Recent Edge Turbulence Movies from C-Mod and NSTX

S.J. Zweben, J.L. Terry, O. Grulke, R. Maqueda, T. Munsat,
T. Biewer, N. Nishino, L. Roquemore, D. Stotler
Princeton Scientific Instruments, and the Alcator C-Mod and NSTX Teams

TTF Meeting 4/04

- Introduction
- C-Mod side view (0:30)
- C-Mod outer midplane GPI (6:19)
- NSTX outer midplane GPI (8:44)
- Velocity maps from GPI (1:00)
- NSTX divertor region (≈ 1:00)
- Observations and Plans

Gas Puff Imaging Diagnostic

- View light emission from neutral atoms where $T_e \approx$ 5 - 50 eV

$$I = n_o \, n_e \, f(n_e, T_e)$$

- Fluctuations in light emission due to fluctuations of plasma

  presumably n & T_e fluctuations are correlated

- View gas puff along B to see radial vs. poloidal structure

References: C-Mod: Terry et al, PoP '03

                   NSTX: Zweben et al, Nucl. Fusion '04
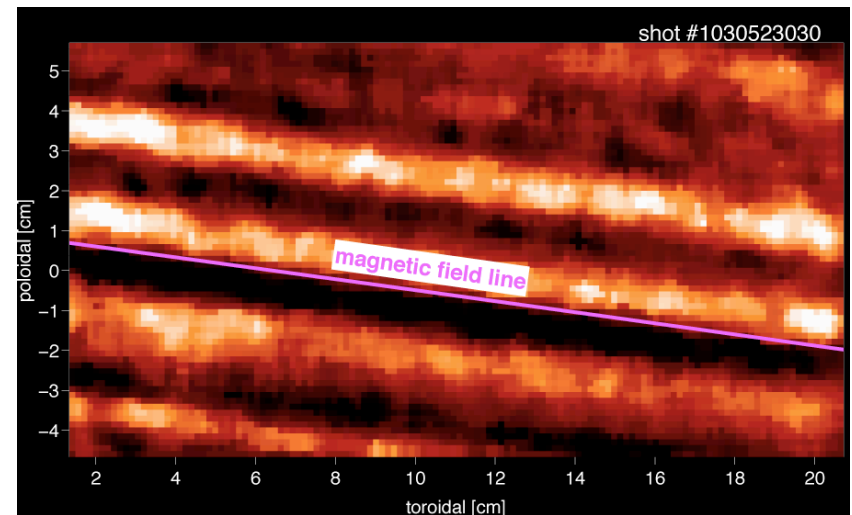
                   GPI diagnostic: R. Maqueda, RSI '03

