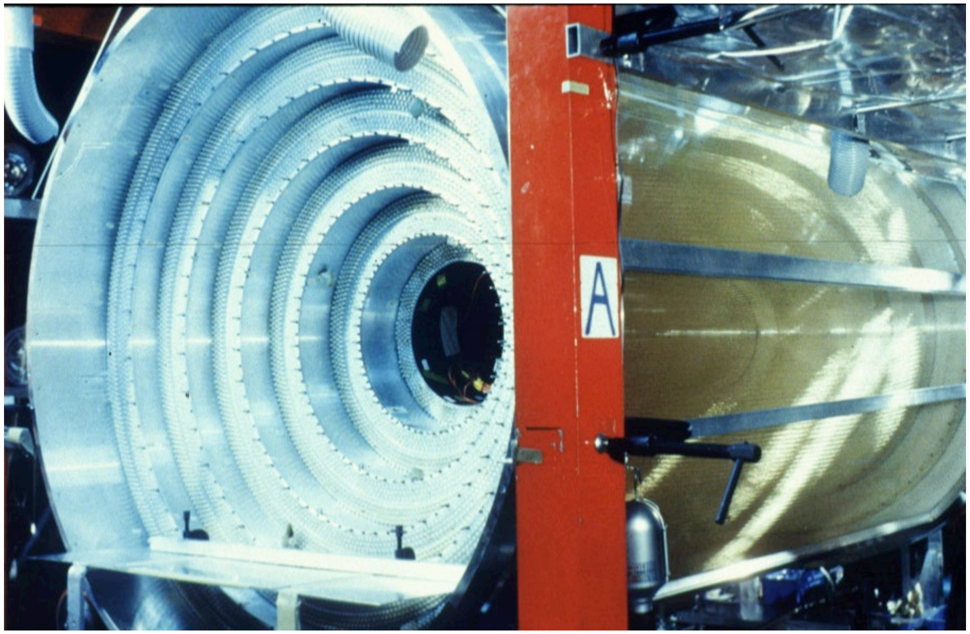
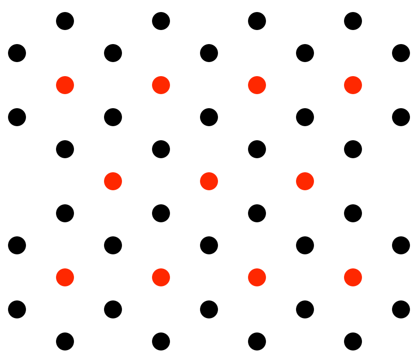
Drift Chambers

