# TSVVs: Status & Interactions with WPs

**Frank Jenko**

**On behalf of the E-TASC Scientific Board**

PSD AWP25 Planning Meeting
October 8, 2024

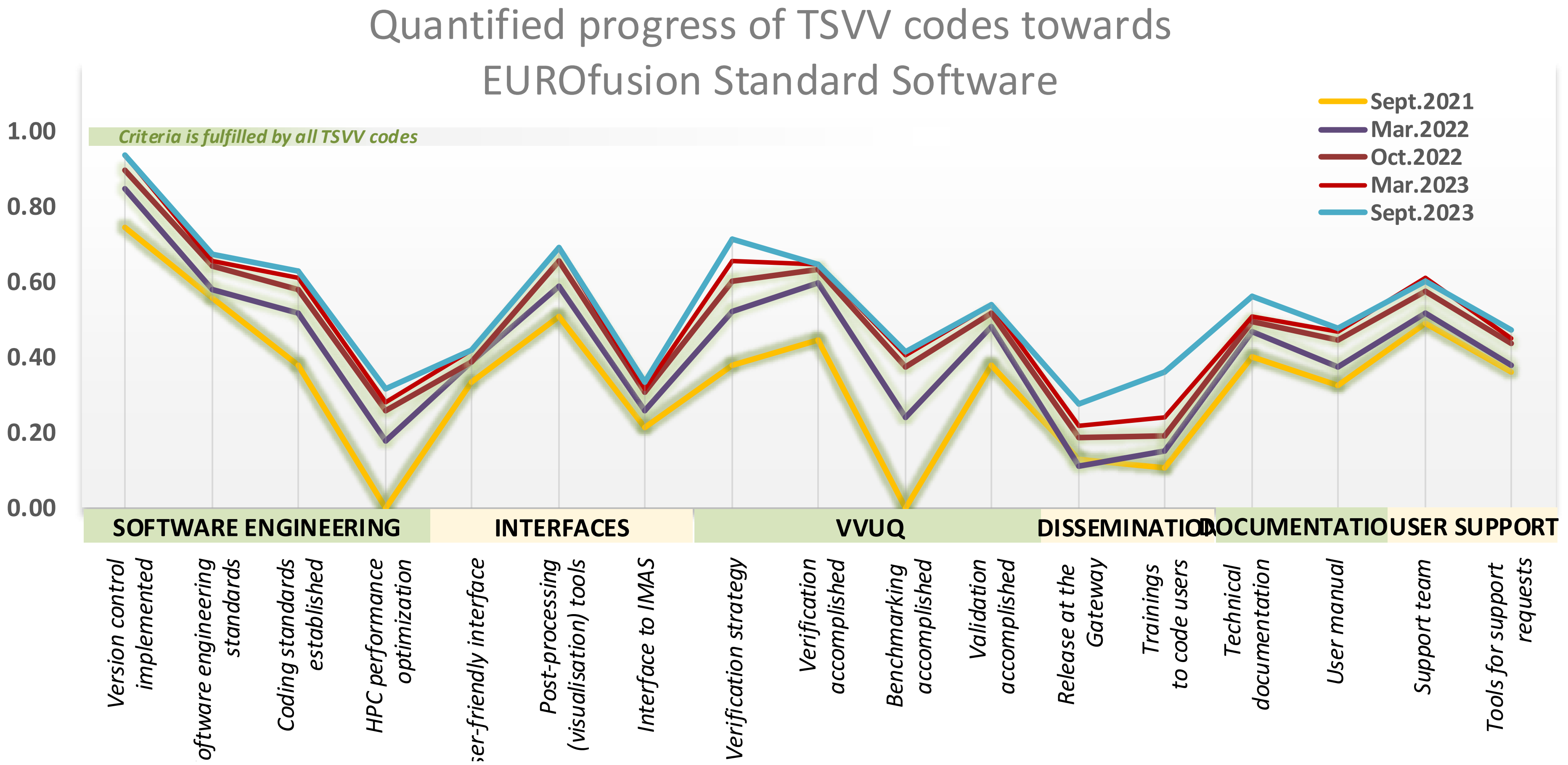
This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 and 2019-2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European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

