Remote meeting, 28 Sept 2011

INTEGRATED SCENARIO MODELLING: Report from ITM General Meeting and discussion on 2012 activities

meeting 28 September 2011

X. LITAUDON, I. VOITSEKHOVITCH

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Deputies: R. Coelho, D. Coster

EFDA CSU Contact Person: D. Kalupin

ITM General meeting, September 12-16, IPP-Garching

1) Training: use of ITM workflows in Kepler, visualisation tools, HPC, …
2) Plenary session: overview of ITM annual activities and achievements (IMPs, W. Houlberg talk on ITER IO strategy on integrated modelling)
3) Parallel project sessions and cross-project sessions
4) Plenary session summarising the project and cross-project activities

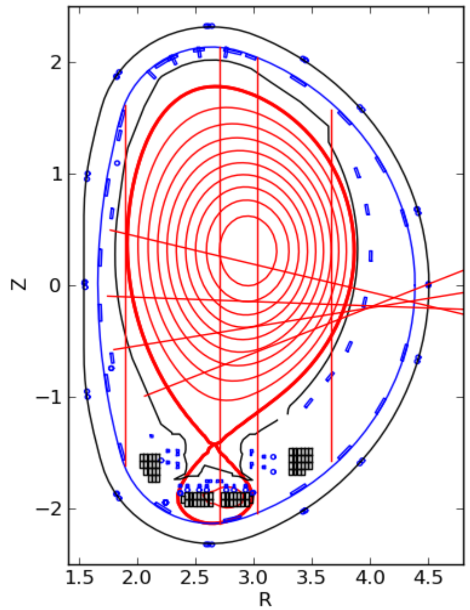
IMP12 (equilibrium, MHD stability)

W. Zwingmann. M. Ottoviani

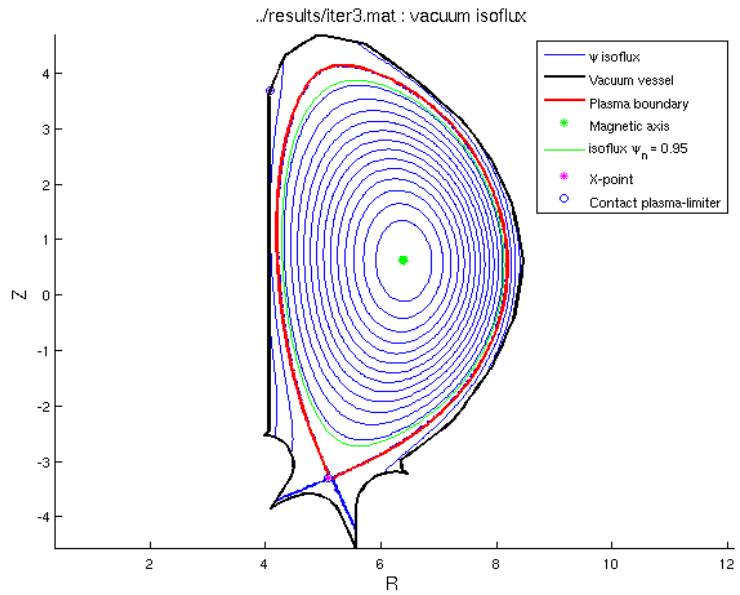
- ***Available modules: equilibrium codes***
  - Interpretive: EQUAL (equivalent to EFIT), CLISTE, EQUINOX
  - Free boundary: CEDRES++, CREATE-NL, FIXFREE
  - Fixed boundary: CAXE, CHEASE, HELENA, (EMEQ), (SPIDER)
- ***Available modules: linear stability***
  - KINX, ILSA, MARS, MARS-F
- ***Workflows essentially ready for deployment:***
  - Equilibrium reconstruction
    - Already in use on Tore Supra
  - High resolution equilibrium and stability (J-α)

    C. Konz talk at EPS-2011
  - Effect of NTM on transport (IMP12-IMP3)

IMP12: Equilibrium Reconstruction



JET by EQUAL (W. Zwingmann)



ITER by CEDRES++ (C. Boulbe)

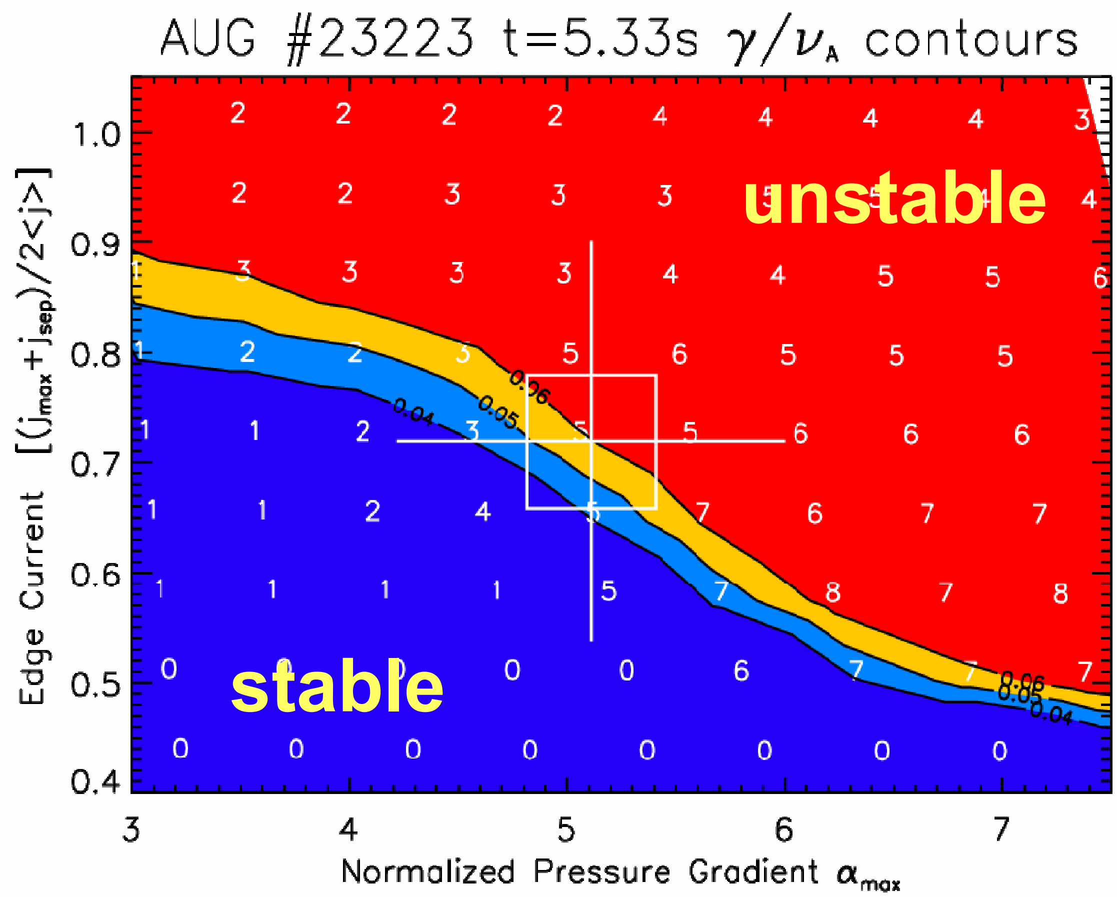
Free Boundary Equilibrium Code	Tokamak
EQUAL	JET, Tore Supra, ITER
EFIT++	JET, MAST
CEDRES++	Tore Supra, ITER
EQUINOX	Tore Supra, ITER
CLISTE	AUG, ITER

IMP12: Pedestal Stability Study

Influence of pedestal width and height on stability [C. Konz, 38th EPS 2011]

