X-RAY LINES RELATIVE INTENSITY DEPENDING ON DETECTOR EFFICIENCY, FOILS AND CASES THICKNESS FOR PRIMARY AND SCATTERED SPECTRA

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(Received April 1, 2011)

Primary and Compton scattered radiation spectra from radioactive source ^{241}Am were measured in various geometry and for various targets. Spectral lines intensity of characteristic X-ray radiation (CXR), Compton and Rayleigh scattering are defined. The back scattering peak for a line $59.54\,keV$ was explored. X-ray quanta were registered by the packaged Si detector $300\,\mu m$ and input Al foil $10\,\mu m$ thicknesses. Radiation interaction with targets and detector atoms was simulated in software code $GEANT\,4\,(LE)$. Simulated spectra, quanta registration efficiency and secondary calculated radiation spectra at $90°...160°$ are compared with experimentally measured energy distributions.

PACS: 07.85.Fv, 61.80.Cb

1. INTRODUCTION

The experimental and calculated radiation spectra are changing essentially, if the radiation source or the detector is placed in the protective container. Lines intensity of low-energy radiation is reduced and, at the same time, lines CXR from a container material and a line of "back scattering" peak are registered. Numerical processing of primary and Compton scattered radiation spectra from X-ray and gamma radiation source (^{241}Am, ^{57}Co, ^{137}Cs, ^{60}Co etc.) demands the complete experiment description: its geometry, the foil thickness, energy and intensity of primary X-ray lines, efficiency of the quanta registration and the energy resolution of the detector. Program code $GEANT\,4$ allows considering all these details and becomes an important methodical base of the experiment description. Compton and Rayleigh spectra were measured and computed for ^{241}Am source in earlier work [1, 2]. We used of X-rays from a radioactive source ^{241}Am for study of the primary and Compton scattered spectra, intensity of radiation lines registered by a thin silicon detector. In this case quanta registration efficiency has an important role. Radioactive sources are convenient for verification of spectrometric channels by preparation for experimental study of properties of the X-rays eradiated by electrons in crystals (called "channeling radiation" [3, 4, 5, 6]). For measuring of such radiation it is necessary know all features of quanta registration in this energy interval. For measuring of intensive X-rays spectra it is necessary to use secondary targets - scatterers with the Compton scattering spectra registration under a certain angle. The experimental method on base of Compton scattering for gamma radiation spectra measuring from electrons with energy of $1200\,MeV$ in single crystals has been earlier described and used in [7, 8, 9]. Application of the Compton scattering method for X-ray radiation it was studied in works [9, 10, 11]. The purpose of the present work is: - investigation of X-rays lines intensity depending on experimental conditions (registration efficiency, the foil and container thickness, the scattering angle); - experimental measuring and $GEANT\,4$ modeling of primary X-rays scattering process on atoms of the target - scatterer in low energy radiation interval ($< 60\,keV$); - restoration of experimental and computing spectra to compare with experimentally measured primary X-ray spectra and make conclusions about Compton scattering procedure possibilities and its optimization.

2. THE EXPERIMENTAL TECHNIQUE AND MODEL

Radiation spectra from two radioactive source ^{241}Am are measured, one of which is placed in the protective container. The X-ray quanta was registered by the packaged Si detector $300\,\mu m$ thickness with size $1.8 \times 1.8\,mm^2$ and input Al foil $10\,\mu m$ thickness. The intensity of lines, "back scattering" peak and ^{241}Am spectra after passage through targets with various thickness was measured. Secondary radiation scattering spectra at angles $90°...130°$ was measured on targets with different Z. The distance between the source and target was $10\,cm$. The radiation source was collimated, the angular resolution of detecting system was specify by the sizes of a silicon detector. Lines CXR, Compton and Rayleigh spectra were observed. Intensity of lines

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was calculated by summation of the areas under corresponding peaks by fitting in program $OriginPro\,8$. Then intensity of lines was normalized on Si detector registration efficiency for quanta with corresponding energy. In program code $GEANT\,4$ ($processes/electromagnetic/LowEnergy$), installed on platform $ScientificLinux\,4$, was computed primary X-rays interaction with a target material in energy range 1...60 keV. The scattering quanta and secondary radiation yield depending on Z targets were calculated. By means of a Monte-Carlo method primary radiation spectra ^{241}Am source were modeled. The X-ray quanta flux was going to a target-scatterer. Then primary quanta was scattered and registered by the Si detector at angles 90°...160°. These scattering spectra were restored on the procedure [7] and compared with primary radiation spectra. The restoration procedure is based on Compton and Klein-Nishina formulae [10]. On evidence of coincidence or discrepancy primary and restored spectra we conclude about possibility of using Compton-restore procedure. The spectra distortions from additional radiation (like CXR)in target are considered. These distortions make difficulties or do impossible of primary spectrum restoration. In $GEANT\,4\,(LE)$ X-ray quanta registration efficiency for thin Si detector 300 μm thickness are calculated. The strong dependence of registration efficiency from quanta energy was shown and take into account in the lines intensity restoration. Computed results are compared with measured and tabular data.

