International Student Practice - Radiation Protection and the Safety of Radiation Sources -

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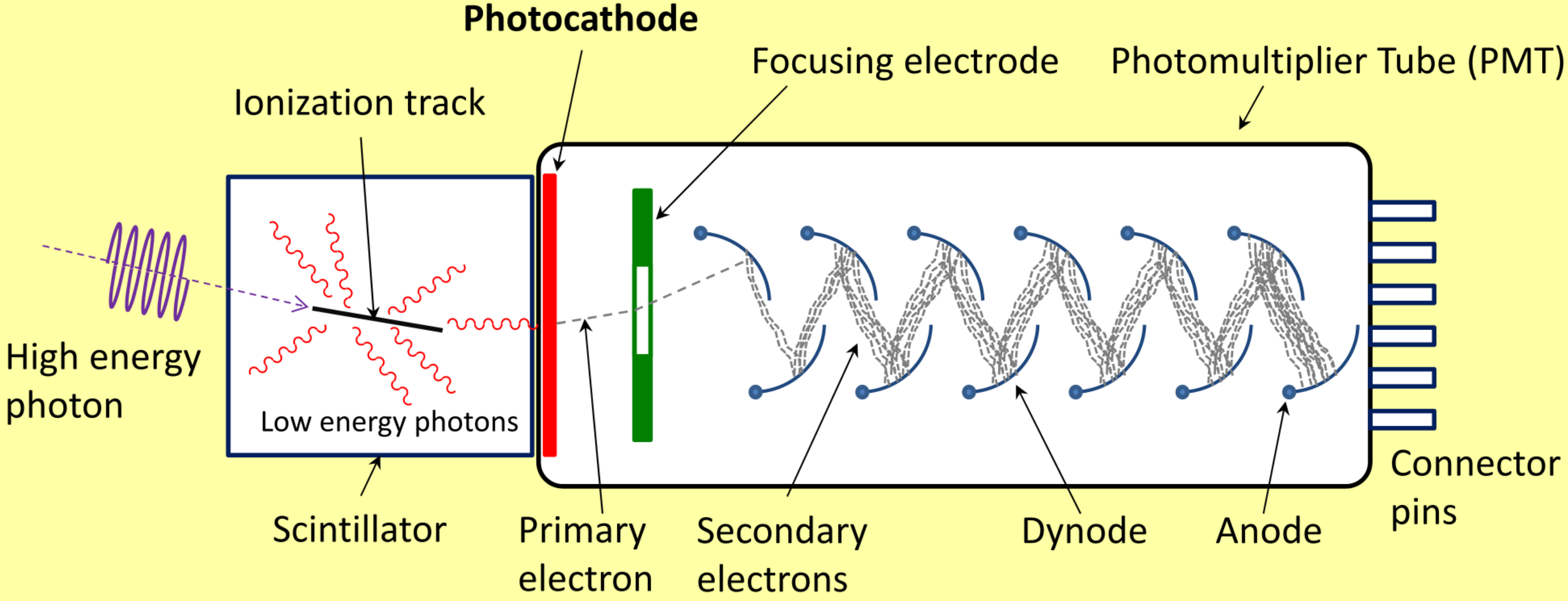
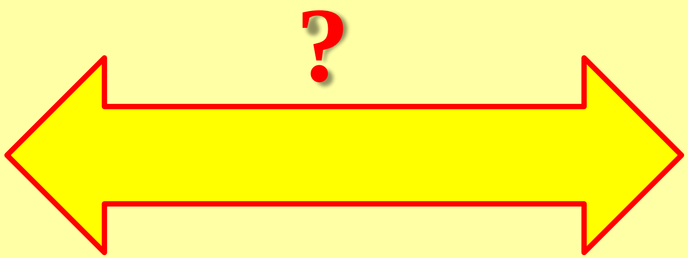
Radiation Protection and Dosimetry

- Types of radiation
- Radiation spectrum
- Activity
- Radiation dose terminology and units
- Occupational dose limits for radiation workers
- Deterministic and stochastic effects
- Types of dosimeters
- Radiation sources used in laboratory and their spectrum

