek (Opole University, Opole) to IPP, 16.03. - 24.04.2012

16) J. Romero (CIEMAT, Madrid) to IPP, 06.05. – 12.05.2012

17) N. Marushchenko (IPP Greifswald) visited TU Eindhoven, 06.05. – 10.05.2012

18) A. Czermak, B. Sowicki (Polish Academy of Sciences, Cracow) to IPP, 28.05.-02.06.2012

19) I. Ksiazek (Opole University, Opole) to IPP, 28.05.-02.06.2012

20) J.L. Velasco (CIEMAT Madrid) to IPP, 29.05. – 09.06.2012

21) C. Beidler (IPP Greifswald) with EFDA: Kick-off-Meeting for “Stellarator Engineering Scoping Studies”, VC mit EFDA Garching, 13.06.2012

22) A. Mishchenko, G. Plunk (IPP Greifswald) visited CIEMAT, 17.06. – 22.06.2012

23) T. Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP, 18.06. - 20.06.2012

24) Y. Kazakov (Chalmers University, Göteborg) to IPP, 19.06. – 22.06.2012

25) S. Kasilov (TU Graz) to IPP, 01.07. – 31.07.2012

26) N. Marushchenko (IPP Greifswald) visited KTH Stockholm, 09.07. – 15.07.2012

27) T. Ilkei (Hungarian Academy of Sciences, Budapest) to IPP, 30.07.-10.08.2012

28) P. Monreal Gonzalez (CIEMAT Madrid) to IPP, 05.08. – 18.08.2012

29) J. Gunn (CEA, Cadarache) to IPP, 06.08. - 08.08.2012

30) M. Lilley (Imperial College, London) to IPP, 29.08.2012

31) P. Urlings (University of Technology, Eindhoven) to IPP, 03.09. – 30.11.2012

32) T. Stoltzfus-Dueck (IPP Greifswald) visited CRPP Lausanne, 10.09. – 13.09.2012

33) G. Plunk (IPP Greifswald) visited Instituto de Plasmas e Fusao Nuclear Lisbon, 11.09. – 15.09.2012

34) P. Helander (IPP Greifswald) visited DTU Risø, 12.09. – 13.09.2012

35) J. Connor (Culham Science Centre) to IPP, 16.09. – 28.09.2012

36) C.Beidler (IPP Greifswald) with EFDA: Progress Report “Stellarator Engineering Scoping Studies”, VC mit EFDA Garching, 20.09.2012

37) J. Svensson (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 21.09. – 22.12.2012

38) P. Helander (IPP Greifswald) visited Culham Science Centre and Oxford University, 28.09. – 13.10.2012

39) J.M. Garcia Regaña (IPP Greifswald) visited CRPP Lausanne, 30.09. – 07.10.2012

40) T. Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP, 07.10. – 20.10.2012

41) H. Oosterbeek (University of Technology, Eindhoven) to IPP, 31.10. – 03.11.2012

42) A. Rodatos (IPP Greifswald) visited CEA, Cadarache, France, 05.11.-07.12.2012

43) J. Baldzuhn, (IPP Greifswald) visited CEA, Cadarache, France, 07.11. - 10.11.2012

44) C. Beidler (IPP Greifswald) with EFDA: Final Report “Stellarator Engineering

Scoping Studies”, IPP Greifswald, 22.11.2012

45) T. Ilkei, G. Kocsis (Hungarian Academy of Sciences, Budapest) to IPP, 03.12. - 07.12.2012

46) P. Helander (IPP Greifswald) visited CRPP Lausanne, 05.12. – 07.12.2012

- **Collaborations with Japan**

1) G. Kawamura (NIFS) to IPP Greifswald, 18.01. – 28.01.2012

2) A. Kus (IPP Greifswald) visited NIFS, Toki, 10.03. – 30.03.2012

3) Y. Suzuki (NIFS) to IPP Greifswald, 11.03. – 14.03.2012

4) M. Yokoyama (NIFS) to IPP Greifswald, 28.05. – 15.06.2012

5) G. Kawamura (NIFS) to IPP Greifswald, 28.05. – 02.06.2012

6) O. Grulke (IPP Greifswald) to NIFS, Toki, 16.07. – 19.10.2012

7) M. Jakubowski (IPP Greifswald) visited NIFS, Toki, 21.10.2012

8) G. Kawamura (NIFS) to IPP Greifswald, 28.10. – 02.11.2012

9) Y. Todo (NIFS) to IPP Greifswald, 31.10. – 10.11.2012

10) M. Krychowiak, E. Winkler (IPP Greifswald) visited NIFS, Toki, 05.11. – 16.11.2012

11) J. Geiger (IPP Greifswald) visited NIFS, 10.11. – 24.11.2012

12) H. Saitoh (University of Tokyo) to IPP, 20.11. - 24.11.2012

13) T. Klinger (IPP Greifswald) visited NIFS, Toki, 30.11. – 03.12.2012

- **Collaborations with Russia**

1) K. Dyabilin (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 26.02.2012

2) M. Isaev (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 11.02.2012

3) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 27.02. – 26.04.2012

4) T. Richert, J. Baldzuhn (IPP Greifswald) and T. Franke (IPP Garching) visited Budker Institute Novosibirsk,16.06. – 20.06.2012

5) T. Richert (IPP Greifswald) visited Budker Institute Novosibirsk 11.09. – 27.09.2012

6) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 22.10. – 14.12.2012

7) N. Marushchenko (IPP Greifswald) visited IOFFE Institute St. Petersburg, 30.10. – 02.11.2012

- **Collaborations with Ukraine**

n.a.

- **Collaborations with USA**

1) P. Helander (IPP Greifswald) visited MIT Boston, 09.01. – 13.01.2012
2) O. Grulke (IPP Greifswald) visited PSFC/MIT, Boston, 04.02. – 13.02.2012
3) X. Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 18.02.-18.03.2012
4) O. Grulke, T. Klinger (IPP Greifswald) to Kick-off-Meeting MPRC Princeton, 27.03. – 30.03.2012
5) P. Helander (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 27.03. – 31.03.2012
6) G. Wurden (Los Alamos Energy Sciences, Los Alamos) to IPP, 20.05.-02.06.2012
7) J. Harris, D. Gates (Princeton Plasma Physics Laboratory, Princeton) to IPP Greifswald, 08.07. – 20.07.2012
8) A. Bader (University of Wisconsin) to IPP Greifswald, 29.07. – 10.08.2012
9) D. Mikkelsen (Princeton Plasma Physics Laboratory) to IPP Greifswald, 12.09. – 22.09.2012
10) H. Smith (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 14.10. – 27.10.2012
11) T. Sunn Pedersen (IPP Greifswald) visited Columbia University, New York, 02.11. - 06.11.2012
12) X. Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 01.12. - 15.12.2012

3.1.2 Conference participation

1) T. Sunn Pedersen: Physics with Trapped Charged Particles, Les Houches, 14.01. - 19.01.2012
2) M. Hirsch: ESTRELL Workshop, 26.01 - 27.01.2012, Nancy, France
3) M. Drevlak, O. Ford, J. Geiger, T. Klinger, H. P. Laqua, T. Sunn Pedersen, R. C. Wolf: 18th International Stellarator/Heliotron Workshop, 29.01. – 03.02.2012, Canberra, Australia
4) G. Kuehner: Software Engineering Conference, 27.02. – 02.03.2012, Berlin, Germany
5) H. Bohlin, M. Drevlak, P. Drewelow, T. Klinger, H. P. Laqua, M. Otte, J. Proll, H. Smith, A. von Stechow, T. Sunn Pedersen, O. Zacharias: DPG-Fruehjahrstagung, 11.03. – 16.03.2012, Stuttgart, Germany

6) T. Bird, P. Helander, A. Mishchenko, G. Plunk and J. Proll: Workshop „Gyrokinetics for ITER“, 18.03. – 23.03.2012, Vienna, Austria

7) X. Sarasola Martin, T. Sunn Pedersen: International Workshop on Positrons in Astrophysics, 19.03. - 23.03.2012, Mürren, Switzerland

8) A. Werner: Smart Systems Integration, 21.03. – 22.03.2012, Zurich, Switzerland

9) A. Dinklage: 7th International Validation Workshop on Data Processing, Analysis and Validation, 26.03. – 28.03.2012, Frascati, Italy

10) J.M. Garcia Regaña: Sherwood Conference, 31.03. – 03.04.2012, Atlanta, USA

11) R. König: 19th Topical Conference High Temperature Plasma Diagnostics, 06.05. – 10.05.2012, Monterey, CA, USA

12) V. Erckmann: 17th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating,07.05. – 10.05.2012, Deurne, The Netherlands

13) Y. Feng, M. Laux, S. Marsen: 20th International Conference on Plasma Surface Interactions, 21.05. – 25.05.2012, Aachen, Germany

14) J. Schacht: 18th Real Time Conference, 09.06. – 15.06.2012 Berkeley, USA

15) H. P. Laqua: 24th Joint Russian-German Meeting on ECRH and Gyrotrons, 10.06. – 16.06.2012, Nizhny Novgorod, Russia

16) A. Rodatos, E. Winkler: 11th Kudowa Summer School, Kudowa Zdróy, 11.06. - 15.06.2012

17) H. Bohlin, P. Drewelow, P. Helander, T. Klinger, P. Kornejew, A. Kus, S. Schmuck, W. Schneider, X. Sarasola Martin, A. von Stechow, T. Sunn Pedersen, H. Thomsen, D. Zhang: 39th European Physical Society Conference on Plasma Physics, 02.07. – 06.07.2012, Stockholm, Sweden

18) M. Borchardt and R. Kleiber: Workshop “Algorithms, Performance and Accuracy in Gyrokinetic Codes”, 22.08. – 24.08.2012, Warwick, GB

19) T. Bird, J.M. Garcia Regaña, C. Nührenberg, J. Proll and O. Zacharias: Joint Varenna – Lausanne International Workshop, 27.08. – 31.08.2012, Varenna, Italy

20) C. Biedermann, X. Sarasola Martin, E. Stenson, T. Sunn Pedersen: 10th International Workshop on Non-neutral Plasmas, 27.-30.08.2012, Greifswald, Germany

21) N. Marushchenko: International Conference and School on Plasma Physics and Controlled Fusion, 17.09. – 22.09.2012, Alushta, Ukraine

22) A. Cardella, K. Grosser, D. Hathiramani, T. Klinger, P. McNeely, G. Michel, M. Schülke, S. Thiel: 27th Symposium on Fusion Technology, 23.09. – 28.09.2012, Liège, Belgium

23) A. Dinklage, M. Hirsch, M. Jakubowski, R. Kleiber, A. Könies, R. C. Wolf: 24th IAEA Fusion Energy Conference, 08.10. – 13.10.2012, San Diego, USA

24) R. C. Wolf: 1st IAEA DEMO Programme Workshop, 15.10. – 18.10.2012, Los Angeles, USA

25) P. Kempkes, B. Buttenschön: AWAKE Collaboration Meeting, 17.10. – 19.10.2012, Cern

26) T. Sunn Pedersen: 54. Annual Meeting of the APS Division of Plasma Physics, 29.10.-02.11.2012, Providence, Rhode Island, USA

27) H. Hölbe, Ringberg Theory Meeting, 05.11. - 09.11.2012, Ringberg, Germany

28) Y. Feng: 20th European Fusion Physics Workshop, 03.12. – 05.12.2012, Ericeira, Portugal

3.1.3 Participation in joint projects

- International stellarator/heliotron confinement data base

EU-US Transport Task Force and EFDA Transport Topical Group Meeting: Padova, Italy, 03.09. – 06.09.2012, T. Bird

- International stellarator/heliotron profile data base

Contributions from A. Dinklage, A. Kus, C. Beidler, H. Maaßberg, S. Marsen

- ITPA diagnostics

Contributions from R. König:

14.05. - 17.05.2012, Moscow, Russia and 24.11. - 30.11.2012 Gandhinagar, India

- ITPA confinement and transport

Contributions from M. Jakubowski, A. Dinklage chairs the 3D working group within the ITPA Transport and Confinement group.

- ITPA edge and pedestal

Contributions from M. Hirsch

- ITPA Fast Particles

1）Könies: ITPA Energetic Particles Topical Group Meeting, 05.03. – 09.03.2012, NIFS, Japan

A. Könies: 9th ITPA Energetic Particles Topical Group Meeting, 15.10. – 17.10.2012, San Diego, USA

3.1.4 Plans for 2013

- **Planning stellarator/heliotron theory**

1) Joachim Geiger plans to go to NIFS to work on 3D MHD equilibrium problems.

2) Axel Könies plans to participate in the ITPA meetings on Fast Particles in Culham an in China.

3) Thomas Bird and Josefine Proll plan to visit the Wolgang-Pauli-Institute in Vienna to work on gyrokinetics.

4) Nikolai Marushchenko plans to visit Culham and Graz to work on heating and current drive.

5) Timothy Stoltzfus-Dueck plans to visit Lausanne to suggest rotation experiments on TCV.

6) Alexey Mishchenko plans to attend the Festival of Theory in Aix-en-Provence.

7) Alexey Runov plans to visit Kharkov to work on Monte Carlo Methods.

8) Josefine Proll plans to visit Culham to work on Microinstabilities in Stellarators.

- **Spectroscopic diagnostics**

1) Rainer Burhenn (IPP Greifswald) plans several visits to TEXTOR (FZJ) for transferring the HEXOS spectrometer to W7-X

2) I. Ksiazek (Institute of Physics, Opole University, Opole) plans several visits (each about 1-2 weeks) to IPP Greifswald in the frame of the cooperation concerning the development of the C/O-monitor diagnostic for W7-X.

3) A. Czermak (Institute of Nuclear Physics PAN, Cracow) plans a visit to IPP Greifswald for the acceptance test of the prototype detectors for the W7-X C/O monitor.

4) M. Krychowiak plans a visit to Tore Supra (CEA) for tests of spectroscopy in-situ monitoring of vacuum windows coatings during long-pulse discharge

- **IR/visible Imaging Diagnostics**

A. Rodatos plans several visits to Tore Supra (CEA) for software development for hot spot detection and image scene understanding within a common framework as part of the EFDA GOT WP10 “Imaging for Fusion”.

- **Collaboration with NIFS**

1) A. Dinklage plans to visit NIFS for particle transport experiments (2 weeks)

- **Neutron diagnostics**

1) Mutual visits (about 1 - 2 per year, each about for 2-3 days) in the frame of collaboration with PTB Braunschweig on the neutron counter system for W7-X are

planned to discuss the progress and the work plan of the project (involving R. Burhenn, R. König, W. Schneider). In addition, W. Schneider will visit PTB Braunschweig (about 6 - 8 times per year for 1 to 2 weeks) to engage in development of neutron monitoring systems and in MCNP calculations.

- **Microwave diagnostics**

1) H. Oosterbeek (Technical University of Eindhoven) + student(s) will visit IPP: Measurement of the power flux density in a microwave stray radiation field

- **International stellarator/heliotron profile data base**

1) Kus plans to visit NIFS within the stellarator-heliotron database cooperation (3 weeks)

2) Kus plans to visit CIEMAT within the stellarator-heliotron database cooperation (2 weeks)

3) Dinklage plans to attend the CWGM (Madrid, Spring 2013)

- **ITPA confinement and transport**

1) M. Jakubowski and A. Dinklage plan to attend the ITPA T&C meetings (spring/fall). Dinklage chairs the 3D working group within the ITPA Transport and Confinement group.

- **Collaboration on ECRH, ECCD and ECE Plans 2013**

1) Heinrich. Laqua , Torsten Stange, Matthias Otte and Melanie Preynas will visit Kyoto University (Heliotron-E) and NIFS (LHD) for the Joint research program "Optimization of high power ECRH application to helical fusion plasma confinement systems" subject to support by DAAD-JSPS

2) Kazunobu Nagasaki . Kazuyoshi Hada (Kyoto University) will visit Greifswald for the Joint research program "Optimization of high power ECRH application to helical fusion plasma confinement systems" subject to support by DAAD-JSPS

- **Conference participation 2013**

1) P. McNeely: Workshop "Frontiers in Low-Temperature Plasma Diagnostics", 09.05. – 12.05.2013, Greifswald, Germany

2) A. Werner: 25th Symposium On Fusion Engeneering (SOFE25), 10.06. – 14.06., San Francisco, USA

3) N. Rust: 40th International Conference on Plasma Science (ICOPS-40), 16.06. – 22.06.2013, San Francisco, USA

4) S. Bozhenkov: 40th European Physical Society Conference on Plasma Physics (EPS-40), 01.07. – 05.07.2013, Espoo, Finland

5) H. Braune, G. Michel: 38th International Conference on Infrared, Millimeter, and Terahertz Waves, 01.09. – 07.09.2013, Mainz, Germany

6) P. McNeely: 15th International Conference on Ion Sources, 09.09. – 13.09.2013, Chiba, Japan

7) A. Dinklage: 8th International Validation Workshop on Data Processing, Analysis and Validation, Oct./Nov. 2012, Ghent, Belgium

8) V. Erckmann: Topical Conference on Radio Frequency Power in Plasmas

3.2 SPAIN

3.2.1 International collaborations in 2012 using TJ-II at CIEMAT

- Collaborations with Russia

1) A. Melnikov and L. Eliseev and members of the HIBP Kurchatov Institute team were visiting CIEMAT to investigate the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements with two slit HIBP detector. The second HIBP system has been built for long-range (zonal flows) correlation studies and the commissioning is planned for beginning 2013.

2) Collaboration with General Physics Institute, Moscow on the characterization of the plasma reflected power on gyrotron performance. This includes preparation and installation of experimental systems in TJ-II, participation in experiments and analysis of the results. The visiting scientists of GPI involved have been: D. Malakhov (19 March-19 April and 23 October-22 December), Y. Bondar (19 March-19 April), N. Kharchev (26 April-26 May and 27 September-26 October), V. Borzosekov (26 April-26 May), E. Konchekov (27 September-26 October), K. Sarksyan (2 -16 October)

- Collaborations in Europe

Germany

3) C. Hidalgo was visiting IPP-Greifswald (August 20-24) to discuss the IPP-CIEMAT collaboration agreement in the field of development and operation of diagnostics and related physics evaluation for W7-X.

4) J. L. Velasco and D. López-Bruna were attending the 10th-CWGM held in Greifswald June 2012

5) J. L. Velasco visited Greifswald during one week in June 2012 to work on Neoclassical Transport Theory.

Portugal

1） Silva and I. Nedzelskiy were visiting CIEMAT to continue our collaboration on edge studies (edge turbulence and transport studies and diagnostic development including RFA and probes) during 2012.

2） D. Baião was working in her PhD thesis on soft x-ray based Te diagnostic for high density plasmas in the TJ-II stellarator (including prototypes construction, testing and measurements in TJ-II).

3) Continuing the collaboration in reflectometry in TJ-II with S. Da-Graça and L. Cupido.

Italy

1) Collaboration with M. Spolaore and the RFXmod team to participate on edge diagnostic development and measurements in TJ-II including the design, development of electromagnetic probes and characterization of the electromagnetic nature of plasma filaments in TJ-II.

2) B. Momo was visiting CIEMAT (May) for studying transport in 3D magnetic confinement devices.

- Collaborations with USA

1) E. Hollmann (USCD) was visiting CIEMAT (1 week, June 2012) working on parallel / radial impurity transport studies.

2) K. McCarthy visited Oak Ridge National Laboratory (1 week, March 2012) for testing the TJ-II pellet injector, which was shipped to Ciemat in August 2012.

3) I. Calvo spent the month of September, 2012 at MIT to work on gyrokinetic theory.

4) E. R. Solano spent January 2012 in S. Diego (D-III-D) to work on MHD dynamics and transport barriers.

5) F. Tabarés was visiting PPPL to discuss plasma-wall issues on Li coating.

- Collaborations with Ukraine

1) The Heavy Ion Beam Probe team (leaded by L. Krupnik, Institute of Plasma Physics, National Science Center “Kharkov Institute of Physics and Technology”, Kharkov) has been fully involved in the characterization of radial electric fields and plasma fluctuations in ECRH and NBI plasmas in the TJ-II stellarator during 2012 experimental campaign. The development of the second HIBP system has been finalized and installed (injector and analyzer) in TJ-II with on-going commissioning activities (December 2012).

- Collaborations with Japan

1) K. Ida and N. Tamura (NIFS) were visiting CIEMAT (March) to study the role of magnetic topology in the radial propagation of heat pulses and development of plasma diagnostics (TESPEL, BES)

2) M. Shoji (NIFS, Japan) was visiting CIEMAT (March) to work on edge diagnostics (fast cameras).

3) Y. Narushima visited CIEMAT during one week (March 2012) to work on island healing in stellarators.

4) Collaboration on fast particle physics. Joint experiments were planned in advance and performed in TJ-II on 14-15 March 2012. First analysis of the results and preliminary discussions took place on 16 March 2012. The visiting scientists involved were:

   T. Ido, Associate Professor of NIFS,

   A. Shimizu, Assistant Professor of NIFS (12-16 March)

   M. Shibuya, Engineer of NIFS (12 March)

   T. Komoto, Engineer of NIFS (12 March)

   K. Mukai, Post Dr. researcher of Osaka Univ. (12-16 March)

   S. Yamamoto, Assistant Professor of Kyoto Univ. (12-16 March)

5) Alonso was visiting Kyoto University (H-J) during 5-9 March 2012, discussing the physics of plasma viscosity in stellarator devices.

6) S. Satake (NIFS) visited CIEMAT during June (11-19) to discuss comparison of neoclassical approaches (MC global and DIKES local calculations) in different stellartor devices.

- **stellarator/heliotron working groups and ITPA**

The 10th Coordinated Working Group meeting (CWGM) was held Greifswald (June 2012) to discuss joint activities. Ciemat staff has participated on different topics including L-H physics, momentum transport, edge transport and fast particle physics.

CIEMAT scientists have been directly involved in the ITPA activities along 2012: E. Ascasibar was attending the ITPA Integrated Operational Scenarios meeting (Madrid April-2012, La Jolla October-20122); C. Hidalgo was attending the ITPA Transport and Confinement meetings (April-2012 Heifei; October-2012 La Jolla); F. Tabarés was attending the ITPA Scrape-off Layer and Divertor meeting (October-2012 La Jolla).

3.2.2 Plans for 2013

The main research activity of Euratom – Ciemat association will remain on concept improvement development and on the fusion technology programme with special emphasis on all the different aspects of fusion materials technology. In addition, we will strengthen and continue with our long standing tradition to extend our physics studies to different confinement concepts (tokamak / stellarators), looking for common clues as a fundamental way to investigate basic properties of magnetic confinement beyond any particular concept.

