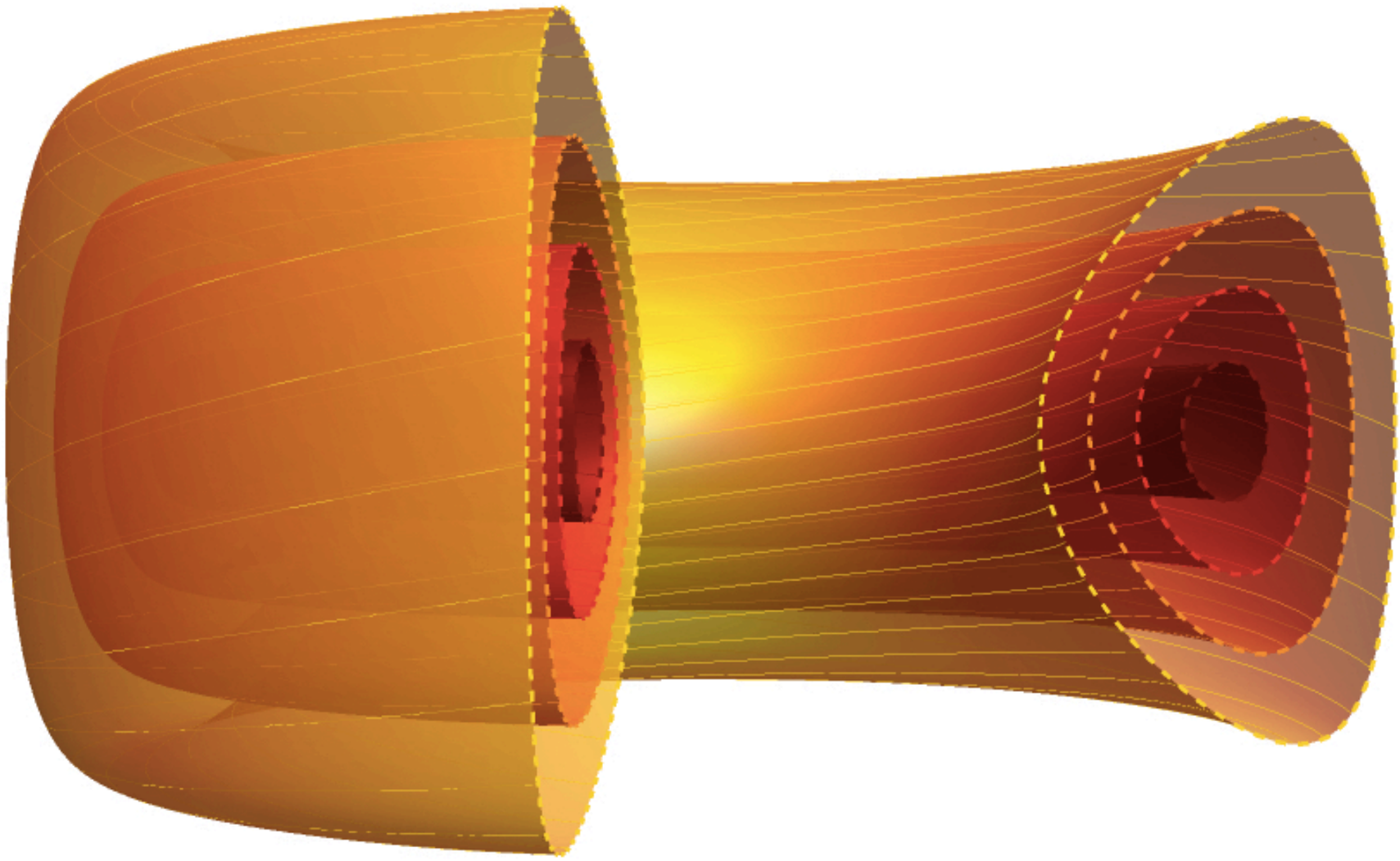
TSVV 2: Negative triangularity and plasma shaping



Justin Ball and the TSVV 2 team

1st Thrust #5 Meeting

7 October 2021

Summary

- TSVV 2 is on schedule and we anticipate all 2021 milestones will be achieved
- Affected little by the late start of the ACHs and no unexpected ACH needs have arisen
- Obtained sufficient computational resources for the planned work (particularly important for turbulence analysis)
- Planned activities and scheduling for 2022 still looks good

