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Response of Bromide-dopped Cesium Iodide Scintillating Cristals to Alpha and Gamma Radiation

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1. Introduction

Cesium iodide scintillating crystals are very well known and widely used as detectors for high energy radiation. Their characteristics of low hygroscopicity, easy handling, high atomic number of its atoms and low scintillation decay times make them very suitable for various applications. These properties can be further manipulated by the addition of dopants, with thalium and sodium being some of the most common among them due to the increase in light output they bring to the crystal. Another less explored alternative is doping the crystals with bromide, which, at the cost of reducing light yield[1], can decrease the scintillation decay time[2] when compared to those of Tl- and Na-dopped ones[3]. Among the many uses of such devices, detection of gamma and alpha radiation is consistently one of the top applications given the abundance and importance of such radiations in modern technology. Thus, the characterization of a potential detector material in such applications is of great importance for the field of high energy physics and similar studies.

2. Methodology

High quality and high purity CsI (99.99%) and CsBr (99.99%) raw materials in powder forms were obtained commercially. The cesium iodide salt was weighed and then added to a quartz crucible, then cesium bromide was added with a concentration of 10^{-2} M in relation to CsI. The quartz crucible was taken to the vacuum line at 10^{-5} Pa and heat treated to remove moisture from the salts. In this procedure, a temperature of 200 °C was applied for 4h.

0.05% of metallic iodine was added in granules in relation to the mass of CsI. For this procedure, a glovebox was assembled, which was filled with argon gas in order to leave an inert atmosphere, without the presence of oxygen. After inserting the iodine, the crucible was taken to the vacuum line until it reached 10^{-5} Pa and then sealed.

After being sealed, the crucible was taken to the vertical oven for crystal growth using the Bridgman technique. The thermocouple was coupled to the crucible in order to monitor the temperature variation in the furnace. The crucible moved to the hottest area of the oven, where it remained until all the salt was melted. After the salt was melted, oven programming began. The crystal growth process using the Bridgman technique requires special care in preparing the starting material, carefully choosing the material from which the crucible is made and its geometric configuration and growth speed. This process lasted 96 hours, in which the quartz crucible was moved to the coldest area of the furnace, the entire process had a speed of 1mm/h.

After growth, heat treatment began, transferring the CsI:Br crystal with dimensions of Ø 26 mm X ↑ 40.60 mm to a clean quartz tube. In this procedure, a continuous vacuum of 10^{-5} Pa and a temperature of 350 ^{o}C were used for 24 h. Figure 1 shows the CsI:Br crystal before and after heat treatment.

After heat treatment, the crystal was cut with the Buehler cutting equipment, ISOMET 11-1180, with a disc with a diamond edge and ethylene glycol P.A. ($C_2H_6O_2$) for lubrication. The crystal was cut in



Figure 1: CsI:Br crystal before (left) and after (right) the heat treatment.

dimensions of 24,0 mm in height and 26,8 mm in diameter (the crucible's internal diameter). The cut was made slowly, avoiding mechanical shocks. Then, Sontara material (DuPont), a highly absorbent and resistant non-woven fiber, composed of 70% viscose and 30% polyester, was used to polish the crystal. To carry out the polishing, the Sontara was used together with ethylene glycol, used as an abrasive, to facilitate polishing, on a flat glass plate, on which light movements were made in the shape of a "figure of eight". This movement is important so that the crystal has an uniform surface. This process was carried on until both faces of the crysal were deemed sufficiently transparent and uniform. The sides were left as they were.

For the measurements, an RCA 8575 21 pins photomultiplier tube was used. The crystal was wrapped in commercial teflon tape to maximize internal reflection, leaving only the side directly coupled to the photomultiplier open, with silicone grease as interface. This end of the tube was then covered with a heavy black plastic. Figure 2 shows this setup. This was then coupled to an Osprey multichannel analyzer connected to a computer where the signal was analyzed with the Genie software. The sources used were ^{133}Ba, ^{109}Cd, ^{137}Cs, ^{22}Na, ^{65}Zn and ^{60}Co for gamma and ^{241}Am for alpha.

