Impact of different confinement regimes on the two dimensional structure of edge turbulence

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Outline

Fast visible camera diagnostics

Fast visible commercial cameras

- Industrial use, crash testing...
- Typical parameters: resolution 80×80 @ 100 kfps (10μs)

Used for plasma imaging
[J L Terry *Phys.Plasmas* 2003, S J Zweben *Nucl.Fusion* 2004]

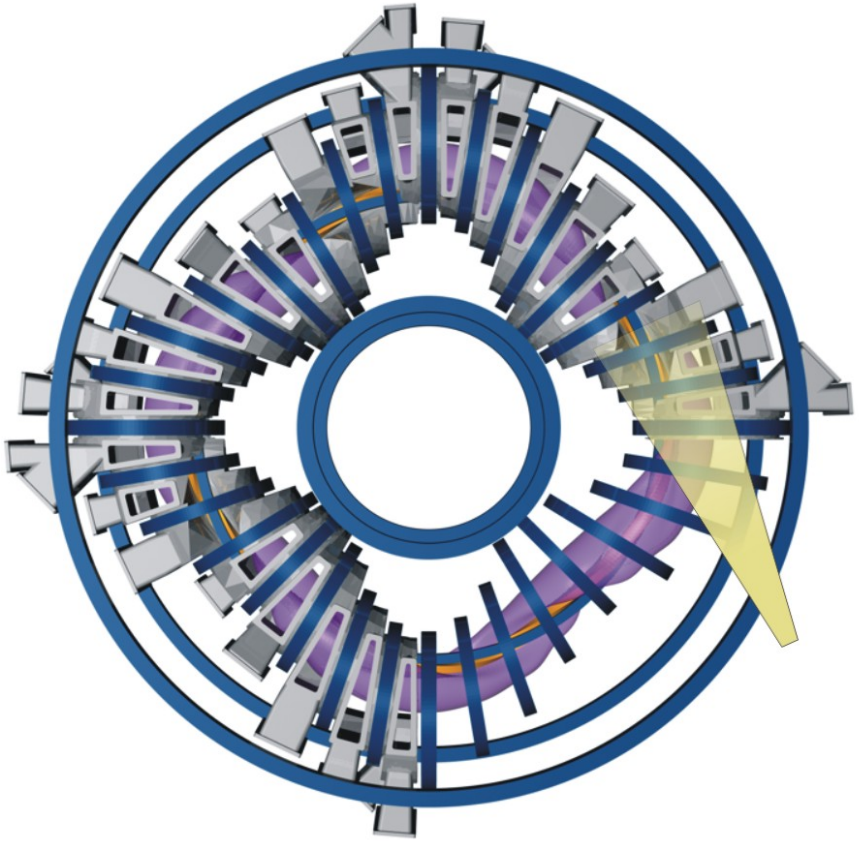
- Gas Puffing Injection to increase H_α signal
- H_α signal dependence

