Studies of Alfvénic modes in DTT positive and negative triangularity equilibria using HYMAGYC

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Milestones, Deliverables for HYMAGYC

Deliverable 2: Interpretive and predictive tools regarding NT stability in terms of MHD (e.g., β- and current limits, both global and in the pedestal) and extended MHD (e.g., exploring kinetic and plasma compressibility effects).

Milestone	Description	Participants	Target date
M2.2.1	Use HYMAGYC to investigate kinetic corrections to MHD	G. Fogaccia	12.2021
M2.2.2	Use HYMAGYC to investigate Alfvénic modes driven by energetic particles, with particular reference to DTT NT equilibria	G. Fogaccia	12.2023
M2.2.3	Use HYMAGYC to investigate the kinetic effects of energetic particles and core ions on the renormalized plasma inertia (compressibility) in scenarios of interest to plasmas close to ignition	G. Fogaccia	12.2025

Deliverable	Description	Participants	Target date
D2.2	Report on MHD stability properties of NT equilibria, including non-ideal effects in NT DTT equilibria and pedestal studies	A. Merle, G. Fogaccia	12.2023

Deliverable 5: Predictive capability of the effect of shaping on fast ion confinement.

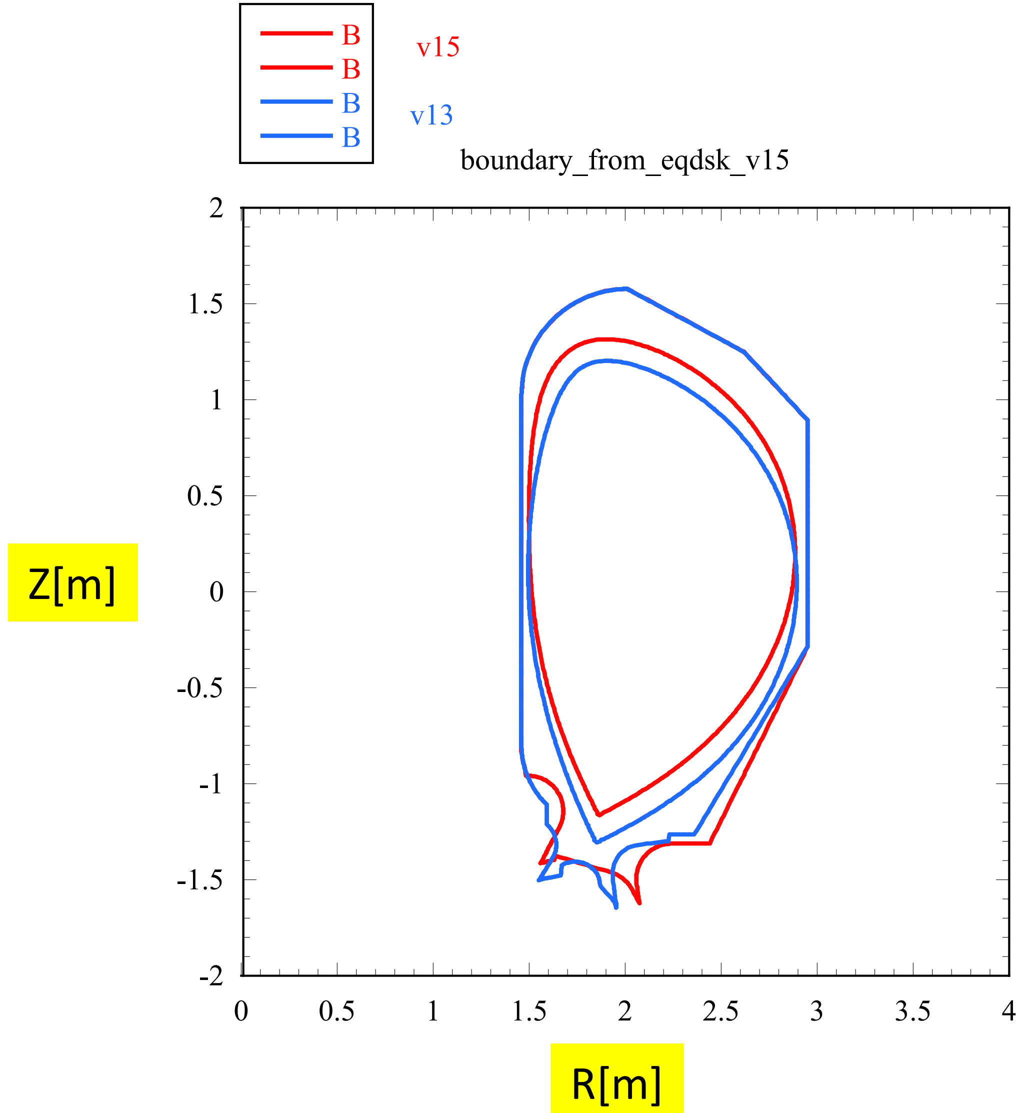
Deliverable	Description	Participants	Target date
D5.2	Report on fast particle confinement and fast particle driven instabilities in NT	M. Vallar, G. Fogaccia	12.2023

DTT new Positive and Negative Triangularity scenarios

The aim of our activity in 2023 is/will be to investigate the MHD stability, in particular the stability of Alfvénic modes driven by energetic particles, in DTT scenarios, with particular reference to the comparison between positive and negative triangularity equilibria.

Recently, a new DTT scenario has been developed, to allow an updated divertor configuration: this new, full power scenario, labelled v15, is a Single Null (SN), Positive Triangularity (PT) one with a cross section shifted upward by approx. 12-14 cm w.r.t. the previous scenarios, and results in an equilibrium with the magnetic axis above the equatorial plane. Among other consequences, this would result in Negative Neutral Beams which will not pass through the plasma center, and, thus, in Energetic Particle radial density profiles peaked off-axis.

DTT new Positive and Negative Triangularity scenarios



DTT new Positive and Negative Triangularity scenarios

Here, v13 vs. v14
(quite similar to v15)

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Interaction of high-energy neutral beams with Divertor Tokamak Test plasma

P. Vincenzi [a,b,*], P. Agostinetti [a,b], R. Ambrosino [c,d,e], T. Bolzonella [b], I. Casiraghi [f,g], A. Castaldo [h], C. De Piccoli [i], G. Granucci [g], P. Mantica [g], L. Pigatto [b], A. Snicker [az], M. Vallar [aa]

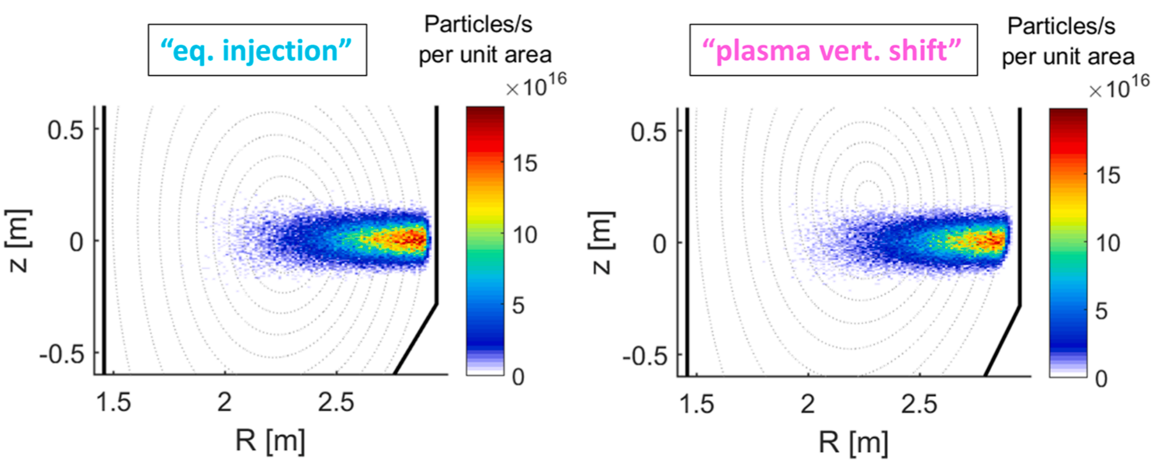


Fig. 4. Poloidal projection of beam ionization flux for the two considered plasma configurations.

