IOS/ITPA (16-19 April 2012) summary report: modelling

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Remote ISM meeting 25.04.2012

IOS/ITPA meeting:

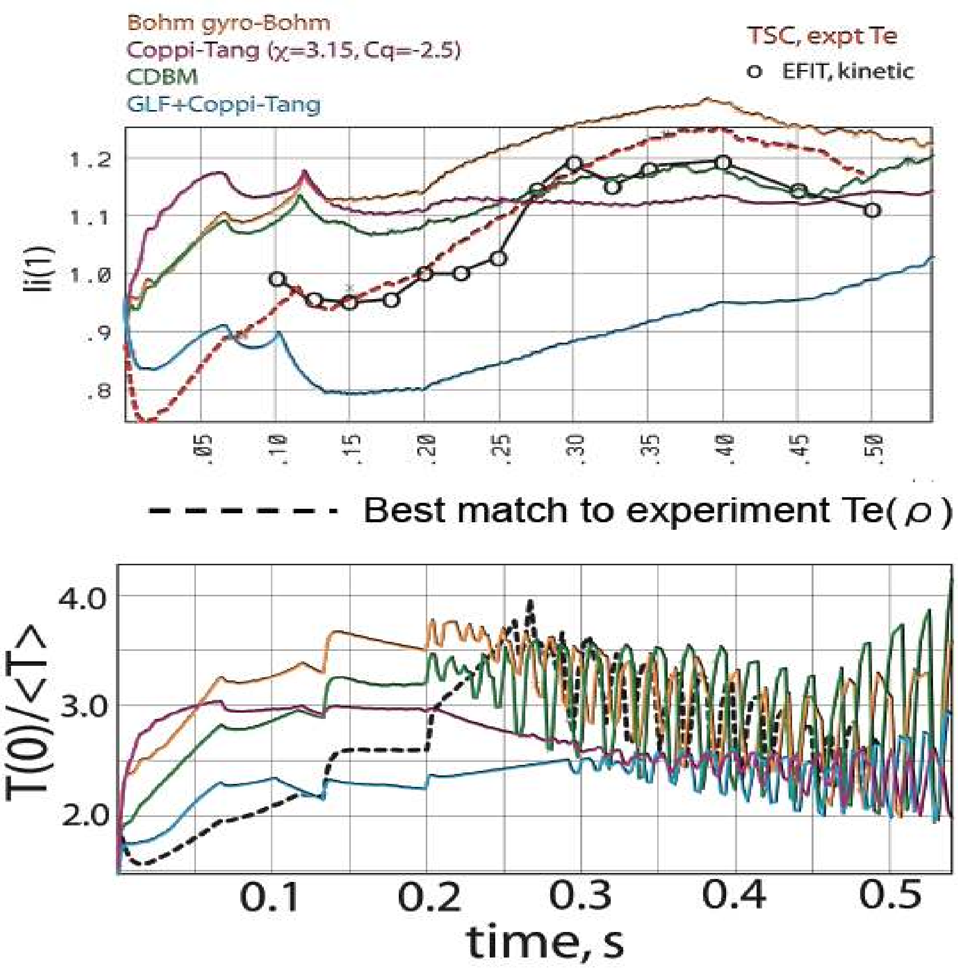
- Reports on machine activities, modelling activity, status of the IOS tasks, discussions of the IAEA contributions, plans
- Emphasis on modelling of hybrid and steady state scenarios for ITER

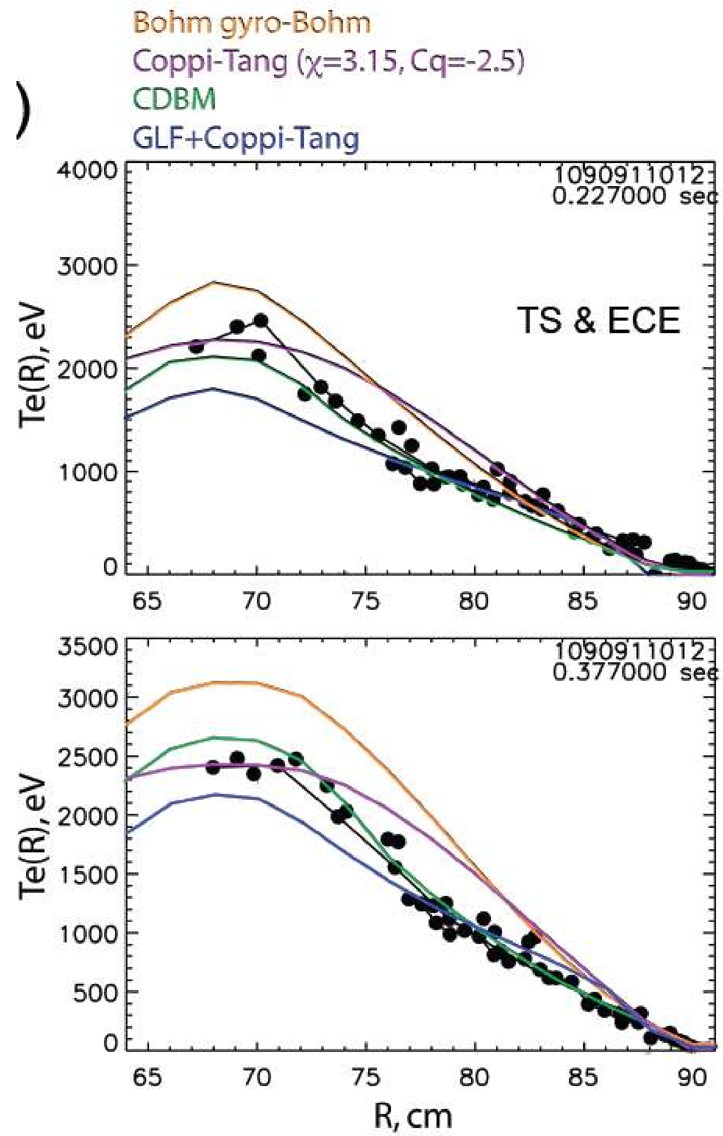
Reports on modelling activity:

