

**INTEREST - INTERnational Remote Student
Training Wave 3**

Radiation Protection and the Safety of the Radiation Sources

08 February - 19 March 2021

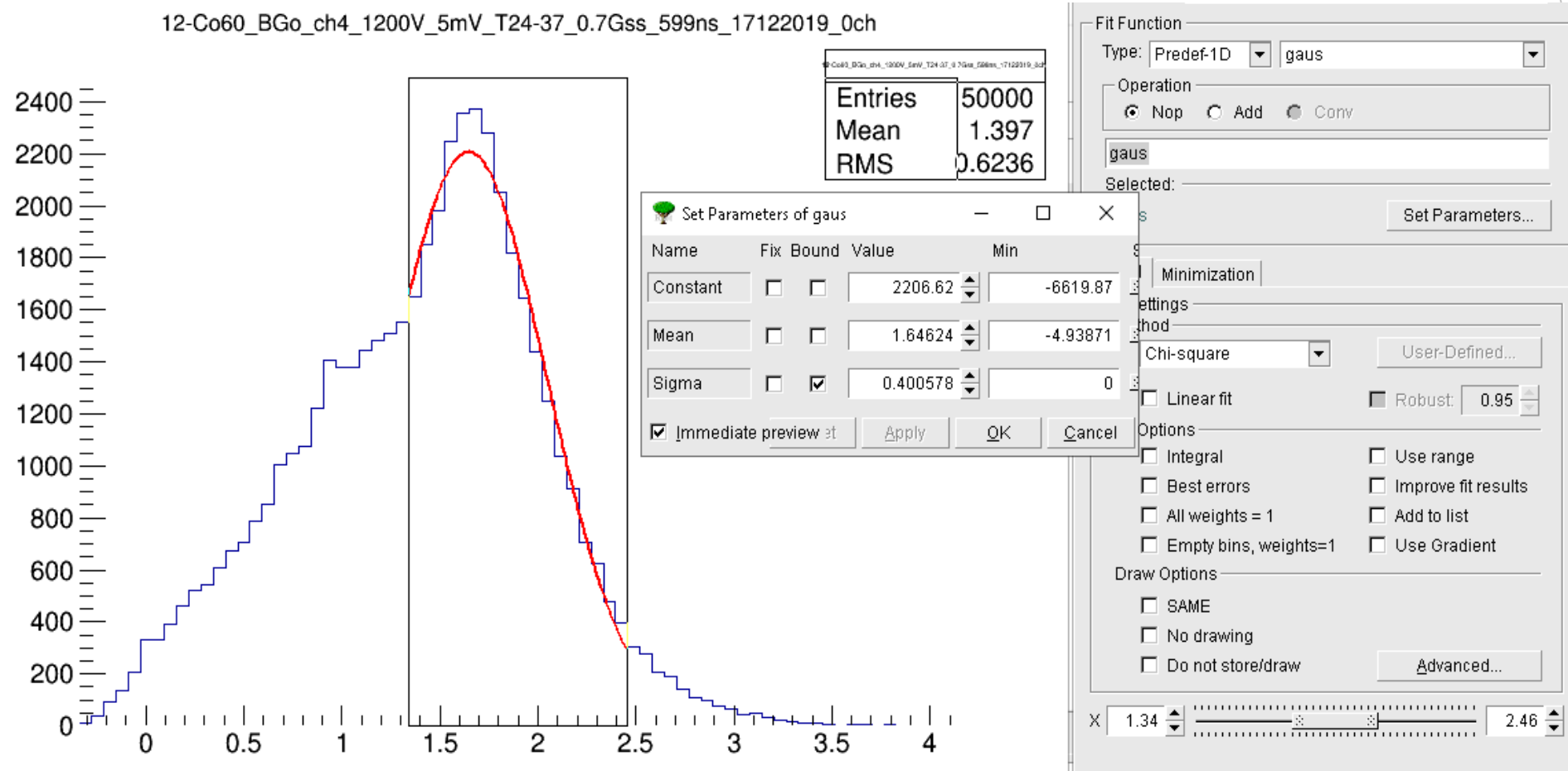
Aydan Khaligzadeh-Azerbaijan

Supervisor: Prof.Dr. Said AbouElazm

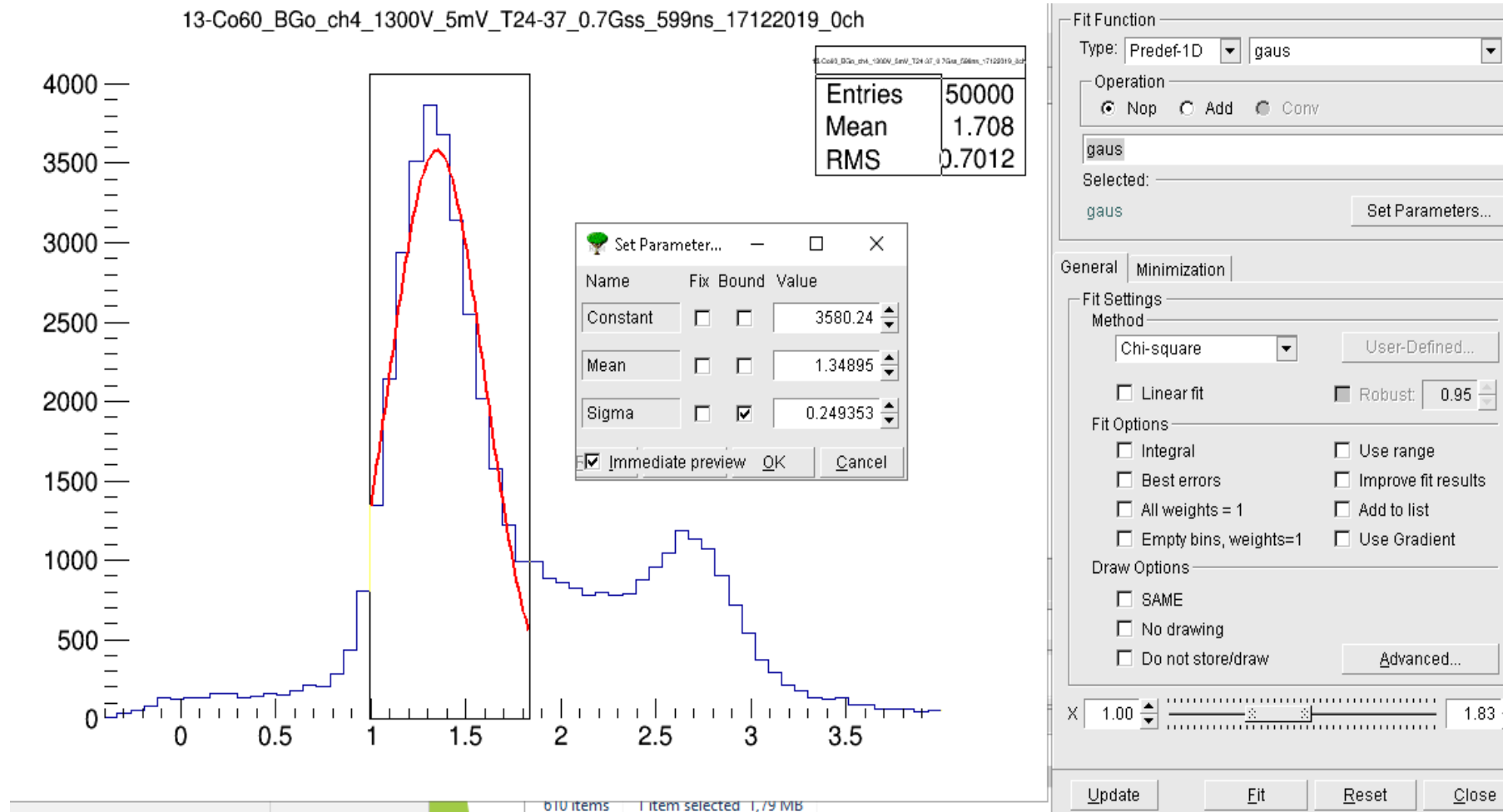
TASK 1

Dependence of resolution on applied voltage for BGO detector

$$\text{Resolution} = (\text{sigma} / \text{mean}) * 2,35 = 0,57$$

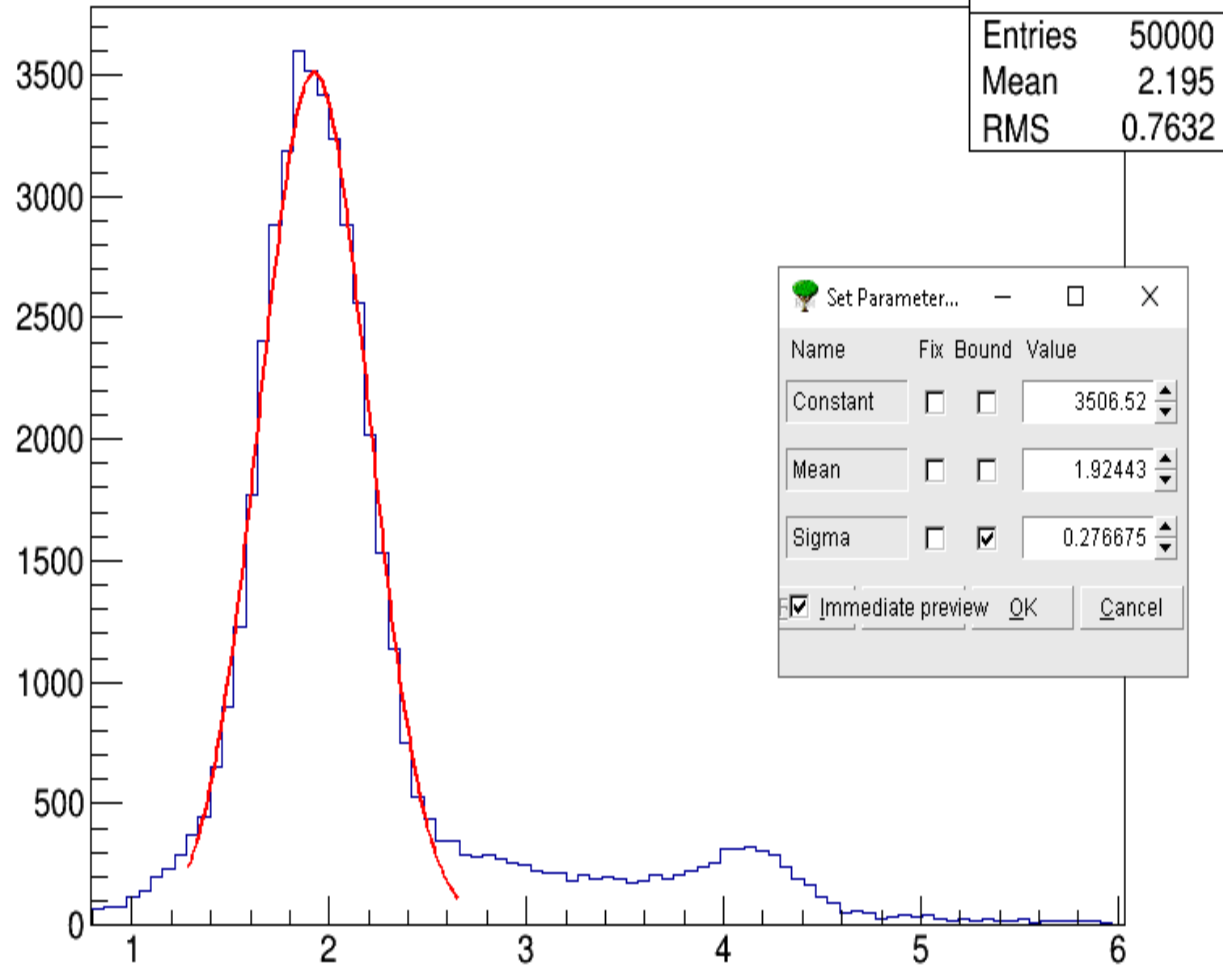


$$\text{Resolution} = (\text{sigma} / \text{mean}) * 2,35 = 0,43$$



Resolution=(sigma/mean)*2,35=0,337

14-Co60_BGo_ch4_1400V_5mV_T24-37_0.7Gss_599ns_17122019_0ch



Fit Function

Type: Predef-1D | gaus

Operation: Nop Add Conv

gaus

Selected: gaus

Set Parameters...

General | Minimization

Fit Settings

Method: Chi-square | User-Defined...

Linear fit Robust: 0.95

Fit Options

Integral Use range

Best errors Improve fit results

All weights = 1 Add to list

Empty bins, weights=1 Use Gradient

Draw Options

SAME

No drawing

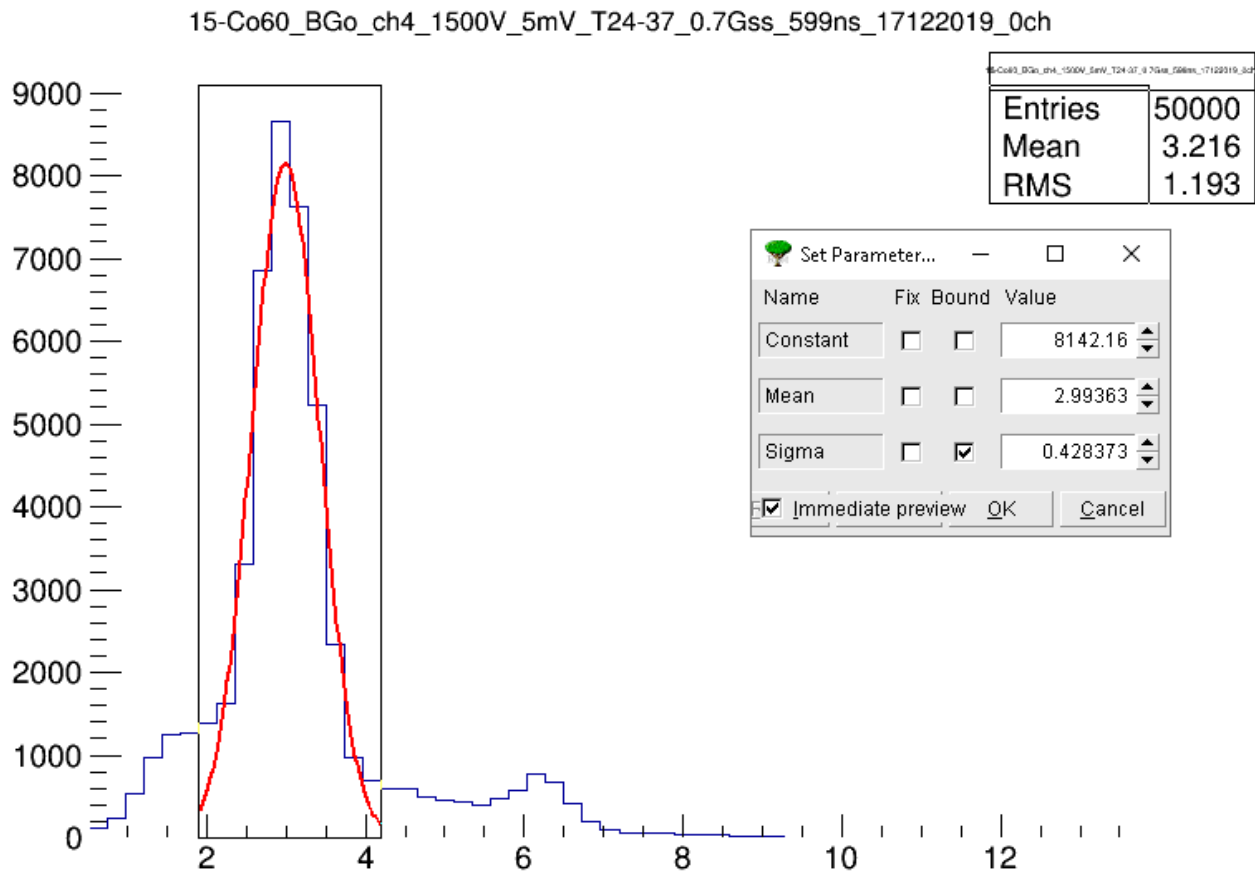
Do not store/draw

Advanced...

X: 0.79 | 6.03

Update | Fit | Reset | Close

Resolution=(sigma/mean)*2,35=0,335



Set Parameter...

Name	Fix	Bound	Value
Constant	<input type="checkbox"/>	<input type="checkbox"/>	8142.16
Mean	<input type="checkbox"/>	<input type="checkbox"/>	2.99363
Sigma	<input type="checkbox"/>	<input checked="" type="checkbox"/>	0.428373

Immediate preview

Fit Function

Type: Predef-1D

Operation: Nop Add Conv

Selected:

General | Minimization

Fit Settings

Method:

Linear fit Robust: 0.95

Fit Options

Integral Use range

Best errors Improve fit results

All weights = 1 Add to list

Empty bins, weights=1 Use Gradient

Draw Options

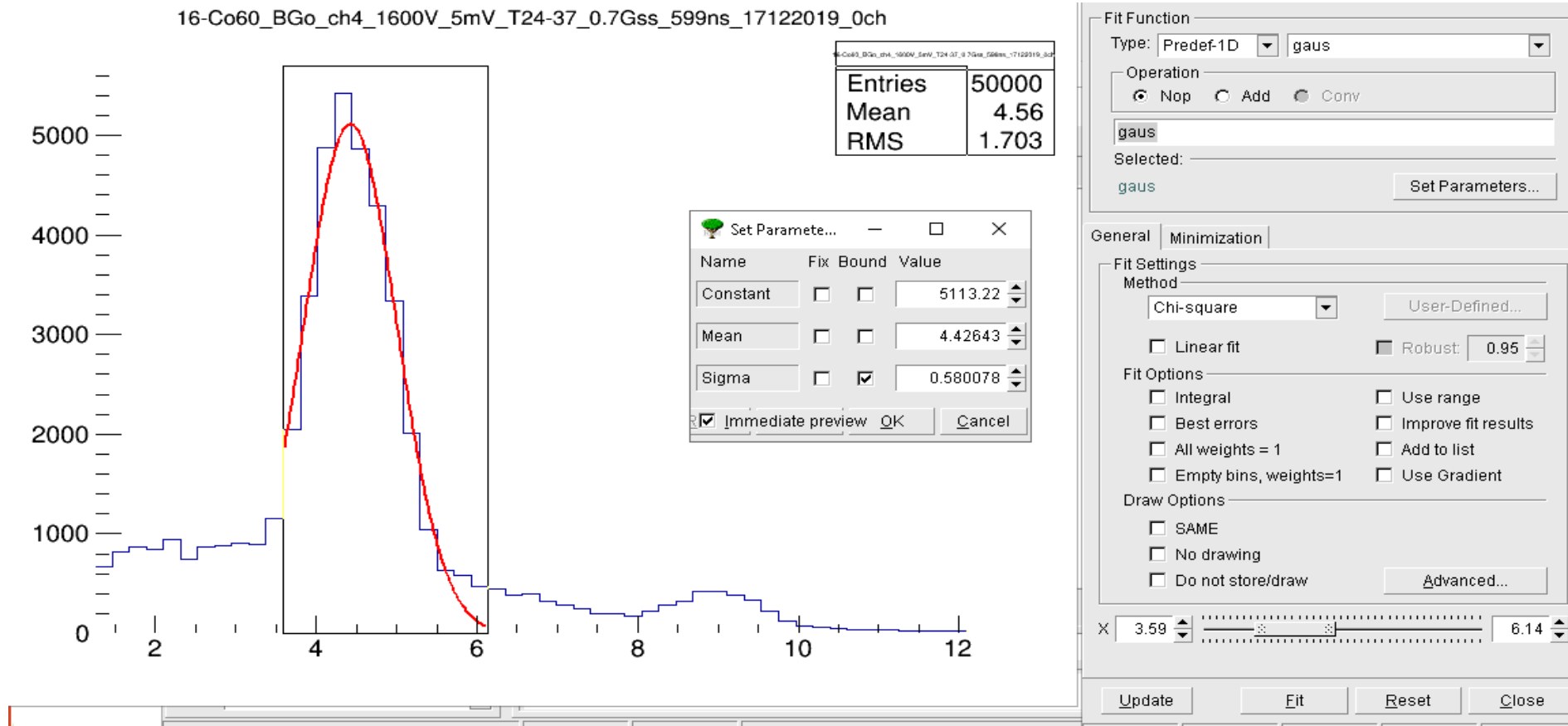
SAME

No drawing

Do not store/draw

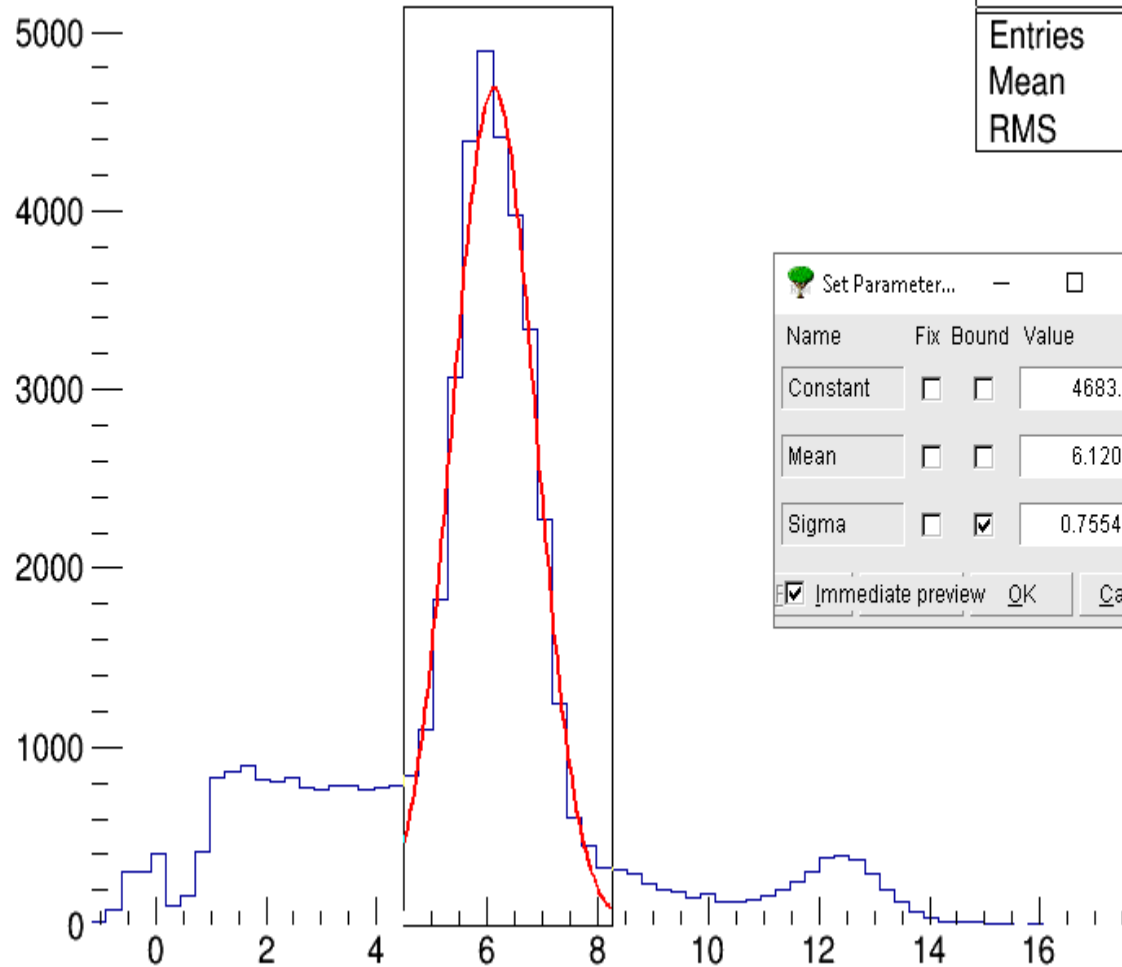
X:

Resolution=(sigma/mean)*2,35=0,308



Resolution=(sigma/mean)*2,35=0,29

17-Co60_BGo_ch4_1700V_5mV_T24-37_0.7Gss_599ns_17122019_0ch



Entries	50000
Mean	5.71
RMS	2.653

Name	Fix	Bound	Value
Constant	<input type="checkbox"/>	<input type="checkbox"/>	4683.28
Mean	<input type="checkbox"/>	<input type="checkbox"/>	6.12034
Sigma	<input type="checkbox"/>	<input checked="" type="checkbox"/>	0.755413

Immediate preview

Fit Function

Type: Predef-1D

Operation
 Nop Add Conv

gaus

Selected:
gaus

General **Minimization**

Fit Settings

Method

Linear fit Robust: 0.95

Fit Options

Integral Use range
 Best errors Improve fit results
 All weights = 1 Add to list
 Empty bins, weights=1 Use Gradient

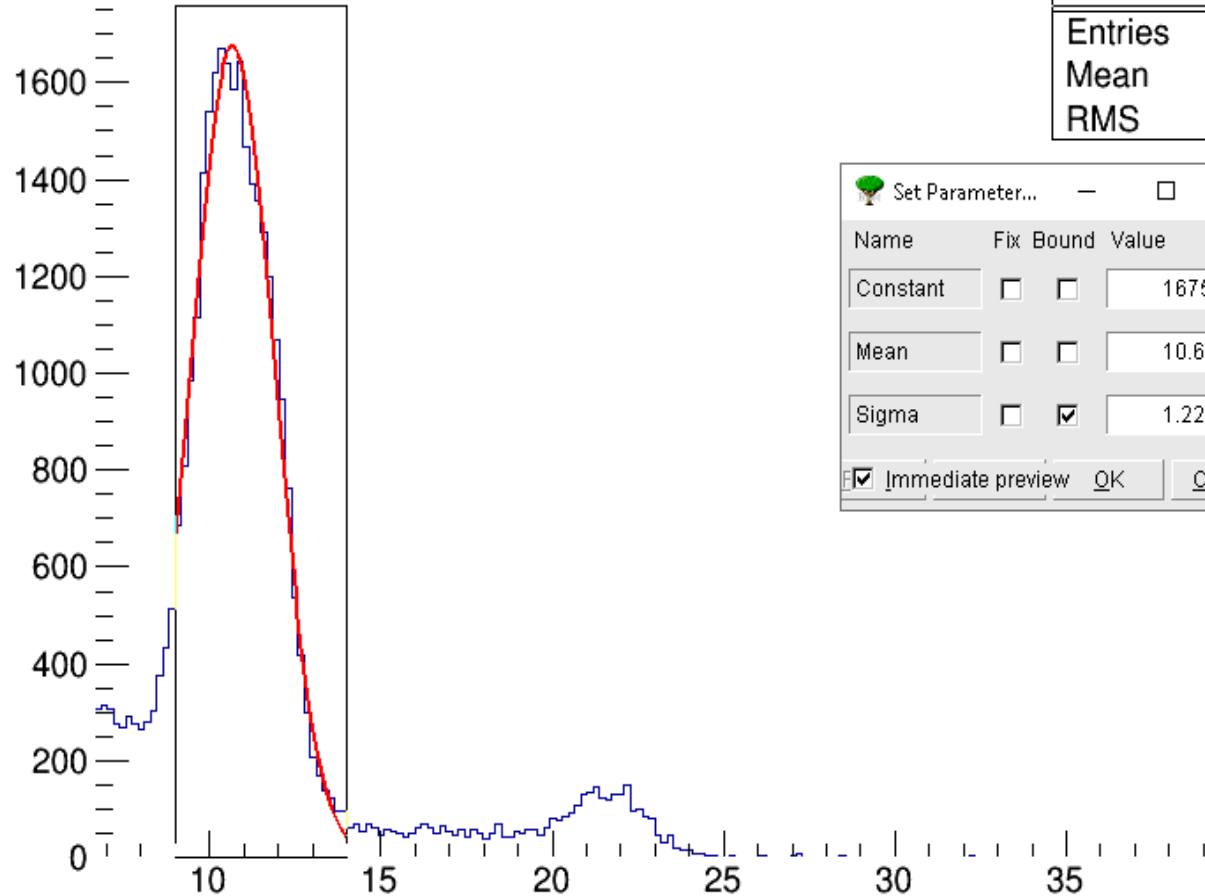
Draw Options

SAME
 No drawing
 Do not store/draw

X

$$\text{Resolution} = (\text{sigma} / \text{mean}) * 2,35 = 0,268$$

19-Co60_BGo_ch4_1900V_5mV_T24-37_0.7Gss_599ns_17122019_0ch



Entries	50000
Mean	11.51
RMS	3.369

Set Parameter...

Name	Fix	Bound	Value
Constant	<input type="checkbox"/>	<input type="checkbox"/>	1675.32
Mean	<input type="checkbox"/>	<input type="checkbox"/>	10.6731
Sigma	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1.22329

Immediate preview

Fit Function

Type: Predef-1D gaus

Operation: Nop Add Conv

gaus

Selected: gaus

General Minimization

Fit Settings

Method: Chi-square User-Defined...

Linear fit Robust: 0.95

Fit Options

Integral Use range

Best errors Improve fit results

All weights = 1 Add to list

Empty bins, weights=1 Use Gradient

Draw Options

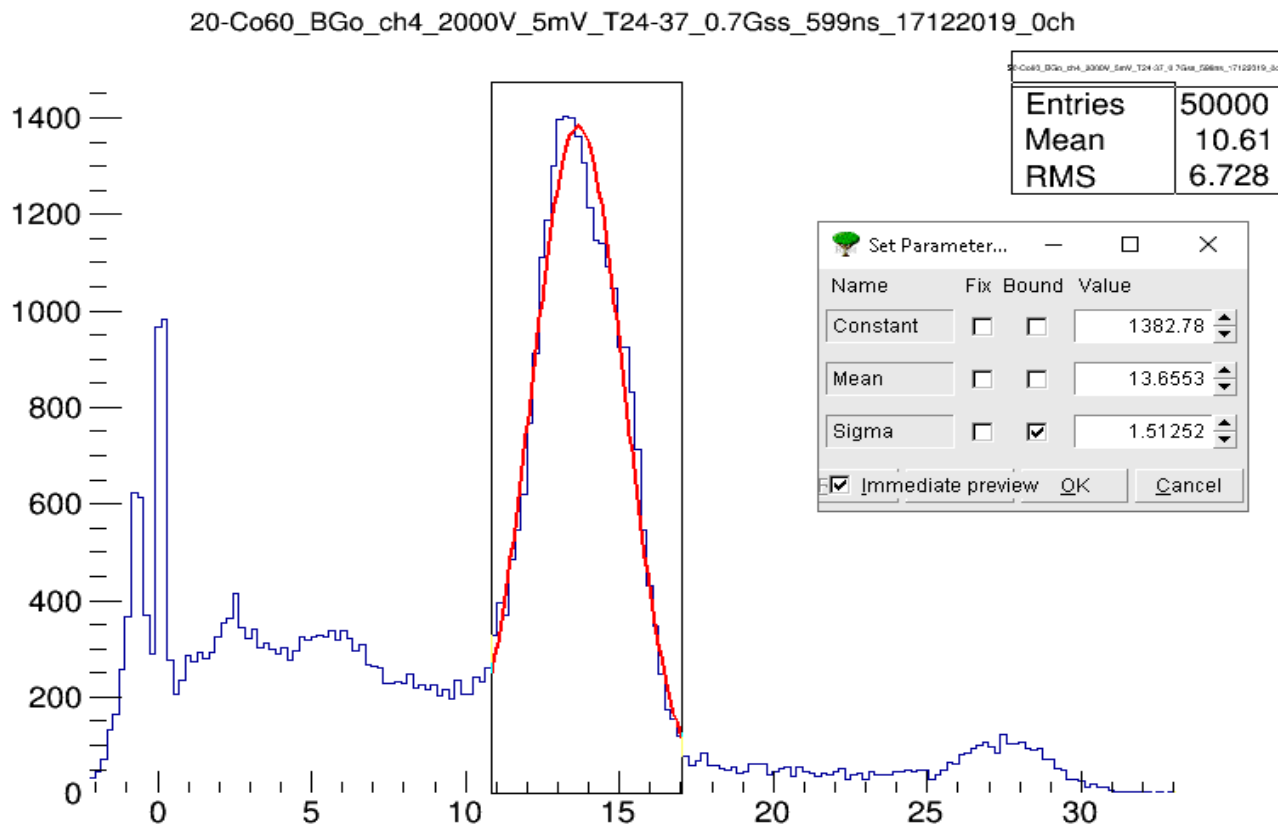
SAME

No drawing

Do not store/draw

X: 8.99 14.02

$$\text{Resolution} = (\text{sigma} / \text{mean}) * 2,35 = 0,26$$



Fit Function

Type: Predef-1D gaus

Operation

Nop Add Conv

gaus

Selected:

gaus

General | Minimization

Fit Settings

Method

Chi-square

Linear fit Robust: 0.95

Fit Options

Integral Use range

Best errors Improve fit results

All weights = 1 Add to list

Empty bins, weights=1 Use Gradient

Draw Options

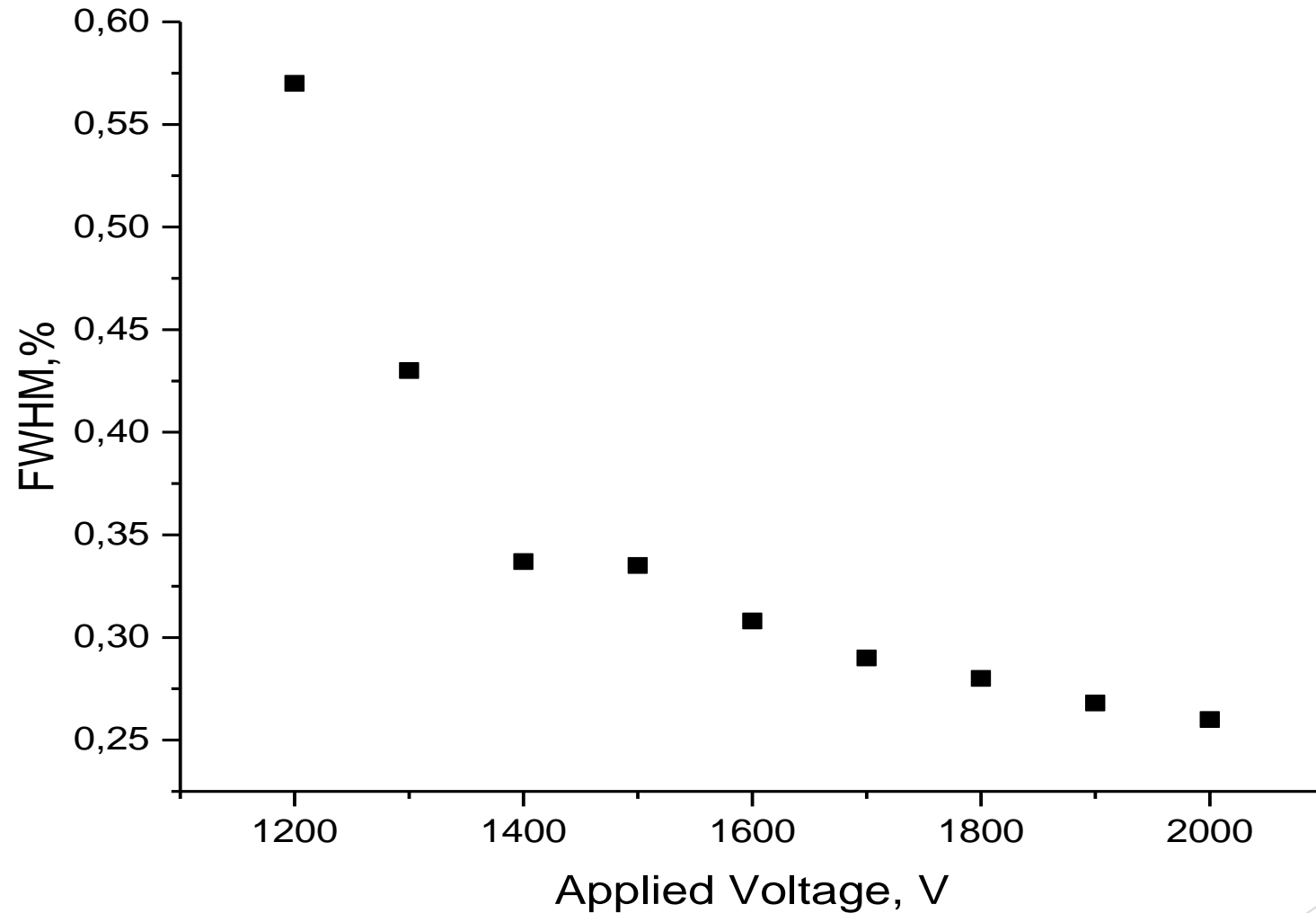
SAME

No drawing

Do not store/draw

X: 10.82 17.06

Dependence of resolution on applied voltage for BGO detector

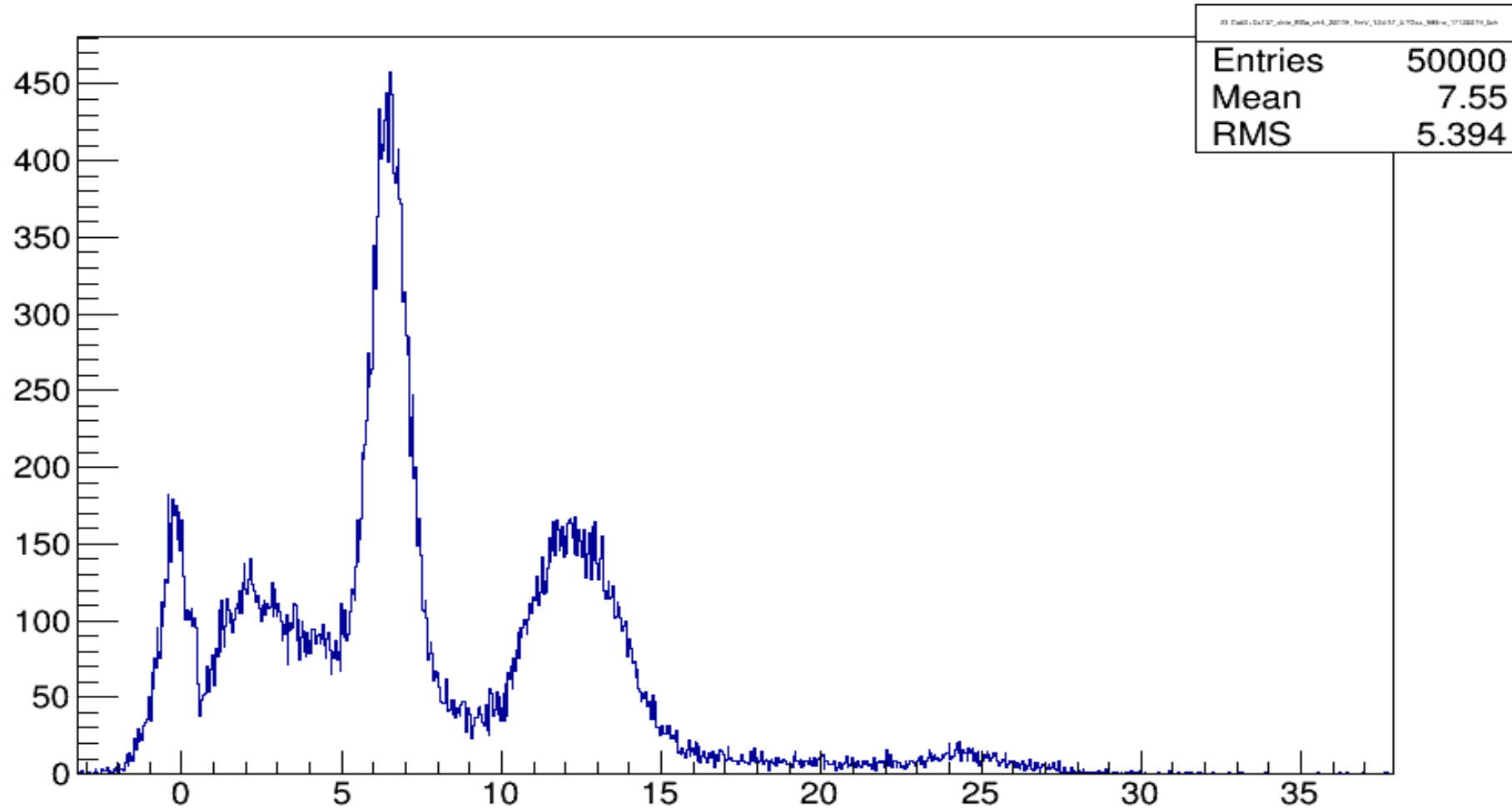


TASK 2

The calibration spectra for BGO detector

BGO-Co60+Cs137-2000V

23-Co60+Cs137_side_BGo_ch4_2000V_5mV_T24-37_0.7Gss_599ns_17122019_0ch

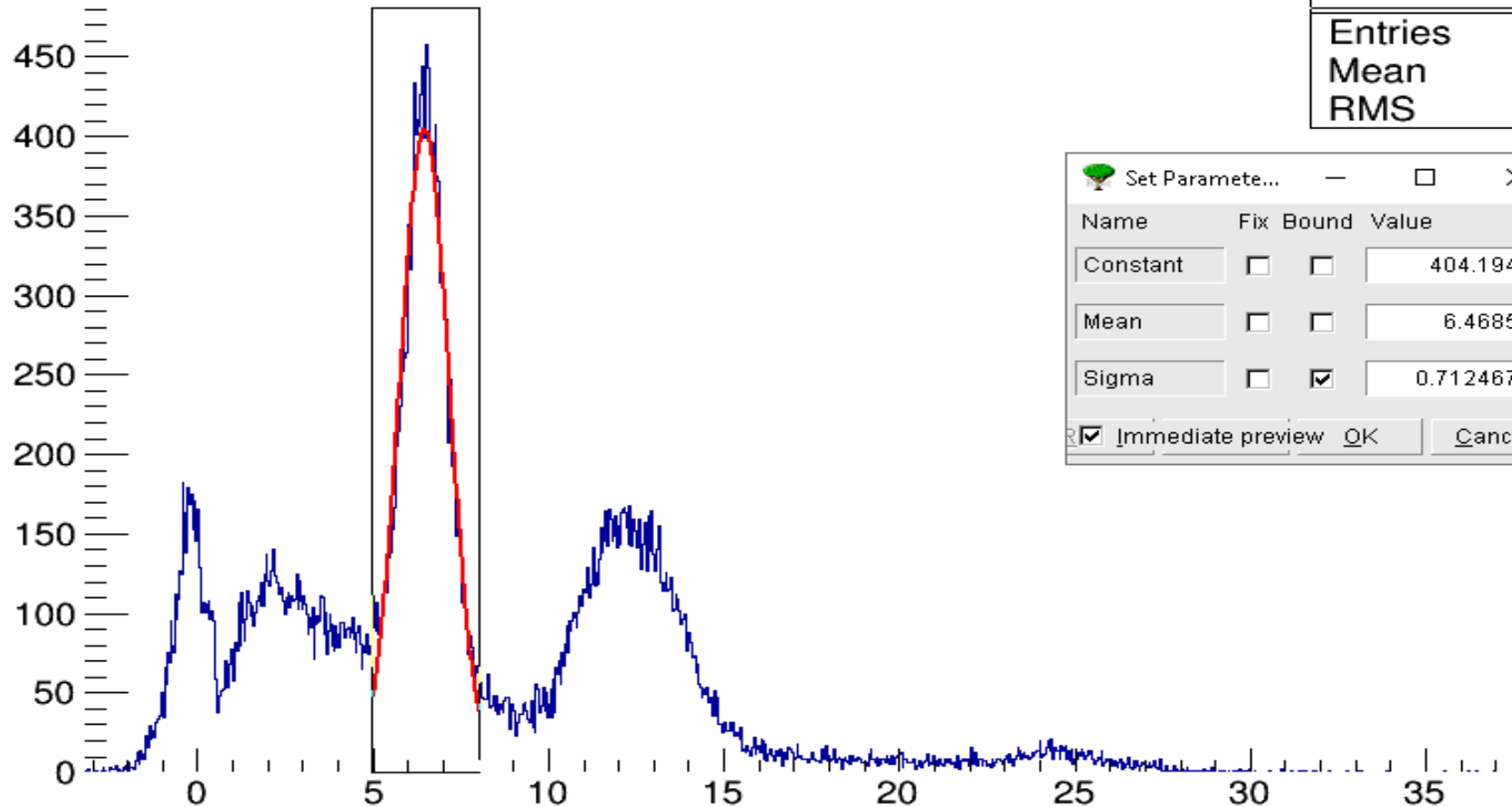


➤ Gaus FIT -first peak

Cs137 energy spectra=0,662MeV

Mean=6,4685

23-Co60+Cs137_side_BGo_ch4_2000V_5mV_T24-37_0.7Gss_599ns_17122019_0ch



23-Co60+Cs137_side_BGo_ch4_2000V_5mV_T24-37_0.7Gss_599ns_17122019_0ch	
Entries	50000
Mean	7.55
RMS	5.394

Name	Fix	Bound	Value
Constant	<input type="checkbox"/>	<input type="checkbox"/>	404.194
Mean	<input type="checkbox"/>	<input type="checkbox"/>	6.4685
Sigma	<input type="checkbox"/>	<input checked="" type="checkbox"/>	0.712467

Immediate preview

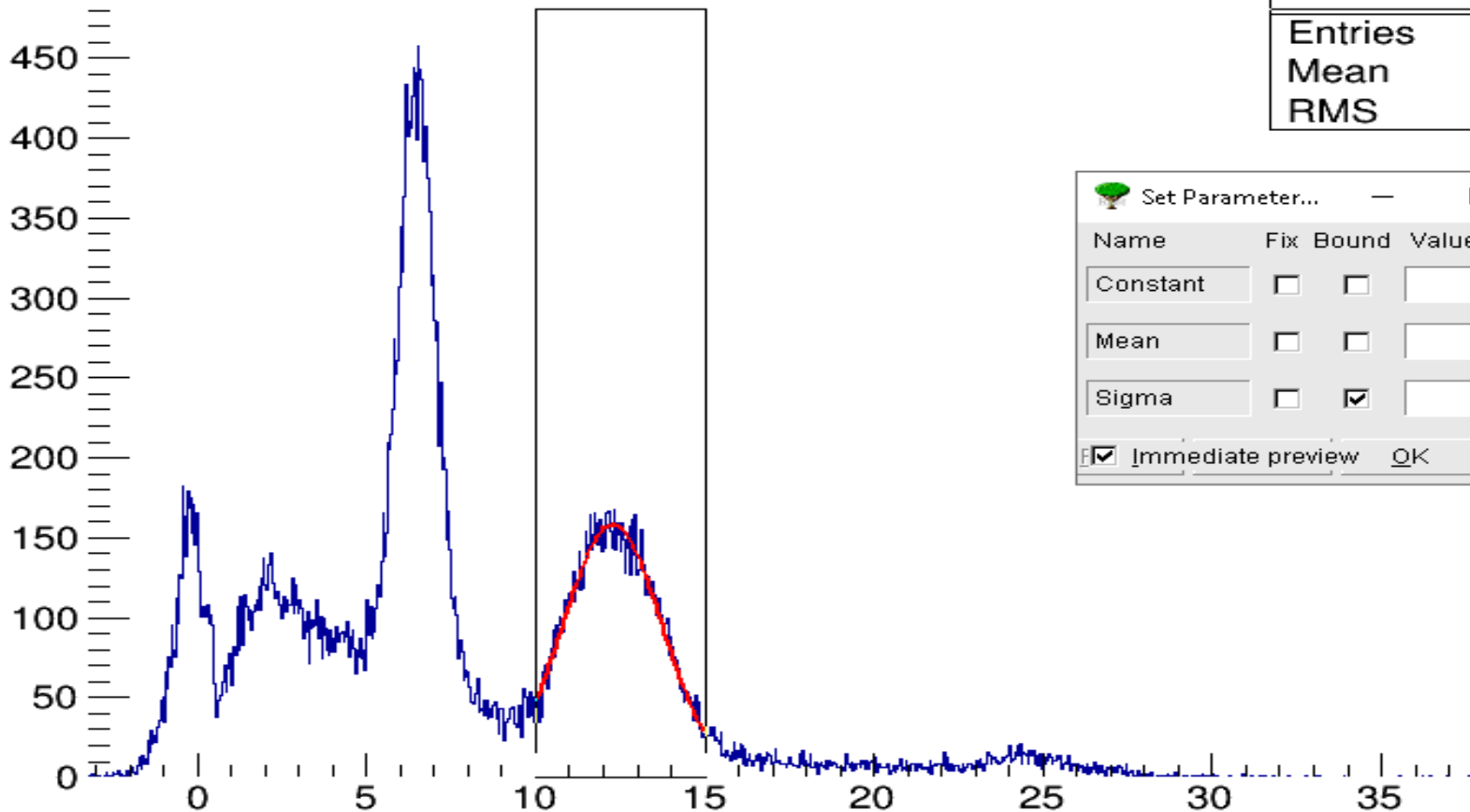
➤ Gaus FIT -second peak

Co60 energy spectra=1,17MeV and 1,33MeV

The average is =1,25MeV

Mean=12,275

23-Co60+Cs137_side_BGo_ch4_2000V_5mV_T24-37_0.7Gss_599ns_17122019_0ch



Entries	50000
Mean	7.55
RMS	5.394

Set Parameter...

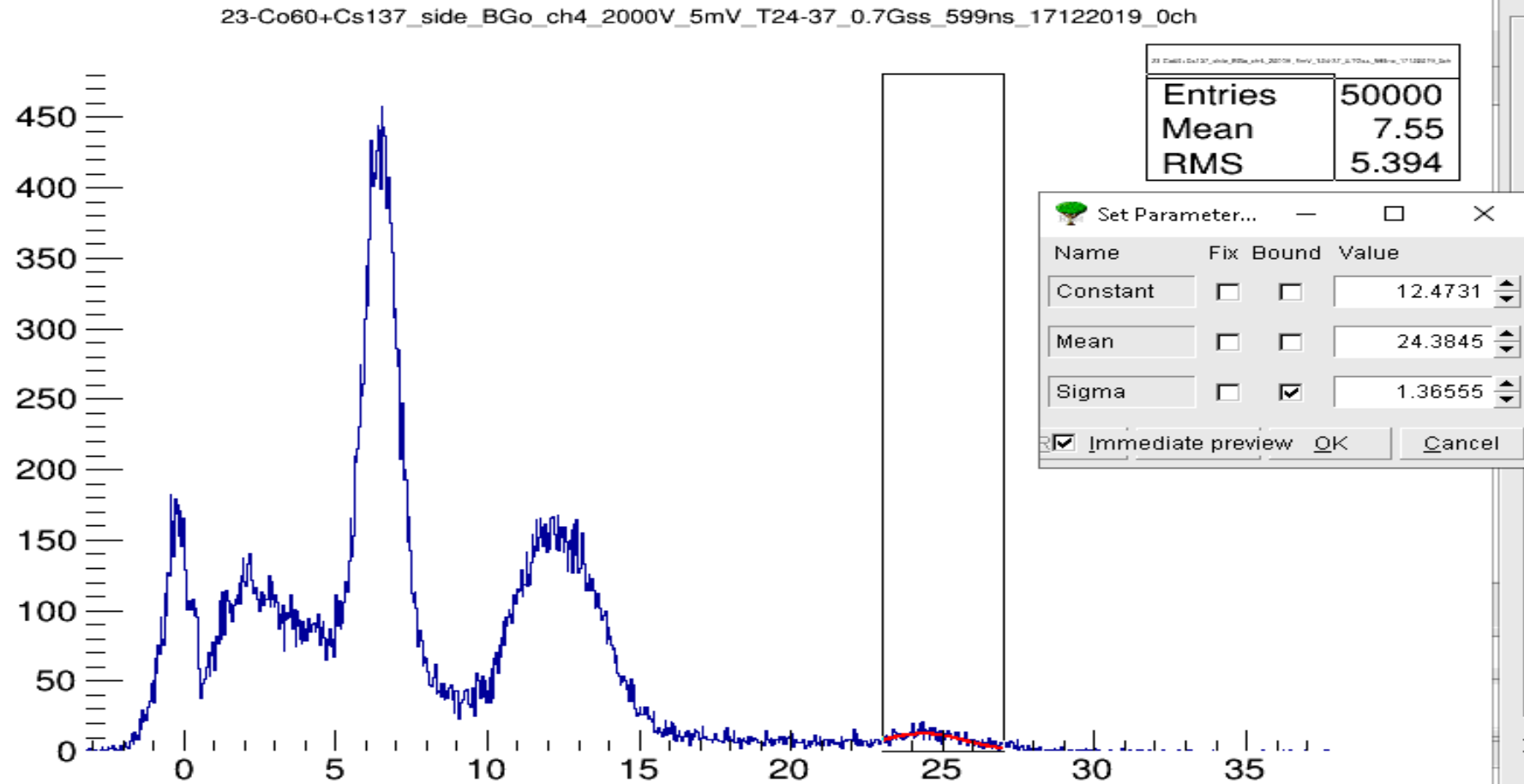
Name	Fix	Bound	Value
Constant	<input type="checkbox"/>	<input type="checkbox"/>	158.029
Mean	<input type="checkbox"/>	<input type="checkbox"/>	12.275
Sigma	<input type="checkbox"/>	<input checked="" type="checkbox"/>	1.46304

