Changes in Edge Turbulence with ρ and Toroidal Rotation Input in NSTX*

Ongoing analysis of correlation reflectometer measurements of edge turbulence made during XP223, "*Effect of ρ* and rotation on non-H-mode NBI-heated plasmas in NSTX*", led by D. Stutman, et al.

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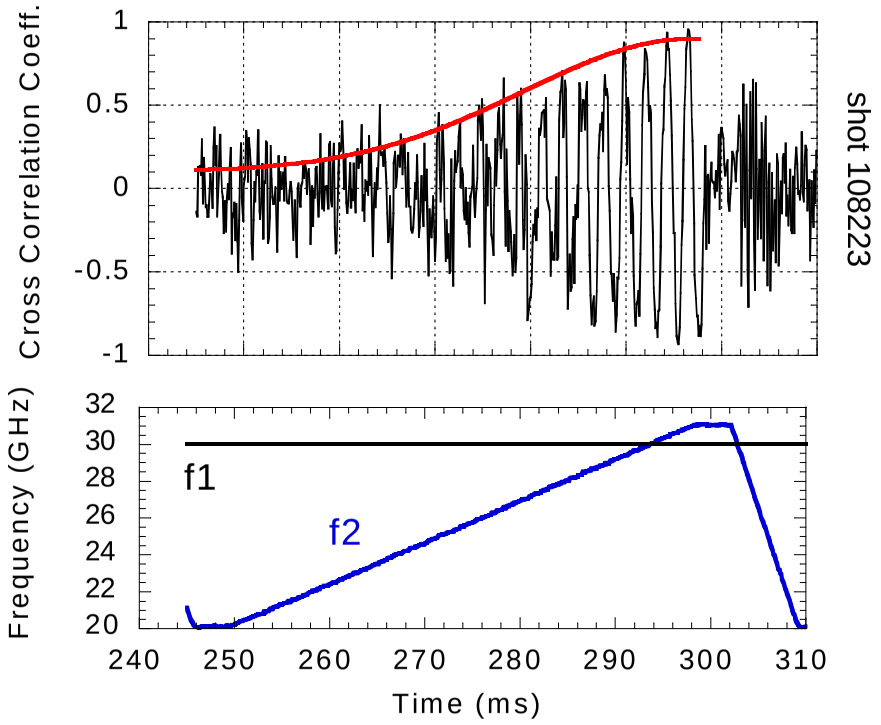
The NSTX / UCLA Correlation Reflectometer

- The correlation reflectometer is a two channel homodyne system, operating in O-mode over 20 - 30 GHz ($n_{CR} \approx 5\times10^{12}$ - 1.1×10^{13} cm^{-3})

- Antennas are mounted inside the vacuum vessel

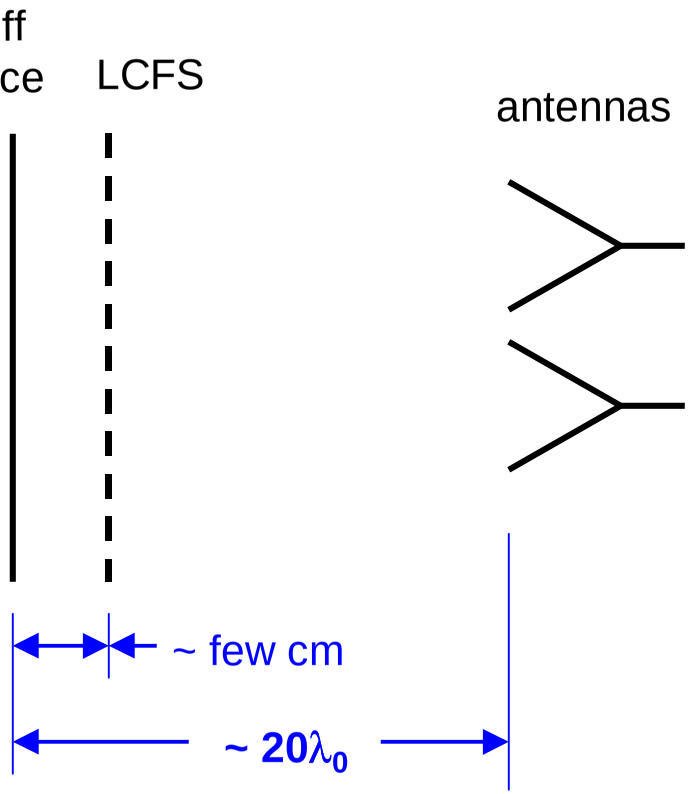
- One frequency (f1) is fixed, the second (f2) is slowly swept (~ 50 ms) over 20-30 GHz, typically.

