GAMMA-RADIATION
SCINTILLATION DETECTOR MODULES

Model DM-BGO
Model DM-CSI

Preliminary Specification

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ILLUSTRATION

1. INTRODUCTION

The RITEC Model DM-BGO and DM-CSI is a scintillation detector module based on BGO- and CsI(Tl)-type scintillators coupled with silicon photomultipliers (SiPM). This detector modules designed for use with a microspectrometers Model µSPEC of Ritec or CUBE527 manufactured by GBS-elektronik GmbH.

The scintillation modules are made up of 4 components: a scintillation detector, pre-amplifier, high voltage power supply for SiPM, electronic circuit for temperature stabilization of detector parameters.

The preamp converts the charge carriers developed in the detector during each absorbed nuclear event to a step function voltage pulse, the amplitude of which is proportional to the total charge accumulated in that event.

Outward appearance of the scintillation detector module is shown in fig.1.

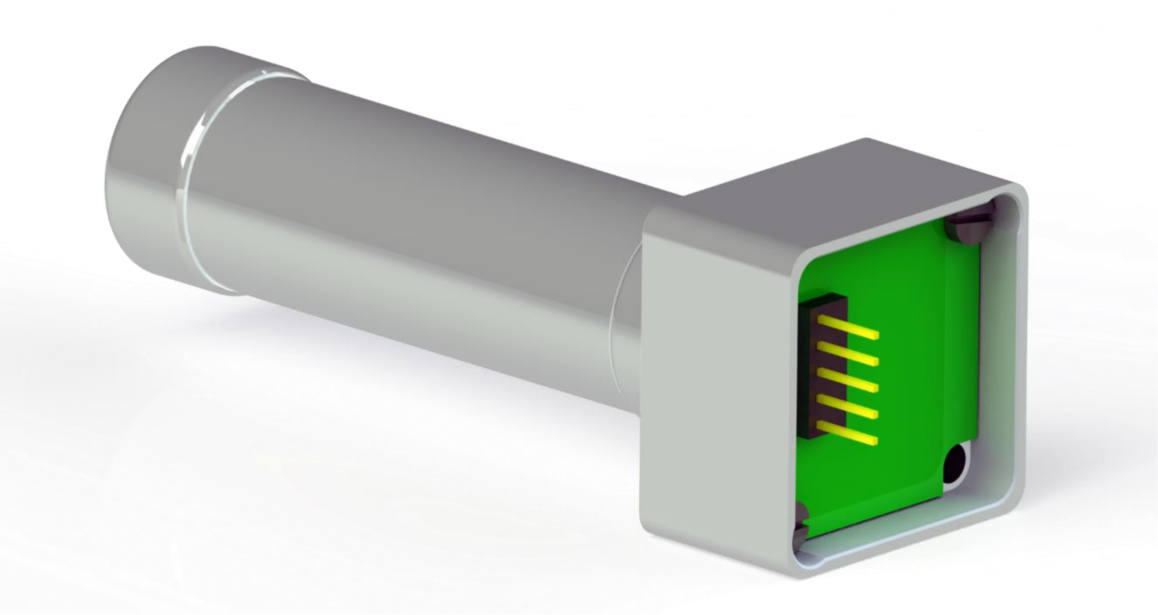

Fig. 1. Scintillation detector module.

2. SPECIFICATION

Base

- Detector materials
  DM-BGO .... BGO
  DM-CSI .... CsI(Tl)
- Detector dimensions
  DM-BGO .... Ø12,5x50 mm
  DM-CSI .... Ø10x50 mm
- Size of SiPM .... 6x6 mm
- Energy resolution (FWHM) at 662 keV@25°C, no more
  DM-BGO .... 16 %
  DM-CSI .... 9 %
- Operation temperature range .... 0°C … 50°C
- Energy range .... 30 keV … 3000 keV
- Gain (peak position) stability in the operation temperature range .... ±1%
- Detection efficiency* at 662 keV@25°C
  DM-BGO 48%
  DM-CSI 17%
- Integral nonlinearity from 50 to 1500 keV, not more 1%
- Output signal polarity .... Positive

Electrical and mechanical

- Power consumption, no more .... +5V, 10 mA
- Detector module external dimensions:
  Total .... 72x25x25 mm
  Head length .... 57±0,5 mm
  Head diameter .... Ø17±0,1 mm
- Input window:
  Material .... Aluminum
  Front thickness .... 0,8±0,1 mm
  Side thickness .... 1,0±0,1 mm
- Weight
  DM-BGO .... 70 g
  DM-CSI .... 50 g

*Detection efficiency of the gamma-radiation in the full energy peak of radionuclide ^{137}Cs, with energy 661,7 keV at a distance of 100 mm from the upper surface of detector.

