



Topic 21: Filamentary transport in high-power H-mode conditions and in no/small-ELM regimes to predict heat and particle loads on PFCs for future devices

N. Vianello and V. Naulin for the Topic 21 Scientific Team

20 September 2017



This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Summary of the campaigns



- ✓ L-Mode experiment, Calendar week 17. It will constitute baseline scenarios to be replicated on the other MSTI devices. **Operation without cryopumps**
 - 1. Performed similar density ramps in an I_p scan at constant q_{95}
 - 2. Performed similar density ramps in an I_p scan at constant B_t
 - 3. Prepare scenarios for H-Mode operation

Summary of the campaigns



- ✓ L-Mode experiment, Calendar week 17. It will constitute baseline scenarios to be replicated on the other MSTI devices. **Operation without cryopumps**
 - 1. Performed similar density ramps in an I_p scan at constant q_{95}
 - 2. Performed similar density ramps in an I_p scan at constant B_t
 - 3. Prepare scenarios for H-Mode operation

Summary of the campaigns



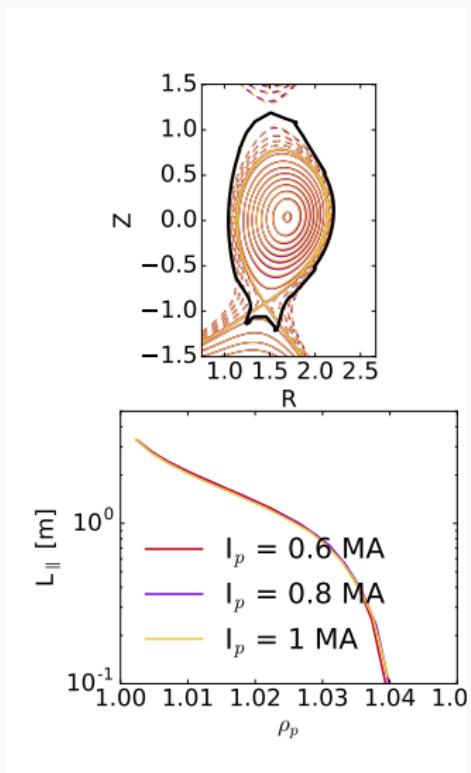
- ✓ L-Mode experiment, Calendar week 17. It will constitute baseline scenarios to be replicated on the other MSTI devices. **Operation without cryopumps**
 1. Performed similar density ramps in an I_p scan at constant q_{95}
 2. Performed similar density ramps in an I_p scan at constant B_t
 3. Prepare scenarios for H-Mode operation
- ✓ H-Mode experiment, CW 21.
 1. Compare divertor/midplane fueling effect on filamentary transport and profiles without cryo-pumps
 2. Compare profiles with the same fueling with/without cryopumps
 3. Determine an H-Mode with the cryopumps matching similar divertor pressure and SOL profiles

Summary of the campaigns



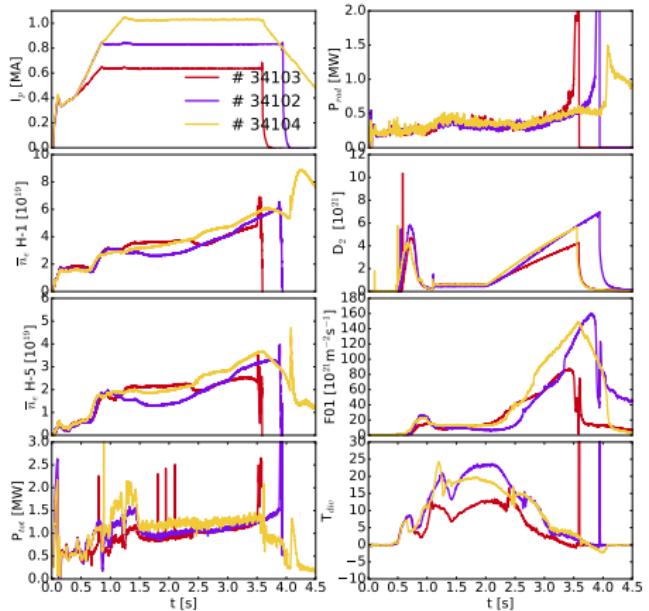
- ✓ L-Mode experiment, Calendar week 17. It will constitute baseline scenarios to be replicated on the other MSTI devices. **Operation without cryopumps**
 1. Performed similar density ramps in an I_p scan at constant q_{95}
 2. Performed similar density ramps in an I_p scan at constant B_t
 3. Prepare scenarios for H-Mode operation
- ✓ H-Mode experiment, CW 21.
 1. Compare divertor/midplane fueling effect on filamentary transport and profiles without cryo-pumps
 2. Compare profiles with the same fueling with/without cryopumps
 3. Determine an H-Mode with the cryopumps matching similar divertor pressure and SOL profiles

