Simulation of Gossip MPGD: Analysis of Tracks in a 1 mm Thick Gas Layer

Wilco Koppert

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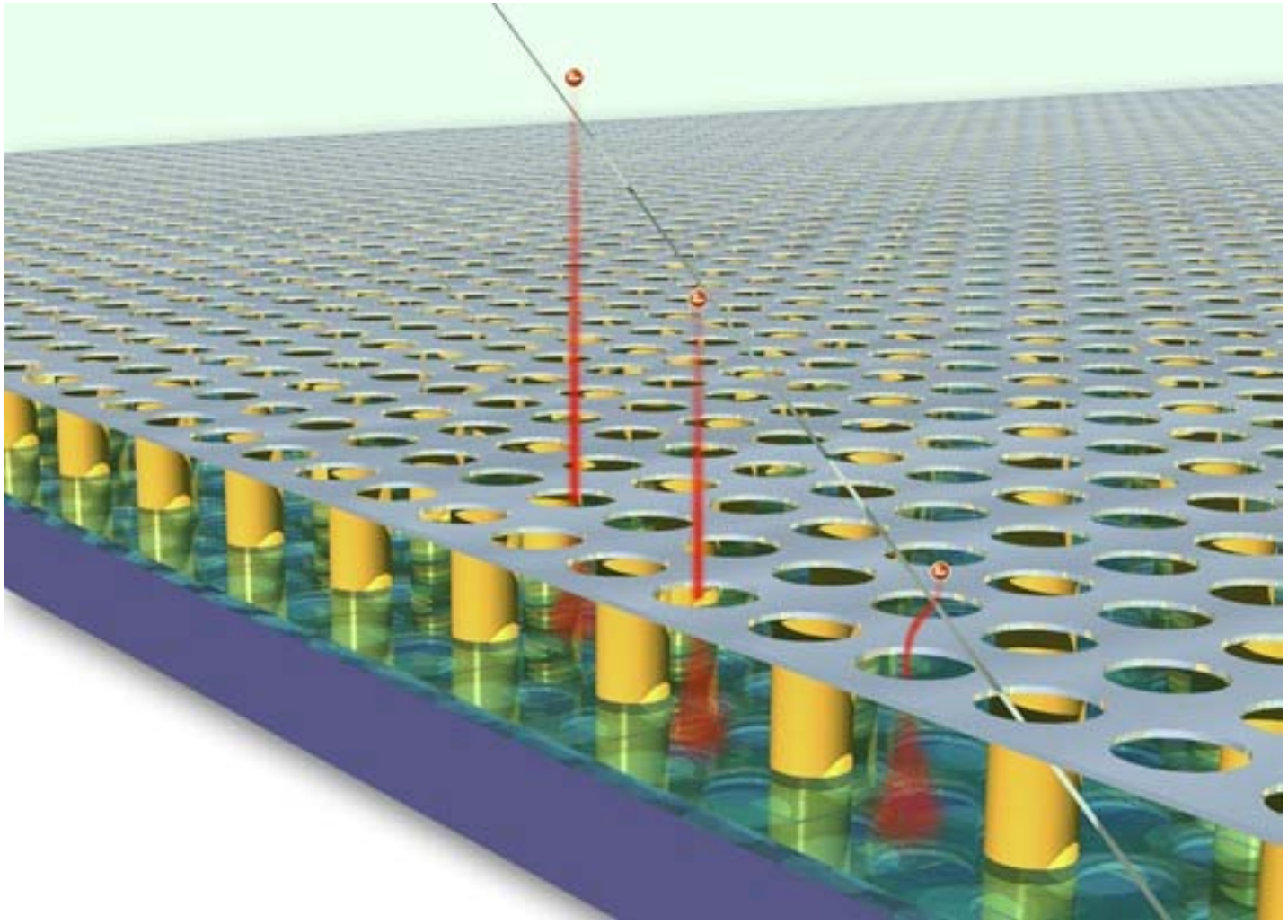
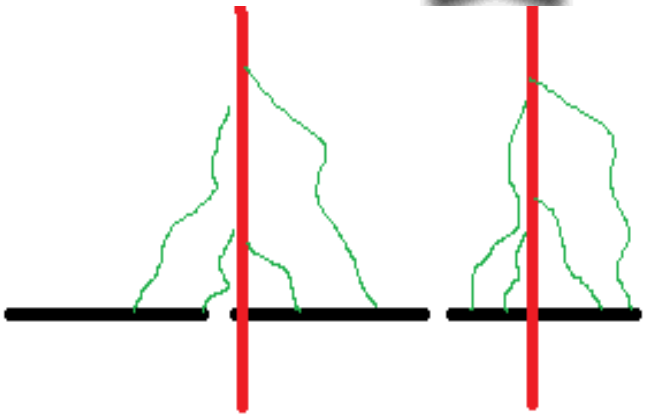
Introduction