C-Mod Side View

- View D_α light emission radially from outer midplane

- Turbulence filaments aligned nearly along B ($k_{||} \approx 0$)
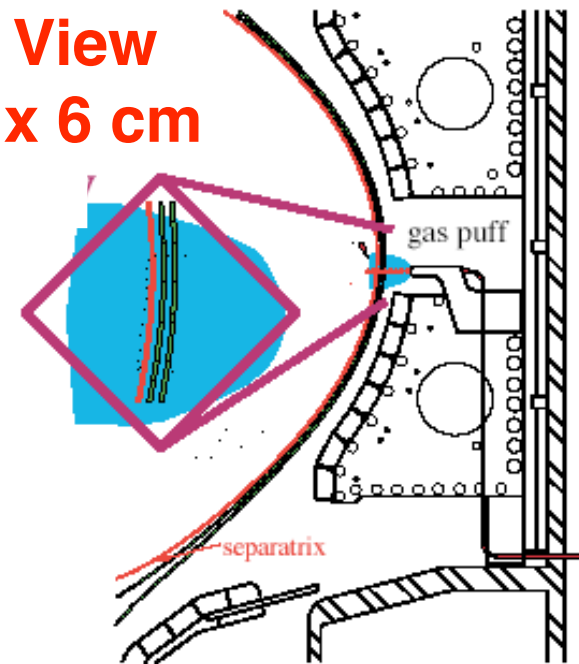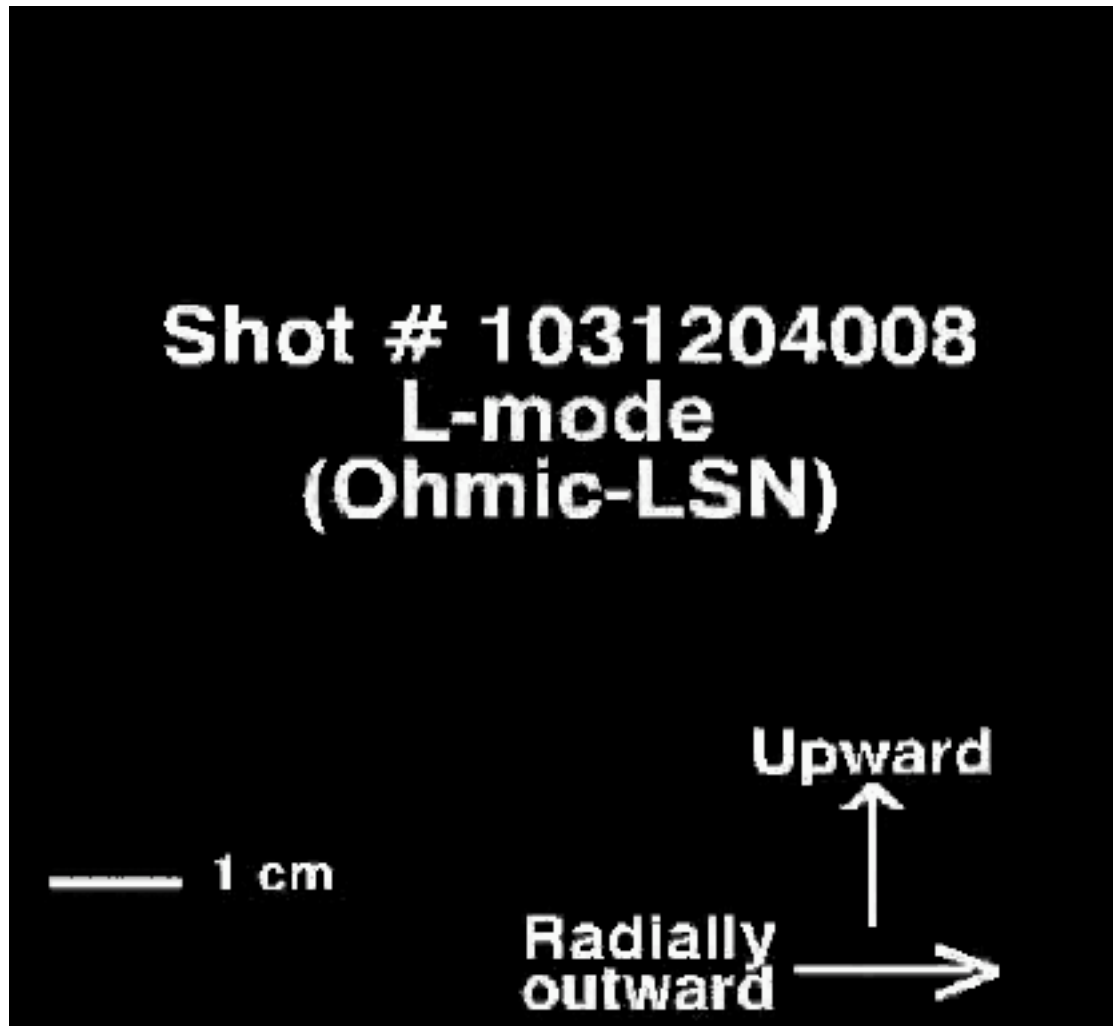
Gas Puff Imaging in C-Mod

