**Meeting of the Steering Committee for the IO-EUROfusion Collaboration on IMAS #2021.9**

**15 September 2021**

**MINUTES**

**Participants**

Steering Committee Members

- Alberto Loarte (Head, IO Science Division)
- Volker Naulin (Head, EUROfusion Fusion Science Department)

Additional attendees

- Hartmut Zohm (Head, Plasma System Division, EUROfusion Fusion Technology Department)
- Xavier Litaudon (Project Leader, EUROfusion Preparation for ITER Operation project )
- Pär Strand (Acting Project Leader, EUROfusion Code Development for Integrated Modelling project as of July 2020)
- Richard Kamendje, (Steering Committee Secretary, EUROfusion)
- Denis Kalupin (Responsible Officer, EUROfusion Advanced Computing project)
- Simon Pinches (Section Leader, IO Plasma Modelling & Analysis Section)
- Richard Pitts (Section Leader, IO Experiments & Plasma Operation Section)
- Olivier Hoenen (IO Plasma Modelling & Analysis Section)

Apologies

- Tim Luce (Head, IO Science and Operations Department)

**Agenda**

| start | duration | Item |
|---|---|---|
| 14:00 | 2’ | **0. Opening and welcome (A. Loarte, V. Naulin)** |
| 14:02 | 1’ | **1. Approval of the Agenda** |
| 14:03 | 90’ | **2. Presentation of latest WPCD results** |
| 15:33 | 10’ | **3. Approval of the Minutes of previous meeting and review of open actions** |
| 15:43 | 30’ | **4. Organization of review of WPPrIO activities with overlap with IO** |
| 16:13 | 5’ | **5. Any other Business** |
| 16:18 | 5’ | **6. Record of Decisions and Actions** |

**Summary of the discussions**

0. Volker Naulin (VN) opens the meeting and welcomes all participants.

1. The agenda of the meeting is approved.

2. Pär Strand presents the latest output of WPCD (see appended presentation). WPCD officially ended 2020 with some lingering activities in 2021 due to COVID delays. The presentation reviews the applications built by WPCD in collaboration with CPT on the Integrated Tokamak Modelling Taskforce toolsets (CPOs,UAL, FC2K,…) and rebased towards IMAS (IDS, AL,FC2K,…). The main aims have been to
    - Bring data to users: Implementing and supporting access methodologies for EUROfusion devices (Machine descriptions, data mappings and access)
    - Bring tools to users: Deployment of workflows and data analysis tools
    - Bring skills to users: User support, training and documentation and
    - Bring feedback from users: New requirements, updates and bugfixes

   In summary, it can be said that WPCD (and ITM-TF) created the philosophy, prototyped and structured the infrastructure (ISP/CPT) and paved the way for IMAS. The intended continuation into the new E-TASC structured largely failed leaving gaps in implementation and several alienated or unsupported model developers. However, a core set of tools remains (ETS; EQSTAB; EQRECONSTRUCT;… ) with an active (and hopefully) expanding user community that is managed through a small ACH activity.

   The discussion after the presentation highlights a number of important points to be further looked into:
    - Access by IO to components included in the license agreement: There are some components that are mentioned to have been meanwhile converted to IMAS, however, IO has never yet had the opportunity to access them and make any use of them. Improvements on this front also depend on the second point
    - The transition to the E-TACS structure within EUROfusion has meant that many of the physics module owners who have spent a lot of time over the years adapting their modules to IMAS currently have no home to support their work in the new structure (neither in the TSVVs nor in the ACHs)
    - It is then agreed that through defined physics objectives, a scheme should be identified within EUROfusion to provide support to the execution of the Administrative Arrangement (AA) for the joint development of IMAS. A starting steps include (i) Simon exercising his duty of observer member in the E-TASC Scientific Board to voice the need for fulfilling the requirements of the AA, (ii) to prepare a presentation that would summarize all the activities that have remain orphan but are very useful for the collaboration as also emphasized by Simon, in the hope that (iii) Volker could on that basis bring the E-TASC Scientific Board to commit to find a way to define and allocate resources to these activities.

3. The minutes of the previous meeting are approved. Action 1 is closed. Action 2 is closed. Action 3 is closed. In connection with Action 1, Oliver Hoenen presents the work done by an intern at IO over the summer on mapping existing ITPA databases to IMAS. The tool developed was applied to the H-mode database for demonstration.

The tool is available to any ITER member having access to a git repository. In order to ensure backward compatibility between new and old defined variables Xavier should organize meeting involving Simon, Olivier and the EUROfusion actors to enable common understanding.

4. Xavier presents activities within the Work Package Preparation for ITER Operation (WPPrIO, that is implementing some elements of the EUROfusion preparation to ITER operation and scientific exploitation) that are linked to IMAS (see appended presentation). These include, in particular the development of analysis and operational tools for (i) breakdown/start-up, (ii) synthetic diagnostics. Also the coordination of EUROfusion databases (on confinement, disruption, L-H transition) is part of the remit of Regarding databases. There is in the plan for 2022 to launch in coordination with IO the call for a coordinator for the L-H database, given the advent of new data from JET, ASDEX Upgrade and other devices. Within TSVV11 (which is within a different Work Package) there is the plan to develop a database on plasma breakdown. Moreover, there is the idea to start in 2022 a new activity together with IO on scenario design using the tools that already exist. Another point worth mentioning in connection with the ITER PDS is that, across several Work Packages, there is the effort to develop reduced models in IMAS that could represent a contribution from EUROfusion to the IO effort. In this context it is agreed that Volker should organize a meeting at the EUROfusion level to establish the status of development and possible contribution to the PDS.

5. The next meeting is agreed to take place on 26 January 2022 at 14:00.

6. Review of decisions and actions

The new actions agreed are as follows:

1. Xavier to organize a meeting to establish the status of the development of the mapping tool for the EUROfusion database in order to identify potential synergies with IO and the possibility to make a join proposal to the ITPA. Participants: coordinators of EU databases, Simon Pinches, Olivier Hoenen, Richard Kamendje.
2. Pär, Simon and Richard K to develop a proposal for making the case to the E-TASC SB of the need to support the implementation of the AA between ITER and the EU on the joint development of IMAS, with the view to find ways to provide continuity to some former WPCD activities that appear essential
3. Volker to organize a meeting at the EUROfusion level on the status of development of reduced models in the various Work Package including the TSVVs, with potential to benefit ITER.

EUROfusion

# Overview of WP Code Development activities in 2020-2021

Pär Strand, and the WPCD team

CHALMERS

ETS

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

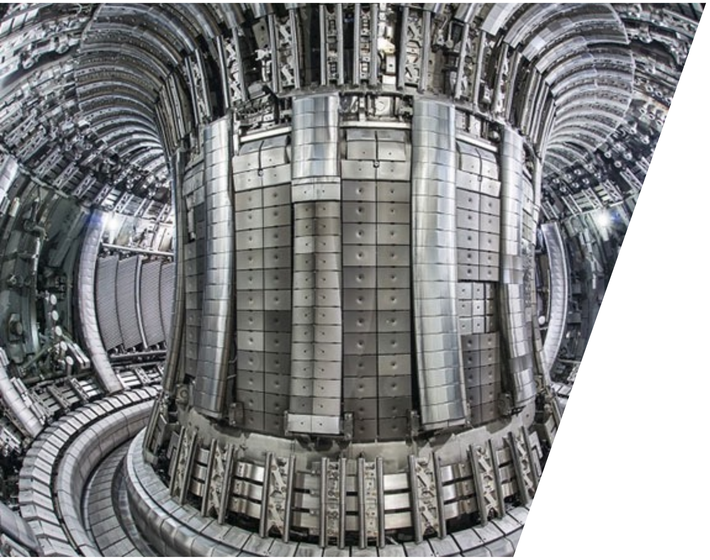
# Outline

General remarks on WP CD activities

A select set of highlights and developments from

- IMASification activities
- Exploitation activities
- Development

Not a complete review – not possible due to time constraints

**WP Code Development officially ended 2020 - some lingering activities in 2021 due to COVID delays:**

- Make data-structure (IMAS / IDS) and workflows developed by WPCD available to **USERS in EUROfusion** for routine analysis and modelling across EUROfusion programs / laboratories
- Demonstrate the added value of **using** the Integrated Modeling (WPCD) tools by supporting their **use** in JET /MST for delivering new scientific results

WPCD workflows as tools for **USERS** and not exclusively for developers

**Some activities within new eTasc structure (TSVVs and ACHs) with reduced level of users support maintained.**

# Aims, achievements and legacy

WPCD in collaboration with CPT built applications on the Integrated Tokamak Modelling Taskforce toolsets (CPOs, UAL, FC2K,…) and rebased these towards IMAS (IDS, AL, FC2K,…)

AIMS

- **Bring data to users:** Implementing and supporting access methodologies for EUROfusion devices (Machine descriptions, data mappings and access)
- **Bring tools to users:** Deployment of workflows and data analysis tools
- **Bring skills to users:** User support, training and documentation and
- **Bring feedback from users:** New requirements, updates and bugfixes

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| ITM-TF | → | WP CD | → | ITER/IMAS |
|---|---|---|---|---|
| Innovation<br>Invention | | Evolution<br>Diffusion<br>(production) | | Deployment<br>Acceptance<br>Production |

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ITM-TF → WP CD → ITER/IMAS

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|---|---|---|
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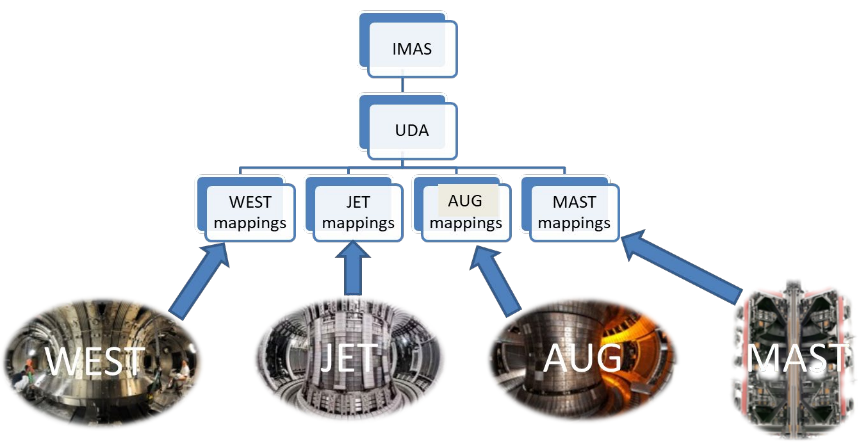
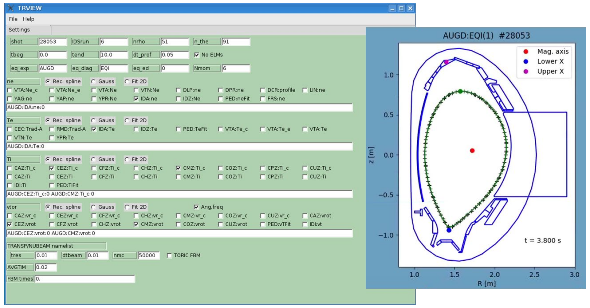
Are we (ITER) suffiently well resourced and structured for this?

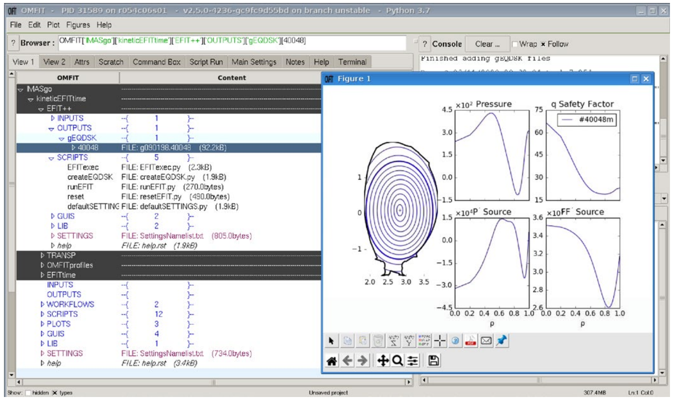
CD-IO meeting

# Aims, achievements and legacy

- **Bring data to users:** Implementing and supporting access methodologies for EUROfusion devices (Machine descriptions, data mappings and access)
  - UDA (In principle available but yet to be fully established as a general tool )
  - Bespoke toolset used to map data from experiments.
    - Exp2itm, Trview (for AUG data), readAUG, IMASgo! (Omfit plugin), TCV2IDS,…




ITER could be an incubator for the IMAS/UDA paradigm. In general, little interest from experiments otherwise to engage.

# Data available in IMAS form

| IDS Name | JET | TCV | AUG | MAST | WEST |
|---|---|---|---|---|---|
| iron_core | | | | | |
| magnetics | | | | | |
| mse | | | | | |
| pf_active | | | | | |
| tf | | | | | |
| thomson_scattering | | | | | |
| wall | | | | | |
| core_profiles | | | | | |
| equilibrium | | | | | |
| nbi | | | | | |
| ic_antennnas | | | | | |
| ec_antennnas | | | | | |
| core_sources | | | | | |

| Colour | Meaning |
|---|---|
| | Data not relevant for this machine |
| | Data is missing |
| | Data mapping in development |
| | Data available |
| | Data validated as input of EWE-2 and EWE-3 workflows |

- Initial experimental input datasets provided for "all" EUROfusion machines
- - Iterative process with workflow owners to test / extend the datasets as required
- Alternates to UDA to process native data and map them in IMAS/IDS have been developed to target specific workflows:
  - TRVIEW
  - IMASgo
  - TCV2IDS
  - ReadAUG-

# Data available in IMAS form

| IDS Name | JET | TCV | AUG | MAST | WEST |
|---|---|---|---|---|---|
| iron_core | (green) | (grey) | (grey) | (grey) | (pink) |
| magnetics | (green) | (green) | (light blue) | (green) | (light blue) |
| mse | (light blue) | (grey) | (pink) | (light blue) | (grey) |
| pf_active | (green) | (green) | (light blue) | (green) | (green) |
| tf | (green) | (green) | (light blue) | (green) | (green) |
| thomson_scattering | (green) | (light blue) | (pink) | (green) | (grey) |
| wall | (green) | (green) | (green) | (green) | (green) |
| core_profiles | (green) | (green) | (green) | (green) | (green) |
| equilibrium | (green) | (green) | (green) | (green) | (green) |
| nbi | (green) | (green) | (green) | (green) | (grey) |
| ic_antennnas | (green) | (grey) | (light yellow) | (grey) | (green) |
| ec_antennnas | (grey) | (green) | (green) | (grey) | (grey) |
| core_sources | (light yellow) | (light yellow) | (light yellow) | (light yellow) | (light yellow) |

| Colour | Meaning |
|---|---|
| (grey) | Data not relevant for this machine |
| (pink) | Data is missing |
| (light yellow) | Data mapping in development |
| (light blue) | Data available |
| (green) | Data validated as input of EWE-2 and EWE-3 workflows |

**TRVIEW (AUG)updates and features:**

- New Gaussian spline method
- Toroidal velocity profiles have been made available (there was a bug before)
- Zeff time traces made reliably written
- Map full equilibrium to IMAS, including COCOS recognition and conversion
- Main species recognition
- Added RABBIT input
- Added angular frequency as option instead of vtor (user's choice)
- Usable also on AUG reversed Ip/Bt shots

TRVIEW is also used for ASTRA and TRANSP

# Data available in IMAS form

| IDS Name | JET | TCV | AUG | MAST | WEST |
|---|---|---|---|---|---|
| iron_core | | | | | |
| magnetics | | | | | |
| mse | | | | | |
| pf_active | | | | | |
| tf | | | | | |
| thomson_scattering | | | | | |
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| core_profiles | | | | | |
| equilibrium | | | | | |
| nbi | | | | | |
| ic_antennnas | | | | | |
| ec_antennnas | | | | | |
| core_sources | | | | | |

| Colour | Meaning |
|---|---|
| | Data not relevant for this machine |
| | Data is missing |
| | Data mapping in development |
| | Data available |
| | Data validated as input of EWE-2 and EWE-3 workflows |

WEST data is native IMAS and available through UDA

**IMASGO updates and features:**

- OMFIT plugin for ETS level input data
- Used for MAST, JET, DIII-D and K-Star data preparation

**IMAS/UDA (magnetics data for EWE-2).**

- MSE and Thomson-Scattering data available for both JET and MAST.
- Interferometry made available MAST UDA
- JET plugin development (allowing private PPF instances not only public).
  - This was useful for e.g. MSE data at JET which is processed manually by individuals outside of the standard Plasma Reconstruction Chain.
- Data for existing EFIT Equilibria is available for both JET and MAST.
- NBI mappings are in progress for MAST but are not yet available.

# Data available in IMAS form

| IDS Name | JET | TCV | AUG | MAST | WEST |
|---|---|---|---|---|---|
| iron_core | green | grey | grey | grey | pink |
| magnetics | green | green | light blue | green | light blue |
| mse | light blue | grey | pink | light blue | grey |
| pf_active | green | green | light blue | green | green |
| tf | green | green | light blue | green | green |
| thomson_scattering | green | light blue | pink | green | grey |
| wall | green | green | green | green | green |
| core_profiles | green | green | green | green | green |
| equilibrium | green | green | green | green | green |
| nbi | green | green | green | green | grey |
| ic_antennnas | green | grey | yellow | grey | green |
| ec_antennnas | grey | green | green | grey | grey |
| core_sources | yellow | yellow | yellow | yellow | yellow |

| Colour | Meaning |
|---|---|
| grey | Data not relevant for this machine |
| pink | Data is missing |
| yellow | Data mapping in development |
| light blue | Data available |
| green | Data validated as input of EWE-2 and EWE-3 workflows |

**TCV2IDS**

Updated data mappings required by the equilibrium reconstruction and stability workflows:

- magnetics
- pf_active
- tf,
- wall
- equilibrium
- core_profiles
- thomson_scattering (new IDS)

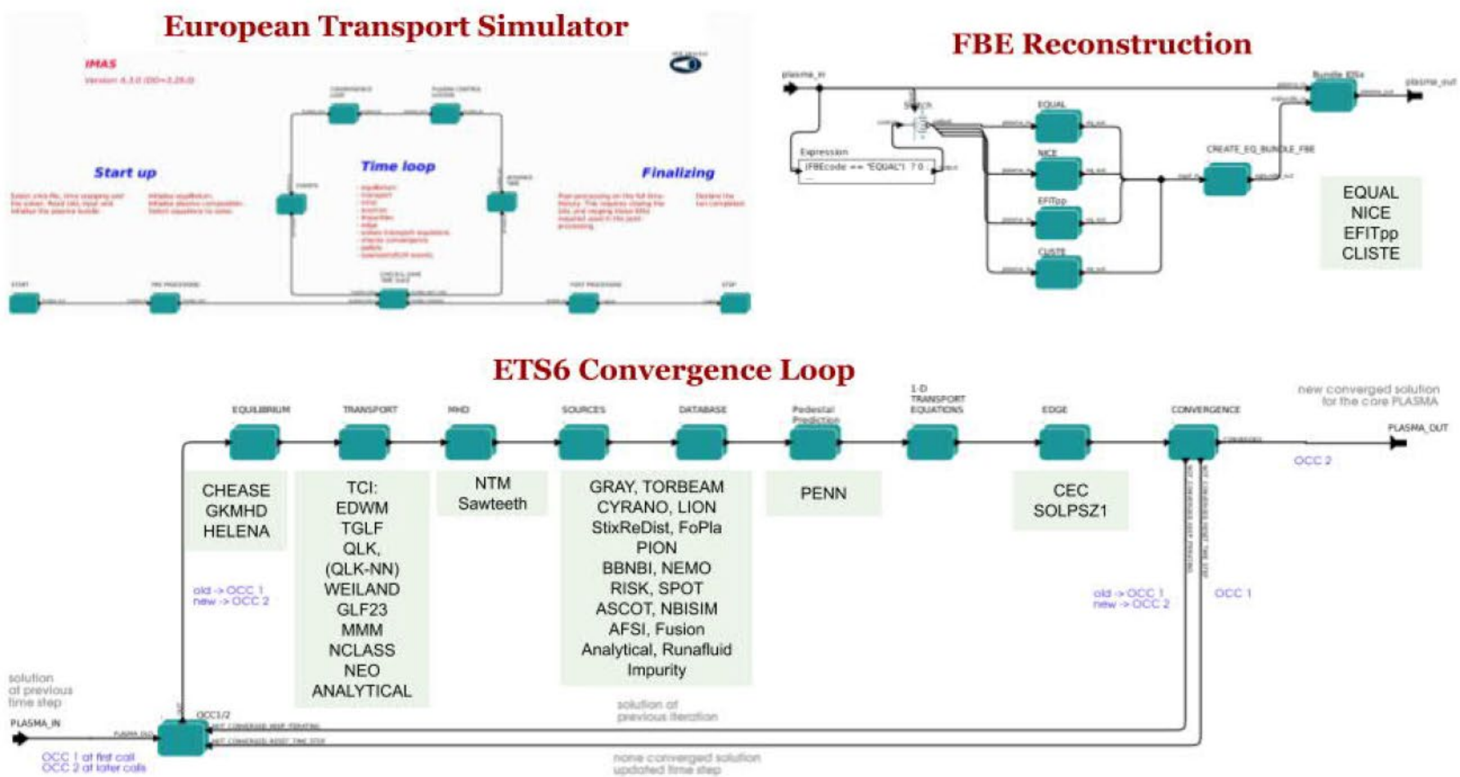
Data required for ETS simulations has also been added:

- ec_launchers
- nbi,
- summary ids.

These 10 IDSs are the present default set for tcv2ids2 database, working on both the gateway and ITER-IO.

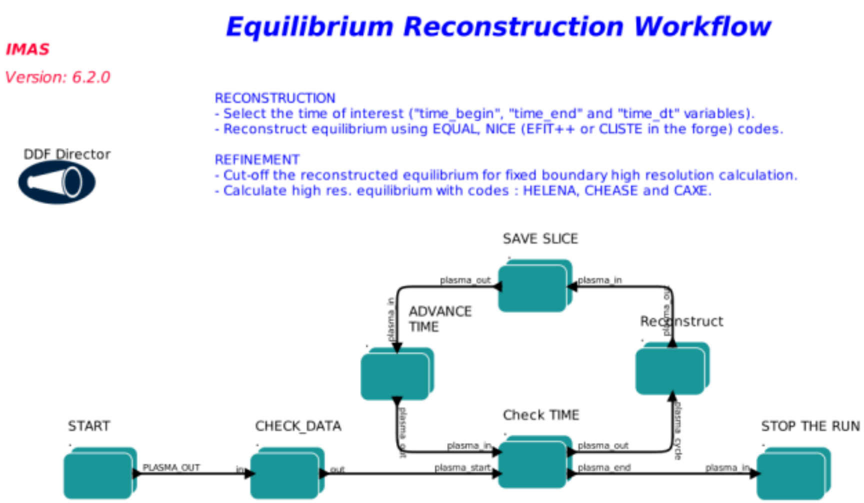
# Aims, achievements and legacy

- **Bring tools to users:** Deployment of workflows and data analysis tools
  - ETS (5→6), EQRECONSTRUCT, EQSTABIL, (EDGETURB) [EWE-2 and EWE-3]
    - Full ecology for interpretative/predictive analysis
  - Multiple interfaces: autoGui, (front end Gui), Canvas (Kepler layer) , ETSviz+other scripts,




CD-IO meeting

# Enabling the exploitation of the equilibrium reconstruction and stability workflow




Workflow uses  data from arbitrary tokamak devices and accommodates “arbitrary” plasma equilibrium reconstruction codes adhering to IMAS.

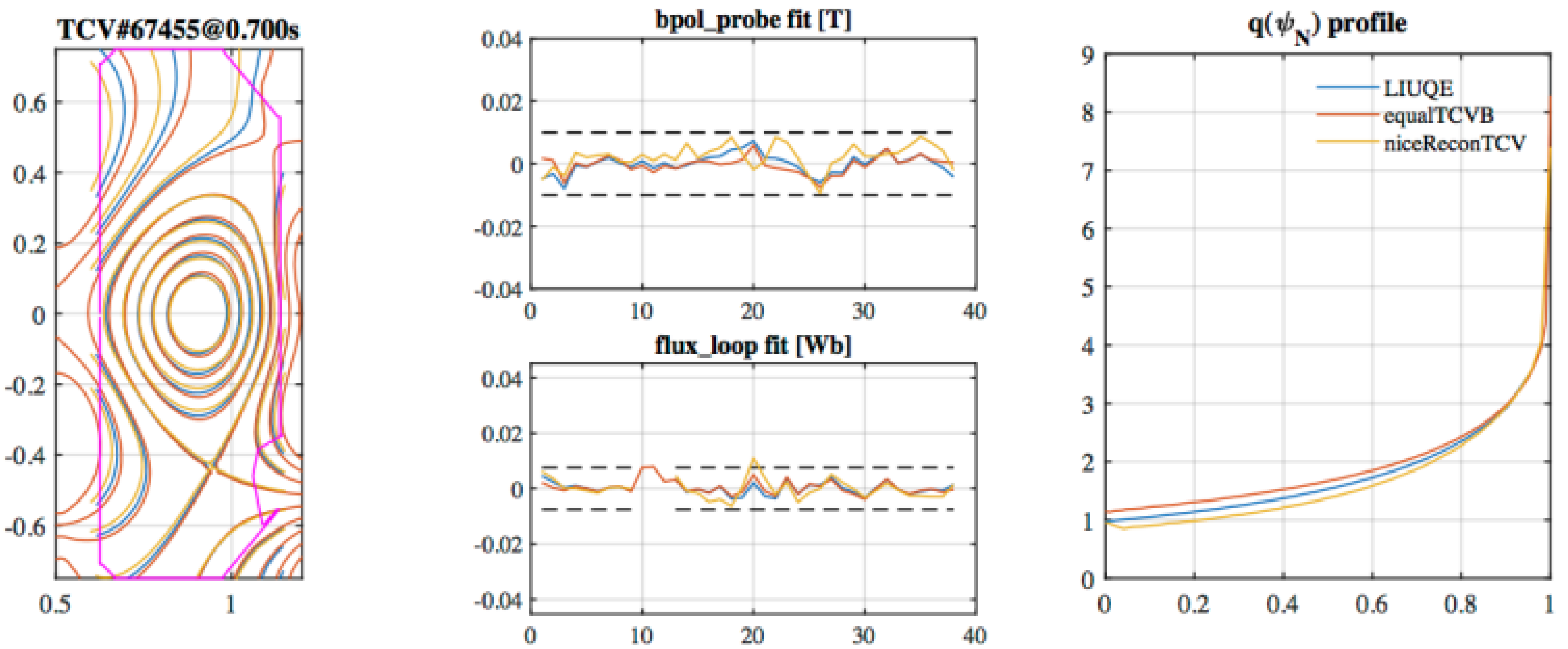
- Default codes EQUAL and NICE
- Operational modes depends on available data:
  - In the more basic mode, only data from magnetic sensors/coils is used, possibly complemented by Faraday rotation or Motional Stark Effect data.
  - At a second (optional) stage, the thermal plasma pressure can be used for a refined reconstruction (to capture pedestal relevant features)

The workflow was used successfully to address typical uses cases from JET, AUG and TCV devices.

It was also attempted on MAST, WEST and KSTAR devices but with little success except very preliminary for MAST. (Cocos adherence apparently hard to maintain).

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

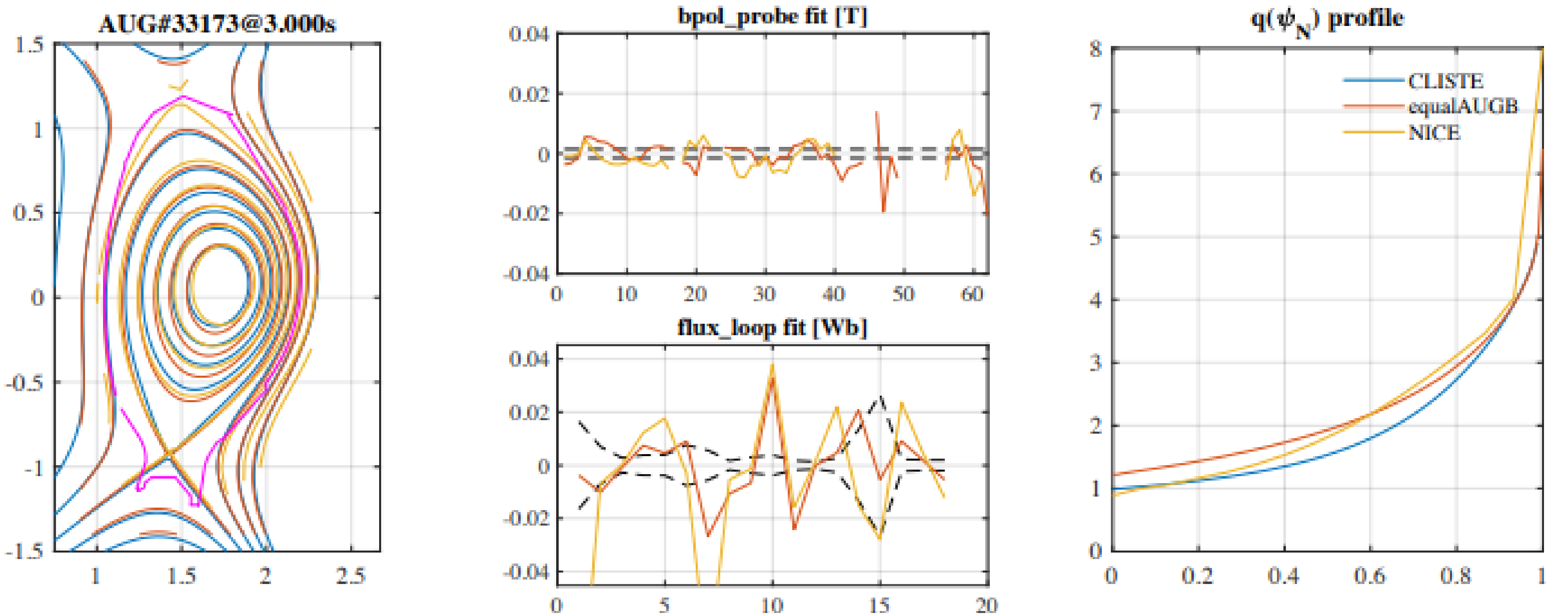
A negative triangularity case with separatrix, TCV




Good agreement is found between the several codes (LIUQE – the in-house tool at TCV, EQUAL and NICE). Comparison of flux contours, magnetic probe and flux loop reconstruction errors and obtained |q| profiles for the codes LIUQE, EQUAL and NICE using data from TCV discharge 67455 at t = 0.7s. Black dashed lines indicate the absolute error for the different signals

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

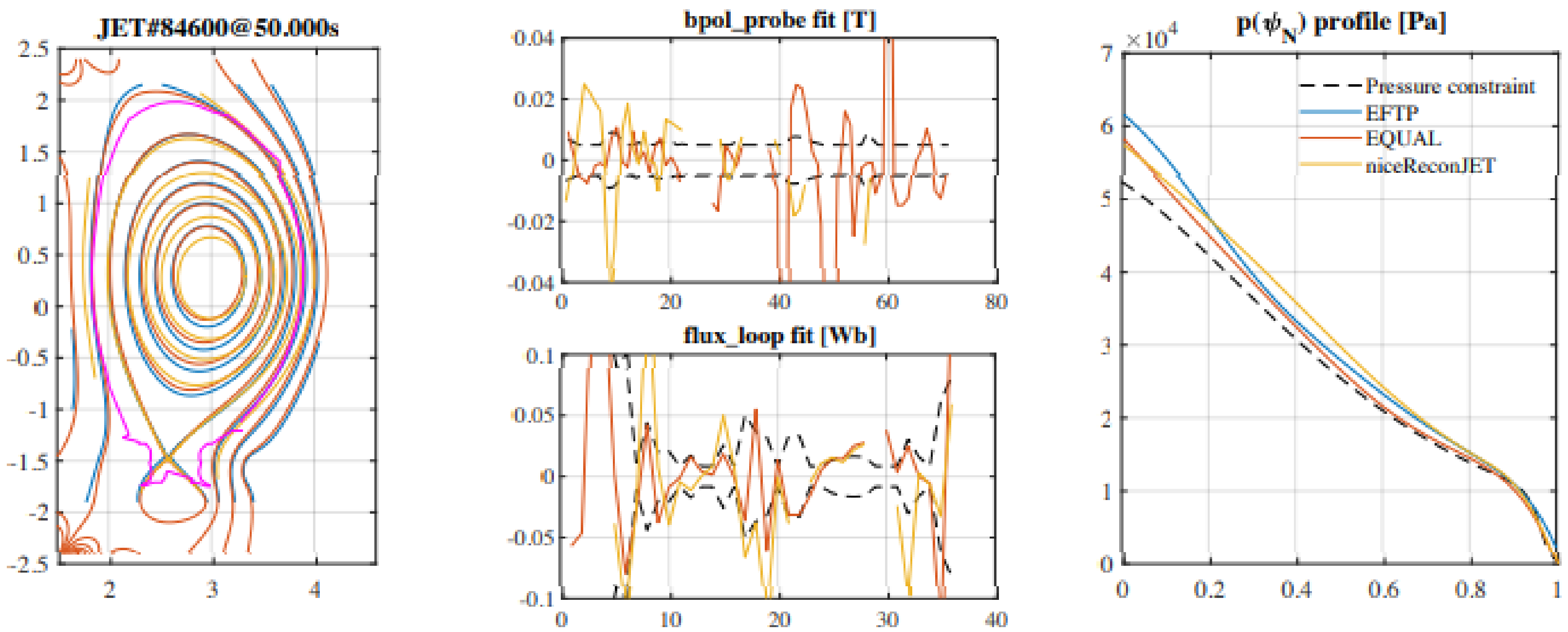
AUG validation/bechmarking with CLISTE on shot 33173




Comparison of flux contours, magnetic probe and flux loop reconstruction errors and obtained |q| profiles for the codes CLISTE, EQUAL and NIICE using data from AUG discharge 33173 at t = 3.0s. Note that the reconstruction errors for CLISTE are missing since this data hasn’t been mapped to IDS format. Improvements are possible  since no fine-tuning was done for the sensitive code parameters e.g. knot positions and weigths for the regularisation.

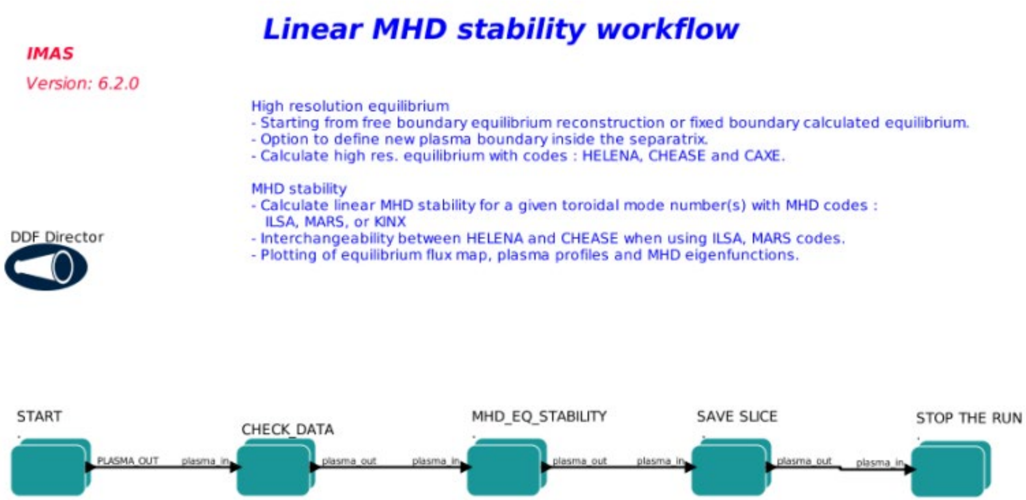
# Enabling the exploitation of the equilibrium reconstruction and stability workflow

JET validation/bechmarking with EFIT++ on shot 86400




Comparison of flux contours, magnetic probe and flux loop reconstruction errors and obtained pressure profiles for the codes EFTP, EQUAL and NICE using data from JET discharge 84600 at t =51.0s. Similarly to CLISTE in figure 3, reconstruction errors are missing for EFTP (branding at JET for EFIT++ constrained with plasma pressure). The closer agreement of EQUAL and EFIT++ may be justified by the closer solver kernel used, both derivations of the EFIT algorithm, whereas NICE uses a rather different approach. UDA mapping updates needed to match magnetics between EFTP and IMAS

# Enabling the exploitation of the equilibrium reconstruction and stability workflow




The linear MHD stability is a single time slice analysis workflow so that I can be easily integrated into larger scope workflows,(ETS or in EQRECONSTRUCT).

Equilibrium codes used

- HELENA, CHEASE and CAXE,

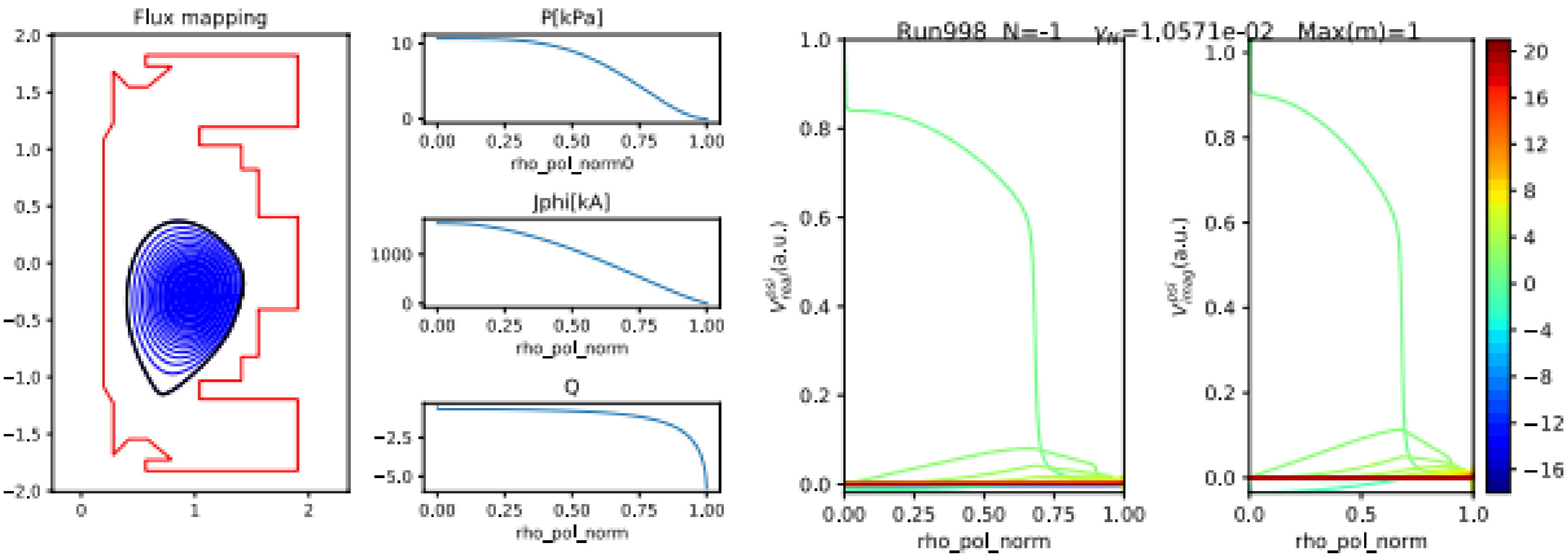
updated to the latest DD versions. It couples stability codes

- Kinx (with Caxe)
- ILSA, MARS and MARS-F (HELENA and CHEASE)

The workflow was used routinely to analyse the MHD stability of plasma from several devices including JT-60SA in the framework of a task in WPSA

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

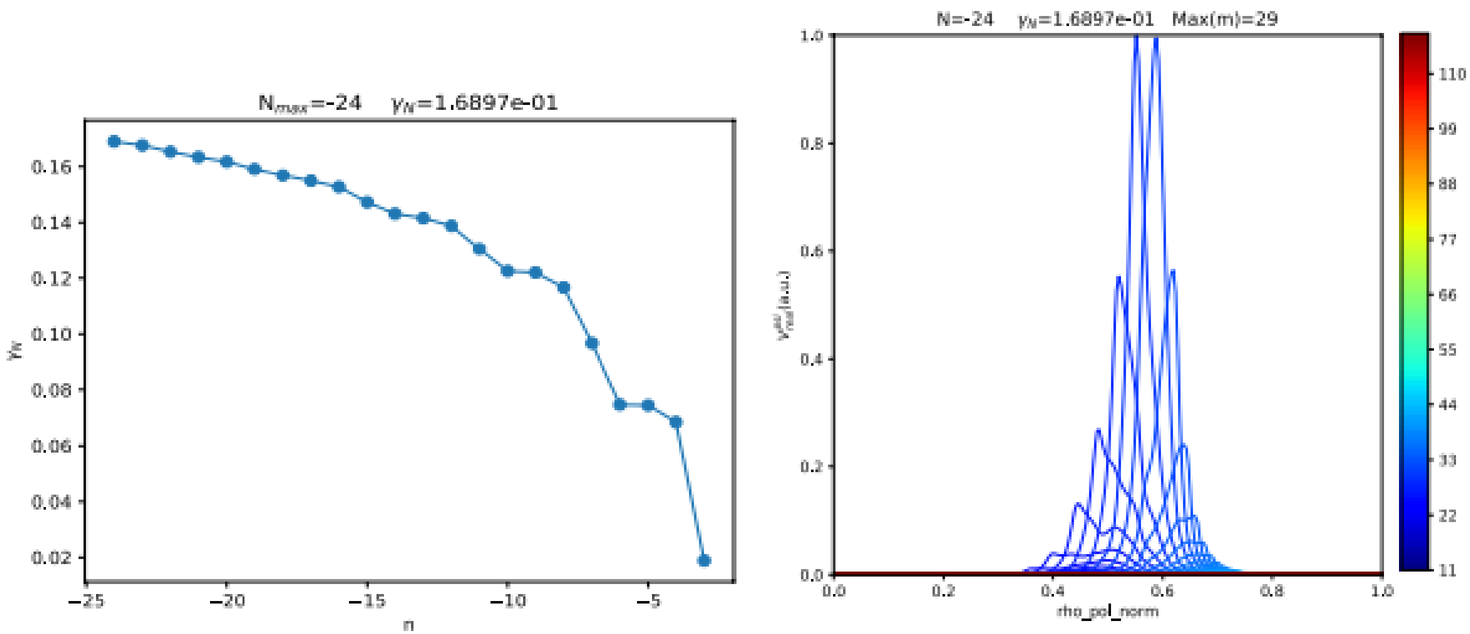
Application to MAST on shot 27205




High resolution equilibrium from MAST (#27205 at t=0.4s) and linear eigenfunction for "radial" velocity component for a n=1 internal kink mode. Input data from IMASgo stored in g2mroma/MAST/27205/1 and HELENA and ILSA codes were used

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

Application to JT-60SA, Scenario 4 with data mapped from eqdsk file, (hybrid scenario with internal transport barrier in ion energy channel). The scenario is characterised by internal infernal like modes where the ITB is located (as found in analysis).



