Realistic and time-based Hyperon Tracking at PANDA

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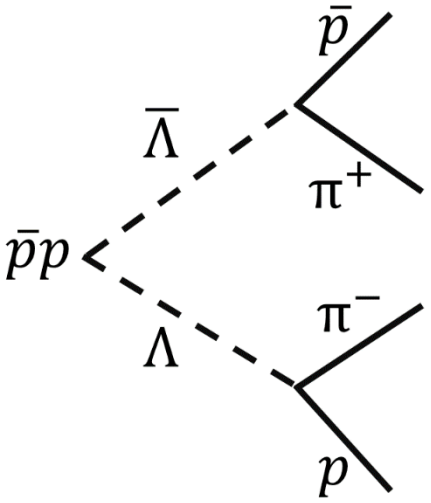
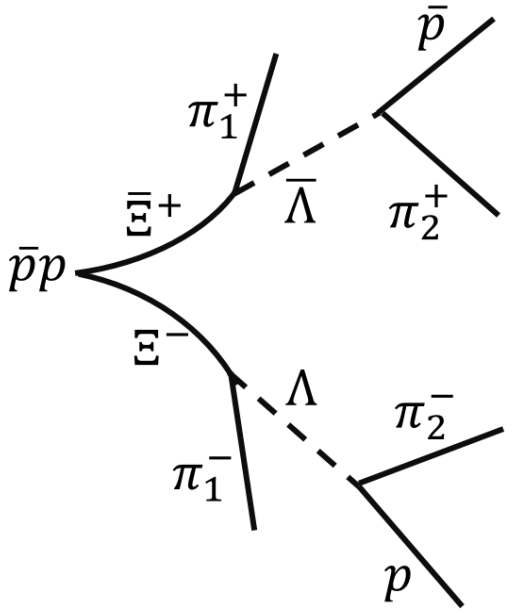
PANDA CM, Hyperon Session
GSI, 24-28 June

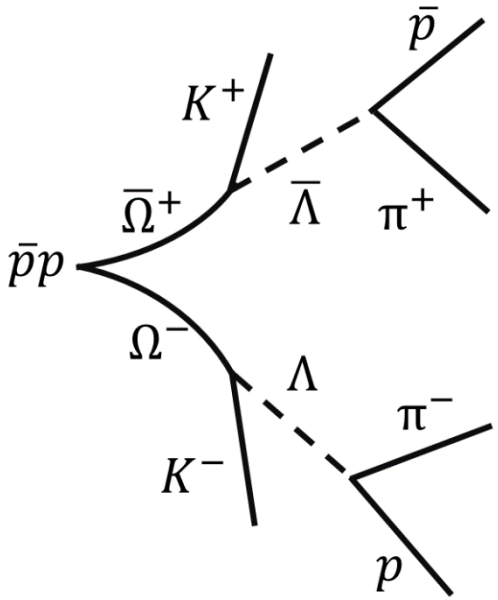
Outline

- Challenges for hyperon tracking
- Realistic time-based tracking algorithms
- Tests
- Outlook

Important Hyperon Reactions



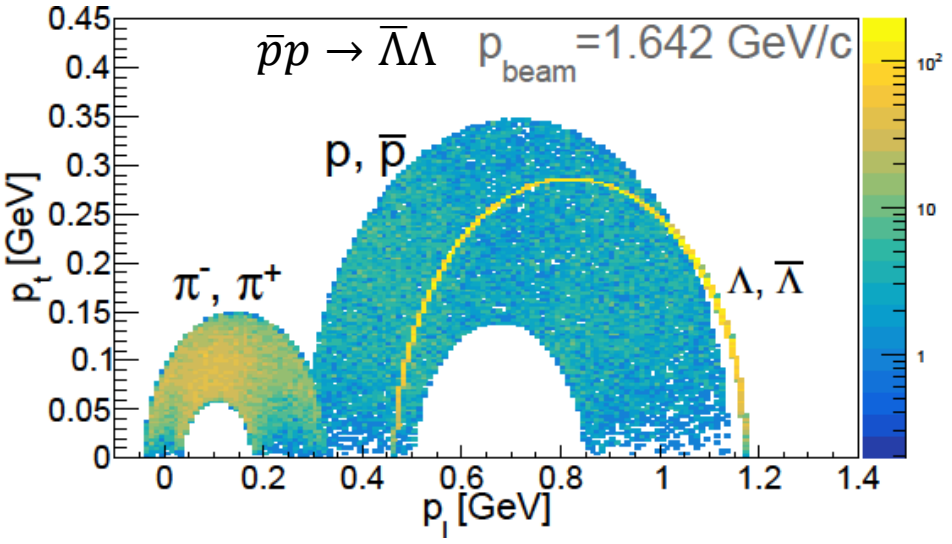


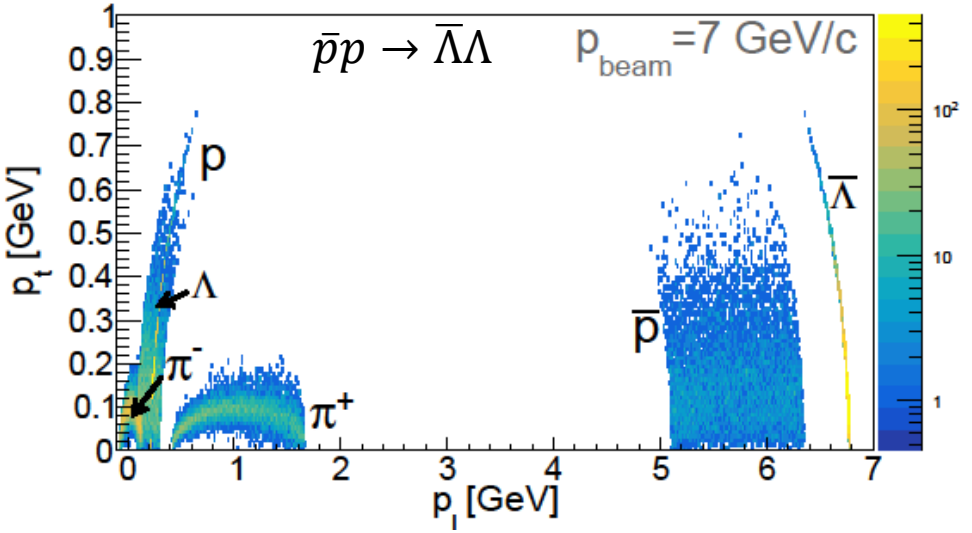


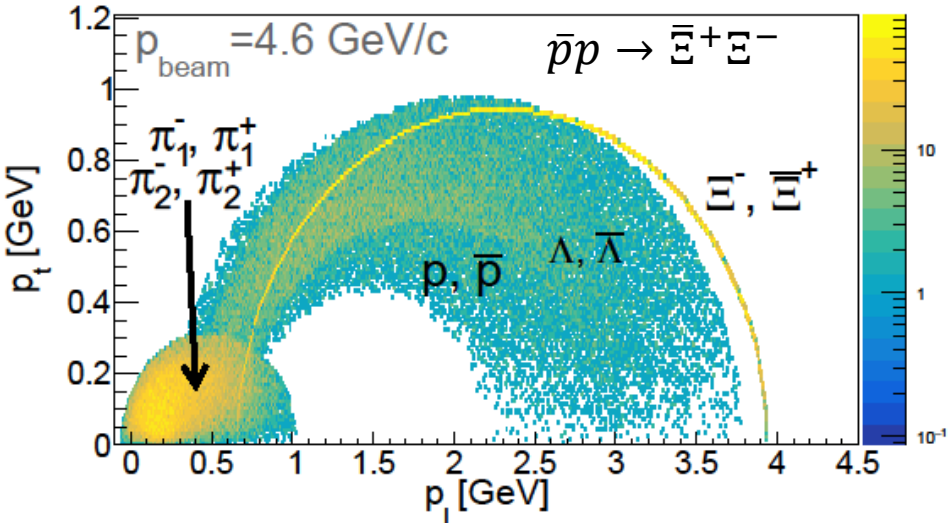
Hyperon events very challenging to reconstruct!

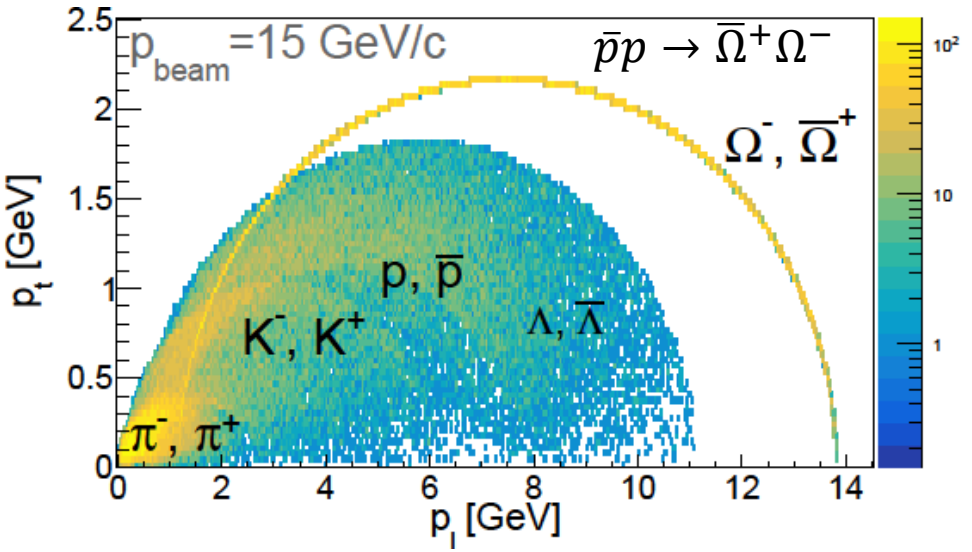
- Complex event topologies
- Neutral hyperons
- Displaced vertices

