



# SOL Filamentary transport: update from joint AUG-TCV MSTI experiment

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presented by N. Vianello

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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 MSTI 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 measurement 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

# Motivation and deliverables



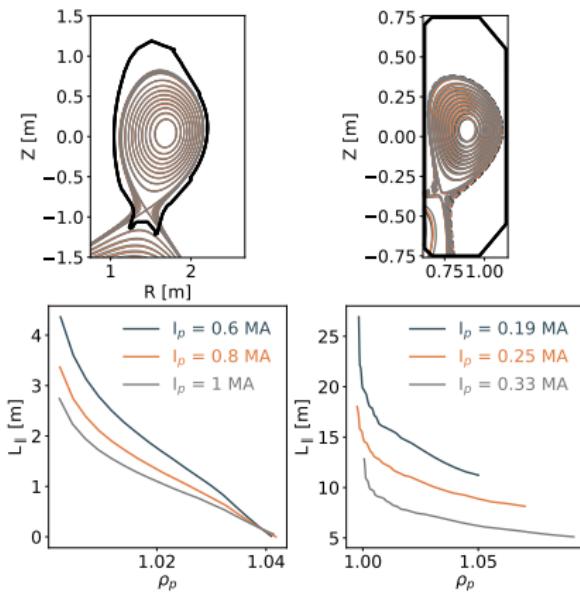
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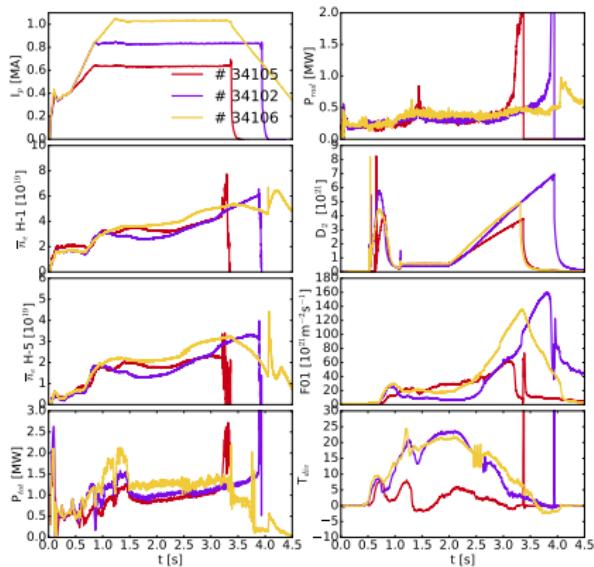
I will report only on few of the deliverables since part of them will be studied in forthcoming campaigns. Remember this is still a work in progress

# Current scan at constant $B_t$



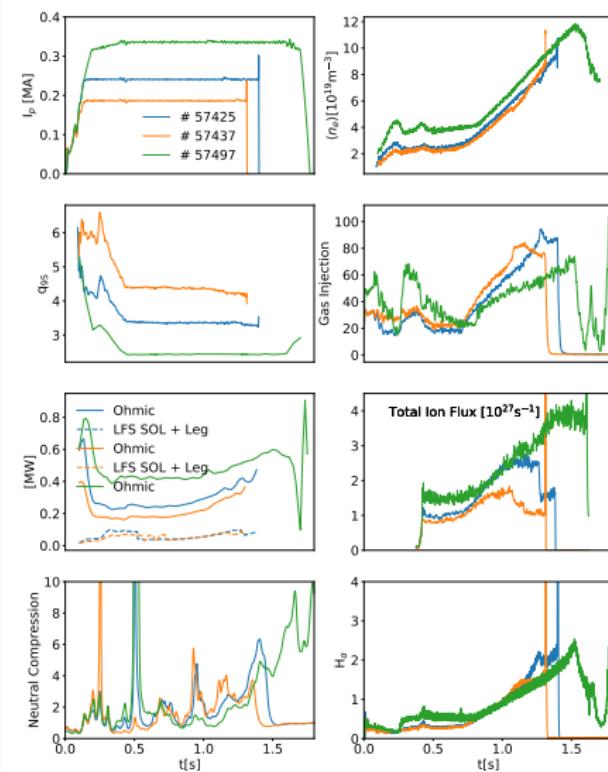
- ✓ Shape matched in within the single scan done for each of the machine
- ✓ The scan implies a modification of the  $L_{||}$ . AUG exhibit a parallel connection length which is 5 times smaller then TCV

# Current scan at constant $B_t$



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

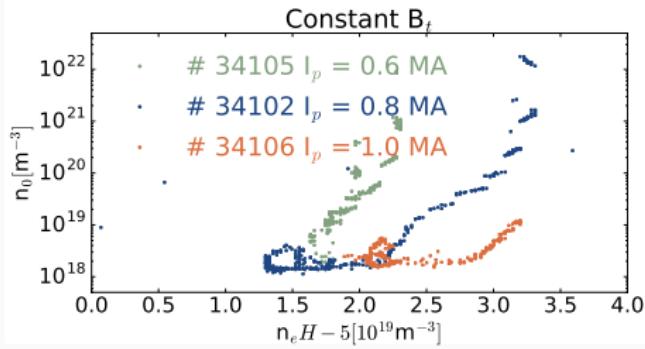
# Current scan at constant $B_t$



- ✓ TCV: Ohmic heating only.  
Similar neutral compression reached and  $D_\alpha$  radiation from the floor.



