TRIUMF Experiment E614
Technical Note #66

Monte Carlo Simulation of multiple hits in E614 drift chambers.

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Multiple hits of the same cells in E614 drift chambers were investigated. Monte Carlo simulations were done using E614 GEANT [1] version 2.0. A beam of polarized muons with 29.79 MeV/c momentum ($\Delta P/P = 0$) was transported from z= -300cm, with spot in focus x=1mm, y=1mm through the detector setup. In simulations explicit delta ray production with reduced Landau fluctuations for energy loss was used. Statistics up to 10^5 thrown events were obtained. Approximately 80% of the events stoped in target. Only these events are included in the following histograms, leading to 79002 total events. Special attention was applied to study (e^+,μ^+) multiple hits with small distances along the wire between the hits.

Multiple hits from different particle pairs.

Multiple hits in any physical setup can be a problem and certainly required special investigation. The best way to do this is by using Mote Carlo simulations. In the E614 detector one can expect multiple hits from different particle pairs. It can be (e^+,e^+) pairs, when the same positron turns in magnetic field and hits the same drift cell as it hit before, or (e^-,e^-) when two or more delta electrons, produced during muon or positron energy loss, hit the same cell, or (e^+,e^-) when a positron coincides with a delta-electron produced by itself, or at the least (e^+,μ^+) pairs, when backward emitted positrons hit exactly the same drift cell as was done previously by the μ^+ beam. Coincidences from the (e^+, μ^+) pairs can have the most impact on the E614 detector track reconstruction quality. The probability and multiplicity of hits (except maybe (e^-,e^-)) pairs can depend on positron decay angle.

Hit multiplicity vs. positron decay angle.

Figure 1 presents the dependence of the number of hits in the same drift cells from positron decay angle θ in the lab frame.

One can see that mainly high multiplicity hits are produced by large theta positrons, which rotated inside the detector many times hitting the same drift cells.

Introducing cuts on theta and x ($0.3 < cos(\theta) < 0.985$, $x > 0.2$) we can significantly decrease multiple hits in detector. Figure 2 presents results after these cuts.

Lets focus on the situation when e^+ and μ^+ hit the same drift cell. As can be seen from lower left parts of fig. 1 and fig. 2, this situation happens only for positrons emitted in the backward hemisphere, as one would expect.

Geometrical origin of decay positron.

While 80% of the events stops in the target, some do not. This produces some (e^+,μ^+) hits for DC chambers placed immediately after the target and also gives an enhancement in chambers placed just before target. That effect was eliminated by selecting only events originating from the target. Nevertheless a small enhancement for the DC just before the target is still obvious (fig. 3), but it is significantly smaller than without having the requirement that the muon stops in target.

Multiple hits from (e^+,μ^+) pairs.

When a positron hits a wire which recently was hit by a muon, one point of interest is when positron hits the wire rather close to place where the muon recently passed through it. In such case residual charge can make that part of wire blind to the passing positron. Or the wire gain can be changed. Taking into account that along the wire (for muon traveling perpendicular to wire and in the absence of magnetic field)the charge can be spread along approximately 0.5mm [2], that the electric field can be changed for distances along wire bigger than this charge size [3] and that the charge can disappear from approximately 0.5μs (with the same assumptions as above) [2] up to as long as $\approx 10\mu$s [3], while the μ^+ decay time is $\approx 2\mu$s, one can conclude that close (e^+, μ^+) hits should be studied in detail. The distribution of distances

