Characterization of density fluctuations during inter-ELM periods in the MAST spherical tokamak

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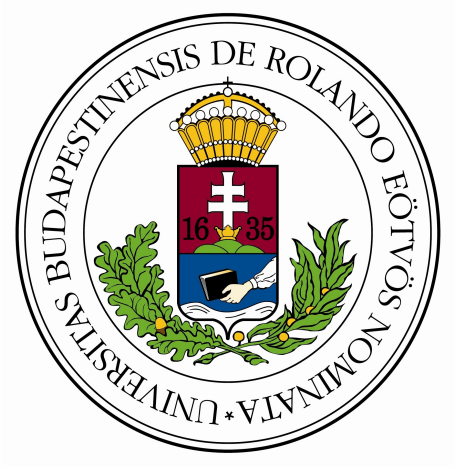


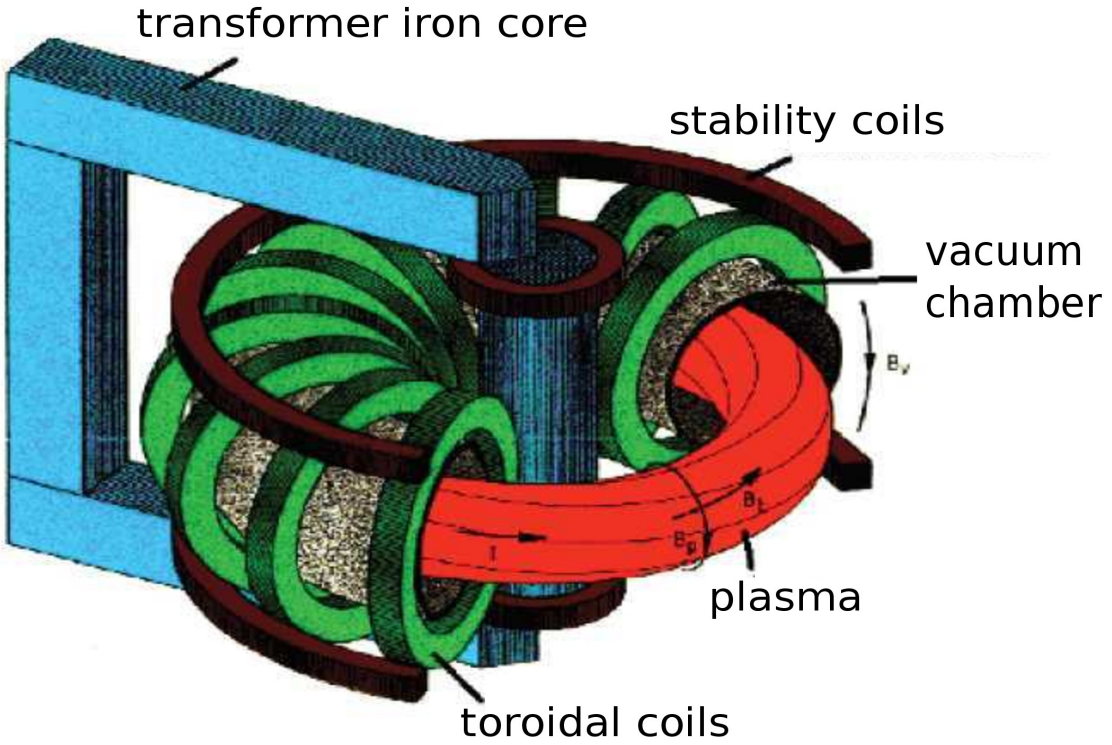
Particle and Astroparticle Physics Autumn Programme 2016

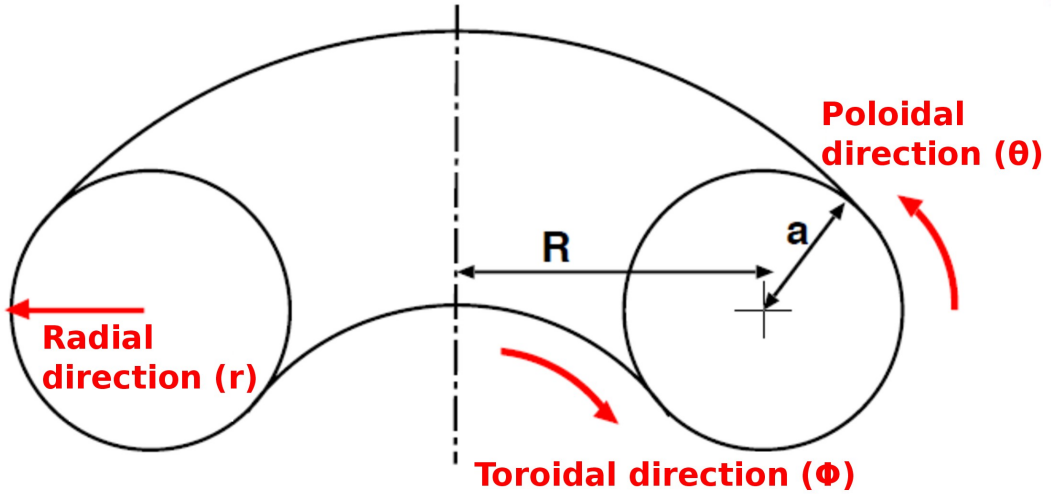
Fusion devices – The tokamak

- Lawson-criteria: $n\tau_E T = 10^{21}\, keV\, \frac{s}{m^3}$
- Tokamak parameters:

$$n \approx 10^{21} m^{-3}$$
$$\tau_E \approx 0{,}1\, s$$
$$T \approx 10\, keV$$

- Field lines closing in torus shape with helical distortion.





