



EFDA

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Task Force
INTEGRATED TOKAMAK MODELLING

*ITM general meeting
Lisbon, 13-17 September 2010*

**INTEGRATED SCENARIO MODELLING,
ISM, WORKPROGRAMME**
Presented by X LITAUDON & I VOITSEKOVITCH

TF Leader : P. Strand,
Deputies: R. Coelho, L-G. Eriksson, G. Falchetto

EFDA CSU Contact Person: D. Kalupin

- **The proposed long term remits of ISM group :**
 - **develop a strong and visible EU presence at the international level: ITER, ITPA, BA**
 - **coordinate interpretative and predictive integrated scenario modelling on existing EU experiments**
 - **coordinate predictive scenario modelling activities to cover the preparation of operational scenario for ITER, JT60-SA, DEMO and new EU facilities**

ISM Mid-term proposal & workprogramme [1/2]

- **foster the ISM group towards common challenges to create a team spirit & a dialog between modellers and experimentalist:**
 - **Develop an hybrid scenario for ITER: Hybrid scenario covers all integrated modelling aspects + active field or research**
 - **Integrate edge and core**
 - **Validate (transport) models on existing experiments**
 - **Propose experiments to validate predictions**
 - **Liaise with the EU Transport Solver (ETS) development & IMP**
 - **Help to validate ITM codes**
 - **ETS benchmarked against existing EU modelling tools**
 - **Develop an ITER hybrid scenario using the ETS**
- establish Hybrid scenario at the level of baseline scenario & deliver publication**

ISM Mid-term proposal & workprogramme [2/2]

- **Develop complete (end to end) predictive ITER simulation with validate transport/source models**
 - evolving all fields : q , T , n , rotation, impurity
 - edge + core integration
 - Integrate core and edge MHD stability
 - Plasma breakdown modelling ?

- **Reinforce links with EFDA transport & MHD group**
 - validate and use transport model, core and edge MHD

- **Coordinate EU effort for ITPA modelling IOS**

- **Access to « ab initio » expertise for some time sequences of Integrated modelling with the help of IMP4 & IMP12**

ISM projects

- **Project-1 : Verification & Validation of the ITM tools (ETS)**
- **Project-2 : Interpretative & predictive integrated scenario modelling on existing devices**
- **Project-3 : Predictive scenario modelling for ITER, JT-60SA, DEMO ...**

Project-1: Verification & Validation of the ITM tools (ETS)

- **Benchmarking of the ITM tools with existing codes as a part of verification procedure**
 - benchmarking of equilibrium and current diffusion between ETS, ASTRA, CRONOS and JETTO
 - Contribution to validation of the ETS solver for density, temperature, impurity
- **One or two JET discharges modelled with the standard chain of ITM tools involving:**
 - Machine Description, Data Mapping, Exp2itm, ETS, Visualisation routines
 - Test fitting procedure for the profiles
- **Analyse with ITM tools a JET ohmic current ramp-up discharge (advanced scenario) JET, # 71827**
- **Extend to Hybrid discharges**

Project-1: Verification & Validation of the ITM tools (ETS)

- **Progressive use of the ITM tools for predictive ITER scenario**
- **Database of predictive ITER modelling on the Gateway**
- **Access of the ISM members to the ITM tools ⇒ accounts on Gateway**

Project-2 : Interpretative & predictive integrated scenario modelling on existing devices

- **Interpretative and predictive modelling of hybrid JET and ASDEX-U discharges**
- **Include ITPA modelling of DIII-D and JT-60U discharges**
- **Focus modelling on key questions for the extrapolation to ITER**
 - Focus on the q-profile dynamics from the ramp-up phase to the main heating phase
 - Focus on the role of the plasma rotation on hybrid confinement
 - Focus on pedestal physics & fuelling
 - Focus on integrated edge-core modelling
- **JET D-T Hybrid predictive modelling**
- **Expand beyond Predictive JET /JT-60U modelling of the identity experiments**

Project-2 : Interpretative & predictive integrated scenario modelling on existing devices

- **Expand beyond Hybrid regime ...**
 - At high I_p : H-mode regime
 - At low I_p : Steady-state scenario
 - ITB modelling (density, e, ion , momentum)
 - Predictive JET /JT-60U modelling of the identity experiments

Project-3 : Predictive scenario modelling for ITER, JT-60SA, DEMO...

