



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

J. Madsen and N. Vianello

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6. First we will report a summary of the achievements and then personal comments and plans

I-mode

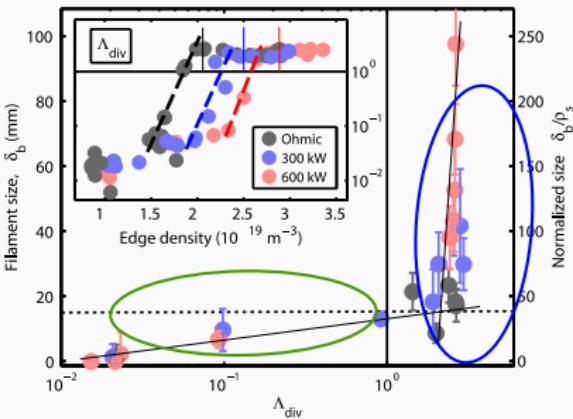
L-Mode studies: AUG/I



- ✓ AUG and JET (Carralero et al. 2015) suggest that

$$\Lambda_{\text{div}} = \frac{L_{\parallel}/c_s}{1/\nu_{ei}} \frac{\Omega_i}{\Omega_e}$$

dominates this process and a transition from **sheath-limited** to **inertial regime**



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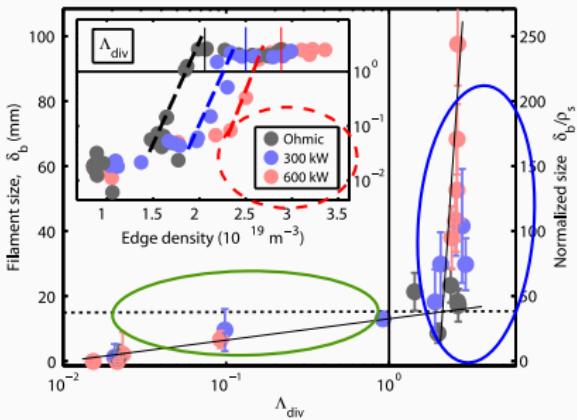


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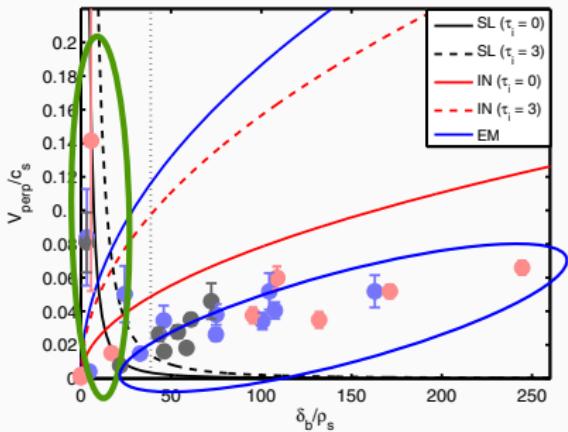


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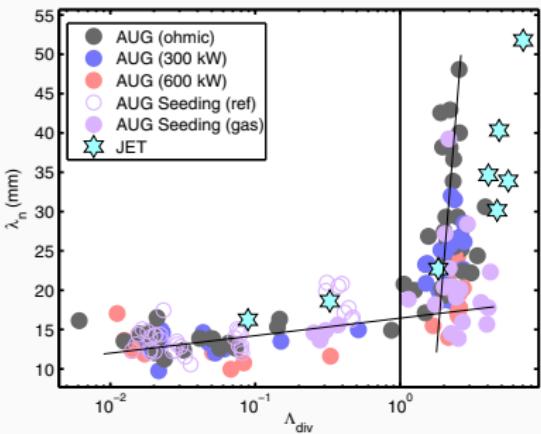


