Observation of neoclassical Ware pinch in core plasma of the Tore-Supra tokamak.

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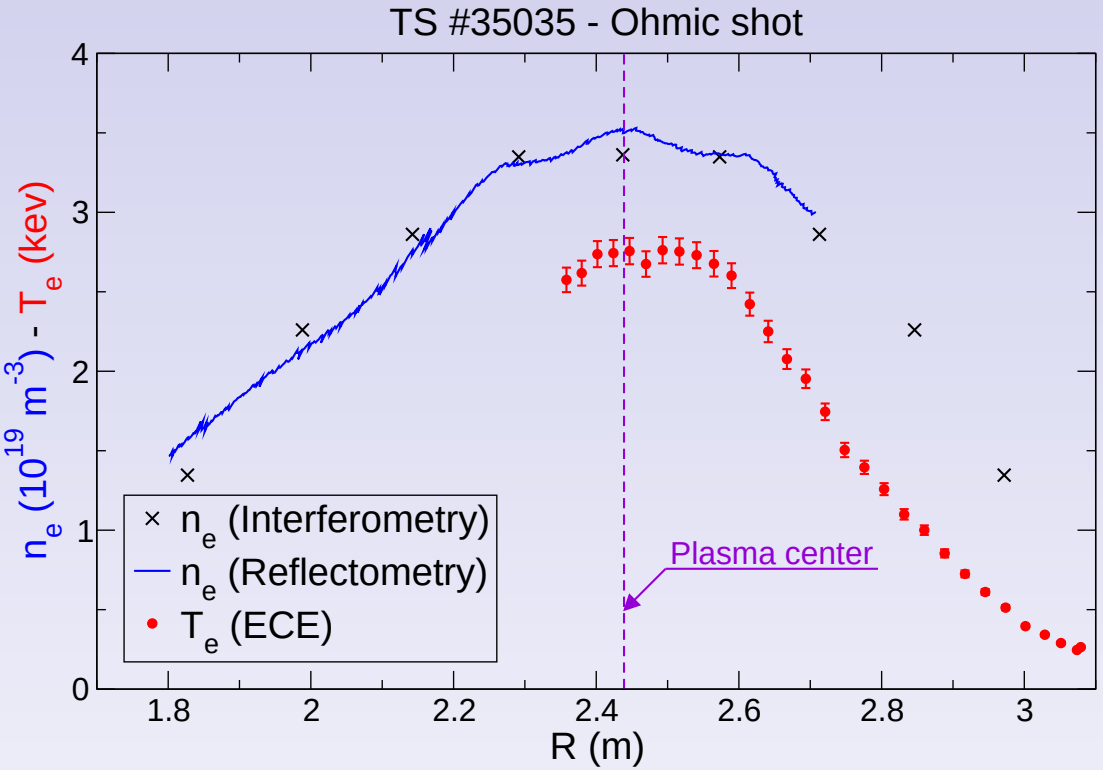
Outline

- Experimental observation of central pinch
- Transport coefficients calculation
- Modification of the density profile and the fluctuation level with RF heatings
- Large density plateau understanding

