

**Initial results from XP411:**

**Investigation of improved electron confinement  
in low density/shear reversal L-mode discharges**

**D. Stutman (JHU), E. Synakowski (PPPL)**

# Goal: Compare e<sup>-</sup> transport in four conditions

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- **low collisionality / 'reversed' q** ← **Low  $\chi_e$**   
(Low  $n_e$  / fast ramp + early beam)
- **low collisionality / 'flat' q** ← ?  
(Low  $n_e$  / slow ramp + late beam)
- **high collisionality / 'reversed' q** ← ?  
(High  $n_e$  / fast ramp + early beam)
- **high collisionality / 'flat' q** ← **High  $\chi_e$**   
(High  $n_e$  / slow ramp + late beam)
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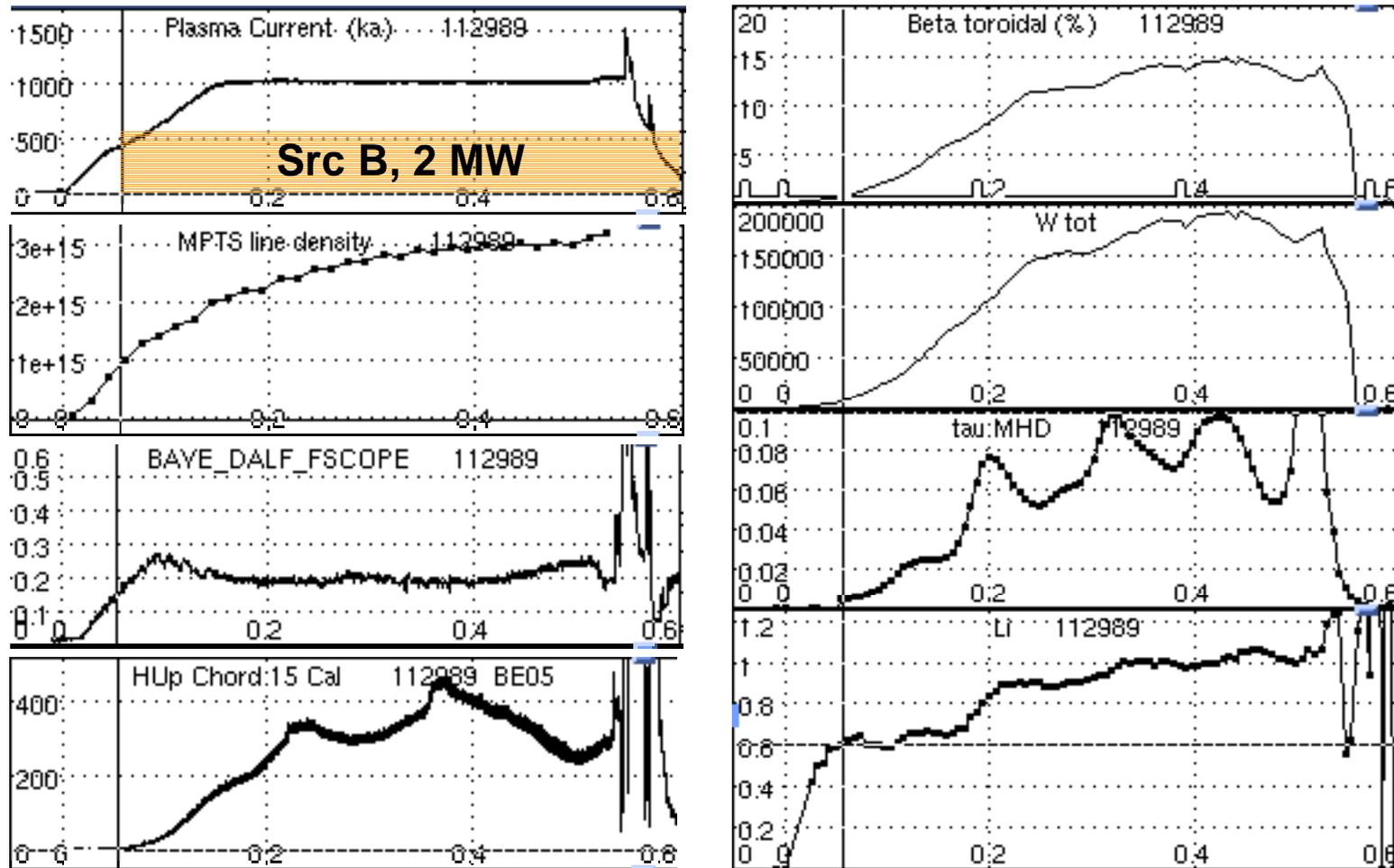
- **Also measure:**
  - $T_e$  response to increased power
  - Neon injection for particle transport

# Initial results

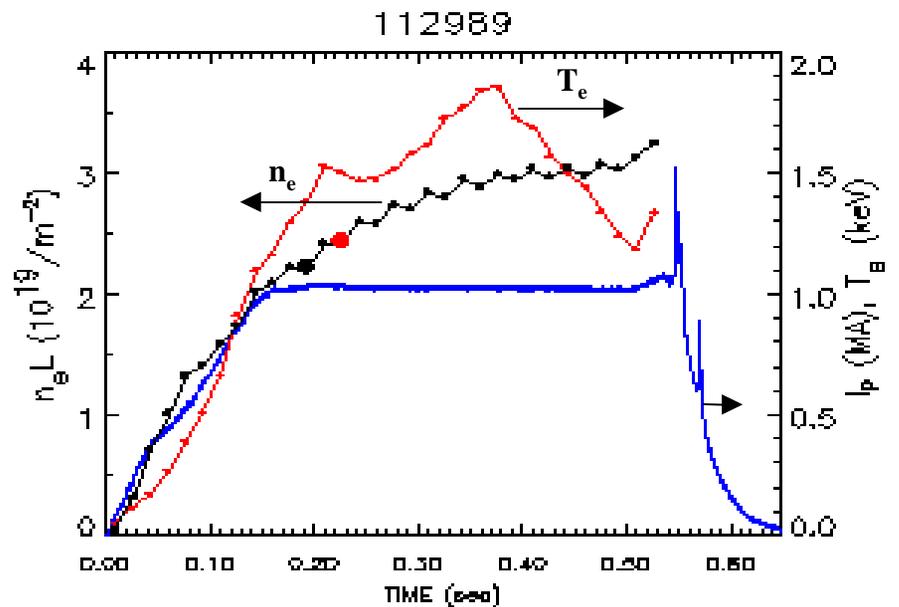
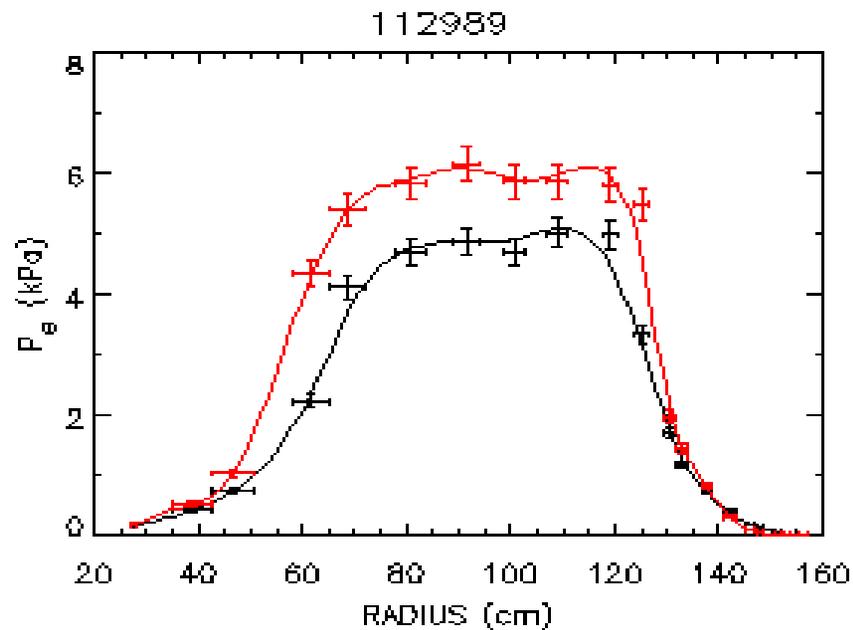
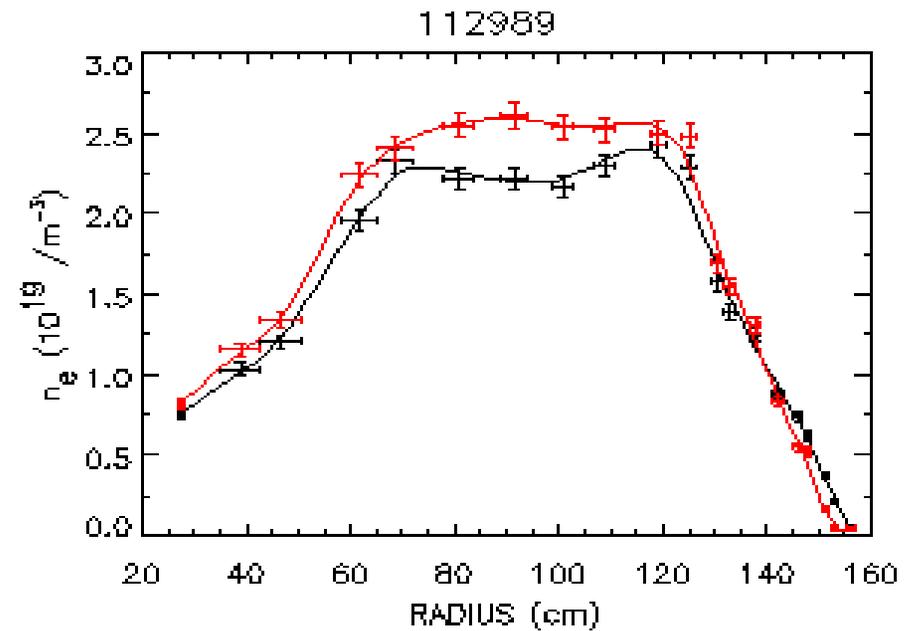
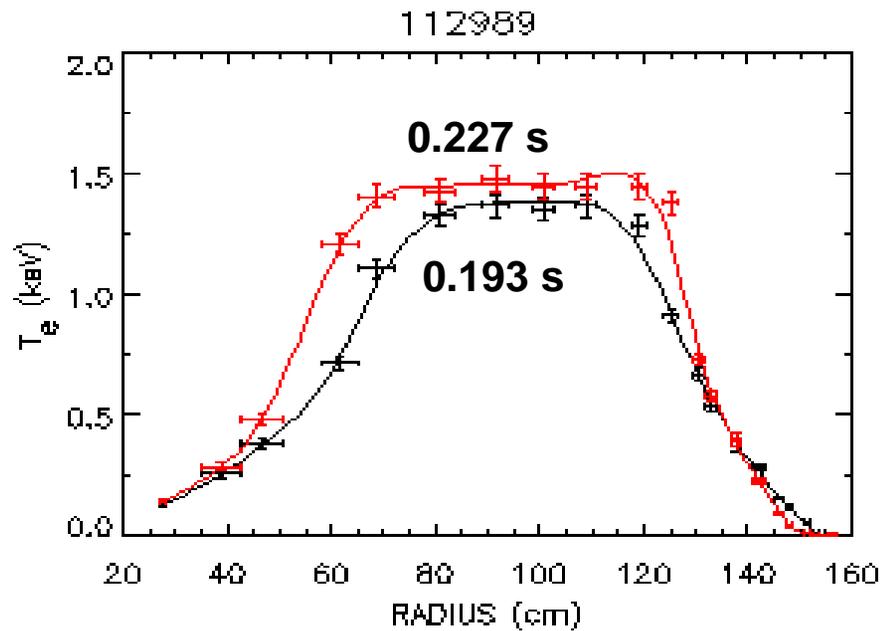
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- Low  $n_e$  / fast ramp + early beam -> high  $T_e$ , square profile
- Low  $n_e$  / slow ramp + late beam -> high  $T_e$ , peaked profile
- High  $n_e$  / fast ramp + early beam-> low  $T_e$ , modest gradient  
(more difficult due to MHD)
- Increased power -> high  $T_e$  regime MHD 'fragile' ?
- Neon injection (low  $n_e$ ) -> transport change w. ramp rate ?
- CHERS, USXR, turbulence (core reflectometry) data
- Main conditions to be later documented with MSE