- Looks at D_α(656 nm) from gas puff $\;I \propto n_o n_e f(n_e, T_e)$
- View along B field line to see 2-D structure $\perp$ B
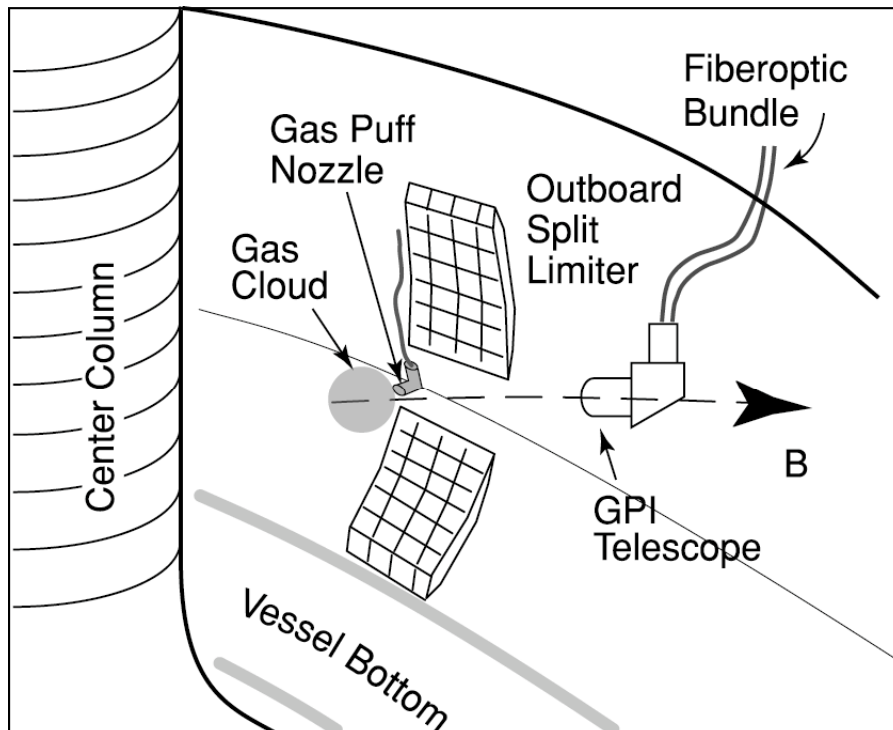
**GPI View
6 cm x 6 cm**

C-Mod GPI Movies (Dec. '03 - Jan. '04)

Shot # 1031204008
L-mode
(Ohmic-LSN)

Upward

Radially outward

1 cm

PSI-5 camera
300 frames
64x64 pixels
250,000 frames/sec
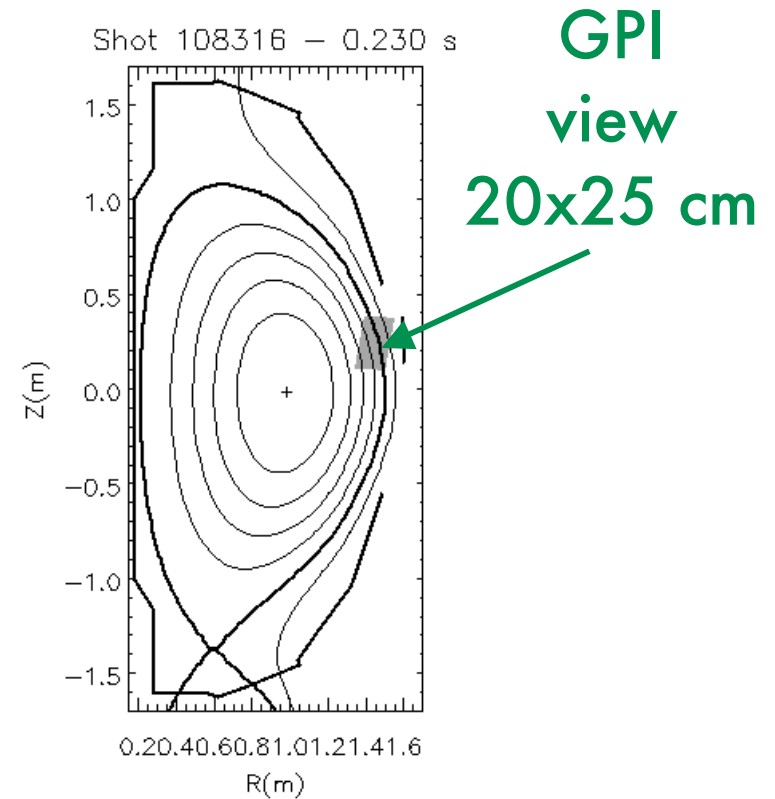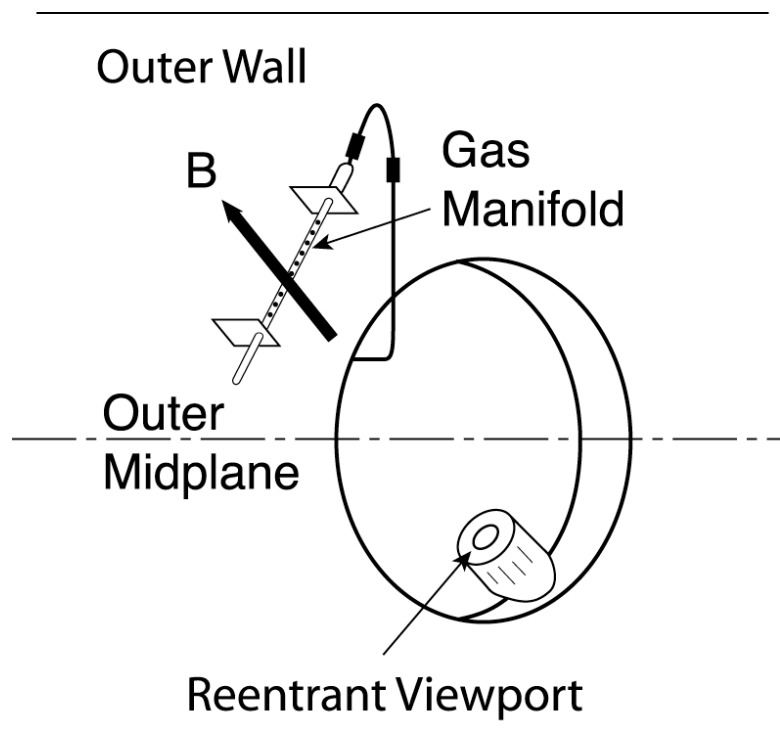4 μsec/frame

