A PARAMETER STUDY TO REDUCE GHOST TRACKS BASED ON THE HOUGH TRACK FINDER

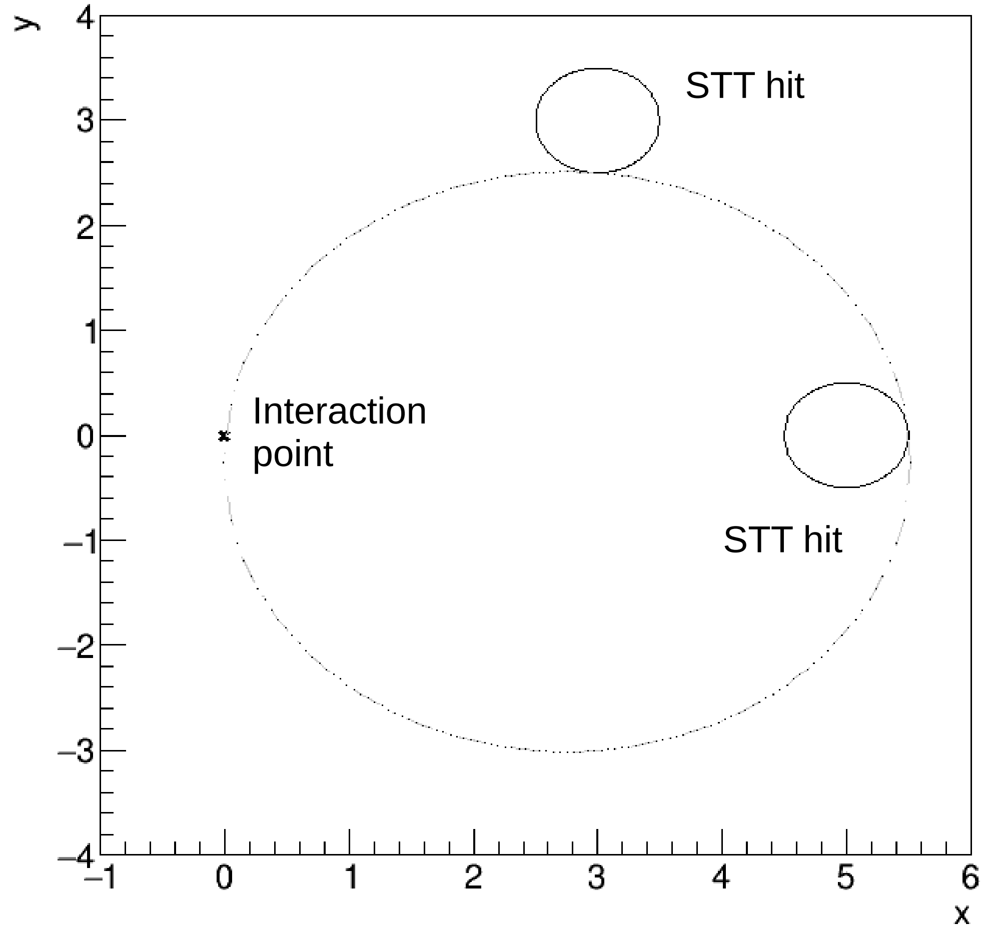
10.03.2020 I ANNA SCHOLL

INTRODUCTION

HoughTrackFinder

- Calculate all possible Tracks for a pair of hits (two hits + interaction point)

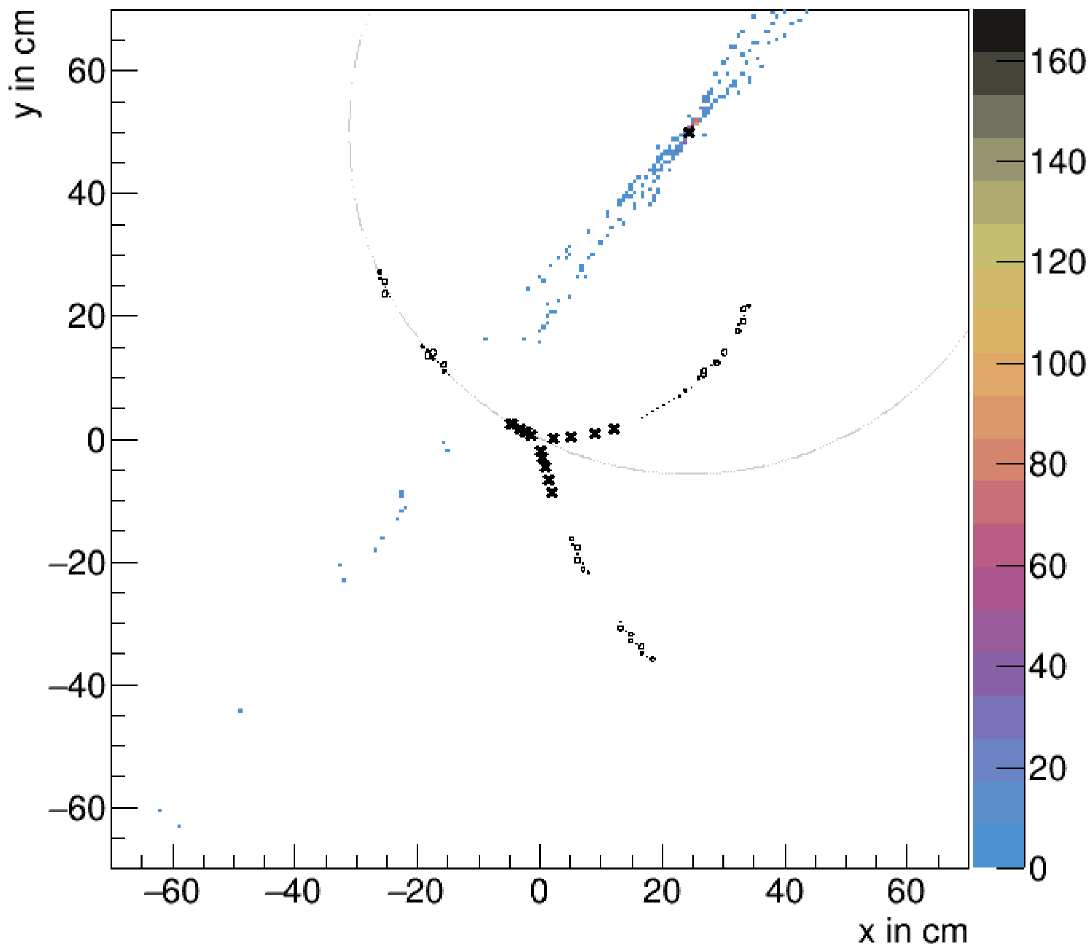
- Calculation is based on the Apollonius problem
- → can be extended to secondaries



INTRODUCTION

HoughTrackFinder

- Calculate all possible Tracks for a pair of hits (two hits + interaction point)
- Calculation is based on the Apollonius problem
- → can be extended to secondaries
- Fill the parameters in a Hough space
- Hits belonging to the same track fill the same bin in the Hough space



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  - Beam momentum: 7 GeV/c
  - DPM background

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  → Algorithm uses interaction point for calculation → currently designed for primary tracks

  - Number of ghosts: **24.1 %**

  → Ghost ratio has to be reduced!

  → Misclassified tracks: Number of found hits of any mc track is < 70%

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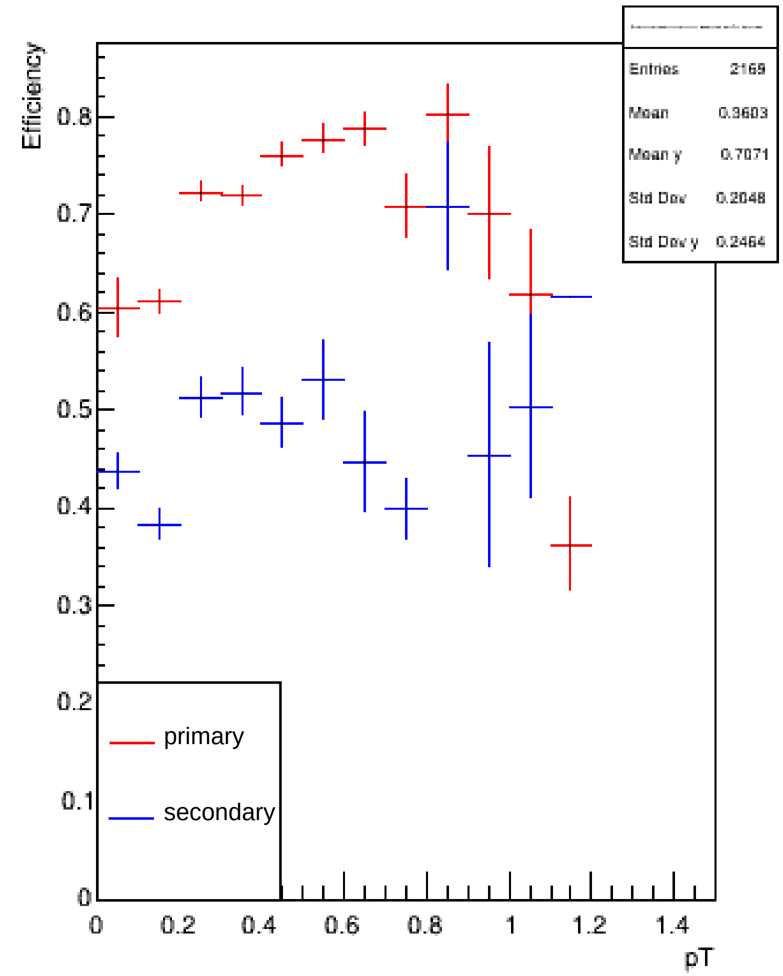
    - Efficiency drops for high p_T



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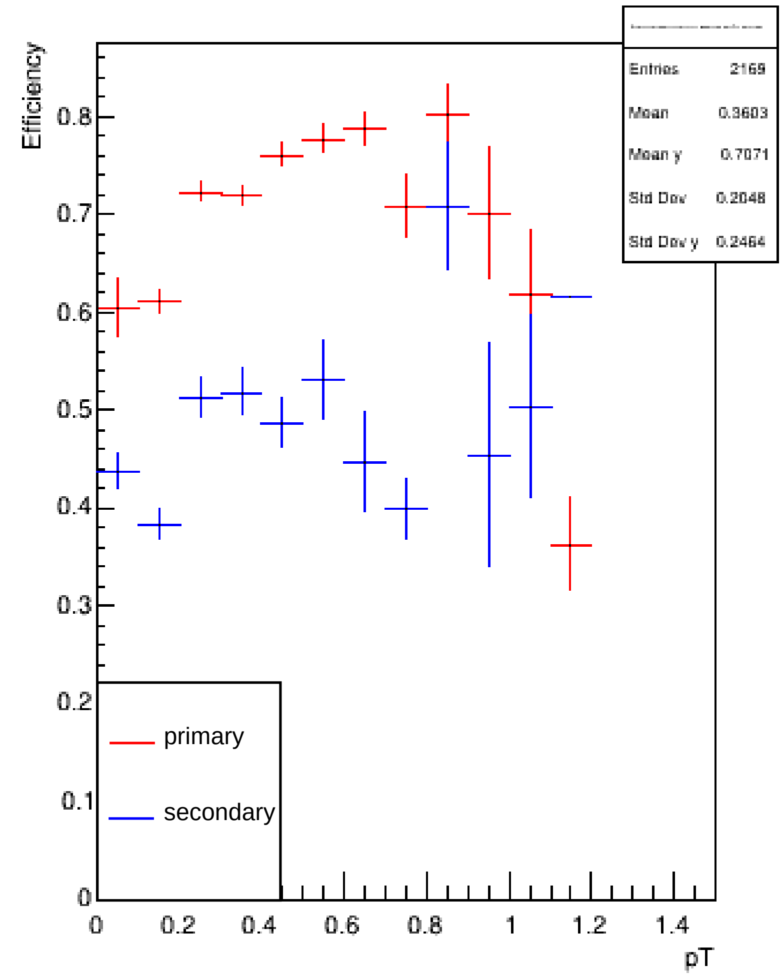
  - Transverse momentum dependency:
    - Efficiency drops for high p_T

    → high p_T leads to straight line

    → different **hough space parametrisaton**?



