



## Physics model development and extensive validation of predictive integrated modelling within the new EU framework programme 2021-2027 (TSVV11 activity)

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# Physics model development and extensive validation of predictive integrated modelling within the new EU framework programme 2021-2027 (TSVV11 activity)

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**EU context** “a strong theory and modelling programme is essential because empirically based predictions are uncertain in unexplored environments like ITER and particularly DEMO, and this will be a stronger focus than foreseen earlier” [2018 Fusion Roadmap]

In EUROfusion Work Package Advanced Computing, 14 ‘Theory, Simulation, Verification and Validation’ activities, **TSVV11 to extend & validate state-of-the-art in predictive integrated tokamak simulation, combining both technical framework and physics-module advances.**

## Guiding principles:

- **Align with ITER technical choices** workflow and database management
- **Improve and validate advanced physics modules** focusing on extensions needed for multi-physics full pulse
- **Demonstrate validation of full pulse predictive modelling** on multiple tokamaks
- Support extended validation against EU operating tokamaks: yearly training, documentation, user friendly interface and **automated validation tools**
- Apply to ITER scenarios. Provide **validated models to flight (or pulse design) simulator** developed in parallel to operate ITER and design DEMO

## Why IMAS Data structure?

IMAS : Integrated Modelling and Analysis Suite Data Dictionnary

**chosen by IO for ITER future experimental data and present modelling in/output**

**machine and code generic.** Capable of covering all experiment subsystems and plasma physics, **extensible**

**promoted as the standard to access all experimental results within EUROfusion** in a unique data format in the FAIR and open science requirements for FP9

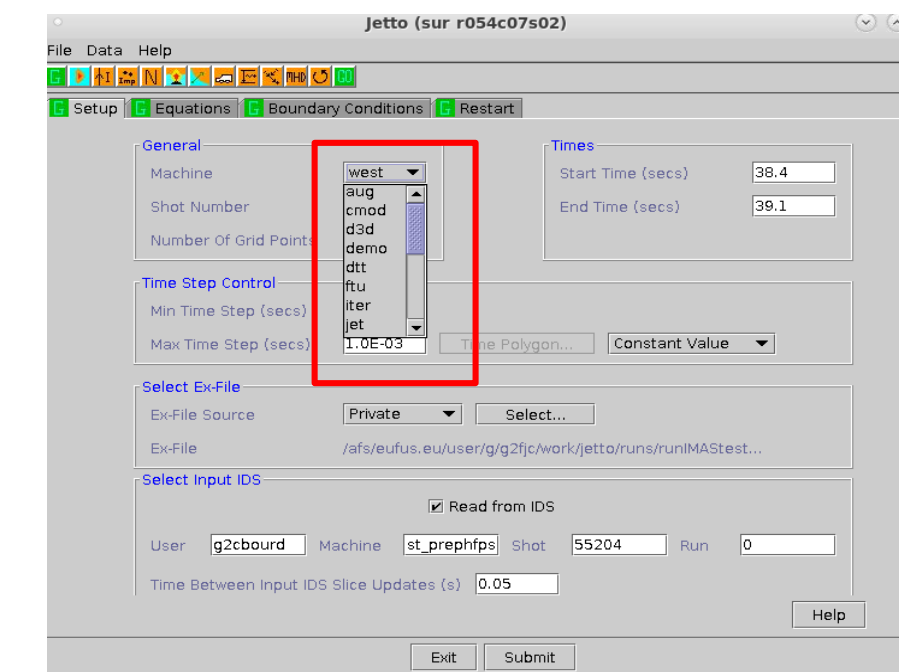
## What is the High Fidelity Pulse Simulator?

Python workflow based on **IMASified JINTRAC (i.e. JETTO+EDGE2D)**

workhorse for scenario preparation in ITER Physics Dept.

