r-t Relationship and Resolution for the ATLAS Drift-Tube Gas Ar/CO_2 (93/7)

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To reach a realistic simulation of events taken at ATLAS the exact response of the drift tubes has to be known. For this, the non-gaussian tails of the drift-time distributions for given impact radii must also be considered.

So far, the r-t relationship and the resolution has been measured for "Datcha Gas", $Ar/N_2/CH_4$ (91/4/5), a gas with the advantageous property of high linearity: its drift velocity depends weakly on the impact radii. On the other hand, Datcha Gas isn't stable under radiation.To avoid the problem of aging another gas mixture, Ar/CO_2 (93/7), is used. One chooses such a small share of CO_2 in order to obtain high drift velocity and thus low occupancy. Unfortunately, the linearity of this gas is considerably worse compared to Datcha Gas.

In the present work Ar/CO_2 is studied. The data for the analysis were taken during the summer 1999 test beam with 300 GeV muons. As trigger and external reference the silicon telescope "Odysseus" was placed behind the drift tube chamber . With a resolution of $7\mu m$ per single plane Odysseus yielded a precision of about $11\mu m$ for the track impact in the nearest tube. The obtained r-t distribution is shown in fig. 1:

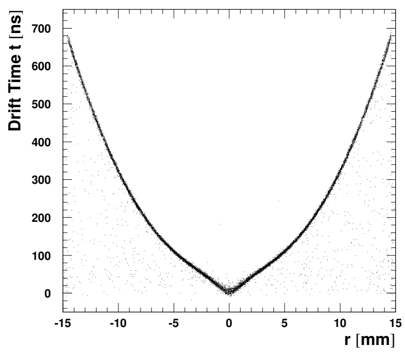

Fig. 1: r-t distribution obtained with the silicon telescope as reference, which determined r

Subdividing this r-t distribution into radial slices we obtain the 1-dimensional time distributions P(t|r) (fig. 2) as projections onto the time axis.

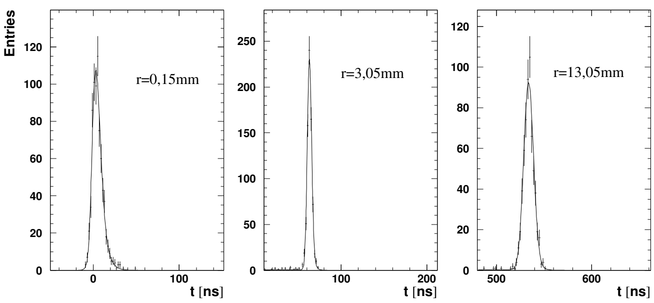

Fig. 2: Drift-time distributions in 100 μm wide radial slices for different radii

The reasons for the asymmetric behaviour of P(t|r) for slices near the wire are the statistical distribution of the ionization electron clusters and the cluster size distribution: In ATLAS drift tubes the time measurement is triggered when a certain number of ionization electrons arrives at the wire (for our studies the threshold was set to 25 electrons). For big track radii many ionization clusters arrive almost at the same time. Therefore the charge distribution along the track has no significant effect on the trigger time. For tracks near the wire however, the arrival times of the different clusters have a big spread. Frequently the cluster containing the triggering electron has been created far away from the wire. Thus the measured time distribution peaks at $t > 0$ and gets a big tail towards long drift times.

Instead of defining a function t(r) with gaussian errors which would be valid only for tracks far away from the wire we parametrize the conditional time distribution P(t|r) for each slice.

To parametrize the 1-dimensional time distributions (fig. 2) the same parametrisation as for Datcha Gas can be used:

$$\begin{aligned} P(t \mid r) &= p_1(r)\frac{1}{p_3(r)}e^{\frac{p_2(r)-t}{p_3(r)}-e^{\frac{p_2(r)-t}{p_3(r)}}} \\ &+ [1-p_1(r)]\frac{1}{\sqrt{2\pi}p_3(r)}e^{-\frac{[t-p_2(r)]^2}{2[p_3(r)]^2}} \end{aligned}$$

The parameters have the following significance:

$p_1(r)$: amount of asymmetric contribution
$p_2(r)$: peak position corresponding to the conventional $t(r)$ function
$p_3(r)$: quantity characterizing the width of the distribution (time resolution)

Variations of $p_1(r), p_2(r), p_3(r)$ with r are shown in fig. 3.

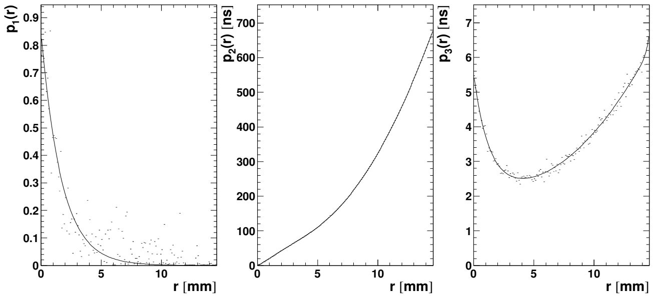

Fig. 3: Parameters of P(t|r) as a function of r

To obtain an estimate for the spatial resolution $\sigma_r(r)$ we divide the "time resolution" $p_3(r)$ by the derivative of the peak position $p_2(r)$ which means multiplication with the drift velocity v(r). It is convention to characterize $\sigma_r(r)$ with the quadratic average for r > 1mm. The cut avoids that the small region of bad resolution dominates this number. The computed value is $\langle\sigma_r^2(r)\rangle = 69\mu m$ for Ar/CO_2. It was $\langle\sigma_r^2(r)\rangle = 80\mu m$ for Datcha Gas.

References

[1] M.Deile, N.P. Hessey and A.Staude: MDT Track fitting with the Maximum Likelihood Method, ATLAS Muon Note 240, CERN 1998