Towards fully-predictive transport modelling in ASDEX-Upgrade H-modes

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Limitations of scaling laws

- Large scatter
- Regressions miss important physics (e.g. ITG->TEM)
- Some dependences do not hold in all scenarios, e.g. IPB98 ne at high ne, P in improved H-modes
- Not fully engineering (e.g. ne input)
-

Yet: **robust** and **easy** to apply, base on large multi-device database

Can we do better, while not using exp input?
- References: IPB [1], ITPA20 [2]
- Figure of merit: **Wth** (core / ped)

Validating quasi-linear models

- Using **TGLF [3]**, **QuaLiKiZ [4]**
- Extending modelling region **out to pedestal top**
- **ITG vs TEM** dominated plasmas
- **Stiffness** validation with ion heat flux scan

The IMEP workflow: assumptions

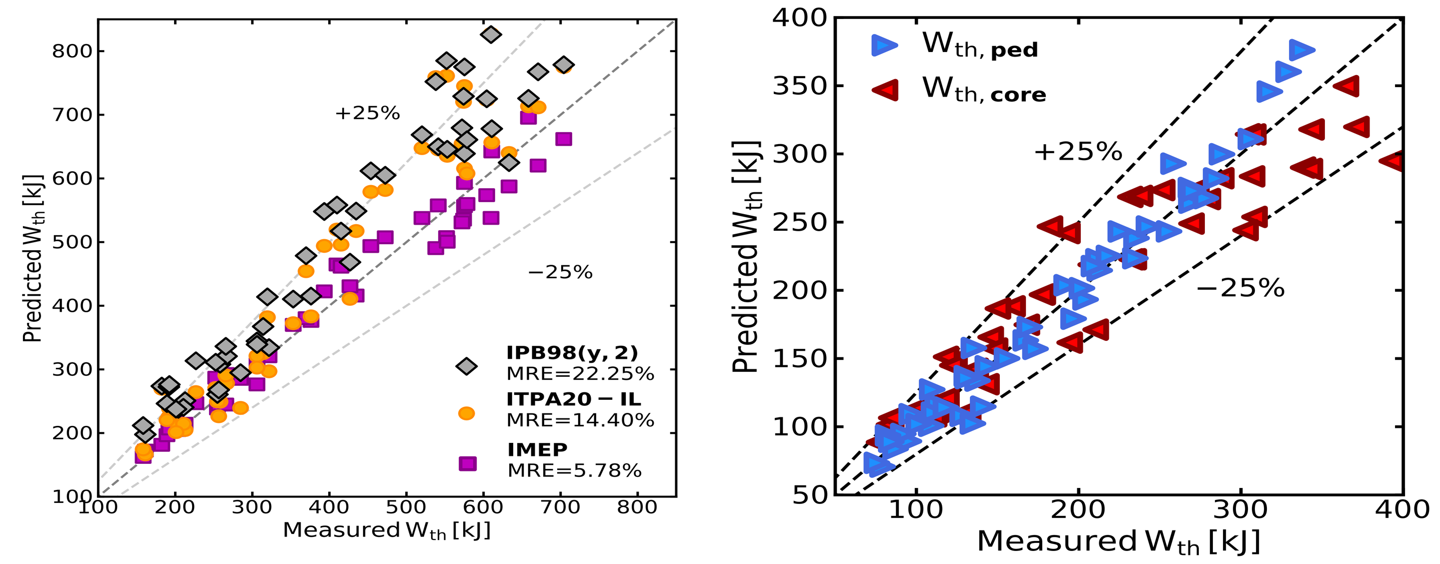
ASTRA [5]: frame for Integrated Modelling with Engineering Parameters (IMEP) [6][7]
Separatrix Te and ne: from formula (tuned for AUG but exportable)
From pedestal to the center: TGLF
Vtor: pedestal top:formula. Core: PR=1
Zeff=1.3, Boron impurity
For a given Δped, constant χe to fulfill <gradTe>/Te,top = -0.5/cm

Several ASTRA-TGLF full simulations, each with a **different Δped** , including TGLF core modelling (need fluxes, Shafranov shift),

MISHKA [8]: **peeling-ballooning** stability **selects** the simulation with the **highest stable pedestal p**