Shot List:
Ohmic - D
Ohmic - He
LSN
USN
EDA H-mode
ELM-free H
ELM-free H

Gas Puff Imaging in NSTX

- Looks at D_α(656 nm) from gas puff $I \propto n_o n_e f(n_e, T_e)$
- View along B field line to see 2-D structure $\perp$ B
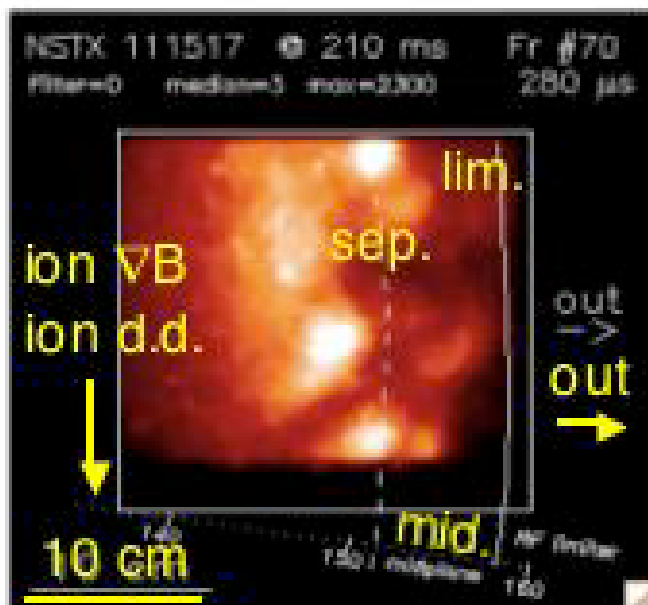

Shot 108316 — 0.230 s

GPI view 20x25 cm

NSTX GPI Movies (1/04 - 3/04)

- PSI-5 camera
- usually D puff with D_α filter
- usually 4 μsec/frame

- Ohmic
- L-mode
- H-mode
- MHD effects
- Highest β shot
- L-H, H-L transitions
- ELMs in H-mode
- RF heating

