ITPA Topical Physics Group on "Integrated Operation Scenarios"
Report of Activities in the period of July 2010 – December 2011

S. Ide, G. Sips and J. Snipes, December 2011

The general scope of the "Integrated Operation Scenarios (IOS)" topical group (the TG) is to contribute to establishing operational scenarios in burning plasma experiments, especially, candidate scenarios in ITER, including standard inductive operation, Hybrid operation and steady state operation.

High priority research topics in 2010 – 2011

Following issues have been centrally discussed in this group both through experiments on machines, tokamaks and stellarators, and modelling.

1. ITER scenario development:
   - Demonstration of the ITER standard scenario.
   - Assessment of the ITER ramp-down scenario.
   - Assessment of the access conditions for advanced scenarios (advanced inductive and steady-state).
   - Development of advanced scenarios.
2. Assessment of heating and current drive actuators:
   - Assessment of actuators and heating mix.
3. Integrated control:
   - Development and assessment of integrated control scheme both in experiment and modelling.

TG Meetings

The TG had three meetings in the period:

The 5th IOS TG meeting:
Seoul University, Seoul, Korea, 18th – 21st October 2010 37 participant

The 6th IOS TG meeting:
Culham CFR, Culham, UK, 11th – 14th April 2011, 34 participants (3 participated remotely from US, IO and Korea)

The 7th IOS TG meeting:
Kyoto University, Kyoto, Japan, 18th – 21st October 2011, 45 participants (8 participated remotely from US and EU)

In these meetings, the progress on the related research was reported and discussions on future issues and coordination were held. Also, ITER research needs and it's status, status and progress in ITER program (especially hardware design) were reported from the IO.

The TG acknowledges the effort of the local organizers to hold these meetings.

Summary of the activities

Summary of the activities during the period in areas of the group's focus are summarized as follow. It is noted that details of discussions can be found in the minutes of each meetings.

Joint experiments (JE)

The following experiments were proposed from the IOS TG for 2010 and 2011.

- IOS-1.1: ITER demo, at q_{95}=3, β_N=1.8, n≤0.85n_{GW}
- IOS-1.2: Study seeding effects
- IOS-2.2: Ramp-down from q_{95}=3 (closed in 2010)
- IOS-2.3: X2-breakdown assist after application of U_{loop}
- IOS-3.1: Beta limit for AT with ITER recommended q-profile.
- IOS-3.2: Define access conditions to get to SS
- IOS-4.1: Access conditions for hybrid with ITER-relevant restrictions
- IOS-4.2: ρ* dependence on transport and stability in hybrid scenarios
- IOS-5.2: Maintaining ICRH Coupling in expected ITER regime
- IOS-5.3: Assessment of lower hybrid current drive at high density for extrapolation to ITER advanced scenarios
- IOS-6.1: Modulation of actuators to qualify real-time profile control methods for hybrid and steady state scenarios (closed in 2011)
- IOS-6.2: li controller (Ip ramp) with primary voltage / additional heating (closed in 2010)
- IOS-6.3: Control of experimentally simulated burning state

These joint experiments are summarized in another document (JE_Summary11_IOS). Details are referred to the document.

ITER scenario development

Development experiments of ITER operational scenarios have been intensively done within JEs:

- Standard H-mode operation (IOS-1.x)
  - IOS-1.1: Demonstration of Standard H-mode
  - IOS-1.2: Study seeding effect
- Advanced Inductive operation (IOS-4.x)
  - IOS-4.1: Access conditions for hybrid with ITER-relevant restrictions
  - IOS-4.2: ρ* dependence on transport and stability in hybrid scenarios
  - IOS-4.3: Collisionality scaling of advanced inductive plasmas
- Steady-state operation (IOS-3.x)
  - IOS-3.1: Beta limit for AT with ITER recommended q-profile.
  - IOS-3.2: Define access conditions to get to SS

Also outside JEs, scenario developments have been carried out, such as scenario optimization of advanced inductive and steady-state operations in various machines.

Heating and current drive actuators

Two JEs are on going in this area:

- IOS-5.2: Maintaining ICRH Coupling in expected ITER regime
- IOS-5.3: Assessment of lower hybrid current drive at high density for

extrapolation to ITER advanced scenarios

Assessments of ITER actuators have been carried out;

EC system: optimization of launching parameters (injection angle)

NB system: effect of filed pitch, beam energy

It was found that more off-axis ECCD could be possible, with some tradeoff, by modifying injection angles of both the equatorial and the steering mirror launchers. In this area, there were frequent reports of status/update of the actuators from the IO, and of activities in side the IO. Compatibilities of the results of these assessments with the engineering constraints should be examined in the next step.

