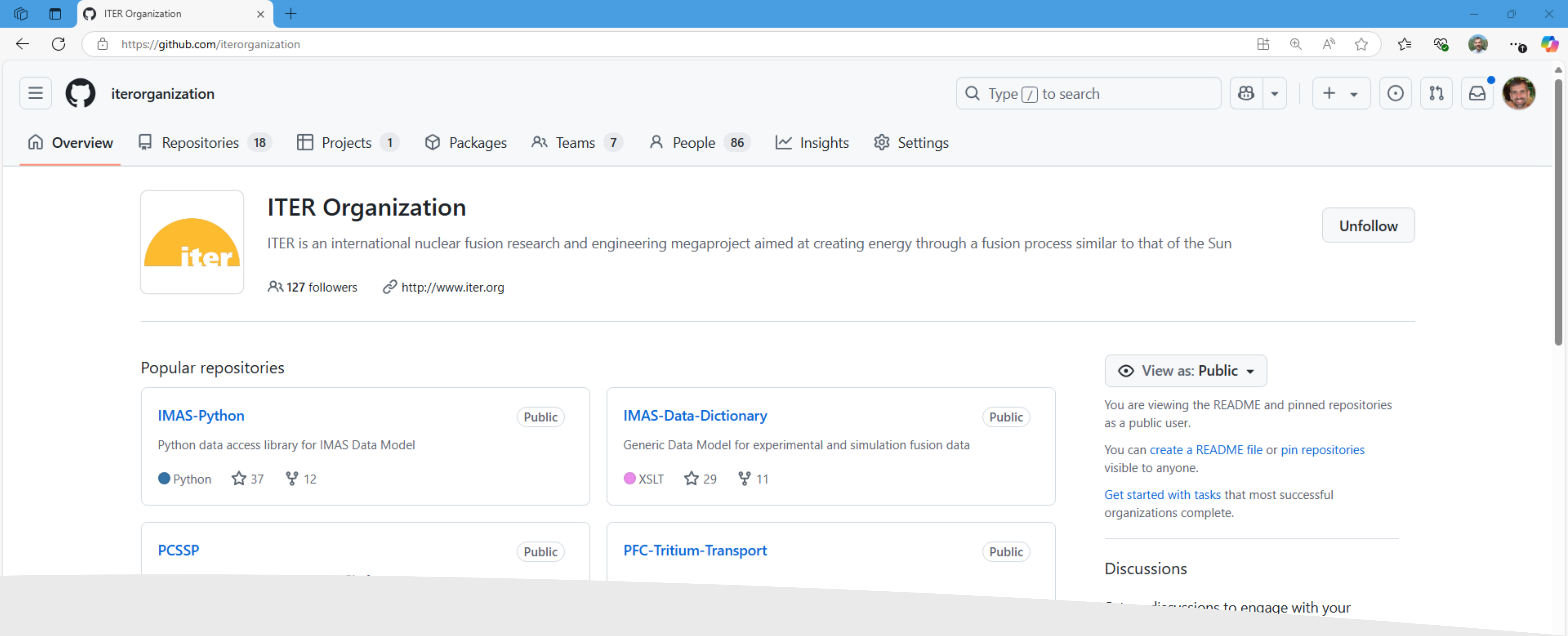


ITER Integrated Modelling Programme

Simon Pinches

Plasma Modelling & Analysis Section Leader
ITER organization

ITER International School, 30 June 2025
IDM UID: E66ZWC

china eu india japan korea russia usa

Disclaimer: The views and opinions expressed herein do not necessarily reflect those of the ITER Organization

IM Programme was endorsed as major element of the ITER Physics Research Programme by 1st ITER Council in November 2007

"Establishment of a programme on integrated modelling and control of fusion plasmas, including benchmarking and validation activities, which would be co-ordinated by the ITER Organization, but which would be developed using the relevant expertise within the Members' fusion programmes, making use of existing co-ordination structures where possible. The overall aims of this programme would be to meet the initial needs of the ITER project for more accurate predictions of ITER fusion performance and for efficient control of ITER plasmas, to support the preparation for ITER operation and, in the longer term, to provide the modelling and control tools required for the ITER exploitation phase."

Purpose of ITER's Integrated Modelling Programme

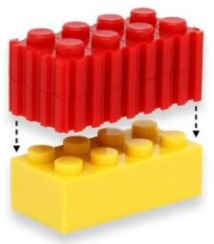
- IM Programme aims to establish a comprehensive framework for integrated modelling of fusion plasmas, which includes benchmarking and validation activities
- Development and implementation is coordinated by the ITER Organization while leveraging the expertise from the Members' fusion programmes
- Ultimate goal is to enhance the accuracy of ITER fusion performance predictions, improve plasma control for the operational phase of ITER, and deliver tools to interpret and analyze measurement data

Supporting ITER's Research Plan

- This mission describes two primary functions of the ITER IM Programme to aid the planning and execution of the ITER Research Plan
  - Providing support to Plasma Operations
  - Providing support to Plasma Research
- But it also issues a directive to engage the community in the development of the IM Programme
- Successful development and implementation requires close collaboration between the ITER Organization (IO) and ITER Members' domestic fusion programmes
  - To take advantage of the wealth of knowledge and experience within present facilities

Integrated Modelling Programme support for Plasma Operations

- Supporting Plasma Operations requires a set of physics modelling tools that are executed prior to operation for pulse design and validation, during the pulse for live display, and post-pulse for comprehensive reconstruction of the plasma from the full set of diagnostic measurements
  - These tools must be computationally efficient, robust, and well-documented
  - They should capture the macroscopic behaviour of the plasma with a level of fidelity that improves as ITER operation explores the new physics domain of burning plasmas
- Collectively, these modelling tools comprise the **Integrated Modelling & Analysis Suite (IMAS)**

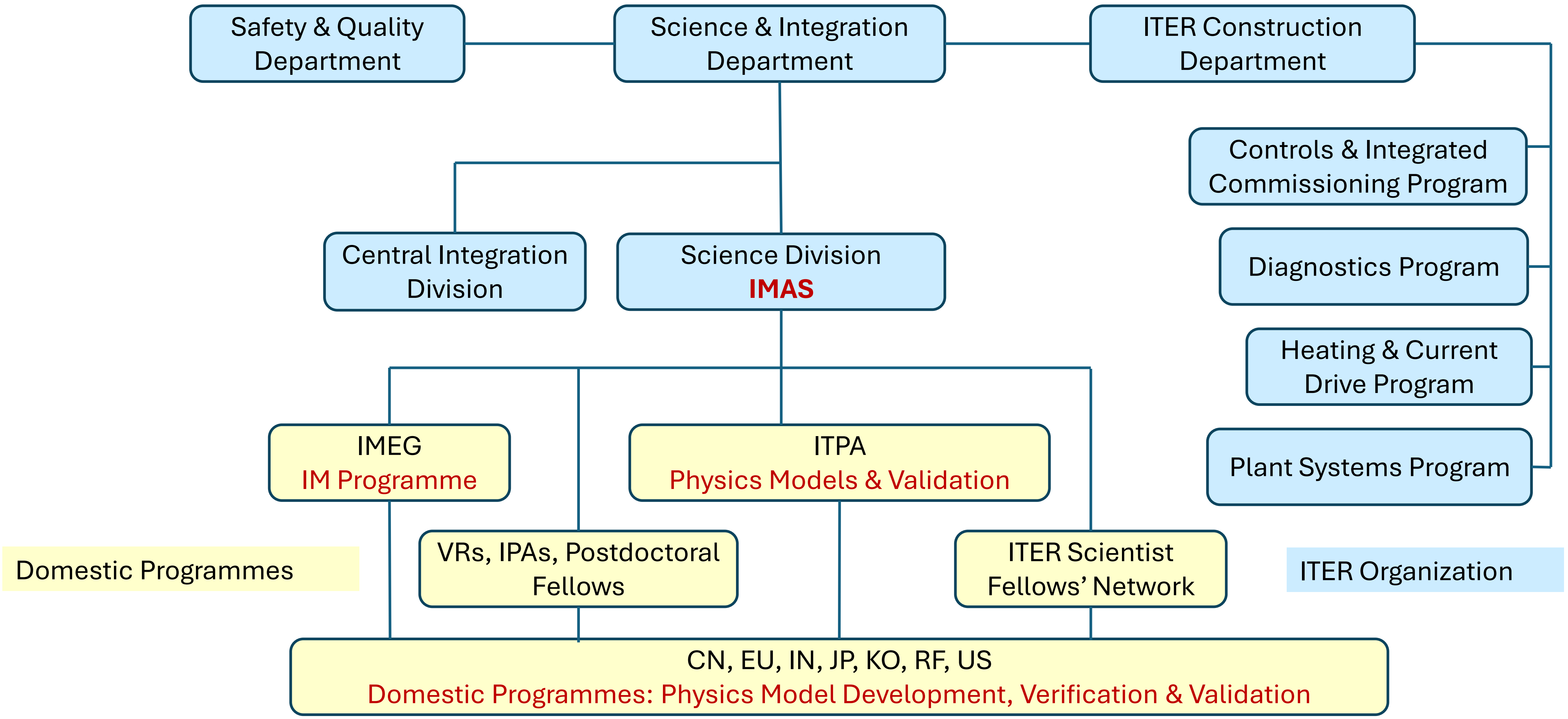


- Development of IMAS requires strong collaboration with the Parties' domestic fusion programmes to take advantage of their experience

