Work progress and plans for data analysis from JET LIBS measurement campaign at UKAEA

SP E: KoM - 6 Feb 2025

Sahithya Atikukke, Shweta Soni, Sanath Shetty, Matej Veis and Pavel Veis (Comenius University in Bratislava)

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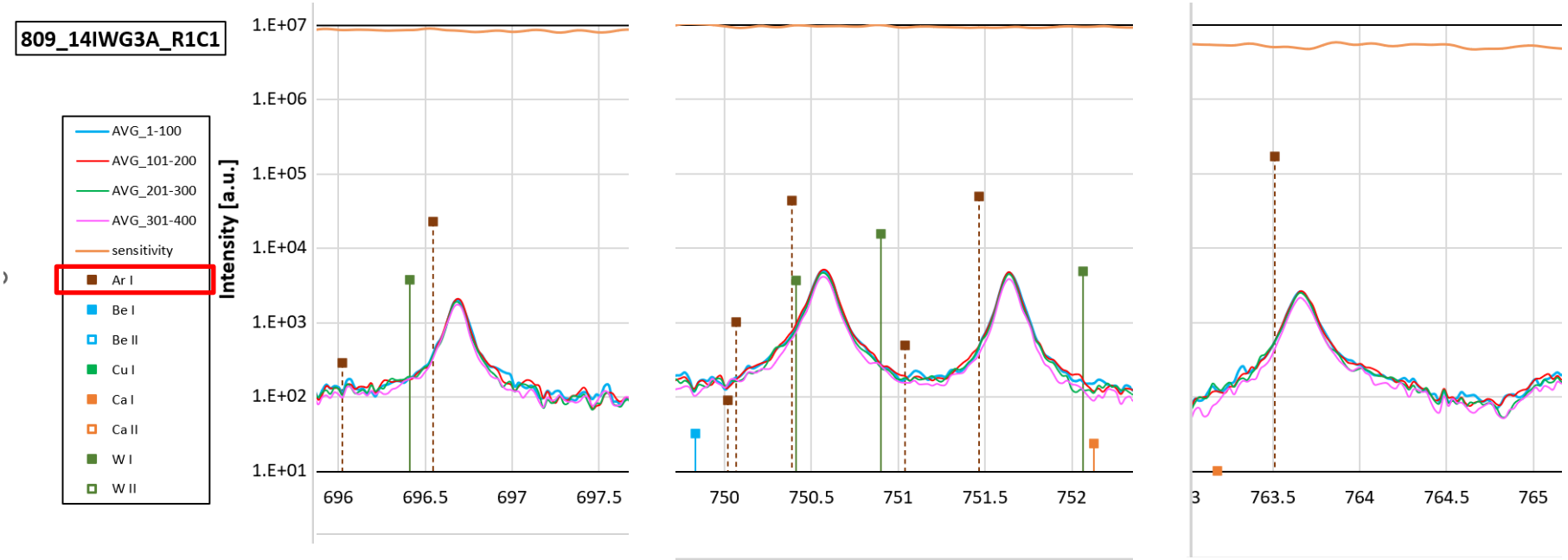
OUTLINE

- **OUTLINE of work progress in data analysis from JET LIBS measurement campaign at UKAEA**
  - First partial data from campaign we received 1 week ago.
  - **Check-up the measured data globally** on using averaged spectra first (100 shots)
  - **OBSERVED lines in** average spectra (Ar I, Be I-II, Mo I)
  - **Shift of real spectra**
  - **The ghosts presence analysis**
  - **Depth profile analysis** (just few spectral lines for few samples).

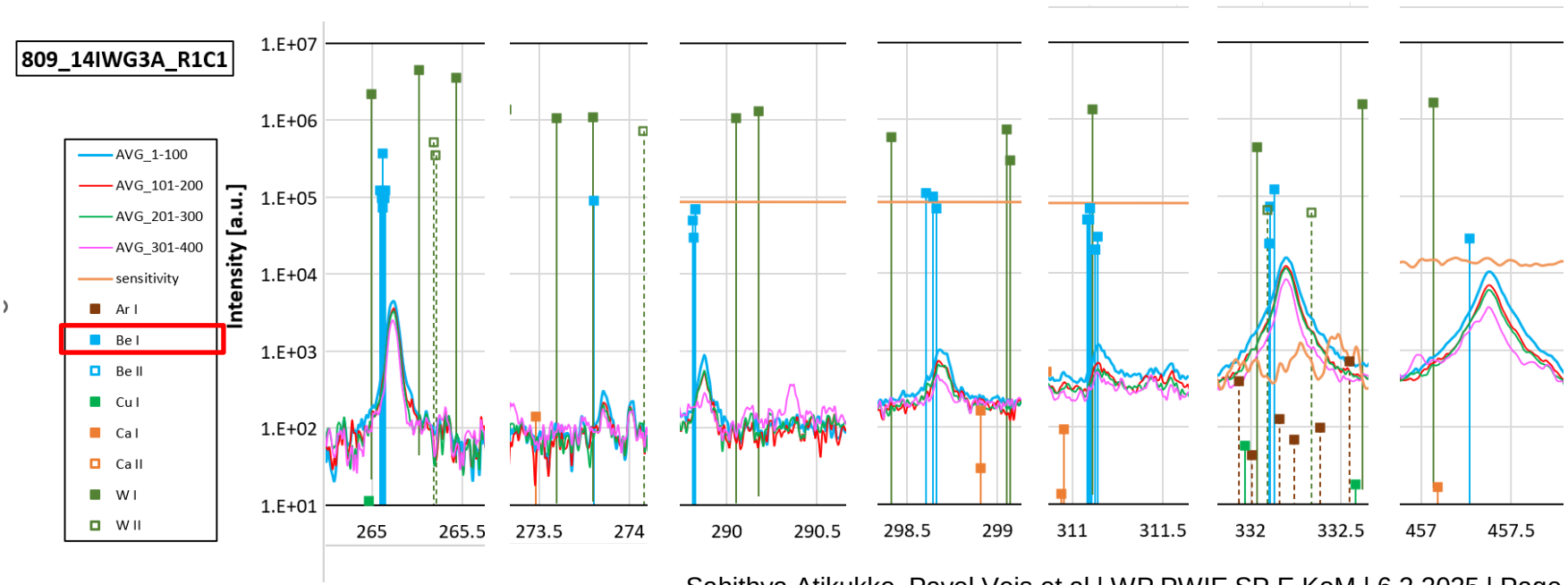
Spectral lines shift - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in NIR range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (around 0.15 nm) – observed on Ar I lines
- ✓ EASY to correct, but as well not negligible shift. How often was the spectrometer calibrated for wavelength using Ar/Hg lamp? Is the calibration spectra recorded?



