Particle Tracking with the SciFi Trackers

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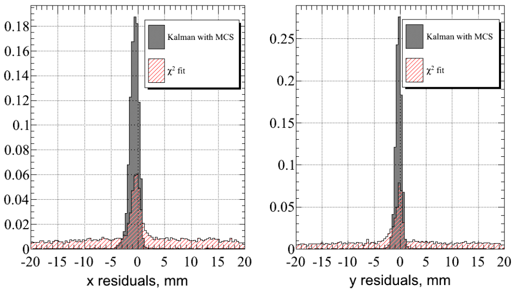
At CM 33...

First results with a Kalman Filter: straight tracks with multiple scattering.



And the promise of:

Helical Tracking;

Energy Loss;

May run analysis:

- add propagation in quadrupoles;

- link TOF's and Single Station.

Tracking in Solenoidal Field

The equations for the propagation of the state-vector are non-linear.

- First-order expansion is required.

Doesn't care about particle ID... till MCS and energy loss are added. Mass is necessary.

- For now, muon assumption in the Monte-Carlo.
- Alternative would be try different mass assumptions and keep the best χ^2.

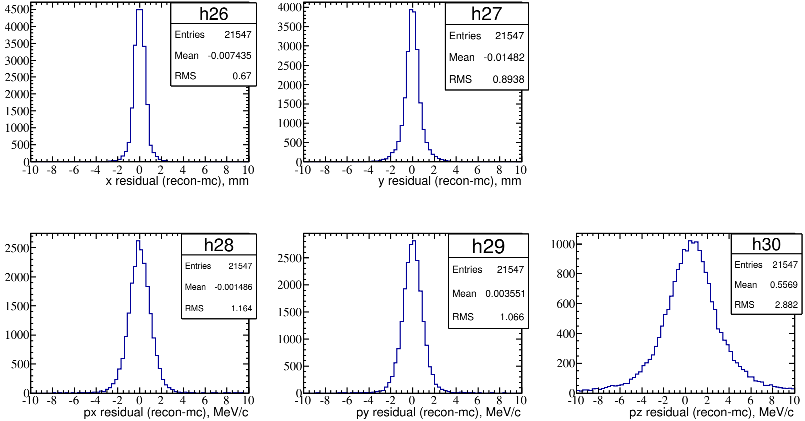
Next slide shows residuals

Reconstruction - Monte-Carlo truth

for x, y, p_x, p_y, p_z.

Solenoidal Field, no corrections

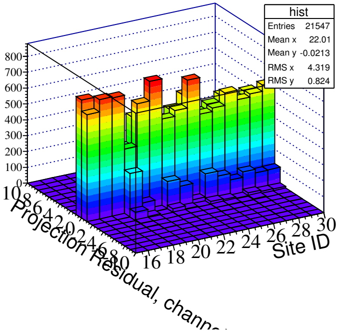
Position and Momentum residuals

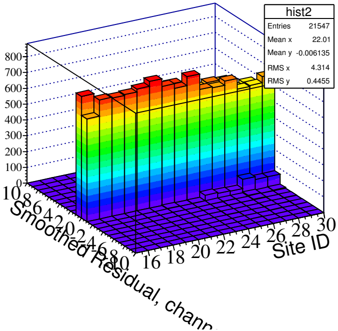


Solenoidal Field, no corrections

Channel residuals

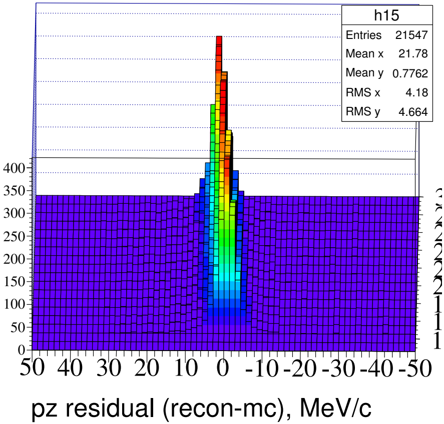
getting your eyes ready for real data...