2010-11 Focus the activity on hybrid ITER modelling

- **ITER Hybrid 0-D modelling with HELIOS and METIS**
 - Scan the operational domain
- **Modelling of the current ramp-up & ramp-down phase including free boundary equilibria**
- **Modelling of the current profile shaping during high performance phase including free boundary equilibria**
- **Modelling of the hybrid fuelling & pellet injection**
- **ITER hybrid pedestal**
- **ITER hybrid SOL modelling with detached plasmas**

Establish Hybrid scenario for ITER

- 1. Select models validated on existing experiments**
- 2. Breakdown modelling ?**
- 3. profile control during the ramp-up phase with the constrains of the PF primary circuits**
- 4. fusion burn control during the high power phase**
- 5. ramp-down phase and H to L mode transition**
- 6. core and pedestal transport**
- 7. real time profile control**
- 8. MHD stability**
- 9. core and edge physics integration**
- 10. edge constrains with ITER plasma facing components**
- 11. particle transport & fuelling issues (e.g. pellets)**
- 12. operational issues and scenario development during the non-activated phase**
- 13. scan of the operational domain including 0-D prediction**

Modelling guideline for Hybrid ITER reference case

- **Liaise with ITER requests & needs**
 - cf W. Houlberg 's talk

- **Reinforce link with ITPA activity and visibility of EU effort**
 - cf Kessel, Giruzzi Nuc Fus 2007
 - revised if needed the modelling guidelines set by ITPA (cf next slide)

- **Extend ITPA effort**
 - Modelling of rotation and density consistently with T_e , T_i and j
 - Integrated core-pedestal-SOL modelling
 - Fuelling & Impurity modelling
 - Scenario optimisation

ITPA activity : Codes, People, and Institutions

ASTRA ---- *Y-S. Na*

National Fusion Research Center, Korea

CRONOS ---- *G. Giruzzi, J. Artaud, F. Imbeaux,
V. Basiuk, M. Schneider*

CEA Cadarache, France

ONETWO ---- *M. Murakami and J-M. Park*

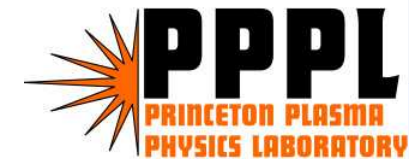
Oak Ridge National Laboratory/General Atomics, USA,
National Fusion Research Center , Korea

TOPICS ---- *T. Oikawa, N. Hayashi, T. Takizuka,
T. Ozeki*

ITER Int'l Team & Japan Atomic Energy Agency, Japan

TSC/TRANSP ---- *C. E. Kessel and R. V. Budny*

Princeton Plasma Physics Laboratory, USA



Revised ITPA- ITER hybrid modelling guidelines (SSO-Boston 2008)

C.E. Kessel, G. Giruzzi, et al., IAEA 2006
 J. Citrin to appear in Nuc Fus 2010

• Global parameters

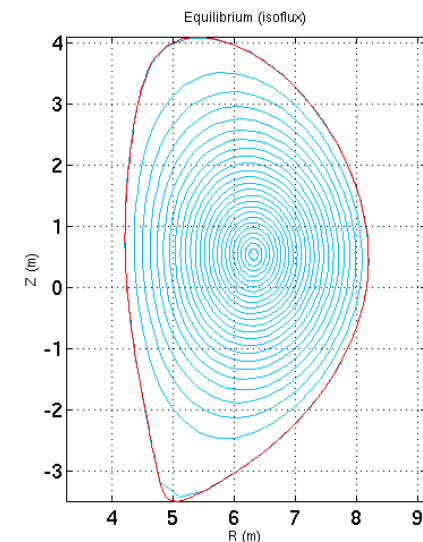
- $I_p = 12$ MA, $B_T = 5.3$ T, $\beta_N \approx 3$, plasma in flat-top phase
- $f_D/(f_D+f_T) = 50\%$, $f_{Be} = 2\%$, $f_{Ar} = 0.12\%$, $\tau_{He^*}/\tau_E = 5$ ($Z_{eff} \sim 1.6$)
- $P_{NBI} = 33$ MW (1 MeV, off-axis), $P_{ICRH} = 20$ MW (53 MHz, 2 T harmonic)
- $P_{ECRH} = 20$ MW, equatorial launcher, $\phi_{tor} = 32^\circ, 38^\circ, 40^\circ$