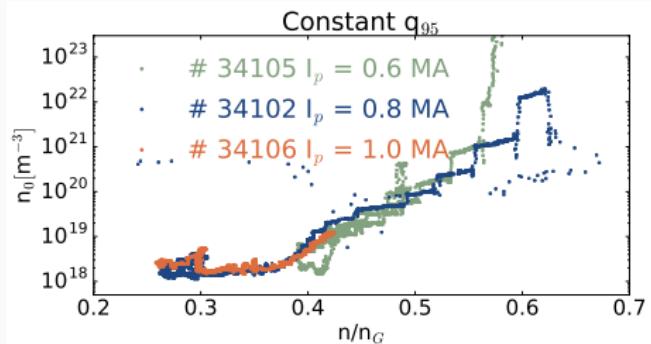
# Current scan at constant $B_t$



- ✓ Divertor neutral density estimated starting from  $D_\alpha$  calibrated camera and using electron density and temperature from LP data. Neutral density increases earlier in edge density at lower current

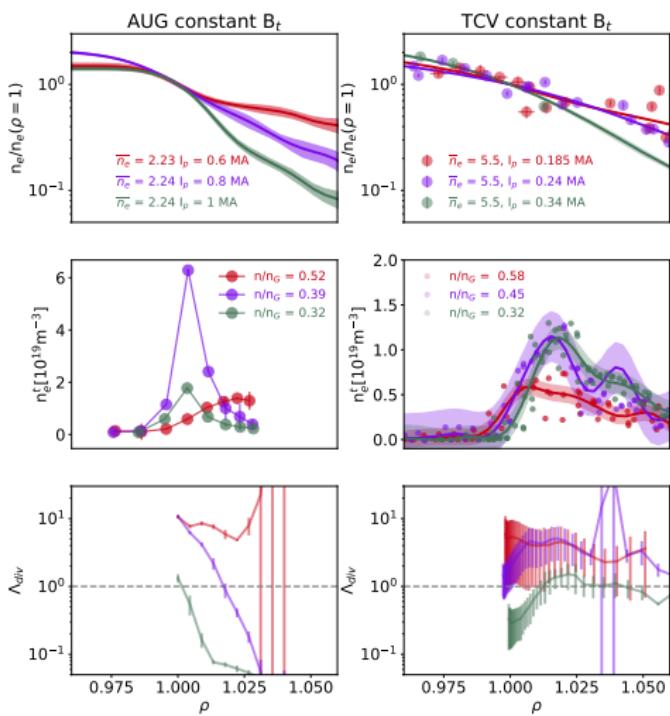


# Current scan at constant $B_t$



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

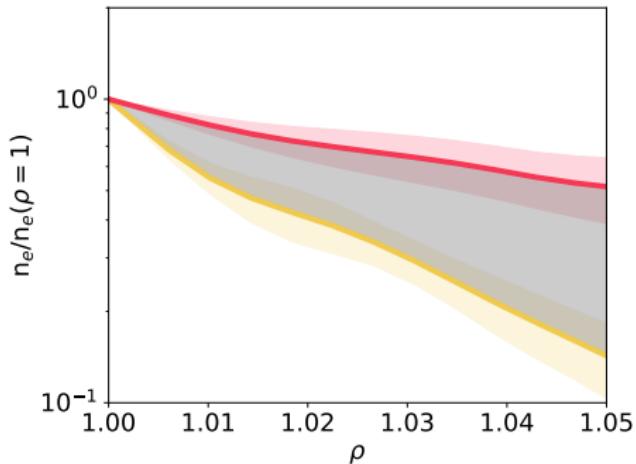
# Current scan at constant $B_t$



- ✓ For both AUG and TCV flattening of normalized upstream profile reached earlier in density at lower current. For both the machine the increase of  $\lambda_n$  reached for larger values of  $\Lambda_{div}$

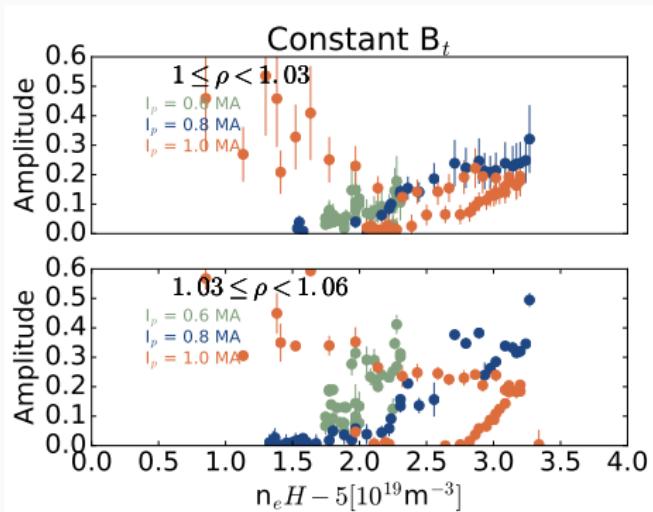


# Current scan at constant $B_t$



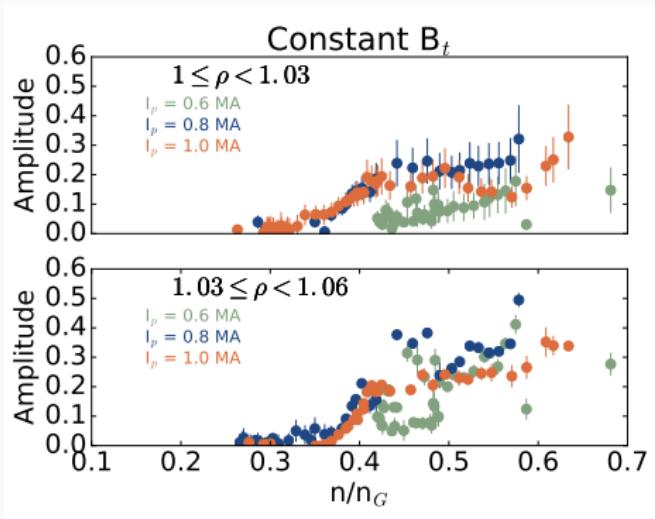
- ✓ Quantifying profile evolution using the **shoulder amplitude metric** introduce by Wynn and Lipschultz for JET.  
Amplitude is the difference between normalized upstream density profiles

