29-2-3

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Fluctuation measurement across the broad range of the low-field side edge plasmas in the TST-2 spherical tokamak

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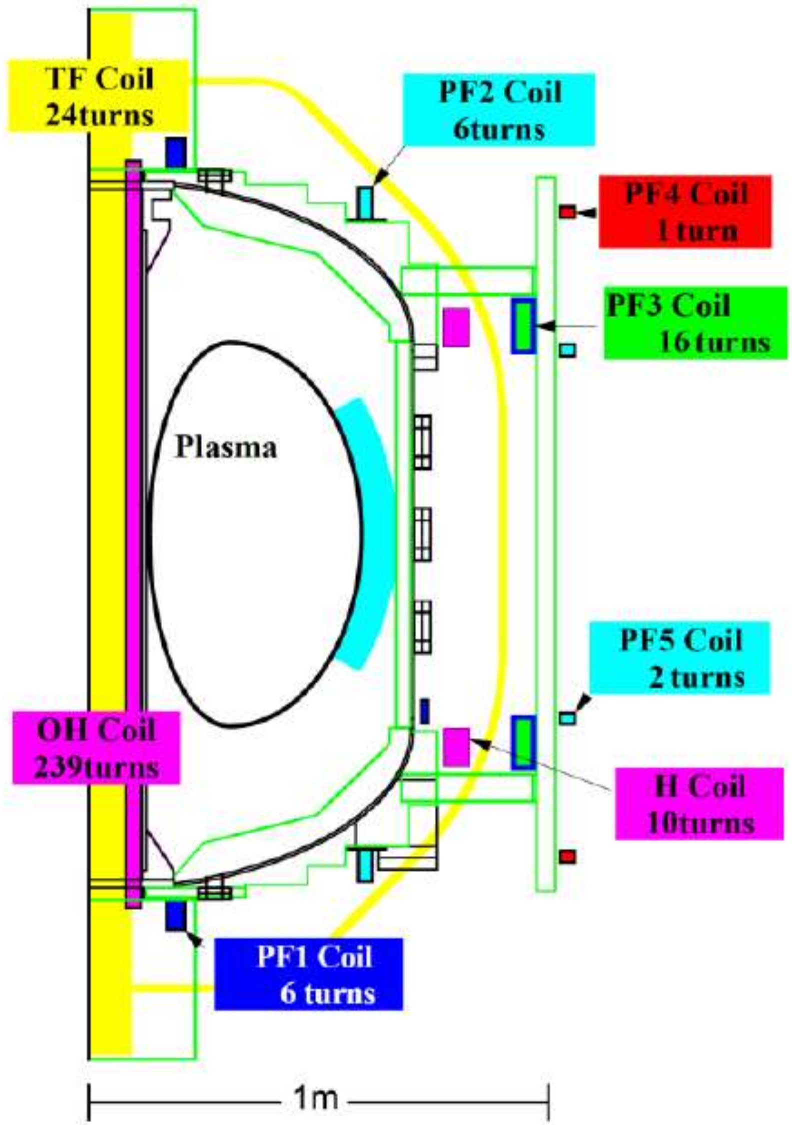
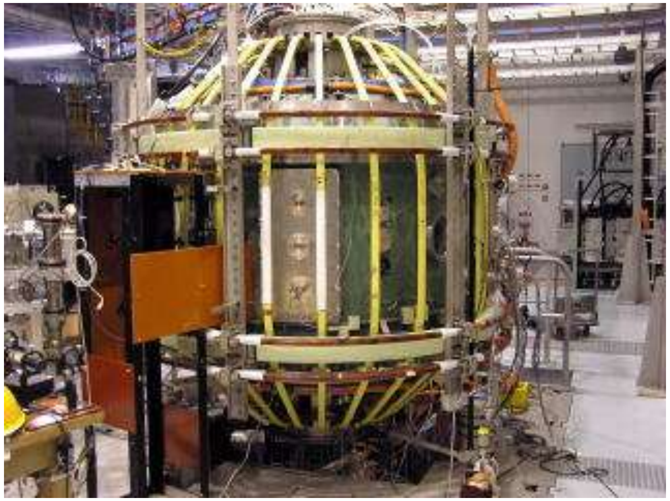
Motivation

- In fusion plasma community, study on **anomalous transport by turbulence** is important to control the transport and plasma operation.
- Recent researches of turbulence have pay special attention on **nonlinear**, **non-local**, **non-stationary** properties of **multi-scale turbulence**.
- Laboratory small tokamak machines have advantage of **turn-around** to explore physics study in detail by using **Langmuir probes**.

We aim to contribute fusion physics to explore nonlinear saturation of turbulence under various plasma operation.

TST-2 spherical tokamak





Plasma control method:

OH coil

Shaping coil

gas

RFs for heating and current drive

Major radius R ∼ 0.38 m

Minor radius a ∼ 0.25 m

Aspect ratio A = R/a > 1.5

Toroidal field B_t <0.3 T

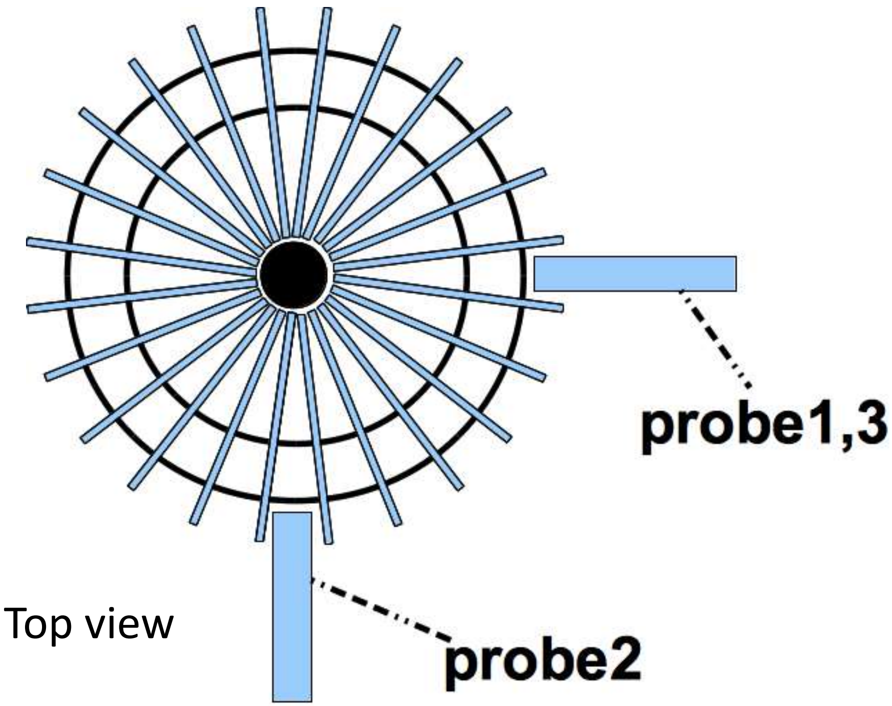
In OH plasmas,

Plasma current I_p ∼ 80 kA

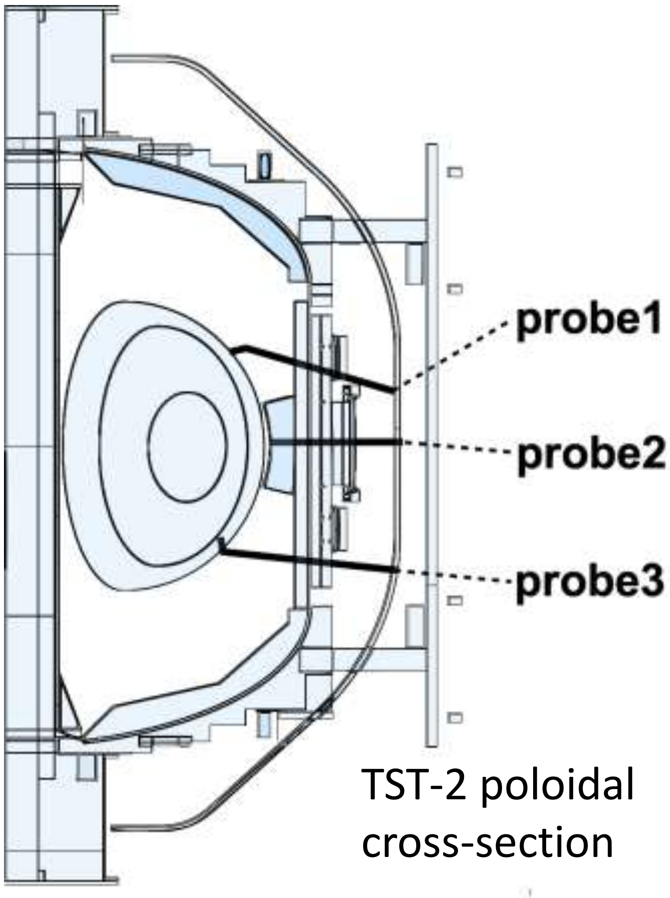
Discharge duration Δt < 40 ms

Locations of Langmuir probes (LP)

- Two LPs (probe 1 and 3) are on the same poloidal cross-section.
- One LP (probe) is located at the midplane, toroidally -90 degree distant from the poloidal cross-section on which the probes 1 and 3 are.