3. DESIGN FEATURES

Currently, scintillation detectors coupled with silicon photomultipliers (SiPMs) are used as gamma-radiation detectors for different applications. Many tasks require the ability to use detectors in environments with varying operating temperatures. However, the profound dependences of the characteristics of both scintillators and SiPMs on temperature make it difficult to use these detectors in changing environmental conditions. The presence of such temperature dependence makes it necessary to use special techniques for the stabilization of the detector parameters.

Detector modules DM-BGO and DM-CSI based on microprocessor control of the SiPM bias voltage for compensating for the temperature instabilities of the gain of an SiPM and the light output of BGO and CsI(Tl) scintillators.

Block diagram of the temperature compensation scheme of a detector module on Fig.2.

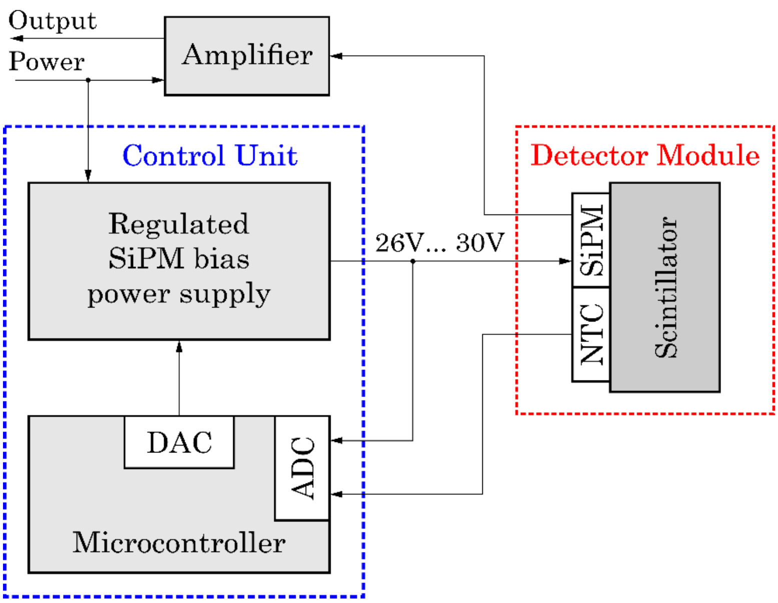

Fig. 2. Block diagram of the temperature compensation scheme of a detector module.

The temperature stabilization of the parameters of the assembled detectors was conducted using the method of active monitoring of the detector bias voltage. The microcontroller, which includes 12-bit ADCs and DACs, achieves the operation control of the entire circuit. Based on the calibration table stored in the processor memory, the required bias voltage of the detector is determined. The microcontroller periodically measures the current temperature of the detector and controls the correctness setting of the bias voltage of the detector. The signal from the detector through the amplification/shaper stage is sent to the subsequent recording equipment.

Main dimensions and the detector location are shown on Fig. 3.

