

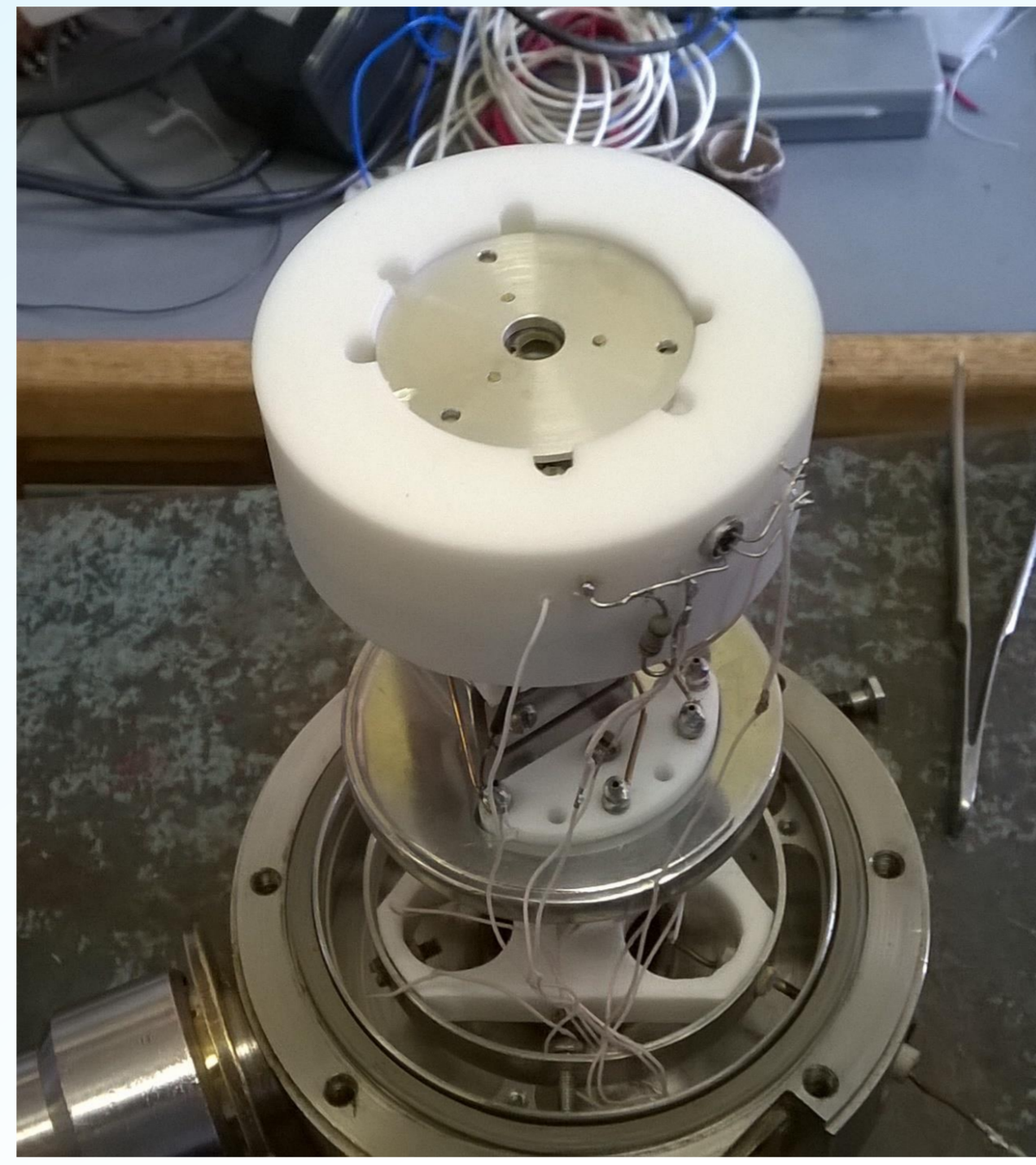
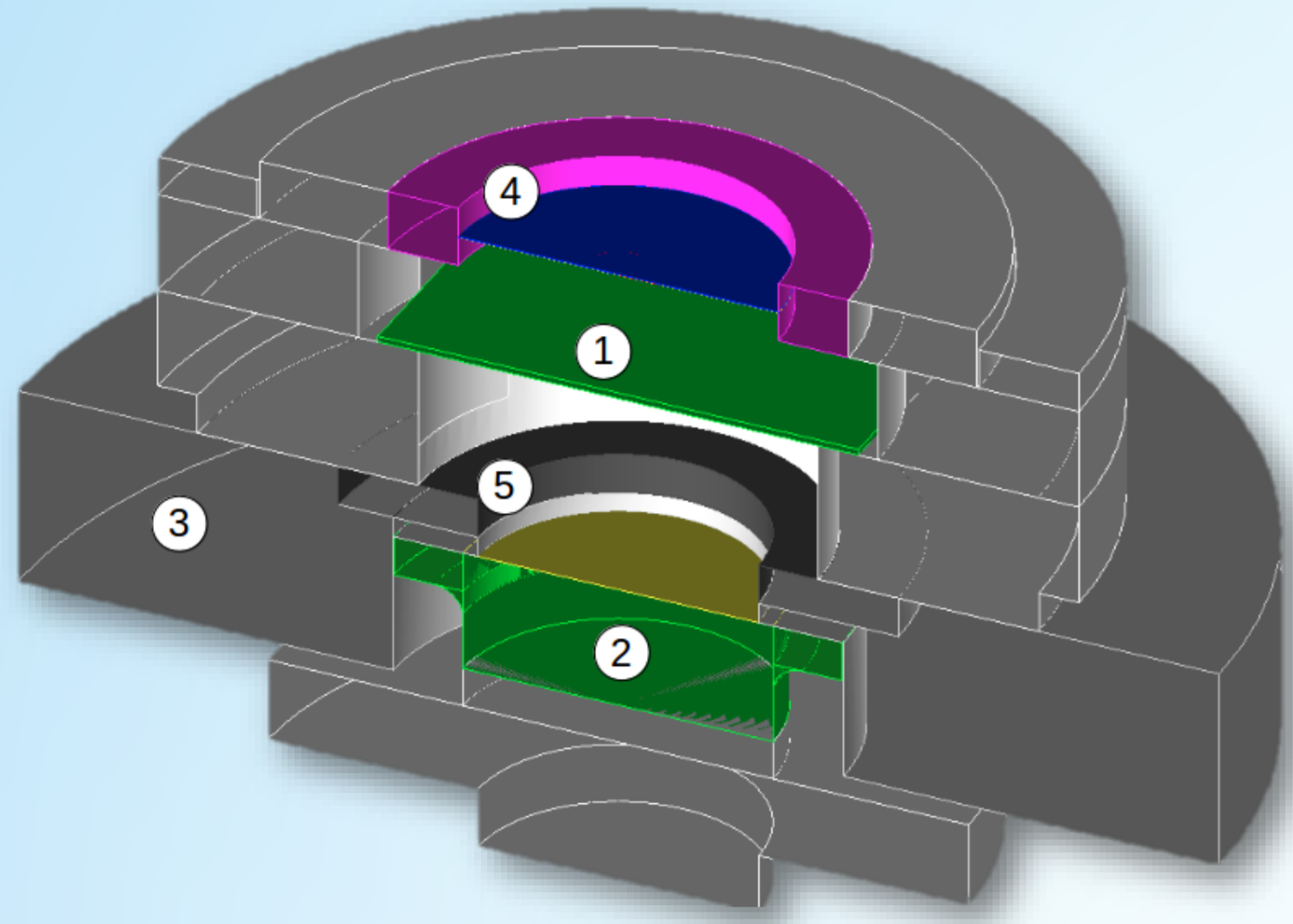


