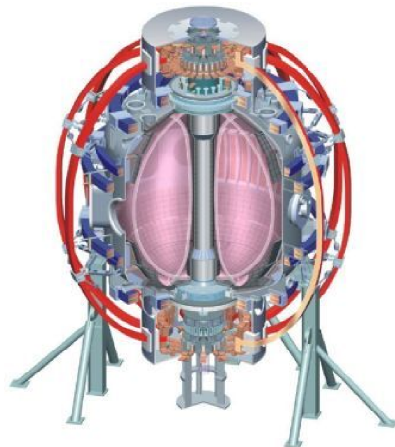# XP-1039: Ohmic H-Modes

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

T&T TSG XP Review
1:30 PM LSB-318
July 27, 2010

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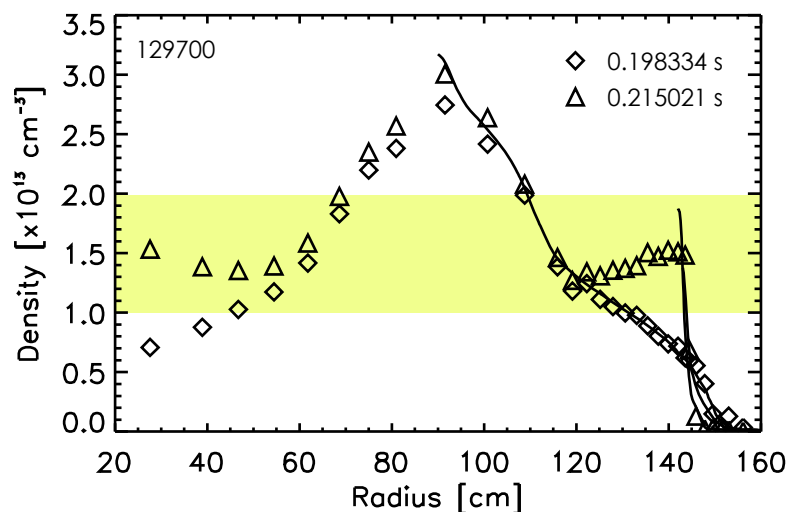
Peak of Edge Electron Density
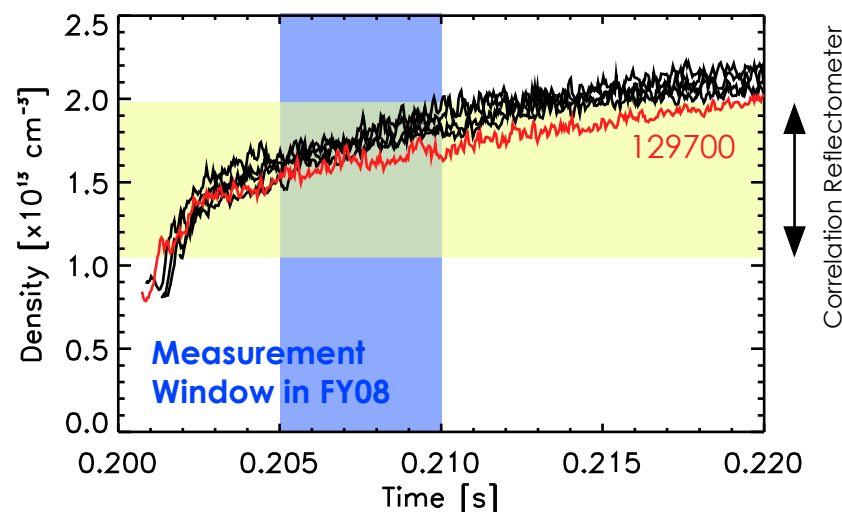
- **XP-506 still incomplete:**
  - FY05, no density profile measurements (run scheduling).
  - FY08, no GPI (scheduling), no pol. correlation reflectometer (req. system to be reconfigured).
  - Goal: Simultaneous measurements of edge & core turbulence, and density profile.

- **FY08 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 ...**


Density profile at 0.2 s.

