ROOT Analysis of Test Beam Data

Multiple Scattering, Track Fits, Non-Perpendicular Incident

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PHYSICS AT THE TERA SCALE
Helmholtz Alliance

March 6th, 2010

Reminder

- Pedestal and Noise treatment.
- Cluster Reconstruction:
  - Finding with Three-Threshold-Algorithm,
    but mostly 1 strip clusters: (no diffusion, perpendicular incident.
  - Position reconstruction as centre of gravity of charges.
- Cluster charges:
  - Peak roughly at 25 000 electrons.
  - Long tail: fit with Landau/Gaus convolution.
  - See small momentum dependence.

Task 2.3a): Hit Resolution From Truth

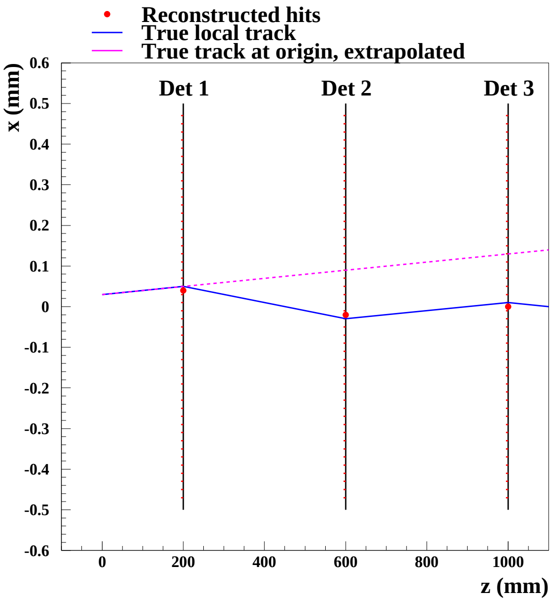
- Comparing hit predeiction with simulated truth.
- What do we expect with the bulk of our clusters with width 1?

Comments

After editing SiTelescope.C:

- `root ../tree_SiTelescope_2GeV.root`
- `SiTelescope->Process("SiTelescope.C+", "2GeV")`
- Similarly for other beam energies:
  - by hand as for 2 GeV
  - or edit testBeam.C and 'root testBeam.C+'
- Note: By default we calculate all in mm, not μm...
- Should there be momentum dependence?

Task 2.3b): Multiple Scattering Effects



- We extrapolate the true track at $z = 0$ and compare with reconstructed positions on sensors: $x_{rec} - x_{extrapol}$.
- Expect differences between momenta!

Task 2.3b): Multiple Scattering Effects (ctd.)

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Comments

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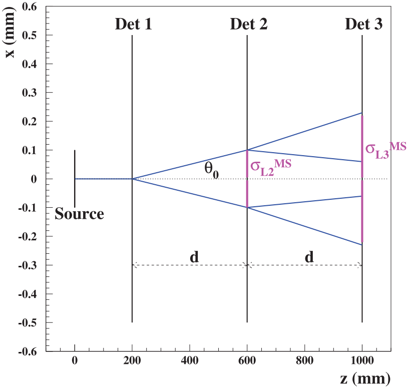
Multiple scattering effects

Dominated by multiple Coulomb scattering from nuclei



According to PDG 2008 Review p.271:

$$\theta^{RMS}_{plane} = \theta_0 = \frac{13.6\,MeV/p}{\beta cp} z\sqrt{X/X_0}[1+0.038\,ln(X/X_0)]$$

In our case

- $z = 1$ (Pions)
- $x = 0.03$ cm; $X_0 = 9.36$ cm

$\Rightarrow \sqrt{X/X_0} = \sqrt{0.03/9.36} = 0.056$

$$\Rightarrow \theta_0 \approx \frac{13.6\,MeV}{p}\sqrt{X/X_0} = \frac{0.77\,mrad}{p[GeV]}$$

$\Rightarrow$ Spread in Layer 2 (from MS in Layer 1):

$$\sigma^{MS}_{L2} = d\cdot\theta_0 = \frac{400\text{ mm}\cdot 0.77\text{ mrad}}{p[GeV]} = \frac{306\ \mu\text{m}}{p[GeV]}$$

$\Rightarrow$ Spread in Layer 3 (from MS in Layer 1 and Layer 2):

$$\sigma^{MS}_{L3} = \sqrt{4d^2+1d^2}\cdot\theta_0 = 2.24\,\sigma^{MS}_{L2} = \frac{684\ \mu\text{m}}{p[GeV]}$$

Task 2.3c): Single Hit Resolution from Data

- Only for 200 GeV to suppress multiple scattering effects.
- Hit resolution from data:
  - For our geometry, $(x_1 + x_3)/2$ is an estimate of x_2.
  - Since our sensors are equal: $\sigma_{hit} = \sigma_1 = \sigma_2 = \sigma_3$

  $\Rightarrow$ Spread of $(x_1 + x_3)/2 - x_2$ and error propagation gives you σ_{hit}.

