TSVV4 updates for Thrust-1

D. Told, TSVV4 Team

Thrust 1 meeting
June 06, 2024

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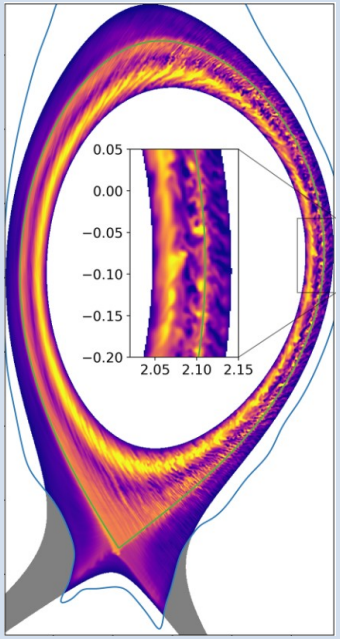
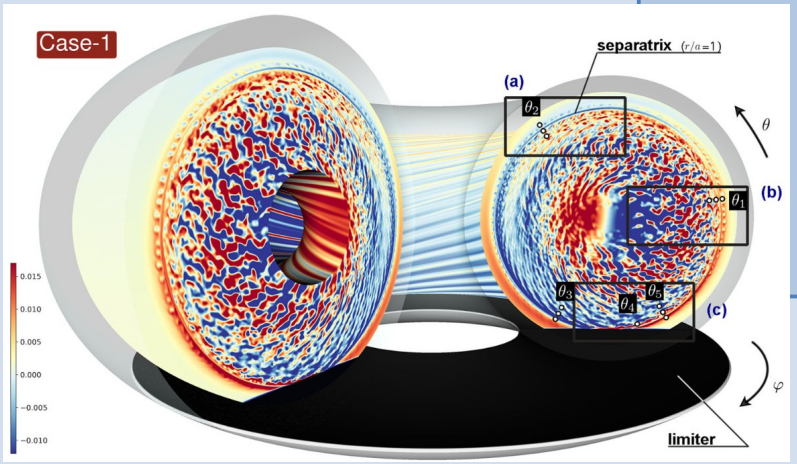
Setup of TSVV Task 4

Key deliverables	Our work
Kinetic codes for the plasma edge ▸ TSVV T1	GENE-X PICLS GyselaX
Deal with open field lines	BIT1 VOICE semi-analytical methods
Limitations of Gyrokinetics	ssV GempicX / BSL6D Moment-based edge GK
Coupling methods	Neutrals Impurities Fluid-kinetic coupling

