TEST OF THE T3 DETECTOR

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1 Introduction

The following report summarizes the analysis of cosmic ray data taken between the 11^{th} and 12^{th} of December 2000. The main goal of this measurement was to debug the T3 hardware setup and to determine the detection efficiency of T3 detector (drift chamber) It was also considered as a preliminary test run and the collected experience will be used to design the test measurements of all drift chambers (T3, T4 and T5) scheduled for March 20-29, 2001.

2 Setup

As the trigger we used the coincident signal from two scintilators attached to the front-top site of T3 shielding frame. Fig. 1 shows measured inclusive hit distribution versus horizontal (X-view) and vertical (Y-view) direction and versus the plane position. Obviously, the number of hits decreased when the distance between scintilators and particular sub-module increased. Neverless, because the distance between the two scintilators was rather small (2-3 cm) there is only a small constrain on the directions of selected particle tracks and the active volume of the selected sub-module is approximately uniformly illuminated. This configuration was very effective for simultaneous test of all channels of electronics.

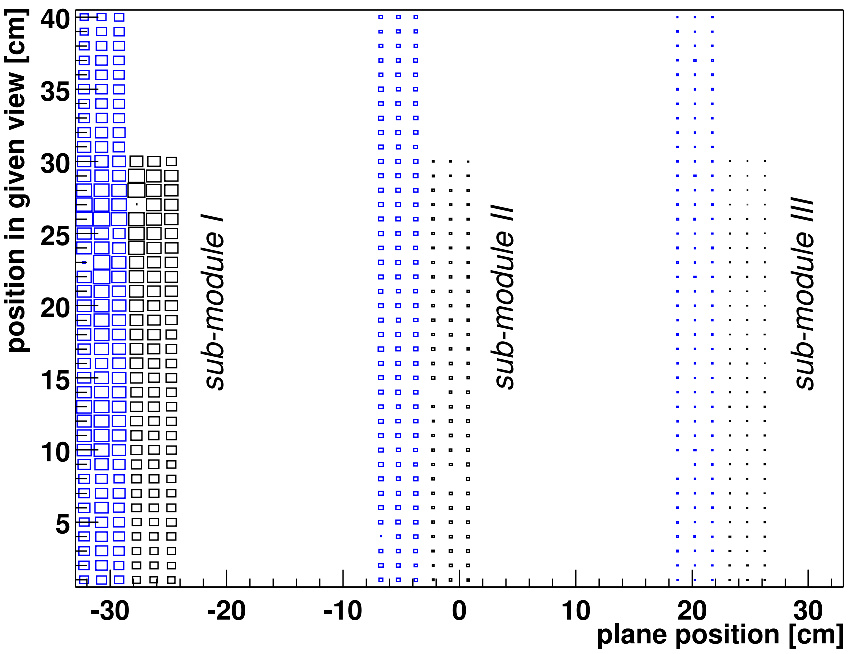

Figure 1: The blue and black colored histograms show the inclusive number of hits measured in the X- and Y-view, respectively. (This picture can be confusing as blue and black histograms refer to the perpendicular directions and are presented here as a parallel.)

3 Efficiency determination

One can select events according to the conditions:

(i) The number of hits in sub-module III (see Fig. 1) in Y-view is 3 or 4.

(ii) The position of the cluster in Y-view is between 2 cm and 10 cm (the reference frame is defined in such a way that the position of the lowest lying wire in Y-view is 1 cm).

The cluster is constructed from the required hits (3 or 4) and it's position is defined as the average position of the hits (in Y-view).

