Analysis of K-lines X-ray fluorescence of Rare-Earth and High-Z elements on storage ring of the VEPP-4M

Outline

BEAMLINE №8 (VEPP - 4M)

Experiment layout for X-ray fluorescence (monochromator, detector, etc.)

XFA-SR experimental setup on the VEPP - 4M

Results of the MDLs REE (65 - 100 keV)

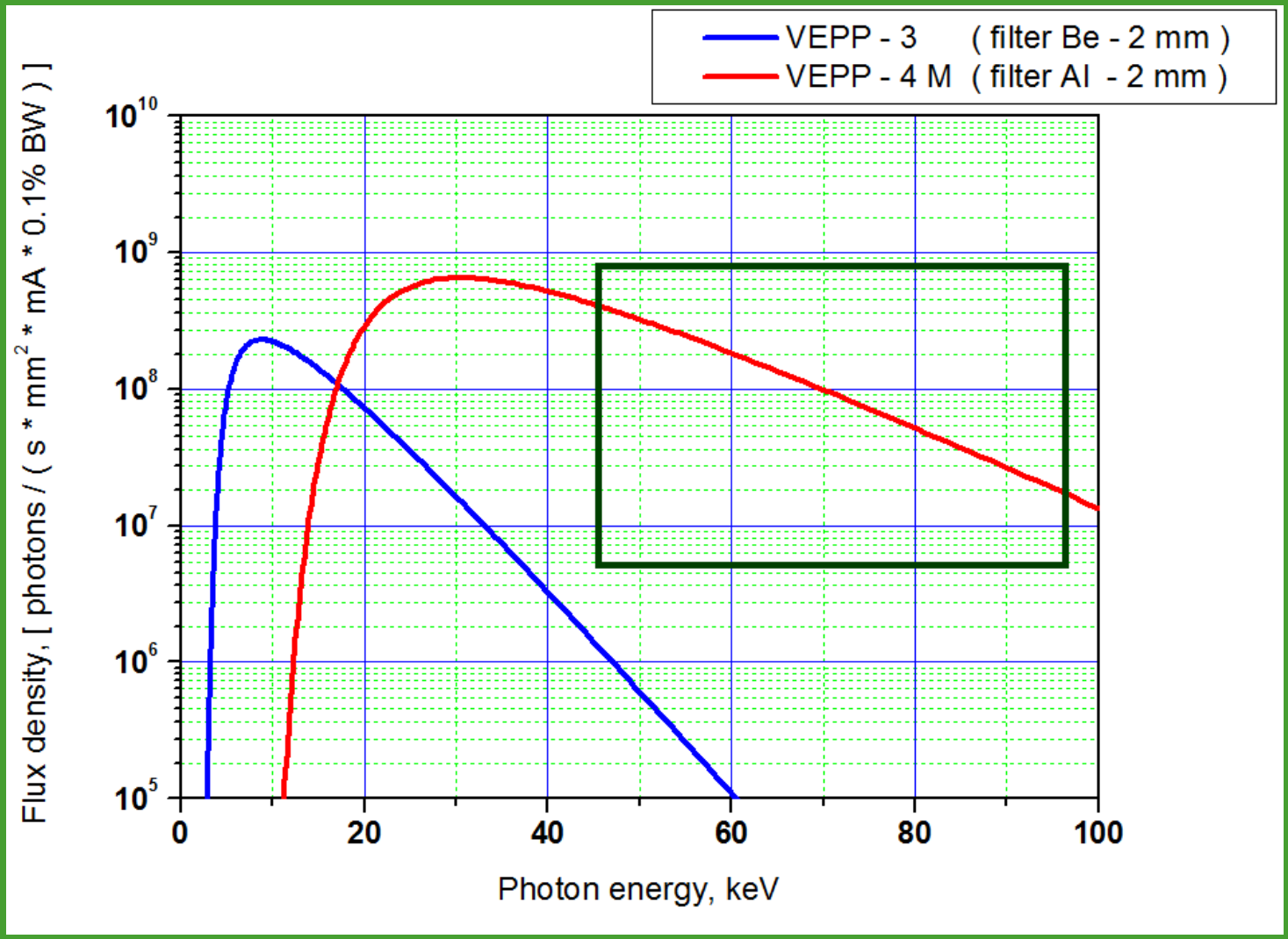
Results of the MDLs heavy platinoides (Os, Ir, Pt, Au) (100 keV)

Conclusion

BEAMLINE №8 (VEPP - 4M)

