Edge/SOL Intermittent Transport in DIII-D

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For UCSD and the DIII-D Team

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See also Rudakov LP1.027, D. D'Ippolito LP1.083, S. Galkin LP1.082 and D. McCarthy LP1.084

▪Motivation

▪*Recent results from ALCATOR C-MOD have indicated that strong recycling occurs at the main chamber wall. DIII-D results confirm.*

▪*The walls are a large source of carbon in various devices.*

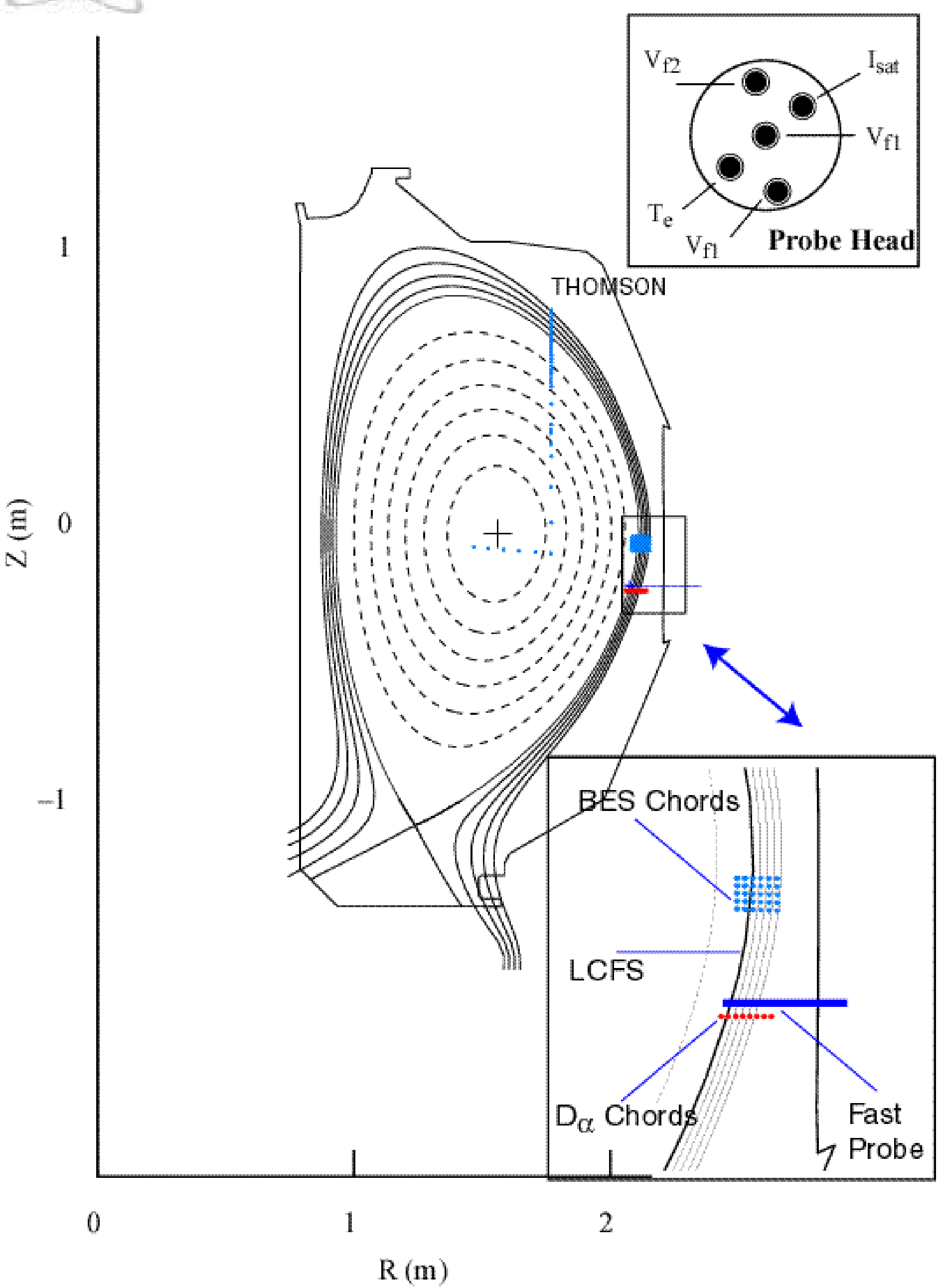
▪*What is then the mechanism that brings plasma to the walls?*

▪*Results in DIII-D and other devices have indicated that:*

- *Transport in the far SOL is stronger than thought.* Moyer *et al* J. Nucl. Mater. 1997, Boedo, et al. 1999, 2000, LaBombard, et al. 2000, 2001
- *Profiles in the far SOL are flat => role of diffusion?* Watkins *et al* J. Nucl. Mater. 1992, Boedo et al RSI 1998
- *Intermittency has* ***long ago*** *been identified as a significant source of transport present in many devices (JET, TJ-I, CASTOR, etc).* Carreras *et al* Nielsen et al., Heller et al.

▪*Intermittency (i.e. fast, intermittent events larger than the rms level) will be characterized in detail in this presentation and connected to transport.*