Configuration

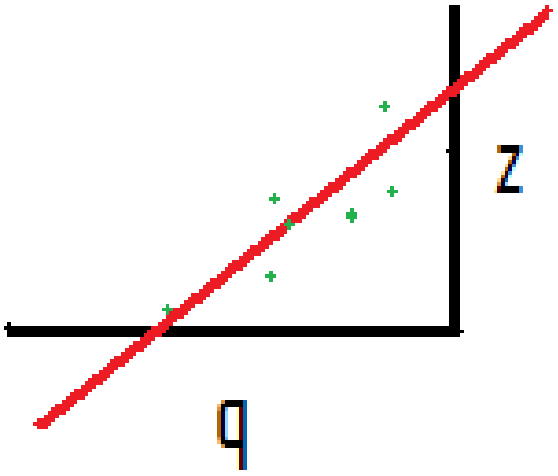
- GARFIELD for Drift Gap, MCGossip
- HEED (gas parameters)
- CO2 (50%), DME (50%), T= 293K, P= 1atm
- Drift Gap 1 mm, Avalanche Gap 50 μm
- Diffusion 98.5 μm/√cm (L), 114.5 μm/√cm (T)
- Sample: 1000 muons (10 GeV MCGossip, 1 GeV Garfield)
- Drift voltage -700 V
- Grid -400 V
- Chip ground
- No Chip MC used (yet)
- Drift velocity: 55,6 μm/ns

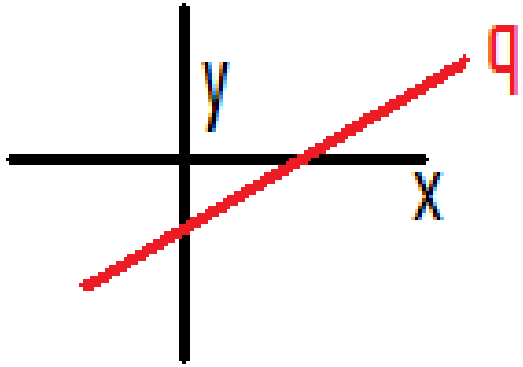
Variables



- Pitch
- Time resolution
- Angle muon track wrt chip (ϕ)

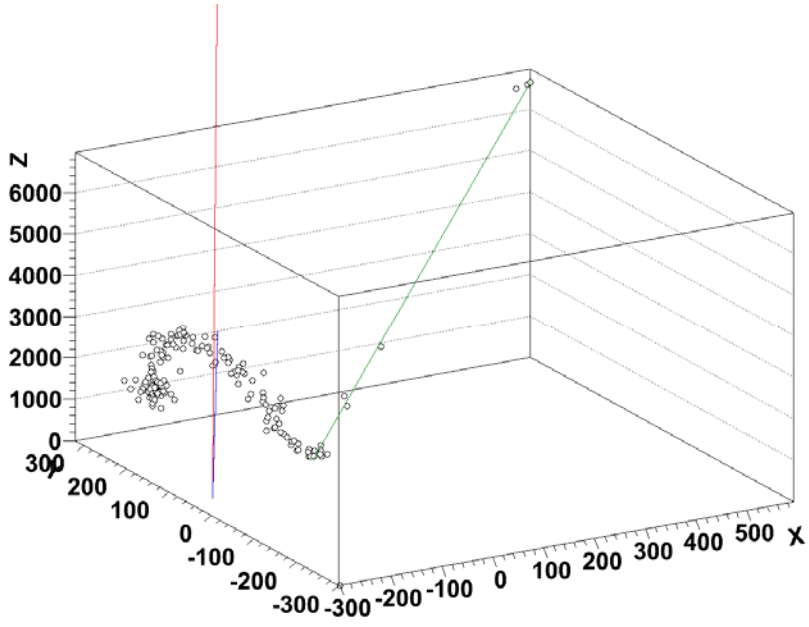
  Goal: optimize variables
- Position muon on pixel ($-0.125<x,y<0.125$ mm)
- Angle muon track wrt x-axis ($0<\theta<\pi/4$, a-symmetry)





Setup MC Simulation

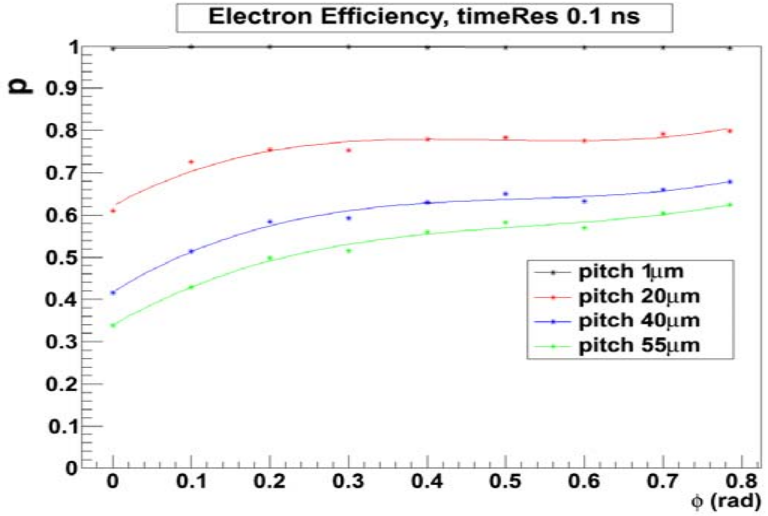
- Delta rays disturb fitting procedure -> perfect analysis or switch off delta rays.
- Samples without delta rays show limits
- In an experiment a muon travels through multiple gossips: constrained ϕ and θ.
- From Garfield exact locations (x,y,z) -> Bin in pixels (nx,ny,nz)
- Choice pitches: 1x1, 20x20, 40x40, 55x55 μm
- Choice Time Res: .1, .5, 1.0, 1.5, 1.8, 2.0 ns

