Rotation and Transport

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T&T ET Meeting

An "ideas" forum

- Charge: Generate an XP that studies something about rotation and momentum transport.

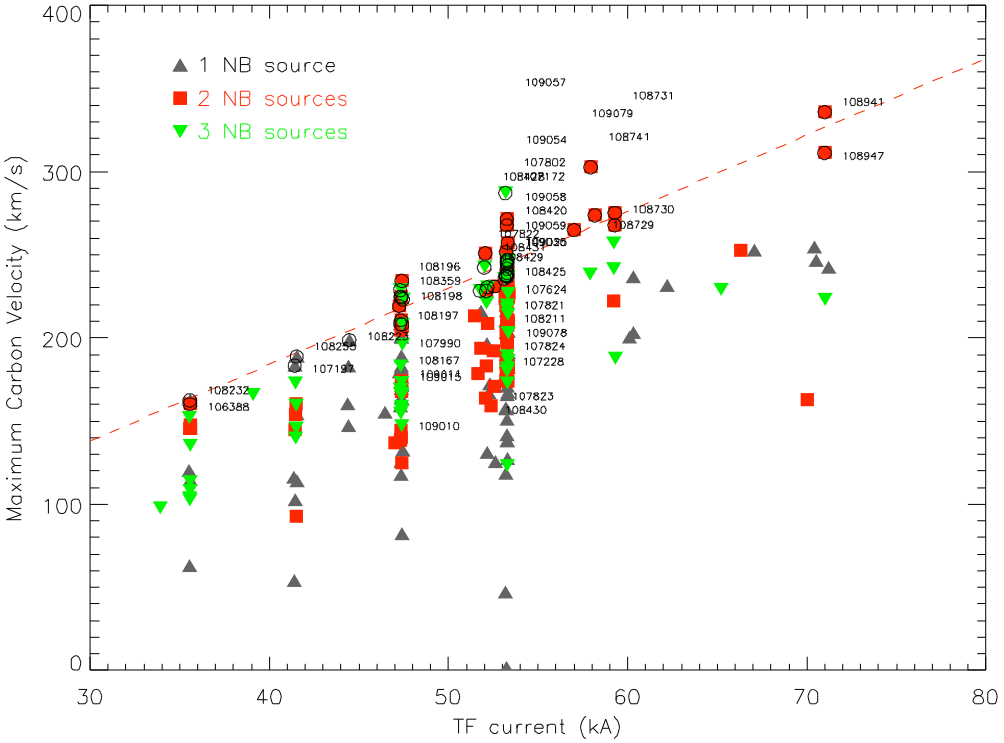
- Question 1: What, specifically, are we interested in?
  - Energy/particle confinement v. rotation speed
  - Effect of q-shear on velocity profile
  - Pressure (density) anisotropy at high rotation

- Question 2: Can a satisfactory XP be executed under the constraints of the early run period, i.e. $B_T < 0.5$ T, RF/NBI compatibility issues, no MSE, etc.?

Effect rotation speed by varying NBI torque

- Energy and particle confinement can be compared to the toroidal rotation speed to look for trends, i.e. does higher rotation = better confinement?
- NSTX has 3 co-current NB sources with differing tangency radii to the plasma
  - Differing amounts of angular momentum can be transferred to the plasma, though the injected power remains constant
  - Plasma: I_p=800 kA, B_t=.45 T, LSN (L-mode)
    - 5 shots ea. w/A,B,C (100kV, 2 MW)= half day XP
- RF heating from the HHFW does not impart angular momentum, and could serve as intermediate- and no-rotation test cases.
  - Plasma: I_p=800 kA, B_t=.45 T, LSN (L-mode)
    - Source B+C (80kV, ~3MW) 3-5 shots
    - Source A+B (80kV, ~3MW) 3-5 shots
    - Source C (1.5 MW) + RF (1.5 MW) 3-5 shots
    - Source A (1.5 MW) + RF (1.5 MW) 3-5 shots
    - RF (3MW) + beam blips for CHERS 3-5 shots
      - Total: 15 to 25 shots (half-day to full-day XP)