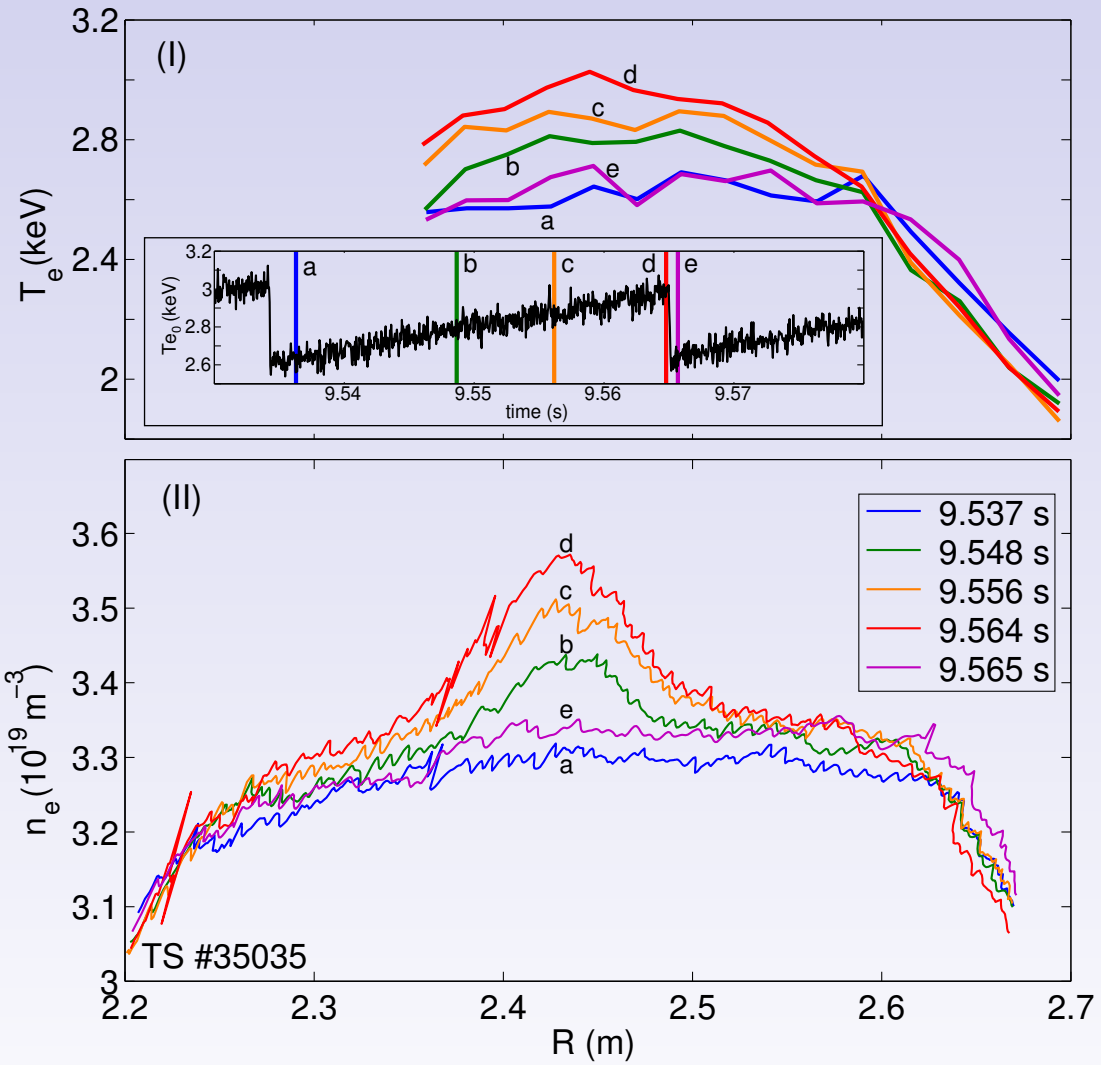
Mexican hat on density profiles



Common feature on Tore-Supra ohmic shots

- Central bump:
  - Up to 10 % of central density
  - Width of 15 cm
- Density plateau:
  - Wider than the temperature
  - Width up to 35 cm

