

The IN-mode in the TCV tokamak

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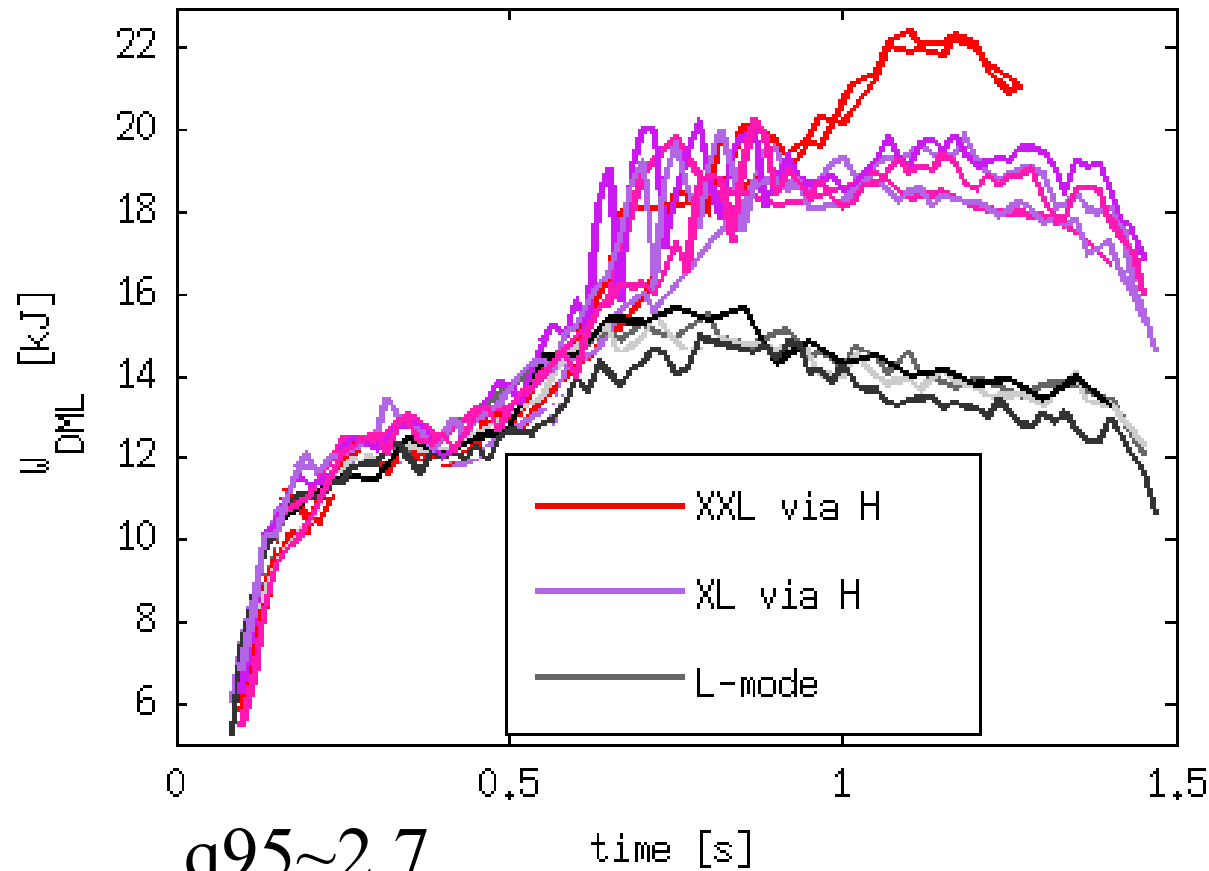
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Lausanne, Switzerland



Outline

- High L-mode confinement in ohmic TCV shots
- Proximity to L-H transition
- Role of density in early phase of the discharge
- Comparison with H-mode profiles
- Similarity of core profiles, role of edge properties
- Conclusions

High L-mode confinement in ohmic TCV shots



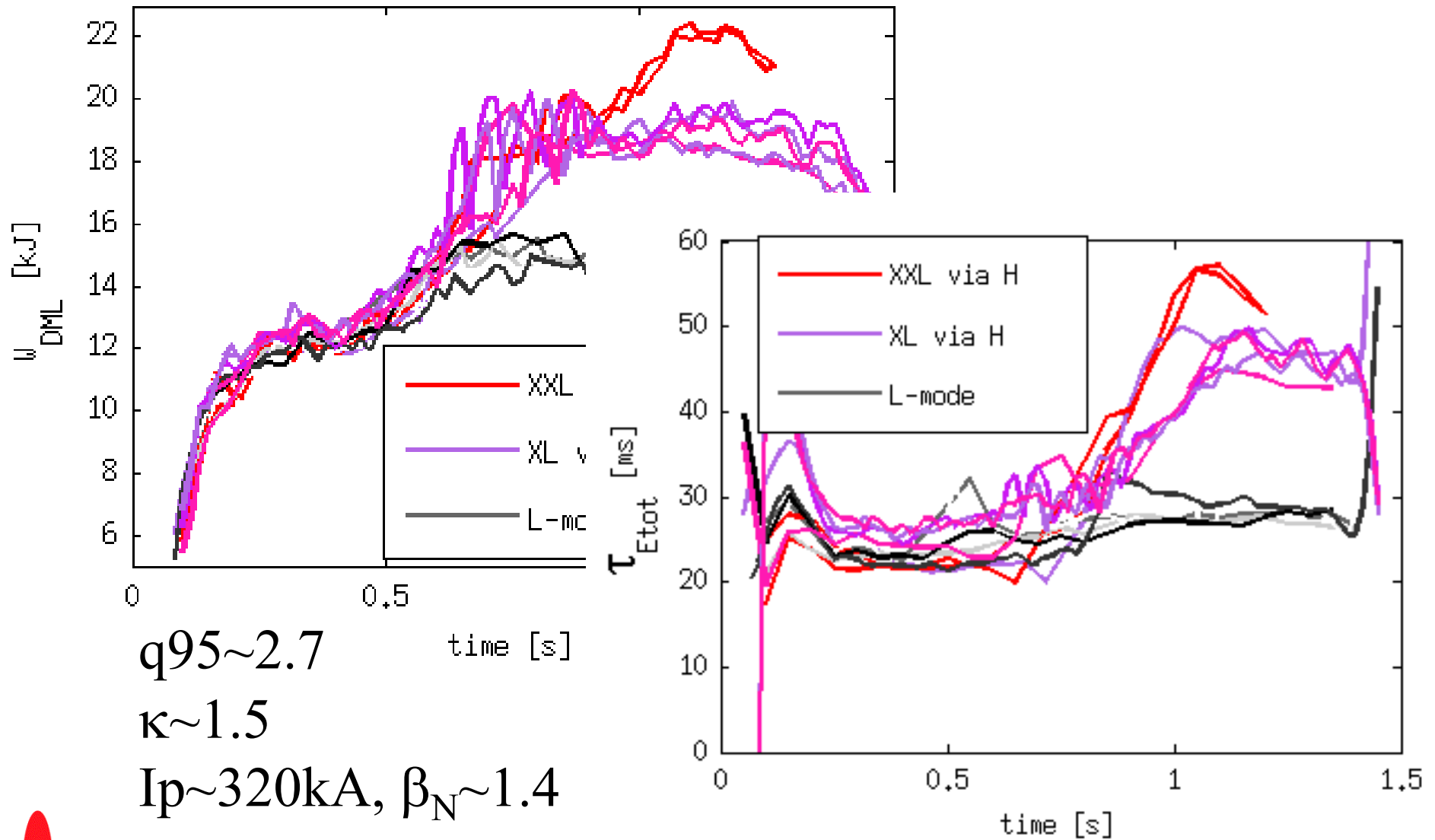
$q_{95} \sim 2.7$ time [s]

$\kappa \sim 1.5$

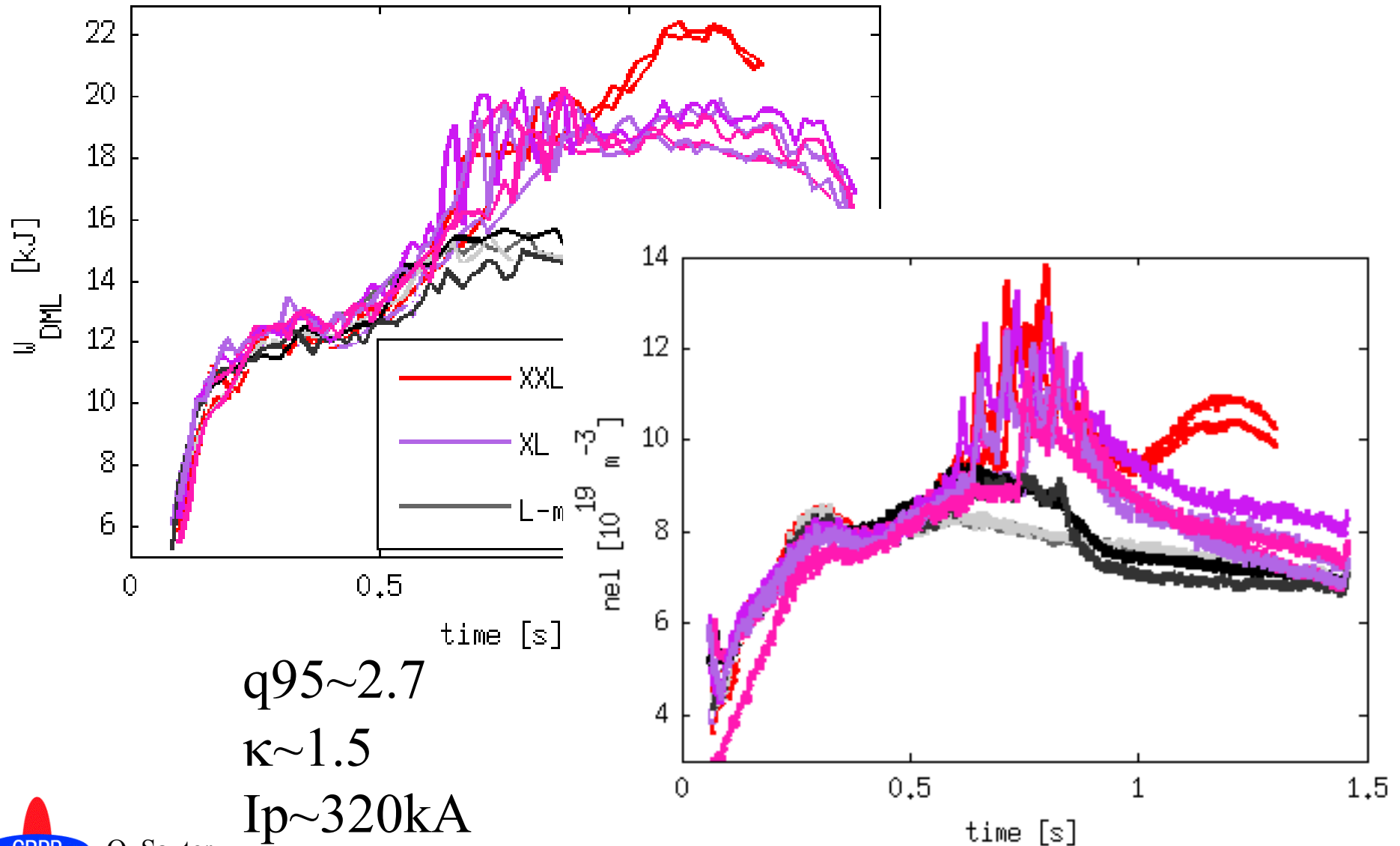
$I_p \sim 320 \text{ kA}$, $\beta_N \sim 1.4$



