

# Counting data of the registration system for BEST

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## Main parts of the BEST counting system

1. Passive shield.
2. Proportional counters.
3. Anticoincidence system (NaT(Tl) detector).
4. Charge-sensitive preamplifiers.
5. System acquisition electronics.
6. On-line software.

# The passive shield of the BEST counting system

**Pad:** Quartz sand.

**Basis:**  $200 \times 200 \times 200$  mm<sup>3</sup> cubes of low-background concrete.

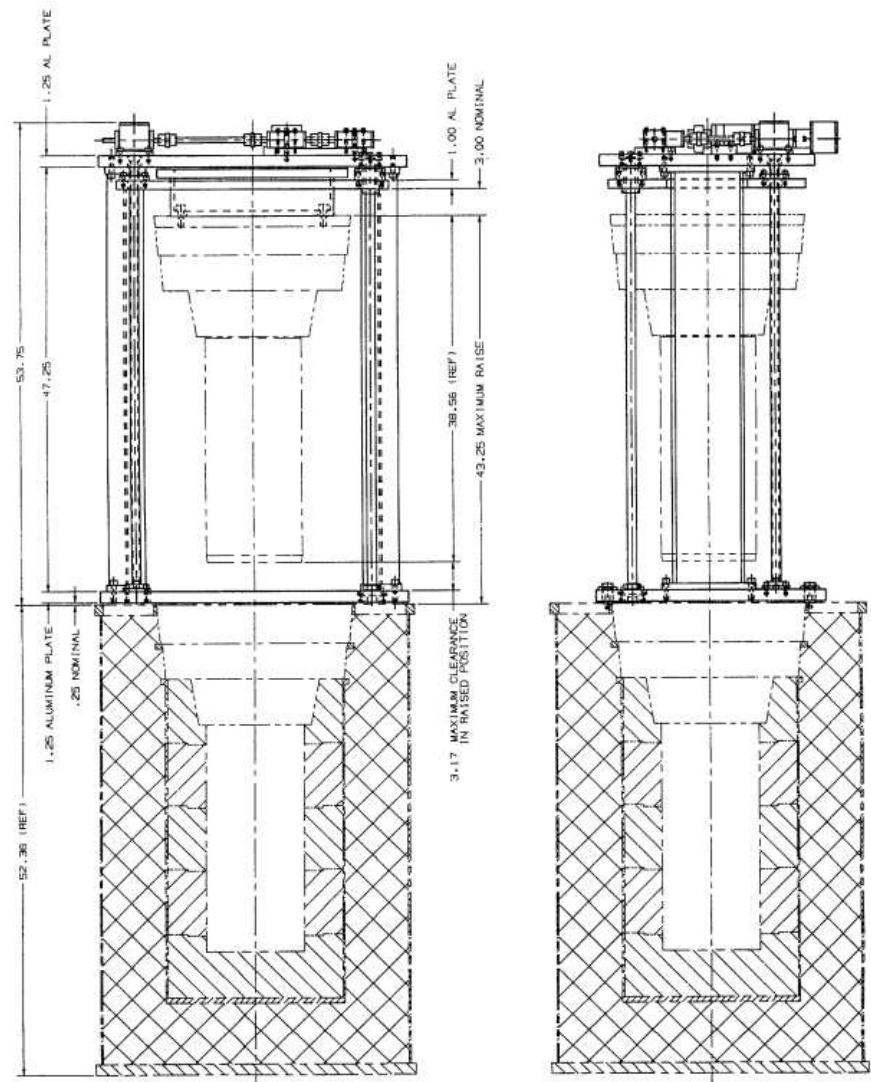
**Internal layer:** 107.5 mm (around), 130 mm (down and up) of copper.

**Intermediate layer:** 20 mm (down and around) of steel.

**External layer:** 300 mm (down and around) of lead ( $\simeq 1000$  bricks).

**Upper cover:** 100+100 mm of steel.

**Total mass:** about 20 t.



## The BEST counting system: YCN counters

**Cathode length:**  $\simeq 50$  mm

**Wall thickness:** 150–200  $\mu\text{m}$

**Cathode diameter:** 4 mm (int.)

**Cathode:**  $\simeq 1$   $\mu\text{m}$  (pirographite)

**Anode thickness:** 11  $\mu\text{m}$  (tungsten)

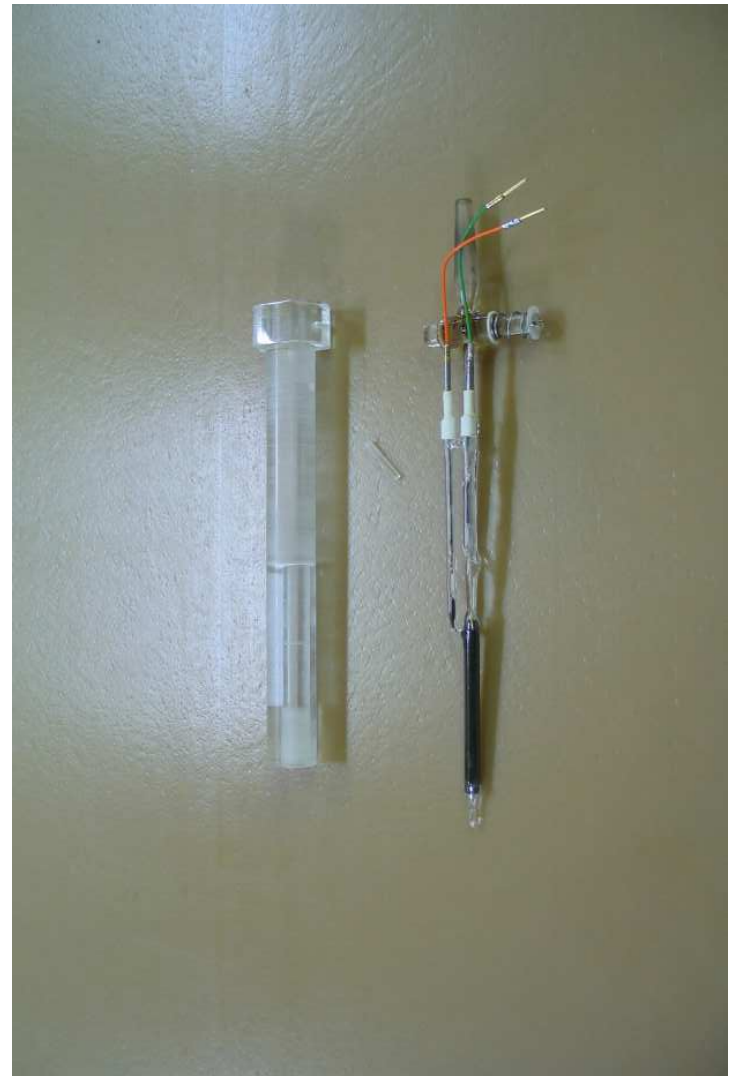
**Gas mixture:** (10–20)%  $\text{GeH}_4 + \text{Xe}$

