DE LA RECHERCHE À L'INDUSTRIE

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Turbulent transport analysis of JET H-MODE and hybrid plasmas using Qualikiz, TGLF and GLF23

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MOTIVATION AND WORK DONE

The validation of the main models available for the plasma simulation is mandatory to achieve a sufficient prediction capability of the performance of the main operation scenarios for present and future fusion machines

Two new sophisticated **quasi-linear first principle transport models** are available:

- **QuaLiKiz**: gyrokinetic base,
  trapped electrons,
  s-α geometry,
  el
  no ExB shear effect
- **TGLF**: gyrofluid,
  trapped electrons,
  Miller/s-α geometry,
  el/em,
  2 ExB shear effect models

QuaLiKiz and TGLF have been recently coupled to the **CRONOS** suite of codes

-> **study of the heat transport in H-modes and hybrids plasmas of JET**:

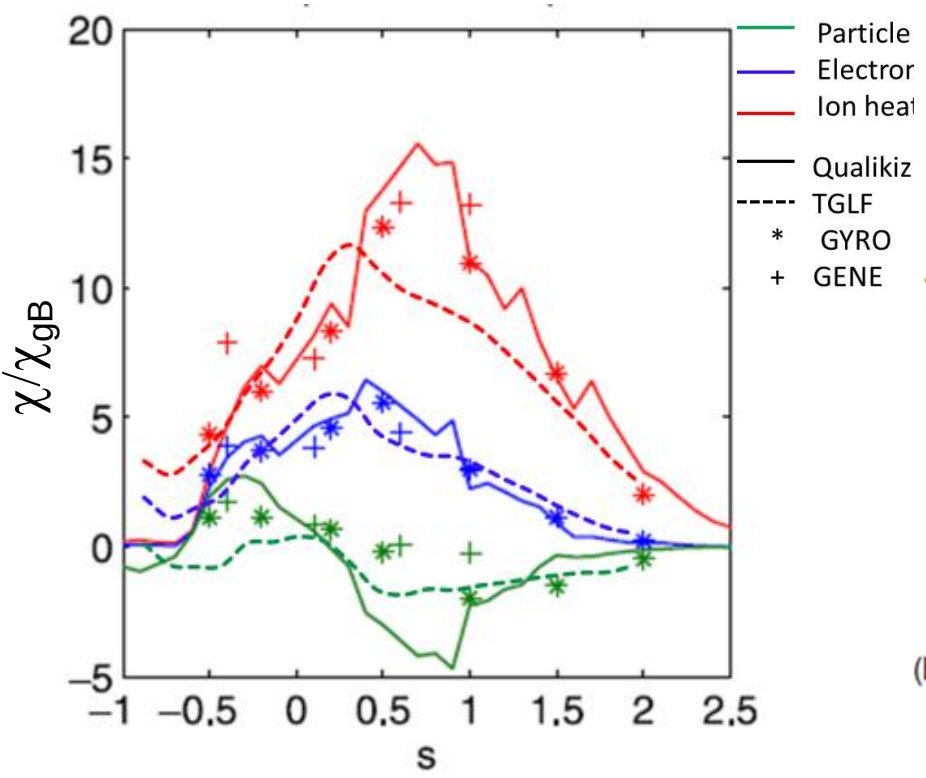
- to **validate** the models through the comparison with the **experimental** data
- to compare the results with **GLF23** (gyrofluid, el, s-α geometry, ExB shear effect);
- to trying to **understand** the possible **physical reasons** of the resulting **discrepancies**.

Simulations: - T and j are modelled;
- T pedestal is fixed (according with the experimental measurements)

