Application of Density Control Techniques in NSTX

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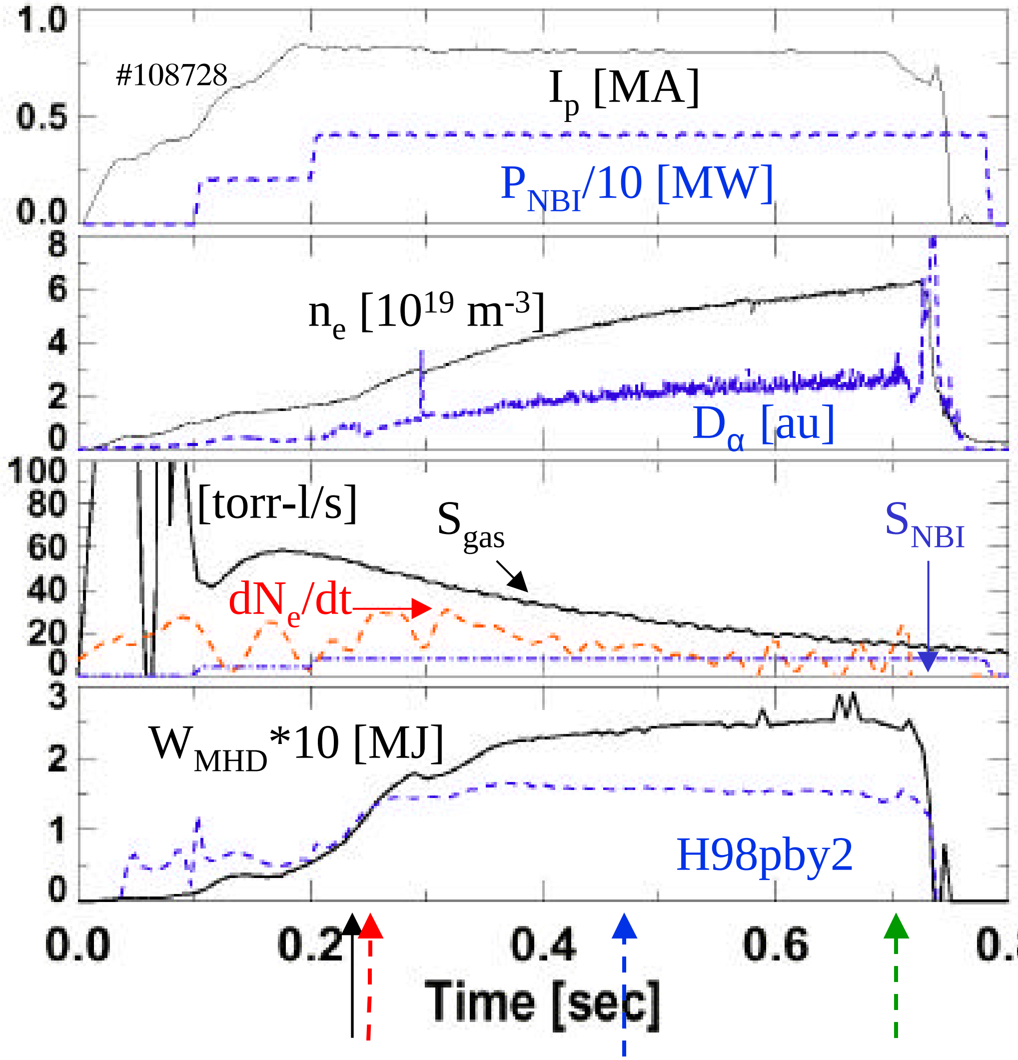
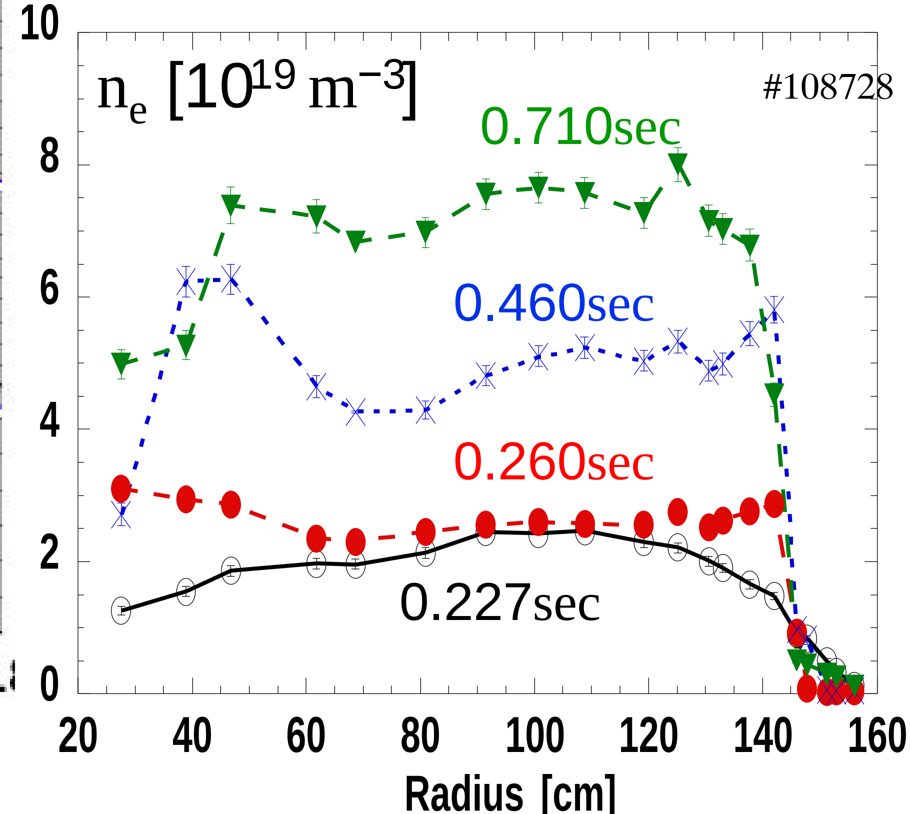
Motivation