$$S \propto n_0 n_e^\alpha T_e^\beta$$

Fast cameras in TJ-II

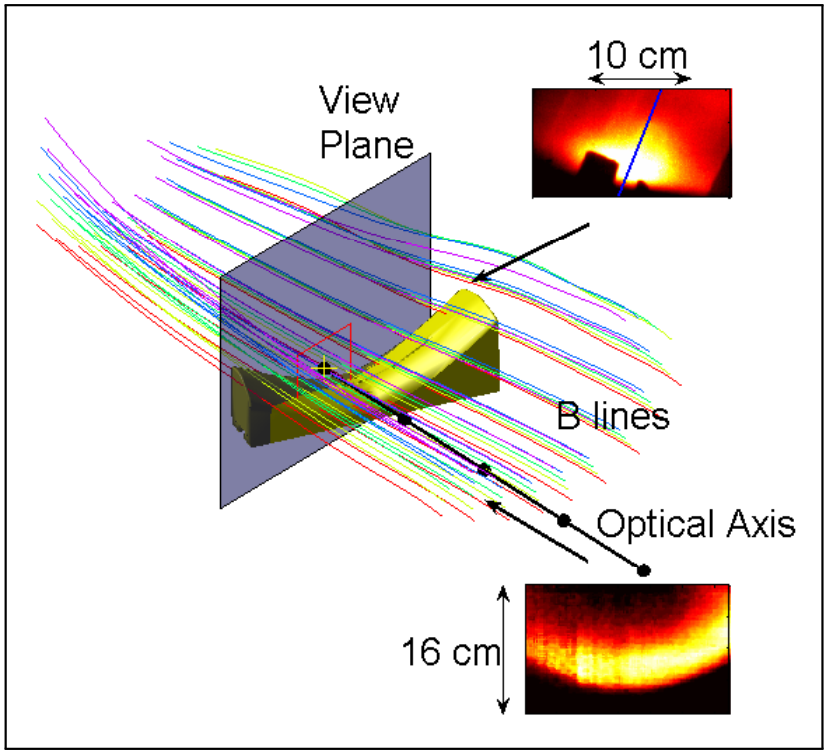
TJ-II stellarator

- 4-periods Flexible Heliac
- 400kW ECRH + 400kW NBI



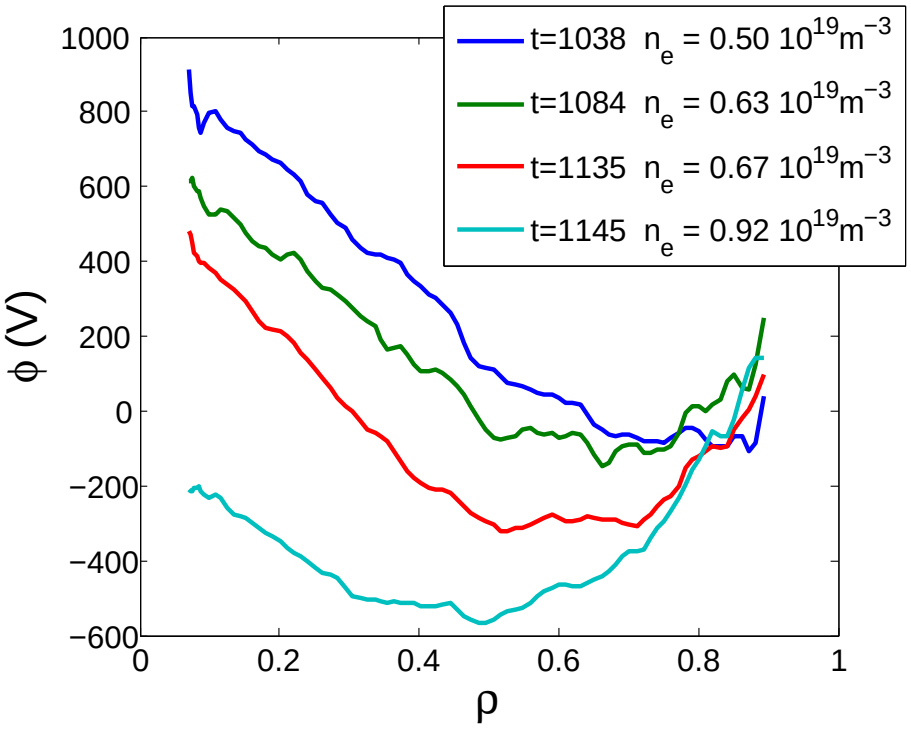
Fast edge plasma imaging

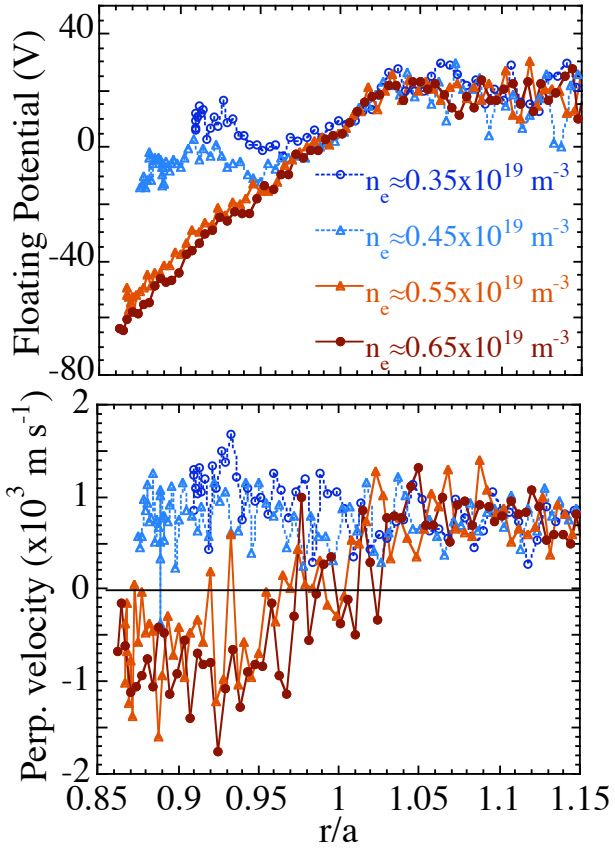
- Neutral recycling at one poloidal limiter used for plasma edge lightening



Natural edge sheared flow in TJ-II stellarator

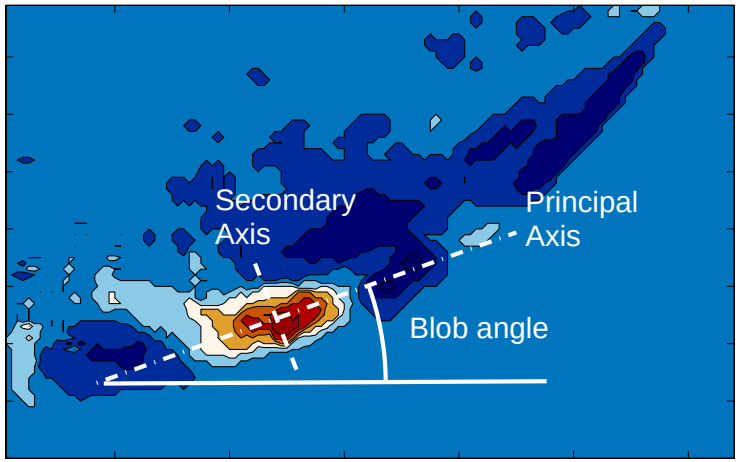
A sheared poloidal flow is formed in the edge above a density threshold $n_e \approx 0.6 \times 10^{19}\ \mathrm{m}^{-3}$ [M A Pedrosa *PPCF* 2005]





Blob geometric parameters

Blobs are ellipse-like spatially coherent structures.