AUG discharge 23223 before onset of type-I ELM

Discharge shows marginal stability vs. pedestal height and width variations

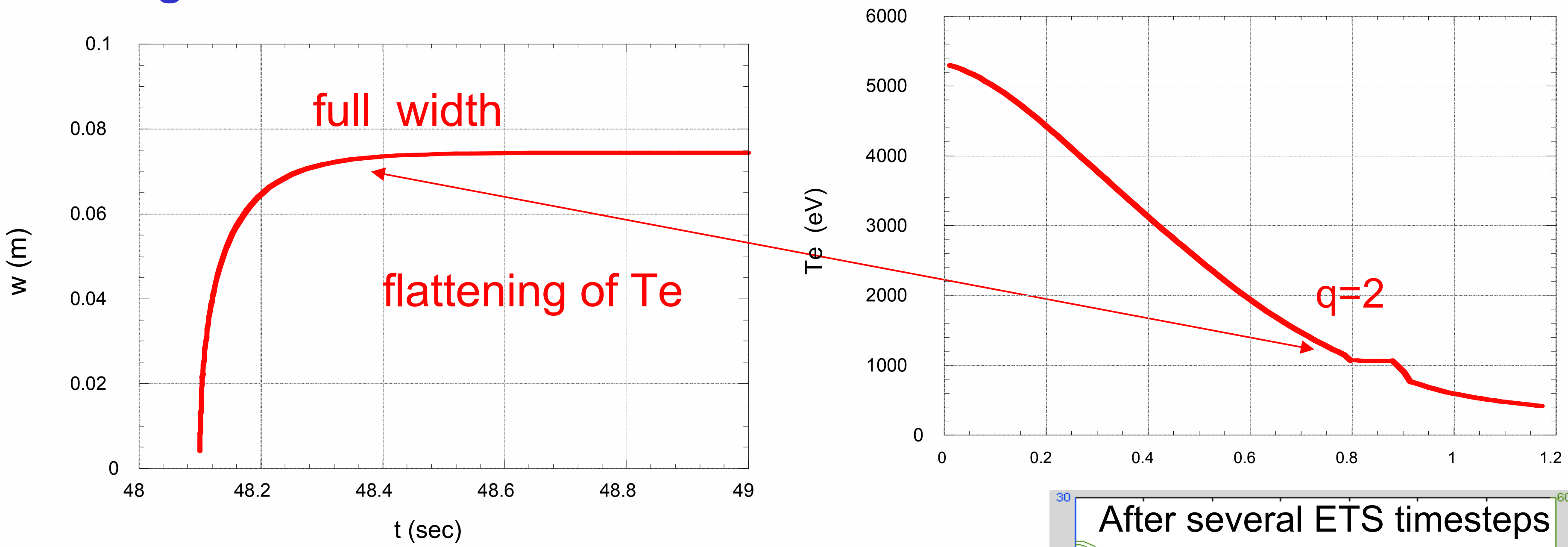


Crosshair marks equilibrium with error bars

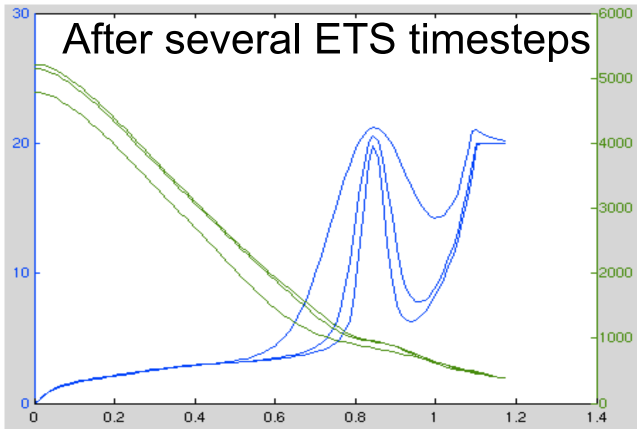
IMP12-IMP3: EFFECT OF NTM on TRANSPORT

S. Nowak, O. Sauter, P. Huynh

NTM workflow in ETS demonstrates the modification of temperature profile as a consequence of increased radial transport due to the magnetic island



$$\chi_{m,Te} = \chi_{Te} \left[1 + \text{coeff} \;\; \exp\{-4\,(\rho-\rho_s)^2 / (\alpha\, w)^2\} \right]$$



IMP3 (core - edge integration):

- ***Transport modules***
  - Core
    - ETS
    - IMPURITY (already running in ETS)
    - NEUTRALS (ready for addition, requested for testing)
  - Edge
    - SOLPS, ASCOT, ERO, BIT1

IMP3: ETS Workflows

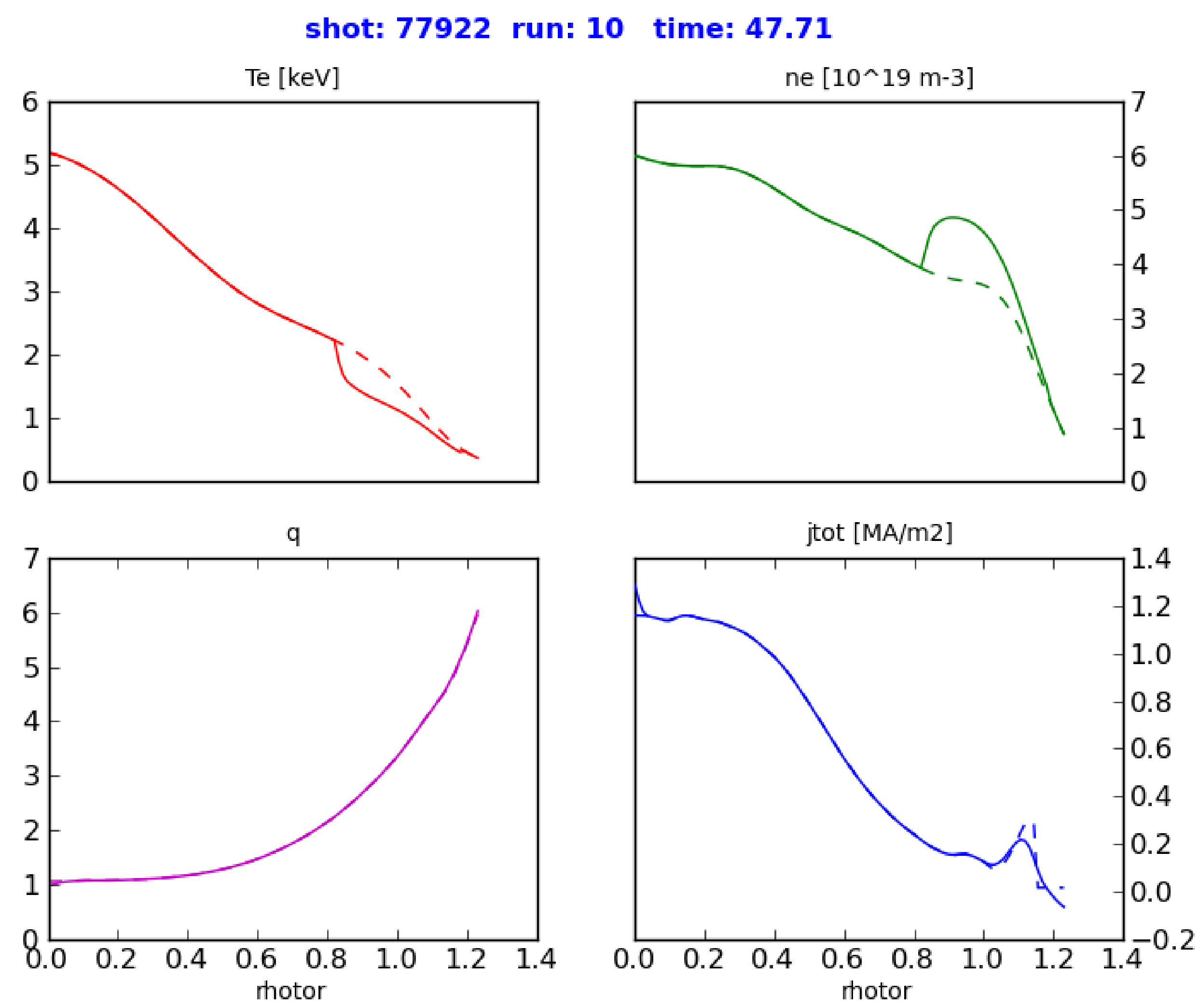
- ***ETS has spread from "workflow developers only" to***
  - Module developers
  - People benchmarking the code against other similar codes
  - Others (*e.g.* training at this meeting)
- ***Current challenges***
  - Adding new modules
  - Speeding up the code
  - Making things more robust
  - Making the workflow easier to use

IMP3 (with IMP4 and IMP5): modules included in the ETS workflows

- ***Equilibrium codes***
  - BDSEQ, EMEQ, HELENA, HELENA21, (SPIDER), (CHEASE)
- ***Transport coefficients***
  - Prescribed, NEOWES, ETAIGB, B_GB, GEM, BohmGB, CoppiTang, NCLASS, (GLF23)
- ***Sources***
  - Prescribed, impurities, ECRH, (ICRH), (LH), (NBI), pellets, (neutrals)
- ***Other***
  - NTM, (Sawteeth), visualization

IMP3: example of pellet simulations

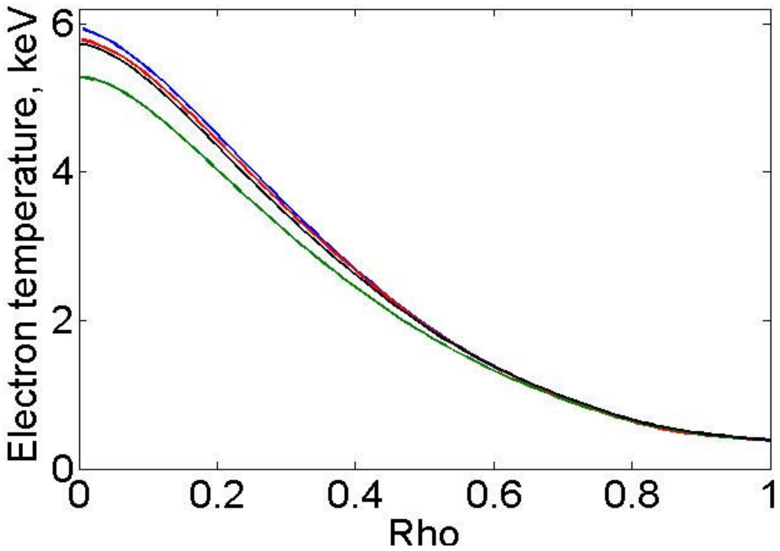
- ***The pellet module is included in the ETS workflow***