AMY experiment at e^+e^- TRISTAN collider

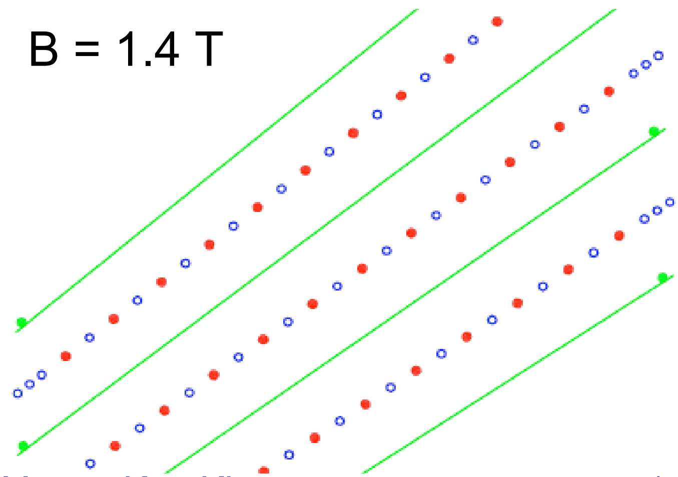


CDF experiment

B = 3 T



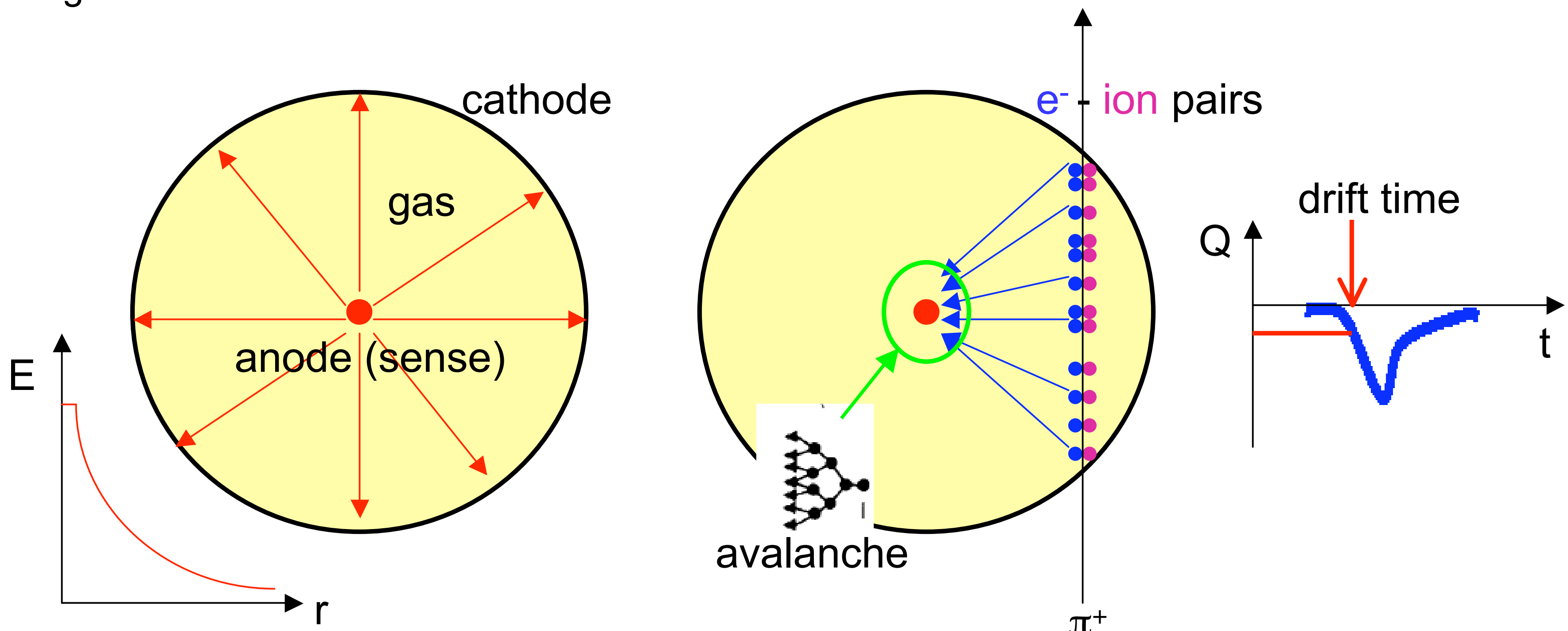
B = 1.4 T



E-field, Drift-Time Relation

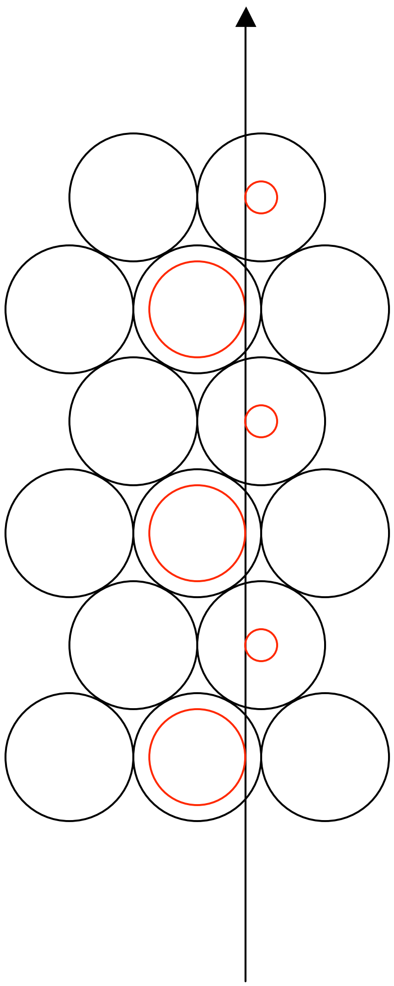
- A charged particle enters gas in E-field, Ionizes gas, produces e^--ion pairs
  - ~300 μm / pair
  - Ionization E ~30 eV / pair
- Primary ionization electrons drift toward anode (sense) wire (low E field region)
- Avalanche multiplication of charges by electron-atom collision in high E field region - within a few radii of the wire.

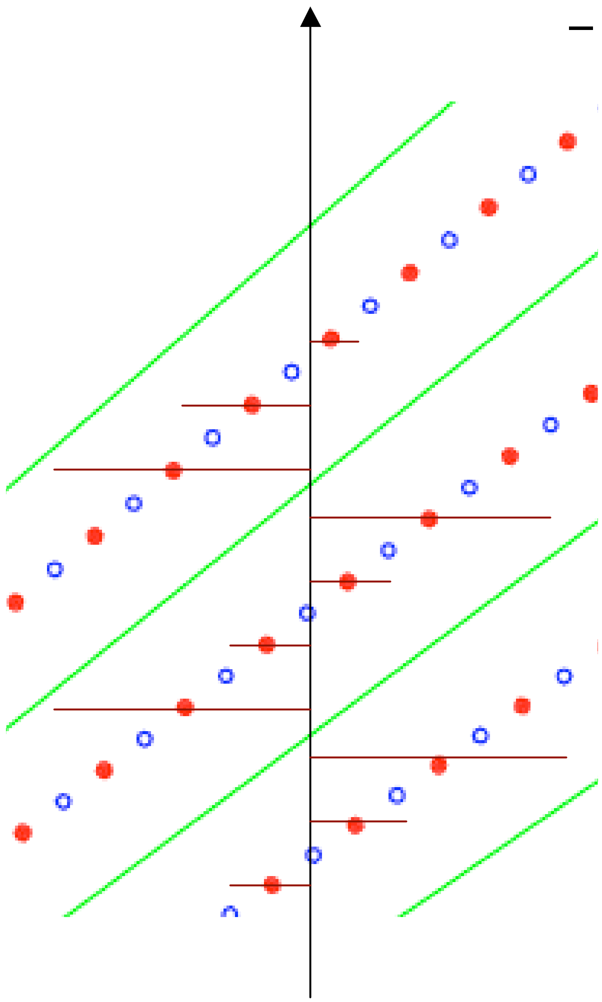
- Signal induced via motion of charges.
- Measure “drift time”, Δt_{drift}, (first arrival time) of electrons at sense wire relative to a time t_0 (e.g. collision time)
- Locate the position of “first” electrons
  - $D = \int_{t0}^{t0 + \Delta t} v(t)\, dt$
  - $D = v\, \Delta t_{drift}$ if the drift velocity is independent of E field.



