Online Tracking with STT

Yutie Liang
Giessen University
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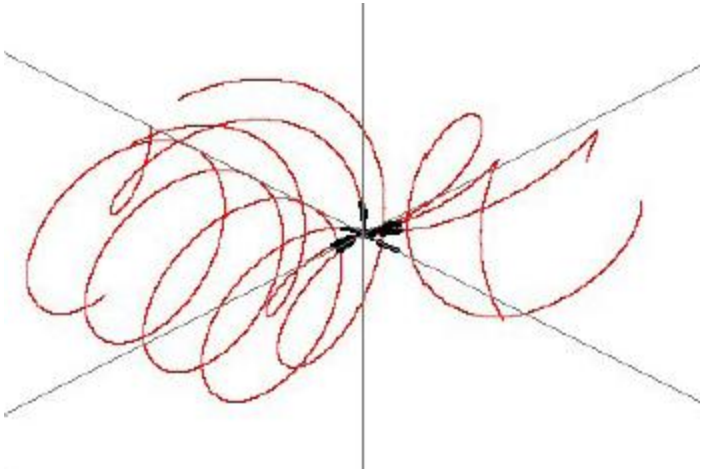
Motivation

- Finding helix shaped tracks in the magnetic field
- Develop an algorithm as part of the online trigger for PANDA

Method: Using transformations to simplify calculations



Based on David's work on diploma thesis, we studied the performance of the algorithm using information from STT detector.
As the first step, we only consider the XY plan now, and no stereo layers used.

Helical track → circle in 2D (momentum←→radius) → straight line(by conformal transformation) → obtain line parameters(by Hough transformation)

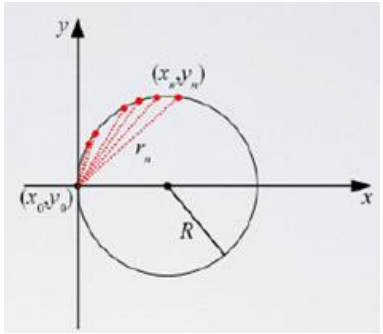
Conformal Transformation

Used for projection perpendicular to the beam direction

Transform circles to straight lines

$$x' = \frac{x - x_0}{r^2}$$

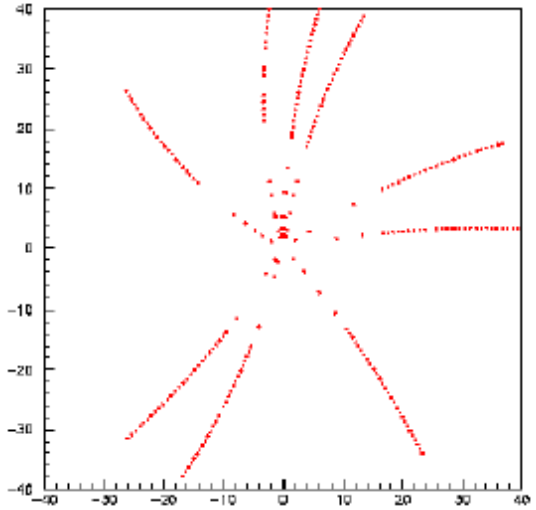
$$y' = \frac{y - y_0}{r^2}$$

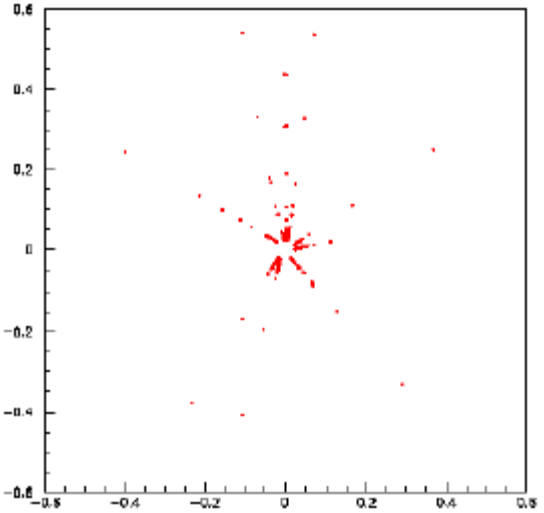


$$r^2 = (x - x_0)^2 + (y - y_0)^2$$

Finding straight lines is less complex than finding circles

Transform circles to straight lines



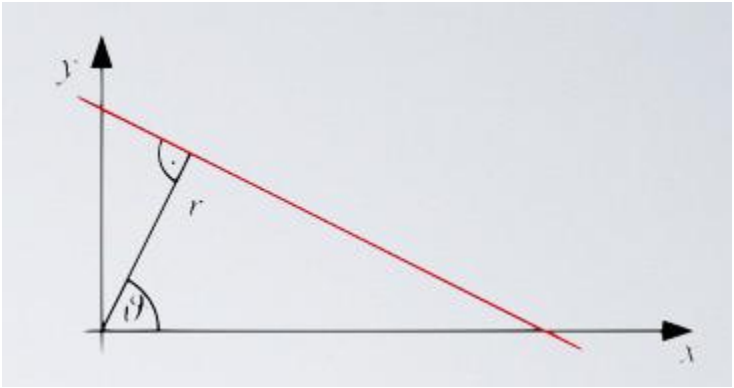


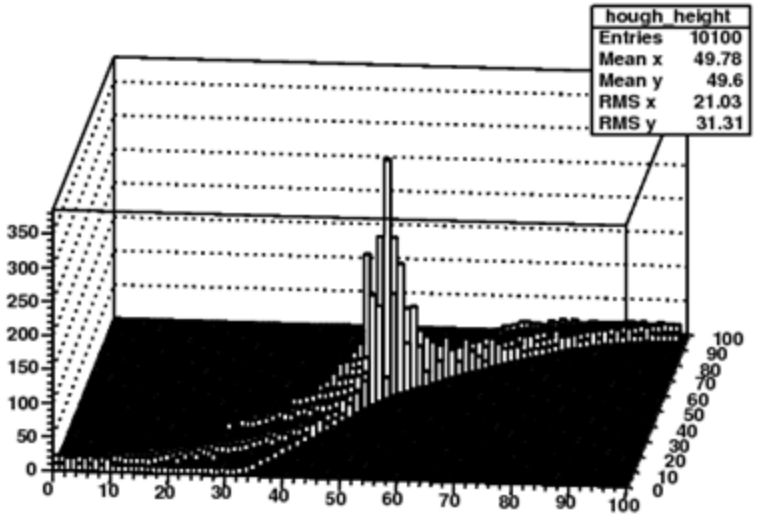
Hough Transformation

Describing points in real space by parameter
For lines: r and θ

$R = x\cos(\theta) + y\sin(\theta)$

- Use all possible angles
- Save data in histogram
- Peaks in histogram represent possible lines in point set





Three cases used in this study

1. Ideal case: Use MC truth position.
   The current algorithm uses accurate position as input.

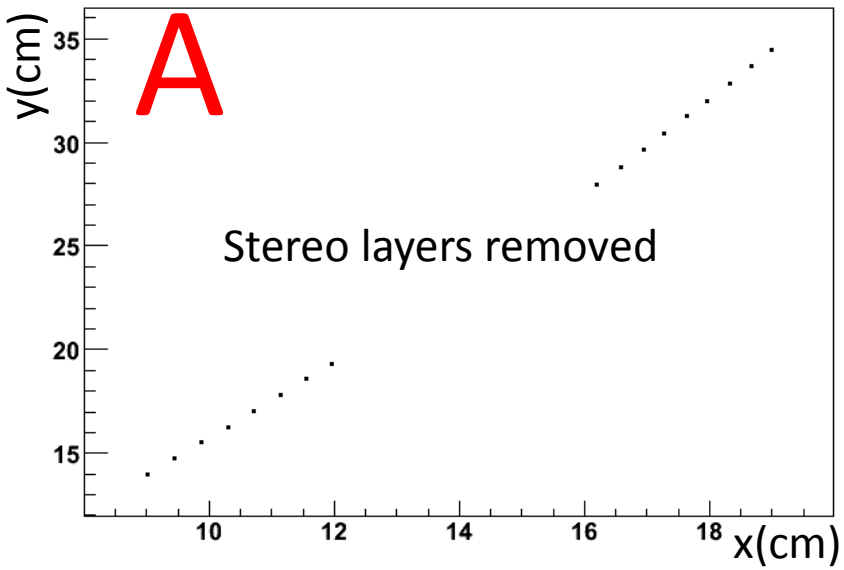
2. Worst case: Use only wire position of STT

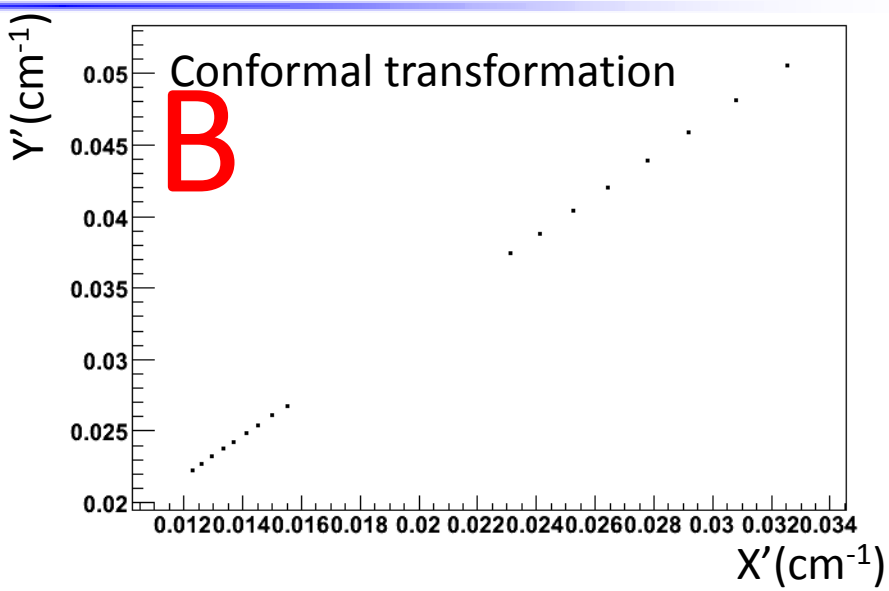
3. Realistic case: Use drift distance information from drift time.