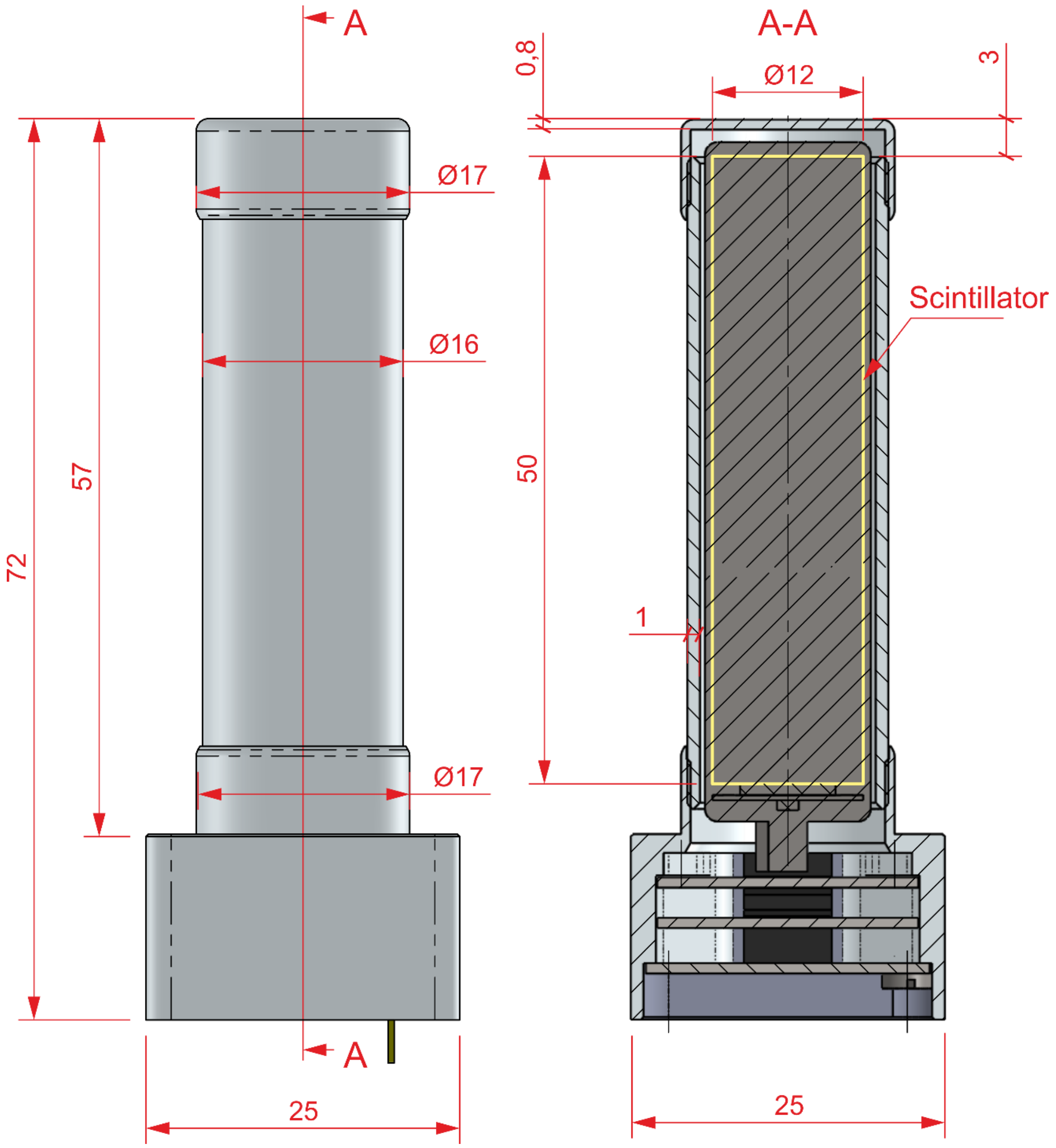

Fig. 3. Main dimensions and the detector location.

