TOKAMAK GOLEM FOR FUSION EDUCATION - CHAPTER 7

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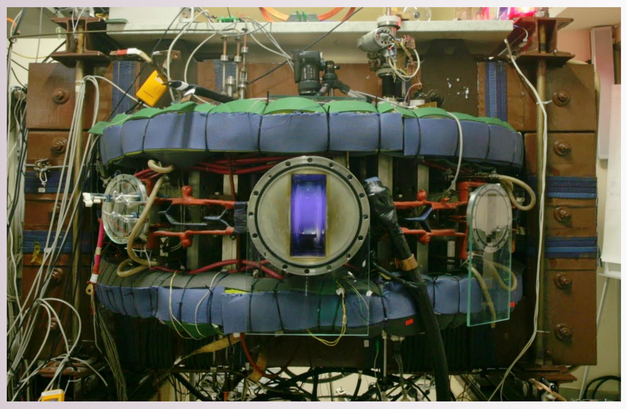
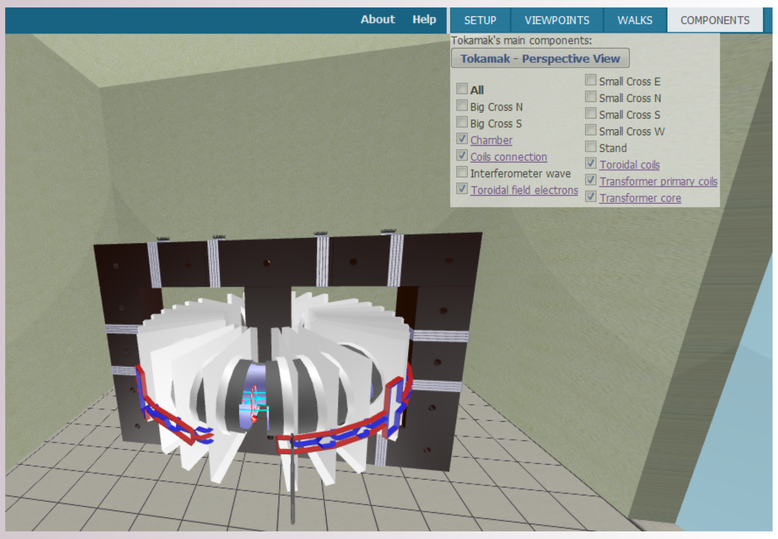
Tokamak GOLEM



- Parameters: $B_t < 0.5$ T, $I_p < 8$ kA, pulse length < 15 ms
- An educational device for domestic as well as foreign students via remote participation/handling
- Students become familiar with probe measurements, data analysis and basic tokamak diagnostics
- Subject of several Bachelor's degree projects and Master's degree theses each year
- At present used in an experimental laboratory course in the basic physics curriculum

3D tokamak model

- A 3D virtual model of GOLEM and its infrastucture has been integrated into the GOLEM web page
- The web interface implements interactive functions which control the virtual world
  - e.g. construct the tokamak part by part, display information about given part
- The web application introduces the tokamak to students



Interactive tokamak construction.

References

[1] T. Markovic, Master thesis, CTU Prague, 2012
[2] K. Jirakova et al., Week of Doctoral Students 2016 (poster contribution), Prague, 2016
[3] K. Dyabilin, Czech. J. Phys. 50/S3 , Prague, 2000

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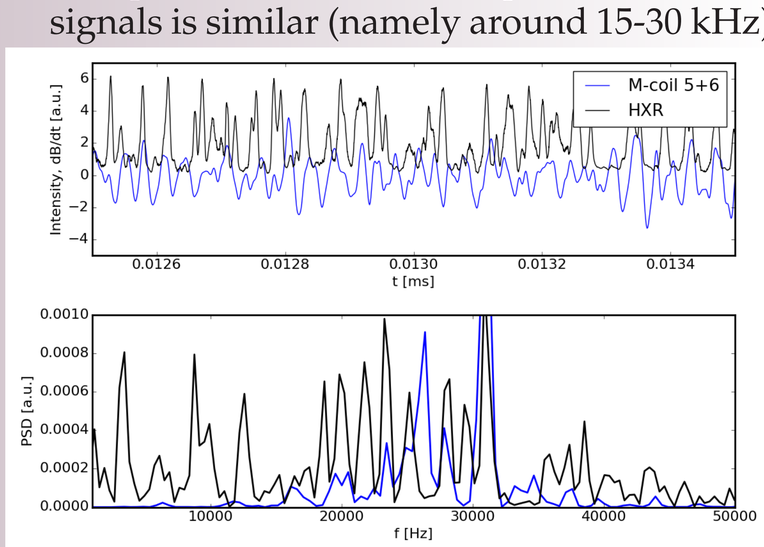
Periodic runaway electron losses

