

MHD modeling of ELM physics and RMPs in view of DTT

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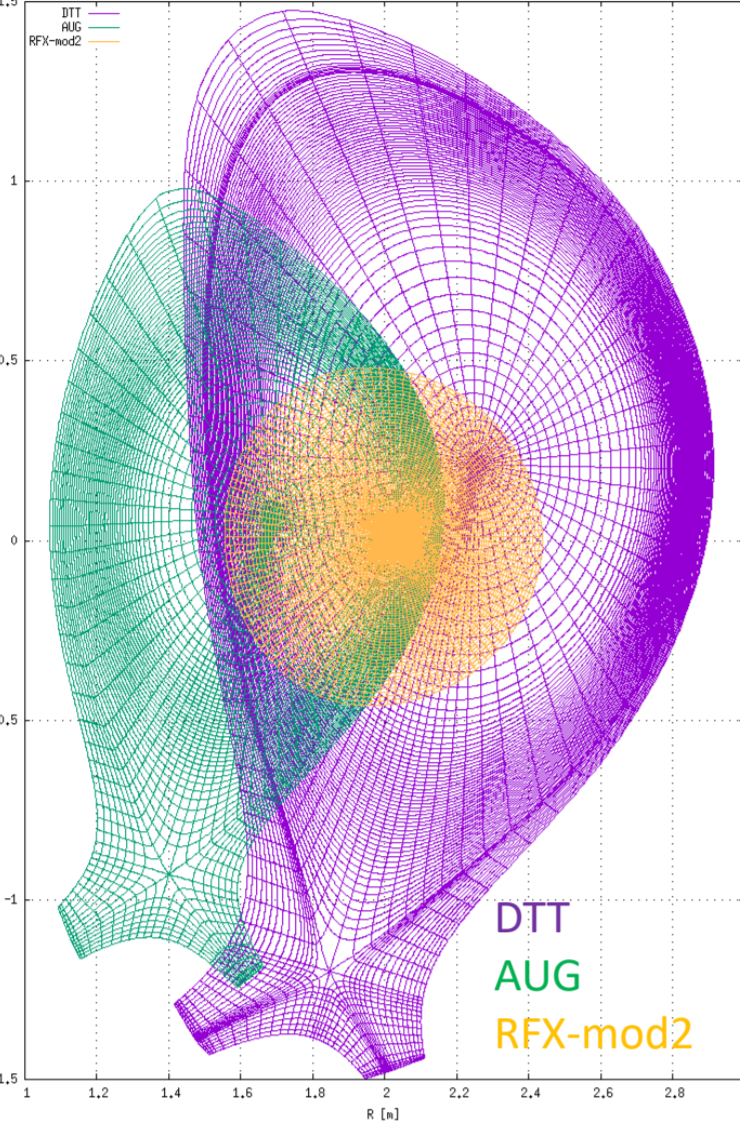
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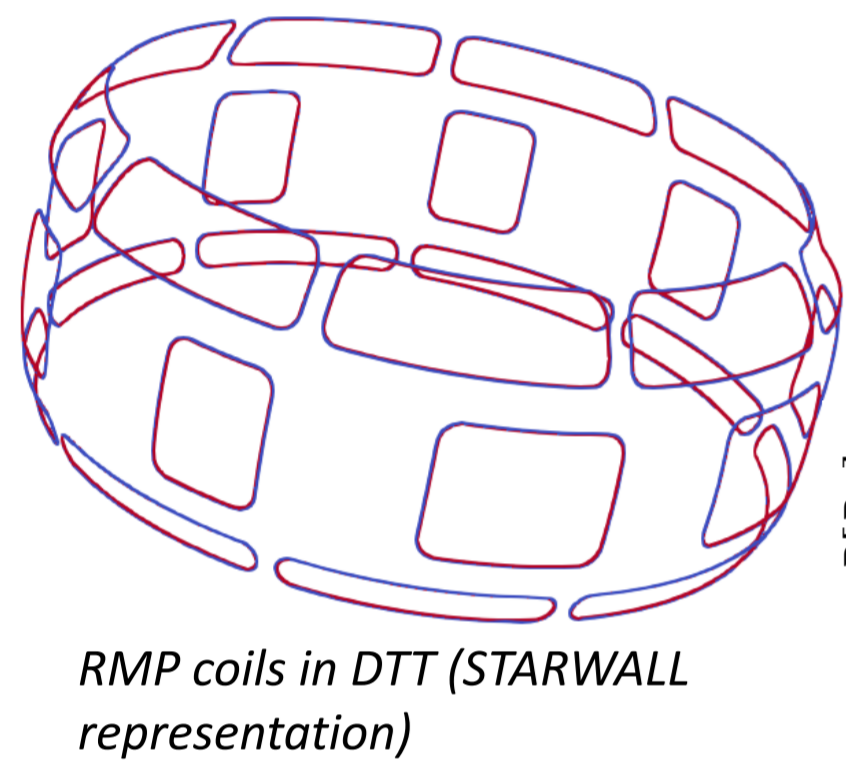
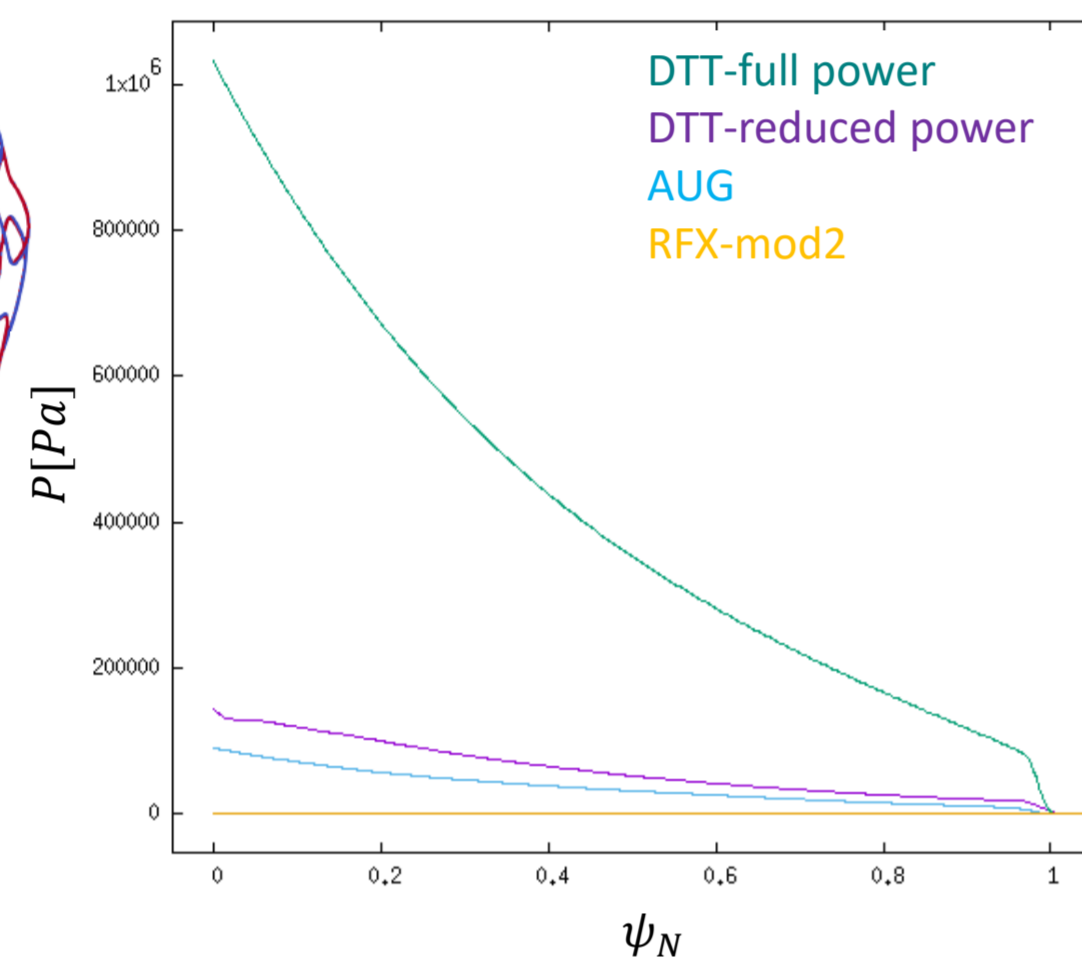
1. Introduction