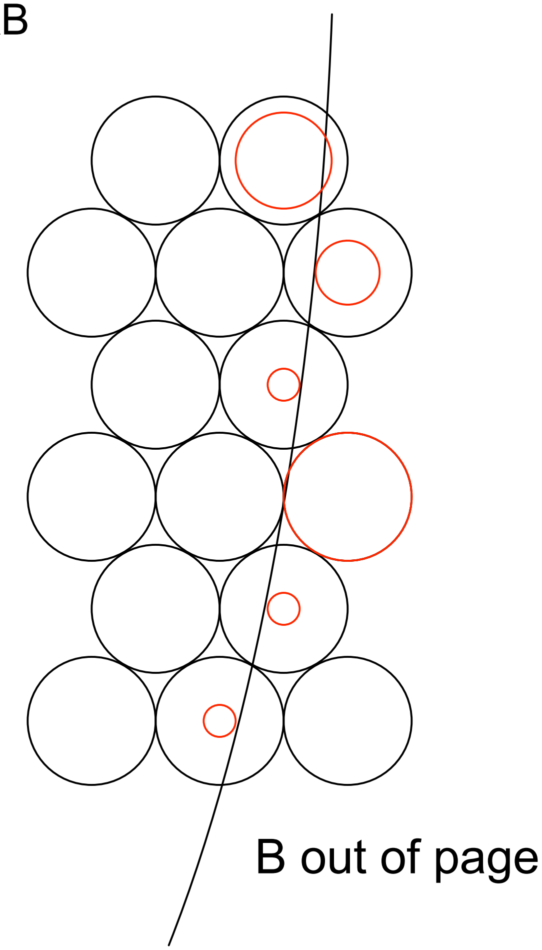
Left-Right Ambiguity,   B field

- Left-right ambiguity
- solved by staggering



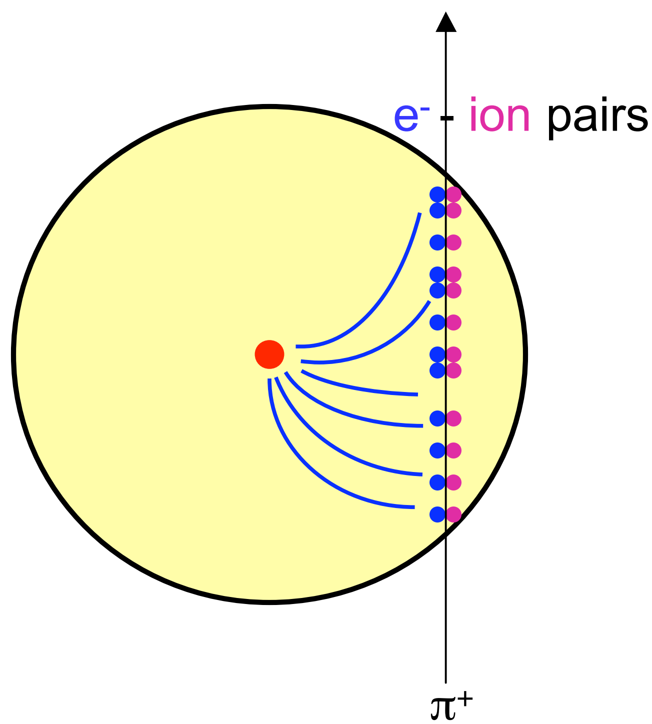


- Apply Magnetic field to measure momentum
  - Measure curvature, C = 1 / R
  - P = 0.3 RB

