IMASification of the HFPS and data preparation tools for large-scale validation

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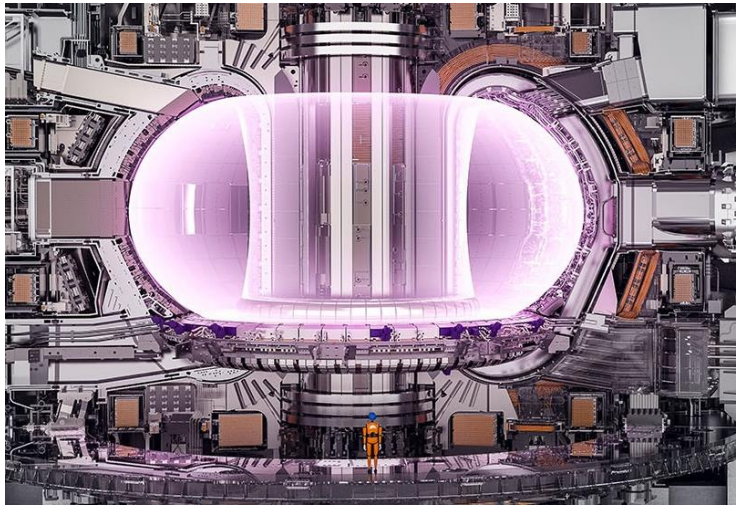
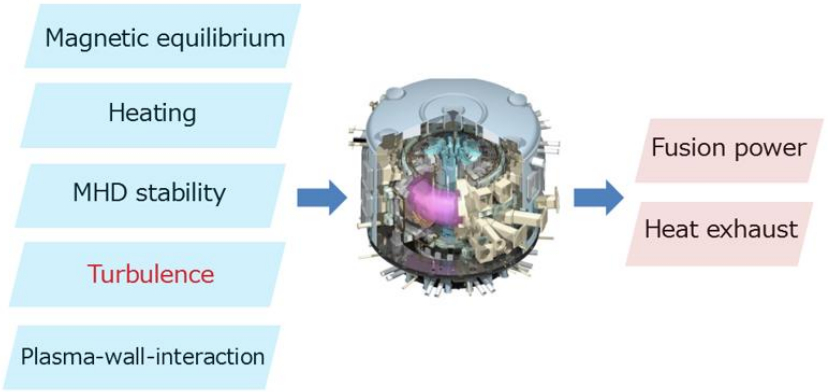
The need for large-scale validation of HFPS