**Gas pressure:** 620–640 mm

**High Voltage:**  $-(1100-1300)$  V

**Gain:**  $10^3-10^4$

**Energy resolution (5.9 keV):** 19–23%



## The measured data of the YCN counters

Counter YC*	N-32	N-41	N-42	N-43	N-46	N-113	N-a9	T-8
$\bar{R}, \%$ (5.9 keV)		19.96	20.54	20.11	23.20	20.02	21.14	20.70
$\sigma_R, \%$		0.34	0.41	0.75	0.42	0.64	1.09	1.25
$Bkg_L, d^{-1}$		0.23	0.83	0.11	0.31	0.17	0.20	
$Bkg_K, d^{-1}$		0.13	1.24	0.05	0.23	0.06	0.20	

## Main performance data of NaI(Tl) detector

**Made:** “Amkris”, Kharkov, Ukraine

**Size:**  $\varnothing 200 \times 200$  mm

**Well:**  $\varnothing 100 \times 150$  mm

**PMTs model:** 3” ET9757QL (4 pieces.)

**Body:** Stainless steel

**Reflector:** Teflon

**Windows:** Quartz

**Volume:**  $5105.1 \text{ cm}^3$

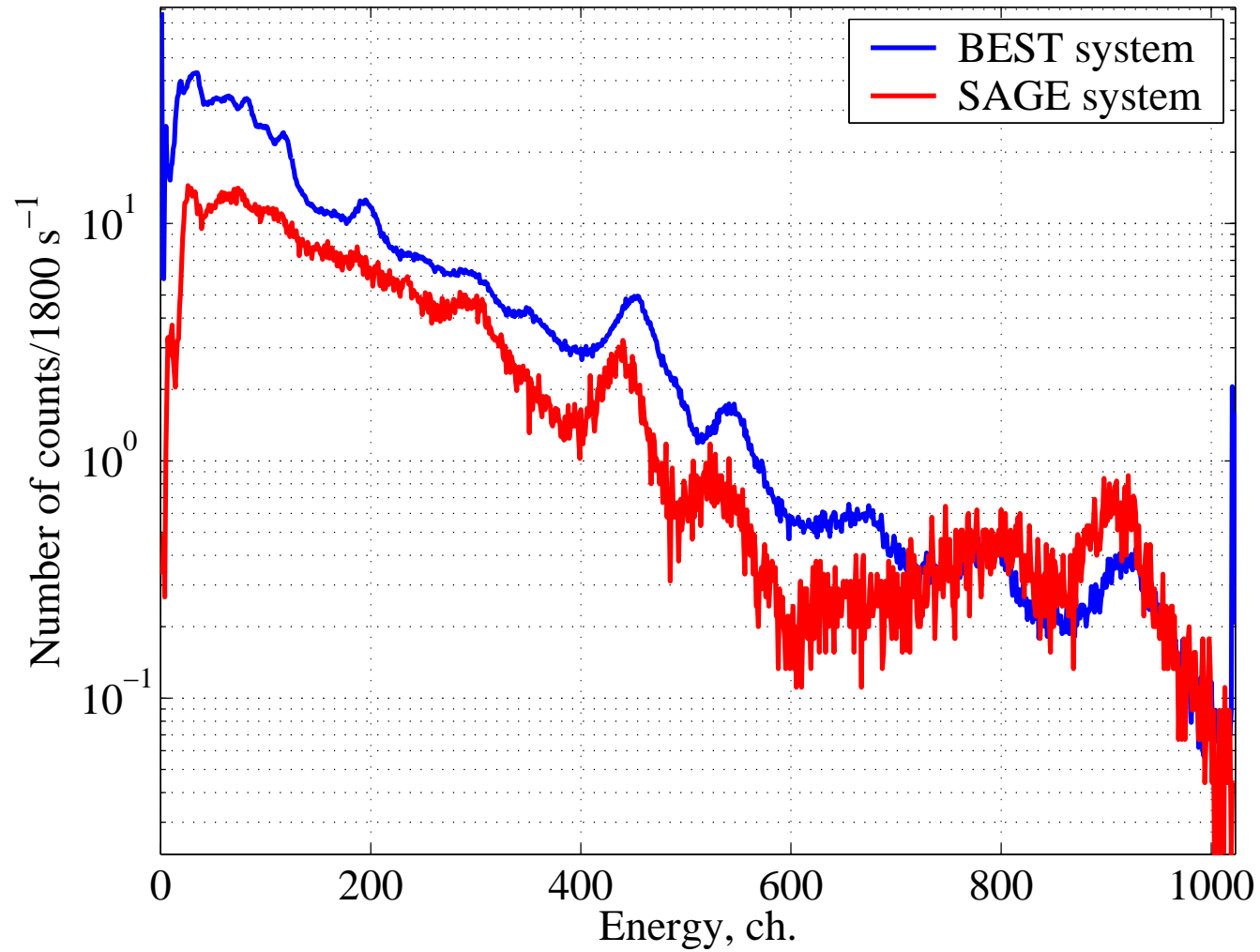
**Mass:** 18.74 kg

**Resolution:**  $R \simeq 7.6\%$   
( $E_\gamma = 1460 \text{ keV}$ )

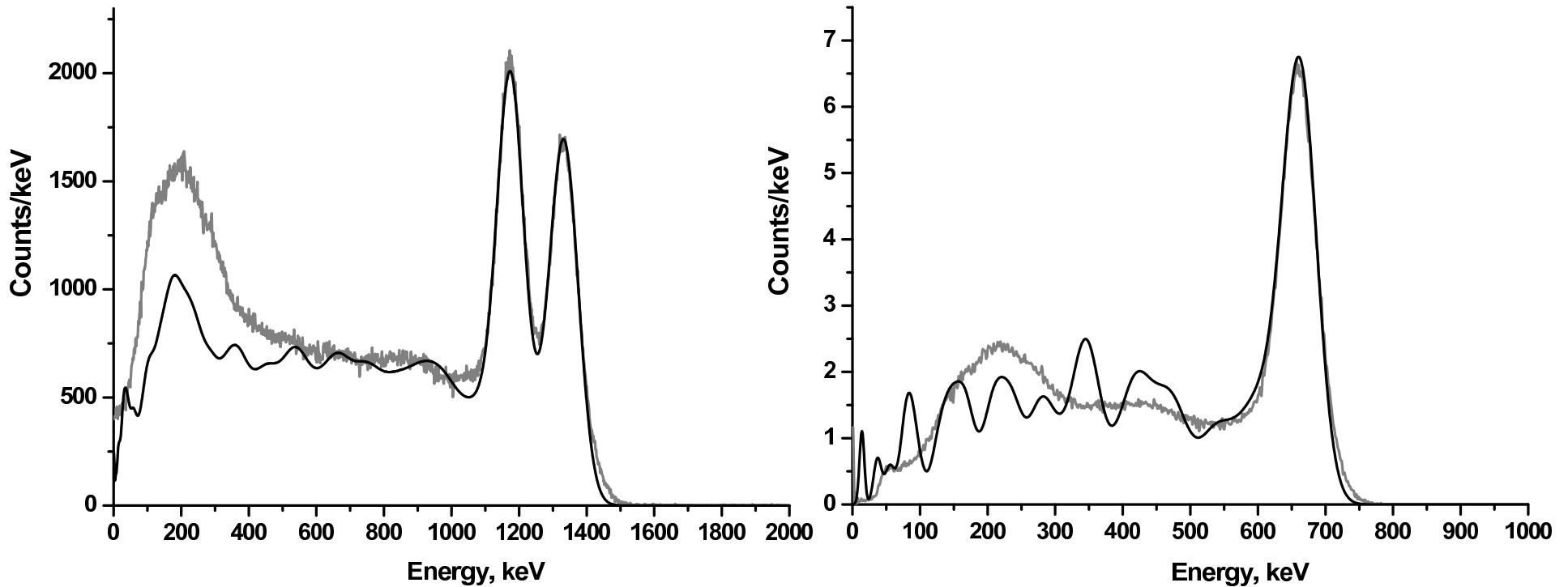
**Bkg:**  $v_{\text{bg}} = 3.24 \pm 0.03 \text{ s}^{-1}$   
( $E_\gamma = 40\text{--}3500 \text{ keV}$ )



# The background spectra of NaI(Tl) detectors



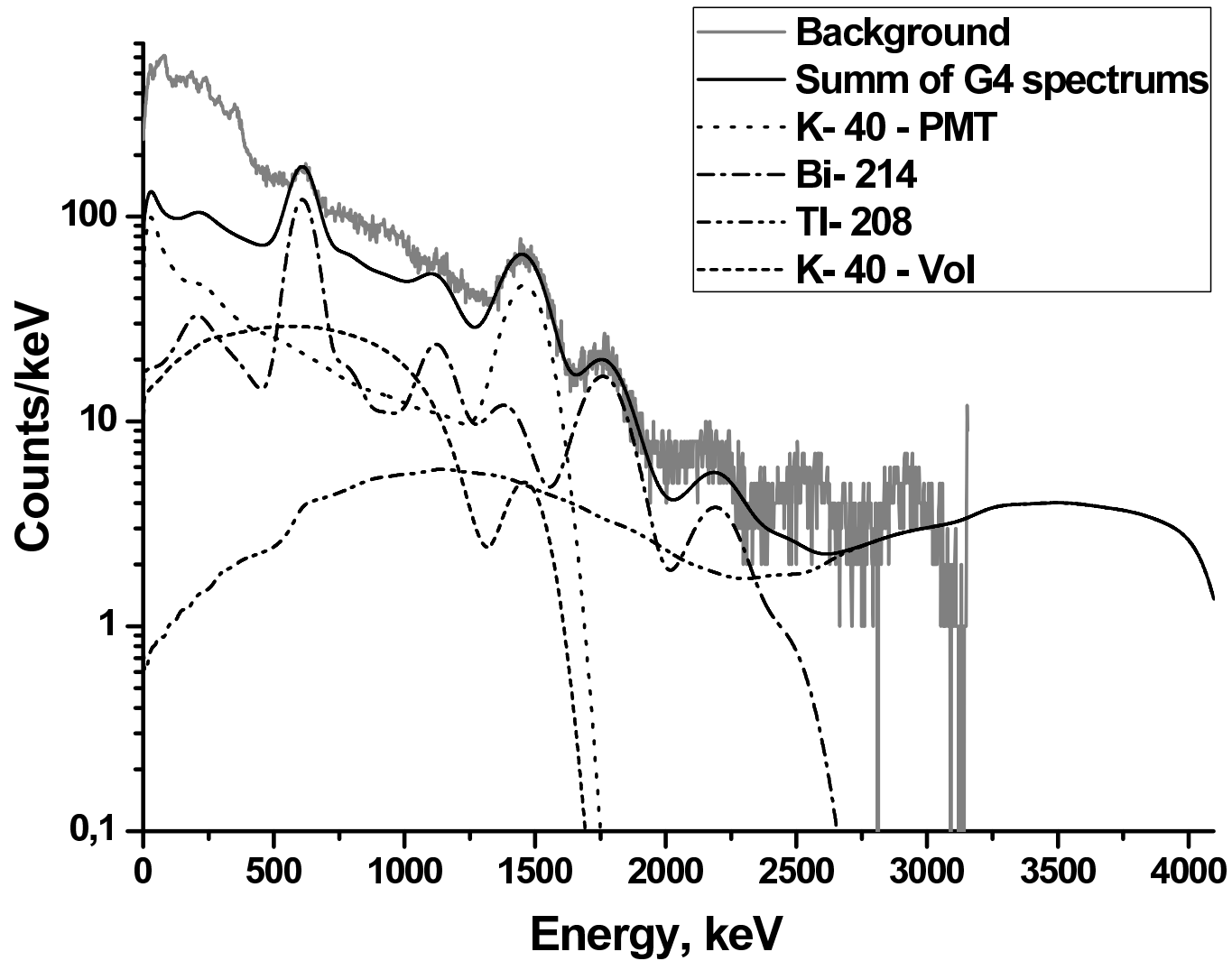
## Calibration spectra of NaI(Tl) detector for the BEST system