STAND ALONE COMPARISON: GA STD CASE

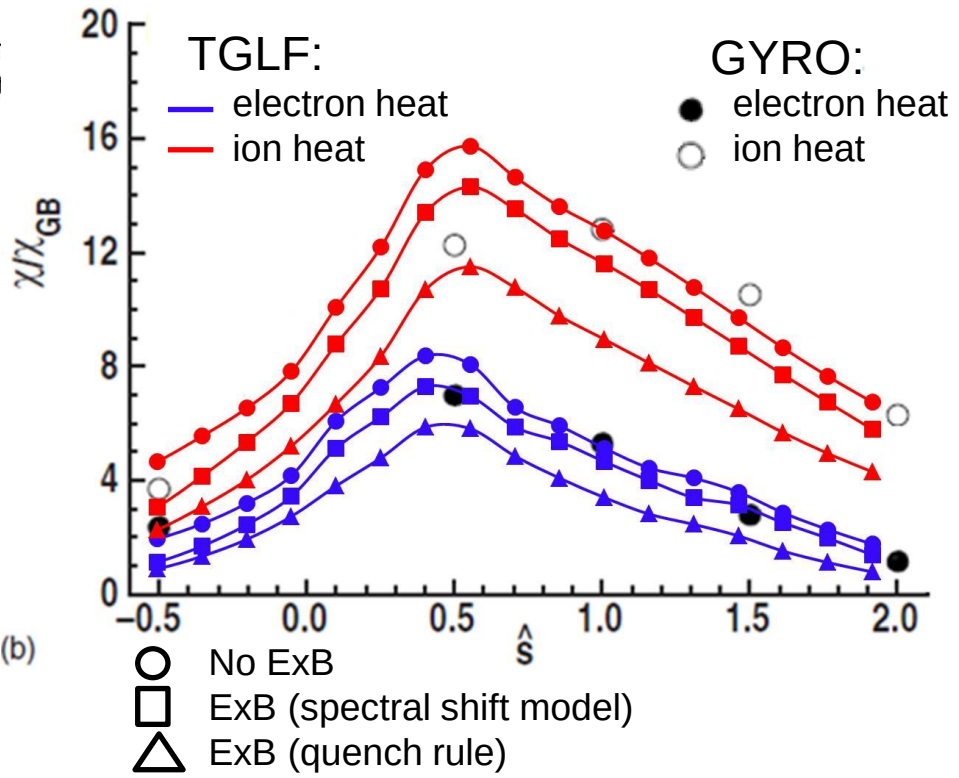
QLK and **TGLF** - non linear simulations (scan of s, R/L_T, T_e/T_i, ν_{ei}, Z_{eff})

s-α geometry



- Substantial agreement among QuaLiKiz, TGLF and non linear simulations

Miller geometry



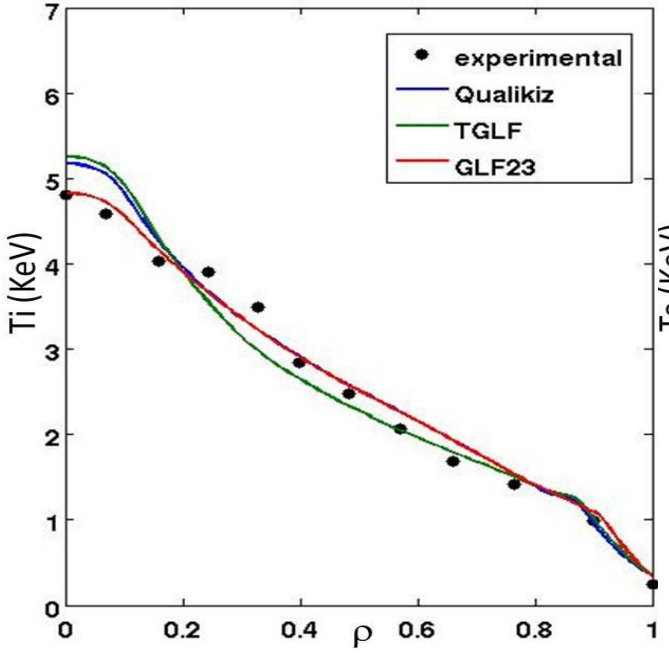
- Better agreement of TGLF with Miller geometry
- Presence of ExB shear factor has significant impact

