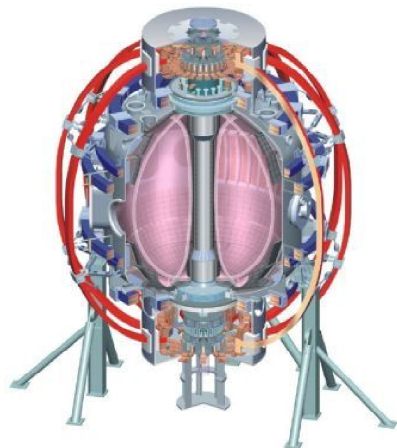


XP-1039: Ohmic H-Modes

S. Kubota, K.C. Lee, R. Maingi, S.J. Zweben,
R.J. Maqueda, R.E. Bell, B.P. LeBlanc,
S.M. Kaye, T.S. Hahm, R. Raman

NSTX Team XP Review
1:30 PM Control Rm Annex
October 6, 2010



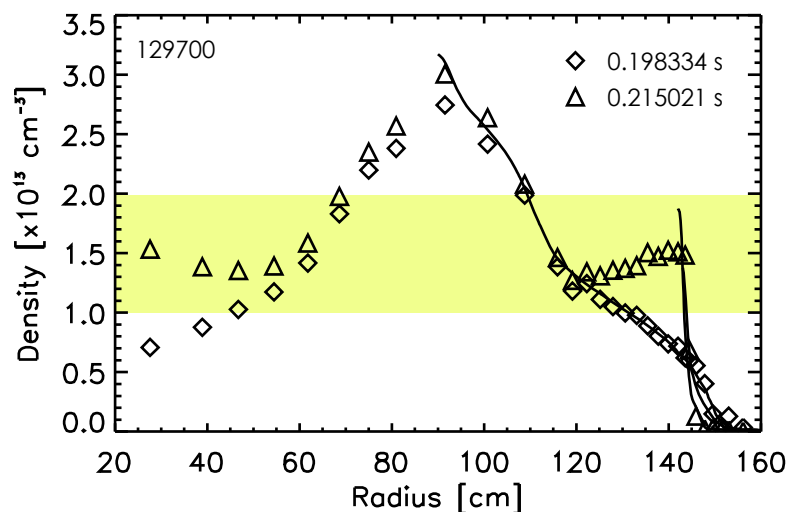
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Old Dominion U
ORNL
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PSI
Princeton U
Purdue U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
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Culham Sci Ctr
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NIFS
Niigata U
U Tokyo
JAEA
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITY
KBSI
KAIST
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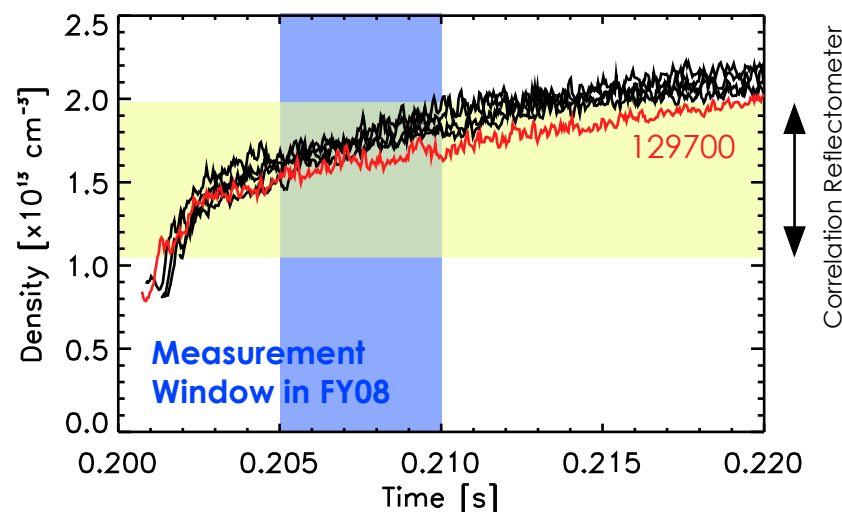
(FY05&08) XP-506: Physics of Ohmically Heated H-Modes

- Some of the original motivations for XP-506:
 - Core and edge turbulence in L- and H-mode and across transition.
 - Non-local (or core) turbulence response to ETB.
 - L-H transition physics (e.g. precursors, critical gradients).
- Ohmic H-Modes target:
 - Peaked density profile is good target for correlation reflectometers.
 - No fast-ion driven fluctuations or external momentum input.

