

Integrated Modeling for ITER Discharges

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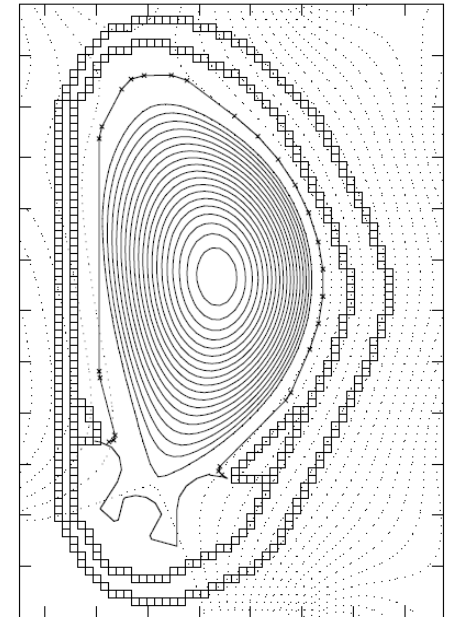
**SWIM Project Meeting
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Princeton Plasma Physics Laboratory**

- **Task: Carried out discharge simulations for ITER scenario development using IPS with heating and current drive components such as NUBEAM, TORIC, LSC, etc.**
- **For FY08, we have done simulations for a reference 15-MA scenario. We use this comprehensive ITER approach to burn to**
 - **compare with previous calculations using model heating and current drive sources.**
 - **understand effects of variables in source models.**
 - **provide plasma states for IPS to run in re-play mode.**
 - **test multi-processor version of the NUBEAM code.**

- **Specific calculations carried out:**
 - EPA/TSC alone with prescribed source profiles
 - EPA/TSC with NUBEAM with varying elevations of the beam aperture
 - EPA/TSC with NUBEAM and TORIC via internal coupling, single processor
 - EPA/TSC with multi-processor NUBEAM
- **IPS components that may be involved in this task:**
 - driver
 - monitor
 - EPA
 - NB
 - FP
 - RF
 - stability