# Measurement of $^{144}\text{Pr}$ beta-spectrum with Si-detectors for the purpose of determining the spectrum of electron antineutrinos



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## Beta-spectrometer with Si-detectors



- 1 - transmission Si detector (thickness 0.3 mm)
- 2 - full absorption Si(Li) detector (thickness 6.5 mm);
- 3 - Al-Mg alloy assembly ring;
- 4 - source (Cerium acetate on mylar substrate);
- 5 - tungsten collimator ring.

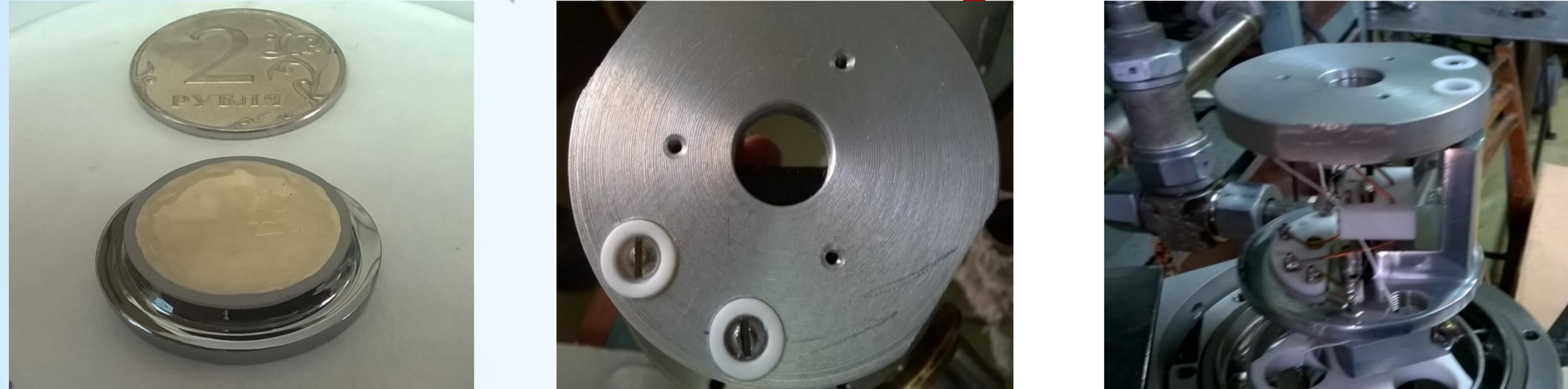
The shape of  $^{144}\text{Pr}$  beta-spectrum has a significant effect on the precision of determining of oscillation parameters for sterile neutrino.  
Bx\_SOX, JHEP08(2013)038

