



Recent optimization and Gyrokinetic simulation of JET D-T plasma in TRIMEG code

IPP

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EUROfusion



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Optimization of TRIMEG-GKX electromagnetic version



2 major optimizations

- Speedup 2.65 ×
- Speedup 1.65 ×
- Using TRIMEG-GKX
[JCP, 440 110384 (2021);
PPCF 65 034004 (2023);
CPC 320 109959 (2026)]

perf: batch G2P + cubspline, 1.65× speedup (JET 4-species)

!7 · created 1 day ago by Guo Meng 80% develop clean up performance

perf: 2.65x particle push speedup via B-spline fast paths (iequmodel=1)

!6 · created 2 weeks ago by Guo Meng 80% develop performance

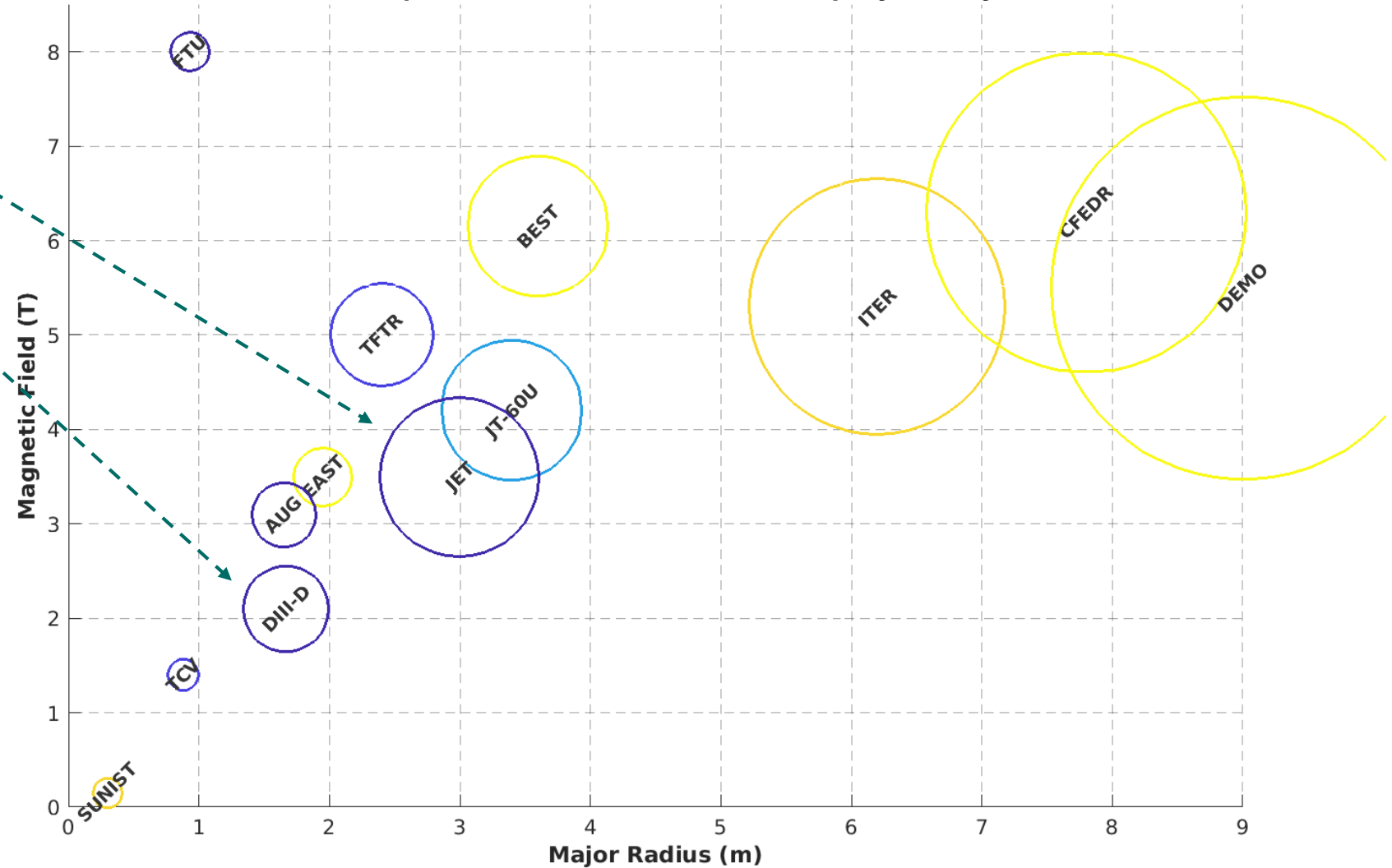
<pre>=====Timer info===== pt init 4.68380000000016E-002 s push+g2p 374.558105999999 s pt p2g 71.4169300000005 s pt Record 4.96114500000010 s ptpullback 10.1041339999997 s ---Record to Data_Particle2.txt--- =====Timer info===== pt init 3.880300000000059E-002 s push+g2p 19.6172910000004 s pt p2g 11.2502519999986 s pt Record 0.118271000000519 s ptpullback 0.829262000000224 s ---Record to Data_Particle3.txt--- =====Timer info===== pt init 4.232999999999976E-002 s push+g2p 19.9353329999988 s pt p2g 11.2104460000013 s pt Record 0.157098999999789 s ptpullback 0.826994000000344 s ---Record to Data_Particle4.txt--- =====Timer info===== pt init 3.891100000000058E-002 s push+g2p 18.5235579999992 s pt p2g 11.1830000000008 s pt Record 0.185062999999722 s ptpullback 0.822772999999859 s =====Timer info===== fd init 2.81139900000000 s fd solve 13.4275790000001 s fd g2p 169.483928999997 s fd Record 0.167511999999988 s ---cputime: 658.4 s (10.97 mins) =====finalize PETSC&MPI===== =====Test GKEM Ends=====</pre>	<pre>=====Timer info===== pt init 4.465499999999967E-002 s push+g2p 77.9984759999997 s pt p2g 22.4465249999998 s pt Record 1.34945200000014 s ptpullback 2.54104600000010 s ---Record to Data_Particle2.txt--- =====Timer info===== pt init 4.035099999999936E-002 s push+g2p 3.53191699999999 s pt p2g 2.46504800000006 s pt Record 5.027699999975965E-002 s ptpullback 0.180881000000088 s ---Record to Data_Particle3.txt--- =====Timer info===== pt init 3.751999999999978E-002 s push+g2p 3.81688500000004 s pt p2g 2.398463999999952 s pt Record 5.001899999980353E-002 s ptpullback 0.167135999999889 s ---Record to Data_Particle4.txt--- =====Timer info===== pt init 4.151799999999994E-002 s push+g2p 3.738048000000019 s pt p2g 2.373636999999959 s pt Record 5.619900000018063E-002 s ptpullback 0.162172000000055 s =====Timer info===== fd init 5.08226800000000 s fd solve 16.2743940000004 s fd g2p 44.3825779999998 s fd Record 0.187814000000088 s ---cputime: 179.3 s (2.99 mins) =====finalize PETSC&MPI===== =====Test GKEM Ends=====</pre>	<pre>=====Timer info===== pt init 2.109000000000005E-002 s push+g2p 28.1804750000001 s pt p2g 17.4445760000003 s pt Record 0.541773999999965 s ptpullback 1.92733299999997 s ---Record to Data_Particle2.txt--- =====Timer info===== pt init 5.966999999999834E-003 s push+g2p 2.74962800000007 s pt p2g 1.96043199999990 s pt Record 3.729000000000582E-002 s ptpullback 0.153175999999968 s ---Record to Data_Particle3.txt--- =====Timer info===== pt init 5.951000000000040E-003 s push+g2p 2.71128599999993 s pt p2g 1.82359699999999 s pt Record 3.525900000001236E-002 s ptpullback 0.132289999999960 s ---Record to Data_Particle4.txt--- =====Timer info===== pt init 5.641999999999925E-003 s push+g2p 2.935004000000009 s pt p2g 1.793581000000008 s pt Record 4.204499999996436E-002 s ptpullback 0.130800999999979 s =====Timer info===== fd init 0.182353000000000 s fd solve 13.5807349999999 s fd g2p 28.6385559999999 s fd Record 0.161969000000022 s ---cputime: 97.2 s (1.62 mins) =====finalize PETSC&MPI===== =====Test GKEM Ends=====</pre>
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Speedup ~2.65 ×