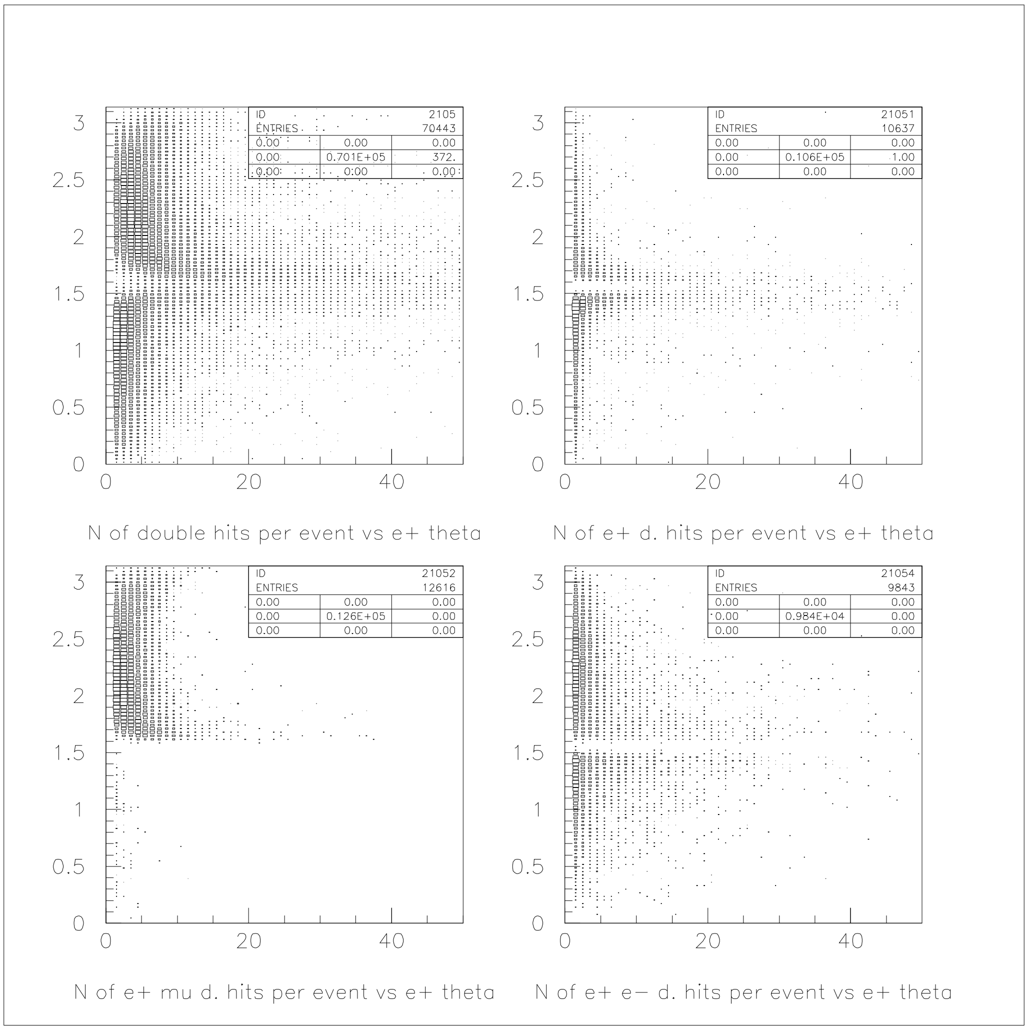

Figure 1: Number of hits in the same drift cells vs. e^+ decay angle θ. Upper left figure shows all hits. Upper right figure shows e^+e^+ hits. Lower left - $e^+\mu^+$ hits. Lower right e^+e^- hits