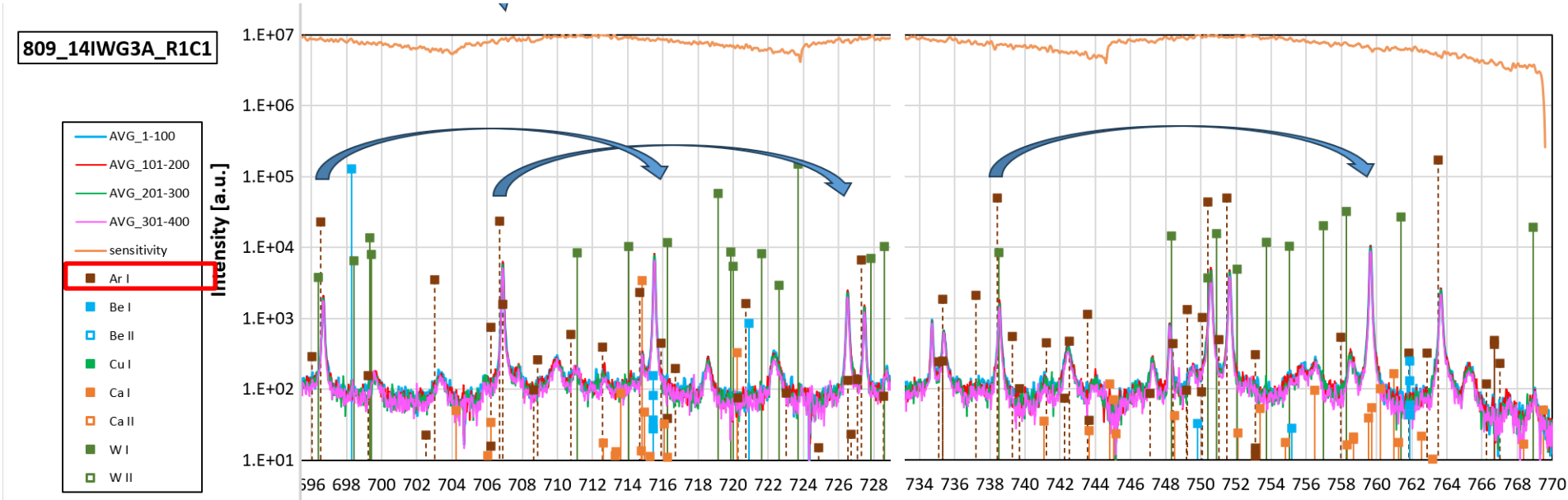
Spectral lines shift - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in UV range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (from 0.06 nm to 0.1 nm increasing with wavelength) – observed on Be I lines
- ✓ QUESTIONS How often was the spectrometer was calibrated for wavelength using Ar/Hg lamp? Are the calibration spectra recorded?