3. INFLUENCE OF THE DETECTOR EFFICIENCY, FOILS AND CONTAINER THICKNESS ON THE RADIATION REGISTRATION

In Fig.1 calculated efficiency of X-ray quanta registration by the Si detector 300 μm and input Al foil 10 μm thicknesses are shown.

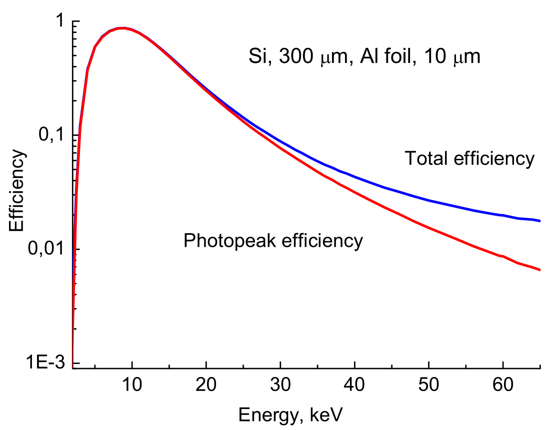

Fig.1. *Calculated efficiency of the X-ray quanta registration by Si detector* 300 μm *and input Al foil* 10 μm *thicknesses*

Total efficiency η_t is response at presence of any detector reactions on transiting X-ray quantum, photopeak efficiency η_{ph} is X-ray quantum registration with energy total absorption. Calculated results have shown that efficiency of detecting system reaches a maximum 0.87 for energies of quanta nearly 9 keV, then efficiency decrease with quantum energy increasing. Efficiency is almost equal 1 up to $E = 8\,keV$ in the absence of a input Al plate. In the energy interval up to 25 keV the total efficiency η_t practically coincides with value of efficiency η_{ph}. Difference between efficiencies η_t and η_{ph} increase with energy increasing: for $E = 50\,keV$ values η_t and η_{ph} are 0.0268 and 0.0154, for $E = 60\,keV$ are 0.0198 and 0.0087, for $E = 80\,keV$ are 0.014 and 0.0033, respectively. The calculated efficiency take into account on restoration experimentally measured lines intensity to real value. In Fig.2 two experimental radiation spectra ^{241}Am are shown. Spectra measured at angle 0° for two types of source: one for the thin source, second for the intensive source in the steel cylinder container with thin exit window (150 μm).

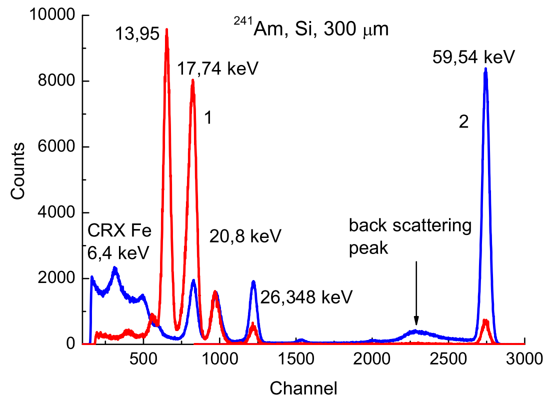

Fig.2. *The experimental radiation spectra* ^{241}Am*, measured at angle* 0° *for two types of source: 1 - thin source; 2 - intensive source in the steel cylinder container*

The standard radiation spectrum ^{241}Am consist from several lines with known energy 13.95, 17.74, 20.8, 26.348 and 59.54 keV and the relative intensity 0.33, 0.487, 0.123, 0.062 and 1, respectively. Such description of lines conventionally as the resolution of silicon detectors with room temperature does not allow to resolve thin structure of some lines. The most intensive line is the line with energy 59.54 keV whereas in experiment with the thin source (spectrum 1) it is weak because of the low registration efficiency. After normalization on computed efficiency obtained out following values of the relative intensity lines: 0.31, 0.494, 0.123, 0.066 and 1. Such result is satisfactory, the error is related to the resolution of the detector $FWHM = 1.1\,keV$ that has not allowed to lines structure resolving and we can‘t take into account efficiency more correct. The experimental radiation spectrum (Fig.2, curve 2) for intensive source in the steel cylinder container have some differences against radiation spectrum of thin source ^{241}Am. Low energy radiation lines are adsorb by container wall, there are only lines with energy $13.95, 20.8, 26.348$ and $59.54\,keV$, the lines intensity relation becomes another. Besides, in the left part of the spectrum Compton scattering "tail" with top energy $11.25\,keV$ was appeared. The peak of K-line CXR from Fe with energy nearly $6.4\,keV$ were also observed. The back scattering peak for the line $59.54\,keV$ with a maximum nearly $49\,keV$ are observed. This peak was noticeably widely for straggling of scattering angles. Fig.3 are presented calculated in $GEANT4$ X-ray quanta spectra in $300\,\mu m\,Si$ detector without the Fe container (top) and with presence Fe foils, thickness $100\,\mu m$ and $150\,\mu m$ (down).

