



# **E-TASC / TSVV Task #13**

## **Stellarator Turbulence Simulation**

### **1<sup>st</sup> meeting**

**J. M. García Regaña**



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# Agenda



#	Title of contribution	Related M or D	Speaker
1	TSVV13 status: useful info and updates	-	J. M. García Regaña (CIEMAT)
2	Comment about validation and verification activities	D1.1/D-REF-CASES	
3	Presentation: <i>Upgrade of Gene-3D to an electromagnetic turbulence code</i>	M1.4/M-GENE-3D-EM	F. Wilms (IPP)
4	Discussion	-	All

## **Regular meetings on first Monday of every month at 15:00 (CET)**

*Purpose: share the results obtained along the deliverables and milestones of the project, get feedback from external participants, everyone knows what the others are doing, etc.*

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# Information since our KoM



- **KoM meeting of all TSVV programme** (23rd of April 2021) to discuss **organisational matters**. **E-TASC PB** discuss **resource distribution within ACHs** (2nd of June 2021).
- Clarification of the role of different organizations and stakeholders: TSVVs, ACHs, E-TASC SB, Theory PB and *Thrust* (communication platform among a group of related TSVVs and WPs, on behalf of the entire E-TASC SB).

## Thrust 4: Stellarators

Facilitator: I. Calvo

[WPW7X]

Involving: P. Helander; J. Regana

[TSVV 12, 13]

X. Litaudon

[WPPriO]

L. Villard; F. Jenko

[E-TASC SB]

- A successful scheme for scientific coordination, collaboration and communication within the W7-X Team has been working for years based on **Topical Groups (TG)** and **W7-X Physics Meetings**.

[w7x-tg-turbulence-join@ipp.mpg.de](mailto:w7x-tg-turbulence-join@ipp.mpg.de)

[w7x-tg-impurity-join@ipp.mpg.de](mailto:w7x-tg-impurity-join@ipp.mpg.de)

[w7x-tg-fast-ions-join@ipp.mpg.de](mailto:w7x-tg-fast-ions-join@ipp.mpg.de)

[w7x-tg-mhd-join@ipp.mpg.de](mailto:w7x-tg-mhd-join@ipp.mpg.de)

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[w7x-tg-divertor-join@ipp.mpg.de](mailto:w7x-tg-divertor-join@ipp.mpg.de)

# Timeline and resource modification



- TSVV projects were launched on the 1st of April 2021.
- Apart from the late start, an additional minor budget adjustment have left the final resources for 2021 in 43 PM of the 60 PM requested. For 2022-2025 60 PM/year are foreseen.
- For the TA preparation, **deliverables, milestones and their due dates have been confirmed** by the responsible persons without shifts to later year.
- Regarding the manpower at ACHs, the requested tasks have been adapted to the available resources, considering the priority.

# TSVV#13 and the ACHs



- **30% of the manpower** of the TSVV will be allocated to the ACHs (24 PM/year)
- Specific task request made to ACHs, which have evaluated and adapted to their available resources.

TSVV	Code	Tasks required to ACH	ACH cat.	Preferred ACH	Proposed PMs/ye	Priority	Accepted for 2021	Accepted for 2022	Comment made by ACHs	
TSVV-13	EUTERPE	Development and application of tools for advanced visualization of 3D data resulting from global simulations will	Cat I. (HPC)	EPFL		2 Medium	0	3		
TSVV-13	EUTERPE	As in the case of GENE-3D, implementing a massively parallel geometrical multigrid solver and	Cat I. (HPC)	MPG		5 High	0	6	An algebraic MG solver should be tested first	
TSVV-13	EUTERPE	Support for the usage of high compression formats to speed up the transfer of large amounts of data.	Cat III. (DB)	VTT		1 Low	0	1	An algebraic MG solver should be tested first	
TSVV-13	GENE-3D	We propose the following projects: i) Improve the performance and scalability of the code.	Cat I. (HPC)	MPG		8 High	0	6		
TSVV-13	stella	Although preliminary checks of the code stella show good scalability with the number of processors, for current	Cat I. (HPC)	CIEMAT		5 High	4	12		
TSVV-13	stella	stella's implicit treatment of parallel streaming is made possible by a Green's function approach that requires	Cat I. (HPC)	CIEMAT		2 High				
TSVV-13	stella	In order to prevent the introduction of bugs in new versions, implementing a target in the makefile that allowed to	Cat I. (HPC)	CIEMAT		1 Medium				
<b>24</b>								<b>4</b>	<b>28</b>	