The following research areas are foreseen in the 2013 research programme:

1) Stellarator physics: confinement data-base, neoclassical transport, stellarator optimization and magnetic configuration effects on confinement. These activities are carried out within the framework of the international stellarator implementing agreement.
2) Plasma diagnostic development and engineering: Diagnostic developments for TJ-II will continue and in a wider context for JET, ITER (reflectometry, VIS-IR spectroscopy) and W7-X (reflectormetry and zonal flow physics)
3) Plasma heating (NBI, ECRH) and their role of fast particles driven modes.
4) Physics of advanced confinement scenarios: transport barrier physics, isotope effect, impurity transport and stability (including the role of magnetic well)
5) Theory and modelling of plasma transport, stability and equilibrium with emphasis on island dynamics and breaking of nested surface topology (3-D effects) and Gyrokinetic theory.
6) Plasma – wall studies, exploring plasma-wall interaction scenarios with Li coating and Li-liquid limiter concepts.
7) Data acquisition, control and advanced data analysis techniques.

The following collaborations are planned during 2013:

- **Collaborations with Russia**

1) Continuation of the collaboration with General Physics Institute, Moscow (K. Sarksyan, N. Kharchev and GPI Team) on the characterization of the plasma reflected power on gyrotron performance.
2) S. Pavlov (Kharkov Institute of Ukraine) will visit Ciemat to work on ECRH theory.
3) S. Petrov and V Nesenevich (IOFFE) will visit CIEMAT to participate on charge exchange spectrometry measurements.
4) A. Melnikov and L. Eliseev and members of the HIBP Kurchatov Institute team will visit CIEMAT to investigate the structure of plasma potential in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements using two HIBP systems for zonal flows experiments in the core plasma region.

- **Collaborations in Europe**

Germany

1) E. Sánchez will visit Greifswald (Germany) to work on Neoclassical transport and gyrokinetic theory respectively.
2) A. Alonso, J. L. Velasco and I. Calvo will visit Greifswald to discuss ongoing impurity studies including role of poloidal asymmetries and underlying mechanisms.

Portugal

1) C. Silva, L. Cupido and I. Nedzelskiy will visit CIEMAT to continue our collaboration on edge studies using arrays of Langmuir probes, Retarding Field Analyzers (RFA) and reflectometry.

Italy

1) Collaboration with M. Spolaore and the RFXmod team to participate on edge diagnostic development and measurements of electromagnetic turbulence in TJ-II.

- Collaborations with USA

1) E. Hollmann (USCD) will visit CIEMAT (June 2013) to work on impurity transport studies in TJ-II.

2) S. Combs (ORNL) and Ch. Foust might visit CIEMAT for pellet injection commissioning experiments along 2013.

3) J.L. Velasco and A. Alonso will visit Wisconsin to discuss ongoing research on role of symmetry on zonal flows and isotopic effect.

4) I. Calvo will visit MIT to work on gyrokinetic Theory development.

- Collaborations with Ukraine

1) L. Krupnik and HIBP team will visit TJ-II for investigation of the structure of radial electric fields using HIBP diagnostic (Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology). The second HIBP system has been design for long-range correlation studies (zonal flows); the final injector installation and test is foreseen during 2012.

- Collaborations with Japan

1) Collaboration on fast particle physics with Japanes institutions will continue. Joint experiments will be performed in TJ-II on March 2013. The visiting scientists likely to be involved will be K. Nagaoka (NIFS), S. Yamamoto (Kyoto Univ.). T. Ido (NIFS) and A. Shimizu (NIFS).

2) Keep in touch activities on BES in stellarators (TJ-II).

3) Based on the TJ-II experience with the pellet injector developed by ORNL, we plan to explore the viability of TESPEL system developed by NIFS (N. Tamura et al.,).

4) J.L. Velasco and A. Alonso will visit NIFS to continue our cooperative effort on neoclassical studies and viscosity analysis including comparison with experimental results.

- **International stellarator/heliotron working groups**

Ciemat staff will participate in the forthcoming CWGM and ITPA meetings to be held along 2013.

4 JAPAN

4.1 International collaborations by the LHD team at NIFS

- **Collaborations with Australia**

1) T.Ido (NIFS) attended 18th International Stellarator/Heliotron Workshop & 10th Asia Pacific Plasma Theory Conference held in Canberra, Australia from 29 January to 3 February 2012 to give an invited talk entitled "Potential Fluctuations of Geodesic Acoustic Mode and Alfvén Eigenmodes Driven by Energetic Particles in the LHD Plasmas."

2) M.Yokoyama (NIFS) visited Australian National University (and Murraramang) from 26 Jan. to 4 Feb. 2012 to organize 9th CWGM, and to attend the 18th International Stellarator-HeliotronWorkshop. He presented the invited talk on Transport Model Validation activity being conducted as topical collaboration in CWGM.

3) A.Wakasa (Kyoto Univ.) visited Australian National University (and Murraramang) from 26 Jan. to 4 Feb. 2012 to organize 9th Coordinated Working Group Meeting (CWGM), and to attend the 18th International Stellarator-Heliotron Workshop.

4) G.Motojima (NIFS) visited the Australian National University and Murramarang resort, Canberra, Australia to attend 18th International Stellarator/Heliotron Workshop & 10th Asia Pacific Plasma Theory Conference from 26 January to 4 February 2012 to give a poster presentation entitled "Observation of Internal Distribution in a Pellet Plasmoid by High-speed Imaging Spectroscopy ".

5) C.Suzuki (NIFS) visited Australian National University (Australia) from 27th Jan. to 3rd Feb. 2012 to join the 9th CWGM and the 18th ISHW meeting to give a presentation on the real-time magnetic coordinate mapping system in LHD.

6) H.Yamada (NIFS) visited Australian National University (and Murraramang) from 28 Jan. to 4 Feb. 2012 for Joint Stellarator-Heliotron Workshop and Asia-Pacific Plasma Theory Conference, and also to attend the 40th Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept.

7) H.Sugama (NIFS) visited Australian National University, Canberra, and Murramarang Beachfront Nature Resort, Australia from January 28th till February 4th. He participated in the 18th International Stellarator/Heliotron Workshop and the 10th Asia Pacific Plasma Theory Conference. He made a presentation entitled

“Plasma Flows and Geometric Symmetry in Toroidal Systems”.

8) G.Motojima (NIFS) visited the Australian National University, Canberra, Australia at 28 January 2012, to promote international collaborative research on pellet refueling. He had discussions in "fueling session" in the 9th CWGM.

9) T.Morisaki (NIFS) visited Australia National University from Jan. 29 to Feb. 4 to participate in the 18th International Stellarator-Heliotron Workshop.

- **Collaborations with EU**

1) H.Yamada (NIFS) visited the IAEA Headquarter (Vienna, Austria) from 8 to 13 Jan. 2012, and attended the Consultancy Meeting on Strategic issues and milestones on the way to a demonstration fusion power plant.

2) G.Kawamura (NIFS) visited Max-Plank-Institut fur Plasmaphysik (Greifswald Germany) from 15 to 27 January 2012, from 27 May to 1 June 2012 and from 28 October to 2 November 2012 for collaboration on simulation modeling of LHD SOL and divertor plasmas.

3) G.Kawamura (NIFS) visited Forschungszentrum Juelich (Juelich Germany) from 28 January to 4 February 2012 and from 21 to 27 October 2012 for collaboration on modeling of plasma-wall interactions for impurity transport simulation.

4) Colm S. Harte (University College Dublin, Ireland) visited NIFS (C. Suzuki) from 7th to 24th Feb. 2012 to make discussions on the analysis of EUV spectra from highly charged tungsten ions observed in LHD.

5) Y.Narushima (NIFS) visited CIEMAT from February 20th to 27th March, 2012 to join experiments regarding a magnet island dynamics.

6) R.Yasuhara (NIFS) visited Culham Science Center in England from 20 Feb. to 25 Feb. 2012 to discuss the international collaboration about the advanced Thomson scattering system for LHD and MAST.

7) H.Nakano visited IPP-Garching (Germany) from Feb. 27 to Mar. 31 to join experiments of RF negative ion source and measure negative ion density with the Cavity Ring Down spectroscopy.

8) H.Yamada (NIFS) visited Fusion 4 Energy (Munich), Max-Planck Institut für Plasmaphysik (Garching and Greifswald) for discussions on range of programmatic collaborations from 28 Feb. to 4 Mar., 2012.

9) Gerard O'Sullivan (University College Dublin, Ireland) will visit NIFS (C. Suzuki) from

28th Feb. to 22nd Mar. 2013 for discussions on the analysis of EUV spectra from highly charged high-Z ions observed in LHD and other light sources.

10) M.Shoji (NIFS) visited to CIEMAT in Madrid, Spain from 4th to 17th March, 2012 to attend international collaboration experiments for observation of dust trajectories released from a poloidal limiter with a fast framing camera in TJ-II.

11) N.Tamura (NIFS) visited CIEMAT from March 6th to March 15th, 2012 to join experiments regarding a nonlocal heat transport.

12) G.Motojima (NIFS) visited Max Planck Institute for Plasma Physics in Garching, Germany from 25 March to 29 March 2012 to discuss the high density H-mode plasma using pellet between Tokamak and stellarator/heliotron within a framework of Erasmus Mundus Program.

13) G.Motojima (NIFS) visited Ghent University in Belgium to give presentations of "Helical systems" and "Technology progress and physics achievements in LHD" from 29 March to 1 April 2012 within a framework of Erasmus Mundus Program.

14) H.Yamada (NIFS) visited Max-Planck Institut für Plasmaphysik (Greifswald) for IPP International Scientific Advisory Board from 1 to 6, May, 2012.

15) C.Suzuki (NIFS) visited University College Dublin (Ireland) from 9th May to 3rd Jul. 2012 for a collaborative research with Prof. O'Sullivan on the laser-produced plasma experiments using lanthanide targets and the comparative analysis of the EUV spectra both from the LHD and from the laser-produced plasmas.

16) V.Antoni and G.Serianni (Consorzio RFX, Italy) visited NIFS (K. Tsumori) from Mar. 19 to Mar. 26 2012 to discuss the benchmark test of numerical codes for secondary particle trajectory and grid heat loading.

17) G.Kawamura (NIFS) visited EUROGRESS (Aachen Germany) to attend the 20th International Conference on Plasma Surface Interactions from 20 to 25 May 2012 to give a poster presentation entitled "Kinetic effects of inclined magnetic field on physical sputtering by impurity ions".

18) M.Shoji (NIFS) attended the 20th International Conference on Plasma Surface Interactions in Aachen, Germany from 21th to 25th May, 2012 in order to give a poster presentation which title is "Effect of a baffle divertor structure on neutral hydrogen and helium transport in the Large Helical Device".

19) M.Yokoyama (NIFS) visited Max-Planck Institute for Plasma Physics (Greifswald) from 27 May. to 16 Jun. 2012 to make joint analyses on transport properties of LHD, TJ-II and W7-AS plasmas towards the joint paper for the 24th IAEA Fusion Energy

Conference. He also played a role as the co-chair for the 10th CWGM, held in Greifswald in 2-4 Jun. during his stay.

20) M.Kisaki visited Consorzio RFX (Italy) from May 28 to July 6 2012 to adopt numerical codes for secondary particle trajectory and grid heat loading to LHD-NBI.

21) S.Yoshimura (NIFS) visited Stockholm Waterfront Congress Centre, Stockholm, Sweden to attend the 39th European Physical Society Conference on Plasma Physics / 16th International Congress on Plasma Physics from 2 June to 6 June 2012. He gave a poster presentation entitled "2D measurement of field-aligned intermittent high-energy electron flux in an ECR discharge plasma".

22) S.Satake (NIFS) visited IPP-Greifswald (Germany) from 6 to 9 June 2012 to attend the 10th Coordinated Working Group Meeting (CWGM 10) and present his simulation study on the relation between poloidal flow and viscosity in LHD biasing plasma. He also visited CIEMAT (Spain) from 11 to 18 June to have a kickoff discussion about inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement among helical devices.

23) H.Sugama, T.-H.Watanabe, M.Nunami, and A.Ishizawa (NIFS) visited CIEMAT to attend the Gyrokinetic Theory Working Group Meeting from 18 June to 29 June, 2012. They presented recent theorerical and numerical simulation results on plasma flows and related turbulent transport phenomena in toroidal systems.

24) K.Ichiguchi (NIFS) visited Carlos III University (Spain) from 24 June to 1 July to discuss nonlinear MHD analysis of LHD plasmas with B.A.Carreras (BACV Solutions Inc. USA).

25) Y.Narushima (NIFS) participated 39th European Physical Society Conference on Plasma Physics held jointly with 16th International Congress on Plasma Physics in Stockholm, Sweden, 2-6 July 2012. He presented "Response of magnetic island to resonant magnetic perturbation in LHD" as a poster.

26) K.Ichiguchi (NIFS) attended 39th European Physics Society Conference on Plasma Physics & 16th International Congress on Plasma Physics, held at Stockholm Waterfront Center, (Sweden), 2-6 July 2012 to make a poster presentation entitled “MHD Simulation of Heliotron Plasma in Change of Background Field”.

27) A.Komori (NIFS) attended European Physical Society Meeting (with International Congress on Plasma Physics) (held in Stockholm) from 3 to 6, Jun., 2012.

28) T.Goto (NIFS) visited IPP Greifswald, Germany from July 5 to 8 to attend the 10th Coordinated Working Group Meeting (CWGM) and to discuss with Prof. R. Wolf about collaborative research on reactor design. He made a presentation titled "Development of System Design Code for Heliotron Reactors and Helical DEMO

Reactor FFHR-d1" in the 10th CWGM.

29) P.Veltri (Consorzio RFX, Italy) visited NIFS (M. Kisaki) from July 5 to Aug. 3 2012 to join the operation of LHD-NBI and benchmark numerical codes for secondary particle trajectory and grid heat loading.

30) M.Yokoyama (NIFS) attended the 1st meeting of the Japan-Spain joint committee on Cooperation in Science and Technology, held in Madrid in 12-13 Jul.2012, and he presented the prosperous collaborative activity on fusion science and technology between CIEMAT and NIFS.

31) Grulke (Max-Planck Institute for Plasmaphysik, Germany) visited NIFS (T. Ido and M. Tanaka) as a guest professor from 16 July to 15 October 2012 to study turbulent transport in SOL/divertor region of the LHD plasmas.

32) C.Suzuki (NIFS) visited Max-Planck Institute for Nuclear Physics and Heidelberg University (Germany) from 29th Aug. to 7th Sep. 2012 to join the 2nd IAEA Research Coordination Meeting of the Coordinated Research Project on "Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV" and the 16th International Conference on the Physics of Highly Charged Ions to give presentations on the analysis of EUV spectra from highly charged tungsten and lanthanide ions observed in LHD.

33) Gerard O'Sullivan (University College Dublin, Ireland) visited NIFS (C. Suzuki) from 1st to 2nd Oct. 2012 to make discussions on the analysis of EUV spectra from highly charged high-Z ions observed in LHD and other light sources

34) H.Yamada (NIFS) visited ITER Organization for the 13th ITER Science and Technology Advisory Committee Meeting from 24 to 26, Oct., 2012.

35) O.Kaneko (NIFS) attended ITER-BA Executive Committee Meeting (held in Belgium) from 4 to 8, Nov., 2012.

36) E.Winkler (IPP Greifswald) and M. Krychowiak (IPP Greifswald) will visit NIFS from Nov. 5 to 16 to discuss the collaboration program about development of helium beam diagnostics for the edge plasma measurements in LHD and W7-X.

37) V.Antoni and G. Serianni will visit NIFS (K. Tsumori) from Dec. 17 to Dec. 21 to discuss the benchmark test of simulation codes and experiments of negative ion beam diagnostics using the test facility in NIFS.

- **Collaborations with Russia**

1) P.Aleynikov, S.Konovalov, V.Lukash and V.D.Pustovitov (Kurchatov Institute) visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.
2) M.Goto (NIFS) attended the International Conference on Spectral-line Profiles, held in St. Petersburg in June 2012.
3) I.A. Sharov V. M. Timokhin (St. Petersburg Polytechnical University, Russia) visited NIFS (S. Sudo and N. Tamura) from October 27th to December 3rd, 2012 to study a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.
4) I.Tolistikhina (P.N. Lebeldev Physical Institute) visited NIFS on 3 Dec. 2012 on the approach from the atomic process on the research for the Tungsten impurity behavior in plasmas.

- **Collaborations with Ukraine**

1) T.Ido (NIFS) attended the international conference on plasma physics and controlled fusion and international workshop on a role of radial electric field on plasma confinement in stellarator and tokamak, held in Alushta, Ukraine from 14 to 22, September. 2012 and present the invited talk on “Characteristics of energetic-particle driven GAM in the Large Helical Device”.

2) T.Ido (NIFS) attended International Conference and School on Plasma Physics and Controlled Fusion & Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks held in Alushta, Ukraine from17 to 22 September 2012 to give an invited talk entitled “Characteristics of energetic - particle driven geodesic acoustic mode in the Large Helical Device.”

3) Beletskii Aleksey (National Science Center, Kharkov Institute of Physics and Technology) attended the 22nd International Toki Conference, held in Toki, Japan from 17 Nov. to 23 Nov. 2012 and discussed on "Electrostatic edge plasma turbulence in the Uragan-3M torsatron"

- **Collaborations with USA**

1) H.Kohno (Lehigh University) visited NIFS on 9 Feb. 2012 for making a seminar and inspecting LHD and VR systems.

2) M.Peng (Oak Ridge National Laboratory) visited NIFS from 22 to 23 Feb. 2012 to attend the ST forum.

3) (Coumbia U.)S.A.Sabbagh, (General Atomics)R.J.La Haye, N.Eidietis, E.J.Strait, R.K.Fisher, (Institute for Fusion Studies, U. Texas)R.Fitzpatrick, (MIT Plasma Science and Fusion Center)R.Granetz, (Oak Ridge National Laboratory)D.A.Spong, J.H.Harris, (Princeton University Plasma Physics Laboratory)M.Okabayashi, S.A.Lazerson, S.C.Jardin, E.Fredrickson (Princeton University)N.C.Logan, (University of Wisconsin-Madison)K.McCollam, J.Sarff visited NIFS in Mar. 2012 to

attend the ITPA MHD and Energetic Particles Topical Group Meeting.

4) M.A.Shapiro (MIT) visited NIFS on 6 Mar. 2012 for collaborative research on the improvement of transmission efficiency in the high-power mm-wave transmission line for ECH.

5) L.M.Konstantin (Univ. Wisconsin-Madison, USA) visited Kyoto University and NIFS from 18 Mar. to 31 Mar. to discuss possible future collaboration between LHD and HSX devices based on CWGM activity, and also to apply the GNET code (developed by S.Murakami, Kyoto Univ.) to HSX experimental analyses.

6) S.Ohdachi (NIFS) visited the Janella Farm at the Colorado University Boulder to inspect the bio-imaging research, from 25 Mar. to 1 Apr. 2012.

7) W.C.Horton (Institute of Fusion Studies, University of Texas at Austin) visited NIFS from 16 to 27 Apr. 2012, for collaborative research on the extended-MHD approach for Rayleigh-Taylor instability and the impurity transport simulation

8) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 24 to 28, Apr., 2012.

9) R.Yasuhara (NIFS) attended the 19th Topical conference high temperature plasma diagnostics (HTPD2012) held at Hyatt regency Monterey from May 5 to 12, 2012. He gave a presentation about the multi-pass Thomson scattering system.

10) I.Yamada (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 5 to 12 May. 2012.

11) T.Tokuzawa (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 12 May. 2012.

12) K.Okada (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 5 to 12 May. 2012.

13) Y.Nagayama (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 12 May. 2012.

14) T.Ozaki (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 13 May. 2012.

15) M.Nishiura (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 13 May. 2012.

16) C.Dong (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 13 May. 2012.

17) B.M.Idaho (Oak Ridge National Laboratory) visited NIFS on 15 May. 2012 for discussion on the US-Japan TITAN project.

18) M.Vanderlaan (National High Magnetic Field Laboratory) visited NIFS on 21 May. 2012 to inspect experimental apparatus (including LHD) at NIFS.

19) S.Usami (NIFS) attended the US-Japan workshop on magnetic reconnection, held in PPPL, from 22 to 27 May. 2012.

20) A.Komori (NIFS) visited ITER Organization to attend the 10th ITER Council (held in Washington) from 19 to 23, Jun., 2012.

21) A.Nishimura (NIFS) attended the 6th Japan-Korea-Berkley Symposium, from 27 Jun. to 3 Jul. 2012.

22) S.Sudo (NIFS) attended the meeting of the Japan-US joint committee on Cooperation in Science and Technology, held in Washington (DoE), and he presented the prosperous collaborative activity on fusion science and technology between Japan and US, from 14 to 18 Jul. 2012.

23) K.Ogawa (NIFS) visited Princeton Plasma Physics Laboratory (Dr. D. S. Darrow) from 22 July 2012 to 30 July 2012 to study the self-shadow problem of the scintillator-based lost-fast ion probe.

24) A.Sagara (NIFS) attended the 20th Topical Meeting on the Technology of Fusion Energy, held in Nashville, from 26 Aug. to 2 Sep. 2012.

25) T.Muroga (NIFS) attended the Technology of Fusion Energy 2012 (TOFE2012), held in Nashville, from 26 Aug. to 1 Sep. 2012.

26) H.Hirooka (NIFS) attended the Technology of Fusion Energy 2012 (TOFE2012), held in Nashville, from 26 Aug. to 1 Sep. 2012.

27) T.Goto (NIFS) attended the 20th ANS Topical Meeting on Technology of Fusion Energy (TOFE-20) held in Nashville, Tennessee, U.S.A. from August 28 to 31, 2012 and made a poster presentation titled "Study on start-up scenario of the LHD-type helical fusion reactor".

28) A.Sagara (NIFS) attended the 11th US-Japan HPD workshop, 24th IAEA Fusion Energy

Conference, and the 1st IAEA DEMO Program workshop, from 4 to 19 Oct. 2012.

29) T.Mito (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.

30) S.Imagawa (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.

31) Y.Hishinuma (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 12 Oct. 2012.

32) S.Morita (NIFS) stayed in Washington DC from 29th September to 6th October 2012 to attend 8th ICAMDATA conference at NIST and in San Diego from 7th to 14th October 2012 to attend 24th IAEA FEC conference.

33) C.Dong (NIFS) visited US from 29 Sep. to 15 Oct. 2012, and made an invited talk in the ICAMDATA conference (at National Institute of Standards and Technology), and the 24th IAEA Fusion Energy Conference.

34) N.Yanagi (NIFS) attended the US-Japan workshop on superconductivity and 24th IAEA Fusion Energy Conference, from 4 to 14 Oct. 2012.

35) P.Zhu (Univ. Wisconsin-Madison) visited NIFS from July 1 to Oct. 7 to develop modeling of ELM physics on benchmark between MIPS and NIMROD codes, 2fluid MHD model of kinetic ballooning, and 3D shaping effects on edge stability.

