JET high field/high current H-mode – extrapolation to DT operation

Extrapolation of Hybrid Scenarios to DT operation (Bohm-gyroBohm, CRONOS) – Jeronimo Garcia, ISM 29.09.2010.

Ian Jenkins: mainly HS extrapolation with rescaled temperatures

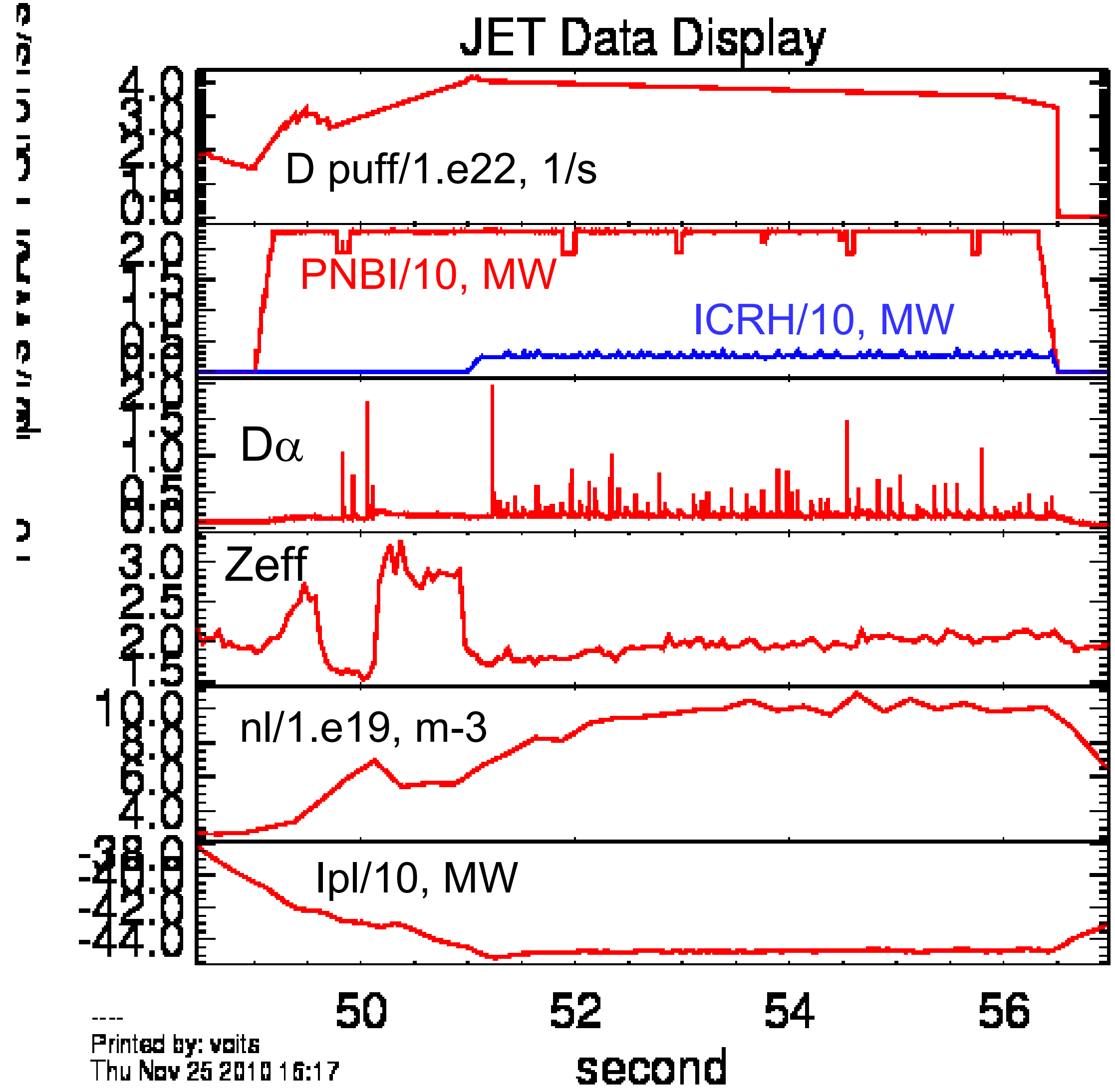
These simulations: extrapolation of the DD H-mode plasma to DT phase (GLF23, MMM08, TRANSP)

