Secondary Track Finder
- status -

Lia Lavezzi
University of Torino & INFN-Torino

LII PANDA Collaboration Meeting
Giessen - March, 16-20, 2015
Pattern Recognition Day

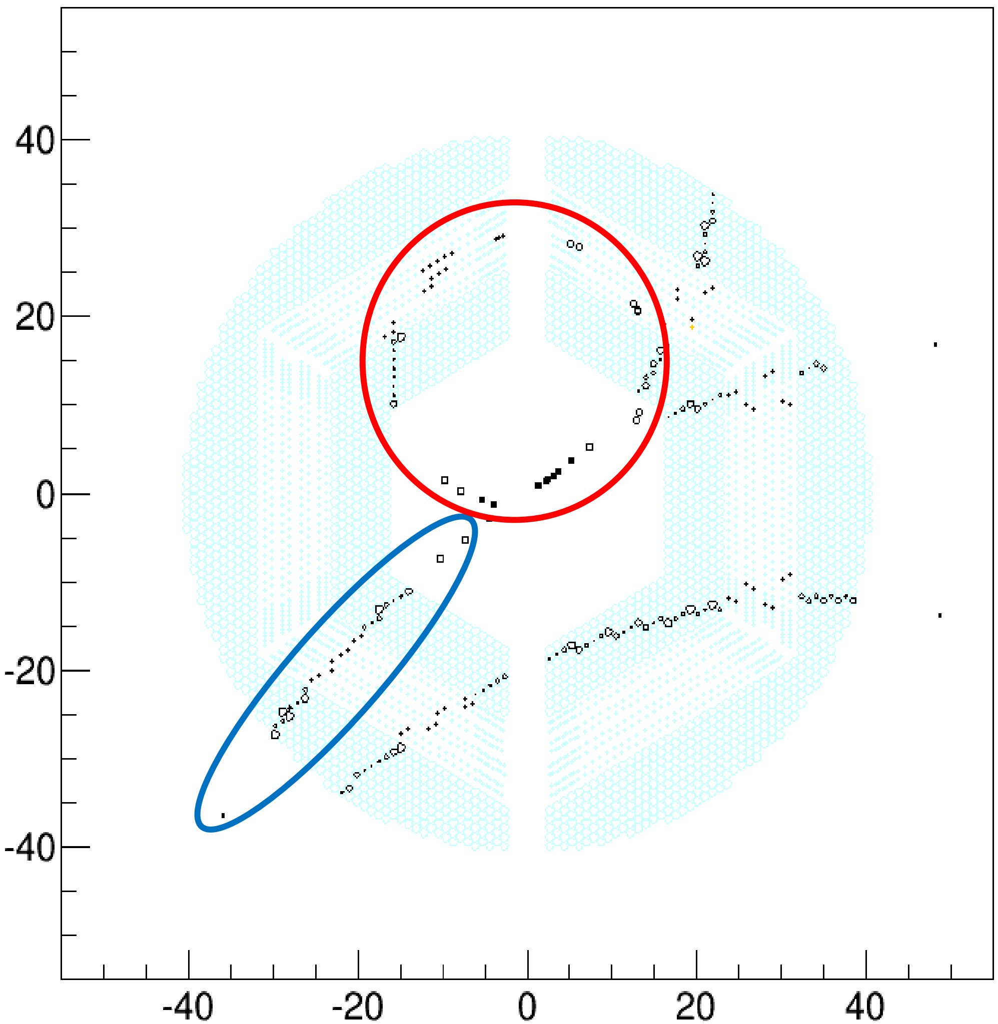
Summary

- Secondary track finder code status
- Tests @ different displaced vertices:
  - in radial direction
  - in longitudinal direction
- Tests with $\bar{\Lambda}\Lambda$ events, phase space model
- Tests with $\bar{\Lambda}\Lambda$ events, boosted model
- Conclusions

The track finding procedure

Track Finding Procedure

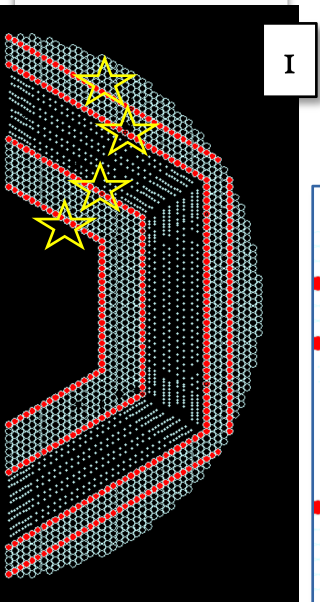
xy plane

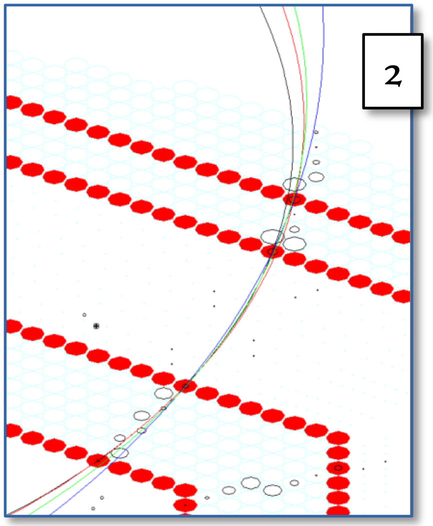


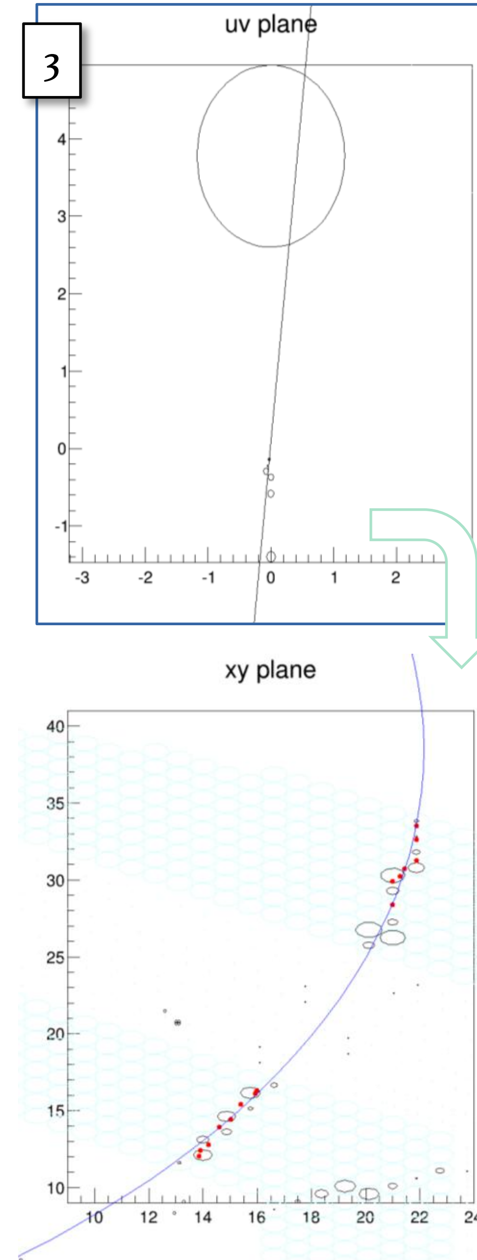
- As usual, the TF finds the tracks in the *xy* plane and then in the $z\phi$ plane
- Several issues:
  - displaced vertices → no (0, 0, 0) constraint
  - low momentum particles
  - forward boost → low θ angle
- Different problems are treated in different parts of the code
- Up-to-now:
  - "*Long*" tracks
  - "*Forward*" tracks

Long Tracks – track finder

ALREADY SHOWN @ LAST CM







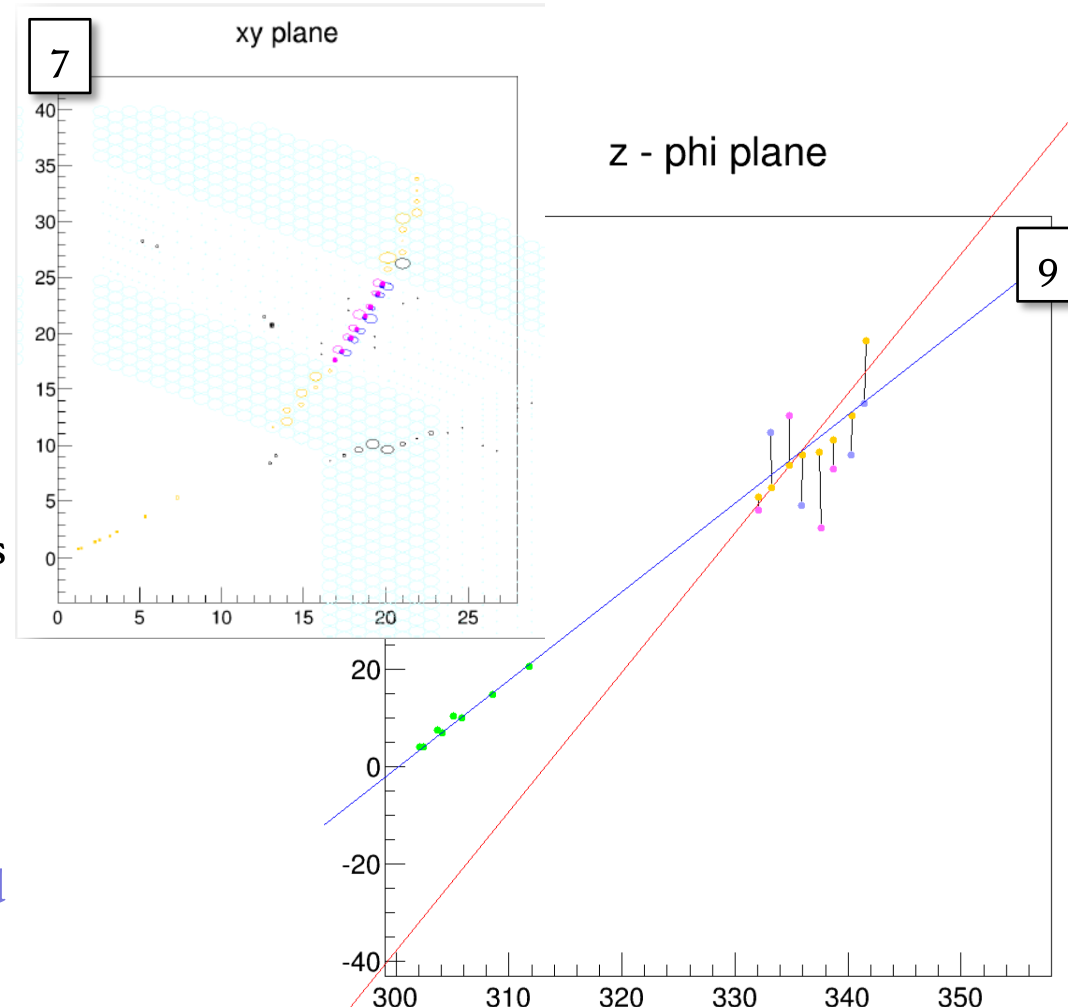
1. A quadruplet of hits on the pivotal layers 0, 7, 16 and 20 are found in the STT
2. The circles through 3 out of these 4 hits are found (all combinations) → mean value
3. A fit is performed via the Legendre transformation in the Conformal plane

4. The tracklet is formed with hits from:
   i. MVD pixel @ distance < 1 cm in sector ± 1
   ii. MVD strip @ distance < 1 cm in sector ± 1
   iii. STT @ distance < 1 cm in the same sector(s)
   iv. GEM @ distance < 1.5 cm in sector ± 1 and radial distance > 42 cm
   v. SciTil @ distance < 10 cm

Long Tracks – track finder

ALREADY SHOWN @ LAST CM

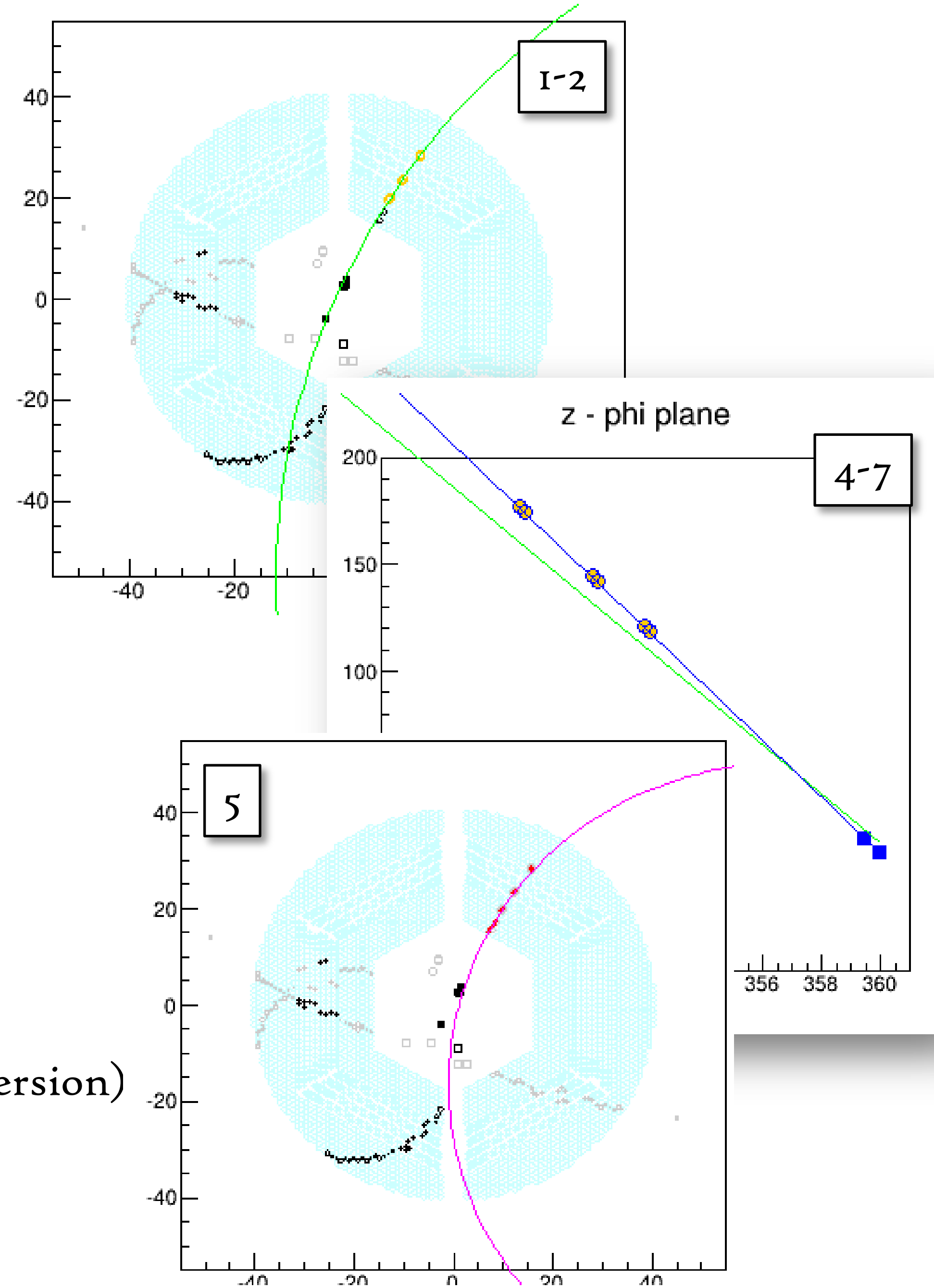
5. An Analytical Fit finds the final *xo*, *yo*, *R* parameters
6. The final *xy* track candidate is then formed with MVD, STT, GEM (and SciTil) hits
7. The *z* finder finds the intersections of the STT skewed tubes to the *xy* circle
8. MVD, GEM and SciTil hits (with *z*!) are added
9. A $z\phi$ plane fit with a straight line is performed to obtain the last two track parameters, *tan*λ and *zo*



PndTrack and PndTrackCand are filled

Forward Tracks – track finder

1. Make a tracklet **out of GEM hits**
2. Compute one hit for each station → 3 hits → circle, which is the first track hypothesis
3. Create a tracklet adding MVD pixel, MVD strip, STT hits @ distance < 3 cm
4. Make a first estimate of $z\phi$ with MVD & GEM to clean the tracklet
5. Go back to *xy* plane and perform an analytical fit
6. Create the final track candidate with MVD, STT, GEM and a hit-to-track distance < 0.5 cm
7. The following *z* procedure is the same as in *long* track case



Long tracks part of code has been quite refined
Forward tracks part of code still has to be refined (1° version)

Test @ different radial/longitudinal distances

Primary *vs* Secondary TF

- Study of the performances of the secondary *vs* primary track finder
- 5000 events of $\bar{p}p \rightarrow \bar{\Lambda}\Lambda$ @ beam mom = 4 GeV/c
- Decay with cτ = 0 → decay in the formation vertex @:
  - x = 0, z = 0
  - x = 0, z = 10 cm
  - x = 10 cm, z = 0
  - x = 10 cm, z = 10 cm
- Secondary track finder with *long* and *forward* track finders *on*
- Primary track finder in its standard layout
- Selection of the *reconstructable* tracks:
  - 3 hits for xy (MVD, STT paral, GEM)
  - 2 hits for $z\phi$ (MVD, STT skew, GEM)
- Association to MC with PndMCTrackAssociator BUT, afterwards, only one reco track for each MC track is considered *true*. Further reco tracks associated to the same MC track are *clones*.