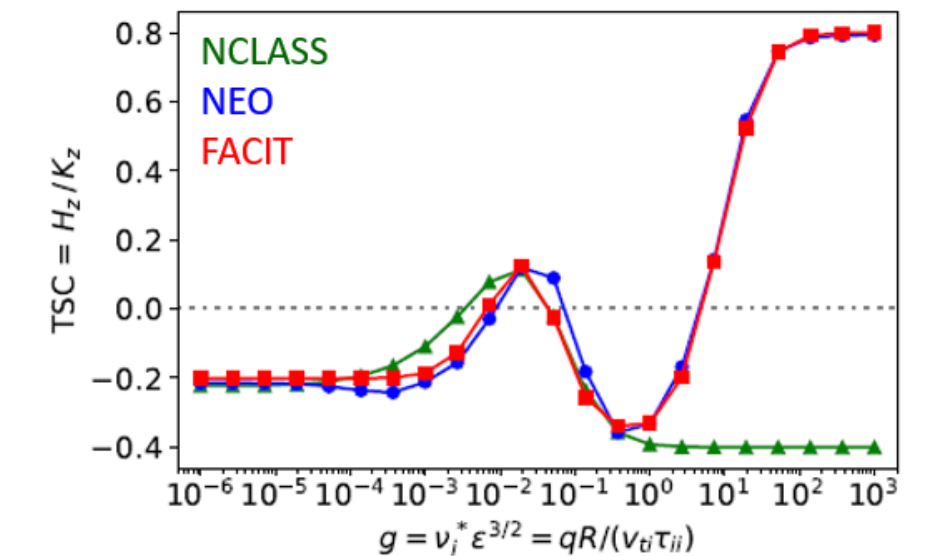
**any IMASified physics module can be included**

Coupled to experimental IMAS data from AUG, JET, TCV, WEST, on the EUROfusion GateWay



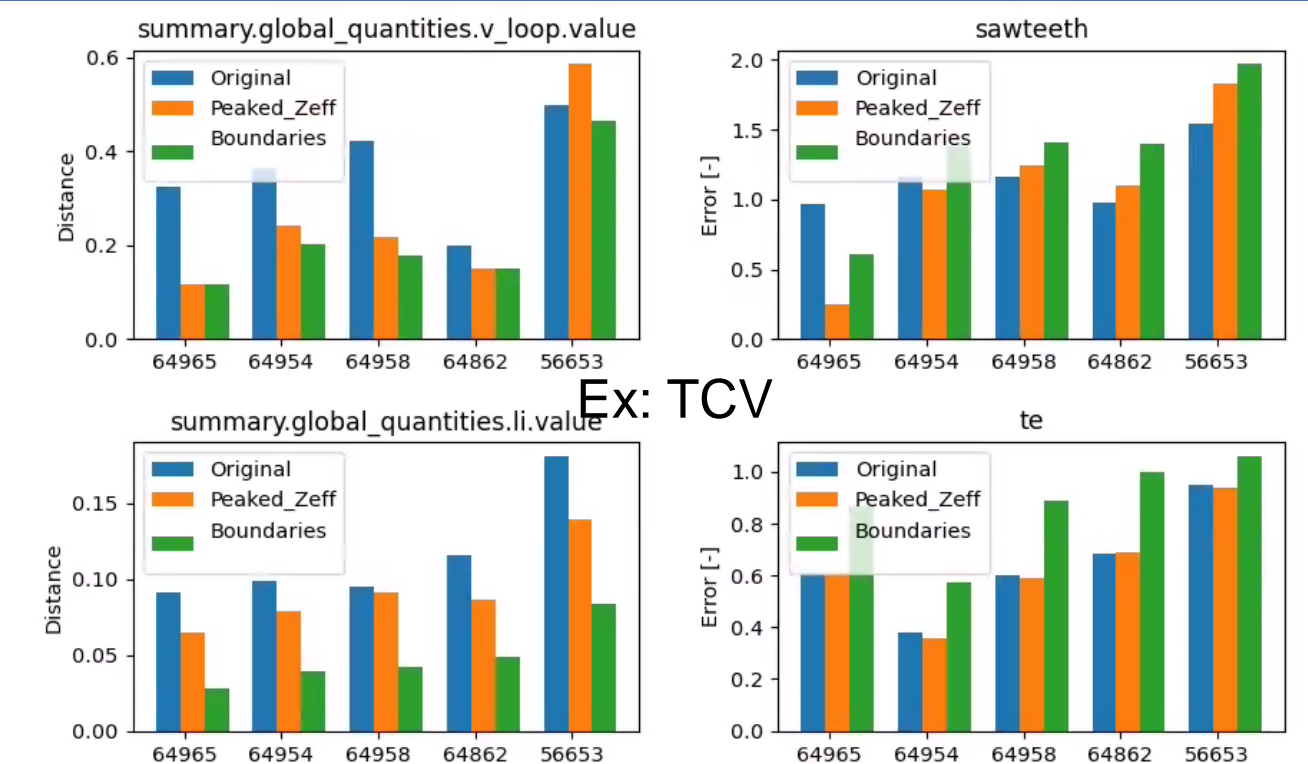
## physics module improvement: faster and as accurate