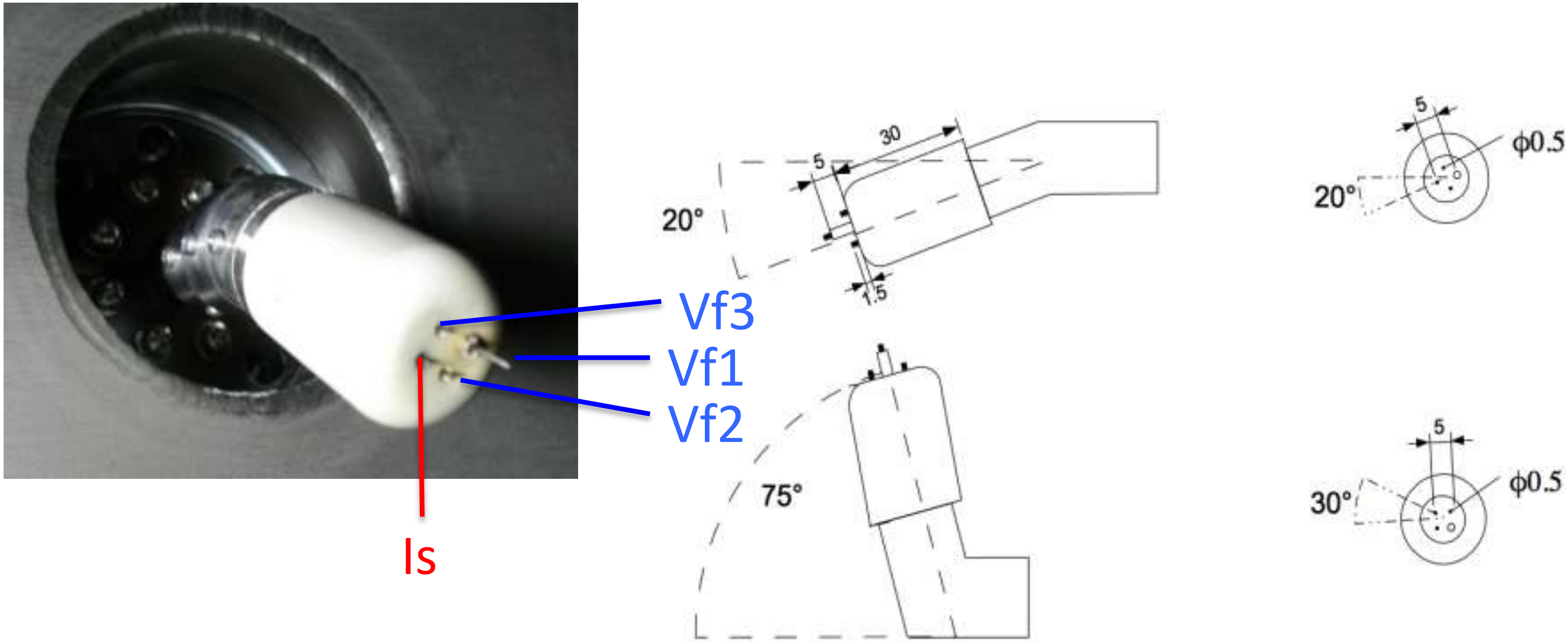


Top view



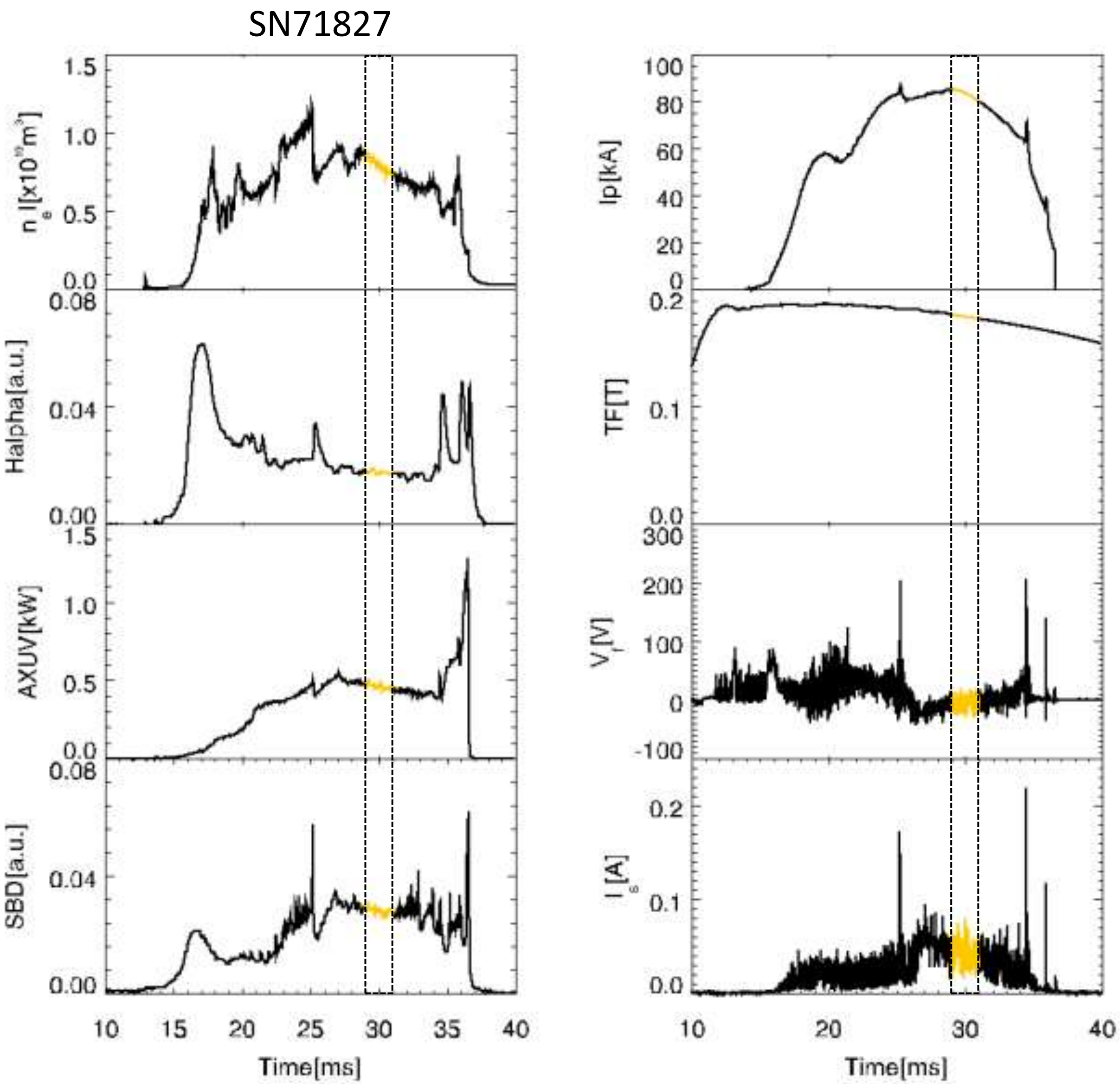
TST-2 poloidal cross-section

Enlarged view of the LP



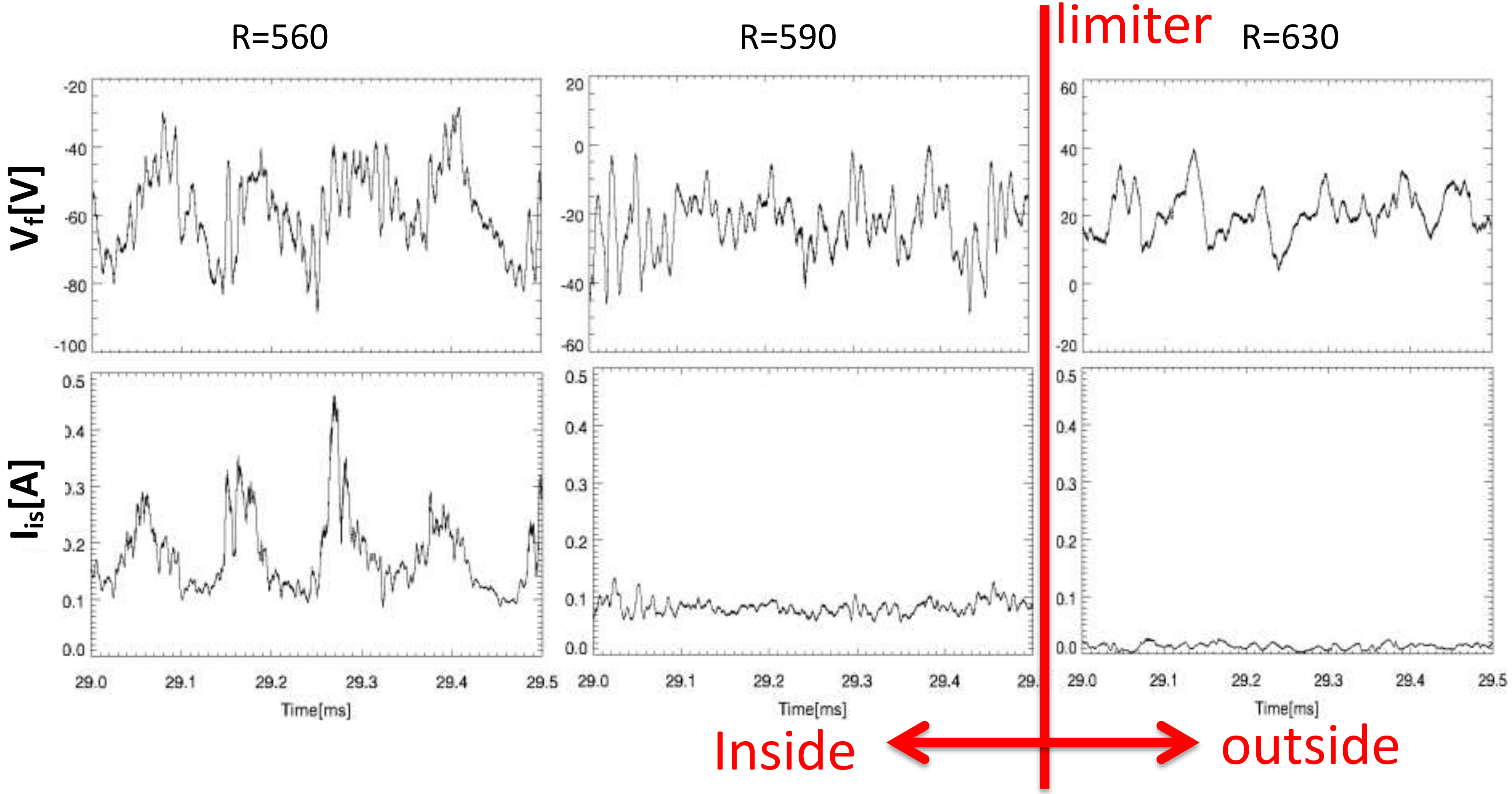
- The LP (probes 1 and 3) have four electrodes, isolated by BN insulator one another.
- Ion saturation current (I_{is}), floating potential (V_f), stationary T_e , etc. were measured.

