EFDA Task Force
Integrated Tokamak Modelling
EUROPEAN FUSION DEVELOPMENT AGREEMENT

IPP

Predictive transport simulations of JET L-mode plasmas: comparison between GLF23 and the new TGLF model

E. Fable, I. Voitsekhovitch, G. Pereverzev

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Outline

- The TGLF model: improvements over GLF23
- Simulations set-up
- Selected discharge
- Numerical results
- Discussion

The TGLF model

- 6 moments gyro-Landau-fluid for passing particles (ions and **electrons**), 3 moments for trapped particles
- Several fit coefficients to better approximate the kinetic closure
- Hermite polynomials expansion of the eigenfunction
- Improved QL rule to fit more GYRO non-linear simulations
- Realistic equilibrium
- Modified Waltz rule for ExB turbulence (self-)quench

[G. M. Staebler *et al.*, Phys. Plasmas **12**, 102508 (2005)]

Simulations set-up

- Experimental profiles taken from JET data and put into ASTRA
- GLF23 model solves for T_e and T_i, at prescribed density
- TGLF model solves for T_e and T_i at prescribed density. A simulation with all predicted profiles (T_e, T_i, n_e) is also performed
- The transport boundary is set at $\rho_V = 0.9$. Sawteeth are included with a Kadomtsev-Porcelli model
- TGLF is sampled both in radius (18 points out of 200, the rest are interpolated) and in time (it is called each 0.01 s)

Selected discharge

- Experimental profiles are given for:

  - JET L-mode #79575 → done

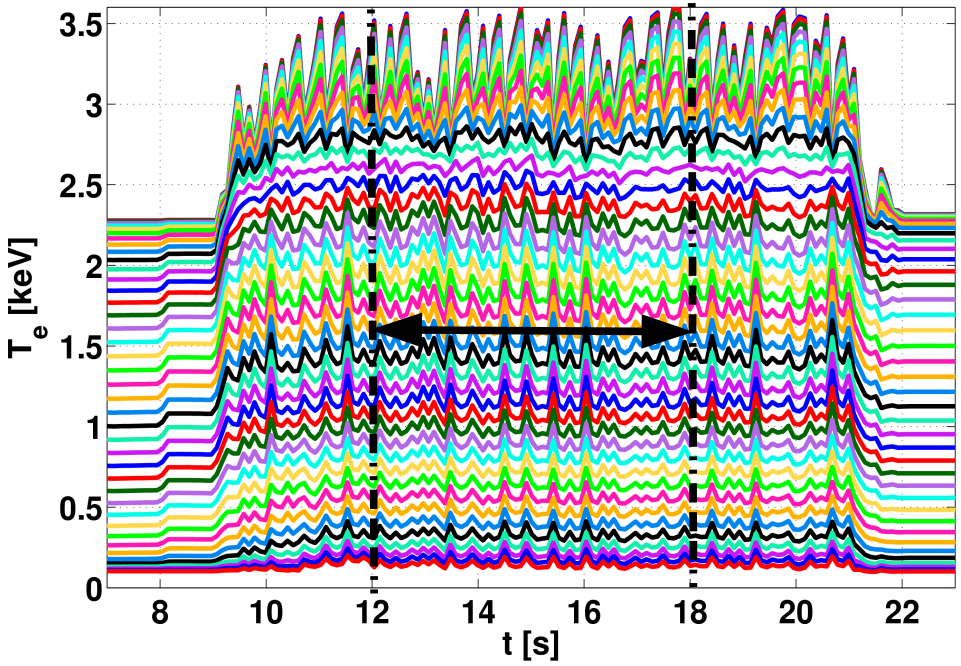
  - JET L-mode #79578 → not yet done

  - JET hybrid #77922 → not yet done

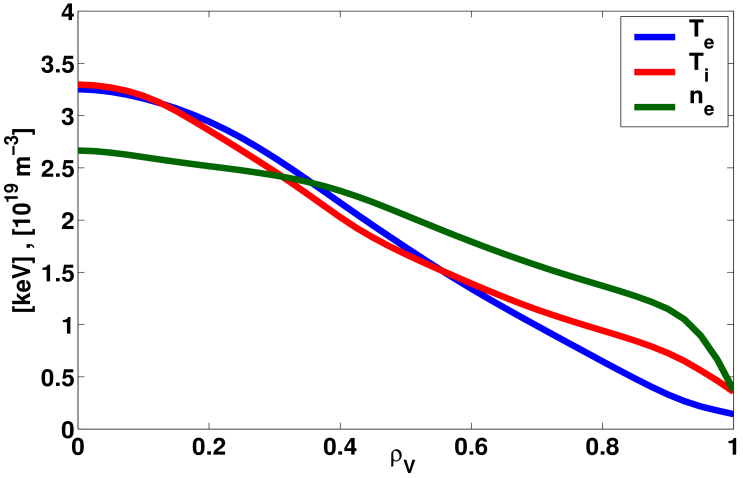
- Selected time intervals include part of the ramp-up and of the flat-top phase

- Simulations are anyway carried on from t = 0, allows to check predicted ramp with the two codes

JET L-mode #79575: time averaging and errors



- Time averaging done in the stationary phase: $\Delta t = [12\ 18]$ s



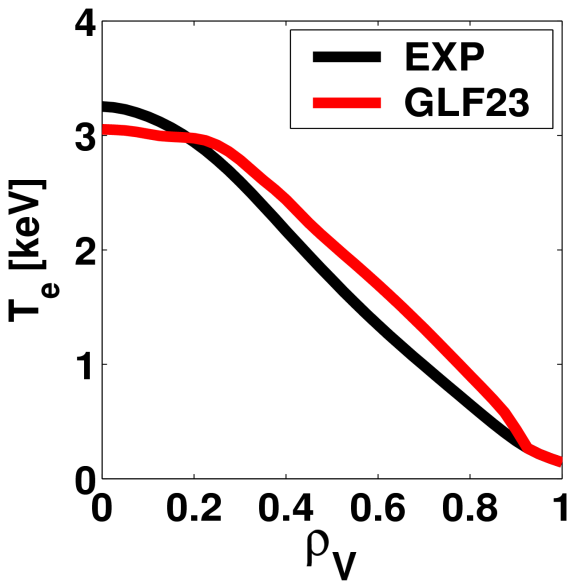
$$Err_r(t) = 100 \left\langle \frac{|f_{mod} - f_{exp}|}{|f_{exp}|} \right\rangle_r$$

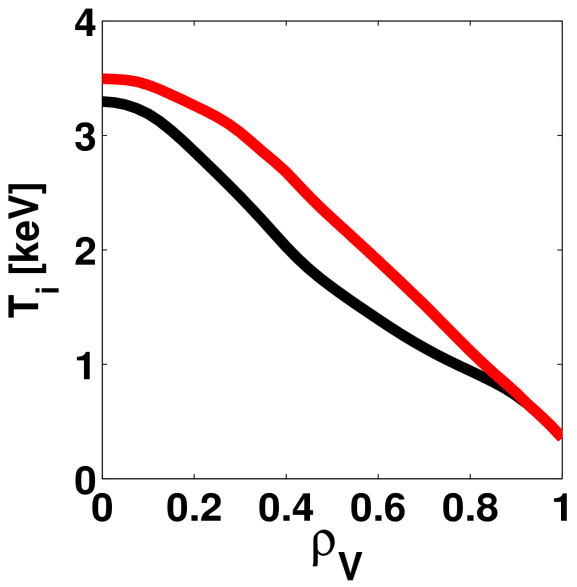
- Radial averaged error to compare time evolution

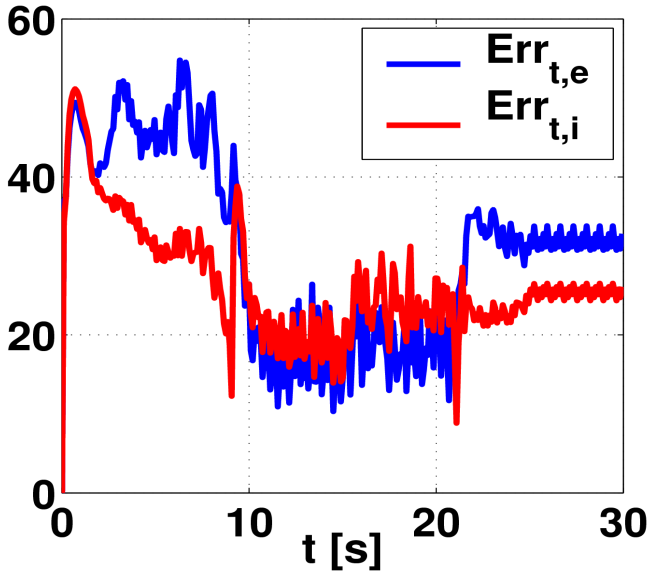
$$Err = 100 \left\langle \frac{|\langle f_{mod} \rangle_t - \langle f_{exp} \rangle_t|}{|\langle f_{exp} \rangle_t|} \right\rangle_r$$