OUTLINE

1. Hough space parametrization:
   - x-y-space
   - r - φ – space
   - 1/r - φ – space

2. Ghost reduction:
   - Investigated parameters
     - number of hits in track
     - number of neighbors (to reduce curling tracks)
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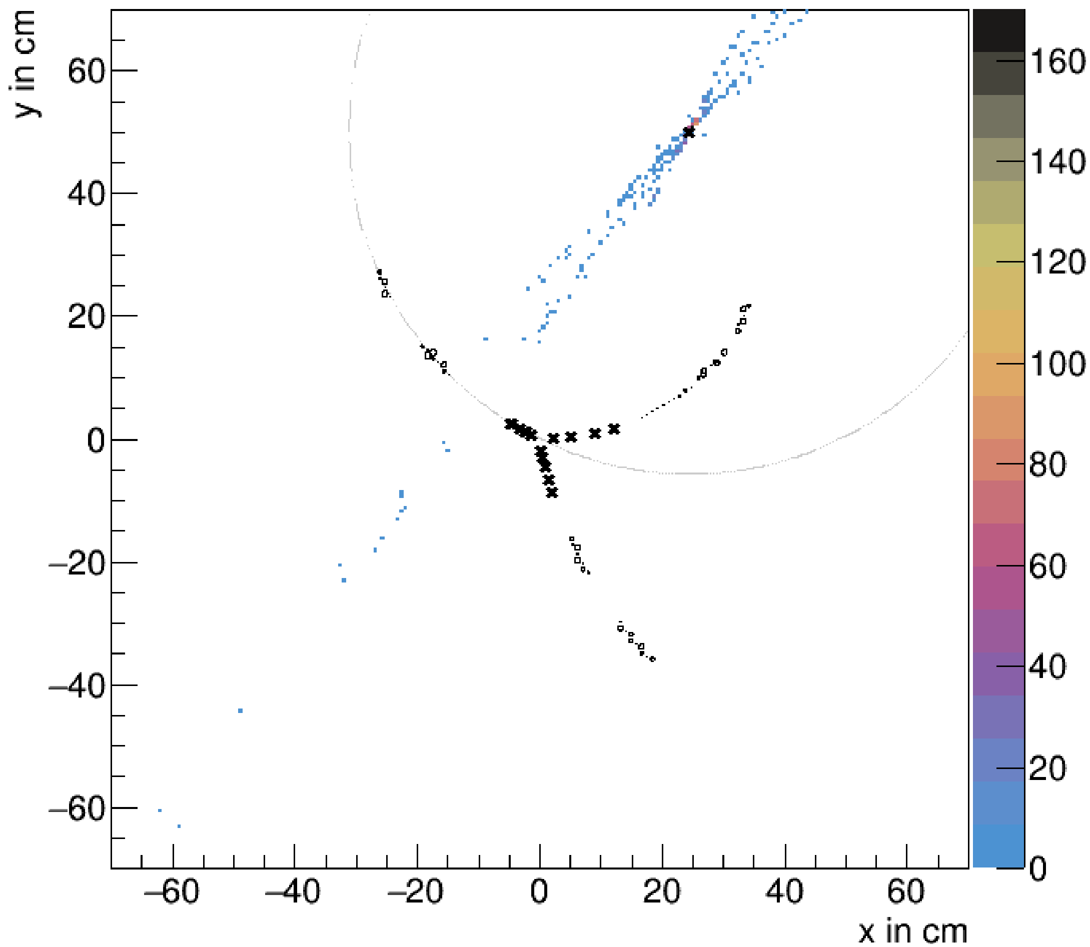
HOUGH SPACE PARAMETRISATION

- Use x-y-space
  - Only circle centers
  - No information about radius



HOUGH SPACE PARAMETRISATION

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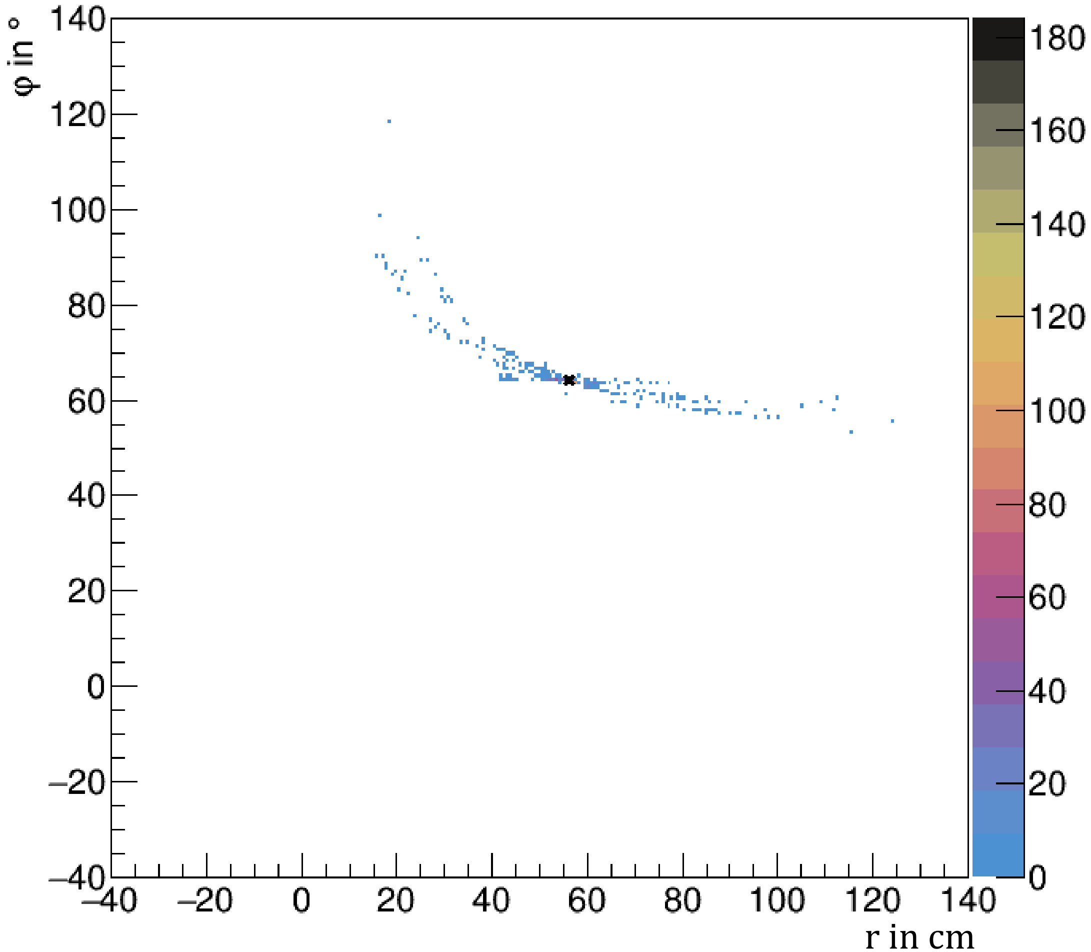
  - Circle center and radius information
  - For high p_T → $r \rightarrow \infty$



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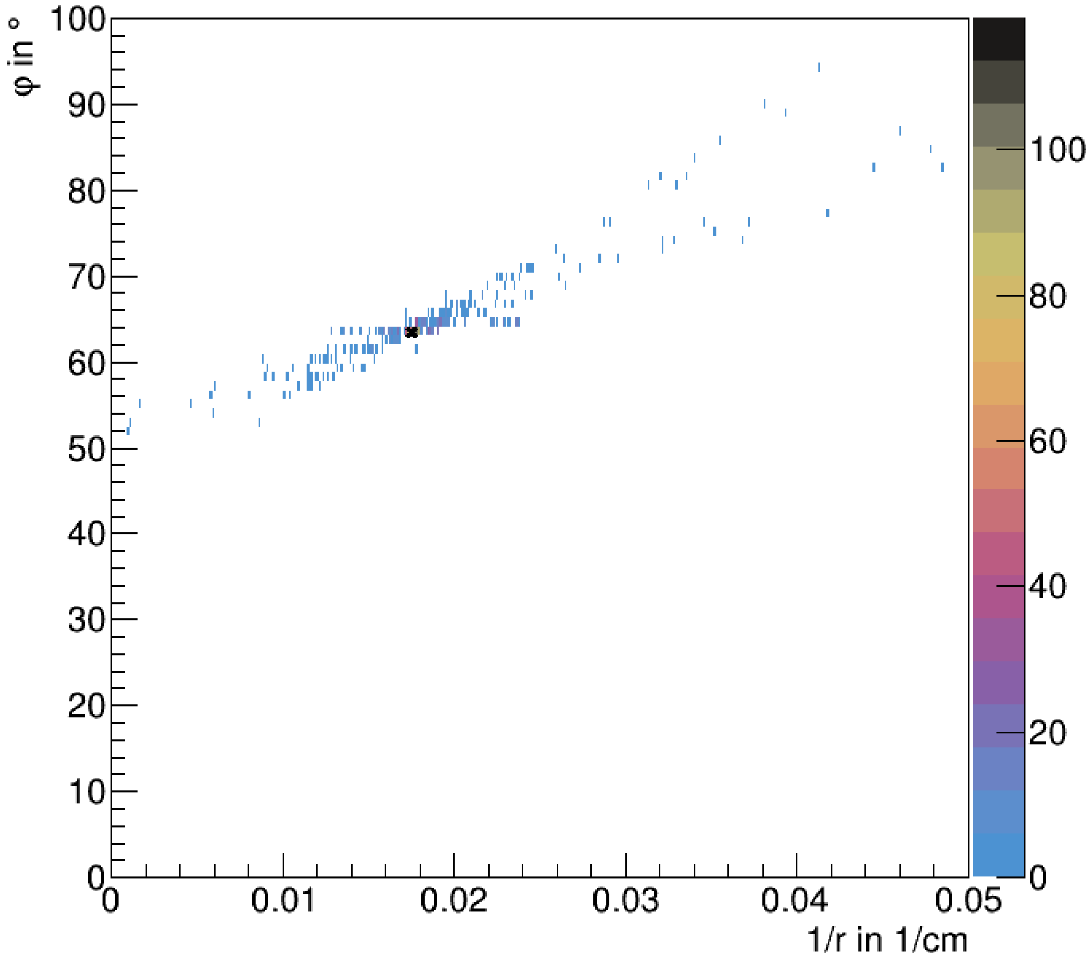
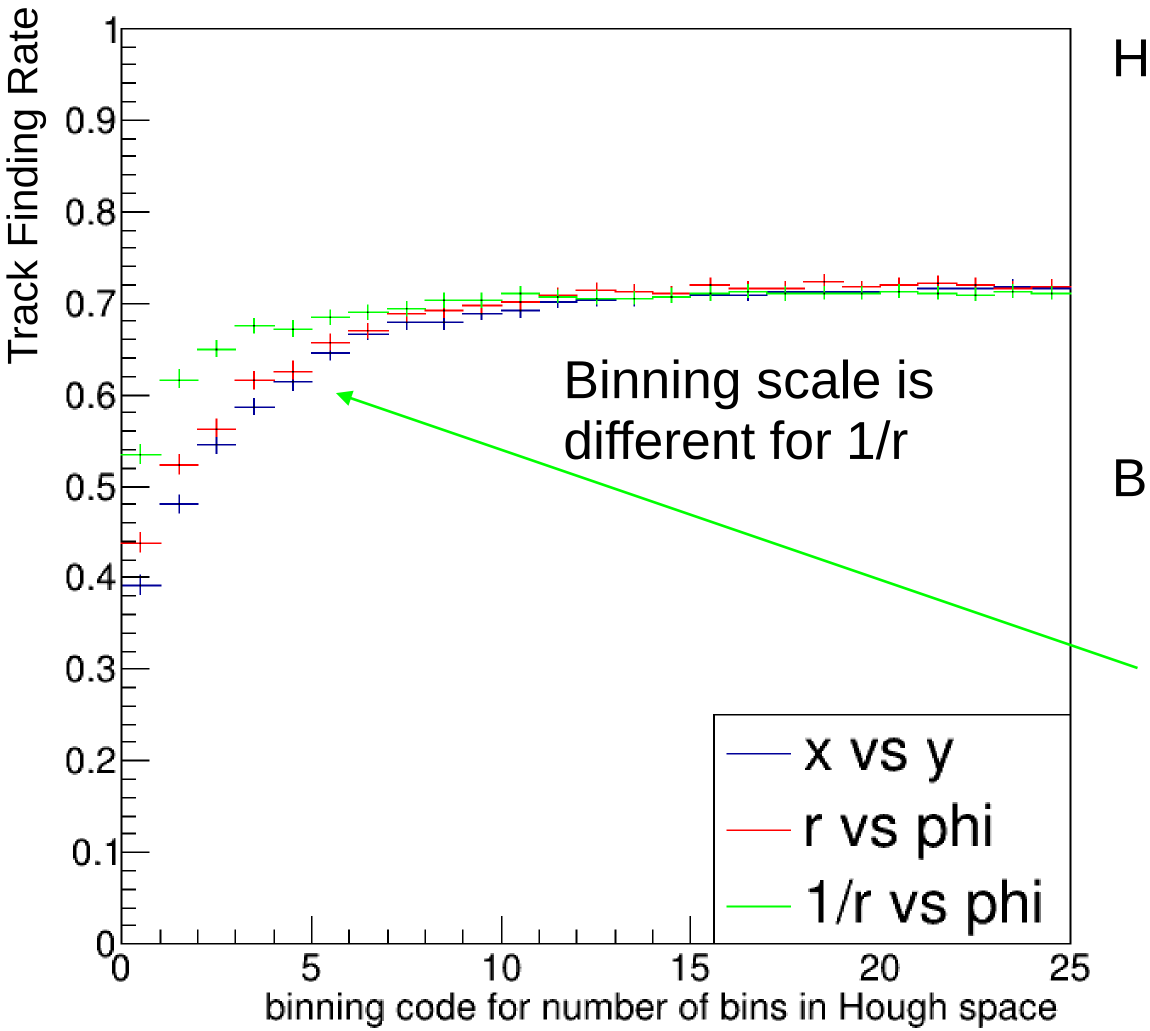
  - For high p_T → $r \to 0$



HOUGH SPACE PARAMETRISATION

Binning vs. Track Finding Rate



Hough spaces range:

$$x, y \in \{-150 < x, y < 150\}$$
$$r \in \{0 < r < 300\}$$
$$\varphi \in \{-180 < \varphi < 180\}$$
$$\frac{1}{r} \in \left\{0 < \frac{1}{r} < 1\right\}$$

Binning code (number of bins):