Source - wiggler, B = 1.2 T (7-pole), E_{el} = 4 GeV, I_{el} = 10 mA

The comparison of radiation from the VEPP-3 and VEPP-4M



Hard X-ray Advantage
REE and Heavy elements analysis

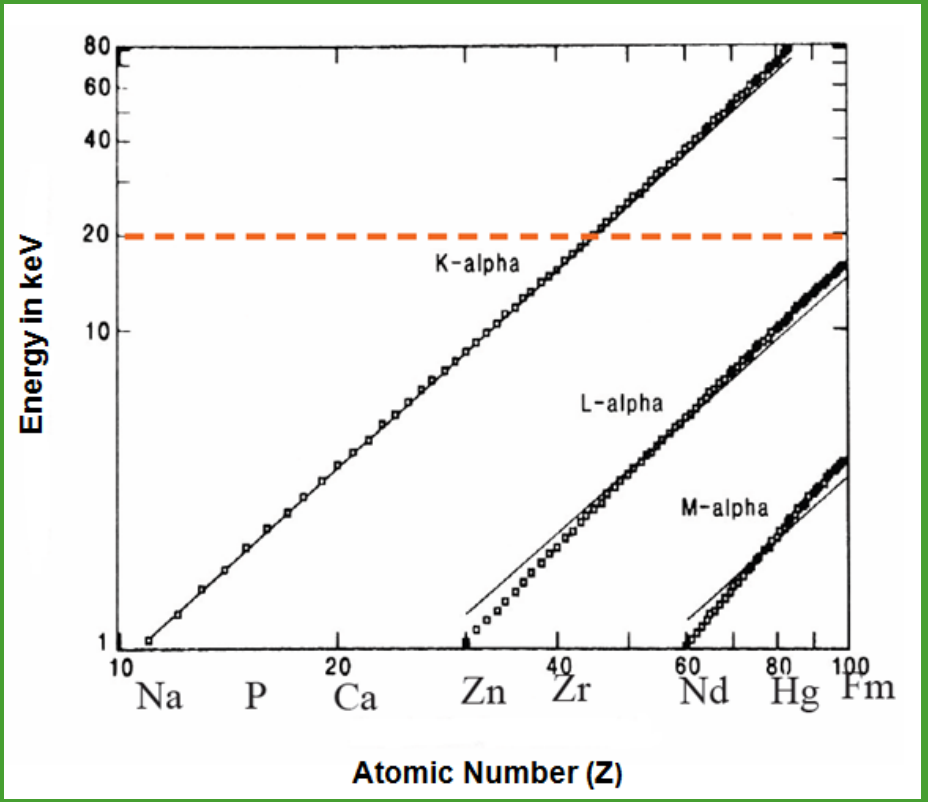
Disadvantage of L series analysis

- *Complicated lines L (α, β, γ, l, s)*
- *Peak overlapping between L and K series lines*

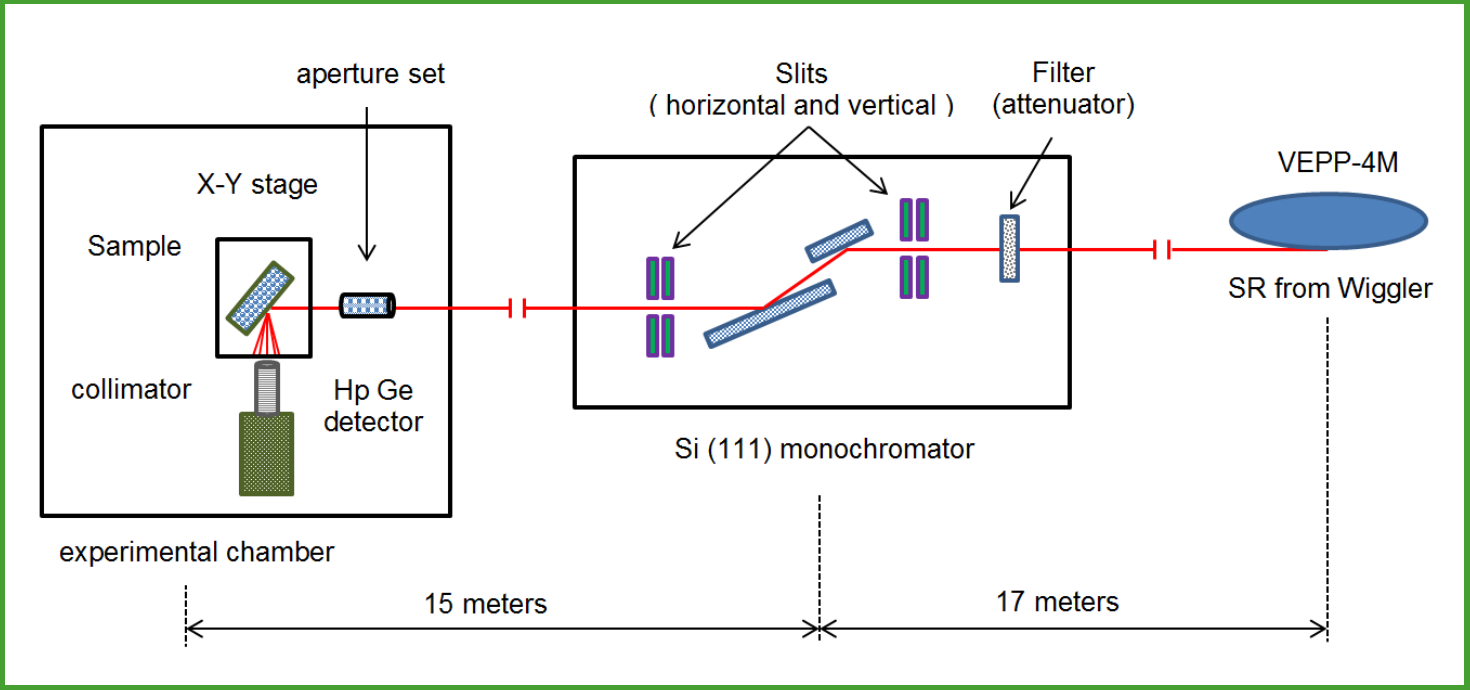
High Energy X-ray Excitation

Advantage of K series analysis

- *Simple line Structure K (α, β)*
- *High sensitivity*
- *Low absorption (bulk analysis)*