36) N.Pablant (Princeton Plasma Physics Laboratory, USA) stayed in NIFS from 24th September to 6th October 2012 to install a new X-ray detector on XICS of LHD.

37) S.Okamura (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

38) M.Kobayashi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

39) S.Sakakibara (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

40) K.Ida (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

41) K.Tanaka (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego),

from 7 to 15 Oct. 2012.

42) S.Mutoh (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

43) H.Takahashi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

44) A.Iwamoto (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

45) T.Tanaka (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

46) K.Itoh (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

47) T.Watanabe (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

48) A.Ishizawa (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

49) M.Sato (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

50) N.Nakajima (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 16 Oct. 2012.

51) S.Toda (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

52) N.Mizuguchi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

53) Y.Nakamura (NIFS) attended the Executive Committee Meeting for the TEXTOR collaboration and 24th IAEA Fusion Energy Conference, from 9 to 13 Oct. 2012.

54) Y.Todo (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particles Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.

55) Y.Suzuki (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA

Plasma Edge-Pedestal Topical Group meeting (San Diego), from 7 to 19 Oct. 2012.

56) A.Nishimura (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particle Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.

57) Y.Yoshimura (NIFS) visited San Diego, USA from 7th to 14th October 2012 to attend 24th International Atomic Energy Agency Fusion Energy Conference (IAEA FEC2012). He gave a poster presentation titled "Electron Bernstein Wave Heating and Electron Cyclotron Current Drive by Use of Upgraded ECH System in LHD".

58) H.Yamada (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 15, Oct., 2012.

59) A.Komori (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA mplementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 14, Oct., 2012.

60) O.Kaneko (NIFS) attended 24th IAEA Fusion Energy Conference (held in San Diego) from 7 to 15, Oct., 2012.

61) K.Ichiguchi (NIFS) attended 24th IAEA Fusion Energy Conference Held at Hilton San Diego Bayfront Hotel (USA), 8-13 October 2012 to make a poster presentation entitled “Multi-Scale MHD Analysis of Heliotron Plasma in Change of Background Field.

62) M.Yokoyama (NIFS) attended (as a clerk) the 41st Executive Committee meeting of the IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept on 9 Oct. 2012, held in San Diego. He also attended the 24th IAEA Fusion Energy Conference in San Diego in 8-13, Oct.2012, and presented the poster presentation with A.Dinklage (IPP) on transport model validation activity.

63) J.Miyazawa (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 10 to 20 Oct. 2012.

64) T.Muroga (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 11 to 20 Oct. 2012.

65) S.Satake (NIFS) visited University Wisconsin-Madison (USA) from 15 to 26 Oct. to promote inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement, as an activity of CWGM. He discussed with J. Talmadge applying FORTEC-3D code to analyze neoclassical transport and

viscosity in HSX and to compare with PENTA code.

66) N.Pablant (Princeton Plasma Physics Laboratory, USA) stayed in NIFS from 17th October to 15th December 2012 to join the LHD experiment and to analyze the data from XICS.

67) H.Sugama (NIFS) visited the Rhode Island Convention Center, Providence, US from October 28th to November 4th, 2012 to participate in the 54th Annual meeting of the APS Division of Plasma Physics. He made a presentation entitled "Extended gyrokinetic field theory for time-dependent magnetic confinement fields".

68) H.Tsuchiya (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

69) R.Seki (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

70) K.Nagaoka (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 2 Nov. 2012.

71) H.Miura (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

72) S.Usami (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 5 Nov. 2012.

73) H.Hasegawa (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 5 Nov. 2012.

74) H.Ohtani (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center, and US-Japan Workshop (Providence, RI) from 28 Oct. to 5 Nov. 2012.

75) S.Yoshimura (NIFS) visited Rhode Island Convention Center, Providence, RI, USA to attend the 54th Annual Meeting of the APS Division of Plasma Physics from 29 October to 2 November 2012. He gave an oral presentation entitled "Statistics of field-aligned intermittent electron flux in a linear ECR plasma".

76) Y.Narushima (NIFS) was invited to 17th workshop on MHD stability control at Columbia University, New York, NY, USA November 5-7, 2012. He presented "Flow effects on RMP field penetration in the LHD" as an invited talk.

77) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting, and for discussions on international collaboration

between NIFS and PPPL, from 6 to 10, Nov., 2012.

78) D.Nishijima (University of California, San Diego) visited NIFS from 19 to 30, Nov. 2012 for joint experiment in LHD (plasma irradiation to Tungsten material).

79) A.Kuley (University of California, Irvine) and Y.Ren (Princeton Plasma Physics Laboratory) attended the 22nd International Toki Conference in Nov. 2012.

80) W.Wang (Princeton Plasma Physics Laboratory) attended the US-Japan JIFT workshop from 24 to 27, Nov. 2012.

81) O.Sinitsyn (University of Maryland) visited NIFS from 9 to 10 Dec. 2012.

4.1.1 Plans for 2013

1) 11th CWGM will be held in CIEMAT in early 2013. Some LHD researchers are expected to participate.

2) M.Kisaki will visit Consorzio RFX (Italy) from Jan. 8 to Feb. 8 2013 to discuss results of benchmark test of simulation codes and modify the codes.

3) E.Winkler (IPP Greifswald) will visit NIFS from Feb. 1, 2013 to Jul. 31, 2014 to develop helium beam diagnostics for his Ph.D. study. We also intend to establish collaboration program between LHD and W7-X about edge and divertor physics.

4) T.Morisaki (NIFS) will visit Forschungszentrum Juelich GmbH (Juelich Germany) from Mar. 18 to 21 to participate in the 6th International Workshop on Stochasticity in Fusion Plasmas.

5) G.Kawamura (NIFS) will visit Cracow (Poland) from 22 to 26 September to attend the 14th International Workshop on Plasma Edge Theory in Fusion Devices.

6) T.Oishi (NIFS) will visit MIT Plasma Science and Fusion Center (Massachusetts, U.S.) on May 2013 for collaboration on impurity transport study based on experimental data of X-ray imaging crystal spectroscopy in Alcator C-Mod tokamak and LHD.

7) G.Kawamura (NIFS) will visit Forschungszentrum Juelich (Juelich Germany) for collaboration on modeling of plasma-wall interactions for impurity transport simulation.

8) G.Kawamura (NIFS) will visit Max-Plank-Institut fur Plasmaphysik (Greifswald Germany) for collaboration on simulation modeling of LHD SOL and divertor plasmas.

4.2 International collaborations by the Heliotron J team at Kyoto University

- Collaborations with Australia

1) Discussions with H-1 team (ANU) were kept along the same line as in 2012.

- Collaborations with EU

1) D. Pretty (Researcher, Australian National University) visited Kyoto University from Feb. 8 to Feb. 19, 2012. Concerning the application of data mining technique to MHD datasets of Heliotron J plasmas, he tried to apply a new clustering method "stream clustering algorithm (SWM11)" which has been successfully applied to the datasets of H1-NF. He also discussed the MHD database to get a unified knowledge of MHD stability in stellarator/heliotron devices based on CWGM activity.

2) S. Yamamoto visited CIEMAT from March 11 to March 18, 2012. He joined the TJ-II experiment to investigate the characteristics of energetic-ion-driven MHD instabilities such as Alfvén eigenmodes (AEs) in low magnetic shear stellarator/heliotron plasmas. He focused on the iota dependence of AE and the effect of AE on energetic ion transport. He obtained the iota dependence of AE using by the iota scan experiment where the iota was varied dynamically and shot by shot in TJ-II.

3) A. Alonso (Researcher, CIEMAT) visited Kyoto University from March 4 to 10, 2012. He joined a bias experiment in Heliotron J, which is a collaboration research program among Tohoku University, NIFS and Kyoto University, to investigate the influence of poloidal viscosity on transition phenomenon. He has an experience of the similar experiment in TJ-II Stellarator and made contribution to the experiment in Kyoto.

4) K. Mukai (PhD student, Kyoto University) visited CIEMAT from March 11 to March 18, 2012. He joined TJ-II experiments and had a collaboration work related to a reflectometer system for measurement of electron density profile and electron density fluctuation with T. Estrada. He estimated the radial electric field from Doppler shift of the frequency spectra.

5) S. Ohshima visited Stuttgart University from on March 17 to 31, 2012. He had a discussion with Dr. M. Ramisch for the activity of turbulence database on the framework of coordinated working group meeting (CWGM) for Stellarator/Heliotron Studies. They exchanged the information of turbulence study in Hliotron J and TJ-K device and shared the information of current status and problems of the turbulence database. They also agreed to continue to collaborate and keep in close touch with

each other for this activity.

6) S. Yamamoto visited IPP, Greifswald from May 5 to May 9, 2012. He joined 10^{th} coordinated working group meeting (CWGM) and made a presentation about possibilities for joint experiment at Heliotron J including present status and plan, and present status of energetic particle session in CWGM. In the introduction of joint experiment at Heliotron J, he mainly introduced on-going international research collaborations including the topics of ECCD collaborating with IPP and Edge fluctuation collaborating with Stuttgart University.

7) S. Yamamoto visited CIEMAT from May 10 to May 24, 2012. He mainly analysed and discussed the iota dependence of AEs in low magnetic shear stellarator/heliotron plasma in TJ-II. In order to identify and clarify the characteristics of observed AEs, he compared the experimental results such as mode frequency and position with shear Alfven spectra where he considered the effect of three-dimensional magnetic field in TJ-II. From the results from TJ-II and Heliotron J, he concluded that global AEs (GAEs) are mainly observed in low magnetic shear helical plasmas and helicity-induced AEs (HAEs) are also destabilized in the case of high iota configuration.

8) K. Nagasaki had a collaboration research on ECH/ECCD physics with N. Marushchenko (IPP, Greifswald). They developed a ray tracing calculation code “TRAVIS” for the Heliotron J device to calculate the EC power deposition and EC driven current efficiency. The TRAVIS data was used for stabilization experiments of energetic-ion-driven MHD instabilities by ECCD. The results were presented in 24^{th} IAEA Fusion Energy Conference held in San Diego, USA.

9) Discussions with W7 team (IPP) were kept along the same line as in 2012.

10) Collaborations with CIEMAT were continued along the same lines as in 2012.

- **Collaborations with Russia**

1) Discussions with Kurchatov Institute related to development of advanced stellarator/heliotron systems were kept along the same line as in 2011.

- **Collaborations with Ukraine**

1) Discussions with Kharkov team about the collaboration in U-2M project were kept along the same line as in 2011.

- **Collaborations with USA**

1) F. Volpe (Assistant Professor, Columbia University) visited Kyoto Univ. from June 1 to Sep. 4, 2012 as a guest professor of Institute of Advanced Energy. He joined the Heliotron J experiment, especially electron cyclotron current drive experiment for Alfven Eigenmode stabilization. He also developed a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas. He also took a lecture on wave physics to graduate students in a summer school.

2) G. Weir (Ph. D. student, Univ. Wisconsin) visited Kyoto Univ. from July 7 to July 21, 2012. He joined the Heliotron J experiment, and learned a calibration method for multi-channel radiometer for electron temperature measurement. He obtained electron temperature profiles in ECH plasmas by using the calibration data.

3) Discussions with the HSX (Wisconsin Univ.) team and CTH (Auburn Univ.) team, groups of ORNL and PPPL, etc.) were kept along the same line as in 2012.

- **Others**

1) F. Sano, T. Mizuuchi, K. Nagasaki and H. Okada attended 18^{th} International Stellarator/Heliotron Workshop & 10^{th} Asia-Pacific Plasma Theory Conference, which was held in Australian National University, Canberra and Murramarang Resort, NSW, on Jan. 29 – Feb. 3.

2) New gas fuelling by supersonic molecular beam injection (SMBI) was successfully applied to ECH/NBI plasma in Heliotron J. The collaboration of fuelling control studies are being discussed with TJ-II team and NIFS.

3) Advanced ECH scenarios including ECCD and EBW heating/current drive were examined through Heliotron J/LHD experiments. Temperature measurement in over-dense plasmas using 35GHz EBW diagnostics was also discussed.

4.2.1 Plans for 2013

1) Plasma fluctuations and structural formation at core and edge regions will be measured with using diagnostics including a beam emission spectrometer, a reflectometer, SX array, Langmuir probes and fast CCD cameras under collaboration with CIEMAT. IPP and Stuttgart University and domestic universities.

2) Confinement improvement of particle, momentum and energy, especially the role of toroidal and poloidal rotation, will be investigated by controlling particle fuelling method and magnetic field configuration under collaboration with Kharkov Institute and CIEMAT.

3) Confinement control of high-energy particles by using the optimized field configuration based on the quasi-isodynamic concept will be examined through Heliotron J NBI/ICRF experiments.

4) MHD instabilities such as interchange instabilities and Alfven Eigenmode instabilities in low-magnetic shear configurations will be studied from the viewpoint of magnetic island control and suppression of energetic-ion loss under collaboration with CIEMAT and IPP.

5) NBI startup using a 2.45GHz microwaves will be performed for high-beta experiments and physics study of plasma production under collaboration with IPP.

6) ECCD experiments using 2^{nd} harmonic 70GHz X-mode will be performed for control of MHD instabilities through rotational transform modification under collaboration with IPP and NIFS.

7) Electron Bernstein heating/current drive and Electron Bernstein emission diagnostics are prepared for overdense plasma heating and electron temperature profile measurement under collaboration with IPP and Columbia University.

8) Particle and heat transport control of edge plasmas will be investigated with regard to divertor optimization.

9) Kyoto University plans to transfer Varian gyrotrons and related components to Oak Ridge National Laboratory.

10) Kyoto University and NIFS made an application of Joint research projects related to ECRH and ECCD physics and technology between Germany and Japan to Japan Society for the Promotion of Science. If approved, personal exchange including researchers and students will be performed.

11) B. Blackwell (Australian National University) plans to visit Kyoto Univ. on December 2012 for collaboration research on MHD mode analysis in H-1 and Heliotron J.

12) S. Darrow (PPPL) plans to visit Kyoto Univ. in 2013 for collaboration research on lost-ion probe diagnostic.

5 RUSSIA

5.1 International Collaboration in 2012

1) K. Dyabilin (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 26.02.2012

2) M. Isaev (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 11.02.2012

3) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 27.02. – 26.04.2012

4) T. Richert, J. Baldzuhn (IPP Greifswald) and T. Franke (IPP Garching) visited

   Budker Institute Novosibirsk,16.06. – 20.06.2012

5) T. Richert (IPP Greifswald) visited Budker Institute Novosibirsk 11.09. – 27.09.2012

6) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 22.10. – 14.12.2012

7) N. Marushchenko (IPP Greifswald) visited IOFFE Institute St. Petersburg, 30.10. – 02.11.2012

8) A. Melnikov and L. Eliseev and members of the HIBP Kurchatov Institute team were visiting CIEMAT to investigate the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements with two slit HIBP detector. The second HIBP system has been built for long-range (zonal flows) correlation studies and the commissioning is planned for beginning 2013.

9) Collaboration with General Physics Institute, Moscow on the characterization of the plasma reflected power on gyrotron performance. This includes preparation and installation of experimental systems in TJ-II, participation in experiments and

analysis of the results. The visiting scientists of GPI involved have been: D. Malakhov (19 March-19 April and 23 October-22 December), Y. Bondar (19 March-19 April), N. Kharchev (26 April-26 May and 27 September-26 October), V. Borzosekov (26 April-26 May), E. Konchekov (27 September-26 October), K. Sarksyan (2 -16 October)

10) P.Aleynikov, S.Konovalov, V.Lukash and V.D.Pustovitov (Kurchatov Institute) visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.

11) M.Goto (NIFS) attended the International Conference on Spectral-line Profiles, held in St. Petersburg in June 2012.

12) I.A. Sharov V. M. Timokhin (St. Petersburg Polytechnical University, Russia) visited NIFS (S. Sudo and N. Tamura) from October 27th to December 3rd, 2012 to study a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.

13) I.Tolistikhina (P.N. Lebeldev Physical Institute) visited NIFS on 3 Dec. 2012 on the approach from the atomic process on the research for the Tungsten impurity behavior in plasmas.

14) Discussions between Kurchatov Institute and Kyoto University related to development of advanced stellarator/heliotron systems were kept along the same line as in 2011.

5.2 Plans for 2013

1) Continuation of the collaboration between General Physics Institute, Moscow (K. Sarksyan, N. Kharchev and GPI Team) and CIEMAT on the characterization of the plasma reflected power on gyrotron performance.

2) S. Pavlov (Kharkov Institute of Ukraine) will visit CIEMAT to work on ECRH theory.

3) S. Petrov and V Nesenevich (IOFFE) will visit CIEMAT to participate on charge exchange spectrometry measurements.

4) A. Melnikov and L. Eliseev and members of the HIBP Kurchatov Institute team will visit CIEMAT to investigate the structure of plasma potential in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements using two HIBP systems for zonal flows experiments in the core plasma region.

6 UKRAINE

6.1 Institute of Plasma Physics of the National Science Center “Kharkov Institute of Physics and Technology” of the NAS of Ukraine (IPP NSC KIPT, NASU)

6.1.1 International collaborations of the NSC KIPT in 2012

- Collaboration with Technische universität Graz, Austria

V.V. Nemov, S.V. Kasilov, and V.N. Kalyuzhnyj in cooperation with W. Kernbichler, M. Heyn (Association EURATOM-ÖAW, Institut für Theoretische Physik - Computational Physics, TU Graz, Petersgasse 16, A–8010 Graz, Austria) and J. Talmadge (University of Wisconsin-Madison, USA) fulfill calculations of collisionless α -particle losses for quasi-helically symmetric (QHS) toroidal stellarators in real space coordinates. The results show that the collisionless α -particle losses for QHS are negligible for particles started at r/a ≈ 0.25. For particles started at r/a ≈ 0.5 roughly a quarter would be lost. This is in agreement with the corresponding results in [W. Lotz, P. Merkel, J. Nührenberg, E. Strumberger, Plasma Phys. Control. Fusion, 34, 1037 (1992)] for r/a ≈ 0.25 and somewhat exceeds those results for r/a ≈ 0.5. For HSX device the particle losses are essentially larger than for QHS. The reason is connected with the presence of additional small magnetic field ripples in HSX. The amplitude of these ripples can be decreased by increasing the number of twisted coils. For such a system with 96 coils instead of 48 coils, the particle losses are decreased to a level comparable to that in QHS.

- Collaborations with Sweden

V.E. Moiseenko will continue the collaboration with O. Agren from Uppsala University on theoretical studies on fission-fusion hybrids.

- Collaborations with Max-Planck-Institut für Plasmaphysik, EURATOM Association, Garching, Germany

V.S. Voitsenya et al. (IPP NSC KIPT) in collaboration with Dr. M. Balden (IPP, Garching, Germany) suggested new model for development of relief on the surface of polycrystalline metal due to long term sputtering.

The results are reported at the International Conference on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine):

1) V.S. Voitsenya, M. Balden, A.F. Bardamid, V.N. Bondarenko, J.W. Davis, V.G. Konovalov, I.V. Ryzhkov, O.O. Skoryk, S.I. Solodovchenko, Zhou Zhang-jian. Development of surface relief on polycrystalline metals due to sputtering.

- Collaborations with Department of Physics, University of Basel, Switzerland

V.S. Voitsenya et al. (IPP NSC KIPT) in collaboration with Dr. B. Eren and Dr. L. Marot (Department of Physics, University of Basel) studied the role of temperature in blistering of Mo film mirrors under exposure to ions of deuterium plasma.

The results are reported at the International Conference on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine): S.I. Solodovchenko, B. Eren, V.G. Konovalov, L. Marot, I.V. Ryzhkov, A.N. Shapoval, A.F. Shtan', O.O. Skoryk, V.S. Voitsenya. Temperature effects on behavior of Mo film mirrors under impact of deuterium plasma ions.

- Collaboration with CIEMAT, Madrid, Spain

Dr. L.I.Krupnik et al (IPP NSC KIPT) in collaboration with Dr. C. Hidalgo and TJ-II team (CIEMAT).

1) The first Heavy Ion Beam Probe system was upgraded to perform measurements of the electric fields and transport flows on TJ-II:
   - development and tuning new control and data acquisition systems
   - fully inspection of the vacuum system.
   - new Cs emitter installation and tuning focusing system of the injector.

2) Providing the experiments with upgraded first HIBP diagnostic of the TJ-II Stellarator. Iinvestigation of the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (inwith Lithium coated walls) and measurements with two slit HIBP detector. To start the related to the physical understanding of fluctuation induced transport in core and edge of plasma confinement volume.

3) Installation of the full parts of hardware (Injector and Detection systems) for second Heavy Ion Beam Probe diagnostic system on TJ-II stellarators. Testing of the second Injector.

- Collaboration with Kurchatov Institute, Moscow, Russia

Dr. L.I.Krupnik and HIBP team (IPP NSC KIPT) in collaboration with Dr. A.V.Melnikov and T-10 team (Kurchatov Institute)).

1) Installation and tuning new modification of the multi-sleet energy analyzer.

2) Investigations of the behavior of plasma potential and fluctuations by upgraded HIBP system in regimes with high plasma density. Comparative study of the GAMs (and AEs) behavior in the T-10 tokamak and TJ-II stellarator during ECR heating with high intensity heavy ion probing beam.

3) Providing the experiments directed to investigations of the Geodesic Acoustic modes and their features in the OH and ECRH regimes.

- Conference participation

1) V.E. Moiseenko: Conference on Plasma Physics and Controlled Fusion, Zvenigorod (Moscow reg.), Russia, February 6—10, 2012.

2) V.E. Moiseenko: Meeting on and technical aspects of volume sources of neutrons for materials science, technology research and problem solving for nuclear energy (VNS-5) Zvenigorod (Moscow reg.), Russia, June 4—8, 2012.

3) V.E. Moiseenko: International Conference on Open Magnetic Systems for Plasma Confinement (OS2012) and the International Workshop on Plasma Material Interaction Facilities for Fusion (PMIF), Tsukuba, Japan, August 27-31, 2012.

4) V.E. Moiseenko: First RCM of IAEA CRP F1.3015: Conceptual Development of Steady-State Compact Fusion Neutron Sources, IAEA, Vienna, 14-16 November, 2012.

5) 31 representatives of the Institute of Plasma Physics of NSC KIPT took part in the International Conference and school on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine).
12 presentations at the Conference were prepared in cooperation with co-authors from abroad: Sweden, Switzerland, Germany, Canada, China, Russia, and Spain.
6) A. Beletskii participated in the 22nd Toki Conference (Toki, Japan, Nov. 19-22, 2012).
7) A. Kasilov and V. Filiipov took part in Joint Experiment at the tokamak COMPASS in the Institute of Plasma Physics, Prague, Czech Republic (10-14 Sept. 2012) and in the COMPASS Programmatic Conference (17-18 Sept. 2012).