# Towards EUROfusion Standard Software

EUROfusion standard software will be developed with a very rigorous, consistent quality assurance process that is common across the E-TASC initiative; it is designed to benefit a wide range of users across EUROfusion, well beyond the team of code developers, and will adhere to the following guidelines and criteria:

- Free availability (within EUROfusion) of an up-to-date release version of the source code used for production runs
- Good software engineering practices (version control, regression/unit testing, shared development rules etc.)
- High-quality code documentation via user manuals and reference publications (including, in particular, a detailed description of the underlying model)
- Excellent support of users, co-developers, and support staff within EUROfusion (via contact person, mailing list, issue tracker, and the like)
- Specific plans for code verification and validation (involving a third party), in particular within EUROfusion, including aspects of uncertainty quantification
- User-friendly, intuitive interfaces and visualisation/post-processing tools, including interfaces to the IMAS Data Dictionary (where applicable)
- Specific plans for code dissemination and user training within EUROfusion

# Towards EUROfusion Standard Software



# Example: Gyrokinetic turbulence code GENE

Open source policy: genecode.org

World-wide user base:
200+ users at 50+ institutions

Developed in int'l collaboration

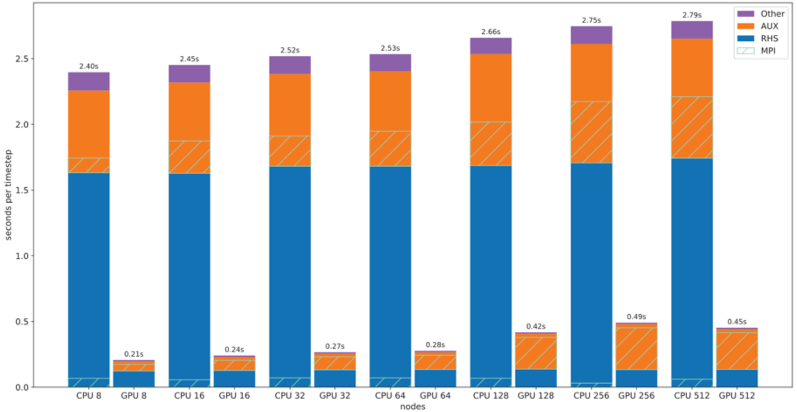
Modern software engineering

Advanced UI and post-processing

Documentation & user support

Code verification & validation

GENE performance on GPU systems

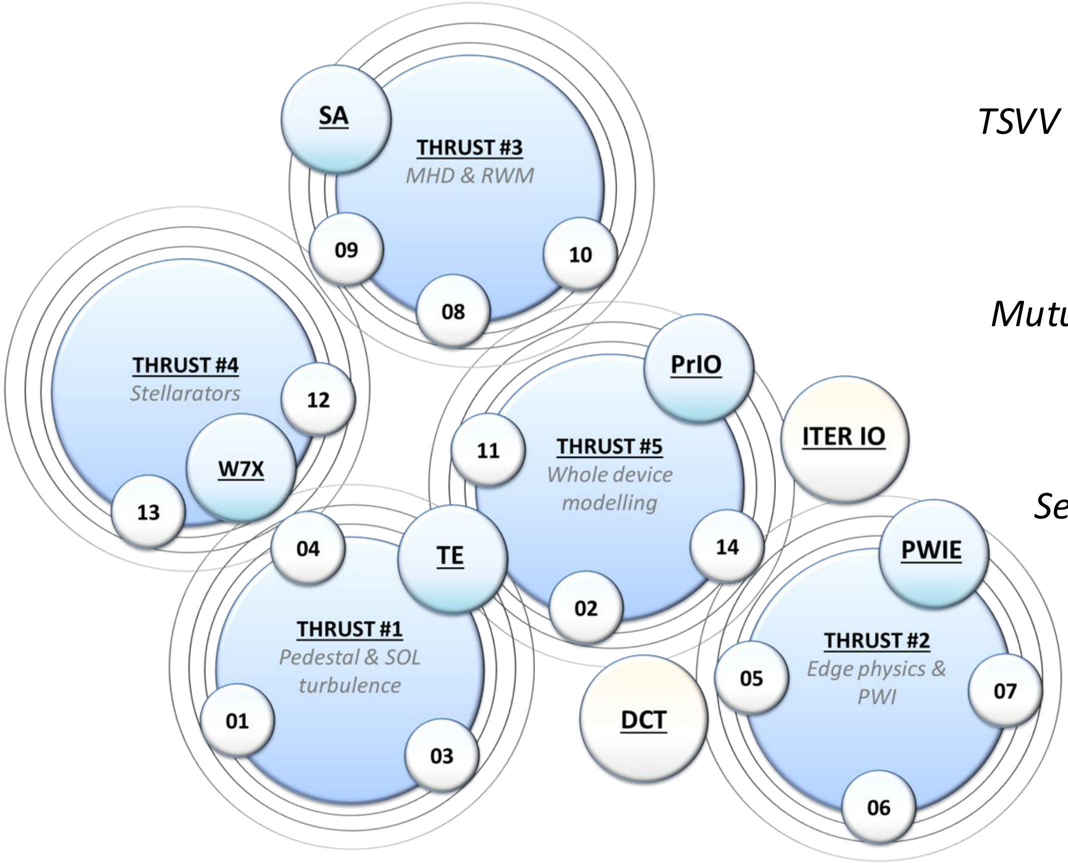



Scientific institutions using GENE

# TSVV tasks: Top-down AND bottom-up

| Dep. | WP | # | Title |
|---|---|---|---|
| FSD | TE | 1 | Physics of the L-H Transition and Pedestals |
| FSD | TE | 2 | Physics Properties of Strongly Shaped Configurations |
| FSD | TE | 3 | Plasma Particle/Heat Exhaust: Fluid/Gyrofluid Edge Codes |
| FSD | TE | 4 | Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes |
| FSD | PWIE | 5 | Neutral Gas Dynamics in the Edge |
| FSD | PWIE | 6 | Impurity Sources, Transport, and Screening |
| FSD | PWIE | 7 | Plasma-Wall Interaction in DEMO |
| FSD | TE | 8 | Integrated Modelling of Transient MHD Events |
| FSD | TE | 9 | Dynamics of Runaway Electrons in Tokamak Disruptions |
| FSD | TE | 10 | Physics of Burning Plasmas |
| FSD | PrIO | 11 | Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks |
| FSD | W7X | 12 | Stellarator Optimization |
| FSD | W7X | 13 | Stellarator Turbulence Simulation |
| FTD | DES | 14 | Multi-Fidelity Systems Code for DEMO |

# The E-TASC ecosystem




*TSVV teams working together in close collaboration*

*Related TSVVs in the "orbits" of Thrusts*

*Mutual interest between Thrusts on specific topics, emerging interactions between tokamak and stellarator efforts (turbulence, 3D, AI)*

*Several services provided (mostly through ACHs) for the benefit of the entire ecosystem*

*Close interactions with ITER IO*

*Interactions with the DCT*

# TSVV selection & monitoring (by E-TASC SB)

Call: Spring 2020

EUROfusion

**TSVV Task 1: Physics of the L-H Transition and Pedestals**

Expected resources: Up to about 10 ppy per year (incl. about 30% for ACH personnel)

**Background**

Regarding the plasma core, present-day gyrokinetic (GK) simulations of turbulent transport may be characterized as relatively mature, allowing for quantitative comparisons with measurements on a regular basis. Meanwhile, an important new frontier of GK is to advance towards a comprehensive, self-consistent description of the pedestal/edge region, including the physics of the L-H transition. The time is ripe to address these outstanding challenges, building on years of preliminary work and exploiting the capabilities of emerging exascale supercomputers.