L-Mode analysis: I_p scan at constant q_{95}



- ✓ All the shots were performed in the so-called Edge Optimized Configuration (EOC) shape
- ✓ We matched correctly the shape and the L_{\parallel} here shown from outer divertor plate up to X-point

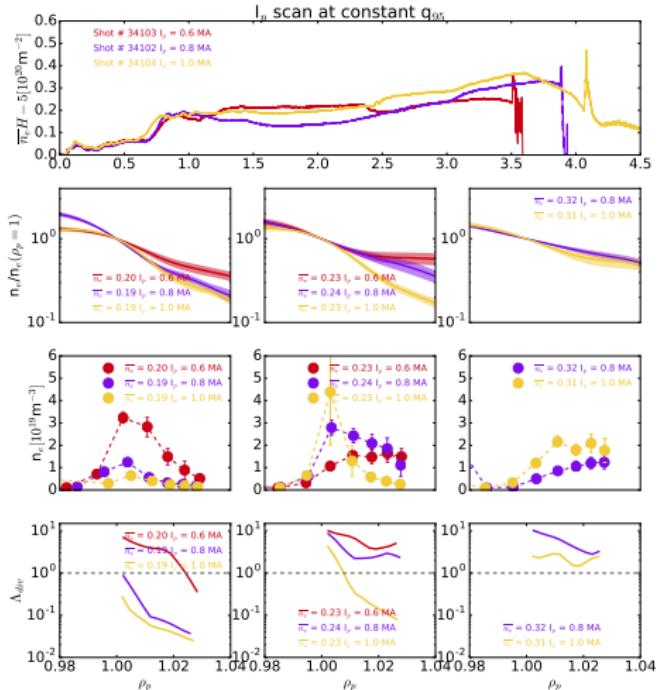
L-Mode analysis: I_p scan at constant q_{95}



- ✓ The scan was performed with similar puffing rate (0.8-1 MA) whereas we reduced it at lower current to avoid early disruption
- ✓ The total power (Ohmic plus NBI) was kept constant throughout the scan
- ✓ We have comparable edge density, divertor neutral pressure and divertor temperature

