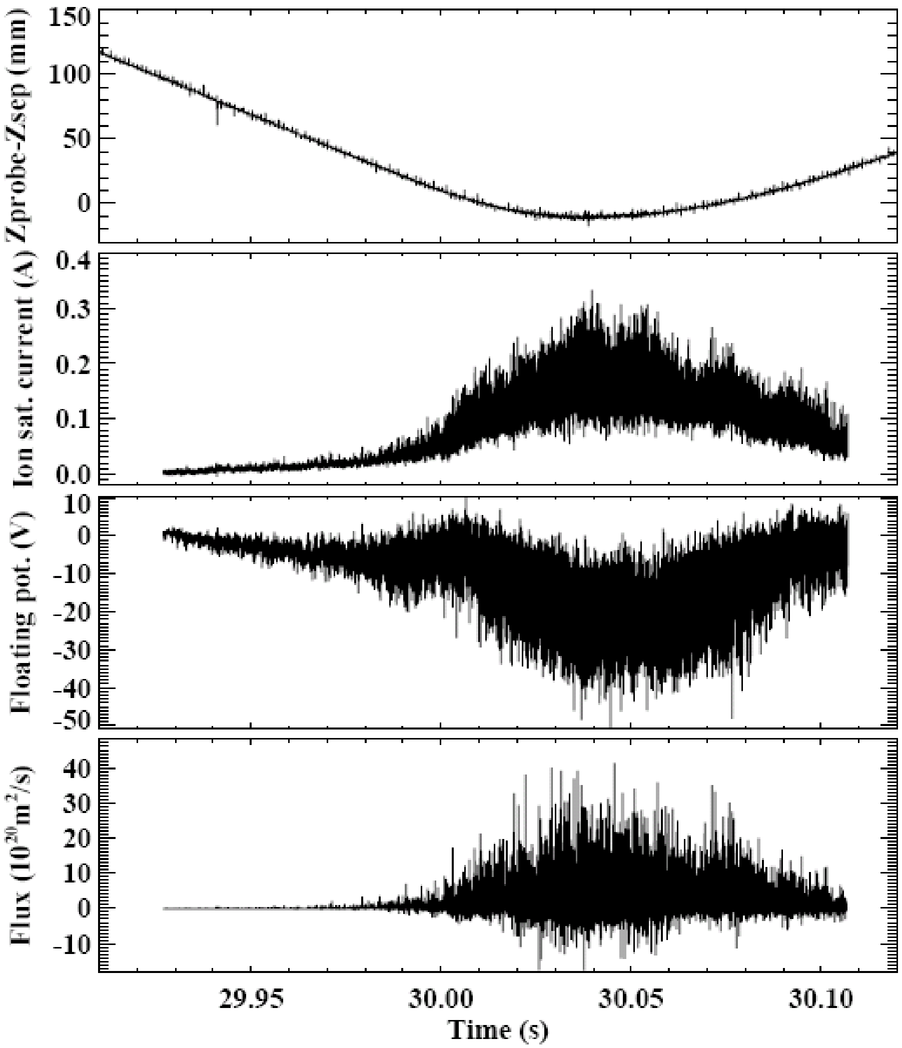
DATA ANALYSIS

Probe data

Probe data looks “noise” but fluctuations contain important information on different edge physics phenomena