Well Diagnosed L-mode and H-mode Discharges

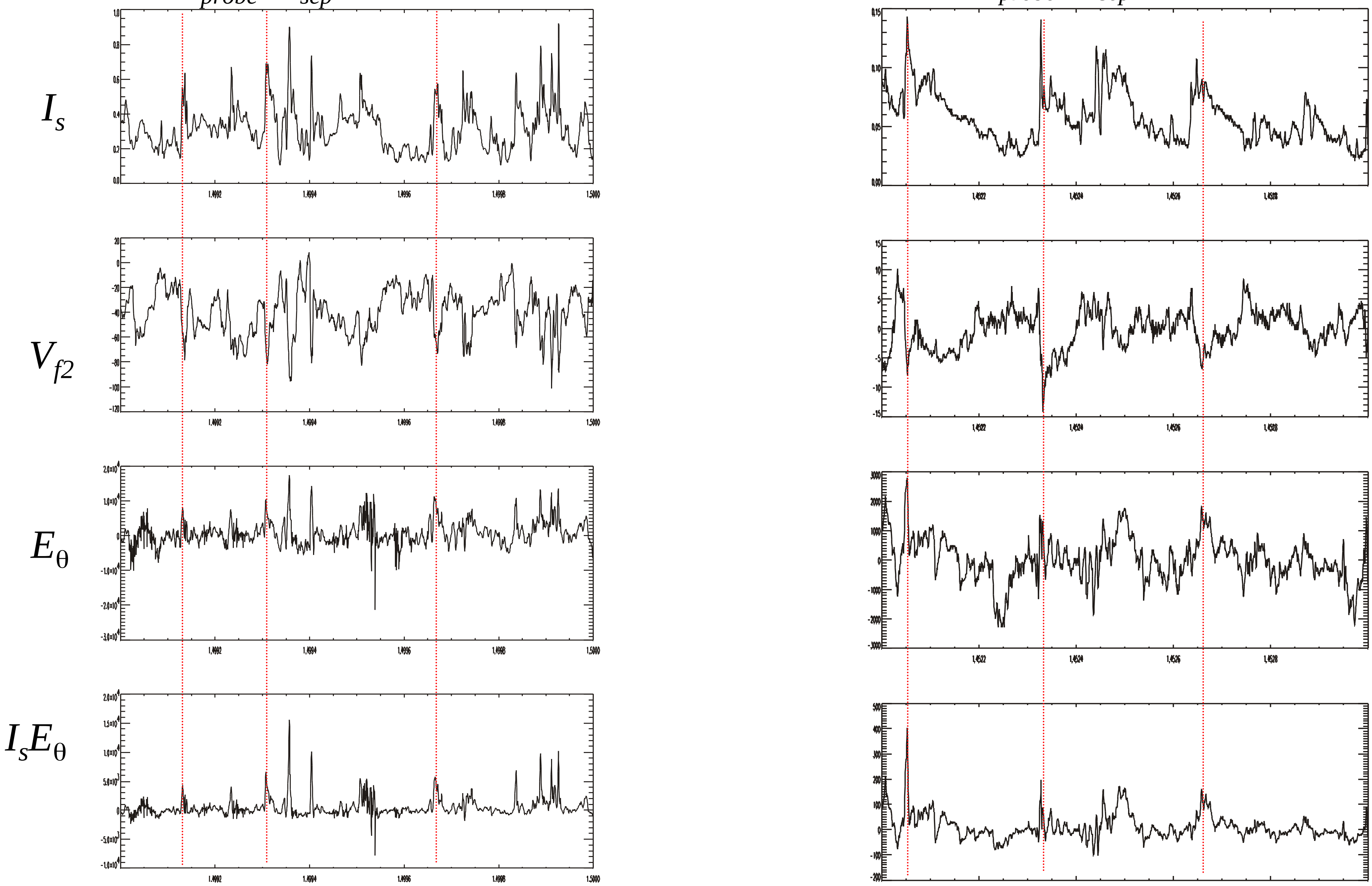


- *Various diagnostics are combined to provide as complete dataset as possible*
- *Scanning probes*
  - *In and out in 200 ms*
  - *Total plunge is 15 cm*
  - *Produce I_{sat}, n_e, T_e, V_f, E_q, V_{pl}, G_r, E_r*
- *BES*
- *D_a arrays*

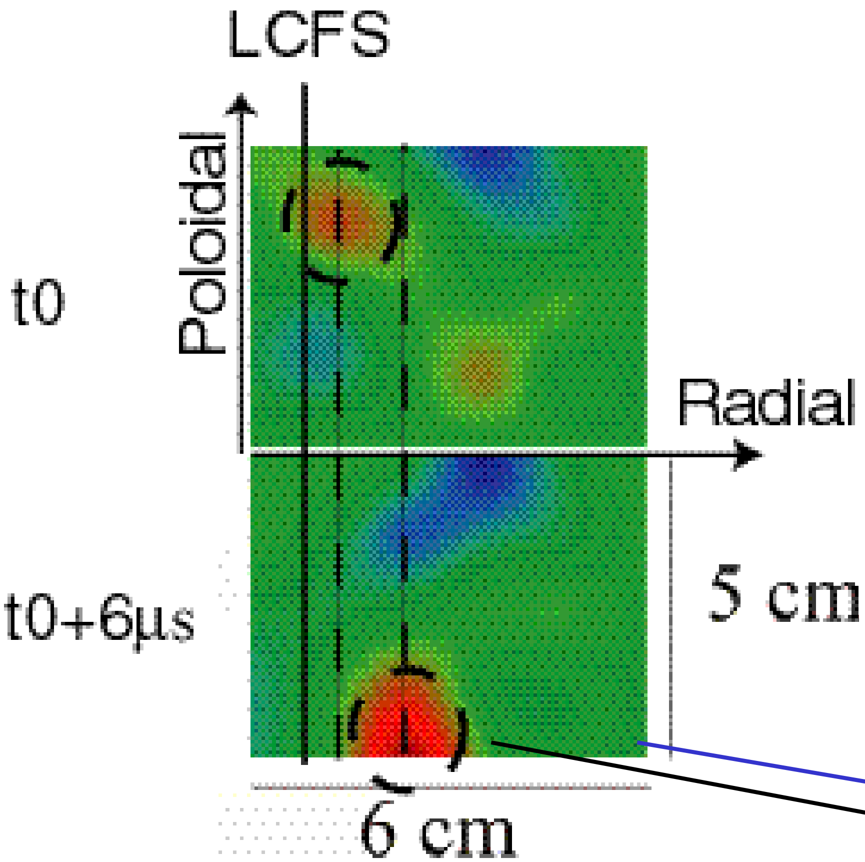
Intermittency in DIII-D Apparent in Short Time Scale (1ms)

