Wendelstein 7-AS

RISØ

Temporal separation of turbulent time series: Measurements and simulations

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1. W7-AS and the density fluctuation diagnostic
2. Phase separation
3. Discharge analysis

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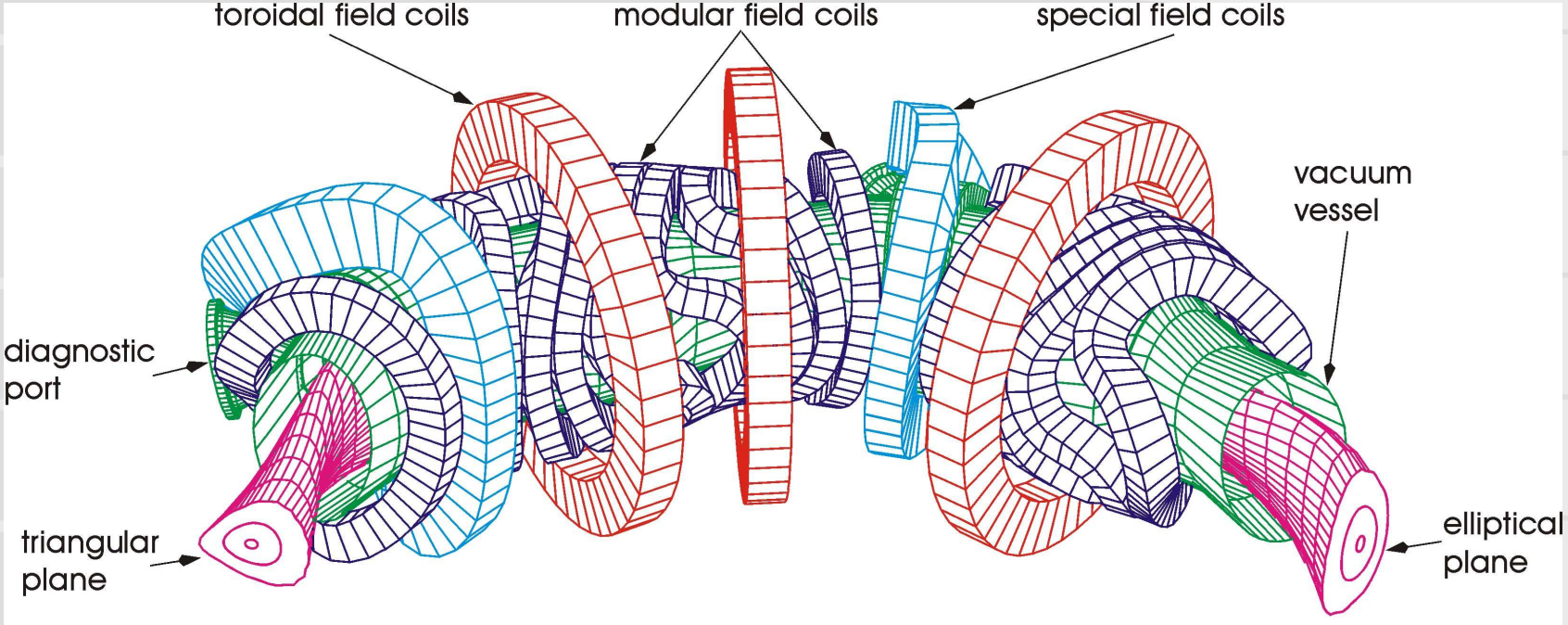
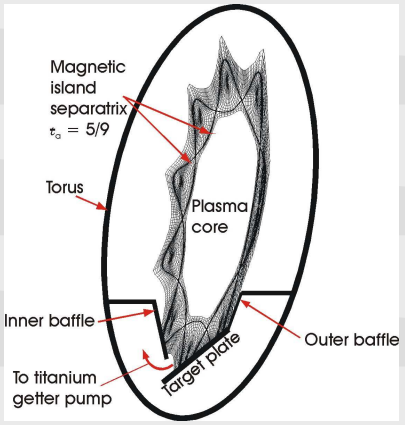
9th European Fusion Theory Conference, 17-19 October 2001, Helsingør, Denmark

