EFDA
EUROPEAN FUSION DEVELOPMENT AGREEMENT
Task Force
INTEGRATED TOKAMAK MODELLING

Remote meeting 24 Oct 2012

INTEGRATED SCENARIO MODELLING, Introduction

Presented by X LITAUDON & I VOITSEKHOVITCH

TF Leader : G. Falchetto
Deputies: R. Coelho, D. Coster
EFDA CSU Contact Person: D. Kalupin

Agenda

1) **Introduction: X. Litaudon**
2) **Integrated modeling for the WEST project (Tore Supra upgrade): F. Imbeaux et al**
3) **Progress in the Simulation of JET hybrid discharge with European Transport Solver: António Figueiredo et al**
4) **LHCD simulations by ASTRA/FRTC of JET discharges E. Barbato**
5) **Short update on particle transport modelling following EPS conf. L Garzotti**
6) **Report form ITPA and action for ISM X. Litaudon**

Remote meetings, WS and CC

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

- 26 Sept 2012
- 08-18 Oct FEC IAEA & ITPA San Diego
- **24 Oct 2012**
- **7 Nov 2012 (??)**
- **Thrid ISM Working session 19-23 Nov.**
- **IMP3 + ISM-ACT1 Code Camp 3-14 Dec., Innsbruck**
- **19 Dec 2012**

Foreseen talks for remote meeting

- **JET – JT-60U modelling J. Garcia**
- **Current ramp-down modelling F. Koechl, J. Bizarro**
- **report on the status of Act 1 T1 support to the ETS validation : Benchmarking of new modules coupled with ETS workflows V. Basiuk**
- **Short reports on the status of publications (Irina, Florian …)**
- **Other proposals?**

2012 ISM Working session

- **First ISM working session**
  - 26 - 30 March at EFDA-Garching

- **Second ISM working session**
  - Monday 21 – Friday 25 May (13:00) Vienna

- **Third ISM working: Culham**
  - **Monday 19 (10:00)– Friday 23 Nov. (13:00) JET Culham**
  - **invitation letter for mobility support: 15 October**
  - **Our local host is Irina irina.Voitsekhovitch@ccfe.ac.uk_Many Thanks !**

EFDA Task Force
EUROPEAN FUSION DEVELOPMENT AGREEMENT
INTEGRATED TOKAMAK MODELLING

Participation to third ISM Working 19-23 Nov. Culham

- **CCFE**
  - I. Voitsekhovitch, L Garzotti, V. Parail, M. Romanelli, D. Harting
- **CEA**
  - X. Litaudon , E. Joffrin, J. Garcia, B. Baiocchi
- **IST**
  - F. Nave, J. P. S. Bizarro, A. Figueiredo, F. Nabais, J. Ferreira, P. Belo
- **ÖAW/ATI:** F. Koechl
- **Differ/NL**
  - J. Citrin, D. Hogeweij
- **ENEA-Frascati:** E. Barbato
- **TEKES:** Paula Siren
- **Association Euratom-IPPLM:** I. Ivanova-Stanik
- **EFDA:** D. Kalupin (?)

Draft agenda
ISM working session

- **Monday Morning 10h-12h:**
  - Introduction and list of actions for the week
  - Draft Agenda

Monday 19-Nov		
10h-10h10	Welcome, Local information Room K1- 0-38	X. Litaudon,I. Voitsekhovitch
10h10-10h30	Agenda and working groups	X. Litaudon
10h30-11h00	JET ILW HS for ISM modelling	E.Joffrin
11h00-11h30	JINTRAC capabilities for integrated core-edge modelling	D. Harting
11.30 – 12.00	ITER 2013 modelling under F4E	V. Parail
12h00-18h00	Working session	

- **Tuesday afternoon : joint meeting with TF-E1 on modelling for JET**
- **Wednesday – Thursday afternoon: meeting room is booked for discussions and talks**
- **Friday : reports**

Provisional announcement

will organize the:

Topics:

1. *Superconducting Devices.*
2. *Long-pulse operation and Advanced Tokamak Physics.*
3. *Steady State Fusion Technologies.*
4. *Long pulse Heating and Current Drive.*
5. *Particle Control and Power Exhaust.*
6. *ITER-related research and Development issues.*

The meeting will be located in the center of Aix en Provence (France) at the Aquabella hotel.