- The resolution limit of measured radial correlation lengths, Δr, is not well known, but is thought to be around $W_{Airy}/2 < \Delta r \leq W_{Airy}$, where $W_{Airy} \approx 0.48 L_n^{1/3} \lambda_0^{2/3}$



Geometry of the Measurements

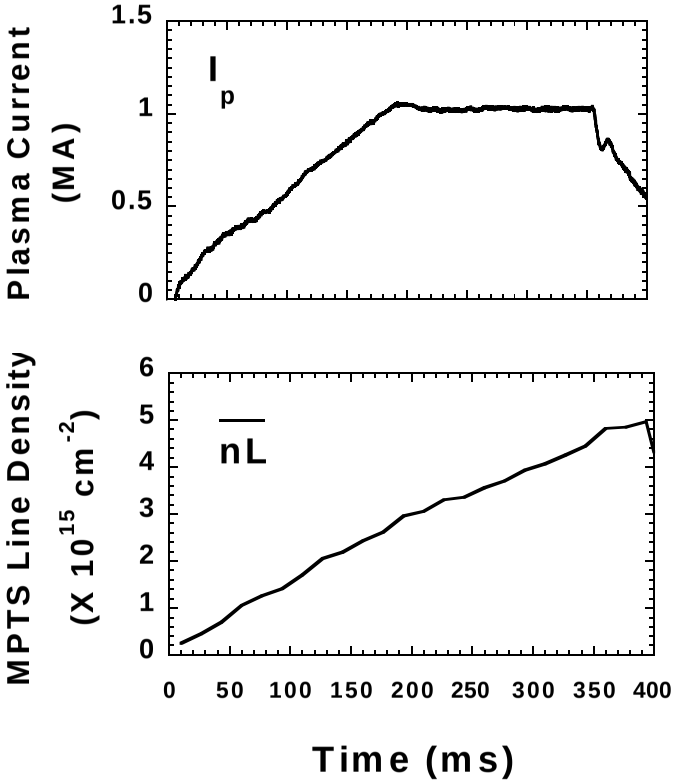
- Cutoff layers where these measurements were made were a few cm inside the LCFS: $0.90 \leq r/a \leq 0.98$ ($R \approx 141$ - 149 cm)
- $T_e \approx 20$ - 100 eV
- $L_n \approx 5$ - 12 cm
- The antenna to cutoff distance was ~ 20 cm (~ $20\lambda_0$)
- This regime (antenna-cutoff distance relative to the diffraction distance, D) has been tested in a lab plasma, and shown good agreement with probe measurements of Δr.[1]

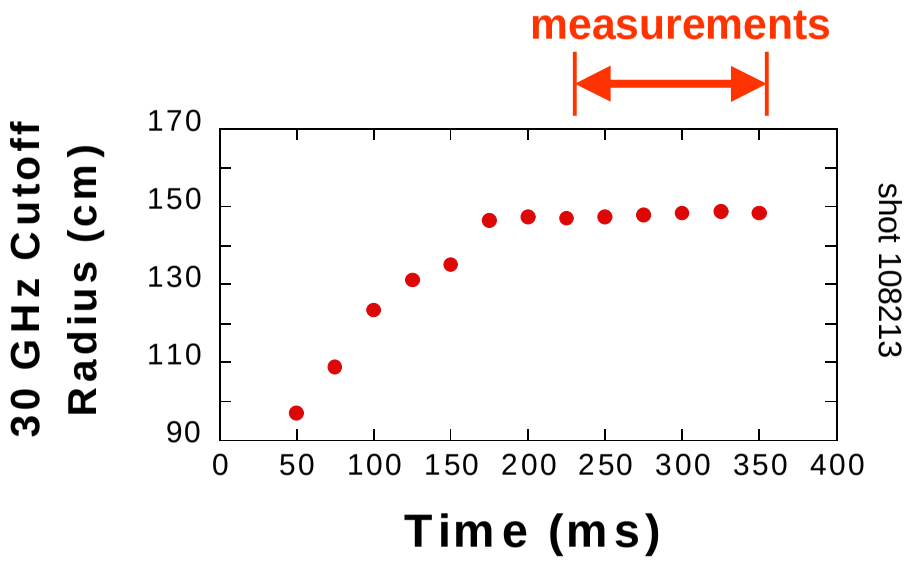


[1] M. Gilmore, *et al*, PPCF, **42**, L1 (2000)
M. Gilmore, *et al*, RSI, **72**, 293 (2001)