- **Modelling for existing machines and model validation:** *DIII-D, JET, JT60U, Cmod*
- **ITER modelling:**
  - *L and H-mode*
  - *hybrid scenario*
  - *steady state scenario*
- **Modules development / improvement**
- **IOS/ITPA modelling actions**

Ramp up modelling of C-Mod discharge (C. Kessel)

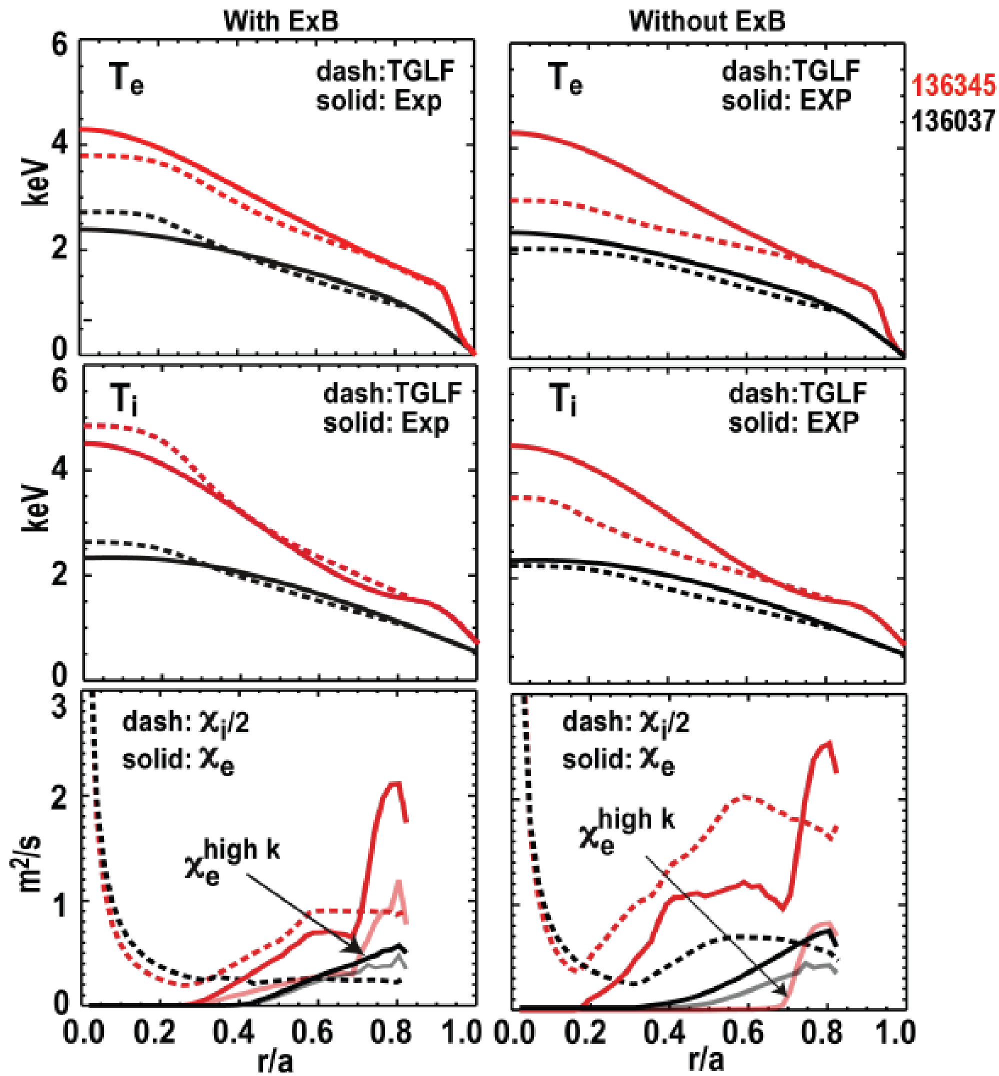
- *ICRF heated L-mode, 5.4 T (ITPA Profile Database)*
- *No model appears to consistently match the Te in C-Mod better than others*
- *The models are not grossly wrong, but inaccurate, missing profile details*