Discharge waveforms



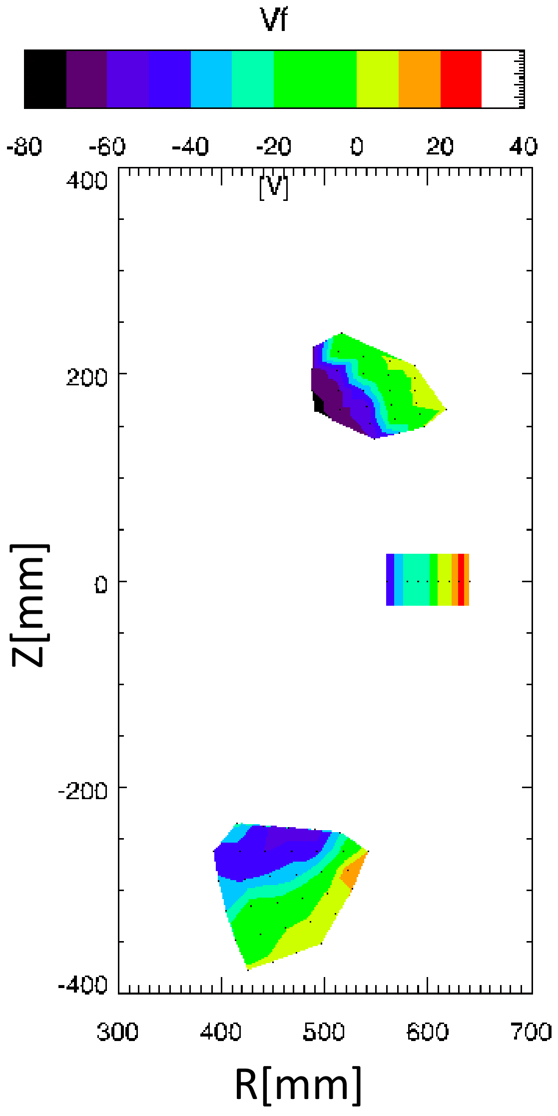
- An OH plasma with good reproducibility is chosen as the target.
- We analyzed stationary fluctuation data of I_{is} and V_f during 29 ~ 31 ms (dt >> $t_{autocorr}$).

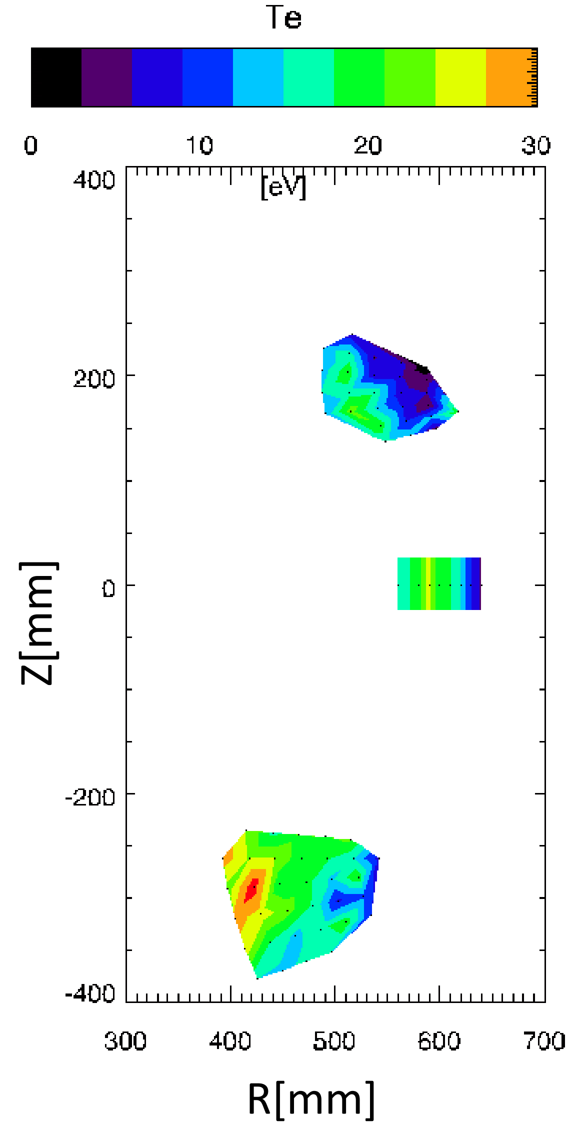
Raw signals at midplane



Fluctuation waveforms observed at different radial locations have wide variation.