8) L.I. Krupnik ISHW/APPTC Conference, Australia 31.1-4.2 2012.

9) L.I. Krupnik, A.D. Komarov: EFTSOMP2010 - 14th Workshop on Electric Fields, Turbulence and Self-Organization in Magnetized Plasmas, Satellite meeting of the 39th EPS Plasma Physics Conference, Stockholm, Sweden, July 9 –10, 2012.

10) L.I. Krupnik, A.I. Zhezhera, G.N. Dezhko: International Conference and School on Plasma Physics and Controlled Fusion, Alushta (Crimea, Ukraine), September 22-27, 2012.

6.1.2 Plans for 2013 of the IPP NSC KIPT

- Collaborations with Sweden

V.E. Moiseenko will continue the collaboration with O. Agen from Uppsala University

- Collaboration with Spain (CIEMAT, Madrid)

1) Upgrade of the control and data acquisition system of the first HIBP equipment on TJ-II.
2) Tuning and start experiment of the second HIBP system. Possibilities of this system was significantly expanded. Injector system with new extraction and focusing systems significantly improved the primary beam parameters: the intensity, stabilisation and focusing. In registration system of the secondary beam there was used two electrostatic energy analyzers. As a result, this year on the TJ-II will be used for plasma investigation two separate HIBP diagnostic systems disposed on 90° along the torus.

3) Study of the plasma potential and electron density during ECR and NBI heating in different magnetic configurations and regimes of device operation. Study of the plasma potential evolution and its fluctuations (Alfven and non-Alfven modes) in two cross-sections of plasma column in combined NBI/ECRH plasmas by two HIBP systems on TJ-II stellarator.

- **Collaboration with Russian Kurchatov Institute, Moscow**

1) Upgrade of the Thallium ion source on the tokamak T-10;

2) Study of the plasma potential and density and their fluctuations by upgraded HIBP system in regimes with high plasma density. Comparative study of the GAMs (and AEs) behavior in the T-10 tokamak and TJ-II stellarator during ECR heating with high intensity heavy ion probing beam.

- **Collaboration with Ioffe Institute of Physics and Technology, St Petersburg, Russia**

1) Upgrade of the secondary beam-line of HIBP diagnostic on TUMAN-3M tokamak.

2) Investigation of the electric field evolution and density and their fluctuations with NBI heating in various operational modes in the TUMAN-3M tokamak

- **Collaboration with Plasma Physics Laboratory, University of Saskatchewan, Canada**

Comparative study of the SXR emissivity behavior and its fluctuations in STOR-M tokamak and URAGAN-3M stellarator.

6.1.3 The tasks to be solved at IPP NSC KIPT in 2013

1) Final adjustments of HIBP diagnostic system installed on Uragan-2M stellarator.
2) Installation at U-3M of limiter for three-half-turn RF antenna.
3) Providing boronization procedure at U-2M torsatron.
4) Investigation of the processes in divertor of the Uragan-3M torsatron accompanying H-like mode transition.
5) Development and assembling of a RF generator with pulsed power up to 1 MW and pulse time duration up to 0.1 s for operation at Uragan-2M torsatron.
6) Investigation of the nature and behavior of high energy particles in Uragan-3M plasma.
7) Investigations on development of RF wall conditioning in Uragan-2M.
8) Further development of the concept of the stellarator-mirror hybrid.
9) Experiments on RF plasma production and heating in Uragan-2M stellarator in the regime of the Alfven resonances excitation.
10) Development of microwave plasma diagnostics for U-3M plasmas (two-polarized interferometer) and for U-2M plasmas (multi-frequency reflectometry).
11) Comparative investigations of different methods of gas puffing into RF-discharge plasma in U-3M torsatron.
12) Investigation of MHD fluctuations in the RF-produced plasmas in U-3M torsatron.
13) Investigation of parametric instability at the plasma periphery.

6.2 V.N.Karazin Kharkiv National University, Kharkiv

6.2.1 Collaborations with Institute of Physics, Ernst-Moritz-Arndt University,

Greifswald, Germany

1) Rough surface sputtering. This year, the investigation the erosion of rough surface under ion beam bombardment has been continued. The total erosion yield of the Si pitch grating exposed to 6 keV Ar ion beam has been measured using Rutherford back-scattering analysis and these experimental data have been compared to results of the simulation using SDTrimSP-2D code. The numerical simulations show reasonable agreement with experimental results.

The new area of investigation has been entered with development of the steady-state high-flux Falcon ion source. This ion source is a versatile, compact, affordable, and highly functional in the research field of the fusion materials. The reversed magnetic field configuration of the source allows precise focusing of the ion beam into small spot of ≈3 mm and also provides the limited capabilities for impurity mass-separation. As the result, the source generates steady-state ion beam, which irradiates surface with high heat (0.3 – 21 MW m−2) and particle fluxes (4 × 1021 – 3 × 1023 m−2s−1), which approaches the upper limit for the flux range expected in ITER.

The results of this research were published:

1) Bizyukov I., Mutzke A., Mayer M., Langhuth H., Krieger K., Schneider R. Macroscopic parameters of the interaction of an Ar+ ion beam with a Si pitch grating// Nuclear Instruments and Methods in Physics Research, vol. B 278, pp. 4–7 (2012)
2) Girka O., Bizyukov I., Sereda K., Bizyukov A., Gutkin M., and Sleptsov V. Compact steady-state and high-flux Falcon ion source for tests of plasma-facing materials// Review Scientific Instruments, vol. 83, 083501 (2012)

- **Collaborations with National Institute for Fusion Science, Toki, Japan**

2) Minority ^{3}He heating in D-^{3}He fusion plasma. The numerical simulation of possibility of fusion reactivity enhancement due to ^{3}He minority ICRF heating in D-^{3}He fusion plasma is investigated analytically and numerically. The non-Maxwellian shape of the ^{3}He distribution function plays the key role for reactivity enhancement.

The modified values for reactivity rates were calculated basing on the distribution function profiles for different RF heating scenarios. It is calculated that the formation of the energetic tail due to RF heating is followed by significant reactivity increasing. We improve the statistic by increasing the number of test particles in numerical model.

The results of the research were presented on the conferences:

1) Shyshkin O.A., Moskvitin A.O., Moskvitina Yu.K. Modification of 3He minority distribution function in D plasma due to ICRF minority selective heating in ITER like toroidal configuration: Numerical simulations // International Conference – School on Plasma Physics and Controlled Fusion, Ukraine, Alushta (Crimea), September 17-22. P1-28. (2012)

2) Shyshkin O., Moskvitina Y., Moskvitin A., Yanagi N., Sagara A. Numerical Simulations for Fusion Reactivity Enhancement in D-3He and D-T Plasmas due to 3He and T Minorities Heating // 24th IAEA Fusion Energy Conference, USA, San Diego, October 8-13. – 2012. – TH/P6-28. (2012)

- **Collaborations with Pusan National University, Busan, South Korea**

3) Kinetic theory of the hydrodynamic instabilities in an edge plasma. Development of the non-modal kinetic theory of the hydrodynamic instabilities of the drift type of the poloidal plasma shear flow of the edge plasmas. The non-modal kinetic theory of the kinetic drift instability of plasma shear flows [Mikhailenko V.S., Mikhailenko V.V., Stepanov K.N., Phys. Plasmas, 18, 062103 (2011)] is extended to the investigation of the long-time evolution of the hydrodynamic ion temperature gradient and resistive drift instabilities in plasma shear flow. It was obtained, that in spite of their hydrodynamic nature, these instabilities in shear flow at the times of the order of the inverse velocity shearing rate pass through the same linear non-modal kinetic processes of their evolution, as the kinetic drift instability. These processes reveal in the non-modal decrease with time the frequency and the growth rate of the unstable perturbations and display the universality in the linear description of the temporal evolution of the electrostatic drift instabilities of shear flows.

The comprehensive analytical and numerical investigations of the drift instabilities of the magnetic field aligned shear flow with inhomogeneous ion temperature. New combined shear-flow-ion-temperature-gradient driven instability is discovered, which is developed, when both factors (velocity shear and ion temperature gradient) are present. The couple action of these factors, which appear to be strongly mutually enhancing in their action in the development of the instability, reveals in the development of the instability at the conditions of far edge and SOL plasma. The development of these instability resulted in the anomalous heating of ions in these regions.

Development of the methodology of the investigations of the spatially bounded shear flows with applications to edge layers of magnetized fusion plasmas. For the first time the methodology of the shearing modes was developed for the investigations of the bounded shear flow and applied to the investigations of the diocotron instability for plane and cylindrical geometry.

The results of this research were reported on the Conferences:

1) Mikhailenko V.S., Mikhailenko V.V. Magnetized plasma in strong electric field: from parametric turbulence to enhanced confinement// International Conference and School on Plasma Physics and Controlled Fusion Alushta (Crimea), Ukraine, September 17-22, 2012
2) Mikhailenko V.V., Lee H.J., Mikhailenko V.S., Koepke M.E. Drift and ion sound instabilities of the magnetic field aligned shear flow with inhomogeneous ion temperature// 54th Annual Meeting of the American Physical Society Division of Plasma Physics, Providence, Rhode Island, USA, October 29 - November 2, 2012
3) Mikhailenko V.V., Lee H.J., Mikhailenko V.S., Non-modal analysis of the diocotron instability// 22-nd International Toki Conference, Toki, Japan, November 19-22, 2012

The results of this research were published:

4) Mikhailenko V.V., Lee H.J., Mikhailenko V.S. Non-modal analysis of the diocotron instability: Plane geometry// Physics of Plasmas, vol. 19, 082112 (8 pages) (2012)
5) Mikhailenko V.V., Mikhailenko V.S., Lee H.J. Non-modal kinetic theory of the hydrodynamic drift instabilities of plasma shear flows// submitted to Nuclear Fusion (2012)

6.2.2 Research within the University

Ion beam interaction with composite structures

Comprehensive studies are continued of the interaction of ion beams with composite structures: the getter alloy ZrV, sapphire, yttrium iron garnet, as well as samples as witnesses for studies: sandwich-layers coverings (Cu sub layer, ≈ 10 μm.)
The following ion beams are used: H^+, H_2^+, D^+, D_2^+, He^+. Range of energies of primary ions beam is: 0.5 - 10 keV. Fluences are applied: 10^{16} - 10^{18} cm^{-2}.
The following studies are carried out:
- Determination of coefficients of ions trapping (Mass-Spectrometry of Thermal Desorption) by the samples after fixed fluencies cumulating.
- Ion-photon emission (IPE) of sputtered particles during the samples irradiation.

- Changing of the composition of secondary ions (Secondary Ions Mass-Spectrometry) sputtered from the surface of the samples at cumulating of fluencies of primary ions with various chemical specifics.
- Surface topography during the accumulation of different fluencies of ions with various chemical specifics.
- Structural-phase transformations of a near-surface zone of a sample at the ion irradiation.

The results are reported at the XX International Conference on Physics Radiation Phenomena and Radiation Materials Science, September 2012, Alushta, Ukraine:
1) Bobkov V.V., Starovoitov R.I., Tishchenko L.P., Kovtunenko Yu.I. Studies of accumulation and release of deuterium and helium in composite structures with Tungsten coatings.
2) Afanasyeva I.A., Bobkov V.V., Gritsyna V.V., Ryzhov D.A., Shevchenko D.I. Effect of surface modification of sapphire under ion irradiation on the yield of excited particles.

The results are published:
1) Bobkov V.V., Afanas'eva I.A., Gritsyna V.V., Gritsyna V.T., Ryzhov D.A., Shevchenko D.I. Characteristic features of ion-photon emission from yttrium-iron garnets // Vacuum, vol. 86, pp. 1624-1629 (2012).
2) Litvinov V.A., Koppe V.T., Bobkov V.V. The study of the initial stages of hydrogenation getter alloy based zirconium by SIMS // Izvestiya RAS, series Phys., vol. 76, № 5, pp. 668 – 673 (2012).

7 UNITED STATES

7.1 International collaboration in 2012

- Collaborations with Australia

1) ORNL (R. Goulding, J. Harris and P. Krstic) and ANU: development of the Materials Diagnostic Facility Prototype and ANU, and proposals for collaborative grants.

2) PPPL, DIIID and ANU – The effect of 3D magnetic perturbations on the edge plasma.

3) B. Breizman (Univ. of Texas, Austin), G. Chen (ORNL) and ANU: in helicon waves with the electromagnetic wave code EMS, as well as the formation of gaps and gap modes in a periodic linear machine.

- Collaborations with Germany (IPP, Greifswald)

1) P. Helander (IPP Greifswald) visited MIT Boston, 09.01. – 13.01.2012

2) O. Grulke (IPP Greifswald) visited PSFC/MIT, Boston, 04.02. – 13.02.2012

3) X. Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 18.02.-18.03.2012

4) O. Grulke, T. Klinger (IPP Greifswald) to Kick-off-Meeting MPRC Princeton, 27.03. – 30.03.2012

5) P. Helander (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 27.03. – 31.03.2012

6) G. Wurden (Los Alamos Energy Sciences, Los Alamos) to IPP, 20.05.-02.06.2012

7) J. Harris, D. Gates (Princeton Plasma Physics Laboratory, Princeton) to IPP Greifswald, 08.07. – 20.07.2012

8) A. Bader (University of Wisconsin) to IPP Greifswald, 29.07. – 10.08.2012

9) D. Mikkelsen (Princeton Plasma Physics Laboratory) to IPP Greifswald, 12.09. – 22.09.2012

10) H. Smith (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 14.10. – 27.10.2012

11) T. Sunn Pedersen (IPP Greifswald) visited Columbia University, New York, 02.11. - 06.11.2012

12) X. Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 01.12. - 15.12.2012

- **Collaborations with Spain (CIEMAT, Madrid)**

1) E.Hollmann (USCD) visited CIEMAT (1 week, June 2012) working on parallel / radial impurity transport studies.

2) K.McCarthy (CIEMAT) visited Oak Ridge National Laboratory (1 week, March 2012) for testing the TJ-II pellet injector, which was shipped to Ciemat in August 2012.

3) I.Calvo spent the month of September, 2012 at MIT to work on gyrokinetic theory.

4) E.R.Solano spent January 2012 in San Diego (DIII-D) to work on MHD dynamics and transport barriers.

5) F.Tabarés visited PPPL to discuss plasma-wall issues on Li coating.

- **Collaborations with Japan (NIFS and Kyoto University)**

1) H.Kohno (Lehigh University) visited NIFS on 9 Feb. 2012 for making a seminar and inspecting LHD and VR systems.

2) M.Peng (Oak Ridge National Laboratory) visited NIFS from 22 to 23 Feb. 2012 to attend the ST forum.

3) (Coumbia U.)S.A.Sabbagh, (General Atomics)R.J.La Haye, N.Eidietis, E.J.Strait, R.K.Fisher, (Institute for Fusion Studies, U. Texas)R.Fitzpatrick, (MIT Plasma Science and Fusion Center)R.Granetz, (Oak Ridge National Laboratory)D.A.Spong, J.H.Harris, (Princeton University Plasma Physics Laboratory)M.Okabayashi, S.A.Lazerson, S.C.Jardin, E.Fredrickson (Princeton University)N.C.Logan, (University of Wisconsin-Madison)K.McCollam, J.Sarff visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.

4) M.A.Shapiro (MIT) visited NIFS on 6 Mar. 2012 for collaborative research on the improvement of transmission efficiency in the high-power mm-wave transmission line for ECH.

5) L.M.Konstantin (Univ. Wisconsin-Madison, USA) visited Kyoto University and NIFS from 18 Mar. to 31 Mar. to discuss possible future collaboration between LHD and HSX devices based on CWGM activity, and also to apply the GNET code (developed by S.Murakami, Kyoto Univ.) to HSX experimental analyses.

6) S.Ohdachi (NIFS) visited the Janella Farm at the Colorado University Boulder to inspect the bio-imaging research, from 25 Mar. to 1 Apr. 2012.

7) W.C.Horton (Institute of Fusion Studies, University of Texas at Austin) visited NIFS from 16 to 27 Apr. 2012, for collaborative research on the extended-MHD approach for Rayleigh-Taylor instability and the impurity transport simulation

8) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 24 to 28, Apr., 2012.

9) R.Yasuhara (NIFS) attended the 19th Topical conference high temperature plasma diagnostics (HTPD2012) held at Hyatt regency Monterey from May 5 to 12, 2012. He gave a presentation about the multi-pass Thomson scattering system.

10) I.Yamada (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 5 to 12 May. 2012.

11) T.Tokuzawa (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 12 May. 2012.

12) K.Okada (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 5 to 12 May. 2012.

13) Y.Nagayama (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 12 May. 2012.

14) T.Ozaki (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 13 May. 2012.

15) M.Nishiura (NIFS) attended the 19th High Temperature Plasma Diagnostics held at University of California, Monterey, from 6 to 13 May. 2012.

16) C.Dong (NIFS) attended the 19th High Temperature Plasma Diagnostics held at

University of California, Monterey, from 6 to 13 May. 2012.

17) B.M.Idaho (Oak Ridge National Laboratory) visited NIFS on 15 May. 2012 for discussion on the US-Japan TITAN project.

18) M.Vanderlaan (National High Magnetic Field Laboratory) visited NIFS on 21 May. 2012 to inspect experimental apparatus (including LHD) at NIFS.

19) S.Usami (NIFS) attended the US-Japan workshop on magnetic reconnection, held in PPPL, from 22 to 27 May. 2012.

20) A.Komori (NIFS) visited ITER Organization to attend the 10th ITER Council (held in Washington) from 19 to 23, Jun., 2012.

21) A.Nishimura (NIFS) attended the 6th Japan-Korea-Berkley Symposium, from 27 Jun. to 3 Jul. 2012.

22) S.Sudo (NIFS) attended the meeting of the Japan-US joint committee on Cooperation in Science and Technology, held in Washington (DoE), and he presented the prosperous collaborative activity on fusion science and technology between Japan and US, from 14 to 18 Jul. 2012.

23) K.Ogawa (NIFS) visited Princeton Plasma Physics Laboratory (Dr. D. S. Darrow) from 22 July 2012 to 30 July 2012 to study the self-shadow problem of the scintillator-based lost-fast ion probe.

24) A.Sagara (NIFS) attended the 20th Topical Meeting on the Technology of Fusion Energy, held in Nashville, from 26 Aug. to 2 Sep. 2012.

25) T.Muroga (NIFS) attended the Technology of Fusion Energy 2012 (TOFE2012), held in Nashville, from 26 Aug. to 1 Sep. 2012.

26) H.Hirooka (NIFS) attended the Technology of Fusion Energy 2012 (TOFE2012), held in Nashville, from 26 Aug. to 1 Sep. 2012.

27) T.Goto (NIFS) attended the 20th ANS Topical Meeting on Technology of Fusion Energy (TOFE-20) held in Nashville, Tennessee, U.S.A. from August 28 to 31, 2012 and made a poster presentation titled "Study on start-up scenario of the LHD-type helical fusion reactor".

28) A.Sagara (NIFS) attended the 11th US-Japan HPD workshop, 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 4 to 19 Oct. 2012.

29) T.Mito (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.

30) S.Imagawa (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.

31) Y.Hishinuma (NIFS) attended the Applied Superconducting Conference 2012, held in

Oregon, from 7 to 12 Oct. 2012.

32) S.Morita (NIFS) stayed in Washington DC from 29th September to 6th October 2012 to attend 8th ICAMDATA conference at NIST and in San Diego from 7th to 14th October 2012 to attend 24th IAEA FEC conference.

33) C.Dong (NIFS) visited US from 29 Sep. to 15 Oct. 2012, and made an invited talk in the ICAMDATA conference (at National Institute of Standards and Technology), and the 24th IAEA Fusion Energy Conference.

34) N.Yanagi (NIFS) attended the US-Japan workshop on superconductivity and 24th IAEA Fusion Energy Conference, from 4 to 14 Oct. 2012.

35) P.Zhu (Univ. Wisconsin-Madison) visited NIFS from July 1 to Oct. 7 to develop modeling of ELM physics on benchmark between MIPS and NIMROD codes, 2fluid MHD model of kinetic ballooning, and 3D shaping effects on edge stability.

36) N.Pablant (Princeton Plasma Physics Laboratory, USA) stayed in NIFS from 24th September to 6th October 2012 to install a new X-ray detector on XICS of LHD.

37) S.Okamura (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

38) M.Kobayashi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

39) S.Sakakibara (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

40) K.Ida (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

41) K.Tanaka (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

42) S.Mutoh (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

43) H.Takahashi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

44) A.Iwamoto (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

45) T.Tanaka (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

46) K.Itoh (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

47) T.Watanabe (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego),

from 7 to 15 Oct. 2012.

48) A.Ishizawa (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

49) M.Sato (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

50) N.Nakajima (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 16 Oct. 2012.

51) S.Toda (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

52) N.Mizuguchi (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), from 7 to 15 Oct. 2012.

53) Y.Nakamura (NIFS) attended the Executive Committee Meeting for the TEXTOR collaboration and 24th IAEA Fusion Energy Conference, from 9 to 13 Oct. 2012.

54) Y.Todo (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particles Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.

55) Y.Suzuki (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Plasma Edge-Pedestal Topical Group meeting (San Diego), from 7 to 19 Oct. 2012.

56) A.Nishimura (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particle Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.

57) Y.Yoshimura (NIFS) visited San Diego, USA from 7th to 14th October 2012 to attend 24th International Atomic Energy Agency Fusion Energy Conference (IAEA FEC2012). He gave a poster presentation titled "Electron Bernstein Wave Heating and Electron Cyclotron Current Drive by Use of Upgraded ECH System in LHD".

58) H.Yamada (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 15, Oct., 2012.

59) A.Komori (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA mplementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 14, Oct., 2012.

60) O.Kaneko (NIFS) attended 24th IAEA Fusion Energy Conference (held in San Diego) from 7 to 15, Oct., 2012.

61) K.Ichiguchi (NIFS) attended 24th IAEA Fusion Energy Conference Held at Hilton San Diego Bayfront Hotel (USA), 8-13 October 2012 to make a poster presentation entitled “Multi-Scale MHD Analysis of Heliotron Plasma in Change of Background Field.

62) M.Yokoyama (NIFS) attended (as a clerk) the 41st Executive Committee meeting of

the IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept on 9 Oct. 2012, held in San Diego. He also attended the 24th IAEA Fusion Energy Conference in San Diego in 8-13, Oct.2012, and presented the poster presentation with A.Dinklage (IPP) on transport model validation activity.

63) J.Miyazawa (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 10 to 20 Oct. 2012.

64) T.Muroga (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 11 to 20 Oct. 2012.