Momentum Distributions

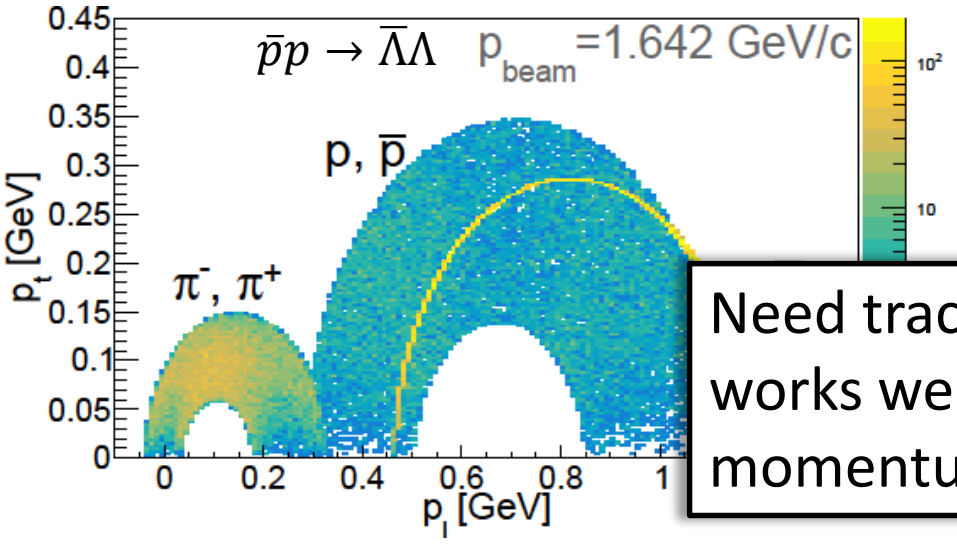


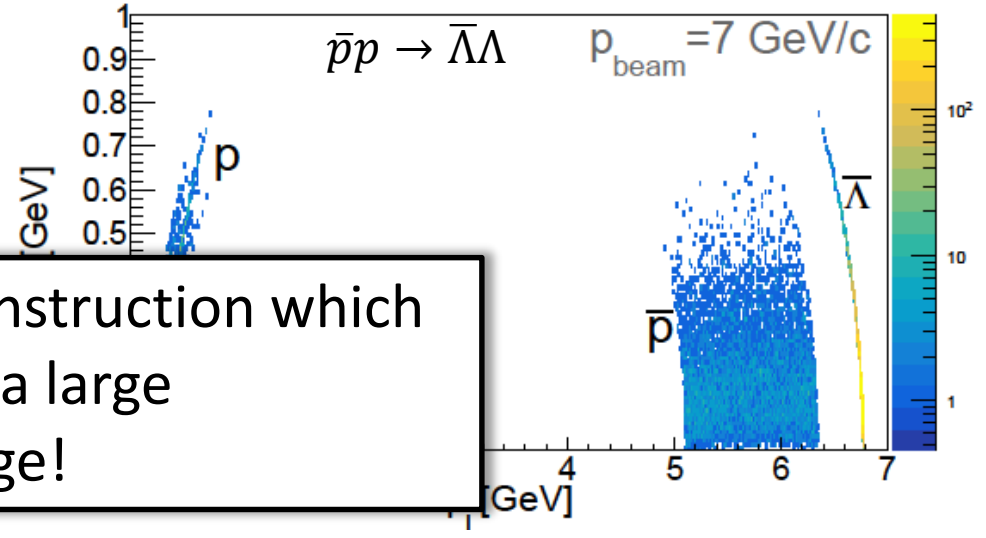




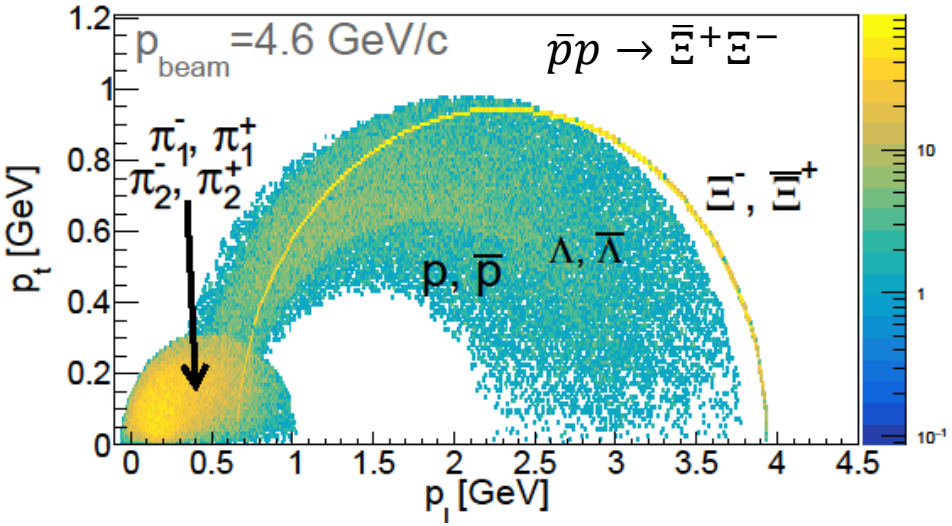


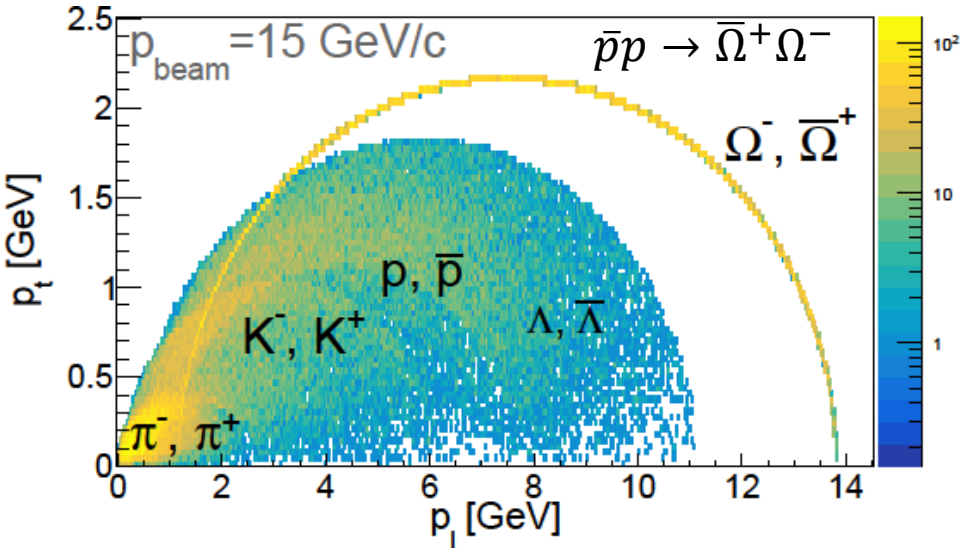
Momentum Distributions



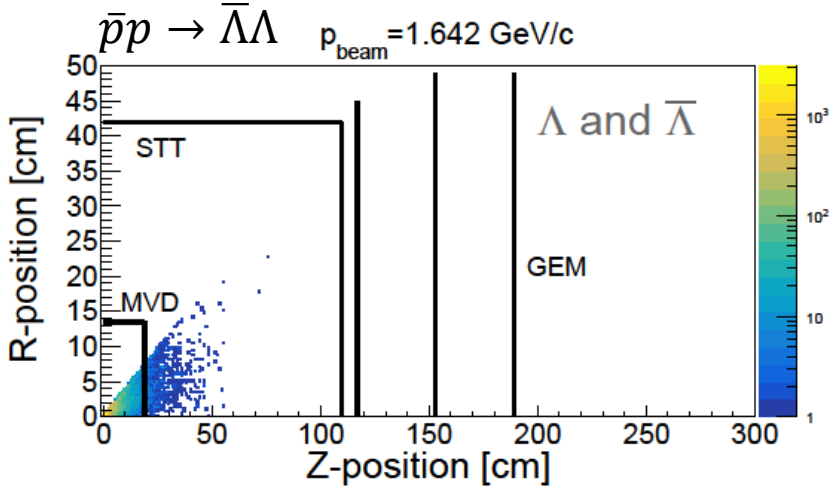


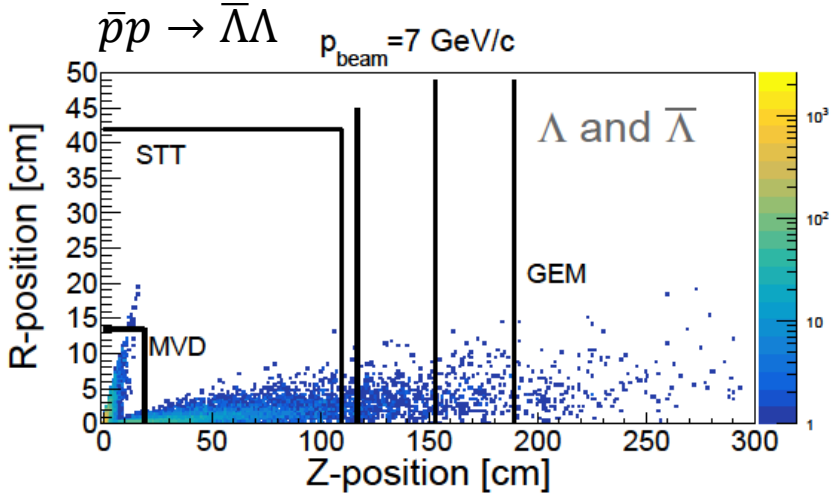
Need track reconstruction which works well over a large momentum range!