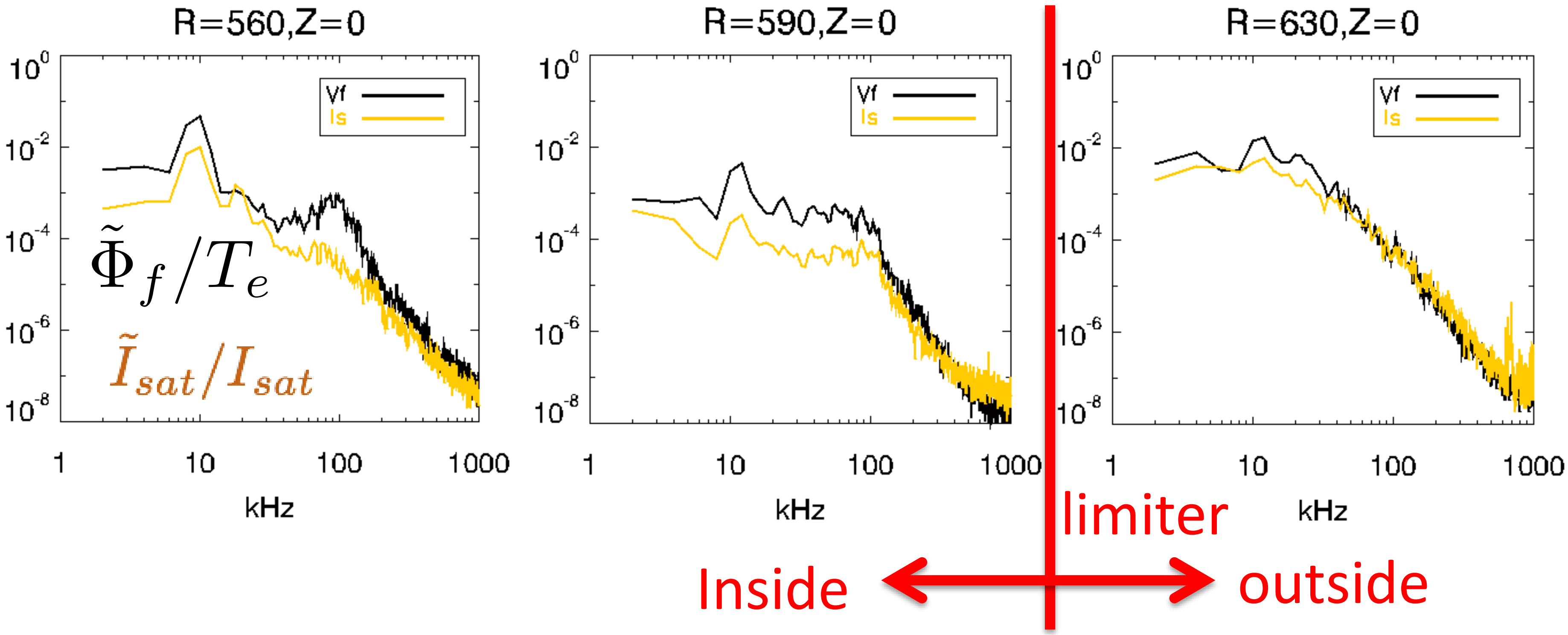
Poloidal profiles of average parameters





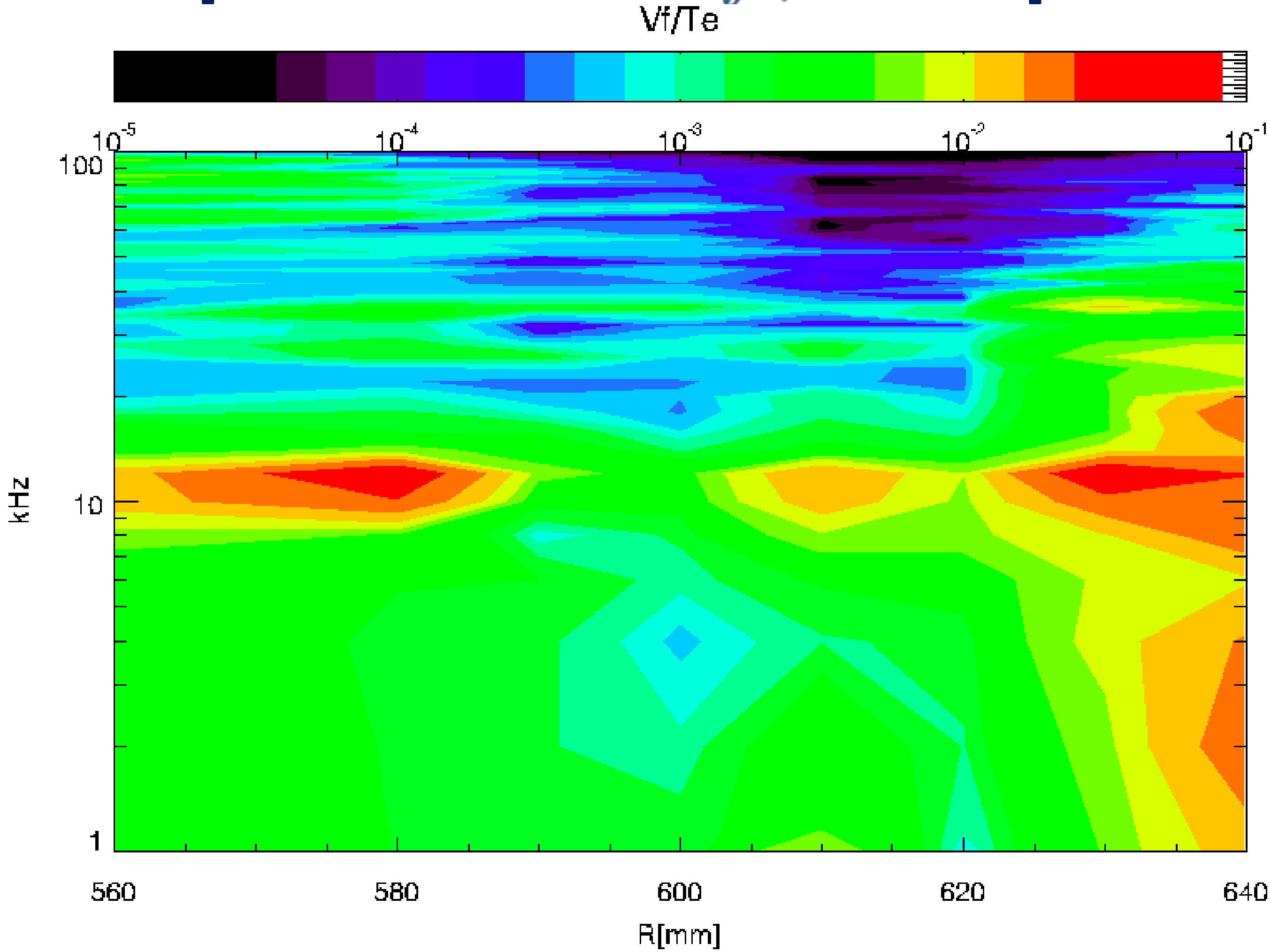
- T_e, and V_f are plotted.

Power spectra at midplane



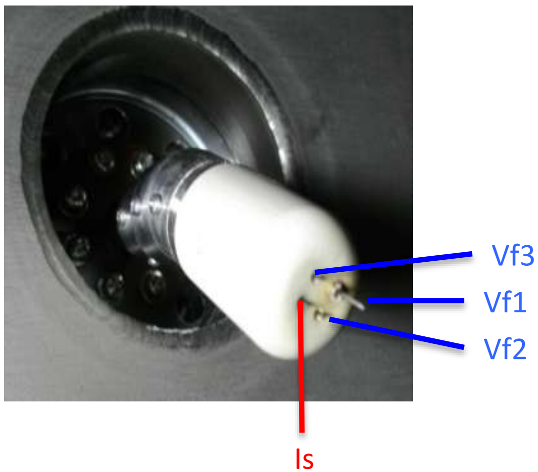
- V_f is larger than I_{isat} inside the plasma, and both intensities have similar magnitude outside the plasma.
- Spectral peak at 10 kHz is observed in the wide radial location.
- Spectral peak at ~70 kHz is mainly observed inside the plasma