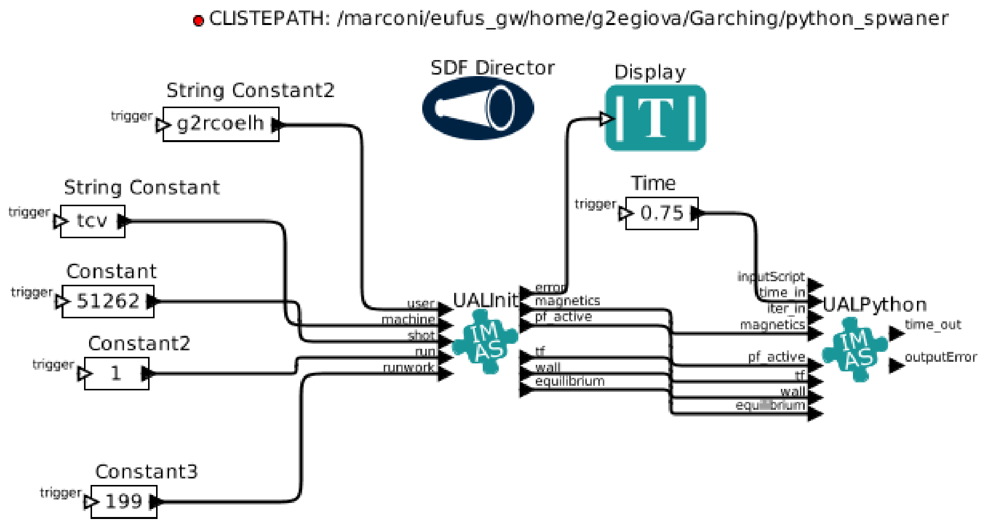

Normalised growth rate scaling with toroidal mode number (left) and radial velocity component of the most unstable mode (right) are shown for the CDBM equilibrium with fast ion pressure included.

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

- CLISTE as a Kepler actor: A Python actor plays the interface role between the IMAS database and CLISTE. The main advantage being that any change in either CPOs or IDSs (IMAS) can be solved inside this Python actor. Moreover, the original CLISTE code can be used without having to deal with different CLISTE versions.

- Intermediate step towards having the whole CLISTE suite interfaced to IDSs

Imasification of CLISTE deemed to resource demanding in view of the compliance to both IDSs and the ASDEX Upgrade environment system and dedicated shotfile system – CLISTE is the de facto intrashot code used in the Research programme of AUG.




*The KEPLER test workflow for the CLISTE code driven by a UALPython actor. In the particular case, a TCV test case is considered (previously tested in the standalone code)*

# Enabling the exploitation of the equilibrium reconstruction and stability workflow

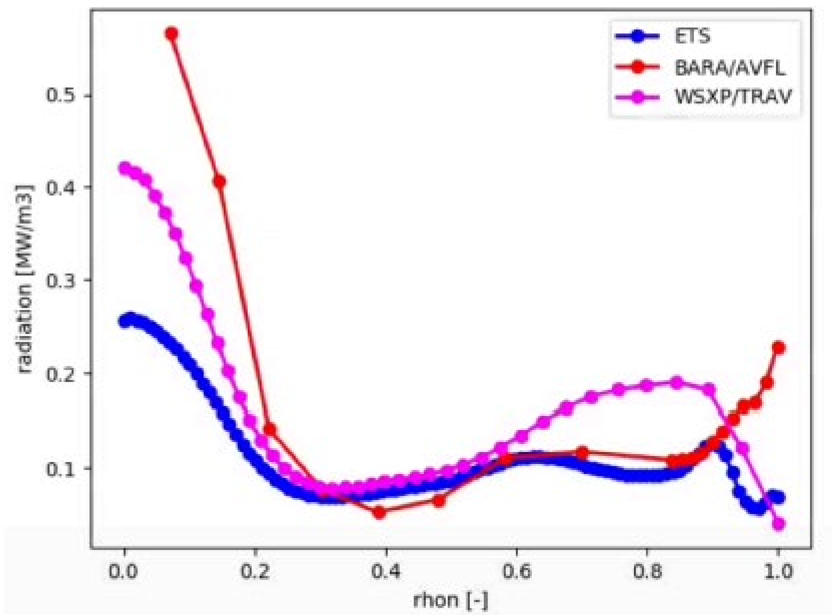
- The integration and testing of EFIT++ in IMAS was severely hampered by extraordinarily long linking times during the build process of the code and actor. Although this was prioritised and support from the CPT was secured, the underlying cause remained unclear though potential culprits might involve either the UAL C++ HLI and/or the massive use of templates by EFIT++ (or both).

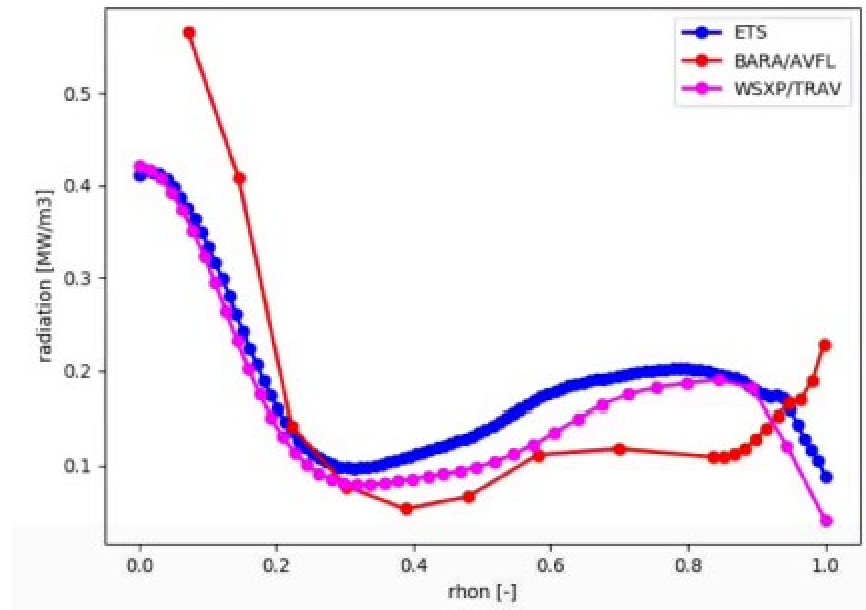
# AMNS data and interfaces in IMAS

- Both the CPO and IDS versions of the AMNS library have seen updates in functionality and/or data.
- Fundamental atomic calculations have been performed for Ne like Mo.
- Extensive calculations have been done on electron backscattering from Be, Be4+ and hydrogen atom and between hydrogen atoms has been performed.
- Significant work has been done on collecting and using atomic cross-section data. JET results seem to indicate that the previously developed T-T nuclear cross section provides a significantly better description than previous cross-sections
- It is not clear what, if any, future exists for AMNS work within EUROfusion with the termination of WPCD.
- It is also not clear what the plans are for the future maintenance of the AMNS library and the curation of future AMNS data.
- More work in the area of cross-sections and nuclear data could usefully be performed in the future, as well as the completion of the beam-stopping work.
- The incorporation and extension of surface data from the CPO version into the IDS version still remains to be done

# AMNS data and interfaces in IMAS

Updating of the W data for the CPO version

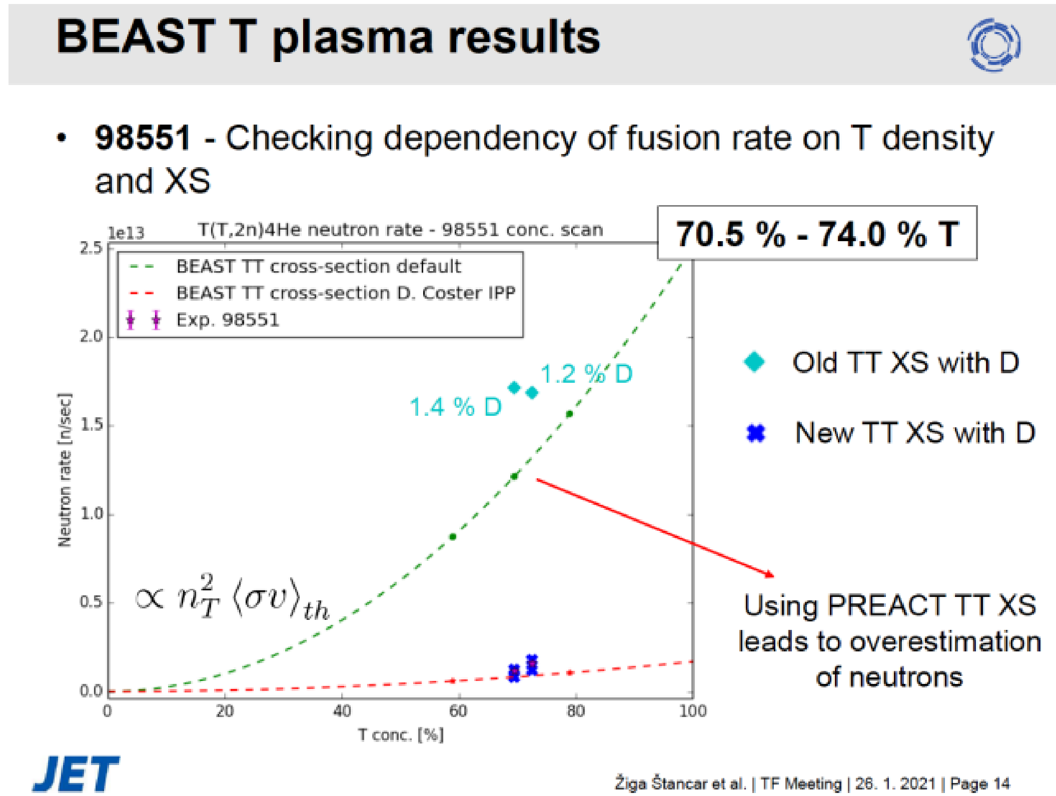



While the W data for the IDS version had been updated, development work had stopped for the CPO version. In comparisons of the ETS-5 with other calculations this issue was identified and the W data was then updated. The left figure used older W data and the right a newer version. The calculated radiation increased by ~55%. CMP ETS implementation and testing

# AMNS data and interfaces in IMAS

Calculation of new T-T cross-section data tested at JET:




In previous work done as part of WPCD and JET activities, the existing nuclear data for T-T reactions was examined. Since the available data disagreed, a new parameterisation was prepared based on ENDF data.

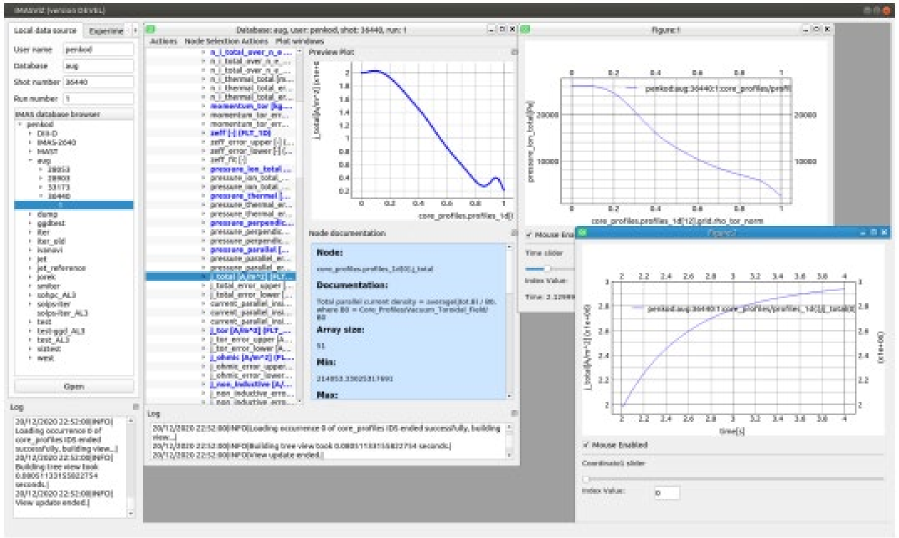
New results from JET suggest that this data is in better agreement with the experimental measurements than the previous data used in TRANSP.

# Visualization tools in IMAS

Aimis to provide plug-ins for visualization tools developed by WPISA:

- Enhanced ParaView plugin for Edge IDSs (Edge Profiles, Edge Sources, Edge Transport) and MHD IDS (under SOLPS-ITER GUI Git)
- IMASviz plugins template and documentation for dashboard inclusion and documentation with template of a simple plugin.
- Plugins for SOLPS, ETS (under IMASViz Git).
- ParaView plugins (GGD based) in separate Git
- ETS plugin for IMASViz (not finalized)
- Support for other IDSs (e.g. Eqstabil workflow)
- AppImage support (Raysect, Cherab) under SMITER GUI

# Visualization tools in IMAS



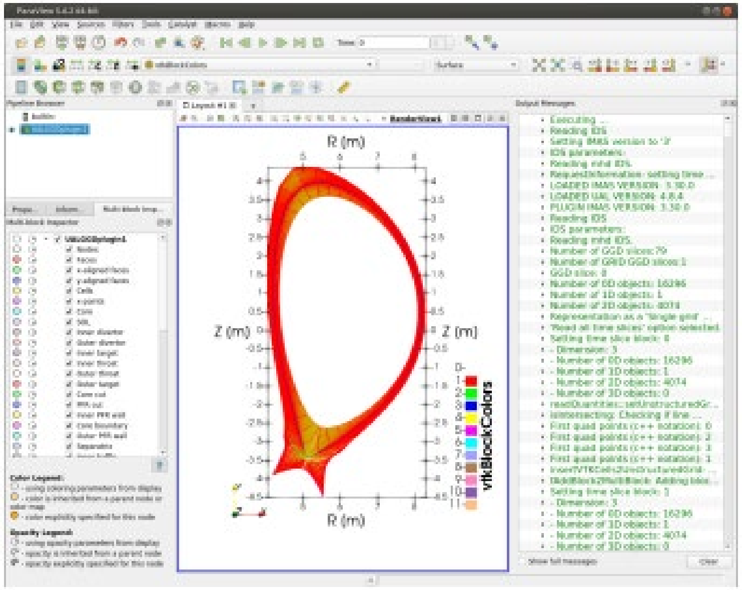
Overview of IMASViz interface and its available features

Implementing the Multiple Document Interface (MDI) in IMASViz, allowing better arrangement of the panels and windows under a single main window

ReadUALGGD ParaView plugin

The ReadUALEdge ParaView plugin  was initially intended for passing the data from Edge Profiles, Edge Transport and Edge Sources Interface Data Structures (IDSs) to ParaView

SOLPS-ITER, EDGE2D



## Synthetic diagnostics in IMAS

- An open-source python library - ToFU, to be used as a numerical toolbox for synthetic diagnostics on Tokamaks, called tofu, was developed (and continues to be developed), providing a production-ready tool to users on EUROfusion devices  and ITER .
- In use at ITER to compute synthetic signal from the prospective ITER bolometry. WEST for other diagnostics thanks to its generic tools and algorithms.
- It is also unit-tested, natively compatible with IMAS and numerically optimized (parallelized), and provides online sources and documentation and bash commands for simple uses for users who are not familiar with python.

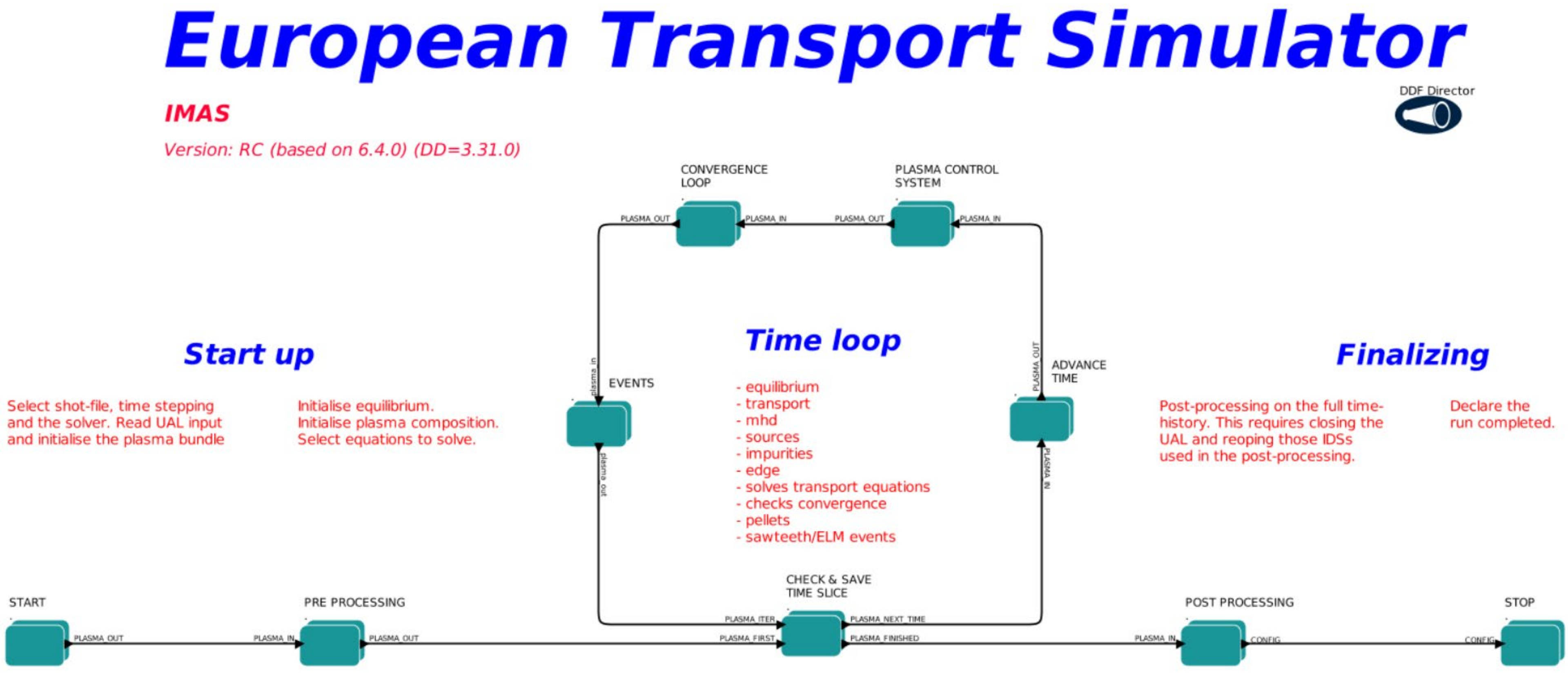
- https://tofuproject.github.io/tofu/releases.html.

## Synthetic diagnostics in IMAS

Several versions of tofu were released  during the year.

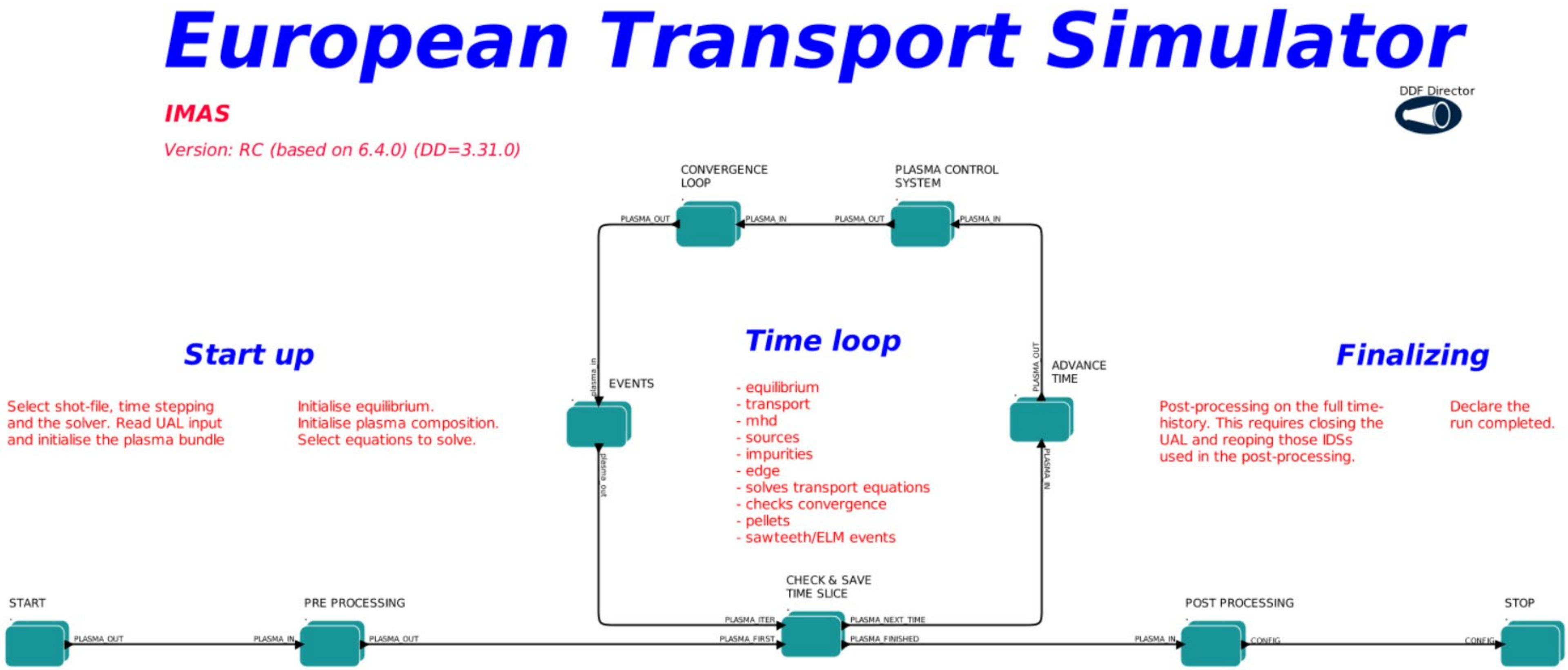
- New default tokamak geometries (ITER, AUG, WEST, TCV…)
- Faster algorithms (optimized / parallelized using cython)  Additional features (handling of basic reflexion mechanisms, interactive plotting)
- Debugging and maintenance
- Features added to satisfy user-feedback (better interactivity of figures, more explicit error messages…)
- IMAS compatibility
- Unit tests
- Documentation updating
- mplementation of coding good practices (coding style conventions, docstrings, comments…)
- Deployment of the library (to very popular online python repositories like Pipy and Conda) to make installation an easy as possible, using pip install tofu ro conda install –c conda-forge tof

# Support and development of ETS




Work on ETS related physics modules and ETS workflow and its exploitation was a significant part of the of the WPCD activities and work relating to WIMAS-2, WIMAS-5 and EWE-3 is reported here in addtion to the related work by The ETS TRO.

# Support and development of ETS

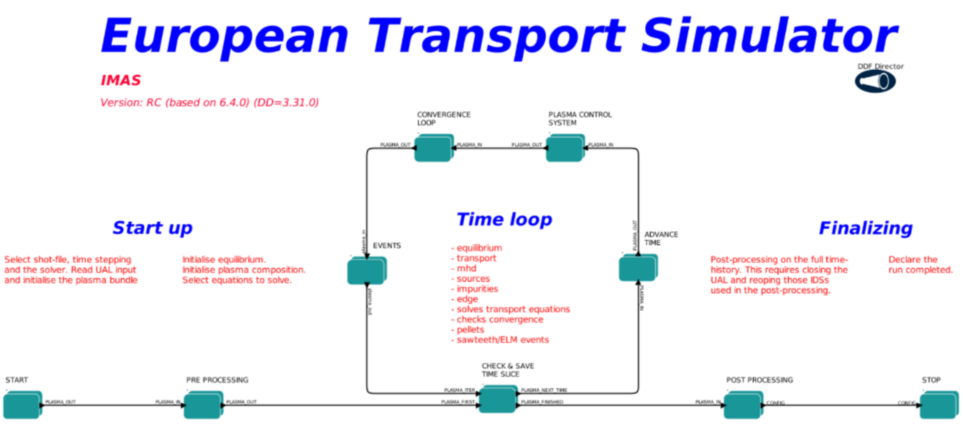


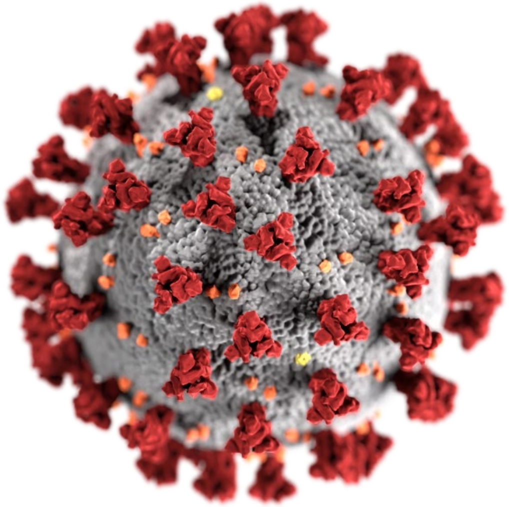

ETS currently exists in two flavours:

- ETS v5 (CPO based version, being phased out)
- ETS v6 (IMAS based version, being phased in)

ETS v6 is more than a simple remapping of ETS v5 to a new data format – extended and adapted based on user requriements and lessons learned.

# Support and development of ETS



Transition to ETS v6 slowed down by the Covid-19 situation

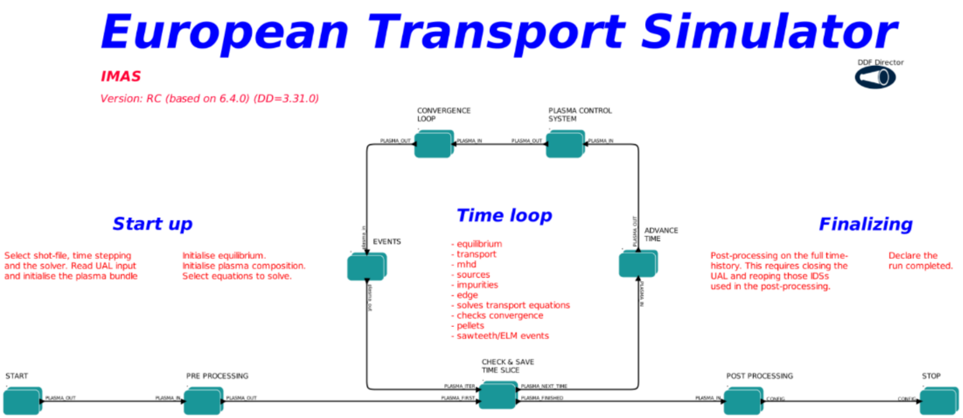
- Small part of WPCD continued until end June 2021.
- WPISA (CPT) workflow support continued until end June 2021.

Qualification of new releases somewhat affected

→

ETS v5 will be kept for verification purposes as long as needed
Users will be supported to move to ETS v6

# Support and development of ETS




WPCD is dispersed in FP9 but support continues from the advanced computing hub Structure for ETS, EQSTAB and EQreconstruct.
The IM modelling hub (IPPLM/PSNC) provides

- Workflow support and maintenance
- IMASification of new physics models

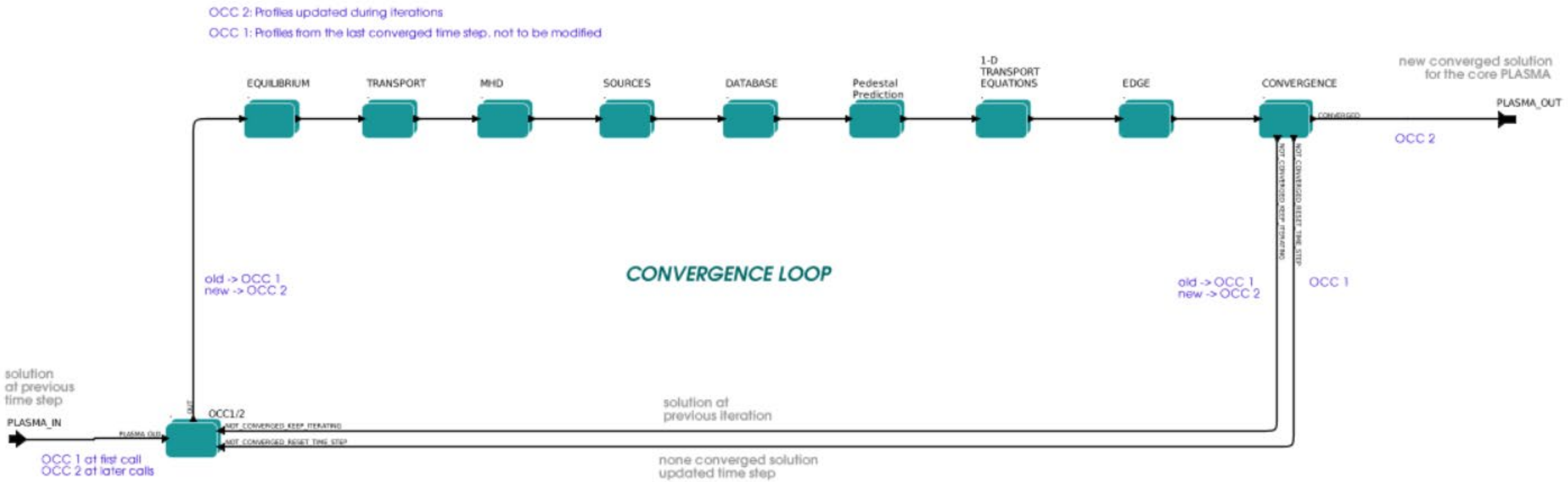
The ETS community will be supported by

- Direct support from the IM ACH hub ETS support staff
- An improved online support structure/presence
- Weekly users/developers meetings (starting after summer vacations in earnest)

# Bulk of the matter: ETS interfaces

The move to IMAS required not only shifting all physics modules and supporting actors from CPOs to IDS but also required changes to the workflow (code) logics.

In addition, improvements on user interfaces to support the end user experience. ETS is highly modular and the user interfaces provide access to almost all configurable aspects of the workflow and the physics modules used.




Two interfaces available: Kepler Canvas interface (above) which provides an excellent overview of software relations including configurations (and has a Powerful shortcut system for expert users).

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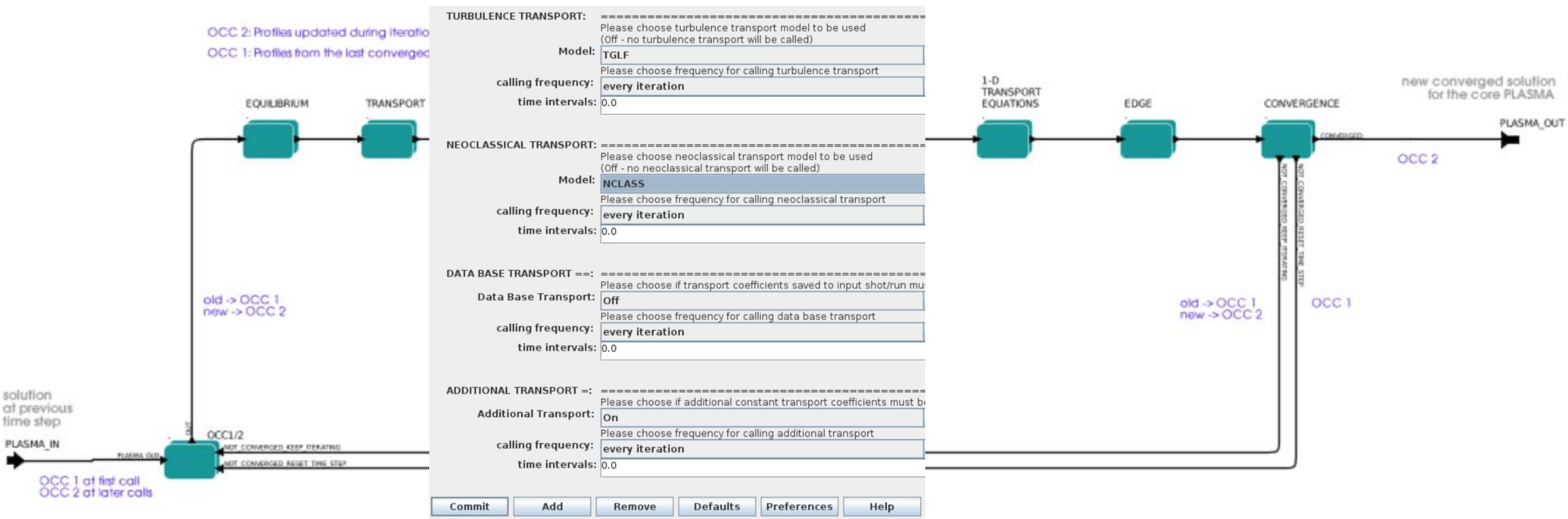


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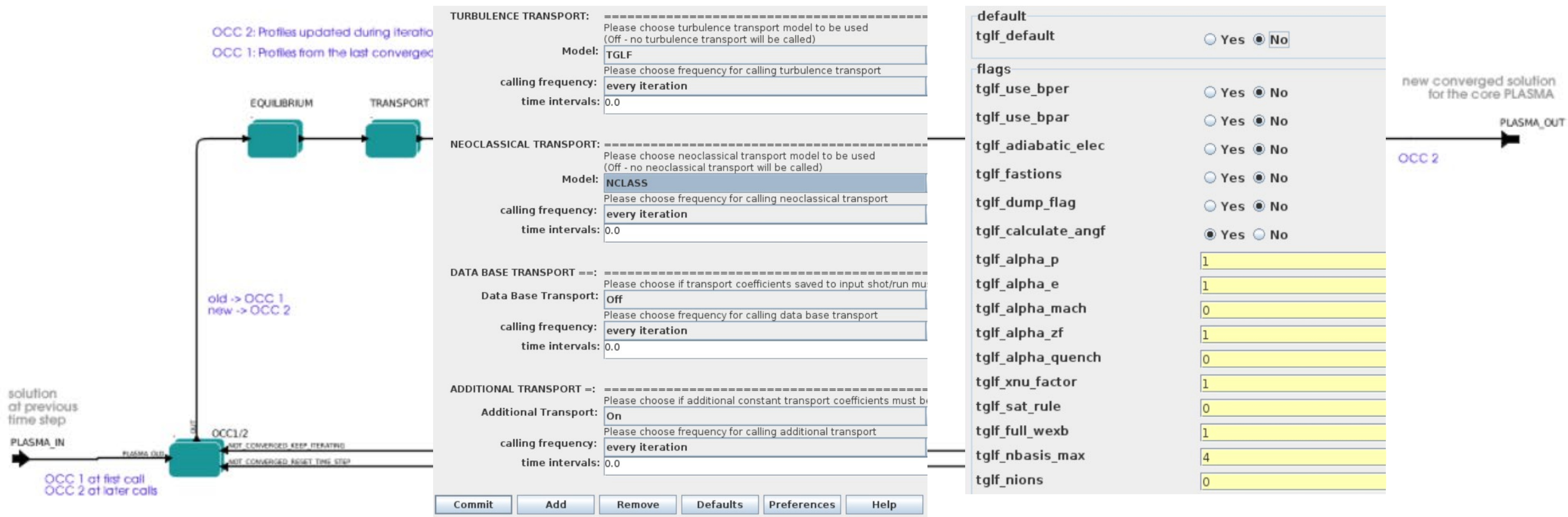
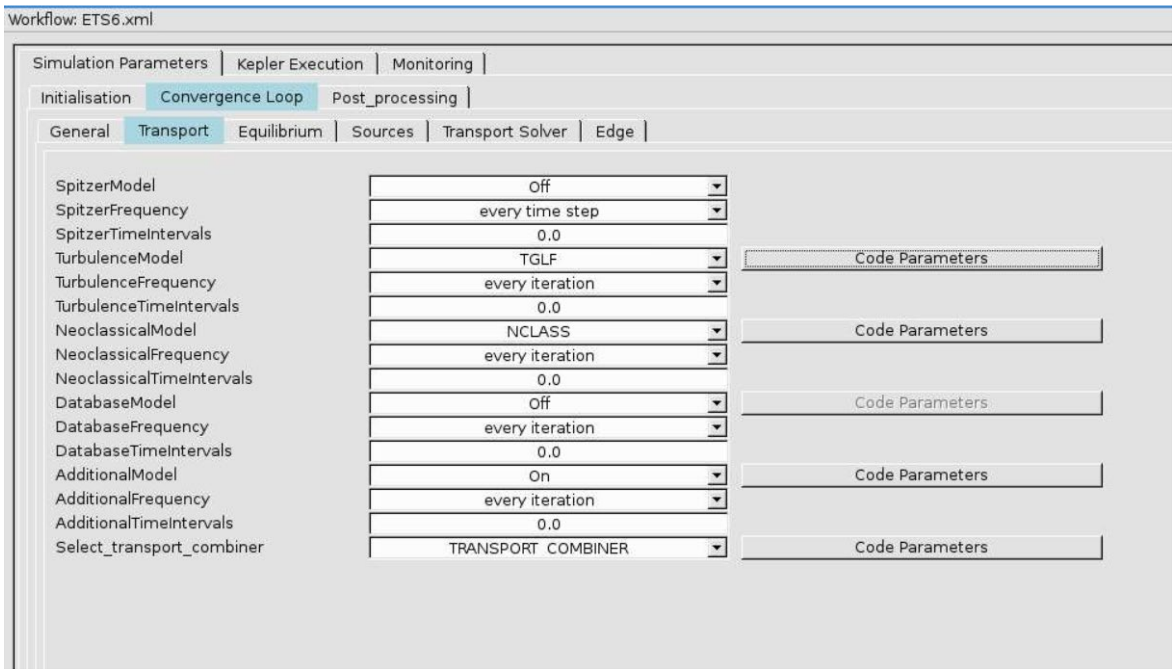
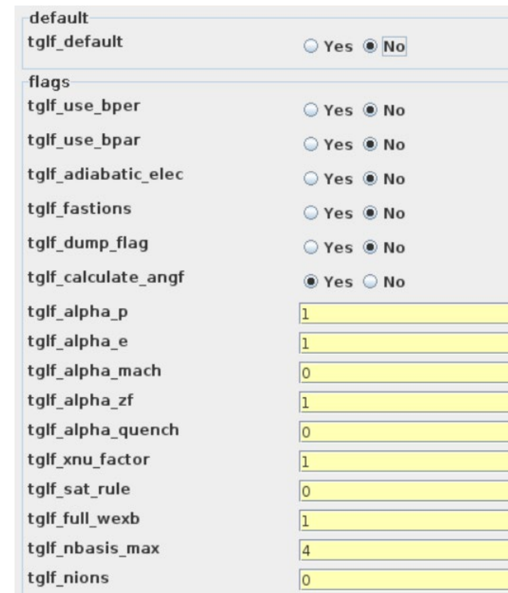



Two interfaces available: Kepler Canvas interface (above) which provides an excellent overview of software relations including configurations (and has a Powerful shortcut system for expert users). Alternative: a flattened GUI! →

# Bulk of the matter: ETS interfaces

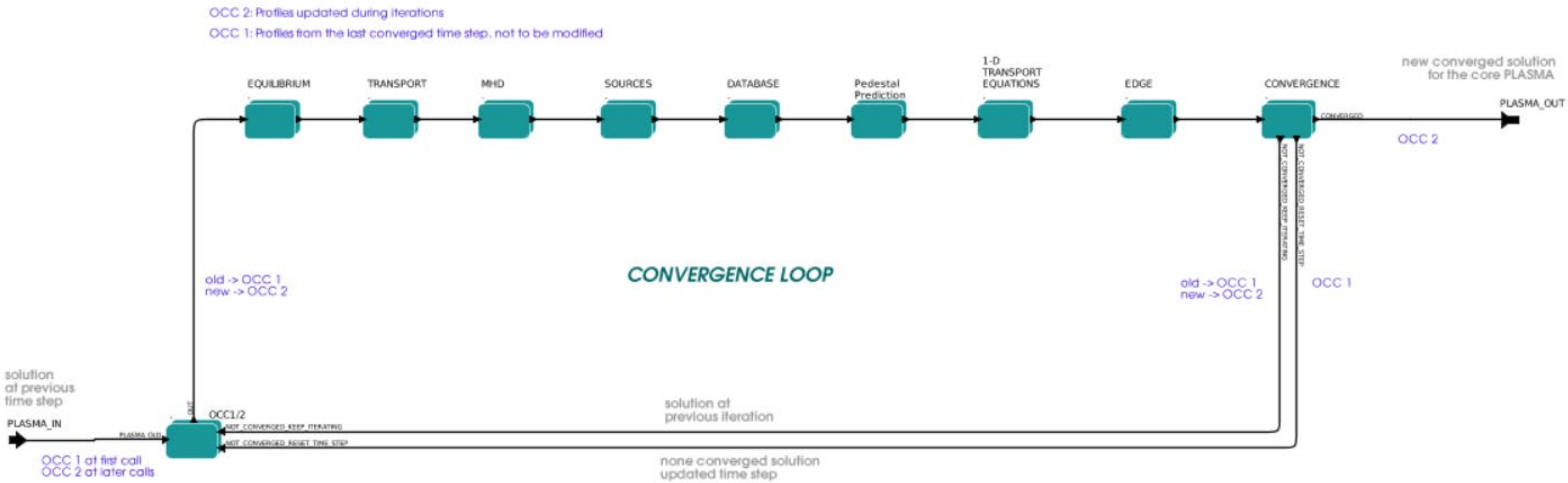
The autoGui is automagically built form the loaded workflow and provides a flatter view of ETS and its settings and in addition has added features of launching and monitoring jobs on the (gateway) cluster.