• Speedup ~2.0 ×

Optimization enables larger device simulations at lower cost

Tokamak Devices: Magnetic Field vs Major Radius
(Circle radius represents Minor Radius, colors uniquely identify devices)



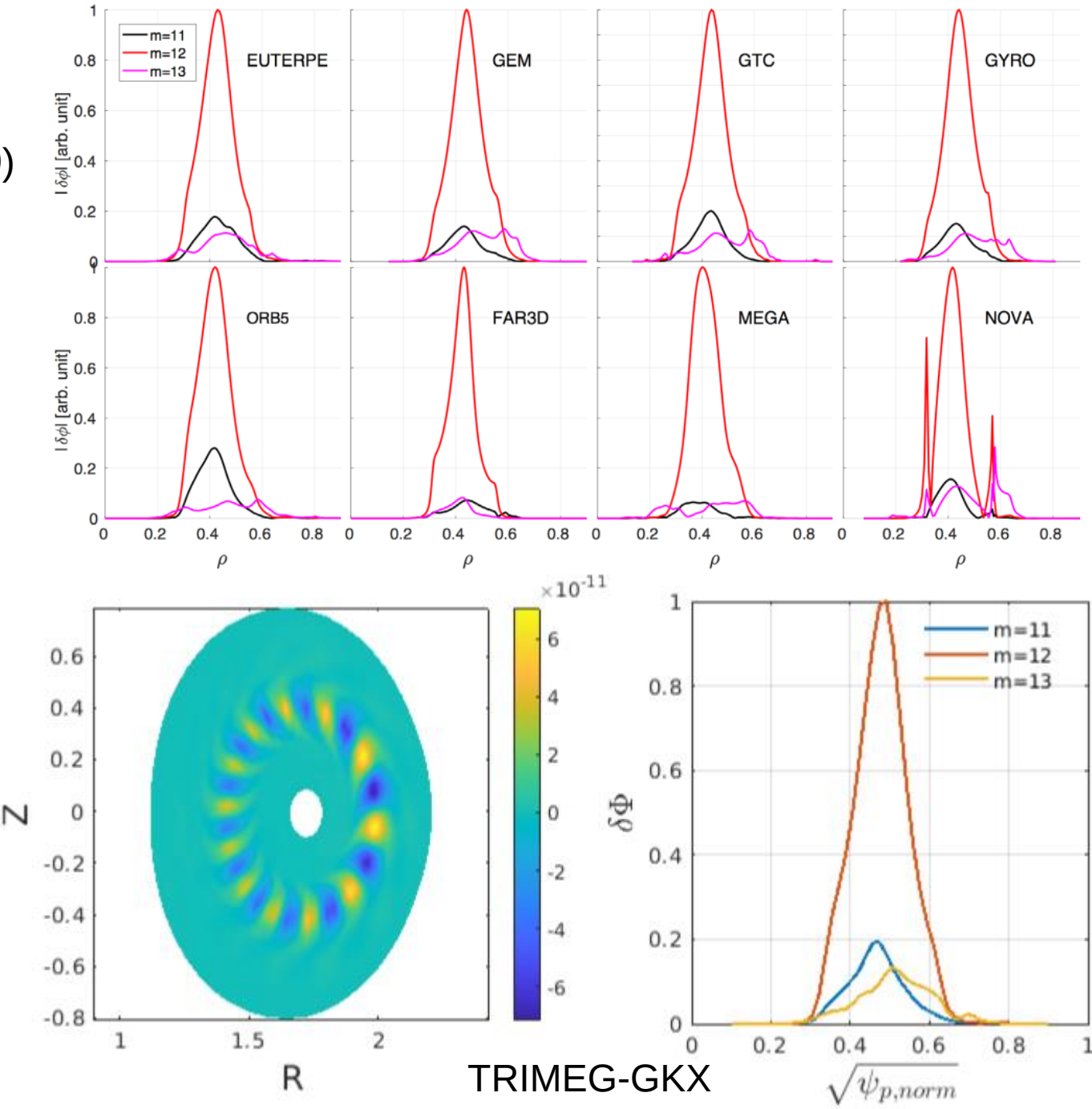
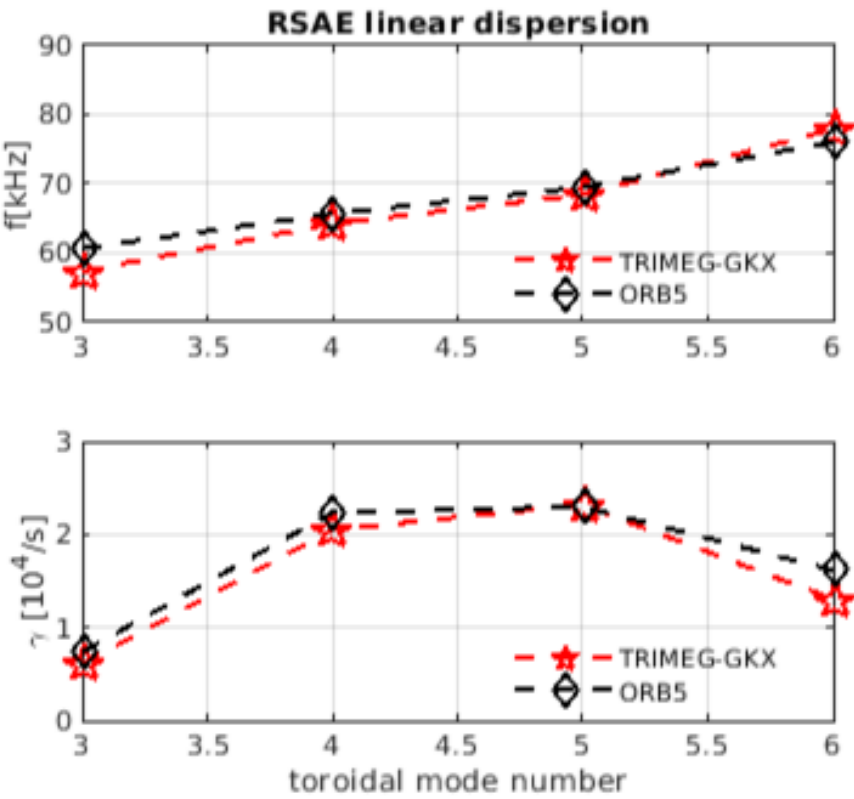
This work: DIII-D, JET