The Wendelstein 7-AS (W7-AS) stellarator





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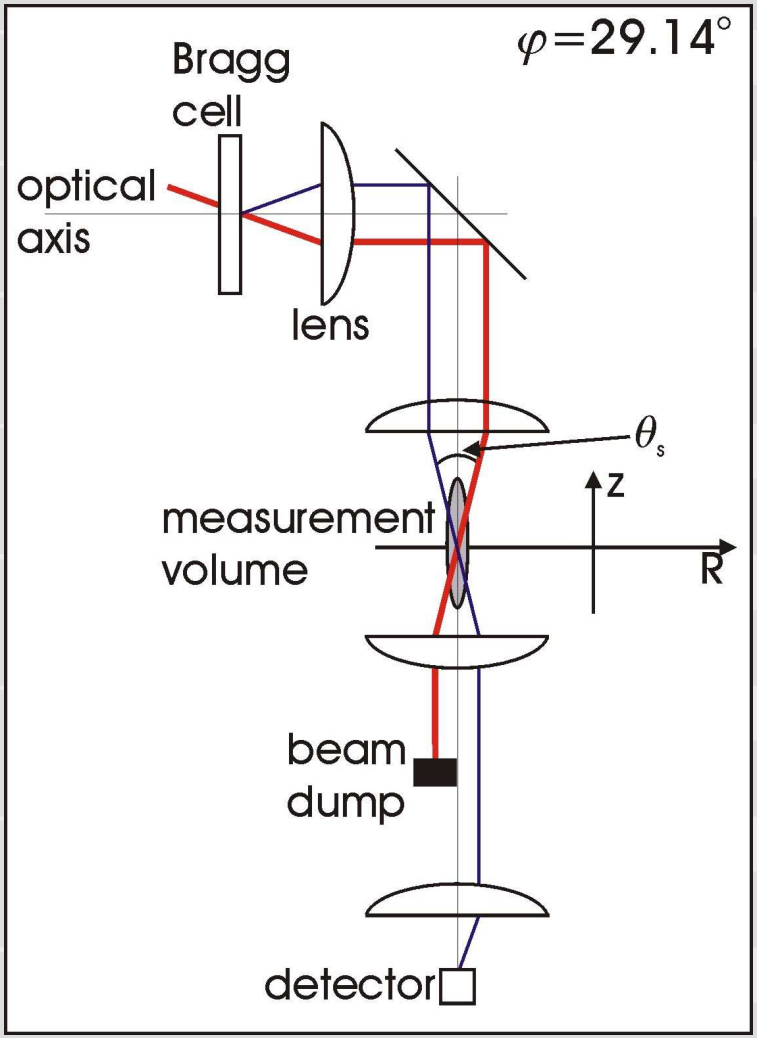
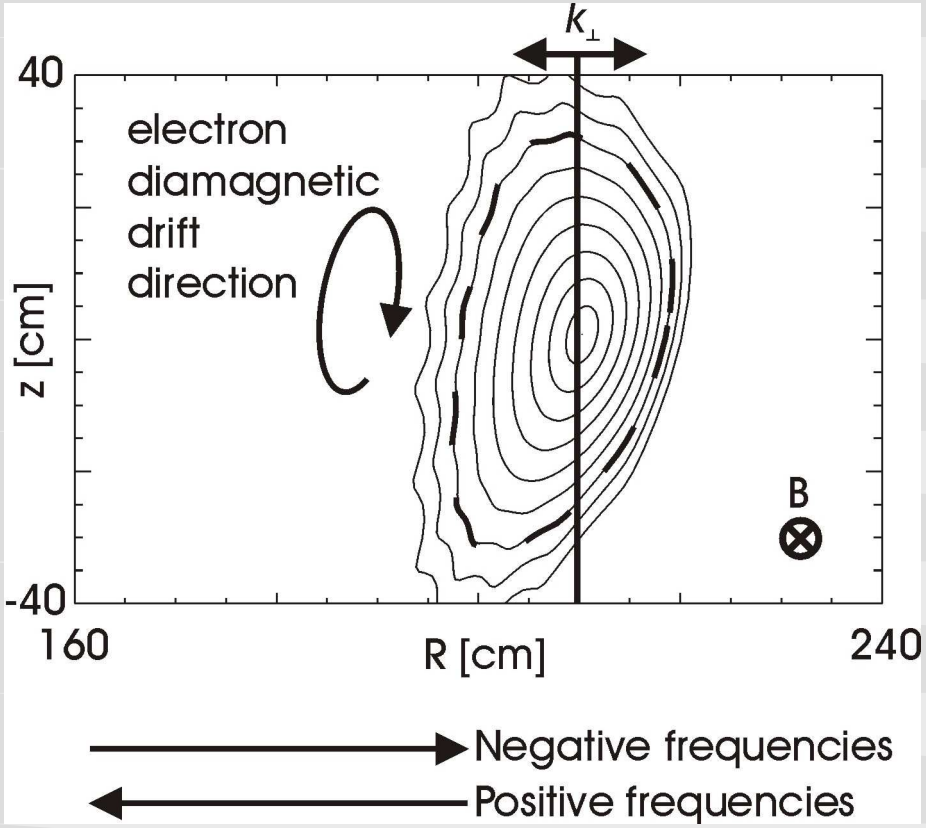
The density fluctuation diagnostic



