EUROfusion

SOL Filamentary transport: update from joint AUG-TCV MST1 experiment

presented by N. Vianello on behalf of MST1-Topic 21 scientific team

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Scientific team

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Motivation and deliverables

- ✓ Relation between downstream divertor conditions and up-stream SOL profiles is not well understood. Influence of SOL blob structures on shoulder formation and divertor conditions is key element towards predictive capabilities. Joint effort within the EUROfusion framework to address this issue on all the MST1 devices (AUG, TCV and MAST-U)

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A series of deliverables are foreseen for 2017-2018 program

1. Cross-machine L-Mode shoulder dependence on current both at constant B_t and at constant q_{95}. Rationale: disentangle the effect of current and parallel connection length
2. Establish robust scenario for density shoulder profile in H-Mode and establish dependence on fuelling/neutral profiles/divertor condition
3. Fluctuations mesurement on AUG to study filamentary transport under high-power H-Mode conditions and under different plasma configurations (SN, DN)
4. Study the role of ELM regimes, neutral compression and particle density in filamentary transport and related shoulder formation
5. Identify the contribution of collisionality and seeding on filamentary transport and related shoulder formation
6. Determine the effect of filaments and shoulder formation on target heat loads in different H-mode plasmas

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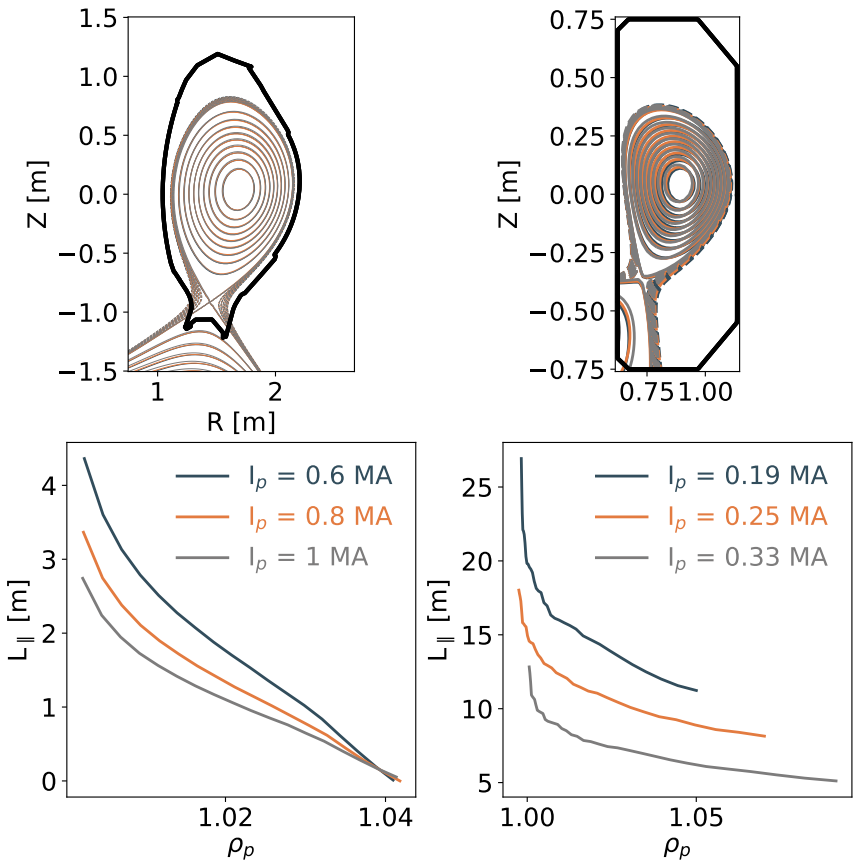
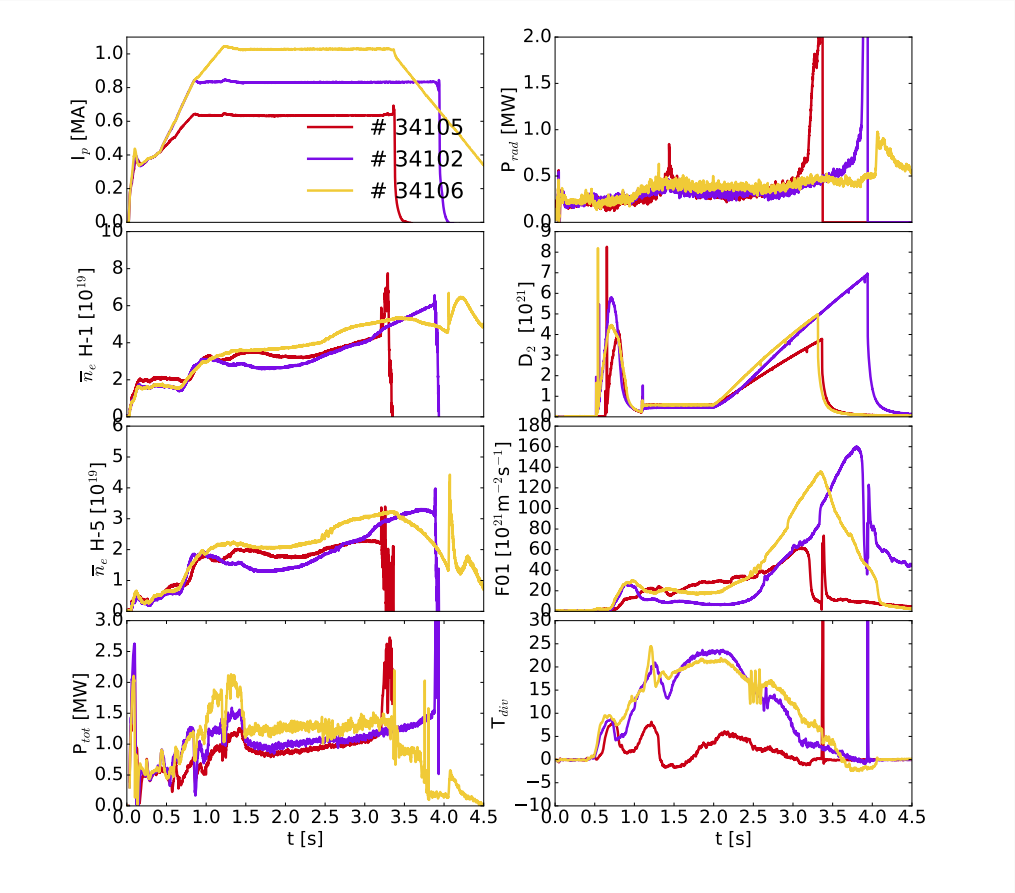
I will report only on few of the deliverables since part of them will be studied in forthcoming campaigns. Remember this is still a work in progress

Current scan at constant B_t in L-Mode plasma



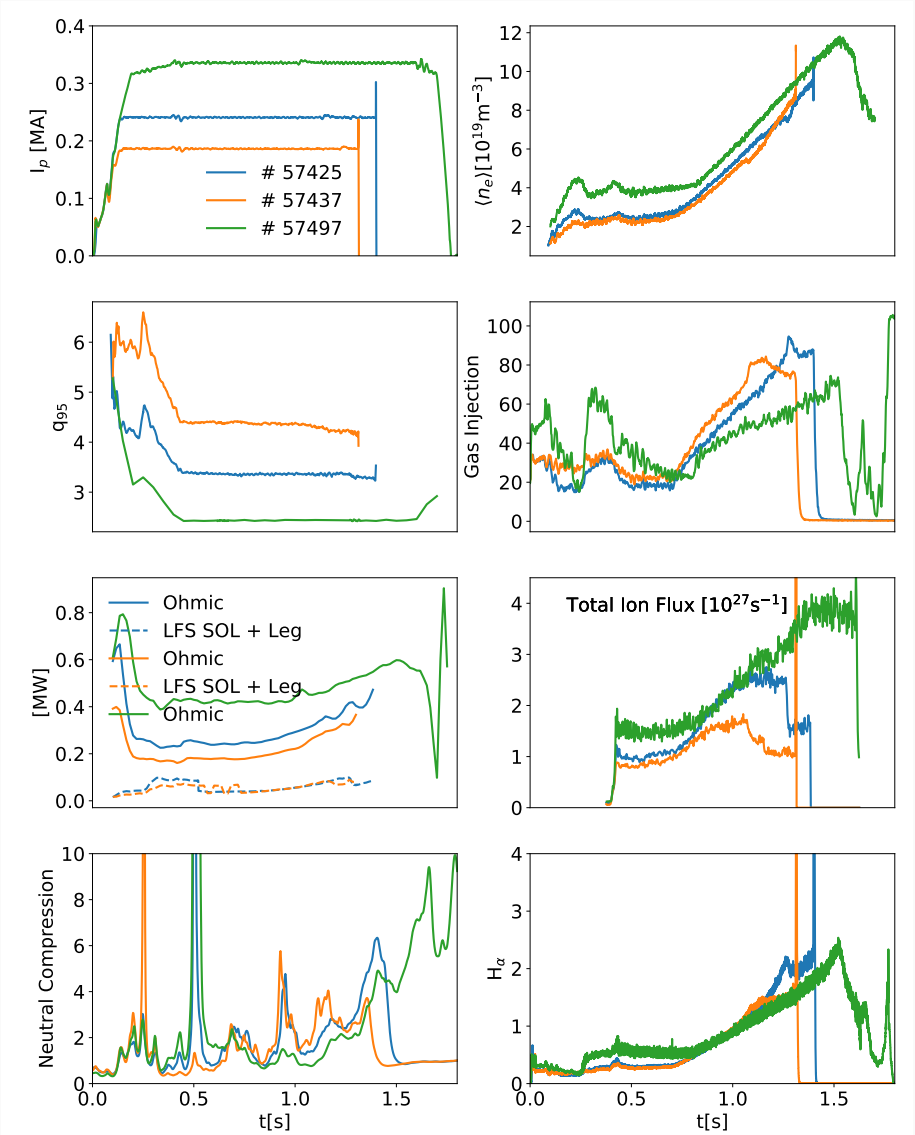
- ✓ Shape matched in within the single scan done for each of the machine
- ✓ The scan implies a modification of the $L_{||}$. AUG exhibit a parallel connection length which is 5 times smaller then TCV

