LARGE VOLUME HEMISPHERICAL NUCLEAR RADIATION DETECTOR CZT/500(S)

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ILLUSTRATION

1. INTRODUCTION

The CZT/500(S) is a nuclear radiation detector based on CADMIUM ZINC TELLURIDE - CdZnTe, a large bandgap semiconductor materials having a high atomic number and high density, which makes these detectors one of the most sensitive small size room temperature operation detectors.

The CZT/500(S) is spectrometric detector intended for gamma radiation registration in a range of an energy registered more then 60 keV.

Availability of the letter “S” in the detector's name means Super Grade (detector with high spectroscopy performance) detector CZT/500S.

Outward appearance of the CZT/500 is shown in fig.1.

Fig. 1 - CZT/500.

Typical spectrum of Cs^{137} measured with CZT/500 is shown in fig. 2.

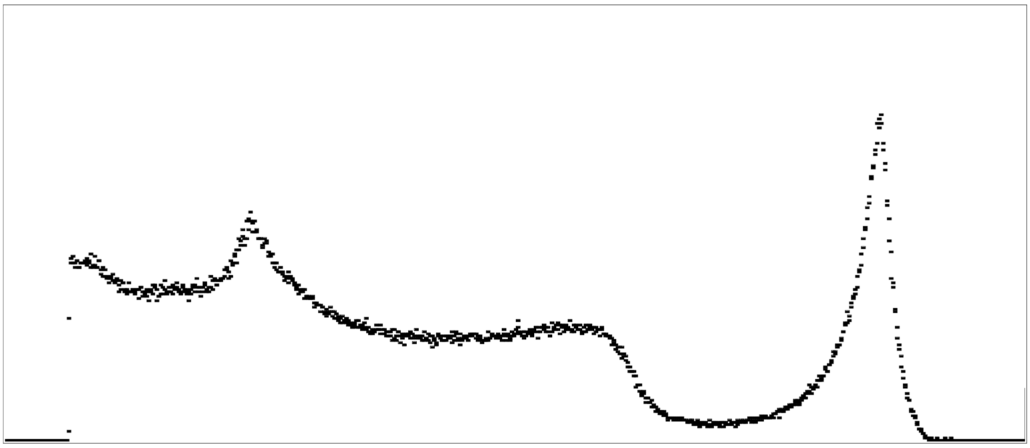


Fig. 2 - Spectrum of Cs^{137} measured with CZT/500.

2. SPECIFICATION

Basic

- detector type .... CdZnTe
- detector geometry.. quasi - hemispherical
- detector sensitive volume ....500 mm^3

Performance (at operation temperature +22 °C)

- energy resolution (FWHM) at 662 keV line

for CZT/500..≤ 30 keV
for CZT/500S ....≤ 18 keV

- peak-to-Compton ratio at 662 keV line

for CZT/500..≥ 2.3
for CZT/500S ....≥ 4.0

Bias voltage requirements

- detector high voltage .... ≤ 1500V
- detector high voltage polarity..positive

Dimensions

- diameter ....23 mm
- length (without connector) ....33 mm
- distance between a top plane of the housing cover
  and sensitive surface of the detector ....7 mm

Connector ....BNC type

3. DESIGN FEATURES OF CZT/500(S)

The CZT/500(S) design features are shown in fig. 3.

The detectors consist of CdZnTe detector, watertight housing and connector.

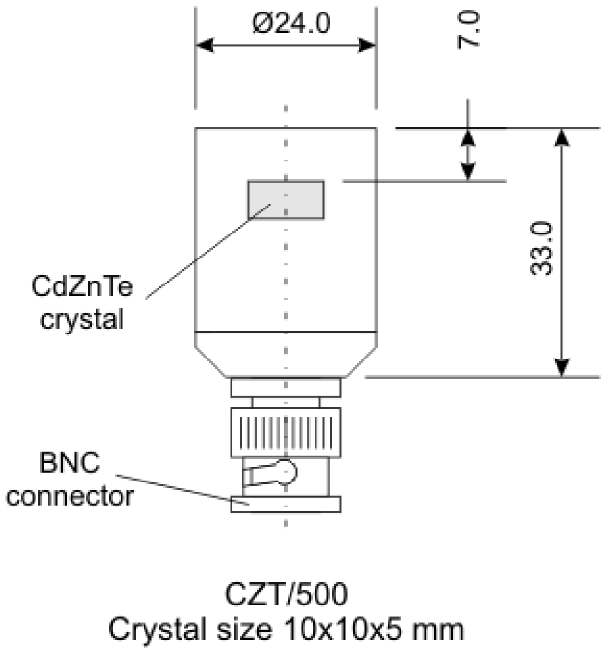


Fig. 3 - Design features of CZT/500(S).