Temporal evolution of the *Mexican hat*

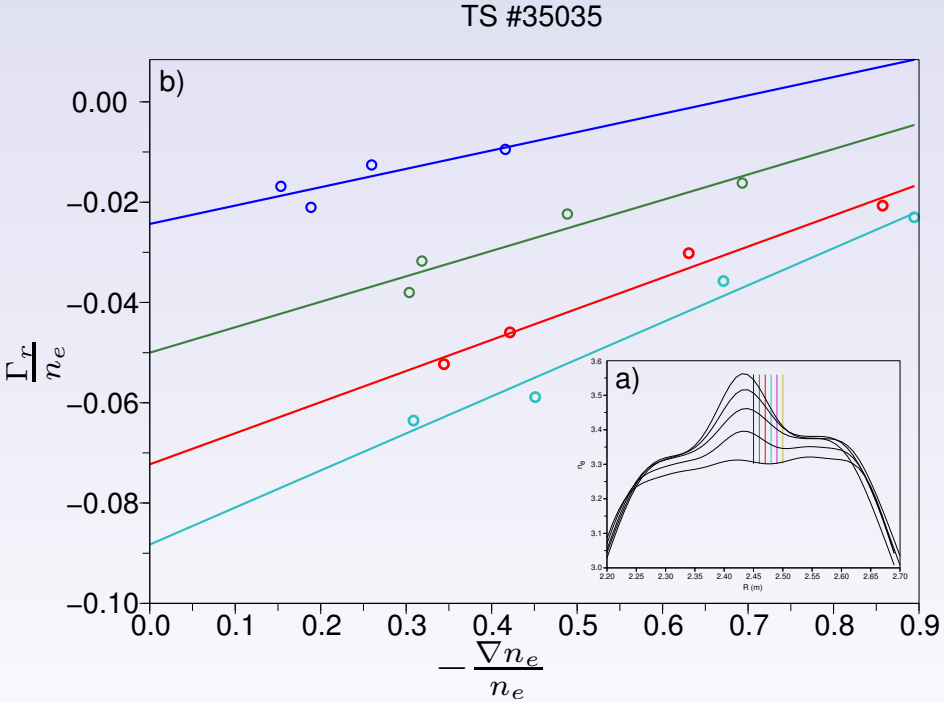


Flux calculation

From the density conservation law in a cylindrical geometry:

$$\partial_t n_e + \nabla.\Gamma = 0 \quad \Rightarrow \quad \Gamma_r = \frac{1}{r}\int_0^r r' \partial_t n_e \, \mathrm{d}r'$$

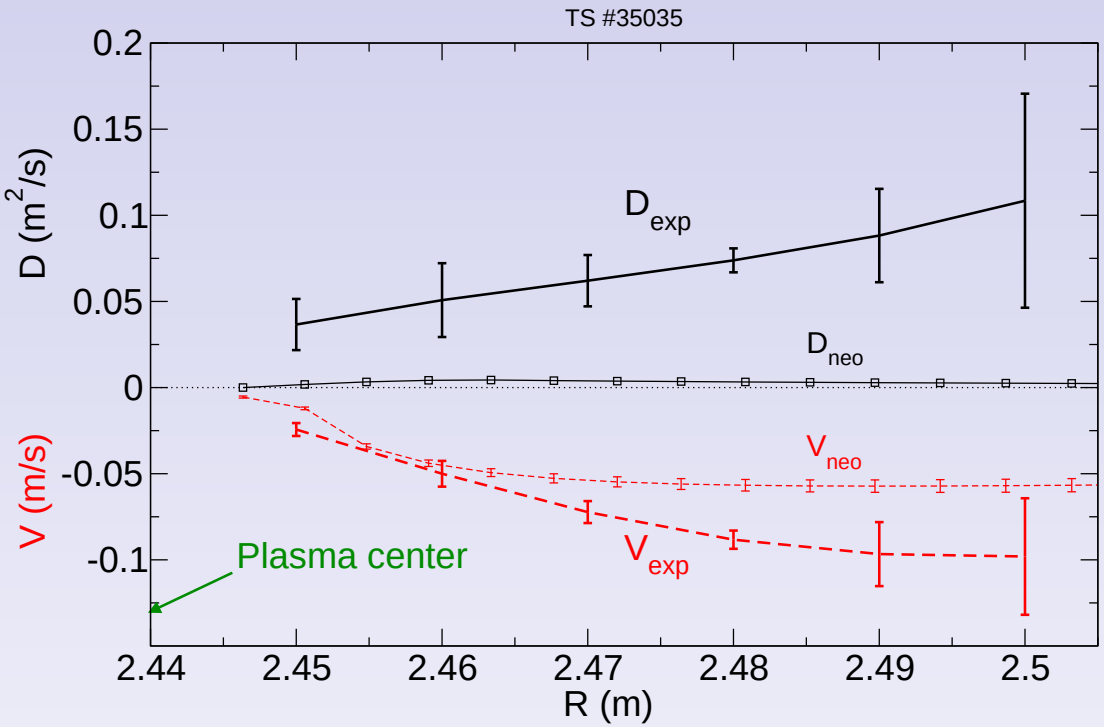
$\Gamma_r(r,t)$ is determined from the experimental profiles.