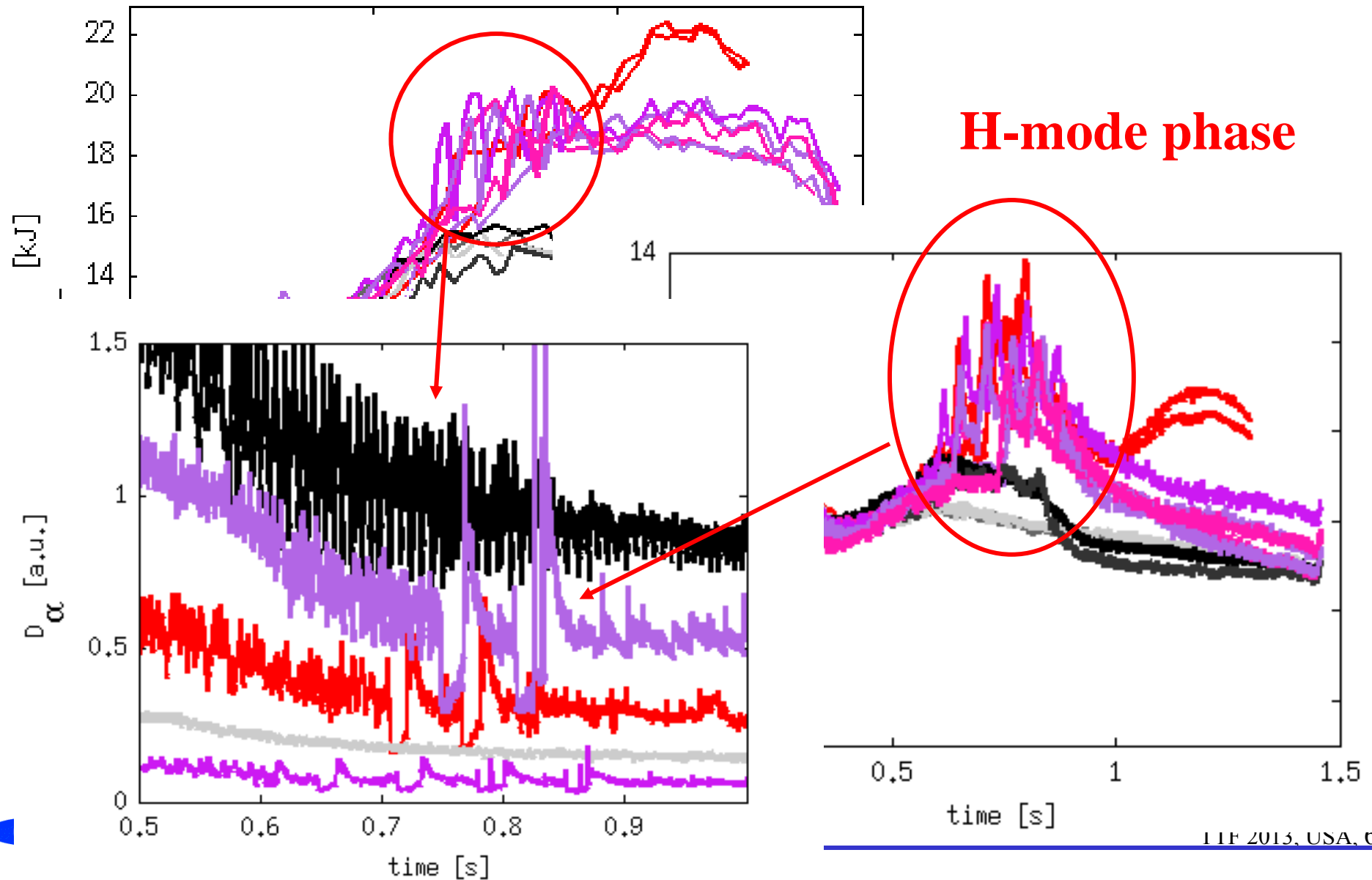
High L-mode confinement in ohmic TCV shots



