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Scintillators and VDC efficiencies for E01-012

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Abstract

In the process of generating cross sections, the performance of the detectors has to be evaluated. Thus hardware and software efficiencies are studied in order to correct the cross section. In this note, the scintillators and the vertical drift chambers (VDC) are examined in detail.

1 VDC: one-track efficiency

1.1 General

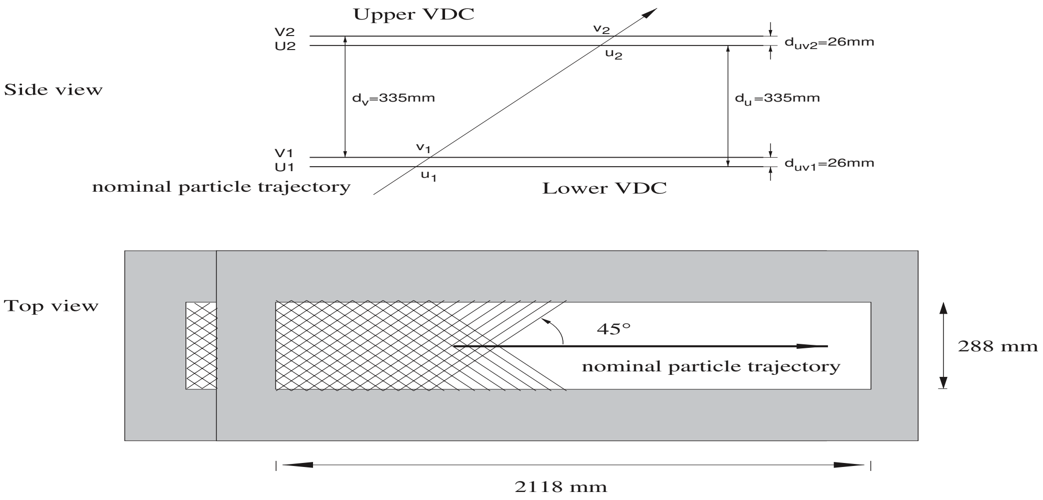

Figure 1: design [2].

In order to achieve a good resolution in position and angle, each spectrometer contains two vertical drift chambers (VDC). Each drift chamber is made of two sense wire planes (368 wires per plane) in a UV configuration as shown on Fig. 1. An electric field is created by golden-plated Mylar planes powered at -4.0kV and placed above and below each sense wire plane. The drift chambers are filled with 62% of argon and 38% of ethane in order to avoid continuous discharge.

Primary ionization happens when incident particles (mostly electrons and pions) collide with gas molecules expulsing electrons. These electrons then drift along the field lines. Close to the wire the electric field becomes purely radial and accelerates the primary ionization electrons. This gain of energy makes multiple ionizations possible and a signal in the sense wire is then detectable. Thus the position of the incident particle can be found since the time between the primary ionization and the signal is proportional to the distance. [1]

The first multi-wire plane in the particle trajectory is at the focal plane of the spectrometer. The particles cross the wire chambers with an angle between approximately 38 and 52°. Therefore in average five wires per plane have fired and the trajectory of the particles can be reconstructed very accurately: position and angular resolutions about 100μm and 0.5mrad respectively.

1.2 Analysis

In order to declare an event as good event, at least 3 wires must have fired. However the wire efficiency is close to 100% [2], therefore by design the VDC hardware efficiency is 100%.

However the software efficiency called also one-track efficiency can be estimate by:

$$\epsilon = \frac{N_{track}(\{1\})}{N_{track}(\{0, 1, 2, 3, 4\})} \tag{1}$$

It is due to bad tracking reconstruction or the possibility of several particles crossing the wire chambers simultaneously. In the last case, several trajectories become possible and it is difficult to conclude of a good a bad event. Because multiple track events are about 1% of the total number of events, they can be safely cut away and an uncertainty on the one-track efficiency is added to take into account the good events inside the multiple tracks.

The zero-track events are mostly cosmic rays crossing the detector in opposite direction as the scattered electrons and are in bigger percentage at lower rates as illustrated on fig. 2.