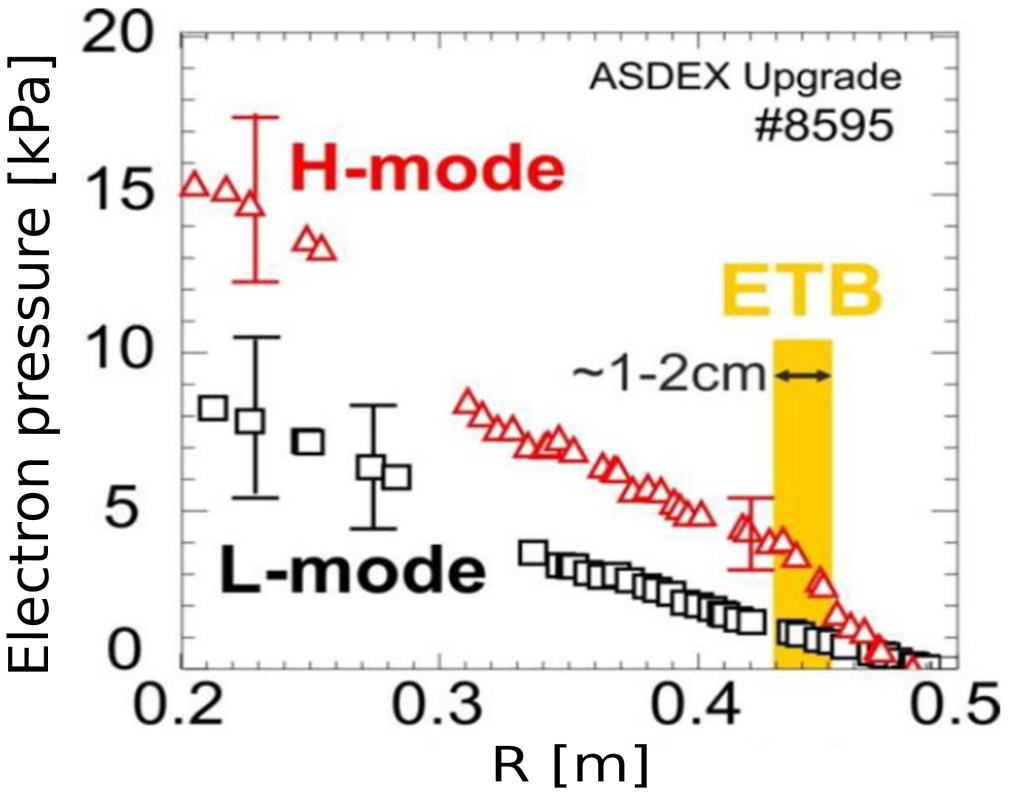
Turbulence, H-mode

- Instabilities from different sources cause eddies that generate turbulent flow.
- This can generate shear flows at the edge of the plasma.
- Operational modes:

  Low Confinement Mode (L-mode)

  High Confinement Mode (H-mode)

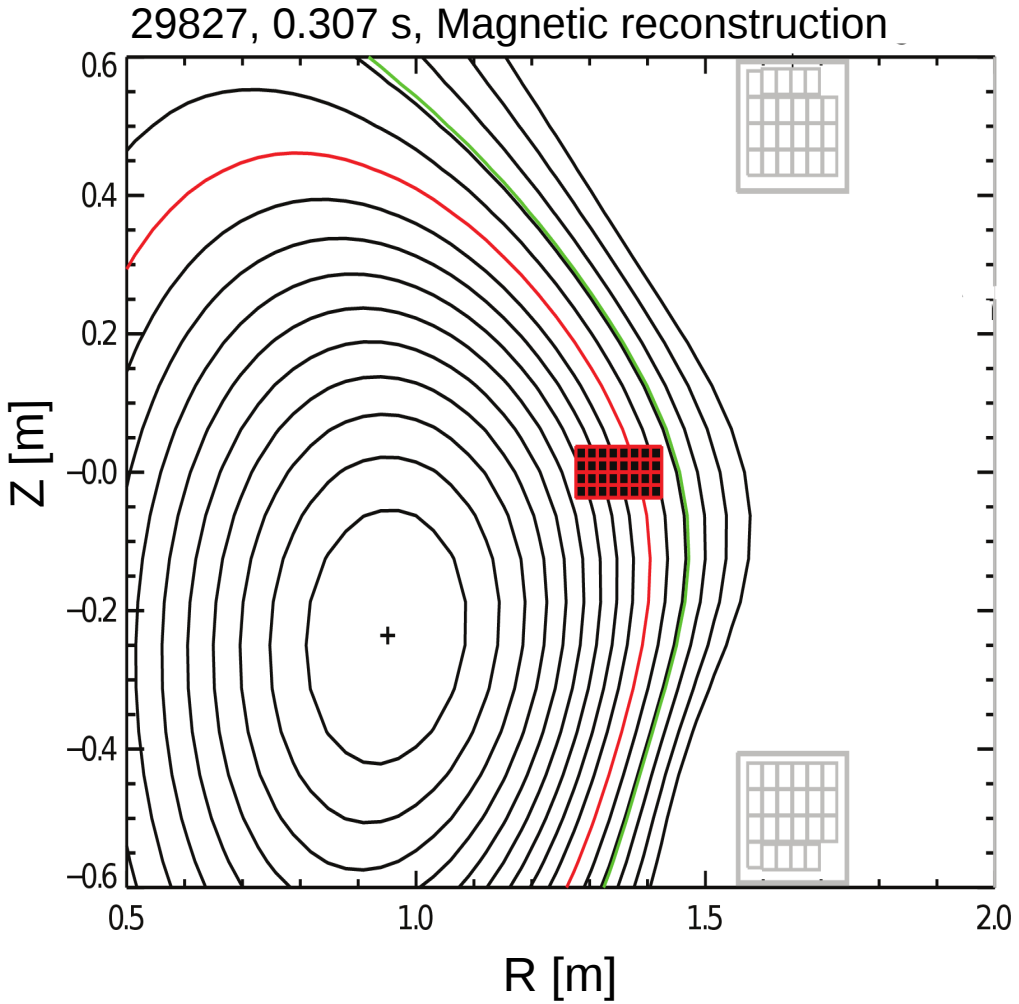
  - Edge Transport Barrier
  - Step-like density and pressure profile