L-Mode

H-Mode
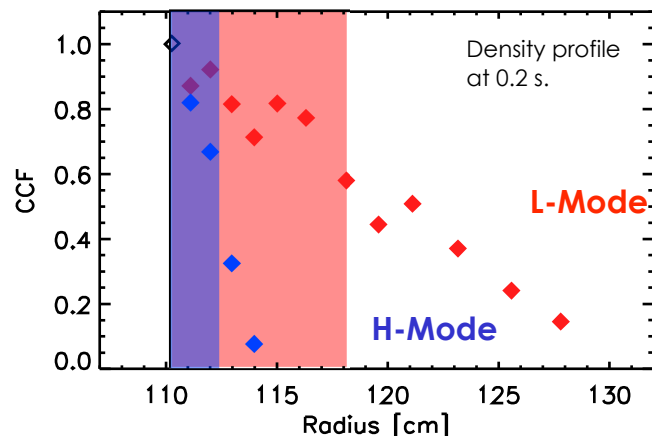
Correlation Coefficient Function (CCF) vs Major Radius

  - **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}~150 cm).**
  - **No GPI, poloidal correlation reflectometer.**

- **Main conclusions:**
  - **Correlation measurements require higher temporal resolution (see next slide).**
  - **ETB location (R~145 cm) needs to be better diagnosed.**
