Drift Chamber Intrinsic Efficiency

Determined From Straight Tracks

TN-59

Maher Quraan

March 05, 2002

The operating high voltage is determined for the TWIST drift chambers. The post-amp threshold over the examined high voltage range is high enough to result in low noise and cross talk levels. The efficiency of each plane and wire in the drift chamber is determined at the operating high voltage to examine plane-to-plane and wire-to-wire variations. The TWIST code is tested for possible biases due to tracking cuts or biases in efficiency calculations.

1 Introduction

The efficiency code uses tracking information to determine which wire in a given plane is expected to display a hit. Once a track is successfully reconstructed, the track parameters are used by the efficiency module to traverse through the detector and find the entrance and exit points of the track through each detector layer. This information is then converted into cell numbers, and the plane is searched to determine whether the TDCs corresponding to these cells (or the neighboring cells) recorded a hit. In all calculations 3 U and 3 V planes are required to carry out the track reconstruction. With a total of 44 planes (and a chamber of high efficiency) the bias due to this requirement is negligible.

It is important to remember that the term efficiency used in this document refers to the intrinsic efficiency of the chamber. This efficiency depends on the gas properties, cell geometry (cell size, wire thickness, presence of drift wires, etc), high voltage and threshold. The presence of a hit does not guarantee that the hit will be used for track reconstruction, since some of these hits (although correspond to the track of interest) may not pass further cuts. Furthermore, plane inefficiencies due to dead wires, or low efficiency wires due to instrumental problems do not degrade the intrinsic efficiency, although their impact on reducing the chamber's acceptance at certain energies and angles are possible.

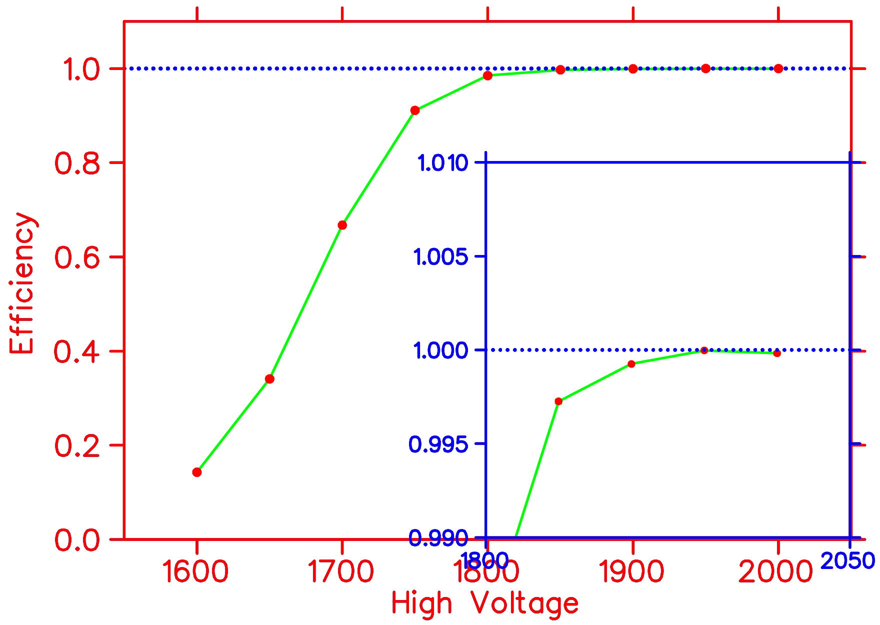

Figure 1: DC efficiency as a function of high voltage.

2 High Voltage Dependence

To determine an operating point for the drift chambers, data were obtained with the high voltage of (roughly) half the modules at 1900 V while the other half's high voltage was varied from 1600 V to 1900 V in steps of 50 V. Figure 1 shows the efficiency as a function of high voltage averaged over all planes for which the HV was being varied. In the inserted figure the "plateau region" is expanded to show the extent to which this region is flat. Although the DC operating point was chosen to be 1900 V for the entire November 2001 run, a slightly higher high voltage would have been desirable as may be seen from the expanded figure. The average efficiency at a high voltage above 1850 V, however, is high enough to make the effect of being slightly below the plateau region negligible.

3 Plane-to-Plane Variations

When a hit is found in a plane within a specified number of cells from the cell intersected by the track, a counter N_p corresponding to plane p is incremented. The efficiency is then defined as $\epsilon = N_p/N_{tp}$ where N_{tp} is the total number of times a track is expected to have passed through plane p.

Figure 2 shows the DC planes efficiency calculated for four different cases. In the first case only wire centers were fitted and a χ^2 cut which resulted in rejecting 6% of the events was imposed. In the second case the same was done but the χ^2 cut was practically removed (99.5% of the events were tracked). In the third case, timing was used and no χ^2 was imposed (again 99.5% of the events were tracked). In the fourth case timing was used and a χ^2 cut which resulted in rejecting 5% of the events was imposed. As may be seen from the figure, while all cases show very close results, the ones with the χ^2 cut show a slightly higher efficiency, which is to be expected since the badly reconstructed tracks are removed (for example tracks with biased parameters due to the presence of noise and/or cross talk hits). For all these calculations plane-to-plane variations are negligible, with all functioning planes showing efficiencies better than 99.8%. Three planes (33, 34 and 36) were dead in these runs, one plane (38) had a dead post-amp resulting in 16 dead wires, and one plane (43) had one dead wire. Efficiencies from these planes do not show up on Figure 1.