Cutoff Layers were Stationary During Correlation Measurements

• Although the line average density continued to ramp up throughout the shot, the edge density changed little during I_p flattop

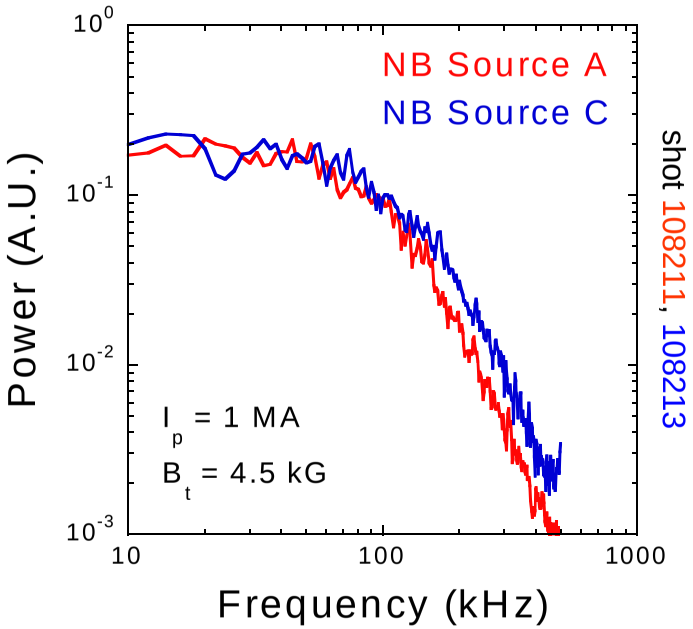




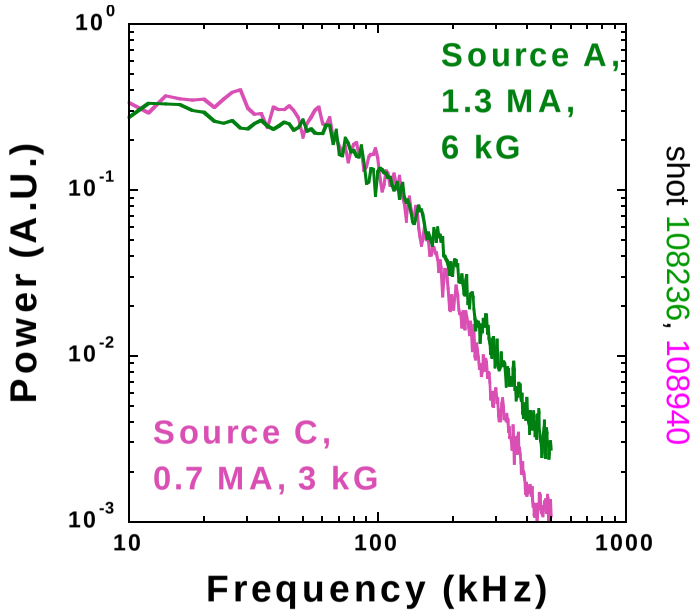
Power Spectra

- *Broadband Power Spectra*
- *Very small (if any) Doppler shifts observed for*
  - NB source C vs. source A
  - Higher I_p and B_t