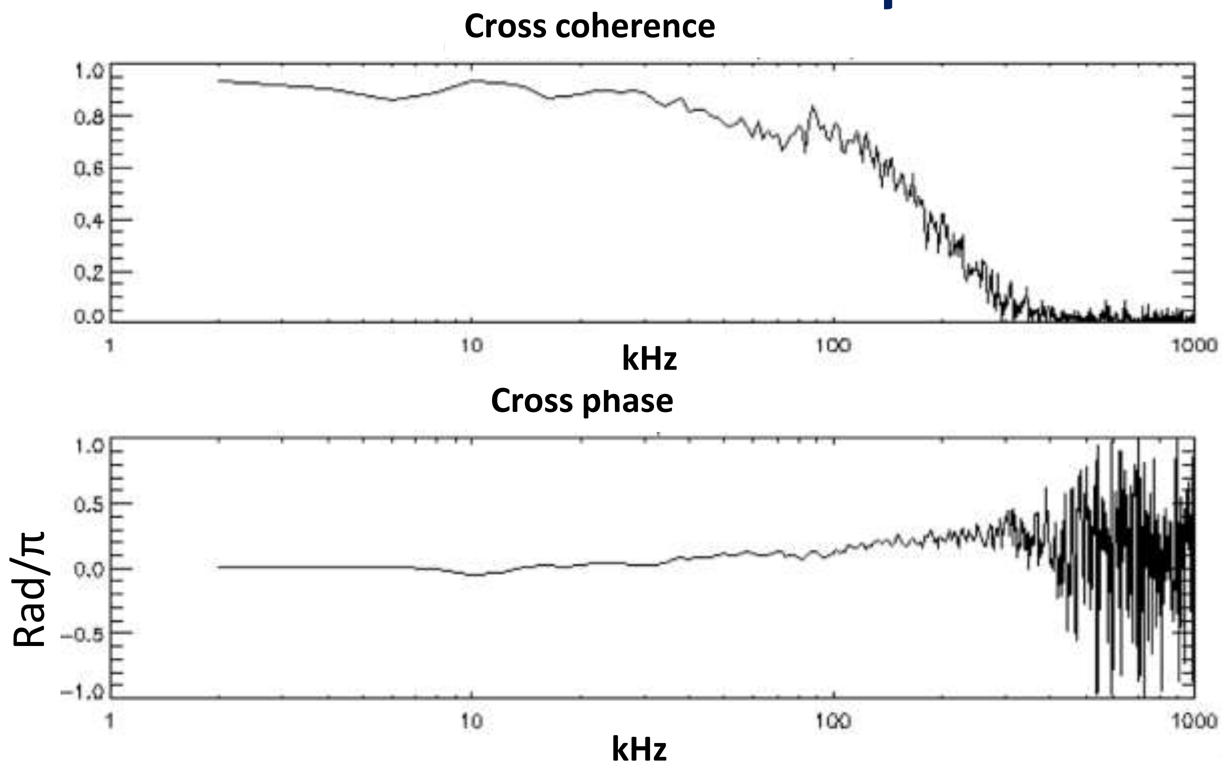
Radial profile of $\tilde{\Phi}_f / T_e$ spectra



- The 10kHz fluctuation distributes in the wide radial location.
- Fluctuations >30 kHz are large in R<600 mm

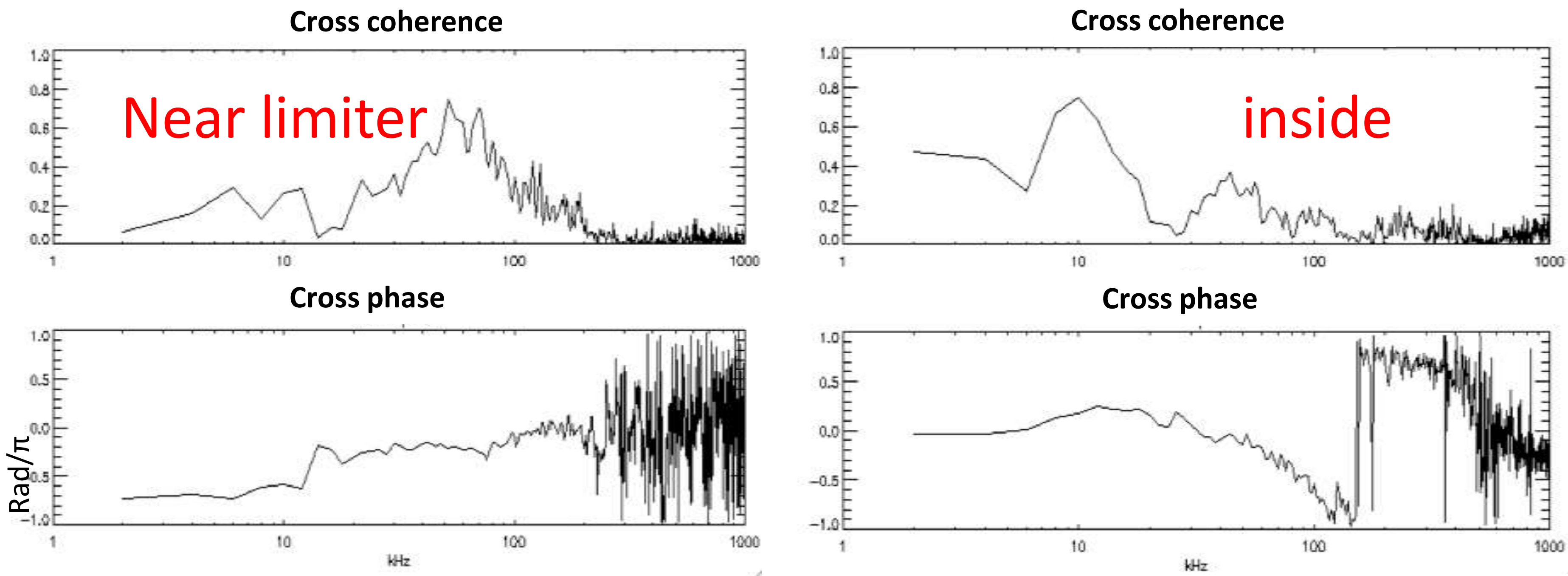
Poloidal coherence and phase between the two electrodes in the same probe





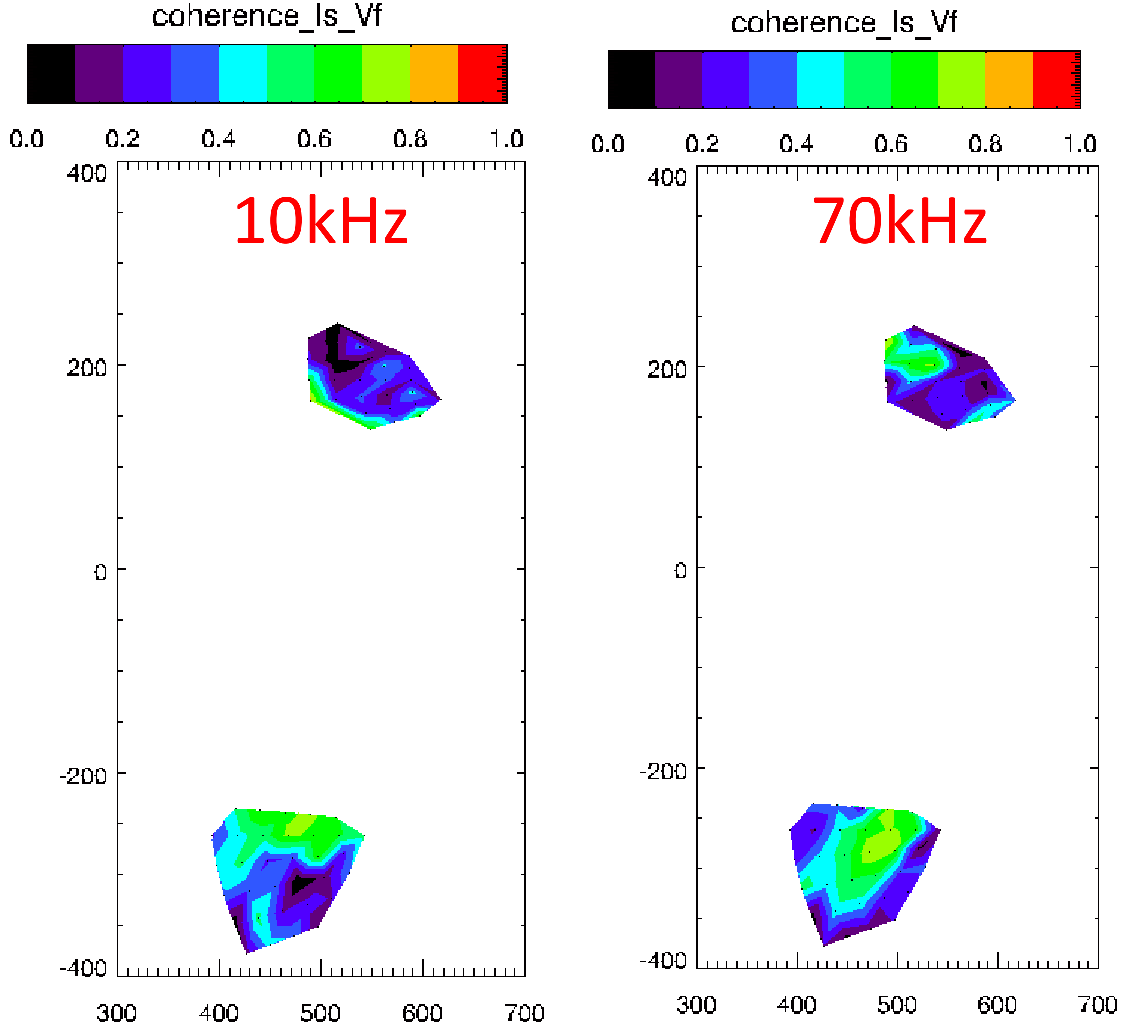
- Large coherence at *f*<200 kHz
- 10 kHz: ion diamag drift direction (λ_θ~a few 10s cm)
- 70 kHz: electron diamag drift direction (λ_θ~several cm)

