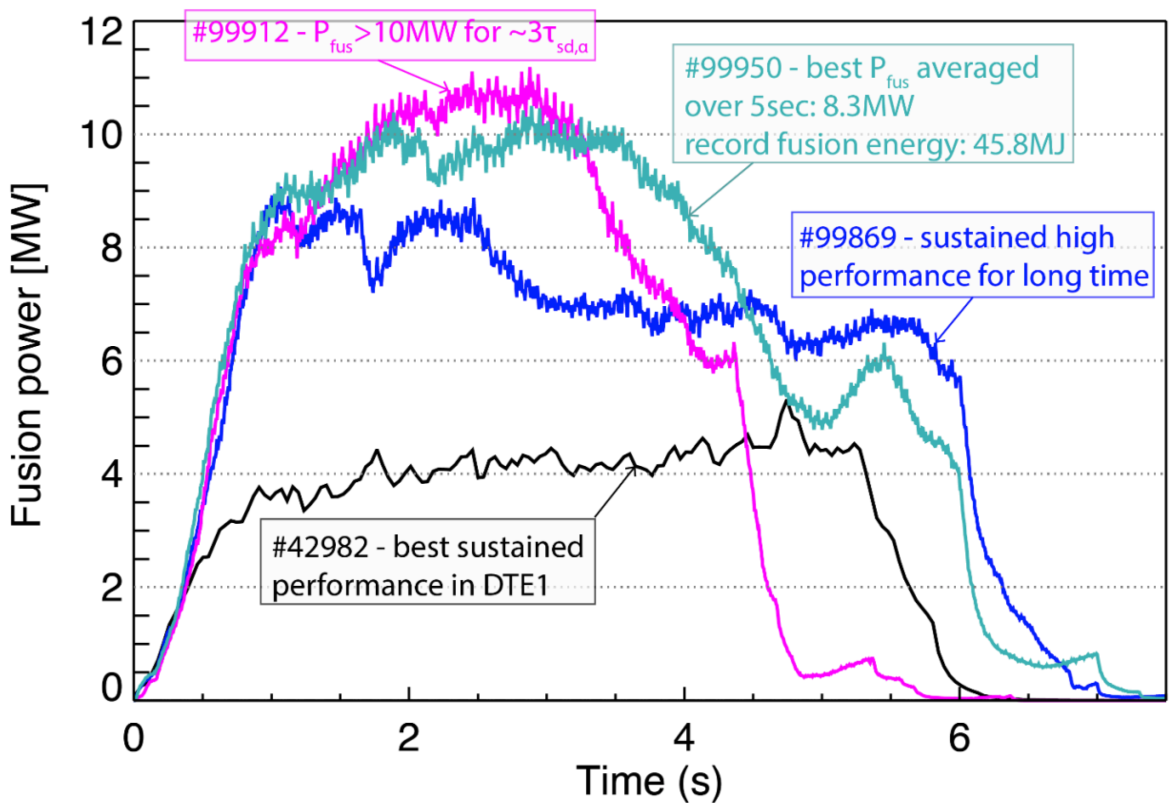
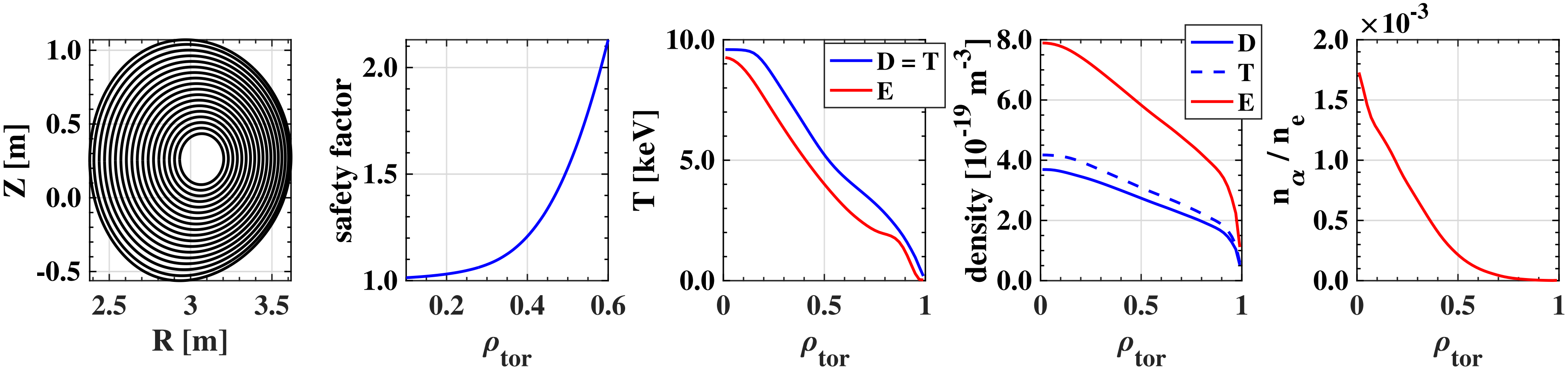
Alpha particle studies at JET with GENE-Tango