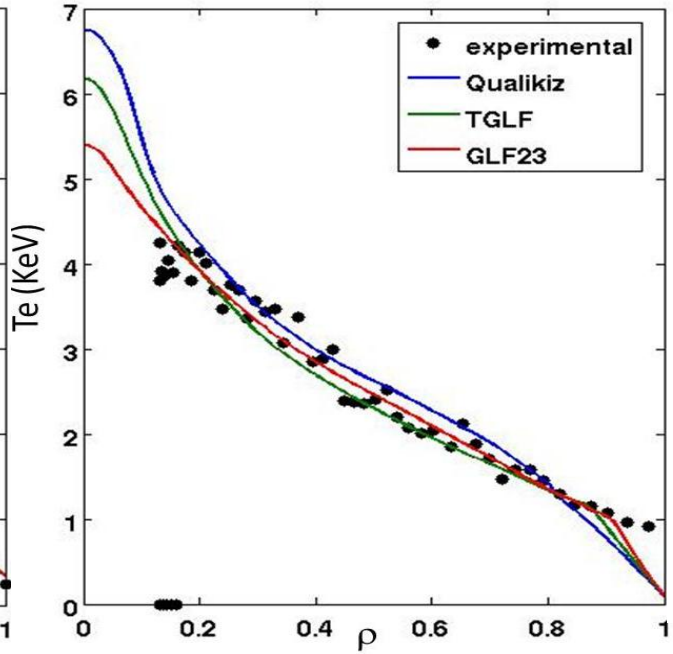
CARBON WALL JET H-MODES

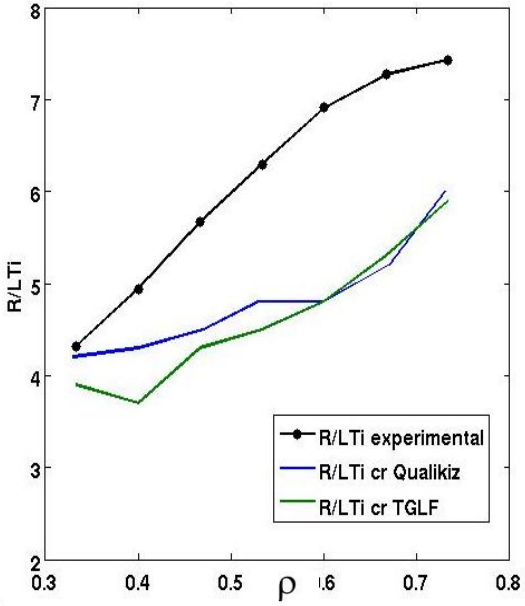
- **73344** (standard) and **73342** (high density) have been simulated

77344

t = 8.8 s







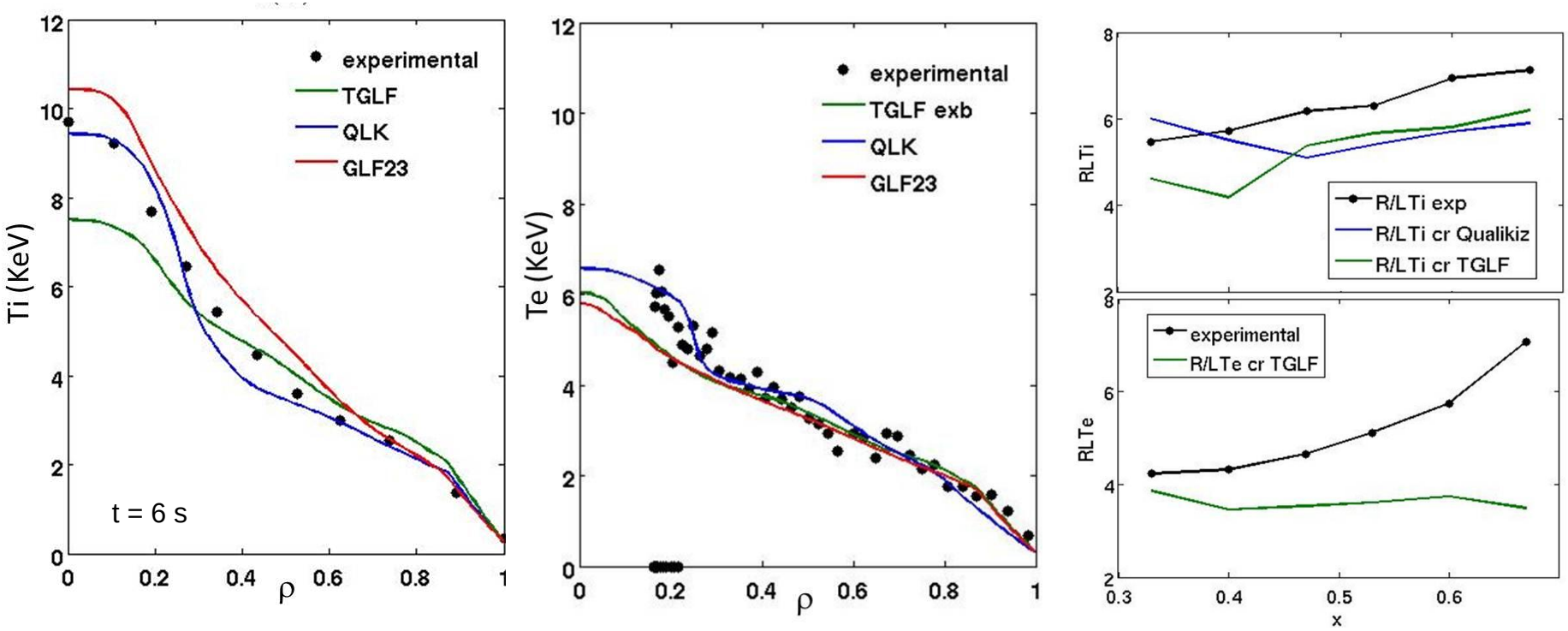
Qualikiz , TGLF and GLF23 agree with experimental T profiles in the core ($0.2<\rho_{tn}<0.8$)