Comments

After editing SiTelescope.C:

- `root ../tree_SiTelescope_200GeV.root`
- `SiTelescope->Process("SiTelescope.C+", "200GeV")`

Calculate σ_{hit} and note the value.

Task 2.3d): Track Fit

- For 200 GeV to suppress multiple scattering effects.
- Straight line fit similar to StraightLineFit.C from Thursday: $x_0 + az$.
- σ_{hit} as determined in 2.3b)

Comments

After editing SiTelescope.C:

- `root ../tree_SiTelescope_200GeV.root`
- `SiTelescope->Process("SiTelescope.C+", "200GeV")`

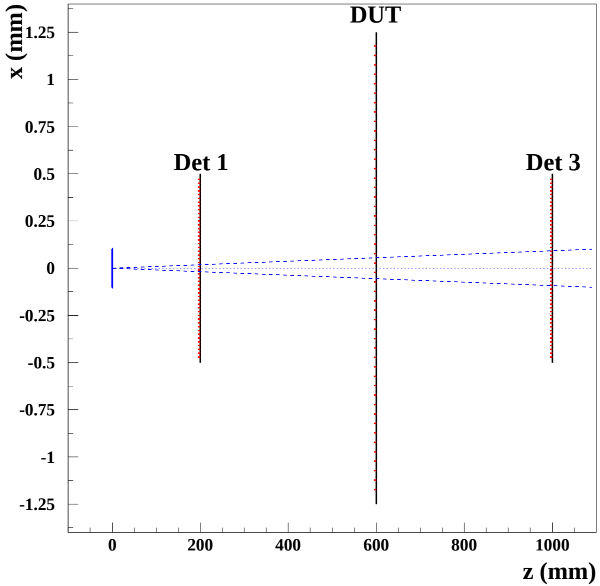
Questions, suggestions on the next slide.

Task 2.3d): Track Fit (ctd.)

Questions, suggestions:

- Why is the measured slope so "spiky"?
- Where do the spikes in the probability distribution come from?
- Re-run with tighter S/N cuts for the clusters:
  `SiTelescope->Process("SiTelescope.C+", "200tight")`?
  (Give another 2nd argument as before to keep the plots open. . .)
- How do the resolutions change?
- Adjust the assumed σ_{hit} to what you now find from the triplet:
  `SiTelescope->Process("SiTelescope.C+", "200tight2")`?
- Run with lower momentum.

The New Setup: Device under Test (DUT)



- DUT replaces middle sensor.
- DUT has larger strip pitch: 50 μm.
- Also some cross talk, i.e. charge induced on neighbour strips.
- Can be rotated: $\theta =$ $0^\circ, 10^\circ, 20^\circ, 40^\circ, 60$

Task 2.4a): Cluster Charges and Rotation Angle θ_{DUT}

- Deposited charge depends on the path length in the silicon.
- Path gets longer for non-perpendicular incident.
- Plot mean charge versus θ_{DUT} and fit expectation.
  (Bonus task: Change from mean to MPV from Landau/Gaus fit.)

Comments

All histograms are already created before, so simply edit testBeam.C:

- `root testBeam.C+`

Is the angular dependence of the cluster charge as expected?
Suggestions:

- Use the tighter S/N cuts in GetClusters: What happens for 60°?
- Look at the single event plots as created code for task 2.1b).
  - `.L testBeam.C+`
  - `singleTree("../tree_DUT_200GeV_60deg.root", "DUT60deg");`

Task 2.4b): Resolution and Rotation Angle θ_{DUT}

- Here use the truth information.
- In principle all code is there from previous tasks, BUT:
- Note some refinements to get information about whether we have DUT (larger pitch) and which angle (effective thickness increases) from the option (e.g. “DUT60deg”) passed to the selector class.

Comments

No need to edit testBeam.C, but have look of what was added.
But edit SiTelescope.C

- `root testBeam.C+`

Can you (qualitatively) explain

- the angular dependence?
- the shape of the residuals for different angles?

Task 2.4c): Resolution and Rotation Angle θ_{DUT}

- Now determine the resolution from data only.
- Again we use the triplet $(x_1 + x_3)/2 - x_2$.
- But now σ_2 is unknown and different from $\sigma_{1/3} = \sigma_{hit}$ (from task 2.3c).

Comments

The triplet hist is already in SiTelescope since task 2.3c).
Simply extend the combination method resolutionVsAngle(..) in testBeam.C.

- `root testBeam.C+`

How well does it match the resolution from truth?

Task 2.4d): Resolution and Cluster Charge

- Study resolution (vs truth) separately for small and low charges (Median as boundary).

Comments

Prepared for single TTree analysis only:

- `.L testBeam.C+`
- `singleTree("../tree_DUT_200GeV_60deg.root", "DUT60deg")`

Can you qualitatively explain the result?

Thanks for attention!