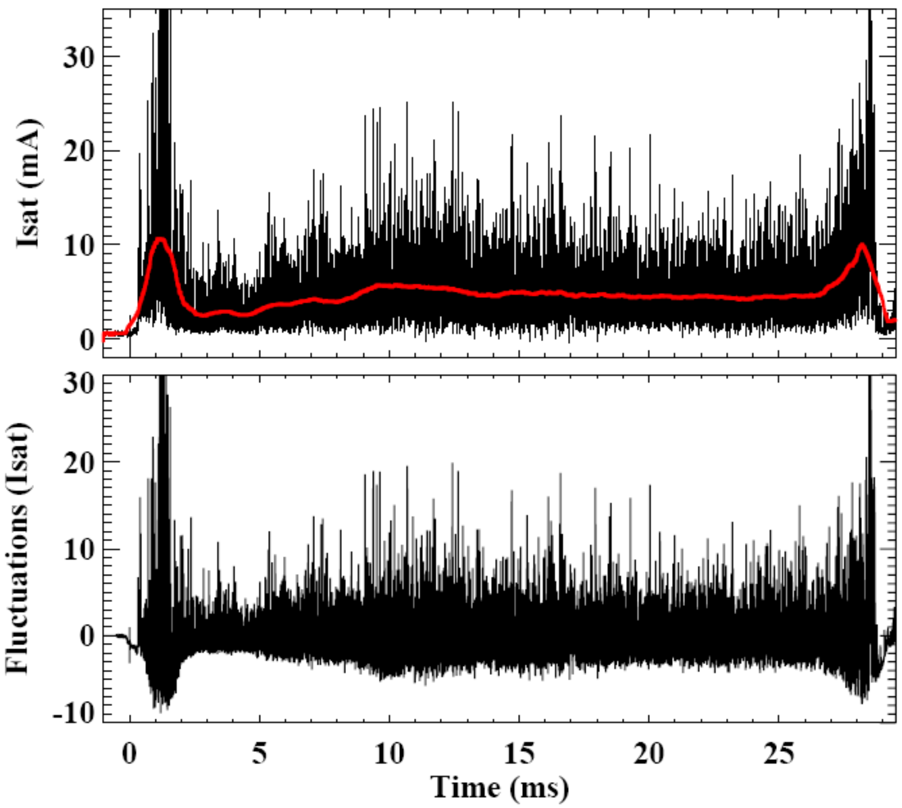
Removing trend

Mean + fluctuations

Fluctuations

F(t) – mean [f(t)]

- *Sliding average: F(t) – smooth[f(t),N]* or filtering the signal to remove the trend
- *NΔt* larger than the time scales of interest *N ~ 1000 (~ 1ms)*

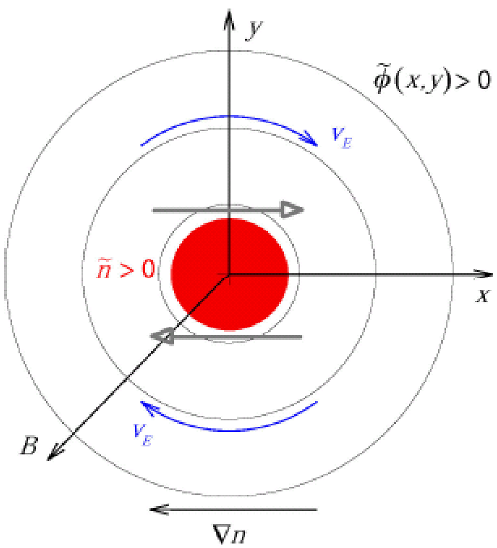


Turbulent particle flux

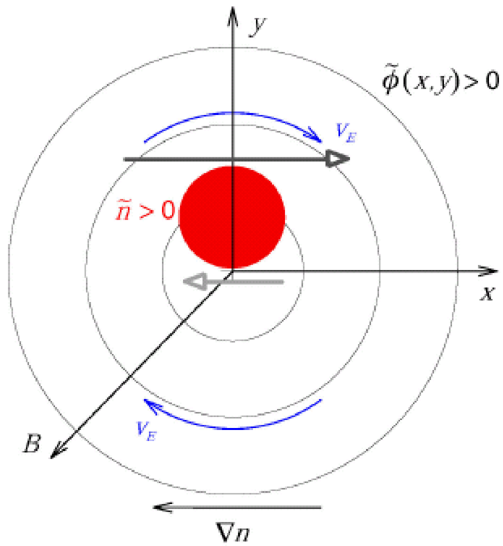
If local density and E_θ fluctuations are in phase then a net time-averaged radial transport exists

$$\tilde{E}_\theta \rightarrow \tilde{v}_r = \frac{\tilde{E}_\theta}{B} \qquad \Gamma_{E\times B} = \frac{\langle \tilde{n}\tilde{E}_\theta \rangle}{B}$$