Knowing $\Gamma_r(r,t)$ and $n_e(r,t)$, D and V are calculated from :

$$\frac{\Gamma_r}{n_e} = -D\frac{\nabla n_e}{n_e} + V$$

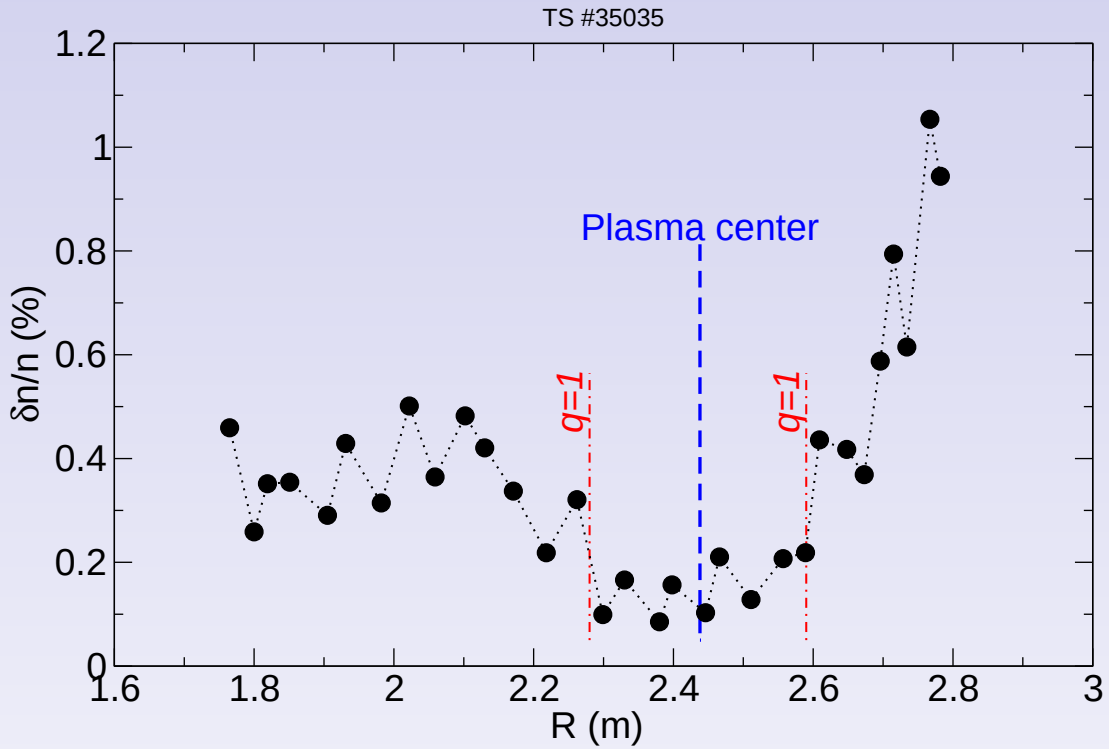
Transport coefficients



Comparison between experimentally deduced coefficients and NCLASS calculation.

- *D*: much larger than neoclassic as expected
- *V*: same order as the neoclassical theory

