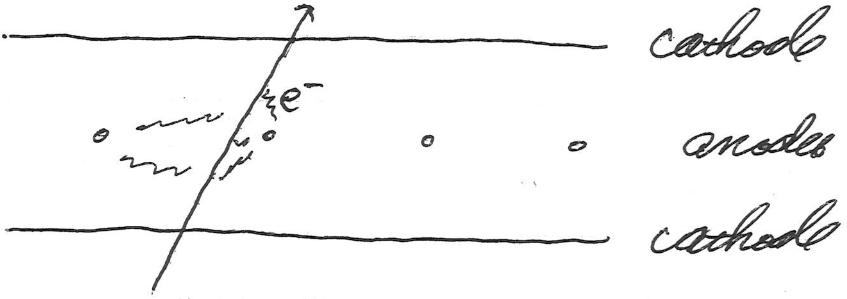
Drift Chamber

Particle passes thru detector (T_d)
- use travel (drift) time of e^-'s ↓ to measure spatial position



→ impact parameter of trajectory to signal wire → drift distance

Consider timing resolution of 2ns and drift velocity ~ 4cm/μs
→ resolution in drift distance

$$\underline{\sigma_x = v\,\delta\tau} \sim 80\,\mu m$$

→ there is a wide range of drift velocities

More Accurate Calculation of Drift Distance

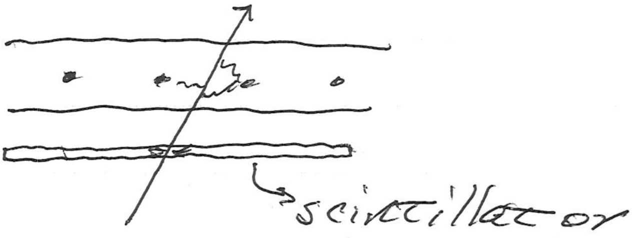
Electric field not strictly constant

- if $w(\tau)$ is the drift velocity as a function of time

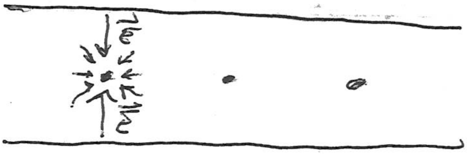
$$X = \int_{\tau_0}^{\tau_0 + T_d} w(\tau)\, d\tau$$

- knowledge of field allows more precise determination of drift distance

Note: a timing reference might be provided by a fast scintillation signal in coincidence



Variation in Drift Velocity



Drift velocity in electric field ($\vec{E}$) direction

$$W_{\parallel} = \frac{2e|E|}{3m}\left\langle \frac{\lambda}{v} \right\rangle + \underbrace{\frac{1}{3}\frac{e|E|}{m}\frac{d\lambda}{dv}}_{\text{(often ignored)}}$$

e, m → charge + mass of electron

λ = mean free path of electron with random velocity $\to v$ in drift chamber gas

→ v randomized by collisions with atoms.

→ average λ/v over random velocities

If consider dispersion of velocities in gas

$$\boxed{W_{\parallel} = \left(\frac{2}{3}\frac{e|E|}{m}\lambda\left(\frac{\Gamma}{3}\right)^{1/2}\right)^{1/2}}$$

Γ is the mean fractional energy lost per collision

$\underline{W_{\parallel} \propto \sqrt{|E|}}$

In presence of Magnetic Field

Consider case where have a magnetic field

→ $\vec{B} \perp \vec{E}$ and in direction of anode wires

→ this will create a net drift velocity $\perp$ to $\vec{E}$

$$W_\perp = \left(1+\frac{e^2B^2\lambda^2}{m^2v^2}\right)^{-1}\left(\frac{1}{3}\frac{e|E|}{m}\omega_L\left<\frac{\lambda^2}{v^2}\right>\right)$$

(ignoring variation in λ due to v)

ω_L is Larmor frequency eB/m

Including effect of velocity dispersion in the gas

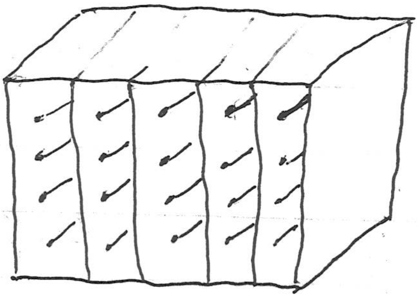
$$\boxed{W_\perp = \frac{eB\lambda}{6m}(3\Gamma)^{1/2}}$$