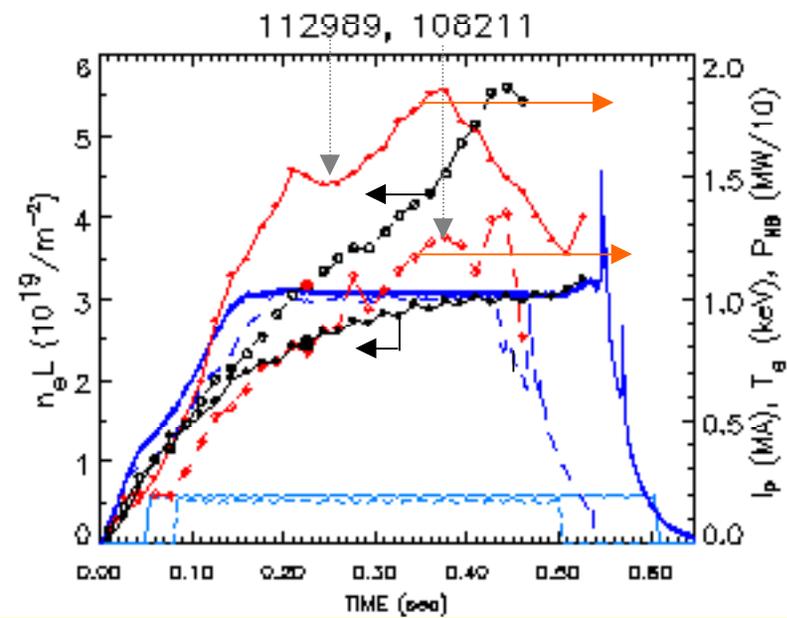
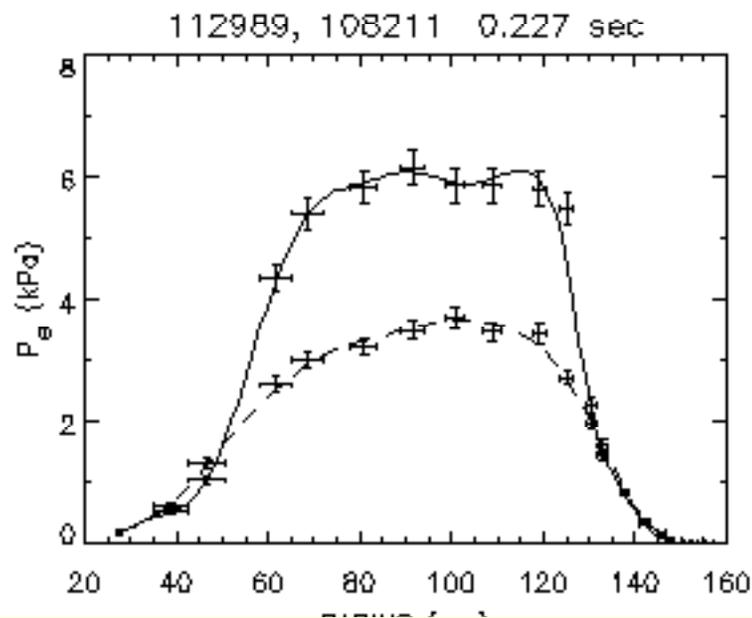
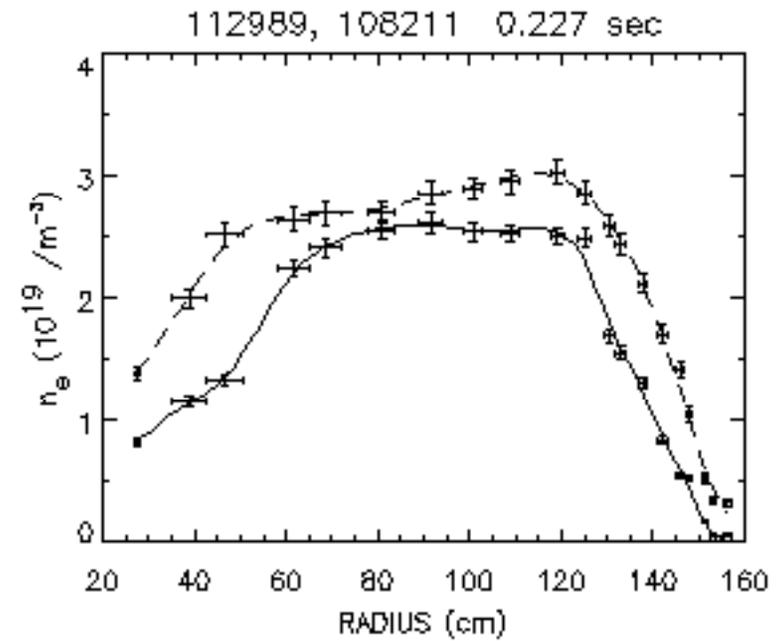
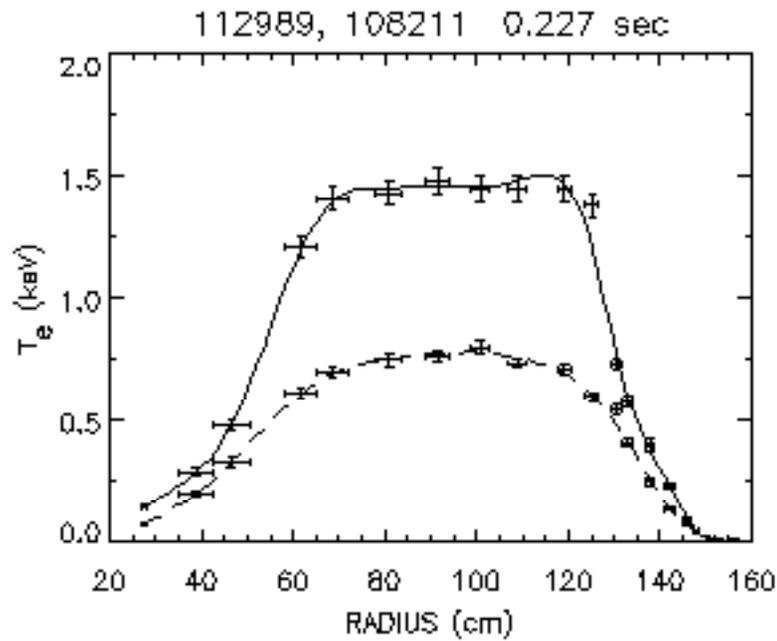
# Low $n_e$ / fast ramp + early beam (112989)



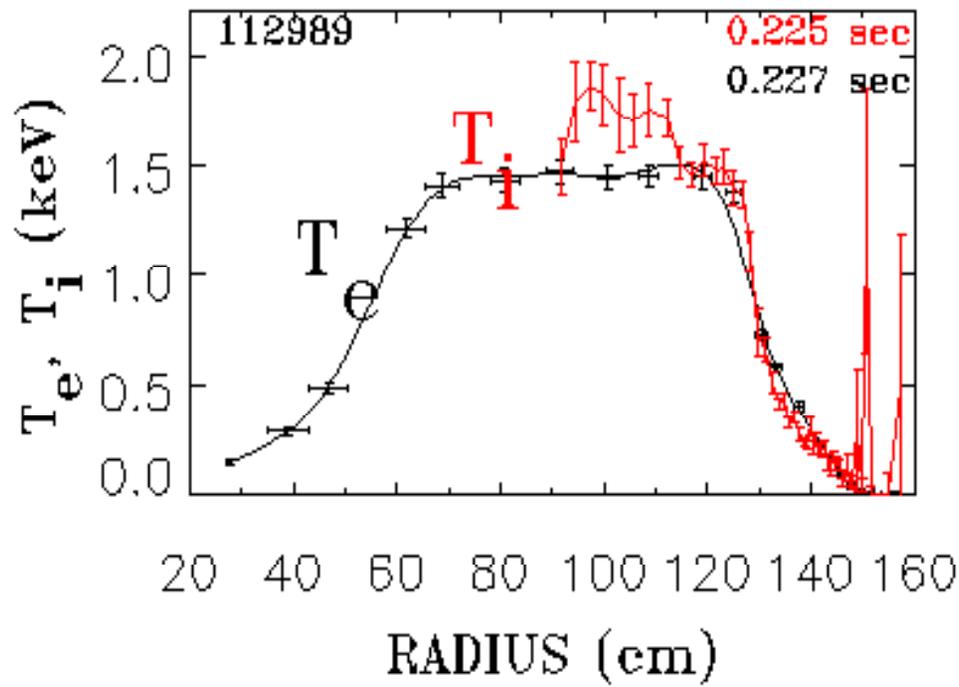
- High confinement,  $\approx$  MHD quiescent L-mode at low density



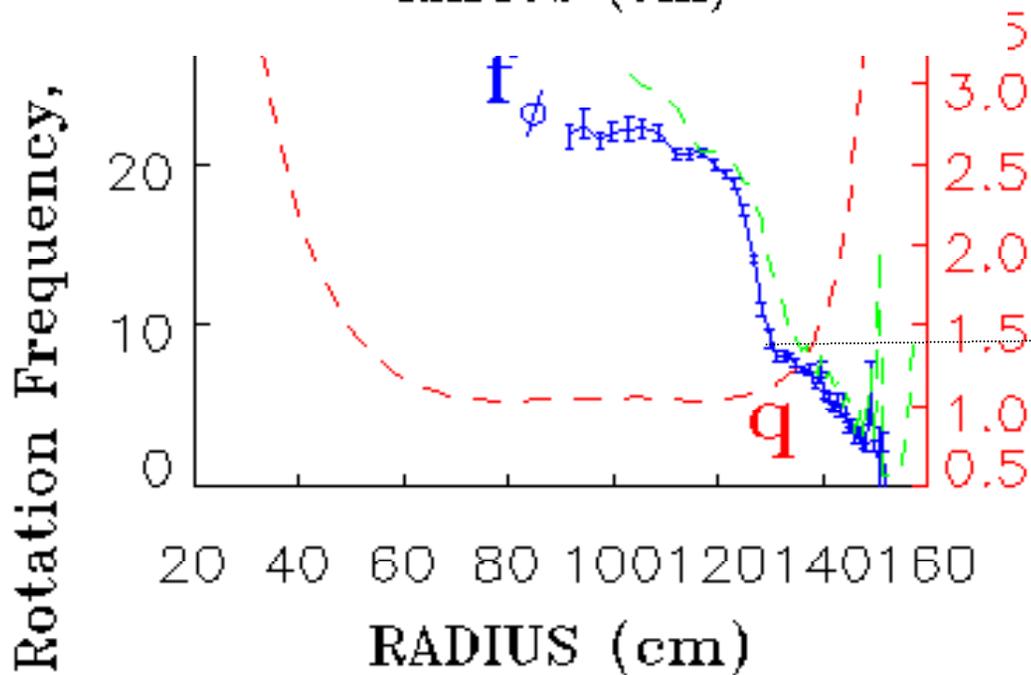
- Early  $T_e$  increase, steep gradients, flat core profile



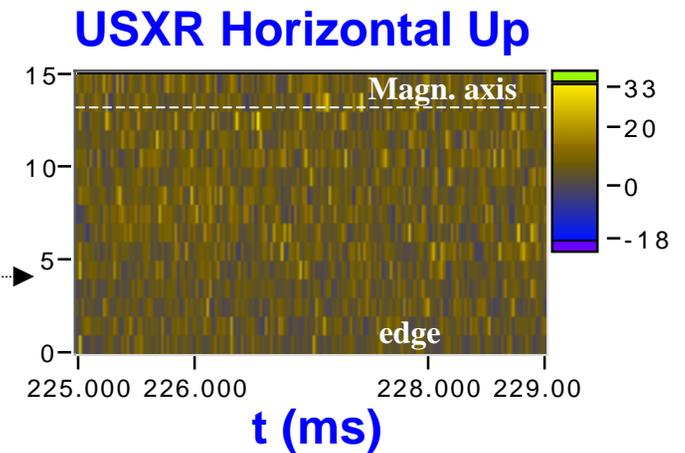
•  $T_e$ ,  $\text{grad}T_e$  much lower in 'typical' L-mode (high  $n_e$ /slow ramp)