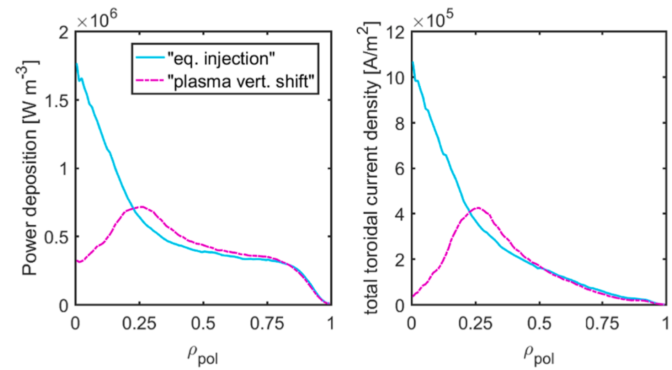
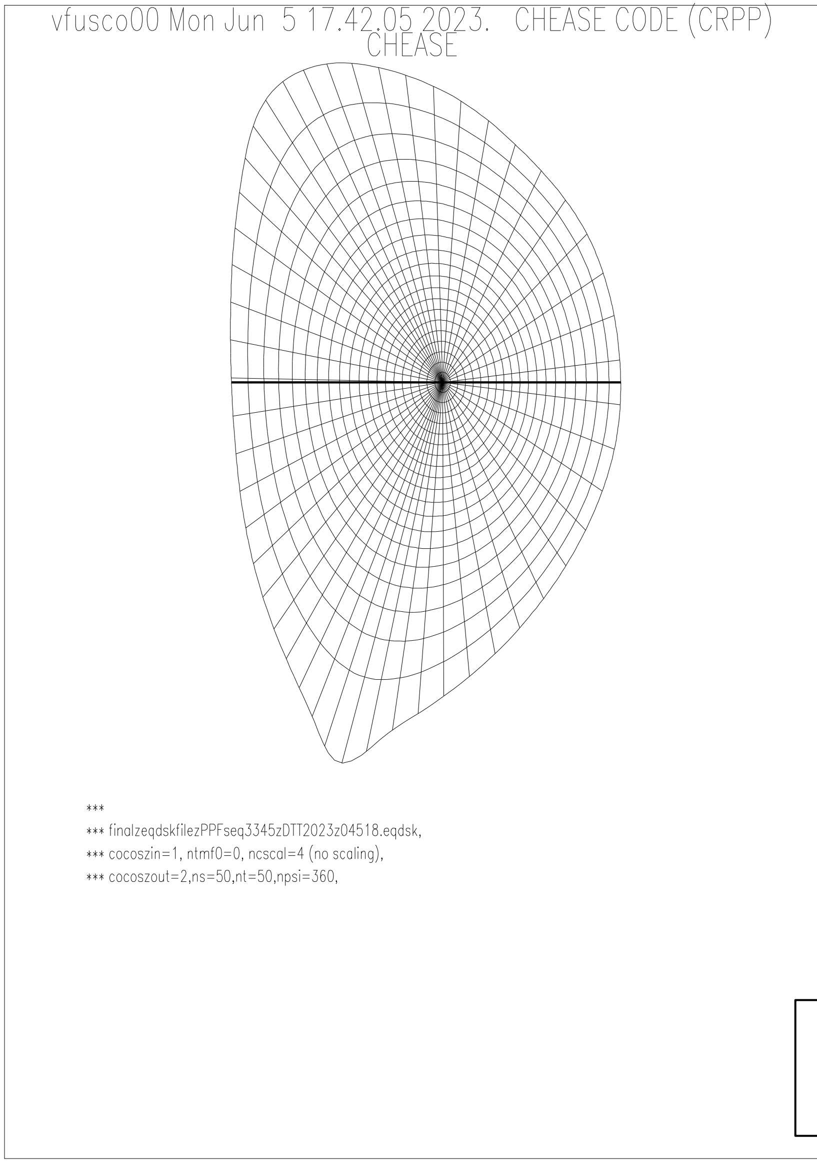
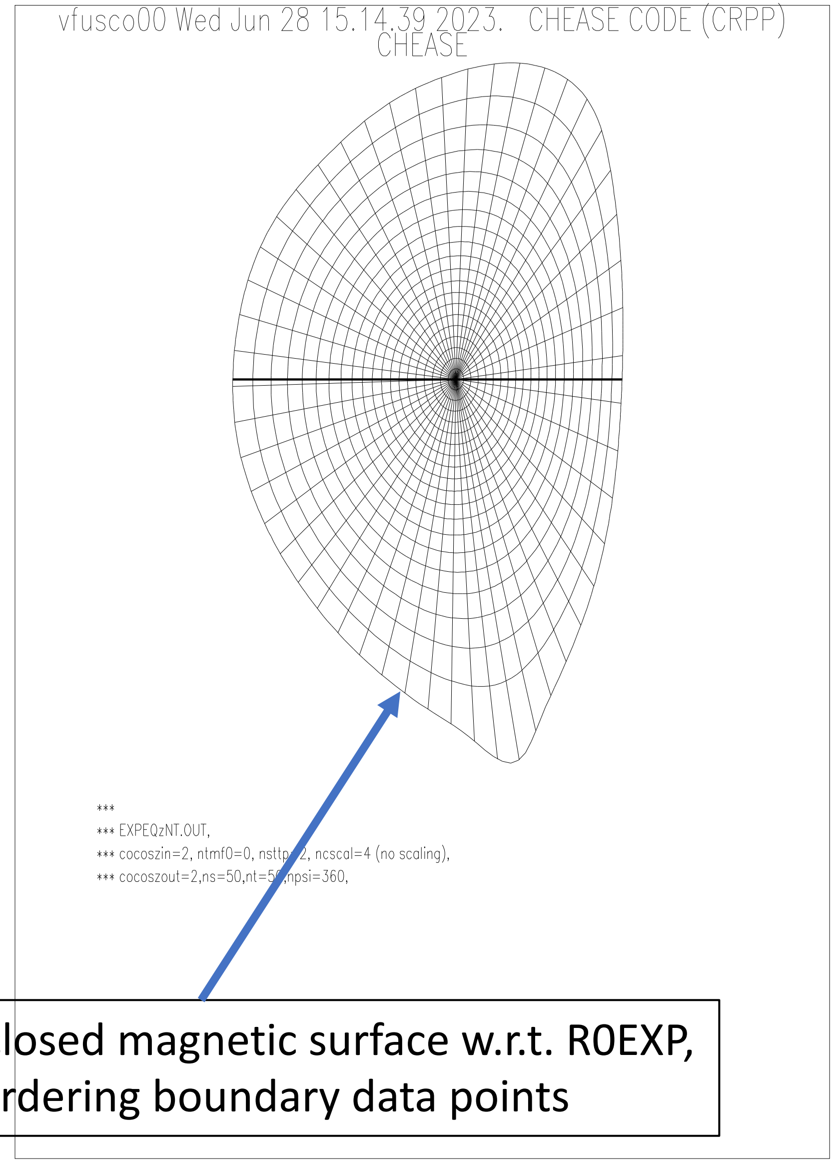


Fig. 5. NBI deposited power density and driven toroidal current density profiles for the two considered plasma configurations.

DTT new Positive and Negative Triangularity scenarios





"Flipped" last closed magnetic surface w.r.t. R0EXP, then reordering boundary data points

DTT new Positive and Negative Triangularity scenarios

Positive Triangularity
v15

R_{axis}= 2.2580m
Z_{axis}= 0.1897m
q_0= 0.6124
q_{edge}= 4.3235

p_0=1.065MPa
I_p= 5.446MA

Beta-axis = 7.115%

Negative Triangularity
flipped (fixed p', I*)

R_{axis}= 2.2931m
Z_{axis}= 0.2010m
q_0= 0.6036
q_{edge}= 2.9984

p_0=1.093MPa
I_p= 5.531MA

Beta-axis = 7.261%

Negative Triangularity
flipped (fixed p', constant-q)