NB Source A vs. C

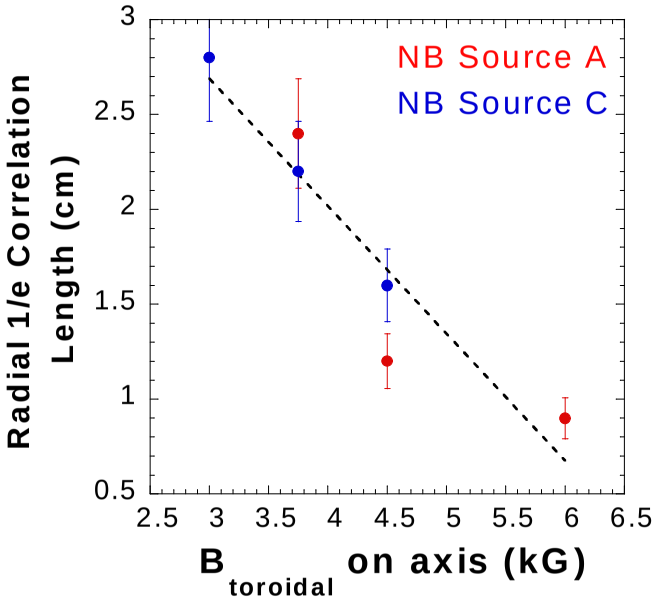


Increasing I_p, B_t

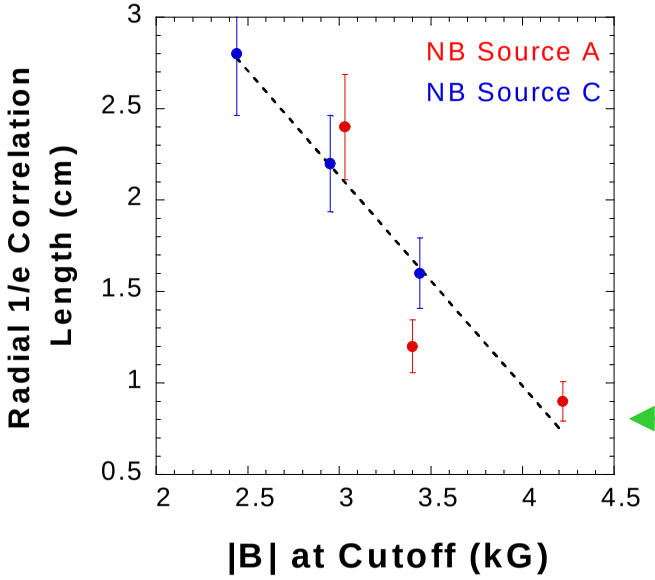


Radial Correlation Lengths Vary With Magnetic Field for Fixed I_p/B_{tor} ("Constant q")