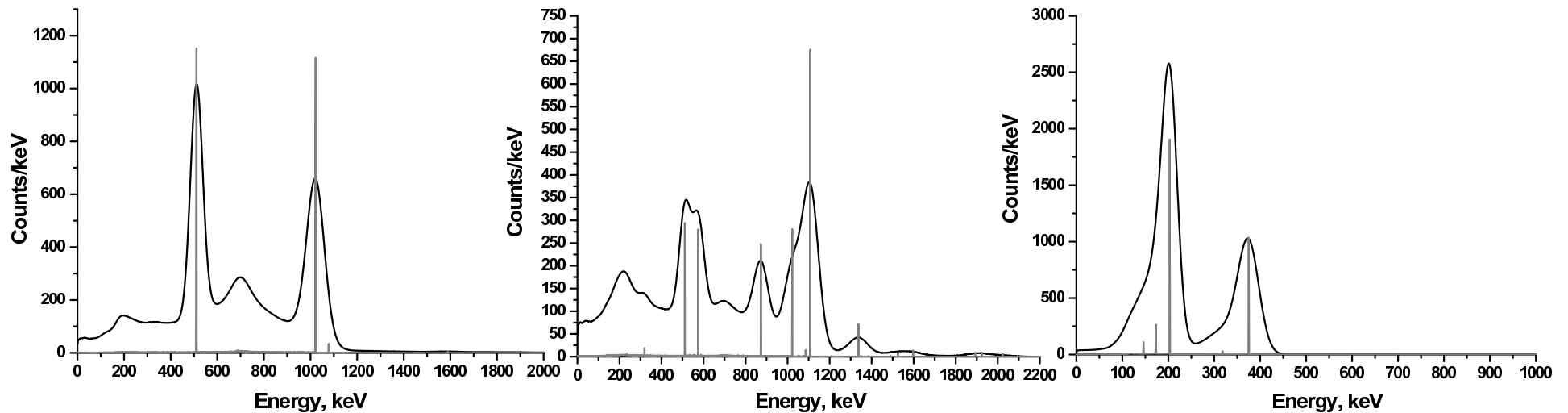
Left:  $^{60}\text{Co}$ , right:  $^{137}\text{Cs}$ . Grey lines — real spectra, black lines — Geant 4 model spectra.