Current scan at constant B_t in L-Mode plasma



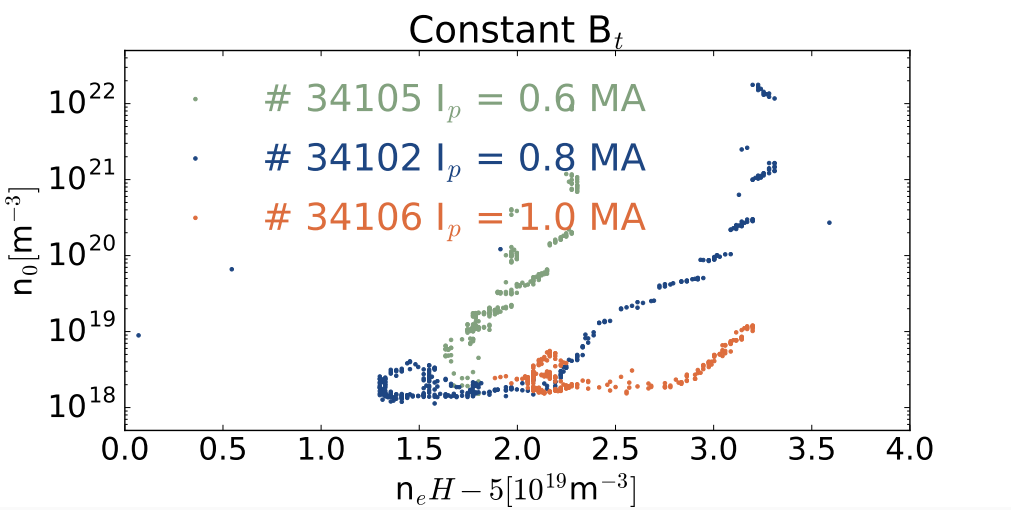
- ✓ AUG: Fueling reduced only at lower I_p to avoid earlier disruption. Similar neutral pressure in the subdivertor region reached. NBI additional power added to keep power in the SOL approximately constant

Current scan at constant B_t in L-Mode plasma



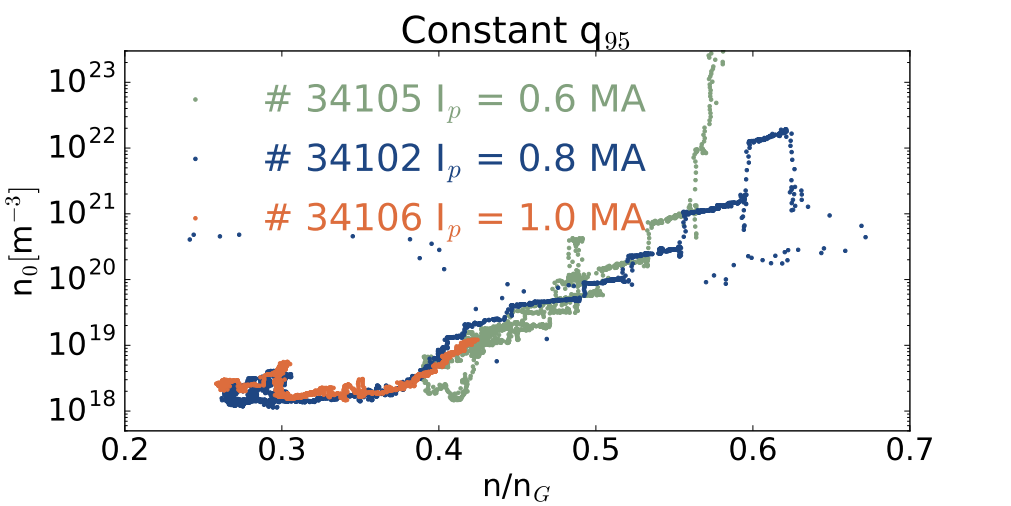
✓ TCV: Ohmic heating only. Similar neutral compression reached and D_α radiation from the floor. Ion flux rollover reached in all the three current, although marginally at 330 kA

Current scan at constant B_t in L-Mode plasma



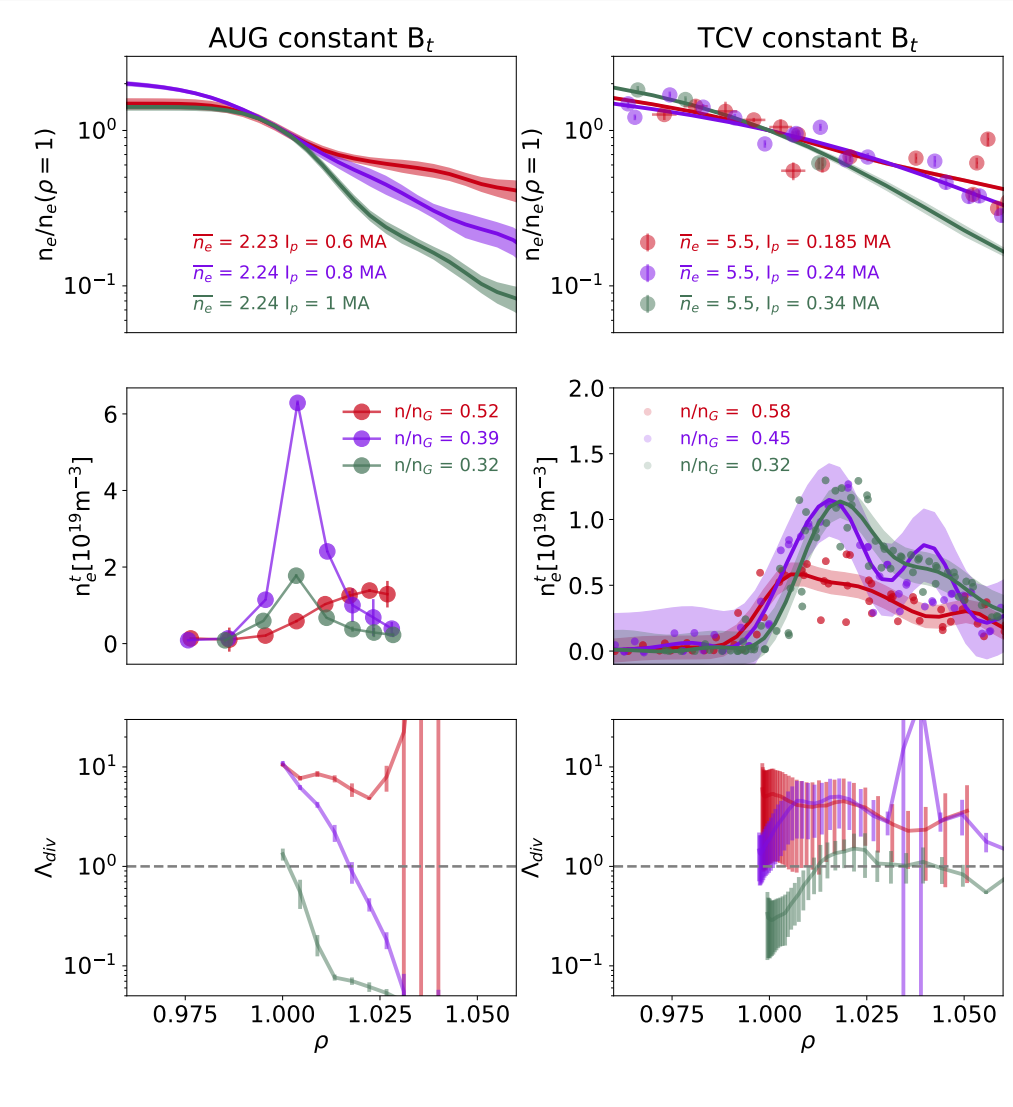
- ✓ AUG: Divertor neutral density estimated starting from D_α calibrated camera and using electron density and temperature from LP data. Neutral density increases earlier in edge density at lower current

