



## EnR-MOD: Pedestal Inference Engine (PIE)

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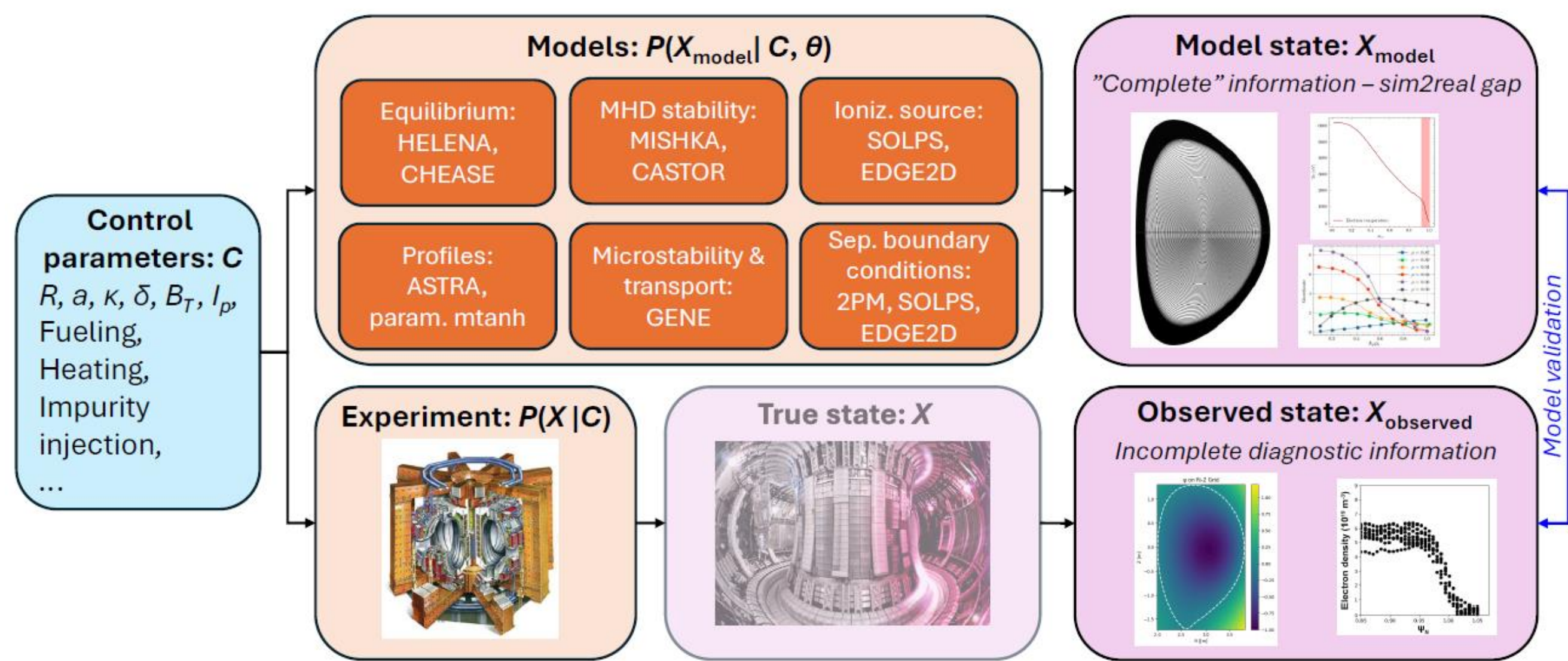
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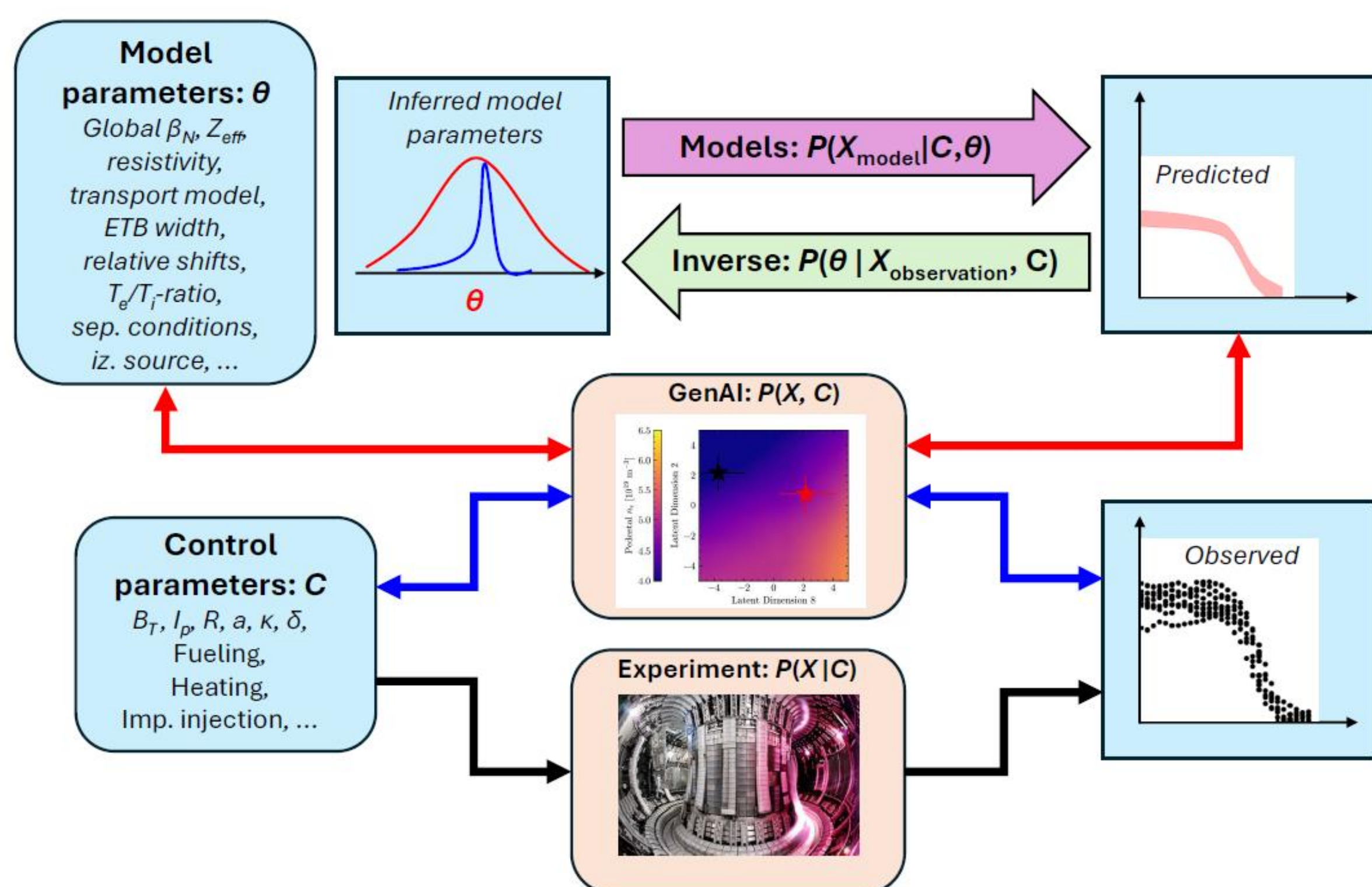
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**Pedestal as an example of a multiscale, multiphysics system:**  
→ Predictions typically point estimates, UQ challenging