Immediate preview

Gaus FIT -third peak

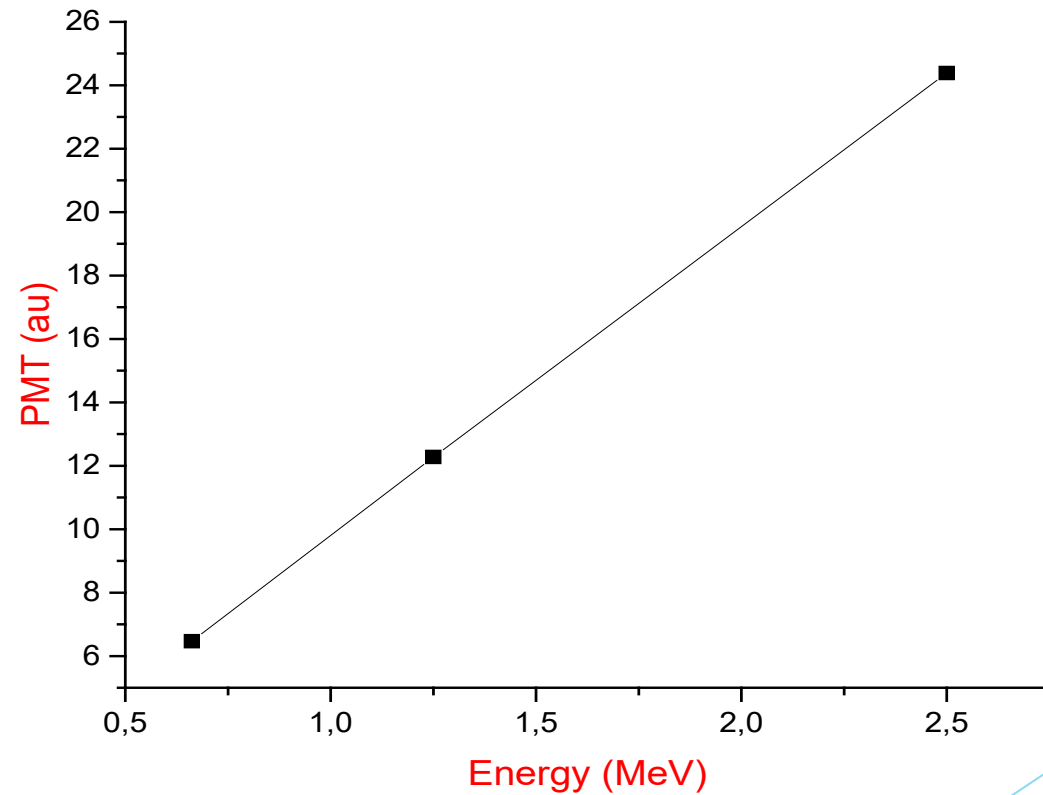
Co60 energy spectra (last peak)=2,5MeV

Mean=24,3845



The calibration spectra for BGO detector

Energy (MeV)	PMT (au)
0,662	6,4685
1,25	12,275
2,5	24,3845

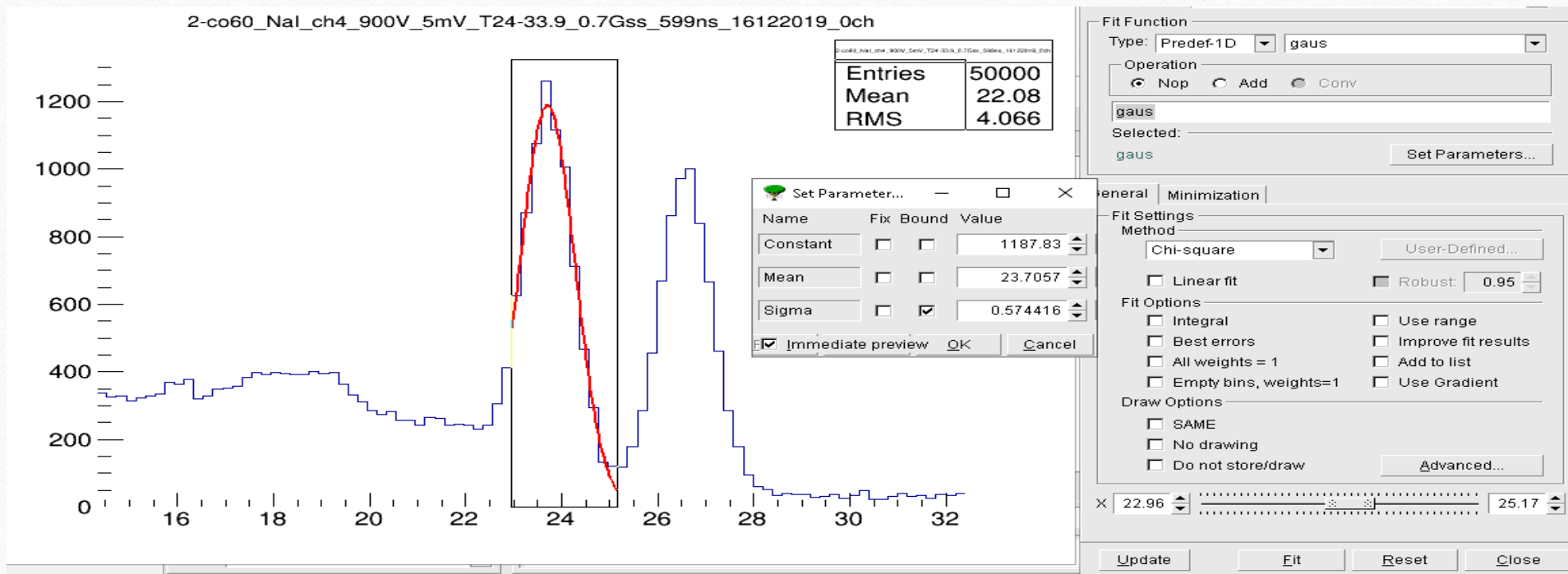


Task 3

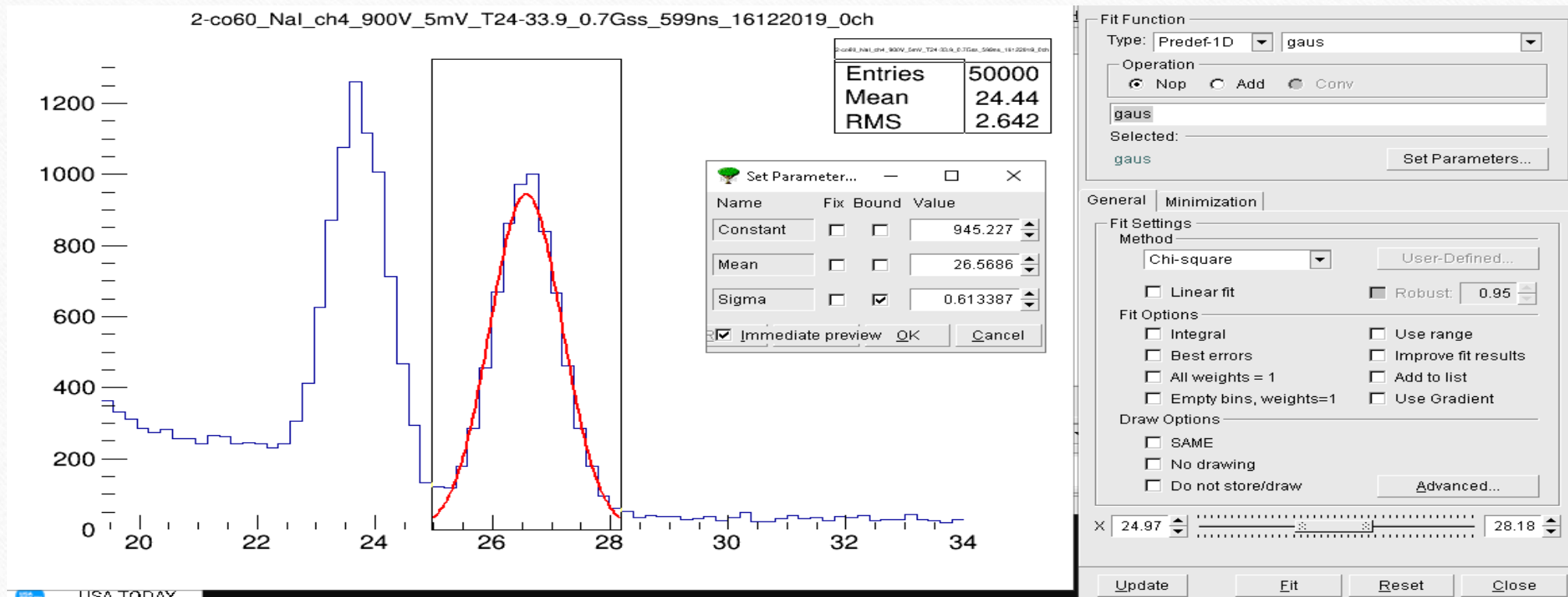
NaI

-
- **Part 1-Dependence of resolution on applied voltage for NaI**

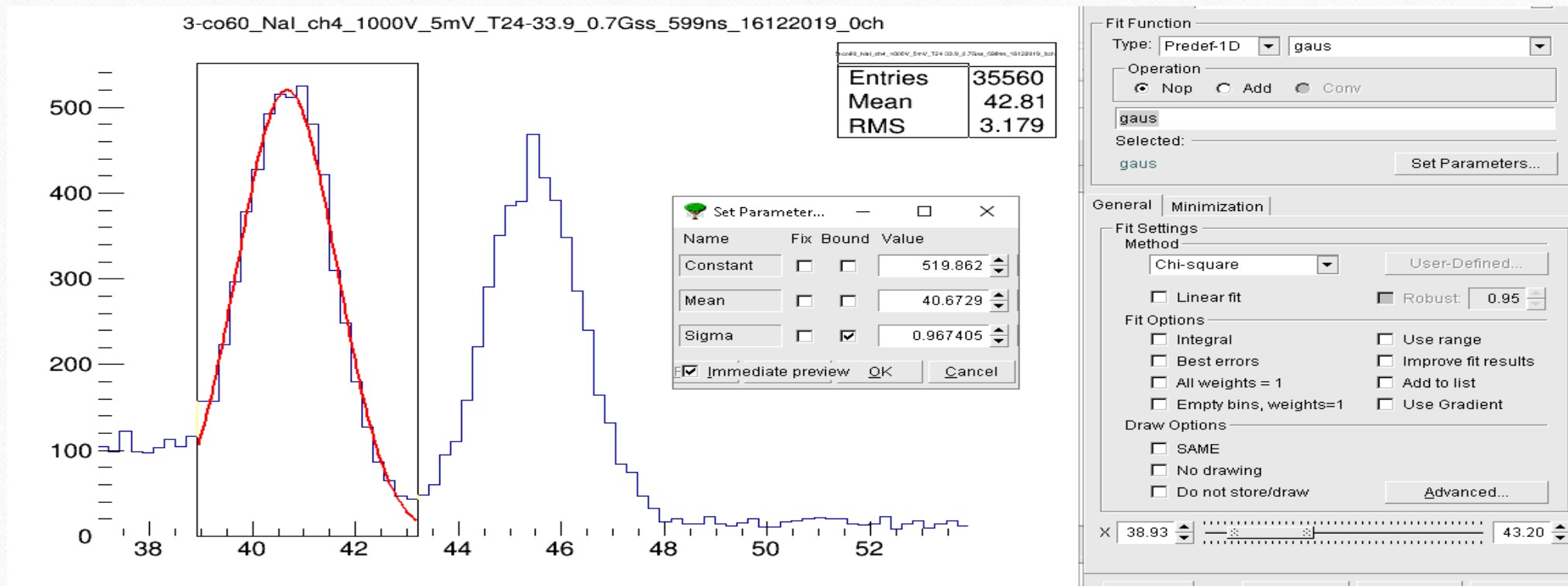
For first peak (900V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0565$



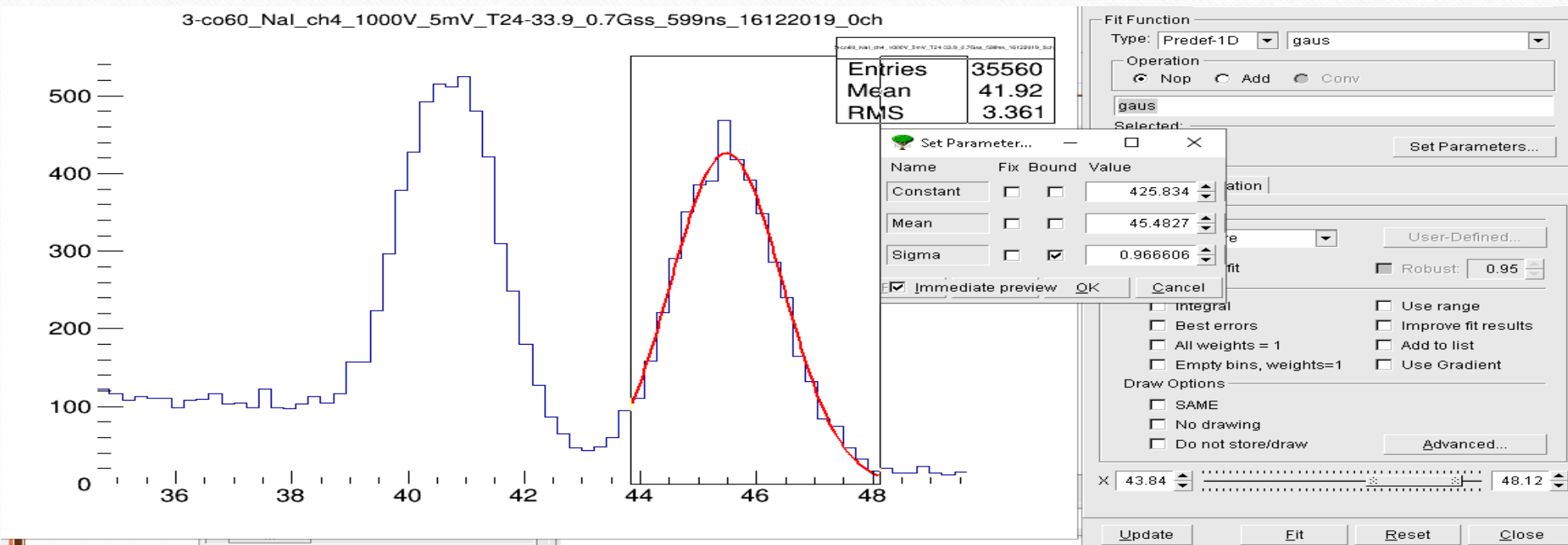
for Second peak (900V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0539$



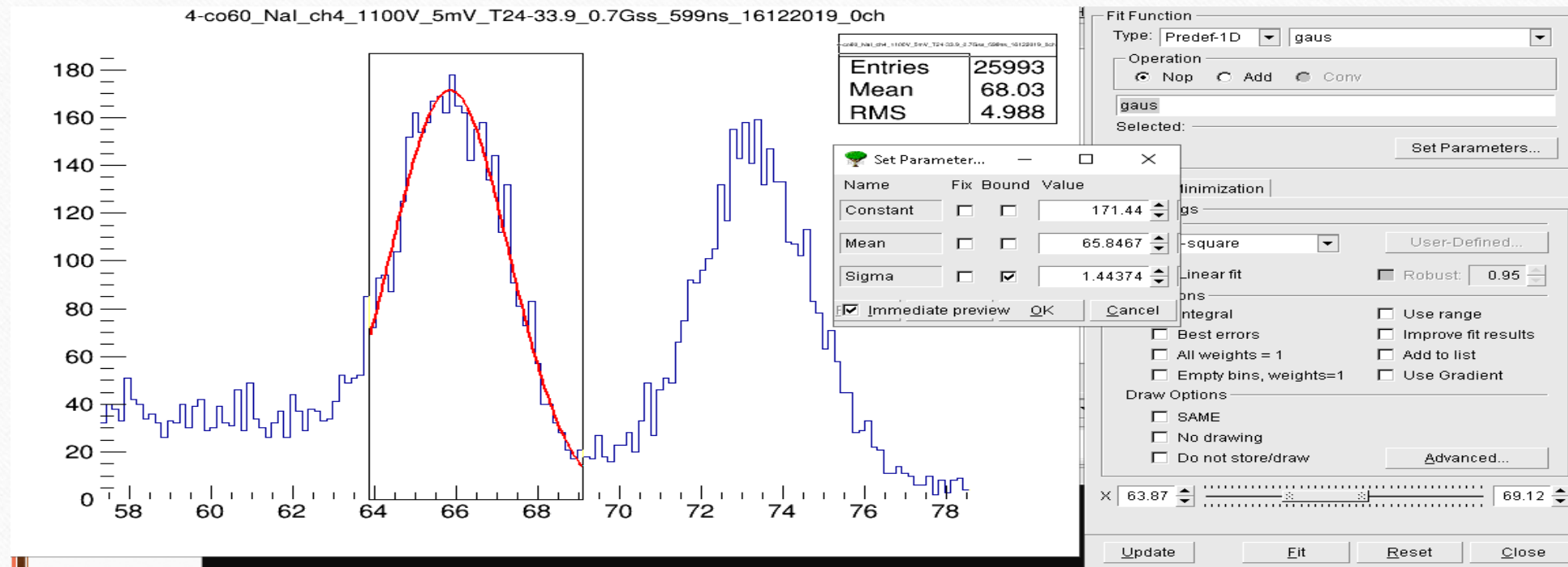
For first peak (1000V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0554$



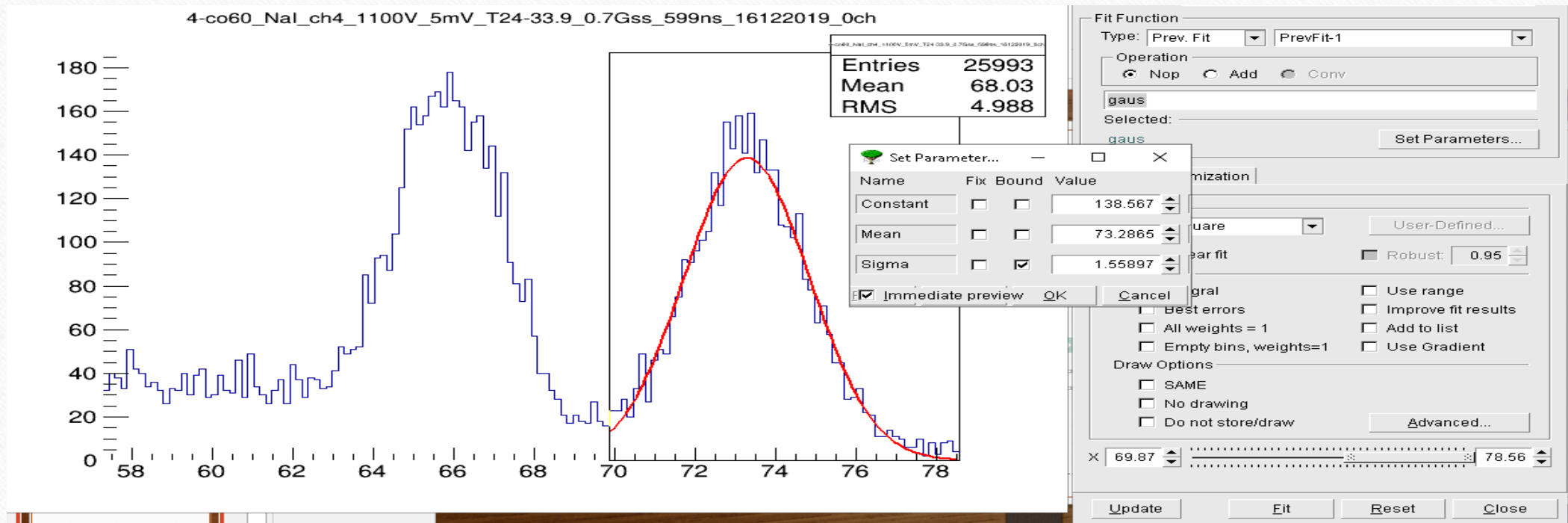
for Second peak (1000V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0499$



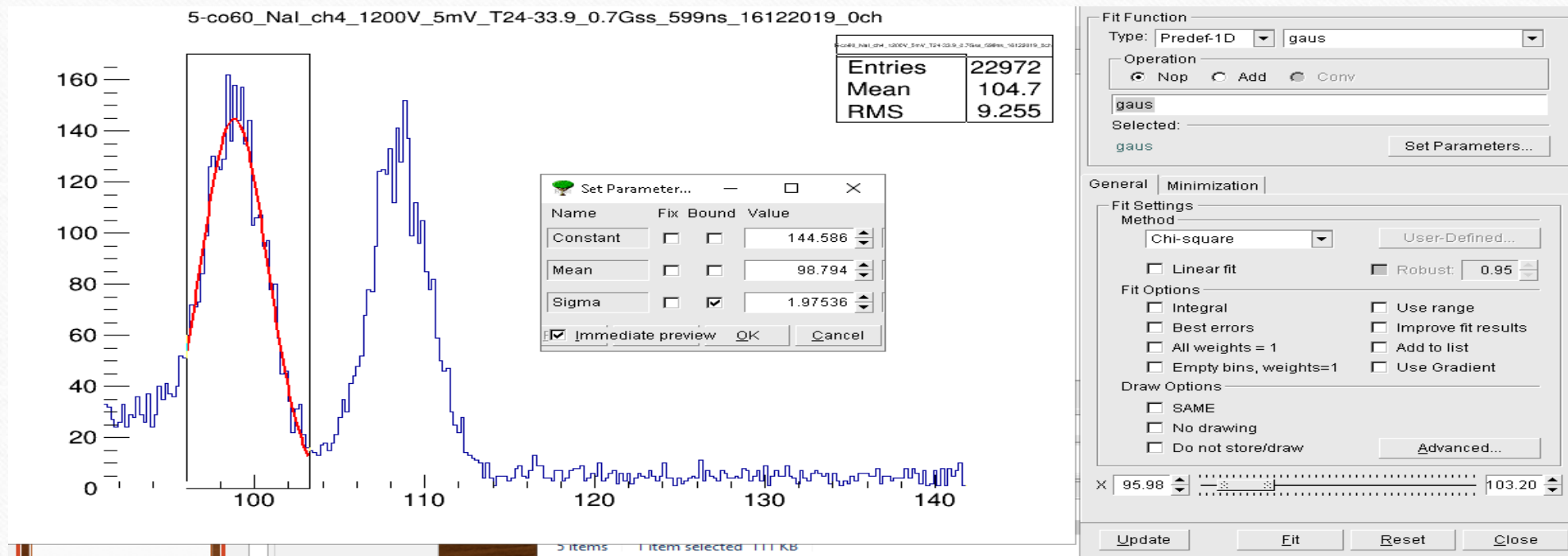
For first peak (1100V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0513$



