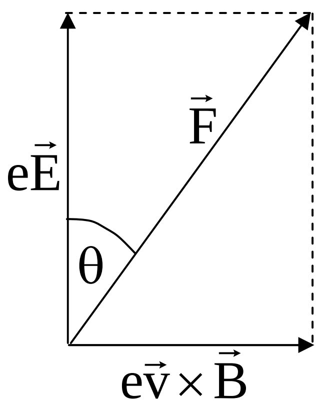
Lorentz angle effects in the CPCCD

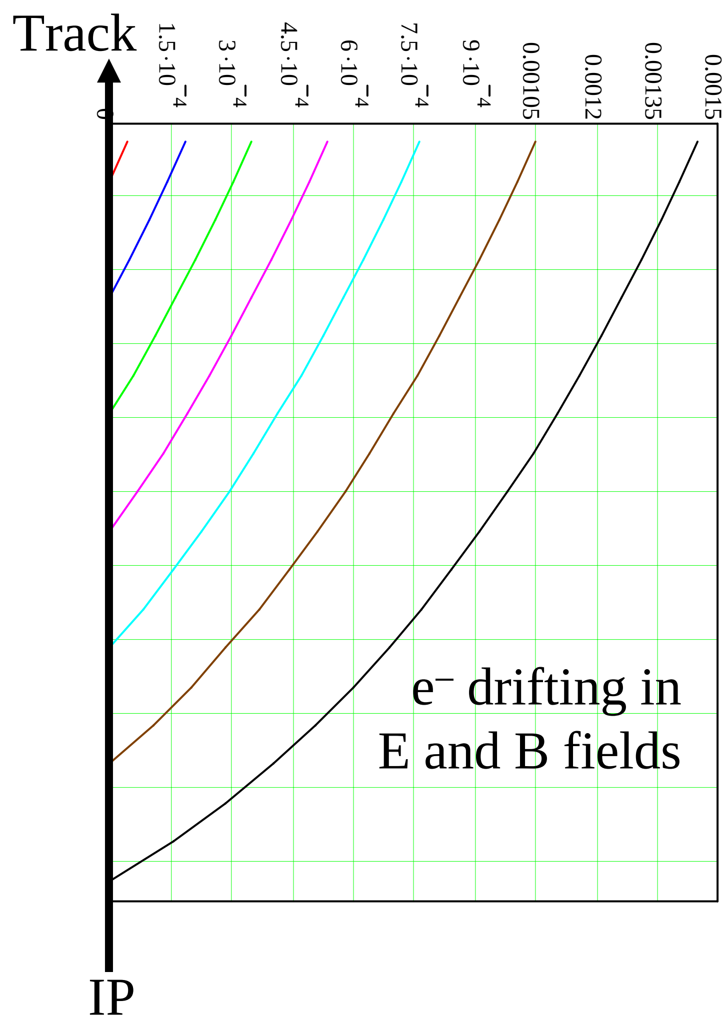
- Electrons drifting in depletion region of CCD experience Lorentz force in magnetic field, $\vec{F} = e\vec{E} + e\vec{v} \times \vec{B}$.
- For normal E and B fields, direction of net force on moving e is at Lorentz angle θ to E field.



$$\tan\theta = \frac{e\vec{v} \times \vec{B}}{e\vec{E}} = \frac{vB}{E} = r_H \mu B$$

- Here μ is mobility, with correction r_H due to effects of B field.

- This causes displacement of hits:

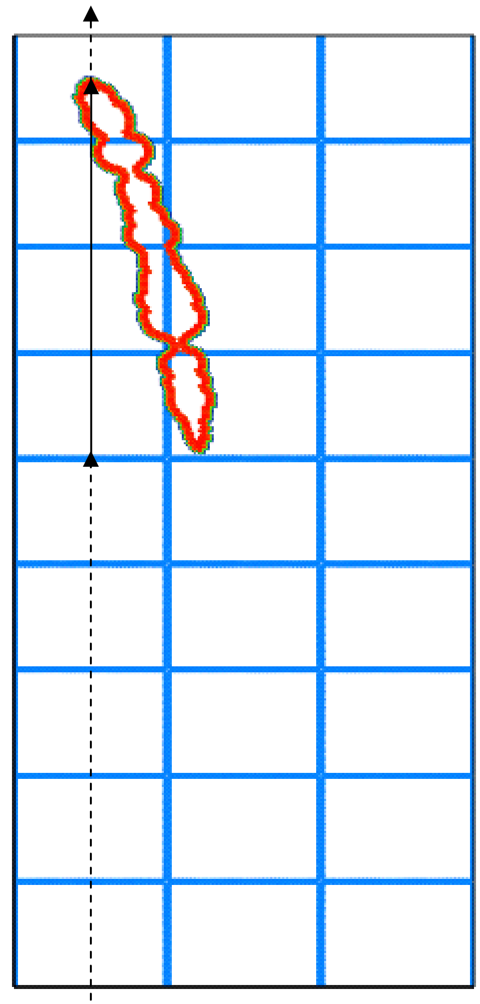


Consequences for readout chip design?

- Consider additional spread in number of pixels in which charge detected due to B field.
- Track high momentum particle at various polar angles with B = 5T.
- Charge deposition taken from data for 1 GeV pions in 1 μm silicon.
- Look at few events.
- All plots have track coming from IP, passing through CCD as shown opposite.
- Clusters show where charge enters buried channel.