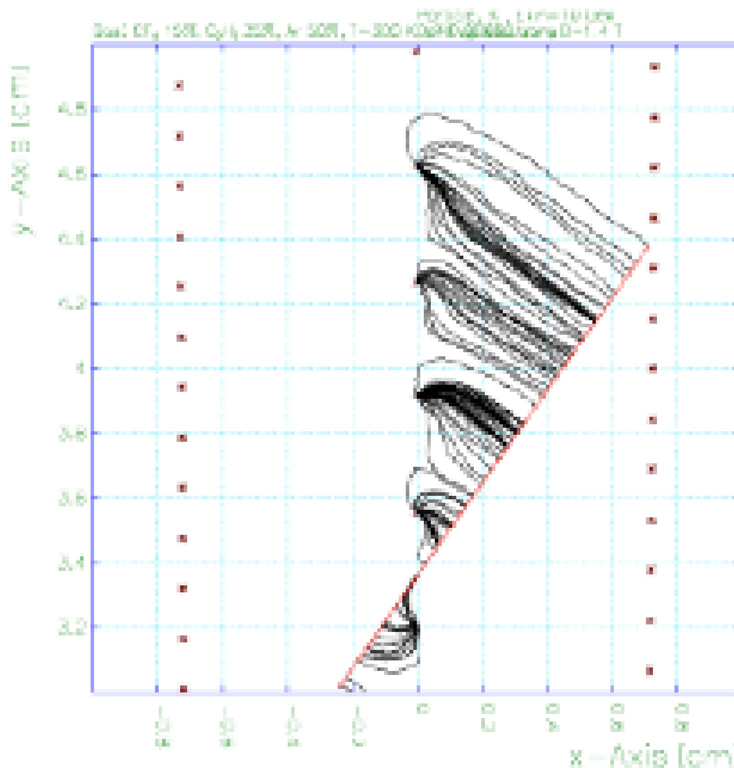


B-fields, Lorentz Angle

- Magnetic fields complicate the drift-time relation
- Introduce the drift angle (Lorentz angle).



- COT
  - Argon: Ethane = 50:50
  - Lorentz angle of ~30^0
  - Tilt cells



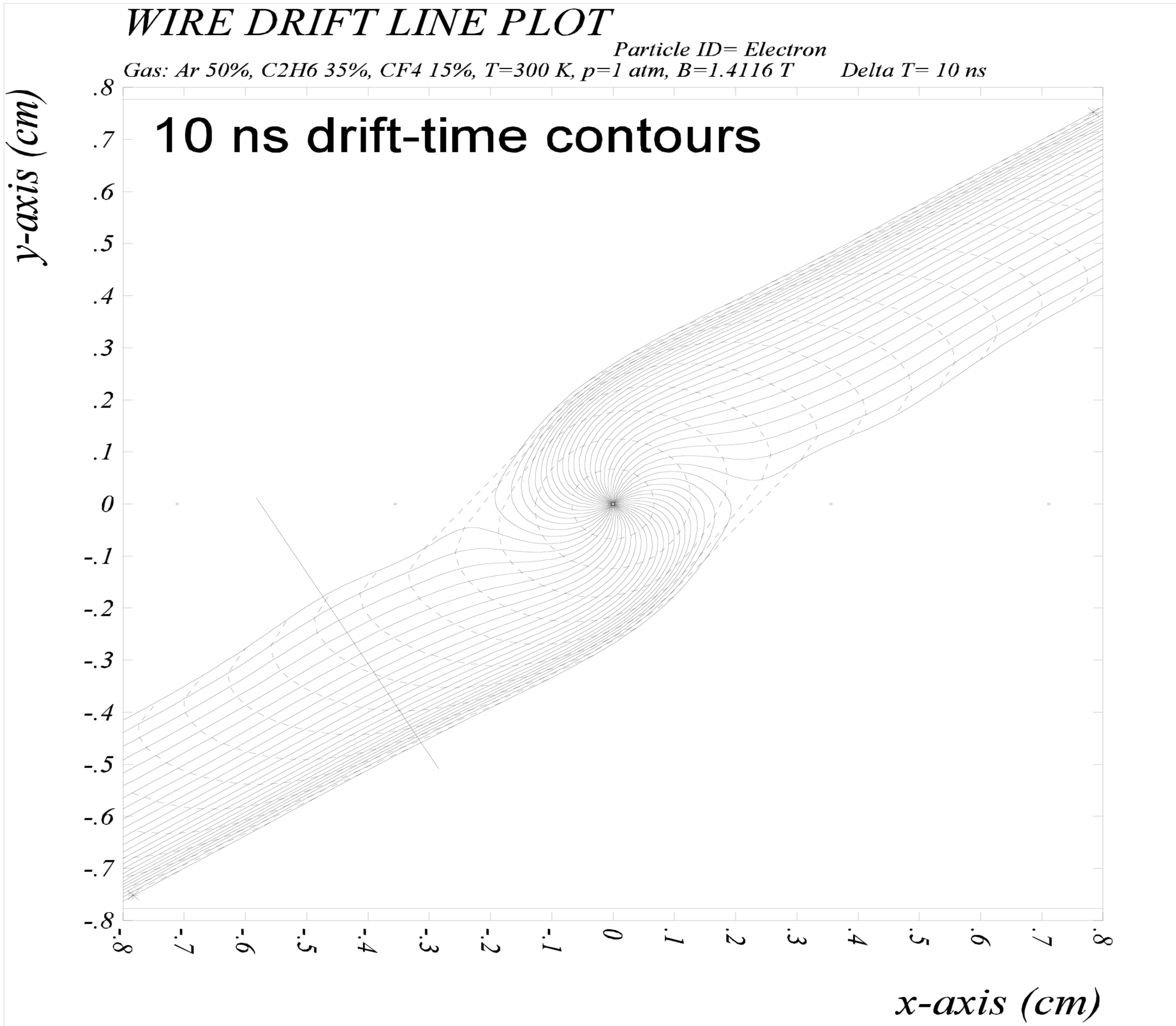
Choice of Gas (desired property)

