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Collaboration in Verification and Validation Activities

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Introduction
Past and current activities in ITPA
Activities in Japan
Subjects of discussion

Introduction

- **What is to be verified?**
  - **Numerical model of each component**:
    - — Numerical stability, convergence, accuracy, performance
    - — Comparison with analytical models in some limits
    - — Comparison with similar codes: Benchmark test
  - **Framework of integration**
    - — Consistency, sufficiency, expandability, universality
    - — Inter-operability
- **What is to be validated?**
  - **Experimental data**
    - — Necessary data items, number of data, quality of data
  - **Physics model**
    - — Conformity with experimental data
    - — Conformity with similar codes in realistic situations

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Past and Current V&V Activities in ITPA

- **ITER Physics Basis**: ITER Physics R&D
  - **Transport modeling**
    - ITER Profile Database
    - Comparison of transport models
    - Benchmark test of transport codes (Fixed transport coefficients)
  - **Activities in ITPA-CDBM TG**
    - **Transport modeling**: IAEA FEC proceedings
  - **Activities in ITPA-SSO TG**
    - **Code benchmark test**
      - ECCD modeling: (ray tracing, Fokker-Plank):
      - LHCD modeling: (ray tracing, Fokker-Plank)
      - ICH modeling: (full wave)
    - **Scenario benchmark test**
      - Transport + NBI + IC + EC

ECCD Benchmark Test (ITPA07f-SSO: R. Prater)

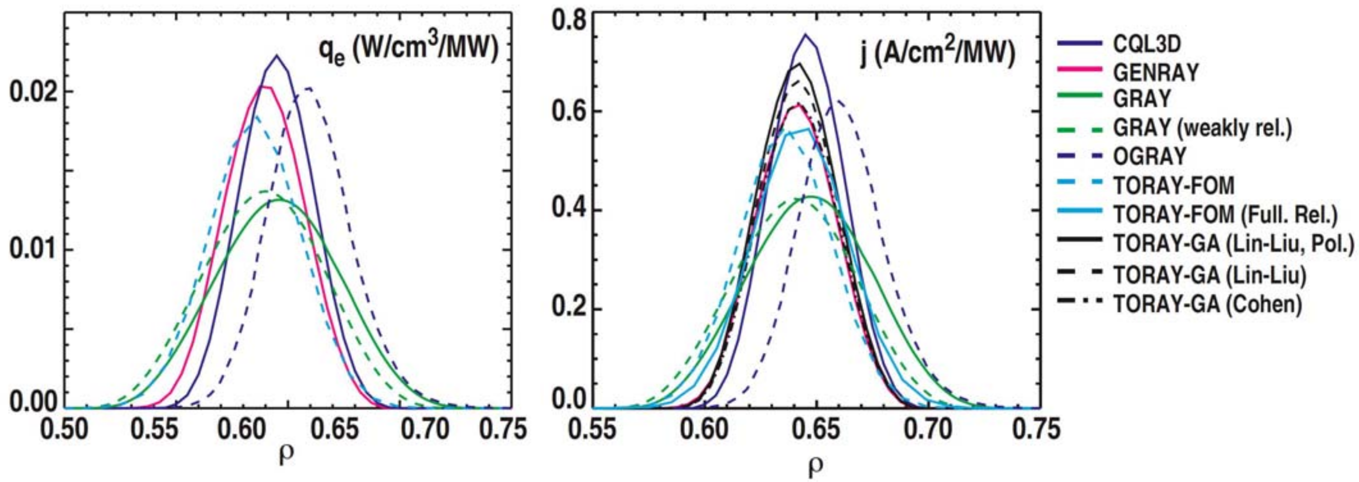
ECH Codes Used in this Benchmarking Study