- RMPs are external 3D magnetic perturbations which can be applied to suppress or mitigate ELMs by decreasing the pressure gradient at the pedestal [1].
- This technique can be modeled in JOREK [3] through the coupling with STARWALL.
- In this work, RMPs and pedestal stability are studied in H-mode scenarios [9] of the Divertor Tokamak Test facility (DTT) under construction in Frascati (Italy), equipped with a system of 3D coils [10].
- For comparison purposes, also ASDEX Upgrade and RFX-mod2 equilibria have been implemented in JOREK
- JOREK and MARS-F results are compared, where the latter allows a fast optimization of the RMP spectrum [2]

Grid comparison among all the devices modeled with JOREK

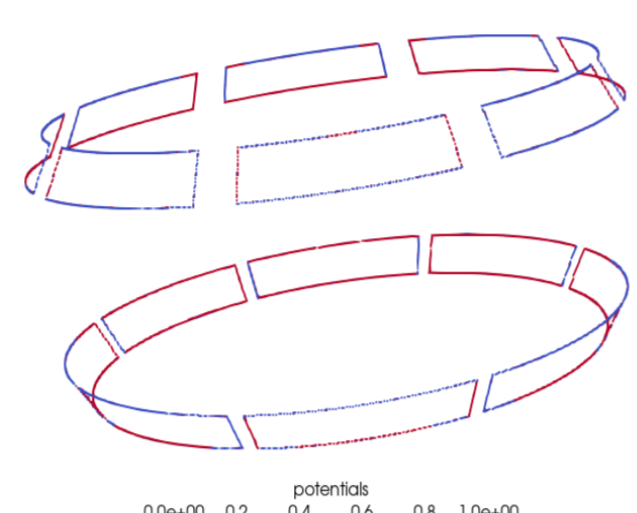


Pressure profiles comparison among all the devices modeled with JOREK

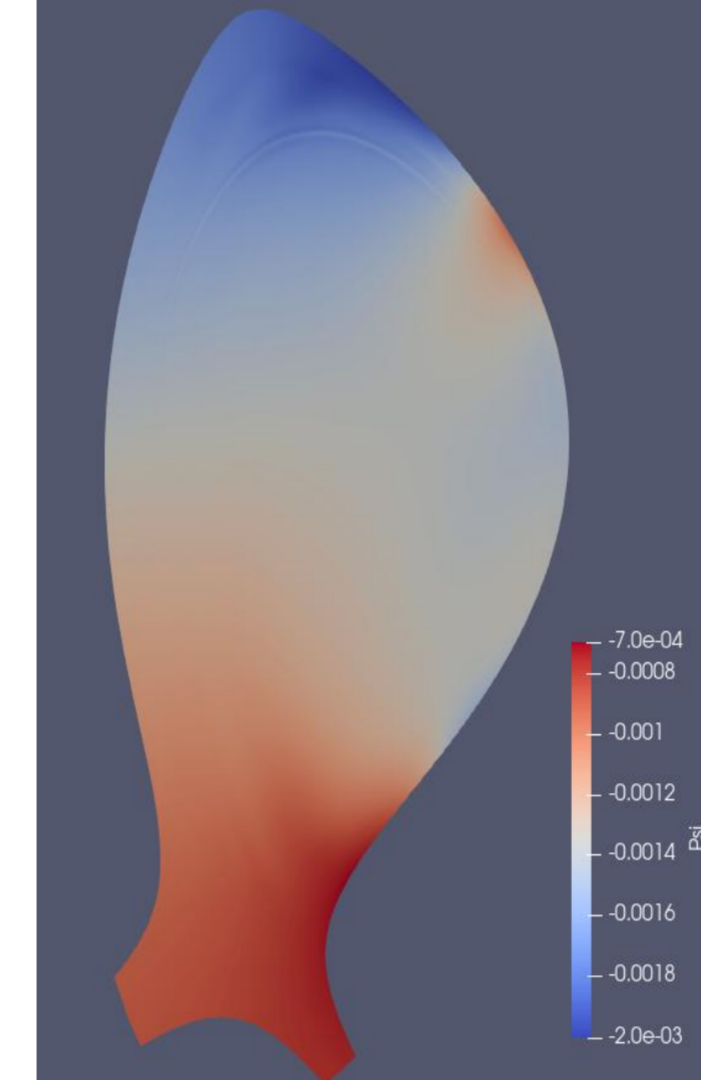


RMP coils in DTT (STARWALL representation)

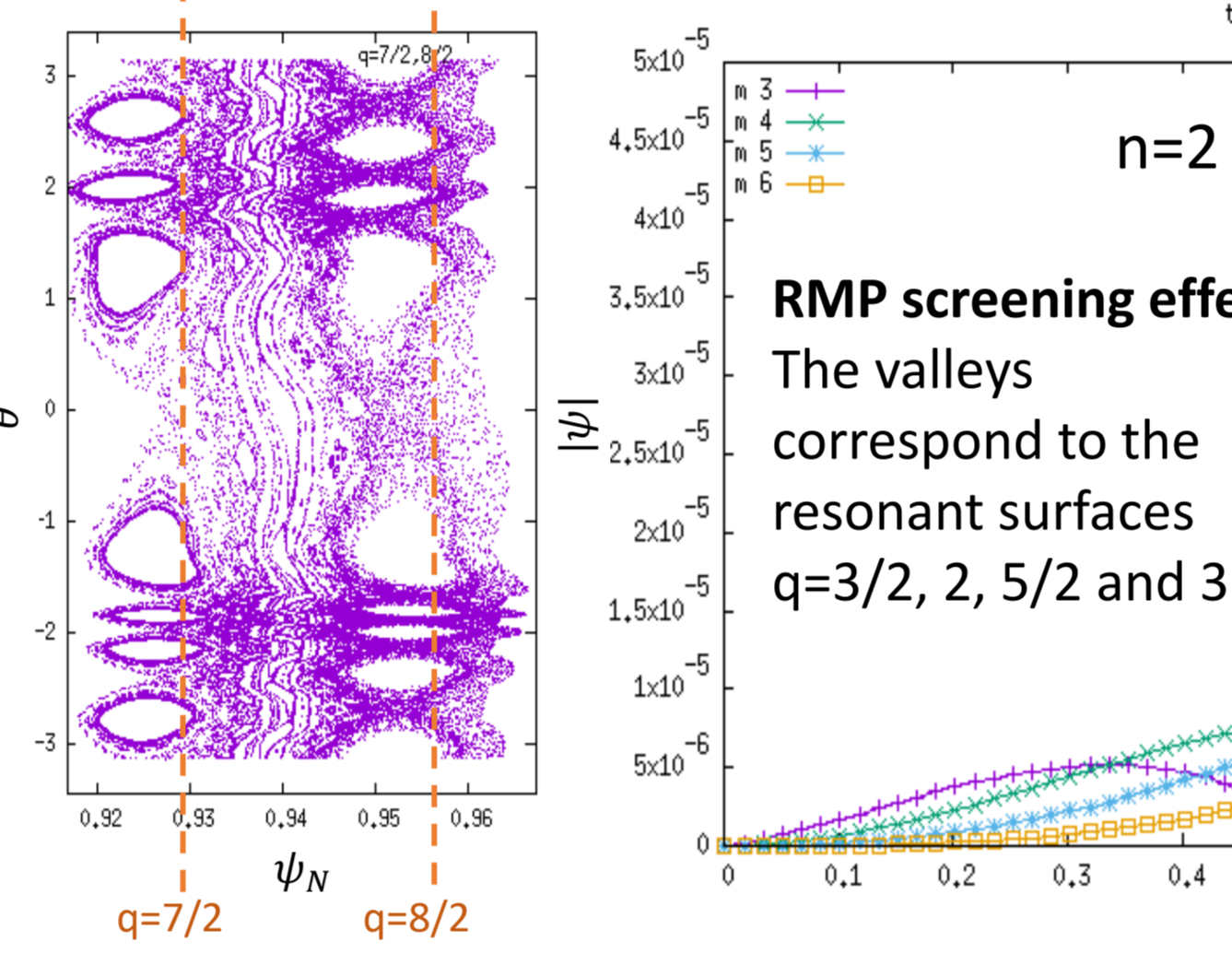
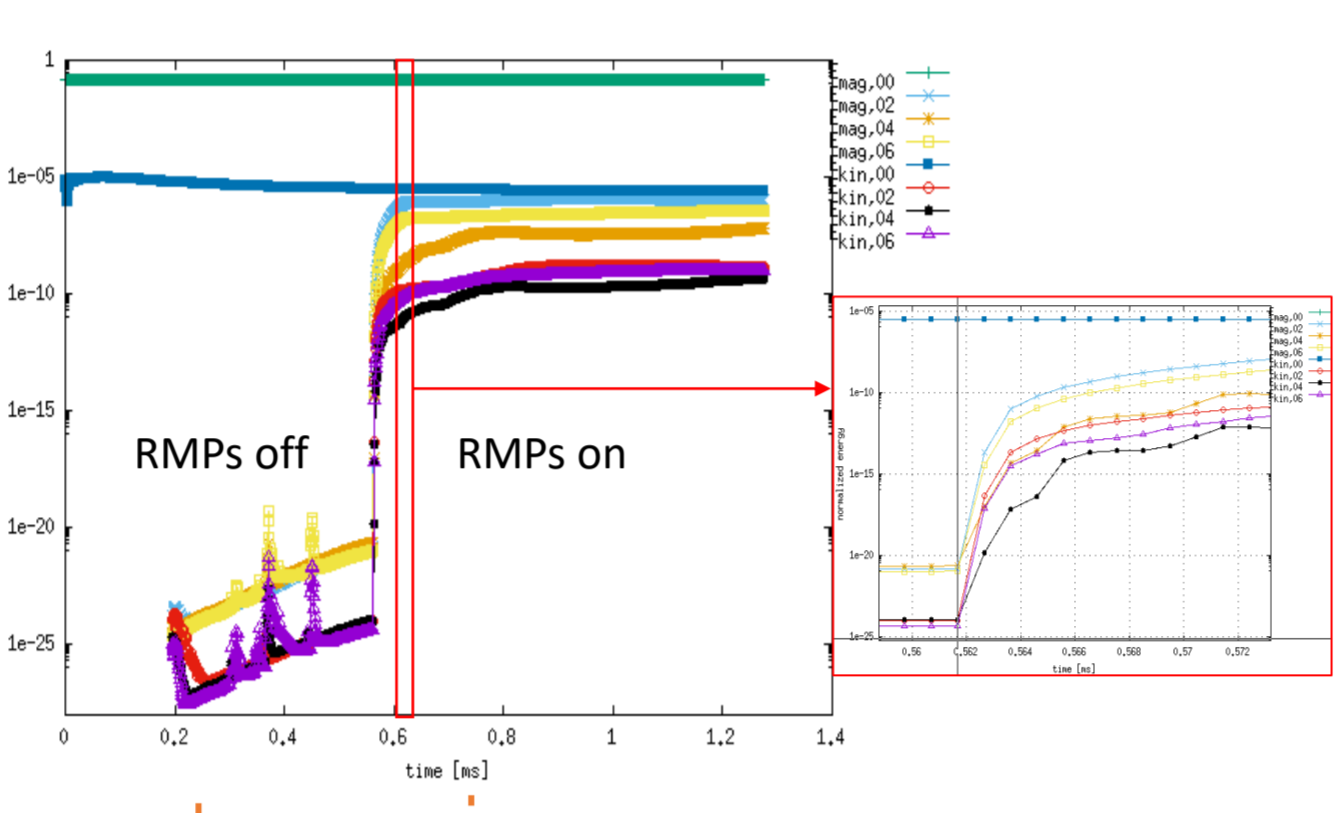
2. RMPs in ASDEX Upgrade – JOREK modeling



