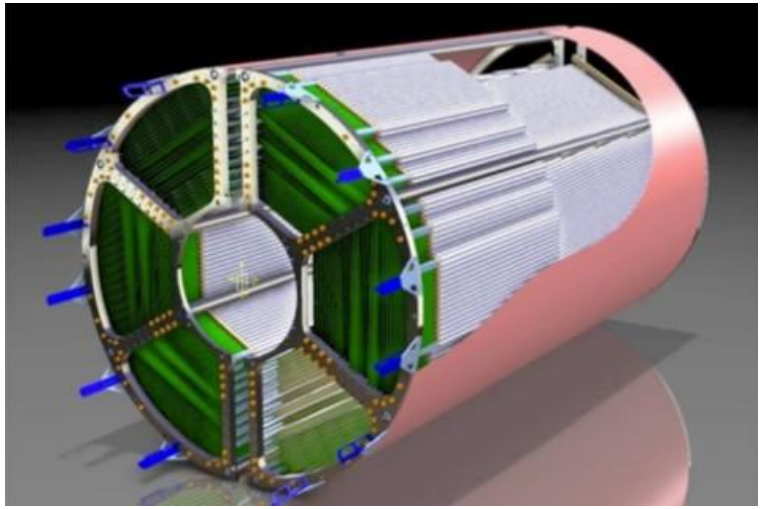
Progress of STT online tracking based on GPU



- Hua Ye [1,2] , Yutie Liang [1], Martin Galuska [1], Jifeng Hu [1], Wolfgang Kühn [1], Jens Sören Lange [1], David Münchow [1], Björn Spruck [1], Xiaoyan Shen [2]

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- 2. IHEP, Beijing

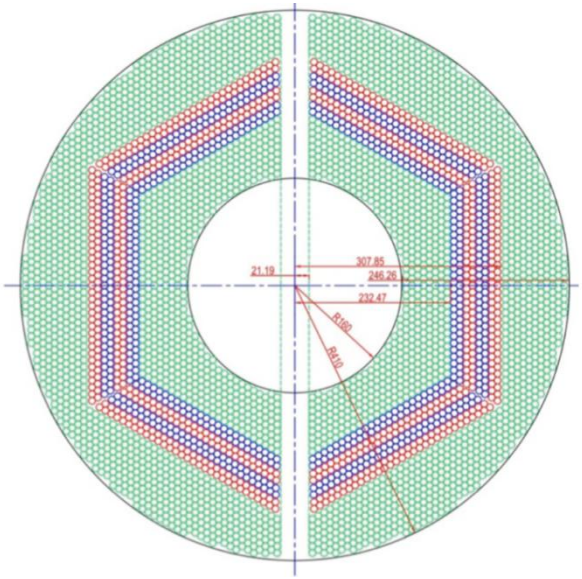
Introduction

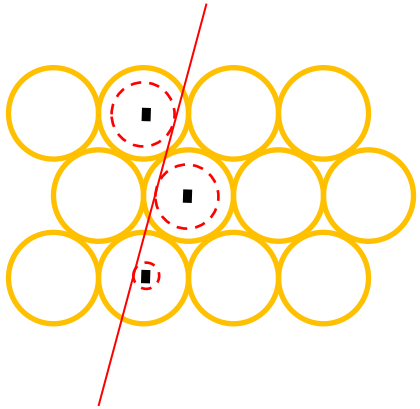
Requirement:

- Helix in x-y plane, hits are drift circles.
- PANDA event rate ~ 20 MHZ

Implementation:

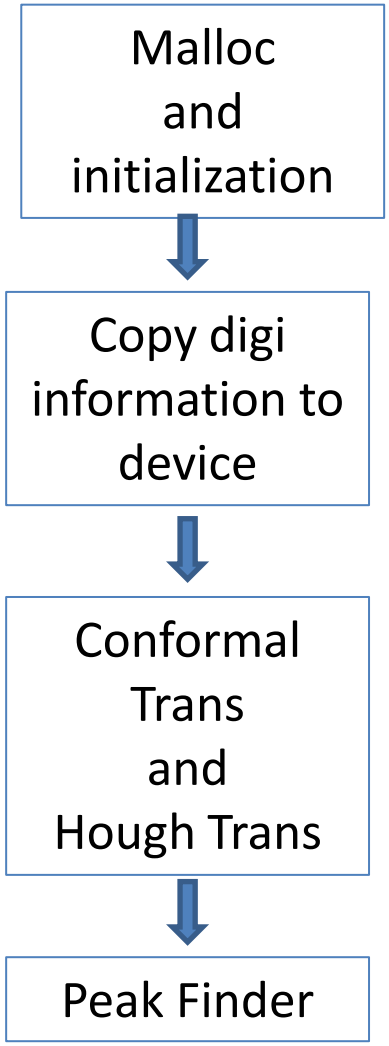
- In parallel on FPGA → talk by Yutie Liang
- Parallel computing on *GPU*.





