

EnR-MOD: Pedestal Inference Engine (PIE)

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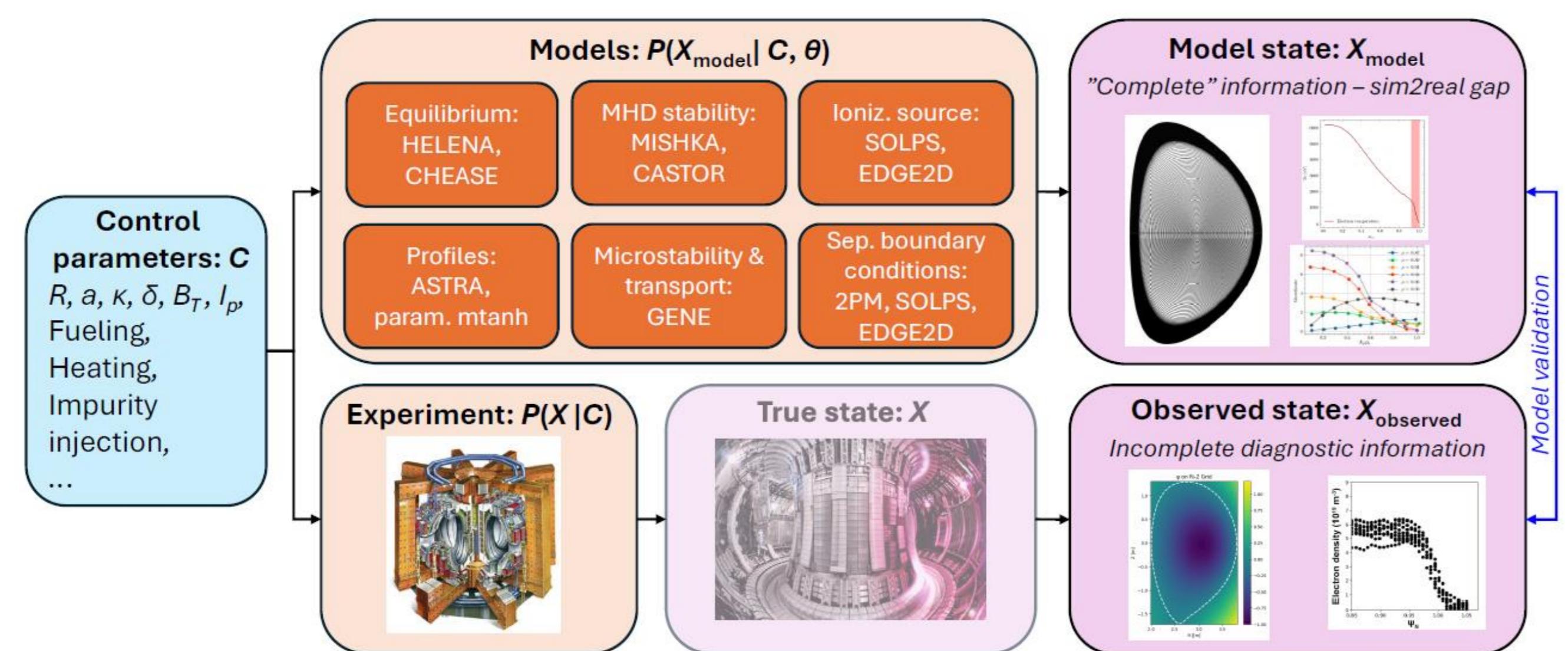
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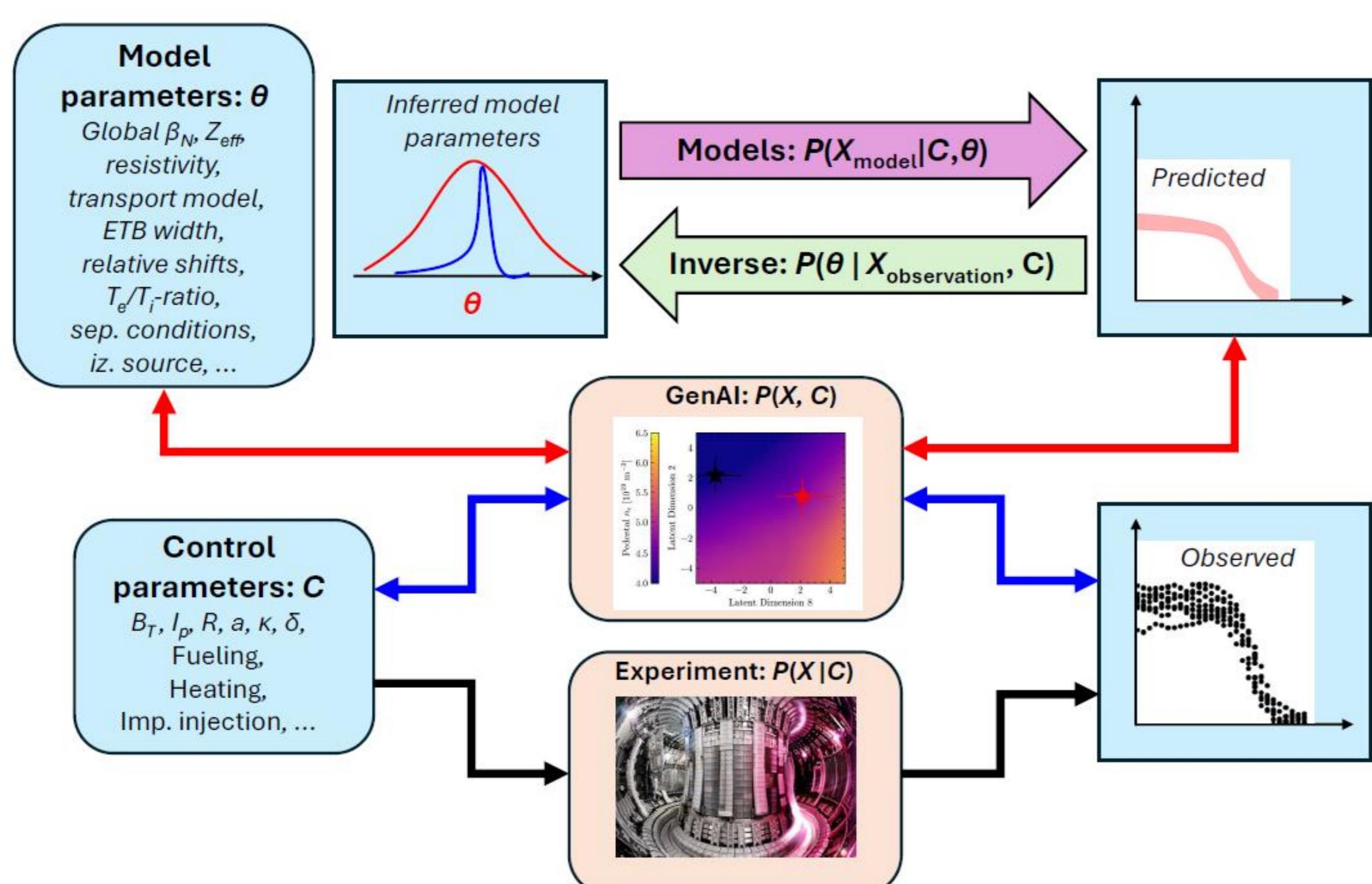
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Pedestal as an example of a multiscale, multiphysics system:
→ Predictions typically point estimates, UQ challenging