Edge Localized Mode (ELM)

- Quasi-periodic global edge-instabilities that appear in the H-mode.
- During an ELM the edge plasma profile collapse, and significant energy and particle loss happens.
- Heat loads on the wall elements have to be controlled in the future fusion reactors.
- The density stays stable during the inter-ELM intervals, probably because of a pedestal instability. The goal of the study was to find this fluctuation in the MAST.

Beam Emission Spectroscopy (BES)

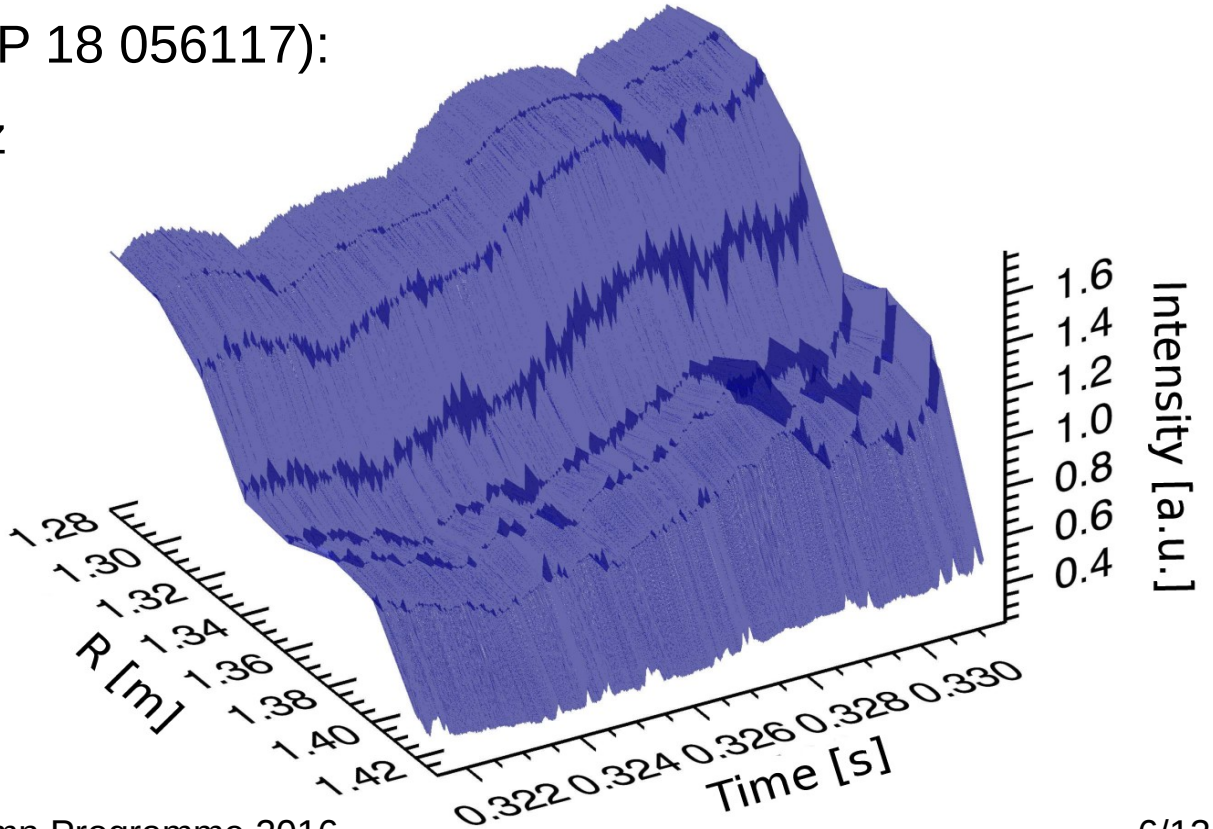


- Beam atoms are excited due to collisions with plasma particles. The excited atoms emit photons with characteristic wavelength.
- Edge plasma measurements with hydrogen beam.
- The measured intensity is proportional to the local density.
- Data analyzing with correlation analysis: covariance functions and power spectra.
- Detector with 4x8 channels, the mapped image is 8x16 cm.

