PHENIX Drift Chamber operation principles

by Sergey Butsyk

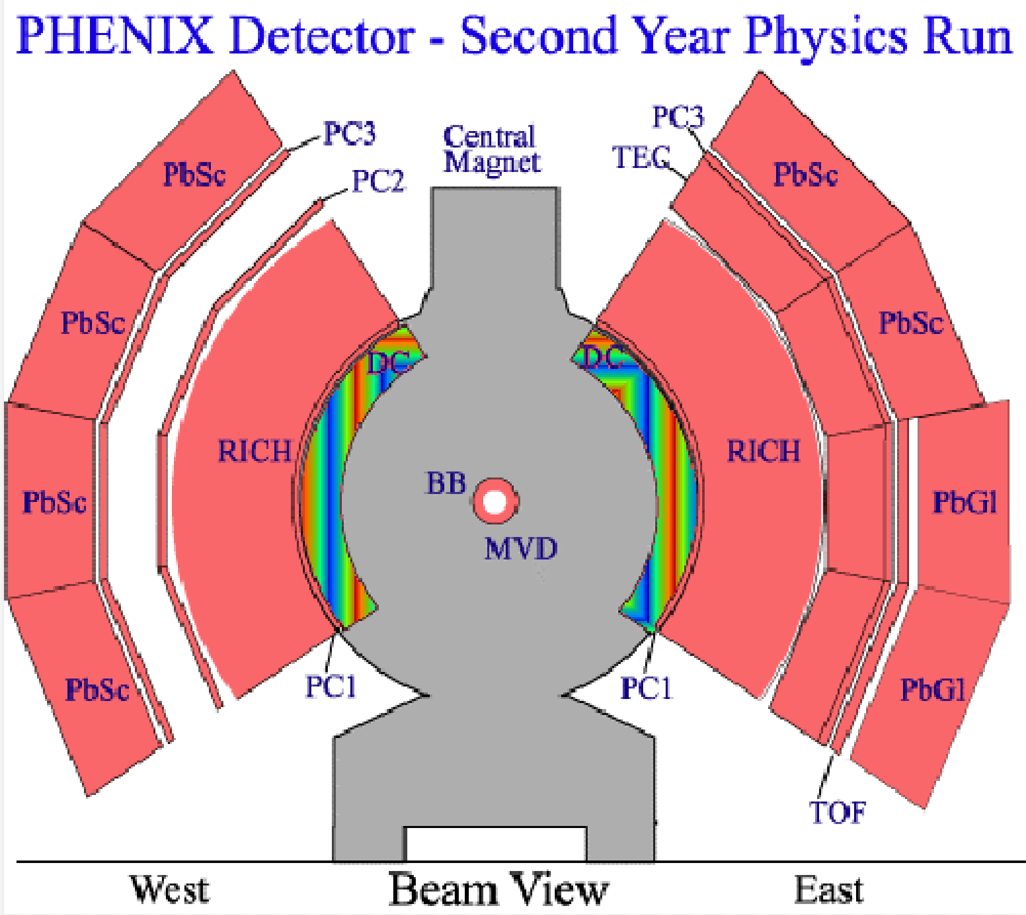
Focus meeting
01/14/03

Outline

- Drift chamber (DCH) design
- Construction and assembling
- Operation principles
- Calibration aspects
- Trackfinding principles
- Future goals

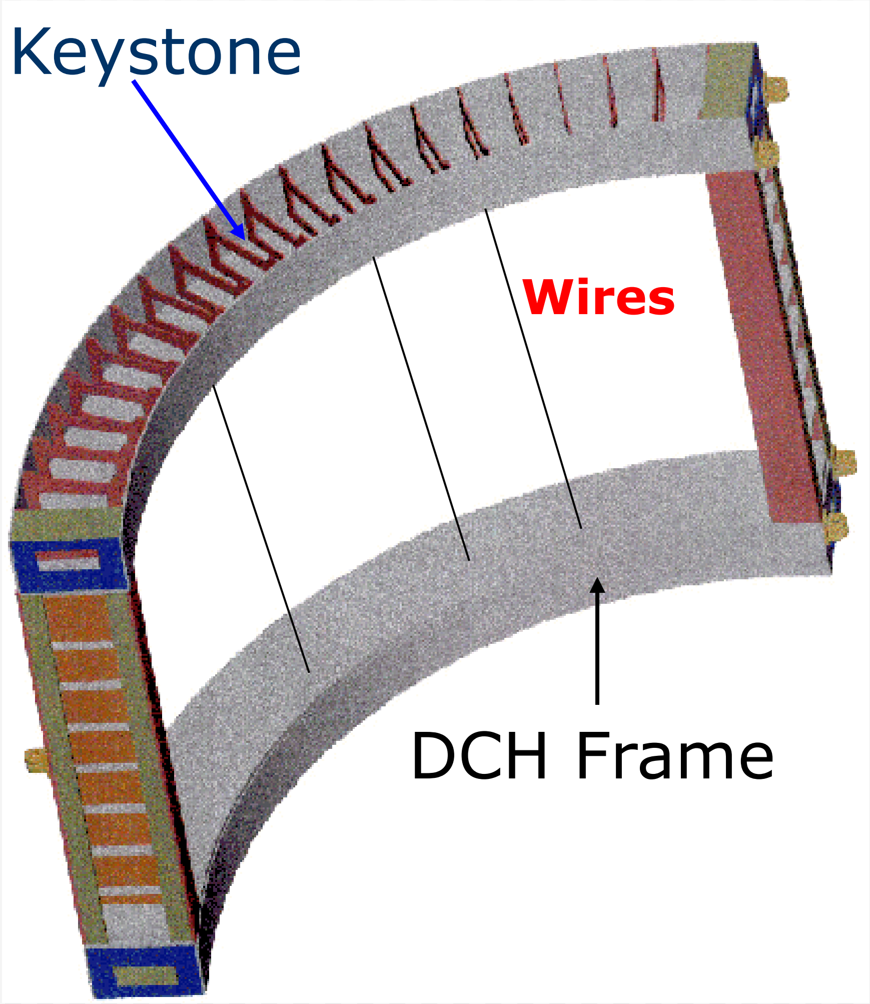
Drift Chamber for PHENIX (basic information)

- Main purpose:
  - Precise measurement of the charged particle's momentum
  - Gives initial information for the global tracking in PHENIX
- Acceptance:
  - 2 arms 90º in ϕ each
  - ±90 cm in Z
  - 0.7 units of η
- Location:
  - Radial :2.02<R<2.48 m
  - Angular:
    - West: -34º < ϕ < 56º
    - East : 125º < ϕ < 215º