no net transport



net transport

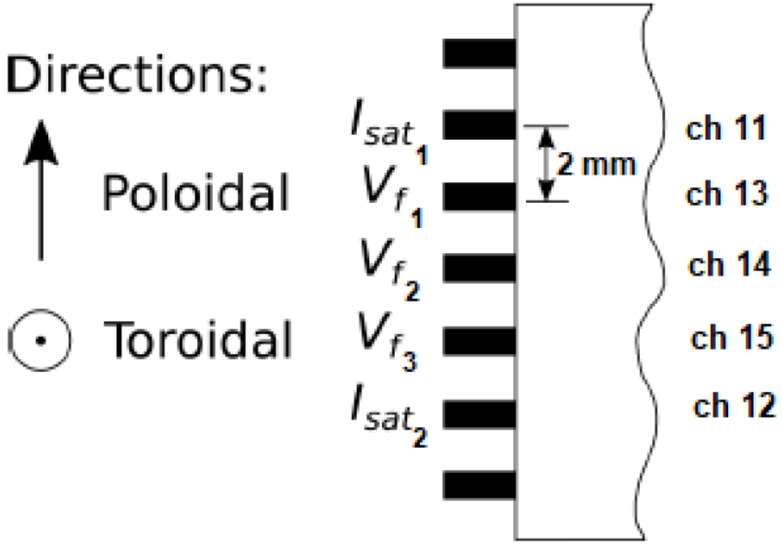


Data to be used

Discharges:

41168 - 70

41172 - 75



IDs

PCIE_ATCA_ADC_16.BOARD_1.CHANNEL_012 Isat

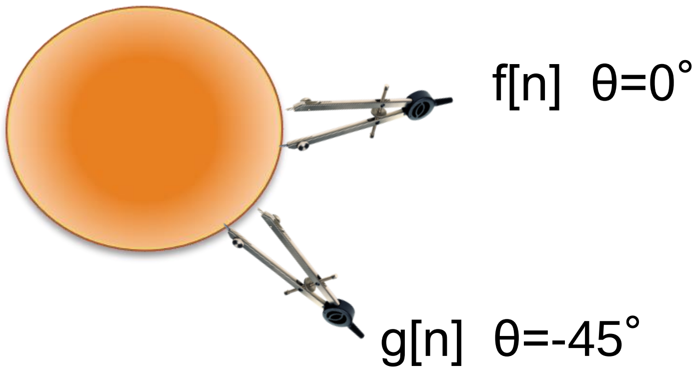
PCIE_ATCA_ADC_16.BOARD_1.CHANNEL_013 Vf

PCIE_ATCA_ADC_16.BOARD_1.CHANNEL_014 Vf

Analysis steps

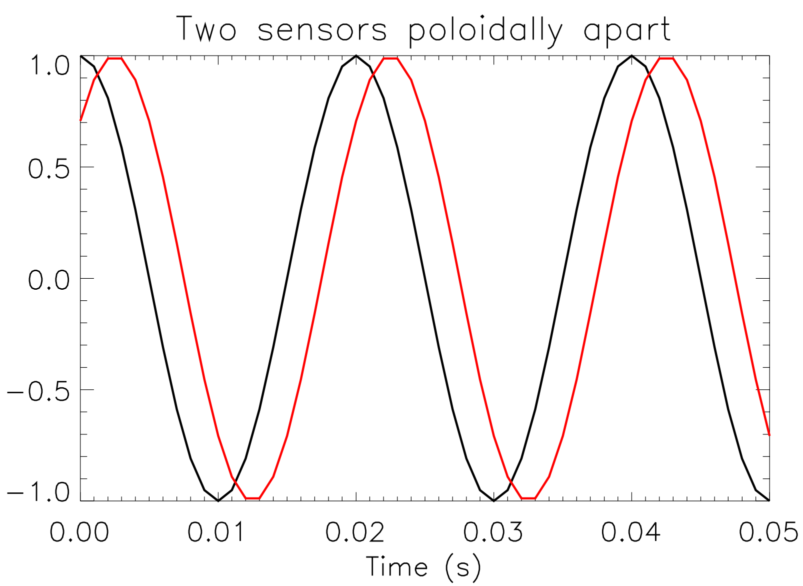
- Estimate fluctuations in Vf1, Vf2 and Isat by removing tend averaged over 1 ms
- Estimate fluctuations in radial velocity, B = 0.5 T, d = 2 mm
- Instantaneous flux = Isat * vr
- Calculate evolution of mean flux over 1 ms

