EFDA Task Force
EUROPEAN FUSION DEVELOPMENT AGREEMENT
INTEGRATED TOKAMAK MODELLING

ISM WS, 4-7 July 2011

ASTRA, JETTO, ETS (DK) benchmarking for current drive case 2: NCLASS

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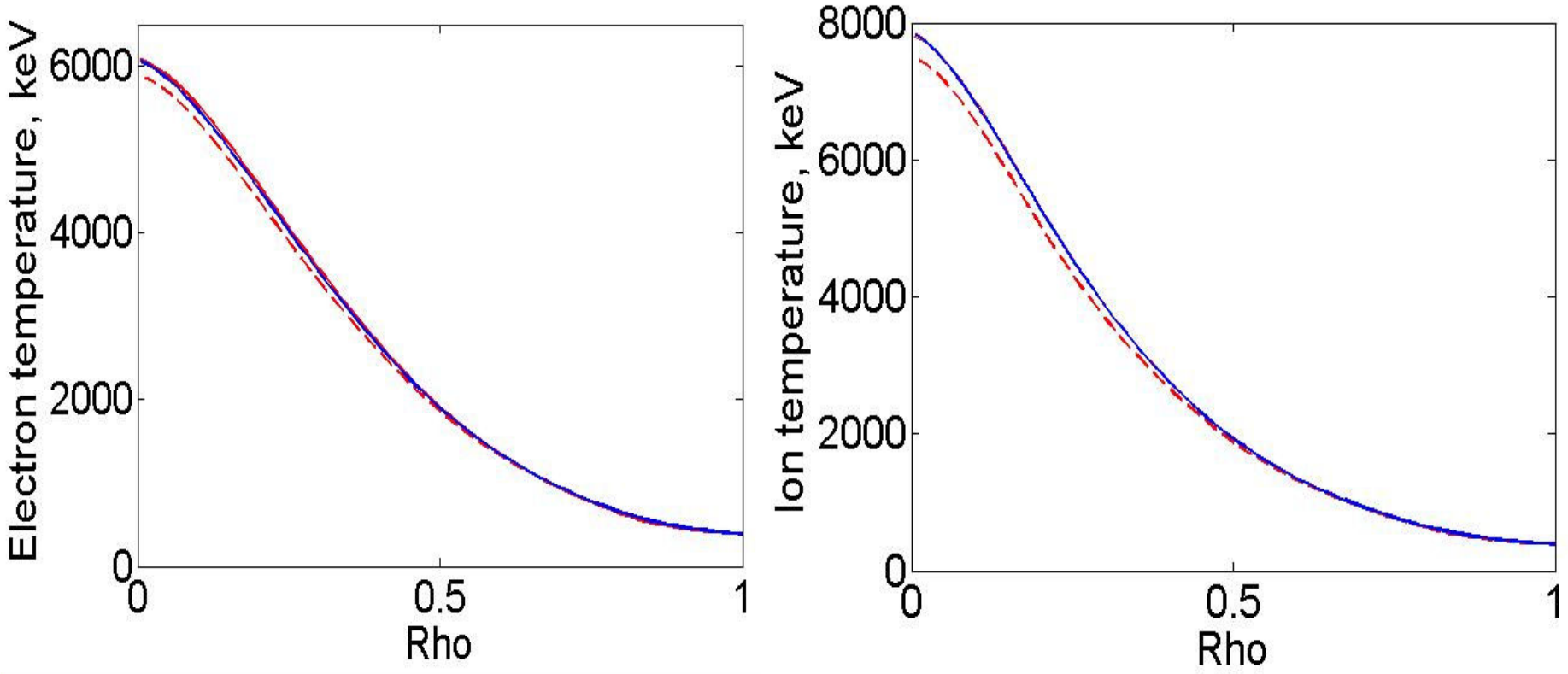
Model and assumptions:

- Simulations of Te, Ti, current density and equilibrium;
- Gaussian heating profiles, OH heating for electrons and e-i energy exchange;
- prescribed electron density
- NCLASS for resistivity and bootstrap current
- Bohm-gyroBohm + 0.1 m2/s for thermal diffusivities