Realistic, large a/ρ , high beta

DIII-D RSAE benchmark

S. Taimourzadeh, et al., NF, 59 (6), 066006 (2019)

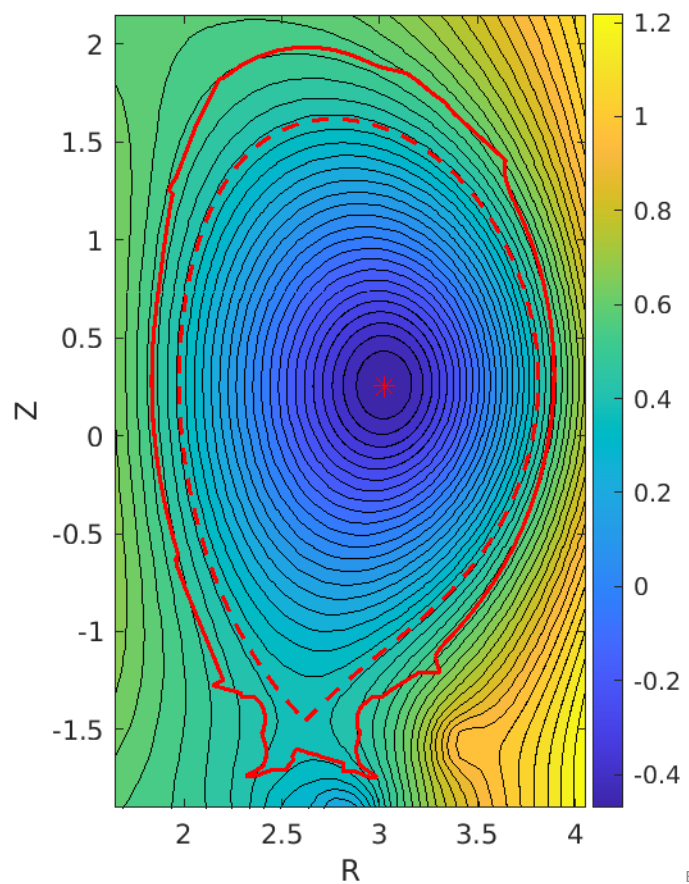
Good agreement with other codes



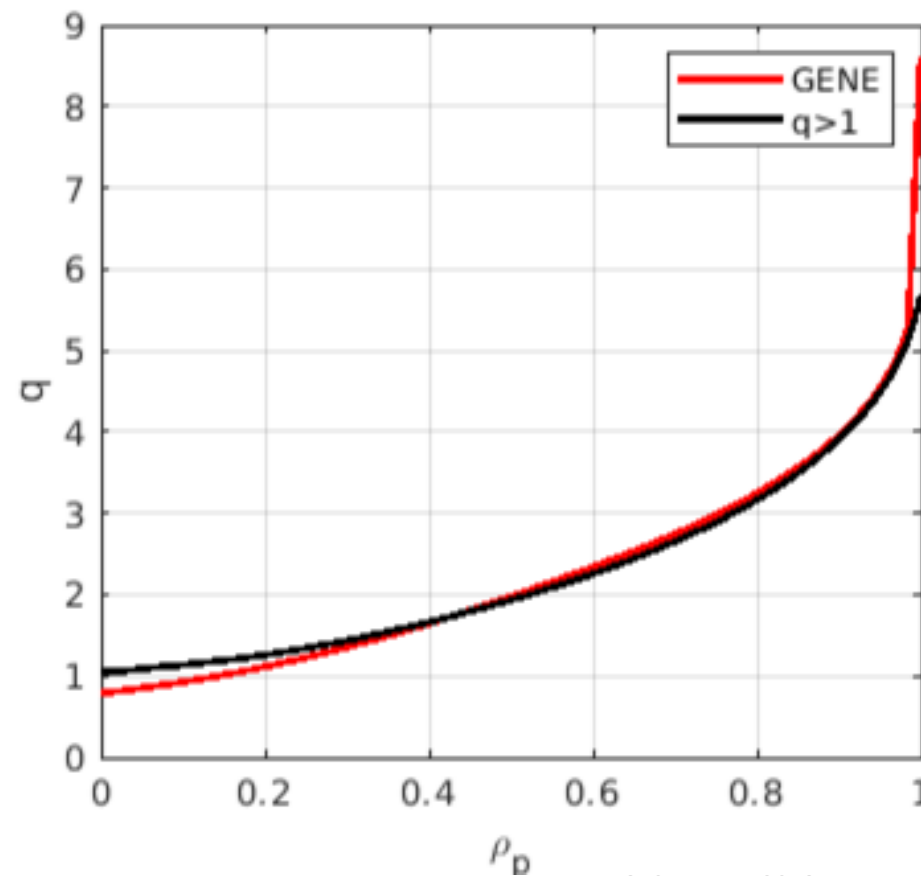
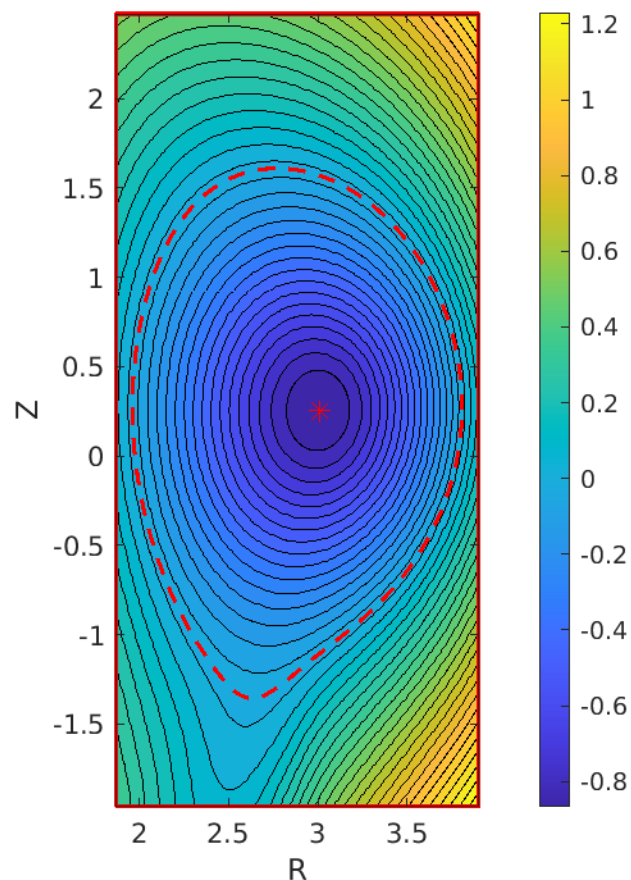
JET case #99896 with D-T