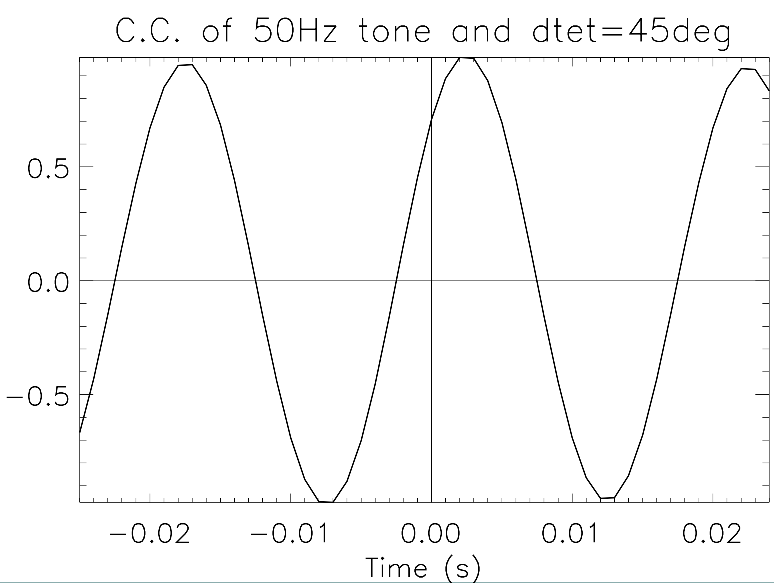
Cross-correlation



Time delay analysis

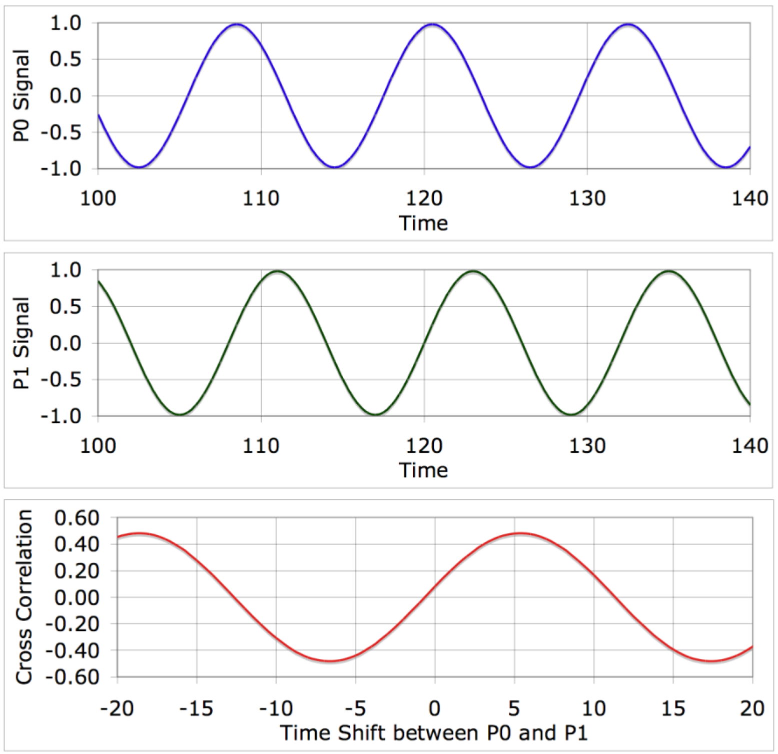
v = Δx/Δt



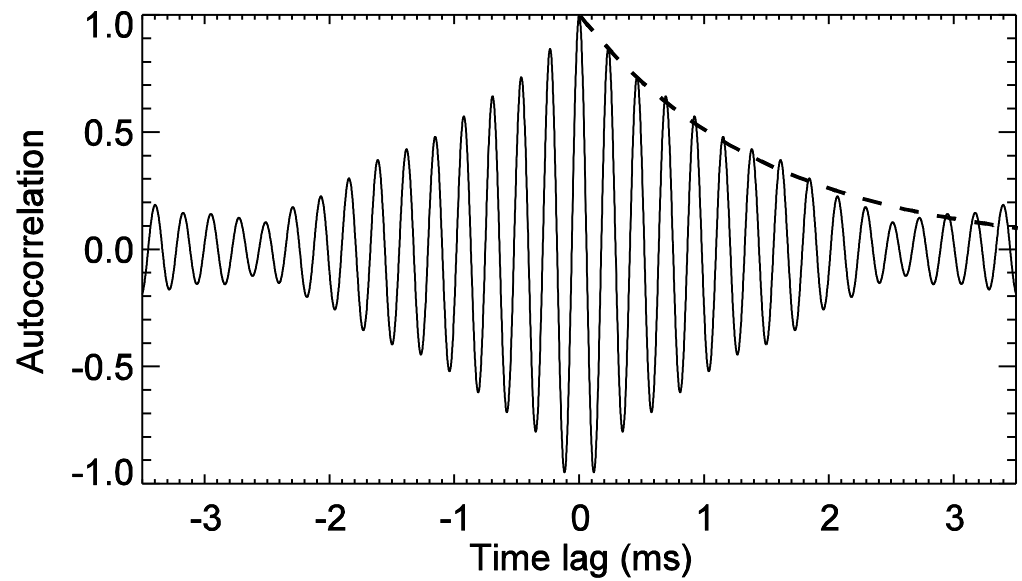


Cross-correlation

$$C_{xy}(\tau) = \langle [x(t+\tau) - \bar{x}][y(t) - \bar{y}] \rangle \Big/ \sqrt{\langle [x(t) - \bar{x}]^2 \rangle \langle [y(t) - \bar{y}]^2 \rangle}$$