Current scan at constant B_t in L-Mode plasma



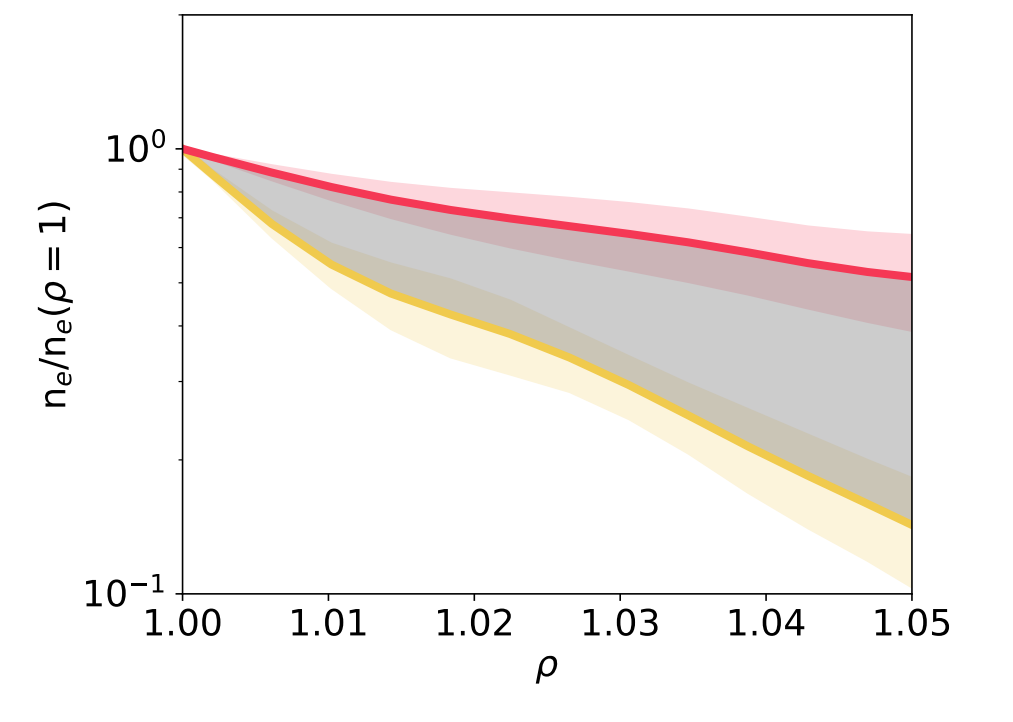
- ✓ AUG: Neutrals behavior reconciled whenever comparison considered as a function of Greenwald fraction

Current scan at constant B_t in L-Mode plasma



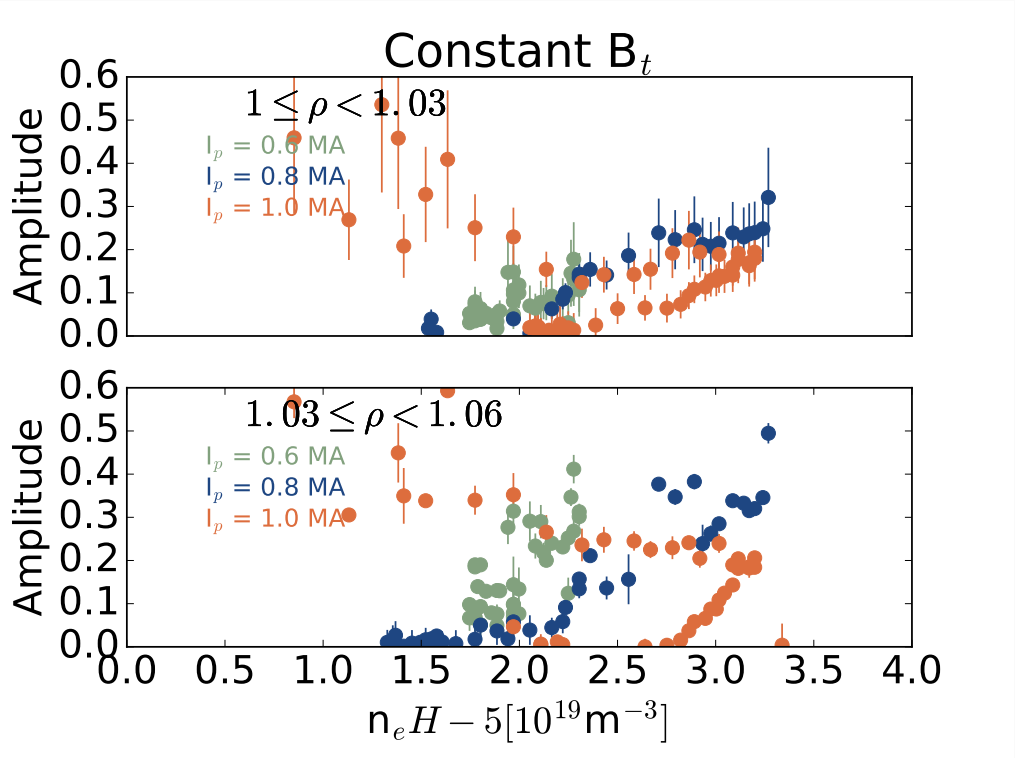
✓ For both AUG and TCV flattening of normalized upstream profile reached earlier in density at lower current. For both the machine the increase of λ_n reached for larger values of divertor collisionality Λ_{div}

Current scan at constant B_t in L-Mode plasma



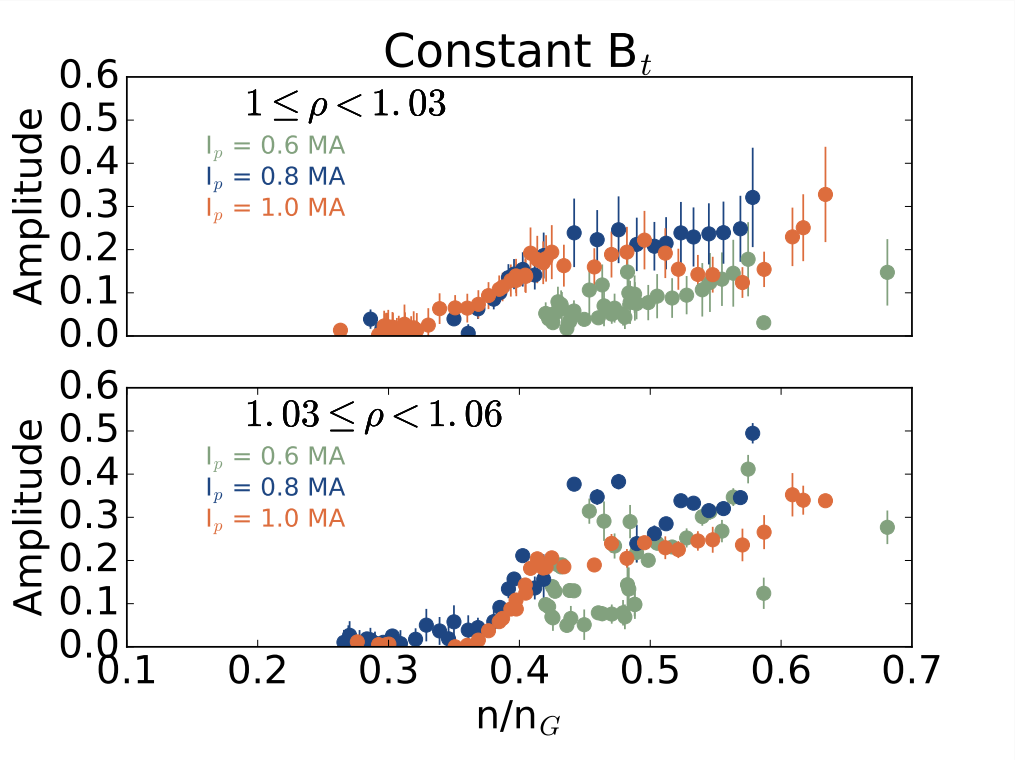
- ✓ Quantifying profile evolution using the shoulder amplitude metric introduce by Wynn and Lipschultz for JET. Amplitude is the difference between normalized upstream density profiles