What we are interested in

SINGLE TRACK
→ **Defined <u>on hits</u>**

EFFICIENCY = # CORRECTLY ASSIGNED HITS / # MC POINTS

PURITY= # CORRECTLY ASSIGNED HITS / # RECO HITS

SINGLE EVENT
→ **Defined <u>on tracks</u>**

EFFICIENCY = # TRACKS WITH SINGLE TRACK EFF > 80% / # MC RECONSTRUCTABLE * TRACKS

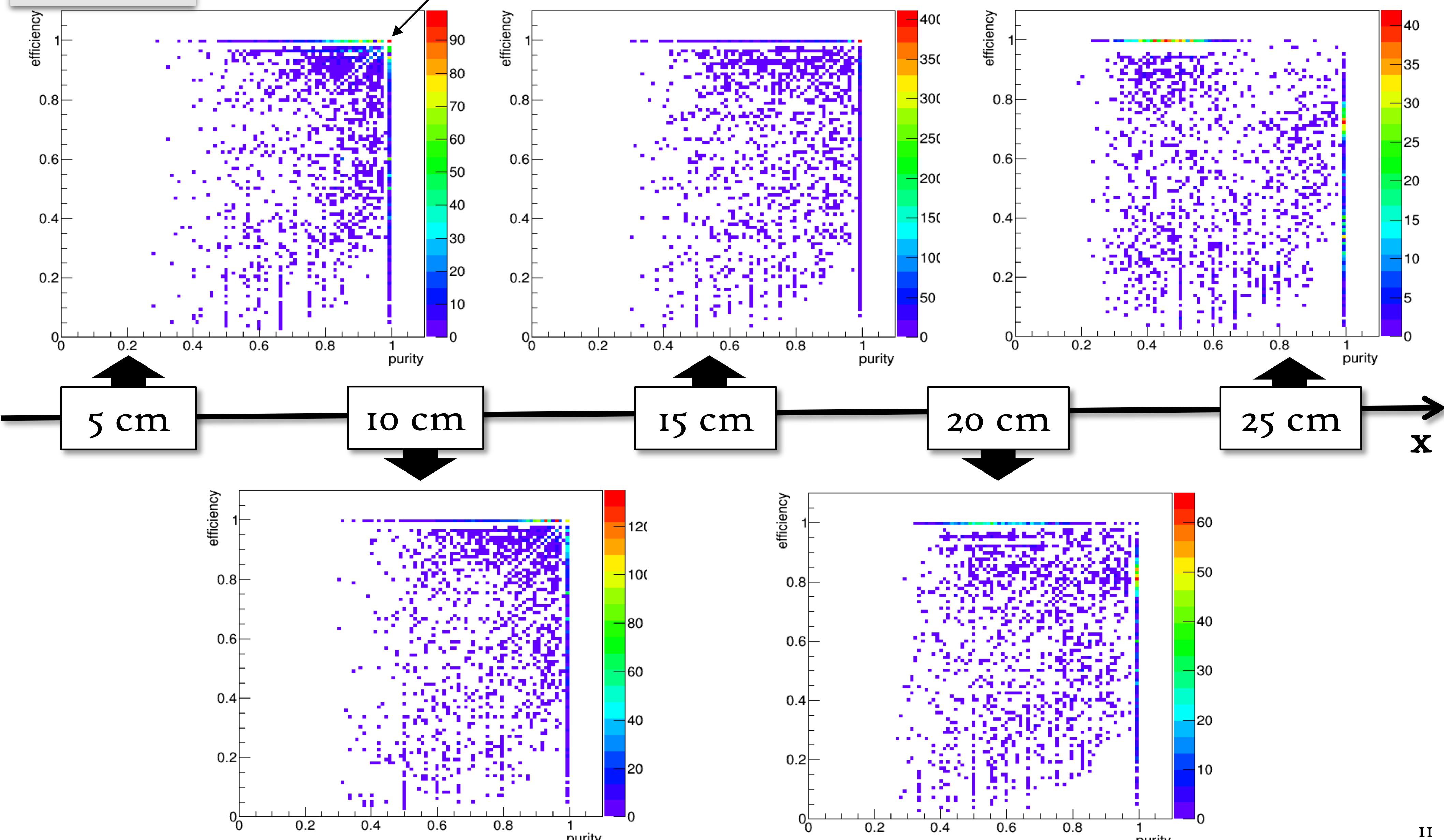
**reconstrubctable* means:
- 3 hits for xy
- 2 hits for $z\phi$

Change radial distance

Z = 0

PIONS, Secondary TF

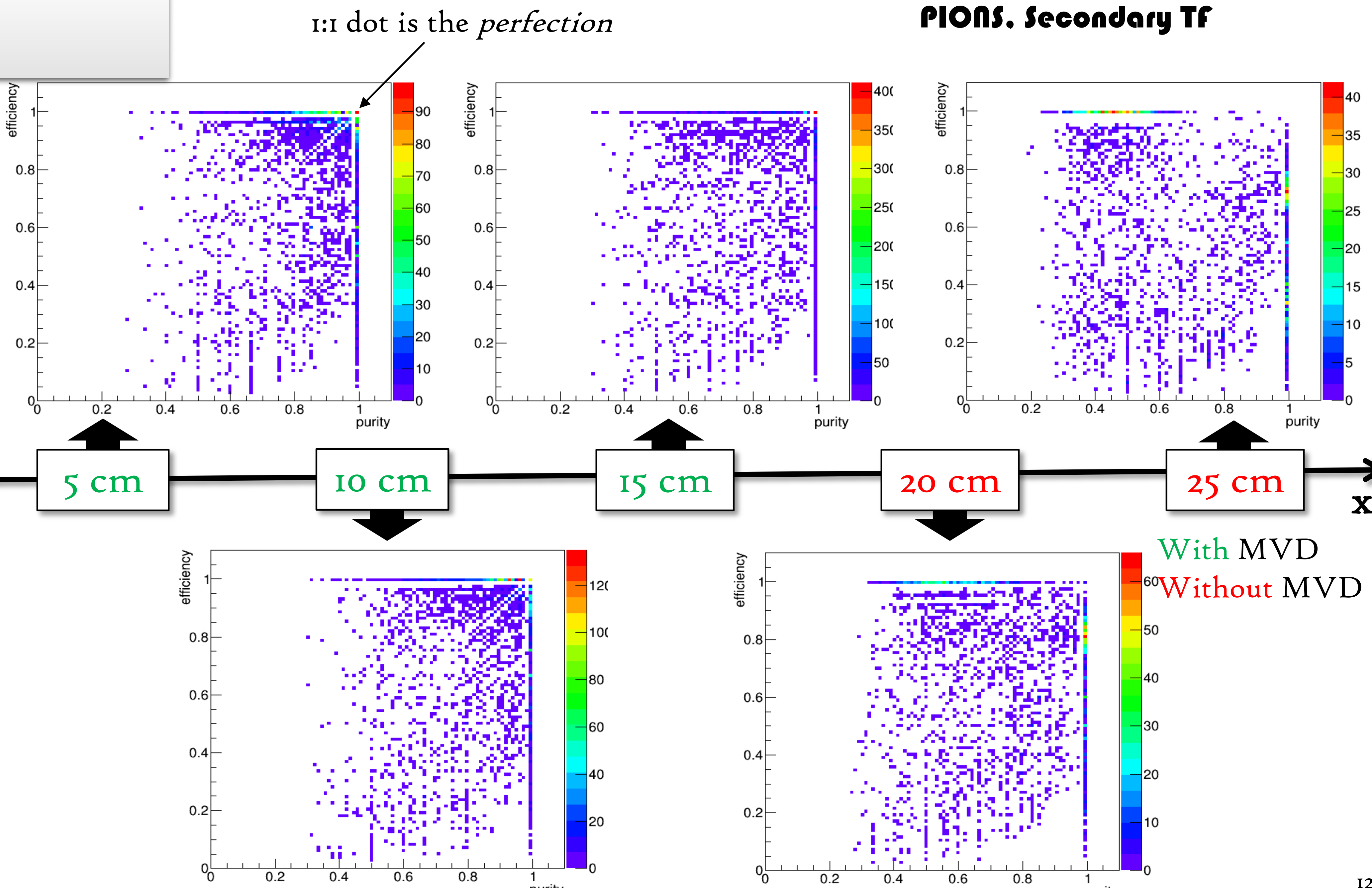
1:1 dot is the *perfection*



Change radial distance

Z = 0

PIONS, Secondary TF

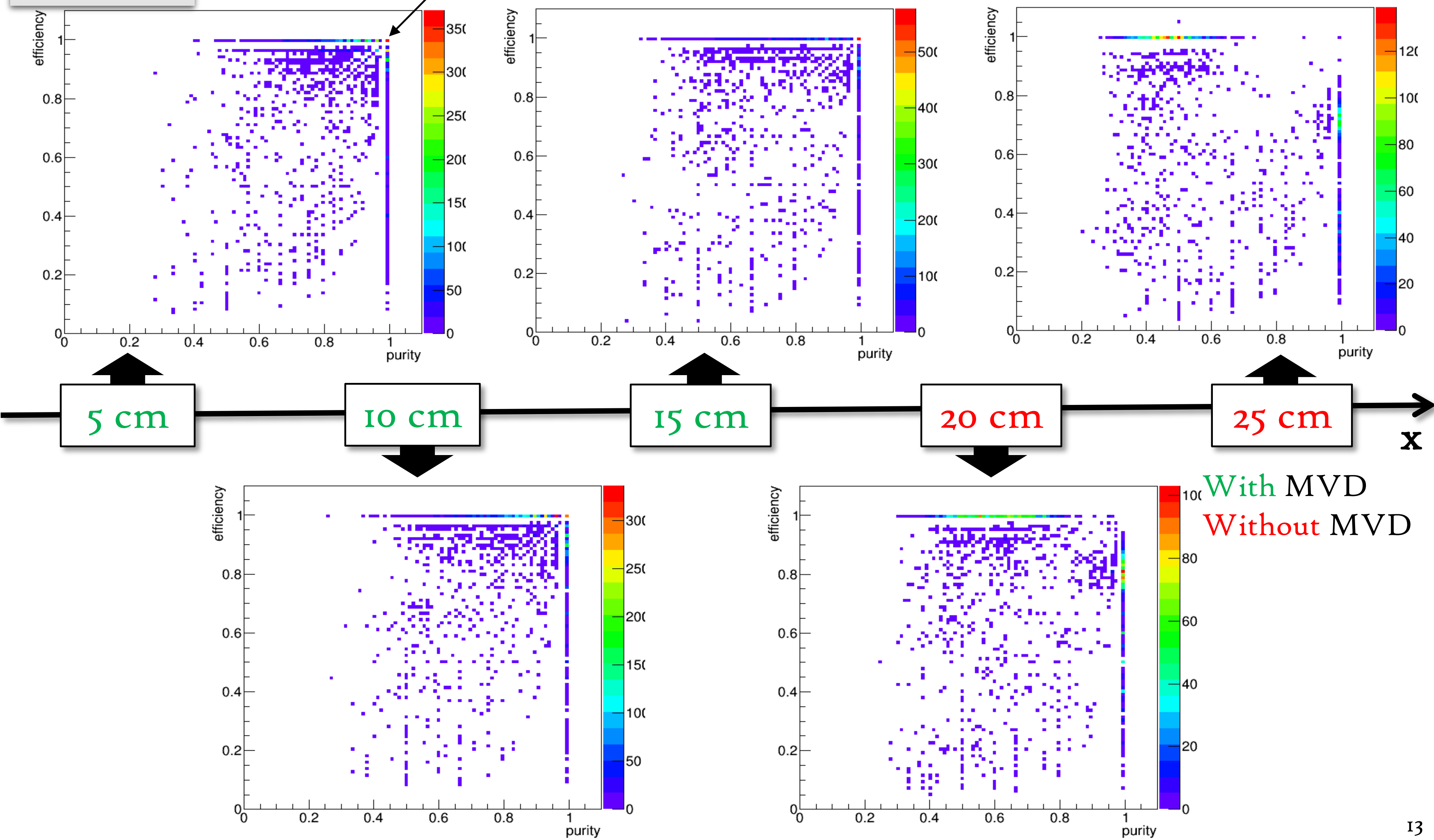


Change radial distance

Z = 0

PROTONS, Secondary TF

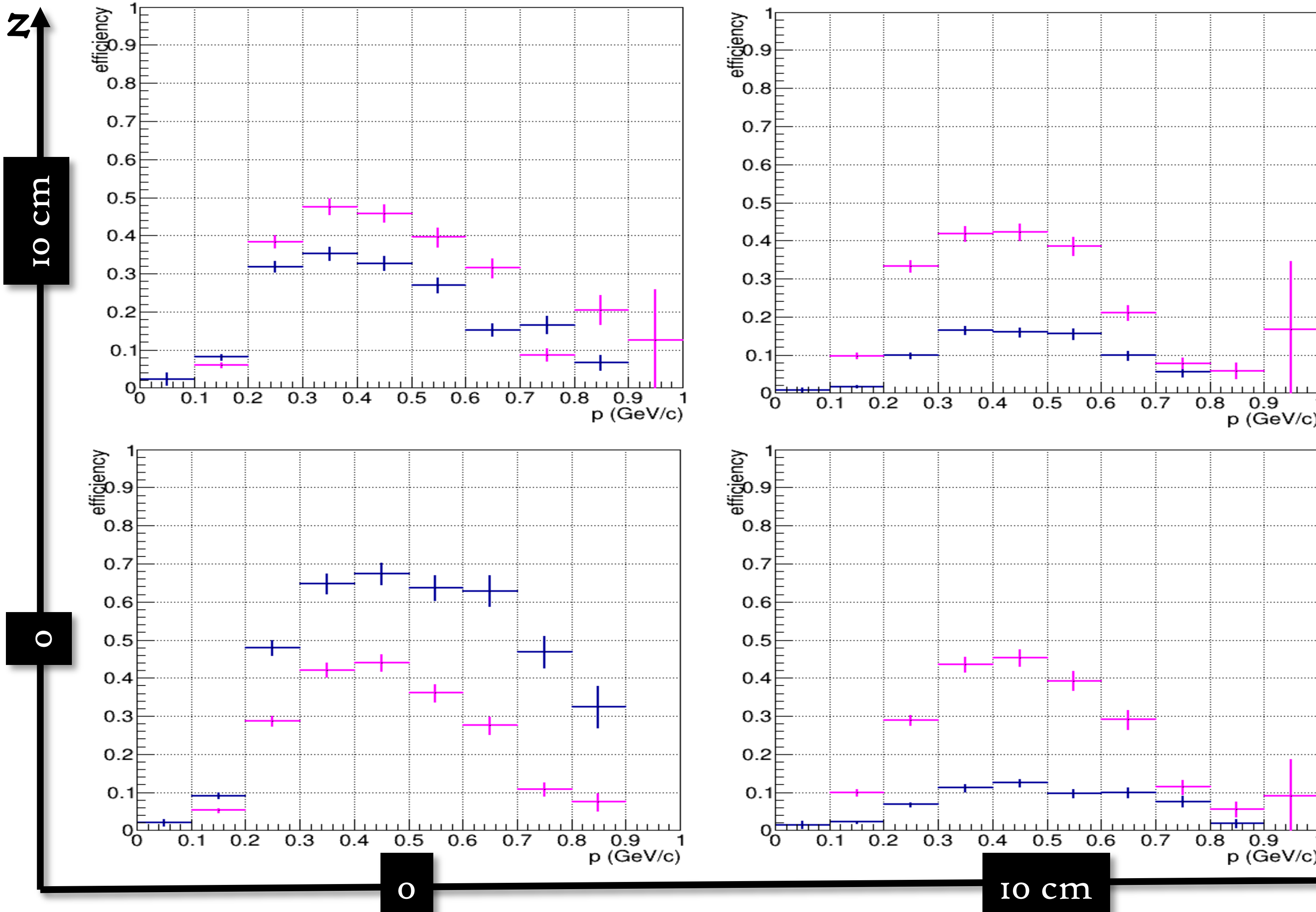
1:1 dot is the *perfection*



ALL

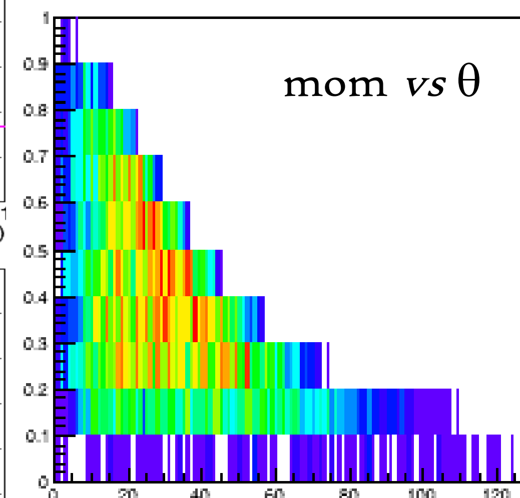
Efficiency vs momentum

EFFICIENCY = $\dfrac{\text{\# TRUE TRACKS WITH > 80\% CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$