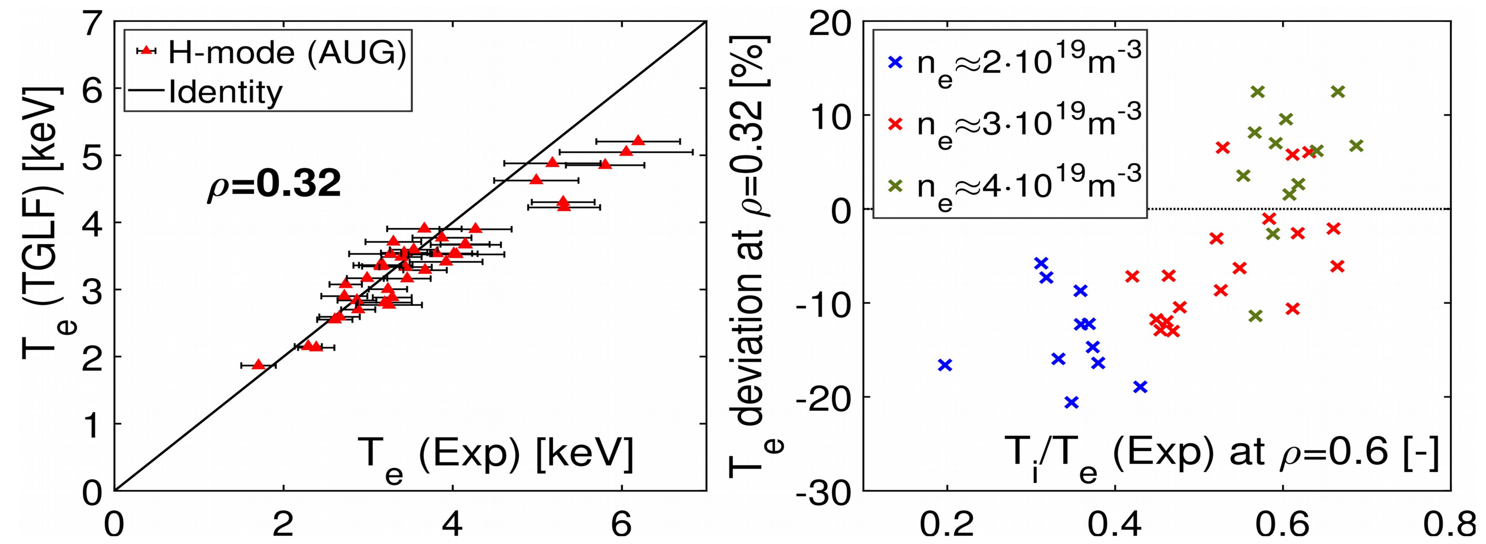
No direct exp input, not even ne,top

Performance of the IMEP workfllow



Significantly **more accurate than IPB98 or ITPA20-IL**
More uncertainty from core than from separatrix+pedestal

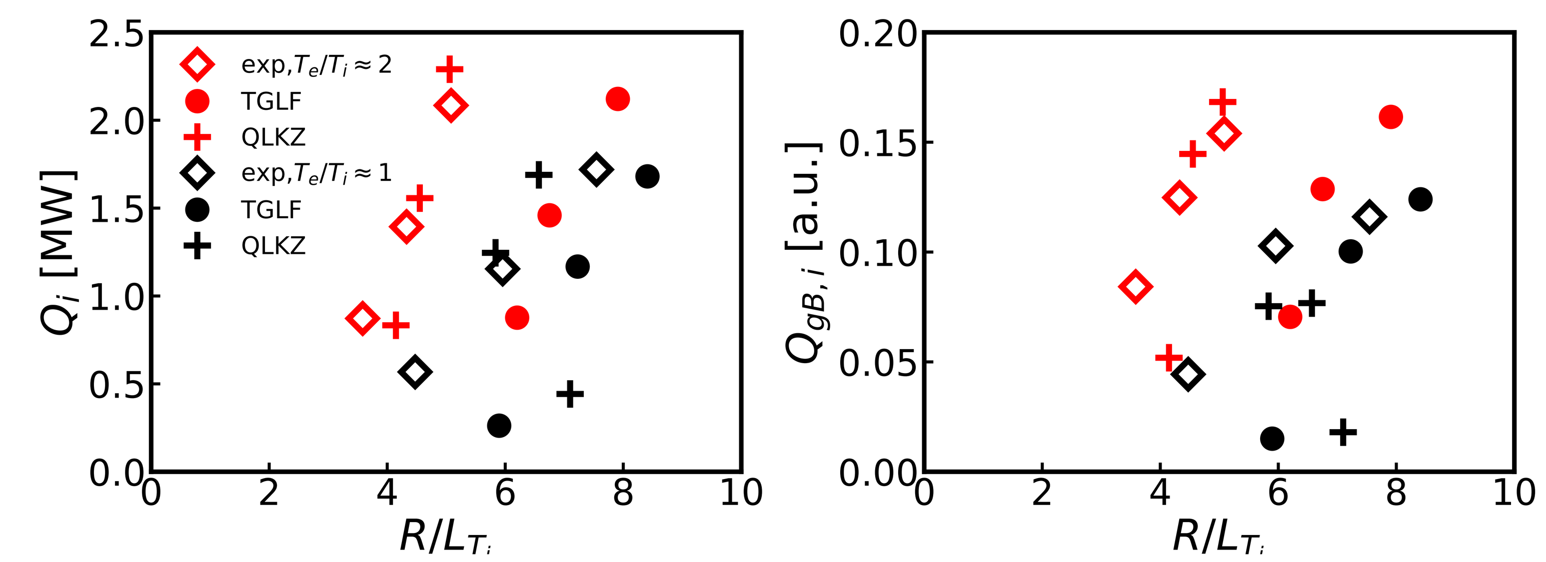
Te prediction with TGLF of AUG H-modes [9]



