EFDA

EUROPEAN FUSION DEVELOPMENT AGREEMENT

Task Force
INTEGRATED TOKAMAK MODELLING

Progress in the simulation of JET hybrid pulse #77922 with the European Transport Solver

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Introduction

What we want to do...

To simulate JET pulse #77922 with the ETS and compare with experiment

...And how we want to do it

- ★ ETS_A workflow using UAL 4.09a*
- ★ Experimental profiles in an ITM database (from TRANSP)
- ★ NBI power deposition (from TRANSP)
- ★ Bohm/gyro-Bohm for core transport (available in ETS_A)
- ★ NCLASS actor for current diffusion (resistivity and bootstrap current)
- ★ Pedestal model (available in ETS_A)

**Since the official NCLASS actor will first be released for UAL 4.09a it's important for the continuation of this work to keep supporting the 4.09a ETS_A workflow in parallel with the upcoming 4.10a ETS_A*

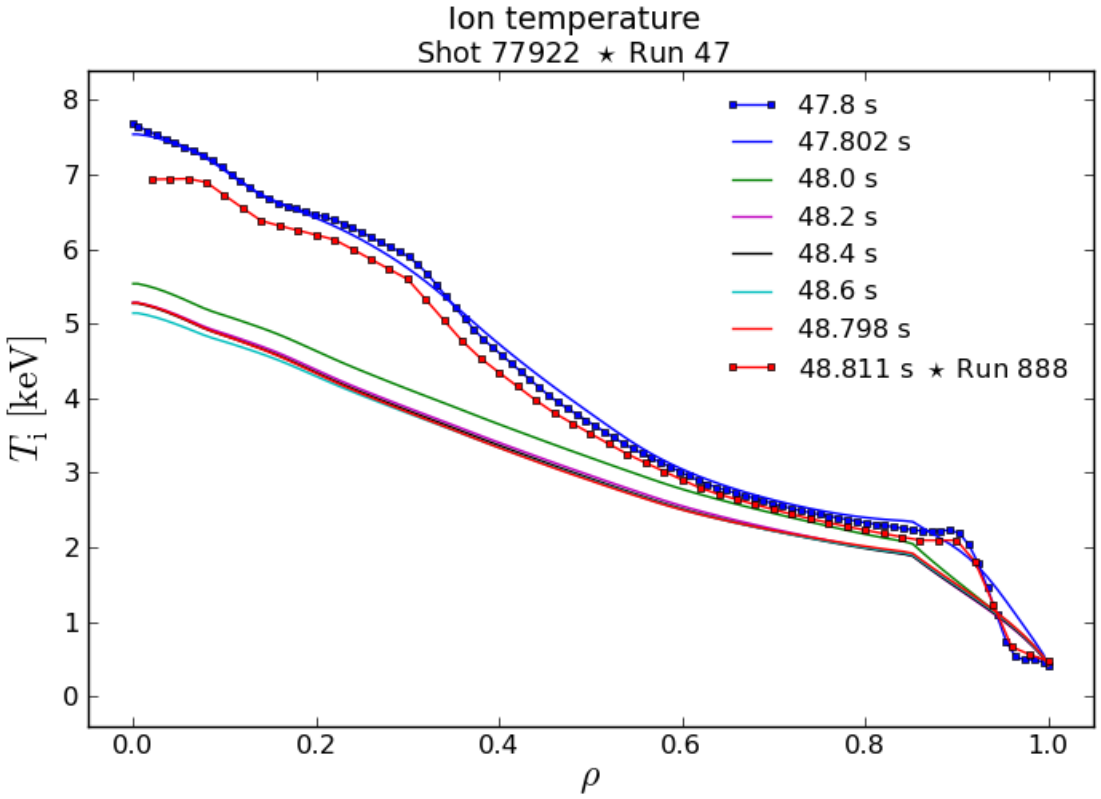
Results...