R_{axis}= 2.2985m
Z_{axis}= 0.2032m
q0= 0.6116
q_{edge}= 4.4115

p_0=0.940MPa
I_p= 4.217MA

Beta-axis = 6.427%

DTT new Positive and Negative Triangularity scenarios

Positive Triangularity v15
- R_{axis}= 2.2580m
- Z_{axis}= 0.1897m
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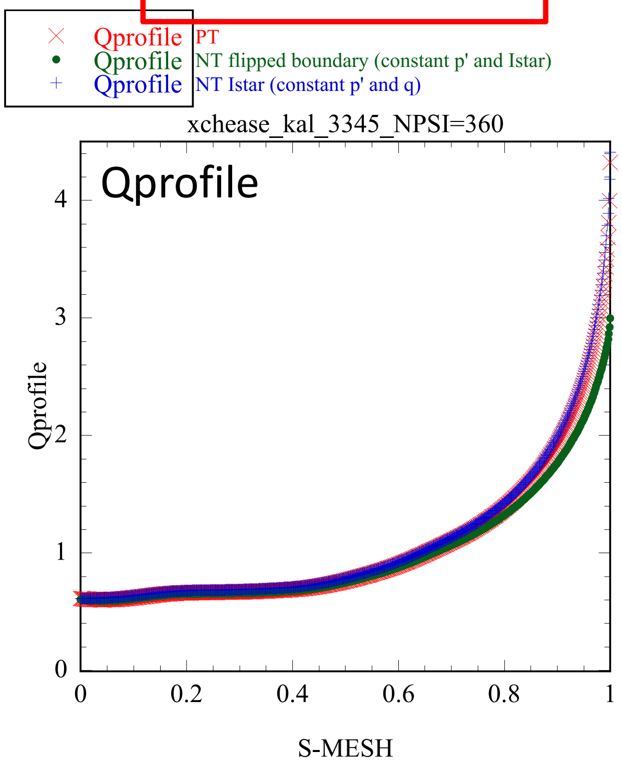
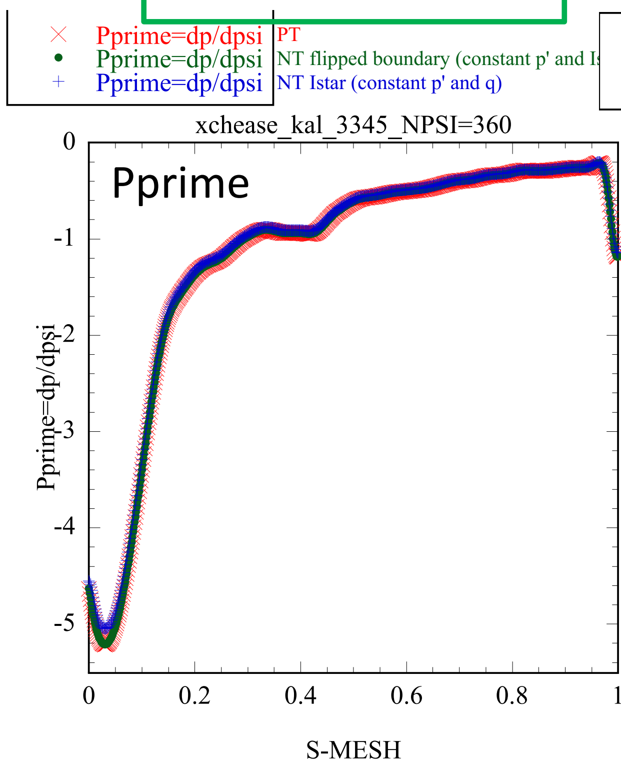
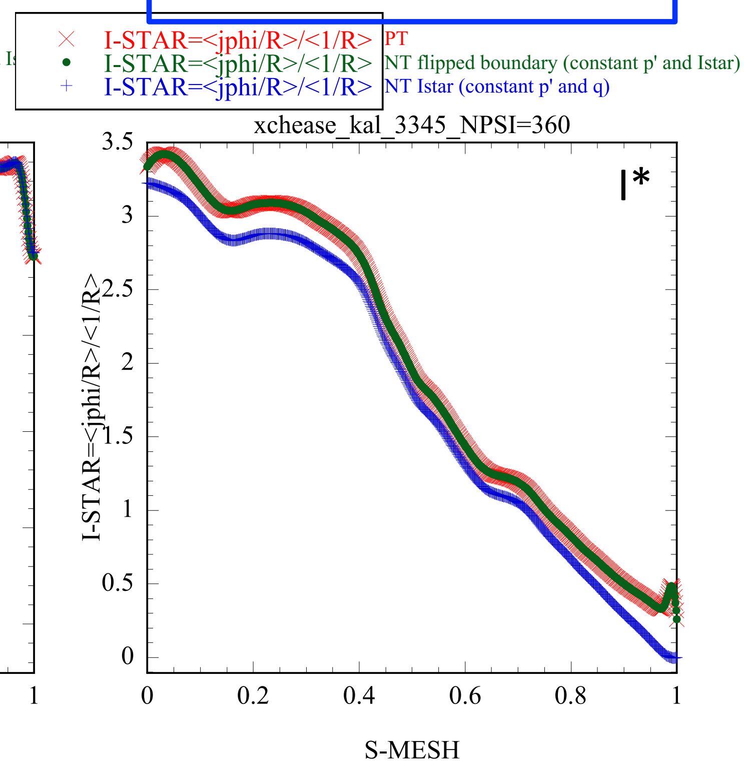
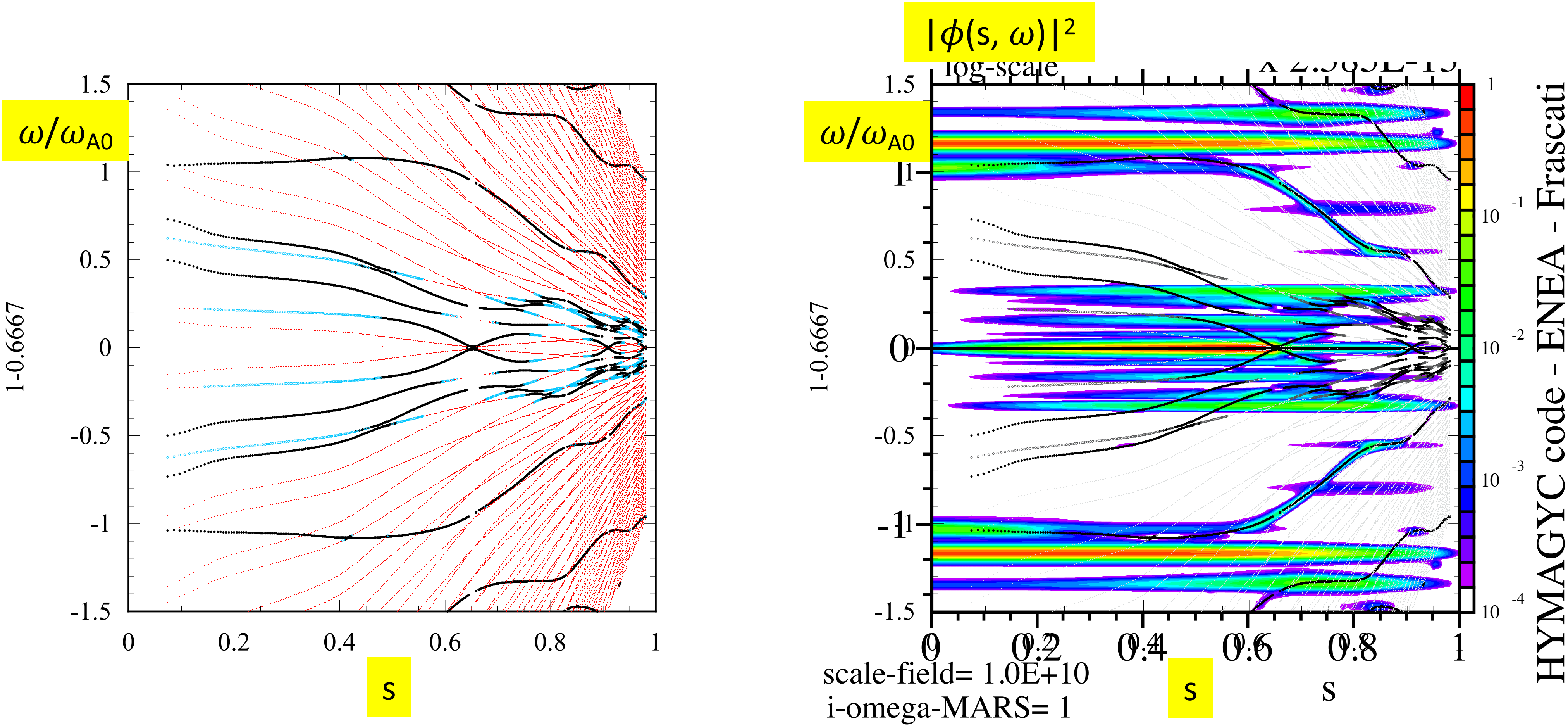