Integrated control

Three JEs in this area:

IOS-6.1: Modulation of actuators to qualify real-time profile control methods for hybrid and steady state ⇒ closed in 2011

IOS-6.2: li controller (Ip ramp) with primary voltage / additional heating ⇒ closed in 2010

IOS-6.3: Control of experimentally simulated burning state

Burn control is an important issue in this group. This JE should be reinforced with help of the modeling activity (IOS-JA8, see below).

The Integrated Plasma Control Working Group (IPCWG) was established pan-TGs. The ITPA IPCWG will determine the physics requirements of the actuators and diagnostics of the ITER Plasma Control System (PCS) to permit the PCS to carry out its control functions and to meet the goals of the ITER reference scenarios. There is participation from the IOS. The latest status has been reported at each meeting. We have had discussion to support the IPCWG activity.

Modeling

Importance and demand of modeling is increasing in many areas. There are many issues in modeling within our group. We have been trying to organize these activities similar to JEs. For that specific issues have been selected and following activities have launched:

IOS-JA1: Modeling ITER-like discharges in DIII-D, JET, AUG, C-Mod, etc,

IOS-JA2: ITER rampdown simulations

IOS-JA3: Hybrid benchmark ⇒ almost closed

IOS-JA4: Steady state benchmark ⇒ almost closed

IOS-JA5: Rampup of ITER Hybrid and Steady State scenarios

IOS-JA6: IC Benchmarking

IOS-JA7: Steady State exploration

IOS-JA8: Burn control simulation

IOS-JA9: Optimisation of Operational Space for Long pulse Scenarios

IOS-JA10: Scenario modeling for low- and non-activation early operation of ITER

IOS-JA1: Modeling of ramp-up discharges in various machines (Alcator C-Mod, ASDEX-U, DIII-D, JET Tore Supra) has been yet continued in collaboration with the Transport and Confinement TG. Various transport models (Coppi-Tang,

empirical Bohm/gyro-Bohm, CDBM, GLF23, MMM08, scaling based models) in various codes (CRONOS, JETTO, TASK, TRANSP, TSC) have been benchmarked with the demonstration discharges. Still more studies would be necessary to find a decent transport model for ramp-up scenario development.
IOS-JA2: Modeling of the ramp-down phase has been also carried out. Impact of H-L back transition has been studied. More experimental data to benchmark modeling would be necessary.
IOS-JA3, 4: These activities are almost closed. New data, if any, will be added into the archive.
IOS-JA5: This has not produced a certain result yet. More input from experiments would be required. Also more participants will be welcome.
IOS-JA6: Nuclear Fusion paper of the IAEA FEC 2010 is now accepted. Further study for poor absorption case, an H plasma with He^3 minority at half current (7.5 MA) and half magnetic field (2.65 T), would be necessary.
IOS-JA-7: It would be necessary to formulate a target steady-state case. Actuator study could be separated after review of the actuator benchmark in the coming meeting.
IOS-JA8: The objective has been set. We'll start from entry into and exit from H-mode. We'll put focus on this activity in 2012.
IOS-JA9: This JA is to explore long pulse DT H-mode operation. Though this is rather a new activity, quite a large number of contributions have been obtained.
IOS-JA10: Investigation of scenarios in H, He and DD plasmas have been initiated. We'll put more focus on this activity in 2012.

Also outside these joint activities, efforts on scenario modeling have been done. Modeling of ITER hybrid and steady-state operations is also underway with several contributors. Stability boundaries for steady-state target were investigated as well. For further development of plasmas in these areas, more established transport models would be required.

Presentations and publications

Seven papers were proposed from the TG and presented at the 23rd IAEA Fusion Energy Conference:

"Benchmarking ICRF simulations for ITER"
R. Budny, et.al.

"Current ramps in tokamaks : from present experiments to ITER scenarios"
F. Imbeaux, et.al.

"Development of Advanced Inductive Scenarios for ITER"
T. Luce, et.al.

"On Maximizing the ICRF Antenna Loading for ITER plasmas "
M.-L. Mayoral, et.al.

"Integrated Modeling of Steady-state Scenarios and Heating and Current Drive Mixes for ITER"
M. Murakami, et.al.