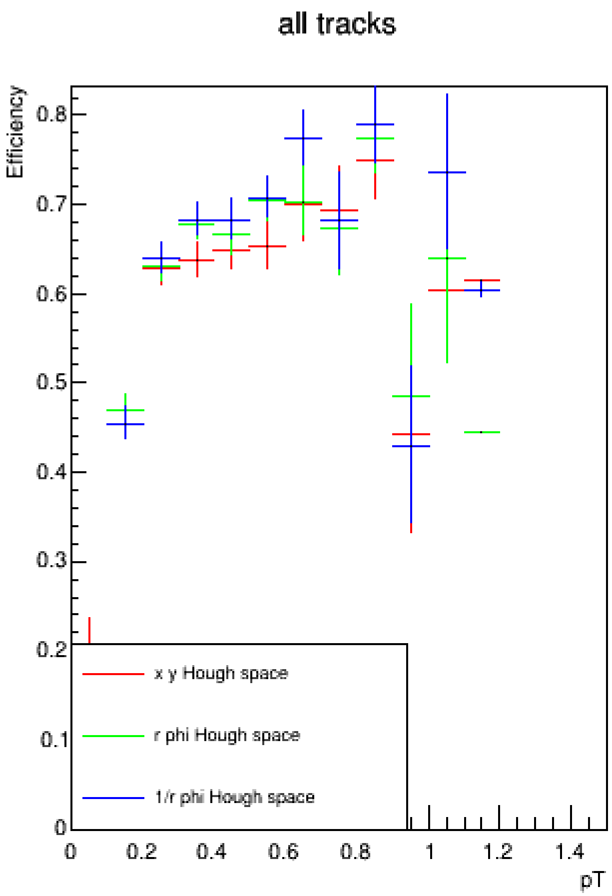
$$x = y = r = \varphi = 20 \cdot (binningcode + 1)$$
$$\frac{1}{r} = 500 \cdot (binningcode + 1)$$

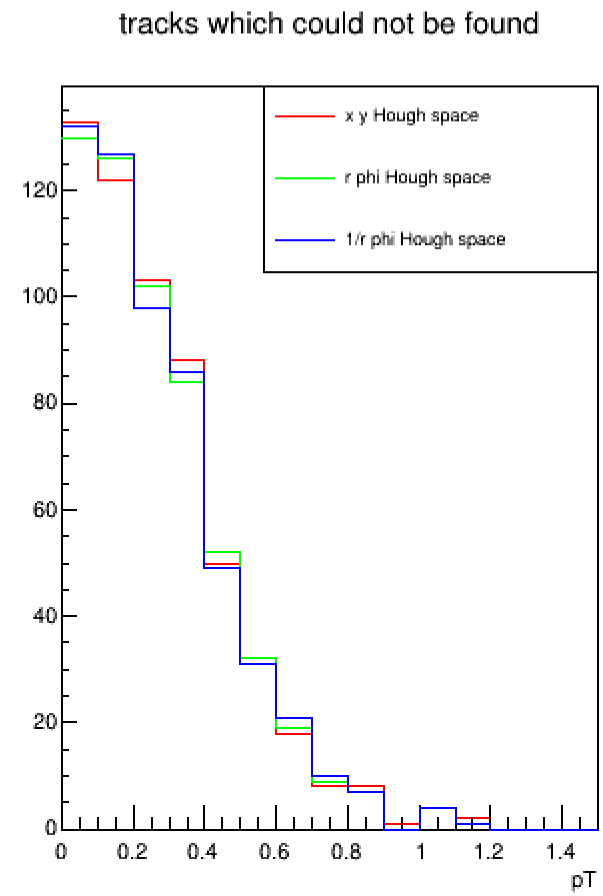
→ no difference for fine binning

→ 1/r needs a much finer binning to reach the same efficiency

HOUGH SPACE PARAMETRISATION

Efficiency vs. transverse momentum

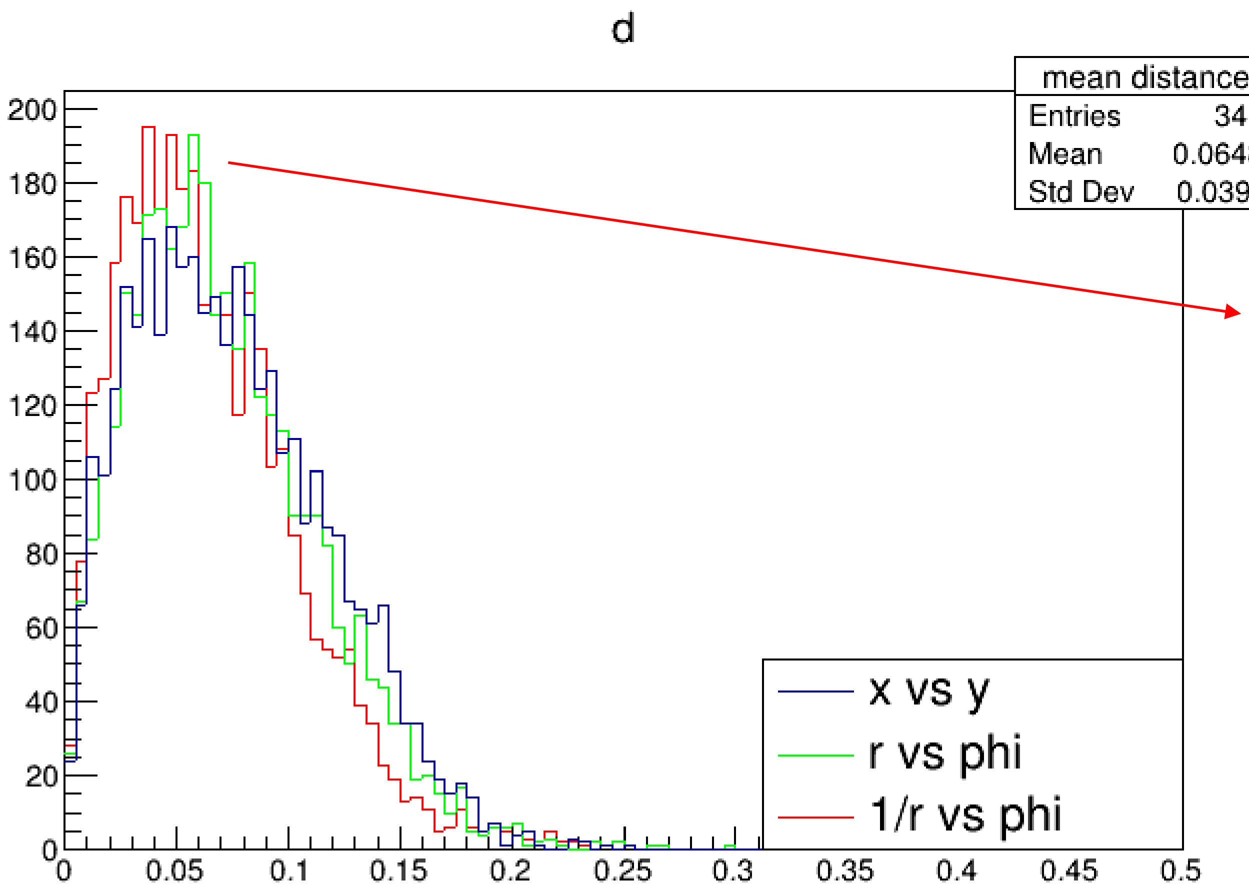




- No clear difference in momentum dependency
- Same momentum ranges could not be found
- → small p_T, curling tracks

HOUGH SPACE PARAMETRISATION

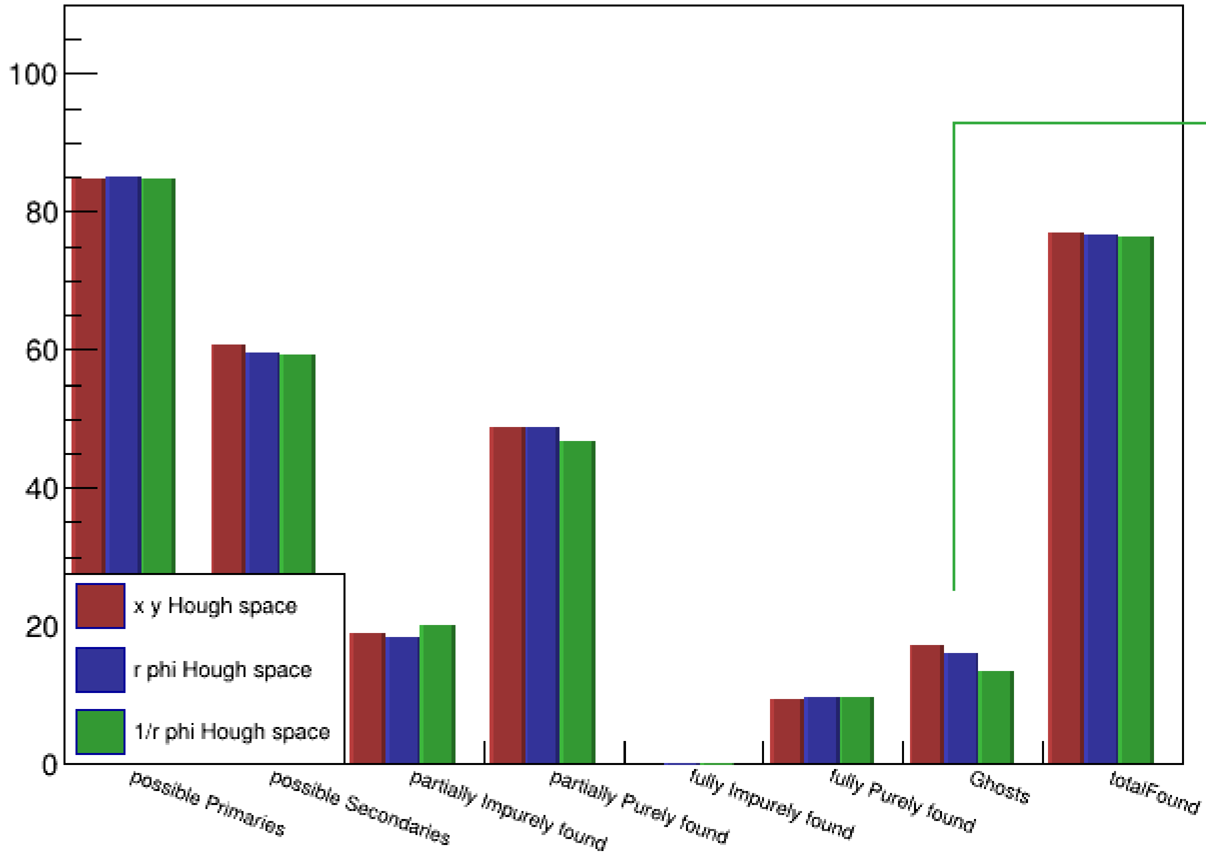
Distance hits to track



1/r leads to smallest distance to track and smallest standard deviation

HOUGH SPACE PARAMETRISATION

Difference of ghost ratio and efficiencies



1/r leads to smallest ghost ratio

→ higher computing time due to finer binning

OUTLINE

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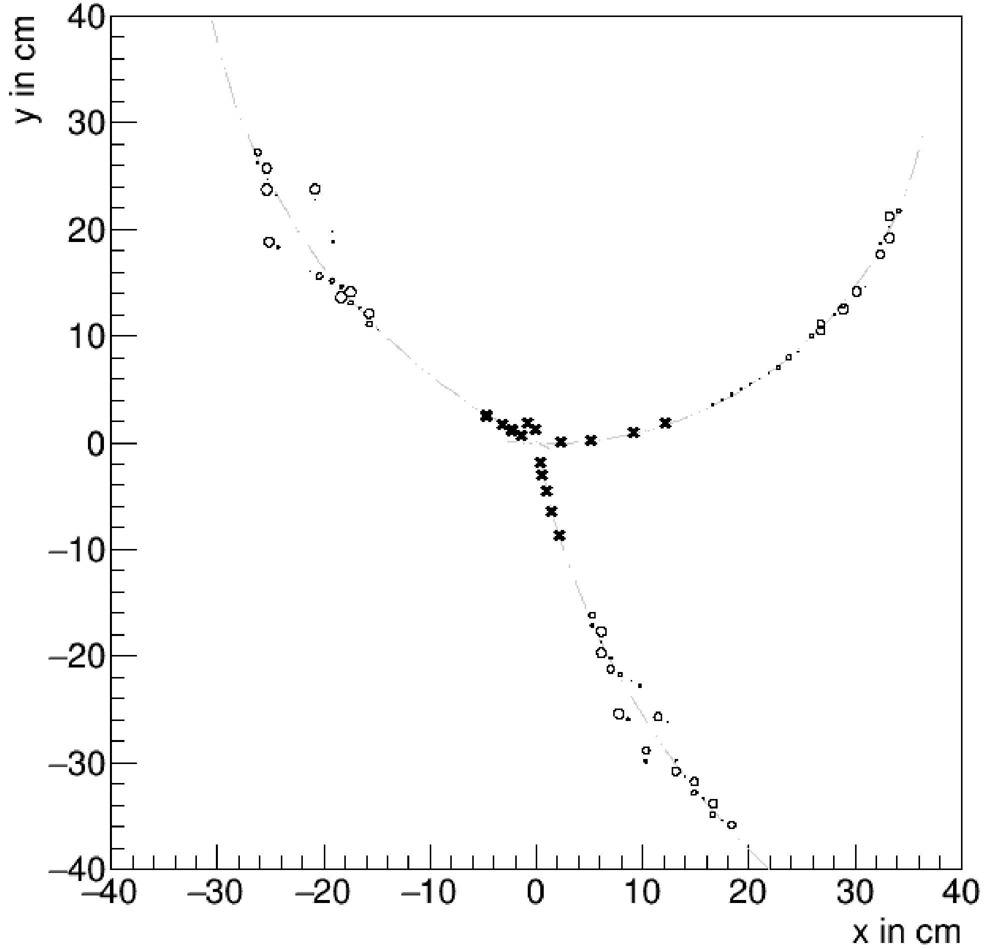
GHOST REDUCTION