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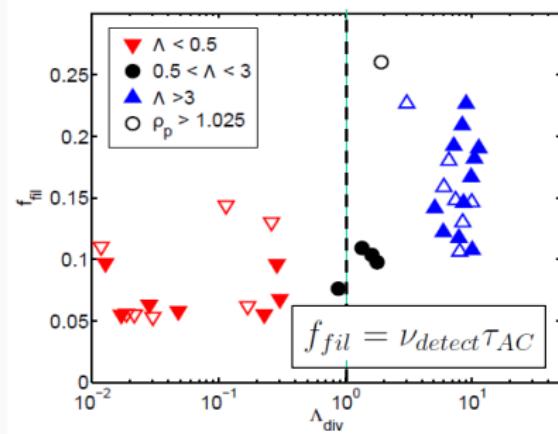
- ✓ Tested by changing n_e and T_e through fueling/seeding/heating
- ✓ This determines a change of the velocity-size scaling. Λ_{div} rules the density profile scale length



L-Mode studies: AUG/2



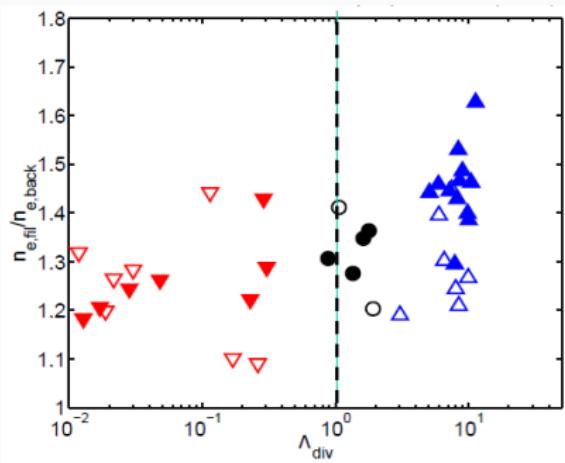
- ✓ Profile modified by increase of blob-size and change of packing fraction: $f_{fil} = \nu_{fil} \tau_{AC}$



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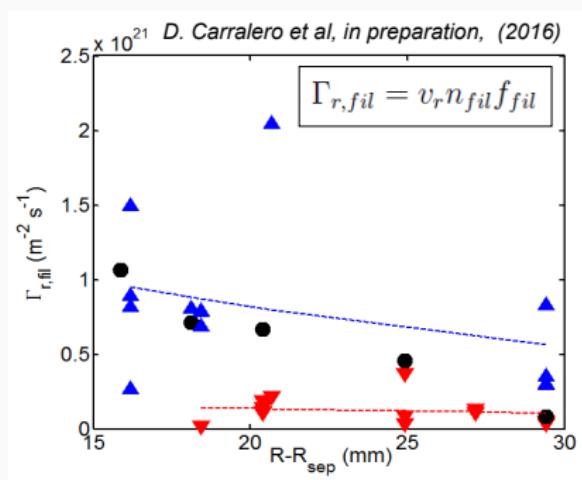
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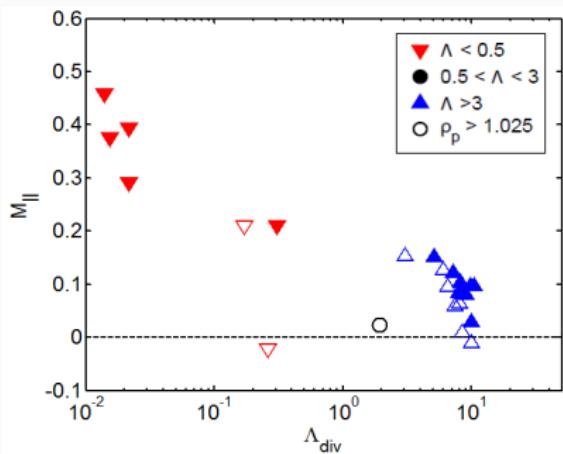
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- ✓ Parallel flow is strongly reduced whenever we increase the divertor collisionality