- Drift velocity independent of E field
  - Good linear distance-time correlations.
  - v ~ 50 μm / ns
- Low working voltage
- High gain operation
- Small diffusion coefficient for electrons traveling though the gas.
  - Amount of diffusion that occurs limits the spatial resolution obtainable
- Argon is widely used as a drift chamber gas. The argon may be mixed with gases consisting of heavy organic molecules ("quenchers").
- Quenchers - heavy organic molecules that have many degrees of freedom and can efficiently absorb energy from the gas.
  - The effective temperature of the electron is reduced.
  - The drift velocity is increased.
  - The diffusion is decreased.
  - Carbon dioxide, isobutane, …
- Avoid elements with strong affinity of electrons.
  - Otherwise the detection efficiency will depend on the drift distance.
  - Avoid O_2, H_2O, F, Cl

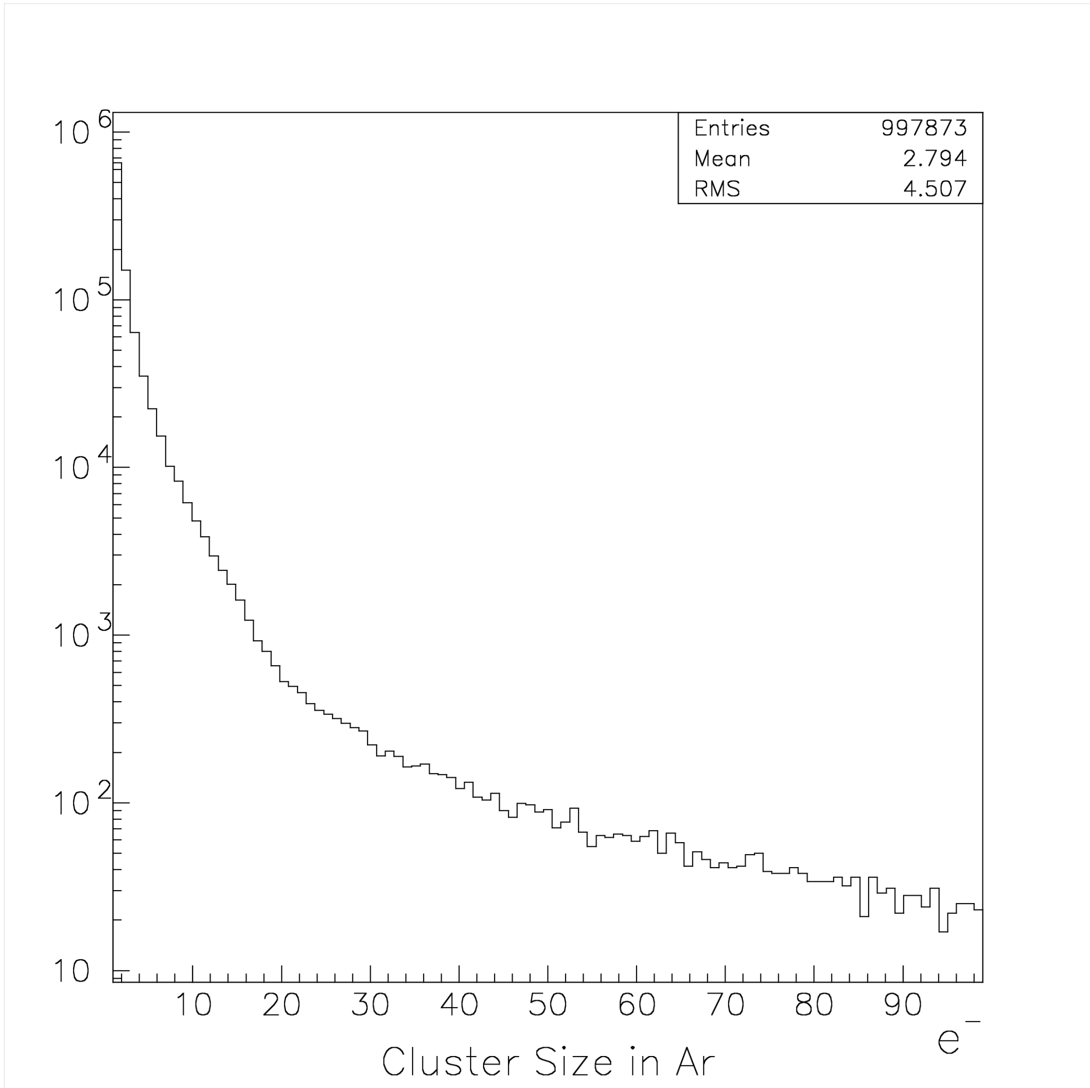
Signal formation, dE/dx

- What happens
  - Charged track traverses the cell and deposits a number of clusters-Poisson distributed
  - Clusters are distributed along the track trajectory uniformly
  - The number of electrons per cluster follows a particular distribution, peaked at about one, mean about 3 in Argon, but with along tail-Landau like tail
  - Drift electrons in along field lines-drift time depends on gas, field, trajectory to the wire
  - Avalanche takes place near wire-Polya distribution
  - Signal forms from electron pulse (10%) and ion drift to cathode-preamplifier cuts this off-pulse shape formed

