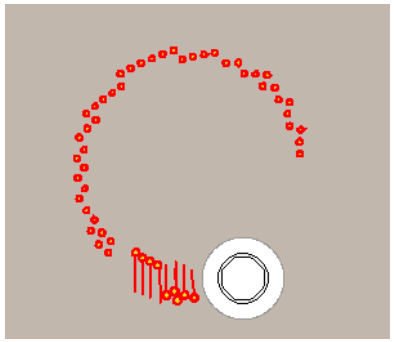
Introduction of updated Hough Transform

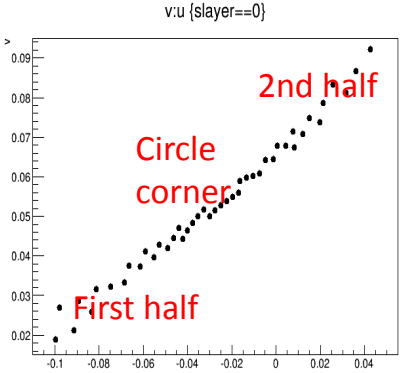
- Conformal transform
- Hough transform
- Modified method
- CFS->HS (Conformal Space->Hough Space)
- Differ half circle
- Bin method on new Hough space
- Test for bin method idea

Conformal transform

- Conformal transform:
  - Circle -> straight line
  - Like to stretching a “bend rope” to staight

- Previous conformal transform
  - u=x/(x*x+y*y)
  - v=y/(x*x+y*y)
  - (x,y) midpoint of hits in real space
  - (u,v) points in CF space
- use only mid point of axial hits
- every points have big error due to neglect drift distance

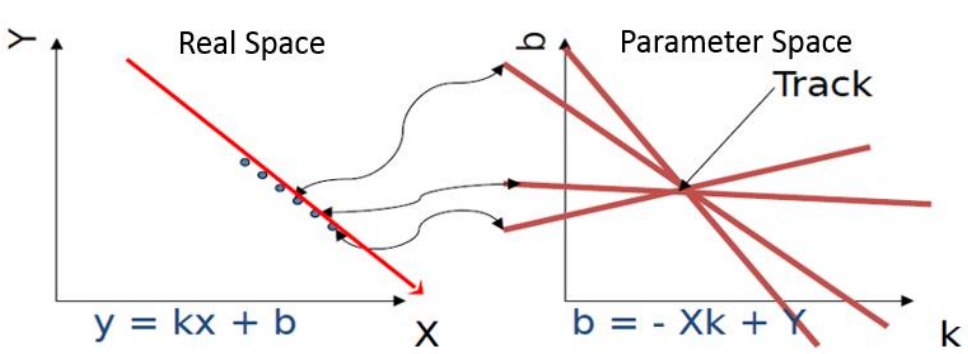


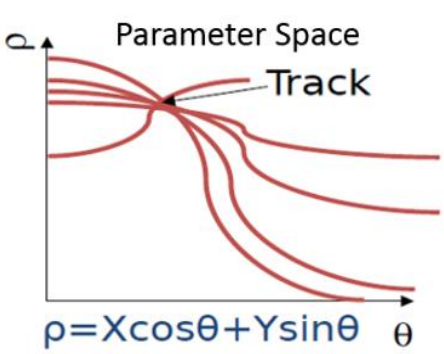


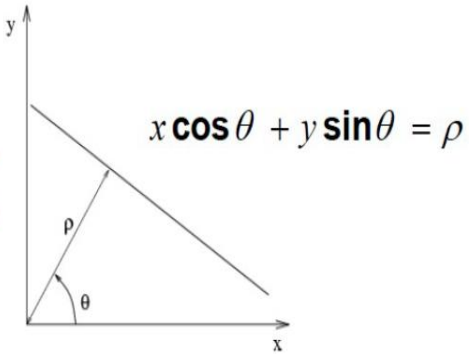
Line performed on Hough Space

- As we use hough transform

Explain of parameters

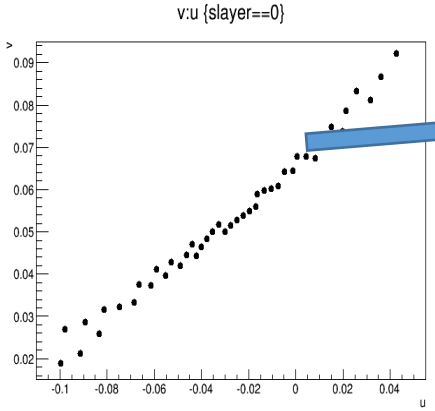


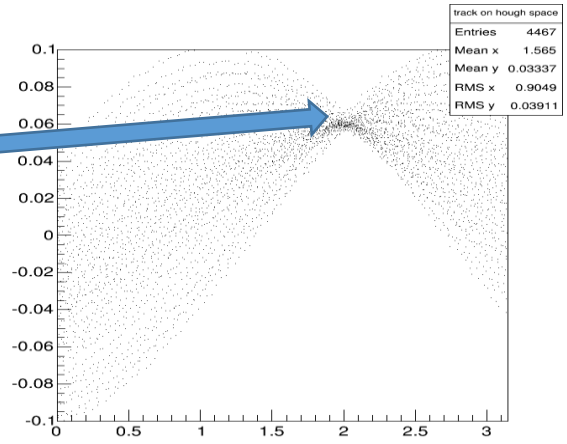




- The error of drift distance bring about

a relative discrete area in the peak





Fix pt 60 MeV for example

Modified CFT and HT method

Circle not passed (0,0) will still be circle by modified CFT

For circle (xc,yc,rc) in real space :