# Current scan at constant $B_t$



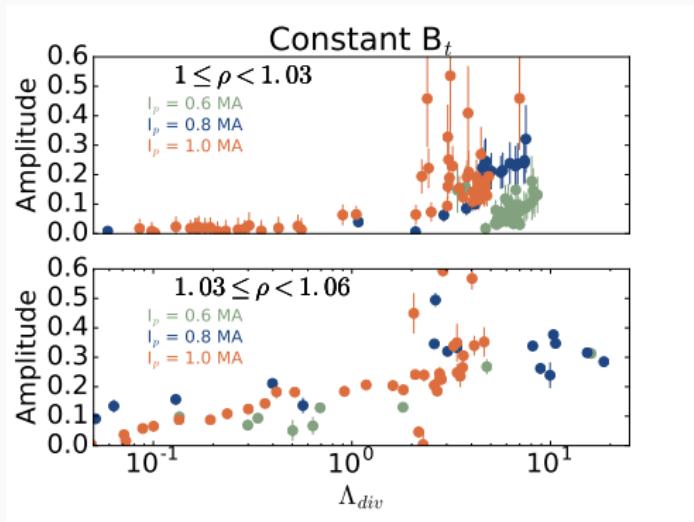
- ✓ Amplitude evolve faster in density at lower current in the far SOL

# Current scan at constant $B_t$



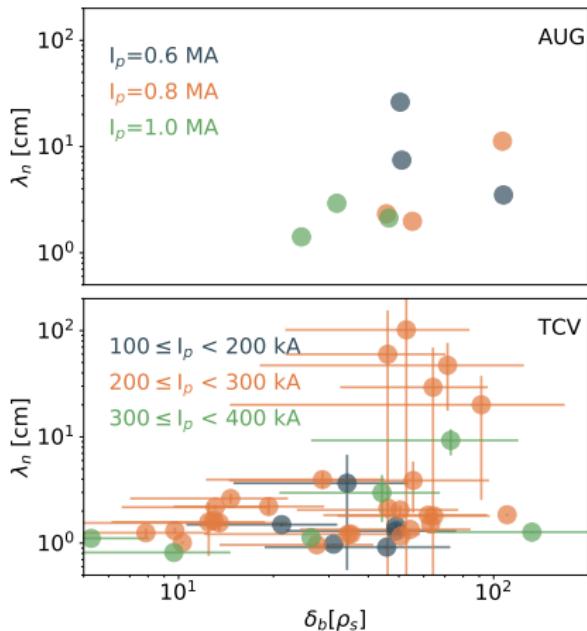
- ✓ Amplitude evolve faster in density at lower current in the far SOL **but once evolution vs greenwald fraction is considered the evolution is equivalent between different current**

# Current scan at constant $B_t$



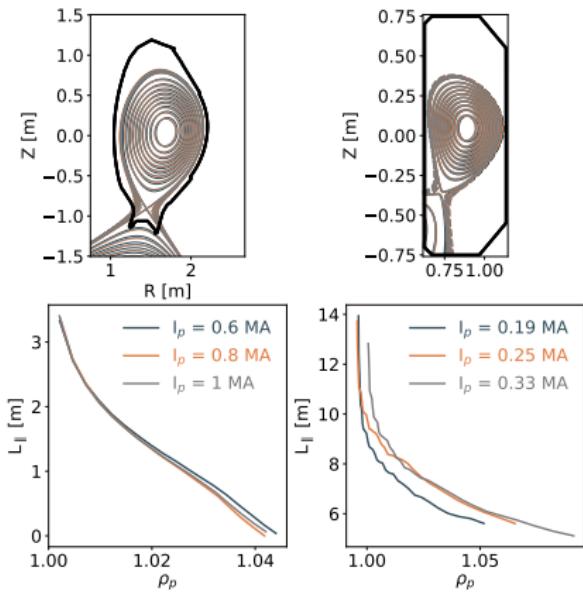
- ✓ Amplitude evolution still reconciled in AUG if considered as a function of local evolution of  $\Lambda_{div}$

# Current scan at constant $B_t$



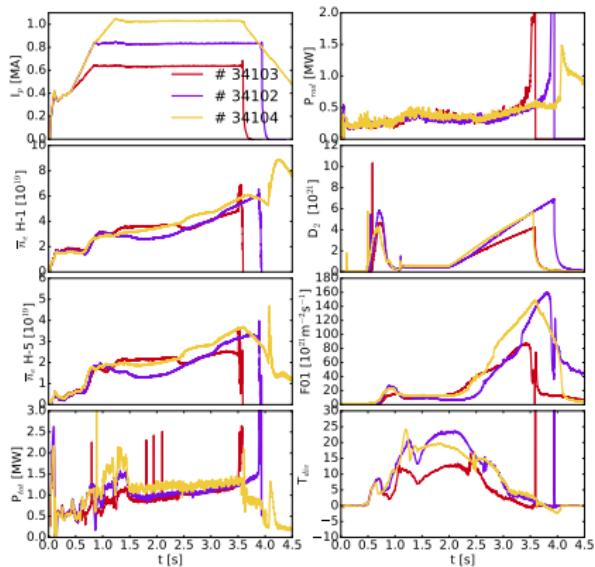
- ✓ For both AUG and TCV  $\lambda_n$  increases with blob size without significant difference within the current explored