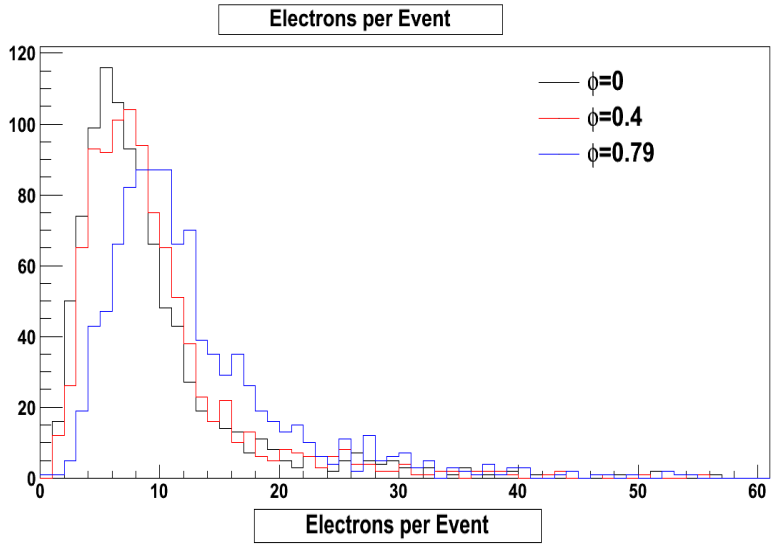


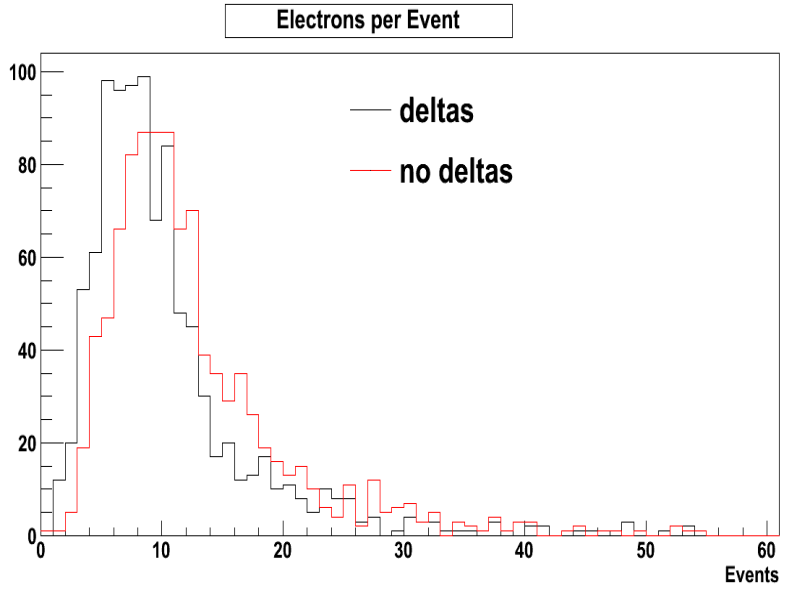
Setup Analysis

- ROOT
- 3D line Fit procedure MINUIT
- Weight electrons ~ Transverse Diffusion
- Fit 3D line through nx,ny,nz per event.
- Contrained -> position where track hits chip (x0,y0)
- Unconstrained -> angles ϕ, θ, x_0 and y_0
- Resolution: $x_{0\ garfield}$-$x_{0\ fit}$ for N_e>1

