Update of STT online tracking based on GPU

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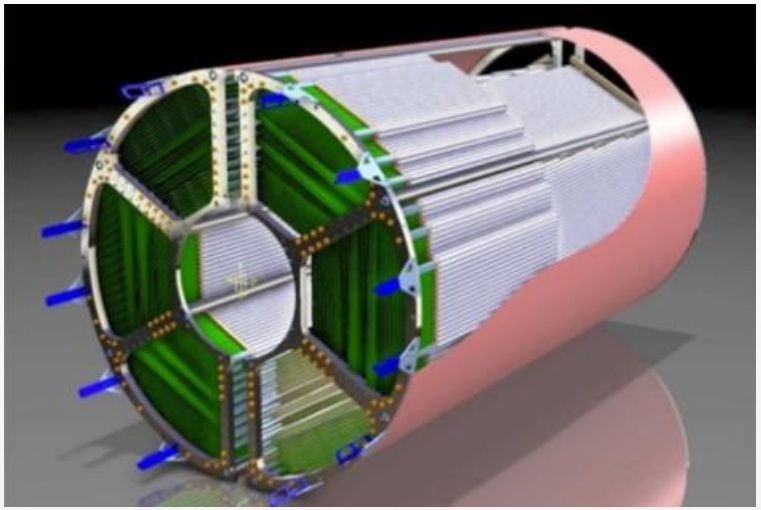
Introduction

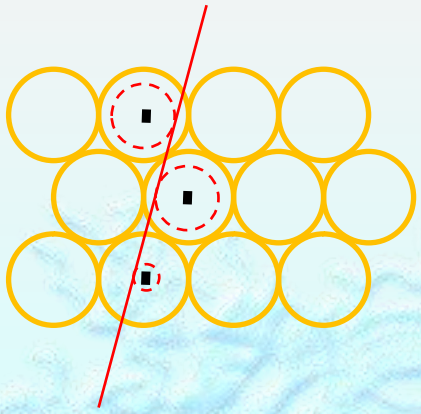


➢PANDA STT tracking chamber:

24 layers (16 axially), Ceil size 10mm
Avg. Track. Multi. ~4-6
Event rate ~ 20 MHZ

➢Fast tracking scheme:

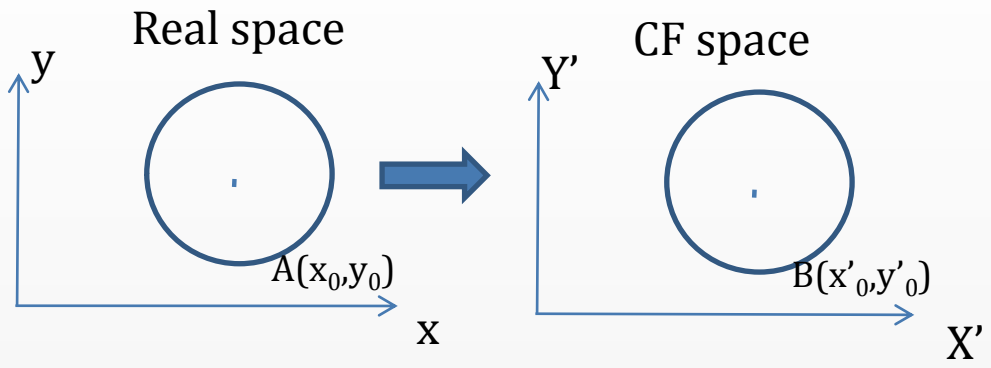
Eg. Conformal Trans. + Hough Trans.



➢Implementation:

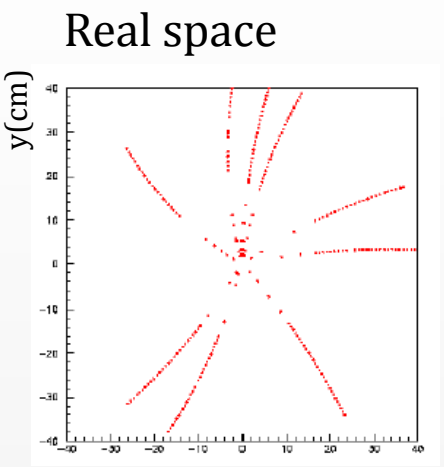
In parallel on FPGA
Parallel computing on *GPU*.