**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**

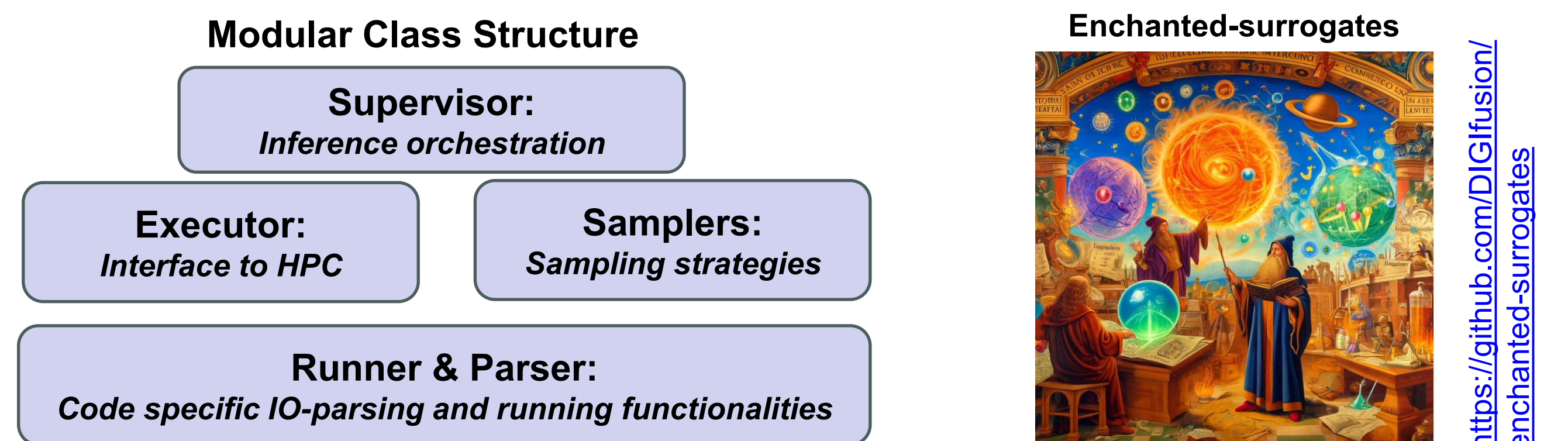
**SP2: Accelerated pedestal forward models**

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

**Planned schedule of tasks and milestones**

ACTIVITY	2026				2027			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
<b>SP1: SBI framework for pedestal analysis and prediction</b>								
T1.1: Probabilistic forward inference for pedestal prediction	M.1					M.5		M.10
T1.2: Inverse UQ for pedestals		M.3				M.8		M.11
T1.3: Generative models for experimental databases				M.6				
T1.4: Generative models for physics-data hybrid representations								M.12
<b>SP2: Accelerated pedestal forward model development</b>								
T2.1: Extend the pedestal MHD surrogate to cover all EUROfusion tokamaks		M.2						
T2.2: Apply active learning to extend to resistive MHD						M.4		
T2.3: Surrogate model for ion scale microstability				M.7				
T2.4: Surrogate models for ETG						M.9		
<b>SP3: Large-scale pedestal analysis</b>								
T3.1: Application of the forward inference framework for EUROfusion PDB	M.1					M.5		M.10
T3.2: Application of the inverse UQ framework for EUROfusion PDB		M.3				M.8		M.11
T3.3: Application of the GenAI augmented SBI for EUROfusion PDB				M.6				M.12