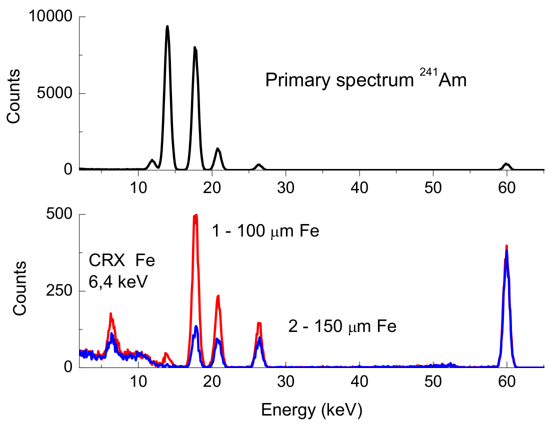

Fig.3. *Calculated in $GEANT4$ X-ray quanta spectra ^{241}Am ($FWHM = 0.94\,keV$) in $300\,\mu m\,Si$ detector without Fe container (top) and with presence Fe foils $100\,\mu m$ (red curve) and $150\,\mu m$ (blue curve) thickness(down)*

The computed results for a $150\,\mu m\,Fe$ foil are very similar to experimental measured spectrum for packaged source (Fig.2, curve 2). The low-energy lines 13.95, 20.8, $26.348\,keV$ have the same intensity. Thus, we have possibility to determine a source container foil thickness.

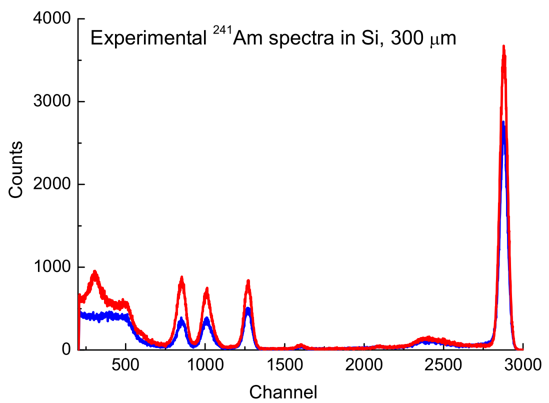

Fig.4. *Radiation spectra ^{241}Am measured in identical geometry. Red curve - packaged ^{241}Am source, blue curve - the same spectrum after passage through the C layer with the thickness $9.5\,mm$*

In Fig.4 are shown two radiation spectra ^{241}Am measured in identical geometry, but in one container (blue curve) between source and the detector the C layer with the thickness $9.5\,mm$ was disposed. We can see that in radiation spectrum with C layer all radiation lines was decreased, Compton "tail" decreased too and CXR Fe peak disappear. Experimental peaks are fitting and defined the areas under them. Lines were attenuated unequally with increase of quanta energy. For the line with energy $E = 17.8\,keV$ attenuation of radiation is 2.59, for $E = 20.8\,keV$ -1.89, for $E = 26.34\,keV$ - 1.6, for $E = 33.2\,keV$ - 1.46 and for the line $E = 59.54\,keV$- 1.3; for energy interval $49...53\,keV$ - 1.34. Almost identical attenuation of intensity radiation 1.3...1.35 for three spectral regions generated by the line $E = 59.54\,keV$ (Compton "tail" $8...10\,keV$, back scattering peak $49...50\,keV$ and a line $59.54\,keV$) are observed. Influence of the surrounding materials on radiation spectra was experimentally studied. The thin source ^{241}Am was closely put to an input diaphragm of the Si detector. Behinde the source placed different plates ($0.5...10\,mm$) from materials with various Z and then were measured radiation spectra. The back scattering peak was increase nonuniformly to increasing Z. In case plate absence the intensity relation line with energy $59.54\,keV$ to back scattering peak have maximum 13.19, i.e. the back scattering peak has the minimum quantity. The intensity relation with increasing Z of plates were: C - 10.5 ($Z = 6$), Al - 9.93 ($Z = 13$), Fe - 10.73 ($Z = 26$), Zn - 11.05 ($Z = 30$), Zr - 10.85 ($Z = 40$), Cd - 10.02 ($Z = 48$), Sn - 11.82 ($Z = 50$), Pb - 12.9 ($Z = 83$). It is difficult to reveal precise regularity because it is necessary to use thin foils of equal thickness. Following dependence are determined - the more CXR quantity from a line $59.54\,keV$ is excited in a plate, the less back scattering peak increase. The CXR lines exciting in plates are good visible and these deformed a radiation spectra against "a pure" source spectra.