A visit of ITER site and Tore Supra will be organized.

Contact: TMSSO2013@cea.fr

Web site: http://www-fusion-magnetique.cea.fr/sso2013/

ITPA-IOS meeting

- focus was on the modelling of ITER baseline scenario CCFE
- Next meeting 15-18 April 2013 at ITER siteCEA

ITER baseline modelling

- Progress report on JA-9 (Optimisation of Operational Space for Long pulse Scenarios) A. Polevoi
- Coupled core-SOL simulations of L-H and H-L transitions in ITER V. Parail
- PTRANSP tests of TGLF and predictions for ITER R. Budny
- Baseline modelling J -M Park
- Non-active scenario simulations for ITER T. Casper

CCFE

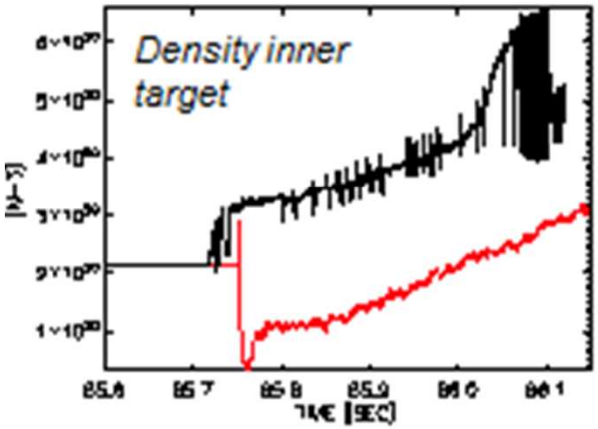
Coupled core-SOL simulations of L-H and H-L transitions in ITER

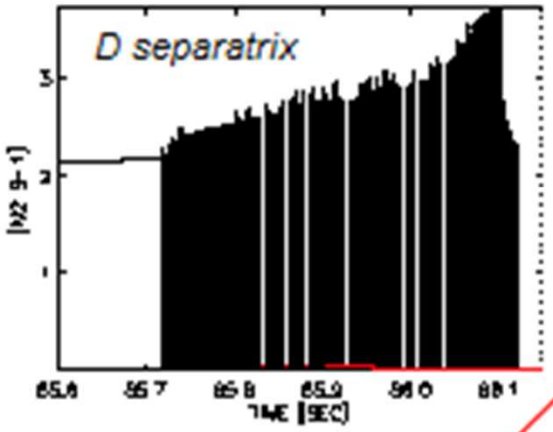
V. Parail, P. Belo, G. Corrigan, F. Koechl, A. Loarte, G. Saibene, R. Sartori

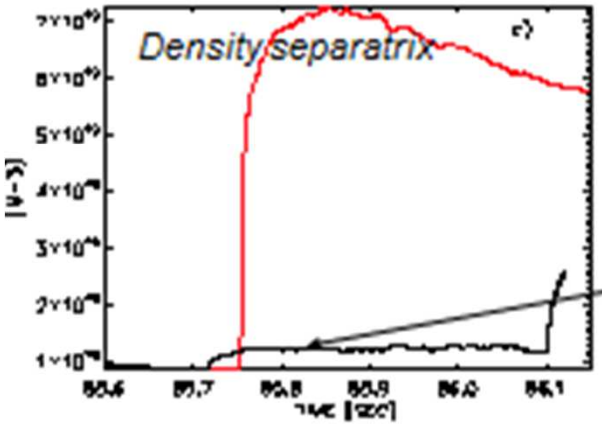
Outlook

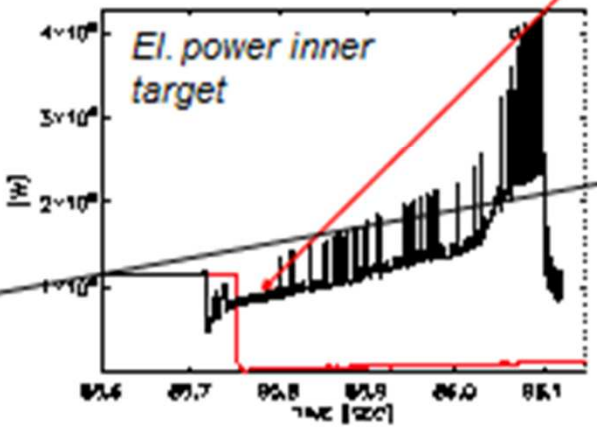
- JINTRAC code;
- Transport models used in coupled core-SOL simulations;
- Preliminary results of coupled core-SOL simulation of plasma evolution after L-H and H-L transition in ITER;
- Conclusions