Ex: neoclassical heavy+light impurity transport (FACIT) reproduces NEO while gaining 3 to 5 order of magnitude in terms of CPU. [D. Fajardo, C. Angioni, P. Maget, P. Manas, PPCF2022]



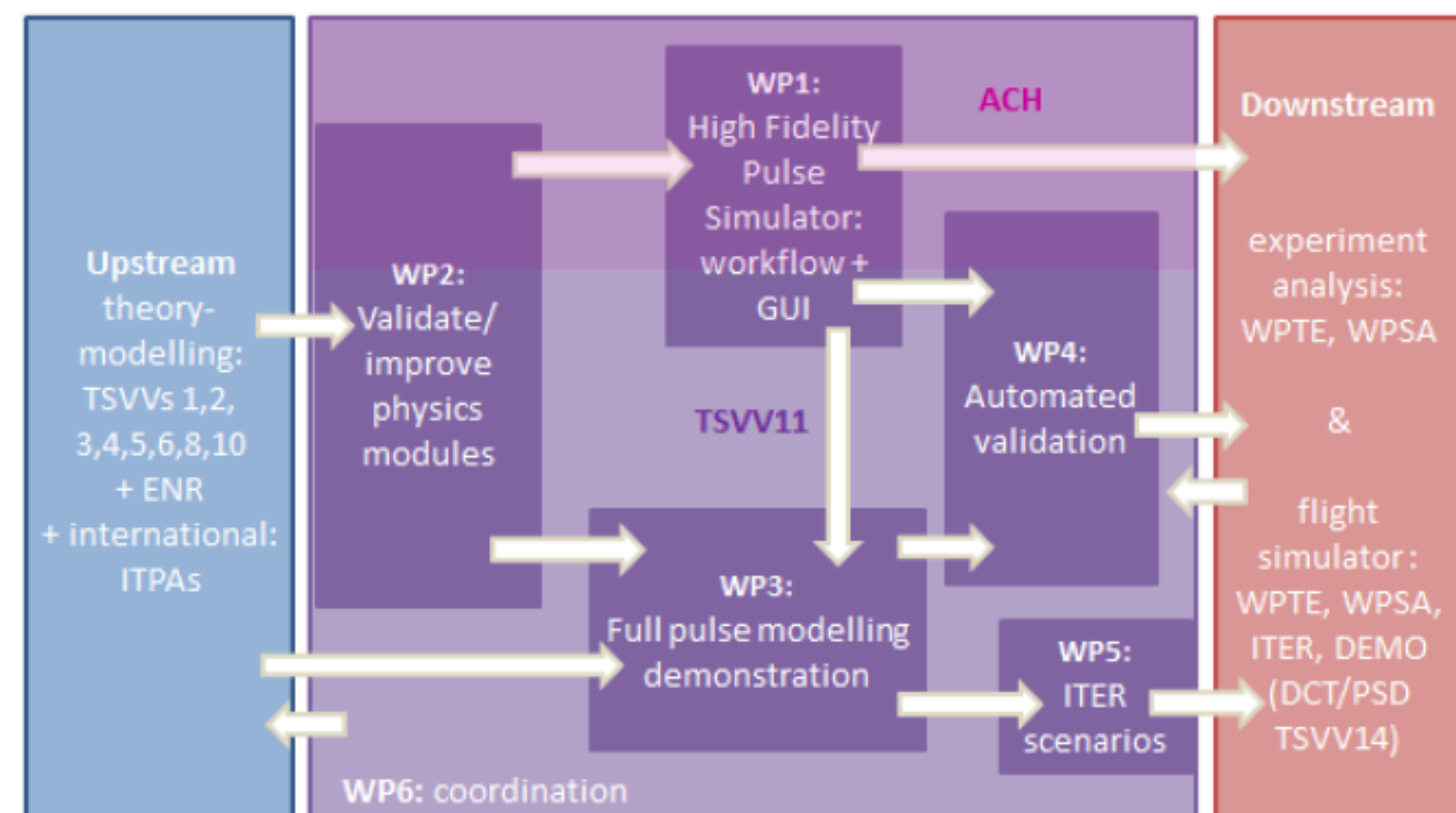
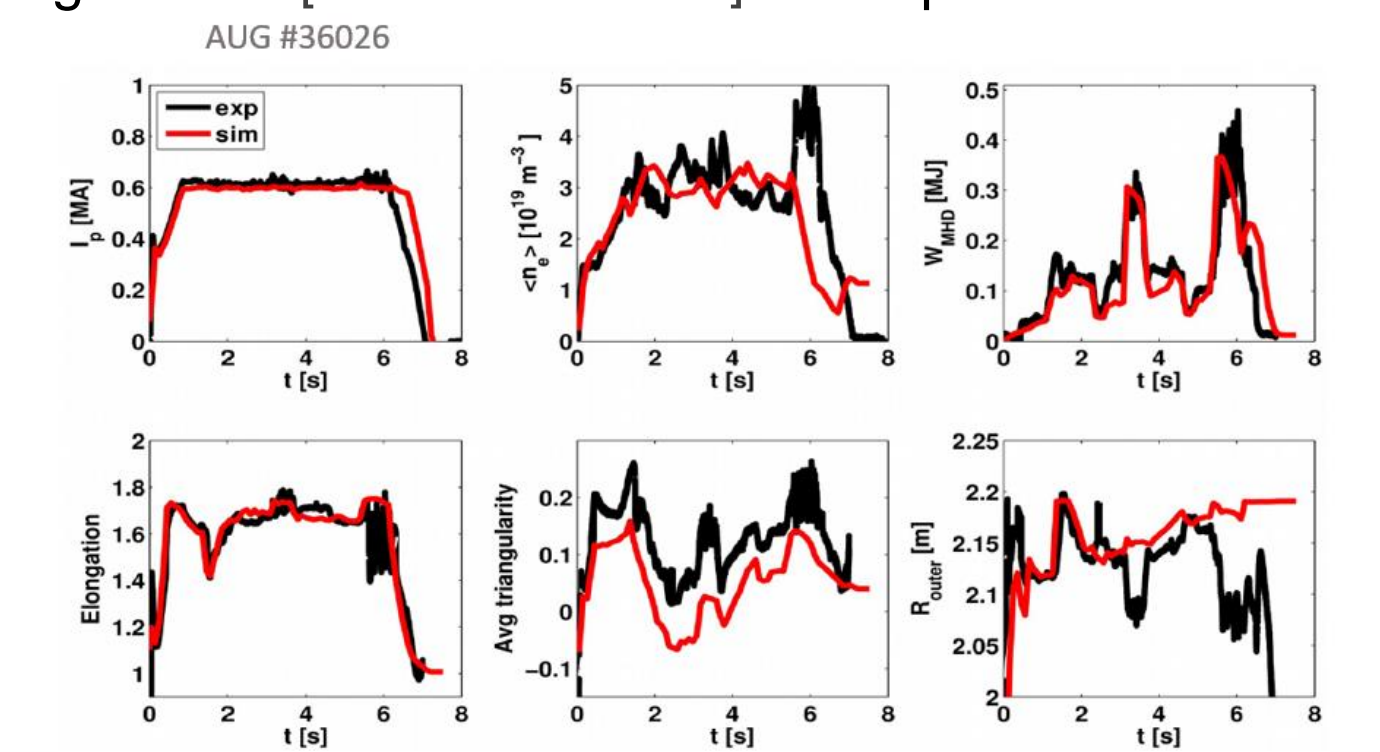
## I\_p ramp-up on multi-machines

