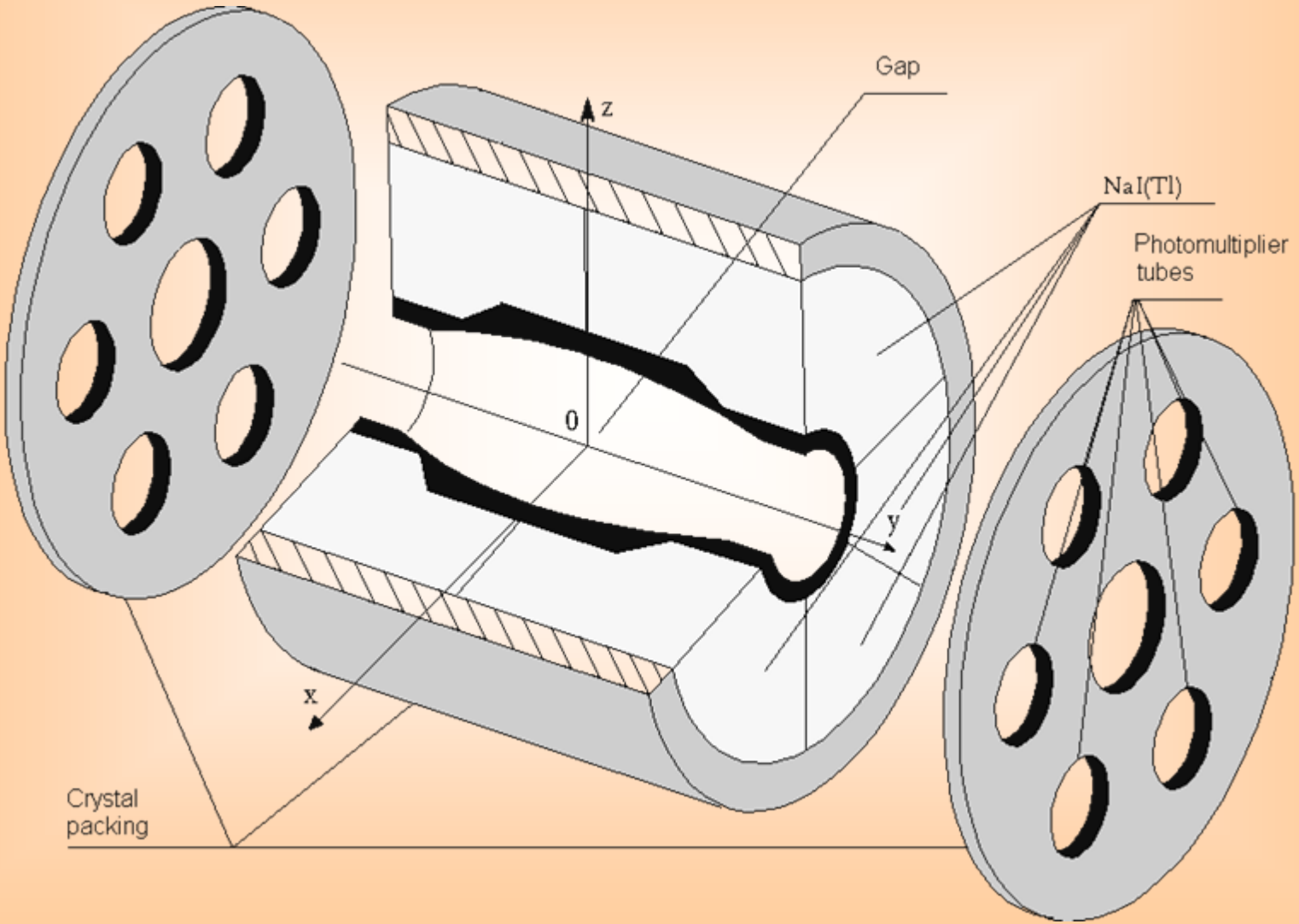
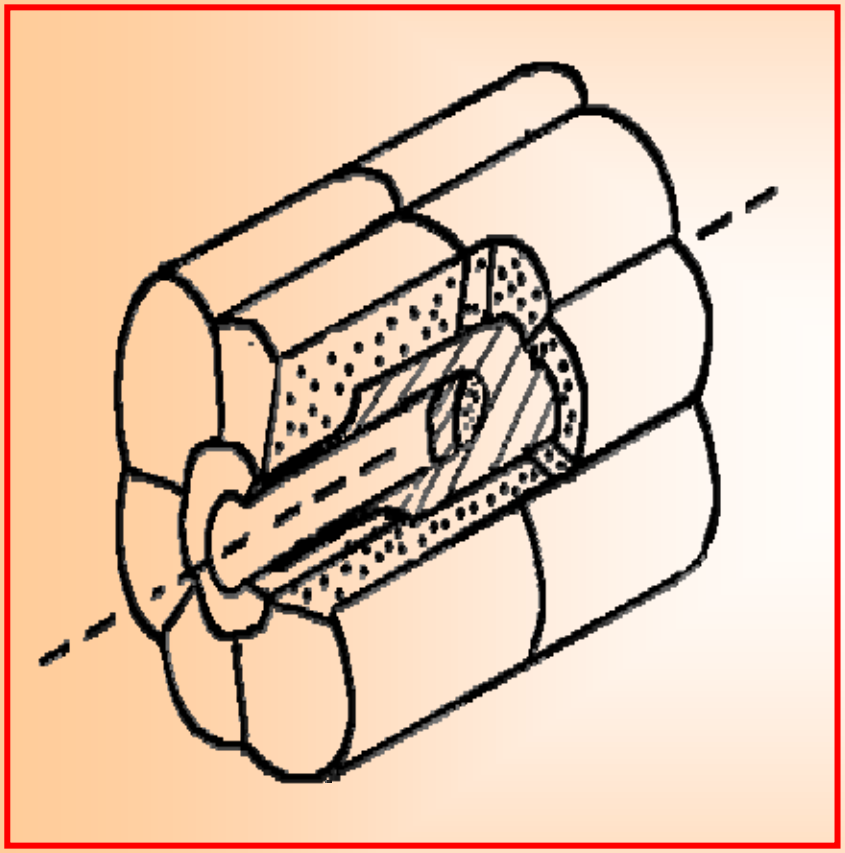
4π-multidetector system Romashka (Daisy)