Scintillation detector – BGO and NaI

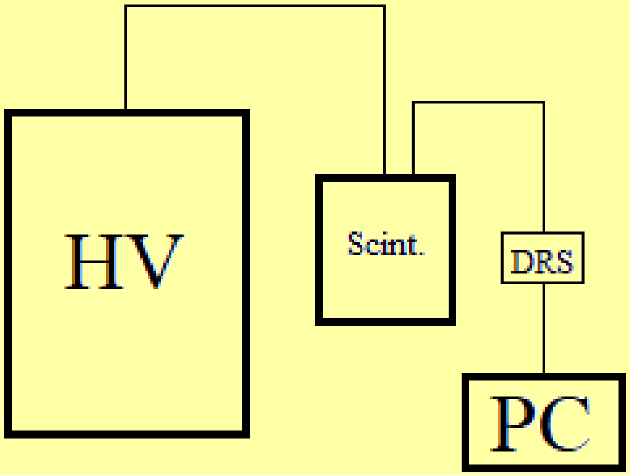


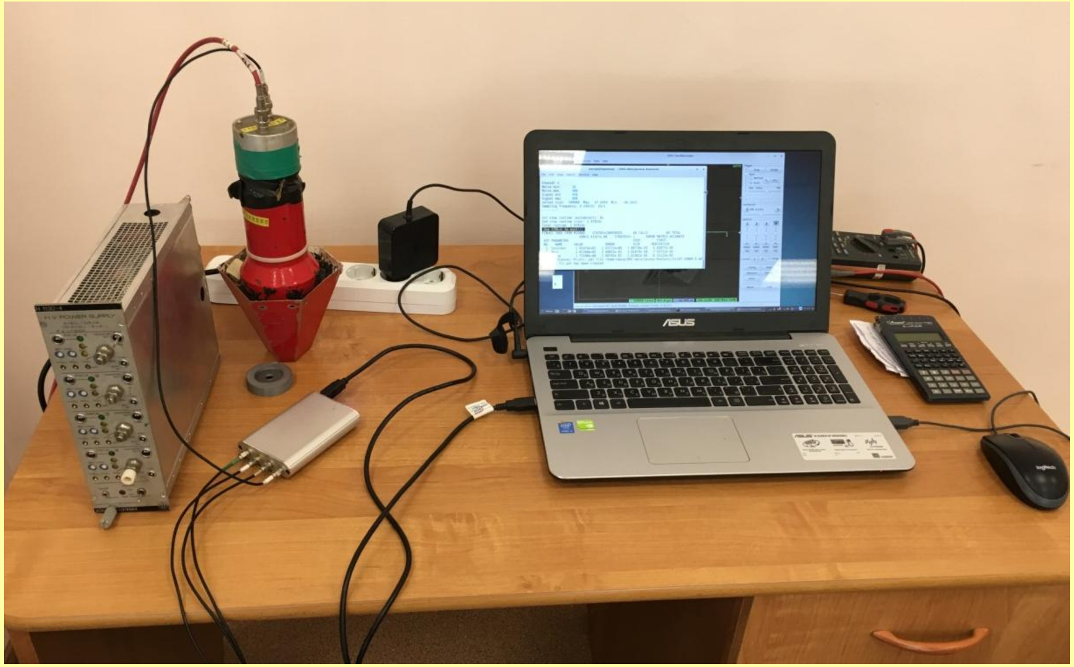
Task No. 1



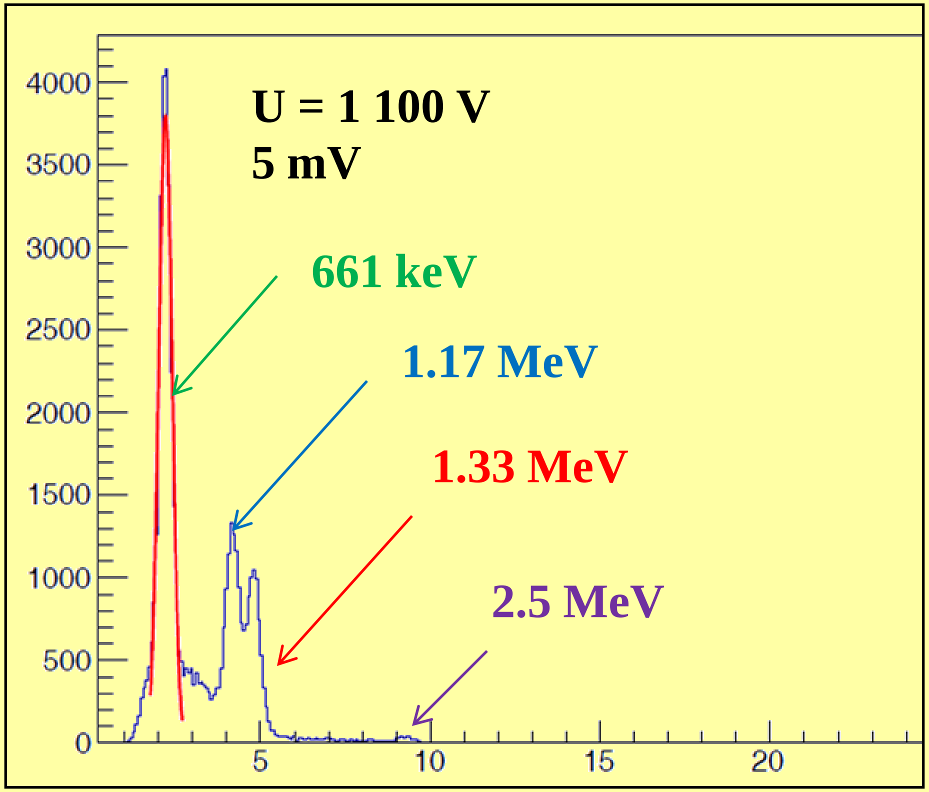
PMT signals ⟷ **Energy**

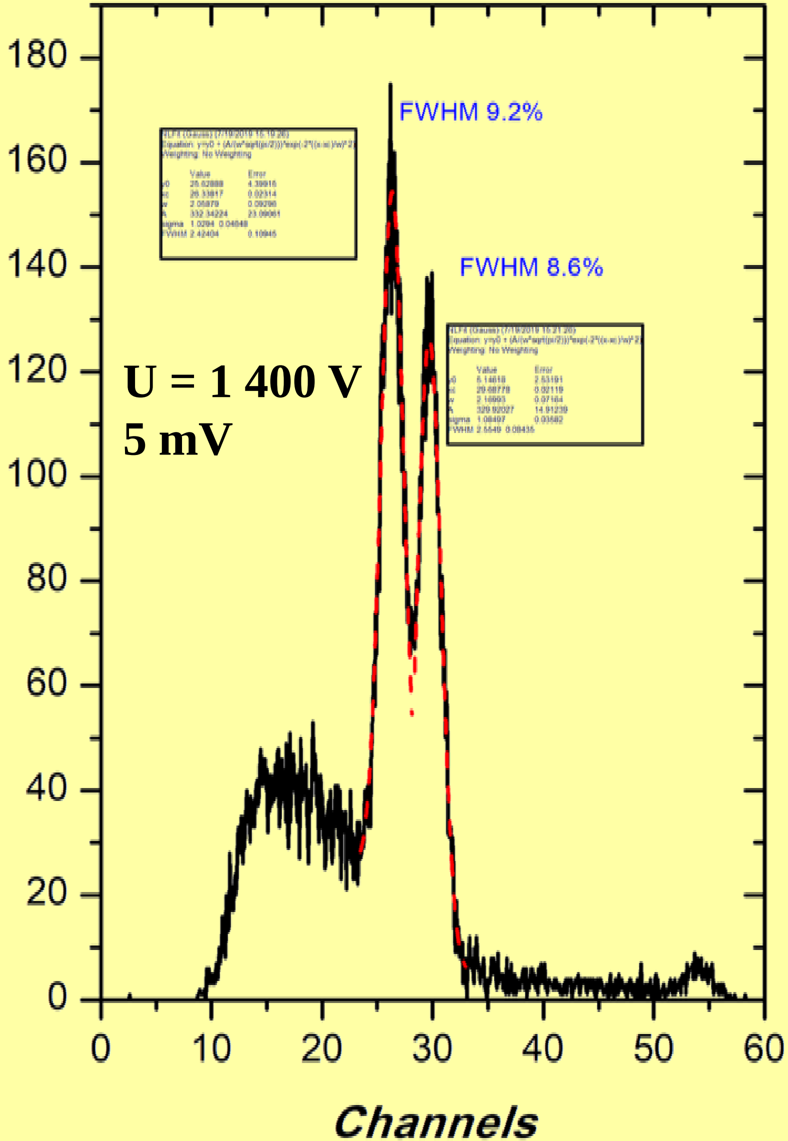
Experimental setup