Current drive case 2: jGauss, NCLASS for BS current and resistivity, Zeff=1

	Time interval	Heating	Equilibrium	Transport	Output files
ASTRA	7.7-47.7 s	OH + Gauss + Pei	3 moment	BgB + 0.1 m2/s	home/voits/a620/.res/lf95/ETS77922_01nclass1
CRONOS	7.7-47.7 s	OH + Gauss + Pei	HELENA	BgB +0.1 m2/s	
JETTO	7.7 - 47.7 s	OH + Gauss + Pei	ESCO	BgB + 0.1 m2/s	PPF: jbizarro seq. 499
ETS: D. Kalupin	7.7 – 47.7 s	OH + Gauss + Pei	HELENA	BgB + 0.1 m2/s	
ETS: V. Basiuk	7.7 – 47.7 s	OH + Gauss + Pei	HELENA	BgB + 0.1 m2/s	

ASTRA/JETTO benchmarking, case 2

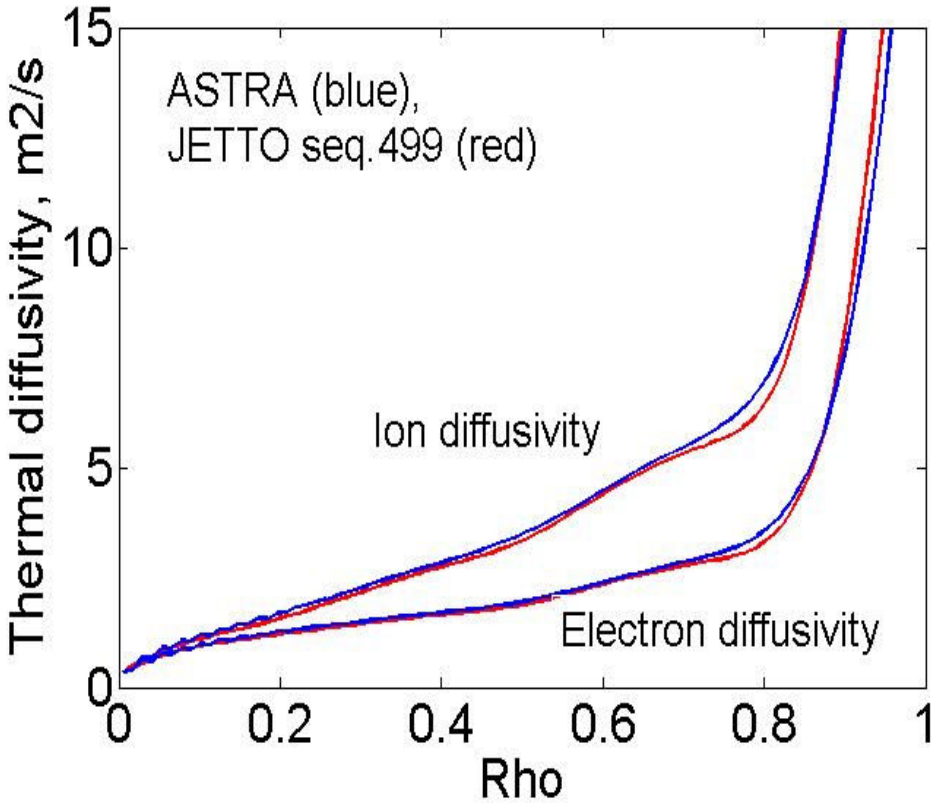


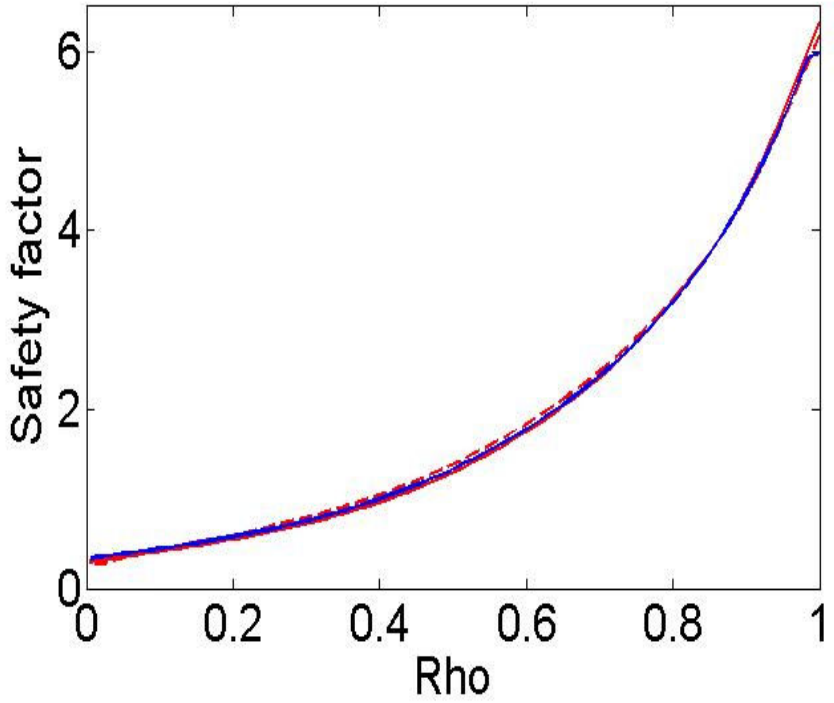
ASTRA (blue)