Δr versus $B_{toroidal}$ on axis



Δr versus $|\underline{B}|$ at cutoff

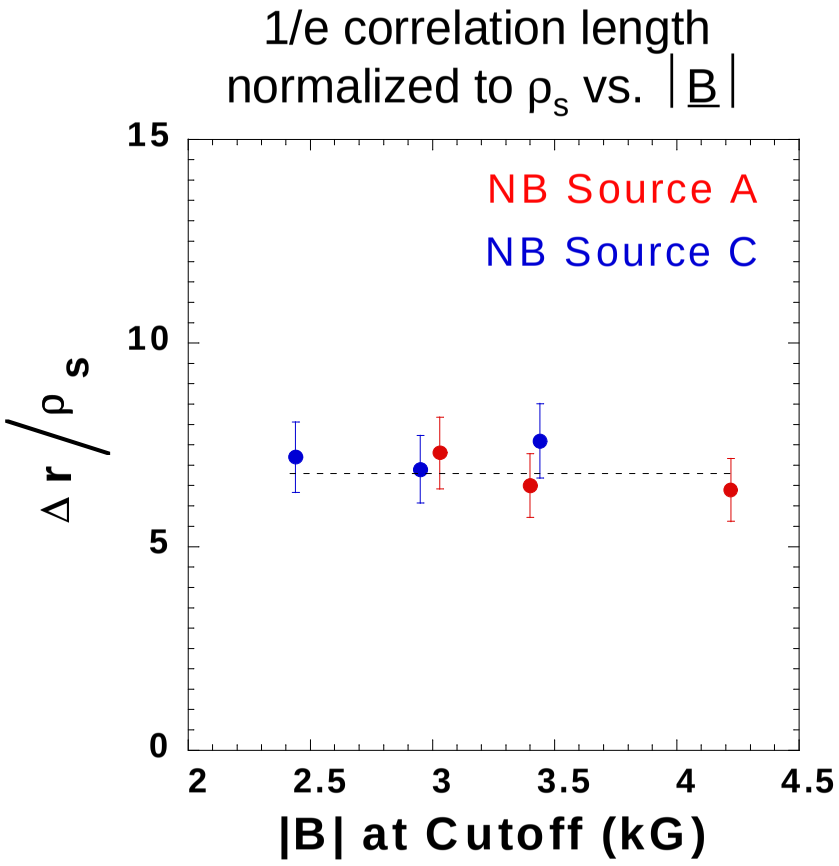


← $W_{Airy} \approx$ 8 mm

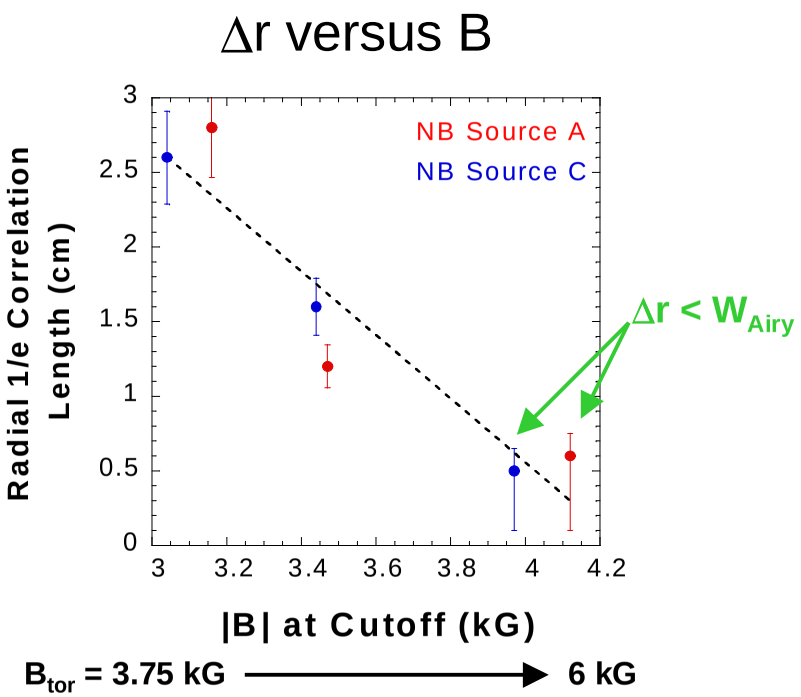
- Fixed line avg density, $\overline{nL}$
- B taken from EFIT01
- No apparent changes with NB source A vs. source C

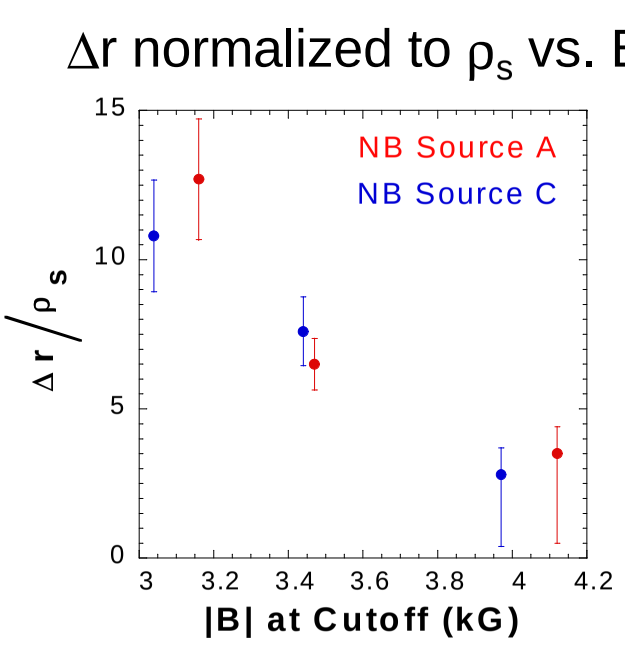
Radial Correlation Lengths Scale with ρ_s at Fixed I_p/B_{tor} ("Constant q")

- $\Delta r \approx 6\text{-}7 \times \rho_s$, where $\rho_s \propto 1/|\underline{B}|$
- $\Delta r \approx 4\text{-}5 \times \rho_{s,toroidal}$, where $\rho_{s,toroidal} \propto 1/B_{toroidal}$
- $\Delta r \approx 3\text{-}4 \times \rho_{s,poloidal}$, where $\rho_{s,poloidal} \propto 1/B_z$ at the midplane