Starting from prior studies [4] [5], a preliminary exercise of RMP application was conducted.

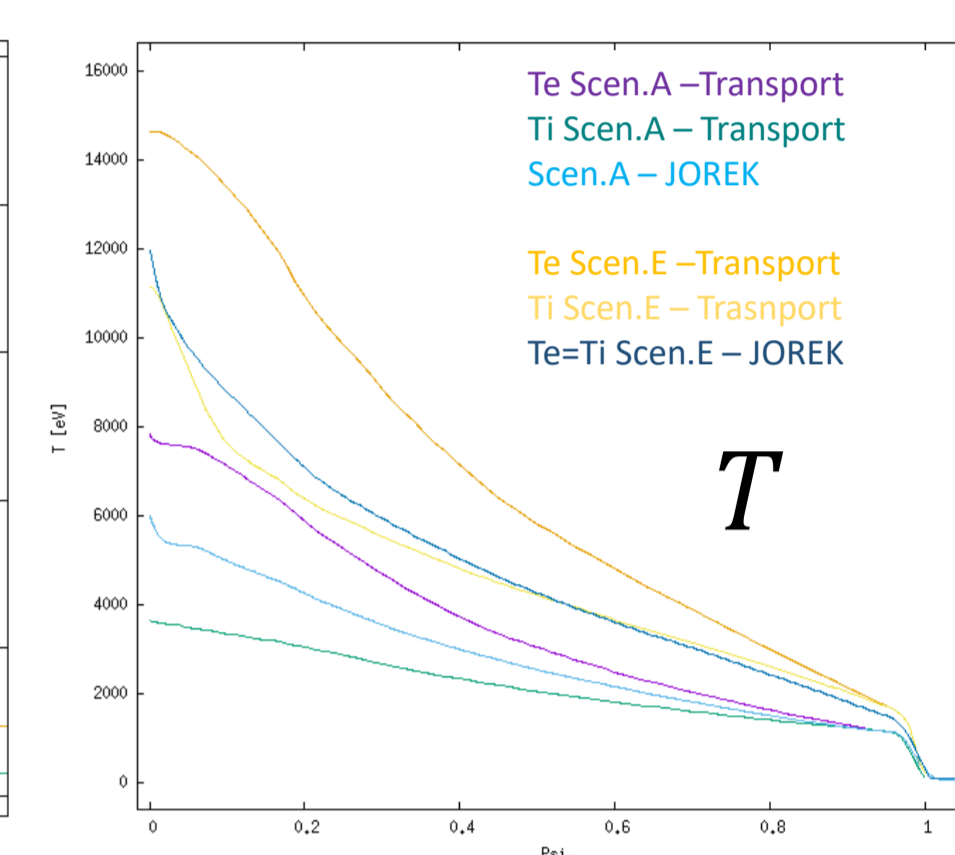
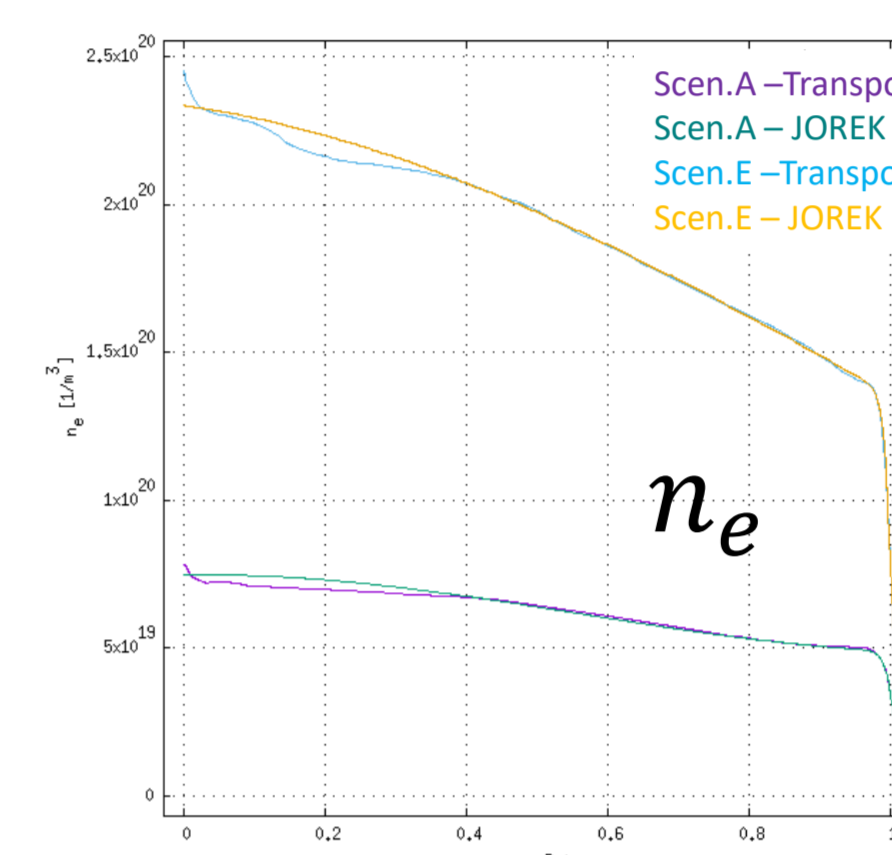
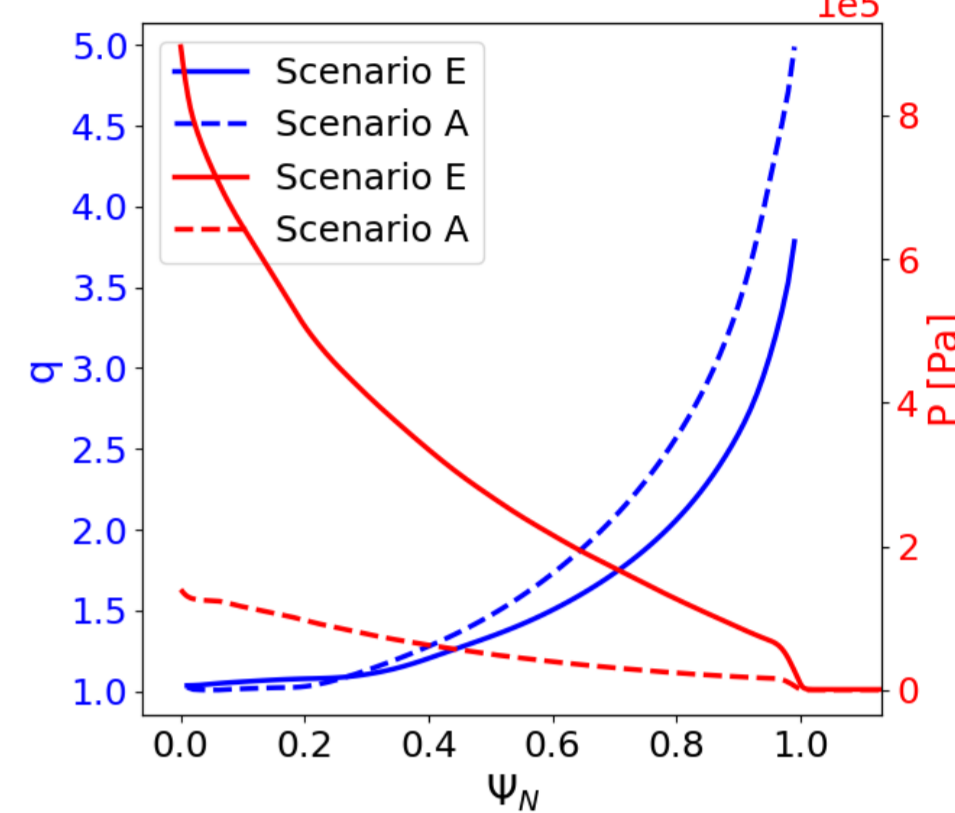


