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Physique Générale et Physique des Particules Elémentaires

Background distribution of the AMANDA PMT in the wave length shifter test set-up

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In PNPE 356 we showed the background signal distribution of the AMANDA PMT used for the wave length shifter tests. This distribution has been recorded with a blind screen in order that the Cerenkov light initiated by the selected CR's crossing the water tank could not reach the PMT. The description of the experimental set up and of the data reduction procedure can be found in PNPE 354. The high voltage on the PMT was set at 1775V.

Although the latter is operated in coincidence with the two scintillation counters selecting the CR's, the total number of counts is rather important (between abscissa 40 and 280: 3.15±0.01% to be compared to 8.87% with the 1cm diameter hole in the screen) and the distribution reveals some structure in the region around the single photoelectron signal.

These are true counts since the fortuitous coincidence rate is expected to be negligible:

- selected CR rate ≈ 1Hz
- PMT background counting rate ≈ 3500 Hz (above recording threshold)
- time resolution of the coincidence circuits ≈1μsec.

A plausible explanation is that we are dealing with CR showers with one of the partners being detected by the two scintillators and another one producing detectable Cerenkov light by crossing any material (water, gel, glass) in front of the PMT photocathode.

In Fig. 1 the background histogram of charge ADC counts relative to the total number of selected CR's has been displayed with the vertical scale expanded Two peaks, centered at channel ~110 and at channel ~210 corresponding to single and double photoelectron emission are clearly visible, the second one being somewhat broader as expected.

Fig. 2 shows the PMT signal distribution profile as calculated from the following formula[1]:

$$D(\mu,x) = N\left[0.1e^{-0.1x} + \sum_{n=1}^{10} \frac{1}{\sqrt{2\pi}\sigma\left(\sqrt{2}\right)^{n-1}} e^{-0.5\frac{(x-nm)^2}{2^{n-1}\sigma^2}} P(n,\mu)\right]$$

in which:

- the first term on the right side simulates the sharp peak at the lower end of the distribution;
- $P(n,\mu) = e^{-\mu}\frac{\mu^n}{n!}$ with μ, the average number of photoelectrons (which is proportionnal to the average number of detectable Cerenkov photons);
- m, the signal mean value from a single photoelectron (to be multiplied by the number of photoelectrons);
- σ, the standard deviation (to be multiplied par $\sqrt{2}$ for each consecutive photoelectron);
- N, an overall normalization factor to make the resulting curve directly comparable to the experimental background distribution .

[1] In the formula used in PNPE 351 (Profils de la réponse d'un PM d'AMANDA en fonction du nombre moyen de photoélectrons), the gaussian normalisation factor $\frac{1}{\sqrt{2\pi}\sigma\left(\sqrt{2}\right)^{n-1}}$ has been erroneously omitted.

It can be seen that the distribution profile represented on Fig. 2 gives a qualitatively good description of the background distribution in the region of the one- and two photoelectron peaks. It has been calculated with the following parameters:

- $m = 100$
- $\sigma = 30$
- $\mu = 2.9$
- $N = 3.46 \times 10^5$

In our test setup with a 1cm diameter hole in the screen, the parameter μ is at most equal to 0.16 as the single photoelectron peak only is visible, resulting from Cerenkov light emission by a 1cm portion of a CR track. Since μ, which is proportional to the amount of detectable light hitting the photocathode, is about 2.9 for the background, the average length of the Cerenkov emitting tracks would be of the order of 18 cm in water or shorter in denser material like the gel or the glass of the OM.

This makes our hypothesized scenario for the background phenomenon quite plausible.

Histogram PL2903 Blind Screen HT OM 1775V Fig.1

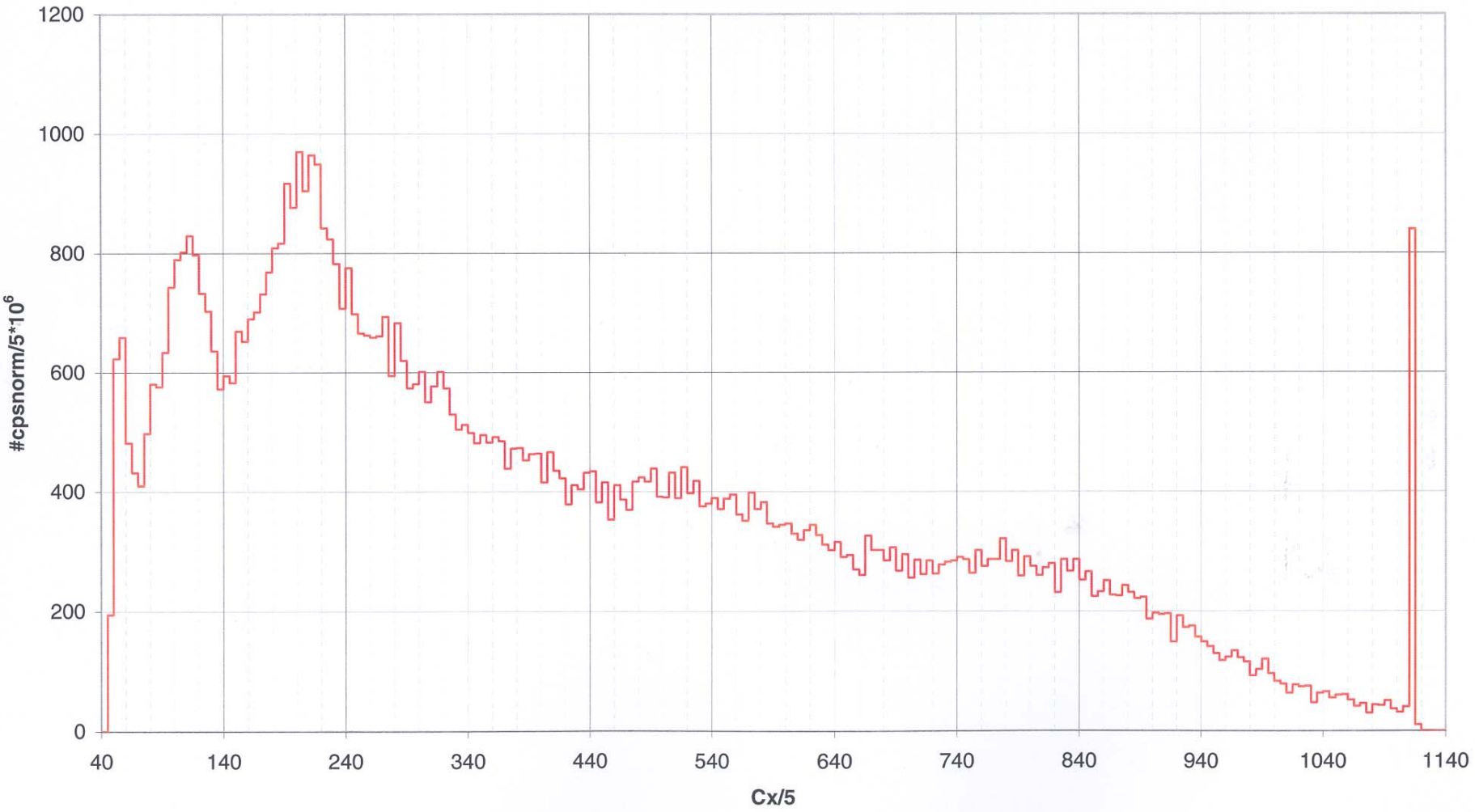

Fig. 2.