# The background of NaI(Tl) detector for the BEST system: real spectrum and Geant 4 model



## The NaI(Tl) detector: Geant 4 model response on different $\gamma$ -sources in a place of proportional counter

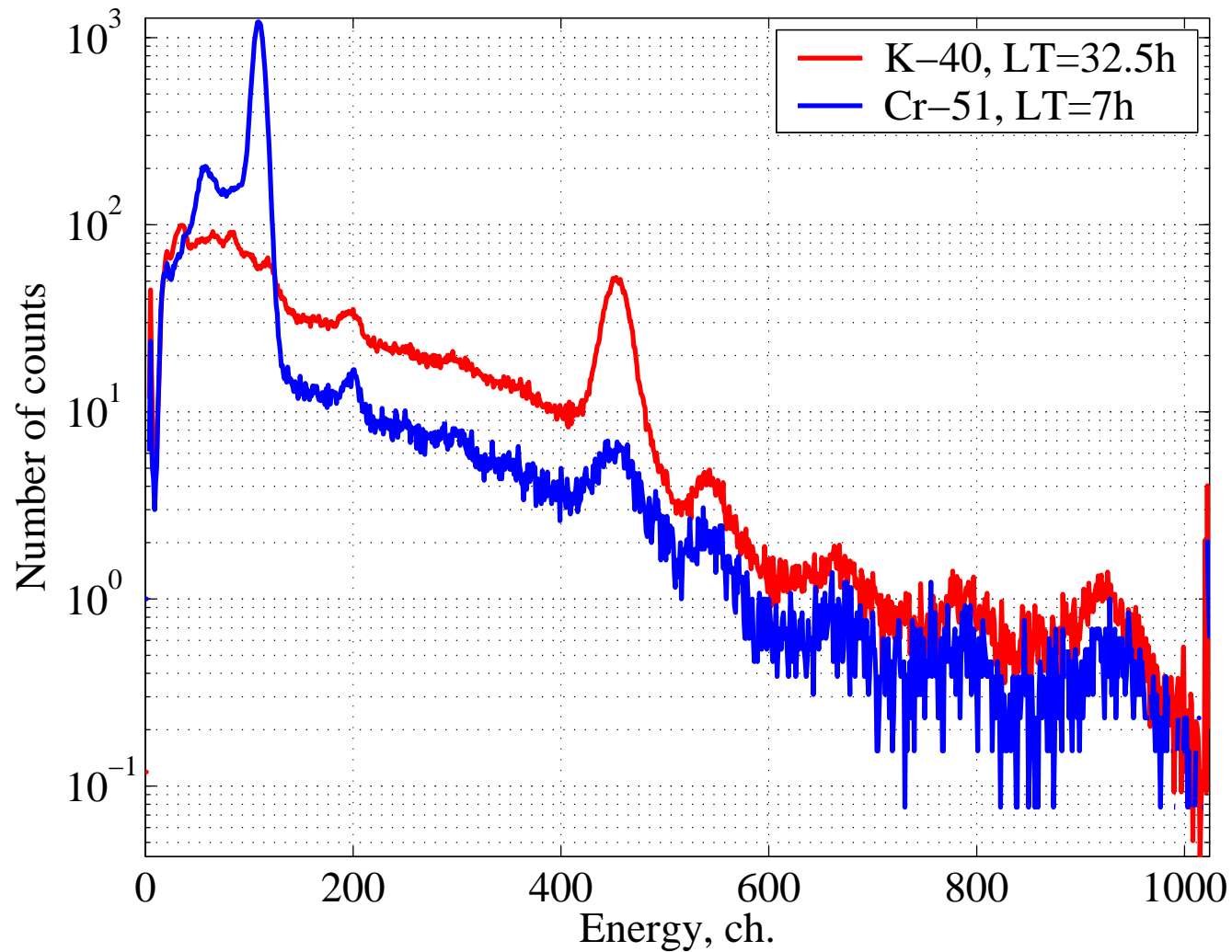


From left to right:  $^{68}\text{Ga}$ ,  $^{69}\text{Ge}$  and  $^{127}\text{Xe}$ . Grey lines — model response, black lines — model response with consideration of energy resolution of real detector.

## Efficiencies of $\gamma$ -lines registration for sources in a place of proportional counter, % (Geant 4 model)

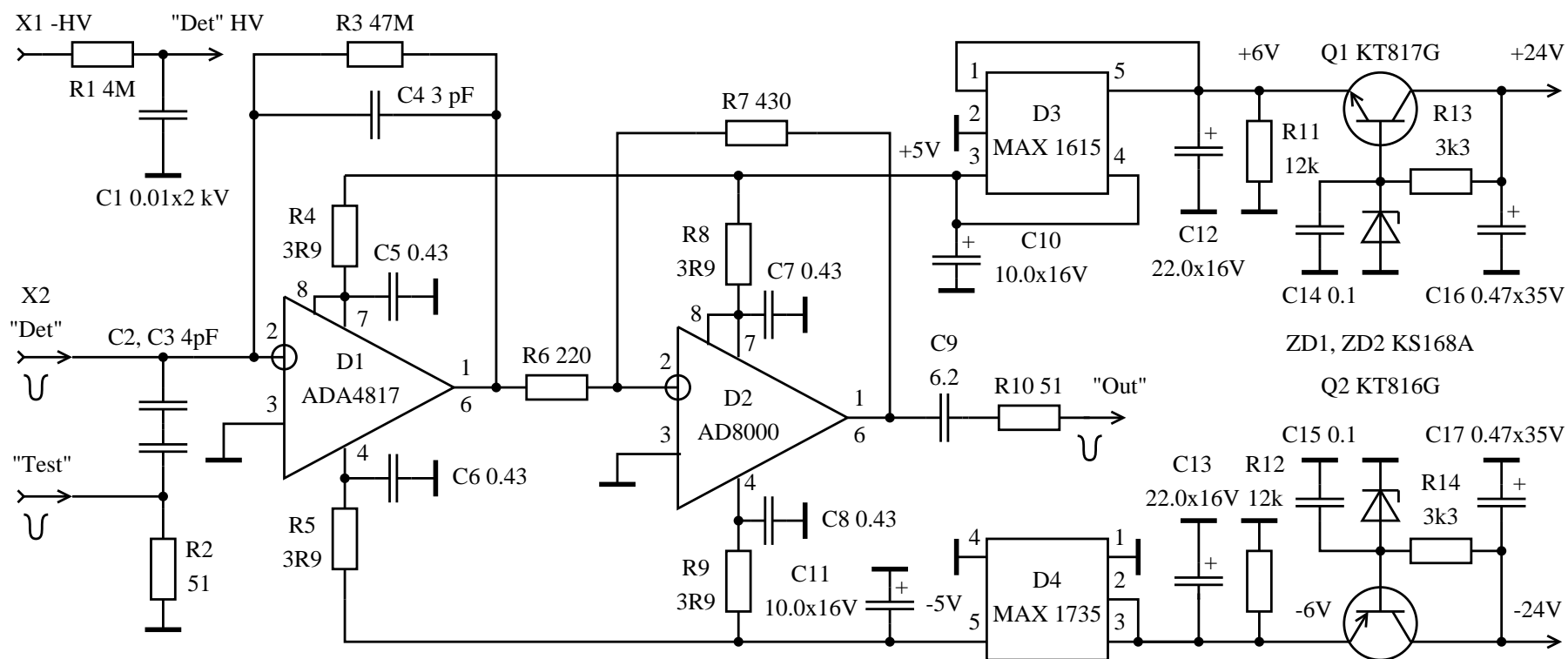
E, keV	145	172	203	375	511	574	872	1107	1336	1460	Abs.
$^{127}\text{Xe}$	43.0	17.2	46.2	99.5							78.7
$^{69}\text{Ge}$					10.5	35.0	34.5	31.0	27.0		69.5
$^{68}\text{Ga}$					10.5						87.5
$^{40}\text{K}$										28.0	77.0