L-H and H-L transition in ITER: COCONUT results (6)









- Local model for L-H transition (black) leads to a dithering transition (or type-III ELMs)?
- Dithering transition *simplifies potential problem with plasma detachment* but dramatically *reduces density increase after L-H transition*

CCFE

Summary

- Large number of important phenomena, which originate on the interface between core and SOL (L-H and H-L transition, plasma fuelling, impurity penetration to plasma core, ELMs and methods of its mitigation and others), can only be effectively simulated using coupling between core and SOL transport codes;
- JINTRAC is, in my view, the best available option and we start to use it for ITER modelling;
- To make our simulations fully trustworthy, it is important to establish a close connection (and benchmarking) between JINTRAC team and ITER-based SOLPS users;
- At least three important ingredients should be added to our present approach:
  - Proper description of at least extrinsic impurities (Ne, Ar?) and possibly heavy intrinsic impurity like W;
  - Plasma detachment should be tried and benchmarked against SOLPS results;
  - Improvement in our description of L-H and H-L transition is needed.
- Testing of our approach on existing experimental data is vitally important.

PTRANSP tests of TGLF and predictions for ITER

R.V. Budny ITPA, San Diego, Oct 15-18, 2012

Summary and discussion

- Verification and validation of TGLF in PTRANSP is being performed
  - Comparisons with a small sample of L-mode, H-mode, and Hybrid plasmas finds T_e or T_i over-predicted
  - Insufficient TGLF and neoclassical transport near the axis
  - Possible MHD and fast ion anomalous diffusion are ignored
- ITER predictions of T_e and T_i in the core are important for fusion power
  - The low transport predicted by TGLF and simple neoclassical $\Rightarrow$ high $_e$ and T_i with small increase in stored energy

PTRANSP tests of TGLF and predictions for ITER

R.V. Budny ITPA, San Diego, Oct 15-18, 2012

Future Research

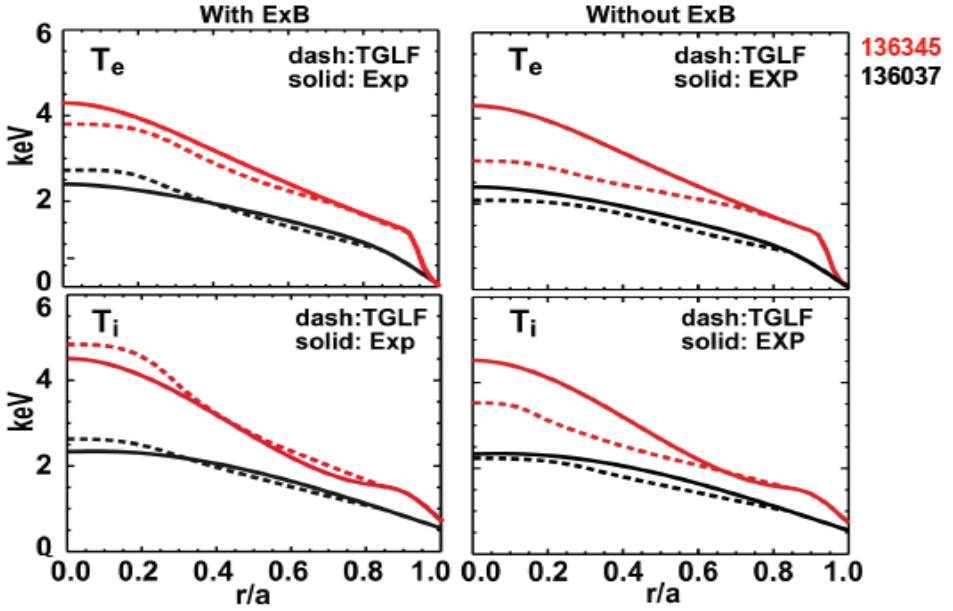
- Explore region near axis
  - Use the NEO code for improved neoclassical predictions
- Shift TGLF boundary closer to the separatrix
- Benchmark with ISM, ASTRA, and CRONOS
- Compare PT-SOLVER time slice predictions w and w.o. dW/dt terms
- Improve PTRANSP time-dependent predictions
- Predict angular momentum
- Increase number of kinetic species
- More tests and predictions with density evolution
- Angular momentum predictions