Integrated Modelling Programme support for Plasma Research

- Supporting Plasma Research requires a much more extensive set of modelling tools to be employed both prior to operation and post-operation
- These tools may examine microscopic behaviour, investigate more rigorous theoretical or computational behaviour, or explore new physics
- They are the primary basis for model improvements and validation. They may be applied to selected pulses, segments or time slices, and may often require significant high performance computing capabilities
- In addition to an initial demonstration of their validity and robustness, there should be a continual cycle of refinement and re-validation

Coordination with ITER Members



IM Programme links with International Tokamak Physics Activities

- The ITPA Charter identifies the following internationally coordinated physics R&D activities relevant to the IM Programme:
  - Provision of validated experimental data according to agreed formats
  - Presentation of analyzed experimental results to advance understanding
  - Organization, management, and updating of qualified databases
  - Development of theoretical models and simulation results to explain and reproduce experimental results
  - Investigation and documentation of plasma scenarios suitable for ITER exploitation
  - Exploration of ITER’s potential as a burning plasma experiment by modelling and simulation experiments in present devices
  - Identification and resolution of key heating and current drive, diagnostics, and fuelling issues which might arise in plasma control and analysis of ITER plasmas

Activities of Integrated Modelling Expert Group (IMEG)

- The IMEG Charter identifies the following Programme Development responsibilities:
  - Identify candidate components for core suite from elements in Members' programs
  - Identify gaps in the coverage of the core physics capabilities
  - Establish schedules and tasks for development / adaptation of core components
  - Estimate resources required for execution of tasks
  - Develop links to supplemental modelling capabilities within the Members' programmes
  - Identify opportunities to use other experimental facilities as test beds for the core suite (e.g., control and data analyses)
  - Identify user support needs for the core suite
  - Establish schedules for workshops and training

IMEG representatives: 1 or 2 from fusion programme of each ITER Member, plus a DA contact

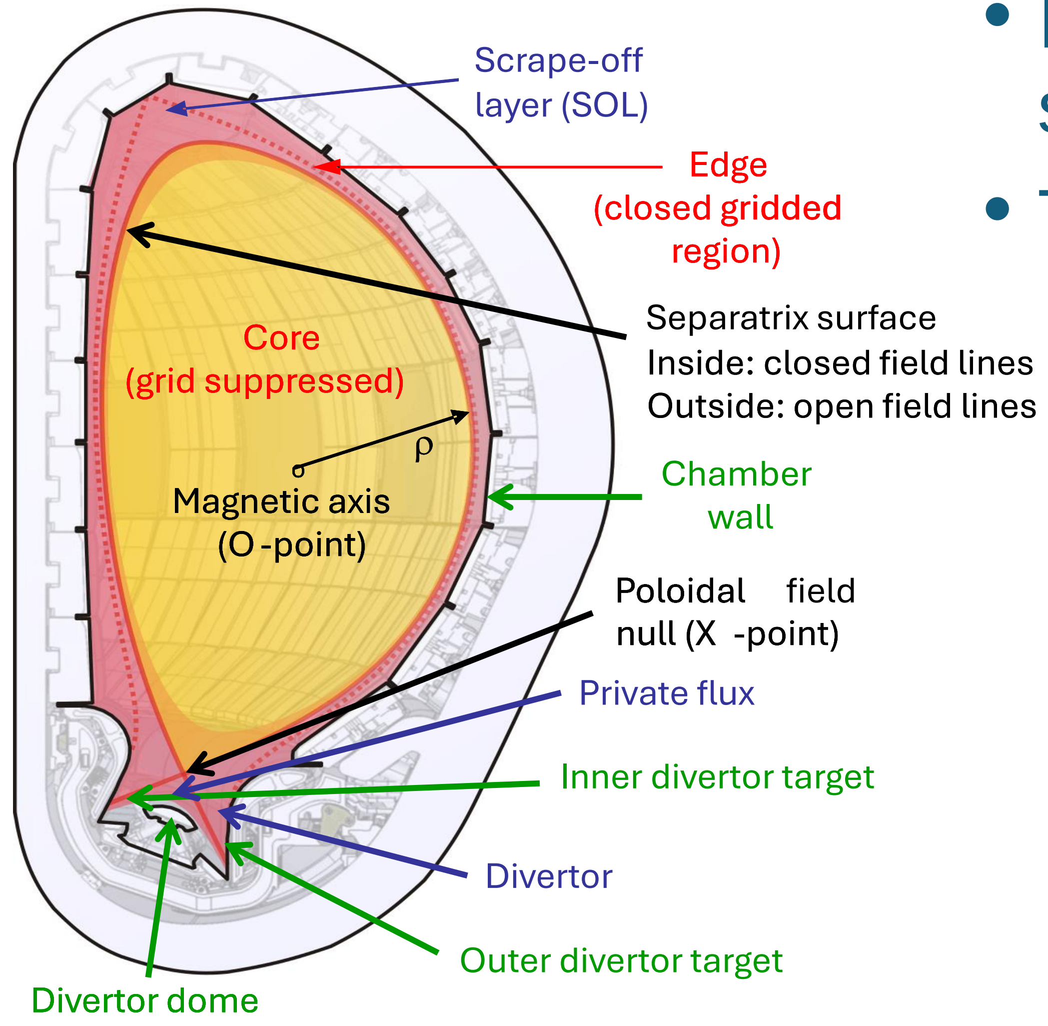
Integrated Modelling & Analysis Suite

IMAS is composed of the following layers:

- **Data Model**
  - Machine independent data structures
  - Simulation and experimental data
  - Can be used for code coupling (→ integrated modelling)
  - Metadata and provenance (→ FAIR principles)
- **Generic software tools**
  - Data access, storage and manipulation
  - Data visualisation
  - Assembling, executing and managing simulations
- **Physics applications**
  - Standalone physics codes
  - Data processing pipelines or workflows
  - Multi-machines databases

IMAS is the collection of physics software which will be used for the systematic planning and analysis of each ITER discharge...

Physics integration challenges



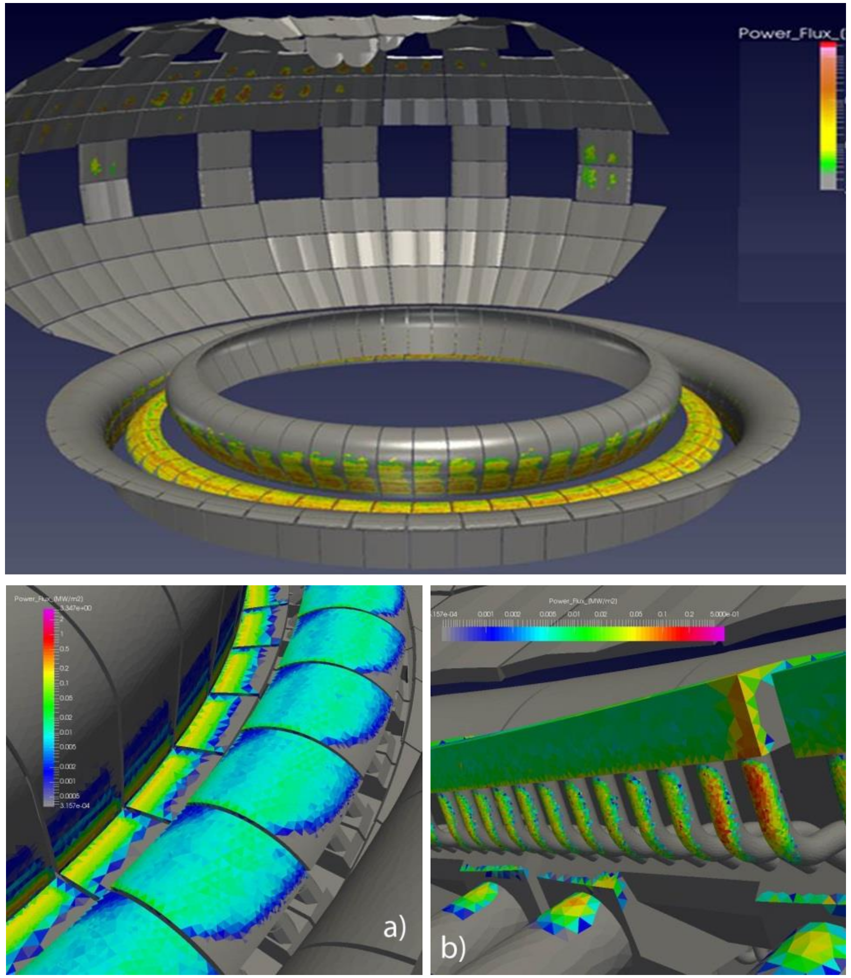
Legend
Magnetic surface features
Plasma on closed flux surfaces
Plasma on open flux surfaces
Limiting material surfaces

- IMAS is expected to evolve toward a more self-consistent description of the plasma
- This ultimately requires:
  i. Coupling of all spatial plasma domains (core, edge, scrape-off layer and divertor);
  ii. Dynamic coupling of individual physics models that are relevant in each domain;
  iii. Interaction between the plasma and plasma facing components (PFCs);
  iv. Models for actuators and diagnostics; and
  v. Coupling of the plasma with external circuits, heating, current drive, fuelling, pumping, etc.

Computational Challenges

- Explore new algorithms and techniques as hardware evolves
  - Re-examine traditional approaches
- Exploit advances in architecture
  - E.g. Speed-up $\times$50 over single core by using GPU to follow fast ions → $\times$200 using four GPU cards
- Exploit Machine Learning (AI/ML) techniques...