- Diagnostic installed on the Wendelstein 7-AS (W7-AS) stellarator
- Small angle collective scattering of infrared light (radiation source is a CO_2 laser)
- Heterodyne, dual volume system (only 1 volume shown for clarity)
- Wavenumber analysed here is 14 cm^{-1} (range is from 14 to 62 cm^{-1})
- M. Saffman et al., Rev. Sci. Instrum. 72 (2001) 2579

The density fluctuation diagnostic



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Phase separation theory

The observed signal consists of counter propagating electron bunches. The light scattering signal *I* can be written

$$I(t) = \sum_{j=1}^{N_b} a_j \exp(i\phi_j) = A \exp(i\Phi),$$

where N_b is the number of bunches, while a_j and ϕ_j is the amplitude and phase of bunch number j, respectively. The measured complex signal can be written

$$S = X + iY = A \exp(i\Phi),$$

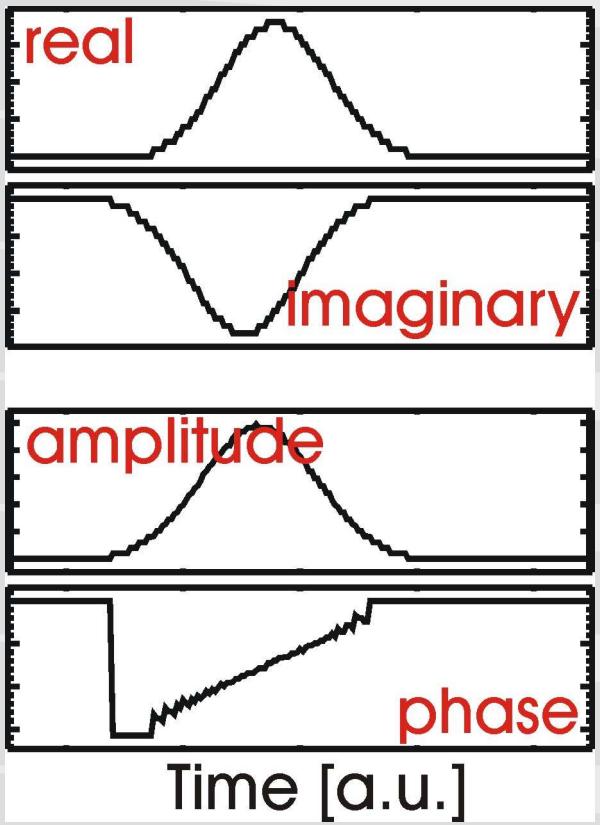
where $\Phi = \boldsymbol{k} \cdot \boldsymbol{U}\, t$. The time derivative of the phase is

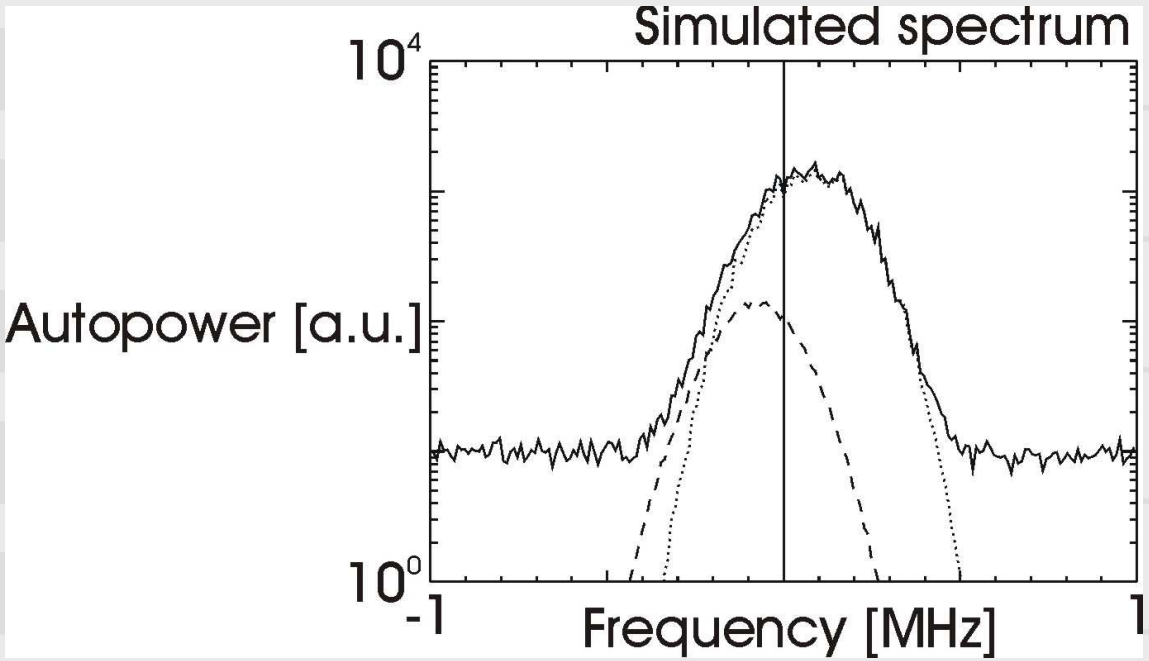
$$\partial_t \Phi = [X \partial_t Y - Y \partial_t X] / A^2$$