$R_{probe} - R_{sep} \approx$ 0.5cm

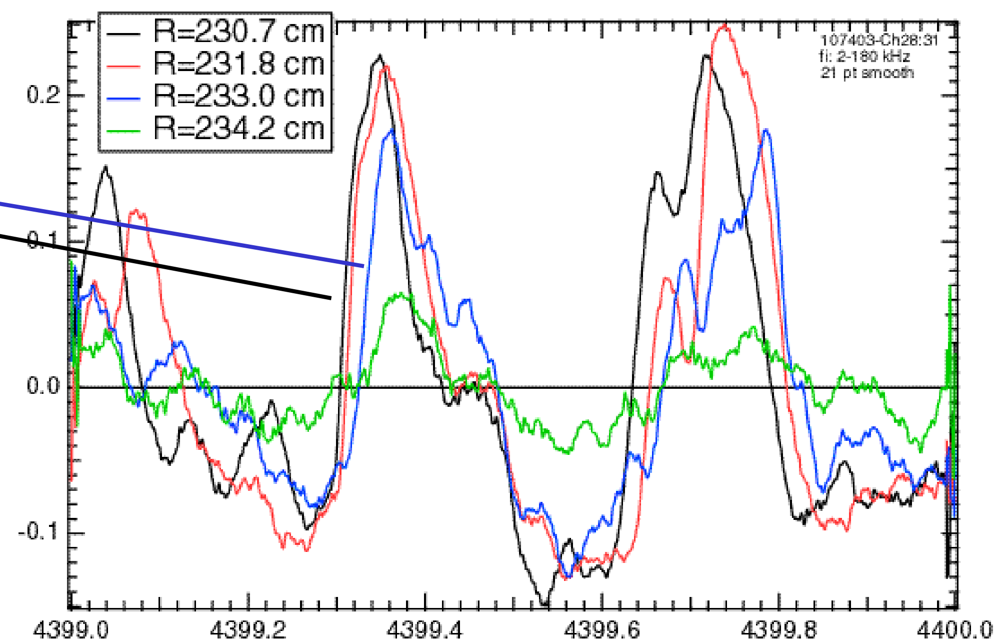
$R_{probe} - R_{sep} \approx$ 10cm



Other Diagnostics Show Similar Behavior: BES

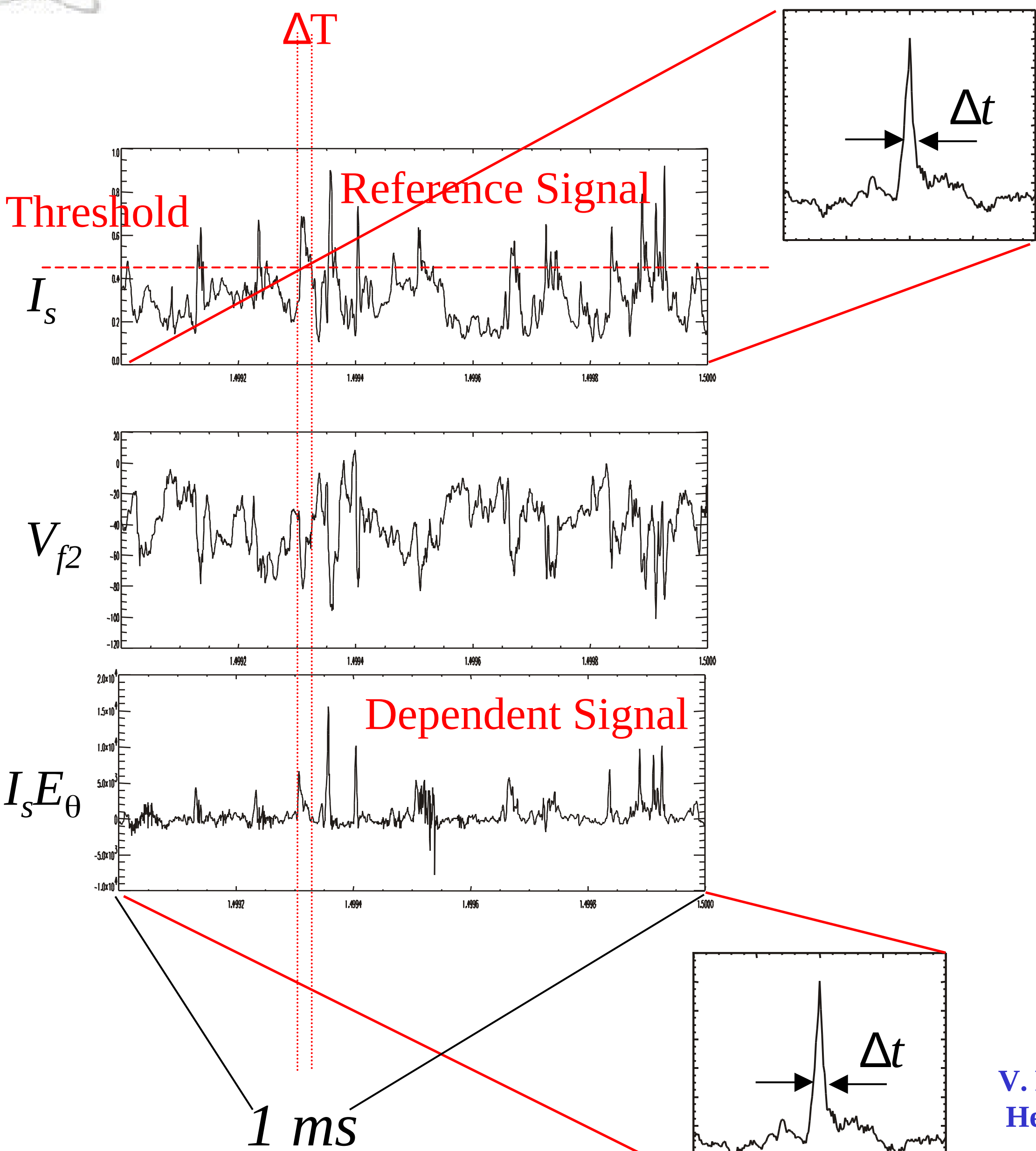


- *Structures move poloidally (5000 m/s at LCFS)*
- *Structures move radially (1500 m/s at LCFS)*
- *The size near the LCFS is ~2x2 cm*