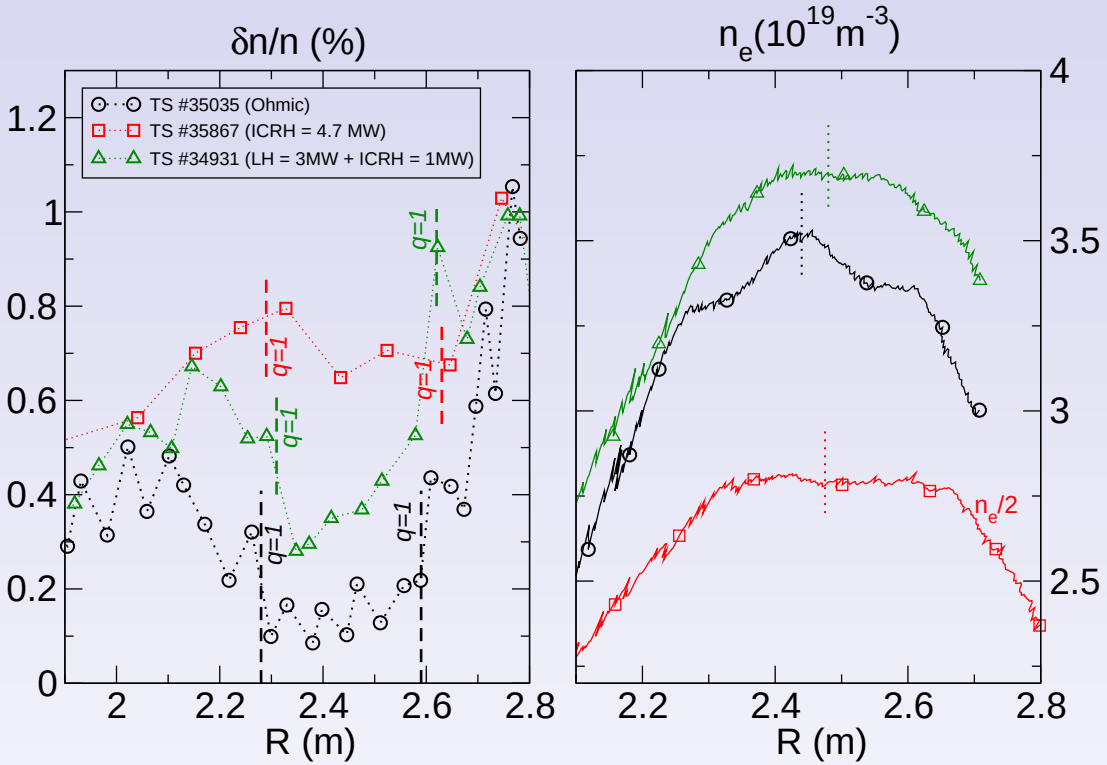
Fluctuation level



Ohmic discharges:

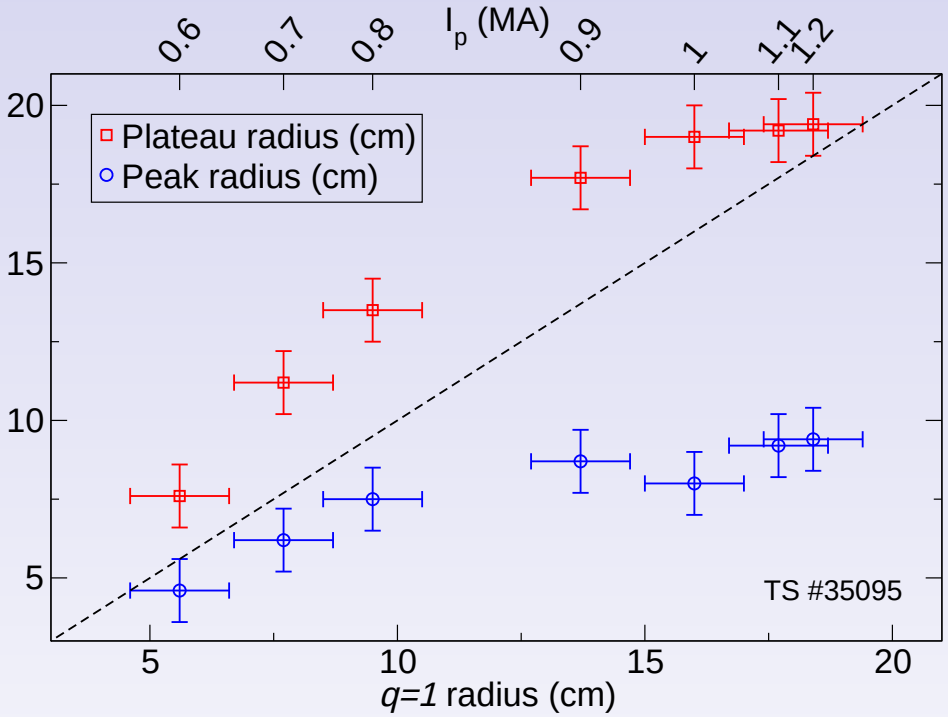
- Drop of the fluctuation level inside $q = 1$
- Lower turbulent diffusion in the plasma center

RF Heatings



- Ohmic:
  - Very low $\delta n/n$ inside $q = 1$
- LHCD:
  - Slight increase of $\delta n/n$
  - $E_\phi \approx 0$: Ware pinch vanishes ($V_W \propto E_\phi/B_\theta$)
- ICRH:
  - Large increase of $\delta n/n$
  - Increase of the turbulent diffusion

