Validation of the Stability, Transport, Equilibrium, & Transport module (STEP) using extensive experimental data

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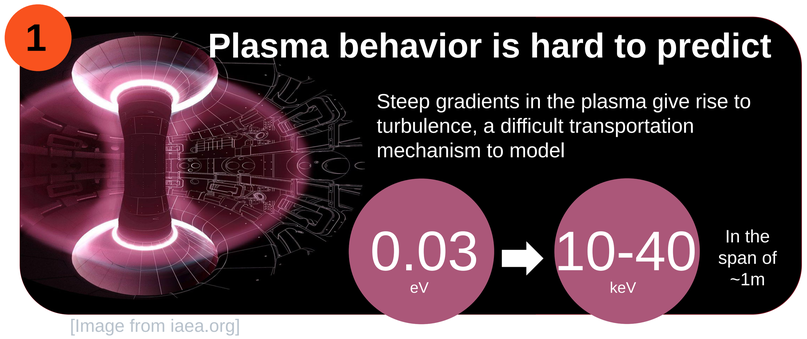
1 Plasma behavior is hard to predict



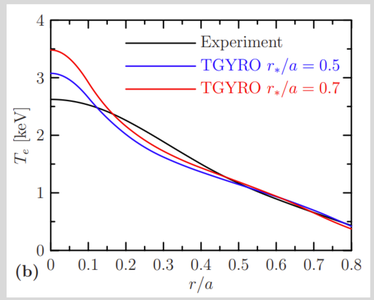
Steep gradients in the plasma give rise to turbulence, a difficult transportation mechanism to model

0.03 eV → 10-40 keV

In the span of ~1m

[Image from iaea.org]

2 STEP workflow (Meneghini 2020) predicts stationary tokamak plasma states

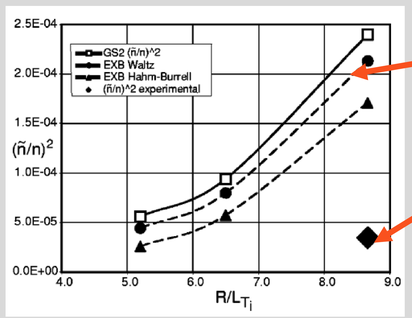


STEP predicts equilibrium, transport, & energy profiles using theory-based codes (ex. TGRO, TGLF, CHEF)

Historically, STEP has predicted future tokamaks, but has **never been** verified against a diverse range of past tokamaks

(Candy PoP 2009)

3 How accurate are the theory-based models to experimental data?



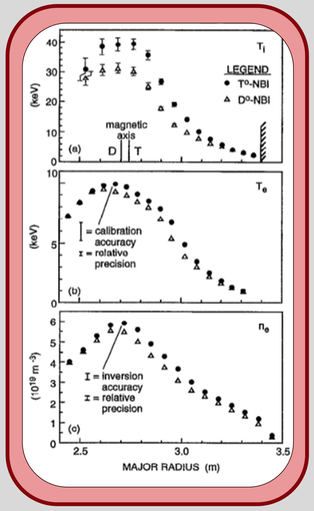
Simulation results for density fluctuation level

Experimental density fluctuation level

[Image from Ross PoP, 2002]

3 simulation results ≠ 1 experimental result

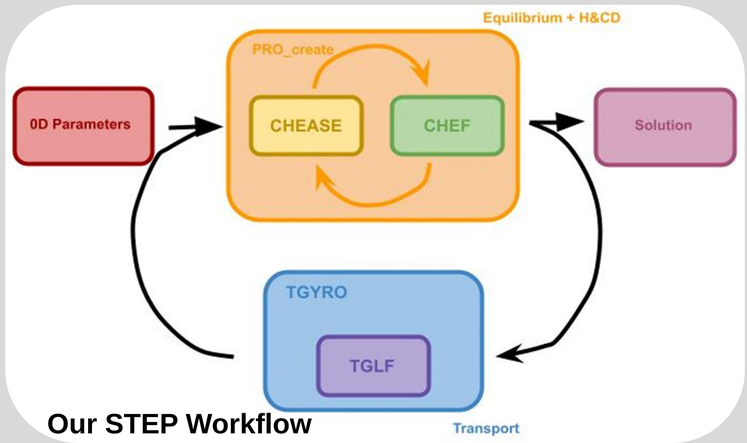
4 Our simulations use 0D parameters to predict experimental findings