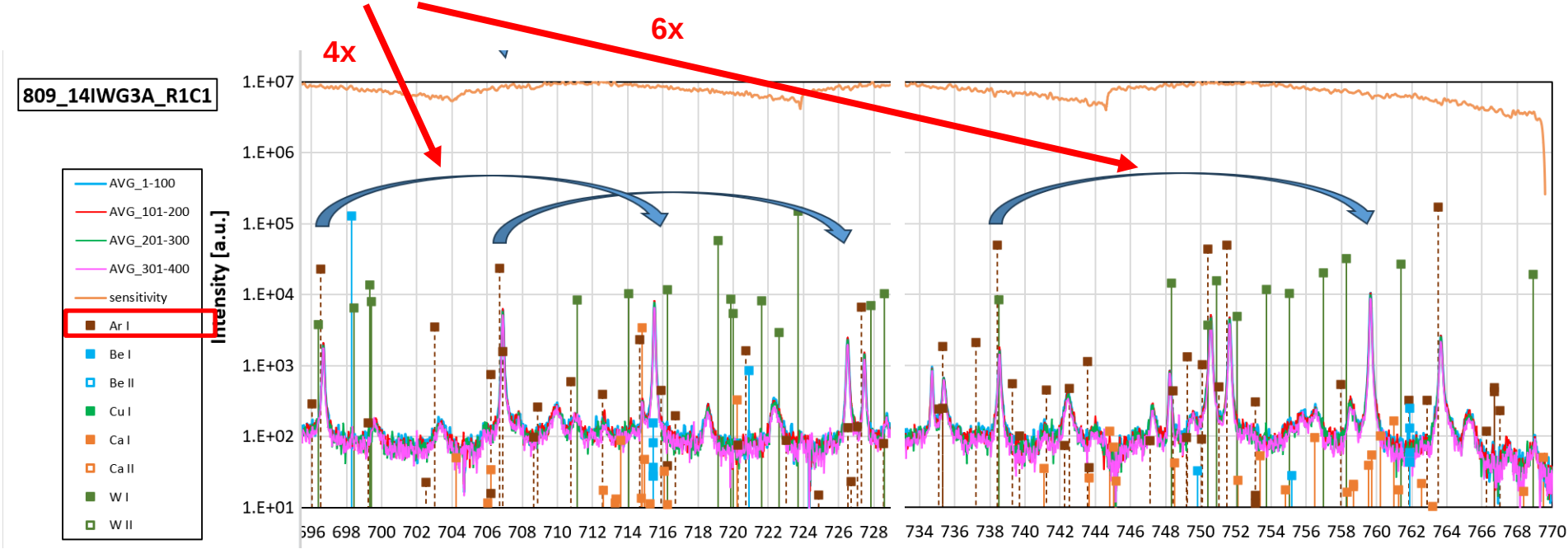
Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in NIR range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (around 0.15 nm) – observed on Ar I lines
- ✓ **Ghosts observed on strong Ar I lines**



Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in NIR range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak shift of real spectra to higher wavelength (around 0.15 nm)
- ✓ **Ghosts observed on strong Ar I lines**
- ✓ **Often the Ghost on the right side is stronger than the main peak (4x-6x)**



Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

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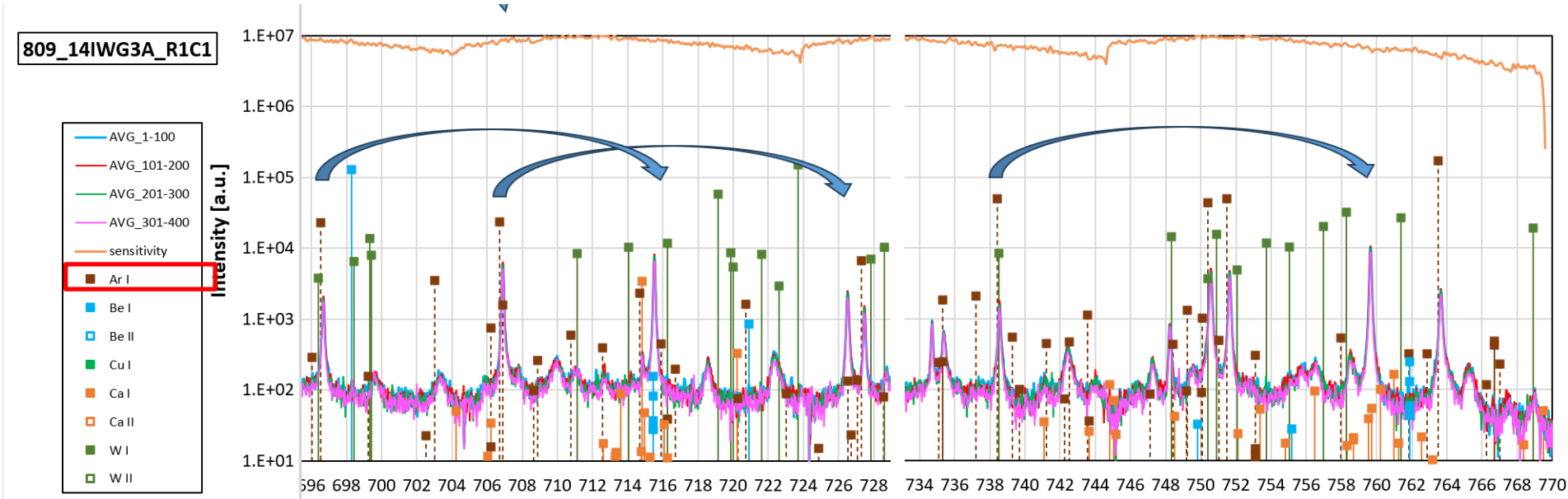
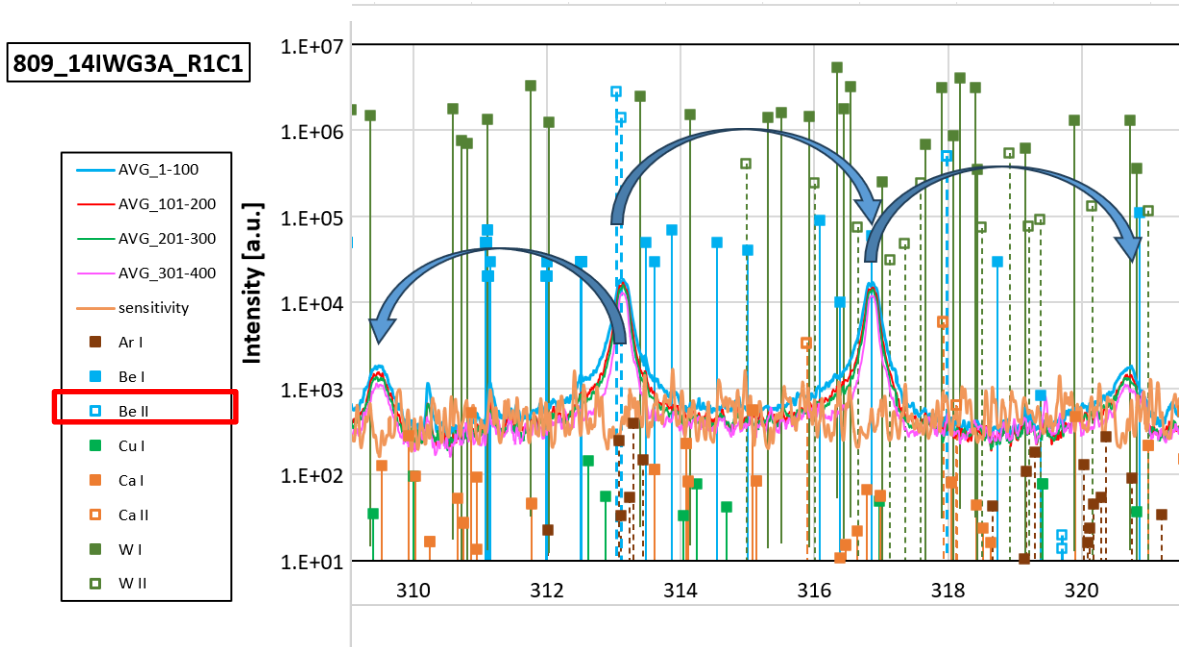