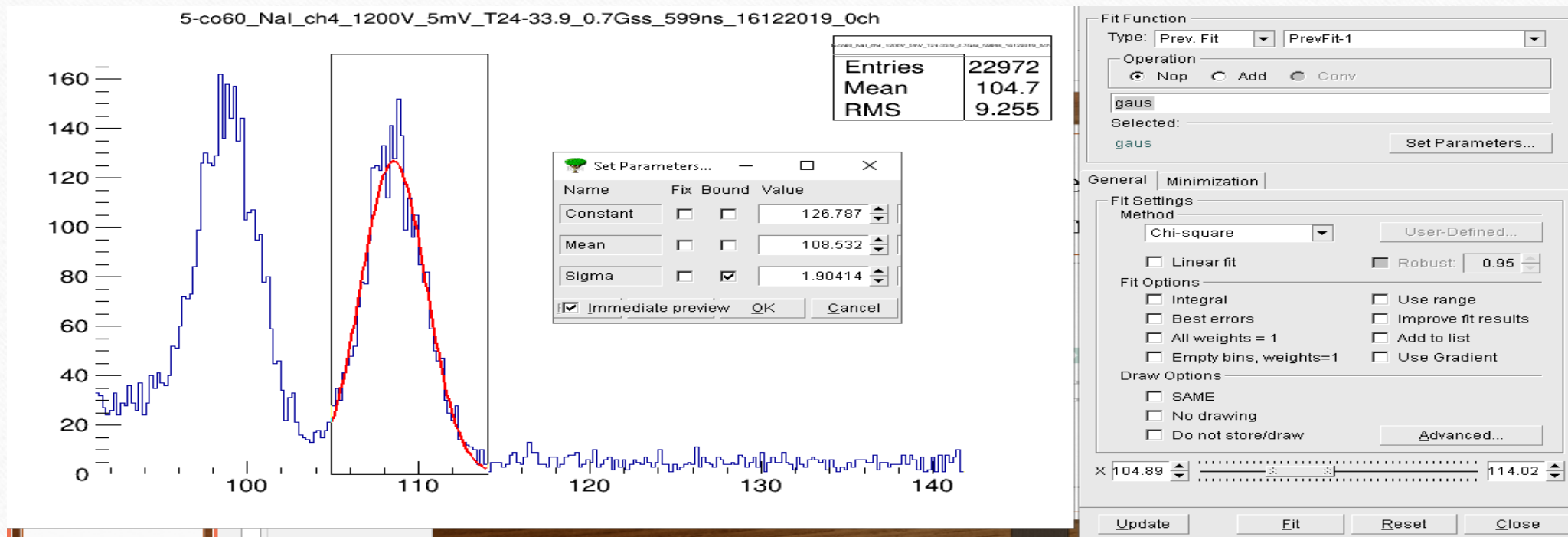
for Second peak (1100V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0459$



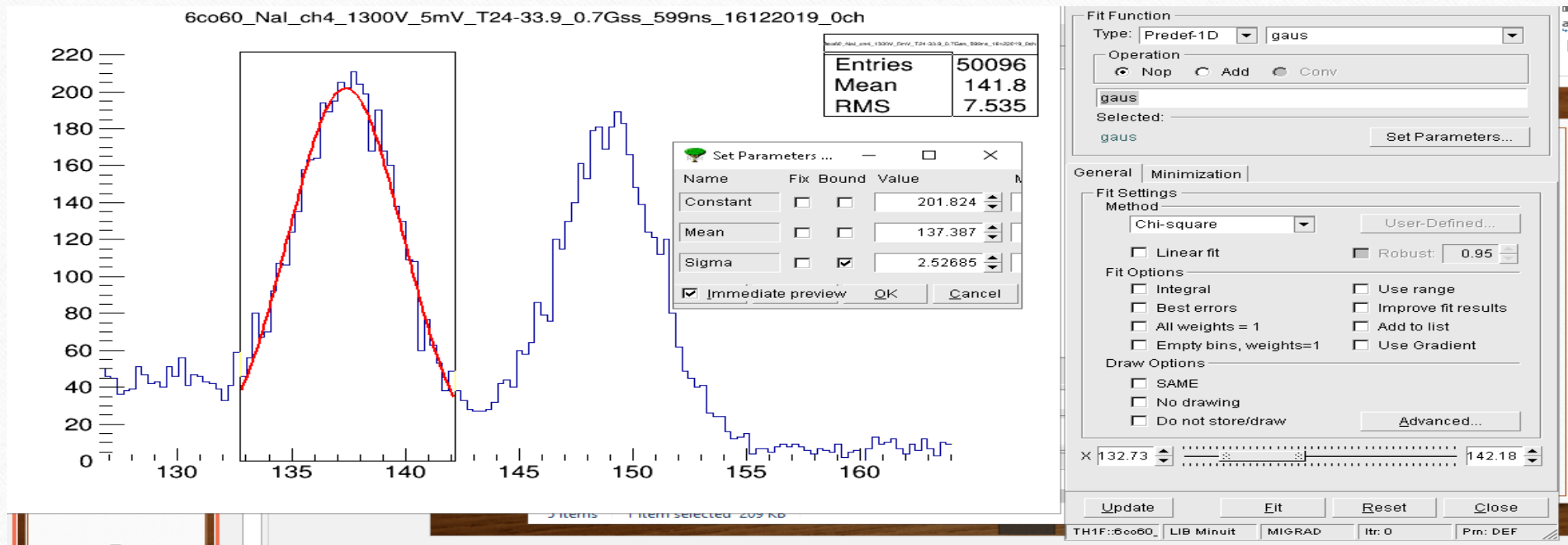
For first peak (1200V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0468$



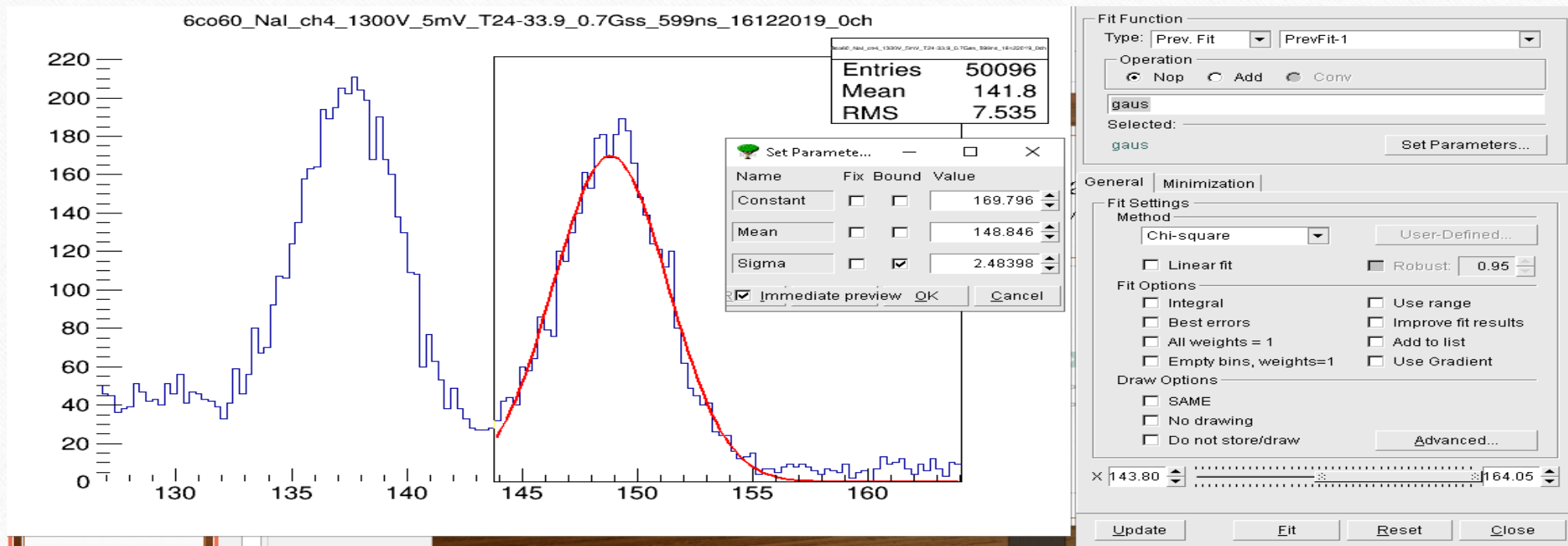
for Second peak (1200V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0411$



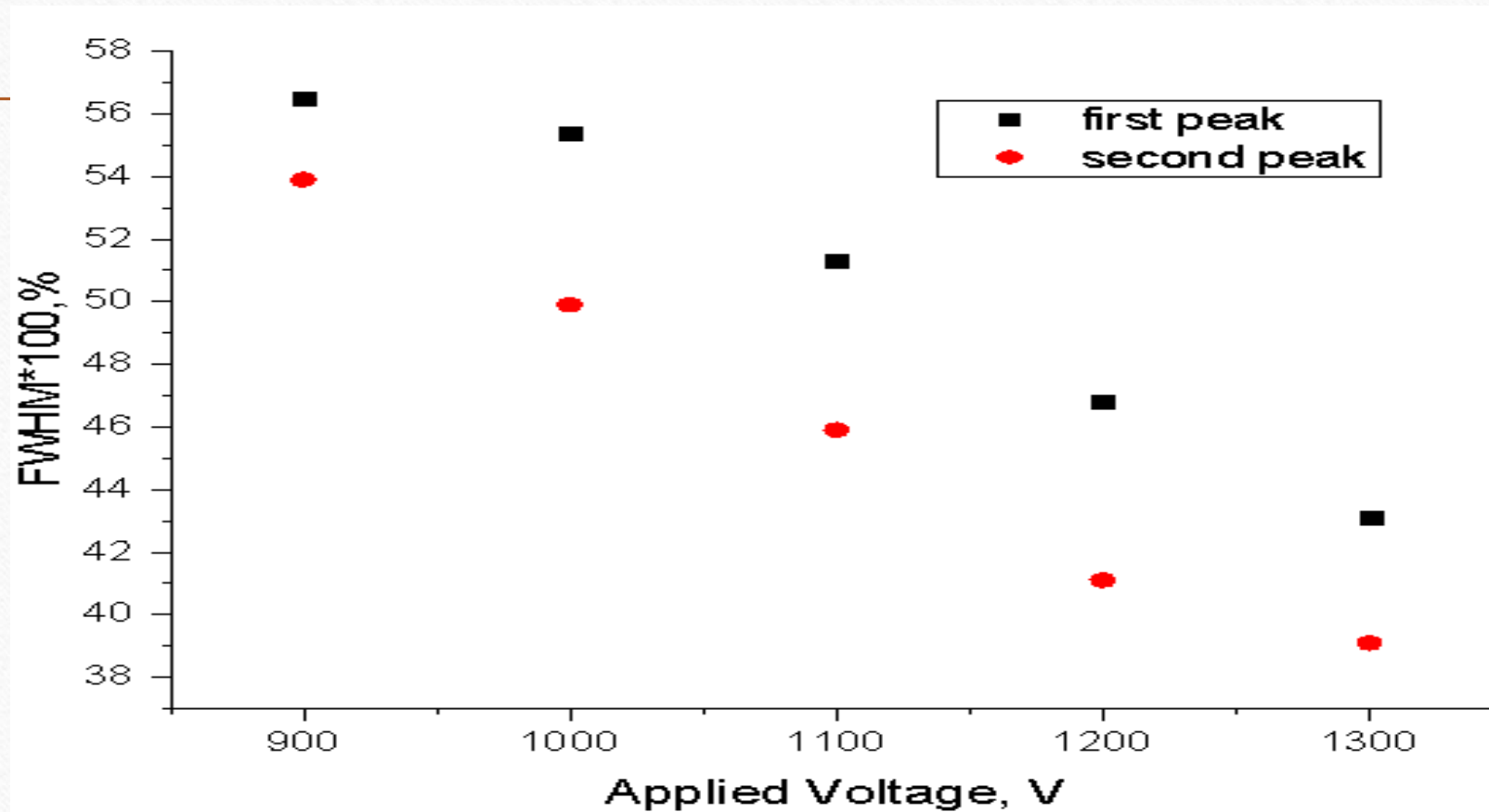
For first peak (1300V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0431$



for Second peak (1300V)
Resolution = $(\text{sigma} / \text{mean}) * 2,35 = 0,0391$



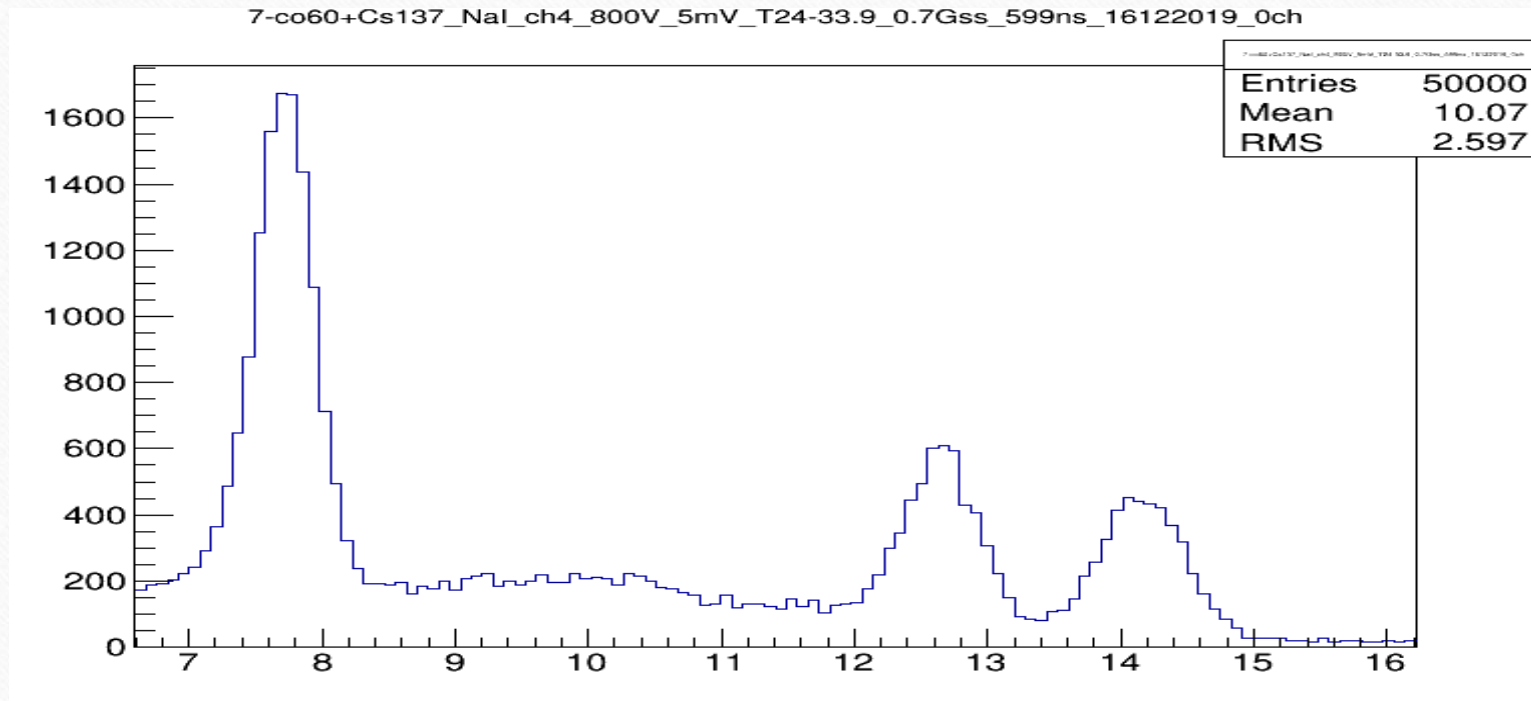
Dependence of resolution on applied voltage for NaI