- **Turbulence study**

- both QuaLiKiz and TGLF predict the **dominance of the ITG** instabilities.
- ITG threshold clearly under the experimental R/LTi values of these discharges, as expected for typical JET H-modes (**ITG regime**).

HYBRID: JET SHOT 75225
SELF CONSISTENT SIMULATIONS, TURBULENCE STUDY

low δ, low ne (n_0 = 5 10^{19} m^{-3}), high rotation (v_{tor} = 1 10^5 rad/s)

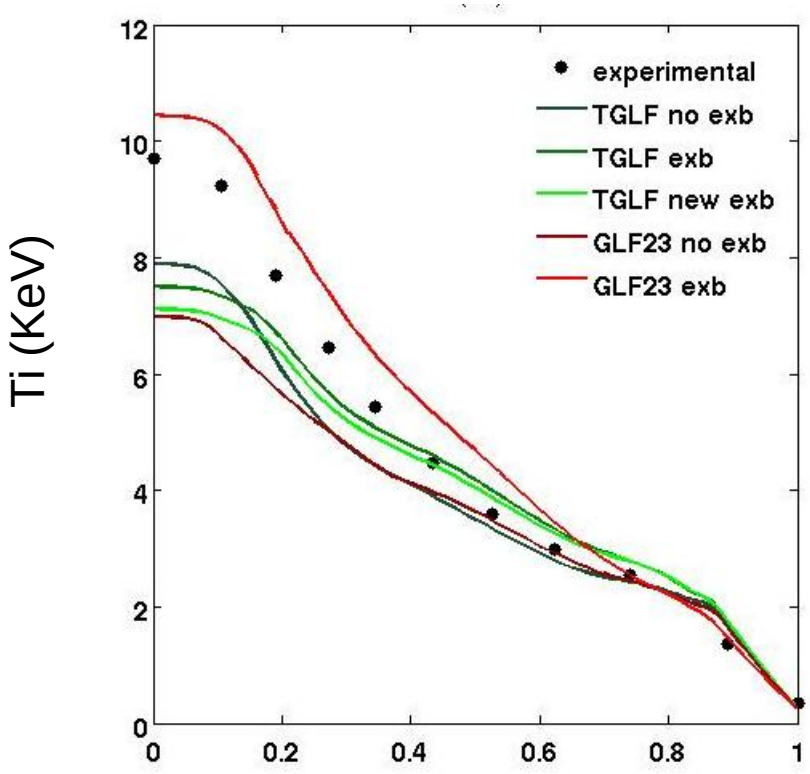


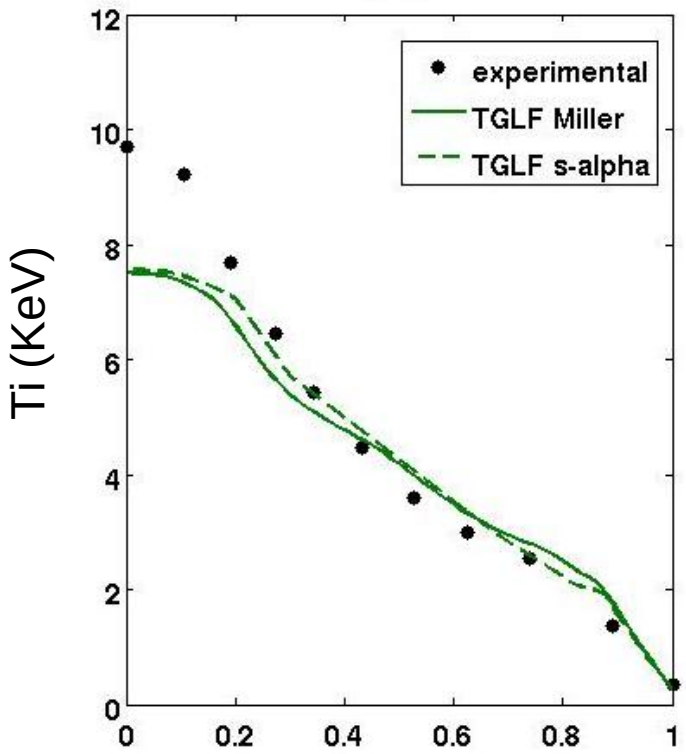
Differences among the simulated temperatures and the experimental data