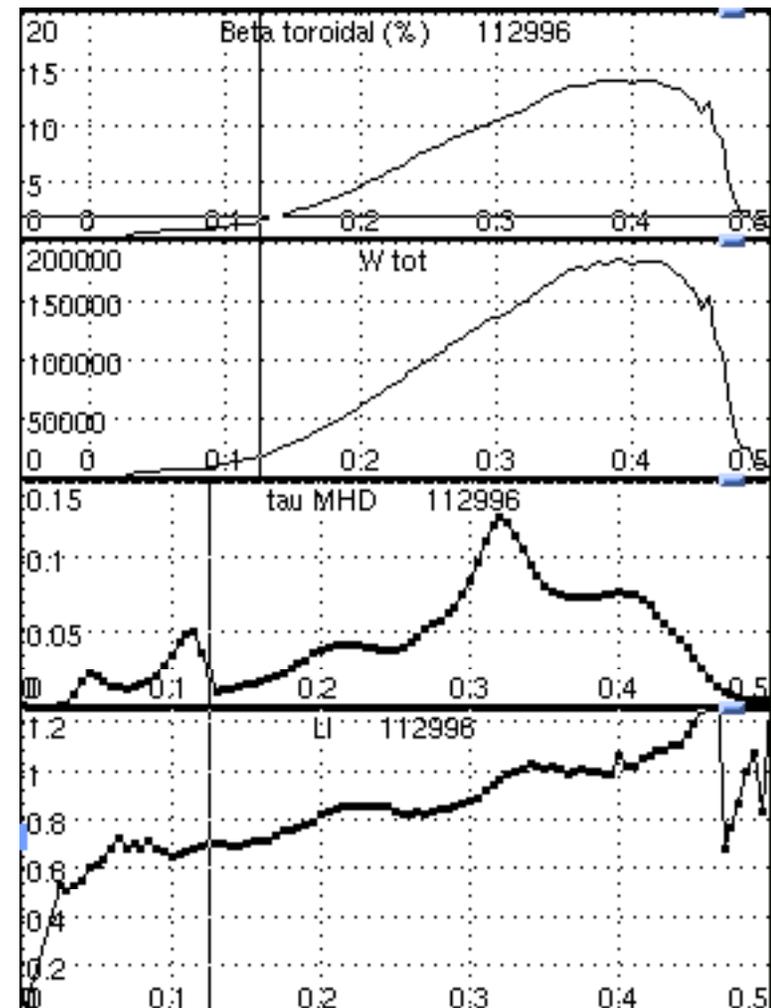
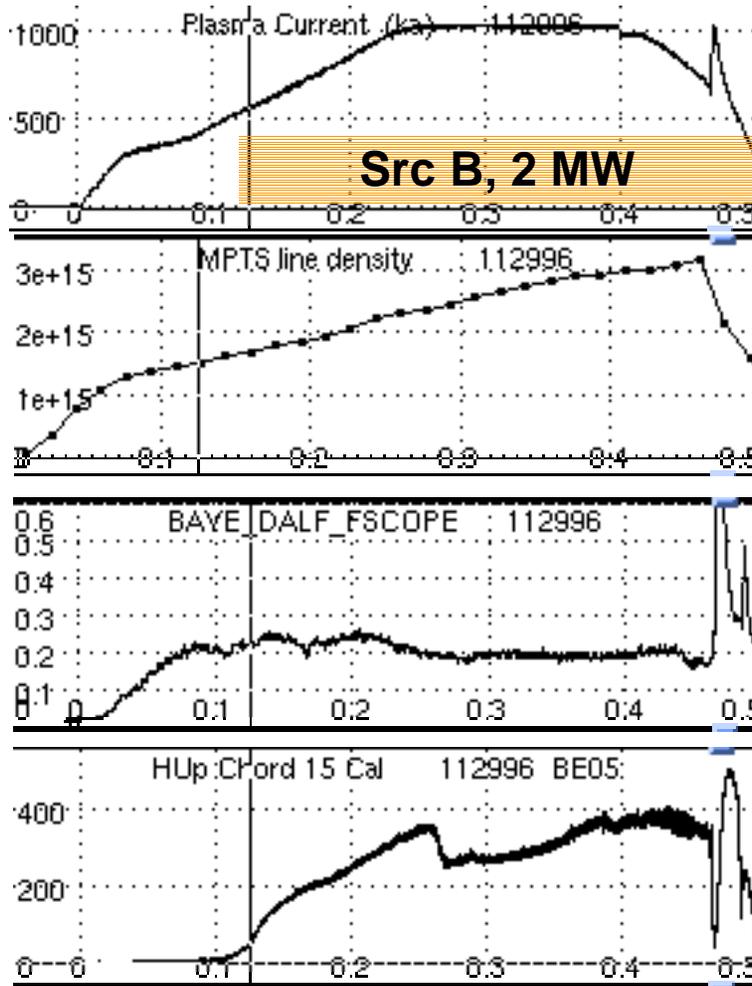
- Sharp gradient also in  $T_i$ ,  $V_\phi$
- $V_\phi$  gradient seems not 'forced' by MHD (magnetics, USXR)
- Strong decrease in  $e^-$ , ion transport at  $R \approx 130$  cm ?



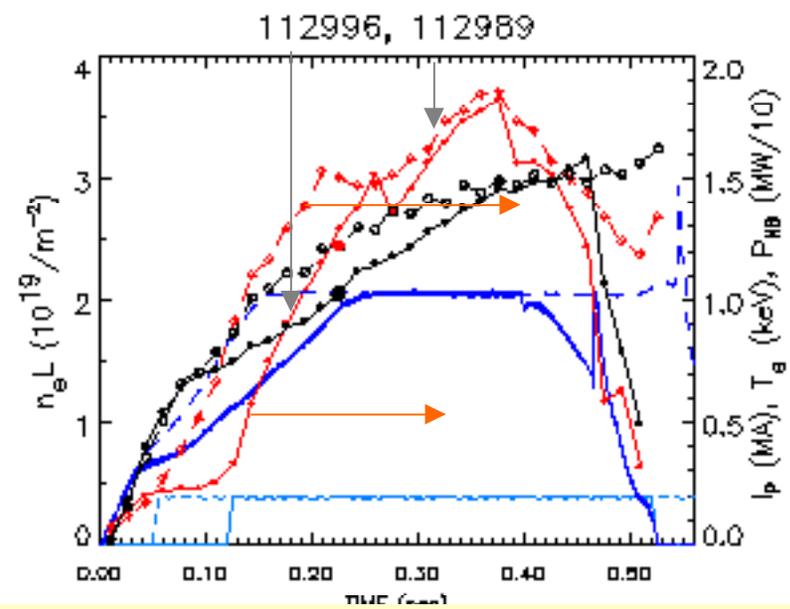
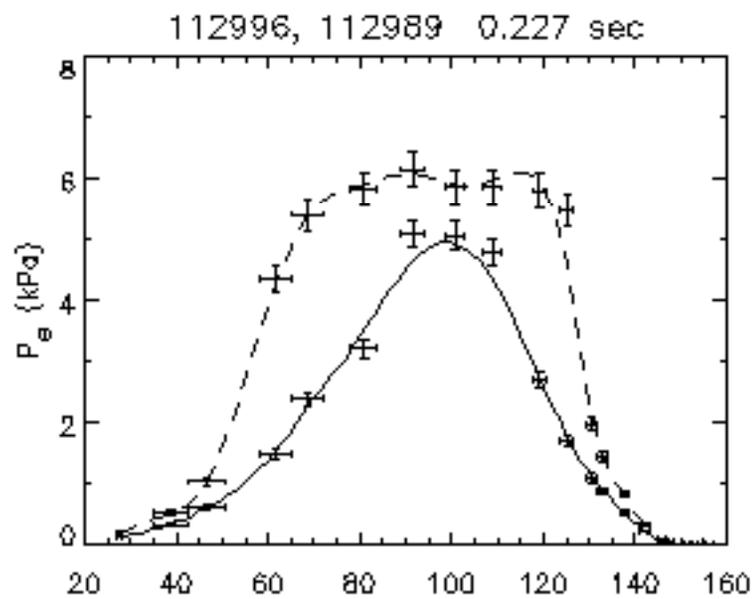
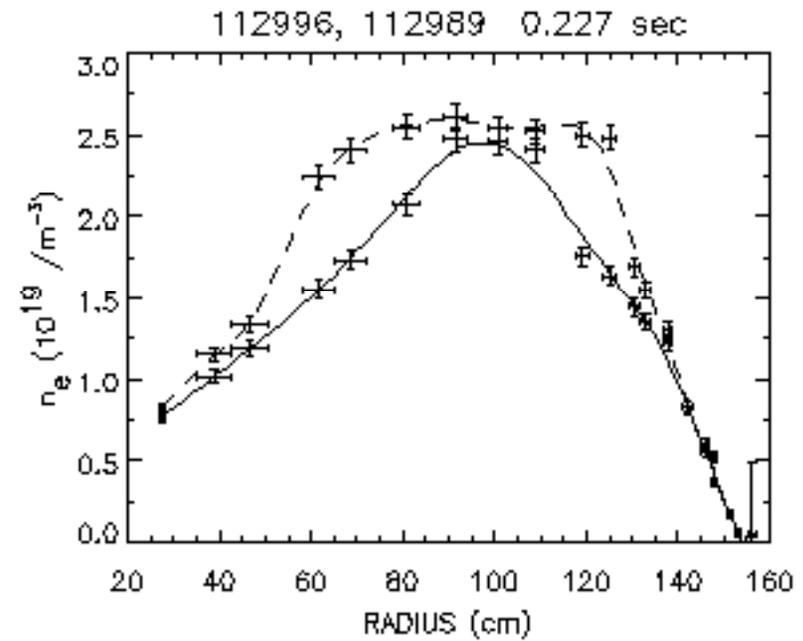
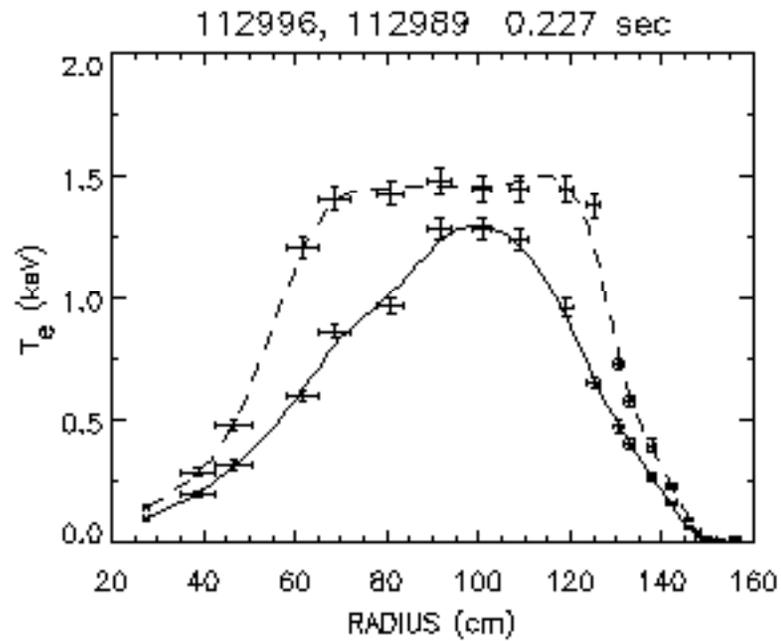
qEFT01



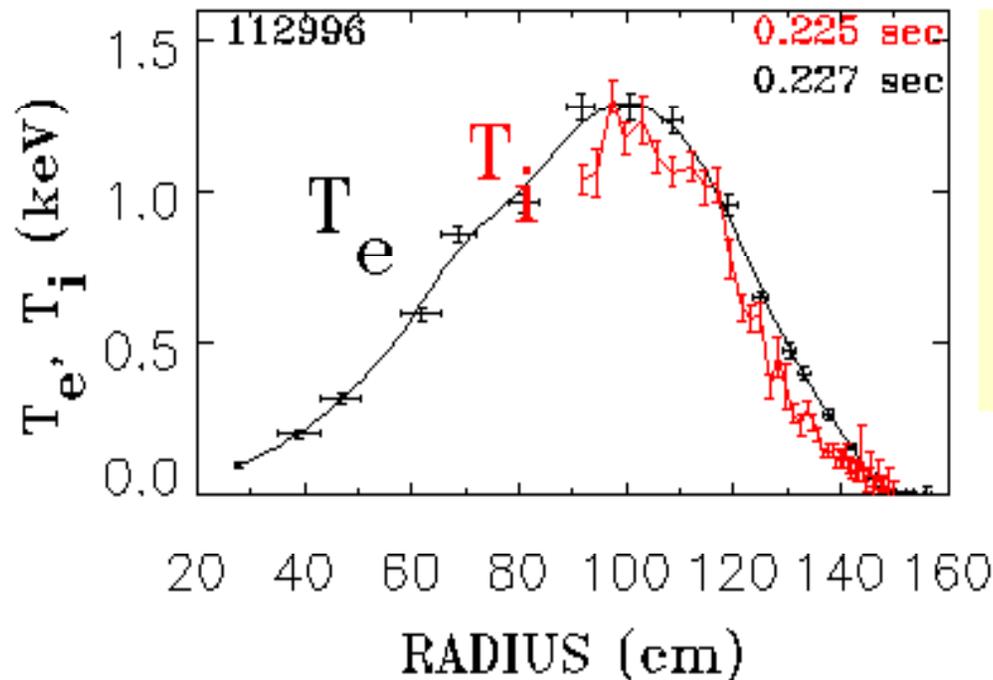
# Low $n_e$ / slow ramp + late beam (112996)