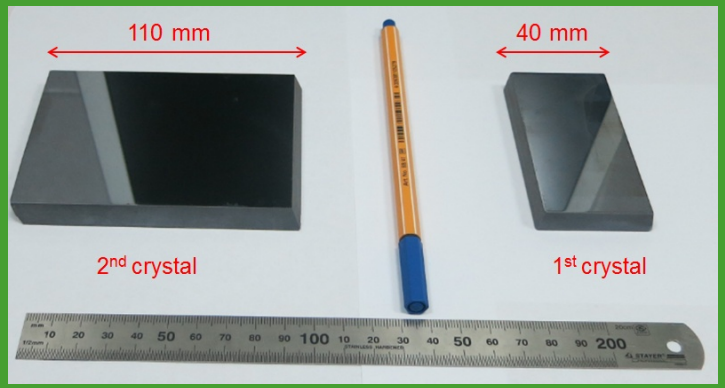


Experiment layout for X-ray fluorescence

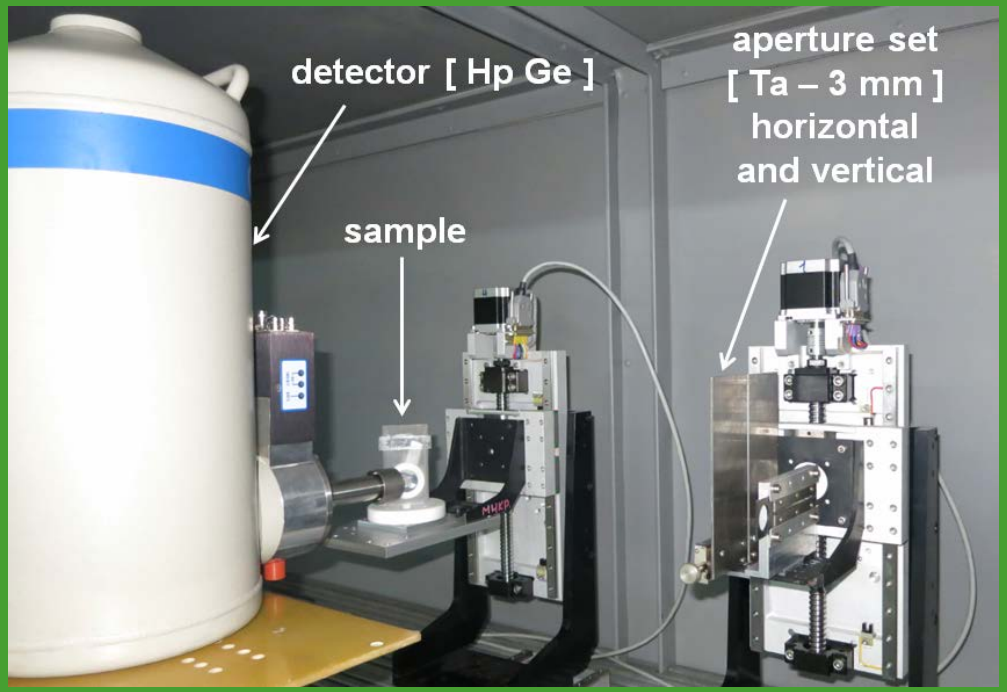


monochromator parameters

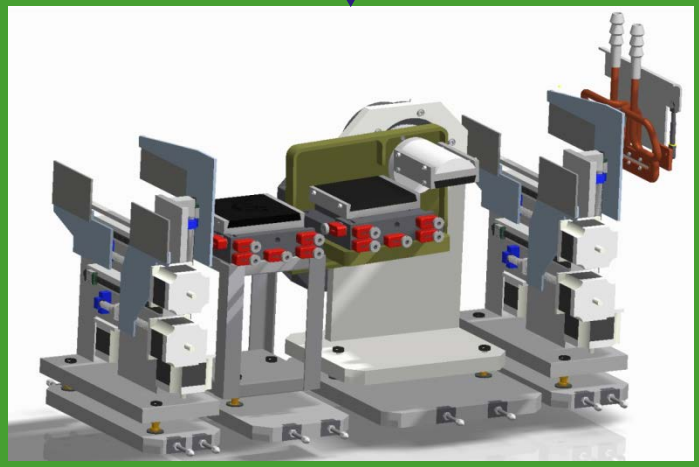
length of the first crystal	40 mm
length of the second crystal	110 mm
distance between crystals	4 mm
period of crystal (2d) for Si (111)	6.271 A
energy range	100 keV (1.13 ^{0}) 40 keV (2.83 ^{0})
energy resolution	$3 \cdot 10^{-3}$