- Most NSTX high performance NBI fueled discharges have uncontrolled density rise
- Best discharges get n_e/n_{GW} ~ 0.8-0.9 before MHD
- If MHD solved, we will (probably soon) hit density limit
- Density control needed to test density effects in many areas
- Proposals to improve density control:
  - Optimization of fueling (i.e. more tests with shoulder injector)
  - Possible use of density feedback and supersonic gas injection to reduce density rise
  - Use of Lithium wall coatings with pellets and evaporation
  - Use of morning and/or between shot boronization
  - Variation of HeGDC glow time
  - Pellets to trigger timely ELMs

Uncontrolled (non-disruptive) density rise in long pulse H-modes



- Density control needed for improved current drive efficiency, transport studies, and power and particle handling research



Classic Density Rise Model Can Be Modified with Realistic Time Dependencies

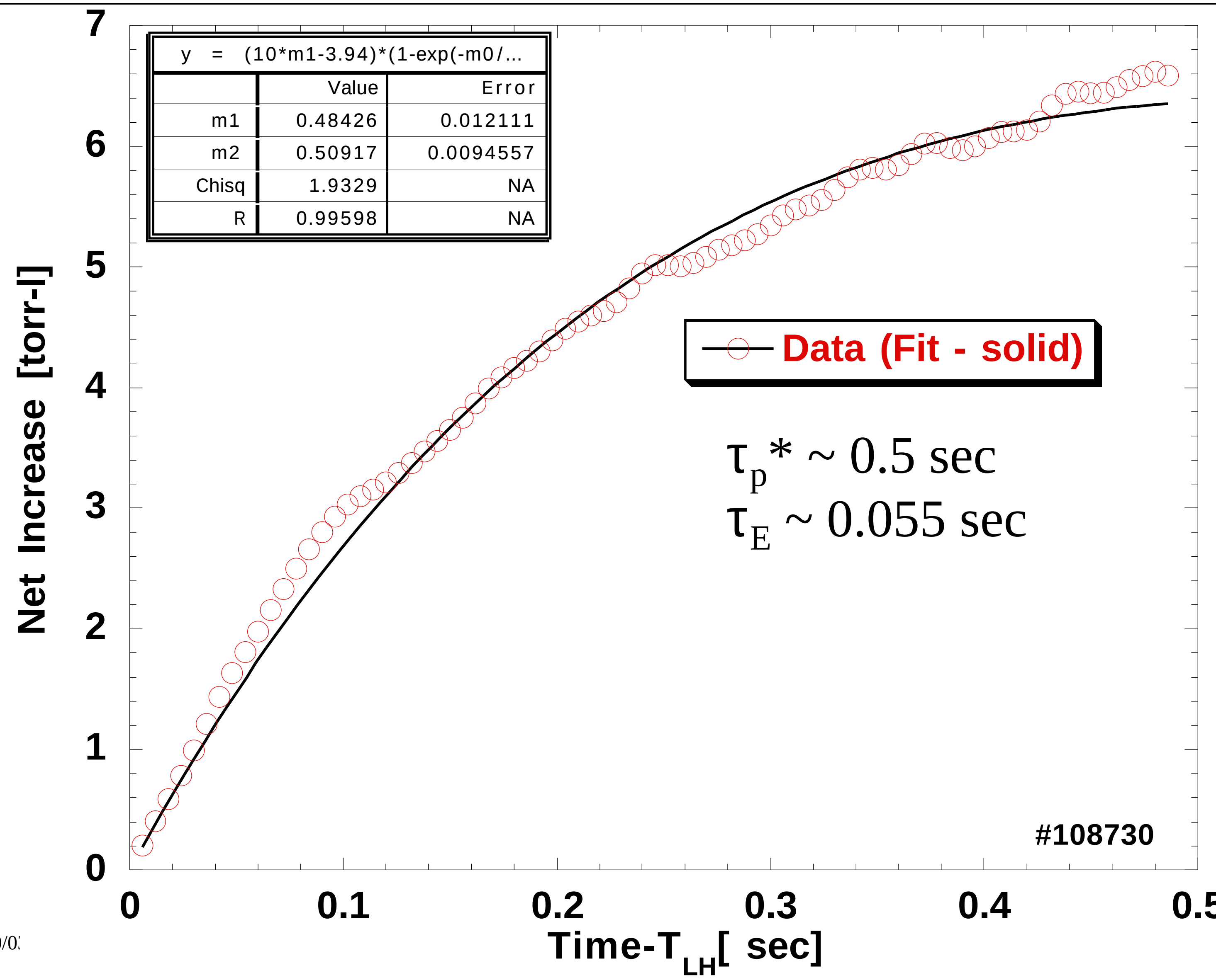
- Assuming time dependent gas source term; time dependence of plasma content has analytic solution

$$\frac{dN}{dt} = \eta_{NBI} S_{NBI} + \eta_{gas} S_{gas}(t) - \frac{N}{\tau_p^*}$$