Two input resources

GENE: 99896, from Alessandro



99896@8.5s ($q>1$), IMAS data

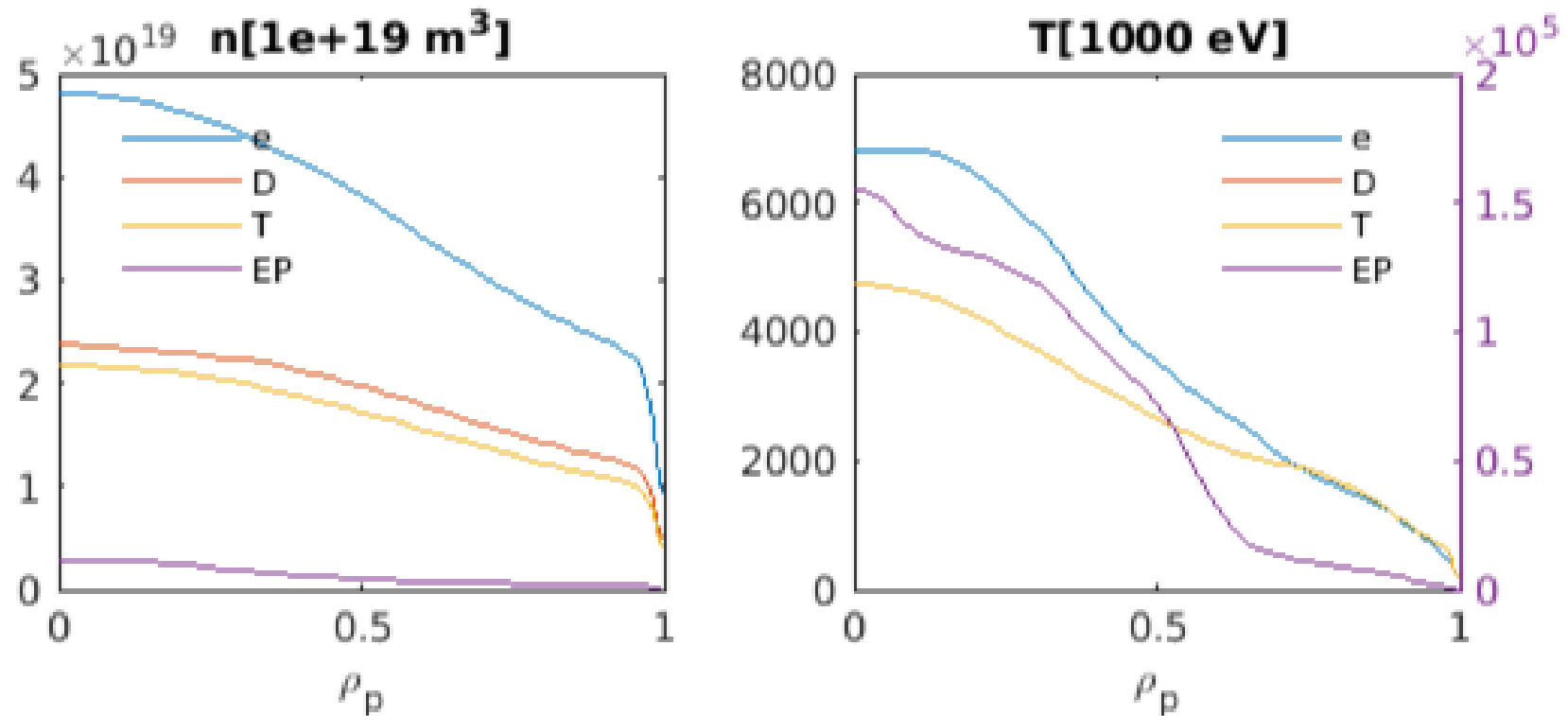


JET D-T simulation using GENE

A. Di Siena Nuclear Fusion 65, 086019 (2025)

4 species: e, D, T, and EP(combined), $m_{EP} = 1.5\text{AU}$

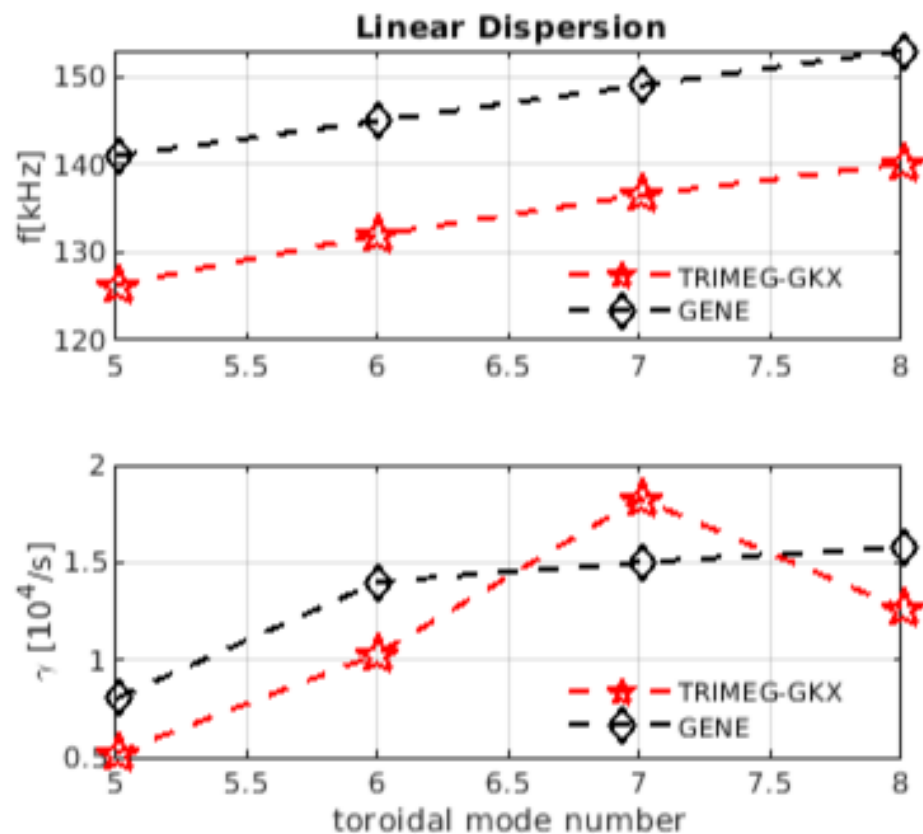
Radial coordinate ρ_T (GENE) is converted to ρ_p for TRIMEG