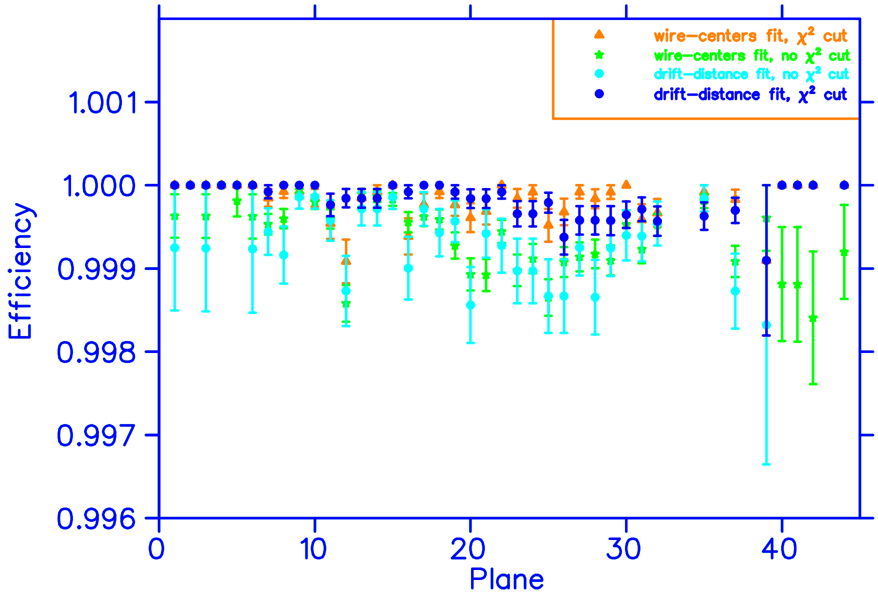

Figure 2: DC planes efficiency determined using four different calculations: a) fitting wire centers and imposing a χ^2 cut, b) fitting wire centers and no χ^2 cut, c) using timing and no χ^2 cut, d) using timing and imposing a χ^2 cut, and d) using individual wire counters

In all these calculations two cells adjacent to the cell expected to display a hit were examined if no hit was found where it is expected. As a result of the low noise in the drift chamber, the bias due to checking adjacent cells is negligible. Since cross talk typically occurs in an adjacent cell in the same plane as the hit, no bias is introdued due to cross talk hits in the same plane. Cross talk from an adjacent plane is negligible, and will therefore have a small bias on the efficiency (if any).

4 Wire-to-Wire Variations

Figure 3 shows the efficiency for each DC wire. On this plot each wire has a unique "wire index" calculated using $wire\_index = plane \times 100 + wire$, so that the first two digits of the wire index represent the wire number, while the last two digits represent plane number. Wires with low statistics (less than 100 expected counts) were removed resulting in only 64% of the wires passing this requirement.

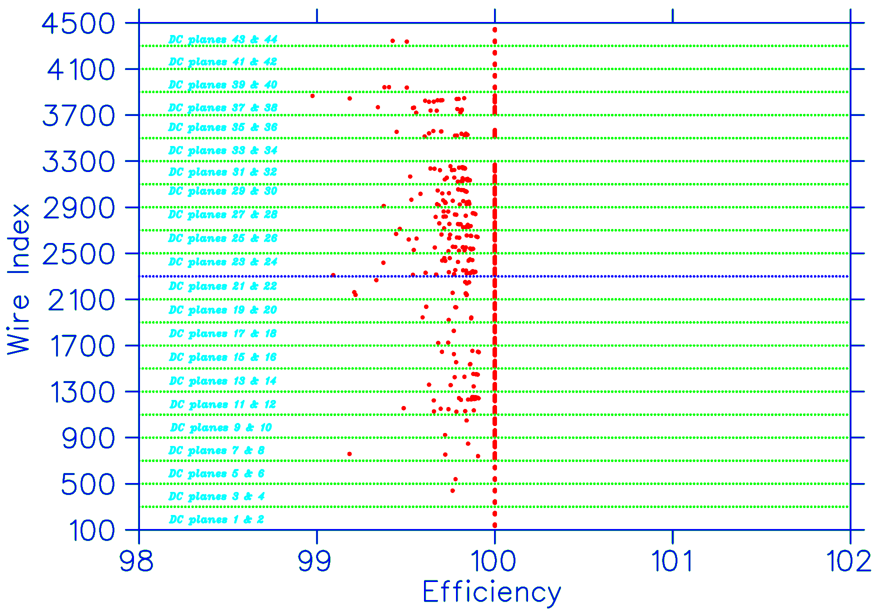

Figure 3: DC chamber efficiency calculated for each wire.