Net drift angle relative to $\vec{E}$

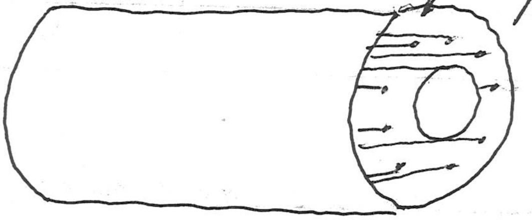
$$\boxed{\tan\alpha = W_\perp / W_\parallel}$$

Configurations of Detectors

Planar Chambers



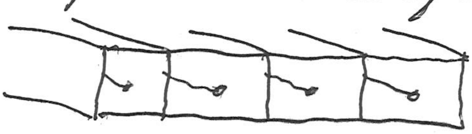
Cylindrical



can have many planes of wires

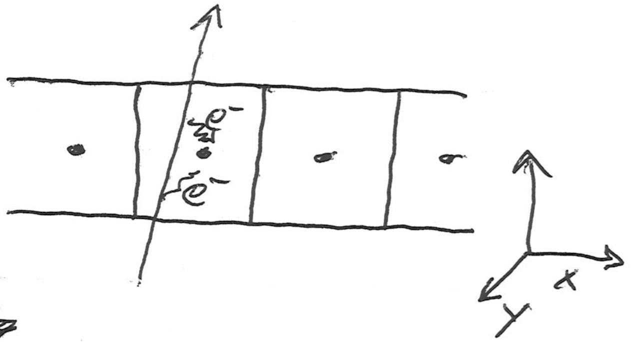
stereo + axial wire planes
→ resolve ghost hits on z - coordinate

Proportional Drift Tubes



Advantages over above
- → easier construction
- → cheaper
- → modular
- → self-supporting structure

Charge Division to Measure Position

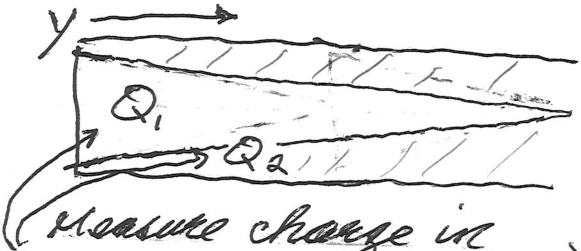


Measure drift time, T_d, relative to a reference time
- perhaps a scintillator signal
- gives drift distance (x-coordinate)

drift distance $\propto T_d$ (drift time)

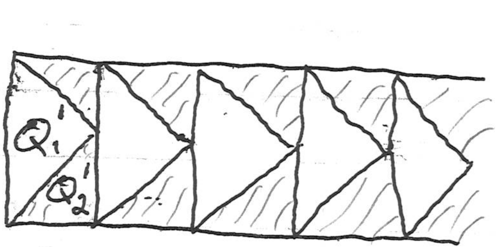
For tube above and below signal wire
- segmented pads can have two granularities
- tops could be

$$y \propto \frac{Q_2 - Q_1}{Q_2 + Q_1}$$



measure charge in separated portions (pads)

- use same principle with other surface
  - smaller granularity
  - → localize y-coordinate

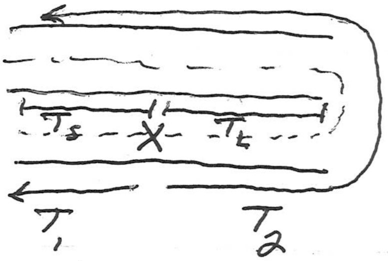


Timing & Charge Division

- Again, measure T_d relative to some reference
  - x-coordinate ⊥ to wire

- Couple wires of adjacent

Need low occupancy →



→ time difference at two ends gives location (approximately) on wire

$$\Delta T = f(T_s - T_L)$$

→ may be accurate to several cm

- Can use charge division to get y-coordinate more accurately

→ 20% measurement of charge
  - can give δy of ~ few mm