65) S.Satake (NIFS) visited University Wisconsin-Madison (USA) from 15 to 26 Oct. to promote inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement, as an activity of CWGM. He discussed with J. Talmadge applying FORTEC-3D code to analyze neoclassical transport and viscosity in HSX and to compare with PENTA code.

66) N.Pablant (Princeton Plasma Physics Laboratory, USA) stayed in NIFS from 17th October to 15th December 2012 to join the LHD experiment and to analyze the data from XICS.

67) H.Sugama (NIFS) visited the Rhode Island Convention Center, Providence, US from October 28th to November 4th, 2012 to participate in the 54th Annual meeting of the APS Division of Plasma Physics. He made a presentation entitled “Extended gyrokinetic field theory for time-dependent magnetic confinement fields”.

68) H.Tsuchiya (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

69) R.Seki (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

70) K.Nagaoka (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 2 Nov. 2012.

71) H.Miura (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.

72) S.Usami (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 5 Nov. 2012.

73) H.Hasegawa (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 5 Nov. 2012.

74) H.Ohtani (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center, and US-Japan Workshop (Providence, RI) from 28 Oct. to 5 Nov. 2012.

75) S.Yoshimura (NIFS) visited Rhode Island Convention Center, Providence, RI, USA to attend the 54th Annual Meeting of the APS Division of Plasma Physics from 29

October to 2 November 2012. He gave an oral presentation entitled "Statistics of field-aligned intermittent electron flux in a linear ECR plasma".

76) Y.Narushima (NIFS) was invited to 17th workshop on MHD stability control at Columbia University, New York, NY, USA November 5-7, 2012. He presented "Flow effects on RMP field penetration in the LHD" as an invited talk.

77) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting, and for discussions on international collaboration between NIFS and PPPL, from 6 to 10, Nov., 2012.

78) D.Nishijima (University of California, San Diego) visited NIFS from 19 to 30, Nov. 2012 for joint experiment in LHD (plasma irradiation to Tungsten material).

79) A.Kuley (University of California, Irvine) and Y.Ren (Princeton Plasma Physics Laboratory) attended the 22nd International Toki Conference in Nov. 2012.

80) W.Wang (Princeton Plasma Physics Laboratory) attended the US-Japan JIFT workshop from 24 to 27, Nov. 2012.

81) O.Sinitsyn (University of Maryland) visited NIFS from 9 to 10 Dec. 2012.

82) F. Volpe (Assistant Professor, Columbia University) visited Kyoto Univ. from June 1 to Sep. 4, 2012 as a guest professor of Institute of Advanced Energy. He joined the Heliotron J experiment, especially electron cyclotron current drive experiment for Alfven Eigenmode stabilization. He also developed a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas. He also took a lecture on wave physics to graduate students in a summer school.

83) G. Weir (Ph. D. student, Univ. Wisconsin) visited Kyoto Univ. from July 7 to July 21, 2012. He joined the Heliotron J experiment, and learned a calibration method for multi-channel radiometer for electron temperature measurement. He obtained electron temperature profiles in ECH plasmas by using the calibration data.

84) Discussions with the HSX (Wisconsin Univ.) team and CTH (Auburn Univ.) team, groups of ORNL and PPPL, etc.) were kept along the same line as in 2012.

APPENDICES: TECHNICAL REPORTS ON 2012 ACTIVITIES

APPENDIX 1: HIGHLIGHTS OF LHD EXPERIMENTS

In 2012, the Large Helical Device (LHD) comes to its 16th experimental campaign (Plasma experiment: from 17 Oct. to 6 Dec. 2012). Progress being made in this experimental campaign will be reported after it finishes and detailed analyses are made.

Baffle-structure to accommodate closed helical divertor has been installed in 8 toroidal sections (from 2 in 2011) of inboard side. A cryo-pumping apparatus for one section has become available so as to assess its pumping capability under the real experimental condition. The one of important missions in this campaign is, then, initial documentation of particle-control capability in the edge of plasmas by means of closed helical divertor. Characterization of high-temperature, high-beta and steady-state plasmas under the modified in-vessel components is a main issue to prospect the next step with larger pumping capability. A newly installed 154GHz-1MW gyrotron (developed under the bi-lateral collaborative framework with Tsukuba University) came in operation. It should increase the local-heating capability in wider range of magnetic configuration and high density regime in combination with already installed 77GHz gyrotron.

Detailed physics studies will be enhanced in expanded LHD parameter regimes such as, detached divertor, resonant magnetic perturbation, stochastization of magnetic fields, magnetic island dynamics, ion heat transport, momentum transport, non-local transport, energetic particles-driven instability, atomic and molecular dynamics, and plasma-wall interaction.

Integration of performance extension and physics understandings progressed in LHD experiment successfully sent 21 papers to the 24th IAEA Fusion Energy Conference (San Diego, Oct. 2012). The 4 (3) of them were presented by domestic (international) collaborators as their first authors.

This fact indicates that LHD has provided opportunities to international as well as domestic collaborations by providing plasmas in a wide range of parameters. The number of international participants to LHD experiment has steadily increased, and it has reached more than 70 in 2011. The LHD Experiment Technical Guide was updated (all in English), and can be found at http://www.lhd.nifs.ac.jp/lhd/databook_2012/. LHD Physics Meeting has been run in English for physics and technical presentations. We hope this management will be of your help to further facilitate to join the LHD experiment.

(Reference)

The list of contributions from NIFS to the 24th IAEA Fusion Energy Conference (including 21 contributions from LHD experiment)

OV/2-1	Kaneko, O	Extension of Operation Regimes and Investigation of Three-dimensional Current-less Plasmas in the Large Helical Device
OV/3-4	Ida, K	Towards an Emerging Understanding of Non-local Transport
OV/P-05	Nakajima, N	Overview of IFERC Project in Broader Approach Activities
EX/2-5	Takahashi, H	Extension of Operational Regime in High-Temperature Plasmas and the Dynamic-Transport Characteristics in the LHD
EX/4-4	Kobayashi, M	Control of 3D edge radiation structure with resonant magnetic perturbation fields applied to the stochastic layer and stabilization of radiative divertor plasma in LHD
EX/8-1	Suzuki, Y	3D plasma response to magnetic field structure in the Large Helical Devic
EX/10-1	Inagaki, S	Is Turbulence Determined by Local Temperature Gradient?
EX/P2-12	Mutoh, T	Steady State Operation Using Improved ICH Antenna and ECH for High Performance Plasma in LHD
EX/P3-27	Kitajima, S	Transition of Porloidal Viscosity by Electrode Biasing in the Large Helical Device
EX/P4-10	Toi, K	Mitigation of Large Amplitude Edge-Localized-Modes by Resonant Magnetic Perturbations on the Large Helical Device
EX/P4-30	Sakakibara, S	Response of MHD Stability to Resonant Magnetic Perturbation in the Large Helical Device
EX/P5-08	Kajita, S	Impact of Arcing on Carbon and Tungsten: from the Observations in JT-60U, LHD, and NAGDIS-II
EX/P5-18	Morita, S	Low Concentration of Iron as First Wall Material in LHD plasmas with Edge Ergodic Layer
EX/P5-29	Morisaki, T	First Results of Closed Helical Divertor Experiment in LHD
EX/P5-32	Koga, K	Control of Dust Flux in LHD and in a Divertor Simulator
EX/P6-16	Yoshimura, Y	Electron Bernstein Wave Heating and Electron Cyclotron Current

		Drive by Use of Upgraded ECH System in LHD
EX/P7-03	Tanaka, K	Characteristics of micro turbulence in H-mode plasma of LHD
TH/8-1	Watanabe, T-H	Turbulence spectra, transport, and ExB flows in helical plasmas
TH/P2-22	Toda, S	Transport Analysis of Oscillatory State for Plasma Dynamics in Helical Plasmas
TH/P2-23	Ishizawa, A	Turbulent Transport due to Kinetic Ballooning Modes in High-Beta Toroidal Plasmas
TH/P2-24	Satake, S	Drift-kinetic Simulation Studies on Neoclassical Toroidal Viscosity in Tokamaks with Small Magnetic Perturbations
TH/P3-14	Ichikuchi, K	Multi-Scale MHD Analysis of Heliotron Plasma in Change of Background Field
TH/P3-25	Sato, M	Characteristics of MHD Stability of High Beta Plasmas in LHD
TH/P3-26	Mizuguchi, N	Numerical Modeling of Formation of Helical Structures in Reversed-Field-Pinch Plasma
TH/P6-20	Wang, H	Linear Properties and Nonlinear Frequency Chirping of Energetic Particle Driven Geodesic Acoustic Mode in LHD
IFE/P6-18	Iwamoto, A	FIREX Foam Cryogenic Target Development – Attempt of Residual Voids Reduction with Solid Hydrogen Refractive Index Measurement -
FTP/P1-20	Minami, R	Development of MW Gyrotrons for Fusion Devices by University of Tsukuba
FTP/P7-10	Hino, T	Performances of Helium, Neon and Argon Glow Discharges for Reduction of Fuel Hydrogen Retention in Tungsten, Stainless Steel and Graphite 」
FTP/P7-14	Muroga, T	Research on Tritium/Heat Transfer and Irradiation Synergism for First Wall and Blanket in the TITAN Project
FTP/P7-34	Miyazawa, J	Multifarious Physics Analyses of the Core Plasma Properties in a Helical DEMO Reactor FFHR-d1
FTP/P7-36	Tanaka, T	Neutronics design of helical type DEMO reactor FFHR-d1
FTP/P7-37	Yanagi, N	Divertor Heat Flux Reduction by Resonant Magnetic Perturbations in the LHD-Type Helical DEMO Reactor

PD/P8-16	Ido, T	Observation of a new energy channel from energetic particles to bulk ions through geodesic acoustic mode
PD/P8-18	Ogawa, K	Study on TAE-Induced Fast-Ion Loss Process in LHD
PD/P8-20	Nishimura, A	Cyclic Stress-Strain Curve for Low Cycle Fatigue Design and Development of Small Specimen Technology
Bidirectional Collaboration		
OV/4-2	Azechi, H	Present Status of Fast Ignition Realization EXperiment (FIREX) and Inertial Fusion Energy Development
EX/5-2	Yamamoto, S	Studies of Energetic-ion-driven MHD Instabilities in Helical Plasmas with Low Magnetic Shear
EX/P2-14	Zushi, H	Non-inductive Current Start-up and Plasma Equilibrium with an Inboard Poloidal Field Null by Means of Electron Cyclotron Waves in QUEST
EX/P3-07	Mizuuchi, T	Study of Fuelling Control for Confinement Experiments in Heliotron J
EX/P4-17	Ohshima, S	Edge Plasma Response to beam-driven MHD Instability in Heliotron J
EX/P6-17	Idei, H	Electron Bernstein Wave Heating and Current Drive Effects in QUEST
EXW/P7-19	Nagasaki, K	Experimental Study Second Harmonic ECCD in Heliotron J
FTP/P1-11	Nakashima, Y	Plasma Characteristics of the End-cell of the GAMMA 10 Tandem Mirror for the Divertor Simulation Experiment
IFE/1-3	Shiraga, H	Fast Ignition Integrated Experiments with Gekko-XII and LFEX Lasers
IFE/P6-05	Nagatomo, H	Computational Study of the Strong Magnetic Field Generation in Non-Spherical Cone-Guided Implosion
IFE/P6-11	Arikawa, Y	Study on the energy transfer efficiency in the fast ignition experiment by using advanced diagnostics
International Collaboration		
OV/4-3	Sharapov, S.E.	Energetic Particle Instabilities in Fusion Plasmas

EX/P3-14	Dinklage, A	Inter-Machine Validation Study of Neoclassical Transport Modeling in Medium- to High-Density Stellarator-Heliotron Plasmas
EX/P4-13	Jakubowski, M.W.	Influence of the resonant magnetic perturbations on particle transport in LHD
EX/P5-09	Douai, D.	Overview of the International Research on Ion Cyclotron Wall Conditioning
EX/P5-23	Koubiti, M.	Improvement of the Spectroscopic Investigation of Pellet Ablation Clouds
TH/7-2	Hanson, J.D.	Non-Axisymmetric Equilibrium Reconstruction for Stellarators, Reversed Field Pinches and Tokamaks

APPENDIX 2: PROGRESS REPORT ON WENDELSTEIN 7-X CONSTRUCTION

The Wendelstein 7-X project coordinates human resources, technical activities, the technical part of industry contracts and the contributions from other research centres and takes care of the interfaces between physics and engineering.

The collaboration with other institutions is of utmost importance for the Wendelstein 7-X project. KIT, FZJ and CEA provide immediate support via the supply of technical components and tests for Wendelstein 7-X subsystems. EURATOM continues to support the project with senior experts consulting on key project tasks. Experts from FZJ are strongly involved in the development of diagnostics.

Cooperation with KIT on the ECRH system is running well. The collaboration with KIT also includes the design and construction of the current leads for the superconducting coils.

The collaboration with Polish research institutes is running smoothly. The activity of the Institute for Nuclear Physics of the Polish Academy of Sciences in Krakow (IFJ PAN), which has provided up to 20 technicians and engineers for assembly of the bus-bar system, has come to an end. IPJ Swierk is continuing their work on the neutral beam injection system for W7-X. Various diagnostic systems are developed by Polish institutes and universities.

Within the collaboration with US laboratories, PPPL will provide the trim coils for W7-X and the respective power supplies. Four out of the five coils have already been delivered to Greifswald. ORNL is developing a design for the divertor scraper element, an additional High Heat Flux component to protect the W7-X plasma vessel during plasma start-up with high power discharges. LANL is developing a fast infrared camera system for divertor monitoring.

- Wendelstein 7-X construction (preferential support activity)

The activities according to scenario 3 for putting Wendelstein 7-X into operation in 2014 have been implemented and are being performed mostly according to schedule.

Magnet system

Assembly of all 70 superconducting coils has been finished. Fabrication of the bus-bar conductors by FZJ and assembly by IPP and IFJ Krakow has been completed.

The support of the coils between each other is provided by different support elements. All these elements in the magnet modules have been assembled. Design and manufacturing of the remaining support elements on the module separation planes is running according to schedule.

Divertor

The detailed design of the test divertor unit (TDU) according to scenario 3 is proceeding to plan. Fabrication of the supporting frames and manufacturing of the carbon tiles is running according to the plan. Most of the components for the first operation phase with the inertially cooled TDU have been delivered to Greifswald already.

Fabrication of the long target elements for the high heat flux (HHF) has started and is progressing according to plan. The design work for the HHF divertor is continued.

Assembly

All five magnet modules have been installed within their respective cryostat module and are positioned on the machine base. In the first four modules all ports have been welded, in the last module this process is still on-going. Connecting the modules is in progress; at three of the five module separation planes, the plasma vessel modules and outer vessel modules have been welded, at the fourth separation plane, this process has just started.

Assembly of the in vessel components has started recently and installation of the peripheral components in the torus hall is being continued.

The end of assembly of W7-X remains to be scheduled for August 2014 (about constant since five years).

- Wendelstein 7-X physics

Wendelstein 7-X heating systems (preferential support activity)

Electron Cyclotron Resonance Heating (Project PMW at KIT)

The ECRH control centre is presently being moved from the provisional location, which was used so far for the commissioning of the gyrotrons and transmission lines, to the dedicated control room. Both hard and software are being upgraded and updated for efficient and reliable remote control of all 10 power units. Manufacture and assembly of the in-vessel components for microwave-diagnostics continues in close collaboration with the KIP-division. The key components for the ECA-Diagnostics were completed and are ready for in-vessel installation in the W7-X torus. The design for the protective diagnostics such as sniffer probes and IR-observation has started.

The TED gyrotron SN7 was delivered to KIT in August 2012. The gyrotron opened a vacuum leak during first installation and had to be sent back to the factory for repair. The leak was identified and the repair gyrotron will be shipped to KIT late November. The delivery of the remaining series gyrotrons SN5 and SN2 is scheduled for May and September 2013, respectively. Some contractual issues are still pending for the repair of SN2.
Special funding by the BMBF was granted in October for the R&D of an advanced ‘Remote Steering Launcher’ for high-field side launch through the N-ports of W7-X. This R&D is performed in cooperation with the IPF at University of Stuttgart, and two industrial partners. The project is of particular importance for reactor application of ECRH.

Ion Cyclotron Resonance Heating (ICRH)

The ICRH systemon W7-X is still postponed until the start of operational phase 2. Within the framework of a collaborative programme with TEC the conceptual design of an ICRH antenna has been started and it is being investigated whether radio-frequency equipment of TEXTOR could be salvaged for the planned ICRH system.
A scaled down radio frequency conditioning system has been successfully put into operation on the WEGA stellarator. It was confirmed that impedance mating between generator and antenna during the whole plasma startup process is possible by feedback adjusting the frequency only. The efficiency of the helium plasma conditioning discharges is still being investigated. A decision on the need to install such a system on W7-X for OP1 will be based on these findings.

Neutral Beam Injection (NBI)

Pre-assembly of the neutral beam injector boxes in the NBI hall was continued. The assembly inside the torus hall is ongoing, mainly with the installation of the internal components of the HV cabins. The design of the routing of the cooling pipes and the duct unit is far advanced, the tendering processes are partially underway.

Progress was achieved within the collaboration with the Polish institute NCBJ Swierk for the procurement of four components, i.e. deflection magnet, beamline support structures, cooling supply systems and torus valves. All contracts with industry have been placed and work is proceeding as expected.

As a further Polish collaboration for the procurement of cryo pumps could not be established, the alternative use of AC driven titanium evaporation pumps is under investigation. A test facility with a simulating magnet field is under construction in Garching.

- Wendelstein 7-X diagnostics

The limited resources available for diagnostic development make it challenging to stay on schedule. Nonetheless, we are still on track to deliver an adequate set of start-up diagnostics for the first plasma operation in 2015. In fact, many diagnostics are now being fabricated and readied for installation. Below follows a status report for selected key diagnostics.

Neutron counters

The number of neutron counters has been reduced from one central plus five peripheral detectors, to one central and two peripheral detectors in order to save resources and stay on track for the development and manufacturing. Optimization and testing of the detector system is continuing.

Dispersion interferometers (single channel and multi-channel systems)

The laboratory set-up of the dispersion interferometer shows promising results – high accuracy and robust operation appears likely. The optical table for the set-up on W7-X is under construction. The support structure has already been ordered. The multichannel interferometer will be realized in cooperation with FZJ, with IPP supplying the necessary in-vessel retro-reflectors.

Thomson scattering

The main support structure for the Thomson scattering system is now under construction after a successful European-wide call for tender. Development of other subsystems is progressing.

Diagnostic neutral beam injector (RuDi-X)

We are continuing close monitoring of the RuDi-X contract with Budker Institute (BINP) in Novosibirsk. The high voltage DC current supply was finished, and has reached the specified values (5s, 10A@60kV) in testing.

Imaging x-ray spectrometer

The Imaging X-ray Spectrometer was successfully tested at TEXTOR, modified for W7-X conditions by FZJ and is currently assembled in IPP.

Infrared and visible diagnostic observation systems

The national call for tender for the simplified infrared/Hα immersion tubes has been completed and manufacturing started. The international call for tender for the long pulse compatible IR/visible endoscopes for divertor thermography has been completed and the order will be placed by the end of November.

In-vessel magnetic diagnostics

The assembly of the first diamagnetic loop for the bean shaped plane has started. The first 20 of 124 Mirnov coils have been assembled and are ready for installation at the wall protection elements. The first 110 of 600 individual Rogowski coils have been assembled and bent into their final shape at an external company. The ECRH stray radiation protection pipes for all Kapton insulated in-vessel signal cables have been handed over to assembly for in-vessel installation.

Edge helium beam diagnostic

Prototypes of the piezo valve system for the thermal He-beam has been built and successfully tested by FZJ. FZJ has completed the detailed design of the diagnostic and started the manufacturing of all components.

APPENDIX 3: SUMMARIES OF THE INSTITUTE OF PLASMA PHYSICS OF THE NSC KIPT, KHARKOV

Plasma Theory

1) A special correcting winding for the l = 2 torsatron with split-type helical coils. A split-type special correcting winding (split-type SCW) for the *l*=2 torsatron toroidal magnetic system with split-type helical coils is considered. The split-type SCW gives the possibility of controlling the position of the magnetic surface configuration in the direction perpendicular to the torus equatorial plane. Numerical simulations were carried out to investigate the influence of the split-type SCW magnetic field on centered and distant relative to the torus surface magnetic surface configuration with a plane magnetic axis, being promising for the fusion reactor. The configuration is realized in the *l*=2 torsatron with split-type helical coils and with the coils of an additional toroidal magnetic field. The calculations show that the split-type SCW magnetic field influence on the initial magnetic surface configuration leads mainly to the magnetic surface configuration displacement along the straight z axis of torus rotation. The displacement of ~ 0.1*a*, *a* is the minor radius of the torus, has no critical effect on the magnetic surface parameters. An idea on the split-type SCW magnetic field structure is obtained by numerical simulations of the effect of this field as a minority magnetic field imposed on the magnetic field of a well-known configuration. The split-type SCW magnetic field is directed, predominantly along the major radius of the torus within its volume. The displacement range of the closed magnetic surface configuration depends on the split-type SCW magnetic field value (V.G.Kotenko).