Can we always reproduce the experimental V\_loop, li, first sawtooth with “reasonable” free parameters? T\_e(1), Z\_eff(ρ)...



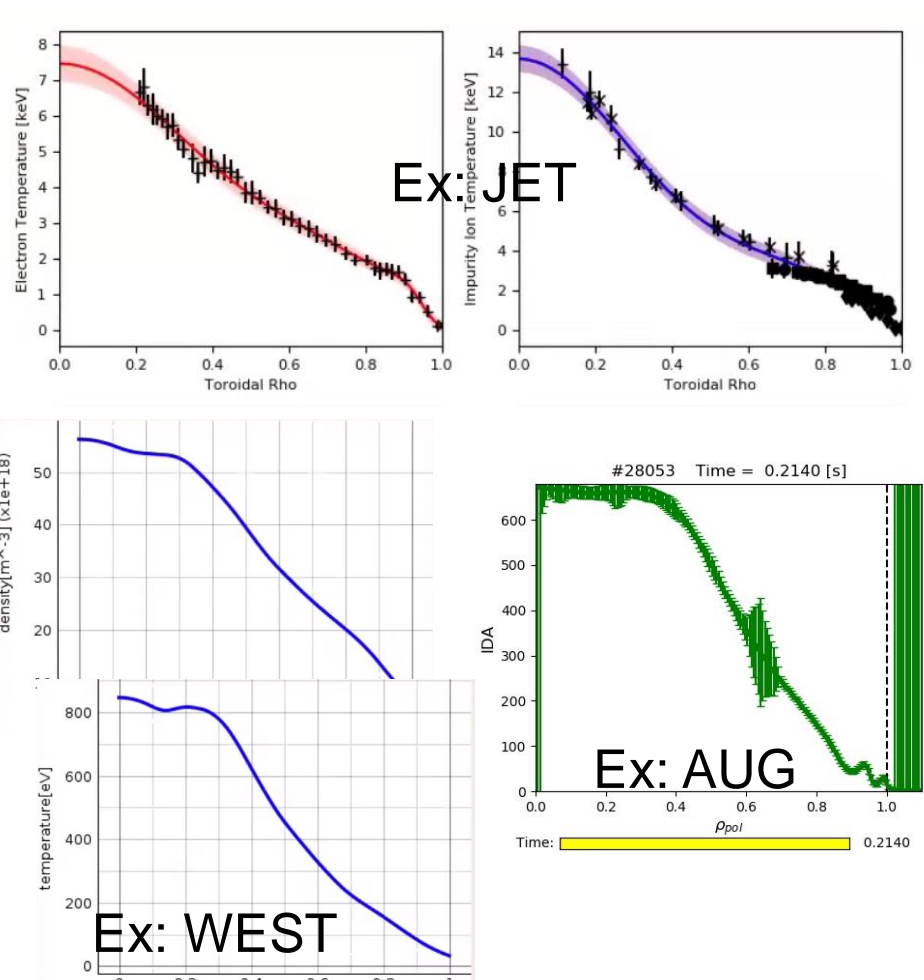
## full pulse modelling capability demonstration

proof-of-principle of full pulse modelling from breakdown to termination using FENIX [Fable PPCF2022] to be pursued with the HFPS