Electron Density Profile Evolution



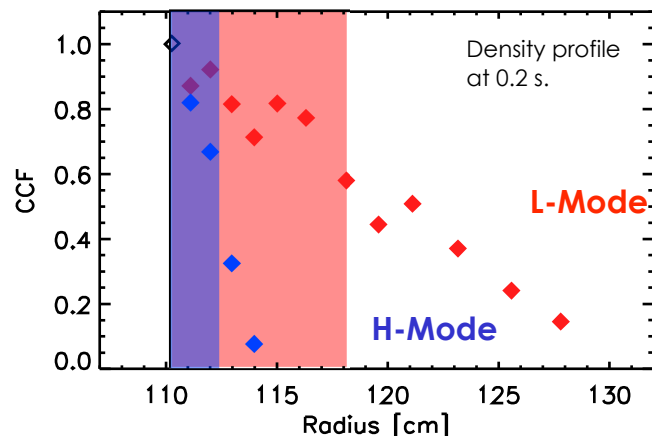
Peak of Edge Electron Density



- XP-506 still incomplete:
 - FY05, no density profile measurements (run scheduling).
 - FY08, no GPI (scheduling), no pol. correlation reflectometer (req. system to be reconfigured).
 - **Goal: Simultaneous measurements of edge & core turbulence, and density profile.**

(FY08) XP-506: Physics of Ohmically Heated H-Modes

- **FY08 version of XP-506:**
 - $I_p=900$ kA, $B_T=4.5$ kG, LSN, Deuterium, 1/2 day XP.
 - L-H transition reproducibly repeated with short I_p rampdown.
- **Main goal of simultaneous core profile and radial correlation measurements across the L-H transition completed, but ...**

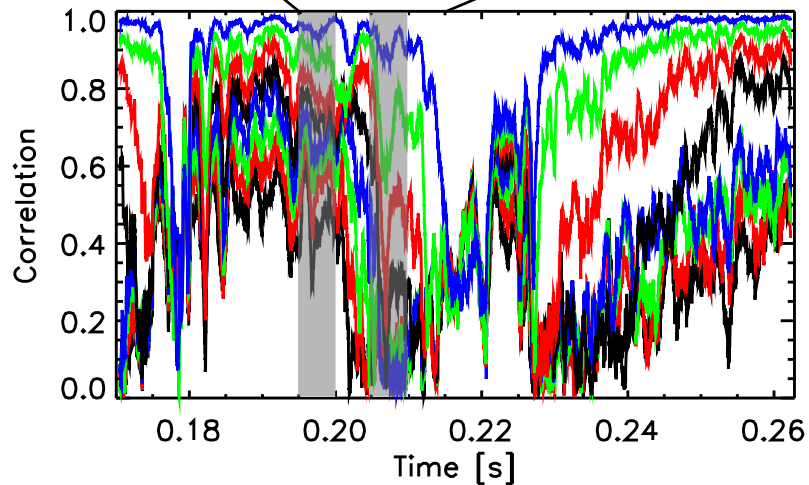
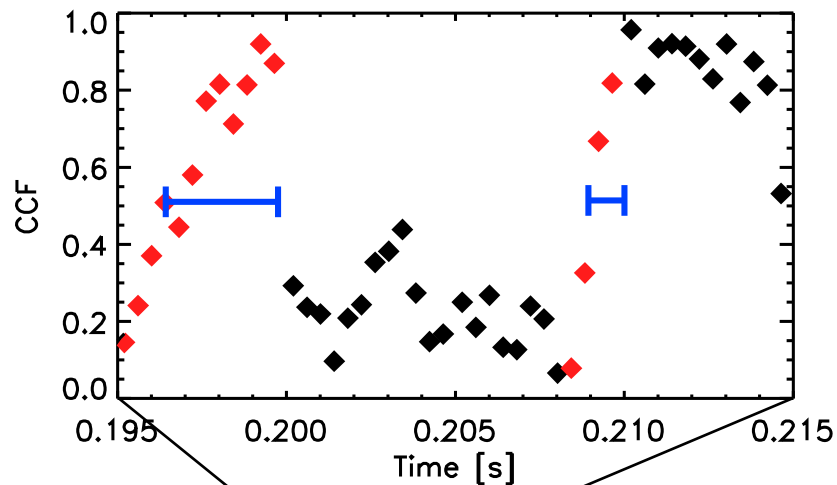


Correlation Coefficient Function (CCF) vs Major Radius

- **Issues:**
 - > These are core measurements. Edge?
 - > k_r spectral information required for quantitative estimates.
 - > Correlation measurements in ~5 ms. Temporal resolution adequate?