ITER Projection of DIII-D ITER Demonstration Baseline Discharge

by J.M. Park

TGLF Transport Simulation Reproduces Change in Transport Processes As Observed in Experiment

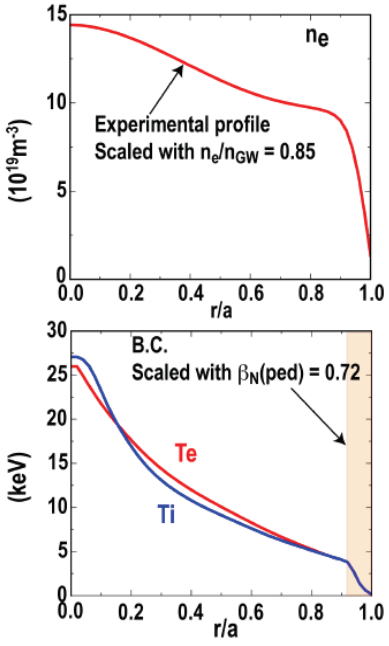
- **Low density**
  - ITG/TEM dominant (low *k* mode)
  - Good agreement only when the *ExB* shear stabilization included
- **High density**
  - ETG dominant (high *k* mode)
  - Relative small effects of *ExB* shear stabilization



ITER Projection of DIII-D ITER Demonstration Baseline Discharge

by J.M. Park

TGLF Projection of the Baseline Scenario Shows ITER Can Achieve the Q~10 Goal with Duration of Burn ~400 s



- I_p = 15 MA, B_T = 5.3 T
- n_{GW} = 0.85
- P_{NBI} = 33 MW
  (1 MeV, on-axis 2001 EDA)
- P_{ICRF} = 10 MW
  (56 MHz, Heating)
- P_{EC} = preserved for NTM control
- P_{fus} = 419 MW
- Q = 9.6
- H_{98} = 0.91
- V_{loop} = ~81 mV
- τ_{burn} = ~ 380 s
  (* assuming 30 Wb available in current flattop)

DIII-D NATIONAL FUSION FACILITY

6

JM Park/ITPA-IOS/Oct 2012.

Summary

- TGLF projection of DIII-D ITER demonstration discharges for baseline scenario in combination with experimental scaling shows ITER can achieve the Q~10 goal with duration of burn ~ 400 s.
  - TGLF reproduces DIII-D discharges reasonably well
- Various transport models (GLF23, MM95, CDBM, BgB) widely used for ITER prediction do not reproduce DIII-D ITER demonstration discharges, especially for ITER relevant regime of low collisionality/dominant electron heating.
  - But ~ same fusion performance for ITER prediction

iter china eu india japan korea russia usa

From IAEA poster: Development of ITER scenarios for pre-DT operations

T.A. Casper[1], D.J. Campbell[1], V.A. Chuyanov[1], Yu.V. Gribov[1], T. Oikawa[1], A.R. Polevoi[1], J.A. Snipes[1], R. Budny[2], I. Voitsekhovitch[3], P. Bonoli[4], F. Koechl[5], and ITPA IOS

[1] *ITER Organization, Route de Vinon sur Verdon, 13115 St Paul-lez-Durance, France*
[2] *Princeton Plasma Physics Laboratory, Princeton, NJ, USA*
[3] *EURATOM/CCFE Fusion Association, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK*
[4] *Massachusetts Institute of Technology, Cambridge, MA 02139, USA*
[5] *Association EURATOM-ÖAW, Atominstitut, TU Wien, 1020 Wien,*