G. McKee, UW (2001)

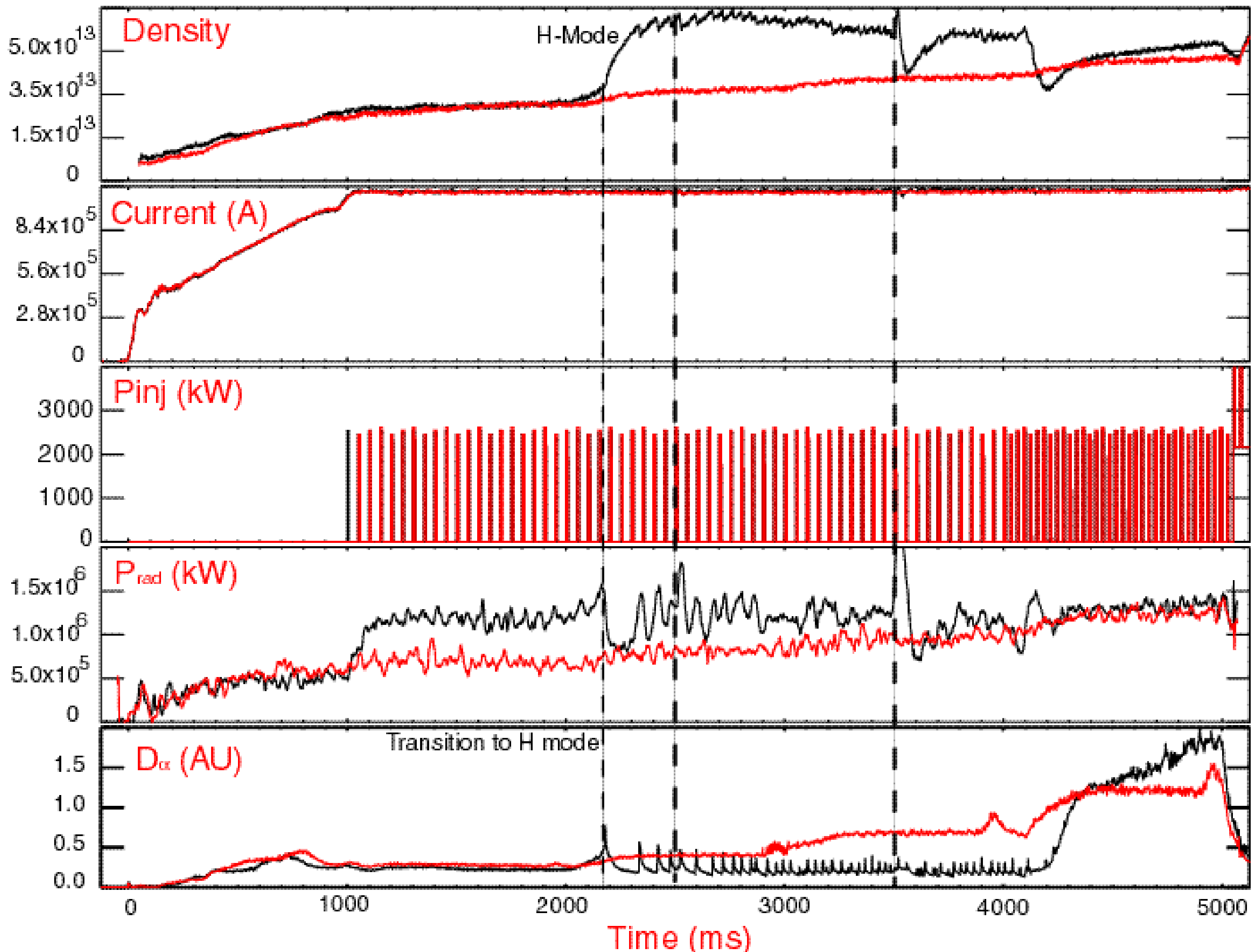
One Tool: Conditional Averaging



- *Conditional averaging tools allow us to extract pulsed or intermittent information from a signal*
- *One signal is the reference.*
- *The rest of the signals are sampled as per the reference one and binned.*
- *Correlated features are brought out*

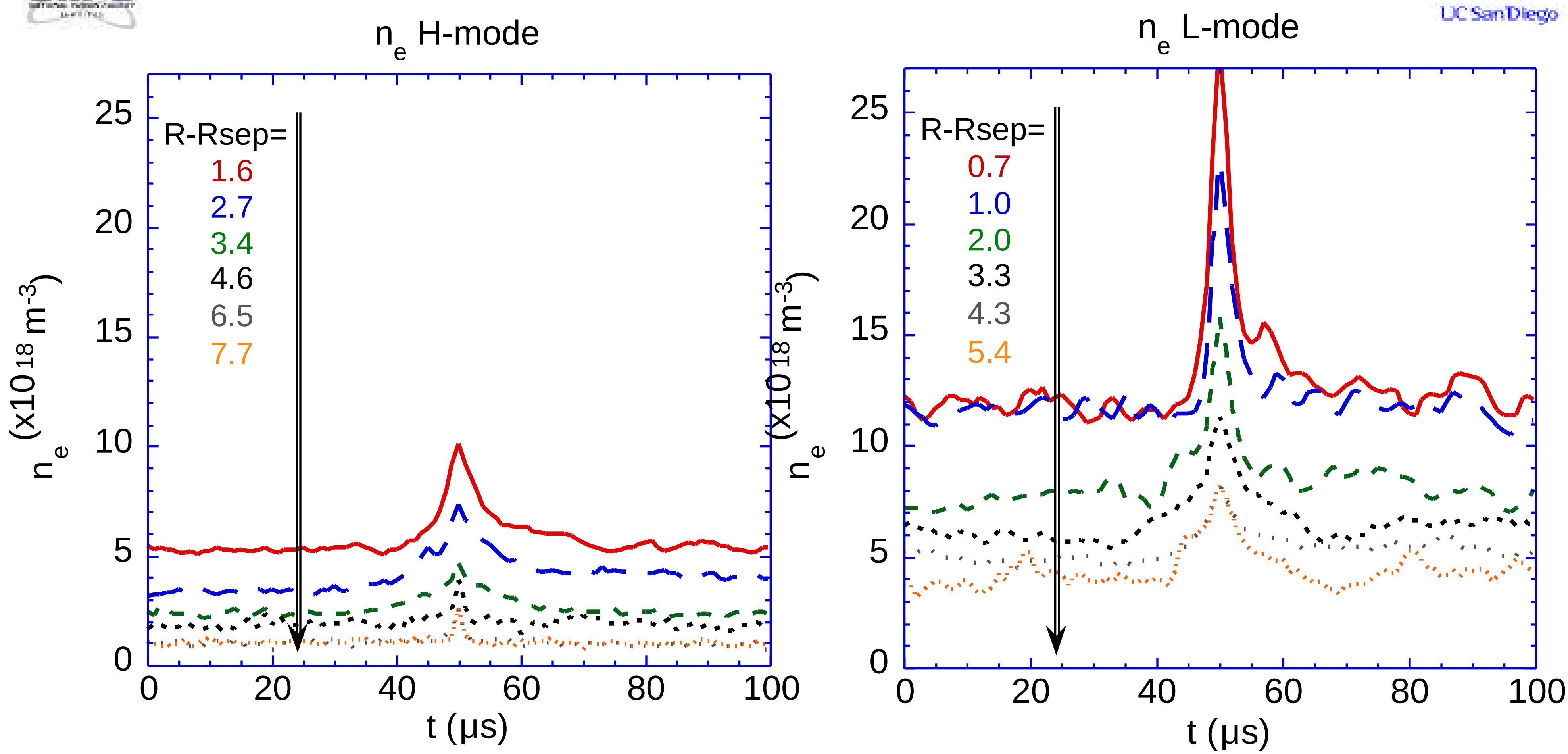
V. Filippas, et al (TEXT 95), A. H. Nielsen et al (96), Heller (CASTOR 99)