(Scott AIP 1995)

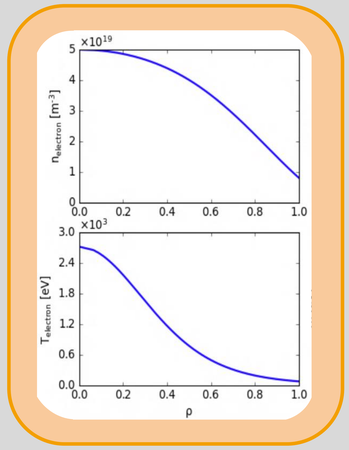
We considered a wide variety of experimental plasmas

Radii ranging from 0.8 m – 3.0 m



Our STEP Workflow

1. Conduct **literature search** of various published papers concerning tokamaks
2. **Run OMFIT** workflow manager with 0D params from papers
3. **Adjust relaxation parameter** so that flux converges in TYGRO
4. **Comparison** of simulation to experimental profile

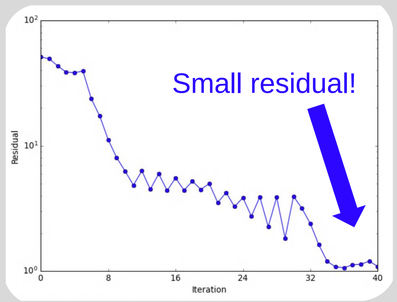


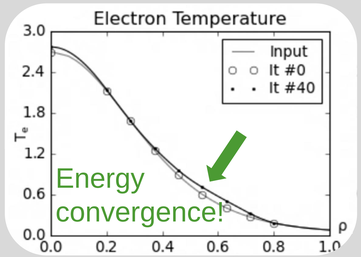
PRO_create generated profiles

Solves the modified Fokker-Plank equation (Hinton PoP 2008) for transport using Newton's Method (Candy 2009)

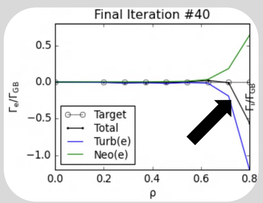
TGYRO: Local residual method

5 There is reasonable convergence!!

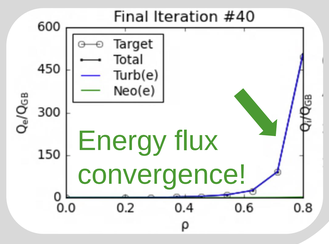




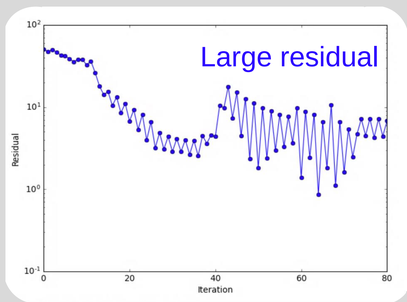
Reasonable particle flux convergence

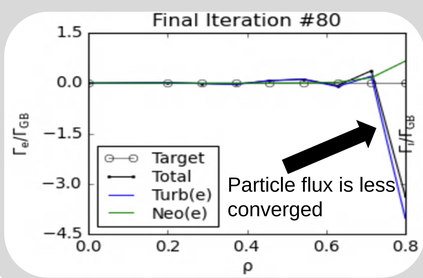


1.1 Smallest residual



6 Coming soon: How and when do modern models agree with historical plasmas?





Electromagnetic flux matching with high convergence for various plasmas

- **Reduce residual**
- Achieve steady state: **match fluxes** (ion, electron energy; electron particle)
- **Repeat for all datasets**
- Overplot simulations with experimental profile plots
- **Analyze trends**

70+ Datasets to analyze

Nuclear Science and Engineering

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2) UC San Diego