- Global error defined as radial averaged error between time-averaged profiles

Numerical results with GLF23 (1)

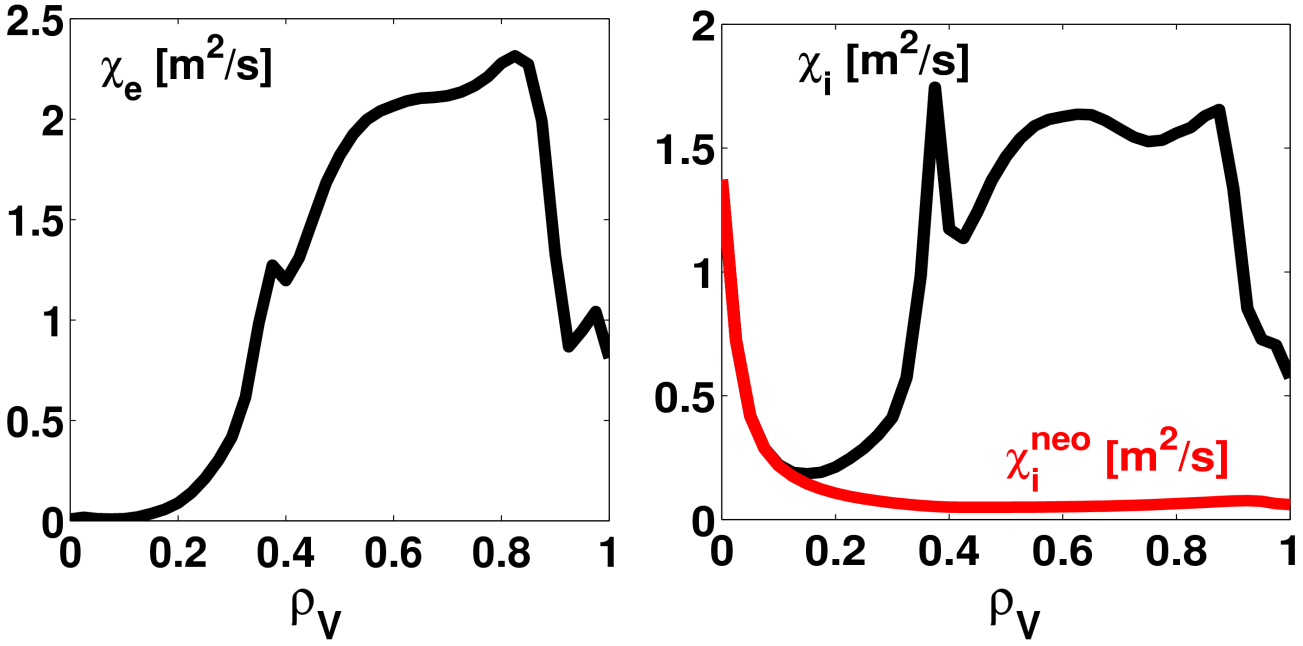






- Nothing new under the sun
- GLF23 reproduces pretty well global profiles, except for edge region
- Overall error ~ 20% in the stationary phase of interest

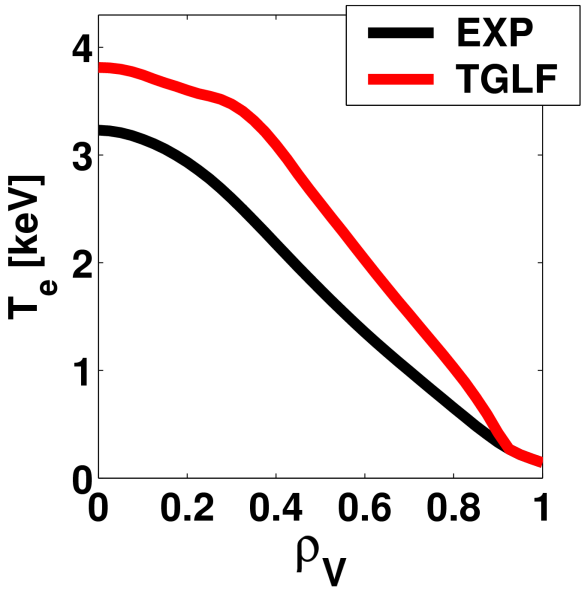
Numerical results with GLF23 (2)