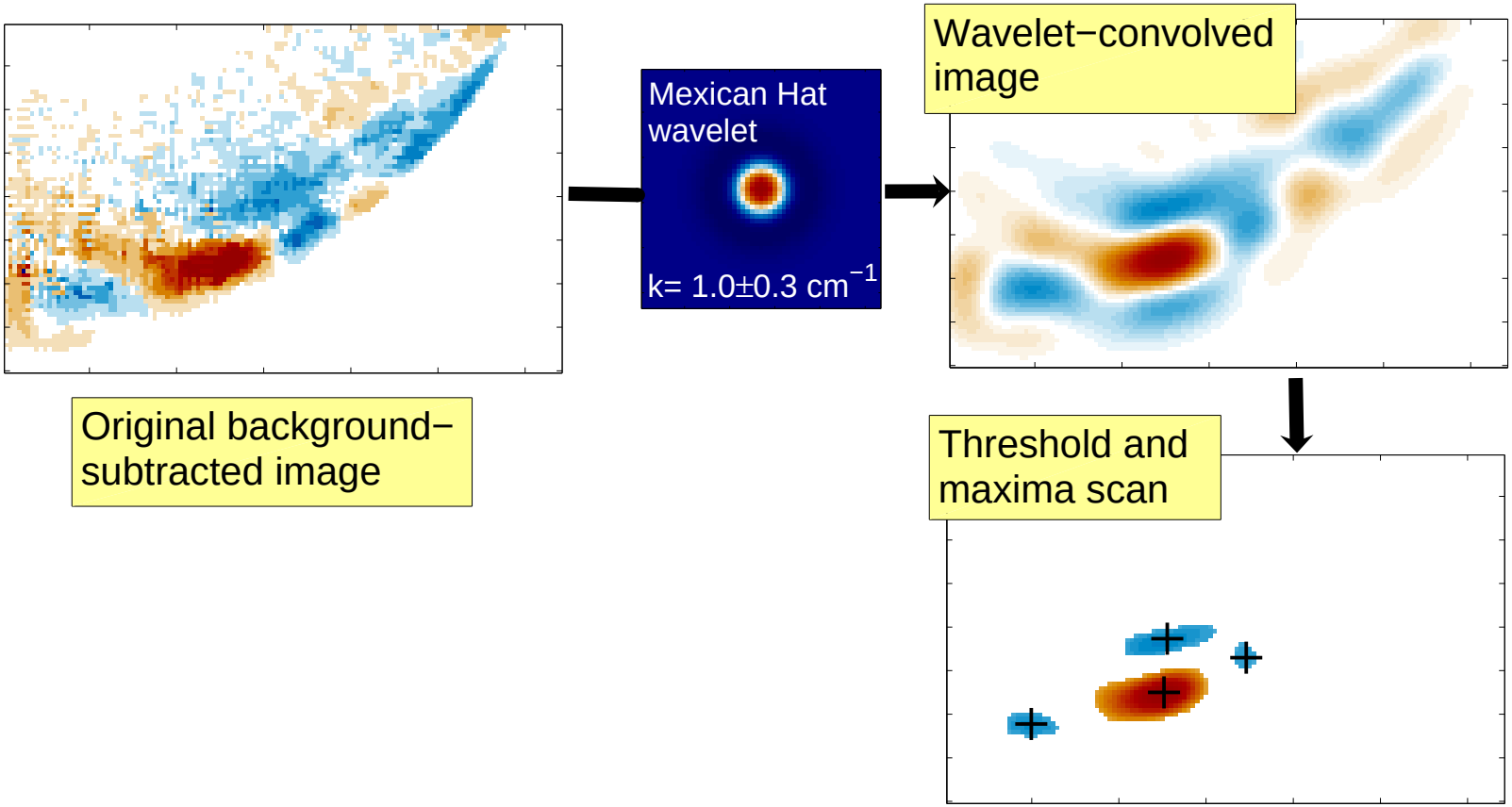


scale structure's size

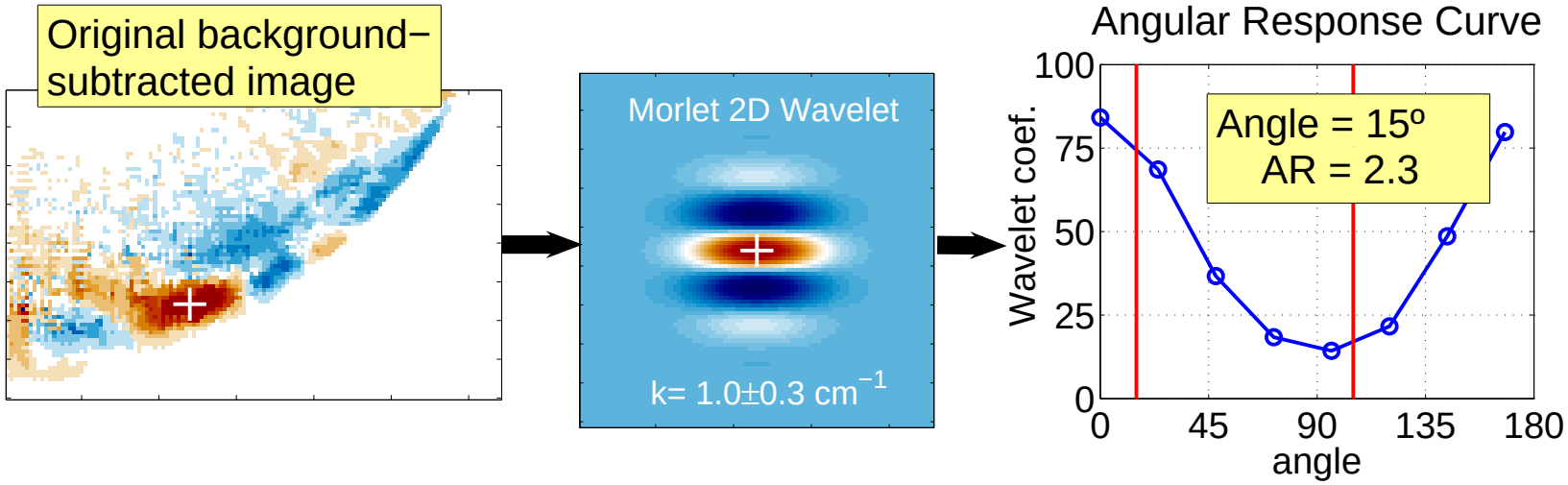
orientation angle angle between principal axis and x axis

aspect ratio ratio of the scale in the principal axis