Results

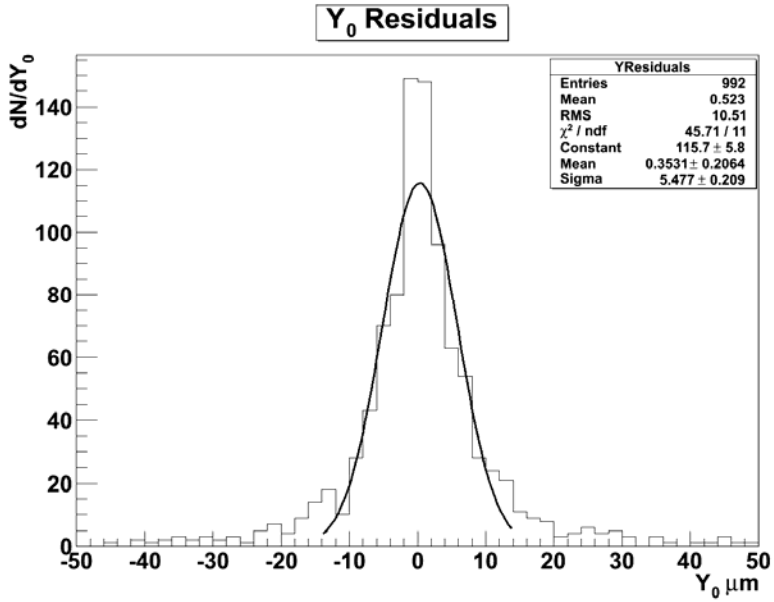


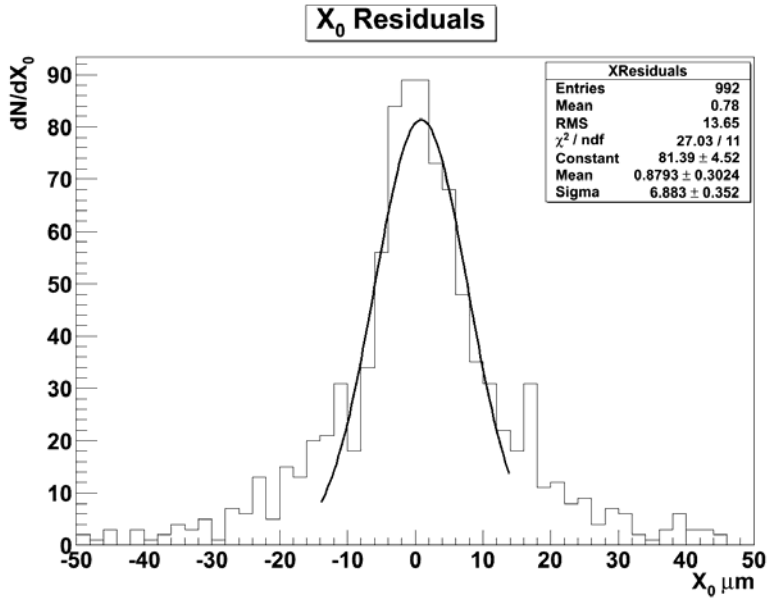


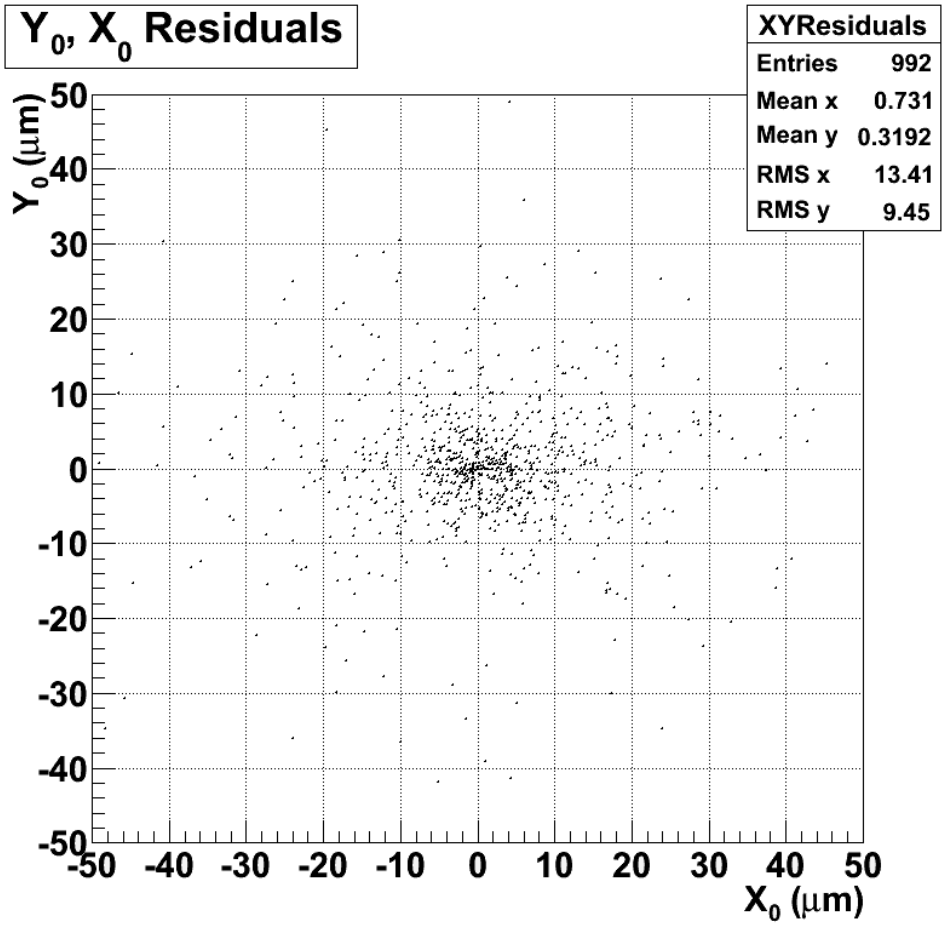


- Electrons per event ~ 5 (small angles) ~ 10 (large angles)
- Electrons efficiency drops to 30% at large pitch and small angles