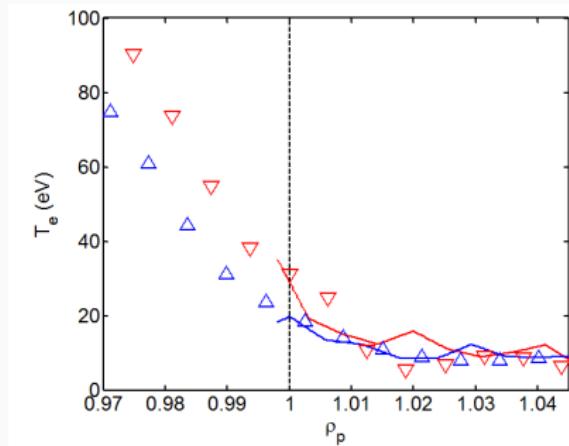


- ✓ Electron and ions behave differently

L-Mode studies:AUG/3



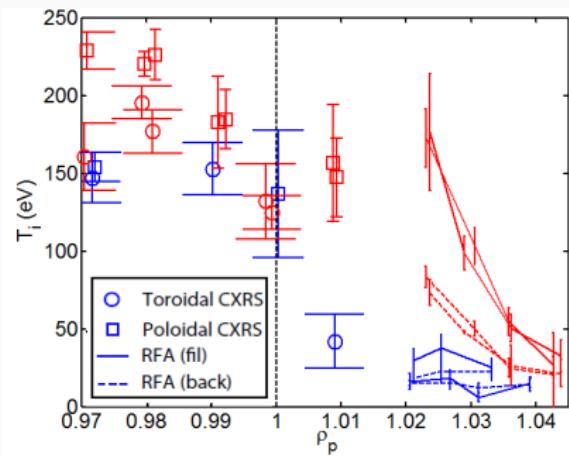
- ✓ Electron and ions behave differently
- ✓ $T_{e,fil} \sim 1.2T_{e,bk}$ roughly constant across the SOL and slightly affected by the increase of divertor collisionality



L-Mode studies:AUG/3



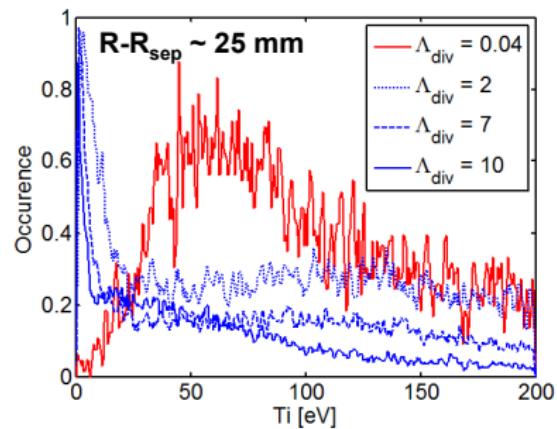
- ✓ Electron and ions behave differently
- ✓ Ions are strongly affected: for $\Lambda_{div} < l$
 $T_{i,fil} > T_{i,bk}$ and $\lambda_{T_i} \sim 30$ mm.
 $\Lambda_{div} > l$ $T_{i,fil} \sim T_{i,bk} \sim 25$ eV and
 $\lambda_{T_i} \sim 8$ mm



L-Mode studies:AUG/3



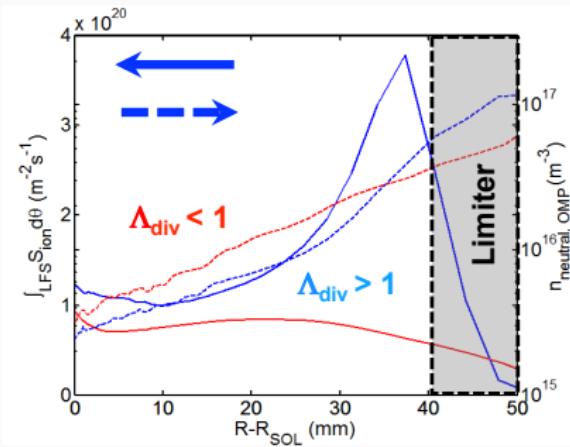
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- ✓ Electron and ions behave differently
- ✓ Ion energy spectrum from $\mathbf{E} \times \mathbf{B}$ analyzer shrinks towards lower energy for $\Lambda_{\text{div}} > 1$
- ✓ EMC3-Eirene simulation suggests that such a reduction can't be accounted for thermalization process. An ionization front builds in front of the limiter shadow