PIONS

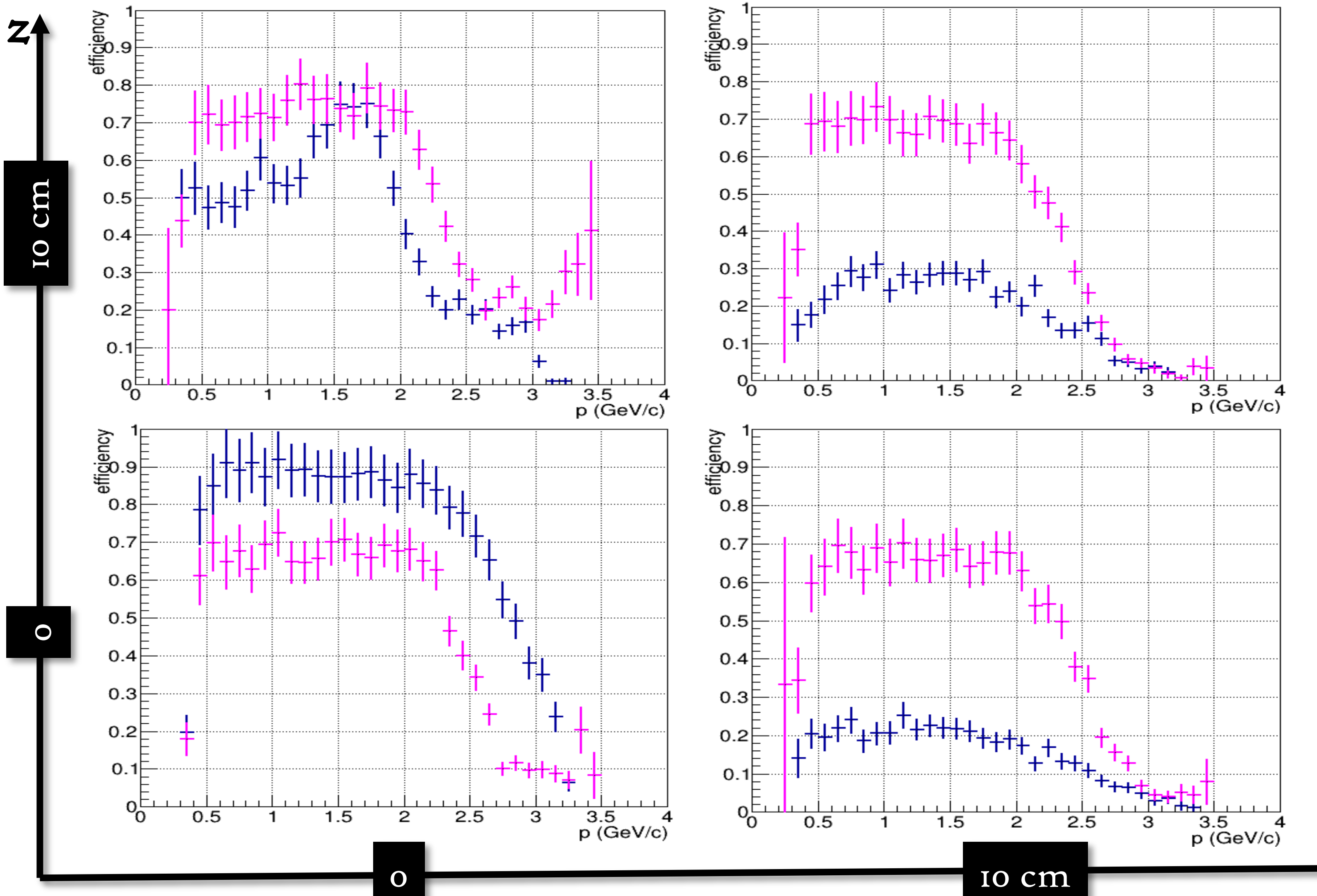
- Primary TF
- Secondary TF



ALL

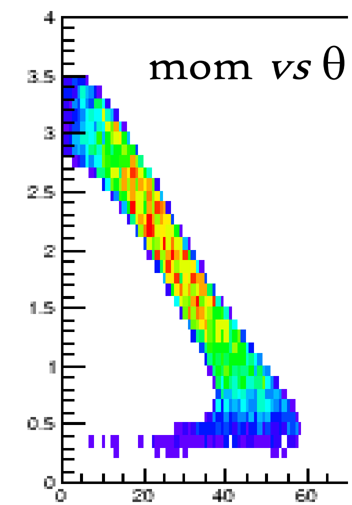
Efficiency vs momentum

EFFICIENCY = $\frac{\text{\# TRUE TRACKS WITH > 80\% CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$



PROTONS

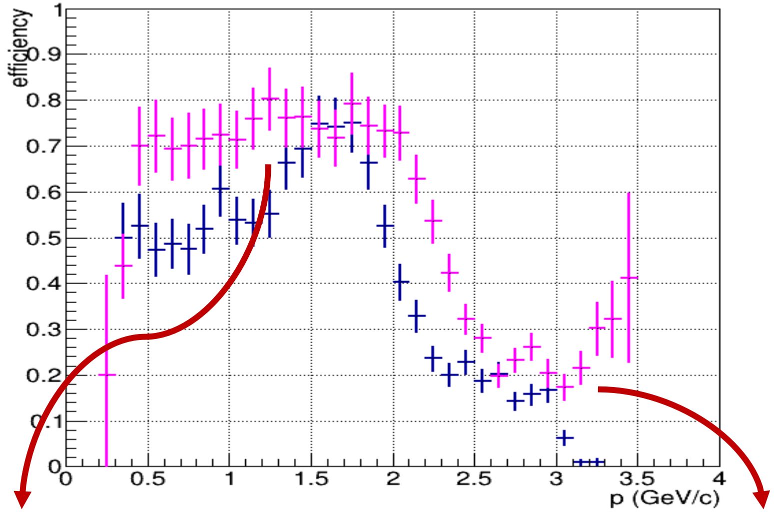
- Primary TF
- Secondary TF



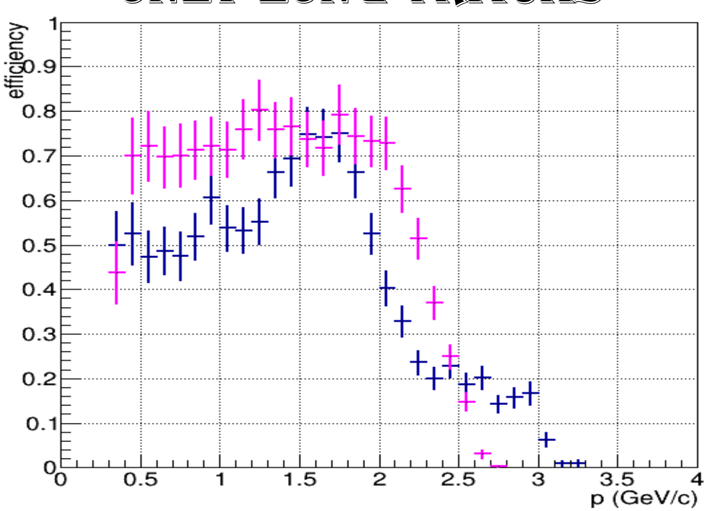
The rise @ high momenta

X = 0, Z = 10 CM

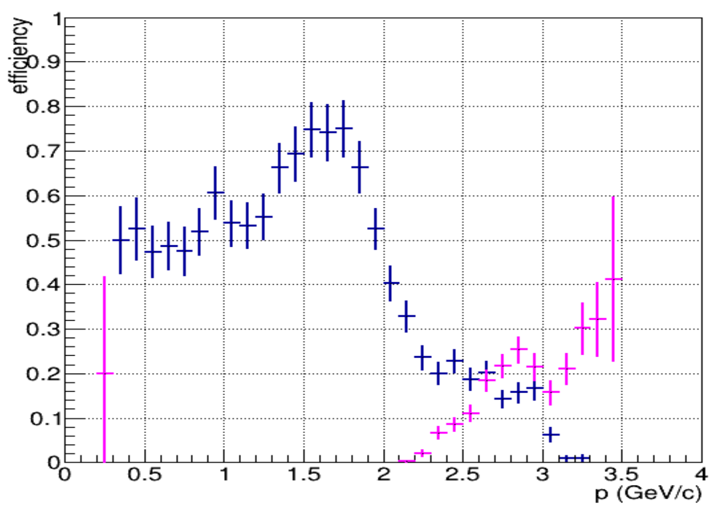
SECONDARY TF
FULL

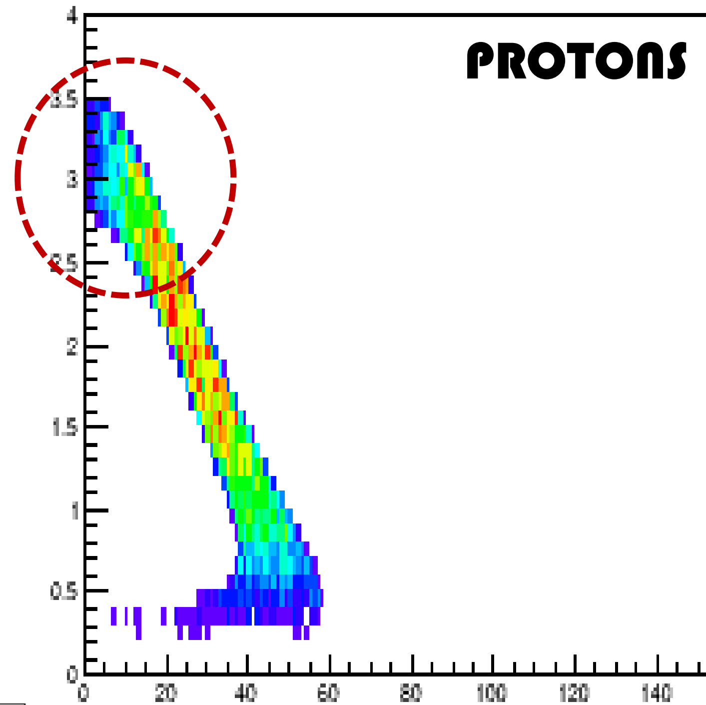


SECONDARY TF
ONLY LONG TRACKS



SECONDARY TF
ONLY FWD TRACKS



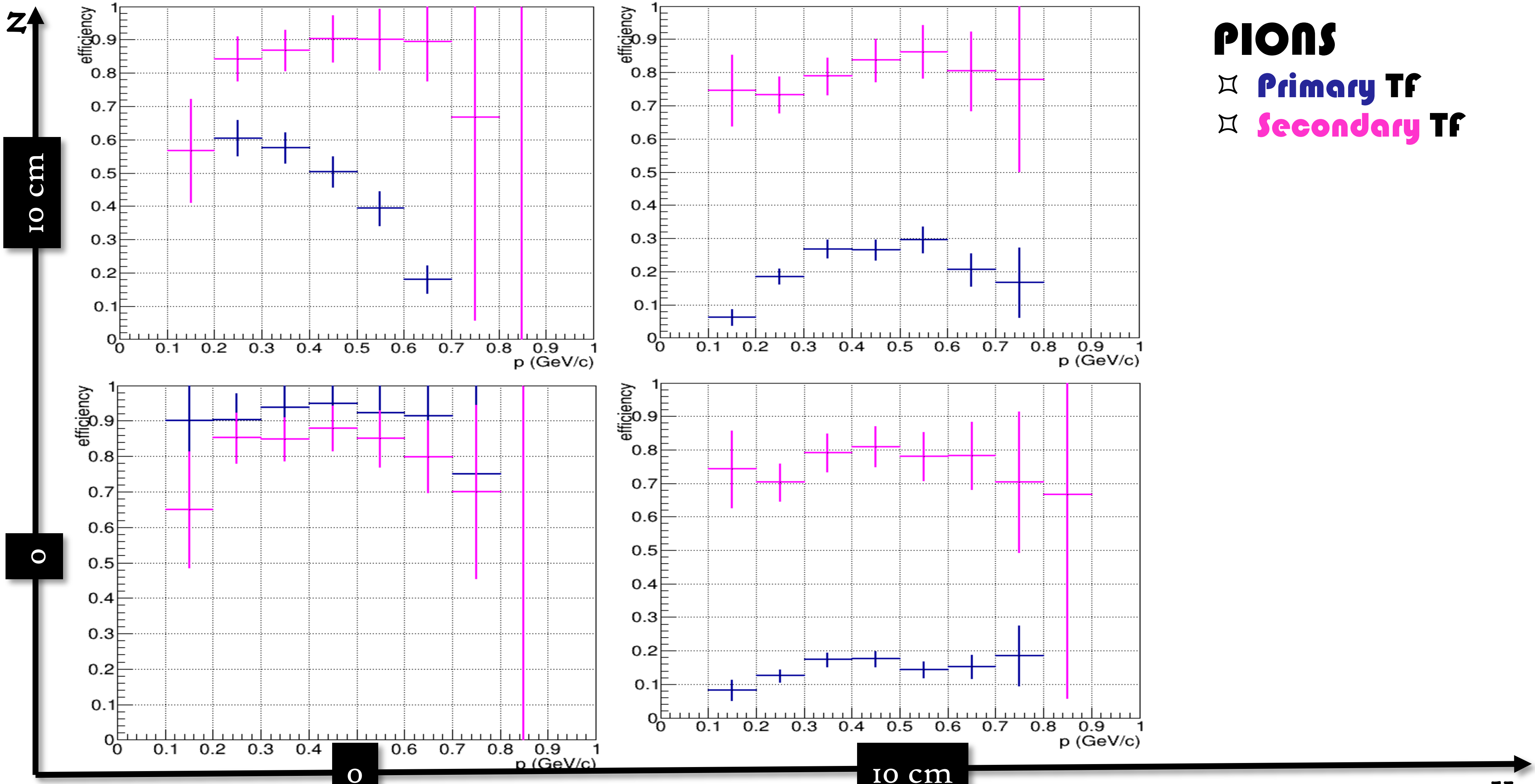


At high momenta the θ angle is small → fwd tracks

4 pivotal layers

Efficiency vs momentum

$$\text{EFFICIENCY} = \frac{\#\ \text{TRUE TRACKS WITH} > 80\%\ \text{CORRECTLY ASSIGNED HITS}}{\#\ \text{MC RECONSTRUCTABLE TRACKS}}$$