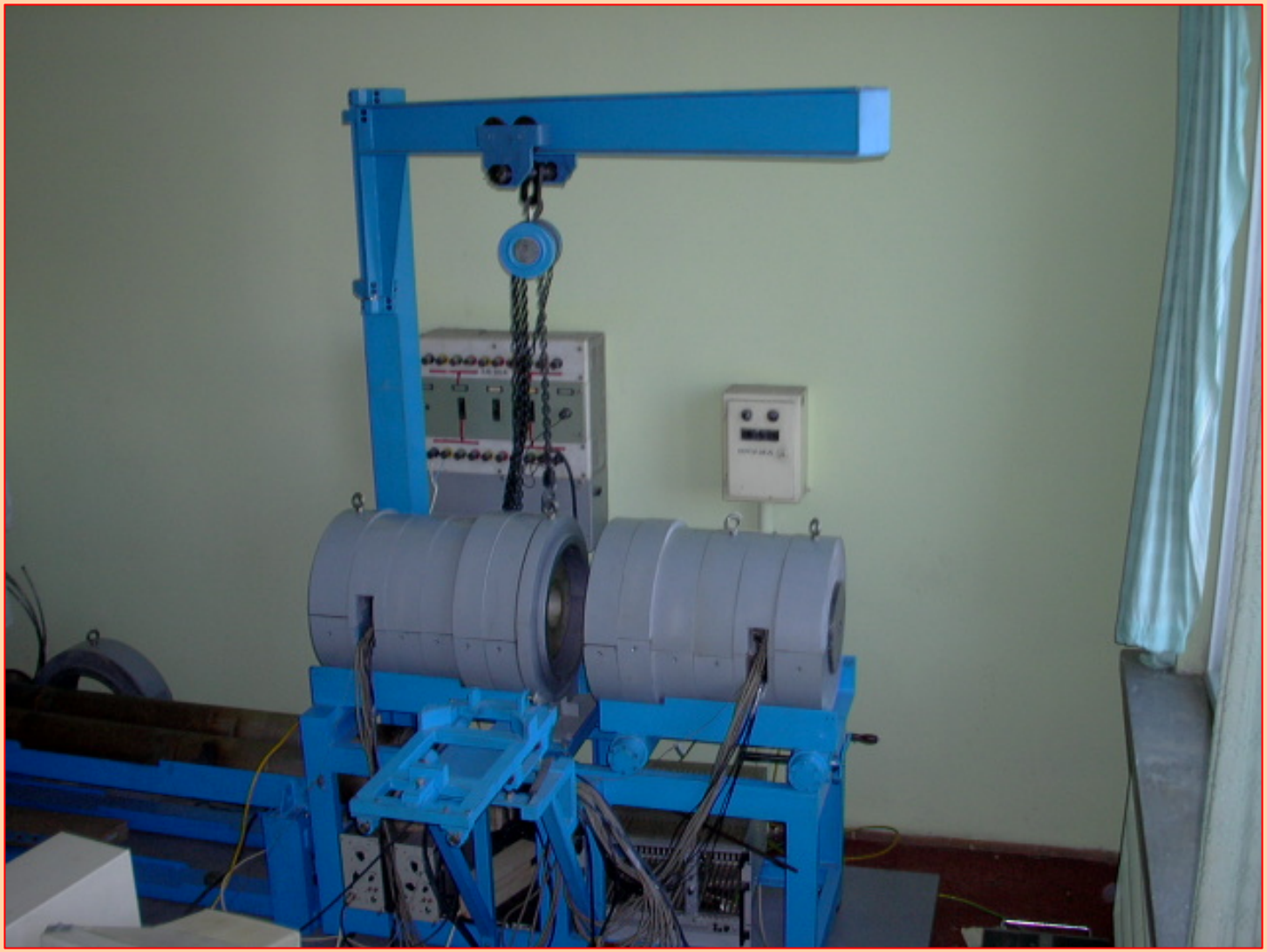
Scintillators of the multidetector system



4π - multidetector system ROMASHKA (Daisy) for gamma low activity measurements is assembled from 12 scintillators NaI(Tl) which are divided on two halves of 6 crystals with a special shape (like a flower Daisy). The crystals measure in total are 16.6 l NaI(Tl) and they are placed in a cylinder with the outside diameter 30 cm