Poloidal section exhibiting n=2 RMPs interacting with the plasma modes

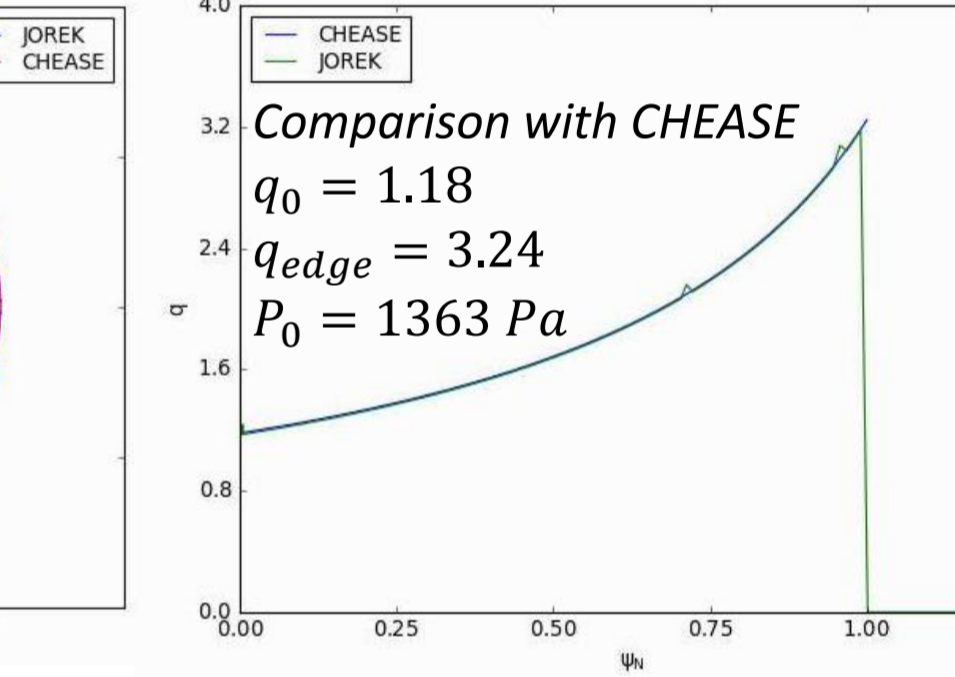
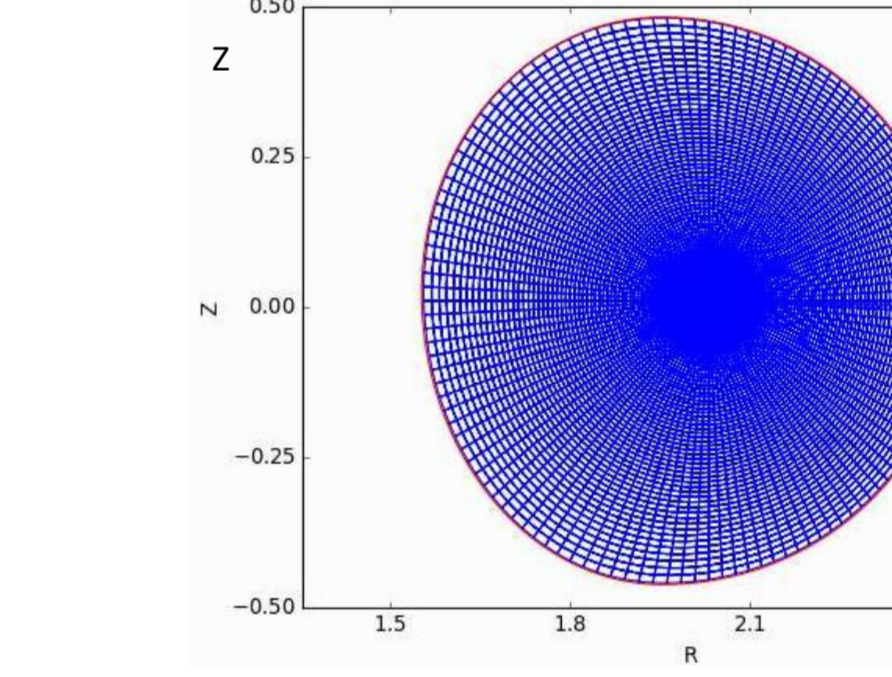


3. DTT and RFX-mod2: implementation in JOREK

- Two DTT equilibria in JOREK: full power scenario ($I_p = 5.5MA, B_{tor} = 5.85T$) and reduced power (Day 0) scenario ($I_p = 2MA, B_{tor} = 3T$) [9]
- Core region modified to avoid internal kink instabilities and simplify the modelling



- RFX-mod2 will allow to explore both the tokamak and the reversed-field-pinch magnetic configurations[6][7]
- It is equipped with 192 independently-fed active coils for MHD stability control and plasma response studies
- A comparison among MARS-F, JOREK and CASTOR-3D [8] is ongoing for stability studies.