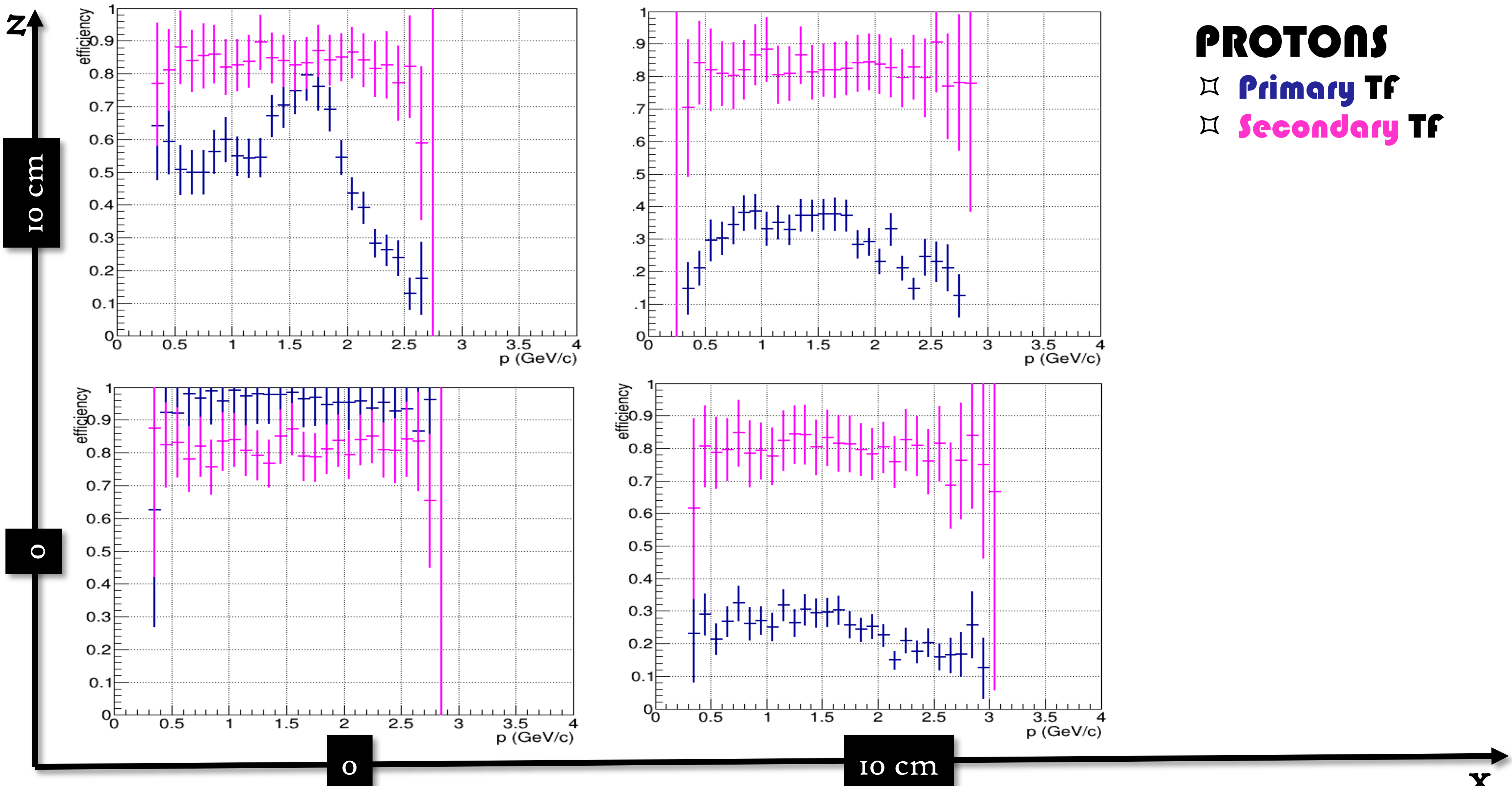


PIONS

- Primary TF
- Secondary TF

Efficiency vs momentum

$$\text{EFFICIENCY} = \frac{\#\ \text{TRUE TRACKS WITH} > 80\%\ \text{CORRECTLY ASSIGNED HITS}}{\#\ \text{MC RECONSTRUCTABLE TRACKS}}$$