## Basic neutrino and antineutrino sources

| Source                            | decay     | $E_\nu$ or $E_{\max}$ (keV) | $\tau$ , days. | Wt/ kCi | kg/ MCi | production                               |
|-----------------------------------|-----------|-----------------------------|----------------|---------|---------|--|
| $^{51}\text{Cr}$                  | EC        | 746 (81%)                   | 40             | 0.19    | 0.01    | $^{50}\text{Cr}(n,\gamma)^{51}\text{Cr}$ |
| $^{37}\text{Ar}$                  | EC        | 813 (100%)                  | 50             | ~0.01   |         | $^{40}\text{Ca}(n,\alpha)^{37}\text{Ar}$ |
| $^{90}\text{Sr}-^{90}\text{Y}$    | $\beta^-$ | 2280 (100%)                 | 1.5E4          | 6.7     | 7.3     | fission fragment                         |
| $^{144}\text{Ce}-^{144}\text{Pr}$ | $\beta^-$ | 2.9975 (97.9%)              | 411            | 7.6     | 0.3     | fission fragment                         |

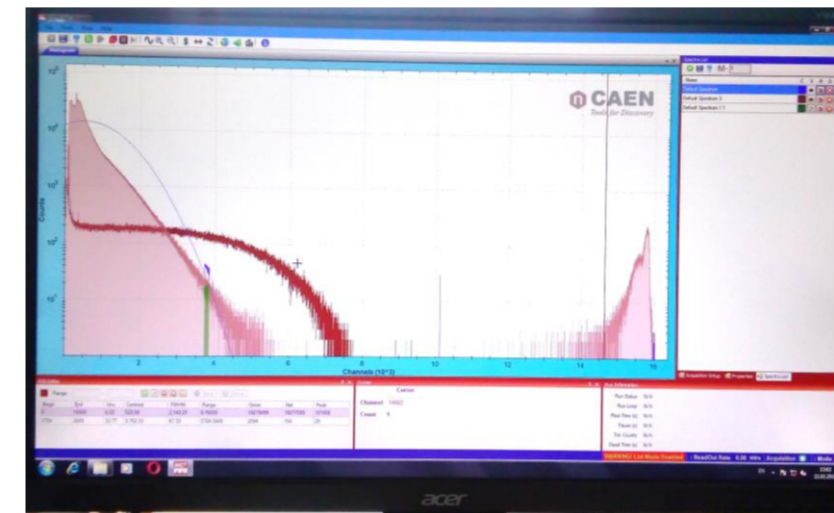
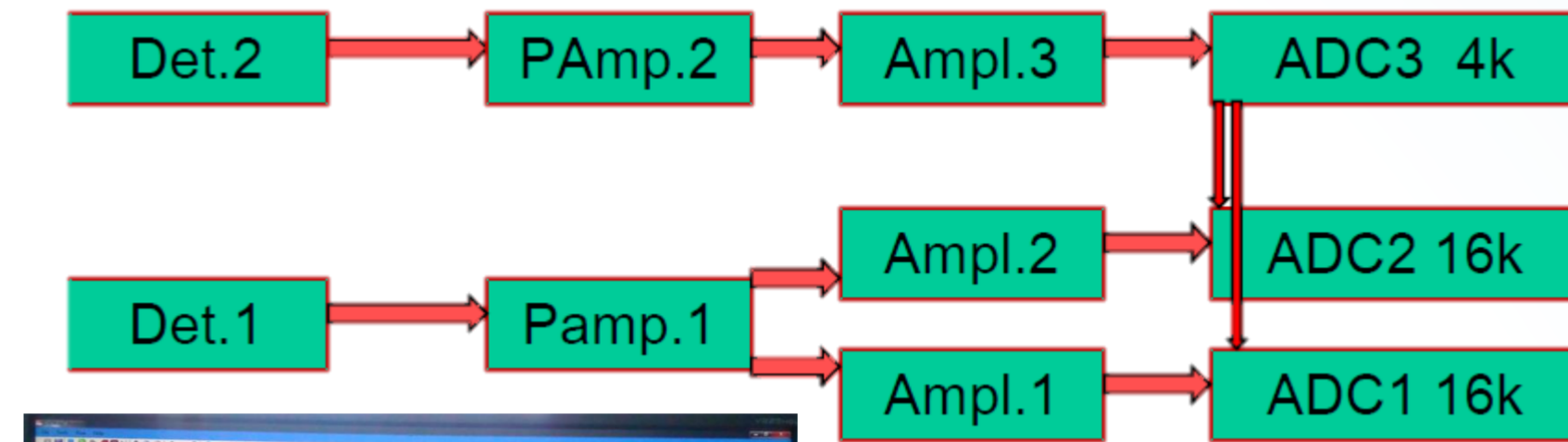
Basic requirements for possible neutrino sources:  
Count rate  $\sim 10^4$  events/ $\tau$ ,  $E > 250$  keV,  $\tau > 30$  d, minimal thermal power, size and r.a. admixtures,  $^{144}\text{Pr}$  seems to be the most promising for searches for neutrino oscillation to a sterile state. SOX 1304.7721 CeLAND 1312.0896v2