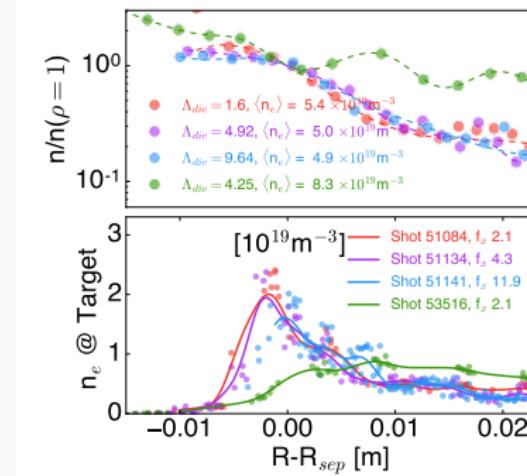
- ✓ Flexibility has allowed to test Λ_{div} dependence on L_{\parallel} by varying flux expansion f_x :

$$f_x = \frac{(B_p/B_t)_{MP}}{(B_p/B_t)_{SP}}$$

in ohmic density ramps (Vianello *et al.* 2016)

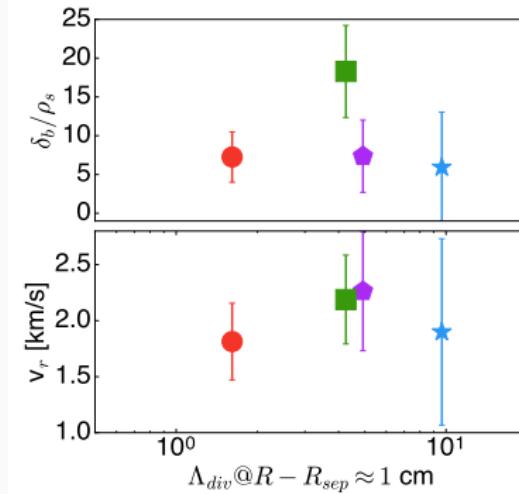


- ✓ Slight variation of density profiles at the target but due to direct dependence on L_{\parallel} large increase of Λ_{div} . Upstream profiles only varies whenever we reach a certain amount of $\langle n_e \rangle$



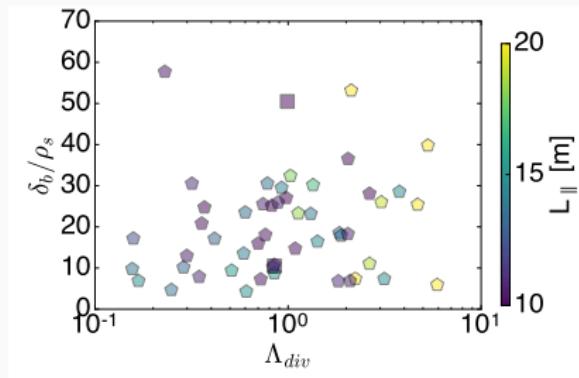


- ✓ Weak dependence of blob-size from Λ_{div} ,



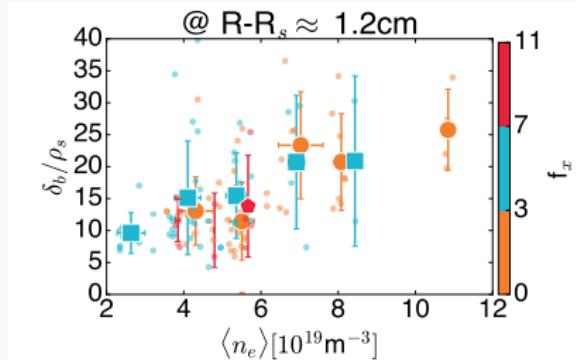


- ✓ Weak dependence of blob-size from Λ_{div} , also on a statistical basis.



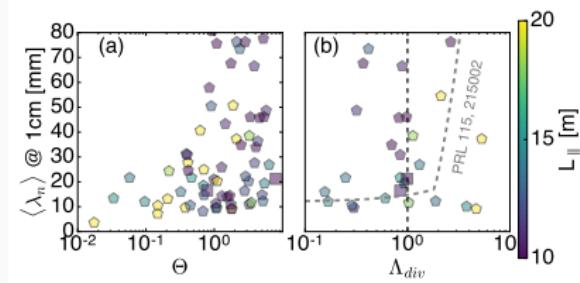


- ✓ Weak dependence of blob-size from Λ_{div} , also on a statistical basis. Strong dependence on average density, independent of L_{\parallel}



