ITPA Topical Physics Group on "Integrated Operation Scenarios"
Report of Activities in the period of July 2008 – July 2009

S. Ide, G. Sips and J. Snipes, xx July 2009

with TP-TG).

SSO-3: Qualify real-time profile control methods for hybrid and steady state scenarios.

SSO-PEP-1: Documentation of the edge pedestal in advanced scenarios. This is a joint proposal with the Pedestal TG (formerly called SSO-4).

SSO-5: Simulation and validation of ITER start-up to achieve advanced scenarios.

SSO-6: Ability to obtain and predict off-axis NBCD.

In addition, the following experiments were proposed from the IOS TG for 2009.

IOS-1.1: ITER demo, at q_{95}=3, β_N=1.8, n!0.85n_{GW}

IOS-1.2: Study seeding effects

IOS-2.1: ECRH breakdown assist at 20^o toroidal angle (from SSO-5)

IOS-2.2: Ramp-down from q_{95}=3

IOS-3.1: Beta limit for AT with ITER recommended q-profile. (from SSO-1)

IOS-3.2: Define access conditions to get to SS

IOS-4.1: Access conditions for hybrid with ITER-relevant restrictions

IOS-4.2: !* dependence on transport and stability in hybrid scenarios (from SSO-2.3)

IOS-5.1: Ability to obtain and predict off-axis NBCD (from SSO-6)

IOS-5.2: Maintaining ICRH Coupling in expected ITER regime

IOS-6: Modulation of actuators to qualify real-time profile control methods for hybrid and steady state scenarios (from SSO-3)

Concerning SSO-1 and IOS-3.1, DIII-D demonstrated full-CD in the ITER shape and the operational boundary was studied. JT-60U reported sustainment of high β_N ~3 > $\beta_N^{no\text{-}wall}$ in a WS plasma and achievement of high β_N ~2.7 at q_{95} ~5.3 and q_{min} ~2 with high f_{BS} ~0.9 in an RS plasma. Also full CD of a WS plasma by combining LHCD+NBCD was demonstrated in JT-60U. JET low field experiments at steady-state relevant q_{95} have extended the domain at high β_N (~3) to higher confinement (H_H ~1.3/q_{min} ~1, H_H~1.2/q_{min} ~2) using an I_p overshoot technique. H41 h-141 (overshoot) -141 (technique.)]TJ 0 289.8535 250.59cm BT 50 0 0 50 0 0 Tm /F2.0

the toroidal rotation profile was also investigated. SSO-5 is tightly related to one of the high priority research topics of the group in 2008 – 2009. DIII-D demonstrated access to the hybrid scenario at high performance with the new ITER start-up scenario. Experimental results were compiled and presented at the 22nd IAEA Fusion Energy Conference at Geneva. A large effort was focused on modelling the ramp-up phase, which will be presented in a later section. Some of the issues concerning the plasma break-down with ECRF were raised in IOS proposal IOS-2.1. Some results have already been obtained and presented at the 2nd meeting. Several machines, DIII-D, QUEST and KSTAR, showed that an optimal magnetic geometry prior to breakdown with ECRF could be different from an ideal null-point configuration. Significant progress was obtained under SSO-6 (IOS

ITER and current devices (Alcator C-Mod, DIII-D, NSTX, JT-60U and so on by AORSA, PSTELLION, TASK) were presented at the meetings. The 3-D full wave approach has made progress. Since it is important to assess ICRF for ITER, it was agreed to launch the IC code benchmark activity. For LHCD, comparison with some codes, CQL3D and LSC, was carried out. An assessment of actuators, alone and in combination, has been increasingly required. An assessment of NBCD and LHCD on Scenario 4 using the ACCOME code was presented. It was shown that even with NBCD only, q_{min} can be maintained above 2, and LHCD is effective in controlling the shear reversal point.
At both meetings, "counter ECCD on ITER" was discussed. Prior to the second meeting, the pros and cons for installing counter ECCD on ITER were collected. Although some objections and concerns were raised at both meetings, no strong supporting agreement for or against counter ECCD was reached by the group.

Scenario modelling and benchmark

In addition to the actuator activity, modelling and simulation of operation scenarios for ITER continues to be an important area and has been intensively carried out since the SSO TG era.
In this period, modelling of the ramp-up was one of the most important issues. Various codes joined the activity (TSC, CORSICA, TASK, ASTRA, DINA, TRANSP, etc.). A large effort was given to comparison of the modeling with the results of the existing experiments, especially those of ITER ramp-up experiments. Though comparisons between the experiments and modelling have shown agreement to some extent, tuning of the assumptions of the models were often required. A more versatile validated model for the ramp-up applicable to ITER is required. Concerning the importance of the ramp-up modelling, a joint session between the T&C group was held at the 2nd

Interactions with MHD) are ready to join.

Collaboration with other TGs

Energetic Particle TG:
At the 1st meeting, one session was shared with the EP TG. NBCD issues and current drive by the alpha particles were discussed. For future collaboration, the IOS TG asked for some input from the EP TG concerning the limitations related to the high energy ions which were important in scenario development. J. Stöber was chosen as a contact person from the IOS TG.

MHD Stability TG:
At the 1st meeting, one session was shared with the MHD TG. At the joint session with the MHD TG, simulations on breakdown and baseline full scenario modeling by DINA and TRANSMAK were presented. Issues related to MHD in scenario development were discussed, such as the l_i limitation for the vertical instability and beta limit in the SS scenario. Issues which require inputs from the MHD TG were listed. T. Luce was chosen as a contact person from the IOS TG.

T&C TG:
As described above, the first day of the 2nd meeting was shared with the T&C TG for discussions on the L-H transition and ramp-up/down issues. Requested inputs from the T&C TG to the IOS TG were presented at the meeting.

The IOS TG greatly appreciate valuable discussions at the joint sessions and effort and discussions dedicated to our requests afterwards by those TGs.

Presentations and publications

The 22nd IAEA Fusion Energy Conference:
“Experimental Studies of ITER Demonstration Discharges”, A.C.C. Sips, et.al., IT/2-2
“Development of ITER 15 MA ELMy H-mode Inductive Scenario”, C. Kessel, et.al., IT/2-3
“Integrated modeling of steady-state scenarios for ITER: physics and computational challenges”, G. Giruzzi, et.al., IT/P6-4
“Benchmarking of Neutral Beam Current Drive Codes as a Basis for the Integrated Modeling for ITER”, T. Oikawa,et.al., IT/P6-5

Journals:
“Experimental Studies of ITER Demonstration Discharges”, A.C.C. Sips, et.al., to appear in NF.
“Development of ITER 15 MA ELMy H-mode Inductive Scenario”, C. Kessel, et.al., to appear in NF.
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High priority research items for 2009 – 2010

For 2009 – 2010, the IOS-TG has contributions to the following for the high priority research items for the TG, including response to ITER's research needs.

1. Joint experiments: mainly focus on,
   Demonstration of the ITER standard scenario.
   Assessment of the ITER ramp-down scenario.
   Assessment of the access conditions for advanced scenarios.
   Requirements for plasma/scenario control.
2. Actuators (heating and current drive):
   Assessment of actuators and heating mix, both experiments and modelling.
3. Scenario modelling:
   Modelling of experimental data, ramp-up/down and demo discharges.
   Modelling benchmark, especially hybrid and steady-state scenarios.
4. Scenario development:
   Stable/routine operation of the ITER standard scenario.