Update on the collaboration project for the analysis of JT60U and JET shots

J. Garcia, N. Hayashi

Scope of the project

Modeling of JET and JT60U plasmas

• Predictive and interpretative simulations of the JET and JT-60U plasma scenarios using both the EU and JA suites of codes.

• Apply plasma models on codes both developed at one side (JA/EU) for plasmas at the other side (EU/JA) to benchmark the codes and models.

• Use this information to design JT60SA scenarios

List of shots

JT60U

- Standard H-mode : SN33654, SN33655
- Advanced Inductive : SN39713 (high performance High β_p H-mode), SN 48158 (Long pulse High β_p H-mode)
- Steady State with ITB : SN43046, SN45903 (RS, long pulse), SN48246 (higher β_N, lower q_{min})

JET

- Standard H-mode : #73344 (high triangularity at 0.8 Greenwald density), #74175 (low triangularity), #77070 (low triangularity) and #73342 (high triangularity at high density above the Greenwald limit)
- Advanced Inductive : #77922 (high triangularity), #77914 (low triangularity), #77280 (20s long pulse Hybrid, low triangularity)
- Steady State with ITB: #77895(high triangularity), #76063 (high β_N), # 53521 (low triangularity strong ITB)

JT60U data obtained

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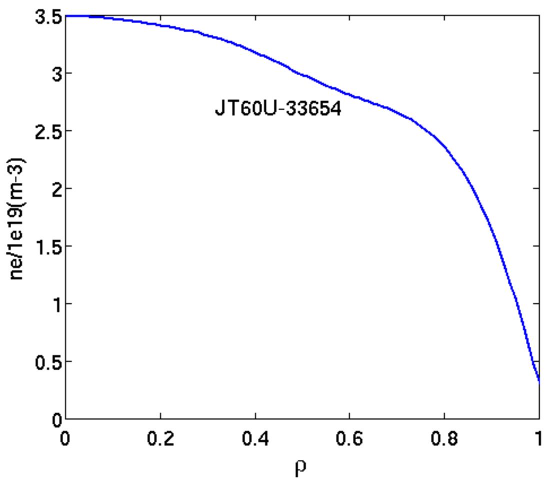
CRONOS

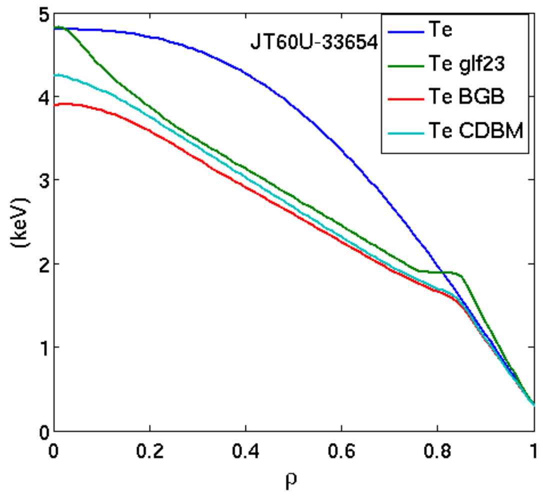
- Standard H-mode : SN33654, SN33655
- Advanced Inductive : SN39713 (high performance High β_p H-mode), SN 48158 (Long pulse High β_p H-mode)
- Steady State with ITB : SN43046, SN45903 (RS, long pulse), SN48246 (higher β_N, lower q_{min})
- In red, profiles obtained by using Adamtool, Febqu and Daisyx
- In black, no data yet
- Remote data connection was established and operational…
- …but the account expired and it is getting more than one month to renew it.
- The steady-state data is in principle available but not yet obtained
- Due to these limitations, just electron and ion temperatures are simulated in predictive simulations
- Next step will include density, pedestal and rotation simulations when possible