## Large-scale validation

generate IMAS IDS format inputs



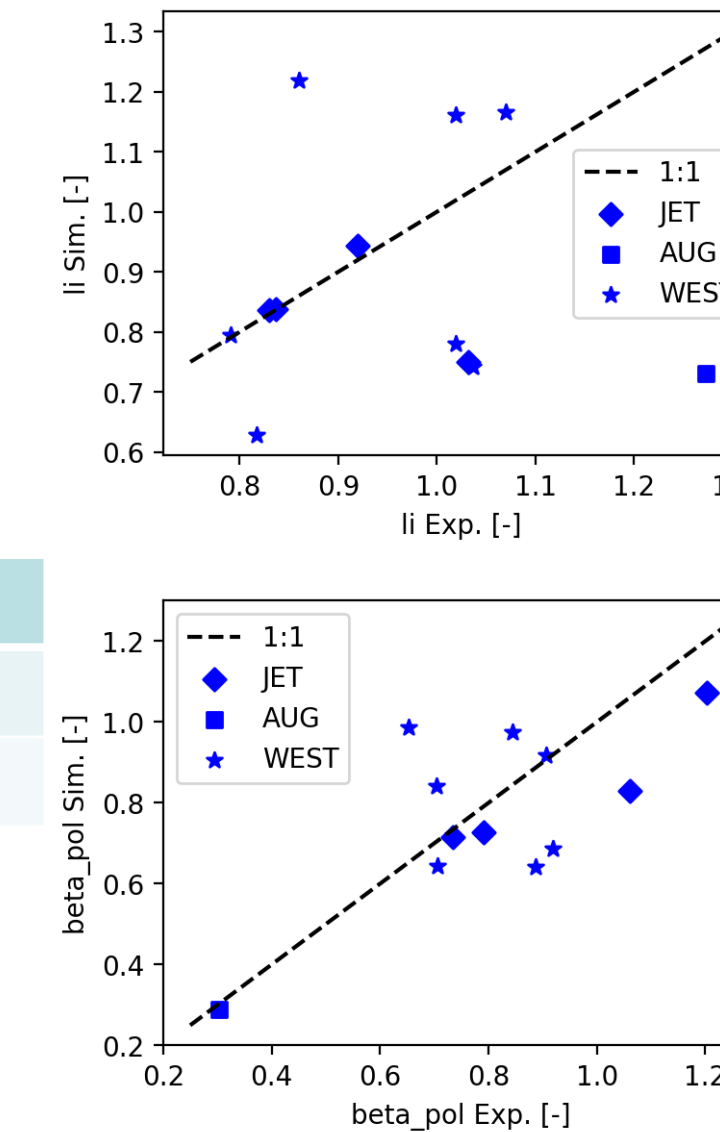
Validation metrics (steady-state analysis)

0D	$l_i, W_{MHD}, V_{loop}, R_n, P_{rad}, \bar{Z}_{eff}, \bar{n}_e, \langle n_e \rangle, \langle T_e \rangle,$
1D	$n_e, T_e, T_i$ (at $\rho = 0, 0.3, 1.0$ ), $\overline{\Delta n_e}, \overline{\Delta T_e}, \overline{\Delta T_i}$ (av. RMS)
2D	Synthetic line-of-sight diagnostics

implemented via a **hierarchy** of use-cases

Tier 1	No evolution	Input sanity check
Tier 2	+ current and equilibrium	$q$ profile relaxation
Tier 3	+ kinetic profiles	Transport validation

Uncertainty quantification on tiers 2 & 3



TSVV11 wikispaces <https://wiki.euro-fusion.org/wiki/TSVV-11>

Questions / suggestions? [clarisse.bourdelle@cea.fr](mailto:clarisse.bourdelle@cea.fr)



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