Beam ion power flux due to 3D fields from ELM coils, TF ripple and ferritic inserts



R. Akers *et al.*, LOCUST-GPU

High Fidelity Plasma Simulator (HFPS)

- A High-Fidelity Plasma Simulator is needed to model complete integrated ITER scenarios (including PF circuits, core-pedestal-SOL and PWI effects)
- Plan is flexible and can adapt to relevant physics and modelling developments within ITER Members
- Use of standardized data representation (IMAS Data Model) supports connections to other workflows such as the Energetic Particle Stability Workflow (EP-WF)
- The primary use cases include
  - Preparation of ITER scenarios for experimental campaigns
  - Support for validation of ITER systems and components (actuators, diagnostics and controls)
  - Interpretative modelling of ITER discharges

Physics components required for HFPS

- Forward free-boundary **equilibrium evolution** in response to **magnetic control** and within coil current, field and force limits
  - Controls and limits need to be quickly updated with as-built components
- Core-edge-SOL coupled **time-dependent** plasma and neutral transport
  - 2D edge/SOL transport grids need to be updated along with the plasma shape (configuration) evolution
- Auxiliary heating and current drive (EC/IC/NB), particle sources and sinks (gas/pellets/pumps/PFC), nuclear reactions
  - Feedforward and/or feedback controls within ITER systems and configurations
- Transport (empirical/scaling-based/physics-based), MHD (STs, NTMs, ELMs, AEs) and plasma stability models
  - Various types of (high performance) physics models

Progress in development of HFPS based on JINTRAC-DINA

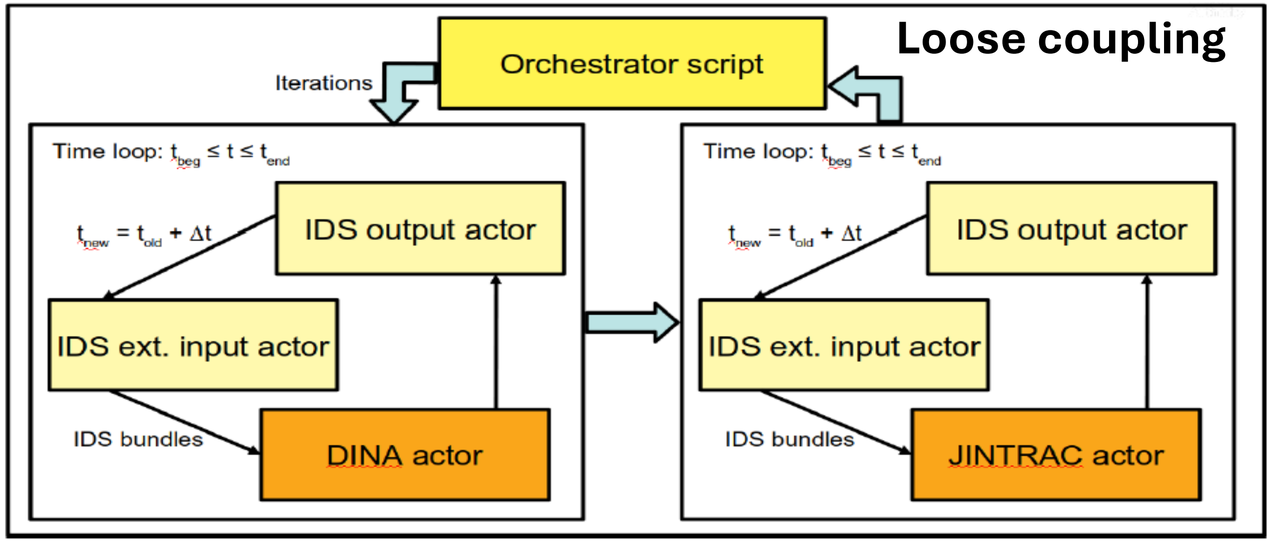
- Current ITER HFPS development activity is based on integration of
  - JINTRAC (core-edge-SOL transport with sources and exhaust, and kinetic control)
  - DINA (free-boundary equilibrium evolution and magnetic control)
  - H&CD workflow (heating and current drive physics)
  - and implementation of new features (2D edge / SOL grid evolution, W wall source, etc.)
- Developments aim to build on previous loose-coupling demonstrations of JINTRAC-DINA to create an efficient tight-coupling workflow exploiting the MUltiScale Coupling Library and Environment, MUSCLE3, and including H&CD workflow

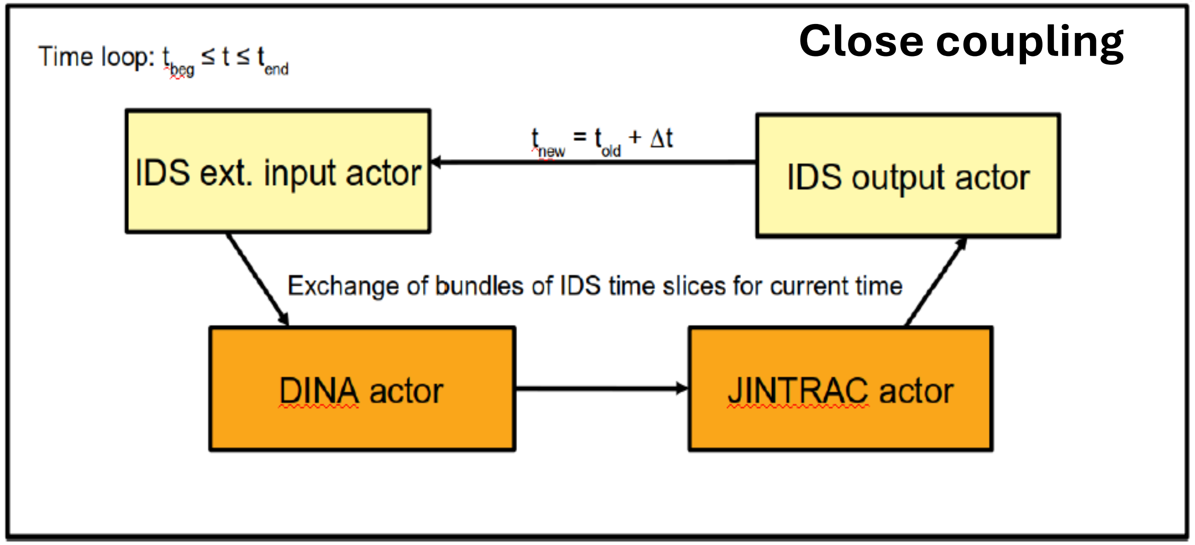
- NB. This is the *only* integrated modelling workflow that is capable of time-dependent coupled FBE core-edge-SOL transport simulations

S.H. Kim, F. Köchl, J. Lee, G. Suarez Lopez

Coupling of DINA and JINTRAC in HFPS

- Code coupling schemes designed to be complementary to each other
  - Loose iterative coupling with a convergence test
  - Close non-iterative coupling with a small time-step required for good convergence
- Both coupling schemes have been demonstrated in previous work
  - Loose coupling of DINA/JINTRAC (F. Koechl, IAEA 2018, P6-14)
  - Close coupling scheme with DINA-CH/CRONOS (S.H. Kim, PPCF 51 (2009) 105007)