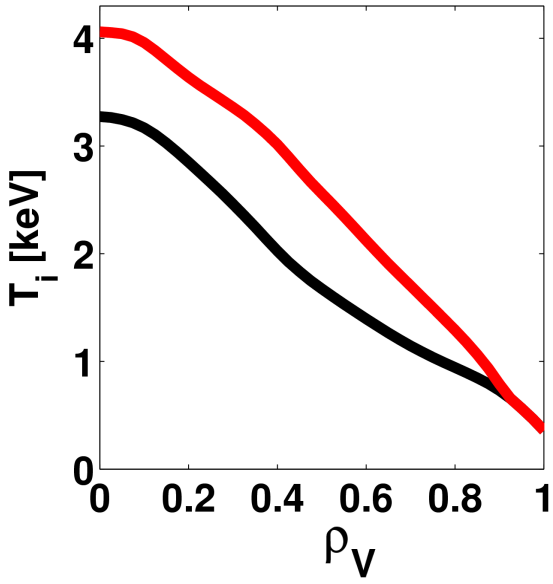


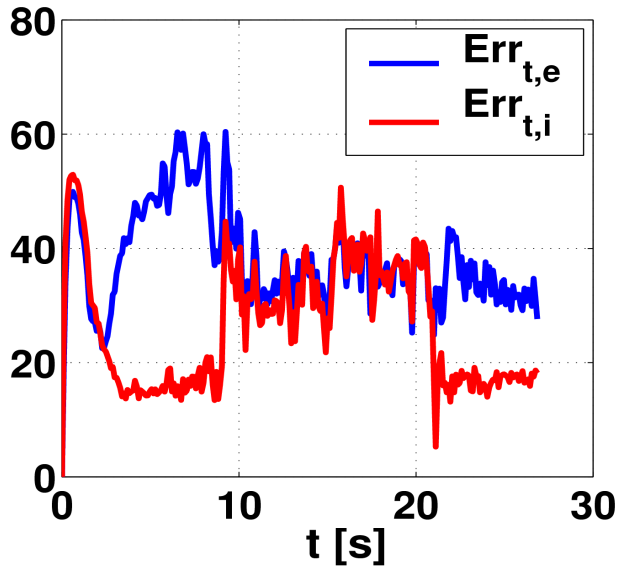
- Heat diffusivities almost constant in the relevant confinement region $\rho V \sim [0.5\text{-}0.8]$, drop in the core due to sawteeth and in the edge due to physics issues with the model itself

- $\chi_e > \chi_i$ maybe not realistic (leads to higher T_i gradients as shown)

Numerical results with TGLF, no density (1)