The case study is the reference H-mode scenario with 100 s ramp-up, ~400 s burn

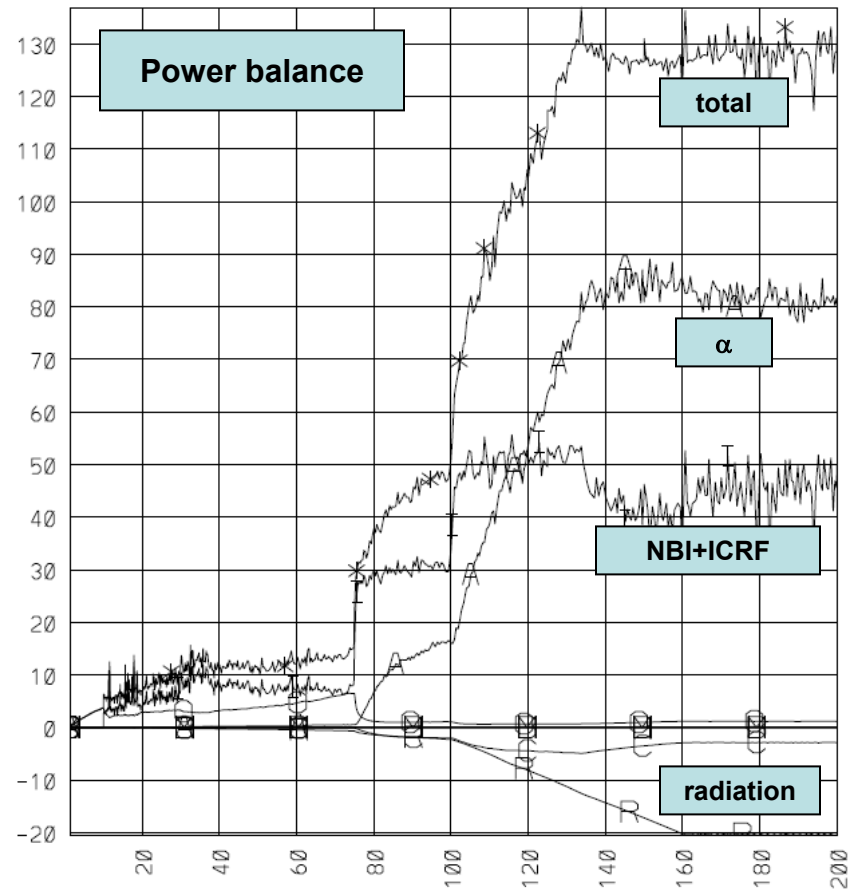
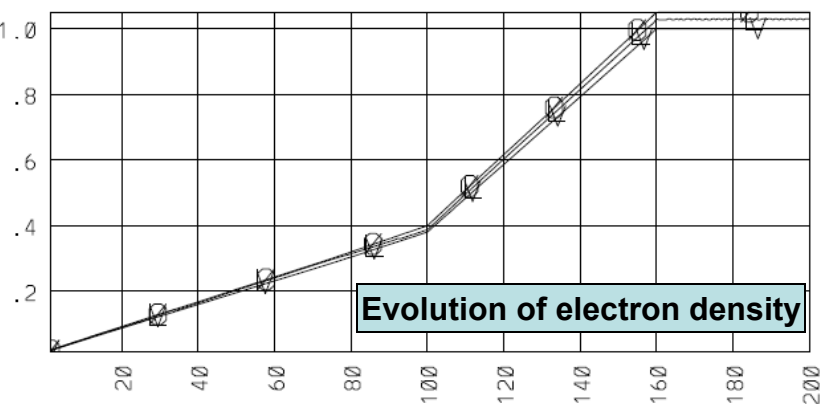
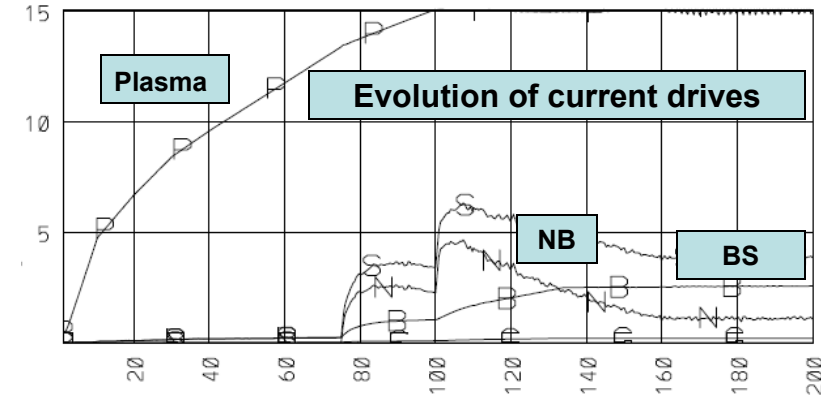
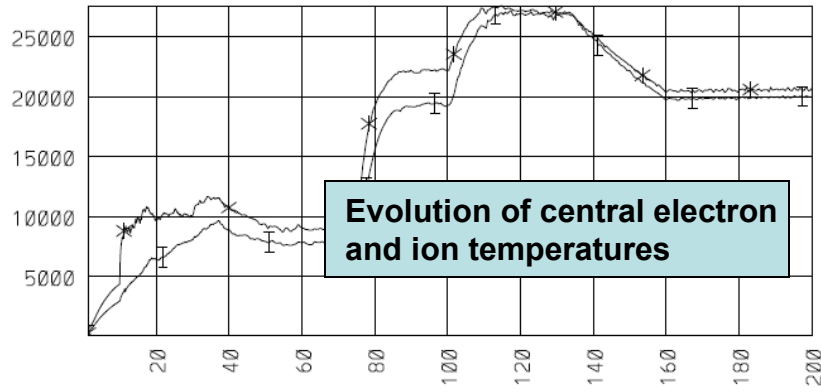
- Discharge scenario – off-axis beam and ICRF heating:
 - $1.5 \text{ s} \leq t \leq 400 \text{ s}$
 - pre-programmed: z_{eff}, n_e, I_p
 - $n_{e20}=1.05 @ t=160 \text{ s}$
 - $Z_{\text{eff}}=1.65 @ t>100 \text{ s}$
 - $I_p=15 \text{ MA} @ t>100 \text{ s}$
 - total internal energy clamped at 325 MJ
 - particle confinement time=25 s
 - energy confinement
 - $t < 75 \text{ s}$ Coppi/Tang profile consistent
 - $t \geq 75 \text{ s}$ relaxed GLF23 and neo-classical