The team

CEA	H. Luetjens
DIFFER	M. Pueschel, J. Citrin
ENEA	G. Fogaccia, P. Innocente, P. Mantica, A. Mariani, G. Vlad
EPFL	J. Ball, P. Donnel, M. Giacomin, A. Merle, O. Sauter, M. Vallar, P. Ricci

- Two personnel changes
  - M. Giacomin is graduating and will be replaced by K. Lim (Nov. 1st)
  - P. Donnel relocated and was replaced by G. Di Giannatale (Sept. 1st)

Meetings (see indico)

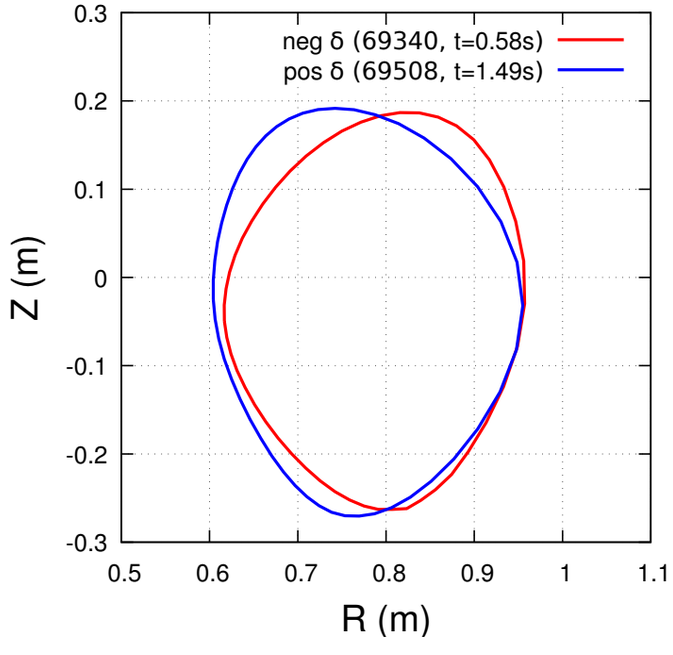
- Monthly whole team meetings during the 4th week of each month
- Three monthly topical group meetings during the 2nd week of each month
  - Core turbulence, SOL turbulence, and MHD+fast particles
  - Informal and flexible
- Links with WPTE RT07 experimental project on negative triangularity have been established in the form of monthly shared topical group meetings

Experimental equilibria have been established

Milestone	Description	Participants	Target date
M3.1	Establish initial magnetic equilibria and plasma profiles (a set based on existing experiment and a set based on DEMO) to be shared amongst the team	O. Sauter	4.2021
M1.1.1	Use local electrostatic GK simulations to assess magnetic equilibria and plasma profiles for consistency with design objectives	J. Ball	5.2021
M2.1.1	Use KINX calculations to assess magnetic equilibria and plasma profiles for consistency with design objectives	A. Merle	9.2021

- TCV shots have been performed in order to hold particular quantities (e.g. P_{heat}, $\langle n_e \rangle$, β_N) fixed between positive and negative triangularity

- 12 equilibria have been established and distributed to the team (and the wider community)



Comp. Num.	Description	Constants of comparison	Discharge	Time (sec)	elong	delta
1	Diverted, PT	q95, betaN	69515	1.02	1.43	+0.29
1	Diverted, NT	q95, betaN	69340	0.58	1.42	-0.28
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2	Diverted, NT	q95, ne, Pheat	69271	1.60	1.42	-0.27
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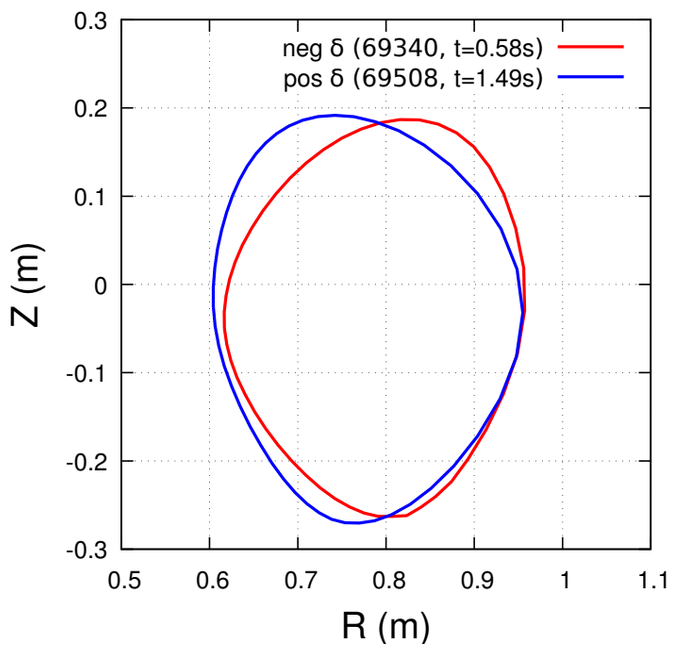
- We were thinking of holding things like turbulent amplitude or “distance” from disruptive limits constant, but did not due to experimental constraints