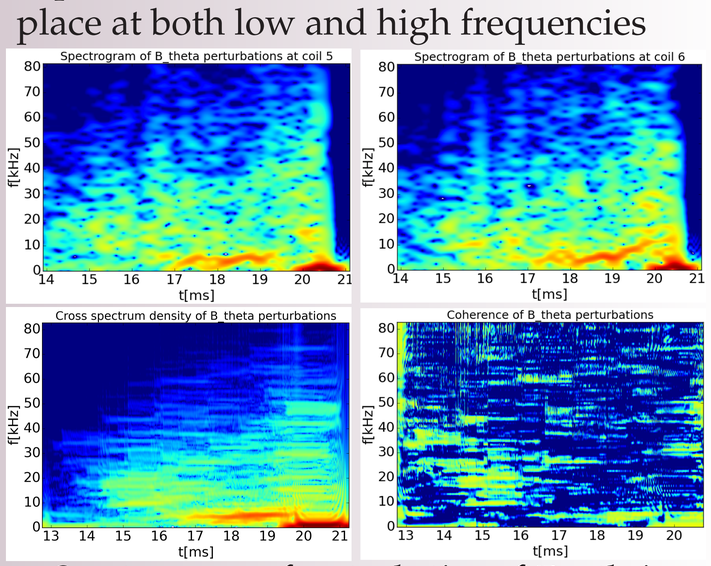
- Magnetic islands - the most suitable instability (detection-wise) that can perturb RE orbits
- Diagnostics: scintillators and a ring of 16 Mirnov coils
- Despite different nature, spectrum of both signals is similar (namely around 15-30 kHz)



Convolved signal of neighbouring Mirnov coils compared to smoothed HXR signal in the time range where strong correlation is expected (top), power spectral density of these signals (bottom). Discharge #21501.

MHD statistical methods studies

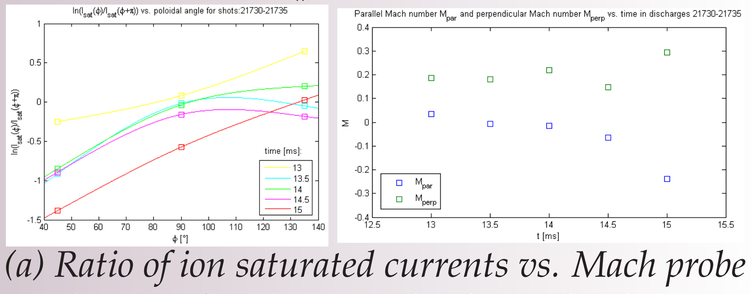
- A new statistical method of spectral coherence was tested
- Coherence describes the similarity of spectra of two signals, yet event time is too short for noise reduction by averaging in process
- Spectral coherence shows events taking place at both low and high frequencies



Spectrograms of perturbation of B_θ, their cross-spectrum time evolution S_{xy} and their spectral coherence. Discharge #10579.

Mach number measurement

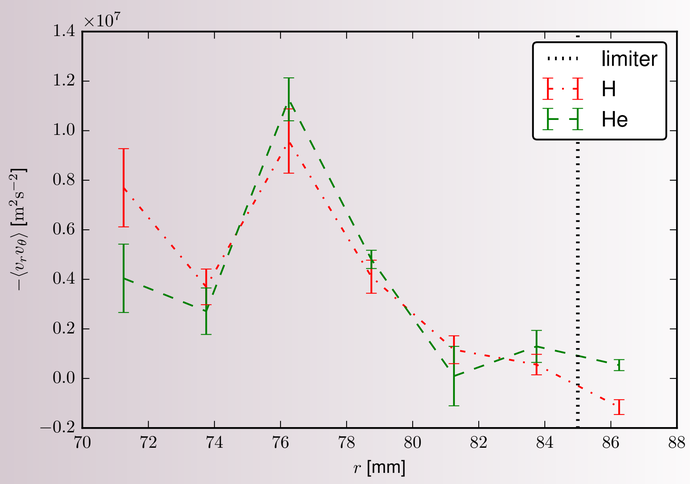
- A rotatable Mach probe was installed on the outer midplane of GOLEM
- Measurements of parallel and perpendicular Mach numbers were made
- In normal field configuration (E-ACW, B-CW), particles are accelerated opposite the main flow $\rightarrow M_{||}$ decreases in time



