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SDC
SOLENOIDAL DETECTOR NOTES

TRACK CROSSING ANGLE IN STRAW SUPERLAYERS

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The SDC straw tracker design includes superlayers in which the wires are tilted with respect to the local axial ray to give a stereo measurement of the dip angle. I derive here a formula that corrects the locally measured segment orientation in stereo superlayers for the effect of our axially displaced tracker sections.

A segment is parameterized by the azimuthal angle ϕ of its intersection with a cylinder of radius r_w midway through the superlayer, by the angle α of its orientation with respect to the normal to the superalayer at (r_w, ϕ), and by the matrix of errors on these parameters from a segment fit. The uncertainty in $r\phi$ is about 85 microns, that of α is about 0.01 radians, and the correlation between these is small. This information is stored by the AR segment finding package in the bank /RECO/HTRK/WRRE/WRRS/WRSG.

For stereo measurements the true value of ϕ is correlated with the axial coordinate z of the track's intersection with the superlayer. What is stored in the segment bank is the segment seen in the reference frame of the tilted wires. With a 3 degree stereo angle and 4 meter wire length the displacement of the apparent azimuth from this effect is about ± 10 cm, or ± 25 straws. However, the crossing angle is independent of z even in these layers, except for a negligible contribution from the beam bunch length. We do have to make a correction for the fact that the straw detector is made in two sections, shifted by about 2 m from $z = 0$, but this correction requires no a priori knowledge about the track.

Consider a track emanating from the beam axis at $z = 0$. At a stereo layer at radius r we have $z = r \cot\theta = \text{const} \times r$, assuming the curvature is not too large. If the true azimuth is ϕ, the apparent azimuth is

$$\begin{aligned} \phi_m &= \phi - \tan^{-1}[\tan\phi_s(z - z_w)/r] \\ &\simeq \phi - \tan\phi_s(z - z_w)/r. \end{aligned}$$

Here ϕ_s is the stereo angle (about 3 degrees), and z_w is the z displacement of the middle of the wire. Because of the relation between z and r for the track, this

becomes

$$\begin{aligned}\phi_m &\simeq \phi - \tan\phi_s(r\cot\theta - z_w)/r \\ &= \phi - \tan\phi_s(\cot\theta - z_w/r).\end{aligned}$$

The only r dependence is in the term that is independent of track parameters ($\cot\theta$). Two successive measurements at radii r_1 and r_2 determine α (see Fig. 1):

$$\begin{aligned}\tan\alpha &= \frac{r_2\sin(\phi_2-\phi_1)}{r_2\cos(\phi_2-\phi_1)-r_1} \\ &\simeq \frac{r_2}{r_2-r_1}(\phi_2-\phi_1).\end{aligned}$$

The measured α_m in a stereo layer is given by

$$\begin{aligned}\tan\alpha_m &\simeq \frac{r_2}{r_2-r_1}(\phi_{2m}-\phi_{1m}) \\ &= \frac{r_2}{r_2-r_1}\left[\left((\phi_2-\tan\phi_s(\cot\theta-\frac{z_w}{r_2})\right)-\left((\phi_1-\tan\phi_s(\cot\theta-\frac{z_w}{r_1})\right)\right] \\ &= \frac{r_2}{r_2-r_1}\left[\phi_2-\phi_1-\tan\phi_s z_w\left(\frac{1}{r_1}-\frac{1}{r_2}\right)\right] \\ &= \tan\alpha - \tan\phi_s\frac{z_w}{r_1}.\end{aligned}$$

Identifying r_1 with the reference radius of the superlayer r_w we see that the correction to α is thus

$$\tan\alpha = \tan\alpha_m + \tan\phi_s\frac{z_w}{r_w}.$$

The segment radius r_w and crossing angle α_m come from the segment bank, and (for our SDC tracker with two z modules) z_w is the half length of the superlayer. Note that z_w is a signed number. Also, although ϕ_s is a small angle, α is not, in general, so one should not replace the tangents with their arguments here.

This result is interesting, aside from the need to get the code right, because it means that in linking segments to tracks, for example with ϕ-curvature clustering, the curvature is just as precisely known for the stereo as for the axial superlayers, without dip angle information. The distributions in α for 2 GeV $p_\perp$ tracks from

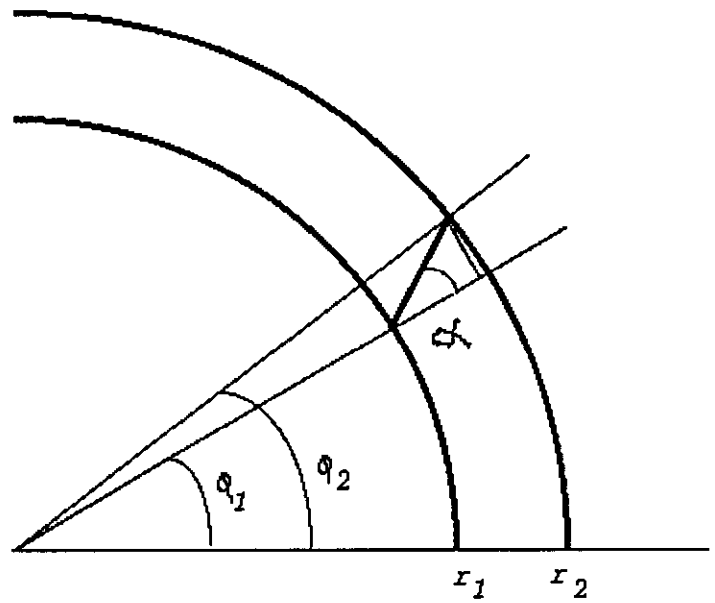

Fig. 1: A segment defined by its endpoints (r_1, ϕ_1), (r_2, ϕ_2).