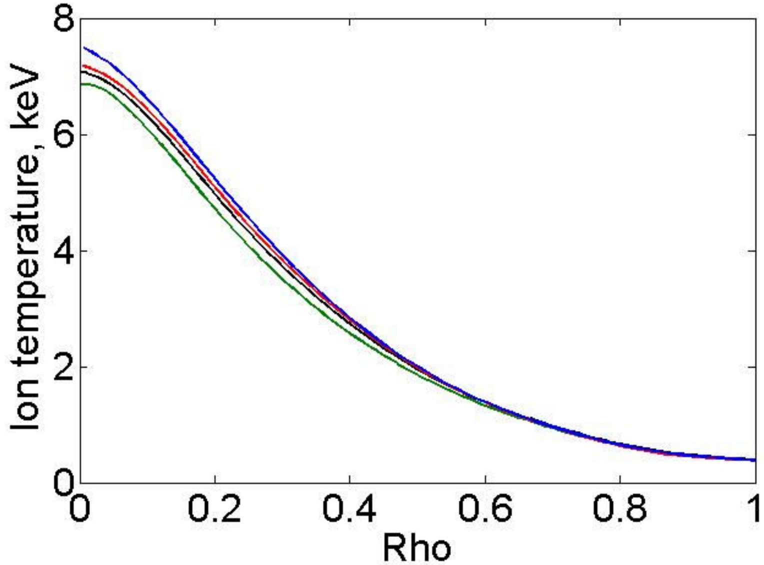


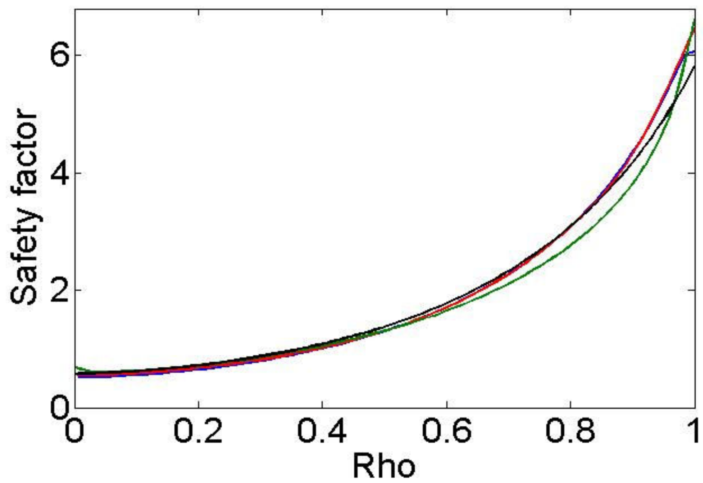
ISM-IMP3: ETS benchmarking

ASTRA/CRONOS/ETS(DK)/JETTO

Profiles obtained at the end of simulations: good agreement for temperatures and safety factor







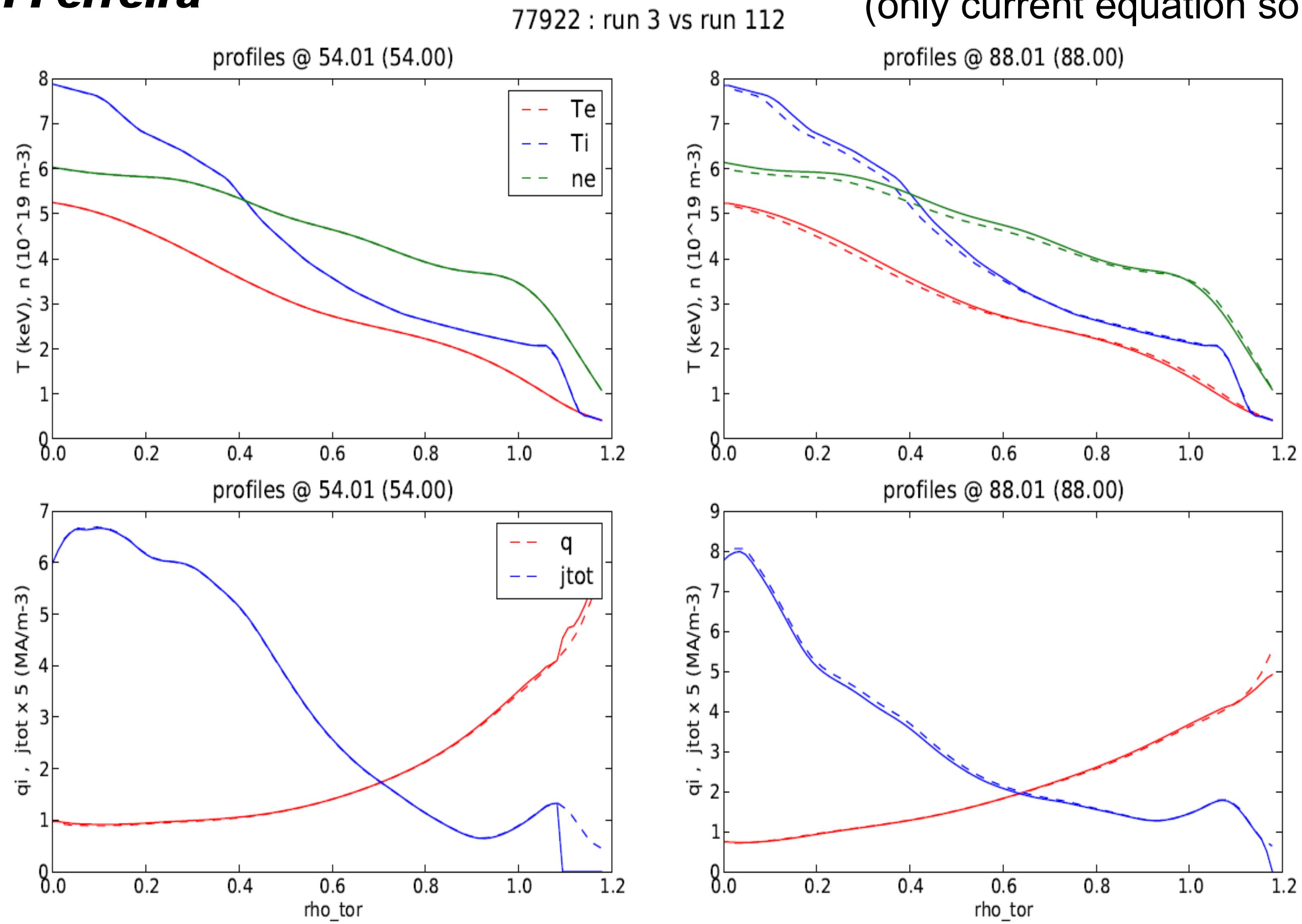
- Te, Ti, current density and equilibrium are simulated
- prescribed electron density
- Gaussian heating profiles, OH heating for electrons and e-i energy exchange
- $\chi = \chi_{Bohm\text{-}gyroBohm}$ + 0.1 m2/s
- Spitzer resistivity & zero BS current

V. Basiuk, J. Bizarro, J. Ferreira, D. Kalupin, F. Koechl, I. Voitsekhovitch

ISM-IMP3: ETS (solid) vs TRANSP (dashed)

J. Ferreira

(only current equation solved)



IMP3: progress in edge codes:

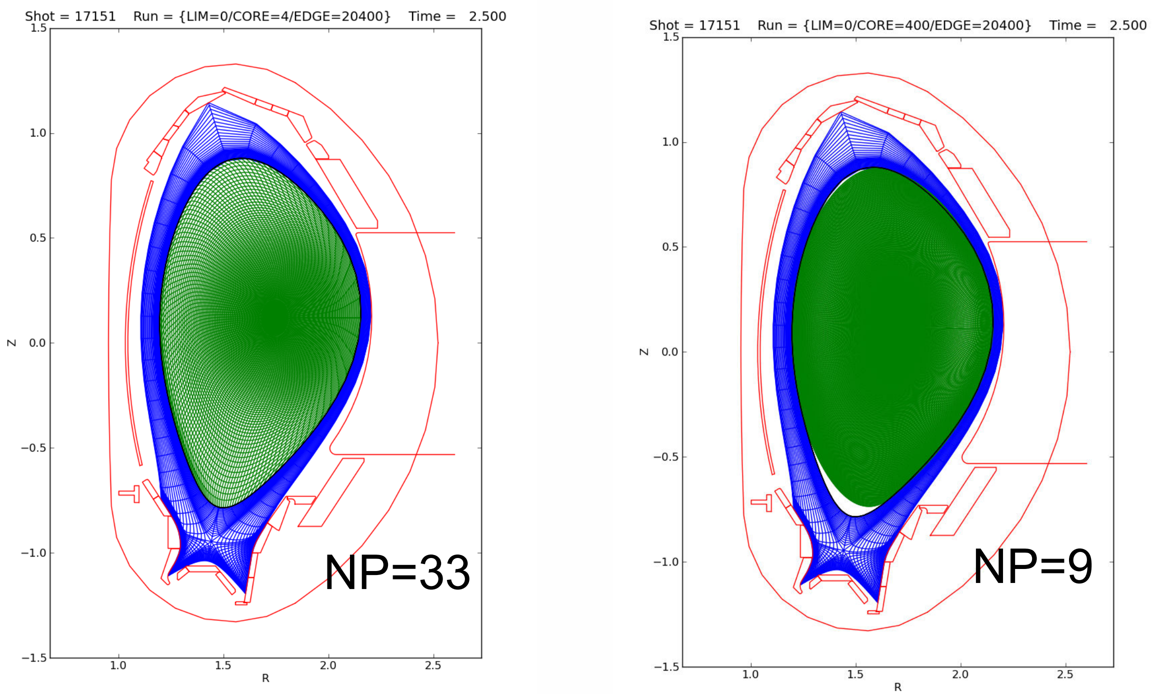
- ***Progress has been made on bringing the edge codes into the ITM (using CPOs, using the AMNS interface, ...)?***
  - SOLPS preprocessor “b2ar” can now use ITM-AMNS in addition to ADPAK, STRAHL and ADAS
  - SOLPS postprocessor “b2_ual_write” writes the output of SOLPS to an EDGE CPO
  - ERO requires an external plasma solution for divertor simulations. The first suitable SOLPS test case has been available in the ITM database since May 2011. The Matlab routine for reading fluid plasma solutions from the database and transforming them for ERO has been upgraded to data structure 4.09a and is under testing with this test case. Implementation of CPO output has not yet been started.
- ***other***
  - The HIIPC (Hydrogen Isotope Inventory Processes Codes) is now working as a stand-alone module, with a data structure akin to the wall CPO proposal. A first publication describing its physics and results in being finalized
  - V&V ongoing (Aho-Mantilla, NF)