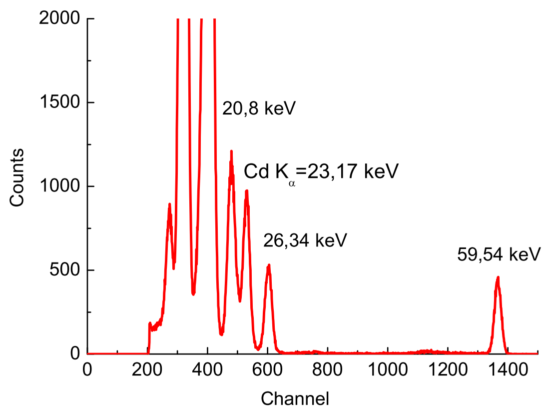

Fig.5. *"Deformed" radiation spectrum from thin ^{241}Am for Cd plate with $0.5\,mm$ thickness disposed behind the source*

In Fig.5 such deformed spectrum for a Cd plate with $0.5\,mm$ thickness are shown. Between radiation peaks ^{241}Am $E = 20.8$ and $26.348\,keV$ was arise additional peak CXR from Cd with energy $K_\alpha = 23.17\,keV$.

In Fig.6 radiation spectra for thin (1) and intensive source in the steel cylinder container (2 and 3) source 241Am are shown. The spectrum 2 corresponds to a direct standing package source (thin foil forward), and the spectrum 3 is measured at source backward direction (thick wall of the container forward).The spectra are normalized on peak $E = 59.54\,keV$ value, the logarithmic scale is chosen. It is clearly visible that back scattering peak for package source essentially increase. Besides, we can see that is immediate to the left side of peak $59.54\,keV$ arise additional quanta which formed peak left side increase. In this region placed low angle Compton scattering quanta. Their quantity in spectrum at passage of thicker wall of the source container are increase.

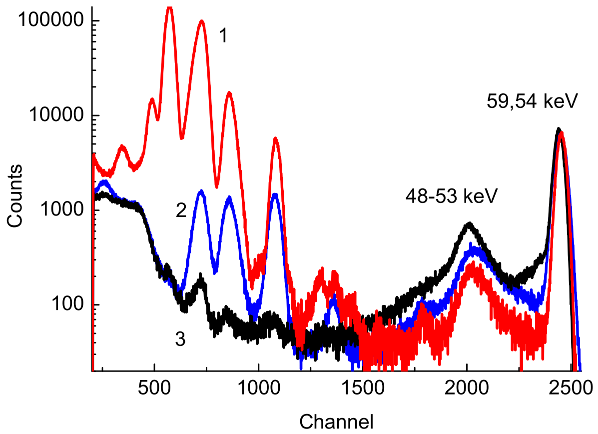

Fig.6. *Radiation spectra at angle 0° for thin (1) and intensive package source ^{241}Am in the steel cylinder container (2 and 3). The spectrum 2 corresponds to direct standing package source (thin foil forward), and the spectrum 3 is measured at source backward direction (thick wall of the container forward)*

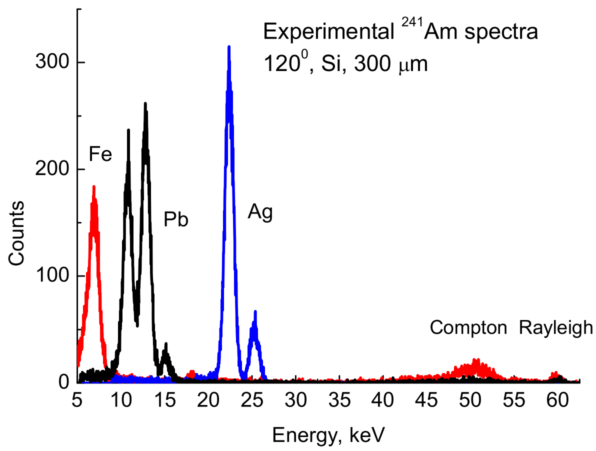

Fig.7. *The experimental spectra measured at angle 120° for thick samples (3 mm) Fe, Ag and Pb*

4. SCATTERED X-RAYS REGISTRATION BY THE THIN SILICON DETECTOR

The spectra measurement of Compton scattered quanta on angle 90°...130° was made at room temperature using X-ray quanta from collimated package source ^{241}Am. The Compton peak for the above experimental angle is at $49...53\,keV$. Experimentally measured spectra consist of CXR lines, Compton and Rayleigh peaks. In Fig.7 the typical experimental spectra measured at angle 120° for thick samples $(3\,mm)$ Fe, Ag and Pb are given. CXR lines are clearly visible, in the region of energy $49...53\,keV$ there is a Compton peak, the Rayleigh peak is near $59.54\,keV$. We can to estimate their relative intensity.