Recent Edge Turbulence Movies from NSTX

S. J. Zweben, T. Munsat, D. Stotler, et al

<u>New camera (PSI-5)</u>
300 frames / shot
64x64 pixels
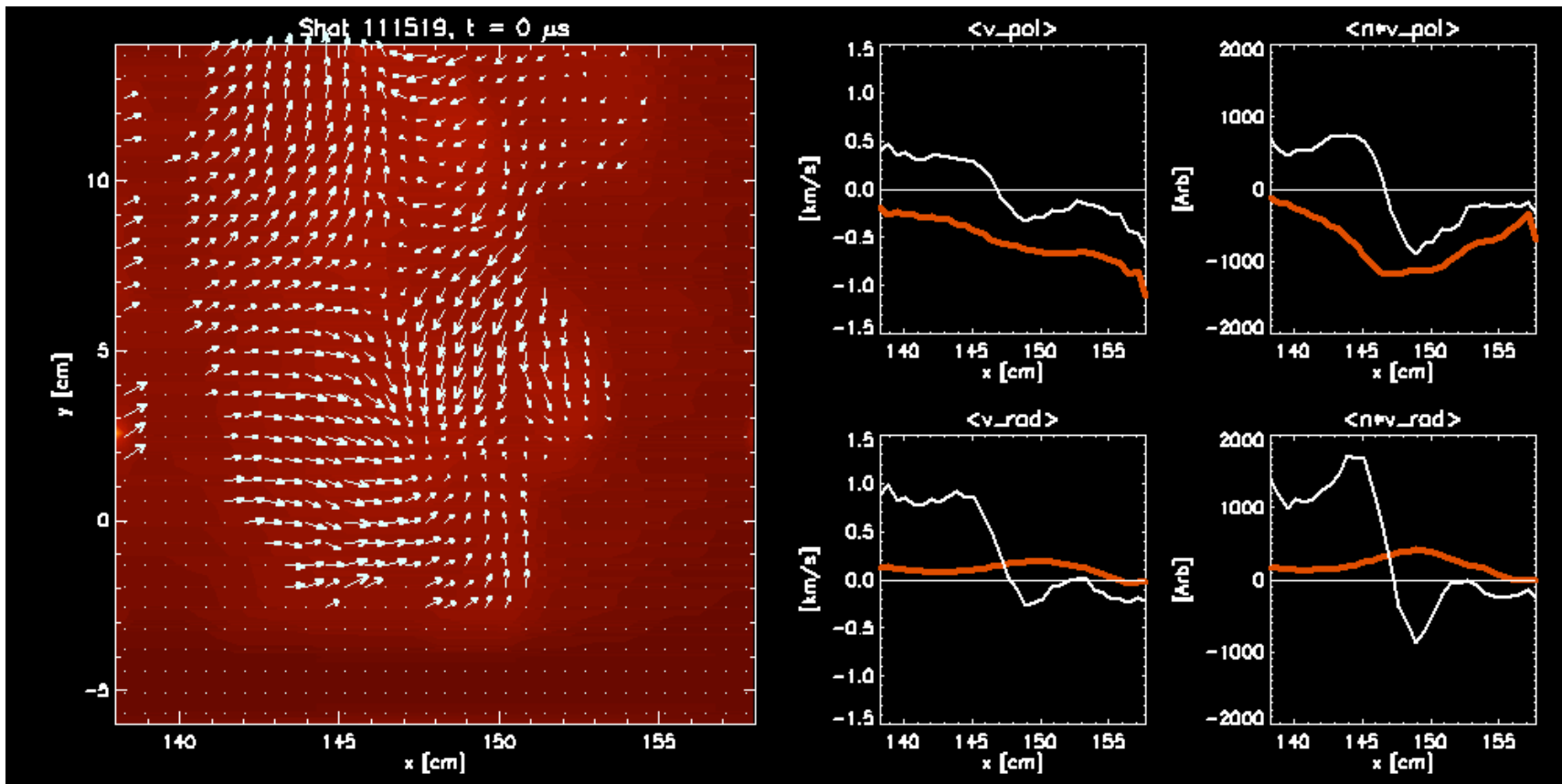$\geq 4 \mu sec$ / frame
intensified