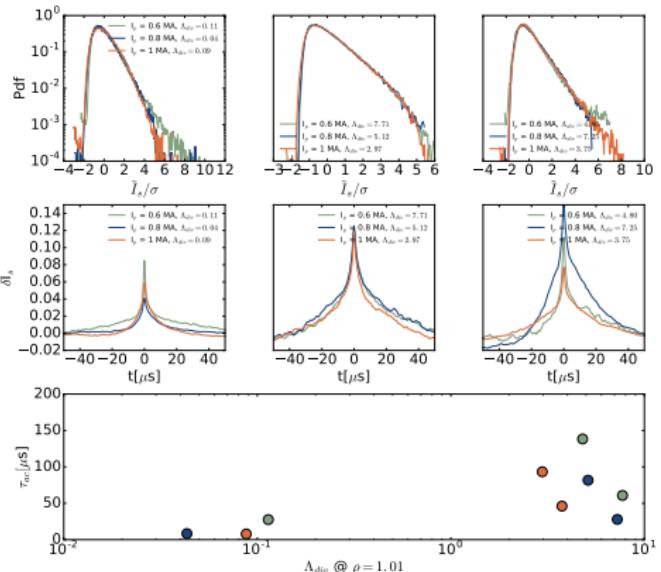


L-Mode analysis: I_p scan at constant q_{95}



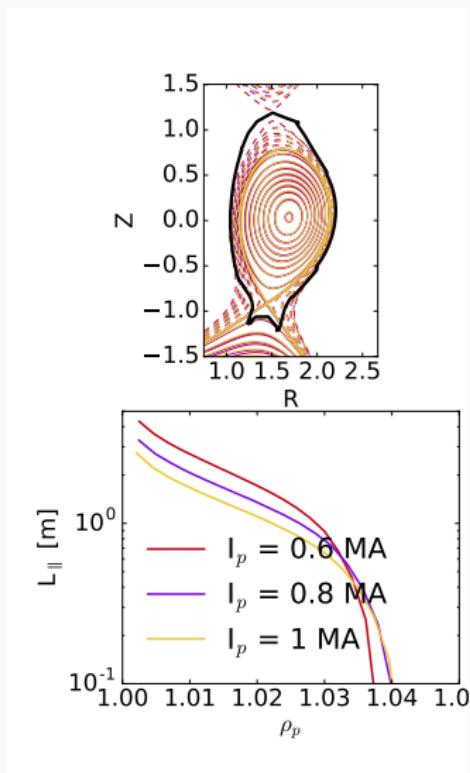
- ✓ At comparable edge density Upstream profiles are different with the tendency to develop shoulder easier at lower current
- ✓ Still need to provide detail evolution of edge profiles as a function of Λ_{\parallel} which are different at different current although same L_{\parallel}

L-Mode analysis: I_p scan at constant q_{95}



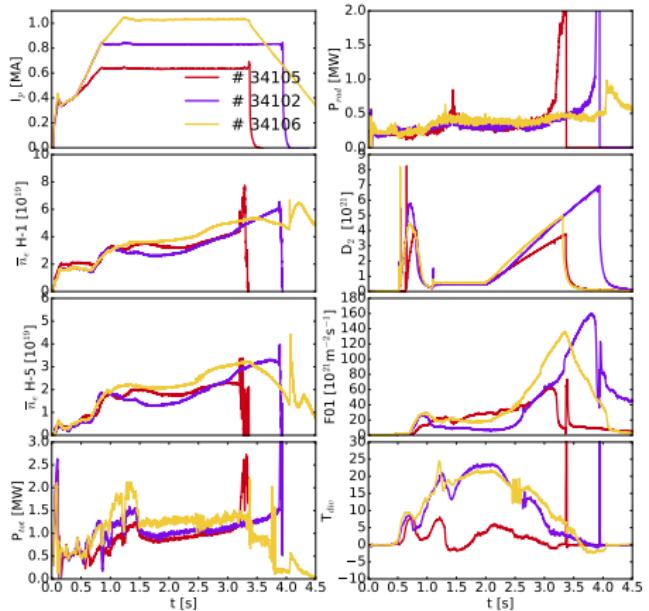
- ✓ No sensible difference of PDFs of J_{sat} at different current even though obtained at different values of Λ_{div} .
- ✓ Autocorrelation time τ_{ac} increases with Λ_{div} without sensible difference among the current

L-Mode analysis: I_p scan at constant B_t



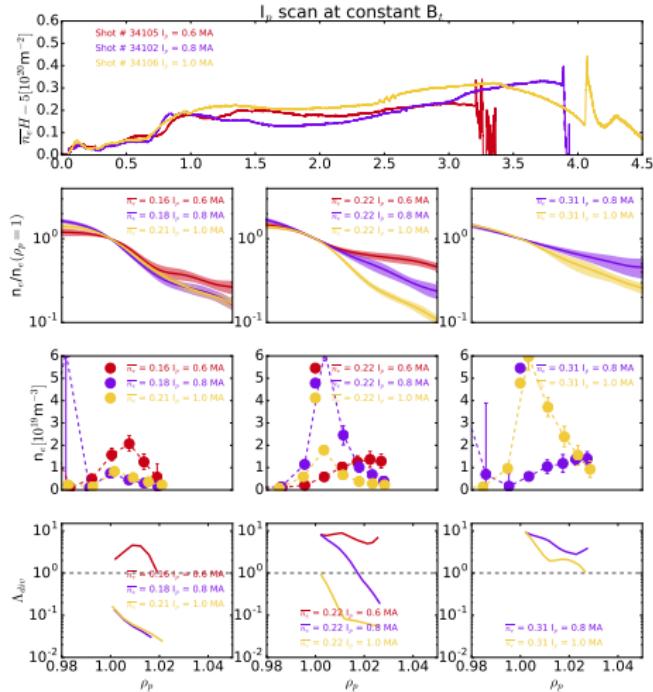
- ✓ We matched correctly the shape the parallel connection length L_{\parallel} is modified consistently