Questioning

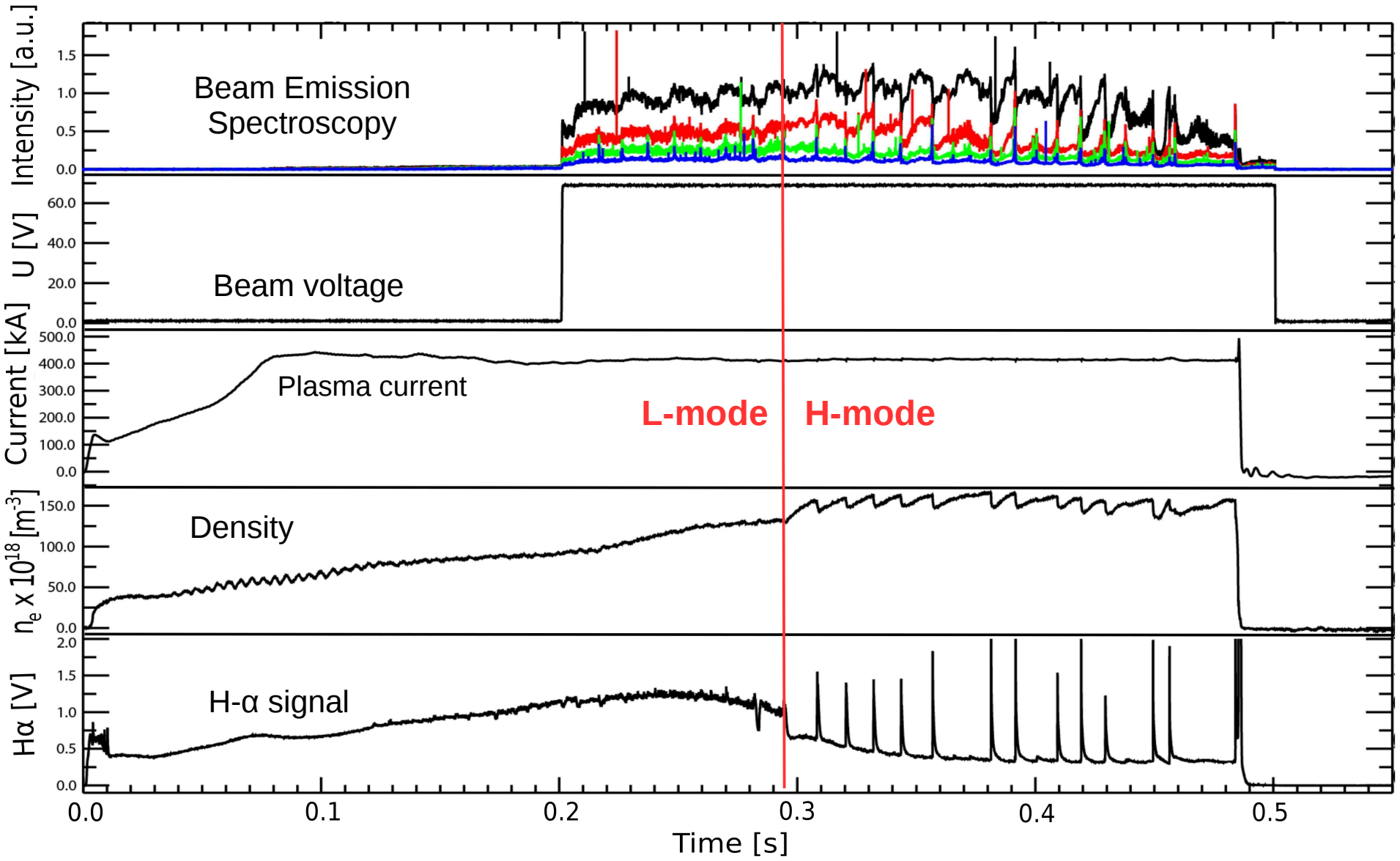
- Question to be answered: what is the phenomenon or structure that could dominate the transport during the inter-ELM intervals?
- Extensive measuring program:
  - NSTX, Princeton, USA (NF 53 093026): 8-50 kHz
  - DIII-D, San Diego, USA (PoP 18 056117):

    50-150 kHz és 200-400 kHz
- Evaluated shot: 29827, Mega Ampere Spherical Tokamak (MAST), Culham, UK
- Each inter-ELM interval was examined between the 40 and 90 % of its whole period.



