Pixel TPC reconstruction

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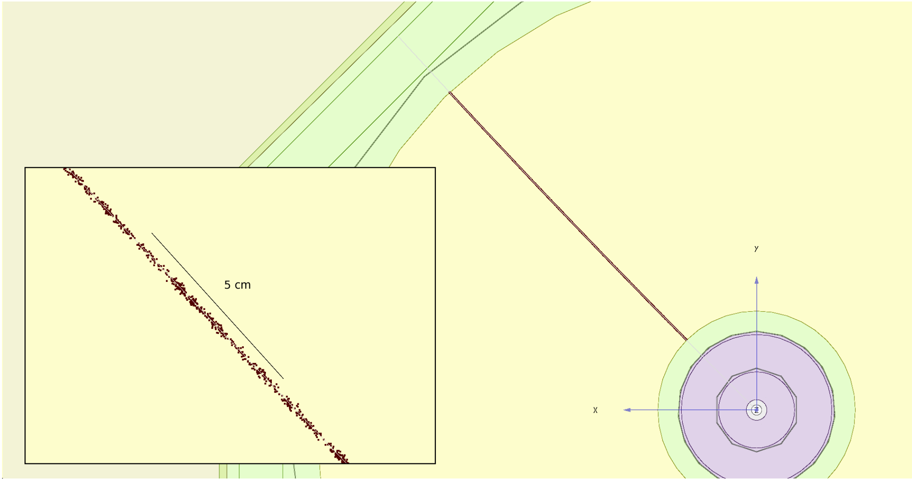
Nikhef lepcol meeting

8 May 2017

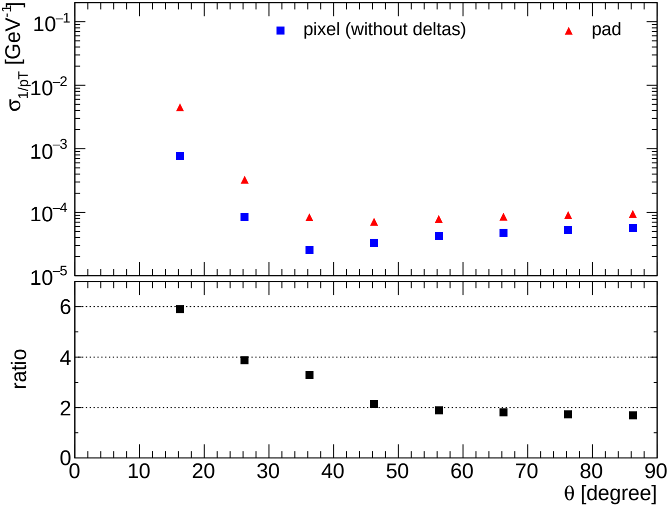
Fit of straight track

50 GeV muon



Momentum resolution from track fit

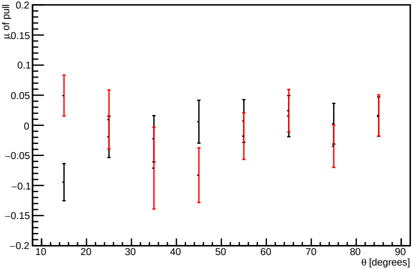
50 GeV muon



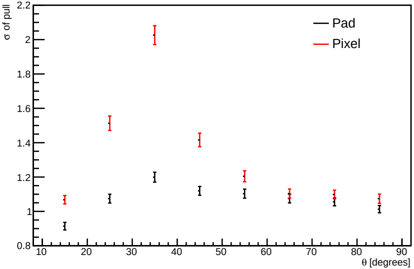
Pixels hits simulated with delta's, but rejected before reconstruction