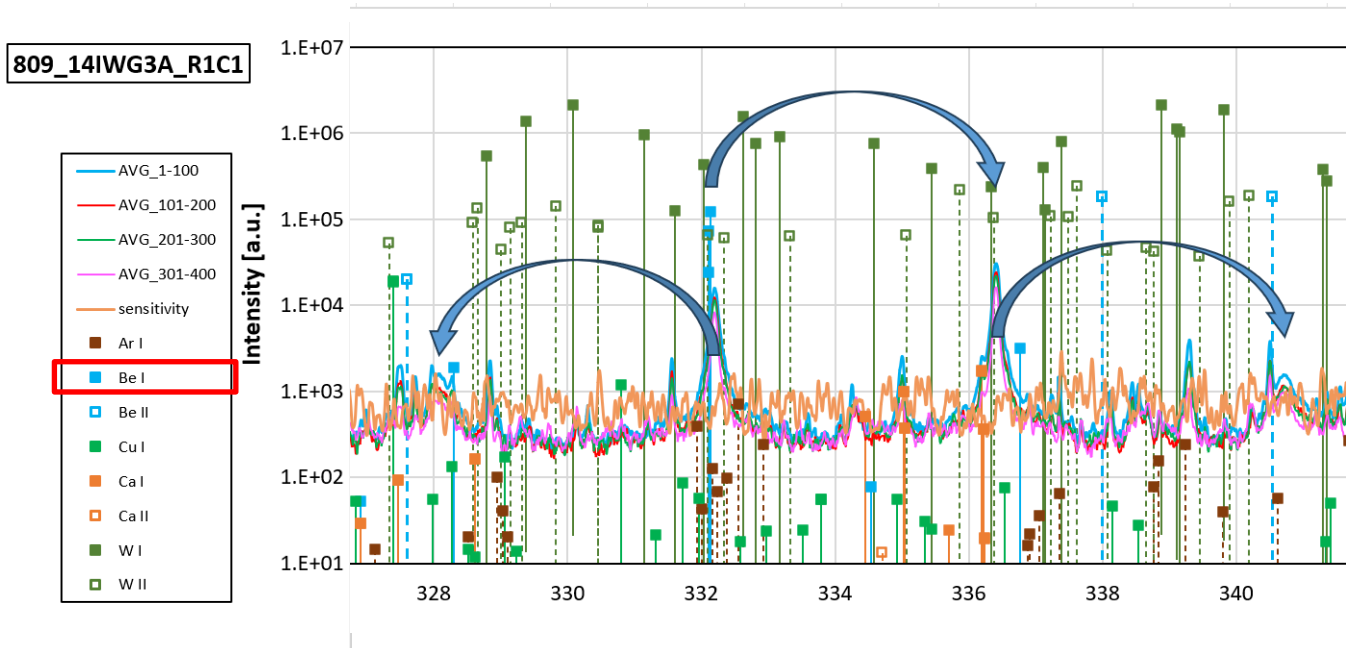
Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in UV range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (around 0.06 nm) – observed on Be I lines
- ✓ **3 ghosts observed on strong Be II line at 313 nm, 2 ghosts on the wings are negligible and ghost on the right side has approx.. the same intensity as the main peak (0.9x)**