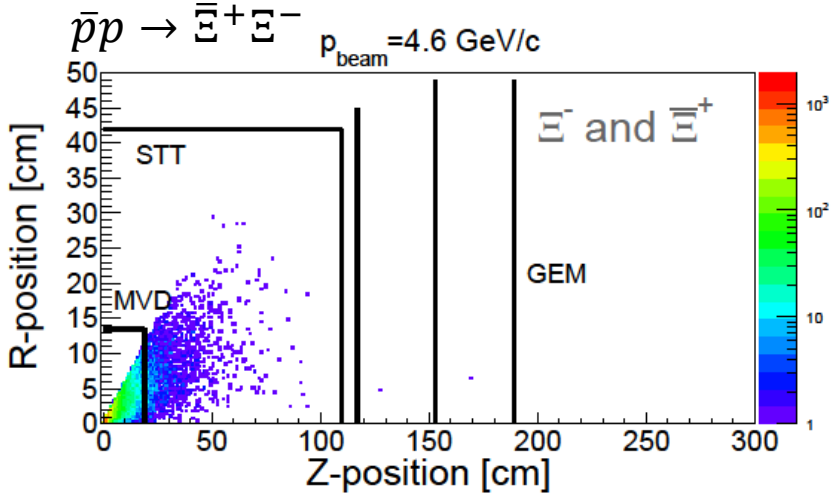


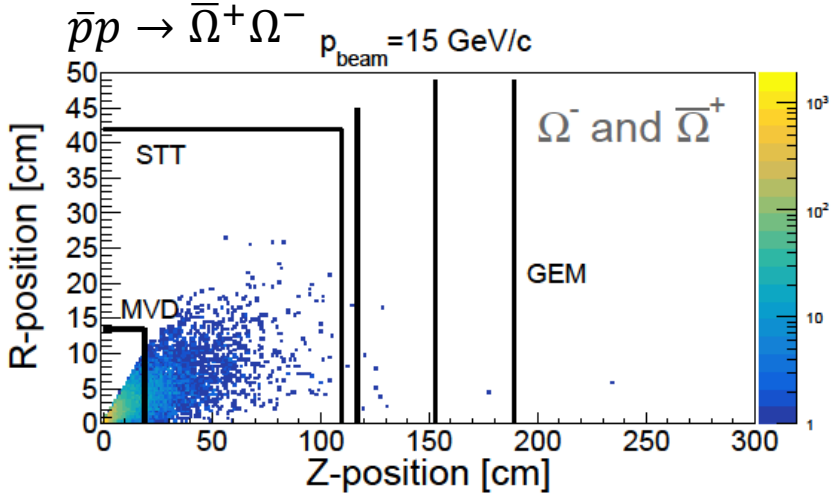


Decay Vertices

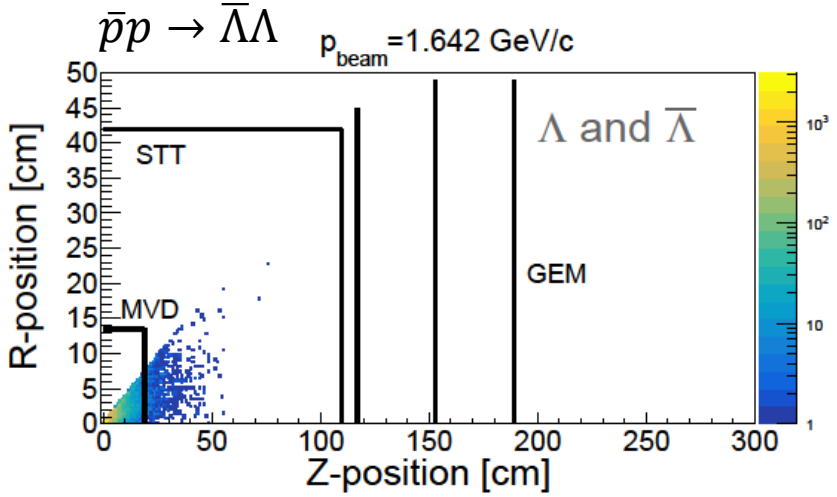


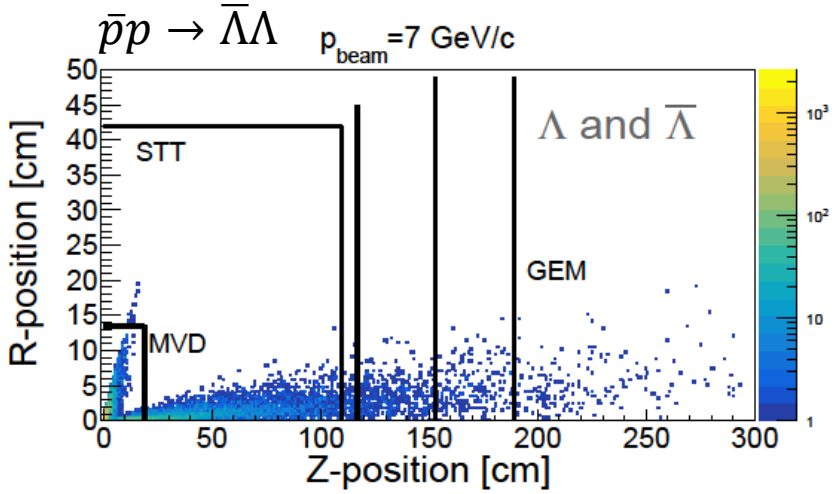


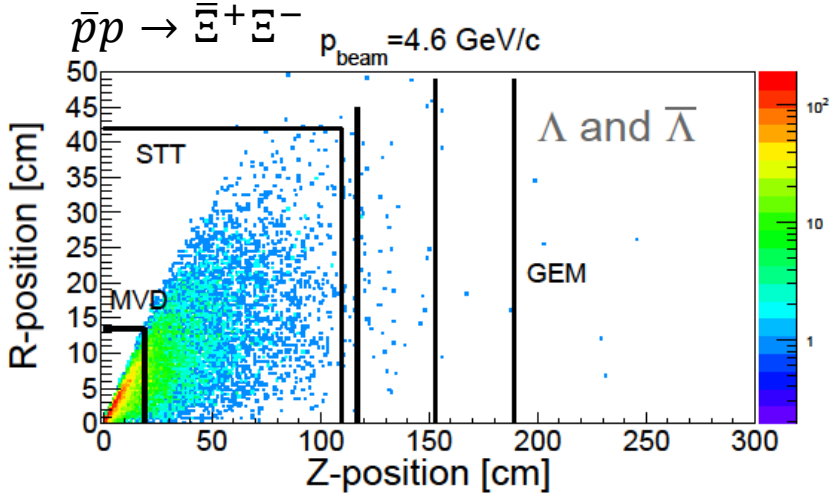


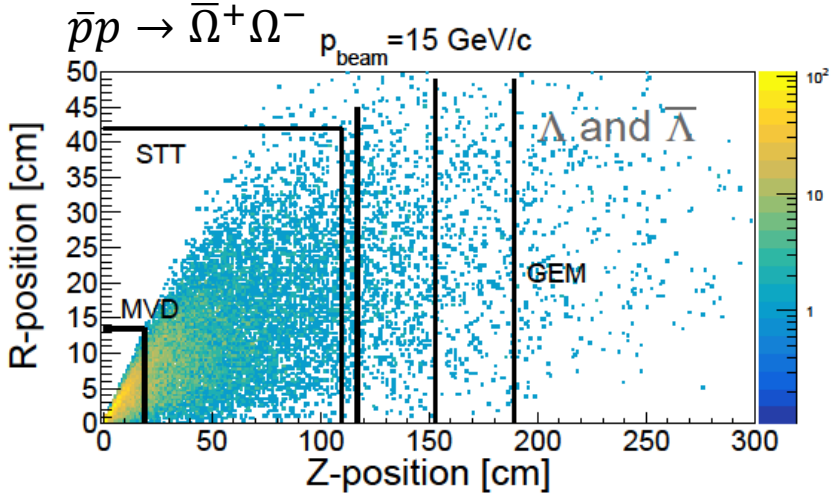


Decay Vertices

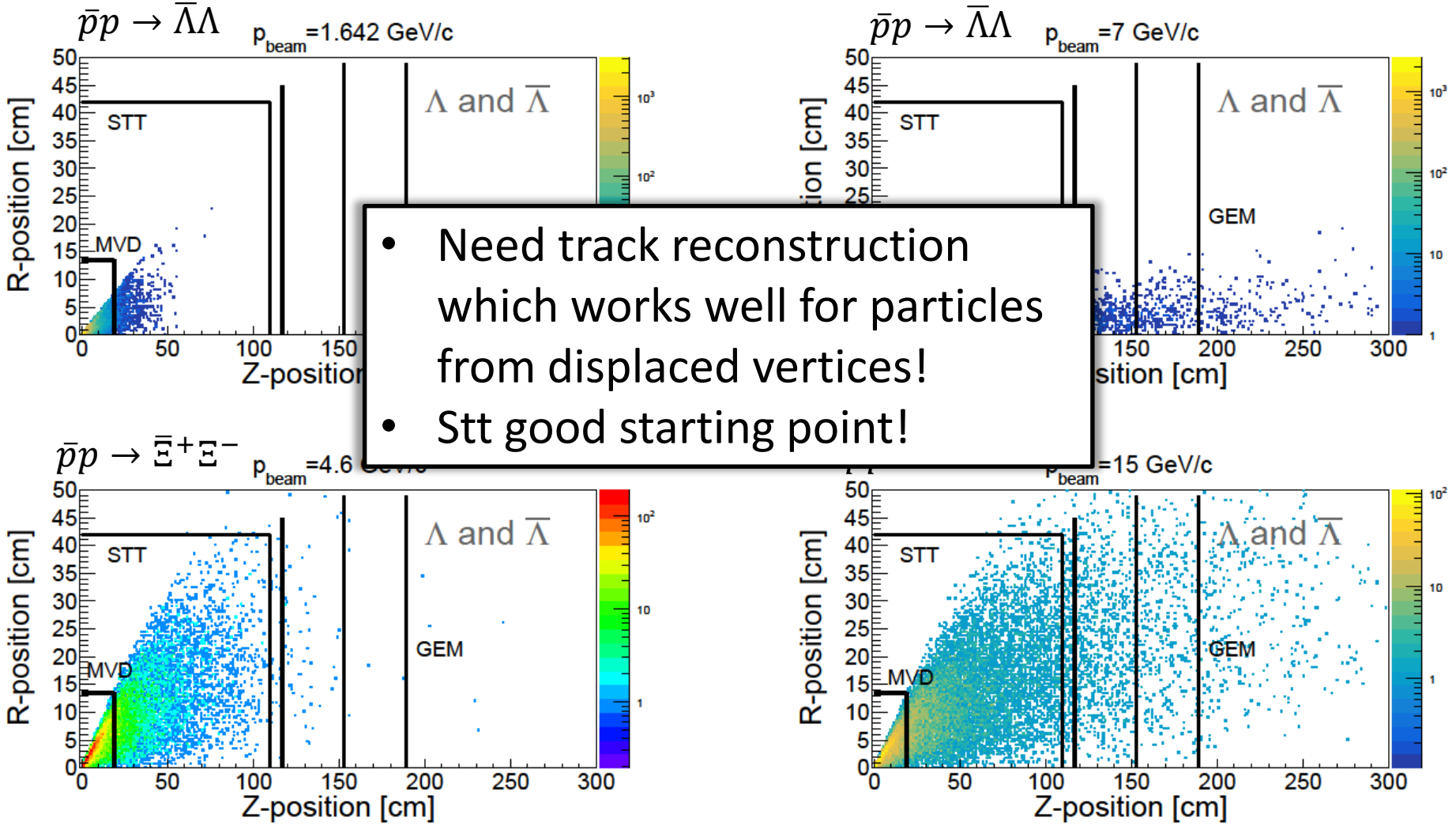






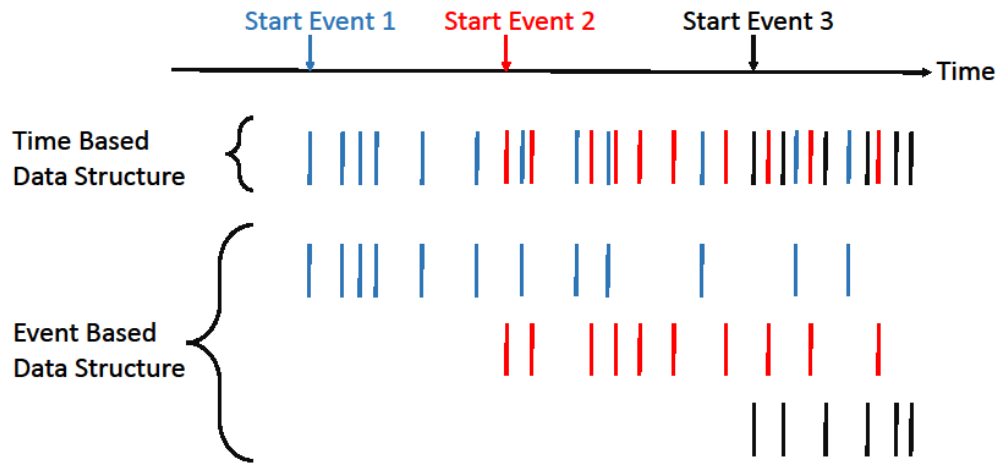


Decay Vertices



- Need track reconstruction which works well for particles from displaced vertices!
- Stt good starting point!