High L-mode confinement in ohmic TCV shots

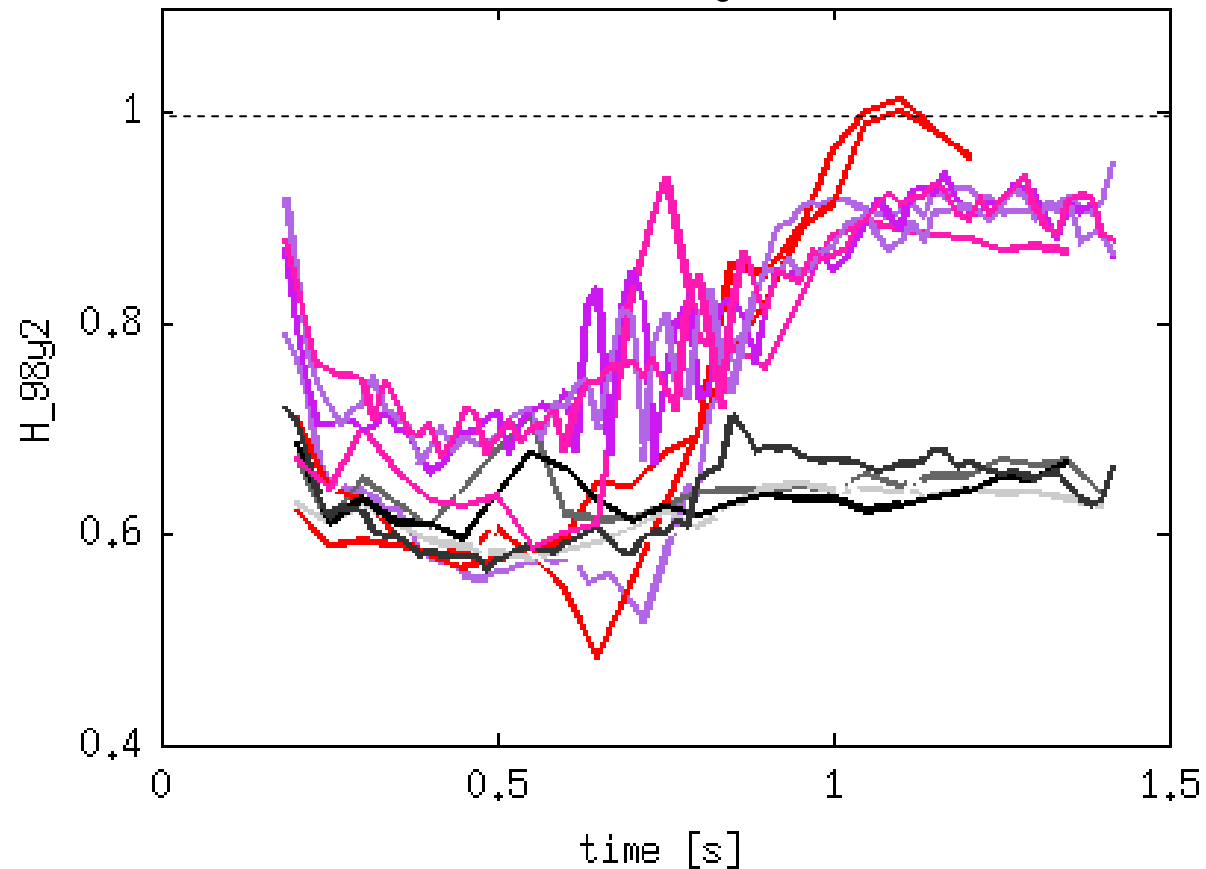


High L-mode confinement in ohmic TCV shots

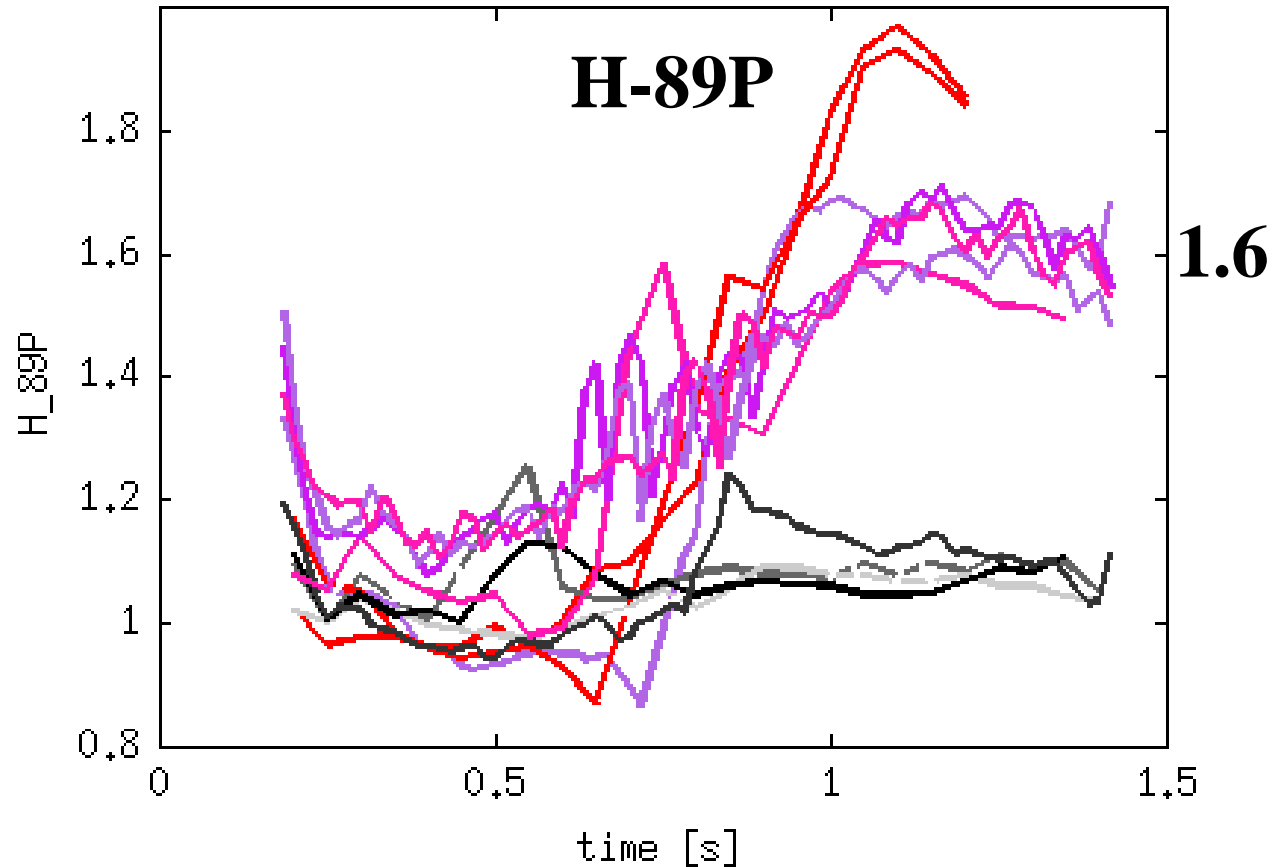


Improved L-mode Thanks to H-mode phase

H-98y2



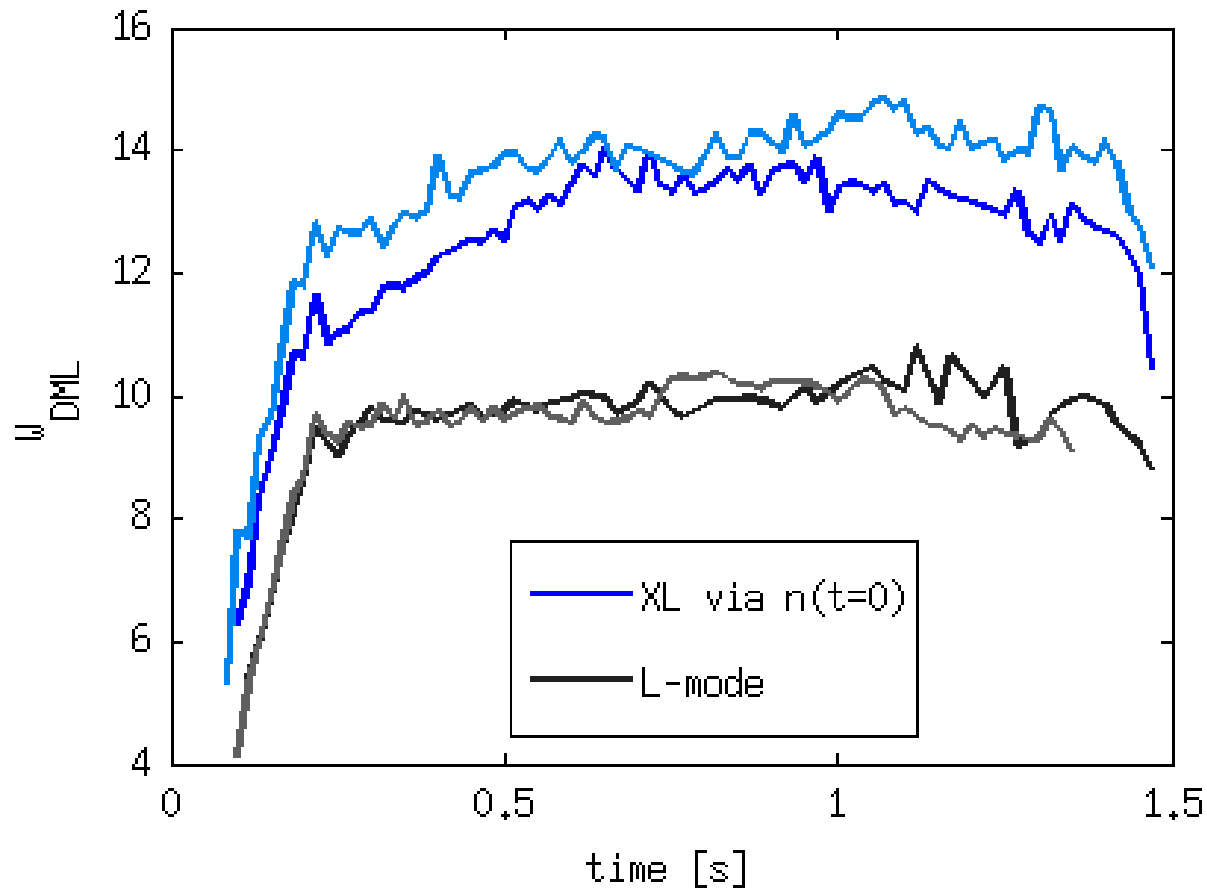
Improved L-mode Thanks to H-mode phase



Through H-mode phase: normal to high L-mode conf.