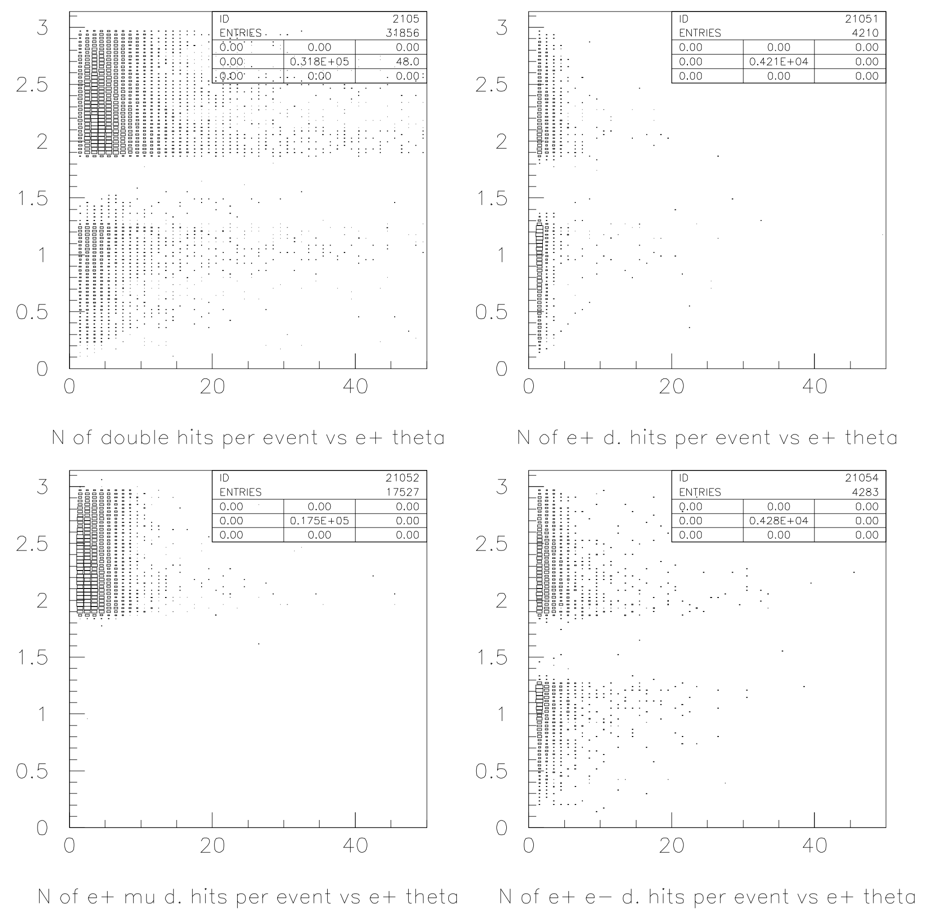

Figure 2: Number of hits in the same drift cells vs. e^+ decay angle θ with $0.3 < cos(\theta) < 0.985$ and $x > 0.2$. Upper left figure shows all hits. Upper right figure shows e^+e^+ hits. Lower left - $e^+\mu^+$ hits. Lower right e^+e^- hits