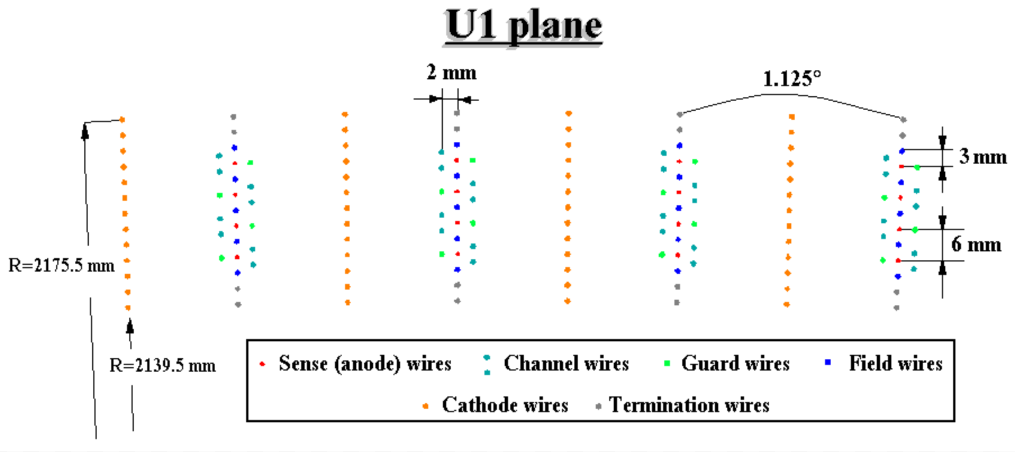
Drift Chamber design

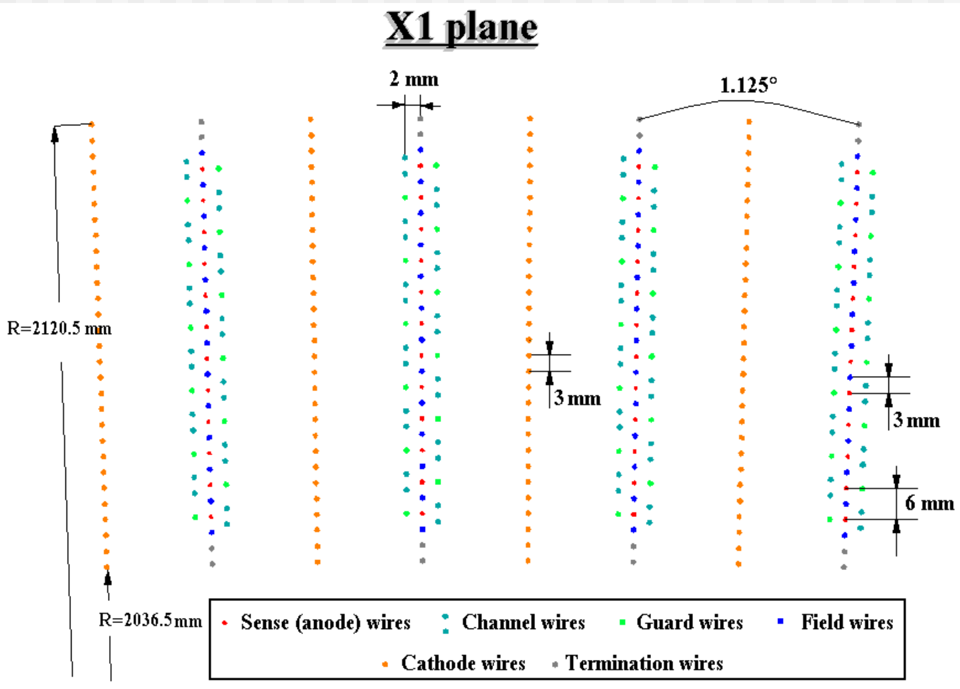
- Multiwire jet-type drift chamber (~12800 readout channels)
- **6x80** (r - ϕ) wire nets per arm
- Titanium alloy support frame with **20** C-shell openings (Keystones)
- Independent signal readout from both sides (North, South)



Wire net configuration

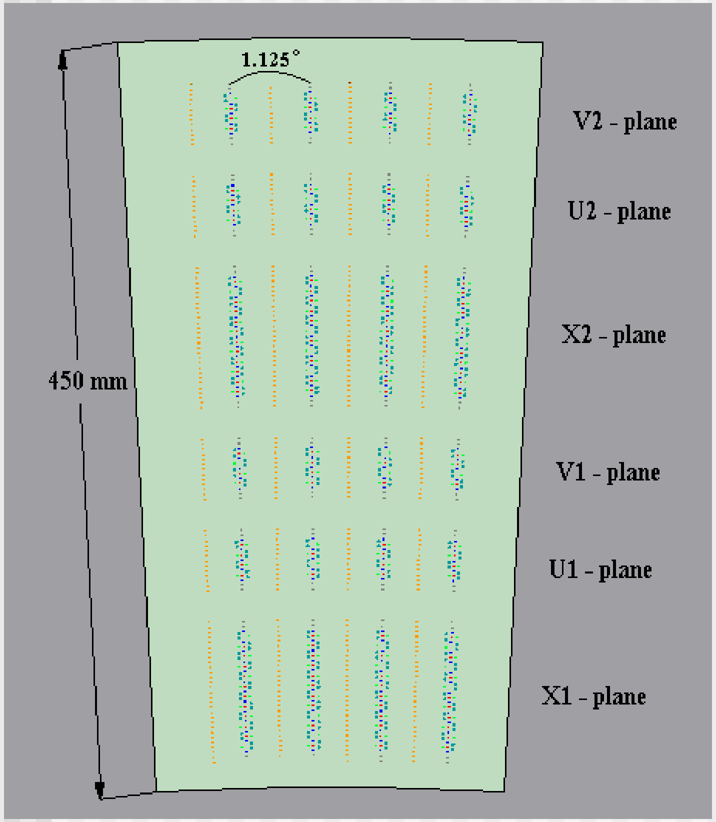
- 6 radial layers of nets (X1,U1,V1,X2,U2,V2)
- **X nets** – measure ϕ coordinate of the track
  - **12 anode wires in each X net**
- **UV (stereo) nets** – measure Z coordinate of the track
  - **4 anode wires in each UV net**
- Cathode nets separate anode nets (see figure)
- Total of 80 anode nets per arm evenly distributed in ϕ