Coherence and phase between V_f and I_s



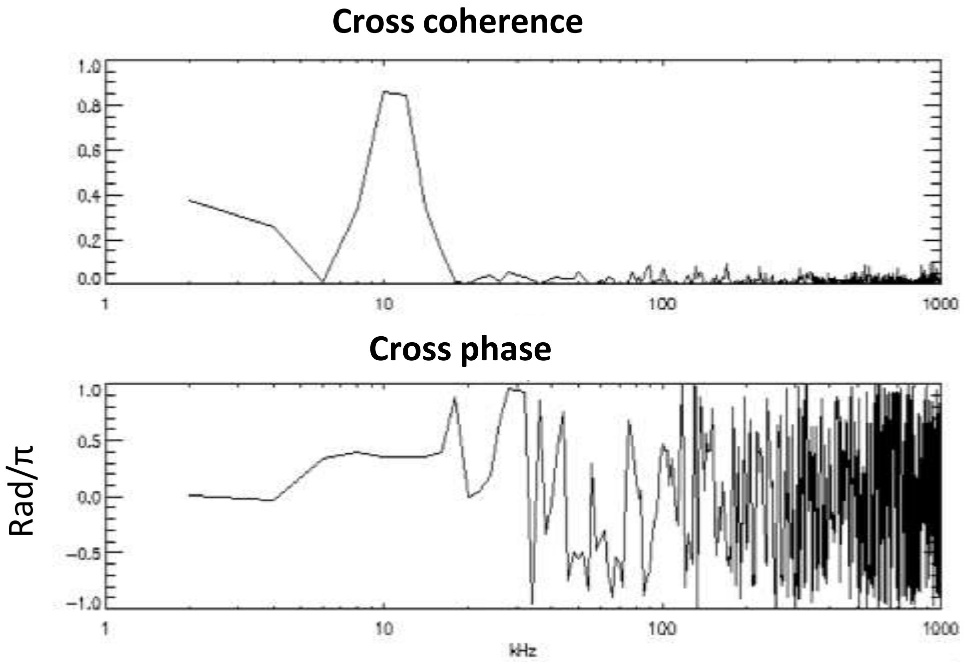
- Large correlation at 10kHz and 70kHz are observed.
- Correlation at 10 kHz outside the plasma are larger than that inside the plasma.
- Correlation at 70 kHz inside the plasma boundary are larger than that outside the plasma.

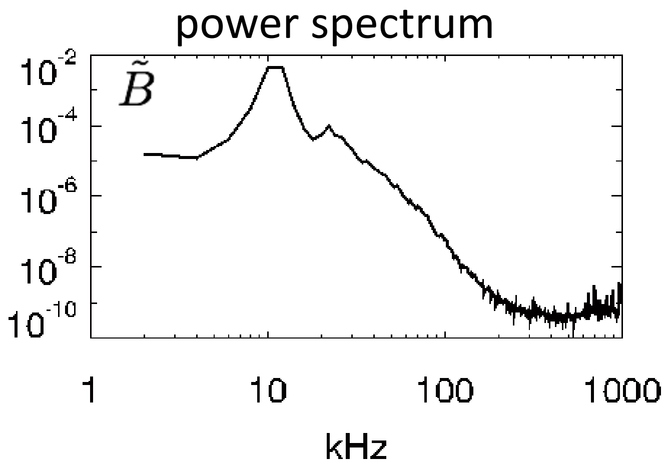
Poloidal profiles of correlation between I_s and V_f within the same probe



- Significant correlations between I_{is} and V_f are observed in the borad range of the low-field side plasma.
- Intensities of coherence are not homogeneous radially and poloidally.

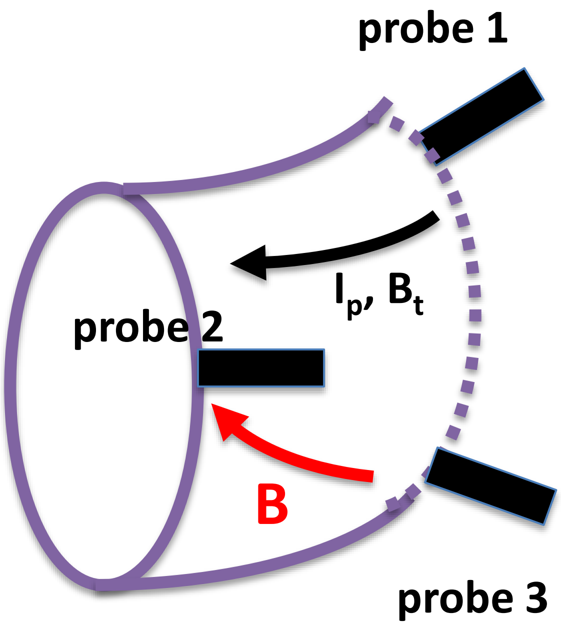
Correlation between V_f of the probe and magnetic fluctuation data on the wall