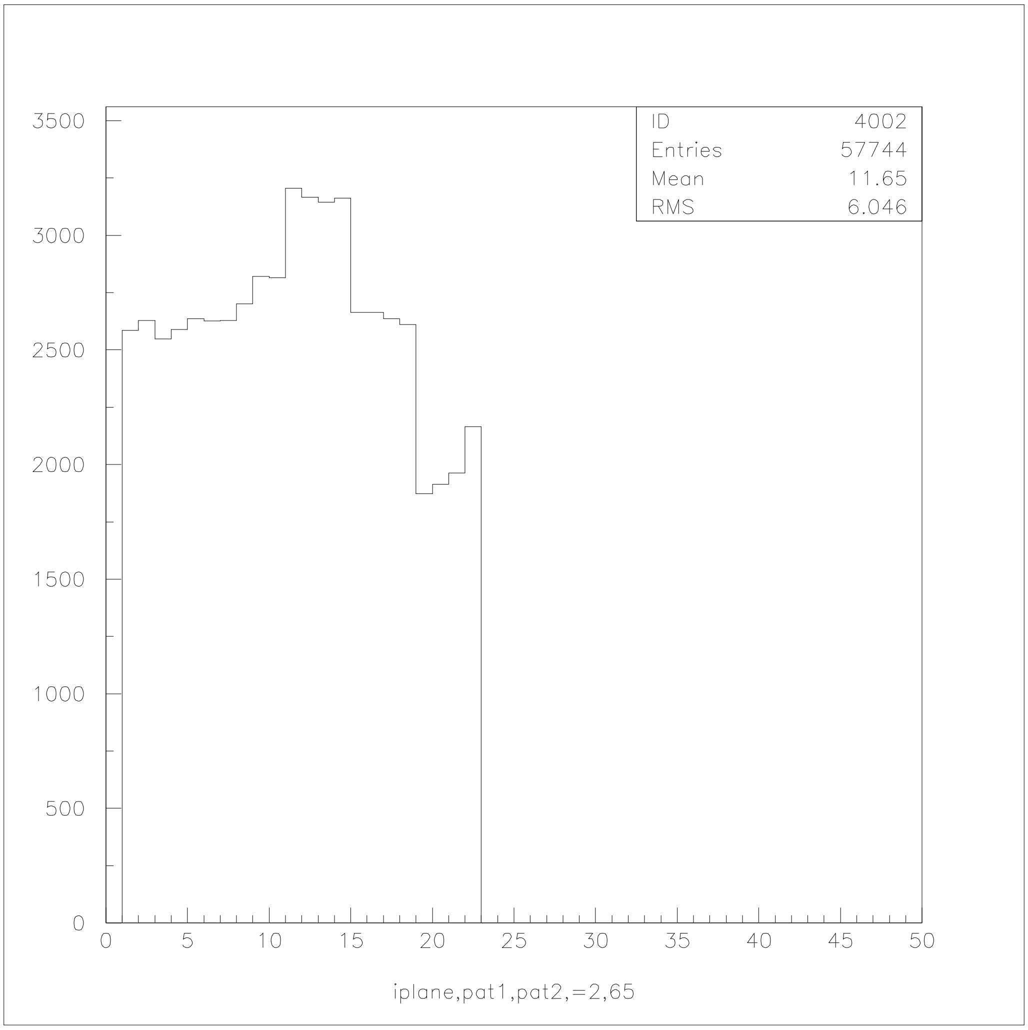

Figure 3: Multiple (e^+ μ^+) hits in drift cells vs. drift plane number.

along the wire between muon and positron hits shown in fig 4 The maximum of the distribution lies at small distances and it is important to learn the probability of such hits.

Figure 5 shows 2 dimensional plots of multiple $e^+\mu^+$ hits within the same DC cells for DC dense stack (planes 1-6) vs. other tracking DC chambers (planes 7-22) for distances along the wire between the hits less than 1mm and 2mm. The same results are summarized in tables 1 and 2

From this information it is seen that up to 3% of the events stoped in the target can have one close ($<$ 2mm) (e^+,μ^+) coincidence in tracking DC chambers without any close (e^+,μ) hits in dense stack and less than 1% of the events will have one close ($<$ 2mm) (e^+,μ^+) coincidence in the dense stack without close (e^+,μ^+) hits in other tracking DCs. Simultaneously one close hit from (e^+,μ^+) in the dense stack and other tracking DCs should occur in only 0.1% of events.

The influence of these numbers on tracking reconstruction and the Michel parameters determination should be further estimated.

References

[1] D.H. Wright, A Users Guide to E614 GEANT, E614 TN-29, 30 March 1999.

[2] Y.Davudov Private communication.

[3] V.Selivanov Private communication.

