Using a Compact Scintillation NaI(Tl) Detector to Study the Environmental Radiation

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Abstract

There is a possibility of using a compact scintillation NaI(Tl) detector, long-term stable and reliable, to monitor the components of the environmental radiation, in the range 0.28-2.8 MeV. The energy spectra recorded at physics department – Lattakia show the peaks are due to very low energy secondary cosmic radiation and to the airborne radioactivity. No anomaly radiation was detected. These results are achieved with cooperation of physical group in Bologna University - in Italy.

Keywords: Secondary cosmic radiation – environmental radiation – scintillation detector.

Introduction:

The environmental radiation (ER) [1,2] originates mainly from the most degraded secondary cosmic rays, airborne radioactivity, the surrounding material and from the detector itself. It gives an energy, which can be exceed more than 50keV [1-11], by an organic or inorganic scintillation detector.

The real time monitoring of the ER, raises warning in real time of possible radiation anomalies of artificial origin (nuclear reactor accidents, nuclear bombs, pollutants, ..etc.) or astrophysical and physical origin (solar flare effects, solar activity). It is surely important for those activity to distinguish between the ER in itself and the background radiation because it can seriously interfere, for instance, with the operation of a health diagnostic apparatus.

Experimental Method:

The detector used belongs to Bologna University, it was borrowed by Tishreen University – Physics Department – for more than six months. A sketch of the structure of scintillation detector is shown in fig.1.
Figure (1): Drawing of the detector. The NaI(Tl) mono-crystal, together with its PMT are embedded in a box of thermal insulator [1, 7, 8]

The monocystal of NaI(Tl), which has a diameter of 8" and a height of 4", has been supplied by Bicron Corp., New bury (OH, USA), the scintillations of the crystal are seen through a light guide by a photomultiplier tube (PMT) of 5" diameter also supplied by Bicron Corp. The PMT is surrounded a multi-metal shield in order to avoid gain variation due to the varying magnetic field. The PMT photocathode is electrically connected to its metalized glass and to the multi-metal shield.

The output signals from the PMT are sent to a charge preamplifier and energy analyzer. The energy analysis is obtained through a multichannel analyzer of 1024 channels of variable width, 7.5-100 keV/channel.

The important feature of the detection system is its time stability. It has been achieved by a back-feed gain control based upon the electric pulse height, corresponding to a photoclectric gain. After fixing the channel in which the peak is desired to be, the possible variations of the corresponding pulse height are recognized and corrected by electronic by means of a feedback on the high voltage supply of the PMT. In our case we have considered the peak corresponding to the 1.461 MeV gamma line of $^{40}$K, naturally present in the surrounding solid material and in the detector itself. By this system the overall pulse height gain can be stabilized within a few permil, as shown in table 1.
Using a Compact Scintillation NaI(Tl) Detector to Study the Environmental Radiation

Table (1): The pulse height stability relation to the photo peaked $^{40}$K and $^{208}$Tl for all the 191 hourly spectra of the considered interval.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>$\gamma$ - line energy</th>
<th>$^{40}$K 1.461 MeV</th>
<th>$^{208}$Tl 2.615 MeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order number of channel (14keV/channel)</td>
<td>103;104;105</td>
<td>181;182;183;184;185</td>
<td></td>
</tr>
<tr>
<td>Frequency of order number</td>
<td>0;576;0</td>
<td>0;42;477;7;6</td>
<td></td>
</tr>
</tbody>
</table>

Results and Discussions:

Fig. (2). shows, in decimal semi-logarithmic coordinates, the behaviour of the average spectrum and also of the minimum and the maximum spectra in the energy interval corresponding to channels n = 16 to n = 200 with 14keV/channel, obtained during the time interval 00:00 h May 1994 to 24:00 h 9th June 1994, altogether 191 three hourly intervals; the monitor was located on the roof of the building of the Physics Department of Bologna University, under a layer of material not greater than 2g/cm$^2$ [3,4,12,13].