# Pinboard clearance



- The **clearance procedure** ⇒ uploading the document to the electronic pinboard at least **2 weeks** prior the deadline for **non-refereed** conference paper or abstract, **3 weeks** for refereed ones:

<https://users.euro-fusion.org/webapps/pinboard/EFDA-JET/index.jsp>

Areas of work (for clearance purposes)

Associate Leader	*	EUROfusion Programme Manager (T.Donne)	▾
Workpackages	*	1.FSD-WPW7X (A.Dinklage)	▾ Primary (workpackage which clearance is being requested from)
		3.TSVV/CIEMAT-01 (J.Regana)	▾ Secondary
			▾ Tertiary

- Please, upload the documents related to the TSVV activities indicating **WPW7X primary** an **TSVV/CIEMAT-01 as secondary**.

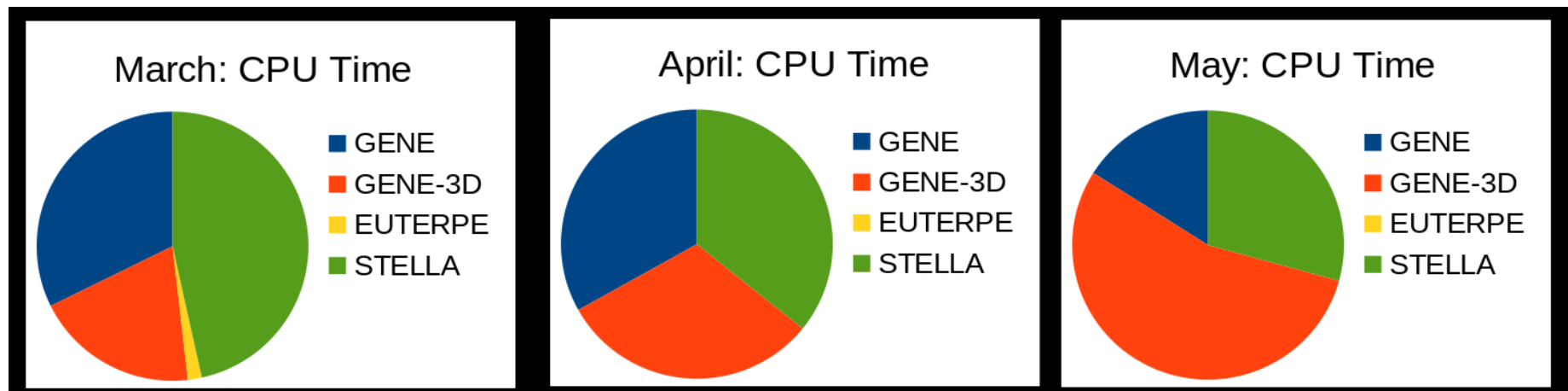
# HPC resources



- TSVV got all the CPU time requested of ~60 Mhrs above the limit established by the CfP for a single project.
- **The usage of the TSVV/Marconi: 25.7 % spent already!!**