In all shown ETS runs ⇨

- ★ T_e and T_i evolve from 47.8 s to 48.8 s with a 2 ms timestep
- ★ 100 points in transport grid & 102 in equilibrium grid
- ★ Spider equilibrium updated once per timestep

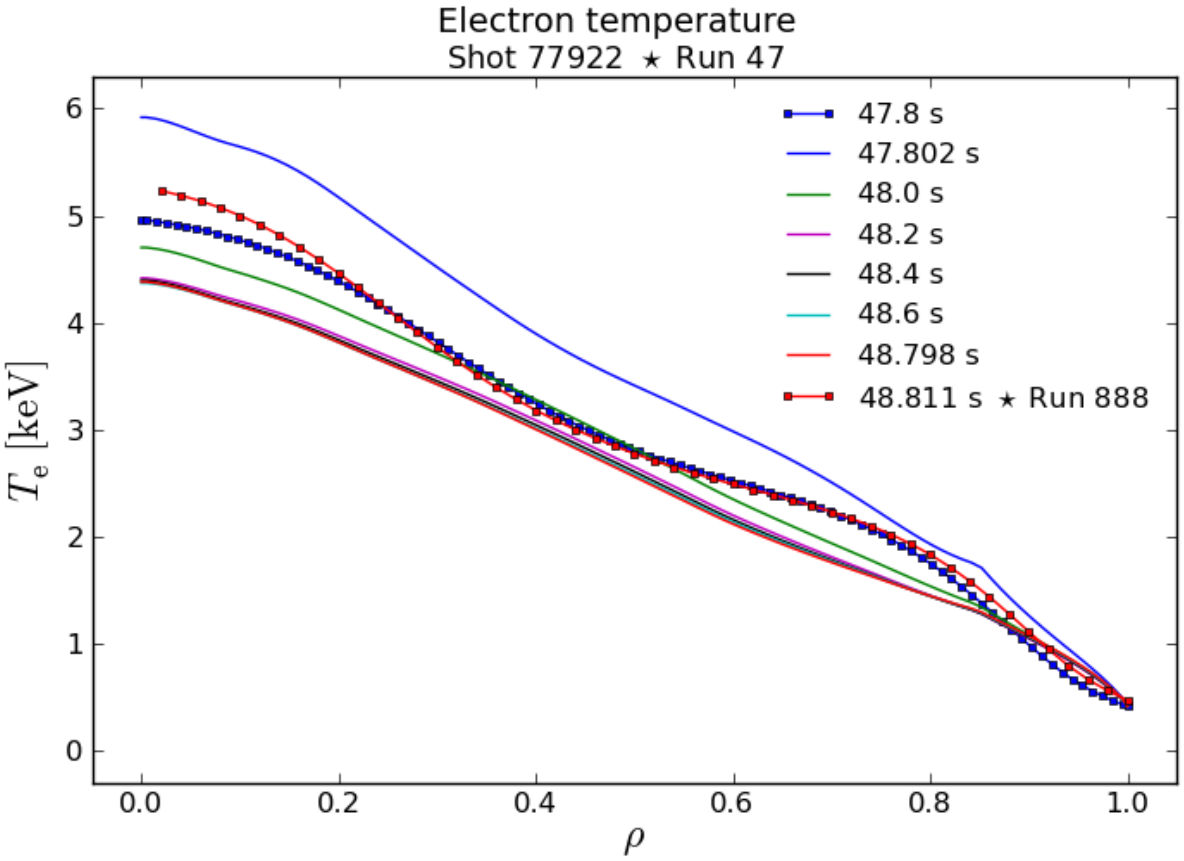
- ★ *All output runs available at the ITM Gateway: user 'figueire', database 'test', data structure 4.09a*
- ★ *The input run is number 888 (from Jorge Ferreira)*

ETB model as in ASTRA: pedestal top at 0.85 with χ_e = 1.8 m²/s & χ_i = 1.0 m²/s inside ETB



- ★ Is the difference in core temperatures due to the L-mode BgB in ETS_A?
- ★ Different definition of normalized ρ in ASTRA & ETS? Or simply a different grid outer limit?
- ★ ETS_A needs an ELM model to have smaller ETB diffusivities