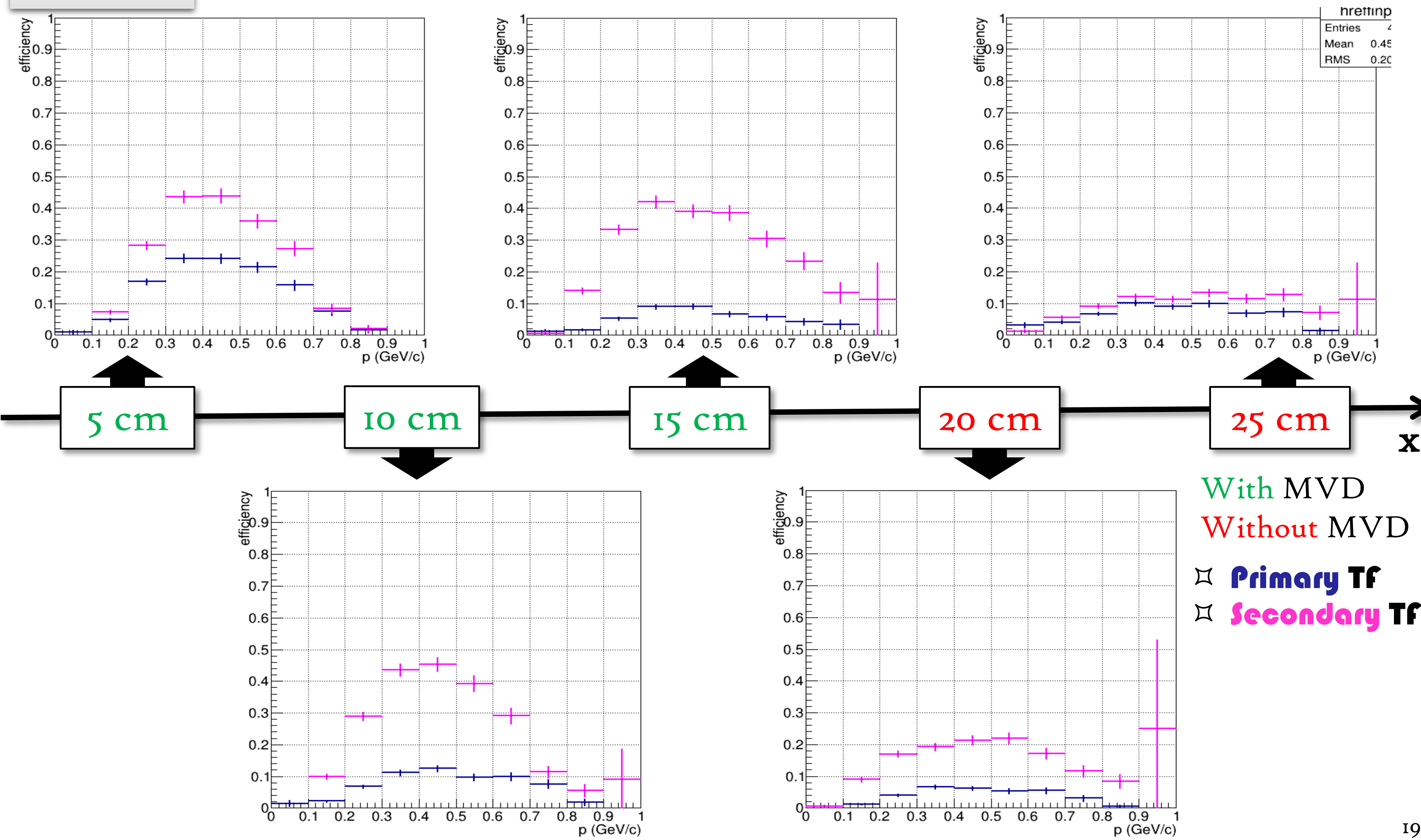


PROTONS

- Primary TF
- Secondary TF

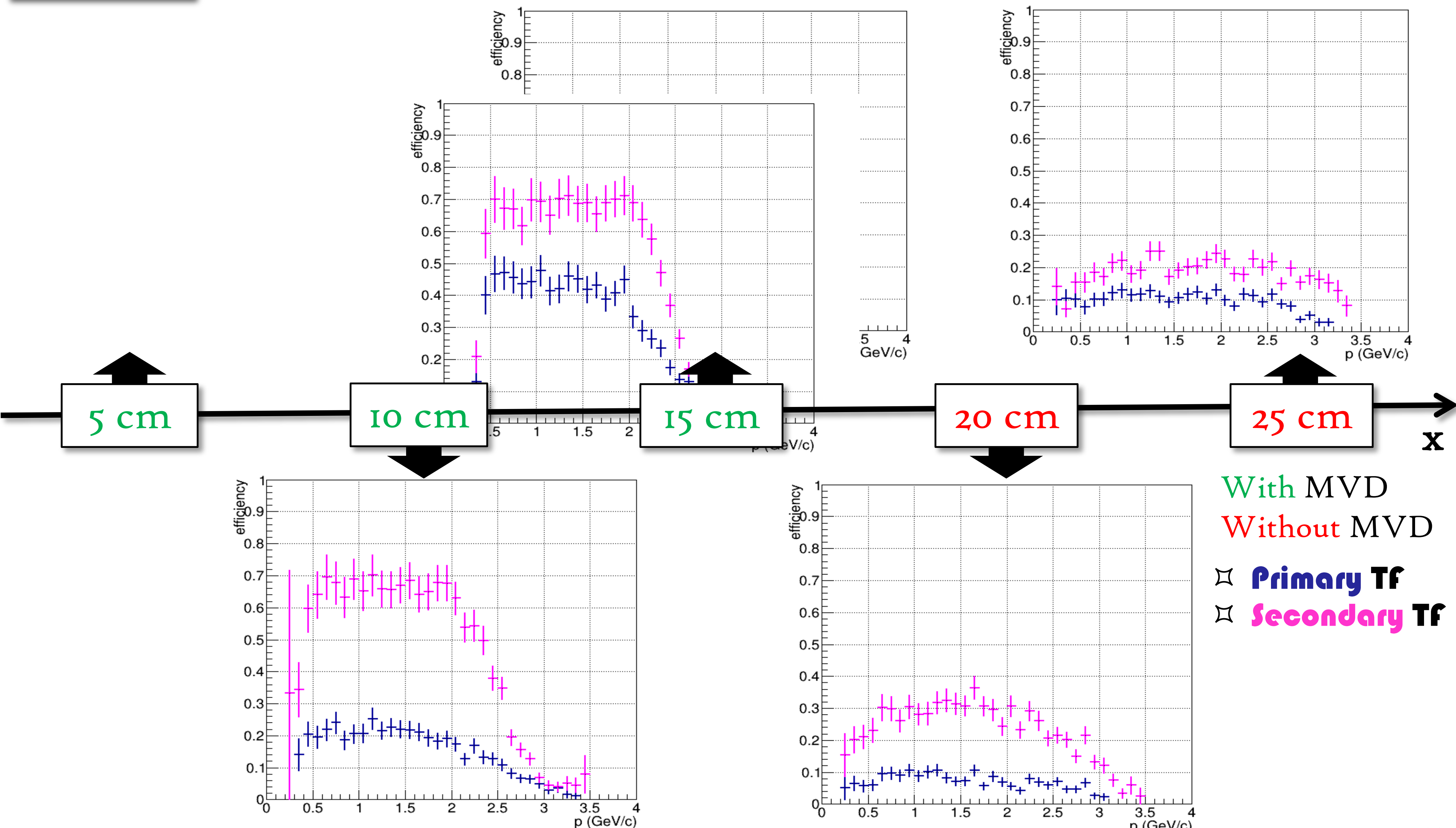
Change radial distance

Z = 0
PIONS



Change radial distance

Z = 0
PROTONS



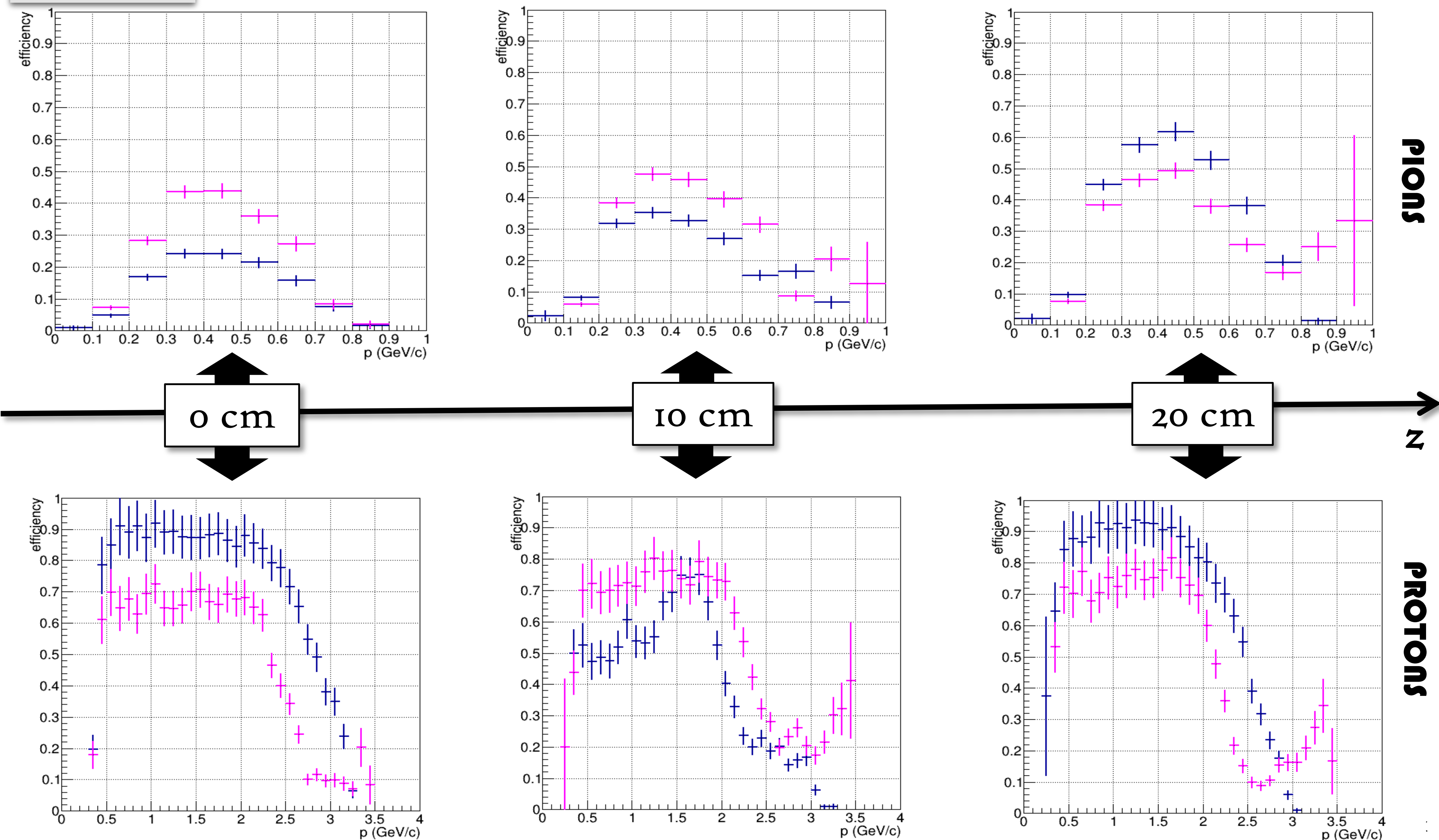
With MVD
Without MVD

- Primary TF
- Secondary TF

Change z position

X = 0

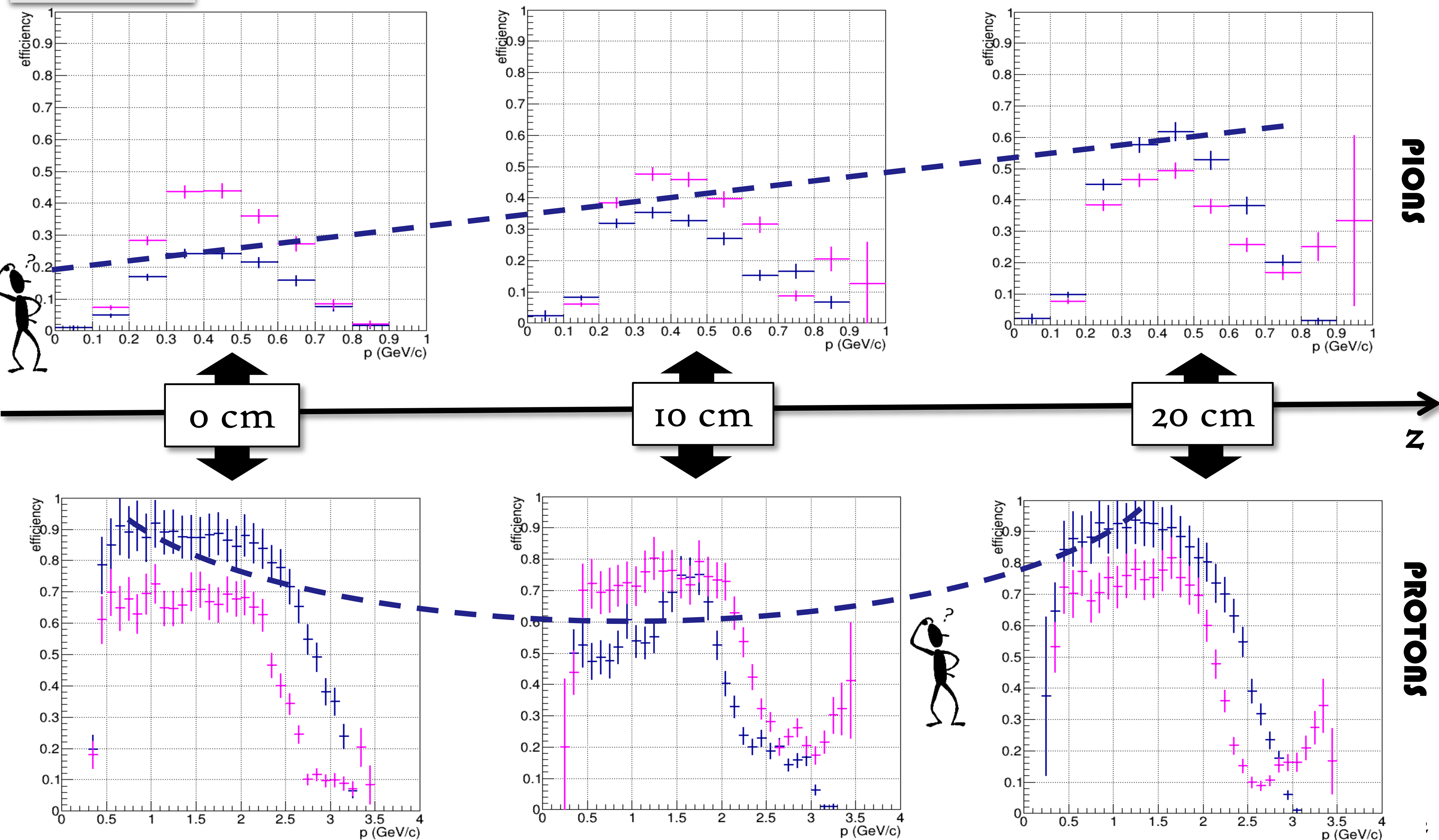
- Primary TF
- Secondary TF



Change z position

X = 0

- **Primary TF**
- **Secondary TF**



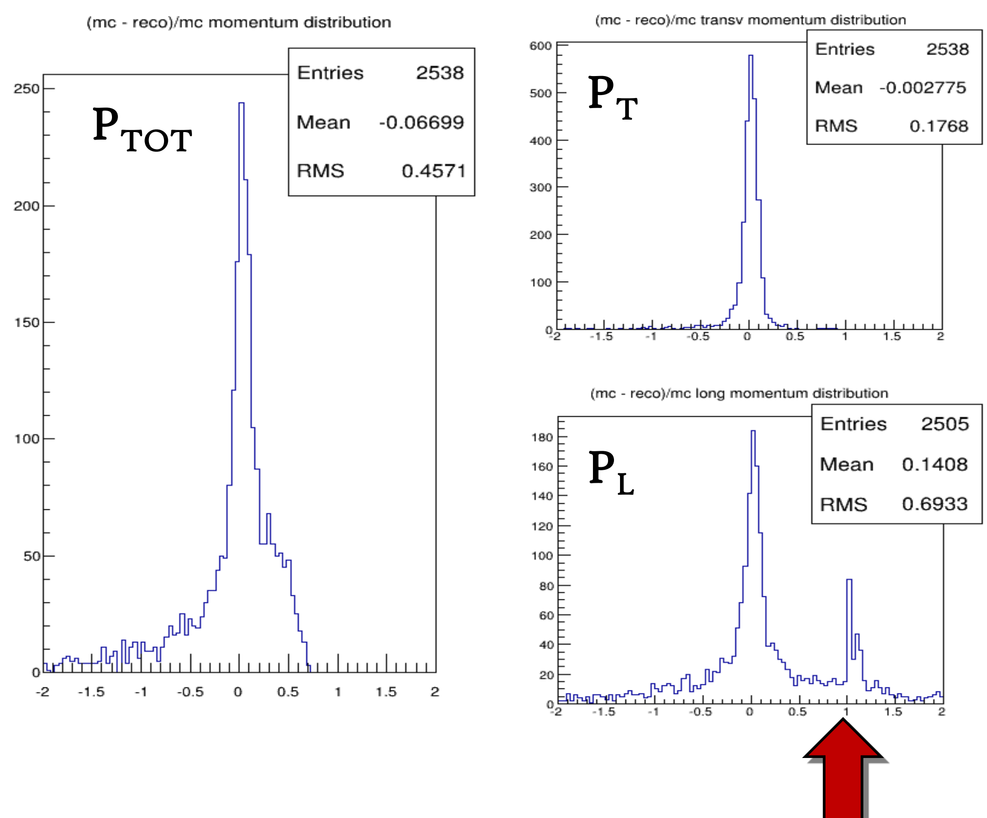
(MC – RECO)/MC distributions

PIONS, Secondary TF

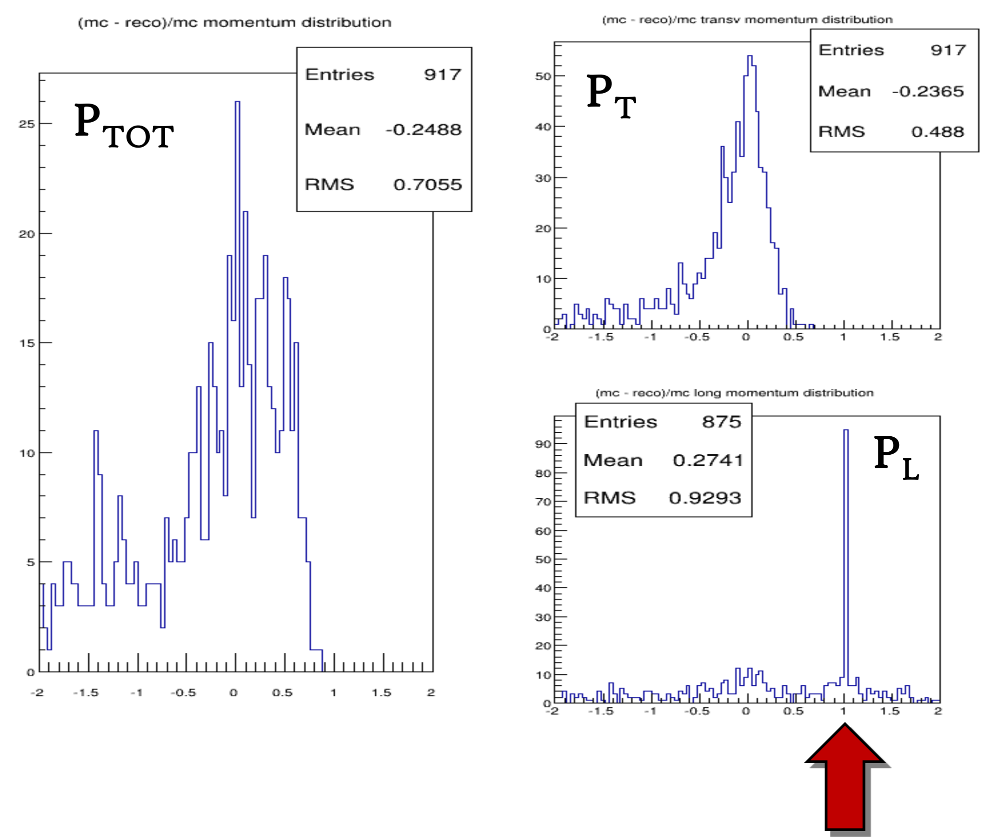
- There is a **peak** @ P_L = 1 and the **tails** in P_L which still have to be understood and possibly fixed

UNDER INVESTIGATION

X = 5 CM, Z = 0



X = 25 CM, Z = 0



(MC – RECO)/MC distributions

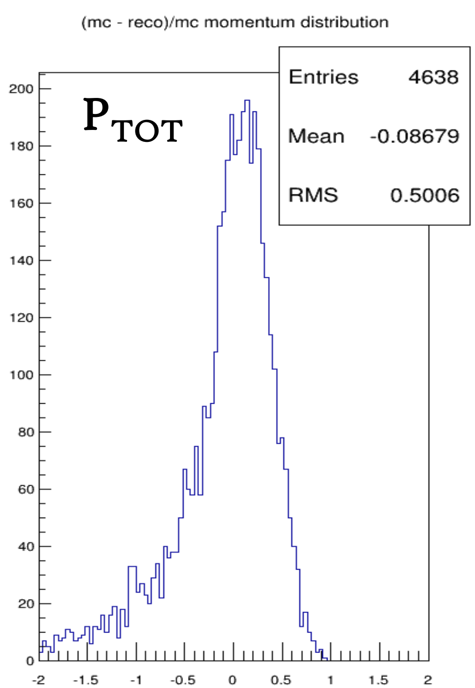
PROTONS, Secondary TF

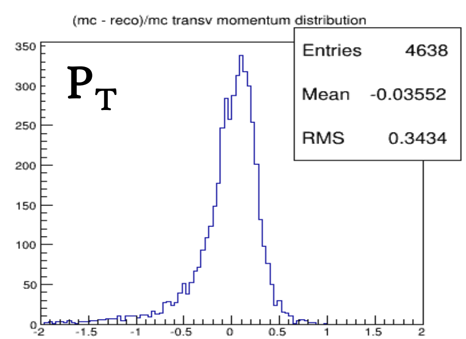
- There is a **peak** @ $P_L = 1$ and the **tails** in P_L which still have to be understood and possibly fixed

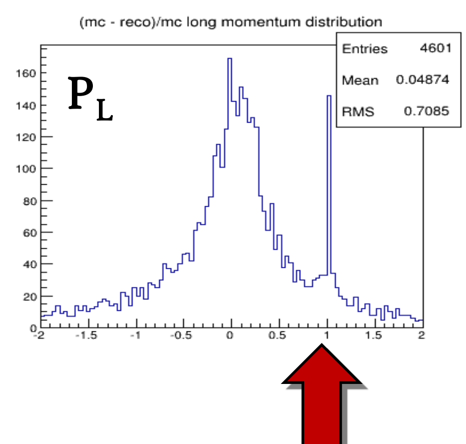
UNDER INVESTIGATION

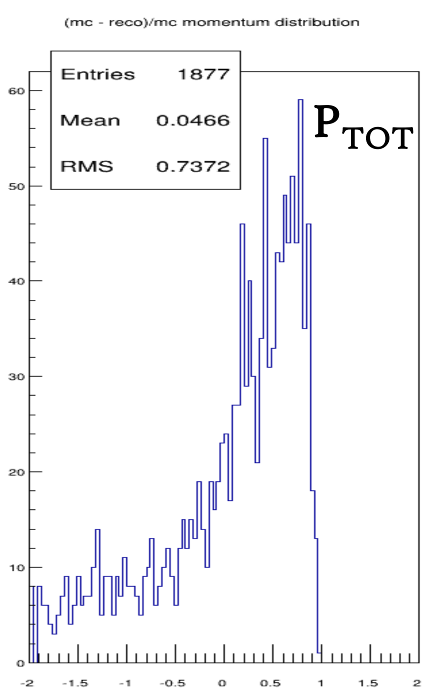
X = 5 CM, Z = 0

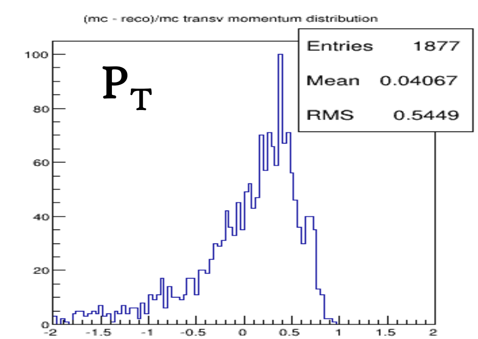
X = 25 CM, Z = 0

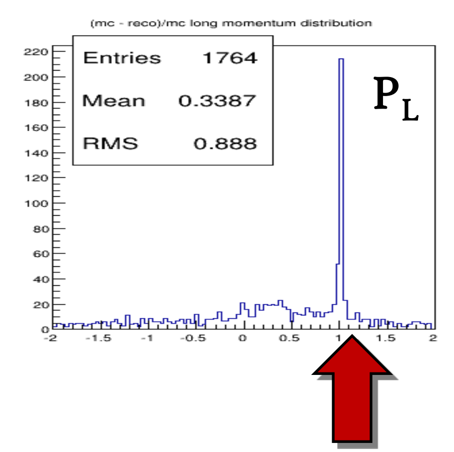












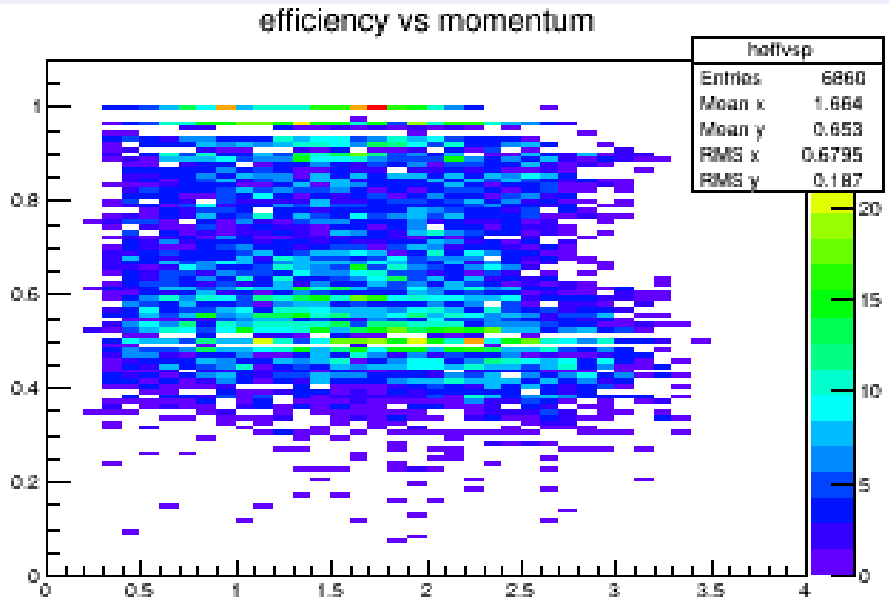
@ $x = 10$ cm, $z = 10$ cm

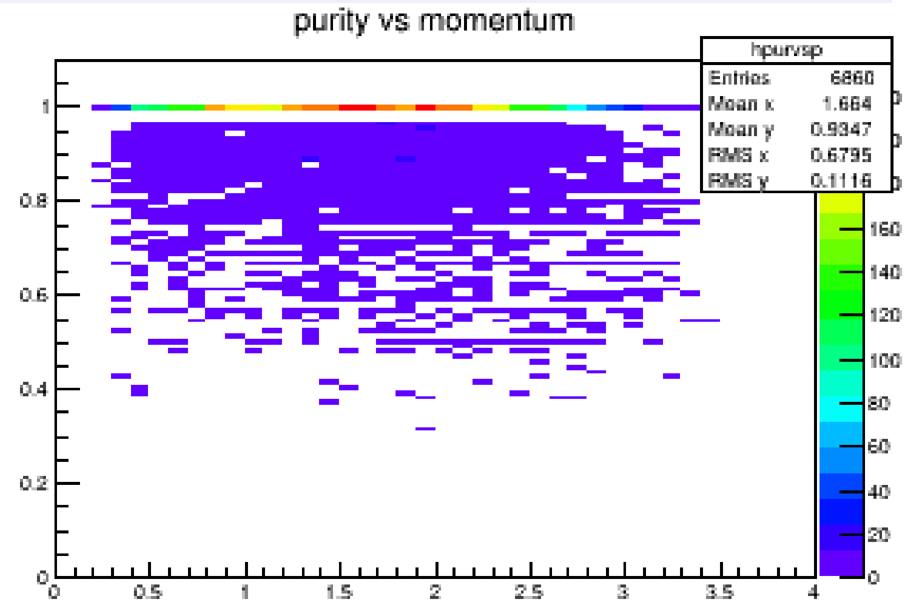
Primary track finder

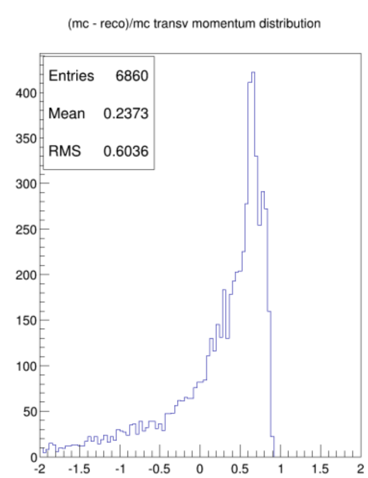
Protons

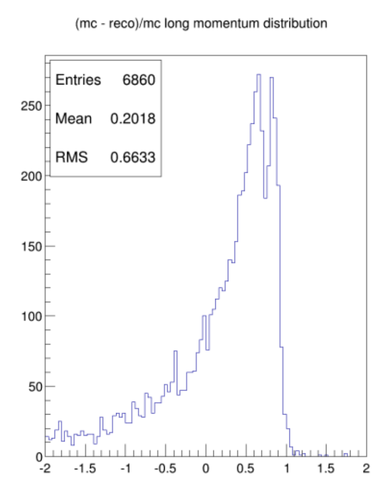
$$\text{Efficiency} = \frac{\#\ \text{correctly assigned hits}}{\#\ \text{MC points}}$$

$$\text{Purity} = \frac{\#\ \text{correctly assigned hits}}{\#\ \text{reco hits}}$$