Outline

1. *NBI simulations and alpha-heating for "reference" DD→DT discharge*
2. *Validation of transport models for reference DD discharge: GLF23, MMM08 and effect of rotation*
3. *NBI power scan for DT plasmas*

Irina Voitsekhovitch, ISM WS, November 2010

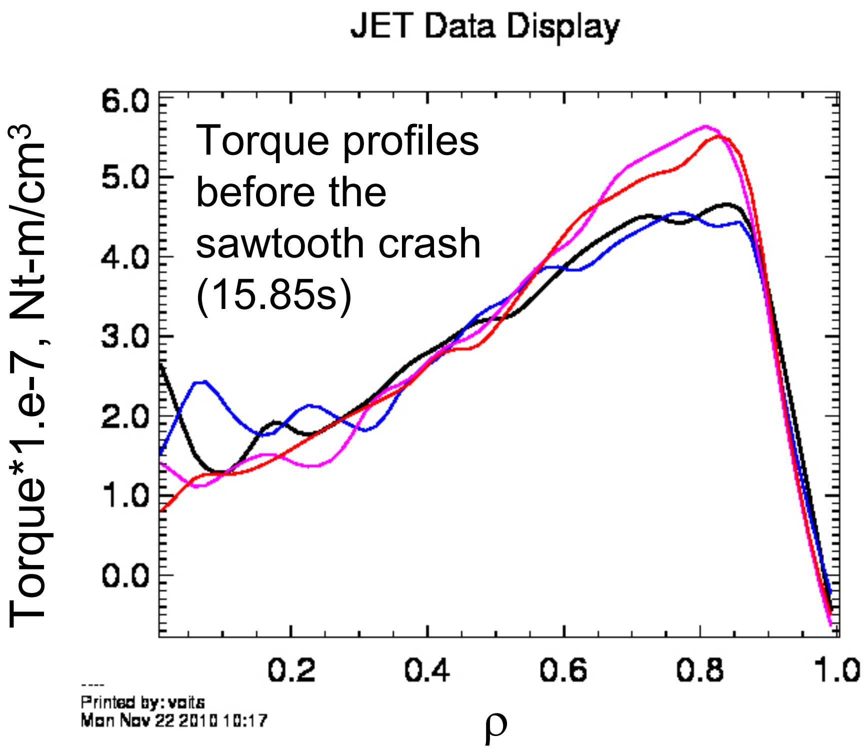
79698: experimental scenario

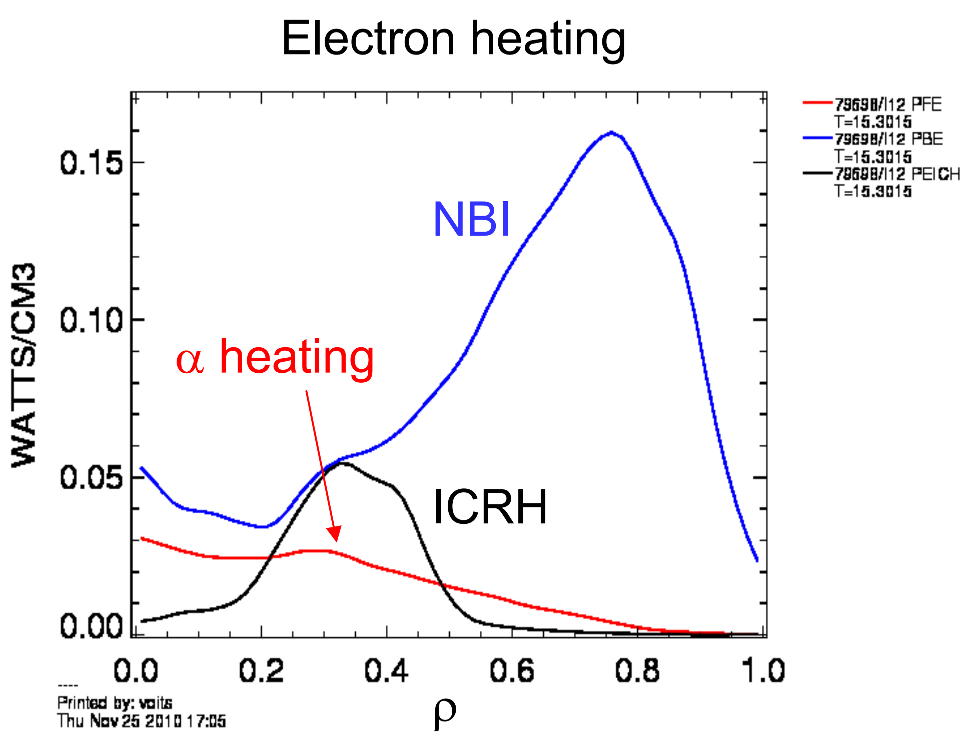


- *3.6 T / 4.5 MA, q95=2.6*
- *High density, n/nGW ≅ 0.6*
- *H98 ≅ 0.9, βN ≅ 1.45*
- *PNBI = 23 MW, PICRH = 2.5 MW*
- *Phase selected for DT projection: 52-56 s*
- *Extrapolation to DT plasmas is done with the same density and rotation*

DD ⇒ DT: NBI simulations and alpha heating for reference discharge

Reference DD (black), thermal DT with D beams (blue), thermal DT+ normal tritium PINI, thermal DT + tangential tritium PINI