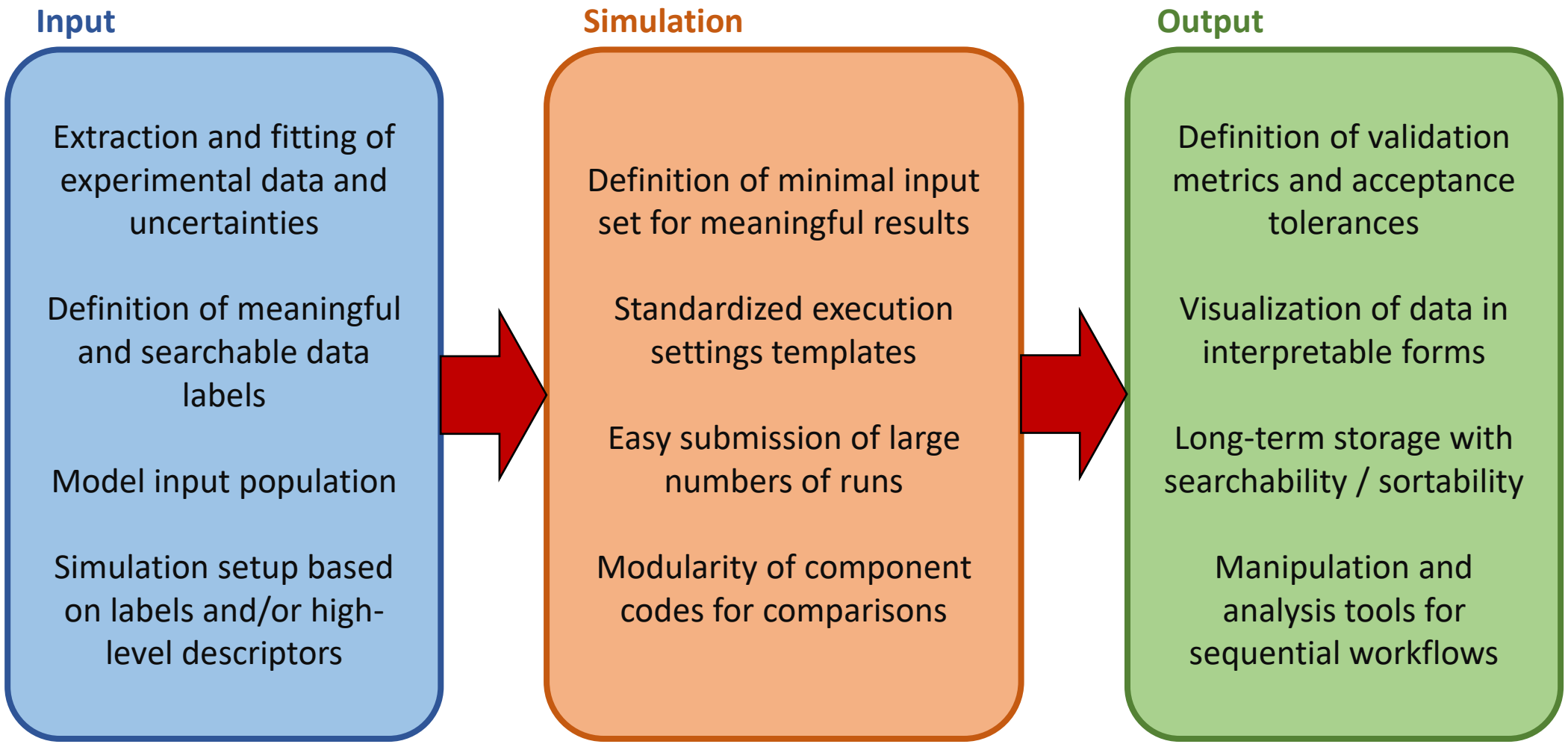


Status:
- ITER and DEMO will require a full-device plasma simulator for scenario development and operational concerns
- Spurred the High-Fidelity Plasma Simulator (HFPS) project
- JINTRAC was selected among the existing codes as the platform on which to build this functionality

Problem:
- Predict-first capability of JINTRAC is largely unexplored, typically adjusted on a case-by-case basis

Goal:
- Perform a large-scale validation of the HFPS and its components to evaluate predict-first capability
- Requires large set of various scenarios and standardized execution settings to avoid bias

Workflow requirements for large-scale validation

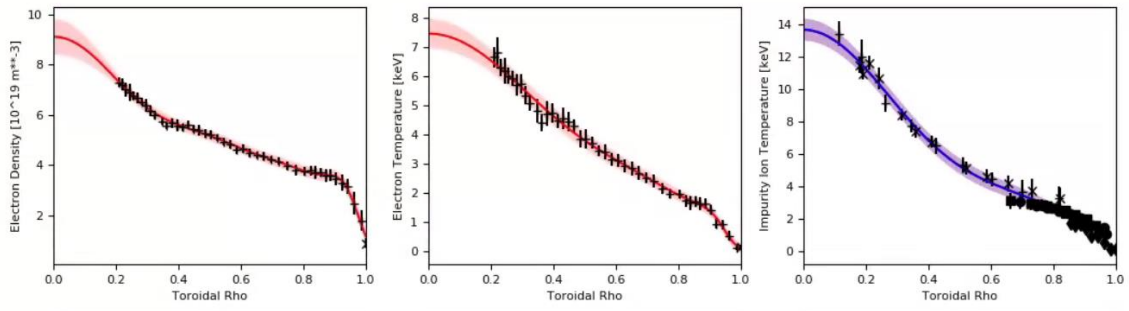


Simulation preparation from experimental data

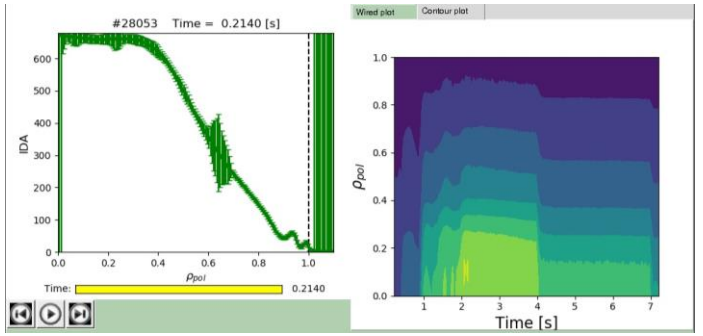
Current strategy:

- Use machine-specific tools to transform experimental data into IDS format for HFPS ingestion
  - JET: EX2GK (A. Ho)
  - AUG: TRgui (G. Tardini)
  - TCV: tcv2ids (O. Sauter)
  - WEST: west_simu_preparation (J.-F. Artaud)
- Unobserved but mandatory input quantities are estimated using domain knowledge within these tools
- Categorization using metadata labels must be done manually, not currently in tools

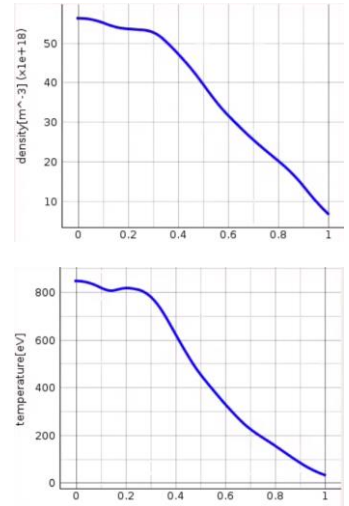
JET



AUG



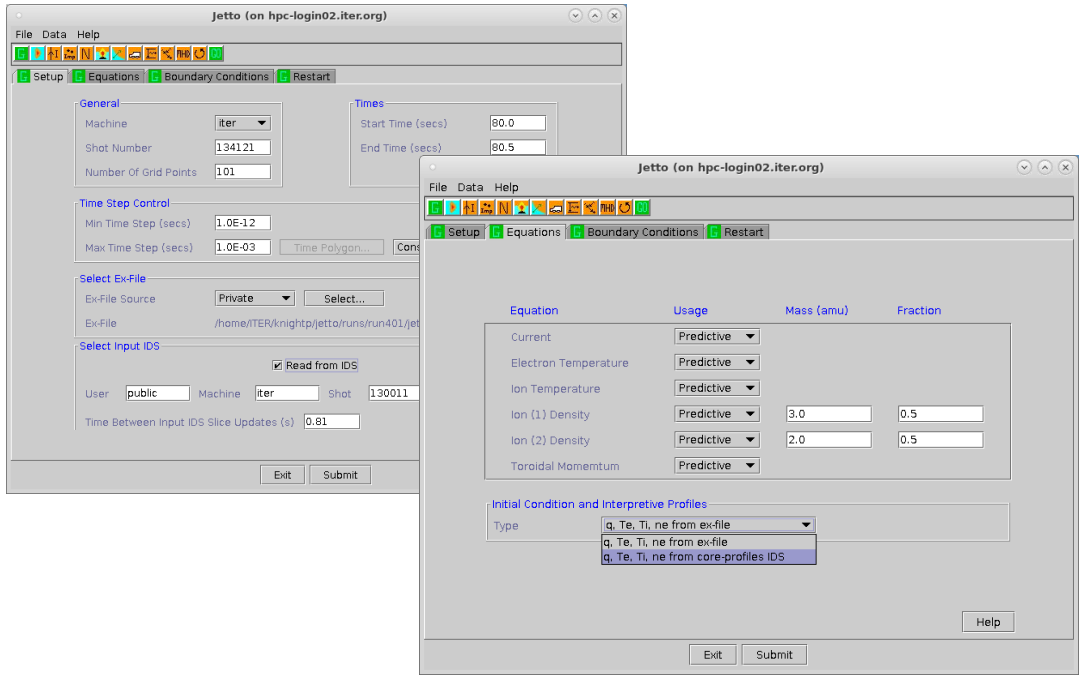
TCV
WEST



Long-term strategy:

- UDA for access and direct transformation of experimental data into IDS
- Standardization of data processing pipeline across machines, compiled into a single tool with IDS in/out

Description of the High Fidelity Plasma Simulator



Current HFPS:

- A collection of IMAS adapted actors that can simulate tokamak fusion plasmas using state-of-the-art models
- *Actors* are well-established, covering many physical phenomena and with tests from long use history
- Prototypical but functional code coupling *framework*, further developments foreseen
- Already combines ETS components (H&CD) and all JINTRAC components

Continual development strategy:

- Agree upon standards for python based workflows, converge on a common set of templates for new users
- Update python driver loop to match these standards and generalize it to extend possible workflows
- Planned extensions: DINA, reduced SOL models, reduced pedestal models, surrogate transport models, additional models developed by TSVVs