The autoGui also allows parameter files be saved, shared and distributed between users - outside of training and developments work the autoGui is the recommended Frontend tool.

# Bulk of the matter: ETS physics modules

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| Runaway fluid | Neutrals |

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| Solvers |
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| Progronka |

| Edge |
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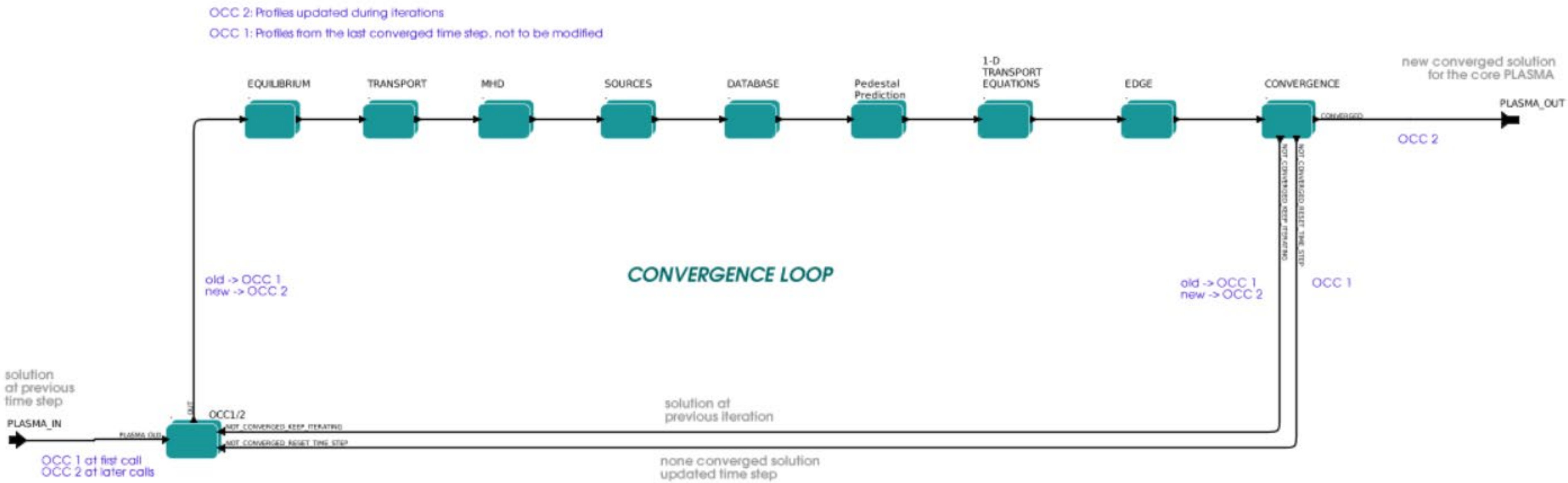
| Solpsz1 |

In short: state of the art set of physics modules in a robust and highly configurable framework

A few models remains to be ported From ETSv5.

# Bulk of the matter: ETS physics modules

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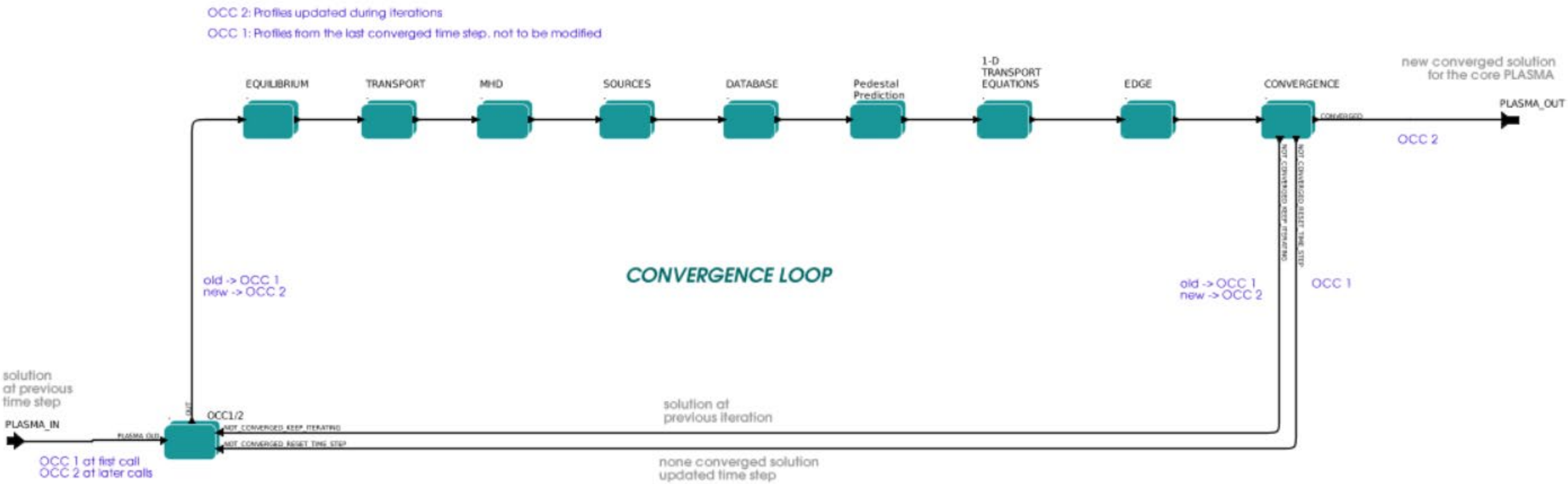
The range of modules available gives a user some flexbility to either ”Zoom” to a specific physics aspect and/or vary fidelity from ”scoping” to ”advanced” through the selection of modules.

# Bulk of the matter: ETS physics modules

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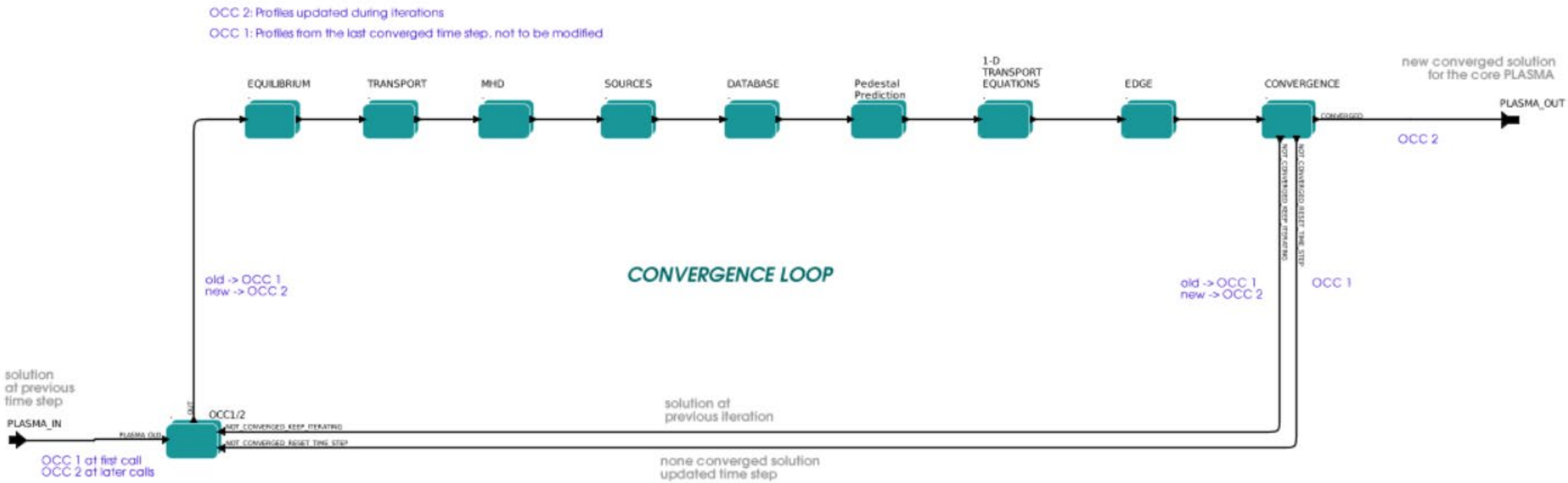
Some lingering general issues
in relation to IMAS implementation:
Where to store ML network data
(files not allowed…)
(Affects QLKNN; PENN)

# Bulk of the matter: ETS physics modules

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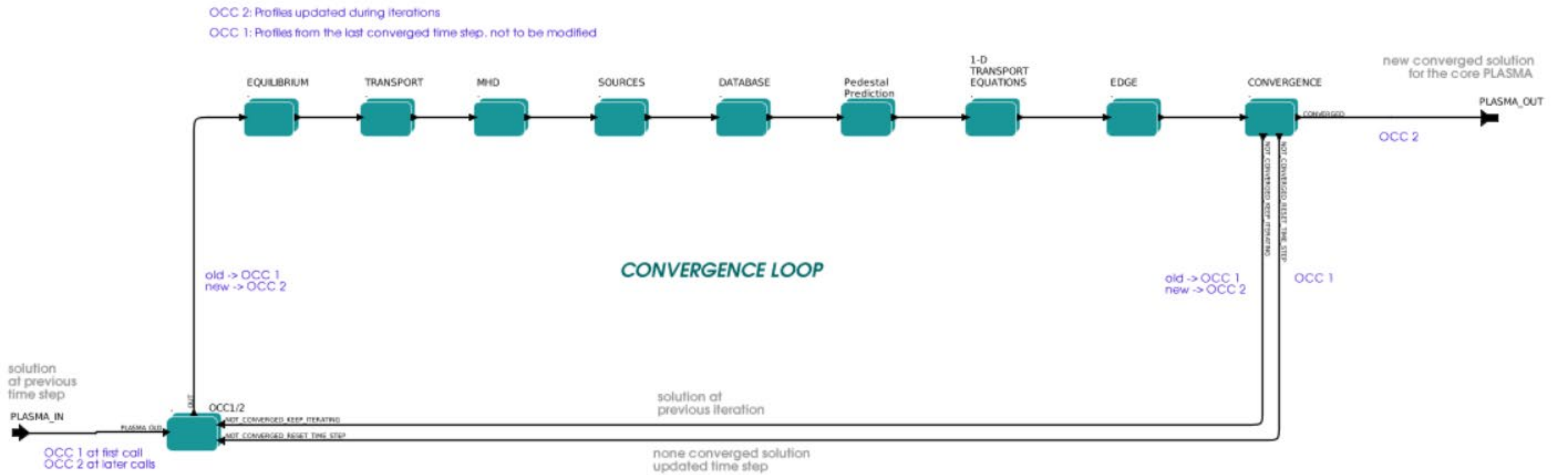
Fast Ion physics is included in the equilibrium and the sources, restricted to dilution only in transport modules - largely by code owners recommendations.

Transport and H&CD well presented before will only discuss other and new aspects today.

# Bulk of the matter: ETS physics modules

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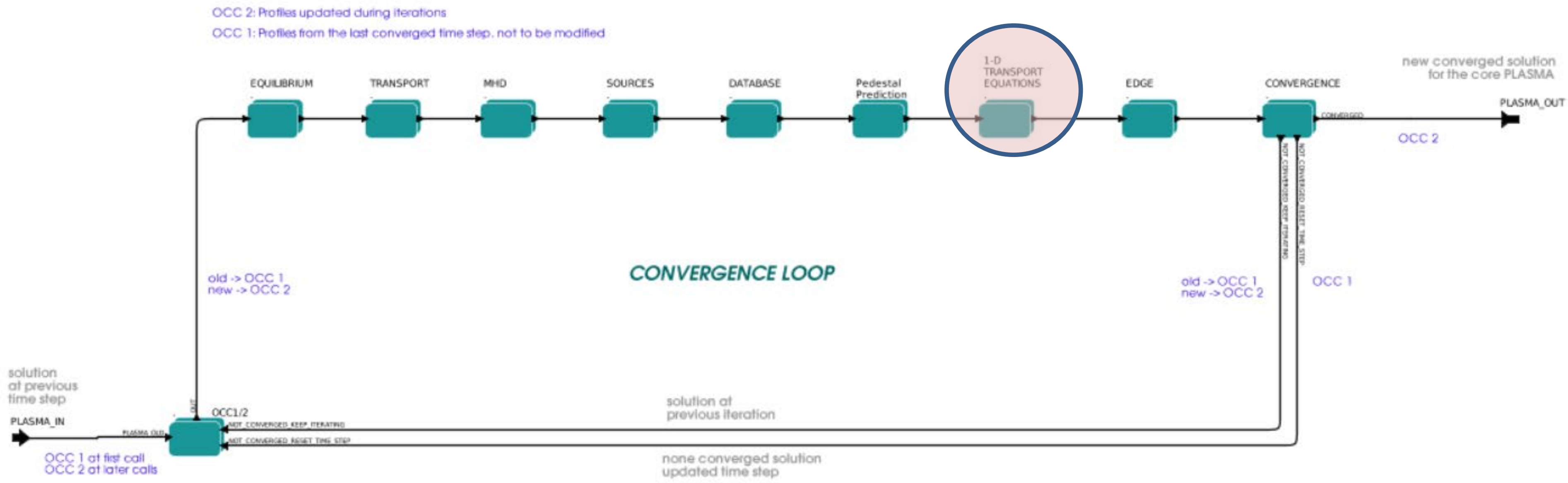
ETS be used for both

- Interpretative and
- Predictive simulations!

Set up for JET; AUG, TCV; DEMO; MAST; ITER; WEST; JT-60SA as well as K-star and DIII-D

# Bulk of the matter: Physics modules – the solvers

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ETS has at its core a set of solvers that implements a comprehensive set of transport equations ("ASTRA-like")

D. Kapulin 35th EPS, 2008

D. Coster, Trans. IEEE 2010

# Solver implementation

Solvers directly imported from ETSv5.

- Progronka  (Stankiewicz et al)
- FEM (Susnjara et al)

Tested and verified

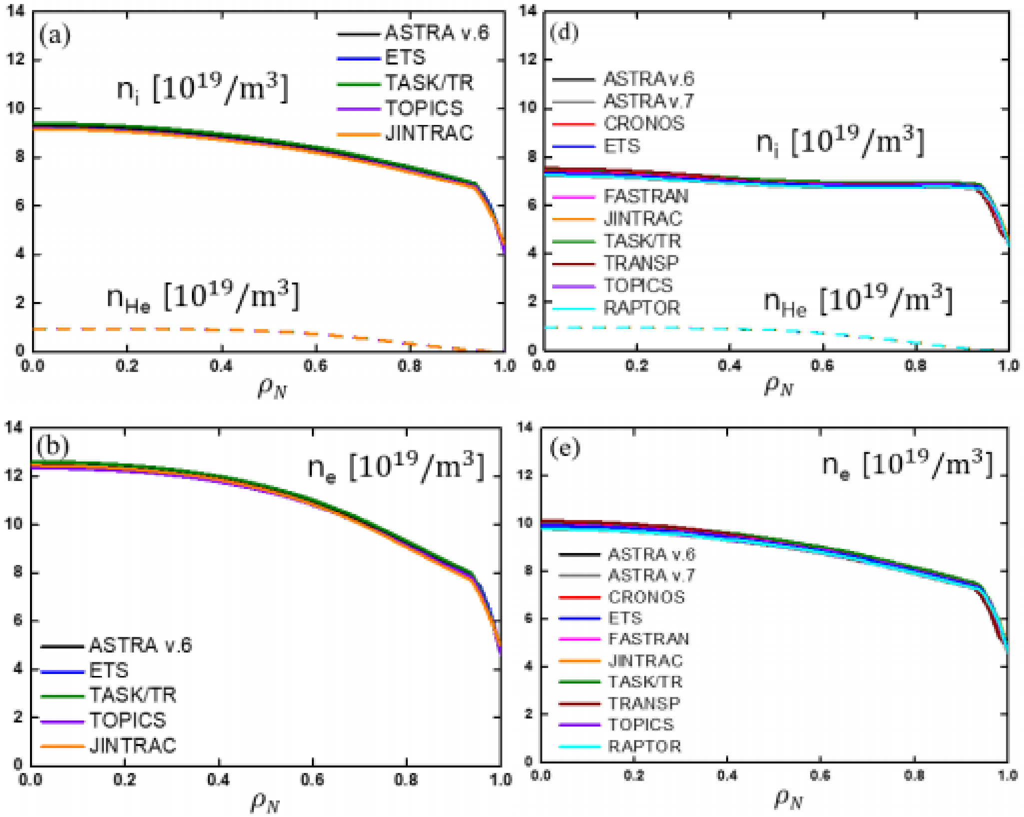
- Methods of Manufactured solutions (MoM)
- ITPA benchmarking →

Pereverzev-Corrigan (CPC, 2008) stabilization scheme

- Required for stiff transport models
- Targetting steady state but usable for (slow) transients with strict time step control

Allowing for Internal Boundary condition r/a < 1

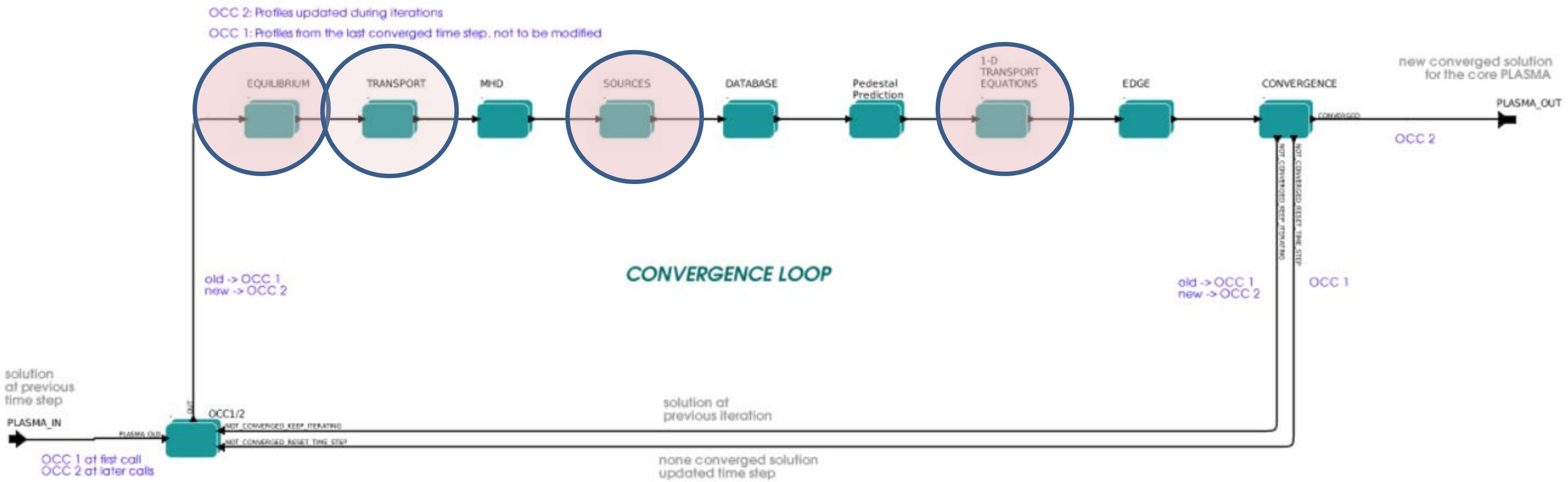
Rewritten equation set to allow for moving boundary




YS Na et al. Nuclear Fusion 59 (7), 076026

Advection-reaction-diffusion equations are very hard to solve for with stiff models in particular where the diffusivity not necessarily is dominant

# Bulk of the matter: ”Transients”

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With stabilization schemes for stiff models activated, evolution is limited to (slowish) ramp-up/ramp down scenarios etc.

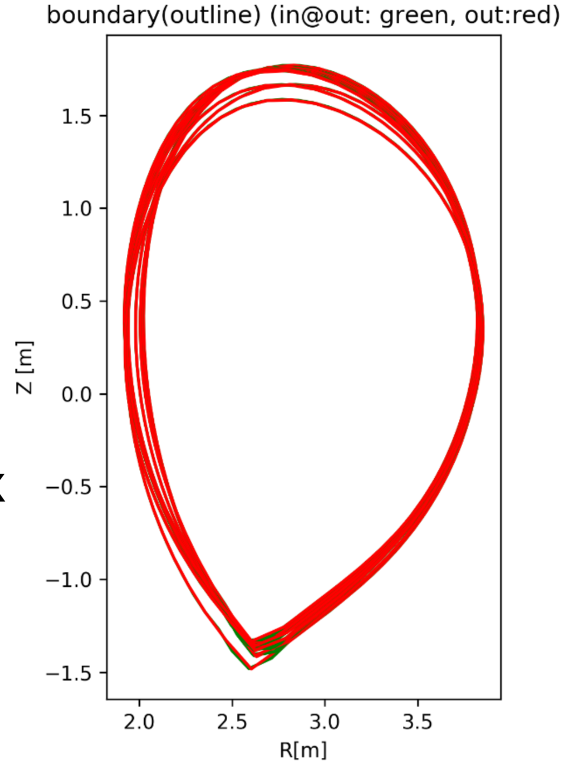
# Current diffusion/ramp up

#96648 - Ohmic 3.0MA baseline test

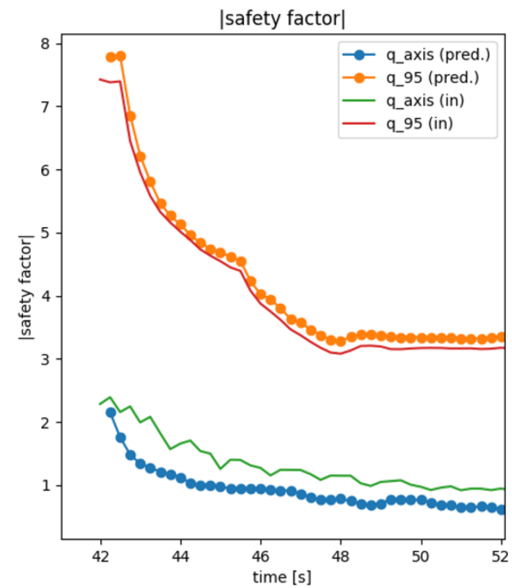

Te = Ti
Zeff = 1 (exp. ~1.2 to 1.4 )
EFTP (EFIT w. pressure)
profiles every 250ms

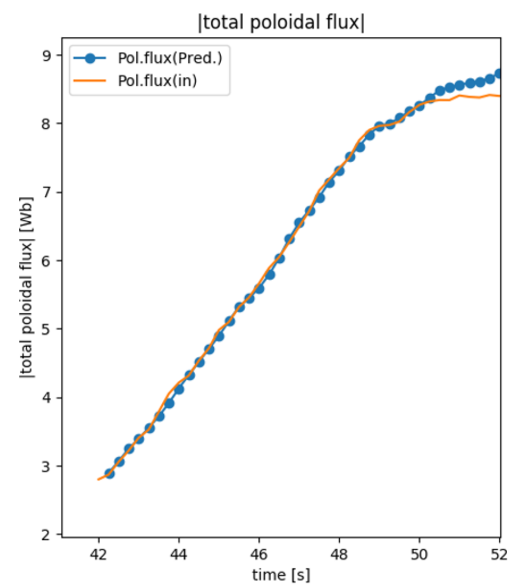
Only solve for poloidal flux (constrained by total current)

FEM solver (Δt = 250ms)
Neoclassic model: NCLASS
(with bootstrap current)
CHEASE (every iteration)




Preprogrammed boundary

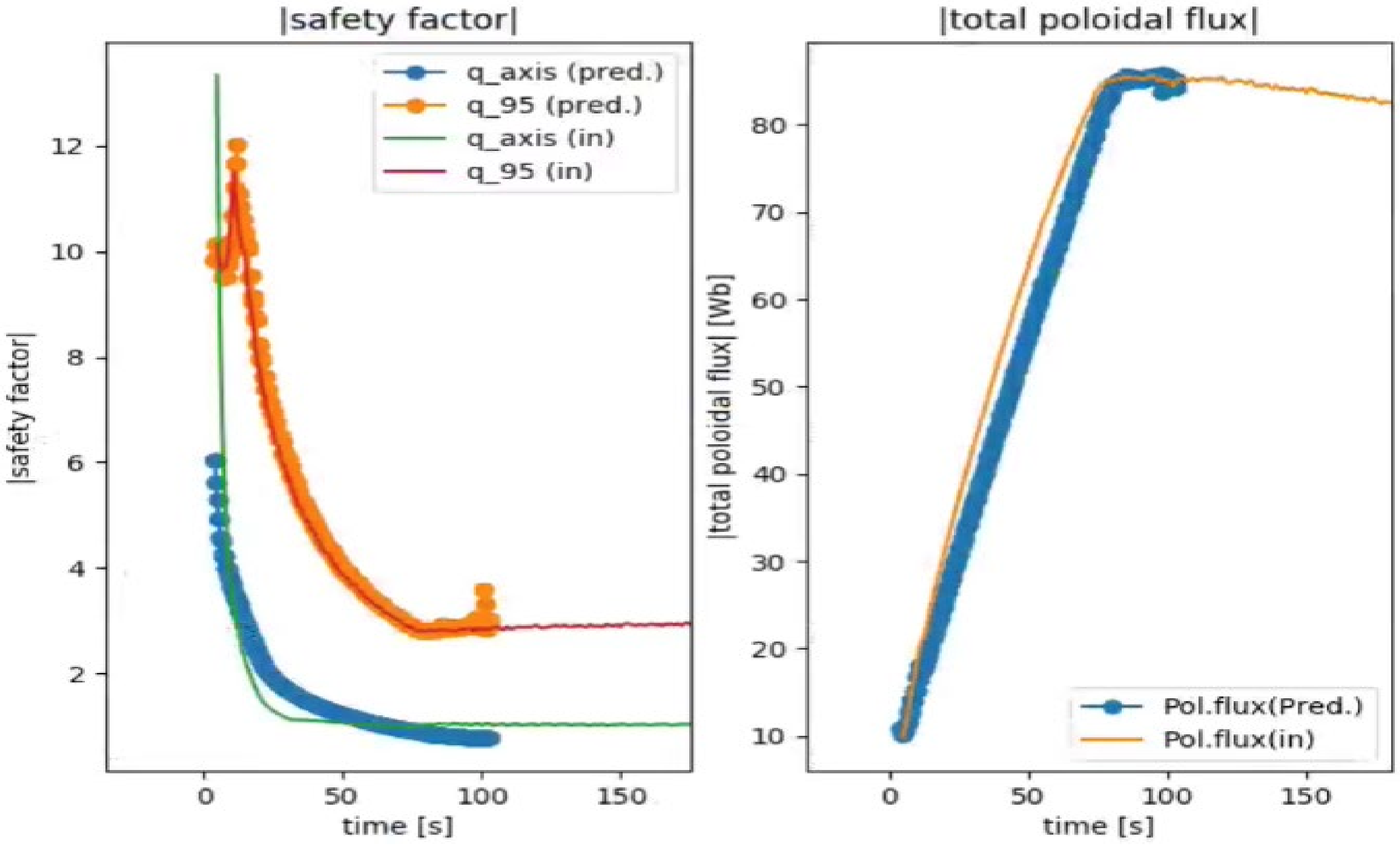



J. Ferreira WIMAS-2 team

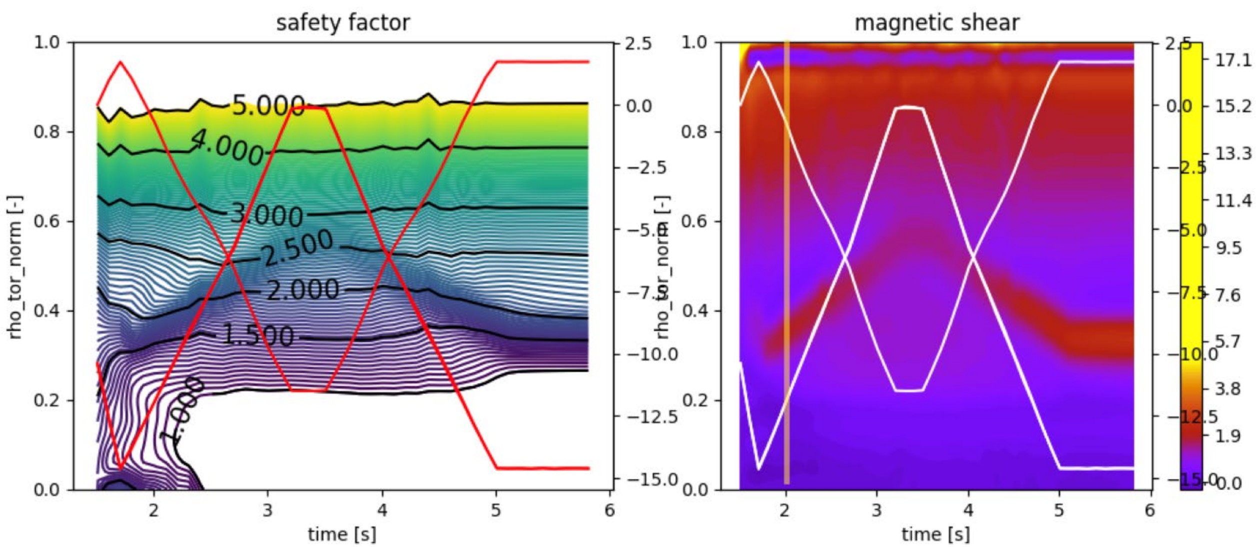
# Current diffusion/ramp up

Similar studies for ITER show similar performance (simple setup)

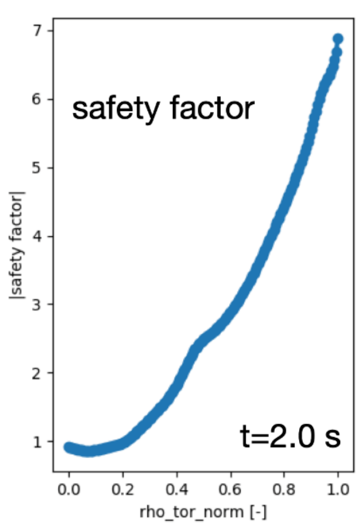


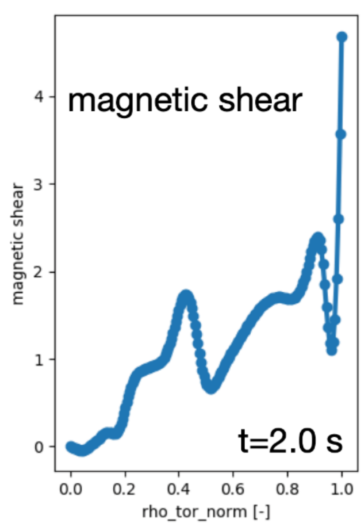

J. Ferreira WIMAS-2 team

# AUG modeling in support of ECCD modelling for TAE stability analysis




q-profile is modified locally by ECCD. The increased magnetic shear has an direct impact on the TAE stability

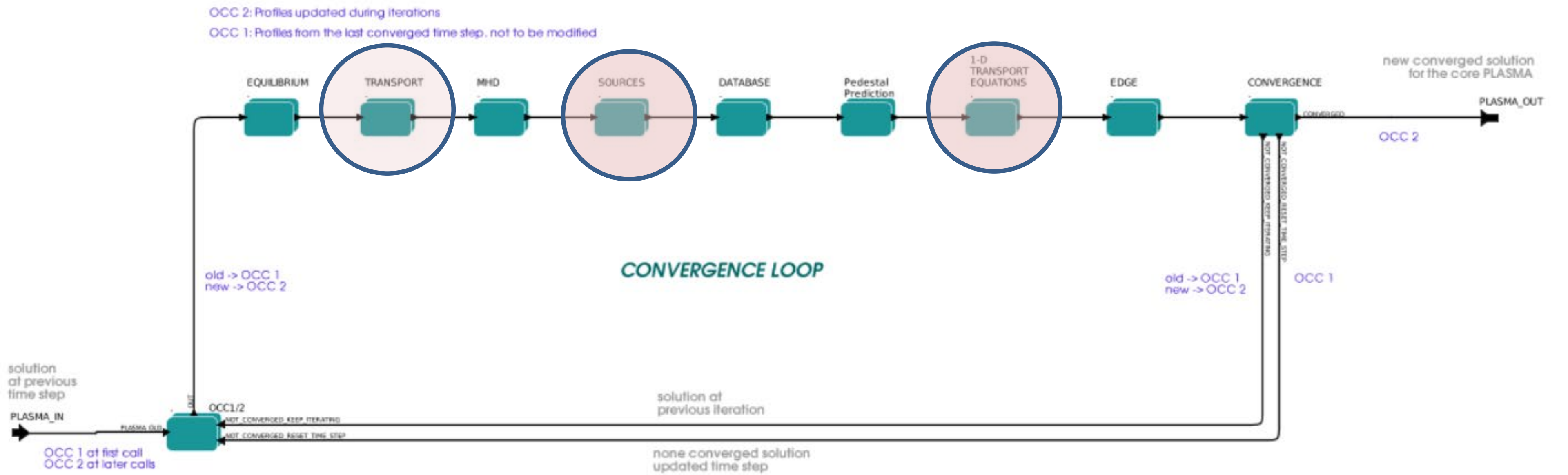



Simulation done with ETS v6 (IMAS) using GRAY and CYRANO/StixReDist for ECCD and ICRH modeling respectively

J. Ferreira

# Bulk of the matter: Impurities & Neutrals

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The impurity and neutrals modules are among the last to be moved to IMAS.