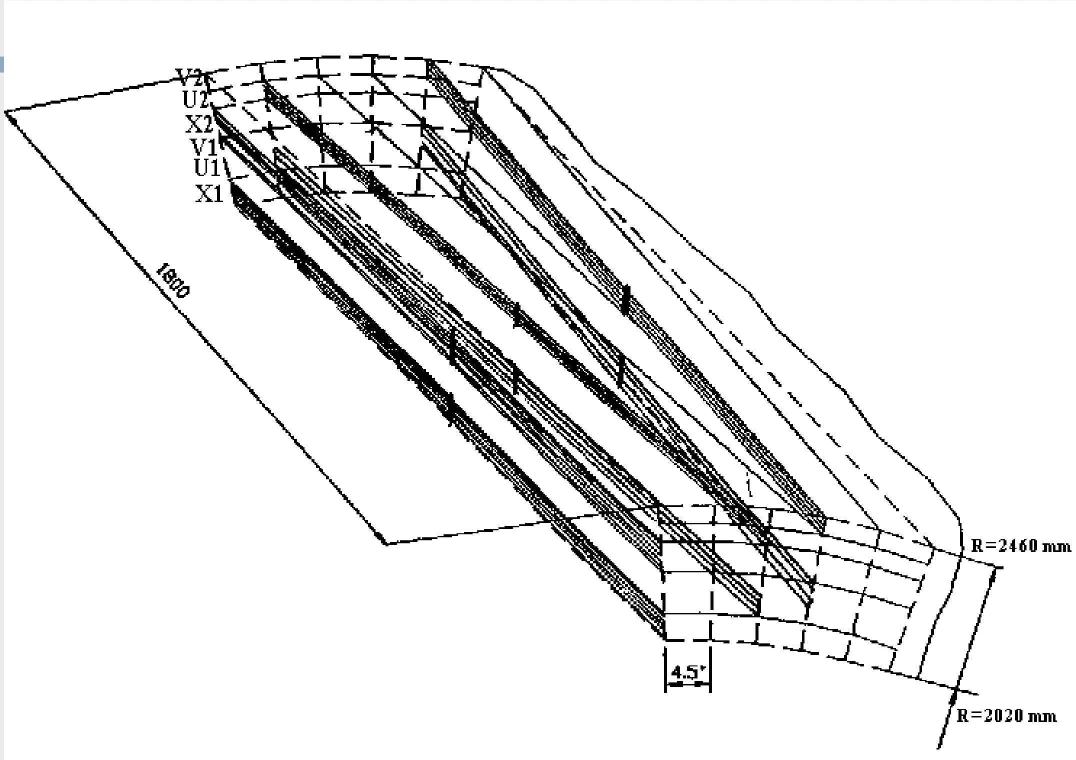




Wire net configuration (II)

- Group of 4 anode-cathode nets makes a keystone

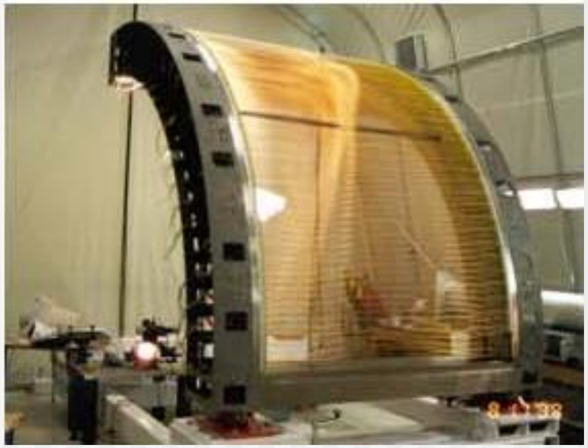


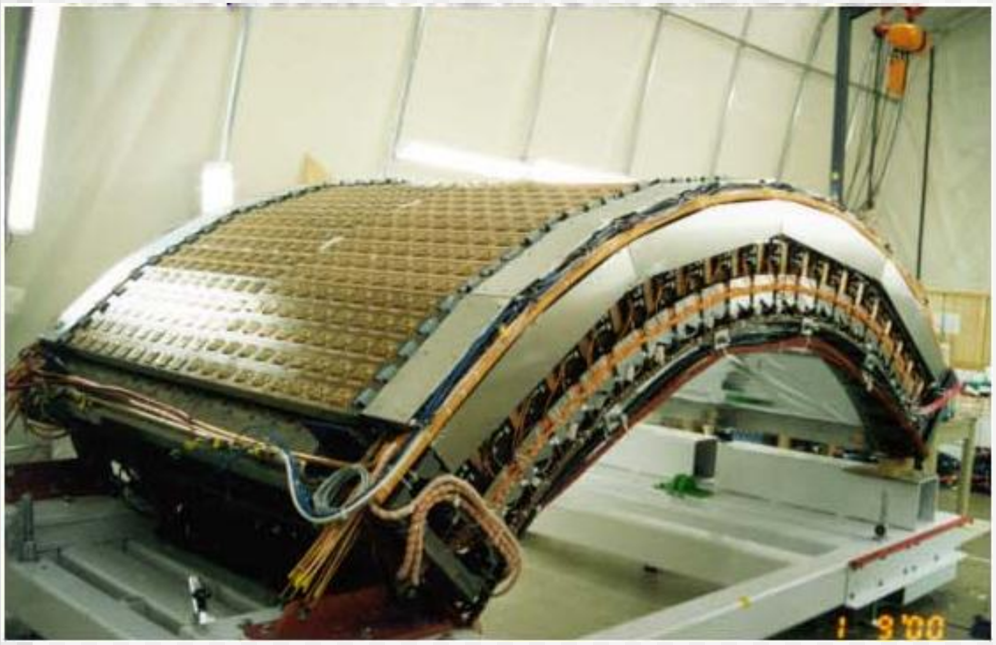


- **Stereo nets starts in one keystone (n) and ends in the neighbouring keystone e.g. (n+1) for U, (n-1) for V**
- **The tilt of UV nets along ϕ allows measurement of Z component of the track**

Construction and assembling

- ***Mechanical design and production*** – PNPI (Russia)
- ***Front Electronics*** – SUNYSB
- ***Wire net production, assembling*** - PNPI,SUNYSB



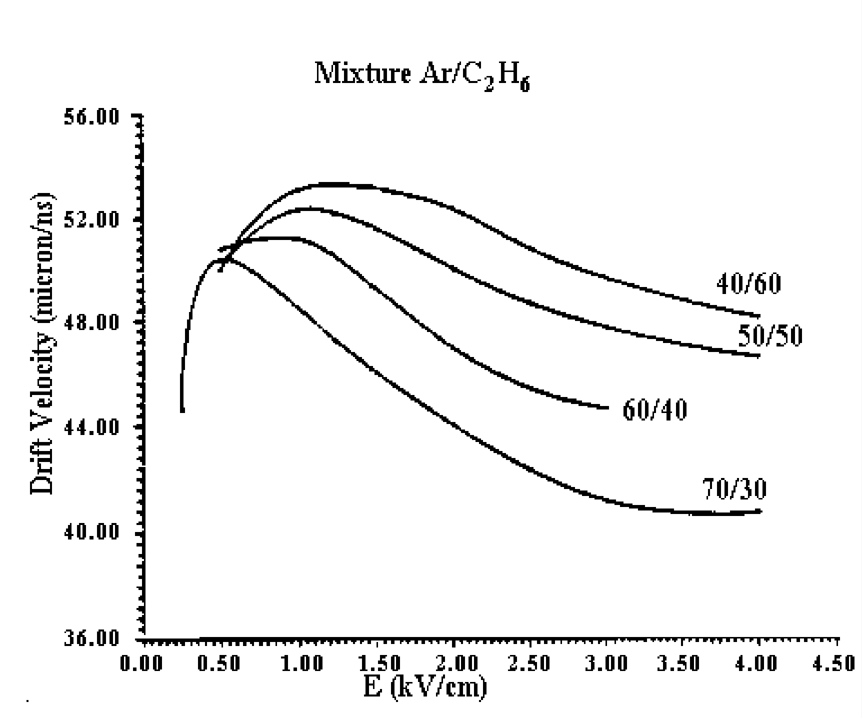


DCH Operation Principles

- **Drift chamber measure the drift time of the electron clusters ionized by the charged particle in an active area of the detector**
- **Drift time from the ionization point to the anode wire (t) can be translated into distance to the ionization point (x) for known xt relation $x = x(t)$**
- **Working gas is chosen to have an uniform drift velocity in the active region ➔ linear xt relation can be used $x = V_{dr} \cdot t$**
- **Gas amplification effect is used to gain the initial ionized charge signal**