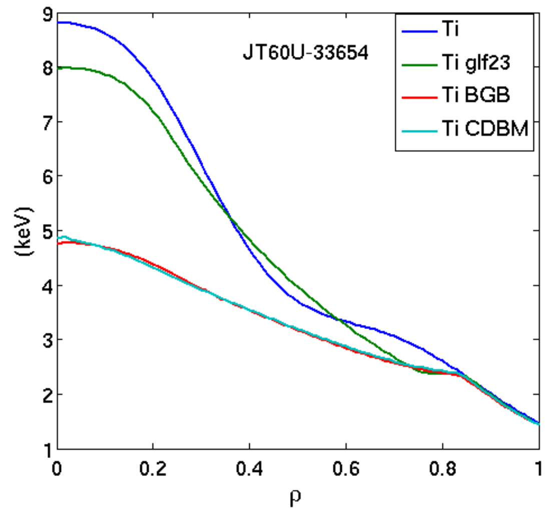
JT60U H-modes

- The two shots selected (SN33654, SN33655) are old
- Just one time slice available
- Limited experimental data available (no q profile evolution)
- Edge data has not good quality
- Three transport models applied for predictive modeling: GLF23, Bohm-GyroBohm and CDBM
- CDBM model has been coupled to CRONOS but still not yet benchmarked with TOPICS (on the way)
- A modification of the CDBM has been implemented: it takes into account of the fast ion population

H-mode SN33654

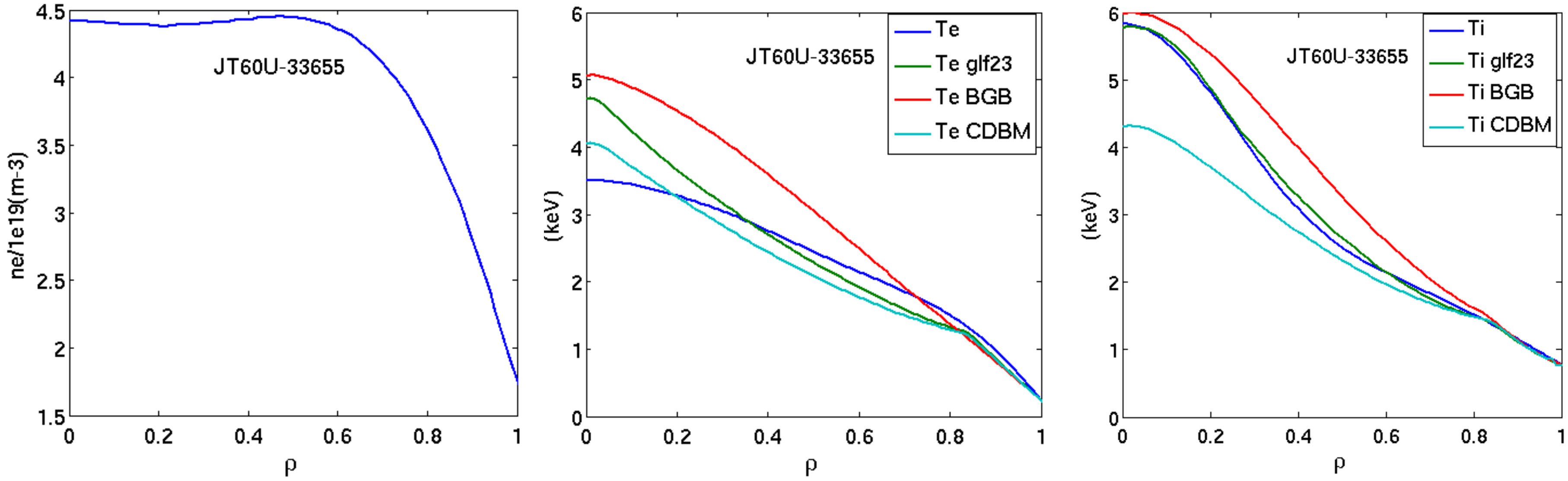






- Low density H-mode with a relatively high population of fast ions
- NBI power deposition calculated with
- The three transport models lead to similar electron temperatures, lower than experiment
- GLF23 gives very good ion temperature agreement, both BGB and CDBM give too low ion temperatures
- The reason why GLF23 and BGB give such a different ion temperatures is investigated

H-mode SN33655



- High density H-mode with a low population of fast ions
- NBI power deposition calculated with
- BGB overestimates the electron temperature whereas CDBM slightly underestimates it.