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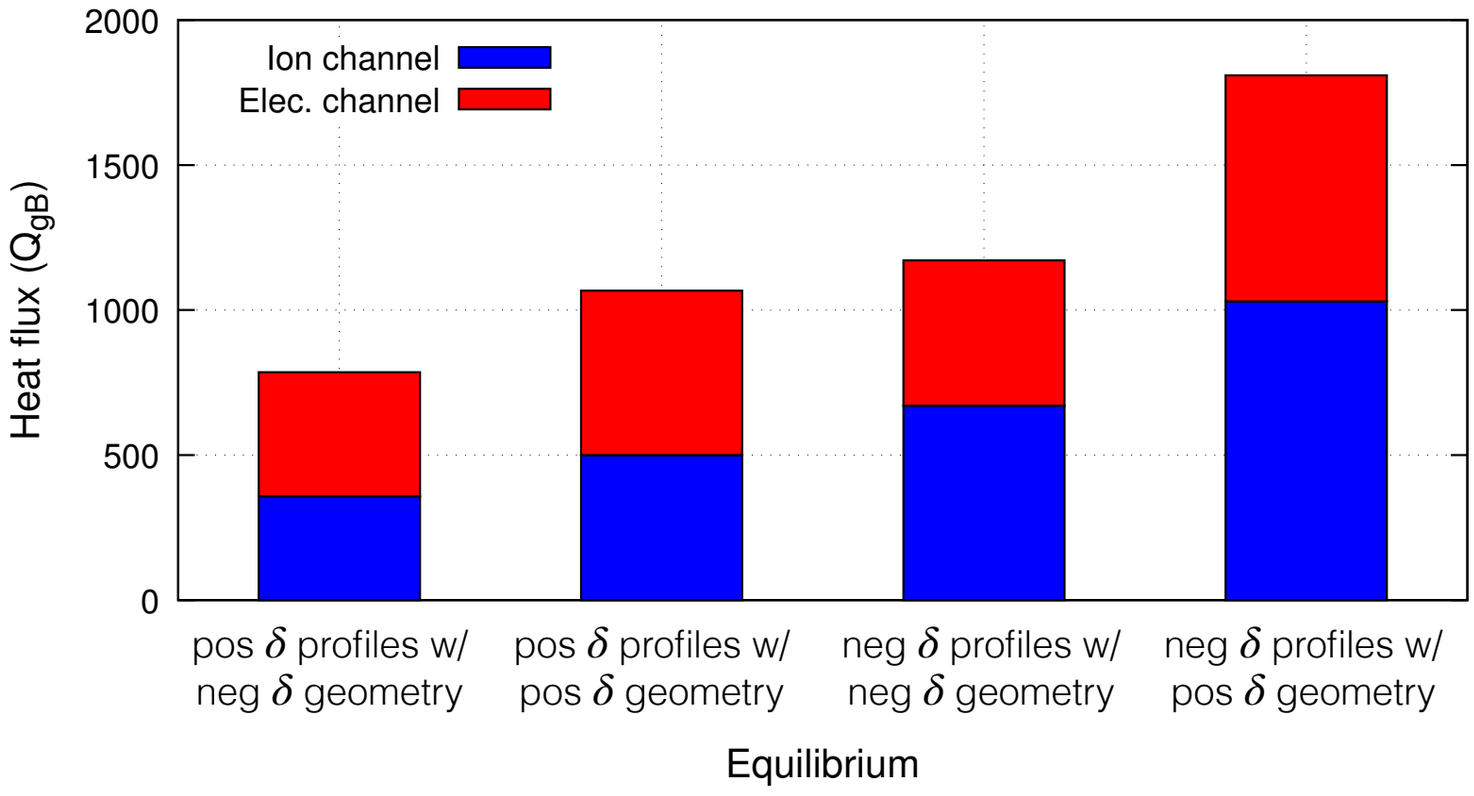
Core turbulence study well underway

[1] G. Merlo, et al. *PPCF* (2015).