The North Star goal of the project is to build a probabilistic scientific inference framework for pedestal plasmas



The project is divided to three sub-projects (SP)

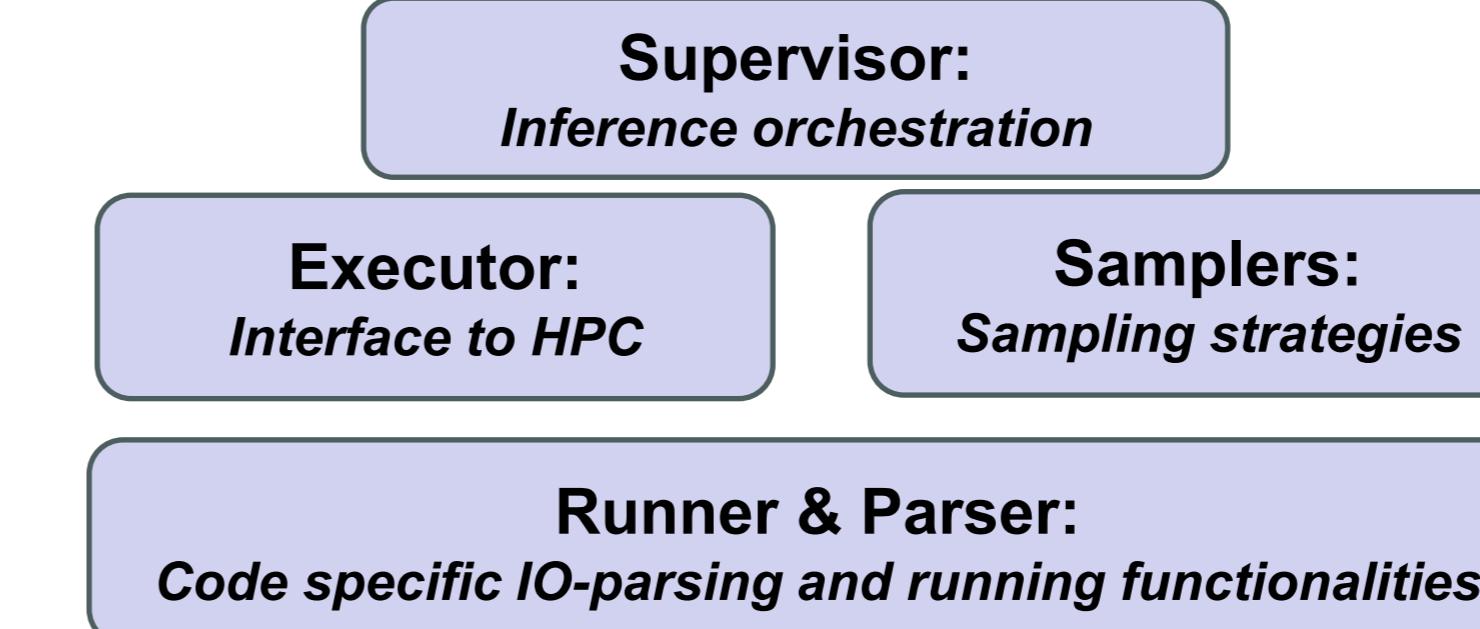
SP1: Simulation-based inference (SBI) framework for pedestal analysis and prediction

SP2: Accelerated pedestal forward models

SP3: Application of the framework for large-scale pedestal analysis tasks

Enchanted-surrogates as the platform – Software package developed for scalable sampling of physics simulations on HPCs