G. Antar et al., Plasma Phys. Control. Fusion 41 (1999) 733

Simulated signal

Simulated events are complex signals having a finite length and a Gaussian time evolution of the amplitude.



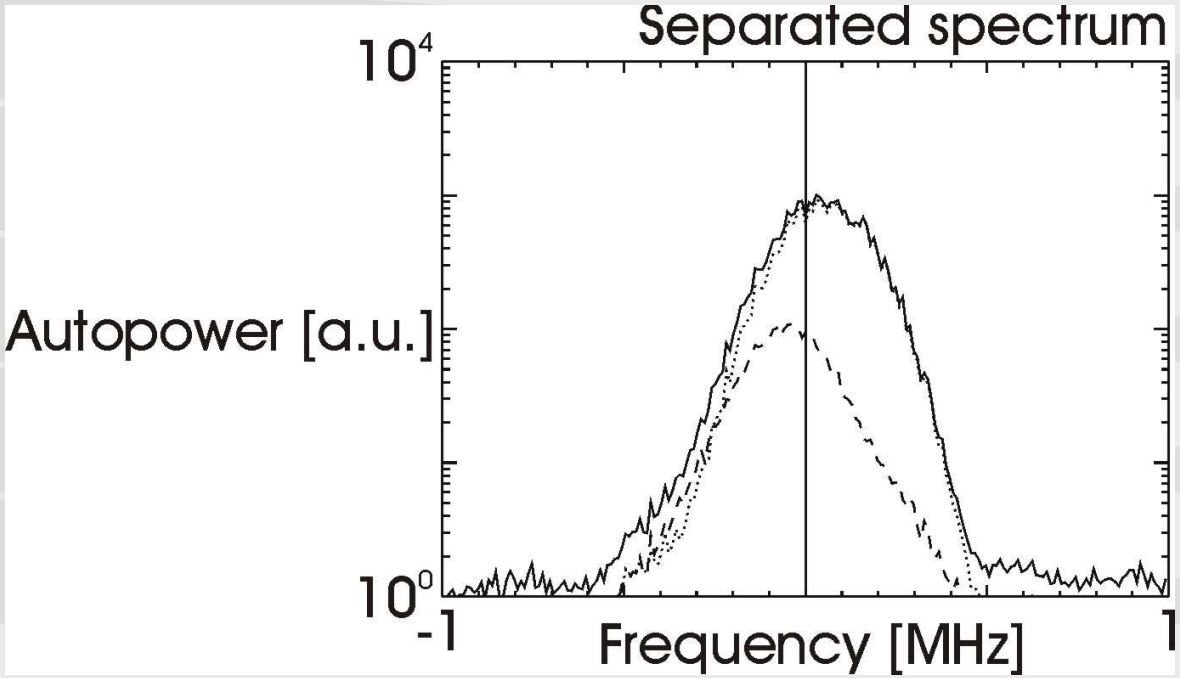


Phase separation tests

The quality of the phase separation technique is gauged by cross correlating the simulated and separated amplitudes.

A variety of parameters can be adjusted:

- Phase velocity
- Noise level
- Number/lifetime/amplitude of events



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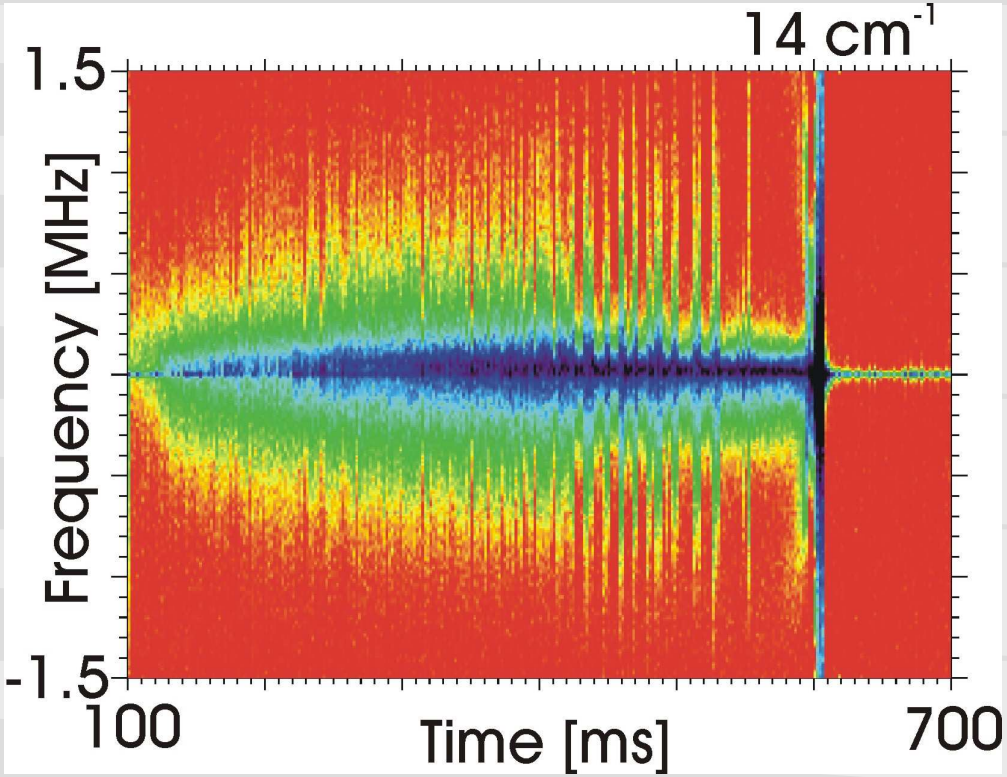
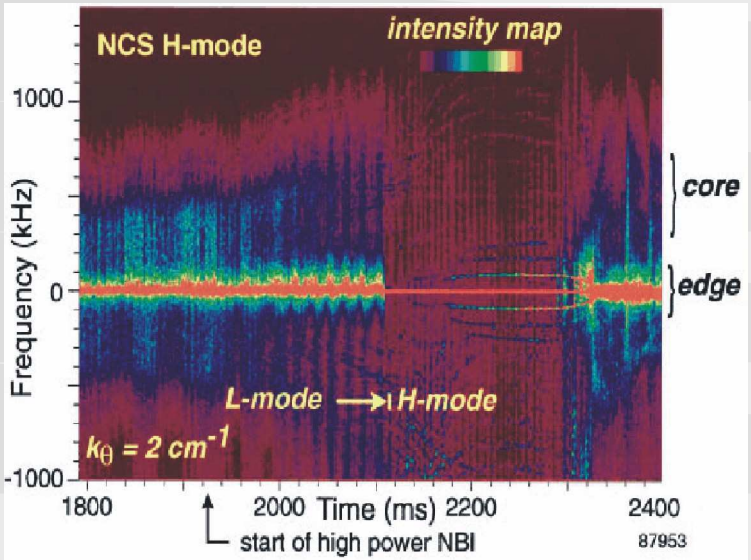
Discharge overview

Right-hand figure:

Autopower spectra from a W7-AS shot displaying three distinct phases:

1. L-mode 100-400 ms
2. Dithering H-mode 400-550 ms
3. ELM-free H-mode 550-600 ms





Left-hand figure:

Autopower spectra from a DIII-D discharge.