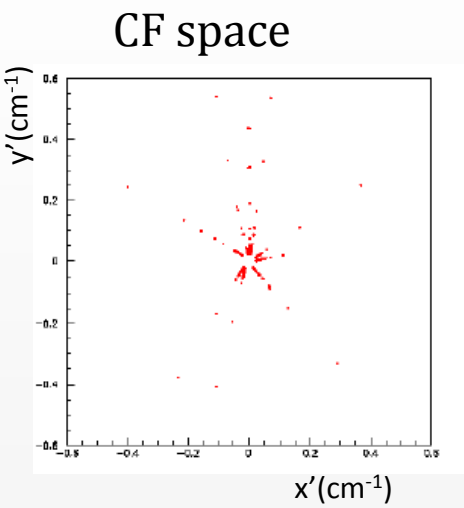
Comformal transformation:



Center: (x_0, y_0)
Radius: r

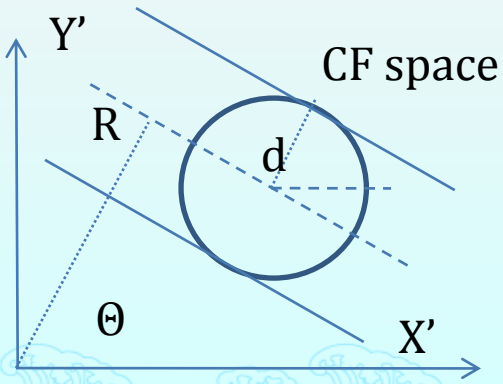
Center: $(x_0/R, y_0/R)$
Radius: r/R
Here, $R=x_0*x_0+y_0*y_0-r*r$

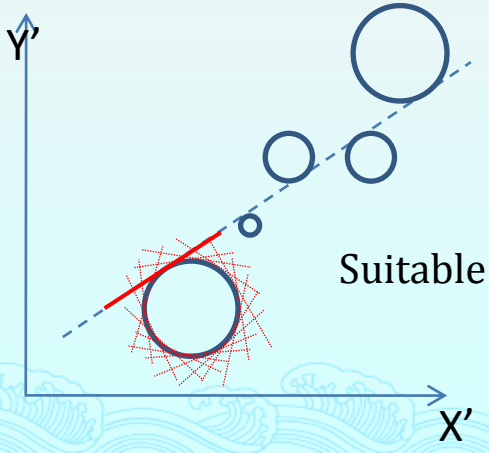


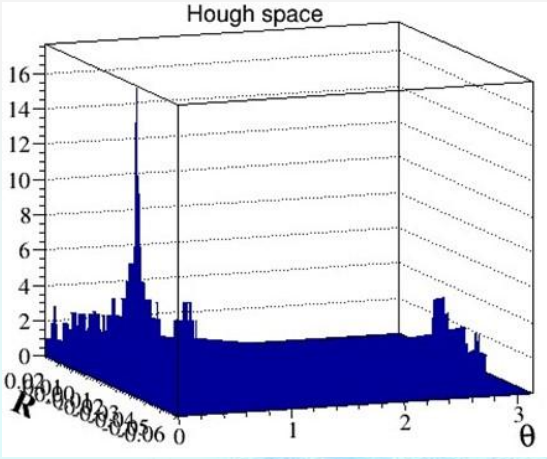


Hough transformation:

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.







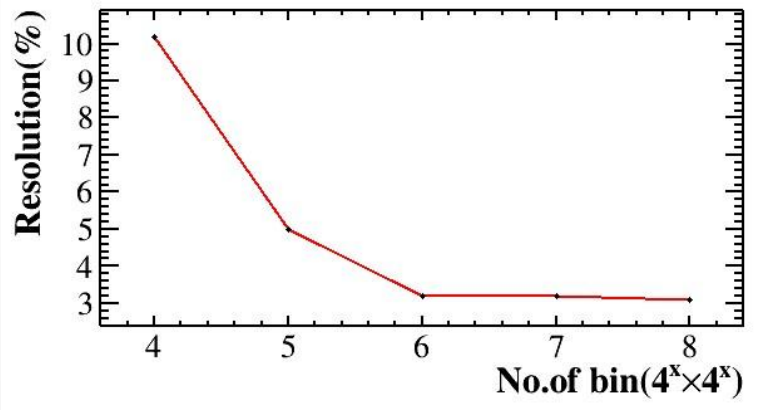
Suitable for Parallel computing

Feature

- Easy to get the number of tracks in each event, and the hits of each track.

- Resolution is improved by using larger histogram, which will cost more time and memory.

- The measured transerve momentum are discrete values (related to the bin size).