Comparison with GENE



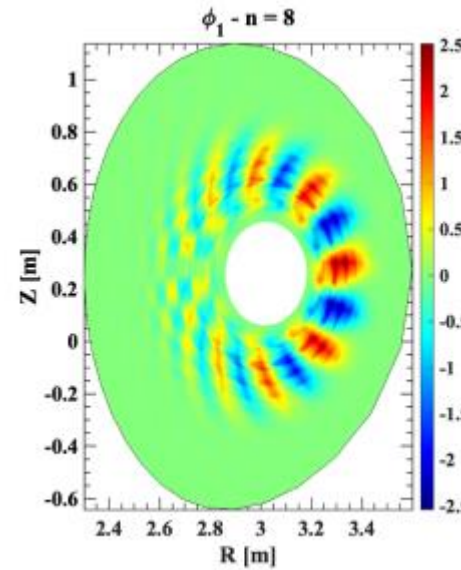
- Lower resolution is adopted in TRIMEG for saving resources
- Higher resolution cases are ongoing



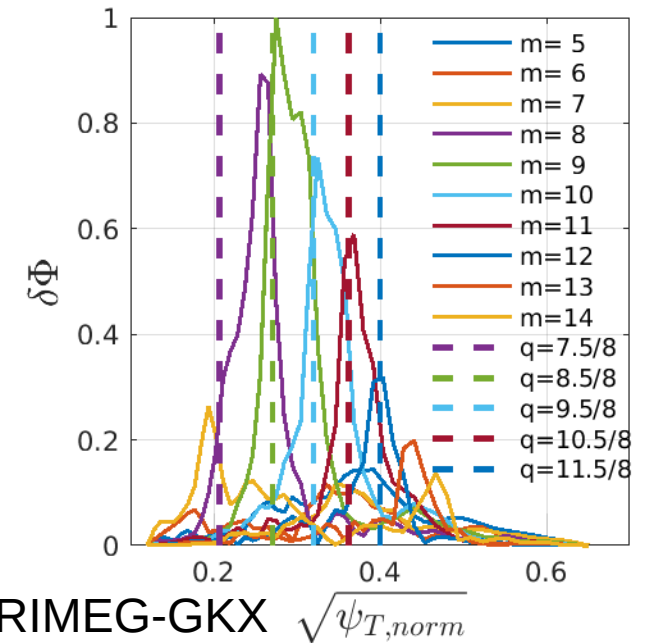
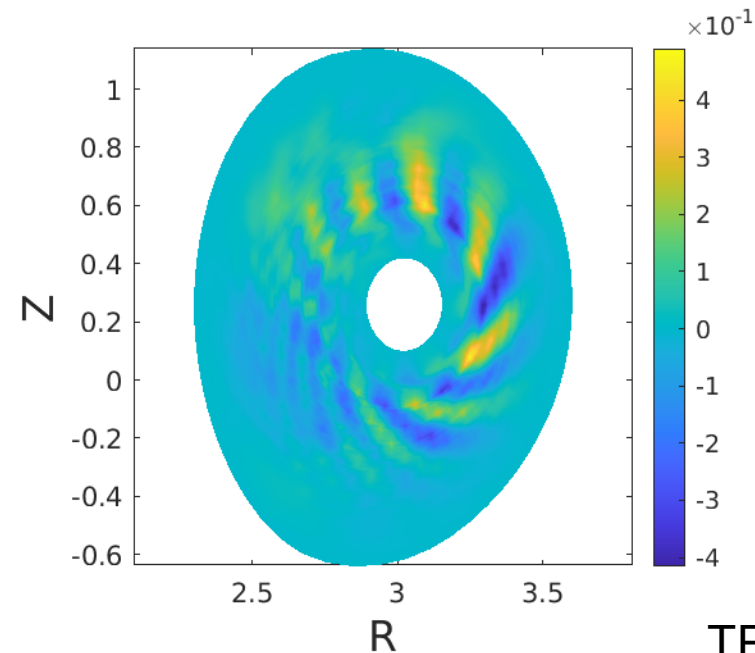
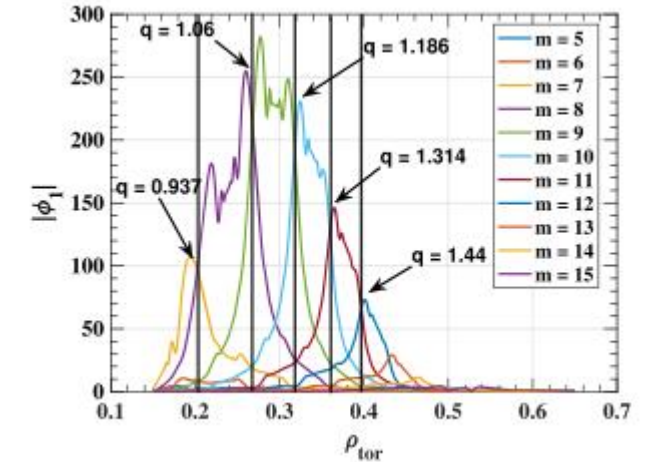
	GENE	TRIMEG
N_r	384	48
N_y or N_θ	64	64
N_ϕ	32	1 (PIF)
m_i/m_e	realistic	100