"ECRH assisted plasma start-up with toroidally inclined launch: multi- machine comparison and perspectives for ITER"

J. Stober, et.al.
"Experimental Investigation And Validation of Neutral Beam Current Drive for ITER through ITPA Joint Experiments"
T. Suzuki, et.al.
Also following three papers accepted for the FEC are closely related to the group activity:
"Development of the ITER Baseline Inductive Scenario"
T. Casper, et.al.
"Development of ITER Advanced Hybrid and Steady State Scenarios"
C. E. Kessel, et.al.
"Plasma Models for Real-Time Control of Advanced Tokamak Scenarios"
D. Moreau, et.al.
Most of these have already been published in Nuclear Fusion.

Five papers will be proposed from the TG to the 24th IAEA Fusion Energy Conference (titles are tentative):
"ITER standard H-mode demonstration (IOS-1.1)"
A. Sips, et.al.
"Study of seeding effect (IOS-1.2)"
A. Kallenbach, et.al.
"LHCD at high density (IOS-5.3)"
A. Tuccillo, et.al.
"Integrated profile control (IOS-6.1)"
D. Moreau, et.al.
"Modeling of low activation scenarios (IOS-JA10)"
T. Casper, et.al.

High priority research items for 2012

For 2012, the IOS-TG has contributions to the following for the high priority research items for the TG, including response to ITER's research needs.

- JE on ITER scenario development:
  - ITER baseline (IOS-1.1, IOS-1.2), including fast current ramp-up
  - Actuators: Coupling issues (IOS-5.2, IOS-5.3)
- Modelling: Continue on all Joint Activities, but focus on:
  - Burn control simulations, entry into H-mode & H - L transition
  - Optimization (exploitation) of operating space for long-pulse scenarios
  - Modelling for H, He and low activation DD operation (including available heating scenarios)
- Plasma Control
  - Support the Integrated Plasma Control Working Group (ITER-IO)
  - Experiments and modelling of kinetic (profile) control
- Actuators
  - EC launch options and implications for ITER scenarios
- Publication and documentation

- Encourage summary and publication from JEs
- IAEA FEC 2012 contributions (5 proposals)

The 8th meeting of the TG will be held in Madrid, Spain, 16th – 19th April 2012.
The 9th meeting of the TG will be held in San Diego, US, 15th – 18th October 2012 (temporal schedule).

Publication list 2008-2011

2008:

"Integrated modeling of steady-state scenarios for ITER: physics and computational challenges", G. Giruzzi et al., Proc. of 22nd IAEA Fusion Energy Conference (Geneva, Switzerland, Oct. 13-18, 2008), IT/P6-4.
http://www-naweb.iaea.org/napc/physics/FEC/FEC2008/papers/it_p6-4.pdf

"Critical threshold behavior for steady-state Internal Transport Barriers in burning plasmas", J. Garcia et al., Phys. Rev. Lett. 100, 255004 (2008).
http://prl.aps.org/pdf/PRL/v100/i25/e255004

"Integrated modeling of ITER steady-state scenarios", J. Garcia et al., Plasma Phys. Contr. Fusion 50, 124032 (2008).
http://iopscience.iop.org/0741-3335/50/12/124032/pdf/0741-3335_50_12_124032.pdf

"Off-axis current drive and real-time control of current profile in JT-60U", T. Suzuki, Nucl. Fusion, 48, 045002, (2008)

"A two-time-scale dynamic-model approach for magnetic and kinetic profile control in advanced tokamak scenarios on JET", D. Moreau, Nucl. Fusion, 48, 106001 (2008)

"ITER shape controller and transport simulations", T.A. Casper, FED, 83, 552-556 (2008)

"JET confinement studies and their scaling to high β N, ITER scenarios", D C McDonald, et.al., Plasma Phys. Control. Fusion 50 124013 (2008)

"ITER startup studies in the DIII-D tokamak", G.L. Jackson, st.al., Nucl. Fusion 48 125002 (2008)

"Design and simulation of extremum-seeking open-loop optimal control of current profile in the DIII-D tokamak", Y Ou, et.al., Plasma Phys. Control. Fusion 50 115001 (2008)

"Influence of toroidal rotation on transport and stability in hybrid scenario plasmas in DIII-D", P.A. Politzer, et.al., Nucl. Fusion 48 075001 (2008)

"Comparison of radiating divertor behaviour in single-null and double-null plasmas in DIII-D", T.W. Petrie, et.al., Nucl. Fusion 48 045010 (2008)

"Beta limit due to m/n = 2/1 tearing mode onset in the DIII-D hybrid scenario", R.J. La Haye, et.al., Nucl. Fusion 48 015005 (2008)