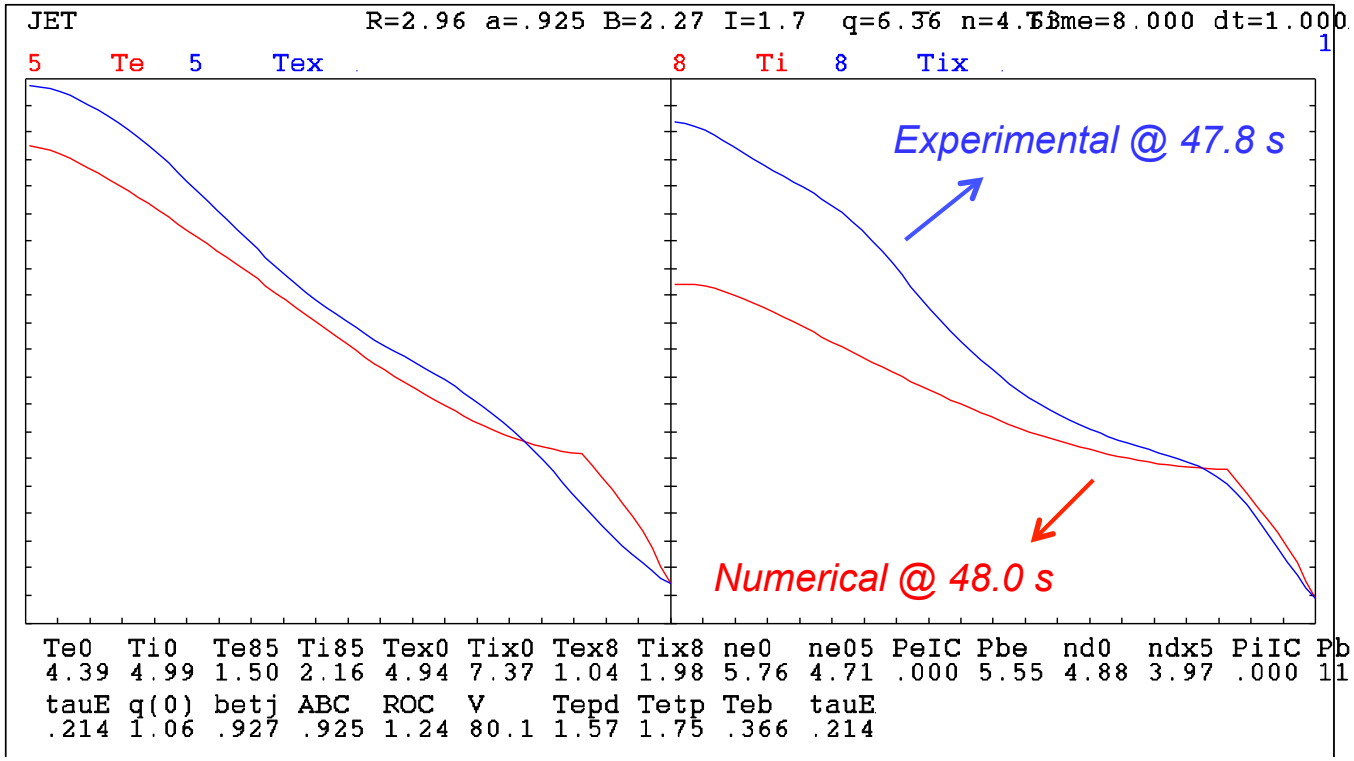
...Results...



★ Electron temperatures (no problem with ions) undergo an abrupt increase of about 1 keV from the initial experimental profile during the first timestep, which suggests a possible problem with the initialization of the profiles in ETS_A

...Results...