Number of hits in track

- Idea:
  - Tracks need to pass the detector
  - → leads to a path consisting of a certain number of hits in a region
  - Example: A track that passes the STT also need to pass the MVD

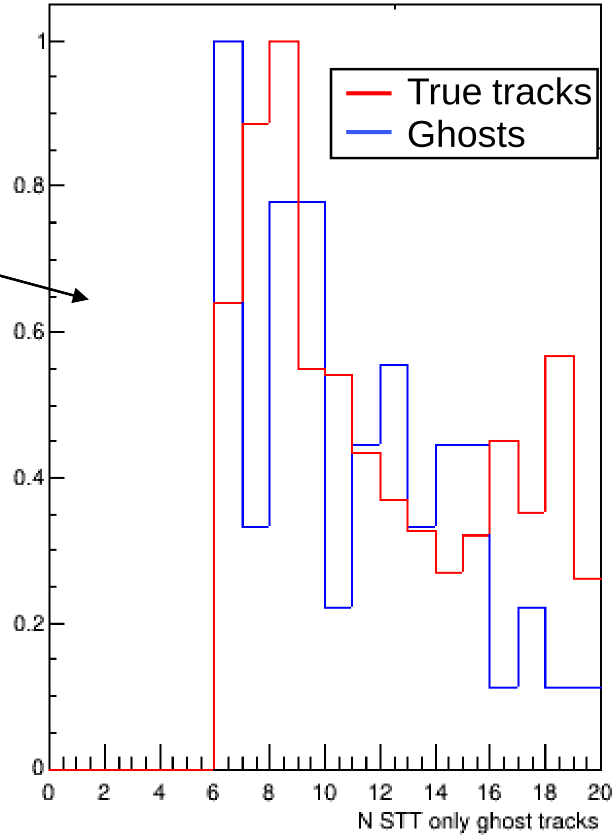


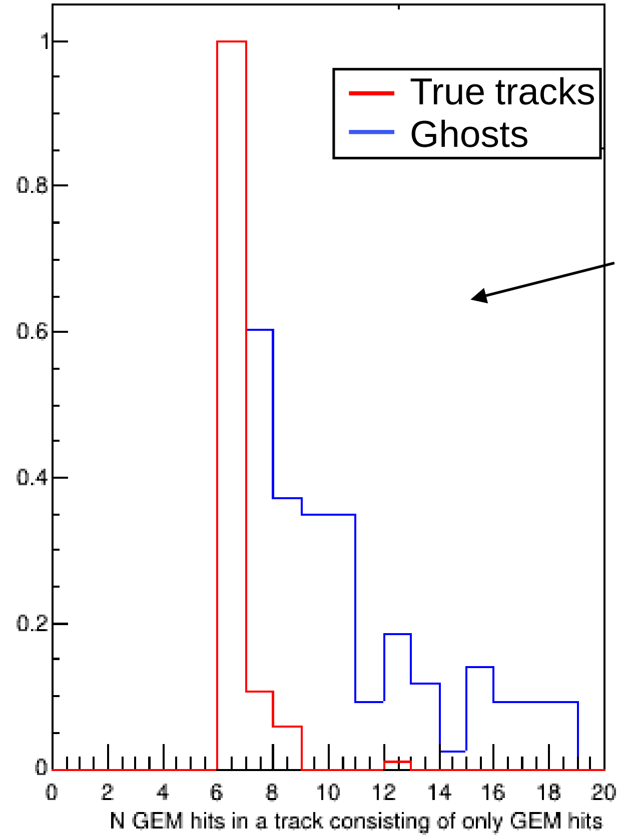
GHOST REDUCTION

Number of hits in track

Does a track that passes the STT also have to pass the MVD?
→ Determine number of hits of found tracks consisting of only one type of hits

Tracks consisting of only STT hits





Tracks consisting of only GEM hits

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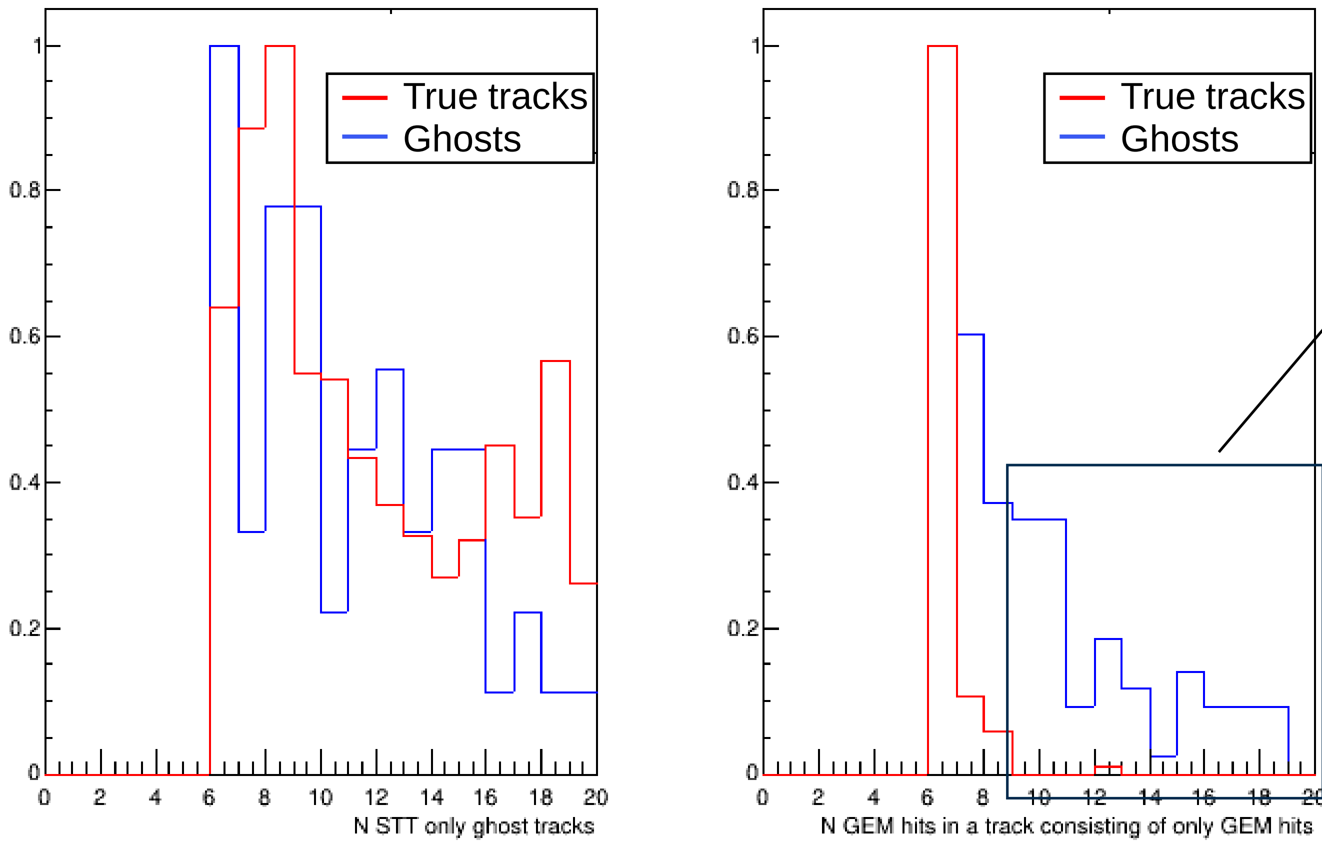


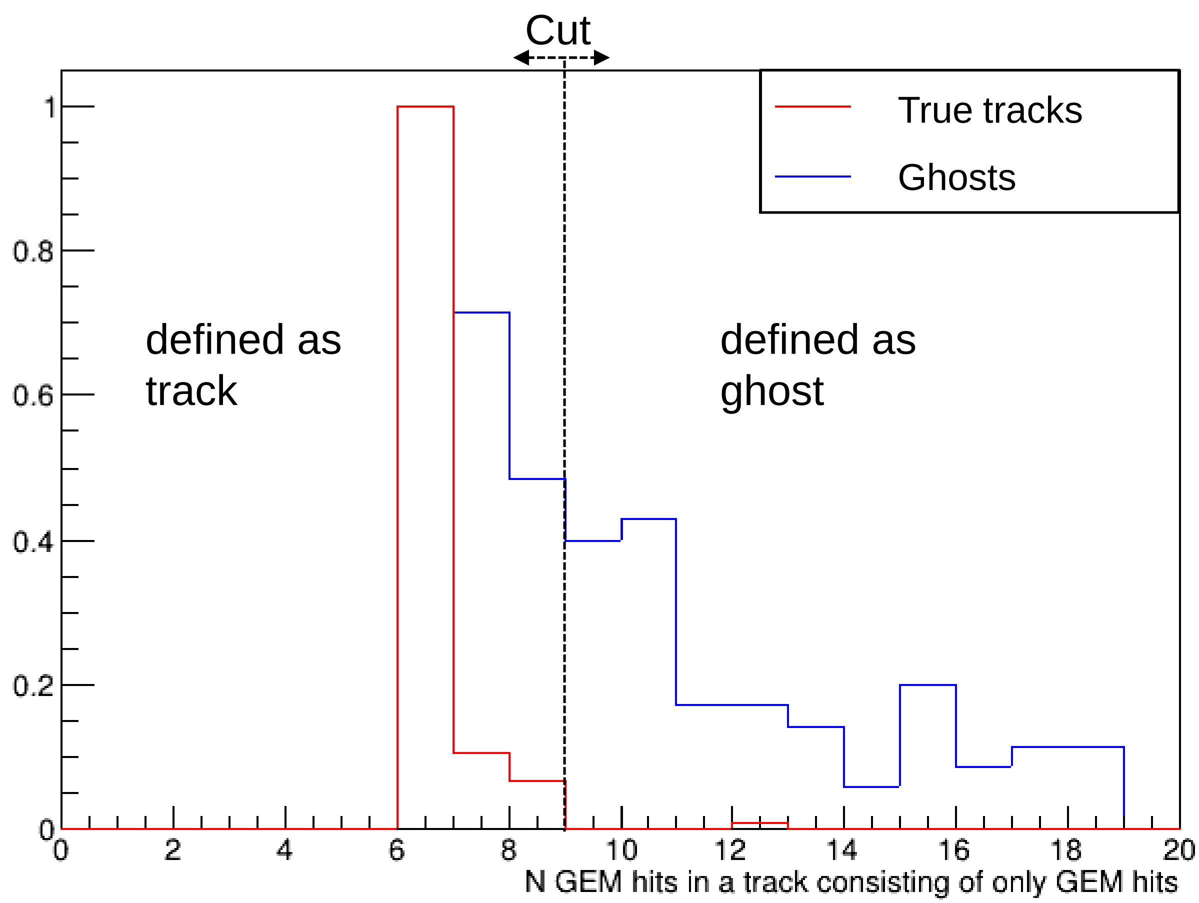
Tracks with many GEM hits often are ghosts

GHOST REDUCTION

Number of hits in track

Calculate ROC curve for GEM only tracks:

- define a cut value:
  - below this value everything is defined as track
  - above this value everything is defined as ghost