Search in L and H Mode Discharges



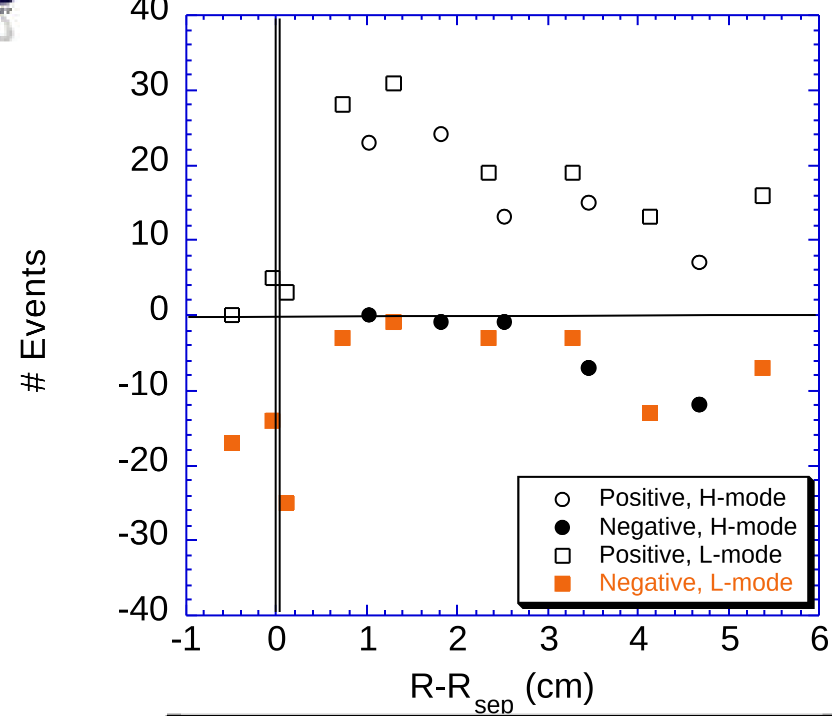
J. Boedo APS 2001

Ne Bursts Larger in L-mode

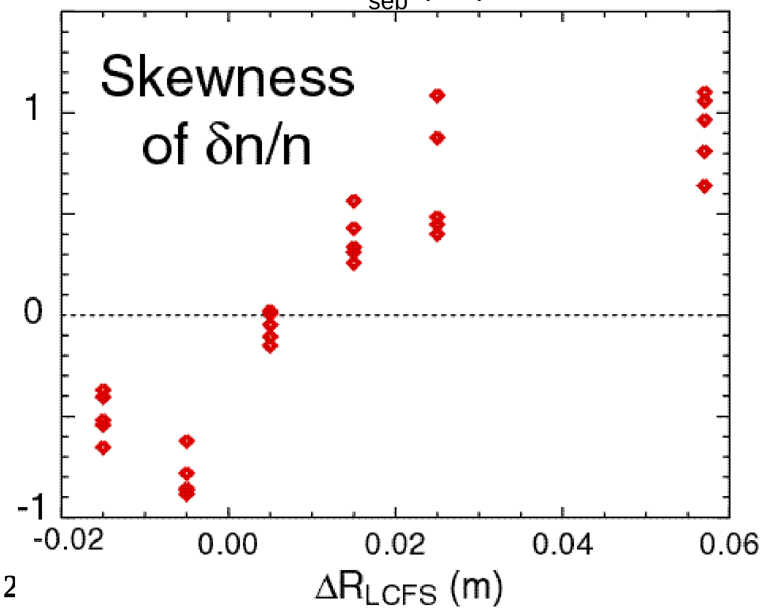


- *Density events are large (~2 x background)*
- *Events are larger in L-mode*

Event Count Supports Creation at LCFS



Probe Isat

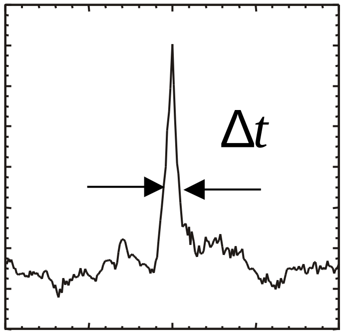


BES Ne

- *ONLY negative events at or inside LCFS*
- *Positive events dominate in SOL*

Bora, 92; Turney, Moyer *et al* APS'99, Carreras 99, 2000, Boedo *et al* POP 2001