IMP3: core-edge coupling (D. Coster)

- ***Examples of coupling ETS (core) and SOLPS (edge)***
  - D only
  - D+He + C
  - D+He + C+Ar+Ne (in progress)
  - steady-state consistent solution

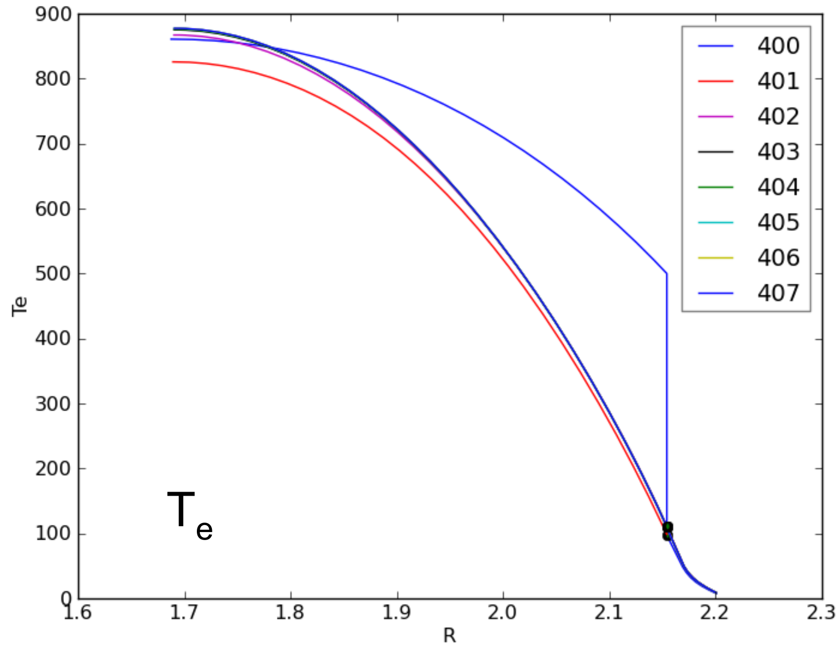
- ***Core-edge coupling procedure***
  - ETS → coreprof, coreimpur CPOs
  - Python script → SOLPS5-B2 boundary condition entries
  - SOLPS → EDGE CPO
  - Python script → new coreprof, coreimpur CPOs
- ***So far used fluxes from ETS and values from SOLPS***

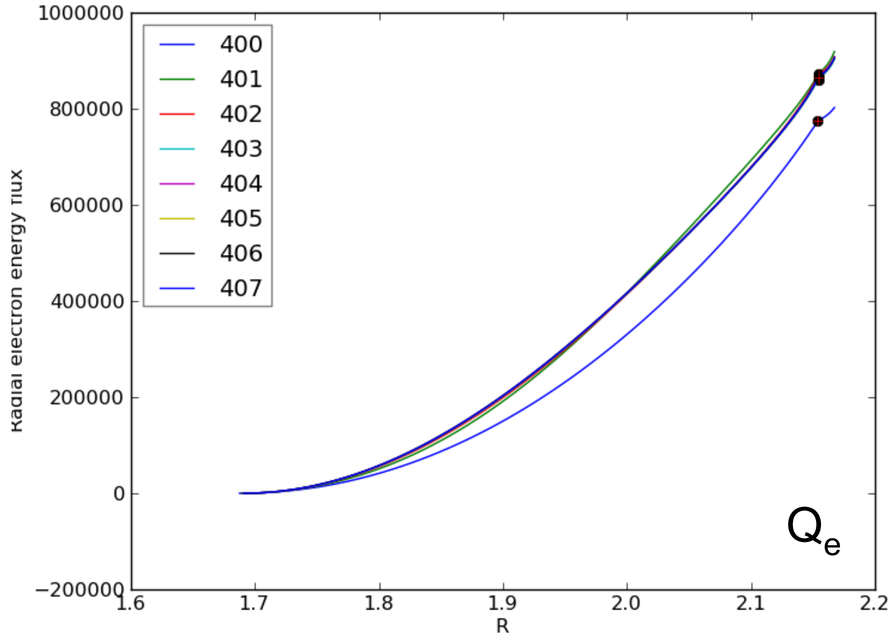
IMP3: core-edge coupling, equilibrium



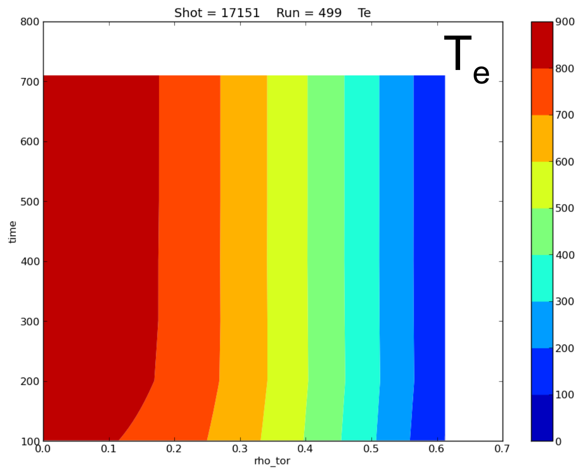
- Import limiter and CLISTE equilibrium from AUG (python) → CPOs
- Run HELENA on data from CLISTE equilibrium to produce a new equilibrium → CPOs
- Run CARRE on data from CLISTE equilibrium to produce the edge geometry CPO

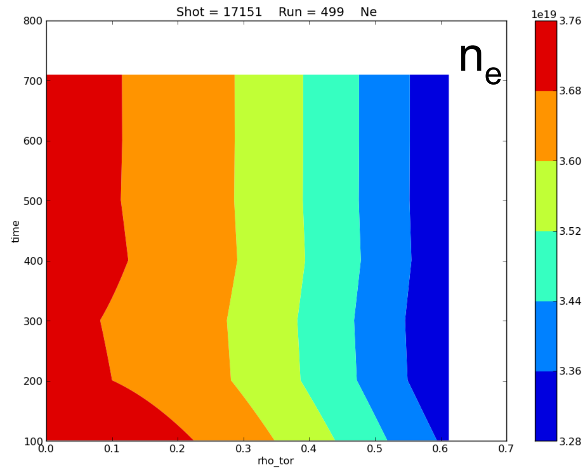
IMP3: results for D (D. Coster)