GLF23 tends to be in between them

- GLF23 gives very good ion temperature again
- BGB and CDBM ion temperatures follow the same trend than for electrons

JET H-modes

- Several shots selected but just two simulated (73344 high triangularity, 77070)
- Two transport models applied for predictive modeling: GLF23, Bohm-GyroBohm
- CDBM results are on the way
- NBI calculations are performed with NEMO-SPOT (CRONOS)

H-mode 73344

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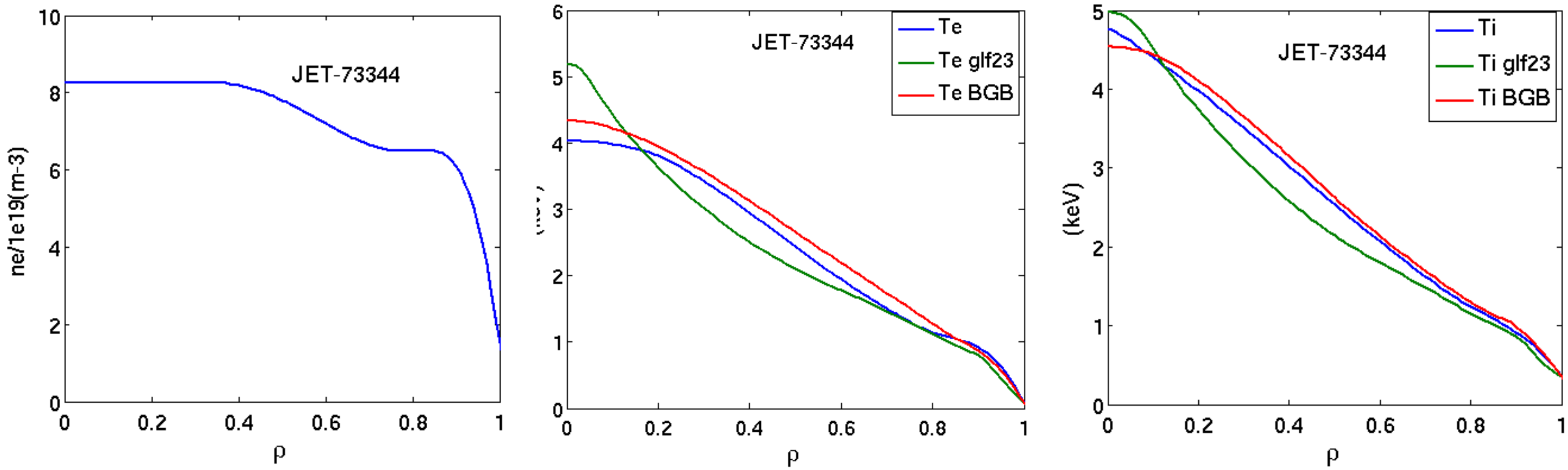
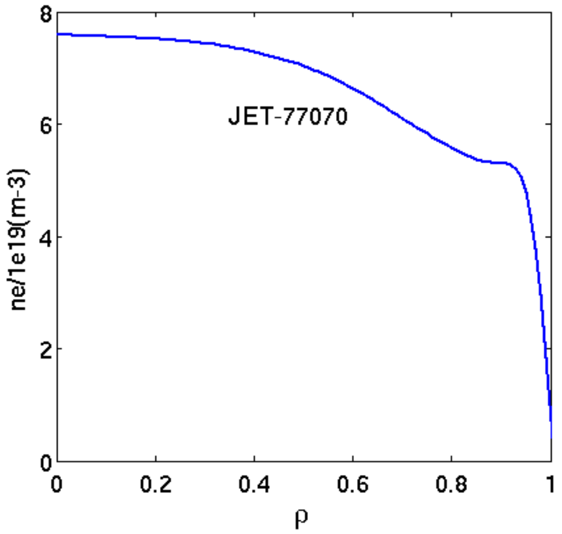
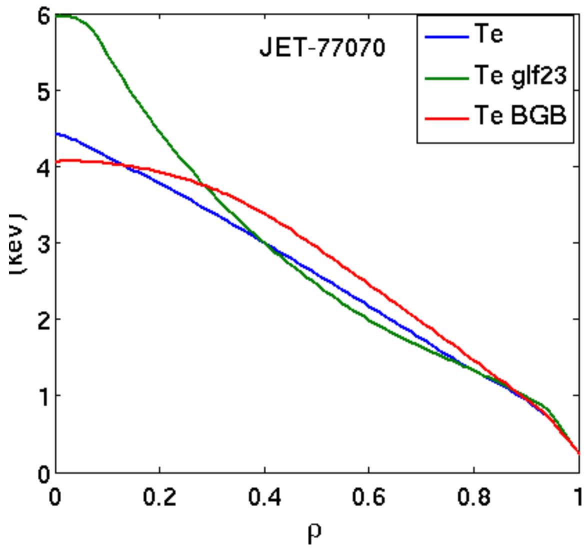
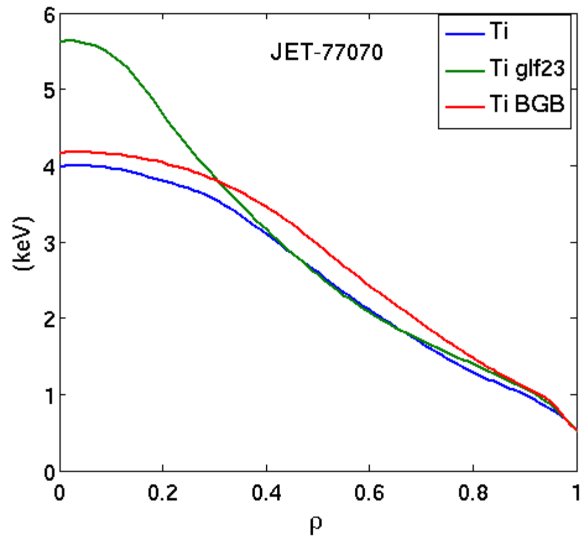


