Drift Chamber

Particle passes thru detector
-use travel (drift) time of $e^-$ to measure spatial position

- impact parameter of trajectory to signal wire = drift distance

Consider timing resolution of 2 ns and drift velocity $\sim 4 \text{cm/\mu s}$
-resolution in drift distance

$$\Delta x \approx \nu \Delta t \sim 80 \mu \text{m}$$

- there is a wide range of drift velocities
More Accurate Calculation of Drift Distance

Electric field not strictly constant

- if \( v(t) \) is the drift velocity as a function of time

\[
x = \int_{t_0}^{t} v(t') \, dt'
\]

- 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 ($\mathbf{E}$) direction

\[ w_{\parallel} = \frac{2 e |E|}{3 m} \mathbf{E} \cdot \mathbf{v} + \frac{1}{3} \frac{e |E|}{m} \mathbf{d} \cdot \mathbf{v} \]

- $e$, $m$ = charge and mass of electron
- $\mathbf{v}$ = mean free path of electron with random velocity in drift direction
- $\mathbf{d}$ = randomized by collisions with atoms
- Average $2/3$ over random velocities

If consider dispersion of velocities in gas

\[ w_{\parallel} = \left( \frac{2}{3} \frac{e |E| \Gamma}{m} \left( \frac{\Gamma}{3} \right)^{1/2} \right)^{1/2} \]

$\Gamma$ is the mean fractional energy lost per collision

$w_{\parallel} \propto \sqrt{|E|}$
In presence of Magnetic Field

Consider case where there is a magnetic field \( \mathbf{B} \) and in direction of anode wires

- This will create a net drift velocity \( \mathbf{v} \)

\[
\mathbf{v} = \left( 1 + \frac{e^2 B^2 a^2}{m^2 v^2} \right)^{-1} \left( \frac{e/5}{m} \right) \left( \frac{2}{v^2} \right)
\]

(ignoring vibration in \( z \) due to \( \omega \))

\( \omega_i \) is Larmor frequency \( eB/m \)

Including effect of velocity dispersion in the gas:

\[
\mathbf{v} = \frac{eB2}{6m} \left( \frac{3}{\Gamma} \right)^{1/2}
\]

Net drift angle relative to \( \mathbf{E} \)

\[
\tan \alpha = \frac{\mathbf{v}_\perp}{\mathbf{v}_||}
\]
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)

For tube above and below signal wire
- segmented pads can have two granularities
- top could be
  \[ y \propto \frac{Q_2 - Q_1}{Q_2 + Q_1} \]
- use same principle with other surfaces
- smaller granularity
  - localize $y$-coordinate
Timing and Charge Division

- Again, measure $T_2$ relative to some reference $x$-coordinate $I$ to wire

- Couple wires of adjacent

Need lower occupancy $ightarrow$

$\rightarrow$ time difference at two ends gives location (approximately) on wire $\Delta T = \int (T_s - T_2)$

$\rightarrow$ may be accurate to several cm

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

$\rightarrow$ 20% measurement of charge can give $oy$ of a few mm