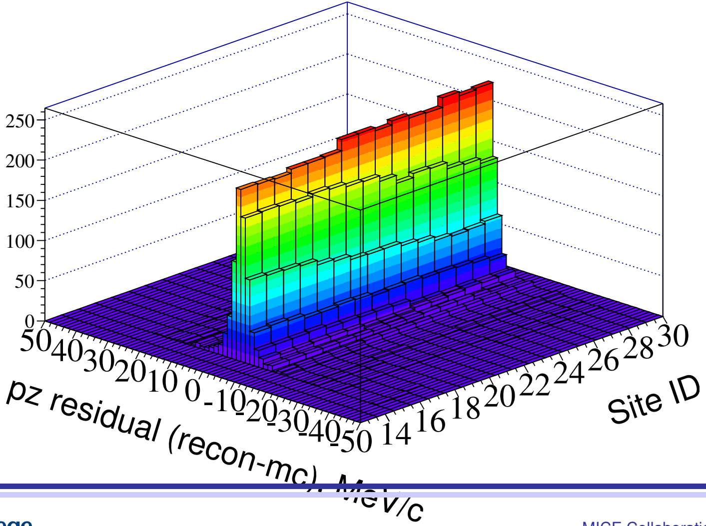
Solenoidal Field, no corrections

P_z residual shifts along the track: E_{loss} effect.



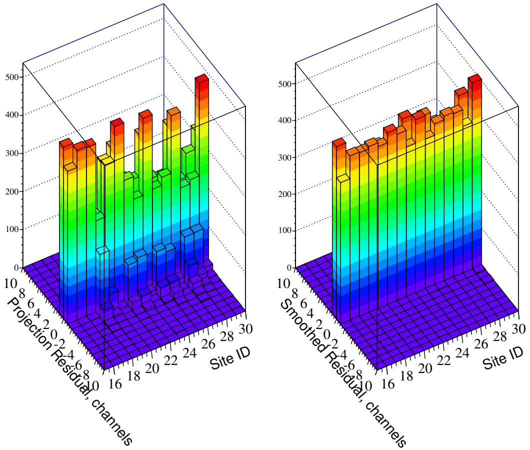
Solenoidal Field, with MCS and E_{loss}

P_z shift is gone.



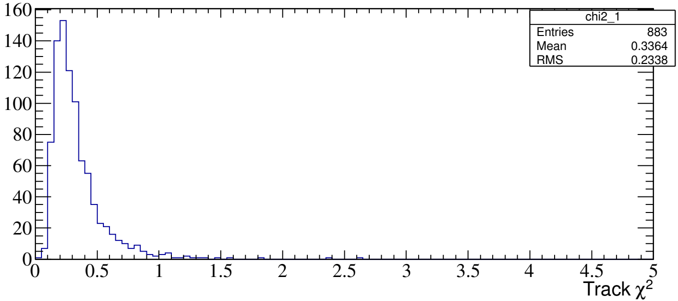
Solenoidal Field, with MCS and E_{loss}

Channel residuals are improved!