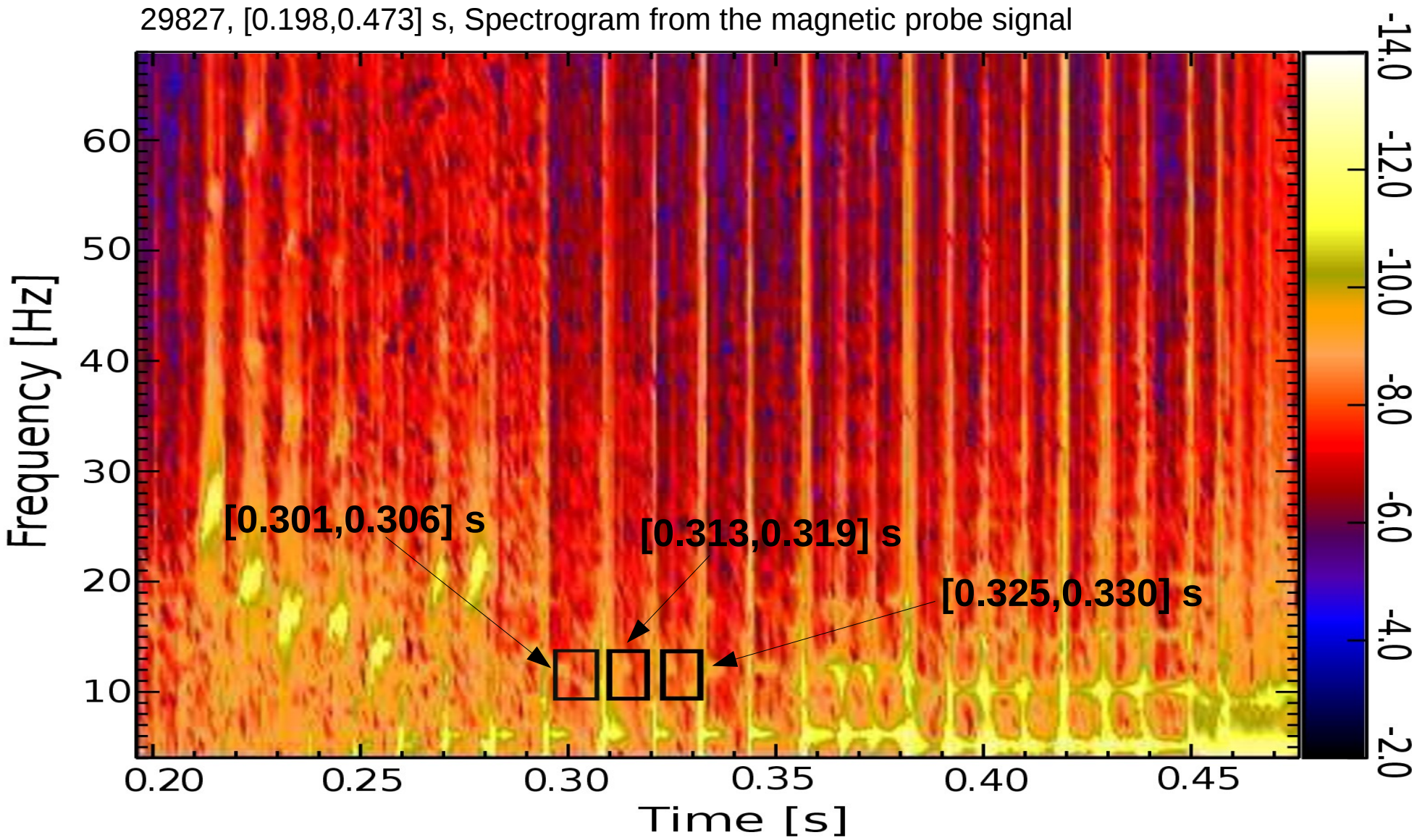
Evaluation of the experimental data

Description of the measurement



Evaluation of the experimental data

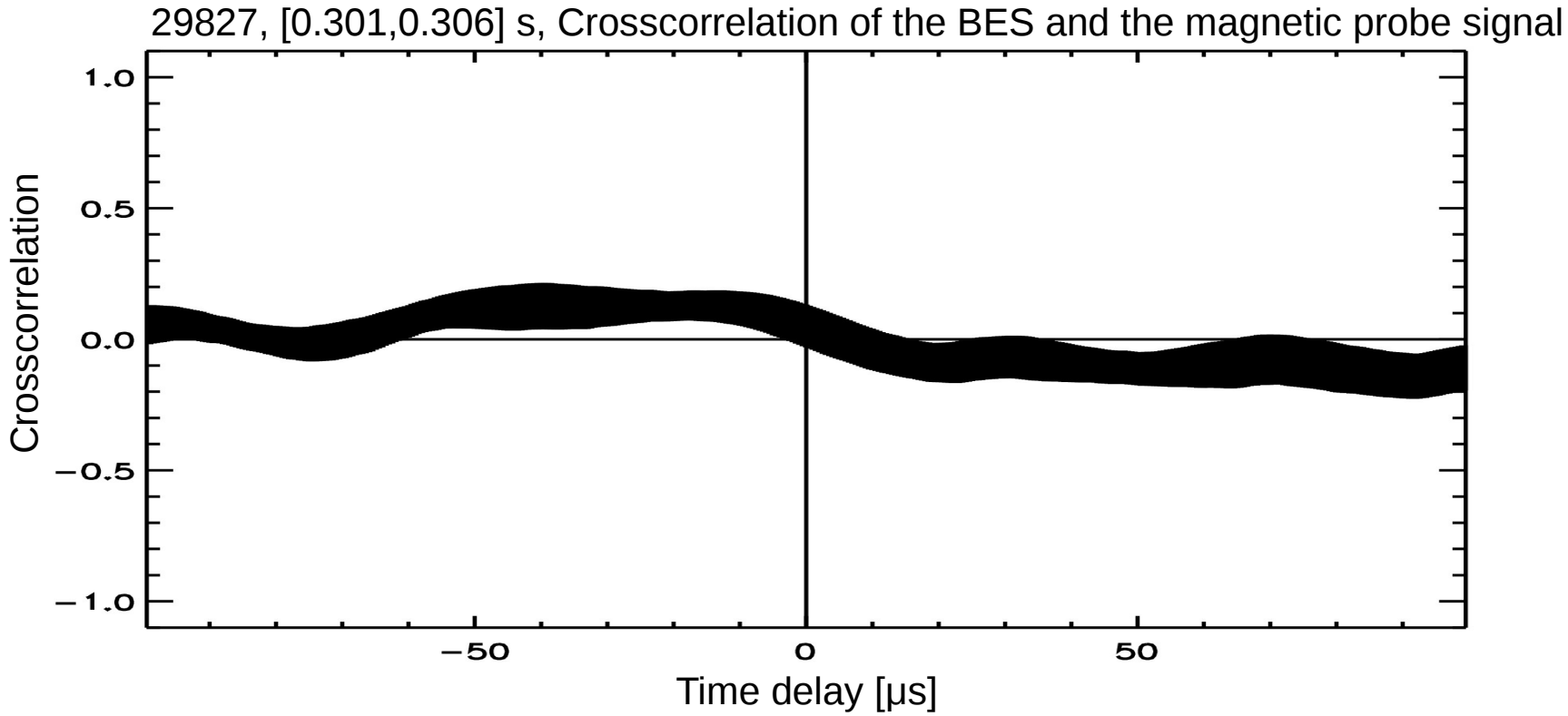
Selection of the examined time intervals



