

# 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

#### Input

Extraction and fitting of experimental data and uncertainties

Definition of meaningful and searchable data labels

Model input population

Simulation setup based on labels and/or highlevel descriptors

#### Simulation

Definition of minimal input set for meaningful results

Standardized execution settings templates

Easy submission of large numbers of runs

Modularity of component codes for comparisons

#### Output

Definition of validation metrics and acceptance tolerances

Visualization of data in interpretable forms

Long-term storage with searchability / sortability

Manipulation and analysis tools for sequential workflows

### 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



#### 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

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### Description of the High Fidelity Plasma Simulator

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#### **Continual development strategy:**

#### **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

- 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



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## 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