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A SIMPLE METHOD FOR DETECTING HIGH-ENERGY LOW-INTENSITY X-RAYS IN A LOW-ENERGY HIGH-INTENSITY X-RAY BACKGROUND

By

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ABSTRACT

The usage of a Cerenkov counter for the detection of x-ray photons is discussed. It has been shown that this method enables one to discriminate against any x-ray photons with energy less than some critical energy E_c.

In some plasma devices it is sometimes necessary to detect high-energy x-ray fluxes of relative low intensity on a high background of low-energy x-rays.

One usually uses the technique of scintillator counters and different absorbers that can discriminate among different components of x-rays according to their energies (Stratton, 1965).

Since it is known that Cerenkov counter can be used to monitor high fluxes of γ rays (Thomas et. al. 1957), we have investigated the possibility of using this technique to measure the energies of high-energy x-ray photons.

If a Cerenkov counter is exposed to x-ray photons with energy E, photo electrons with the same energy will be created inside the counter. When E satisfies the condition

$$E \geq E_c = \{[\frac{n^2}{n^2-1}]^{\frac{1}{2}} - 1\} mc^2 \qquad \ldots 1$$

(m is the rest mass of an electron and n is the refractive index of the counter) Cerenkov radiation will be emitted. X-rays with energy less than E_c will also produce photo electrons but no Cerenkov radiation will be emitted.

Since the refractive index can be varied from n = 1.93 (Double Extra Dense Flint) to $n \simeq 1$ using different materials, one can imploy this technique to monitor only the x-rays whose energy are greater than E_c (e.g. for Double

Extra Dense Flint, E_c = 60 KeV, for "Lucite", E_c = 180 KeV and for liquid N_2, E_c = 410 KeV).

For example, in a device at Cornell University in which a beam of electrons with energy of 350 KeV is trasversing a background gas we were able to use the above technique for discriminating against the high flux "low" energy x-rays and to detect only x-rays photons with energy ≥ 180 KeV (Figure 1). We have used "Lucite", $n = 1.49$, as our Cerenkov detector and the light has been detected by a RCA - 8575 photomultiplier tube. The signal was reduced by a factor of 6 when 1/8 inch of Lead was placed in front of the counter indicating an (average) energy of 250 KeV for the x-ray photons.

This technique is limited in applicability to cases where one has a high enough intensity of x-ray photons because of the low efficiency of the Cerenkov counters (Jelley 1958).

As an example, an estimate of the efficiency of conversion of x-ray photons to optical ones via the Cerenkov effect can be made by considering the following points:

1. The number of photo-electrons $I_{p.e.}$ emitted can be calculated from the relation

$$I_{p.e.} = I(1 - e^{-\mu x}) \qquad \ldots 2$$

   where: I is the number of x-ray photons, μ the attenuation coefficient for the production of photo-electrons, and x the thickness of the Cerenkov counter.

2. The range of electrons in a material can be calculated from the initial and the final energy (E_c).

3. The number of Cerenkov photons between 3000 Å and 7000 Å emitted per unité length is,

$$\frac{dN}{dx} = 490 \left(1 - \frac{1}{\beta^2 n^2}\right) \quad . \qquad \ldots 3$$

We have calculated that the efficiency of converting ~ 250 KeV photons to optical photons using Cerenkov counter made of Lucite of thickness 6 millimeters is 10^{-4} optical photon/x-ray photon.

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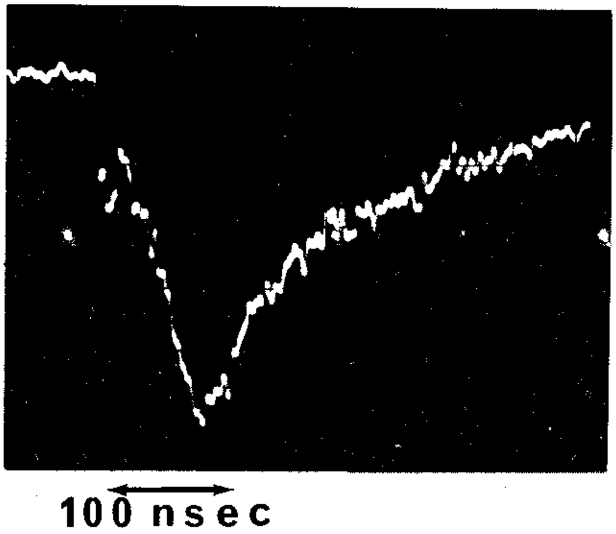

Figure 1. Signal from a Cerenkov counter radiated with high energy x-rays

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