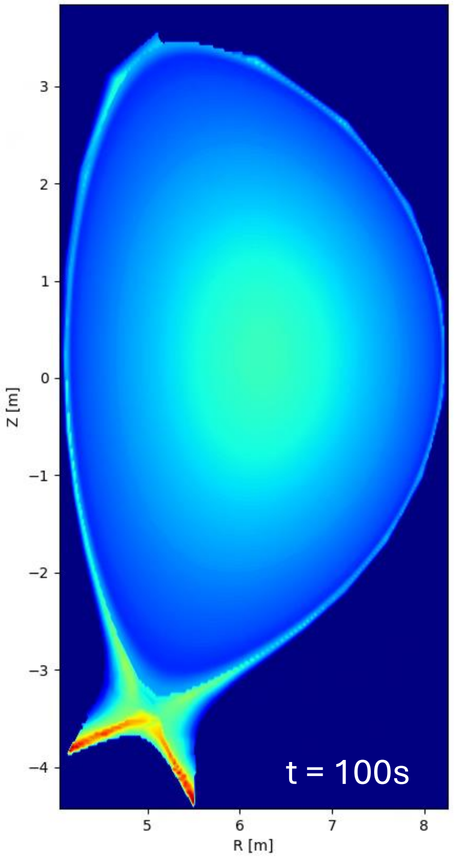


First integrated physics assessment of baseline DT scenario

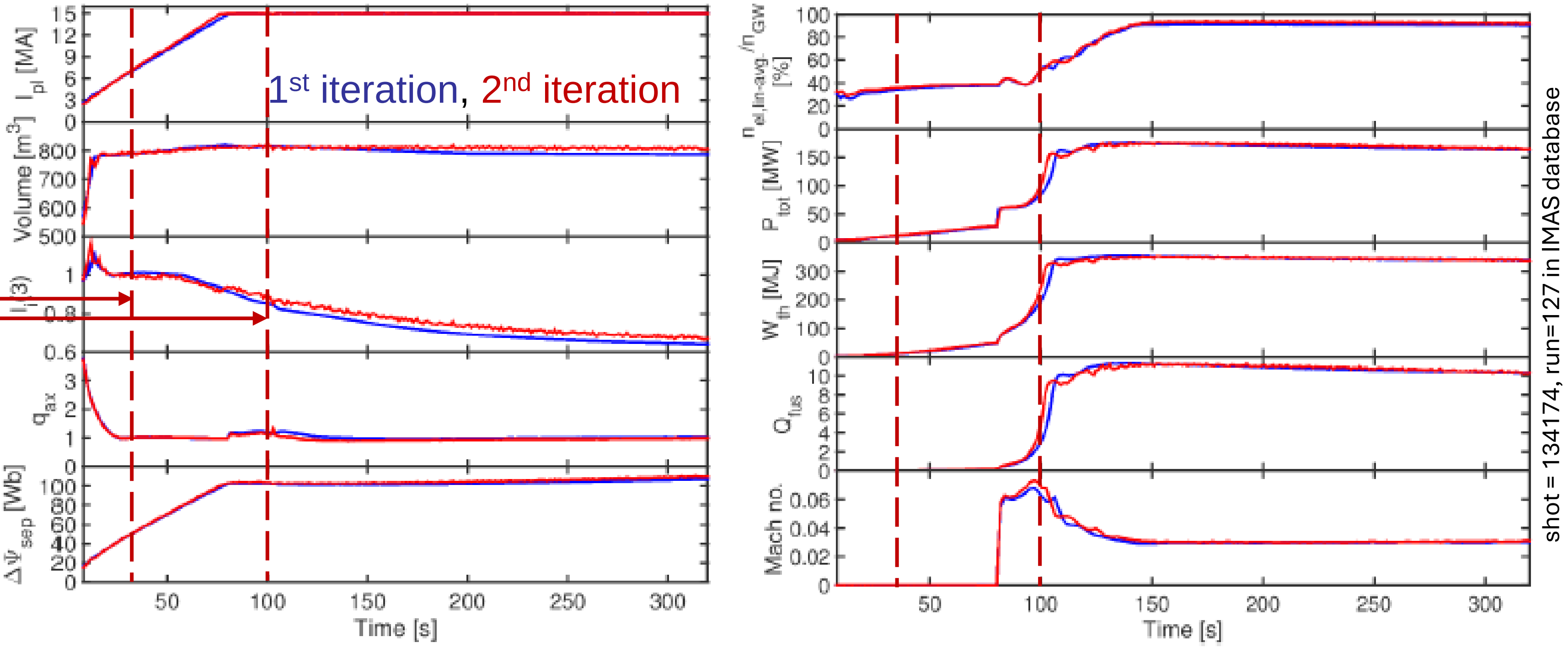
- Free-boundary equilibrium code DINA and the JINTRAC suite of codes adapted to IMAS and used to simulate the 15 MA / 5.3 T DT Q=10 ITER baseline scenario (F. Koechl, IAEA 2018, P6-14)

- For first time, scenario as… e ev… amp-up ph… fo… amp- dc… nt- lin… neans of int… s ind… and SC… ne- de… dary pl… l pe… termined by… nsistent ec… nalysis

2-D radiation



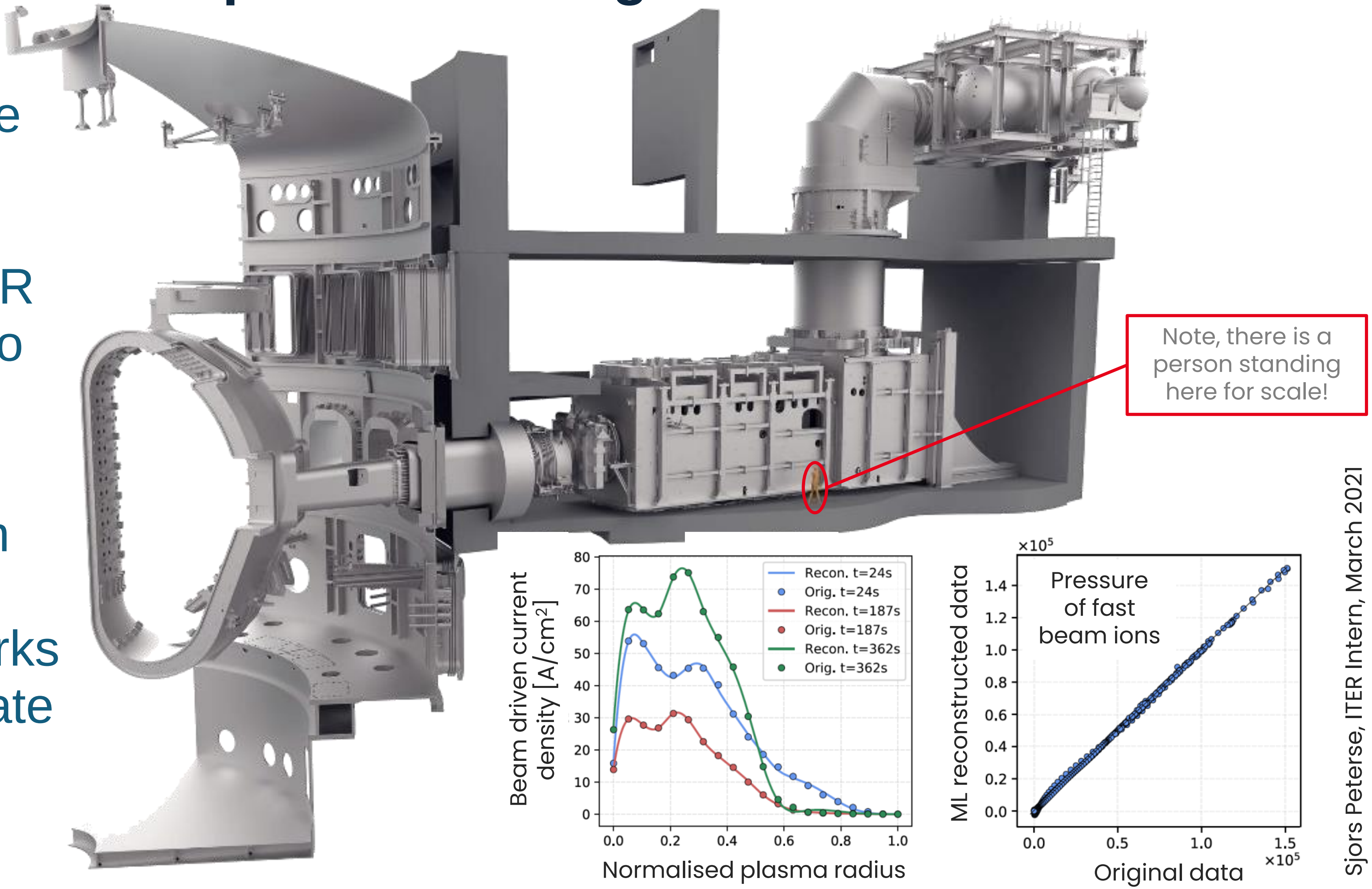
End-to-end IMAS simulation of 15 MA Q = 10 DT baseline scenario with DINA-JINTRAC IMAS workflow



Good convergence between JINTRAC and DINA after 3rd manual iteration

Accelerating simulations of plasma heating

- The IO's well-validated high-fidelity models have a computational burden that means a full high-fidelity simulation of ITER takes around a month to complete
- Machine Learning (ML) has allowed the creation of surrogate models based on Neural Networks that can retain appropriate physics fidelity but are tens of thousands of times faster, if not more!