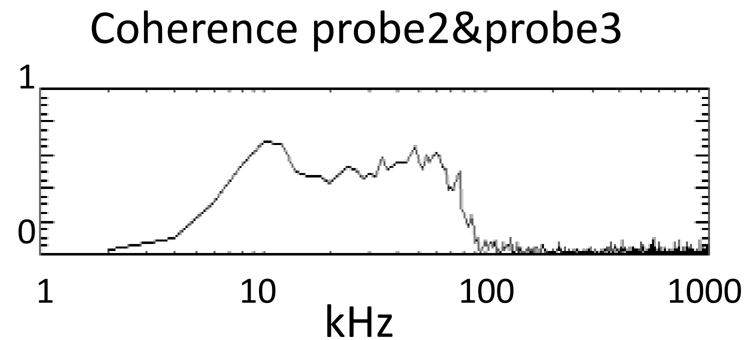


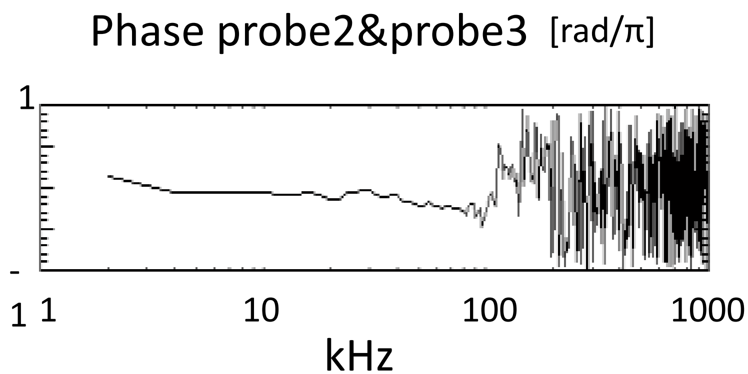


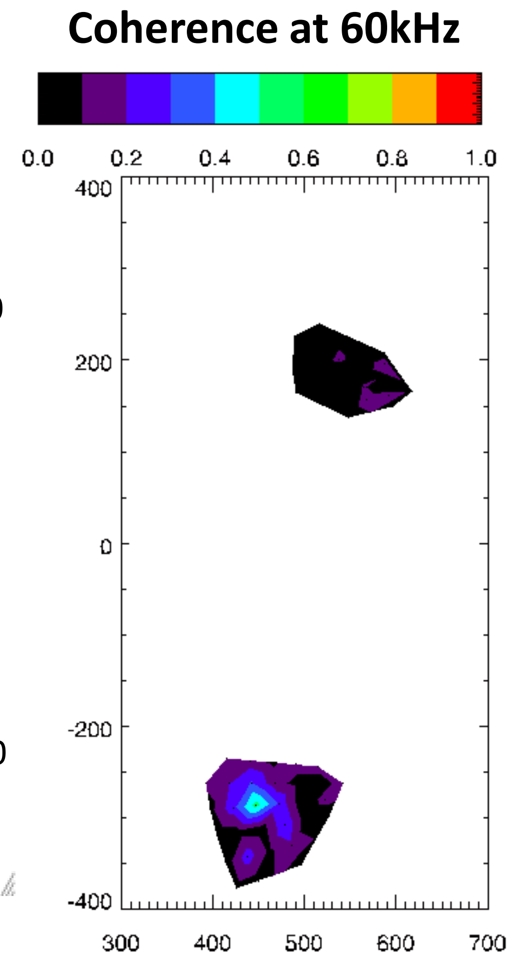
- Significant large correlation between V_f and magnetic fluctuation at 10 kHz.
- Fluctuation at 10kHz has significant magnetic components.

Long range correlation



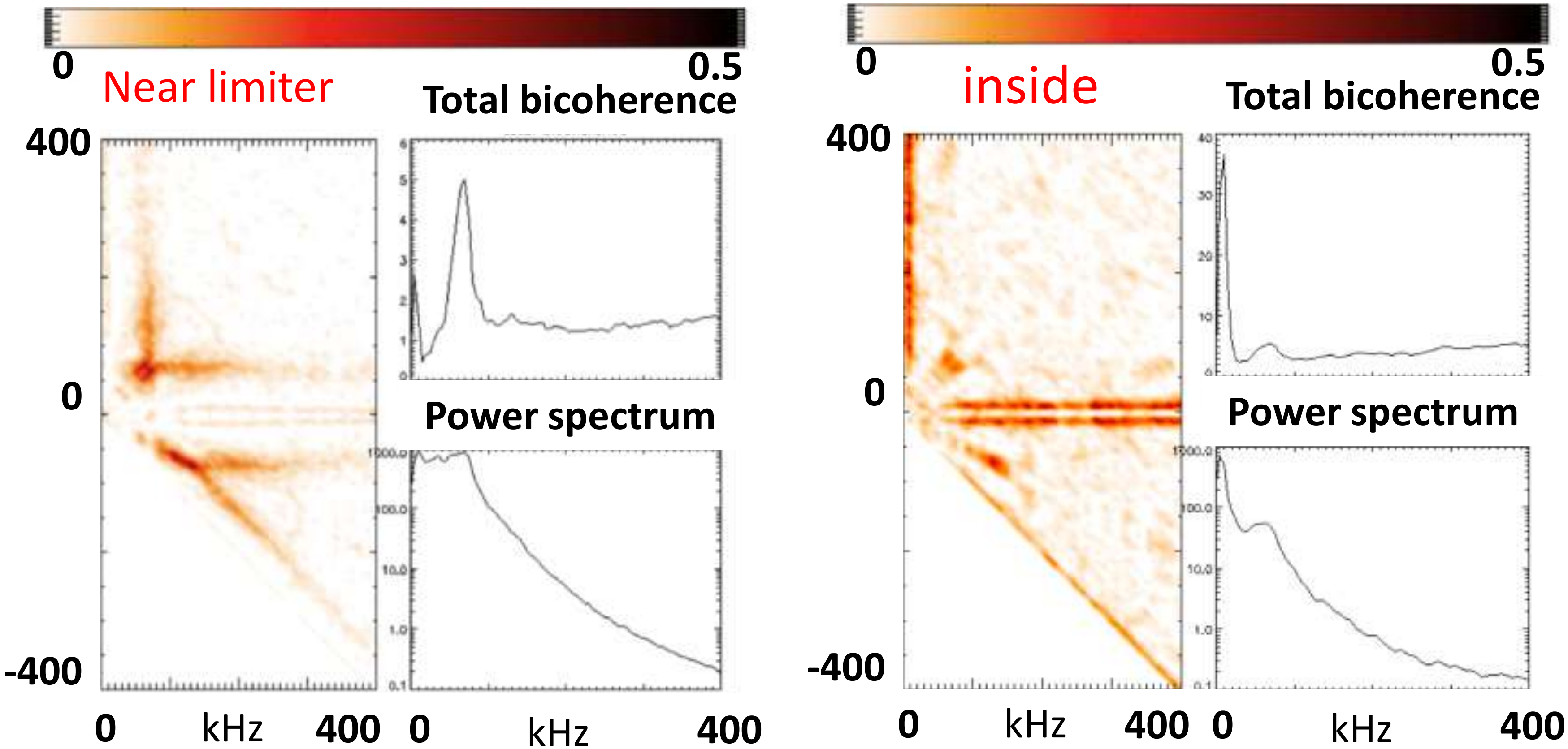






- **Long range correlations are analyzed between probe 1(probe 3) and probe2.**
- **Correlations are poloidally asymmetric. Large correlation between probe3 data and probe 2 data is observed at limited location.**
- **Connection along the magnetic field line is a candidate reason.**

Bispectral analysis of V_f fluctuation



- **Outside the plasma, magnetic fluctuation modulates turbulent fluctuations.**
- **Inside the plasma, 70 kHz fluctuation is nonlinearly coupled to turbulence.**

Summary

- Fluctuations in the broad range of the low-field side of TST-2 were preliminarily investigated.
- In LP data, spectral peaks at 10 kHz and 70 kHz are observed in the broad area.
- In the edge plasma, correlations I_{is} and V_f at 70 kHz are significant.
- Poloidally asymmetric long range correlation of fluctuations at f<100 kHz are observed.
- Bispectral analysis shows significant nonlinear coupling of 10 or 70 kHz to higher frequency components.