IMASification status of HFPS

- Convert user-facing JINTRAC inputs / outputs to IDS – completed
  - JETTO IDS inputs: *core_profiles, core_sources, equilibrium, nbi, pellets*
  - JETTO IDS outputs: *core_profiles, core_sources, core_transport, equilibrium, summary, dataset_description*
  - Grid2D IDS inputs: *equilibrium*
  - EDGE2D IDS outputs: *edge_profiles, edge_transport, edge_sources, transport_solver_numerics, dataset_description*
  - COCONUT IDS coupling: *transport_solver_numerics*

- Build JINTRAC actors for JETTO, Edge2D, Coconut (FC2K compatible) – completed

- Demonstrate couplings to existing actors - completed
  - Opted for **python** workflows – for source control, lighter dependencies, and wider support community

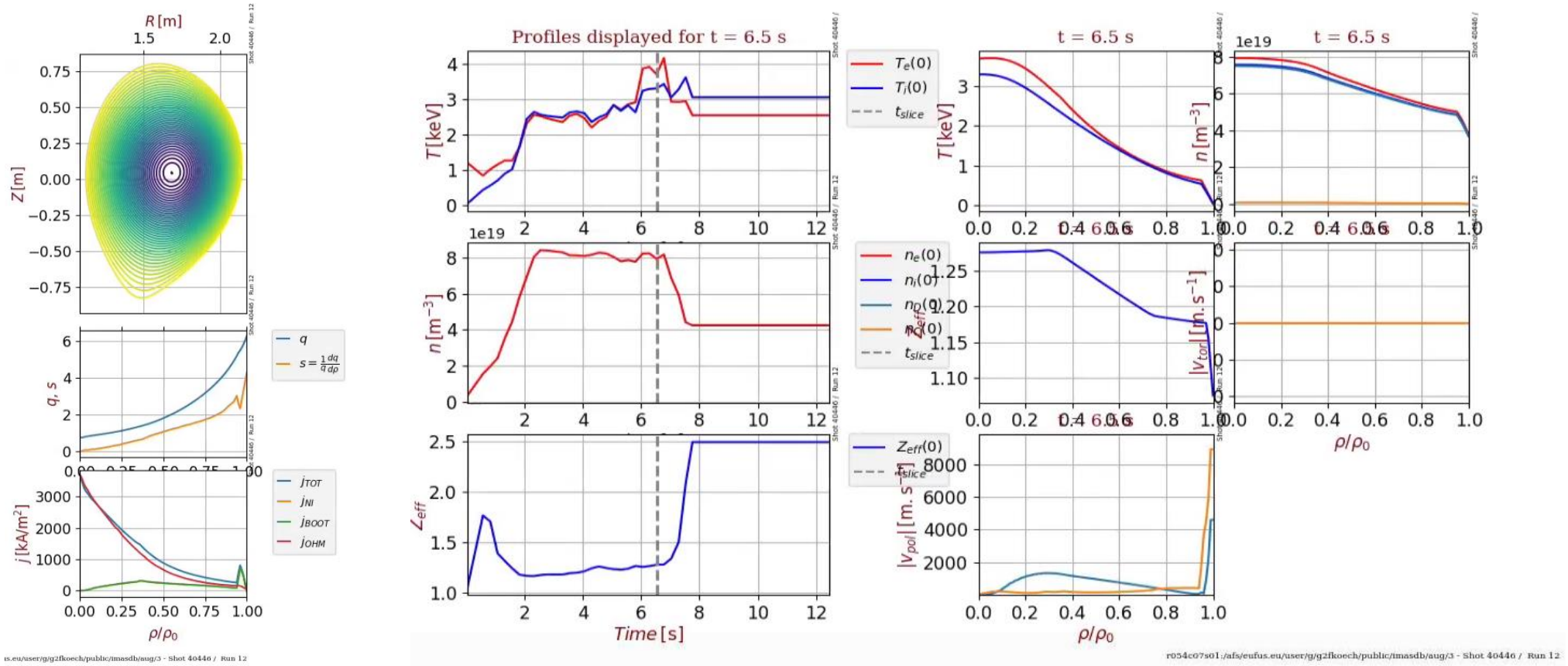
- Adapt SimDB architecture as simulation catalog – completed but not deployed

- Adapt code-dependent parameters for proposed python actor workflow – not completed
  - Hard XML requirement requires significant investment to adapt for a complex code