- JET 50-50 D-T hybrid scenario #99912 achieved record sustained $P_{fus} > 10MW$ for ~ 3 α-particle slowing down time.
- $I_p = 2.3$MA, $B_0 = 3.45$T, $q_{95} \sim 4.8$, $\beta_{pol} = 1.4$, gas injection only, lower density, $T_i > T_e$.



Experimantal scenario

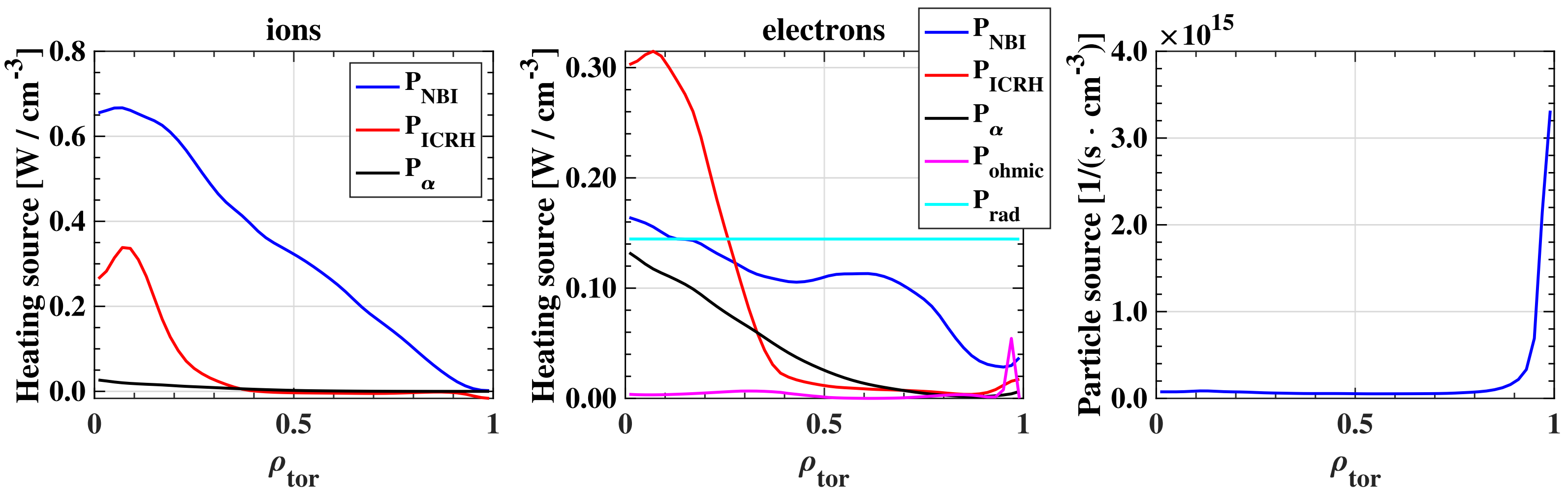
- GENE (global)-Tango simulations are performed with realistic electron-ion mass ratio, collisions and finite β.
- Magnetic equilibrium reconstructed via pressure contrained EFIT.
- Equivalent Maxwellian used for each plasma species.
- Fishbones present in this discharge.



- Negligible alpha particle density for the nominal profiles.