dir. and the dir. perpendicular to this

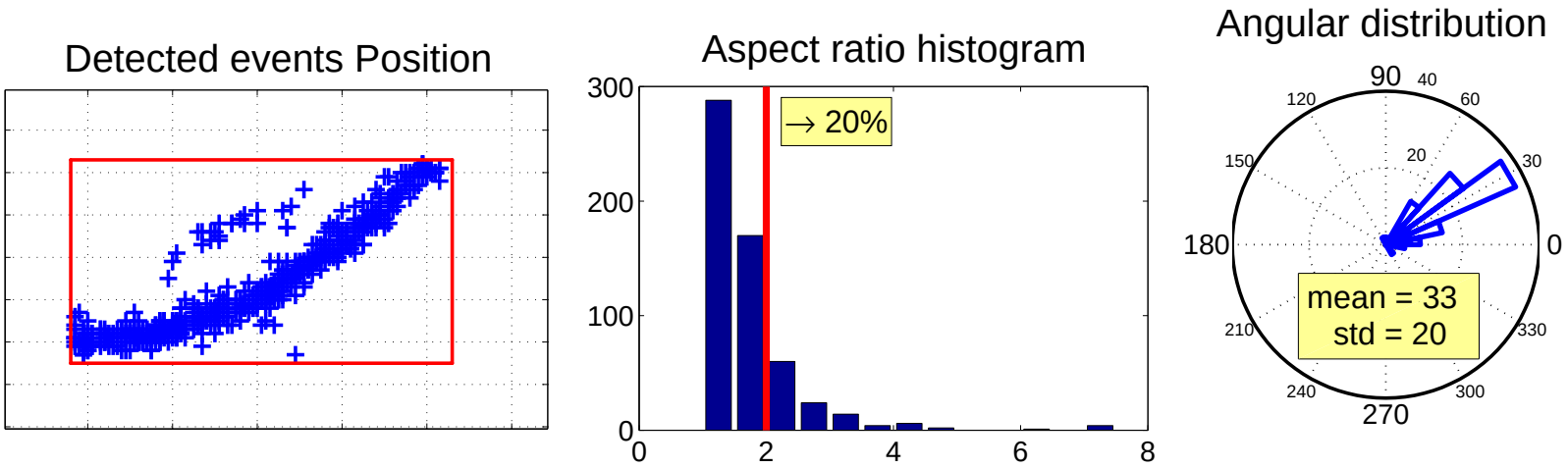
1 Detection


Mexican Hat wavelet
k= 1.0±0.3 cm^{-1}
Wavelet−convolved image
Original background−subtracted image
Threshold and maxima scan