Milestone	Description	Participants	Target date
M1.1.2	Perform local electrostatic GK simulations of PT and NT equilibria and swap individual geometric coefficients and plasma parameters to identify the dominate terms	J. Ball	11.2021
M1.1.3	Perform comprehensive study of critical gradient and stiffness as a function of minor radius using local GK simulations	J. Ball	3.2022

- Gyrokinetic simulations of TCV discharges display the expected trends

- Proving difficult to get quantitative agreement with TCV heat fluxes



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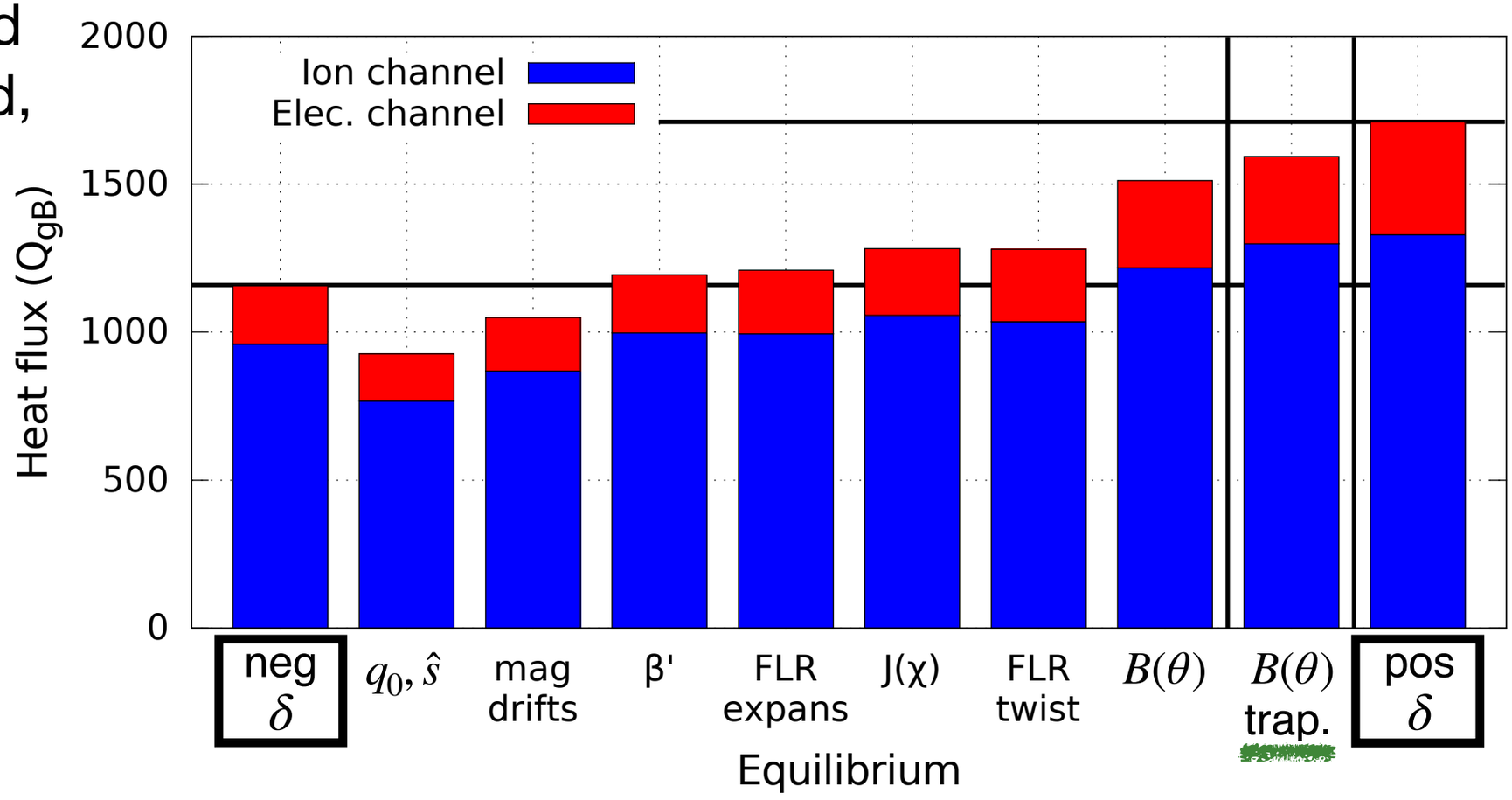
- EU DEMO inspired equilibria analyzed, with interesting results to be confirmed using DIII-D or TCV equilibria