## Main Si(Li)-detector parameters



Si(Li) detector produced in PNPI with diameter of sensitive region 16 mm, thick 6.5 mm,  $I=10$  pA at 1000 V. The low threshold of detected energy is 5 keV. The energy resolution measured with  $\gamma$  lines of  $^{241}\text{Am}$  is FWHM= 1.1 keV. All spectra, each with 16 000 channels, were stored in the computer memory.

## Electronics and DAQ system

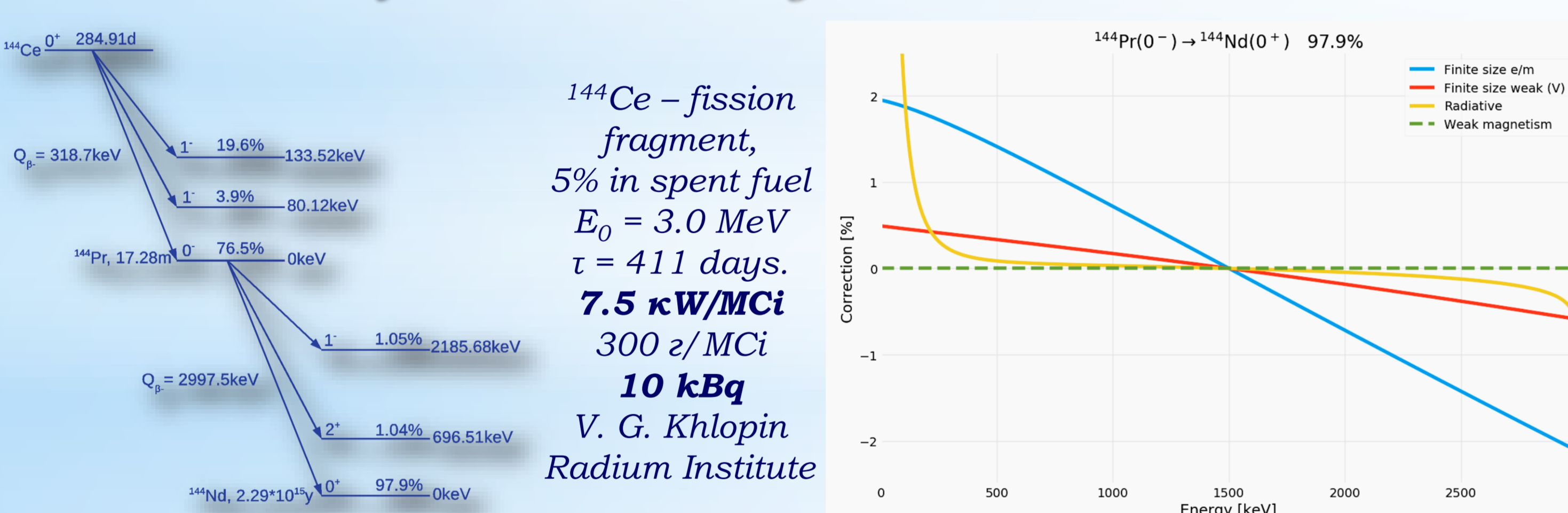


First ADC measures the spectrum up to 0.5 MeV energy and the second one - up to 6 MeV.