XFA-SR experimental setup on VEPP-4M



Monochromator components



monochromator chamber

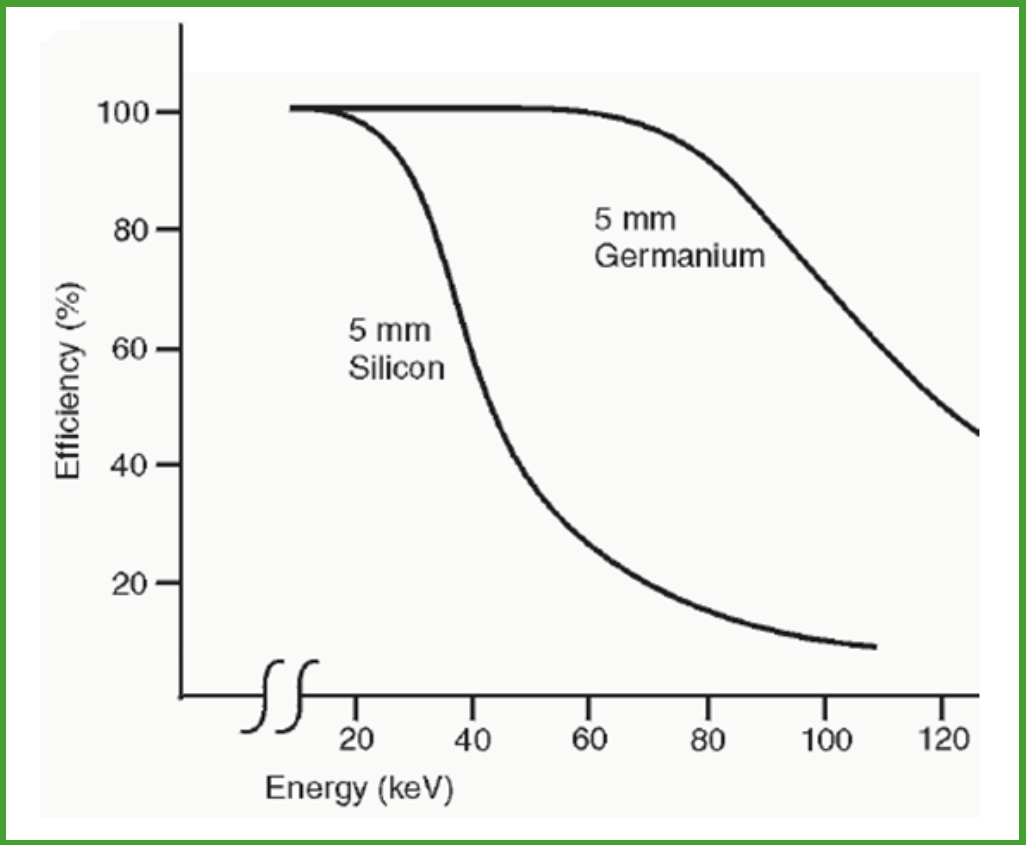
experimental chamber

Physical Characteristics

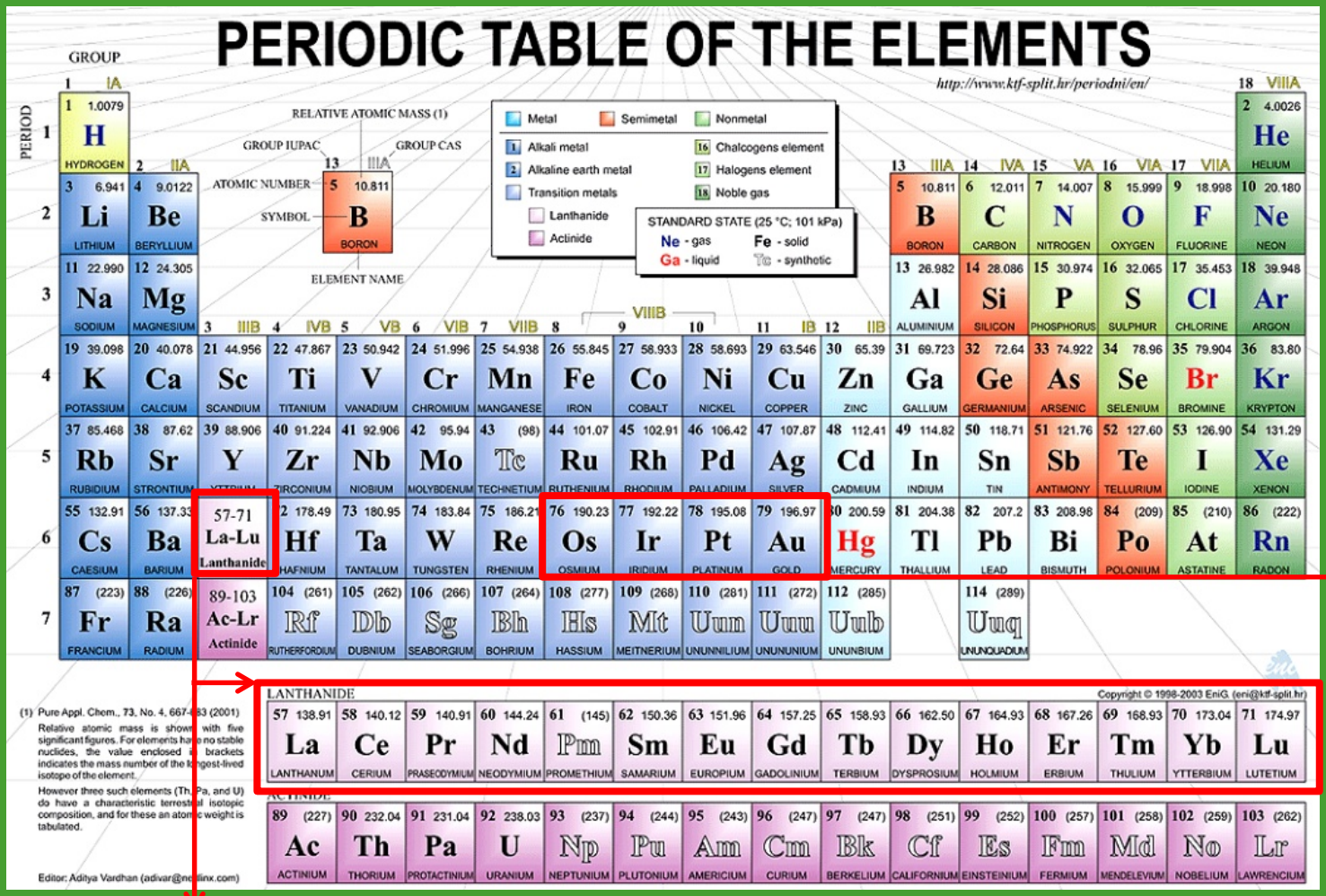
Germanium Detector «CANBERRA»

Active diameter – 3.6 mm
Active area - 10 mm^2
Thickness (Ge) – 5 mm
Thickness windows (Be) – 0.025 mm