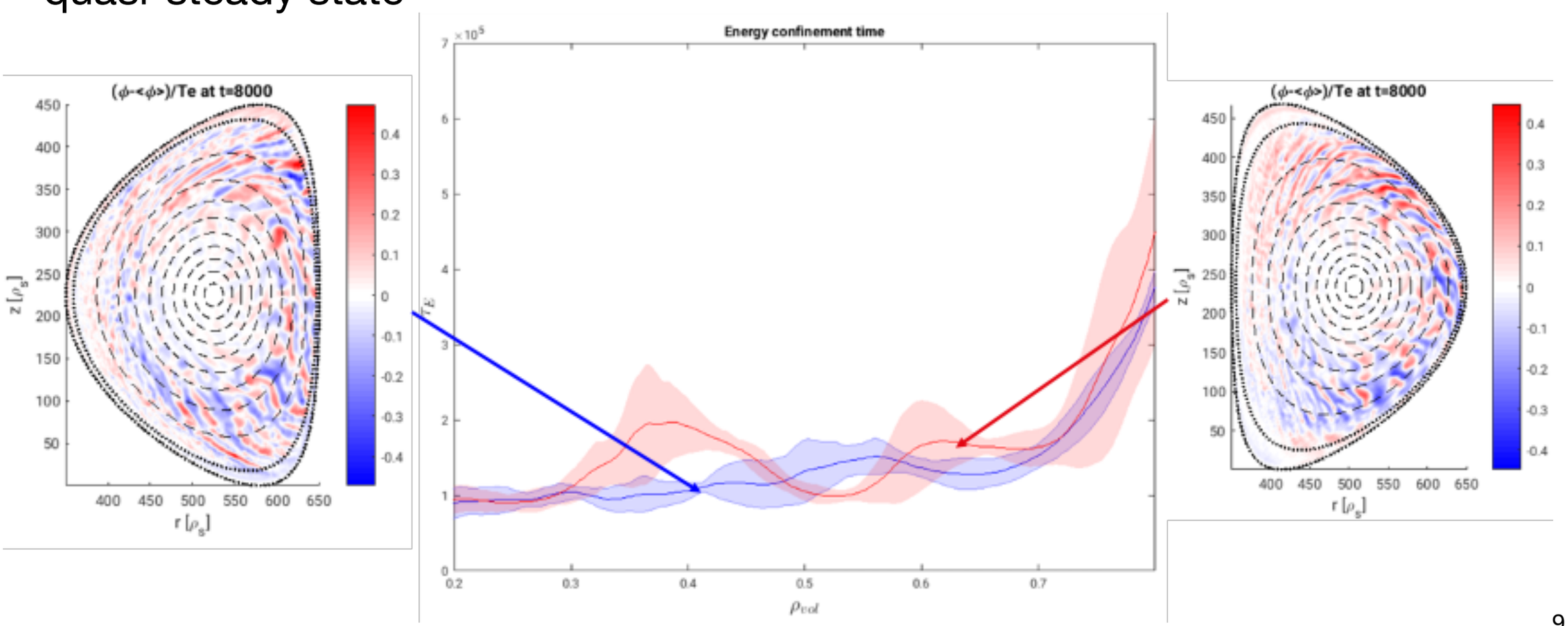
- Little effect on stiffness [1]



Core turbulence study well underway

- Simulations with hybrid electrons and collisions have been performed, but only for decaying turbulence

- The same simulations with an ECRH source are on-going and should enable quasi-steady state