C. L. Rettig et al., Phys. Plasmas 4 (1997) 4009

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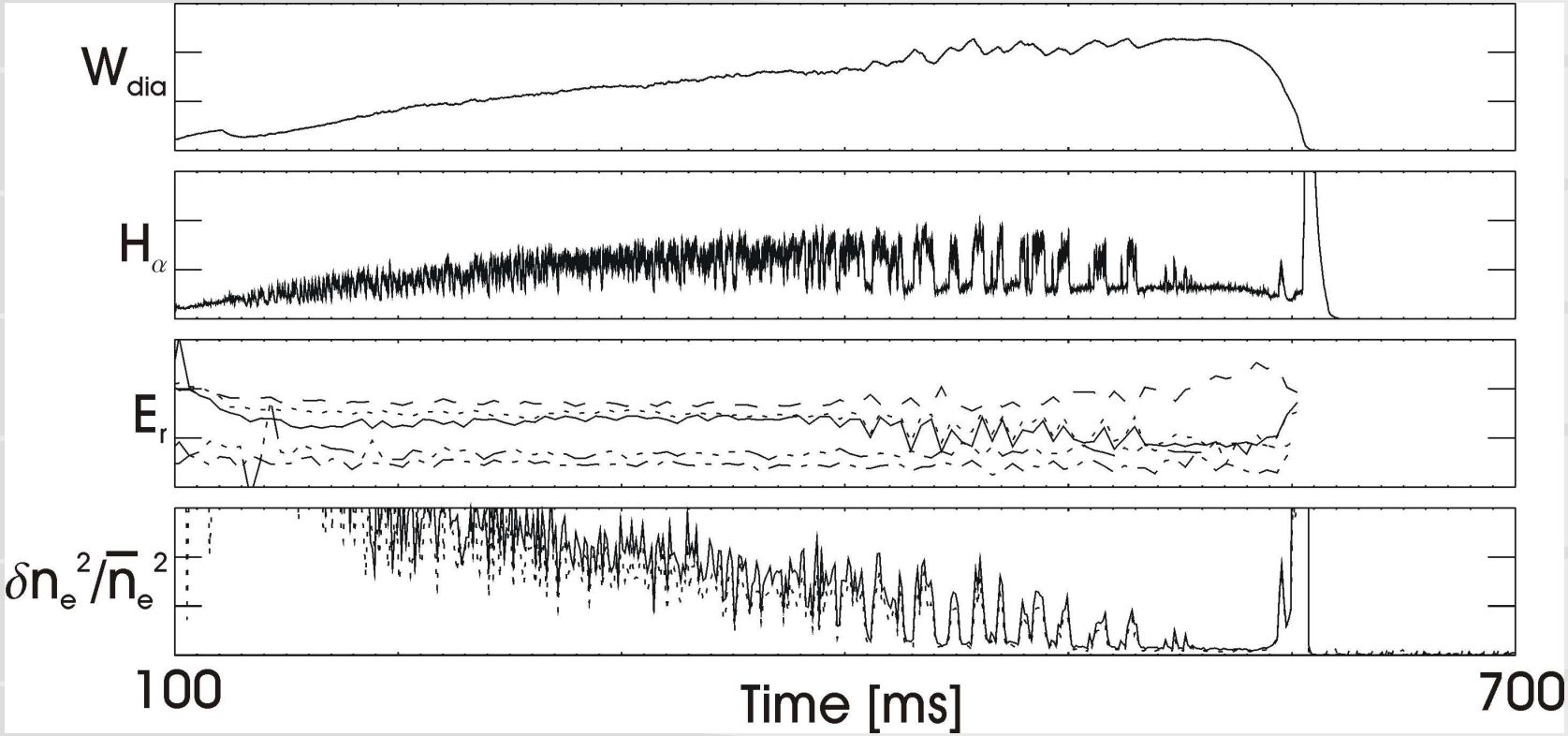
Discharge overview

Run-of-the-mill L-H switching:



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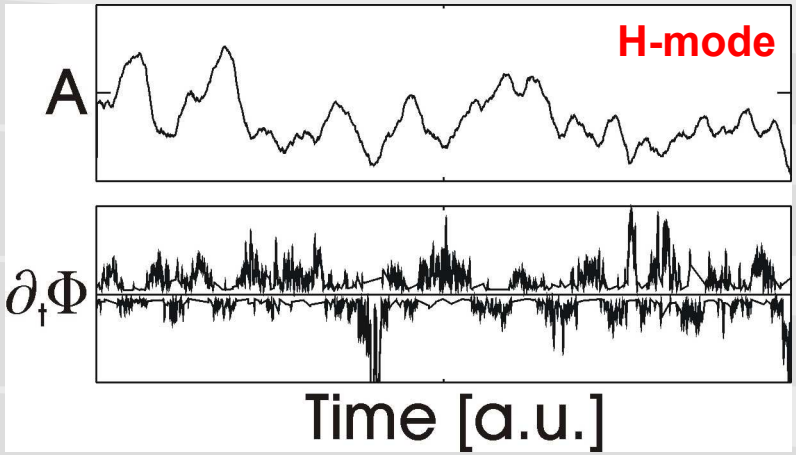
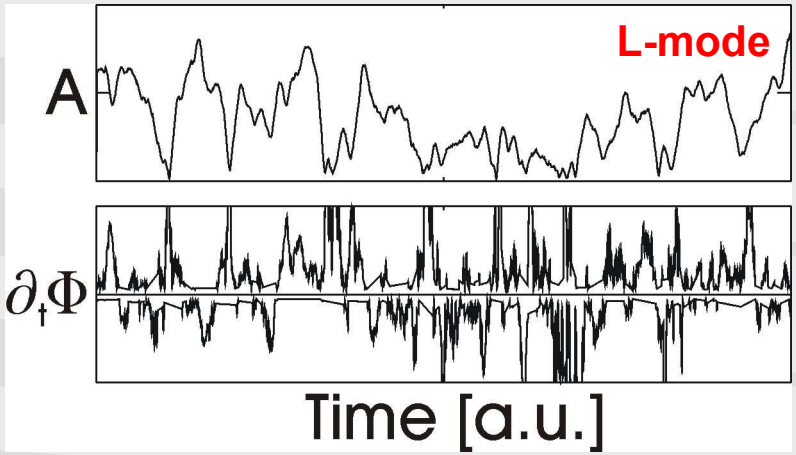
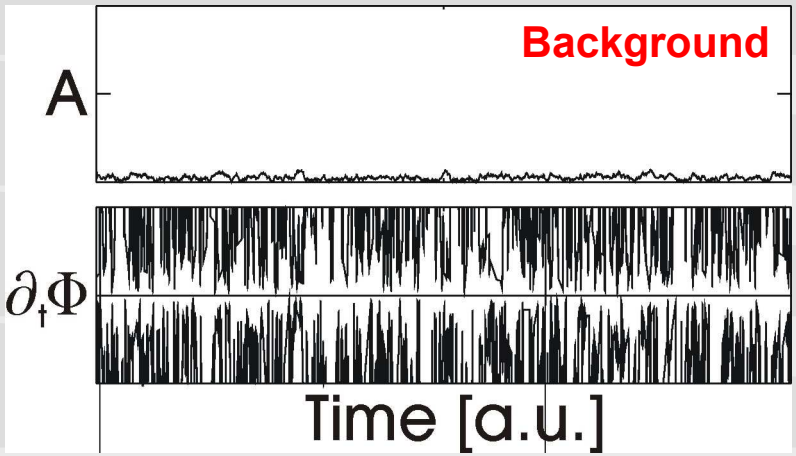
Events in L- and H-mode