Modular Class Structure



<https://github.com/DIGfusion/enchanted-surrogates>

2026 Milestones

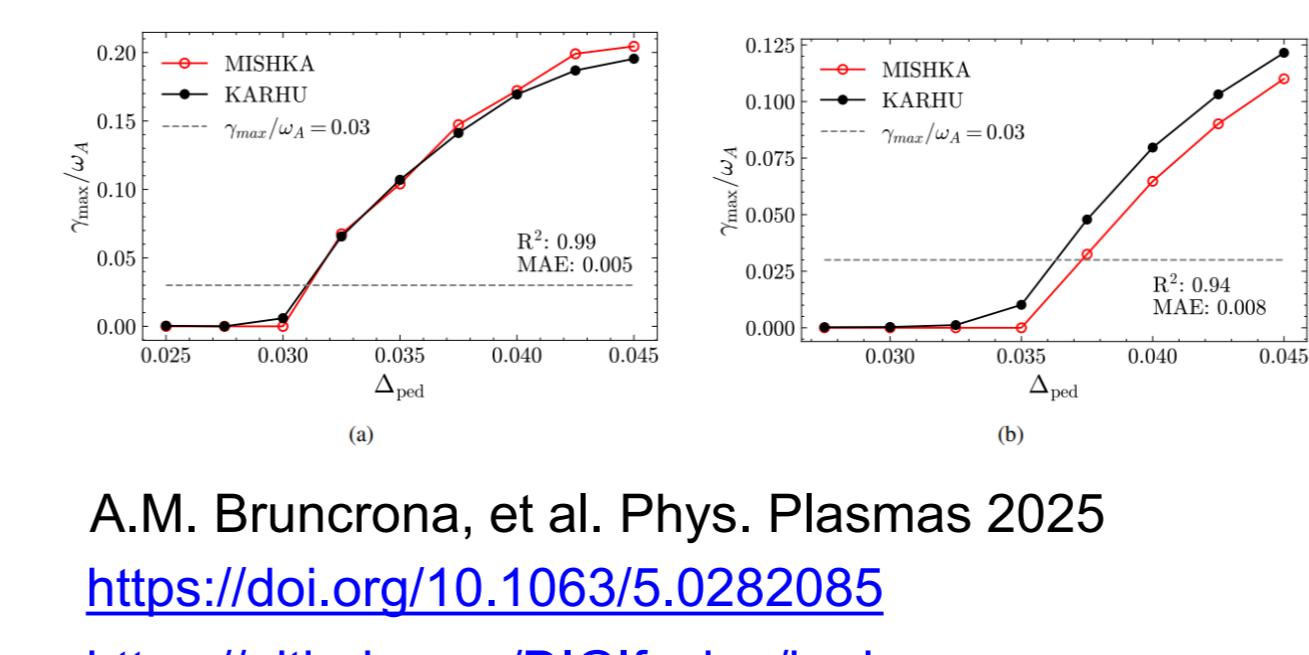
- M.1: Probabilistic Europe demonstration (forward model demonstration)
- M.3: Infer Eped BCP multiplier (inverse inference demonstration)

2027 Milestones

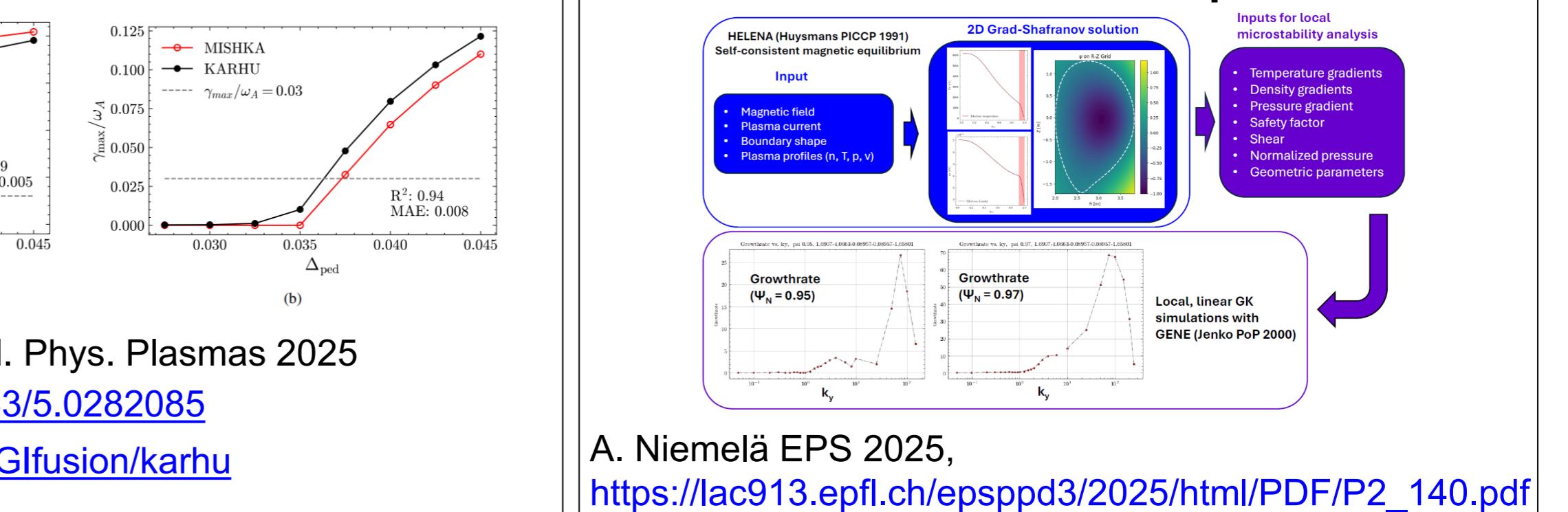
- M.5: Probabilistic Europe with CASTOR demonstrated
- M.8: Multidimensional Europe input parameter inference demonstration
- M.10: Probabilistic Europe with non-BCP transport
- M.11: Application of the framework for pedestal transport model parameter inference task