ITPA/IOS meeting
October 15 - 18, 2012
San Diego, CA USA

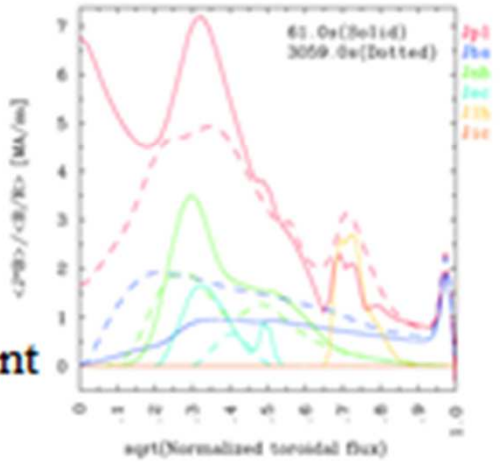
Joint modeling activity under the International Tokamak Physics Activity (ITPA), Integrated Operating Scenarios (IOS)

- Developing full time-dependent scenarios
  - Use 1½D codes: 2D equilibrium + 1D transport
  - Free-boundary equilibrium to evaluate coil limitations and control
  - Same approach as for 15MA baseline inductive and hybrid scenario development
    - ✓ Casper, T.A. *et al* in Fusion Energy 2010 (Proc. 23rd Int. Conf. Daejeon, 2010) (Vienna: IAEA) CD-ROM file ITR/P1-19, to be published Nuc. Fusion
    - ✓ Kessel, C.E. *et al* Nucl. Fusion **49** (2009) 085034
    - ✓ Kim, S.H. *et al* 39th EPS Conf. on Plasma Physics, Stockholm, Sweden 2012, P5.089
    - ✓ Kim, S.H. *et al* IAEA 2012 San Diego
- Results from two 1½D predictive simulation codes:
  - CORSICA – implicit free-boundary equilibrium and transport solutions each step
    - ✓ "backing out" – prescribed boundary evolution + free-boundary at each time step
    - ✓ "forward" – use controller for shape + vertical instability control
  - JINTRAC – equilibrium and transport code run with weak coupling (iterative runs) to CREATE-NL shapes and post-processing flattop limitations
  - Independent evaluation of scenarios (rather than code benchmark)

Summary: operation in H, He, or D at I_p=7.5MA and B_T=2.56T

- First look at development of time-dependent, non-activation operating scenarios for ITER – based on CORSICA and JINTRAC simulations
  - Conclusions robust to differences in modeling assumptions
  - Free-boundary assessment of coil and force limitations satisfactory
  - Critically dependent on H-mode threshold power modeling (Martin)
- Operation at full parameters, I_p=15MA and B_T=5.2T, with H or He in H-mode not likely due to lack of alpha-power heating and high access threshold
  - L-mode operation for short duration flattop 30 – 50s possible
  - Density dependent and can avoid coil current and force limits
- At half parameters, I_p=7.5MA and B_T=2.65T, operation in H-mode likely for H, D and He
  - Hydrogen requires full power due to threshold mass scaling
  - Deuterium pulse length limited due to tritium and activation considerations – requires licensing
- Future work: source modeling compatibility, self-consistent ramp down strategy, and plasma control assessment

From SS scenario by S.H. Kim



Progress Report on IOS JA-9: Optimisation of Operational Space (OS) for Long-pulse Scenarios

= Basic goal:

To assess the OS to justify the optimal parameters (I_p, n, etc.) for long pulse operation and TBM program (There was no systematic scan on I_p, n yet)

= Relation to the ITER Physics Operation Workprogram:

DT baseline long-pulse scenarios $\Delta t_{FT} > 1000$ s, $P_{fus} > 250$ MW, $Q > 5$

= Contributors (2011, 2012):