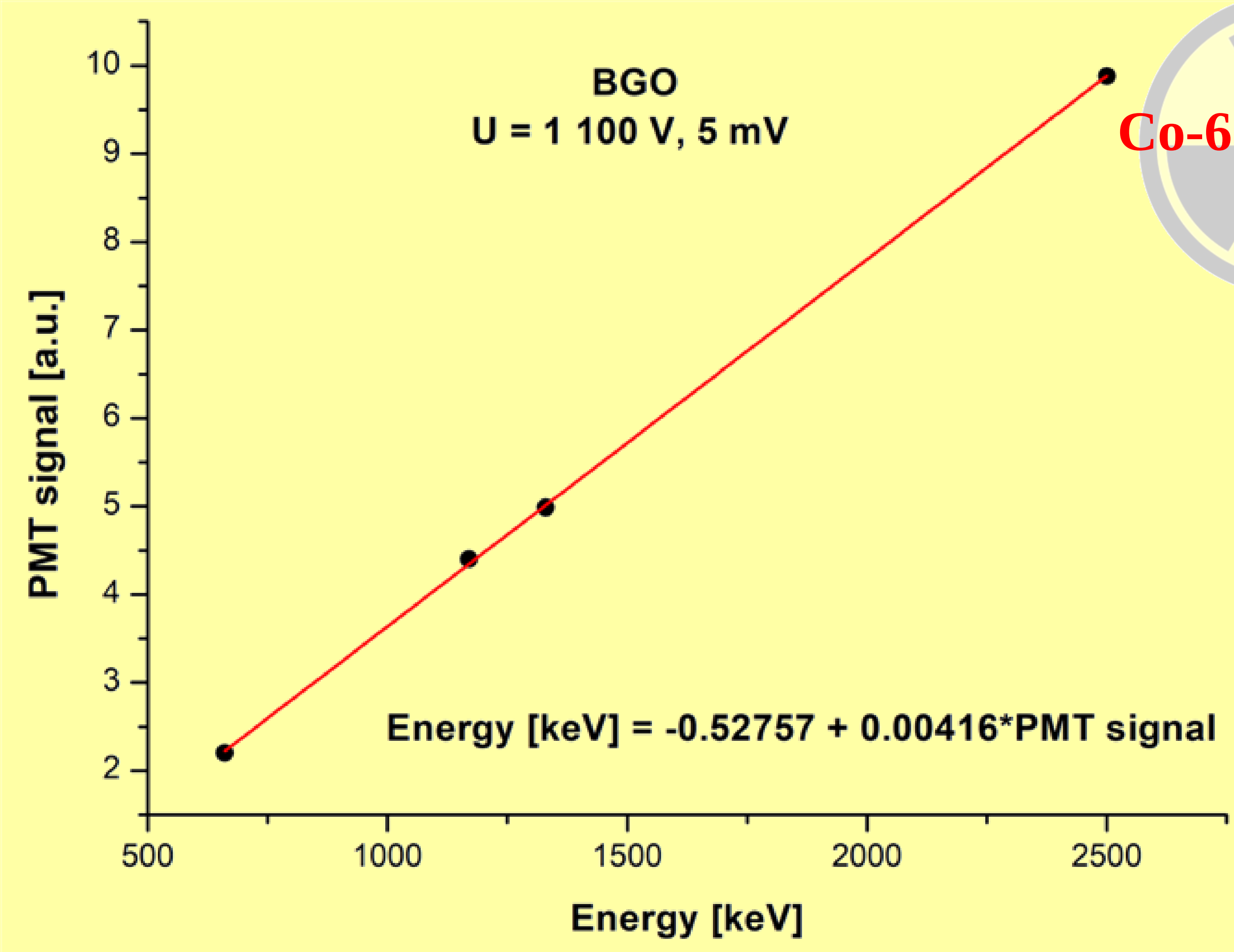


BGO (circular shape), Co-60 + Cs-137





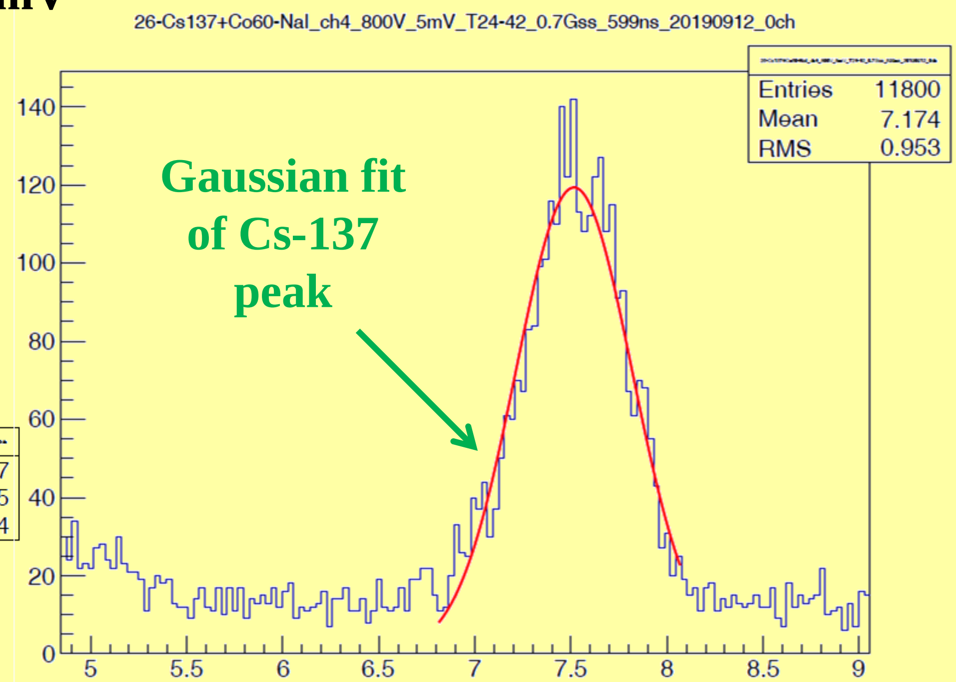
Energy calibration for BGO

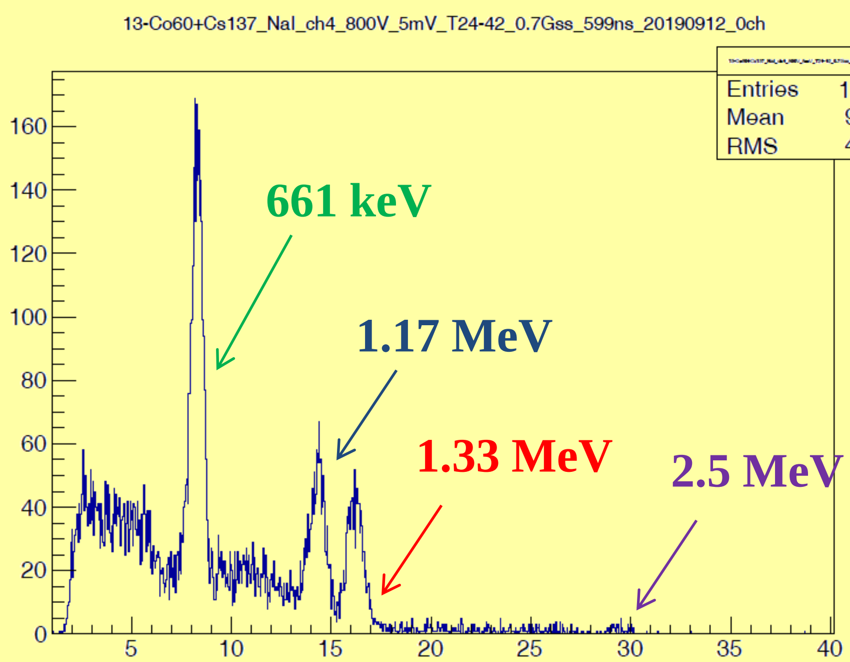


Co-60+Cs-137

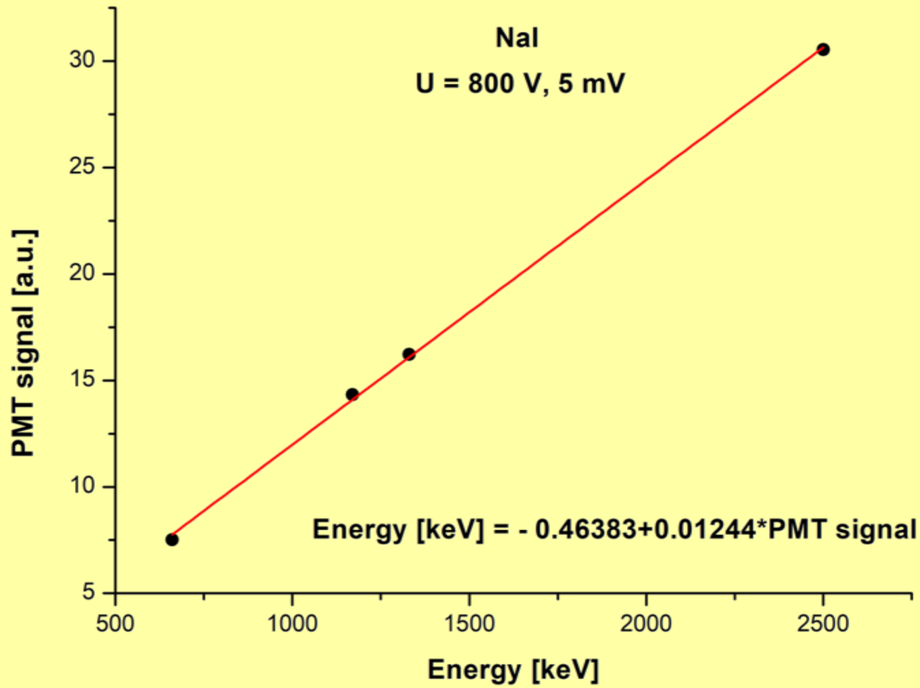
NaI, Co-60+Cs-137