Time-based Reconstruction



Event-based: data sorted according to events
Time-based: data sorted according to time-stamp

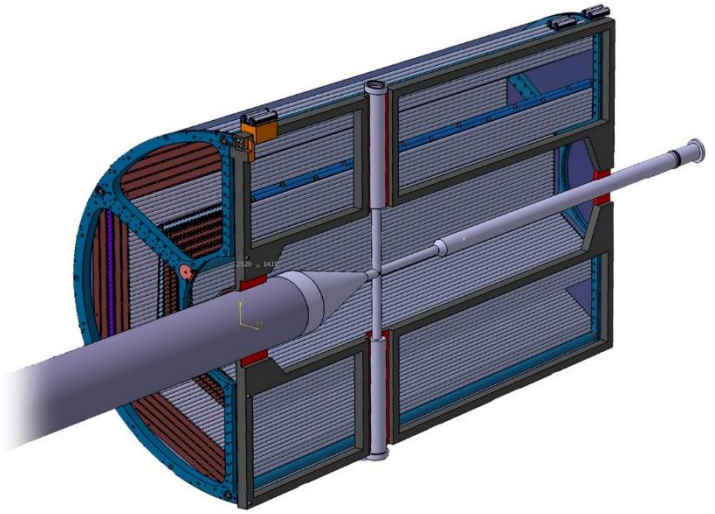
1. Time based digitization works for main barrel tracking detectors [1]
2. Realistic track reconstruction able to handle time-based data; SttCellTrackFinder and MvdHitFinder
3. Need tracking quality assurance which can handle time based data

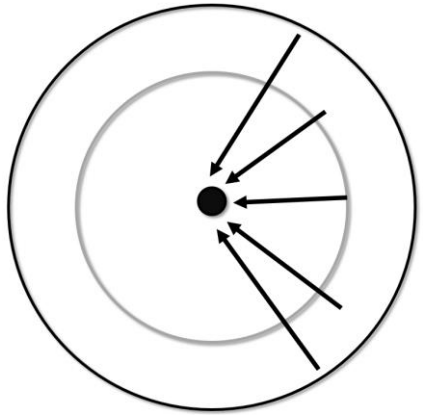
[1] https://indico.gsi.de/event/6354/contribution/7/material/slides/0.pdf

SttCellTrackFinder

Developed by J. Shumann

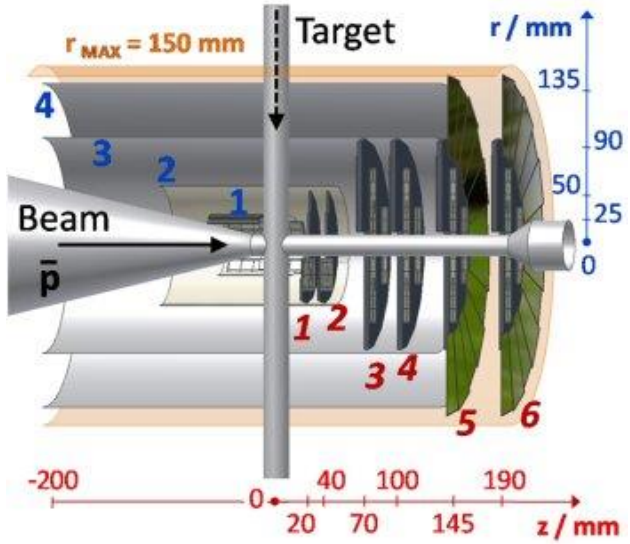
- Cellular Automaton
- Riemann Fit
- Utilizes STT hit information
- Have procedure for utilizing isochrones information
- Parts run on GPU





MvdHitFinder

- Extrapolation of tracks to MVD
- Utilizes MVD hit information

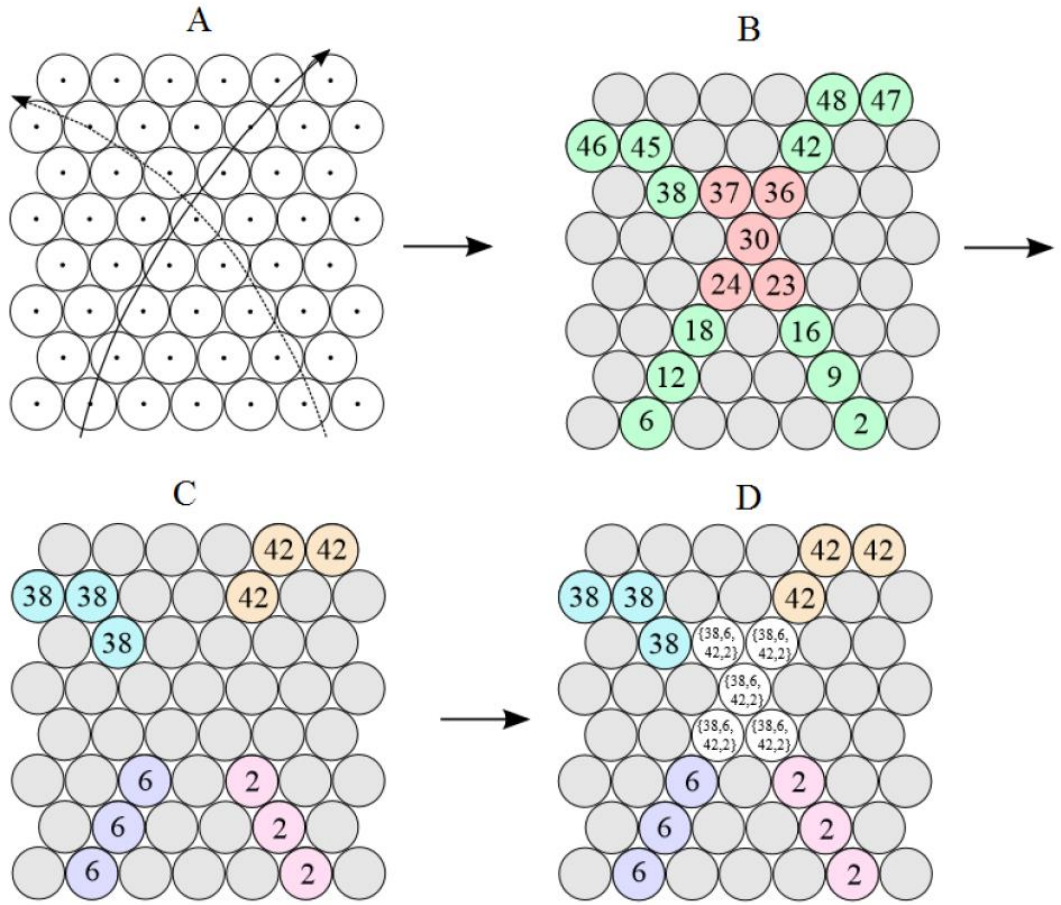


- Mainly use xy-information
- Do not assume tracks originate from interaction point

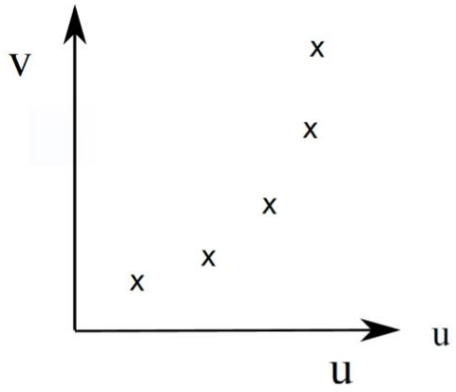
The Cellular Automaton

A. Tracks traverse STT
B. Hit tubes are numbered
C. Unambiguous hits are iteratively renumbered until hits in one cluster have same number
D. Ambiguous hits are given all numbers possible

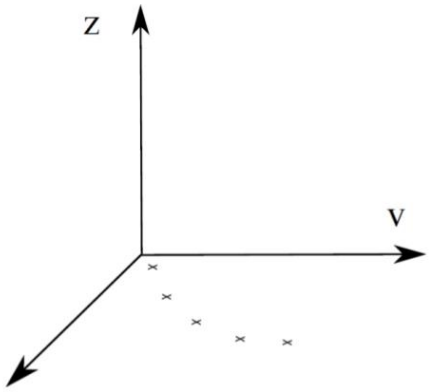
- Time information can be taken into account
- Two separate unambigous hit clusters can only be connected to longer track segment if they are interconnected via ambigous hits



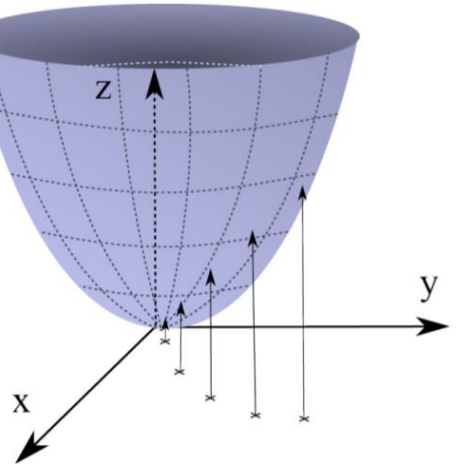
The Riemann Fit



Points to be fitted



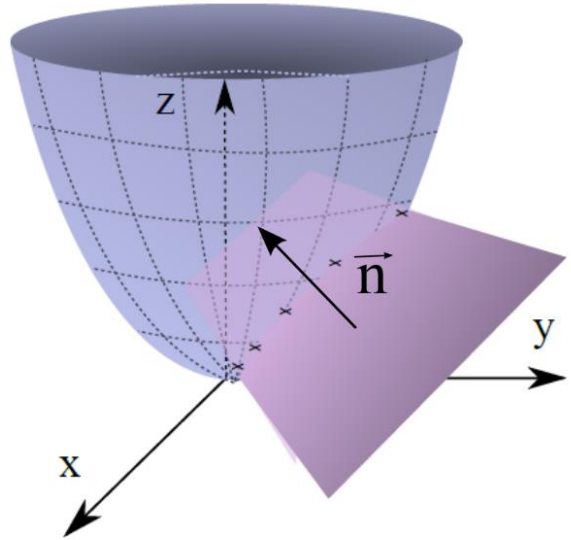
Add z-dimension



Map onto paraboloid

For STT, u=x, v=y

$z=x^2+y^2$



Calculation of plane through 3D points

simple eigenvalue determination

From $\vec{n}$, cirlcle parameters are known:

$$u_0 = -\frac{n_1}{2n_3}$$
$$v_0 = -\frac{n_2}{2n_3}$$

} Circle center

$$\rho^2 = \frac{1 - n_3^2 - 4cn_3}{4n_3^2}$$ Radius

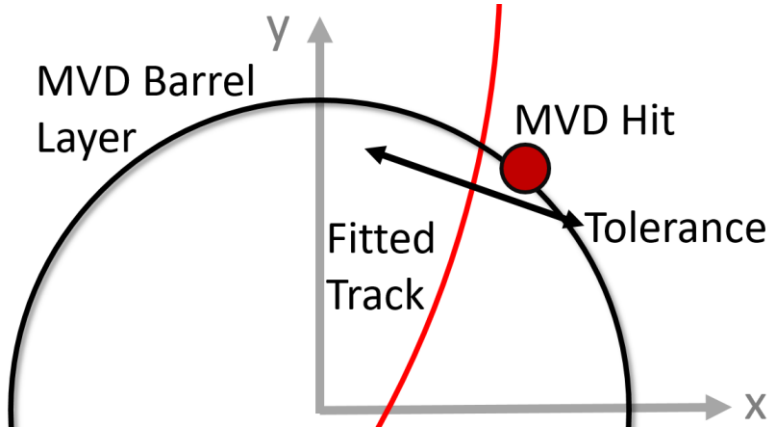
$c+n_1x+n_2y+n_3z=0$

Mvd Hit inclusion

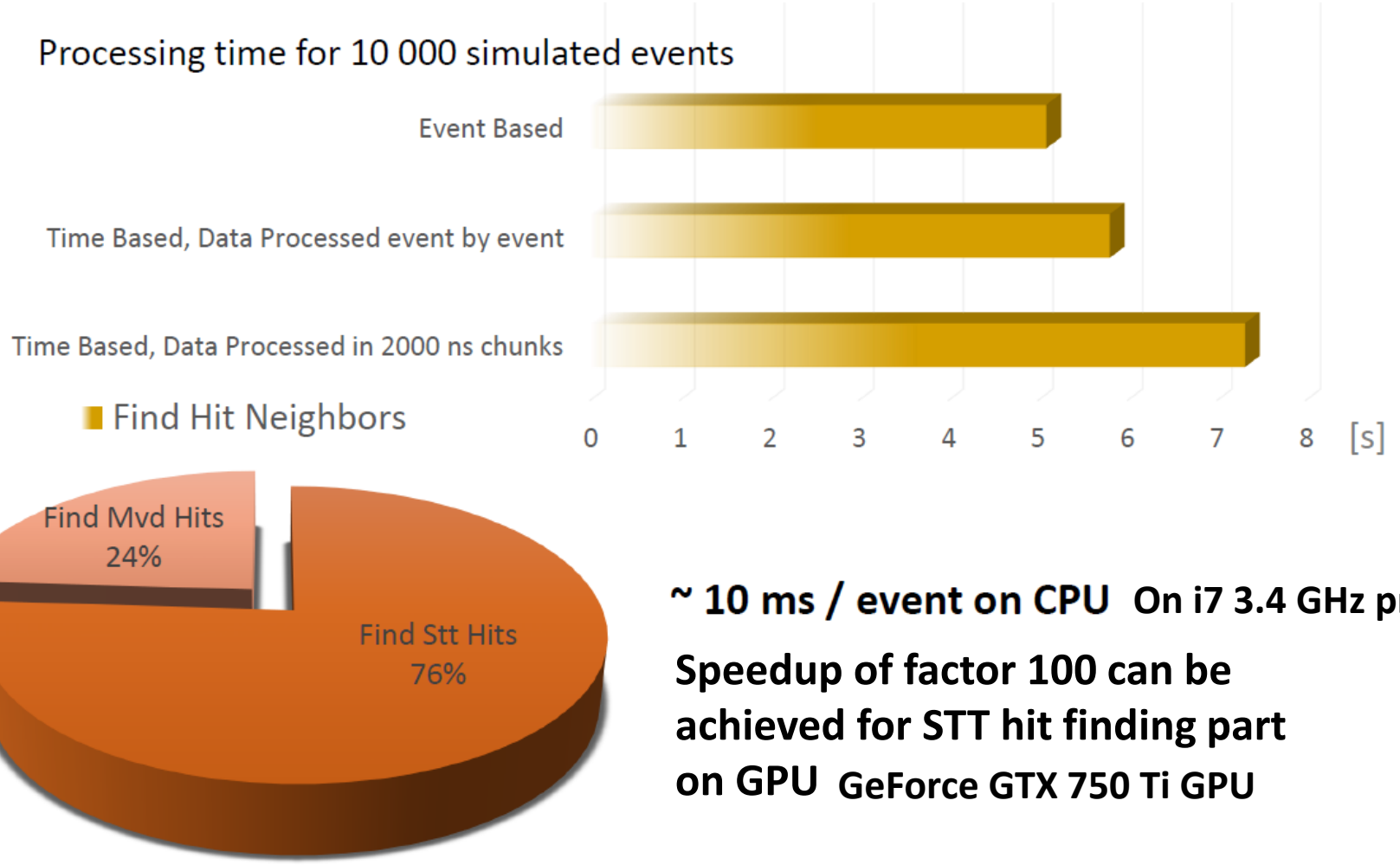
Procedure:

- Take already fitted track
- Add MVD hit to track if hit is within certain tolerance of track
- Add only best (closest) hit from each layer
- Refit track
- Repeat for each layer
- Outermost layer → Innermost layer

- Not sensitive to missing hits in layers
- Currently only handle barrel layers
- One hit can be added to several tracks



Runtime analysis

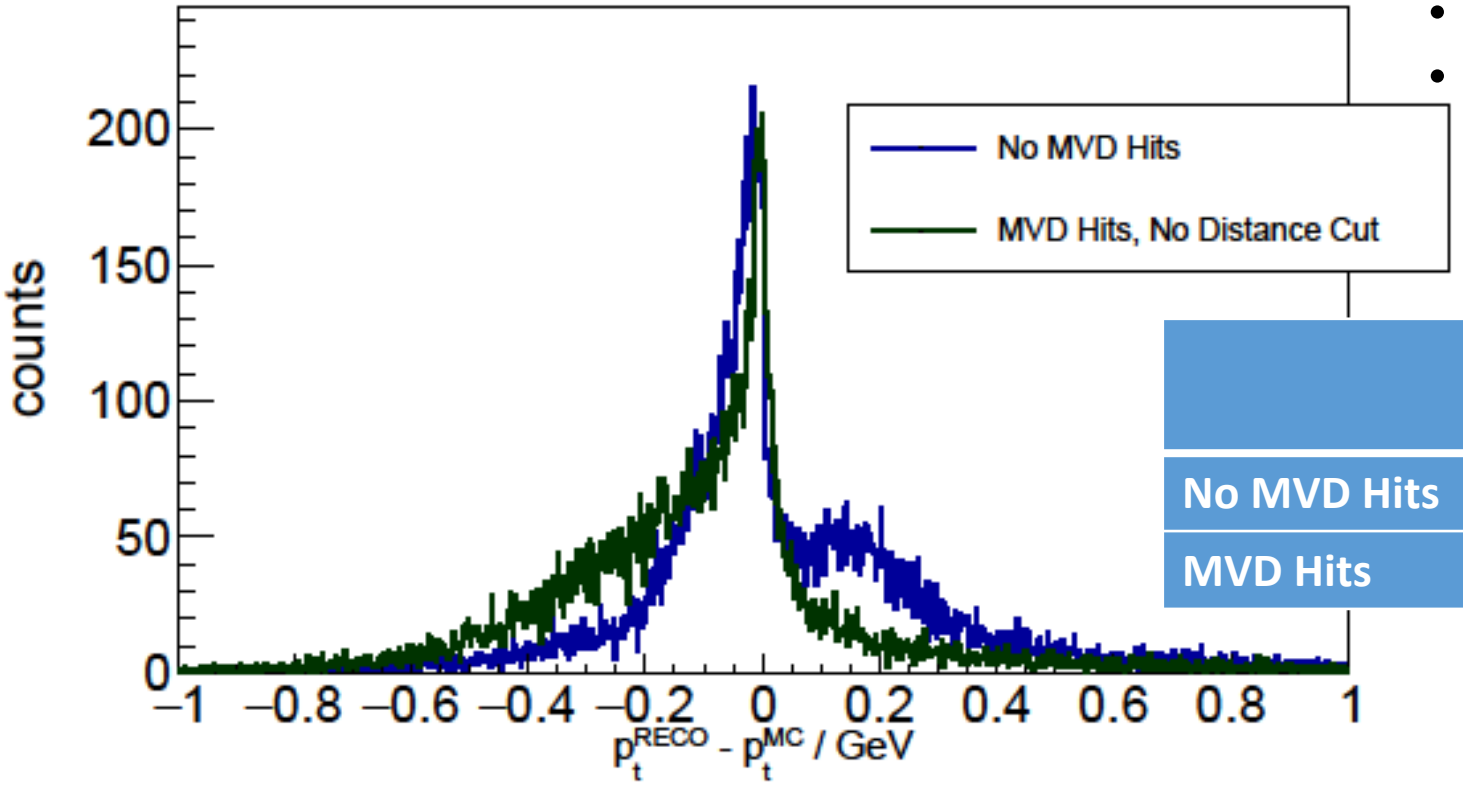


~ 10 ms / event on CPU **On i7 3.4 GHz processor**

Speedup of factor 100 can be achieved for STT hit finding part on GPU **GeForce GTX 750 Ti GPU**