Normalized Correlation Lengths Decrease with B_{tor} at Fixed I_p (1 MA)



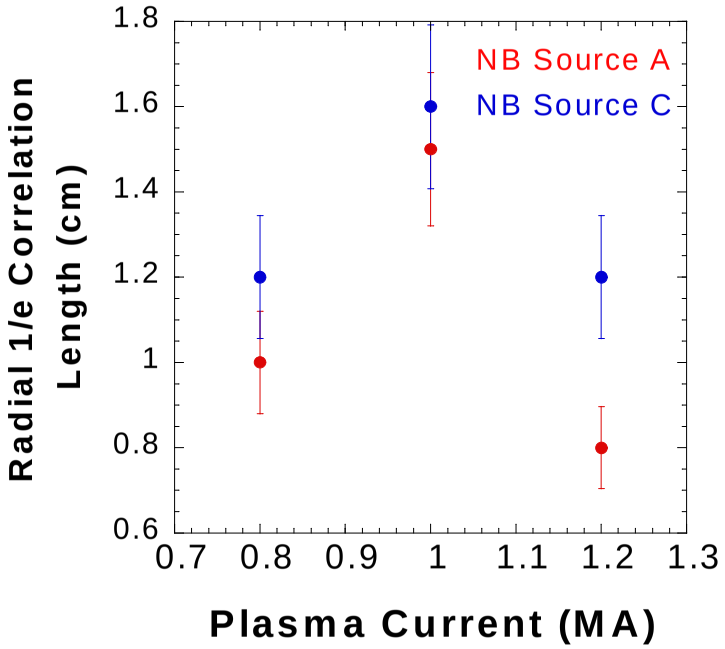


- **Δr varies with $|\underline{B}|$ (or B_{tor} on axis), but Δr / ρ_s not constant**
- **scaling by $\rho_{s,toroidal}$, $\rho_{s,poloidal}$ show the same trend**

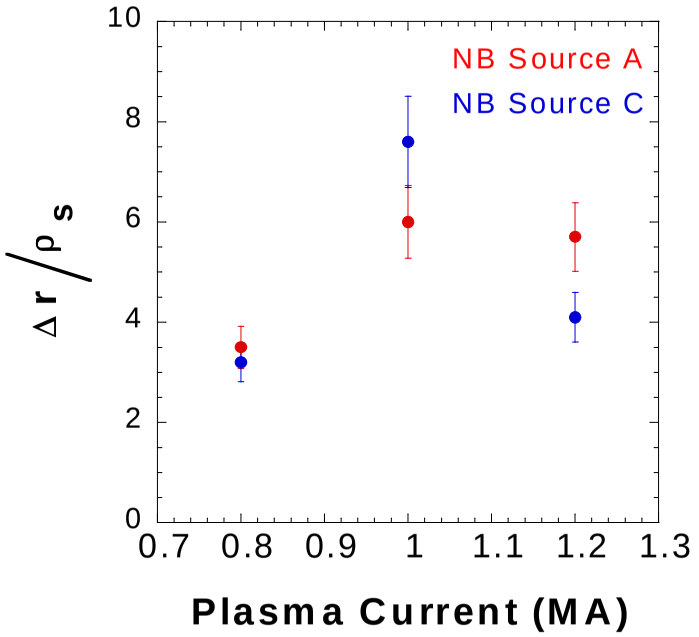
No Clear Trend with I_p at Fixed B_{tor}

- B_t on axis = 4.5 kG
- fixed line avg density, $\overline{nL}$
- q at cutoff nearly constant (pitch angle ≈ 37→ 39°, antennas ≈ 40°) (??)