# Current scan at constant $q_{95}$



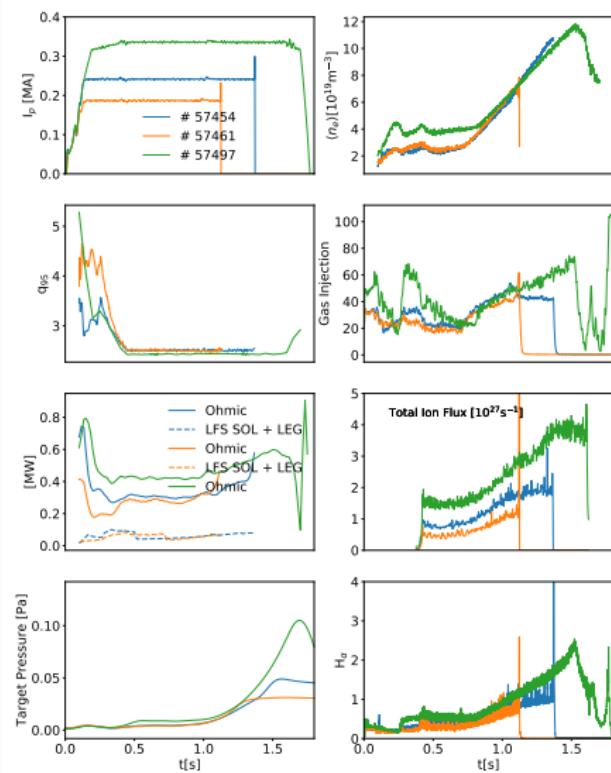
- ✓ Shape matched in within the single scan even though this required for TCV operation with very low toroidal field (0.8T)
- ✓ The parallel connection length remains almost unchanged

# Current scan at constant $q_{95}$



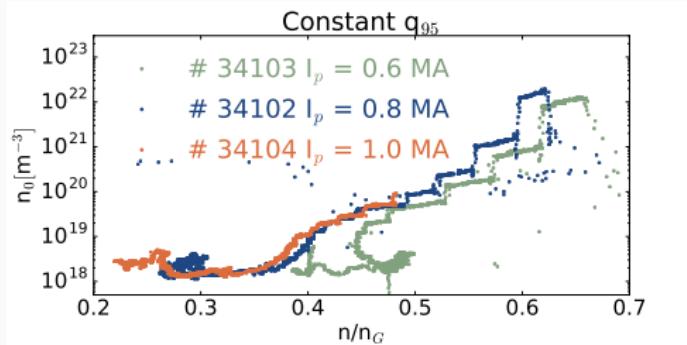
- ✓ AUG: As for the case of constant  $B_t$  we have pretty reproducible behavior matching basically the plasma condition in within the current scan

# 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

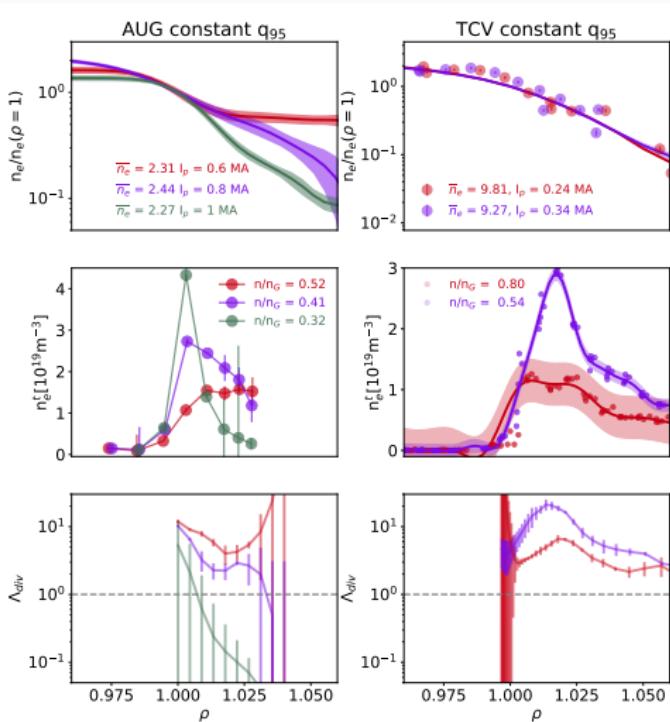
# Current scan at constant $q_{95}$



- ✓ AUG: Divertor neutral density exhibits still the same behavior is considered as a function of greenwald fraction