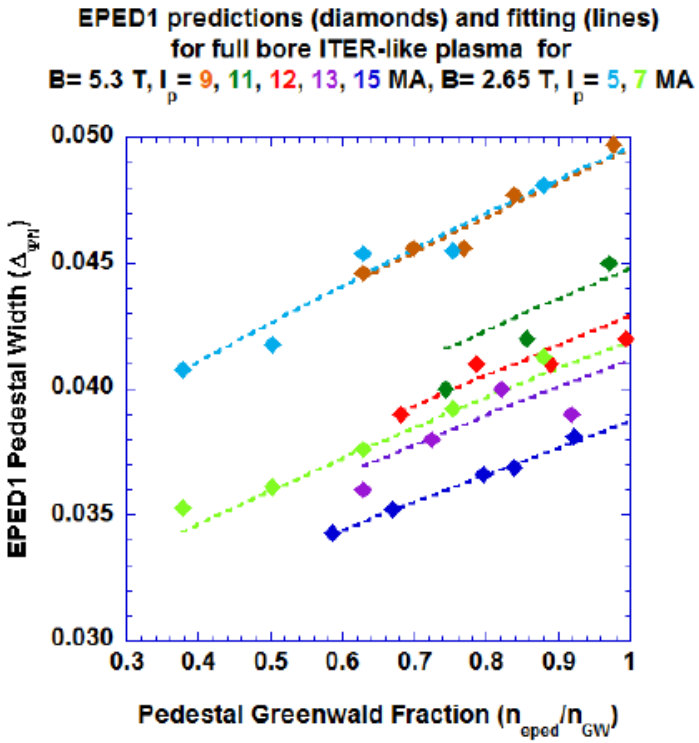
EU: F. Koechl (11,12), J. Citrin (11)
JA: N. Hayashi (11, 12);
KO: Y.S. Na, H.S. Kim (12)
RF: V.M. Leonov (11, 12); S.Y. Medvedev (12)
US: J. M. Park (11, 12), M. Murakami(11), A.Y. Pankin (11, 12), P. Snyder(12);
IO: S.H. Kim (12), A.S. Kukushkin (12), A.R. Polevoi (11, 12)

= Contact Person:

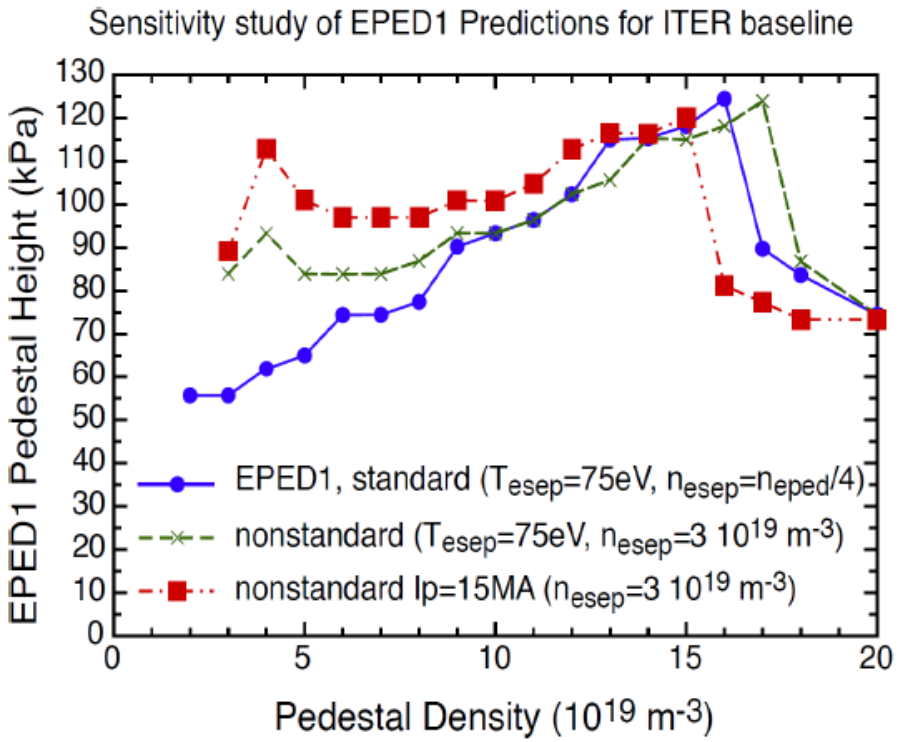
A.R. Polevoi (IO)

= Progress 2012: New data provided in 2012 by October

A.S. Kukushkin (SOLPS), P. Snyder (EPED1 with SOLPS boundary)



Analytical approximation for pedestal width predicted by EPED1 for full bore ITER case



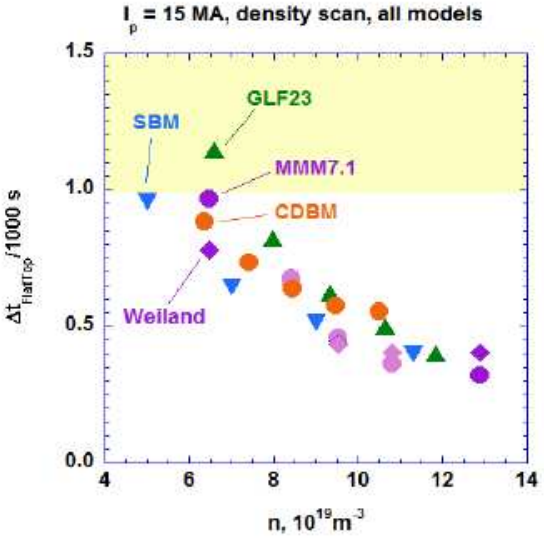
Pedestal pressure, p_{ped} by EPED1 with standard (12 MA) and SOLPS boundary (15 MA, 12 MA)