Current scan at constant B_t in L-Mode plasma



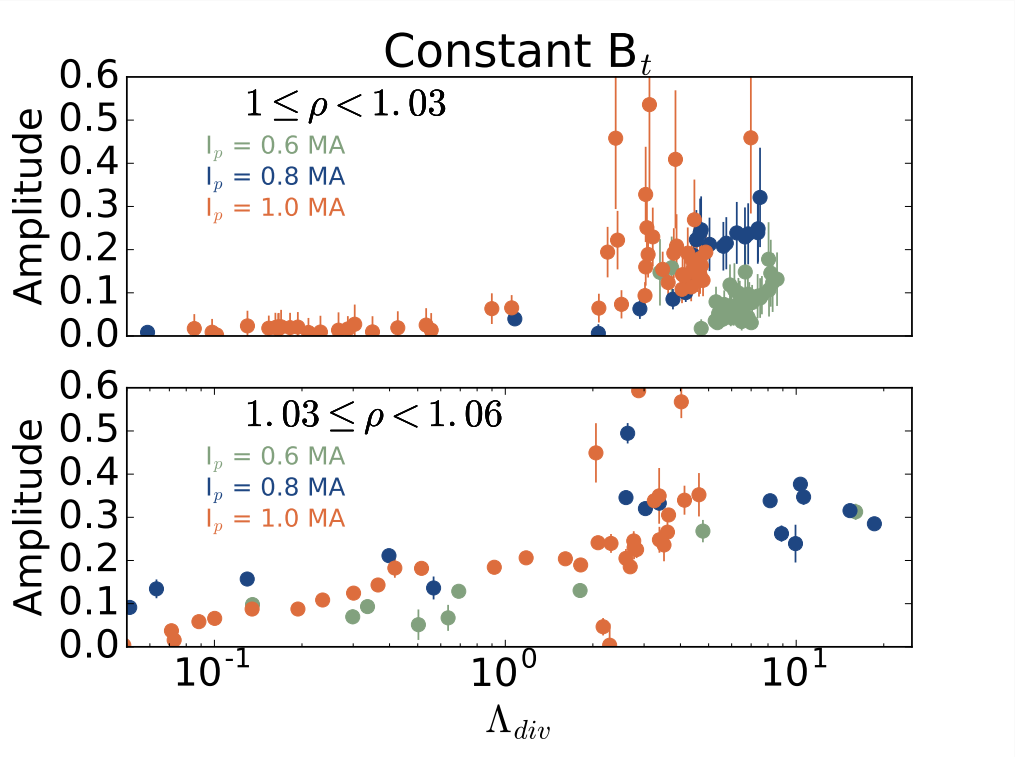
- ✓ Amplitude evolve faster in density at lower current in the far SOL

Current scan at constant B_t in L-Mode plasma



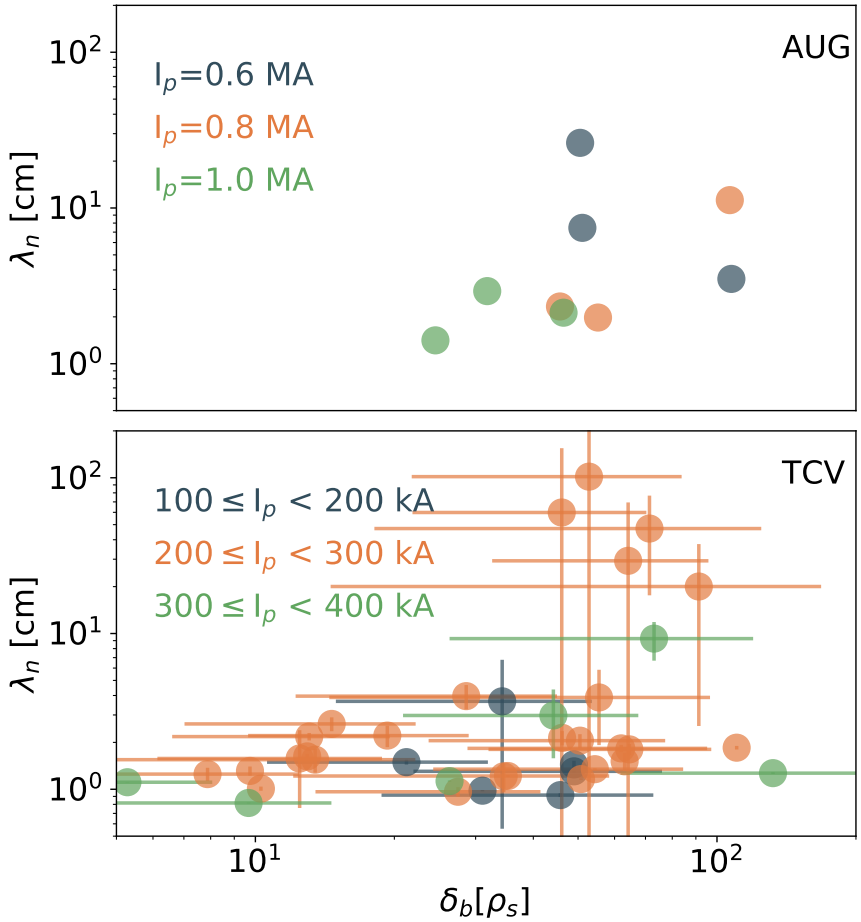
- ✓ Amplitude evolve faster in density at lower current in the far SOL but once evolution *vs* greenwald fraction is considered the evolution is equivalent between different current

Current scan at constant B_t in L-Mode plasma



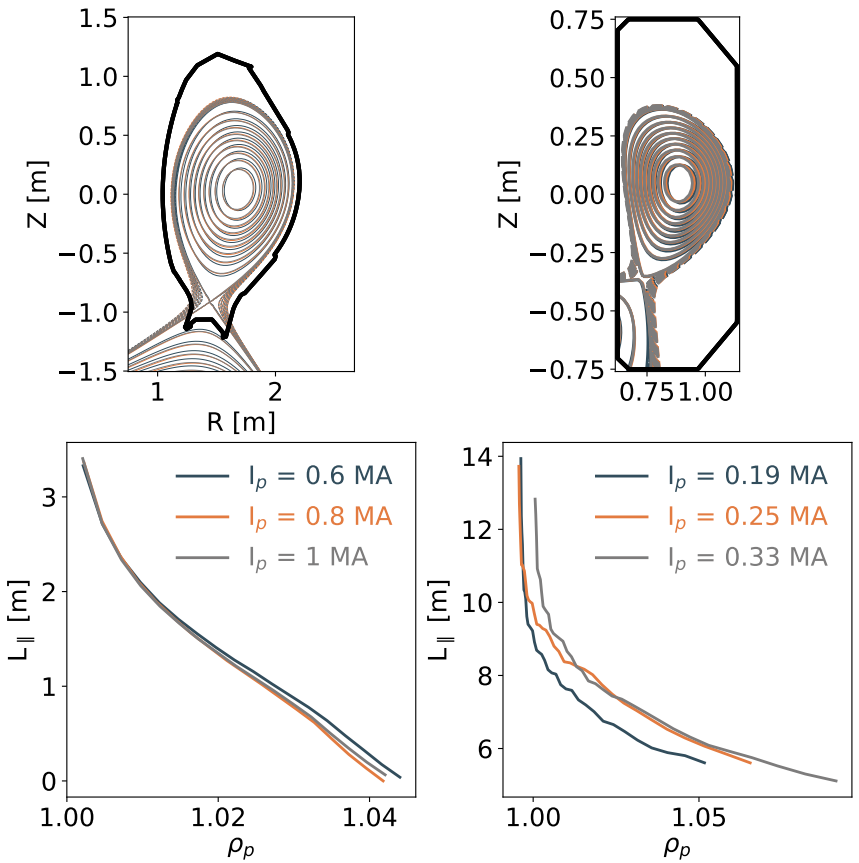
- ✓ Amplitude evolution still reconciled in AUG if considered as a function of local evolution of Λ_{div}

Current scan at constant B_t in L-Mode plasma



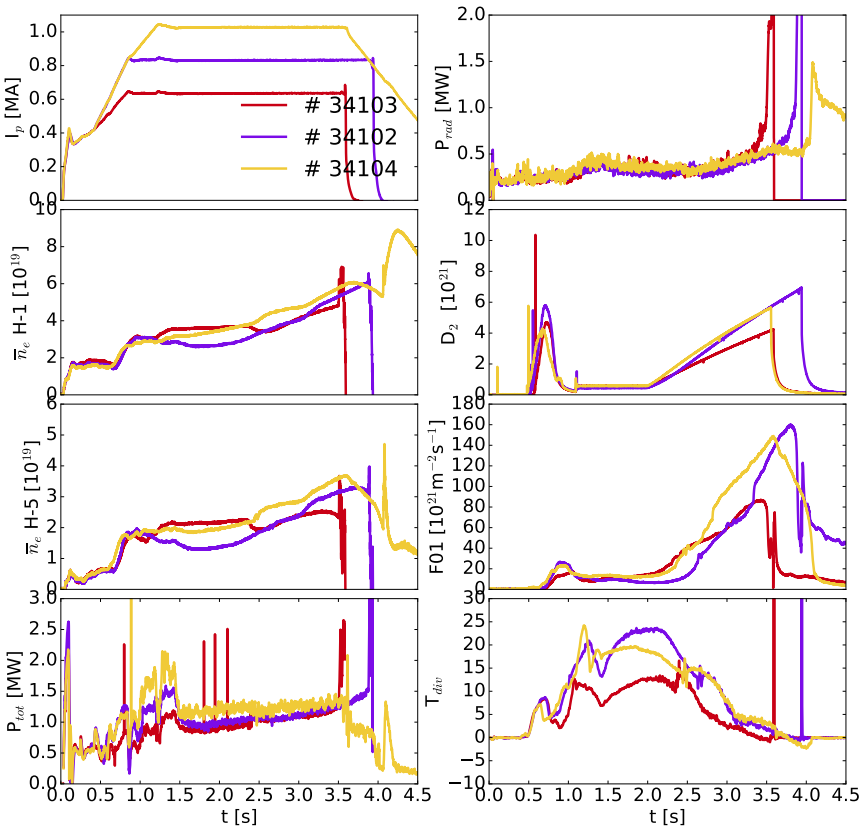
✓ For both AUG and TCV density decay length λ_n increases with blob size without significant difference within the current explored

