THE ANGULAR RESOLUTION OF AIR SHOWER GAMMA RAY TELESCOPES

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A crucial characteristic of air shower arrays in the field of high energy gamma-ray Astronomy is their angular resolving power, the arrival directions being obtained by the time of flight measurements. An approach to the optimization of "air shower array-telescopes" has been recently discussed by J.Linsley (1). By using the small installation operating at the Plateau Rosà station (3500 m a.s.l.) we have studied the resolution in the definition of the shower front as a function of the shower size.

The apparatus (2) consists of four liquid scintillator detectors positioned at the corners of a rhombus (7 x 14 m diagonals, 8 m side). The detectors dimensions are 100 x 100 x 30 cm^3, each of them is viewed by two photomultipliers placed at two opposite corners.
The traversal of a particle is defined by the coincidence of the two photomultipliers and its arrival time by the mean of the two detection times (the discrimination is done in leading edge mode, at a 0.25 particle Level).An EAS is defined by a four-fold coincidence.
The timing resolution is obtained by measuring $\Delta T = T_1 - T_2$ (δT = 50 ps step), where T_1 and T_2 are the time of flights between the detectors placed at the vertex of two parallel sides.
Different shower sizes are selected by measuring the particle density on a central plastic scintillator (0.5 m^2 area, 15 cm thick), see Fig. 1. For given thresholds in the number of particles (N) on the central detector: the mean number $\bar{n}$ of particles on each 1 m^2 detector, the mean distance $\bar{r}$ from the shower core, and the mean primary energy $\bar{E}_o$, are calculated on the hypotesis of pure electromagnetic cascades.
Due to the tails in the timing distributions we have defined our errors as the half widths of the distributions at half maxima (HWHM). The measured HWHM of the response of an isolated detector to the trasversal of a single particle is S_{id} = 1.25 ns and that of the sole electronic system (including the rise time fluctuations of the PM s) is S_{ie} = 0.59 ns. Since we don't expect the temporal response of the detector being constant as a function of the number of particles on it, we have used for the instrumental uncertainties (S_i) the two extreme values S_{id} and S_{ie}. After subtracting from the HWHM (S) of the distribution of $T_1 - T_2$

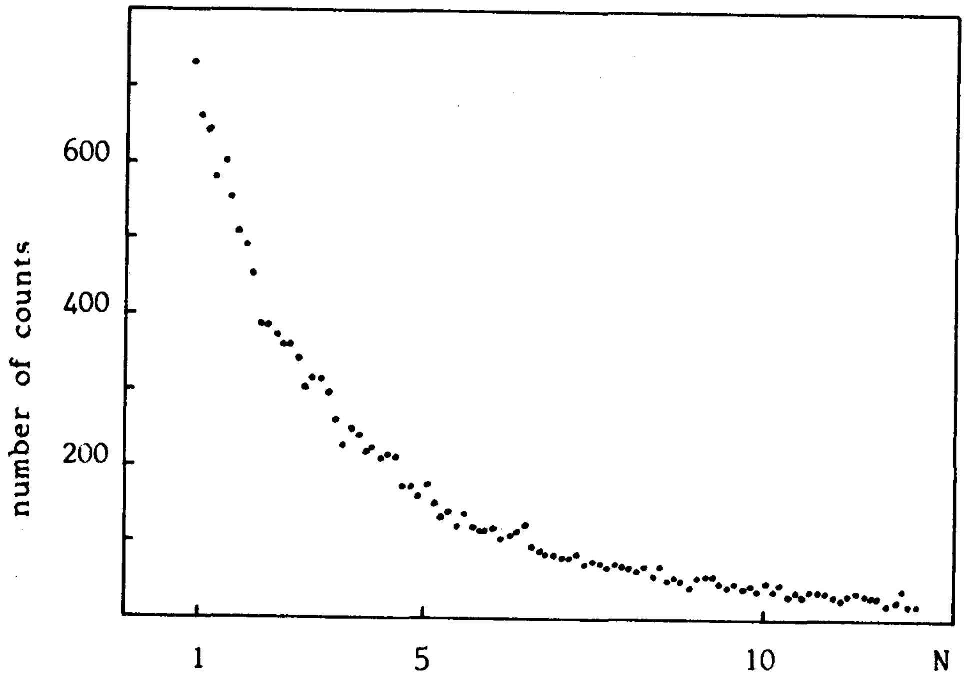

Fig.1: Pulse height spectrum of the central detector triggered by the fourfold coincidence. The cut on the left side is due to the ADC threshold.

such instrumental resolution, we obtain the physical limit to the accuracy in the definition of the shower front as a function of N. Fig. 2 shows such accuracies:

a) measured ($\sqrt{(S_N/2)^2 - S_i^2}$);

b) deduced from the resolution measured at the 1 particle level,

scaling by $1/\sqrt{\bar{n}}$ ($S_V/\sqrt{\bar{n}}$, $S_V = \sqrt{2\ (S_o/2)^2 - S_i^2}$);

c) obtained by using the Linsley's formula ($2.6\ (\bar{r}/30 + 1)^{1.5}/\sqrt{\bar{n}}$ ns, $\bar{r}$ in m)

agaist N, $\bar{n}$, $\bar{r}$, $\bar{E}_o$.