Δr versus I_p

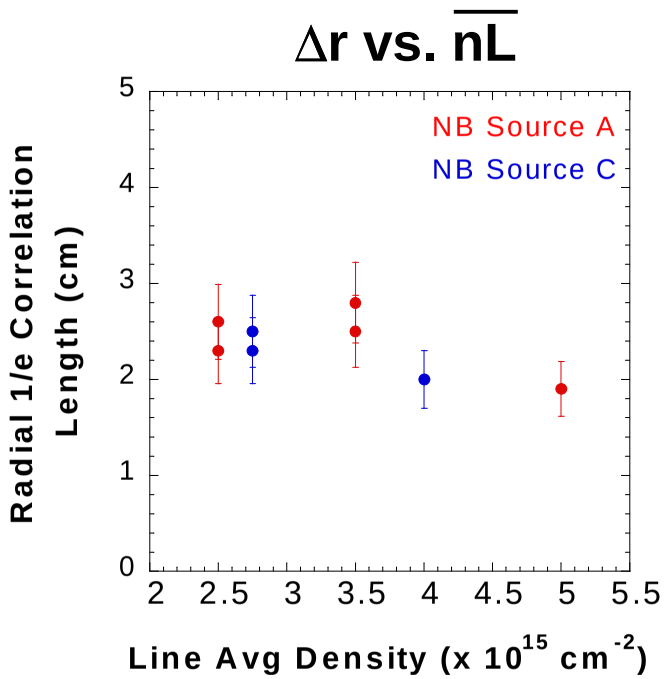


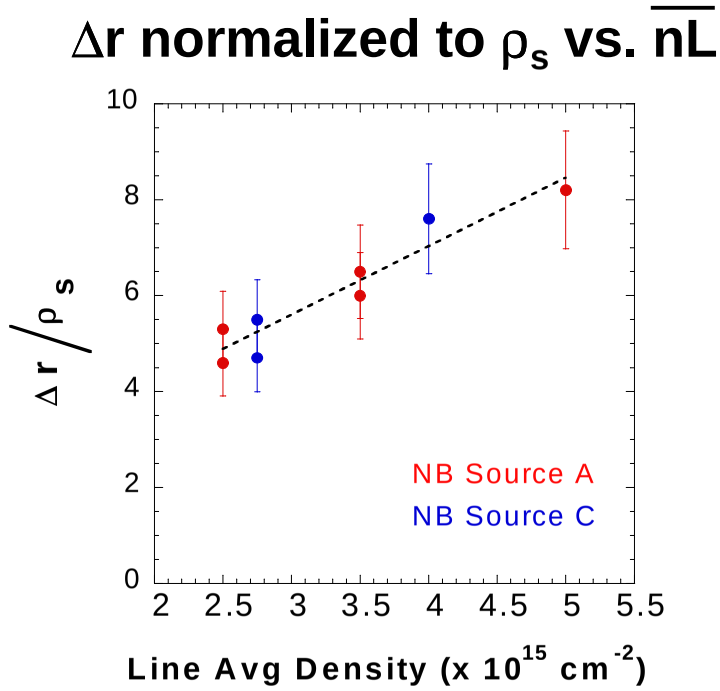
Δr normalized to ρ_s vs. I_p



Apparent Increase in Normalized Correlation Lengths with Increasing Line Density

- *Fixed I_p (1 MA) and B_{tor} on axis (4.5 kG)*
- *T_e decreasing as* $\overline{nL}$ increases





Additional Observation

- Autocorrelation times, τ_{AC} ~ 10 μs ⇒ $(\Delta r)^2 / \tau_{AC}$ ~ 3 - 80 m^2/s. A systematic study vs. parameters not yet completed.

Further Analysis (before APS!)

- Correlation length scalings with NBI power scan
- Correlation length scalings with and without CAE's: *Does CAE-induced transport affect edge turbulence?*
- Long-range correlations and intermittency (e.g. avalanches)
- *How do these results fit into the global picture of transport in these discharges?*

Summary

- The scaling of normalized radial correlation lengths, $\Delta r / \rho_s$, with discharge parameters a few cm inside the LCFS ($0.90 < r/a < 0.98$) has been investigated for shots during XP223. It has been found that:
  - $\Delta r / \rho_s$ was constant ($\approx$ 6-7) as B_{tor} was varied at fixed q
  - $\Delta r / \rho_s$ decreased with increasing B_{tor} at fixed I_p
  - $\Delta r / \rho_s$ exhibited no clear trend with varied I_p at fixed B_{tor}
  - $\Delta r / \rho_s$ appeared to increase with increasing $\overline{nL}$ at fixed I_p, B_{tor}

- No changes in correlation lengths or Doppler shifts were observed between NB Source A and Source C

- Analysis is ongoing

UCLA

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