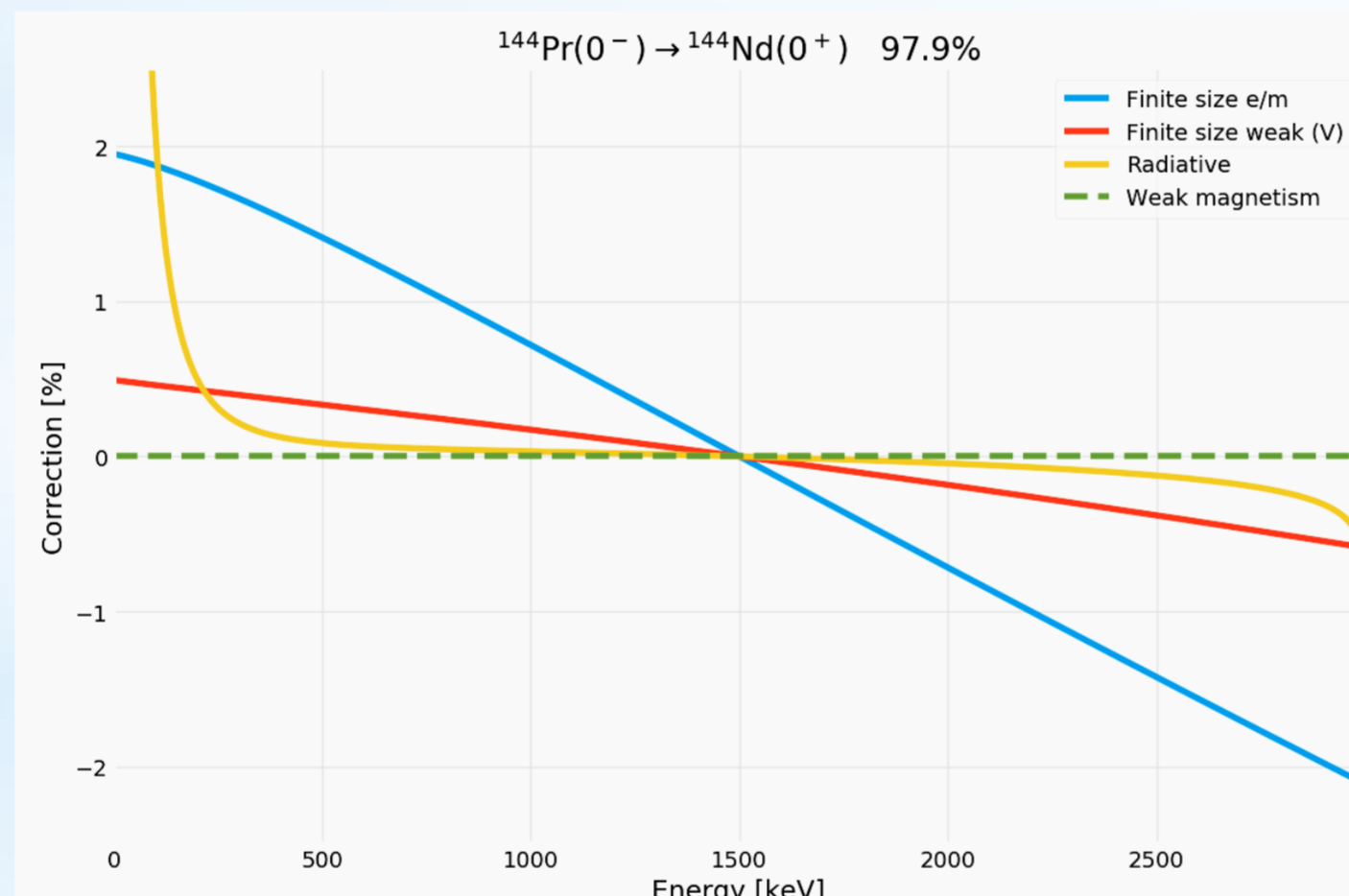


The Si(Li)-detector has two spectrometric channels: a preamplifier with resistive feedback, a 14-bit (16000 channels) ADCs and digital shaper with a time constant 6  $\mu\text{s}$ .