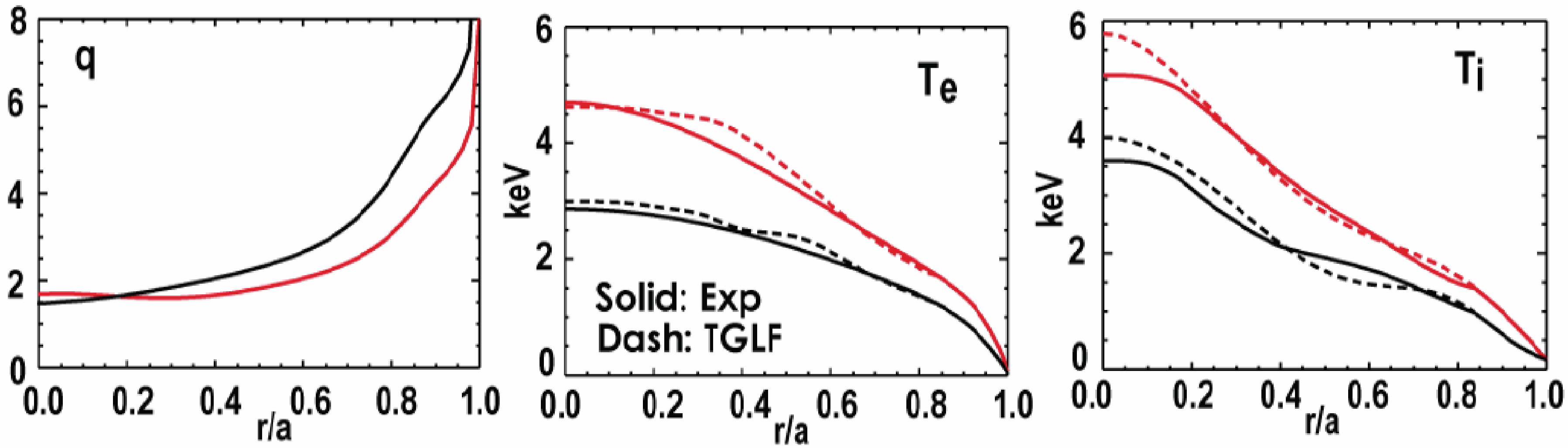


Modelling of ITER demonstration discharges in DIII-D tokamak - H-mode (J. M. Park)

- Density (collisionality scan), νe^*=0.1-0.6. Low density with ECH
- H98 ~1, but significant change in local thermal transport
- Low ne (136345): ITG/TEM dominant, ExB shear is important.
- High ne (136037): ETG dominant, weak effect of ExB shear
- Reduced plasma rotation at low ne (counter NBI) reduces confinement in baseline scenario (H98 changes by ~15%, but core χe increases by factor ~2)
- Density peaking is less sensitive to collisionality than AUG or JET
- TGLF predicts inward particle flux
- Edge MHD: peeling-ballooning at high ne, peeling at low ne



Modelling of Steady State ITER demonstration discharges in DIII-D tokamak (J. M. Park)



- Electron and ion thermal diffusivities correlated mainly with magnetic shear both in the power balance analysis by TRANSP and in the TGLF modeling

- Need for optimising q95 to get larger Q and NI fraction,

-Tradeoff between stability and confinement to achieve higher βN at lower q95

- pedestal height and width decrease with q95

Iterative steady state solution procedure: steady state solution (d/dt=0) of core transport (TGLF) using FASTRAN+EFIT+ (NUBEAM,TORRAY,CURRAY)

JT-60U modelling with modified CDBM transport model (N. Hayashi)

Modified version : $\chi^{mod}_{CDBM} = C \frac{c^2}{\omega_{pe}^2}\frac{v_A}{qR}|\alpha_{th}|^{3/2}F(s,\alpha)G(\kappa),$

using thermal pressure

F(s, α) still uses total pressure

-Validation on H-mode plasmas: Ipl=1.8 MA, Btor=3.1 T

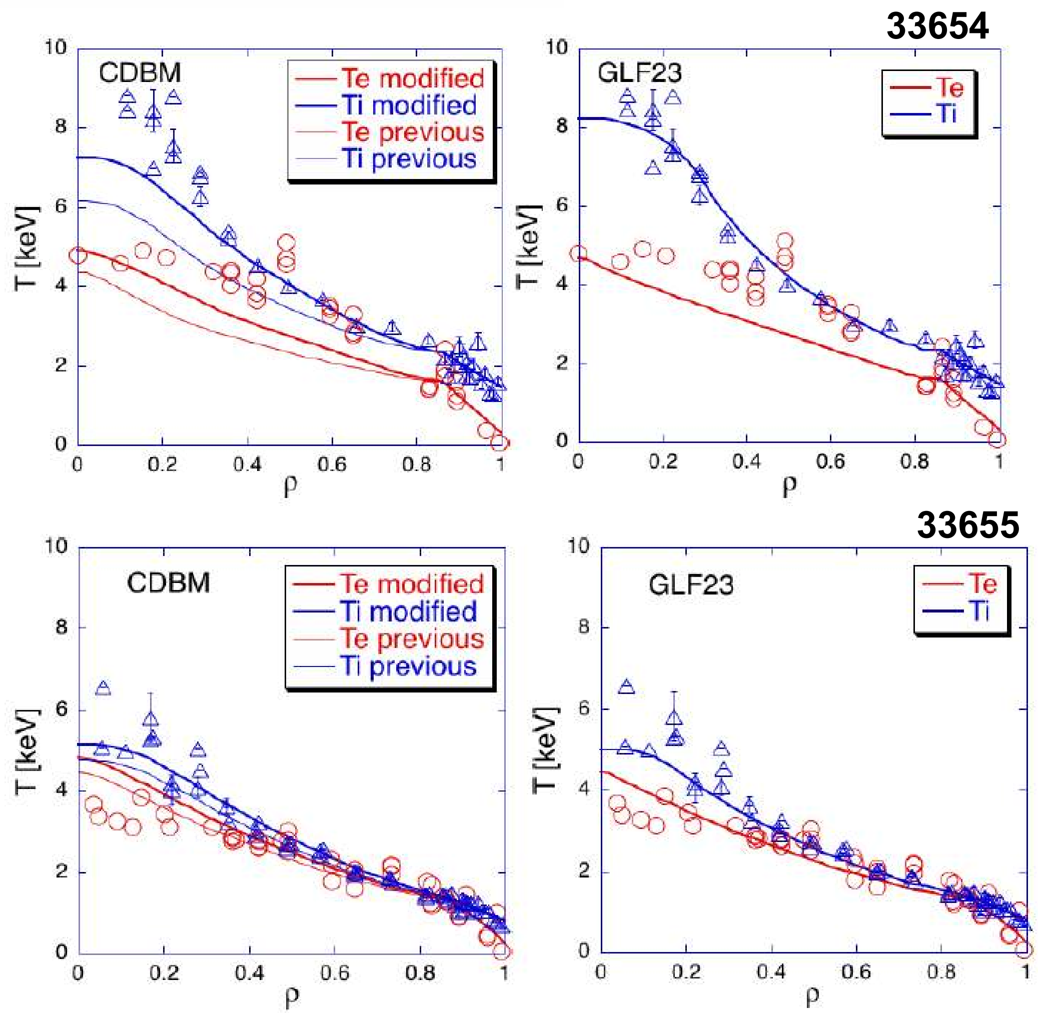
- Measured ne, <ne>=2.5e19 m-3 for 33654, 3.8e19 m-3 for 33655