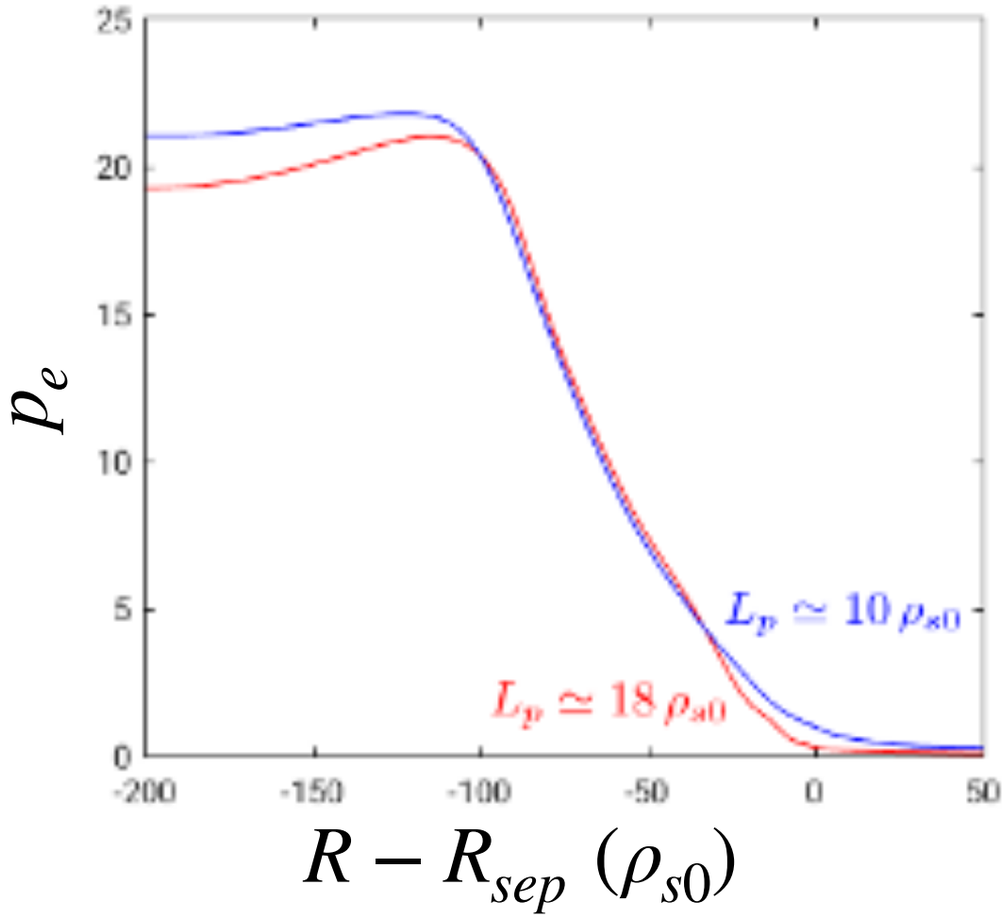
SOL turbulence study already has solid results

Milestone	Description	Participants	Target date
M1.3.1	Perform GBS simulations to understand the effect of plasma triangularity on single-null configurations with no neutrals	M. Giacomin	3.2022

- The drift-reduced Braginskii model of GBS indicates positive and negative δ have a similar SOL

$\delta = -0.3$

$\delta = +0.3$



MHD stability study still in preparation

Milestone	Description	Participants	Target date
M2.2.1	Use HYMAGYC to investigate kinetic corrections to MHD	G. Fogaccia	3.2022
M2.3.1	Influence of NT on the stability limits of tearing modes and NTMs with XTOR-K	H. Luetjens	3.2022

- Significant technical updates performed for XTOR-K throughout summer

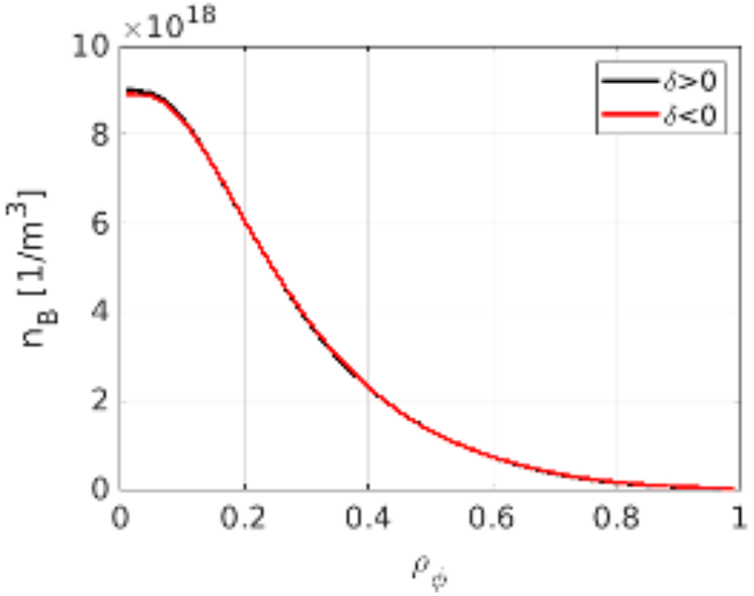
- Benchmark planned between HYMAGYC and XTOR for tearing modes