Current scan at constant q_{95}



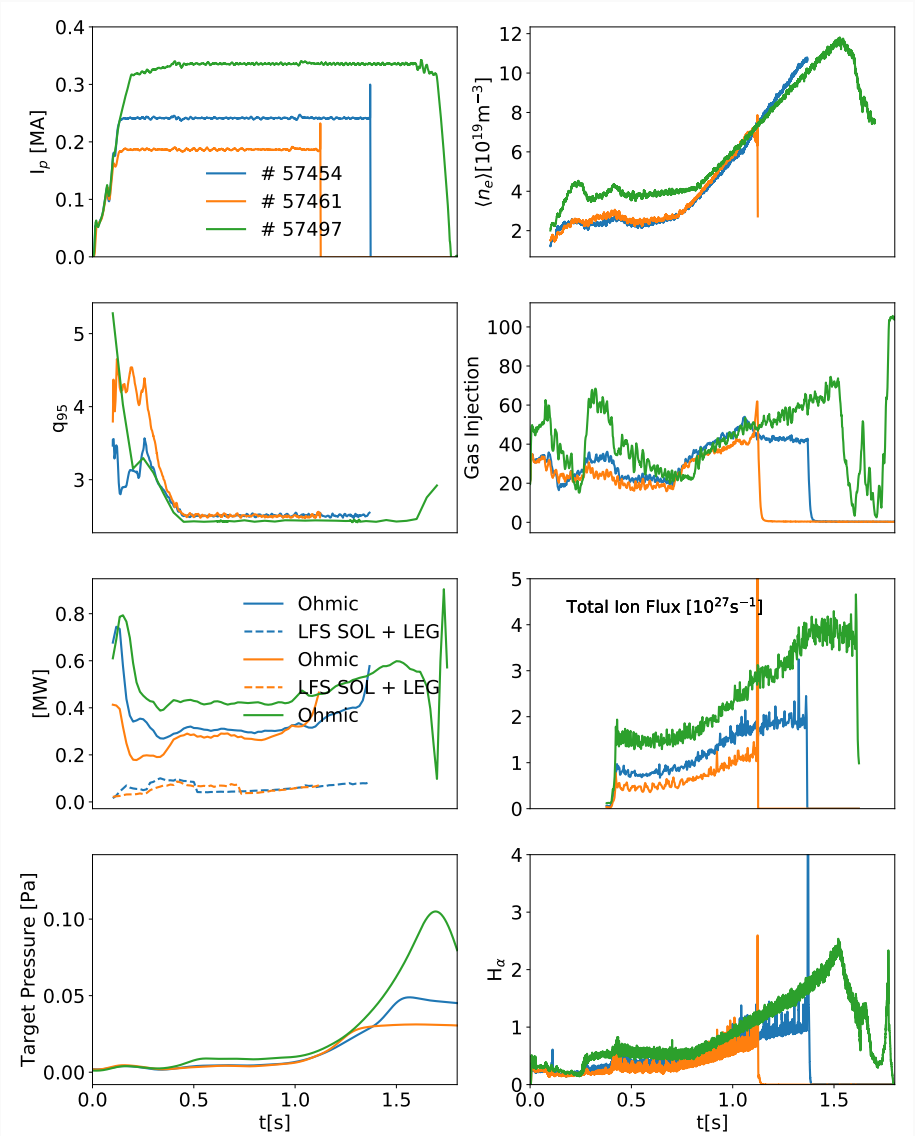
- ✓ Shape matched in within the single scan even though this required for TCV operation with very low toroidal field (0.8T)
- ✓ The parallel connection length remains almost unchanged

Current scan at constant q_{95}



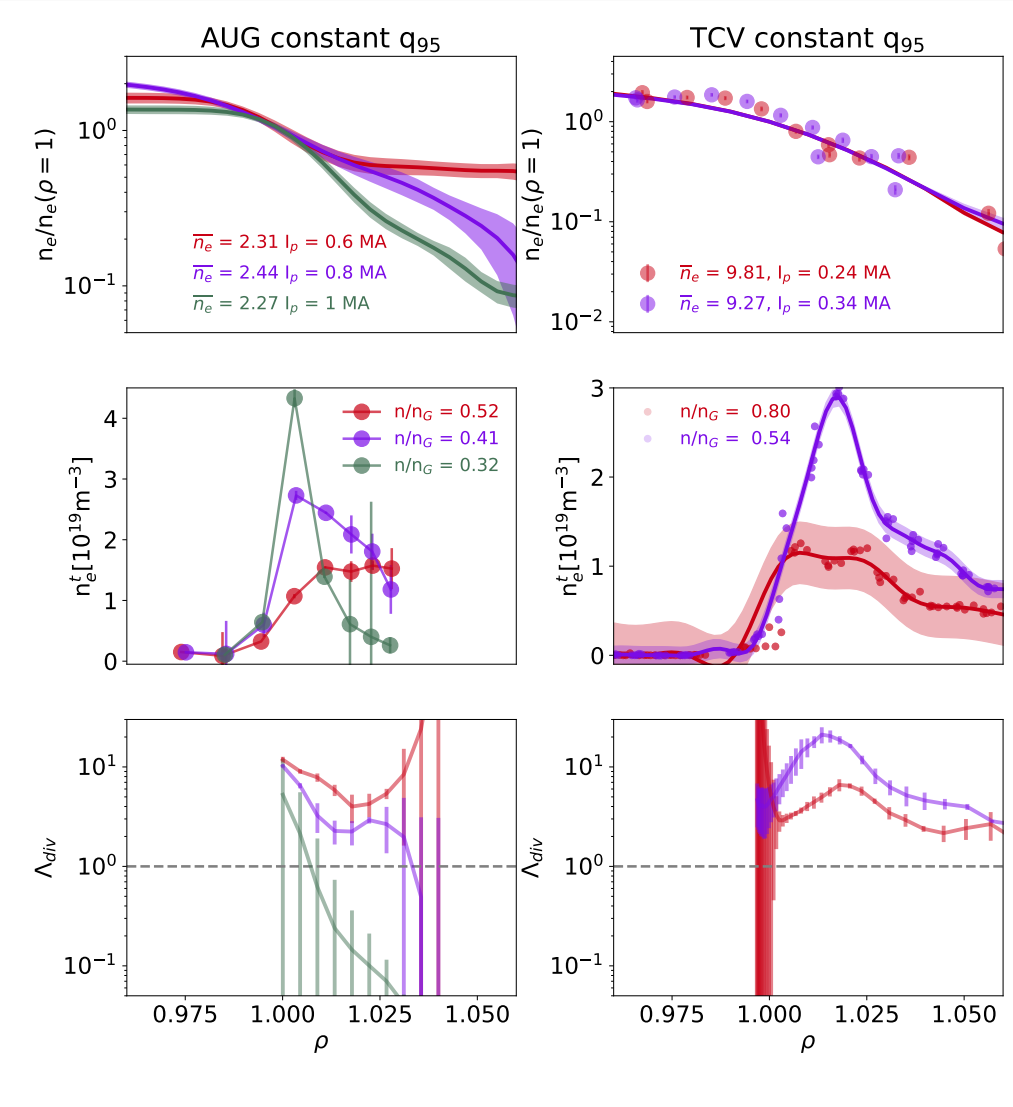
- ✓ AUG: As for the case of constant B_t we have pretty reproducible behavior matching basically the plasma condition in within the current scan