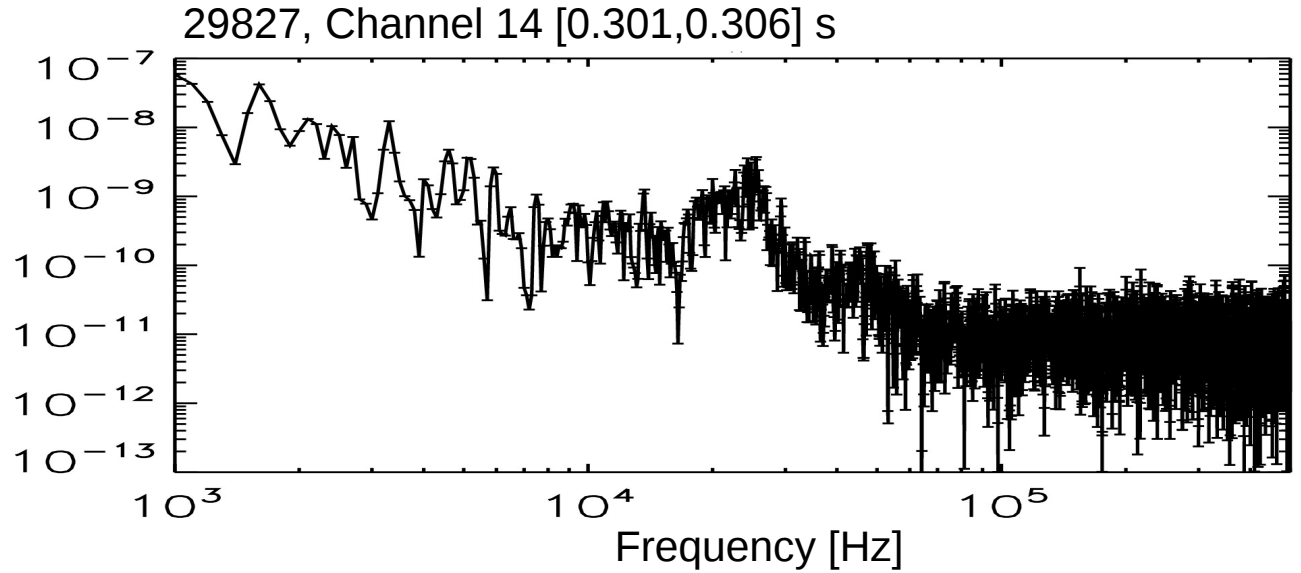
Evaluation of the experimental data

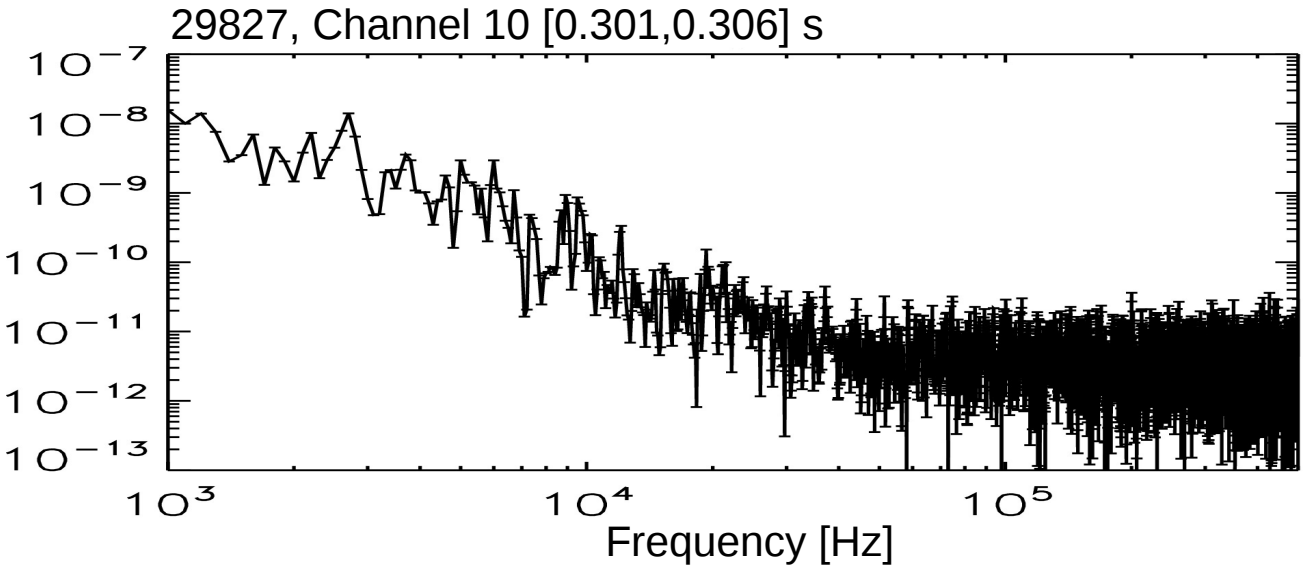
Selection of the examined time intervals

- Most of the time a low frequency structure dominates the transport, it appears in the signal of the magnetic probes.
- A fluctuation localized in the pedestal that does not appear in the magnetic signal was in the interest of the study.