4. Performance

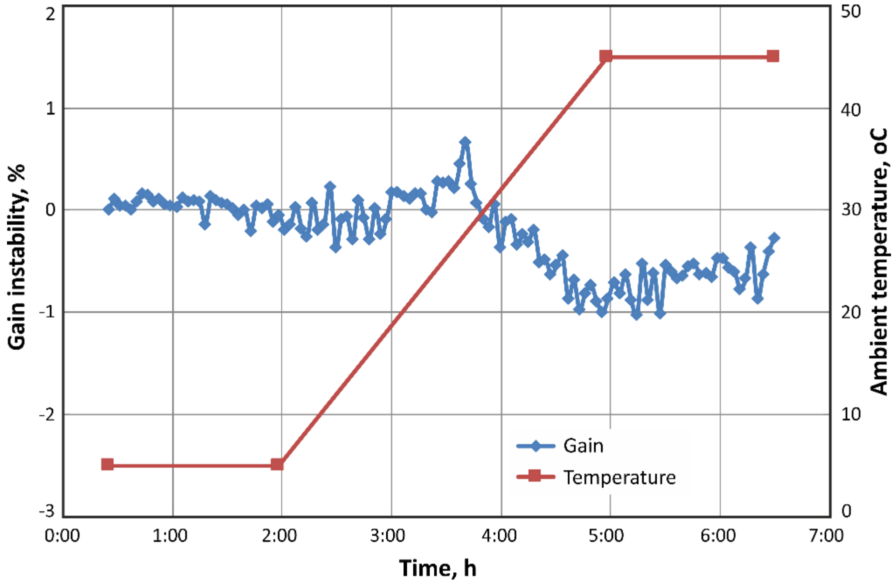

Fig. 4. Model DM-BGO gain instability at ^{137}Cs line vs. continuously variable temperature.

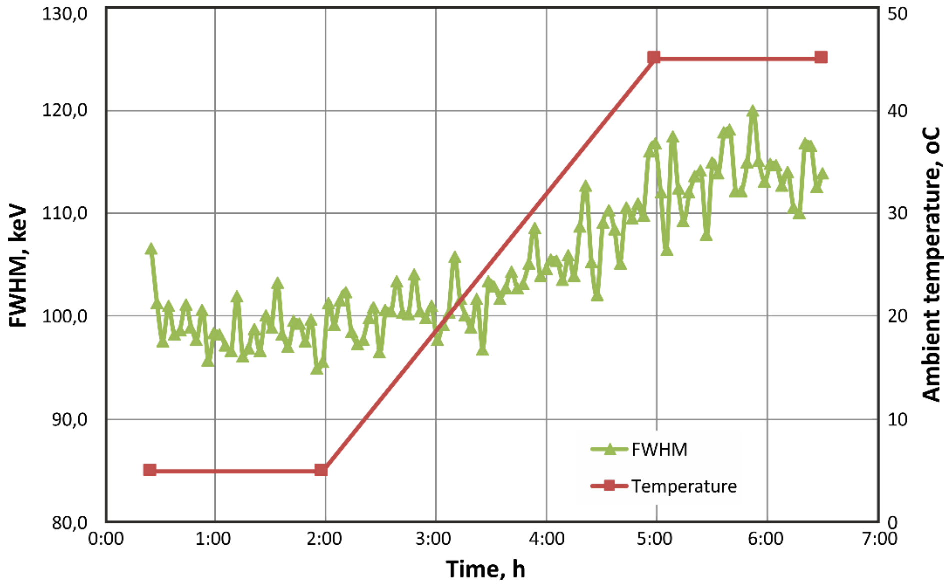

Fig. 5. Model DM-BGO energy resolution (FWHM) at ^{137}Cs line vs. continuously variable temperature.

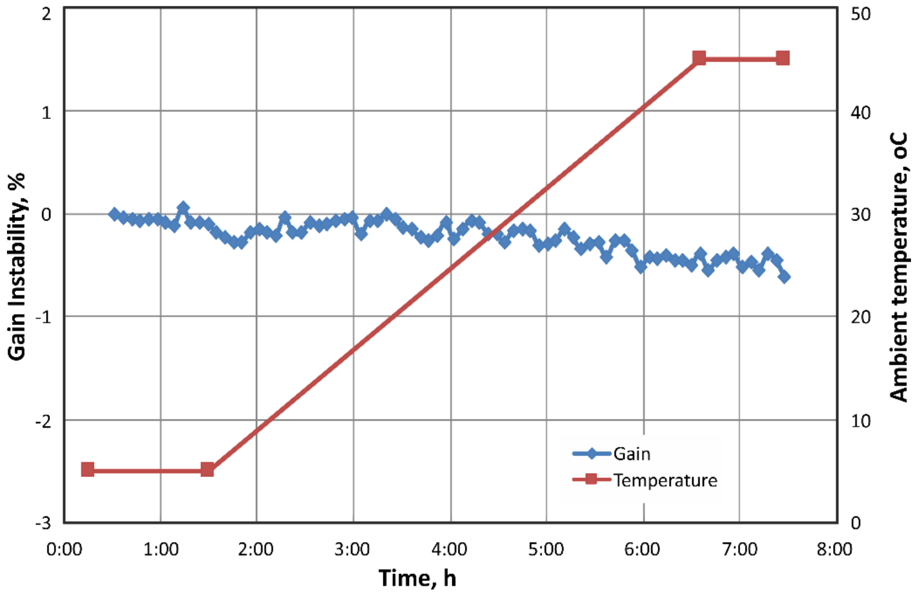

Fig. 6. Model DM-CSI gain instability at ^{137}Cs line vs. continuously variable temperature.