Pull of $1/p_T$

from 8×1000 tracks of 50 GeV muons

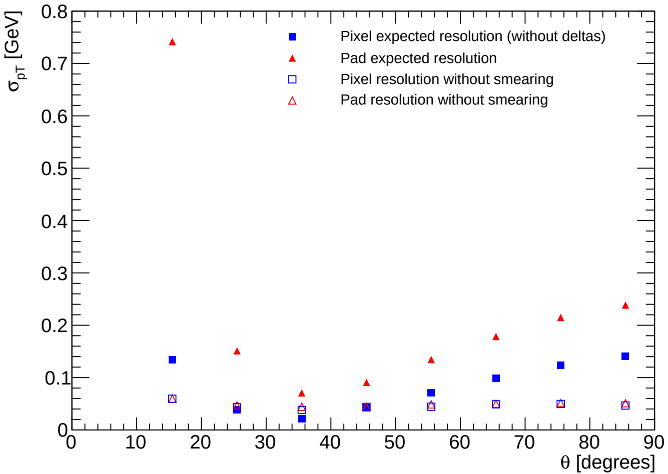


Mean μ does not indicate any biases



σ of pull is too large at angles with the best momentum resolution

Distortion of σ of pull



p_T difference between input and fit to unsmeared hits is $\sim$ 40 MeV

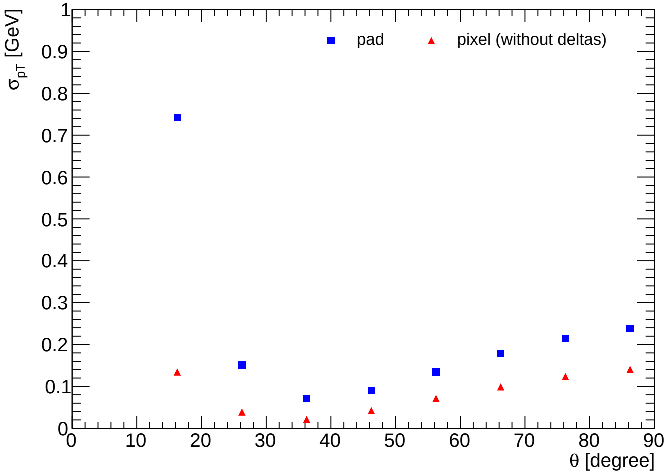
σ of pull is increased by precision settings or a bug in the code

Conclusion

- First estimates of the pixel readout performance show a factor $\sim 2-6$ improvement over to the pad readout
- Next steps:
  - Update to newest ilcsoft software version v01-19
  - Fix pull of track fit
  - Do delta rejection using an algorithm
  - Continue studies of performance of pixel readout
  - Investigate dE/dx performance
  - Implement an endplate layout with more realistic coverage ($\sim 80\%$)
  - Simulate and reconstruct physics events with a pixel readout

Momentum resolution from track fit covariance matrix

50 GeV muon



Extended Kalman filter

Recursive fitting algorithm to find state vector $\boldsymbol{a}_k$ and covariance $\boldsymbol{C}_k$ at site k from a series of measurements $\boldsymbol{m}_k$ by procedure:

- Predict
  - $\boldsymbol{a}_k^{k-1} = \boldsymbol{f}_{k-1}(\boldsymbol{a}_{k-1})$, where $\boldsymbol{f}_k(\boldsymbol{a}_k)$ is the state-propagator
  - $\boldsymbol{C}_k^{k-1} = \boldsymbol{F}_{k-1}\boldsymbol{C}_{k-1}\boldsymbol{F}_{k-1}^T + \boldsymbol{Q}_{k-1}$, where $\boldsymbol{F}_{k-1} = \frac{\partial \boldsymbol{f}_{k-1}}{\partial \boldsymbol{a}_{k-1}}$, and $\boldsymbol{Q}_k$ the covariance of the process noise
- Update
  - $\boldsymbol{a}_k = \boldsymbol{a}_k^{k-1} + \boldsymbol{K}_k\left(\boldsymbol{m}_k - \boldsymbol{h}_k(\boldsymbol{a}_k^{k-1})\right)$, where $\boldsymbol{h}_k(\boldsymbol{a}_k)$ the projector, $\boldsymbol{K}_k = \boldsymbol{C}_k^{k-1}\boldsymbol{H}_k^T(\boldsymbol{V}_k + \boldsymbol{H}_k\boldsymbol{C}_k^{k-1}\boldsymbol{H}_k^T)^{-1}$, $\boldsymbol{H}_k = \frac{\partial \boldsymbol{h}_k}{\partial \boldsymbol{a}_k^{k-1}}$, and $\boldsymbol{V}_k$ the coveriance of the measurement noise
  - $\boldsymbol{C}_k = \left((\boldsymbol{C}_k^{k-1})^{-1} + \boldsymbol{H}_k^T\boldsymbol{G}_k\boldsymbol{H}_k\right)^{-1}$, where $\boldsymbol{G}_k = (\boldsymbol{V}_k)^{-1}$
- (Smooth...)

See: Keisuke Fujii, Extended Kalman Filter, The AFCA-SIM-J Group

Diffusion and hit resolution is simulated by smearing the hits by the expected resolution in TPCDigiProcessor

$$
\begin{aligned}
a &= \sigma_{r\phi 0}^2 + \sigma_{\phi 0}^2 \sin^2(\phi_{\text{pad}}) \\
b &= \frac{D_{r\phi}^2}{N_{\text{Eff}}} \sin(\theta_{\text{pad}}) \left(\frac{6 \text{ mm}}{h_{\text{pad}}}\right) \left(\frac{4.0 \text{ T}}{B}\right) \\
\sigma_{r\phi} &= \sqrt{a + bL} \\
\sigma_z &= \sqrt{\sigma_{z0}^2 + D_z^2 L}
\end{aligned}
$$

,

$$
\begin{aligned}
\sigma_{r\phi 0} &= 0.05 \text{ mm} & \sigma_{z0} &= 0.4 \text{ mm} & \sigma_{\phi 0} &= 0.9 \text{ mm} \\
D_{r\phi} &= 0.025 \text{mm}/\sqrt{\text{cm}} & D_z &= 0.08 \text{mm}/\sqrt{\text{cm}} & N_{\text{Eff}} &= 22.
\end{aligned}
$$