Power spectra



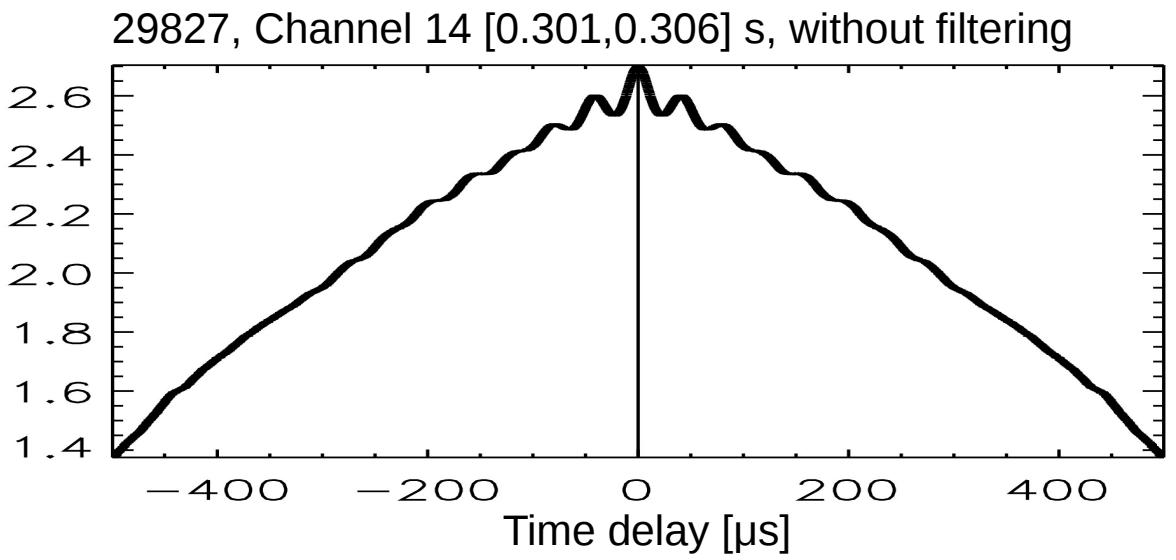


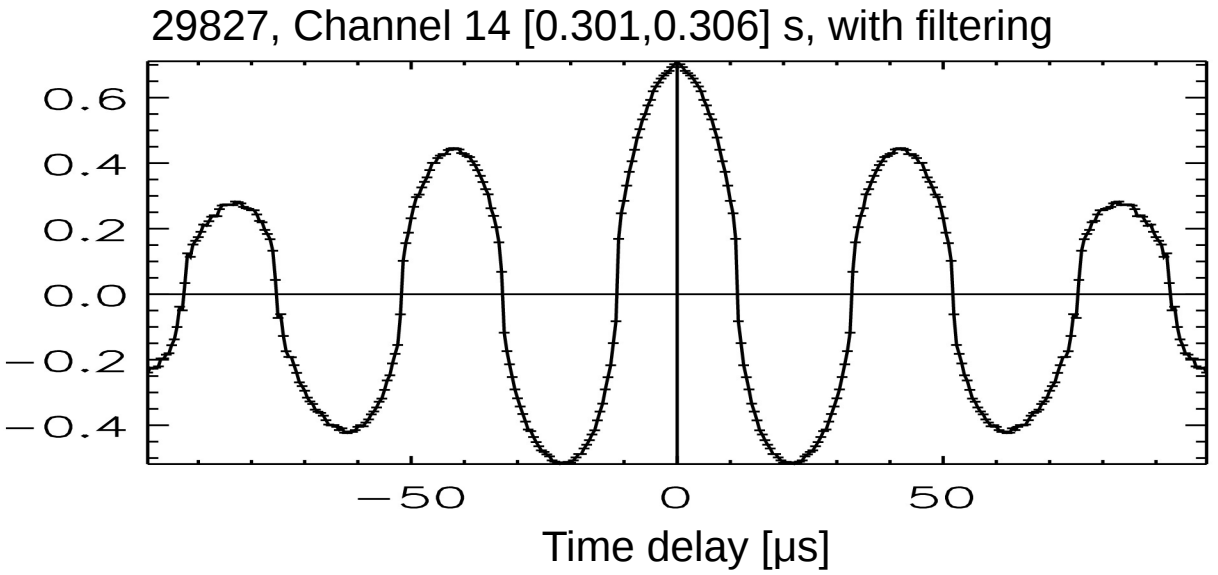
- Fluctuation with 20-25 kHz in the inner-middle channels.
- This structure disappears for the outer channels in the Scrape Off Layer.
- A low frequency structure sometimes suppress the found fluctuation.

Evaluation of the experimental data

Normalized Autocovariance [%]

- Square root of the autocovariance normalized with the amplitude of the original signal.
- A low frequency structure dominates the results as expected.
- Frequency filtering below 5 kHz based on the power spectra.
- The found mode appears.