Mode structure for $n = 8$

- 2D mode structure and radial structure of poloidal harmonics
- Studies with larger N_r is ongoing

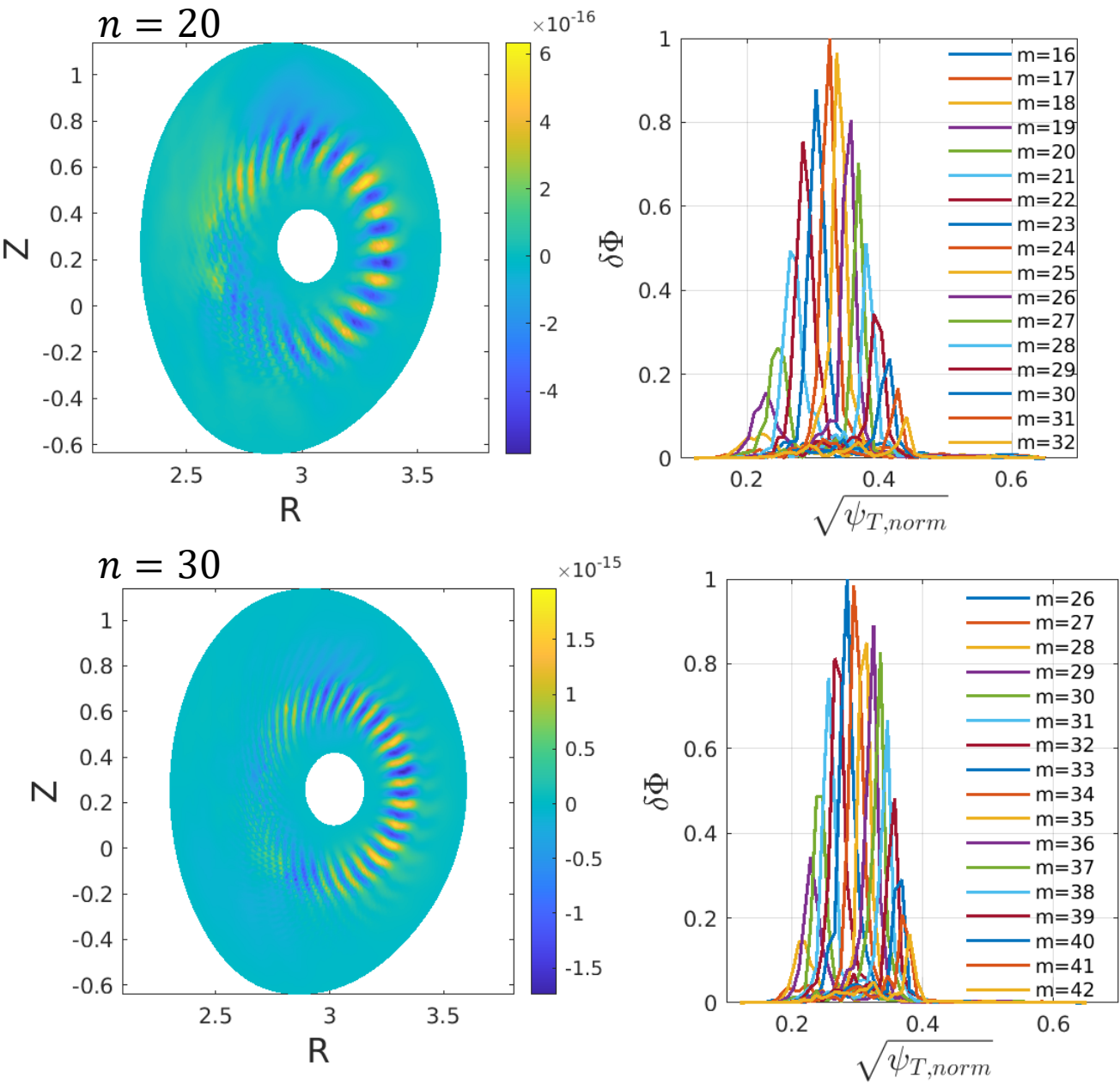
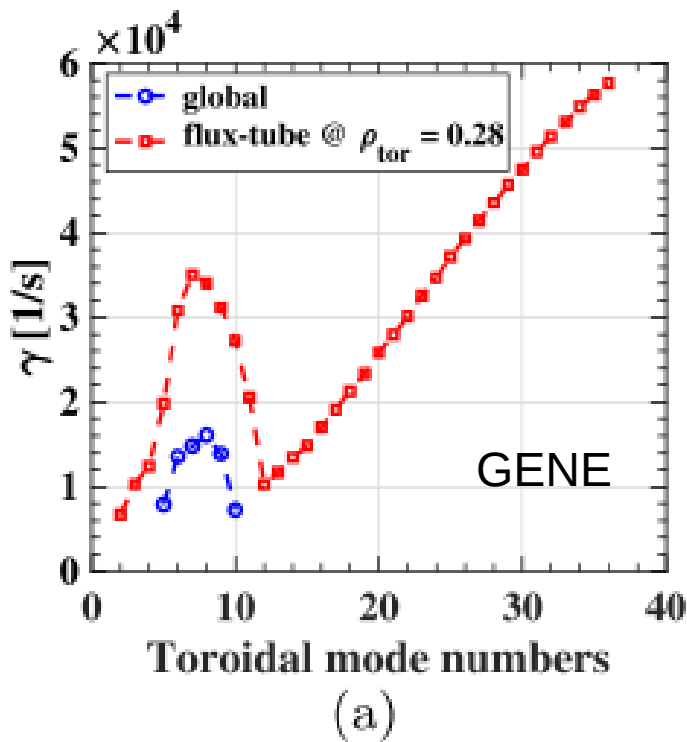