- Impurities already released
- Neutral package pending

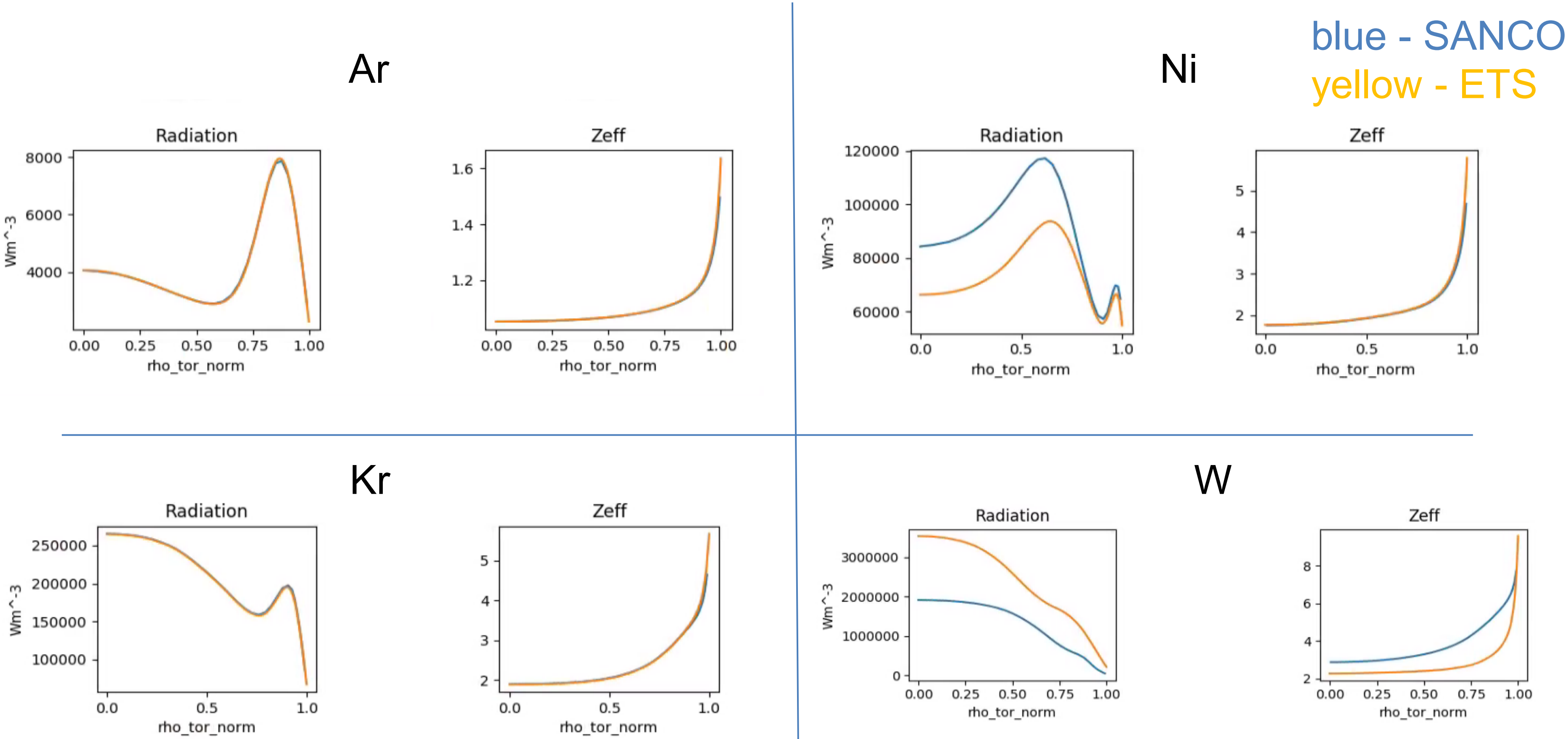
Impurities are now solved for as part of the general solvers

# Impurities in ETS6 (implementation)

- Both interpretive/static and predictive evolution of the impurity densities is implemented
- Multiple impurities can be initialized ‘from scratch’ or read from the input IDSs
- Transport coefficients can be calculated by dedicated transport codes (NCLASS,EDWM,TGLF, QLK) or can be prescribed
  - Different ways of forming anomalous transport (per charge state, effective impurity species, or ignored)
- Source terms are obtained using latest version of ADAS database implemented through the AMNS library
- Difference from ETS5 implementation:
  - No longer a separate solver – impurities integrated in main solver

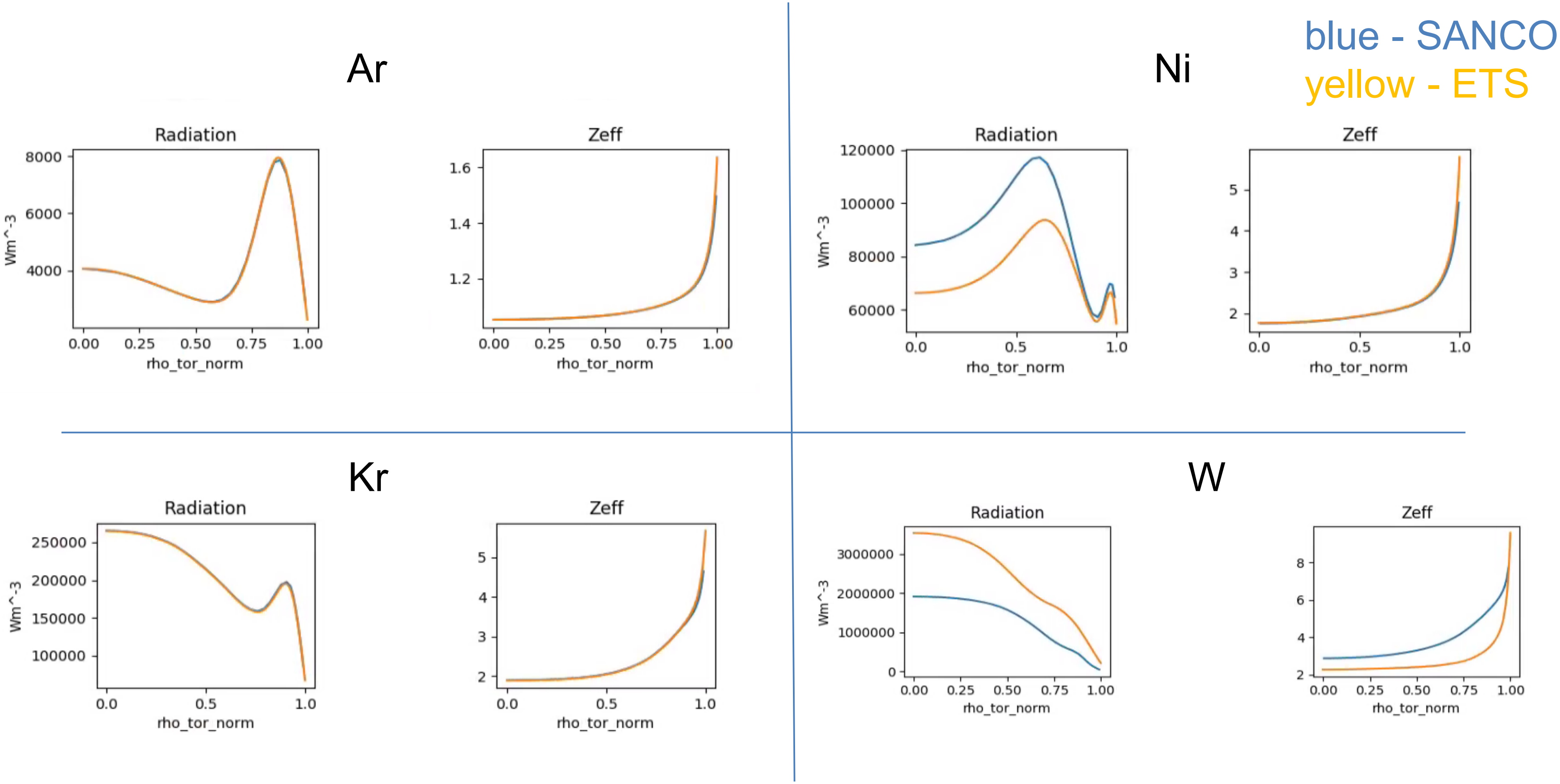
D. Yadikin, I. Ivanova-Stanik, T. Johnson

# Impurities in ETS6: verification



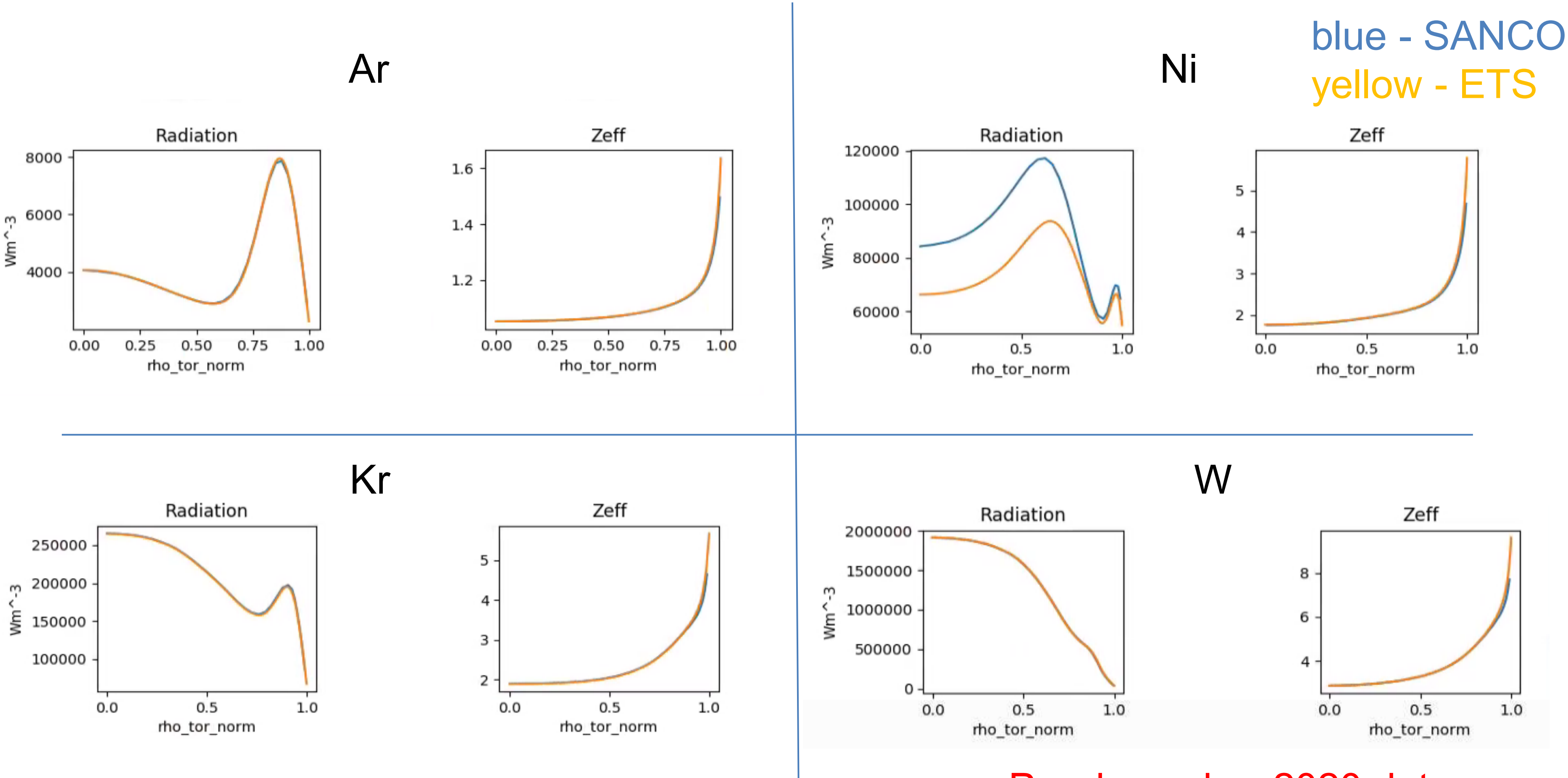

- Comparison with standalone SANCO (K. Kirov).
  - Based on JET #71827 (equilibrium), parabolic profiles, charge state bundles corresponding to boundary value 1.0e17m-3,
  - prescribed transport of 1.0m^2/s is used, atomic data (ADAS, AMNS) sources
  - Run until steady state (flat profiles)

# Impurities in ETS6: verification




- W results: discrepancy obtained using the latest version of the AMNS data (modified in Dec 2020) in ETS.
- Ni radiation: different atomic data used at JET, need further work to verify which version is ‘correct’

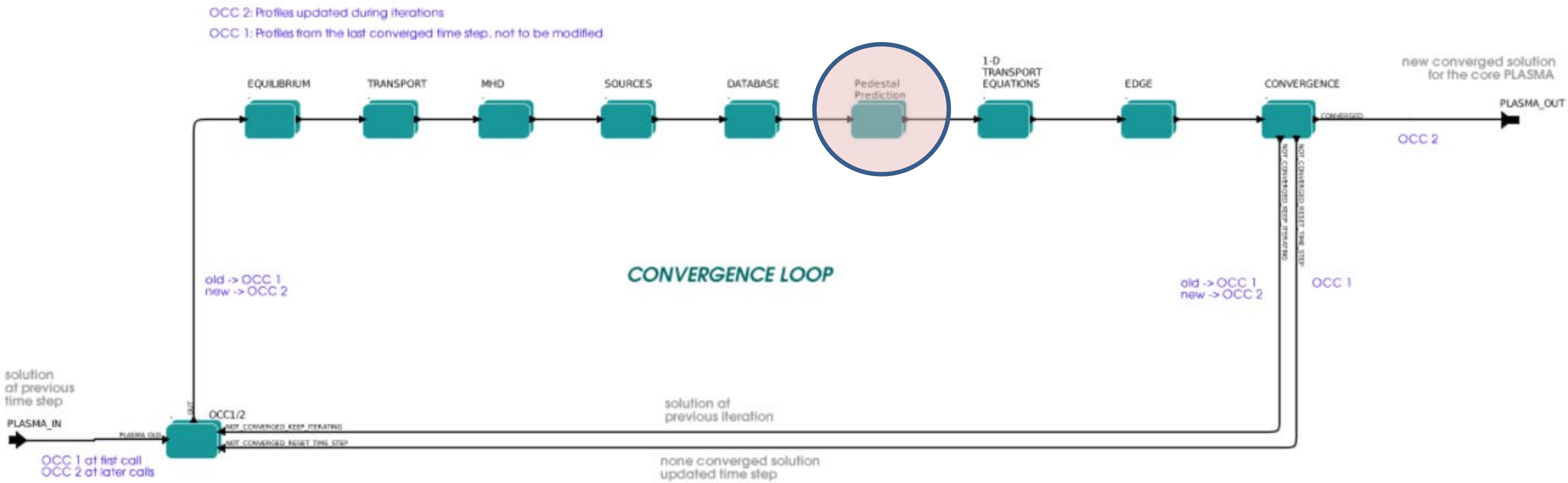
# Impurities in ETS6: verification




Pre december 2020 data

- W results: discrepancy obtained using the latest version of the AMNS data (modified in Dec 2020) in ETS. Understood! Fixed!
- Ni radiation: different atomic data used at JET, need further work to verify which version is ‘correct’. Needs some further investigation!

# Bulk of the matter: Pedestal predictions




| Equlibrium |
|---|
| Static |
| Interpretative |
| Chease |
| Helena |
| GKMHD |

| Transport | |
|---|---|
| Database | MMM |
| Analytical | RITM |
| GLF23 | |
| Weiland | CDBM |
| EDWM | BgB |
| TGLF | Neowes |
| QLK | Neos |
| NCLASS | |
| NEO | |

| Sources | |
|---|---|
| Database | Cyrano |
| Analytical | Lion |
| BBNBI | Nbisim2 |
| Nemo | Risk |
| AFSI | Spot |
| Fusion_sources | Ascot4 |
| GRAY | StixRedist |
| GENRAY | FoPla |
| Torayfom | Pion |
| Torbeam | Iccoup |
| runaway indicator | Impurities |
| Runaway fluid | Neutrals |

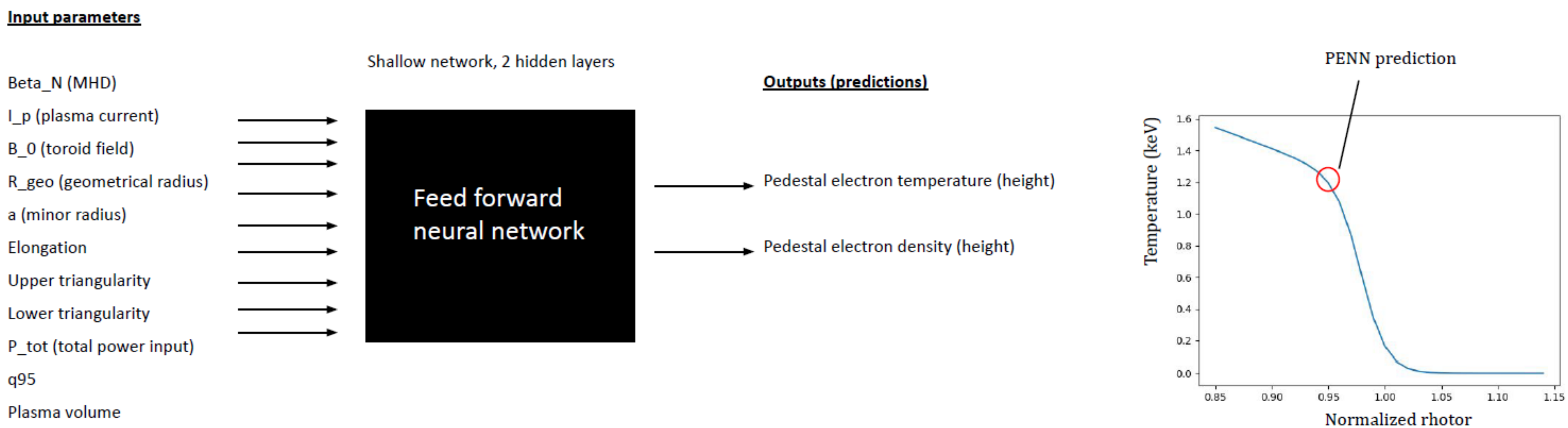
| Pedestal |
|---|
| PENN |

| Solvers |
|---|
| FEM |
| Progronka |

| Edge |
|---|
| CEC |
| Solpsz1 |

# Pedestal predictions - PENN

- PENN - Pedestal Neural Networks model
  - Estimates pedestal values from global/engineering parameters




- Database: EUROfusion JET pedestal database, provided by Lorenzo Frassinetti
- Size of training set: ~ 1500 entries (after dropping entries with missing values)
- We have data for electrons, not ions
- True values in database are used to optimize neural network through back-propagation

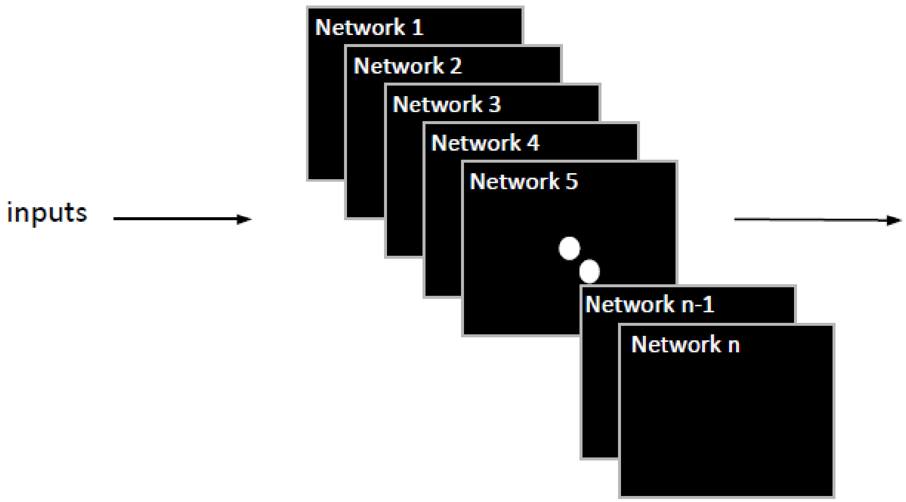
***Training tools:*** *Keras/Tensorflow interface, input and output normalization, mini-batches*

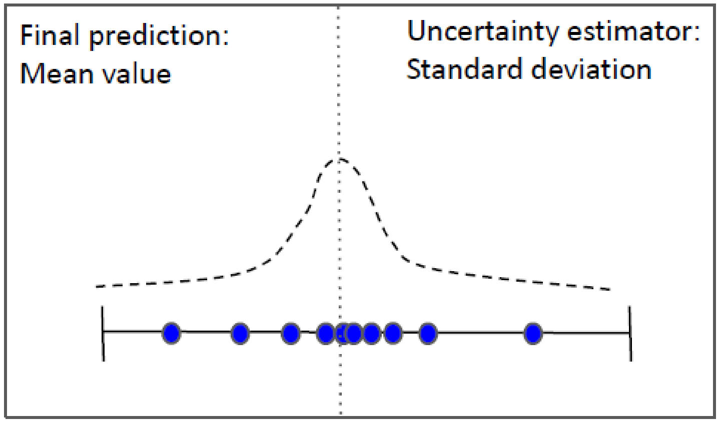
Andreas Gillgren

# Pedestal predictions - PENN

Addressing Prediction Uncertainty: Simple bayesian approach:- train several neural networks to perform the same task

- The ensemble of predictions can be analysed to estimate uncertainty / detect extrapolation
- Ensemble networks may increase stability



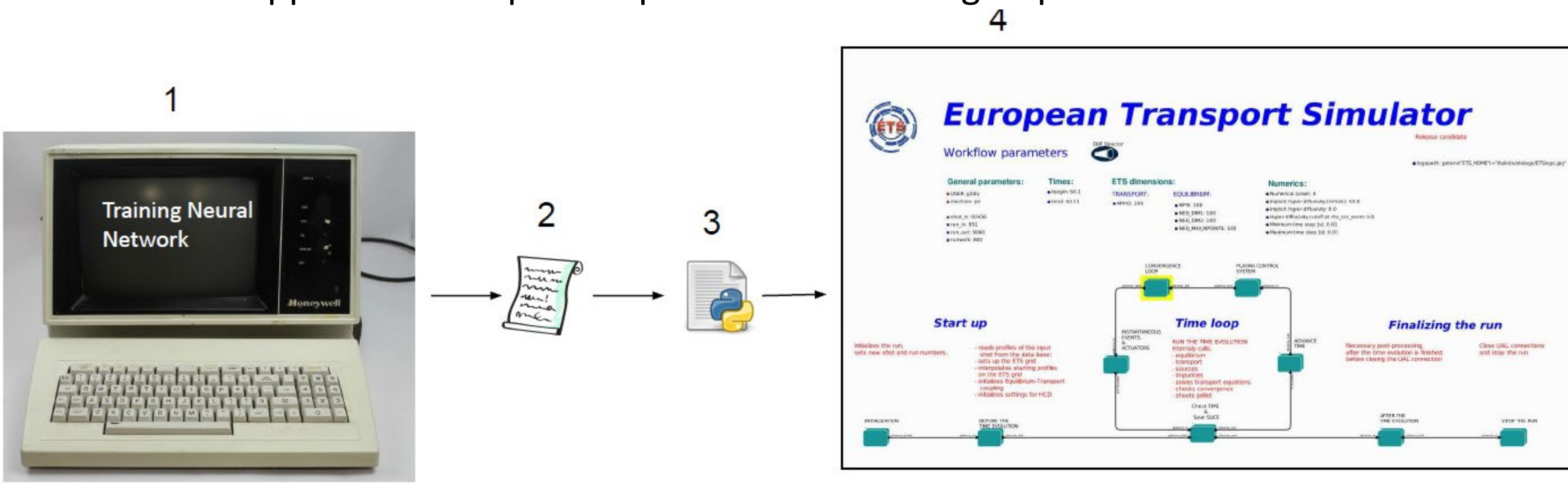

*Currently mainly based on JET data but broader adaptation to EUROfusion Pedestal dabatases underway. AUG data being assessed (however limited by AUG database size). Method obviously applies to synthetic data as well, EPED databases tec.*

Andreas Gillgren

# PENN in ETS

Generic Framework:

1. Training of neural networks is done before implementation (computational demanding part)
2. Parameters of optimized neural networks are exported to separate script/file
3. Python script on ETS to use neural network parameters and make rapid predictions (fortran based version planned)
4. Generic approach  - adapted to predictive modelling requirement in ETS




*General implementation issue for all NN based models:  how to deal with ensembles of network data in IMAS environments (e.g. how to avoid critical input files floating about at random  - provenance capture, reusability, performance,…..)*
*AMNS like library structure? Blessed file locations?*

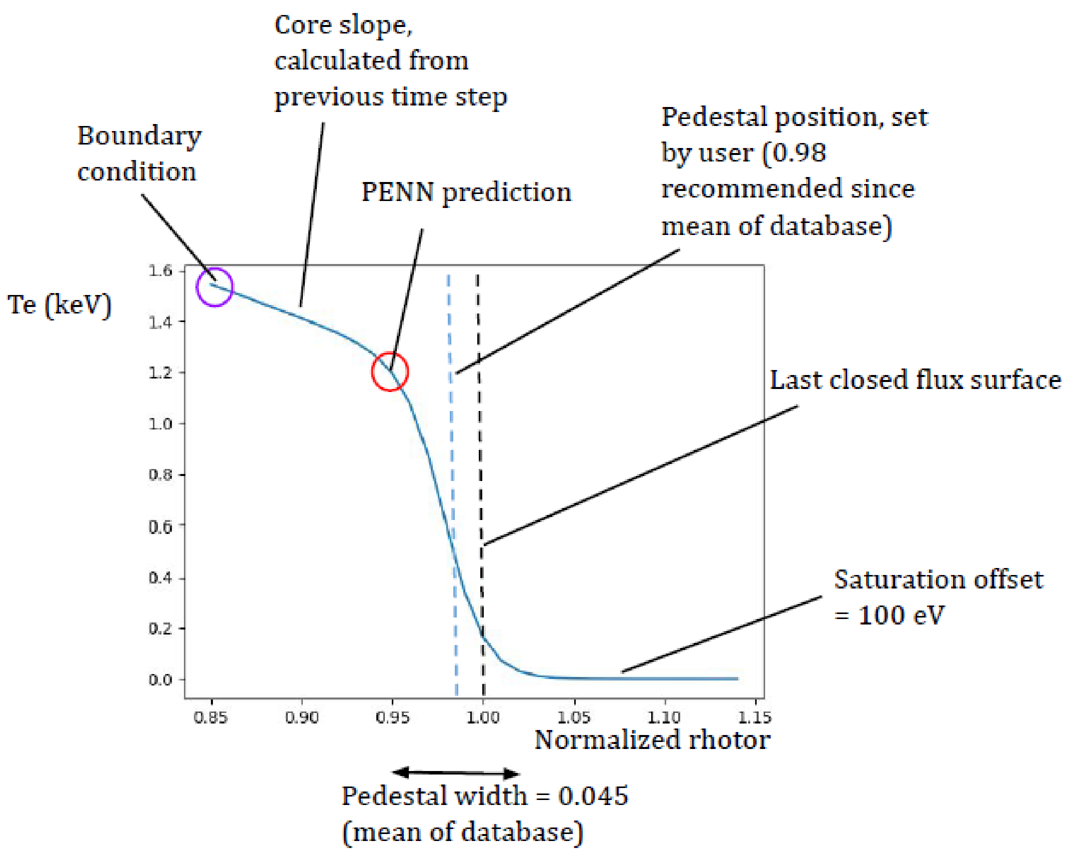
Andreas Gillgren, Dmitriy Yadikin

# PENN in ETS

- Makes predictions from input IDS (IMAS framework) or CPOs (ITM framework)
- Writes new outer profiles (from boundary condition to LCFS)
- Uses modified tanh, requires 5 pedestal parameters (height, width, position, core slope, offset) to “extrapolate” to potential interior boundary point

➔

- **Non-static boundary conditions**
- **Predictive pedestals for predictive simulations**




Work continues partially in and ENR and the intention is to provide model(s) (with better statistics) for all devices

Andreas Gillgren, Dmitriy Yadikin

# PENN in ETS

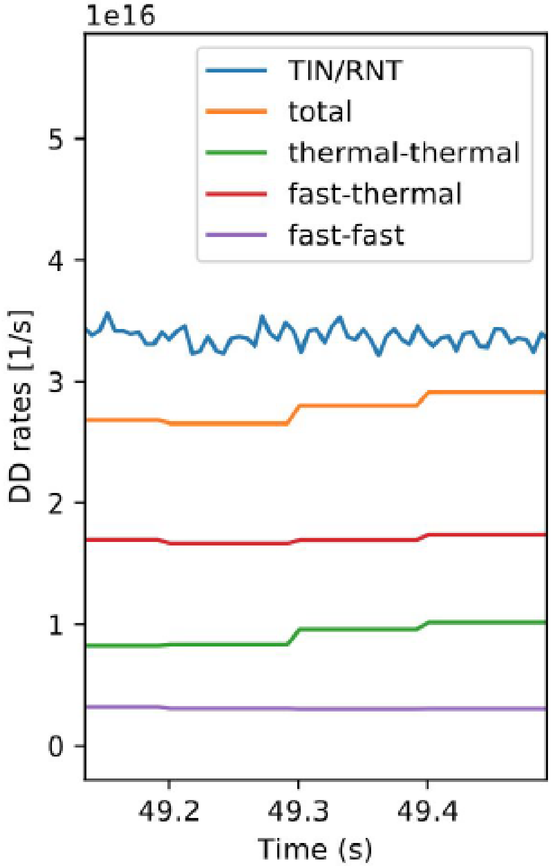
JET shot 97781, Penn for pedestal (Gray area), TGLF for core, interpretatitve TRANSP

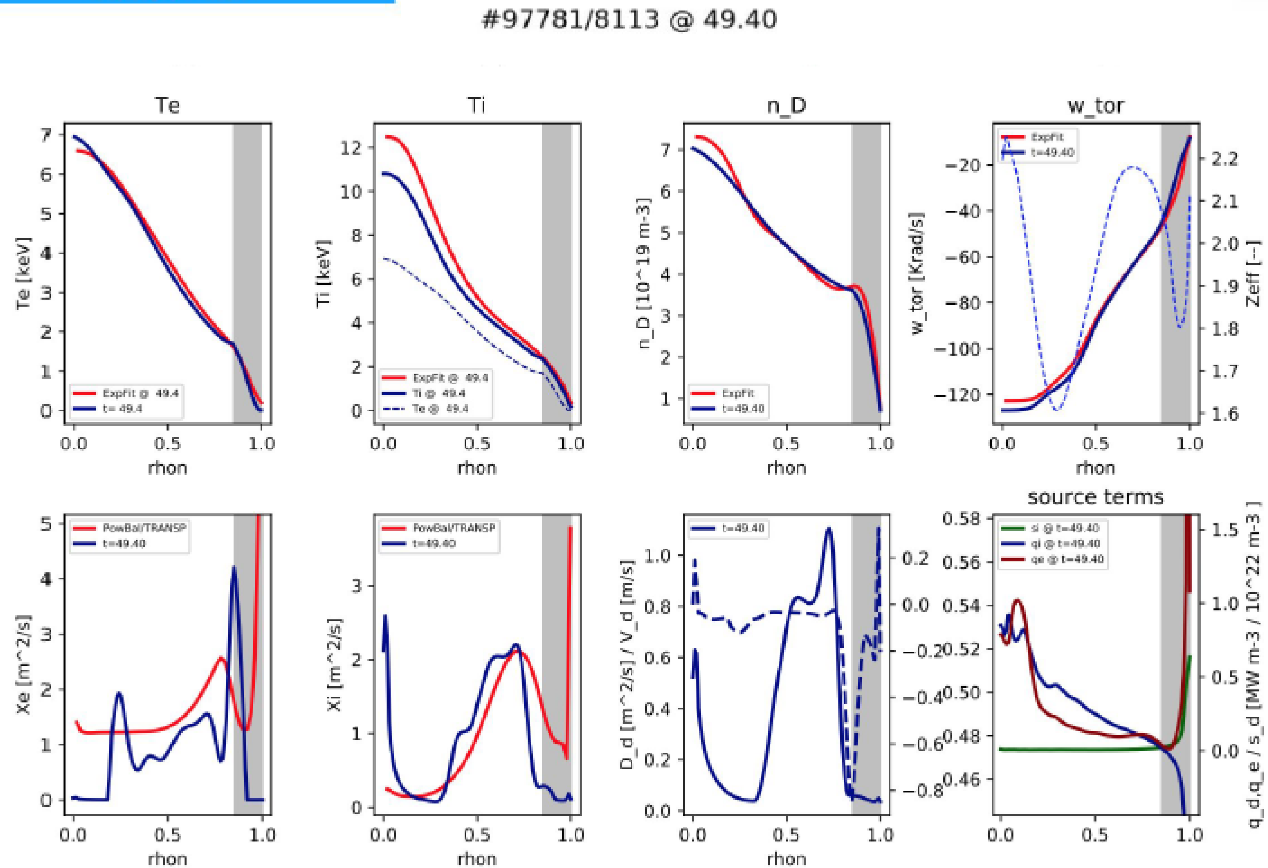
**Comparison between INTERPRETIVE/TRANSP and PREDICTIVE ETS for 49.0 s -> 49.5 s**

**Neutron yield**

**advanced pedestal modelling with PENN Ti/Te = 1.4**

**First preliminary test run with PENN ETS profiles @ 49.4 s**



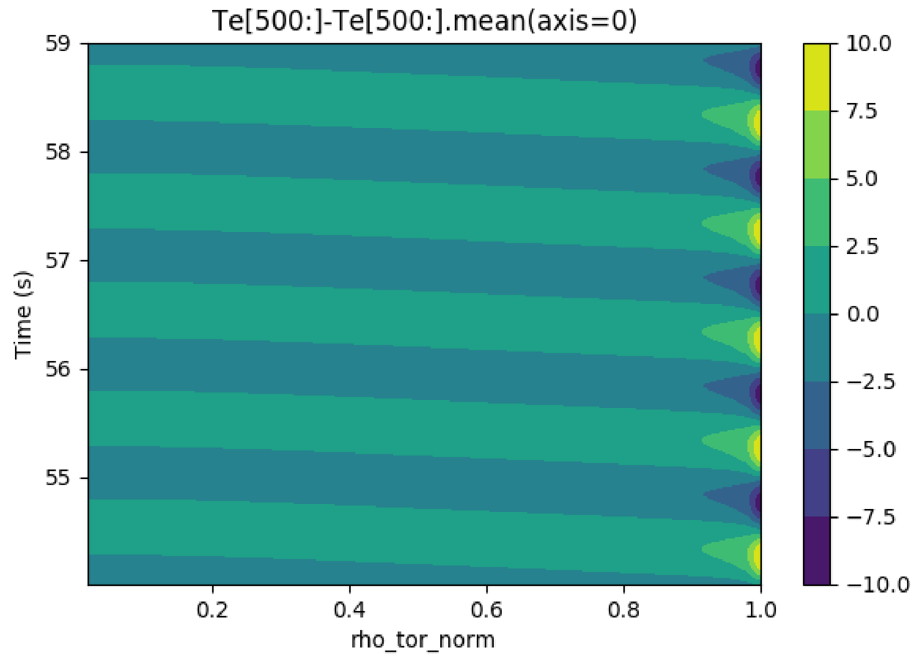

Jorge Ferreira

# Core edge coupling

CEC -
Core –edge
coupling

Generic actor for passing data between core elements and edge codes.

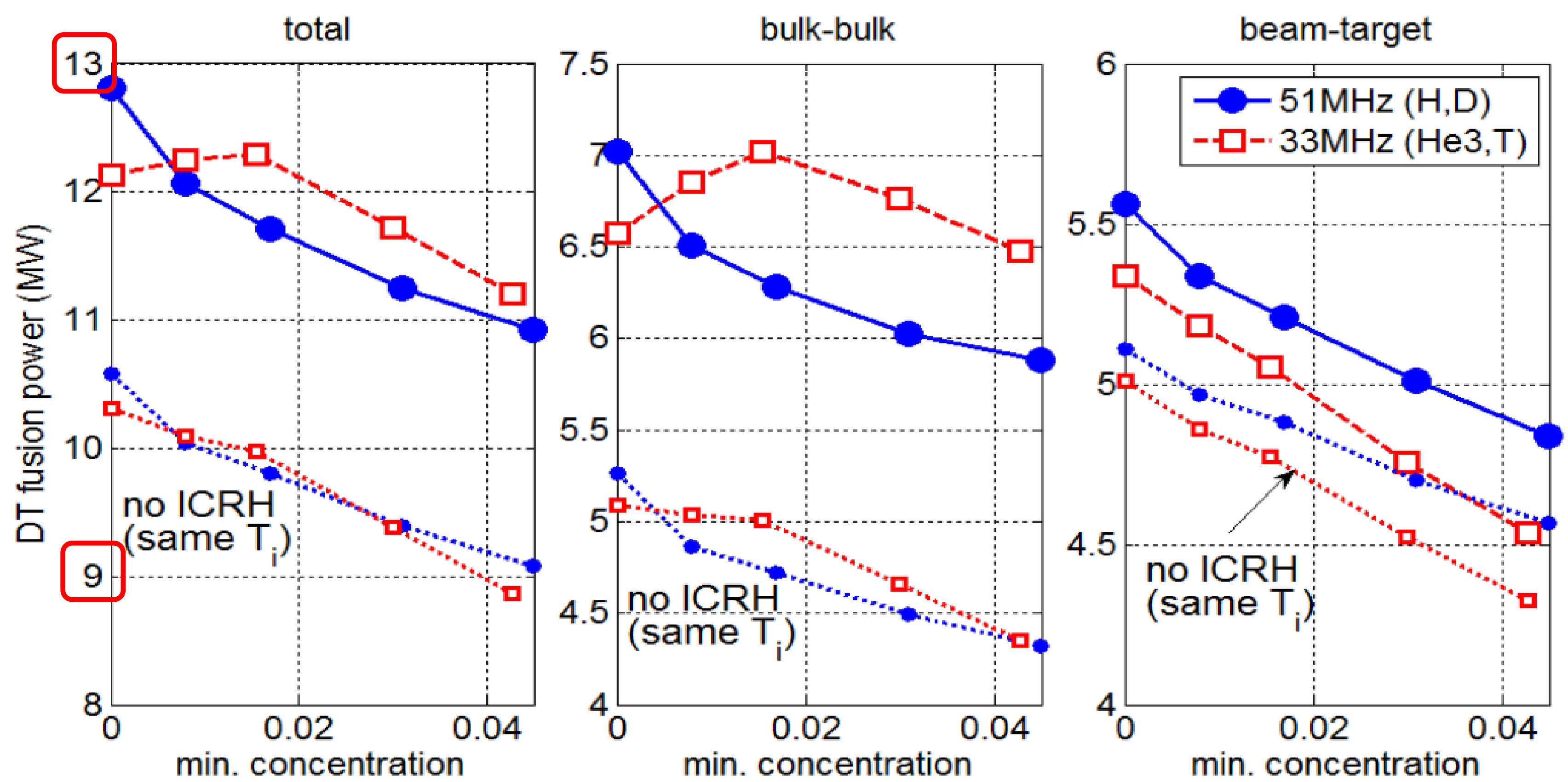
*Temperature evolution with oscillating edge.*




Proof of principle use here but a very useful extension to bring in different edge modules - from simple analytical models to full blown edge codes.