L-Mode analysis: I_p scan at constant B_t



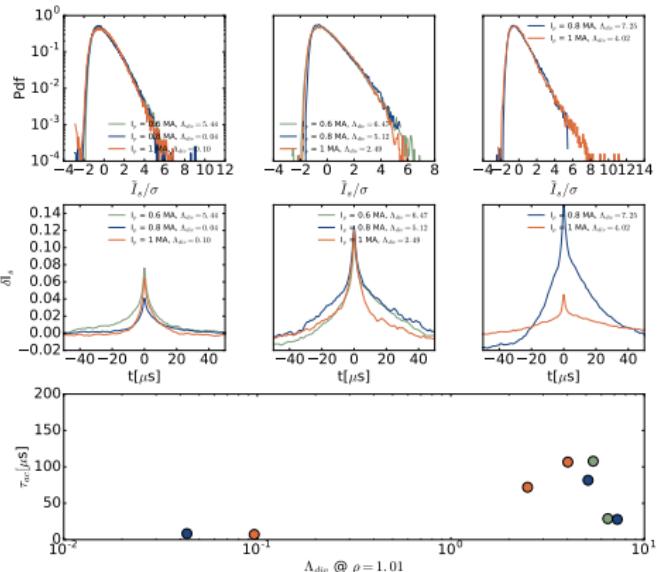
- ✓ The scan was performed with similar puffing rate (0.8-1 MA) whereas we reduced it at lower current to avoid early disruption
- ✓ We have comparable edge density and divertor neutral pressure even though pressure increase earlier at higher current

L-Mode analysis: I_p scan at constant B_t



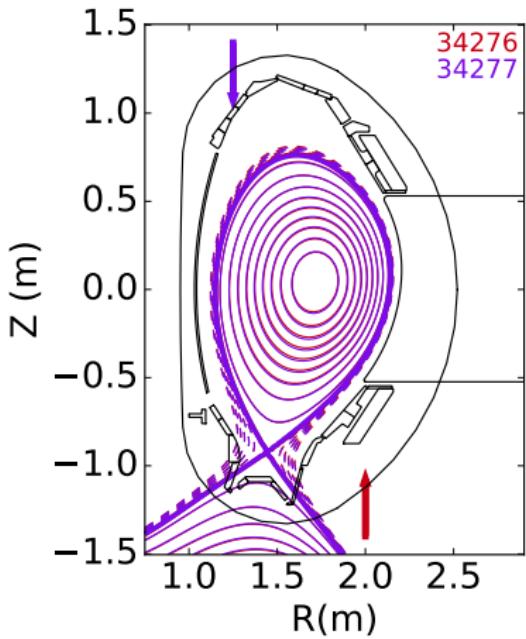
- ✓ At comparable edge density Upstream profiles are different with the tendency to develop shoulder easier at lower current
- ✓ Still need to provide detail evolution of edge profiles as a function of Λ_{div} which are different at different current although same L_{\parallel}

L-Mode analysis: I_p scan at constant B_t



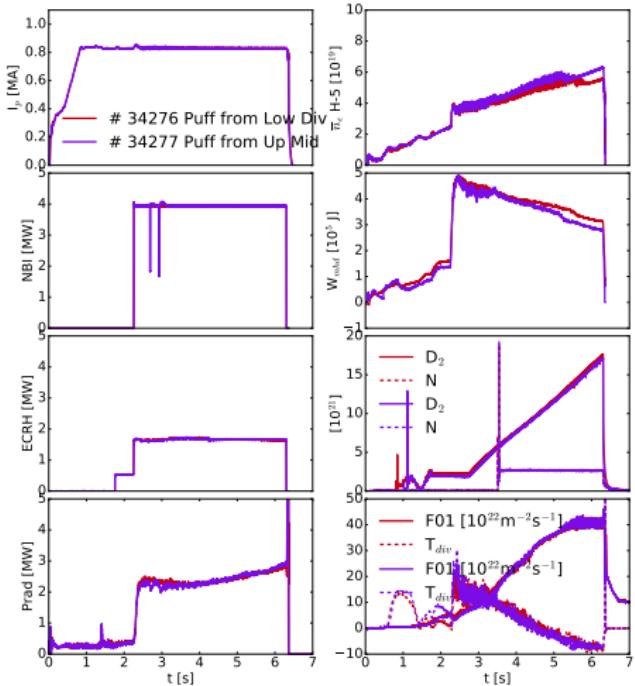
- ✓ No sensible difference of PDFs of J_{sat} at different current even though obtained at different values of Λ_{die} .
- ✓ Remarkable difference in the shape of typical structure, even though τ_{ac} follow usual trend apart from very last points. **To be double-checked**