Transverse Momentum Resolution

- DPM Sample, P_{beam}=5 GeV/c, 10,000 Events



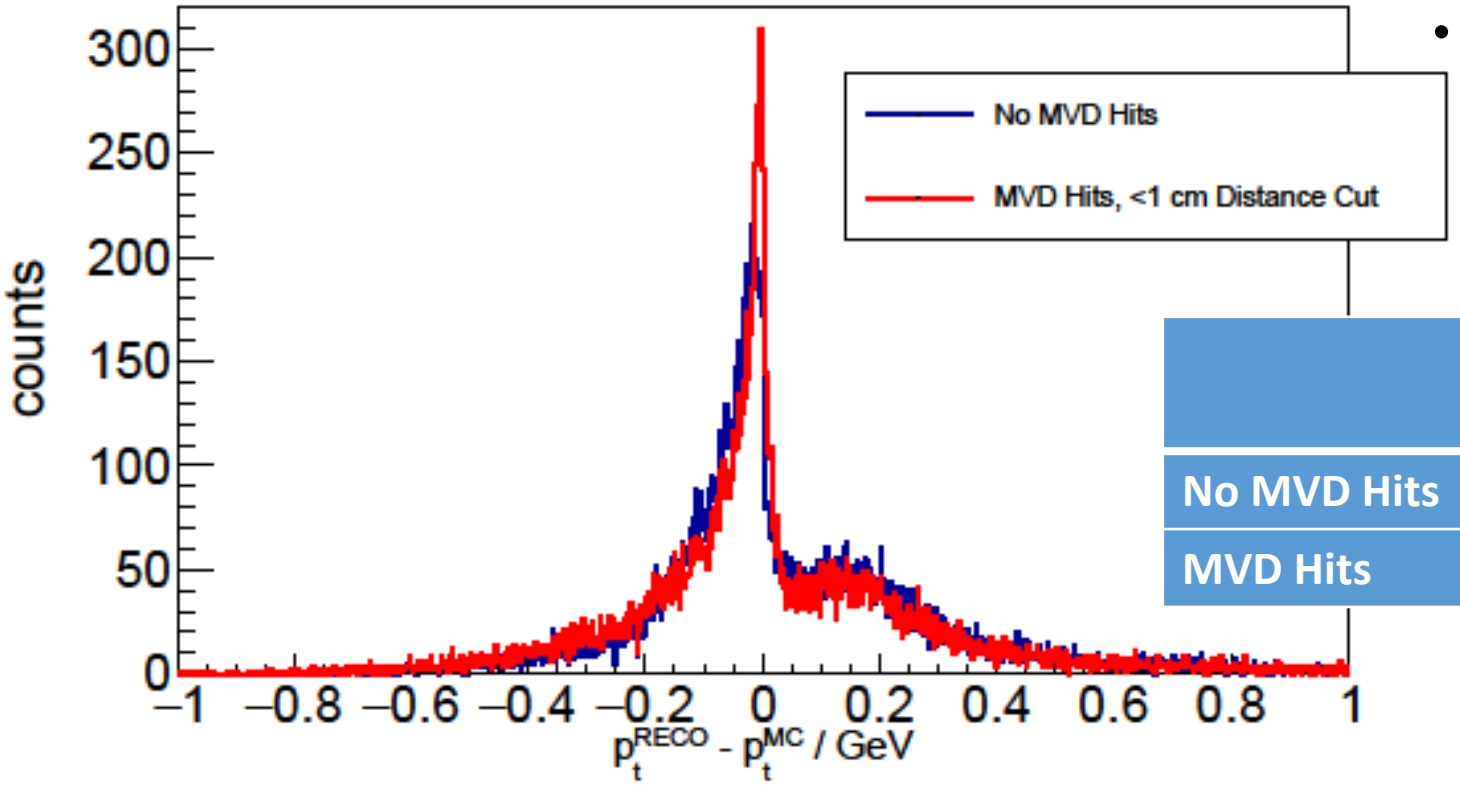
- Absolute momentum resolution
- No isochrones
- Different qualitative shape of curves
- Peak somewhat narrower and much closer to zero when using MVD hits

	Peak Position (at peak maximum)	FWHM
No MVD Hits	-0.017	0.074
MVD Hits	-0.001	0.060

Results from tracking workshop last year: https://indico.gsi.de/event/7584/contribution/6/material/slides/0.pdf

Transverse Momentum Resolution

- DPM Sample, P_{beam}=5 GeV/c, 10,000 Events



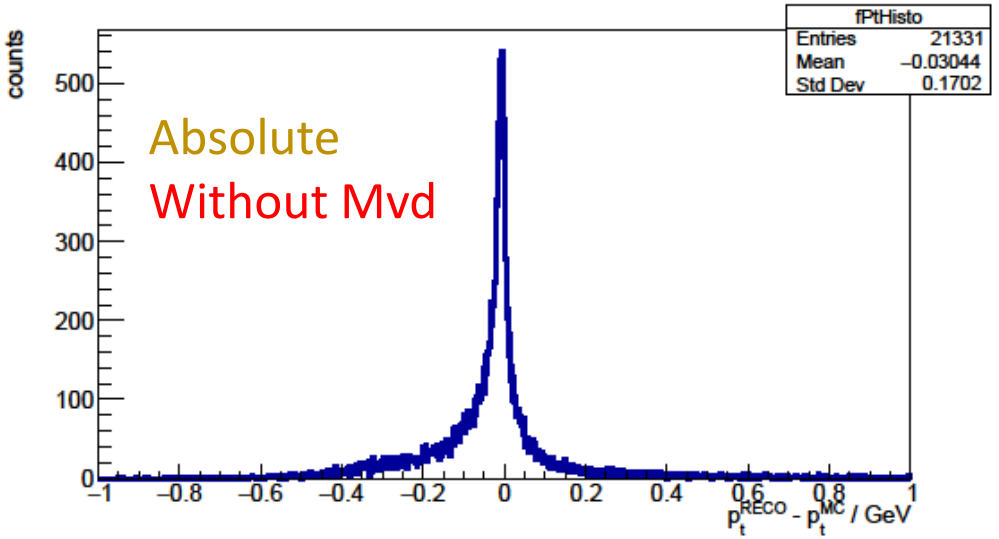
- Absolute momentum resolution
- No isochrones
- Similar qualitative shape of curves
- Peak narrower and closer to zero when using MVD hits

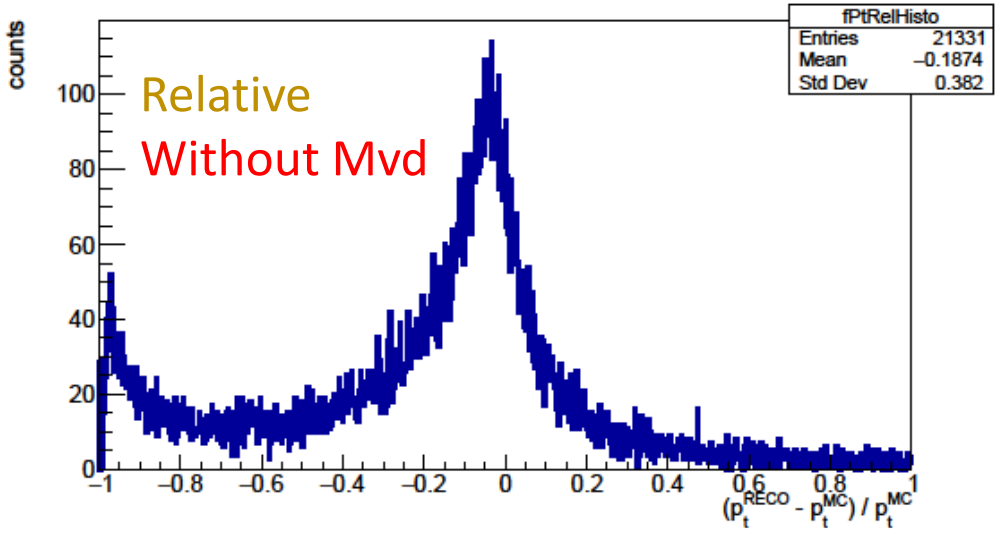
	Peak Position (at peak maximum)	FWHM
No MVD Hits	-0.017	0.074
MVD Hits	-0.003	0.028

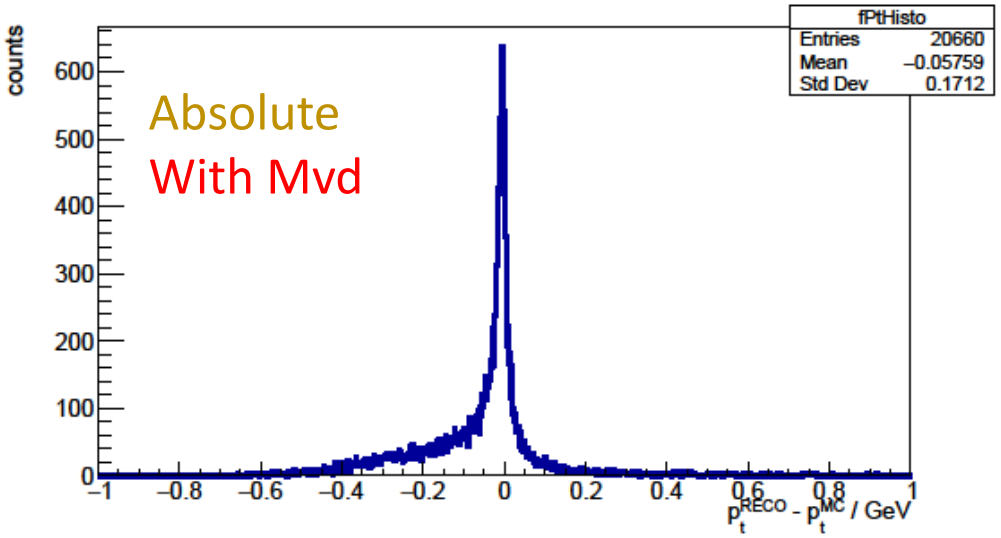
Results from tracking workshop last year: https://indico.gsi.de/event/7584/contribution/6/material/slides/0.pdf

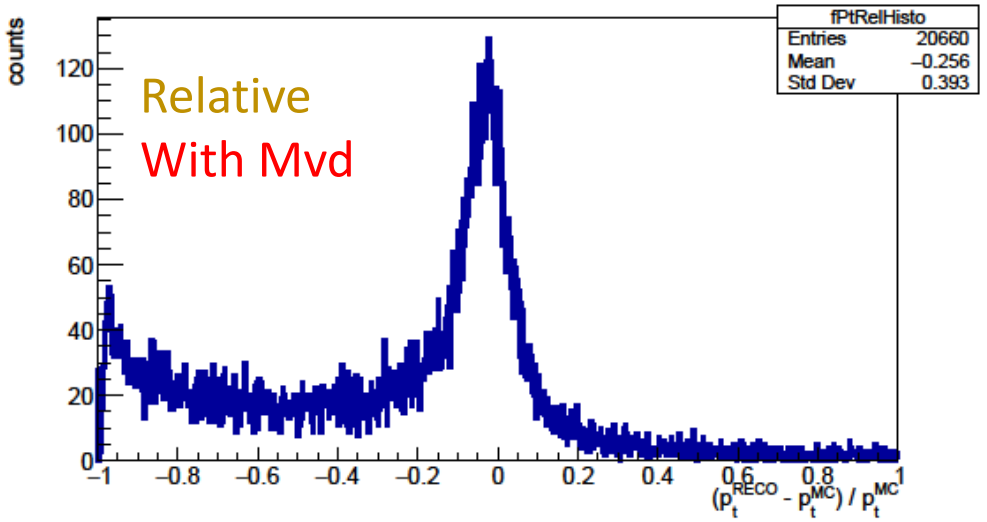
Momentum resolution

- Isochrones included in tracking procedure
- No Kalman filter
- DPM events
- P_{beam}=2 GeV/c









Tests of SttCellTrackFinder

Definitions:

- **Reference track set:** Tracks with >5 STT Hits
- **Condition for SttCellTrackFinder reconstructibility:** >5 STT Hits
- If a track contains hits from several MC tracks, the one from which the most hits originate is counted as the true one