The hits distribution for such selected events is shown in Fig. 2. It is seen that the

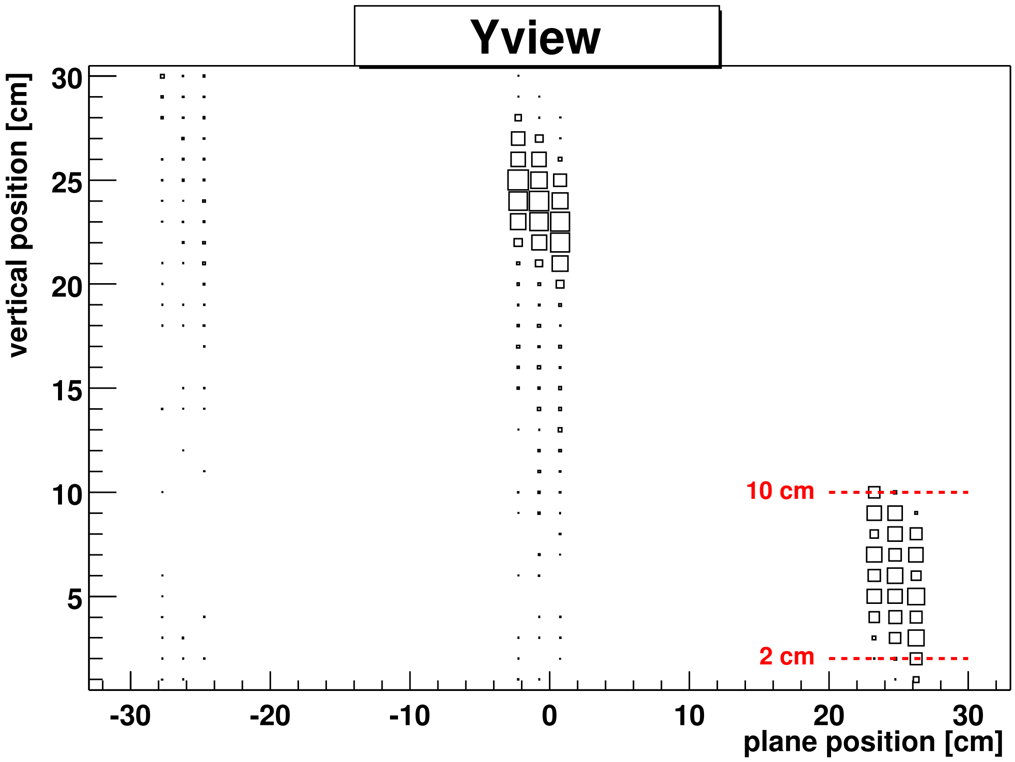

Figure 2: Number of hits for selected events. Red-dashed lines indicate the cut imposed on cluster position.

selected events contain one or more tracks that are within the geometrical acceptance of the middle sub-module (sub-module II), and therefore can be used to evaluate the detection efficiency.

Now, let us consider the hit multiplicity distribution measured in sub-module II when the conditions applied for event selection were as described above. In the ideal case, without presence of any noise, this distribution should be binomial with a mean value equal $N \times p$, where N is the total number of planes in sub-module ($N = 10$ for T3) and p is a probability of detection (detection efficiency). Figures 3, 4 and 5 present hit number distributions measured in sub-module II (black solid dots), in run number 2881, 2901 and 2903, respectively. The HV settings used in these runs (indicated on figures) were: 2200V for run 2881, 2250V for run 2901 and 2350V for run 2903. In runs 2901 and 2903 we used high threshold voltage $V_{th} = 5V$, but in run 2881 the

