Cross-comparison of long-wavelength turbulence characteristics in NSTX, DIII-D and ET

Tony Peebles, Shigeyuki Kubota,

Mark Gilmore, Edward Doyle,Terry Rhodes

University of California Los Angeles

Machine & Measurement Characteristics

- **NSTX**
  - ***Small*** aspect ratio ~1.3
  - ***Large*** magnetic shear
  - ***Low*** field Bo ~4kG
  - ***Correlation reflectometry***
  - Fixed frequency quadrature reflectometry
  - Gas puff imaging, Langmuir probes
  - Line integrated interferometry $\tilde{\phi}/\phi$
- **DIII-D**
  - ***Moderate*** aspect ratio ~2.3
  - ***Moderate*** magnetic shear
  - ***Medium*** field Bo ~ 20kG
  - Can operate at 6kG
  - ***Correlation reflectometry***
  - Fixed frequency quadrature reflectometry
  - BES, PCI, Langmuir probes
  - Line integrated interferometry $\tilde{\phi}/\phi$
- **ET Electric Tokamak**
  - ***Large*** aspect ratio ~5
  - ***Weak*** magnetic shear
  - ***Low*** field Bo ~ 2.5kG
  - ***Correlation reflectometry***
  - Langmuir probes
  - Line integrated interferometry $\tilde{\phi}/\phi$
  - Can access high field region

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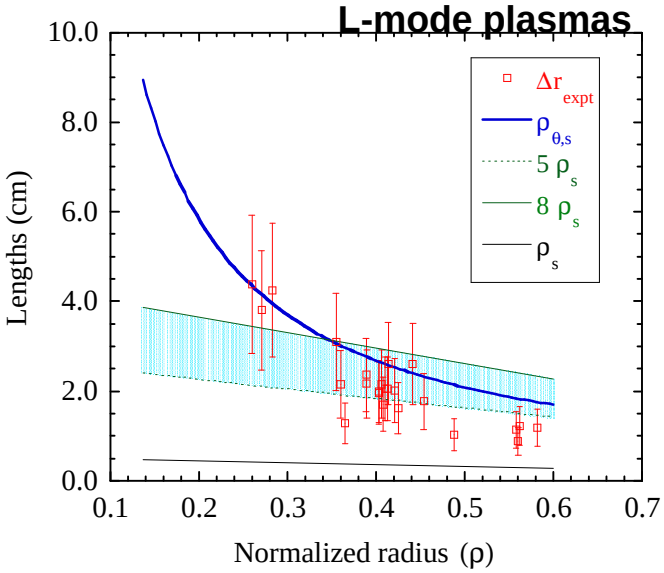
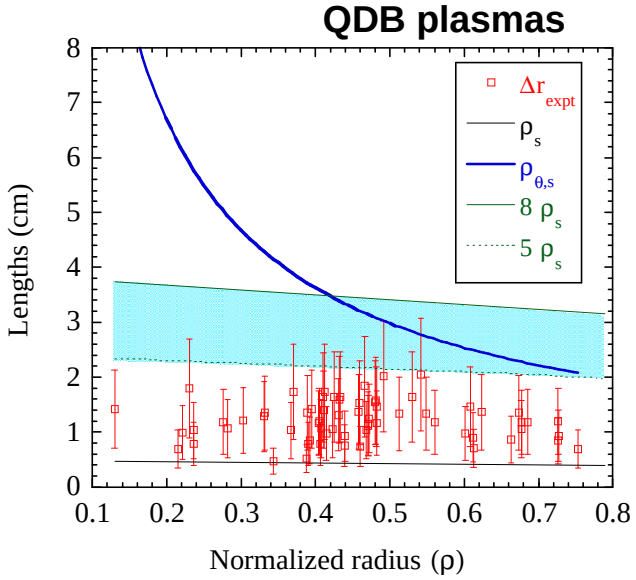
Previous Correlation Length Measurements in DIII-D

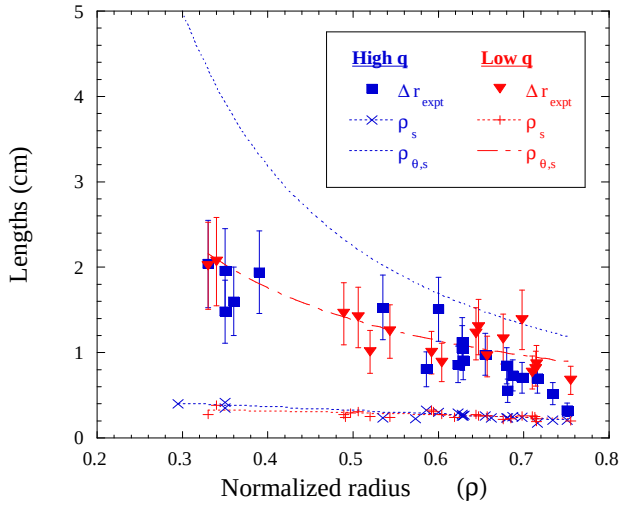


Correlation length varies from ~5 to 10 times the gyroradius in L – mode plasmas. Similar results in Ohmic plasmas



Correlation length is much smaller in QDB discharges relative to the gyroradius – especially in core where it approaches 2ρs.