Aim: GK codes for Edge + SOL

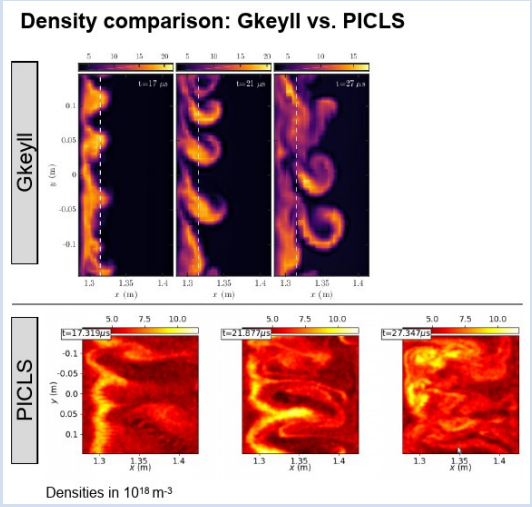


GENE-X /
D. Michels et al.,
Phys. Plasmas 2022



GyselaX /
G. Dif-Pradalier et al.,
Commun. Phys. 2022

PICLS /
A. Bottino
2021



Progress on “to dos” from midterms: GyselaX

GyselaX

2D field solver for arbitrary geometry + nonlinear Poisson equation

Translate VOICE boundary to Gysela

Neutrals / Impurities

GENE-X

Generalize to 3D geometry

Neutrals

Impurities

Improved sheath boundary conditions

Improved gyrokinetics

$B_{\parallel}$ electromagnetics

PICLS

Electromagnetics, improved edge GK

Coupling to neutrals + impurities

Coupling with core codes for limiter simulations, crossing separatrix

Improved sheath boundary conditions

Geometry improvements

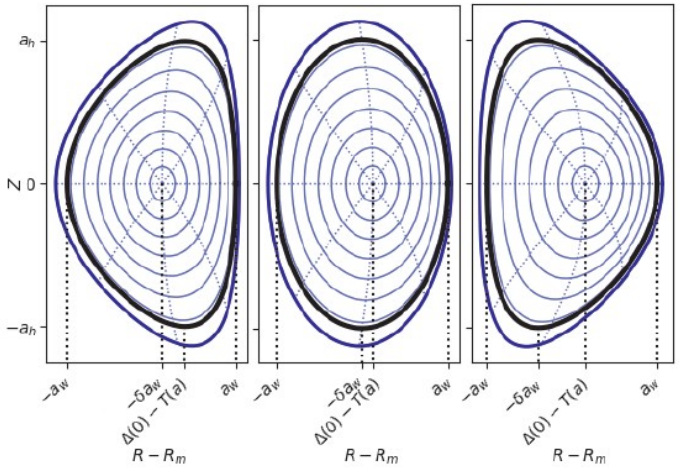
= as defined by milestones

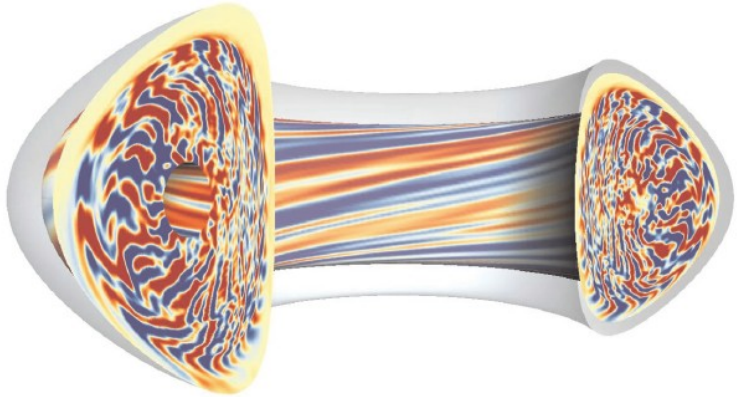
Elongation & triangularity studied with Gysela

- Non-circular 'Culham equilibria' implemented [Donnel & Obrejan '23]

Special focus on negative triangularity plasmas

- analytic model: TEM growth revisited → shows importance of **finite orbit widths** & **ballooning mode structure** [Garbet IAEA '23 & NF submitted]
- ongoing confrontation to GYSELA in turbulent regime [deGianni, PhD]





ITG & TEMs in TCV configuration

Progress on “to dos” from midterms: GENE-X

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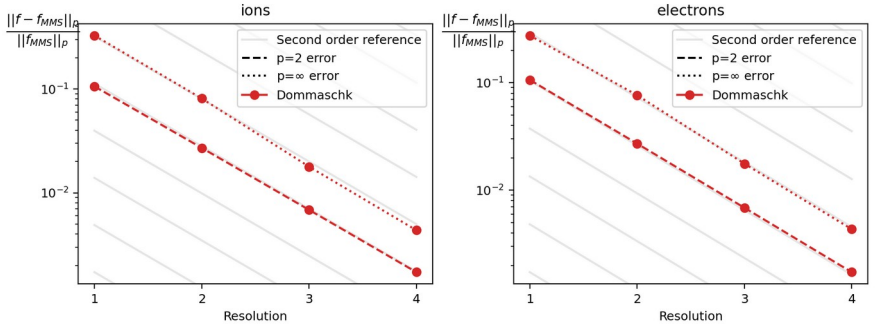
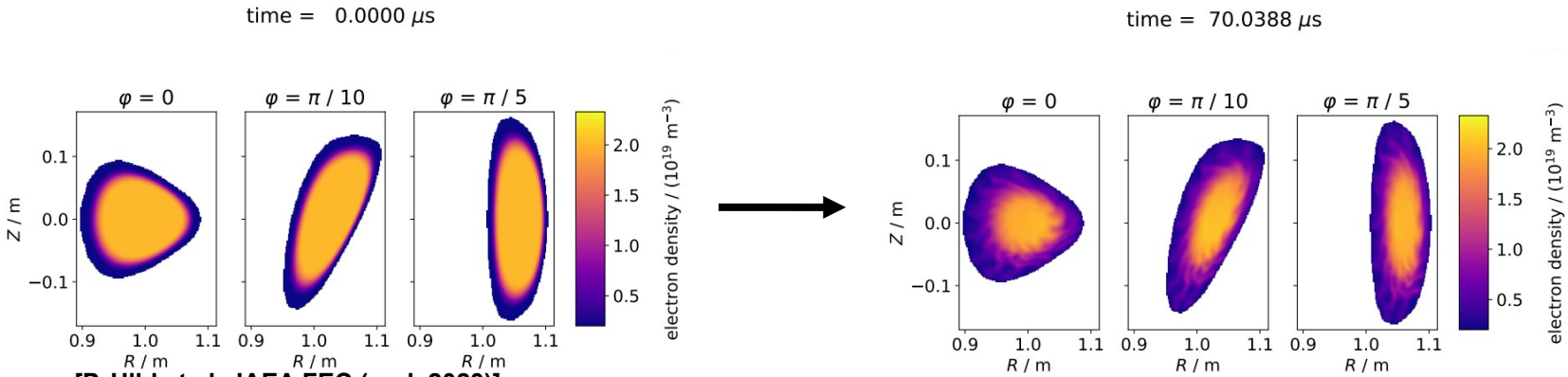
Progress on 3D upgrade for GENE-X

Extension of GENE-X to stellarators was verified using MMS and first proof-of-principle turbulence simulations have been performed

- L2 and Linf error of ion/electron distributions and EM fields converge with 2nd order in Dommaschk geometry
- Next steps: W7-AS or down-sized W7-X simulations. Possibly validation.