TABLE I

Code	Propagation Model	Propagation Dispersion Relation	Resonance	Absorption	ECCD Model
BANDIT-3D	Rays	Cold	Relativistic	Fokker-Planck	Fokker-Planck
CQL3D	Rays	Cold	Relativistic	Fokker-Planck	Fokker-Planck
GENRAY	Rays	Relativistic	Relativistic	Mazzucato	Cohen
		Relativistic (R2D2)	Relativistic	R2D2	Cohen
		Relativistic (Westerhof-Tokman)	Relativistic	Relativistic	Cohen
GRAY	Quasi-optical	Cold	Relativistic	Analytic	Farina
			Weakly relativistic	Analytic	Farina
OGRAY	Gaussian	Cold	Relativistic	Fokker-Planck	Fokker-Planck
TORAY-FOM	Rays	Cold	Weakly relativistic	Westerhof	Cohen
		Cold	Relativistic	Westerhof	Cohen
TORAY-GA	Rays	Cold	Relativistic	Mazzucato	Cohen
				Mazzucato	Lin-Liu
				Mazzucato	Lin-Liu pol
TORBEAM	Gaussian	Cold	Weakly relativistic	Westerhof	Cohen

ECCD Benchmark Test (ITPA07f-SSO: R. Prater)

Profiles Differ More Than Integrated Values



- No consistent way was found to evaluate EC beam dispersion for ray tracing and beam propagation

323-06/RP/jy

ITER Hybrid Benchmark Simulations

(more work is needed to strictly enforce these prescriptions for the simulations)

Plasma in flattop phase (as stationary as possible)

$Ip = 12$ MA
$B_T = 5.3$ T
$t_P^*/t_E = 5.0$
$f_D/(f_D+f_T) = 0.5$
$f_{Be} = 2\%$
$f_{Ar} = 0.12\%$

$P_{NBI} = 33$ MW (1 MeV, off-axis, $Z_{NBcenter} = -0.42$ m @ R = 5.3 m)
$P_{ICRF} = 20$ MW (53 MHz, heating only, 2T)
$P_{EC} = 20$ MW (170 GHz, midplane launch, $\alpha_{1,2,3} = 0^o$, $\beta_{1,2,3} = 30^o$, $P_{1,2,3} = 6.67$ MW)

R_b,Z_b for fixed boundary (also PF coil currents, l_i, β_P for free-boundary)

$\rho_{ped} = 0.925$

$n_{ped} = n(\rho = 0.925) = n(0)$
$T_{ped} = 5.0$ keV

$n(0) = 0.85 \times 10^{20}$ /m3
$n(\rho = 0.0 - 0.925) = n(0)$
Linear drop from $\rho = 0.925 - 1.0$
$n(\rho = 1.0) = 0.35 \times n(0)$
$T(\rho = 1.0) = 200$ eV

$n_Z(\rho)/n_Z(0)$ same as electrons

Te(ρ) and Ti(ρ) profiles from GLF23

T_Z(r) same as fuel ions

Hybrid #1) NB + IC

Hybrid #2) NB + IC + EC

Benchmark Test for ITER Hybrid Scenario

- **C.E. Kessel et al.: IAEA2006 IT/P1-7** (ITPA/SSO)
- Codes: **CRONOS, ONETWO, TSC/TRANSP, TOPICS, ASTRA**

