Resolution formulae

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Abstract

These formulae were produced by Keisuke in an email sent on 15 May 2017. The figure captions give the formulae numbers used in his mail.

The r-phi single hit resolution is given asymptotically (at long drift distance where the hodoscope effect is negligible) by

$$\sigma_{r\phi}^2 = \frac{A}{N_{eff}} + \frac{L^2}{12\hat{N}_{eff}} \tan^2\phi + \frac{C_d^2}{N_{eff}} z$$

Fig. 1. Formula 1.

where, on the right-hand side, the first term:

$$\sigma_0^2 = \frac{A}{N_{eff}} = (50[\mu m])^2 (\text{currently})$$

Fig. 2. Formula 11.

represents the constant term and the effective number of track electrons is given by

N is the number of track electrons contributing to the pad row in question and G is the gas gain for a single seed electron. We could also insert the sin(phi) factor in the denominator if we wish, which is not done in the current ILD simulations. The current Neff value

$$N_{eff} \simeq \left[\left\langle \frac{1}{N} \right\rangle \left\langle \left(\frac{G}{\langle G \rangle} \right)^2 \right\rangle \right]^{-1/2}$$
$$\simeq N_{eff}(\theta = 0)/\sin\theta$$

Fig. 3. Formula 12.

$$N_{eff}(\theta = 0) \simeq 22(\text{currently})$$

Fig. 4. Formula 10.

implies

$$A = \sigma_0^2 \, N_{eff} \simeq (50[\mu m])^2 \times 22 = 55000 \; [(\mu m)^2]$$

Fig. 5. Formula 18.

This Neff value could be updated with a more recent value from test beam experiments. (Be careful for 5 GeV electron dE/dx is about 1.4 times larger than MIP.)

The 2nd term on the r.h.s. of the resolution formular represents the angular pad effect and is controlled by

$$L : \text{pad length} \simeq 5 \ [\text{mm}]$$

Fig. 6. Formula 13.

and the fluctuation of the number of primary ionization clusters as well as by their spatial fluctuations along the track segment corresponding to the pad row in question:

$$\hat{N}_{eff} : \text{effective number of clusters} \simeq \hat{N}_{eff}(\theta = 0)/\sin\theta$$

Fig. 7. Formula 5.

In the current ILD simulation, either sin(theta) nor sin(phi) dependence is included for the angle term though we could have. From

$$\frac{L^2}{12\hat{N}_{eff}} \tan^2\phi \simeq (900 \ [\mu m])^2 \sin^2\phi$$

Fig. 8. Formula 14.

and tan(phi) ≈ sin(phi) for small phi values, we have

$$\hat{N}_{eff}(\theta = 0) \simeq \frac{L^2}{12\,(900 \ [\mu m])^2} \simeq \frac{5000^2}{12 \times 900^2} \simeq 2.6(\text{currently})$$

Fig. 9. Formula 15.

which seems a little bit too pessimistic. I think that Neff is more like 4-6. This is on the safe side though.

The 3rd term on the r.h.s. is the well known diffusion term and is controlled by the drift distance, Neff, and the diffusion constant:

$$C_d \simeq C_d(B = 4T) \times (4T/B)$$

Fig. 10. Formula 7.

with

$$C_d(B = 4T) \simeq 25 \ [\mu m/\sqrt{cm}](\text{currently})$$

Fig. 11. Formula 17.