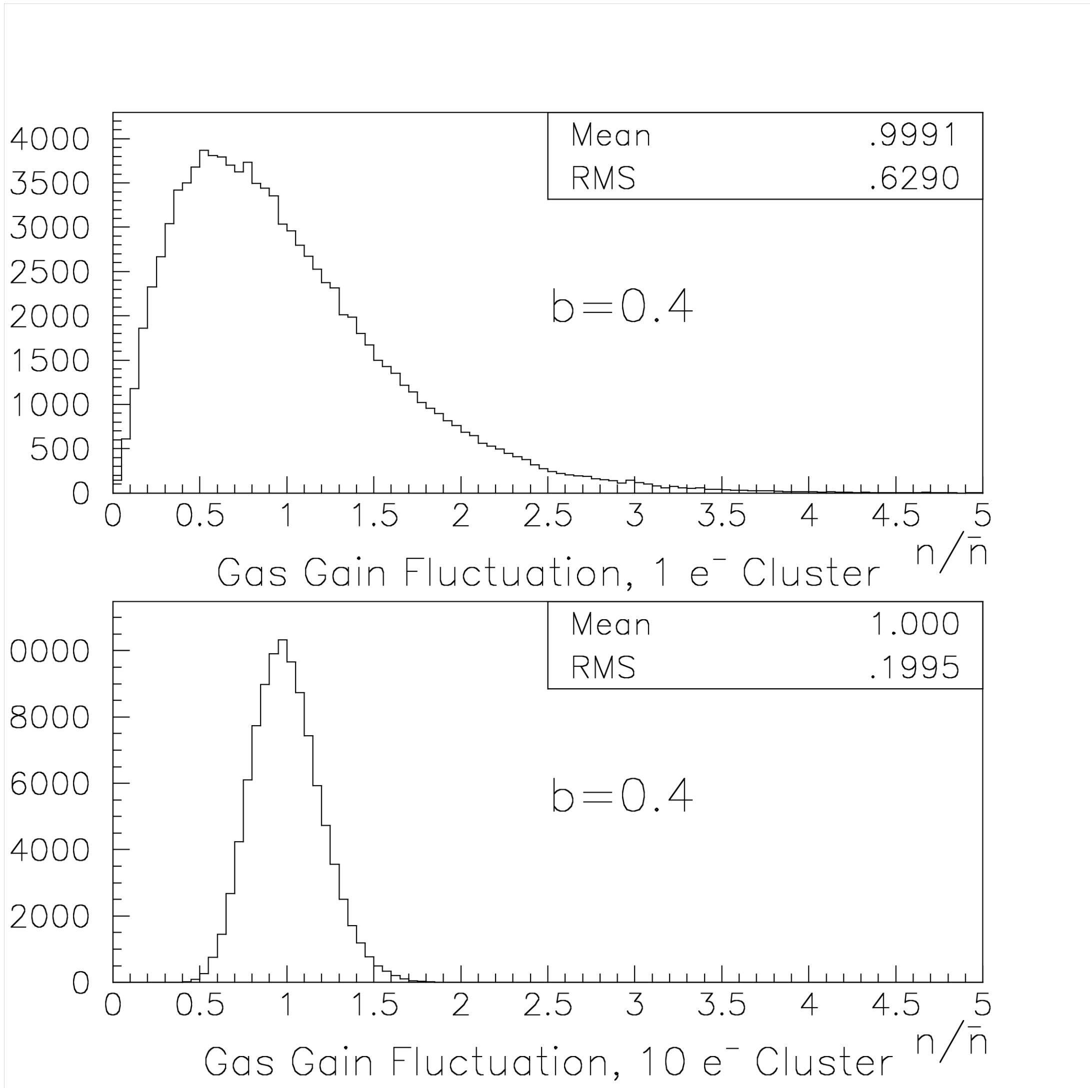
Drift time contours (isochrones)