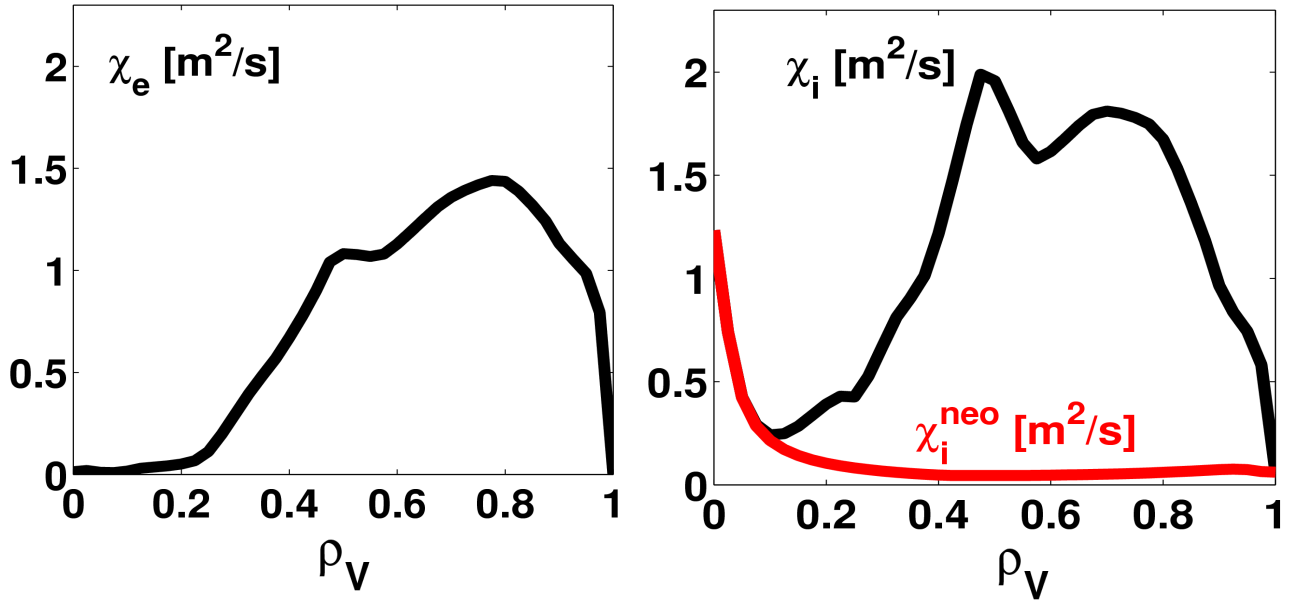






- Slightly higher gradients than GLF23 predicted (TGLF is less stiff to trapped electrons driven turbulence)
- Same problem as GLF23 in the edge region
- Overall error ~ 30%

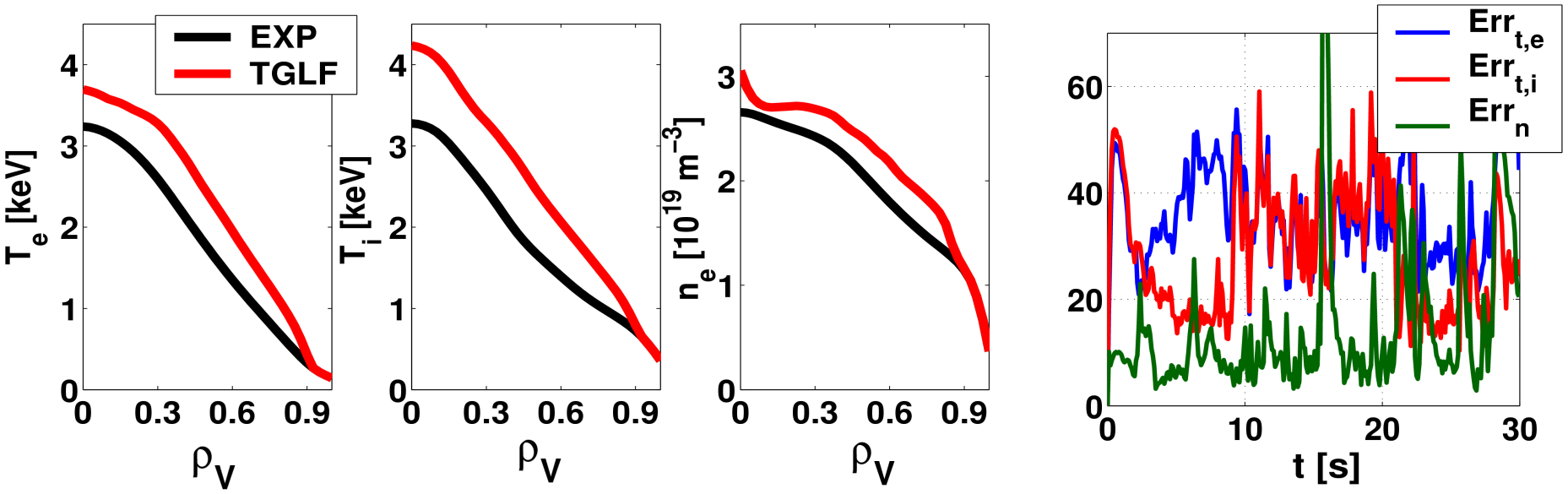
Numerical results with TGLF, no density (2)