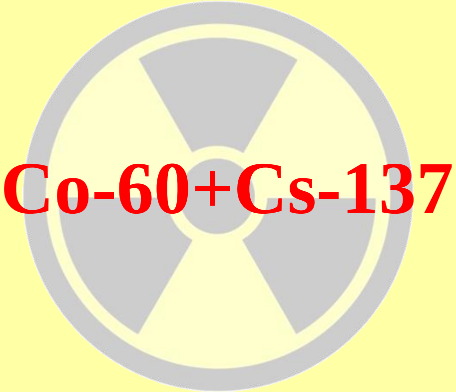
U = 800 V
5 mV

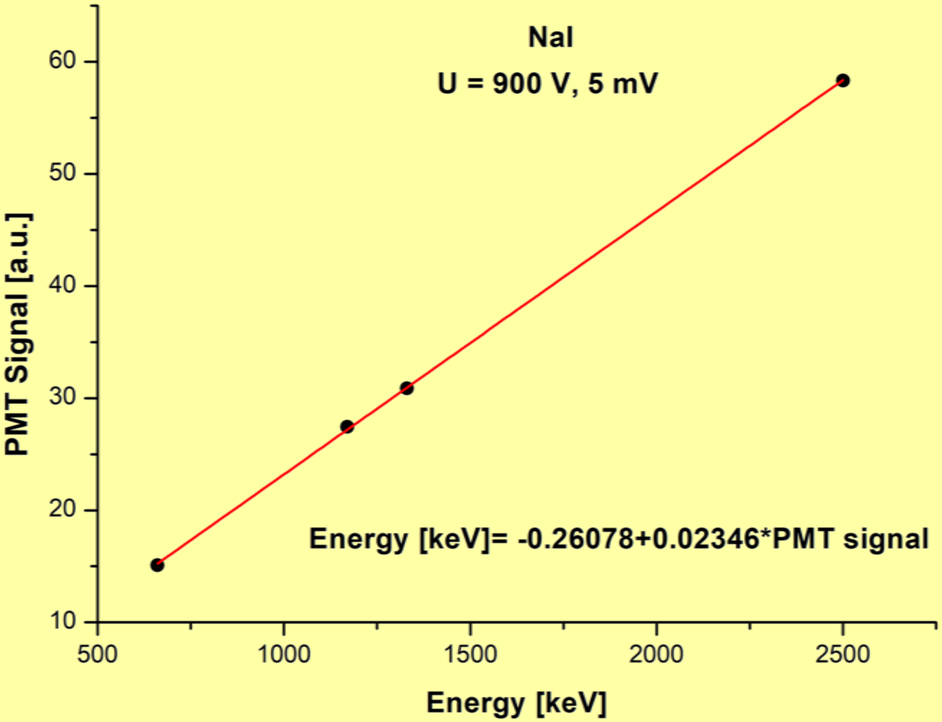




Energy calibration for NaI

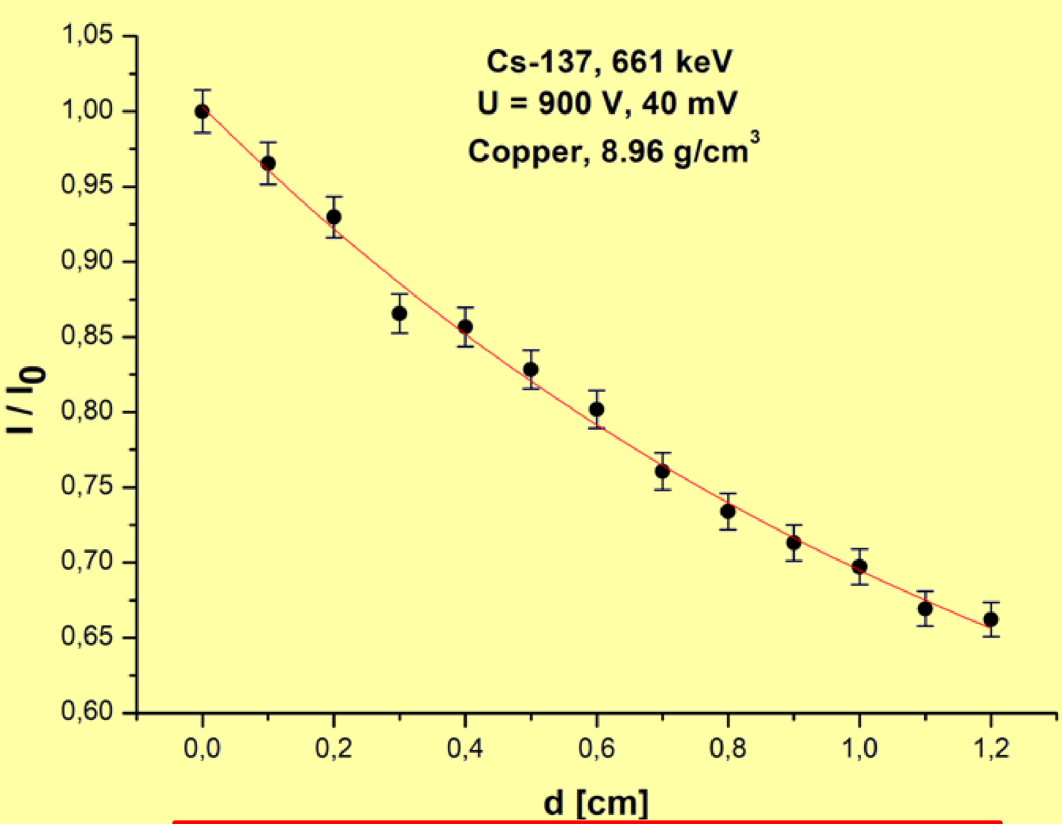






Task No. 2

To obtain the attenuation coefficient for cooper