JETTO with NCLASS for current conductivity and bootstrap current (red solid)

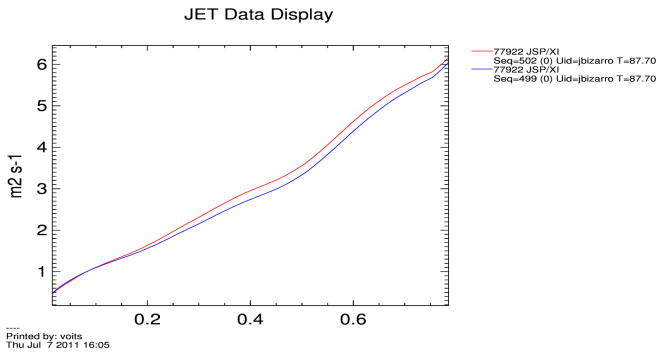
JETTO with NCLASS for current conductivity, bootstrap current and transport (red dashed)

ASTRA/JETTO benchmarking, case 2

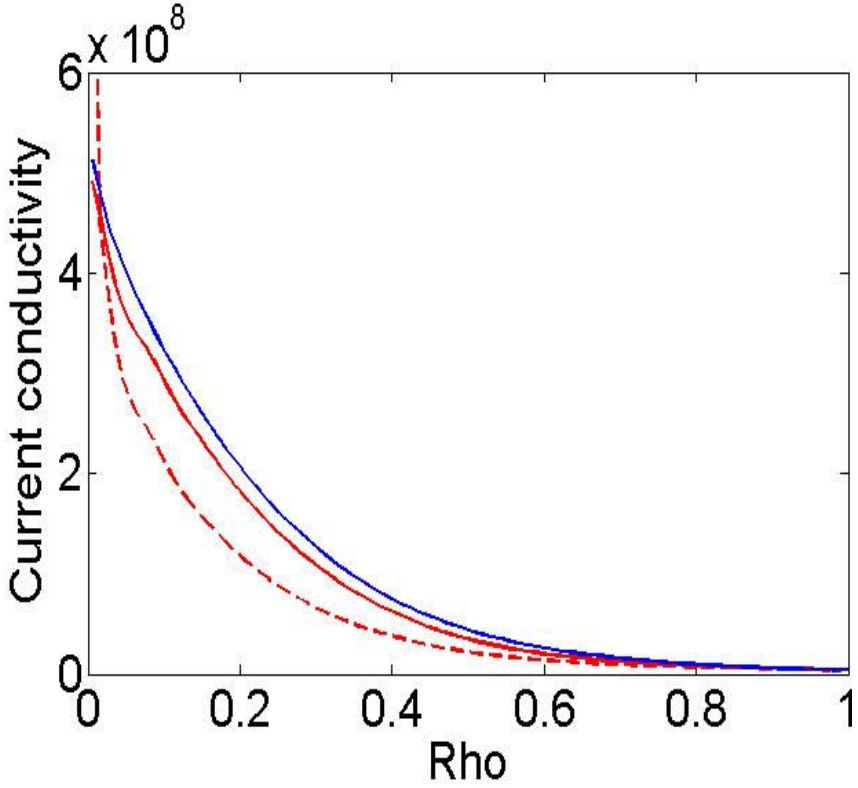


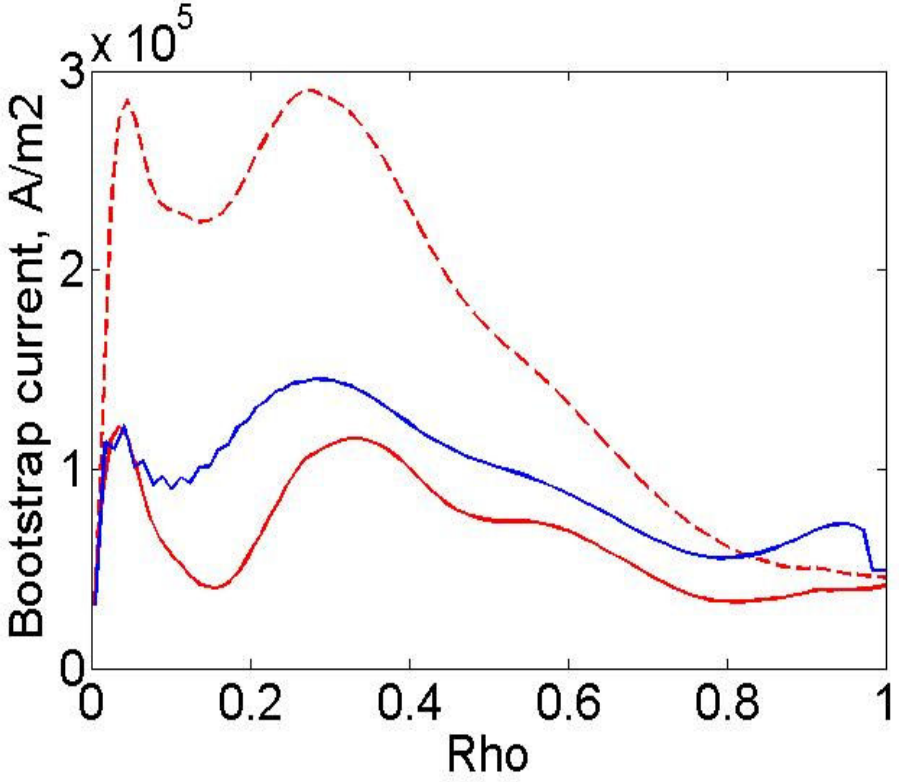


JETTO thermal ion diffusivity with (red) and without (blue) NCLASS



ASTRA/JETTO benchmarking, case 2



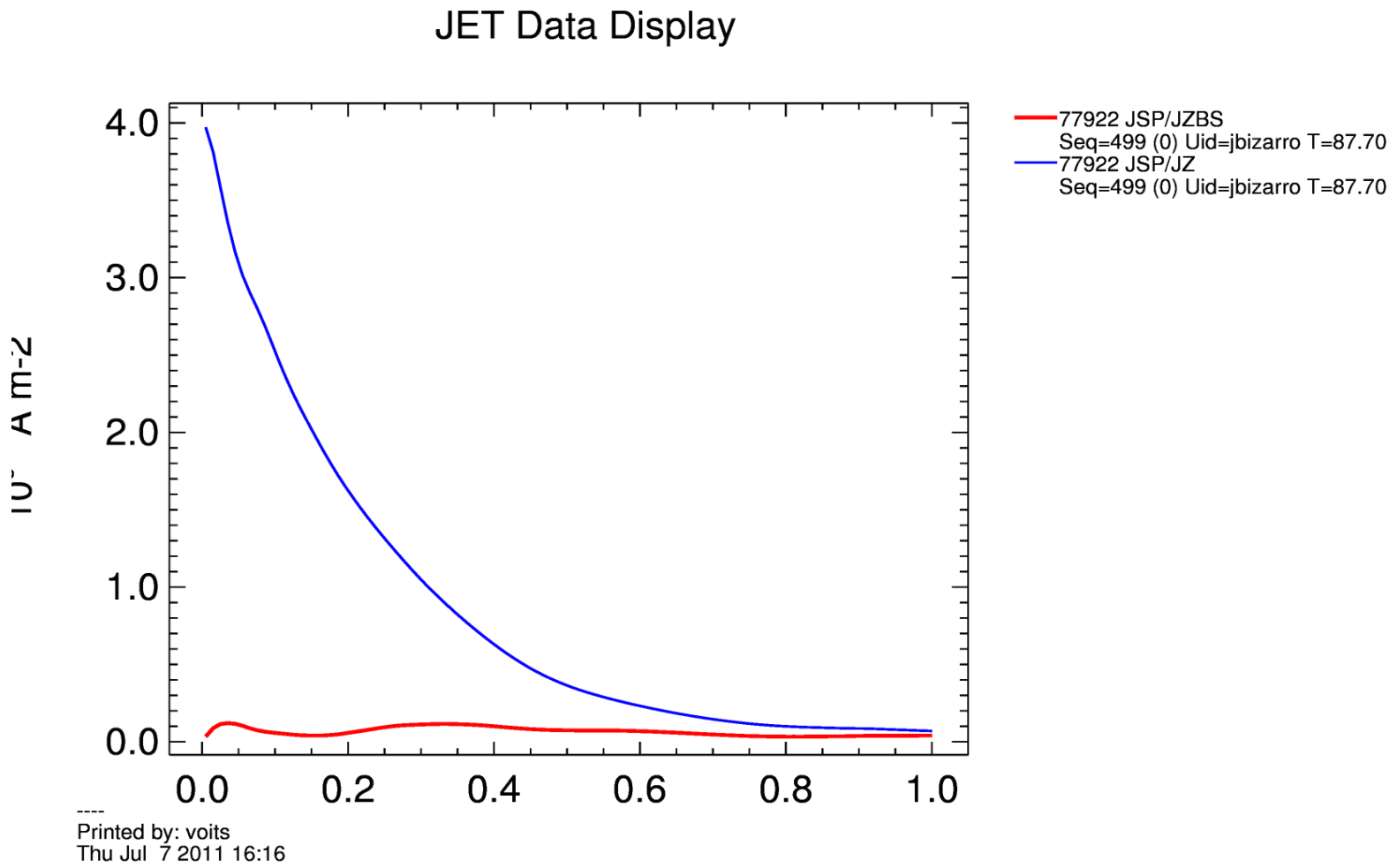


- JETTO with NCLASS for current conductivity and bootstrap current (solid curves) and with NCLASS for current conductivity, bootstrap current and transport (dashed curves)

- ASTRA is slightly unstable in the core region

- reasons for the differences between JETTO runs?

Total and bootstrap current



JETTO runs to clarify the NCLASS settings & model

- Seq. 487 with trapped particles on, NCLASS for transport is off: χBgB + 0.1 m2/s, no BS
- Seq. 489 (with trapped particles off, NCLASS for transport is off) = Spitzer resistivity | case 1, no BS
- Seq. 490 with trapped particles on, NCLASS for transport is on: χBgB + χNCLASS + 0.1 m2/s, no BS