Surrogate / multifidelity models for pedestal MHD and transport

Pedestal MHD



Pedestal GK sampler



2026 Milestones

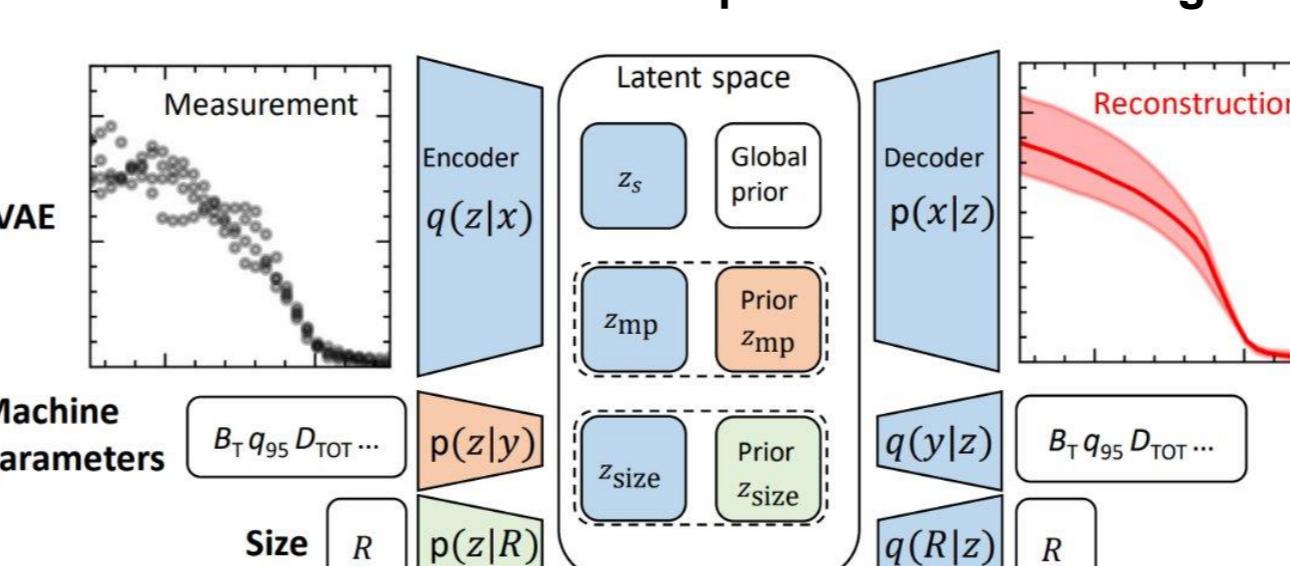
- M.2: Extend the coverage of the pedestal MHD surrogate model to all EUROfusion devices
- M.7: Completion of the reduced-model KBM and MT databases using the upgraded Solve_AP and KEY codes as well as the ion scale GK database using GENE; interpretation of parameter-spaces with good pedestal transport properties.