D. Coster

# DT extrapolations: fusion power

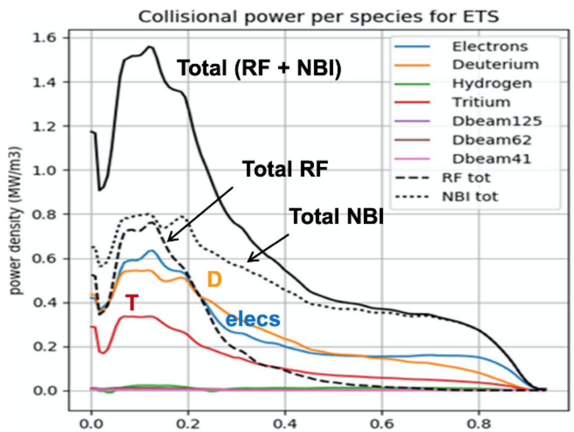



- General trend: less fusion power at larger minority fractions
- H min. case: Mainly dilution and smaller direct second harmonic acceleration of $D+D_{nbi}$ ions (weaker bulk ion tails); *better performance at lower X[H]*
- $^3$He min. case: Dilution and smaller $T+T_{nbi}$ acceleration, but maximum power achieved around X[$^3$He]=2% due to more efficient bulk ion heating

P. Huynh

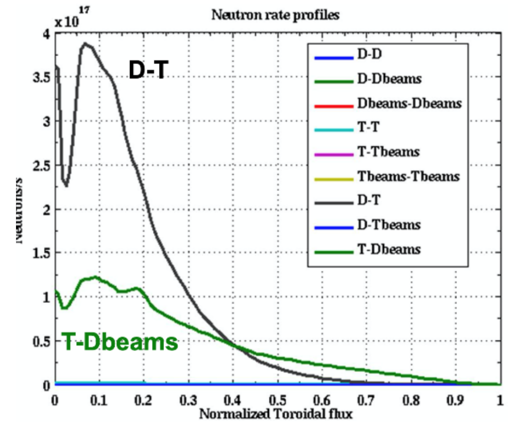
# JET modeling for DT extrapolation

- External heating profiles (RF + NBI) at the final time 49s (FoPla)




- Dominant ion (D+T) heating. External heating on D ions is larger than T ions; Central elec. heating due to ICRH (H min. + N=2 D acceleration)

Neutron rate at the final time 49s (fusreac)




Integrated neutron rate:

| | |
|---|---|
| D-D | 0.781E+16 |
| D-Dbeam | 0.111E+17 |
| Dbeam-Dbeam | 0.126E+16 |
| T-T | 0.167E+17 |
| T-Tbeam | 0.000E+00 |
| Tbeam-Tbeam | 0.000E+00 |
| **D-T** | **0.258E+19** |
| D-Tbeam | 0.000E+00 |
| **T-Dbeam** | **0.203E+19** |
| Dbeam-Tbeam | 0.000E+00 |

Grand total: **0.465E+19 neutrons/s**

**Fusion Power: 13.01 MW**

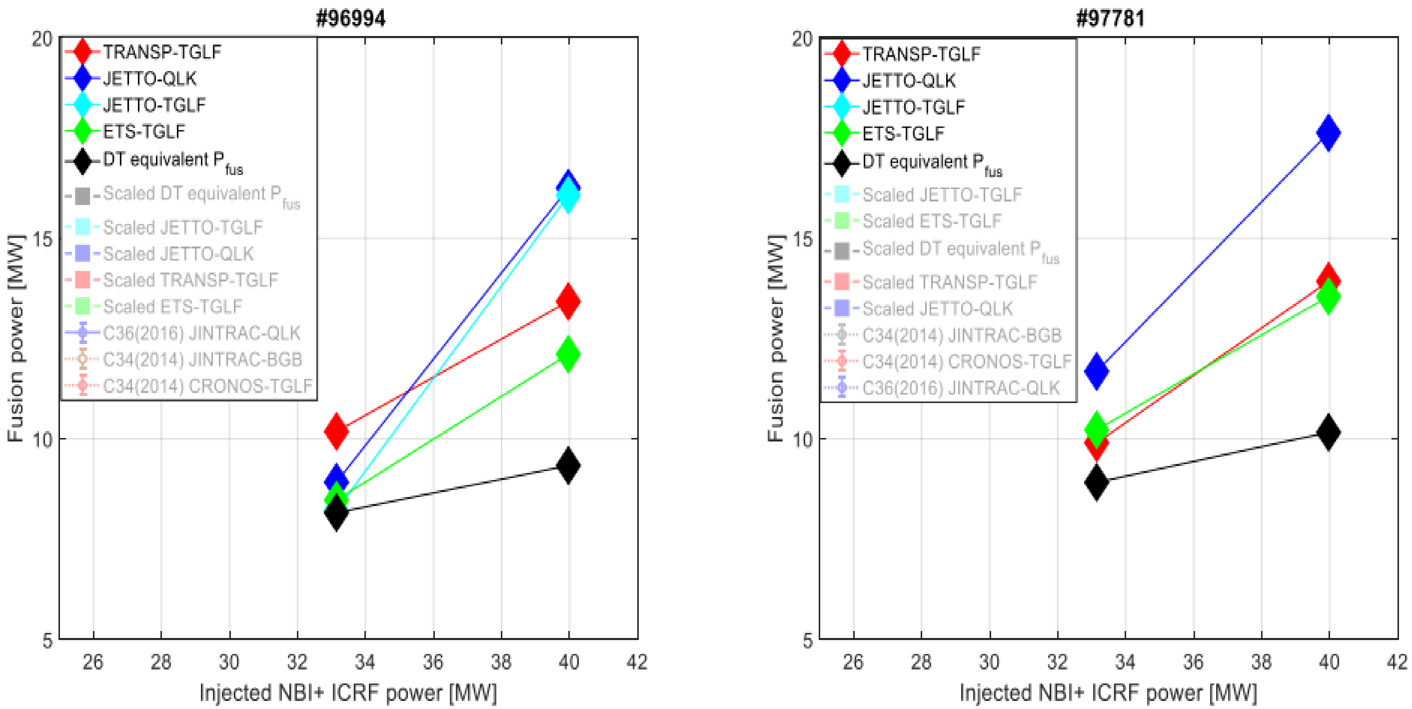
**from:** Predictive simulations with ETS including NBI/ICRH Synergy for baseline shot 92436, P. Huynh, E. Lerche, D.Van Eester, JET TEAM and WPCD TEAM,
JET TF Meeting

**References:**


P. Hyunh, *et al.,* European Transport Simulator modelling: Modelling of the role of ICRH/NBI synergy in the DT extrapolation of high-power JET D scenarios to D-T, accepted for publication in Nuclear Fusion

P.Huyn, *et al.*, Modeling ICRH and ICRH-NBI synergy in high power JET scenarios using European transport simulator (ETS), AIP Conference Proceedings 2254, 060003 (2020); https://doi.org/10.1063/5.0014240

# Fusion power prediction with the reference discharges (#96994 and #97781) in DTE2

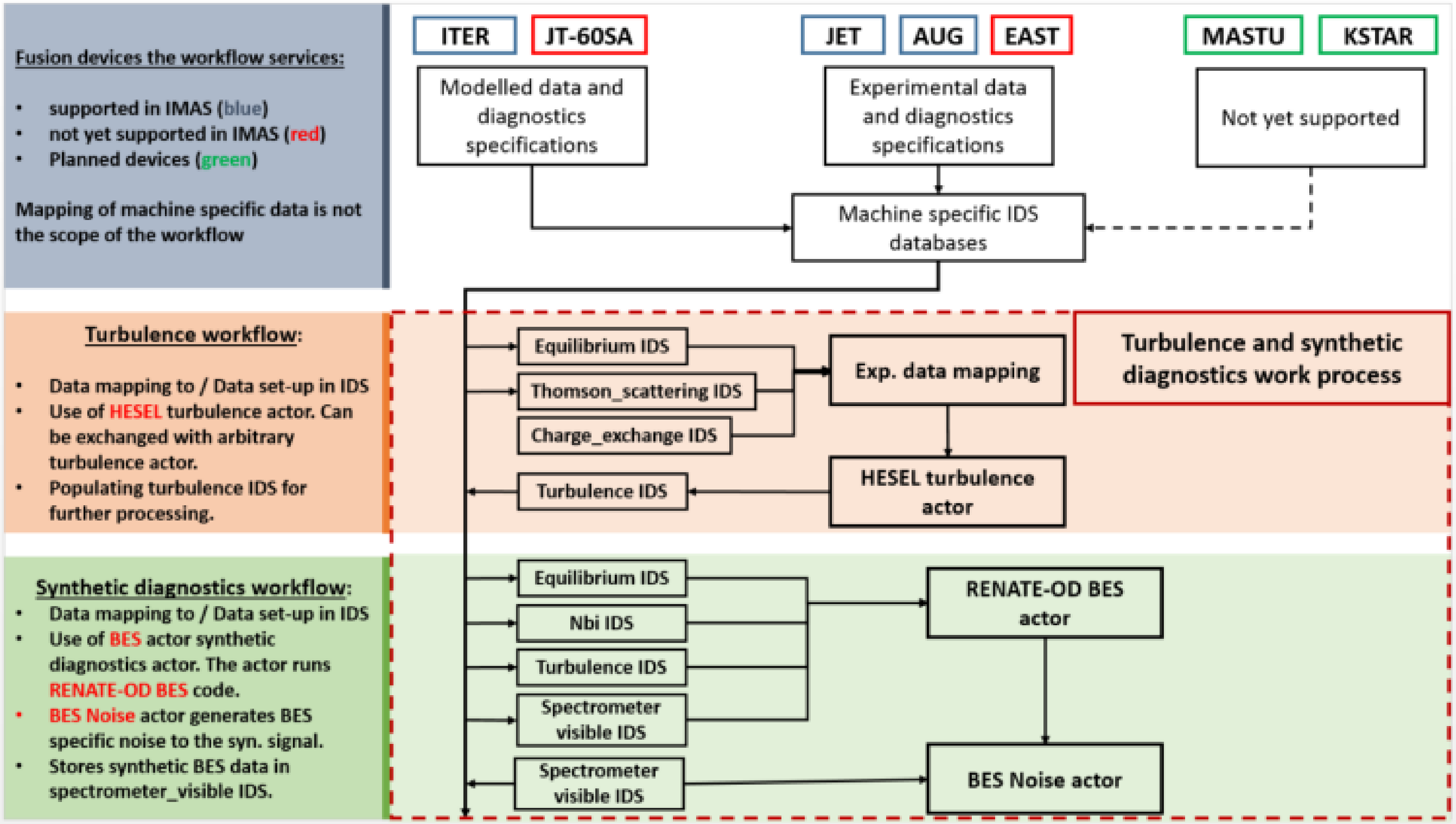



- DT equivalent fusion power (i.e. no increase in $T_i$ and $n_i$ profiles due to positive isotopic effect and high heating) = 9 ~ 10MW in both baseline and hybrid
- Predicted DT fusion power with predicted $T_i$ and $n_i$ profiles
  - DT simulation with 33MW heating: 8~10.5MW in baseline and 10~12MW in hybrid.
  - DT simulation with 40MW heating: 12~16MW in baseline and 13~17.5MW in hybrid.



T17-07 modelling is progressing and this is likely not the current state of affairs

# Edge turbulence WF with synthetic diagnostics

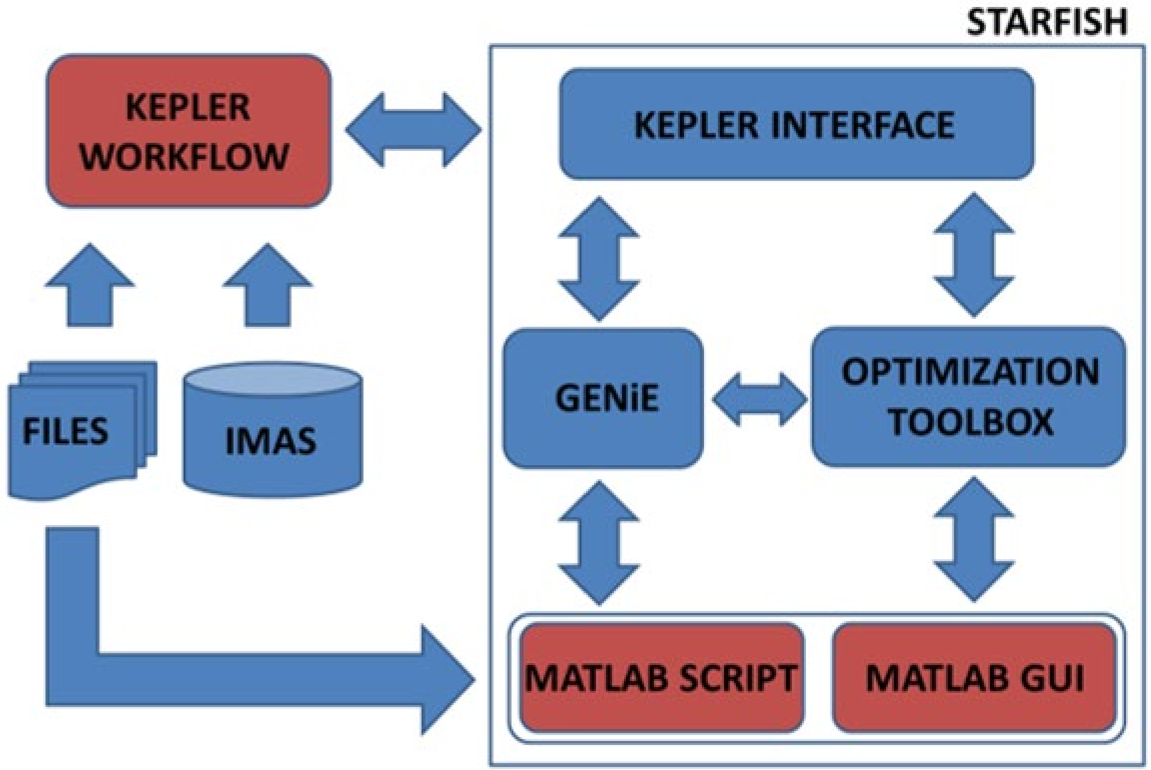



Turbulence WPCD workflows including synthetic diagnostics to compare modelled data of SOL filamentary transport to experimental data in collaboration with WPMST1 and WPJET1.

# Linear MHD stability chain for energetic particles and non-linear codes for fast-ion MHD interaction

- Updates to HYMAGYC now includes, among others, the possibility to load a Energetic Particle population accordingly to the parametrised distribution function fitted from H&CD modelling codes.
  - It runs as a parallel actor both using a fortran "driver" and a test Workflow.
- The hybrid drift-kinetic code CASTOR-K has been adapted to use IDSs. A driver code also exists to enable the running of the code offline, cast as an element of a dedicated workflow.
- A new fitting tool called STARFISH has been implemented to perform the global fit of the numerically obtained energetic particles distribution functions using a parametric Equilibrium Distribution Function (EDF) in term of constants of motion, w (kinetic energy per unit mass), λ=μ/w (the generalized pitch angle), P_ϕ (the canonical toroidal momentum).
  - The implementation is now fully integrated with the Kepler Environment and with the ITER Integrated Modelling and Analysis (IMAS) framework.
  - The STARFISH project has been created on the WPCD GFORGE repository and a first tag for the STARFISH suite of fitting tools has been released.

# Linear MHD stability chain for energetic particles and non-linear codes for fast-ion MHD interaction




A MATLAB code has been implemented to perform the best fit of the parametrized EDF solving a bound-constraint global optimization problem. A custom Genetic Algorithm (GA) has been implemented to perform a population-based elitist global search in 6D parameter space and in cascade (GENiE toolbox), if selected by the end-user, a local search can be performed by means of state-of-the-art local optimizers. The implementation is integrated with the Kepler Environment and with the ITER Integrated Modelling and Analysis (IMAS) framework.

# Summary

WPCD (and ITM-TF) created the philosophy, prototyped and structured the infrastructure (ISP/CPT) and paved the way or IMAS.

The intended continuation into the new e-tasc structured largely failed leaving gaps in implementation, several alienated or unsupported model developers – however

A core set of tools remains (ETS; EQSTAB; EQRECONSTRUCT;… ) with an active (and hopefully) expanding user community that is managed through a small ACH activity.

EUROfusion

# Preparation of ITER Operation, WPPrIO

X. Litaudon (PL), Gloria Falchetto (PSO) on behalf of WPrIO team

DE LA RECHERCHE À L'INDUSTRIE

cea

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# WPPrIO: High level objectives

- Contribute to lay the foundation of a **coordinated significant EUROfusion participation in the ITER team** benefiting from the strength of the EUROfusion programme in **operation, technology and simulation**
- **Integrate Physics and Engineering Optimization** in line with the Roadmap priorities
- Implement some of the recommendations* on "EUROfusion role in ITER operation and scientific exploitation"

*) EUROFUSION GA (20) 32 - 4.7 - ITER White Paper Report WG1 Issue 1 10-Dec-2020 (Decision).docx and EUROFUSION GA (20) 32 - 4.7 - ITER White Paper Report WG2 Issue 3 7-Dec-2020 (Decision).docx

# Recommendations* on "EUROfusion role in ITER op. & scientific exploitation"and PrIO contributions

*) EUROFUSION GA (20) 32 - 4.7

2022 ?

| Sub-systems | Required involvement for EU implication in ITER operation | Impact level on the EU DEMO design |
|---|---|---|
| → TF & PF Magnets and Cryo-plant | *** in commissioning phase (* during full operation) | ++ (for DEMO design) |
| → Divertor & PFCs | *** | ++ |
| Tritium Plant | *** | +++ |
| Breeding Blanket System | *** | +++ |
| → H&CD: Neutral Beam | *** (NBTF) | +++ |
| → Diagnostics | *** | +++ |
| → Control and Analysis/operational/simulation tools | *** | ++ (+++ for some control aspects) |
| → Neutronics, Waste and Radiological Protection | ** | +++ |
| H&CD: Electron Cyclotron | ** | ++ |
| H&CD: Ion Cyclotron | ** (present operation in present facilities) | + |
| Vacuum Vessel | * | + |
| Remote Handling Equipment | * | + |
| Vacuum Pumping & fueling | * | + |
| Building and Electrical Power Supply & Distribution System | * | +++ (for DEMO design) |

(+++): Unique, (++) High, (+) Significant

(***) Strong: Organized team with defined commitments, (**) Organized team, (*) Expertise for follow-up

# WPrIO : 4 objectives

1. **Contribute to the preparation at the EUROfusion level of the initial ITER experimental campaigns**
2. **Support knowledge transfer on operational topics and Develop training opportunities**
3. **Contribute to the NBTF activities and exploitation of smaller ITER-like ion sources**
4. **Improve EUROfusion knowledge on neutronics, instrumentation, nuclear codes, and techniques**

# Project structure as in IMS

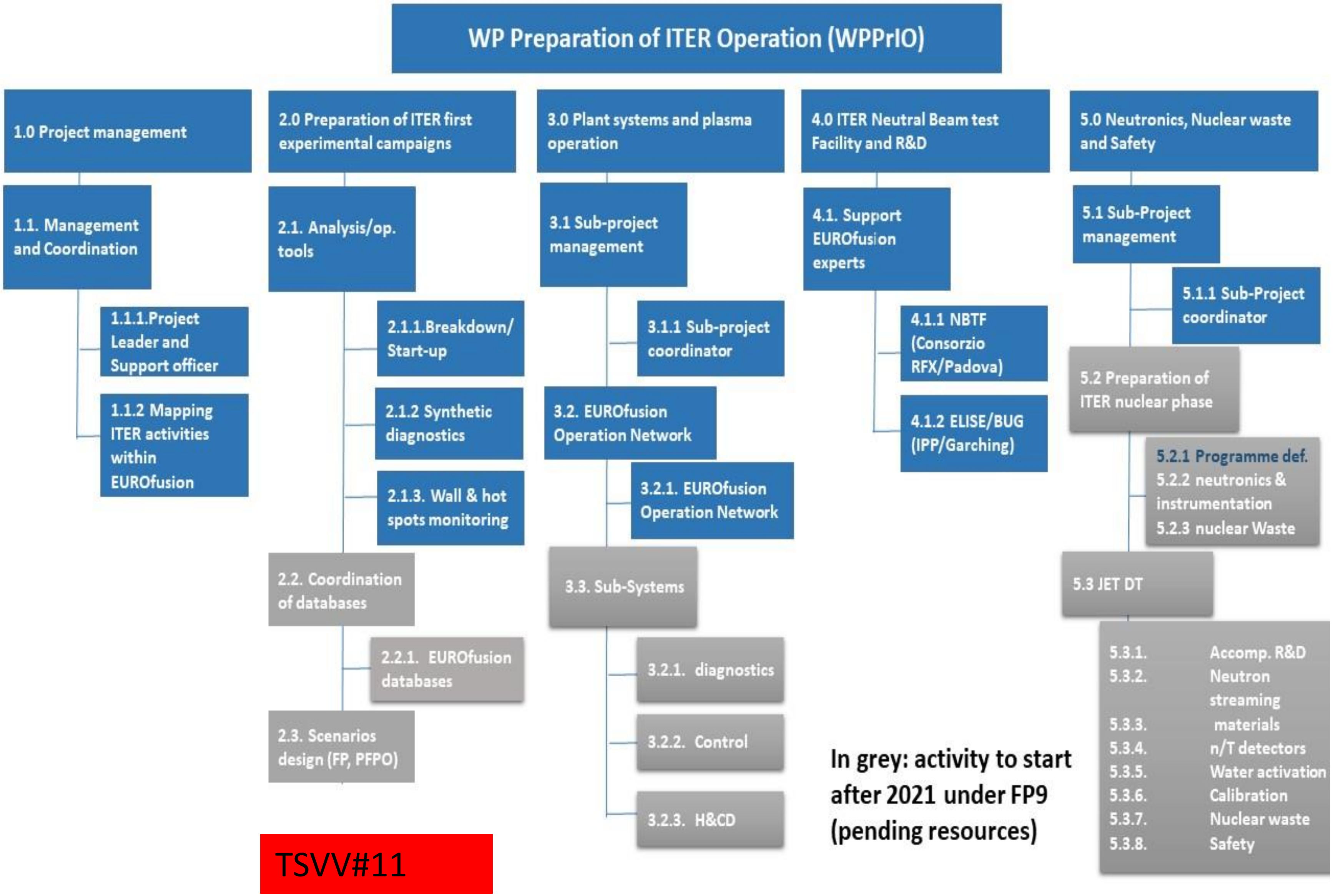
- **SP-1: Project management and coordination**
- **SP-2: Preparation of ITER first experimental campaigns**
- **SP-3: Plant System and Plasma Operations**
- **SP-4: Neutral Beam test Facility and R&D for ITER Neutral Beam**
- **SP-5: Neutronics, Nuclear waste and safety**

✓ **WP is implementing some elements of the EUROfusion preparation to ITER operation and scientific exploitation**

✓ **reference documents:**

- ITER Research Plan within the Staged Approach: https://www.iter.org/technical-reports?id=9
- Required R&D in Existing Fusion Facilities to Support the ITER Research Plan A. Loarte (for the Science Division) https://www.iter.org/technical-reports?id=14
- Cooperation agreement on NBTF

# Work Breakdown Structure - 5 Sub-Projects



# Roles and Responsibilities

**WPrIO Project Leader X. LITAUDON**
**Project Support Officer: G. FALCHETTO**

[June 2021]

## SP-2
Sub-Project coordinator: X. LITAUDON

- Breakdown/Start-up — Topic leader: H.T. KIM
- FOCS Synthetic diagnostic — Topic leader: A. GOUSSAROV
- IR Synthetic diagnostic — Topic leader: M.H. AUMEUNIER
- Wall events & hot spot monitoring — Topic leader: R. MITTEAU
- Disruption database — Topic leader: A. PAU
- Confinement database — Topic leader: E. PELUSO
- Pedestal database — Topic leader: L. FRASSINETTI

## SP-3
Sub-Project coordinator: E. BELONOHY

- EUROfusion Operation network coordinator: E. BELONOHY

## SP-4
Sub-Project coordinator: X. LITAUDON

- EUROfusion delegates to NBTF Advisory Committee (NAC) — H.J.N. VAN ECK, M.Q. TRAN
- NBTF (Consorzio RFX/Padova) — Topic leader: V. TOIGO
- ELISE/BUG facilities (IPP/Garching) — Topic leader: U. FANTZ

## SP-5
Sub-Project coordinator: R. VILLARI

- EUROfusion contribution to ITER neutronics/instrumentation — Coordinator: S. VILLARI
- JET3 (FP8) — PL: P. Batistoni

TSVV#11

[In grey : database and JET3 under FP8 resources]

# Progress summary and status for 2021:

**WP activities, TSVV links, status of allocated resources, risks, synergies, international collaborations, status of the 2021 GA milestones/deliverables,…**

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# SP-1: Project management and coordination

- **Set-up the new project structure**
- **Initiate a mapping of the EUROfusion scientific and collaborative activities for ITER with the support of the contact persons for ITER specific activities in the various EU labs**
- **Initiate a mapping of the specific ITER cross-WPs activities performed within the EUROfusion**
- **Link with ITPA TG activities (web page)**
- **PL Member of E-TASC Scientific Board and Thrust facilitator on whole device modelling**
  - Physics Properties of Strongly Shaped Configurations (TSVV#02)
  - Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks (TSVV#11)
  - Multi-Fidelity Systems Code for DEMO (TSVV#14)

# SP-2: Preparation of ITER first experimental campaigns

- **Plasma breakdown/burn-through simulation tools and application for ITER operation plasma**
  - Synergy and link with TE, SA, TSVV11 has been set-up (joint meetings)
- **IR synthetic diagnostic and first wall/divertor monitoring system for real time PFC's protection**
- **Synthetic diagnostic for the Fiber Optics Current Sensor based on JET experience**
- **EUROfusion databases on disruption, core confinement and pedestal (FP8 resource)**

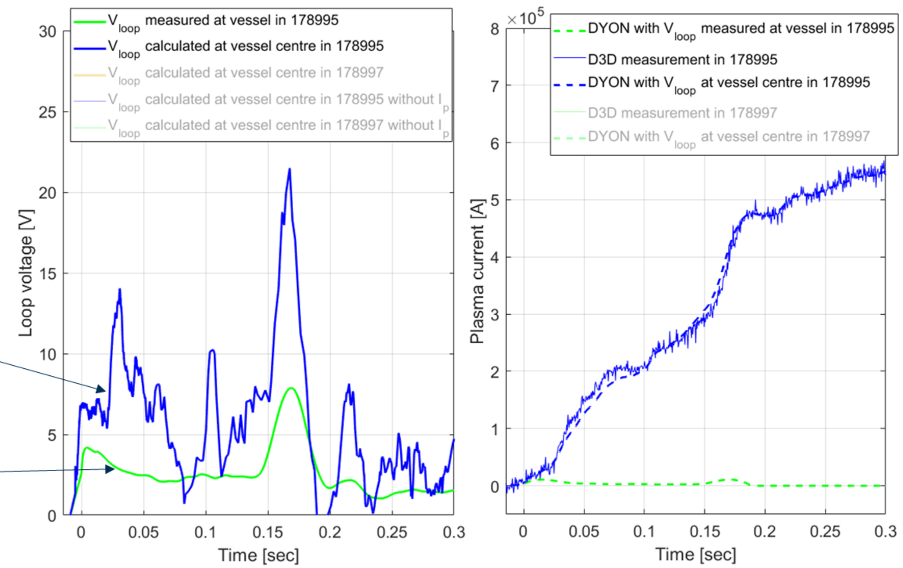
# SP-2: Preparation of ITER first experimental campaigns: Plasma initiation

- **Full circuit equations have been integrated in DYON, and synthetic flux loop data agrees well with measurement.**

D-IIID modelling with DYON

**$V_{loop}$ calculated in the plasma position**

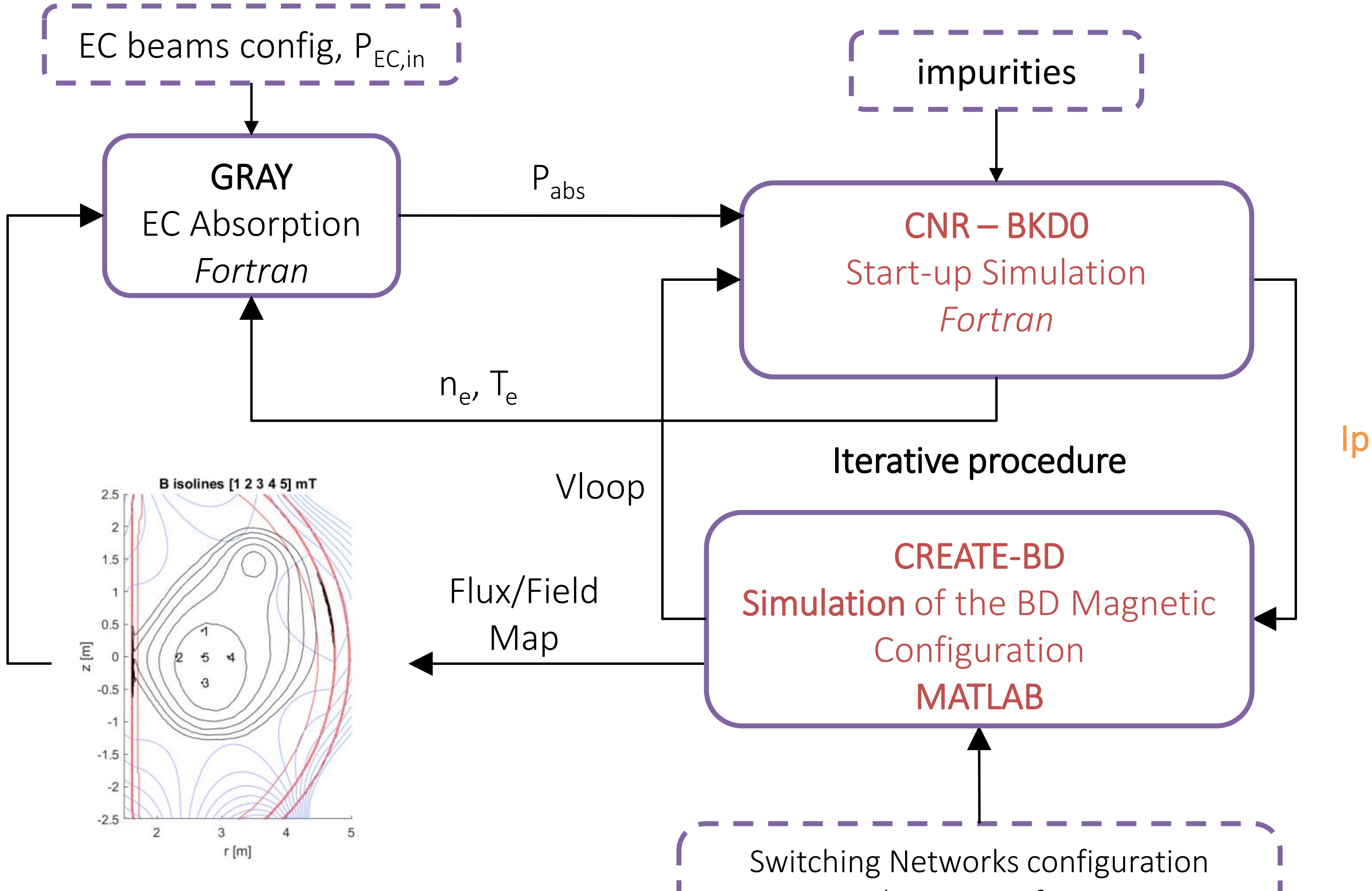
**$V_{loop}$ measured in the inboard mid-plane in D-IIID**




[H.T KIM]

- **Initiate the coupling to IMAS of CREATE-BD/BKD0/GRAY workflow**
  - GRAY for EC beam reflection models
- **Validation of CREATE-BD/BKD0/GRAY workflow**
- **Assess ECRH absorption in the initial phase of ITER**

# SP-2 : GRAY – BKD0 – CREATEBD : The direct simulation scheme to be used for ITER-BD

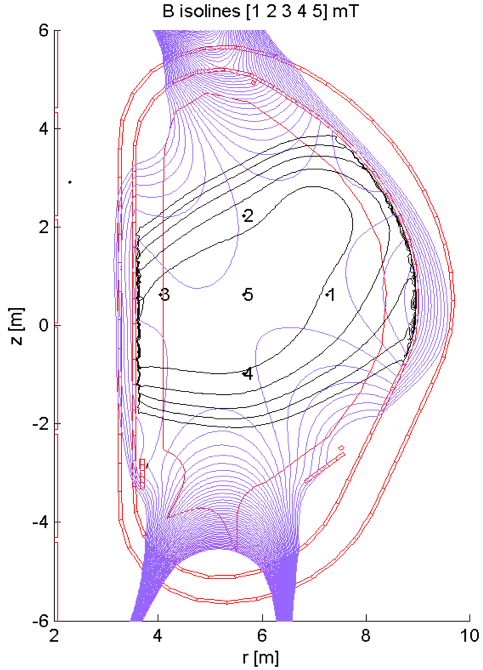


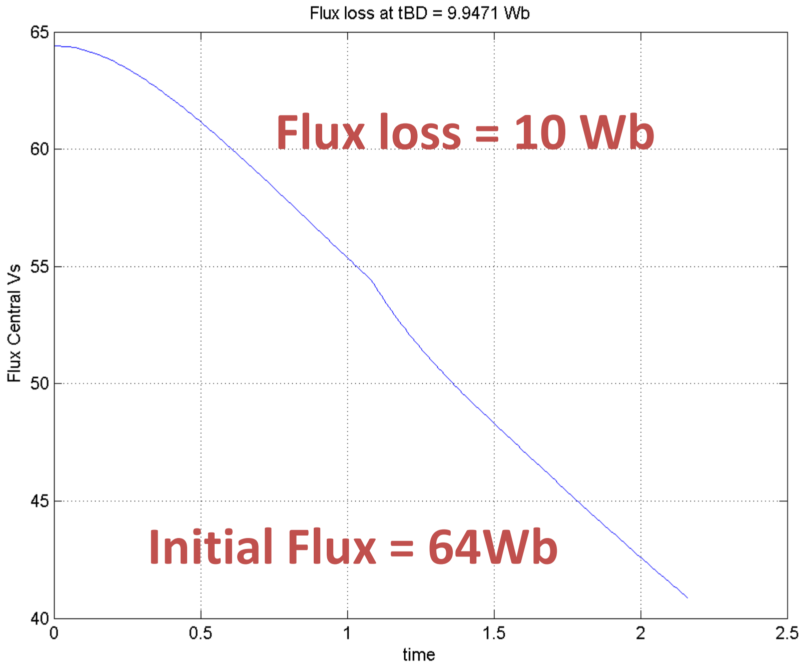

**Driving waveforms can be assumed from past CREATE or DINA scenarios**

D. Ricci, M. Mattei, L. Figini

# SP2 : ITER magnetic model – Scenario Definition

- ITER magnetic Model for the BD phase has been developed by CREATE and compared with DINA models output
- Latest studies concentrated on FPO breakdown scenarios with half field and reduced current in the Central Solenoid




**Half toroidal field – Reduced current in the CS – FPO (DINA/TRANSMAK-like Scenario ITER_D_WDRNWZ Doc. 23/4/18)**

D. Ricci, M. Mattei, L. Figini

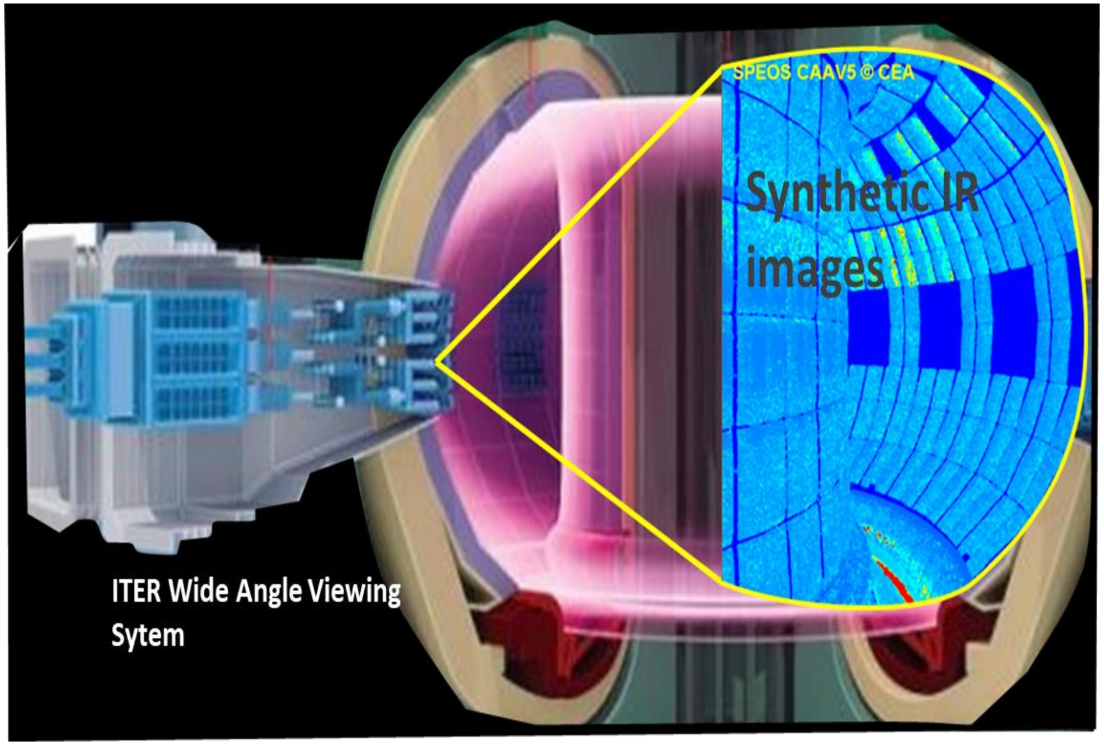
# SP-2 Development of IR temperature synthetic diagnostic for ITER real-time application and offline analysis.

**A synthetic diagnostic**: an **end-to-end simulation** aiming to model all physical phenomenon involved in the IR measurement chain: **from source to optical response of instrument**

**1** **IR Source Modeling**
- Modeling of plasma heat loads deposited on PFCs (main IR source)
- Modeling of resulting 3D temperature field

**2** **Materials Thermal-radiative Modeling**
- Emissivity model
- Reflectivity Model

**3** **Optics Modeling**
- Camera model
- Optical Transfer Function

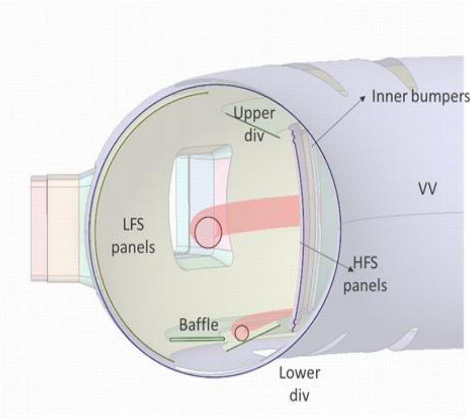



Light propagation in 3D model based on **Monte Carlo Ray Tracing (MCRT) code** (ANSYS-SPEOS CAAV5 here) getting all radiations of thermal scene

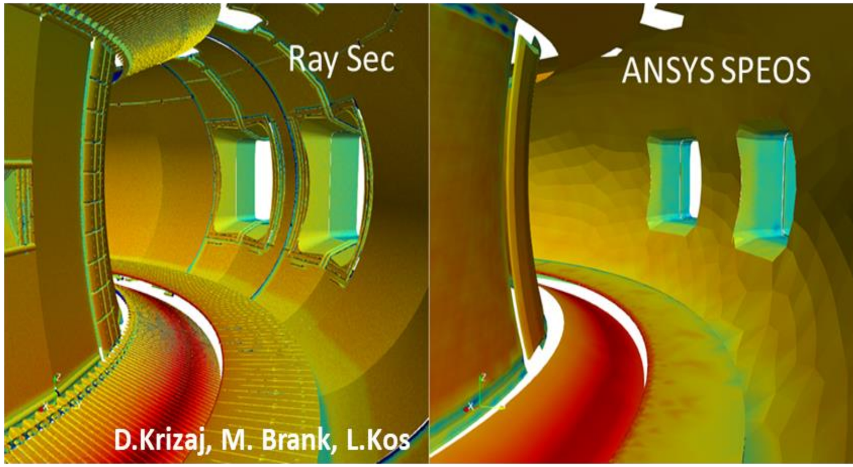
# First results of RaySect vs ANSYS-SPEOS benchmarking

First comparison achieved on WEST tokamak:

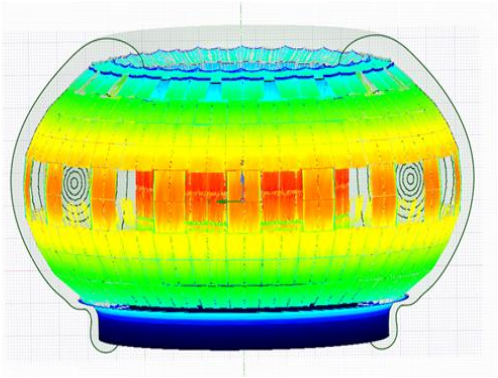
- Good results obtained **in non-reflective case** (considering absorbing surface for all materials)




**Non reflective case simulation**




- **Points to work** :
  - Computation of absorbed flux **in reflective case** in RaySec code
  - Modeling of complex optical properties in Ray Sect
  - Quantify the impact of sampling of plasma source (ITER antenna)



**Incorporation of Ray-Sect inside the generalized platform SMITER**

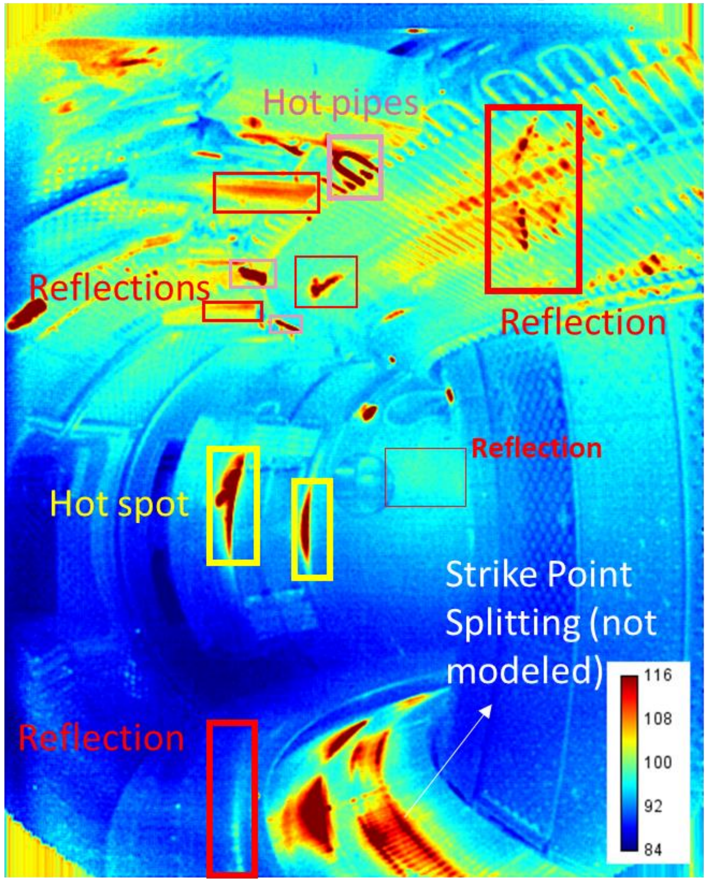
# SP-2 Development of a wall thermal events & hot spot monitoring system