Experimantal scenario

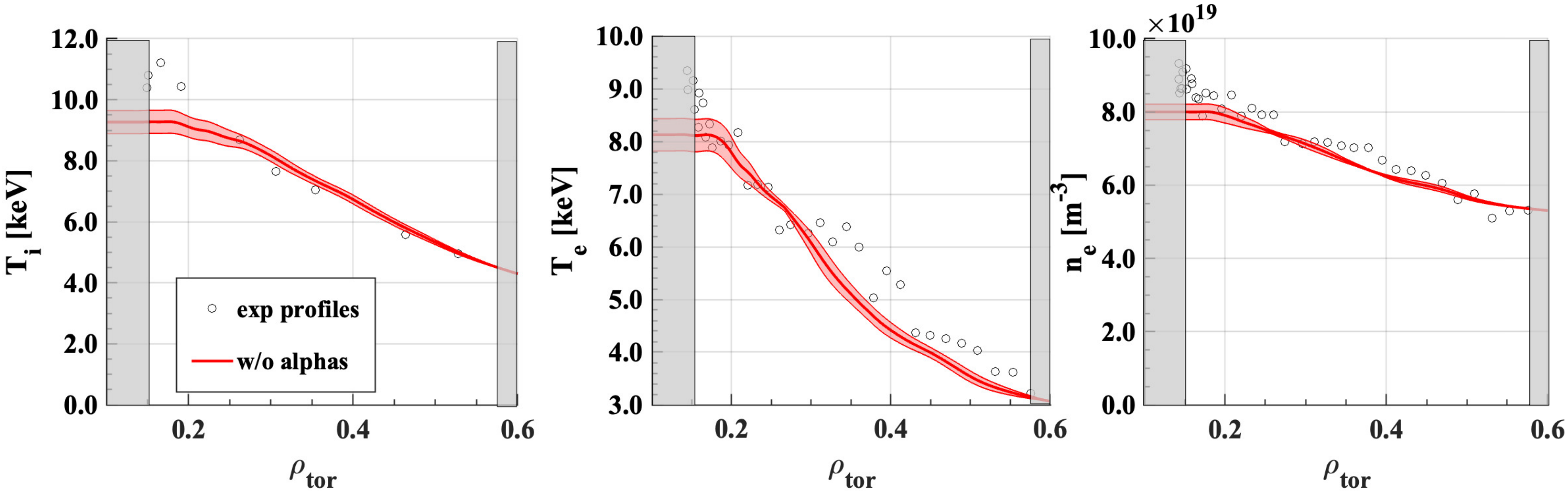
- Heat, particle sources and initial guess for plasma profiles computed by TRANSP interpretative runs.



- Negligible alpha particle heating on thermal ions; considerable contribution to electrons.
- Cases analyzed: (i) without alpha particles in GENE, (ii) with alpha particles in GENE, (iii) without alpha particles in GENE and alpha heating in Tango.

GENE-Tango simulations: w/o alpha particles in GENE

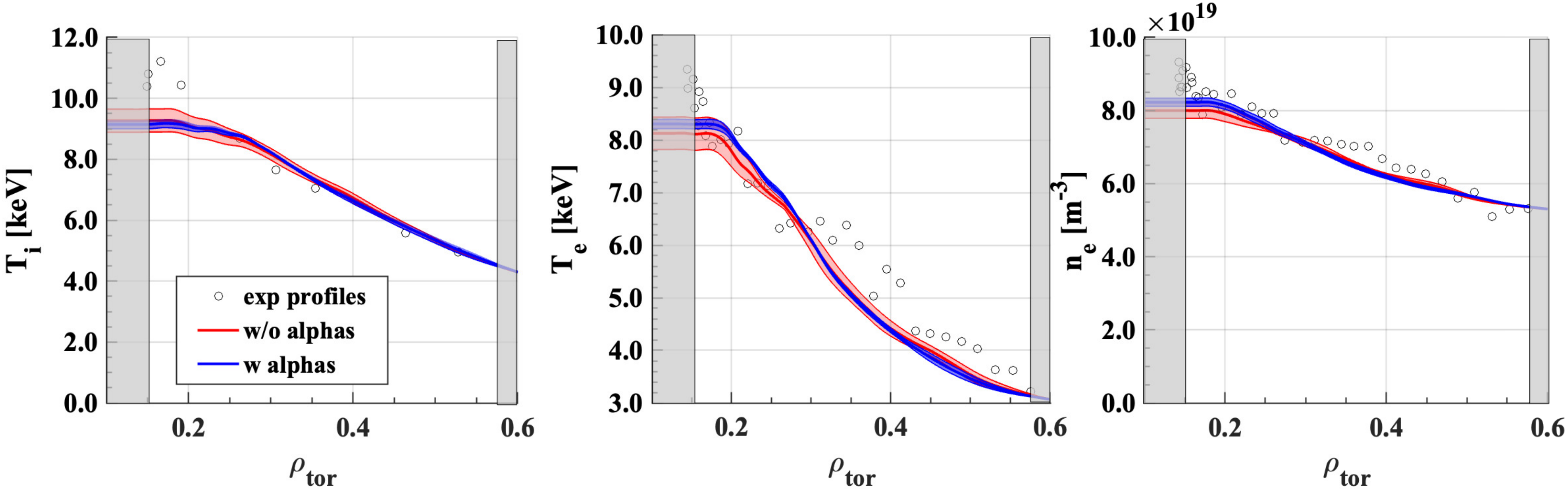
- GENE-Tango simulations performed until reaching steady-state → turbulent fluxes match volume integral of injected sources at each location.
- Alpha particles are neglected from GENE, but alpha heating contribution is retained in Tango.