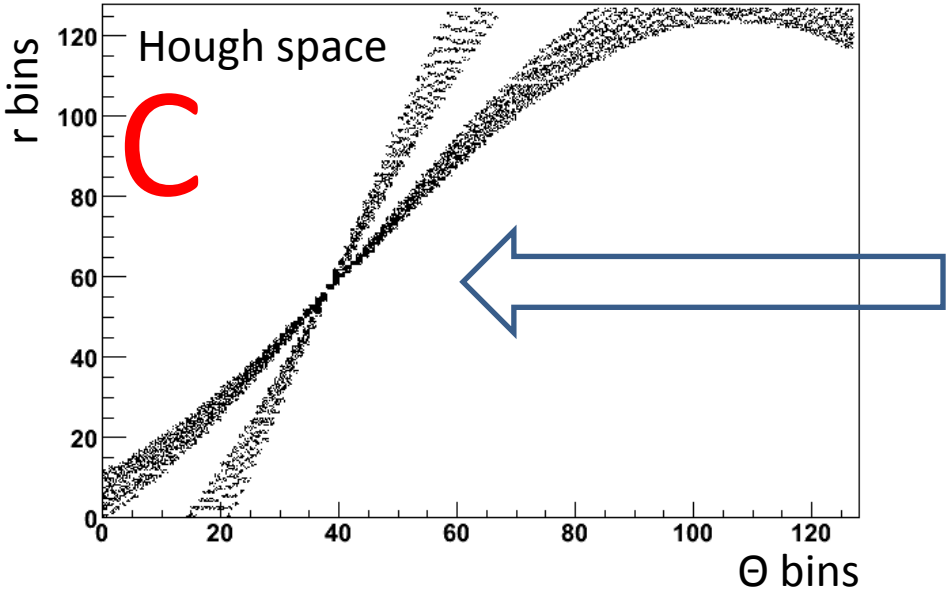
   First Method
   - method A
   - method B

   Second Method

One example using MC truth position from STT – Ideal case

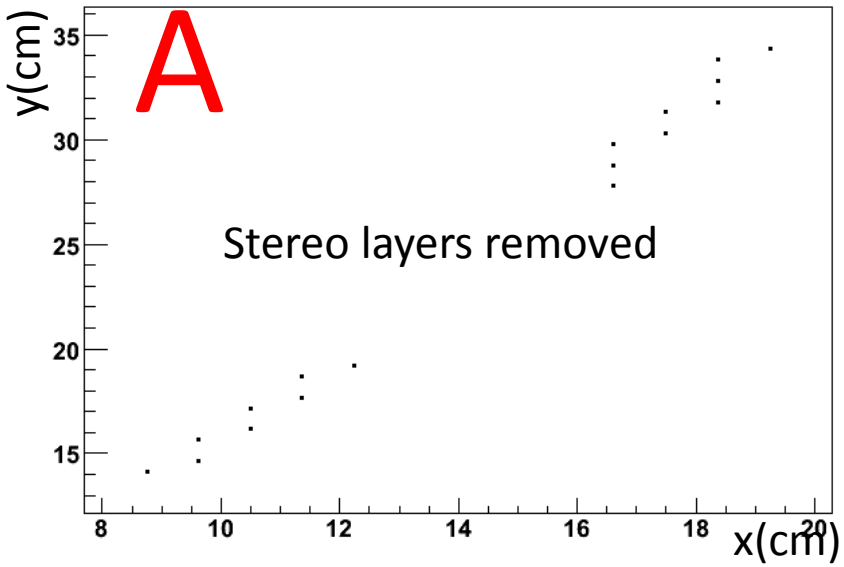


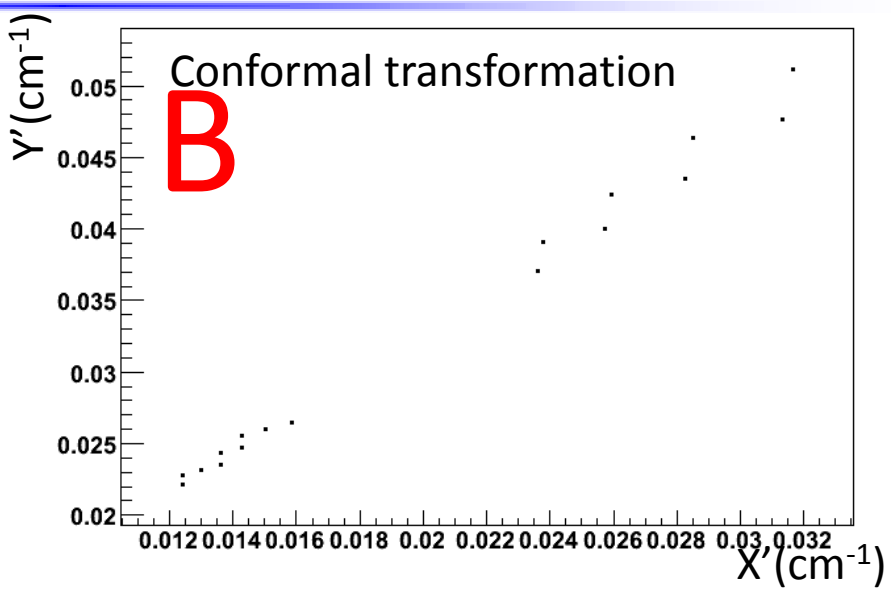


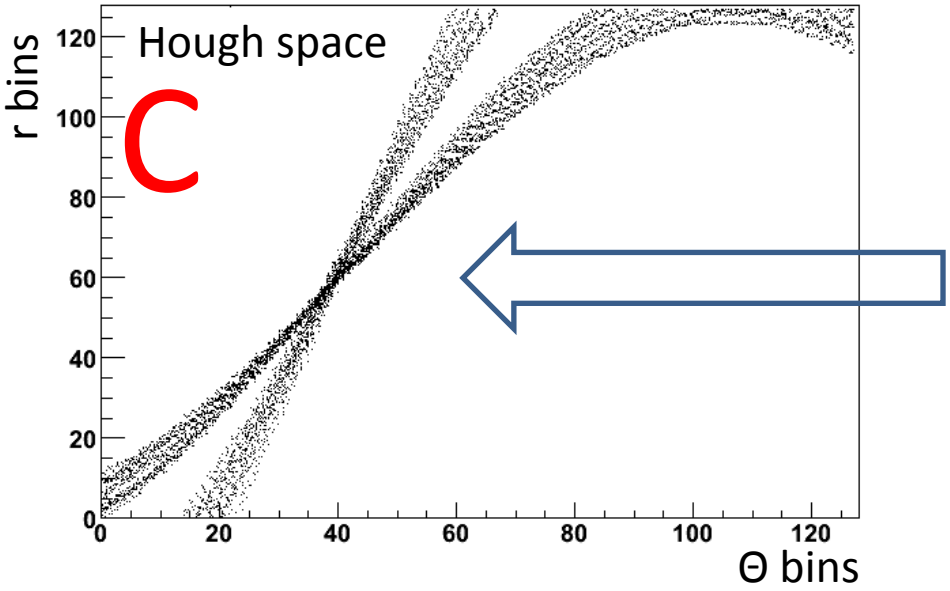


The cross point forms peak in histogram

One example using wire position of STT – worst case

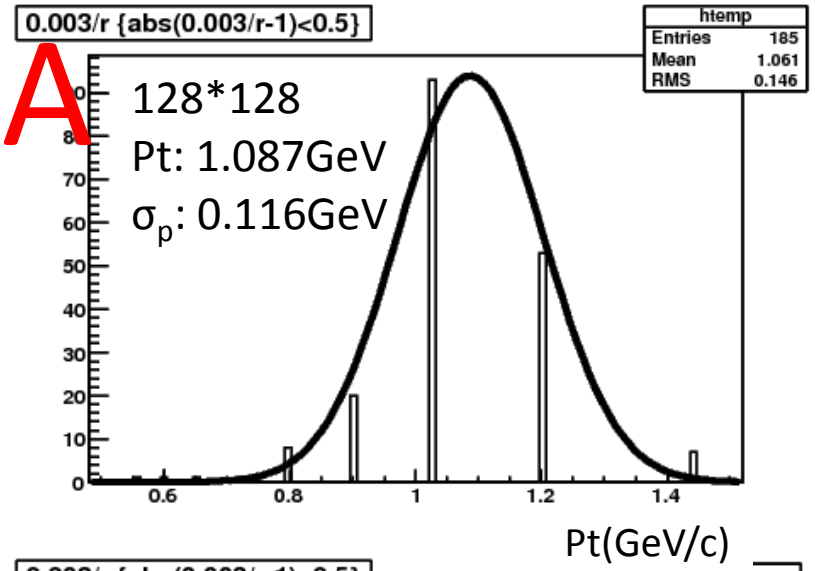


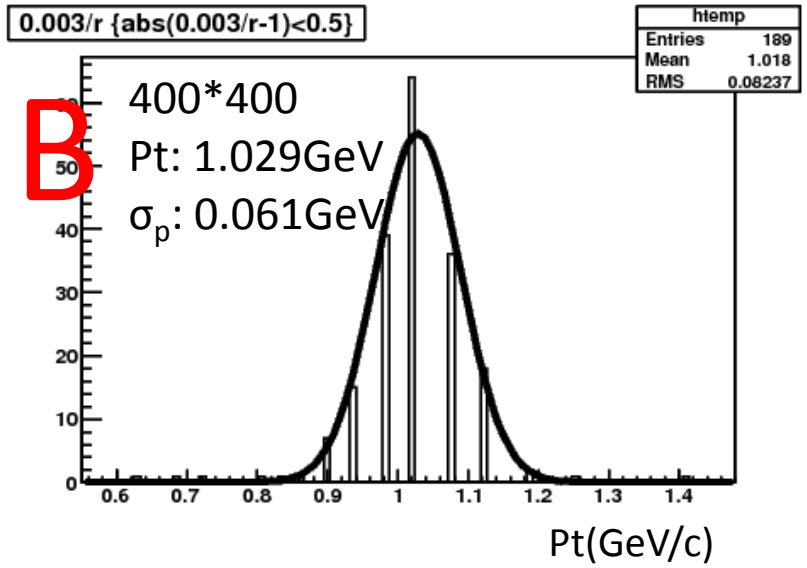


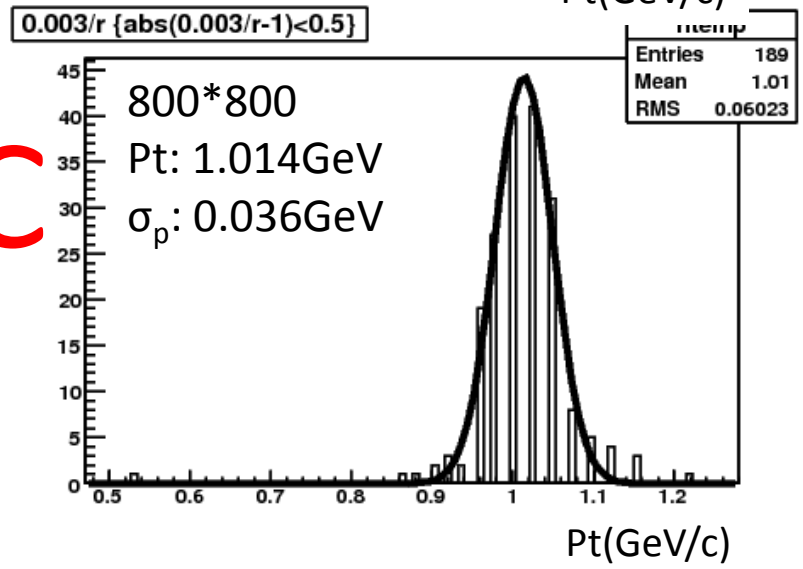


The cross point still exist, but more broad.