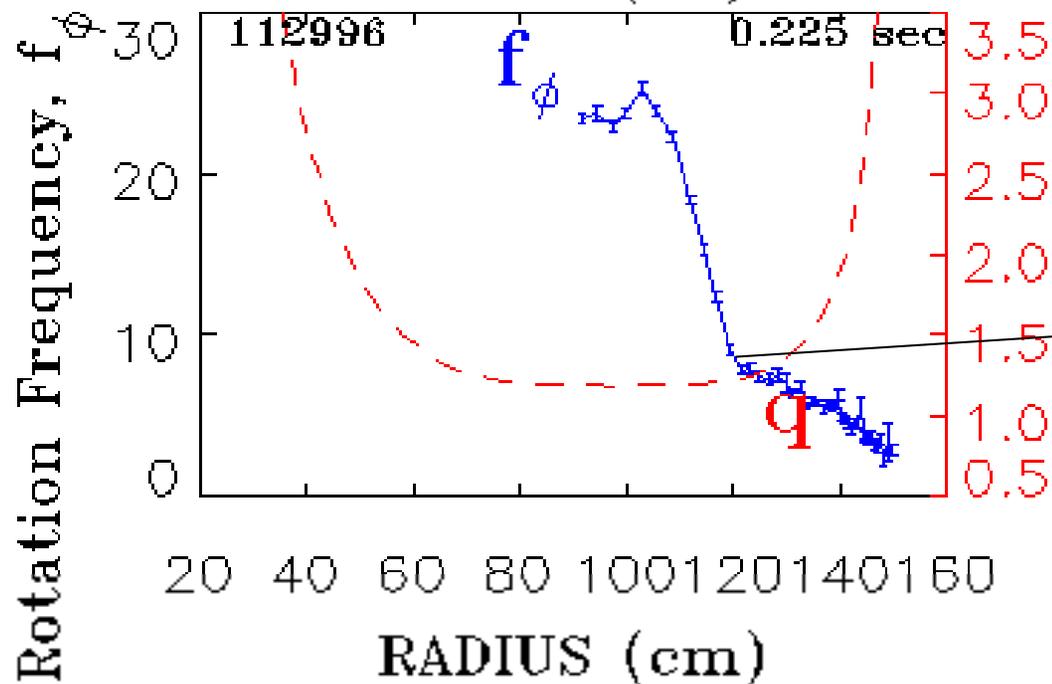
- Slower  $W_{\text{tot}}$  rise, but still high confinement late
- Also MHD  $\approx$  quiescent



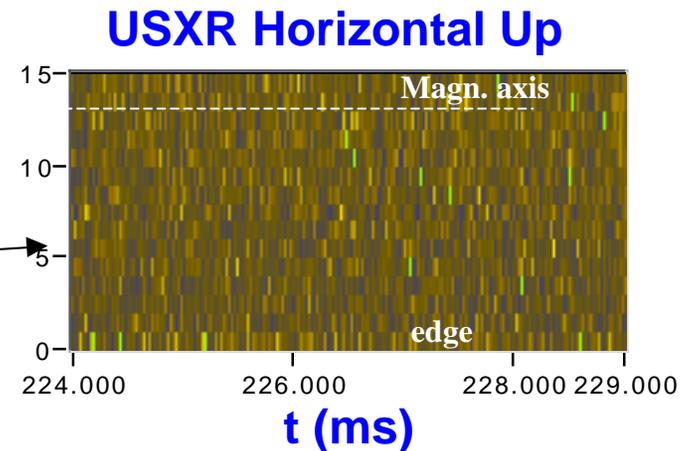
- Quite high  $T_e(0)$ , but less steep gradient than with fast ramp



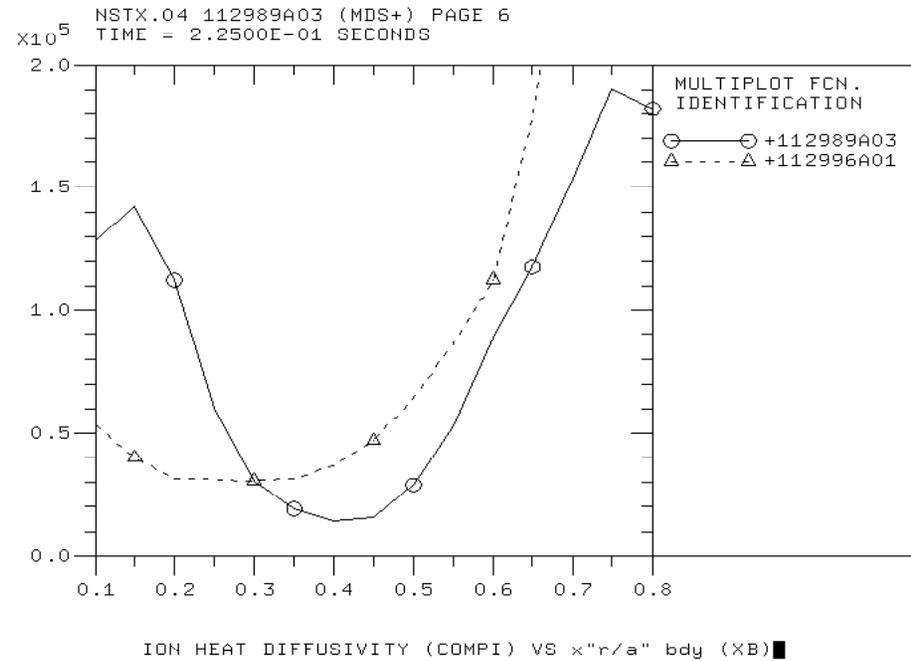
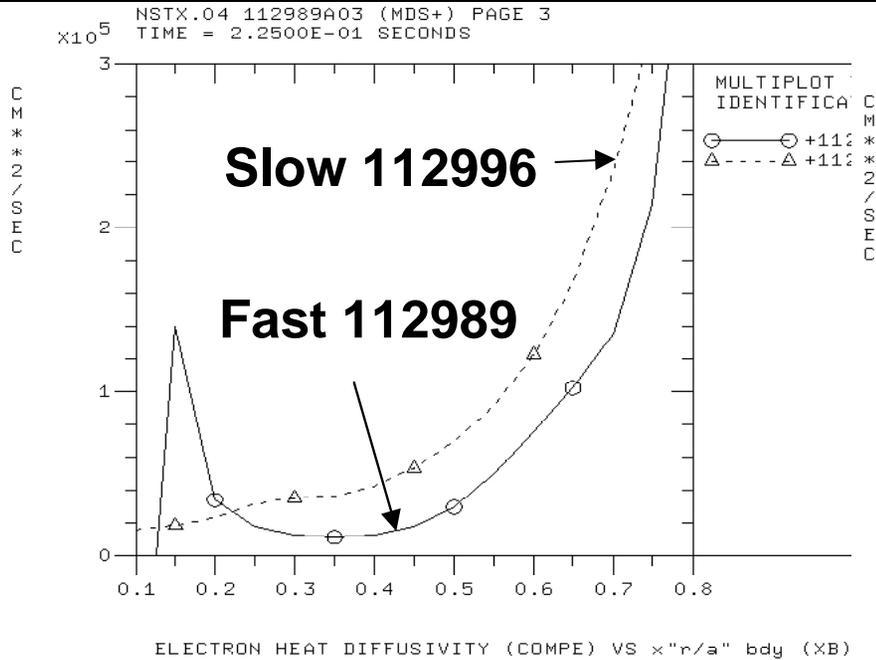
- $T_i, V_\phi$  gradients also less steep
- As in 112989, not much MHD early



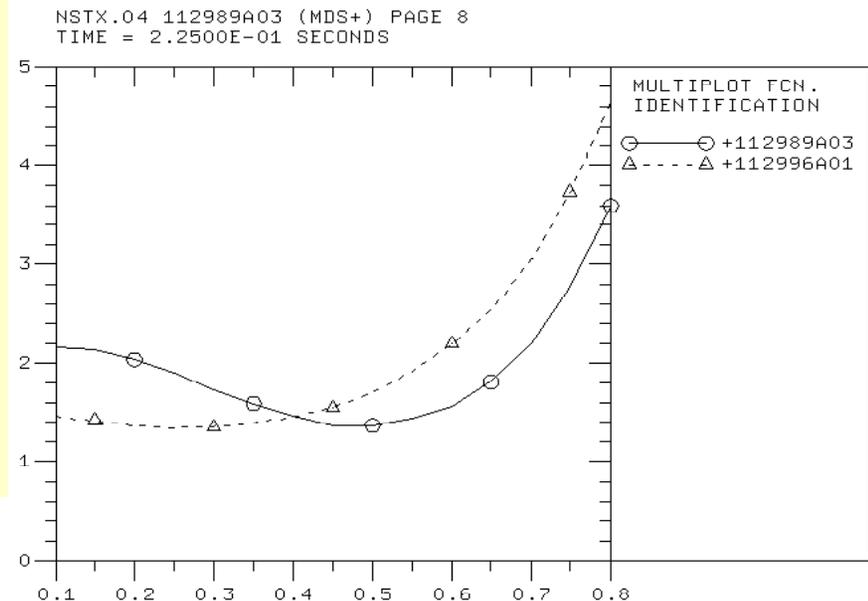
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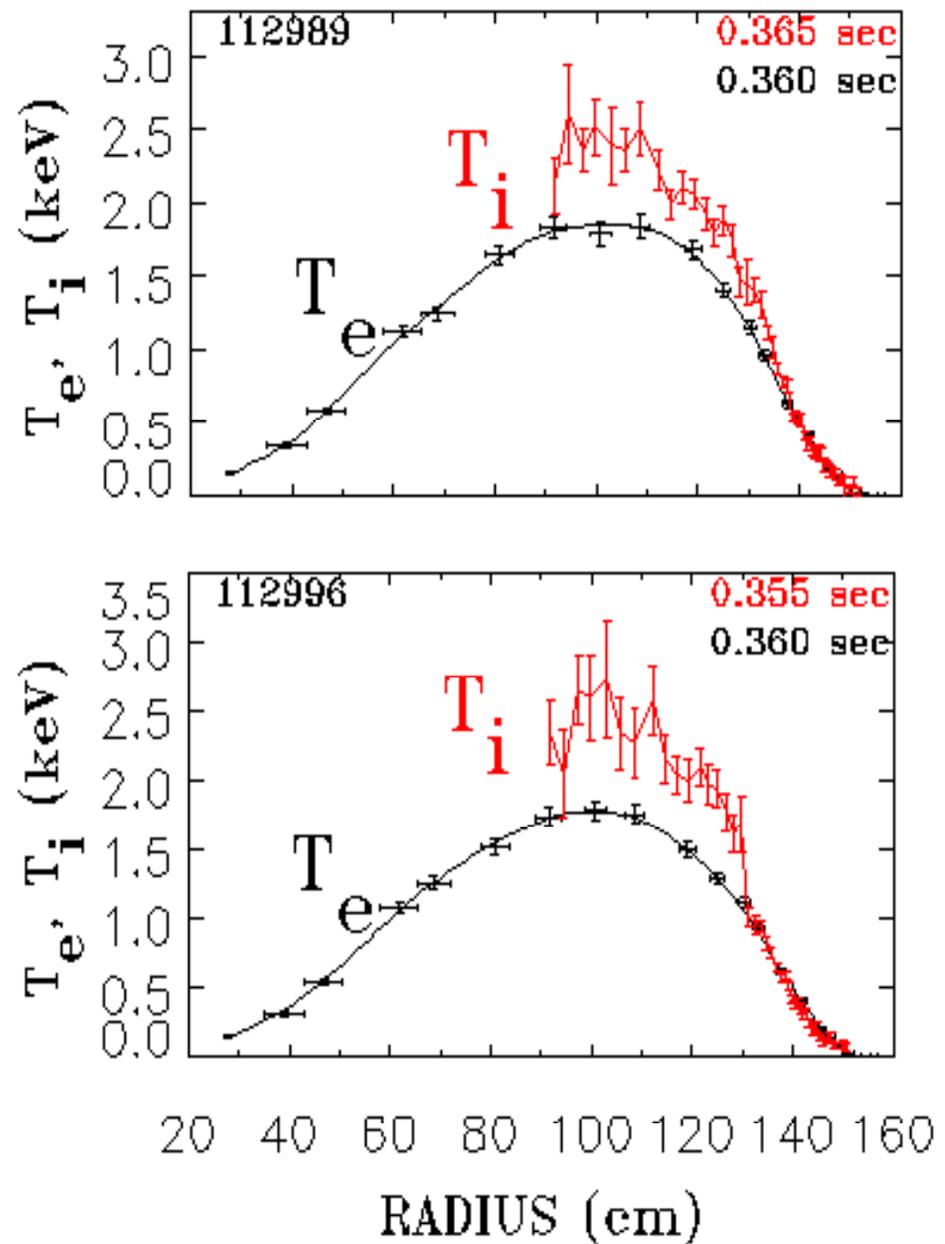
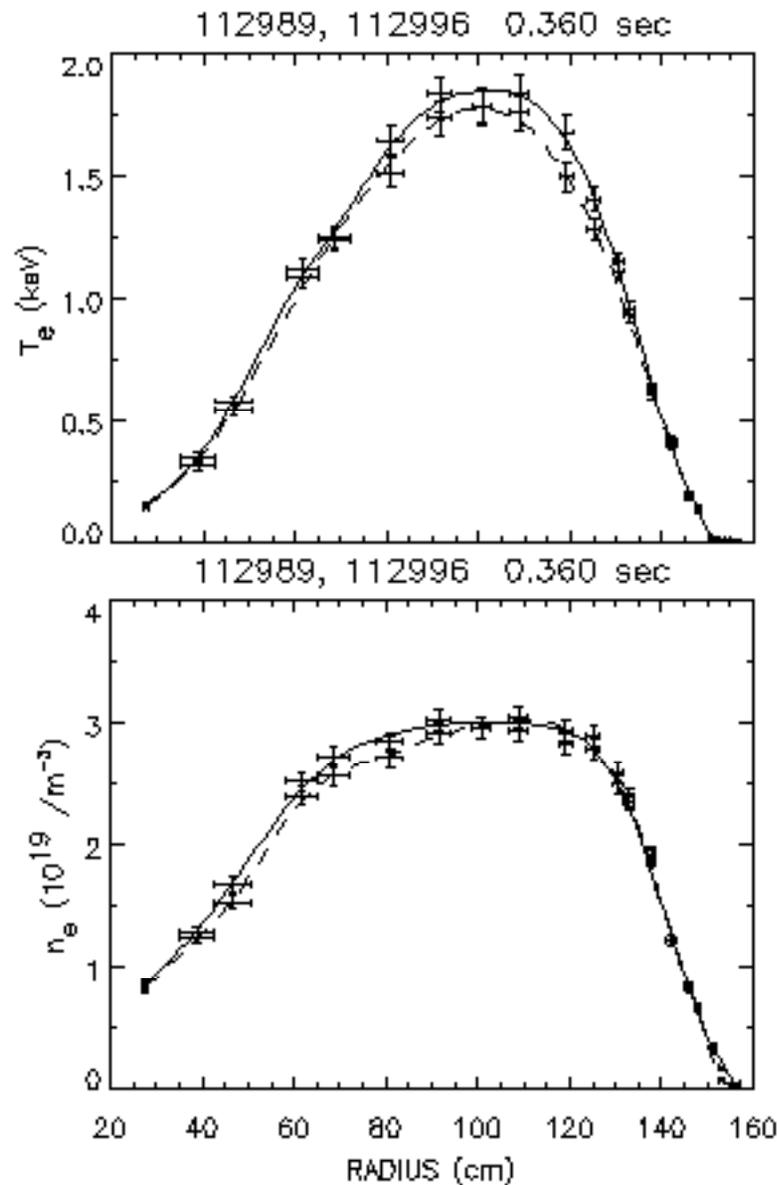
# Preliminary TRANSP comparison of fast/slow cases

