Multi-Diagnostic-Setup at the Atomki-ECRIS to Investigate the Two-Close-Frequency Heating Phenomena

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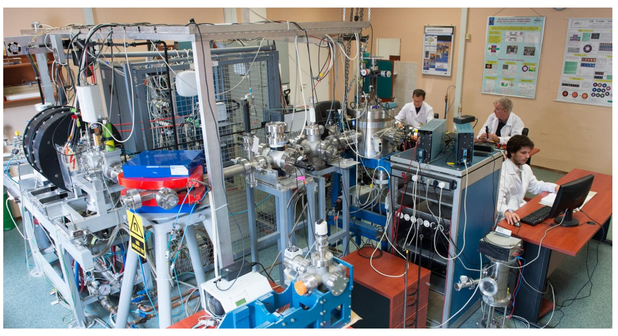
Aims



- 1st microwave: 14.25 GHz, 1000 W (KLY)
- 2nd microwave: 13.6-14.6 GHz, 500 W (TWT)
- Permanent magnet hexapole: 1.2 T
- Room-temperate coils: 1.26-0.39-0.95 T
- No post acceleration, independent
- Highly applicable for ECR plasma physics investigations!

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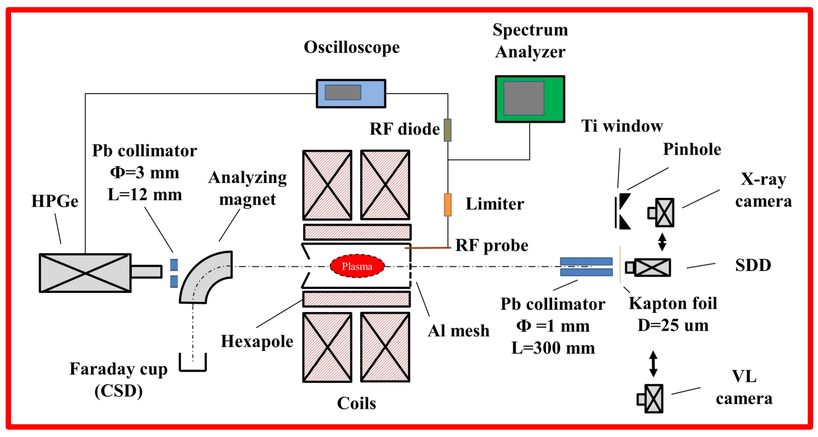
- Exact mechanism of two-close-frequency heating
- Role of 2nd frq. to suppress plasma instabilities
- Two-frequency plasmas in X-ray ranges
- X-ray spectra in the unstable regimes
- Structural changes triggered by instabilities
- Structural changes when the turbulences are suppressed

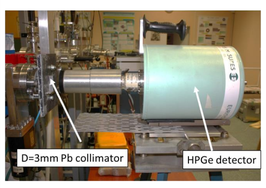
Atomki ECRIS Laboratory

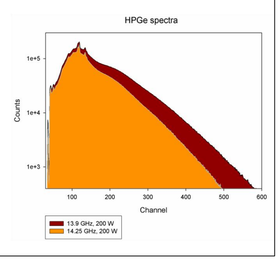
Diagnostics tools (experimental setup)

In order to carry out complex plasma diagnostics we installed and applied an arsenal of diagnostic tools and methods.



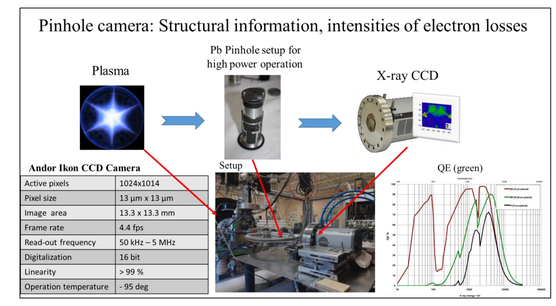
HPGe (High Purity Germanium Detector): Spectral temperature (time integrated)





~30 KeV – ~400 MeV
Area: 3800 mm², Res: 200 eV at 40 KeV

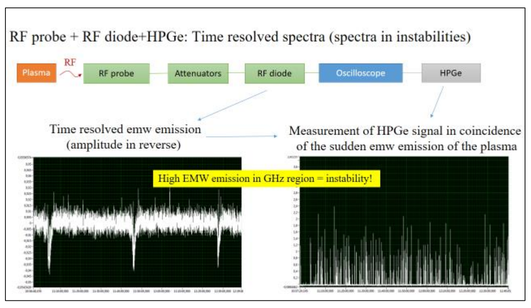
Pinhole camera: Structural information, intensities of electron losses