Energy [keV]	5.9	122
Resolution (FWHM) [eV]	150	460



REE – Rare Earth Elements and HP - Heavy Platinoids



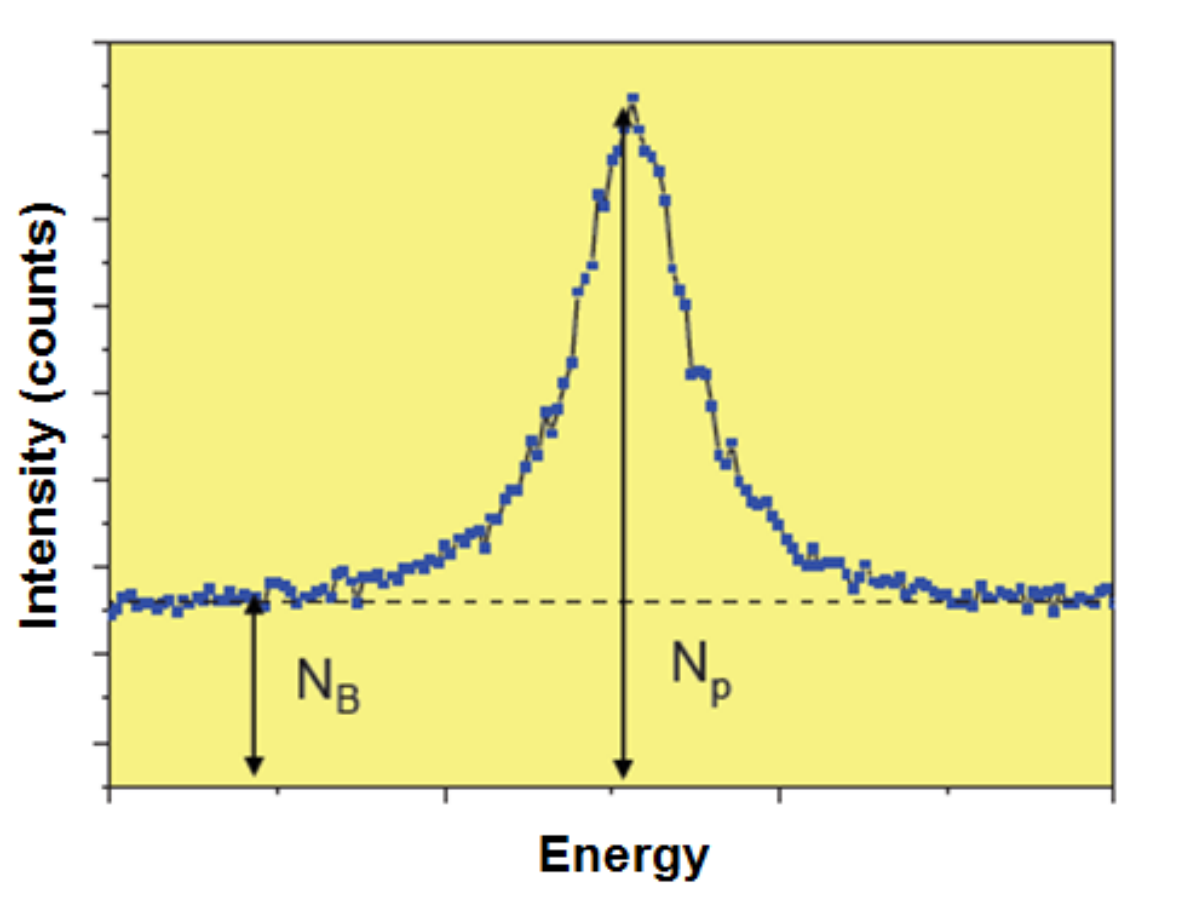
Rare Earth Elements La [Z=57] – Lu [Z=71]

Emission K – lines from 33 keV to 61 keV

Heavy platinoides Os [Z=76] – Au [Z=79]

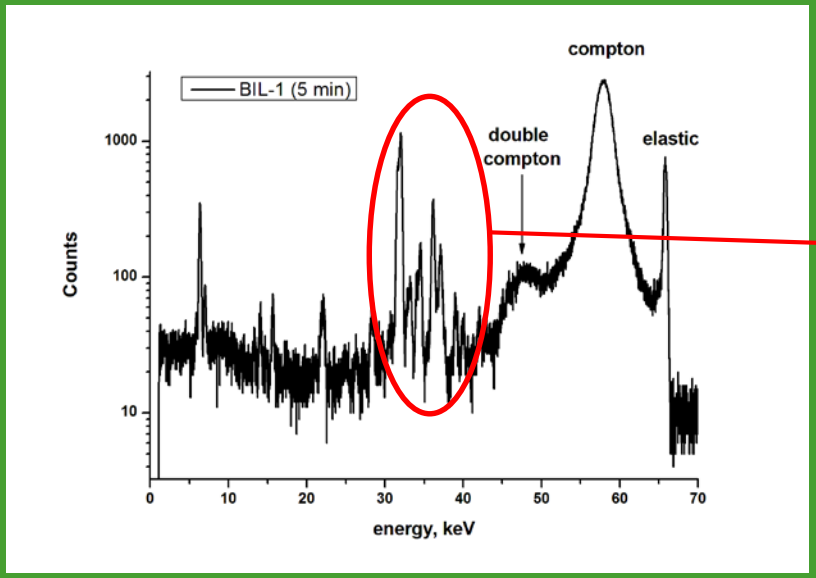
Emission K – lines from 63 keV to 78 keV