Momentum resolution using MC truth – varying bin size of Hough space





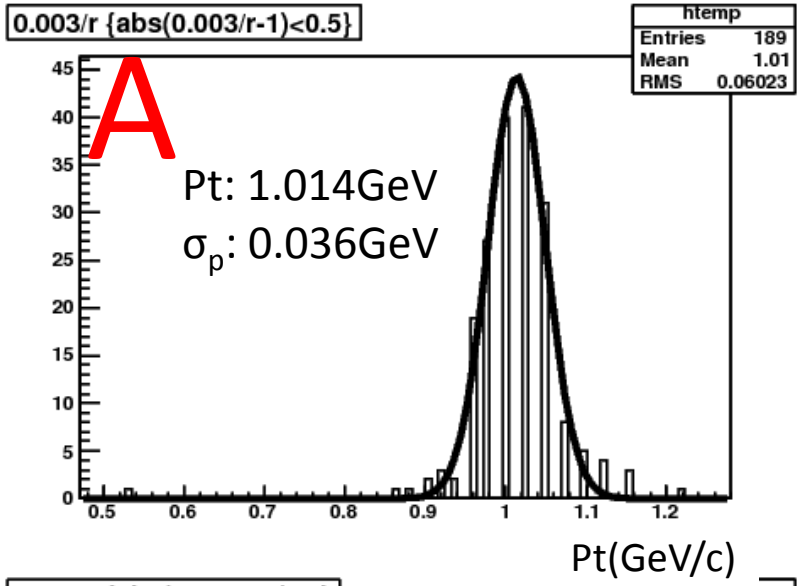


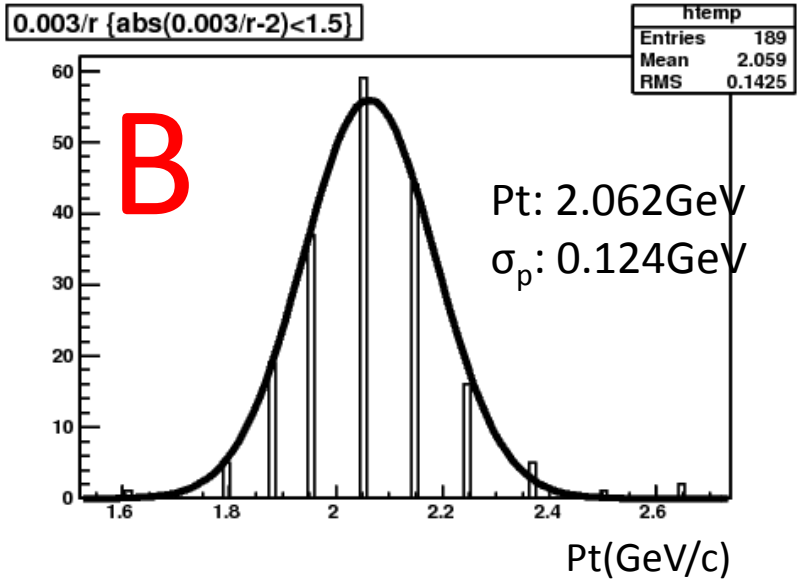
Input: single mu+, 200 events
Pt: 1GeV, θ(15,120), Φ(0,360)

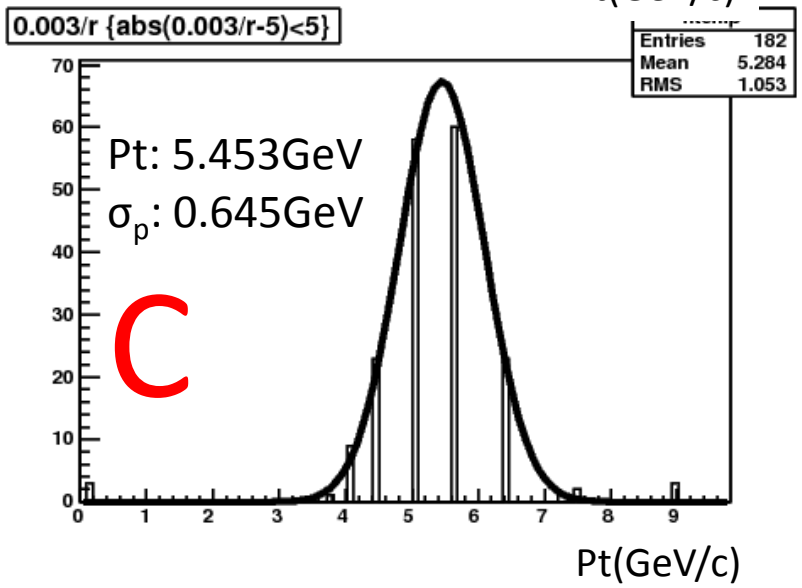
Using MC truth position in a straw tube.
Only pick up the highest bin in each event

The momentum resolution improves obviously using more bins.

Momentum resolution using MC truth – varying Pt







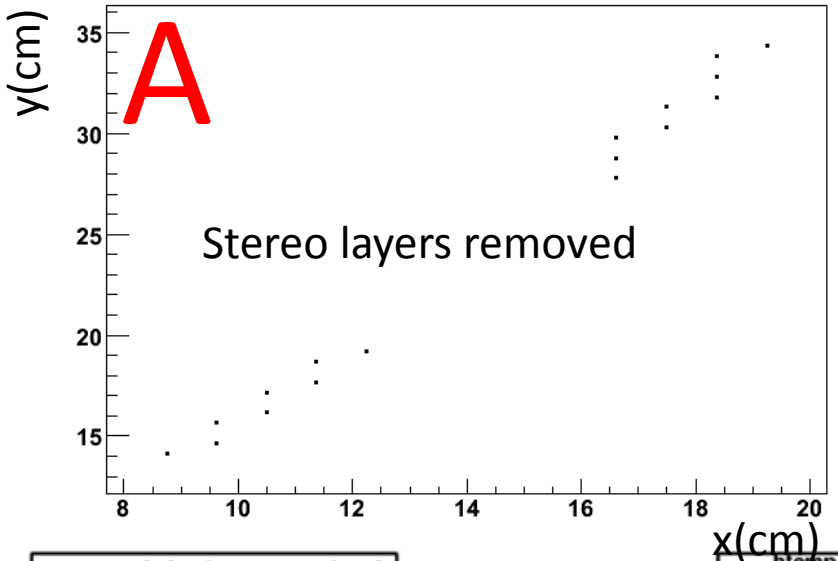
Momentum resolution:

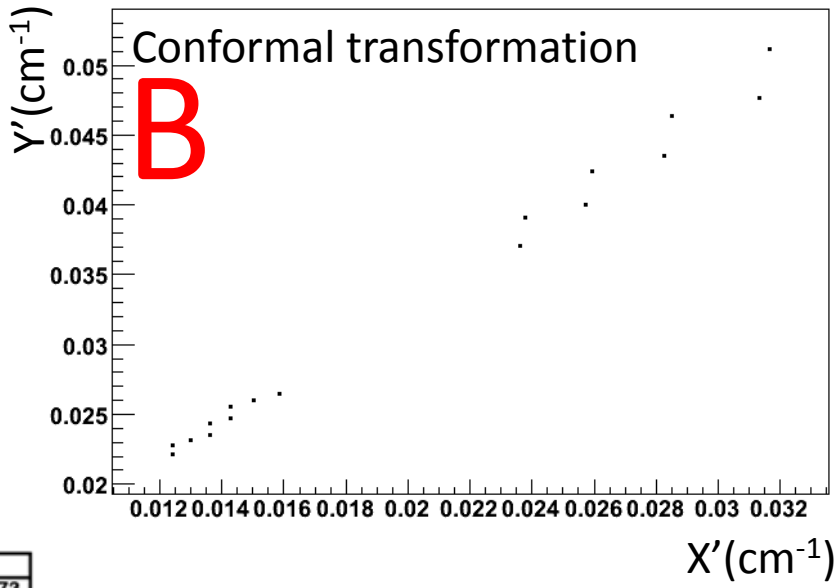
1GeV: ~3.6%

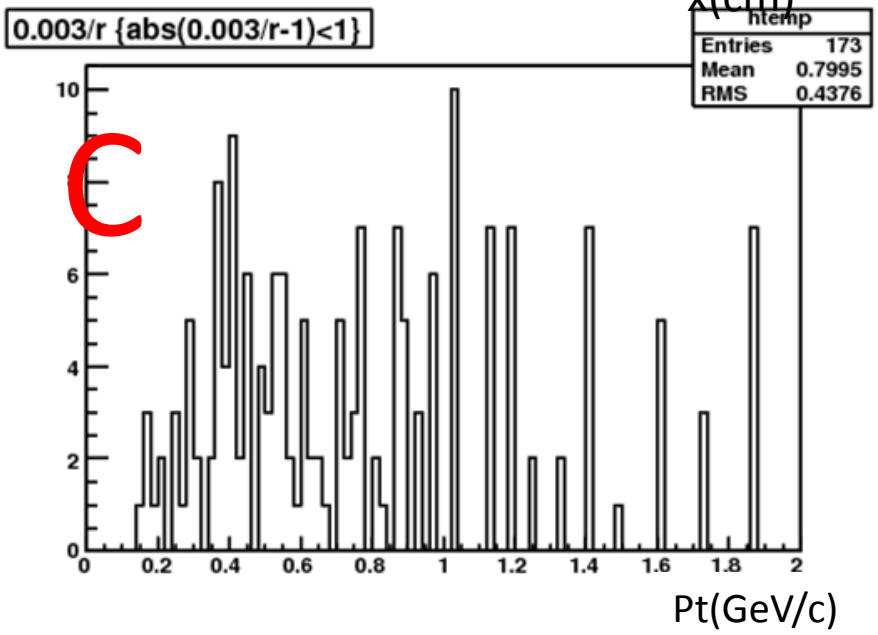
2GeV: ~6.2%

5GeV: ~12.9%

Performance of using STT information– only wire position





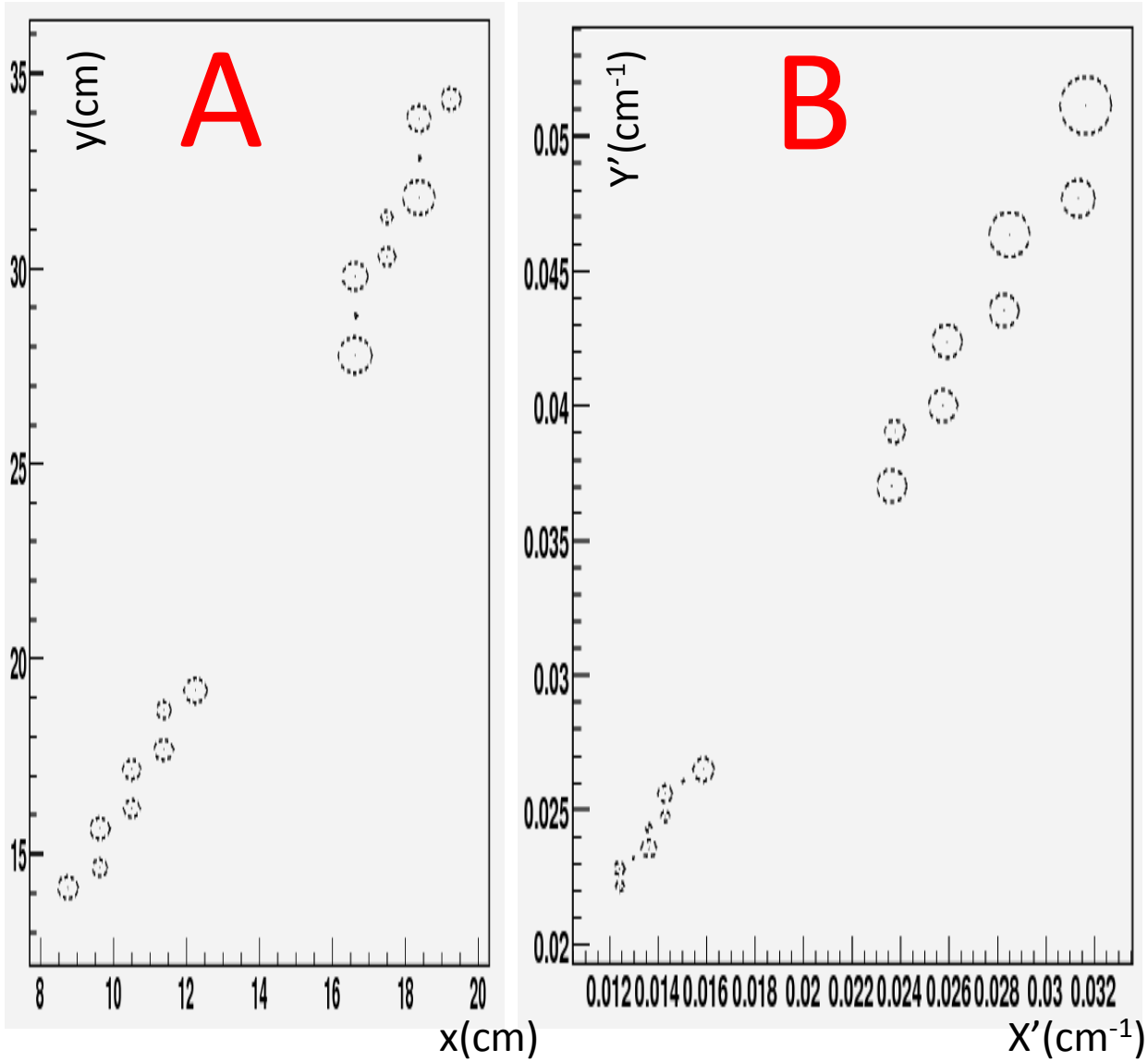


Input: single mu+, 200 events
Pt: 1GeV, θ(15,120), Φ(0,360)

Using STT center position only.
Only pick up the highest bin in each event

The output momentum is too bad.

Attempt to include drift distance

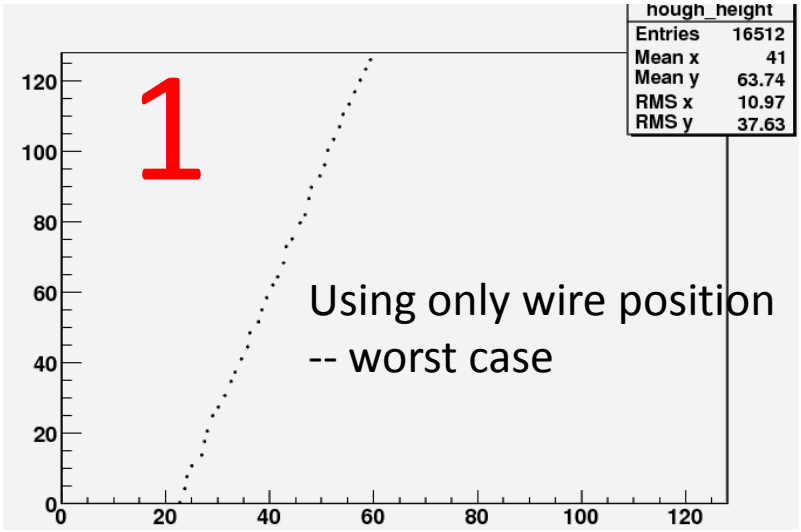


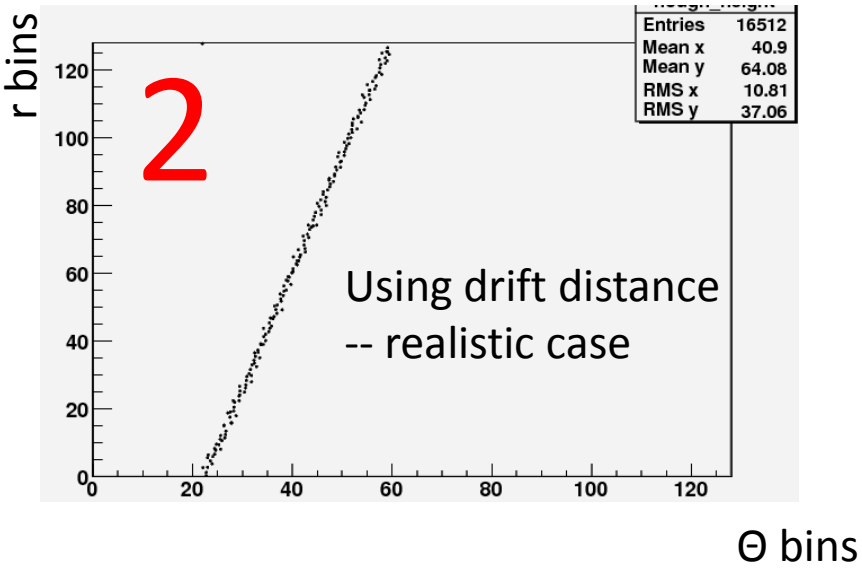
Method:
(x_center, y_center)
± (drift distance)

Conformal:
(x', y') ±(error)

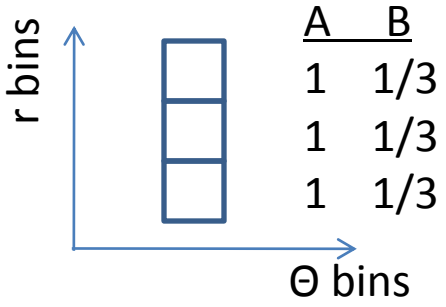
Hough:
Before: Θ -> r
Now: Θ -> r ± Δr

Attempt to include drift distance



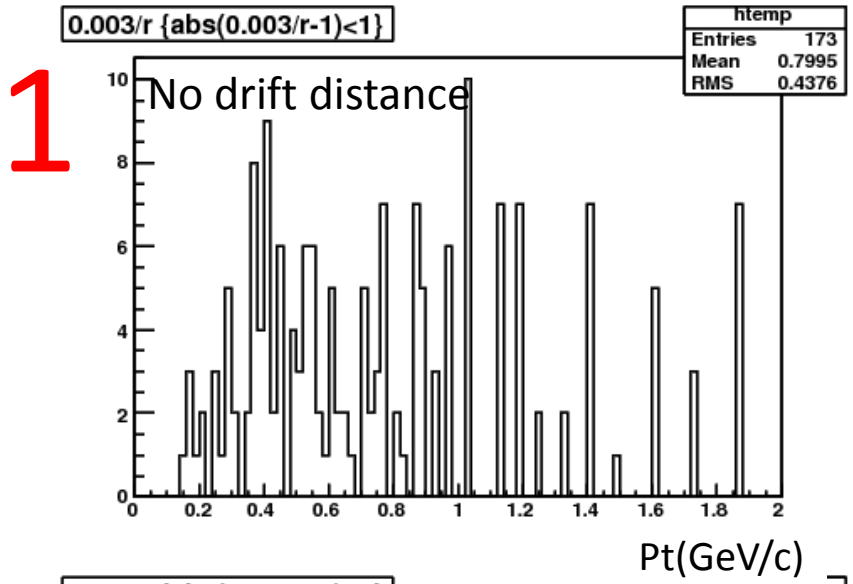


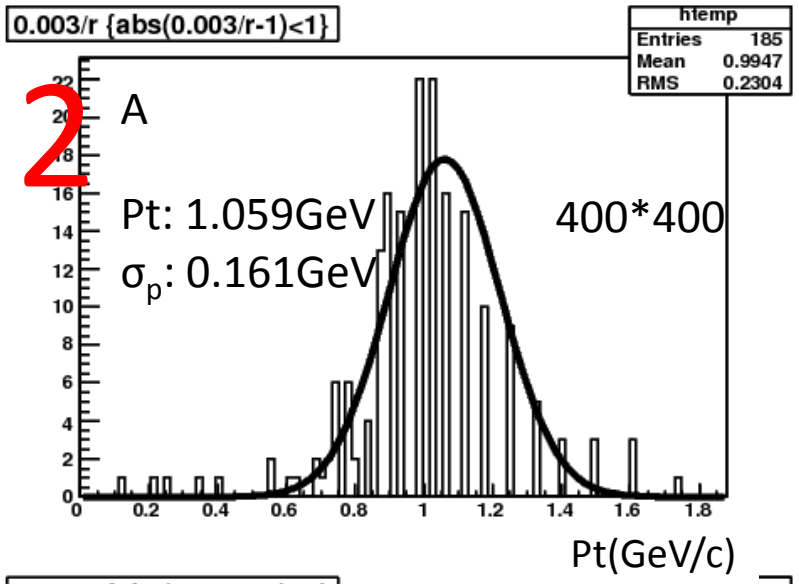
Two ways to fill the histogram:
A: fill "1" to each possible (Θ, r) bin
B: fill a weighted value 1/N_r(Θ) to each bin possible (Θ, r). N_r(Θ) stands for the number of r bins need to fill at Θ angle.