The 3 figures below show the amplitude (top) and phase derivative (bottom) for time windows of 100 μs.





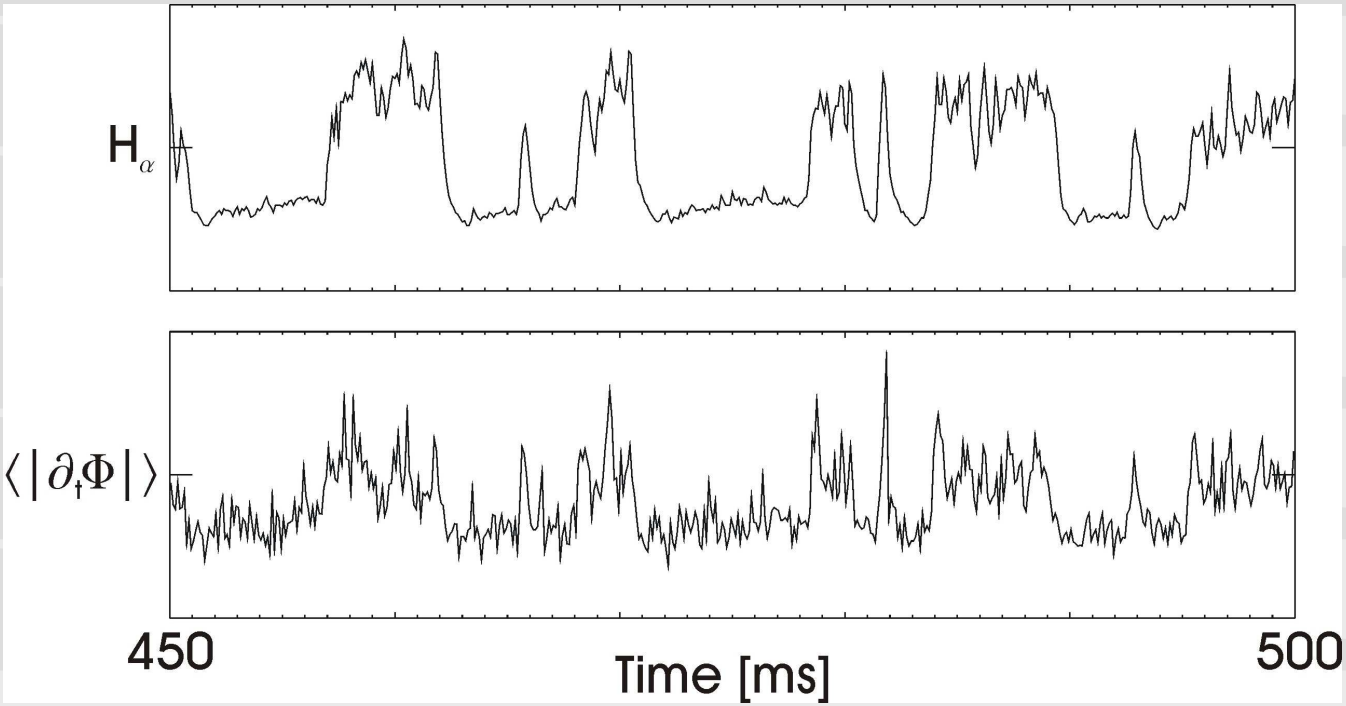


The raw data has been bandpass filtered between 1 kHz and 1 MHz before the amplitude and phase derivative was calculated.