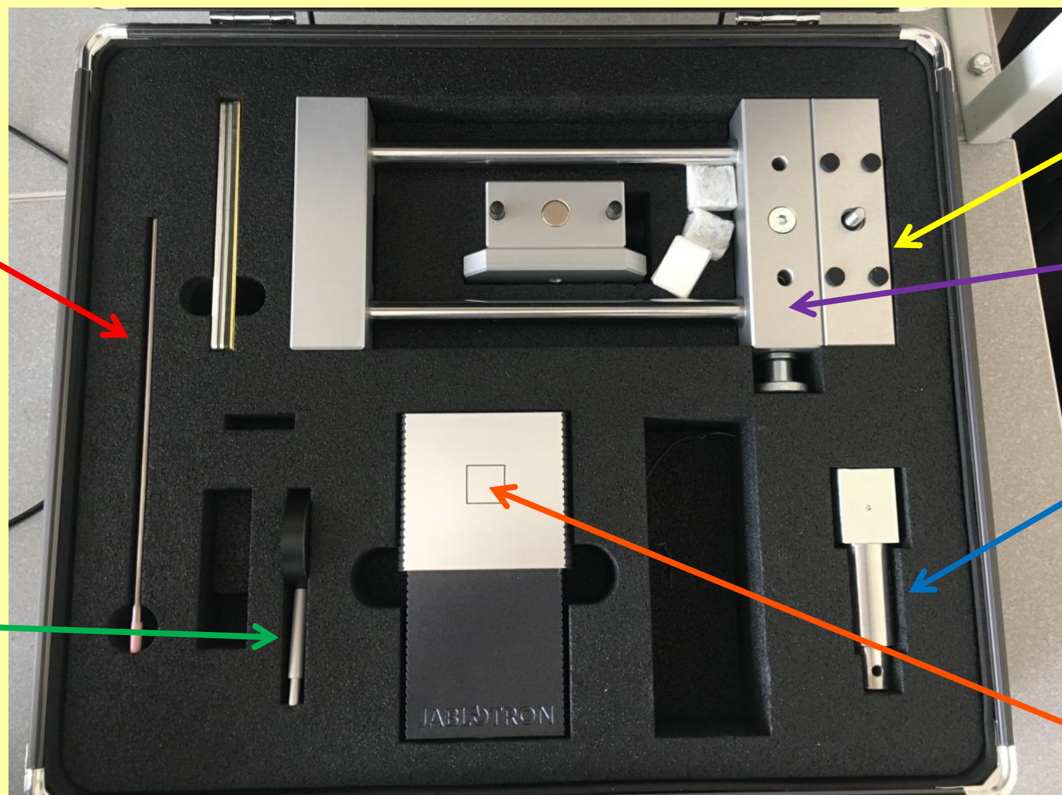


$$\mu = (0.744 \pm 0.142)\ \mathrm{cm}^{-1}$$

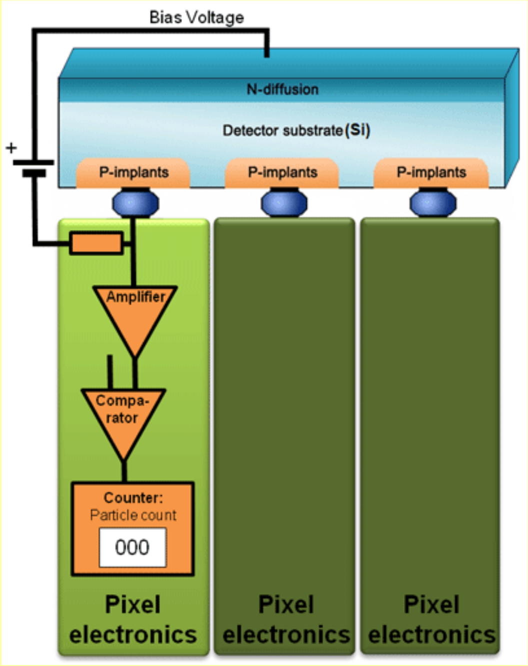
$$\mu_m = (0.083 \pm 0.016)\ \mathrm{cm}^2\ \mathrm{g}^{-1}$$

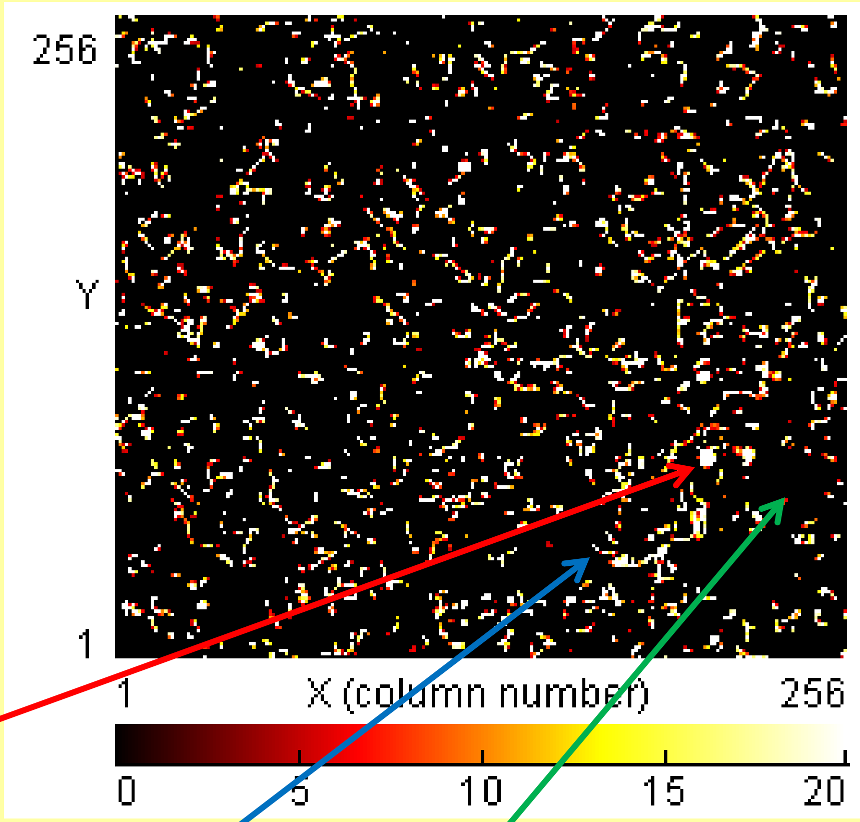
Task No. 3

To obtain the kinetic energy absorbed in the sensor and particle speed