Work space      **`/marconi_work/FUA35_STELTURB/`**

Scratch space   **`/marconi_scratch/userexternal/`**



Courtesy of H. Thienpondt



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# Deliverables in 2021



Deliverable ID / Short name	Key deliverable(s)	Due date
D1.1 / D-REF-CASES	1, 3, 4	March 2021
<b>Motivation:</b> The stellarator gyrokinetic community lacks a reference case, similar to the Cyclone Base Case (CBC) in tokamaks (...) Tokamak equilibria with broken axisymmetry will also be considered.		
<b>SMART deliverable:</b> agreed W7-X reference case and set of representative OP2 operation scenarios for comparisons, benchmark activities and OP2 predictive modelling tasks (...) a natural step will be that other codes with extended capabilities (e.g. <i>spatial domain beyond flux-tube, collisions, etc.</i> ) expand the set of simulations for that reference case. (T) Due date: March 2021		
D1.2 / D-TURB-ZTRANSP	3, 4	Dec. 2021
<b>Motivation:</b> Due to the larger mass and charge of impurities (...) natural question about the effect of collisions on the turbulent transport of impurities.		
<b>SMART deliverable:</b> (S) Study of the effect of collisions on the background turbulence and impurity transport in multispecies electrostatic flux tube simulations (...) MB*, A. v. Boetticher (AvB, U. Oxford, PhD project), FP and JGR. (...) Due date: Dec. 2021.		

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<b>SMART deliverable:</b> <b>agreed W7-X reference case</b> and set of <b>representative OP2 operation scenarios</b> for <b>comparisons, benchmark activities</b> and OP2 predictive modelling tasks (...) a natural step will be that other codes with extended capabilities (e.g. <b>spatial domain beyond flux-tube, collisions, etc.</b> ) expand the set of simulations for that reference case. (T) Due date: March 2021		
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# W7-X reference case



Under consideration for publication in *J. Plasma Phys.*

1

- A set of test cases has been considered for a comparison of the flux tube versions of GENE and stella.
- Chosen configuration: W7-X high mirror (KJM) configuration, with  $\langle\beta\rangle=3\%$ , fixed boundary VMEC equilibrium.
- Manuscript to be submitted to JPP.
- To be presented by A. González-Jerez on 5th of July TSVV#13 regular meeting.

## A reference case for gyrokinetic simulations in Wendelstein 7-X geometry: comparison between the codes stella and GENE

A. González-Jerez<sup>1†</sup>, P. Xanthopoulos<sup>2</sup>, J. M. García-Regaña<sup>1</sup>, J. Alcusón<sup>2</sup>, A. Bañón-Navarro<sup>3</sup>, I. Calvo<sup>1</sup>, M. Barnes<sup>4</sup>, F. I. Parra<sup>4</sup> and J. Geiger<sup>2</sup>

	Flux tube	$[N_\theta^m, N_\theta^M]$	$a/L_{Ti}$	$a/L_{ni}$	$N_z$	$N_{v\parallel}$	$N_\mu$	$N_{\mathbf{k},j}$	$\Delta tv_{th,i}/a$	Compared
Test 1.	bean	[1, 6]	3	1	256	36	24	Off	stella 0.15 GENE 0.14	$\gamma(k_x), \omega(k_x)$ $\gamma(k_y), \omega(k_y)$
Test 2.	triangular	[4, 6]	3	1	512	36	24	Off	stella 0.15 GENE 0.14	$\gamma(k_x), \omega(k_x)$
Test 3.	bean	[2, 8]	0	3	512	36	24	Off	stella 0.04 GENE 0.004	$\gamma(k_y), \omega(k_y)$ $ \hat{\varphi}_{\mathbf{k}} (z)$
Test 4.	bean	[4, 4]	0	0	512	256	32	Off	stella 0.15 GENE 0.1	$\langle \text{Re}(\hat{\varphi}_{\mathbf{k}}) \rangle_z(t)$
Test 5.	bean <sup>††</sup>	[1, 1]	3	1	128	60	24	On	stella 0.09 GENE 0.09	$\sum_{k_y} Q_i(t)$ $Q_i(k_x, k_y)$ $\sum_{k_x} Q_i(k_x, k_y)$

