A flexible framework for Integrated Tokamak Modelling

Integrated Tokamak Modelling

- Aim: consistent modelling of the plasma and the tokamak subsystems (heating systems, diagnostics, magnetic coils)
- Strategy: divide the global problem into Elementary Physics Problems (equilibrium, transport, MHD, source terms, diagnostic response, …)

The ITM-TF Approach

- User-friendly framework allowing to compose workflows by assembling « components » solving Elementary Physics Problems
- Components communicate via Standardized interfaces defined from the Elementary Physics Problems (CPOs) → the data model allows fully flexible combination of Elementary Physics Problems in the workflow
- As a result, any tokamak modelling activity can be composed on this framework: interpetative analysis of diagnostic signals, usual « transport code », ab initio calculations, system design, …
- Access to High Performance Computing (HPC) within an Integrated Modelling Framework

Generic Access to Experimental Data

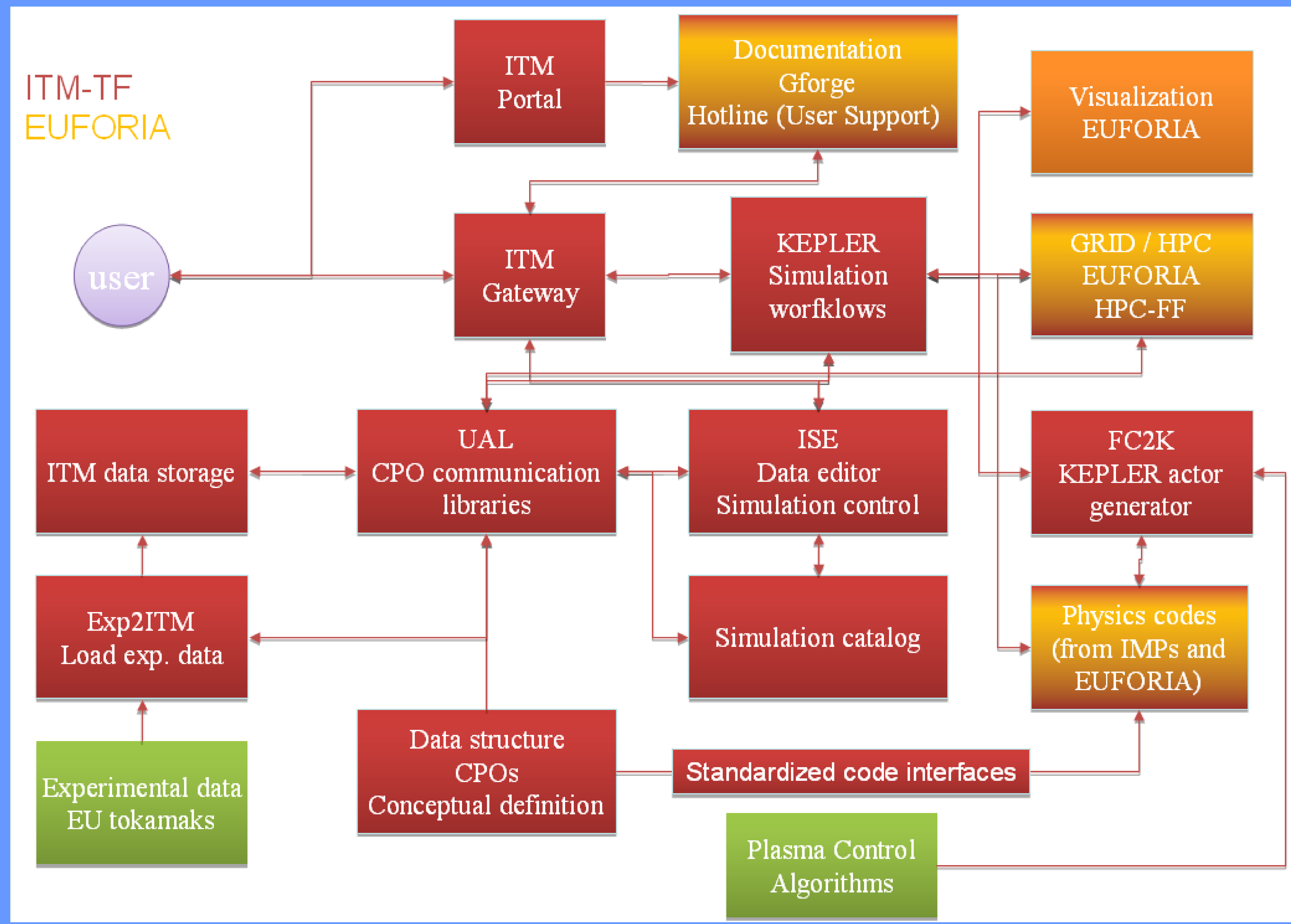
- A generic method has been developed to import data from any tokamak into the ITM-TF data model
- The ITM-TF Framework allows then to process data from any experiment with the same suite of tools

Access to GRID/HPC

- Specific actors have been developed to launch transparently components from Kepler to GRID or HPC infrastructures