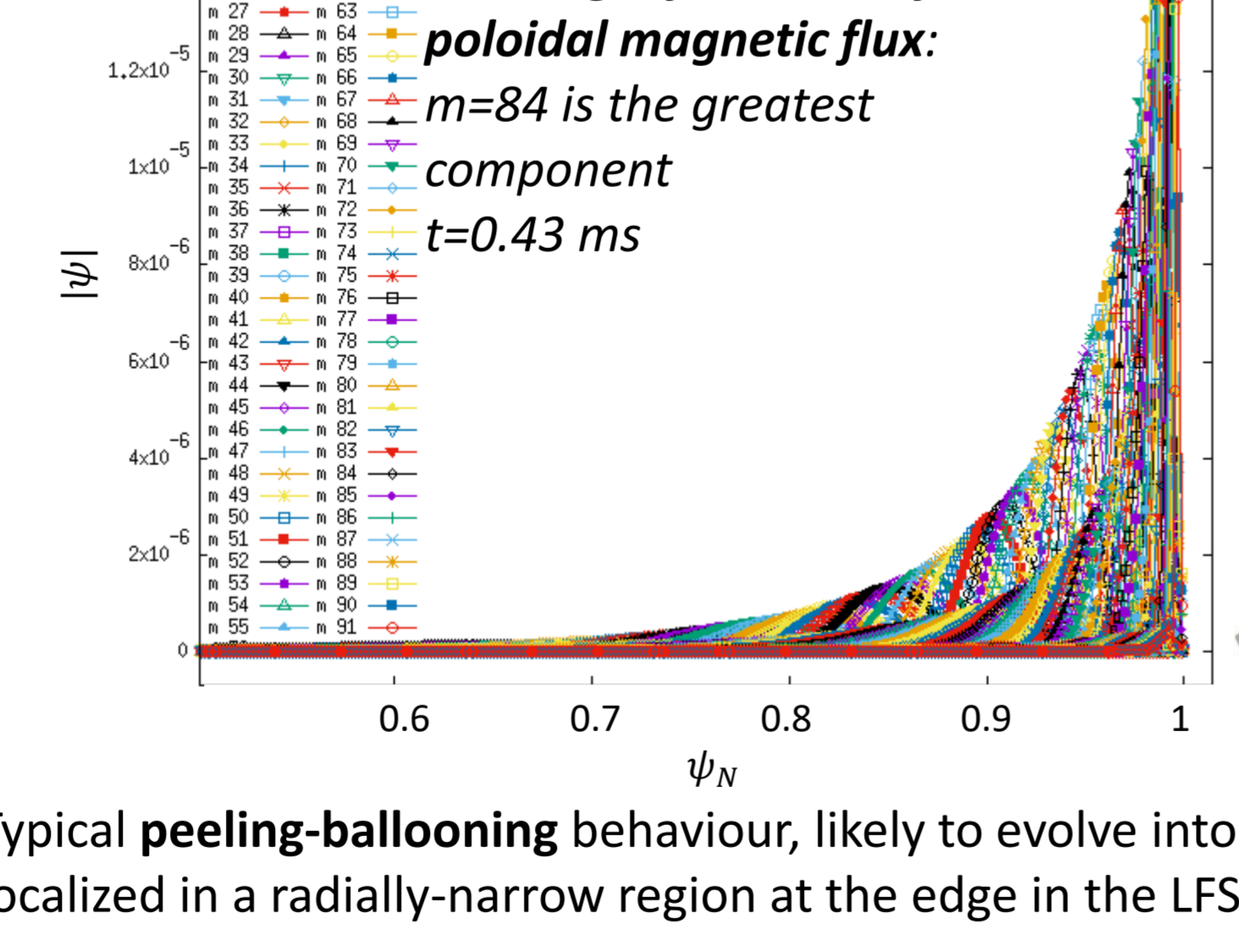
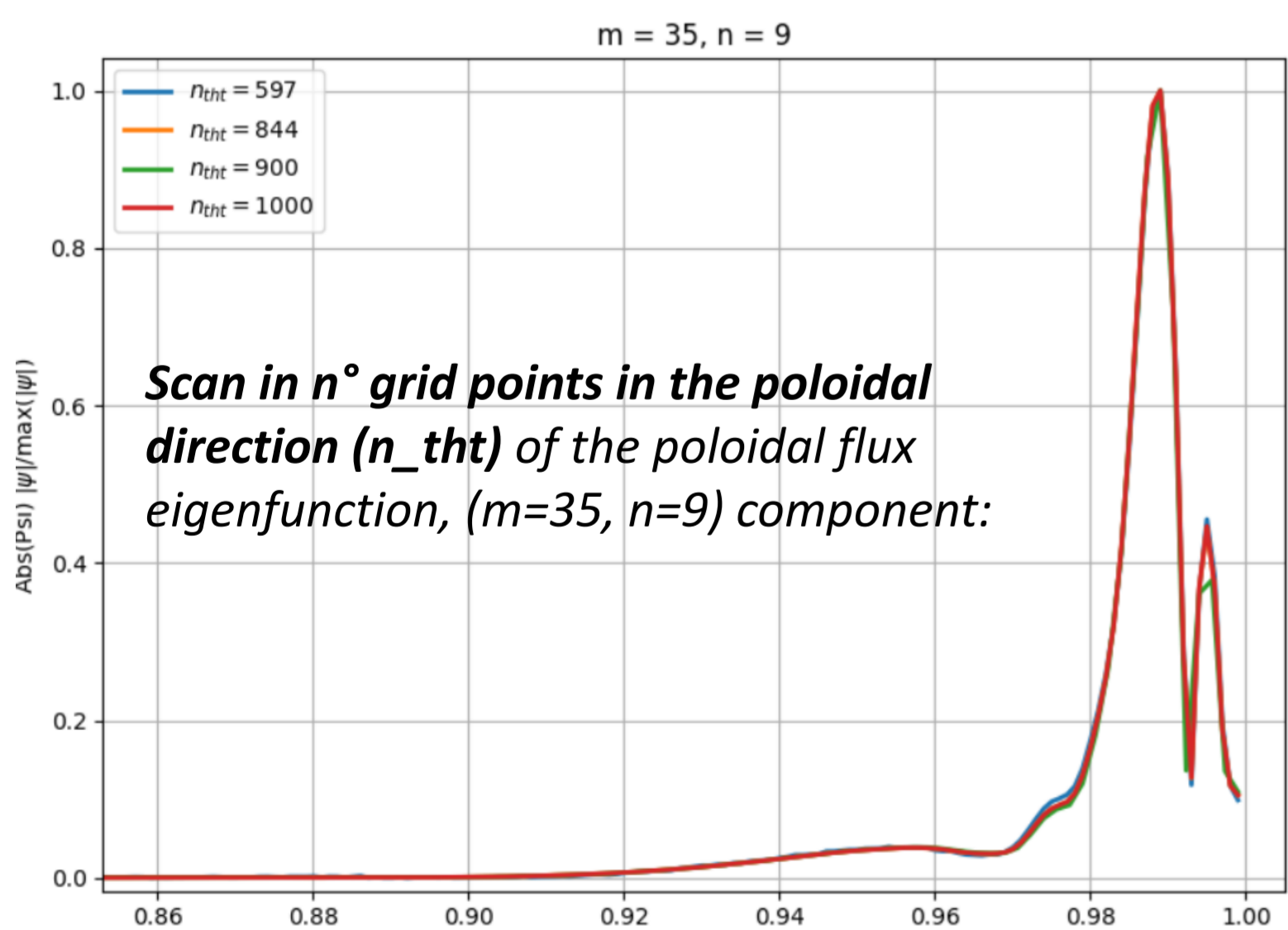