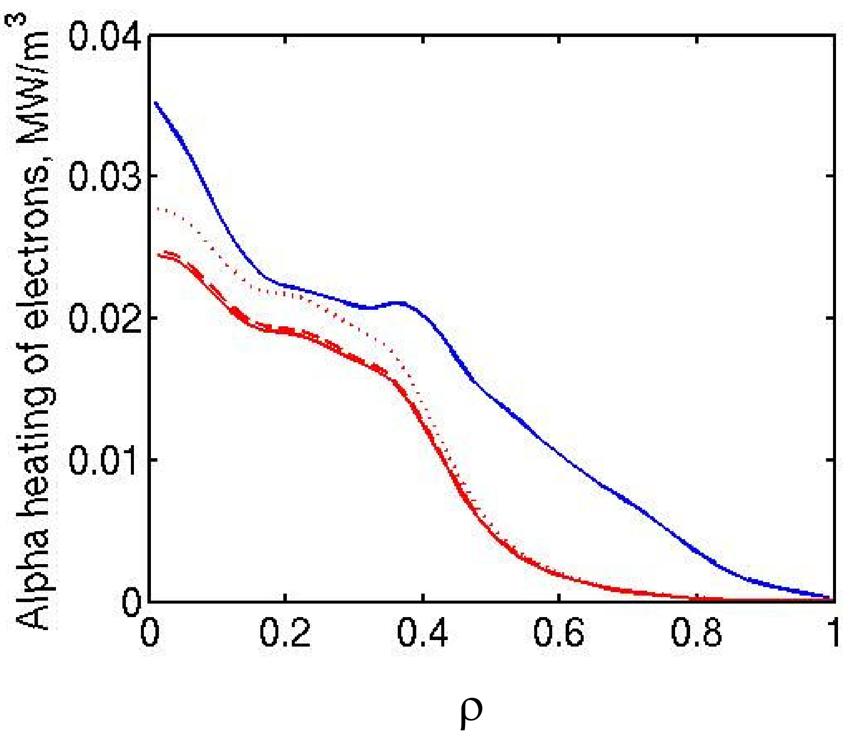


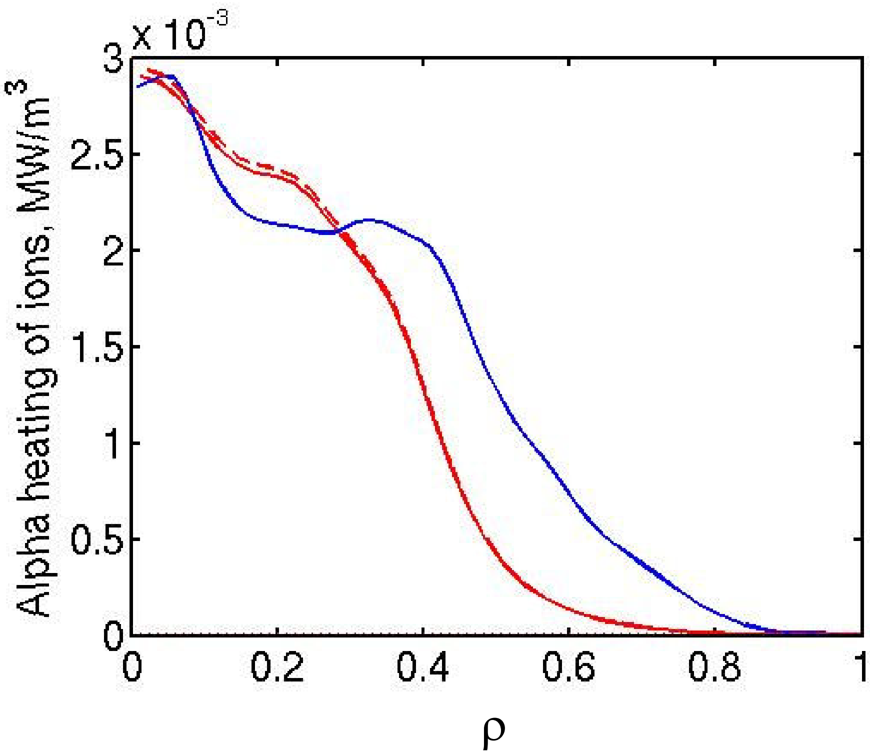
- ***measured ne, Te, Ti, Zeff, tritium is injected via gas puff only, gas puff + tangential or normal beams;***

- ***~20% higher torque at the outer part of plasma with tritium beams;***

- ***$P\alpha$ = 0.7-0.85 MW, Q = 0.16-0.19, but local α-heating is comparable with central NBI heating***

Benchmarking of alpha heating in ASTRA and TRANSP (79698, 13 s)