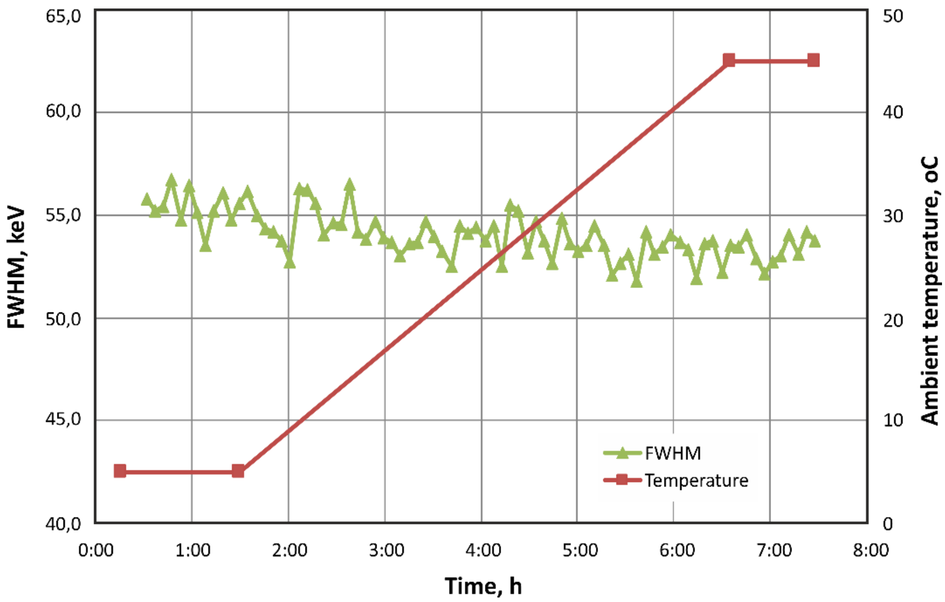

Fig. 7. Model DM-CSI energy resolution (FWHM) at ^{137}Cs line vs. continuously variable temperature.