- Prescribed q, q_axis=1 no MSE

- NBI heating from F3D-OFMC

- CDBM or GLF23 (with ExB shear stabilisation) plus neoclassical transport

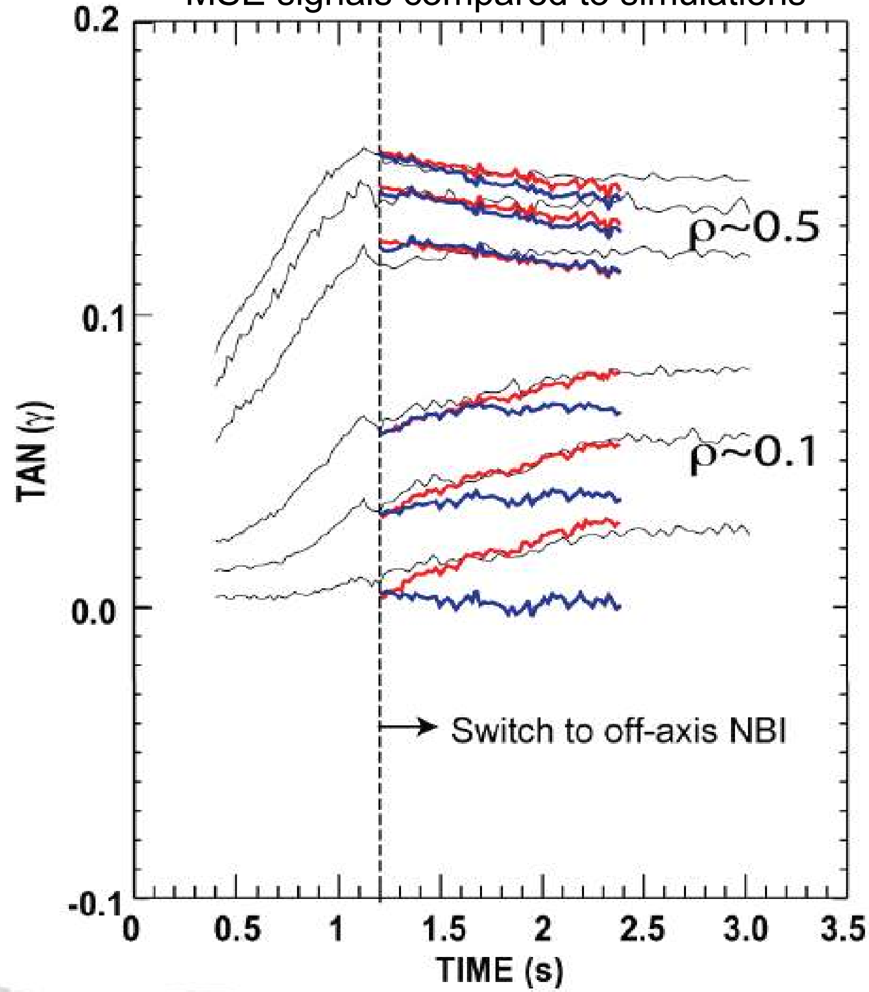
- Te and Ti are simulated within $\rho < 0.85$



Validation of Off-axis NBCD Physics Using New Tilted Beam in DIII-D (J. M. Park)

- DIII-D neutral beam has been successfully modified for off-axis injection, providing H&CD for physics studies
- Beam emission, fast ion population and current drive are consistent with off axis NBI
- The measure off-axis NBCD is very sensitive to B_T direction
  - Dependency of the off-axis NBCD efficiency on the toroidal field direction is crucial to the optimum use of the off-axis beams not only for DIII-D but also for ITER
- The measured off-axis NBCD is consistent with the NUBEAM modeling without anomalous fast ion transport for a range plasma β and E_b/T_e
  - ITER is not likely to suffer from the loss of NBCD efficiency due additional transport from microturbulence