- Seq. 491 with trapped particles off, NCLASS for transport is on: χBgB + χNCLASS + 0.1 m2/s, no BS
- Seq. 502 BS, trapped ptcls on, NCLASS for transport (=490)
- Seq. 499, BS, trapped ptcls on, no NCLASS for transport (=487) - reference

Settings to be discussed with G. Corrigan

Summary

- ***ASTRA and JETTO runs for the ETS benchmarking are provided.***
- ***Excellent agreement for Te, Ti and q is achieved***
- ***The reasons for a large discrepancy in bootstrap current and some discrepancy in current conductivity need further investigation***
- ***ASTRA simulation with numerically stable solution in the plasma core is in progress***
- ***JETTO settings need clarification (Joao will discuss with Gerard Corrigan during his visit to JET)***

2012 actions for discussion:

- physics study: current diffusion during the OH current ramp up on MAST [D. Keeling et al, EPS 2011] – ISM WS at JET. Team: J. Ferreira, D. Keeling, C. Challis, … Tools: ETS, JETTO (?)

- particle transport with BgB model (w/o pinch) or with pinch if it will be implemented – to be discussed with ETS team

- equation for rotation with constant D and V – to be discussed with ETS team

- depending on ETS development: NBI + current diffusion + temperature evolution - to be discussed with ETS team

- Coppi-Tang model is implemented and can be tested

Benchmark case prepared within ISM-ACT1:

- ***JET 77922: hybrid scenario with current overshoot, Btor = 2.3 T, Ipl = 1.7 MA, high triangularity (0.38), 18 MW of NBI, nl = 4.8e19 m-3, βN = 2.8***
- ***Selected initial time slice 7.7 s: same input data for all codes taken from TRANSP run I14 with normalised square root of toroidal flux coordinate. Input PPFs: voits/TRAU/TE,TI,NE,NC,CUR,Q,OMEG seq. 431, Zeff=1***
- ***Bohm/gyroBohm transport model for χe and χi (+ 0.1 m2/s)***
- ***Constant density profile taken at 7.7s***
- ***Long run till steady state (40 s, limited by the ETS run time). Te, Ti, j and equilibrium are simulated***
- ***Gaussian profile for H&CD (centred at ρ=0, half-width $\Delta\rho$=0.3), Ptot=18 MW, Ini=0.12 MA. Power & current are not evolving. 70% on ion and 30% electron heating. Ohmic heating, equipartition***
- ***Two cases : i) Spitzer resistivity, zero BS current, Zeff=1, ii) Neoclassical resistivity & BS current, Zeff=1***