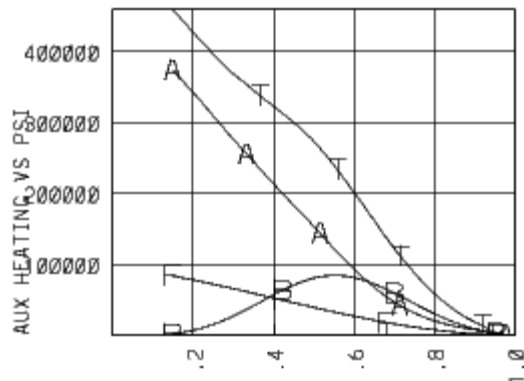
Flux contours for the free-boundary equilibrium @200 s
 $B=5.3 \text{ T}$, $R=6.2 \text{ m}$, $a=2.0 \text{ m}$,
 $\epsilon=1.84$, $\delta=0.45$, $\beta=2.4\%$,
 $\beta_p=0.66$, $q(0)=0.89$, $q(1)=3.63$

- **Models for heating and current drive**
 - **Neutral beams**
 - off-axis (beam tangency 5.295 m), 1st beam on @ 75s, 2nd beam on @ 100 s. Co, 1 MeV D, full power 16.5 MW.
 - NUBEAM, sample size=1000.
 - **ICRF**
 - 1 antenna, 52.5 MHz, 5 MW @ 10 s, 8 MW @ 30 s 20 MW @ 100 s, ³He minority (0.001).
 - TORIC, 31 poloidal modes, 128 radial, 64 angular grids
 - **Alpha particles**
 - Monte Carlo fast ion slowing down, sample size=1000.
 - **Source integration time – 25 ms.**

Simulation of the ITER Approach to Burn with TSC/NUBEAM/TORIC/PS2

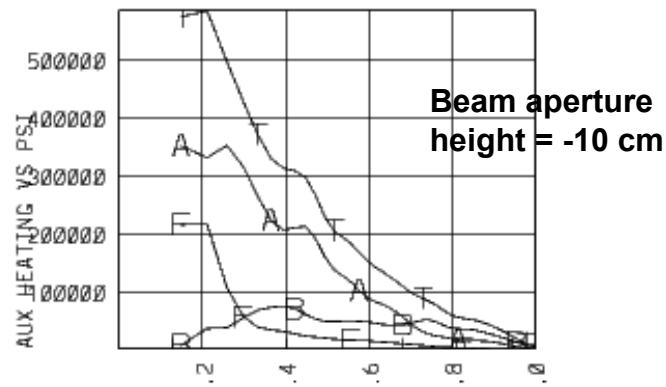


Temperatures and α power are not particularly sensitive to the source models used.