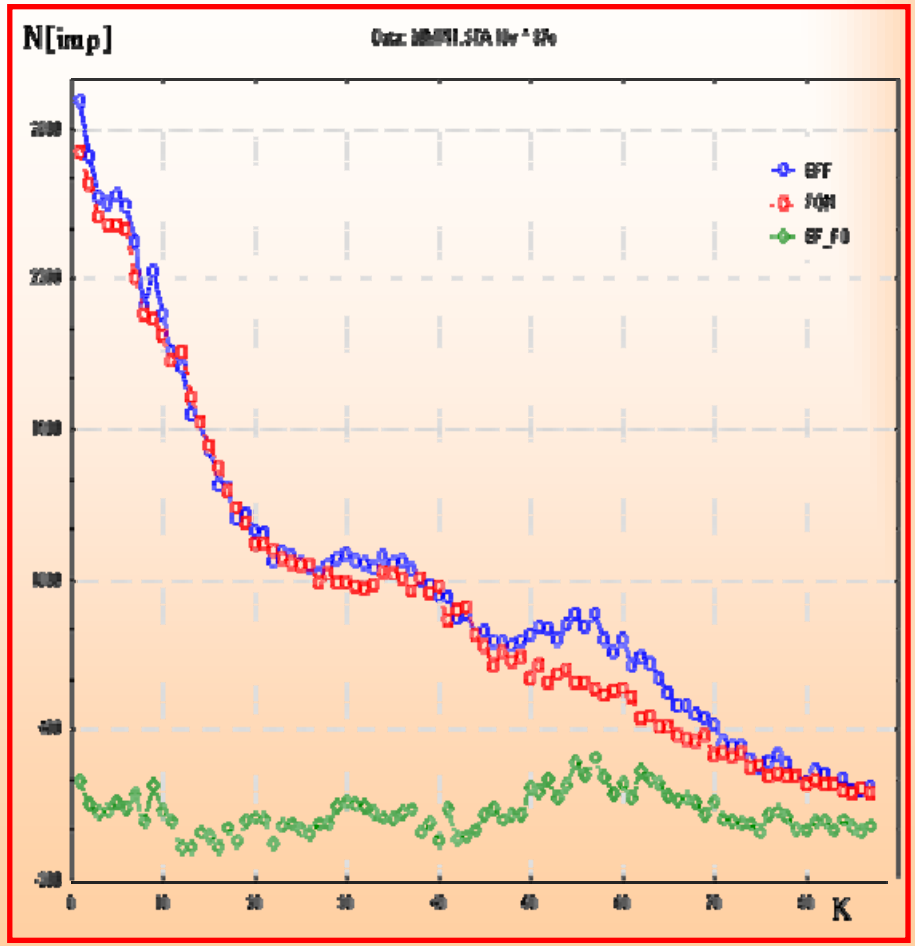
The scintillations of each crystal are seen through a light guide by a photomultiplier tube. The pulses are sent to a summator of amplitude and than to an amplifier, amplified signals are supplied to a multichannel analyzer or they are proceeded by a computer.

4π-multidetector system Romashka (Daisy)



Properties and applications

4π-multidetector system "Romashka" is a detector of full absorption of gamma quanta. The system's efficiency is 97% and is checked experimentally by measuring a calibrated radioactive source ^{40}K with gamma energy E = 1.46 MeV and known activity of 10 Bq. The lower curve represents the difference between the number of pulses that are obtained from the sample in each channel and the number of background pulses.

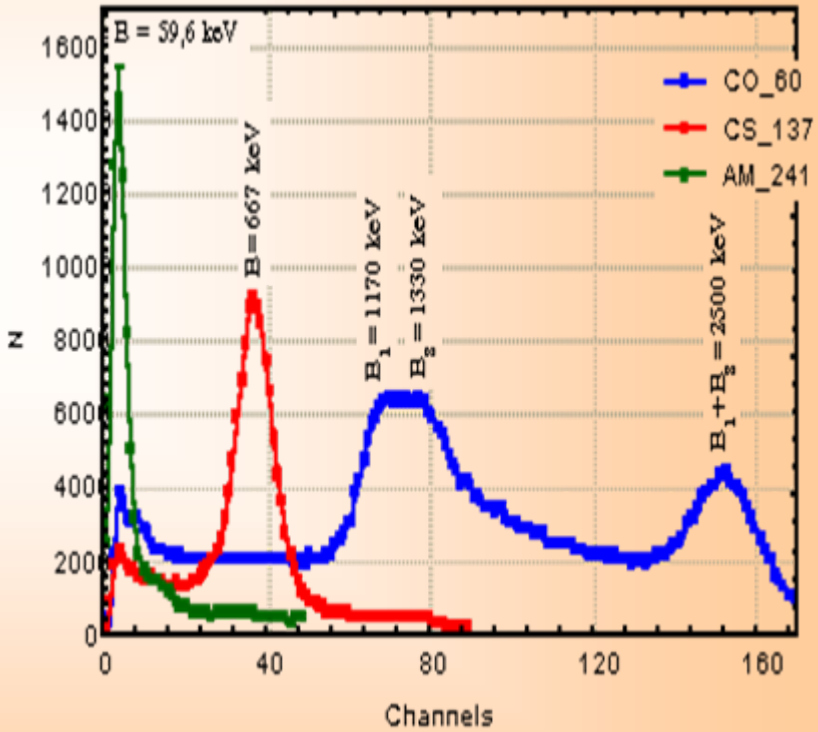


Measurements of radioactive sources of ^{60}Co (E=1330 keV, E=1170 keV), ^{137}Cs (E=667 keV) and ^{147}Am(E=59.6 keV).