Average derivative

Averaging the <u>absolute</u> value of the phase derivative over 100 μs time windows, a clear correlation is seen with the dithering in other plasma parameters such as the H_α-light.

This is not the case for the standard average – work is in progress.



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Conclusions and outlook

We have in this presentation outlined an investigation dealing with time derivatives of the phase of our signal:

- The procedure as first used by G. Antar *et al.* on Tore Supra data is applicable to W7-AS discharges
- Simulations creating autopower spectra similar to those measured have shown that phase separation of events in counter propagating directions is a valid approach
- Events in L- and H-mode time windows have distinguishable phase derivatives

<u>Outlook:</u>

- Continue search for quantities differing in L- and H-mode (e.g. $\partial_{tt}\Phi$, PDF's), work on bandpass filtering and physics interpretation
- Use the technique for calculating phase separated autopower spectra in L- and H-modes

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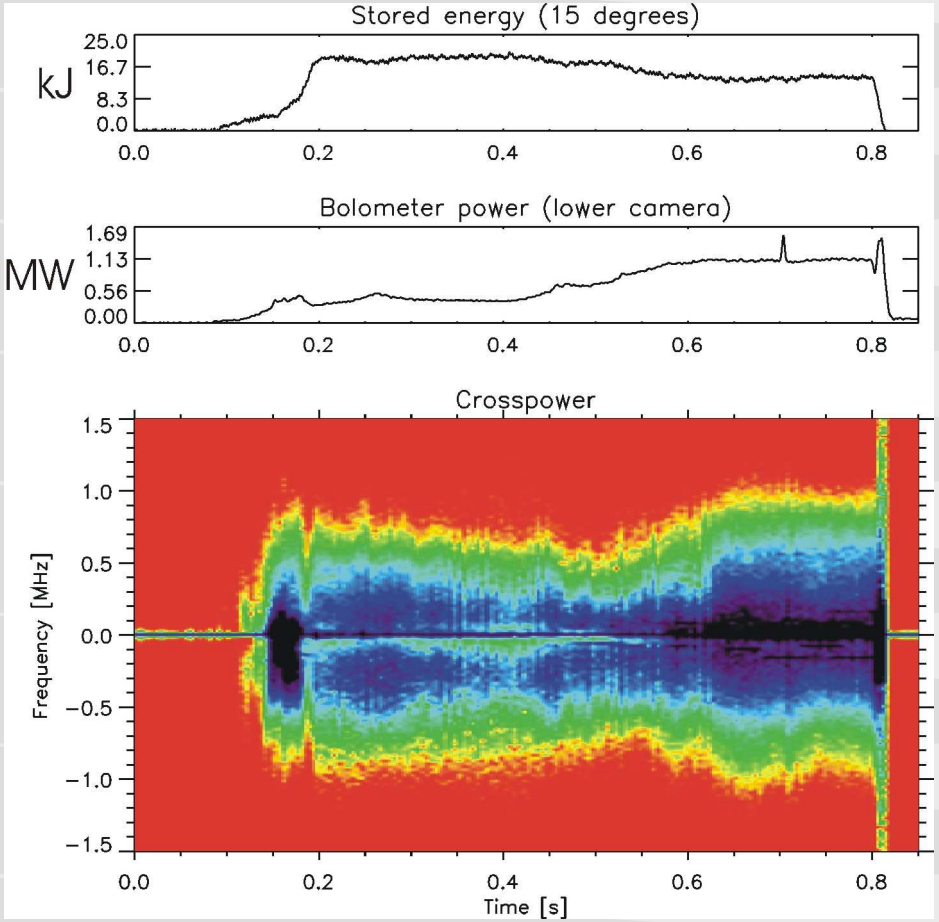
Completed work and ongoing studies: www.npb.dk

MAY 2001:
Detachment in W7-AS divertor plasmas



- First modular stellarator divertor (10 discrete toroidal sections) is operating in W7-AS
- 2 MW NBI power, ι_a = 0.556
- Two density plateaus (we have obtained densities of $\geq 4 \cdot 10^{20}$ m^{-3})
- Strictly speaking the discharge was partially detached, strike points still visible (thermography, H_α)
- Observed wavenumber 20 cm^{-1}
- Spectra broaden at detachment
- Frequency integrated fluctuations increase at detachment