STT Wire position + drift time

Scheme of STT Online Tracking

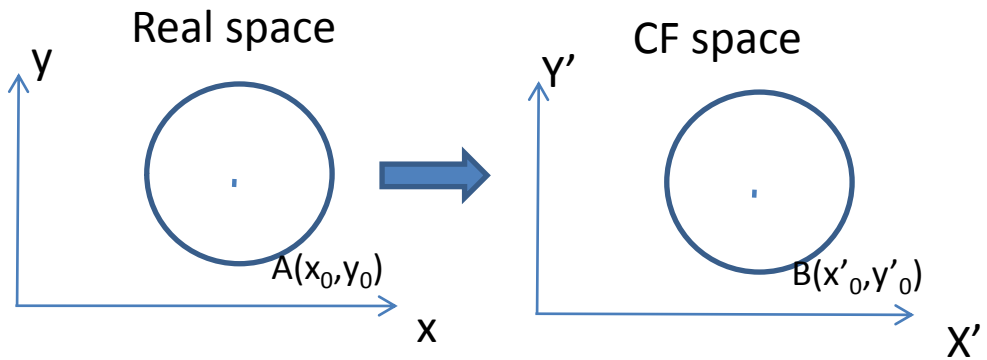


2D histogram in device.

GPU.

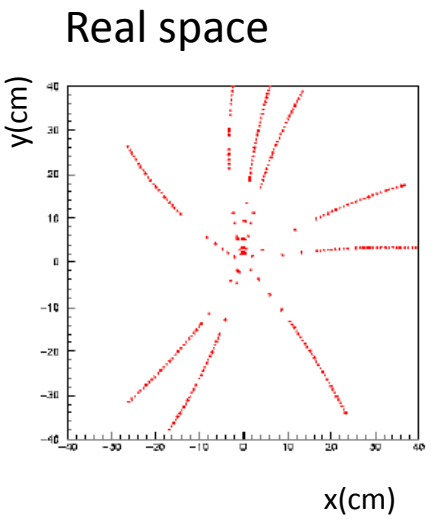
Thrust

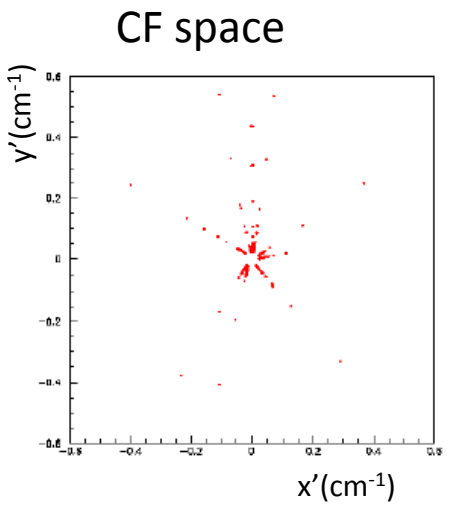
Comformal transformation:



Center: (x_0, y_0)
Radius: r

Center: $(x_0/R, y_0/R)$
Radius: r/R
Here, $R=x_0*x_0+y_0*y_0-r*r$



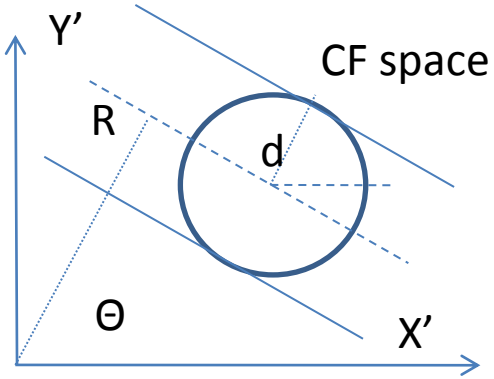


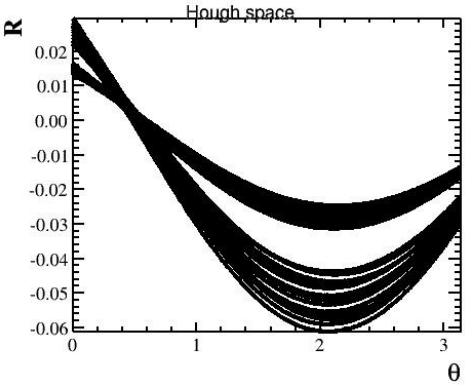
Hough transformation:

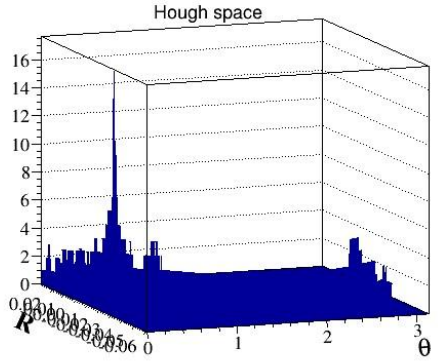
For lines: y = mx + b can be described by (m,b) or (r, θ)

Hough parameter defination :

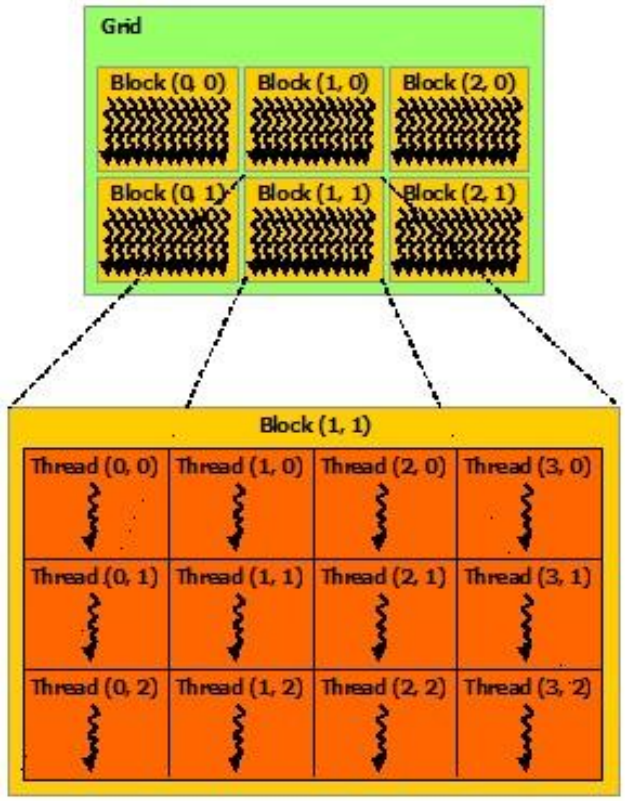
Θ from 0 to π; R = cos(Θ) X +sin(Θ) Y ± d.







From Yutie's talk on the PANDA Collaboration Meeting in Dec.2012.



A kernel is executed as a grid of many parallel threads. They are organized into a two-level hierarchy:

- A grid is organized as up to 3-dim array of thread blocks.
- Each block is organized into up to 3-dim array of threads
- All blocks have the same number of threads and organized in the same manner.

Thrust is a powerful library of parallel algorithms and data structures just like STL in C++.

Our GPU : NVIDIA GEFORCE GTX 680
Max grid dimension: (2147483647, 65535, 65535)
Max thread per dimension: (1024, 1024, 64)

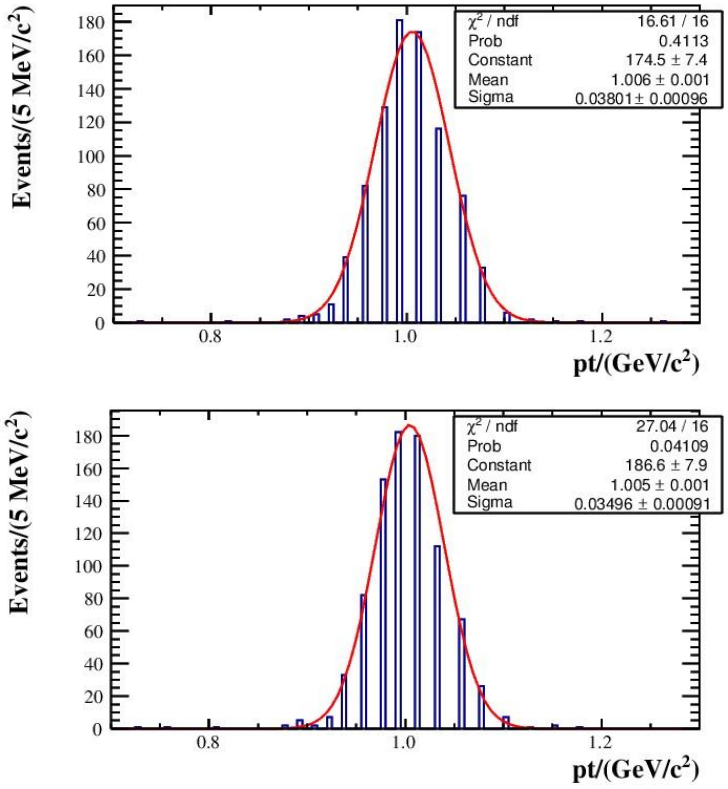
Performance using GPU

Studying single track events which pt equals 1GeV.