Initial applications of GK codes to the near-edge region of tokamak plasmas over the last decade or so have highlighted the importance of a range of physical effects, calling for global simulations in realistic magnetic geometries – involving electromagnetic effects, high-quality collision operators, and the ability to retain both sub-ion-scale fluctuations and relevant macroscopic (MHD-like) instabilities. Moreover, GK codes have demonstrated the capability to reproduce experimentally measured fluxes in near-edge L-mode plasmas and have been used to explore to some degree the residual turbulent transport in H-, QH-, and I-mode pedestals. In addition, full-f GK codes applicable to the edge and SOL are being developed (see TSVV Task 4), providing new ways to attack the L-H transition problem. Another key aspect of the present TSVV task is the development of validated and fast reduced transport models – on the basis of the GK simulations – to be used in integrated modelling codes.

**Aims of the project**

- Capability to carry out self-consistent, robust, and validated GK simulations of L-H transitions and to accurately predict the pedestal profiles; extension to QH-/I-mode discharges.
- Validated and fast reduced transport models which can be used for multi-channel core-edge predictive modelling.
- Applications of GK simulations and reduced models to (natural or controlled) small/no ELM regimes, studying their transferability to ITER and DEMO.

**Key deliverables**

1. Validated local and global (electromagnetic, collisional) GK simulations of ion-scale, electron-scale, and multi-scale turbulent transport in the H-, QH-, I-, and L-mode edge.
2. Extension of these simulations to self-consistently include relevant macroscopic (MHD-like) instabilities and the development of a radial electric field.
3. Consistent application of at least one edge GK code (developed in TSVV Task 4) – which is able to bridge the core, pedestal, and SOL regions and includes neutral physics – to the L-H transition problem.
4. An interpretative and predictive capability of L-H transitions (based on a sound validation strategy and ideally also including extensions to QH-/I-mode discharges) accurately capturing the observed edge plasma dynamics in various machines.
5. Reduced transport models for the pedestal on the basis of GK simulations, involving electron-scale, ion-scale, and macroscopic (MHD-like) instabilities; these can then be included in MHD and transport studies, exploiting synergies with TSVV Tasks 8 and 11.

**Detailed workplan with timeline, milestones, SMART deliverables, and risk assessment (2021-25)**

## Mid-term review of Theory Simulation Verification & Validation (TSVV) projects 2021-2025 by the E-TASC Scientific Board

Mid-term review: Fall 2023

***Purpose of the review***

The goal of this review is to assess the TSVV projects' performance, the achievements in computational science and plasma physics, the efficiency of the project management, and the project's broader impacts on the EUROfusion programme and the wider scientific community.

The project achievements are considered, along with possible deviations from the original proposal. Specific challenges and opportunities are identified, and changes to project priorities, activities and objectives are proposed.

Furthermore, on a higher level, additional synergetic interactions between projects in EUROfusion and adjustments to the overall project portfolio are proposed.

***Methodology***

The review was carried out as a three-step process:

- Presentation of each TSVV project's achievements to date to a broad audience of EUROfusion scientists, focusing on the main scientific and technical highlights, briefly mentioning specific impacts (achieved or anticipated) on the WPs, and plans. All materials are available at https://indico.euro-fusion.org/event/2429/