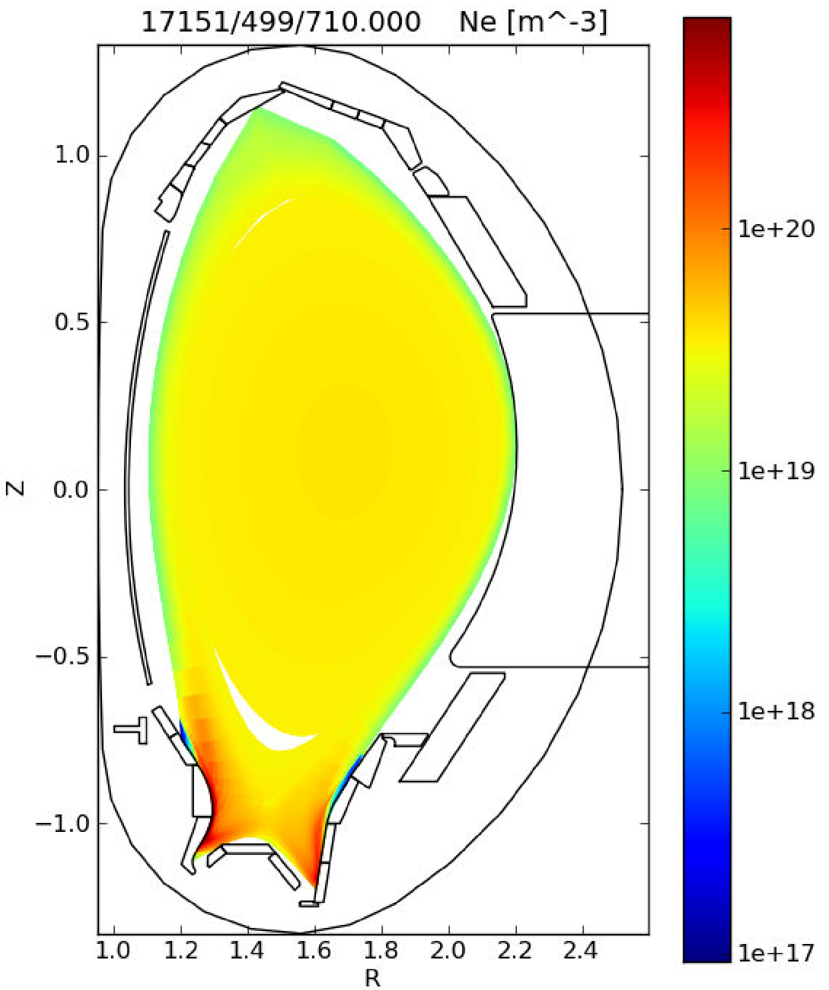
- ***Iterations 0→7***

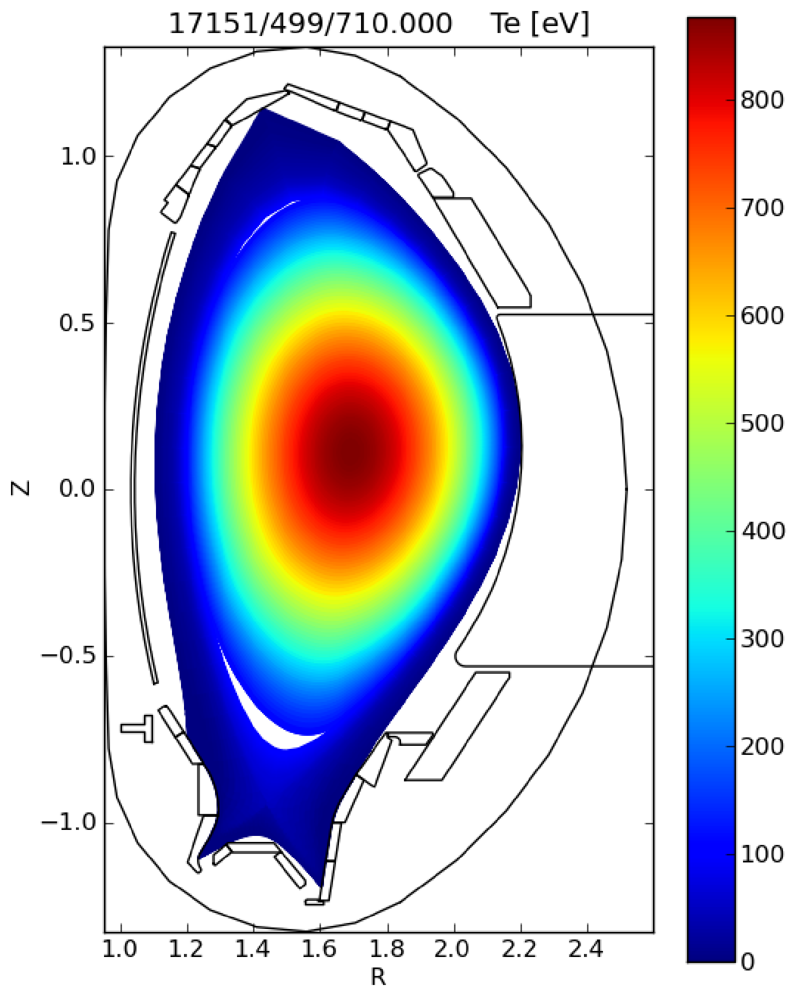




IMP3: results for D (D. Coster)

- **Combined plots: ETS + SOLPS**

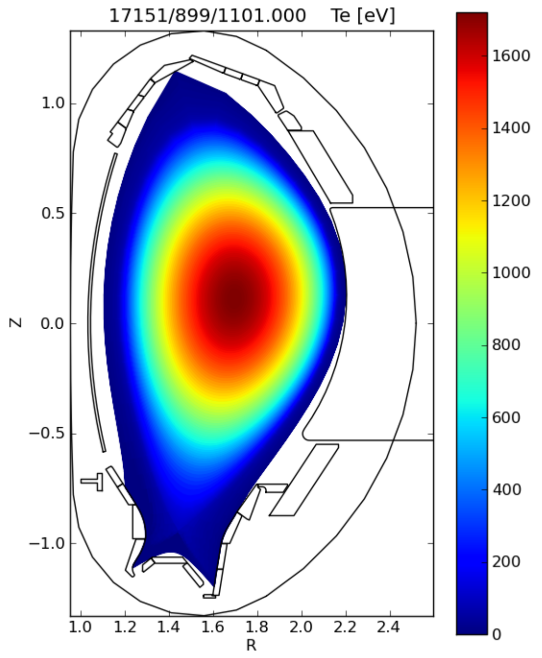




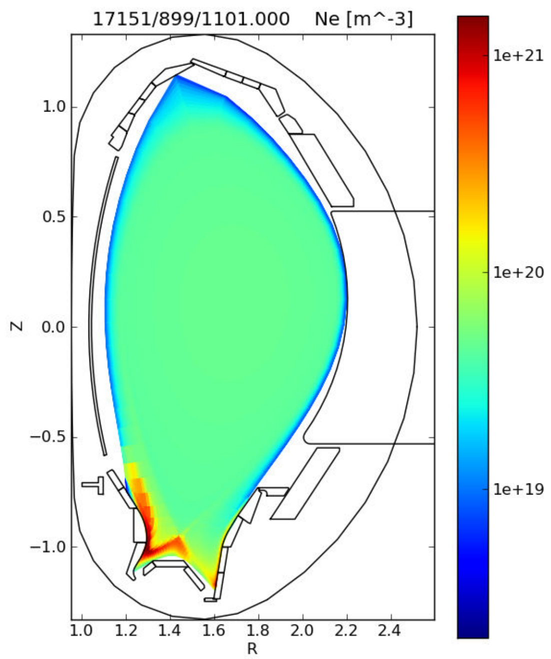
Results: D + He + C (D. Coster)

- ***D+ + He2+ treated as main ions in ETS***
- ***C1+ – C6+ treated as impurities in IMPURITY code***