2048*2048 Bins for Hough Trans

Input : Truth ; σ(pt)/pt = 3.8%

Input : Smeared ; σ(pt)/pt = 3.5%



Time

Malloc	**0.141 ms**
Init Hist	**0.142 ms**
Copy data to Device	**0.049 ms**
Trans and Fill Histo	**0.096 ms**
Find Maximum	**0.298 ms**
Total	**0.736 ms**

Related to bin size!

Other bin size

Time

Malloc	**0.297 ms**
Init Hist	**0.432 ms**
Copy data to Device	**0.050 ms**
Trans and Fill Histo	**0.181 ms**
Find Maximum	**0.785 ms**
Total	**1.803 ms**

4096*4096 Bins for Hough Trans

Input : Truth ; σ(pt)/pt = 3.3%

Input : Smeared ; σ(pt)/pt = 3.3%

From Yutie's talk on the PANDA Collaboration Meeting in Dec.2012.

65536X65536 Bins => **σ(pt)/pt =** 2.6%

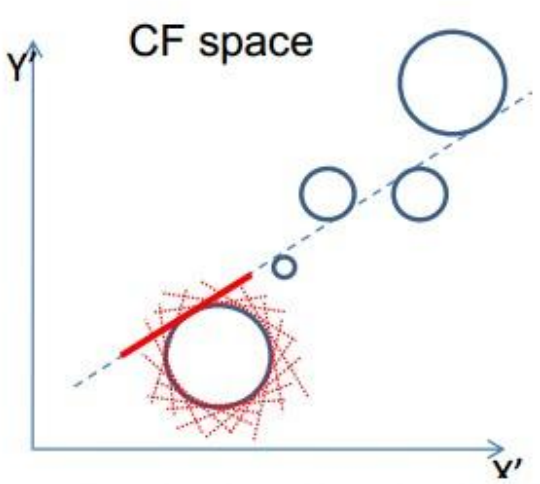
About the bin size requirement for design resolution:

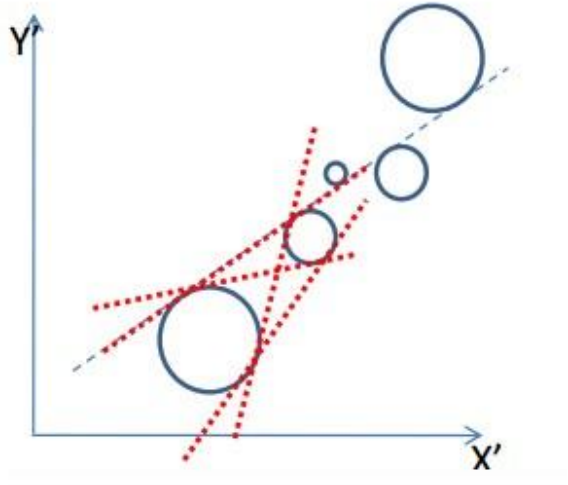
- spatial resolution < 150 μm

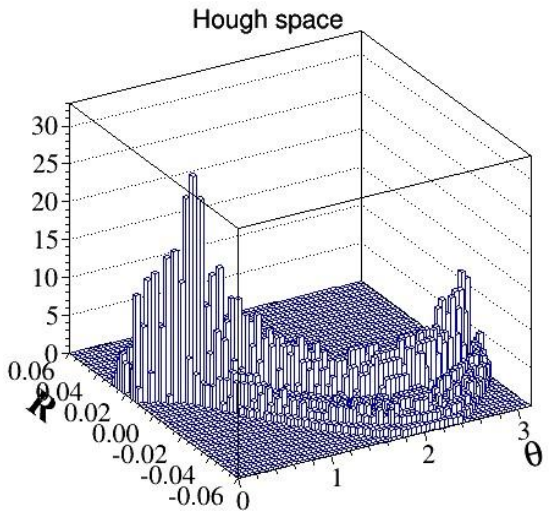
And Rmax in Hough space is typically 0.06 cm-1 for 1GeV tracks.
=> If bin number is larger than about 13800, it's becoming meaningless.