**Off-line automatic detection of Hot-Spot**

**Experimental IR Image**

#Pulse 55210 @ 7s(Ip=500 kA, 4.4MW LH + 0.7MW FCI

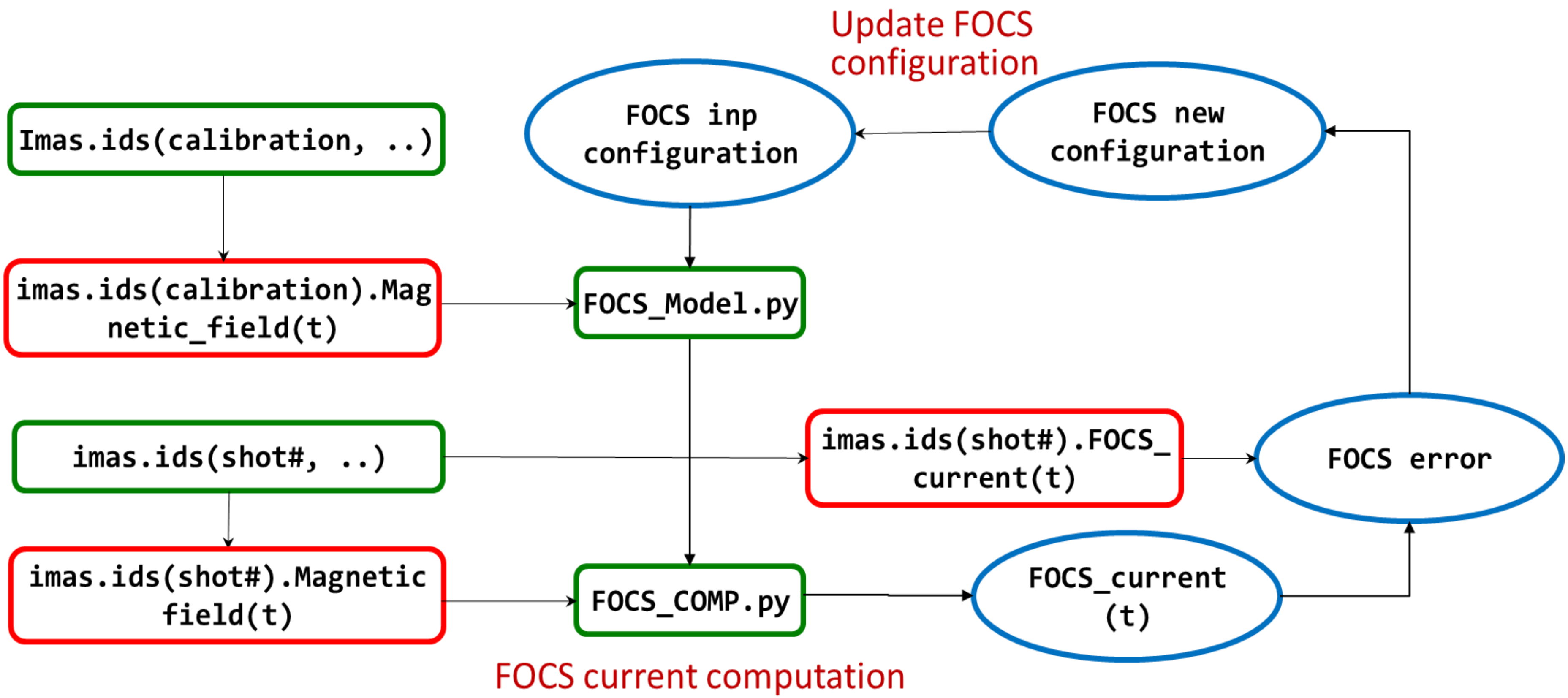
*Brightness T° Map*




- **develop a wall monitoring system for real time protection of ITER PFC**
  - provide safe and high performance steady-state long duration operation
- **To be tested on existing long pulse facilities (W7X and WEST) before ITER application**
- **human operators could not process a large numbers of thermal events**
  - automatic detection with AI

# SP-2 : Develop synthetic diagnostic for the Fiber Optics Current Sensor

- **2021 consists of defining the algorithm for a FOCS synthetic diagnostics fully compatible with ITER requirement and IMAS**



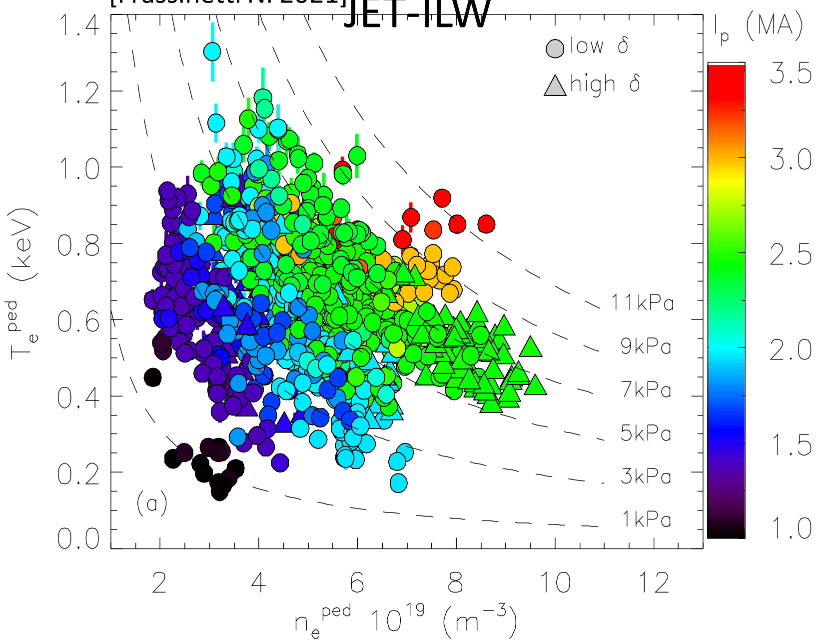

- **In 2022-23 the FOCS synthetic diagnostic in IMAS**

# SP2- EUROfusion databases in support to ITPA

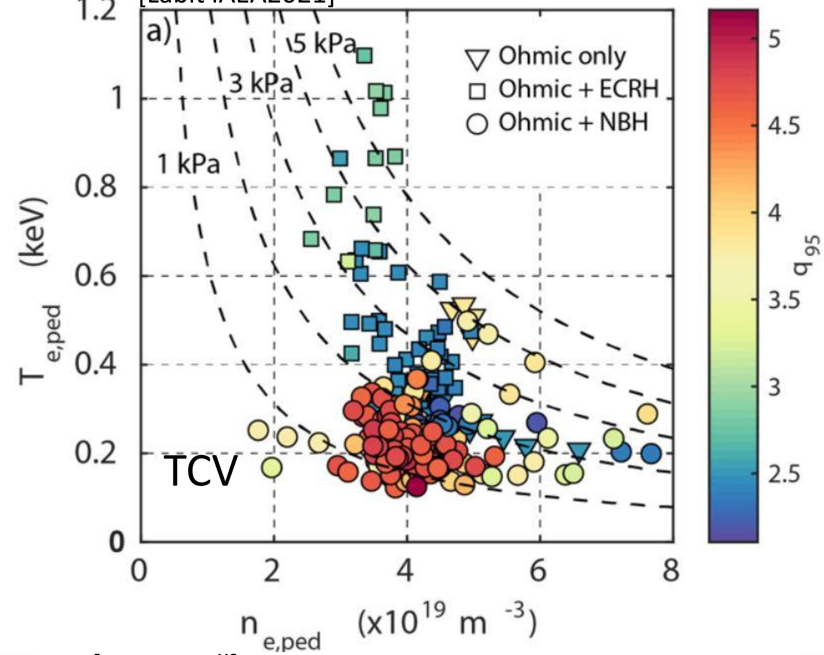
- **Pedestal**
  - More 4000 entries ( JET, TCV, AUG, MAST-U)
  - Validation by TE/JET participants
  - 3 publications
- **Confinement database**
  - 0D: focus on Metallic wall machine
  - Around 2000 entries : JET, AUG are included (data to be updated) – WEST has been contacted
  - Start definition 1D data – JET pilot case
- **Disruption database**
  - well-structured and standardized architecture: consistent data validation, provenance tracking and capability of reproducing analysis
  - Automatic RE detection has been defined
  - Support of disruption avoidance & modeling , Baseline scenario development at JET

# Multi machines analysis of pedestal height

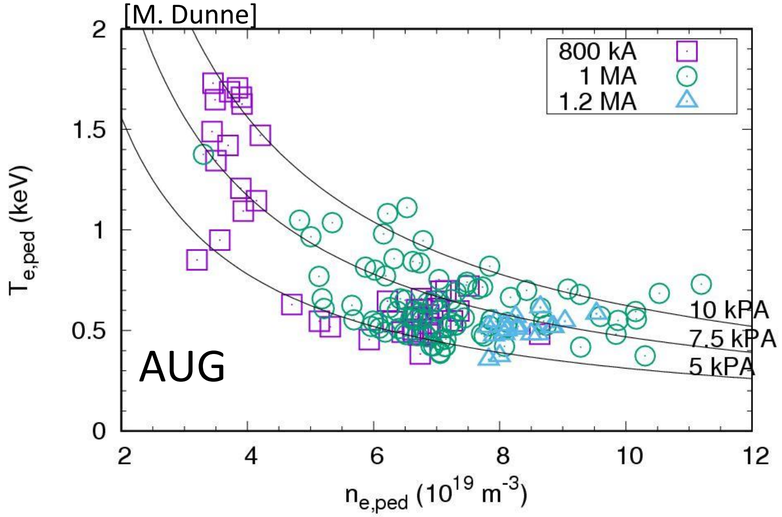
[Frassinetti NF2021]



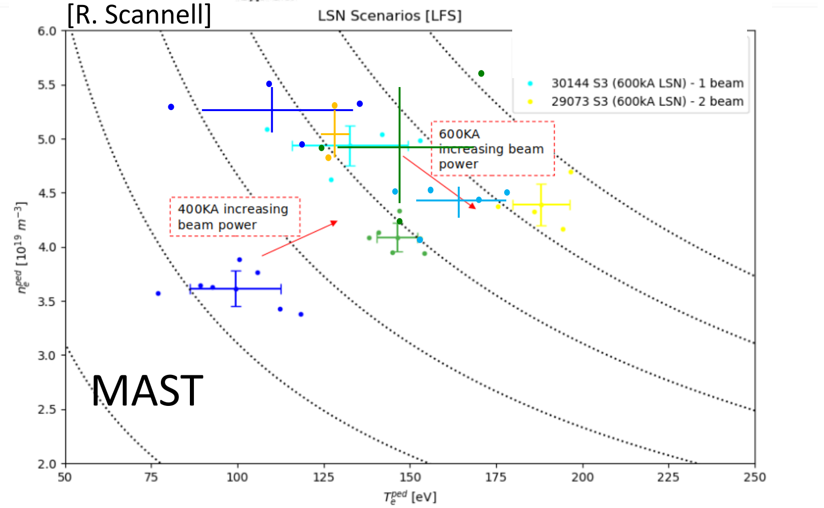

[Labit IAEA2021]




[M. Dunne]




[R. Scannell]



# SP-3: Plant System and Plasma Operations

## EUROfusion Operation Network (EON) established in 2021

https://wiki.euro-fusion.org/index.php?title=WPPrIO-OP:_EUROfusion_Operations_Network_(EON)

- 18 members from 9 associations including all European tokamak and stellarator facilities
- facilitate connection between the operational groups of EUROfusion facilities, to share operational experience, improve reliability and performance and support training of operators
- Set up competency-based subnetworks : NBI in 2021
- Support the EUROfusion preparations for ITER (integrated) commissioning and operation

| 2021 activities – "Foundation year" | Status |
|---|---|
| Establish EON network | Completed. First meeting held on 10th June 2021 |
| Map out operational areas and identify the competencies of EUROfusion associations | Structure agreed. Expected at 2nd EON meeting on 24/9/2021. |
| Map out operational roles and operator training in EUROfusion facilities | Structure agreed. Expected at 2nd EON meeting on 24/9/2021. |
| Set up pilot EON subnetwork on the NBI competency | NBI seminar series with all NBI teams in Europe + JT-60SA, ITER and NBTF. First seminar expected in 2021. |

# EON subnetwork pilot: NBI seminar series

## WPPrIO area – NBTF – Negative Beam Test Facilities (Padova, Garching)

**Proposal developed through discussions with and support from:**

- EUROfusion PMU: Programme Manager, FSD Department Head, International Relations, Education
- Fusion for Energy: JT-60SA (deputy) project leader
- EUROfusion work packages: project leaders of WPPrIO, WPHCD, WPSA
- Consorzio-RFX, Padova - NBTF
- Large NBI teams; IPP Garching and Greifswald, UKAEA, QST
- Smaller NBI teams: IPP-Prague, CIEMAT, EPFL
- ITER Organisation – NBI group

**Monthly NBI seminar series starting in 2021:**

- Join the positive and negative ion beam communities in Europe and Japan focusing mainly on operations, although open to other topics as well.
- 2-hour monthly remote seminar. Focused-Discussion. Invite whole NBI operational team.
- Open to EUROfusion experts, ITER, F4E and QST staff.
- Bottom-up approach in participation, presenting and proposal of topics.

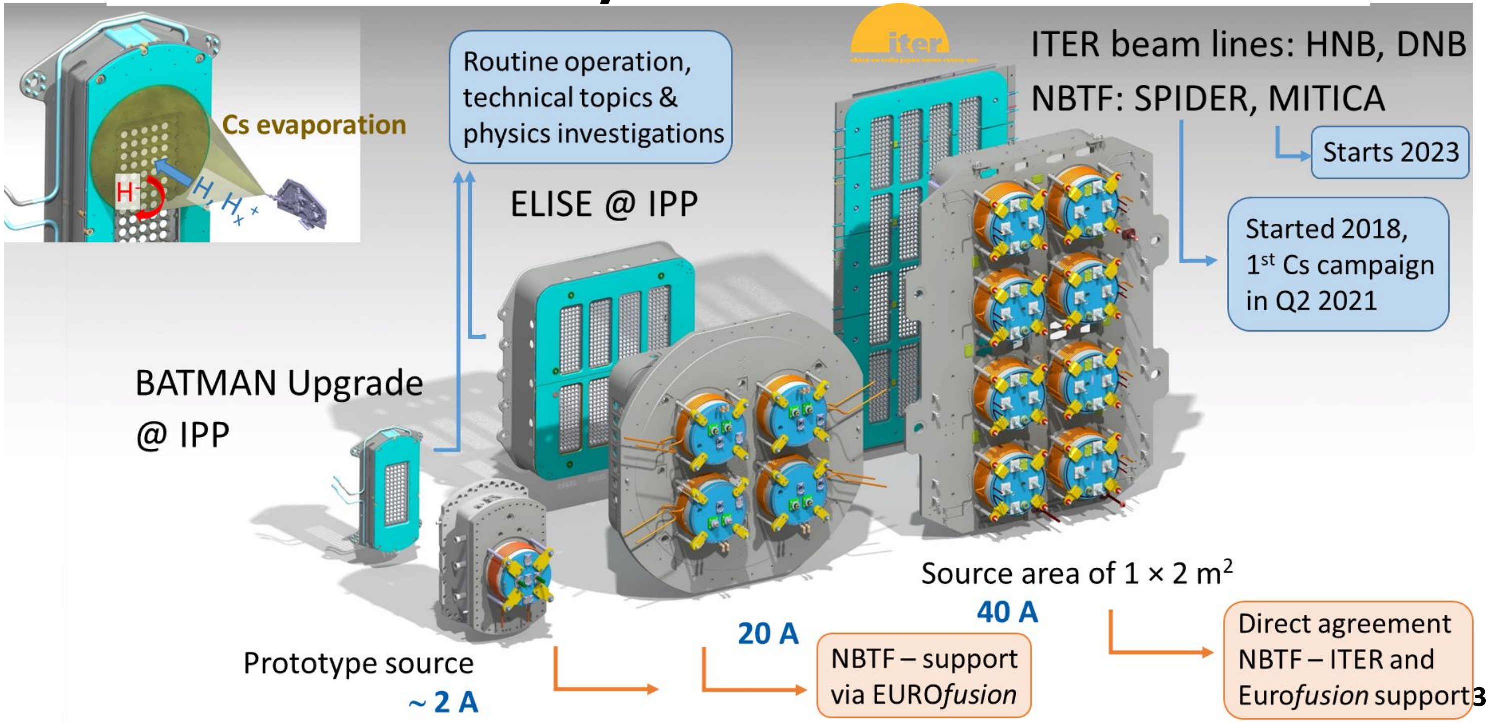
# SP-3: Plant System and Plasma Operations

- **Knowledge capture, management and transfer of commissioning, operational experience and training**
  - Initial discussions with G. Lange (PMU Education)
  - Need for access-controlled knowledge database with advanced search tools and clearly identified short and long-term functionality.
  - Identify the type of operational information to begin knowledge database.

- **Contribute to ITER FILD diagnostic design – on hold**
  - Review: reciprocating scintillator detector or dedicated IR based solution?

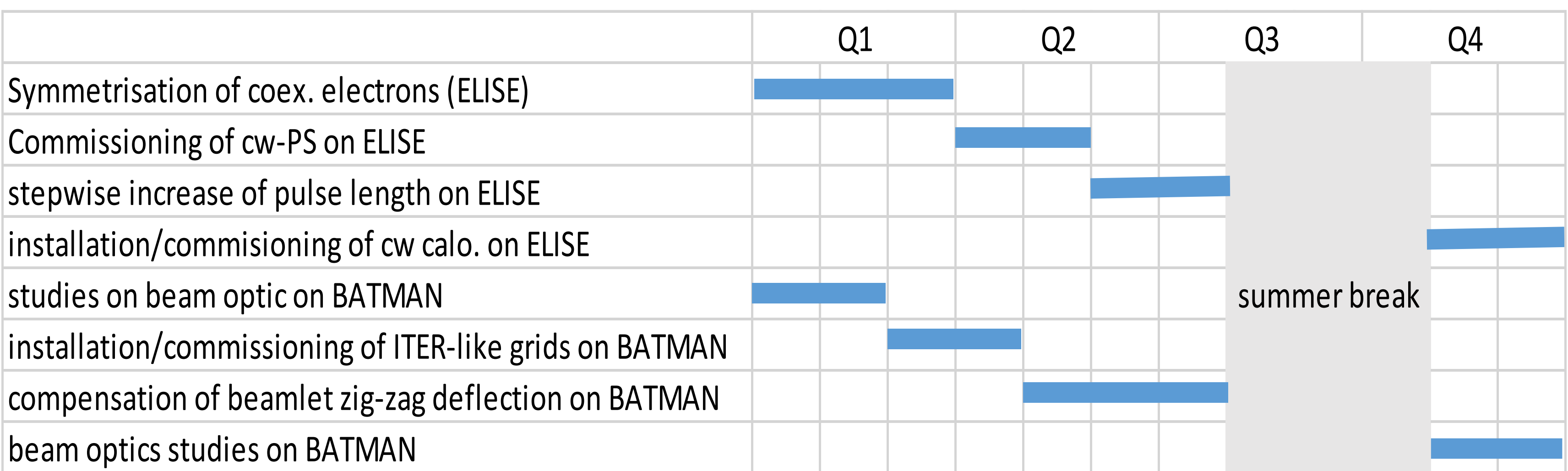
# SP-4: Neutral Beam Test Facility and R&D for ITER Neutral Beam

- **Support EUROfusion experts at NBTF (Consorzio RFX/Padova)**
  - Participate in the operation of the ITER Neutral Beam Test Facility SPIDER and MITICA Up to 14 ppy/y
- **Support EUROfusion experts at ELISE (IPP/Garching)**
  - ELISE and BATMAN Upgrade for the demonstration of CW operation in D or H Up to 6 ppy/y
- **Participation in the NBTF Advisory Committee**



# SP-4: IPP support to NBTF and ITER NBI

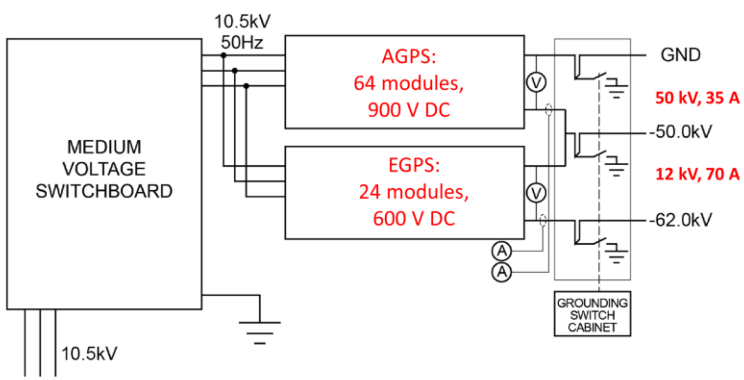
- **Symmetrisation and reduction of co-extracted electrons ($D_2$ op.)**
  - Biasing surfaces in combination with magnetic filter field configuration
- **Long pulse operation**
  - Test HV power supply has started (July) on ELISE following a successful completion of the tests on dummy load , 35kV reached (60kV Max) for short pulse
- **Temporally stable co-extracted electron current for long pulses**
  - Cs management, evaporation rate, oven position and nozzle, modelling with CsFlow3D
- **Detailed studies of beam optics: divergence and beamlet deflection**
  - Experiments complete with the “MITICA like grid” on BUG following request from IO



# ELISE: Upgrade for cw beam extraction

- Installation of a cw calorimeter → end 2021
- **CW power supply for beam extraction**
  Supported by EUROfusion

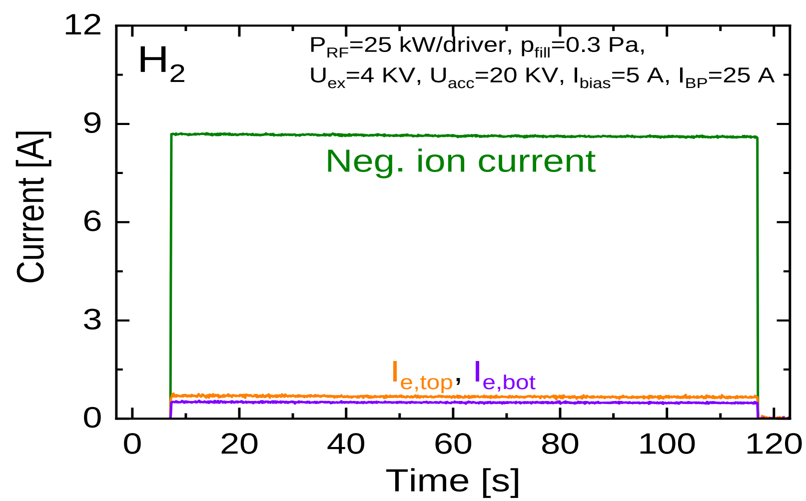
**Full relevance of ELISE for NBTF & ITER**




50 kV, 27 A
Tested at ELISE
11.5 kV, 45 A

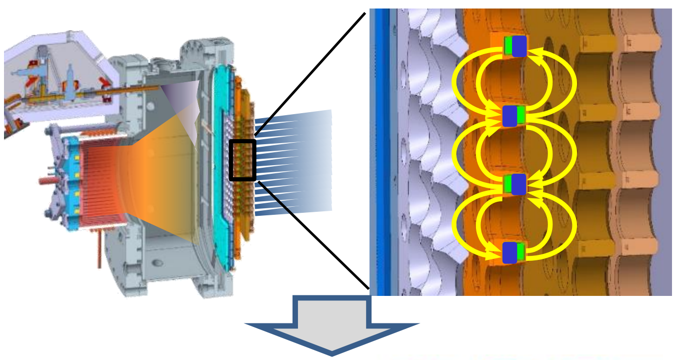
Commissioning started in 2021

- ✓ Completed on dummy load in April 2021
- ✓ Connected to ELISE in July 2021
- ✓ First 100 s cw extraction achieved

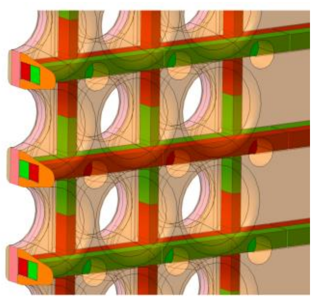


# Beam optic studies: BUG-MLE- Test of MITICA-like grid extraction system

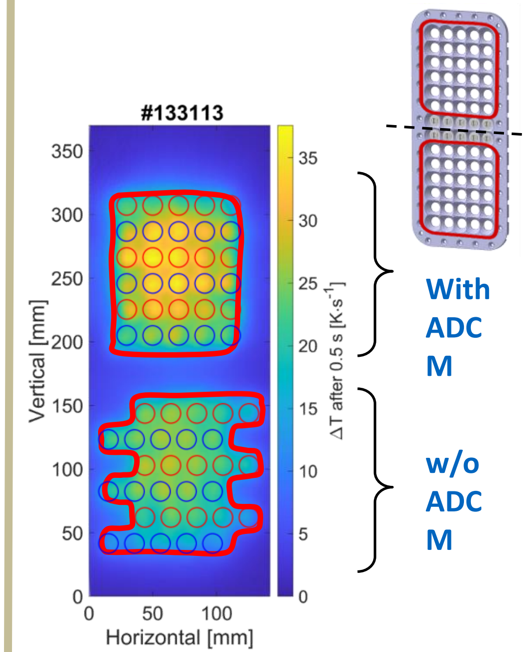
- **co-extracted electrons deflected out of the beamlet by permanent magnets before acceleration: induce a row-wise zig-zag deflection of the beamlets.**



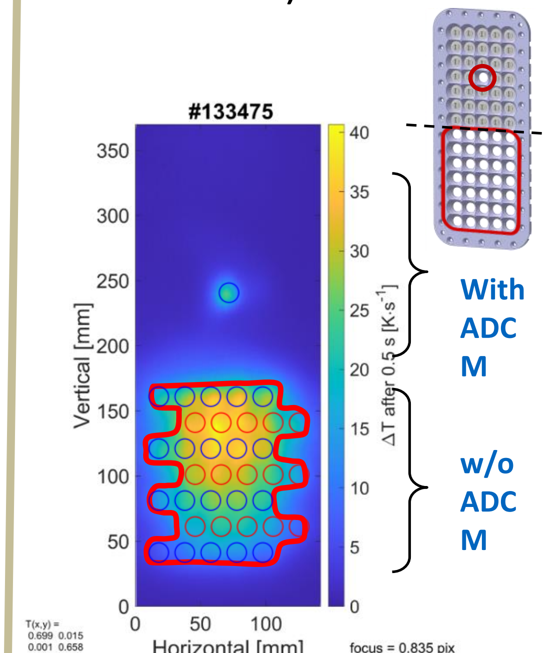
**Correction magnets: ADCM**



**Compensation of zig-zag deflection →** **Successful in a wide operational regime**




**Single beamlet divergence deflection →** Measurement of footprint possible (new 1D CFC calorimeter)




Jul. 2021
Report sent to ITER

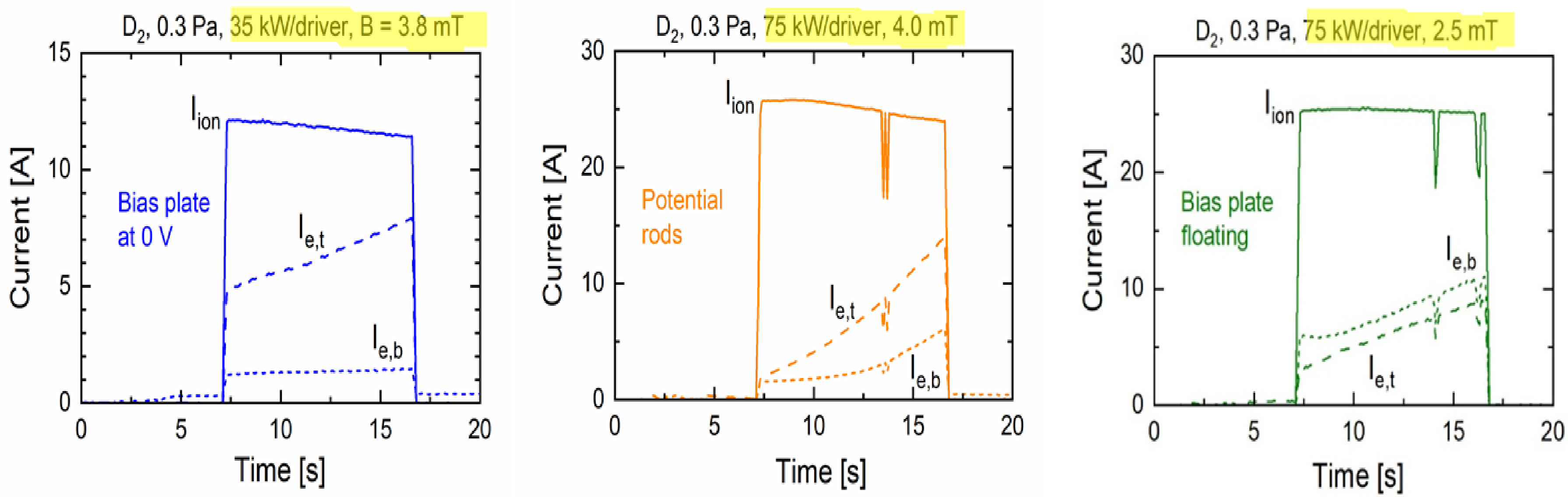
# ELISE: Symmetry and reduction of co-extracted electrons in D

## Change of potentials by biasing surfaces and adjusting magnetic filter field

**Reference scenario (ITER case)**
PG positively biased, source at 0 V
bias plate connected to source

**Additional potential rods**
(introduced at ELISE
to achieve hydrogen target)

**Bias plate floating**
can replace additional rods
ITER relevant




**Performance limited by electrons**

Strong reduction and improved symmetry of co-extracted electrons

**High power pulses possible -> long pulses will be tested next**

# SP-4: SPIDER and MITICA in 2021

## SPIDER

- **Campaign up to Mid-July**
  - First campaign using caesium in $H_2$ and $D_2$
- **Issues with HV breakdowns that induce noises in the PS electronics and stop op.:**
  - dedicated campaign of 4-6 weeks (starting end of august) to understand/solve before long shutdown starting early Oct.
- **Long shutdown:**
  - Update SPIDER Beam source
  - Enhancement of vacuum system
  - Substitution of RF oscillators with solid state amplifiers

## MITICA

- **Commissioning of PS**
  - integrated tests
    - No load tests
    - Load tests
    - Test simulating grid breakdowns
- **Complete inspection performed to clarify the reasons of the breakdown reported during the commissioning of 1MV PS.**
- **Schedule is being updated**
  - Objective is to complete investigation by September so that the plan for repair could be developed
- **High Voltage Holding Tests**

# SP-5: Neutronics, Nuclear Waste and Safety

- **Assumption: JET operation ends in 2021**
- **2022 and 2023 resources allocated to complete DT analysis**
- **2021 elaboration of EUROfusion activities for ITER**
  - **Neutronics, nuclear instrumentation**
  - **Working group (EUROfusion, IO, F4E) to define the 2022-2025 activities**
    - **Rosaria Villari ENEA Chair**
    - Yannick Peneliau CEA
    - Lee Packer CCFE
    - Rafael Jaurez CIEMAT
    - Maurizio Angelone ENEA
    - Jerzy Mietelski IPPLM
    - Luka Snoj JSI
    - Dieter Leichtle KIT
    - Theodora Vasilopoulou NCSRD
    - **M. Loughlin, IO and M. Fabbri, F4E**

# US-DOE collaboration on Neutronics

- Collaboration extended for one year 2021
  - Benchmark Neutronics Simulation Computer Codes under the EURATOM – U.S. DOE Agreement
  - Exploitation of Advantage
  - optimization of ORNL tools for application EU DEMO analysis
- Decision on the collaboration extension beyond 2021 to be taken once clarity is provided on the JET extension & programme and « neutronics » activity under PrIO

EUROfusion

# PLANNING (Gantt chart), MILESTONES, DELIVERABLES

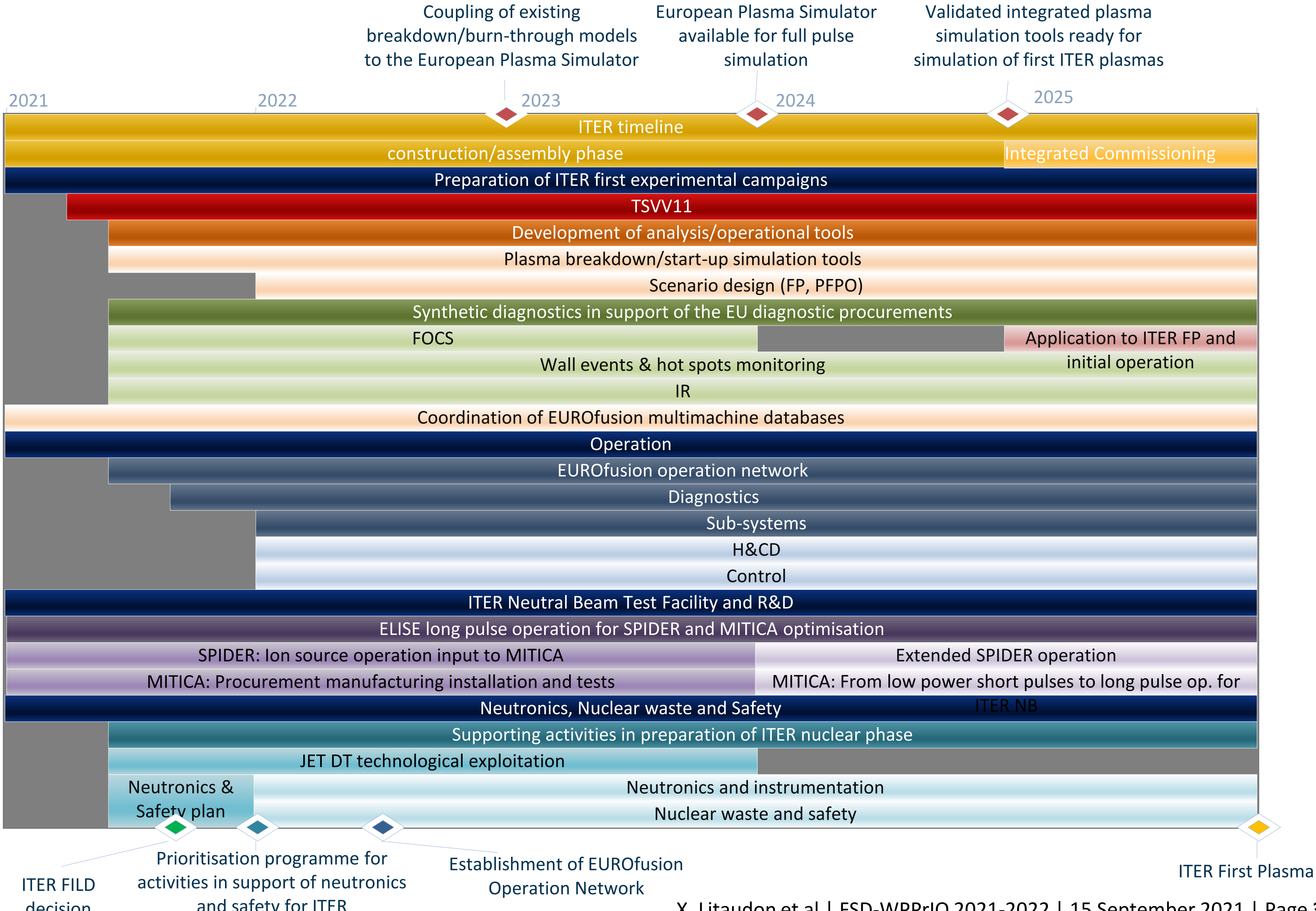
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# 2021 Milestones and Grant Deliverables

| no. | Milestones | Due Date |
|---|---|---|
| PRIO.M.01 | All existing components of the European Plasma Simulator (Python workflow) hosted on the EUROfusion Git (TSVV11) | Dec. 2021 |
| PRIO.M.02 | First release of a user friendly interface for the European Plasma Simulator (Python workflow) (WPAC and TSVV11) | Dec. 2021 |
| PRIO.M.08 | Assessment of the EUROfusion human resources requirements and their implementation for the efficient EUROfusion participation in the NBTF completed | Jun. 2021 |
| PRIO.M.09 | Commission the new CW power supply on ELISE facility completed | Jun. 2021 |
| PRIO.M.10 | Installation and commissioning of CW diagnostic calorimeter on ELISE facility completed | Dec. 2021 |
| PRIO.M.13 | Prioritisation programme for 2022-2025 of activities in support of neutronics and safety for ITER | Dec. 2021 |

| no. | Deliverables | Due Date |
|---|---|---|
| PRIO.D.11 | Report on EUROfusion participation in ITER NBTF, ELISE and BUG activities | Dec. 2021 |

# PrIO Baseline timeline - Gantt chart



EUROfusion

# Resources

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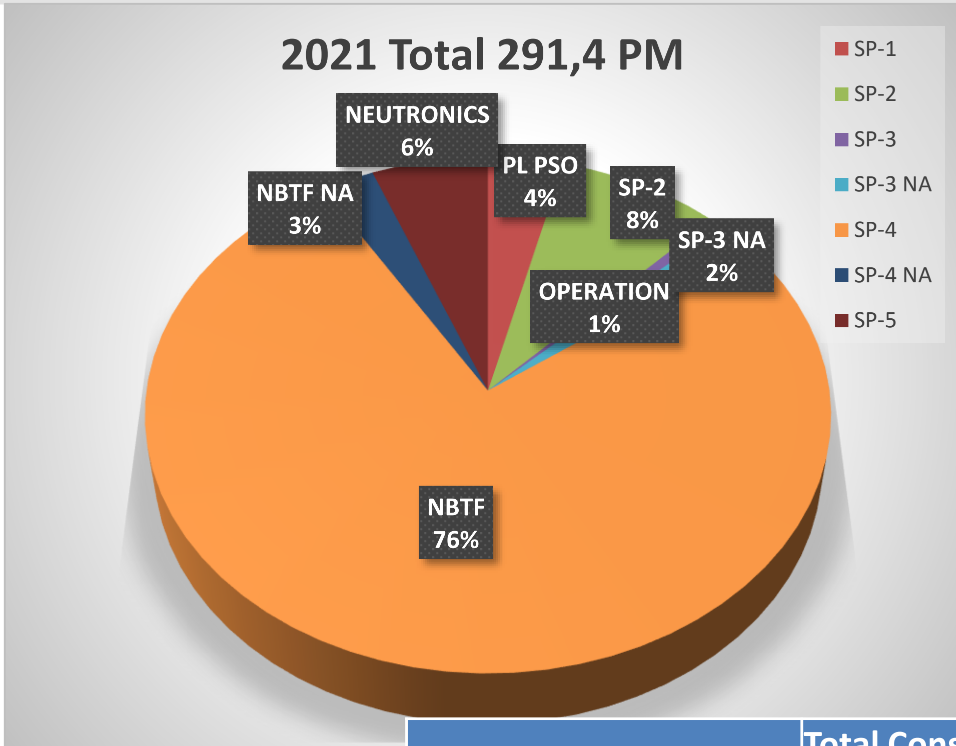
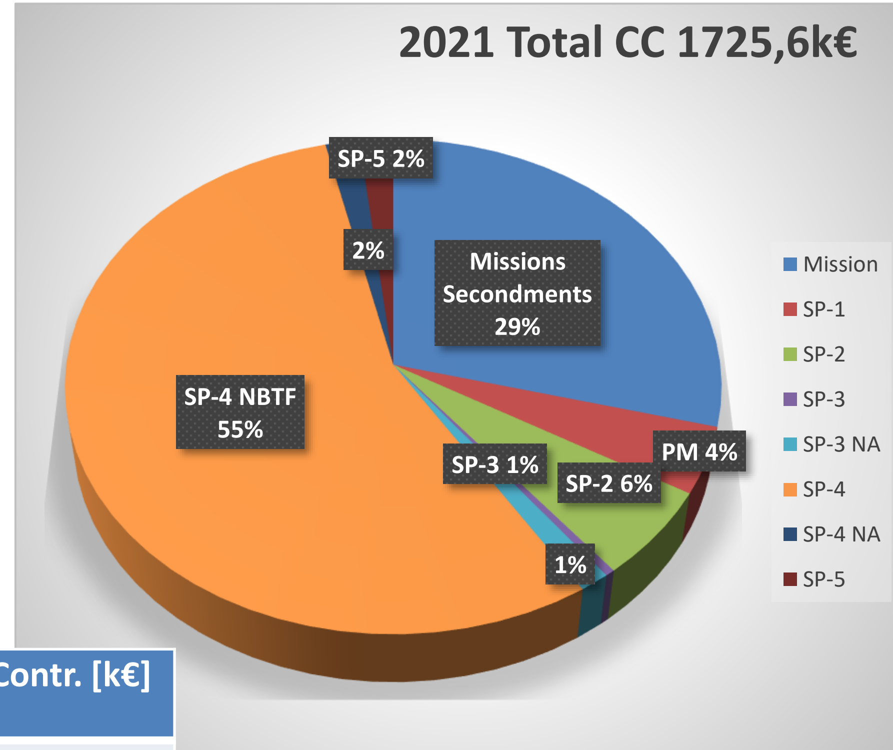
# 2021 Resources distribution per sub-project




| | Total Cons. Contr. [k€] 2021 |
|---|---|
| SP-1 PL & PSO | 75,228 |
| SP-2 | 101,247 |
| SP-3 Operation | 7,625 |
| SP-3 NA | 23,438 |
| SP-4 NBTF | 955,234 |
| SP-4 NA | 31,250 |
| SP-5 Neutronics | 31,294 |
| Mission & Secondement | 500,250 |
| Total général | 1725,567 |

EUROfusion

# Back-up

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# Introduction in the Grant Proposal

- **"Whilst integration between work packages is essential for both ITER and DEMO, there are two convening work packages that bring together this breadth: WPPrIO consolidates the preparation for ITER operation, though the contributions to ITER exist in every work package, whilst the DEMO Central Team (supported by WPDES) coheres the design capabilities in each work package, whilst taking advantage of the capabilities and skills developed for ITER"**

# WG recommendations on ITER operation and scientific exploitation

- **Divertor and Plasma Facing Components:**
  - Pursue and develop a comprehensive programme (EUROfusion/F4E)
- **Nuclear aspects (safety, licensing and neutronics)**
  - Actions on knowledge management to be elaborated
- **Neutral Beam Heating and CD system**
  - Ensure the success of NBTF operation
- **Diagnostics**
  - Promote actions to take advantage of the diagnostics provided by F4E
- **Analysis/operational/simulation tools**
  - Effort to be focused on scientific priorities
- **Knowledge Management**
  - managing proactively the involvement in ITER Operation and Commissioning in view of both developing experienced engineers and transferring knowledge to DEMO design

A. Grosman, J Pamela

# SP-2 : Pedestal Database People involved

In blue: people active in 2021 in the project via the database actvity, via WPJET1 or via WPMST1/WPTE

- Coordinator: L. Frassinetti
- JET
  - **L. Frassinetti** (KTH): workflow, main scripts for local DB in IDL, pre-ELM data processing, script to transfers DB to IMAS, coordination
  - **P. Bilkova** (IPP.CR), **P. Bohm** (IPP.CR), R. Fridström (KTH) for pre-ELM data processing
  - S. Saarelma (UKAEA), **H. Nyström** (KTH) for PB stability analysis
  - E. Giovanozzi (ENEA), equilibrium
- TCV
  - **B. Labit** (SCP): main scripts in matlab, pre-ELM data processing, PB stability analysis, script to transfers DB to IMAS
- AUG
  - **M. Dunne** (IPP): main scripts in matlab, pre-ELM data processing, PB stability analysis, script to transfers DB to IMAS
- MAST-U
  - **R. Scannell** (UKAEA) main scripts in matlab, pre-ELM data processing, PB stability analysis, script to transfers DB to IMAS
- IMAS
  - **F. Imbeaux, M. Owsiak**

# SP2: Confinement database 0D and 1D databases

- **0D**: Metallic wall machine are considered: JET, AUG are included (data to be updated). WEST has been contacted in August 2021.