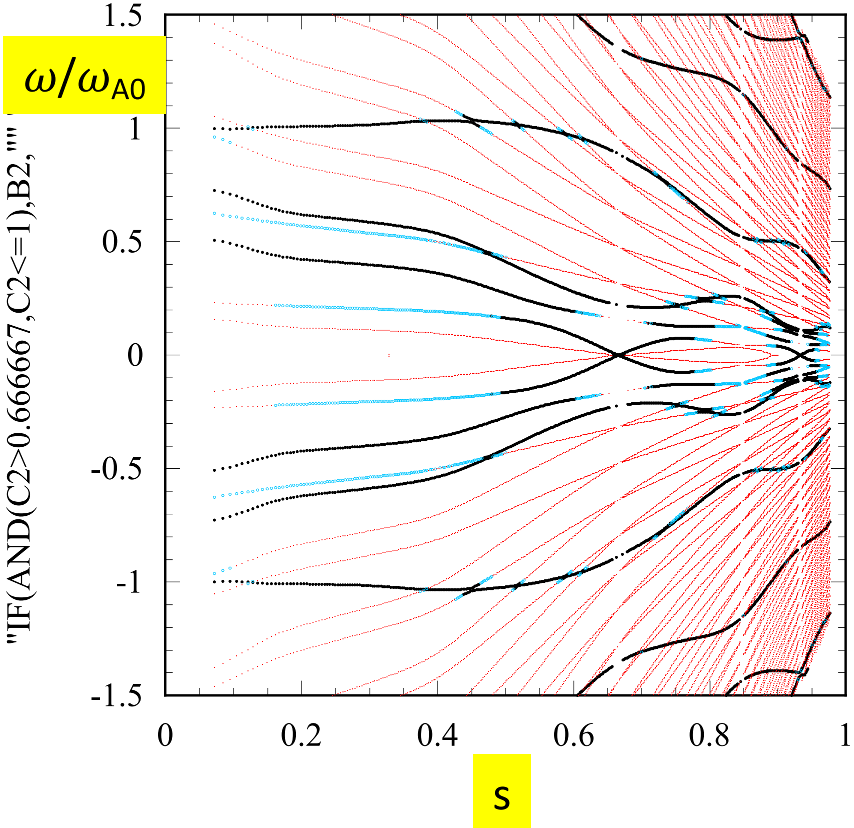
Alfvén continua using FALCON and HYMAGYC: PT

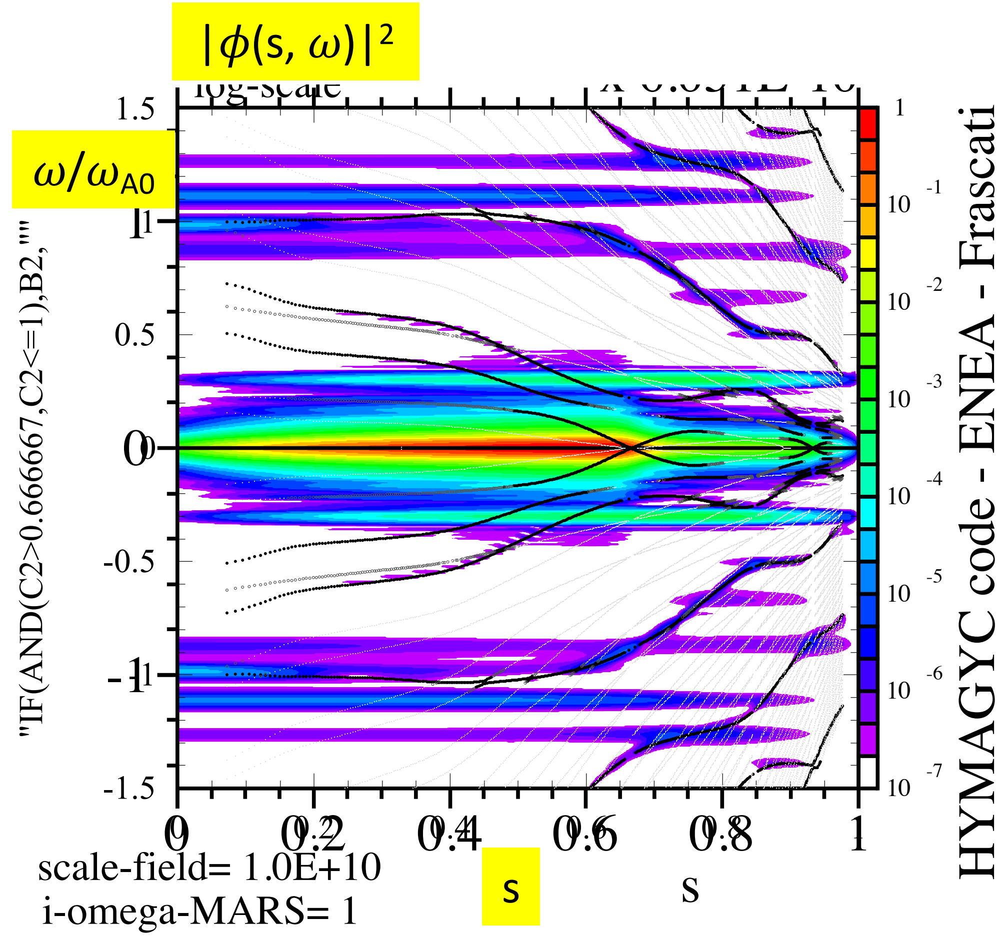
caso_DTT_3345_MHD_n1 HYMAGYC+FALCON:
three intervals for Alfvénicity: 1-0.6667; 0.6667-0.3334; 0.3334-0.



Alfvén continua using FALCON and HYMAGYC: NT, fixed p’, I*

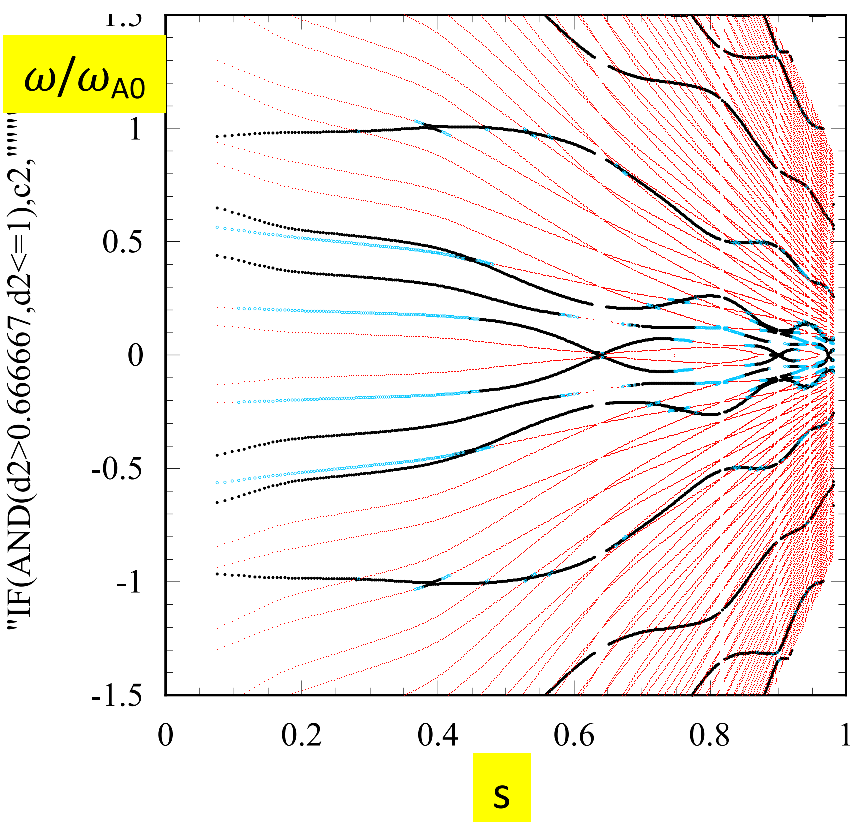
caso_DTT_3345_MHD_n1_NT HYMAGYC+FALCON:
three intervals for Alfvénicity: 1-0.6667; 0.6667-0.3334; 0.3334-0.