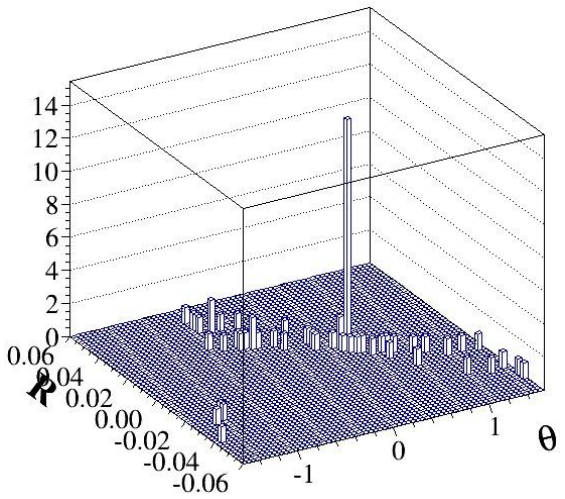
Some Geometry:
STT tubes : length of 1500mm; inner diameter of 10mm.
STT detector: inner radius of 150mm; outer radius of 420mm; length of 1650mm.

Common tangent of drift circles









Performance using common tangent

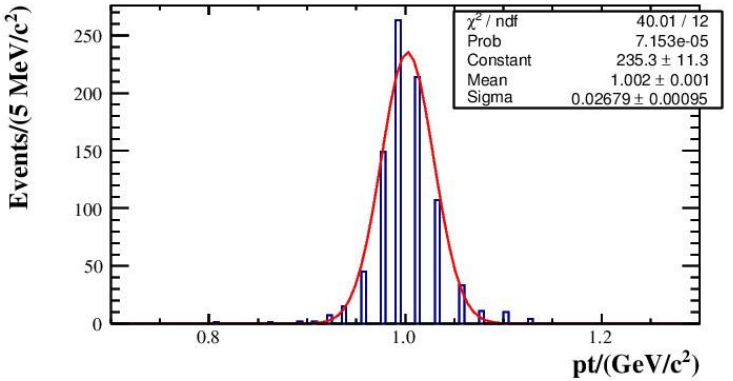
Studying single track events which pt equals 1GeV.

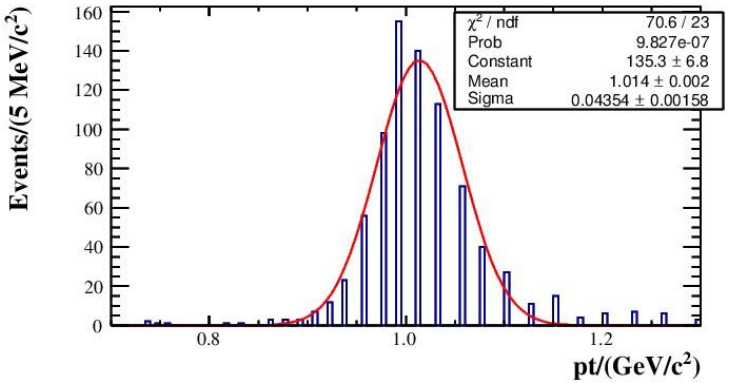
Tangent lines to next 3 draft circles are calculated.