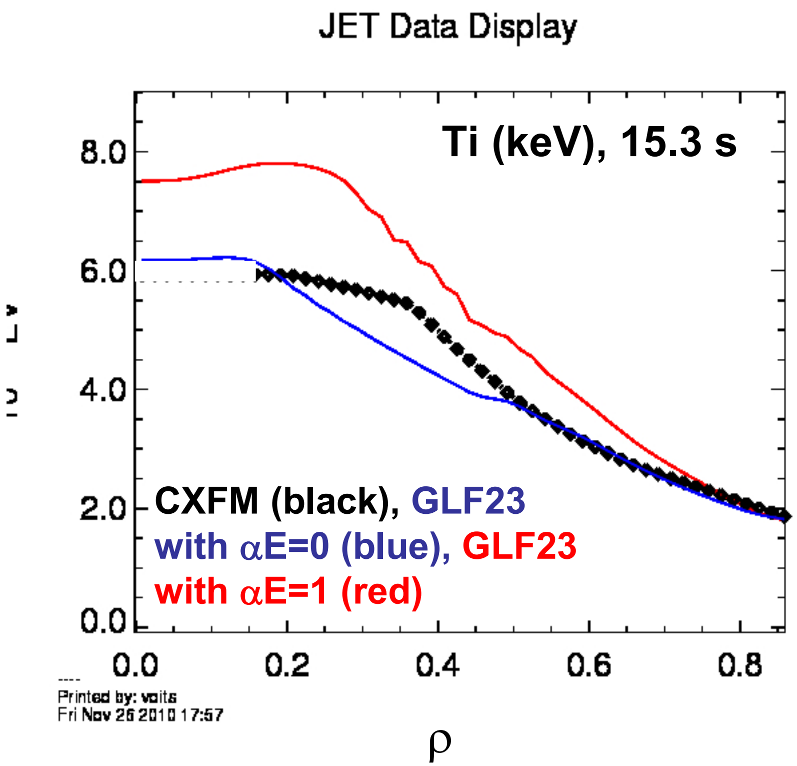


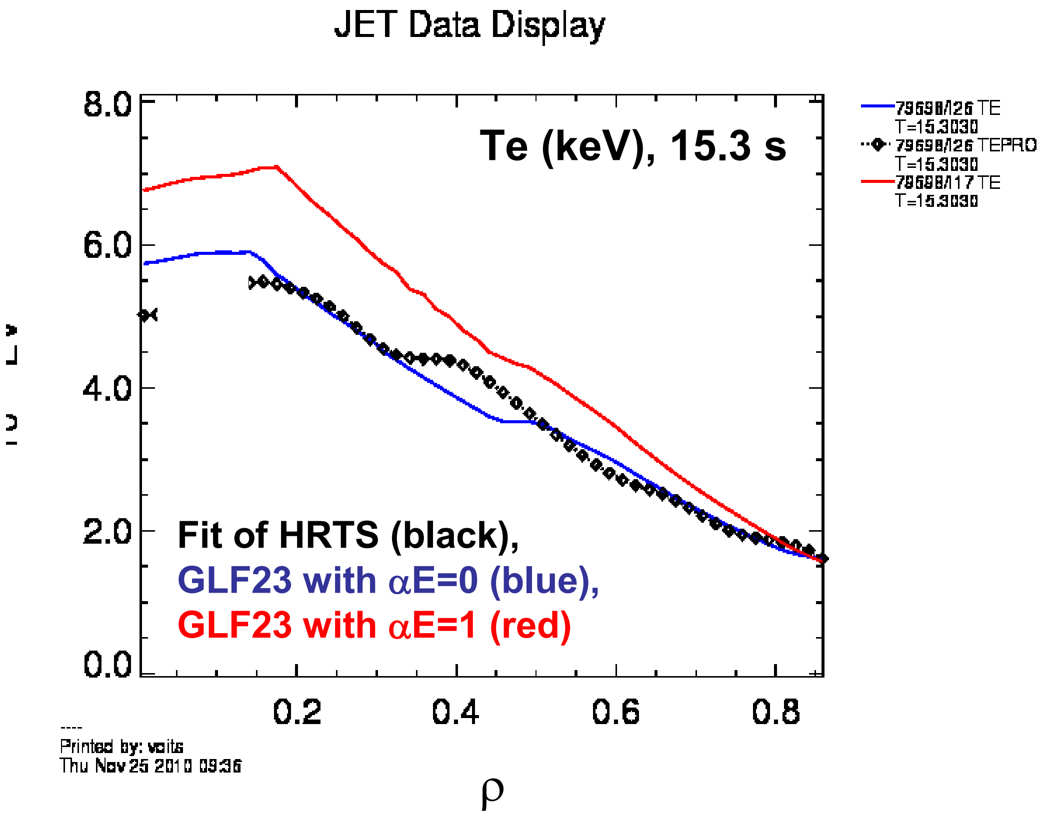


- the output of TRANSP analysis run is used as an input for ASTRA
- different analytical expressions in ASTRA, MC simulations (NUBEAM) in TRANSP