- High density H-mode with very low population of fast ions
- As expected, BGB gives very good results for both electrons and ions
- GLF23 underestimates the temperatures in the region 0.2<ρ<0.9 whereas overestimates them in the region 0<ρ<0.2
- In any case the results obtained by GLF23 are not dramatically wrong

H-mode 77070

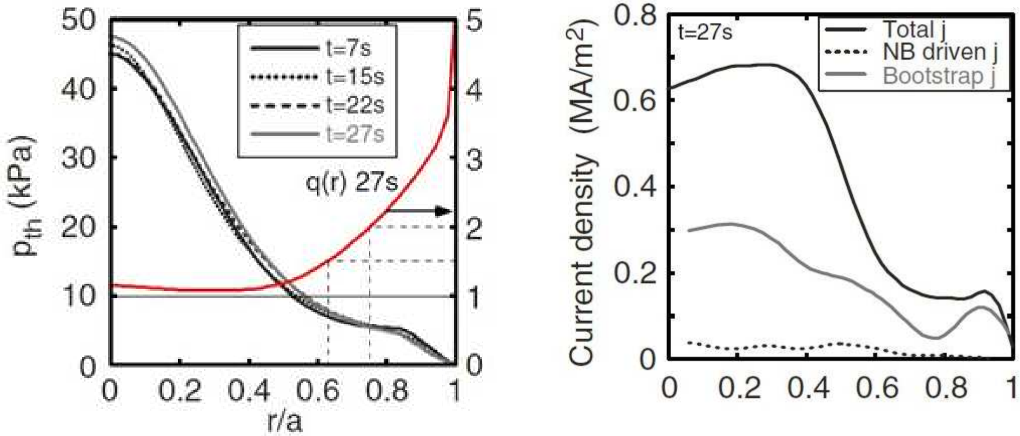




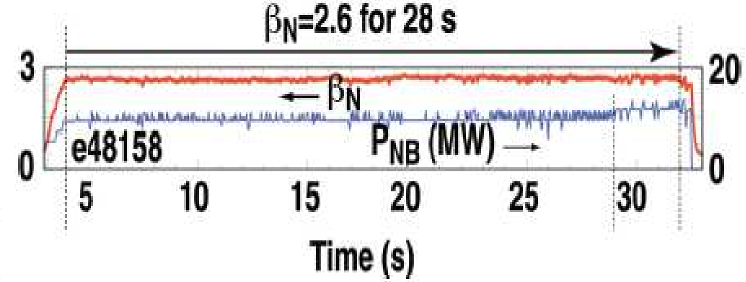


- High density H-mode with very low population of fast ions
- As expected, BGB gives very good results for both electrons and ions although worse than for the previous discharge
- GLF23 gives very good ion temperature agreement for the region 0.3<ρ<0.9 although tends to overestimate in the region 0<ρ<0.3 , as for the previous discharge