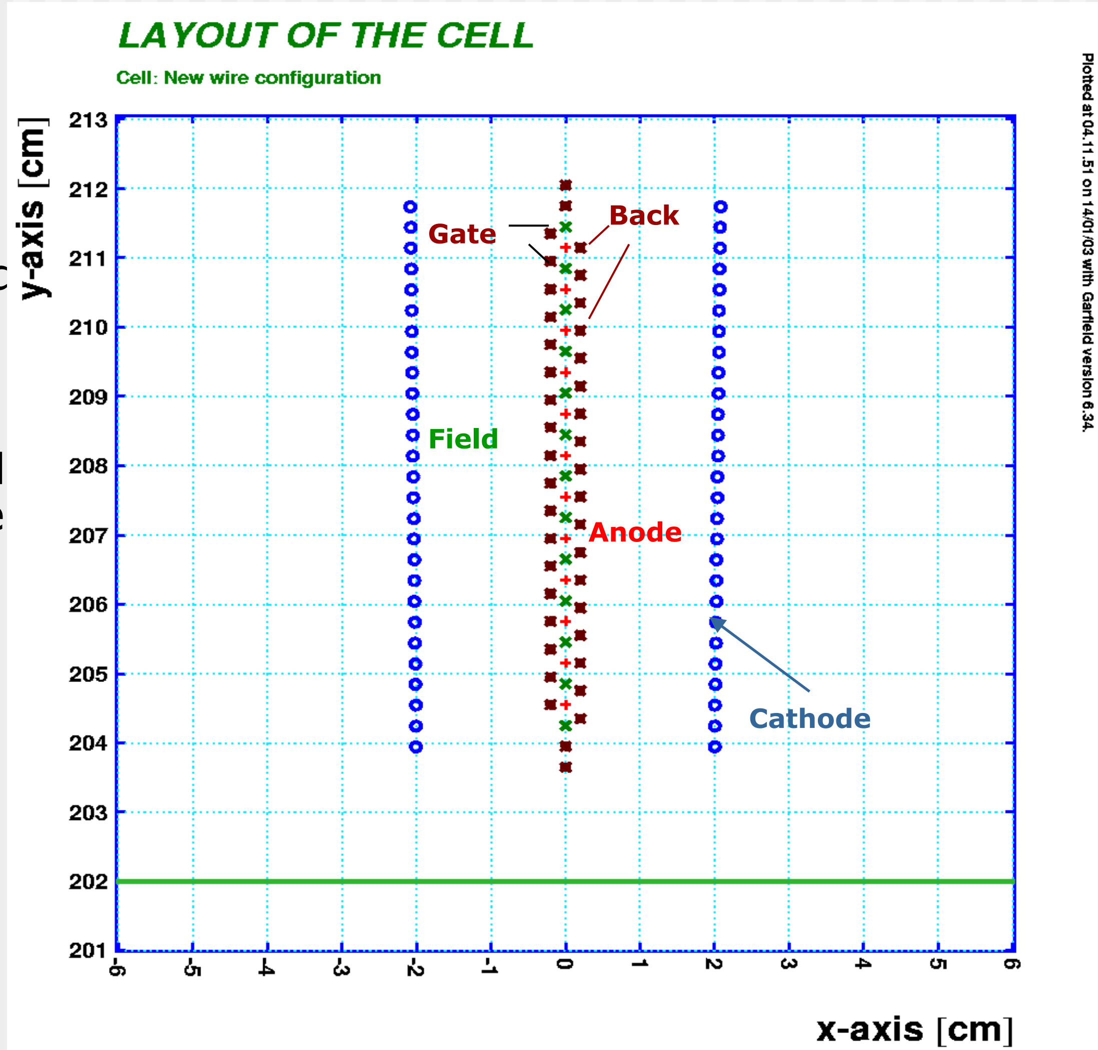
Gas mixture choice

- 50% Ar - 50% C_2H_6 mixture is chosen for operation based on:
  - uniform drift velocity at E~1 kV/cm
  - High Gas Gain
  - Low diffusion coefficient
- In Year2 ~1.5% Ethanol was added to the mixture to improve HV holding of the nets