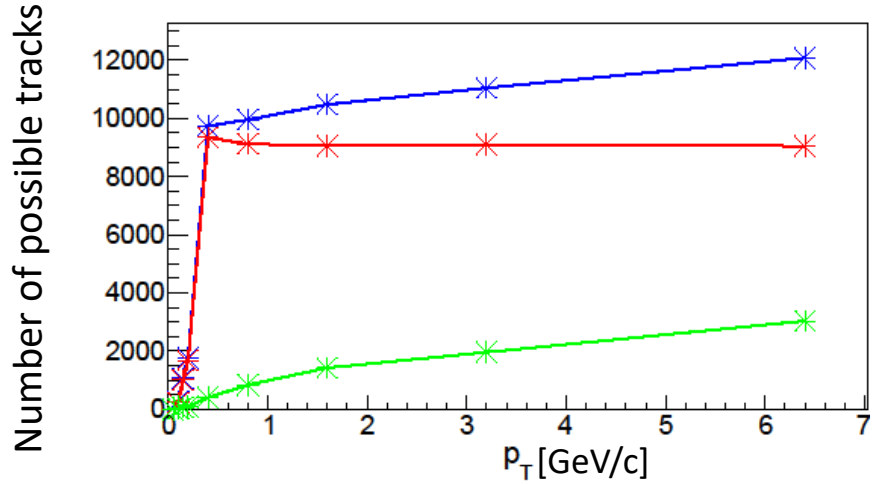
$$\text{Fraction of Reconstructed tracks} = \frac{\#\ Reconstructed\ tracks\ by\ SttCellTrackFinder}{\#\ Tracks\ in\ reference\ track\ set}$$

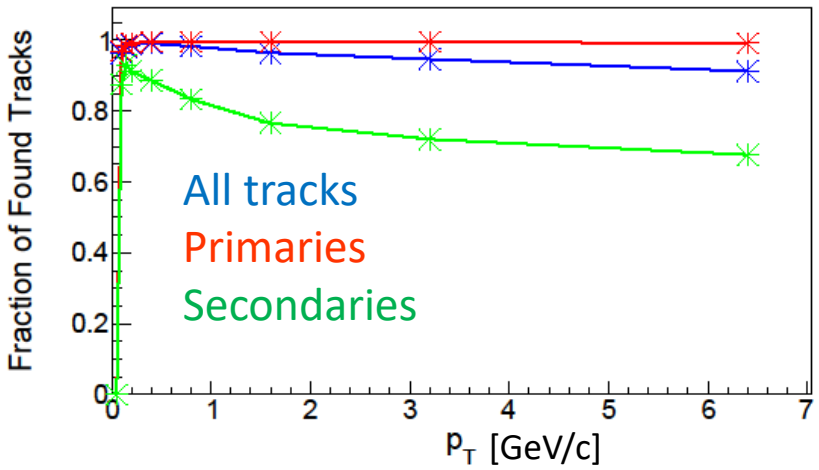
Varying P_t

- Box Generator
- **Varying p_t**
- **Particles originate from (0,0,0)**
- Isotropic $10<\theta<120$, $0<\varphi<360$
- 1 particle per event
- Protons and Pions
- 10,000 primaries/data point

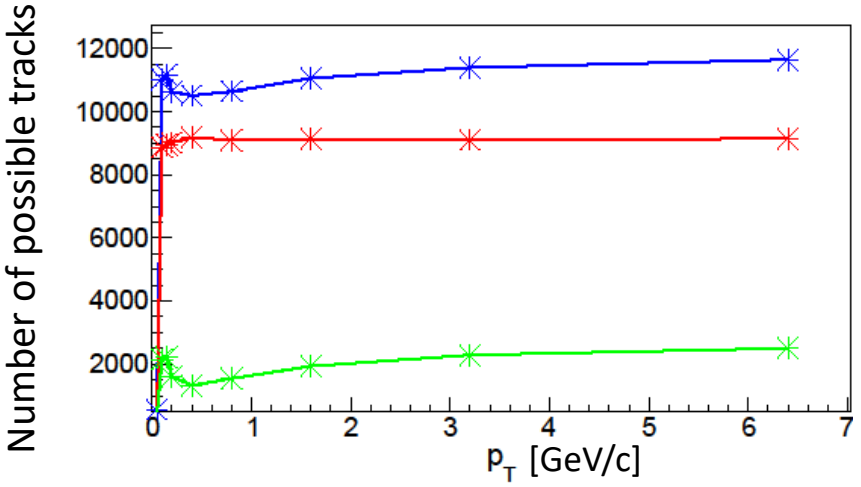
Results

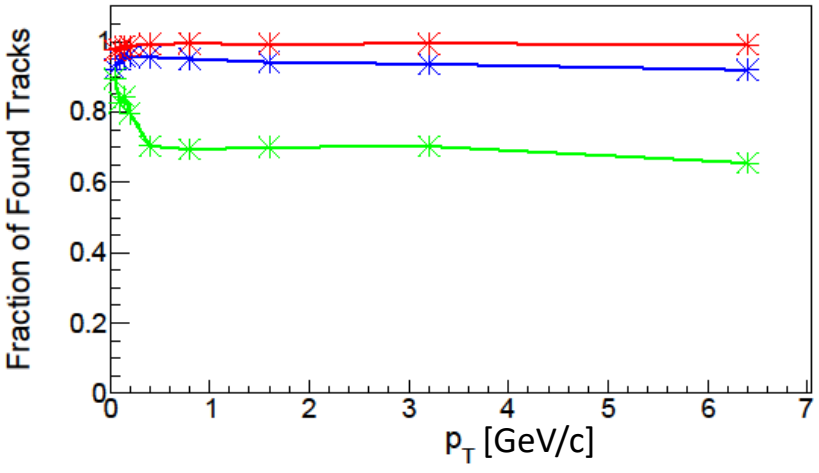
p


Number of possible tracks
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7
p_T [GeV/c]


Fraction of Found Tracks
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7
p_T [GeV/c]
All tracks
Primaries
Secondaries

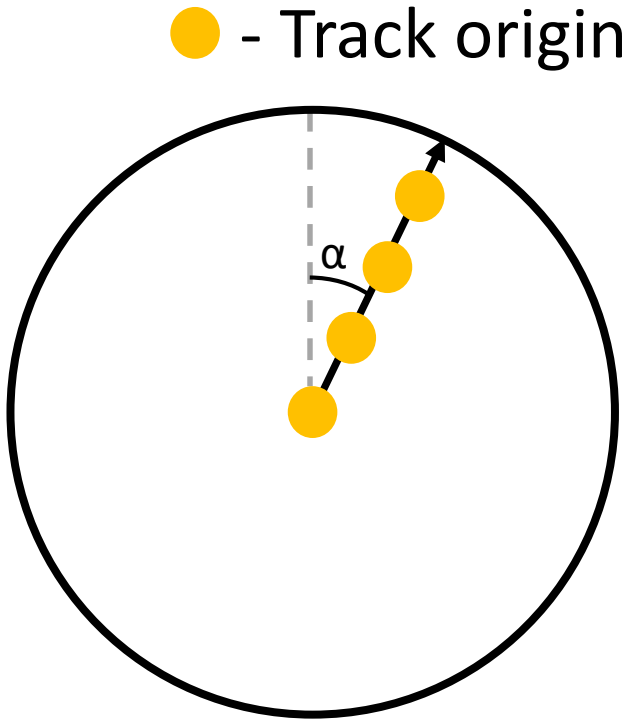
π^-


Number of possible tracks
12000
10000
8000
6000
4000
2000
0
0 1 2 3 4 5 6 7
p_T [GeV/c]


Fraction of Found Tracks
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7
p_T [GeV/c]

Varying radial track origin

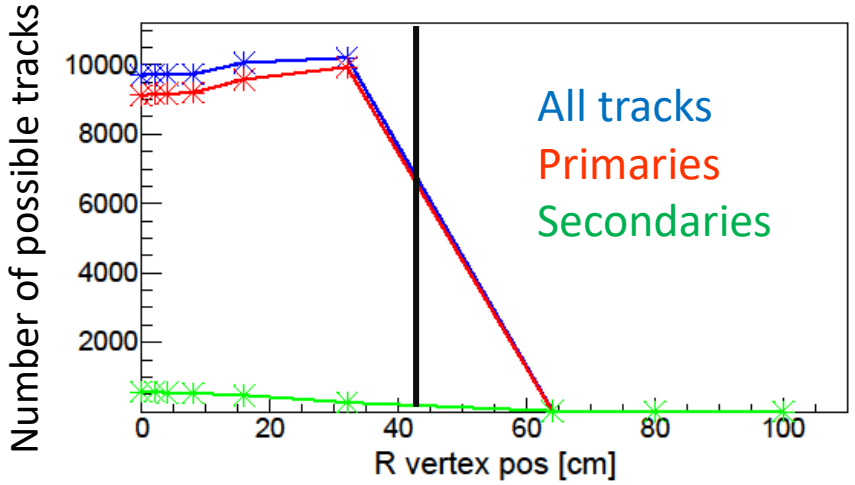
- Box Generator
- **P_t=1 GeV/c**
- **Varying origin, $R=x^2+y^2$**
- **z=0 cm, α=25°**
- Isotropic $10<\theta<120$, $0<\varphi<360$
- 1 particle per event
- Protons and Pions
- 10,000 primaries/data point