TASK 2

The calibration spectra for NaI

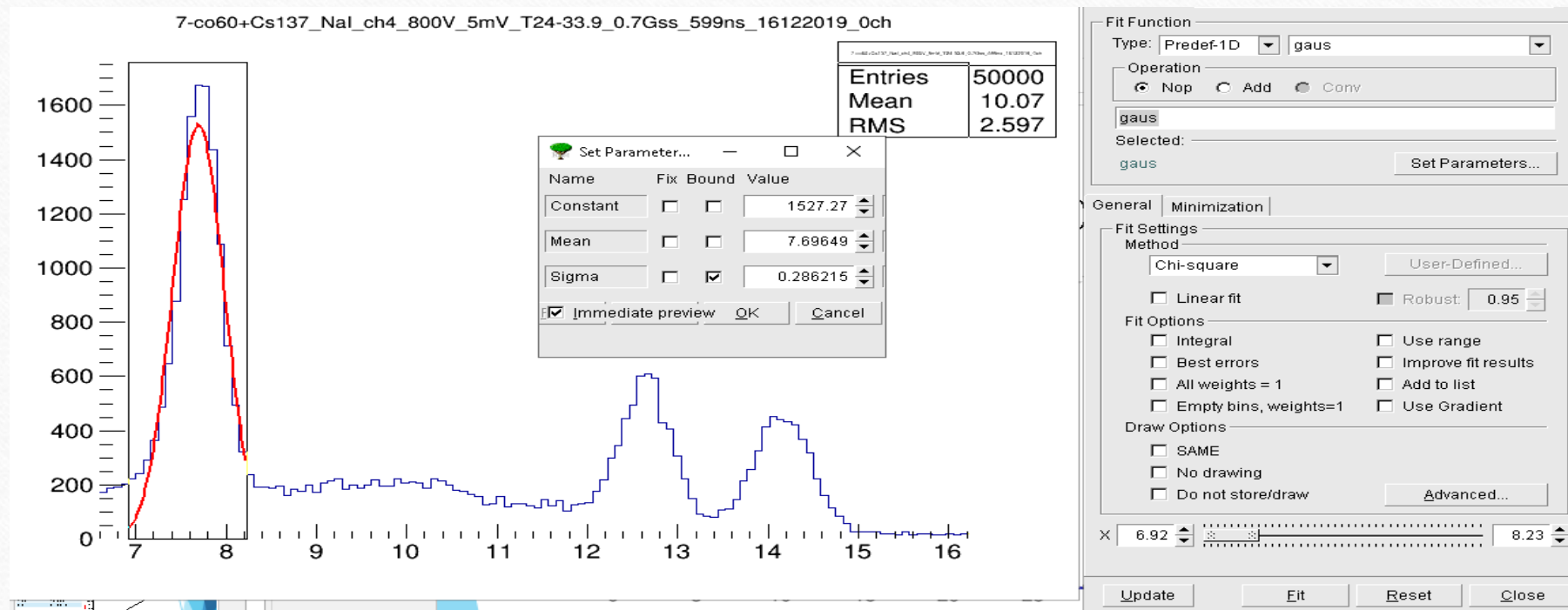
Co60+Cs137-NaI-800V



➤ Gaus FIT –first peak

Cs137 energy spectra=0,662MeV

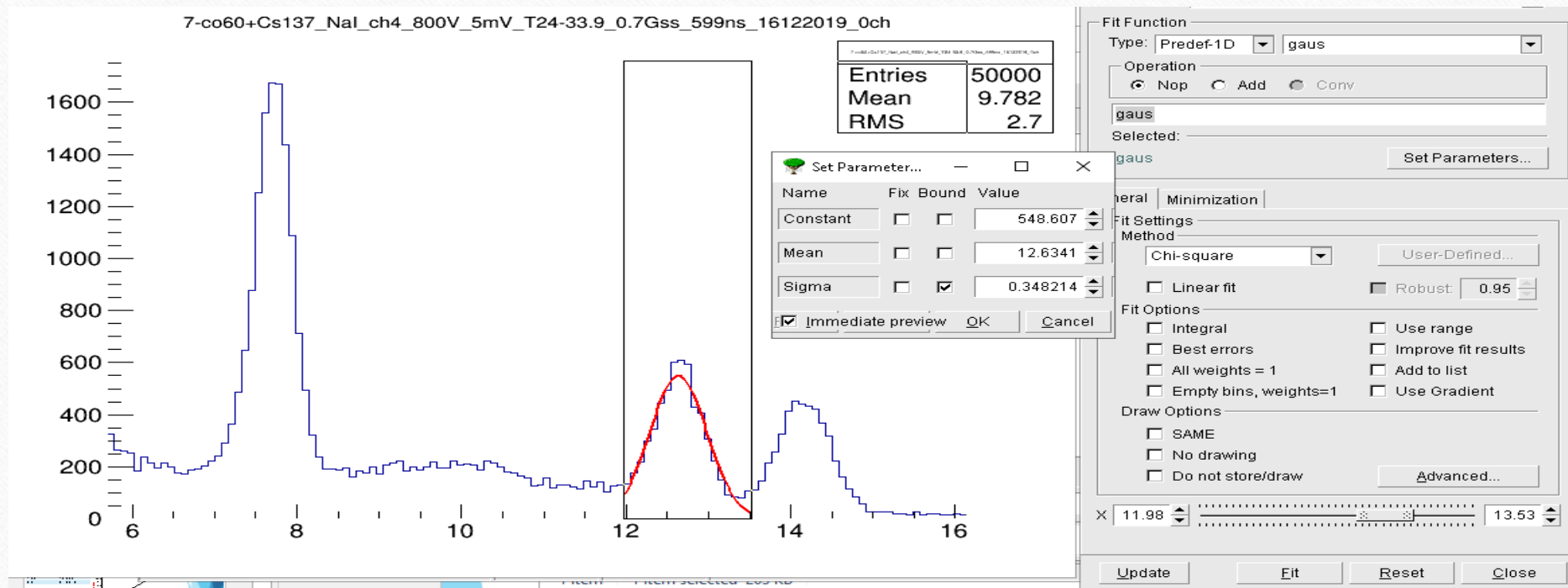
Mean=7,696



➤ Gaus FIT –second peak

Co60 energy spectra=1,25MeV

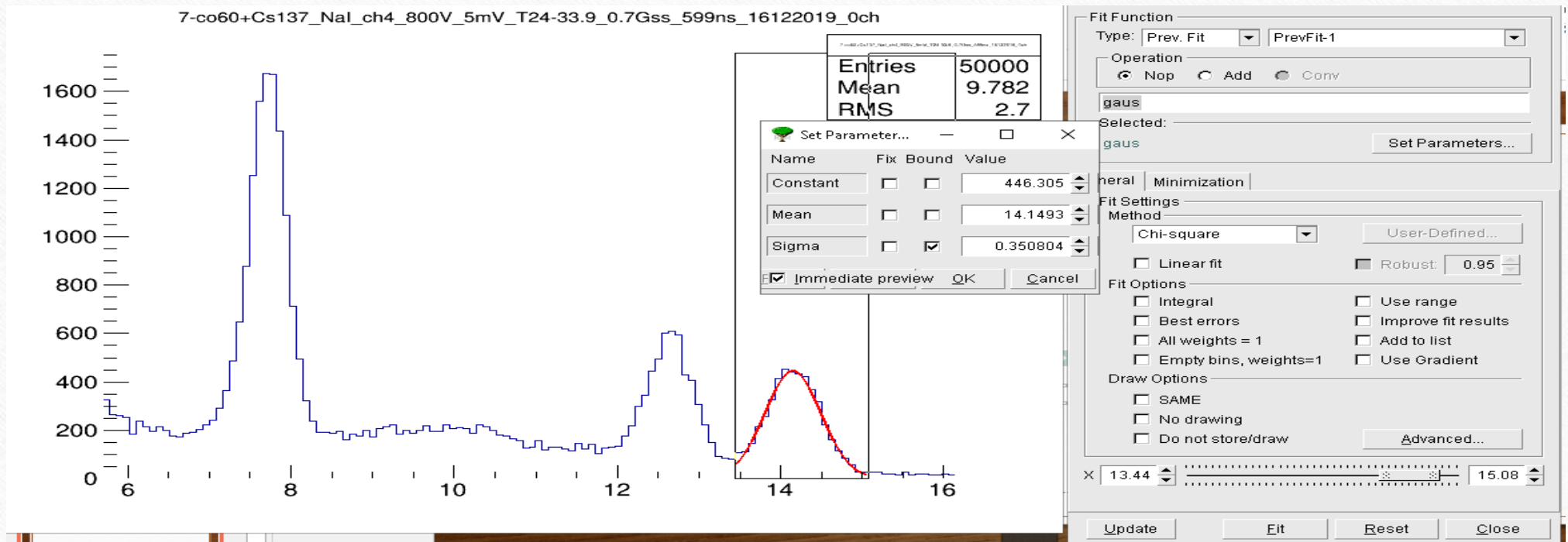
Mean=12,63



➤ Gaus FIT –third peak

Co60 energy spectra=1,33MeV

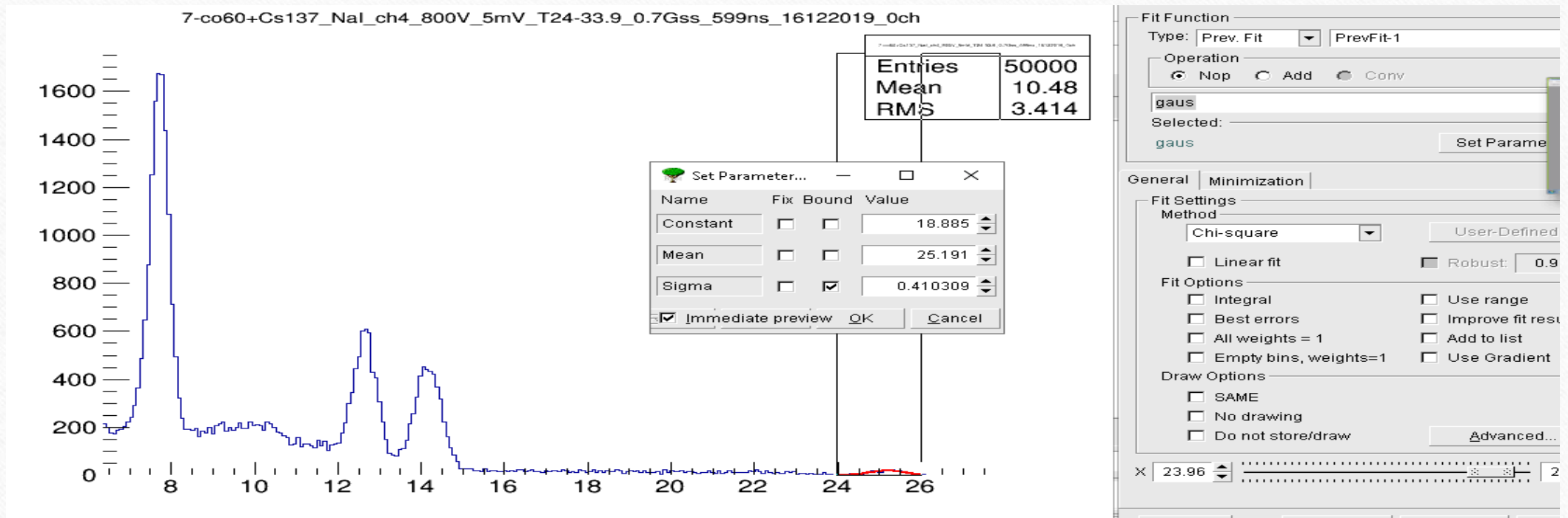
Mean=14,149



➤ Gaus FIT –fourth peak

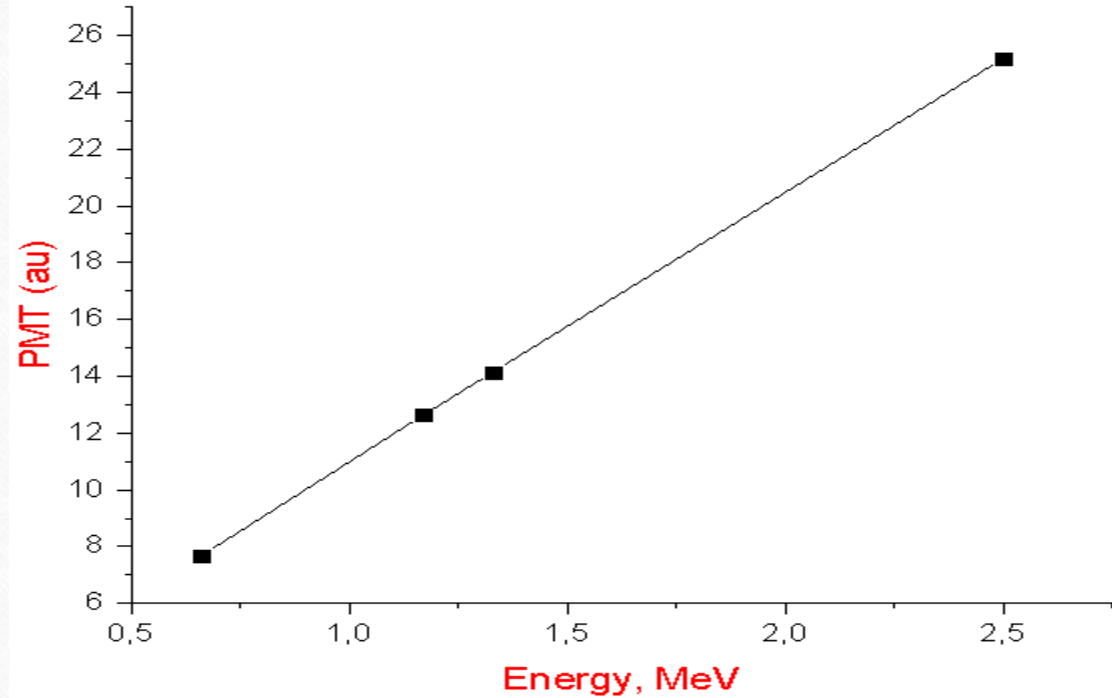
Co60 energy spectra (last peak)=2,5MeV

Mean=25,191



The calibration spectra for NaI

Energy (MeV)	PMT (au)
0,662	7,696
1,17	12,63
1,33	14,149
2,5	25,191



Unknown source

- We have the spectra of the unknown source
- We make gaus fit at the biggest peak
- We find MEAN (y)
- We have the calibration for NaI detector
- We find the energy (x) with equation from calibration