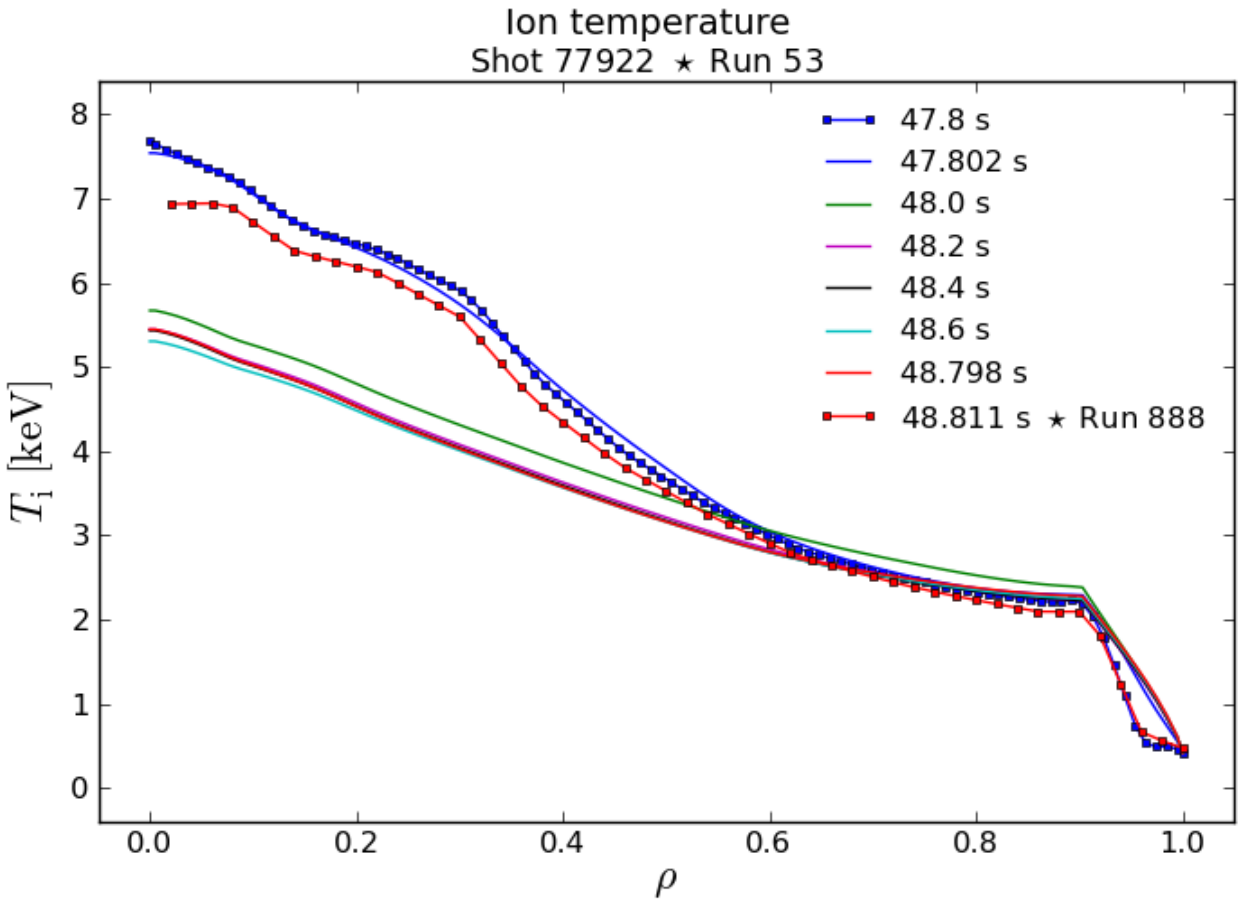
ASTRA *(1 ms timestep)*: pedestal top at 0.85 with χ_e = 1.8 m^2/s & χ_i = 1.0 m^2/s inside ETB



- ★ This run uses L-mode BgB but there is still a significant difference in core temperatures with H-mode BgB
  - ➢ Is the BgB model not suitable for this plasma?
  - ➢ Nevertheless, L-mode BgB works better for this pulse than H-mode BgB
- ★ The edge boundary (last radial grid point) is different from ETS runs, e.g., in the experimental profiles of T_i, which might explain the difference in the normalized ρ coordinate