JT60U Advanced H-mode regimes



N. Oyama et al., Nucl. Fusion **49** (2009) 065026



Luce T. et al., 23rd IAEA Fusion Energy Conference, 11-16 October 2010, Korea, ITR/1-5.

- Two shots selected (SN39713 , SN48158) corresponding to high density and low density hybrid scenarios
- More experimental data available (but very few q profile measurements if any)
- A interpretative and predictive simulation of the discharge 48158 has been carried out
- Data for 39713 is available but not yet retrieved

Shot 48158 interpretative analysis

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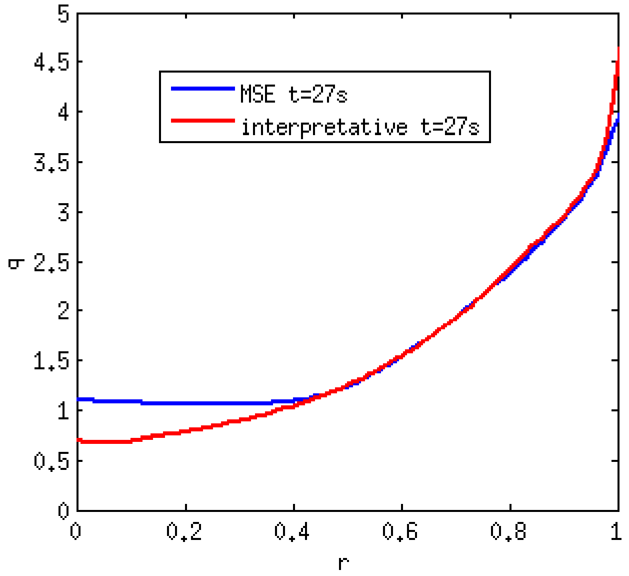

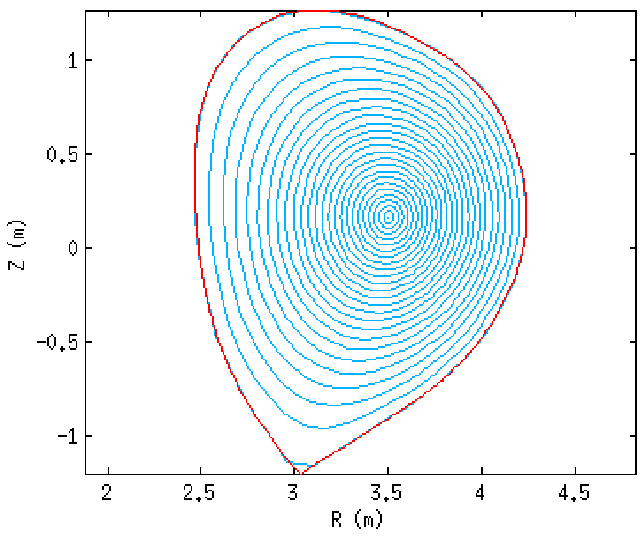

- The interpretative analysis shows that the q profile is not well simulated
- q0 drops below 1
- However just ne MSE measurement available for the full discharge
- The situation is similar to that obtained in AUG