H-Mode investigation: puffing location



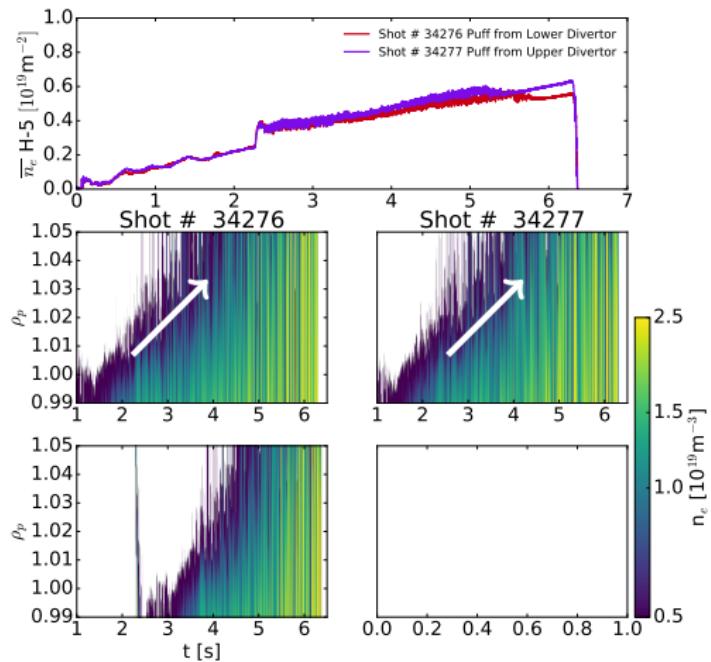
- ✓ Similar puff from Lower and Upper divertor valves (we asked for divertor/midplane valves)

H-Mode investigation: puffing location



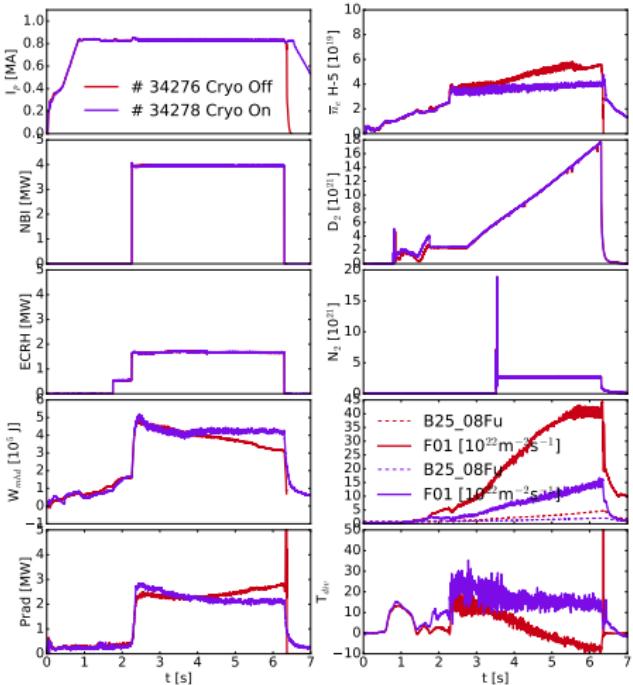
- ✓ Similar puff from Lower and Upper divertor valves (we asked for divertor/midplane valves)
- ✓ Discharge with a total amount 6.5 heating power with equivalent behavior also in the lower divertor independently from the puffing location