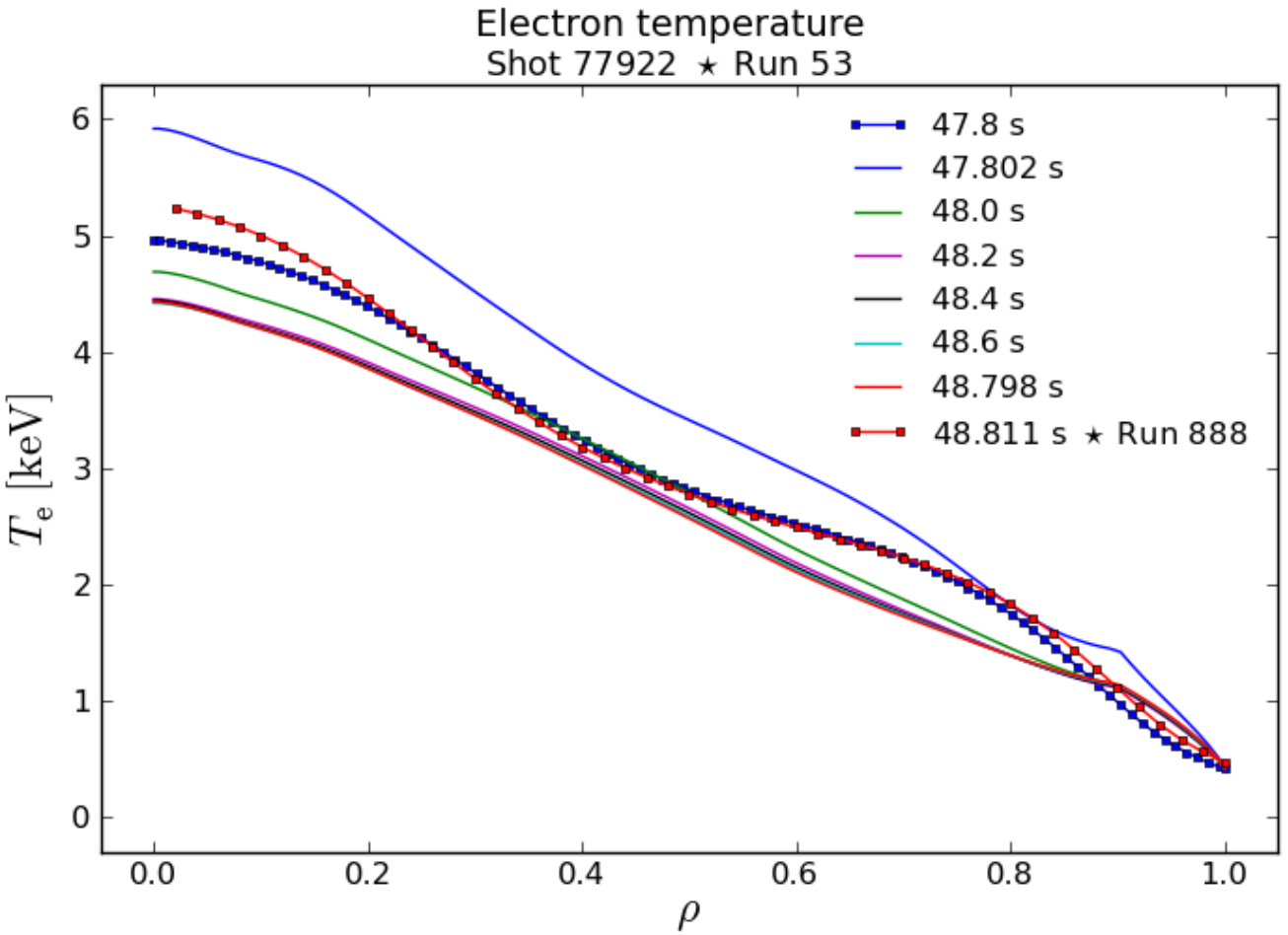
...Results...

Tweaked ETB: pedestal top at 0.90 with χ_e = 2.0 m^2/s & χ_i = 0.4 m^2/s inside ETB



- ★ Improved agreement with experiment from 0.6 to pedestal top
- ★ The shape of the pedestal could be improved in ETS_A, perhaps defining two regions? Or simply crop the experimental profiles?