MSE signals compared to simulations



- Red: with NBCD
- Blue: without NBCD

ITER baseline summary table

Team / codes	Anomalous transport model	H&CD	Scenario details	Results
C. Kessel et al/TSC	Coppi-Tang (H98~1), GLF23, Tped=4.7-5	33 MW NBI + 40 MW RF	15MA/100s, L-H at 100s, ne rise	Scan in nAr, ne ramp, flattop H98, feedbacks
F. Koechl & F4F G255/ CREATE-NL + JINTRAC	L-mode: BgBohm, H-mode: GLF23 + cont. ELM with prescribed α_c	33 MW NBI + 20 MW ICRH + 20 MW ECRH (central)	dIpl/dt=0.3MA/s at 0.25nGr, 0.65nGr during the Ipl flattop	-15MA, zero Vloop ramp-down for 15 -> 5M - 17MA, zero Vloop ramp-down for 17 -> 5 MA - 17 MA, zero Vloop ramp-down for 13 -> 5 MA with slower dIpl/dt at higher current
R. Budny / PTRANSP	GLF23, $\chi\varphi=0.5\chi i$_GLF23 & $\chi\varphi=\chi\varphi$_GLF23	50-73 MW		L-mode, scan in pedestal pressure (H-mode), inward/outward pinch for He ash, heat mix. Pα range: 7 – 120 MW
N. Hayashi et al / TOPICS-IB	CDBM mod., Tped=2.2 keV	33 MW NBI + 7 MW ICRH	15 MA, L-H at Ipl flattop, ne(0)= 1.1e20 m^{-3}, ITB, H-L at 8 MA	Comparison of old and new CDBM: Q ~ 10.4 -> 14.5, βN ~ 1.69 -> 2.12, H_H ~ 1.03 -> 1.14
A. Polevoi et al / JETTO, ASTRA, TOPICS-IB	SBM, GLF23, Weiland, MMM	33 MW NBI + 20 MW ECCD (EL)	10-15 MA, (5-12)e19 m^{-3}, fixed nTped ~30 keV*10^{19} m^{-3}	Density and Ipl scan with different transport models

ITER hybrid summary table

Team / codes	Anomalous transport model	H&CD	Scenario details	Results
S.H.Kim et al / CORSICA	Coppi-Tang, parametrised EPED1	Up to 53 MW		Scan in dIpl/dt, flat-top Ipl, flat-top ne, plasma confinement, ne ramp-up scenario. VDE
K. Besseghir et al/ DINA-CH &CRONOS	??	NBI (33MW) + ICRH (20MW) + ECRH (20MW)	0.4MA→12.2 MA→0.9MA, Q~8, q~1 for 1000 s	- Scenario within the PF limits on forces, fields, currents, voltages -L-H and H-L transition with no wall contact - Scenario evolved similarly to the prescribed-boundary one (small variations in H&CD timing & ECRH mirror angles
N. Hayashi et al / TOPICS-IB	CDBM mod., Tped=5.8 keV	NBI 33 MW, ICRH 20 MW, ECRH 20 MW	12.5 MA, ne(0) = 0.85e20m3	Comparison of old and new CDBM: Q ~ 4.83 → 5.6, βN ~ 2.12 → 2.38

ITER steady state summary table

Team/code	Anomalous transport model	H&CD	Scenario details	Results
S.H.Kim et al / CORSICA	Coppi-Tang x 0.7 to get H98~1.6, ITB not modelled, parameterised EPED1	56.5 MW: NBI (16.5 off-axis) + EC (20) + LH (20)	9 MA in 60s, 3000s, 0.85nGr, 210 s of Ipl ramp down	Estimation of flux consumptions, coil currents. Fully NI operation with Q > 5
F. Poli, C. Kessel / TSC + ideal MHD stability (M3D, PEST2)	Coppi-Tang or prescribed χ to produce ITB & scale to H98~1.6, CDBM. Tped=3.3-3.7 keV	73 MW: EC(20)+IC(20)+NBI(33) EC(20)+LH(20)+NBI(33) 93 MW: EC(40)+IC(20)+NBI(33) LH(40)+IC(20)+NBI(33) 68MW: LH(40)+IC(20)+NBI(8)	7-10 MA, 100% NI, bootstrap 40-70%, Prad 25-35 MW	Ideal MHD for various nGr, pressure peaking, heating scenarios
K. Besseghir et al /DINA-CH&CRONOS	CRONOS for heat transport	NBI (33MW) + ICRH (20MW) + ECRH (20MW) + LHCD (15MW)	0.4MA→10MA →0.6MA, Q~5	- Scenario within the PF limits on forces, fields, currents, voltages -L-H and H-L transition with no wall contact
V. Leonov et al / ASTRA+ ZIMPUR	Scaling-based	Feedback for NBI (~30→50MW) and LHCD(~20→40MW)	9 MA, ne=7.e19, Pfus~350 MW	Control of ne (via fuelling), Pfus (PNBI), Vloop=0 (PLH), Ploss (Ar seeding), nHe (He pump)

Steady State exploration: H&CD requirements for MHD stability and ITB formation (F. Poli and C. Kessel, IOS/ITPA, 16-19 April 2012)