  - **k_r spectral information required for quantitative estimate of correlation length.**

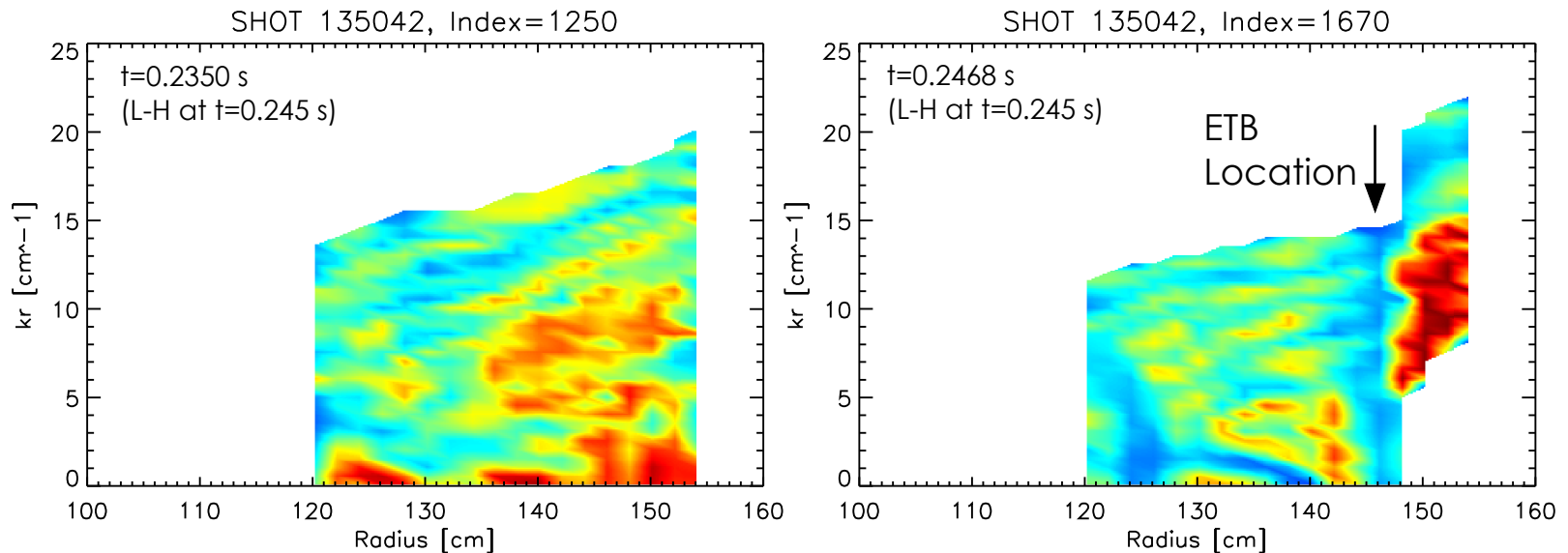# Turbulence Evolving on Fast Timescale
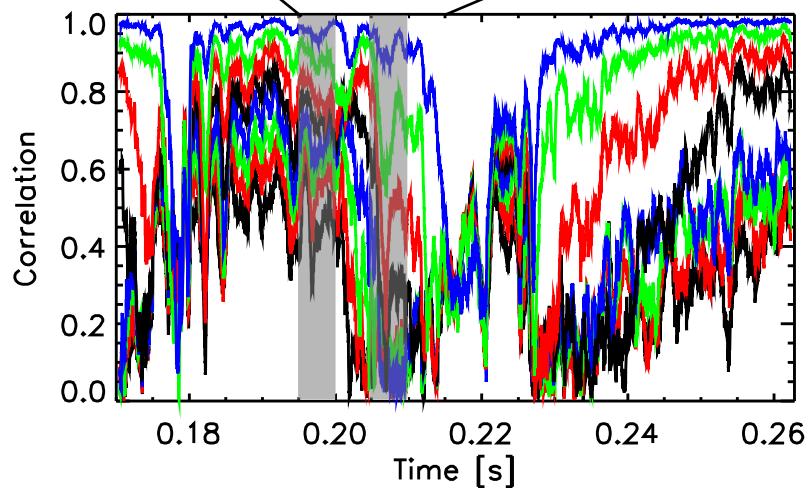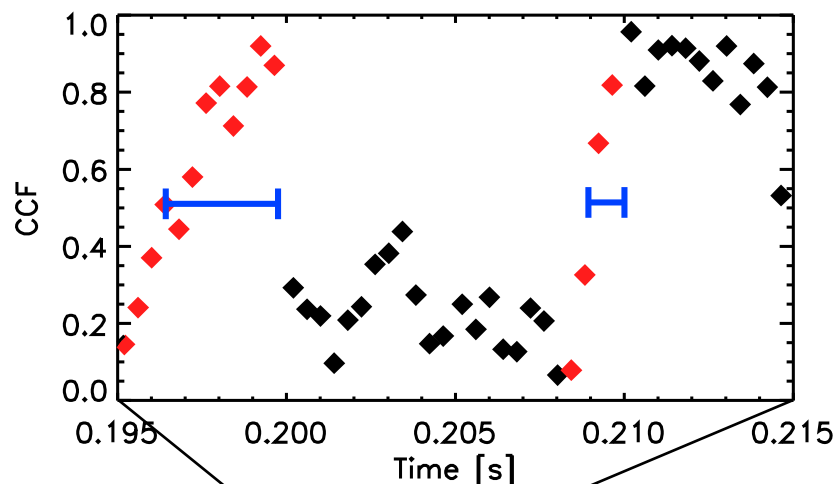
- **2-channel correlation reflectometer**
  - 5 ms time resolution
  - $1\text{-}2\times10^{13}$ cm^{-3} density coverage