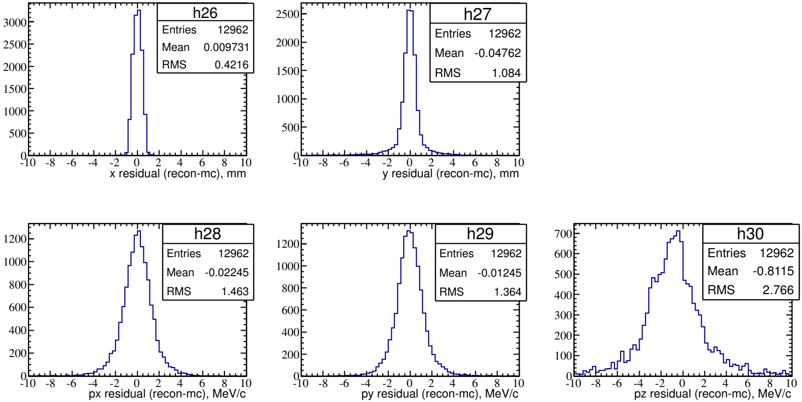
Solenoidal Field, with MCS and E_{loss}

χ^2/ndf for each track



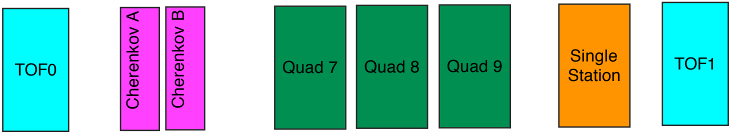
Solenoidal Field, with MCS and E_{loss}

Not a closed issue. Corrections need refinement.

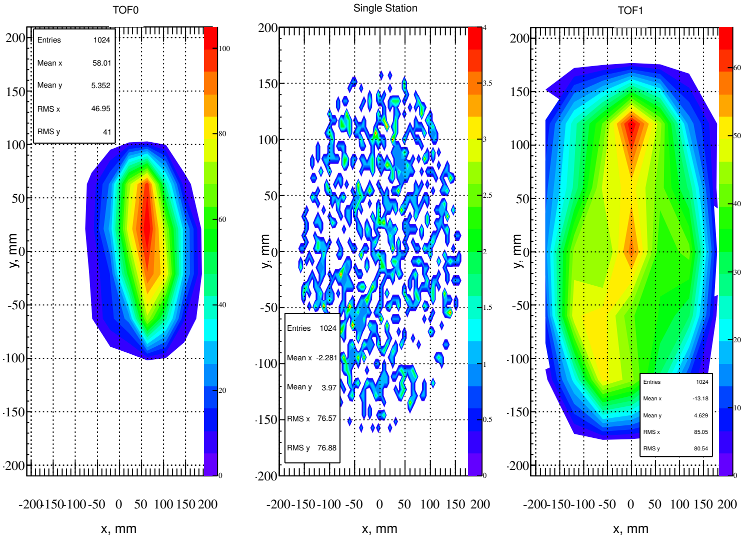


TOF’s + Single Station Fit

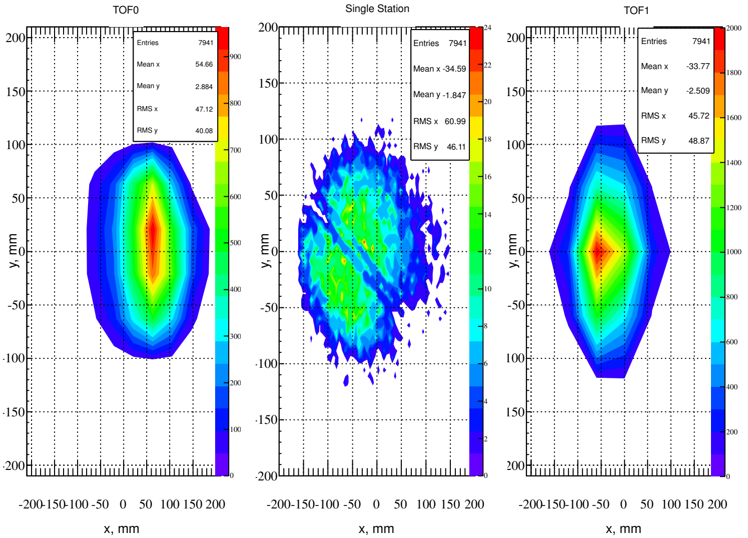
This section looks at data from runs **4102** & **4103**:
Pions, 200 MeV/c (nominal Q1-6)
Beamline Polarity: +
Run 4102: Q7-9 off
Run 4103: Q7-9 set for 200 MeV/c