Ideal MHD stable for $\rho_{ITB}>0.5$ and $q_{min}>2$

R=6.2, a=2.0

κ=1.8, δ~0.45

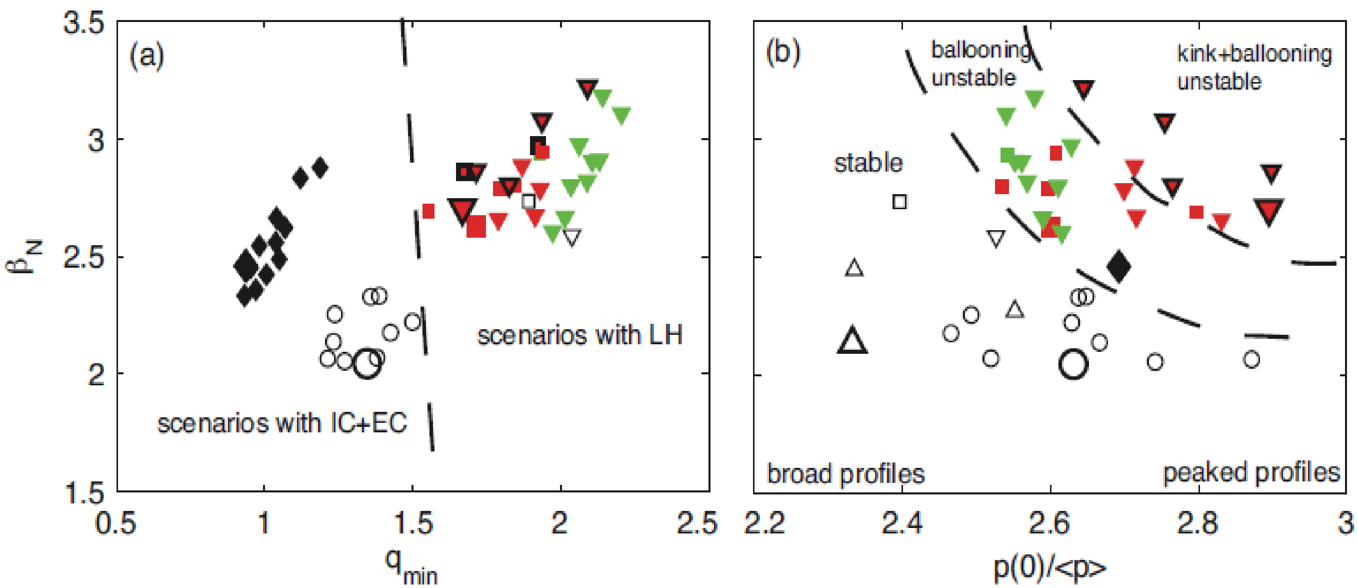
n/n_{Gr} ~ 0.75-1.1

n(0)/<n> = 1.3-1.5

EPED1 (P. Snyder)

T_{ped} ~ 3.3-3.7 keV

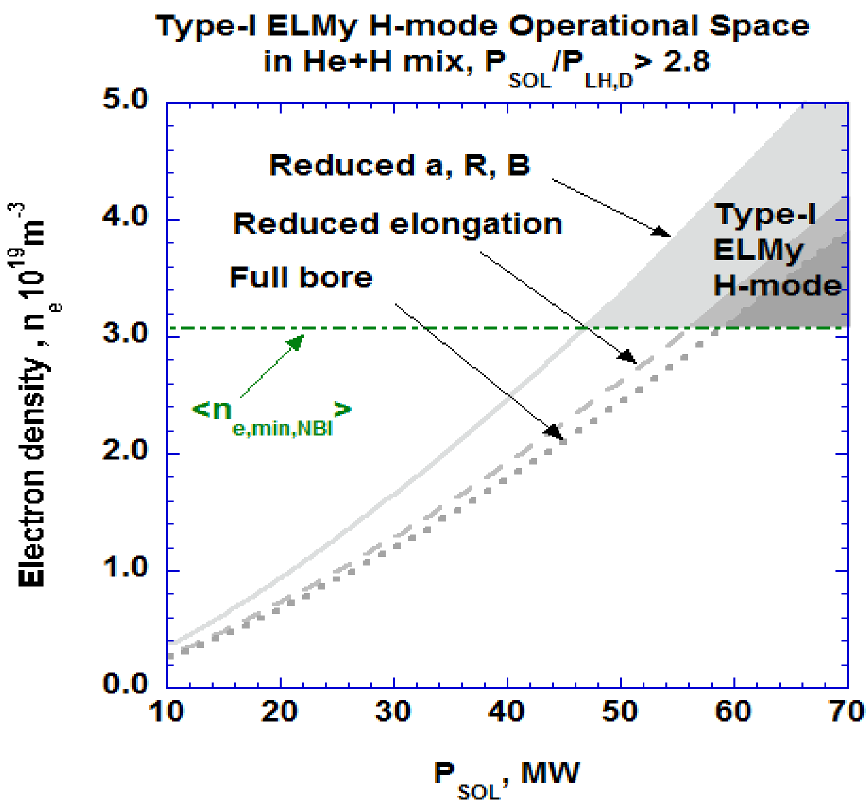
ρ_{ped} ~0.94



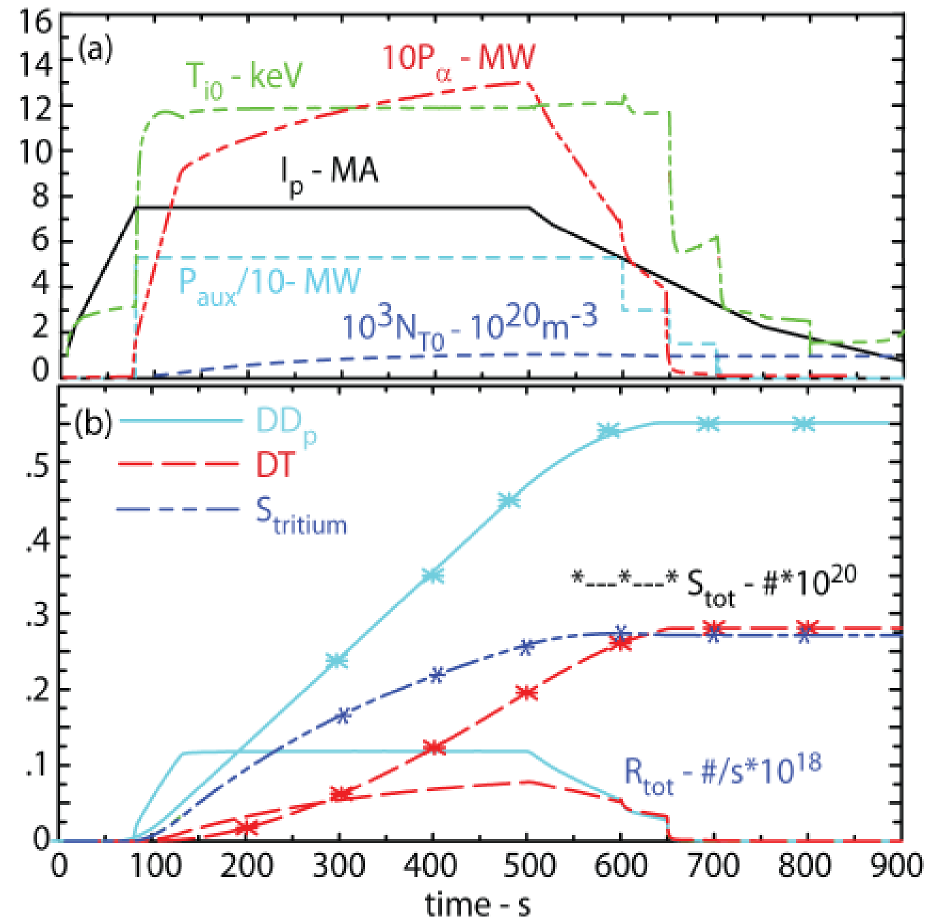
With LH heating => most likely $q_{min}>2$