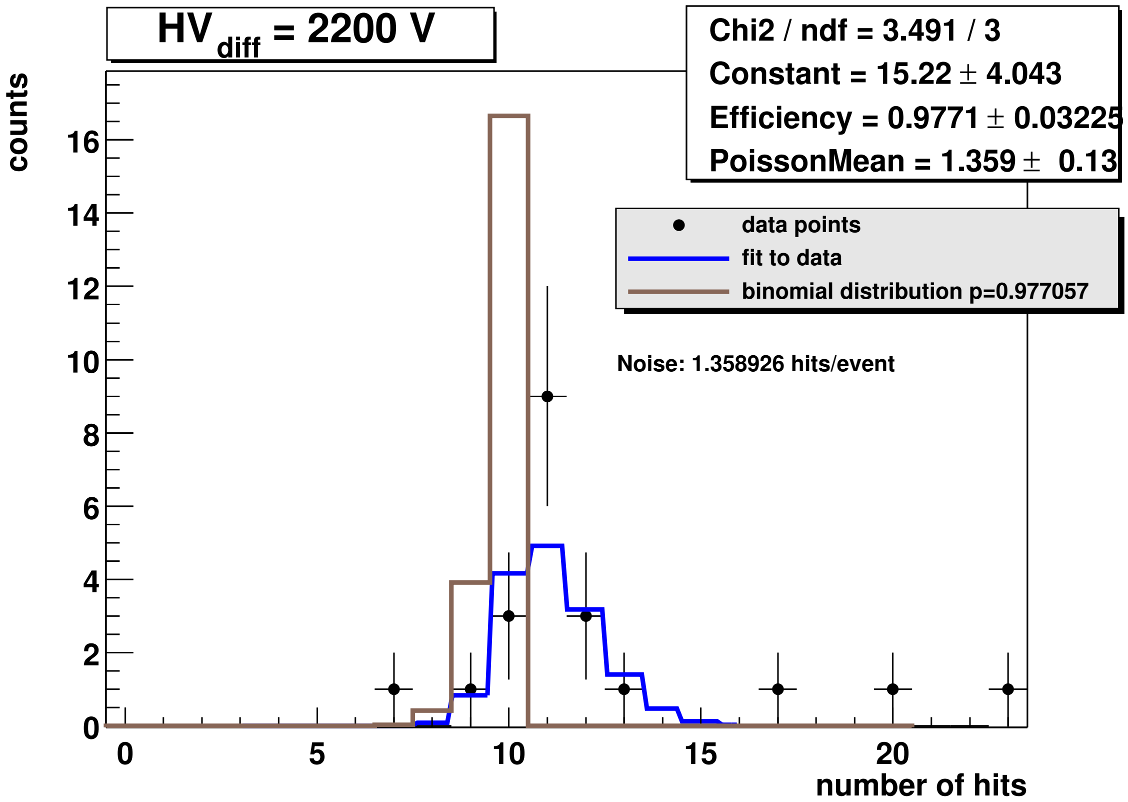

Figure 3: Hit distribution for selected events (black dots), blue colored histogram represents the fit to data points with convolution of binomial and Poisson distributions (see text for details). Brown colored histogram shows binomial distribution extracted from the fit.

threshold voltage was significantly lower: $V_{th} = 3.2$V. It is seen from the figures that the measured distributions have mean value above 10 and can not be considered purely binomial distributions. The most probable reason for this is the presence of noise which affects the observed distributions. It is assumed that the number of hits generated by noise is Poisson distributed. If it is so, a function that describes the observed distribution well can be constructed as a convolution of binomial and Poisson distributions:

$$N(i) \quad = \quad const \times \sum_{j,k;\, k+j=i} P_{binom}(j)\; P_{poiss}(k), \tag{1}$$

where $N(i)$ is the number of events with a number of observed hits equal i, j is the number of hits generated by a passing particle and k is the number of hits produced by noise. The probabilities P_{binom} and P_{poiss} are given by:

$$P_{binom}(j) \quad = \quad \binom{N}{j} p^j\; (1-p)^{N-j} \tag{2}$$

and

$$P_{poiss}(k) \quad = \quad \frac{\mu^k\; e^{-\mu}}{k!}, \tag{3}$$

where N is the total number of planes, p is the detection probability and μ is the mean value of the Poisson distribution (average number of hits generated by noise).