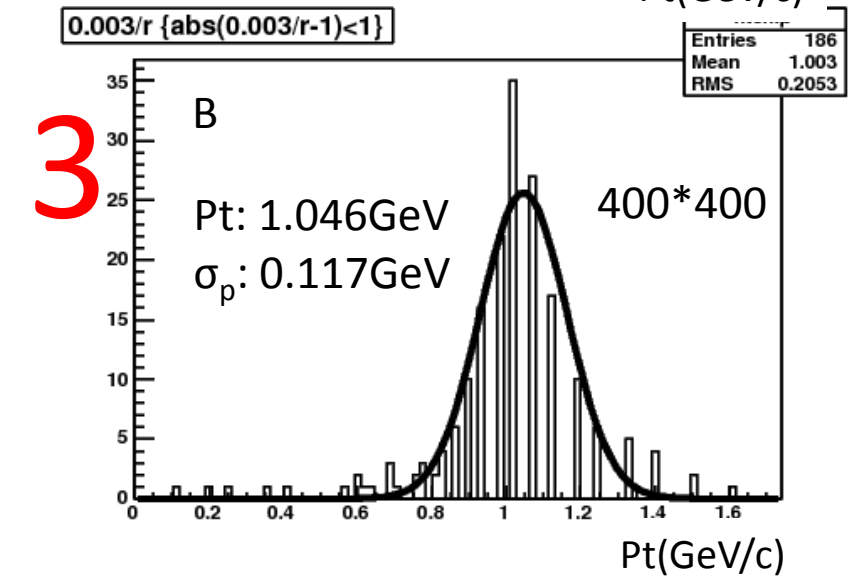


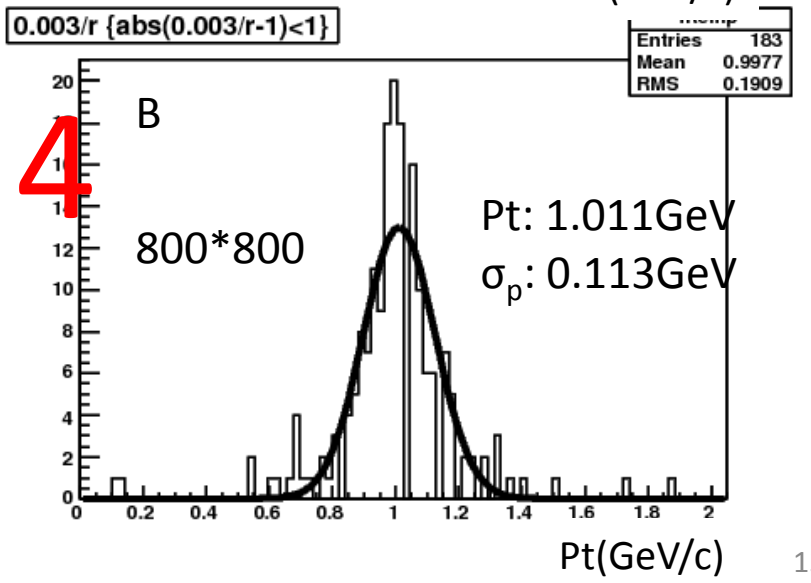
A	B
1	1/3
1	1/3
1	1/3

Different methods of using drift distance



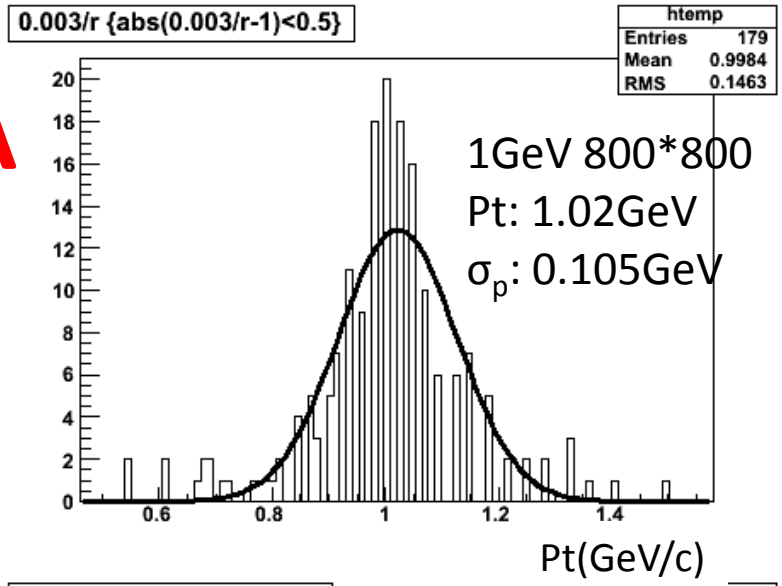






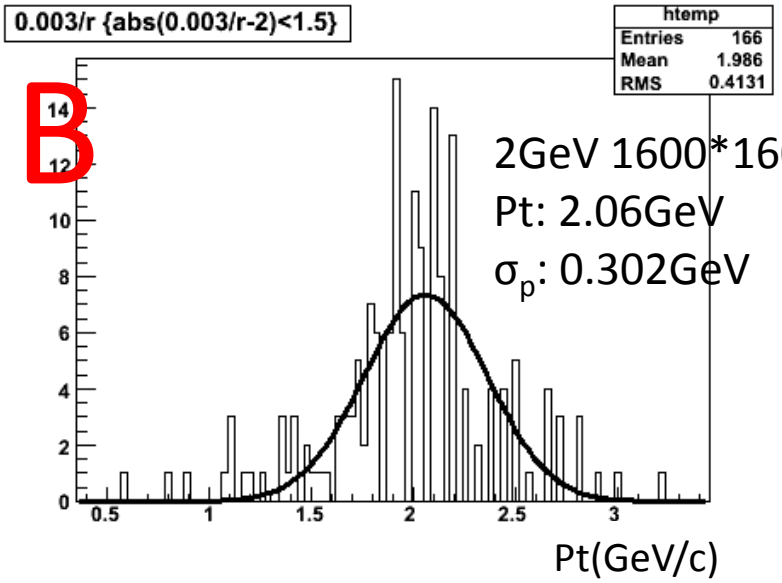
Momentum resolution using STT— drift distance method B

A



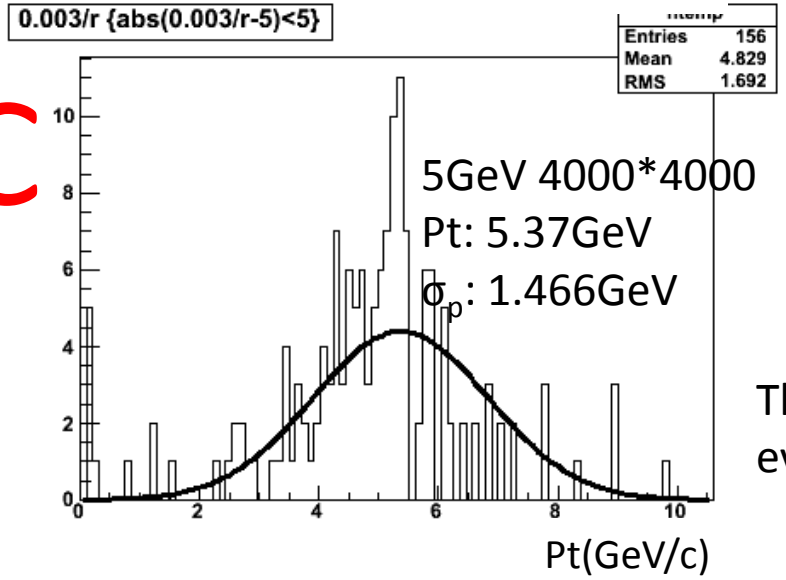
1GeV 800*800
Pt: 1.02GeV
σ_p: 0.105GeV

B



2GeV 1600*1600
Pt: 2.06GeV
σ_p: 0.302GeV

C

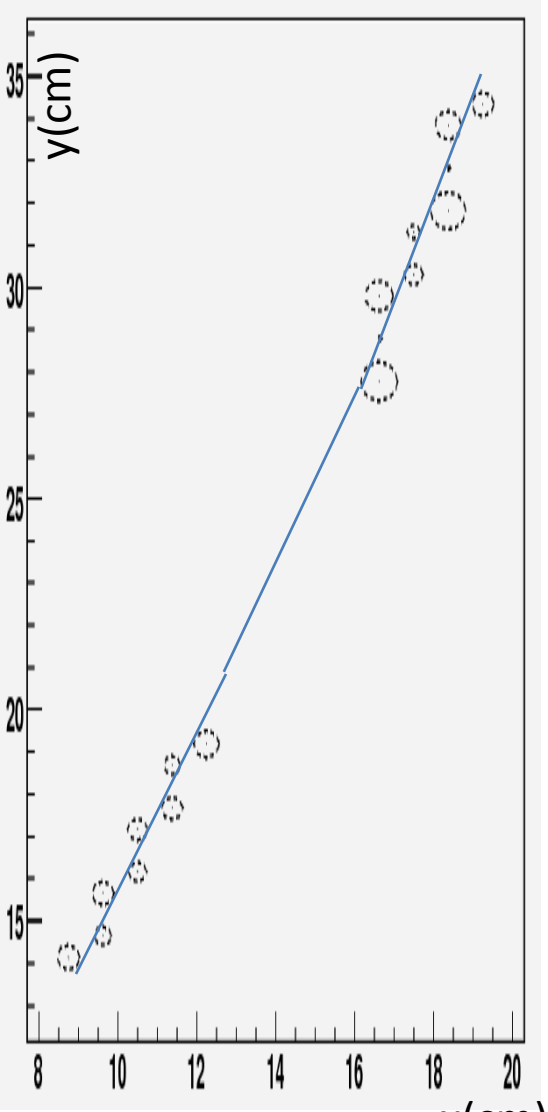


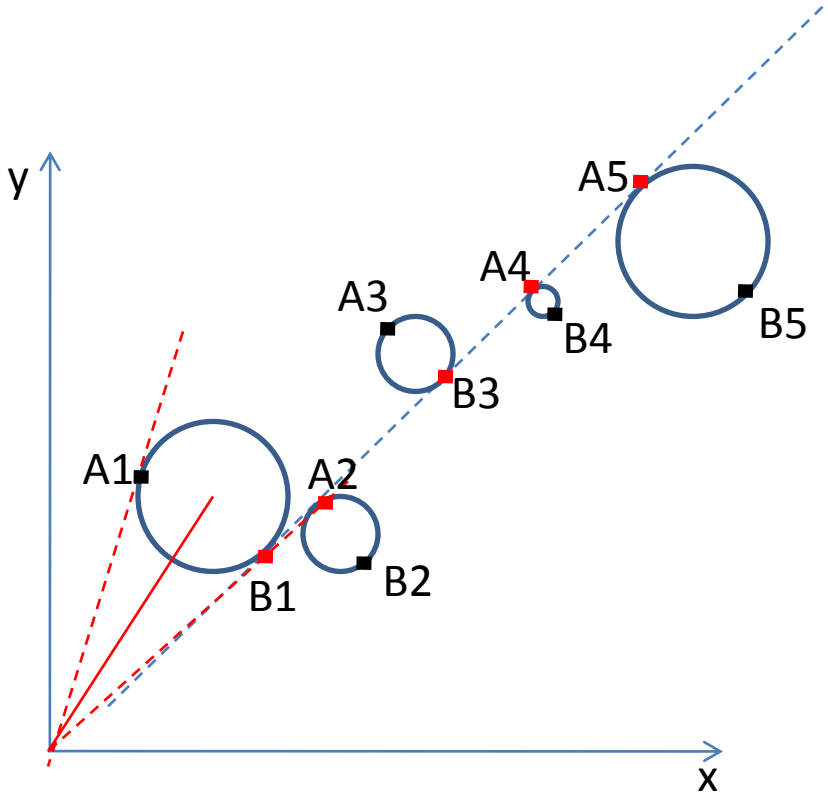
5GeV 4000*4000
Pt: 5.37GeV
σ_p: 1.466GeV