Performance using GPU (reported on last Collaboration Meeting)

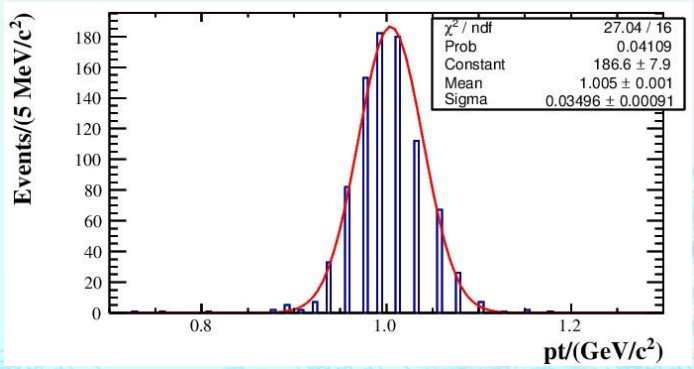
4096*4096 Bins for Hough Trans

Input : pt=1GeV muon (Smeared drift distance)

Resolution: σ(pt)/pt = 3.3%

Cost time

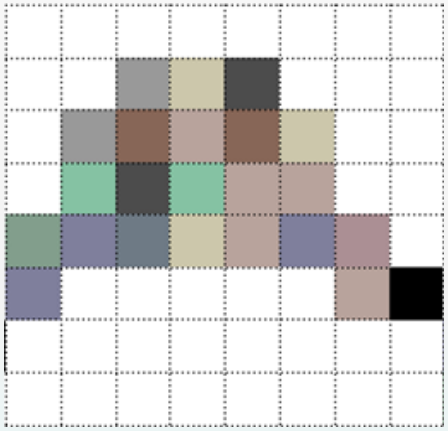
Malloc	**0.297 ms**
Init Hist	**0.432 ms**
Copy data to Device	**0.050 ms**
Trans and Fill Histo	**0.181 ms**
Find Maximum	**0.785 ms**
Total	**1.803 ms**

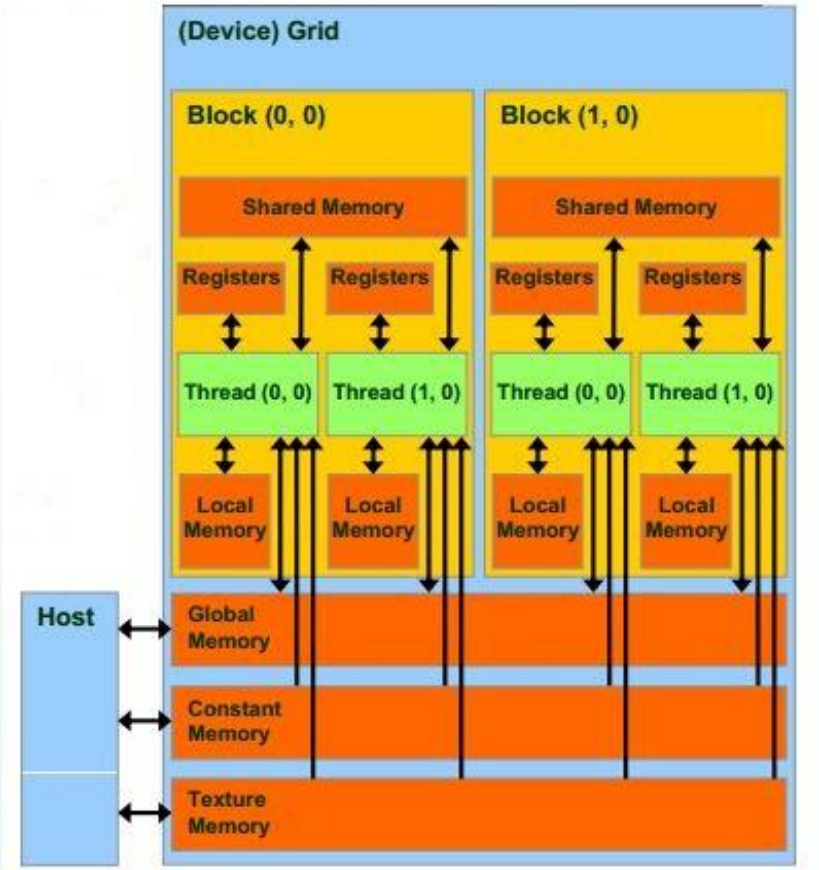


Improvements

- Reuse the histogram for hough trans.

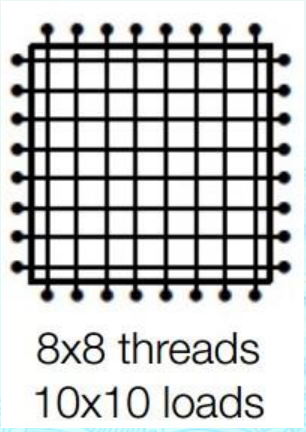
If the bin content is larger than the 8 bins around it, it's defined as a peak.