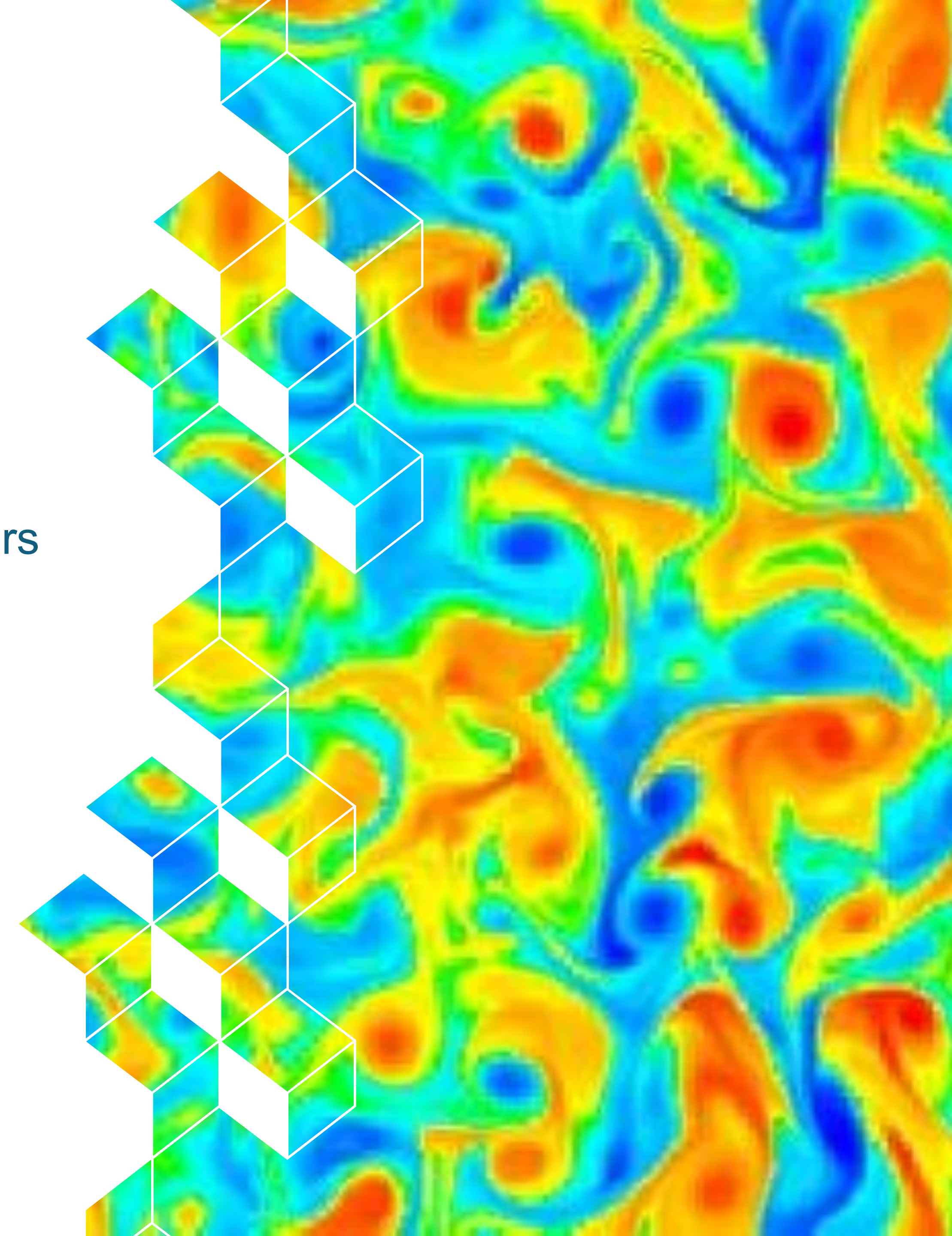


Sjors Peterse, ITER Intern, March 2021

Turbulent transport models that are hundreds of thousands of times faster

- Properly describing turbulent transport is crucial for understanding how heat, particles, and momentum are confined in fusion-relevant plasmas
- First-principles models like gyrokinetic simulations are highly accurate but computationally expensive – ITER simulations are run on the world's fastest supercomputers
- Reduced models (e.g. TGLF, QuaLiKiz) offer a faster alternative but still have limitations in speed and scope
- AI (ML) can be used to build surrogate models that emulate complex transport models but are *much* faster ($\times\ 10^3 – 10^5$) than even the reduced models

- The ITER Integrated Modelling Programme will endeavour to capitalize on such approaches



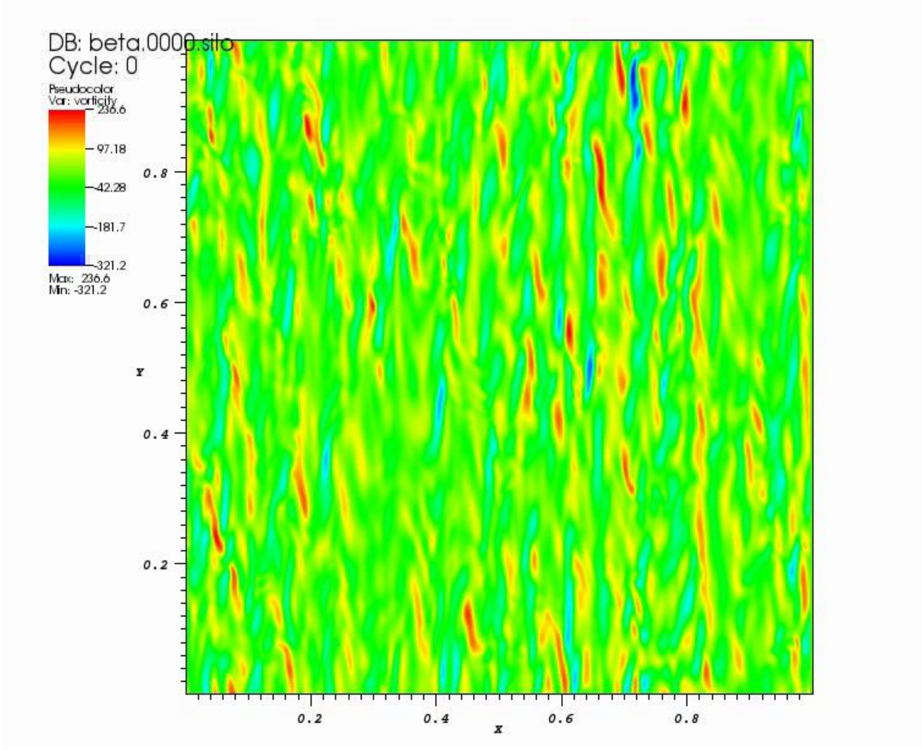
K.L. van de Plassche et al., Phys. Plasmas 27, 022310 (2020)

Other simulation acceleration techniques

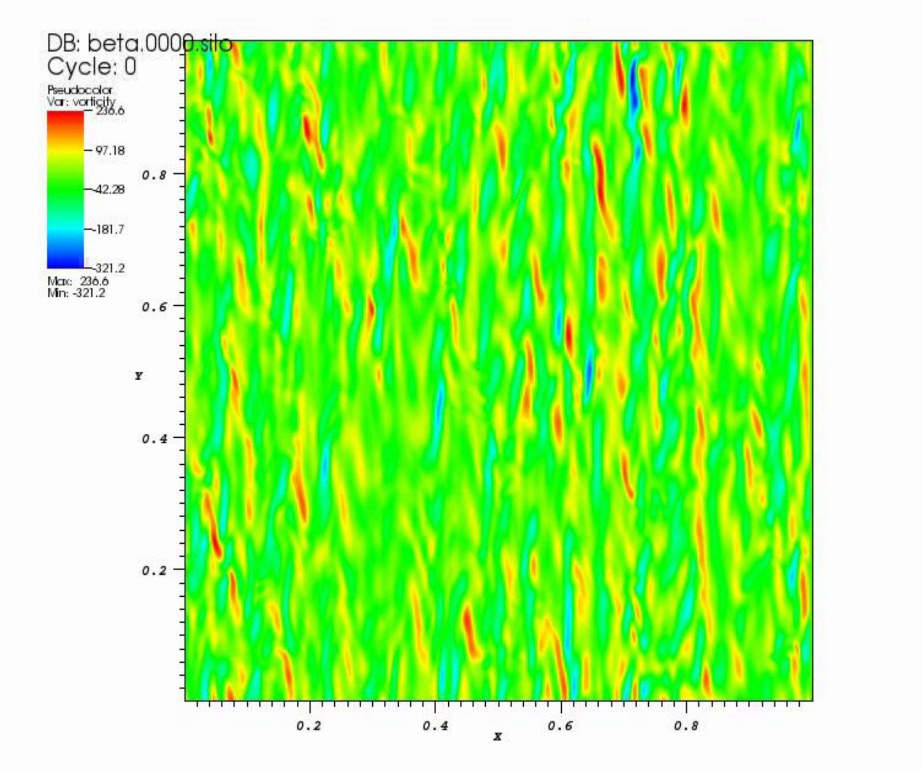
- Parareal technique (time parallelisation based on an iterative predictor–corrector approach) investigated as method to accelerate ITER transport simulations performed with CORSICA
  - 2D equilibrium package + transport models + source modules developed by Lawrence Livermore National Laboratory, USA
- Computationally intensive
- Parareal algorithm relies upon ability to create coarse / fine runs and the ability to restart
- With analytic source terms: Gain of **8.32** on 12 processors
- With NBI source terms: Gain of **10.13** on 32 processors