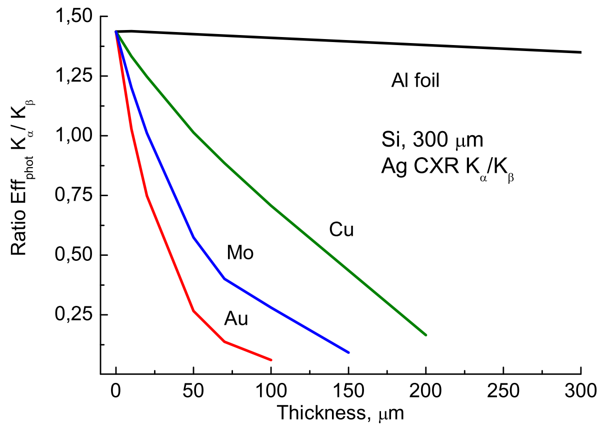

Fig.8. *The relation of registration efficiencies η_{ph} for Ag $K_\alpha = 22.16\,keV$ and $K_\beta = 24.94\,keV$ in $300\,\mu m$ Si detector for Al, Cu, Mo and Au foils*

Easy to estimate a relation of lines in CXR L-triplet for Pb target. For Pb three lines L series α, β, γ with energies 10.5, 12.6 and $15\,keV$ are observed. The experimental relation of intensity lines without correction on quanta registration efficiency is 7.86, 9.78 and 1, and after the correction on efficiency: 4.76, 7.28 and 1, respectively. Calculation in $GEANT\,4$ gives 3.4, 7.40 and 1. For Ag foil in experimental radiation spectrum is observed Rayleigh, Compton peaks and two CXR lines $K_\alpha = 22.16\,keV$ and $K_\beta = 24.94\,keV$ with the computed relation intensity $K_\alpha/K_\beta = 4.06$ $(GEANT\,4)$. For experimental intensity definition it is necessary to consider efficiency of detecting system for these lines. In our container efficiency is 0.187 and 0.133 for quanta energy 22.16 and $24.94\,keV$. The relation of efficiencies is 1.4. Experimentally measured (sourse ^{241}Am, scattering angle 120°) relation of intensity of lines give $K_\alpha/K_\beta = 5.62$, and after the efficiency correction it decreases to 4.0 that is close to calculated 4.06. In Fig.8 relations of registration efficiencies η_{ph} for these two CXR lines in Si detector for Al, Cu, Mo, Au foils with various thickness are presented. For Cu, Mo and Au foils relations of efficiencies smaller 1 are observed already at small foil thickness. It means stronger absorption of K_α line.

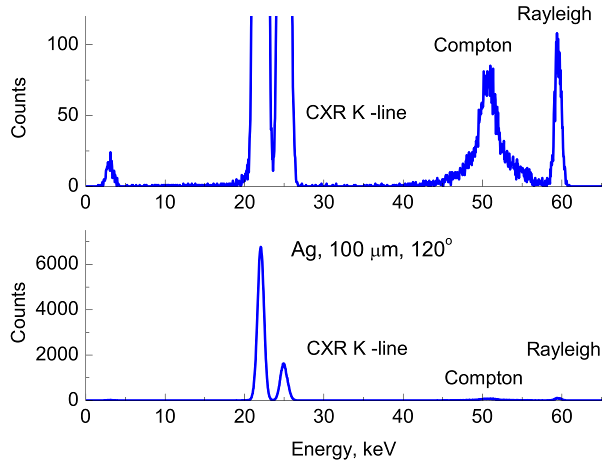

Fig.9. *Calculated spectrum CXR, Compton and Rayleigh scattering, registered at angle* 120° *on Ag foil* 0.1 *mm thickness. Primary quanta energy* $E = 59.54\,keV$

If a efficiency registration relation is the order 0.25 intensities of CXR K_α and K_β lines registered in experiment will be equal. Such effect observed in [1]. These strong changes lines intensity should be considered at interpretation of experiment data. Intensity relations for CXR lines (K_α/K_β) and relations of intensity Compton and Rayleigh scattering ($K = C/R$) are presented in Table 1,2. For correction of the experimental intensity to real the calculated registration efficiency for quanta was used (see Fig.1). In Fig.9, 10 the computed scattering spectra for primary quanta with energy $E = 59.54\,keV$ at registration angle 120° for Ag, Fe, Cu target with the thickness of 0.1 mm are shown. One can see that for all targets the width of Compton peak always is more than width of Rayleigh peak. It is related with Doppler broadening of lines arising at Compton scattering. The relation intensity Compton and Rayleigh peak $K = C/R$ differs for different Z targets (Table 2).

Table 1. *Calculation and experimental results of intensity relation CXR lines* (K_α/K_β)

Z	K_α/K_β *exp.*	K_α/K_β *exp.*/Eff	Data [12]	$GEANT$ 4
Ag	5.62	4.0	4.26	4.06
Sn	6.11	4.31	4.09	4.14
Nb	5.83	4.46	4.57	3.98
In	6.43	4.51	4.15	4.26
Mo	6.25	4.79	4.53	4.26
Zr	5.95	4.53	4.71	4.35
Cd	5.86	4.19	4.15	4.07
Cu	6.87	6.97	7.49	6.62
Dy	6.67	4.24	-	3.6

Table 2. *Relations of intensity Compton and Rayleigh scattering (K=C/R)and CXR. The scattering angle* 120°