# ACH selection & monitoring (by E-TASC SB)

Call: Spring 2020

EUROfusion

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PROGRAMME MANAGEMENT UNIT
**Tony Donné**
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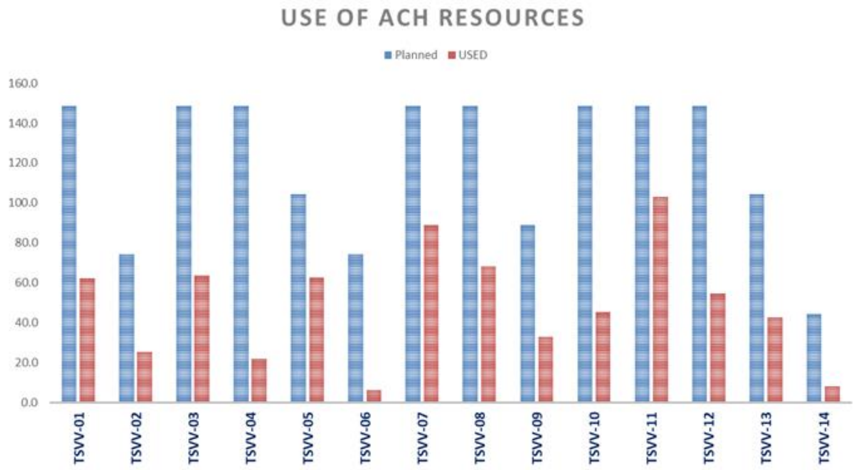
Our ref: PMU/1740

Date: 12th May 2020

**To the Members of the General Assembly**

**Subject: Work Plan for the Implementation of the Fusion Roadmap in 2021 – 2025: Call for proposals for hosting *Advanced Computing Hubs* within the *EUROfusion – Theory and Advanced Simulation Coordination (E-TASC)***