Current scan at constant q_{95}



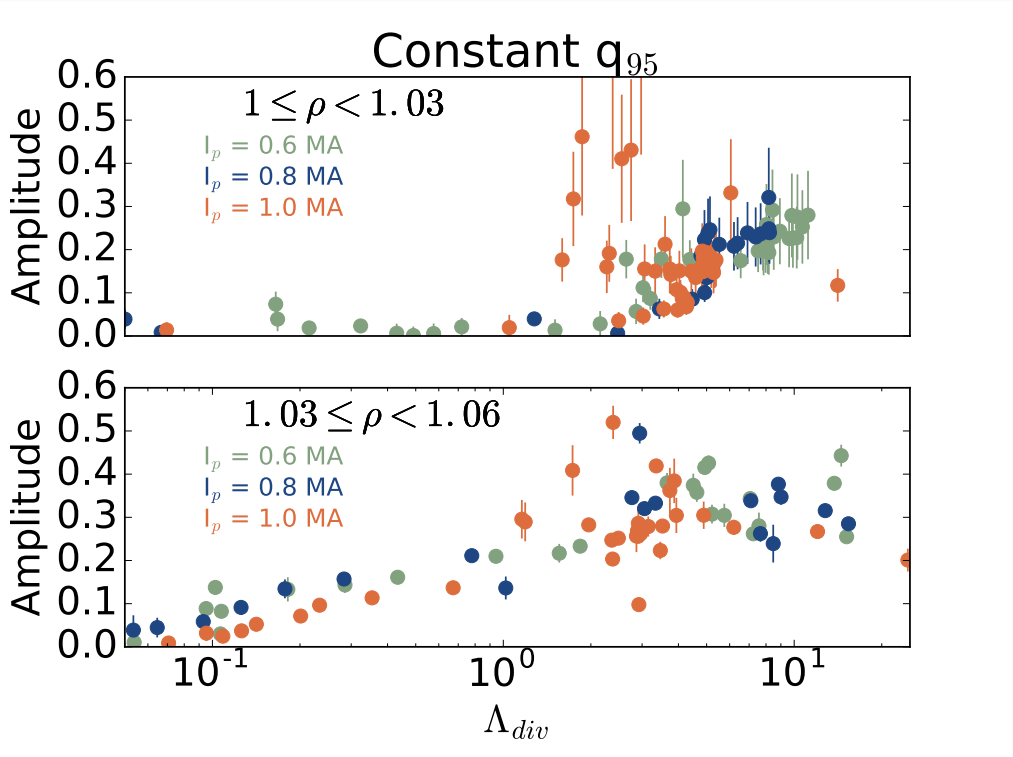
✓ TCV: Even at such an high density at lower current (and lower B_t) no sign of target ion flux rollover/detachment

Current scan at constant q_{95}



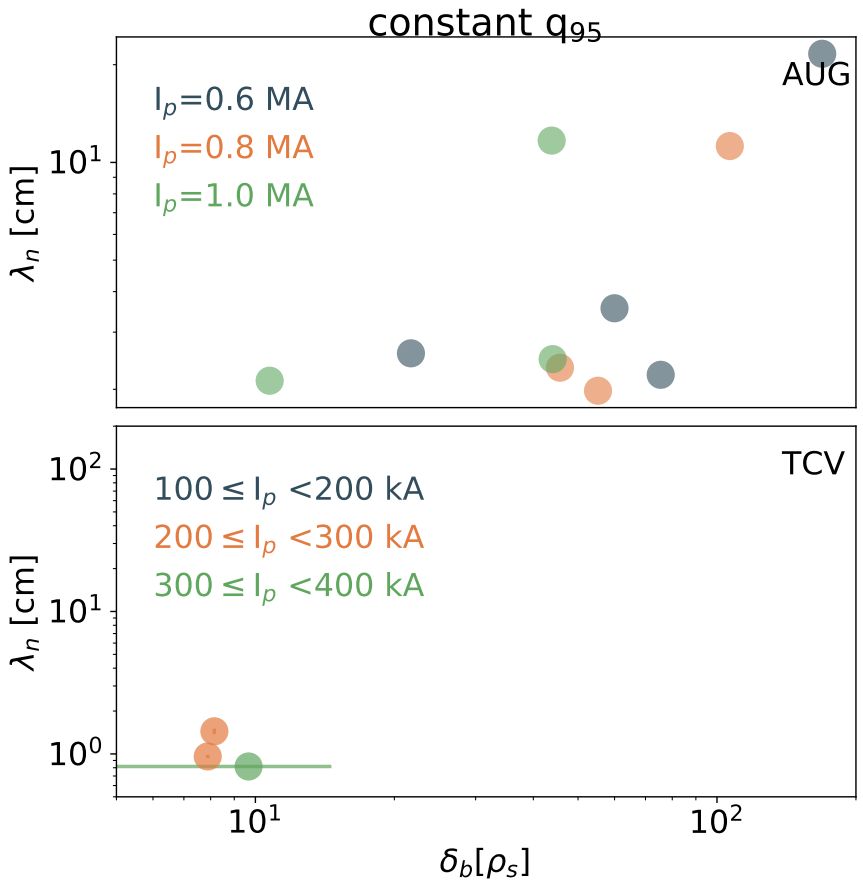
✓ For AUG upstream and target profiles still exhibit flattening earlier in density at lower current but always at large values of Λ_{div}. For TCV no sign of upstream profile flattening even at very large values of Λ_{div}. No clear sign of detachment which is mandatory for upstream profile modication in TCV

Current scan at constant q_{95}



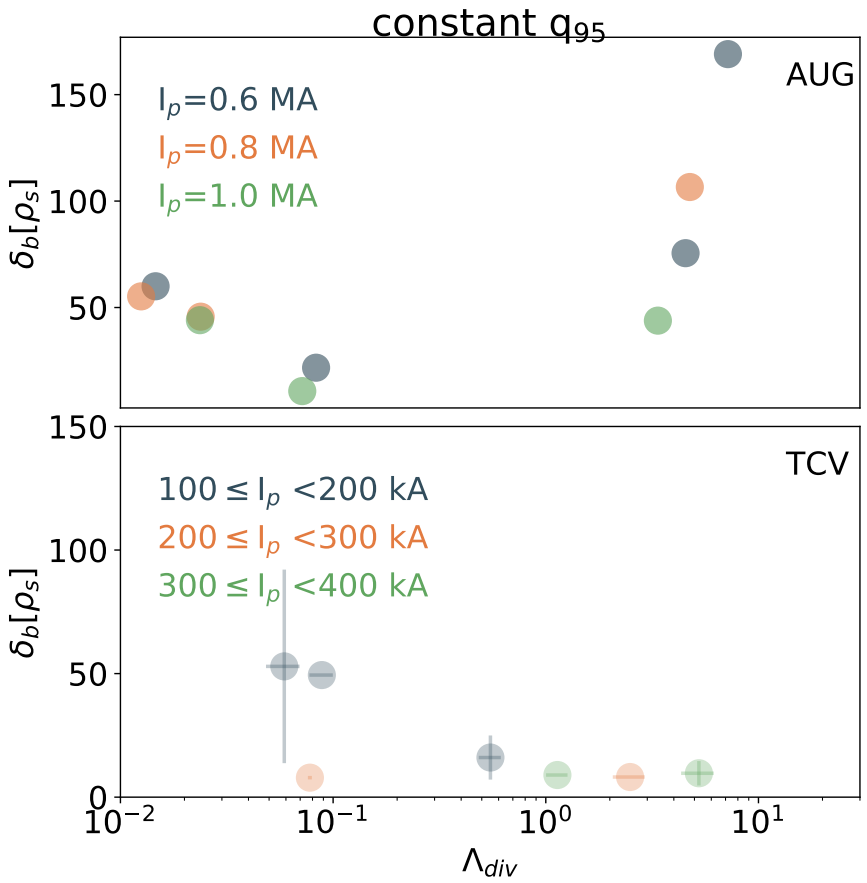
✓ AUG: Amplitude evolution as a function of Λ_{div} still reconcile the explored current scan

Current scan at constant q_{95}



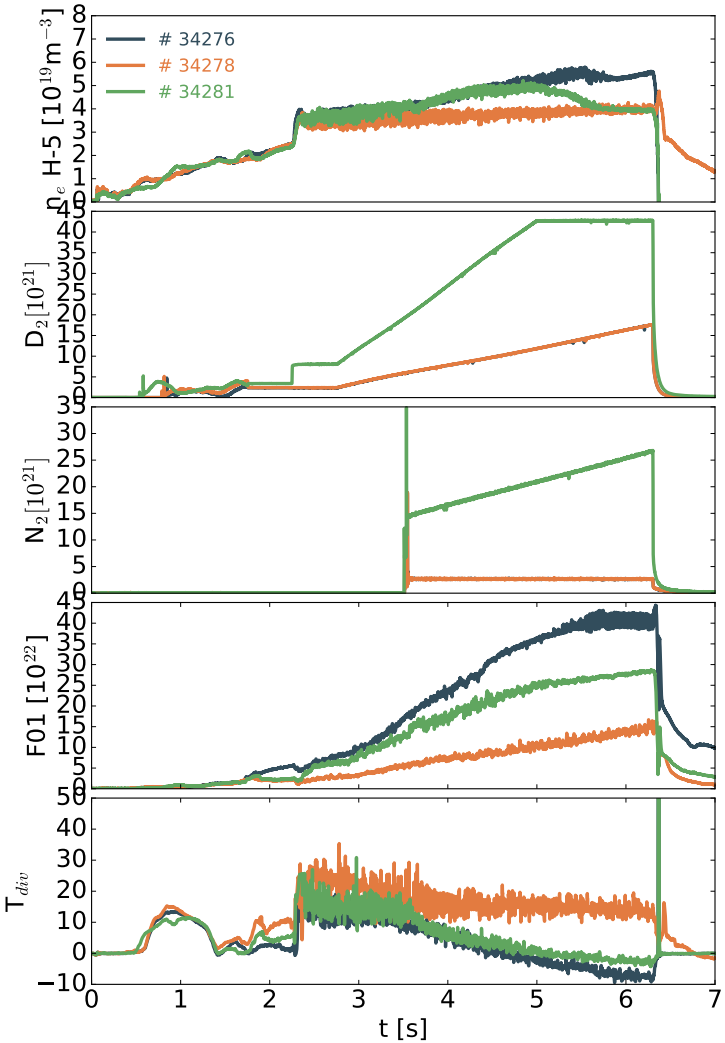
✓ AUG exhibit consistently an increase of λ_n with blob-size whereas for TCV the profile remains flat consistently with a small variation of δ_b