Xc=2*x /(xc*xc + yc*yc - rc*rc)
Yc=2*y / (xc*xc + yc*yc - rc*rc)
Rc=2*rc /(xc*xc + yc*yc - rc*rc)

$$\left(X-\frac{2x_c}{x_c^2+y_c^2-R^2}\right)^2+\left(Y-\frac{2y_c}{x_c^2+y_c^2-R^2}\right)^2=\left(\frac{2R}{x_c^2+y_c^2-R^2}\right)^2,$$

Circle (xc,yc,rc) turned to (Xc,Yc,R) in CF space

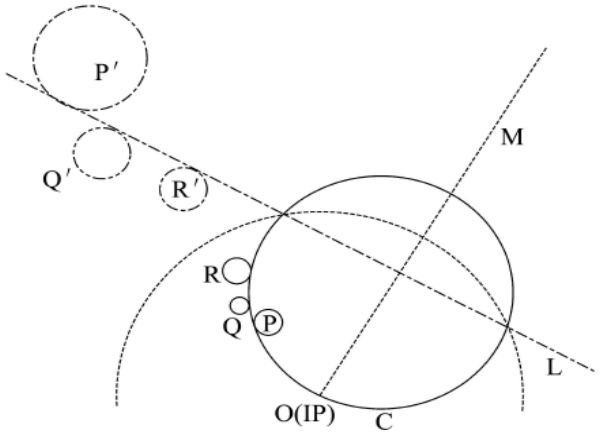


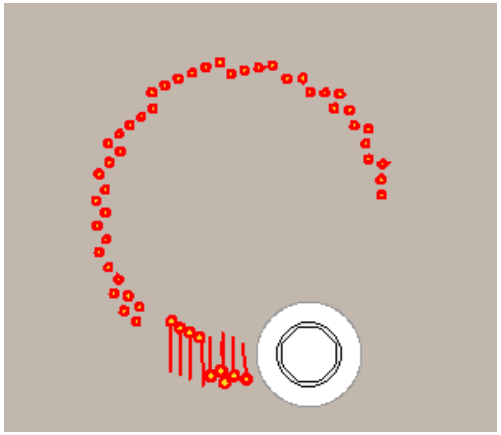
Fig. 2. After conformal transformation, the circle C which passes O(IP) is transferred into line L; the circles P, Q and R which do not pass O are transferred into new circles P′, Q′ and R′.

Proved by legendre transform , circle tangent to the same circle will tagent to the straight line in CF space

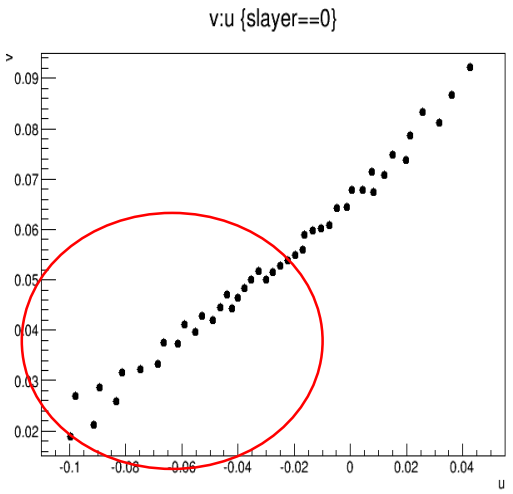
Perform on Hough Space

- Every drift circle is transformed by CFT to CF space

$$Xc = x/(x*x + y*y - drift*drift)$$
$$Yc = y/(x*x + y*y - drift*drift)$$
$$CFdrift = drift/(x*x + y*y - drift*drift)$$