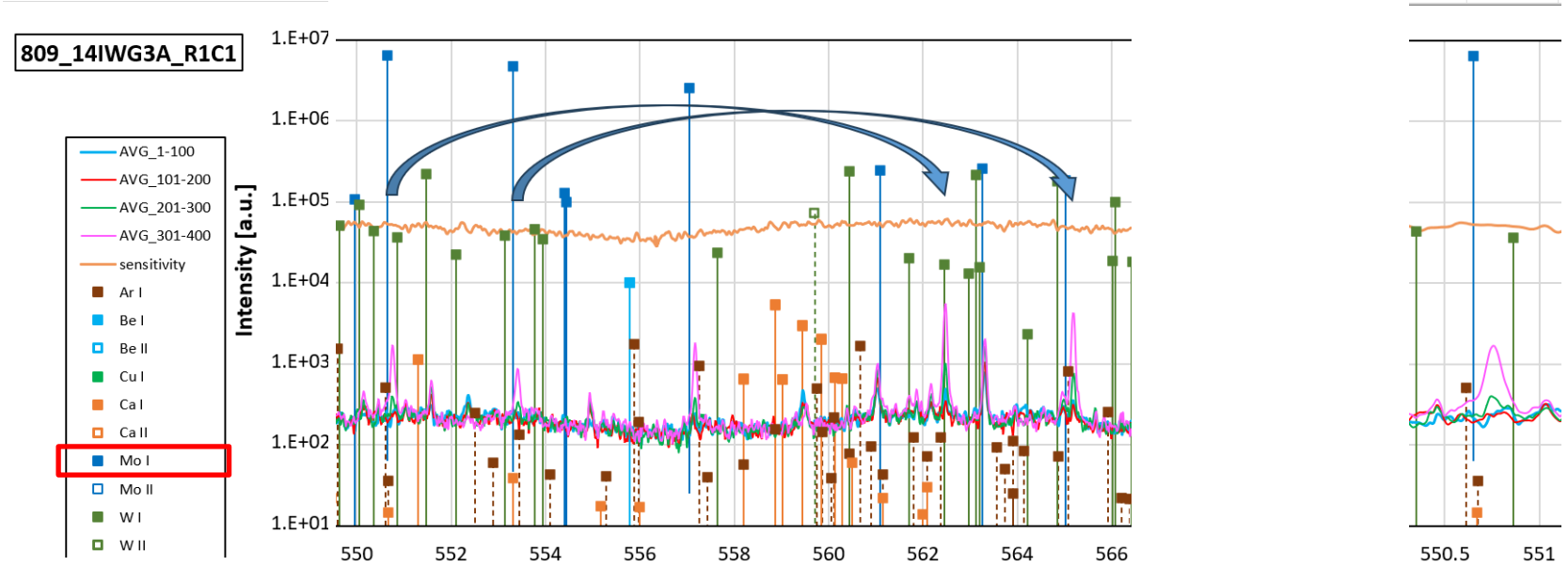
Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in UV range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (around 0.06 nm) – observed on Be I lines
- ✓ **3 ghosts observed on strong Be I line at 332 nm, 2 ghosts on the wings are negligible and ghost on the right side has higher intensity as the main peak (1.9x)**



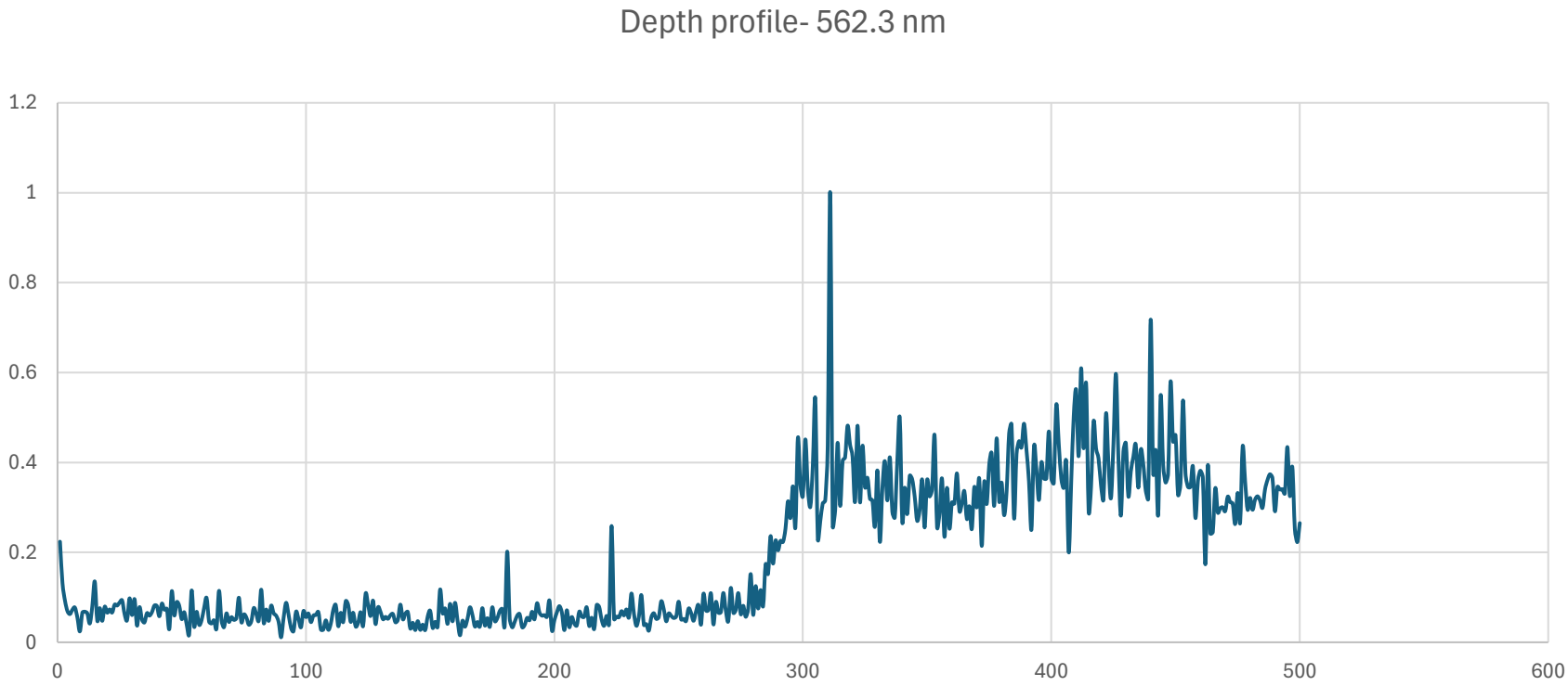
Spectral lines Ghosts - data analysis from JET LIBS campaign 2024