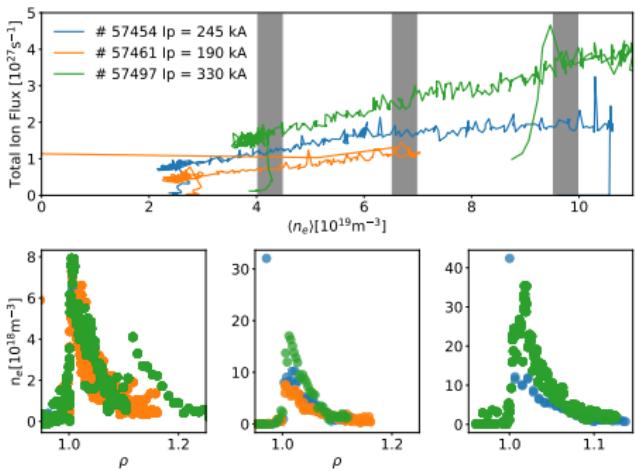


# Current scan at constant $q_{95}$



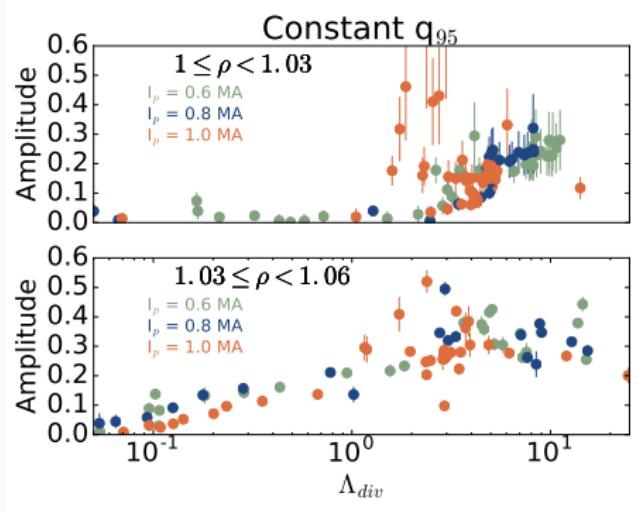
✓ For AUG upstream and target profiles exhibit the same behavior with flattening observed at large values of  $\Lambda_{div}$ . TCV actually even at high value of density no sign of upstream profile flattening even at very large values of  $\Lambda_{div}$

# Current scan at constant $q_{95}$



- ✓ This is due to the fact we did not reach divertor detachment which seems necessary for upstream profile modification

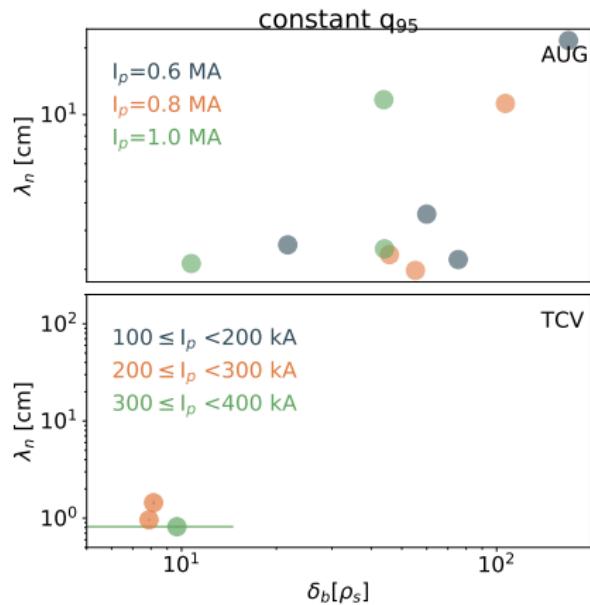
# Current scan at constant $q_{95}$



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

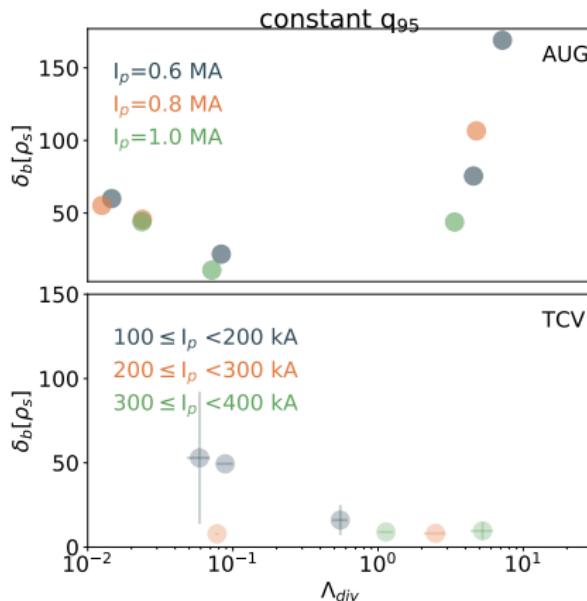


# Current scan at constant $q_{95}$



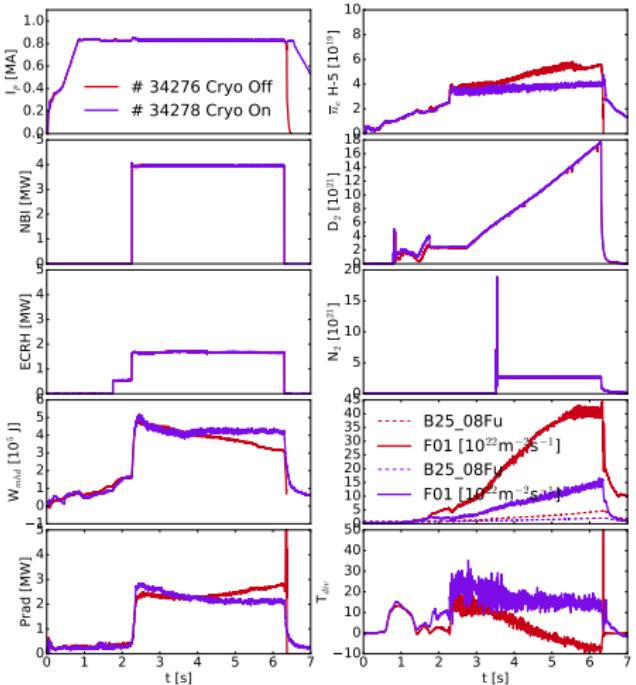
- ✓ AUG exhibit consistently an increase of  $\lambda_n$  with blob-size whereas for TCV the profile remains flat consistently with a small variation of  $\delta_b$