Mid-term review: Spring 2024




| 1 | Year | ACH | Customer Project/WP | Code | Project Coordin | PM's requested | PM's assigned | ACH team members | Tasks description | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 2021 | EPFL | TSVV-10 | EUTERPE | | 2,0 | 0,5 | Lanti | Further development of GPU functionality (OpenACC) for large-scale EM turbulence simulations; | |
| 12 | 2021 | EPFL | TSVV-13 | EUTERPE | | 2,0 | 0,0 | To be hired in eM+ | Development and application of tools for advanced visualization of 3D data resulting from global | |
| 13 | 2021 | EPFL | TSVV-03 | FELTOR | | 1,5 | 0,5 | | | task distributed per code |
| 14 | 2021 | EPFL | TSVV-03 | GBS | | 1,5 | 0,5 | | | task distributed per code |
| 15 | 2021 | EPFL | TSVV-03 | GBS | | 1,2 | 1,0 | Lanti | Optimization of kinetic neutrals treatment (method of characteristics and coupling to EIRENE) | |
| 16 | 2021 | EPFL | TSVV-03 | GBS | | 6,0 | 1,0 | Peybernes/Varini | Code profiling and optimization | |
| 17 | 2021 | EPFL | TSVV-03 | GRILLIX | | 1,5 | 0,5 | | | task distributed per code |
| 18 | 2021 | EPFL | TSVV-03 | GRILLIX | | 6,0 | 1,0 | Peybernes/Varini | Code profiling and optimization | |
| 19 | 2021 | EPFL | TSVV-01 | GYSELA | | 1,5 | 1,0 | Peybernes | Support for GPU porting and increased vectorisation for ARM-based architectures | |
| 20 | 2021 | EPFL | TSVV-04 | GYSELA | | 1,5 | 1,0 | Peybernes | Support for GPU porting and increased vectorisation for ARM-based architectures | |
| 21 | 2021 | EPFL | ACH | management | Paolo Ricci | 1,5 | 1,5 | Paolo Ricci | management of ACH activities | |
| 22 | 2021 | EPFL | TSVV-01 | ORB5 | | 4,0 | 1,0 | Lanti | Improve multi-threading of ORB5 & particularly of its field solver. Adaptations to the M100 | |
| 23 | 2021 | EPFL | TSVV-02 | ORB5 | | 4,0 | 1,0 | Lanti | Improve multi-threading of ORB5 and particularly of its field solver. Adaptations to the M100 | |
| 24 | 2021 | EPFL | TSVV-09 | ORB5 | | 4,0 | 1,0 | Lanti | Further development of GPU functionality (OpenACC) for large-scale EM turbulence simulations; | task distributed per code |
| 25 | 2021 | EPFL | TSVV-10 | ORB5 | | 2,0 | 0,5 | Lanti | Further development of GPU functionality (OpenACC) for large-scale EM turbulence simulations; | task distributed per code |
| 26 | 2021 | EPFL | TSVV-03 | SOLEDGE3X | | 1,5 | 0,5 | Varini | Poisson solver optimization, including porting to GPU | |
| 27 | 2021 | EPFL | TSVV-06 | SOLEDGE3X | | 3,0 | 1,0 | Peybernes/Varini | Profiling and optimisation of SOLEDGE3X in the case of high number of species | |
| 28 | 2021 | EPFL | TSVV-01 | Various codes | | 2,0 | 0,0 | To be hired in eM+ | Development of community visualisation tools that will enable us to easily navigate the huge | |
| 29 | 2021 | IPPLM | ALL | AAI | Liviu Joita | 5,0 | 5,0 | Pawel Spychala | AAI Infrastructure Rollout and support | |
| 30 | 2021 | IPPLM | TSVV-12 | ASCOT5 | Per | 0,5 | 0,2 | Michal Poradzinski | ASCOT5. Implementation in IMAS framework | |
| 31 | 2021 | IPPLM | TSVV-12 | BEAMS3D | Per | 0,5 | 0,2 | Michal Poradzinski | BEAMS3D. Implementation in IMAS framework | |
| 32 | 2021 | IPPLM | TSVV-07 | BIT1 | Dmitry | 2,5 | 0,2 | Dimitriy Yadykin | code adaptation to IMAS, focusing firstly on IMAS compatible outputs.BIT-1D, BIT-3D | |