It is worth noting that the algorithm for calculating plane and wire efficiencies are different, so identical results are not expected when the wire efficiency counters are summed to produce plane efficiencies. For wire efficiencies if a hit is not found in the expected cell but in an adjacent cell, one has two choices: decrement the number of expected hits for that cell, or increment the number of present hits in that cell as if a hit was found. The first method was used in all wire efficiency calculations. This difficulty does not occur in calculating plane efficiencies since there is one counter for the entire plane.

5 Code Verification

In order to further test the software, the efficiency was calculated for a case where 20% of the hits were randomly rejected right after the unpacking of the TDCs. The rejection factor was then set to 2%. The effiiciency for both cases is plotted in Figure 4 and shows that the efficiency code was indeed able to recover the "designed" efficiency.

To further test the efficiency code for possible small biases, as well as sensitivities to efficiencies of the order of 1×10^{-3}, the rejection factor was set to 0.001 and 0.002 and the difference in the calculated efficiency between the two cases was computed. The results are plotted in Figure 5 showing the difference to be the expected 0.001.

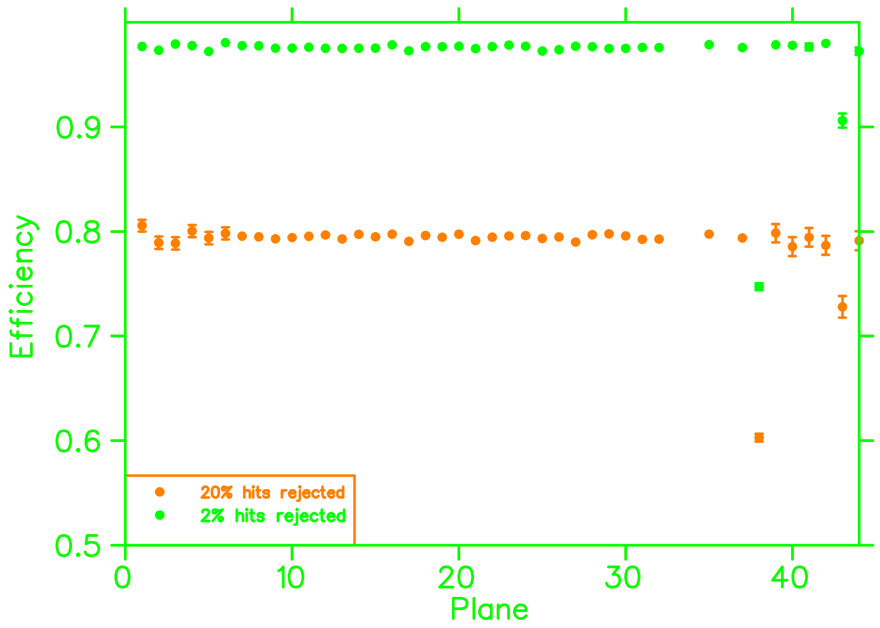

Figure 4: Observed DC planes efficiency after 20% and 2% of the hits are randomly rejected following the unpacking of the TDCs for testing purposes.

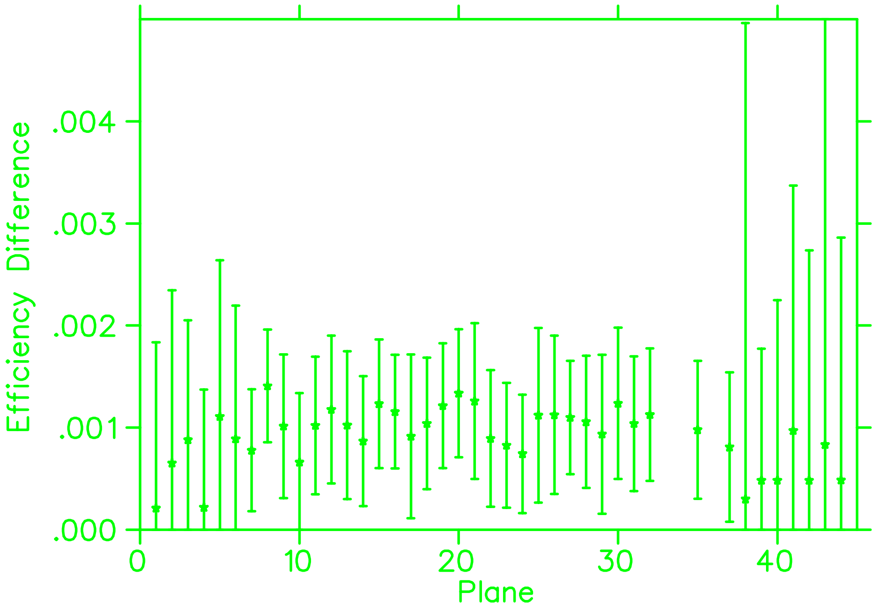

Figure 5: Difference in DC efficiency between a case where 0.001% of the hits are rejected and a case where 0.002% of the hits are rejected.