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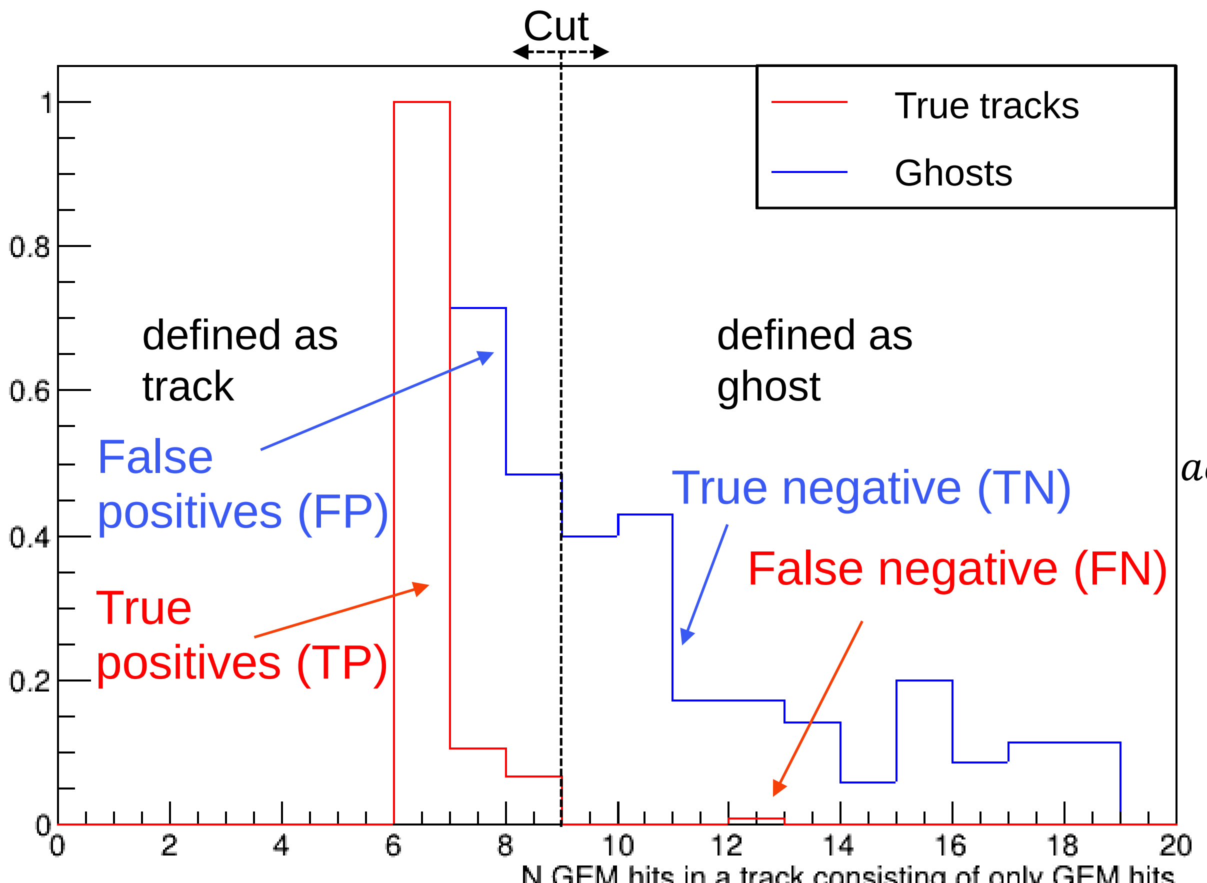


$$FPRate = \frac{FP}{FP + TN}$$

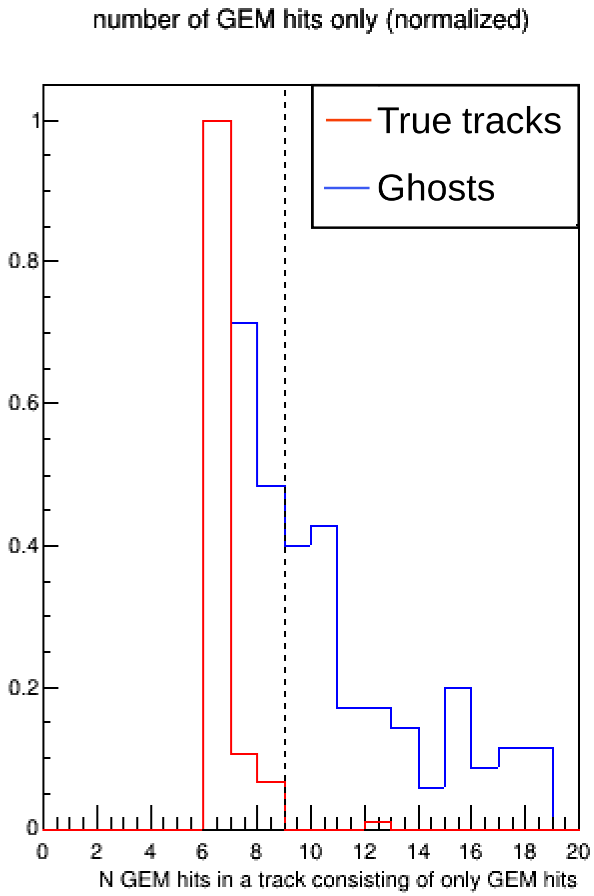
$$TPRate = \frac{TP}{TP + FN}$$

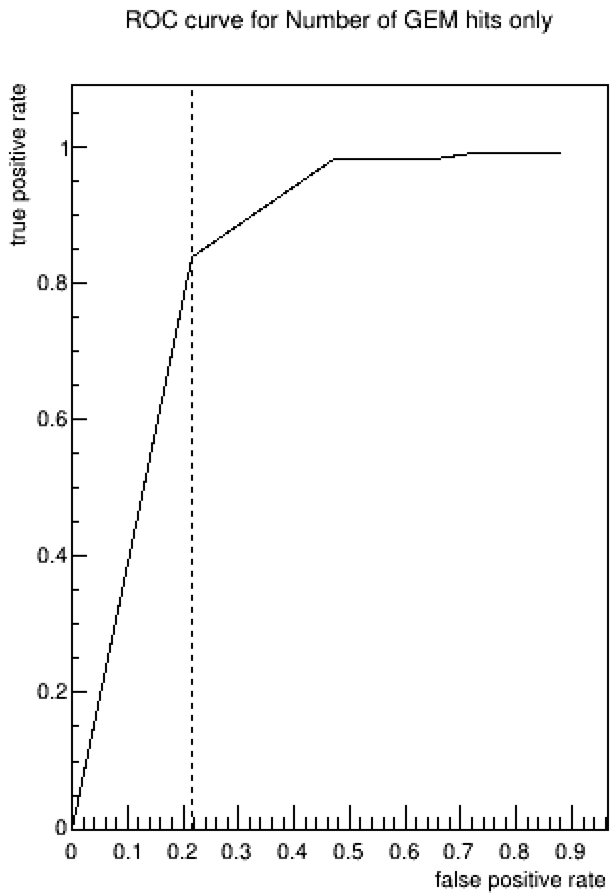
$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

GHOST REDUCTION

Number of hits in track

Calculate ROC curve for GEM only tracks





accuracy	70.8 %
False Positive Rate	50.0 %
True Positive Rate	98.4 %
False Negative Rate	1.6 %
True Negative Rate	50.0 %
Reduction of ghosts	1.9 %
Reduction of possible primaries	0.3 %

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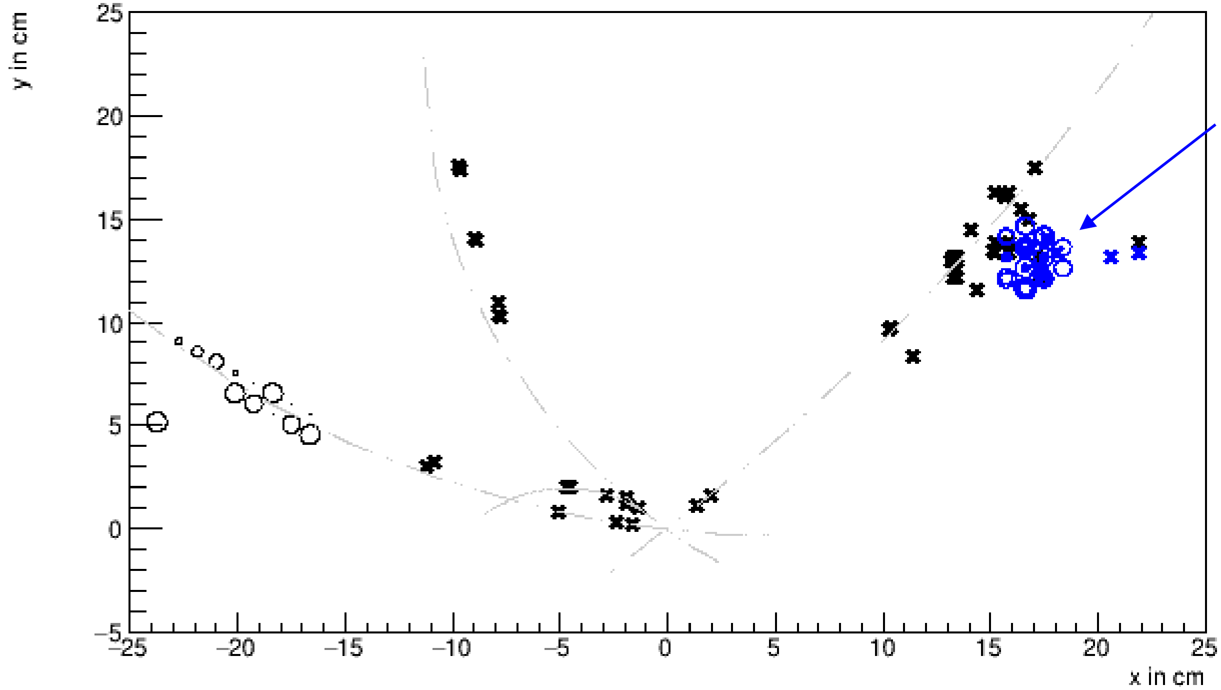
GHOST REDUCTION

Number of Neighbors (STT)

Curling tracks lead to a lot of clones or ghosts
→ have more neighbors
→ use STT neighborhood relations



curling track
→ „blob“ of STT hits

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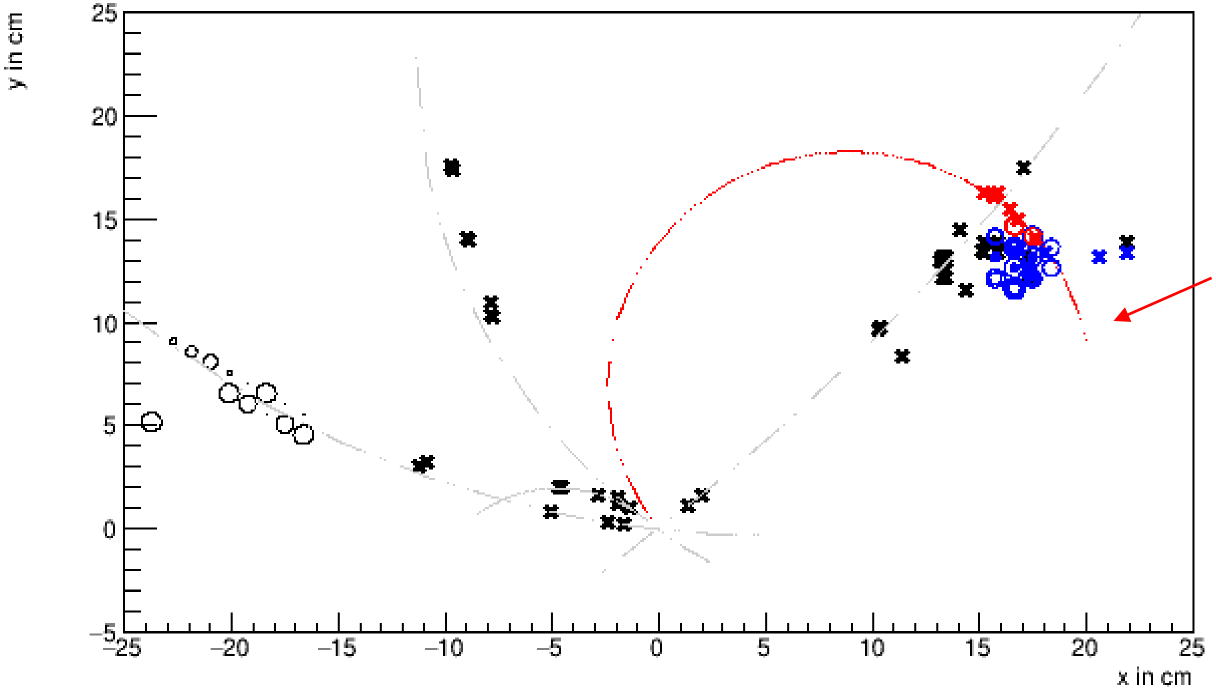


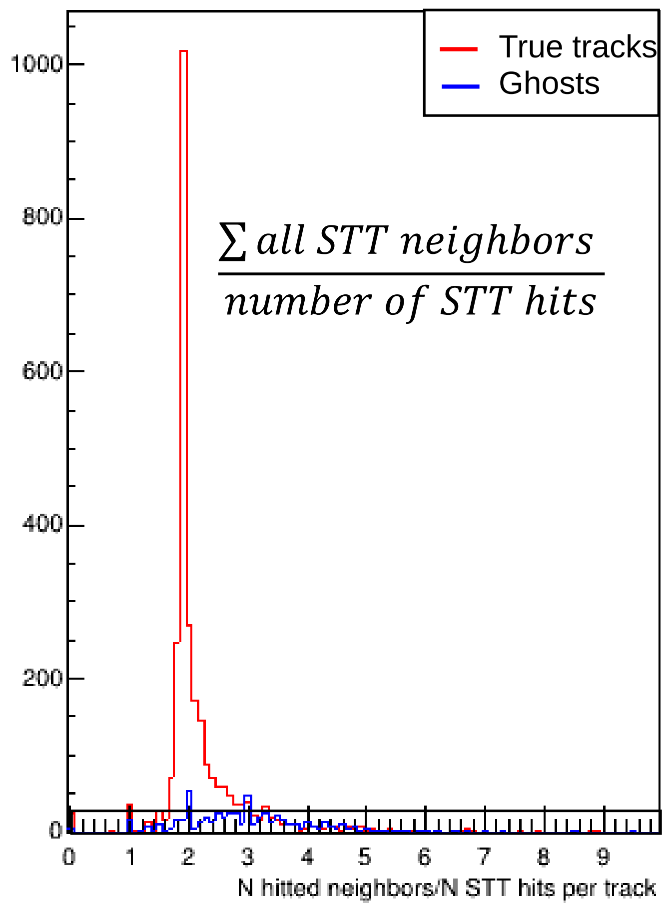
curling track
→ „blob“ of STT hits

→ ghost

GHOST REDUCTION

Number of Neighbors (STT)