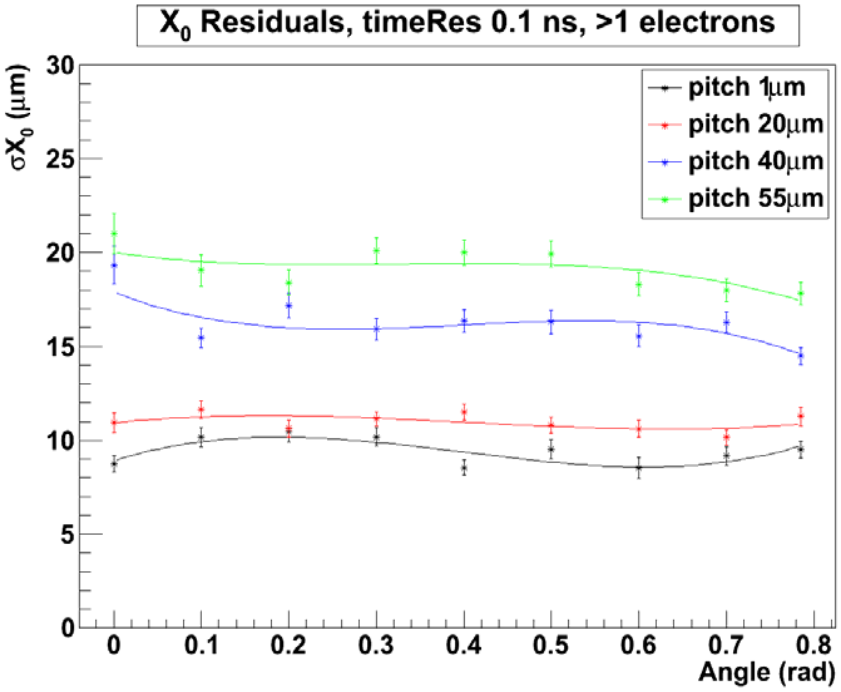
Results

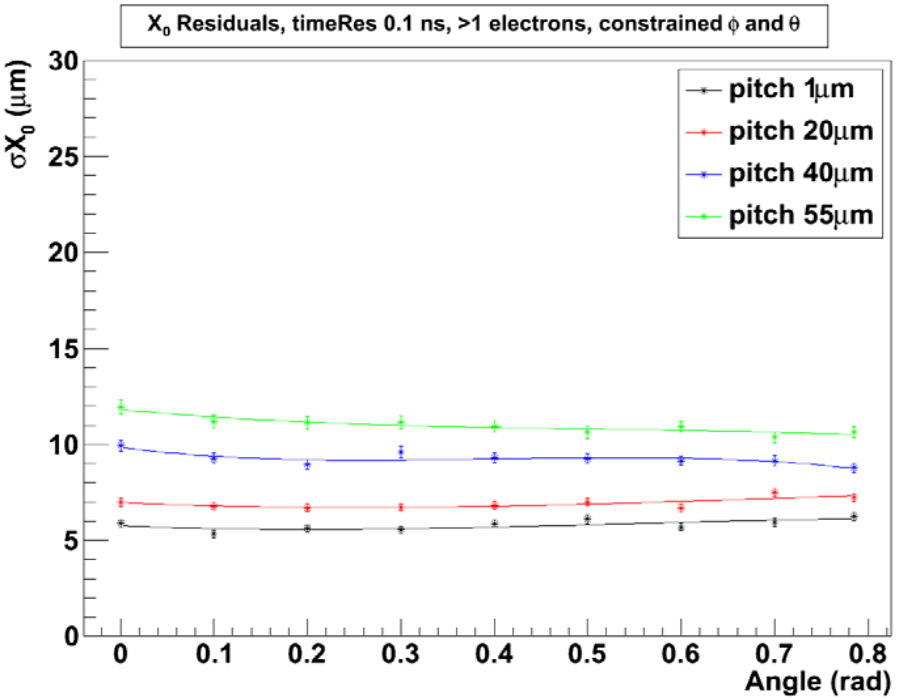

Y0 Residuals
YResiduals
Entries 992
Mean 0.523
RMS 10.51
χ² / ndf 45.71 / 11
Constant 115.7 ± 5.8
Mean 0.3531 ± 0.2064
Sigma 5.477 ± 0.209
dN/dY0
Y0 μm


X0 Residuals
XResiduals
Entries 992
Mean 0.78
RMS 13.65
χ² / ndf 27.03 / 11
Constant 81.39 ± 4.52
Mean 0.8793 ± 0.3024
Sigma 6.883 ± 0.352
dN/dX0
X0 μm