Higgs events are shown in Fig. 2. Note that the distribution of the (corrected) α from the stereo layers is just as sharp as the one from the 6-layer axial layer. The 8-layer axial layers have a sharper distribution because of the greater lever arm (and more hits). From this point of view we prefer 8-layer superlayers, which determine α with 1.6 times the precision of 6-layer superlayers.

The correction for displacement of the detector in z could be made to the α that is stored in the bank, so that the readback code wouldn't have to worry about it. This is not done at present. Should we decide to set it up this way in the future, the changes will be made to AR and to the reconstruction packages, with appropriate documentation in the code and bank structure description file.

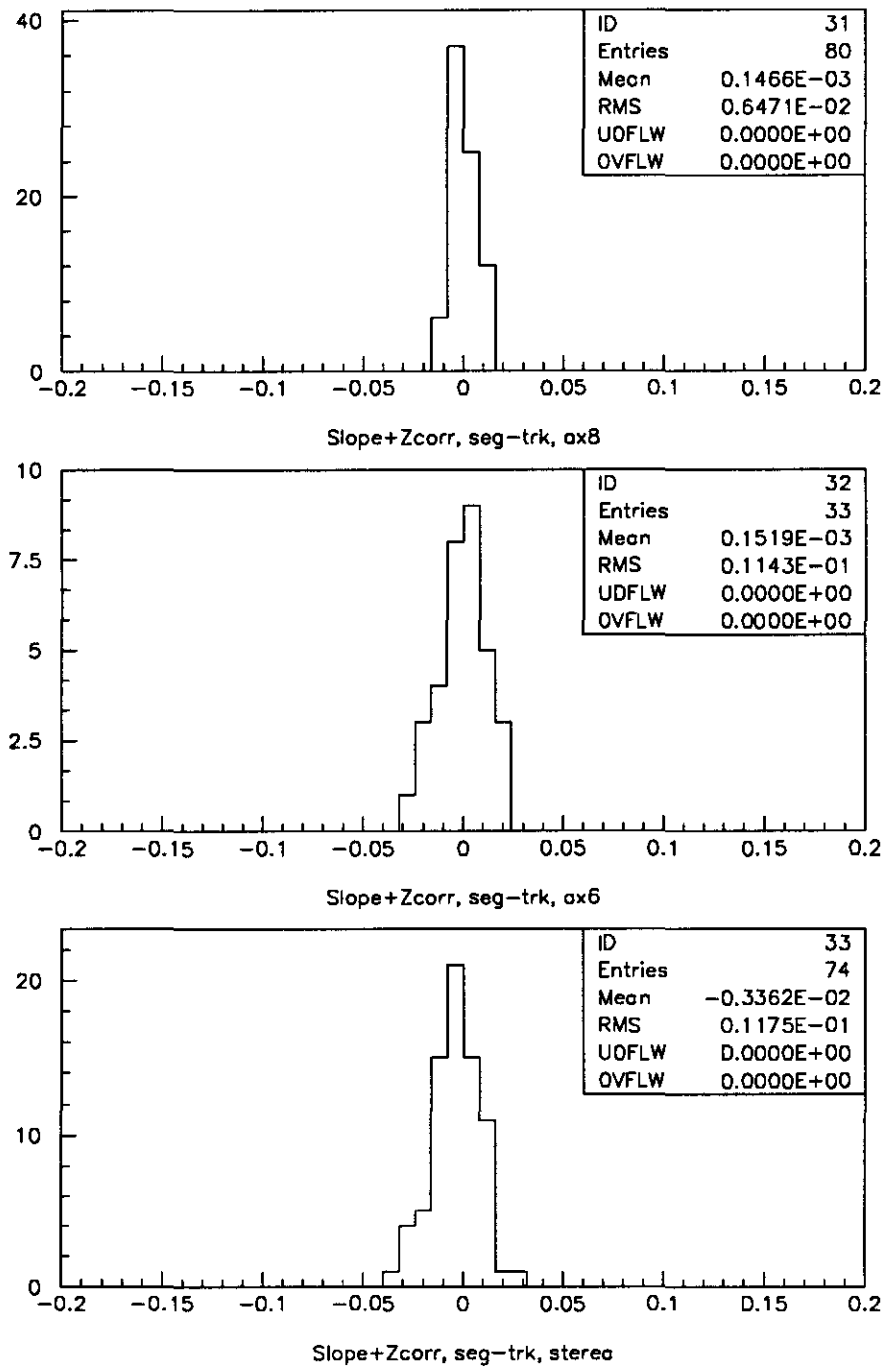

Fig. 2: Distributions of α (corrected as described in the text for the stereo layers) for (top) 8-layer axial superlayers; (middle) 6-layer superlayer; (bottom) (6-layer) stereo layers.