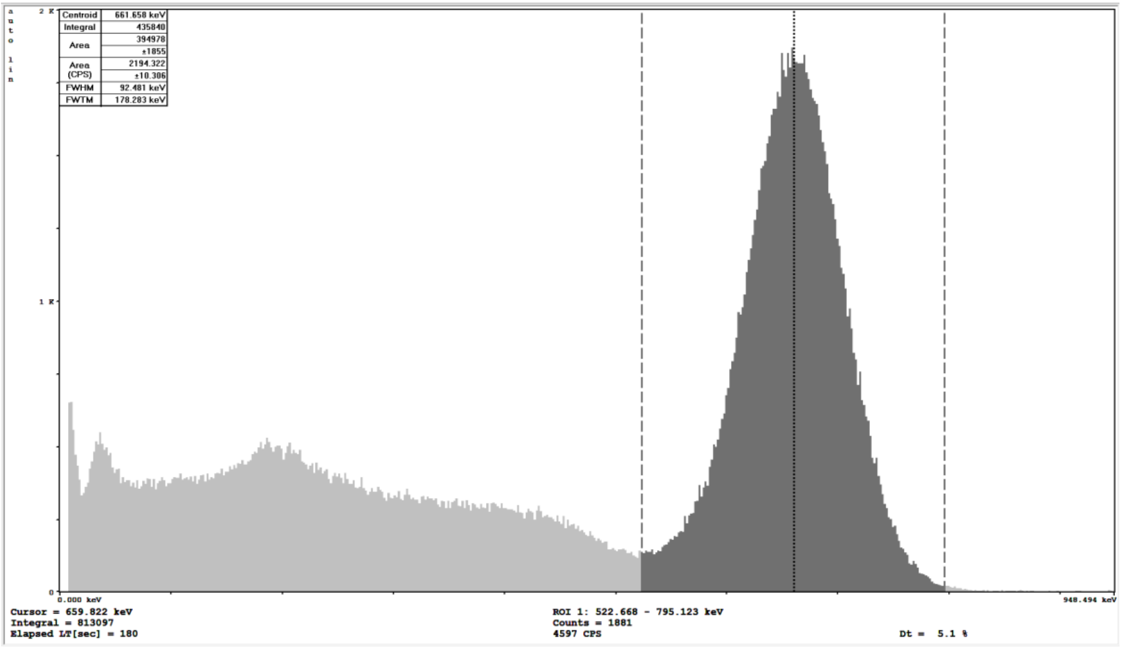

Fig. 8. Typical spectrum ^{137}Cs measured Model DM-BGO.

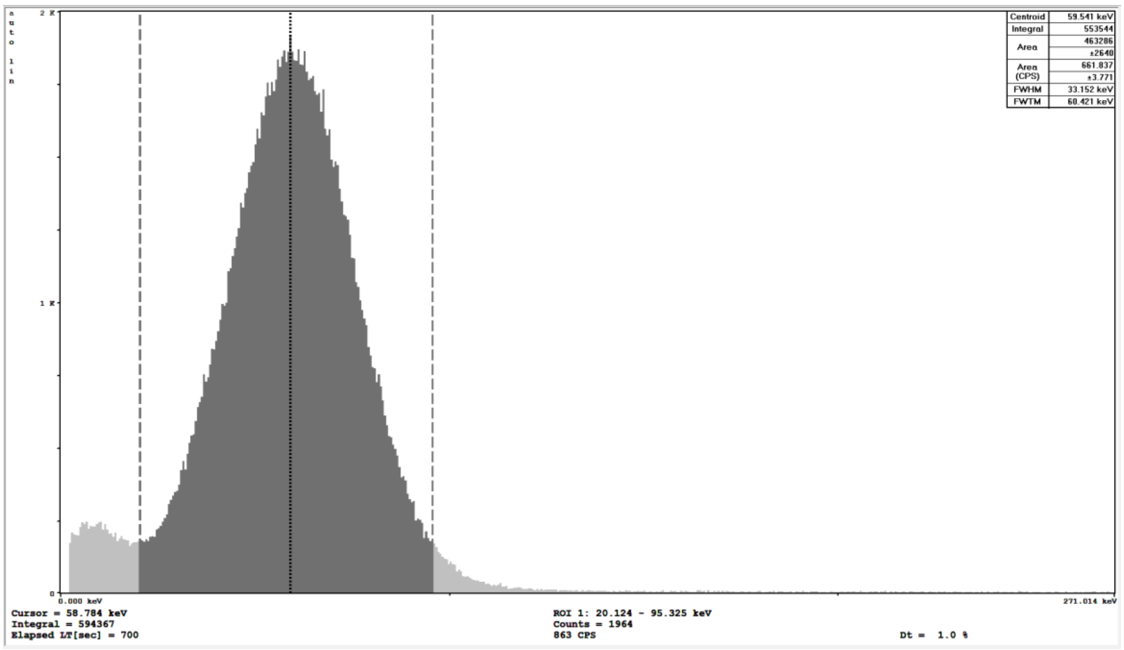

Fig. 9. Typical spectrum ^{241}Am measured Model DM-BGO.