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



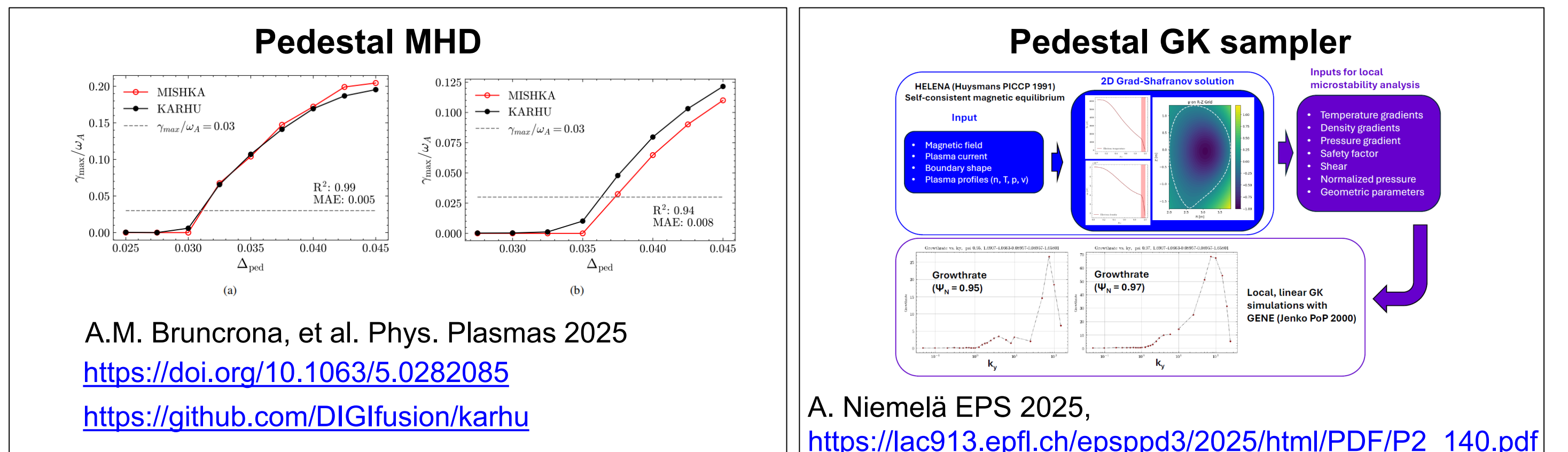
**2026 Milestones**

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

**2027 Milestones**

- M.5: Probabilistic Europol with CASTOR demonstrated
- M.8: Multidimensional Europol input parameter inference demonstration
- M.10: Probabilistic Europol 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**



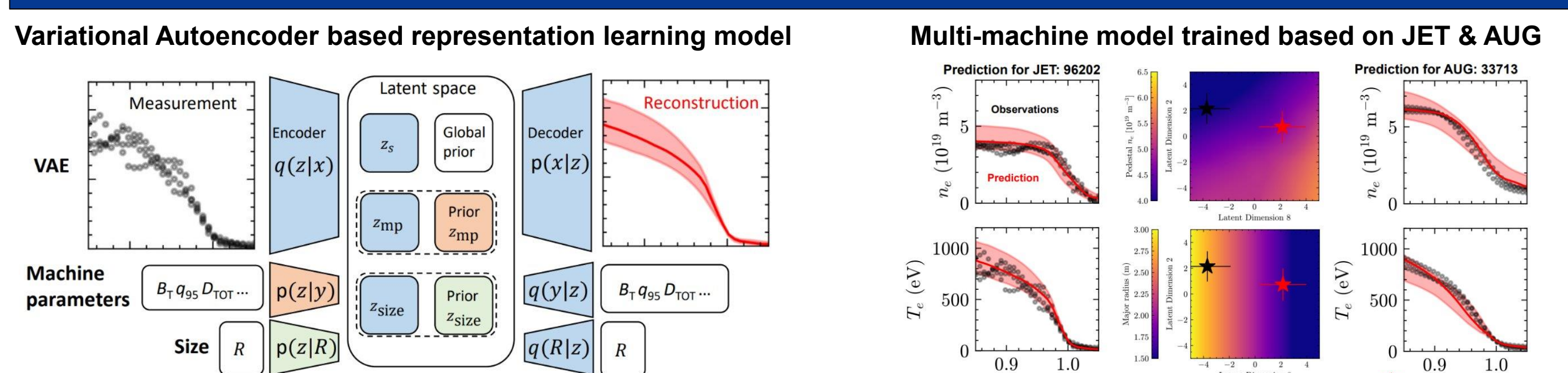
**2026 Milestones**

- 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**



A.E. Järvinen, PoP 2024 <https://doi.org/10.1063/5.0177005>; A. Kit, PoP 2024 <https://doi.org/10.1063/5.0174128>

**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 wiki page / 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/DIGIfusion/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**