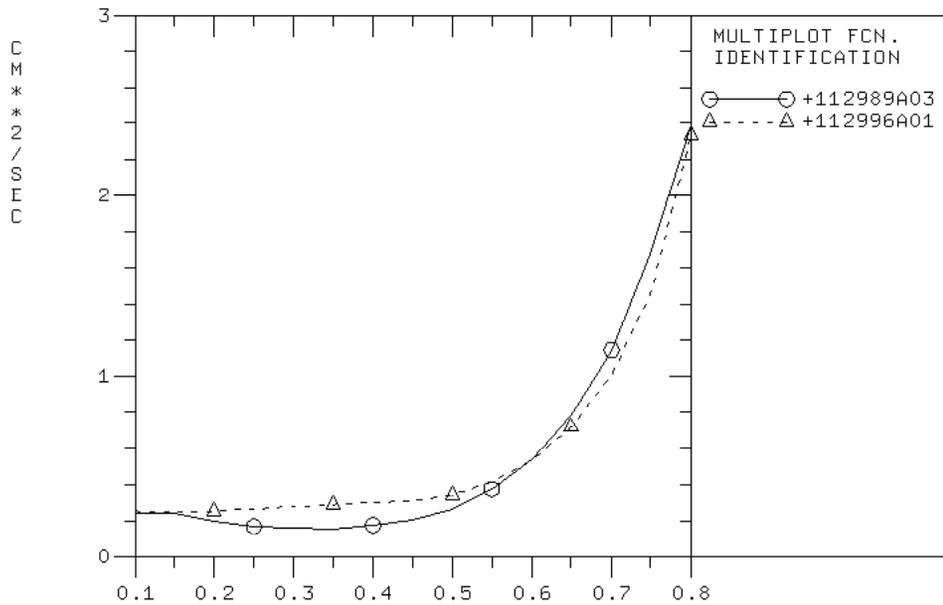


- Early reduction in  $\chi_e, \chi_i$  at  $r/a \geq 0.3$ , with fast ramp
- TRANSP q reversed with fast ramp,  $\approx$  flat with slow
- $\chi_e$  comparable to  $\chi_i$  at low  $n_e$