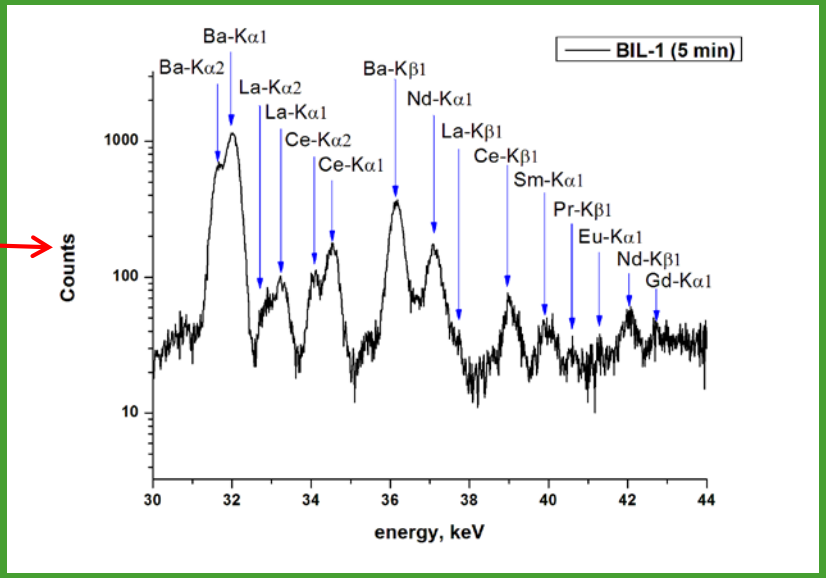
MDL (Minimum detection limit)