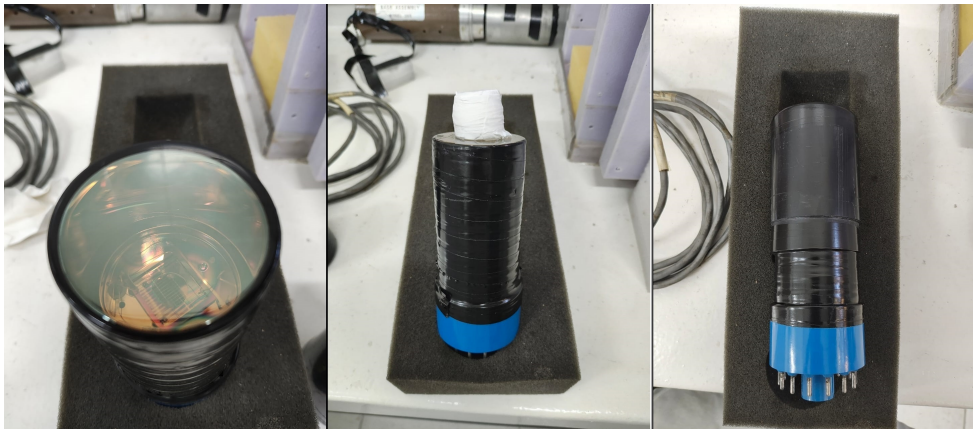


Figure 2: The setup for the coupling of a crystal and the photomultiplier tube.

3. Results and Discussion

Figures 3 and 4 show, respectively, the results of the gamma and alpha spectroscopic measurements.