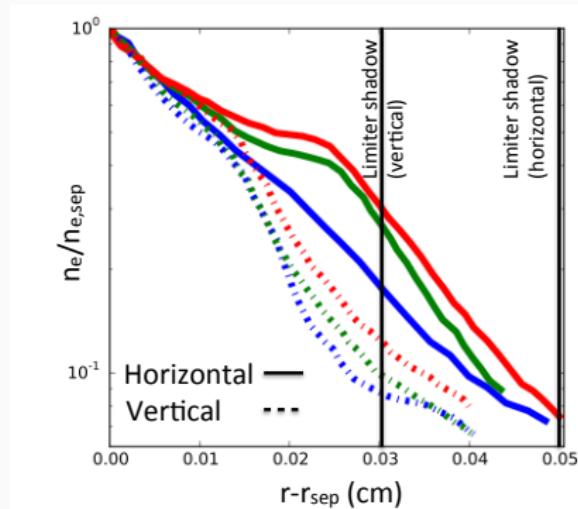


- ✓ λ_n depends clearly on blob-size whereas the dependence on divertor condition is less obvious. Λ_{div} necessary but not sufficient



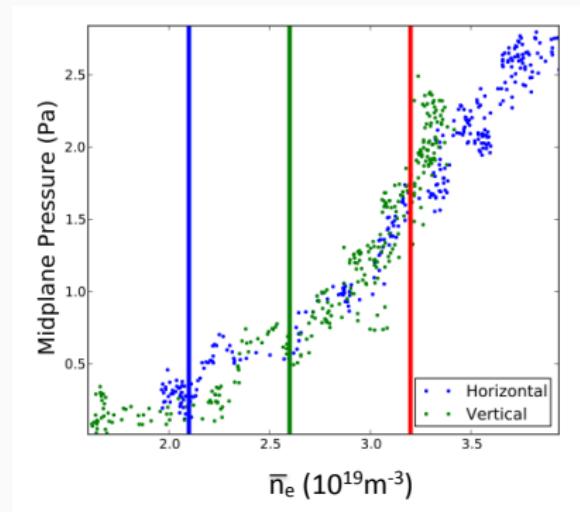


- ✓ The shoulder formation strongly depends on divertor geometry, disappear with vertical target and strike point closest to cryogenics pumps (Wynn et al. 2016)



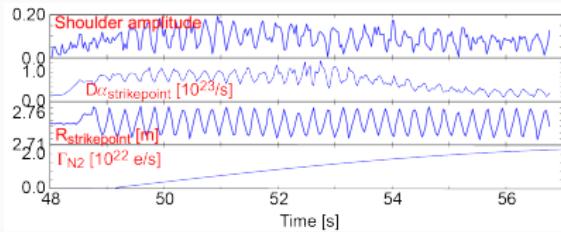


- ✓ The midplane pressure from baratrons is equivalent between the different divertor. This would indicate that SOL neutral density does not play any role



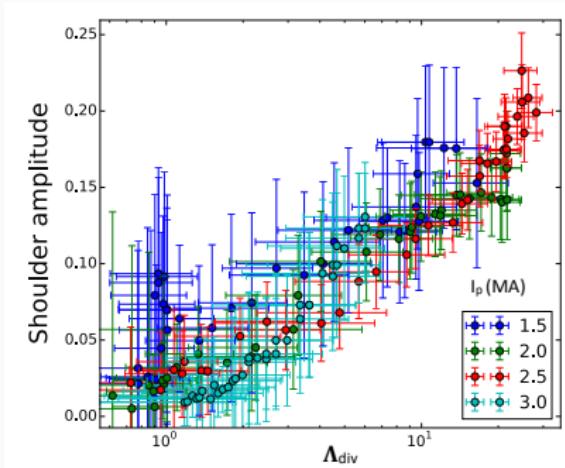


- ✓ In the horizontal target configuration the results indicate that the shoulder forms right at the transition from sheath-limited to high-recycling where also Λ_{div} strongly increase



