

Low Density Start-up

D. Mueller, R. Raman,
M.Bell, S. Gerhardt

Lower collisionality by reducing density & reduce fueling to explore benefits of Li

- Low density (low fueling) discharges have frequently suffered MHD or locked modes
- Low-density plasma start-up is possible
 - plasmas can remain stable to start of flat-top and beyond
- 133367, 141175, 141179 are examples without LFS gas
- CHI start-up (e.g. 142140) has produced stable, large R_p , 300kA, low I_i (~ 0.4) (L-mode) plasmas
 - n_e about 1/3 that in a typical inductive shot

Propose two approaches to achieving start-up with low fueling

- Mimic CHI start-up by using *high* loop voltage to get high I_p early at large R_p , low I_i
- Use *low* voltage start-up (~ 1.5 V/turn) and low I_p ramp rate to investigate if this can reduce MHD and permit lower fueling
- In both cases use no LFS gas and aim toward the fiducial shape at 900 kA

High voltage start-up (rapid initiation like CHI)

- Increase initial loop voltage $>4\text{V/turn}$ – about double usual
- Reduce PF5 ramp 10 – 20% adjust prefill
- Control to fiducial shape starting at 20 ms, but use lower PF3:PF5 ratio from CHI case until ~ 35 ms to get lower I_i
- 1 – 2 NBI sources starting at 20 – 80 ms
- Use I_p ramp-rate from fiducial then investigate varying it
- Adjust PF1AU&L to avoid plasma moving during ramp-up
- Increase $R_p \sim 10\text{cm}$ until ~ 70 ms (start of isoflux control)
- Vary CS injector pressure
 - CHI shot did not use any LFS gas, but did use 1100T on CS

Low voltage start-up (breakdown phase, $t < 40$ ms)

- Use < 1.5 V/turn initially (usually ~ 2 V)
- Lower prefill and lower PF5 ramp
- Adjust PF3/PF5 ratio to vary size of plasma during start-up and to lower I_i
- Investigate whether H-mode can be achieved without resorting to HFS gas
 - Vary NBI timing, gap evolution
- During slow ramp-up (5 – 7 MA/s) phase, need ~ 2 V in L-Mode or ~ 1 V in H-Mode

Slow ramp-up

with or without low voltage start-up

- Ramp I_p at $<2.5\text{MA/s}$ after 40 ms (about $\frac{1}{2}$ normal 6MA/s)
 - If plasma stays L-Mode it will run out of OH flux at $\sim 1\text{ MA}$, $\sim 0.4\text{ s}$
 - If it achieves H-Mode early, a few 100 ms of flattop is possible
- 1 – 2 NBI sources starting at 20 ms
- Control to fiducial shape starting at 20 ms, but use lower PF3:PF5 ratio to match plasma volume and I_i in CHI case
- Adjust PF1AU&L for vertical position
- Try to get $R_p \sim 10\text{ cm}$ larger until about 70 ms (start of isoflux control)
- Delay start of isoflux control if I_p not yet high enough ($\sim 275\text{ kA}$) for rtEFIT to find reasonable solution
- Reduce CS injector

Exploring possibilities for lowering density will take dedicated run time

- Try several approaches in order of increasing complexity:
 - Low voltage start-up: 1-2 Days
 - Low ramp-rate: 1-2 Days
 - High voltage start-up: 2-4 Days
- Best if experiment is conducted in ½ day chunks
- NSTX operational space is complex
 - Timing of transition to H-Mode has a major influence on n_e , duration, stability, etc.
 - Depends on many variables
- Need good conditions to ensure that any MHD is not due to the usual suspects