Calculate average number of STT neighbors per hit



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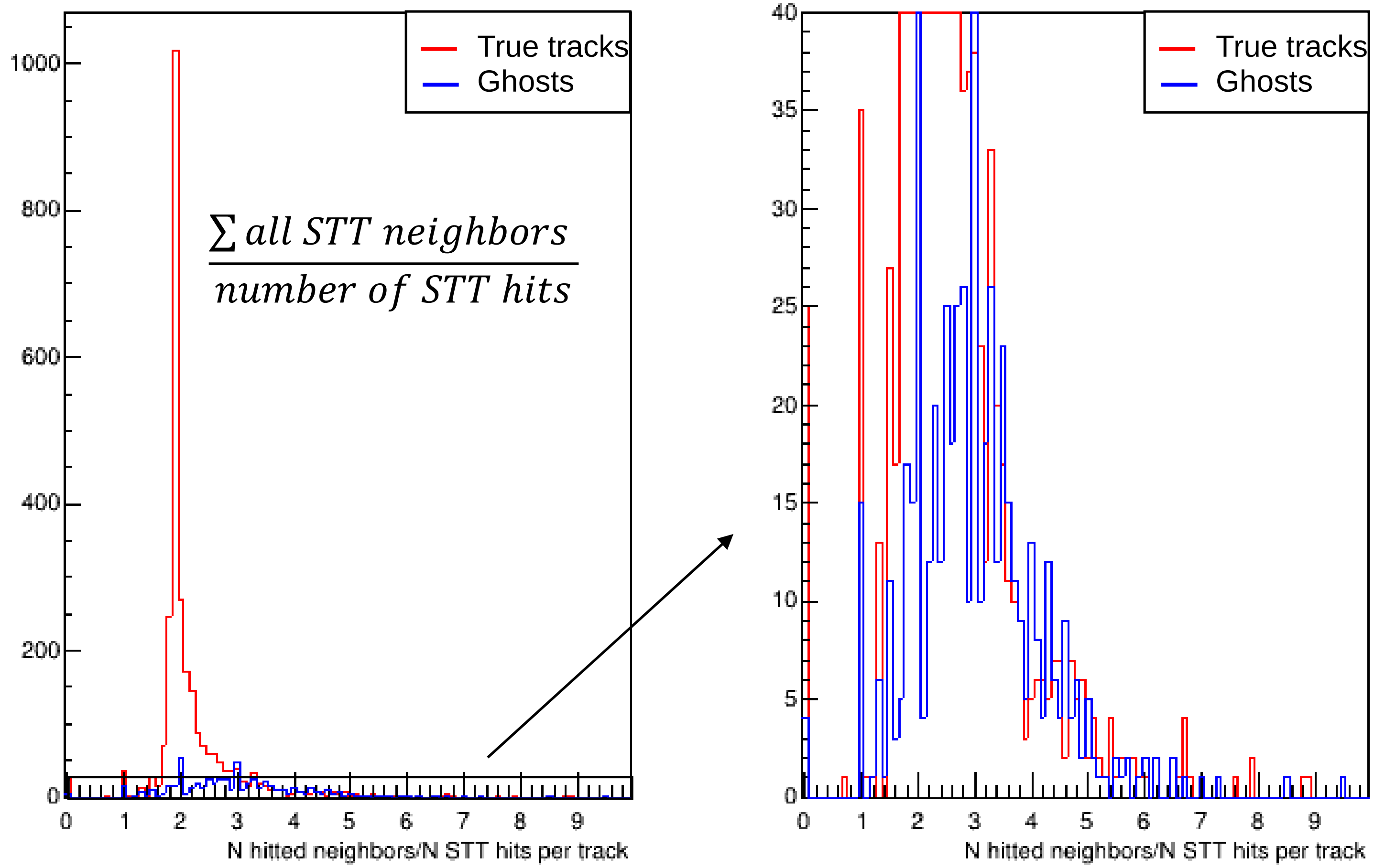

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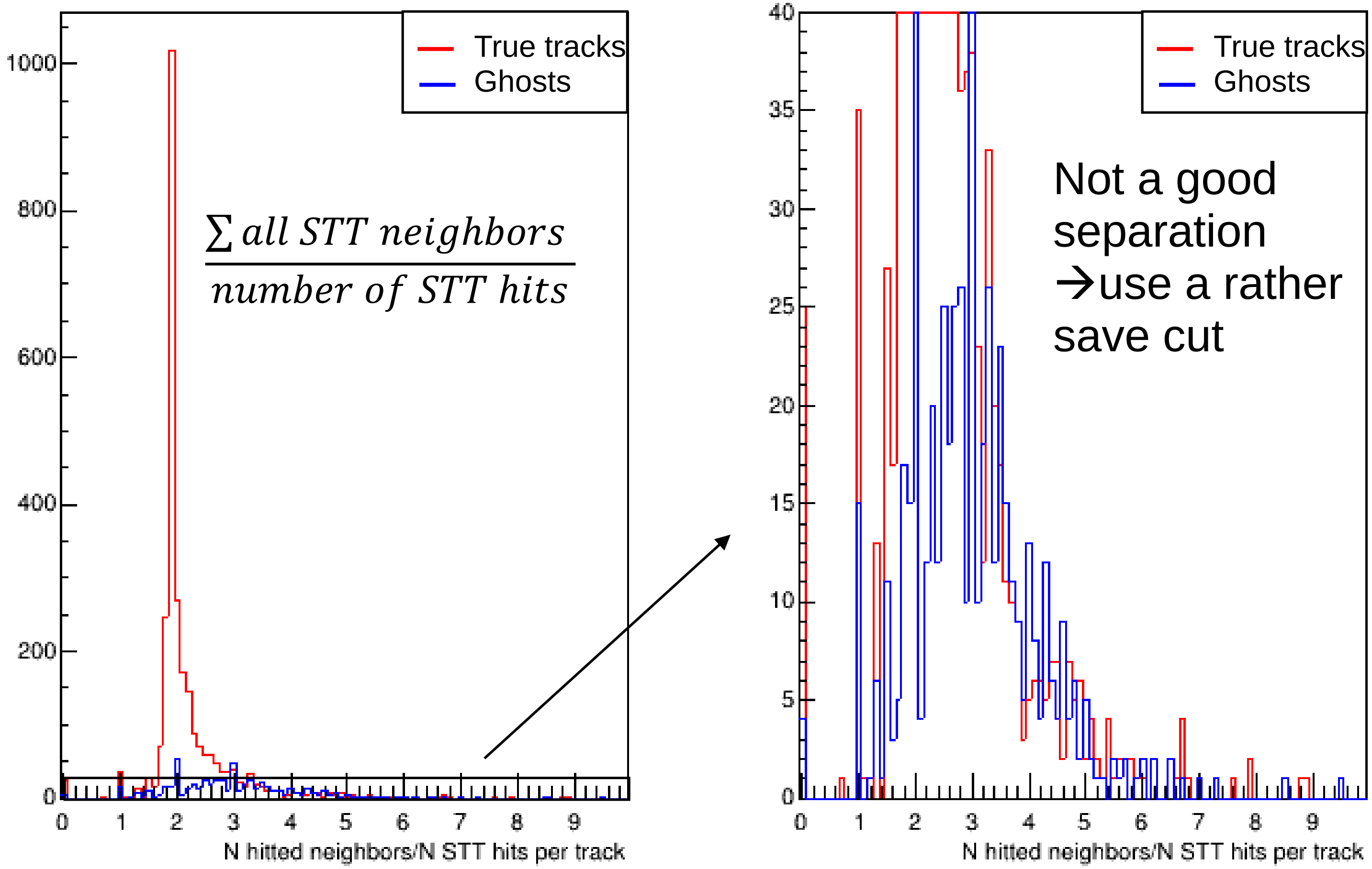
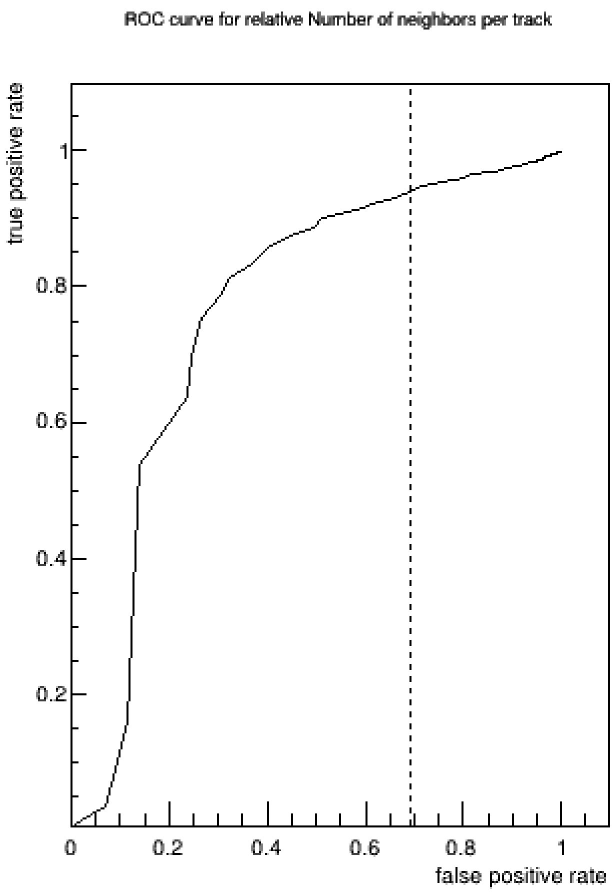


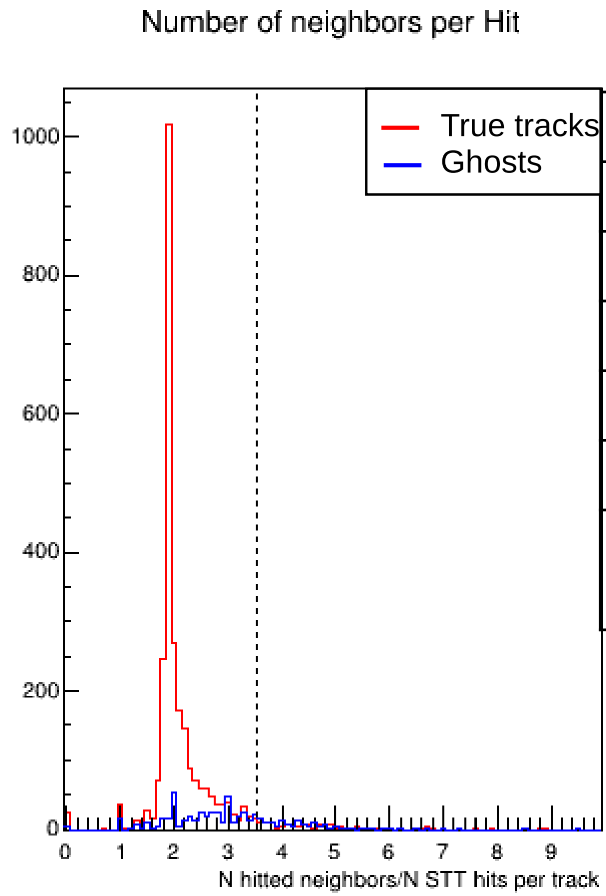
$$\frac{\sum all\ STT\ neighbors}{number\ of\ STT\ hits}$$

GHOST REDUCTION

Number of Neighbors (STT)

Calculate average number of STT neighbors per hit
→ ROC calculation





Accuracy	83.9 %
False Positive Rate	70.4 %
True Positive Rate	94.9 %
False Negative Rate	5.1 %
True Negative Rate	29.6 %
Reduction of ghosts	4.0 %
Reduction of possible primaries	0.8 %

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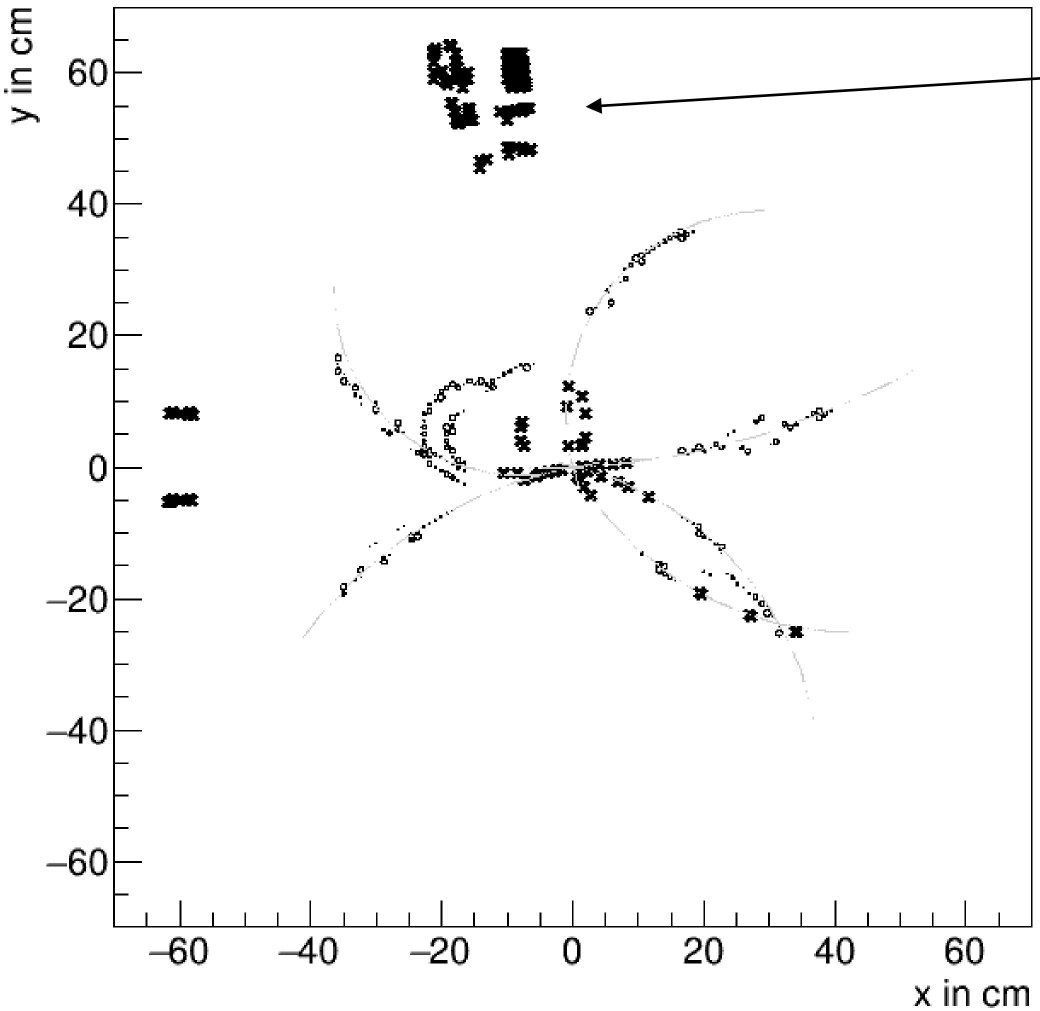
GHOST REDUCTION