- **Set of turbulence measurements not complete, connection between core/edge:**
 - Radial correlation reflectometers (CR), high-k.
 - BEaP probes (far SOL), reciprocating probe (near SOL, separatrix), FIRETIP ($R_{tan} \sim 150$ cm).
 - **No GPI, poloidal correlation reflectometer.**
- **Main conclusions:**
 - Correlation measurements require higher temporal resolution (see next slide).
 - ETB location ($R \sim 145$ cm) needs to be better diagnosed.
 - k_r spectral information required for quantitative estimate of correlation length.

Turbulence Evolving on Fast Timescale

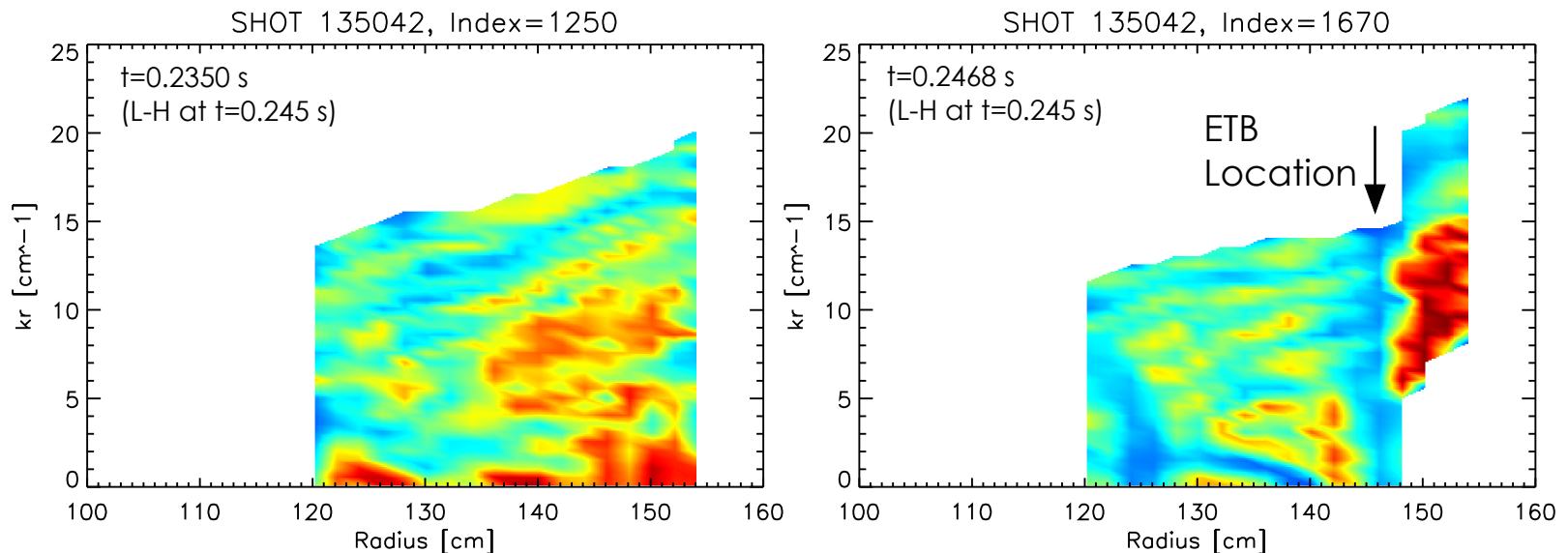


- **2-channel correlation reflectometer**
 - 5 ms time resolution
 - $1\text{-}2 \times 10^{13}$ cm⁻³ density coverage
- **FMCW-based radial correlation**
 - 100 μ s time resolution
 - $0.2\text{-}3.5 \times 10^{13}$ cm⁻³ density coverage