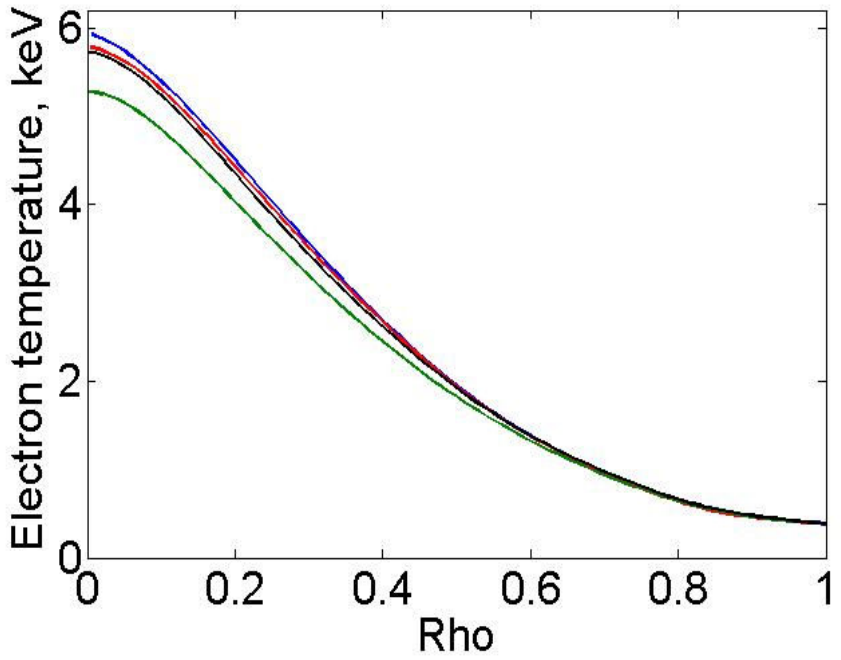
Current drive case 1: jGauss, no BS current, Spitzer resistivity, Zeff=1

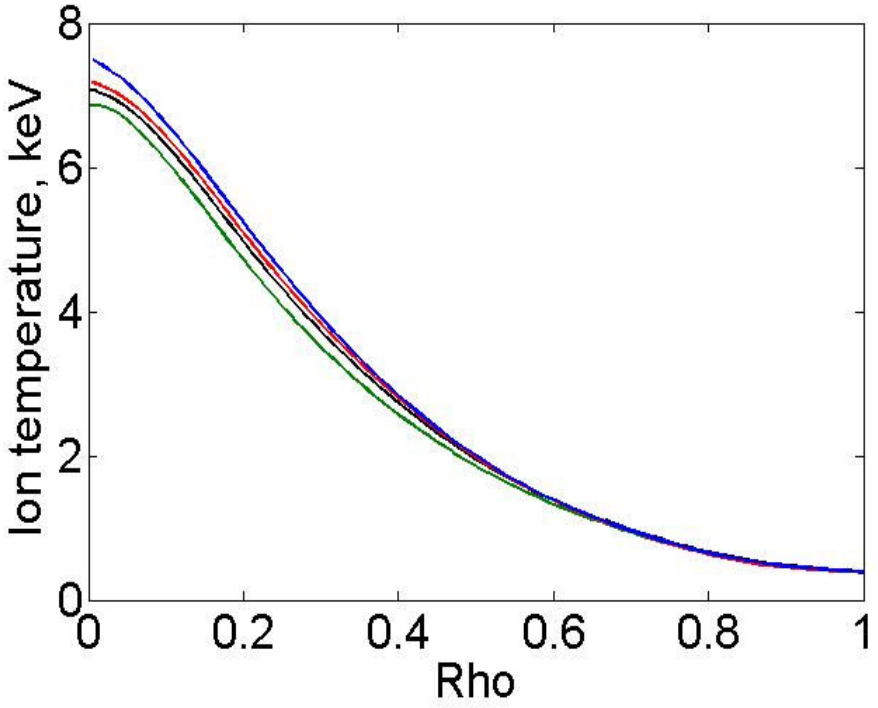
	Time interval	Heating	Equilibrium	Transport	Output files
ASTRA	7.7-47.7 s	OH + Gauss + Pei	3 moment	Bohm+ 0.1 m2/s	home/voits/a620/.res/lf95/ETS77922_01stab2
CRONOS	7.7-47.7 s	OH + Gauss + Pei	HELENA	BgB + 0.1 m2/s	~basiuk/public/shot77922_simucronos.mat
JETTO	7.7 - 47.7 s	OH + Gauss + Pei	ESCO	BgB + 0.1 m2/s	fkoclh, seq. 484 #77922/jun1811/seq.1/ppfseq.484
ETS: V. Basiuk	7.7 – 57.7 s	OH + Gauss + Pei	HELENA	BgB + 0.1 m2/s	~basiuk/public/analyse_ISM.mat
ETS: D. Kalupin	7.7 – 40.7 s	OH + Gauss + Pei	3 moment	BgB + 0.1 m2/s	~kalupin/public/itmdb/itm_tree/test/4.08b/mdsplus/0/euitm_779220015.* (dt=0.1s,7.7-15.7s) and *779220016.* (dt=1s, 7.7-47.7s)

Benchmark cases are saved in “private” public directories – should we think about common public directory for the benchmark cases on Gateway?