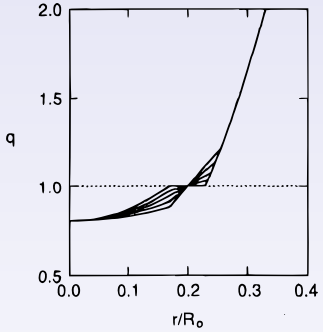
Density plateau goes past the $q = 1$ surface

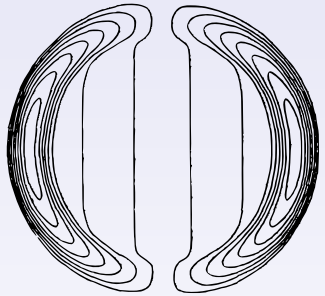


I_p scan:

- Plateau always goes over $q = 1$
- Peak width saturate to 15 cm

Plateau expansion still not fully understood. Flattening of the q profile around $q = 1$?



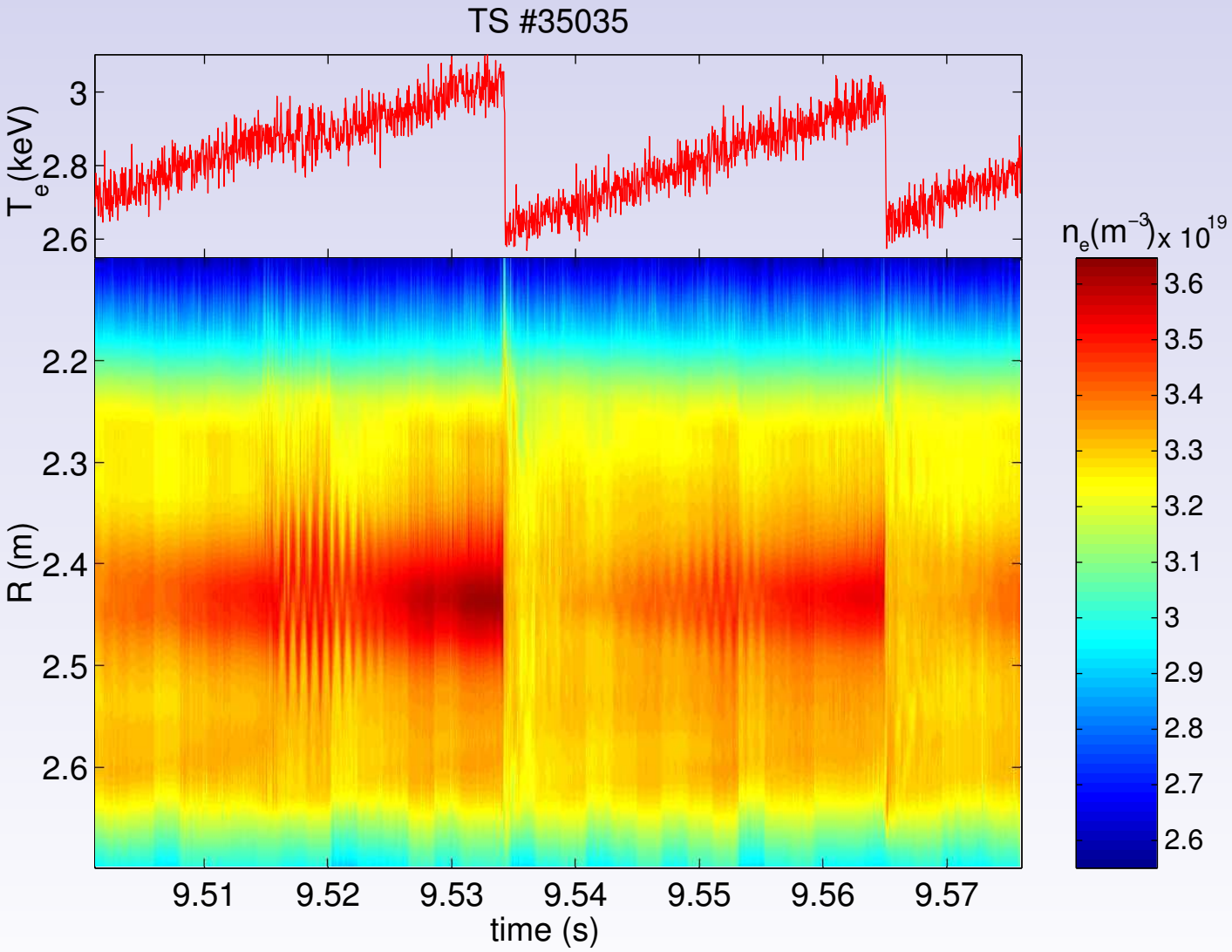


[de Blank, Phys. Fluids B, 1991]