El.	Z	C	R	$\frac{C}{R}$	CXR	$\frac{C}{R}$ *exp*	$\frac{CXR}{C}$
C	6	1269	0.83	1523	0.	-	0.
Al	13	1566	41	38.19	1	25.6	0.
Ti	22	2459	168	14.64	236	-	0.096
Fe	26	3657	303	12.07	1058	5.8	0.29
Ni	28	4001	384	10.42	1862	6.91	0.46
Cu	29	3846	370	10.39	2531	4.3	0.66
Zr	40	2111	440	4.8	22941	-	10.87
Mo	42	2423	636	3.81	32029	-	13.22
Ag	47	1905	689	2.76	58434	2.08	30.67
Sn	50	1634	606	2.69	69912	-	42.78
W	74	3015	2192	1.38	897	-	0.3
Pt	78	2689	2225	1.21	1483	-	0.55
Pb	82	1939	1836	1.06	2544	1.67	1.31
Bi	83	1728	1697	1.02	2818	-	1.63
U	92	1483	2036	0.73	5678	-	3.83

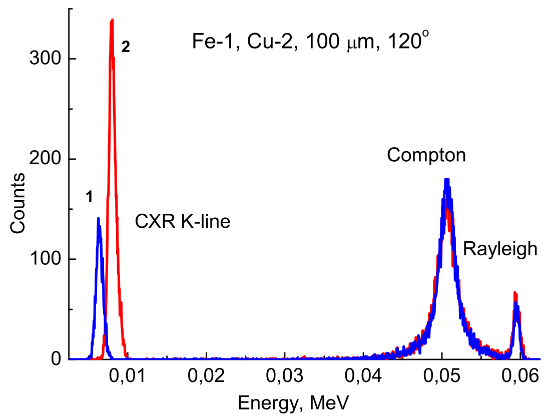

Fig.10. *Calculated spectrum CXR, Compton and Rayleigh scattering, registered at angle* 120° *on Fe, Cu foil* 0.1 *mm thickness. Primary quanta energy* $E = 59.54\,keV$

For scattering quanta with energy 59.54 keV photo absorption in Ag foil becomes the dominating mechanism of interaction and CXR intensive lines are generated (see Fig.9, top). For Fe, Cu it has less expressed character (see Fig.10) because K-edge energy value are less (for $Fe = 7.1\,keV$, $Cu = 8.98\,keV$). The spectrum becomes simpler for C target, there is only an expressed Compton scattering peak, the Rayleigh scattering peak and CXR lines practically misses. The Compton and Rayleigh scattering contribution in the resultant spectrum were investigated by calculation procedure in which the quanta flux from modeling spectrum ^{241}Am on different target are directed. The reflected radiation spectra separately computed for only Compton or Rayleigh scattering. It is possible in $GEANT$ 4. In Fig.11 one of calculated results for

Si scatterer with thickness $2\,mm$ are shown. These two spectra are computed for detector efficiency 1.

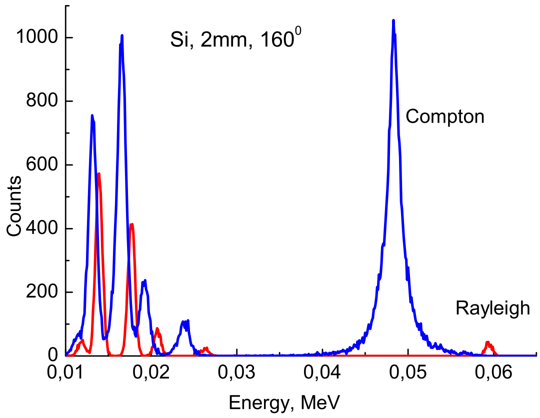

Fig.11. *Compton and Rayleigh scattering spectra. Detector efficiency is* 1

Compton spectra are shifted in field of low energies, the Rayleigh spectra contribution increases with decrease of quanta energy. All Compton lines are widened. In Fig.12 the radiation spectrum ^{241}Am, placed in the steel container and scattering radiation spectrum on Pb target with thickness $3\,mm$ are presented. The experimental spectrum (Fig.12, curve 2) for ^{241}Am intensive source in the steel cylinder container have only lines with energy 13.95, 20.8, 26.348 and $59.54\,keV$. In the left part of a spectrum there is Compton scattering "tail" and peak of K-line CXR from Fe with energy nearly $6.4\,keV$. For Pb target three lines L of a series α, β, γ with energies 10.5, 12.6 and $15\,keV$ are observed. Compton and Rayleigh scattering is small. The lines with energy 17.8, 20.8, $26.34\,keV$ are not observed.