- Palpha_astra = 0.412 MW, Palpha_transp = 0.8 MW

Transport modelling (GLF23/TRANSP) for reference D discharge

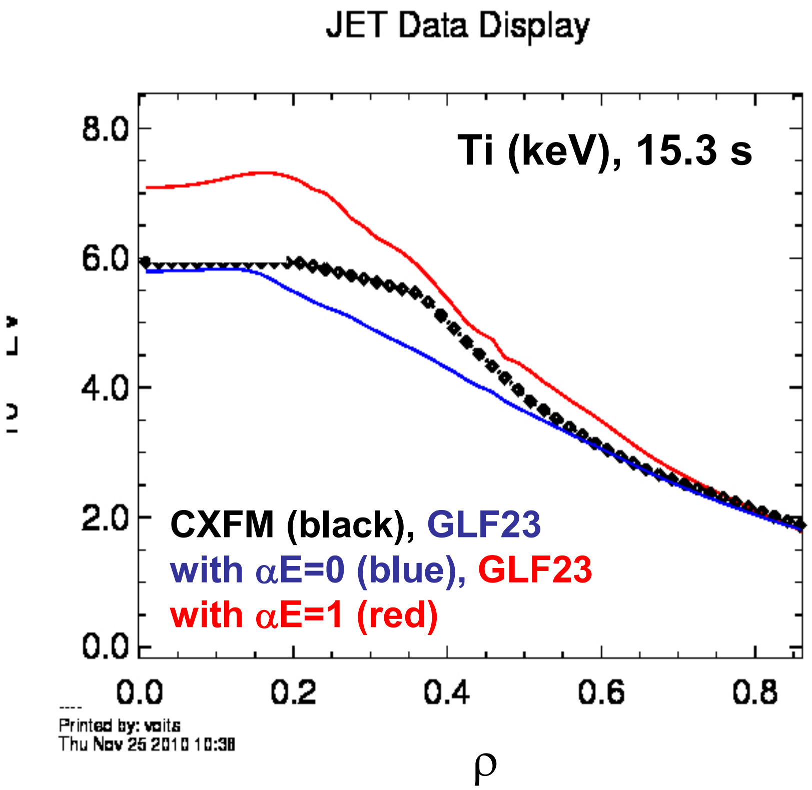
Te, Ti, j and equilibrium are simulated with measured plasma profiles (ne, Vtor)

