HPD: new UV detector for Imaging Air Cherenkov Telescopes


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Abstract

We propose to use a new large photocathodic area UV Rb₂Te HPD developed at CERN (TOM collaboration) as a detector well suited for IACT experiments. Some aspects of UV atmospheric transmission are presented.

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PACS: 95.55.Ka; 95.85.Pw; 96.40.Pq

Keywords: IACT; UV Cherenkov light; HPD

1. Introduction

CLUE [1] is an Imaging Atmospheric Cherenkov Telescope (IACT) array (9 telescopes) located at La Palma Island (2.2 km asl). The observation of the UV Cherenkov light of the atmospheric showers produced by VHE (10 GeV–10 TeV) cosmic- and γ-rays, allows IACT experiments to have long duty-cycle, to take measurement in brightly sky zones (like Milky Way Center) and to point directly to the moon. CLUE [2] has detected the class A (T. Weekes catalog) extragalactic VHE source AGN Mkn421 at 17σ significance level, using a Multi Wire Proportional Chamber (MWPC) in the range 190–220 nm as UV detector. The light yield by VHE atmospheric showers is suppressed by the ozone layer so that the number of signal photons on the mirror focal plane is relatively low (∼80 ph/m²@2.2 km asl). We are investigating the possibility to use a new large photocathodic area UV Rb₂Te HPD [3], developed at CERN laboratories, as a detector well suited for this kind of experiment. The most important characteristics of this detector are: high sensitivity to single photon, good photon counting capabilities, no dead zones on photocathode surface, good imaging properties and fast time response. The main characteristics of this new detector are described elsewhere in these conference proceedings [4].

2. Atmospheric transmission

The number of Cherenkov photons detected is the most important parameter for reconstruction
techniques used by IACT experiments to measure the CR and γR characteristics (direction, energy and type of particle). This number depends on two factors:

1) production mechanism: shower development and Cherenkov effect \( dN/d\lambda \propto 1/\lambda^2 \);
2) transmission of photons in the atmosphere: probability that a photon produced at a certain altitude reaches observation level \( P(\lambda, h) \).

Fig. 1 shows, the probability that a 200–300 nm photon produced at a relatively low heights \( (h \approx 10 \text{ km}) \) reaches observation level is not negligible. On the other hand Fig. 2 shows that the same probability for photons coming from the outside of the atmosphere is reduced to zero.

3. IACT experiment

Present IACT characteristic has allowed the identification of 2 γR sources (AGN) at Mpc distances (extragalactic sources). Many of these γR sources observed by space-based experiments like EGRET, have not been detected by ground based experiments like IACT. Taking into account the lower energy thresholds (~ keV) of the present space-based experiments with respect to the energy thresholds of ground-based experiments (~0.5 TeV) and the fast γR decreasing flux with increasing energy \( (\Phi \propto E^{-2.7}) \), it is clear that an energetic gap exists between 0.5 and 500 GeV where no experimental observation of this kind of source have been made. Observation of possible cut-off in γR extragalactic sources energy spectra together with the knowledge of their distances, give useful information on the models of propagation–absorption of γ radiation in the Universe.

For this reason among others, the main aim of the next generation IACT experiments is to lower the energy threshold from 0.5 TeV to few GeV. The lowering of the energy threshold implies the observation of atmospheric showers characterized by a lower number of photons on the detector of the experiments. For this aim an efficient trigger system and a good discrimination between Cherenkov signal photons and atmospheric background photons are necessary.

The Cherenkov light (SIGNAL) that hits the detector is always superimposed to the background light (usually called Night Sky Background (NSB)). It is possible to evaluate the S/N ratio between Cherenkov and NSB photons: as Fig. 3 shows, the S/N ratio increases with photon energy, however, taking into account that the longitudinal profile of the light released by a VHE
atmospheric shower has a typical maximum between 10 and 4 km [6] depending (logarithmically) on its energy, the signal UV light is not significantly less than visible light, see Fig. 4.

To compute the real $S/N$ ratio for a single shower it must be considered all the longitudinal light profiles and a model for the NSB that gives the amount of light at a certain wavelength and its height production; this model must distinguish the NSB produced inside and outside the atmosphere. It is also interesting to study how these quantities depend on observation height [7], considering that there is one proposal [8] concerning very big telescope at 5.0 km altitude.

Another important HPD characteristic is its high energetic resolution or good photon counting, see Fig. 5. This characteristic makes a simple, efficient and fast absolute calibration possible and it is effective in the choice of a precise trigger threshold even in the single photon case, moreover while working with a low number of photons on detector it is important to know with good precision the exact number of photons that hit single pixels.

4. Conclusion

We are investigating the possibility of applying the HPD detector to IACT experiment CLUE. We are performing MC simulations in order to know the overall characteristics of the experiment in this new configuration. Moreover we are considering the possibility to apply the HPD to IACT...
experiments with different characteristics (observation height, diameter and number of mirror). We are planning a first test on the CLUE site for the beginning of the year 2003.

References