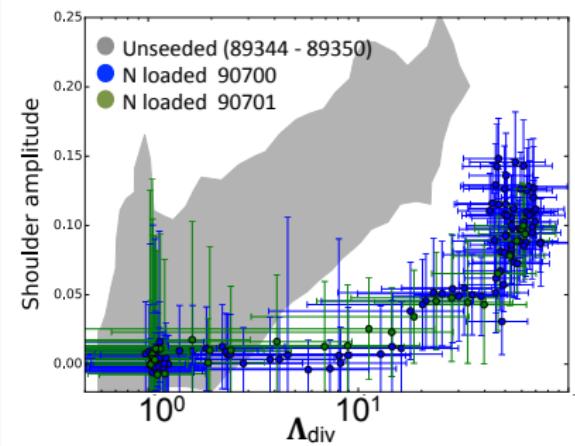


- ✓ Shoulder amplitude correlates with strike points position. Shoulder, ionization and $\Gamma_{ion,plate}$ larger when R_{strike} smaller away from the pump





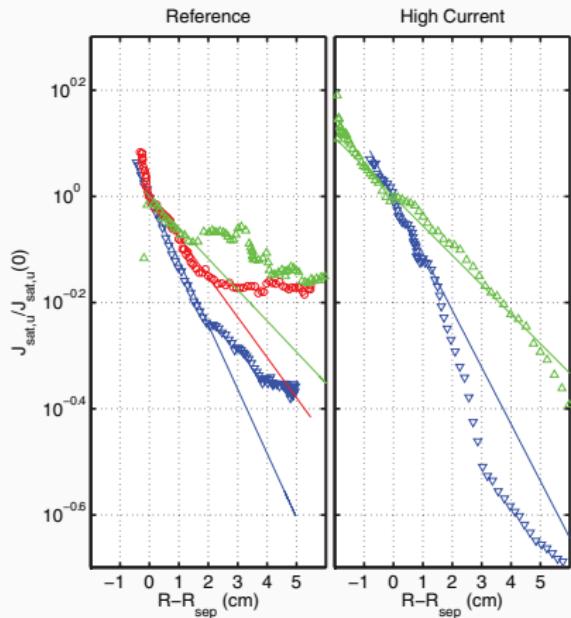
- ✓ In seeded discharges the transition observed at very high level of $\Lambda_{div} \gg 1$



L-Mode: MAST

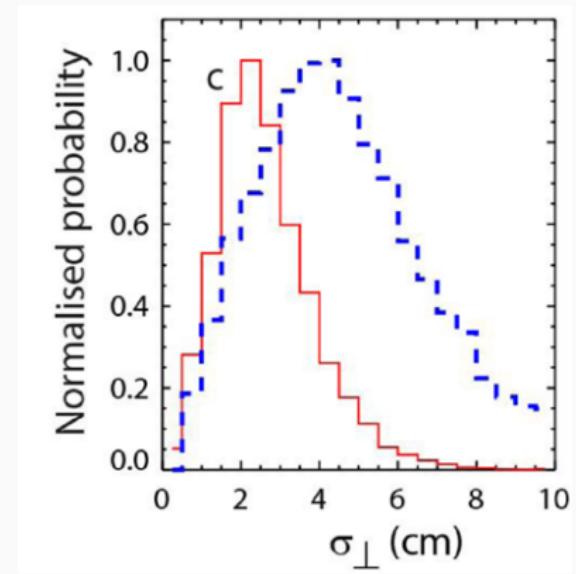


- ✓ Strong dependence on I_p (Militello *et al.* 2016). Increasing I_p at constant toroidal field shoulder disappear. Consistent with observation in other devices



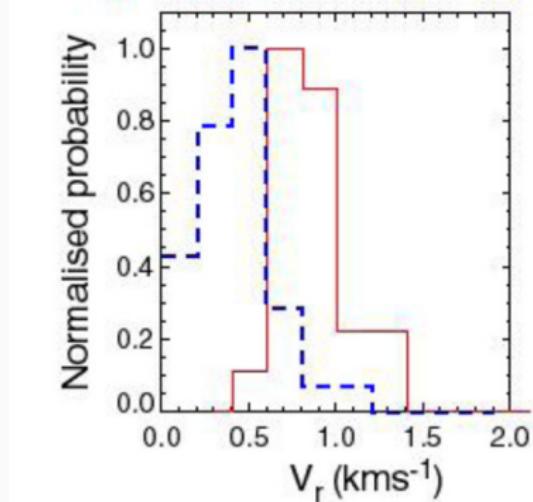


- ✓ Filaments binormal dimension increases with current (Kirk et al. 2016) or equivalently decreases with L_{\parallel}