Momentum resolution:
1GeV: 10.5%
2GeV: 15.1%
5GeV: 30%

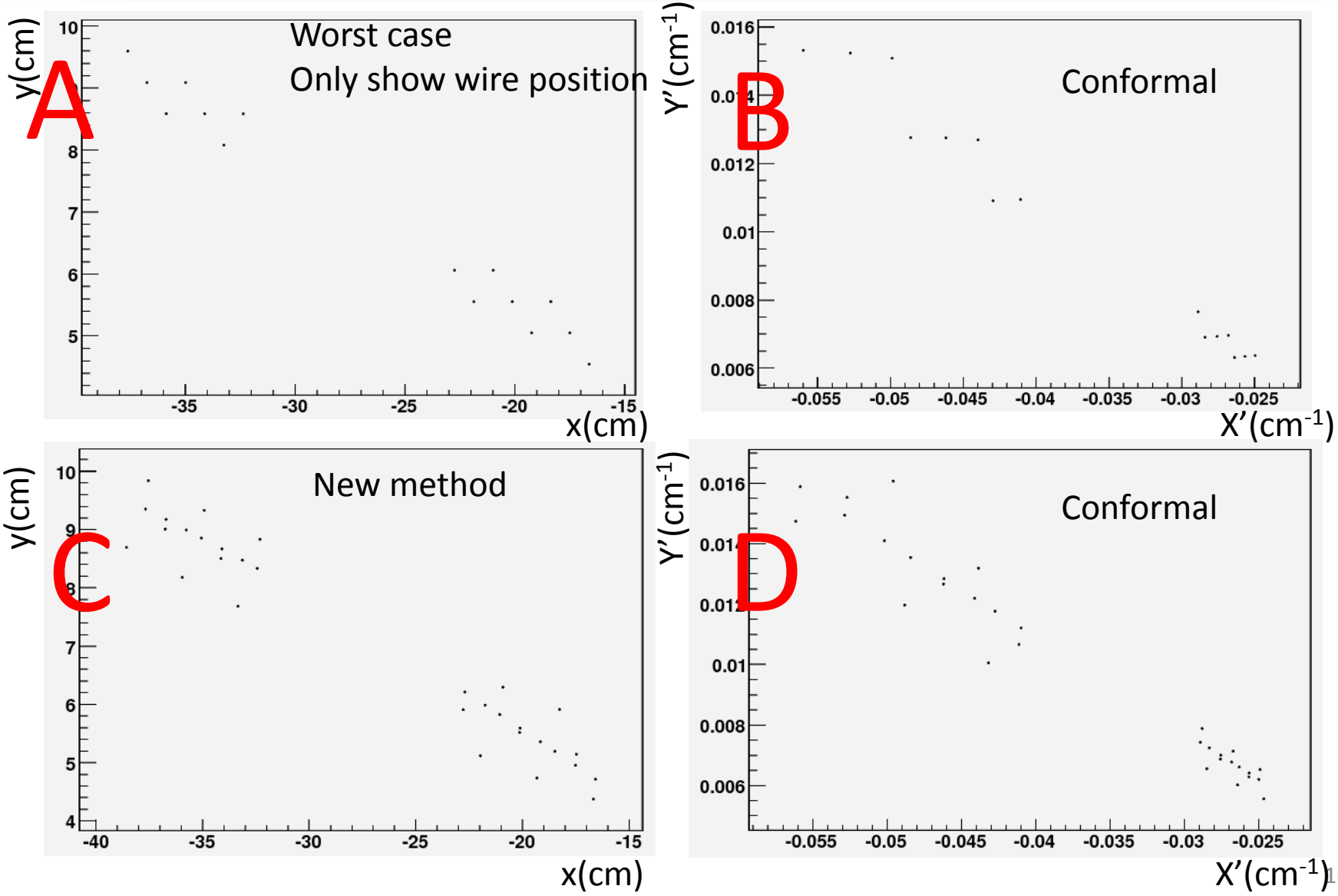
The momentum resolution at high Pt is very bad, even though we use 4000*4000 bins.

A try of new method to include drift distance

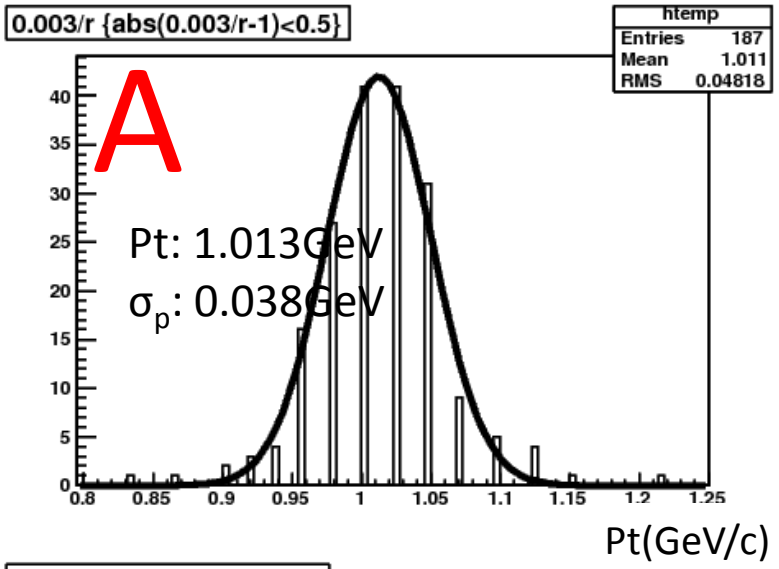


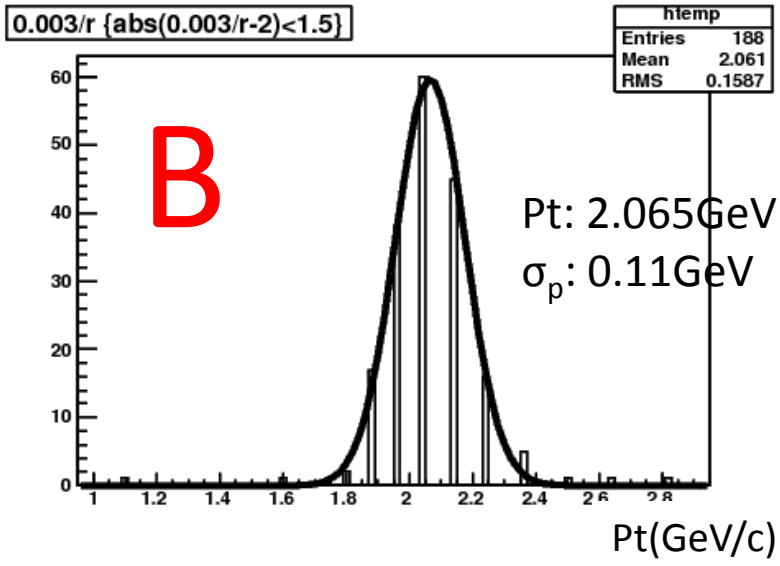


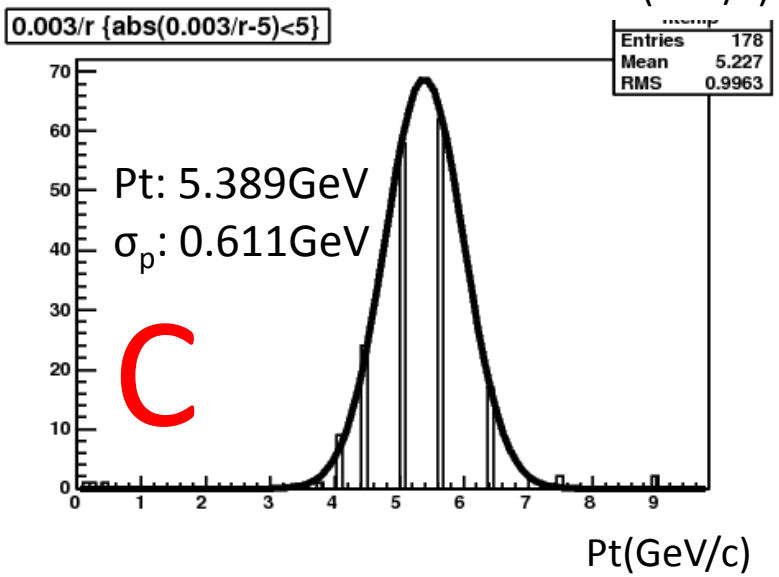
One example event using the new method



Momentum resolution using this new method







σ_p

New method	First method	
	Realistic	Ideal case:
1GeV: ~3.8%	10.5%	~3.6%
2GeV: ~5.5%	15.1%	~6.2%
5GeV: ~12.2%	30%	~12.9%

Summary

1. The performance using only STT wire position is too bad.

2. First method: Including drift distance, filling weighted value in histogram, momentum resolution is bad.
   σ_{pt}: 10% @ 1GeV, 15% @ 2GeV, 30% @ 5GeV

3. Second method: Draw tangent line from interaction point…
   σ_{pt}: 3.8% @ 1GeV, 5.5% @ 2GeV, 12.2% @ 5GeV

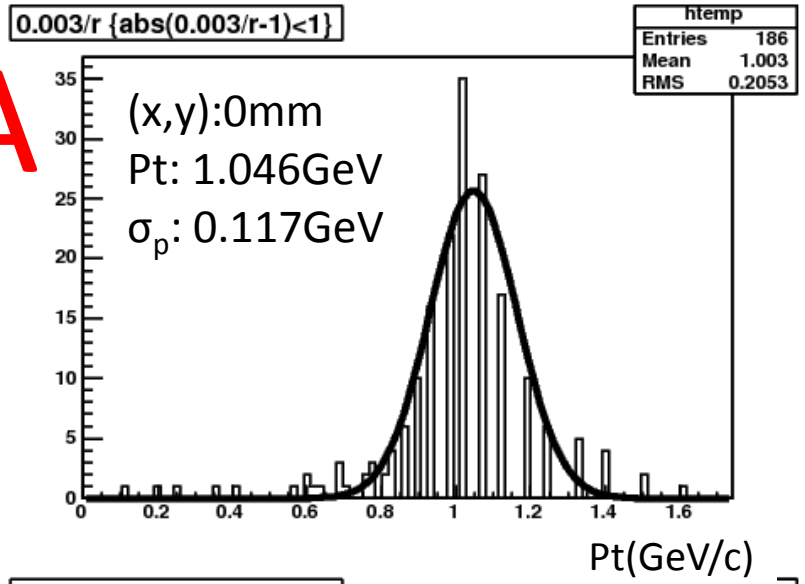
First method: depend on Vertex
Second method: depend on Vertex, not suit for very low momentum

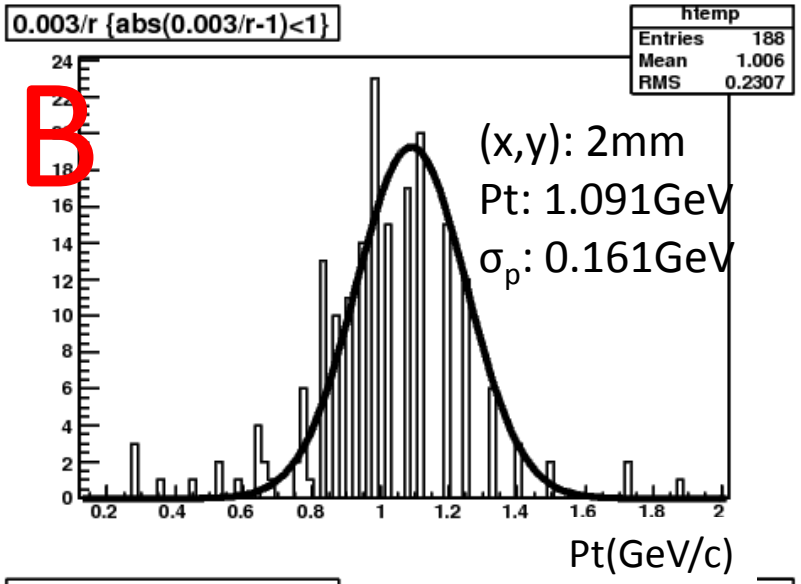
Next to do:
1. Combine MVD information to improve the momentum resolution, could also be used as vertex.