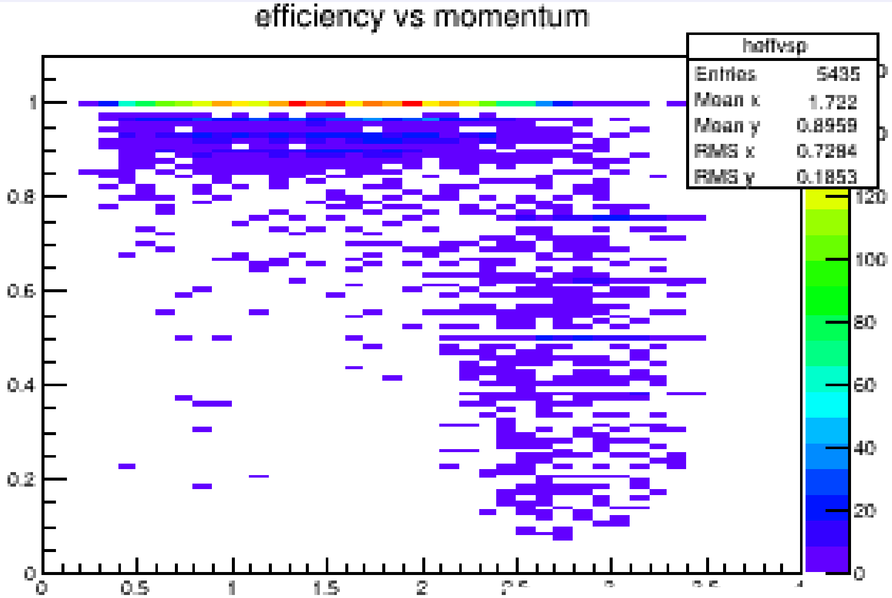


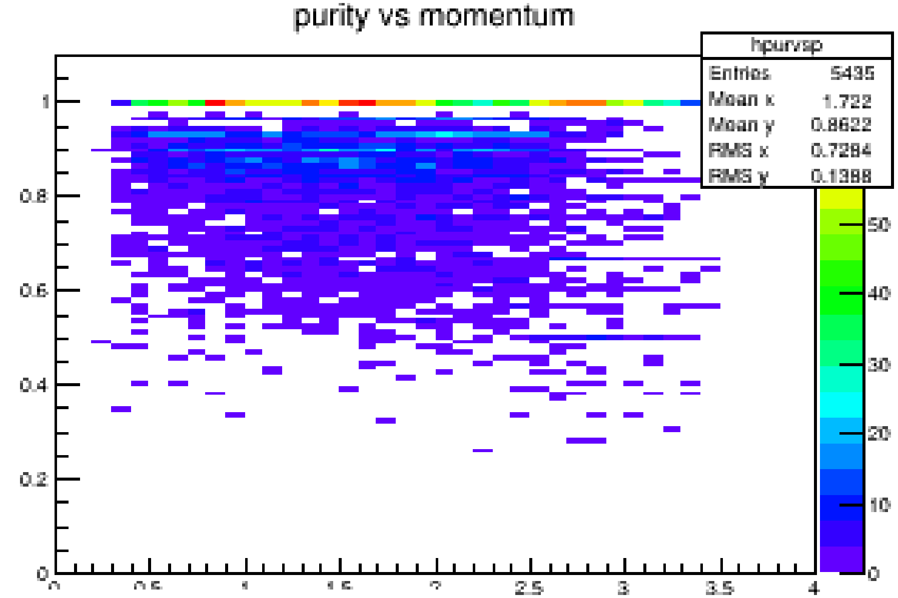
Secondary track finder

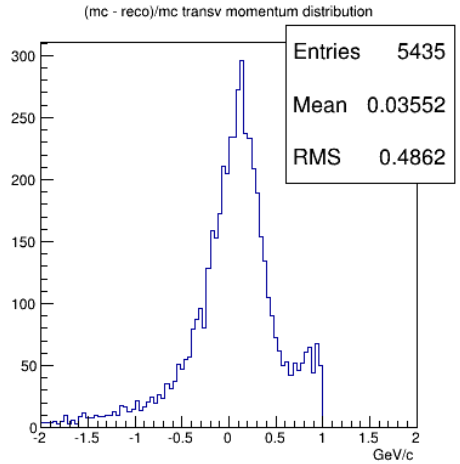
protons

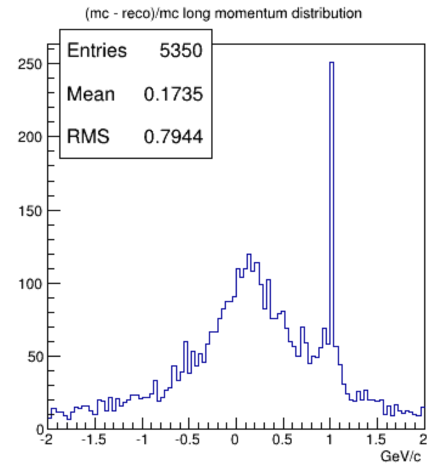
EFFICIENCY = $\frac{\text{\# CORRECTLY ASSIGNED HITS}}{\text{\# MC POINTS}}$