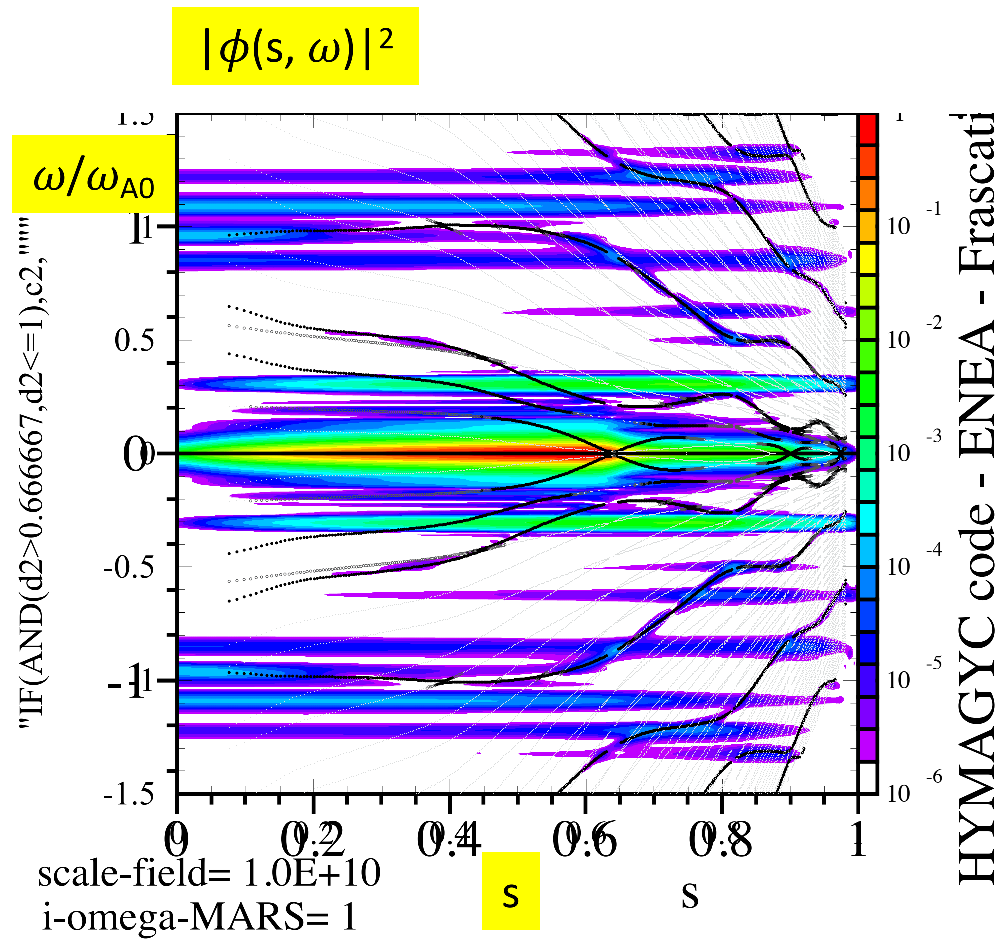




Alfvén continua using FALCON and HYMAGYC: NT. fixed p’, constant-q

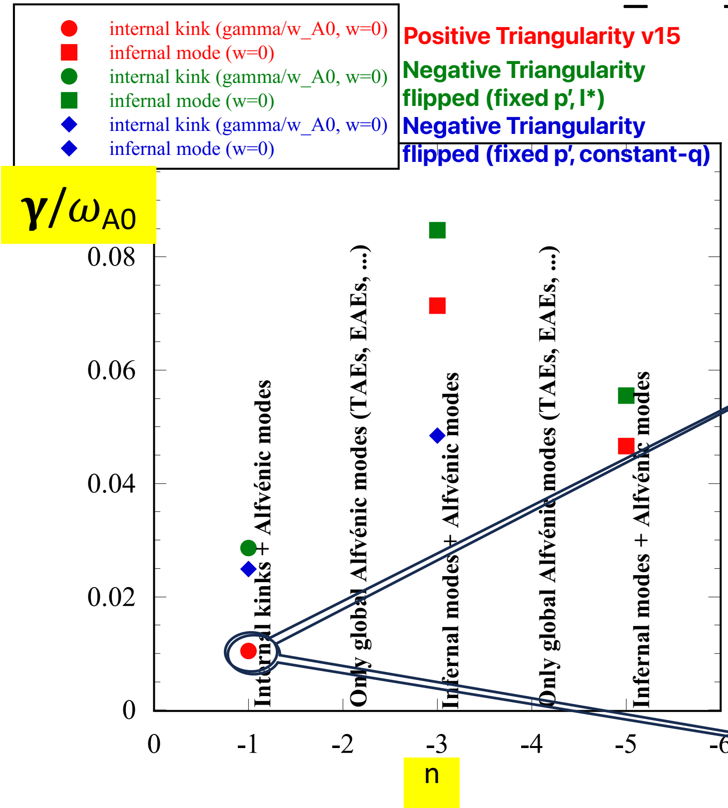
caso_DTT_3345_MHD_n1_NT_Istar_constant_q HYMAGYC+FALCON:
three intervals for Alfvénicity: 1-0.6667; 0.6667-0.3334; 0.3334-0.

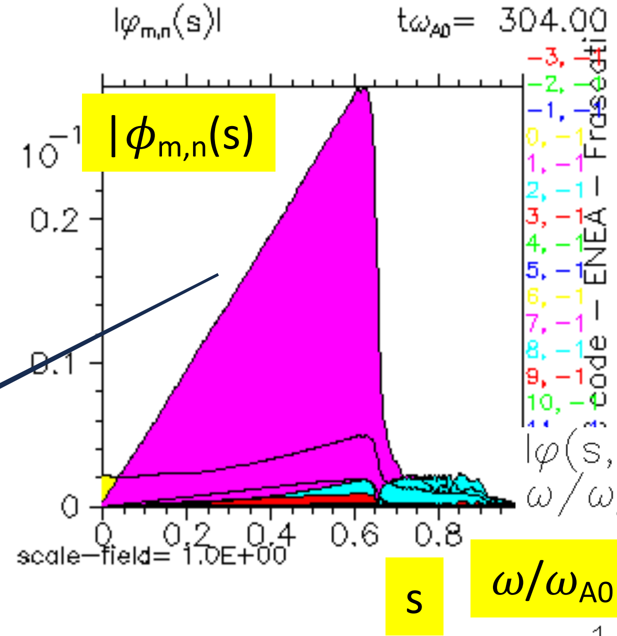


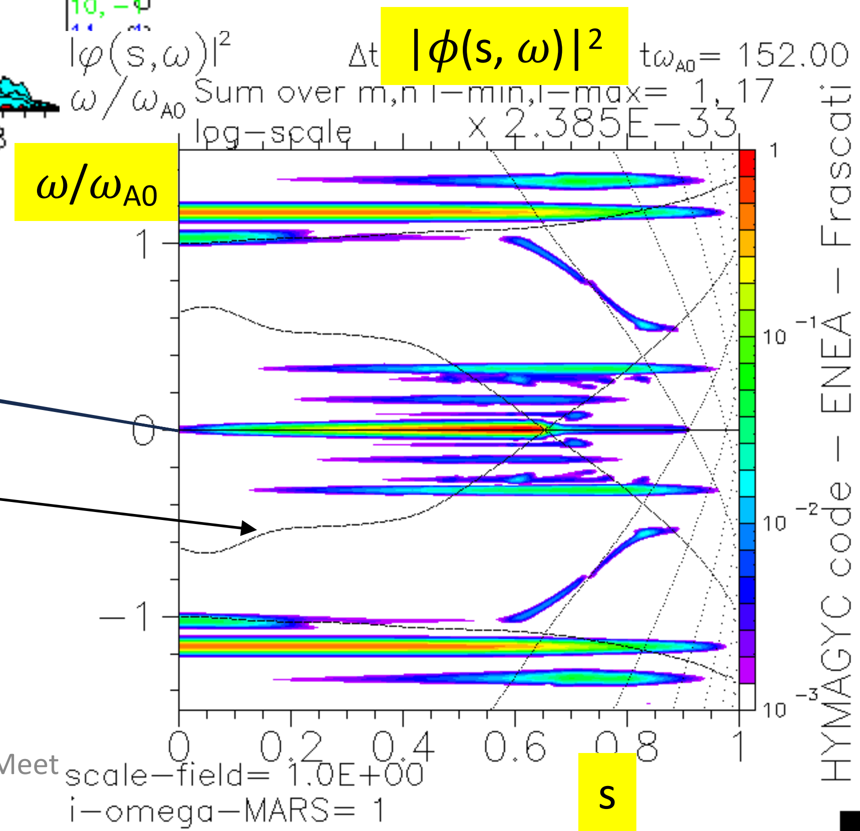


Internal kink, n=-1: PT

caso_DTT_3345_MHD_n1 HYMAGYC (only MHD):