- Excellent agreement between GENE-Tango and experimental measurements!

GENE-Tango simulations: w alpha particles in GENE

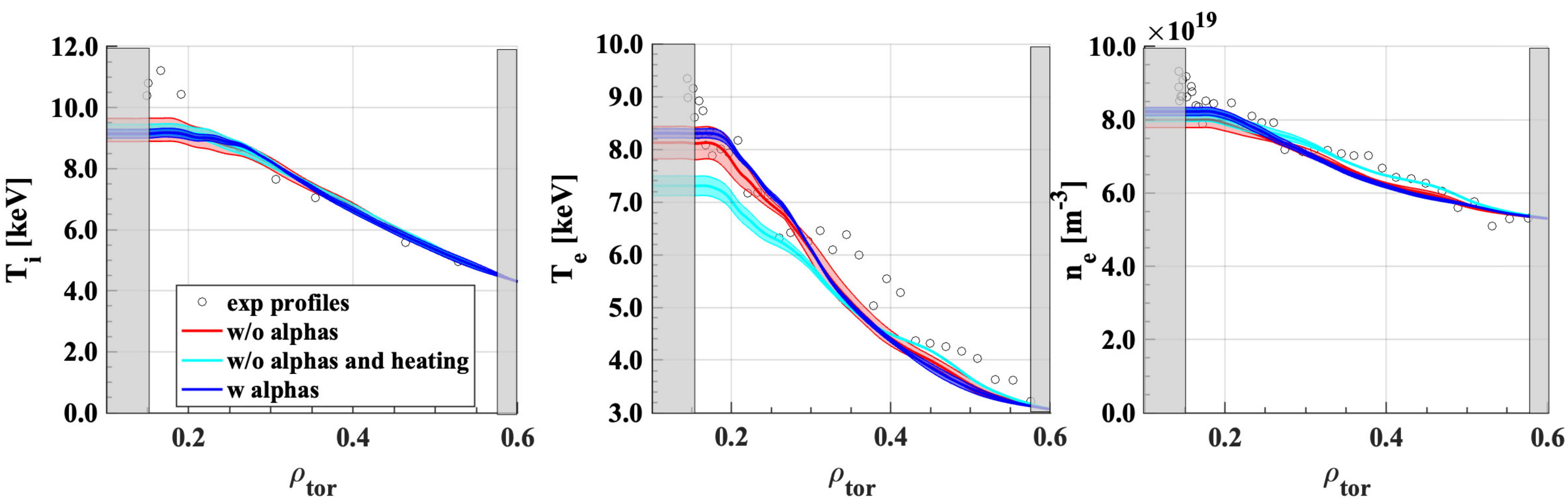
- GENE-Tango simulations performed until reaching steady-state → turbulent fluxes match volume integral of injected sources at each location.
- Alpha particles are included in GENE and alpha heating is retained in Tango.



- GENE-Tango recovers the same plasma profiles obtained without alpha particles → alpha particle density is too low to make a significant contribution.

GENE-Tango simulations: w/o alpha particles and alpha heating

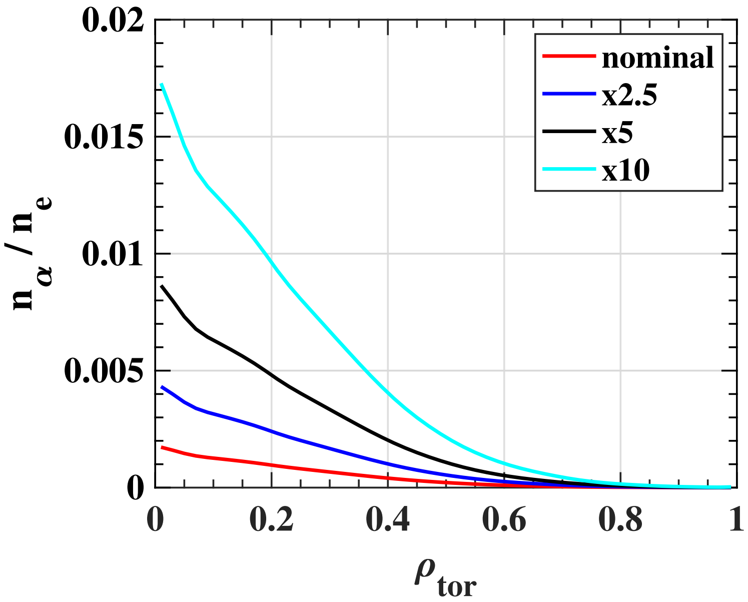
- GENE-Tango simulations performed until reaching steady-state → turbulent fluxes match volume integral of injected sources at each location.
- Both alpha particles and alpha heating neglected in the modelling.