Shot 48158 predictive simulation with Bohm GyroBohm model

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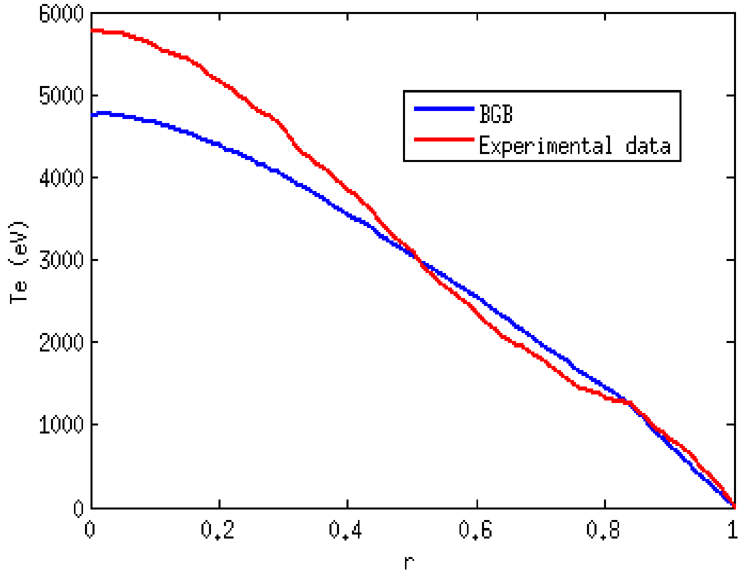

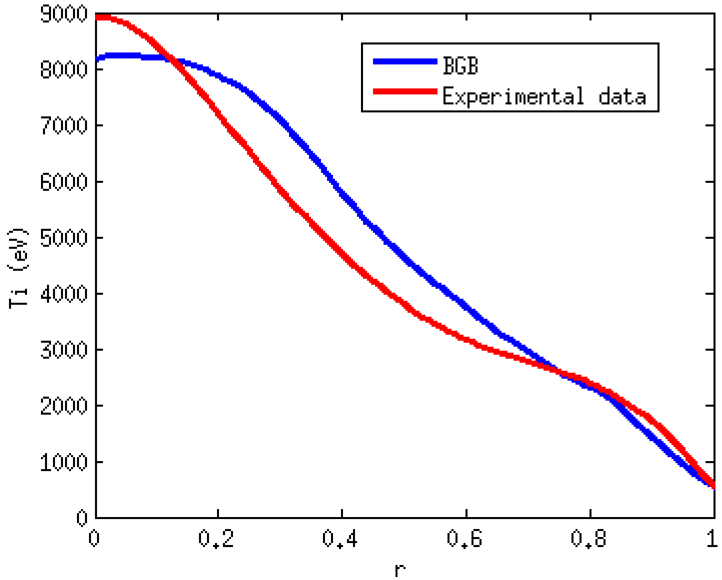

- Pedestal and rotation profile taken from experiment
- Electron and ion temperatures reasonably well simulated
- The level of agreement is similar to JET
- Transport barrier for the ions predicted at r<0.5 like in the experiment

JET Hybrid scenarios

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- Three discharges selected for predictive validation (77922 high triangularity, 75225 low triangularity and 77280 low triangularity 20s discharge)
- Initial q profile of the simulation taken from first MSE measurement
- The evolution of the q profile is neoclassical for these three discharges (checked by comparing with MSE q profile evolution)
- CDBM results are on the way
- NBI calculations are performed with NEMO-SPOT (CRONOS)