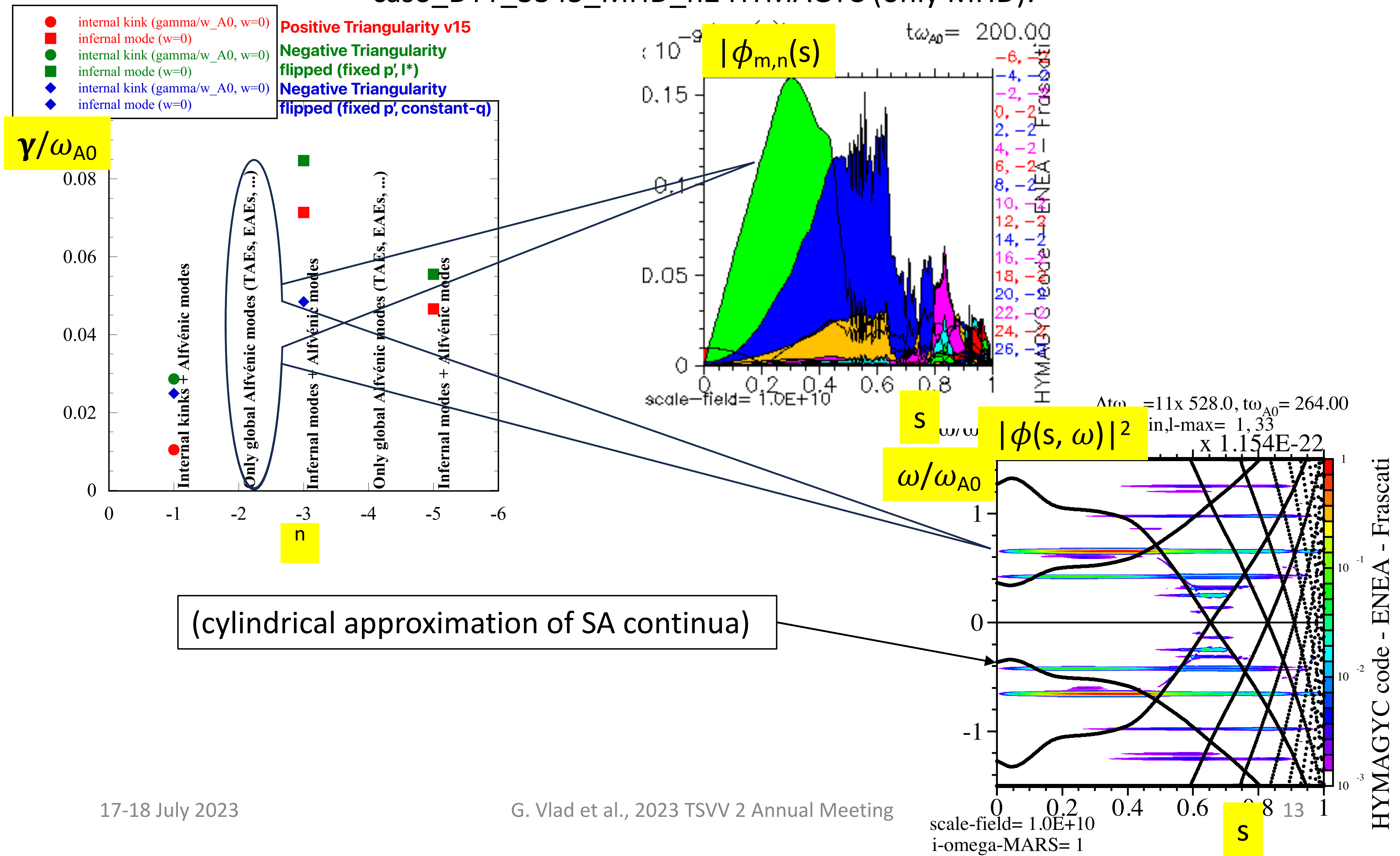




(cylindrical approximation of SA continua)

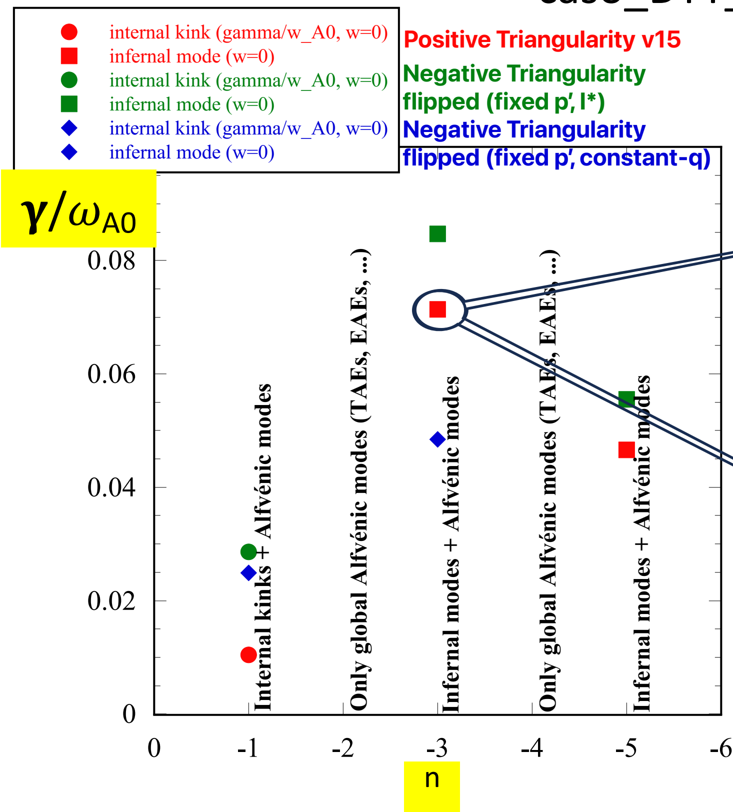
Global Alfvénic modes, n=-2: PT

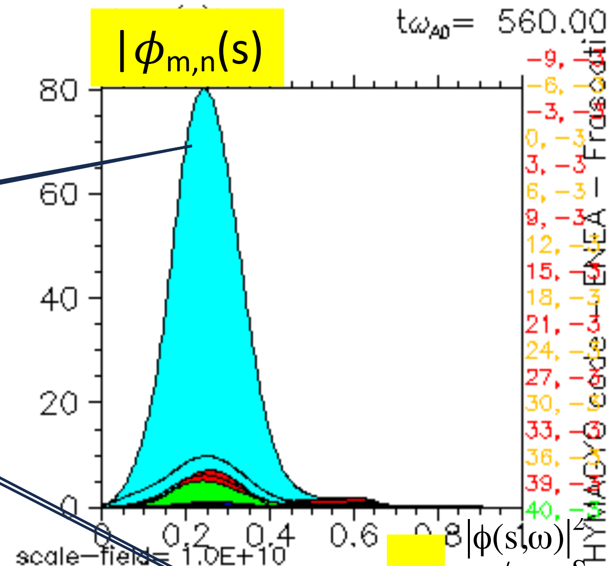
caso_DTT_3345_MHD_n2 HYMAGYC (only MHD):

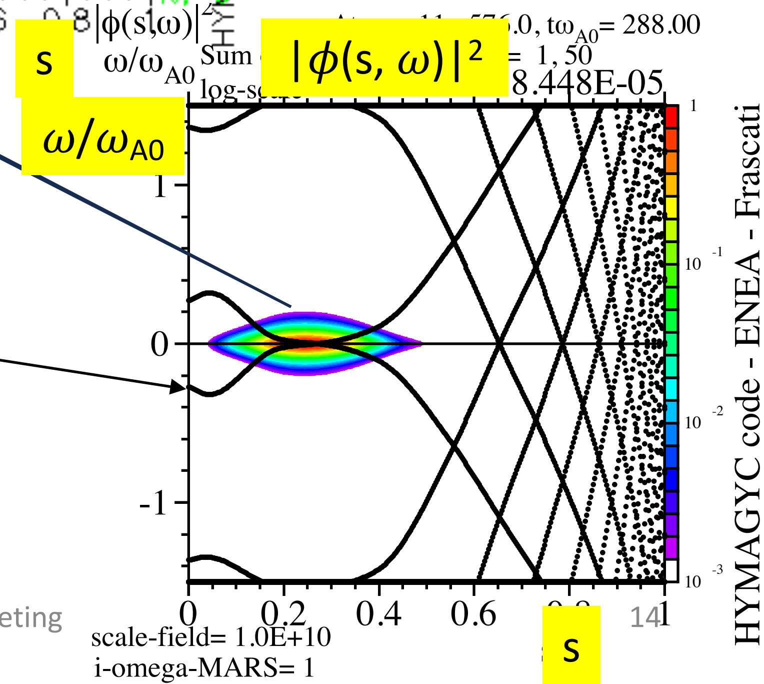


Infernal mode n=-3: PT

caso_DTT_3345_MHD_n3 HYMAGYC (only MHD):