Without H-mode phase at lower I_p



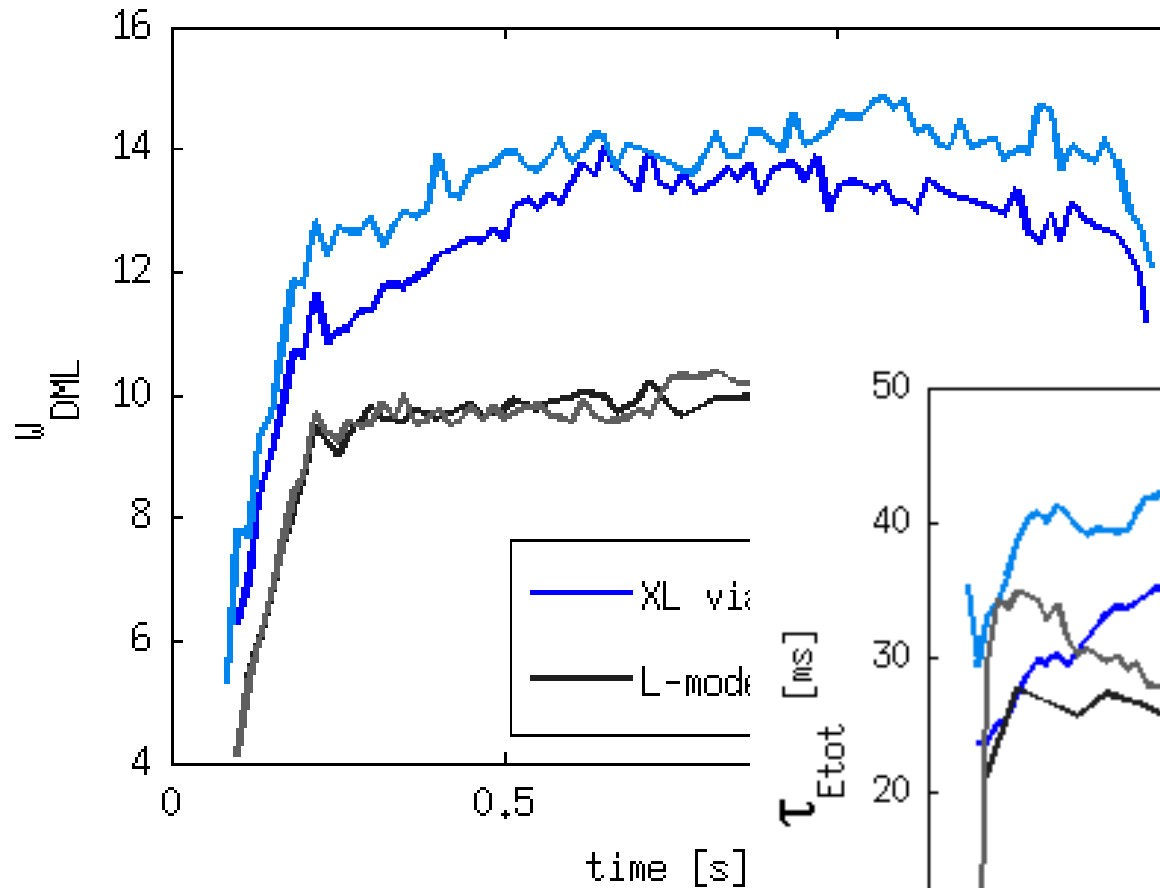
$q_{95} \sim 3.3$

$\kappa \sim 1.4$

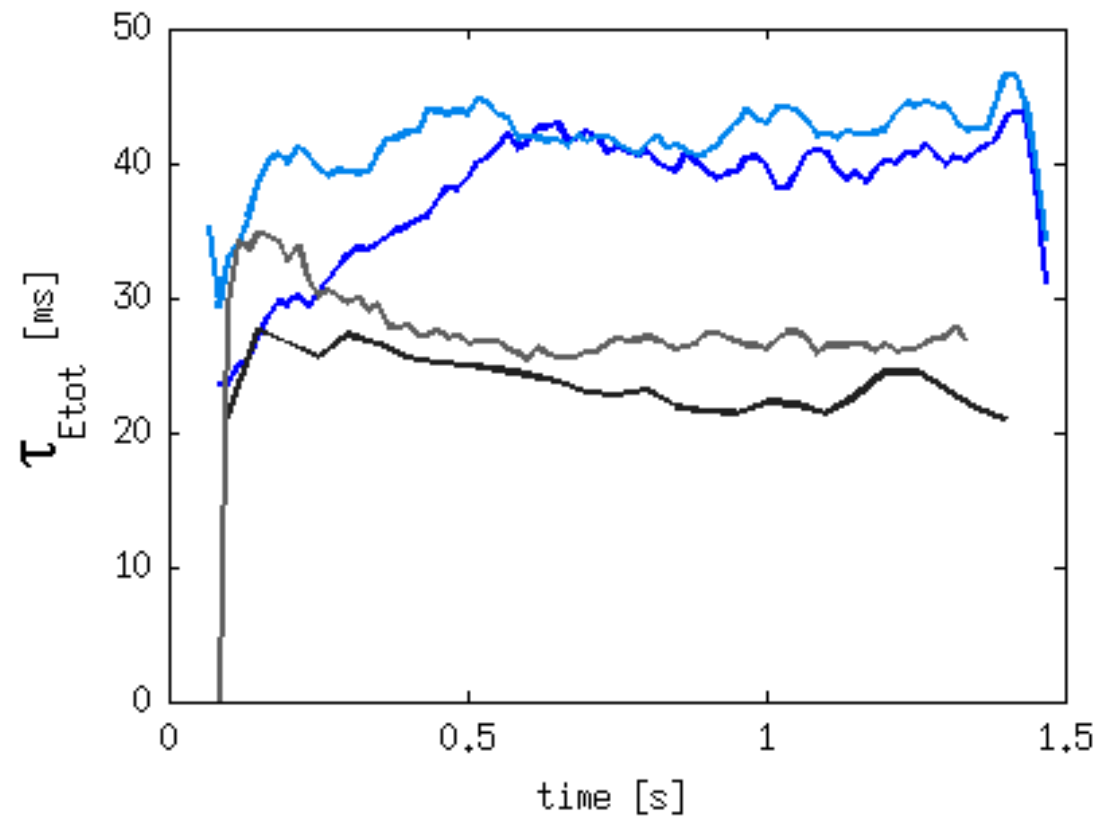
$I_p \sim 270 \text{ kA}$



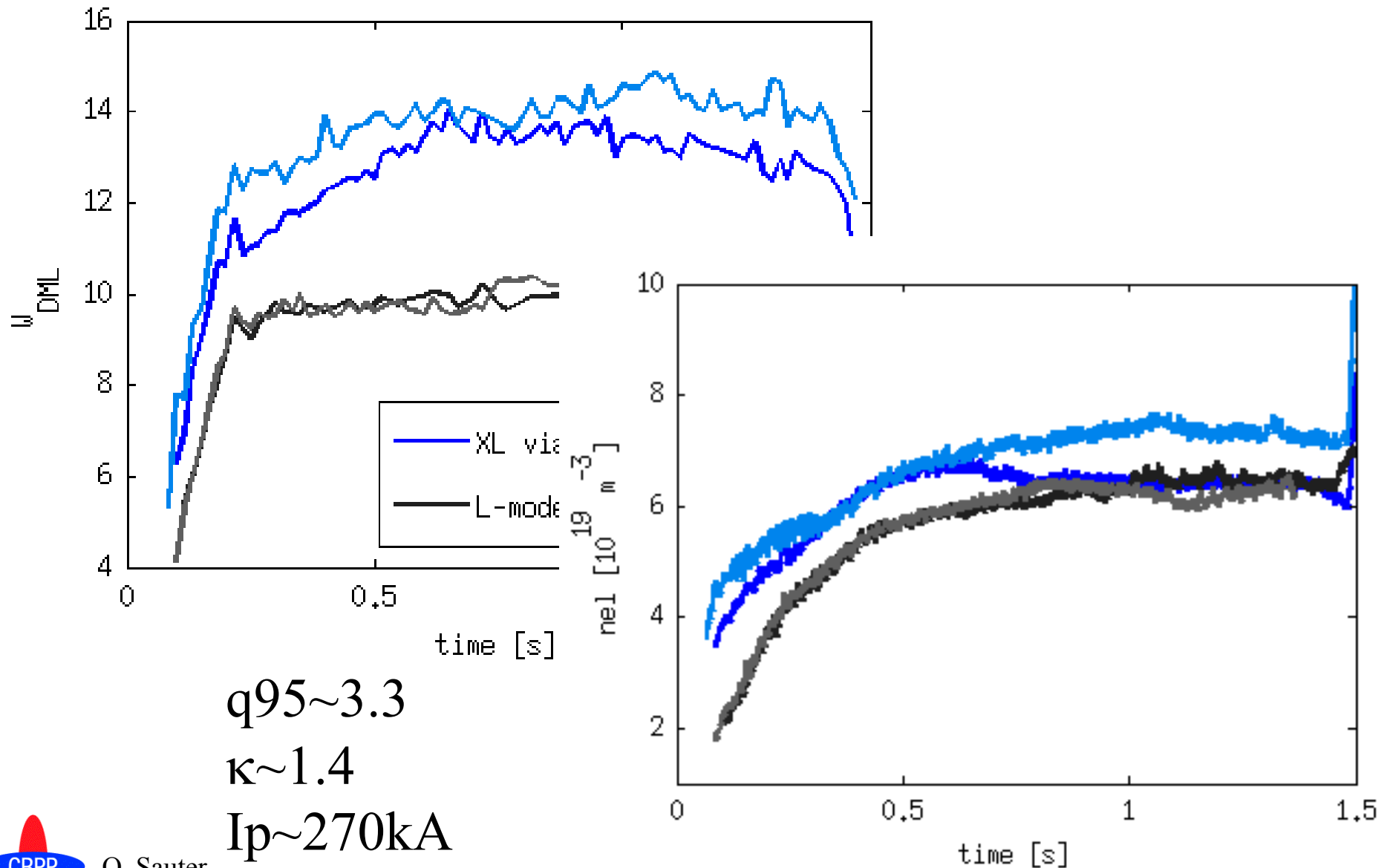
Without H-mode phase at lower I_p



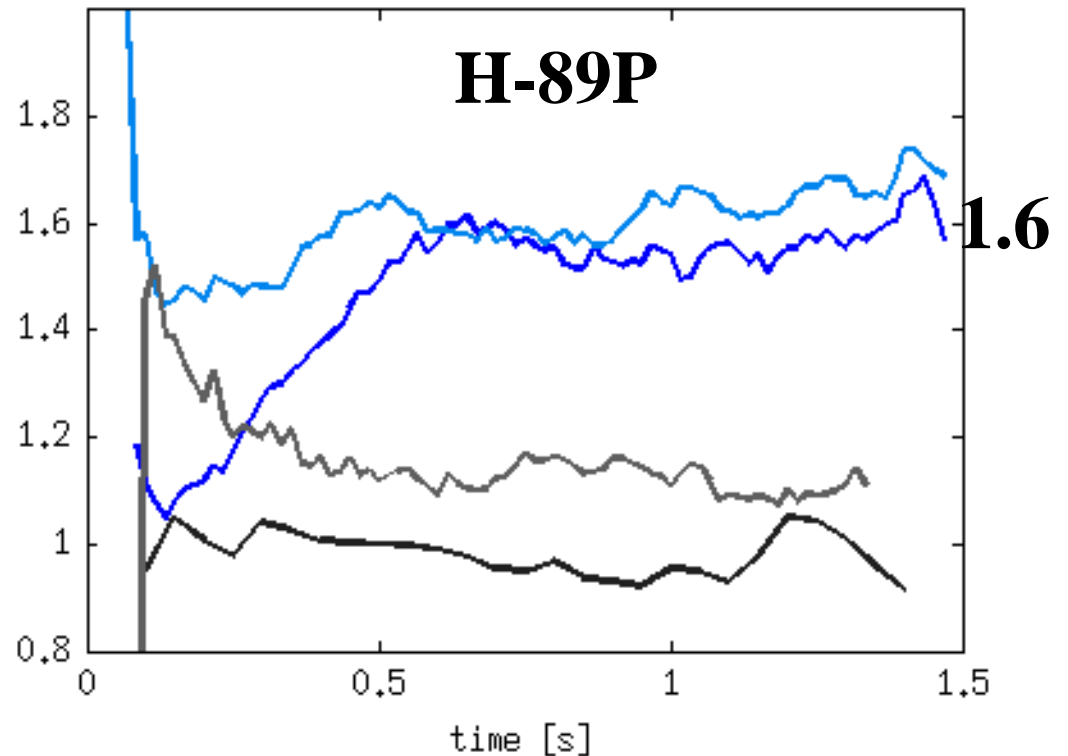
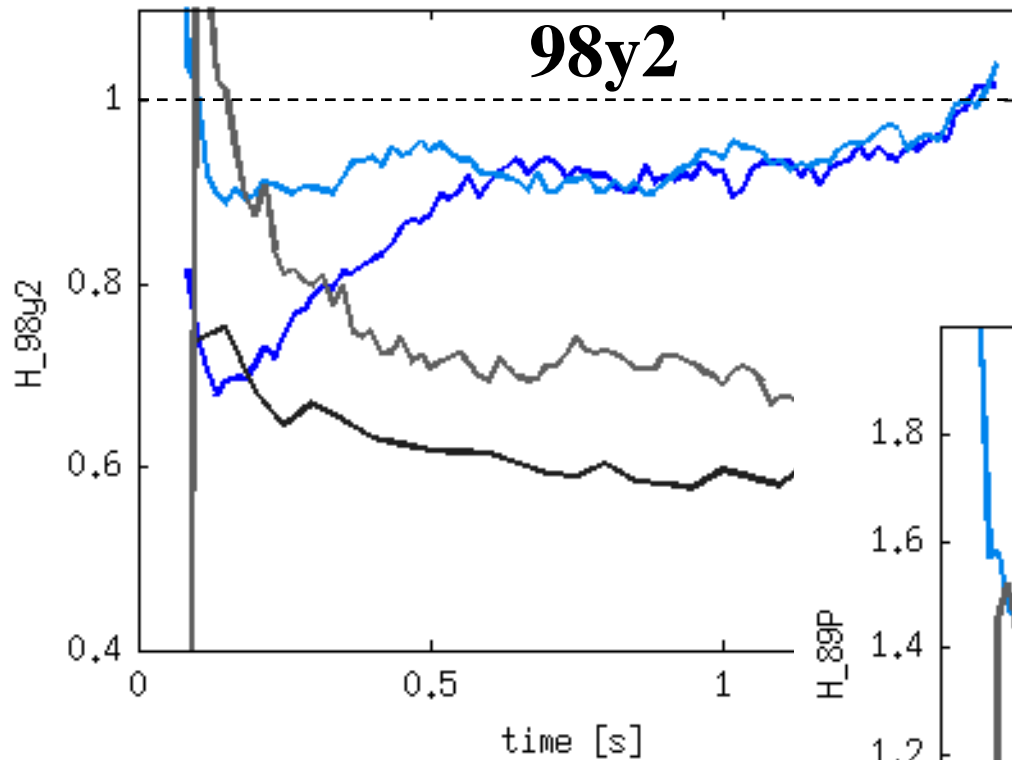
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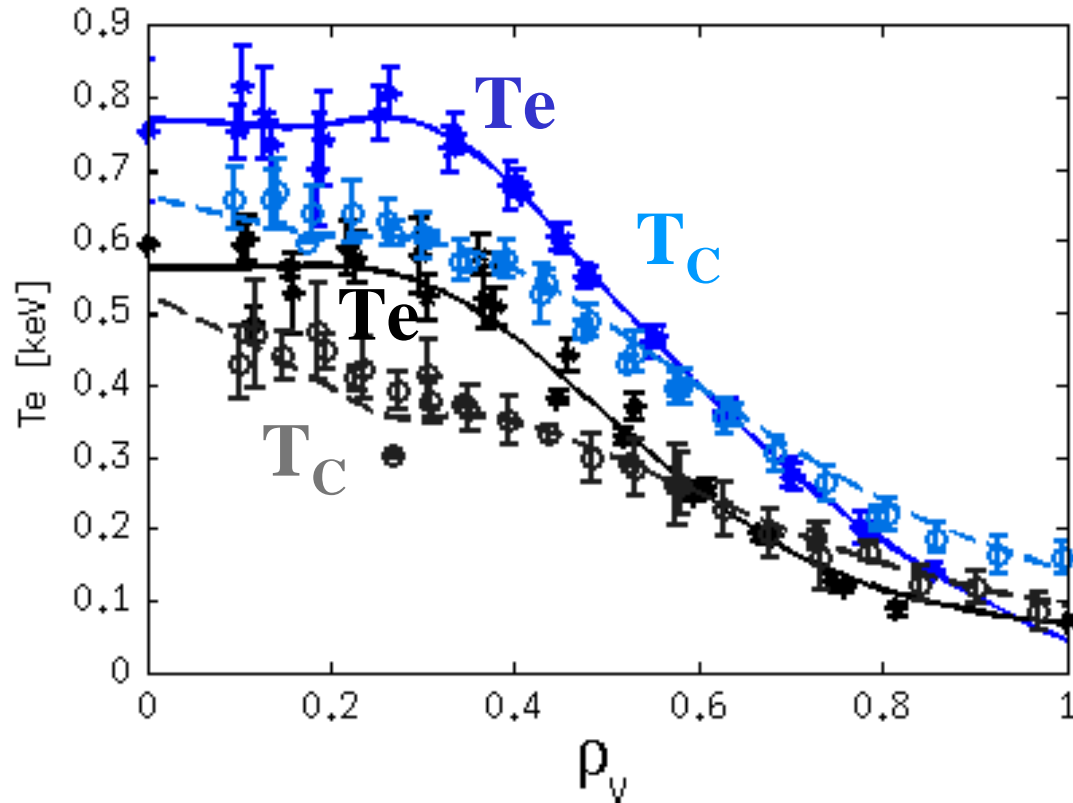
Without H-mode phase at lower I_p



Without H-mode phase at lower Ip: similar H-factors: L-mode with $H_{98y2} \approx 0.9$



T_e, T_i in low I_p IN-mode: $T_e \sim T_i$ (high n_e)



$I_p=260\text{kA}, n_{e1}=6.3e19$

45870: ($W_{dml}=13.5$)

$W_e=7.0\text{kJ}$

$W_i=5.5\text{kJ}$

46178: ($W_{dml}=10$)