...Results

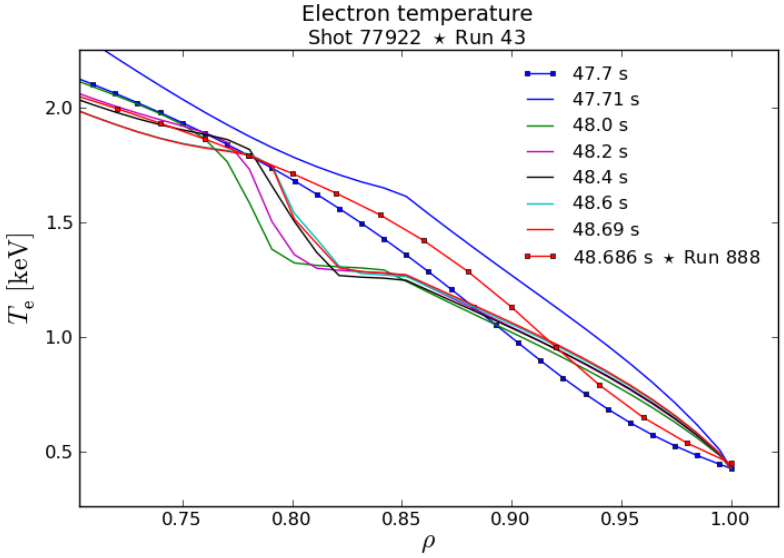


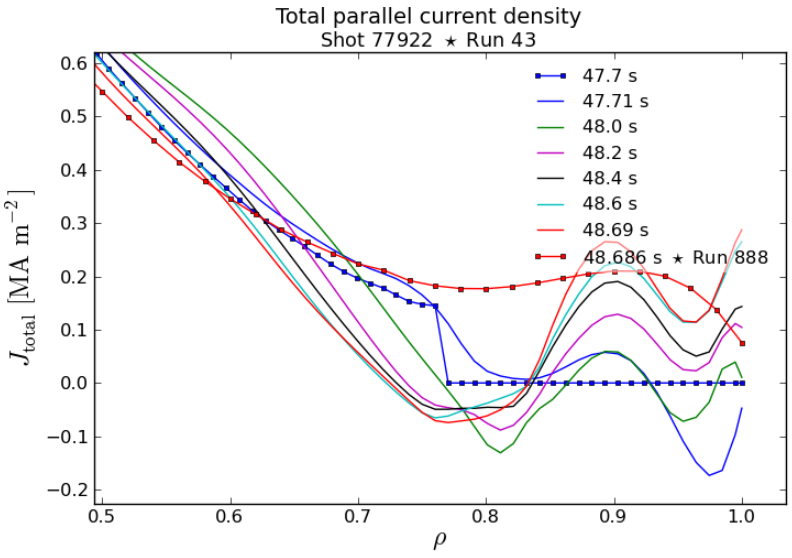
★ Pedestal position in ETS_A cannot be chosen differently for ions & electrons

Other issues...

- ★ Changes done to the ETS_A workflow (thanks to Denis):
  - ➢ Bootstrap current from neoclassical actor is now used as source in current diffusion equation (new 'neoclassic2coresource' actor)
  - ➢ 'neoclassic' CPO output by neoclassical actor is now written to database

- ★ Oscillations appeared in temperatures and thermal diffusivities, which by coincidence or not are located at the position where current is cutoff in the initial equilibrium-transport coupling