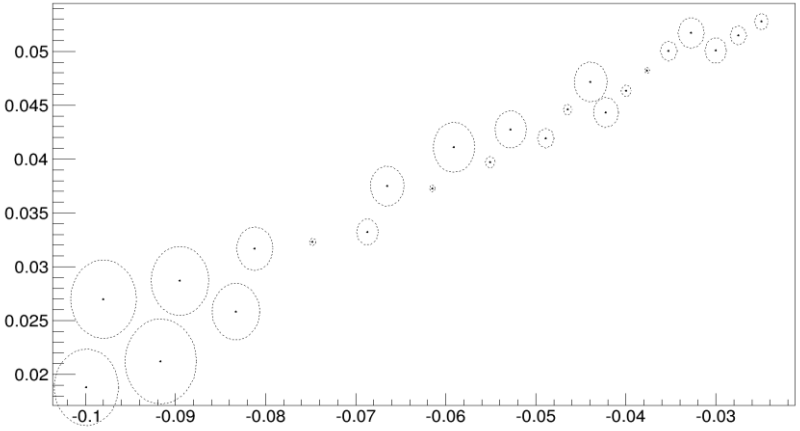


Real Space



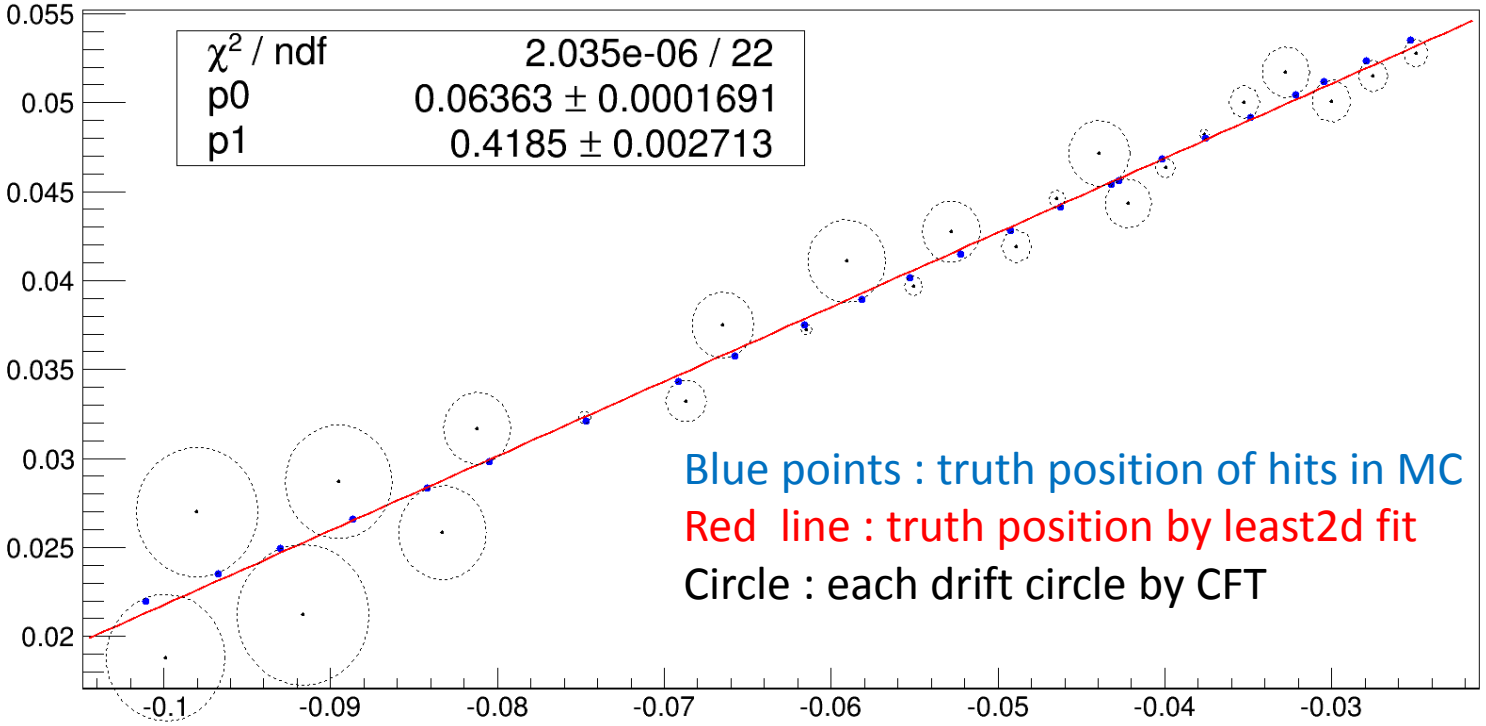
Old CFT

Only use 1st half circle hits



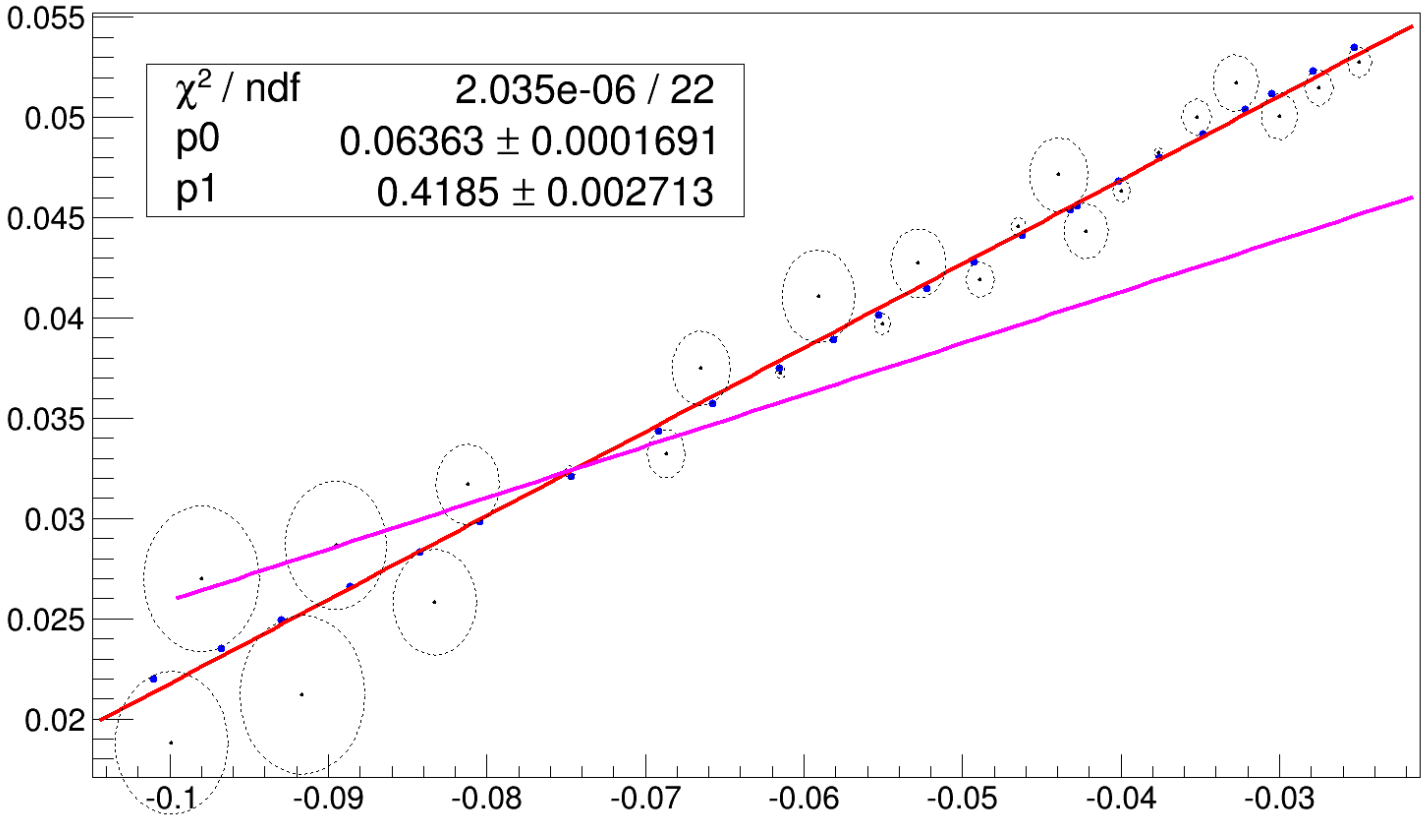
new CFT

Truth point on CF space



- Hit truth position is close on drift circle in CF space
- Aim is changed to look for a straight line tangent to each drift circle
- Each tangent point is the position of the track passing the MDC wire

Why use the truth position of hits

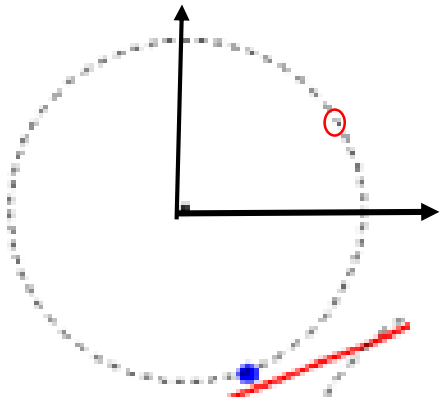


Pink line is the truth particle , think of energy loss , far from the real circumstance

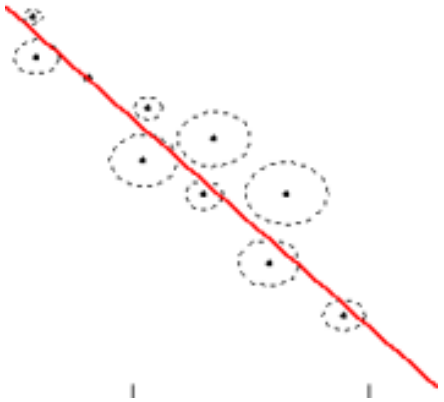