<u>Images</u>
$\approx$ 20 cm x 20 cm view
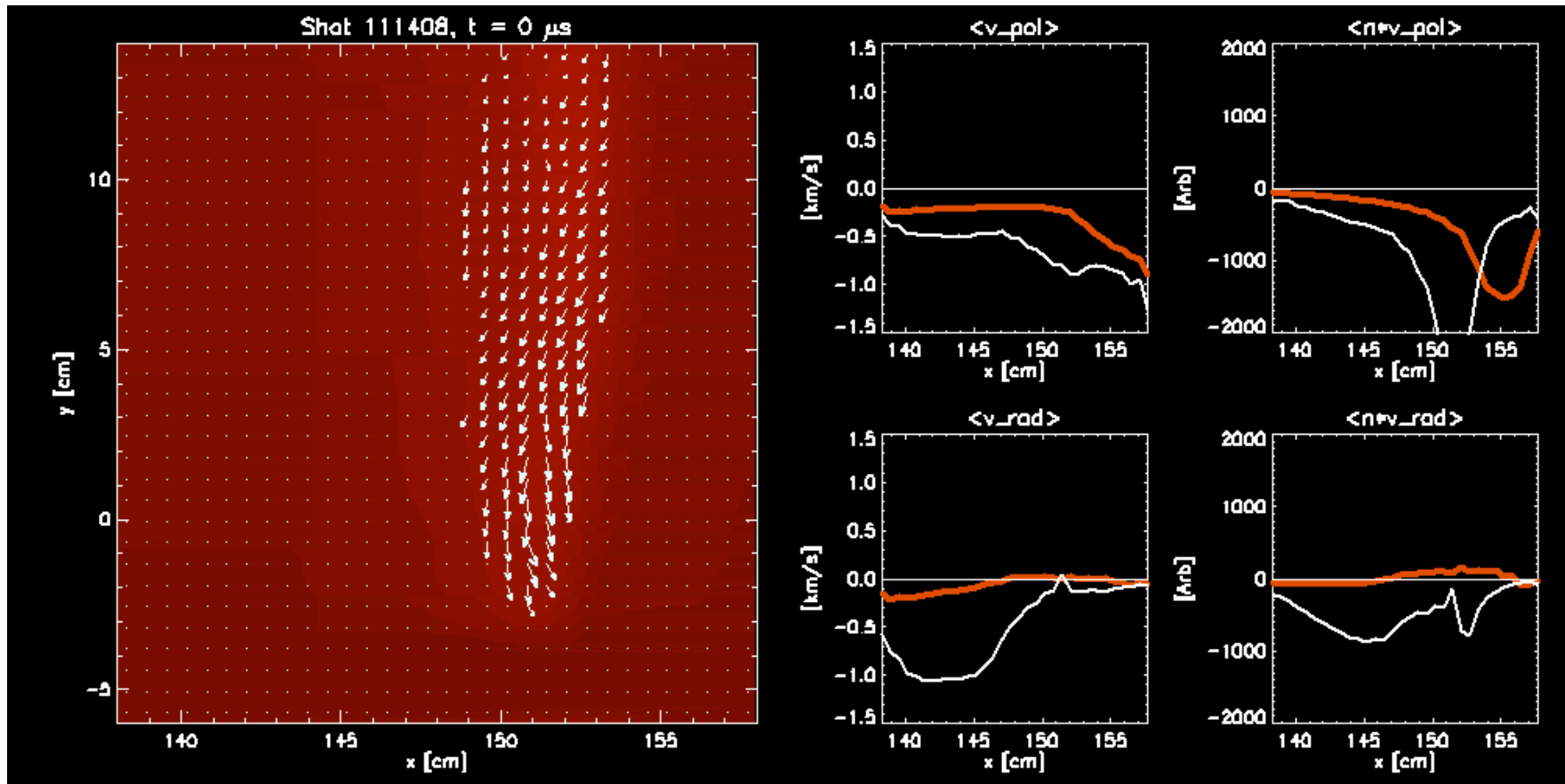smoothed over $\leq$ 1 cm
scaled to single maximum