PURITY= $\frac{\text{\# CORRECTLY ASSIGNED HITS}}{\text{\# RECO HITS}}$





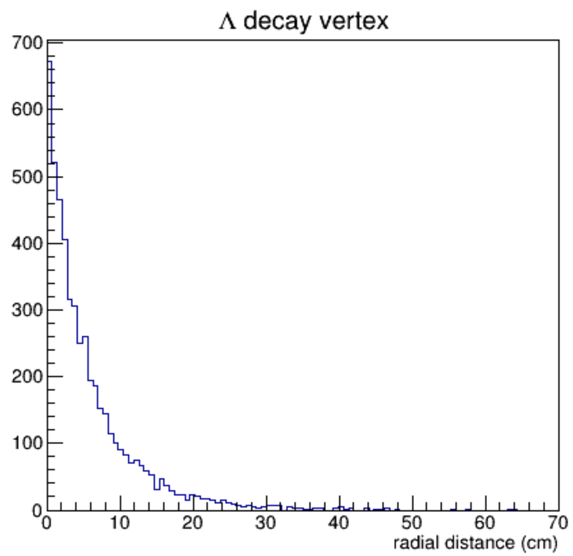


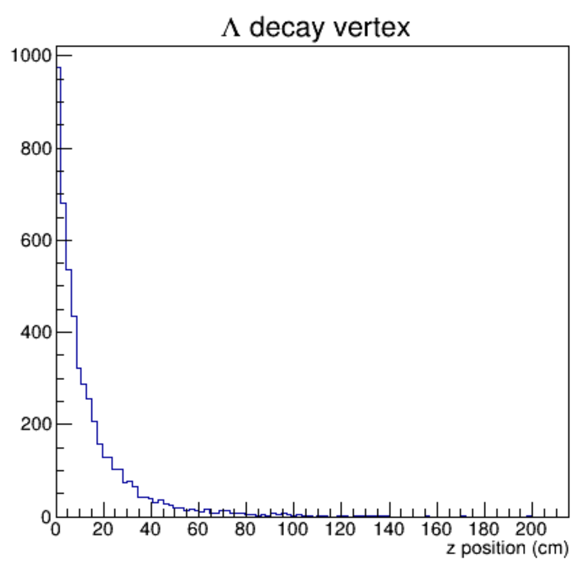


$\bar{p}p \to \bar{\Lambda}\Lambda$, phase space model

MC information

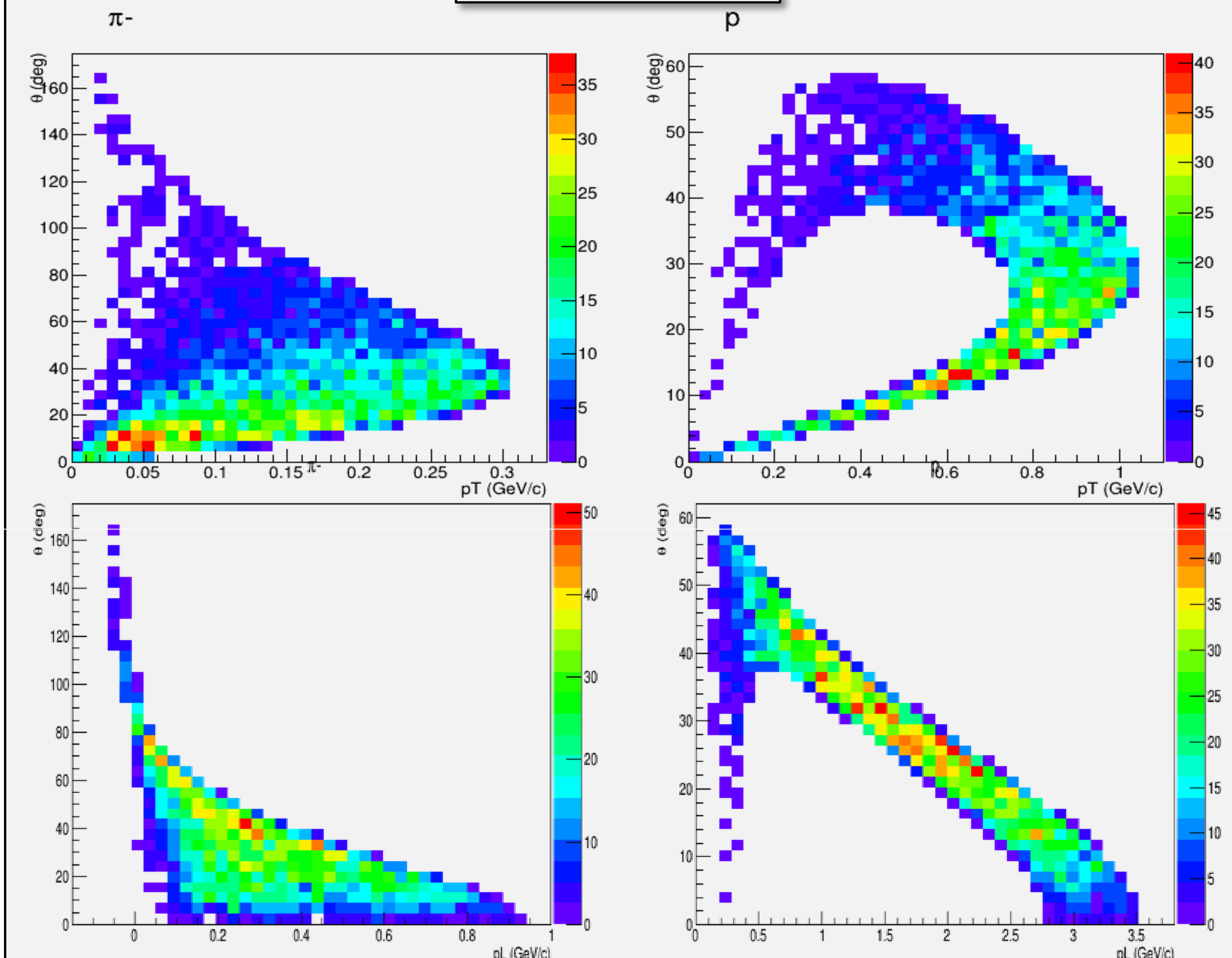
Decay vertex position

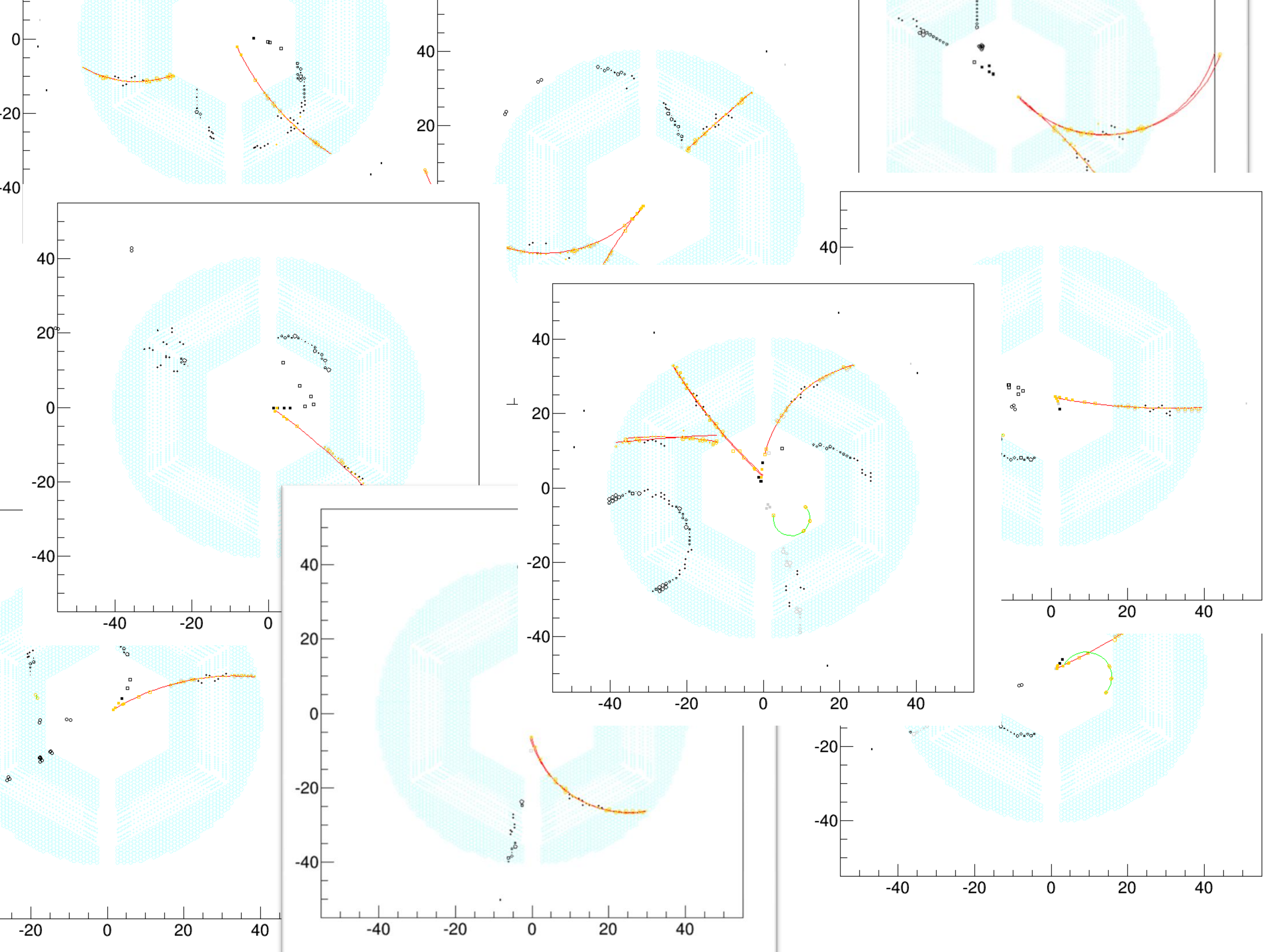




θ *vs* momentum

The same for $\bar{\Lambda}$ and $\pi^{+}, \bar{p}$





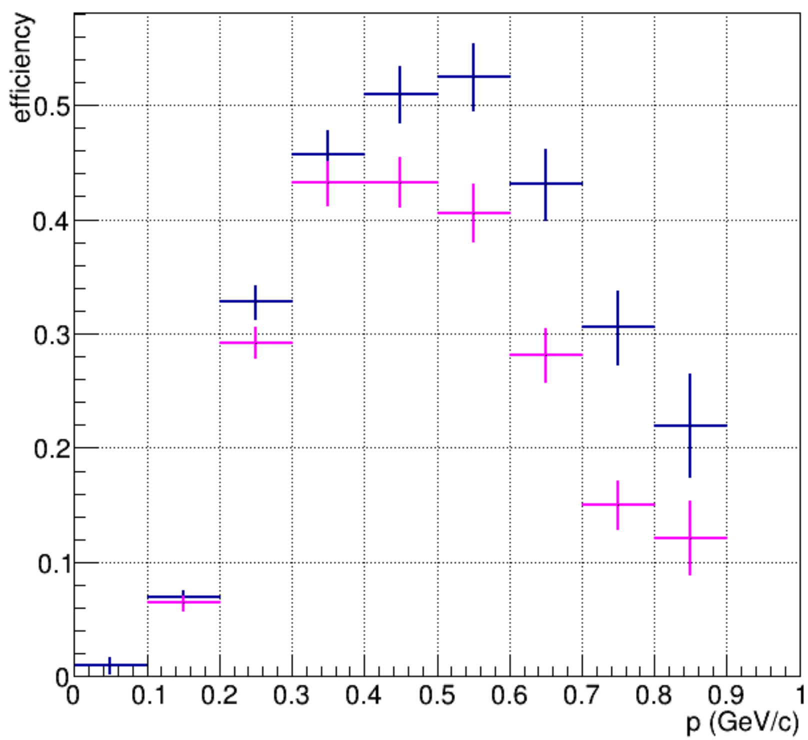
40
20
0
-20
-40

Efficiency vs momentum PHSP

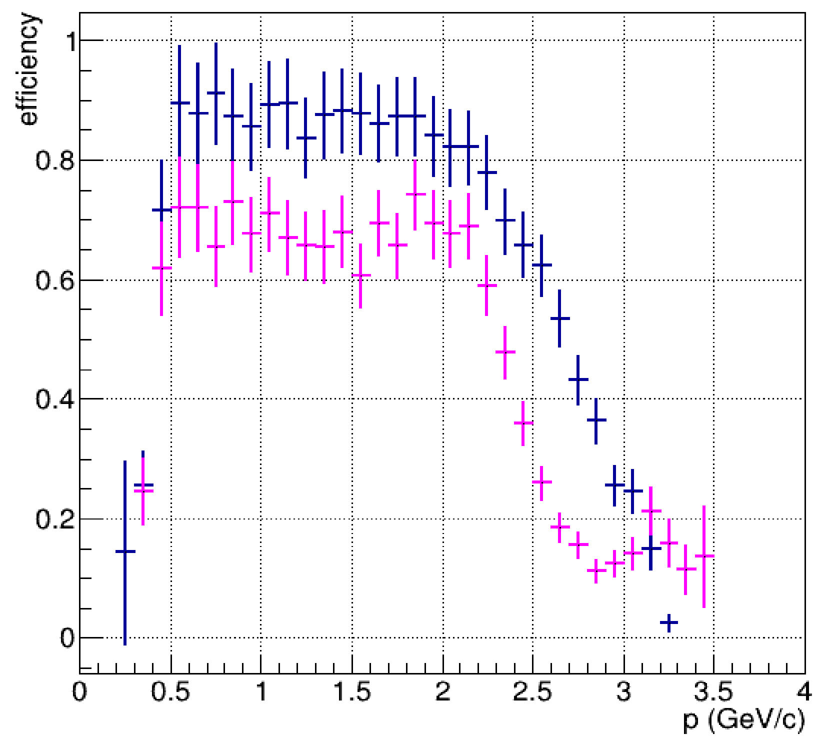
$$\text{EFFICIENCY} = \frac{\text{\# TRUE TRACKS WITH > 80\% CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$$

- **Primary** TF
- **Secondary** TF

PIONS



PROTONS

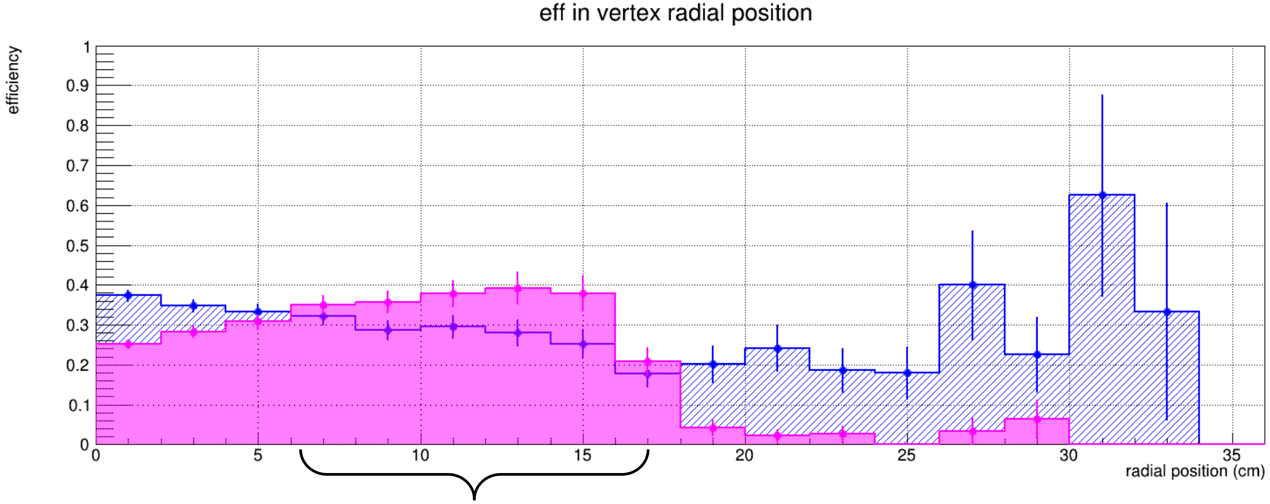


Efficiency vs position

Efficiency = # true tracks with > 80% correctly assigned hits / # MC reconstructable tracks

- **Primary** TF
- **Secondary** TF

PIONS
300 000 events



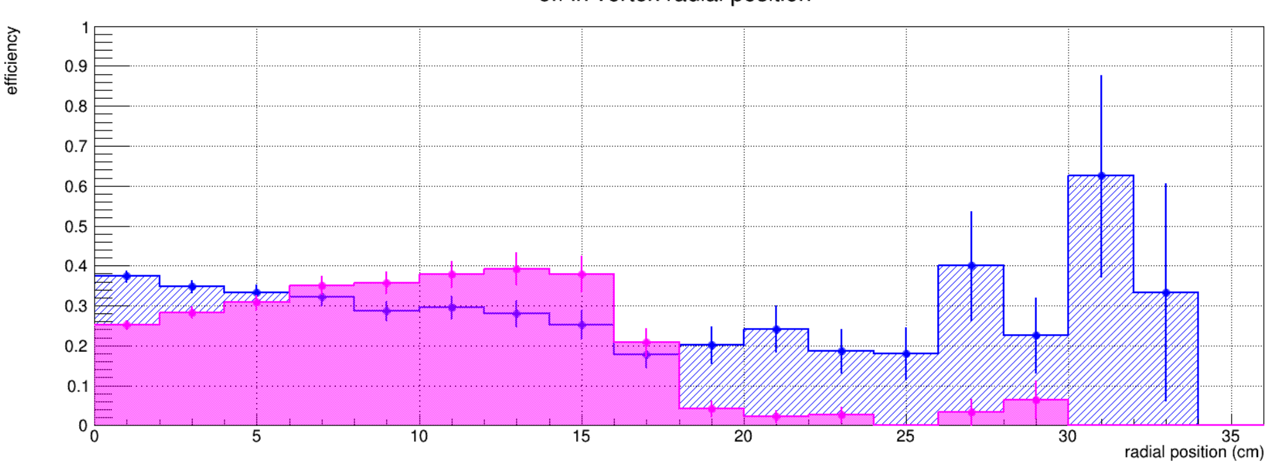
- < 5 cm, the primary TF is better (still close enough to IP)
- 5 cm < x < 15 cm, the secondary TF is better (MVD + STT)
- > 15 cm, the primary TF is better

Efficiency vs position

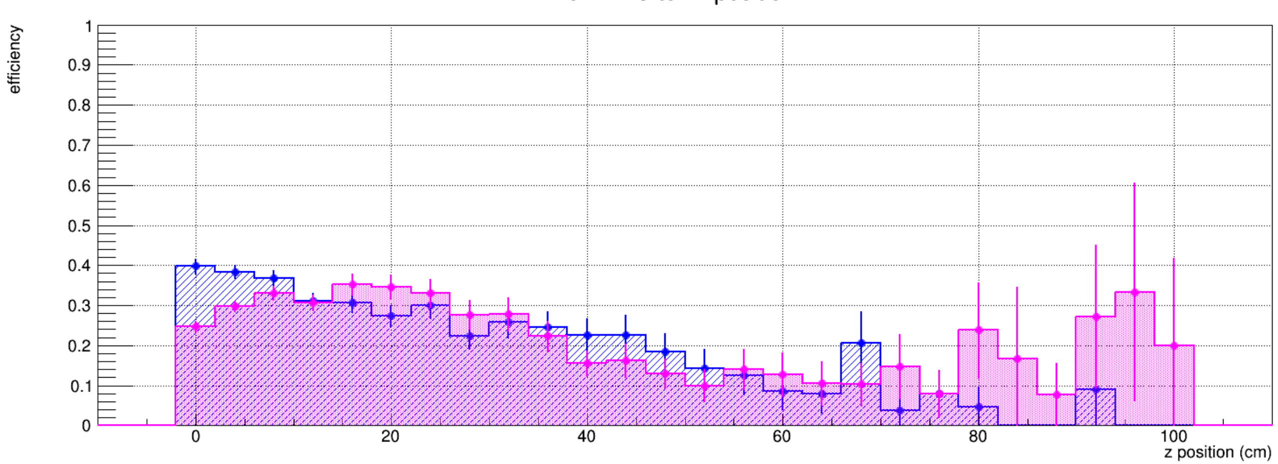
$$\text{EFFICIENCY} = \frac{\text{\# TRUE TRACKS WITH} > 80\% \text{ CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$$

- **Primary TF**
- **Secondary TF**

PIONS
300 000 events



- < 5 cm, the primary TF is better (still close enough to IP)
- 5 cm < x < 15 cm, the secondary TF is better (MVD + STT)
- > 15 cm, the primary TF is better



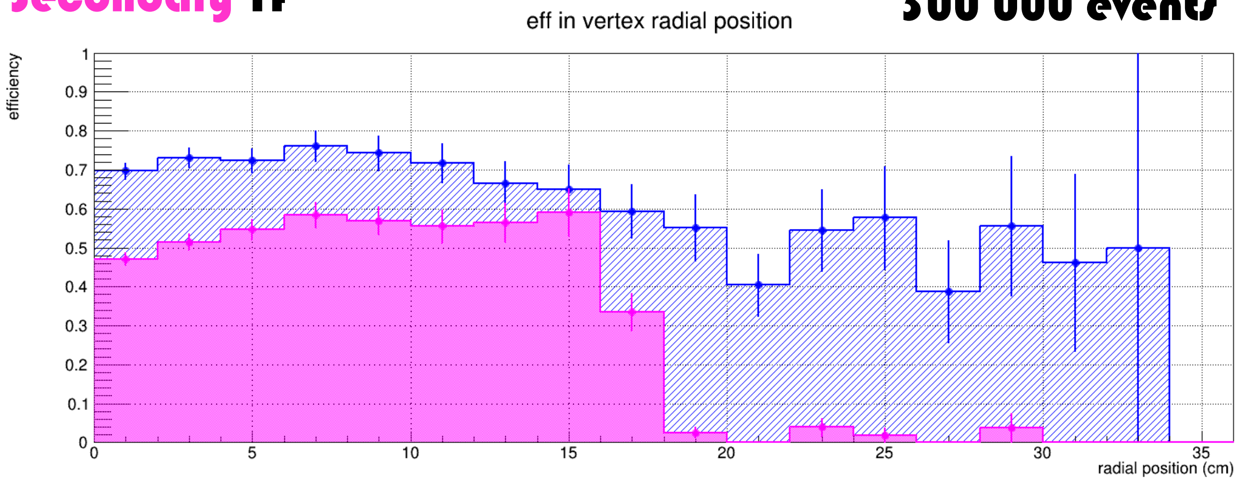
- < 10 cm, the primary TF is better (still close enough to IP)
- 10 cm < x < 30 cm, the secondary TF is better
- > 30 cm, comparable

Efficiency vs position

$$\text{EFFICIENCY} = \frac{\text{\# TRUE TRACKS WITH > 80\% CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$$

- **Primary TF**
- **Secondary TF**

PROTONS
300 000 events



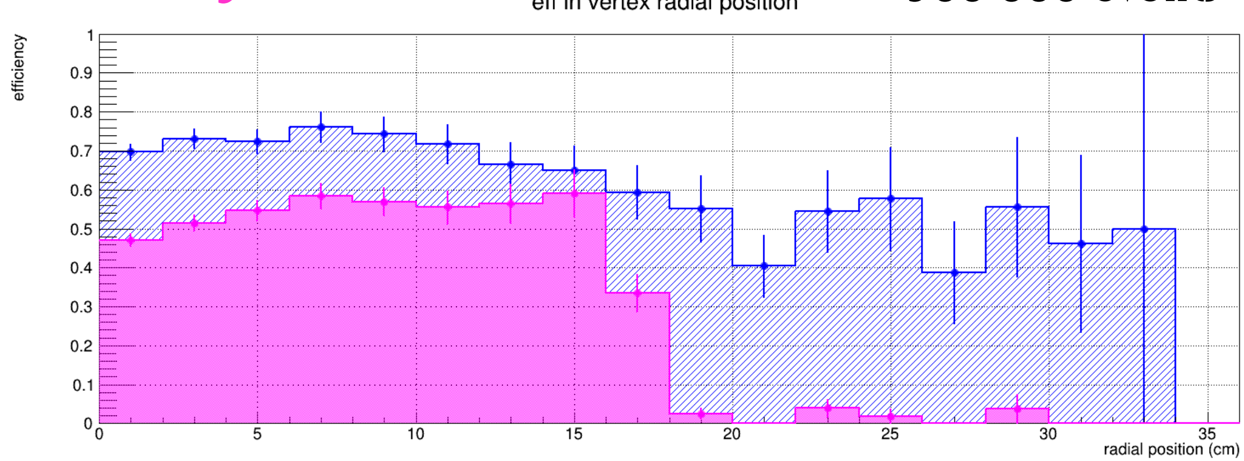
- Primary TF always better than secondary TF