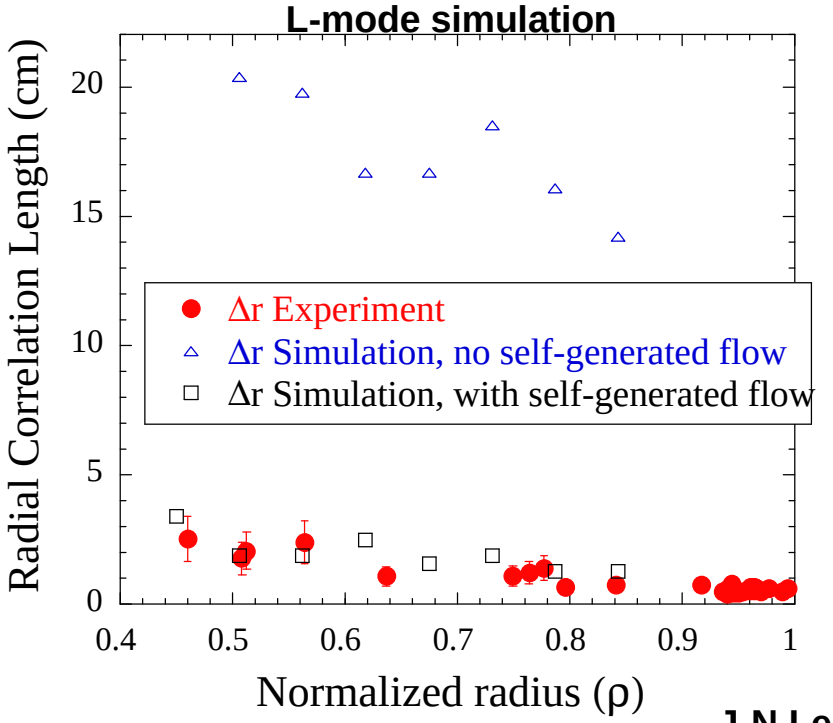
Terry Rhodes, UCLA

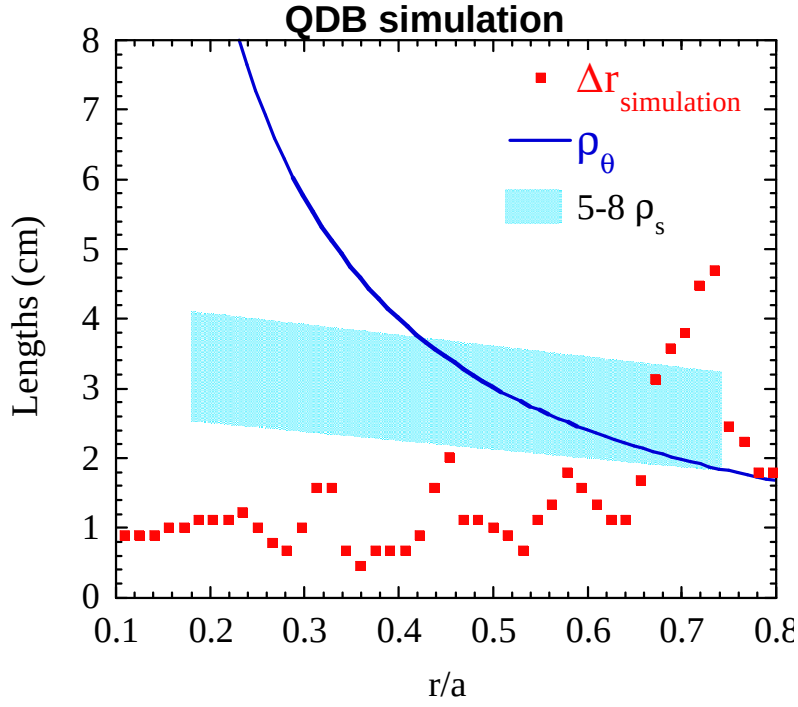


Correlation length did not vary strongly with poloidal magnetic field indicating that scaling was *not* related to the poloidal gyro radius.

Predictions of theory can be tested over a wide range

- **Theory predicts (for NSTX) ETG modes unstable whereas ITG mostly stable.**
  - Fluctuation levels at long wavelengths should be smaller on NSTX than on DIII-D or ET.
- **Gyrokinetic codes can be utilized to predict correlation lengths**
  - Comparison with experiment should provide an excellent test since differences in predicted correlation lengths can be maximized.