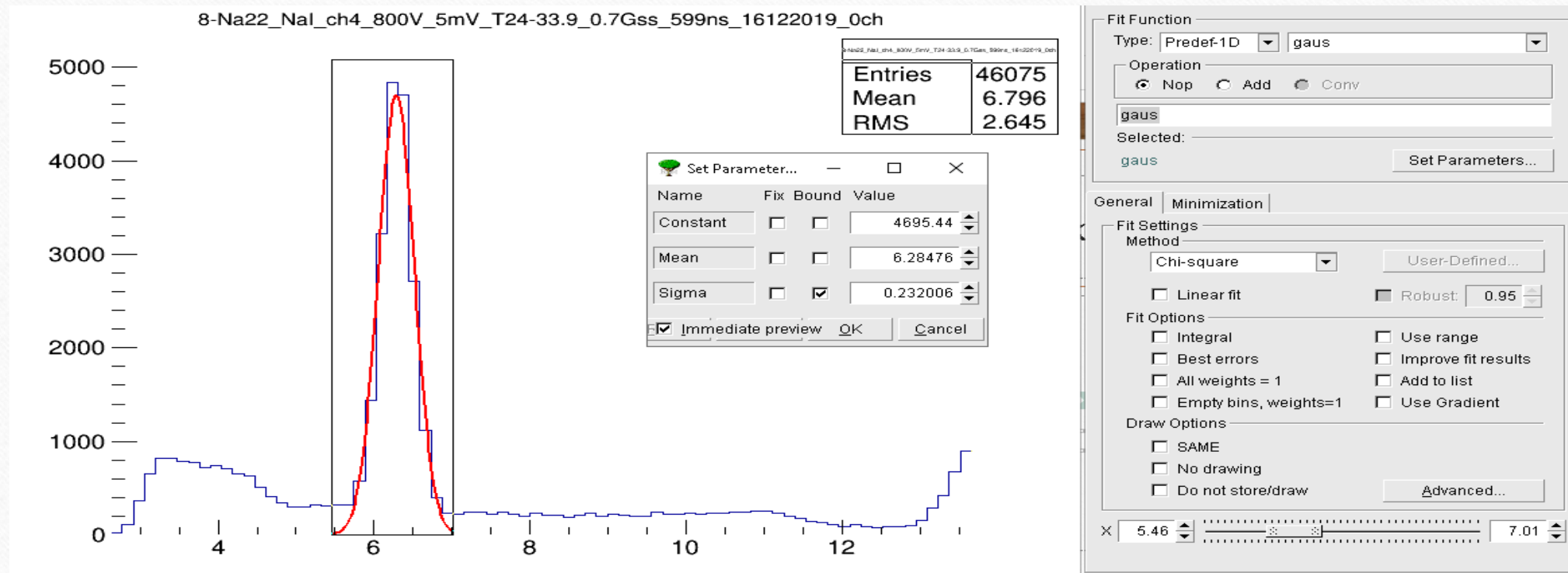
$$y=9,5078x+1,458$$

Unknown source 1

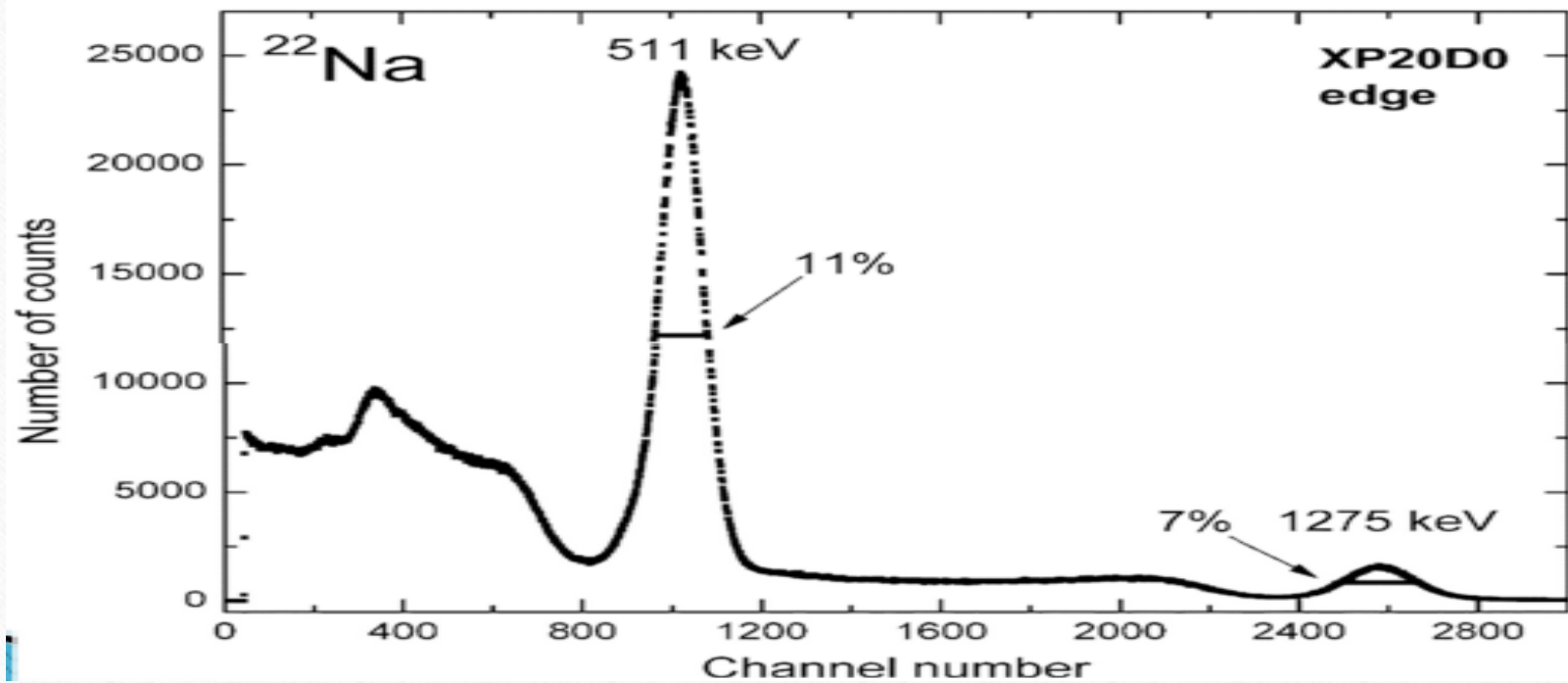
Mean= $y=6,284$

$y=9,5078x+1,458$, $x=(y-1,458)/9,5078=(6,284-1,458)/9,5078=0,507$

$E=0,507\text{MeV}$



Unknown source 1= ^{22}Na

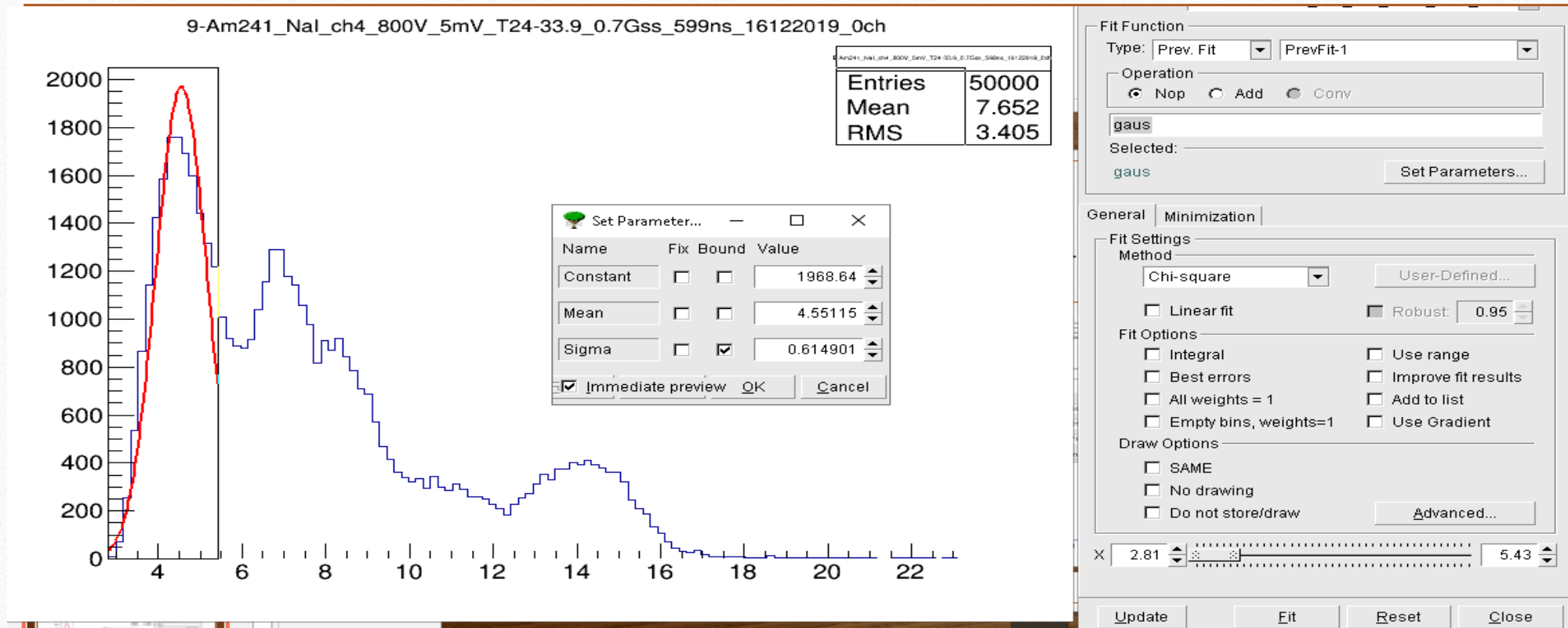


Unknown source 2

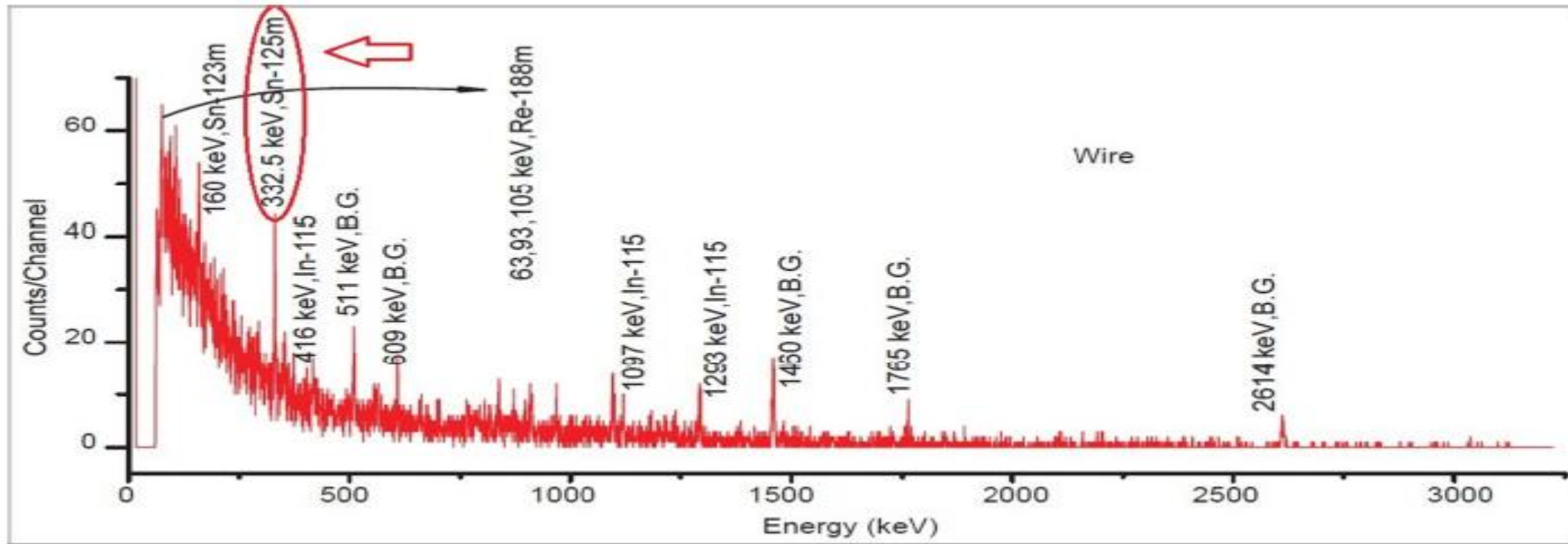
Mean= $y=4,551$

$y=9,5078x+1,458$, $x=(y-1,458)/9,5078=(4,551-1,458)/9,5078=0,325$

$E=0,325\text{MeV}$



Unknown source 2=Sn-125m



Task4

Attenuation Coefficient

Finding Attenuation Coefficient

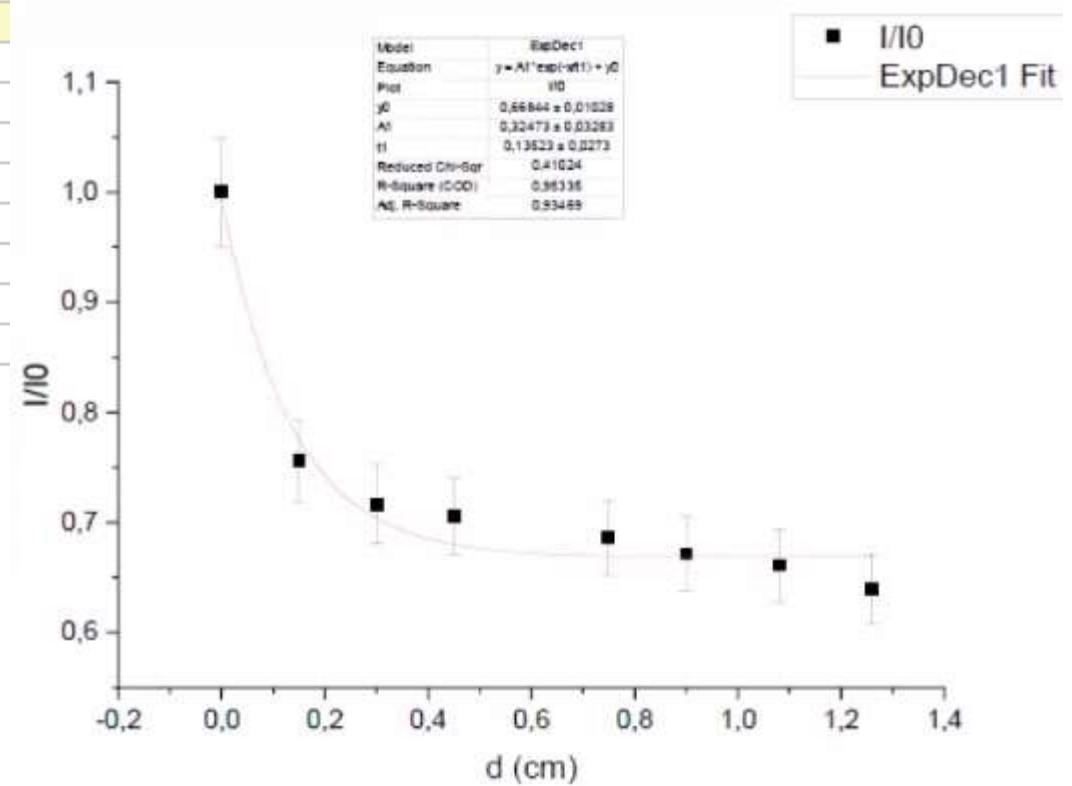
- We want to determine the attenuation coefficient μ

$$I = I_0 e^{-\mu x}$$

- We have shields of different thickness. For each shield we determine I/I_0
- We make a graph where we have I/I_0 on Oy and Thickness on Ox
- We make exponential fit and we find μ

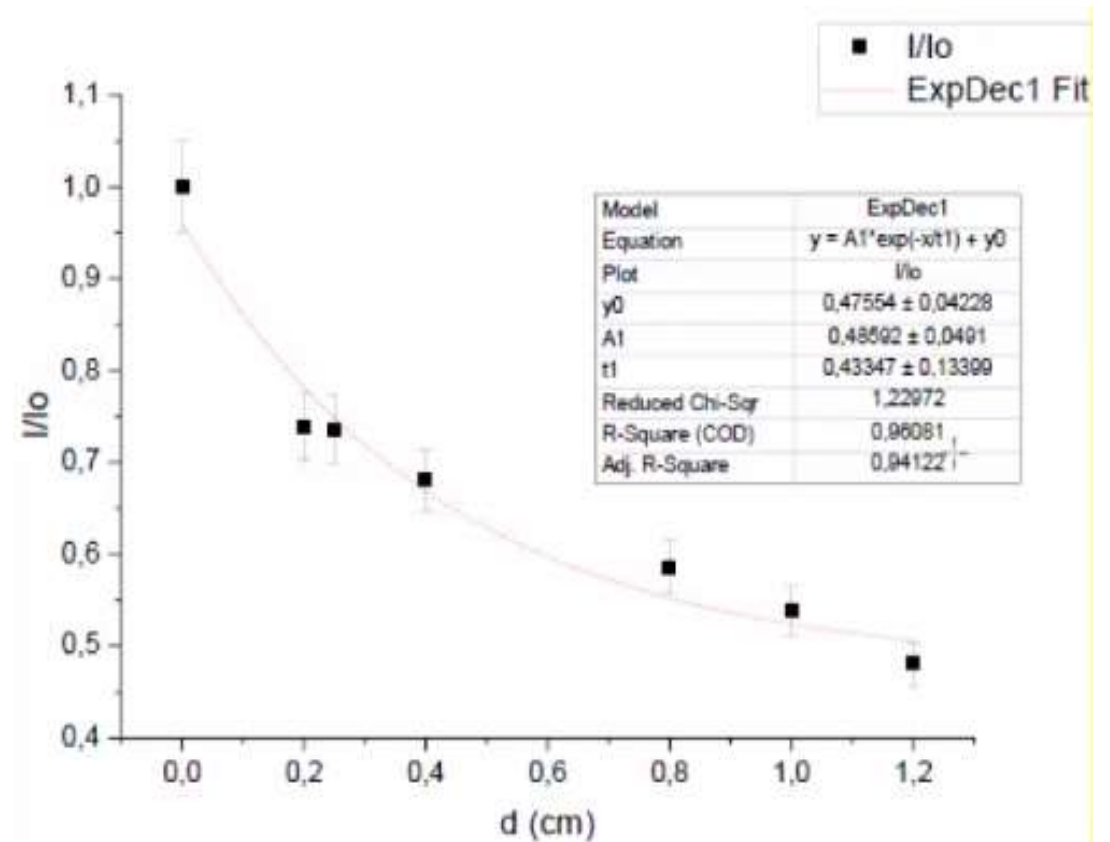
Al

	A(X)	B(Y)
Long Name		
Units		
Comments		
F(x)	Thickness, cm	I/I0
1	0	1
2	0,15	0,75573
3	0,3	0,71623
4	0,45	0,70569
5	0,75	0,68596
6	0,9	0,67155
7	1,08	0,66103
8	1,26	0,63939



Cu

	A(x)	B(y)
Long Name		
Units		
Comments		
F(x)	Thickness, cm	I/I0
1	0	1
2	0,2	0,73931
3	0,25	0,7357
4	0,4	0,68065
5	0,8	0,58611
6	1	0,53827
7	1,2	0,48042





TASK5

SRIM PROGRAM + CALCULATION OF HE RANGE IN AIR

- **We use plastic detector to calculate the alpha particle range in the air using Plutonium 239 source with energy=5MeV**

SRIM PROGRAM-SIMULATION

SRIM-2013.00
File Help, FAQ and Scientific Explanations

Help **Analyze** Focus TRIM Change TRIM 100% ION ENERGY 0% Now: 736 of 99999 Ions

ION

Ion Type: He 4.003 amu
Ion Energy: 5 MeV
Ion Angle: 0 degrees

Completed: 744 of 99999

SHOW LIVE DATA HELP

TARGET DATA

He (5000) into Layer 1 (1 layers, 4 atoms)

Layer Name	Width (A)	Density	C (12.011)	O (15.999)	N (14.007)	Ar (39.948)
1 Air, Dry (ICRU-104)	500000000	0.001205	0.00015	0.21076	0.78442	0.0
Lattice Binding Energy			3	3	3	
Surface Binding Energy			7.41	2	2	

Calculation Parameters

Backscattered Ions: 0
Transmitted Ions: 0
Vacancies/Ion: 105.7

ION STATS

	Range	Straggle
Longitudinal	36.1 um	529. um
Lateral Proj.	530. um	730. um
Radial	840. um	665. um

Type of Damage Calculation

Quick Kinchin-Pease

Stopping Power Version

SRIM-2008

ENERGY LOSS

	Ions	Recoils
Ionization	99.72	0.08
Vacancies	0.00	0.00
Phonons	0.03	0.15

SPUTTERING YIELD

	Atoms/ion	eV/Atom
TOTAL		
C	0.000000	0.00
O	0.000000	0.00
N	0.000000	0.00

Save every 10000 ions
Random Number: 607286
Counter: **HELP**

COLLISION PLOTS

Ion/Recoils (XY) All
 Ion/Recoils (YZ) None
 Ions (no recoils) Tile
 Lateral View (YZ) Clear

Background color White/Black.

DISTRIBUTIONS

File Plot

- Ion Distribution
- Ion/Recoil Distribution
- Lateral Range
- Ionization
- Phonons
- Energy to Recoils
- Damage Events
- Integral Sputtered Ions
- Differential Ions
- Backscattered Ions
- Transmitted Ions
- Collision Details

3-D Plots 3D Help

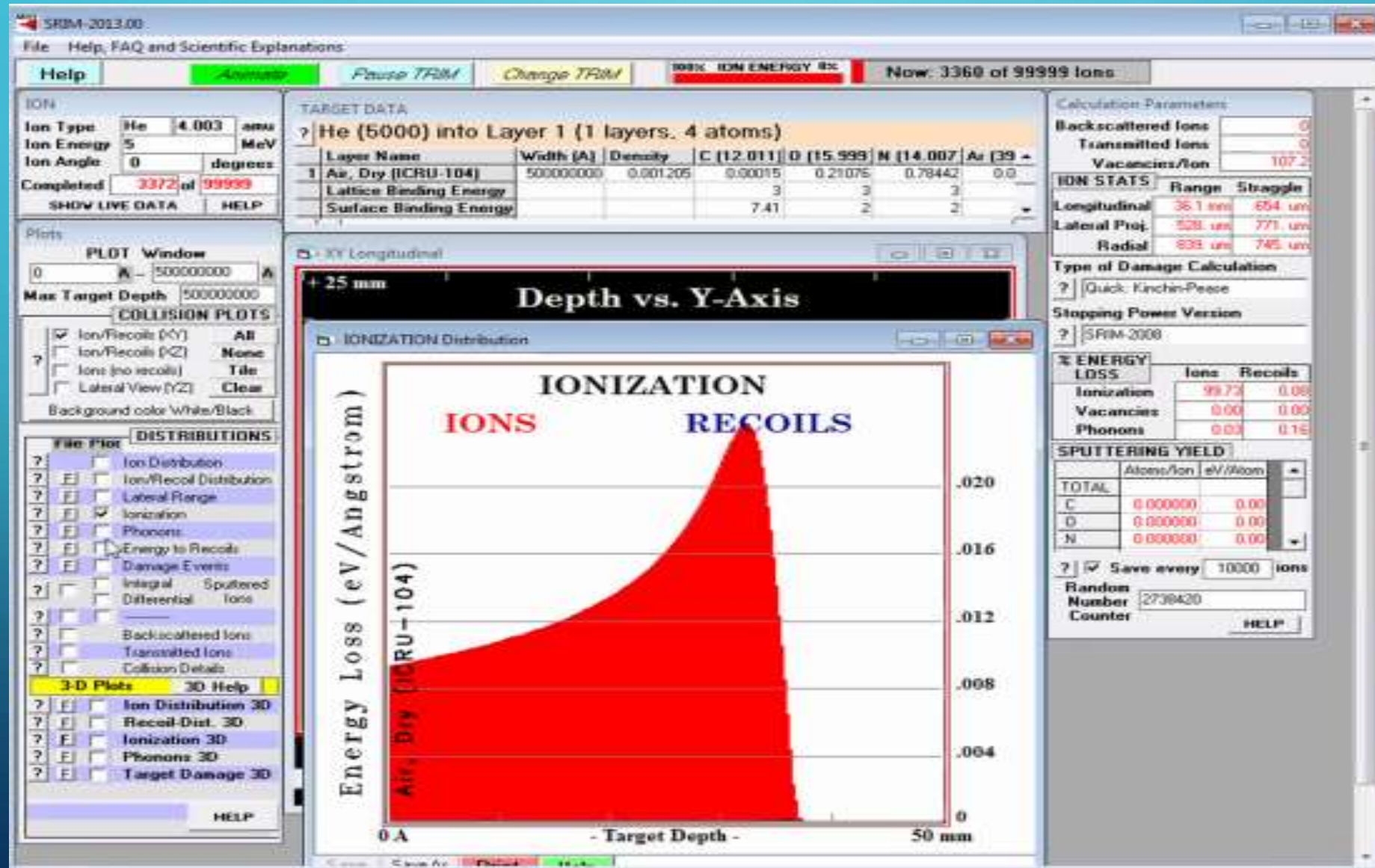
- Ion Distribution 3D
- Recoil Dist. 3D
- Ionization 3D
- Phonons 3D
- Target Damage 3D