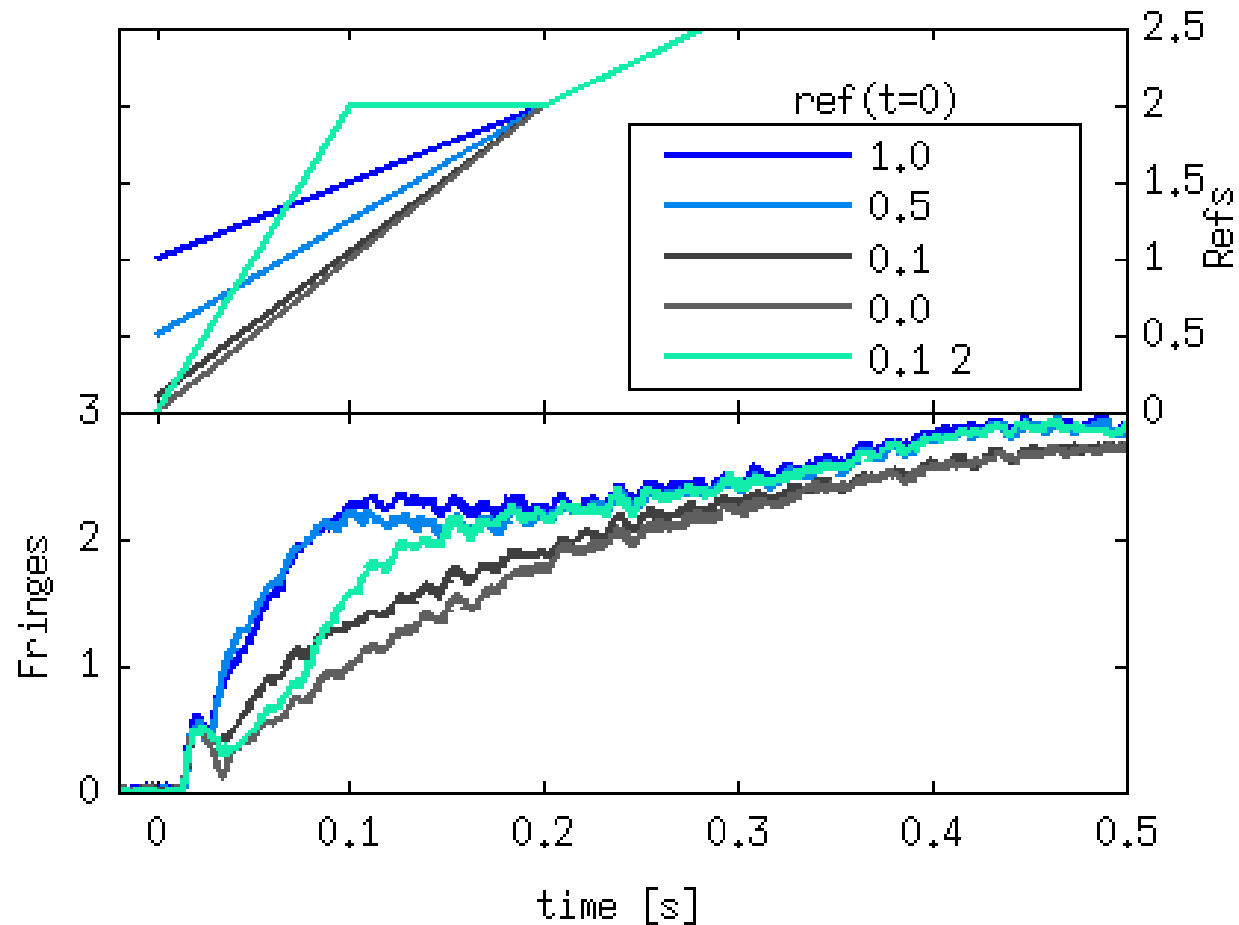
$W_e=4.5\text{kJ}$

$W_i=4.0\text{kJ}$

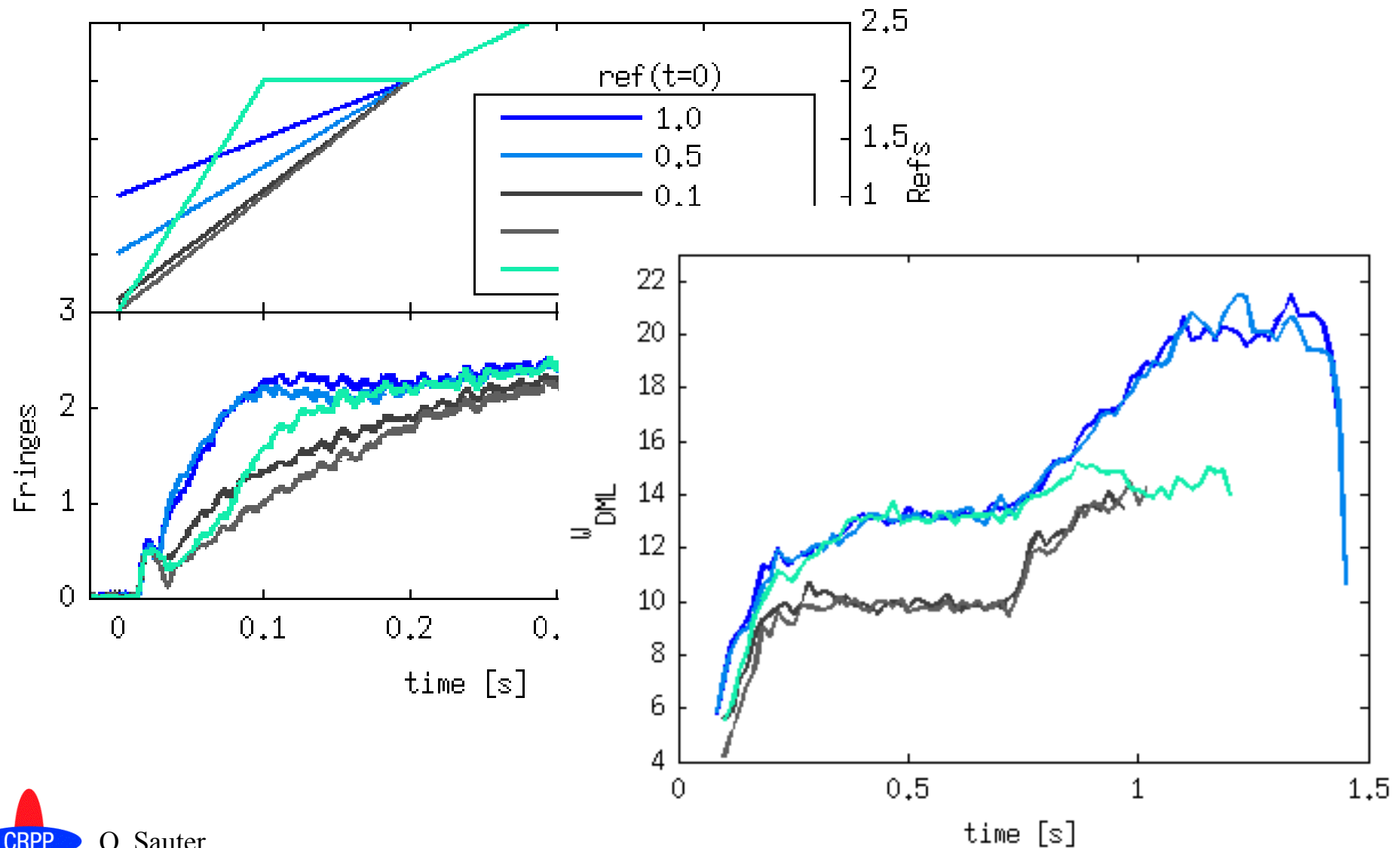
- Both T_e and T_i improve
- $T_i > T_e$ in edge region
- Density profiles are similar (n_{e1} control)



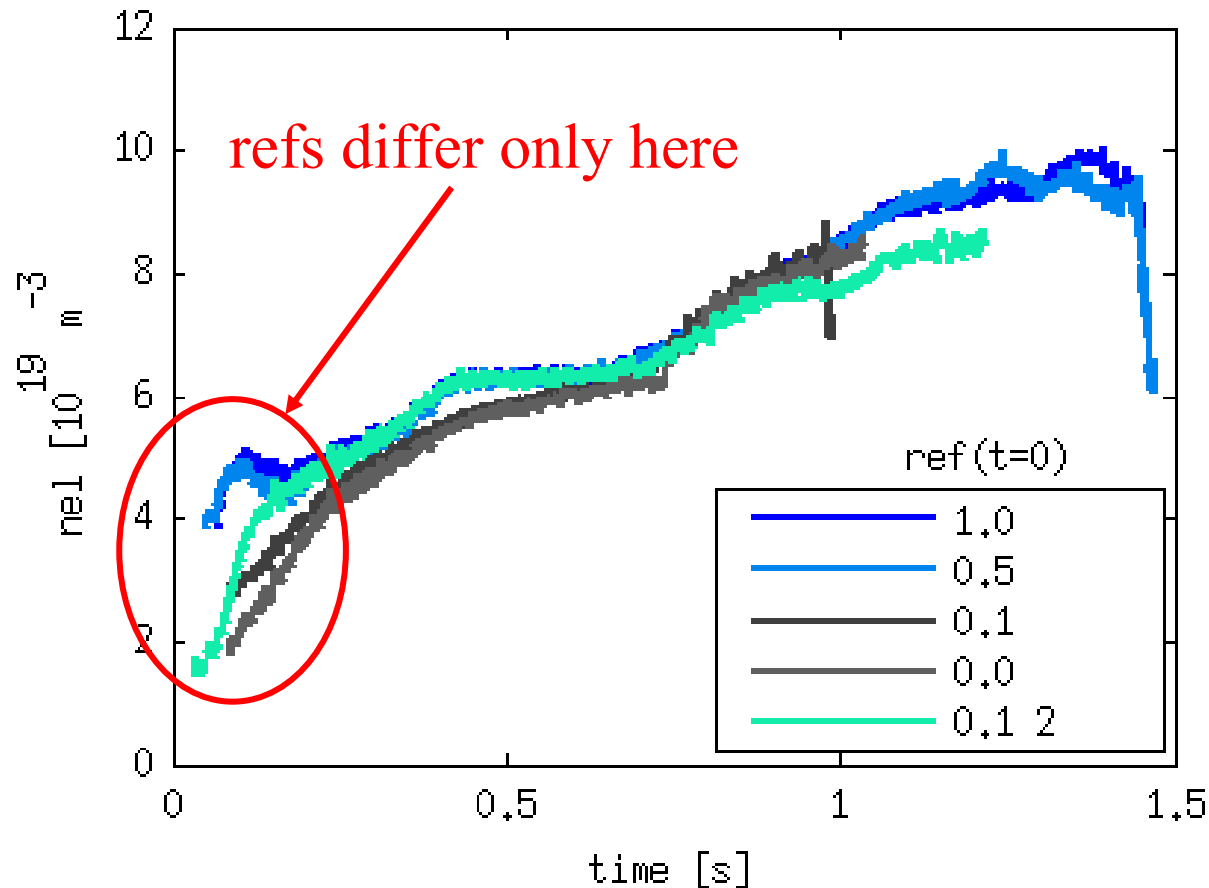
Without H-mode phase: Importance of early density reference



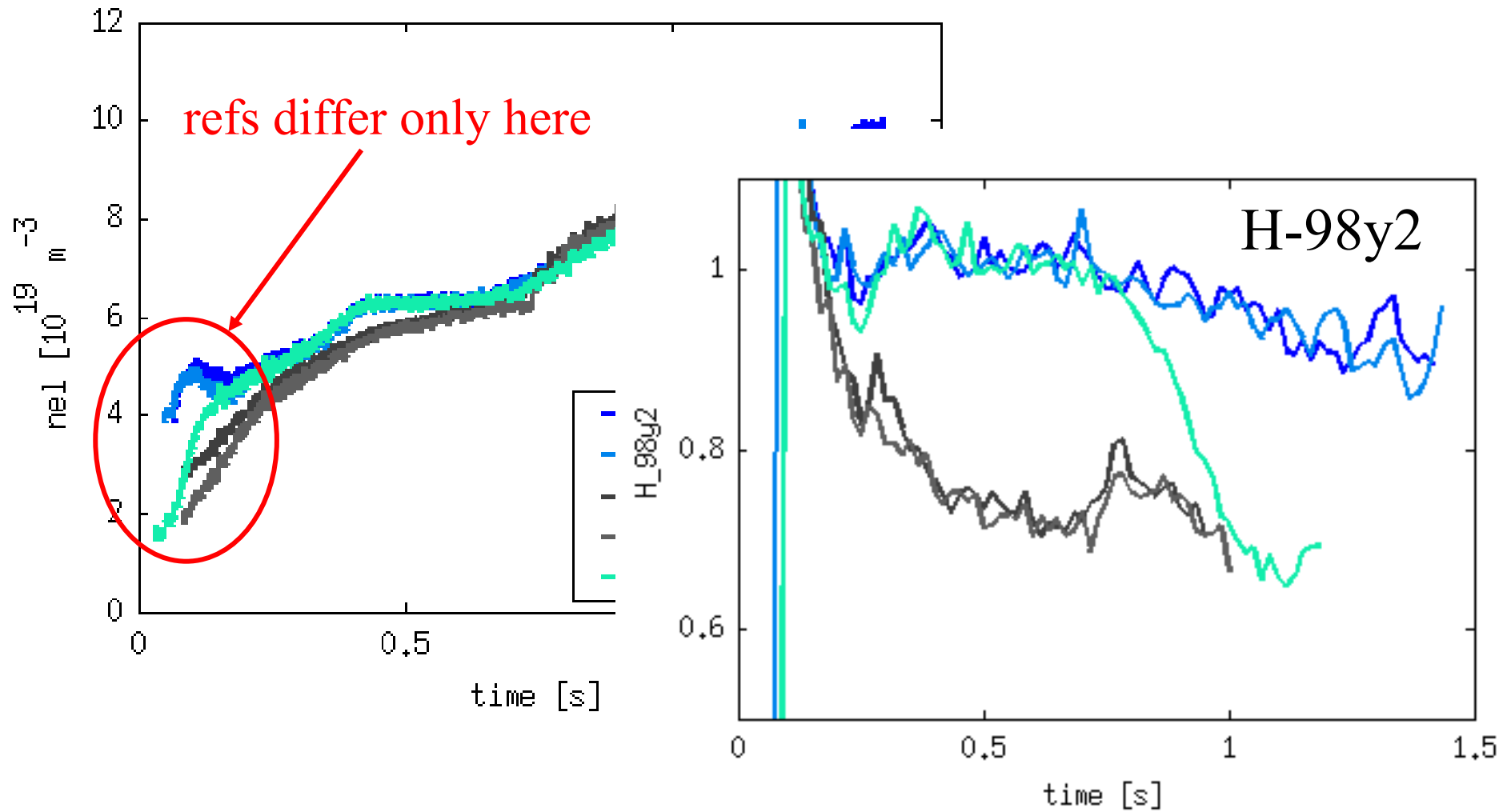
Without H-mode phase: Importance of early density reference