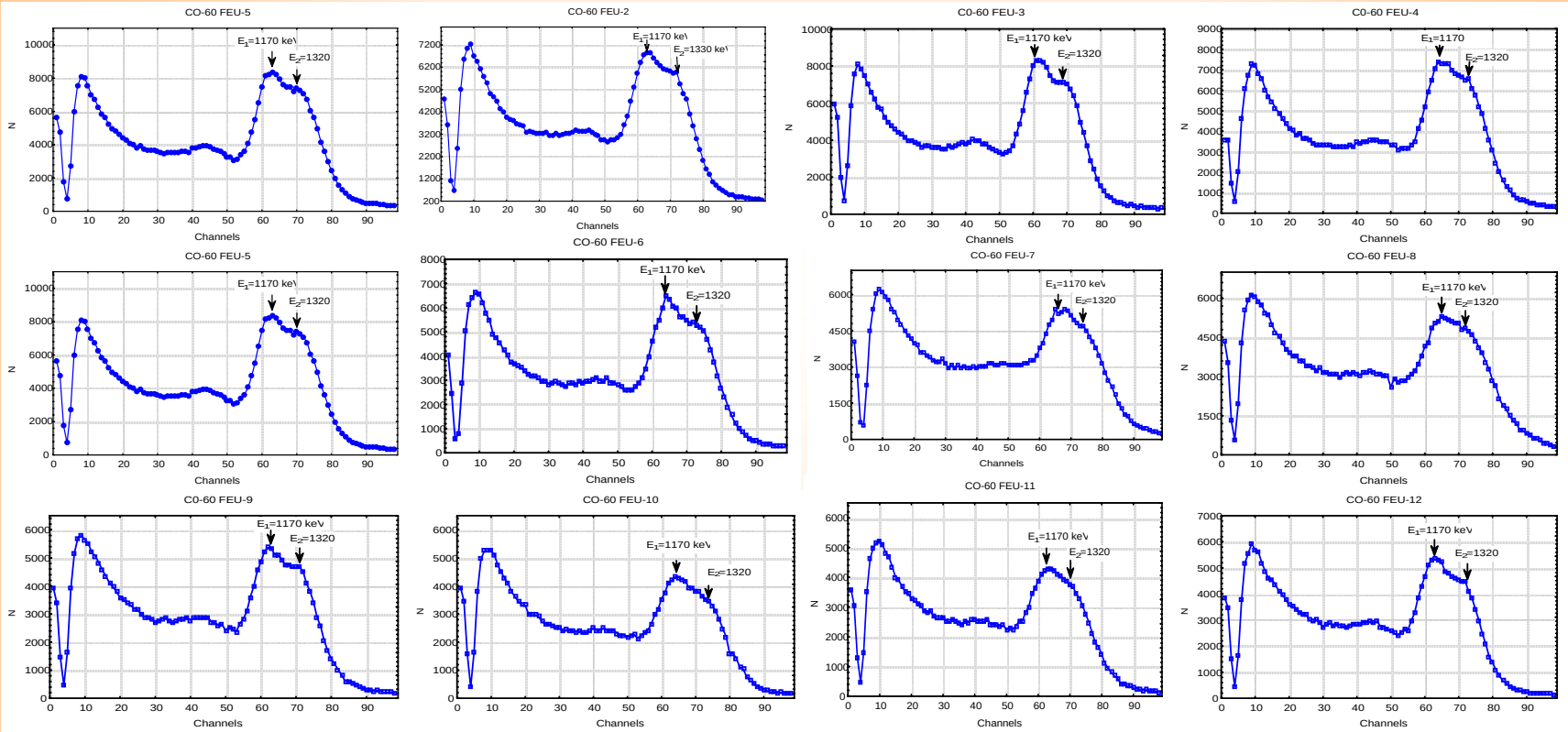
ENERGY CALIBRATION

The relation between the amplitude and energy in the range 0 - 3 MeV is linear.

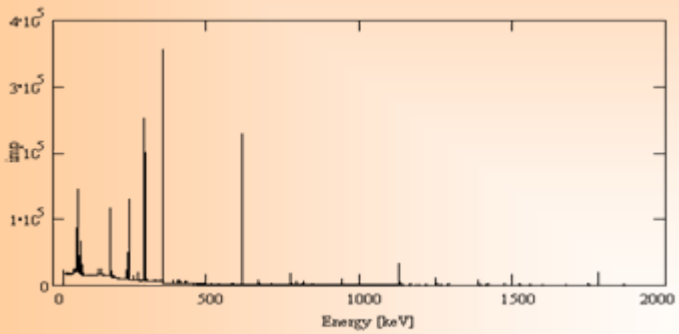
The energy resolution of the whole system is about 15%, for a single crystals this is better, about 10%. The photopeaks of ^{60}Co can be positioned on the same analyzer channel for each of the detector's crystals (as the position of the peak can be adjusted).