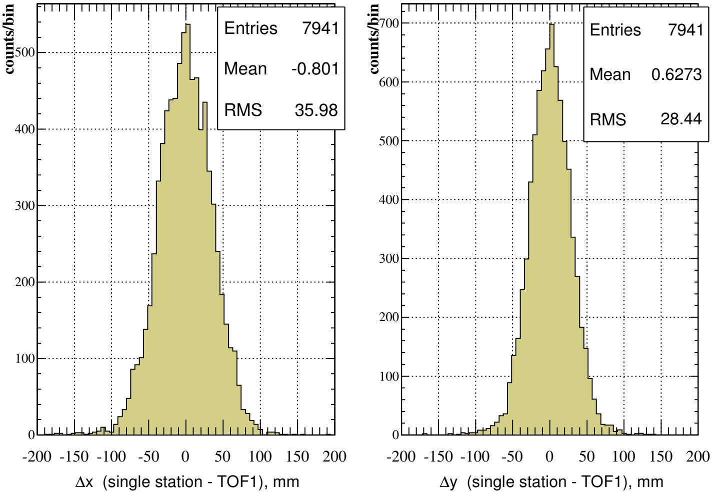
Run 4102: Q7-9 off



Run 4103: Q7-9 set for 200 MeV/c

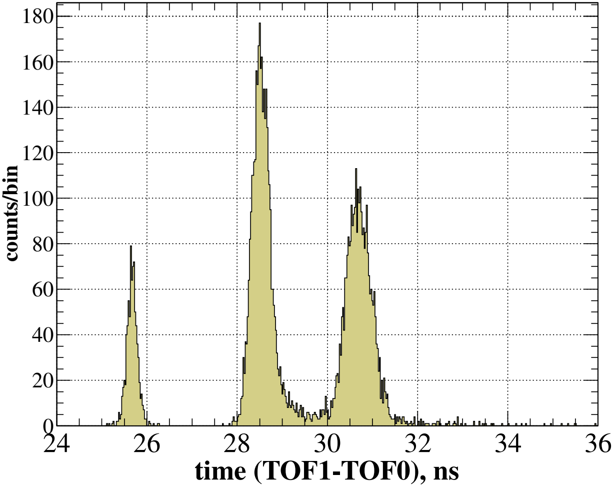


First look at the data: do the particle positions for Single Station and TOF1 agree?

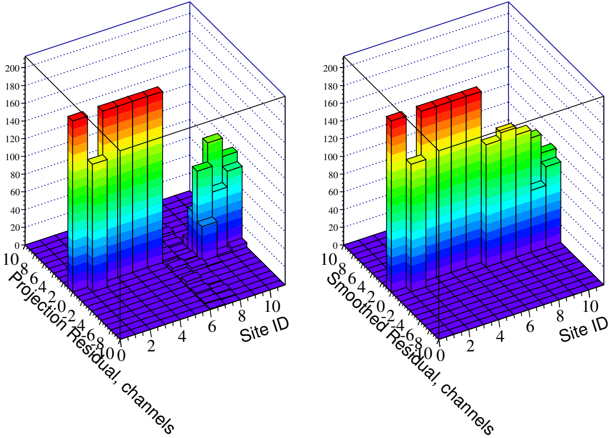


Preparing the Filter: PID

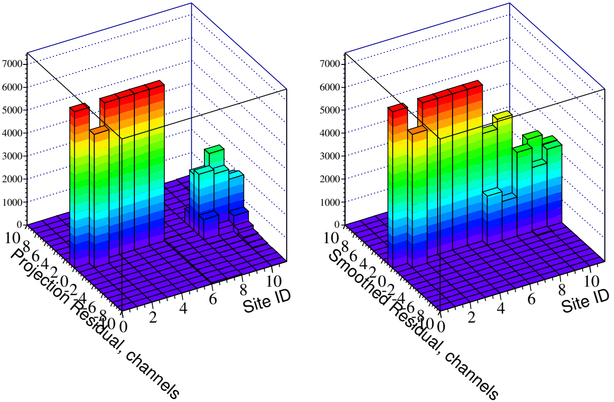
From left to right: positrons, muons, pions.