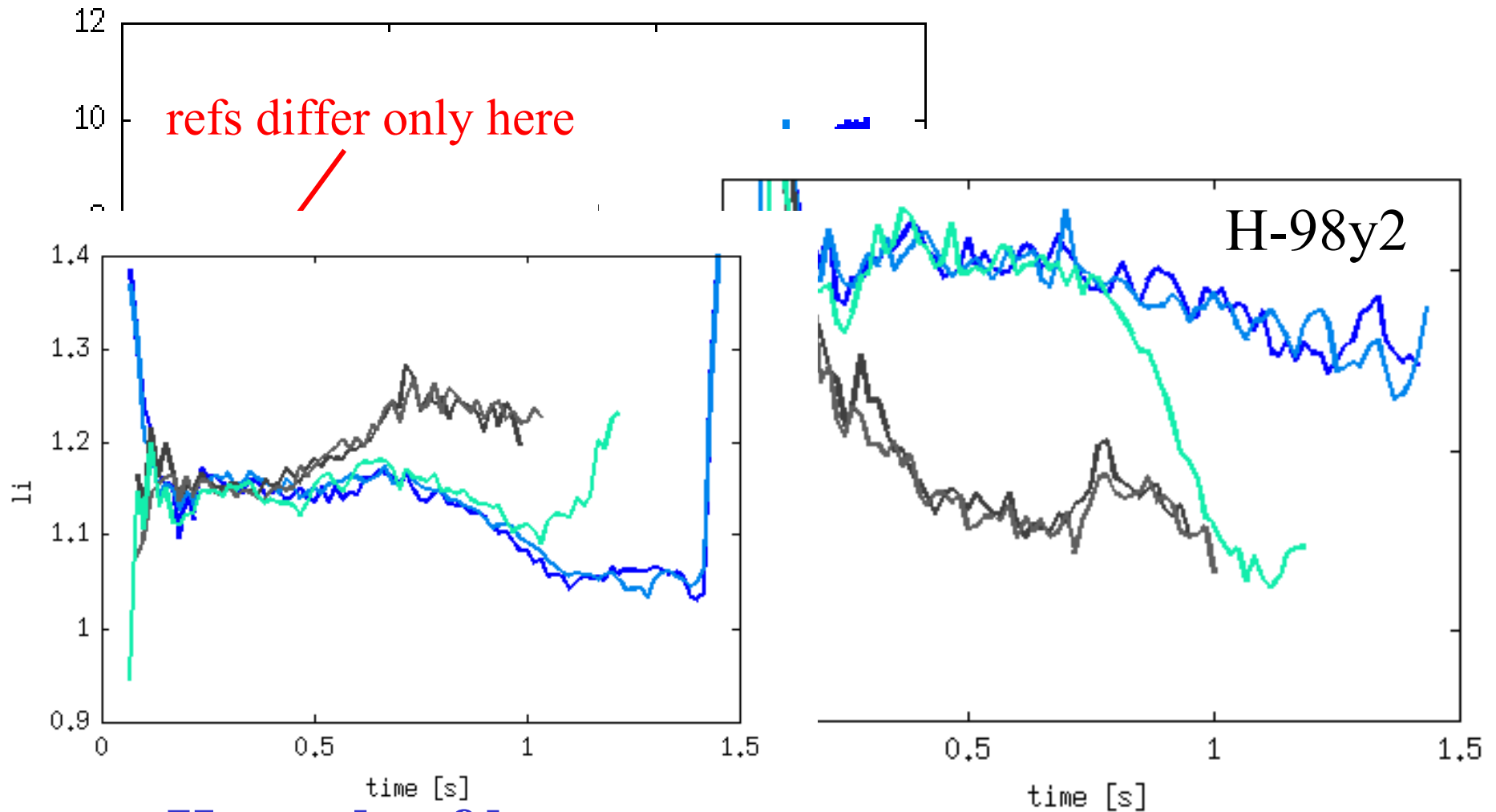
Without H-mode phase: Importance of early density reference



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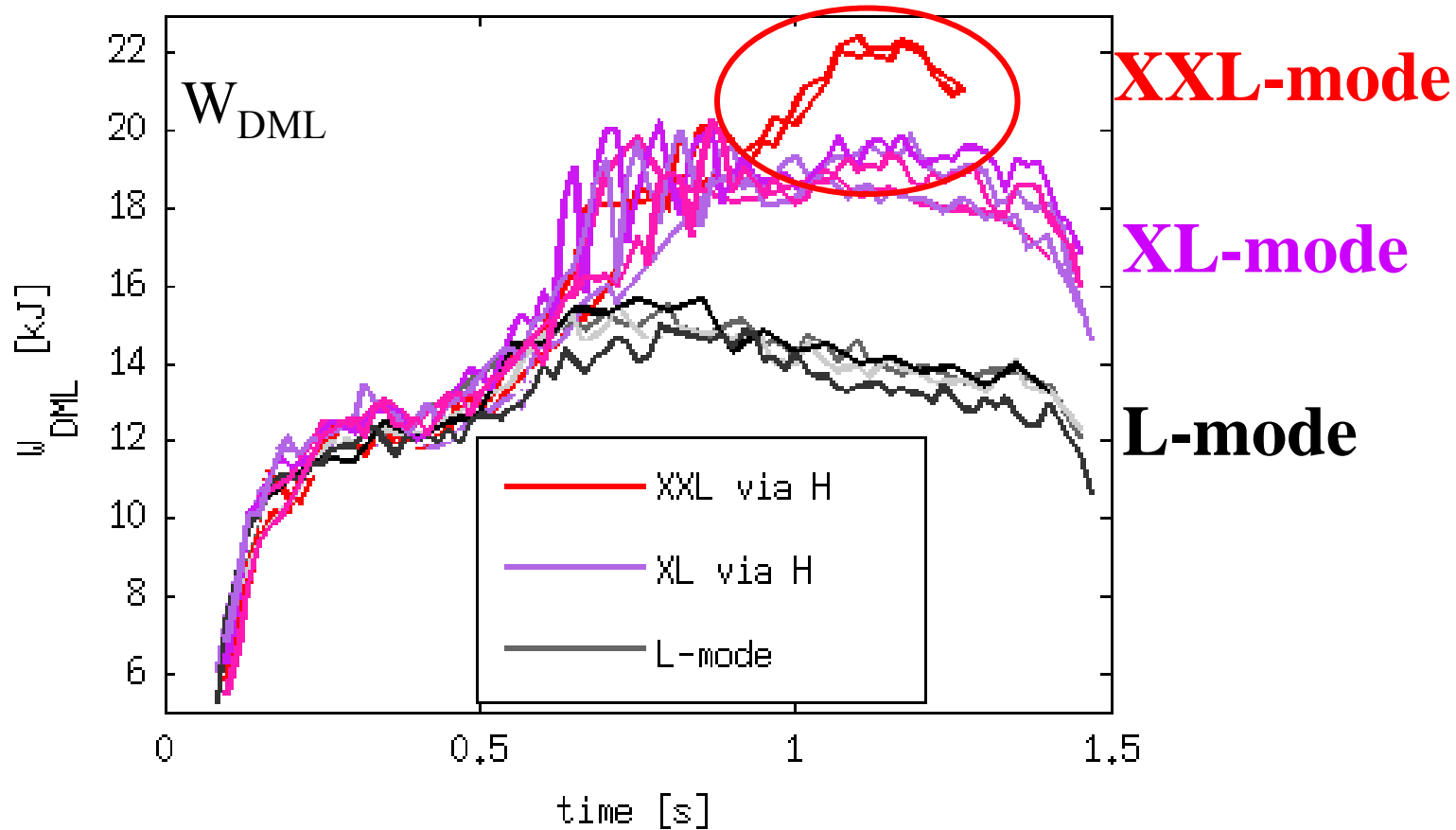
Without H-mode phase: Importance of early density reference