ASTRA/CRONOS/ETS(DK)/JETTO

Good overall agreement between different codes is achieved





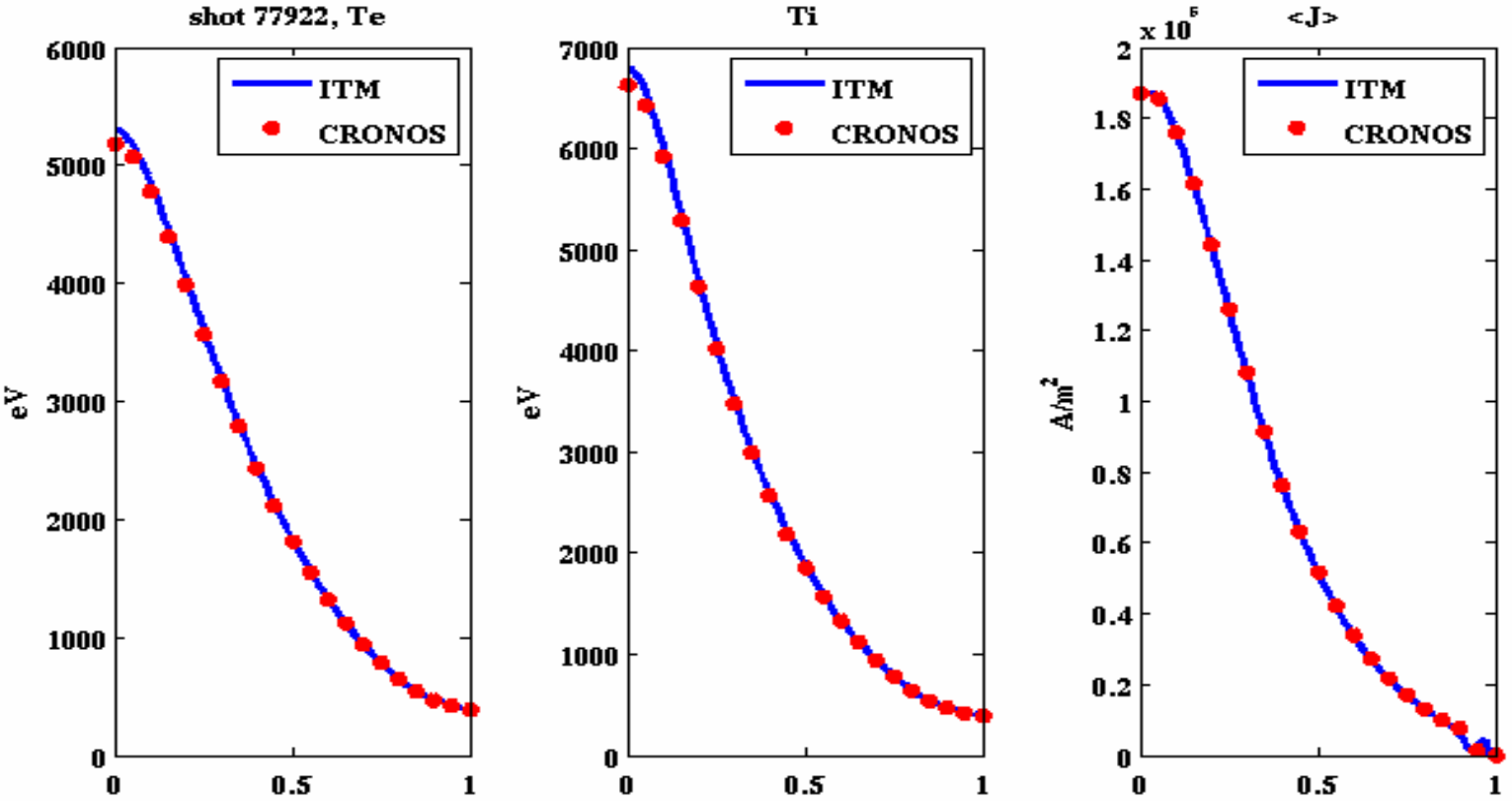
Details:

- best agreement is between JETTO and ETS/DK

- slightly lower temperatures in CRONOS, slightly higher temperatures in ASTRA

Excellent agreement between CRONOS/ETS(VB)

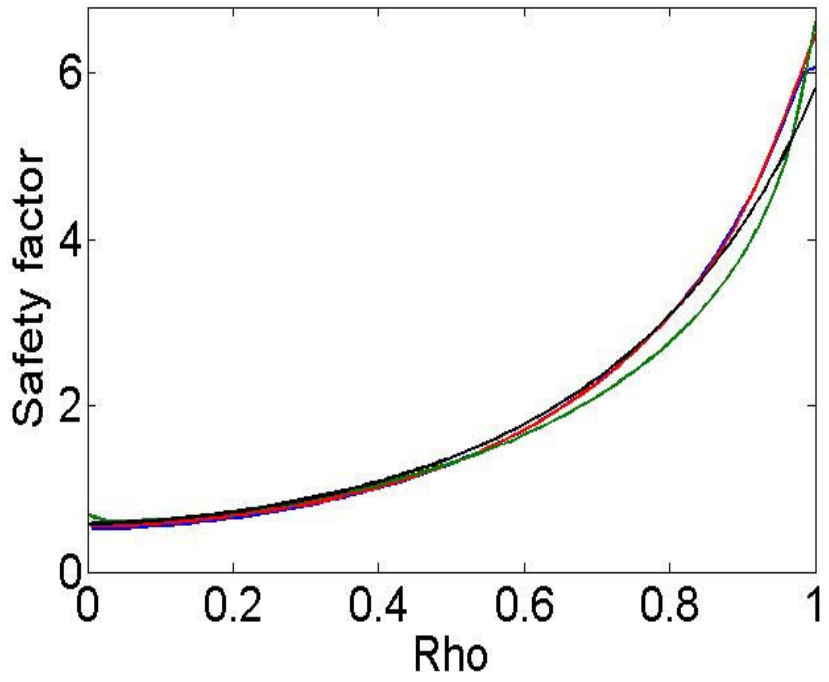
Vincent Basiuk



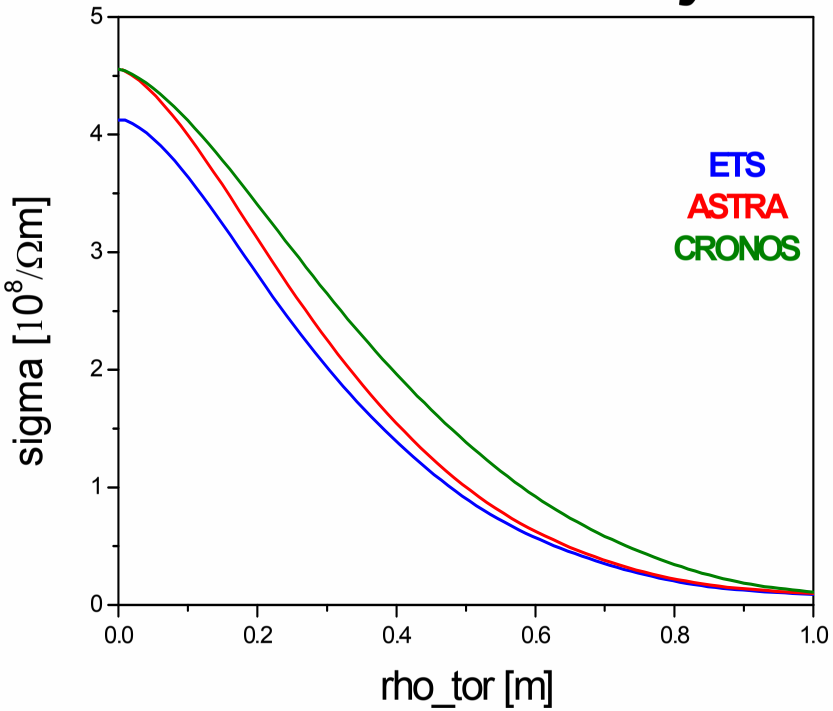
time=57.9 s

frozen equilibrium and dV'/dt=0, drhomax/dt = 0

ASTRA/CRONOS/ETS/JETTO



Current conductivity



Why Spitzer current conductivities are so different? Expressions need to be compared

ASTRA/CRONOS/ETS: thermal diffusivities and auxiliary heating profiles

D. Kalupin et al, EPS 2011