We Can Obtain Quantitative Information from these Measurements



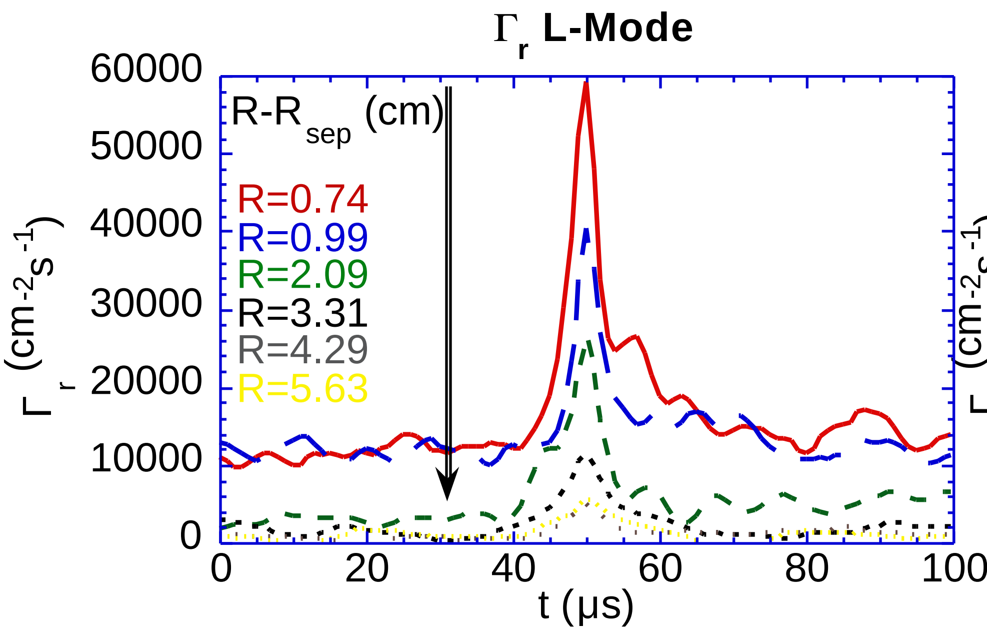
$$\Delta t \approx \delta_r / V_r$$

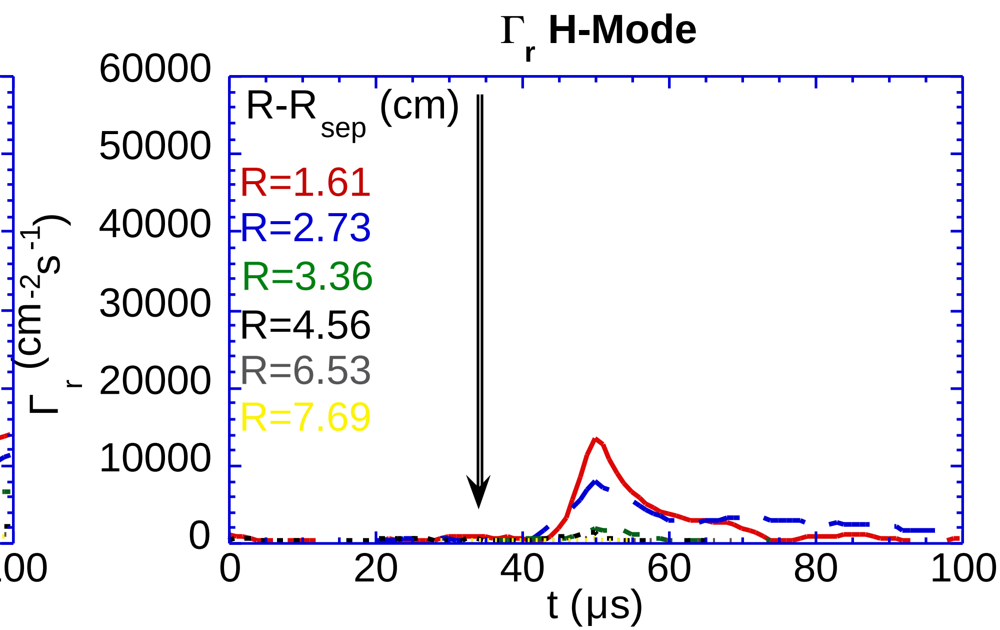
V_r can be calculated as E_θ / B_φ

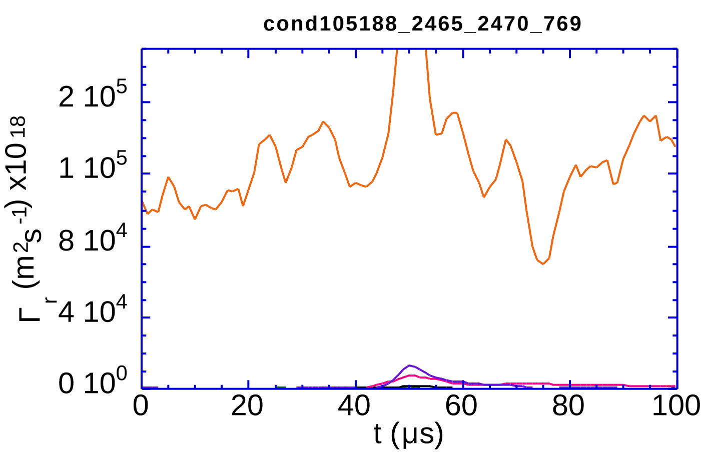
	R_{probe}- R_{sep} (cm)	Δt (s)	E_θ (V/m)	V_r(m/s)	δ_r(cm)
LCFS	0.5	1.5×10^{-5}	4000	2000	3
	5	2×10^{-5}	1500	750	1.5
Wall	10	1.5×10^{-5}	500	250	0.37

- *The radial size of the intermittent plasma objects (IPOs) can be calculated at ~2 cm at LCFS*
    - *Agreement with BES*
- *The IPOs are slowing down, decaying and thinning as they move out*
- *Rate is about 10^4 per s*