# Comparisons *beyond flux tube*



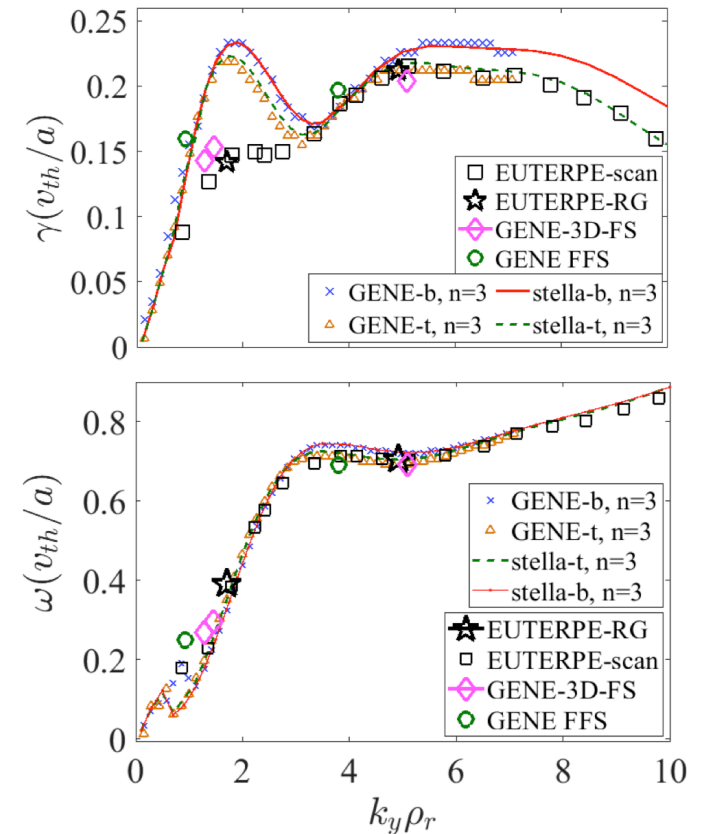
Gyrokinetic simulations in stellarators using different computational domains

E. Sánchez<sup>1</sup>, J. M. García-Regaña<sup>1</sup>, A. Bañón Navarro<sup>2</sup>, J. H. E. Proll<sup>3</sup>, C. Mora Moreno<sup>3</sup>, A. González-Jerez<sup>1</sup>, I. Calvo<sup>1</sup>, R. Kleiber<sup>4</sup>, J. Riemann<sup>4</sup>, J. Smoniewski<sup>5</sup>, M. Barnes<sup>6</sup>, F. I. Parra<sup>6</sup>

Comparisons between GENE-3D, EUTERPE, stella and GENE, performed for that same KJM configuration as well as for LHD.

Linear electrostatic simulations .

[https://users.euro-fusion.org/repository/pinboard/EFDA-JET/conference/90821\\_sanchez\\_iaea2020\\_nucfus\\_20210519.pdf](https://users.euro-fusion.org/repository/pinboard/EFDA-JET/conference/90821_sanchez_iaea2020_nucfus_20210519.pdf)