=> $\beta_N \geq 4 l_i$ with ideal wall stabilization

Development of ITER scenarios for pre-DT operations (T. Casper)



Parameter space calculations



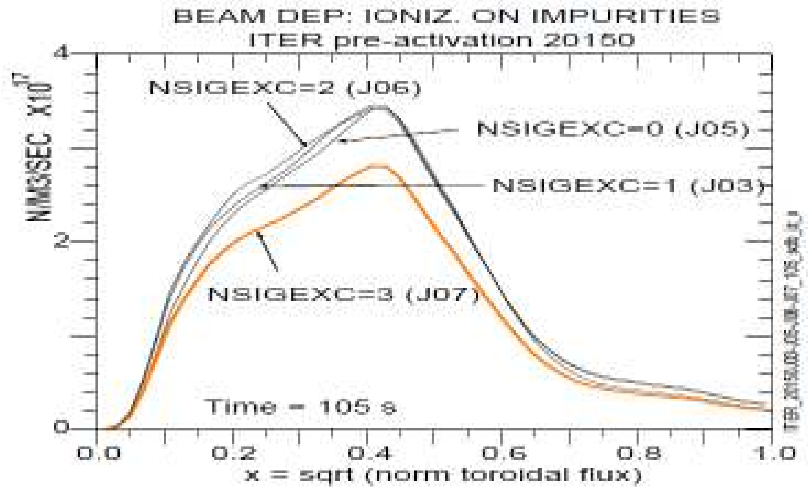
Low activation DD simulations

Needed: input on He experiments on JET, ITER simulations to compare with CORSICA

Modules development/improvement: improved multi-step ionization of NNB ions in ITER (R. Budny)

- Beam neutrals can get excited without being ionized
- Ionizations from excited states increase beam deposition and reduce the shine-through power
- Approximate models have been used to predict this effect

ITER: H plasmas

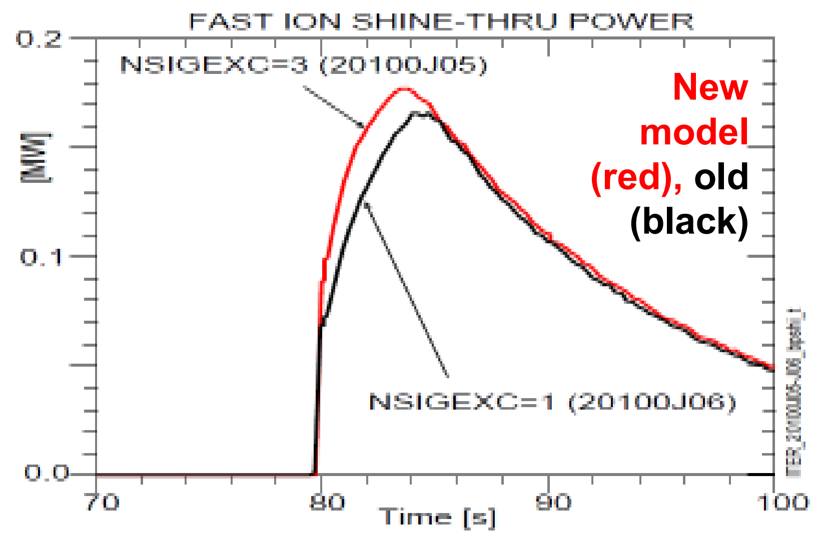


New, consistent excited state model in NUBEAM

- New module ADAS310_FORTRAN_DRIVER in NUBEAM and TRANSP (Marina Gorelenkova)
  - Use ADAS (Atomic Data and Analysis Structure)
  - Module based on ADAS310 library
  - Atomic physics data for an effective ionization and charge-exchange coefficients of H/D/T beam atoms in an impure plasma
  - Bundle-n approximation for levels above Z = 10