2 Recognition



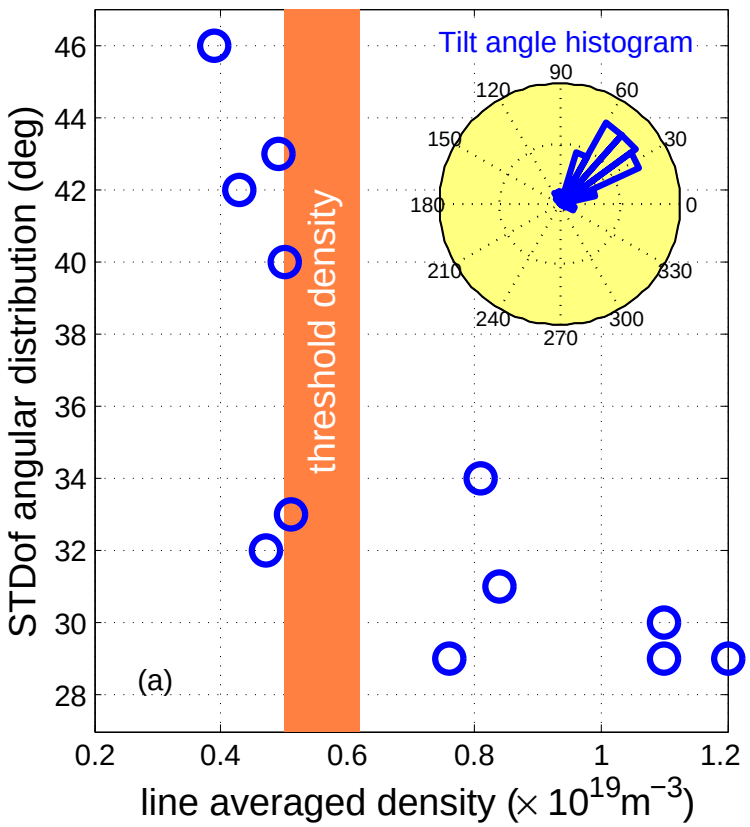
Frame series statistics

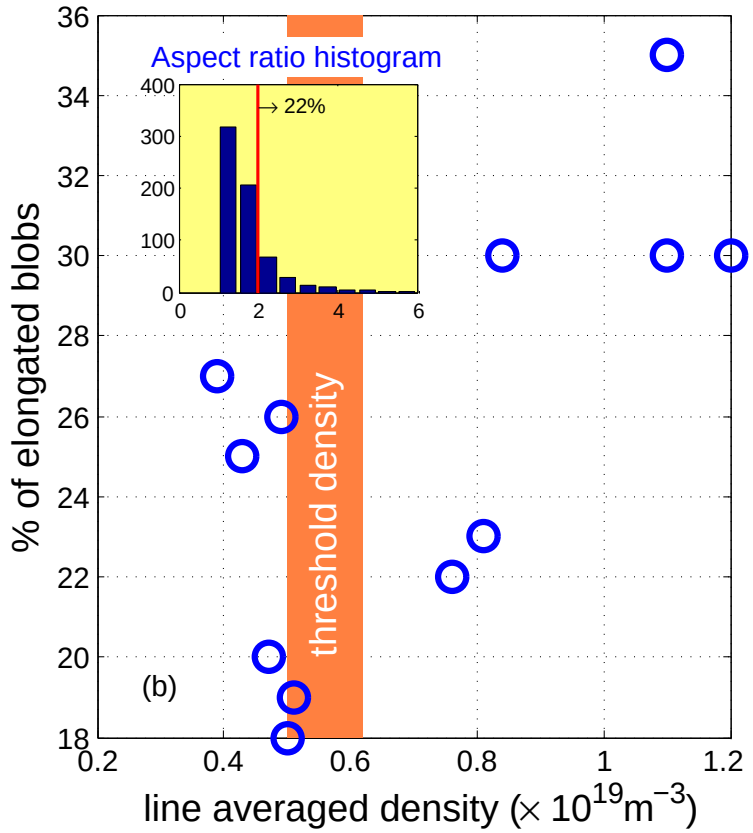


- Percentage of elongated blobs (measure of stretch)
- Standard deviation of angular distribution (measure of ordering)

