Quasianalytic Reconstruction of Straight Tracks in Drift-Tube Chambers of the ATLAS Experiment

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Introduction

The high-resolution elements of the ATLAS muon spectrometer are pressurized drift-tube chambers. These drift-tube chambers consist of two triple or quadruple layers of high-pressure drift-tubes. The drift tubes are made up of aluminium tubes with 3 *cm* diameter. The distance of both multilayers ranges from 15 *cm* in small chambers to 40 *cm* in the largest. The anode wire is centered in the tube and read out by fast electronics.

Straight Tracks in Drift-Tube Chambers

In a drift-tube chamber one measures, via the drift time, the radius of a circle, to which the particle trajectory is tangential. Straight tracks in a muon chamber are tangents to the measured drift circles. The reconstruction of straight tracks is, therefore, equivalent to the calculation of the common tangent to all drift circles. A χ^2-minimization is a non-linear problem and cannot be solved analytically. A numerical χ^2-procedure or a similar can be avoided by the quasianalytic method which is explained in the present write-up.

Quasianalytic Reconstruction of Straight Tracks

The method of the quasianalytic reconstruction of straight tracks is based on the observation that one can analytically determine the tangent to two circles. The formula for this tangent becomes particularly simple by the clever choice of the coordinate system, as can be extracted from figure 1.

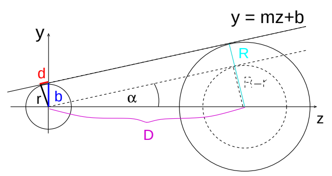

Fig. 1: A tangent to two circles.

Figure 1 shows the path of a straight track in the plane perpendicular to the tubes. The track passes the tubes at distance r respectively R. The origin of the coordinate system is put to the centre of the left circle; the centres of both circles lie on the z-axis. The y-coordinate of the track as a function of the z-position is given by the equation $y = mz + b$.

The slope m is the tangent of the angle α in the triangle which one obtains by moving a line parallel to the track into the centre of the left circle.

$$m = \tan\alpha = \frac{R-r}{\sqrt{D^2-(R-r)^2}},$$

where D is the distance of the tubes from each other. The intercept b is the length of the hypotenuse in the triangle bdr inside the left circle, hence

$$b = \sqrt{r^2+d_2} = \sqrt{r^2+(r\cdot\tan\alpha)^2} = r\sqrt{1+m^2}.$$

In order to reconstruct a straight track in a muon chamber, one has to calculate the best common tangent to all drift circles. In case of the quasianalytic approach, the slopes and intercepts of the tangents to all pairs of circles are calculated and the weighted average is taken as the best estimate of the slope and intercept of the muon track. This is, however, only justified, if the slope and intercept of a single pair are not correlated with each other and the slopes respectively intercepts of different pairs are themselves not correlated. The first condition can be fulfilled by averaging over pairs of tubes only which belong to different multilayers, as tubes of different multilayers are so much separated that the individual slopes and intercepts are correlated only very little. The second condition is not fulfilled since the same tube is used in more than one combination. Fortunately, the results of the Monte-Carlo study presented below show that the remaining correlation causes no problems.

Monte-Carlo Test of the Method

Straight tracks are measured at the cosmic-ray test-stand of the LMU in Garching. This stand was simulated and tracks were reconstructed with the quasianalytic and the conventional approach. Both methods have the same tracking efficiency, are unbiased, and have the same accuracy. This is proven by figure 2 where the deviation of the reconstructed slope from the true slope is plotted for the conventional and the quasianalytic approach. Both distributions are centered at 0 and have the same spread. The quasianalytic method is faster and more robust than the conventional method and has some interesting scope for fast track finding.

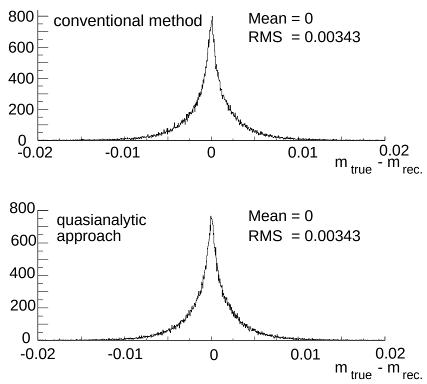

Fig. 2: Deviations of reconstructed track slope from true slope.