- Beam shine-through

ITER DT plasma



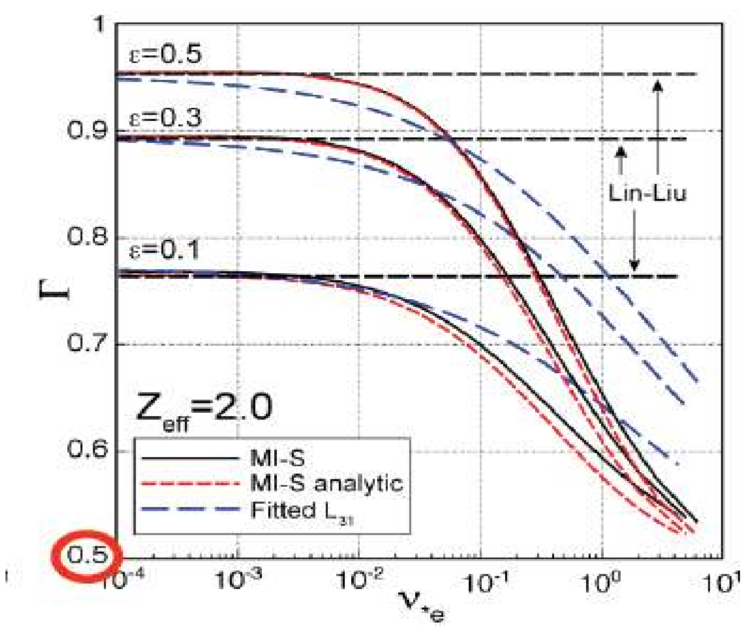
Collisionality dependence of a shielding factor of a beam driven current (M. Honda et al)

- *NBCD calculation sometime overestimate driven current*

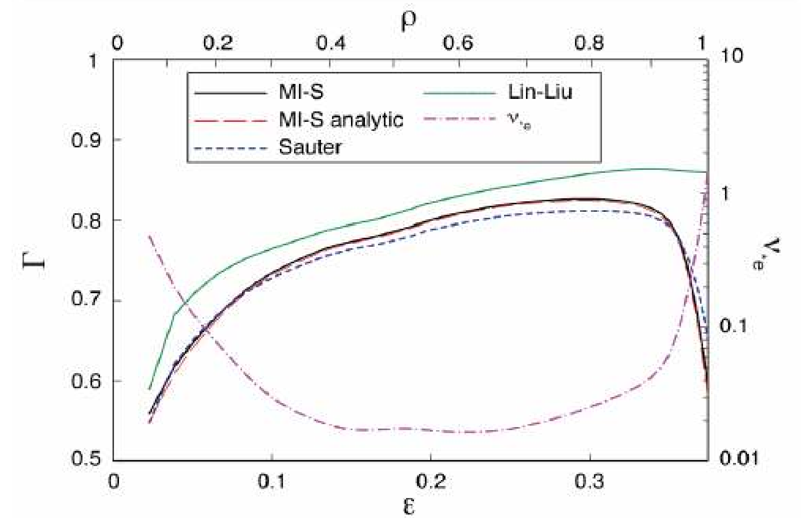
- *Two shielding factor models covering all collisionality regimes have been developed using matrix inversion (MI)*

- *L_{31} coefficient [Sauter PoP1999] is equivalent to shielding factor Γ: fitted formulae for the collisionality dependent L_{31} can be used for Γ*

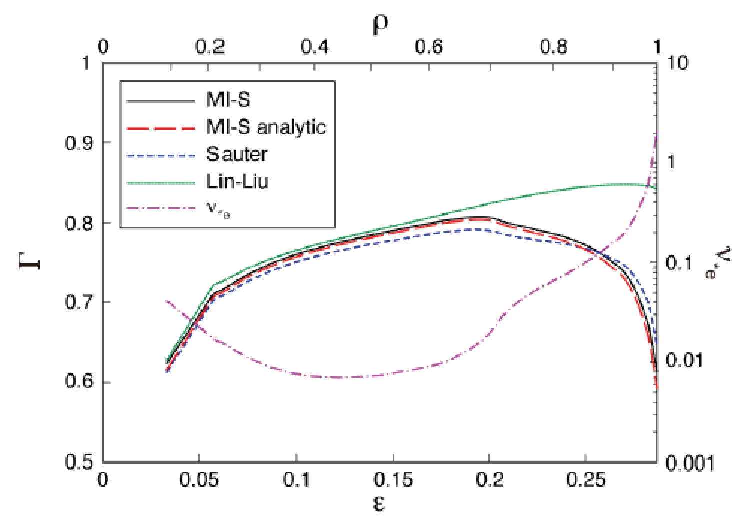
$\nu_{*e} \to 0$, Z_b=1, nearly concentric circular equilibrium, $f_t = 1.46\varepsilon^{1/2} - 0.46\varepsilon^{3/2}$



JT-60SA LSN SS 2.3MA



ITER 9MA SS DT scenario



Action list (Hybrid and SS) Modelling

Review of action list of 1 year goals:

• Pedestal consistent with EPED1. EPED1 parameterization for ITER shape and ½ + full TF : All scenarios

• More routine (ideal) MHD stability calculations: SS

• Particle transport: document that the density peaking (particle transport) is important*, particle source, particle transport*

• Data from experiments: s and q dependence, data from ITB scenarios from JT-60U and EU-JP selected discharges

• Kukushkin's SOL/DIV parameters to include in codes

• Review SS scenario simulations

Action list for JA's

For the next meeting (15-19 October 2012, San Diego)

- Modelling of He target plasmas for NBI
- Old Hybrid benchmark: compare p_{fast}, rotation and plasma equilibrium
- Long pulse 10-15MA: to get to some closure and publication strategy

In the next 6-12 months:

- IOS-JA8: Burn control simulation
- IOS-JA9: Optimisation of Operational Space for Long pulse Scenarios
- IOS-JA2: ITER ramp down simulations

Longer term activities (report when required or when progress is made)

- IOS-JA1: Modelling ITER-like discharges in DIII-D, JET, AUG, C-Mod
- IOS-JA5: Ramp up of ITER Hybrid and Steady State scenarios
- IOS-JA7: Steady State exploration
- IOS-JA10: Scenario modelling for low- and non-activation operation of ITER