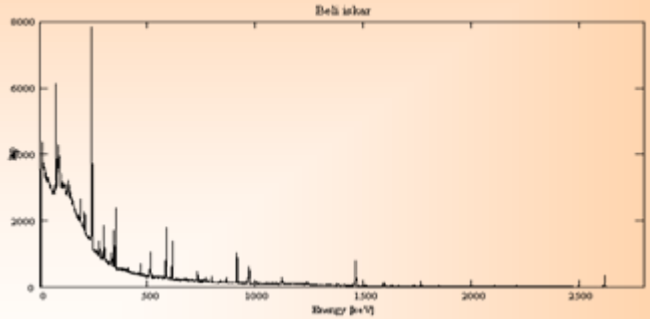
Measurement with ^{60}Co source for each crystal of the system



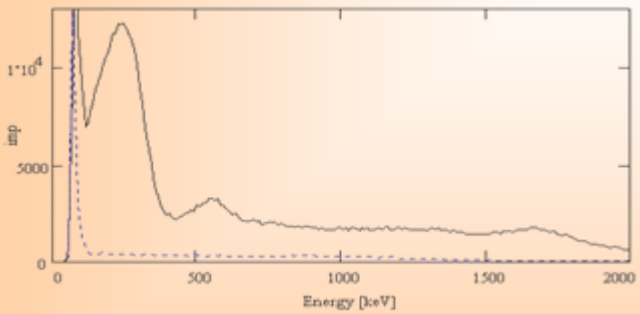
Sample of U-ore, HPGe detector, counting time T = 72000 s



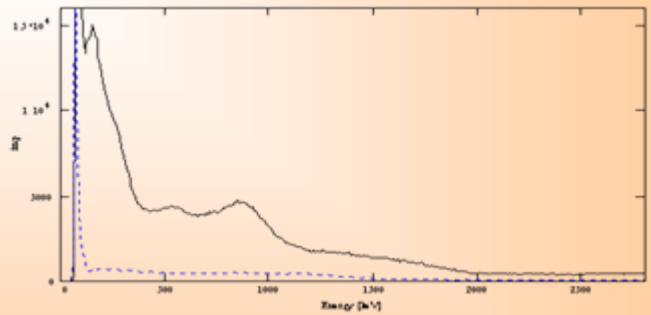
Sample of Fe-ore , HPGe detector, counting time T=144000 s



The same sample, 4π-multidetector system Romashka, counting time T=800 s



The same sample, 4π-multidetector system, counting time T=1200 s



The 4π-multidetector system Romashka in express analysis of polluted soil samples

Minimum detectable activity of the system

A counting system may be characterized by a minimum detectable activity (MDA) for a specified choice of parameters such as counting times

The **MDA** (minimum detectable activity) is an amount of activity that yields a result above the decision level (95% confidence).

$$MDA \cong \varepsilon (K_A + K_B) \sqrt{R_b * (\frac{1}{t_b} + \frac{1}{t_g})}$$

The choice of optimal sample $\mathbf{t_g}$ and background $\mathbf{t_b}$ measuring time is determined from:

$$\left.\frac{t_b}{t_g}\right|_{optimal} = \sqrt{\frac{R_b}{R_g}}$$

$\mathbf{R_g}$, $\mathbf{R_b}$ counting rates from sample and background; **DL**– if we have measured a net count greater then it there is an activity in the sample.

$$DL = \varepsilon K_A \sqrt{R_b * (\frac{1}{t_b} + \frac{1}{t_g})}$$

The values of MDA and DL of the 4π–multidetector system, with a degree of confidence – 95% , are:

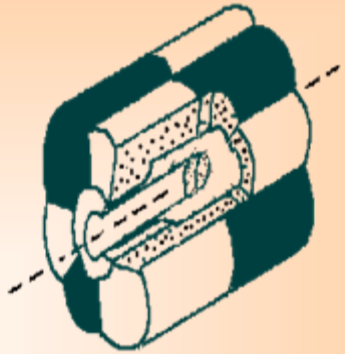
DL = 0.265Bq **MDL = 0.53Bq**

t_b = 1200 s; t_g = 1200 s; R_b = 17 cps (counts per second); ε = 96% experimentaly checked; (K_A=1.64; K_B = 1.64 correspond to confidence ~ 95%).

The threshold detection limit is 0.256Bq , activity above is detected with a confidential level of 95%.

Improving the resolution and background suppression

The large volume is resulted in high background level. For suppressing in some degree the background we applied the anticoincidence mode.
The cosmic radiation will likely penetrate simultaneously all sections of the detector system and therefore can be eliminated with anticoincidence arrangements. As a bonus Compton scattering should be suppressed.