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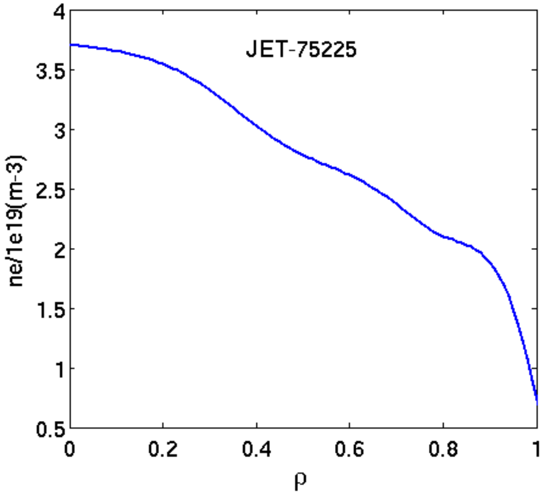
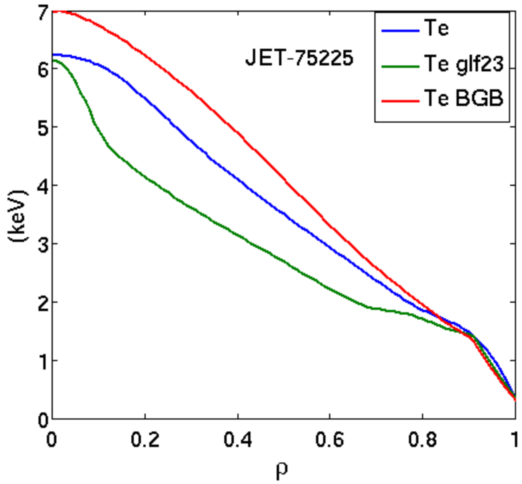
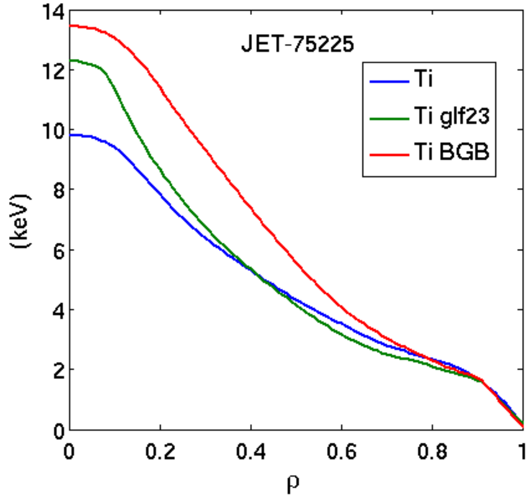
JET hybrid 75225







- Low density Hybrid scenario with high population of fast ions
- BGB overestimates both electron and ion temperatures
- GLF23 underestimates electron temperature and slightly overestimated ion temperature in the region

JET hybrid 77922

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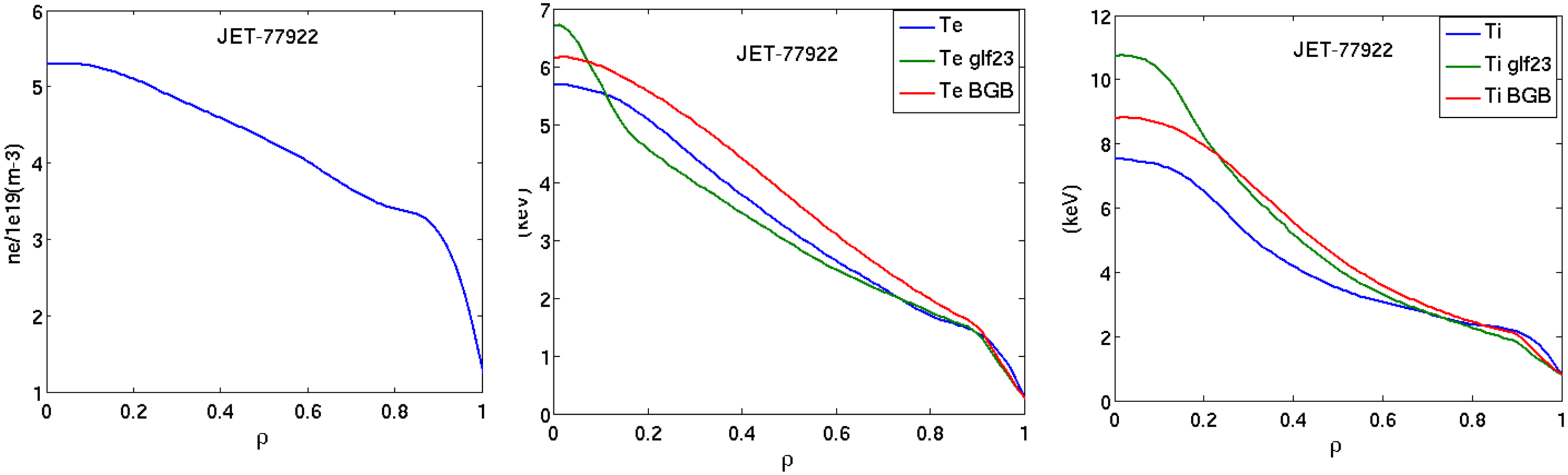