"Benchmarking of codes for electron cyclotron heating and electron cyclotron current drive under ITER conditions", R. Prater, et.al., Nucl. Fusion 48 035006 (2008)

Fusion Science and Technology

"Prospects for Off-Axis Neutral Beam Current Drive in the DIII-D Tokamak", M. Murakami, et.al., Fusion Sci. and Tech., 54 994-1002 (2008)

"The influence of rotation on the β N threshold for the 2/1 neoclassical tearing mode in DIII-D", R. J. Buttery, et.al., Phys. Plasmas 15, 056115 (2008)

"Assessment of current drive efficiency and the synergetic effect for ECCD and LHCD and the possibility of long pulse operation in ITER", A. Polevoi, et al., Nucl. Fusion 48, 015002 (2008)

"Assessment of Plasma Parameters for Low Activation Phase of ITER Operation", A.R. Polevoi, et al., Proc. of 22nd IAEA Fusion Energy Conference (Geneva, Switzerland, Oct. 13-18, 2008), IT/P6-6, (Nucl. Fusion, accepted for publication)

2009:
"Development of ITER 15 MA ELMy H-mode inductive scenario", C. Kessel, et al., Nucl. Fusion, **49** (2009) 085034.

"Experimental studies of ITER demonstration discharges", A.C.C. Sips, et al., Nuclear Fusion 49, 085015 (2009)

"Development of advanced operation scenarios in weak magnetic-shear regime on JT-60U", T. Suzuki, et al., Nucl. Fusion, 49, 085003, (2009)

"Development of reversed shear plasmas with high bootstrap current fraction towards reactor relevant regime in JT-60U", Y. Sakamotoet al., Nucl. Fusion, 49, 095017 (2009)

"Long-pulse hybrid scenario development in JT-60U", N. Oyama, et al., Nucl. Fusion, 49, 065026, (2009)

"Lower Hybrid assisted plasma current ramp-up in ITER", S.H. Kim, Plasma Phys. and Cont. Fusion 51, 065020 (2009)

"Full tokamak discharge simulation of ITER by combining DINA-CH and CRONOS", S.H. Kim, Plasma Phys. and Cont. Fusion 51, 105007 (2009)

"Comprehensive control of resistive wall modes in DIII-D advanced tokamak plasmas", M. Okabayashi, et.al., Nucl. Fusion 49 125003 (2009)

"Simulating ITER plasma startup and rampdown scenarios in the DIII-D tokamak", G.L. Jackson, et.al., Nucl. Fusion 49 115027 (2009)

"Off-axis neutral beam current drive for advanced scenario development in DIII-D", M. Murakami, et.al., Nucl. Fusion 49 065031 (2009)

"Impurity behaviour under puff-and-pump radiating divertor conditions", T.W. Petrie, et.al., Nucl. Fusion 49 065013 (2009)

"Principal physics developments evaluated in the ITER design review", R.J. Hawryluk, et.al., Nucl. Fusion 49 065012 (2009)

"Non-inductive current drive and transport in high β N plasmas in JET", I. Voitsekhovitch, et.al., Nucl. Fusion 49 055026 (2009)

"Experimental vertical stability studies for ITER performance and design guidance", D.A. Humphreys, et.al., Nucl. Fusion 49 115003 (2009)

"Effect of resonant and non-resonant magnetic braking on error field tolerance in high beta plasmas", H. Reimerdes, et.al., Nucl. Fusion 49 115001 (2009)

"ECH pre-ionization and assisted startup in the fully superconducting KSTAR tokamak using second harmonic", Y.S. Bae, et.al., Nucl. Fusion 49 022001 (2009)

"Overview of the results on divertor heat loads in RMP controlled H-mode plasmas on DIII-D", M.W. Jakubowski, et.al., Nucl. Fusion 49 095013 (2009)

"Beam-ion confinement for different injection geometries", W W Heidbrink, et.al., Plasma Phys. Control. Fusion 51 125001 (2009)

"Simulations of KSTAR high performance steady state operation scenarios", Yong-Su Na, et.al., Nucl. Fusion 49 115018 (2009)

"Magnetic-Flux Pumping in High-Performance, Stationary Plasmas with Tearing Modes", C. C. Petty, et.al., Phys. Rev. Lett. 102, 045005 (2009)

"Validation of on- and off-axis neutral beam current drive against experiment in DIII-D", J. M. Park et al. Phys. Plasmas 16, 092508 (2009)