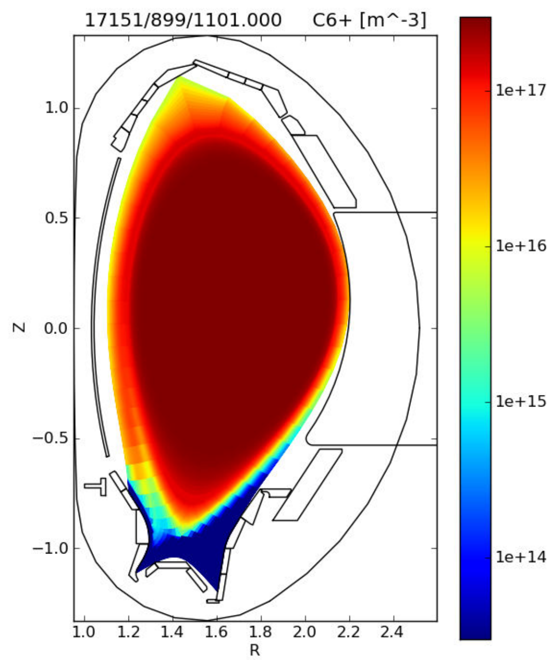
Te



ne



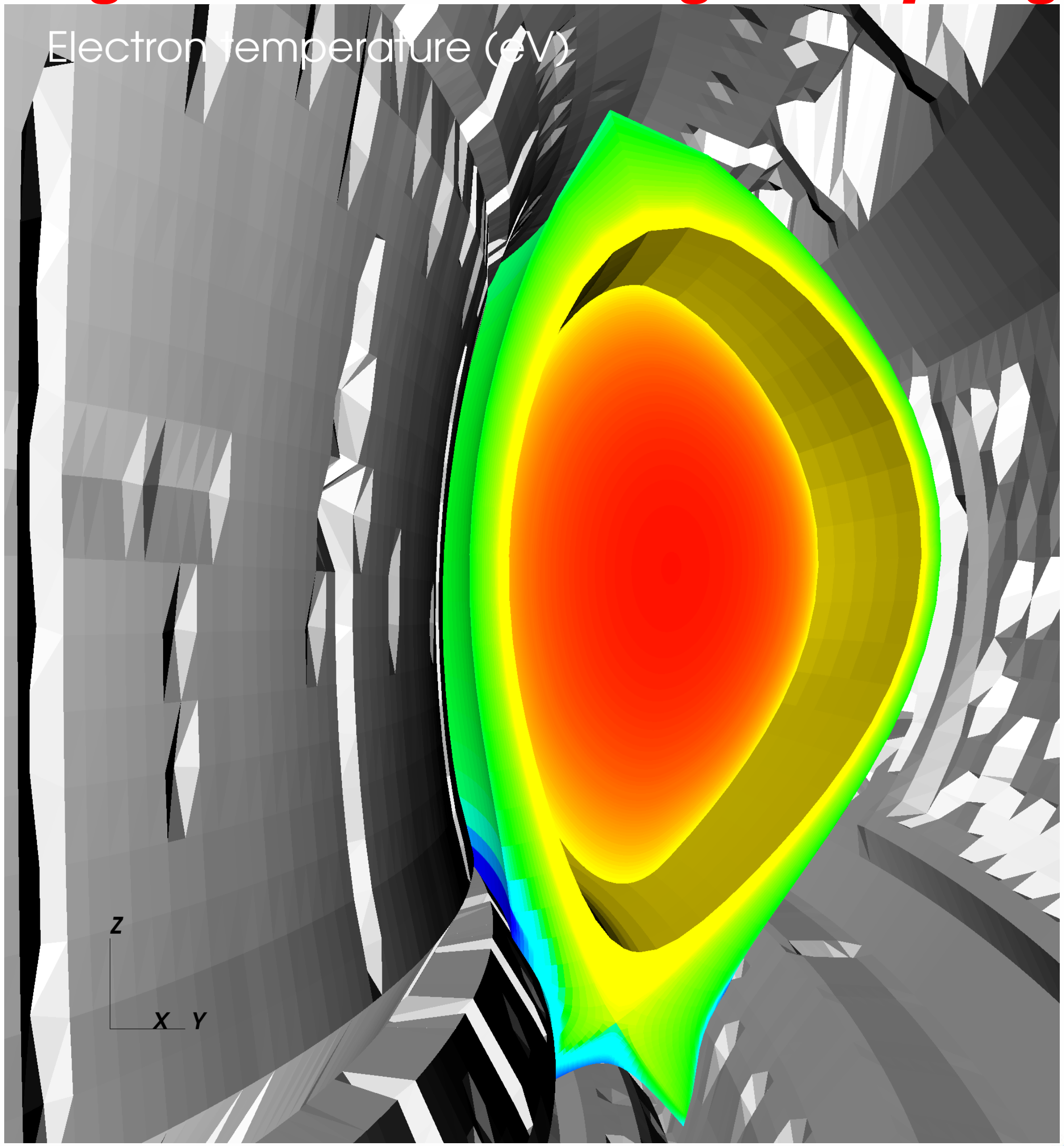
nC6+



- ***NP=33 in HELENA (rather than 9 or 17)***
- ***Feedback zero-flux boundary condition in SOLPS***

Edge CPO & Core-Edge Coupling

- ***T_e in the Scrape-Off Layer computed by SOLPS***
- ***T_e in the core computed by ETS (coreprof → edge)***
- ***Visualized in the ASDEX Upgrade device geometry***
- ***Raw geometry data provided by IPP Garching (T. Lunt),***
- ***Postprocessing done at Aalto University, Helsinki (T. Kuoskela)***
- ***Simulation and integrated visualization performed at IPP Garching (H.-J. Klingshirn),***
- ***Using VisIt visualization software and general-purpose ITM tools***



IMP4 (turbulence and transport):

B. Scott

- ***Transport coefficients implemented in ETS***
  - Bohm-gyroBohm, Coppi-Tang, NTM, NEOWES, constant coefficients

- ***Work on NCLASS, GLF23 and Weiland model is in progress (GLF23 implemented at the end of GM)***

- ***Turbulence codes as MPI actors to other workflows, turbulence CPO for transport and edge turbulence study***

- ***Benchmarking case has been set up:***

- standard test workflow for turbulence/transport actors
  - reads case (JET shot 77817/1 from M Romanelli) from UAL
  - runs equilibrium code HELENA to fill `equilibrium` CPO
  - runs actor and writes `coretransp` CPO into UAL
- IMP4 MPI codes fully capable in ETS workflows

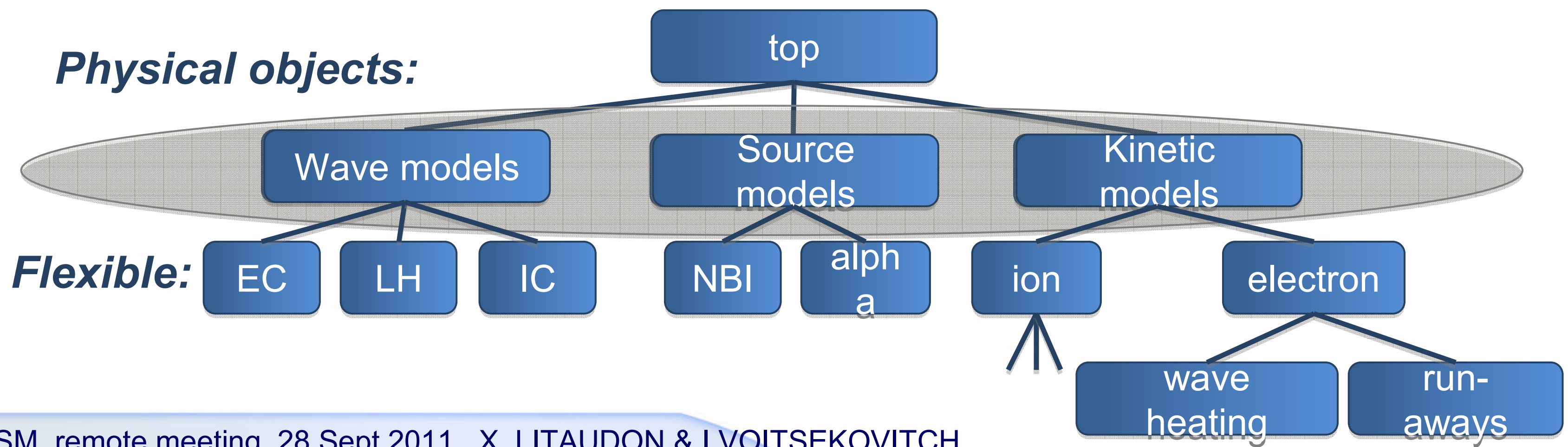
IMP5 (heating and current drive, fast particles physics)

D. Farina, T Johnson, G. Vlad

- ***Available modules:***

  GRAY, TORBEAM, TRAVIS, TORAY-FOM, RELAX, FWTOR, RAYLH, TORIC, SSFPQL, SPOT, NEMO, RISK, NBISIM, EVE, FPSIM, SELFO-light, RFOF, ASCOT, BBNBI, SOFI, FIDIT, SNBI, OAW Orbit Following Monte Carlo

Development of the structure for integration of H&CD modules



IMP5: summary

- ***IMP5 have developed an actor that merges all heating schemes***
- ***Primary application is the ETS***
  - but it could be applied to any problem needing integrated HCD & fast particle modelling
- ***Modularised according to the physics; in line with CPOs***
  - allow treatment of synergies
  - strongly coupled problems could be included through local convergence loops inside the actor
- ***The actor still lack physics modules for LH and alphas***
  - IC and NBI have been delayed by 4.09a

AMNS (Atomic, Molecular, Nuclear and Surface Data)

Presented by D. Coster

Status of the data

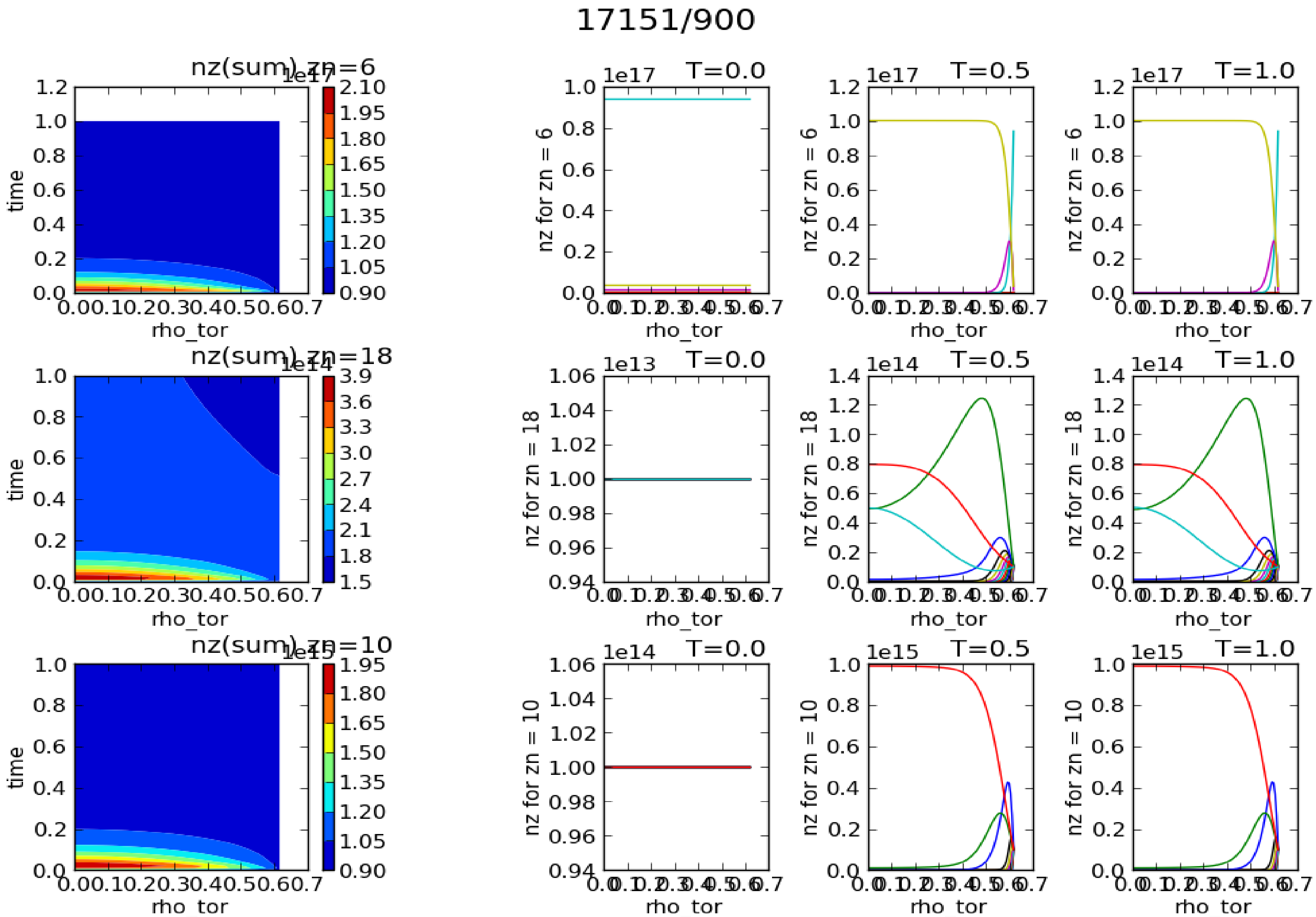
Category	Reaction class	Status
Atomic	Rate coefficients	Implemented for H, He, Li, Be, B, C, N, O, F, Ne, Al, Si, S, Cl, Ar, Cr, Fe, Ni, Cu, Ge, Kr, Mo and Xe (Recombination, Electron Impact Ionisation, CX recombination, Recomb/brems power, Line radiation, Effective Charge, Effective Square Charge and Effective Ionisation Potential)
Atomic	Cross sections	Concept, not yet coded
Molecular		Nothing yet
Nuclear	Cross sections	Implemented for D-D, D-T, D-^{3}He
Surface	Sputtering	Concept, some code