Y0, X0 Residuals
XYResiduals
Entries 992
Mean x 0.731
Mean y 0.3192
RMS x 13.41
RMS y 9.45
Y0 (μm)
X0 (μm)

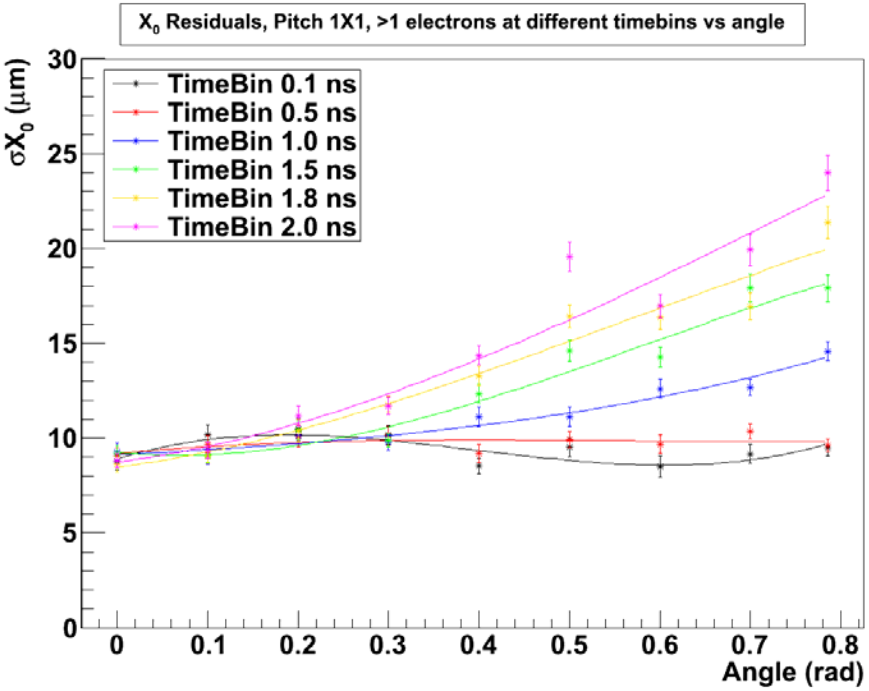
Results

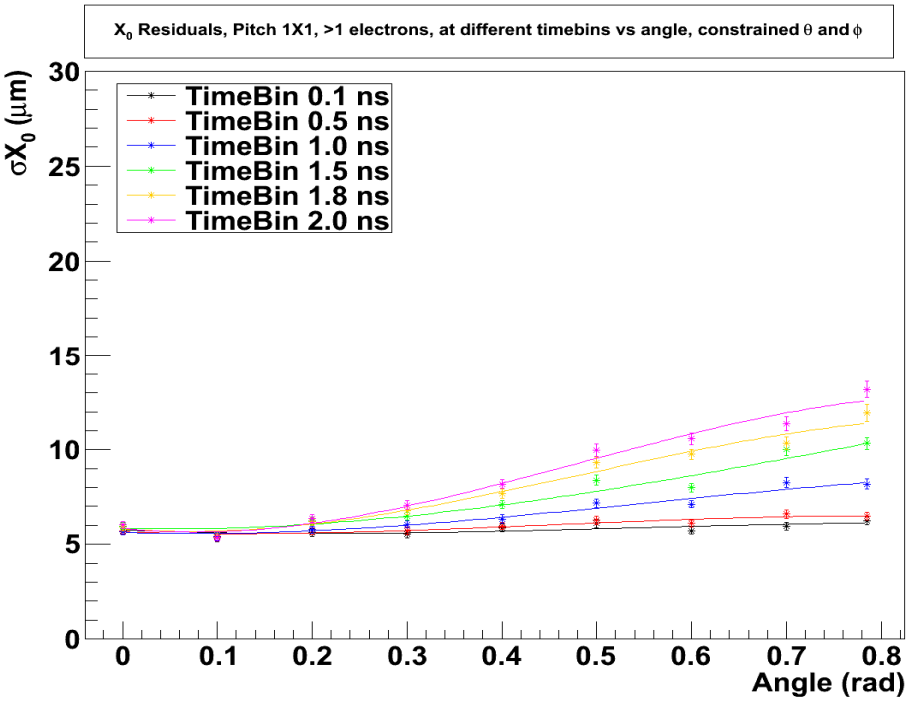




- $\sigma_{constr} < \sigma_{constr}$ as expected and stays constant for TimeRes=0.1 ns, for constrained ϕ and θ (better resolution for longer tracks canceled by Z-diffusion)