sections used for spectrometric pulses

sections used for logical pulses

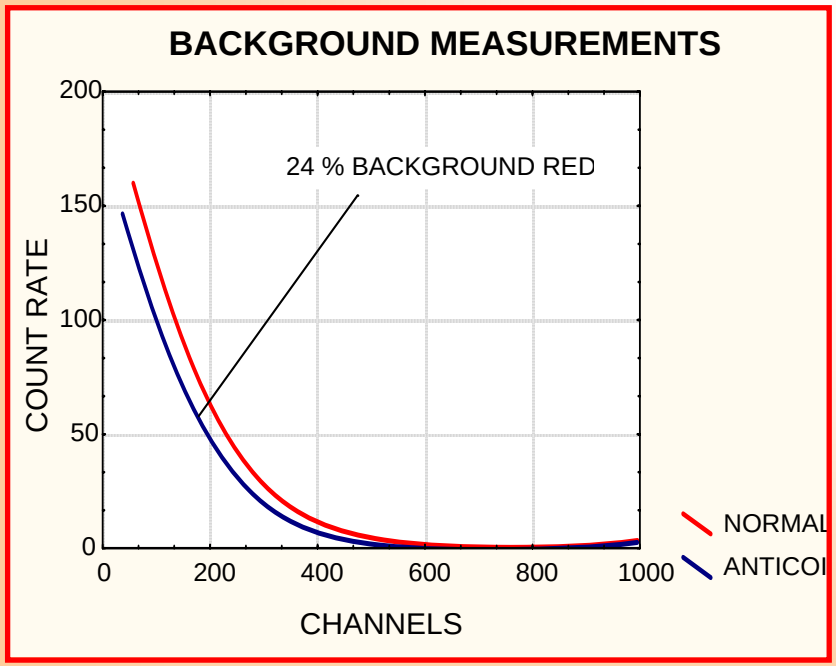
As the scattered gamma quanta interact mostly with neighbor sections the anticoincidence mode with those leads to the Compton suppressing and improving the resolution. In this way we reject the registration of scattered gamma quantum from a neighbor section.

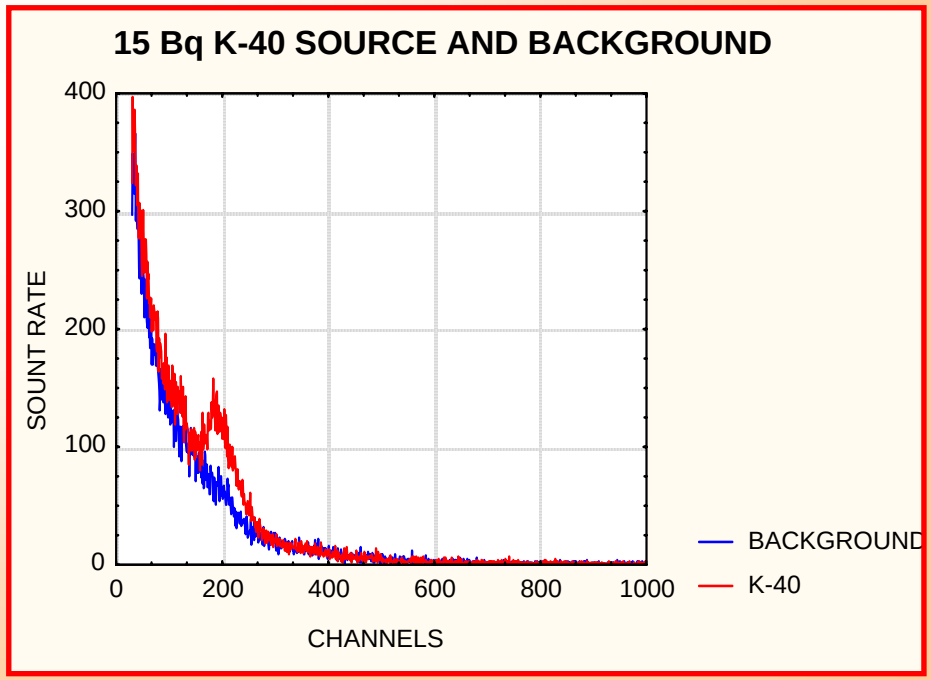
The electronics for these measurements is quite simple and consists of two amplifiers, timing single channel analyzer and delay line amplifier.

Measurements in anticoincidence mode

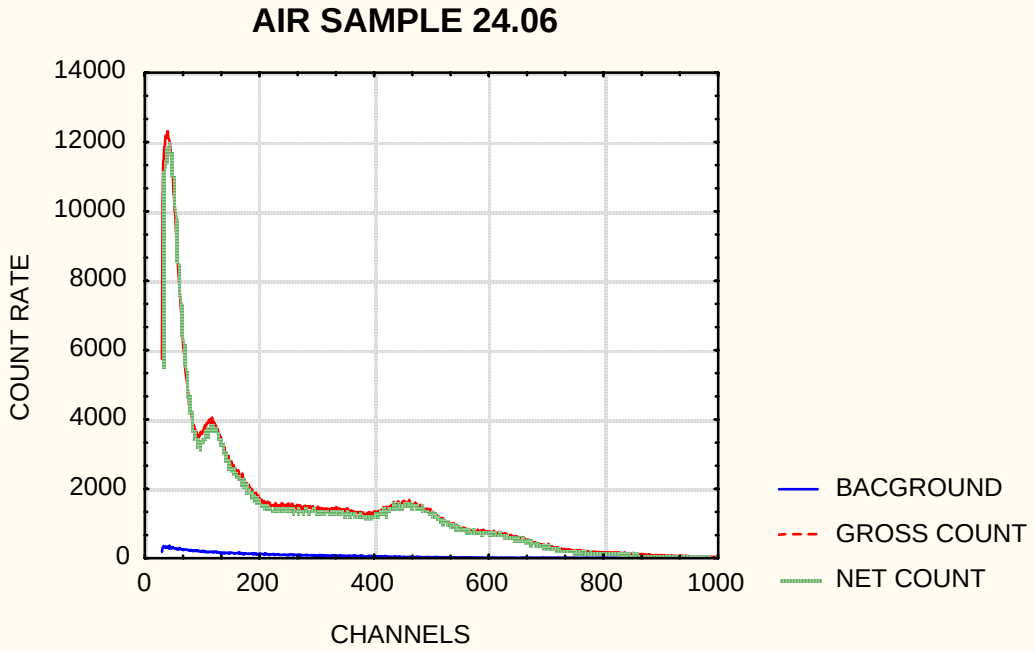
The background reduction in anticoincidence mode of measurements is 24 %.