AMNS: Status of the Interface

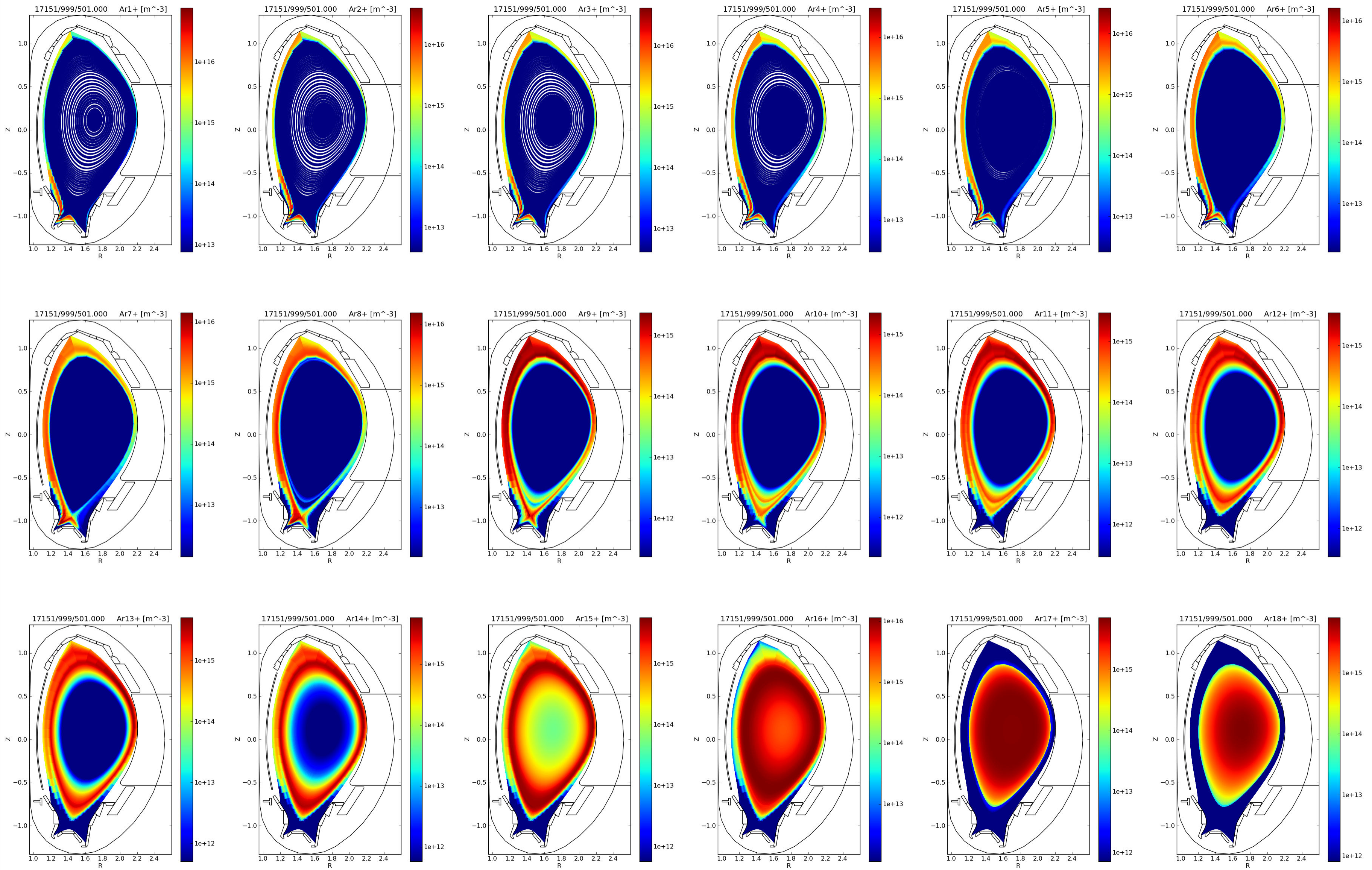
- ***Interface for F90 codes available***
- ***Interface for C/C++ codes under development***

- ***Used by***
  - **ETS-Impurity code**
  - **SOLPS-b2ar**

AMNS-IMP3: simulations of C, Ar, Ne



AMNS-IMP3: core-edge coupling, Ar



AMNS: next steps

- ***Next steps:***
- ***need more data***
  - Atomic cross sections
  - More nuclear data
  - Surface data
  - Molecular data
- ***C/C++ interface to the AMNS library***
- ***Implementation in more codes***

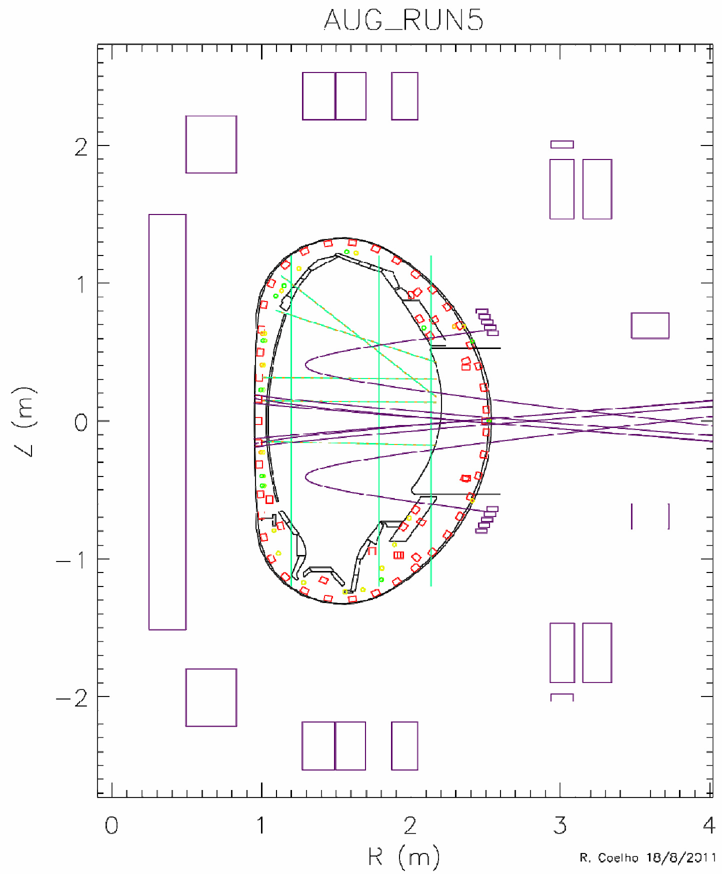
EDRG (Experimentalists and Diagnosticians Resource Group))