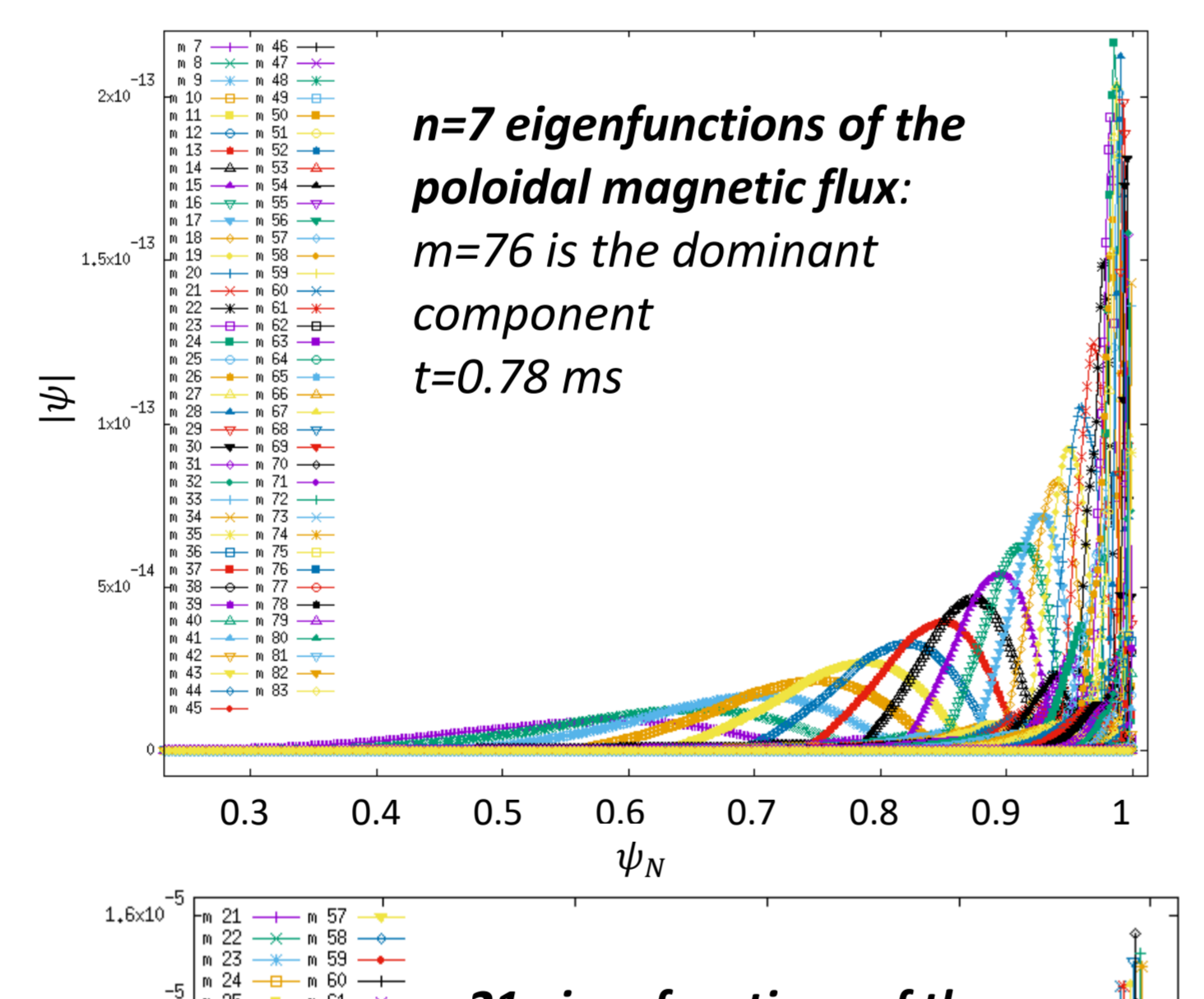
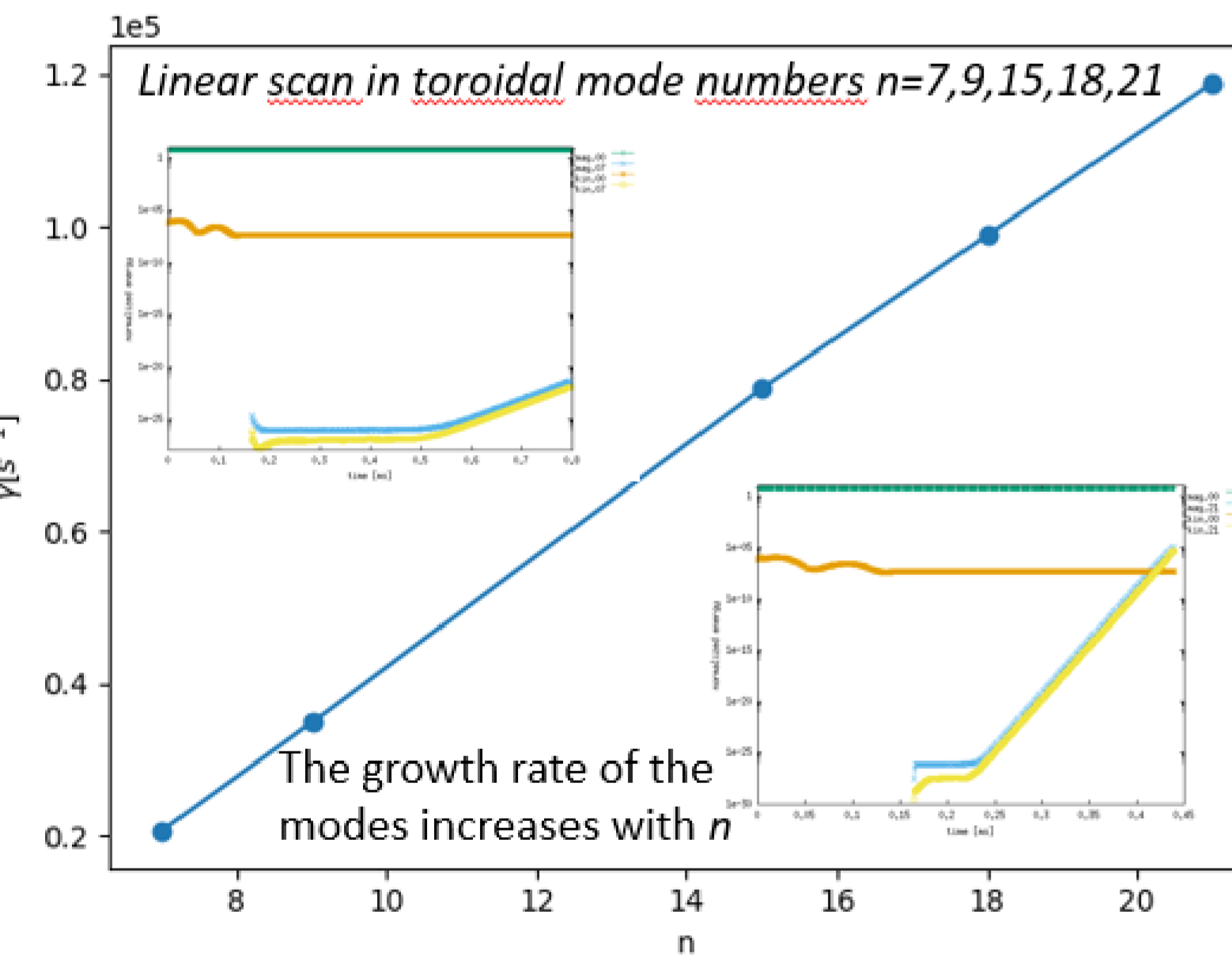