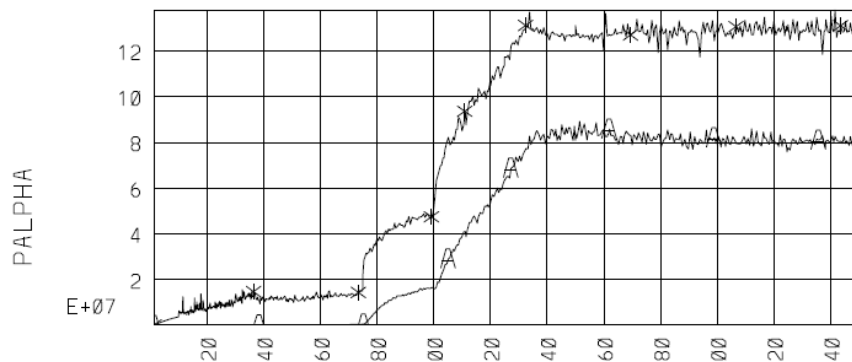
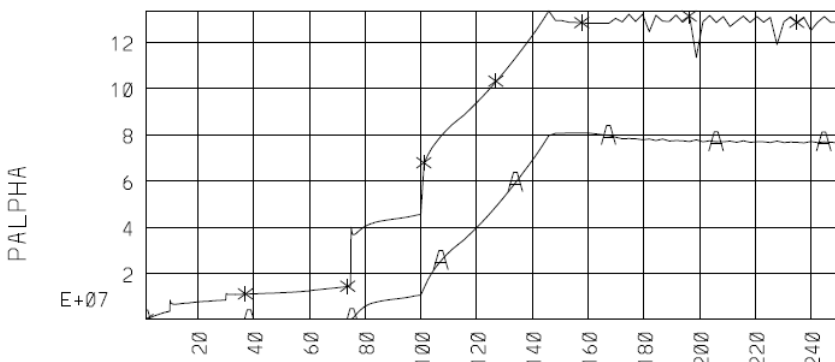
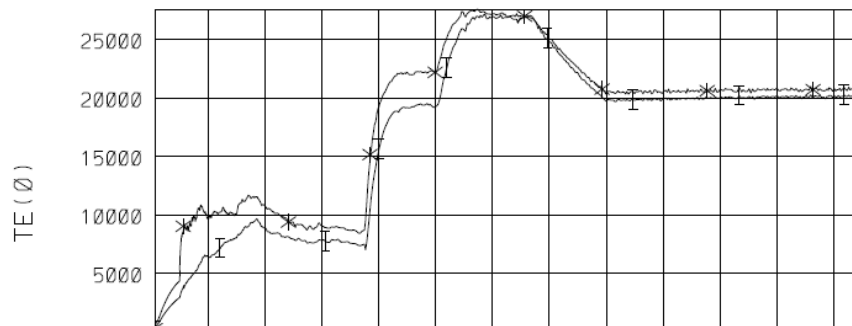
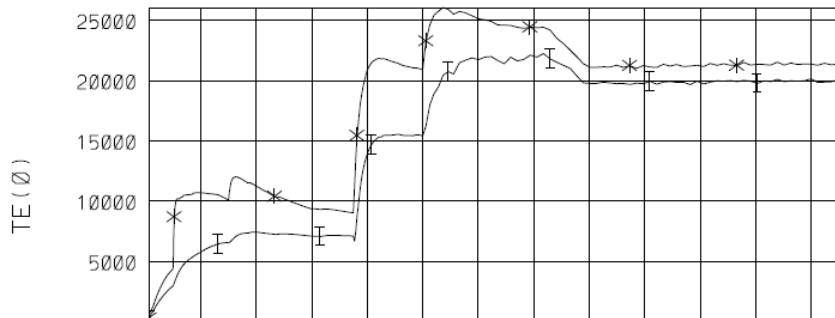


Model calc.

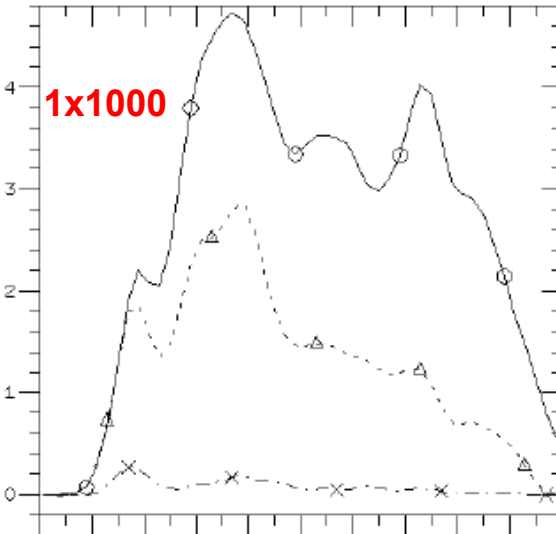
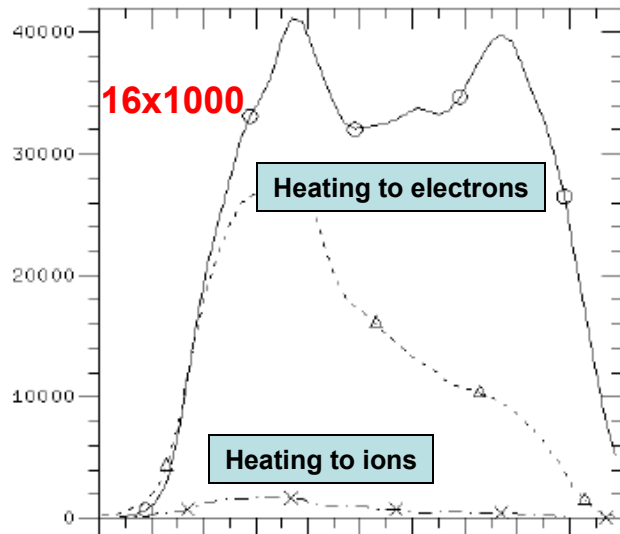
Heat deposition profiles @200s