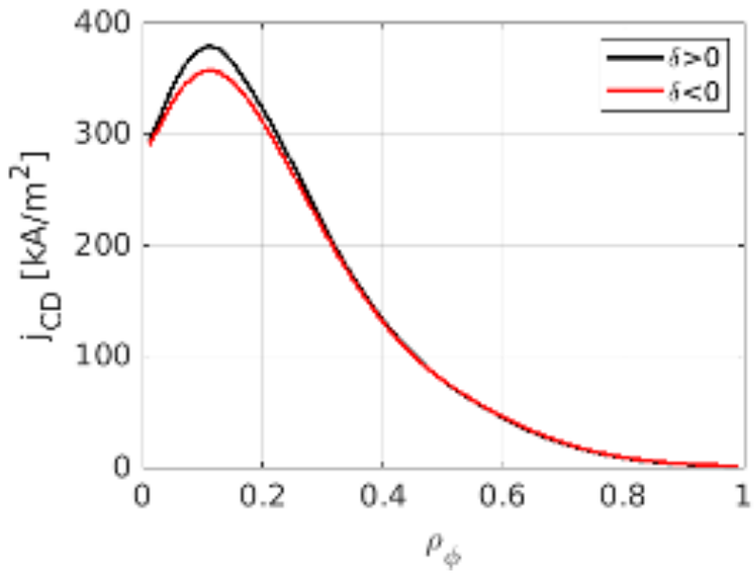
- Both codes have successfully used TCV equilibria as input

Fast ion modeling is on-schedule

Milestone	Description	Participants	Target date
M5.1.1	Model fast ion transport using ASCOT and TRANSP/NUBEAM	M. Vallar	9.2021
M5.1.2	Model energetic particle-driven modes using LIGKA	M. Vallar	3.2022

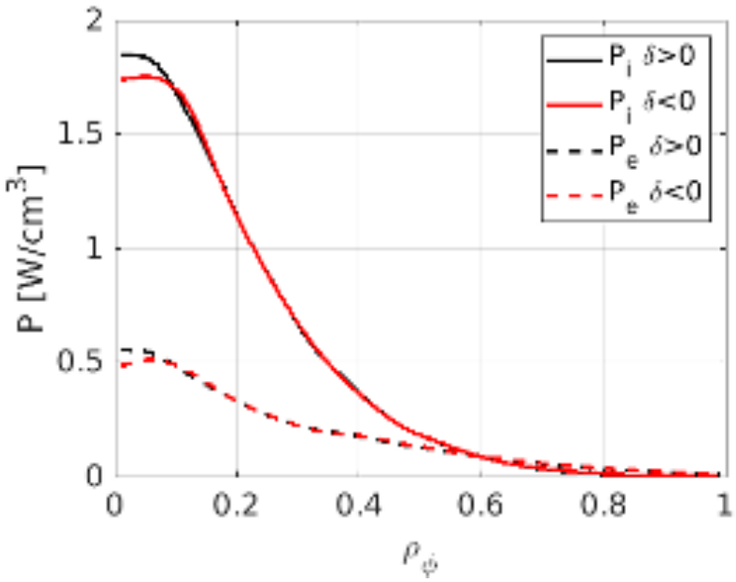
- Using ASCOT and TRANSP, the slowing down of fast ions from the neutral beam in TCV has been modeled





- Found that the magnetic geometry in isolation has little impact on the fast ion density, current deposition, and power deposition profiles

- Differences in fast ions are expected to be due to differences in the background plasma profiles