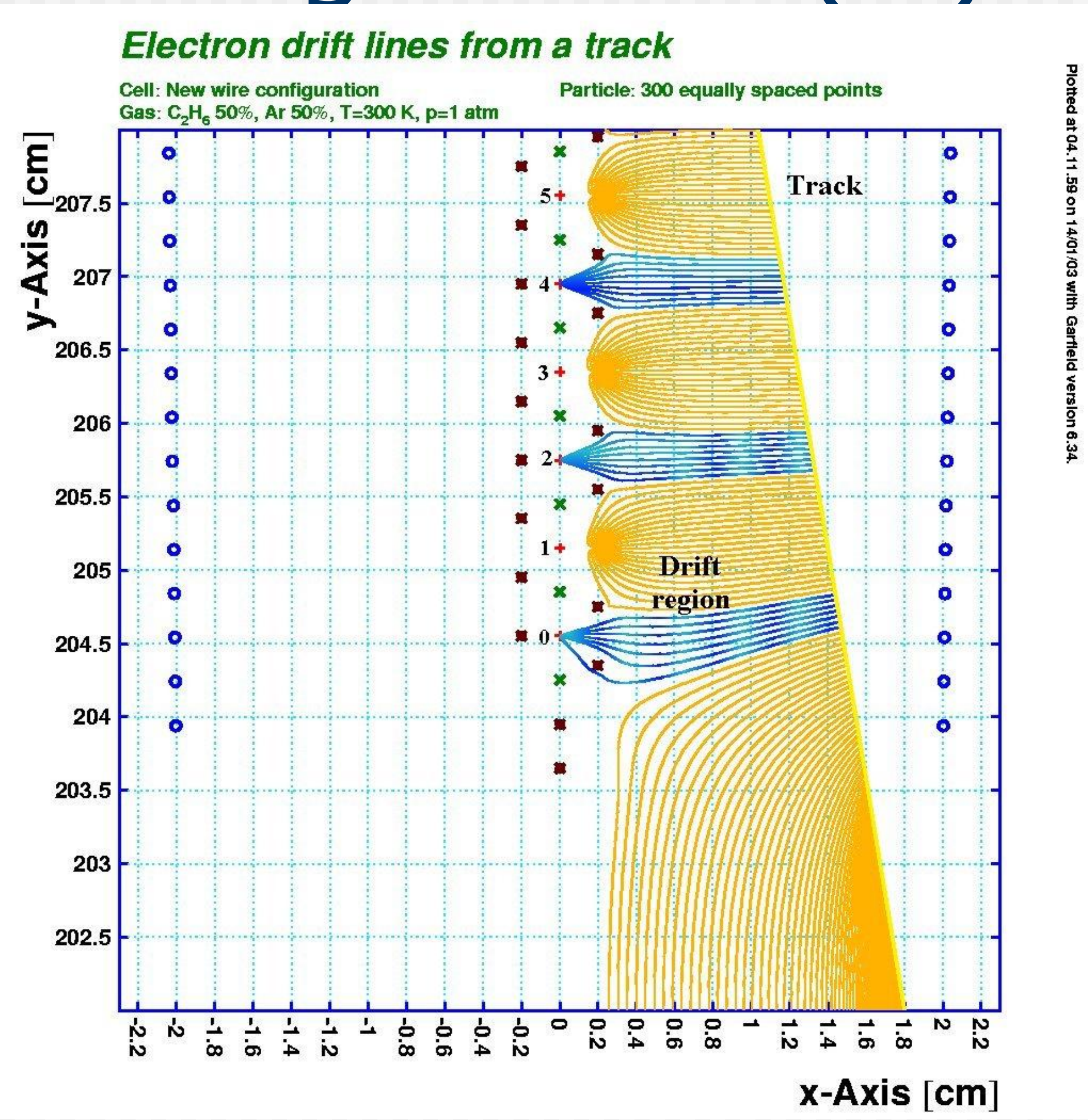
Drift field configuration

- Specific field configuration around **anode wire** called drift region is created by "field forming" wires:
  - **Cathode Wires** – Create uniform drift fielc between anode and cathode
  - **Field Wires** – Create high electric field strength near the anode wire
  - **Back Wires** – Stop drift from one side of the anode wire
  - **Gate Wires** – Also create high field near the anode wire, Localize the drift region width



Drift Field Configuration (II)

- Here is what happens when the charged particle passes through the wire cell
- Note that only even wires collect charge due to the **back wires** that block the odd anode wires !
- Back wires solves left-right ambiguity problem



DCH Performance (Run02)

- ***Single wire efficiency*** ~ 95-98%
- ***Back efficiency (probability to get hit from the back closed side)*** < 7%
- ***Spatial Resolution*** ~ 100-120 mkm
- ***Angular resolution*** $d\alpha/\alpha$ ~ 1 mrad

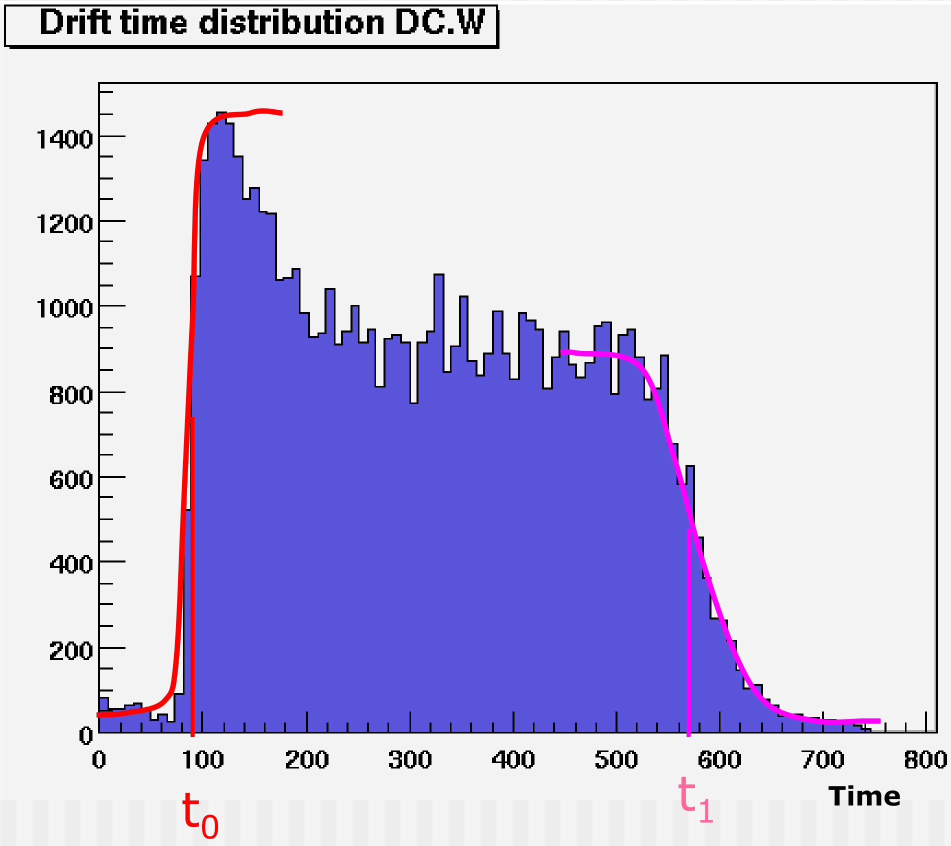
Calibration aspects

- **DCH main calibration parameters**:
  - t_0 - effective time at which the ionization occurred exactly on the anode wire (we measure the relative time with respect the RHIC clock, t_0 is our absolute scale reference)
  - V_{dr} – effective drift velocity in the drift region
- Once we know those parameters:

  $x(t) = V_{dr} \cdot (t-t_0)$ ➔ we know everything!

Global calibration

- Timing distribution for each arm have a characteristic shape
- By fitting the leading and trailing edge of the distribution with Fermi function we obtain time at ½ height. t_0 and t_1
- t_0 is assumed to be global t_0 for the arm
- V_{dr} = $\langle dist_{ac} \rangle/(t_1-t_0)$ is global drift velocity



Other calibration effects taken into account

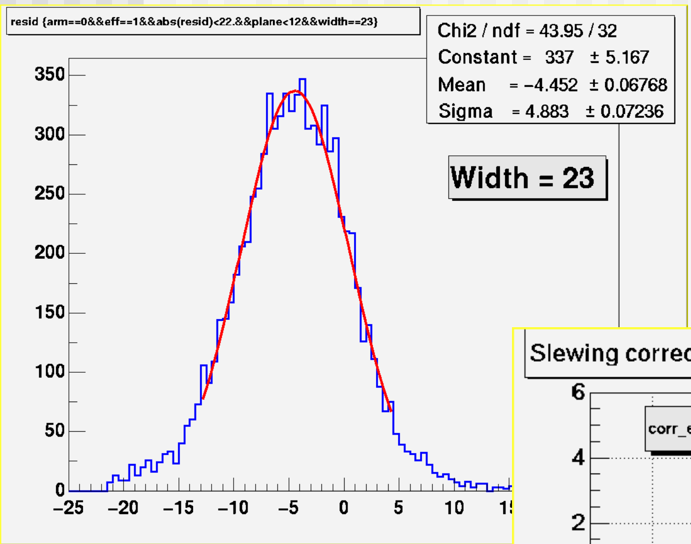
- **Slewing corrections** – dependence of arrival time as a function of the signal width
- **Shape of the drift region** – the wires close to the mylar window experience distortion of the electric field
- **Wire-by-wire t_0 corrections** – includes geometrical shifts of the wires within the net, electronics channel-by-channel variations e.t.c
- **Plane-by-plane V_{dr} corrections** – V_{dr} is electric field dependant, thus it changes significantly on the side-standing wires where edge effects distorts the field strength
- **Global alignment to the vertex** – center of the arm can be shifted from the vertex location. Translation of the arm center can be found by centering a distribution around zero in field-off data

