

## 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  $\sigma$ ) 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  $S/N(\text{strip})=2$ ,  $S/N(\text{seed strip})=3$  and  $S/N(\text{cluster})=5$ , 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  $\sigma_{hit}$ : 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<sup>2</sup> =  $A + B/p^2$ , 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  $\sigma_{hit}$  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 ( $\sigma$  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 fit errors (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 $\theta_{DUT}$**

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  $\theta_{DUT}$ , determine the mean values and compare the results to expectations
- b) determine the hit resolution vs  $\theta_{DUT}$  from the difference true - measured
- c) determine the hit resolution vs  $\theta_{DUT}$  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,  $(x,y) = (\text{horizontal}, \text{vertical})$

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

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

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

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

### Pion beam:

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

### Sensor simulation:

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