(a) Ratio of ion saturated currents vs. Mach probe angle. (90°-flow is perpendicular to the electrode surface). (b) Perpendicular $M_\perp$ and parallel $M_{||}$ Mach numbers in time.

Reynolds stress profile

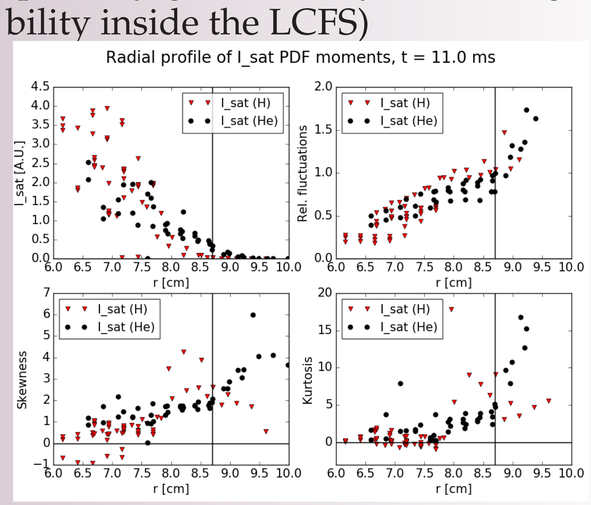
- Radial profile of Reynolds stress $\langle v_r v_\theta \rangle$ was measured in H and He discharges
- Diagnostic: 2D Langmuir probe array (2x8 pins)
- Peak of Reynols stress ~1 cm inside the limiter $\rightarrow$ shear flow layer generation



Radial profiles of Reynolds stress measured with a 2D Langmuir probe array in H and He discharges.

Edge plasma fluctuations

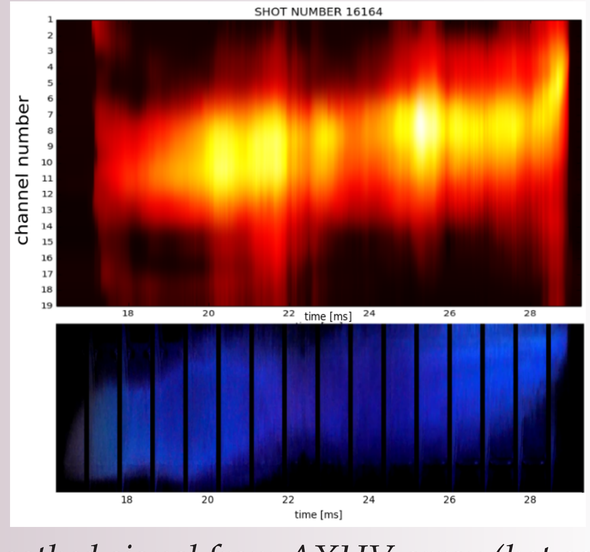
- Radial profile of ion saturated current I_{sat} was obtained in H and He plasma
- The PDF of I_{sat} fluctuations was described by its moments
- Positive skewness is found in H SOL, dropping to zero after the LCFS is crossed.
- Shows presence of turbulent structures (possibly generated by interchange instability inside the LCFS)



Radial profile of I_{sat} fluctuations PDF in hydrogen and helium plasma.

Plasma radiation studies

- An AXUV (Absolute eXeme Ultra Violet) module was installed and tested
- The module consists of 20 AXUV fast photodiods placed behind a pinhole
- Estimation of plasma vertical position was compared with fast camera data



Smoothed signal from AXUV array (hot scale) compared to signal from fast camera (blue).