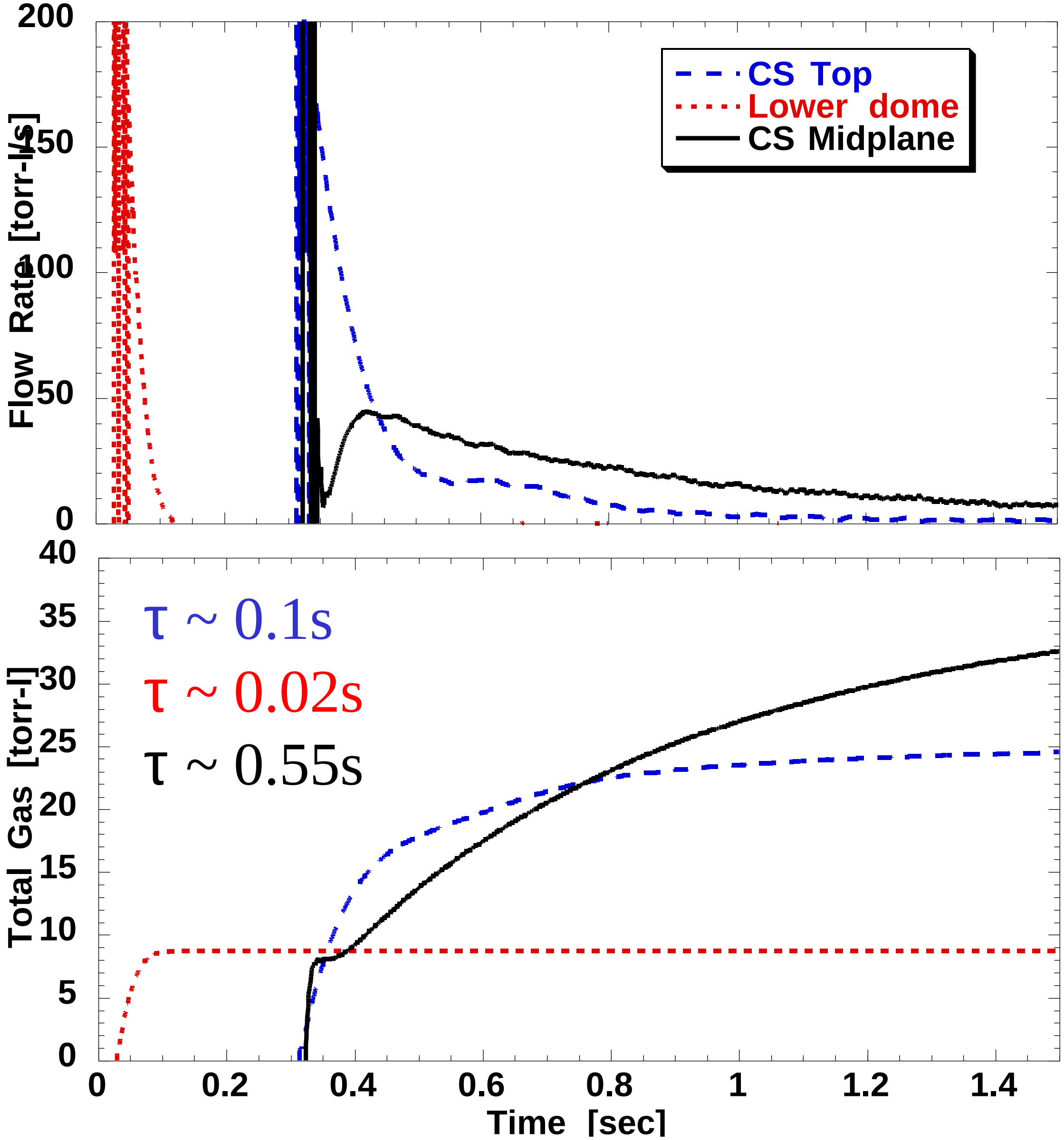
$$\text{where } S_{gas}(t) = S_{gas,0} \exp\left(-\frac{t}{\tau_{gas}}\right); \tau_{gas} \sim 0.55 \sec$$

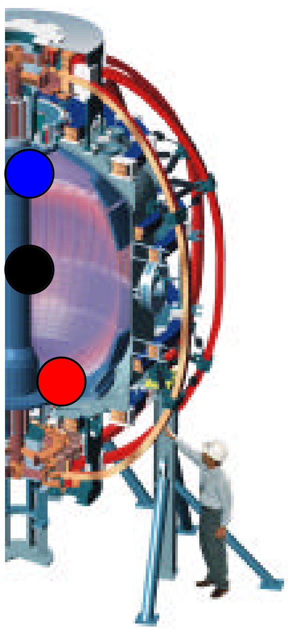
$$N(t) - N_o = \left(\eta_{NBI} S_{NBI} \tau_p^* - N_o\right)\left(1 - \exp\left(-\frac{t}{\tau_p^*}\right)\right) + \left[\frac{\eta_{gas} S_{gas,0} \tau_{gas} \tau_p^*}{\tau_{gas} - \tau_p^*}\right]\left[\exp\left(-\frac{t}{\tau_{gas}}\right) - \exp\left(-\frac{t}{\tau_p^*}\right)\right]$$

Particle Containment Times ~ 0.5 sec. in NSTX with more realistic gas fueling rate model