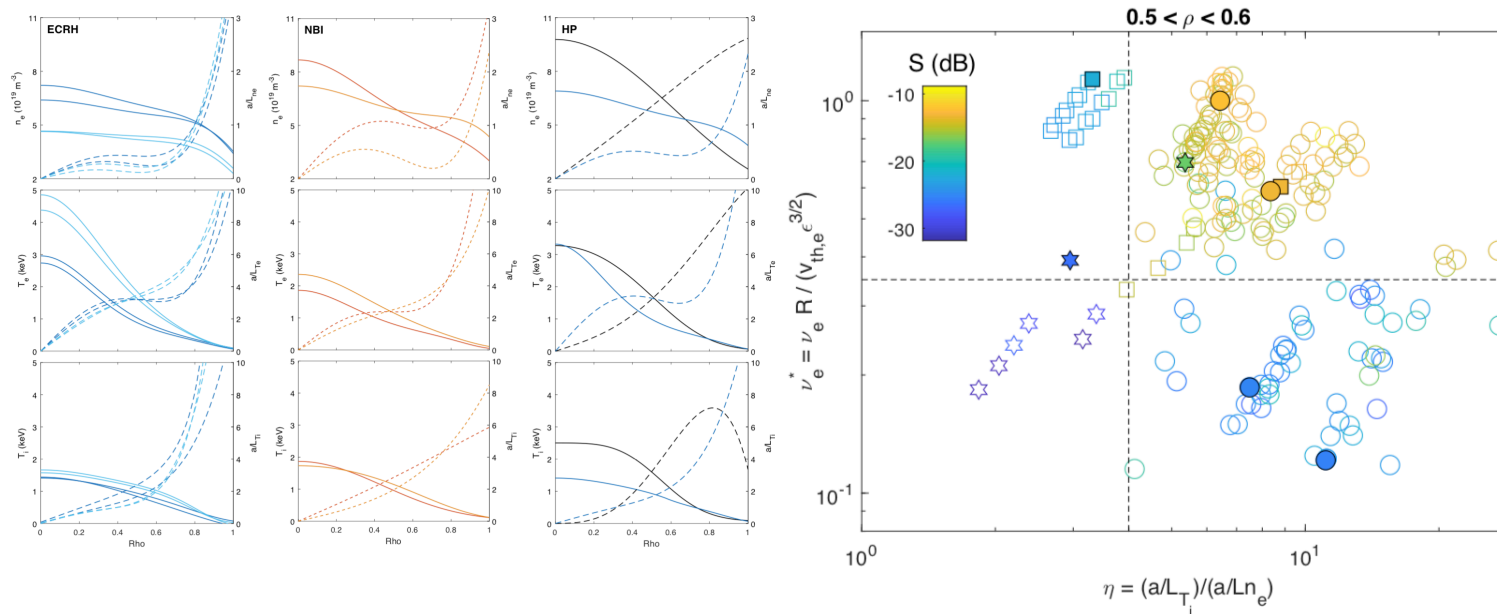


**Figure 11.** Comparison of growth rate  $\gamma$  (top) and frequency  $\omega$  (bottom) vs normalized wavenumber  $k_y \rho_r$  for FT, FFS and RG simulations in the KJM configuration of W7-X with  $\beta=3\%$  at  $r/a = 0.5$ .

# Representative W7-X scenarios



- *D. Carralero et al. An experimental characterization of core turbulence regimes in W7-X. Submitted to Nucl. Fusion: <https://arxiv.org/pdf/2105.05107.pdf>*



- Clasification of main scenarios during OP1\* campaigns, dependence of fluctuations measured with Doppler Reflectometry on driving gradients, identification of thresholds in  $\eta_i$ ,  $v_e$ , etc.
- Power balance analyses ongoing, to be presented on **Physics Meeting on 9th of June at 15:00.**

# Milestones in 2021



Miles-tone ID	Short name	Brief description	Participants	Due date
M1.1	M-STELLA-COLL	Implementation of the full linearized collision operator in stella.	MB*, FP	Jul. 21
M1.2	M-BENCHMARK-ES-GLOB	Benchmark between GENE-3D and EUTERPE for electrostatic turbulence with adiabatic electrons.	ES*, ABN, JR, JGR	<b>Jul. 21 → Dec. 21</b>
M1.3	M-STELLA-FFS	Development of a full-flux-surface (FFS) version of stella.	MB*, FP	Dec. 21
M1.4	M-GENE-3D-EM	Development of an electromagnetic version of GENE-3D and implementation of methods that allow to use larger time steps in GENE-3D simulations.	ABN*	Dec. 21

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# Backup slides



# TSVV-13 logistics and useful info



- A wiki, whose maintenance and update is responsibility of the PI, has been set up:

<https://wiki.euro-fusion.org/wiki/TSVV-13>

- Indico repository for presentations:

<https://indico.euro-fusion.org/category/286/>

- To login the two sites, the credentials are those of your EUROfusion IMS account, which is also used for mission application

<https://ims.euro-fusion.org/>