• Profile parameters

- n_e profile fixed, pedestal fixed
- $\rho_{ped} = 0.925$, $n_{ped} = n_e(0)$, T_{ped} varied to obtain β_N
- $n_e(0) = 0.85 \cdot 10^{20} \text{ m}^{-3}$, flat for $0 < \rho < \rho_{ped}$,
 linear drop from ρ_{ped} to $\rho = 1$, $n_e(\rho = 1) = 0.35 n_e(0)$

• Test cases

- **TEST #1:** NBI+ICRH, fixed sources, test of GLF23 + j-diffusion
- **TEST #2:** NBI+ICRH, fixed T and n profiles, test of sources + j-diffusion
- **TEST #3:** NBI+ICRH+ECCD, same as test #2



Aim of Lisbon's meeting

- **Hand-over & wrap-up of past ISM activities**
- **Define & write precisely the detailed tasks within the various projects**
 - 'ISM Tasks' template will be filled
- **Agree on the Hybrid ITER modelling guidelines for ISM**
- **Participate to ISM working sessions**
- **Participate to training sessions of the ITM tools**

ISM Task description

**ISM
modelling
tasks**

- Task name:
- Project : P1 , P2 or P3
- Task reference:
- Version:
- Start date:
- Date of revision:
- Tentative completion date:
- Staff involved:
- Codes involved and version:
- Machine and pulses numbers:
- Detailed Task description:
- Related actions:

ISM Task description

Task name: Verification of ETS tool on JET ohmic pulse

Project : P1 (Verification & Validation of the ITM tools (ETS))

Task reference: ISM-P1-2010-1

Version: 1

Start date: September 2010

Date of revision:

Tentative completion date:

Staff involved: G. Pereverzev, J. Ferreira, J. Bizarro, D. Kalupin, D. Coster, I. Voitsekhovitch (may be someone from CRONOS side?)

Codes involved and version: Exp2itm, ETS, ITM tools: ASTRA, JETTO

Machine and pulses numbers: JET, # 71827 (ohmic ramp-up , already analysed within the ISM)

Detailed Task description:

The aim of ETS WP2010 is to have at least 1 or 2 JET discharges modelled with the standard chain of ITM tools involving: **Machine Description, Data Mapping, Exp2itm, ETS, Visualisation routines**

Related actions:

1. Therefore ISM should identify 1-2 JET shots taken previously into the analysis by the ISM group.
2. These shots, if possible, have to be simple in terms of scenario, and should be well diagnosed, that the plasma state (COREPROF CPO) can be generated.
3. The ISM group will provide the list of diagnostic signals (with sequence numbers) which should be used by Exp2itm (! Should be consistent with what other ISM codes have been using in their analysis)
4. List of ISM simulations done for these shots
5. Code settings for these simulations, that ETS is running in similar configuration
6. Action on ITM (Rui): provide ISM with the list of information, needed to run Exp2itm, particularly what is missing at the moment.