- Quantities are labelled according to the ITPA standard; data will be provided to EUROfusion according to IMAS standards.

- JET: 938 entries from 853 pulses, with isotopic mixtures and high performing pulses ($I_p \in [1.0,4.0]MA, n_e \in [2.0,9.7]10^{19}m^{-3}, B_t \in [1.0,3.9]T, M_{eff} \in [1,2], \tau_{th} \in [0.13,0.36]s$)

- AUG: 866 entries from 422 pulses. The fast particle contributions and confinement times have been corrected for specific pulses (313/422 pulses) by AUG experts using the RABBIT code ( $I_p \in [0.6,1.2]MA, n_e \in [3.7,15.9] \cdot 10^{19}m^{-3}, B_t \in [1.6,2.9]T, M_{eff} \in [1,3], \tau_{th} \in [0.03,0.2]s$).

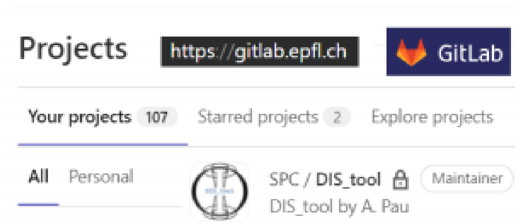
- WEST : Contacts with WEST started in 2021. Data will be added when available.

- **1D**: JET data have been chosen to build the starting nucleus of the DB.

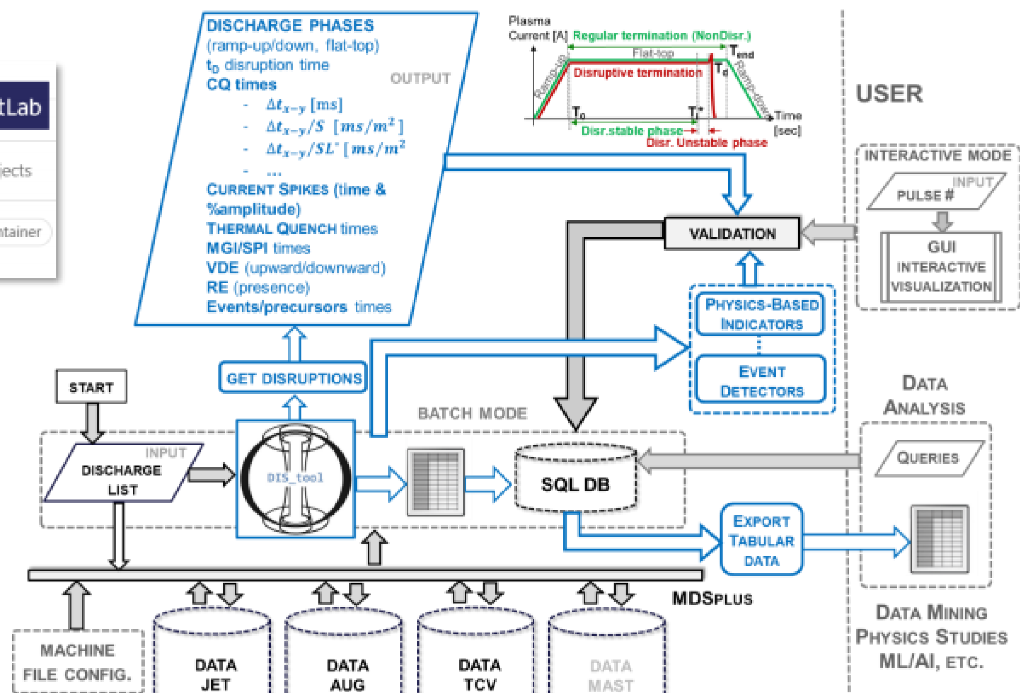
- Preparatory meetings have been done with selected specialists; others, also with modelers (from TSVV11) are expected to be scheduled by the end of the 2021 activities to outline the required features to be added.

# SP2: Disruption database

- Disruption database workflow has been finalized in a standardized/generic way , GUI for visualisation
- Automatic RE detection has been defined
- well-structured and standardized architecture: consistent data validation, provenance tracking and capability of reproducing analysis
- Support of disruption avoidance & modeling , Baseline scenario development at JET
- Future work: advance with disruption validation (several concrete applications so far and preliminary validation for hundreds/thousands of disruptions for AUG-TCV-JET) and fill Web catalogue




- Project under **version control;**
- Regularly maintained by **SPC-EPFL** (full pipeline implemented on "**Lacs**");
- The code can be run as well on **FREIA**, **Heimdall** (CCFE) and **TOKI** (IPP) computing clusters.



EUROfusion

# Risk Identification

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

| Risk Identification | Rating Pre-Mitigation | | | | | | Strategy / Mitigation |
|---|---|---|---|---|---|---|---|
| **Risk Title, Category, Owner, Description & Details**<br>(a) "As a result of…"<br>(b) "There is the risk that…"<br>(c) "Resulting in…" | **Likelihood**[1] | Impact[2] Tech | Impact[2] Cost | Impact[2] Sched. | Risk Level[3] | | **Treatment Strategy &**<br>**Risk Mitigation Actions**<br>(Comments, Details, Due Dates, etc.) |
| Risk Title: European Plasma Simulator not sufficient to provide answers required for ITER<br>Risk Category: Technical<br>Risk Owner: C. Bourdelle<br>Description: As a result of reduced resources there is a risk that European Plasma Simulator and IMAS workflows are not ready for ITER simulations | 3 | 3 | 1 | 3 | 9 | high | Treatment Strategy: escalate/transfer<br>Risk Mitigation Actions: Increase resources for code development and for IMAS support |
| Risk Title: Lack of EU involvement in the participation in the EUROfusion Operation Network<br>Risk Category: Project Management<br>Risk Owner: E. Belonohy<br>Description: As a result of low resources there is a risk of a lack of involvement and support in the participation in the EUROfusion Operation Network | 2 | 1 | 1 | 1 | 2 | Low | Treatment Strategy: avoid<br>Risk Mitigation Actions: Increase coordination and resources on specific funded tasks. Prioritise activities |
| Reduced EUROfusion participation in the NBTF and ELISE/ BATMAN Upgrade facilities<br>Risk Category: Project Management<br>Risk Owner: X. Litaudon<br>Description: As a result of lack of EUROFusion interest there is a reduction in the EUROfusion participation in the NBTF and ELISE/ BATMAN Upgrade facilities | 2 | 3 | 1 | 3 | 6 | medium | Treatment Strategy: reduce<br>Risk Mitigation Actions: Promote this R&D activity (e.g. EUROfusion seminars, career development plan with ITER to attract and retain the new generation of engineers) at the EU level |
| Delay in the achievement of long pulse operation (up to 3600s) extraction on ELISE | 2 | 3 | 3 | 3 | 6 | medium | Treatment Strategy: reduce<br>Risk Mitigation Actions: Focus EU effort to understanding |

| Risk Identification | Rating Pre-Mitigation | | | | | | Strategy / Mitigation |
|---|---|---|---|---|---|---|---|
| **Risk Title, Category, Owner, Description & Details**<br>(a) "As a result of…"<br>(b) "There is the risk that…"<br>(c) "Resulting in…" | **Likelihood[1]** | **Impact[2]** | | | **Risk Level[3]** | | **Treatment Strategy &**<br>**Risk Mitigation Actions**<br>(Comments, Details, Due Dates, etc.) |
| | | Tech | Cost | Sched. | | | |
| Delay in the achievement of long pulse operation (up to 3600s) extraction on ELISE facility<br>Risk Category: Technical<br>Risk Owner: U. Fantz<br>Description: For technical reasons it is difficult to achieve long pulse operation on ELISE | 2 | 3 | 3 | 3 | 6 | medium | Treatment Strategy: reduce<br>Risk Mitigation Actions: Focus EU effort to understanding (including modelling) the limiting factors and consequences for ITER |
| JET DT does not provide enough data for neutronics analysis<br>(Reduced performance of the JET DT campaigns and reduced level of 14 MeV neutrons)<br>Risk Category: technical / external<br>Risk Owner: R. Villari<br>Description: For scientific reasons the level of D-T neutrons is lower than expected for neutronics analysis. | 3 | 4 | 3 | 3 | 12 | Very-High | Treatment Strategy: accept<br>Risk Mitigation Actions:<br>Revise the objectives in terms of irradiation of ITER materials and radiation damage. Revise the resources on the related modelling activities. |
| Low level of coordination between WPPrIO and ITER-IO on common topics (IMAS development, ITER simulation, neutronics, NBTF…)<br>Risk Category: Project management<br>Risk Owner: X. Litaudon<br>Description: As a result of insufficient coordination there is a risk a divergence between the priority actions set within PrIO and the ones requested by ITER-IO or F4E | 2 | 3 | 1 | 1 | 6 | Medium | Treatment Strategy: avoid /escalate<br>Risk Mitigation Actions:<br>Increase the coordination level between WPPrIO and ITER-IO/F4E by setting-up specific coordination meetings. |

# Resources

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# International Collaborations

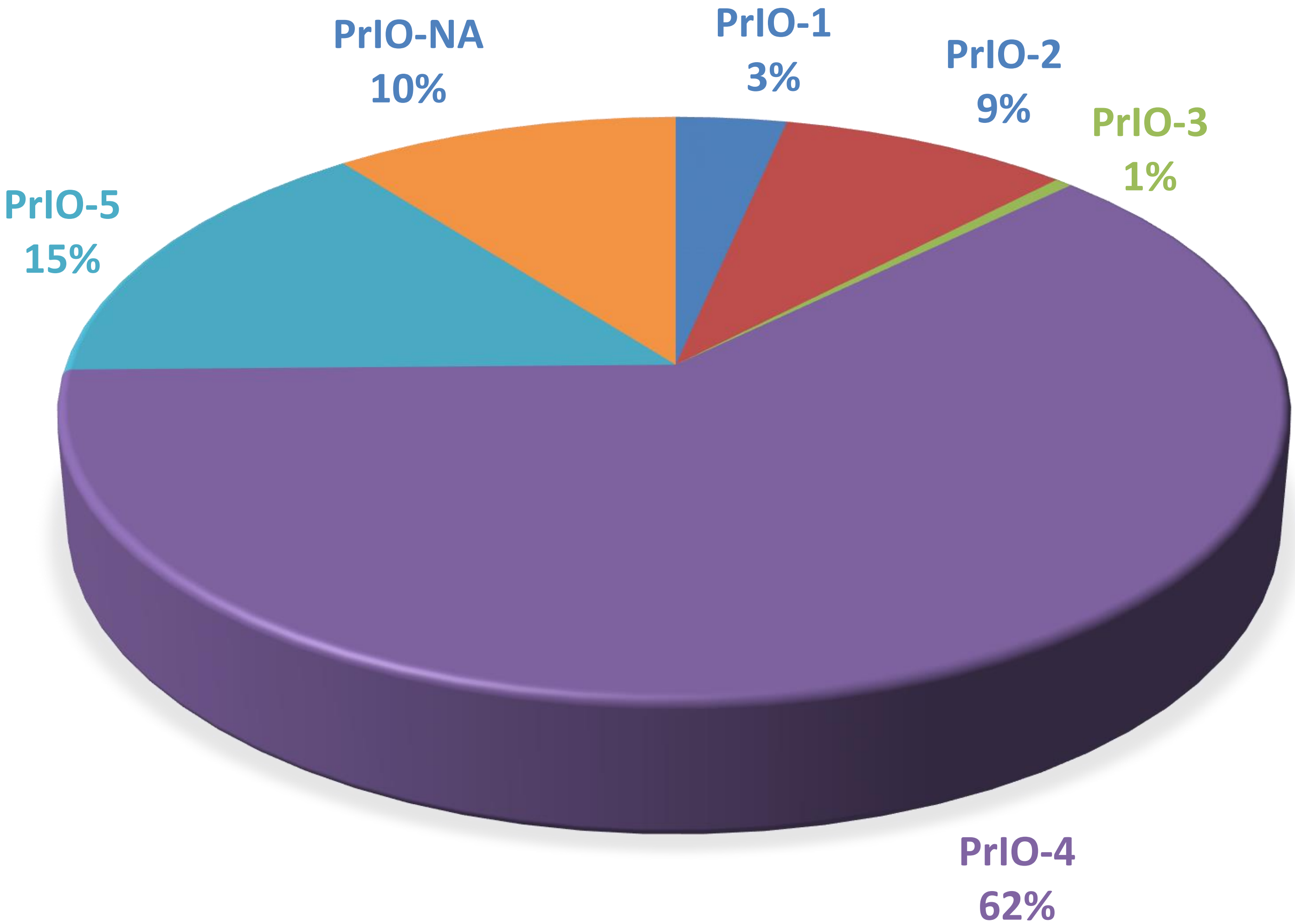
| ID | International Collaboration in WP Activities | Planned period(s) of engagement |
|---|---|---|
| **IC01** | US:<br>- Collaboration on integrated modelling with SciDac initiatives<br>- Collaboration on neutronics code development and validation with Oak-Ridge National Laboratory and University of Wisconsin | 2021-2025 |
| **IC02** | IO:<br>Coordination and support to the participation to the International Tokamak Physics Activity (ITPA), ITER fellow network, ITER operation network and specific ITER Task Forces | 2021-2025 |
| **IC03** | IO/F4E:<br>- Scientific collaboration that needs to be developed to ensure that WPPrIO Programme remains focused on the ITER Research Plan<br>-Collaboration on integrated modelling | 2021-2025 |
| **IC04** | IO, F4E, India, Japan: Collaboration on the NBTF operation and scientific involvement | 2021-2025 |

# Resources 2021-2025 per sub-project

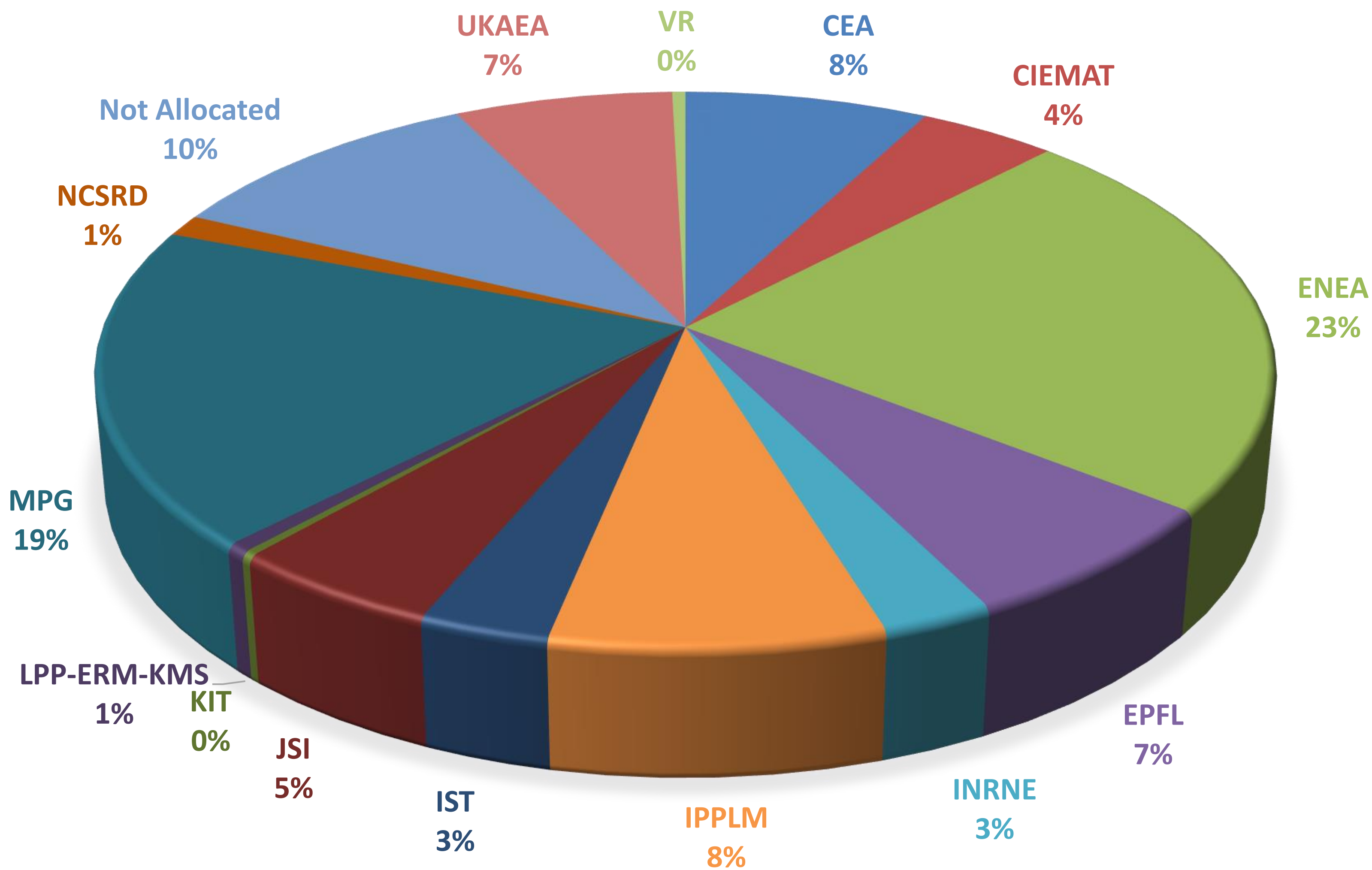
| Sub-project | PM | Total Resources [k€] | Total Cons. Contr. [k€] |
|---|---|---|---|
| SP-1 | 64,0 | 622,7 | 435,9 |
| SP-2 | 168,5 | 1484,7 | 742,4 |
| SP-3 | 10,0 | 78,6 | 39,3 |
| SP-4 | 1182,0 | 12943,8 | 7560,1 |
| SP-5 | 282,3 | 1773,2 | 743,2 |
| PrIO-NA[3] | 199,4 | 1601,8 | 809,6 |
| Sum | 1906,2 | 18504,8 | 10330,5 |

[3]PrIO-NA covers all the non-allocated resources (mission, NBTF secondment, human resources)

# PM Resource 2021-2025 per sub-project



# PM Resources 2021-2025 per beneficiaries



# Resources 2021-2025 per beneficiaries

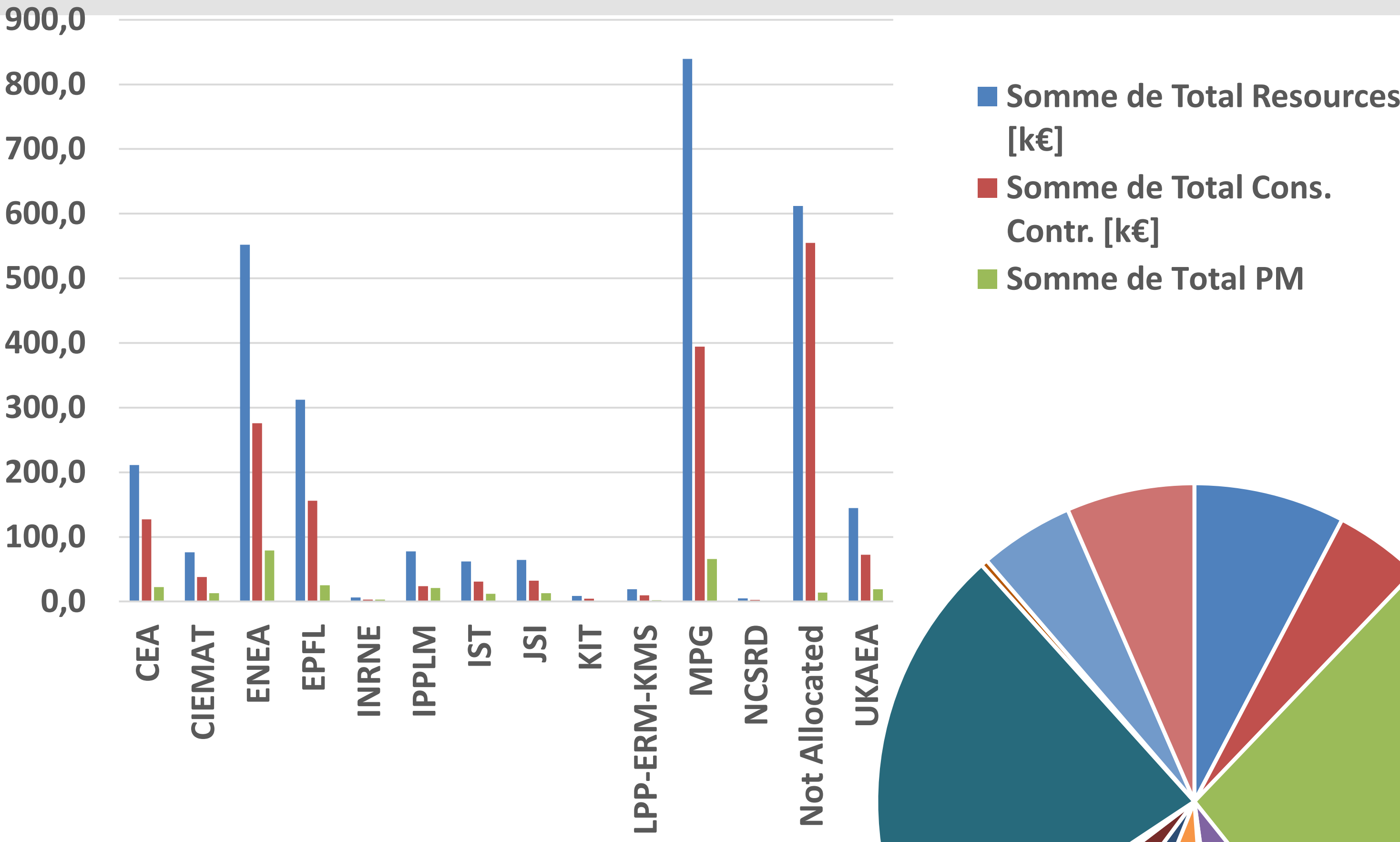
| Beneficiary | PM | Total Resources (k€) | Cons. Contr. (k€) |
|---|---|---|---|
| CEA | 148,0 | 1439,0 | 844,0 |
| CIEMAT | 84,0 | 507,2 | 253,6 |
| ENEA | 446,0 | 3229,4 | 1613,0 |
| EPFL | 133,0 | 1711,5 | 855,7 |
| INRNE | 51,0 | 111,0 | 55,5 |
| IPPLM | 153,0 | 702,1 | 190,6 |
| IST | 60,0 | 319,0 | 159,5 |
| JSI | 98,0 | 498,3 | 249,2 |
| KIT | 5,0 | 44,9 | 22,4 |
| LPP-ERM-KMS | 10,0 | 97,2 | 48,6 |
| MPG | 354,0 | 4498,6 | 2123,4 |
| NCSRD | 24,0 | 124,1 | 61,2 |
| UKAEA | 132,8 | 1077,7 | 535,1 |
| VR | 8,0 | 68,0 | 34,0 |
| Secondment | 0,0 | 2475,0 | 2475,0 |
| Non-allocated | 199,4 | 1601,8 | 809,6 |
| **Sum** | **1906,2** | **18504,8** | **10330,5** |

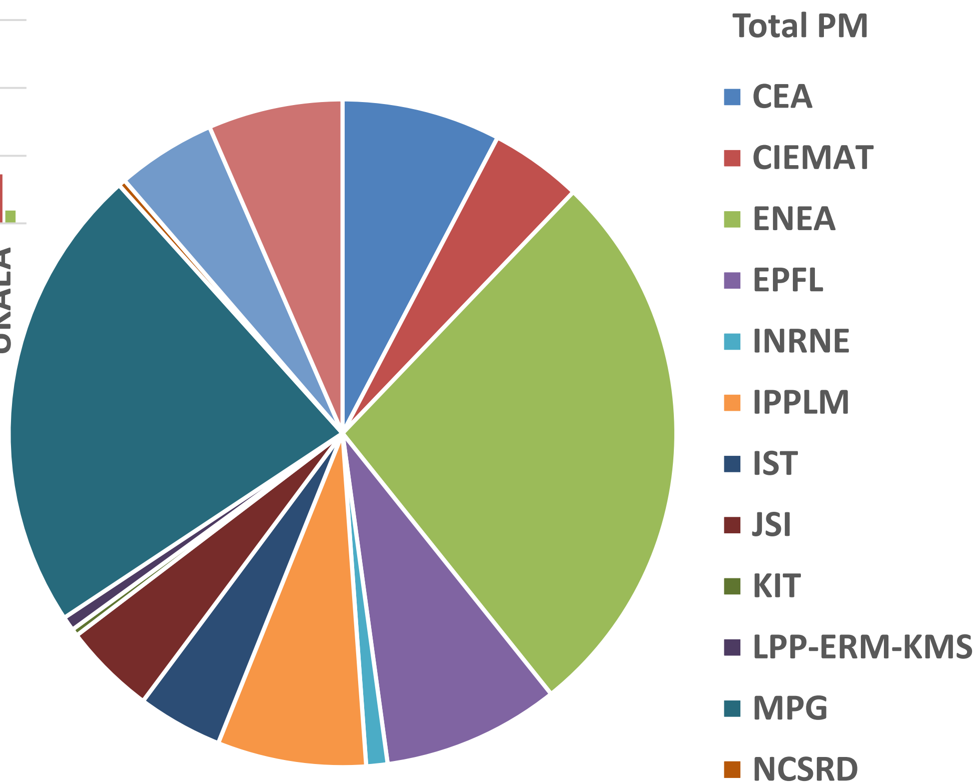
# Resources Breakdown for 2021

| Beneficiary | PM | Total Resources [k€] | Total Cons. Contr. [k€] |
|---|---|---|---|
| CEA | 22,4 | 211,2 | 127,1 |
| CIEMAT | 13,0 | 76,4 | 38,2 |
| ENEA | 79,0 | 552,2 | 276,1 |
| EPFL | 25,0 | 312,0 | 156,0 |
| INRNE | 3,0 | 6,3 | 3,1 |
| IPPLM | 21,0 | 77,7 | 24,0 |
| IST | 12,0 | 61,9 | 30,9 |
| JSI | 13,0 | 64,2 | 32,1 |
| KIT | 1,0 | 8,8 | 4,4 |
| LPP-ERM-KMS | 2,0 | 19,0 | 9,5 |
| MPG | 66,0 | 839,5 | 394,4 |
| NCSRD | 1,0 | 4,7 | 2,4 |
| UKAEA | 19,0 | 144,9 | 72,4 |
| Non-Allocated | 14,0 | 611,9 | 554,9 |
| Sum | **291,4** | **2990,5** | **1725,6** |

**non-allocated resources: mission, NBTF secondment**

# Resources Breakdown for 2021

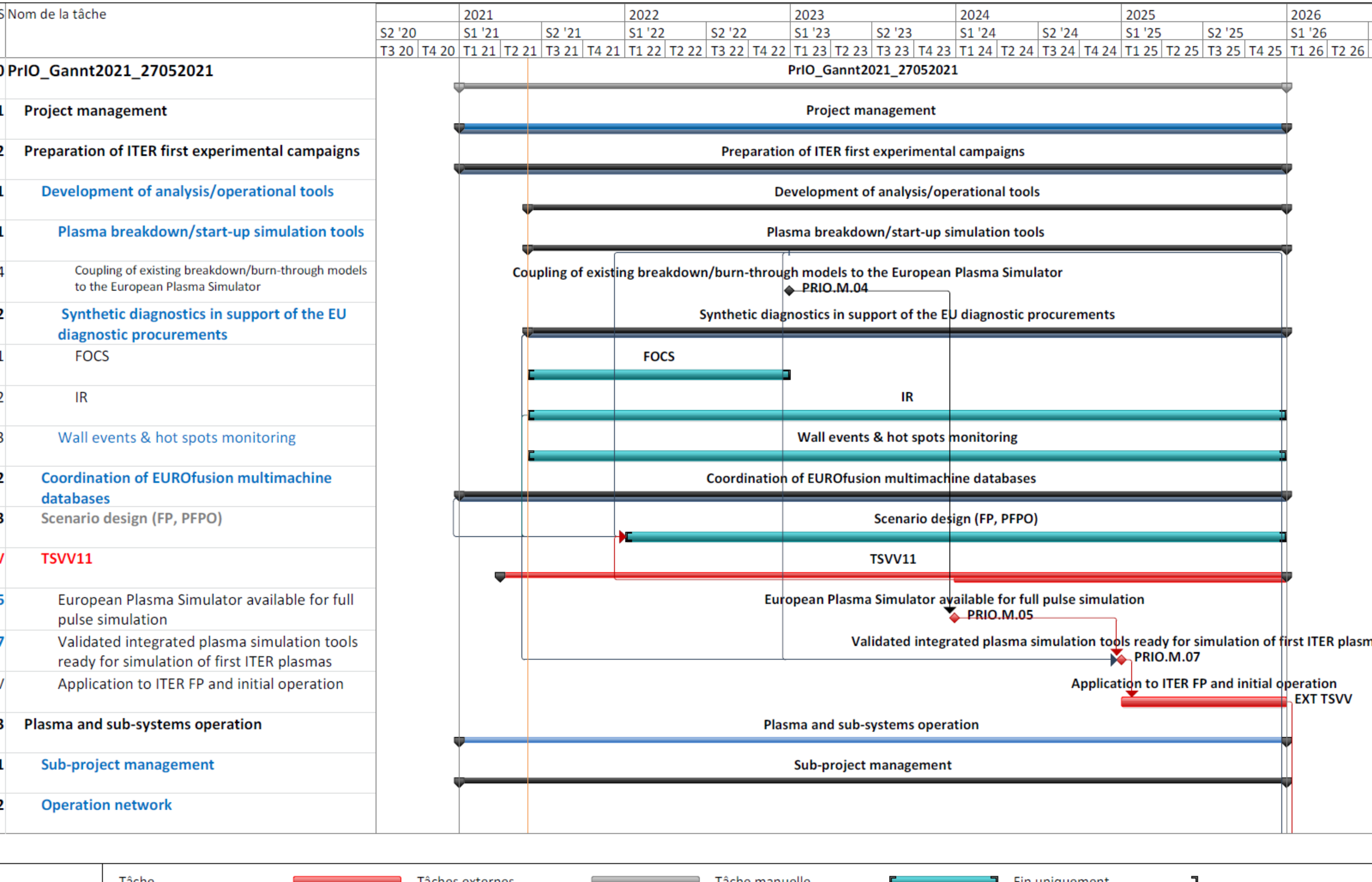


# Key assumptions

- **Prioritization following recommendations of the white paper on the preparation of EUROfusion role in ITER operation**
- **Synthetic diagnostics and data analysis tools**
  - Focus on a very limited number of activities mainly on the topic on the "Divertor and Plasma Facing Component"
  - EUROfusion participation in the design of ITER Fast Ions Lost Detectors diagnostic on hold pending peer review by ITER-IO
  - EUROfusion Database coordination under FP8 resources in 2021
- **ITER scenario design for first plasma & PFPO**
  - Activity to be initiated in 2022
  - TSVV#11 under WPAC
- **Neutronics**
  - JET operation ends in 2021. If JET is extended with a third D-T campaign further resources need to be allocated
  - 2021: JET neutronics funded with FP8 resources  (WPJET3)
  - 2022-2023: WPPrIO cover JET neutronics, materials and waste analyses

# Gantt chart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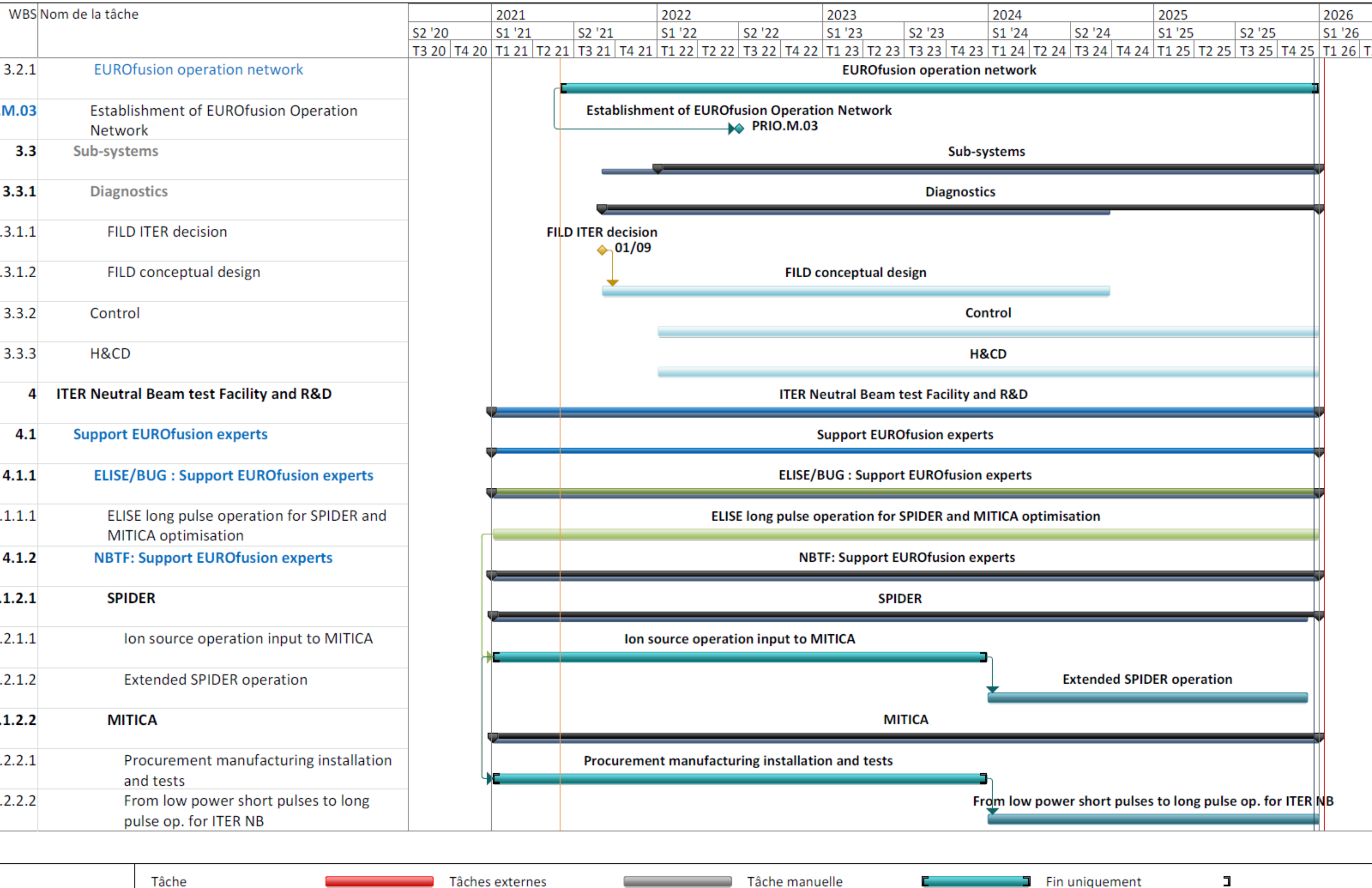
Project management
Preparation of ITER first experimental campaigns
Development of analysis/operational tools
Plasma breakdown/start-up simulation tools
Coupling of existing breakdown/burn-through models to the European Plasma Simulator
Synthetic diagnostics in support of the EU diagnostic procurements
FOCS
IR
Wall events & hot spots monitoring
Coordination of EUROfusion multimachine databases
Scenario design (FP, PFPO)
TSVV11
European Plasma Simulator available for full pulse simulation
Validated integrated plasma simulation tools ready for simulation of first ITER plasmas
Application to ITER FP and initial operation
Plasma and sub-systems operation
Sub-project management
Operation network
PRIO.M.04
PRIO.M.05
PRIO.M.07
EXT TSVV
Tâche
Tâches externes
Tâche manuelle
Fin uniquement

# Gantt chart



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3.2.1 EUROfusion operation network
M.03 Establishment of EUROfusion Operation Network
3.3 Sub-systems
3.3.1 Diagnostics
.3.1.1 FILD ITER decision
.3.1.2 FILD conceptual design
3.3.2 Control
3.3.3 H&CD
4 ITER Neutral Beam test Facility and R&D
4.1 Support EUROfusion experts
4.1.1 ELISE/BUG : Support EUROfusion experts
.1.1.1 ELISE long pulse operation for SPIDER and MITICA optimisation
4.1.2 NBTF: Support EUROfusion experts
.1.2.1 SPIDER
.2.1.1 Ion source operation input to MITICA
.2.1.2 Extended SPIDER operation
.1.2.2 MITICA
.2.2.1 Procurement manufacturing installation and tests
.2.2.2 From low power short pulses to long pulse op. for ITER NB
EUROfusion operation network
Establishment of EUROfusion Operation Network
PRIO.M.03
Sub-systems
Diagnostics
FILD ITER decision
01/09
FILD conceptual design
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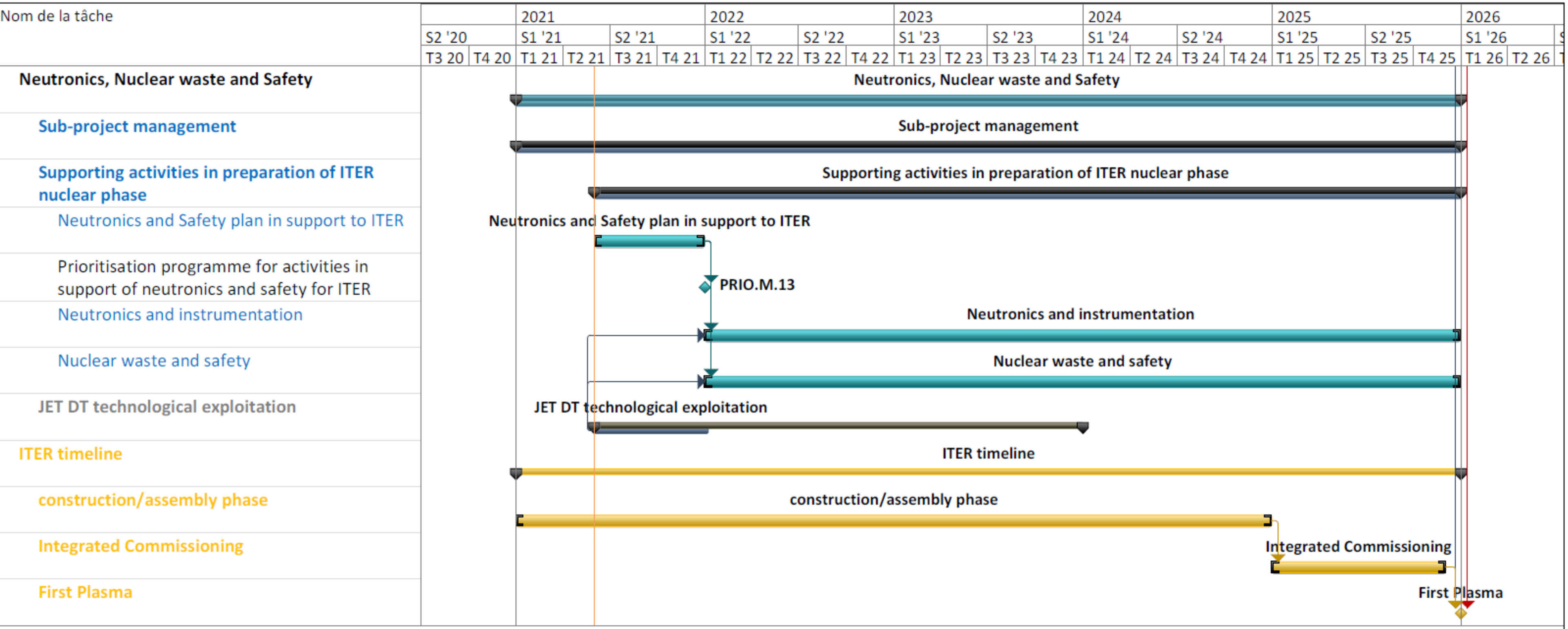
# Gantt chart