Results





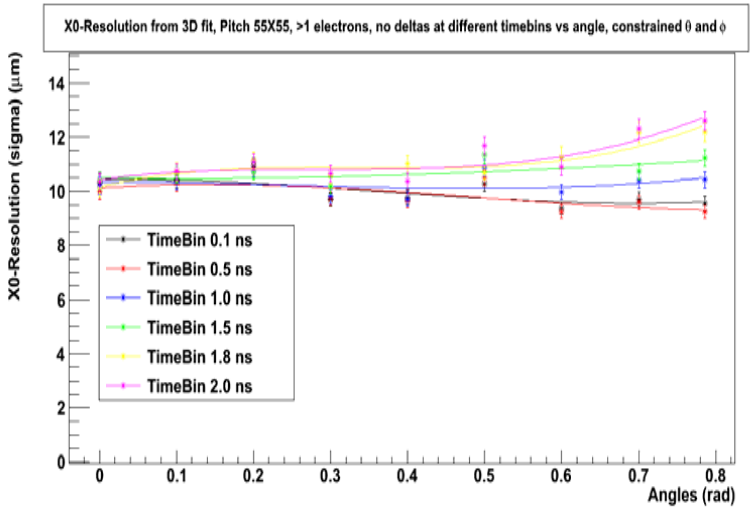
-Worser TimeRes dominates resolution at large angles, but resolution stays small at constrained θ and ϕ.