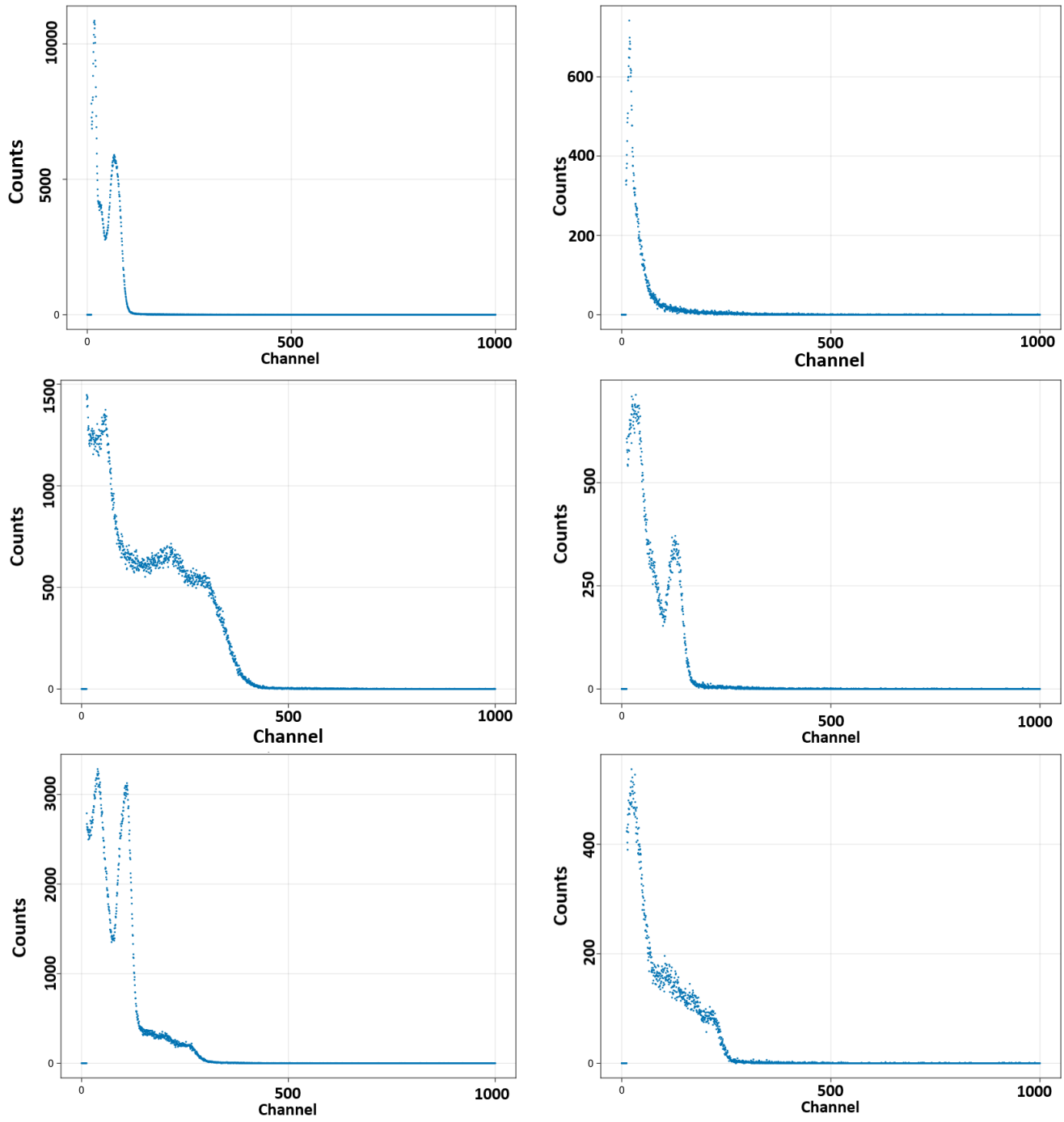


Figure 3: Gamma spectroscopy results for ^{133}Ba (top left), ^{109}Cd (top right), ^{60}Co (mid left), ^{137}Cs (mid right), ^{22}Na (bottom left) and ^{65}Zn (bottom right).

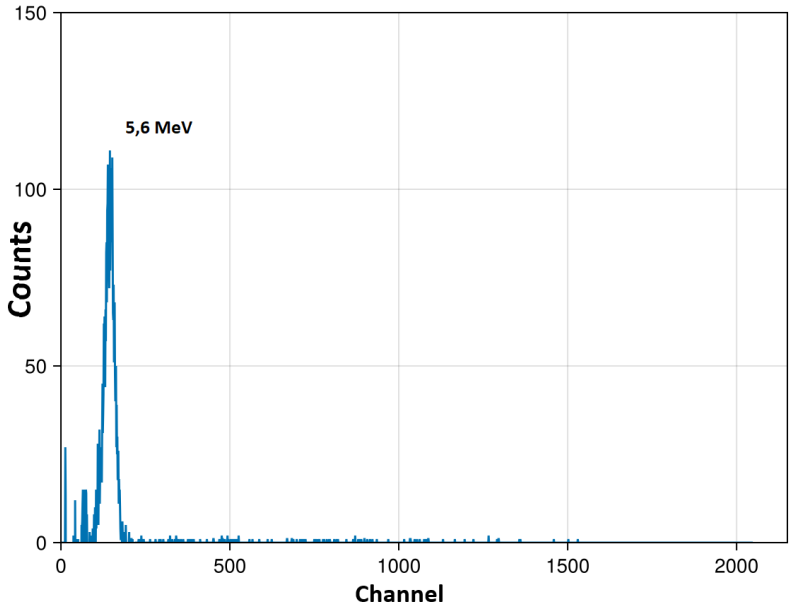


Figure 4: Alpha spectroscopy for ^{241}Am.

4. Conclusions

The results show a general tendency of low response for higher energies but a better one for lower and middle cases, though it also shows a somewhat lacking resolution even in these cases, as can be seen by the fact that the energies of 276,4, 302,9, 356,0 and 383,9 keV from ^{133}Ba show up as a single peak. As for the alpha, shows a well-defined and intense single peak corresponding to the 5,48 MeV emission of the ^{241}Am atom.

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