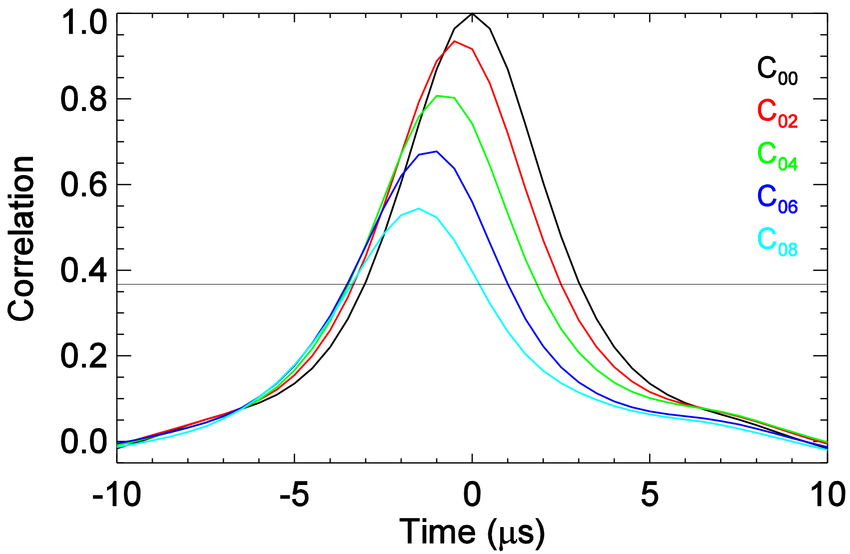


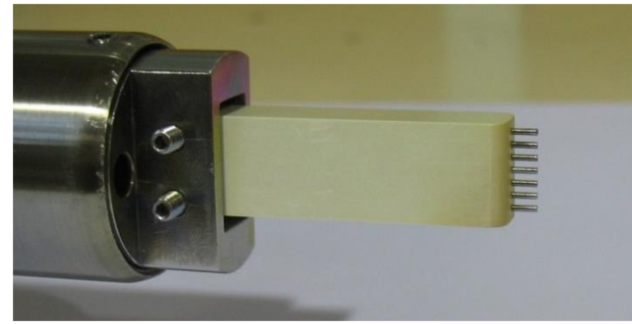
- If the phase is not coherent in time (noise) (correlation time >> period)



Cross-correlation

correlate(x1,x1, time lag)
correlate(x1,x2, time lag)
correlate(x1,x3, time lag)
...