Current scan at constant q_{95}



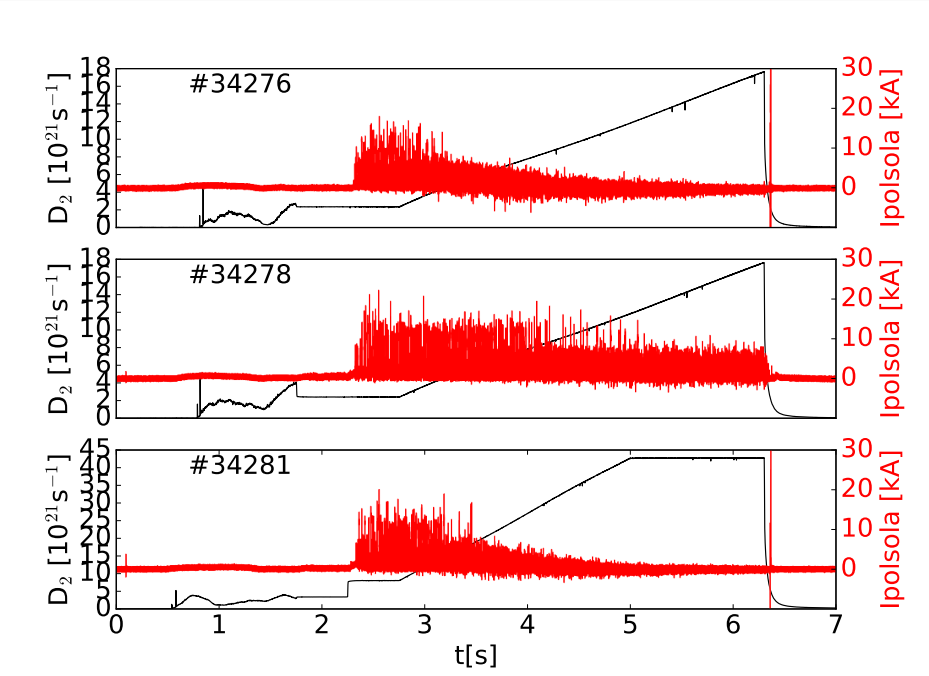
✓ And for TCV this is true even at high value of Λ_{div}. Λ_{div} is not sufficient to guarantee flat profiles on TCV.

H-Mode analysis on AUG



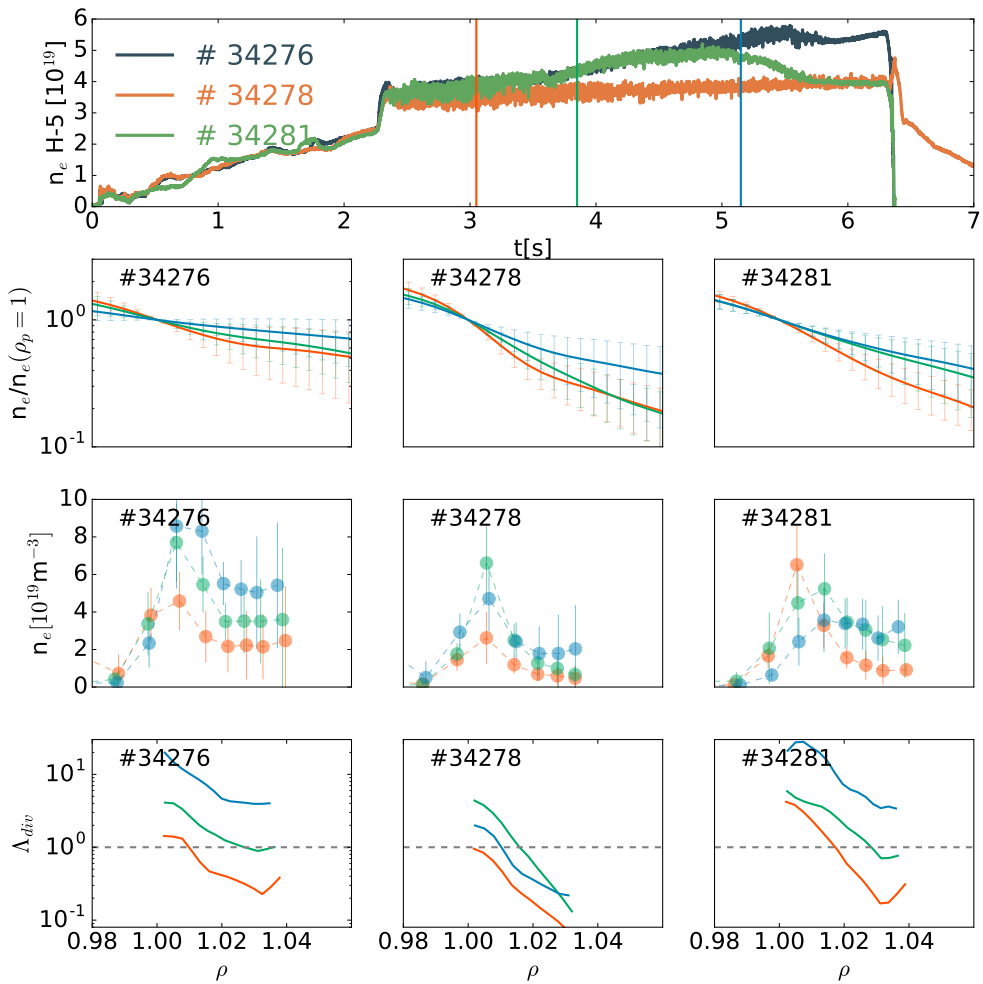
- ✓ We perform a series of shots in H-Mode with 6.5 MW total heating power where we changed the fueling and the efficiency of cryopumps. Specifically we have
  - ✓ # 34276 without the cryompumps
  - ✓ # 34278 with the same fueling as # 34276 but with the cryompump
  - ✓ #34281 where we increase fueling and seeding trying to mimic the same subdivertor pressure as # 34276
- ✓ Keeping the same fueling with the cryopump in operation clearly reduce the pressure in the the sub-divertor area, plasma detachment is not reached and edge density is constant despite the increase fueling. Degraded H-mode reached later without the cryopump

H-Mode analysis on AUG



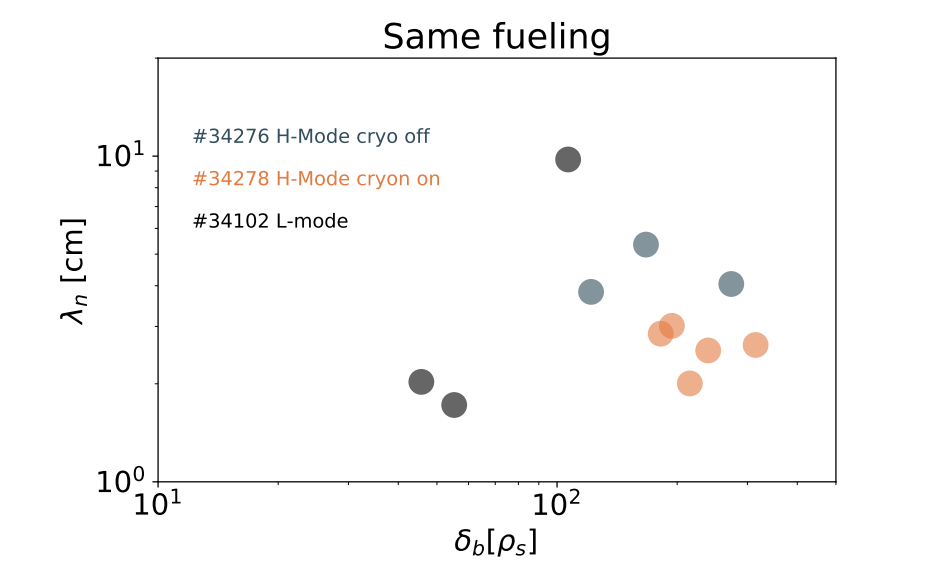
✓ Different behavior of ELM during the fueling ramp. ELM size and frequency changes strongly without the cryopump or during extreme fueling case