"Optimizing stability, transport, and divertor operation through plasma shaping for steady-state scenario development in DIII-D", C. T. Holcomb et al., Phys. Plasmas 16, 056116 (2009)

"Progress in physics and control of the resistive wall mode in advanced tokamaks", Yueqiang Liu, et.al., Phys. Plasmas 16, 056113 (2009)

"Recent results on the fuelling and control of plasmas by pellet injection, application to ITER", Bernard Pegourie, et al., Plasma Phys. Control. Fusion 51, 124023 (2009)

2010:
"Impact of heating and current drive mix on the ITER hybrid scenario", J. Citrin, Nucl. Fusion, 50, 115007 (2010)

"Demonstration of ITER operational scenarios on DIII-D", E.J. Doyle, 50, 075005 (2010).

"Absorption of lower hybrid waves in the scrape off layer of a diverted tokamak", G.M. Wallace, et al, Physics of Plasmas **17** (8) 082508 (2010).

"Development of Advanced Inductive Scenarios for ITER", T.C. Luce, et al., Proc. of 23rd IAEA Fusion Energy Conference (Daejon, Korea, 11-16 October 2010), ITR/1-5

"On Maximizing the ICRF Antenna Loading for ITER plasmas", ML. Mayoral, et al., Proc. of 23rd IAEA Fusion Energy Conference (Daejon, Korea, 11-16 October 2010), ITR/P1-11

"Development of ITER Advanced Hybrid and Steady State Scenarios", C.E. Kessel, et al., Proc. of 23rd IAEA Fusion Energy Conference (Daejon, Korea, 11-16 October 2010), ITR/P1-22

"Impact of the current profile evolution on tearing stability of ITER demonstration discharges in DIII-D", F. Turco and T.C. Luce, Nucl. Fusion 50 095010 (2010)

"Demonstration of ITER operational scenarios on DIII-D", E.J. Doyle, et.al., Nucl. Fusion 50 075005 (2010)

"Experimental simulation of ITER rampdown in DIII-D" P.A. Politzer, et.al., Nucl. Fusion 50 035011 (2010)

"Observation of ELM suppression in hybrid discharges using n = 3 magnetic perturbations on DIII-D" C.C. Petty, et.al., Nucl. Fusion 50 022002 (2010)

"On the roles of direct feedback and error field correction in stabilizing resistive-wall modes", Y. In, et.al., Nucl. Fusion 50 042001 (2010)

"Requirements for active resistive wall mode (RWM) feedback control", Y In, et.al., Plasma Phys. Control. Fusion 52 104004 (2010)

"On the roles of direct feedback and error field correction in stabilizing resistive-wall modes", Y. In, et.al., Nucl. Fusion 50 042001 (2010)

"Stabilization of the external kink and the resistive wall mode", M S Chu and M Okabayashi, Plasma Phys. Control. Fusion 52 123001 (2010)

"On the heating mix of ITER", F Wagner, et.al., Plasma Phys. Control. Fusion 52 124044 (2010)

"Plasma Initiation and Start-Up Studies in the DIII-D Tokamak with Second-Harmonic EC Assist", G. L. Jackson, et.al., Fusion Sci. and Tech., 57 27-40 (2010)

"Effect of Particle Transport on the Measured Electron Cyclotron Current Drive Profile at High Relative Power Density", C. C. Petty, et.al., Fusion Sci. and Tech., 57 10-18 (2010)

"Understanding and predicting the dynamics of tokamak discharges during startup and rampdown", G. L. Jackson, et.al., Phys. Plasmas 17, 056116 (2010)

"Iterated finite-orbit Monte Carlo simulations with full-wave fields for modeling tokamak ion cyclotron resonance frequency wave heating experiments", M. Choi, et.al., Phys. Plasmas 17, 056102 (2010)

2011:
"ECRH-assisted plasma start-up with toroidally inclined launch: multi-machine comparison and perspectives for ITER", J. Stober, et al., Nucl. Fusion, 51, 083031 (2011)
http://iopscience.iop.org/0029-5515/51/8/083031?fromSearchPage=true

"Current ramps in tokamaks: from present experiments to ITER scenarios", F. Imbeaux, et al., Nucl. Fusion 51 083026 (2011)
http://iopscience.iop.org/0029-5515/51/8/083026?fromSearchPage=true

"Experimental investigation and validation of neutral beam current drive for ITER through ITPA Joint Experiments", T. Suzuki, Nucl. Fusion, 51, 083020, (2011)

"Integrated modelling of steady-state scenarios and heating and current drive mixes for ITER", M. Murakami, Nucl. Fusion, 51, 103006 (2011).