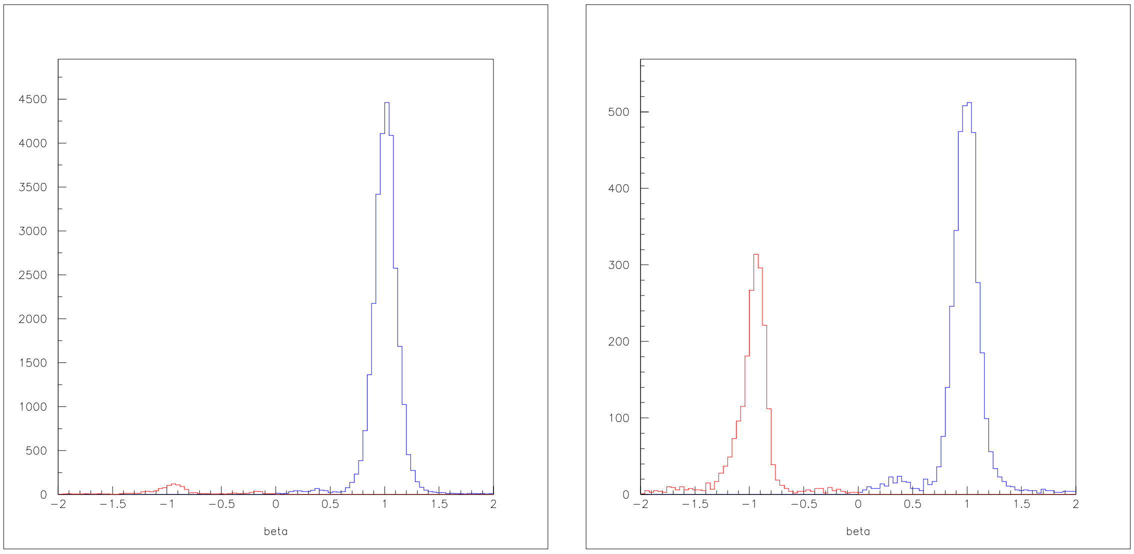

Figure 2: Particle velocity (β) for different kinematics: left and right plot kinematics have a rate of about 100Hz and 20Hz respectively. The cosmic contamination is shown in red. The β-optimization was done by N. Liyanage.

To estimate the efficiency of the good electrons, a set of cuts was applied in order to discriminate between good electrons and background:

- helicity +1 or -1 is required;
- only main trigger events are kept;
- PID cuts are applied [3].

Then the cosmic events are removed with a loose cut on the particle velocity: $0.0 < \beta < 2.0$.

1.3 Results

During the experiment, one-track efficiency was better than 99% for both HRS VDCs (see Fig. 3 and table 1). An uncertainty of ???% was estimated to take into account the good events from the multiple tracks.

In the cross section analysis, the efficiency for each run will be used. This is a good check of the VDC performance along the experiment and runs with problems can be removed from the analysis.