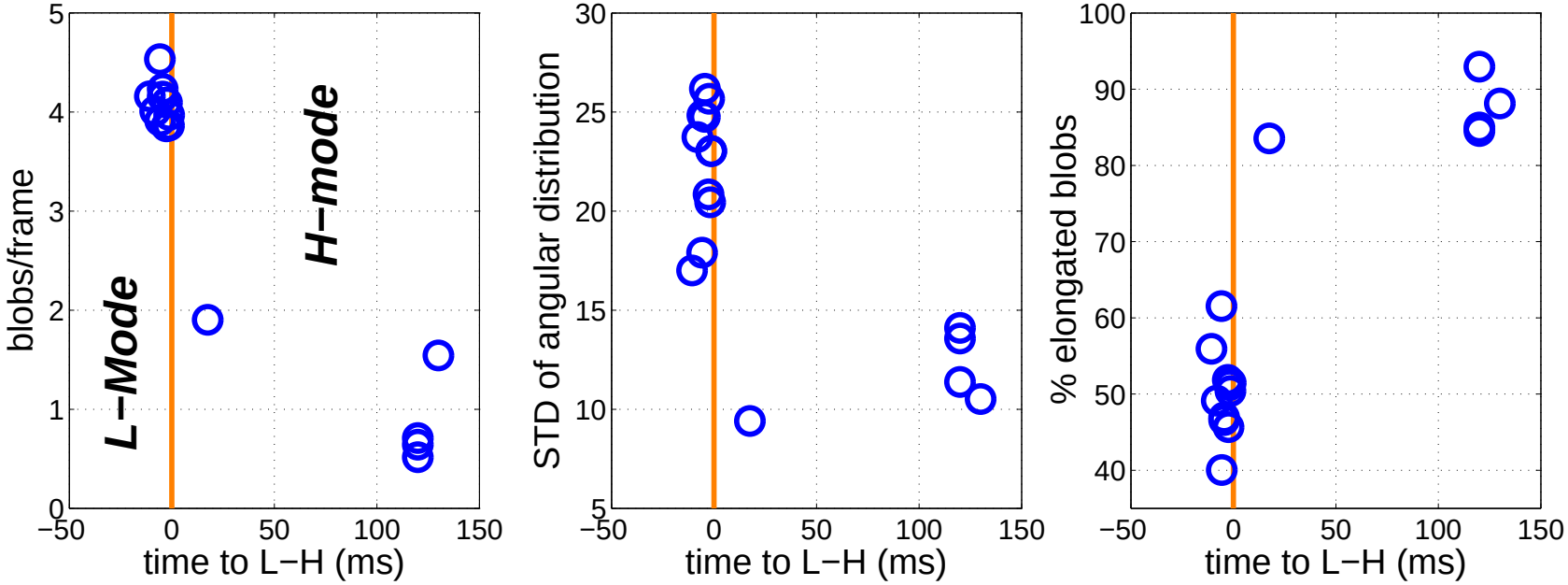
Effect of natural shear layer in TJ-II on blob geometry