The measurements of calibrated source ^{40}K with activity of 15 Bq and background. As can be seen the photo peak of ^{40}K is clearer than in previous measurements with the whole system.



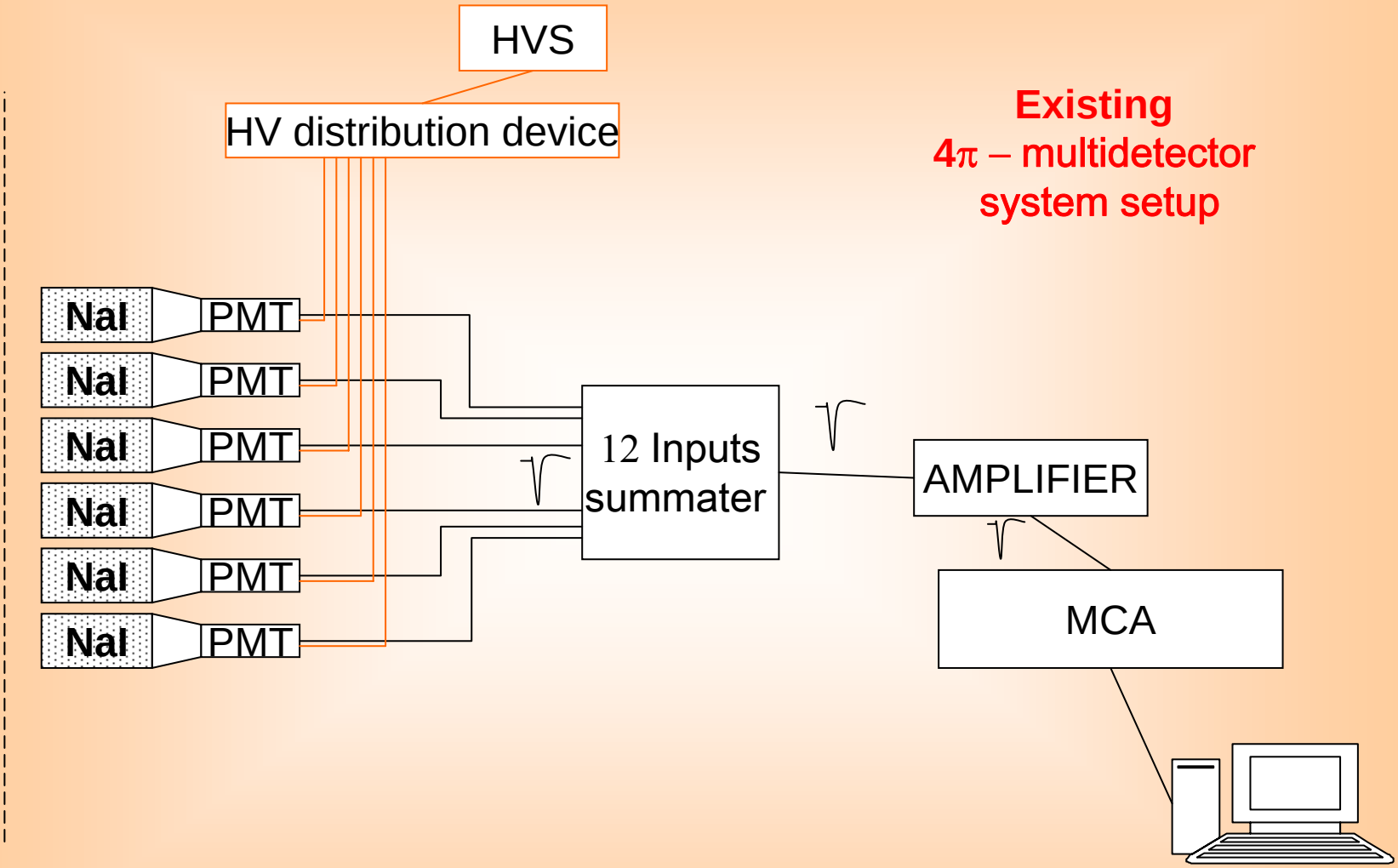


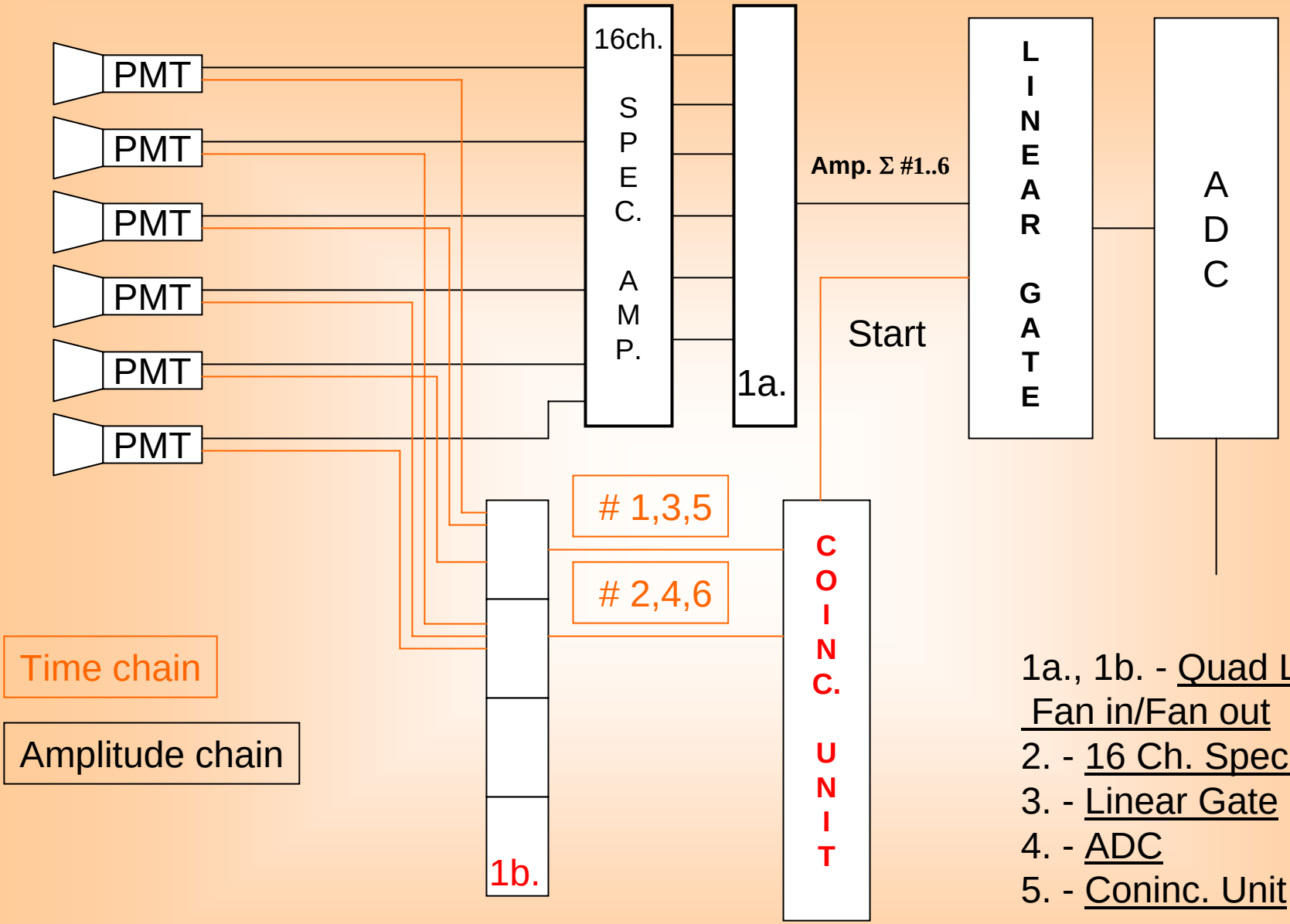
The efficiency of gamma quanta registration in this mode decreases to 40 % but it is quite enough as in this way we have the optimal ratio of efficiency and resolution. So we can recognize some peaks and group of peaks.



The spectrum from air sample obtained in anticoincidence mode of measurement. It is evident that the peaks of ^{214}Pb, ^{214}Bi (0.61 MeV, 1.12MeV,1.76 MeV), ^{40}K (1.46 MeV) ant ^{208}Tl (0.58MeV,2.61MeV) are recognized.

The high efficiency of registration (40 % in anticoincidence mode and 95 % usually) allows application of the 4π-multidetector system in low activity measurements as well the improved resolution and low noise level make system suitable for samples from the environment. In anticoincidence mode of measurements we accurately estimate not only the radioactivity of the sample but also some of the radio nuclides in it.


HVS
HV distribution device
Existing
4π – multidetector
system setup
NaI
PMT
NaI
PMT
NaI
PMT
NaI
PMT
NaI
PMT
NaI
PMT
12 Inputs
summater
AMPLIFIER
MCA



1a., 1b. - Quad Linear Fan in/Fan out
2. - 16 Ch. Spec. Amp.
3. - Linear Gate
4. - ADC
5. - Coninc. Unit

How much does it cost?

The total price of the upgrading of the electronics is
About
20K €

It will lead to more precise measurements of low active samples from the environment as well as the possibility

of further improving of the measurements and developing a new reliable approach for High resolution measurements of low active samples from the environment.

4π-multidetector system Romashka (Daisy) as an Active Shielding of HPGe detector

For high resolution, low-gamma active measurements is possible to be applied Anti Compton and Anti Background approach, as

4π-multidetector system Romashka is set

as an active shielding of Ge detector

Ge Detector place

DEWAR HOLDER

THANK YOU VERY MUCH FOR THE ATTENTION AND SUPPORT