Pixel detectors





Alpha particle

Beta particle

Gamma quanta

Relativistic **or** **Classical**

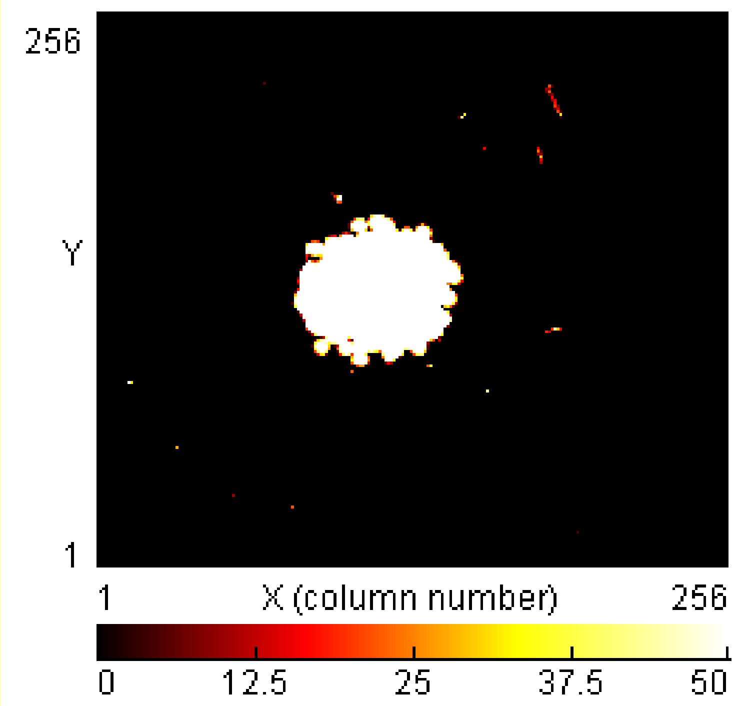
$$E_k = E_0\left(\frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} - 1\right)$$