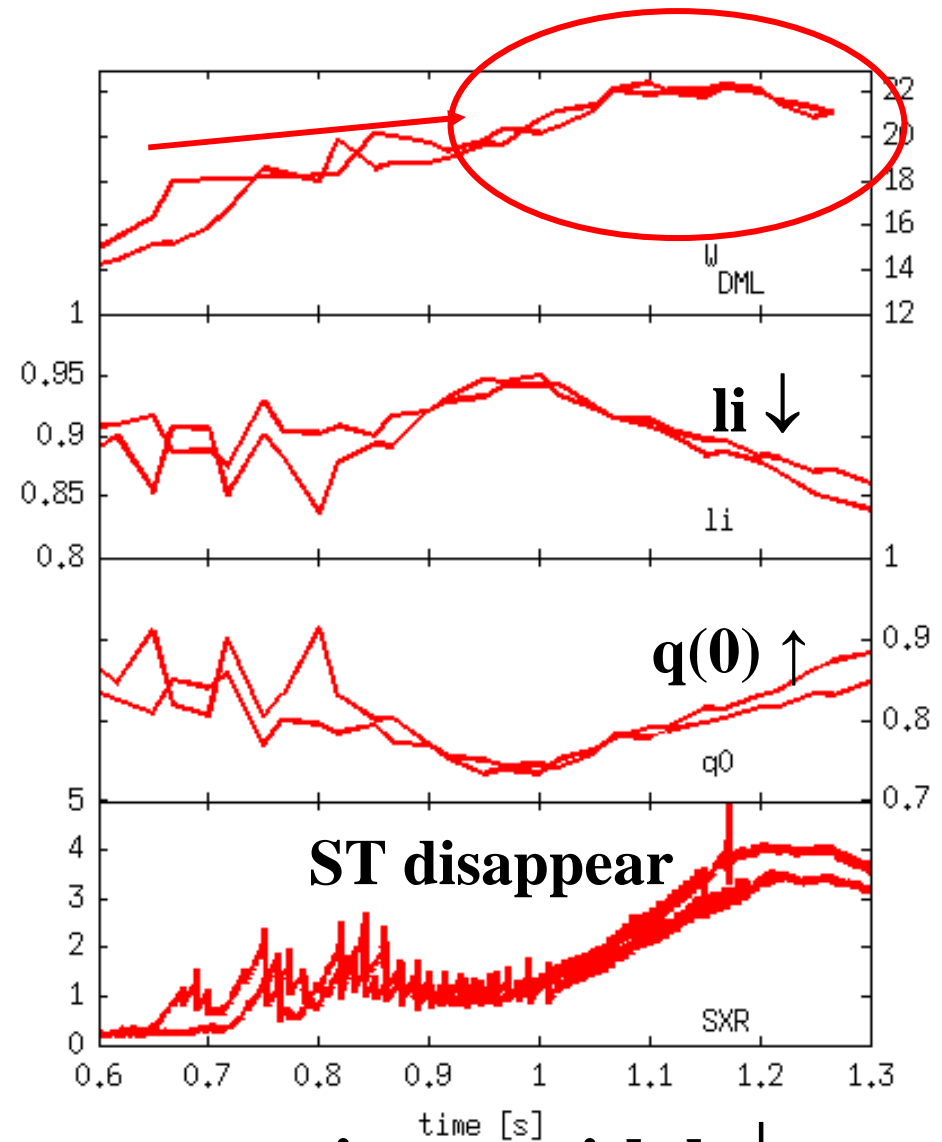
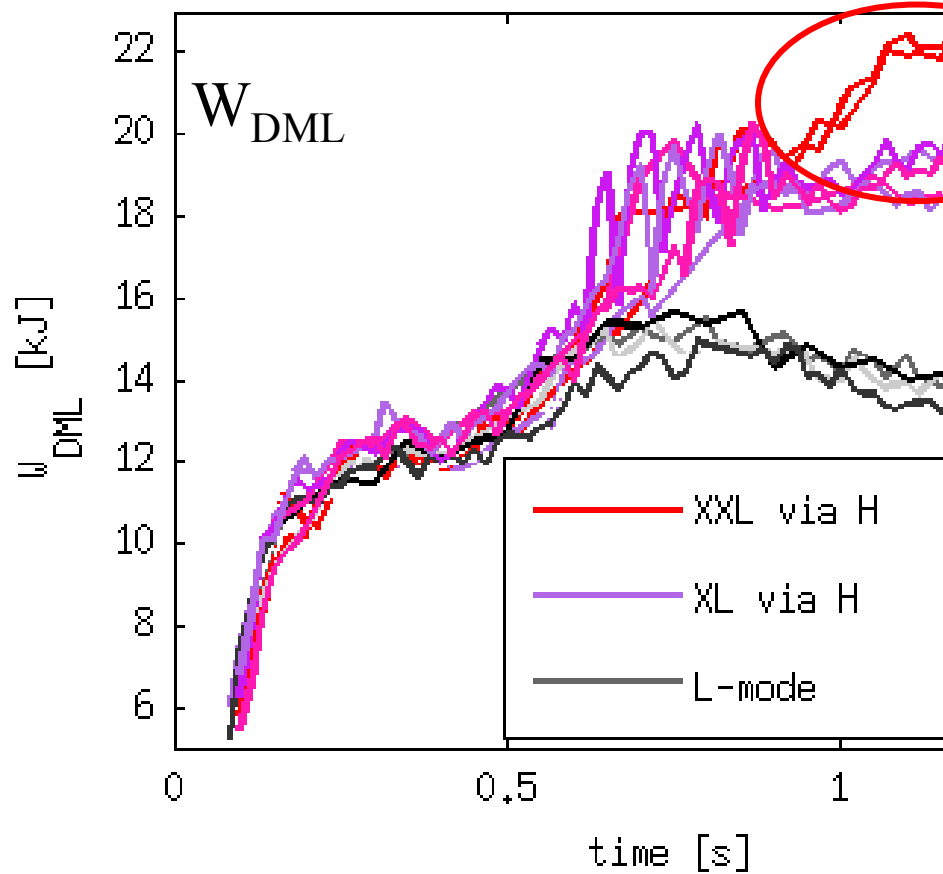
Key role of keeping a low l_i



Back to high L-mode conf. via H-mode phase



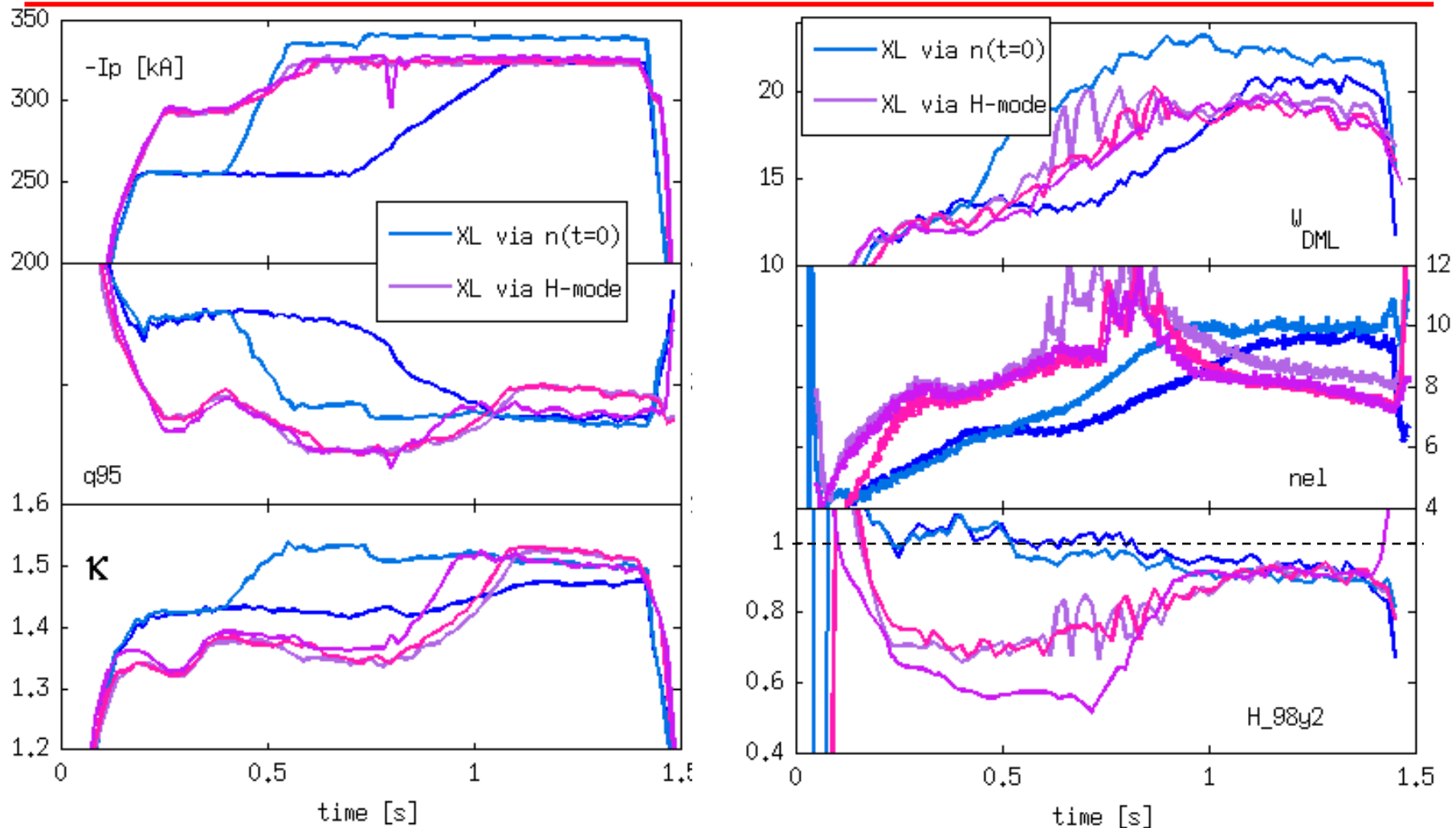
Back to high L-mode conf. via H-mode phase



Further conf. improvement consistent with li ↓



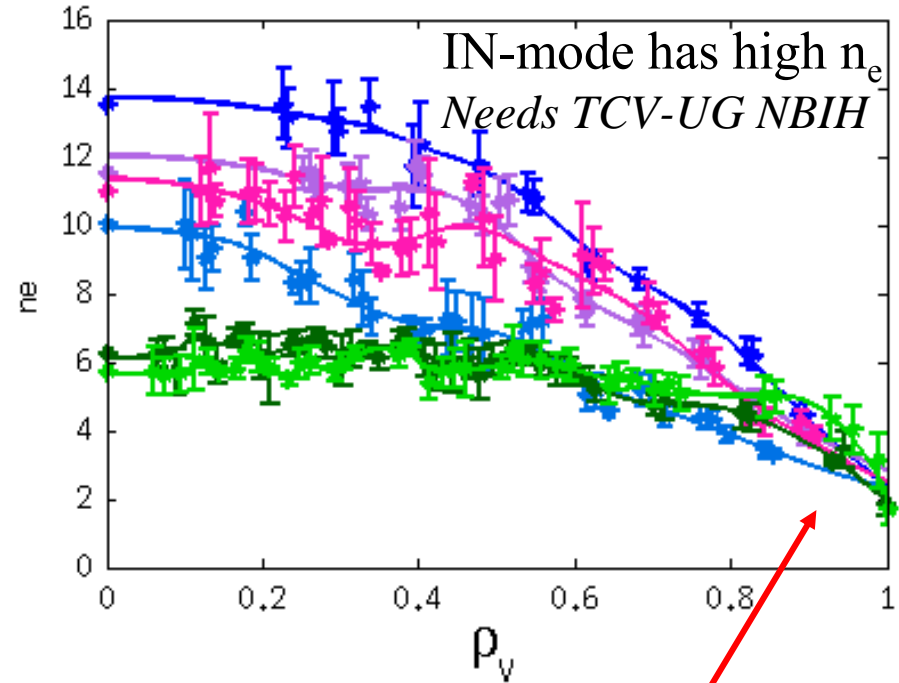
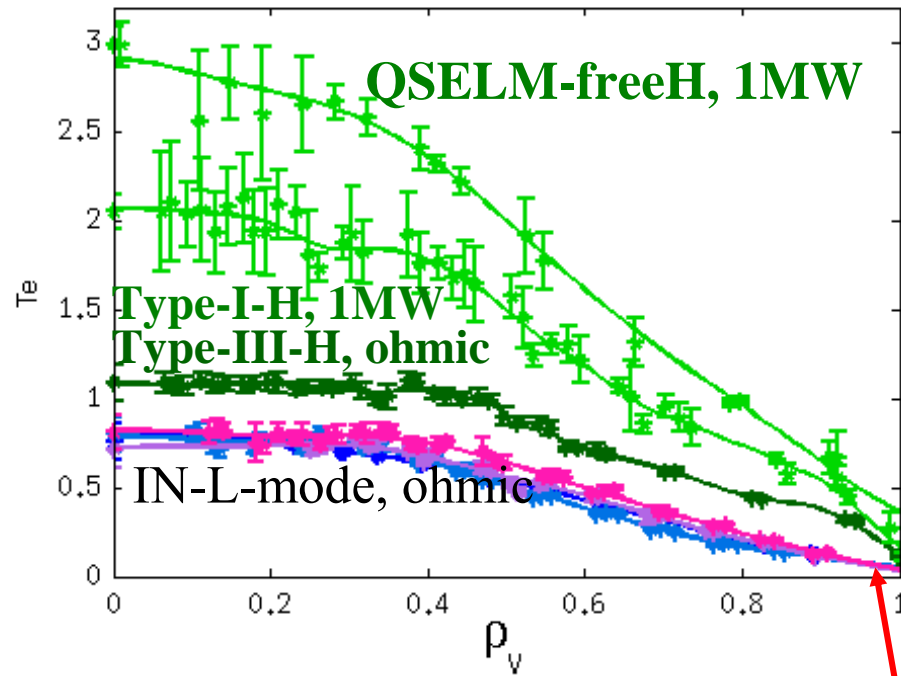
Aiming at same final high parameters