## Decay schemes of $^{144}\text{Ce} - ^{144}\text{Pr}$

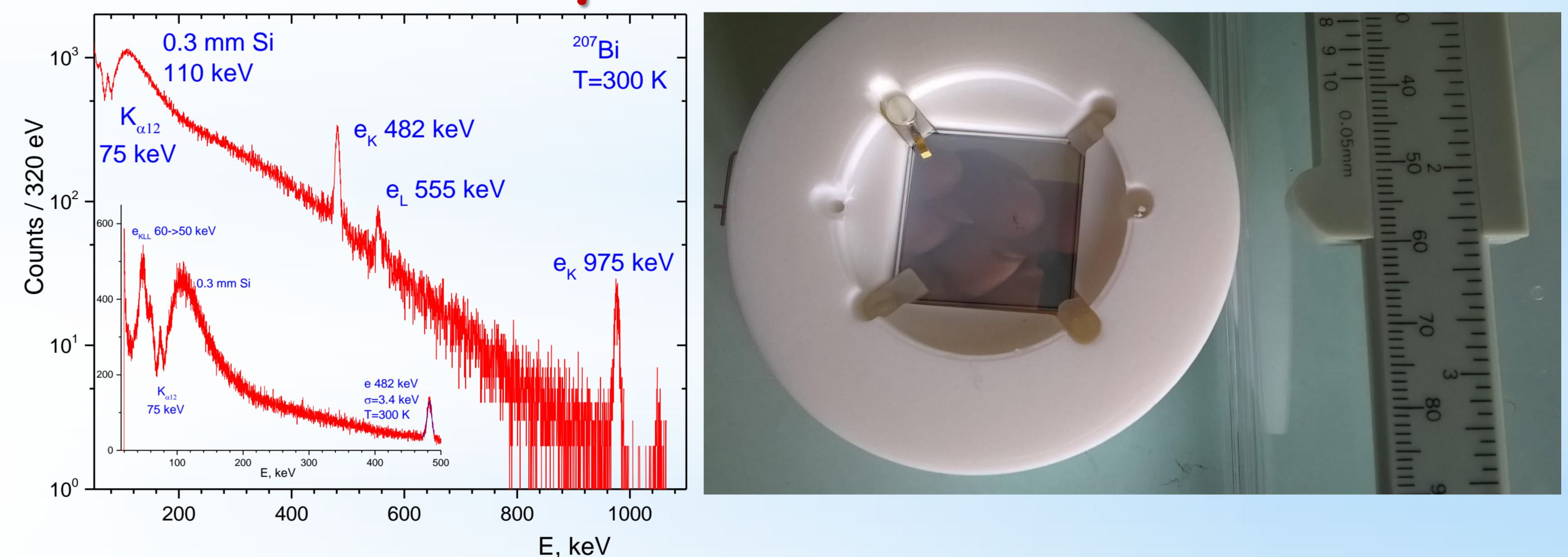


$^{144}\text{Ce}$  - fission fragment, 5% in spent fuel  
 $E_0 = 3.0$  MeV  
 $\tau = 411$  days.  
7.5  $\kappa\text{W/MCi}$   
300  $\mu\text{Ci/MCi}$   
10 kBq  
V. G. Khlopin  
Radium Institute



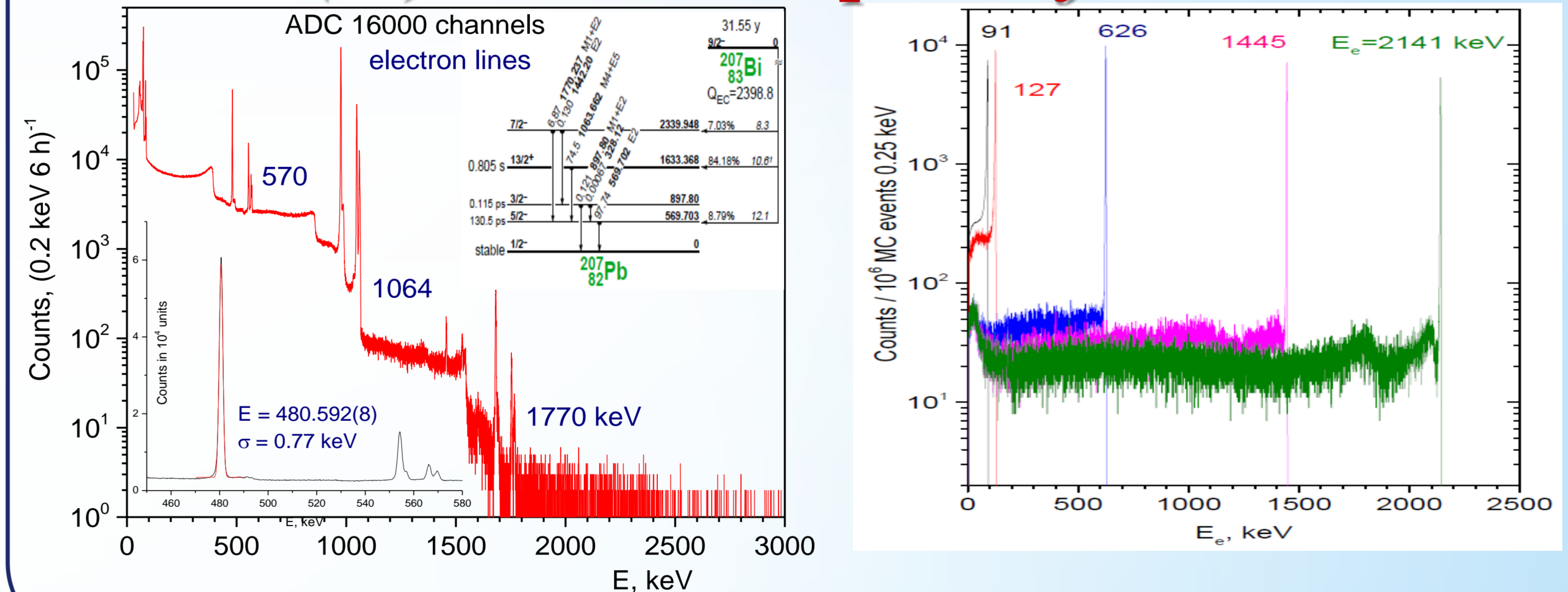
| $Q_\beta$ | $^{144}\text{Ce}$ | $Q_\beta$ | $^{144}\text{Pr}$ | $\gamma$ | $^{144}\text{Ce}$ | $\gamma$ | $^{144}\text{Pr}$ |
|-----------|-------------------|-----------|-------------------|----------|-------------------|----------|-------------------|
| 318.7     | (76.5%)           | 2997.5    | (97.9%)           | 133.5    | (11.1%)           | 696.5    | (1.3%)            |
| 185.2     | (19.6%)           | 2301.0    | (1.04%)           | 80.1     | (1.36%)           | 2185.7   | (0.69%)           |
| 238.6     | (3.9%)            | 811.8     | (1.05%)           | 41.0     | (0.26%)           | 1489.1   | (0.28%)           |