- Alpha heating has a negligible effect on ion temperature and plasma density, but a visible effect on electron temperature → T_e relaxes on axis by ~ 1keV.

Scans over alpha particle density with GENE - preliminary

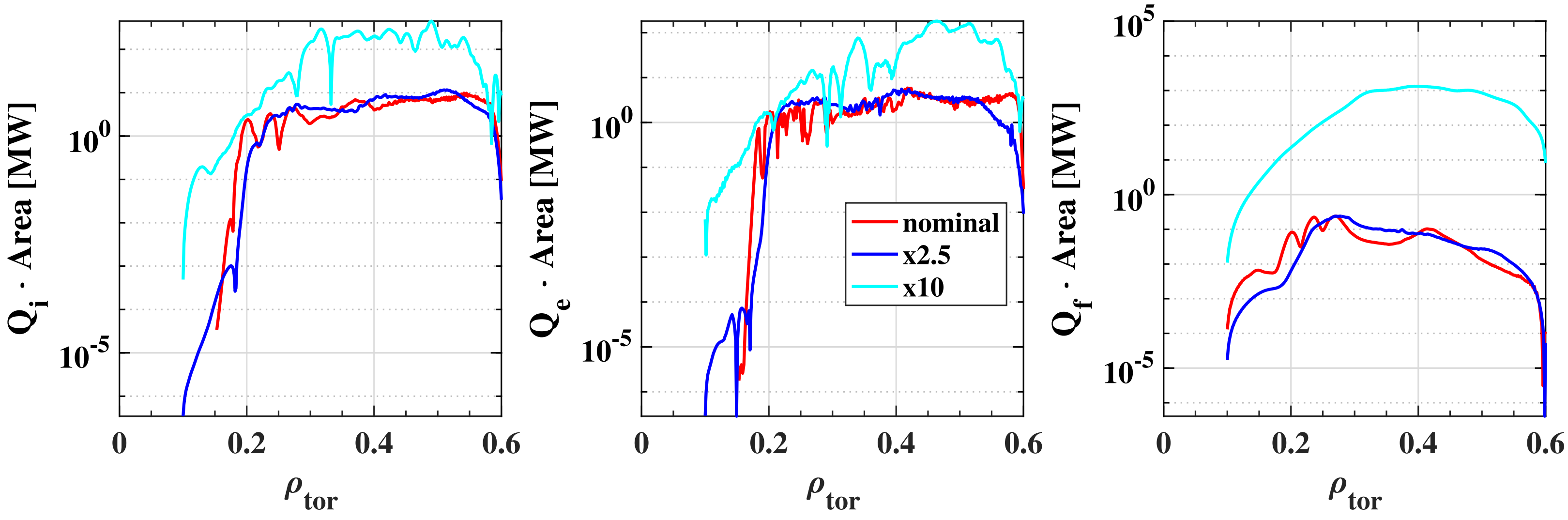
- Alpha particle density is artificially increased respect to the nominal density to increase alpha particle effects on core turbulence.
- We consider four cases spanning from $n_\alpha/n_e \sim 0.15\ \%$ to $n_\alpha/n_e \sim 1.5\ \%$ (ITER like density).



- Thermal profiles are not self-consistent and cannot sustain $n_\alpha/n_e > 0.15\ \%$.