Can reach high ohmic L-mode perf. with both approach



Comparison with H-mode profiles



- edge n_e in IN-mode similar to H-modes
- not edge T_e

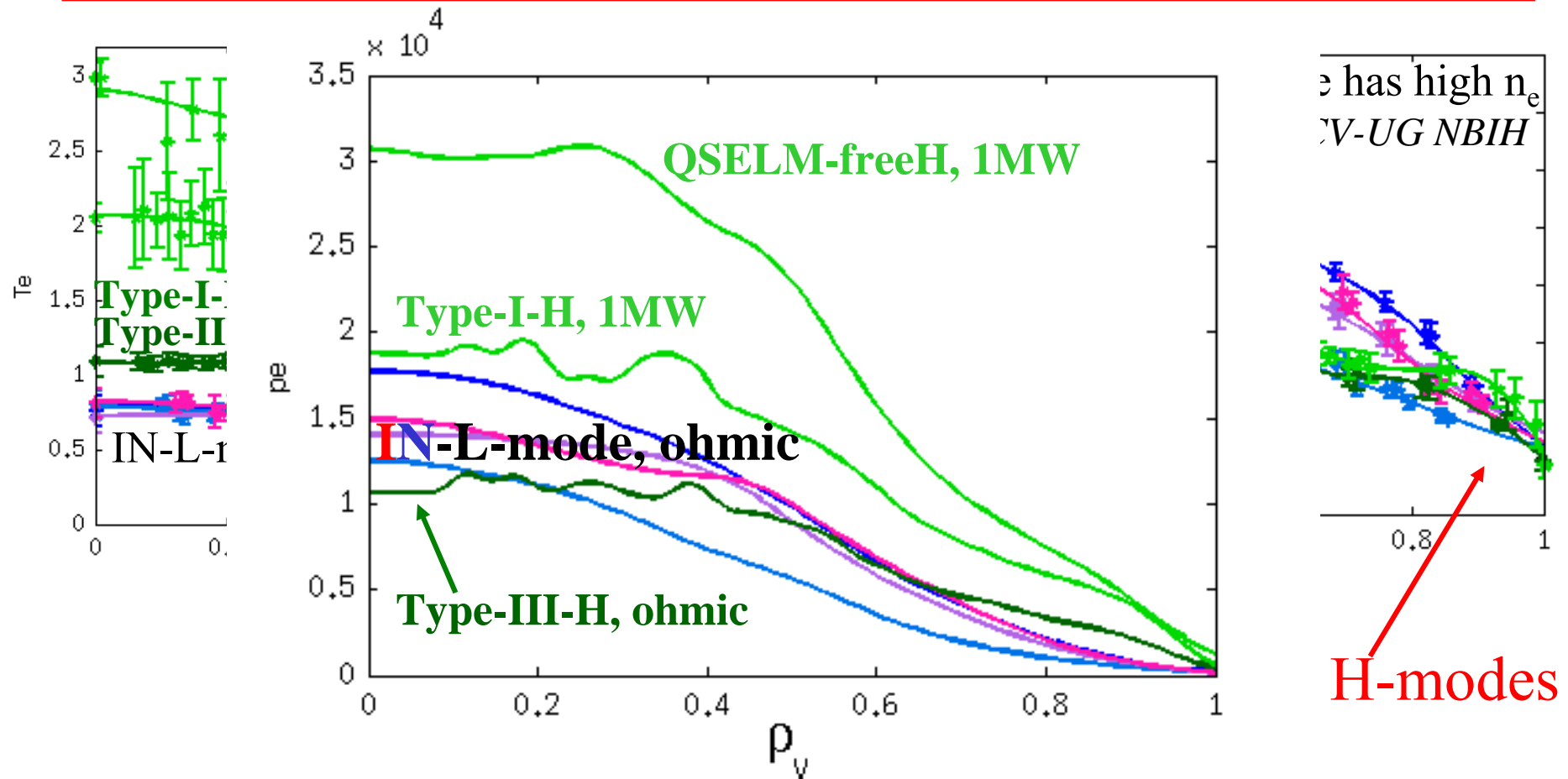
L. Porte et al Nucl. Fusion **47** (2007) 952

A. Pitzshke et al PPCF **54** (2012) 015007

TTF 2013, USA, 22

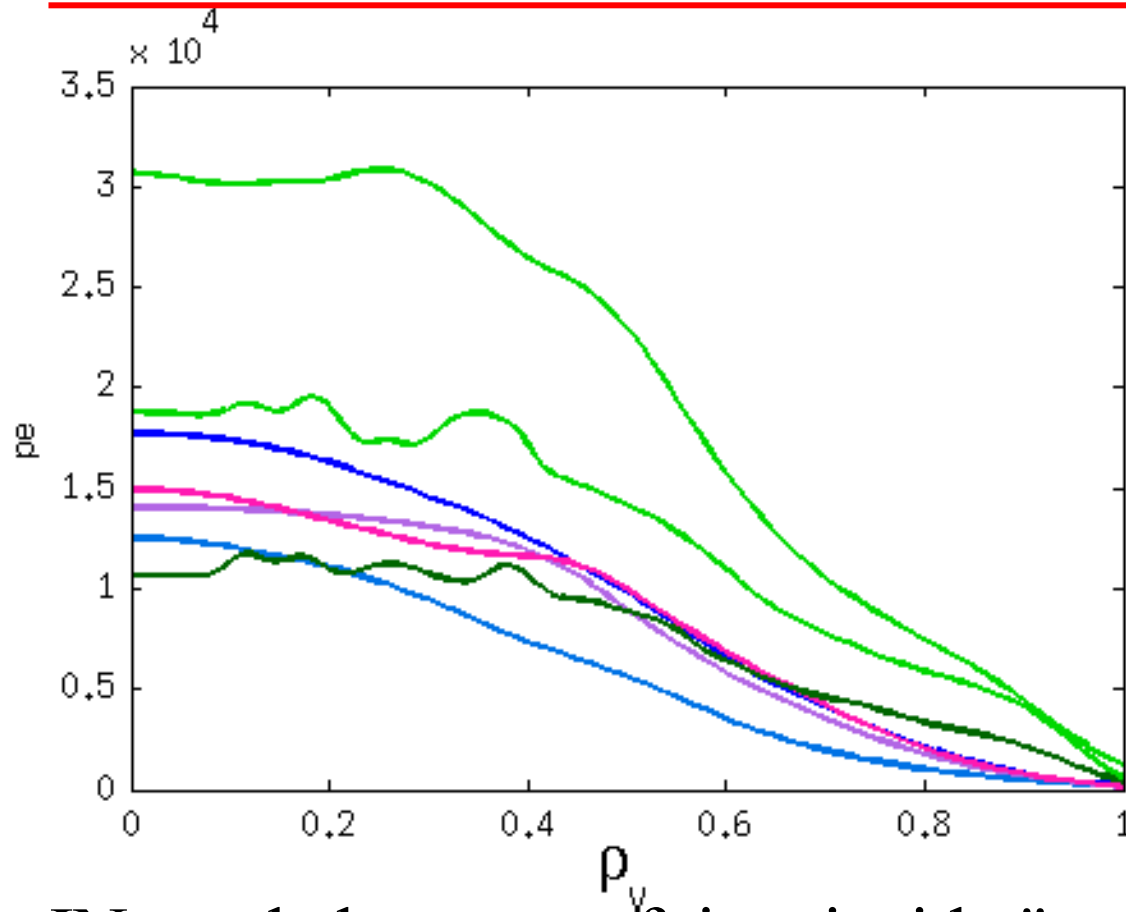


Comparison with H-mode profiles



- IN-L-mode in TCV close to H-mode profiles
- Fills in H-mode range of profiles 0.5-1.5MW

IN-mode and H-mode profiles are ~self-similar



- IN-mode better conf. just inside "pedestal"? (+n_e(ρ=1))
- Edge L-modes are not stiff => wide variety of scenarios

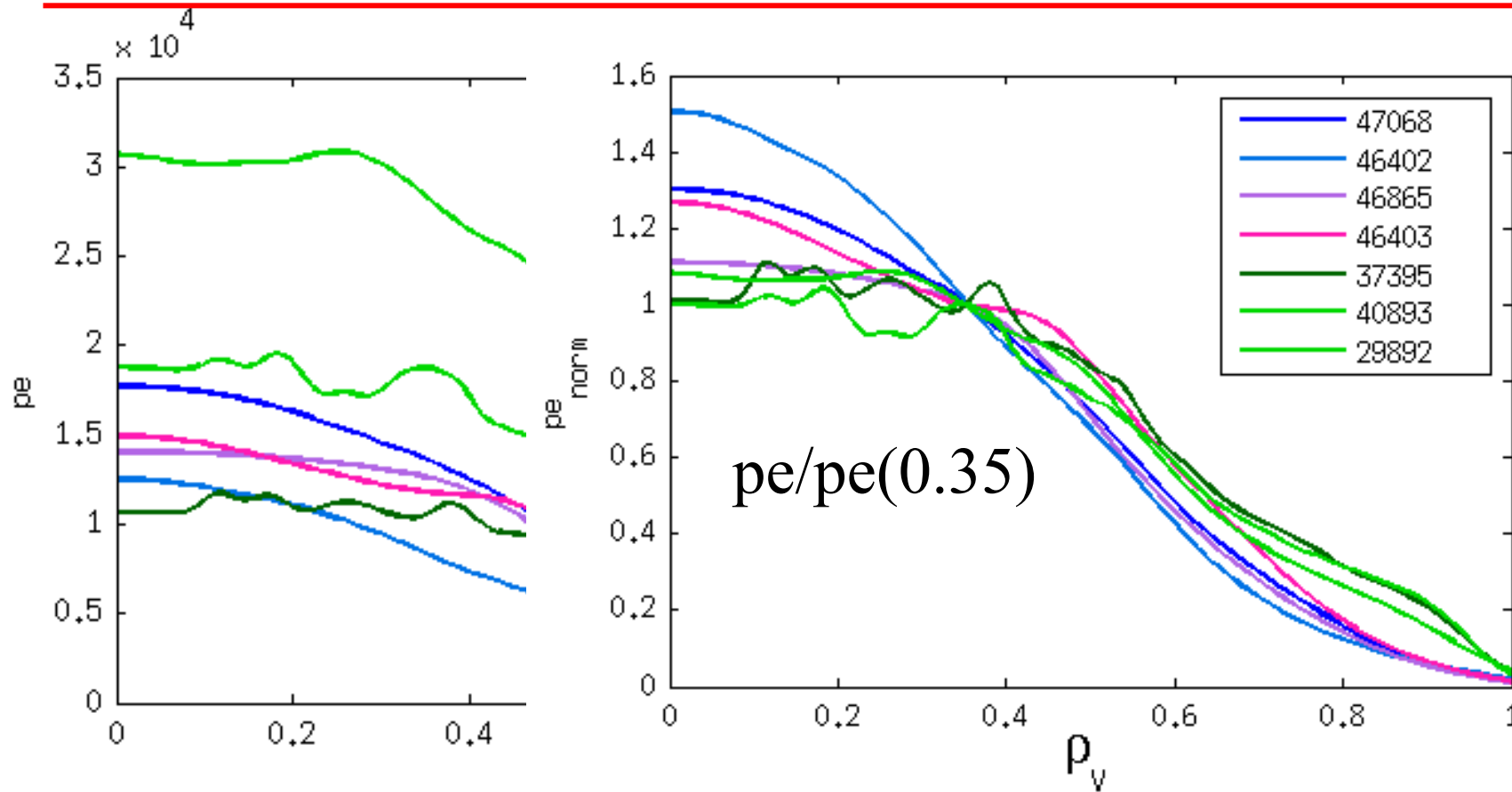
On the non-stiffness of edge transport in L-modes, O. Sauter et al, TTF2013

O. Sauter

TTF 2013, USA, 24



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Conclusions

- IN-mode is "another" improved L-mode
- IN-mode reached $H_{98y} \sim 0.9-1$ in stationary ohmic L-mode
- It has low edge T_e ($< 100\text{eV}$) and relatively high edge n_e
- A) Limited H-modes was triggered when forming IN-mode
- B) High n_e request from $t=0$ helped creating IN-mode
- In both A and B series, I_i is lower with good confinement
- With both A, B series, similar parameters were obtained
- Stationary improved confinement does not depend on initial conditions but needed to "create" good confinement
- It shows that L-modes can have a very wide range of edge and core profiles: namely "I-family" (*edge non-stiff*)