H-Mode analysis on AUG



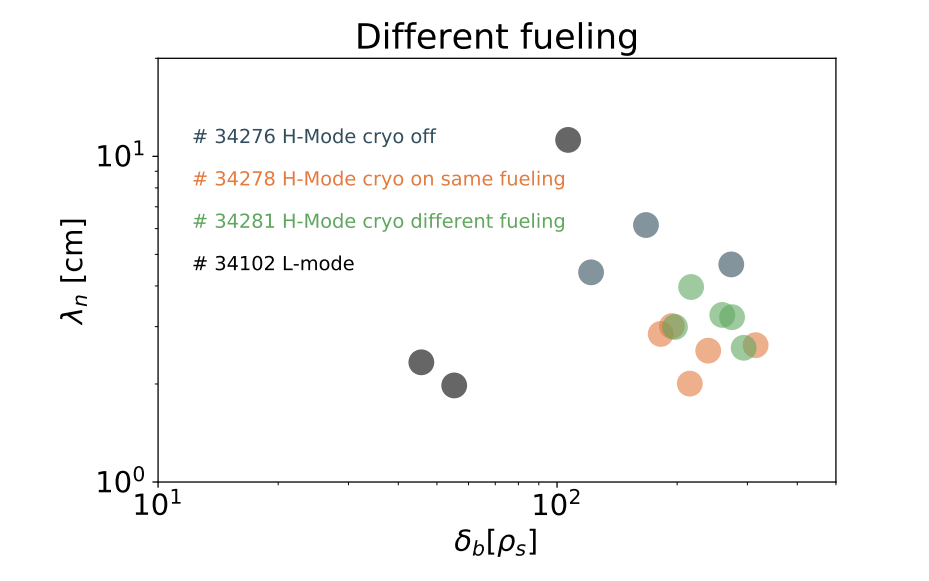
✓ The profiles for shot # 34278 with the cryopump and lower fueling remains steeper in all the three timing window and the plasma is still attached. Interestingly for shot # 34281 with the cryopumps and higher fueling target profiles are broader

H-Mode analysis on AUG



✓ Without the cryopumps, we reached flatter profiles and relatively large inter-ELM resolved blob-size of the same size as L-Mode. This indicates strong neutral pressure effects in determining upstream profiles. Preliminary work. Further analysis needed to confirm the observed values.

H-Mode analysis on AUG

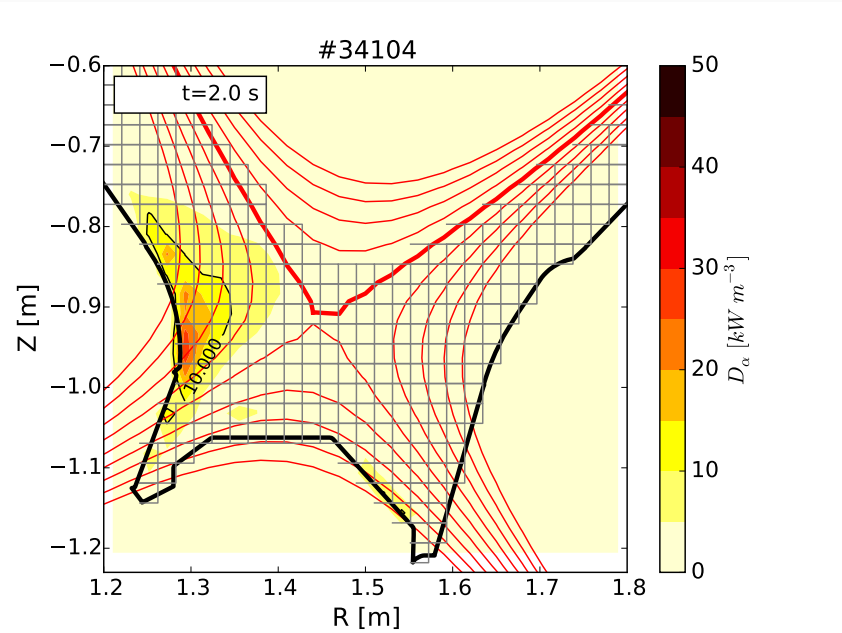


✓ Increasing the fueling and correspondingly the divertor neutral pressure move towards a situation similar to # 34276 without the cryopump. Preliminary work. Further analysis needed to confirm the observed values.

Conclusion

- ✓ Current scan at constant B_t and at constant q_{95} performed during density ramps L-Mode experiments both at AUG and TCV
- ✓ For the scan at constant B_t nn both the machines shoulder appear earlier in density at lower current but AUG shows reconciliation of behavior if considered as a function of greenwald fraction and Λ_{div}
- ✓ Both the experiments exhibit at constant B_t flattening of the profile as blob size is increasing, independently from the current. The same behavior is observed during current scan at constant q_{95} only on AUG
- ✓ On TCV during the current scan at constant q_{95} detachment not reached and this prevents upstream profile flattening
- ✓ H-Mode experiments performed on AUG where fueling and pumping have been varied. Proved inter-ELM profile flattening also in H-Mode with a more efficient shoulder formation with high neutral pressure (no cryopumps or very high fueling). Hints on the role of neutrals also in H-Mode

D_α tomography: work in progress



- ✓ Preliminary results from inversion tomography from calibrated D_α camera under the assumption of toroidally symmetric emission limited to the region outside the LCFS
- ✓ *Simultaneous Algebraic Reconstruction Technique (SART) (A.H. Anderson and A.C.Kak, Ultrasonic Imaging* ***6****, 81 (1984))*

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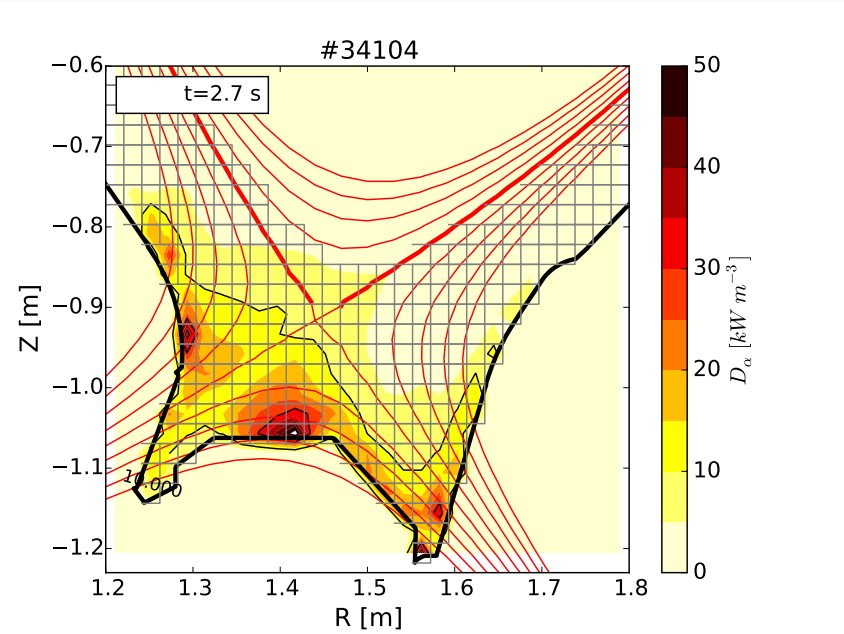

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- ✓ As time evolves during the L-Mode ramp we observe D_α radiation moving from HFS towards the LFS common flux region

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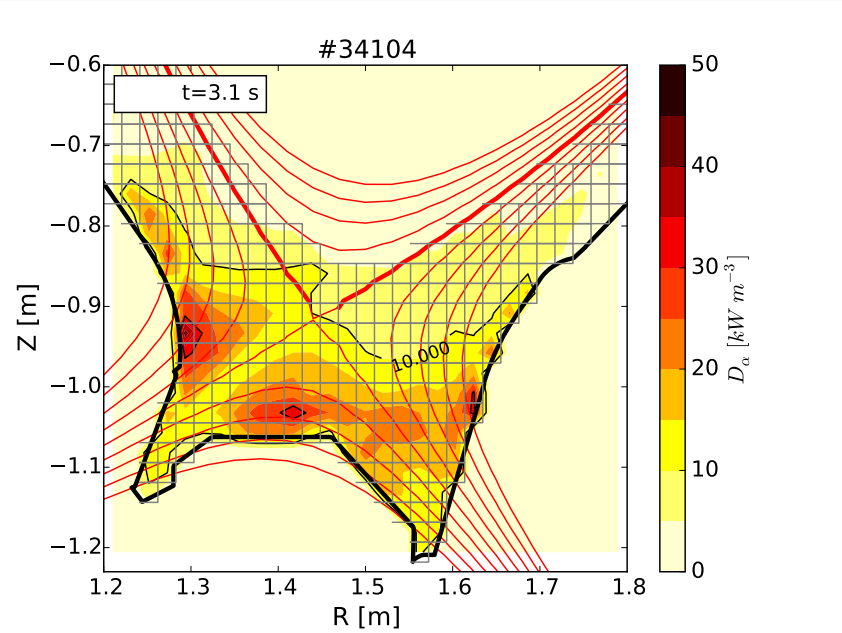

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- ✓ As time evolves during the L-Mode ramp we observe D_α radiation moving from HFS towards the LFS common flux region
- ✓ This is consistent with JET observation in Horizontal target regime whenever shoulder is observed