Scans over alpha particle density with GENE - preliminary

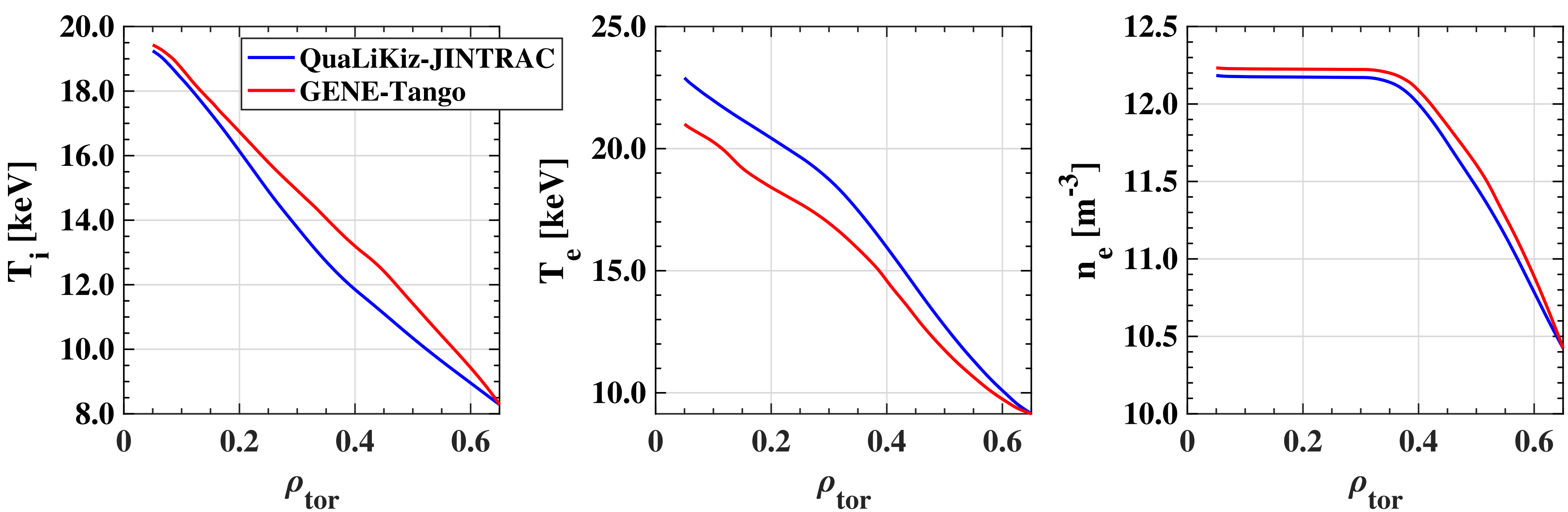
- No visible alpha particle effect on turbulece for $n_\alpha/n_e < 0.5\ \%$.
- Alpha particles lead to strong heat losses when their density is increased above $n_\alpha/n_e > 0.5\ \%$.



- Convergence studies are on-going!
- Analyses on linear stability for alpha-driven AE modes is on-going.