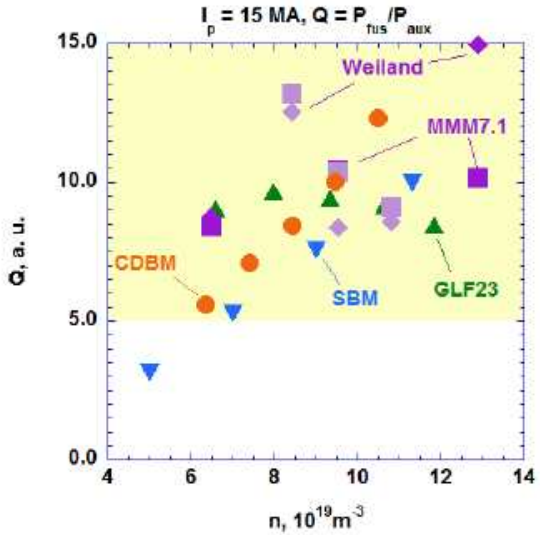
In contrast with standard EPED1 p_{ped} for EPED1+SOLPS dependence on density becomes weaker

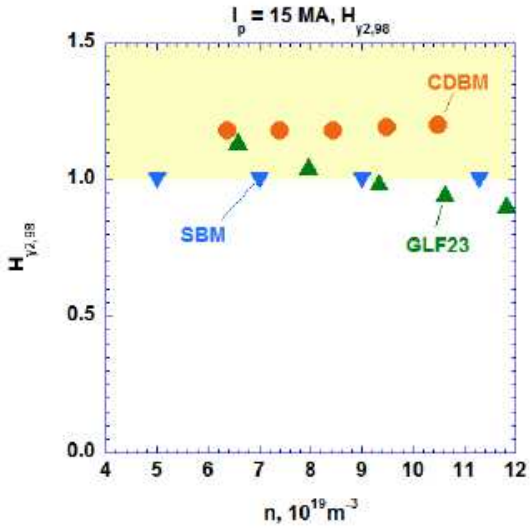
- Density scan for original assumptions of transport models for I_p=15 MA, p_{ped}= const

GLF23 (FK), SBM (VL), modified CDBM (NH),
MMM and Weiland (same n shape), MMM and Weiland (variable n_0/n_{ped}) (APn).

Same assumptions as for 500 MW, 15 MA, Q =10







For 15 MA for all models operation with Δt_{FT}~1000 s, Q ~ 5 looks possible at n/n_G ~ 0.5 with $H_{y2,98}$ ~ 1-1.2 keeping the same model assumptions used for Q=10

ITPA-IOS action list on modelling (from G. Sips)

Actions for Spring 2013 meeting

Action	Description
• Current rise with metal walls and comparison with carbon walls	Report on the current rise in Metal vs. C walls, using experimental data from JET, AUG, C-Mod, and DIII-D
• Include physics-based model in simulation codes (EPED1)	How to include these models into the scenario simulations.
• Constrain simulations by ideal MHD stability	Report in spring 2013 on method to compute MHD stability in scenario codes
• Demonstrate the variation of results when changing particle transport assumptions	What can be done to include particle transport, and can this be done in various codes.

Action	Description
• Include Kikushkin DIVSOL maps to constrain simulations	How to include these models into the scenario simulations.
• Review steady-state scenario exploration	Report at the IOS-TG on overview of SS scenario simulation results
• Report on JA-8 burn control	Update on burn control at the spring 2013 meeting, involve other modelers/codes
• Report on JA-2 ramp-down simulations	Status of ramp down modelling. Include li control (Romero and DINA-CH)
• Comment on deferrals and consistency with ITER research plan and fixed date for Q=10	Write to ITER-IO as to the concerns on the ITER RP and the required scenario preparation