Ordering + Stretching



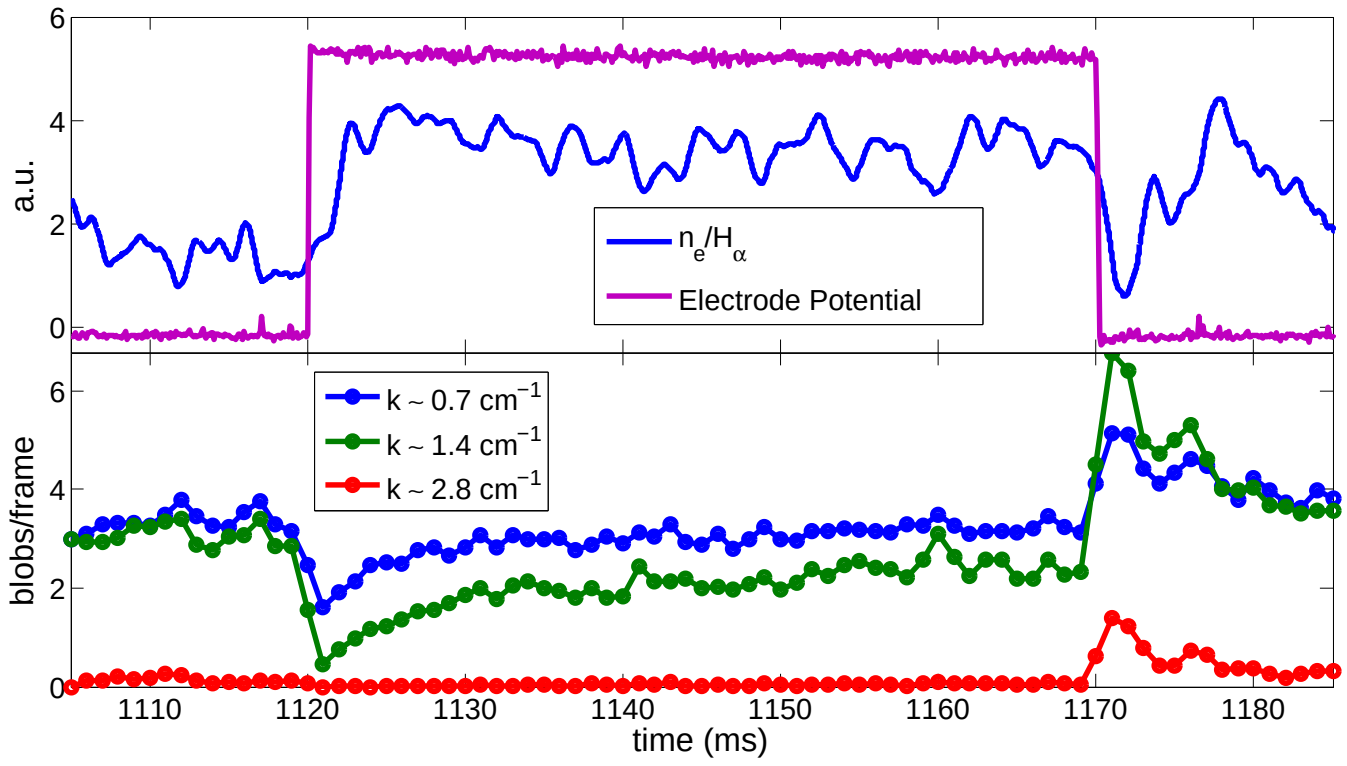


Comparison with NSTX L and H modes



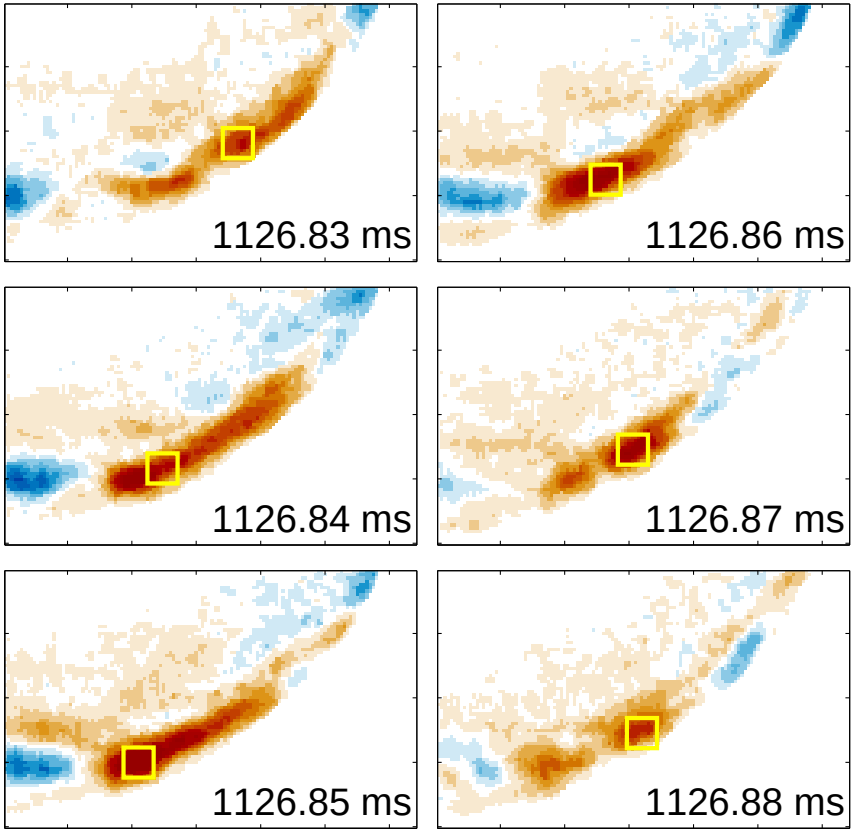
Results of NSTX blob statistics in L and H regimes are in agreement with TJ-II observations during spontaneous shear flow (close to marginal stability) development.

Biasing-induced improved confinement regime in TJ-II



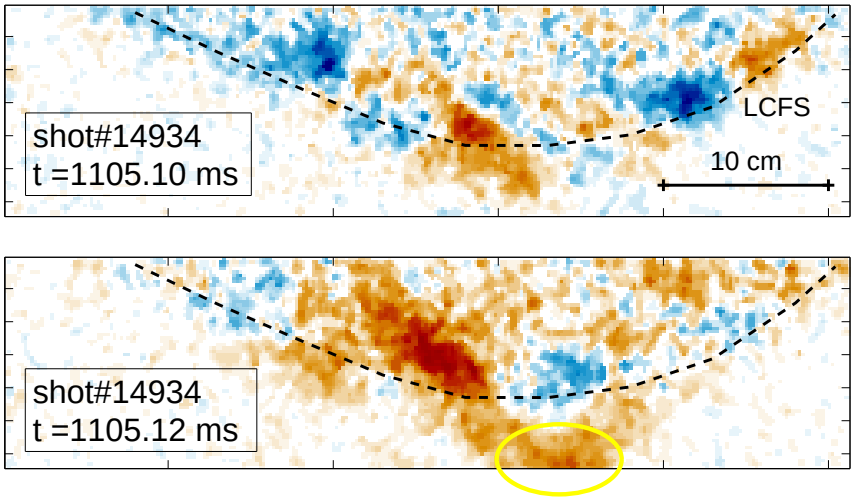
There are some evidence that the turbulence reduction during external biasing might be scale-selective.

Time scales for sheared flow development



Flow reversal can be seen to happen in few tens of μs ($\sim 50\mu$s)$\longrightarrow$ few turbulence autocorrelation times.