TGLF sat1-geo accurate near pedestal top,→ BC outside
Good core predictions
Te well matched, trend to underestimate for high Te/Ti

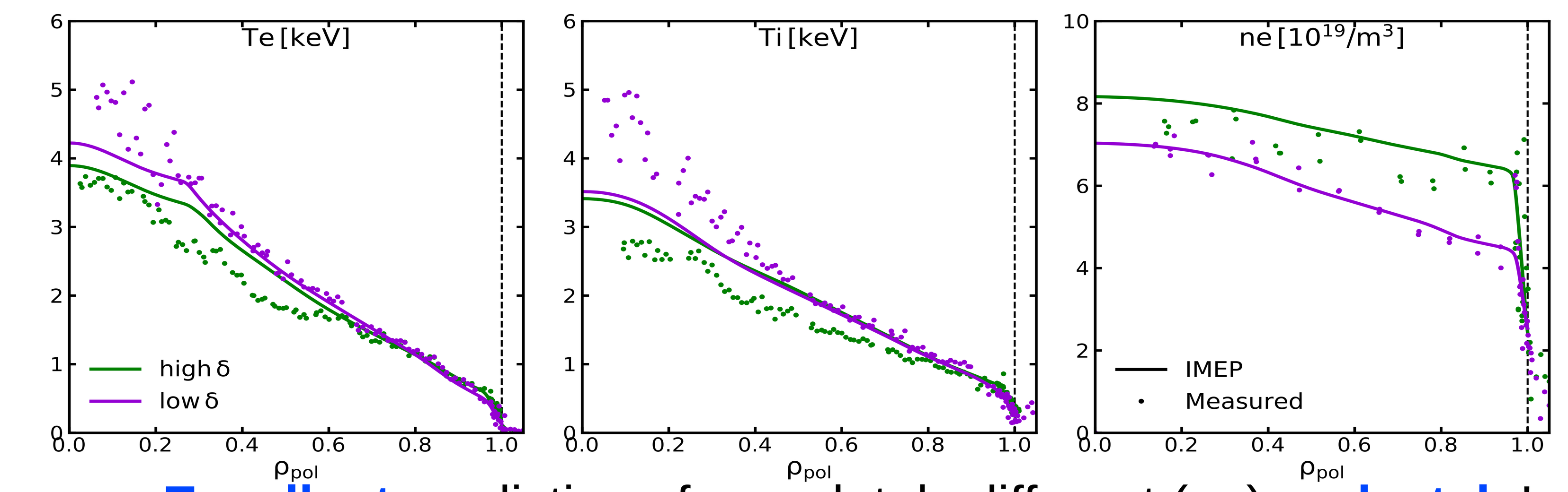
Ti stiffness for dedicated ion heat flux scan [10]

NBI: 2on, 1on+1off, 2off (within same discharge)
PECRH **0.65 MW / 2.7 MW,** **Te/Ti=1.3** / **Te/Ti=1.9**