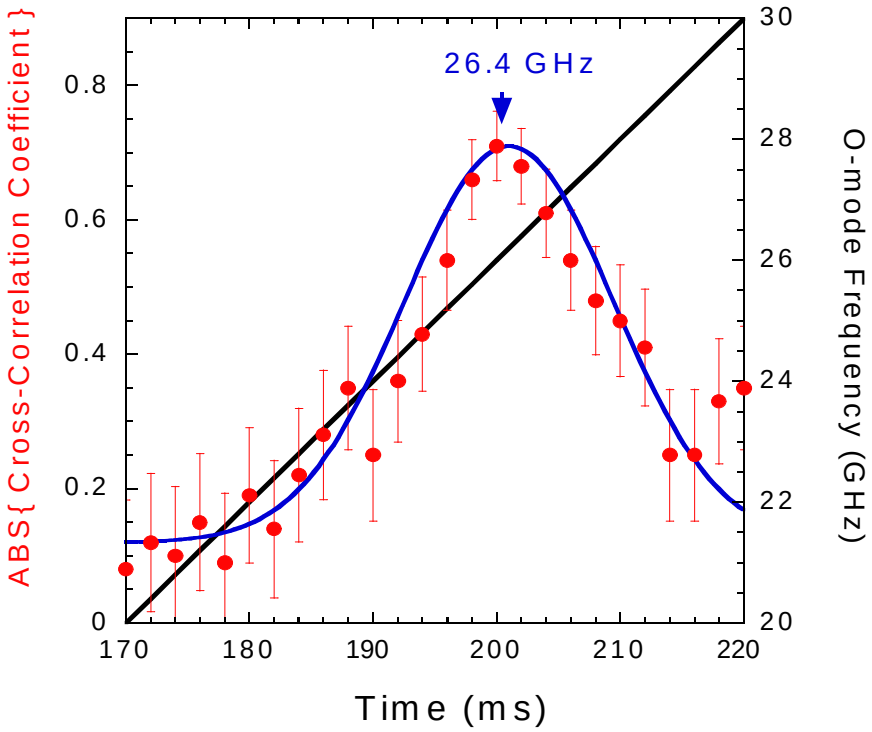




J-N Leboeuf, R Sydora et al.

Preliminary Correlation Length Measurements in NSTX

- A 20-30 GHz correlation reflectometer was modified to operate in a dual mode (O-X) configuration.
- $f_{x\text{-mode}}$ = 30.0 GHz
- $f_{o\text{-mode}}$ swept over 20-30 GHz
- measurements to-date have been in the 20-30GHz band (n = 0.5 - 1 $\times 10^{19}$ m^{-3}) using both O-X and O-O correlation.
- correlation lengths are currently measured over tens of milliseconds - this will be improved during future operation
- 1/e Δr varies from ~0.7cm (edge) to 2.8cm (early core). ***These values are roughly equal to the ion gyro radius.***



- ***Extension of correlation measurements to 60GHz (n_e ~ 4.5 x $10^{13}cm^{-3}$) planned during 2002. This will allow access to the core of NSTX plasmas.***

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Potential Comparisons

- **NSTX, DIII-D and ET form an interesting contrast in machine parameters especially *aspect ratio, magnetic field strength* and *shear.***
- **There are a number of potentially interesting cross-comparisons that can be performed that may significantly improve understanding of transport and turbulence in fusion plasmas**
  - Operate NSTX at 6kG field and measure turbulence and transport properties
  - Operate DIII-D at 20kG and then 6kG. Document transport and turbulence properties. This would provide information on aspect ratio, as well as magnetic field strength or Larmor radius dependencies. ***Could be difficult to get time for this plasma on DIII-D this year !***
  - ***An interesting practical alternative, that would motivate future experimental comparison between DIII-D and NSTX, would be as follows***.
  - ***Reduce magnetic field on NSTX to 4kG and then to 2.5kG. Repeat transport and turbulence measurements.***
  - ***Results at 2.5kG could be directly contrasted with those obtained from the Electric Tokamak (ET) at UCLA. This comparison would maximize the differences in magnetic shear and aspect ratio. Detailed measurements would be possible on ET using both Langmuir probes and correlation reflectometry.***
  - ***Ideally perform with Ohmic heating alone – no beams.***

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Summary

- **During 2002 new turbulence measurement capabilities will be added to NSTX**
  - Correlation length measurements in to densities of 4.5 x 10^{13}cm^{-3}.
  - An absolute measure of line integrated turbulence levels at long wavelengths Δk ~1.5cm^{-1}
  - Langmuir probe measurements in the edge plasma
- **Initially focus on comparison of the turbulence characteristics on NSTX and ET**
  - Maximizes differences in aspect ratio, magnetic shear variation at similar field strengths.
- **Perform comparison of numerically predicted correlation length and turbulence levels at long wavelengths**
  - Gyrokinetic code (UCAN – Sydora) has predicted observed trends in DIII-D L mode and QDB mode discharges.
  - Can GS2 be used on NSTX and ET to make similar predictions which can then be compared with experiment ? I suspect this would provide a stringent test of the predictive ability of the codes. It will clearly lead to increased understanding of fusion plasmas, as well as providing an important initial connection between theory and experiment across machines.
- **Dependent on the results of this cross-comparison between NSTX and ET, future comparisons could also include DIII-D.**

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