Turbulence study

- TGLF: ITG, importance of TEM
- QuaLiKiz: dominance of ITG, stable inside ρ=0.4 (where s=0)

HYBRID: JET SHOT 75225
EFFECT OF ROTATION SHEAR AND GEOMETRY





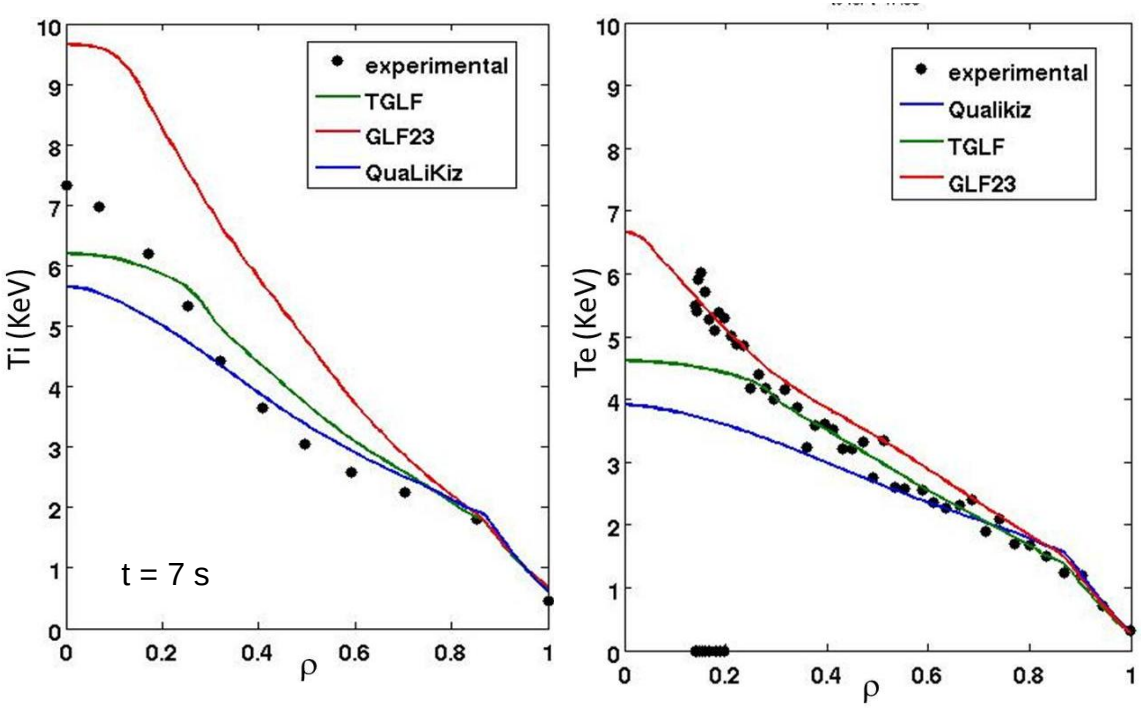
- TGLF: effect of rotation shear significant
  agreement with experiment for $\rho > 0.2$
- GLF23: effect of rotation shear overestimated

TGLF: quench rule/spectral shift model
GLF23: quench rule
when rotation shear, exb shear and v par shear

- TGLF: different geometry
  has very small impact.