- Heat diffusivities similar to GLF23, except in this case the ion energy diffuses faster than the electron energy

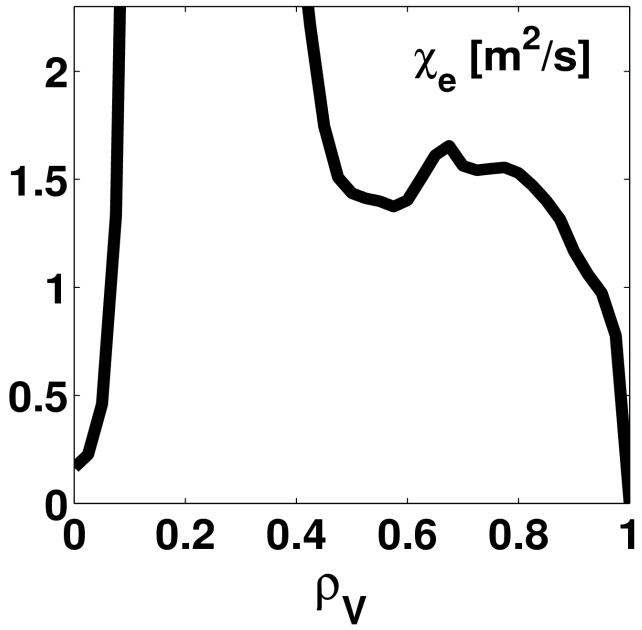
- As in GLF23, edge transport is predicted low, not realistic

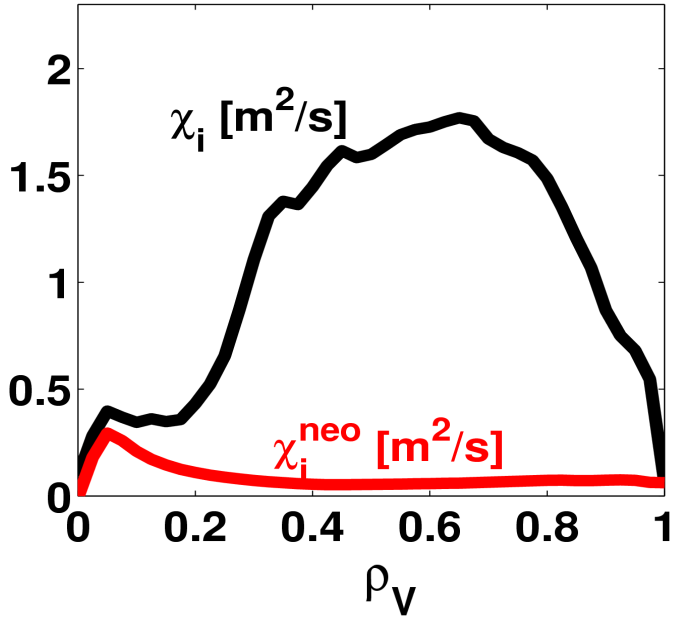
Numerical results with TGLF, with density (1)



- Temperature profiles predicted as in the no-density case
- Density profile well reproduced, except for edge gradient and on-axis region (should put artificial diffusivity anyway)
- Overall error ~ 30% for temperatures, ~ 10% for density

Numerical results with TGLF, with density (2)





- Heat diffusivities predicted as in the case without density evolution (high electron heat diffusivity in the center is an artifact from both sawteeth and sampling/averaging procedure)
- Again, low transport as edge is approached

Discussion

- Rather good agreement between TGLF, GLF23 and experimental data, notice that TGLF is less 'stiff' than GLF23

- However, also TGLF suffers from the 'edge transport hole' problem

- Density prediction from TGLF is also rather good, overall peaking is well reproduced

- Computational time for this case (run on 1 Linux processor):

  - GLF23: ~ 1 hour (full radius, full time slices)

  - TGLF: ~ 1 night (1/10 radial points, sampled in time)

Is it then worth using TGLF over GLF23 ?

- In terms of **core** physics content and improvements over GLF23:

  YES

- In terms of **edge** transport: **the same as GLF23, NO**

- In terms of computational cost: **NO**

- In terms of density (and I guess even rotation) modelling: **YES**

- In terms of stability: well that depends on the sampling scheme

- My personal opinion: **YES**, it should be employed in place of GLF23, although for test cases it could be frustrating to run