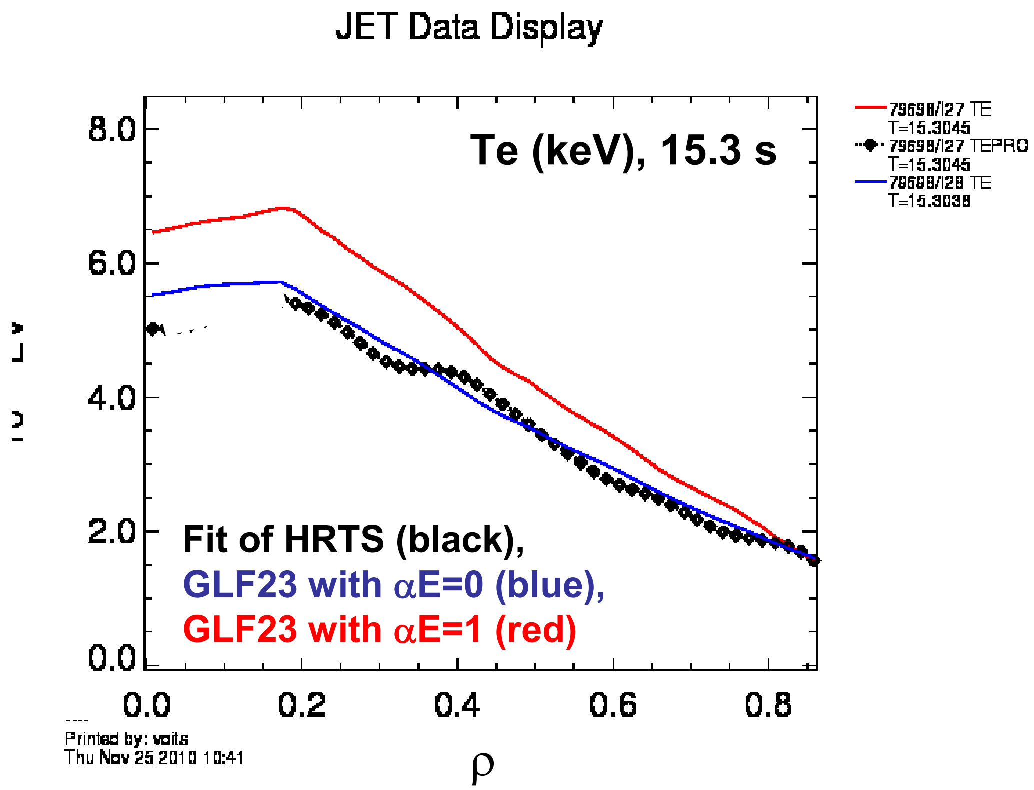




- ***simulation domain:*** $0 \leq \rho \leq 0.85$***, profiles are shown before the sawtooth crash***
- ***modes are stable at*** $\rho \leq 0.15$
- ***similar temperature prediction when DD is replaced with DT plasmas***