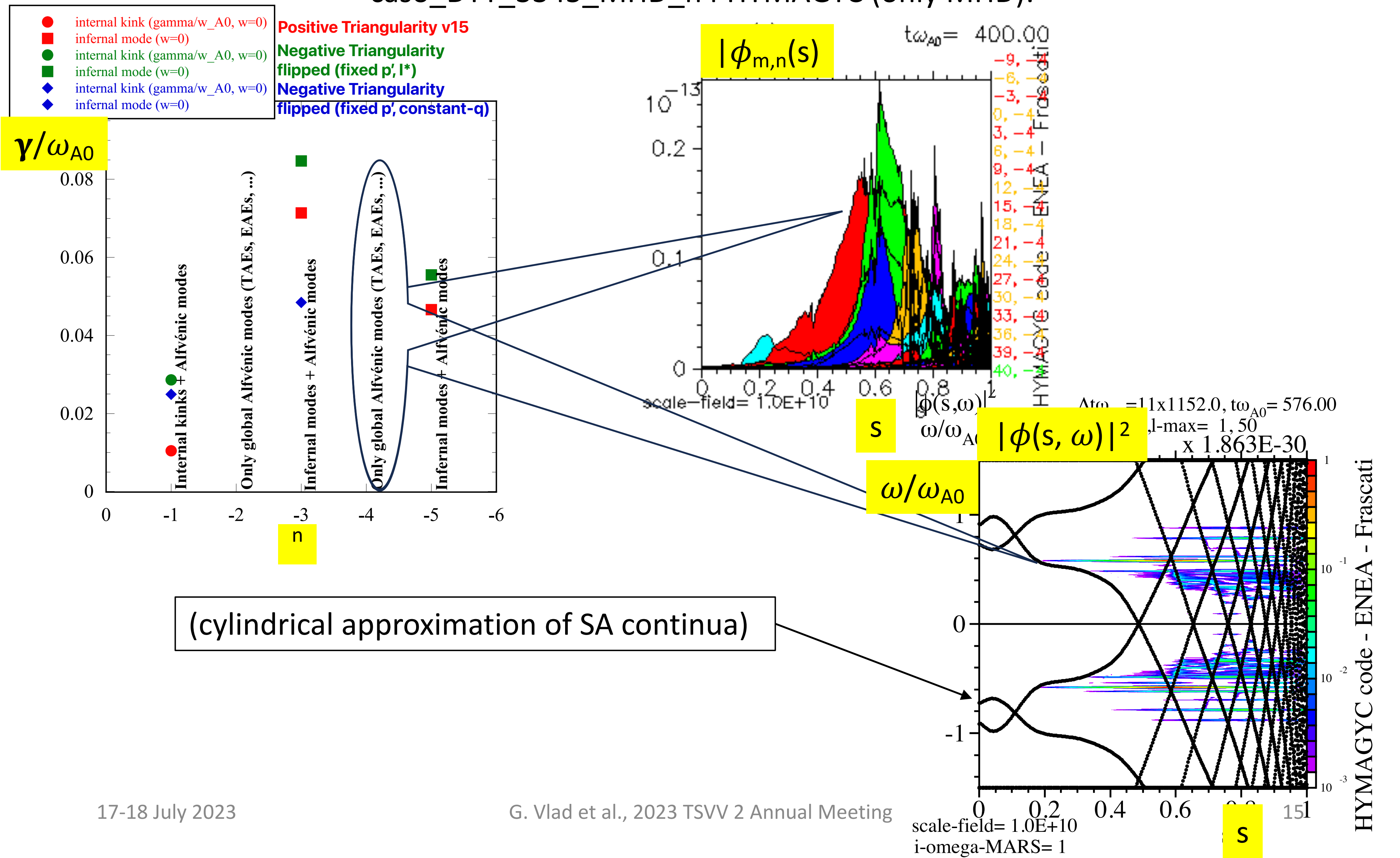




(cylindrical approximation of SA continua)

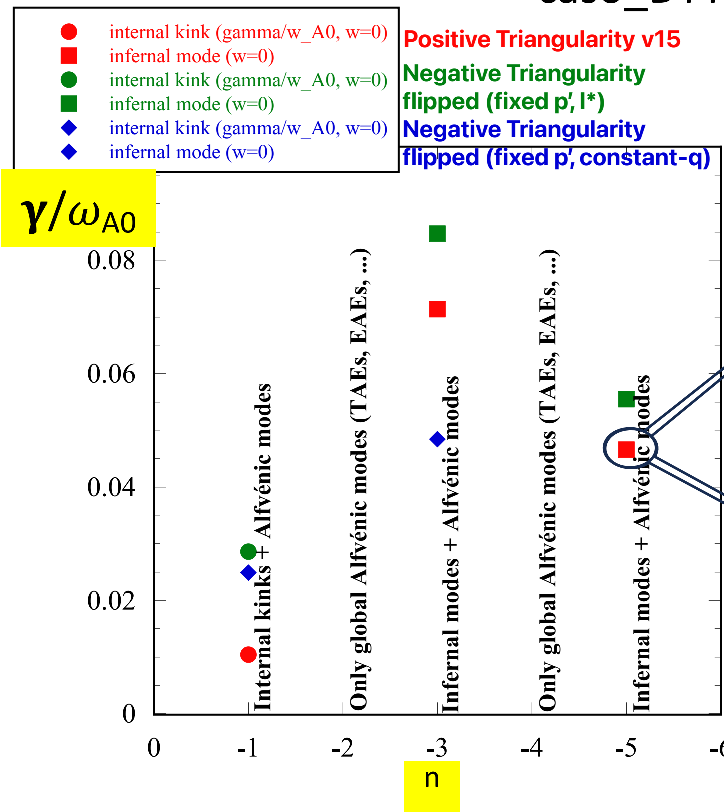
Global Alfvénic modes, n=-4: PT

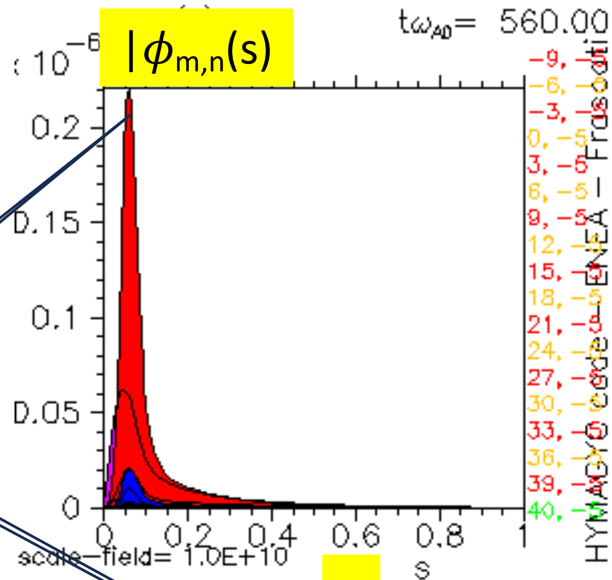
caso_DTT_3345_MHD_n4 HYMAGYC (only MHD):



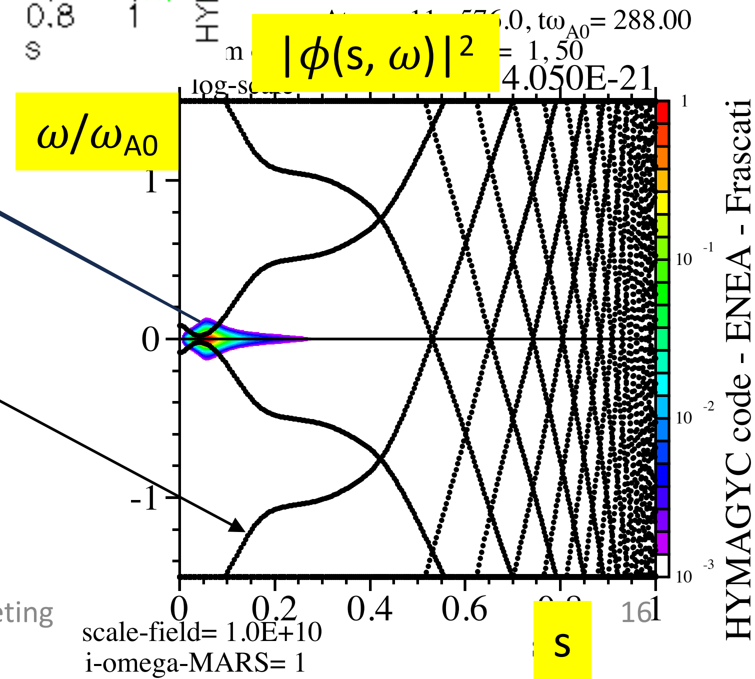
Infernal mode n=-5: PT

caso_DTT_3345_MHD_n5 HYMAGYC (only MHD):





