

TokaLab: A Modular Virtual Tokamak Laboratory for Education, Open Access, and Algorithm Benchmarking

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Aims

- Develop **open, transparent & transferable knowledge frameworks**, essential for advancing plasma physics research
- Support both theoretical and experimental studies
- Foster learning, collaboration and the adoption of **FAIR principles** (Findable, Accessible, Interoperable, and Reusable) within the plasma physics community

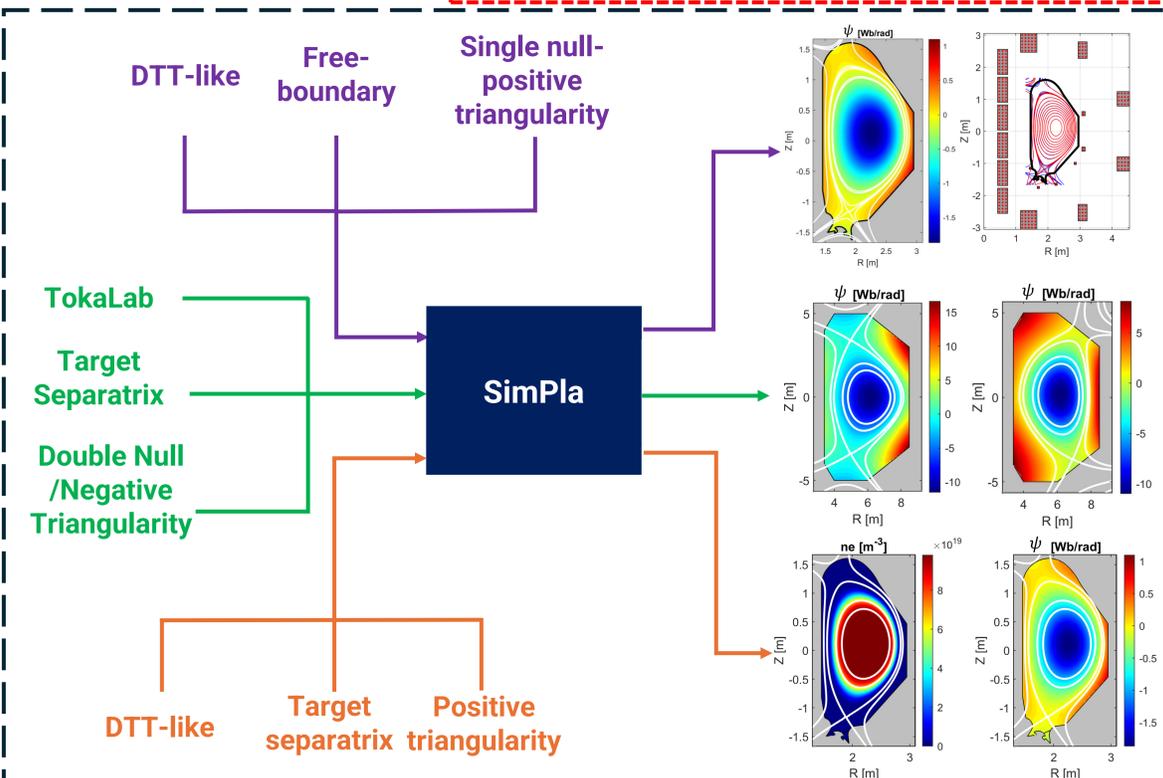
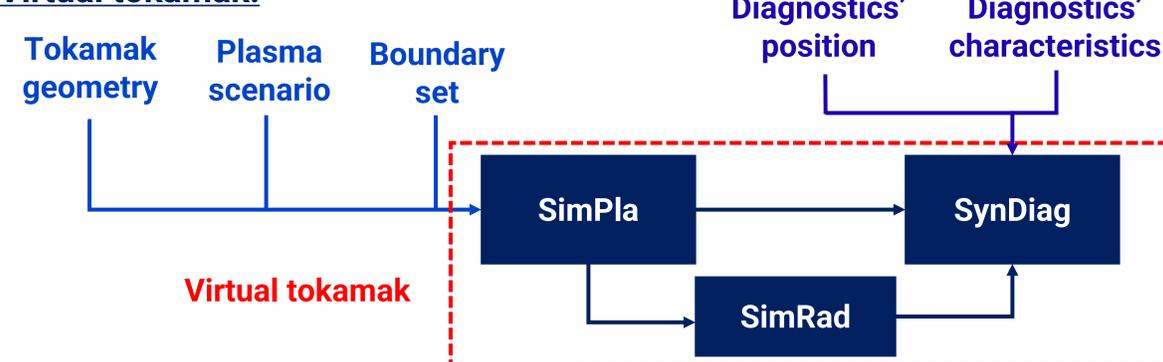
TokaLab features a **modular and flexible architecture** that enables the integration of new geometries, diagnostics, and simulation tools at various levels of complexity, rendering it easily extensible and adaptable. Note that it is **multi-language** (MATLAB and Python).

For Education and Research TokaLab serves not only as an **engaging educational platform** but also as a **powerful resource for synthetic data generation and computational method exchange**, facilitating the **benchmarking and validation of algorithms**, including AI-based and inverse problem approaches in thermonuclear plasma physics.

Modules now available:

1. **SimPla** (Simulated Plasma) – module designed to reconstruct plasma equilibrium solving the Grad-Shafranov equation. It enables detailed modelling of tokamak plasma behaviour through a structured and modular approach. Allows different geometries and tokamak specifications as inputs
2. **SynDiag** (Synthetic Diagnostics) – designed to simulate various tokamak diagnostics in a modular way. Each diagnostic technique is implemented as a separate class, enabling flexible and detailed synthetic data generation for experimental comparison and validation. Implemented diagnostics: **Pick-Up Coils, Flux Loops, Saddle Loops, Thomson Scattering, Interferometer-Polarimeter, Bolometers**
3. **TokaPlot** – designed to easily and rapidly plot fields, diagnostics and measurements with several options
4. **SimRad** – module simulating the radiative scenario

Virtual tokamak.



TokaLab next steps

- Develop New Modules
- Create Advanced Didactic Tools for Education
- Complete Python Conversion
- Promote a Multi-Language Approach to foster open access