Fitting with Quads OFF

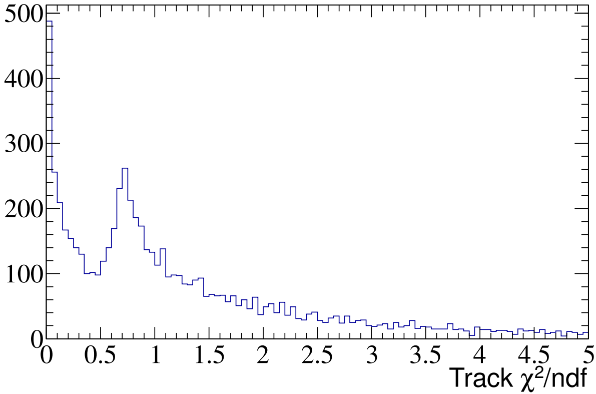


Fitting with Quads ON



Fitting with Quads ON

Track χ^2/ndf



Summary

The SciFi Kalman Track Fitting

- includes **Energy Loss** and **Multiple Scattering**;
- *needs refinement*

Can follow tracks in regions with:

- no field,
- solenoidal field;
- quadrupole field;

Work to be done:

- consider inhomogeneous magnetic fields;
- add alignment functionality.
- ...

Acknowledgments:

Adam and Summer (SciFi Pattern Recognition)
Jason and Matt for helping on Geometry and ConfigDB
Linda for all the prompt replies pointing me on the right direction
Maria Leonova for her perfect and prompt answers to my beam line questions
Jaroslav Pasternak for the discussions on the quad drift
Yordan for help in TOF related issues.

Backup Notes

a word about Multiple Scattering & Energy Loss

Multiple Scattering Adds to Covariance Matrix

$$< x_i, x_j >= \sigma^2(\theta) \left(\frac{\partial x_i}{\partial \theta_1} \frac{\partial x_j}{\partial \theta_1} + \frac{\partial x_i}{\partial \theta_2} \frac{\partial x_j}{\partial \theta_2} \right)$$

Energy loss computed from Bethe-Bloch

$$\Delta p = \int_0^L \frac{dp}{dx} dx = \int_0^L \frac{1}{\beta} \frac{dE}{dx} dx = \int_0^L \frac{A}{\beta^3} [\ln(\frac{2 m_e c^2 \beta^2 \gamma^2}{I_0}) - \beta^2] dx$$

impacts the state vector momentum components. For a minimum ionising muon, $\Delta p \approx 0.133 MeV/c$ per SciFi plane.