- ✓ LIBA spectrum in VIS range - sample JET_809_14IWG3A – Ar atmosphere / non divided by sensitivity
- ✓ Weak **shift** of real spectra to higher wavelength (around 0.1 nm) – observed on Mo I line at 550.65 nm
- ✓ **Ghosts observed on strong Mo I line at 550.65 and 553.3 nm, ghost situated on the right side has higher intensity as the main peak (3.5x-5.5x)**
- ✓ **Mo I line appears in last 2 average spectra from 301-400 and from 401-500.**



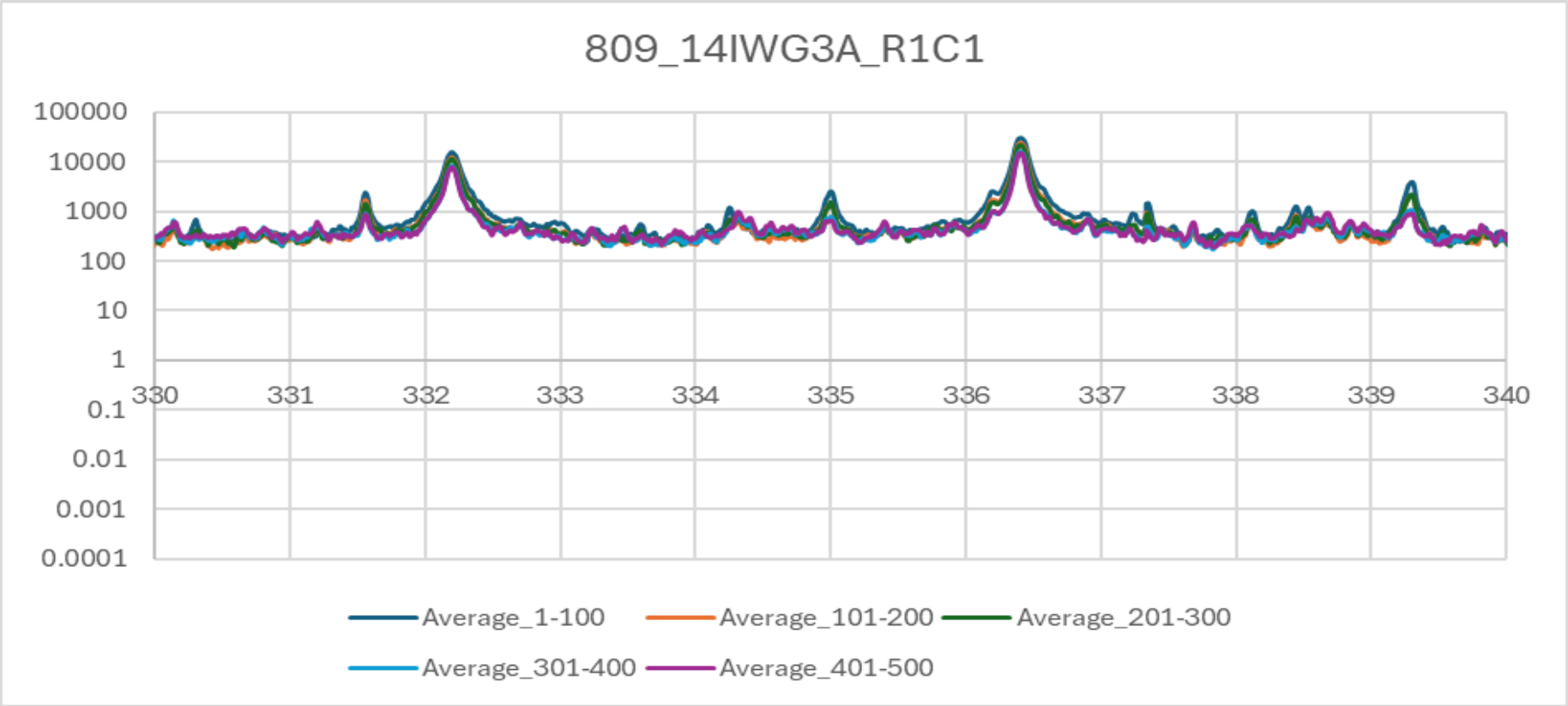
Depth profile analysis of data from JET LIBS campaign 2024

Mo I line @ 550.65 nm and its ghost @ 562.3 nm with 5.5x higher intensity =>
=> Depth profile analysis on the ghost.