The blue colored histograms in Figures 3, 4 and 5 represent fits to the data points where the fitted function is given by equation 1. The fits provide the parameter p which

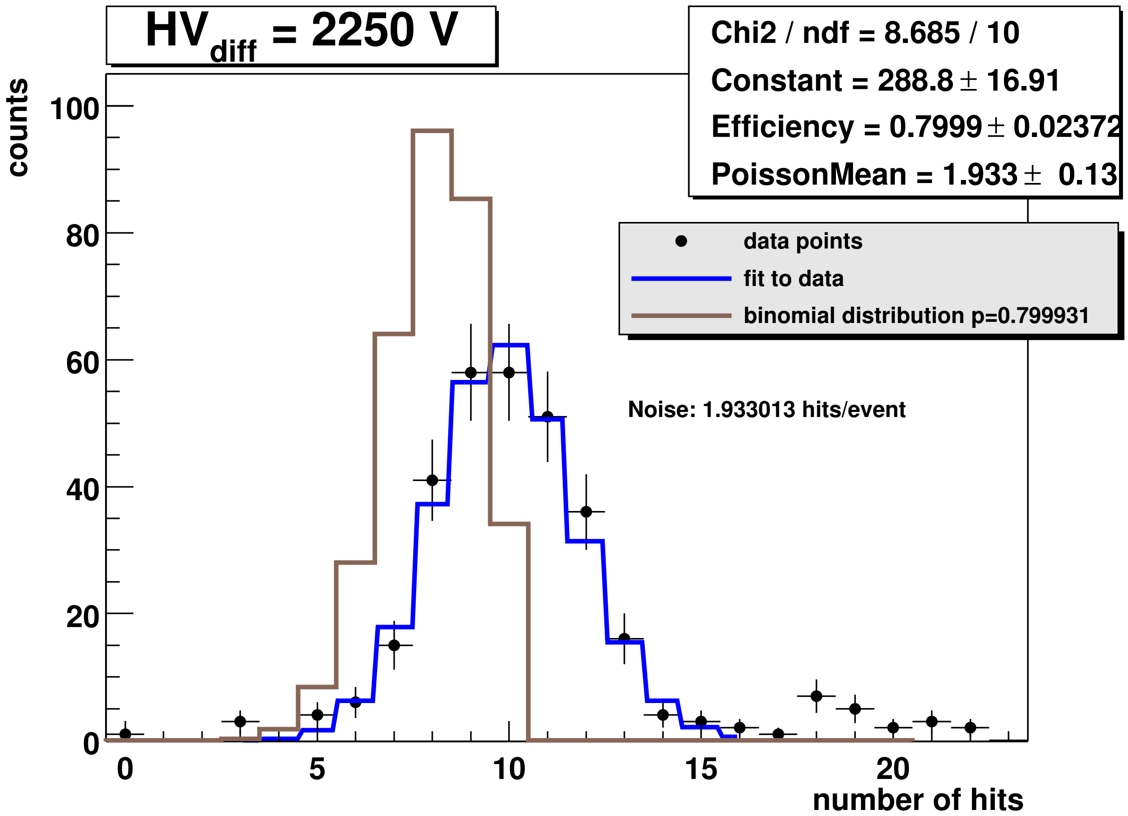

Figure 4: Same as for Fig. 3.

is the effective efficiency of sub-module II. For HV$_{diff}$ = 2250V and V$_{th}$=5V (run 2801) $p = 0.8 \pm 0.02$ for HV$_{diff}$ = 2350V and V$_{th}$=5V (run 2903) $p = 0.934 \pm 0.01$ and for HV$_{diff}$ = 2200V and V$_{th}$=3.2V (run 2881) $p = 0.977 \pm 0.03$. Additionally, fitting procedure allowed us to extract the average number of noise hits which is between 1.9 hits/event/sub-module (run 2901) and 1.36 hits/event/sub-module (run 2881).

4 Comments

Only the three runs presented here have statistics suitable for this analysis. Still, run 2881 has rather poor statistics and the fit may not be accurate (the data collection time for this run was 37 mins and 53 seconds). The errors quoted in the previous section are only statistical. In order to get feeling of how the extracted detection efficiencies depend on the form of fitting function we modeled the noise by an exponential, rather than the Poisson distribution described above. The extracted values of efficiency, compare to values presented in this note, are larger by 1% to 2% depending on the run studied.