H-Mode investigation: puffing location



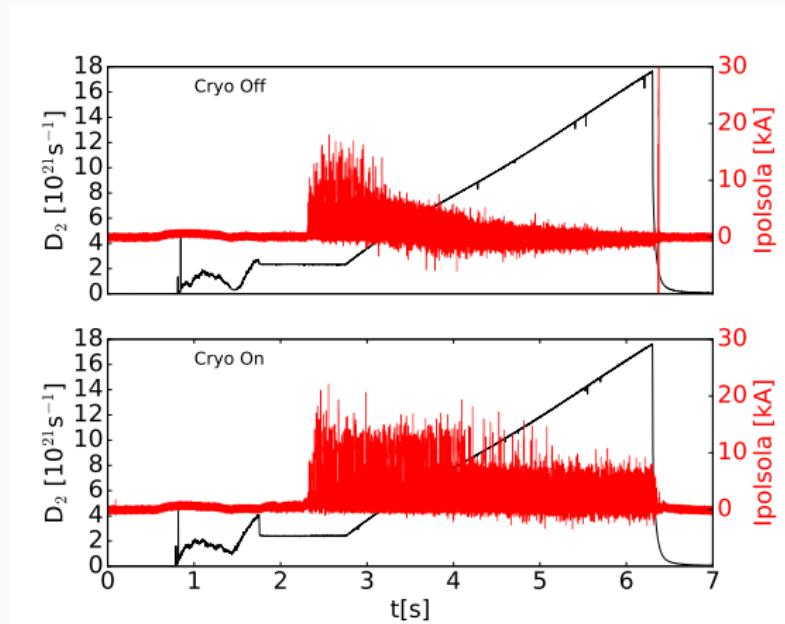
- ✓ Similar puff from Lower and Upper divertor valves (we asked for divertor/midplane valves)
- ✓ Discharge with a total amount 6.5 heating power with equivalent behavior also in the lower divertor independently from the puffing location
- ✓ Edge density profiles from Li-Beam evolution are pretty similar
- ✓ Similar behavior observed from RIC Antenna 4 for the available shot

Compare Similar fueling with/without cryopumps



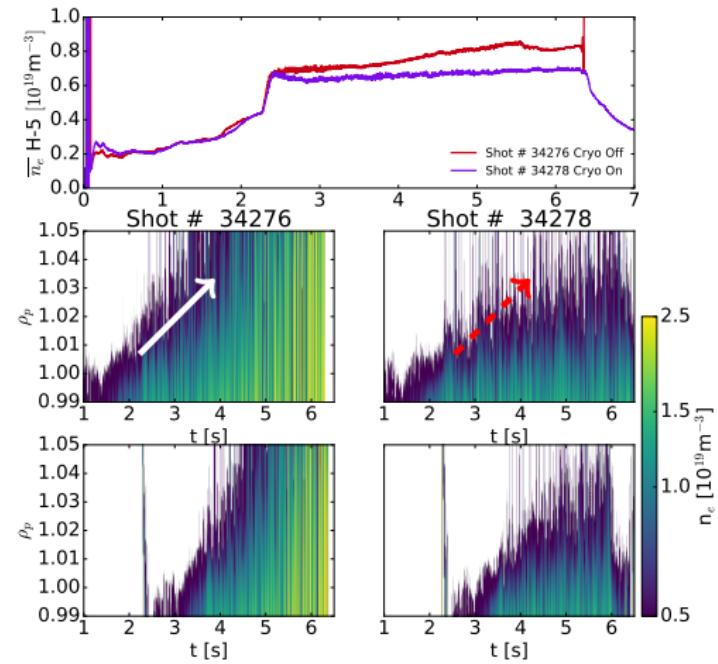
- ✓ Same fueling but with cryo-pumps
- ✓ H-5 density is different and remain constant, both divertor and midplane pressure are reduced (to 1/3 approximately) no sign of detachment

Compare Similar fueling with/without cryopumps



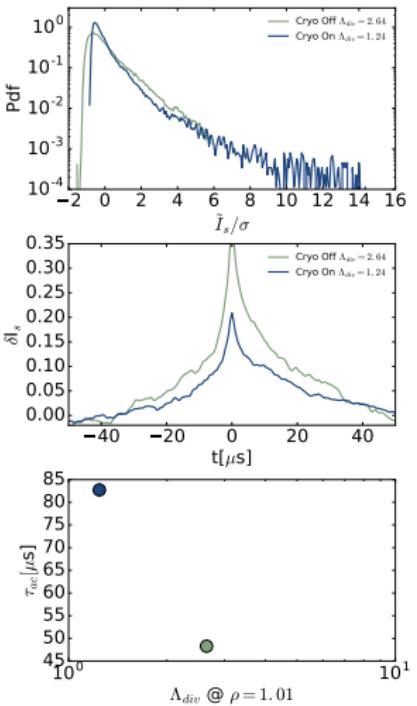
- ✓ Same fueling but with cryo-pumps
- ✓ H-5 density is different and remain constant, both divertor and midplane pressure are reduced (to 1/3 approximately) no sign of detachment
- ✓ Different ELM regimes reached with reduced size and increased frequency without the cryopumps