"Plasma models for real-time control of advanced tokamak scenarios", D. Moreau, et al., Nucl. Fusion 51 063009 (2011)
http://iopscience.iop.org/0029-5515/51/6/063009?fromSearchPage=true

"Development of the ITER baseline inductive scenario", T. Casper, Nucl. Fusion, 51 accepted for publication (2011).

"Benchmarking ICRF simulations for ITER", R. Budny, et.al, Nucl. Fusion, 51 accepted for publication (2011).

"Advances on modelling of ITER scenarios: physics and computational challenges", G. GIRUZZI et al., Plasma Phys. Contr. Fusion 53, 124010 (2011).
http://iopscience.iop.org/0741-3335/53/12/124010/pdf/0741-3335_53_12_124010.pdf

"Effect of N2, Ne and Ar seeding on Alcator C-Mod H-mode confinement", M.L. Reinke, et al., J. Nucl. Mater. 415, S340-S344 (2011)

"High confinement/high radiated power H-mode experiments in Alcator C-Mod and consequences for International Thermonuclear Experimental Reactor (ITER) Q_{DT}=10 operation", A. Loarte, et al., Phys. Plasmas 18, 056105 (2011)

"Power requirements for superior H-mode confinement on Alcator C-Mod: experiments in support of ITER", J.W. Hughes, et al., Nucl. Fusion 51 083007 (2011).

"Lower Hybrid Current Drive at High Density in Alcator C-Mod", G. Wallace, et.al., Nucl. Fusion **51** (2011) 083032.

"Core transport properties in JT-60U and JET identity plasmas", X. Litaudon, et. at., Nucl. Fusion 51 073020 (2011)
http://iopscience.iop.org/0029-5515/51/7/073020?fromSearchPage=true

"Balancing current drive and heating in DIII-D high noninductive current fraction discharges through choice of the toroidal field", J.R. Ferron, et.al., Nucl. Fusion 51 113007 (2011)

"Noninductive plasma initiation and startup in the DIII-D tokamak", G.L. Jackson, et.al., Nucl. Fusion 51 083015 (2011)

"Results from radiating divertor experiments with RMP ELM suppression and mitigation", T.W. Petrie, et.al., Nucl. Fusion 51 073003 (2011)

"Optimization of the safety factor profile for high noninductive current fraction discharges in DIII-D", J.R. Ferron, et.al., Nucl. Fusion 51 063026 (2011)

"Validation of the thermal transport model used for ITER startup scenario predictions with DIII-D experimental data", T.A. Casper, et.al., Nucl. Fusion 51 013001 (2011)

"Influence of plasma flow shear on tearing in DIII-D hybrids", R.J. La Haye, et.al., Nucl. Fusion 51 053013 (2011)

"Control Issues Related to Start-Up of Tokamaks", G. L. Jackson, et.al., Fusion Sci. and Tech., 59 621-622 (2011)

"Electron Cyclotron Heating Program and Electron Cyclotron Emission Diagnostics on the EAST and HT-7 Superconducting Tokamaks", Baonian Wan, et.al., Fusion Sci. and Tech., 59 631-639 (2011)

Electron Cyclotron Heating and Current Drive Program for KSTAR Based on the 170-GHz Gyrotron" Y. S. Bae, Fusion Sci. and Tech., 59 640-646 (2011)

"Evidence for the Importance of Trapped Particle Resonances for Resistive Wall Mode Stability in High Beta Tokamak Plasmas" H. Reimerdes, et.al., Phys. Rev. Lett. 106, 215002 (2011)

"Realizing steady-state tokamak operation for fusion energy", T. C. Luce, Phys. Plasmas 18, 030501 (2011)

"Off-axis fishbone-like instability and excitation of resistive wall modes in JT-60U and DIII-D", M. Okabayashi, et.al., Phys. Plasmas 18, 056112 (2011)

"Electron cyclotron current drive in low collisionality limit: On parallel momentum conservation", N. B. Marushchenko, et.al., Phys. Plasmas 18, 032501 (2011)

"Physics requirements on fuel throughput in ITER", A.S. Kukushkin et al., Journal of Nuclear Materials 415, S497–S500 (2011)

"Results of Predictive Fokker–Planck Modelling of NBI Deuterons in ITER", V. Yavorskij, et al., J Fusion Energ, 30:307–322 (2011)