Debasmita Samaddar, ITER Monaco Postdoctoral Fellow

Parareal Algorithm and Turbulence



Serial Solution



Parareal Solution
8.805 × faster on 88 processors

D. Samaddar *et al.*, J Comp. Phys. **229** 18 (2010)

Achieving more self-consistency

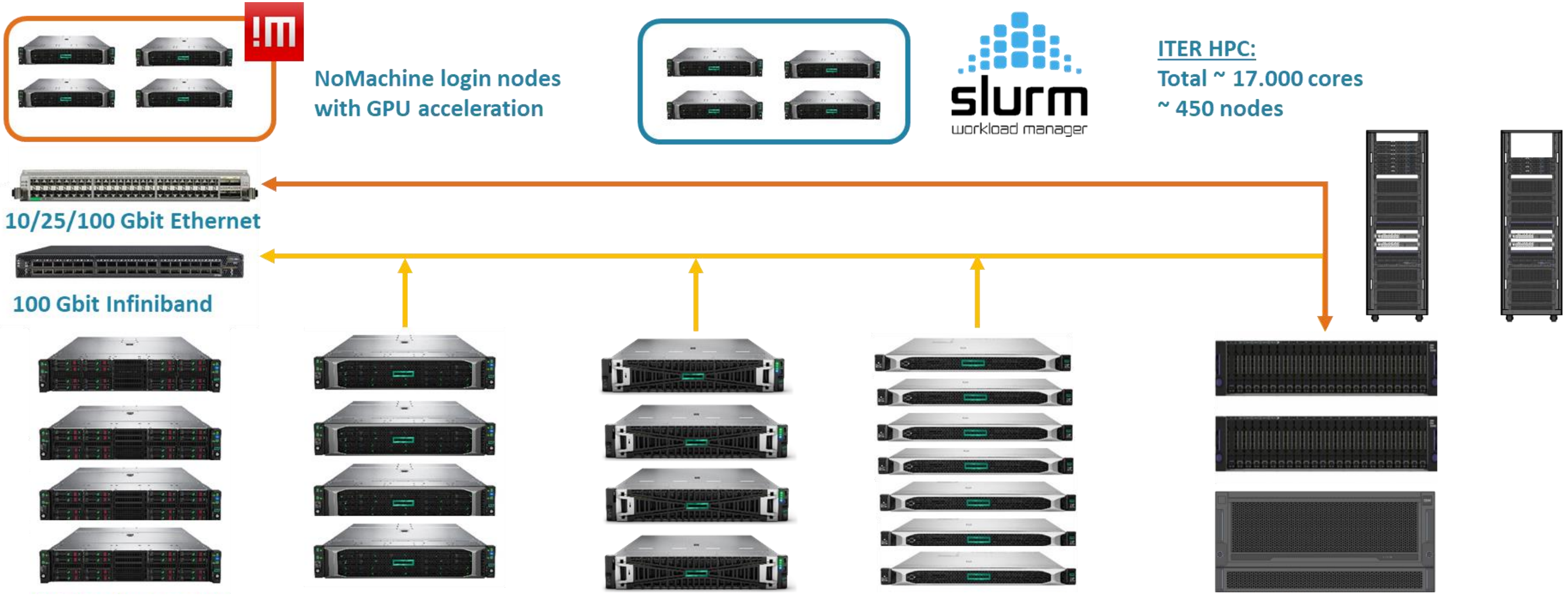
- Limiter plasma start-up (EC-assisted with W accumulation from consistent sources and edge/core transport) is an example of a highly nonlinear phase that would benefit from a more self-consistent treatment
- A complementary architecture is therefore being explored that more explicitly exploits MUSCLE3 to deliver more self-consistent coupling of multiscale and multi-physics (not just code coupling) with stateful actors
- The modularity of the core components of the European Transport Solver (ETS) makes it suitable for initial development and testing
- Increased modularity and flexibility is also expected to empower community contributions and collaboration → First release end of 2025
- The approach is intended to be compatible with any external physics models that respect IMAS APIs for input/output

F. Poli

Pulse Design Simulator (PDS)

- A multi-component application for the rapid design and simulation of ITER pulses that are ensured to operate within predefined limits and conditions
- PDS will interface with:
  - Pulse Schedule Preparation System (PSPS) and Pulse Schedule Editor (PSE) to read and write pulse schedules and submit them for operation approval
  - The CODAC Configuration, Verification and Validation Framework (CVVF) to ensure that a pulse design will operate within defined operating limits and conditions (OLC)
  - Plasma Control System Simulation Platform (PCSSP) to perform co-simulations with PCS components
- Initial developments include models for
  - Plasma initiation (TRANSMAK/SCENPLINT), equilibrium and transport (DINA, TORAX, NICE), and H&CD

ITER's Scientific Data & Computing Centre (SDCC)



HPE Apollo Gen9 Cluster
102 Compute nodes
2 X Intel 16 core
128 GB Ram
56 Gbit Infiniband
10/25 Gbit Ethernet

HPE Apollo Gen10 Cluster
156 Compute nodes
2 X Intel 5220 18 core
192 GB Ram
56/100 Gbit Infiniband
10/25 Gbit Ethernet

HPE Apollo Gen11 Cluster
80 Compute nodes
2 X Intel 6348 28 core
512 GB Ram
100 Gbit Infiniband
10/25/100 Gbit Ethernet

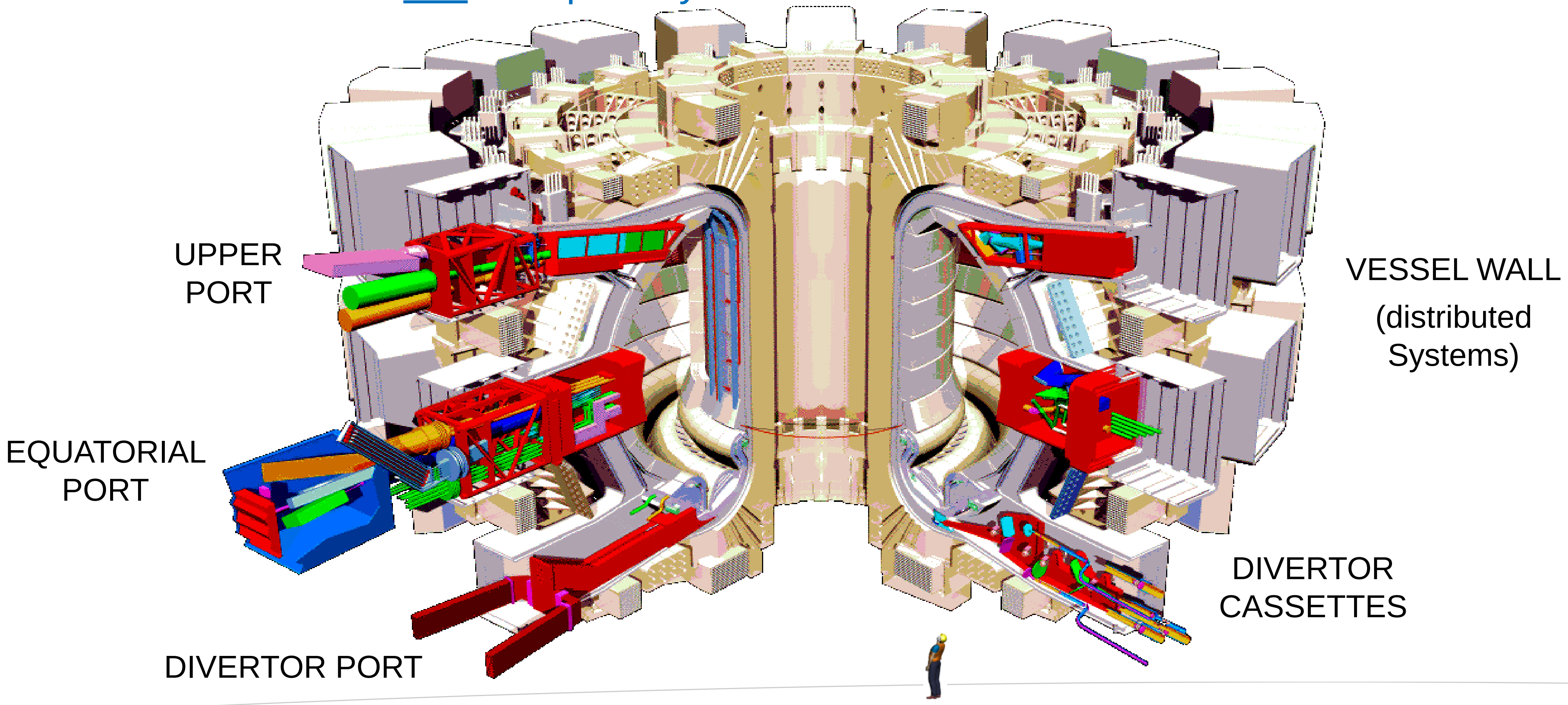
HPE DL360 Gen11 Cluster
139 Compute nodes
2 X Intel 6416 18 core
512 GB Ram
100 Gbit Infiniband
10/25/100 Gbit Ethernet

IBM ESS 3500 V7000 Storage Cluster
16 - 60 GB/s Write / 120 GB/s Read
7 PB Total Capacity (+ 4 offsite)
15+ File systems
HPC / SDCC / BACKUP
8 x 100 Gbit IB

ITER diagnostics will generate Big Data

About 40 major diagnostic systems (= very well diagnosed)

- For **machine protection**, **control** and **physics studies**
- Can reach 2.2 PB of raw data per day



ITER will produce Big Data: Volume Estimates

- In DT phase, ITER will operate for 16 out of 24 months
  - 2 years × 52 weeks × 16 / 24 = 69 weeks every 2 years
- Operation consists of 2 shifts for 12 / 14 days
  - 12 / 14 × 69 = 59 weeks of data producing days every 2 years
- Typical day expected to produce up to ~2.2 PB of raw data
  - 2.2 PB × 59 × 7 / 2 = 0.45 EB / year of raw data
  - Data processing and analysis will further increase volume, although this is not expected to be significant
  - Largest fraction of data is expected to be camera data

Automated Processing of Data

- Envisaged data processing chains will run concurrently (in-pulse on dedicated hardware) as soon as their input raw data dependencies (in form of IDSs) are satisfied during a pulse
  - Whilst some simple linear chains will have modest computational requirements, more complex statistical (Bayesian) inference chains may consume significant resources
  - Since these latter chains are envisaged to be highly parallelizable, computational capabilities should ensure delivery of processed data does not impact inter-shot time or delay next pulse

    → Scalable parallel computing infrastructure (testing Kubernetes)
  - Close collaboration with devices which can map and serve raw data and matching Machine Description data → allows development and validation of workflows now
  - First example/near-term target: magnetics-only equilibria