HYBRID: JET SHOT 77922
SELF CONSISTENT SIMULATIONS, TURBULENCE STUDY

high δ, high ne

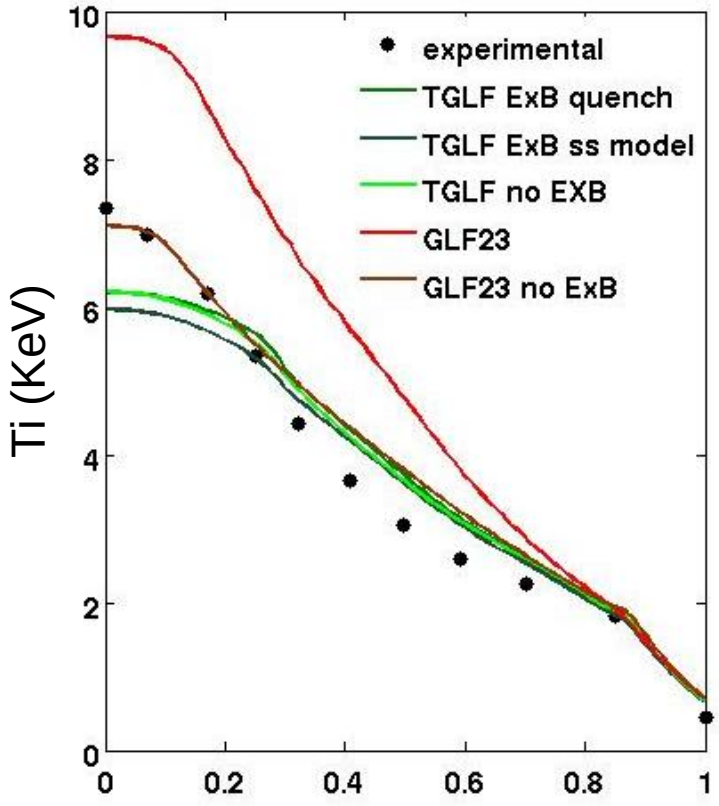


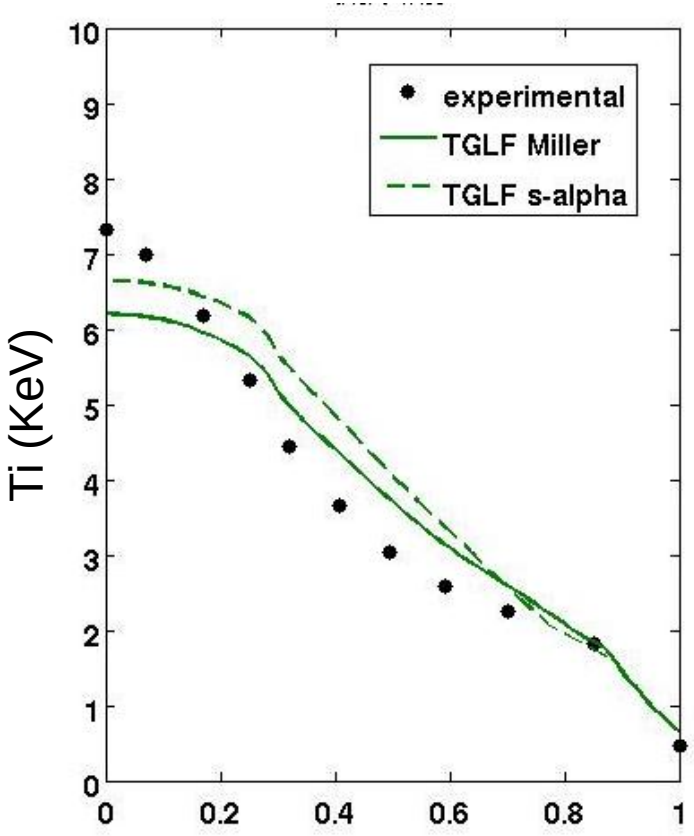
Differences among the simulated temperatures and the experimental data