## Si 300 $\mu\text{m}$ thin detector



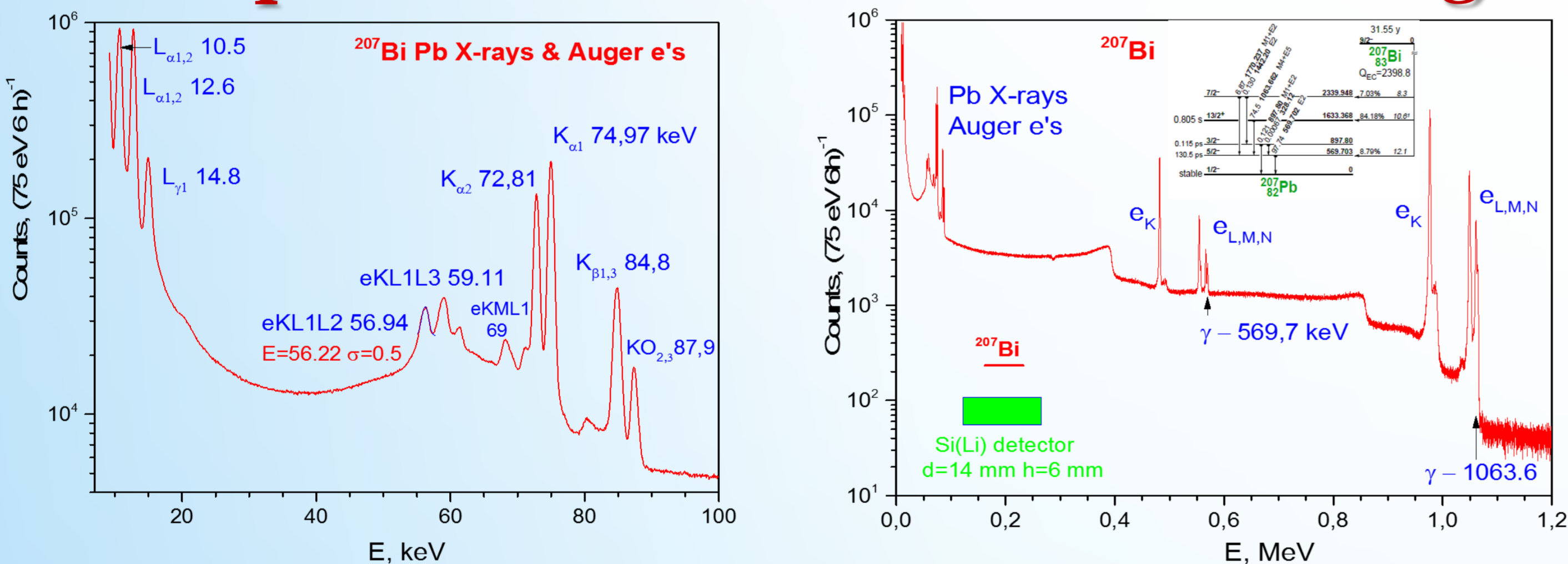
Size 24x24x0.3 mm, Dead layer = 0.3  $\mu\text{m}$ ,  $I=2.4$  nA at 100 V (300 K),  $C=90$  pF, Produced Zelenograd & Ioffe Institute, St. Petersburg