- High density Hybrid scenario with low population of fast ions
- BGB again overestimates both electron and ion temperatures
- GLF23 again underestimates electron temperature (slightly this time) and highly overestimates ion temperature due to a too strong effect of rotation

JET hybrid 77280

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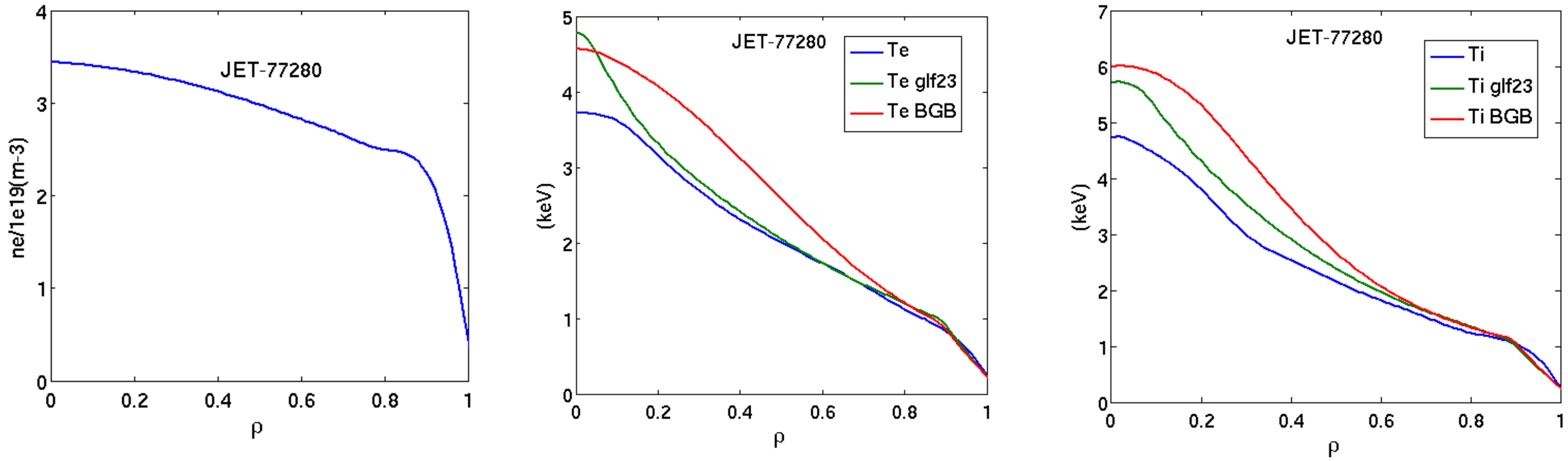
CRONOS



- Low density Hybrid scenario with high population of fast ions
- BGB again overestimates both electron and ion temperatures
- GLF23 gives good electron temperature and overestimates again ion temperature due to a too strong effect of rotation

Conclusions

- Predictive simulations for the electron and ions temperatures have been carried out for JT60U and JET
- For JT60U H-mode discharges, GLF23 tends to give the best results. BGB does not deviate strongly but tends to be worse
- The results of CDBM must be carefully evaluated and benchmarked
- For JET H-mode discharges BGB is quite accurate, however GLF23 is not far except for the region for which the diffusivities are too low (this was already well known)
- For hybrid JT60U discharge 48158, Bohm-Gyrobohm is reasonably good. Weird results obtained from GLF23. Analysis on the way
- The q profile evolution cannot be simulated by means of neoclassical resistivity. For predictive simulations, fixed q profile is used.
- For JET hybrids BGB overestimates both electron and ion temperatures.
- GLF23 remains closer to experimental values for hybrids although it also overestimates ion temperature

Conclusions

Work to be done:

- Transfer missing data from JT60U to CRONOS
- Benchmark CDBM transport model in CRONOS
- Benchmark NBI modules with both codes
- Perform interpretative and predictive simulations of all the shots
- Continue with the simulation of density, pedestal and rotation
- Discuss extrapolation to JT60SA