# Current scan at constant $q_{95}$



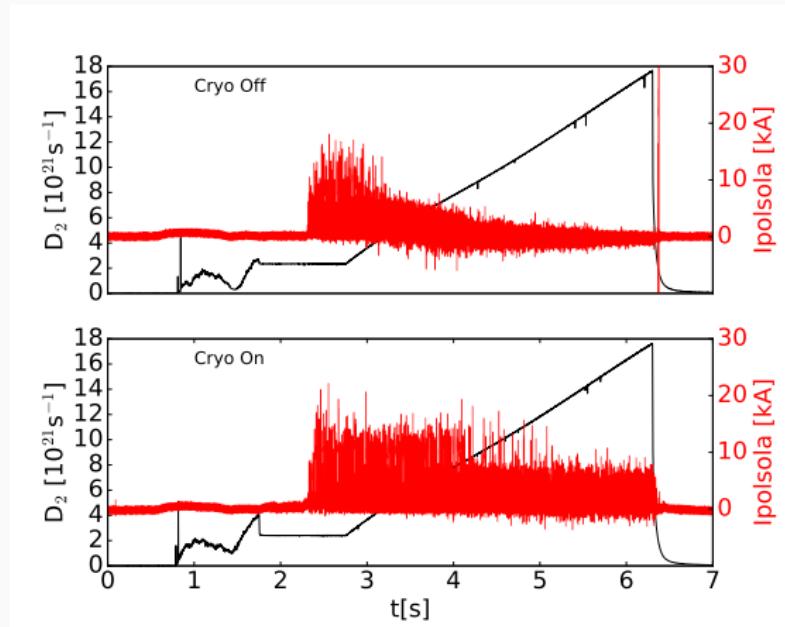
✓ And for TCV this is true even  
at high value of  $\Lambda_{div}$

# H-Mode compare fueling with/wo cryopump



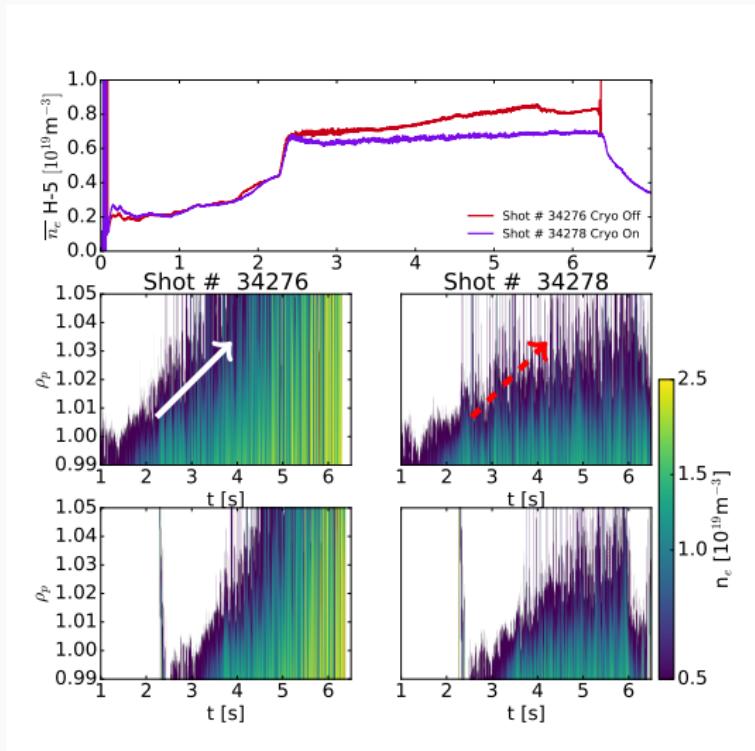
- ✓ Same fueling but with cryo-pumps. To check role of neutral density in H-Mode
- ✓ H-5 density is different and remain constant, both divertor and midplane pressure are reduced (to 1/3 approximately)  
no sign of detachment

# H-Mode compare fueling with/wo cryopump



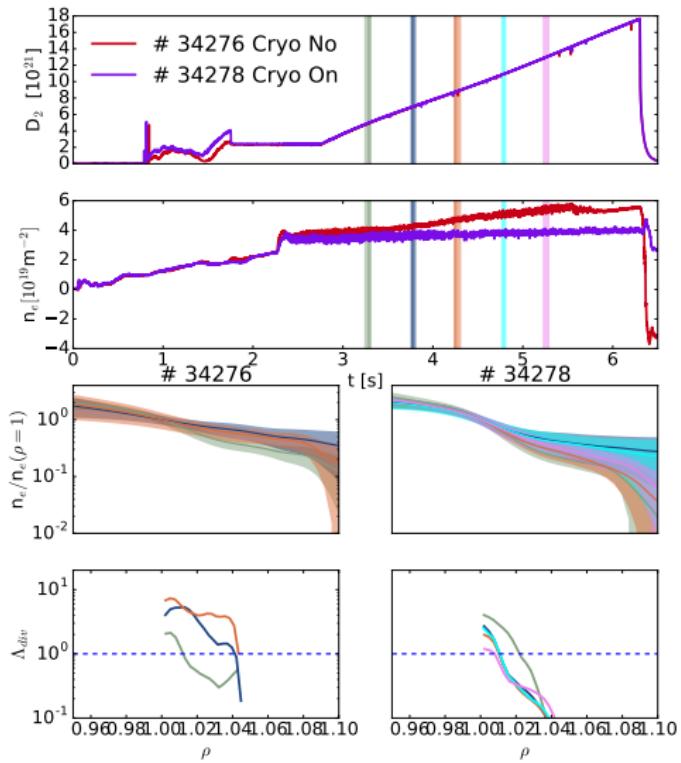
- ✓ Different ELM regimes reached with reduced size and increased frequency without the cryopumps