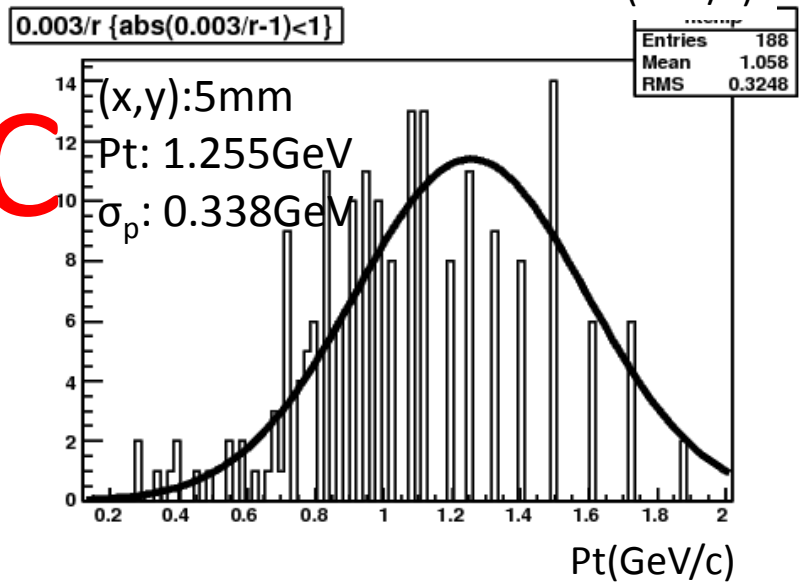
2. Inclusion of stereo layers.