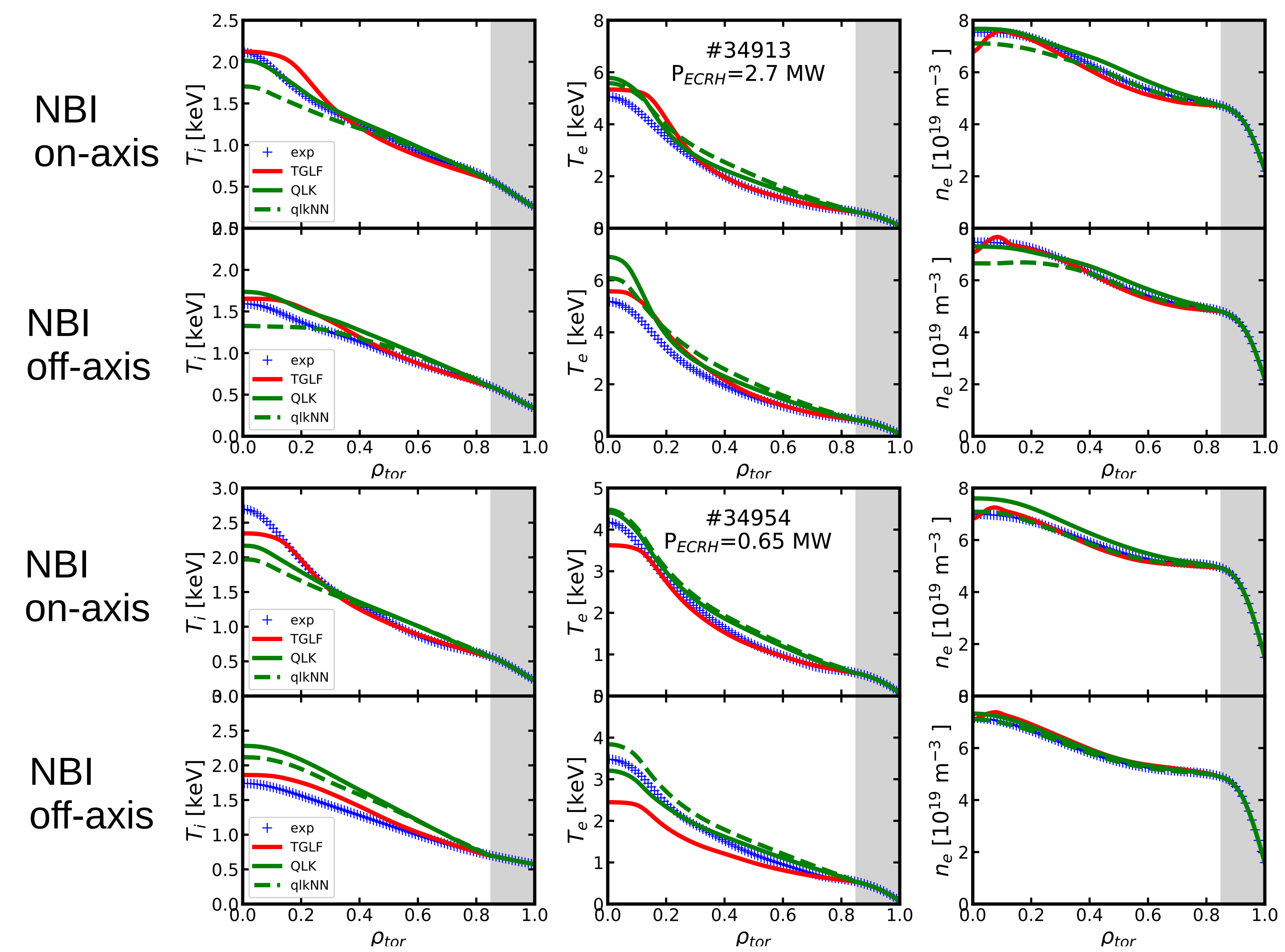
TGLF sat2 (unit=CGYRO) **excellent for Te/TI~1**, too low stiffness for Te/Ti~2
QLKZ: similar to TGLF, good except low ECRH, off-axis NBI

Triangularity scan



Excellent prediction of completely different (ne) **pedestals**!
Good core confinement, especially **density peaking**

Ion heat flux scan



TGLF: perfect ne peaking, excellent Te Ti at Te/Ti~1, overpredicted for large Te/Ti
QLKZ: excellent with new collision model; NN similar to full QLKZ!

Conclusions

Successful center-to-separatrix with IMEP!
TGLF, QLKZ (official repos): good up to pedestal top (BC)
TGLF better for Te/Ti~1, lower stiffness otherwise, tested SAT2
QLKZ ok with new collisionality model, also NN

Outlook

Apply IMEP to other tokamaks
SAT rules in TGLF, Prad

References

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EUROfusion

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