CF Space -> Hough Space

The straight line is tangent to each drift circle on CFS

Split the drift circle along alpha , for example (0~360) to 60 points



Method 1: straight line will pass through the drift circle

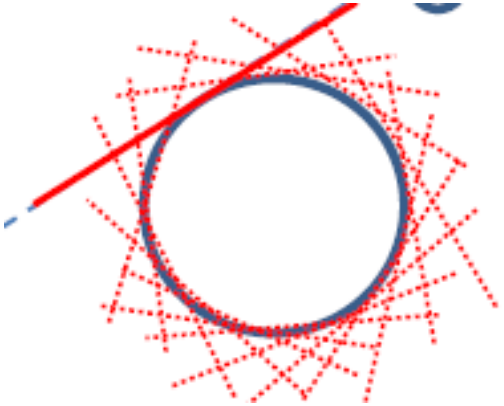


Two method for hough transform

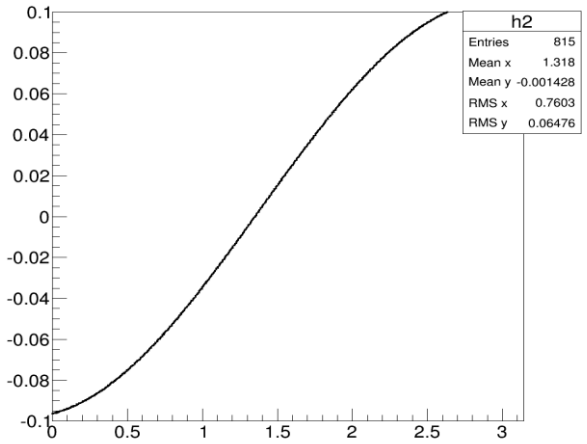
- Each points to a sino curve line to Hough space
- tangent line to circle at each points to Hough space

CF Space -> Hough Space

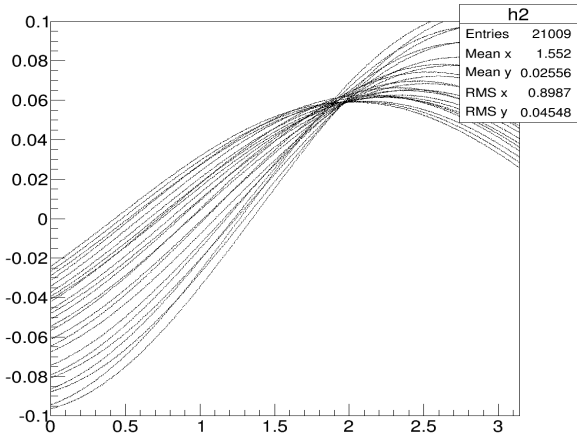
Calculate tangent line of each points on the drift circle
Convert parameters to (rho,theta) , and fill Hough Space