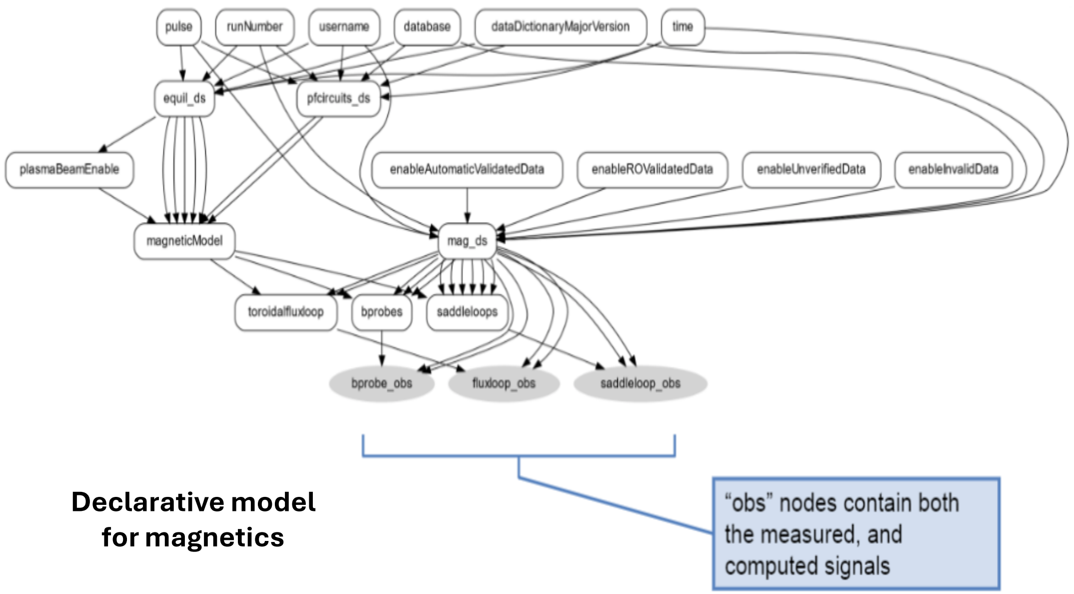
Data Analysis and Interpretation Platform

- Call for initial development launched following discussions with ITPA Topical Group on Diagnostics and IAEA Technical Meeting on Fusion Data Processing, Validation and Analysis (driven by IMEG)
  - ITPA Diagnostics provide voluntary support for development, evaluation and testing;
- Minerva being evaluated for rigorous interpretation and analysis of experimental data and for a community of users (IO staff & externals) to gain experience with its use and application (in parallel with other community-led approaches)
  - Interpret data from individual diagnostics;
  - Unified methodology for integrating data from multiple diagnostics to obtain improved results with derived uncertainties;
  - Support generation of realistic synthetic diagnostic data to assess performance of diagnostics and develop data interpretation techniques;
  - Estimate hardware requirements to support running automated interpretation workflows that combine a realistically achievable combination of diagnostics during ITER's SRO and DT phases;

Synthetic diagnostics in Minerva

- Initial focus on developing diagnostic forward models (synthetic diagnostics) for SRO operation
- Population of associated Machine Description data:
  - Magnetic coils, flux loops, Rogowski loops:
    - input = magnetics, pf_active, pf_passive, equilibrium
    - output = magnetics
  - VSRS, H-alpha:
    - spectrometer_visible
  - interferometry:
    - interferometer
  - X-ray spectrometer (edge/core/survey):
    - x_ray_crystal_spectrometer

- Model to compute toroidal flux loops, saddle loops and pickup probes.
  - Both pf currents and plasma current included



Declarative model for magnetics

- Early application:
  - Assessment of diagnostic coverage for early detection of L-H transition (Anna Medvedeva, Monaco PDR)

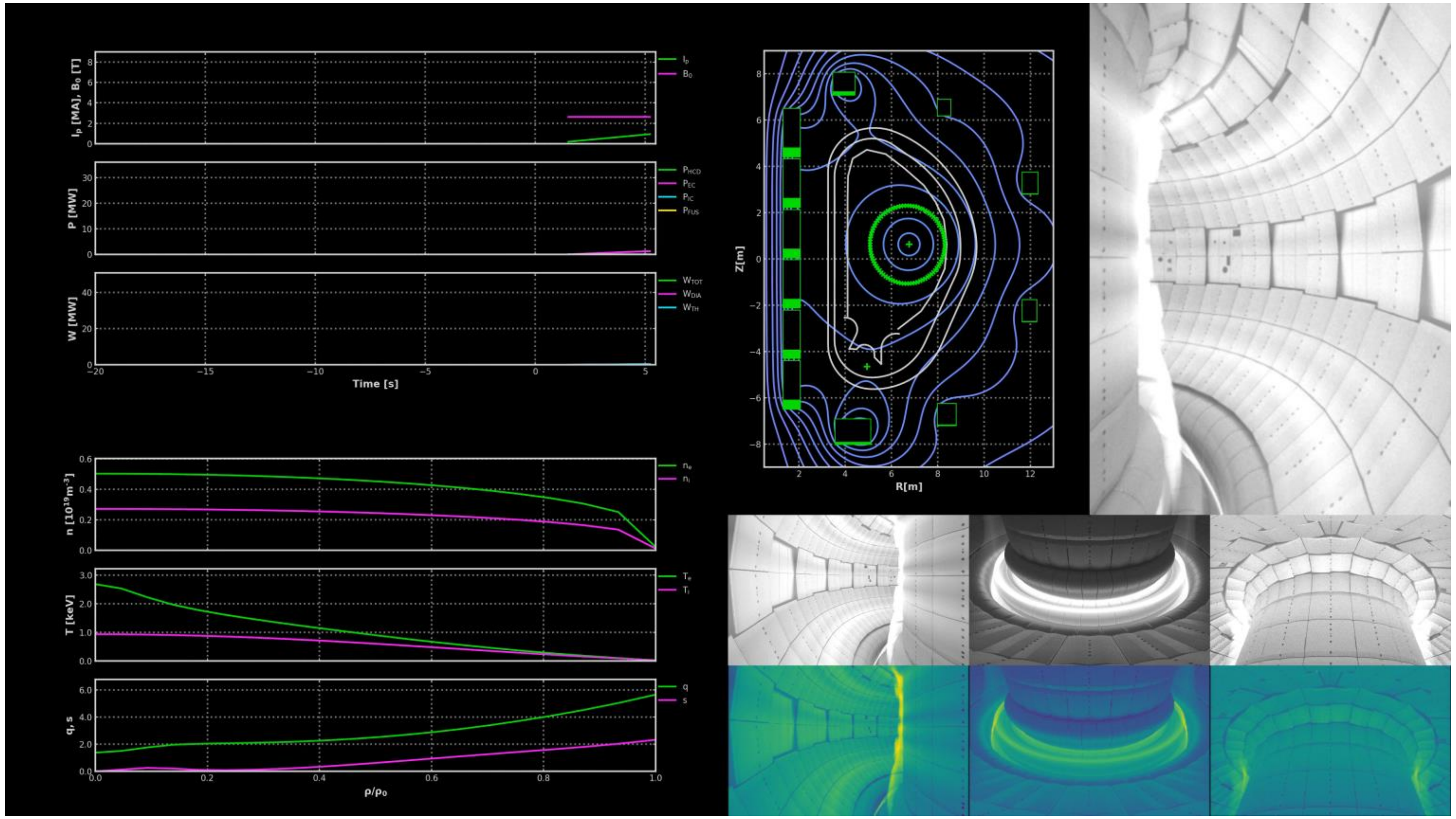
Integrated Data Analysis

- Growing list of synthetic diagnostics developed for, or adapted to, IMAS
  - >20 models
- Start of development of IDA workflows for combining signals

Diagnostic (+ITER PBS identifier)	Contacts	Source Code Repository	Dependencies	In IMAS	Regression Tests	Documentation	Demonstration input data	Applications: Design, Physics, Control
Magnetics **55.A***	Author: @Appel Lynton EXT IO Contact: @Abreu Paulo	predictMagnetics	Minerva	yes	CI tests in bamboo	Implementing Agreement with UKAEA, Task 5 Report	DINA scenarios: 105027/2/public/ITER and 135011/7 ASTRA scenarios: 134046/2/public/ITER	D/P
Calculates the generic light spectrum for all visible spectrometers and cameras.	Multi-authors. Current main developer: @Shabashov Aleksei EXT IO contact: @De Bock Maarten	CASPER	CHERAB	yes	no	In the future to come.		D/P
Charge Exchange Recombination Spectroscopy, for Core / Edge / Pedestal **55.E1 / 55.EC / 55.EF**	Author: Alexey Shabashov IO contact: @De Bock Maarten	CXRS	CHERAB	yes	no	Presentation: 3U2DBZ Report by Maxim Bykov based on old material (Matlab): X3NAVL		D/P
H-alpha and Visible Spectroscopy **55.E2**	Author: @Khusnutdinov Radmir EXT IO contact: @De Bock Maarten	H-alpha	CHERAB	yes	no	Report: 2N57XR		D/P
Divertor Impurity Monitor (DIM) **55.E4**	Author: @Natsume Hiroki EXT IO contact: @De Bock Maarten	DIM	CHERAB	yes	no	Presentation: 2C7R9M To be published in Plasma and Fusion Research: 3Z47PC		D/P
Visible Spectroscopy Reference System (VSRS) **55.E6**	Author: Bart van den Boorn IO contact: @De Bock Maarten	VSRS	CHERAB	yes	no	Report: 3AKPSV Presentation: 3TY5AU	134000/60/public/ITER 122264/2/public/ITER	D/P
Thomson Scattering: • **55.C1: Core** • **55.C2: Edge** • **55.C4: Divertor**	Author: Matej Tomes @Tomes Matej EXT IO Contact: C1 and C2: Michele Bassan @Bassan Michele EXT C4: Mark Kempenaars	CASPER (in development)	CHERAB	yes	no	In development. Regular progress meetings here (look for "TS modelling").		D/P

Control Room Live Display

- Simulation of 7.5 MA / 2.65 T He^4 plasma in ITER



Example control-room Live Display calculated using ITER scenario database and showing plasma equilibrium, waveforms and profiles (based on JINTRAC simulation, shot=110005; run=1), together with synthetic views from the Wide Angle Viewing System (WAVS) (based on shot=122264, run=1).