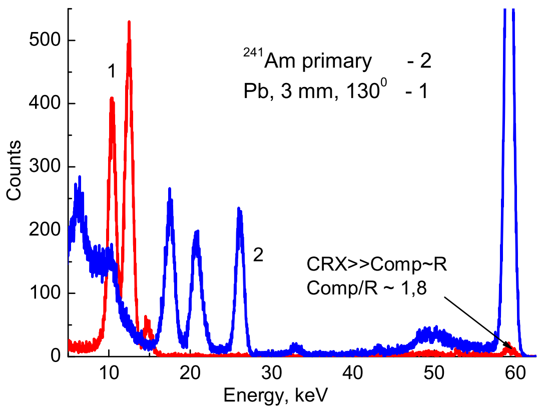

Fig.12. *The experimental radiation spectra from* ^{241}Am *at* 0° *- curve 2, and scattering radiation spectrum on Pb target* $3\,mm$ *thickness at angle* 130° *- curve 1*

In Fig.13 the experimental radiation spectrum from ^{241}Am for Al target $5\,mm$ thickness, measured in the same geometry are shown.

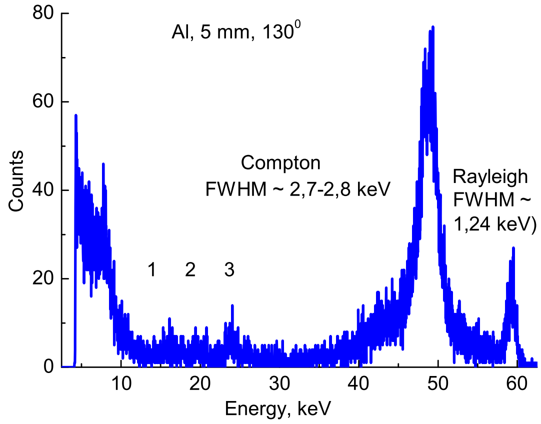

Fig.13. *The experimental radiation spectrum from* ^{241}Am *for Al target* $5\,mm$ *thickness, scattering angle* 130°

The Compton scattering peak have $FWHM = 2.75\,keV$ and Rayleigh scattering peak have $FWHM = 1.24\,keV$. Calculation in $GEANT4$ gives $FWHM = 2.5$ and $1.2\,keV$, respectively. The detector resolution for line $E = 59.54\,keV$ is $FWHM = 1.15\,keV$, for energy $26,348\,keV$ we take $FWHM = 1.09\,keV$. Asymmetry of Compton peak were observed. Radiation lines 17.8, 20.8 and $26.34\,keV$ make visible. In Fig.14 the experimental scattering quanta spectrum from ^{241}Am for C target with the thickness $10\,mm$ and calculated (only for the line $59.54\,keV$) scattering spectrum are presented.

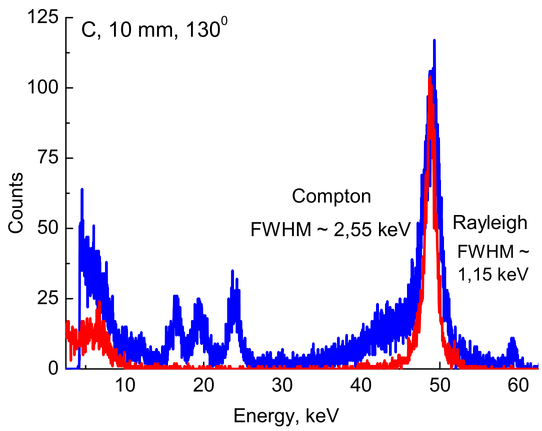

Fig.14. *Experimental (blue curve)and calculated (red curve, for line* $E = 59.54\,keV$*) scattering spectra for C target* $10\,mm$ *thickness, scattering angle* 130°

The compute scattering spectrum does not give Compton spectrum asymmetry. Asymmetry is related to features of ^{241}Am source (presence of "back scattering" peak). The back scattering peak forms an "additional" radiation line with energy $48...53\,keV$. Energy quanta decreases to $40...44\,keV$ after scattering at angle 130°. In this region the Compton scattering spectra are deformed. In Fig.15 shown primary radiation spectrum from

^{241}Am and the spectra restored after scattering on a C target with thickness $10\,mm$ at angles $90°$ and $130°$. Spectra normalization is chosen free.

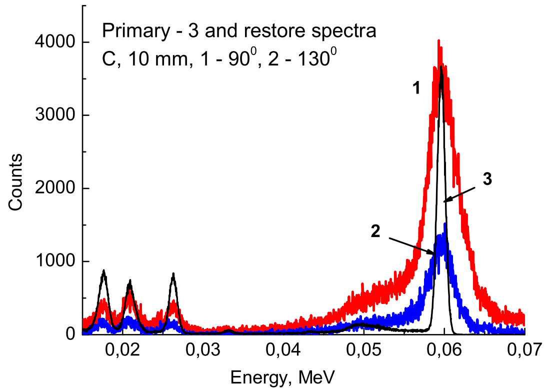

Fig.15. *Spectra of ^{241}Am: 1-restored from experimental spectrum scattered from C target $10\,mm$ thickness under the angle of $90°$; and 2-under the angle of $130°$; 3-primary spectrum*

The strong broadening of primary lines are observed. The initial width of line $FWHM = 1.15\,keV$ for energy $59.54\,keV$ was increasing after Compton scattering to $FWHM = 2,55\,keV$, on restore procedure there was a broadening to $FWHM = 4.3\,keV$. Thus, narrow primary radiation lines are recovered with the broadening (influence of Doppler effect). For low Z targets the Doppler line broadening is less than for heavy materials. The additional line broadening is related also with straggling of registration angles.