Number of Neighbors (GEM)



GEM „blobs“ lead to many ghosts

→ Similar to STT „blobs“

→ no neighborhood relation as for STT exist

GHOST REDUCTION

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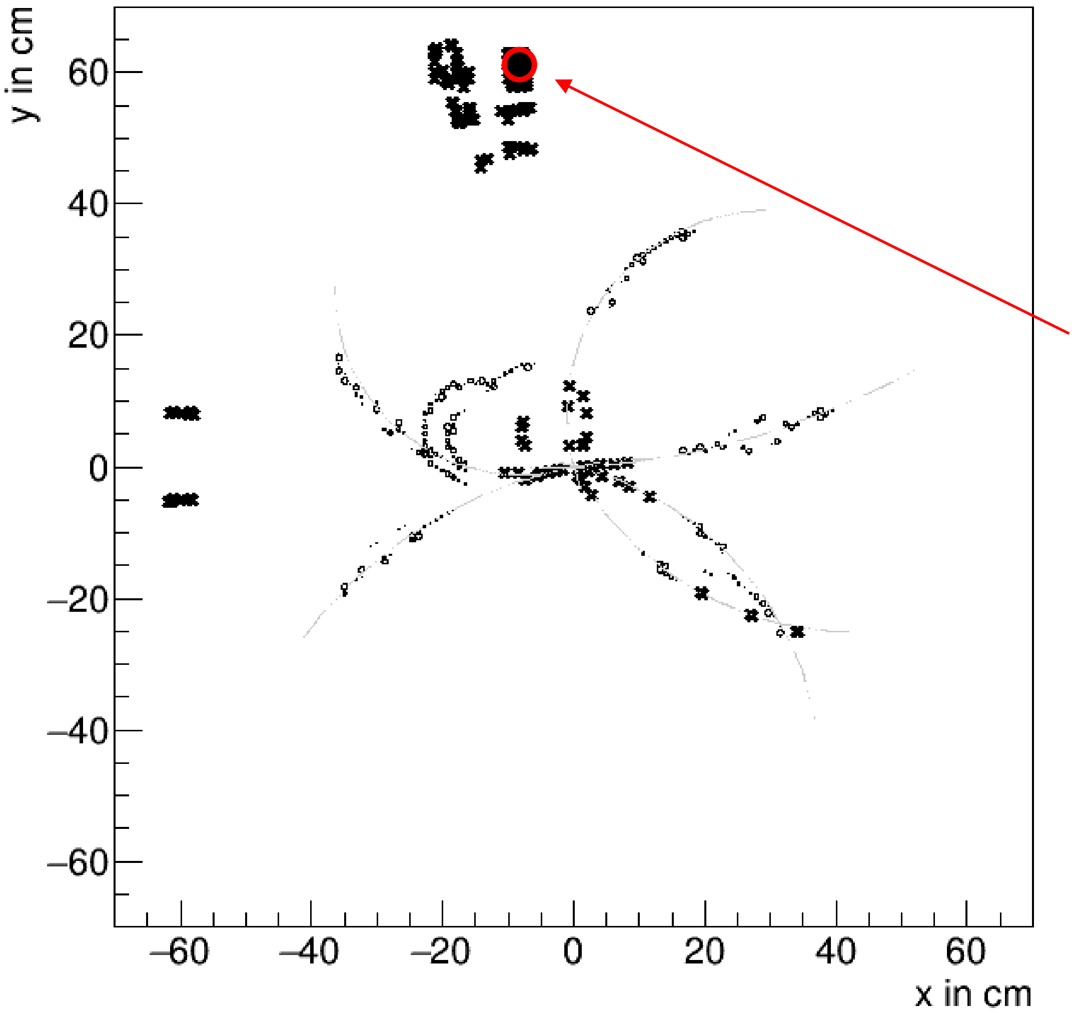


GEM „blobs“ lead to many ghosts
→ Similar to STT „blobs“
→ no neighborhood relation as for STT exist

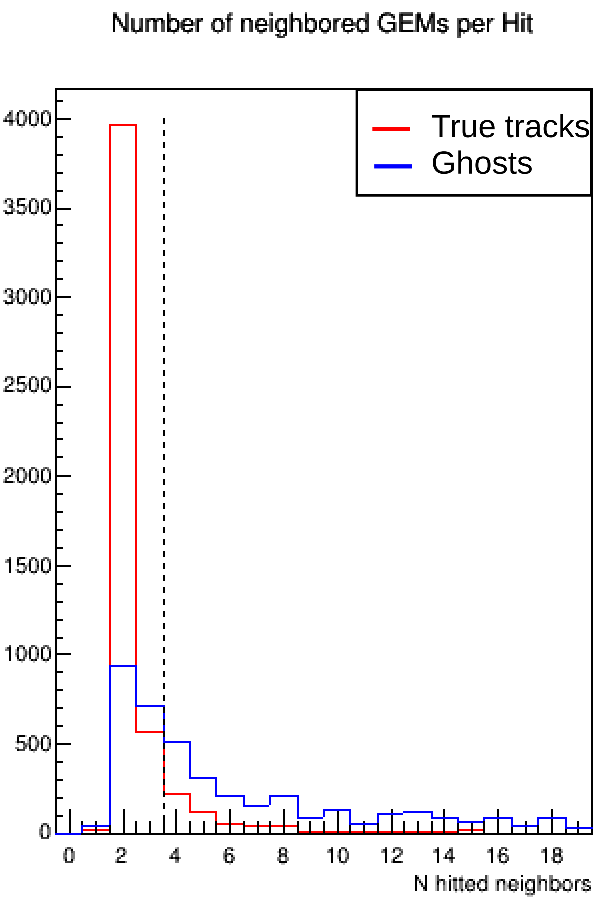
→ Define a region around a GEM hit where all other GEM hits are counted

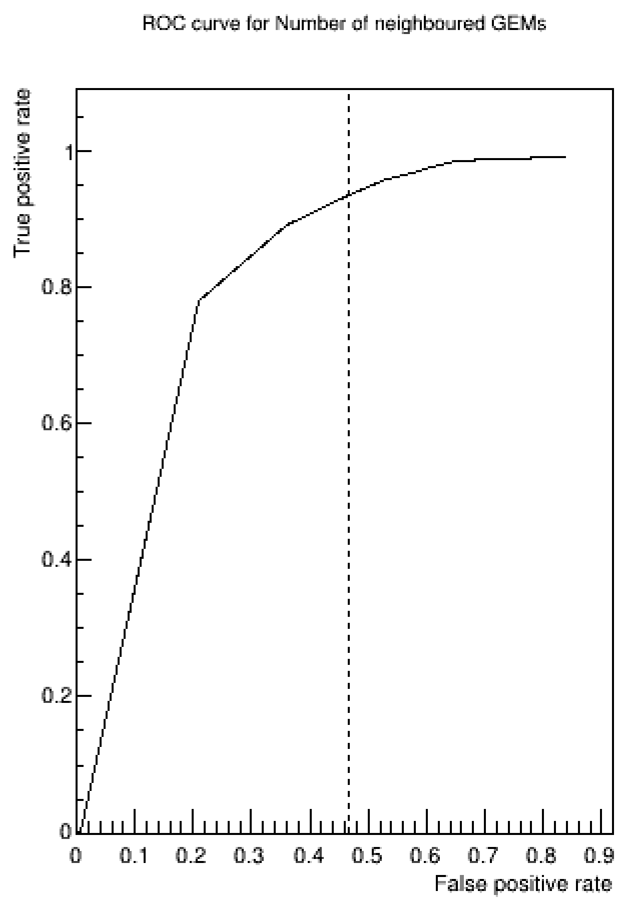
in this example: 29 GEM hits inside the region

GHOST REDUCTION

Number of Neighbors (GEM)

ROC analysis





Accuracy	74.2 %
False Positive Rate	46.7 %
True Positive Rate	93.6 %
False Negative Rate	6.4 %
True Negative Rate	53.4%
Reduction of ghosts	9.7 %
Reduction of possible primaries	3.5 %

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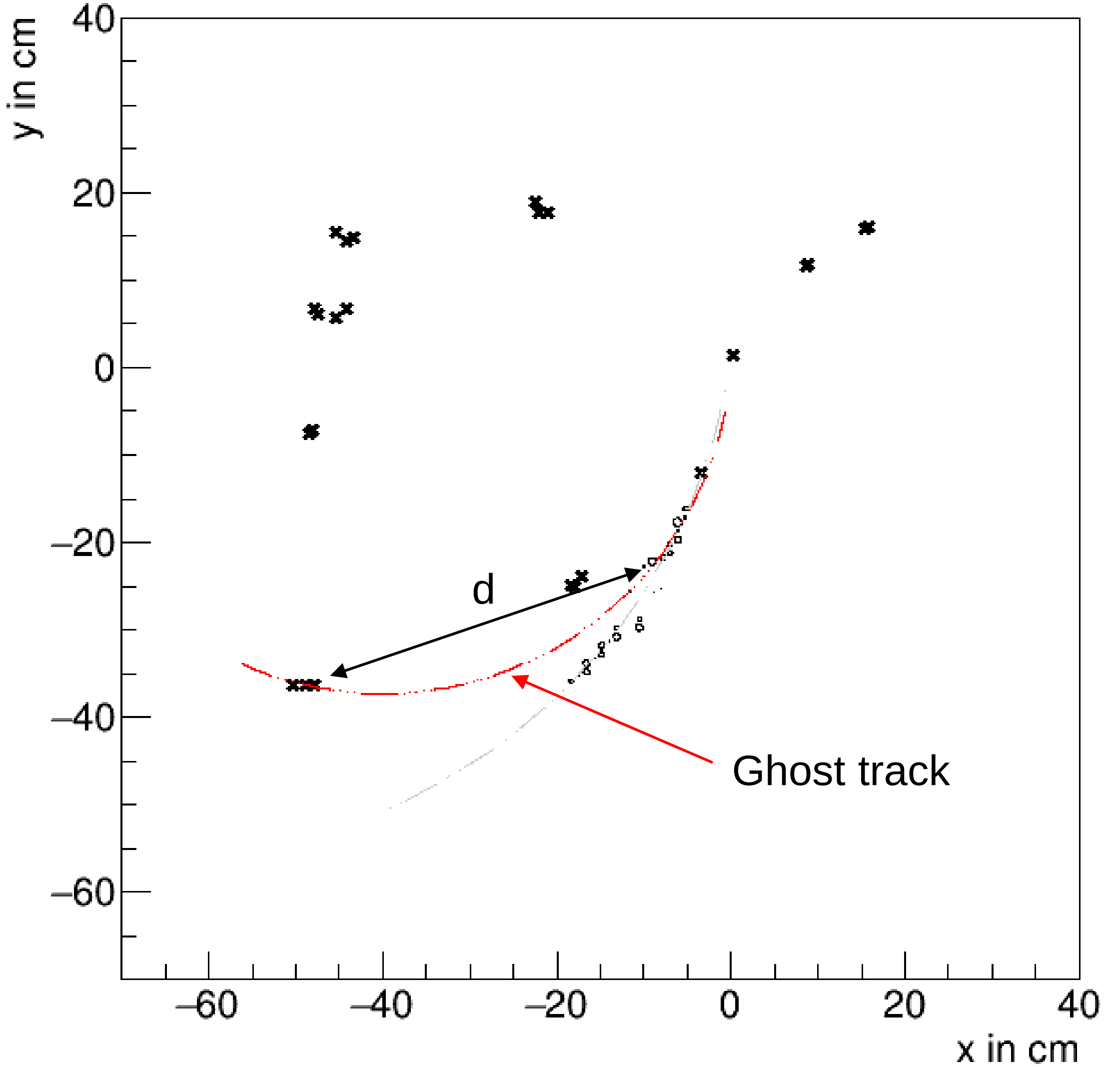
GHOST REDUCTION

Distance between Hits



ghost tracks are created by using hits of :