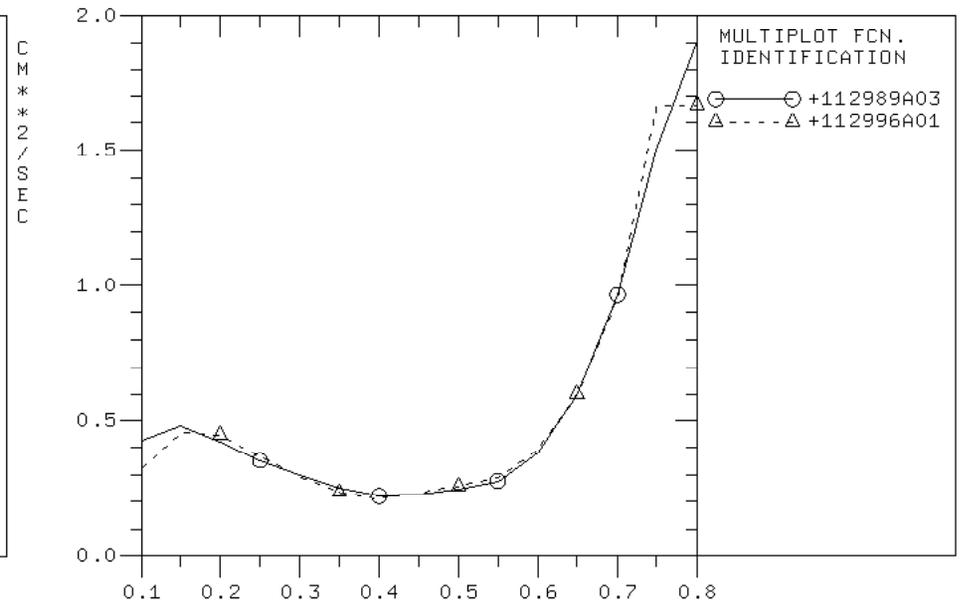


# Late in time profiles similar for fast and slow cases



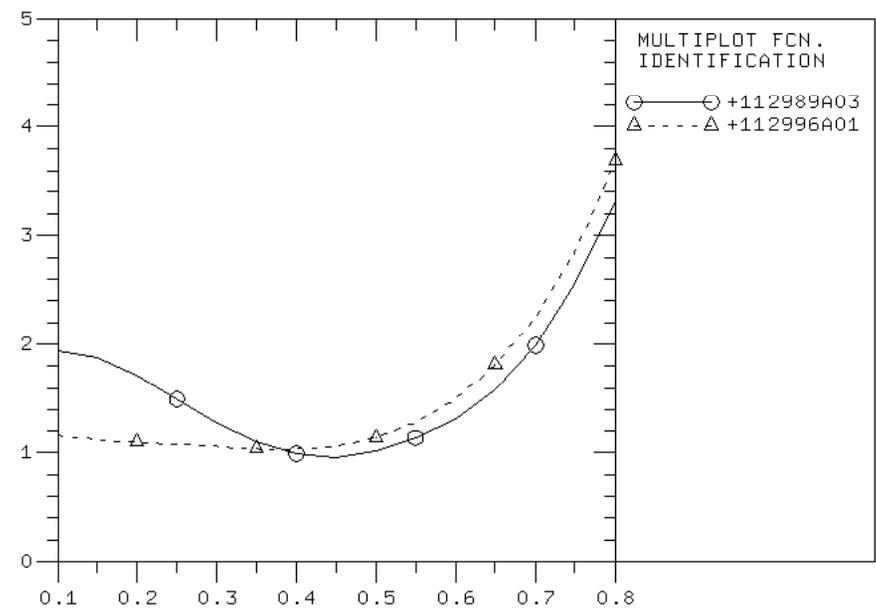


ELECTRON HEAT DIFFUSIVITY (COMPE) VS x"r/a" bdy (XB) ■

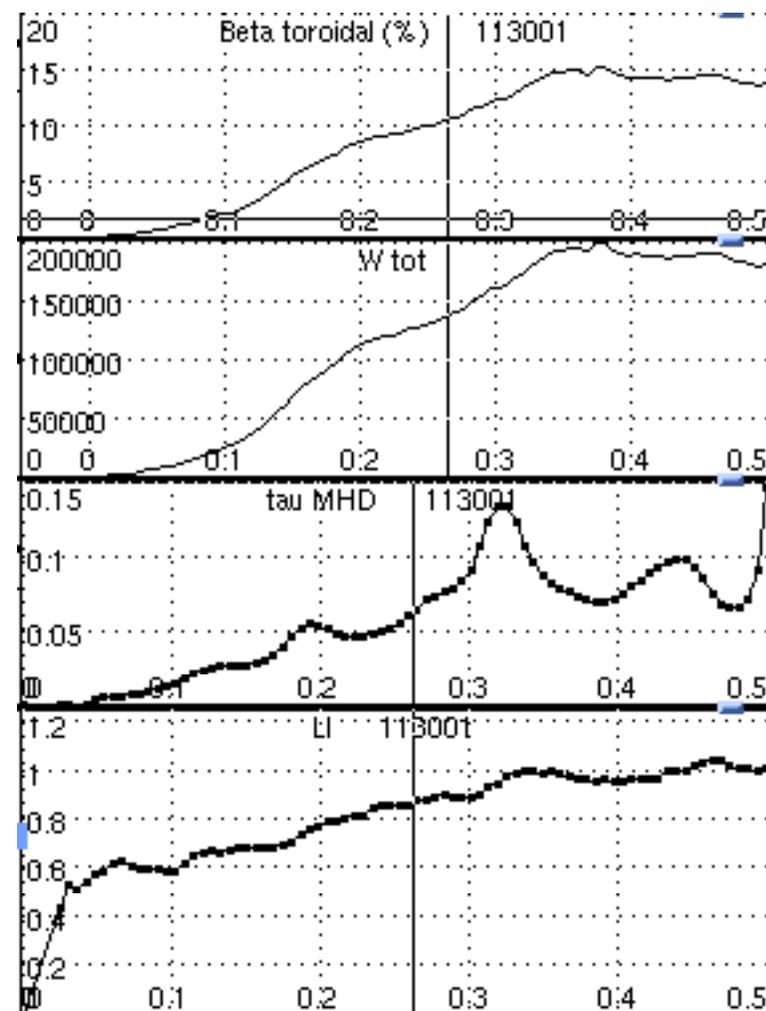
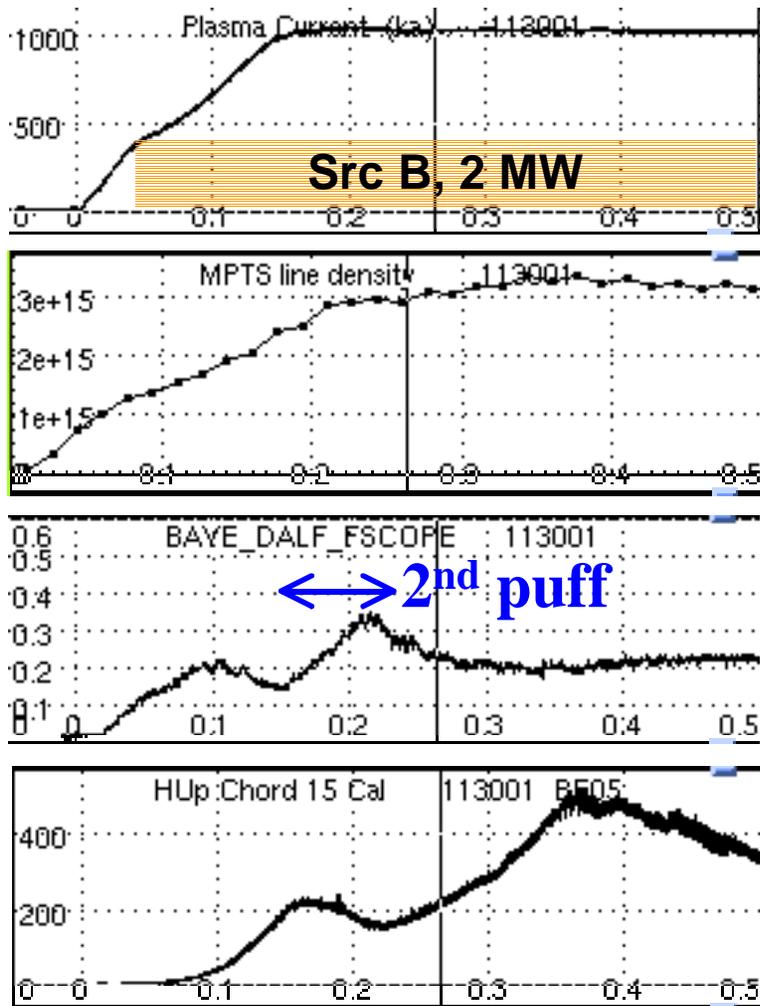


ION HEAT DIFFUSIVITY (COMPI) VS x"r/a" bdy (XB) ■

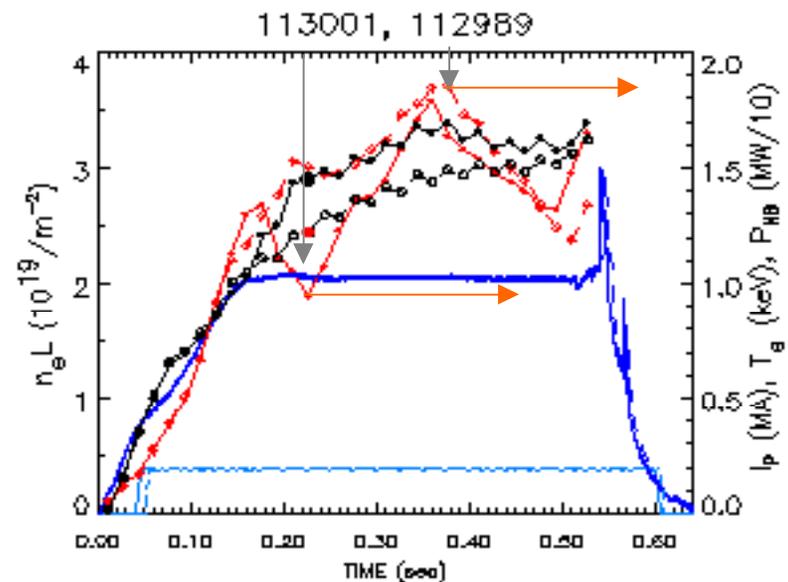
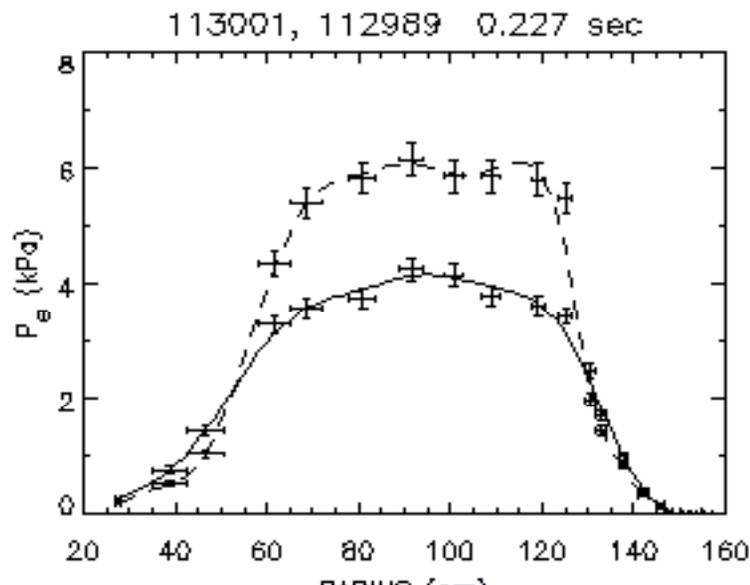
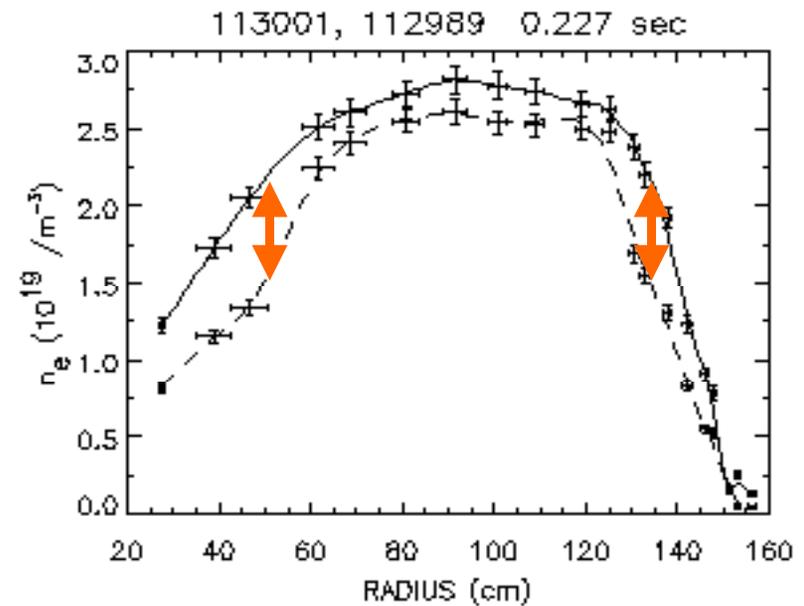
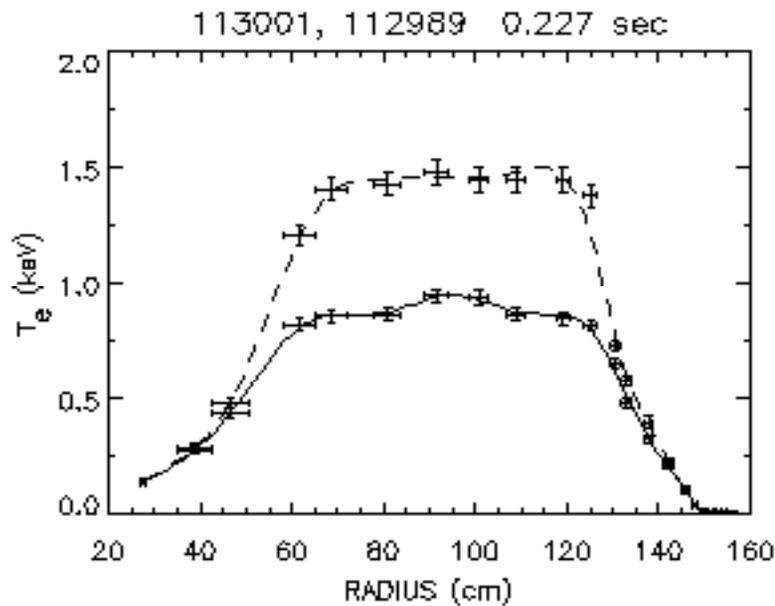
- Late in time  $\chi_e, \chi_i$  become very similar (as opposed to high  $n_e$  case when  $\chi_e \gg \chi_i$ )
- TRANSP q-profile still reversed for fast case (effect of off-axis sawteeth however not accounted)



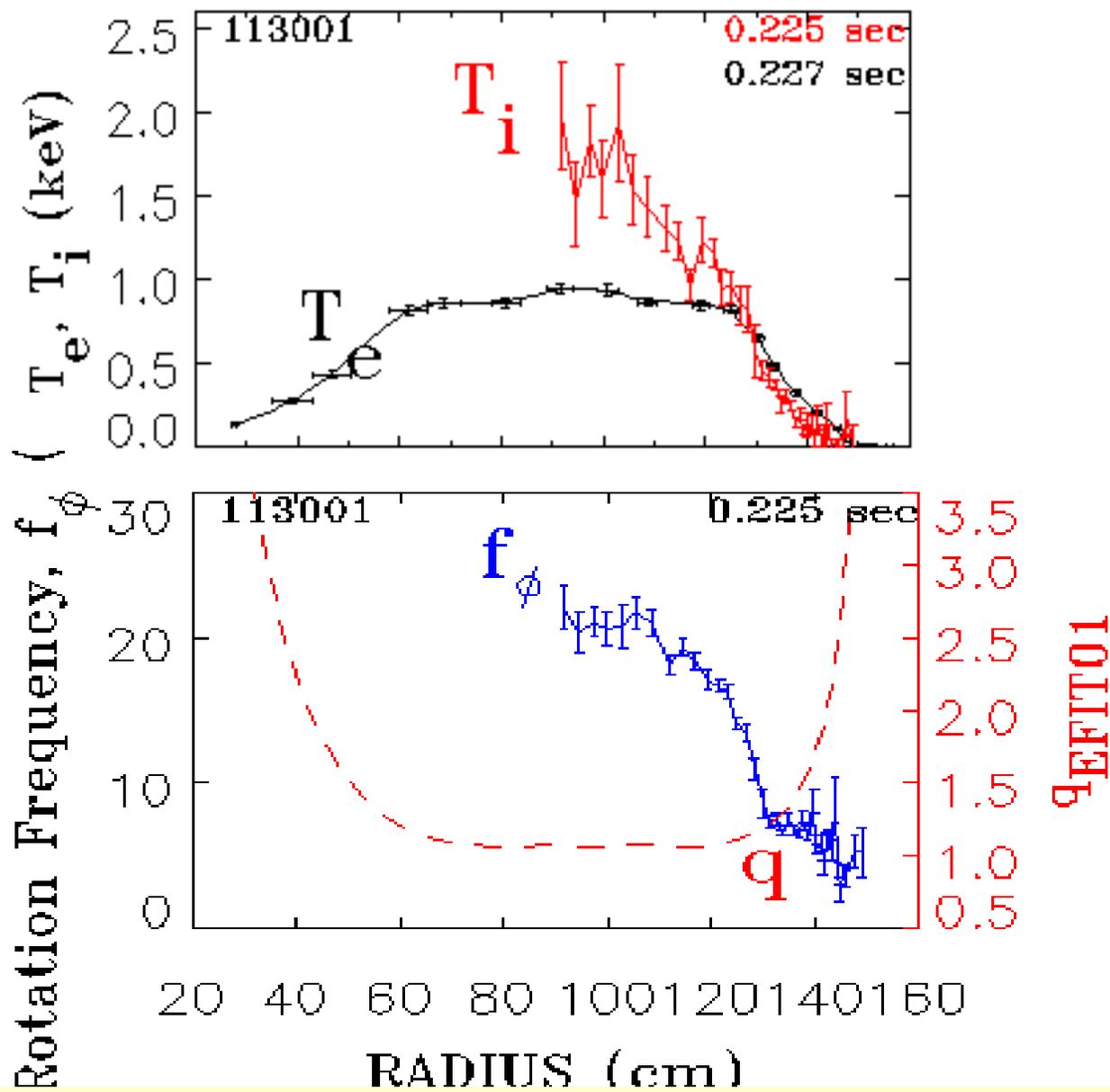
# High $n_e$ / fast ramp + early beam (113001)