Flux vs R, L and H-mode



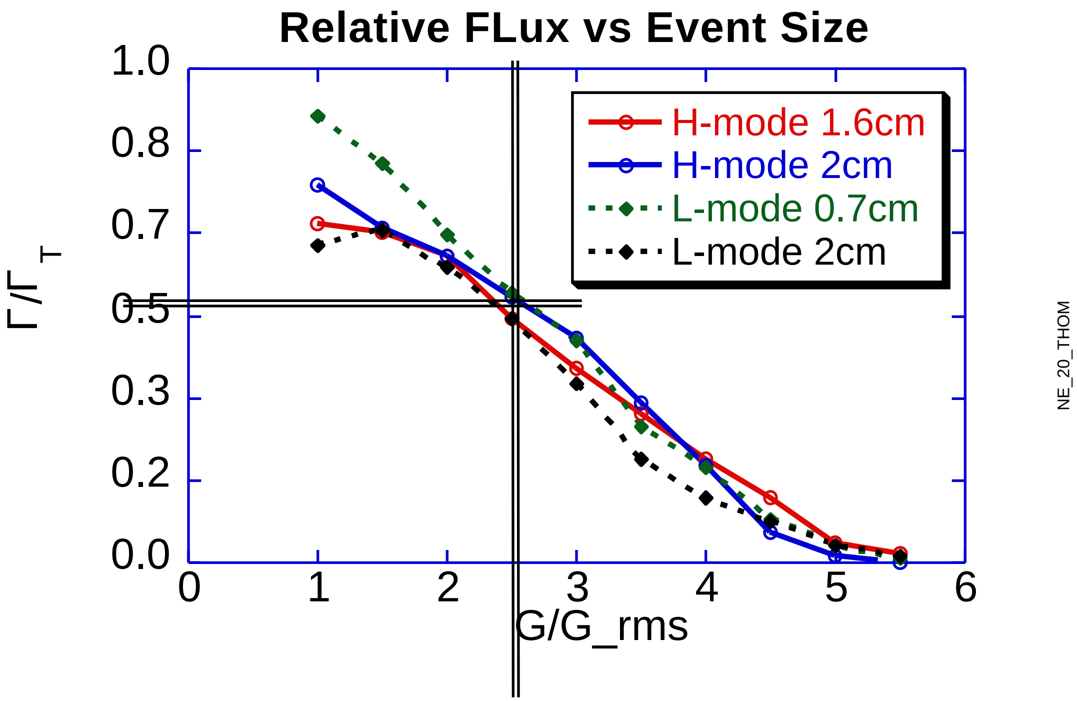


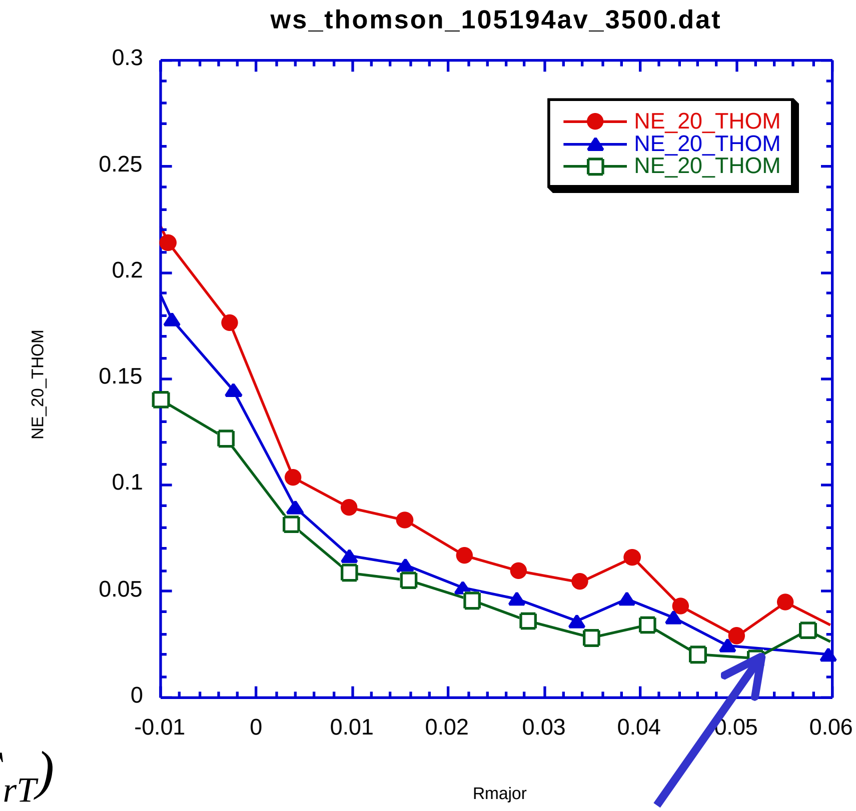


- *H-mode ExB Flux is much higher right at LCFS and falls rapidly with R (within 0.5 cm)*
- *L-mode flux is much higher in the SOL*

J. Boedo APS 2001

Spikes >2.5 rms are ~ 50% of total ExB transport





Fraction of transport due to spikes: $(\Gamma_{rS})/(\Gamma_{rT})$

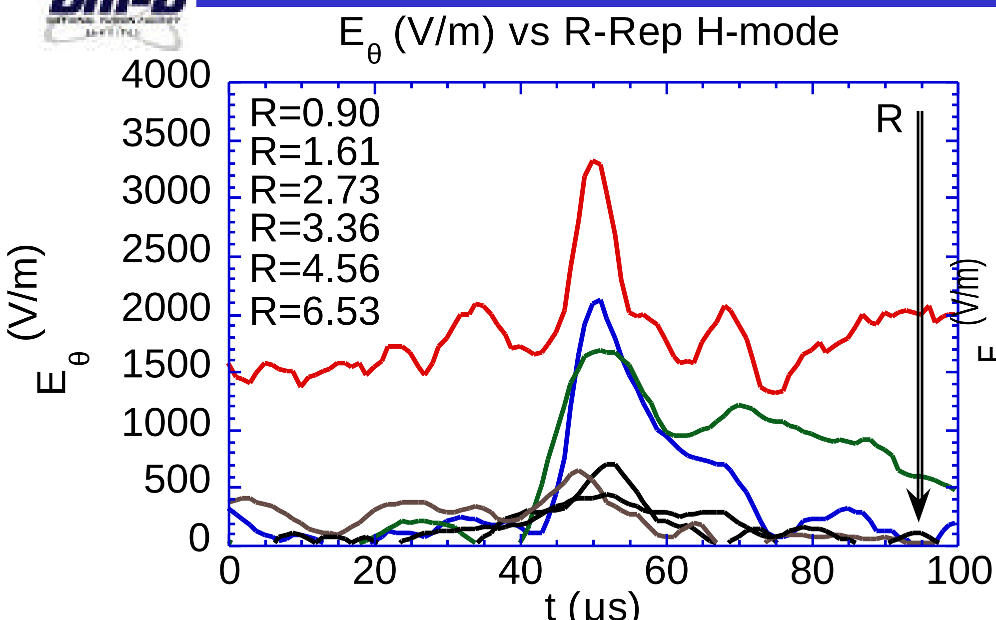
Highly relevant transport at all radii in H and L modes

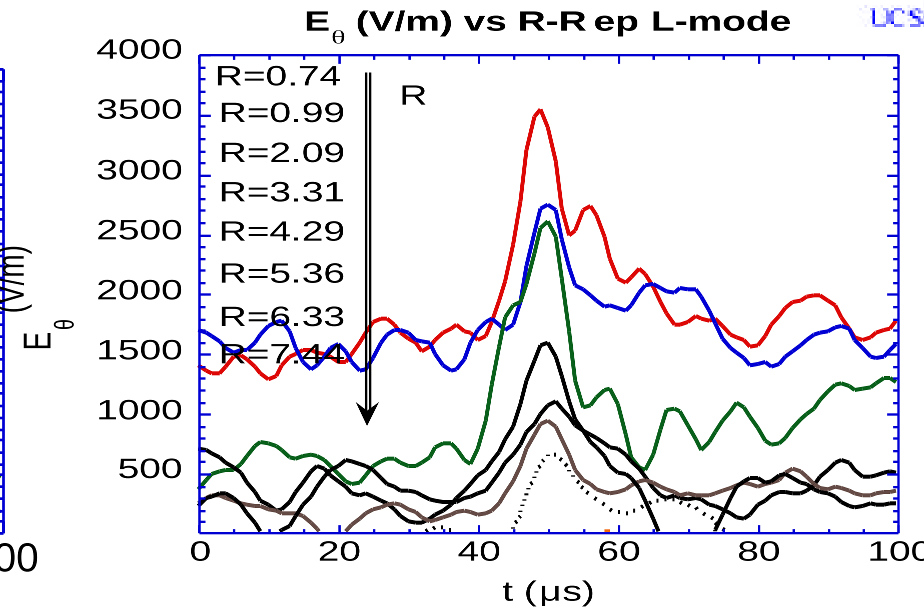
Flattish n_e profiles far (6-10 cm) into SOL

Convective component becomes important in modeling

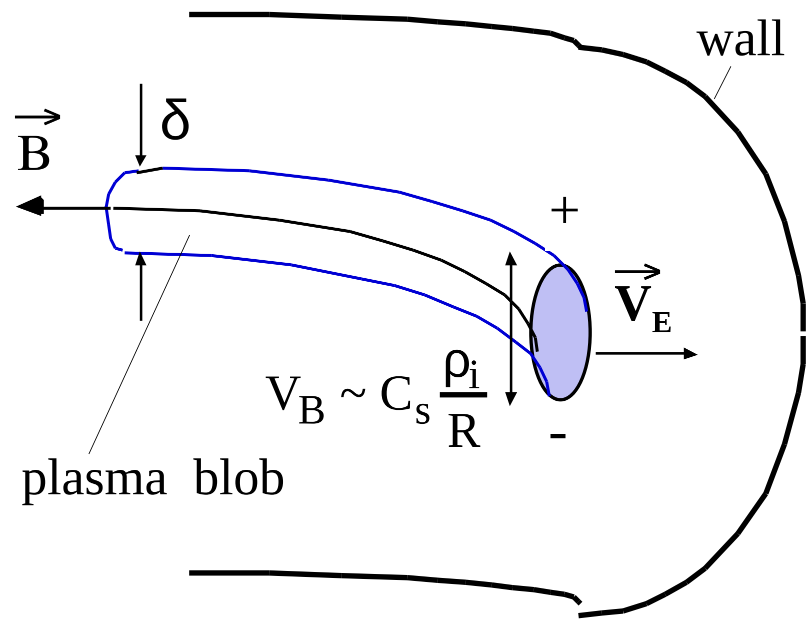
A. Pigarov **LP1.085, D. D'Ippolito LP1.083**