Some Critical New Diagnostic Capabilities

- **FY08 measurements motivated several modifications to microwave diagnostics.**
 - **Radial correlation reflectometers (FMCW modified):**
 - > **Electron density profiles with 7 μs time resolution.**
 - > **Sub-millisecond turbulence radial correlations (100 μs), previous slide.**
 - > **Broad- k_r back-scattering (30 μs), see below (from XP-929).**
 - **Dedicated 2-channel poloidal correlation measurements for poloidal flow.**
- **Additional new or upgraded diagnostics for 2010.**
 - **BES, ultra-fast GPI (400k fps), high- k (remote capability), FReTIP (4 MHz bandwidth).**

k_r Spectrum vs R in Core-Edge Across L-H Transition



XP-1039 Overview

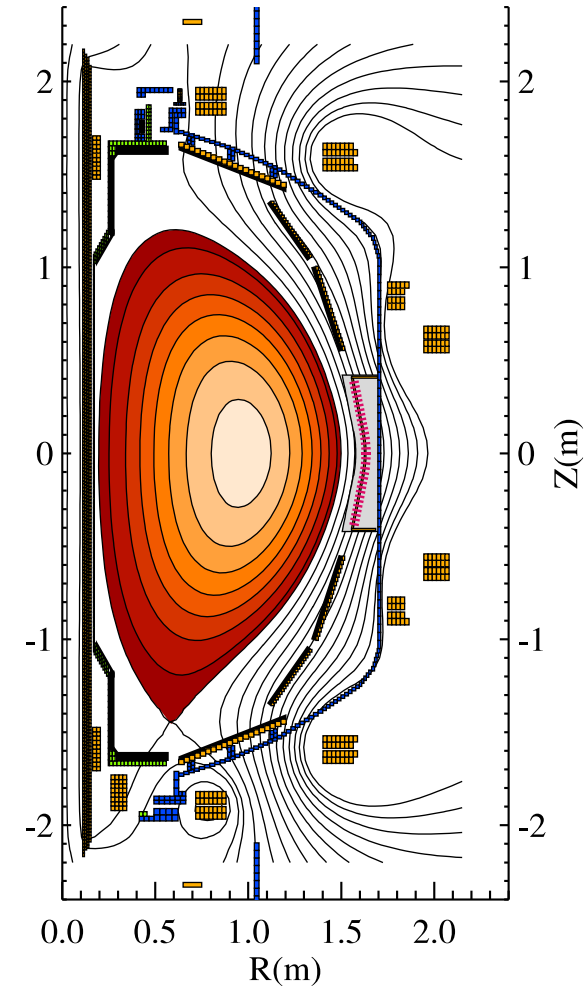
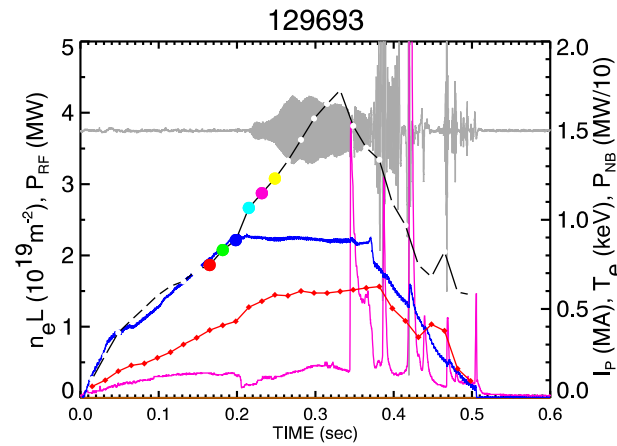
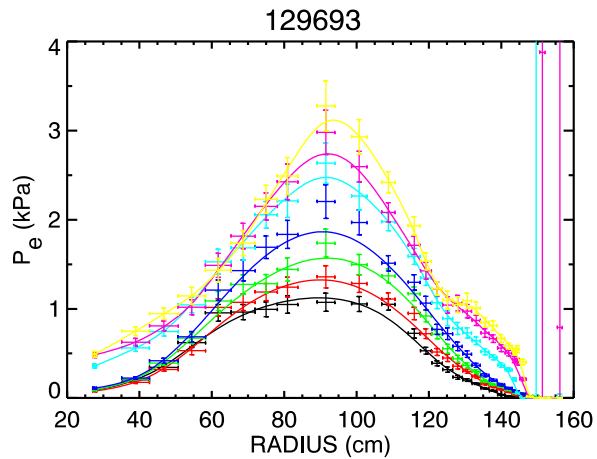
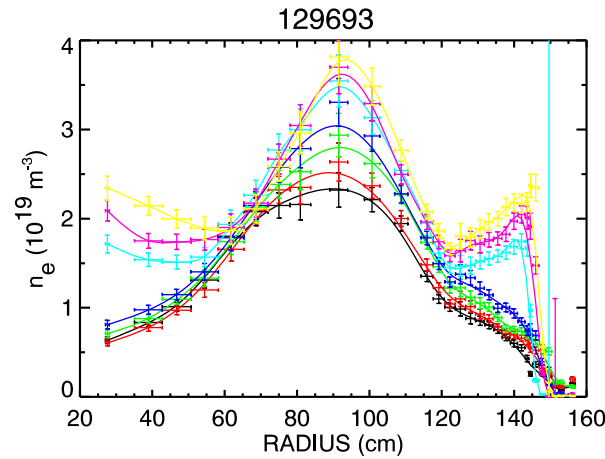
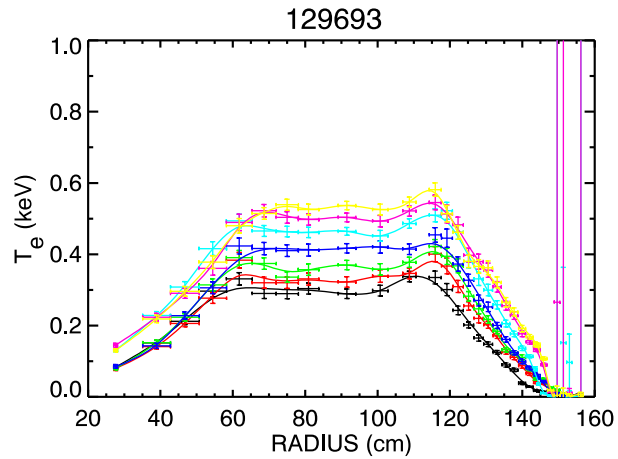
- **Goals**
 - Revisit Ohmic H-mode with advanced and upgraded turbulence diagnostics.
 - Study turbulence in L-mode, H-mode and in relation to the L-H transition.
 - > Look at correlation of local (edge) and non-local (core) turbulence with ETB formation.
 - > Compare data with L-H transition theories, e.g. K.C. Lee's gyrocenter shift.
- **Motivation**
 - Ohmic H-modes.
 - > Peaked density profiles are good targets for reflectometers.
 - > No fast-ion driven fluctuations to complicate turbulence measurements.
 - > Avoid complicating physics due to external momentum input and hot fueling.
 - New and upgraded turbulence diagnostics available for 2010.
 - > Better coverage of core/edge with higher spatial and temporal resolution.
- **Required Operations and Conditions**
 - Clean machine condition.
 - $I_p=900$ kA, $B_T=4.5$ kG, Deuterium, Ohmic.
 - Edge density $\sim 1.5 \times 10^{13}$ cm⁻³.
 - LSN and DND.
- **Additional Requirements (Piggyback or XMP)**
 - For quantitative evaluation of reflectometer turbulence data.
 - L-mode target, Ohmic or low NBI power:
 - > Constant B_T/I_p scan (S.J. Zweben's XP proposal, XP-1038)
 - > Magnetic axis vertical position and κ scans (XMP).