- Evolve to a more general “HFPS” GUI – long term plan – using existing JAMS GUI in medium term
  - Internal logical checks of simulation settings conflicts with modular data-driven GUI approach

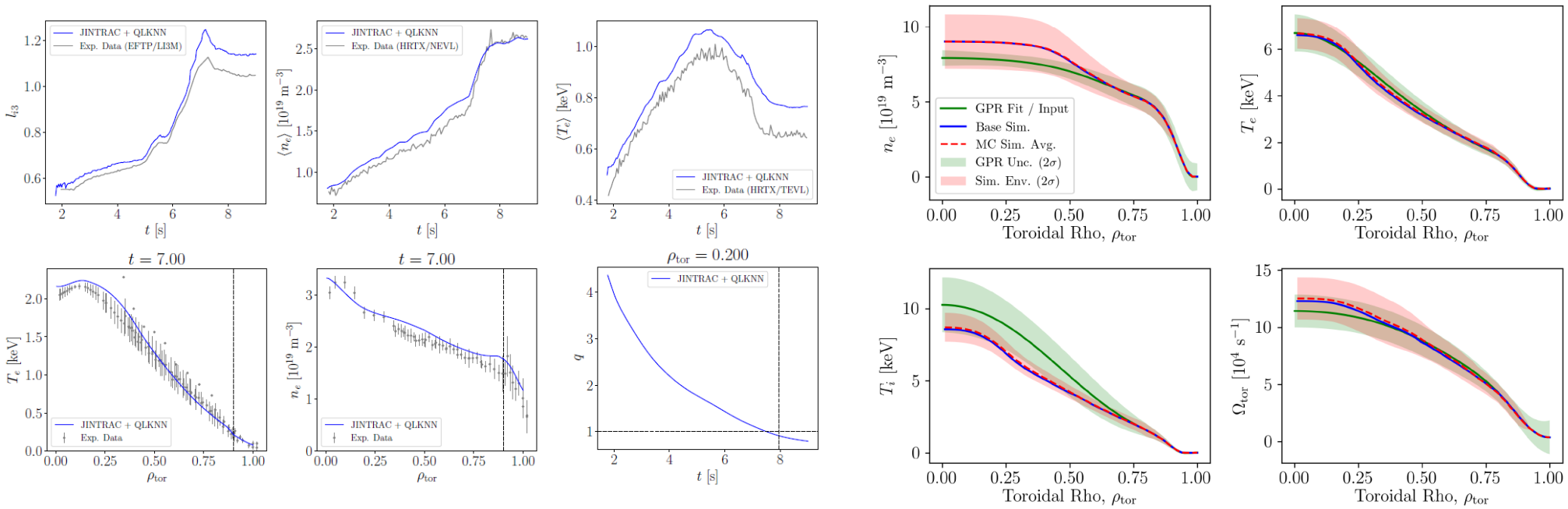
Preliminary test run of dynamic HFPS simulation

- HFPS simulation of 8 s AUG plasma pulse, scenario intended for comparison between HFPS and Fenix
- Manual setup with heavy iteration, output visualization via Scenplot and Kinplot tools



Initial phase in large-scale validation workflow

- HFPS validation workflow under development – preliminary process defined and first runs underway
- Close collaboration between TSVV-11 and ERG of A. Ho to ensure workflow meets modelling needs
- Heavy iteration is expected with additional test cases, fast models, and data tooling



Future requirements:

- Automation of workflow to handle large-scale execution and data reduction
- Additional storage space on Gateway system to house large number of validation simulations (~10 TB)

Summary and outlook

Large-scale validation via automated workflows allows blind testing of models to experiments to judge predict-first capability of HFPS – crucial for ITER scenario design and operation

Input

- Experimental data tools are currently machine-dependent, good interim solution to allow progress
- IDS-centric workflow ensures compatibility with future tool development and standardization
- Difficulty is not in coding, but getting machines to agree on a single procedure / strategy

Simulation

- HFPS is now compliant with IDS input and output, capable of using python workflows to couple actors
- First demonstrations of HFPS capability to interface and compare with other integrated models via IDS
- Preliminary validation workflow defined and template settings developed, requires testing
- Current execution requires JAMS GUI to translate between user settings and internal flags, legacy logical checks may make automation difficult

Output

- Preliminary validation metrics defined, acceptance tolerances still to be determined
- Validation-specific visualization and comparison tools needed
- Additional storage space required on the Gateway system, IDS file sizes larger than originally expected