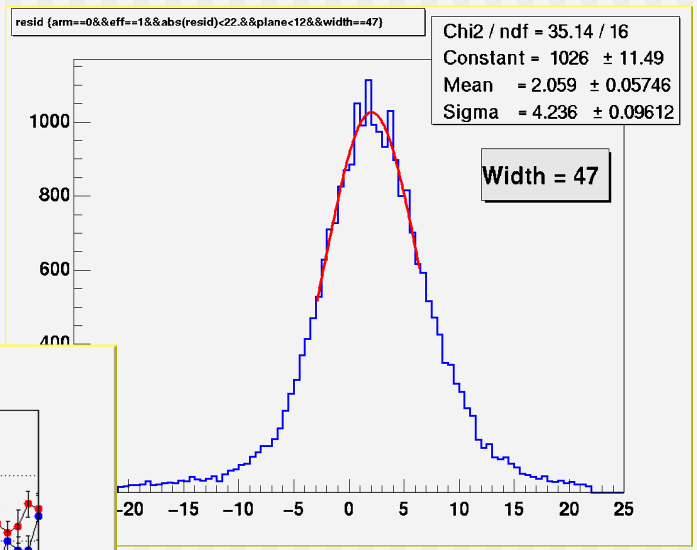
Residual distributions

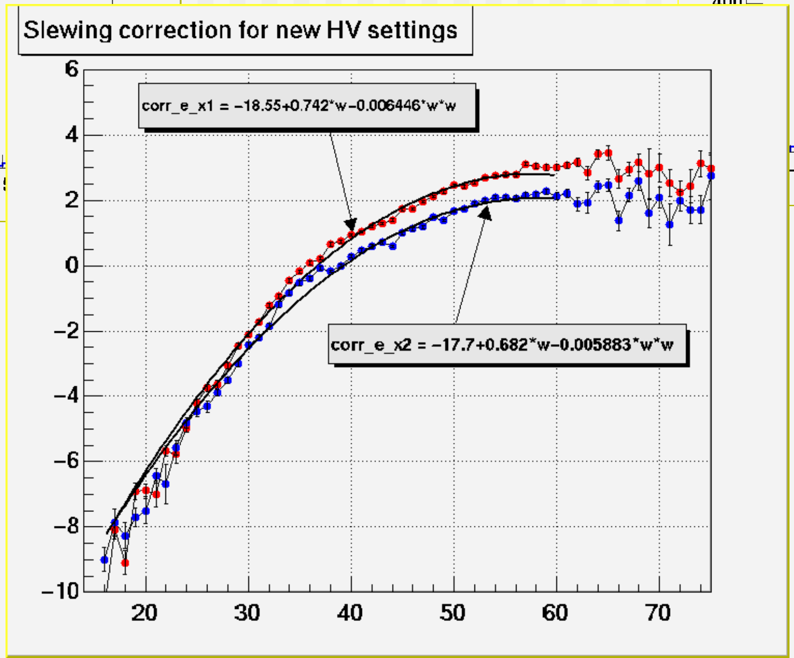
- Pick hits of the track on 3 neighboring wires (i.e. 0,2,4)
  - Residual is: $dt_2 = (t_0 + t_4)/2 - t_2$
- Basic idea of local calibrations is to center all residuals at zero for all the parameters (i.e. align ever three neighboring wires)
- This is a strong handle on local calibration corrections