Compare Similar fueling with/without cryopumps



- ✓ Same fueling but with cryo-pumps
- ✓ H-5 density is different and remain constant, both divertor and midplane pressure are reduced (to 1/3 approximately) no sign of detachment
- ✓ Different ELMy regimes reached with reduced size and increased frequency without the cryopumps
- ✓ Also with this amount of fueling no instance of SOL saturation observed as confirmed by Li-Beam and by RIC (Antenna 4)

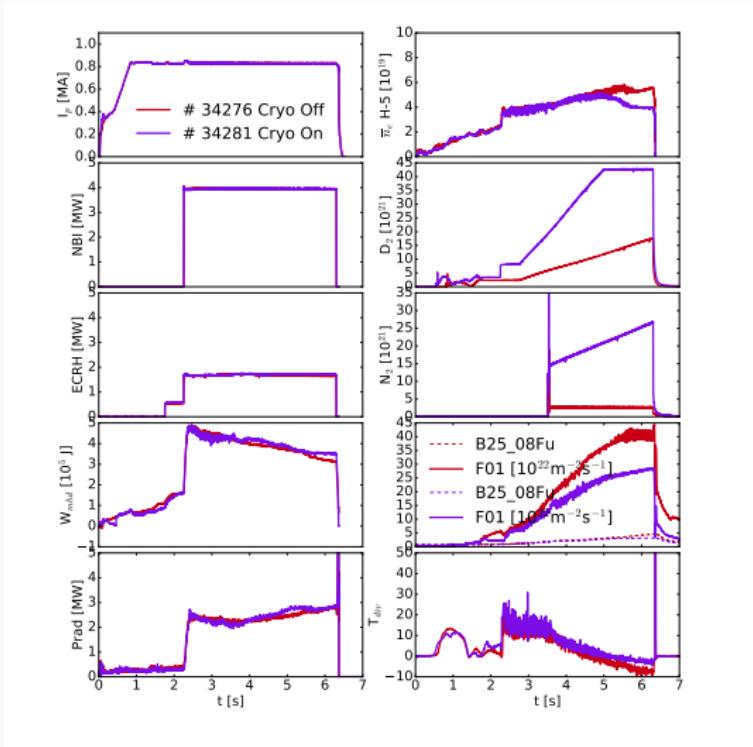
Compare Similar fueling with/without cryopumps



- ✓ Same fueling but with cryo-pumps
- ✓ H-5 density is different and remain constant, both divertor and midplane pressure are reduced (to 1/3 approximately) no sign of detachment
- ✓ Different ELMy regimes reached with reduced size and increased frequency without the cryopumps
- ✓ Also with this amount of fueling no instance of SOL saturation observed as confirmed by Li-Beam and by RIC (Antenna 4)
- ✓ Comparison of fluctuations during the plunge at higher density (**ELM included**) reveal differences in fluctuations. **ELM resolved measurement to be properly done**