# H-Mode compare fueling with/wo cryopump



- ✓ Also with this amount of fueling weaker indication of SOL saturation observed as confirmed by Li-Beam and by RIC (Antenna 4)

# H-Mode compare fueling with/wo cryopump

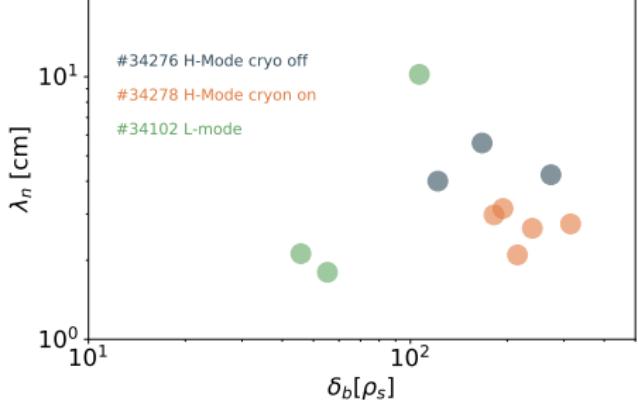


- ✓ Inter-ELM resolved profile suggest a flattening even with the cryopumps still even though  $\Lambda_{div}$  is marginal above I only in the near SOL

# H-Mode compare fueling with/wo cryopump



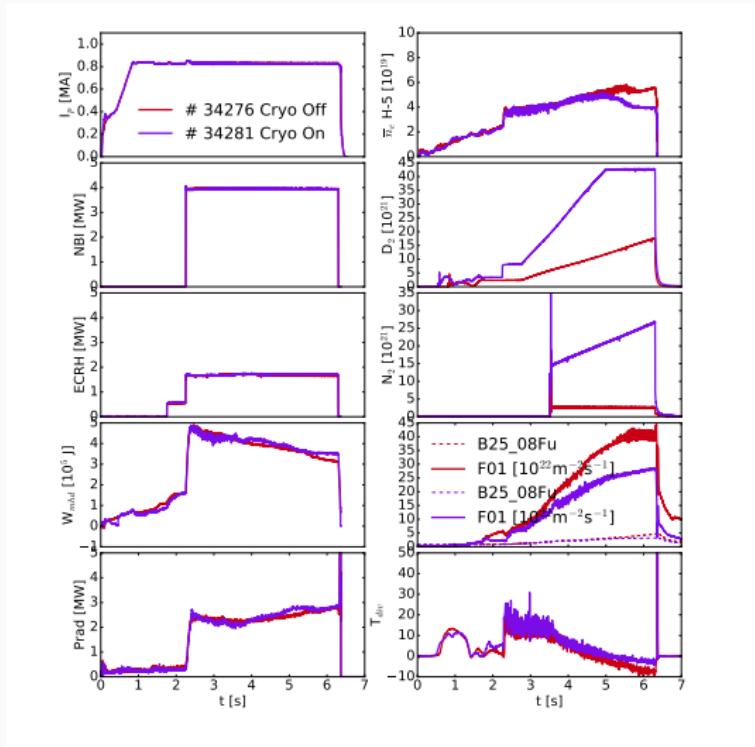
Same fueling



- ✓ Without the cryopumps, we reached flatter profiles with comparable inter-ELM resolved blob-size. This indicates strong neutral pressure effects in determining upstream profiles

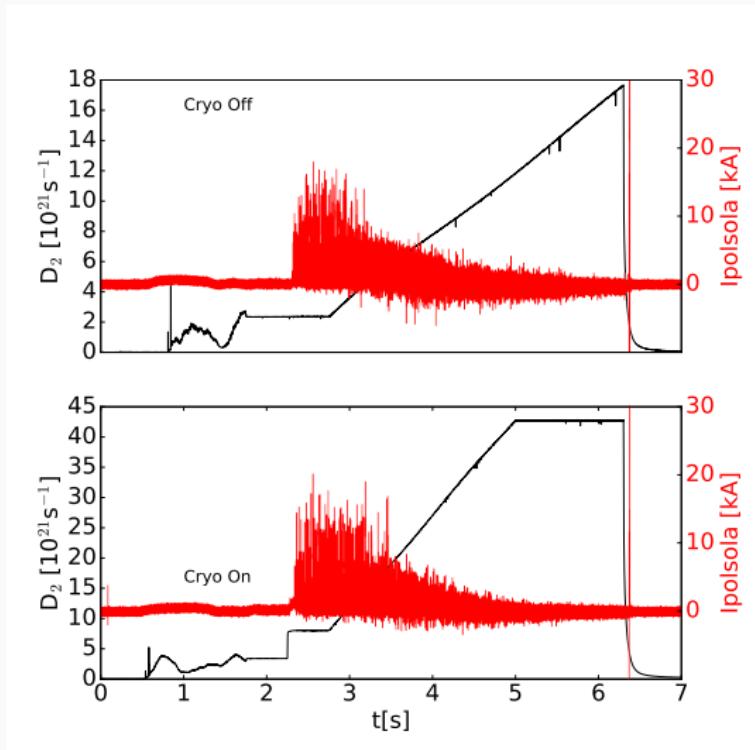


# Matching scenarios with cryo-pumps



- ✓ To match similar edge density and divertor pressure and to reach the same level of detachment we increase the fueling by almost a factor of 3, increasing also the rate. In addition to that we also increase substantially the N puffing.  
Degraded H-Mode reached earlier in density without the cryopumps