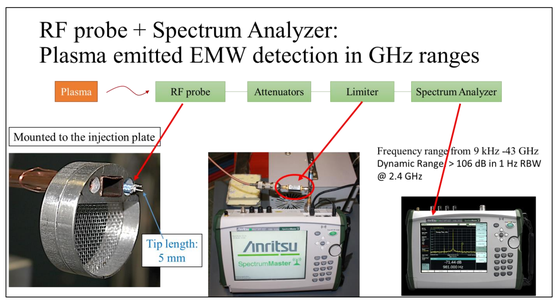
Andor Ikon CCD Camera	
Active pixels	1024x1014
Pixel size	13 µm x 13 µm
Image area	13.3 x 13.3 mm
Frame rate	4.4 fps
Read-out frequency	50 kHz – 5 MHz
Digitalization	16 bit
Linearity	> 99 %
Operation temperature	- 95 deg

The Pinhole camera, the SD Detector and the VL camera were alternatively used at injection side.

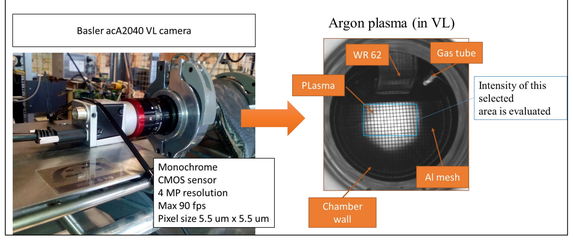
RF probe + RF diode+HPGe: Time resolved spectra (spectra in instabilities)



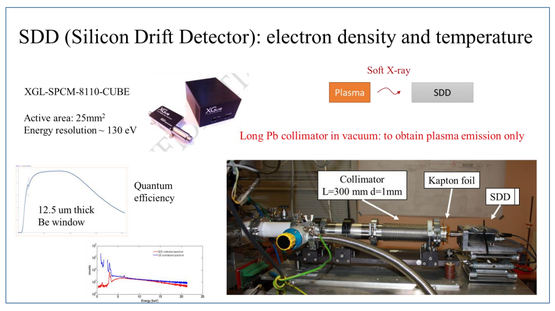
RF probe + Spectrum Analyzer: Plasma emitted EMW detection in GHz ranges



VL camera: Information on the low energy component of the EEDF



SDD (Silicon Drift Detector): electron density and temperature



Alterings on the ECRIS for this experiment

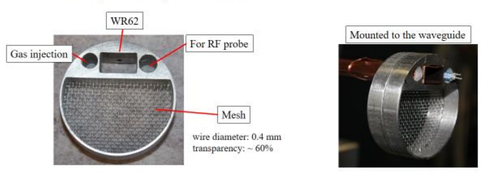
The plasma chamber of the ECRIS in normal setup is stainless steel (Fe, Cr, Ni, Mo, …). After careful selection we made or covered the three main parts of the chamber with three different metals.

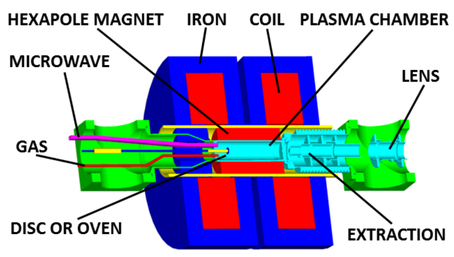
Part of chamber	Material	K_α	K_β	L_α
Plasma electrode	Titanium	4.51 keV	4.93 keV	0.45 keV
Lateral wall	Tantalum	57 keV	65 keV	8.14 keV
Injection plate	Aluminum	1.49 keV	1.56 keV	
Plasma	Argon	2.96 keV	3.19 keV	
1.49 – 1.56 – 2.96 – 3.19 – 4.51 – 4.93 – 8.14				

The microwave system was also significantly modified to inject two close, but different frequency EM-waves into the plasma and to measure the net power with high precision.