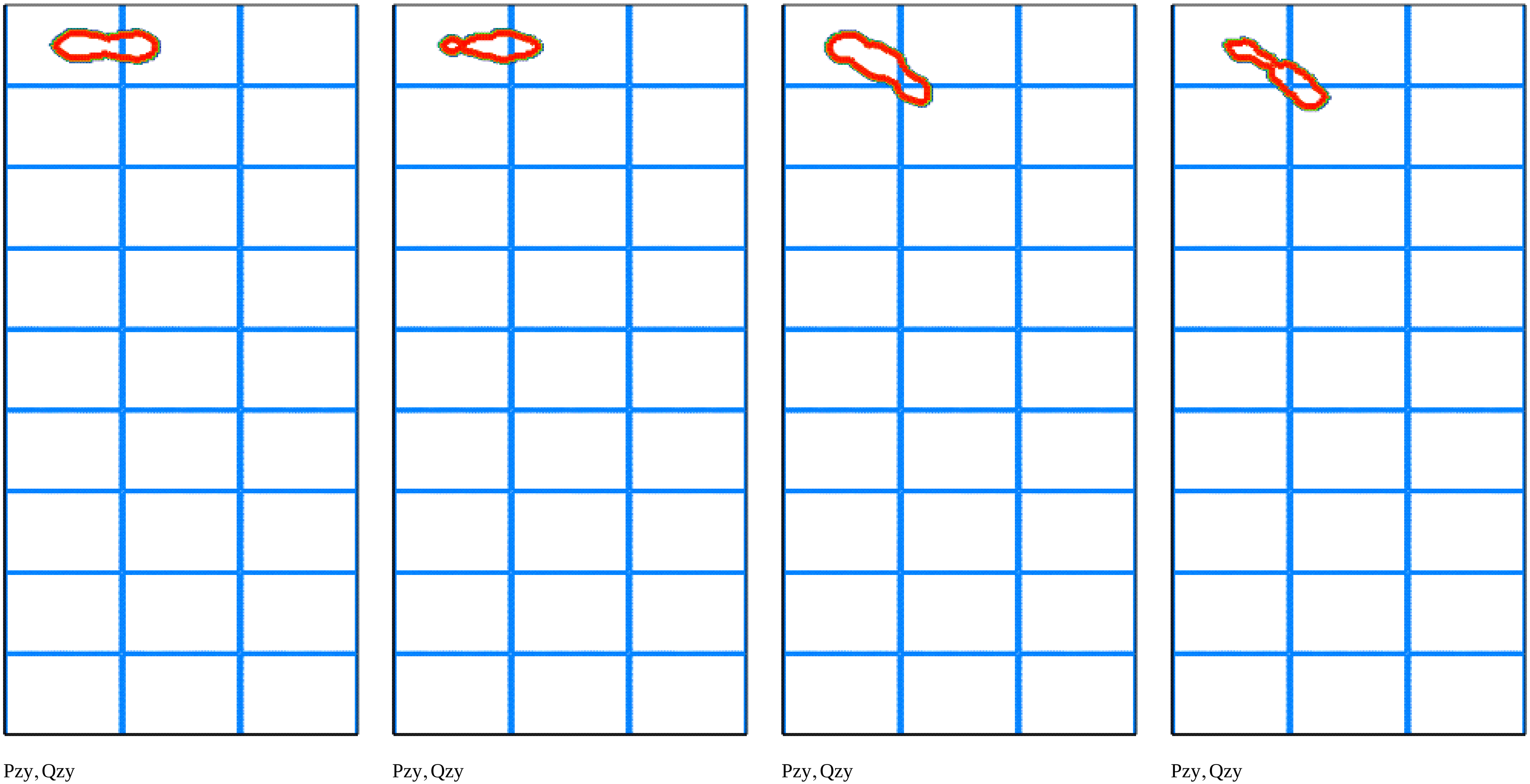
Track leaves upper surface of CCD

Track enters lower surface of CCD



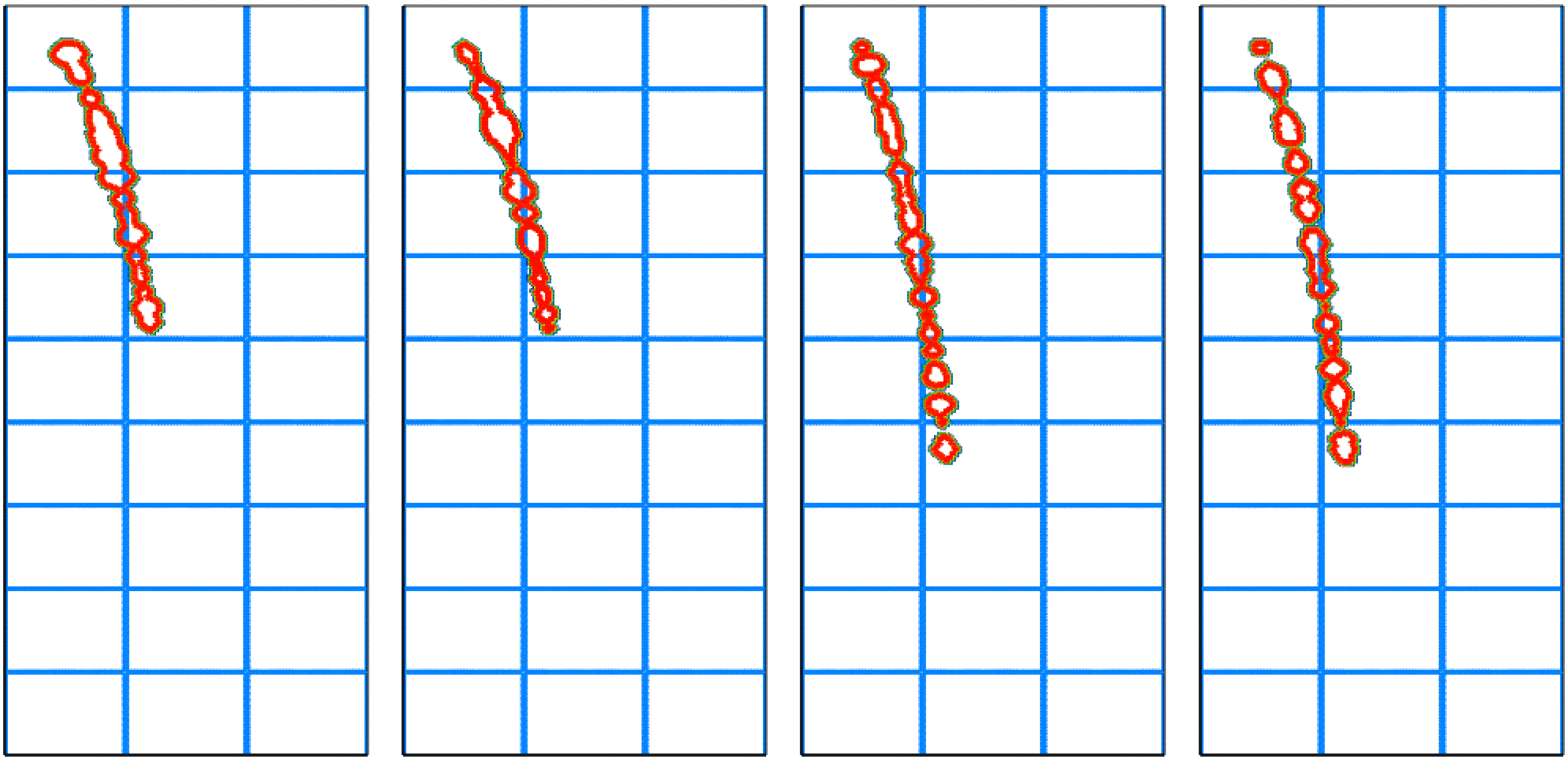
Example events:

$\theta = 90°$ $\theta = 60°$



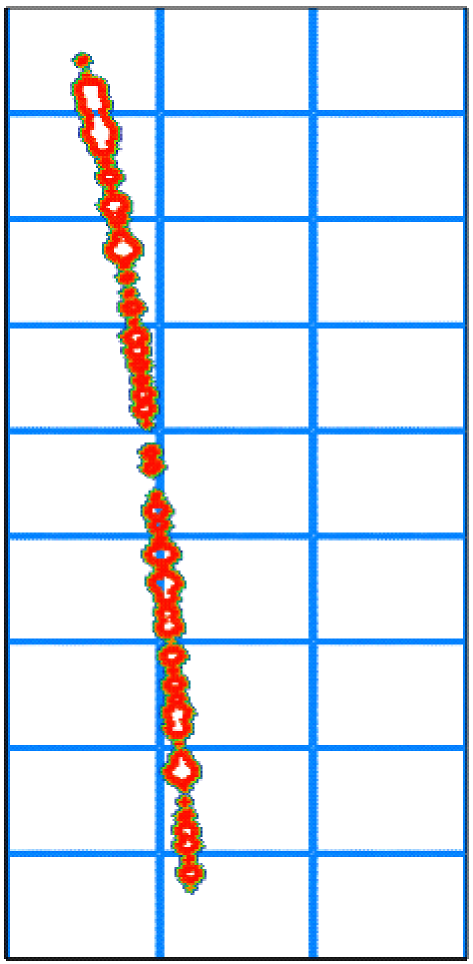
Example events:

$\theta = 30°$ $\theta = 25°$

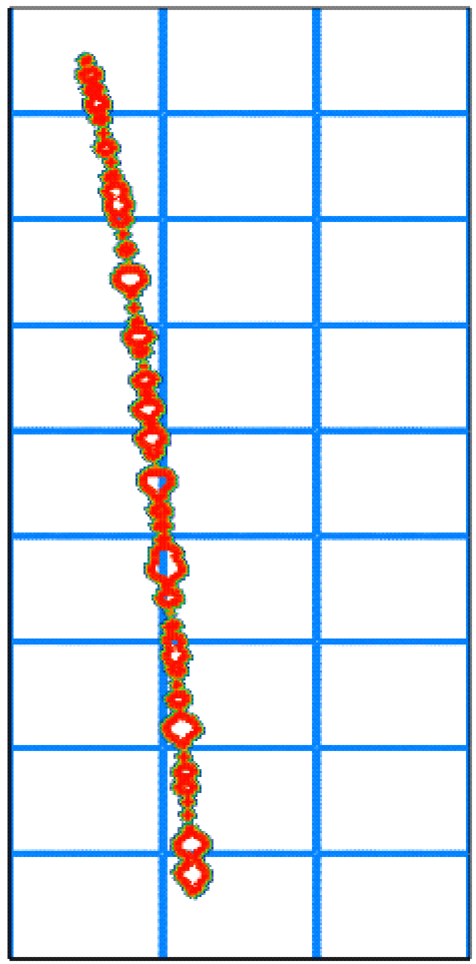


Pzy, Qzy Pzy, Qzy Pzy, Qzy Pzy, Qzy

Example events: θ = 20°



Pzy, Qzy



Pzy, Qzy

Summary

- Details of charge spread due to B field are affected by temperature, B and E field strengths, resistivity, depth of the depletion layer...
- Is effect large enough to measure in test beam?
- This effect should be considered when designing algorithms for the readout chip to ensure efficient cluster finding for signal tracks at all angles.
- Must also recall that majority of pair background hits are at large polar angle.
- Such tracks can deposit charge in a large number of pixels.