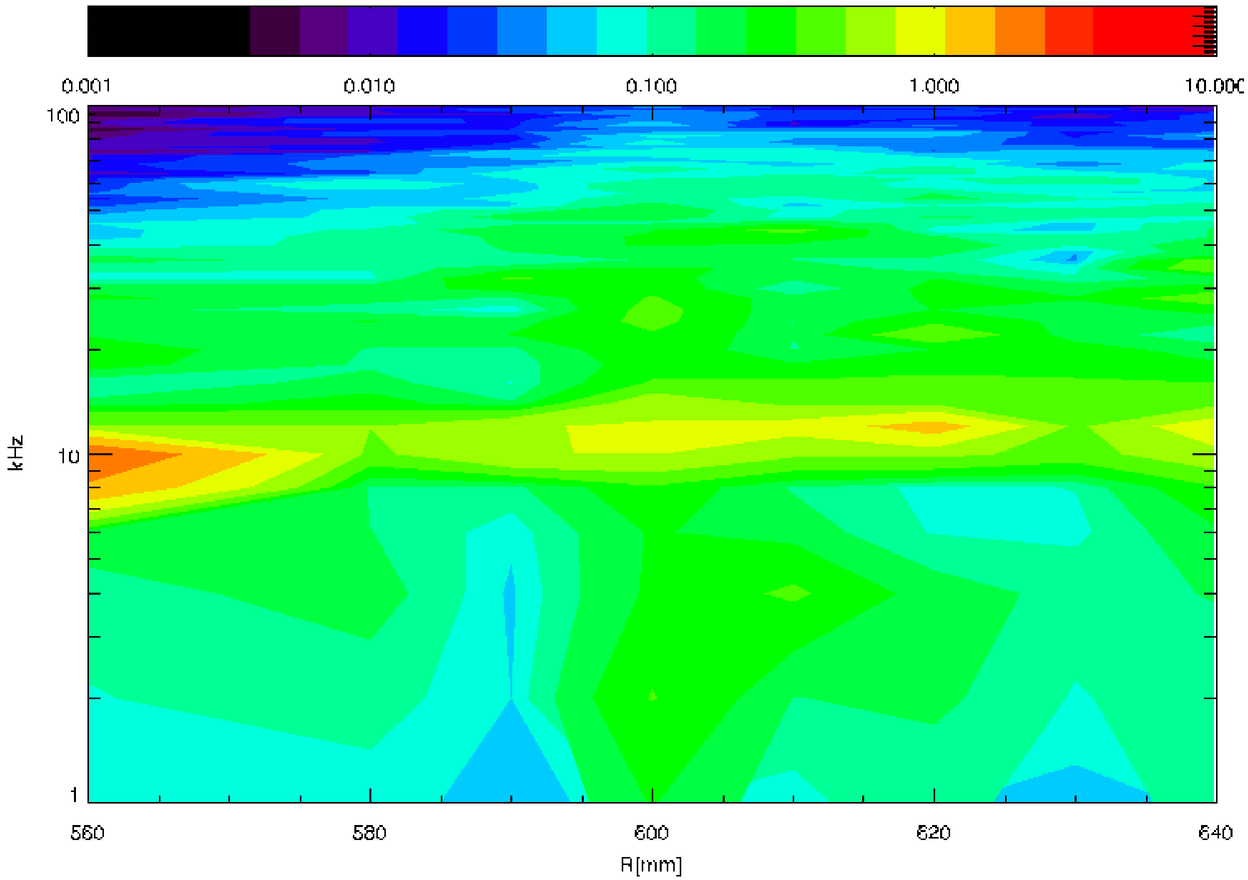
Future direction

- Development of equilibrium reconstruction in various case
- Magnetic measurement inside the limiter
- High field side fluctuation measurements
- Reynolds and Maxwell stress measurements
- Current measurement and its transport at low field side edge plasma.

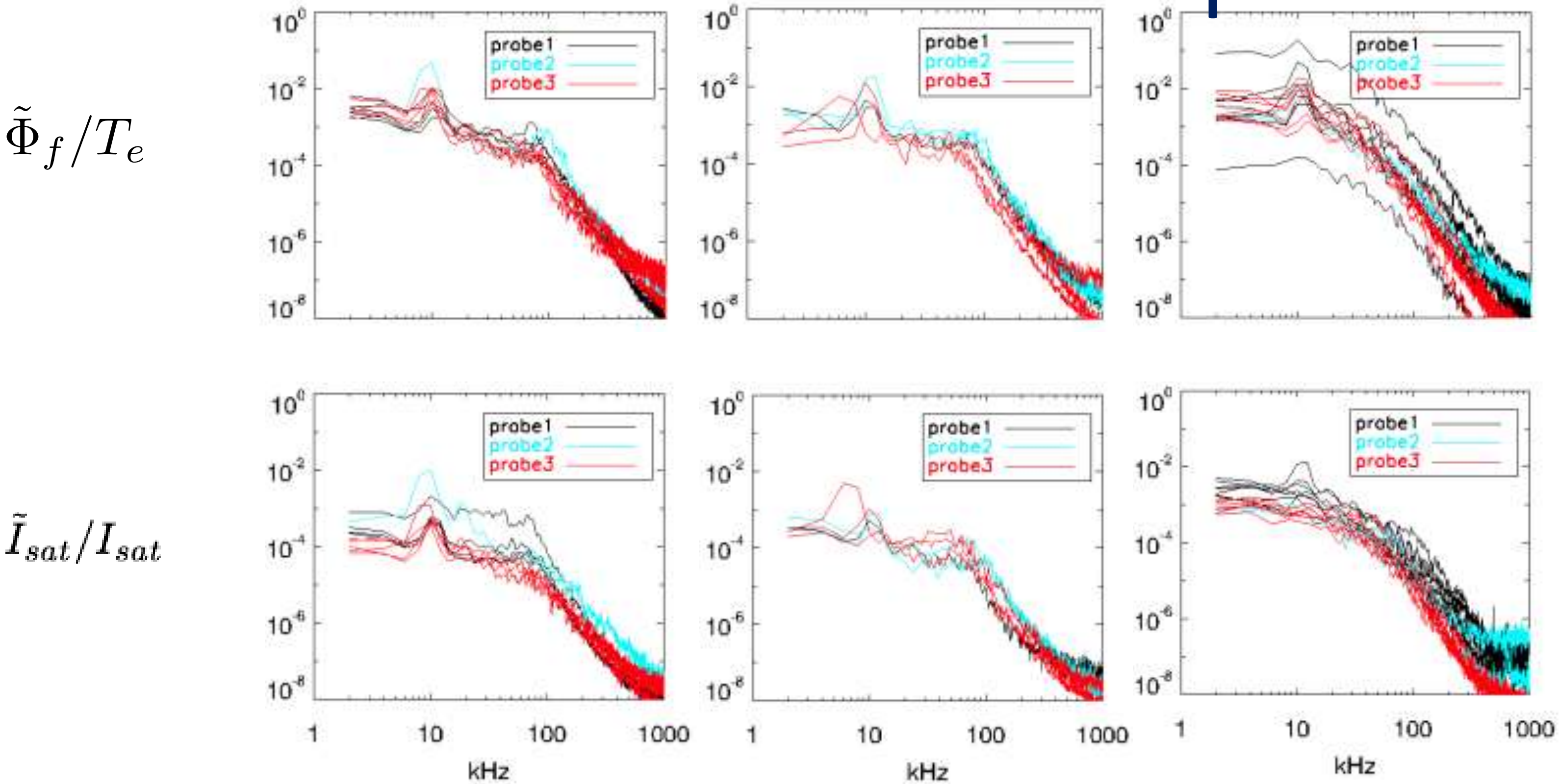
Acknowledgment

This work is supported by Grants-in-Aid for Scientific Research (B) 23360409, for Scientific Research (S) 21226021, and Scientific Research (A) 21246137 of JSPS, Japan.

Power spectra at the reference probe during radial scan of the midplane probe

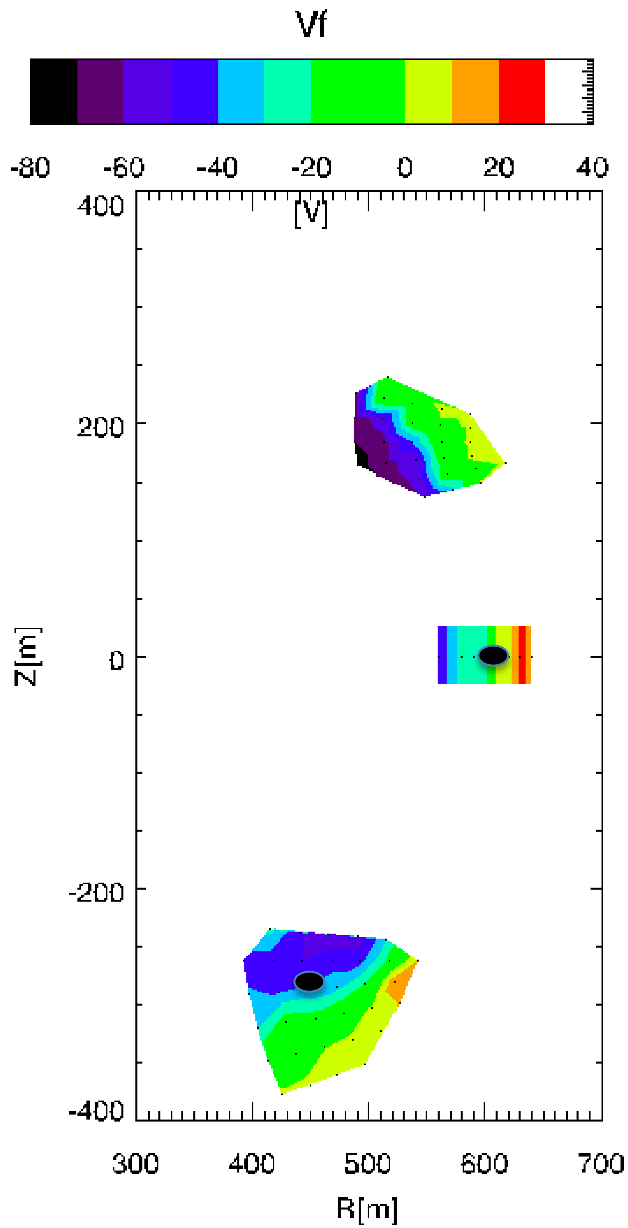


Comparison of power spectra measured at the different poloidal locations with the same V_f values



-60~-45V   -35~-25V   0~10V

Vf profile



Two-points where the long-range correlation was observed.