Polarization is Well Defined in L and H-mode



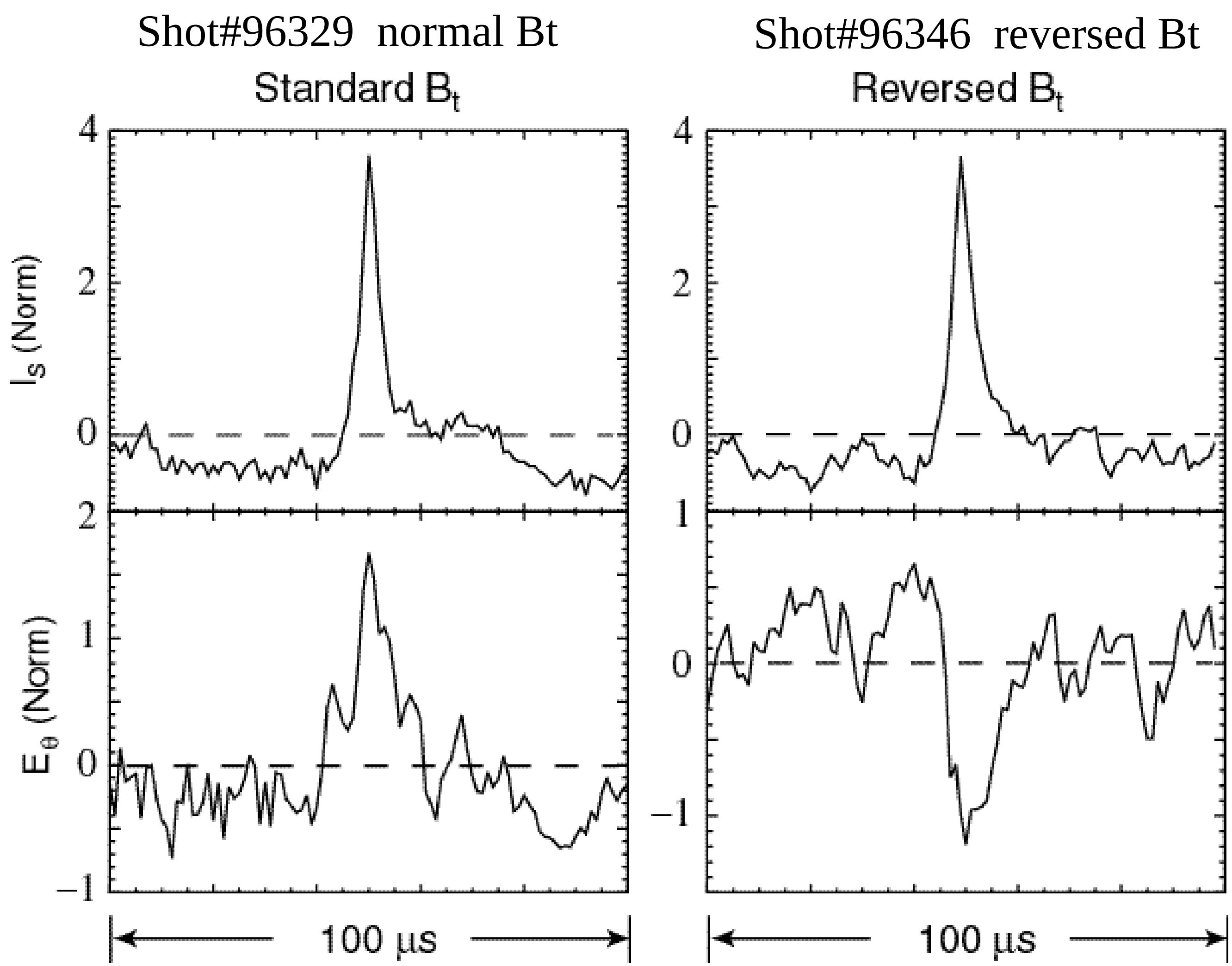


- *Objects spread with radius*
- *A "tail" is developed (shockwave-like)*
- *Well defined polarization*
- *Plasma structures detach from the bulk plasma due to turbulence effects.*
- *Structures extend along B.*
- *Propagate due to* $\vec{B}\times B$ *plasma polarization and associated* $\vec{E}\times\vec{B}$ *drift.*



Krashenninikov, PLA 2001

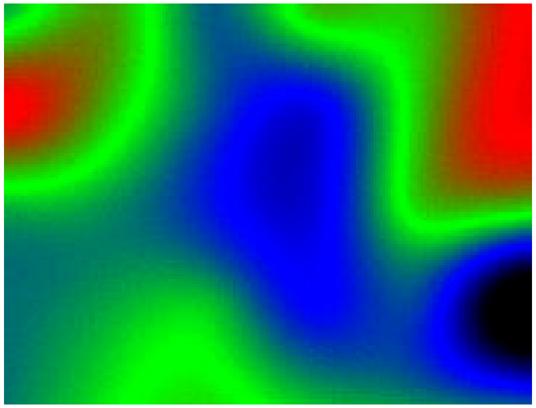
Reversal of Bt results in reversed object polarization



- *ExB flux is still outward*
- *Not in disagreement with the GradB drift polarization mechanism*

Conclusions

- *Intermittency exists in L and H-mode (universality long proven)*
    - *IPO density greater in L-mode*



- *IPOs carry ~50% of particle and heat across SOL*
- *The IPOs are created near the LCFS*
- *IPOs are polarized, thus ExB radial velocity and IPO size can be calculated*
    - *IPOs slow down as they move radially*
        - V_r *from 2 km/s to 0.2 km/s*
        - V_{pol} *from 5 km/s to ~0.1-0.2 km/s*
    - *IPOs shrink from 2 cm at the LCFS to 0.5 cm at the wall*
- *Statistics of IPOs across machines done by Carreras, Hidalgo, etc.*