It can be seen that the trend of the measured resolutions as $1/\sqrt{\bar{n}}$ is verified inside the uncertainty of the instrumental dispersion and also the absolute values do not move much away from those obtained by using the Linsley's formula.

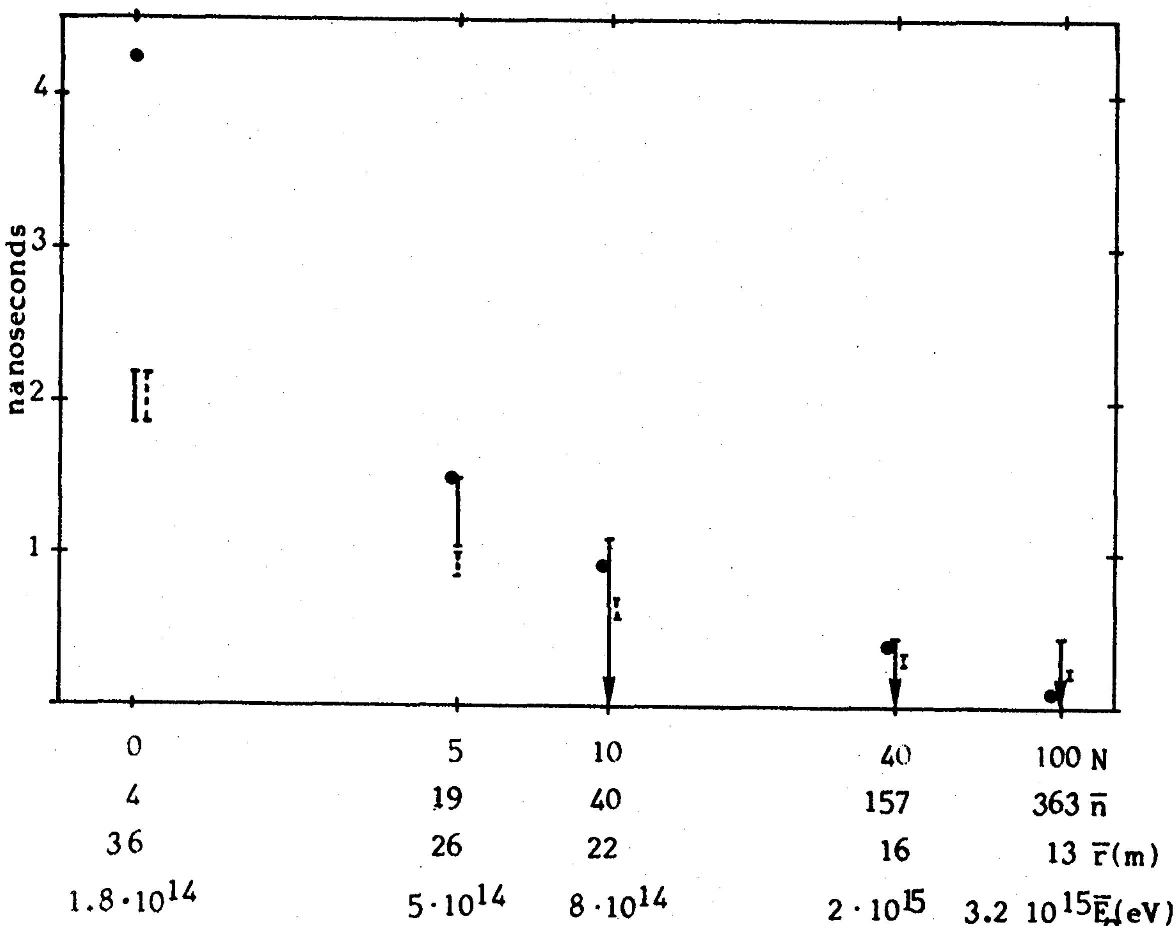

Fig.2: Accuracies in the definition of the shower front: a- continuous line; b- dotted line; c- full dots (see text).

At our atmosperic depth and by using detectors of 1 m^2 area an accuracy in the definition of the shower front St $<$ 0.5 ns can be reached at primary energies $\bar{E}_o \sim 2.10^{15}$ eV at a typical core distance $\bar{r}$ = 16 m.

References

1. Linsley J. (1984), Research Note UNML - 7/6/84, University of New Mexico, Albunquerque.

2. Morello C. and Navarra G., (1981), N.I.M., 187,533