# The NaI(Tl) detector: real response on different $\gamma$ -sources in a place of proportional counter

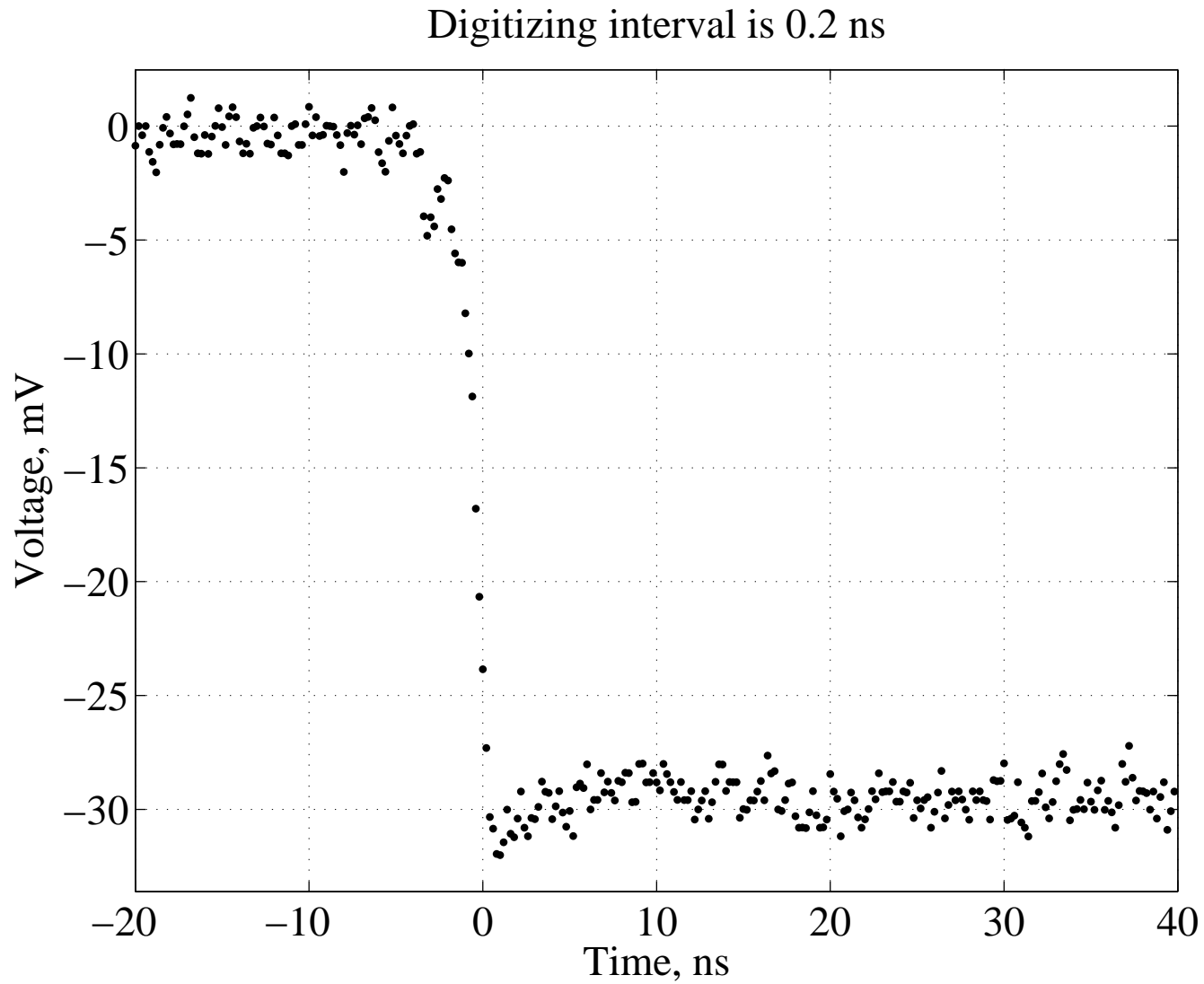


# Integrated OA charge-sensitive preamplifier:

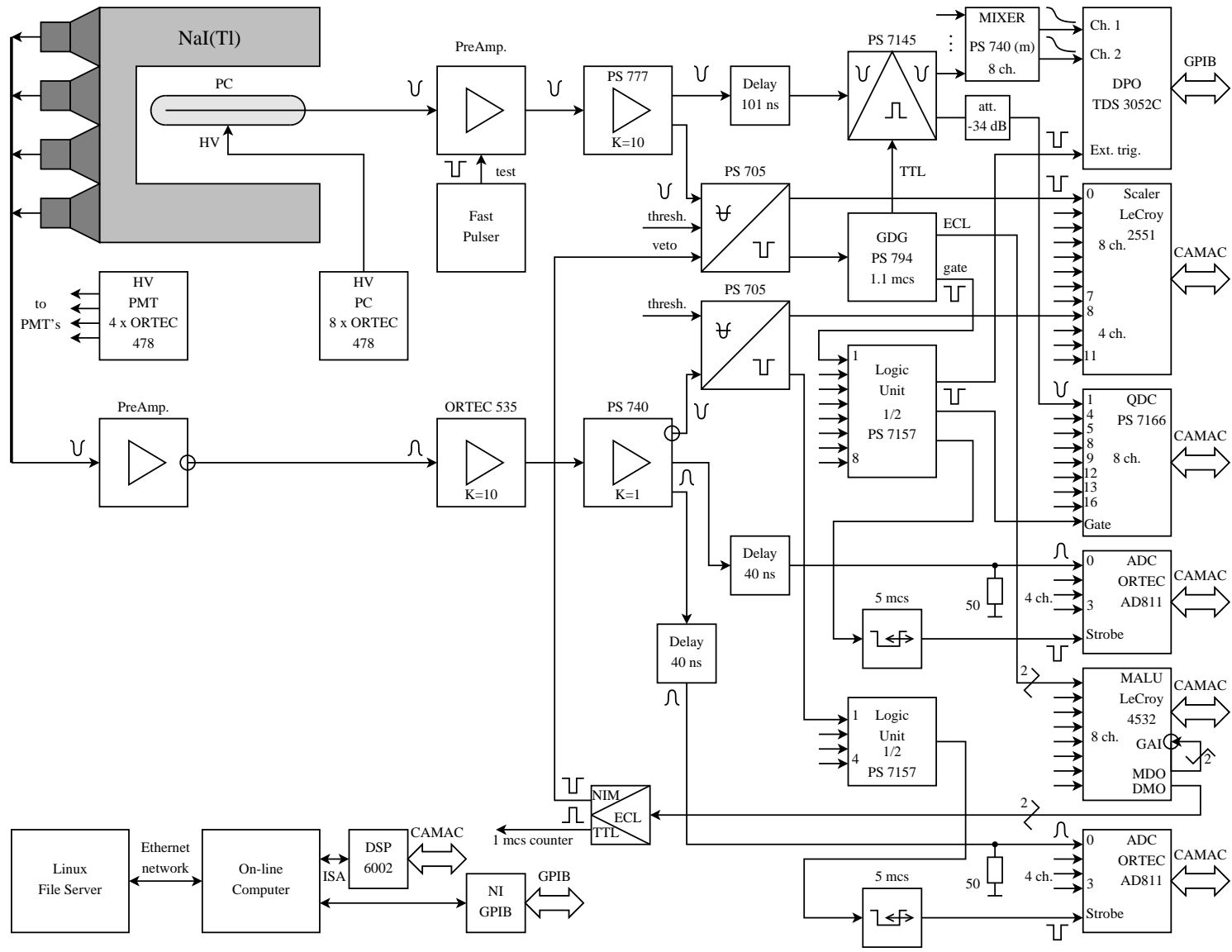