4. SAFETY AND PRECAUTION

Equipment Precautions:

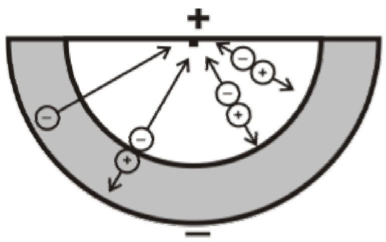
- The CZT/500(S) must be connected to the **POSITIVE** high voltage supply.
- The detector housing is fragile and should not be strongly squeezed.
- When possible, use radiation shield and (or) collimator or maintain the detectors a distance from strong neutron-gamma sources for prevention of detector and connector's insulator radiating damages.
- Decontamination or cleaning of detectors can is carried out with water or other non-corrosive liquids.

Radiation Dose Caution:

- The detector should be routinely checked for contamination and decontaminated if necessary after use to avoid possibility of radioactive contamination.

5. THEORY OF THE HEMISPHERICAL DETECTOR OPERATION

The resolution of the wide band semiconductor detectors, such as CT or CZT detectors optimized by choosing a small hemispherical crystal geometry with a positive contact at the center of the flat surface and the outer spherical surface grounded (see fig. 4). The electric field is essentially radial and therefore much stronger near the positive contact. Assume first that only electron charge collection occurs with no appreciable electron carrier trapping. The pulse that is registered from a photoelectric event with a constant number of electrons produced would arise mainly from the induced charge from the electron carriers traversing the high field region. Even so, gamma photoelectric interactions in the lower field region (cross hatched) constitute the majority of the peak area (cross hatched) since this is where the majority of the detector volume resides. The electron carriers from throughout the detector volume drift toward the positive electrode reaching their highest velocity near the positive electrode. The electron collection time is less then 0.5 μs.



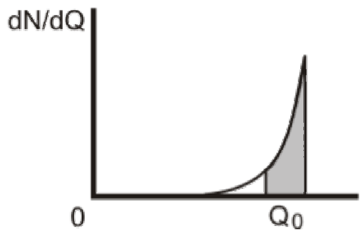


Fig. 4 - Cross sectional view of a hemispherical detector showing the drift of electrons toward a positive “point“ electrode and the resulting induced charge pulse. The majority of the induced pulse arises from electrons originating in the cross-hatched region of the hemisphere.

The pulse height from a gamma interaction does not appreciably depend on holes collection due both to the hemispherical geometry and the short pulse shaping time. This is fortunate since hole drift velocities are an order of magnitude smaller causing hole collection time to be typically 5 μs and hole trapping to become important. The hole pulse height contribution tends to be very small since few holes traverse the high field region drifting rather toward the negative hemispherical surface electrode, thus a far smaller pulse is induced and the pulse shaping time of about 1 μs “clips“ this pulse contribution well before it reaches its full height. The 1 μs shaping time does no clipping to the electron collection signal. The CZT or CT detector resolution is limited primarily by trapping of holes due to impurities and inhomogeneities in the crystal.

Manufacturing of detectors with ideal hemispherical geometry is labor-consuming process. Therefore in detection units are used quasi-hemispherical detectors. The appearance of such detectors is shown in fig. 5. Researches have shown that the replacement of ideal hemispherical geometry of the detector on quasi-hemispherical a little bit worsens the spectrometer performance.

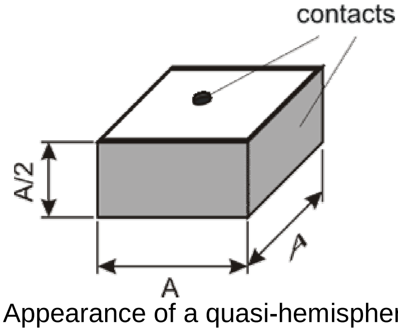


Fig. 5 - Appearance of a quasi-hemispherical detector.