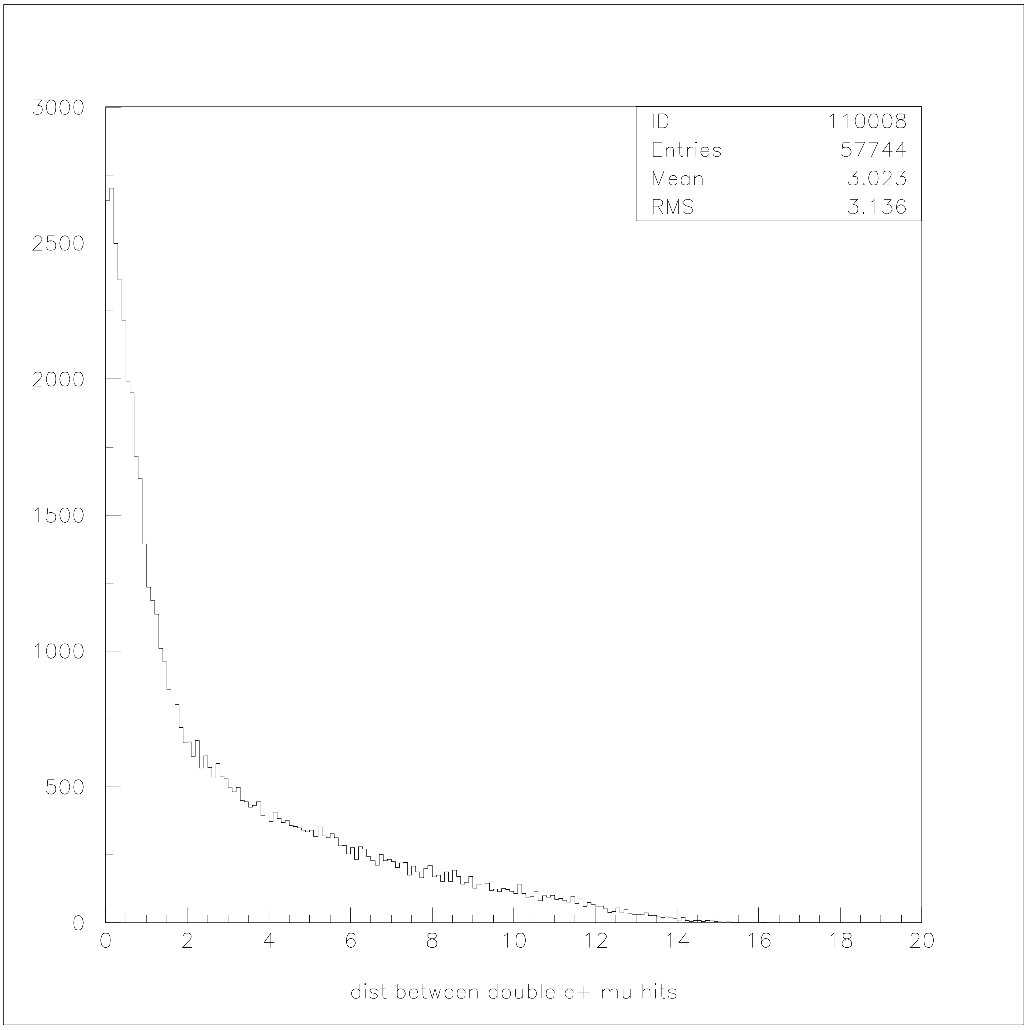

Figure 4: Distance along the wire between e^+ μ^+ hits.