4a. Linear stability study of DTT full power scenario «E» with JOREK

Setup of JOREK linear simulations :

- Pedestal stability in DTT scenarios was optimized with EPED → for a preliminary study of unstable PB modes, resistivity was increased: $\eta \sim 10 \cdot \eta_{Spitzer}$

- No diamagnetic effects or equilibrium flows
- JETTO-JINTRAC temperature and density profiles [9]
- Balance between diffusion and source terms for pedestal stabilization in time



Typical peeling-ballooning behaviour, likely to evolve into ELMs. The modes are localized in a radially-narrow region at the edge in the LFS (bad curvature region)

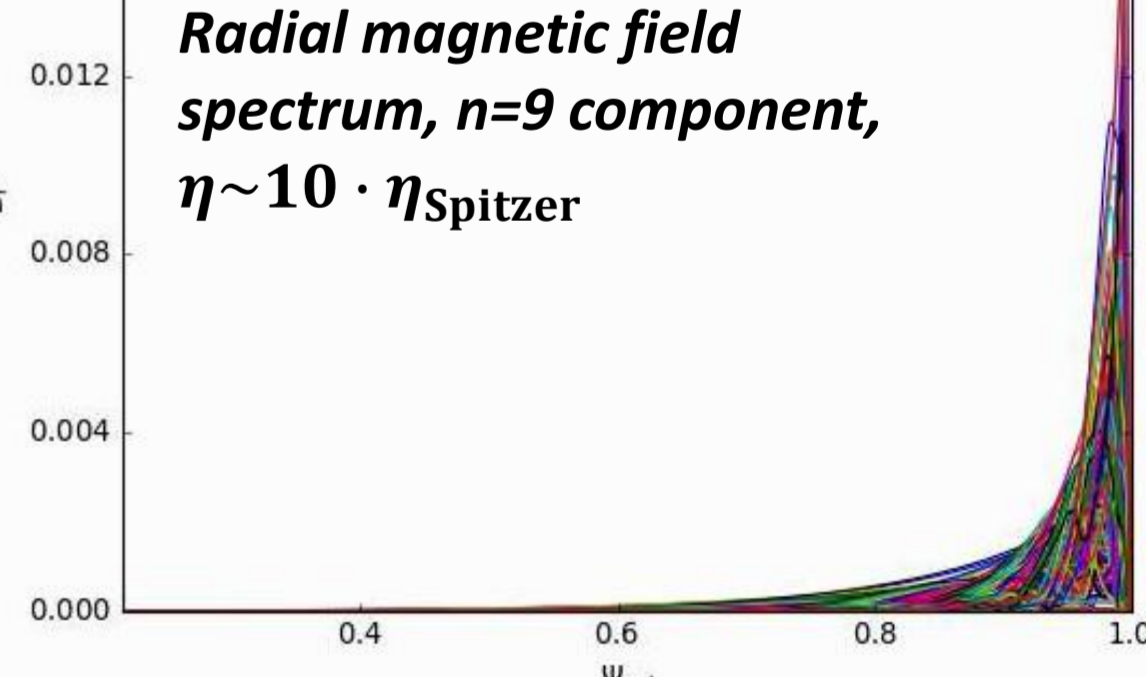
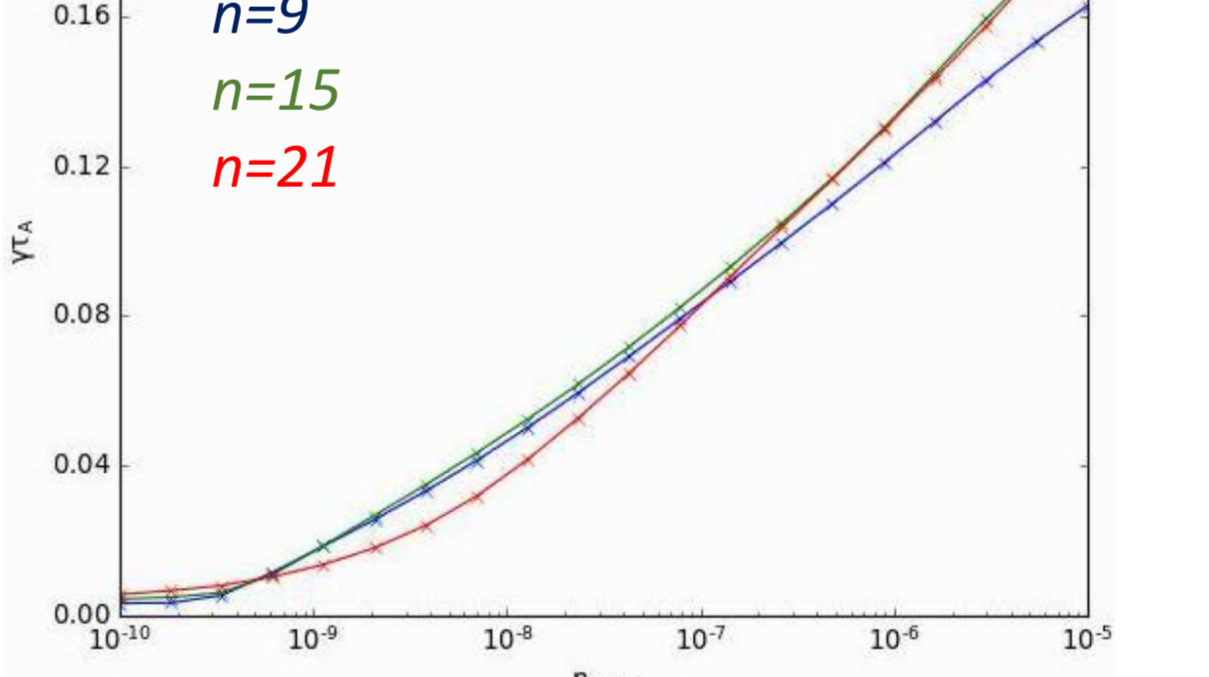
While there is a variation in magnitude, at the same time instant (0.31 ms after starting the non-axisymmetric simulation) the shape of the eigenfunction is rather similar, suggesting that the underlying physics is captured