Transport modelling (MMM08/TRANSP) for reference D discharge

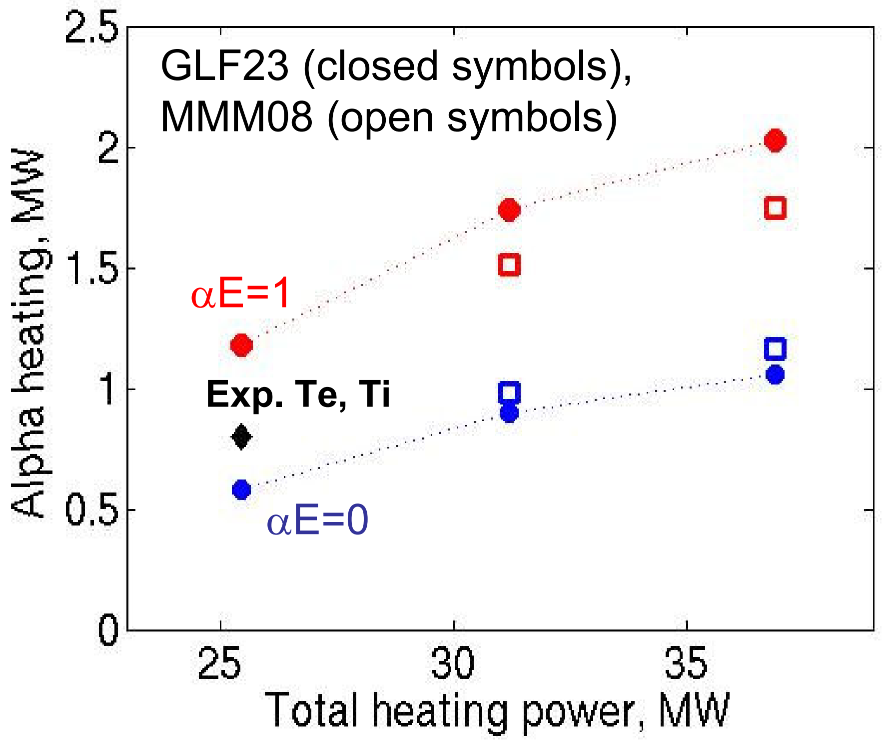


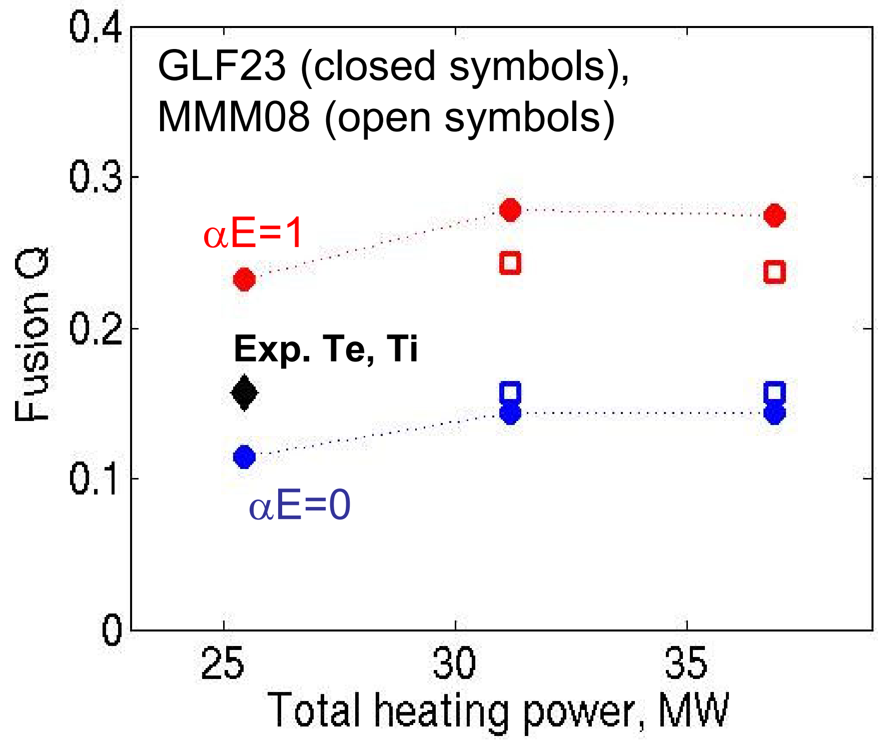


- *Te, Ti, j and equilibrium are simulated with measured plasma profiles (ne, Vtor)*
- *paleoclassical and DRBM contributions are off, Weiland part is dominant*
- *modes are stable at $\rho \leq 0.15$*
- *similar prediction accuracy with MMM08 and GLF23*

NBI power scan in DT plasma

All parameters are averaged over 14.5 – 15.7 s (two sawtooth crashes)





- Increase of NBI power → increase of χs → little/no increase of temperature → stiffness increases with power → test of stiffness for the DD phase
- measured density, rotation & pedestal at 23MW of NBI power has been used and not re-scaled
- break of stiffness is needed to achieved high Q → accurate prediction of rotation is important

Summary / actions

- Role of rotation and pedestal for obtaining high Q at JET?
- Prediction of rotation: database for reference DD scenarios (power scan, density scan)?
- Possible approaches **[ISM-P2-2010-02]**:

  - test of theory-based models for rotation: GLF23, Weiland (benchmarking with ONETWO as a first step)

  - empirical approach: $\chi\varphi$ is a fraction of χi. Need in momentum pinch?