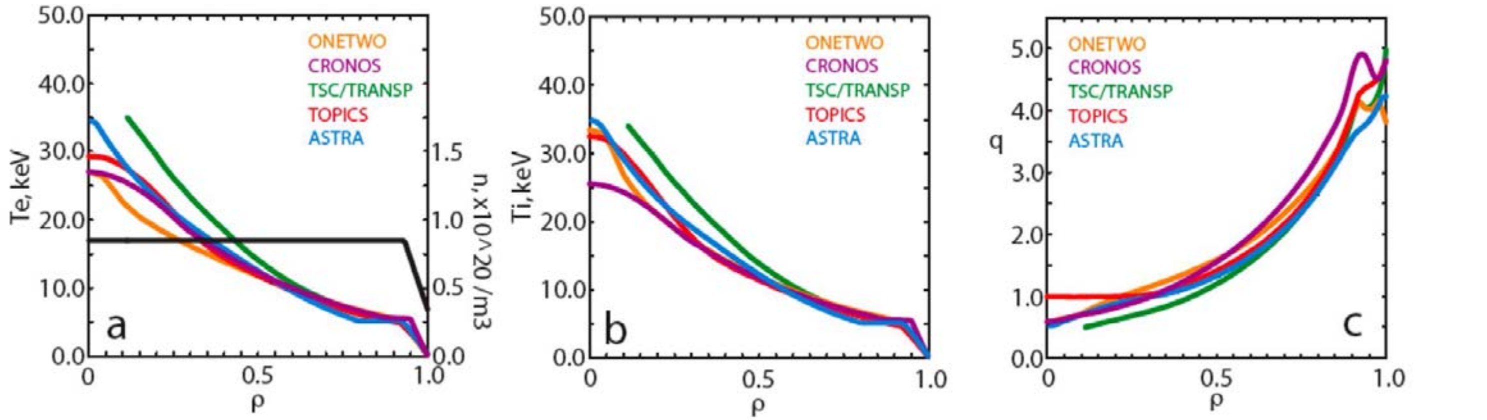


Figure 1. Electron temperature profiles and density profile (a), ion temperature profiles (b), safety factor profiles (c), for the NB+IC ITER Hybrid simulations.

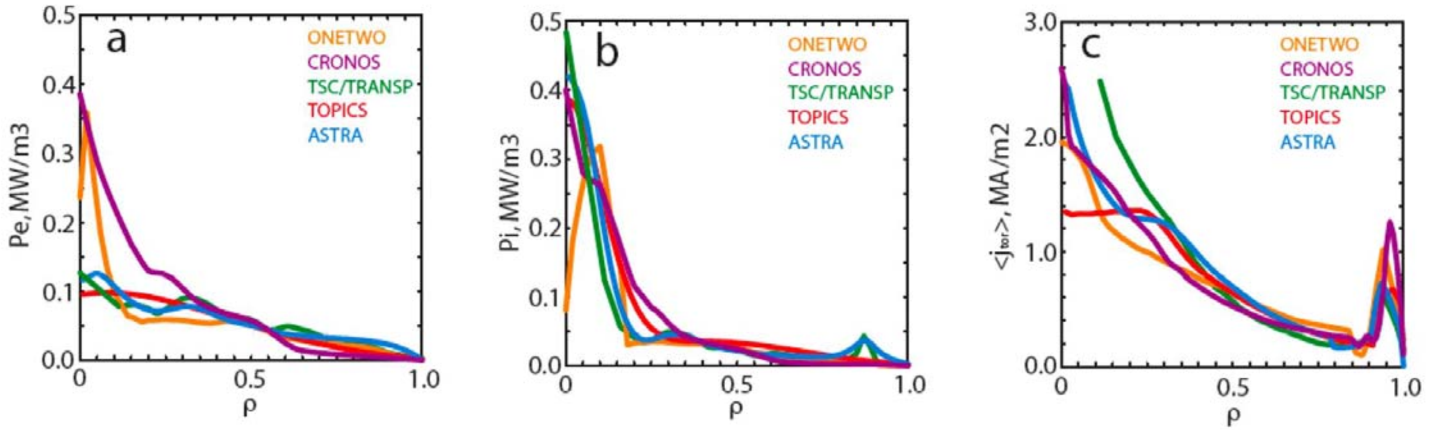


Figure 2. External power deposition profiles to electrons (a) and ions (b) and the toroidal current density (c) for the NB+IC ITER Hybrid simulations.