As an example

Validation of ETS tools on JET ohmic pulse

ISM Task report

Task name:

Project :

Task reference:

Version:

Date of this report:

Report on the actions /difficulties/issues

Reports (dates of the ISM meeting where the activity has been reported):

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Conferences/Workshop/ITPA meeting:

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Summary slides :

Scenario output (precise where the results have been stored, directory, pff numbers) + key assumptions:

Code	Dates	Run number	Machine	Pulse number	Ppf or directory where the data have been stored	Comments /assumptions

Publication :

ISM modelling tasks report

**Standard basic information
+
Summary slides**

All the information to be stored on the ISM web

Possible Tasks within P1

Ref.	Task name	Start date	Status/comments
ISM-P1-2010-1	Verification of ETS tool on JET ohmic pulse	Sept 2010	
ISM-P1-2010-2	Verification of temperature and density transport solvers in ETS	Sept 2010	
ISM-P1-2010-3	Verification of impurity solver in ETS	Sept 2010	
ISM-P1-2010-4	Verification of equilibrium solver and PFDE in ETS		
ISM-P1-2010-5	ITER Machine description		

Possible tasks within P2

Ref.	Task name	Start date	Status/comments
ISM-P2-2010-1	JET DT extrapolation of hybrid regime	Sept 2010	
ISM-P2-2010-2	Modelling of plasma rotation in Hybrid Scenario	Sept 2010	
ISM-P2-2010-3	Current ramp up JET discharges with li control.	Sept 2010	
ISM-P2-2010-4	Modelling of DIII-D current ramp up discharges (ITPA database)		
ISM-P2-2010-05	Current ramp up in JET Hybrid Scenario : modelling and optimisation.		
ISM-P2-2010-06	Modelling of JET current ramp down experiments – optimisation of flux consumption and li		
ISM-P2-2010-07	Current profile diffusion in JET hybrid scenario		
	Predictive JET /JT-60U modelling of the identity experiments		
	ASDEX interpretative hybrid modelling		

Possible task within P3

Ref.	Task name	Start date	Status/comments
ISM-P3-2010-1	Migration of 2009 ISM ITER modelling to ITM-TF Gateway	Sept 2010	
ISM-P3-2010-2	ITER Hybrid 0-D modelling with HELIOS		
ISM-P3-2010-3	ITER Hybrid 0-D modelling with METIS		
ISM-P3-2010-4	ITER hybrid free boundary equilibria during ramp-up		
	ITER hybrid free boundary equilibria during ramp-down		
	ITER hybrid free boundary equilibria during burn phase		
	ITER hybrid MHD stability of scenario		
	ITER hybrid edge modelling		
	ITER hybrid ELMs modelling		
	ITER hybrid fuelling and particle transport		
	ITER hybrid heating and current drive mix		
	ITER hybrid current profile control during ramp-up		
	ITER hybrid flux consumption and pulse length		
	ITER hybrid real time control		

ISM web page

- **ISM web page under construction ...**
- **should use the MediaWiki structure**
- **Should contain the following information**
 - **ISM meeting**
 - **ISM modelling tasks (description & report)**
 - **ISM reference materials**
 - **ISM Publications & conferences**
 - **Collaboration & ITPA**

LISBON' s meeting agenda

➤ **Monday 13/09 14h-18h**

- Modelling of Hybrid regime: past ISM activities, requests ITER, JET, ASDEX-U

➤ **Tuesday 14/09**

- Working session: Definition of the 2010/2011 tasks around 3 ISM projects

➤ **Wednesday 15/09 09h-12h**

- Working session on option for Poloidal Field Diffusion + on going publication IAEA/Nuc Fus paper F. Imbeaux & L. Garzotti

➤ **Thursday + Friday 16/09 & 17/09**

- ISM Working session + Training session on ITM-TF tools

Remote meeting

Regular remote meeting on Wednesday morning 10h30-12h00 CET (09h30-11h00 GMT) :

- **Wed 29/09 10h30-12h00 CET**
- **Wed 13/10 10h30-12h00 CET**
 - To be confirmed week of IAEA ?
- **Wed 27/10 10h30-12h00 CET**
 - Report from ITPA , IAEA
- **Wed 10/11 10h30-12h00 CET**
- **Wed 24/11 10h30-12h00 CET**
- **Wed 08/12 10h30-12h00 CET**

2010 ISM meeting

- **Requirement for a meeting ?**
- **One week or two weeks ?**
- **Possible dates in 2010**
 - 22 nov – 26 nov
 - 29 nov – 03 Dec

- **Location ?**
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