Track Fitting Generalities

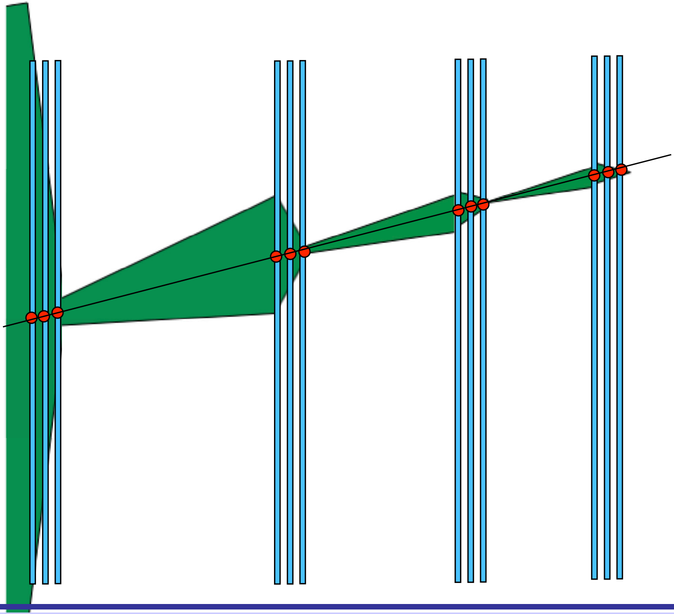
Ingredients

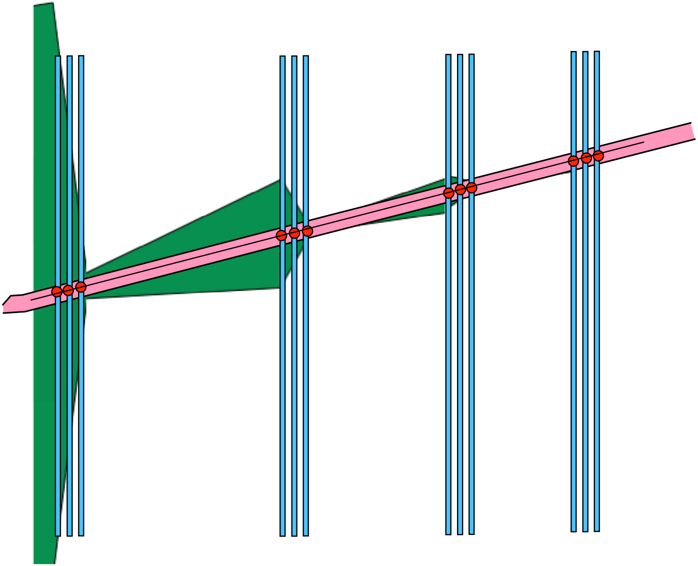
a State Vector [x, px, y, py, 1/pz];

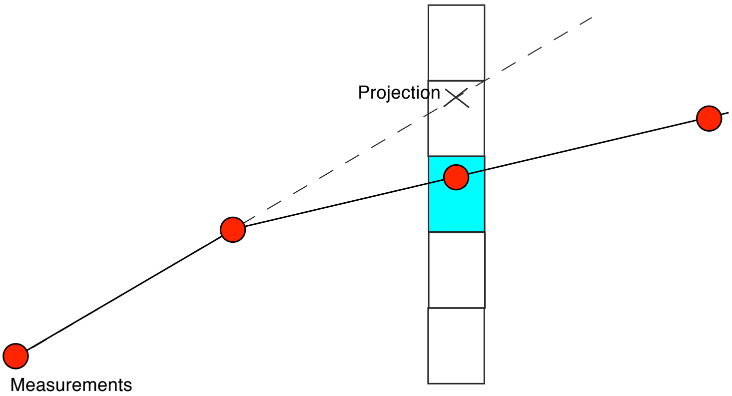
a matrix to extrapolate that state vector along the beam line (*Projection*);

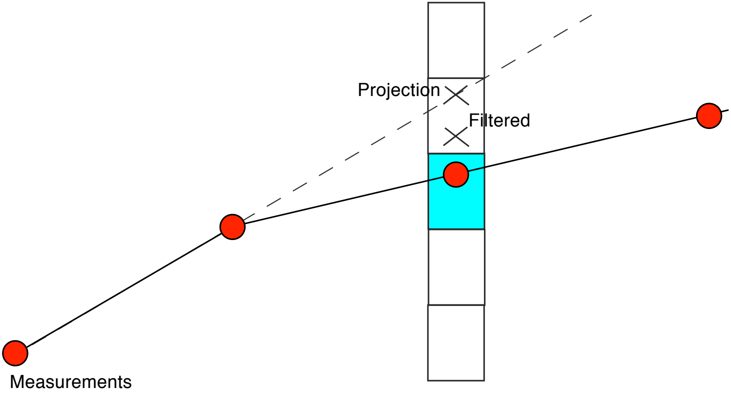
a matrix to convert state vector into ”expected measurement.” This is **detector dependent.**

The state vector has a variance/covariance matrix associated with. It is also propagated and filtered.






Projection
Measurements


Projection
Filtered
Measurements

(go back)