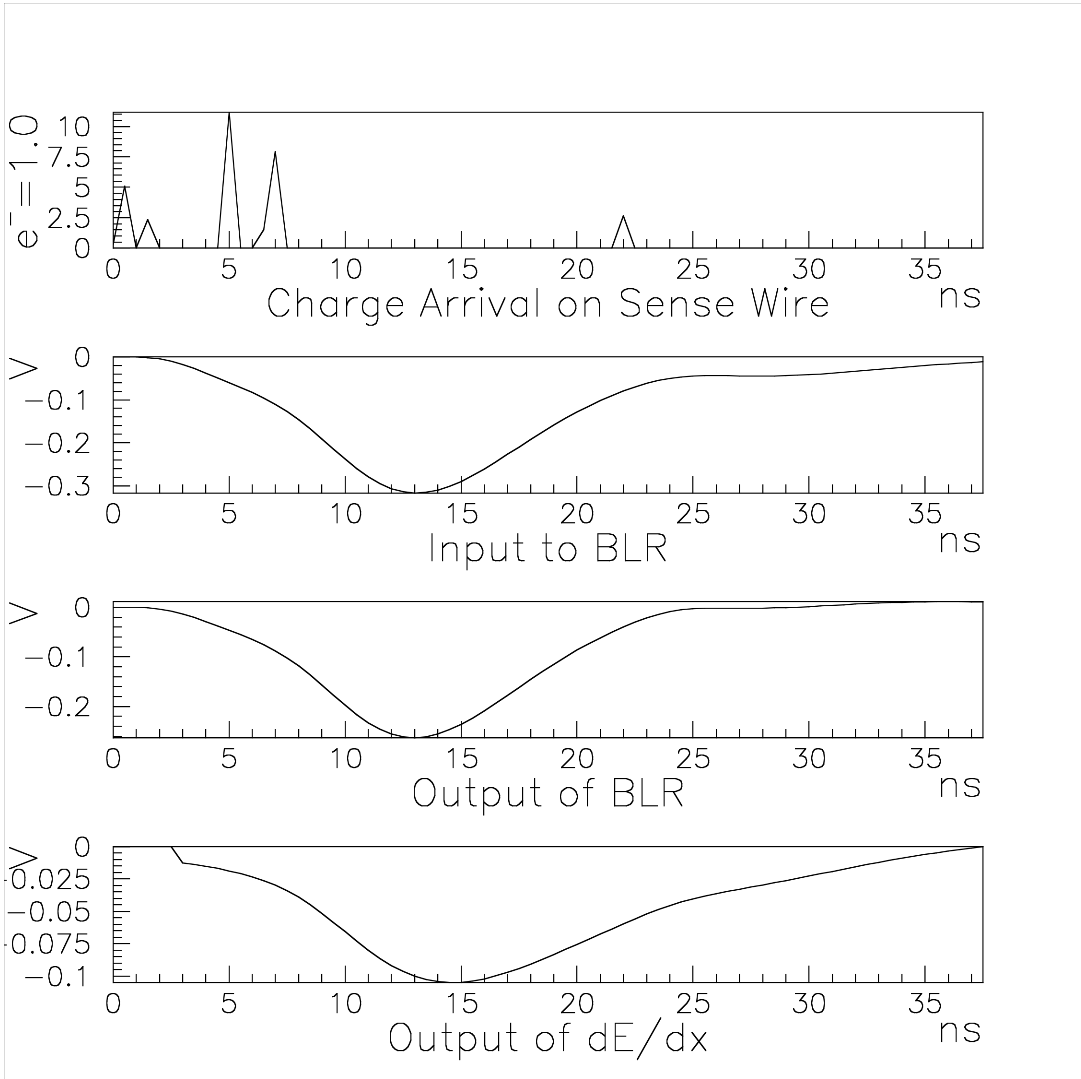
Electrons per Cluster



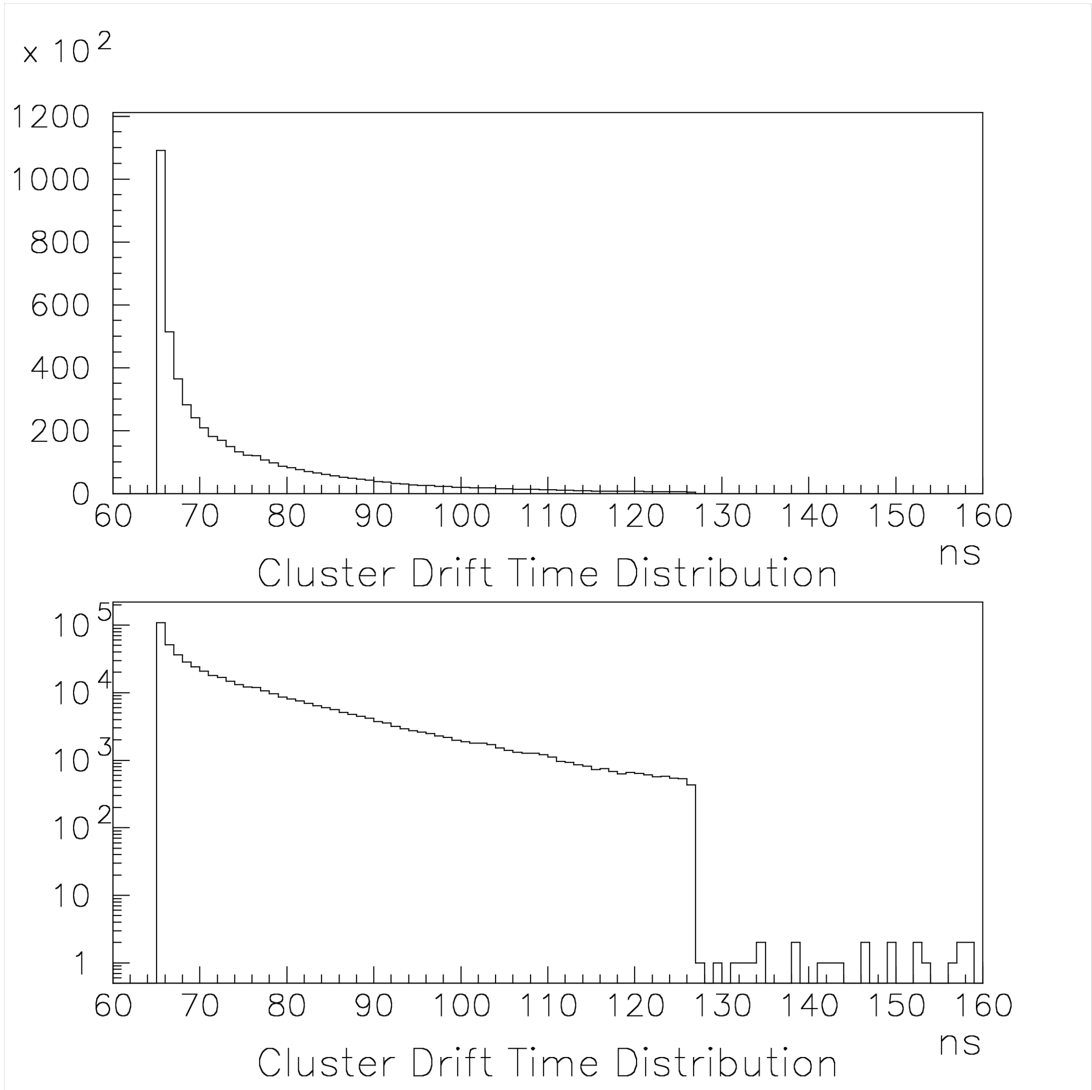
Polya Distribution