Shared memory is shared by all threads in the block, and is faster than global memory.

- A larger 2D array is loaded in shared memory.



Quick circle fit

- Equation of a circle: $x^2 + y^2 - a \cdot x - b \cdot y + c = 0$
- Assuming (0,0) is on the circle => c=0. Reduced to 2 parameters (a,b)
- Then the circle can be found by minimizing the cost function

$$S = \sum_{i=1}^{N} (x_i^2 + y_i^2 - a \cdot x - b \cdot y)^2$$

N is the number of the hits belonging to this track.

- Which means to solve:

$$\begin{bmatrix} Sxx & Sxy \\ Sxy & Syy \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} Sxd \\ Syd \end{bmatrix}$$

,where $S\mu\nu = \sum_{i=0}^{N} \mu_i \nu_i$

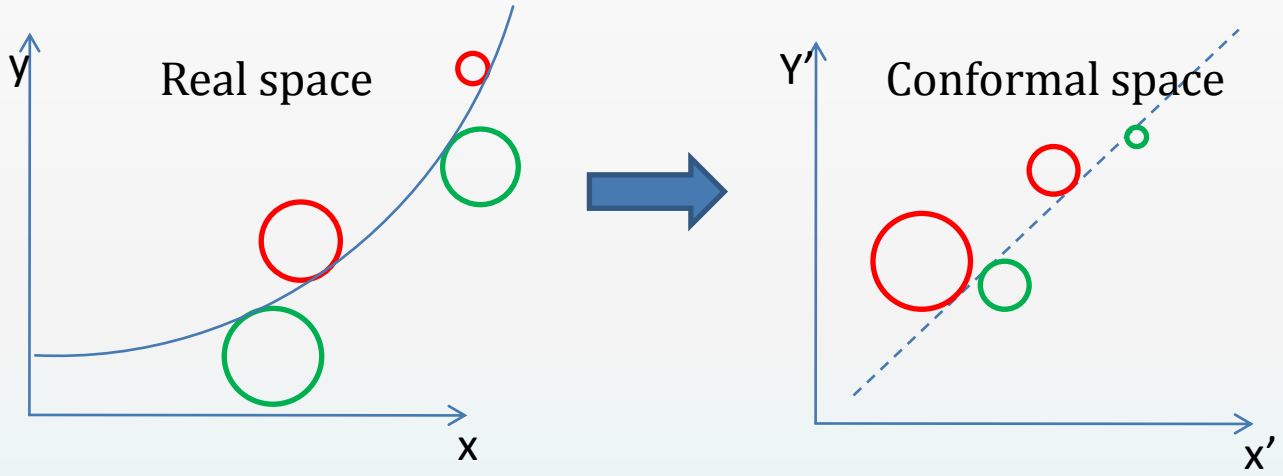
$d_i = x_i^2 + y_i^2$

Similar to the fits with Riemann Sphere

Consider drift distance into the fit.

We find that without considering the drift distance, the fit result is bad.

With the initial track parameters, we can do left/right identification.



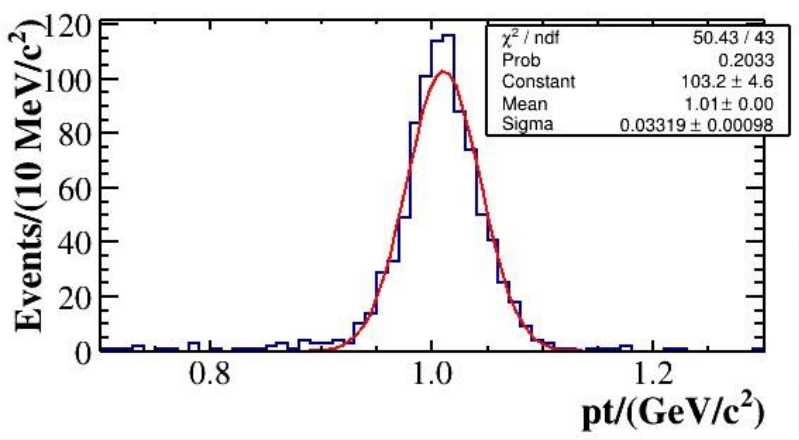
The fit uses the closest points on the drift circles to the track.