Depth profile analysis of data from JET LIBS campaign 2024

Be I line @ 332.2 nm and its ghost is not desapearing in shots range up to 500.



CF LIBS analysis of „know how in CU group“

- CU group has more than 10 years experience in CF LIBS analysis for different alloys and fusion related samples
- We wrote **our own CF LIBS analysis program** based on **manual preselection and controle of lines**
- We have **large knowledge about suitable lines** from previous paper on CF LIBS of **W, Mo, Be based layers**.
- In our program of CF LIBS analysis the **self absorbed lines are excluded**.
- **Evaluation of Te and ne** for plasma diagnostics could be provide from several approaches (Stark broadening, Saha equation)
- **See enclosed overview of our papers**

- **WE are interested to provide Te, ne, depth profile analysis and if data will be suitable also CF LIBS analysis**

CF LIBS analysis of „know how in CU group“

Spectrochimica Acta Part B: Atomic Spectroscopy 216 (2024) 106930

Contents lists available at ScienceDirect

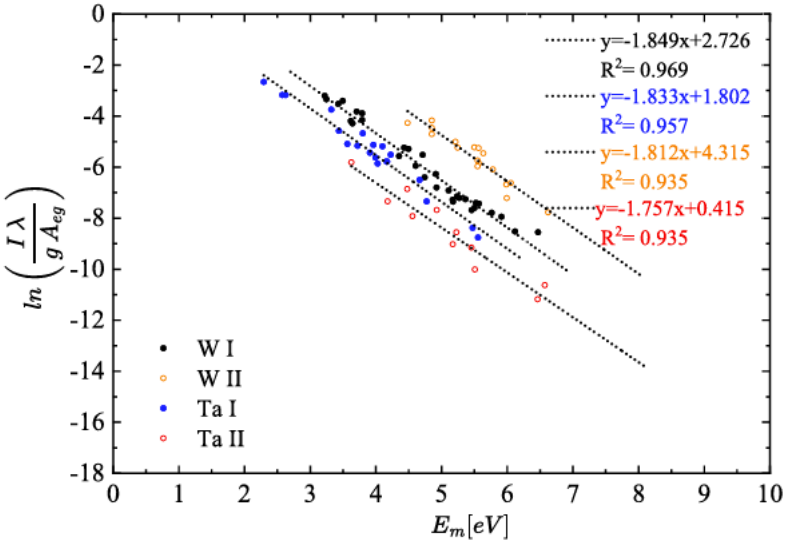
Spectrochimica Acta Part B: Atomic Spectroscopy

journal homepage: www.elsevier.com/locate/sab

Depth profiling of W—Ta based fusion-relevant samples using picosecond laser ablation

Shweta Soni [a], Sahithya Atikukke [b], Matej Veis [a], Nima Bolouki [c], Pavol Ďurina [a], Pavel Dvořák [c], Martina Mrkvičková [c], Eduard Grigore [d], Pavel Veis [a,*]

Gate Delay (ns)	GDOES conc. (at. %)		CF-LIBS conc. (at. %)	
	W	Ta	W	Ta
200	90.20	9.80	89.87	10.13
300			89.61	10.39
450			89.68	10.32
200	97.48	2.52	89.87	10.13
300			89.61	10.39
450			89.68	10.32
200			96.45	3.55
300			96.71	3.29
450			96.52	3.48
200			96.46	3.54
300			97.05	2.95
450			97.26	2.74



CF LIBS analysis of „know how in CU group“

Nuclear Materials and Energy 38 (2024) 101558

Contents lists available at ScienceDirect

Nuclear Materials and Energy

journal homepage: www.elsevier.com/locate/nme

Resonant Laser Induced Breakdown Spectroscopy for quantitative elemental depth profile analysis of WTa coating

Sahithya Atikukke [a], Matej Veis [a], Waseem Khan [b], Eduard Grigore [c], Flaviu Baiasu [c], Pavol Ďurina [a], Tomáš Roch [a], Pavel Dvořák [b], Pavel Veis [a,*]

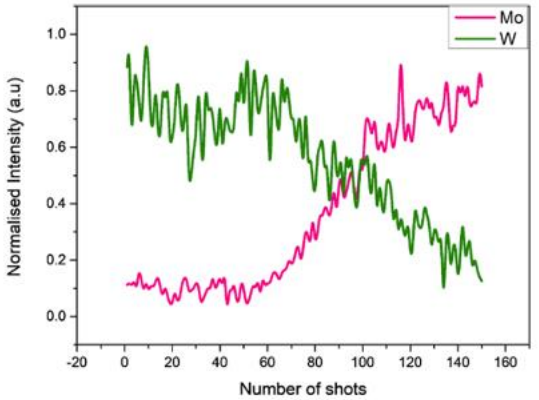


Table 3
Quantification on WTa coating at resonant conditions.