2048*2048 Bins for Histogram

Input : Truth ; σ(pt)/pt = 2.6%

Input : Smeared ; σ(pt)/pt = 4.3%





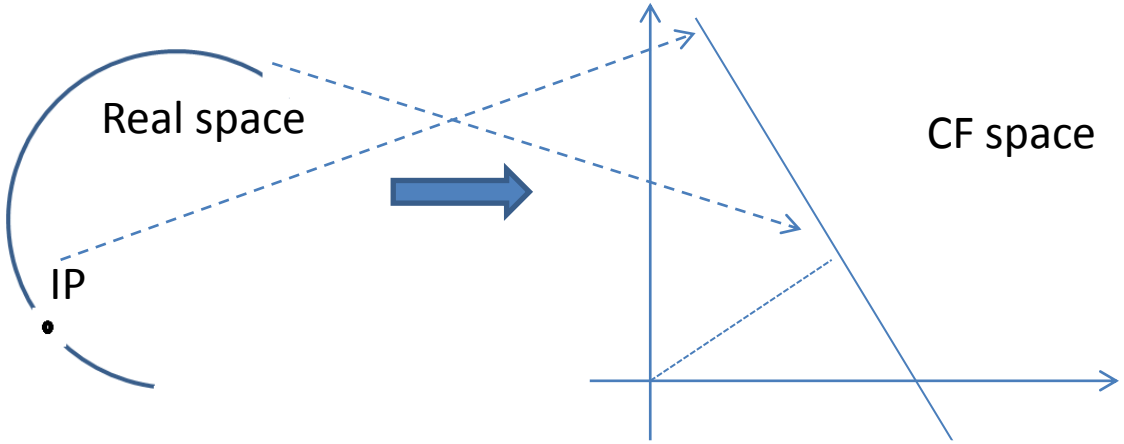
Time

Malloc	**0.162 ms**
Init Hist	**0.142 ms**
Copy data to Device	**0.051 ms**
Trans and Fill Histo	**0.063 ms** ★
Find Maximum	**0.293 ms**
Total	**0.711 ms**

Time for transformation and filling histogram is optimized about 30%.

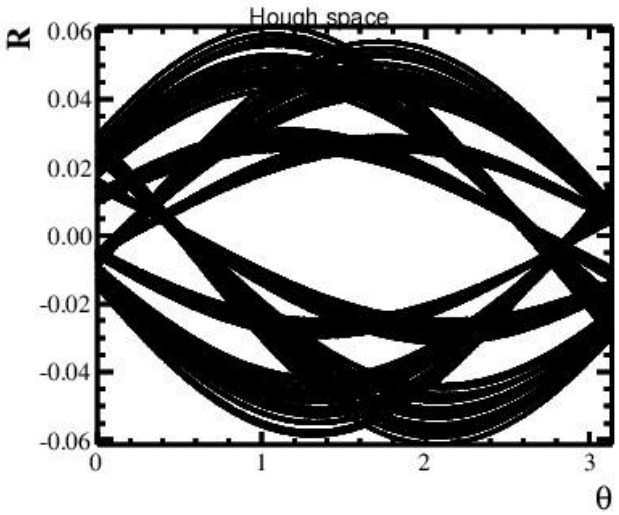
Muti-Track Events (now in CPU)

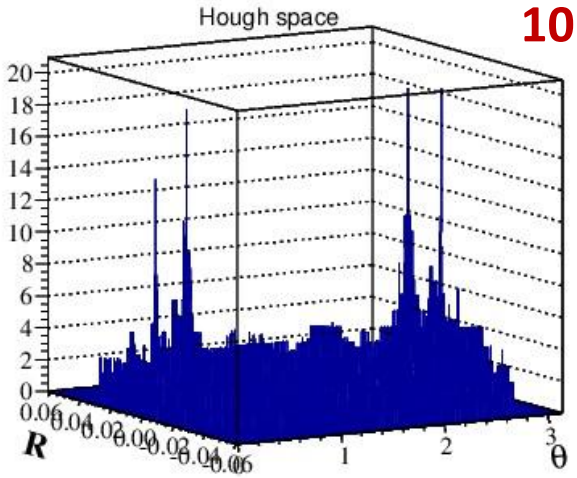
How to determine which hits belong to the found track



How to determine the track number.

4 tracks with transverse momentum of 1GeV.