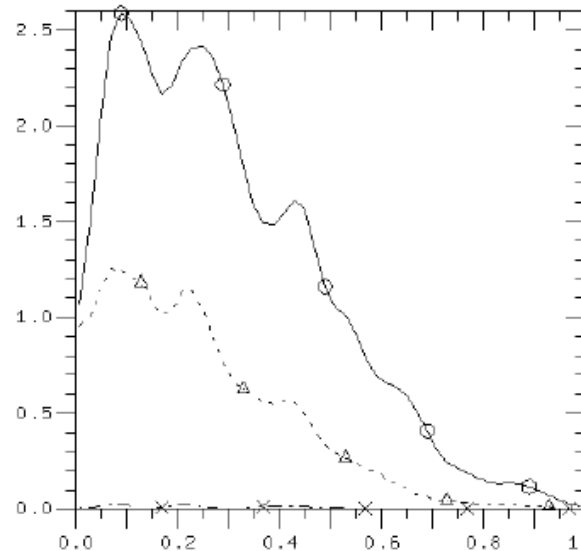
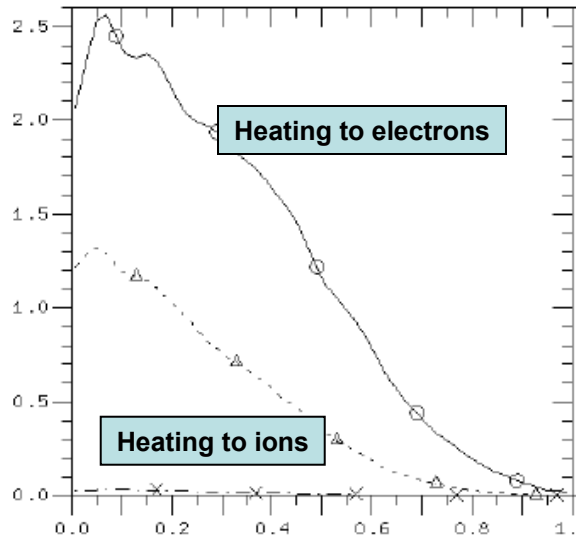
NUBEAM/TORIC



MPI version of NUBEAM offers smooth heating profile without incurring extra computation time.



Beam heating profile @ t=200 s



α -particle heating profile @ t=200 s

Remarks

- **Plasma states for replay available in**
 - `/p/swim1/lpku/IPS/runs/ITER_REPLAY` for 10-400 s in 25 s increment.
- **Simulation under IPS control**
 - readily accessible to users (Kessel, Budney, and others)
 - having templates setup for machines (ITER, KSTAR, NSTX, CMOD)
 - Will be useful to invoke multi-processor NUBEAM and RF components.
- **Possible IPS enhancement**
 - Sawteeth and generalized time stepping.
- **Possible EPA/TSC enhancement**
 - Implement new GLF23 and standardized transport interface
 - Implement interface with machine description files
 - Add prediction of plasma rotation profile
 - Include fast ion pressure in equilibrium evolution
 - Implement options for edge pedestal model (including ELMs)