Reduced modeling already has solid results

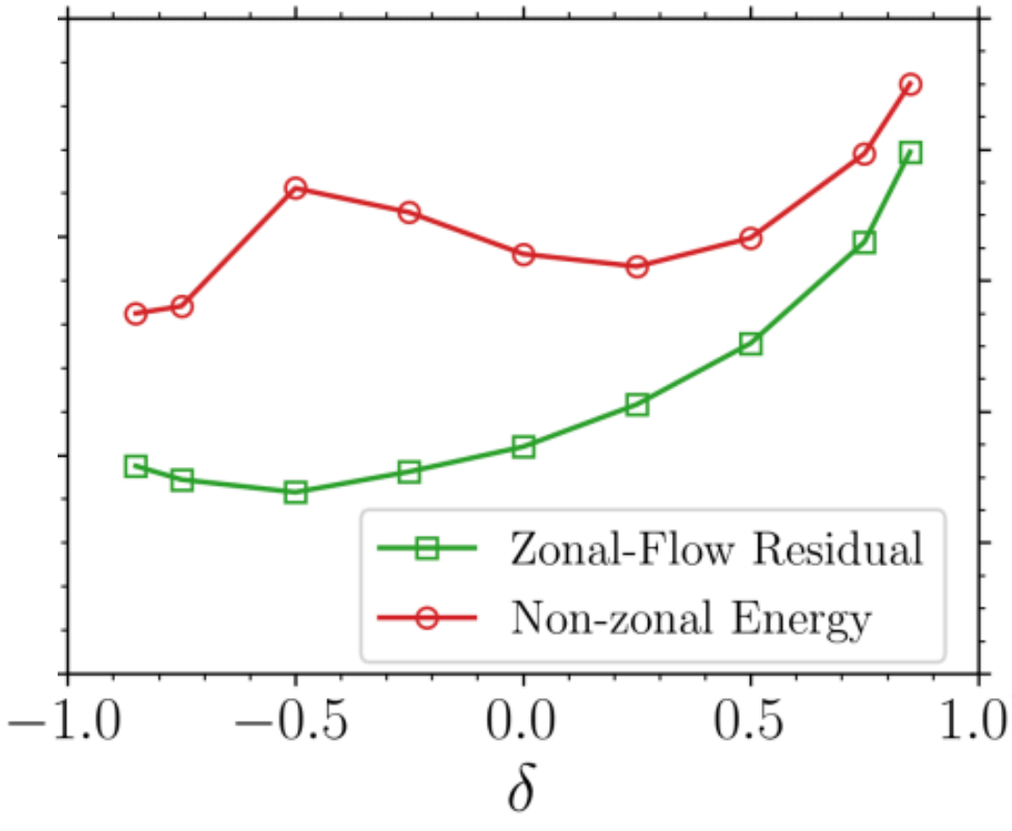
J.M. Duff, et al. *Phys. Plasmas* (submitted).

Milestone	Description	Participants	Target date
M6.1	Detailed verification of TGLF SAT1 vs GK simulations and optimization of TGLF settings for standard DTT NT case and extreme NT DTT case	A. Mariani	3.2022
M6.2.1	Conduct encompassing linear and nonlinear gyrokinetic GENE flux-tube studies of PT and NT scenarios, specifically looking at saturation physics and nonlinear coupling, with a special focus on experimental cases	M. Pueschel	3.2022

- A paper has been submitted on a gyrokinetic study of zonal flow saturation in view of developing reduced models for negative triangularity

- Used proxies for zonal flow damping and drive to argue negative δ makes more efficient use of zonal flows for saturation

- TGLF work waiting on a Masters student



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All done.

TCV experimental equilibria

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1	Diverted, PT	q95, betaN	69515	1.02	1.43	+0.29	0.97	636	3.17	242	4.0	not great q95 match
1	Diverted, NT	q95, betaN	69340	0.58	1.42	-0.28	0.97	362	2.94	218	3.3	with Langmuir probes
2	Diverted, PT	q95, ne, Pheat	69515	1.02	1.43	+0.29	0.97	636	3.17	242	4.0	not great q95 match
2	Diverted, NT	q95, ne, Pheat	69271	1.60	1.42	-0.27	1.59	612	2.90	217	4.4	-
3	Diverted, PT	Ip, betaN, ne	69508	1.49	1.43	+0.28	1.12	735	3.31	217	4.0	-
3	Diverted, NT	Ip, betaN, ne	69340	0.58	1.42	-0.28	0.97	362	2.94	218	3.3	with Langmuir probes
4	Limited, PT	Ip, betaN, ne	69511	1.50	1.34	+0.35	1.25	1030	3.38	228	3.4	-
4	Limited, NT	Ip, betaN, ne	69273	0.85	1.29	-0.29	1.30	475	2.85	228	3.4	-
5	Limited, PT	Ip, Pheat	69511	1.50	1.34	+0.35	1.25	1030	3.38	228	3.4	-
5	Limited, NT	Ip, Pheat	69273	1.70	1.26	-0.26	2.02	1020	2.79	226	4.6	-
-	Diverted, PT	-	69515	1.58	1.43	+0.34	1.84	1020	3.29	239	7.1	in H-mode; no CXRS so Ti=Te
-	Diverted, NT	-	69340	1.60	1.40	-0.27			2.92	217	5.4	with Langmuir probes

ACH support

- Made four requests for support, but only ORB5 multi-threading (joint with TSVV 1 and TSVV 10) and IMAS compatibility were accepted

- ORB5 request is being led by Thomas Hayward-Schneider in TSVV 10

- IMAS compatibility is led by TSVVs 1 (GENE), 3 (GBS), 6 (SOLEDGE), 10 (ORB5, XTOR, HYMAGYC, LIGKA), 12 (ASCOT) as these TSVVs include more significant code development