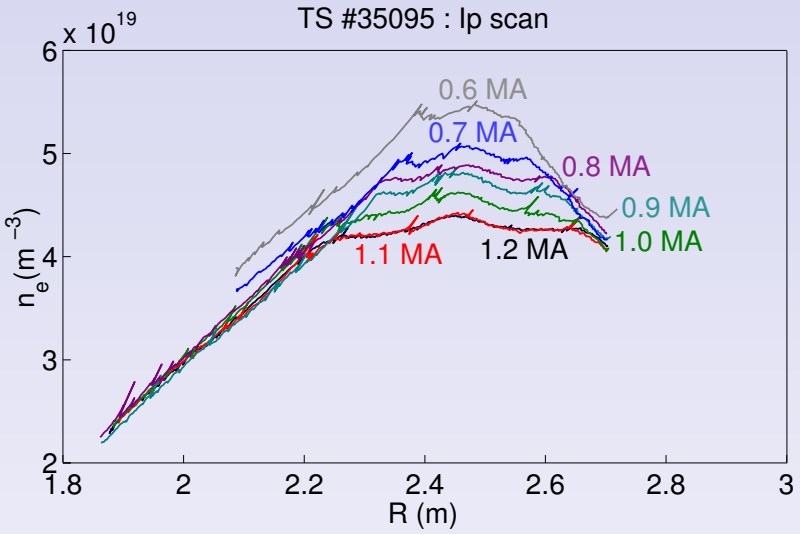
Conclusions

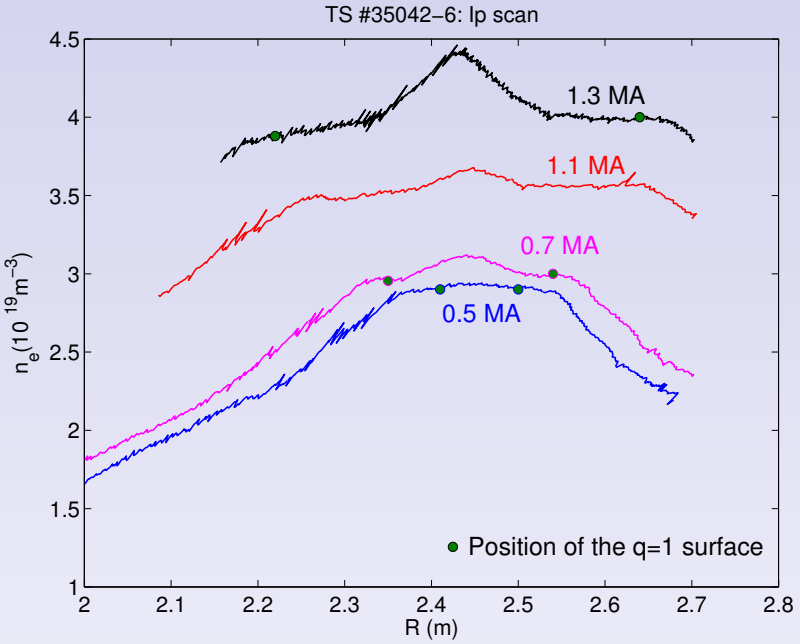
- Tore-Supra ohmic shots present a central density peaking
- This *Mexican hat* can be explained by:
  - Ware pinch effect
  - Low turbulent diffusion
- When $E_\phi \approx 0$ the central peak vanishes
  $\rightarrow$ Ware pinch signature
- For higher level of $\delta n/n$: no more central peak
  $\rightarrow$ increase of the turbulent diffusion
- Density plateau extends beyond $q = 1$ surface

Contour plot of the core evolution during sawtooth activity



I_p scans





- Plateau width linked with $q = 1$ position
- Bump width seems to saturate
- No *Mexican hat* for $I_p < 0.6$ MA