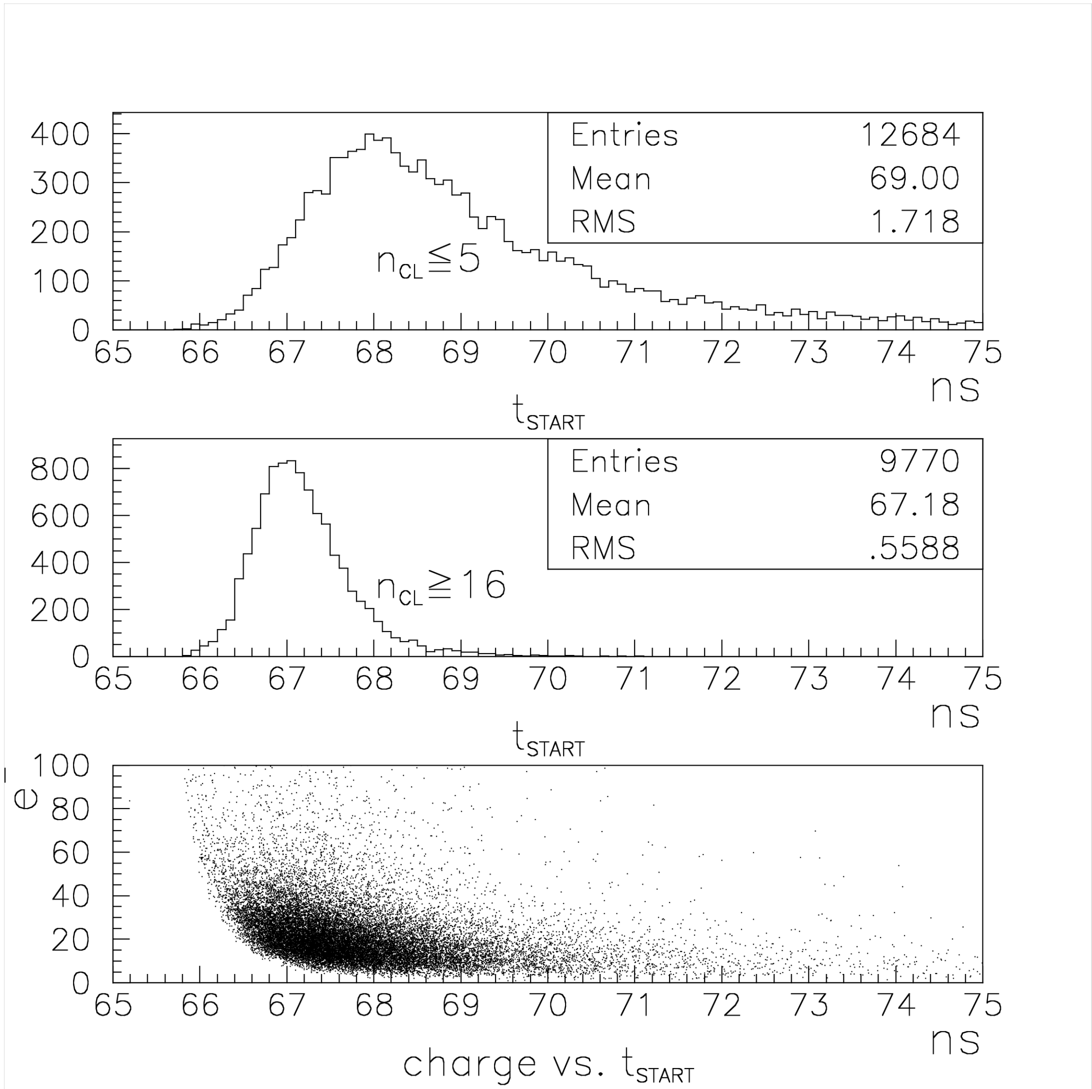
Signal Formation



Cluster Time Distribution



Charge versus T_{start}



Charge versus Width