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Neutronics, Nuclear waste and Safety
Sub-project management
Supporting activities in preparation of ITER nuclear phase
Neutronics and Safety plan in support to ITER
Prioritisation programme for activities in support of neutronics and safety for ITER
Neutronics and instrumentation
Nuclear waste and safety
JET DT technological exploitation
ITER timeline
construction/assembly phase
Integrated Commissioning
First Plasma
Neutronics, Nuclear waste and Safety
Sub-project management
Supporting activities in preparation of ITER nuclear phase
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PRIO.M.13
Neutronics and instrumentation
Nuclear waste and safety
JET DT technological exploitation
ITER timeline
construction/assembly phase
Integrated Commissioning
First Plasma

EUROfusion

# Preparation of ITER Operation, WPPrIO

X. Litaudon (PL), Gloria Falchetto (PSO) on behalf of WPrIO team

DE LA RECHERCHE À L'INDUSTRIE

cea

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

# 2022 programme goals & strategy (AWP 2022):

## WP activities, TSVV links, resource allocations, risks, synergies, international collaborations, 2022 GA milestones/deliverables…

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# Recommendations* on "EUROfusion role in ITER op. & scientific exploitation"and PrIO contributions

*) EUROFUSION GA (20) 32 - 4.7

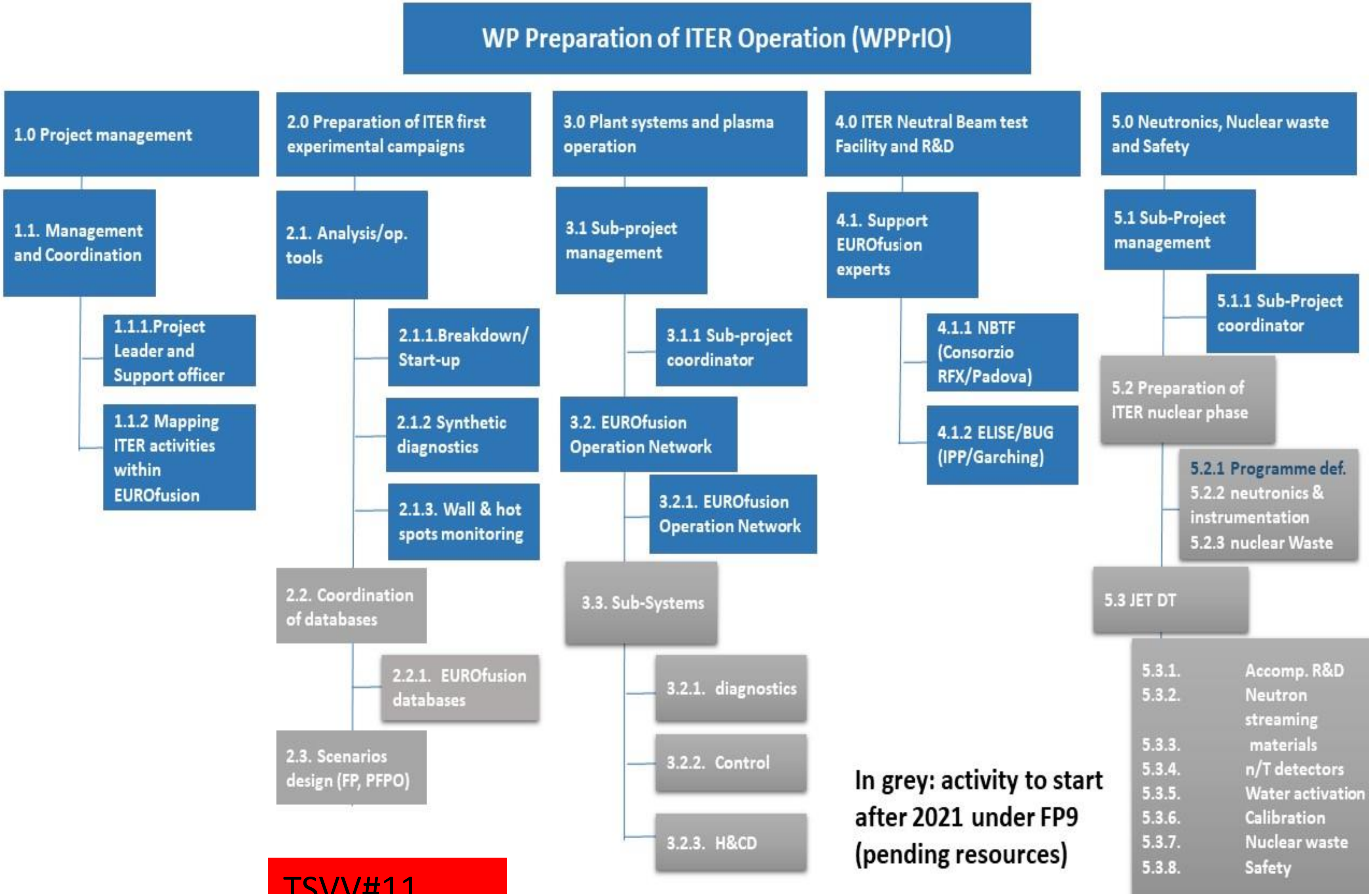
2022 ?

| Sub-systems | Required involvement for EU implication in ITER operation | Impact level on the EU DEMO design |
|---|---|---|
| → TF & PF Magnets and Cryo-plant | *** in commissioning phase (* during full operation) | ++ (for DEMO design) |
| → Divertor & PFCs | *** | ++ |
| Tritium Plant | *** | +++ |
| Breeding Blanket System | *** | +++ |
| → H&CD: Neutral Beam | *** (NBTF) | +++ |
| → Diagnostics | *** | +++ |
| → Control and Analysis/operational/simulation tools | *** | ++ (+++ for some control aspects) |
| H&CD: Electron Cyclotron | ** | ++ |
| H&CD: Ion Cyclotron | ** (present operation in present facilities) | + |
| → Neutronics, Waste and Radiological Protection | ** | +++ |
| Vacuum Vessel | * | + |
| Remote Handling Equipment | * | + |
| Vacuum Pumping & fueling | * | + |
| Building and Electrical Power Supply & Distribution System | * | +++ (for DEMO design) |

(+++): Unique, (++) High, (+) Significant

(***) Strong: Organized team with defined commitments, (**) Organized team, (*) Expertise for follow-up

# Work Breakdown Structure - 5 Sub-Projects




In grey: activity to start after 2021 under FP9 (pending resources)

TSVV#11

# 2022 Milestones and Grant Agreement Deliverables

| | Milestones Table |
|---|---|
| PRIO.M.03 | Establishment of the EUROfusion Operation Network |
| PRIO.M.04 | Coupling of existing breakdown/burn-through models to the European Plasma Simulator (together with TSVV11) |
| PRIO.M.14 | Preliminary analyses of measurements and simulations of JET nuclear quantities (neutron flux, dose rate, neutron induced activation, radiation damage) in DT |
| PRIO.M.15 | n/T validated data with detectors for the breeder blankets at JET during DT |
| PRIO.M.16 | Completion of collection of Occupational Radiation Exposure and waste data |
| PRIO.M.17 | Completion of calibration verification at JET in DT operations |

| | Deliverables Table |
|---|---|
| PRIO.D.01 | European Plasma Simulator (Python workflow) released to the EUROfusion community including all available IMAS modules and a user friendly interface (TSVV11) |
| PRIO.D.02 | Report on the procedure for an automated and systematic validation of predictive integrated modelling including uncertainty quantification (TSVV11) |
| PRIO.D.12 | Report on EUROfusion participation in ITER NBTF, ELISE and BUG activities |
| PRIO.D.13 | Report on long pulse operation 1000s extraction of H- on ELISE facility |
| PRIO.D.22 | Report on testing of n/T detectors in JET DT for breeder blanket |
| PRIO.D.23 | Report on Occupational Radiation Exposure and waste data collected at JET in DT operation |
| PRIO.D.24 | Report on calibration verification at JET in DT operation |

# SP-1 Project Management and coordination
# New coordination activity related to ITPA

- **WPrIO keeps track on the PrIO Wiki page of the TG group meetings, list of EU members, ITPA-JEX etc**
  - https://www.iter.org/org/team/fst/itpa
- **WPrIO organises with the other relevant WP Leaders and PMU coordinators meetings with the EU TG members between two ITPA meetings**
  - Improve the scientific coordination between ITPA and EUROfusion
  - Get feedback on the important ITER priorities
  - Review/comments the main ITER 'hot topics' that could influence the WP activities (ITPA experiment, joint analysis …)
  - Prepare EUROfusion inputs for the next TG meetings
- **WPrIO funds (with extra resources) and validates missions of the EU experts and keeps track of scientific mission reports**

# SP-2: Plasma initiation

- **Complete the development of plasma volume evolution model (circuit equation) in DYON and validate against experiments**
- **For ECH pre-ionization modelling, localized electron avalanche to be modelled with a Particle-In-Cell code.**
- **Automatize the scenario optimization workflow in DYON, validate it against experiments and apply it to ITER**
- **Adaptation of the simulation codes to IMAS (CREATE-BD/BKD0/GRAY)**
  - Support from ACH is formally requested
- **Operational window for ITER, i.e. a scan in ($P_{EC,}$ $n_{neut}$, impurities...)**
- **Benchmark CREATE-BD/BKD0/GRAY workflow with Dyon**
- **Link with TSVV11**
  - Breakdown database for direct comparison to modelling
  - Procedure for the transition from plasma initiation to ramp-up

# SP-2 : development of IR temperature synthetic diagnostic for ITER real-time application and offline analysis

- **1: Development of ray tracing codes**
  - Benchmarking codes Raysect (open-source) vs ANSYS-SPEOS: application to ITER antenna heat flux
- **2: Characterization of optical properties of materials**
  - investigation of detailed numerical models of Bidirectional Reflectance Distribution Function and emissivity for implementing in IR synthetic diagnostics
- **3: IR experiments in tokamaks**
  - comparison of photonic models and experimental results
  - Include transient events (Disruption , ELM) in the IR synthetic diagnostics and simulation. This may require to run predictive codes for transient events (JOREK simulations) and coupling to SPEOS (IR image simulator)

# SP2 : Development of a wall thermal events & hot spot monitoring system for ITER

- **2022 : Demonstration of a data pipeline for processing thermal events in a thermographic movie operating off-line. Key actions: detection, data enrichment and classification.**
- **2023 : on-line test**
- **2024 and beyond : Algorithm to be developed for ITER and tested with synthetic data**

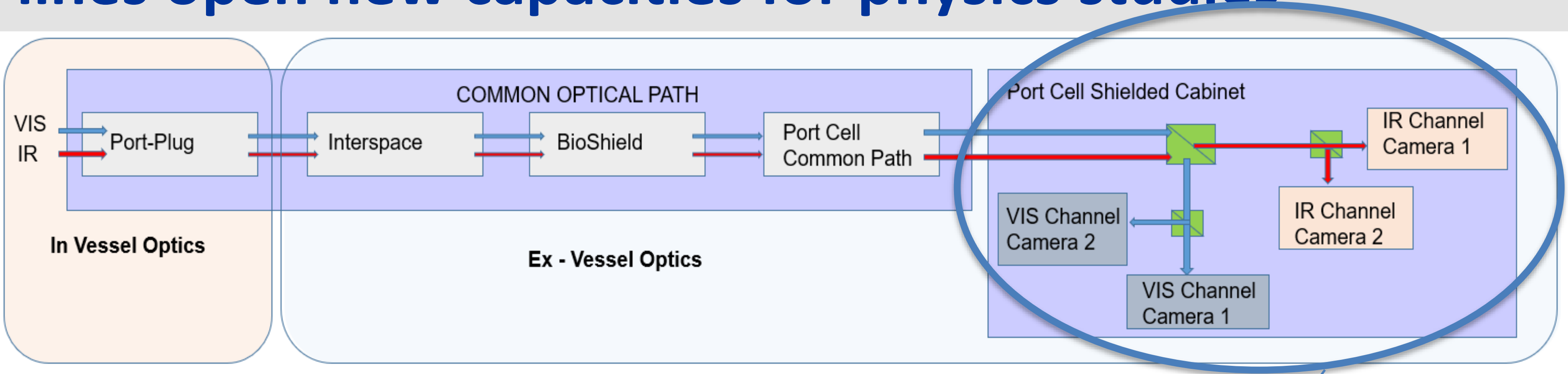
# SP-2: Preparation of ITER first experimental campaigns (PFPO-1/2) : Proposed new activities-

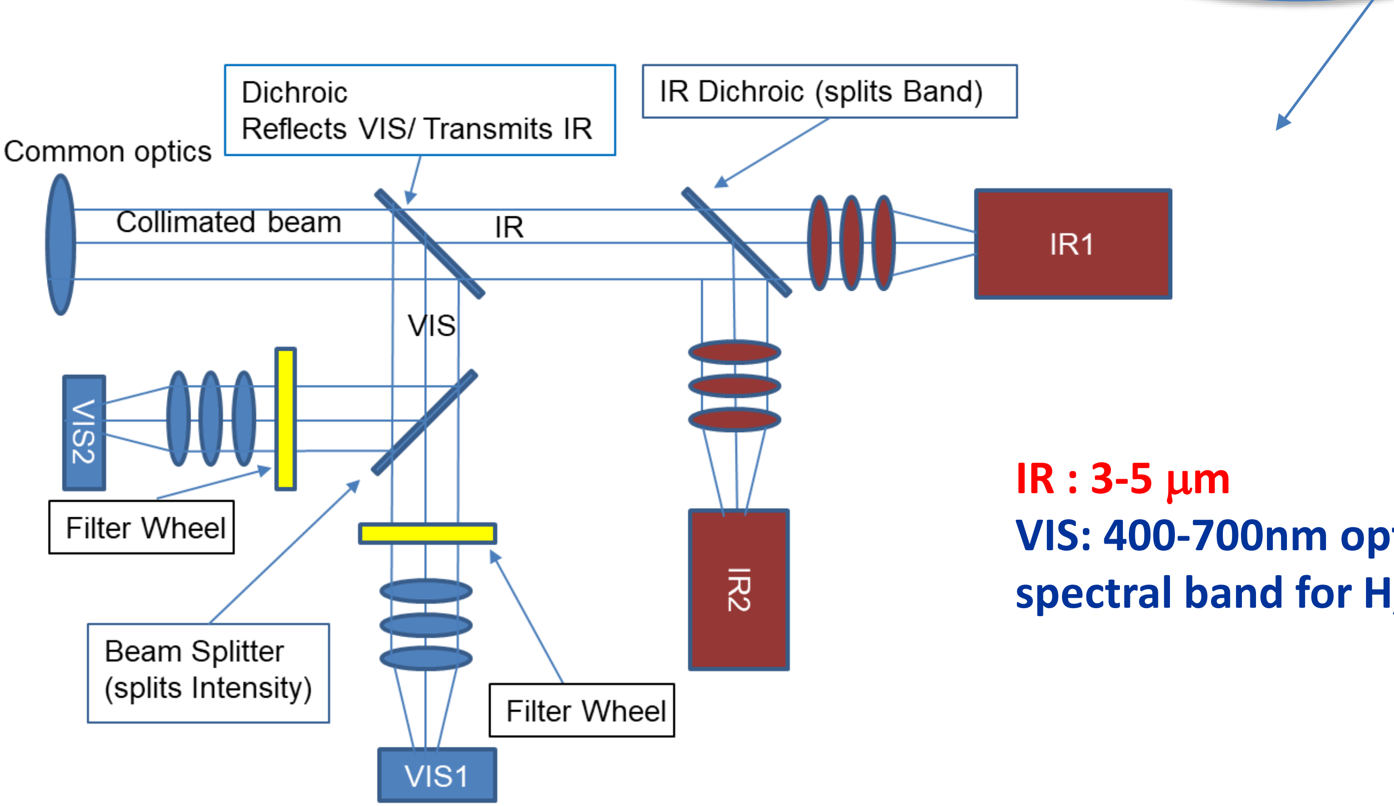
- **Scenario design for ITER first experimental campaigns**
  - ITER preparation of first campaigns and simulations using existing tools liaising with IO
  - Extrapolation based on lessons learnt from EUROfusion results : e.g. isotope effects, H and He campaigns, transition from H, D, DT
  - Support TSVV11 development activity
  - Synergy simulation DEMO Central Team:
    - Simulation ITER, DEMO by same team
  - Improved coordination with F4E needed
  - Needed resources : 18PM/year + new call
- **EUROfusion databases**
  - Add L-H transition database with a focus on new results from JET, AUG on isotope effects , He campaign
  - Transfer to IMAS, include new data
  - Support to TSVV#11
  - Needed resources : 2PM/year + new call
  - IMAS support formally requested

# SP-2: Preparation of ITER first experimental campaigns (PFPO-1/2) : Proposed new activities-

- **IR and visible diagnostics for ITER**
  - Expand the 2021 activity to visible light with the new capabilities of WAVS (c.f. next slides) and AI/Deep Learning techniques of large databases of visible images
  - Needed resources : 18PM/year + new call
  - improved coordination with F4E needed

# ITER Wide Angle Viewing System: IR and Visible lines open new capacities for physics studies




**IR : 3-5 μm**

**VIS: 400-700nm optimised in the spectral band for H/D$_\alpha$ 656nm**

# Visible lines open new capabilities for physics studies (ITER Wide Angle Viewing System)

- **Further explore new capabilities for 2D characterization of Be and W erosion / transport studies in synergy with WPPWIE and in coordination with F4E**
  - based on experiments in EUROfusion facilities [e.g. 1,2]
- **Development of advanced automatic image analysis tools using IA /Deep Learning techniques in synergy with effort on IR**
  - Analysis of ITER Big Data (~ 2 PB per day !) will require to develop automatic process
  - Automatic search for patterns in large database of visible images [e.g. 3]
  - Many physics applications to the physics breakdown, disruption and mitigation with SPI (c.f. JET fast camera), fast ion losses
  - Application to other diagnostics (2D data of ITER Thomson Scattering): automatic filtering of stray lights using Deep Learning techniques

[1] J. Karhunen et al. Nuclear Mat. and Energy **25** (2020) 100831
[2] A. Huber et al. Nucl. Mat. and Energy **18** (2019) 118
[3] A. Bustos et al. PPCF **63** (2021) 09501

# SP-3: Plant systems and plasma operation
# Proposed new activities

- **Participation in ITER plant & integrated commissioning/operation**
  - **Preparation** of ITER superconducting magnets IC as a pilot project
    - Thermohydraulic, structural, electromagnetic and control **modelling**
    - Instrumentation and interpretation
    - Control, responses to Faults and Off-normal behaviour
  - strong expertise & synergy with WPJT-60SA activity, knowledge transfer to DTT and WPMAG for DEMO design
  - Ensure transition from JT-60SA to ITER and ITER to DEMO
  - Initiate the work in 2022 with reduced level of resources
  - Needed resources growing up to 12 PM + new call
- **Diagnostics:**
  - Participation in ITER FILD diagnostic design
  - Resources already attributed but on hold pending IO review: reciprocating scintillator detector or dedicated IR based solution.
  - IO Decision by end of October 2021.

# SP-3: Plant systems and plasma operation
## Proposed new activities

**EUROfusion Operations Network (EON):** share operational experience, operator trainings and identify joint activities on EUROfusion and ITER-revelant operational issues

- European members meetings of the ITER Operations Network (ION) to coordinate our activities prior and after ION meetings (like ITPA)
- Set-up new **EON competency-based subnetworks** with workshops on high-priority operational topics for EUROfusion and ITER
  - Pilot subnetwork: NBI seminar series (starting in 2021)
    - online and open to EUROfusion experts incl. QST/JT-60SA staff, F4E and IO
  - New subnetwork areas in 2022 to be defined (vacuum conditioning, ECRH, ..) based on EUROfusion and F4E/ITER priorities -> 2-4 events in 2022
- Create **knowledge base for Operations** (contribute to knowledge management activities and platform managed by the PMU)
  - Agreed Knowledge Management pilot with the PMU on NBI.
  - Build Session Leader knowledge base

# SP-3: Plant systems and plasma operation
# Proposed new activities

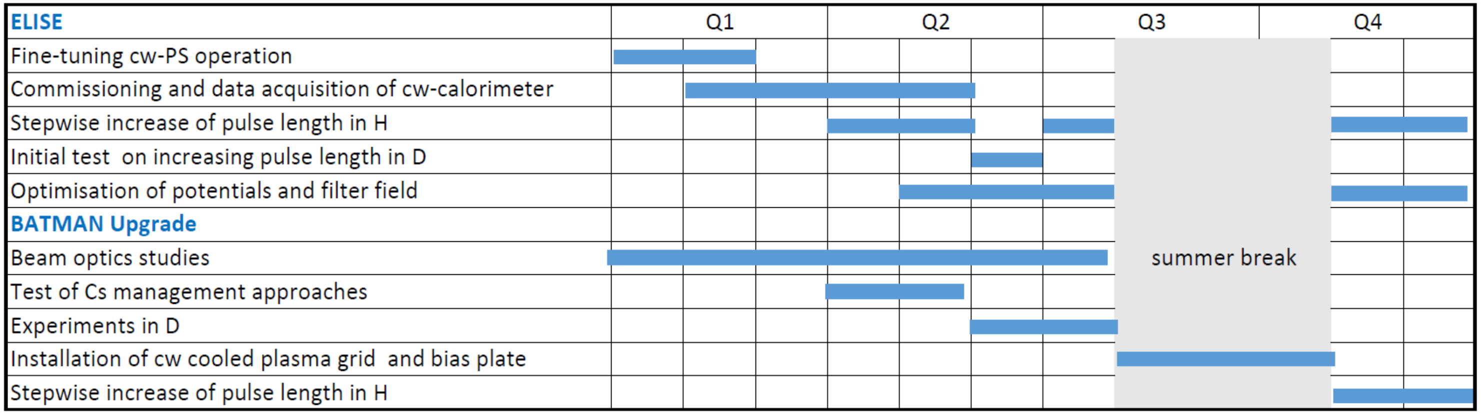
**EUROfusion Operations Network (EON):** Support **operator training** in EUROfusion on ITER-relevant operational issues

1. **On-site participation in local operator training courses**
   - e.g. external participants in Session Leader courses
   - Needed resources: 1 week participation for ~20 candidates (WPPrIO) and mission for selected SL during Campaign (WPTE ?)
2. Pilot project on **Session Leader Subnetwork**
   - Beginner course on session leading (15 topics x 2 hour): new SLs, SCs, EEG, …
   - Advanced workshops for current session leaders and operations experts to discuss and share experience across all EUROfusion devices (incl. JT-60SA, invite IO/F4E)

- **Support short-term missions of technical experts to EUROfusion facilities to support commissioning of plant systems and plasma operations on ITER related issues**
  - Topics to be identified where we have a gap and level of support
  - Needed resources: 6 PM (6-12 experts for 2-4-weeks)

# SP-4: Neutral Beam Test Facility and R&D for ITER Neutral Beam: ELISE & BUG

- **Symmetrisation and reduction of the current of co-extracted electrons**
- **Stable long pulse operation: stable co-extracted electron current**
  - Routine operation of the new CW power supply on ELISE
  - up to 1000s in H on ELISE and BATMAN, inital test in D
  - CW diagnostic calorimeter (ELISE)
  - New Cs management approaches on BATMAN
- **Detailed studies of beam optics**
  - Continuation of study of beam optic dependencies on various source parameters
  - Characterisation of the beam as well single beamlets with an extended set of



# SP-4: Neutral Beam Test Facility and R&D for ITER Neutral Beam: SPIDER

- **SPIDER entered in a long shut down to improve future operation**
- **Improvement interventions :**
  1. Upgrading of the pumping system
  2. Replacement of RF oscillators with solid state amplifiers
  3. Maintenance and improvement of the Beam Source
- **Start of the experimental phase expected in December 2022**

# SP-4: Neutral Beam Test Facility and R&D for ITER Neutral Beam: MITICA

- **Background : In 2021, failures occurred during the 1MV power integrated tests due to BreakDowns (BD) that damaged two components of the power supply system:**
  - Diode bridge of stage DCG1 (800kV-1MV)
  - HV bushing of the 1 MV insulating transformer
- **The 2022 MITICA schedule is being updated taking into account :**
  - Repair and improvement of the MITICA power supply system
  - Completion of the integrated power tests of MITICA's power supplies
- **An updated MITICA schedule will be developed in October and presented to the NAC**

# Scientific activity: EUROfusion team fully integrated to NBTF team

- **Experiments:**
  - Analysis of data collected in 2018-2021:
    - Operation without and with caesium
    - Assessment of main issues emerging from experiments
  - Characterisation of caesiated samples in CATS
- **Modelling:**
  - Simulations of SPIDER plasma and beam operations for preparation of tests and modifications and for diagnostics improvement
  - Simulation of initial MITICA beam operations in view of parameter setting and diagnostics
  - Tuning of caesium model with experimental data
  - Tuning of BIRD model with experimental data
- **HV holding:**
  - voltage holding tests of MITICA
  - tests of electrodes with HV Short Gap Test Facility

# SP-5: Neutronics, Nuclear Waste and Safety

- **Structure the activity along 4 thrusts for JET/ITER**
  1. Neutronics code simulations and development
  2. Neutron activation and damage in materials
  3. Nuclear measurements and instrumentation
  4. Nuclear safety and waste
- **JET DTE2:**
  - analysis in 2022 and 2023 after completion of DT campaign under PrIO
  - Re-assess/re-scope the analysis needs following DTE2
  - Organise the hand-over from JET3 (2021) to PrIO
- **JET DTE3 (pending JET extension) : New activity (extra resources)**
  - New resources (80 PM/y – Ref. JET3 140-180PM/y) to be allocated for the elaboration of DTE3
  - Assess possibility of Water Activation Experiment
- **EUROfusion activities for ITER: New activity**
  - High Impact level on ITER and on the EU DEMO design
  - On-going selection by a joint working group with EUROfusion, F4E and IO
  - Activity within resources attributed to SP-5

# SP-5: Neutronics, Nuclear Waste and Safety

- **Working group (EUROfusion, IO, F4E) to define the 2022-2025 activities on EUROfusion activities for ITER**
  - **Rosaria Villari ENEA Chair**
  - Yannick Peneliau CEA
  - Lee Packer CCFE
  - Rafael Jaurez CIEMAT
  - Maurizio Angelone ENEA
  - Jerzy Mietelski IPPLM
  - Luka Snoj JSI
  - Dieter Leichtle KIT ( link with DEMO aspects)
  - Theodora Vasilopoulou NCSRD
  - Anders Hjalmarsson or Göran Ericsson VR
  - **M. Loughlin, IO & M. Fabbri, F4E**
- **4 Workshops on 4 high priority topics (01 & 02 Sept.) High participation and interest**
  - Neutronics code simulations and development
  - Neutron activation and damage in materials
  - Nuclear measurements and instrumentation
  - Nuclear safety and waste
- **13 & 16 September 2021: Review and selection of proposals within the resources**
- **High interest from all EU labs and oversubscription by a factor 5 vs SP-5 resources**

# Topics for ITER – High priority

1. **Neutron and gamma source in early ITER operations**
2. **Activation corrosion products methodology/assessment/experiment**
3. **Fluid activation methodology/assessment/experiment**
4. **Shielding measurements under 6 MeV photons emitted from water activation**
5. **Measurements of low dose levels in DD and DT plasmas**
6. **Beryllium and Tritium contamination**

**Even if PrIO selects only these 6 high priority ITER topics out of ~35 topics proposed we are still oversubscribed**

# Training : EUROfusion Engineering Grants AWP2022

- EEG21-17 Development of Infra-Red monitoring system using artificial intelligence techniques in view of ITER application
  - Formally in WPW7X but in strong connection with WPrIO
- EEG21-18 Engineering support on the wall conditioning and ITER GDC design
  - Candidate did withdraw at last minute
  - To be proposed in 2022 call

# International Collaboration for 2022 – New activities

- **EU-Korea**
  - Collaboration on DYON upgrade developments for breakdown simulations
- **EU-US-DOE**
  - Extend collaboration agreement :
  - For JET beyond 2021 and JETDTE3
  - Other neutronics simulation activities and ADVANTAGE support in EU

# Interfaces/Synergies , Resources

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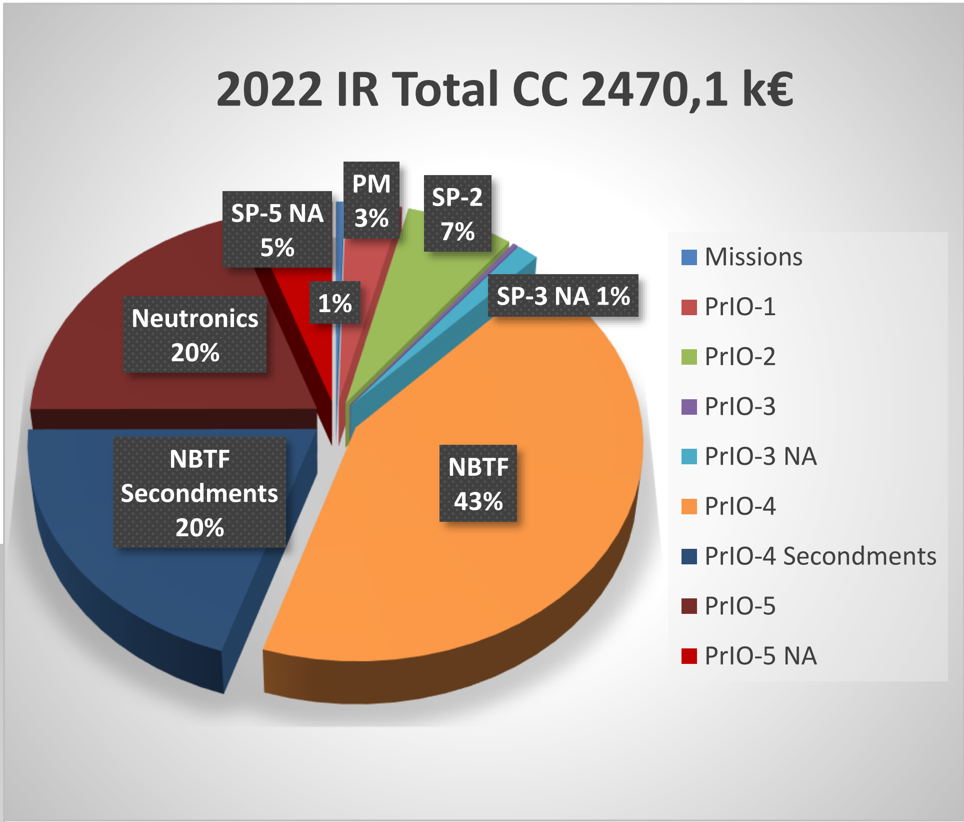
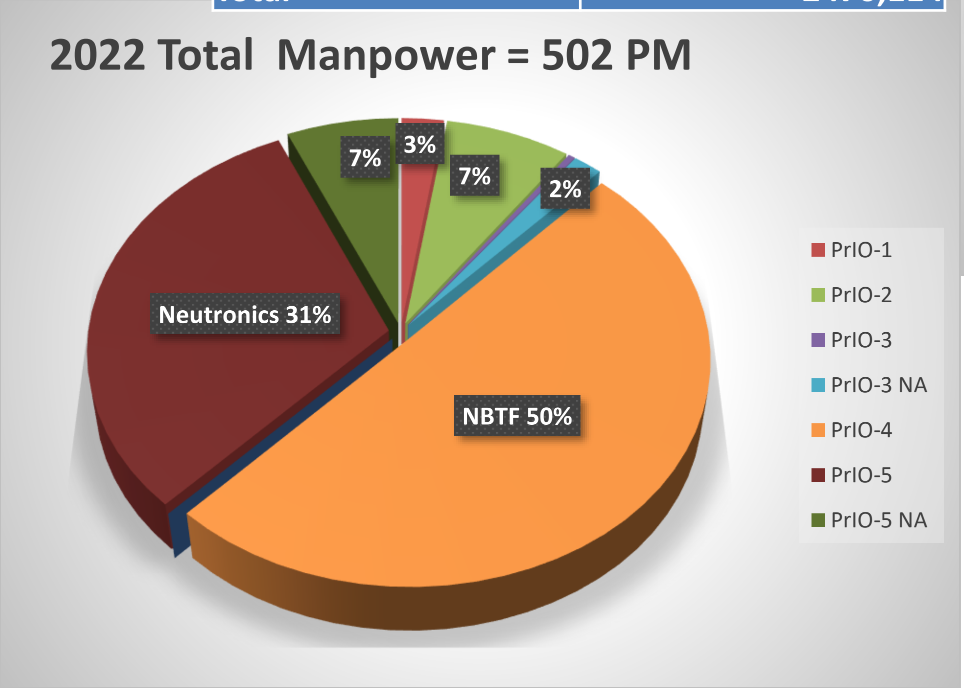
# Interfaces/Synergies

- **Scenario modelling with TSVV11, FDT-CDT**
- **Breakdown simulator activity in synergy with TSVV, WPSA and WPTE (Tokamak Exploitation)**
- **Development of synthetic diagnostics (WPSA, WPTE, WPAC/TSVVs...)**
- **Development of reduced model (WPAC/TSVV)**
- **Real time protection of the plasma facing components (WPTE, WPW7X)**
- **Multi-machines databases (WPTE, ITPA)**
  - JT-60SA disruption database could be connected to the EUROfusion database
- **Wall conditioning topics (WPPWIE, WPTE, WPW7X)**
- **EUROfusion Operations Network: seminars, workshops, trainings open to IO & JT-60SA staff**
- **Interface with IO is working well**
- **Low level of interaction/communication with F4E except on neutronics**

# 2022 Indicative Resources per sub-project

| | Total Cons. Contr. (k€) 2022 |
|---|---|
| PrIO-1 | 83,093 |
| PrIO-2 | 161,596 |
| PrIO-3 | 7,740 |
| PrIO-3 NA | 33,789 |
| PrIO-4 | 1012,813 |
| PrIO-4 Secondements | 541,875 |
| PrIO-5 | 489,365 |
| PrIO-5 NA | 128,906 |
| Missions | 10,938 |
| **Total** | **2470,114** |




Extra budget for new activities: 252k€
~10% Total WP PrIO budget

# Summary of new activities and required resources for 2022-2025

| Sub project | Task | Required PM / y | Total CC cost |
|---|---|---|---|
| SP-2 | Scenario design for ITER first experimental campaigns | 18 | |
| SP-2 | L-H transition database | 2 | |
| SP-2 | visible synthetic diagnostics for ITER | 18 | |
| SP-3 | Session Leaders training | 5 | ~14 k€ (3 months secondment Unit Cost) |
| SP-3 | Participation in ITER IC commissioning and operation of superconducting magnets | 12 | |
| SP-3 | Mission of technical experts in support to commissioning and operation | 6 | |
| SP-5 | JET DTE3 (pending JET extension) | 80 ? | |
| SP-5 | EUROfusion Neutronics, Nuclear Waste and Safety activities for ITER | 30 | Included within SP-5 NA 105 k€/y on average |
| | TOTAL | 61 PM w/o JET | Extra ~252 k€ requested ~10% |

**Activities and resources should grow when approaching ITER operation**

# Back-up

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# SP-2 pedestal database : future plans

- JET:
  The tools for the database creation are ready and the scripts to transfer the database to IMAS have been finilzied. So the future will focus on:
  - extend to the database to TT and DT pedestal and to the new campaigns
  - make the local JET version easily available to JET users

- AUG, TCV, MAST-U:
  The tools for the database creation are ready. The future will focus on:
  - finilize scripts to transfer data to IMAS
  - Extend the databases

- People involved via WP PrIO:
  - Only the database coordinator: L. Frassinetti
  - Other personnel  will be involved via WPTE

# SP-2 Confinement database 2022 Tasks

- 0D:
- JET, in collaboration with the contact person to be appointed:
  - include pulses from C38A forward from JET data, especially DTE2 data;
  - include He pulses from C31 forward;
  - include pellets fueled pulses;
  - include high radiative discharges;

- AUG, in collaboration with the contact person:
  - include pulses from more recent campaigns;
  - increase the number of discharges with isotopic mixtures;
  - Increase the number of high radiative discharges;

- WEST, in collaboration with the contact person:
  - Include data in stable H mode phase

- Scientific exploitation of collected data within the EUROfusion framework, then transfer to ITPA group

- 1D:
- Start building the DB.

# SP2 : Development of a wall thermal events & hot spot monitoring system for ITER

| Year | Milestones |
| --- | --- |
| 2021-2022 | Demonstration of a data pipeline for processing thermal events in a thermographic movie operating off-line. Key actions: detection, data enrichment and classification. |
| 2022-2023 | Same as 1 but including the additional constraints of being interfaced with WEST and W7-X pulse management infrastructure and operating in between experiments. Investigation of real time application. |
| 2023-2024 | System engineered data pipeline for processing thermal events in ITER, equipped with a wide angle tangential viewing system. Specification and objectives, expected ground truth made from both events extrapolated from current devices and simulated events. |

| Year | Deliverables |
| --- | --- |
| 2022 | • Off-line data pipelines, including algorithms, methods and computer vision solutions.<br>• Source code(s).<br>• Technical report(s) describing methods and rationale for the technical choices. |
| 2023 | • On-line data pipelines, including algorithms, methods and computer vision solutions.<br>• Source code(s).<br>• Technical report(s) describing methods, rationale for the technical choices. |
| 2024 | • ITER data pipelines, including algorithm, methods and computer vision solutions. Data set extrapolated to ITER wide angle viewing system.<br>• Source code(s).<br>• Technical report(s) describing methods, rationale. System engineering documentation (mission goal, technical requirements, interface management). |

## EEG programme proposed in 2022 (joint WPW7X-WPPRIO)

# Potential Session Leader Foundation Course Topics (machine independent, beginner level)

- **Introduction, Operations Management**
- **Coils and power supplies**
- **Plasma shape control**
- **Vacuum conditioning**
- **Fueling (gas and pellet injection)**
- **Heating systems (NBI, ECRH, ICRH)**
- **Disruptions, predictions and mitigation (MGI, SPI)**
- **Diagnostic setup**
- **Breakdown and current ramp up, runaways**
- **Protection systems**
- **Real-time networks (scientific)**
- **Termination and event handling**
- **Operational tools (editors, data/plant viewers, event handlers)**
- **Operation of stellarators**
- **Scaling up operation (small, medium, large to ITER)**

**Target:**
- Students (MSc, PhD, Post-doc)
- EEGs and ERGs
- Scientific Coordinators
- Engineers, Researchers
- Generic interest

**Aims:**

-> Recruit session leaders

-> Improve preparation of experimental proposals and experimental sessions

-> Improve interaction between control room competencies

# SP-4: Neutral Beam Test Facility and R&D for ITER Neutral Beam: MITICA

- **In 2021, failures occurred during the 1MV power integrated tests due to BreakDowns (BD) that damaged two components of the power supply system:**
  - Diode bridge of stage DCG1 (800kV-1MV)
  - HV bushing of the 1 MV insulating transformer
- **In 2021, inspections and analyses using high frequency models were carried out to determine the root cause**
- **The 2022 MITICA schedule is being updated taking into account :**
  - Repair and improvement of the MITICA power supply system
  - Completion of the integrated power tests of MITICA's power supplies
- **An updated MITICA schedule will be developed in October and presented to the NAC**