- **FMCW-based radial correlation**
  - 100 μs time resolution
  - $0.2\text{-}3.5\times10^{13}$ 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), FIReTIP (4 MHz bandwidth).**

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

SHOT 135042, Index=1250

t=0.2350 s
(L-H at t=0.245 s)

SHOT 135042, Index=1670

t=0.2468 s
(L-H at t=0.245 s)

ETB Location

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 ~1.5×10^{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.**   **4 shots**
    - I_p=900 kA, B_T=4.5 kG, LSN, Deuterium.
    - Adjust gas puff for higher target density: ~1.5×10^{13} cm^{-3}.
    - 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.**   **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, ERD, MPTS, Magnetics, Calibrated Dα, CHERS (passive).
    - Requested: BES, high-k, USXR, ME-SXR (available Aug-Sept?), edge probes.

- **Analysis:**
    - EFIT, TRANSP, core and edge turbulence codes.

Reference Discharge

from \EFIT02, Shot 129693, time=200ms
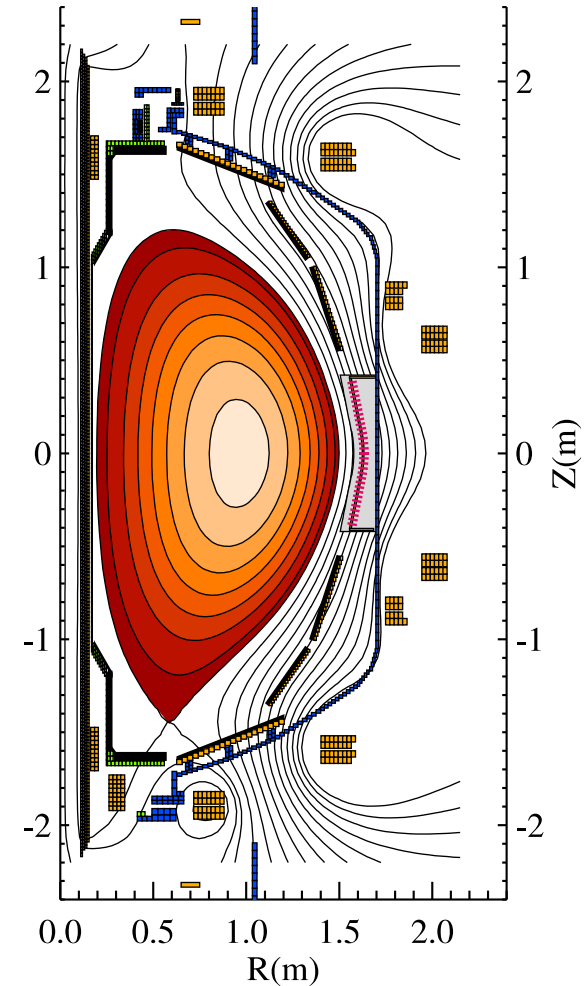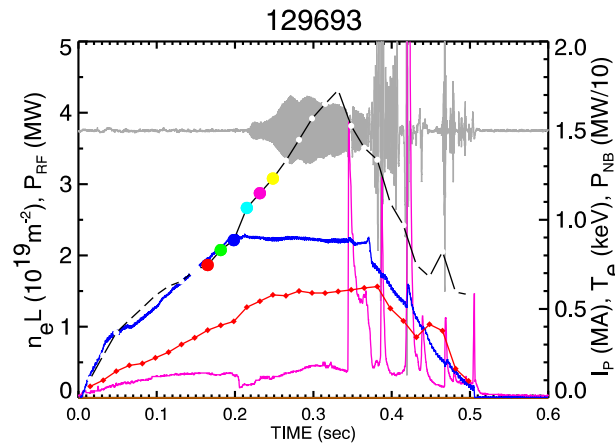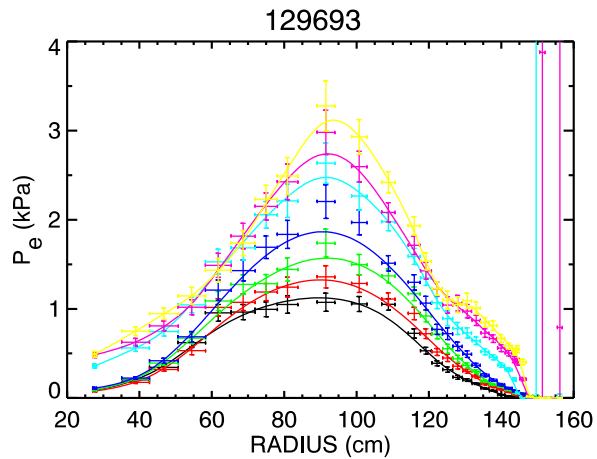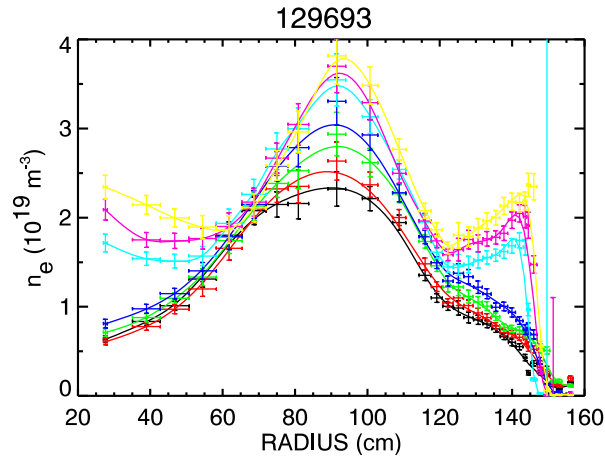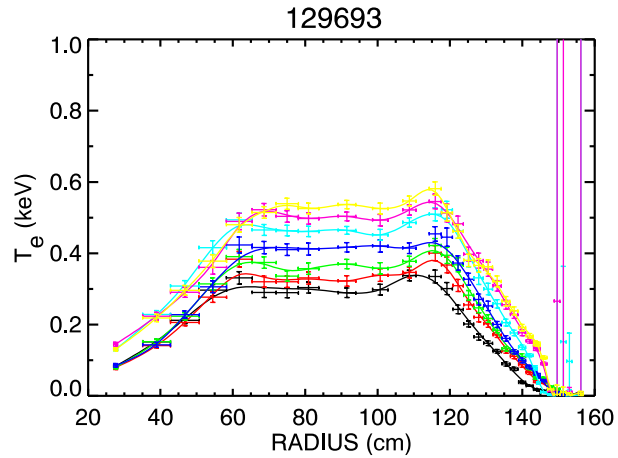
Target Density and Reflecometer Coverage