Radially propagating blobs in the SOL (*with intensified camera*)

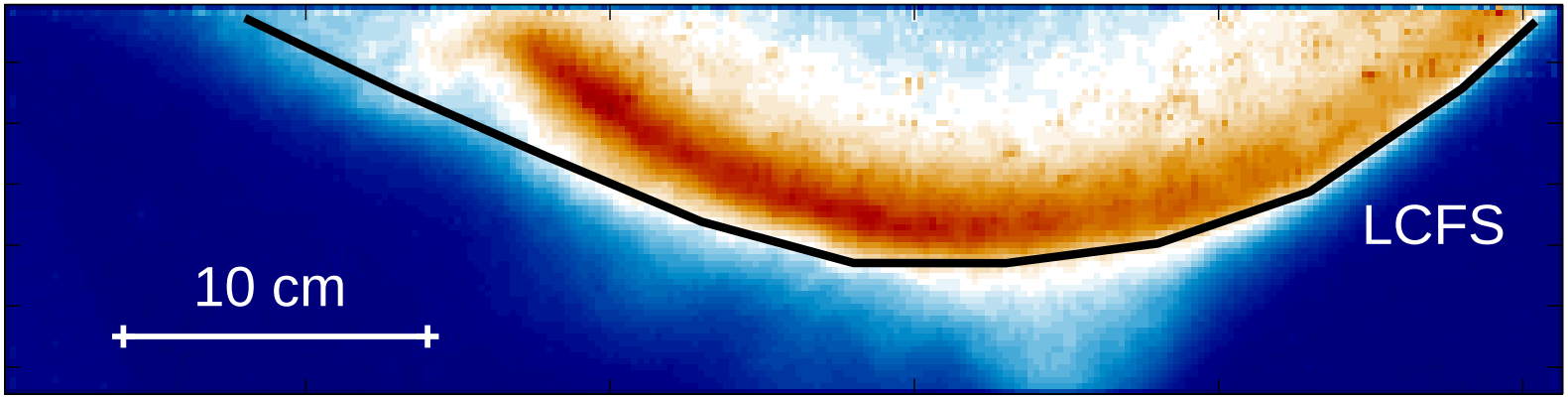


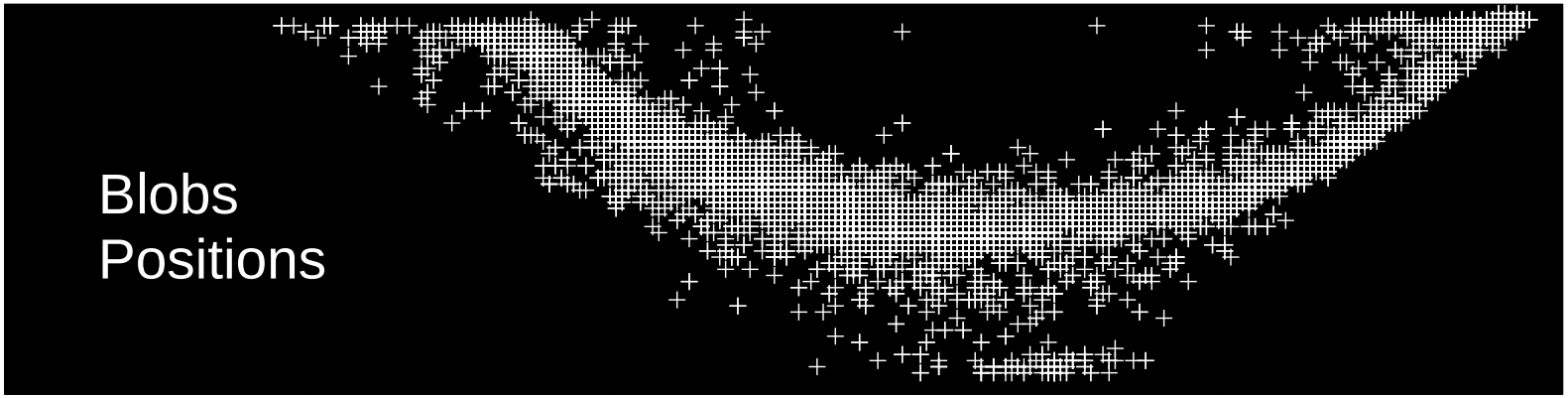
v_r up to 1000 m/s
(In the tail of $v_r = \frac{\langle \Gamma_{E\times B} \rangle}{\langle n \rangle}$ PDFs)

Importance of the dependence $v_r(k)$.
Bigger blobs propagate faster/slower?
[S Krasheninnikov, *Phys. Rev. A* 2001, O E Garcia *et al*, *Phys. Plasmas* 2005]

Inhomogeneous blob distribution in the SOL

Spatial distribution of detected structures in the SOL is poloidally inhomogeneous.





Conclusions

- Fast camera measurements have been found to be in good agreement with HIBP and Langmuir probes in TJ-II.
- The spontaneous shear flow in TJ-II seems to stretch and order the structures. Similar behavior is found in NSTX when going from L to H regimes.
- During NSTX H-mode and Biasing-induced Improved Confinement Regime in TJ-II, structures where seen to decrease in number.
- Large coherent structures are seen in the SOL of TJ-II. Their spatial distribution seems to be poloidally inhomogeneous.
- Fast visible camera is a valuable plasma diagnostic from which qualitative and quantitative information can be extracted.