XP-1039 Run Plan

- **Target shot: 129693 with GPI gas puff on.** **6 shots**
 - $I_p=900$ kA, $B_T=4.5$ kG, LSN, Deuterium.
 - Adjust gas puff/Li for target density: $\sim 1.0-1.5 \times 10^{13}$ cm⁻³ during first 100 ms of flattop.
 - Recent Ohmic H-mode shot 138118 has target densities that are very close.
 - If L-H transition doesn't occur here, use slight I_p rampdown for reproducible L-H transition time.
- **Set conditions and document.** **6 shots**
 - Vary poloidal correlation reflectometer frequency:
 - > Reflection layer ~ETB radius. (2 shots)
 - > Reflection layer outside ETB radius. (2 shots)
 - > Reflection layer inside ETB radius. (2 shots)
- **Change magnetic configuration to DND.** **2+6 shots**
 - Vary poloidal correlation reflectometer frequency:
 - > Reflection layer ~ETB radius. (2 shots)
 - If time permits:
 - > Reflection layer outside ETB radius. (2 shots)
 - > Reflection layer inside ETB radius. (2 shots)
- **Diagnostics:**
 - Required: Reflectometers (FMCW, CR, fixed-freq.), GPI, FIRETIP edge channel, ERD, MPTS, Magnetics, CHERS (passive).
 - Requested: edge neutral density diagnostic, SOL reflectometer, high-k, USXR, ME-SXR, edge probes.

Reference Discharge

from \VEFIT02, Shot 129693, time=200ms



Target Density and Reflectometer Coverage