- Second gas puff added at 155 ms to increase  $n_e$
- Only modest  $n_e$  increase could be sustained without MHD

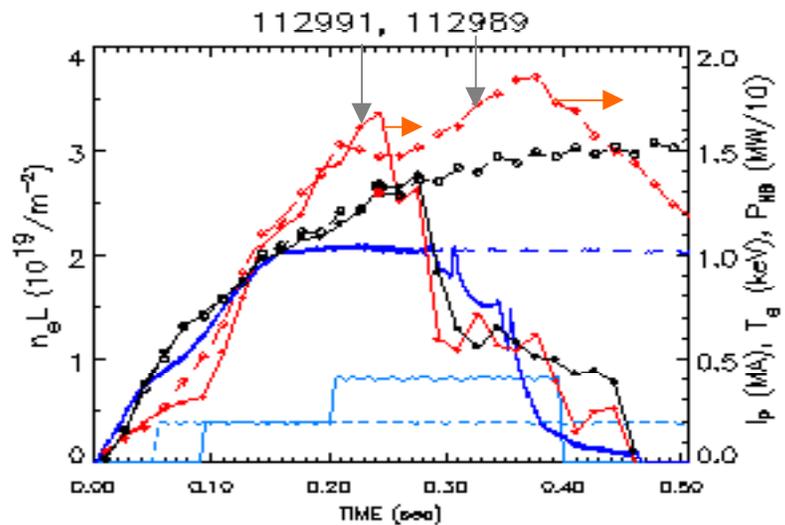
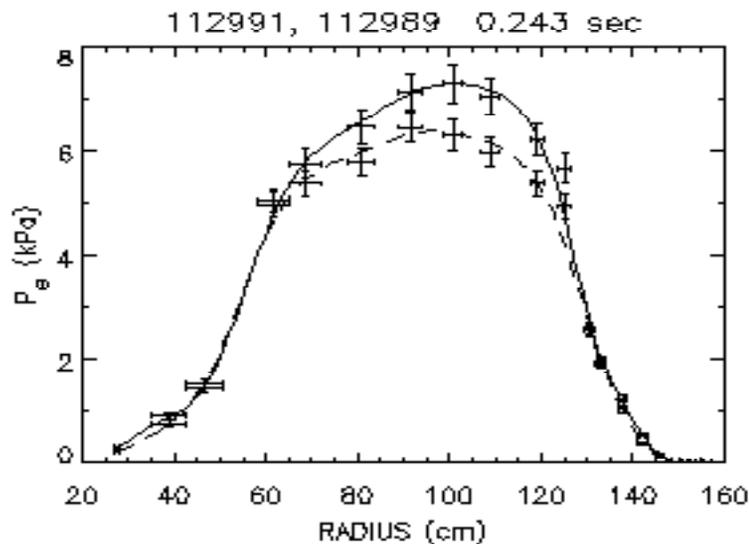
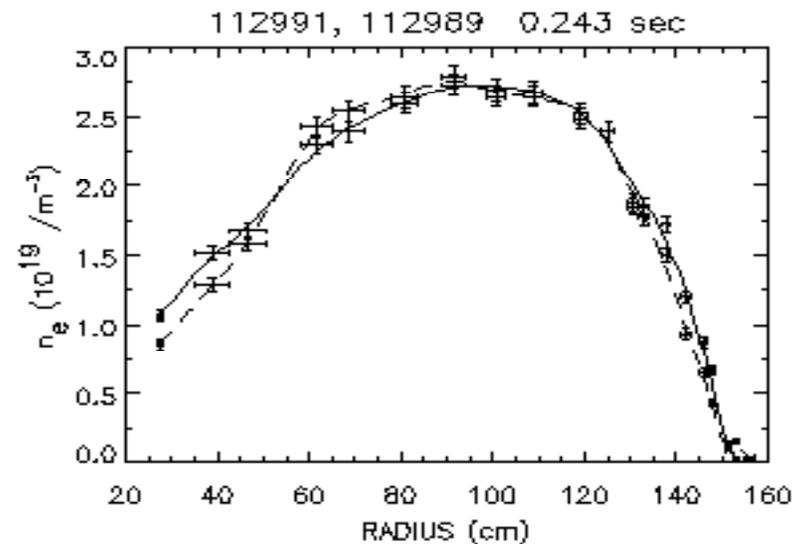
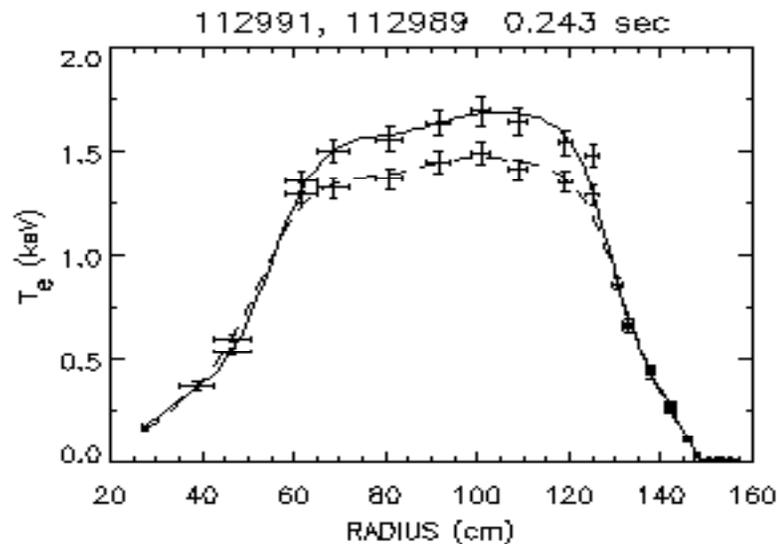


- Modest  $n_e$  increase in outer plasma causes  $T_e$  to drop
- 'Phase-transition' like threshold ??



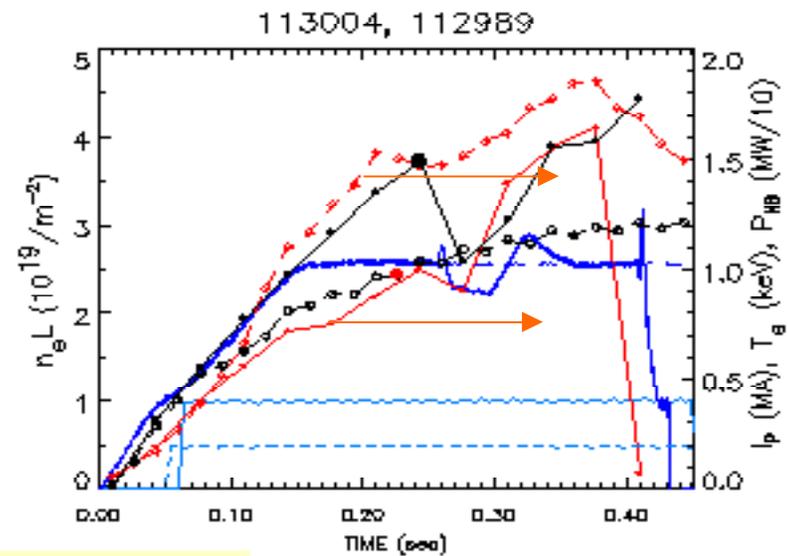
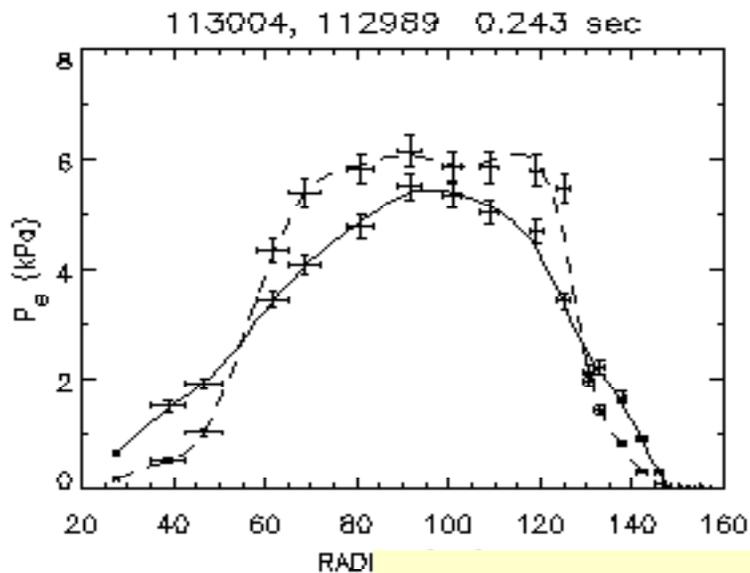
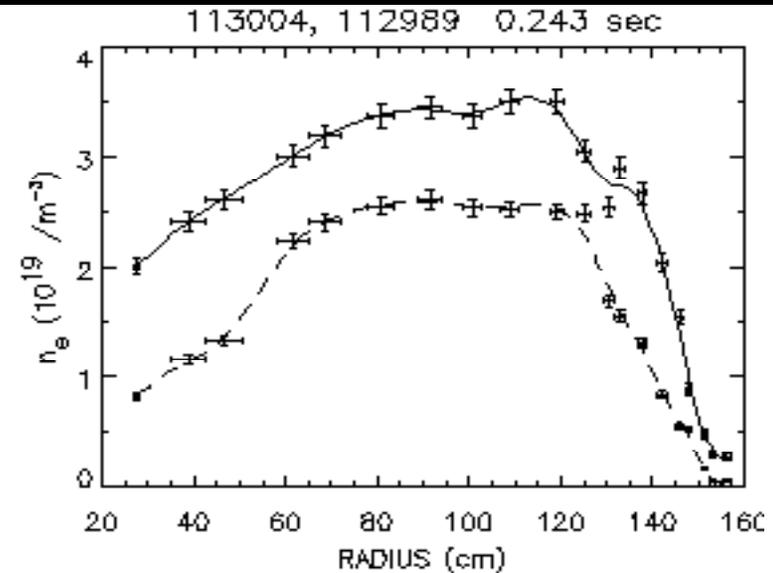
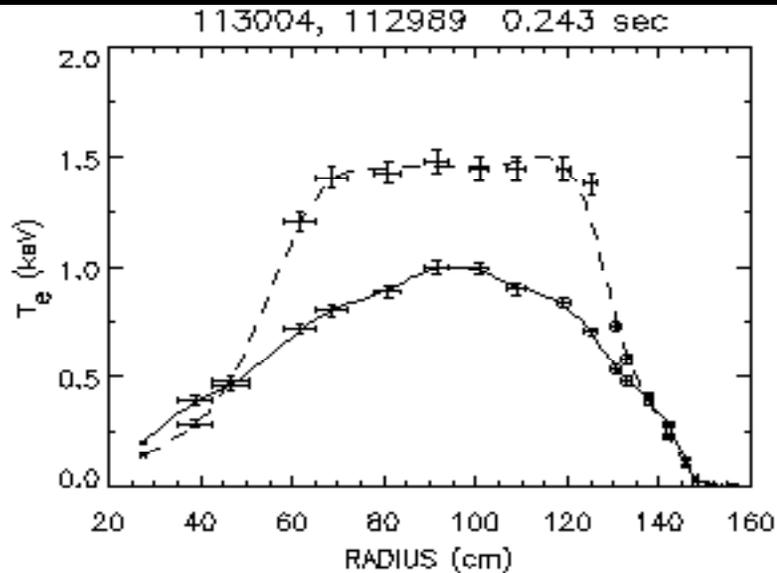
- Steep  $T_i$  gradient also lost, but central  $T_i$  less affected