(D. V. Serebryakov, A. A. Shikhin, INR RAS, 2015)



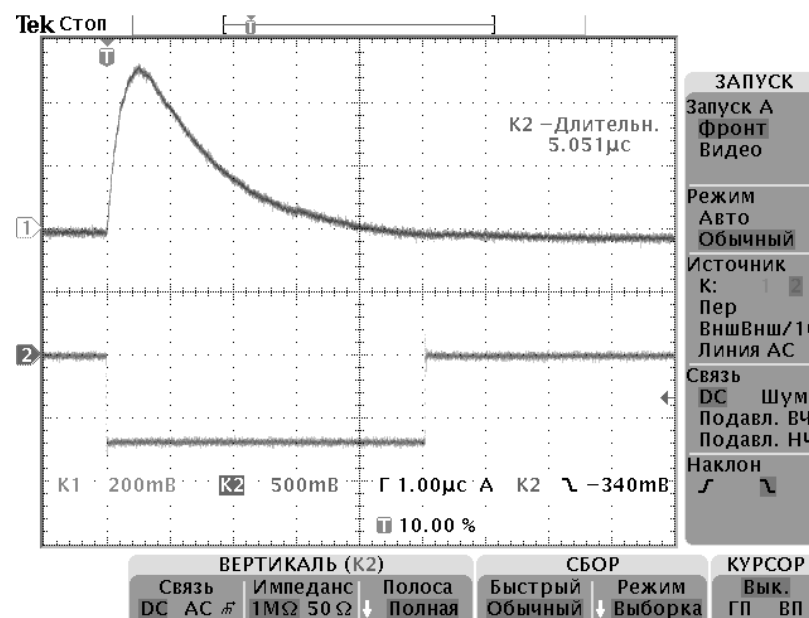
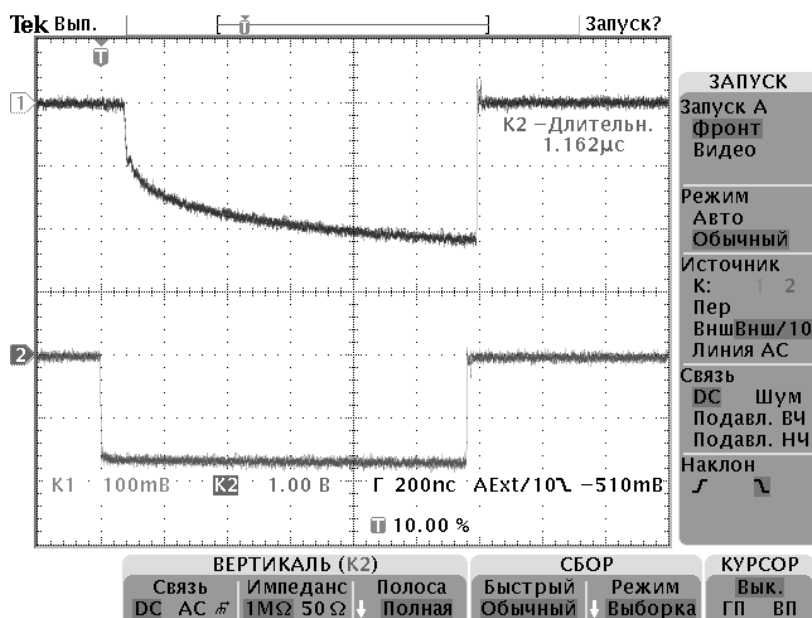
# The charge-sensitive preamplifier: risetime response