2) Special correcting winding for the l = 2 torsatron with internal splitting of helical coils. A special correcting winding for the *l*=2 torsatron toroidal magnetic system with non-standard (internal) split-type helical coils and with the coils of an additional toroidal magnetic field is considered. The numerical calculations have shown that the winding action upon the initial magnetic surface configuration leads mainly to a displacement of the magnetic surface configuration along the straight *z* axis of the torus (V.G.Kotenko)

3) Self-consistent modelling of plasma density increase with radio-frequency heating. In stellarator type machines, besides the electron-cyclotron method, the plasma production in the ion-cyclotron range of frequencies is practiced. The self-consistent model of the radio-frequency (RF) plasma production in stellarators is described in this work. With this model of plasma production, one can perform calculations for different antenna systems. The self-consistent model includes the system of the particle and energy balance equations and the boundary problem for the Maxwell's equations. The balance of the electron energy includes the RF heating, the energy losses for the excitation and the ionization of atoms by the electron impact, energy exchange with ions vie Coulomb collisions and the losses caused by the heat transport. The balance of the charged particles includes the particle supply owing to ionization and the diffusion particle losses. In the model, it is assumed that the neutral gas is uniformly distributed throughout the vacuum chamber volume, including the plasma column. Besides plasma build-up inside the confinement volume, the RF field produces plasma outside it. The losses of the charged particles in this zone have a direct character because the particles of plasma escape to the wall along lines of force of the magnetic field. This process is accounted in the model in tau-approximation. The

RF power density is calculated from the solution of the boundary problem for the Maxwell's equations. The collisional and Landau wave damping are accounted as mechanisms of the RF field dumping. The Maxwell's equations are solved each time moment for the current plasma density and temperature distributions. The calculated value of the local RF power, deposited to the electron component of plasma, is used in the energy balance equation. This value influences on the electron temperature and, in this way, on the ionization rate which determines the evolution of plasma density. The model for the stellarator plasma column is the plasma cylinder with identical ends. The plasma is assumed to be azimuthally symmetrical and uniformly distributed along plasma column. The Crank-Nicholson method is used for solving the system of the balance equations. The Maxwell's equations are solved in 1D using the Fourier series in the azimuthal and the longitudinal coordinates. Using this self-consistent model, the plasma density ramp-up with four-strap π-phased antenna is modelled. Antenna is fed with the frequency below ion-cyclotron and, plasma production in the Alfvén resonance heating regime is realized. (V.E. Moiseenko, Yu.S. Stadnik, A.I. Lyssoivan)

4) Neutronic model of the fusion neutron source. The applications of neutrons are unique because of the interaction particularity of neutrons with matter. Neutrons interact with nuclei but not with the electron shells. Scattering length can be very different for different isotopes of one element. The neutron diagnostics is a powerful method of isotopic contrast giving a possibility to detect light nuclei within heavy ones. The capabilities of neutron diffraction are manifested most clearly in the hydrogen-containing systems, such as polymers, biological systems, organic and water solutions. Besides, a neutron has a magnetic moment. Therefore, neutron diffraction is a direct method for diagnosing the magnetic structures, both in the interior and on the surface. The beams of polarized neutrons are especially effective tool for magnetic diagnostics. Neutrons interact weakly with the matter, so they do not destroy even the delicate biological systems and can penetrate deeply into the interior that is important for studying their volumetric properties. Powerful sources of fusion neutrons with energies ~ 14 MeV are of particular interest. Stand-alone application of fusion neutrons is testing of materials for fusion reactor. The purpose of this study is to find a principal design of a steady-state fusion neutron source. The MCNPX numerical code has been used to model the neutron kinetics and to calculate the neutron flux in the contemplated location of sample exposure. In the calculation model the main part of the source has a cylindrical shape with an inner radius of 88 cm and a length of 4 m. A vacuum chamber with a radius of 0.5 m containing a 4 m long hot D-T plasma producing fusion neutrons is located inside. For the first wall a thickness of 3 cm was chosen. Behind the first wall there is a liquid-metal coolant for heat removal. There have been considered two versions of the coolant: lead and bismuth eutectic (LBE), and sodium. A shield surrounding the model was used to absorb the outcoming neutrons. The paper presents calculation results for the neutron flux and spectrum at the sample area and inside the first wall for 2 coolants. The radial leakage of neutrons through the shield has also been calculated. (S.V. Chernitskiy, V.E. Moiseenko, O. Ågren)

5) Surfaces of stellarator-mirror hybrid at Uragan-2M device. This research is performed for grounding of a possibility of creation of the fusion neutron source on the base of plasma trap with combined magnetic system for driving a sub-critical fast nuclear reactor. The experiments on measuring magnetic surfaces at Uragan-2M, a torsatron with additional toroidal field, have been performed when the stellarator-mirror magnetic system is created by switching off one toroidal coil. The experiments confirm existence of closed magnetic surfaces in such a combined system in regime with k_φ= 0.24 (k_φ is the ratio of the toroidal magnetic field of the helical winding to the total toroidal field). The parameters of the magnetic configuration are in reasonable agreement with the numerical calculations. (G.G. Lesnyakov, V.E. Moiseenko, A.N. Shapoval and others)

6) Stellarator-mirror hybrid with neutral beam injection. A version of a fusion-fission hybrid, i.e. a sub-critical fast fission assembly with a fusion plasma neutron source, is proposed. The plasma part of the reactor is based on a stellarator with a small mirror part. In the magnetic well of the mirror part, fusion reactions occur from collisions of an RF heated hot ion component (tritium) having high perpendicular energy with cold background plasma ions. The majority of the hot ions are trapped in the magnetic mirror part. The stellarator part which connects to the mirror part provides confinement for the bulk (deuterium) plasma. A more conventional method to sustain the hot ions is neutral beam injection (NBI). NBI is here studied numerically for the above-mentioned hybrid. For these studies, a new kinetic code, KNBIM, has been developed. The code accounts for Coulomb collisions of the hot ions with the background plasma. The geometry of the confining magnetic field is arbitrary for the code. It is accounted via a numerical bounce averaging procedure. Along with the kinetic calculations the neutron generation intensity and its spatial distribution are computed. The power balance for such a hybrid is investigated using the KNBIM code together with the ISS04 stellarator confinement scaling. In the calculations the energy of NBI, its intensity and the mirror ratio in the open trap part are optimized. The calculations show that the optimum mirror ratio in the mirror part of the hybrid is not big and may be chosen in the range 1.2-1.8. Despite this, the neutron flux at the stellarator part is substantially smaller than at the mirror part. Although the energetic cost to produce fusion neutrons is high, a positive electric power balance could still be achieved starting from a medium-scale hybrid with about 200 MW continuous electric power.(V.E. Moiseenko, O. Ågren)

7) Calculations of collisionless α -particle losses. V.V. Nemov, S.V. Kasilov, and V.N. Kalyuzhnyj in cooperation with W. Kernbichler, M. Heyn (Association EURATOM-ÖAW, Institut für Theoretische Physik - Computational Physics, TU Graz, Petersgasse 16, A–8010 Graz, Austria) and J. Talmadge (University of Wisconsin-Madison, USA) fulfill calculations of collisionless α -particle losses for quasi-helically symmetric (QHS) toroidal stellarators in real space coordinates. The results show that the collisionless α -particle losses for QHS are negligible for particles started at $r/a \approx 0.25$. For particles started at $r/a \approx 0.5$ roughly a quarter would be lost. This is in agreement with the corresponding results in [W. Lotz, P. Merkel, J. Nührenberg, E. Strumberger, Plasma Phys. Control. Fusion, 34, 1037 (1992)] for $r/a \approx 0.25$ and somewhat exceeds those results for $r/a \approx 0.5$. For HSX device the particle losses are essentially larger than for QHS. The reason is connected with the presence of additional small magnetic field ripples in HSX. The amplitude of these ripples can be decreased by increasing the number of twisted coils. For such a system with 96 coils instead of 48 coils, the particle losses are decreased to a level comparable to that in QHS.

Plasma Experiment

1) Longitudinal oscillations of plasma in torsatron U2-M. Plasma oscillations were

investigated on the basis of microwave interferometry signals crossing the plasma confinement volume in two poloidal cross sections spaced along the torus axis. Plasma with density $(2 – 3.5)\cdot 10^{12}$ cm^{-3} was produced by RF fields excited by two antennas with frequencies below Alfven frequencies. The spectrum of oscillations appeared on transmitted microwave probing beams was spread to ~300 kHz. They were found to propagate along the torus. Results of correlation analyses and linear dependence of oscillation frequencies on the strength of toroidal magnetic field indicate that they can belong to Alfven eigenmodes. With this supposition the effective ion-to-proton mass ratio ~1.3 was estimated.
(A.I. Skibenko and others)

2) Feasibility of creating an island divertor in the Uragan-2M torsatron. In stellarators, where the toroidal magnetic field plays a decisive role in the formation of closed magnetic surfaces, it is every so often difficult to create a helical magnetic divertor structure. The present work has reduced to finding (both experimentally and numerically) out of a vast number of possible regimes those several regimes with the islands at the edge, which would decide the issues of island divertor creation. The experimental magnetic field structure studies by the scanning luminescent rod technique as well as the computational investigations demonstrated an existence in the Uragan-2M torsatron of ten modes of configurations with the islands of resonances at the rotational transform angles $i/2\pi$=1/3, 3/7, 2/5, 1/2, 4/5, which lie outside the last closed magnetic surfaces. These modes are: (1) k_φ=0.285, $\langle B_\perp/B_0\rangle$=1.45% (islands $i/2\pi\approx 1/3$); (2) k_φ=0.295, $\langle B_\perp/B_0\rangle$=1.8% (islands $i/2\pi$=1/3); (3) k_φ=0.295, $\langle B_\perp/B_0\rangle$=3.21% (islands $i/2\pi$=2/5); (4) k_φ=0.31, $\langle B_\perp/B_0\rangle$=1.5% (islands $i/2\pi$=2/5); (5 and 6) k_φ=0.31, $\langle B_\perp/B_0\rangle$=1.14% and $\langle B_\perp/B_0\rangle$=1.85% (islands $i/2\pi\approx 1/3$); (7 and 8) k_φ=0.32, $\langle B_\perp/B_0\rangle$=1.34% and $\langle B_\perp/B_0\rangle$=1.58% (islands $i/2\pi\approx 1/3$); (9) k_φ=0.33, $\langle B_\perp/B_0\rangle$=1.92% (islands $i/2\pi$=2/5 and $i/2\pi$=3/7); (10) k_φ=0.36, $\langle B_\perp/B_0\rangle$=2.03% (islands $i/2\pi$=1/2). The combination of the low-density plasma discharge with the scanning luminescent rod procedure to measure the magnetic surface has first visually demonstrated the operation of the island divertor in U-2M fusion device. It has also been shown that by varying the value of vertical magnetic field in the configuration it is possible to provide the following capabilities for controlling the island divertor operation: i) to cut off the islands by the vacuum chamber wall; ii) to use the remains of the islands already broken down by the existing perturbations; iii) to reduce and suppress the islands. In another variant of the island divertor realization, when the islands are positioned inside but close to the last closed magnetic surfaces, a movable local limiter can be used. (G.G. Lesnyakov and others)

3) Study of plasma density rise in U-3M after switching off RF-power**.** On torsatron U-3M the investigations of the nature of plasma density increase after RF heating termination were performed. In the confinement volume plasma was in the mode of rare collisions. With an average density measurements carried out using 2-mm interferometer, the size of the plasma column by optical methods, and microwave probing at frequencies near the plasma electron frequency, the change of plasma density profile during RF discharge and just after its termination was constructed. It was found that the time of plasma density rise after switching off the RF pulse coincides with the bootstrap current decay time. The value of plasma density increment after RF pulse end is proportional to the rate of the current decrease. As a result, it was supposed that one of the main mechanisms of plasma density increase after RF pulse switching off is the effect of pinching of particles trapped in the magnetic field inhomogeneities of torsatron configuration. Electric field, causing this pinching is associated with reducing bootstrap current. (V.K. Pashnev and others)

4) Investigation of electromagnetic waves excited just outside of plasma

confinement volume. With the help of magnetic probes located outside the plasma volume, it was shown that the RF plasma heating using different antennas, in the gap between the confined plasma and helical winding electromagnetic waves propagate. The frequency spectrum of waves consists of discrete harmonics in the frequency range from heating frequency $f \approx 9$ MHz to 80 MHz. In some heating modes the amplitude of these harmonics is close to magnitude of heating frequency harmonic. The phase velocity of propagation in the radial direction for different harmonics is in the range $2 \cdot 10^6 \div 4 \cdot 10^7$ cm/sec. Electromagnetic waves propagating in the gap between the plasma confinement volume and the helical winding provide a significant influence on plasma behavior due to partial screening of neutral hydrogen inflow from the space between helical coils and of income of metallic impurities from metallic plasma surroundings. (V.K. Pashnev and others)

5) Magnetic surfaces in stellarator-mirror hybrid at Uragan-2M device. The research was performed for grounding of a possibility of creation of the fusion neutron source on the base of plasma trap with combined magnetic system stellarator – magnetic mirror for driving a sub-critical fast nuclear reactor. The experiments on measuring magnetic surfaces at Uragan-2M, a torsatron with additional toroidal field, have been performed with luminescent rod, when the stellarator-mirror magnetic system is created by switching off one of 16 toroidal coils. It was shown experimentally that the magnetic configuration of the hybrid stellarator-mirror with closed magnetic surfaces of an average radius of 11 cm$\leq a \leq$12.5 cm and angles of rotational transform $i/2\pi(0) \approx 0.115$ to $i/2\pi(a) \approx 0.154$ is created in mode with $k_\varphi = 0.24$ (k_φ is the ratio of the toroidal magnetic field of the helical winding to the total toroidal field) and planar magnetic axis in the Uragan-2M torsatron with an additional toroidal magnetic field when a single coil of the toroidal field coils was switched off. The average radii of the closed magnetic surfaces of both the torsatron and a hybrid stellarator-mirror created on its basis are determined by the general level of disturbances that exist in the device. It is determined that the magnetic axes of the measured configurations shift up quite a bit, and the magnetic surface structures change their inclination from the vertical to the equatorial plane of the torus as a function of distance along the torus between their location and the coil switched off. (G.G. Lesnyakov, V.E. Moiseenko and others)

6) Microwave interferometer with two polarizations designed for density radial distribution measurement in the U-3M and U-2M torsatrons. Recently a new microwave diagnostic technique was designed and tested on the U-3M and U-2M torsatrons. A transmitting horn-type antenna radiates simultaneously microwaves of two polarizations. A receiving horn-type antenna is also received two polarizations of the microwave. Its size is slowly decreased to the standard waveguide size 11x5.5 mm^2. This waveguide is oversized for frequency range 33-38 GHz, and therefore allows both polarizations to propagate. Decupling of these two polarizations and their independent comparison with the input wave is necessary for such an analysis. A standard polarization selector has been designed and manufactured for available standard waveguide cross-sections 7.2x3.4 mm^2 operating in a single mode. The developed interferometer schemes allow to determine radial distributions of the electron density according to theoretical calculations. (V.L. Berezhnyj and V.V. Filippov)

7) Study of dynamics of CX atom flux in U-3M from RF produced plasma. Dependences of the charge exchange (CX) fluxes of neutral are investigated via neutral particle analyzers (NPA) in the U-3M torsatron. Fast (≤0.5 ms) decay of the vertical and tangential CX fluxes has been observed after turning off RF heating power. According to these measurements, the U-3M energy confinement time of the 0.5-4.5keV ions is less than 0.5 ms in the low density ($n_e = (1\text{-}4) \cdot 10^{12}$ cm^{-3}) discharges. No difference between confinement of the ion energy component parallel to the magnetic field and confinement of the perpendicular to the magnetic field one was observed in U-3M. Evidently, an ion cooling through CX collisions with neutrals sustain the main channel of the 0.5-4.5 keV ion energy loss in the U-3M torsatron. (M. Dreval, A.S. Slavnij)

8) U-3M discharge start-up scenario with the use of pulsed gas puffing. In order to reduce flux of the neutrals, U-3M discharge start-up scenario maintained by impulse gas puffing has been proposed. Absence of constant working gas feeding in this scenario open a possibility to reduce working gas pressure in the U-3M vacuum vessel. It was shown that the time of entire vessel filling after sharp gas puffing pulse is about 10-20 ms. In discharges with 5-6 kV in the RF generators and proposed start-up scenario a delay between GP pulse and plasma creation was shorter when the chamber filling time. Same level of the electron density has been achieved in the discharge under consideration and conventional 5-6 kV discharge maintained by the constant gas feeding only. The H_α emission waveform in the considered discharges is similar to its waveforms in the conventional devises where chamber and plasma sizes are close each other. (M.Dreval and U-3M Team)

***9) Further studies of processes accompanying the H-like mode transition in the RF heated plasma of the U-3M torsatron*.** In the Uragan-3M torsatron (U-3M: $\ell = 3$, $m = 9$, $R_0 = 100$ cm, $\bar{a} \approx 12$ cm, $\iota(a)/2\pi \approx 0.3$, $B_\phi \lesssim 1$ T) a hydrogen plasma with the density $\bar{n}_e$ units 10^{12} cm^{-3}, the ion and electron temperatures $T_i \sim 300\text{-}600$ eV and $T_e(0) \sim 500\text{-}700$ eV (the rare collisionality regime) is produced and heated by RF fields in the $\omega \lesssim \omega_{ci}$ range of frequencies, using a non-shielded frame-like antenna with a broad spectrum of parallel wavelengths. The RF power irradiated by the antenna attains $P = 150$ kW in the 40 ms pulse. A distinctive feature of U-3M is that its whole magnetic system is enclosed into a large, 5 m diameter vacuum chamber, so an open natural helical divertor is realized.

With the power P high enough and a certain ω, B_ϕ and $\bar{n}_e$ combination, where optimum conditions for plasma heating arise with local Alfven resonances being present in the plasma, the H-like mode transition occurs.

In the year under review, in order to get a better understanding of processes developing in the RF discharge before and after the transition, a detailed analysis of these processes has been undertaken. As a result, it is inferred that the processes can be divided in two groups by the time scale of plasma parameters variation. To the *slower processes* (units – tens ms) those are related that “prepare” conditions for the H-transition. These are plasma density decay, first of all, accompanied by a monotonous rise of W_{dia} , ECE and the fast ion (FI, $\gtrsim$ 500 eV) content.

Against a background of slower processes completed by achieving a maximum of FI content, the *faster processes* (tens – hundreds μs) arise, which determine the H-like mode transition in itself. The transition is triggered by a short-time burst of enhanced FI loss (~500 μs). The burst initiates the edge E_r bifurcation to a more negative value with a stronger E_r shear (~50 μs). The stronger E_r shear suppresses the edge turbulence and turbulence-induced anomalous transport (~100 μs). (V.V. Chechkin and others)

***10) Effects of the H-like mode transition on plasma parameters in the divertor flows*.** Due to the peculiarity of plasma production in U-3M a considerable part of the RF power irradiated by the antenna is exhausted for plasma generation outside the confinement volume. Therefore, the peripheral plasma can amount to a significant part of the diverted plasma, in the general case. It is shown that those components of the total diverted plasma flow which outflow predominantly from the confinement volume to the spacing between the helical coils really drop with the transition, thus indicating a reduction of the plasma loss from the confinement volume. These components propagate on the electron $B \times \nabla B$ drift side and have a considerably higher electron temperature (hundreds eV) than those on the ion side (tens eV). This confirms the idea that the H-like mode transition in U-3M results in the loss reduction mainly through the electron channel. (V.V. Chechkin and others)

11) The use of X-mode and O-mode probing for plasma density profile. The aim of the work is to determine plasma density profile in U-3M via phase shifts of X-mode and O-mode measured experimentally. Experimental datasets consist of phase shifts values measured during the discharge. Measurements of plasma density by dual-polarization interferometry give us information not only about an average plasma density but about density profile form too. Up to now, plasma density profiles were established for two time periods of U-3M discharge. But, we need in simultaneous (in the same time points) and more precise data to make conclusion about plasma profile behavior from the beginning to the end of discharge in U-3M torsatron. We have to start the work at modification of the interferometer in order to obtain signals proportional to cosφ and sinφ for each polarization. This modification will solve the problem with the change of the signal amplitude and the exact definition of the dynamics of the phase shift during plasma discharge. Supposed accuracy of the phase shift will be about 2 degrees. (V.L. Berezhnyj, D.L. Grekov, K.K. Tretyak, and V.V. Fillipov)

12) Investigation of plasma facing wall surfaces conditions after pumping and RF discharge cleaning procedures in the Uragan-2M torsatron. The thermal desorption method has been developed for operative diagnosing impurity level of Uragan-2M (U-2M) vacuum chamber surfaces in situ. To perform the experiments the device was designed, manufactured and installed in the U-2M vacuum chamber, which gives possibility to register low flows of gases desorbed from the 12KH18N10T stainless steel (SS) strip-like probe during its pulsed heating up to temperature 250-300ºC. The investigations were carried out of SS probe outgassing rate and estimation of the number of monolayers on its surface after preliminary pumping and RF discharge cleaning in one of conditioning regimes. The decrease of surface impurity by more than one order of magnitude was measured at the vacuum improvement from $1.6 \cdot 10^{-6}$ Torr up to $6.5 \cdot 10^{-7}$ Torr after pumping and RF discharge cleaning. Mass-spectrometric measurements has shown H_2O(18 a.m.u.), CO_2(44 a.m.u.) and 28 a.m.u., as the main gases desorbed from probe surface during its heating. Heavy hydrocarbon masses were also registered. Some practical conclusions were made for the U-2M wall conditioning procedure but to provide the estimation of efficiency of various scenarios of wall conditioning process in the U-2M torsatron the additional experiments will be provided. The results have been published in paper: Method for diagnostics of the Uragan-2M vacuum chamber surface conditions. Physical surface engineering. 2012. V.10, #2, p. 173-176, (G.P. Glazunov, V.K. Pashnev), and have been reported on the International Conference-school on plasma physics and controlled fusion. (G.P. Glazunov and others)

13) Studies on magnetic surface structures and basic magnetic field properties in "ultimate" configurations of the l=1, m=13 torsatron. The paper is concerned with numerical investigation of various magnetic configurations of a single-pole toroidal l=1, m=13 "ultimate" torsatron having a low aspect ratio A_h=4.345 and the modulation factors (-0.23)≤ α ≤ 0.71 (K=1, β=0) of the helix law $-m\varphi=\theta-\alpha K\mathrm{Sin}\theta - \beta K\sin 2\theta$ (φ is toroidal and θ is poloidal angles). The extremums of the basic properties of closed magnetic surfaces as functions of the coefficient α in the neighborhood of $\alpha\approx0.4$, as well as the structures of the edge magnetic field (*substructures of virtual current*) and the separatrix have been first determined for the l=1, m=13 "ultimate" torsatrons and the "Vint-20" torsatron. Unusual positions of the separatrix X-points in the cross sections for 1/4- and 3/4- magnetic field periods have been identified. The formula that takes into account the modulation factor α of the helix law was first derived to

determine the average vertical magnetic field on the geometrical axis of the torus.
The undertaken studies point to a new interesting possibility of ***l***=1 torsatron application with a potential usefulness. Now one may state that the ***l***=1 "ultimate" torsatron with a low aspect ratio and a large number of magnetic field periods presents an example of the easiest natural tandem stellarator-mirror trap hybrid system. It should be noted that this possibility, based on the peculiarities of the ***l***=1 torsatron and its magnetic surface properties, can be successfully put into practice unlike the other two hypothetic possibilities of creating compact torus-stellarator and mirror trap-stellarator hybrid configurations, published in literature. (G.G. Lesnyakov)

Studies on magnetic surface structures and basic magnetic field properties in "ultimate" configurations of the ***l***=1, *m*=13 torsatron and the "Vint-20" torsatron: Preprint KhIPT 2012-2/ G.G. Lesnyakov. – Kharkov: NSC KhIPT, 2012. - 30 p.