Using AI to help refactor legacy code and lower maintenance burden

- Not a turn-key solution: lack of open-source Fortran code causes difficulties for LLMs

- **Original source code, created in 1985**
- Includes common blocks and nested go to statements

```
c**                                                                    **
c**     RECORD OF MODIFICATION:                                        **
c**          05 03/85..........first created                           **
c**                                                                    **
c**                                                                    **
c***********************************************************************
      dimension   psi(nwnh), sia(nwnh)
      common/bunemn/m,n,s,shift,dr,dz
c-----------------------------------------------------------------------
c copy psi into sia rowwise                                            --
c-----------------------------------------------------------------------
      do 2 i = 1,nwb
      ii = (i-1)*nhb + 1
      do 2 j = 1, nhb
      sia(i+j*nwb-nwb) = psi(ii-1+j)
    2 continue
      ia = nwb+nwb
      ju = n*nwb
c-----------------------------
c set up for rzpois
c-----------------------------
      do 3 i = ia,ju,nwb
      sia(i-m+1) = sia(i-m+1)+(.5+.25/(1.+shift/dr))*sia(i-m)/s
```

- **Code refactoring using Copilot…**
- Benefits from increased readability and a reduced maintenance burden

```
! bunema.f - Modernized version with module-based approach
! Refactored to remove common blocks and use modern Fortran standards

program main
  use bunema_mod
  implicit none

  ! Declare variables
  double precision, dimension(:), allocatable :: psi, sia
  integer :: nwb, nhb, nwnh

  ! Initialize variables
  nwb = 10
  nhb = 10
  nwnh = 100

  ! Allocate arrays
  allocate(psi(nwnh), sia(nwnh))

  ! Initialize arrays
  psi = 0.0d0
  sia = 0.0d0
```

The Data Dictionary is a core component of IMAS

Definitions are stored in multiple files using markup language

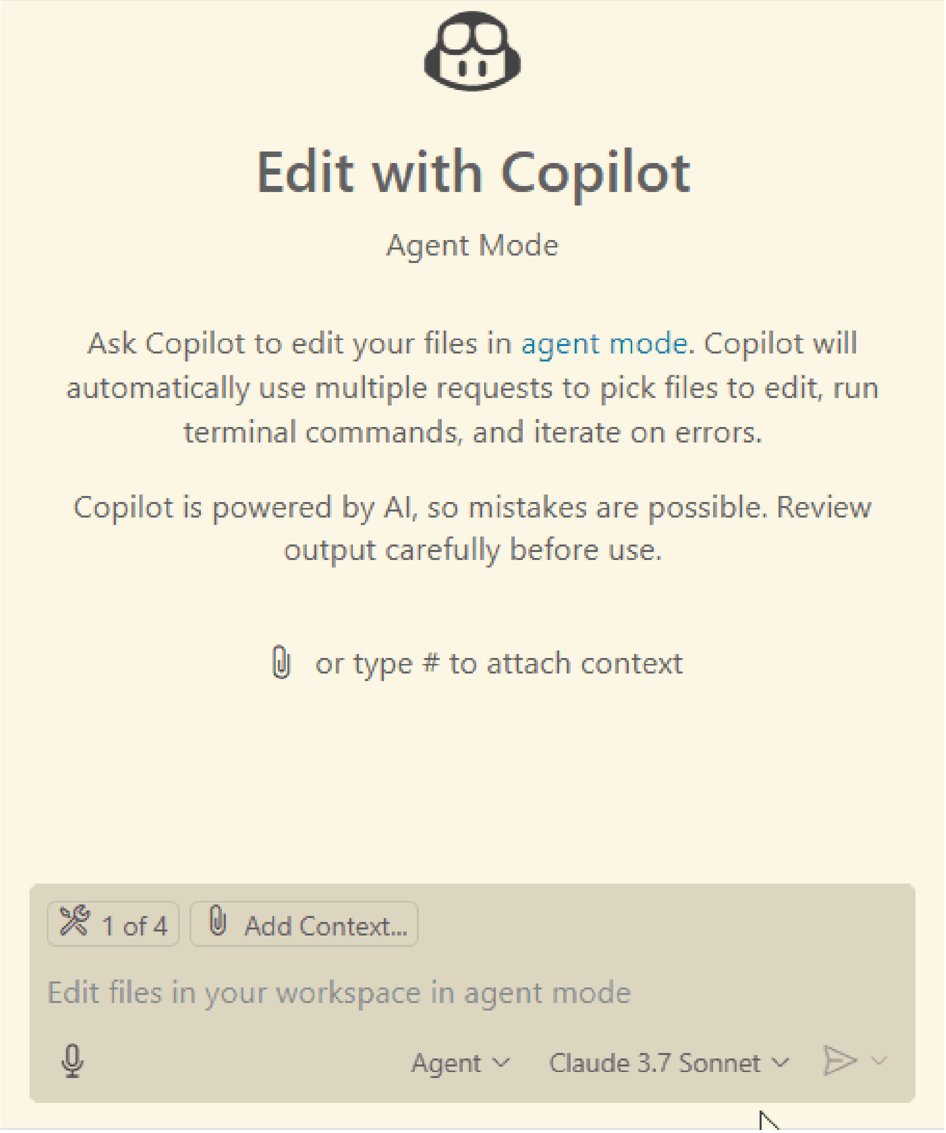
- The Integrated Modelling & Analysis Suite (**IMAS**) is the collection of physics software used at ITER
- Development of the Data Dictionary is a multi-institute physics-led activity spanning ~20 years
- The IMAS Data Dictionary schema is stored across many XSD files that are difficult to understand
- A single large XML file (close to 400k lines) is derived from the XSD files and used to generate HTML documentation and data access APIs
- The **IMAS Data Dictionary** became **Open-Source** at the start of this year

```
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elem
    <xs:complexType name="equilibrium_contour_tree">
        <xs:sequence>
            <xs:element name="edges">
            </xs:element>
        </xs:sequence>
    </xs:complexType>
    <xs:complexType name="equilibrium_gap">
        <xs:annotation>
            <xs:documentation>Gap for describing the plasma
        </xs:annotation>
        <xs:sequence>
            <xs:element name="name">
                <xs:annotation>
                    <xs:documentation>Short string identifi
                    <xs:appinfo>
                        <type>dynamic</type>
                    </xs:appinfo>
                </xs:annotation>
                <xs:complexType>
                    <xs:group ref="STR_0D"/>
                </xs:complexType>
            </xs:element>
            <xs:element name="description">
                <xs:annotation>
                    <xs:documentation>Description, e.g. mid
                    <xs:appinfo>
                        <type>dynamic</type>
                        <introduced_after_version>3</introd
                    </xs:appinfo>
                </xs:annotation>
                <xs:complexType>
                    <xs:group ref="STR_0D"/>
                </xs:complexType>
            </xs:element>
```

LLM models are not familiar with the IMAS Data Dictionary…

Making AI agents aware of IMAS

- An IMAS Model Context Protocol (MCP) server provides AI-agents with ITER relevant context
- The MCP is an open standard that creates a two-way connection between LLMs and data
- The MCP enables access to relevant data when processing queries
- The IMAS Data Dictionary MCP server can:
  - List all IDS schemas
  - Serve an IDS schema
  - Serve documentation
- Copilot queries made without the IMAS MCP server rely on web searches, returning vague and inaccurate responses
  - Copilot queries made using the IMAS MCP server:
  - Provide accurate responses in a clear format
  - Expose information hidden in the source files



Example Copilot query with custom MCP context

Open sourcing IMAS and PCSSP

- The ITER Organization Director General has approved the release of IMAS and PCSSP software under open-source licenses, to allow it to become a world-wide standard for fusion research and to lower the barriers to developing, validating, applying and contributing to this software.
- To make this possible, the ITER Organization is seeking permission from the owners of any Background Intellectual Property (BIP) upon which IMAS, and any codes not developed by the ITER Organization which are included in IMAS.

> *"ITER Organization DG approved the release of IMAS and PCSSP software under open-source licenses"*

> *"… permission from the owners of background IP for software to be included in IMAS"*

First IO Software Released as Open-Source in November 2024

- IO has released all IMAS and PCSSP software for which it owns all Generated Intellectual Property (GIP) using new publication procedure
  - IMAS-Data-Dictionary
    - Standard and generic representation of fusion data developed with input from all the ITER Members
  - IMAS-Python
    - Python software that facilitates interacting with data represented according to the IMAS-Data-Dictionary
  - IMAS-ParaView
    - ParaView plugins for visualising IMAS data
  - IMAS-Validator
    - Python toolbox to support the validation of IDS data against generic and specific rulesets
  - PCSSP
    - The Plasma Control System Simulation Platform
- All software made open-access on GitHub: https://github.com/iterorganization

Getting involved and contributing

- If you're a software developer, you can contribute with new physics models or help refine existing open-source components, such as here
  - https://github.com/iterorganization
- If you have data, then mapping it to the IMAS Data Model (Machine Description data and experimental / simulation data) will help to verify, test and validate components including data analysis and interpretation
- Or work with us on-site by applying for an internship or ITER Postdoctoral Fellowship
  - Advertised on https://www.iter.org
- If you have more experience, then you could come as a Visiting Researcher or join the ITER Scientist Fellows Network