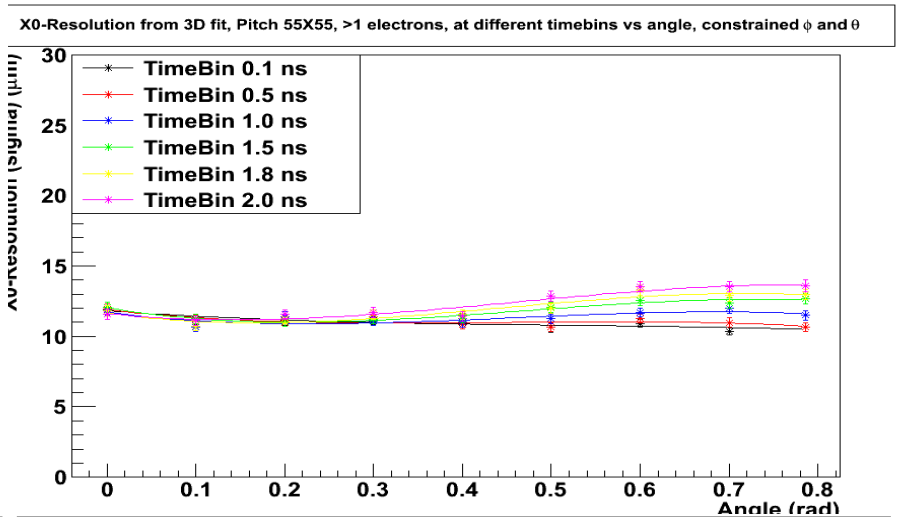
Results MC for 55x55 um

No Deltas

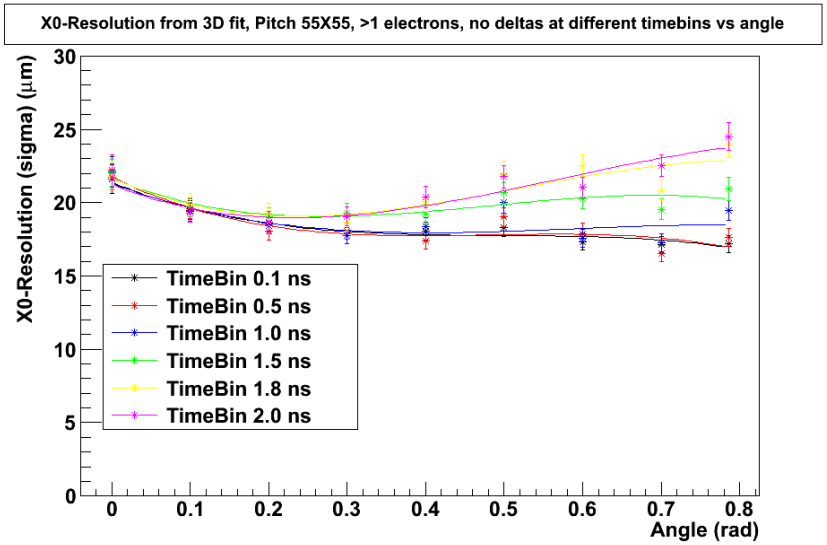
Deltas

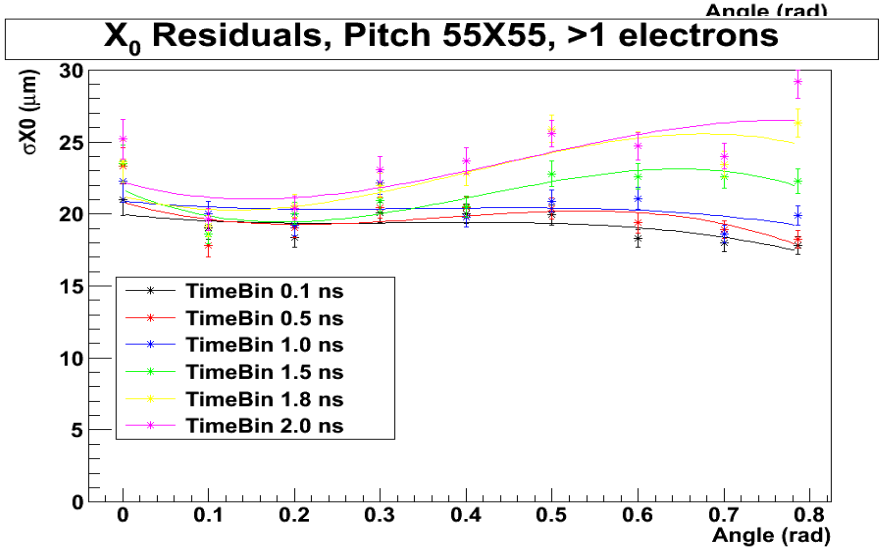
Constr





Unconstr





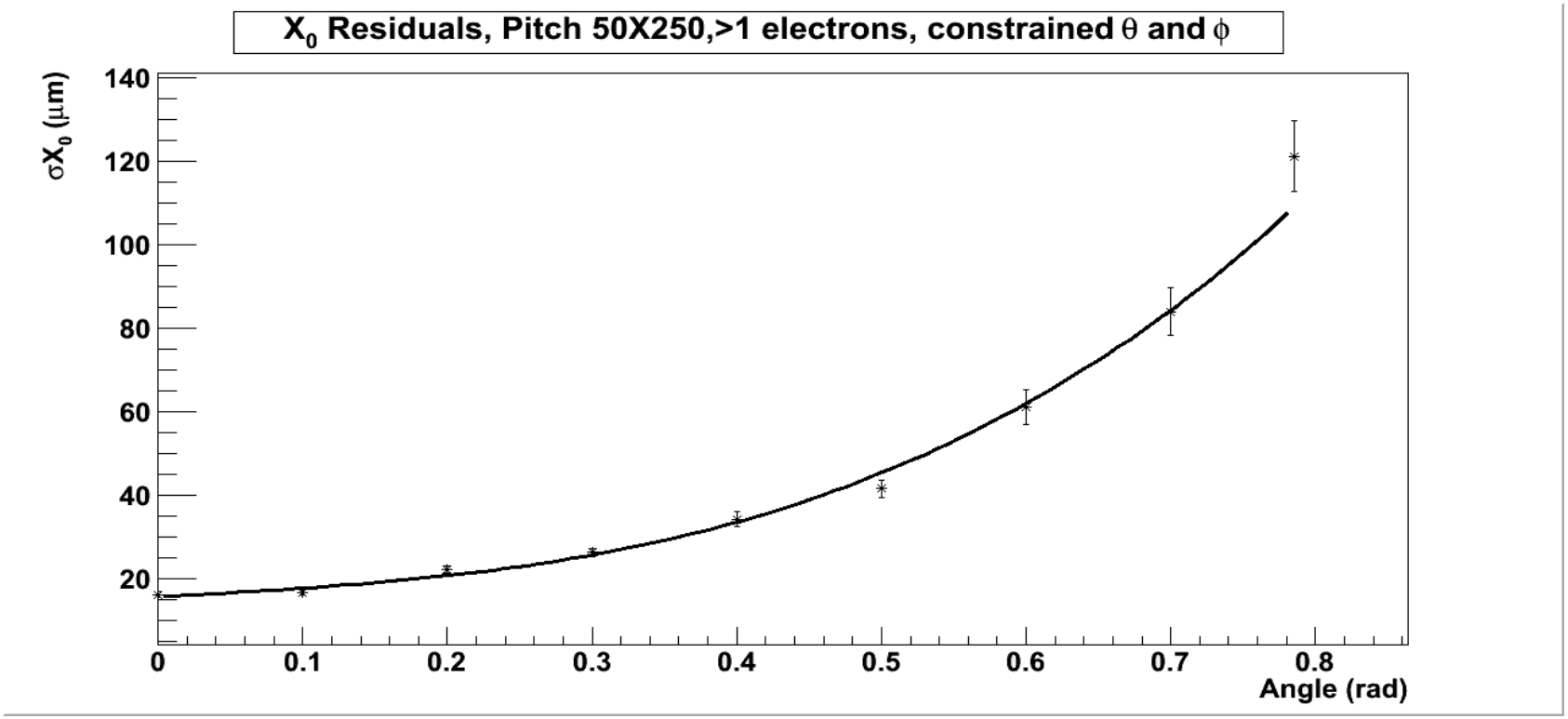
Conclusions

- Time resolution dominates at large angles

  Best Performance at ϕ = 0.1-0.2 rad
- Constrained angles improve resolution ~2 times
- Good analysis (excluding deltas) few μm improvement
- Physical limit GOSSIP σ~5 μm (with this settings)
- Expected resolution current timepix

  ~10-11 μm (constrained) @ ϕ = 0.1-0.2 rad

Fe-I4 results



- Fe-I4 50X250, ATLAS chip, for the no delta case

To Do

- Verify results in test beam for current TimePix
- Develop analysis method to extract deltas
- Add electronics + signal development to simulation (distinguish two hits on one pixel?)
- Find Gas with smaller diffusion?