14) ***Behaviour of electron cyclotron emission for optically thin plasmas during various RF plasma production scenarios at Uragan-3m torsatron.*** The straightforward evaluation of measured ECE spectra used on most tokamaks and stellarators shows that the reliable data for the conversion of obtained radiation temperature have to satisfy simple conditions that plasma has to be optically thick for most of plasma radius. Thus, an additional interpretation technique for optically thin plasma emission data analysis has been proposed. A standard radiometer with multiple frequency resolved measurement of the ECE intensity constitutes a radially resolved measurement of the electron temperature profile. Temperature profile evaluation was conducted in the main framework of the U-3M plasma turbulent transport experiments, main feature of which is occurrence of an H-like confinement mode after threshold power deposition into the plasma. It was shown that it could be a promising confinement regime by forming the edge transport barrier (like in other tokamaks and helical systems) and significant reduction of the radial turbulent particle flux.
For the quick but approximate deduction of the central electron density simultaneous ECE measurements of radiation intensity from second and third harmonics were conducted as a test drive. The frequencies of the receivers were chosen to pick-up radiation from the same radial position in the vicinity of plasma center.
Since the central electron temperature can be reliably measured from the central plasma second harmonic radiation, the third harmonic optical thickness can be directly obtained as combination of the second and the third harmonic radiation intensities from which central plasma density can be evaluated. In the absence of density profile diagnostics such comparison between normalized densities deducted from ECE radiation and measured by 2mm interferometer could be used as a quick and simple monitor for a peakedness profile changes. (R.O. Pavlichenko and others)

15) The dynamics of inductively accelerated electrons in the U-3M torsatron. Recent studies have shown that the flows of runaway electrons may be formed in both tokamaks and stellarators. In particular, such flows may be formed during the confining magnetic field intensity variation, which is usually observed in the devices where the magnetic field is formed by a pulse of current in the magnetic field coils. Non-zero dH/dt creates an electric field which could accelerate the charged particles and, eventually create the electron flow with energies of 0.8 MeV and above, according to previous X-Ray measurements. In the present work we continue our previous studies of the flow parameters. The conditions of formation of accelerated electrons and their propagation were investigated. In particular the results of the flow current measurements are presented together with the flow radiation which was studied at different frequency ranges. (I.K. Tarasov et. al.)

16) Usage of three-halfturn antenna at the Uragan-3M device. Three-halfturn (THT) antenna is regularly used at Uragan-3M device for Alvén plasma heating, while initial plasma is created with loop antenna which pulse precedes THT antenna impulse. The characteristic feature of this THT antenna regime is a possibility of operation at low initial neutral gas pressure ~$3\text{-}5\cdot10^{-6}$ Torr. Plasma density increases gradually during impulse and can approach 10^{13} cm^{-3}. Mainly plasma electrons are heated up to the temperature about 100 eV. RF power was supplied to antenna in a programmable way (by three-step increase) to the Uragan-3M plasma with the aim of keeping minimal start-up time of discharge and minimizing the antenna voltage. However, the programmable steps don't guarantee reproducible plasma generation (no gas breakdown occurs with probability of 3%). Moreover, the discharge start-up time Δt randomly deviates within the margins of 3-7 ms, that doesn't allow maintaining stationary regime in reproducible way. THT antenna doesn't create dense plasma in standard regime of Uragam-3M (toroidal magnetic field ≈0.72 T, RF heating frequency 8.6MHz), but low density plasma ≈10^{10} cm^{-3} is created sufficiently stably. This effect can be explained by slow wave generation that is excited by THT antenna via electrostatic mechanism. Experiments show that such plasma is quite suitable as initial for further stable production of dense plasma with the help of loop antenna. Decrease of magnetic field decreases a critical density value, starting from which Alvén resonances appear in plasma column. As soon as this value gets less than the plasma density created with the slow wave, plasma production becomes possible in the relay-race mode regime. It's experimentally shown that THT antenna impulse creates high temperature dense plasma at magnetic field less than 0.7 T without pre-ionization, and plasma creation delay time decreases with magnetic field. Simultaneous work of loop and THT antennas provided high temperature dense plasma during whole impulse at magnetic field 0.68 T. The role of THT antenna was to create target plasma and to maintain plasma parameters both simultaneously with loop antenna and after loop antenna switch-off. (V.E. Moiseenko, V.V. Chechkin and others)

17) Magnetic diagnostics for U-2M torsatron. The set of new sensors of magnetic diagnostics – two diamagnetic loops and set of 16 Mirnov coils has been developed, manufactured and installed inside vacuum chamber U-2M torsatron for providing the research program. With these sensors it possible to determine: the value of longitudinal plasma current, horizontal plasma current shift, the magnetic field of Pfirsch-Schluter currents, vertical plasma current shift and time history of the radial electric field, the island structure of magnetic surfaces, helical equilibrium plasma currents, the plasma energy content, the power inputed into the plasma, the plasma energy confinement time, the shift and deformation of magnetic surfaces, the magnetic island structure, the MHD oscillations, etc. Before being installed in the vacuum chamber of the U-2M torsatron, the magnetic sensors were calibrated and their characteristics were measured for their comparison under the conditions with and without metal environment of U-2M torsatron vacuum chamber. The findings of model investigations will be used while processing the signals registered by magnetic sensors in the experiments at the U-2M torsatron. (V.K. Pashnev, A.A. Petrushenya)

18) HIBP diagnostic as a tool to study quasicoherent modes in TJ-II plasmas. HIBP in TJ-II operates with Cs^+ ions that have a probing beam energy E_b = 125 keV. HIBP provides the simultaneous measurements of three independent quantities: the plasma electric potential φ, density n_e and poloidal magnetic field B_{pol} with a good spatial (< 1 cm) and temporal (1 μs) resolution over the whole radial range from the low field side edge to the high field side. Presently HIBP operates with two sample volumes, which are observed simultaneously. The pair of sample volumes are oriented in the poloidal direction to measure the poloidal component of the electric field E_{pol} by the difference in local potentials, $E_{pol} = (\varphi_1 - \varphi_2)/x$. x~1 cm, which limits the observed poloidal wave vector, $k_\theta < 2$ cm^{-1}. These data provide the radial $E\times B$ drift velocity: V_r =

E_{pol}/B_{tor}. Our HIBP allows direct determination of the radial electrostatic component of the turbulent particle flux, which we also report here. Finally, the radial electrostatic turbulent particle flux $\Gamma_r(t) = \tilde{n}_e \tilde{V}_r = 1/B_{tor}\ \tilde{n}_e(t)\ \tilde{E}_{pol}(t) = \Gamma_{E\times B}$ is measured in the core plasma.Simultaneous poloidally resolved HIBP measurements provide the cross-phase of two separated signals, which is in principle sufficient to extract the poloidal wavelength, and phase velocity of the perturbations.

19) In the experiments with ECRH power modulation plasma potential was found to follow the electron temperature evolution. It was found recently that the amplitute of the potential modulation is a function of plasma density. It was constant when density increase from n_e = 0.25 to 0.6 $x10^{19}m^{-3}$. When density increases farther, it also decreases monotonically. This behavior may be explained by the electron temperature evolution. The similar behavior was found in the T-10 tokamak .
Recently the new observation of the fast particle generated quasicoherent modes were observed in the regimes with NBI heating along with conventional Alfven Eigenmodes. There are several new types of the NBI induced modes found, which presents non-Alfvenic density dependence.

20) NBI induced modes with non-Alfvenic density dependence. Energetic particle modes have been observed in the TJ-II NBI heated plasmas combined with ECRH. In the low density ECRH/NBI plasma the mode exists in the form of the chirping-up mode. The chirping mode has pronounced magnetic component, observed by Magnetic Probes (MP) and Heavy Ion Beam Probe (HIBP), some pressure component, manifested by density perturbation (Reflectometry, HIBP) and some electrostatic component, manifested by potential perturbation (HIBP). The mode spatial structure is not poloidally symmetric, surprisingly, magnetic component of the mode is clearly visible in the High Field Side (HFS) of the torus (-0.4< [illegible]), but not in the Low Field Side (LFS) as seen by HIBP. Note that Reflectometer sees the mode in the LFS, seems, MP also. After the ECRH switch – off the mode presents transformation from the chirping to the eigenmode form. Additionally to reflectometer and MP, it becomes pronounced in HIBP potential, density and B_{pol}, and also in the edge plasma density and potential measured by Langmuir probe. The AE mode spatial structure becomes poloidally symmetric. The results suggest the particle losses induced by the ECRH pump-out are responsible for the formation of the non-linear relations between energetic ions and bulk plasma particles resulting in chirping modes.

21) The chirping modes, which were found in ECRH/NBI plasmas of TJ-II are characterized by HIBP and MP. The typical frequency range is 200-400 kHz. The chirping modes have pronounced magnetic component and some minor electrostatic and density components. According to the HIBP data, the chirping mode seems to be "antiballooning", locating in the HFS, $-0.4<\rho<-0.8$ with finite radial area in HFS. Chirping modes are pronounced in low-density ECRH/NBI plasma. When density increasing, the chirping range (difference between lowest and highest frequencies) decreases gradually up to the negligible values. Slight (<10%) ECE power reduction leads to the vanishing in the mode chirping range and the mode amplitude. The chirping modes undergo fast transformation to the AE modes when ECRH is switching-off or beyond the ECRH cut-off. The chirping modes present the fast frequency increase from lower stable level to the upper stable level. After the transformation, both levels become pronounced in the AE form, having symmetrical radial structure. The turbulent particle flux due to the modes is small in comparison with broadband turbulence. Iota evolution may lead to the chirping-AE transformation, suggesting the effect of the low-order rational iota value.

22) The measurements of radial plasma potential and electron density and also their fluctuations by Heavy Ion Beam Probe diagnostic and study of their influence on the plasma confinement in tokamak T-10 with ECR and OH heating were continued in the frame of the collaboration of IPP NSC KIPT with Kurchatov Institute (Moscow).

23) Electric fields study with HIBP in oh and ecrh plasmas on T-10. The direct measurements of the electric potential φ in the core plasma are very important for understanding of the role of the radial electric field E_r as the confinement regulating mechanism. The new observations of the potential evolution were performed in the T-10 tokamak (B_0=1.5-2.5 T, R=1.5 m, a=0.3 m) with Heavy Ion Beam Probing in a wide range of densities $\bar{n}_e=(0.6\text{-}4.7)\times10^{19}$ m^{-3}. Ohmic (OH) and ECRH D_2 plasmas (T_e<1 keV, T_i<0.7 keV) are characterized by a negative potential up to φ(0)=-1400 V at the centre and monotonically increasing towards the edge. The density rise due to gas puffing is accompanied by an increasing the absolute value of the negative potential. Correspondingly, the average E_r increases from -18 V/cm to -60 V/cm. This is valid both for the steady-state plasmas and for the initial stage with ramped plasma current and density. When the density approaches a certain value $\bar{n}_e=2.5\text{-}3.5\times10^{19}$ m^{-3}, the growth of potential saturates, while the plasma stored energy is still growing with density. Note, that in the NBI heated regimes in the TJ-II stellarator, φ also saturates, when the density is about $\bar{n}_e= 3.5\times10^{19}$ m^{-3}. Powerful electron cyclotron heating (ECRH, P_{EC}< 3 MW) leads to the increase of T_e up to 3 keV, diminishing the central line-averaged density ("pump-out") up to $\Delta n_e/n_e$ <30% and the decrease of the absolute potential value, Δφ=200-400 V. Δφ is constant, ~400 V, independently on the density up to $\bar{n}_e=2.5\times10^{19}$ m^{-3} and then decreases by 200 V, when the density raises up to 5×10^{19} m^{-3}. At the lower density, $\bar{n}_e=(0.6\text{-}0.8)\times10^{19}$ m^{-3}, the edge E_r decays by zero. The ECR heating leads to formation of the positive edge E_r.

Neoclassical modeling (both analytical and numerical VENUS+ code [2], taking into account the toroidal field ripple) agrees with measured φ profiles. When the ion and electron temperatures are comparable, T_e/T_i ~1, the ion flux dominates and E_r<0. When T_e/T_i >>1, E_r may be positive because the ion and electron fluxes become comparable.

In summary, these results present the important features of φ profiles and non-linear links between the potential and the energy confinement.

24) Progress report in the HIBP diagnostic. The Heavy Beam Probe diagnostic system was installed at Uragan-2M stellarator. The calculations for HIBP to U-2M application were done by computer code and optimized conditions of geometry and design HIBP parameters wee found. Trajectories of the probing heavy Tl^+ and Cs^+ beams were obtained for the various diagnostics ports and two values of the confinement magnetic field: B_0 = 0.8 T (first stage device operation) and 2.4T(second one). The covered measurable radial range is 0.1 < r/a < 1. Necessary energy interval of probing ion beam is 200-800 keV. At present HIBP diagnostic complex for Uragan-2M is manufactured and tested for first step of stellarator operation. Energy of probing beam can arise up to 200 keV. Electrostatic analyzer of the secondary ions has energy resolution $\Delta E/E \sim 10^{-4}$. It is proposed a program of the electric potential profiles measurements in different regimes of stellarator operation, as well as plasma turbulence investigations.

Some publications of IPP NSC KIPT members:

1. G.G. Lesnyakov. Studies on magnetic surface structures and basic magnetic field properties in "ultimate" configurations of the ***l***=1, *m*=13 torsatron and the "Vint-20" torsatron: Preprint KhIPT 2012-2 – Kharkov: NSC KhIPT, 2012. - 30 p.
2. V.G.Kotenko. A special correcting winding for the l = 2 torsatron with split-type helical coils. Fusion Engineering and Design, **87** (2012) 118–123.

3. A. Zhezhera G. Deshko A.Komarov, L. Krupnik, A. Chmyga, S.Kozachek, S. Khrebtov **The Development of the Light Ion Injector for the Plasma Diagnostic System Based on Beam Emission Spectroscopy,** International Conference & School on Plasma Physics and Control Fusion and the Adjoint Workshop"Nano-and micro-sized structure in plasmas" 17-22 September, Alushta, 2012 Book of Abstracts, p.204.

Some of joint presentations at different conferences and joint publications:

1. V. E. Moiseenko, S. V. Chernitskiy, O. Ågren, and K. Noack "A fuel for sub-critical fast reactor" AIP Conf. Proc. **1442** (2012), pp. 132-136; doi:http://dx.doi.org/10.1063/1.4706860.
2. V. G. Kotenko, V. E. Moiseenko, and O. Ågren "Magnetic field of a combined plasma trap" AIP Conf. Proc. **1442** (2012), pp. 167-172; doi:http://dx.doi.org/10.1063/1.4706866.
3. O. Ågren, V. E. Moiseenko, K. Noack, and A. Hagnestål "Radial drift invariant in long-thin mirrors" AIP Conf. Proc. **1442** (2012), pp. 255-258; doi:http://dx.doi.org/10.1063/1.4706876.
4. V. E. Moiseenko and O. Ågren "Fusion neutron generation computations in a stellarator-mirror hybrid with neutral beam injection" AIP Conf. Proc. **1442** (2012), pp. 259-264; doi:http://dx.doi.org/10.1063/1.4706877.
5. O. Agren, V.E. Moiseenko, K. Noack, and A. Hagnestal "Radial drift invariant in long-thin mirrors" Eur. Phys. J. D (2012) **66**: 28, DOI: 10.1140/epjd/e2011-20477-4.
6. O. Ågren, V.E. Moiseenko, A. Hagnestål, K. Noack. Correcting winding for the l = 2 torsatron with split-type helical coils. Fusion "Comments on the power amplification factor of a driven subcritical system http://dx.doi.org/10.1016/j.anucene.2012.06.020
7. Toroidal plasma rotation measurements during sharp gas puffing and compact torus injection experiments in the STOR-M tokamak. (M.Dreval in collaboration with A. Hirose, C.Xiao, T. Onchi). Presented in Fusion Energy Conference 2012; submitted to PPCF.
8. Alfven Eigenmodes in the combined NBI/ECRH plasmas in TJ-IIA. (L Krupnik, in collaboration with A.V.Melnikov, K.Nagaoka, S.Yamamoto, E.Ascasibar, T.Ido, L.Eliseev, and others). Presented at 22th International Toki Conference (ITC-22), Toki-city, Gigu Japan, 19-22 November, 2012, P2-2.
9. A Lyssoivan, D Douai, R. Koch, J Ongena, V Philipps, F C Schüller, D Van Eester, T Wauters, T Blackman, V Bobkov, S Brezinsek, E de la Cal, F Durodié, E Gauthier, T Gerbaud, M Graham, S Jachmich, E Joffrin, A Kreter, V Kyrytsya, E Lerche, P Lomas, F Louche, M Maslov, M-L Mayoral, V Moiseenko, I Monakhov, I Pankratov, M K Paul, R A Pitts, V Plyusnin, G Sergienko, M Shimada, V L Vdovin and JET EFDA Contributors. Simulation of ITER full-field ICWC scenario in JET: RF physics aspects. PPCF, V**54** (2012) 074014.

10. L. Krupnik, A. Melnikov, L. Eliseev, A. Alonso, C. Hidalgo, R. Jimenez-Gomez, A. Chmyga, E. Ascasibar, T. Estrada, A. Komarov, A. Kozachek, A. Cappa, M. Liniers, S.E. Lysenko, V. Mavrin, M. Ochando, J.L. de Pablos, M. Pedrosa, S. Perfilov, A. Zhezhera, I. Pastor and TJ-II Team, Recent Results of the Electric Potential Profiles and Plasma Turbulence Study in TJ-II (review). 18^{th} International Stellarator/Heliotron Workshop & 10^{th} Asia Pacific Plasma Theory Conference 29/1-3/2 2-12 Australia. S7. 2Ex2.

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13. A.A. Belokurov, L.G. Ashkinazi, A.D. Komarov, V.A. Kornev, S.V. Krikunov, L.I. Krupnik, S.V. Lebedev, A.S.Tukachinsky, M.I. Vildjunis, N.A. Zhubr. Electric Field Dynamics Studies in TUMAN-3M Tokamak, International Conference & School on Plasma Physics and Control Fusion and the Adjoint Workshop"Nano-and micro-sized structure in plasmas" 17-22 September, Alushta, 2012 Book of Abstracts, p.58.

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15. A.V.Melnikov, K.Nagaoka, S.Yamamoto, E.Ascasibar, T.Ido, L.Eliseev,

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APPENDIX 4: TECHNICAL REPORT ON TJ-II ACTIVITIES IN 2012

TJ-II is a medium-size Heliac-type stellarator operating at low magnetic shear. The results achieved in the TJ-II stellarator during 2012 were obtained in plasmas created and heated by Electron Cyclotron Resonance Heating (ECRH) (2 x 300 kW gyrotrons, at 53.2 GHz, 2nd harmonic, X-mode polarisation) and Neutral Beam Injection (NBI). Two beams of 400 kW port-through (H0) power at 30 kV, were injected on TJ-II.

Recently the TJ-II research programme has been focussed in the understanding of the plasma flow dynamics in relationship with TJ-II confinement transitions. All the results have been obtained under Li coated wall conditions, which allows us to achieve density control reaching high density plasmas and transition to H−mode.

The dynamics of fluctuating electric field structures in the plasma edge, that display zonal flow-like features, has been studied. These structures have been shown to be global and affect particle transport dynamically. Their typical decay time of time has been found to be in agreement both with simulations of collisionless damping in the presence of ambient radial electric field and with neoclassical calculations. In low-density plasmas, the neo- classical viscosity is predicted to vanish, thus leaving these flows collisionaly undamped, which can explain its larger amplitude immediately before the confinement transition. The probability distribution of the measured turbulent momentum flux (Reynolds stress) shows events that could provide the observed acceleration or radial electric field excur- sions. However no clear cause-effect relationship was found with conditional average techniques. The temporal dynamics of the turbulence-flow interaction has been measured at the L-H transition in TJ-II plasmas.

Close to the L−H transition threshold conditions, the turbulence-flow interaction displays an oscillatory behaviour with a characteristic predator-prey relationship supporting the predator-prey theory model of the L-I-H transition. The spatial evolution of this oscillation-pattern shows both, radial outward and inward propagation velocities of the turbulence-flow front. The results show the need of approaching L-H transition studies within a 1−D spatiotemporal frame- work. The relevant turbulence scales involved in the energy transfer of the predator-prey process have been identified. In the I-phase, the turbulence is regulated mainly by the zonal-flow generation which effectively takes place at intermediate turbulence scales. As the plasma enters into the H-mode, additional mechanisms like turbulence decorrelation by mean sheared flow may become active affecting a broader range of turbulence scales. The interplay between transport, turbulence and zonal flows could explain the non-linear dependence of turbulent transport and plasma gradients.

The properties of fast ion confinement have also been investigated from both theoretical and experimental points of view, including the appearance of Alfven modes and the dynamics of the fast ions created by Neutral Beam Injection. TJ-II is a unique device for the studies of ECRH effect on AEs thanks its diagnostic capabilities and the flexible ECRH and NBI systems; recent experiments have shown that the chirping behaviour of AE modes is only observed with NBI and additional off-axis ECRH whereas continuous AE modes are observed with NBI heating.

APPENDIX 5: TECHNICAL REPORT ON HELIOTRON J ACTIVITIES IN 2012

Particle fuelling control, effects of the confinement configuration on fast ion confinement, bulk thermal confinement, MHD stability and edge fluctuation have been investigated in Heliotron J, a flexible helical-axis heliotron, with special regard to the optimization study of the helical system with a spatial magnetic-axis and a vacuum magnetic well. To attain the drift optimization of the L=1 helical-axis heliotron, the bumpiness control is essential to reduce the neoclassical transport (or the effective helical ripple). The experiments have been performed in several configurations. The Heliotron J activities in 2012 are summarized as follows:

1) Optimization of gas-fuelling scenario has been studied to examine the plasma confinement. Gas fuelling effects on plasma profile are discussed by comparing two fuelling methods, a short pulse H_2-beam fuelling with a supersonic molecular-beam injection (SMBI) technique and a high-intensity gas-puff fuelling (HIGP) with a conventional gas puff technique. The maximum plasma stored energy W_p was obtained after SMBI, which was about 20 % higher than that after HIGP in the NBI-only sustained plasma experiment. The core electron and ion temperatures for the SMBI case are higher than those in the HIGP case at the timing of maximum W_p. A peaked density profile is observed after SMBI, while it is flat or a slightly hollow for the case of HIGP. The effects of fuelling on plasma fluctuations and effectiveness of fuelling control for triggering of the L-H transitions were also studied.

2) Parallel flow velocity in Heliotron J plasmas is measured with a charge exchange recombination spectroscopy for three different toroidal mirror configurations; the high, standard and reversed mirror configurations. The mirror magnetic field configurations are established by changing bumpy component. In the plasma core, parallel flow velocities in the standard and reversed mirror configurations are 3-4 times as high as that in the high mirror configuration. The parallel flow velocity near the plasma center shows a negative dependence on the magnetic ripple strength. The NC parallel viscosity coefficients are estimated to investigate the damping force in the plateau regime and those profiles are hollow profiles. However, the effective parallel viscosity coefficient does not agree with the NC parallel viscosity in three mirror configurations.