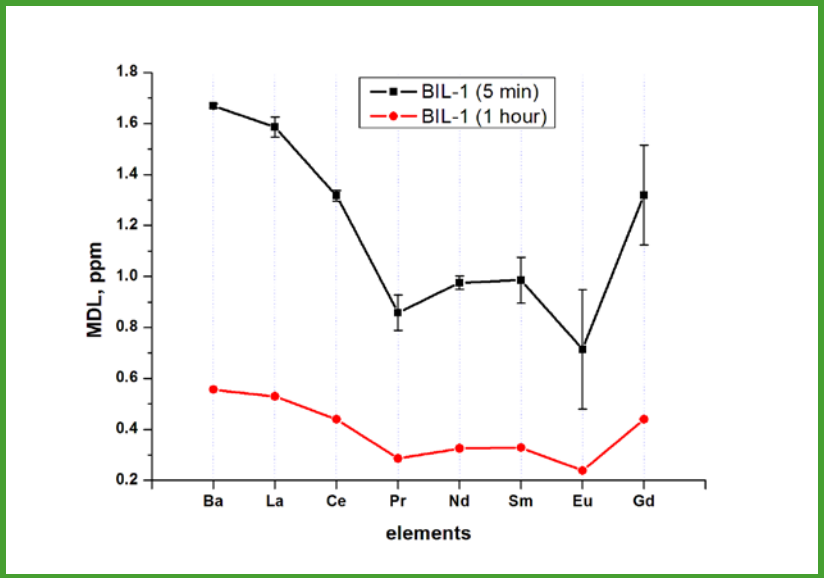


$$\mathrm{MDL} = \frac{3 \cdot C \cdot \sqrt{N_B}}{N_P - N_B}$$

Energy of excitation 65 keV



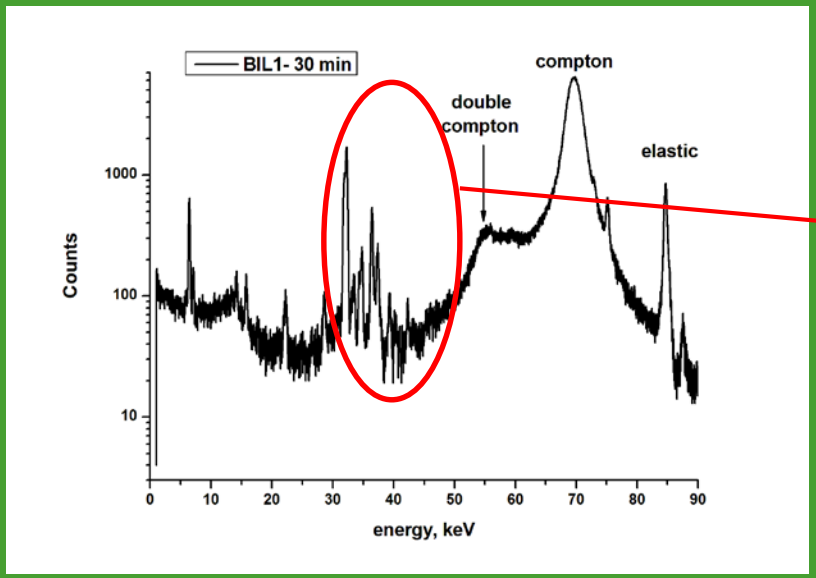


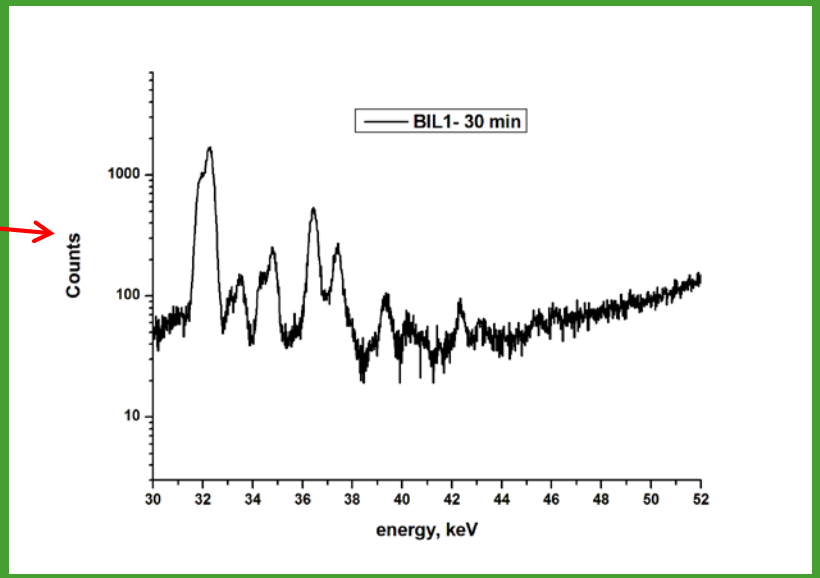


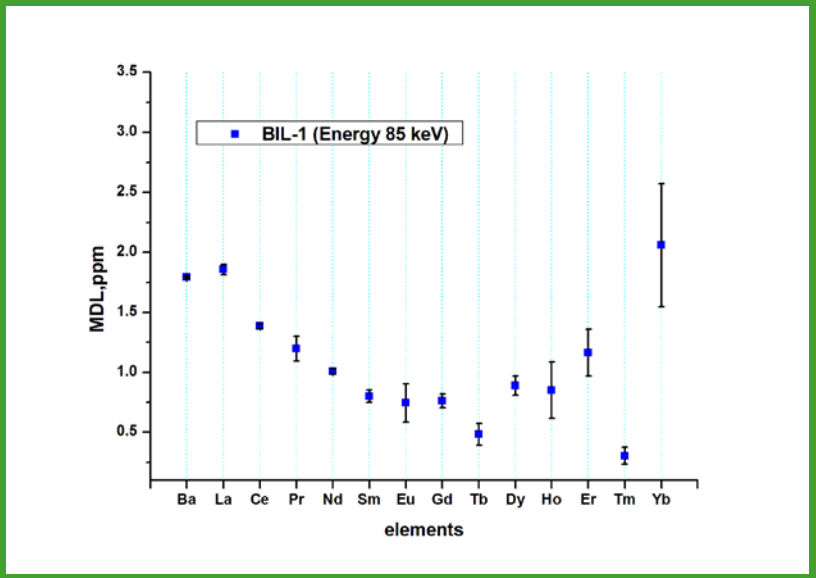
reference sample BIL-1

element	concentration (ppm)
Ba	710
La	45
Ce	80
Pr	8
Nd	39
Sm	7
Eu	1.4
Gd	5.8

Energy of excitation 85 keV



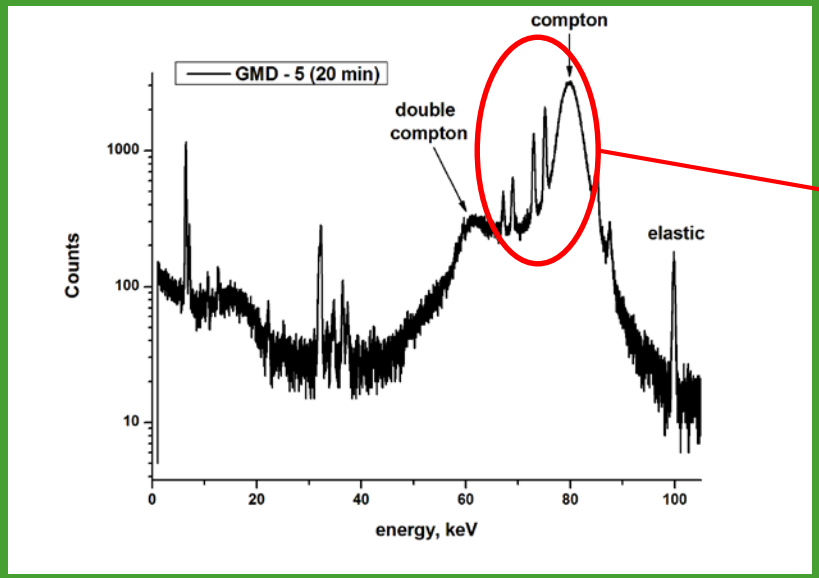


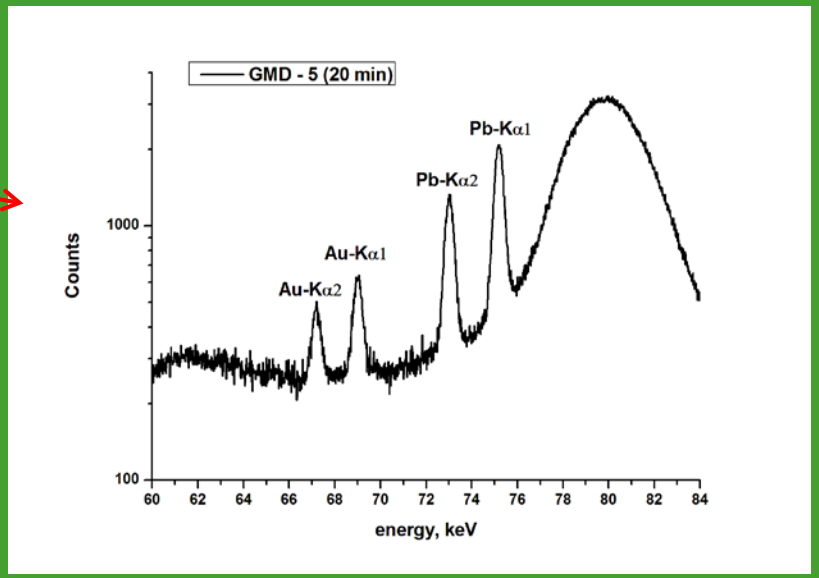


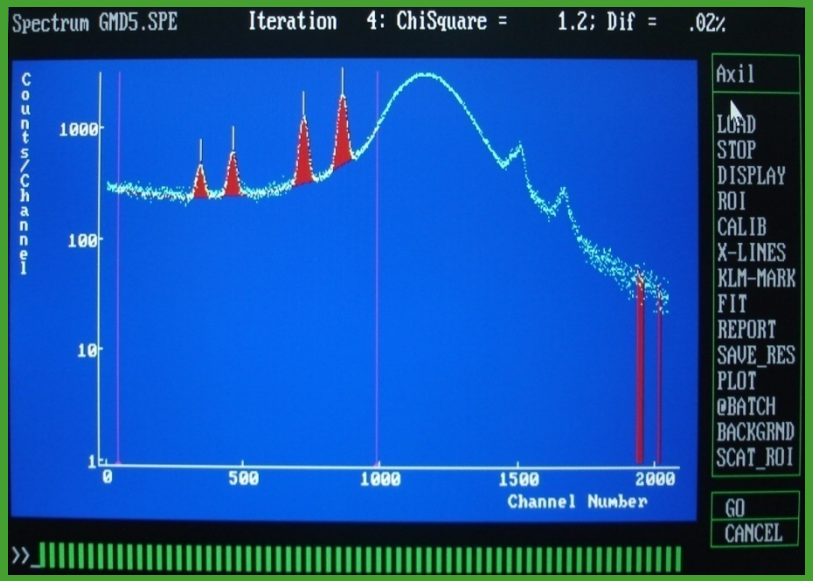
reference sample BIL-1

element	concentration (ppm)
Ba	710
La	45
Ce	80
Pr	8
Nd	39
Sm	7
Eu	1.4
Gd	5.8
Tb	0.9
Dy	4.6
Ho	1
Er	2.6
Tm	0.4
Yb	2.9

Energy of excitation 100 keV



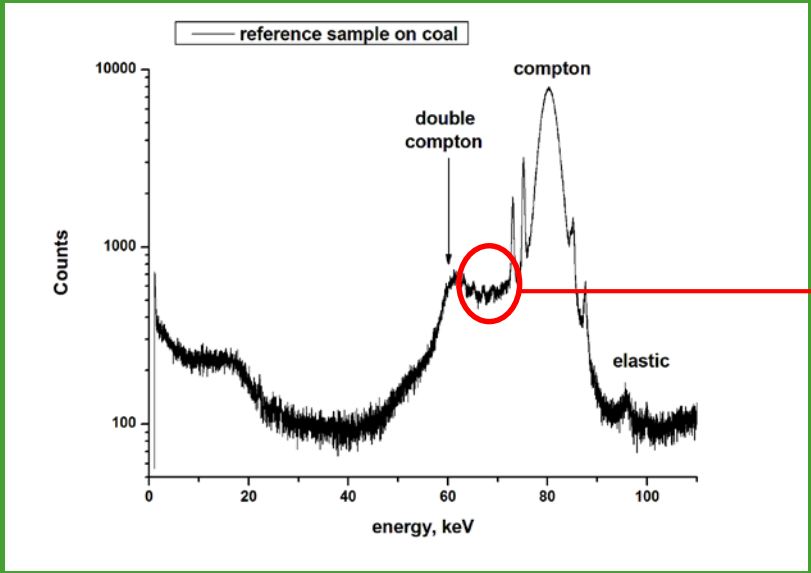


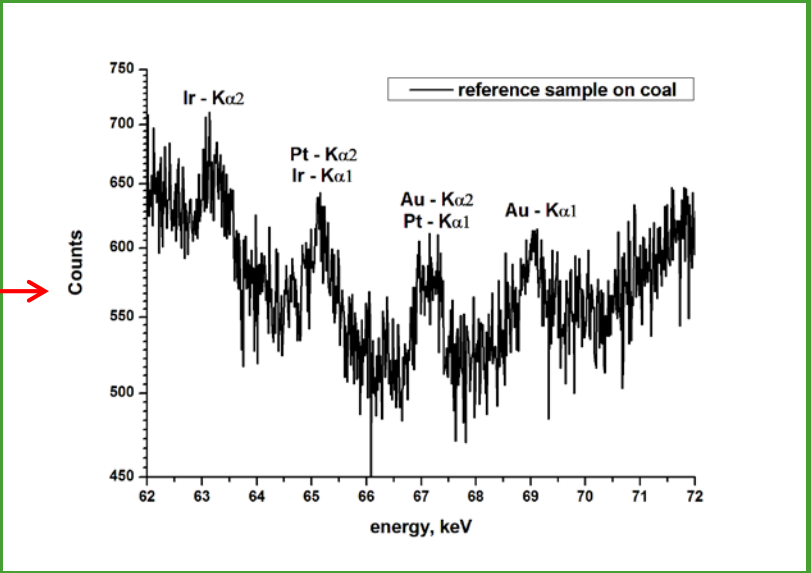


reference sample GMD-5
(concentration Au – 44 ppm)

element	MDL (ppm)
Au – K α1	0.75
Au – K α2	1.24

Energy of excitation 100 keV





coal reference sample (concentration Ir, Pt, and Au = 10 ppm)

element	lines energy [keV]	peaks overlap [eV]	MDL (ppm)
Ir – K α2	63.28	no	1.1
Ir – K α1 Pt – K α2	64.89 65.11	220	----- 0.8
Pt – K α1 Au – K α2	66.82 66.98	160	----- -----
Au – K α1	68.79	no	1.0

Conclusion

- **The powerful measurement technique has been developed at the new XFA-SR station of VEPP-4M storage ring for the analysis of geological, archaeological and geochemical samples containing heavy and rare earth elements**
- **The experimental values for minimum detection limits of rare earth elements from La to Lu are in the range from 0.2 to 1 ppm**
- **The experimental values for minimum detection limits of heavy platinoids (Os, Ir, Pt, Au) are in the range below 1 ppm**
- **We invite all the interested users to carry out the scientific experiments at our new XFA-SR station of VEPP-4M storage ring**

Thank you for your attention