![Graph showing three hourly pulse spectra for channel interval 16 to 200.](image)

Fig. (2). Three hourly pulse spectra for channel interval 16 to 200.
Some Measurements at Physics Department – Tishreen University:

The detector used can be easily dismantled and assembled. The upper shield surrounding only the NaI crystal can be easily removed. It was put in the first floor at Physics Department near the window. The PM high voltage supplied by the ACQ card coupled to a personal computer is very stable. It can accumulate 2048 channel every minute with tunable energy resolution. On-line programs allow a quick look analysis and graphical inspection of data collected in different pre-set energy bands. In fig. 3 we present the data acquisition during the period 21/03/2001 to 20/5/2001.

![Graph showing data acquisition](image)

**Fig. 3.** Plot of the data acquisition quick look for two months, each point represent a spectrum, and each data for 15 minutes.

For the calibration of the detector, we used two sources: the first is $^{40}$K, and the second $^{208}$Tl, were positioned on the detector to allow adjustment of the $^{40}$K photo peak and $^{208}$Tl photo peak positions in the spectrum by means of the feedback device which provided adequate correction to possible deviations of the HV of the phototube. It has therefore been possible to the $^{40}$K photo peak, $^{208}$TI photo peak, absolutely stable at the same channel of the spectrum for the entire duration of the experiment.

![Graph showing energy spectrum](image)

**Fig. 4.** Energy spectrum of gamma radiation detected by the detector, 2.8keV/channel.
Using a Compact Scintillation NaI(Tl) Detector to Study the Environmental Radiation

Fig. 4. Shows the energy spectrum of gamma radiation in the energy interval (0-3MeV). The peak of 1.461 MeV gamma line belongs to $^{40}$K which is present in the surrounding solid material part and cement has about 2% of $^{40}$K. While the peak of 2.615 MeV belongs to $^{238}$U (one of the Thorium chain product) which is mainly due to the building material.

The other photo-peak corresponding to the $^{214}$Bi (934keV, 609.3keV) and $^{214}$Pb (351.9keV) daughter products from the $^{238}$U are easily identifiable. The second peak is due to $^{212}$Pb (238.6keV) and/or backscattered Compton photons. The first one is probably due to the counter Pb-flourescent X-rays at 77keV.

Conclusion:

The detector we have used for the continuous monitoring of the ER has provided its reliability being able to work continuously, but with the few interruptions due to human interference.

The analysis of the data collected is at present very preliminary and we hope to present an updated and more complete analysis in the future.

The main conclusion that the radiation detected is essentially due to cosmic radiation and to the airborne radioactivity. No anomaly behaviour was observed, which means the absence of artificial radiation sources, and hence, the Lattakia environment is safe and clean.

NaI(Tl)

أستخدم كاشف وبغي من نوع

لدراسة الأشعاعات البيئية

جهاد كامل ملحم و جيتو توقل جيتو

ملخص

تругد امكانية لاستخدام كاشف وبغي مدمج, NaI(Tl), فعلاً، ويتبعه ب الكريم استقرار طويل, لدراسة مكونات الأشعاعات البيئية. في مدى الطاقة 0.28-2.8 ميليون فيون فولت (MeV).

تظهر أفراد الطاقة التي تم تسجيلها، في قسم الفيزياء، في كلية العلوم (جامعة دمشق - اللاذقية - سوريا)، أن الخطوط الطيفية كانت نسبة الأشعاعات الكونية الثانوية والأشعاعات البيئية. ذات الطاقة المنخفضة. بالإضافة إلى ذلك، لم تكتشف أي أشعاعات غير طبيعيية.

إذا هذه النتائج التي نُعرّضها تم الحصول عليها بالتعاون مع المجموعة الفيزيائية في جامعة بولونيا في إيطاليا، التي تعمل في هذا المجال.

الكلمات المفتاحية: إشعاع كوني ثانوي - إشعاع بيئي - كاشف وبغي.
References