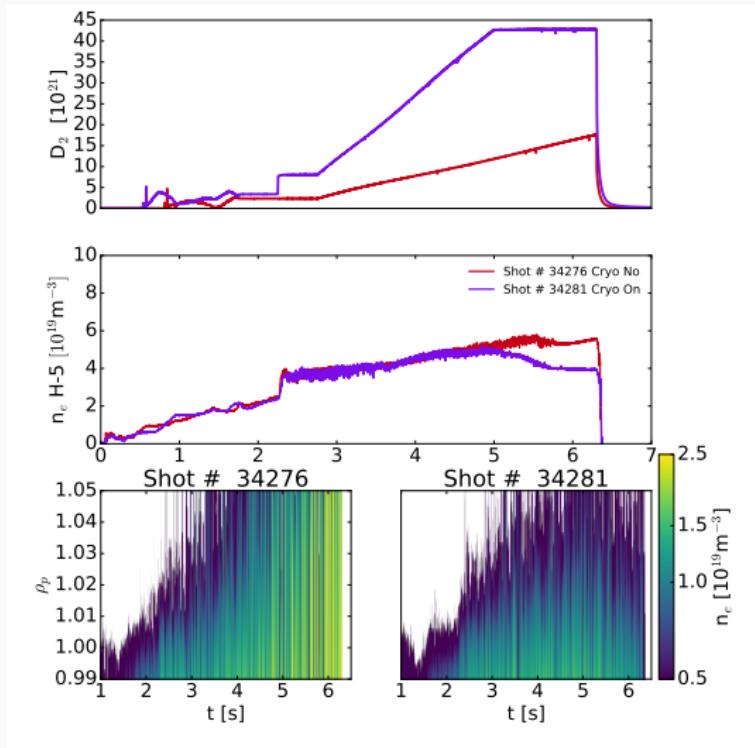
# Matching scenarios with cryo-pumps



- ✓ Similar ELM behavior obtained during the density ramp



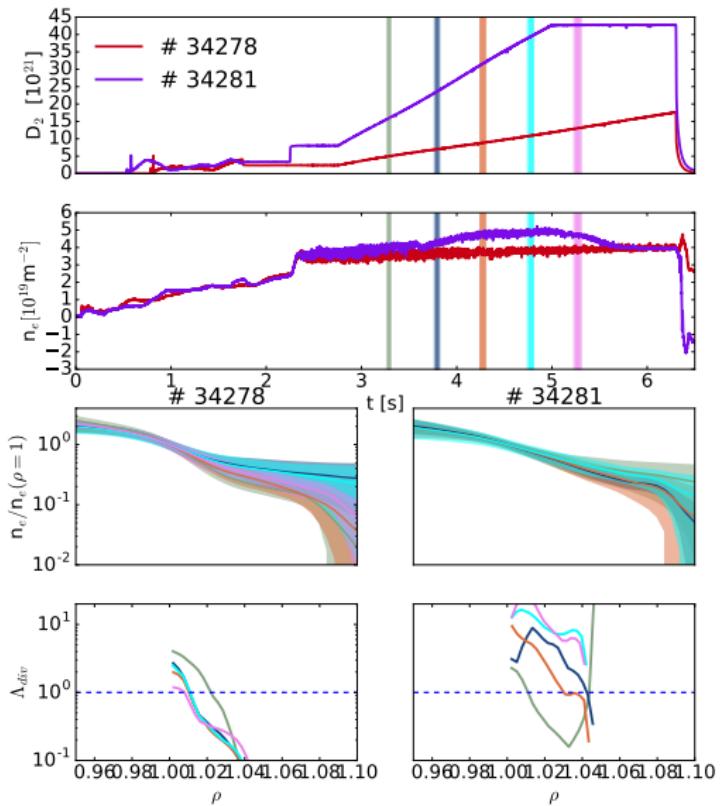
# Matching scenarios with cryo-pumps



- ✓ Now the scenario suggest a strong profile flattening even with the cryopumps



# Matching scenarios with cryo-pumps

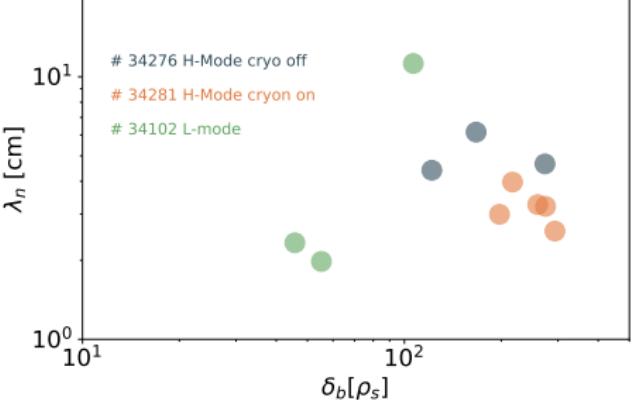


- ✓ Inter-ELM resolved Li-Be profiles confirm this with shoulder formed with similar strength even with the cryopumps in operation.

# Matching scenarios with cryo-pumps



Different fueling



- ✓ Both size and  $\lambda_n$  closer with/wo the cryopumps