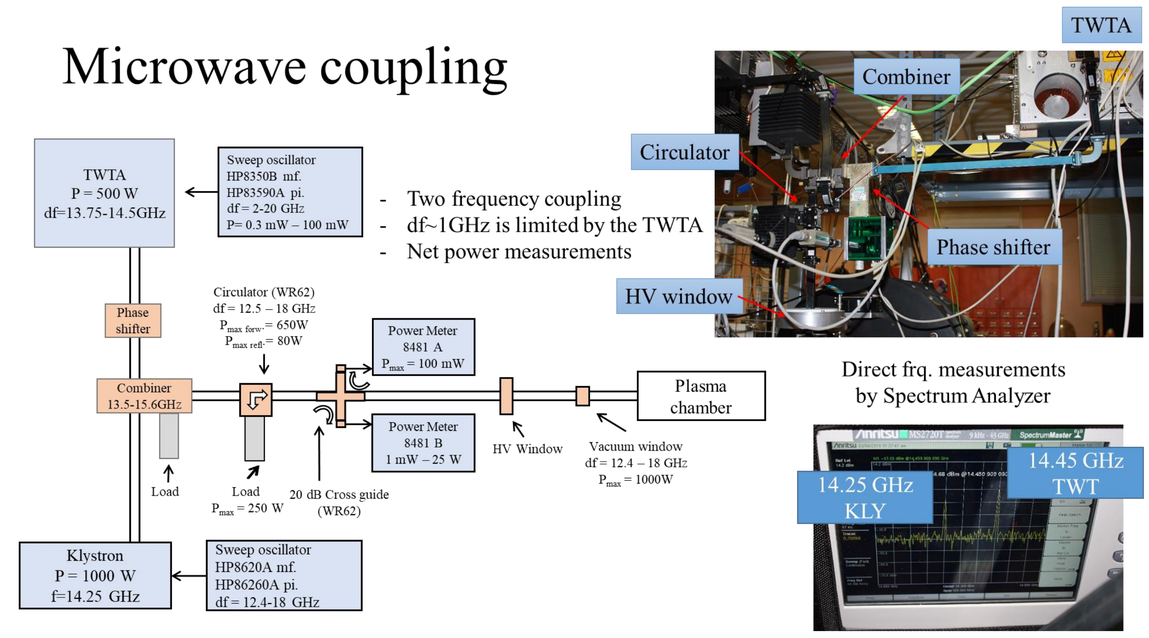
Injection plate design

Material: pure (99%) **Aluminum** (**Kα = 1.5keV**) ring, holder and mesh
More than 2/3 part of the plasma is visible.





Microwave coupling

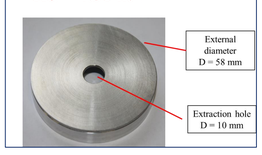


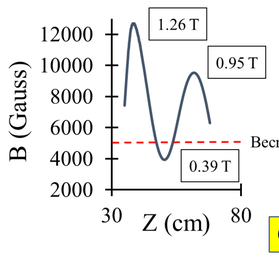
Plasma chamber lateral wall

Liner for the lateral wall of the plasma chamber
(diameter: 58 mm, length: 210 mm).
Tantalum (Kα = 57.5 keV, **Lα = 8.1 keV**)

Titanium plasma electrode without pumping hole

Kα = 4.51 keV

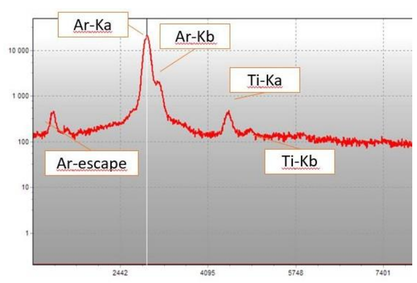




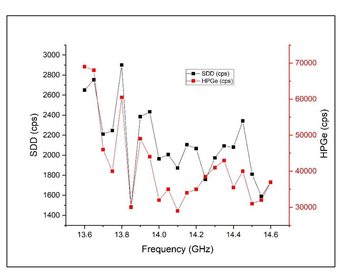
Close to critical value…

First results - highlights

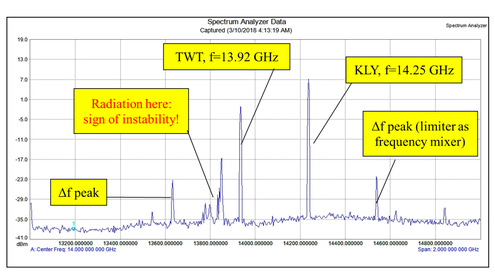
SDD spectrum (looking through the plasma)



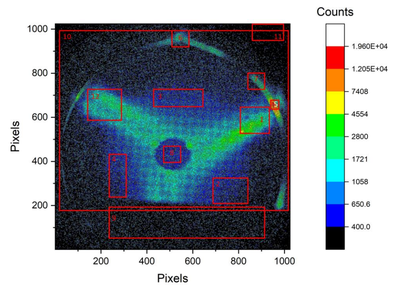
Plasma-emitted x-ray rates vs TWT-frequency



RF-probe + Spectrum Analysator



Pinhole camera picture with ROIs



Titanium plasma electrode

Lab still life …

More results are in 2 accompanying talks/papers: R. Racz (Wednesday, 10:30) and E. Naselli (Friday, 11:40)