Benchmark Test for ITER Steady-State Scenario

- Codes: **TOPICS, CRONOS, TSC/TRANSP**

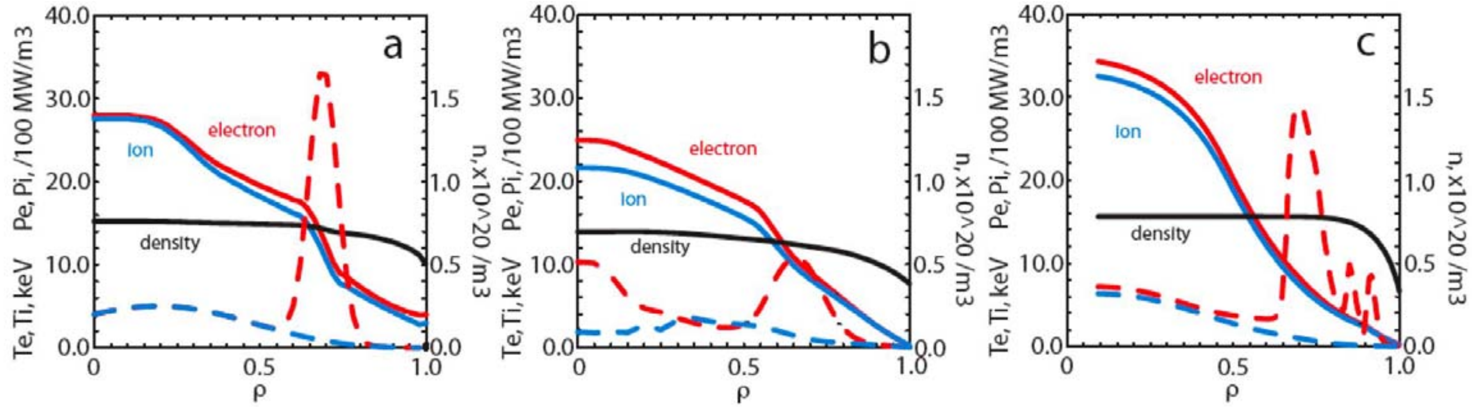


Figure 5. Electron and ion temperature, density, and external power deposition profiles for Steady State ITER simulations, (a) TOPICS (NB+EC), (b) CRONOS (NB+IC+LH), and (c) TSC/TRANSP (NB+IC+LH).