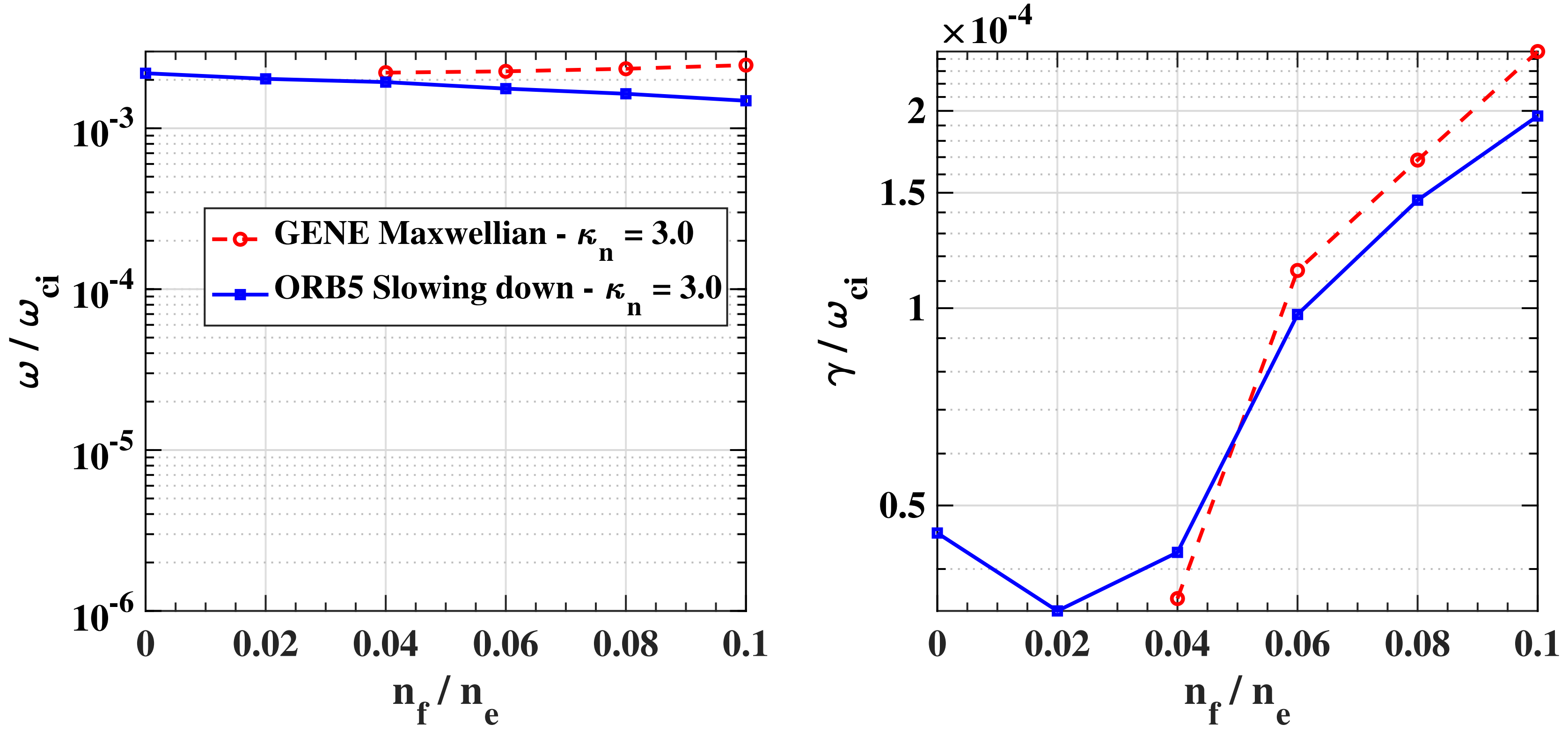
ITER: profiles - on-going

- GENE-Tango simulations at ITER for baseline $Q = 10$, $I_p = 15MA$ are currently on-going.
- Plasma profiles initialized to the ones computed by QualiKiz-JETTO.
- Simulated cases: (i) without alpha particles in GENE, (ii) with alpha particles in GENE.