Resonance/Delay	500 ns	1000 ns
W (at %)	80.80 ± 1.40	80.80 ± 2.00
Ta (at %)	19.20 ± 1.20	20.00 ± 2.00

Table 4
Quantification on WTa coating at off-resonant conditions.

Non-Resonance/Delay	500 ns	1000 ns
W (at %)	80.80 ± 1.50	80.10 ± 1.80
Ta (at %)	19.20 ± 1.50	19.90 ± 1.80

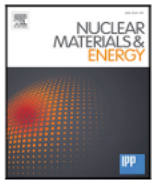
CF LIBS analysis of „know how in CU group“

Nuclear Materials and Energy 37 (2023) 101547

Contents lists available at ScienceDirect

Nuclear Materials and Energy

journal homepage: www.elsevier.com/locate/nme



Depth profile CF LIBS analysis of the wall deposited layer in the COMPASS tokamak after LiSn testing campaign

Sanath J. Shetty [a,1], Matej Veis [a,1], Sahithya Atikukke [a], P
Renaud Dejarnac [b], Pavel Veis [a,*]

Phys. Scr. **96** (2021) 124066 https://doi.org/10.1088/1402-4896/ac3a4e

Physica Scripta

PAPER

Calibration-free laser-based spectroscopic study of Sn-based alloys

Sahithya Atikukke[1], Alicia Marín Roldán[1], Vishal Dwivedi[1], Matej Veis[1,2] and Pavel Veis[1]

[1] Department of Experimental Physics, FMPI, Comenius Univ., Mlynská dol. F2, Bratislava 842 48, Slovakia
[2] Dept. of Inorganic Chemistry, FNS, Comenius Univ., Ilkovičova 6, Bratislava 842 15, Slovakia

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CF LIBS analysis of „know how in CU group“

Fusion Engineering and Design 172 (2021) 112898

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

LIBS investigation of metals suitable for plasma-facing components: Characteristics and comparison of picosecond and nanosecond regimes

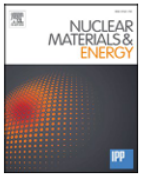
Alicia Marín Roldán [a], Vishal Dwivedi [a], Matej Pisarčík [a], Matej Veis [a], Julia Miškovičová [a], Yuriy Halahovets [b], Peter Šiffalovic [b], Milan Držík [c], Pavel Veis [a,*]

Nuclear Materials and Energy 27 (2021) 100990

Contents lists available at ScienceDirect

Nuclear Materials and Energy

journal homepage: www.elsevier.com/locate/nme



CF-LIBS quantification and depth profile analysis of Be coating mixed layers

V. Dwivedi [a], A. Marín-Roldán [a], J. Karhunen [b], P. Paris [c], I. Jõgi [c], C. Porosnicu [d], C.P. Lungu [d], H. van der Meiden [e], A. Hakola [f], P. Veis [a,*]

CF LIBS analysis of „know how in CU group“

Spectrochimica Acta Part B: Atomic Spectroscopy 177 (2021) 106055

Contents lists available at ScienceDirect

Spectrochimica Acta Part B: Atomic Spectroscopy

journal homepage: www.elsevier.com/locate/sab

Calibration-free analysis of a tungsten-based target for diagnostics of relevant fusion materials comparing picosecond and nanosecond LIBS

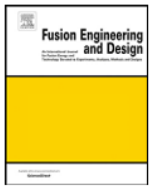
Alicia Marín Roldán [a], Matej Pisarčík [a], Matej Vei

Fusion Engineering and Design 153 (2020) 111488

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes



Selection of molybdenum lines by quantitative analysis of molybdenum-zirconium-titanium alloy by CF-LIBS for future fusion applications

J. Miškovičová[a,*], M. Anguš[a], H. van der Meiden[b], P. Veis[a,*]

Plans for 2025

- **Work progress in data analysis from JET LIBS measurement campaign at UKAEA**
  - First partial data from campaign we received 1 week ago.
  - Firstly, we started to **check the data globally** on averaged spectra
  - The **Be I, Ar I, Mo I and few Be II were observed** on average spectra
  - The weak **shift of real spectra** to the higher wavelength was observed **(0.5-1.5 nm)**
  - The ghosts of strong spectral lines was observed – **the ghost has higher intensity up to 6x** , what leads to problems in the interpretation of presented spectra lines (more intense lines are at the ghost position). **Were the echelograms recorded, If yes than the ghost analysis and the spectra correction should be done first.**
  - **D**epth profile analysis was done for few spectral lines.
- **Plans for 2025**
  - Correction of wavelength calibration incertitude.
  - Global analysis of ghost presence in measurements for incorporation of ghosts in data LIBS analysis.
  - Calibration curve realisation.
  - Analysis of presence of different spectral lines of different elements in measured spectra and selection of lines for Te evaluation.
  - Depth profile analysis of different elements (Be, Mo)
  - Realisation of calibration free LIBS analysis for suitable spectra with enough spectral lines