$$E_k = \frac{mv^2}{2}$$

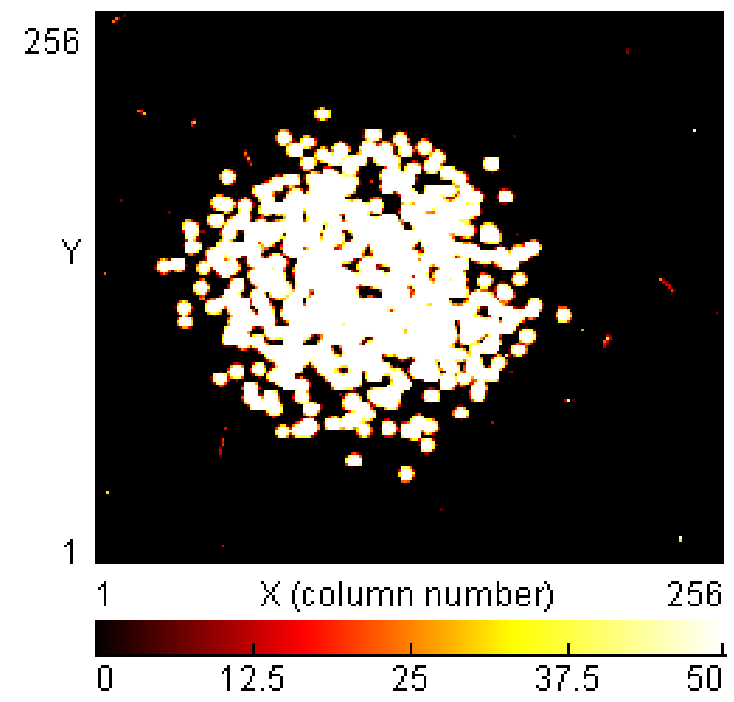
Source	**Uranium glass**	**Thorium rod**	**Am-241**
Energy	$E_{k\beta} = 100\ keV$ $E_{k0} = 511\ keV$	$E_{k\beta} = 80\ keV$ $E_{k0} = 511\ keV$	$E_{k\alpha} = 3.6\ MeV$ $E_{k0} = 3\,735\ MeV$
$\left(\frac{v}{c}\right)_{relativistic}$	0.548	0.502	0.04387
$\left(\frac{v}{c}\right)_{classical}$	0.625	0.559	0.04390
δ [%]	14	11	0.072

Task No. 4

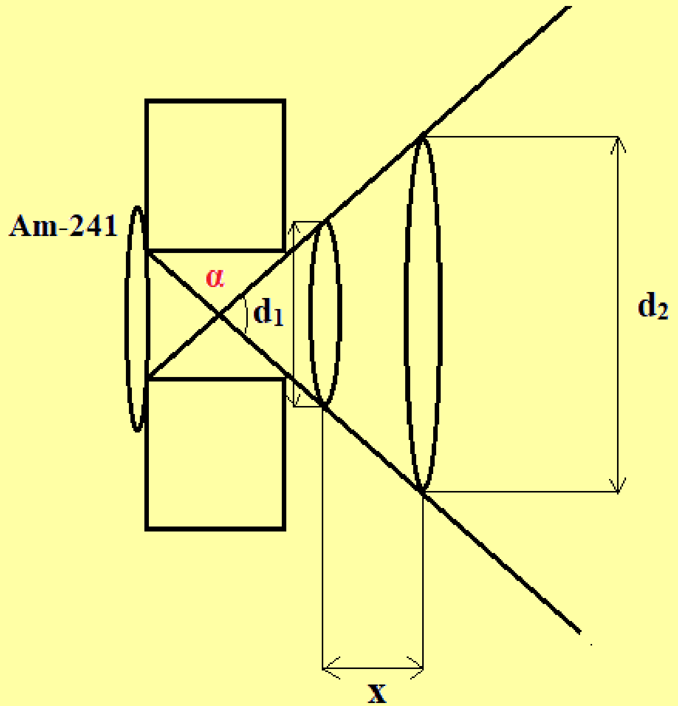
To calculate the spatial angle of collimated beam



Am-241, Collimated beam, Distance from the detector: 0 mm



Am-241, Collimated beam, Distance from the detector: 10 mm

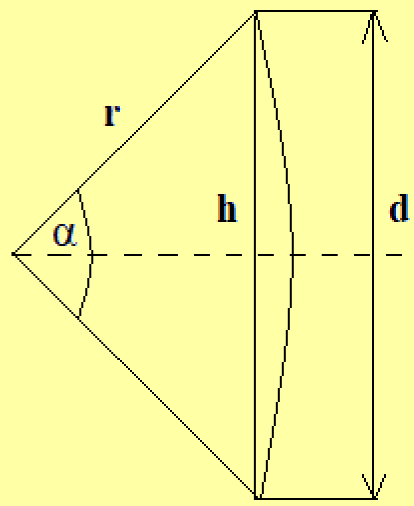


$$\alpha = 2 \cdot arctg\frac{d_2 - d_1}{2x}$$

d_1 (0 mm) = 3.52 mm

d_2 (10 mm) = 8.86 mm

α = 29.9°



$$\Omega = \frac{S}{r^2} = \frac{2\pi r h}{r^2} = \frac{2\pi h}{r}$$

$$h = r \cdot \left(1 - cos\frac{\alpha}{2}\right)$$

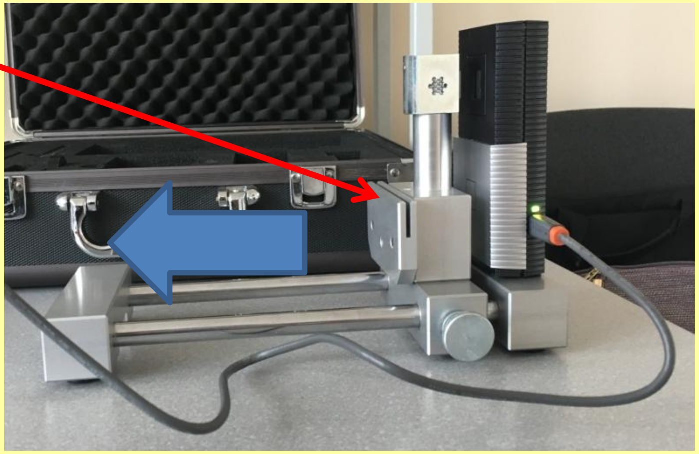
$$\Omega = \frac{2\pi r \cdot \left(1 - cos\frac{\alpha}{2}\right)}{r} = 2\pi r \cdot \left(1 - cos\frac{\alpha}{2}\right)$$