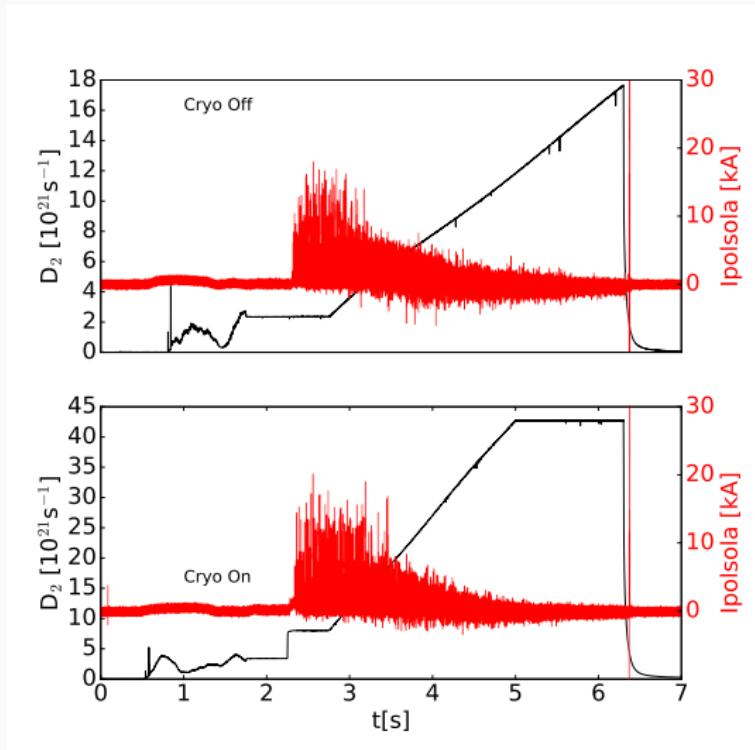
Matching scenarios with cryo-pumps



- ✓ 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



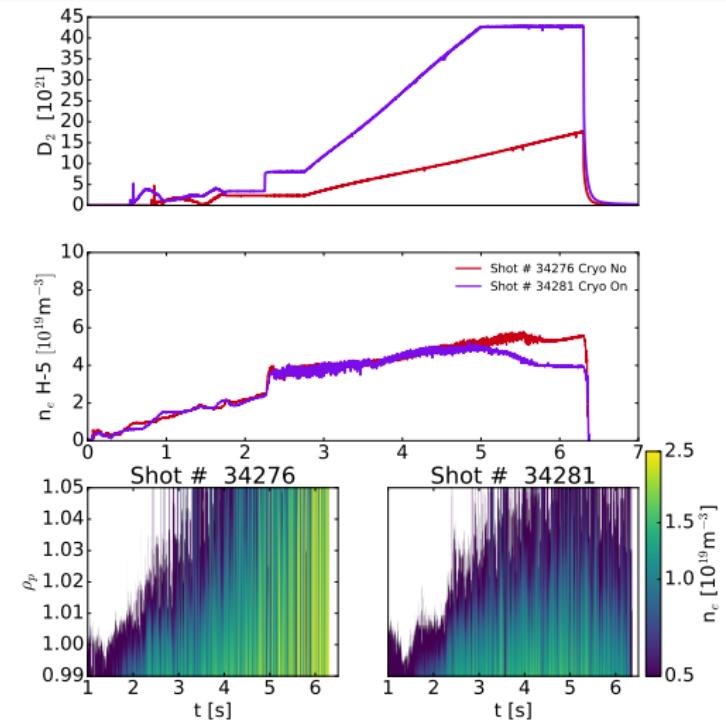
Matching scenarios with cryo-pumps



- ✓ 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
- ✓ Similar ELM behavior obtained during the density ramp



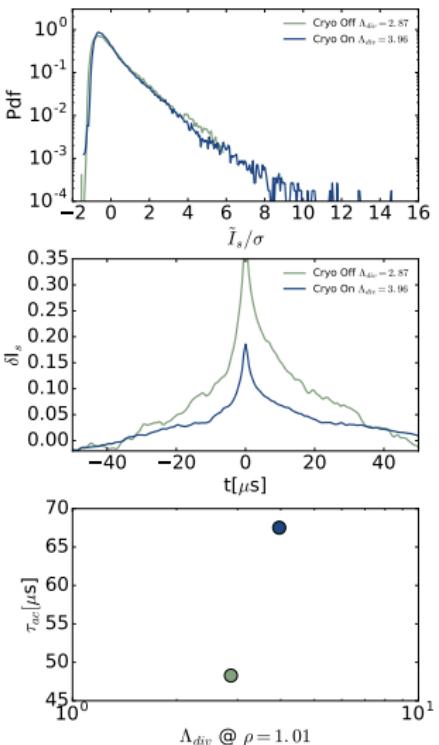
Matching scenarios with cryo-pumps



- ✓ 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
- ✓ Similar ELM behavior obtained during the density ramp
- ✓ Without cryopumps evidence of stronger SOL profile flattening from Li-Be. **To be compared with appropriate variation of Λ_{div}**



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
- ✓ Similar ELM behavior obtained during the density ramp
- ✓ Without cryopumps evidence of stronger SOL profile flattening from Li-Be. **To be compared with appropriate variation of Λ_{div}**
- ✓ The shape of the PDF is rather similar with closer values of autocorrelation time at similar values of divertor collisionality.
Not yet ELM resolved

What is missing



The analysis is still in progress and we are not ready yet to draw final conclusions. Among the future on going analysis we can list:

1. RIC profiles with possible poloidal variation among the antennas in particular in H-Mode. **To be done**
2. Li-Be ELM resolved profile variation with Λ_{div} **To be done**
3. Li-Be fluctuations **To be done**
4. Structures size and velocities in L-Mode **In progress**
5. Radiation front movement **In progress**
6. Evolution of divertor profiles from Spectroscopy **In progress**
7. Neutrals analysis from D_α camera combined with KN1D code for evolution of neutrals **In progress**
8. Fast-camera **To be done**