# $P_{\text{beam}}$ increase at low $n_e$ / fast ramp (112991)



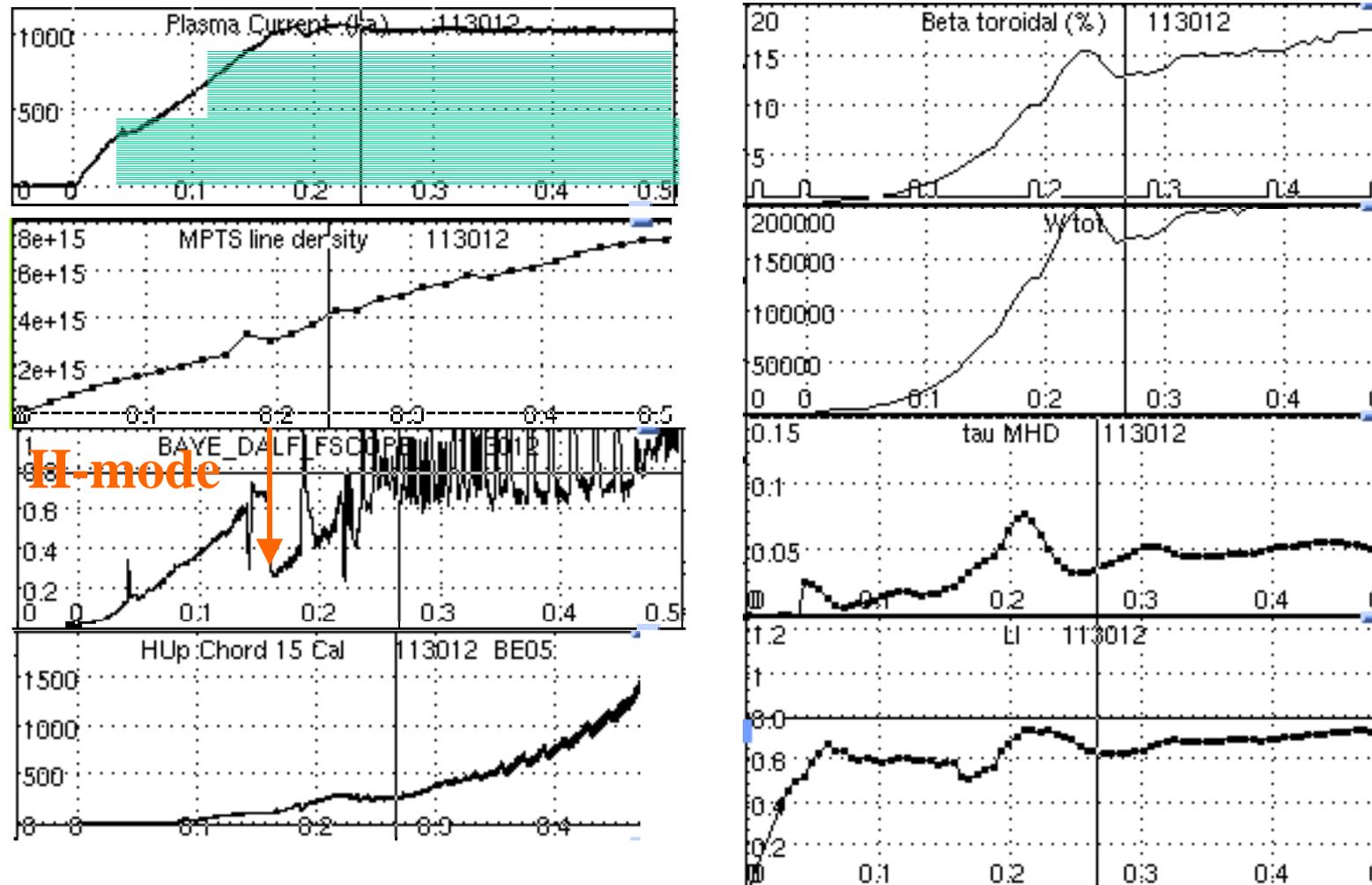
- Possibly small  $T_e$  increase, followed by MHD collapse

# $P_{\text{beam}}$ increase at high $n_e$ / fast ramp (113004)

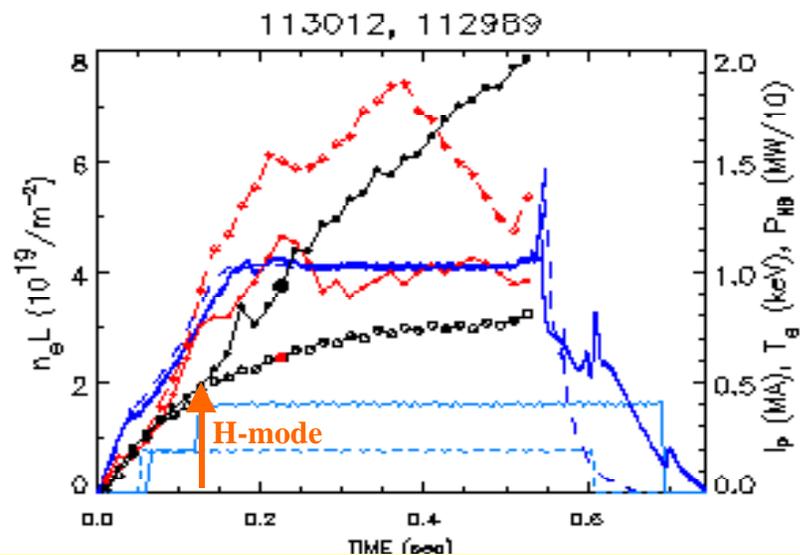
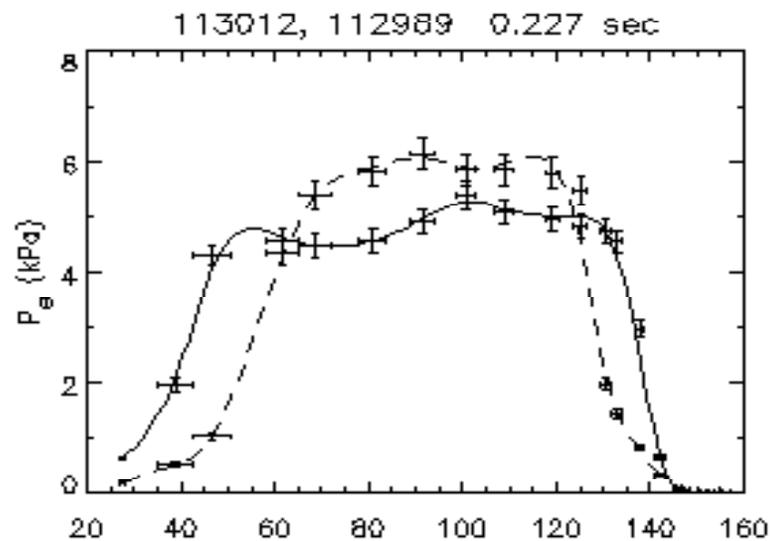
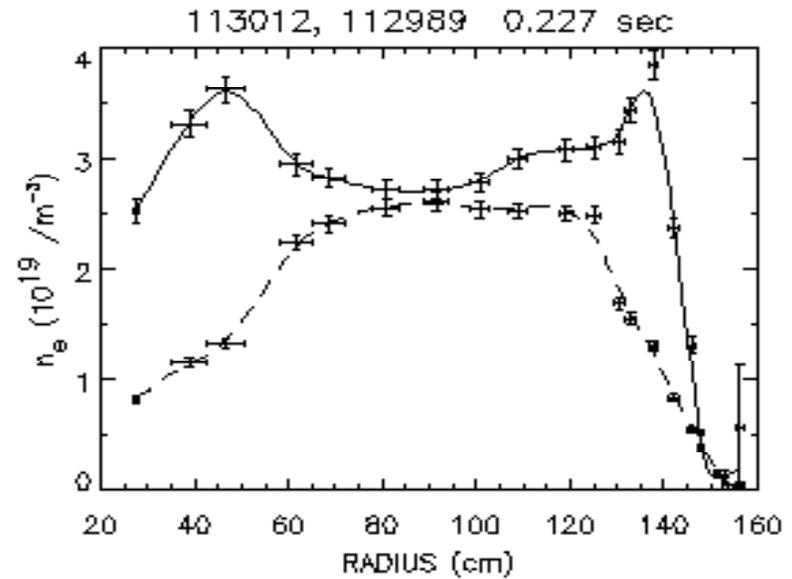
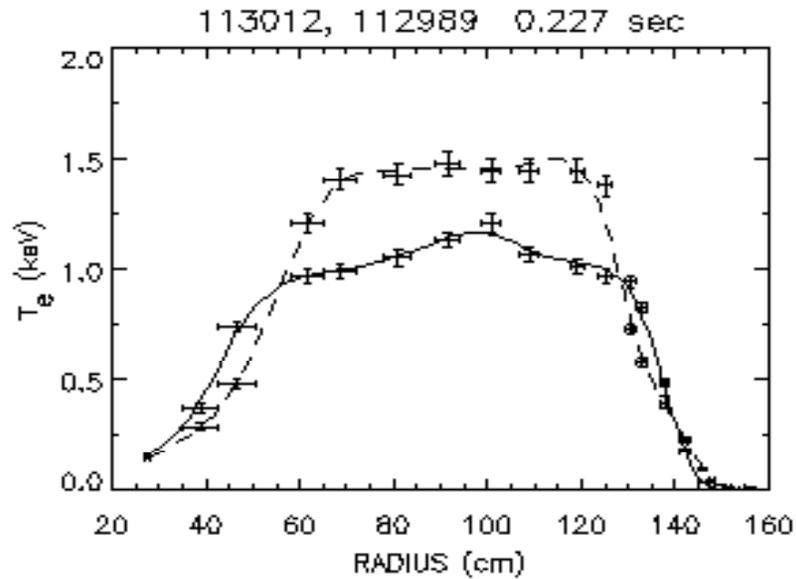


•  $T_e$  stays low

# H-mode in high $n_e$ /fast ramp + early beam (113012)



- $W_{tot}$  rises early, low  $I_i$  throughout

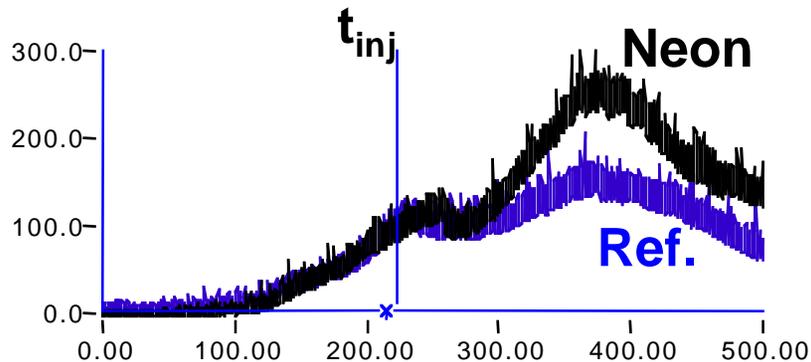


- Low central  $T_e$  even with 4 MW
- Broad profile nevertheless (correlates with broad  $j(r)$  ?)

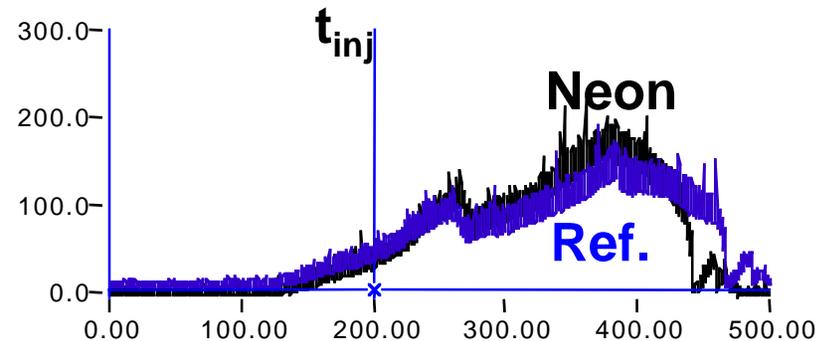
# Neon injection (low $n_e$ )

**$E > 1.4$  keV USXR core signal (fully stripped Neon)**

**Fast ramp (112995)**



**Slow ramp (112998)**



- More Neon penetrates the core in fast ramp case
- Possibly effect of earlier (off-axis) sawteeth with faster ramp, rather than increased transport

# Summary

- We tried to separate the effects of q-profile and density on electron transport
- At low  $n_e$ , 'reversed' vs. 'flat' q-profile likely has significant effect on electron (and ion ?) transport
- However, density also seems to play a significant role:
  - modest increase in (peripheral ?)  $n_e$  takes out central  $T_e$
  - consistently, high  $T_e$  is obtained only at low  $n_e$
  - **threshold effect ??**
- Consistently  $\chi_e \approx \chi_i \approx$  few  $\text{m}^2/\text{s}$  at low  $n_e$ , as opposed to  $\chi_e \gg \chi_i < 1 \text{ m}^2/\text{s}$  in high  $n_e$  L-mode
- High  $T_e$  regime relatively fragile to power increase, so far
- Neon injection possibly affected by off-axis sawteeth