## Si(Li) detector response functions



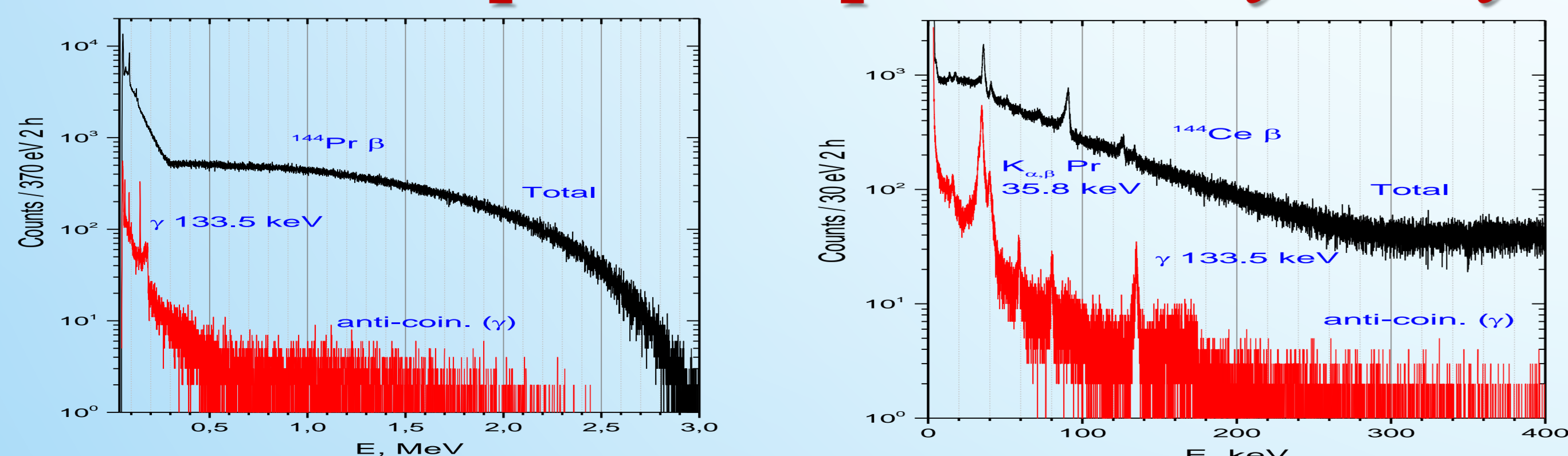
$^{207}\text{Bi}$  spectrum and Monte-Carlo simulation of monoenergetic 91 - 2141 keV electrons

## $^{207}\text{Bi}$ spectrum in the 7 - 1200 keV range



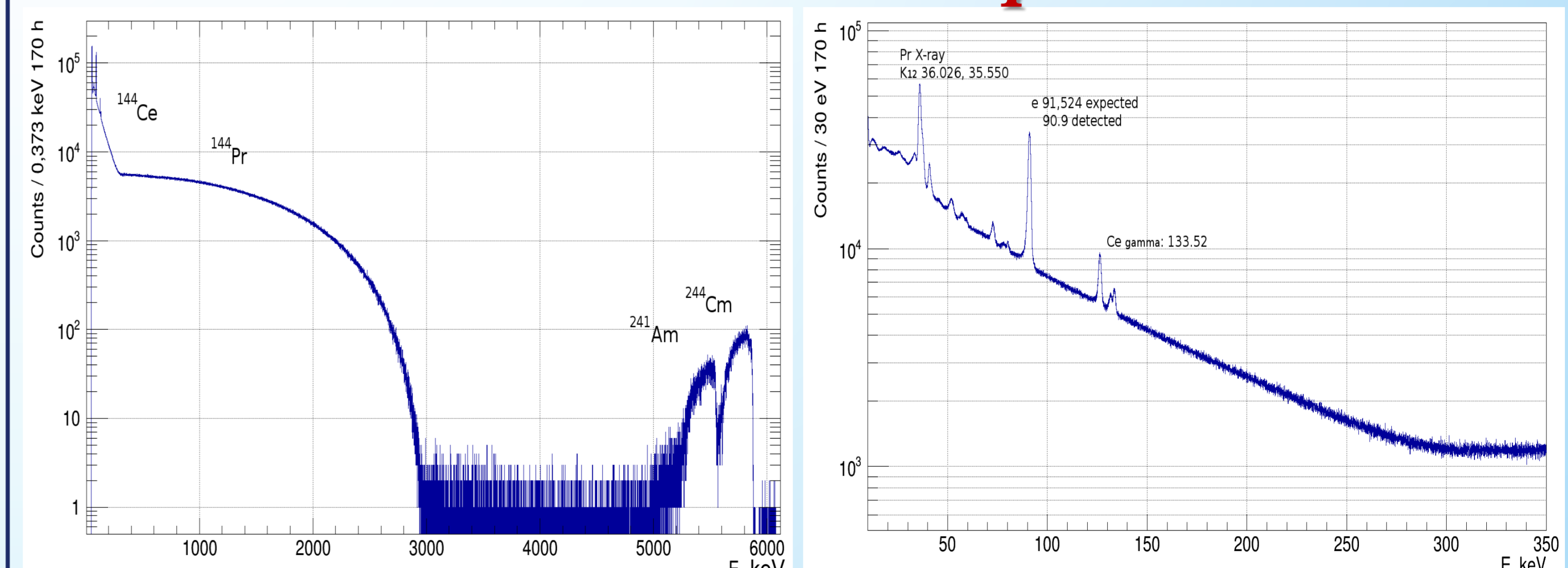
Conversion an Auger electrons, gamma-lines and X-rays.

## Coincidence spectra & preliminary analysis



Fermi function, screening, weak and electromagnetic finite size, weak magnetism, radiative corrections have to be taken into account to find the parameters of shape factor.

## $^{144}\text{Ce} - ^{144}\text{Pr}$ beta spectra



240 series each lasting 1 h were carried out. After the main measurements were completed the thin silicon detector was mounted and  $\gamma$ - and X-rays activity was measured by Si(Li)-detector in anticoincidence with thin Si-detector.