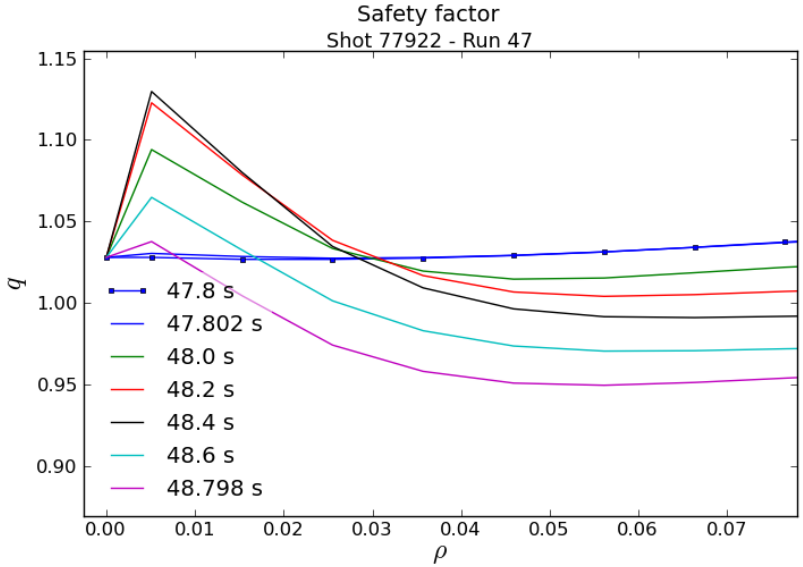
  - ➢ These oscillations have been effectively removed by using a smaller timestep of 2 ms

- ★ Without an ELM model the ETB thermal diffusivities must be increased to include average heat losses due to ELMs
  - ➢ Lower values χ_e = 0.3 m^2/s & χ_i = 0.15 m^2/s have been used by Paula Belo in EDGE2D

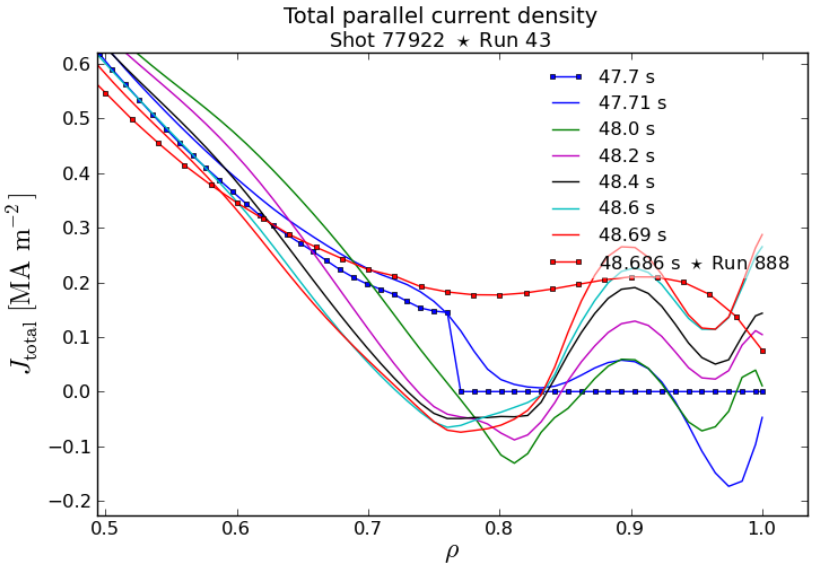
...Other issues

- ★ NaN values in the initial profiles of the ohmic heating power density (connected with initial abrupt change in T_e?)
- ★ The official ITM Kepler actor for NCLASS is not available and the one currently integrated in ETS_A produces incorrect and incomplete output that does not evolve in time
- ★ An H-mode Bohm/gyro-Bohm model is needed in ETS_A
  - ➢ It's possible to process the current BgB actor output (source unavailable) to implement the JETTO model, or
  - ➢ Edit the BgB Fortran code available in the ETS trunk and create a new actor

- ★ ETS_A produces artifacts in q, Ψ and current profiles near the axis
  - ➢ Very easy to fix as recently done in the ETS trunk by D. Coster



- ★ The total parallel current density is incorrect at the few last radial points, most likely due to large errors in the derivatives of Ψ
  - ➢ Need to write derivatives to database, which is done in the 'figueiredo' branch and could be transposed to the trunk



- ★ Relatively large timesteps around 1 ms crashed the ETS whereas ASTRA used smaller timesteps (0.2 ms)