Slewing corrections

- Look at residuals vs. width

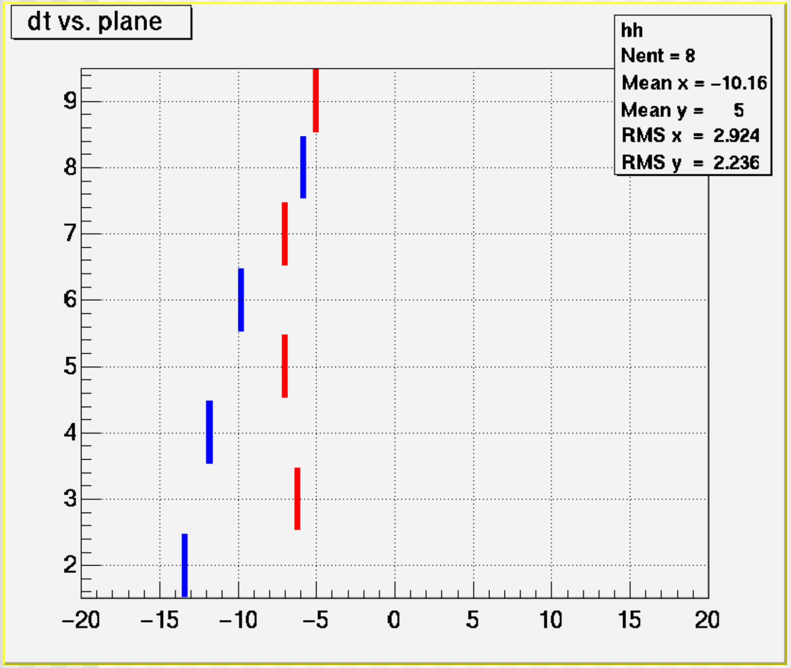


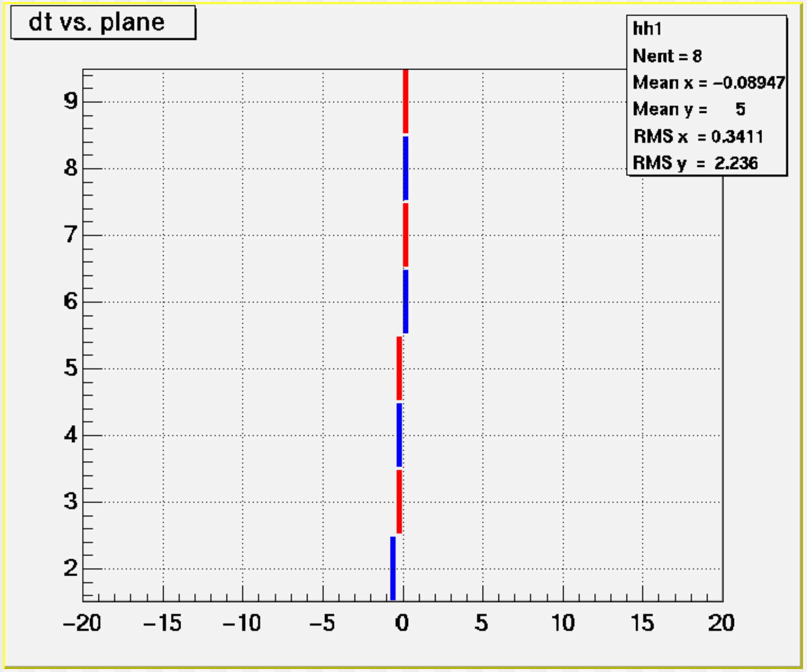




Wire-by-wire t_0 corrections

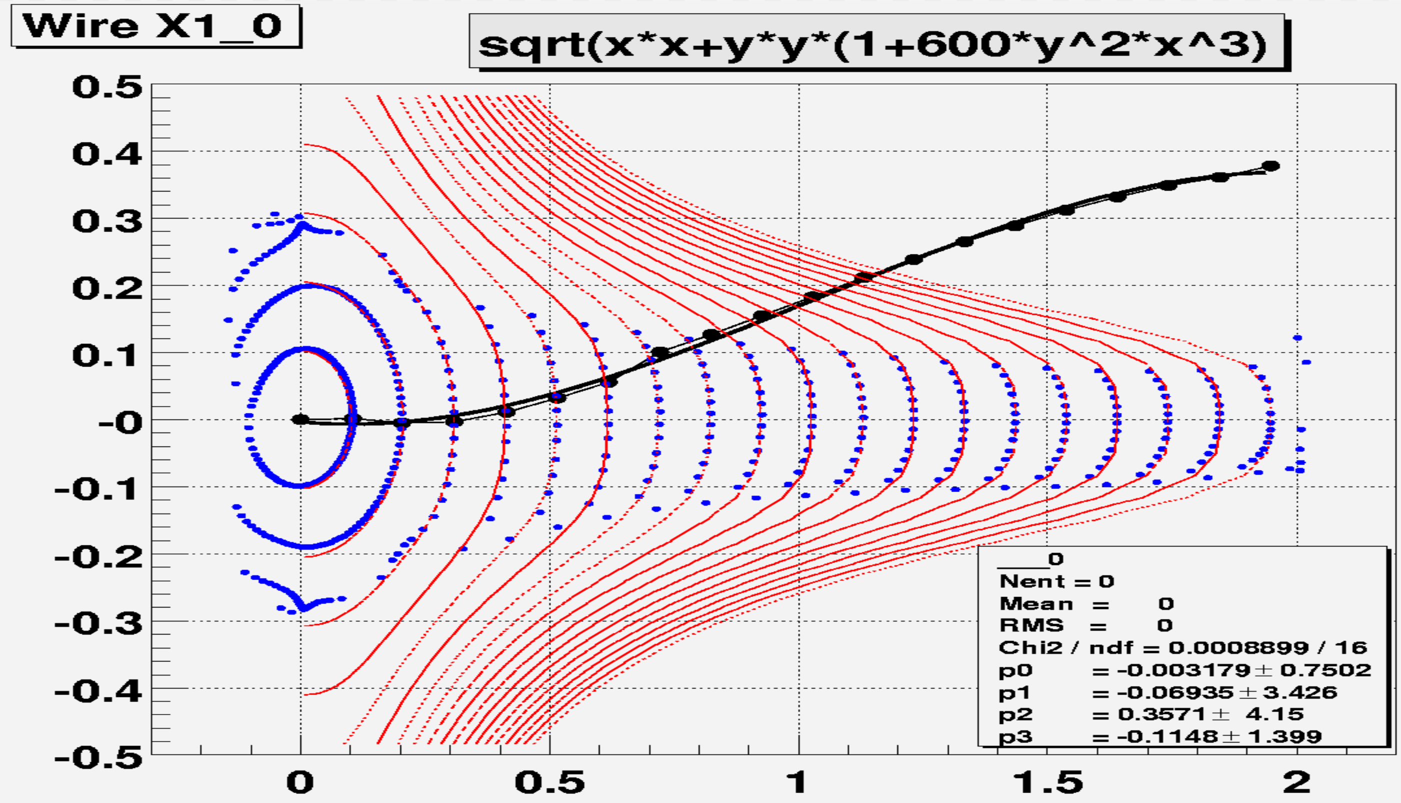
- Study residuals shifts within one net
- We can deduce t_0 shifts that zero the mean of residuals distributions



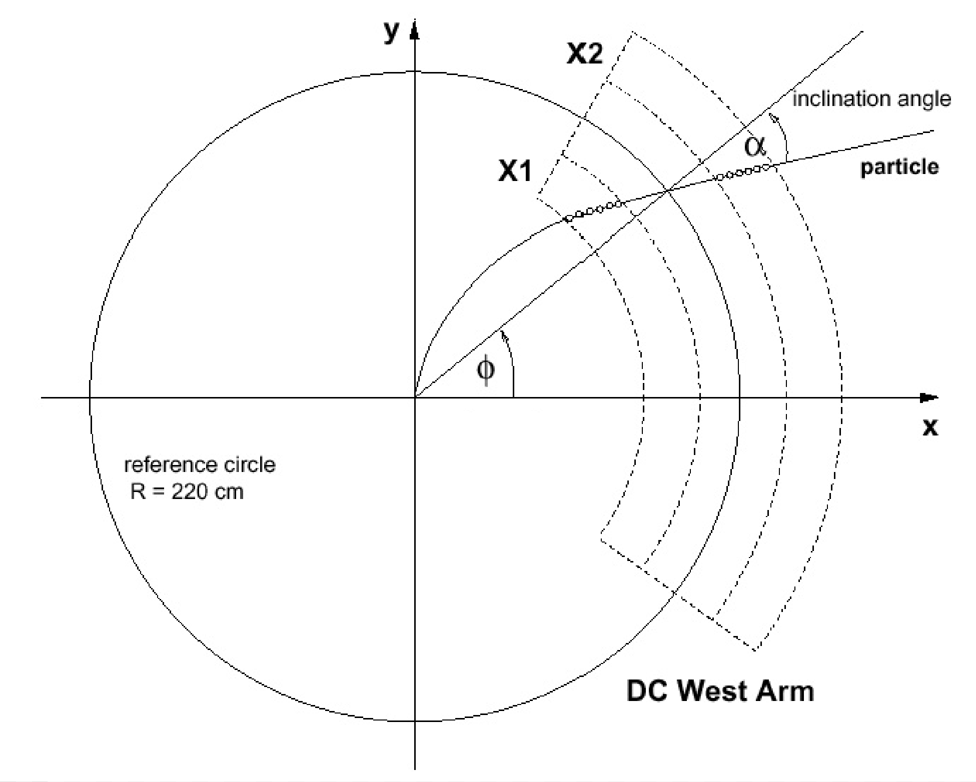


Shape of the drift region

- The shape of the drift region was simulated in GARFIELD and parameterized in the offline software



Tracking principles



Main assumptions:

• Track is straight in the detector region

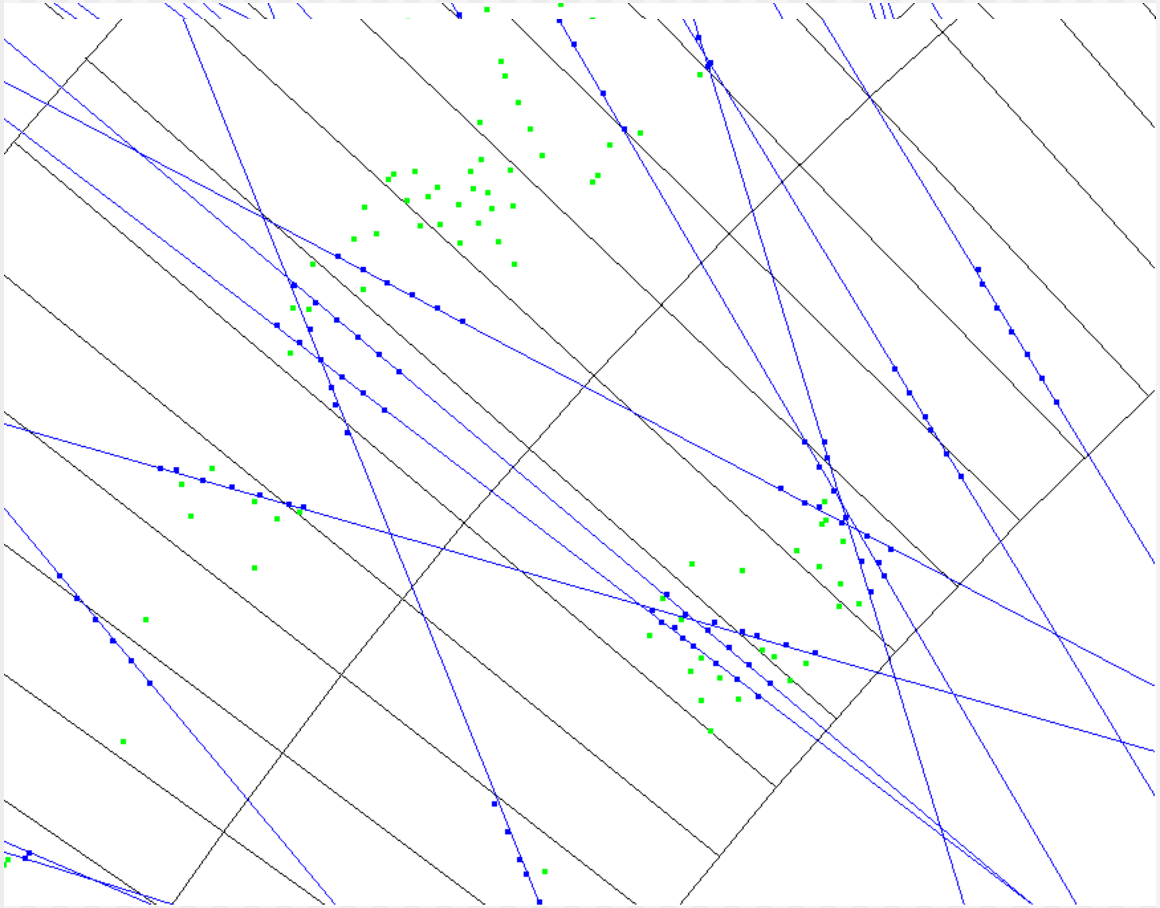
 ϕ and α variables defined on the figure

•Use hough transform – calculate ϕ and α for all possible combinations of hits and bin those values into hough array – 2D histogram on ϕ and α

• Look for local maxima in hough array that surpass the threshold

Track Candidates

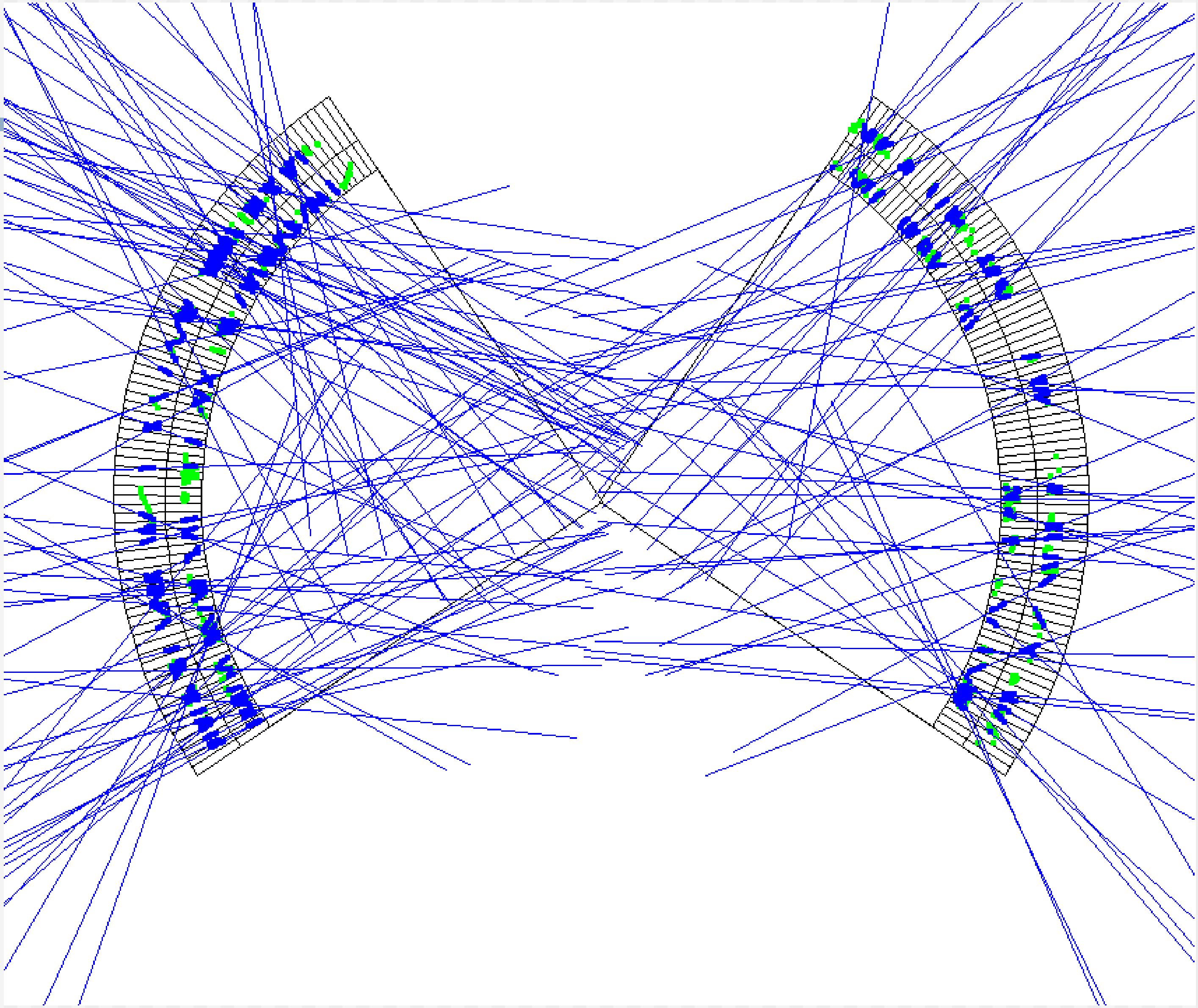
- The results of the hough transform are track candidates
- Several stages of hit association and track purging follows
- Finally we left with the following tracks



X1X2 and X-only tracking

- First we look for tracks with X1 and X2 hits
- Remaining unassociated hits goes into X1 only and X2 only tracking
- All the track candidates are being liked after this and Z information is being applied to them by PC1-UV-vertex tracking

Final results



Future goals

- Calibration of the detector is a main contributor to the momentum resolution ➔ need to improve the absolute calibration methods
  - Use outer detector's matching
  - Online Calibration
- Improve HV stability over the run
- Control gas mixture properties during the run
- Improve UV reconstruction for better ghost rejection