- not reconstructable tracks
- hits not assigned to the correct track

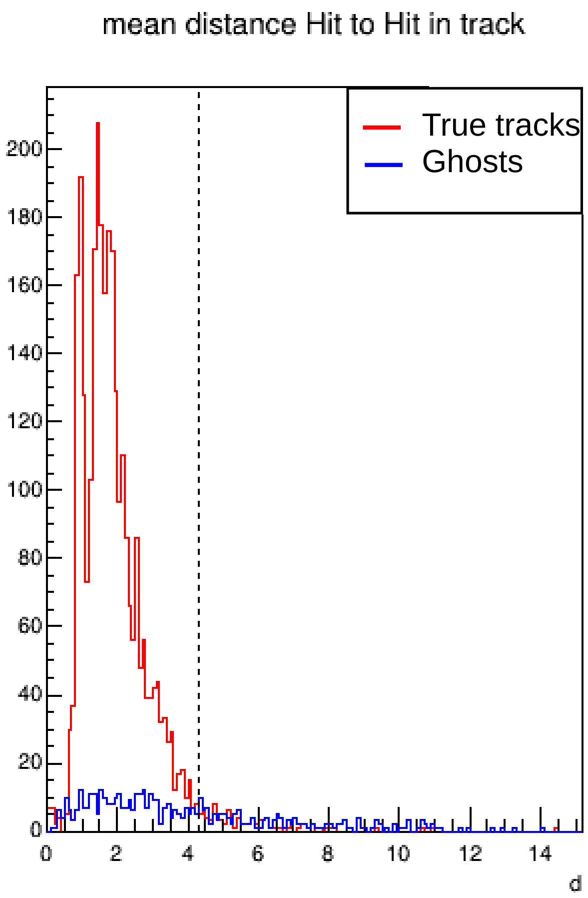
→ Ghost tracks can contain hits from different detector regions

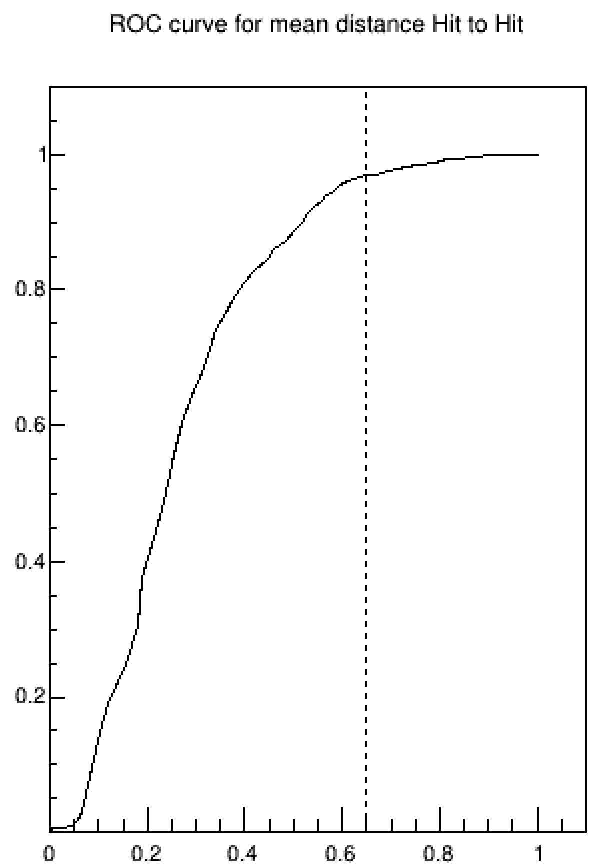
→ Assumption: mean distance between hits is larger

GHOST REDUCTION

Distance between Hits

ROC analysis





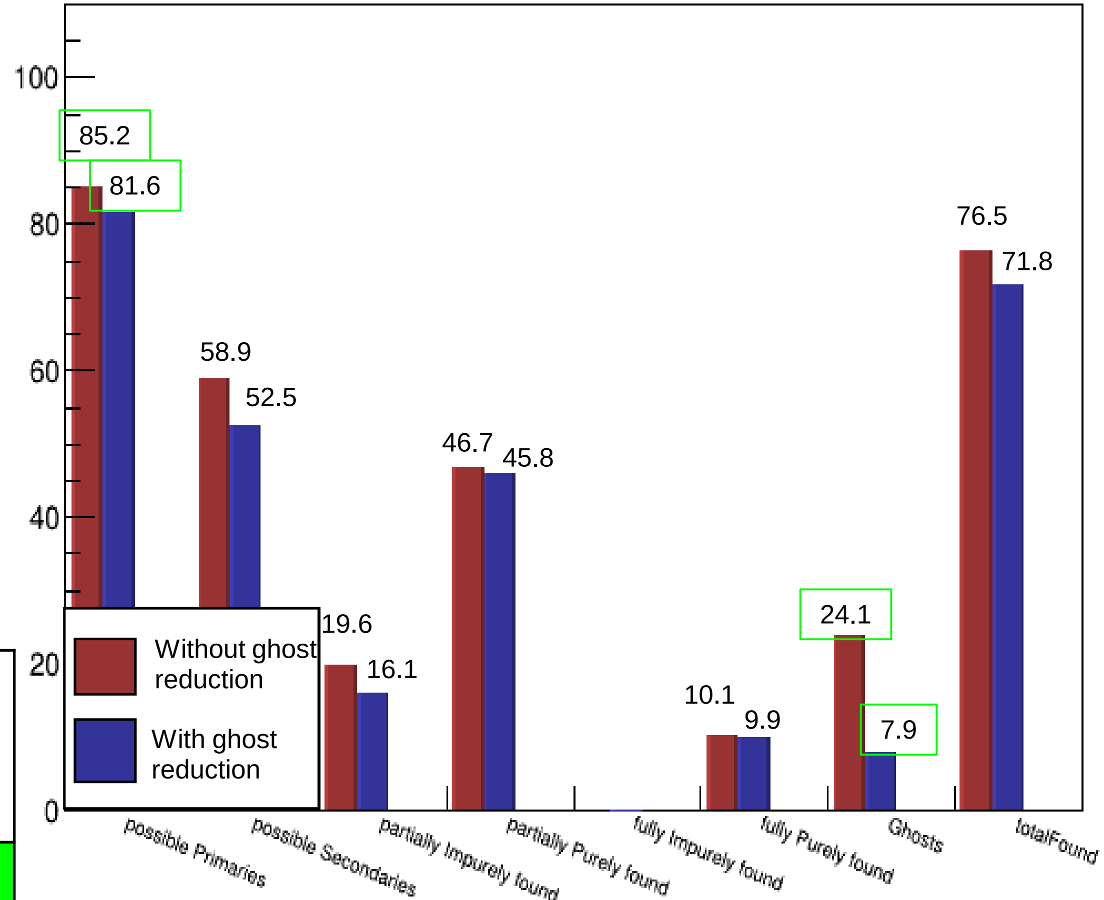
Accuracy	81.6 %
False Positive rate	69.9 %
True Positive rate	96.1 %
False Negative rate	3.9 %
True Negative rate	30.1 %
Reduction of ghosts	6.9 %
Reduction of possible primaries	2.4 %

RESULTS

Parameter Study to Reduce the Ghost Ratio

- Total ghost reduction depends on order of cuts (sequential cuts)
- Best order still under investigation
- First result for order:
  1. distance between hits
  2. number of neighbors (GEM)
  3. number of hits in track
  4. number of neighbors (STT)

Parameter	Ghost reduction abs. (rel.)	Efficiency loss abs. (rel.)
Total	16.2 (67.2 %)	3.6 (4.2 %)



RESULTS AND OUTLOOK

Investigation:

- Hough space parametrization:
  - x – y – space
  - r – φ – space
  - 1/r – φ – space
- ghost reduction:
  - number of hits in track
  - number of neighbors (STT)
  - number of neighbors (GEM)
  - distance between hits

Outlook:

- order of cuts
- secondaries

Results:

1/r - φ – space
less ghosts, smallest distance to track
Higher computing time

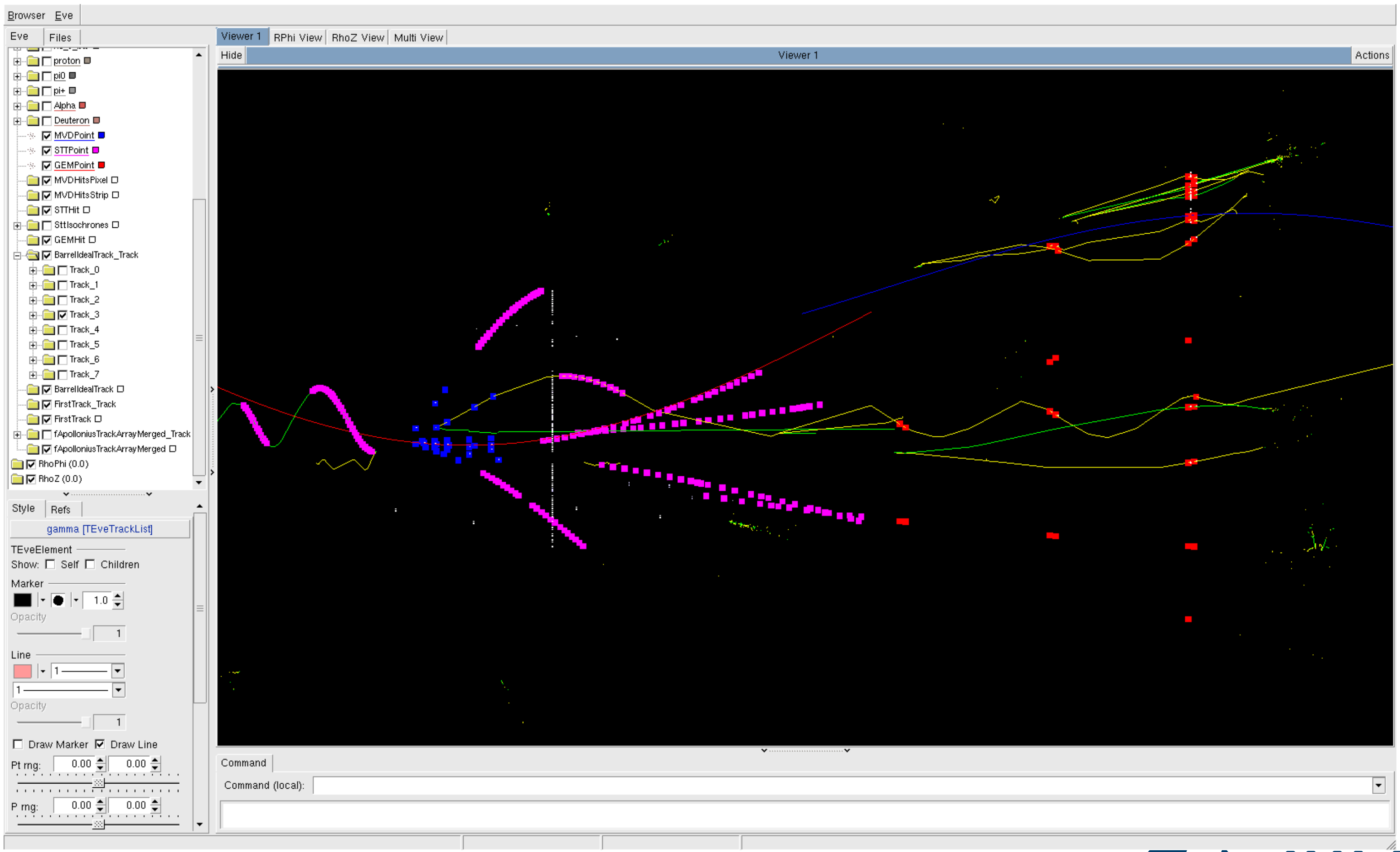
Ghost reduction abs. (rel.)	Efficiency loss abs. (rel.)
16.2 (67.2 %)	3.6 (4.2 %)

THANK YOU FOR YOUR ATTENTION!

BACKUP

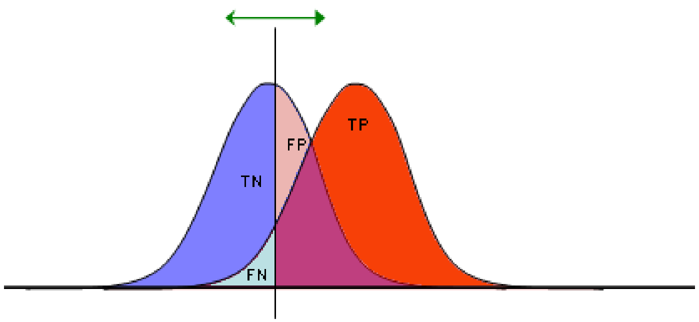
GHOST REDUCTION

Number of Neighbors (GEM)



ROC ANALYSIS

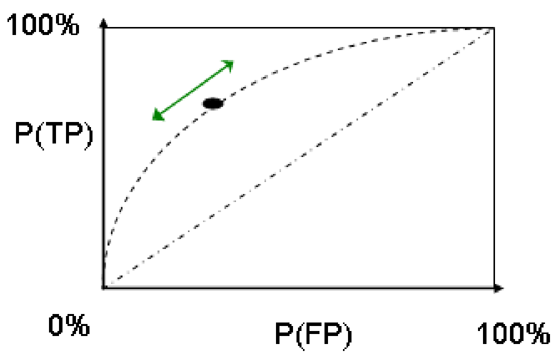
Definition of false positive rate, true positive rate and accuracy



TP	FP
FN	TN
1	1

$$FPRate = \frac{FP}{FP + TN}$$

$$TPRate = \frac{TP}{TP + FN}$$



$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

From: https://de.wikipedia.org/wiki/ROC-Kurve