XY Longitudinal

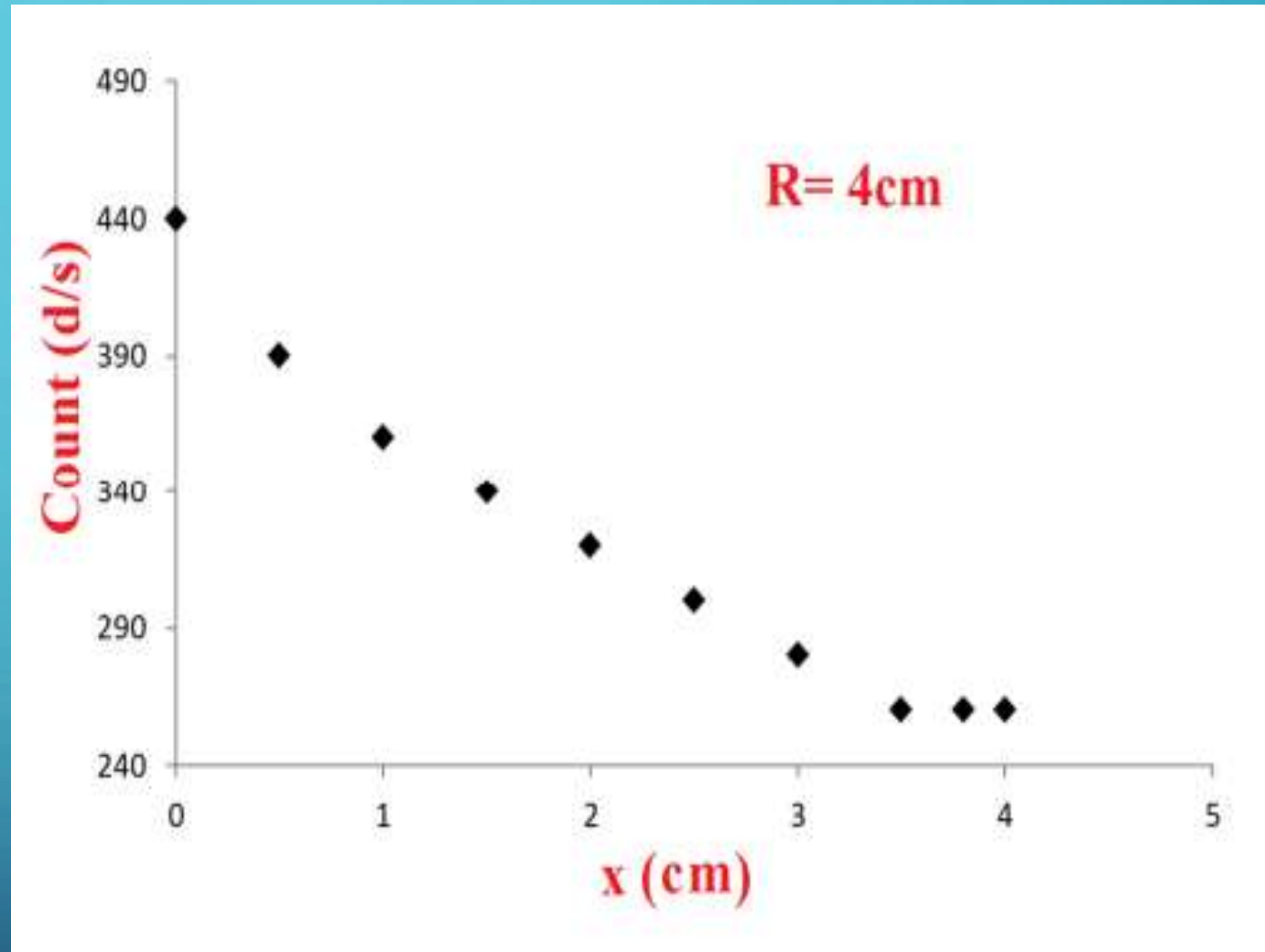
Depth vs. Y-Axis

Save As Print Label Clear

SRIM PROGRAM-SIMULATION



	A(x)	B(y)
Long Name		
Units		
Comments		
F(x)		
1	440	0
2	390	0,5
3	360	1
4	340	1,5
5	320	2
6	300	2,5
7	280	3
8	260	3,5
9	260	3,8
10	260	4
11		
12		



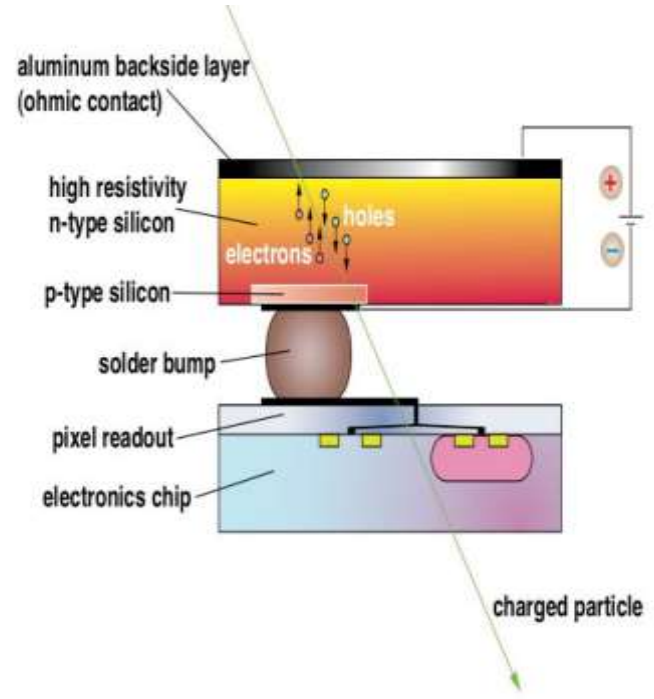
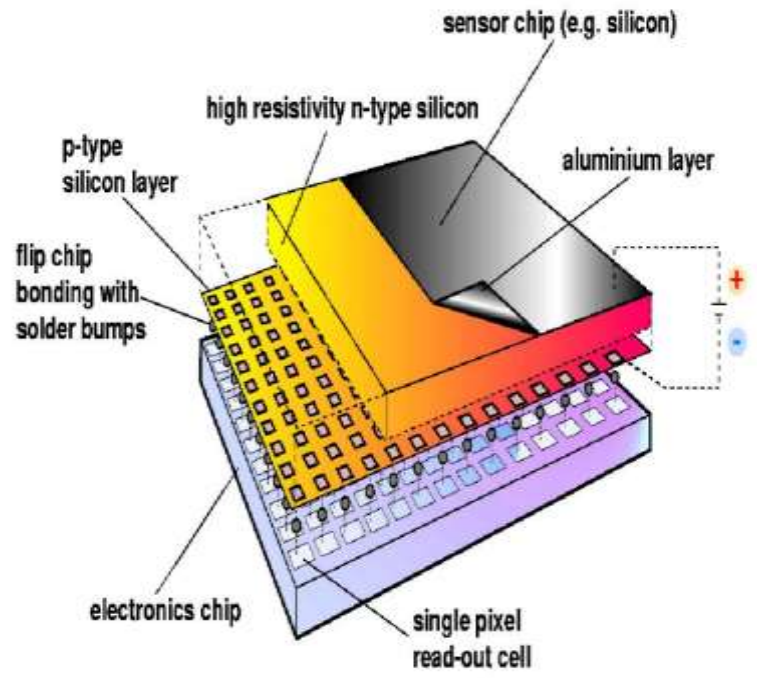
The background features abstract, overlapping geometric shapes in various shades of blue, ranging from light sky blue to deep navy blue. These shapes are primarily located on the right side of the frame, creating a modern, layered effect. The rest of the background is plain white.

TASK6

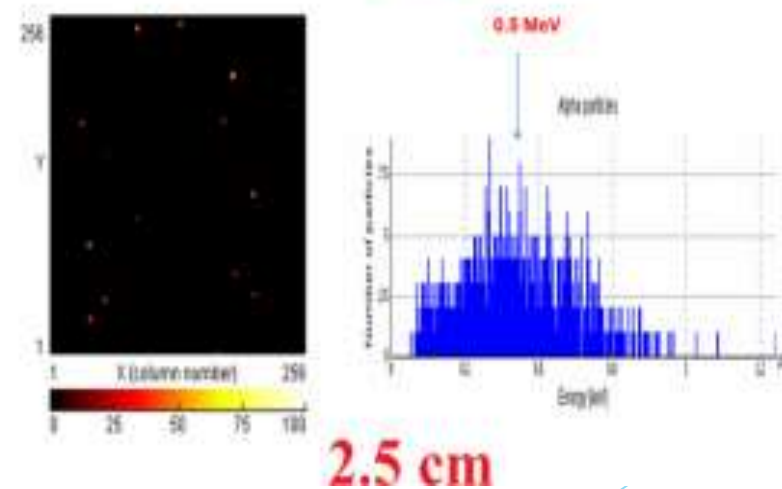
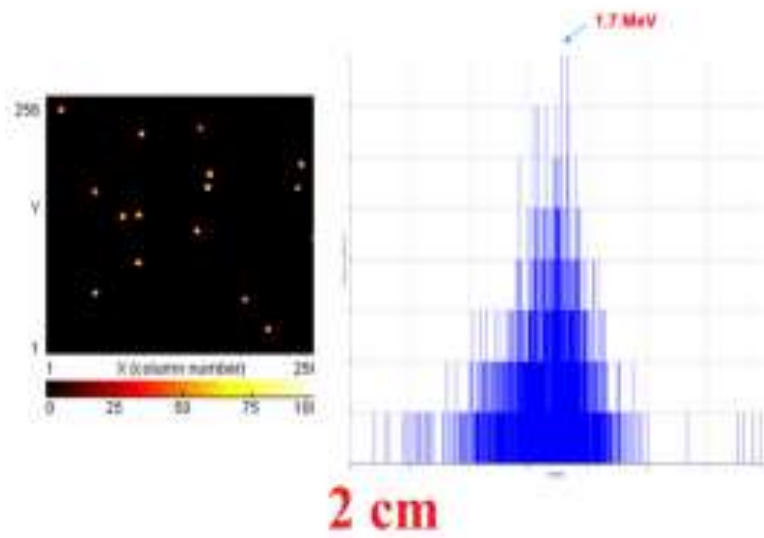
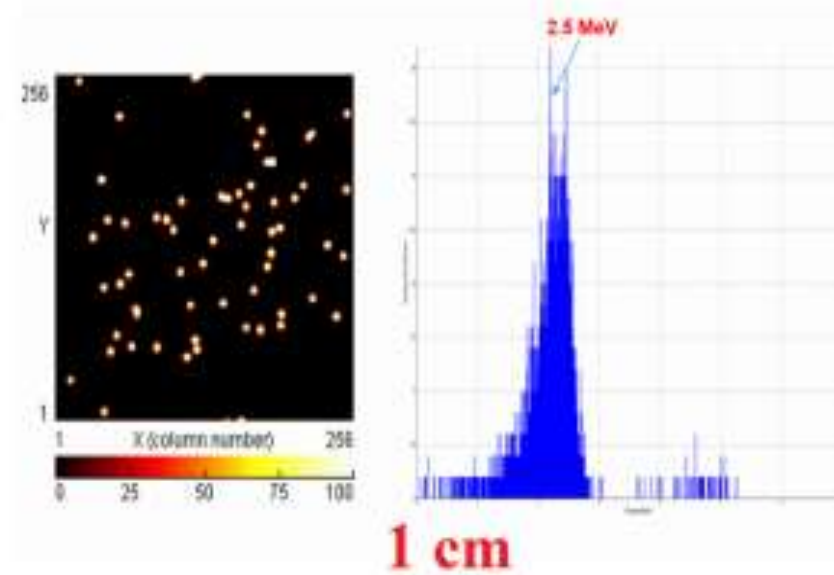
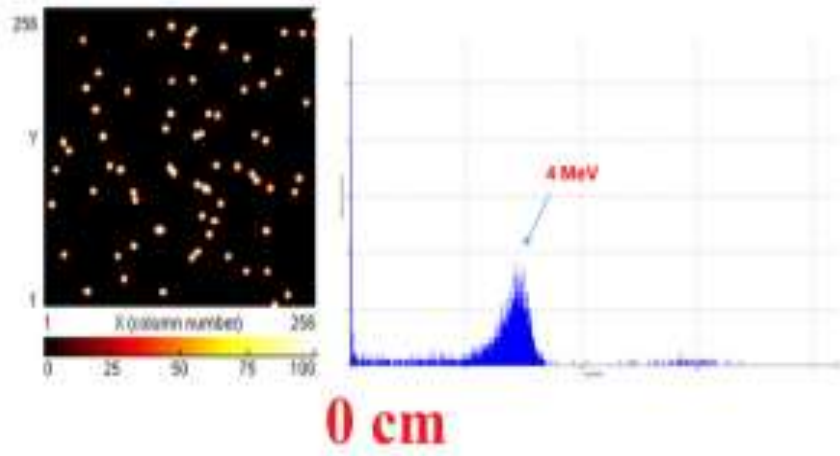
PIXEL DETECTOR

- ▶ It is an advanced detector like a digital camera
- ▶ It has 3 parts -**sensor, electronic chip and Usb**
- ▶ The size of the sensor is 1.5x1.5 cm.
- ▶ It has 256 x 256 pixels (65.536 pixel).
- ▶ The pixel size is 55 μ m x 55 μ m
- ▶ The pixel size is 55 μ m x 55 μ m
- ▶ It has high resolution and It is used for registration different types of radiation





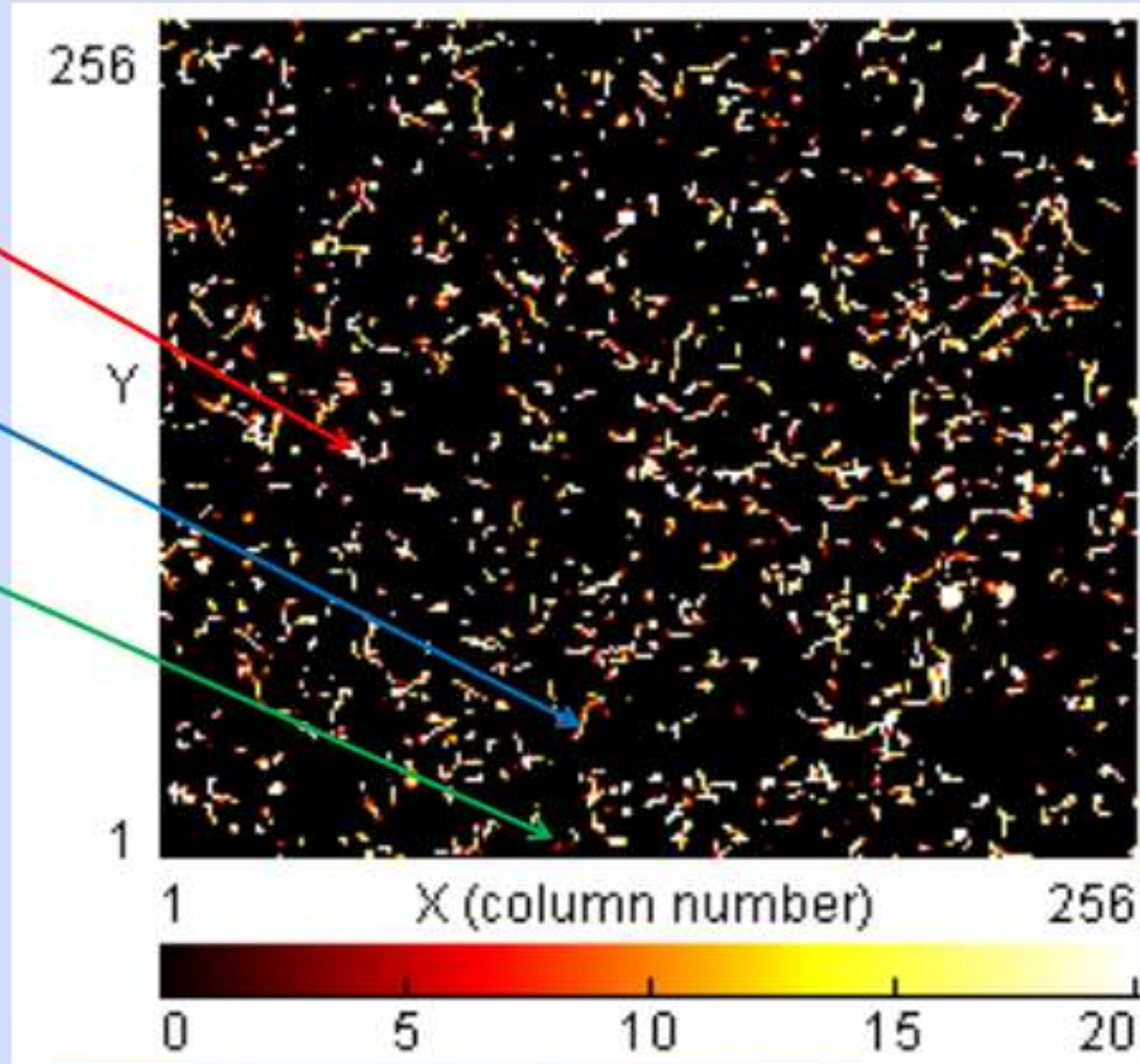
- ▶ Determination the range of Alpha particles with (Am-241) energy about 4 MeV in air using pixel detector



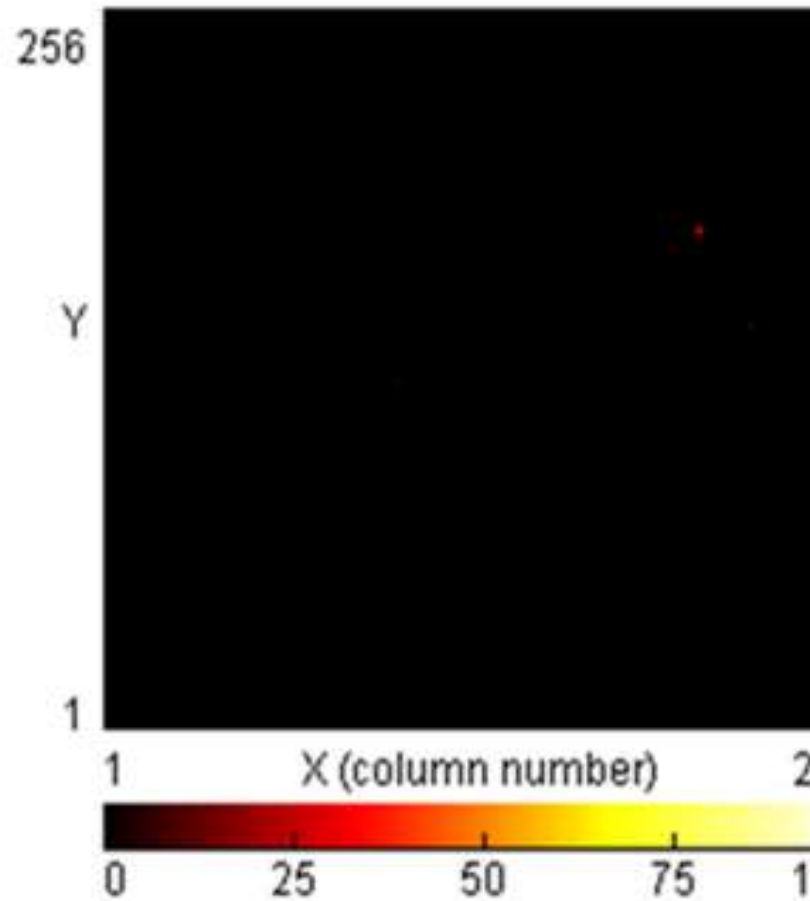
Alpha particle

Beta particle

Gamma quanta



- ▶ no alpha particles are detected
- ▶ Maximum of alpha particle range is 3 cm
- ▶ $R=3$ cm



Conclusion

This practice helped us to gain experience in:

- ▶ Different types of radiation sources, and detection of radiation.
- ▶ Radioactivity and naturally occurring radioactive materials
- ▶ Calculation of **Resolution** different scintillation detectors (BGO and NaI).
- ▶ **Energy calibration** of some scintillation detectors by using standard sources.
- ▶ Identify of **unknown source** by using energy calibration curve.
- ▶ Determination of **Attenuation coefficient** for different materials (Al and Cu).
- ▶ Determination of **alpha range in air** using Pixel and Plastic detectors.
- ▶ Monte Carlo simulation SIRM software.

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