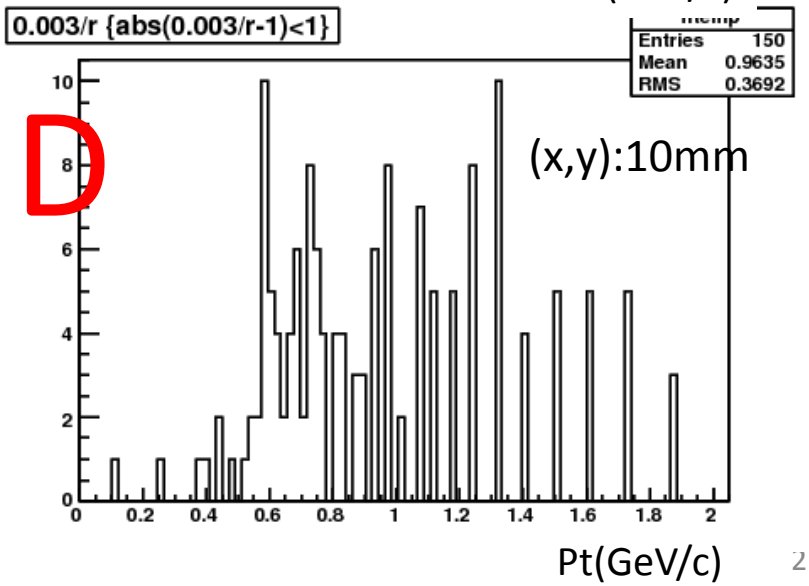
Thank you

Displaced vertex --old method



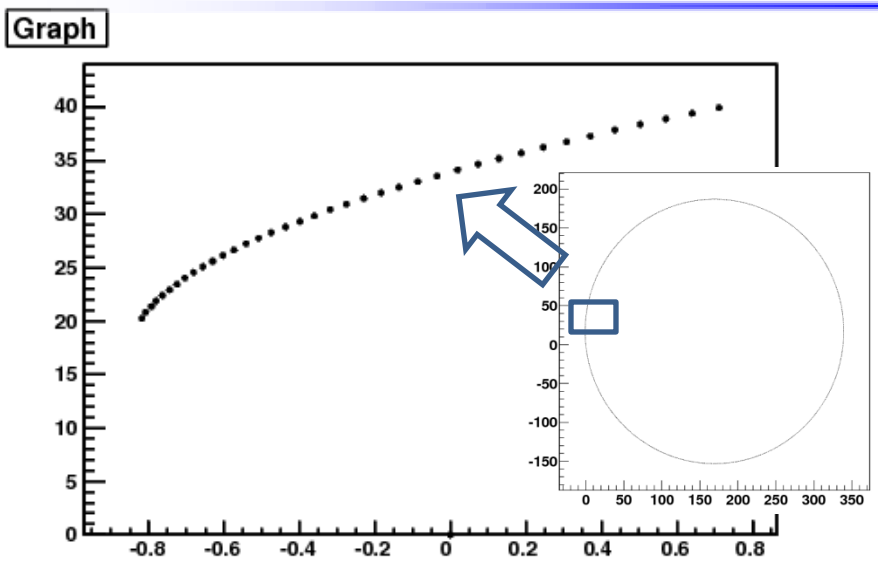


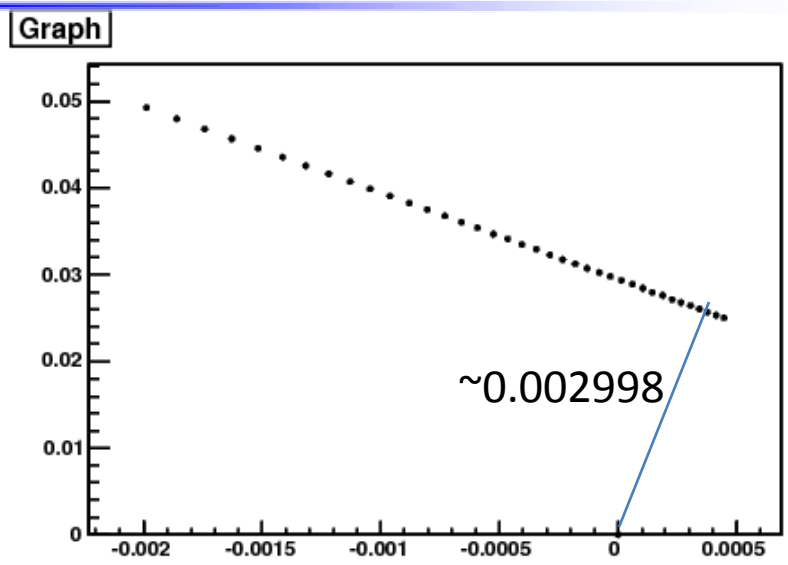


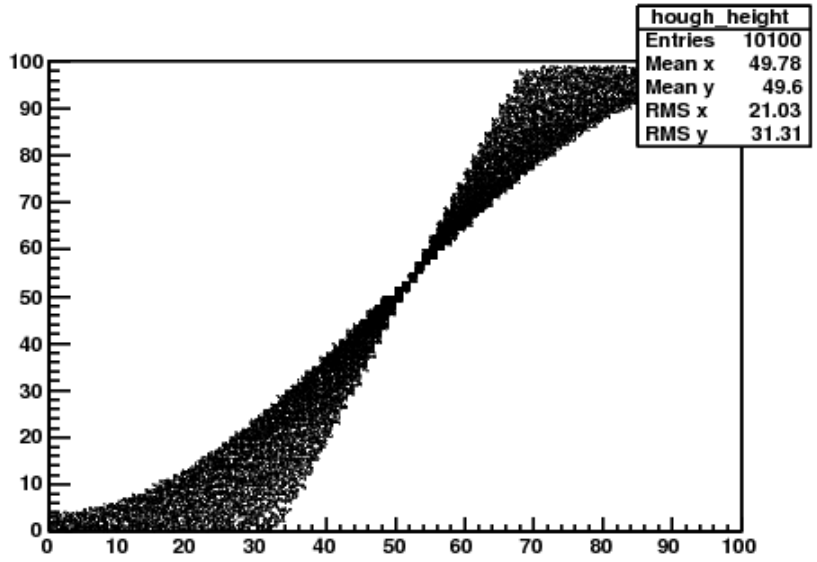


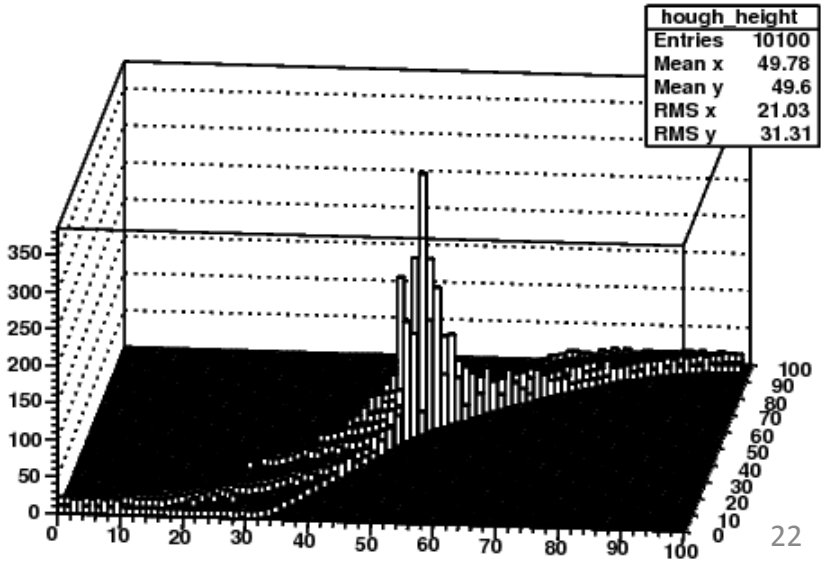
Behavior of transformations

P = 1GeV phi = 100



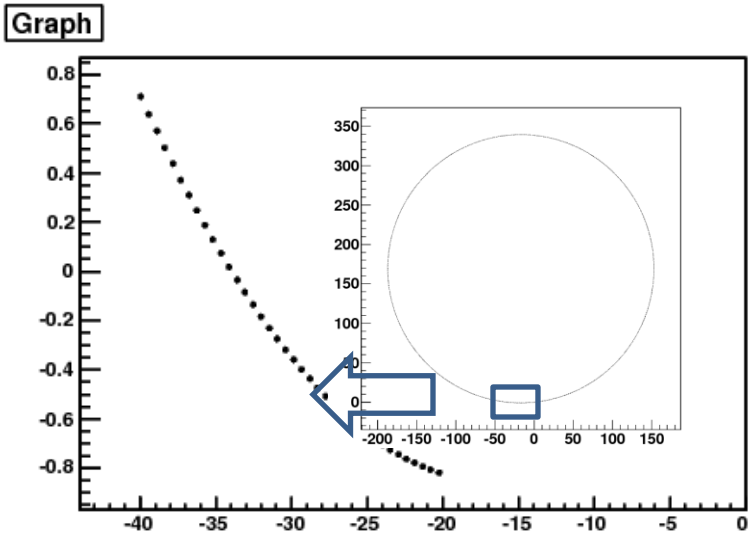


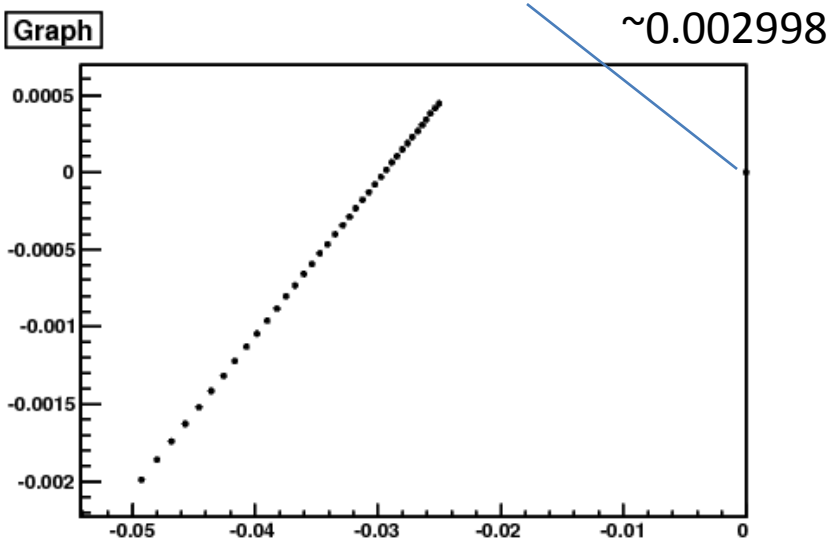




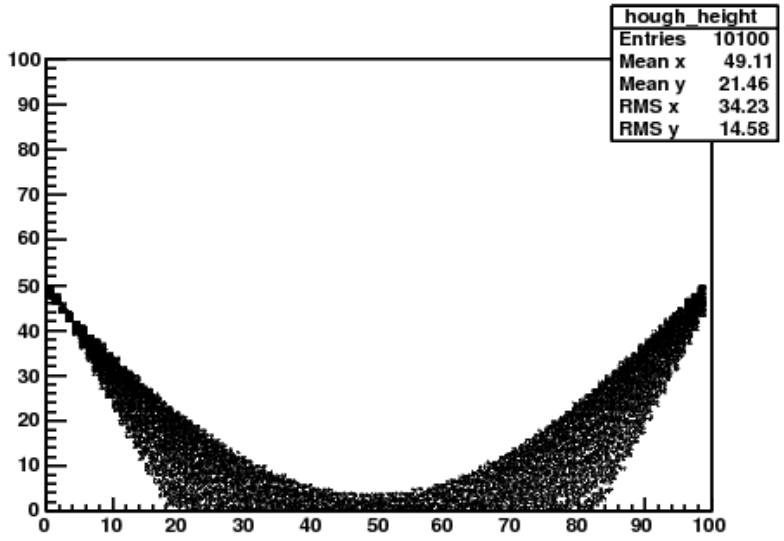
Behavior of transformations

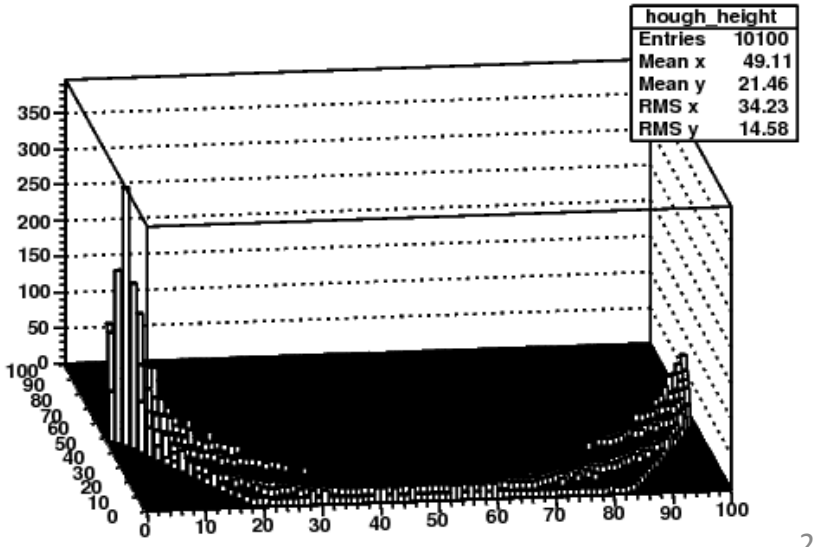
P = 1GeV phi = 190





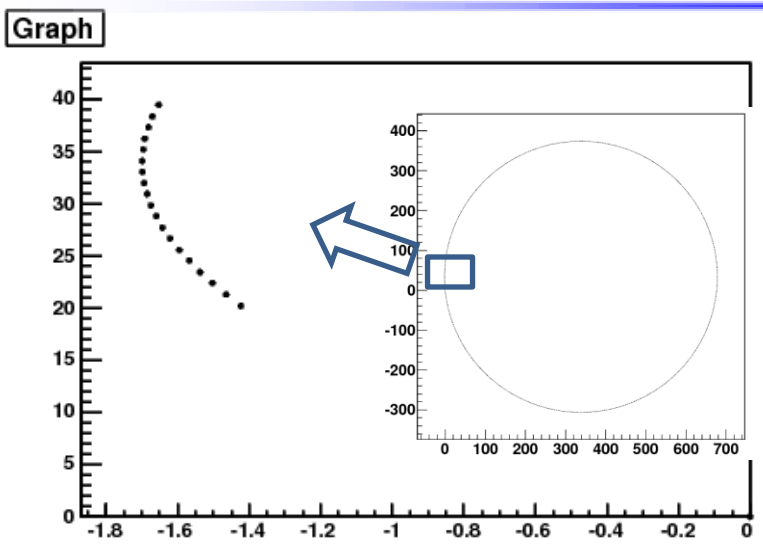
~0.002998

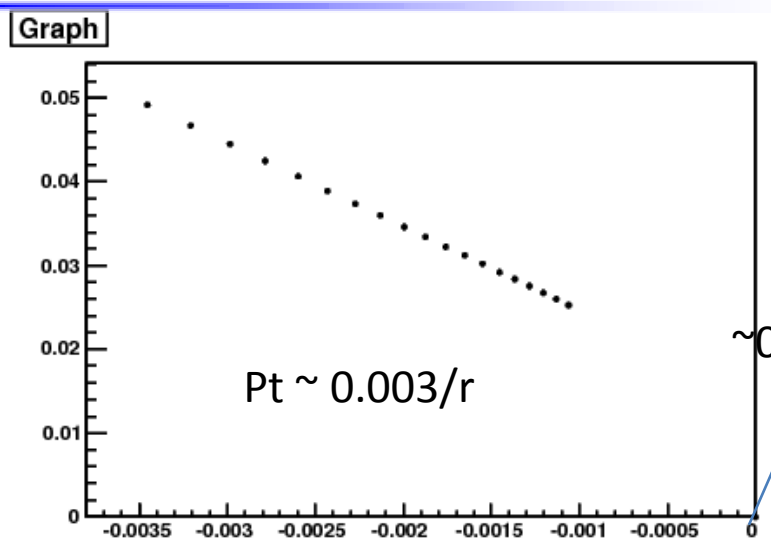


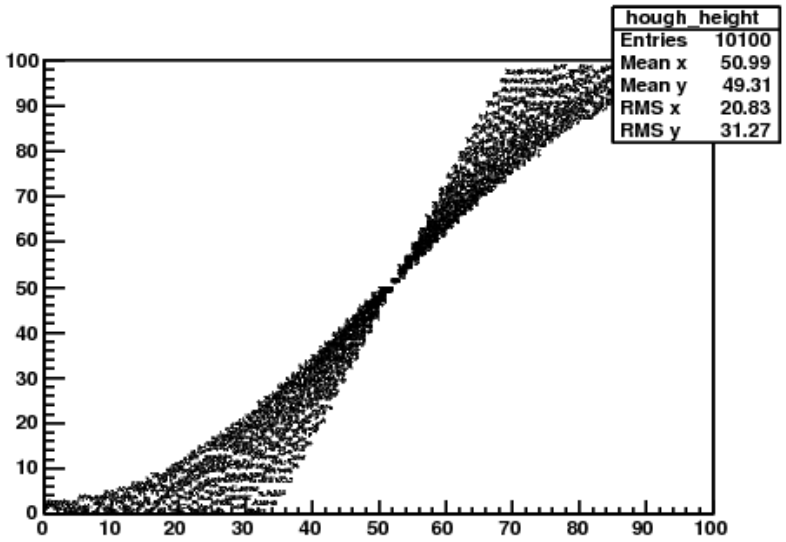


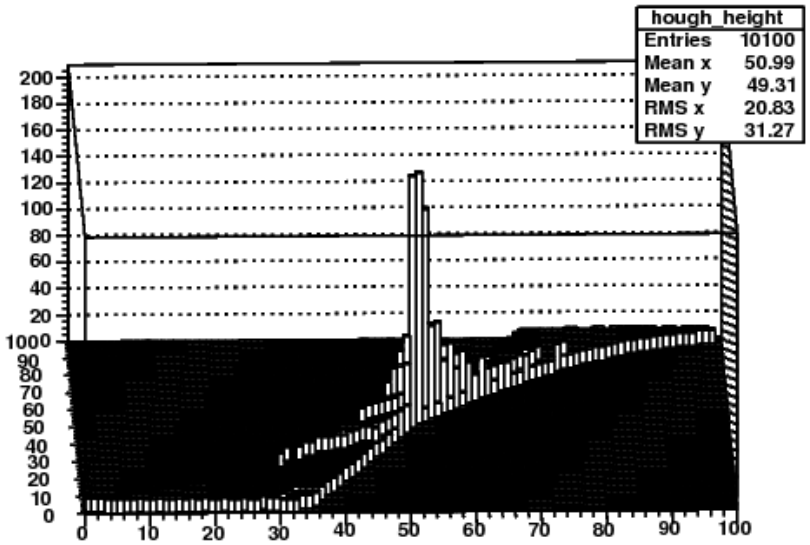
Behavior of transformations

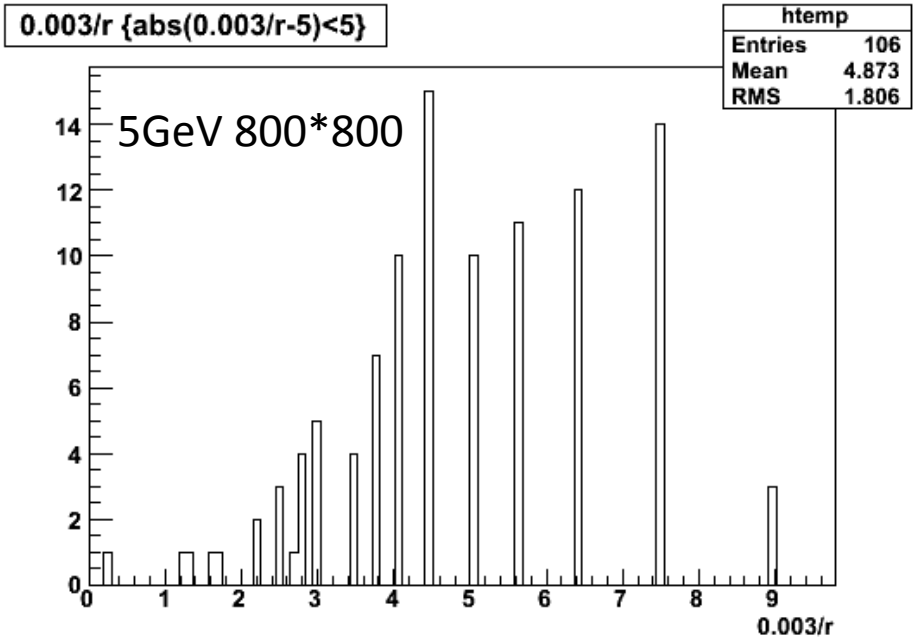
P = 2GeV phi = 100







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