A drift circle on Hough Space

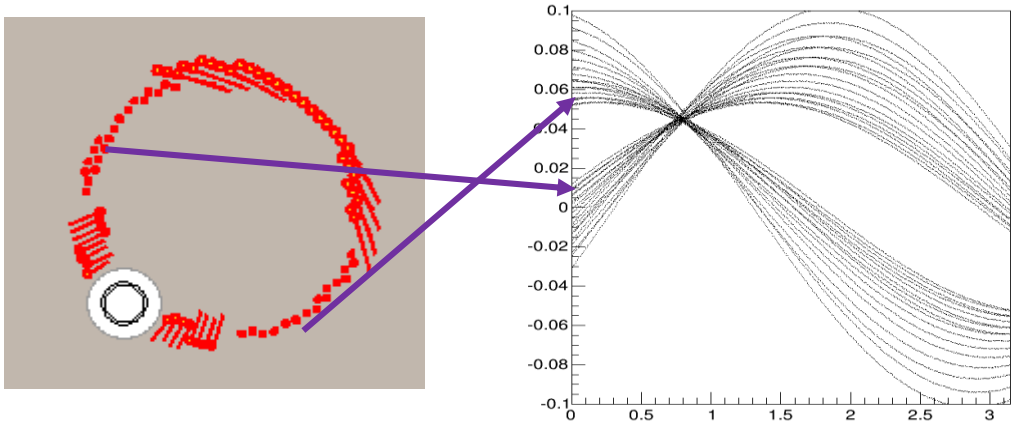


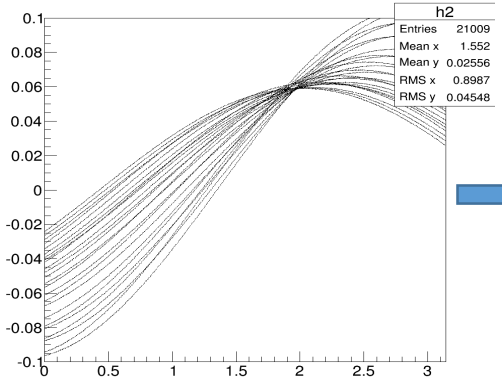
all drift circles on Hough Space



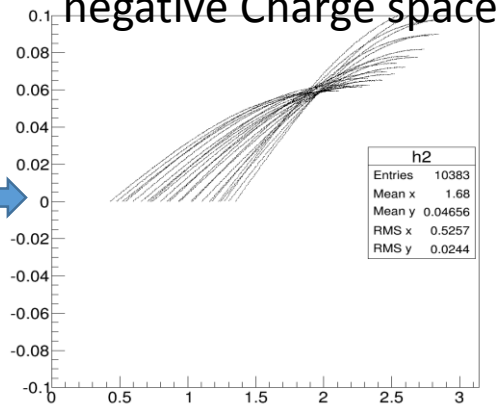
Differ half circle hits

Same with the previous method
Determine by sign of slant & sign of rho
(sign of slant) *(sign of ρ)





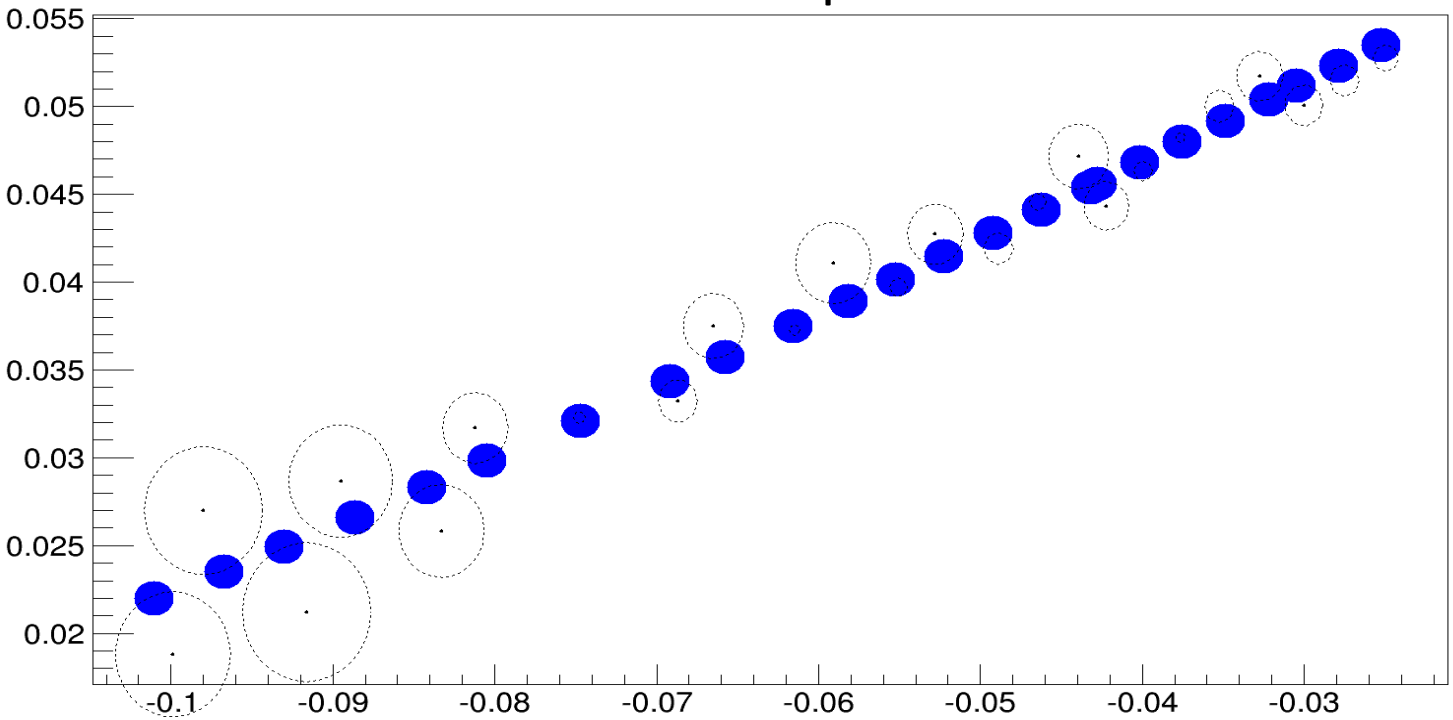
negative Charge space



Hits on 1st half and 2nd half have different sign of slant when there appears a track