| 33 | 2021 | IPPLM | TSVV-03 | DATABASES | Patrick | 6,0 | 2,5 | Daniel Figat | This task is led by VTT ACH. We can help with the Repository and Continuous Integration | |
| 34 | 2021 | IPPLM | TSVV-11 | DATABASES | Clarisse | 3,0 | 1,0 | Dimitriy Yadykin | Initial implementation of multimachine remote data gathering and (for 1D profiles) fitting using | |
| 35 | 2021 | IPPLM | ALL | DEVOPS | Clarisse | 2,4 | 3,0 | Daniel Figat | Aid with setup and maintenance of potential new DevOps platform and documentation. To be | |
| 36 | 2021 | IPPLM | TSVV-09 | DREAM | Eric Nardon | 6,0 | 0,5 | Dimitriy Yadykin | DREAM.Integration into IMAS | |
| 37 | 2021 | IPPLM | TSVV-11 | DYON | Clarisse | 1,2 | 0,0 | Michal Owsiak | Adapt DYON to IMAS and containerise (and adapt from matlab to octave or python) | |
| 38 | 2021 | IPPLM | TSVV-05 | EIRENE | Dmitriy | 0,5 | 0,2 | Dimitriy Yadykin | Integration of code I/O in the IMAS: | |
| 39 | 2021 | IPPLM | TSVV-07 | ERO2.0 | Dmitry | 2,5 | 0,2 | Dimitriy Yadykin | code adaptation to IMAS, focusing firstly on IMAS compatible outputs.ERO2.0 | |
| 40 | 2021 | IPPLM | ALL | ETS | Par Strand | 3,9 | 3,9 | Par Strand | ACH-wokflows/ETS | |
| 41 | 2021 | IPPLM | TSVV-03 | FELTOR | | 1,5 | 0,1 | | | task distributed per code |
| 42 | 2021 | IPPLM | TSVV-03 | GBS | | 1,5 | 0,1 | | | task distributed per code |
| 43 | 2021 | IPPLM | TSVV-02 | GENE | Justin Ball | 0,0 | 0,2 | Michal Poradzinski | Ensure IMAS compatibility of software. All codes (GENE, ORB5, GBS, HYMAGYC, XTOR) | |
| 44 | 2021 | IPPLM | TSVV-03 | GRILLIX | | 1,5 | 0,1 | | | task distributed per code |
| 45 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 3,0 | 3,0 | Bartosz Bosak | Containerise HCD workflow (Docker) | |
| 46 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 1,2 | 2,0 | Piotr Grabowski | Give input into concept design for a generic python GUI - cloud native, web based, data driven | |
| 47 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 1,8 | 1,0 | Barek Palak | Adapt existing HFPS python components from FC2K to Iwrap | |
| 48 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 2,4 | 3,0 | Daniel Figat | Setup common IMAS-python workflow testing framework. Add CI build and run tests for HFPS | |
| 49 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 3,0 | 2,0 | Bartek Palak | Adapt existing Kepler based components to IMAS Python workflows and Iwrap | |
| 50 | 2021 | IPPLM | TSVV-11 | HFPS | Clarisse | 0,6 | 0,0 | Dimitriy Yadykin | Provide SOL models (as in Luda NF2020 for example) parameterisation as a simple IMAS python | |
| 51 | 2021 | IPPLM | ALL | IMAS | Marcin | 8,0 | 8,0 | Marcin Plociennik | IMAS Ecosystem Infrastructure support+maintanance+deployments | |
| 52 | 2021 | IPPLM | TSVV-01 | IMAS | Tobias | 1,0 | 0,2 | Michal Owsiak | IMAS code output support/training | |
| 53 | 2021 | IPPLM | TSVV-10 | IMAS | Oleksiy | 2,0 | 2,0 | Par Strand | Up-to-date IMAS support including ITER/WPCD integrated modeling tools, experimental data | |
| 54 | 2021 | IPPLM | TSVV-11 | IMAS | Clarisse | 1,2 | 1,0 | Tomasz Zok | Design python IMAS workflows for multiple containers, use JINTRAC-HCD as template / proof of | |
| 55 | 2021 | IPPLM | TSVV-11 | IMAS | Clarisse | 1,2 | 1,0 | Bartosz Bosak | Containerise NICE (Docker) | |