GENE



High n mode

Microinstability is excited for $n > 10$



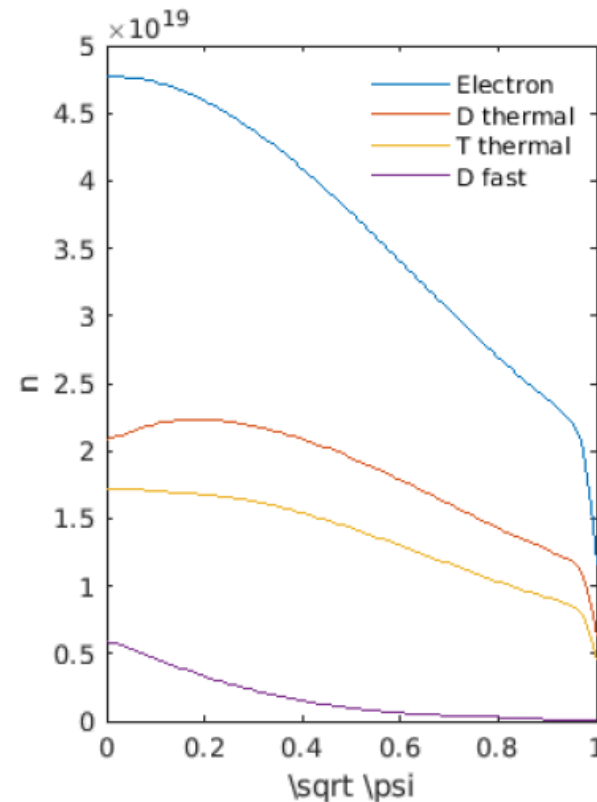
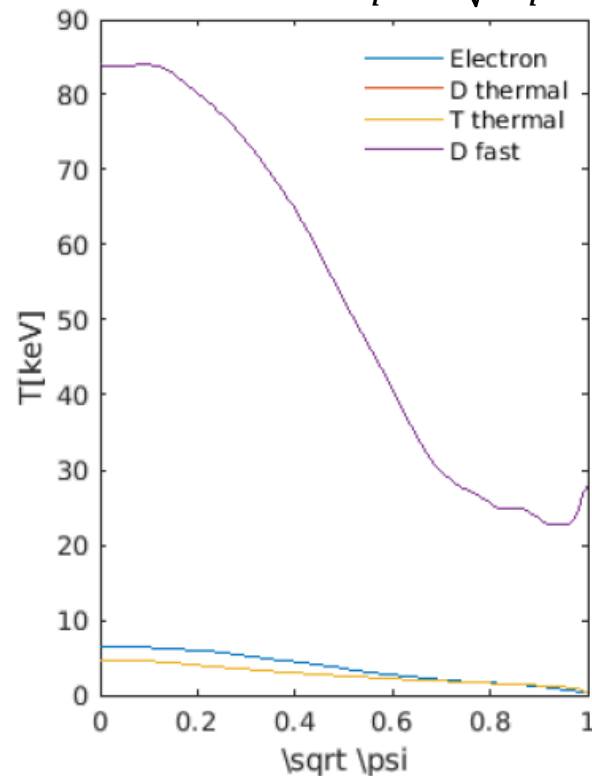
Inputs from IMAS

274 time slice, choose @8.508 s

9 species include impurities, in simulations we use 4 species: e, D, T, and fast D

IDS Convert to EQDSK for TRIMEG (cocos 3)

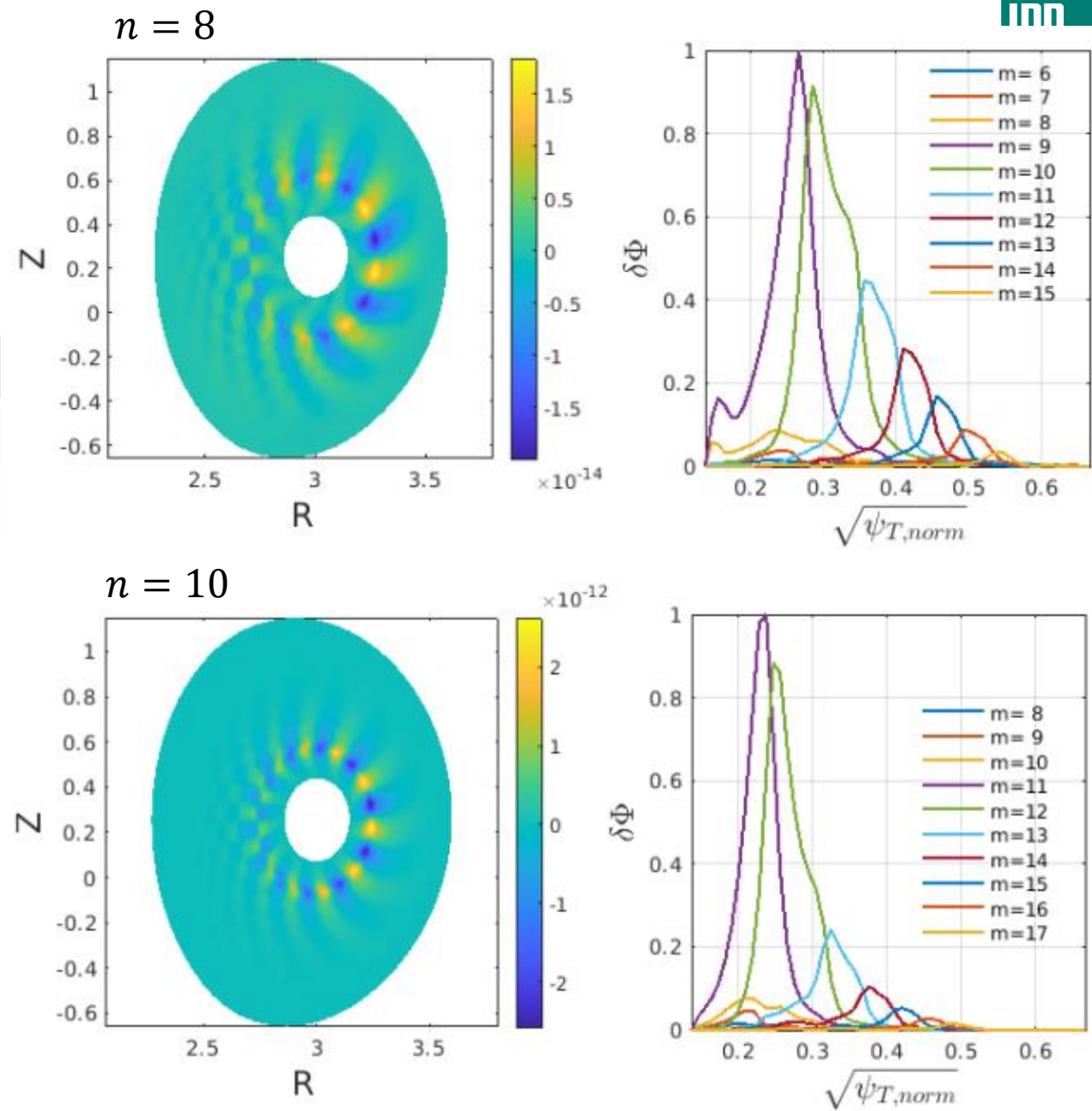
Profiles convert to radial coord. $\rho_p = \sqrt{\psi_p}$