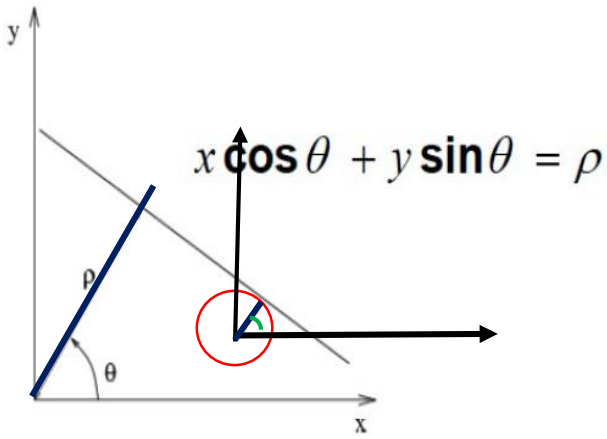
What is the range to determine line?

a Sketch map of CFS

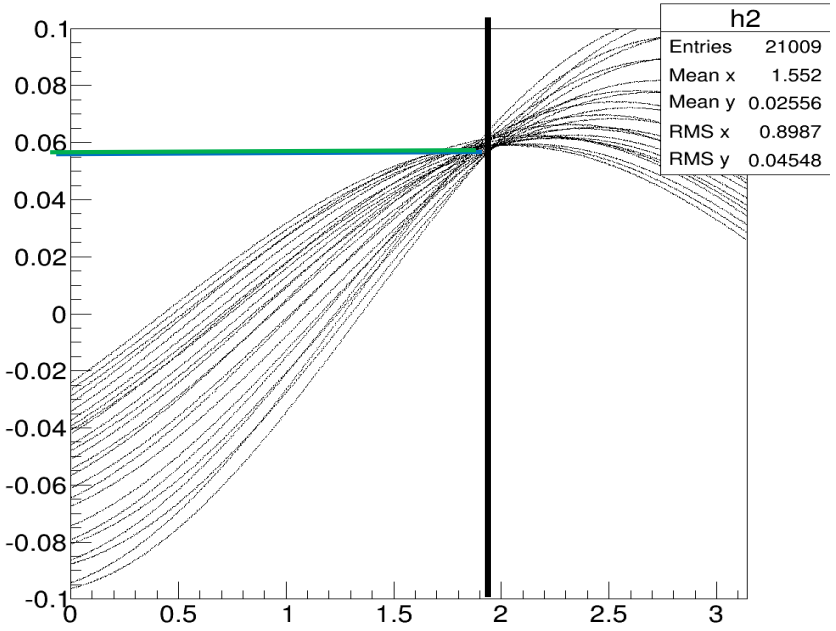


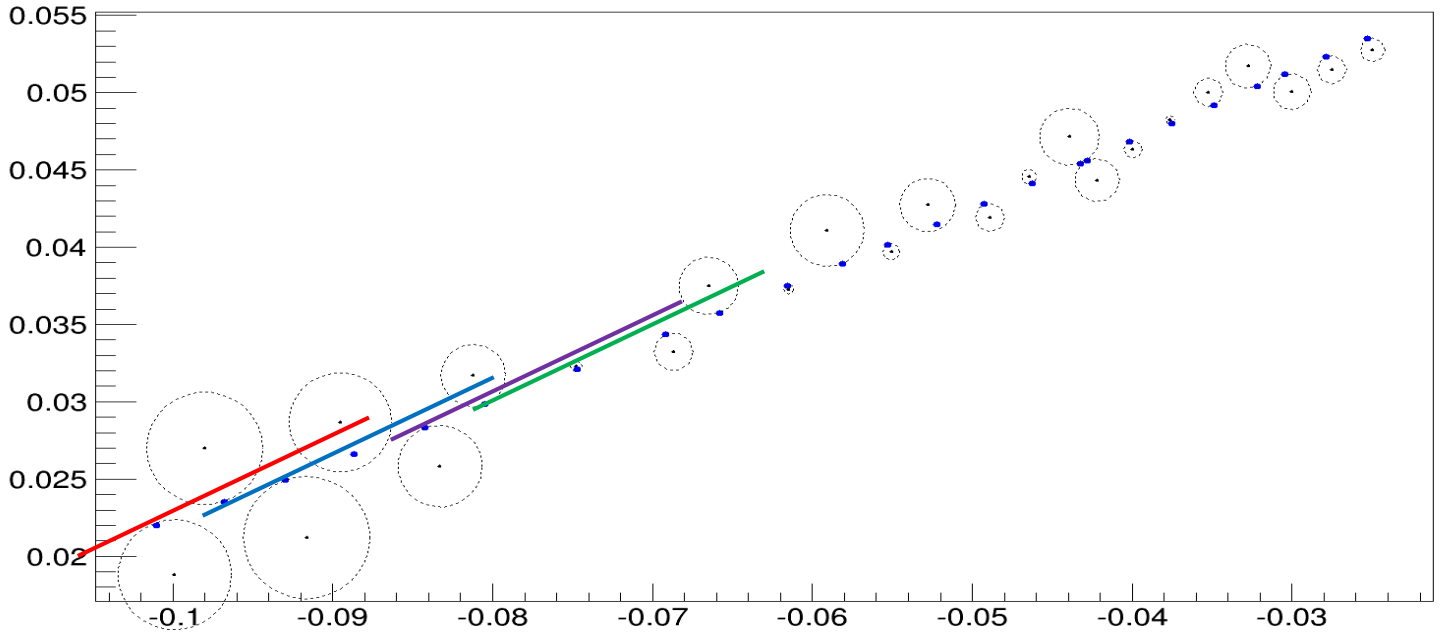
- Actually , think of the position differentiate , truth position can be transformed into a list of circles in CFS
- the range of straight line is contain all the maximum & minmum (rho,theta)