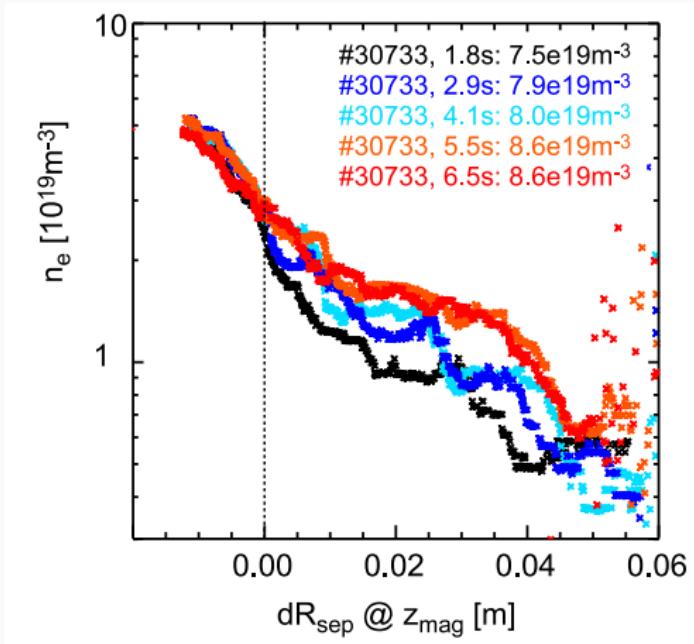
- ✓ Filament radial velocity decreases with current as well as the radial dimension
(Kirk et al. 2016)



h-mode

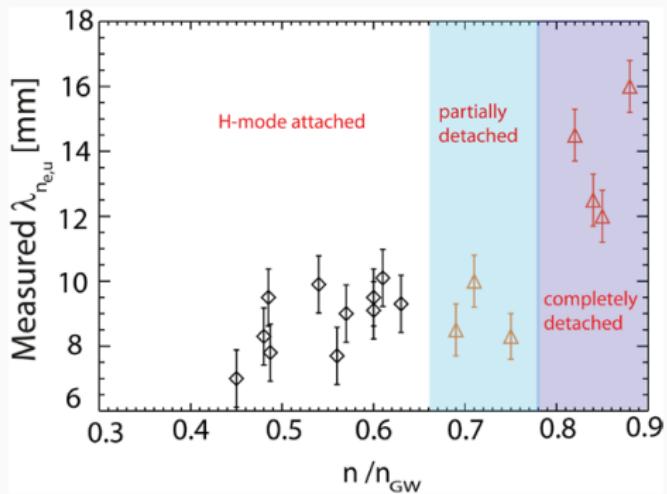


- ✓ SOL profiles in H-Mode so far investigated on AUG
(Müller et al. 2015; Sun et al. 2015)



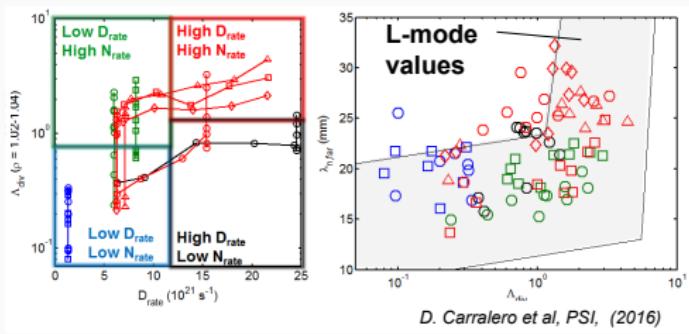


- ✓ Differently from L-Mode, complete detachment suggested to be mandatory for increasing of λ_n (Sun et al. 2015)





- ✓ In weak H-Mode (Carralero et al. 2016) shoulder depends on a combination of Λ_{div} and fueling rate



open issue

Open and unresolved issues



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5. Can be translate straightforward from L to H-Mode? So far no as shown in H-Mode AUG. We need higher detachment condition and we need enough fueling