2. Analysis Tasks

Note: When we talk about the

- spread or Root Mean Square (RMS) value of a distribution we mean the standard deviation of the distribution.
- resolution (or σ) of an observable we also mean the standard deviation of the distribution: reconstructed - true.

Task 2.1: Position reconstruction

a) determine pedestal and noise (from noise file)

b) plot signal distributions of first five events

c) implement cluster search algorithm with three signal/noise (S/N) threshold cuts, using S/N(strip)=2, S/N(seed strip)=3 and S/N(cluster)=5, plot number of cluster per event and number of strips per cluster

d) implement hit position reconstruction using centre-of-gravity of cluster algorithm (plot position in units of strip number)

Task 2.2: Cluster charge distributions (Energy loss vs p and Landau distributions)
for $p_{beam} = (2, 5, 10, 200)$ GeV/c:

a) histogram cluster charge distribution for the different momenta

b) perform Landau type fit to the cluster charge distributions

c) determine for the cluster charge distributions: most probable value, mean and median energy loss and energy spread for the different momenta

Task 2.3: Momentum dependence of position and angular resolution
for $p_{beam} = (2, 5, 10, 200)$ GeV/c:

a) determine single hit resolutions σ_{hit}: histogram residua reconstructed hit - true track positions at sensor planes and note down the RMS values (may plot vs momenta)

b) compare measured vs expected hit position, for the latter use the true track parameters at z=0 and extrapolate the track to the sensor planes (thus neglecting multiple scattering effects). Histogram the corresponding residua and check if they agree with expectations:

- mean of zero (within the estimated error) and
- spread$^2 = A + B/p^2$, determine A and B and compare to back on the envelope calculations of the multiple scattering effects

c) This task only for the 200 GeV/c p_{beam} data in order to suppress multiple scattering effects: determine single hit resolution σ_{hit} from the reconstructed data only, using the triplet method: $res = 1/2 \cdot (x_1 + x_3) - x_2$, where the x_i refer to the measured cluster positions in the three sensors. The spread of the residuum distribution should be equal to $\sqrt{3/2}\,\sigma_{hit}$

d) perform a straight line fit $x = a_0 + a_1 \cdot z$ to the three reconstructed hits (σ from 2.3c) for $p_{beam} = 200$ GeV/c. Histogram the fit parameter resolution distributions: $a_{0,fit} - a_{0,true}$ and $a_{1,fit} - a_{1,true}$. Note down mean and spread values. Compare the observed spreads with the fiterrors (output by the fit) of a_0 and a_1. *Optional task:* Repeat this analysis for other p_{beam} values. How does it change and why?

Task 2.4: Position resolution of the DUT vs rotation angle θ_{DUT}
for $p_{beam} = 200$ GeV/c only:
The DUT sensor replaces the middle plane of the telescope.

a) histogram the cluster charge for the different DUT rotation angles θ_{DUT}, determine the mean values and compare the results to expectations

b) determine the hit resolution vs θ_{DUT} from the difference true - measured

c) determine the hit resolution vs θ_{DUT} using the triplet method:
$res = 1/2 \cdot (x_1 + x_3) - x_{DUT}$ with $\sigma_{1/3}$ from 2.3c

d) determine how the hit position resolution depends on the cluster charge Q (e.g. by comparing the data $Q > Q_{median}$ with $Q < Q_{median}$)

Reminder: Definition of the detector and beam

Coordinate system: z along beam, (x,y) = (horizontal, vertical)

Si beam telescope: 3 x-planes (i.e. stripes in y-direction):

- sensor thickness: 300 μm
- no. strips: 48
- strip pitch: 20 μm
- strip length: 10 mm
- conversion energy-loss to no.electrons: 3.6 eV/e
- rms noise (Gauss): 1000 e
- cross talk: none
- z-positions: $z_{sensor} = (200, 600, 1000)$ mm

Device under test (DUT): 1 x-plane can be rotated around y axis:

- sensor thickness: 300 μm
- no. strips: 48
- **strip pitch: 50 μm**
- strip length: 10 mm
- conversion energy-loss to no.electrons: 3.6 eV/e
- rms noise (Gauss): 1000 e
- **cross talk: 5%**
- z-positions: $z_{DUT} = 600$ mm (replacing the central plane of the beam telescope)

Pion beam:

- mean position at $z = 0$ mm: $\langle x_{beam} \rangle = \langle y_{beam} \rangle = 0$ mm
- spread position at $z = 0$ mm: $\sqrt{\langle x_{beam}^2 \rangle} = \sqrt{\langle y_{beam}^2 \rangle} = 0.1$ mm
- mean angle at $z = 0$ mm: $\langle \theta_x \rangle = \langle \theta_y \rangle = 0$ mrad
- spread angle at $z = 0$ mm: $\sqrt{\langle \theta_x^2 \rangle} = \sqrt{\langle \theta_y^2 \rangle} = 0.1$ mrad
- $p_{beam} = (2, 5, 10, 200)$ GeV/c

Sensor simulation:

- define strip volume (xyz): (strip pitch, strip length, sensor thickness)
- calculate energy in MeV deposited in strip volume
- convert energy to charges (3.6 eV/e)
- introduce cross talk (make sure that no charge is lost!)
- introduce noise (Gauss with rms noise)