Bin method along theta

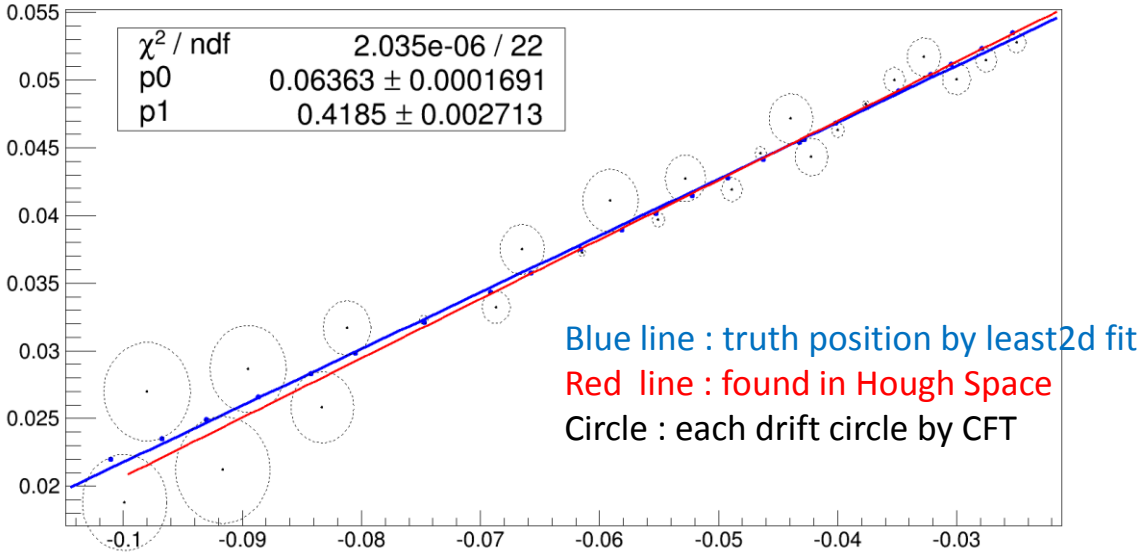


- Alpha -> theta one to one match
- How to split the drift circle determine the theta bin on Hough map
- By this method :
- Each bin along theta axis of HS represent one possible position of the straight line in CFS


h2
Entries 21009
Mean x 1.552
Mean y 0.02556
RMS x 0.8987
RMS y 0.04548
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
0
0.5
1
1.5
2
2.5
3

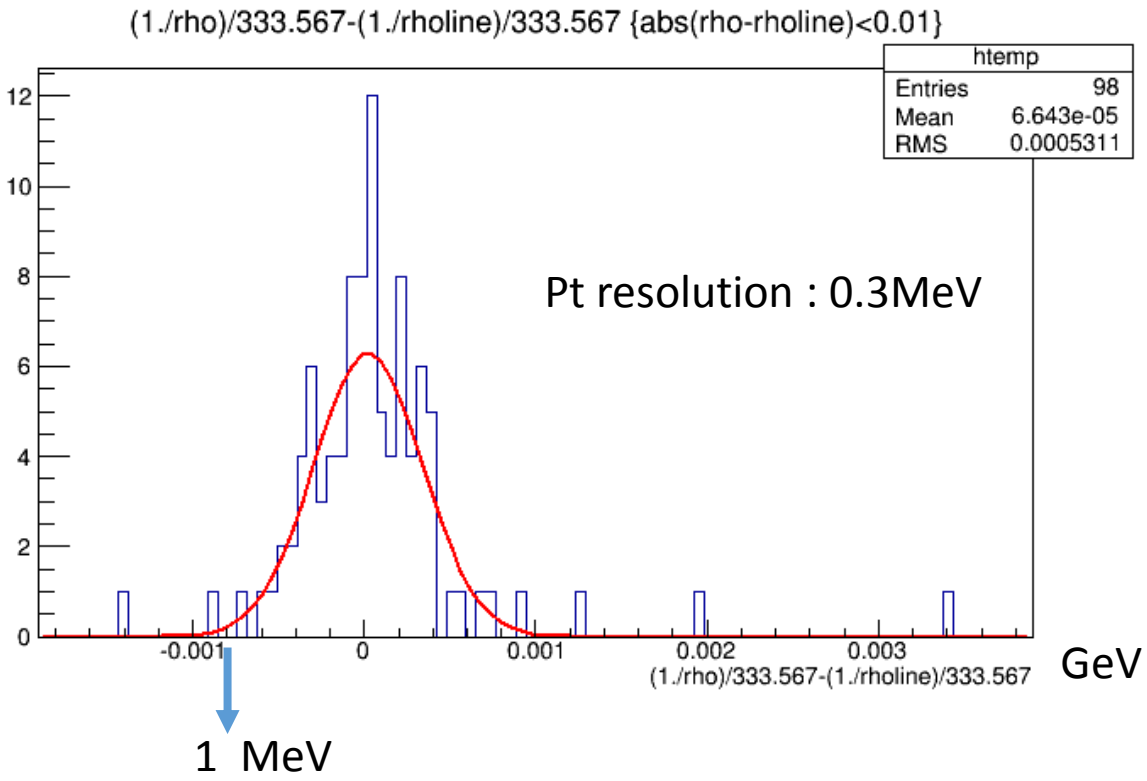

0.055
0.05
0.045
0.04
0.035
0.03
0.025
0.02
-0.1
-0.09
-0.08
-0.07
-0.06
-0.05
-0.04
-0.03