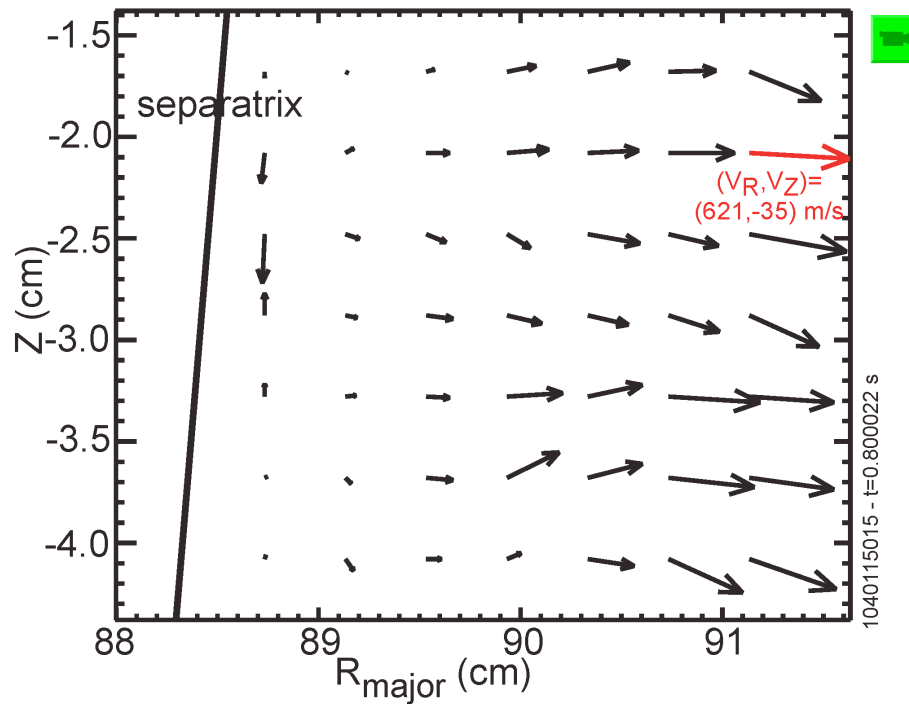# NSTX Velocity Map #1

T. Munsat

NSTX Velocity Map #2

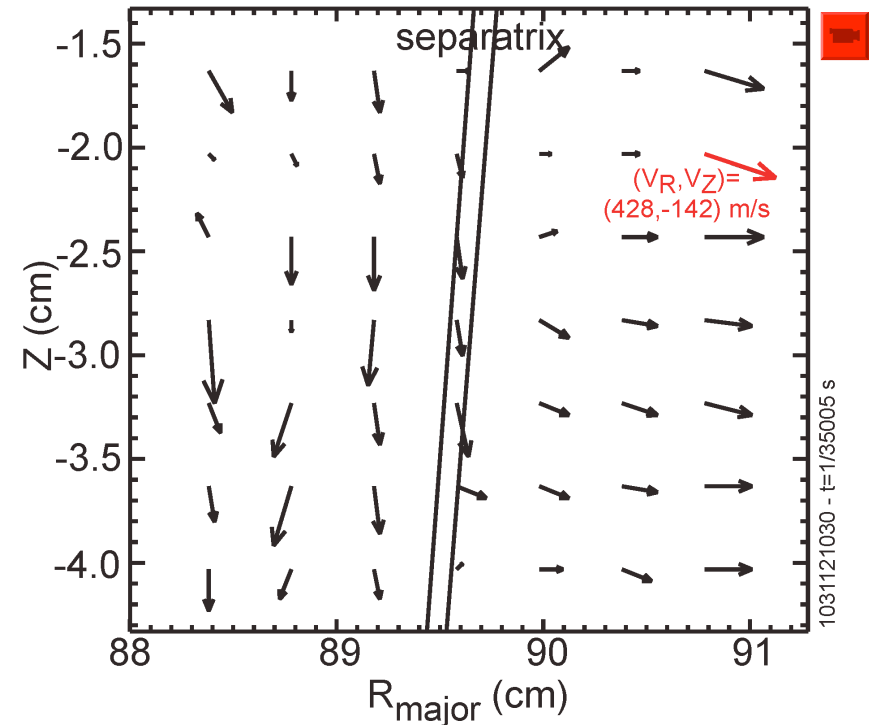

T. Munsat

C-Mod 300 Frame Movies give clear
Visualization of Turbulence Flow
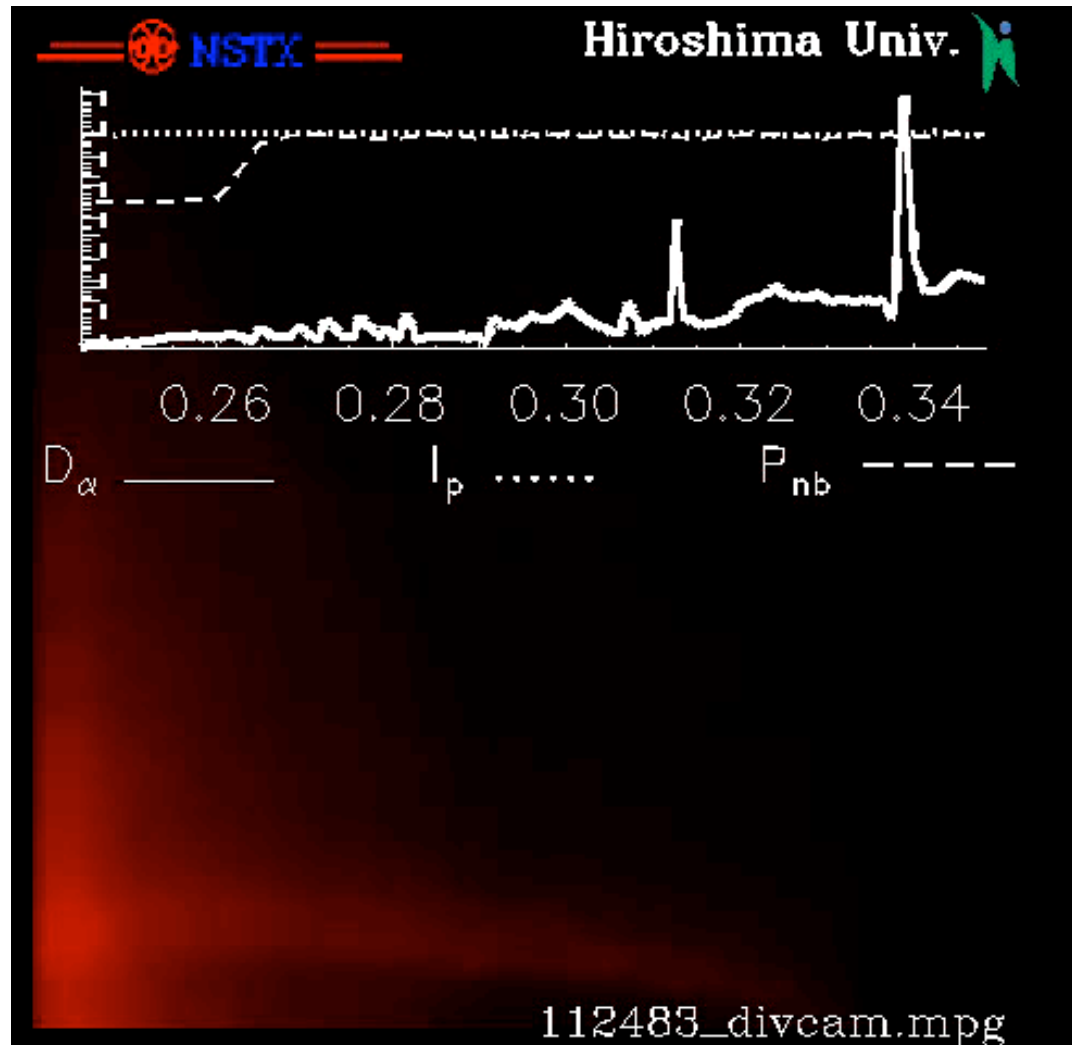

Flow fields derived from spatial maximum in cross-correlation at each
point in 2D grid (1.2 ms average)

J. Terry

NSTX Divertor Region

Hiroshima Univ.
Photron camera

40,000 frames/s

viewing D_α

Qualitative Observations

- Ohmic and L-mode plasmas look similar

- H-mode plasmas can be almost quiescent

- Blobs seem to form, mutate, and/or disappear

- Clear "MHD" wave effects, including high-n modes

- Sometimes see mixture of "blobs" and "waves"

- No obvious zonal flows or GAM modes (yet)

- No "smoking gun" in L-H or H-L transitions (yet)

Analysis Plans

- Measure large-scale and zonal flows vs. radius

- Quantify blob creation, mutation, and propagation

- Look for changes causing L-H and H-L transitions

- Evaluate radial flow and compare with transport

- Compare with simple dynamical models (?)

- Compare with blob models (Lodestar)

- Compare with BOUT runs (LLNL)