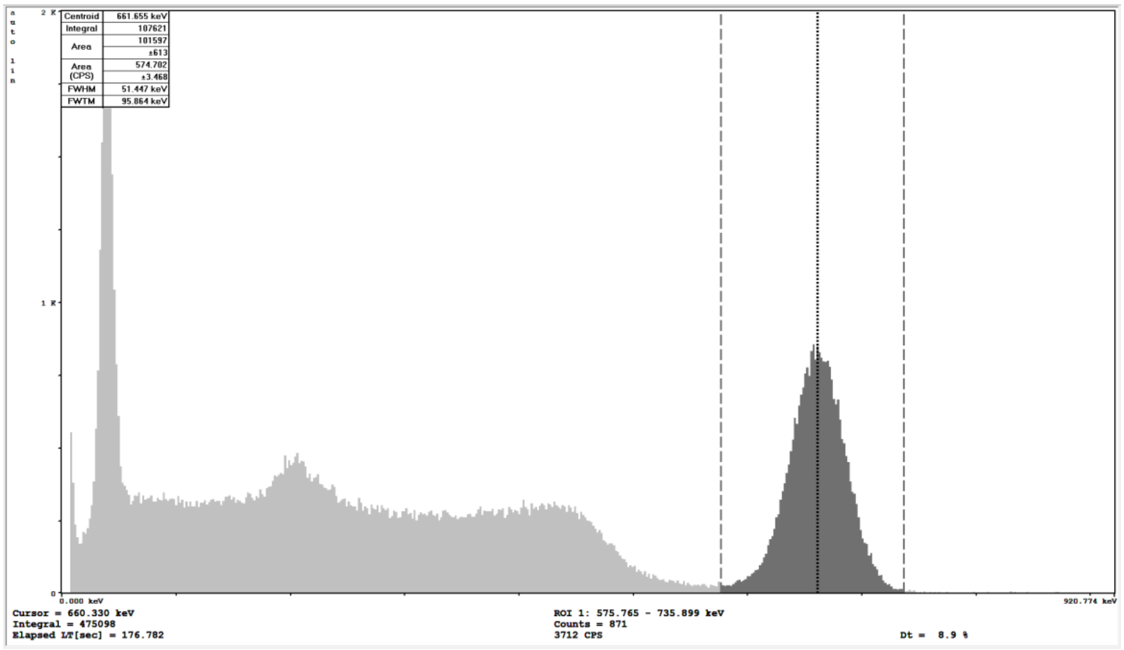

Fig. 10. Typical spectrum ^{137}Cs measured Model DM-CSI.

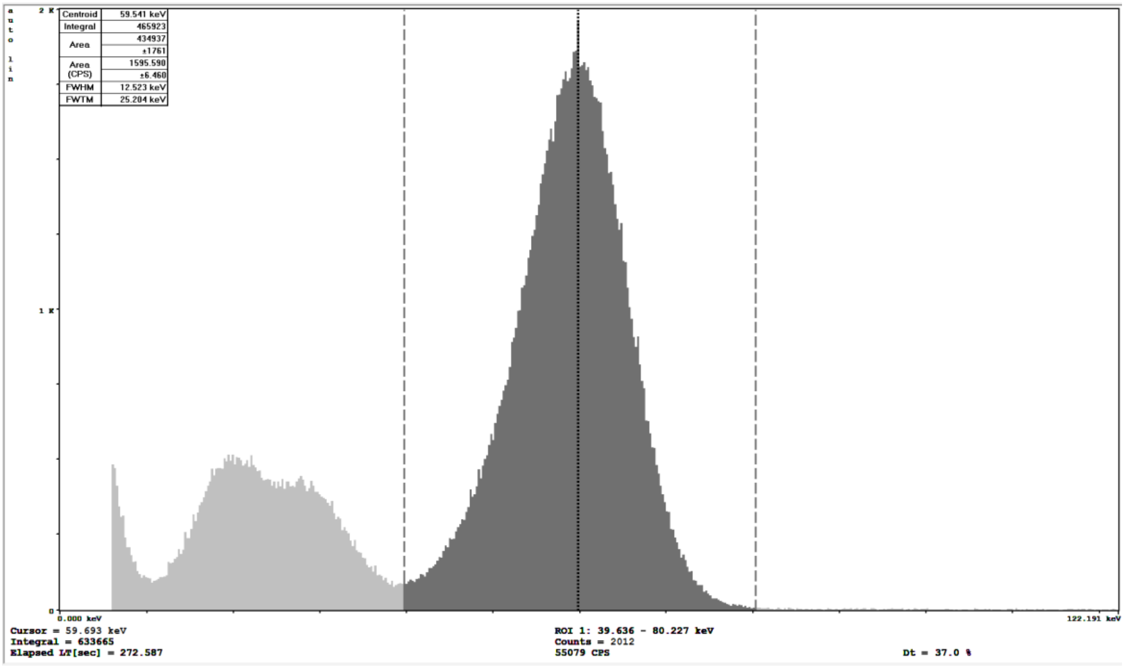

Fig. 11. Typical spectrum ^{241}Am measured Model DM-CSI.