[P. Ulbl et al., IAEA FEC (oral, 2023)]

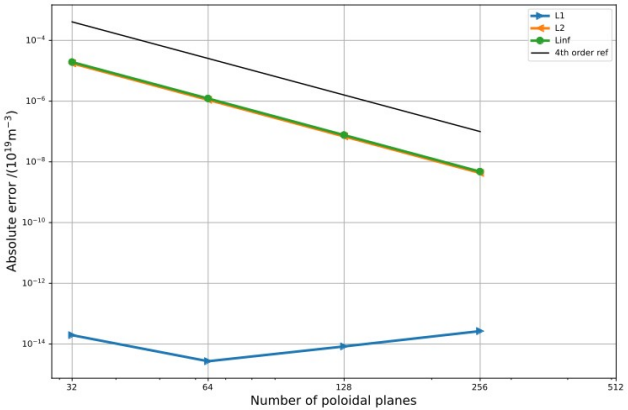
[M. Smedberg]

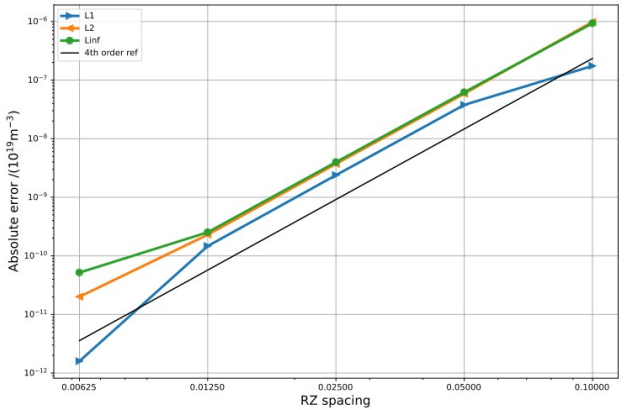
Progress on neutral gas model for GENE-X

First neutral-gas 1-moment fluid evolution model has been added and verified in GENE-X

- Considers evolution of neutrals density. Momentum and temperature are kept the same as for the ions.
- Implementation with 4th order CD. Convergence with grid spacing and number of poloidal planes has been verified.
- Next steps: Coupling fluid neutrals to GK. Adding reaction coefficients. First blob studies.

$$\partial_t n_\sigma = \nabla \cdot \frac{D_\sigma}{T_\sigma} \nabla (n_\sigma T_\sigma) + \mathcal{S}_\sigma^n = \nabla \cdot D_\sigma \nabla n_\sigma + \nabla \cdot D_\sigma n_\sigma \nabla \ln(T_\sigma) + \mathcal{S}_\sigma^n$$



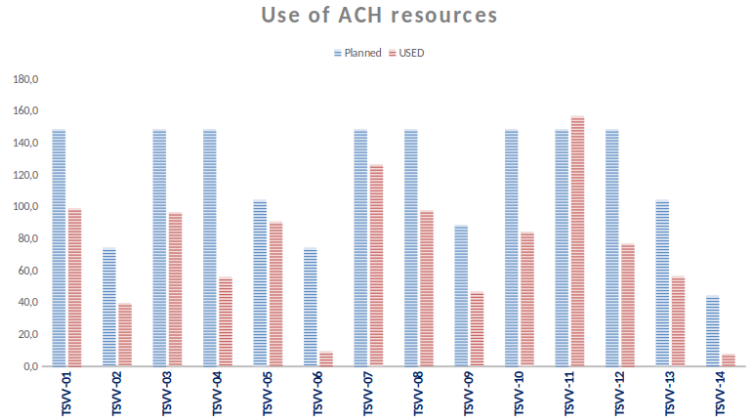


[S. Ogier-Collin]

ACH discussion

- Some caveats
- Up to 2024, TSVV-4 has seen under-allocation of ACH projects (22pm excl. 2024)

Main users of ACH projects in TSVV-4:
GENE-X and GyselaX
(in 2024: new projects for BIT1, GempicX, PICLS)



- Overall, satisfaction rate with outcomes of ACH projects was mostly high.
- In some cases, projects experienced lack of / declining communication
- Sometimes allocated project length was insufficient to get beyond startup phase
- Some team members noted lack of transparency / a central resource regarding available ACH capabilities and resources

Conclusions

Progress on some outstanding milestones:

- **Gysela:** Implemented **arbitrary geometry** on closed flux surfaces
  Studies on elongation and triangularity underway
- **GENE-X:**
  3d extensions maturing; first proof-of-principle stellarator turbulence runs have been performed
  Neutral gas model implemented

Overall, TSVV-4 codes have made good experiences with ACH projects and benefitted from them.