$$\Omega = 0.46\ sr$$

Task No. 5

Approximate estimation of the mean linear range of alpha particles in the air

Am-241



$$R = 2.55\ cm$$

$$R[cm] \approx 0.31 \cdot (E_k[MeV])^{\frac{3}{2}}$$

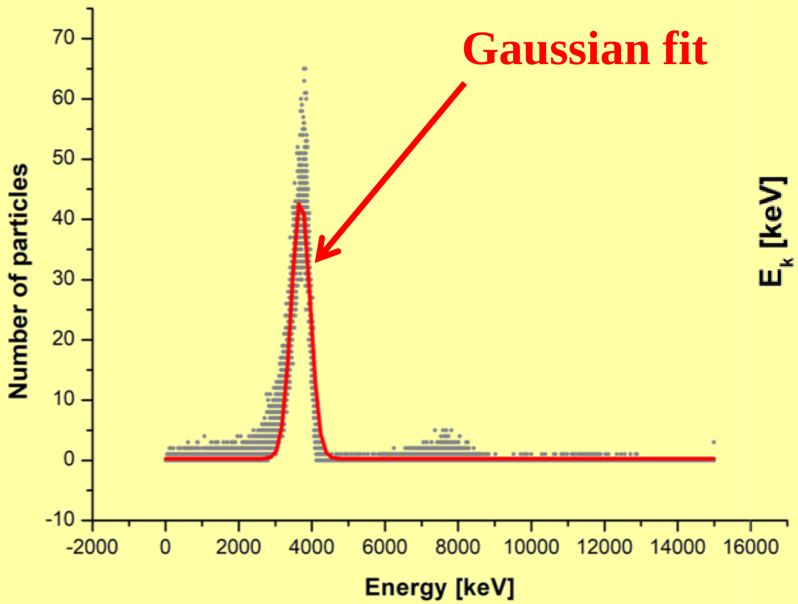
$$E_k = \left(\frac{R}{0.31}\right)^{\frac{2}{3}}$$

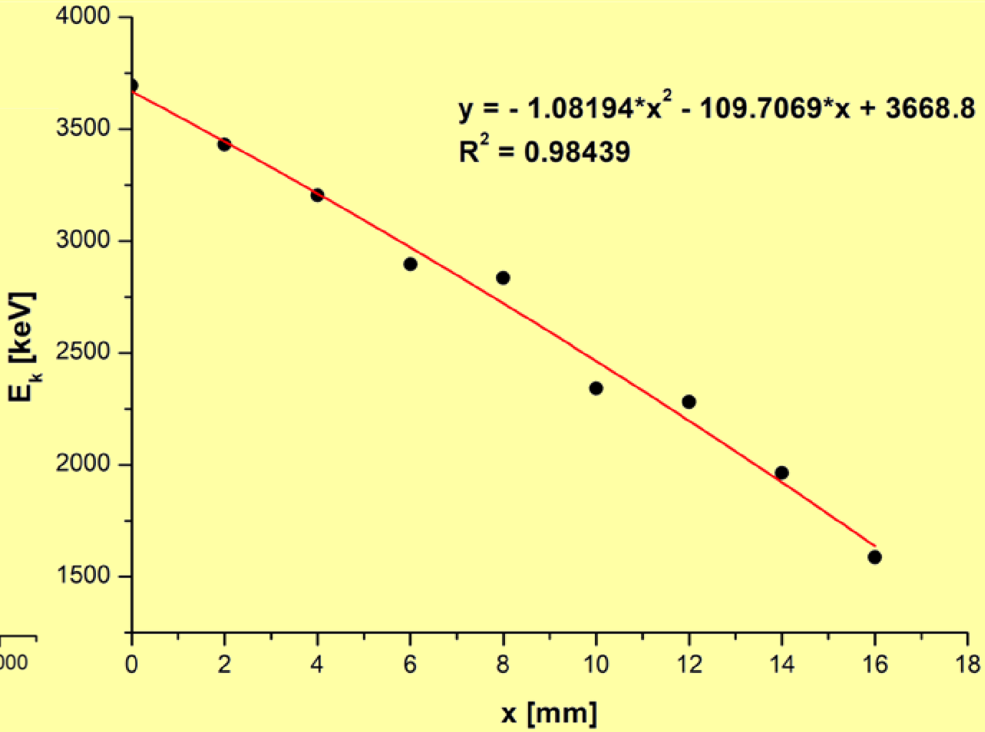
$$E_k = 4.1\ MeV$$

The result roughly confirms the formula for range of alpha particles in the air

Task No. 6

Energy loss of alpha particles in the air





Mean linear range

$$0 = -1.08194 \cdot R^2 - 109.7069 \cdot R + 3668.8$$

$$\boxed{R \approx 25\ mm}$$

Back to the formula for approximate range . . .

$$R[cm] \approx 0.31 \cdot (E_k[MeV])^{\frac{3}{2}}$$

$$E_k \approx 3.6\ MeV$$

$$\boxed{R \approx 21\ mm}$$

And more . . .

$$\text{Number of ion pairs} = \frac{\frac{dE}{dx}}{E_1} = \frac{113.08\,\frac{keV}{mm}}{34\ eV} = 33\,250\ \text{iona/cm}$$

The aims of the project...

✓ to acquire a sound basis in radiation protection and the safety of radiation sources at the basic level

✓ to provide the necessary practical skills and basic tools for work in the field of radiation protection and the safe use of radiation sources

✓ to study different types of radiation as well as radiation doses

✓ to study response of different types of detectors – scintillation detectors and pixel detectors

✓ to perform calibration of detectors

✓ to study attenuation of gamma radiation

✓ to derive the ranges of alpha particles

THANK YOU FOR YOUR ATTENTION!

"Science brings nations together"