3) Features of energetic-ion-driven MHD instabilities such as Alfvén eigenmodes (AEs) have been studied in three-dimensional magnetic configuration with low magnetic shear and low toroidal field period number that are characteristic of advanced helical plasmas. Comparison of experimental and numerical studies in Heliotron J with those in TJ-II indicates that the most unstable AE is global AE (GAE) in low magnetic shear configuration in spite of the iota and that the helicity-induced AE (HAE) is also the most unstable AE in the high iota configuration.

4) Second harmonic electron cyclotron current drive (ECCD) has been applied in Heliotron J to stabilize magnetohydrodynamic (MHD) modes in Heliotron J. Localized EC current driven at central region modifies the rotational transform profile, $\iota/2\pi$, leading to formation of a high magnetic shear. An energetic-ion-driven MHD mode of 80 kHz has been fully stabilized by counter-ECCD, and other modes of 90 kHz and 140 kHz have been stabilized by co-ECCD, indicating that both co-

and counter-ECCD are effective at stabilizing the energetic-ion-driven MHD modes. An experiment of scanning the EC driven current shows that there is a threshold in magnetic shear to stabilize the energetic-ion-driven MHD modes.

5) Nonlinear behavior of broad-band fluctuation and dynamical potential change, associated with energetic-ion-driven MHD phenomena, are observed around edge region in Heliotron J. Nonlinear phase relationship between the MHD and broad-band fluctuation is demonstrated as a result of bicoherence and envelope analyses applied to floating potential signals measured with multiple Langmuir probes in NBI heated plasmas. A structural change of potential profile synchronized with the cyclic MHD burst is also found. These experimental observations suggest that such MHD fluctuations can have influence on the confinement property of bulk plasma through nonlinear process and/or change of electric field structure.

6) Measurement of the density fluctuation was made using a beam emission spectroscopy. In order to optimize the sightlines, the numerical calculations are carried out to estimate the spatial resolution and the observation location. When a tangential neutral beam is used as diagnostic one, suitable sightlines from the newly installed diagnostic port are selected whose spatial resolution $\Delta\rho$ is less than $\pm$ 0.07 over the entire plasma region. Modification of the interference filter and the detection systems enables us to measure the radial profile of the density fluctuation. Several coherent modes were observed, which were excited by fast-ion-driven MHD instabilities and had different radial structure of the density fluctuation.

7) Generation and confinement of fast protons have been investigated experimentally using fast protons generated by ICRF minority heating. Strong vertical angle dependence of the energy spectra is found in the high bumpiness. The effective temperature of hydrogen is also dependent on the vertical angle. This result indicates the spatial change of fast protons is large in central heating in the high bumpiness as well as inner side heating in the medium bumpiness. In each angle, the effective temperature of fast protons is larger in the high bumpiness than in the medium bumpiness. A Monte-Carlo simulation of fast ions (protons) reproduces the high-energy tail up to 20 keV, which was measured only in the high bumpiness case. The better production and confinement of fast ions in the high bumpiness is reproduced in the Monte-Carlo calculation. The result is consistent with the fact that the bulk heating efficiency in the minority heating is better in the inner side heating case.

8) A perpendicular-view fast camera has been installed in Heliotron J to observe the filament behaviour of edge plasma turbulence across the last close flux surface. Supersonic molecular-beam injection (SMBI) intensively increases the edge H_α emission so that we can gain high imaging and shutter speed to capture the behaviour of fast propagating filaments. High-pass FFT filter on time dimension was adopted to extract the fluctuation component from the raw data on each pixel. The motion of the filament is clearly visible when we applied an amplitude threshold to identify the “blob” filament. A time-resolved 2D cross-correlation technique is also adopted to estimate the poloidal phase velocity of turbulence from camera data. An interesting behaviour of the filament motion has been

identified with this method in which the direction of filament motion was found to be reversed suddenly at 100μs after SMBI pulse.

9) Overdense plasmas have been produced using a 2.45GHz ECH at low magnetic field of around 0.1T. The line-averaged electron density reached maximum at 75 % of the electron cyclotron resonance magnetic field. The accessible density is 10 times as high as the O-mode cut-off in Neon plasmas, and it is 4 times as high as that in deuterium plasmas. In Neon plasmas, the ECH power is deposited over the confinement region under on-axis heating condition, while it is deposited around the magnetic axis under off-axis heating conditions, indicating Doppler shifted resonance heating.

10) A hybrid probe system (Langmuir probes and magnetic probes), a fast camera and a gas puff were installed at the same toroidal section to study peripheral plasma turbulence/fluctuation. The fast camera views the location of the probe system so that the probe system can yield the time evolution of the turbulence/fluctuation, while the camera images the spatial profile of those. The gas puff at the same toroidal section was used to control the plasma density and simultaneous gas puff imaging technique. Using this combined system, a blob (filamentary structure) associated with the magnetic fluctuation was found. The other fluctuation without magnetic fluctuation was also observed at another experiment.

11) A new Nd:YAG Thomson scattering system is under development to study of the improved confinement physics. Two high repetition Nd:YAG lasers of over 550mJ at 50Hz realize the measurement of the time evolution of the plasma profile with around 10ms intervals. The laser beam is injected obliquely from outer downward side to inner upward side. The obliquely backscattered light is detected using the large concave mirror (D=800mm) and the optical fiber bundles in the staircase pattern. The laser transmission optics to the plasma is well optimized to achieve the higher signal to noise ratio of the scattered light. The system has 25 spatial points with around 10mm resolution. The data acquisition is performed by a VME-based system which is operated by the CINOS.

12) To deepen the understanding of the configuration effects on confinement, the following new diagnostics are designed and/or installed; an improved CXRS system for the measurement of ion temperature and toroidal rotation, far-infrared interferometer for density profile, upgraded Langmuir probes, magnetic probes and fluctuation measurement by using an SX tomography and a reflectometer for density fluctuation. Advanced wall conditioning method using a Li coating is under development.

Minutes of 41st Stellarator-Heliotron Executive Committee Meeting

9th October, 2012

12:40 – 14:40

Room 202A, Hilton San Diego Bayfront Hotel,

San Diego, USA

Attendees

Australia	B.Blackwell
EU	R.Wolf
	C.Hidalgo
Japan	O.Motojima (chairperson)
	A.Komori
	H.Yamada (secretary)
USA	M.C.Zarnstorff (vice chairperson)
	D.T.Anderson

RFP ExCo member

Italy	P.Martin
Japan	S.Masamune
USA	J.Sarff

Observer

IEA	C.Pottinger
Sweden	M.Tendler
Japan	M.Yokoyama (clerk)

Agenda

1) Approval of agenda

2) Approval of minutes of 40th Stellarator-Heliotron (S-H) ExCo meeting

3) Confirmation of membership of S-H ExCo

4) Chairmanship of S-H ExCo

5) 19th International Stellarator-Heliotron Workshop 2013 jointly with RFP workshop

6) Status of domestic activities and international collaborations

7) Development of S-H working groups

8) Miscellaneous and final remarks

Meeting was opened by O.Motojima. He welcomed all participants to the 41st Stellarator-Heliotron Executive Committee (S-H-ExCo) meeting. The participants were introduced. This time, we invited IEA-IA RFP ExCo members to discuss on joint workshop in 2013. Professor M.Tendler (Royal Institute of Technology, Sweden) was asked to attend since he is a specialist of RFP. Ms.C.Pottinger (IEA) was also introduced. It was confirmed that a quorum was satisfied.

1. Approval of Agenda

The proposed agenda was approved.

2. Approval of minutes of the 40th S-H ExCo meeting

The minutes were approved as they are.

3. Chairmanship of S-H ExCo (the order of the agenda was changed)

Motojima: I have been happy to serve as a chairman for several years. But, I am now the DG of ITER organization. Time has been coming to ask you to select the new chairman of this ExCo. Any proposals?

Hidalgo: I read through minutes of the last ExCo, and it is quite obvious that the general consensus is to select new chairman from LHD group, keeping in mind its leading role in our community.

Anderson: This is correct.

Zarnstorff: I second. “Somebody from LHD” should be decided.

Wolf: I also fully agree with this proposal.

Anderson: Prof.Komori is a natural choice.

Motojima: My next duty is to confirm Prof.Komori’s will.

Komori: I will accept. It’s my pleasure to serve as the chairman of this ExCo.

Motojima: It is unanimously agreed. Formal agreement from IEA is also obtained.

Komori: Over the next few years, LHD will complete to set up its closed divertor. We expect improved confinement through advanced control of the edge plasma. Based on these results and support from other helical devices, the advent of the W7-X, computer simulation studies, progress of ITER operation in the next decade will make strong case to fusion society for helical DEMO. I'm counting all of your strong participation and support as we face these challenges together.

4. Confirmation of membership of S-H ExCo

Komori: Coming back to the confirmation of this ExCo.

Yamada: Please see a member list.

Komori: Japan proposes, instead Prof.Motojima, Prof.Yamada will fully join this ExCo as a member.

Yamada: We would like to appoint Yokoyama-san as a secretary. I ask him to take over.

Yamada: I have to point out that Russian colleagues have not had any contacts for these two years. We would like to communicate how to encourage them, how to deal with this situation. Ukraine members have kept communications with us, although they, unfortunately, cannot come this time. I have not received any responses from Russian members.

Pottinger: We have a same problem in FPCC. Members of ROSATOM, because it is the state cooperation, can no longer travel abroad unless they have agreement from the ministry of foreign affairs. The request must first go to MFA, and then MFA contacts ROSATOM, and then they can attend the meeting. They have no authority otherwise.

Yamada: It is better to have communications with them, although they cannot attend the meeting. Do you have any Russian colleagues, who you have had contact these days?

Zarnstorff: Certainly Ioffe group. Also, we have contact with Kurchatov.

Yamada: Are they interested in S-H studies?

Zarnstorff: Kurchatov still continues some theoretical optimization study.

Wolf: I could ask Dr.F.Wagner. Now he is in Ioffe institute.

Zarnstorff: Director of Kurchatov (Dr.Kuteev) is here in IAEA-FEC. We may ask him.

Tendler: They also have problems to get the visa. This is exactly a procedure problem.

Hidalgo: Just for clarification, have you received any e-mails from them?

Yamada; Never in these two years.

Zarnstorff: There are a number of people here (IAEA-FEC) from Ioffe.

Tendler: Kurchatov belongs to ROSATOM, and Ioffe to Academy of Science. They are much different.

Motojima: Are there any information on whether General Physics Institute has S-H activity?

Tendler: I can ask Academy of Science.

Yamada: Prof.Tendler kindly contacts Academy of Science. That means Ioffe.

Tendler: Prokhorov Institute also belongs to academy.

Yamada: Do we have other channel to Kurchatov?

Hidalgo: We have some contacts.

Zarnstorff: We have some e-mail discussions with Kurchatov.

Yamada: Who will contact with them as a representative of this ExCo?

Zarnstorff: I will do.

Yamada: Please promote them to discuss in Russia. Then, we would like to promote them to contact with ROSATOM for a membership of this ExCo.

5. 19th International Stellarator-Heliotron Workshop 2013 jointly with RFP workshop

Komori: We must decide date and chairperson of the program committee.

Yamada: We have already decided to have a next workshop in Padova. Dr.Martin kindly accepted our proposal, I have to mention this is originally Dr.Klinger's idea, and Dr.Zarnstorff supported this idea. At this ExCo, we would like to select some options for the date, and also appoint the chairman of the international program committee. Dr.Martin prepared some materials. He will explain some background and provisional preparation.

Martin: In the last 2-3 years, collaborations between RFP and S-H community have been growing, which make this joint WS proposal natural. We talk to each other, share views and results. Prof.Komori is also a member of RFP ExCo. First thing, we started to find a venue. "Centro Cultural San Gaetano" would be preferable solution, in downtown Padova. There are many hotels in walking distance. This is a public structure, and we expect that the cost should be reasonable. This venue has a very large underground meeting hall, that can be organized as two halls, ex., one larger for S-H, one smaller for RFP. I just like to point out that the 234 people is the maximum capacity. If we plan to have much larger attendee, this solution cannot be possible.
Sarff: maybe 50 for RFP. In Padova, maybe a bit more.

Blackwell: In the last ISHW in Australia, we had 126 registrants, but it was a joint WS. We probably had about 100 S-H registrants.

Anderson: That was also the case for Madison meeting.

Zarnstorff: As for Princeton meeting, it was also about 120 registrants.

Yamada: In our case (Japan, 2007), very large, more than 200.

Martin: So, we RFP at most 80, S-H can think of order of 150.

Zarnstorff: We should try to avoid parallel sessions.

Martin: By the way, RFP WS is short, 2-3 days. Yours is typically 5 days, according to Prof.Yamada. About the local organizing committee, I started to set up it in Padova. I have Dr.Terranova in mind as the chair. It seems to be that the venue is still open in autumn in 2013.

Yamada: Let's discuss about timeframe. We have many meetings in autumn. Original proposal is in mid-September. The most serious constraint is the IPP Fachabeirat. It is scheduled on 23-25, September. Also, in the 1st week in October, we will have H-mode WS in Japan, and Princeton will host the other meeting.

Martin: From our side, please give us some options. The hotel prices may be a bit high in September, and weather-wise, all these 3 months should be fine.

After some discussions, the following 4 options are nominated.

(1) 21-25, October, (2) 14-18 October, (3) 9-13 September, and (4) 7-11 October.

Dr. Martin will contact the venue with these options.

(postscript) After follow-up communication among ExCo members, the date for the joint workshop was unanimously agreed (on 30 October, 2012) to be "16 to 20 September, 2013".

Komori: Then, let us appoint the chairman of the program committee.

Zarnstorff: That should be Dr.Blackwell from S-H side according to the order.

Yamada: I do not have a single recommendation. Dr.Blackwell is a strong candidate because he has an experience of joint workshop last time and if we see the order, Australian representative is quite natural. Nonetheless I would like to say that this joint arrangement with RFP is Klinger's idea. Thus, he can be a candidate.

Wolf: He has a lot of other duties. I'm not so sure whether he can accept. Have you talked with him?

Yamada: No, I just respect his idea.

Martin: I think we can share the role, the one from RFP and the one from S-H. I would be happy in the organization, but for me, it is better to overlook everything, and for the program committee, I would like to appoint other person in my mind.

Komori: Dr.Blackwell, could you accept?

Blackwell: Sure.

Martin: I will ask Maria Ester. We will meet tomorrow at RFP ExCo.

Zarnstorff: We usually send one person to program committee from each country.

Yamada: We will send a recommendation from each country to Dr.Blackwell.

6. Status of domestic activities and international collaborations

USA

Zarnstorff: The present situation in the US is complicated and uncertain because divided issues are still not resolved. Basically congress has put off making decisions on the budget basically until March by passing what is called a continuing resolution which means that they continue with the budget of last year. There is a debate going on how to fund the ITER contribution. The consequence of what they have done is that they are neither providing the needed moneys to ITER on the other hand this continuation, the way it is being interpreted they are reducing the size of the non-ITER program by what would have been the ITER contribution. So the domestic program is being reduced by about 50 million dollars per year that would have been the ITER increase. At the moment we have indecision and there is a substantial risk that this indecision will continue through the rest of the year. In the meantime there is a FESAC panel that has been formed to prioritize and identify what are the priorities for the domestic program. This panel will report somewhere in the range of December to February. And there are signs of their interest in stellarators, but we do not actually know what they will actually write for their report. We do not actually know what they are doing or where they are headed exactly. So I would say at the moment that things are highly uncertain. There was a competition that we all submitted proposals on international collaboration this year. Because of this uncertainty the date in which they announce the results has been pushed back to March. So they will not even decide things at that level until after the budget gets resolved. There will be another competition which will exclusively involve stellarators this coming year. But exactly when that is going to be held also get caught up in the uncertainty.

Pottinger: And how would the US elections affect that?

Zarnstorff: We all think that it is likely that they will affect it, and even the direction that it will affect is not certain. It was the elections four years ago; congress came back from after the election. The lame duck congress, the congress that was completing their term, let's say. Lame duck is a colloquialism in the US. So the congress that was completing their term basically did not do anything on the budget when they came back. The new congress when they came in decided there was not any purpose in spending too much time on the ongoing fiscal year that was partially completed so they decided not to bother and just work on the coming year and so that led to the indecision being continued through the end of the year.

Anderson: There is potentially an even bigger problem which is called sequestration. Because the budget committee two years ago did not solve the problems they put in place an automatic budget cut of 8.4 or 8.6 % on all the domestic programs, to be effective January 1st. So if they do nothing these cuts will be made.

Zarnstorff: At the moment we have 3 budgets on the table. The President's budget which proposed to increase the ITER contribution by only 50 million, but did that in a fixed overall fusion funding so the domestic program was reduced by 50 million. The House budget (which has been passed by the house) actually increased the ITER budget by 75 million and kept the domestic flat which was actually pretty hopeful. The Senate budget, however, went with president's budget. Two budgets need to be resolved to go forward. There are signs that it might come close to house budget, we are hopeful but that may not be right. That is partly why we are disappointed that the house budget which has been passed has not being taken up. It is a time of great frustration and confusion. There are a lot of political tension between the parties, between the different houses of congress, between the congress and the executive branch, so it is hard to say where it is going to go.

Pottinger: I think the real problem in the US is that there is a disconnection between the strategic energy priorities and the budget process.

Zarnstorff: It's partly because of our energy situation. The cost of natural gas is extremely low, and closing coal mines because it cannot afford.

Spain

Hidalgo: Crisis is affecting our community, mainly to the future of the next generation. Fusion is a very unique situation in Spain, the international collaboration; ITER and W7-X are driving force. But, number of positions for young scientists is significantly reduced. We might think about to emphasize young scientists' mobility, postdoc positions in different labs.

Motojima: Yes, the education is very important.

Anderson: Closing MIT is a very big impact.

Sarff: Alcator C-mod is the most visible. But, in last few years, high-temperature plasma research has been significantly reduced in all universities in US universities. University community has been really depressed.

Motojima: Important point from IO side, young generation engineers are extending their career in IO. They are brought up, and these human resources are carefully treated and kept to next-step DEMO. IO will keep them even after design phase and "sell" them with "high price" to other members. People who got experiences in IO will be highly evaluated. This is closely linked to education.

Germany

Wolf: We have just produced the roadmap the EU Commission asked for, what are the priorities for the next framework program till 2020. In Germany, we are strongly affected by our energy policy, energy system to shutdown fission power plant till 2022. This was a political decision. Now, the facts have been popping up, it costs a lot of money. Electricity price has been increasing something like 10-15% per year. This cannot go forever, a question of time; we would start to realize technical problems.

Within German research system, we are in Max-Planck society, funded by Helmholtz Association, where the energy research budgets have been increased to solve scientific issues. Fusion is not a short-term solution, and it is now proposed and basically agreed that the fusion budget to be cut in the next program starting in 2014. This is basically done by moving parts of fusion research to more general energy research program. In some sense, this is not a real reduction of funding, but the shifting to other program. But this will have a big significant impact on the fusion program.

Wendelstein 7-X is the top of the priority in German fusion program, which was a statement made by government. Some conflicts with European fusion since ITER is the top priority there, and there is an on-going question about European contribution to W7-X. Coming to the international collaboration, we have many collaboration partners. US contribution, (e.g. trim coils) is going very well. Spanish and Japanese colleagues as well. We are planning to install the program committee for W7-X for the commissioning and first phase of experiment. W7-X assembly will be completed till 2014. The remaining risks of the assembly are the in-vessel components, ,superconducting current leads, and installations in the periphery of W7-X.

Yamada: As a science advisor to the MEXT, I surveyed effects of Fukushima on fusion research in foreign countries. I have found the newspaper, Die Zeit, which was issued in last June or July, entitled by "fascination has gone". That article said IPP made a public opinion survey on fusion and it would be published in a couple weeks. I think it has been published. Do you know some information on this?

Wolf: I will send it to you. According to the official report by government, fusion is an important option for future energy, beyond 2050. In European roadmap discussion, there was a big discussion on how much specific statements one should make regarding DEMO to liberate electricity.

Japan

Yamada: Let me make a brief report from LHD. We made a major modification to accommodate closed divertor system. We had a plan to start the experimental campaign one month ago, but we had a helium leak problem in the cryostat. We could fix it immediately, but we had to stop the cooling process. We lost one month. Then, the experimental campaign will start next week. It is quite pity that we cannot report initial results of divertor experiment. It will come.

Australia

Blackwell: Joint ISHW/APPTC was very successful (apart from the weather): 126 registrations, 64 Oral, 61 posters, and 19 papers submitted to PPCF. Politically, we have a carbon tax, electricity prices have been going up 15%, because there is an incentive for companies to invest for infrastructure. We are funded under facility scheme not from energy issues. We also have an election next year, and we will have a funding gap of 18 months. Approximately 33 national facilities are competing 30M$/year holding money. Machine is in the final year of upgrade process. We installed 2x200kW supplier, cooled antenna and multi-channel interferometer. We have revised the strategic plan for fusion, to be presented to government in a month.

Pottinger: What's the time frame for revised fusion strategic plan?

Blackwell: we are looking at 5-10-year timeframe. We are talking to the energy minister. Election is coming up. We continue to make a noise, and we hope they will include fusion in a long-term energy plan.

Pottiner: What are the main lines of the strategic plan?

Blackwell: The capability to attract students, postdocs. It has to be some visible outcome, at the moment, development of diagnostics to ITER's uncommitted diagnostics. Several small diagnostics have not signed. We have a small number of successful mid-career postdoc positions.

7. Development of Stellarator-Heliotron working groups

Yokoyama: We marked successfully 10th CWGM, held in June this year in Greifswald. On this occasion, Prof.Yamada made a memorial talk to look back the role of CWGM, providing comprehensive understanding, through the activities like joint experiment, database, benchmarking and joint papers. Then, through these activities, we successfully export our 3D physics to tokamak community through the ITPA. In the 10th CWGM, we launched the interaction between physics and power plant design through this comprehensive understanding. How the physics understanding can be imported to power plant design. We could formulate work plans and targets for 2012-2013. In this IAEA-FEC, we successfully send some joint papers from several devices. Wide range of collaborations has been practically going on. CWGM has been playing a great role to encourage younger generation to lead topical sessions, and joint papers etc. Lastly, just for advertisement, ITC22, "Cross-Validation of Experiment and Modeling for Fusion and

Astrophysical Plasmas", would be the natural platform for joint activities, we have submitted our joint papers

Hidalgo: It is very important for S-H community to be more active in ITPA activity. Connections between ITPA and CWGM would enhance our scientific credibility.

8. Miscellaneous and final remarks

Next ExCo will be held in Padova during ISHW/RFP joint workshop. Closing remarks by Prof.Komori.