- More bins we split along theta axis, more accurate of the straight line
- Split bin into 1000*1000 of HoughSpace
- Select the max bin as the “found track”

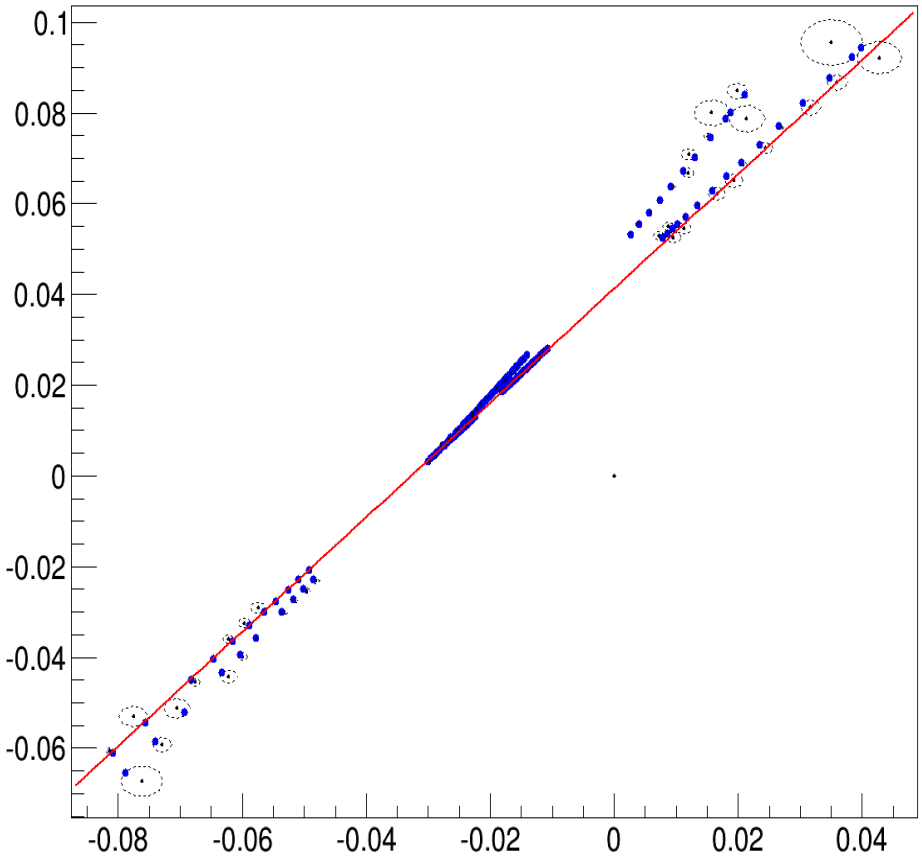


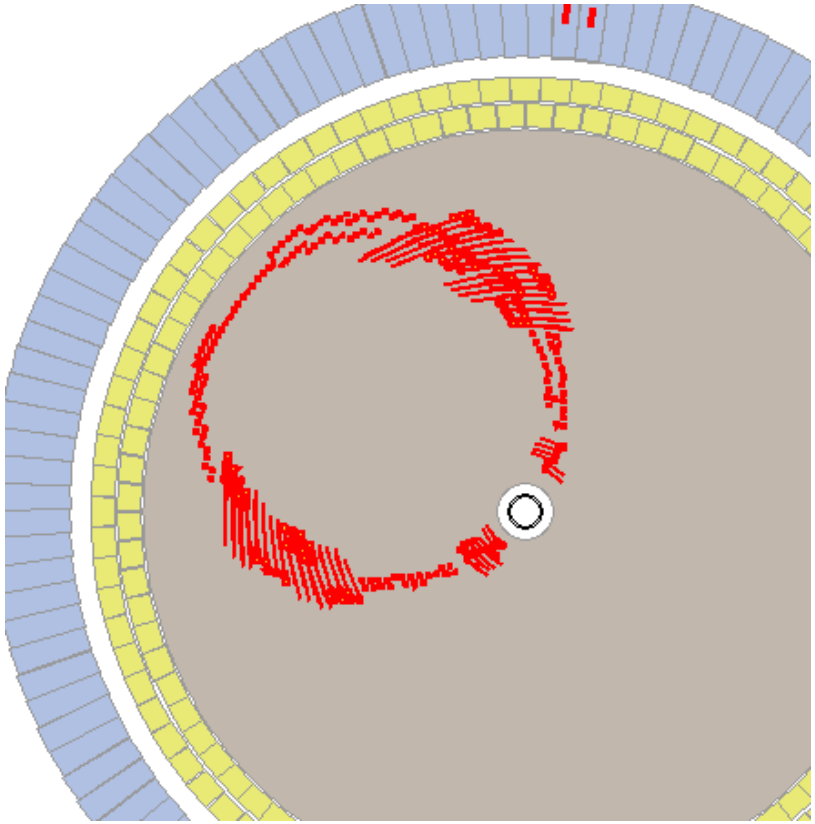
Test 100 fixpt 60 MeV events

Pt1: Truth pt : truth position of all hits fit by least2d
Pt2: Pt of “found track “ : found in Hough Space by maximum bin
Pt resolution : pt1-pt2



Deal with multi turn tracks ?





Red line : found in Hough Space

Now finding the method how to deal with the rho axis …

Idea is to calculate the width of bin along rho axis at maximum bin

a Sketch map