During this short run we had not enough time to wait until the gas mixture (Argon+Izobutan+Alcohol) became stable, so the comparison of results obtained for different runs can be affected by changing gas conditions.

A detailed study of the geometry of the experimental setup indicates that some of selected tracks can be out of the acceptance of X-view planes of sub-module II. Thus, the detection efficiencies presented are probably underestimated.

The value p=0.977 obtained for HV$_{diff}$=2200 and low threshold voltage is close to the desired value $\simeq 1$ and is than the values obtained for higher HV and threshold level

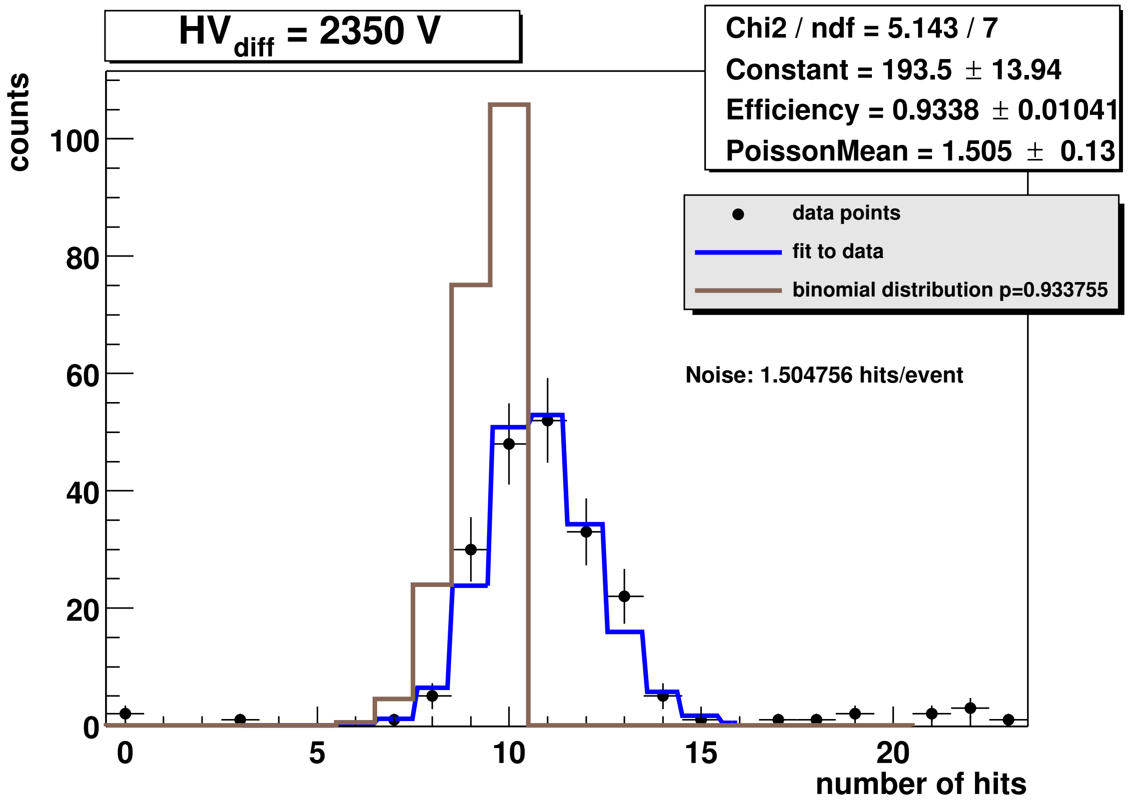

Figure 5: Same as for Fig. 3.

settings.

The important conclusion is that the geometrical setup used is a good choice for debugging of electronics (entire chamber is sufficiently illuminated) but is far from optimal for measurements of efficiency. For the next upcoming test measurements we are planning to use as a trigger two scintilators, one placed in front of the drift chamber and second just behind the drift chamber. The proposed setup will allow us to extract efficiency for each sub-module.