# The functional diagram of the BEST counting system

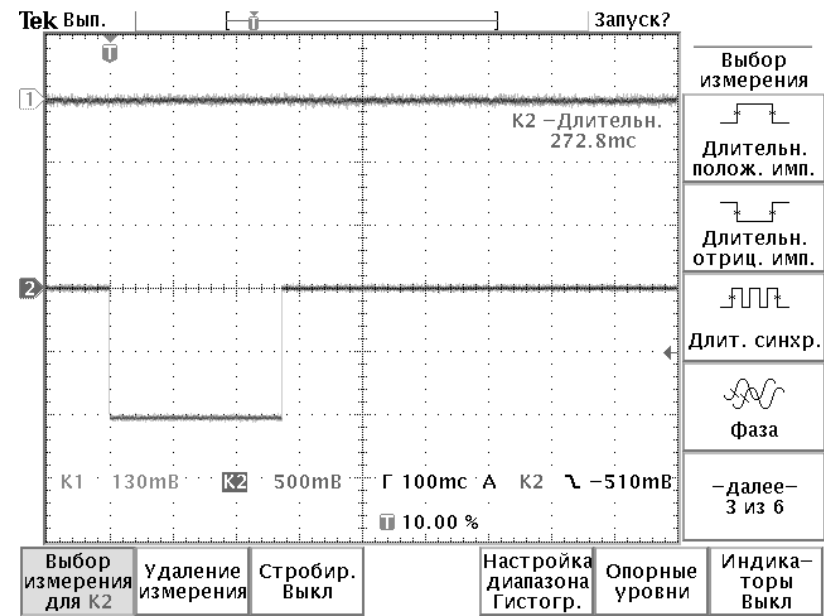
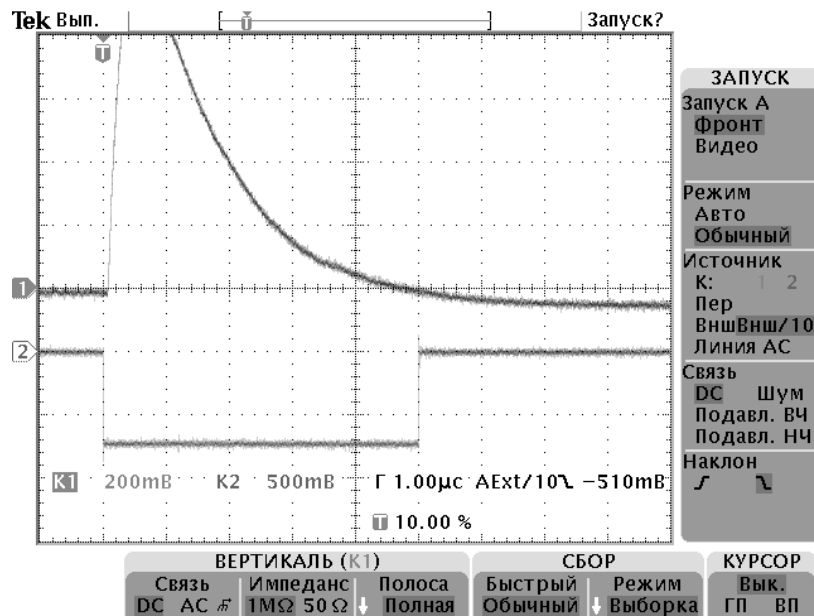


# The energy of events from the proportional counter (left) and NaI(Tl) (right) measurement





# The energy of real coincidence event from NaI(Tl) (left) and veto signal (dead time) measurement



## The software for the BEST counting system

- DOS software (MS DOS, FreeDOS+dosemu+Linux).
  - Utility for PMT gain calibration and bkg of the NaI(Tl) detector measurement.
  - Utility for check of proportional counters operation and their calibration.
  - Utility for check of TDS 3052 DPO operation and pulse shapes recording from counters.
  - On-line software for simultaneous calibration of all installed proportional counters.
  - On-line software for rare events registration.
  - The full set of software for the SAGE counting system are in using also.
- The Geant 4 model for anticoincidence system.

## Main performance data of the BEST counting system

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Number of counting channels	8
Energy range (counter channel), keV	0.3–16
Bandwidth (pulse shape recording channel), MHz	>125
Risetime (pulse shape recording channel), ns	<3
Digitizing frequency (pulse shape recording channel), GHz	1(5 max)
Frame volume (pulse shape recording channel), points	1000 (10000 max)
Digital resolution of DPO (pulse shape recording channel), bit	2×8(9 max)
Digital resolution in the “Energy” channel, bit	11(12 max)
Gate width in the “Energy” channel, ns	1100–1200
Dead time, ms	270
Digital resolution in NaI channel, bit	10(11 max)
Shaping time constant in NaI channel, $\mu$ s	1.1
Anticoincidence gate width, $\mu$ s	5
Energy range (NaI channel), keV	60–3000

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## The BEST counting system: history of using

(from october 2015 to may 2017)

**YCN-32:** bg1057

**YCN-41:** 6R1126, 6R1057

**YCN-42:** Ge681095, bg2047

**YCN-43:** 7R2105, 7R2016, bg1056, 7R2076, 7R2106, 7R2017, R2-1047

**YCN-46:** 7R3035, bg4047

**YCN-113:** bg1105, R2-1096, R2-1027

**YCN-a9:** bg1034, R2-1106, R2-1037

**YCT-8:** bg1076, bg3057

## Current status of the BEST system

1. 8 counting channels in real operation.
2. The first extractions samples counting from both volumes of the BEST target.
3. The second extractions samples counting.
4. The background measurement of new installed counters.
5. Complete software integration to standard data analysis.
6. The system polishing by the “fine file” continues.