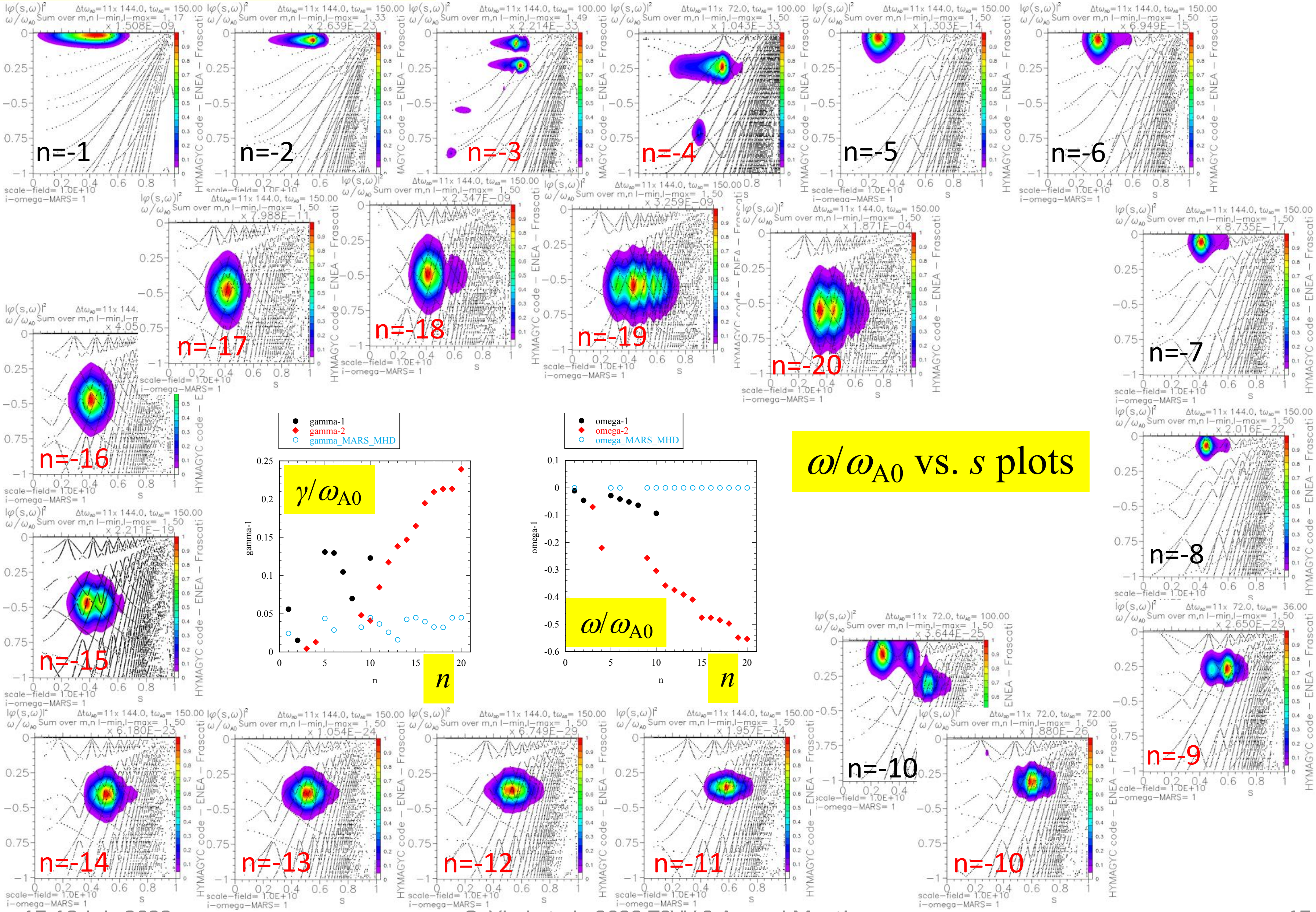
dominant m=3, at q(s)=3/5



(cylindrical approximation of SA continua)

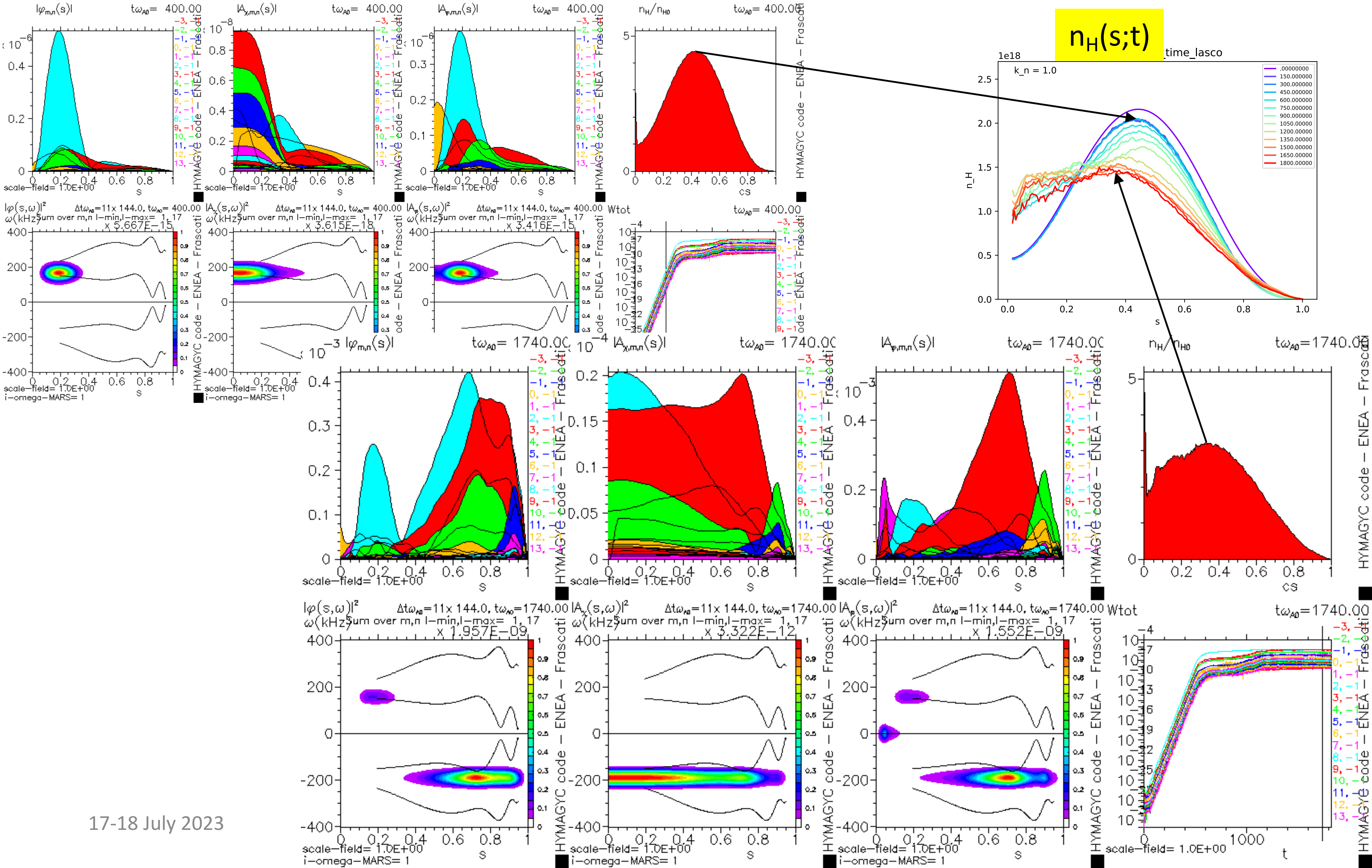
Next add Energetic Particles from NNBI (to be done...)

- Example of old DTT equilibrium, EPs as for ITER case, etc. for modes driven by EPs:



Next add Energetic Particles from NNBI (to be done...)

- Experience in Energetic Particle density profile peaked off-axis (AUG, n=-1, TSVV#10):



New update on using HYMAGYC to explore kinetic effects on MHD modes (2022.10.04)

- Consider two cases: Γ=0 (open symbols in plots), Γ=5/3 (filled symbols in plots)
- Smoothly switching on the kinetic contribution of thermal ions:
  - varying thermal ion density (keeping the thermal ion temperature unchanged)
  - varying thermal ion temperature (keeping the thermal ion density unchanged, thermal ion resonances changes in this latter case…)

Summary plots