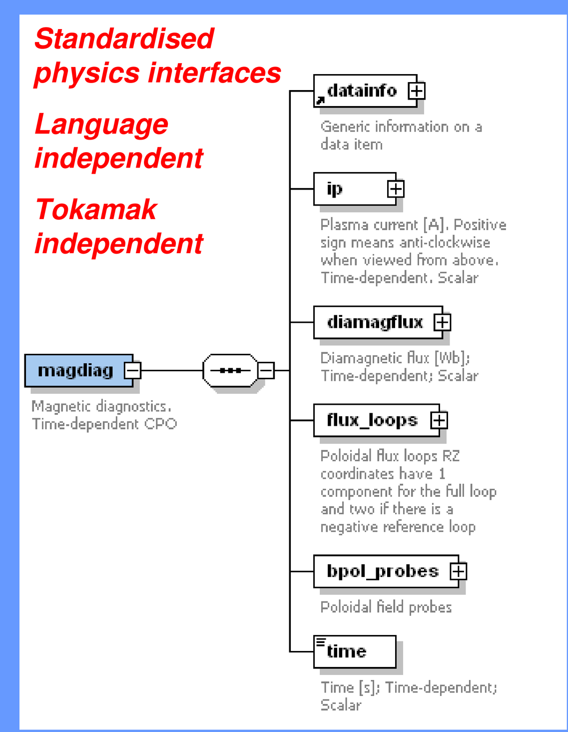
A multi-language framework

- Automated generation of the CPO communication libraries in C++, Fortran 90/95, Java, Python, Matlab
- Physicists can write their component in any of these languages



Data structure: concept of Consistent Physical Objects (CPOs)

- Standardized and Modular Interface between physics components,
  - Abstract physical concepts (equilibrium, wave propagation, distribution function…)
  - Tokamak sub-systems (diagnostics, heating systems, …)
- The CPOs gather all information related to a physical concept / tokamak subsystem.
- The definition of the CPOs is independent of
  - Particular physics components
  - Programming language
  - Particular tokamak experiment
- The CPOs are the transferable data units in a fully modular and flexible workflow: components exchange physical concepts or tokamak subsystem structures instead of hundreds of individual signals

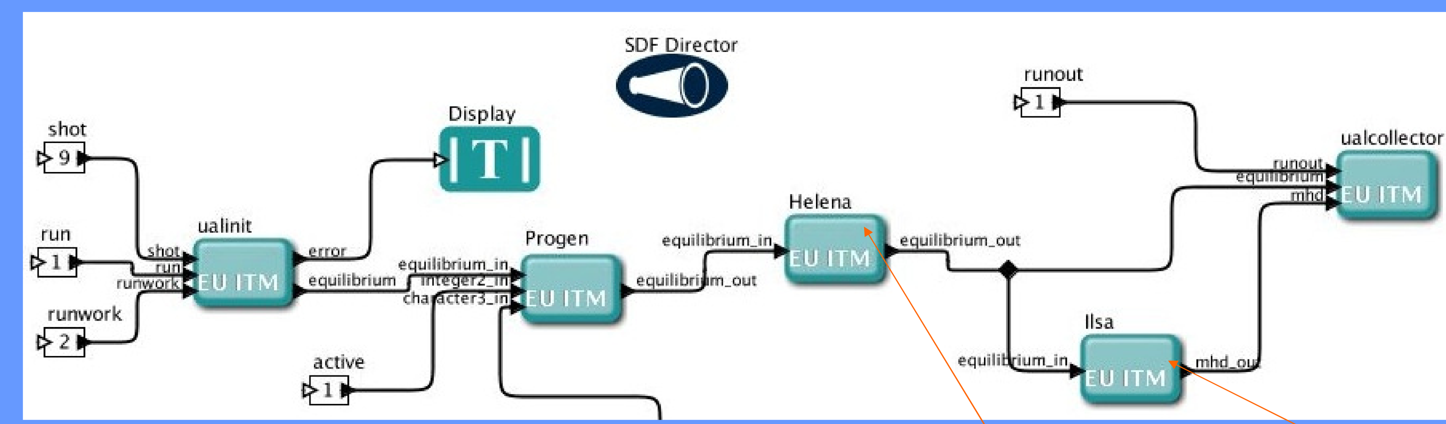


Data structure for the magnetic diagnostics (showing only the top hierarchical level)

[F. Imbeaux et al, Comp. Phys. Commun. 181 (2010) 987]

Workflow concepts

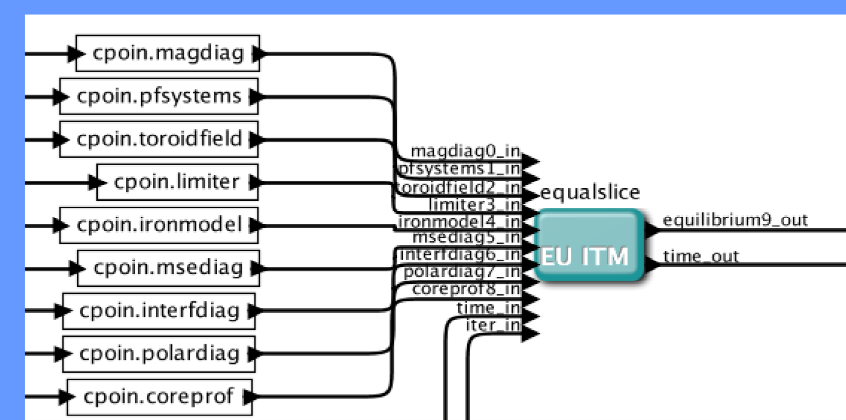
- Workflows are composed by assembling physical components in a Graphic Environment → modular, flexible, Physicist-friendly
- Owing to the physics based nature of the component interfaces (CPOs), Workflows transparently display the physics processes and their interaction
- Demonstrated with the KEPLER software (workflow orchestration http://kepler-project.org) but independent of KEPLER



Simple MHD analysis workflow (refined equilibrium + linear MHD)

Physicist-friendly generation of «components»

- The adaptation of codes for ITM framework required to physicists is minimal: it is only needed to map I/O to the relevant data structures (CPOs). No ITM specific instructions inside the code.
- A GUI allows an automated generation of a Kepler actor from the physics code



The Physicist's code appears as a component in the Kepler workflow, with links showing the input and output CPOs (here : EQUAL equilibrium reconstruction component)