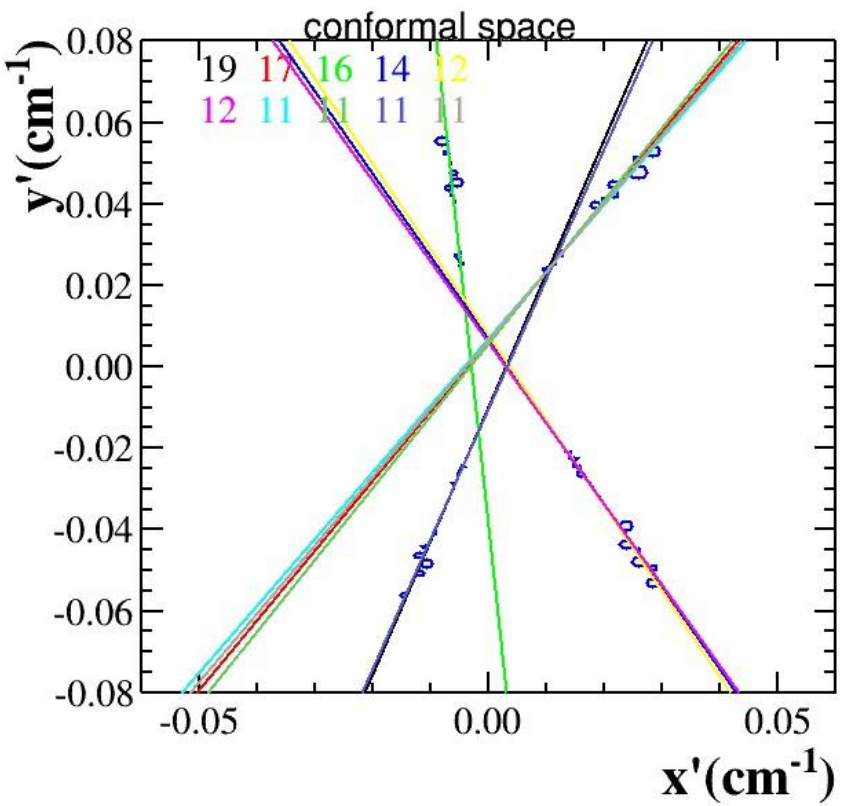


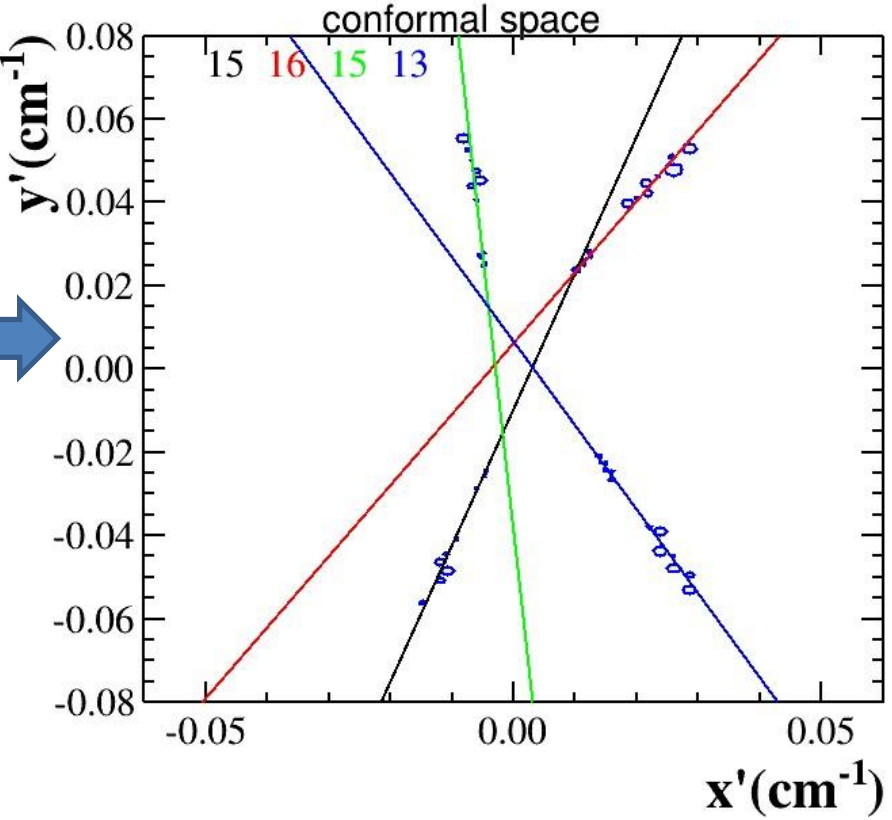


1024 X 1024

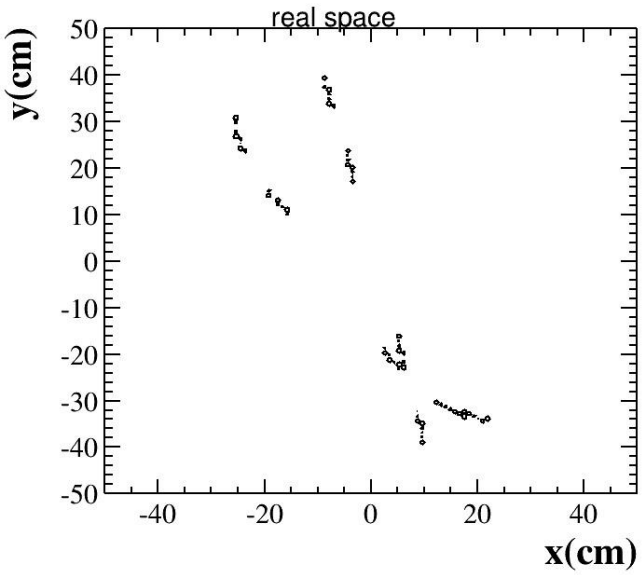
Each track candidate:

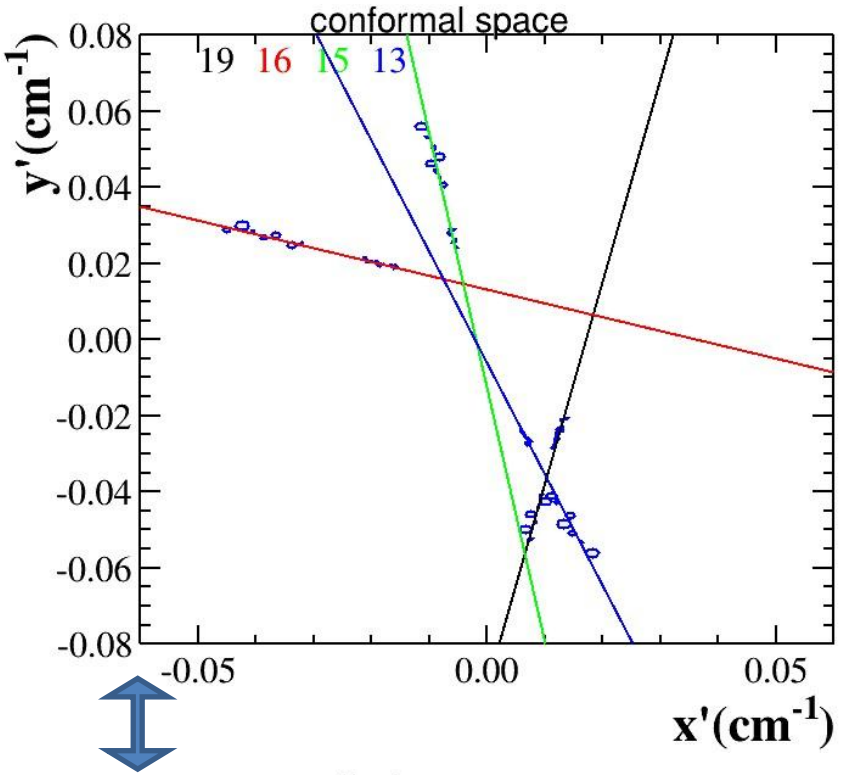
- Number of hits should be larger than 8.
- If two track candidates share 70% hits, the one with less hits is droped.

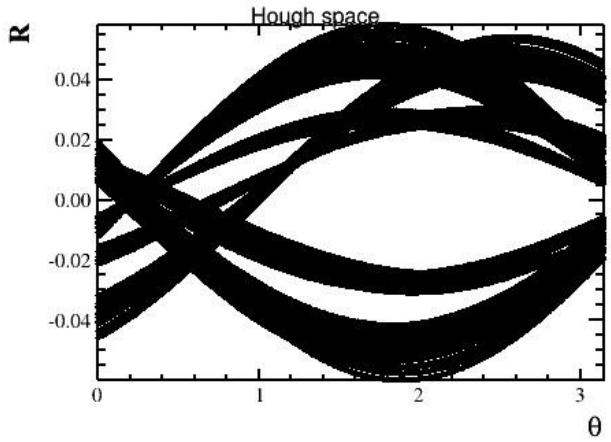


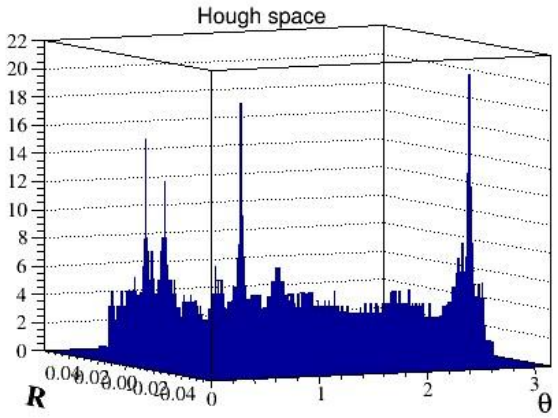


Ψ(3686) -> π+ π- J/Ψ; J/Ψ -> μ+μ-









Summary

- Conformal transformation and Hough transformation are used for STT online tracking and are achived in GPU framework.
- Tangent lines between adjacent drift circles are applied.
- Operations on histrogram cost lots of time. More studies are needed.
- Algorithm for muti-track event (in CPU).

Next to do ...

- More optimization.
- Muti-tracks cases.
- 3D tracking.

Backup

Some details in CUDA programming:

1. Histogram operation : (atomic functions)

Atomic means that it is guaranteed to be performed without interference from other threads.