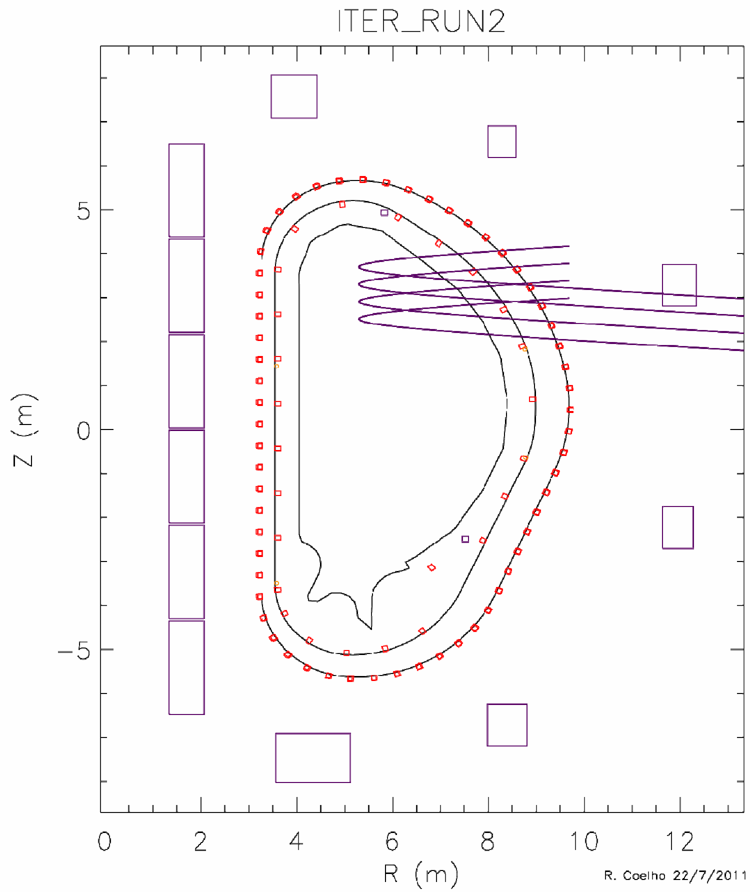
R. Coelho

- ***On-going work on***
  - Consolidation of Machine Description and Data Mapping
  - Provisioning of Testbed of exp.data.
  - 3D first wall defeaturing tool and grid storage.
  - New diagnostic CPOs as requested by IMPs.
  - Coordination of control activities (CEDRES++, CREATE-NL)
  - Integration of synthetic diagnostics modules (press on 3D reflectometry + MSE + neutron spectrometer + NPA/FILD).

EDRG: progress on machine description and data mapping

Good progress on AsdexUpgrade (cont.) and ITER (new)





Run 0 available for testing on Gforge : tags/candidates/4.0XX

EDRG: progress on machine description and data mapping

➢ Summary of device coverage

JET	Tore Supra	ASDEX Upgrade	FTU/FAST	MAST	ITER
Pfsystems	Pfsystems	Pfsystems	Pfsystems	Pfsystems	Pfsystems
Iron	Iron				
Vessel	Vessel	Vessel	Vessel	Vessel	Vessel
Limiter	Limiter	Limiter	Limiter	Limiter	Limiter
Toroidfield	Toroidfield	Toroidfield	Toroidfield	Toroidfield	Toroidfield
Magdiag	Magdiag	Magdiag	Magdiag	Magdiag	Magdiag
MSEdiag	MSEdiag	MSEdiag		MSEdiag	
Interfdiag	Interfdiag	Interfdiag	Interfdiag	Interfdiag	
Polardiag	Polardiag				
	ECE				
	LH				
NBI	antenna	NBI			NBI

ISM plans for 2012

ISM / ACT1:

Following the ETS progress a new activity is added to ACT1

ACT1-2012:

1. ***Provide support to the ETS validation***
2. ***ETS application for physics studies***

1. Provide support to the ETS validation

1. ***Benchmarking of transport models: NCLASS, Bohm-gBohm model for particle transport (including D and V), GLF23 (ISM+IMP3+IMP4)***
2. ***Self-consistent simulations of plasma parameters (Te, Ti, j) with heating and current drive sources (ECCD, NBI) (ISM+IMP3+IMP5)***
3. ***Impurity transport (ISM+IMP3): benchmark for Be and W***
4. ***Benchmarking of neutral module in ETS (ISM+IMP3)***
5. ***Test of pellet model in ETS and comparison with the JETTO pellet model (ISM+IMP3)***
6. ***Benchmarking of α-heating and neutron yield in the NBI heated plasmas and comparison with measurements (ISM+IMP5)***
7. ***Benchmarking of ETS with multiple ion species (ISM+IMP3)***

II. ETS application for physics studies:

1. ***Effect of NTM on transport and confinement in Hybrid scenario (ISM+IMP3+IMP12)***
2. ***Edge MHD analysis for JET Hybrid scenario (ISM+IMP12)***
3. ***Current diffusion during OH current ramp up on MAST: ETS simulation of MAST discharges using different equilibrium modules, NCLASS and possibly other models for current conductivity (ISM + IMP3 + IMP12 + IMP4)***
4. ***Modelling of particle transport in scenario with pellet fuelling (ISM+IMP3)***
5. ***Integrated core-edge simulations using Bohm-gyroBohm model for core transport. Simulations of Be or W impurity (ISM+IMP3)***
6. ***Simulations of turbulent transport (GEM+ETS) and comparison with measurements (ISM+IMP3+IMP4)***

Effect of (3,2) NTM on confinement of JET plasmas

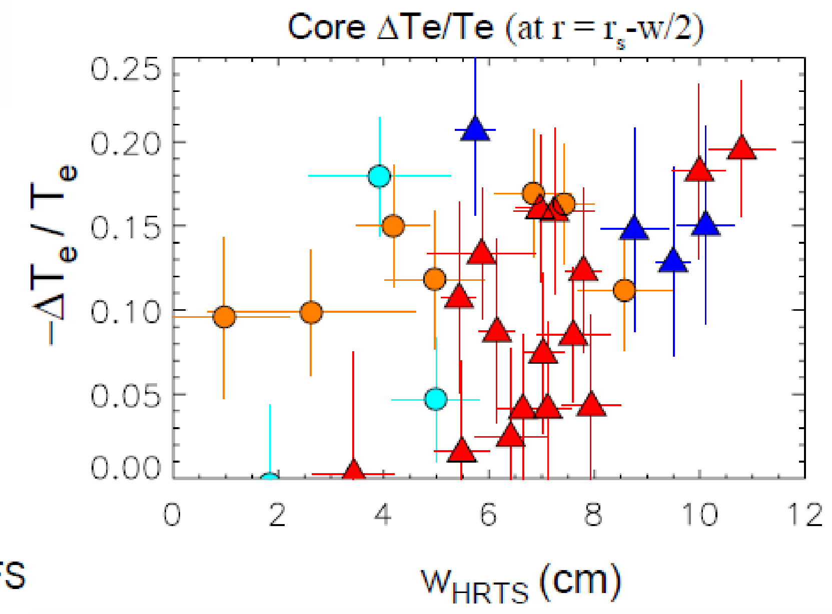
L. Frassinetti et al, 13th Int. Workshop on H-mode physics and TB, Oxford, UK, 2011

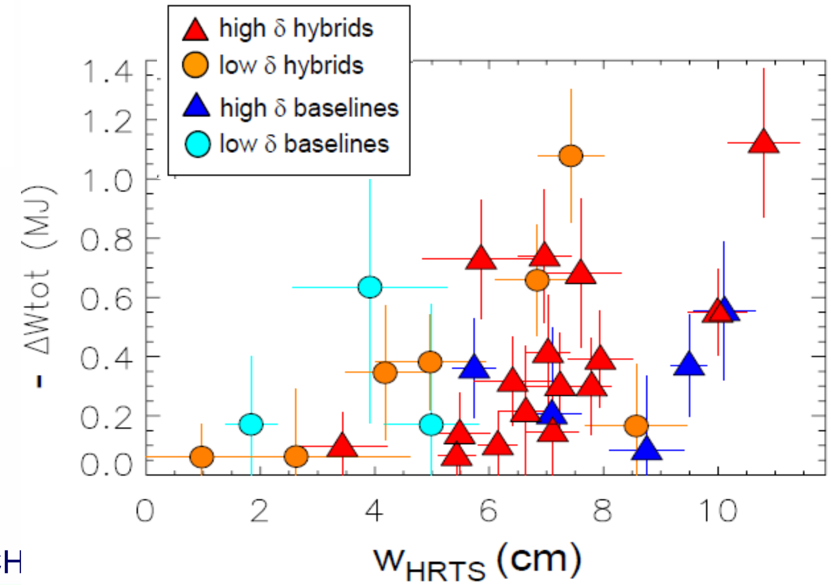
Effects of the (3,2) NTM:

- Reduction of Te in the core (up to 25%)
- No effect on the Te pedestal
- Reduction of Ti in the core (up to 15%)
- Increase of the ratio Ti/Te in the core
- Reduction of Ne in the core (up to 30%)
- Reduction of Ne at the pedestal (up to 25%)

  The pedestal reduction is well correlated with a change in the LCFS

- The total stored energy is reduced up to 30%
- The main part of the total energy reduction comes from the core, but the effect on the pedestal energy is not negligible (up to 0.6MJ)





- ➢ ***Validation of the model for island width***
- ➢ ***Effect of NTM width on confinement***

ISM-ACT2

- ***Modelling of current diffusion, thermal and particle transport, validation of transport models including TGLF for existing and new discharges***
- ***JET - JT-60U scenario modelling***
- ***Modelling of JET - ASDEX-U hybrid similarity experiments***
- ***Current diffusion in JET – AUG – DIII-D hybrid discharges***
- ***Momentum transport in JET hybrid scenario***
- ***Core-edge simulations in preparation of JET experiments***

ISM-ACT3

- ***ITER hybrid ramp down***
- ***ITER density effect with first principle modelling***
- ***ITER real time profile control***
- ***Expand the operational domain of hybrid scenario with q on-axis below one by controlling the sawtooth period***
- ***1-D JT-60SA scenario modelling***
- ***DEMO – 0D modelling using Kepler workflow***