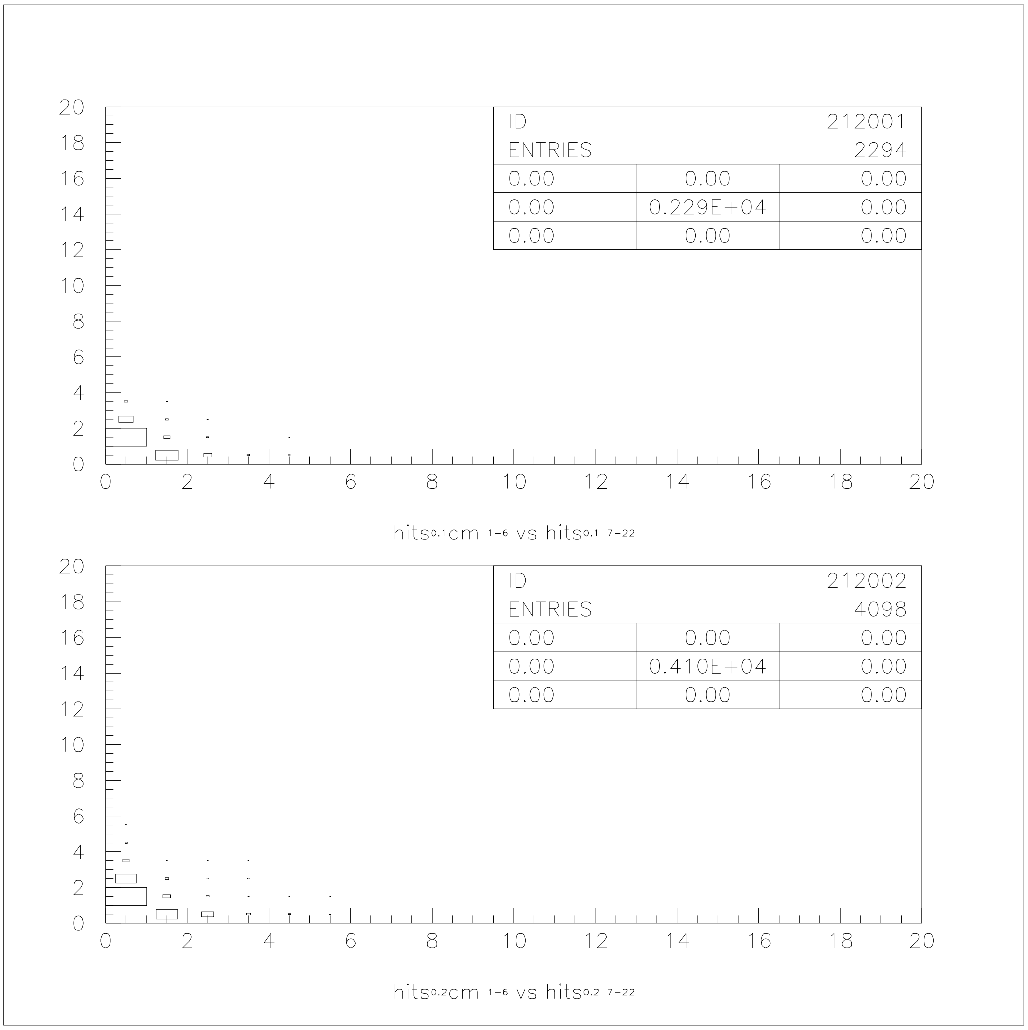

Figure 5: (e^+,μ^+) hit multiplicity in dense stack vs. tracking DC chambers. Upper plot - distances between hits less then 1mm. Lower plot - distances between hits less than 2mm.

Table 1: Probability (in %) of (e^+,μ^+) hits in the dense stack DCs and tracking DCs for different hit multiplicity. Distance along the wire between e^+ and $\mu^+ <$ 1mm

Tracking DC	Dense Stack DC					
N of same cell (e^+,μ) hits/event with $L < 1mm$.						
	0	1	2	3	4	Total
0	97.1	0.6	0.08	0.01	0.003	97.8
1	1.9	0.05	0.006	0	0.001	1.95
2	0.2	0.008	0.003	0	0	0.21
3	0.01	0.003	0	0	0	0.01
Total	99.2	0.66	0.09	0.01	0.004	100

Table 2: Probability (in %) of (e^+,μ^+) hits in the dense stack DCs and tracking DCs for different hit multiplicity. Distance along the wire between e^+ and $\mu^+ <$ 2mm

Tracking DC	Dense Stack DC						
N of same cell (e^+,μ^+) hits/event with $L < 2mm$.							
	0	1	2	3	4	5	Total
0	94.7	0.9	0.3	0.03	0.009	0.004	95.9
1	3.0	0.1	0.02	0.003	0.001	0.001	3.1
2	0.8	0.03	0.006	0.005	0	0	0.84
3	0.08	0.003	0.001	0.001	0	0	0.09
Total	98.6	1.0	0.33	0.04	0.01	0.005	100