# E-TASC General Meeting (Nov 11-15, 2024)

**Plenary Session 1: Research gaps and opportunities in simulation / theory**
- Perspective of the Plasma Science Department (Marco Wischmeier)
- Perspective of the DEMO Central Team (Hartmut Zohm)
- Simulation and Theory in the USA (Michael Halfmoon)
- Simulation and Theory in the UK (Andy Davis)

**Plenary Session 2: Status and plans of the TSVVs**
- Overview talk (Frank Jenko)
- Poster session (TSVV coordinators)

Breakout sessions:
- PSD clarifications
- DEMO clarifications
- UK initiatives
- DMP use cases demo
- ITER clarifications
- Benefits of open science and open source software
- EUROfusion strategy for integrated modelling tools
- Round table discussion for TSVV PIs
- Round table discussion for ACH PIs

Details and registration:

**https://indico.euro-fusion.org/event/3034**

**Plenary Session 3: E-TASC and DSD beyond 2025**
- DSD — present and future (Volker Naulin)
- E-TASC — present and future (Frank Jenko)
- Update on the Data Management Plan (Par Strand)
- Guided discussion: Further development of the TSVV-ACH ecosystem
- ITER-related research gaps (Simon Pinches)
- Guided discussion: Closing research gaps (incl. engineering & materials)

**Plenary Session 4: Code dissemination**
- Existing examples within EUROfusion (various speakers)
- Guided discussion: Building user communities & Practical implementation

**Plenary Session 5: Towards EUROfusion Standard Software**
- Motivation, criteria, progress, and challenges (Frank Jenko)
- Steps forward and the role of ACHs (Mervi Mantsinen)

# Some thoughts on the E-TASC / DSD future

- The ideas presented by Volker Naulin yesterday still **need to be discussed with the E-TASC Scientific Board**.
- New management positions should always be linked to **tangible added value.**
- **E-TASC has been operating very successfully so far**; the hybrid top-down and bottom-up approach is fruitful, and the E-TASC SB is highly agile.
- An **update of the TSVV ecosystem for 2026-27** is warranted, and the continuation of the ACHs is recommended.
- A key task for E-TASC in 2026-27 will be the **dissemination and expanded application of the newly developed simulation tools within the WPs**.