Turbulence study

- TGLF: ITG, TEM important (centre, 0.5<ρ<1)
- QuaLiKiz: dominance of ITG, even in the centre (low T)

HYBRID: JET SHOT 77922
EFFECT OF ROTATION SHEAR AND GEOMETRY





- GLF23: overestimates ExB shear effect
- TGLF: ExB shear effect negligible

- TGLF: geometry has a relevant impact

TGLF: quench rule/spectral shift model

GLF23: quench rule

when rotation shear, exb shear and v par shear

SUMMARY AND CONCLUSION

- **Heat transport simulation** of 2 carbon wall **JET H-modes** and 2 **JET hybrids using** the two new quasilinear first principle transport models **QuaLiKiz** and **TGLF in CRONOS**;
- **Turbulence analysis** with the study of the threshold for ITG and TEM;
- Study of the impact of the **ExB shear effect** and of the **geometry**;

-> **JET H-MODES**

- good agreement among QuaLiKiz, TGLF with GLF23 simulations and experimental data (ITG regime);

-> **JET HYBRIDS**

- discrepancies among QuaLiKiz, TGLF, GLF23 simulations and experimental data;
- QuaLiKiz: far from experimental data;
  ITG are always the dominant mode;
- TGLF: better results;
  importance of TEM;
  sophisticated ExB shear effect and Miller geometry contribute in a relevant way to improve the results

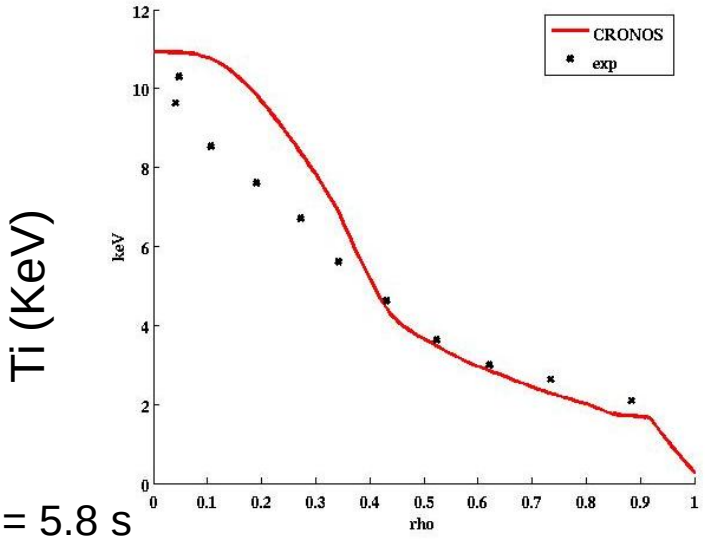
OUTLOOK

go ahead and deeper in the **analysis of hybrid discharges:**

- to analyze the effect of the parameters studied here
- to use GENE (girokinetic code) for the stand alone comparison, in order to understand the physical reason for the TGLF and QuaLiKiz differences when not due to the geometry and to the ExB shear effects.

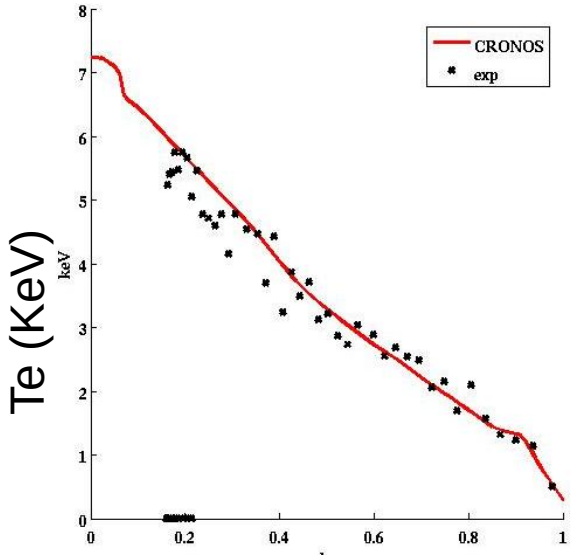
many **other factors** play an important role in **hybrid** plasmas:

- magnetic shear
- fast ions



t = 5.8 s

TGLF



Fast ions as impurities (dilution)

Big effect in the inner part of the plasma

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