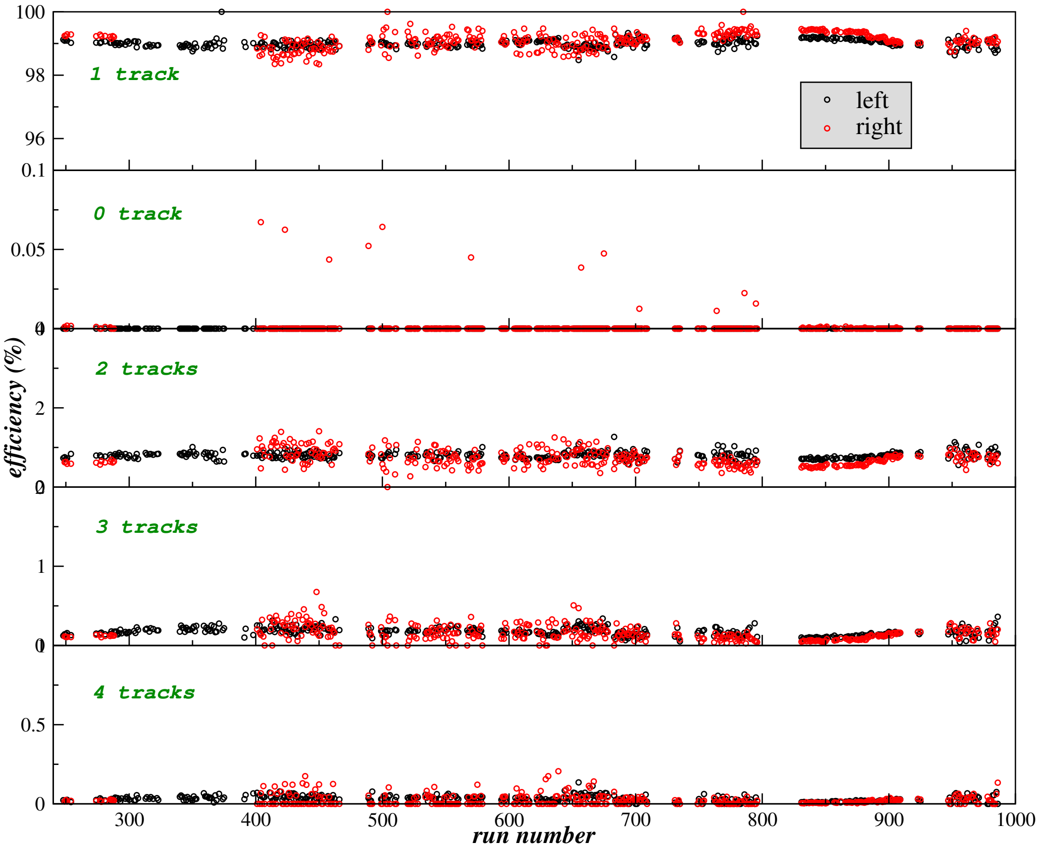

Figure 3: All track efficiencies for left and right arms.

Table 1: Average tracking efficiency for the left and right arm VDCs.

# of tracks	ϵ (%)	
	left	right
0	0.25	0.28
1	99.01	99.10
2	1.05	1.00
3	0.42	0.43
4	0.28	0.30

2 Scintillator efficiency

2.1 General

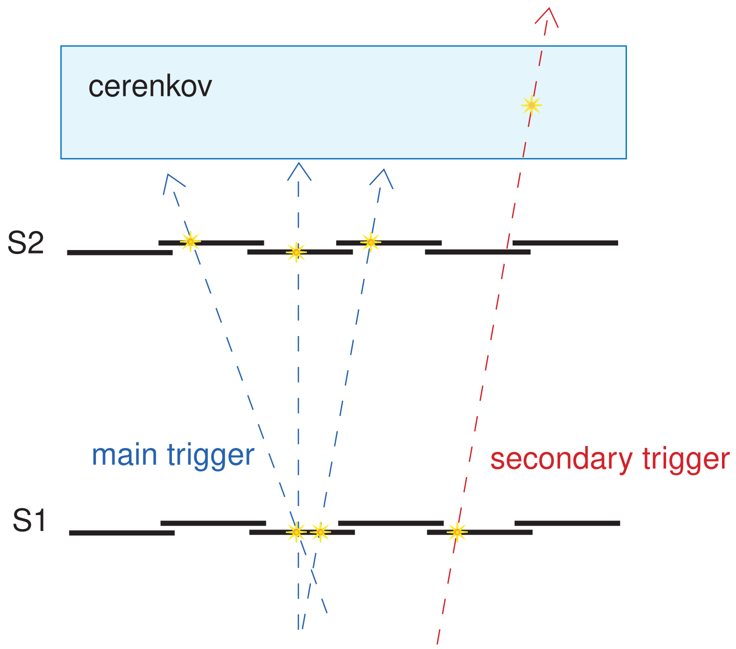

Figure 4: Cartoon.

Both spectrometers use two scintillators planes (S1 and S2) for triggering [2]. Each plane is composed of 6 overlapping plastic paddles with one photo-multiplier at each end of a paddle. Different trigger types are associated with specific scenarios as illustrated on fig. 4:

- Type 1 and 3 are called *main trigger* for the right and left arms respectively and are considered as *good events*. They are characterized by:
  - the events trigger the scintillator planes S1 and S2.
  - the angle of their trajectories are small enough, that is if the event trigger paddle $\#n$ of S1 then to be elected as a good event it will have to trigger paddle $\#n$ or $\#(n-1)$ or $\#(n+1)$ of S2 and vis versa.