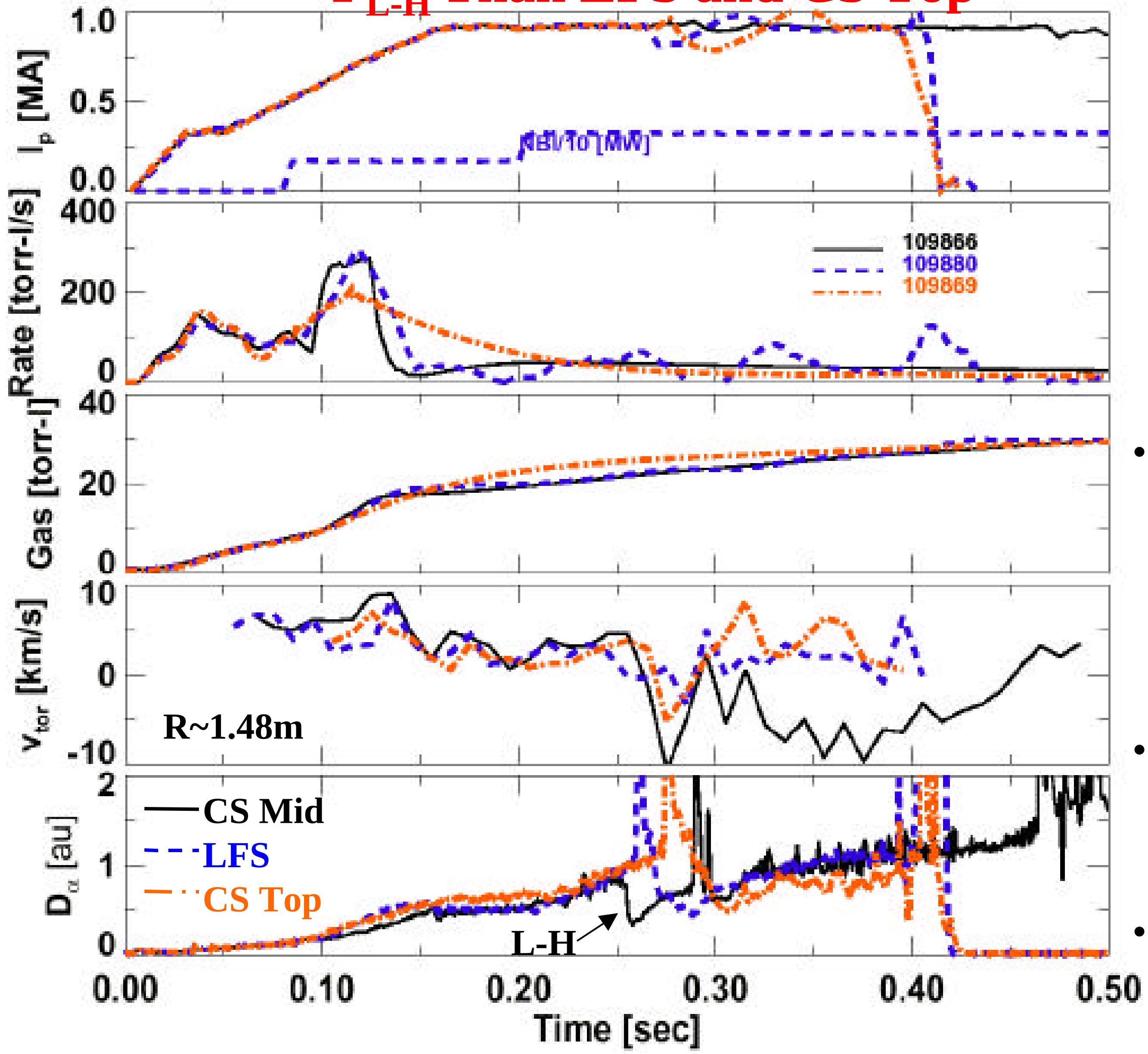


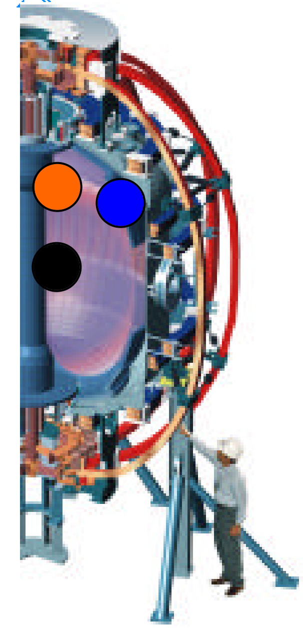
Load-and-Dump Gas Injectors Have Different Flow Characteristics and Delay Time





Center-stack Midplane Gas Injector Fueling Has Lower $P_{L\text{-}H}$ Than LFS and CS Top





- Experiment run when L-H power threshold was ~ 1-2 NBI src (*start of run 2003*)
- Note LFS shot and CS top had no L-H -> higher $P_{L\text{-}H}$
- No difference in DN $P_{L\text{-}H}$ (CS top and mid)

Proposals Summary

- Optimization of fueling (i.e. more tests with shoulder injector and low field side)
- Density feedback and supersonic gas injection to reduce density rise
- Lithium wall coatings with pellets and evaporation
- Use of morning and/or between shot boronization
- Variation of HeGDC glow time
- Pellet triggered ELMs

Backups

Density also rises faster than NBI fuel rate in long pulse L-modes