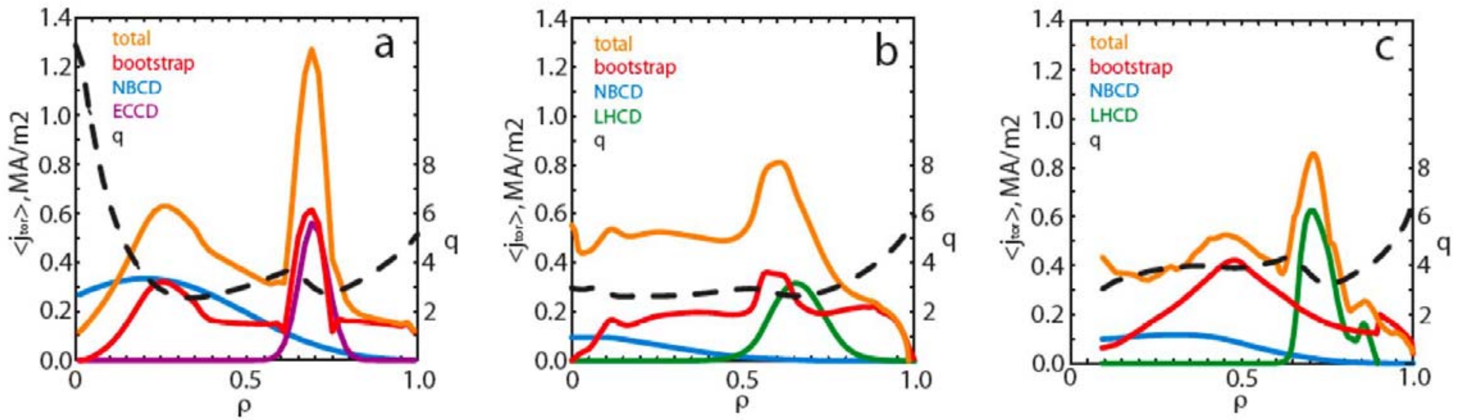
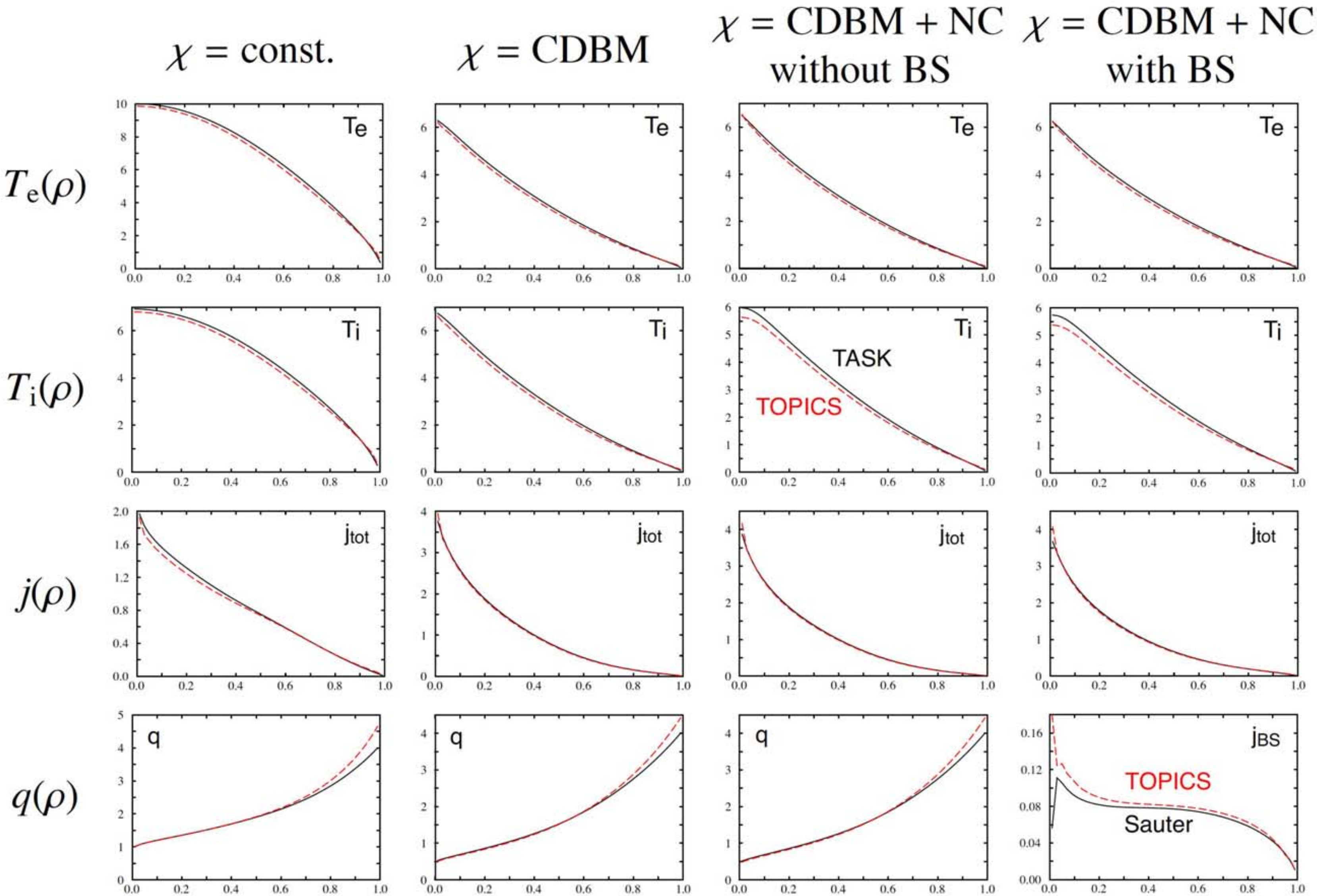


Figure 6. Safety factor and toroidal current density profiles and its contributions for Steady State ITER simulations, (a) TOPICS (NB+EC), (b) CRONOS (NB+IC+LH), and (c) TSC/TRANSP (NB+IC+LH).

Bentimark Test of TASK/TR and TOPICS



Discussion on Collaborative Activities

- **Benchmark Test**
  - **Transport code**
    - Simple non-stiff transport model (e.g. CDBM05)
    - Same transport solver
    - Own transport solver
- **Joint Metrics**
  -
  -
- **Standardized Test Case**
  - Experimental results or ITER prediction?
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