– the left and right PMTs of the paddle have fired.

- Type 2 and 4 might be good events but failed one of the previous characteristics. Thus they are required to have fired a third detector as in our case the Cerenkov counter.

The various trigger signals are sent to the trigger supervisor and then the data acquisition can start.

Another use of the scintillators is for the determination of the particle speed (fig. 2) through the time-of-flight between S1 and S2.

2.2 Analysis results

The scintillator efficiency is defined by:

$$\epsilon_{R(L)} = \frac{T_{1(3)}}{T_{1(3)} + T_{2(4)}} \tag{2}$$

To estimate the efficiency of the good electrons, a set of cuts was applied in order to discriminate between good electrons and background:

- helicity +1 or -1 is required;
- only one-track events are kept;
- PID cuts are applied [3].

Fig. 5 shows the scintillator efficiency for all runs. The efficiency is better than 99.8%. Therefore the number of events T2(T4) inside the cuts are very small and the fact of cutting them away in our analysis has a negligeable effect.

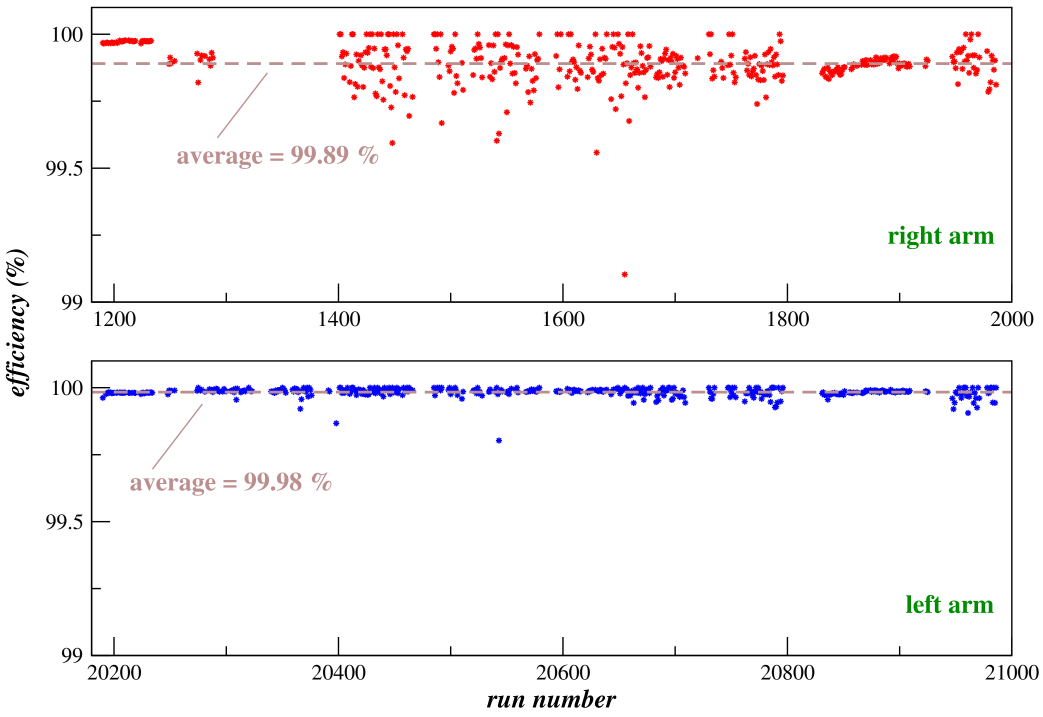

Figure 5: Scintillator efficiency for the right (top plot) and left (bottom plot) arms. Only good electrons were selected.

Conclusion

Small corrections.

References

[1] W.R. Leo,"*Techniques for Nuclear and Particle Physics Experiments, A How-to Approach*", 2nd ed. (Springer-Verlag, 1994).

[2] J. Alcorn *et al.*,"*Basic instrumentation for Hall A at Jefferson Lab*", Nucl. Inst. Meth. **A522**, 294 (2004).

[3] P. Solvignon, "*PID Efficiency for E01-012*", E01-012 Analysis Report 02 (2004).