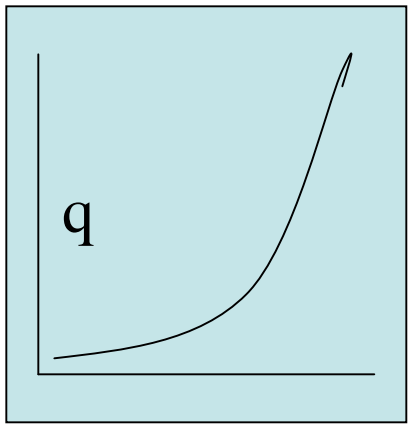
Effect rotation via B_t scan

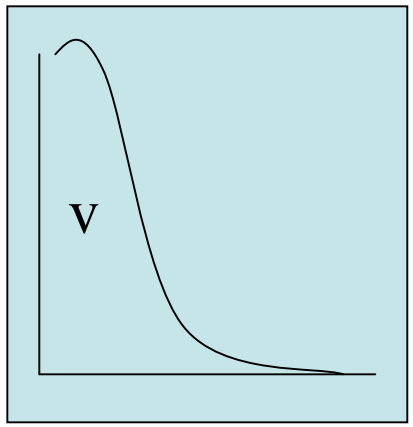


- Measurements indicate that rotation velocity scales linearly with B_t (R. Bell)
  - High B_t means delayed onset of MHD, hence higher rotation speed.
- Plasma: Source A+B (80kV, 3MW) LSN (Lmode)
  - I_p=800 kA, B_t= .35 T 3 shots
  - I_p=800 kA, B_t= .40 T 3 shots
  - I_p=800 kA, B_t= .45 T 3 shots
    - Total 9 shots (half-day XP)
  - The ability to go to higher field will greatly improve this scan. Do that later?

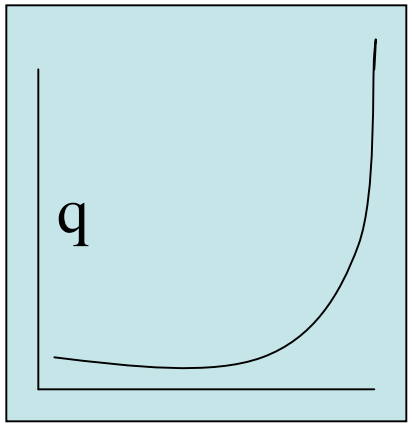
Effect rotation via I_p and/or B_t scan

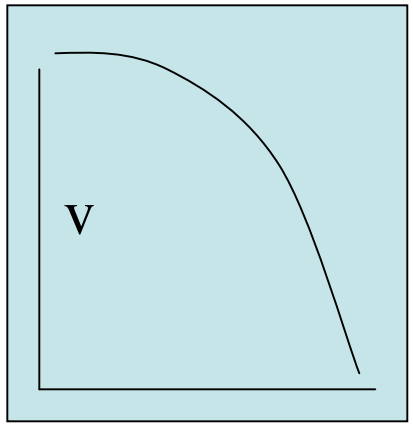
Early time





Later time





- Experimental intuition (R. Bell) that the current profile and rotation profile evolve during a discharge.
- Is the q-profile shear limiting the interaction of NTM's, allowing higher rotation? $q(a) \sim a^2 B_t / R I_p$
- Vary the edge shear by varying the plasma current at fixed B_t.

Effect rotation via I_p and B_t scan

- Plasma: Source A+B (80kV, 3MW) LSN (Lmode)
  - I_p=600 kA, B_t= .45 T 3 shots
  - I_p=800 kA, B_t= .45 T 3 shots
  - I_p=1000 kA, B_t= .45 T 3 shots
  - I_p=1000 kA, B_t= .35 T 3 shots
    - Total 12 shots (half-day XP)
  - The ability to go to higher field might improve this scan. Do that later?
- Could incorporate beam-torque experiments by adding:
  - I_p=800 kA, B_t=.45 T, Source B+C (80kV, ~3MW) 3 shots
  - I_p=800 kA, B_t=.45 T, Source C (1.5 MW) + RF (1.5 MW) 3 shots
  - RF (3MW) + beam blips for CHERS 3 shots
    - Total 12+9= 21 shots (full-day XP)

Do high rotation rates distort the density profile?

- PPPL Theory Seminar (Dec. 12, 2002) Speaker: Luca Guazzotto (U. Rochester) "The equilibrium code FLOW and application to NSTX"
  - "The combination of a tight aspect ratio and fast toroidal rotation in NSTX leads to MHD equilibria that are considerably different from static ones. If the toroidal flow is of the order of the sound speed, the density and pressure are squeezed outward by the centrifugal force."
  - "Additional complications arise when pressure anisotropy and finite poloidal flows are included in the computation. For instance, when the poloidal flow is of the order of the poloidal sound speed [Poloidal sound speed = Sound speed * B_poloidal / B], the pressure, density, and velocity profiles develop radial discontinuities at the transonic surface."

- In addition to the confinement v. rotation studies outlined above, we can use this XP to study "density profile shape" v. rotation.
  - Higher rotation rates are attainable at higher B_t. Should we wait for the .6T shots at the end of the run?

Summary

- Want to systematically investigate what rotation does to/for a plasma.
  - Can measure the rotation
    - toroidal measurements--51 chnl. CHERS (beam blips & notches)
    - edge poloidal measurements--ERD
  - Have identified methods of varying rotation speed
    - Vary input torque via NB & RF scan
    - Vary internal torque (MHD?) via I_p, B_t scans
  - Need to identify the relevant physical quantities effected by rotation
    - Confinement properties
    - Density profile shape
    - . . .