Simulation with IMAS data

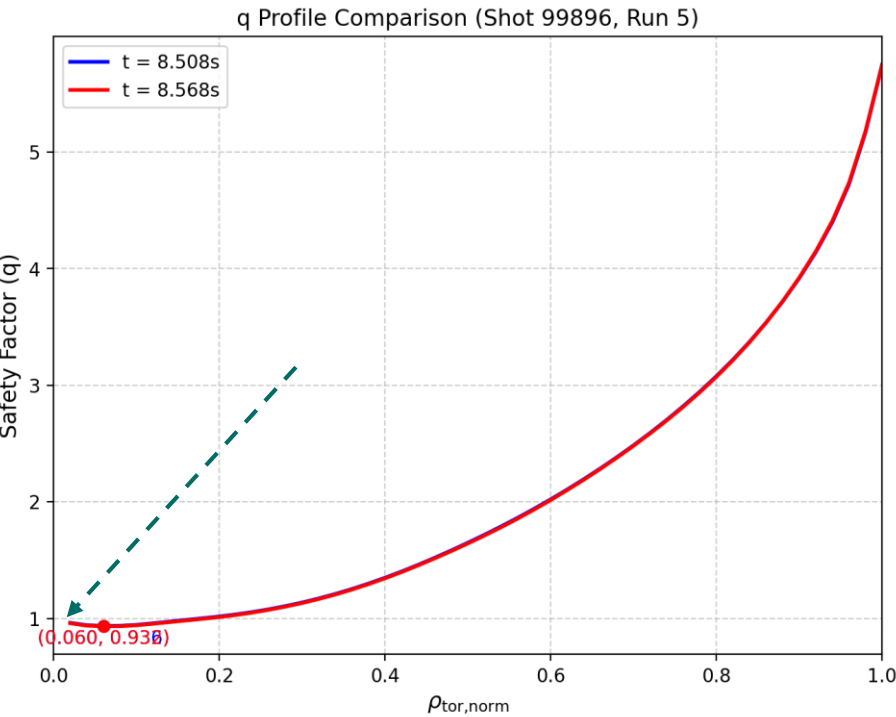
- 4 species: e, D, T, fast D

n	$\gamma [10^4/s]$	$\omega [kHz]$
8	1.89	143
10	3.56	148



Identifying the Root Cause of q-Profile Differences

- checked **ORIGINAL** IMAS q profile @8.51 and 8.56
qmin<1
- IDS to eqdsk (chease) , q slightly varied (q>1)
- Next step: contact CHEASE people



-----at t= 8.508 -----
rho_tor_norm | q

0.020		0.962
0.040		0.942
0.060		0.936
0.080		0.937
0.100		0.944
0.120		0.958

-----at t= 8.568 -----
rho_tor_norm | q

0.020		0.958
0.040		0.937
0.060		0.932
0.080		0.933
0.100		0.940
0.120		0.953

Summary

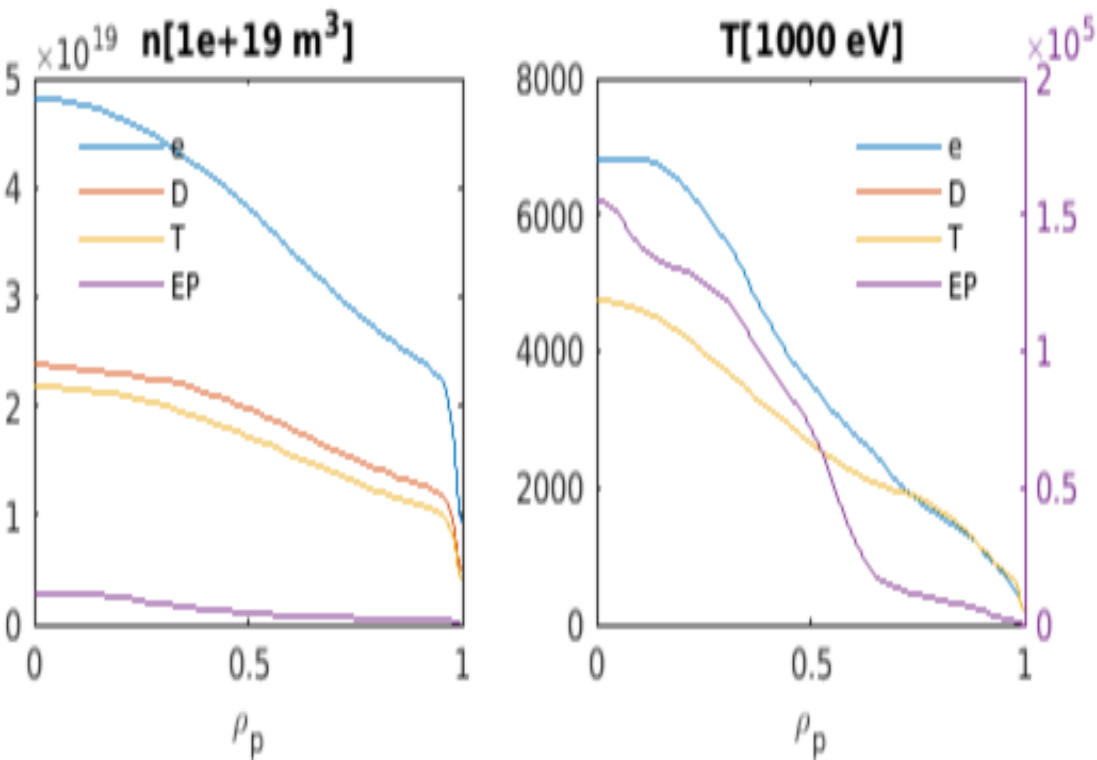


- TRIMEG-GKX has been optimized recently with $>5x$ speedup in total
- Good agreement with other codes is achieved for DIII-D benchmark case
- JET D-T case is ongoing, with agreement with GENE
- Nonlinear studies are ongoing

Profiles Check



• GENE



• IMAS