  - empirical global scaling-based approach (similar to thermal transport during ramp up): $\tau\varphi \simeq \tau E$, τE is determined by H98 scaling, $\chi\varphi$ profile is parabolic

Weiland model: isotope effect

H. Nordman et al, PPCF 2005

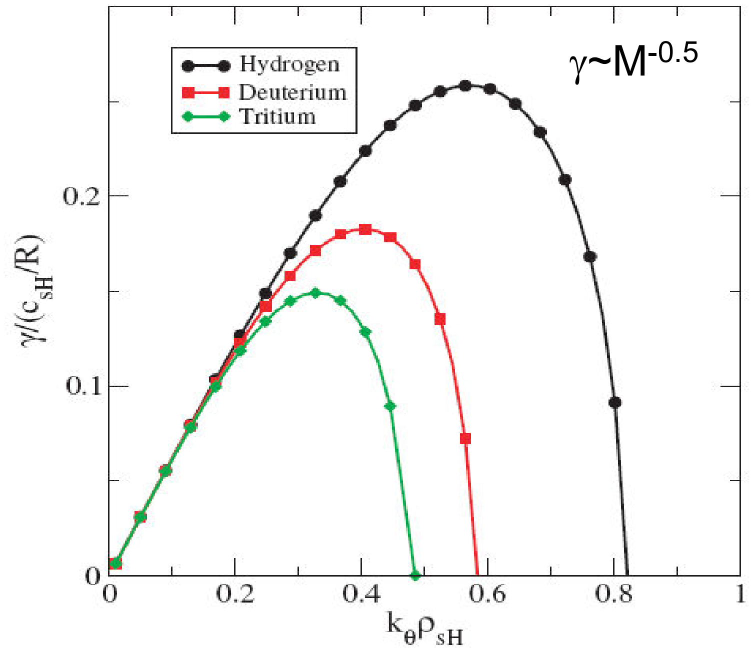


Figure 1. The normalized ITG growth rate, $\gamma/(c_{sH}/R)$, as a function of $k_\theta \rho_{sH}$ for pure hydroger deuterium and tritium with $R/L_n = 2$, $R/L_T = 3.75$, $T_e/T_i = 1$ and $f_t = 0$.

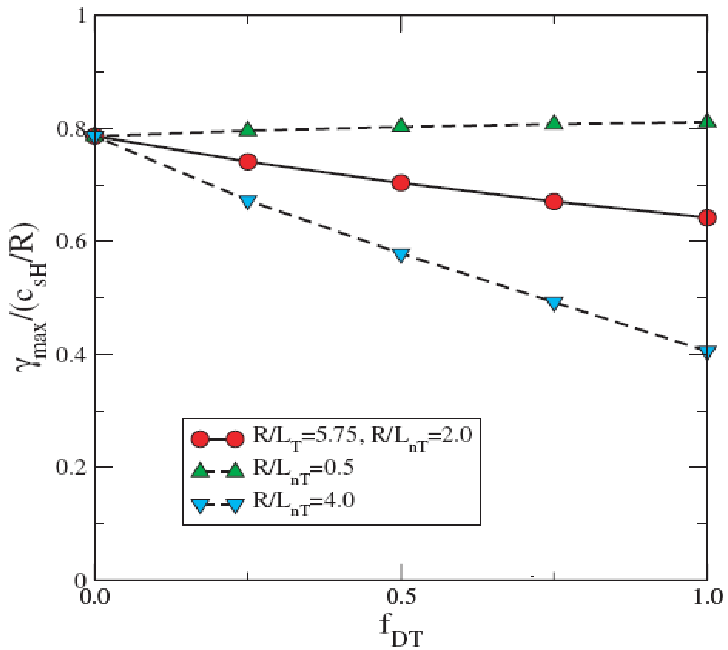


Figure 2. The maximum ITG mode growth rates (normalized to c_{sH}/R) as a function of the fraction of tritium (f_{DT}) for $R/L_T = 5.75$, $T_e/T_i = 1$, $f_t = 0$ and $R/L_{nD} = 2.0$. The tritium density scale length is varied as $R/L_{nT} = 0.5$, 2.0 and 4.0.