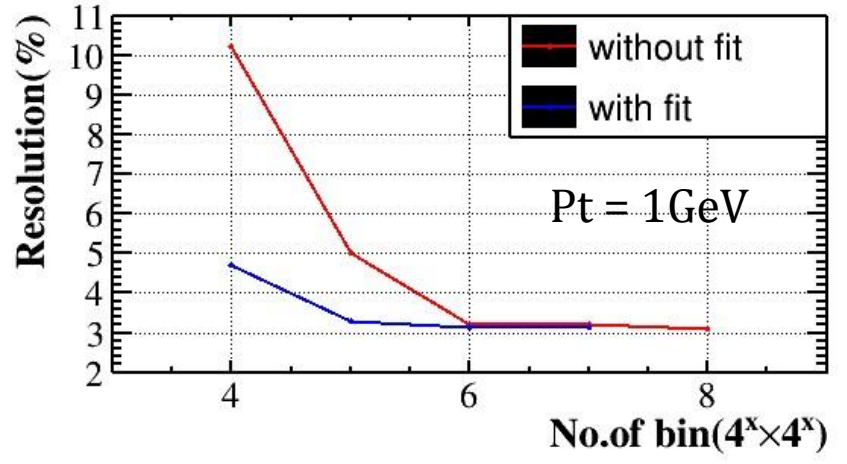
Performace of the fit.

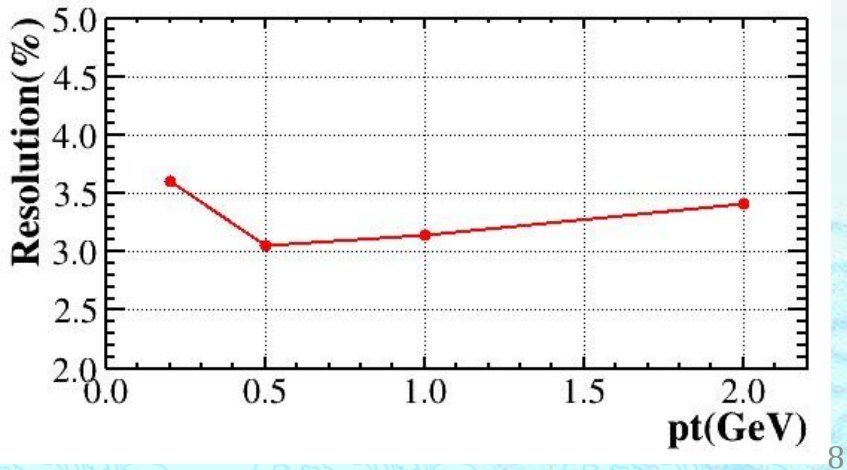
Pt = 1GeV muon. 1024*1024 histogram: **σ(pt)/pt = 3.3%**

Cost time

Init Hist	**0.047 ms**
Copy data to Device	**0.049 ms**
Trans and Fill Histo	**0.056 ms**
Find Maximum	**0.337 ms**
Circle Fit	**0.027 ms**
Total	**0.523 ms**







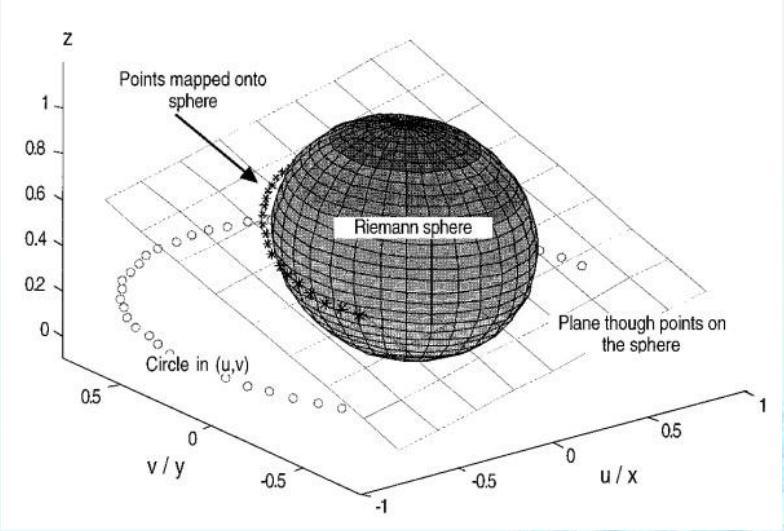
What's more...

$$S = \sum_{i=1}^{N} w_i (x_i^2 + y_i^2 - a \cdot x - b \cdot y)^2$$

➢With the weighted cost function,
we can take the measurement errors into acount.

➢Treatment of multiple scattering.
Cost function can be writtern $S = d^T G d$, where G is a diagonal matrix which is related to the original measurements.

Multiple scattering will impose a non-diagonal matrix G.



Particle tracks fitted on the Riemann sphere

Summary

Performance of Conformal and Hough transformation is improved.

A quick circle fit is applied.

Mutiple scattering will be considered in furture.

Thank you!