5. CONCLUSIONS

The primary radiation spectra ^{241}Am source in various geometry are experimentally measured, CXR lines, back scattering peak and spectra deforming near left edge line $E = 59.54\,keV$ are studied. Scattering radiation spectra for various targets (CXR, Compton and Rayleigh scattering) are measured. X-ray quanta were registered by the packaged Si detector $300\,\mu m$, input Al foil $10\,\mu m$ thicknesses. In software code $GEANT\,4\,(LE)$ was simulated of photons interaction with targets and detectors atoms, radiation spectra ^{241}Am are obtained, quanta registration efficiency are calculated, scattering radiation spectra scattering at angle $90°...160°$ are computed. Restored scattering spectra were compared with primary energy distributions. Results of modeling in program code $GEANT\,4\,(LE)$ have shown a correctness of its use for radiation spectra calculations. Our calculation and experiment result are shown the real practical possibility of spectra restoration at low energies using Compton scattering procedure. Advantages of use light targets-scatterer are also shown, the difficulties related with photo absorption process in a heavy targets are revealed. The strong broadening of primary ^{241}Am lines is observed. The initial width of line $FWHM = 1.15\,keV$ for energy $59.54\,keV$ was incresing after Compton scattering to $FWHM = 2,55\,keV$, on restore procedure there was a broadening to $FWHM = 4.3\,keV$. Thus, narrow primary radiation lines are recovered with a broadening (influence of Doppler effect).The asymmetry of Compton scattering spectra are found. Asymmetry is related to features of ^{241}Am source (presence of peak of "back scattering"). The back scattering peak was formed an "additional" radiation line with energy $48...53\,keV$. The important role of quanta registration efficiency for restore primary radiation lines intensity by use a thin silicon detector are shown. Experimental and calculated CXR intensity relations K_α/K_β-lines, intensity Compton and Rayleigh scattering are determined.

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ОТНОСИТЕЛЬНЫЕ ИНТЕНСИВНОСТИ ЛИНИЙ РЕНТГЕНОВСКОГО ИЗЛУЧЕНИЯ В ЗАВИСИМОСТИ ОТ ЭФФЕКТИВНОСТИ ДЕТЕКТОРА, ТОЛЩИН ФОЛЬГ И КОРПУСОВ ДЛЯ ПЕРВИЧНЫХ И РАССЕЯННЫХ СПЕКТРОВ

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Измерены прямые и комптоновски рассеянные спектры излучения от радиоактивного источника ^{241}Am в различной геометрии для различных мишеней. Определены интенсивности рентгеновских линий характеристического рентгеновского излучения (ХРИ), комптоновского и рэлеевского рассеяния в рассеянных спектрах. Изучался пик обратного рассеяния для линии 59.54 кэВ. Рентгеновские кванты регистрировались корпусированным Si - детектором толщиной 300 мкм и входной Al фольгой толщиной 10 мкм. В программном коде $GEANT\,4\,(LE)$ моделировалось взаимодействие излучения с атомами мишени и детектора. Расчетные спектры излучения ^{241}Am, эффективность регистрации квантов и спектры вторичного излучения, рассеянного под углами 90°...160°, сравниваются с экспериментально измеренными энергетическими распределениями.

ВІДНОСНІ ІНТЕНСИВНОСТІ ЛІНІЙ РЕНТГЕНІВСЬКОГО ВИПРОМІНЮВАННЯ В ЗАЛЕЖНОСТІ ВІД ЕФЕКТИВНОСТІ ДЕТЕКТОРА, ТОВЩИН ФОЛЬГ І КОРПУСІВ ДЛЯ ПЕРВИННИХ ТА РОЗСІЯНИХ СПЕКТРІВ

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Виміряні прямі і комптонівськи розсіяні спектри від радіоактивного джерела ^{241}Am в різній геометрії для різних мішеней. Визначені інтенсивності рентгенівських ліній характеристичного рентгенівського випромінювання (ХРІ), комптонівського і релеєвського розсіяння в розсіяних спектрах. Вивчався пік зворотнього розсіювання для лінії 59.54 кеВ. Рентгенівські кванти реєструвалися корпусованим Si - детектором товщиною 300 мкм і вхідною фольгою Al товщиною 10 мкм. У програмному коді $GEANT\,4\,(LE)$ моделювалася взаємодія випромінювання з атомами мішені і детектора. Розраховані спектри випромінювання ^{241}Am, ефективність реєстрації квантів, спектри вторинного випромінювання, розсіяного під кутами 90°...160°, порівнюються з первинними енергетичними розподілами.