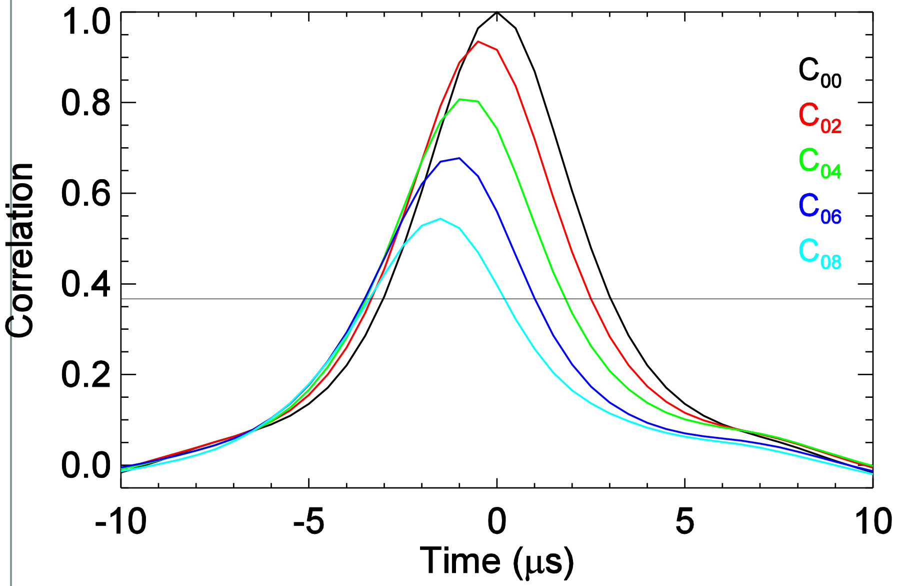


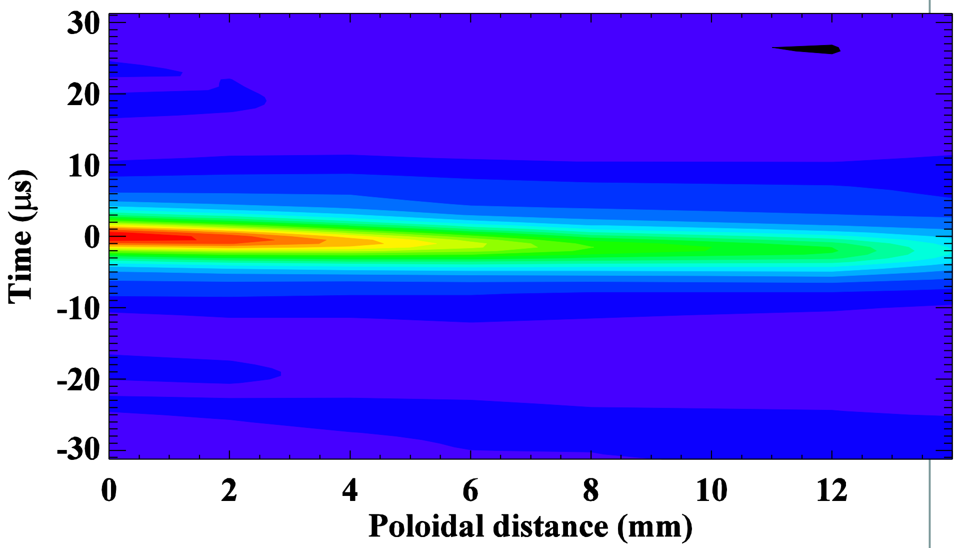
$$C_{xy}(\tau) = \frac{\langle [x(t+\tau) - \bar{x}][y(t) - \bar{y}] \rangle}{\sqrt{\langle [x(t) - \bar{x}]^2 \rangle \langle [y(t) - \bar{y}]^2 \rangle}}$$

numpy.correlate
important to read documentation

```
a = (a - np.mean(a)) / (np.std(a) * len(a))
b = (b - np.mean(b)) / (np.std(b))
c = np.correlate(a, b, 'full')
```

Cross-correlation





Parameters estimated from cross-correlation

- Propagation velocity (time delay)
- Size of the structures : $\Delta x = v.\Delta t$
- Characteristic time of the fluctuations

Home work

- 8 pins vertically separated by 2 mm measuring Isat
- Discharge: 16574
- ID: IONIC.TR512_B02.CHANNEL_0 (top) a _7 (bottom)

- Determine the poloidal structure of the electrostatic fluctuations as well as the plasma poloidal rotation velocity using the cross-correlation

- Remove trend in a time scale of 1 ms
- Use windows of 2-5 ms during the discharge flat-top