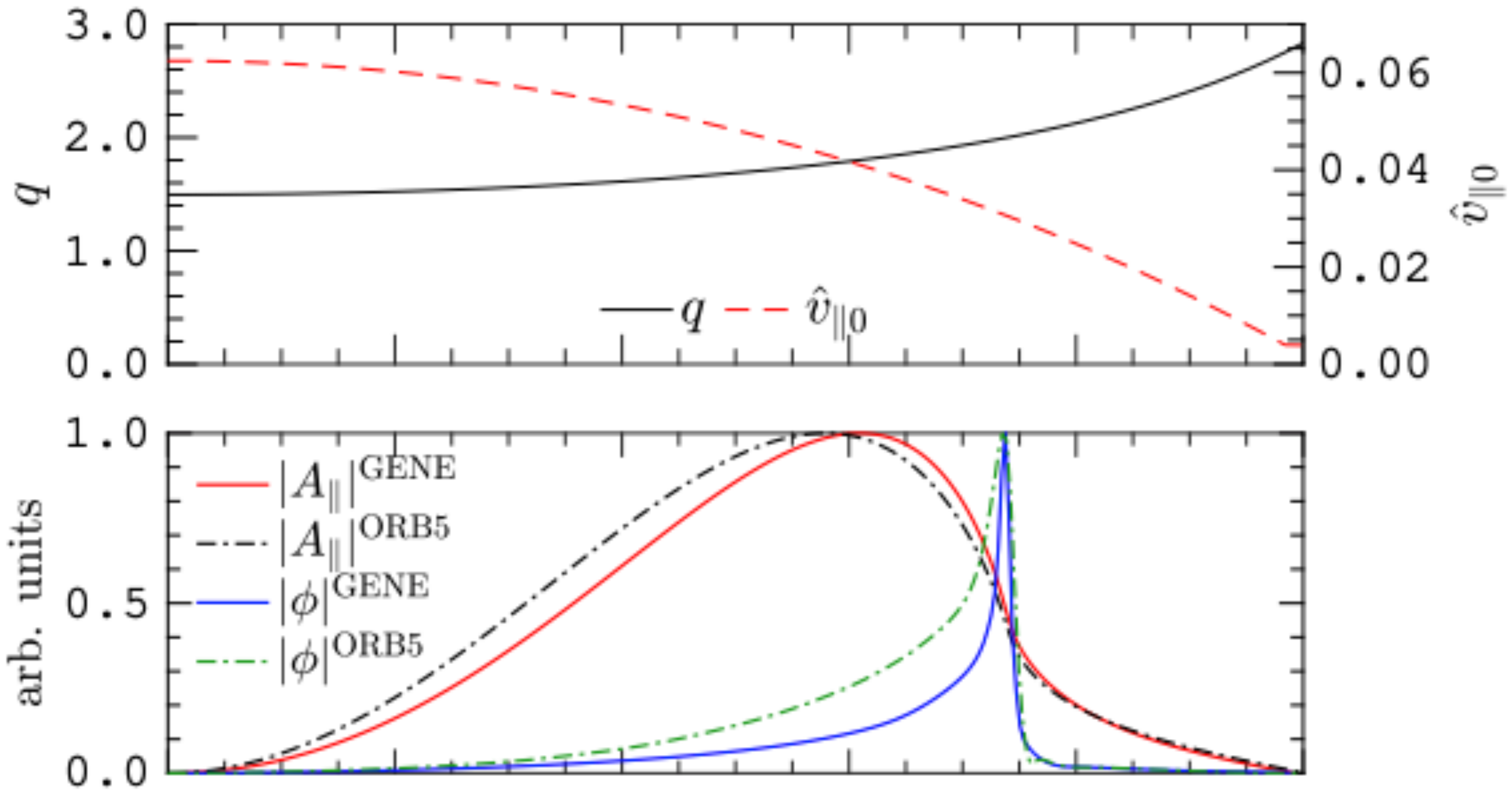


- Turbulent fluxes are still far from the steady-state solution → more iterations required.

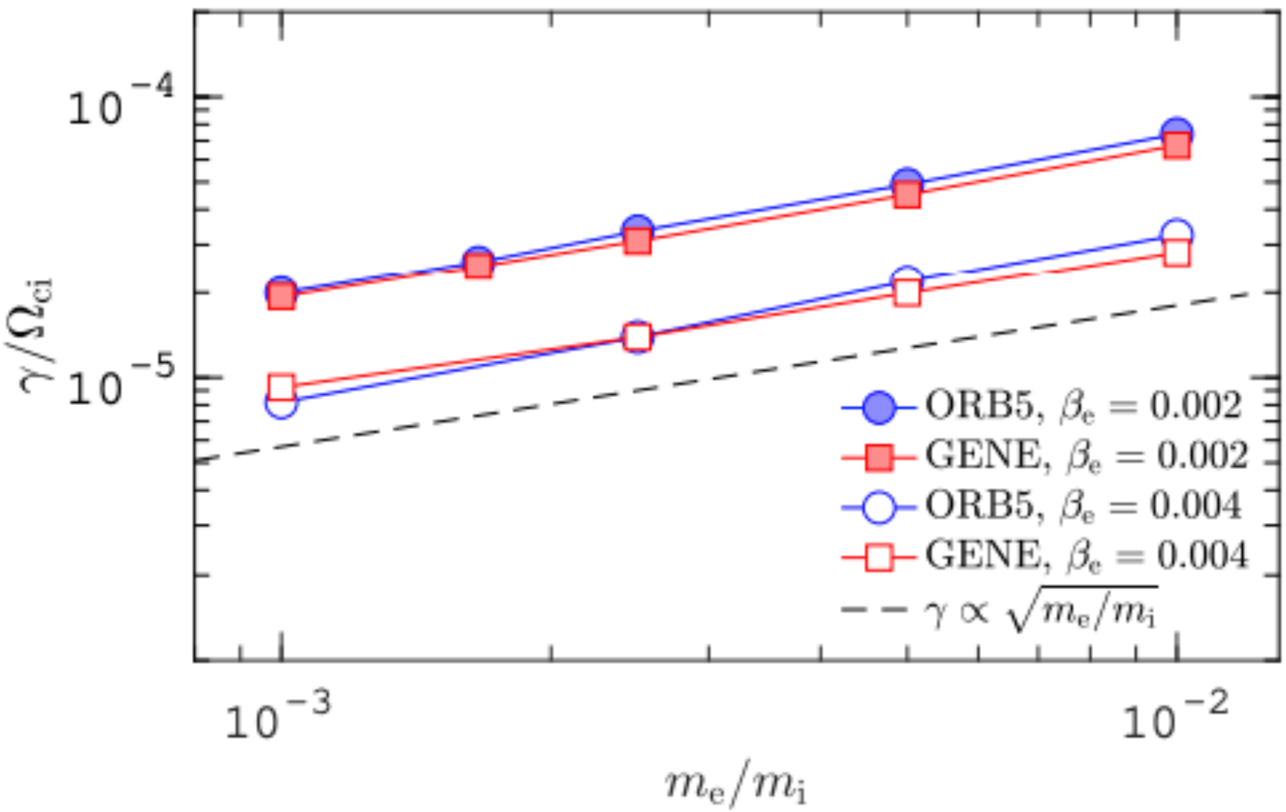
Fishbones


GENE Maxwellian - κn = 3.0
ORB5 Slowing down - κn = 3.0
ω / ωci
10-3
10-4
10-5
10-6
0
0.02
0.04
0.06
0.08
0.1
nf / ne
×10-4
2
1.5
1
0.5
γ / ωci
0
0.02
0.04
0.06
0.08
0.1
nf / ne

Global tearing modes



Global tearing modes



Global tearing modes