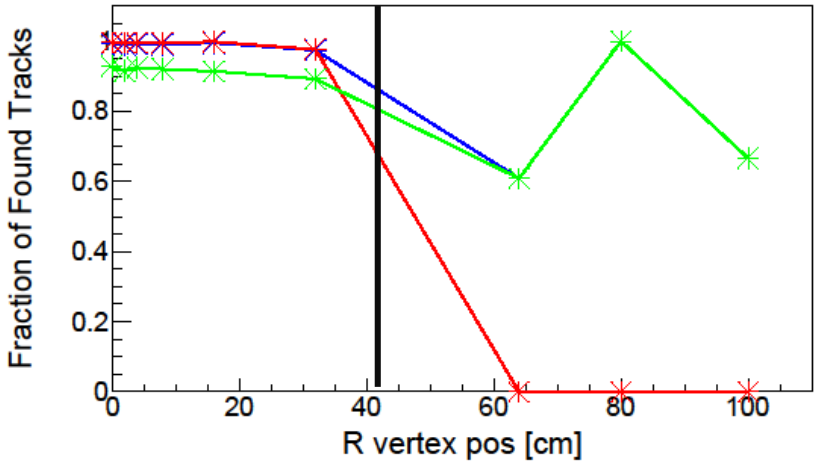


Results

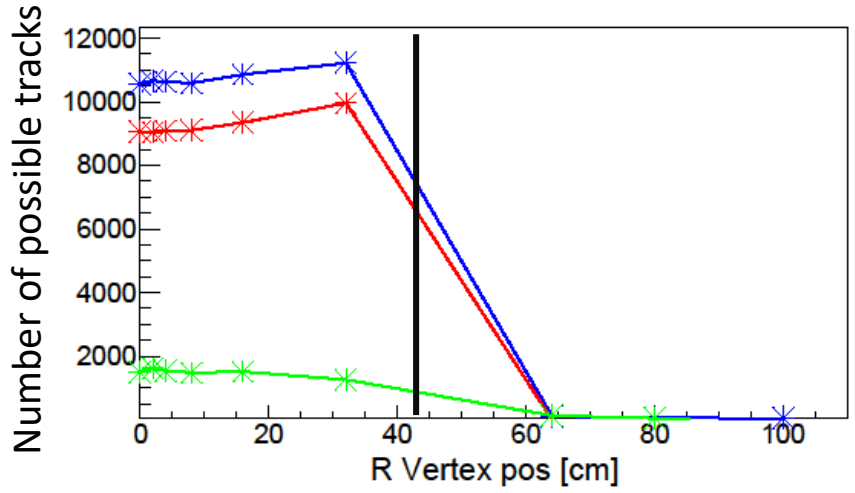
Vertical lines=STT outer radius

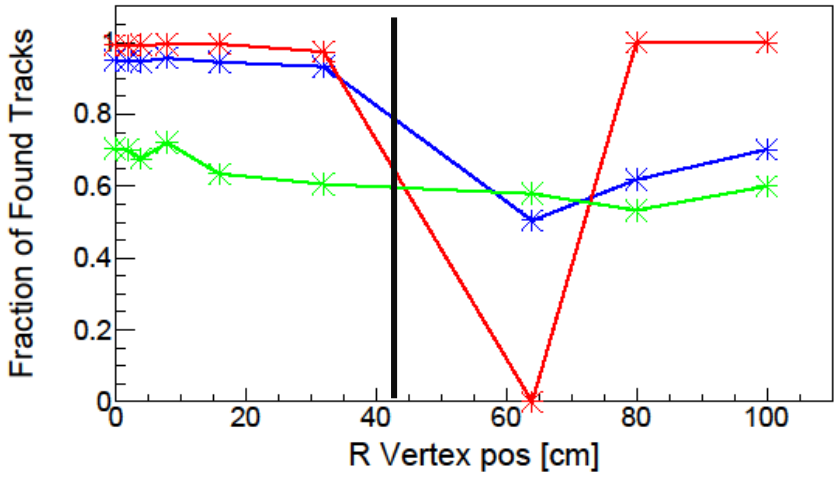
p





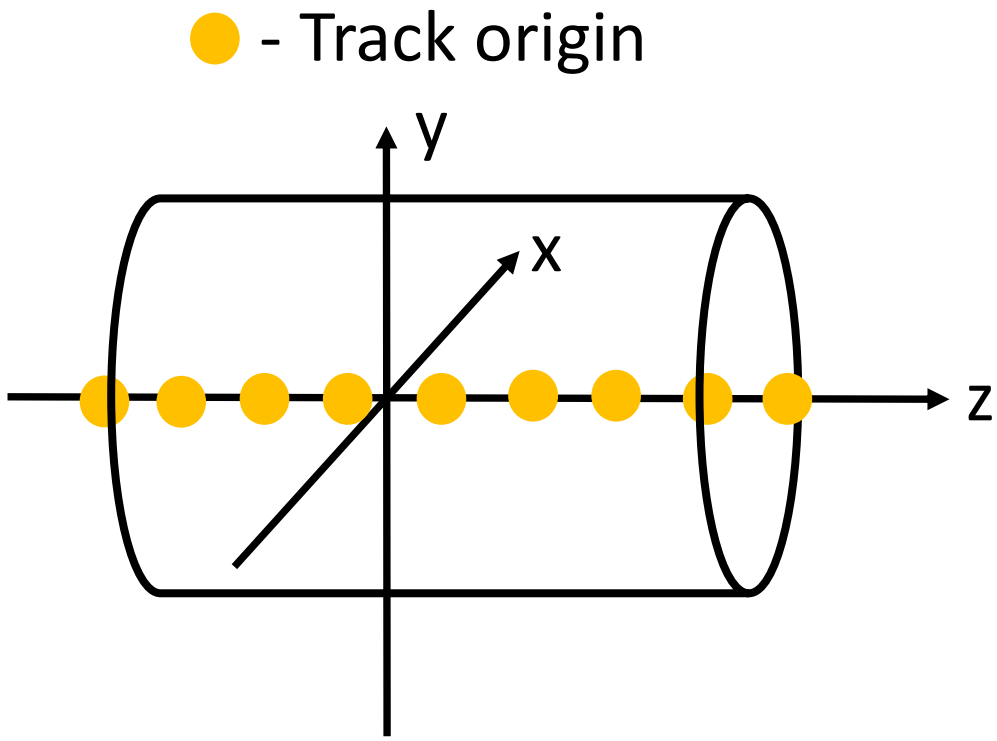
π^-





Varying z-position of track origin

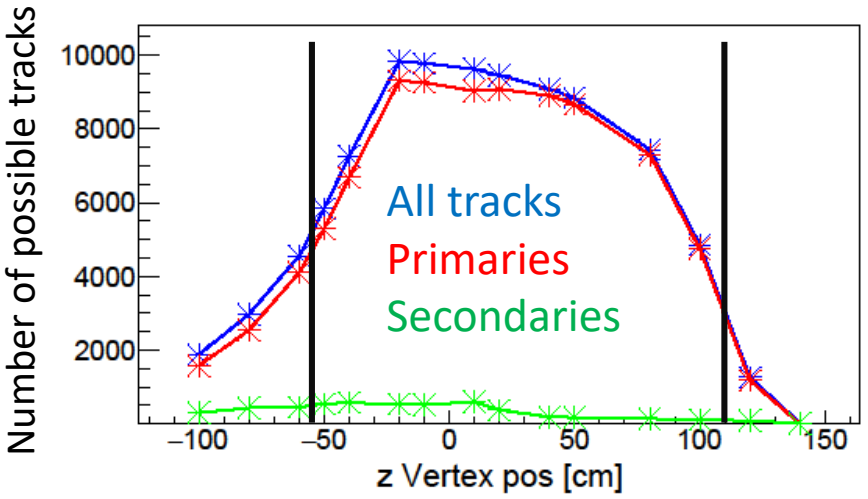
- Box Generator
- **P_t=1 GeV/c**
- **Varying origin, z**
- **x=y=0 cm**
- Isotropic $10<\theta<120$, $0<\varphi<360$
- 1 particle per event
- Protons and Pions
- 10,000 primaries/data point

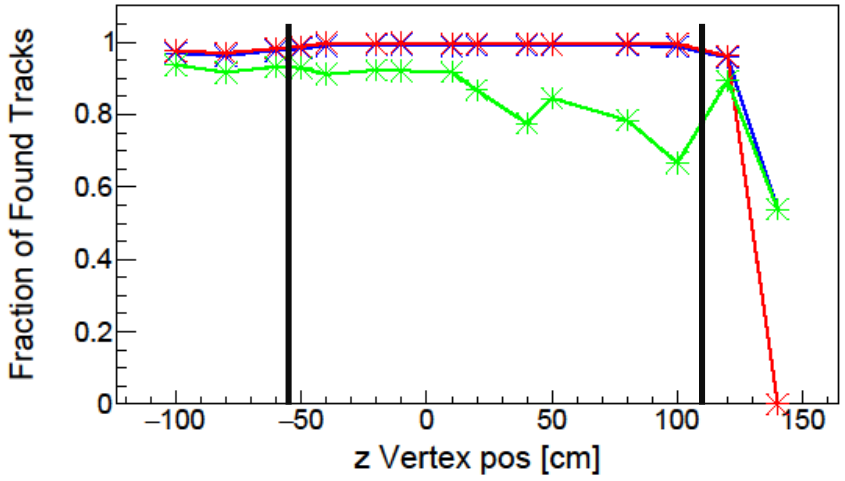


Results

Vertical lines=STT outer boundaries

p





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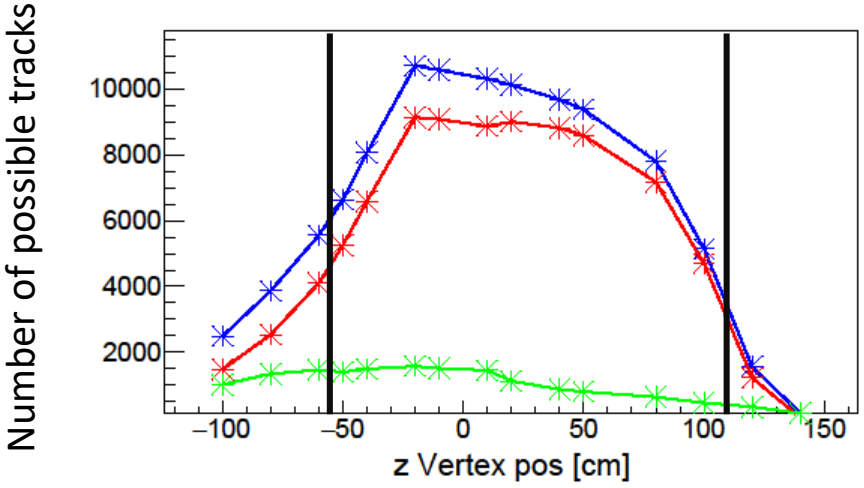

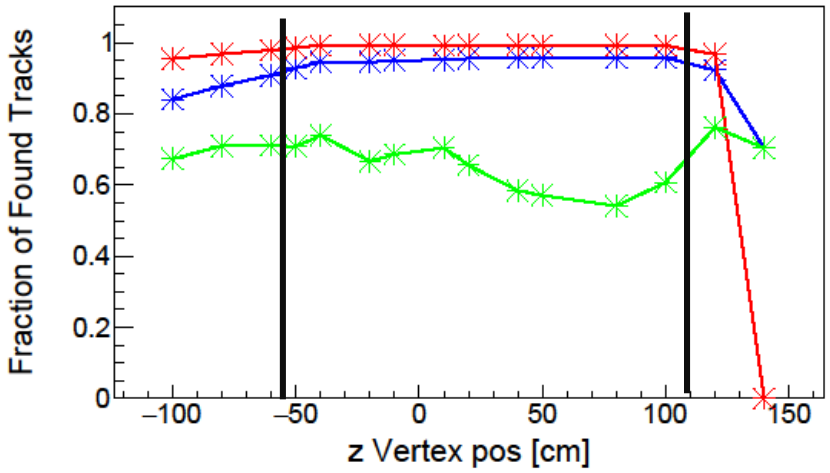

Outlook

- Test on hyperon events and varying p_{beam}
- Test on time based data
- Test with p_z-finder [2]
- Work ongoing for algorithm improvements [3]
- Possibility: examine low p_t region closer
- Possibility: examine kaons and muons

[2] Walter Ikegami Anderssons talk from computing session yesterday:
https://indico.gsi.de/event/8999/contribution/4/material/slides/0.pdf
[3] My talk from computing session yesterday:
https://indico.gsi.de/event/8999/contribution/2/material/slides/0.pdf

Thank You!