4b. Linear stability study of DTT full power scenario «E» with MARS-F

The peeling-ballooning modes were also found in the same analysis performed with MARS-F, with the following setup:

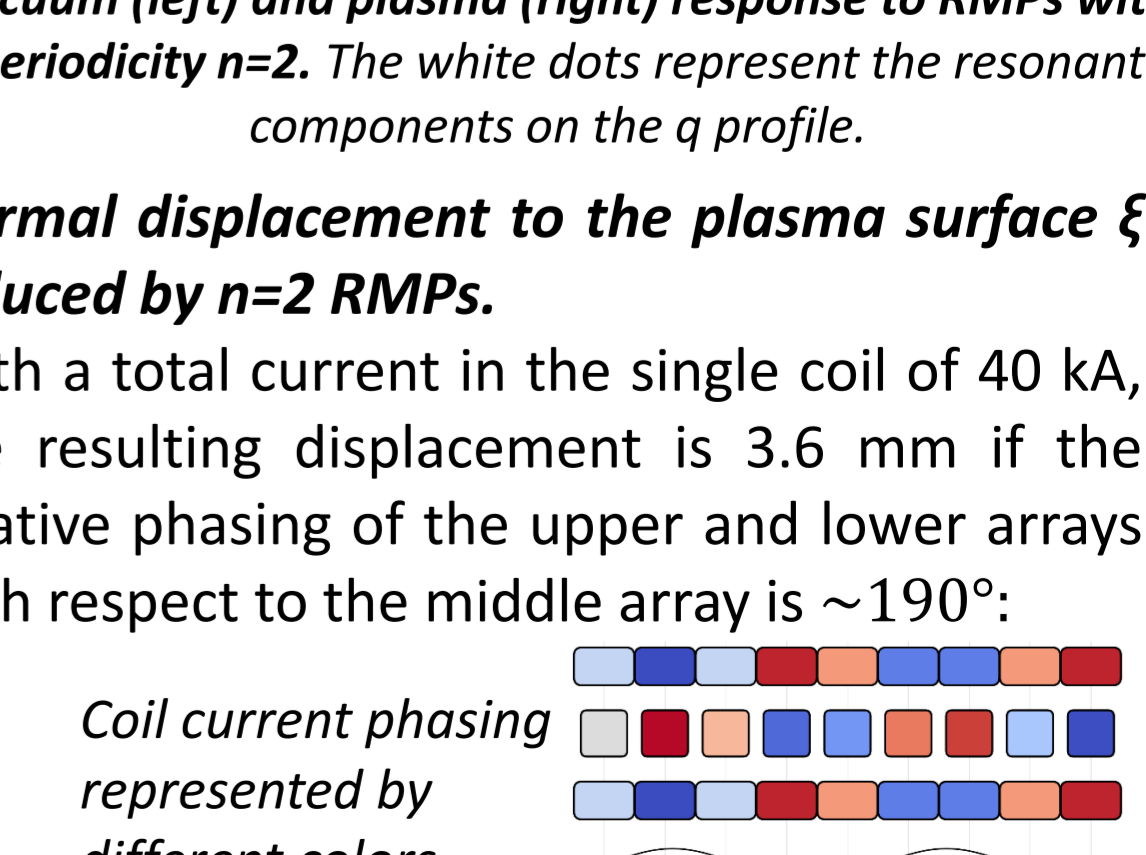
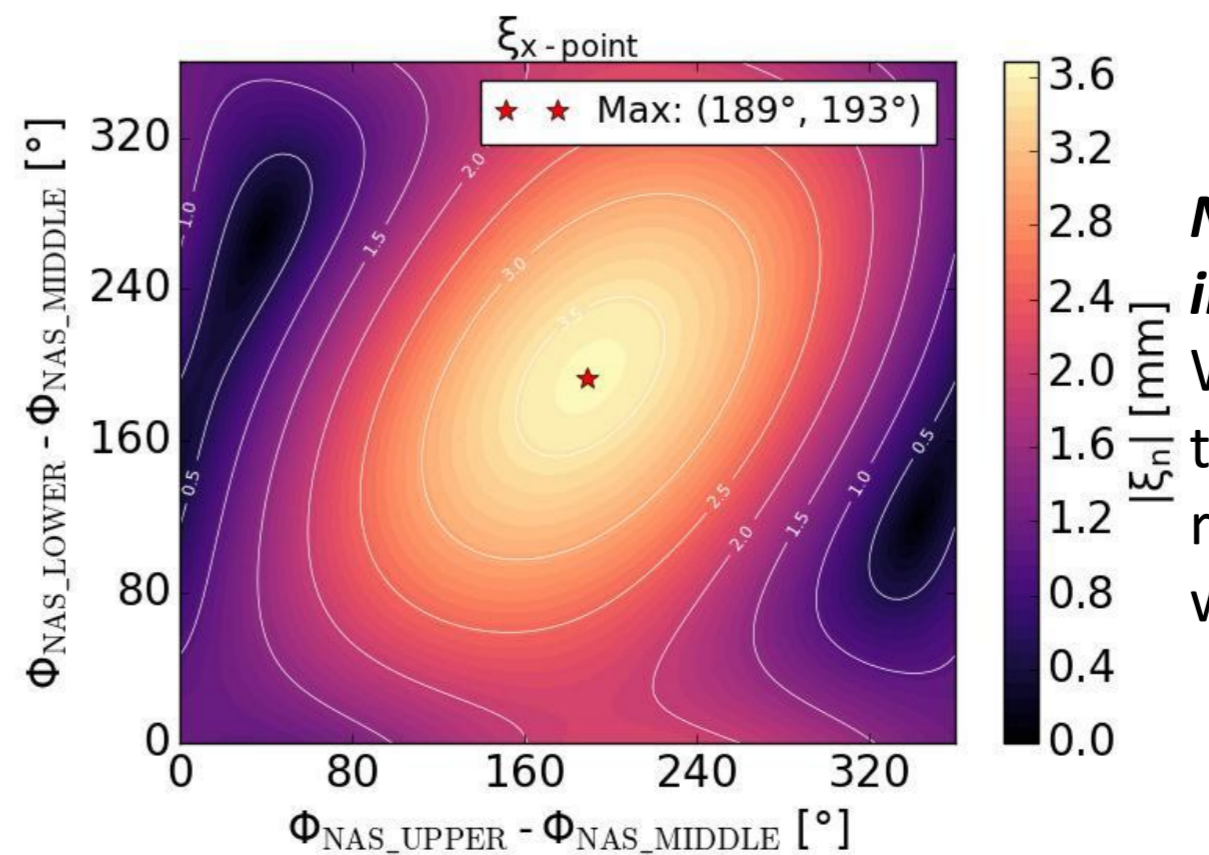
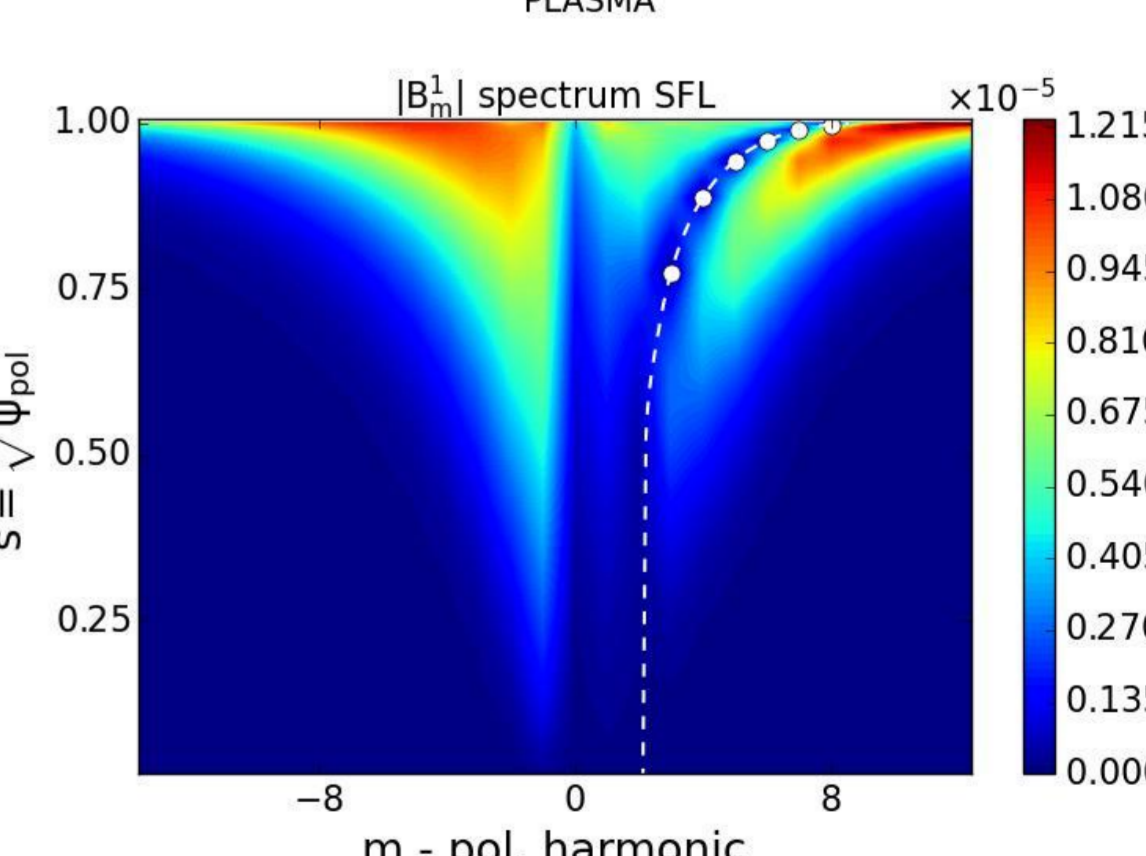
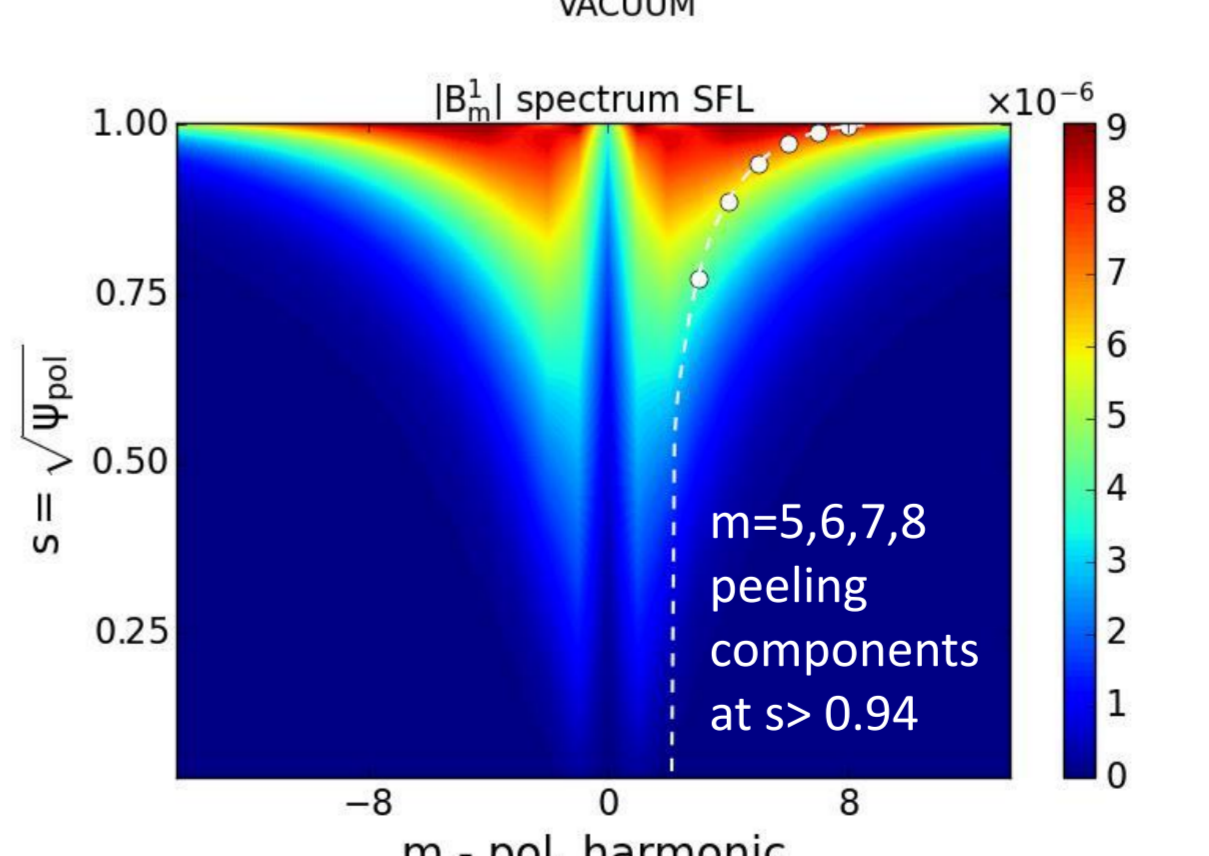
- Ideal wall lying on the plasma surface, like in JOREK fixed boundary DTT simulations

- No flow effects
- JETTO-JINTRAC temperature, density and rotation profiles [9]
- Spitzer resistivity profile (target amplitude on axis)



5. Plasma response and RMP spectrum optimization with MARS-F

Plasma response to RMP perturbations with n=1,2,3: in all cases, the RMP screening effect is clearly visible at the resonant surfaces in the plasma response spectra. In the n=2 case, only the m=8 component penetrates partially.



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Conclusions

- On JOREK side:**
- The linear stability with $\eta \sim 10 \cdot \eta_{Spitzer}$ was modeled in the DTT full-power scenario and the typical physics of PB modes was unveiled.
 - DTT RMPs geometry was implemented in JOREK via the coupling with STARWALL
- For the future:** 1) Destabilization of the equilibria at $\eta_{Spitzer}$ (see left)
2) The optimized RMPs shall be included in the modeling to study their impact on PB stability.

On MARS-F side:

The optimized coil current values and phasing between the RMP coil arrays were provided through MARS-F plasma response simulations for DTT.

For the future: An analysis in terms of dependence on the plasma toroidal rotation profile is planned (here $\Omega_{axis} = 0.01\Omega_{edge}$)