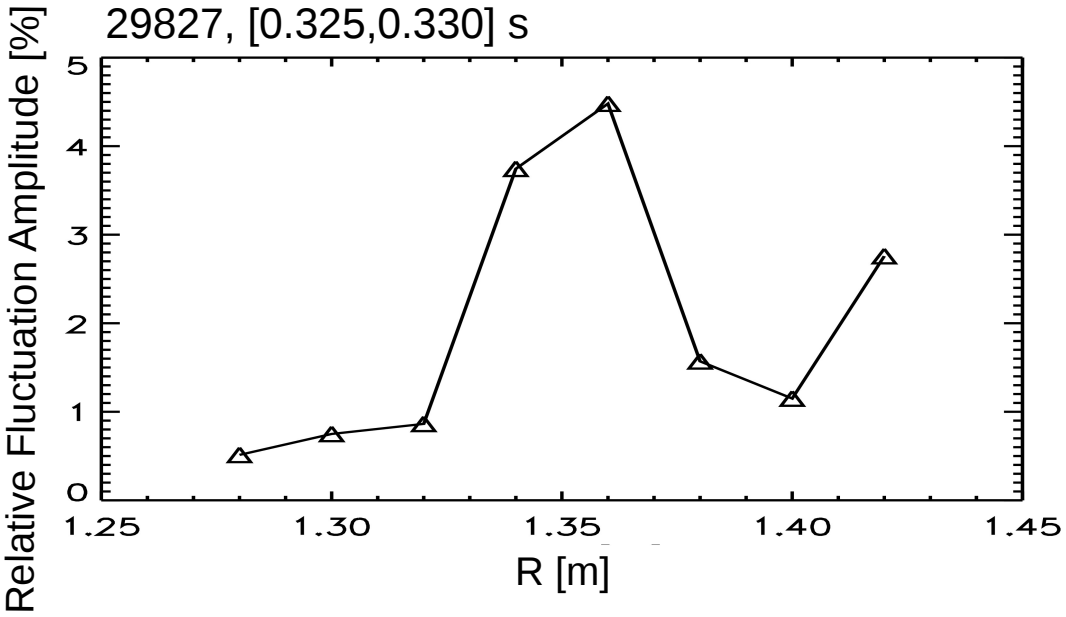


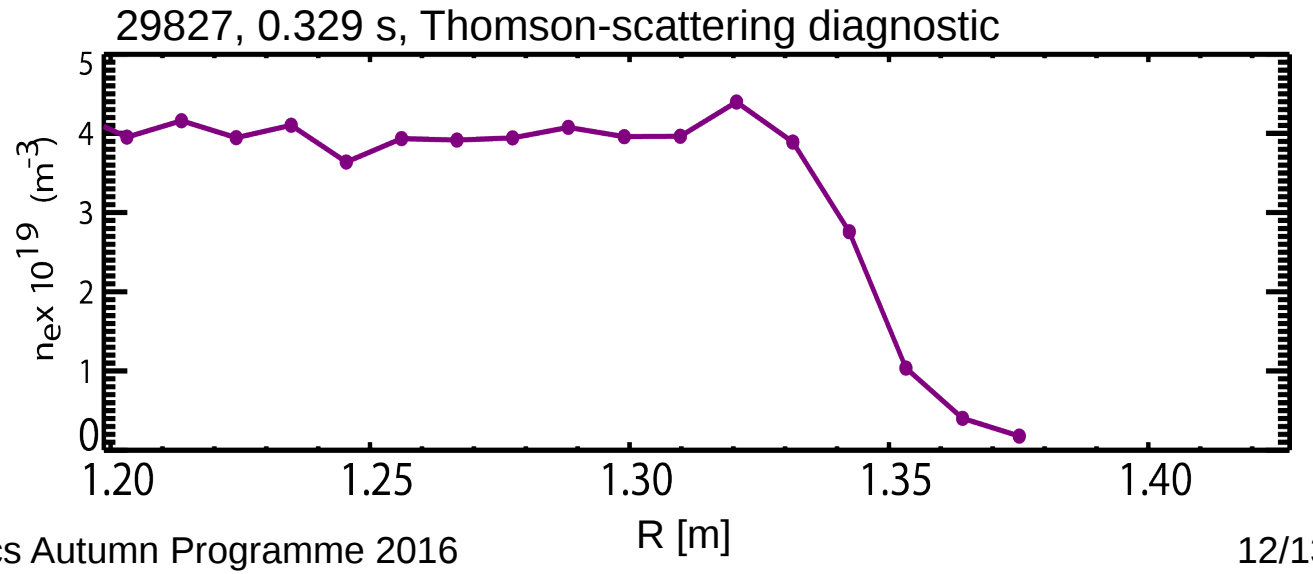


Evaluation of the experimental data

Relative Fluctuation Amplitude

- The radial distribution of the maximum of the normalized autocovariance was examined.
- Its examination with frequency filtering gives where the observed structure is radially localized.
- Peak in the middle channels, and the fluctuation is the strongest here.
- Comparison with the density profile.





Summary

- Beam Emission Spectroscopy signals of inter-ELM intervals were analyzed.
- A fluctuation was found with 20-25 kHz frequency, radially localized in the gradient region of the pedestal.
- This fluctuation might be responsible for keeping the density stable during the inter-ELM intervals.
- In the future, examination of density fluctuations of inter-ELM intervals of further shots is recommended to establish some kind of statistics and a dependence on configuration.