2027 Milestones

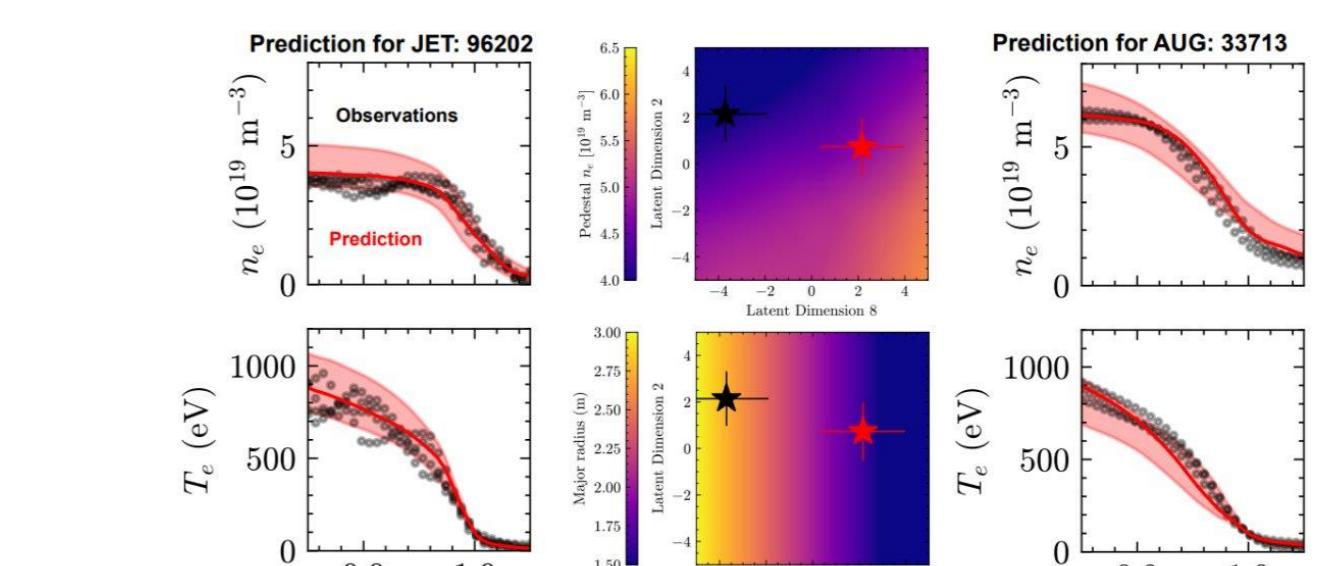
- M.4: Extension of the pedestal MHD surrogate for JET with CASTOR for resistive features (presently proof-of-principle done)
- M.9: Completion of the reduced-model ETG database as well as the corresponding electron scale GK database; interpretation of parameter-spaces with good pedestal transport properties.

GenAI to represent large experimental databases in the inference workflow

Variational Autoencoder based representation learning model



Multi-machine model trained based on JET & AUG



2026 Milestones

- M.6: Demonstration of GenAI approach to learning key model parameters

2027 Milestones

- M.12: Demonstration of physics-data informed GenAI in large-scale analysis

Communication and collaboration

• Progress meetings:

- Organized monthly / Monday 15.30 – 17.30 CET / To be posted on the wikipage / Next meeting 16.2.2026.
- Every third meeting, a review of milestone/deliverable completion.
- Onsite meetings at DIFFER (Summer 2026) and at VTT (Summer 2027).
- Developed software tools publicly available in GitHub, e.g., <https://github.com/DIGfusion/enchanted-surrogates>
- Maintain close collaboration with WP TE, TSVV-A and -H, ITER Organization, and international programs, via shared team members, ISFN, pre-existing international collaboration, and team members actively joining relevant progress meetings

ACTIVITY	2026				2027			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SP1: SBI framework for pedestal analysis and prediction								
T1.1: Probabilistic forward inference for pedestal prediction								
T1.2: Inverse UQ for pedestals								
T1.3: Generative models for experimental databases								
T1.4: Generative models for physics-data hybrid representations								
SP2: Accelerated pedestal forward model development								
T2.1: Extend the pedestal MHD surrogate to cover all EUROfusion tokamaks								
T2.2: Apply active learning to extend to resistive MHD								
T2.3: Surrogate model for ion scale microstability								
T2.4: Surrogate models for ETG								
SP3: Large-scale pedestal analysis								
T3.1: Application of the forward inference framework for EUROfusion PDB								
T3.2: Application of the inverse UQ framework for EUROfusion PDB								
T3.3: Application of the GenAI augmented SBI for EUROfusion PDB								