Efficiency vs position

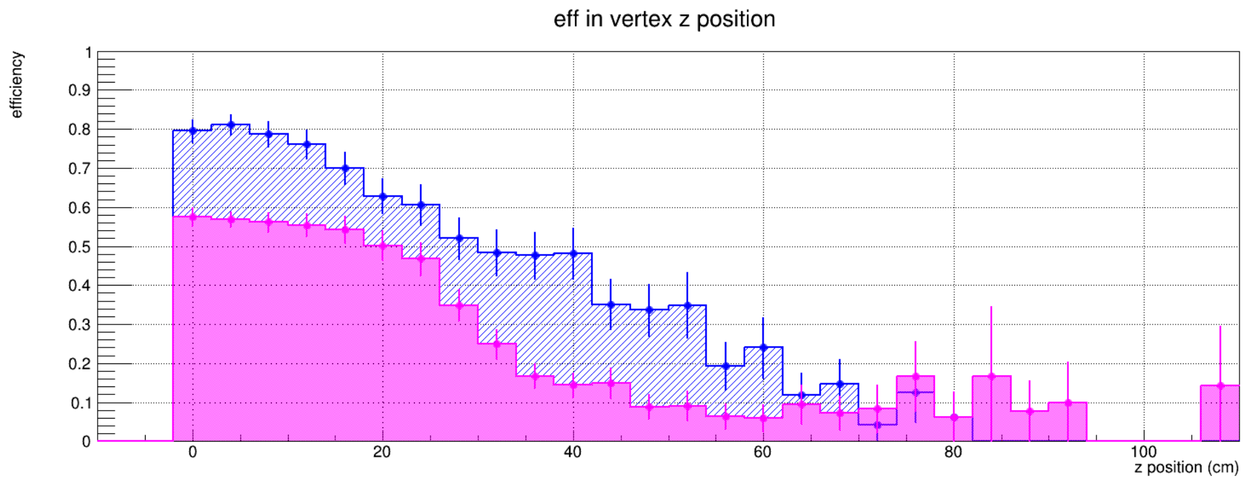
EFFICIENCY = $\frac{\text{\# TRUE TRACKS WITH > 80\% CORRECTLY ASSIGNED HITS}}{\text{\# MC RECONSTRUCTABLE TRACKS}}$

- **Primary** TF
- **Secondary** TF

PROTONS
300 000 events

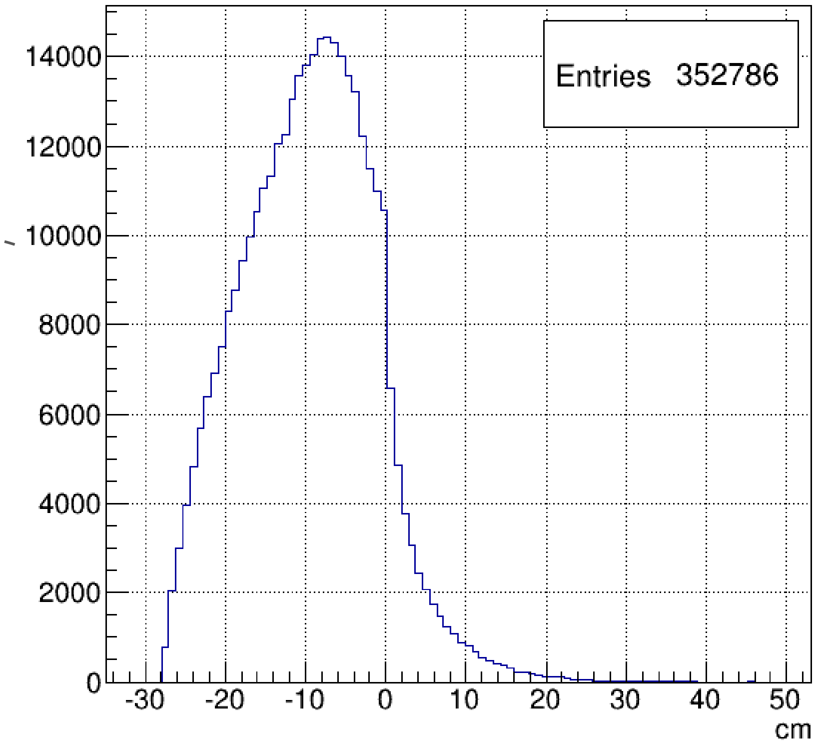


- Primary TF always better than secondary TF

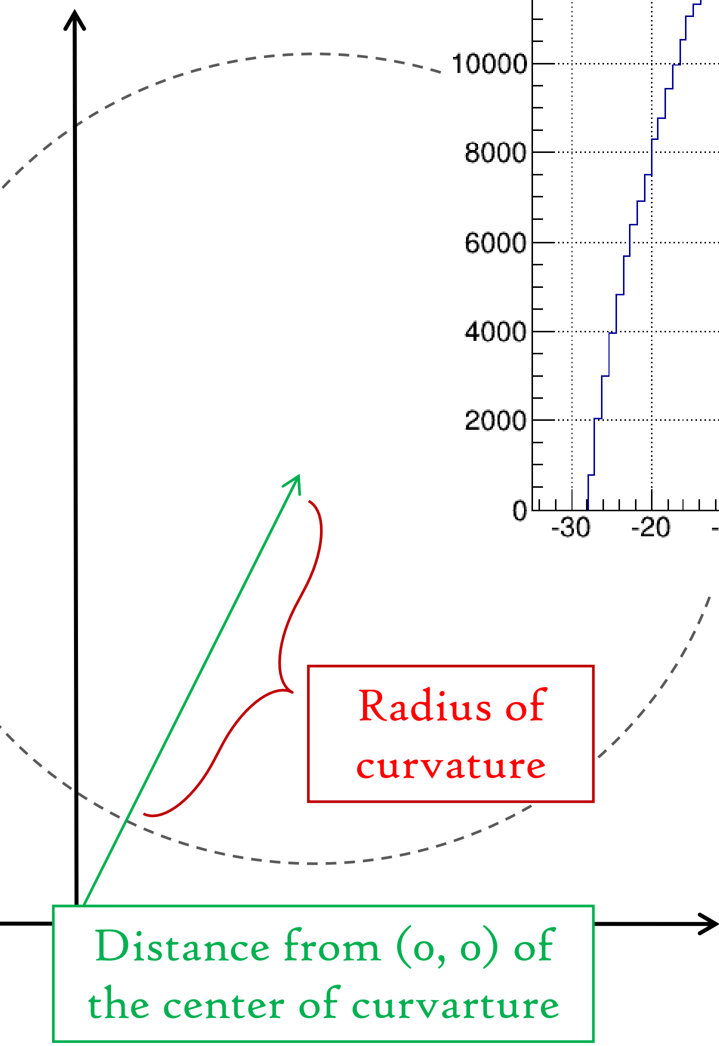


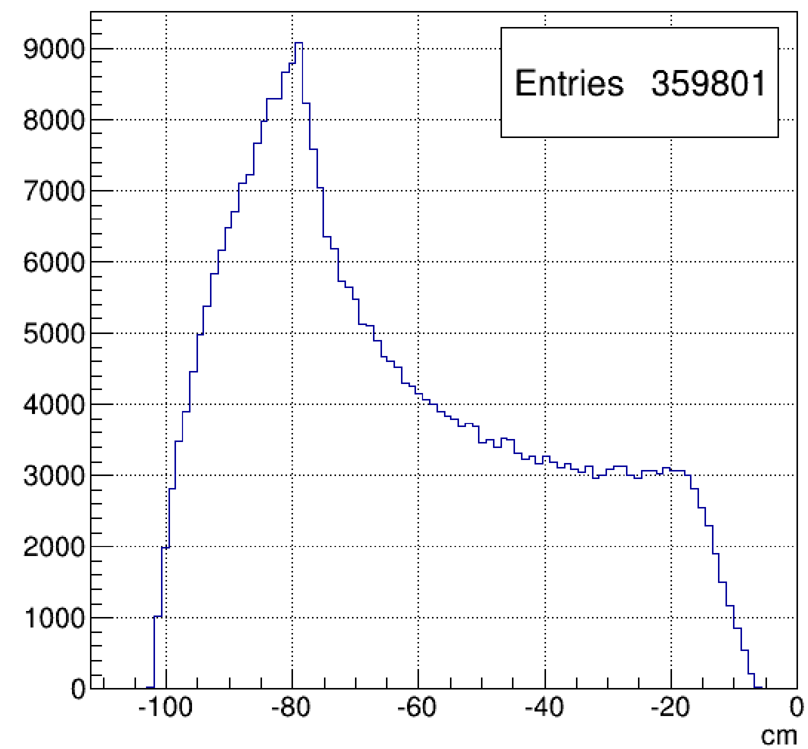
- Primary TF always better than secondary TF

Position distributions

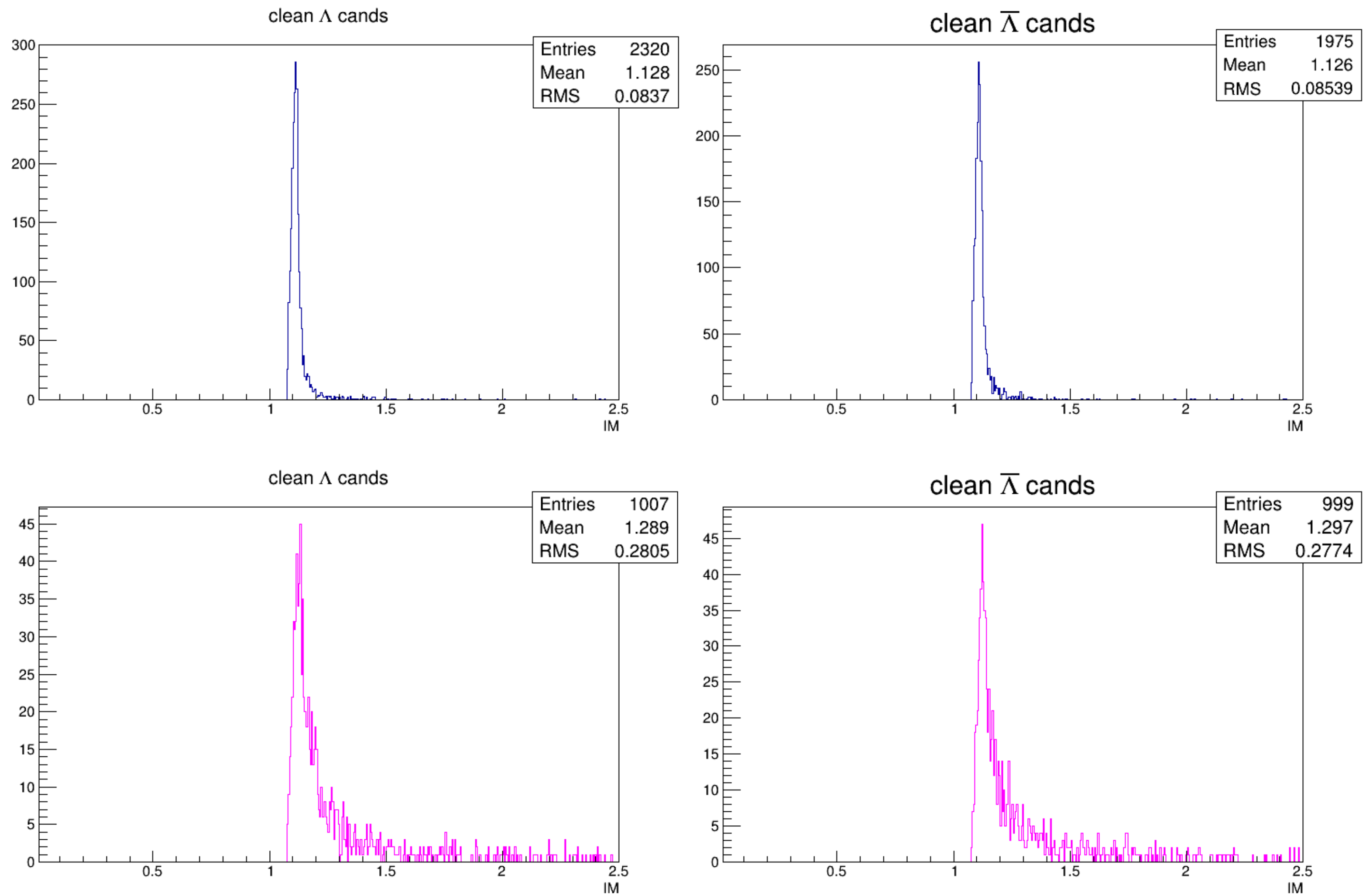


Distance from (0,0) of the center of curvature – radius of curvature (cm)





IM for clean tracks



- **Primary TF**
- **Secondary TF**

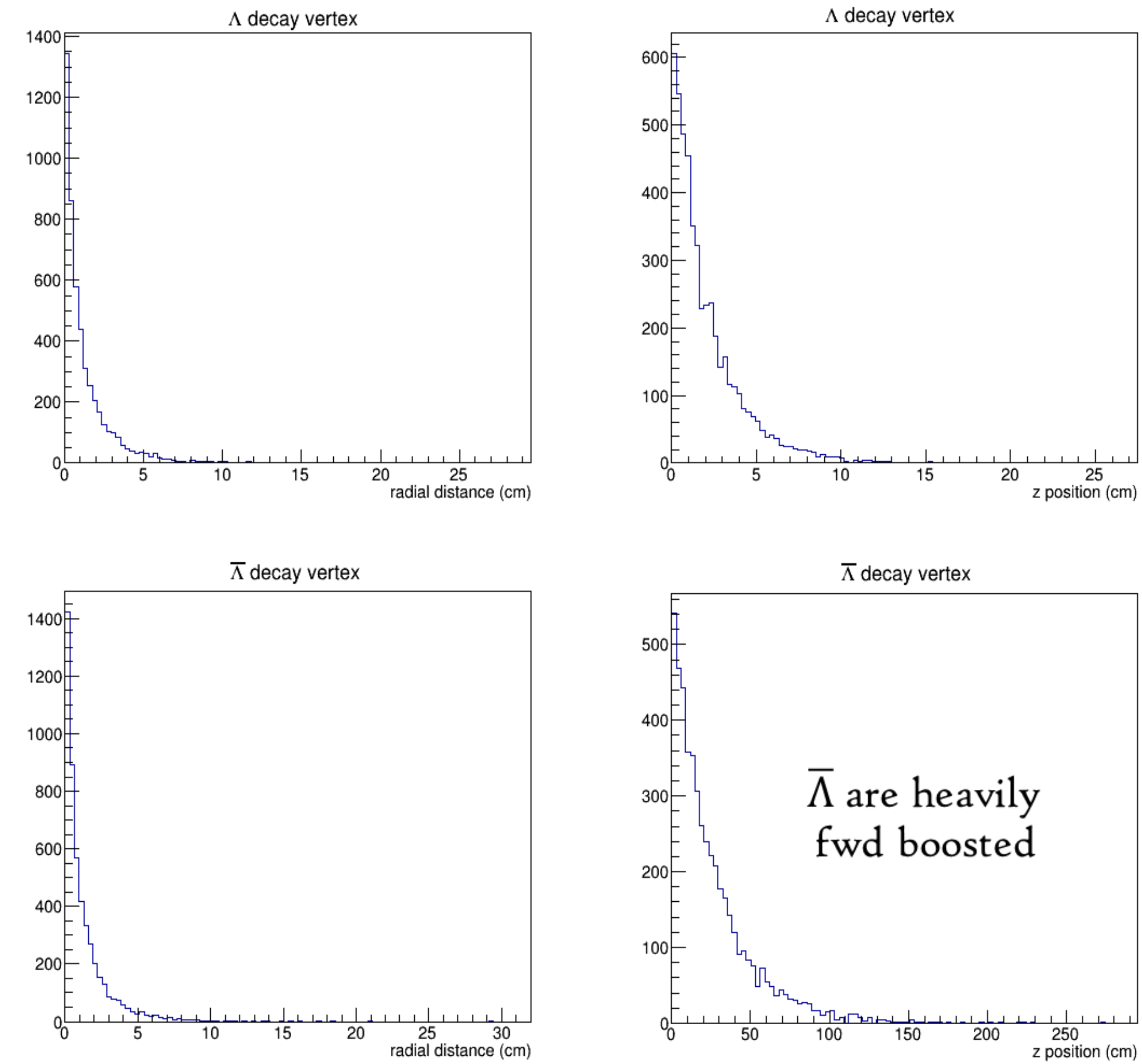
Clean

- PID from Monte Carlo
- only one true track
- primaries only

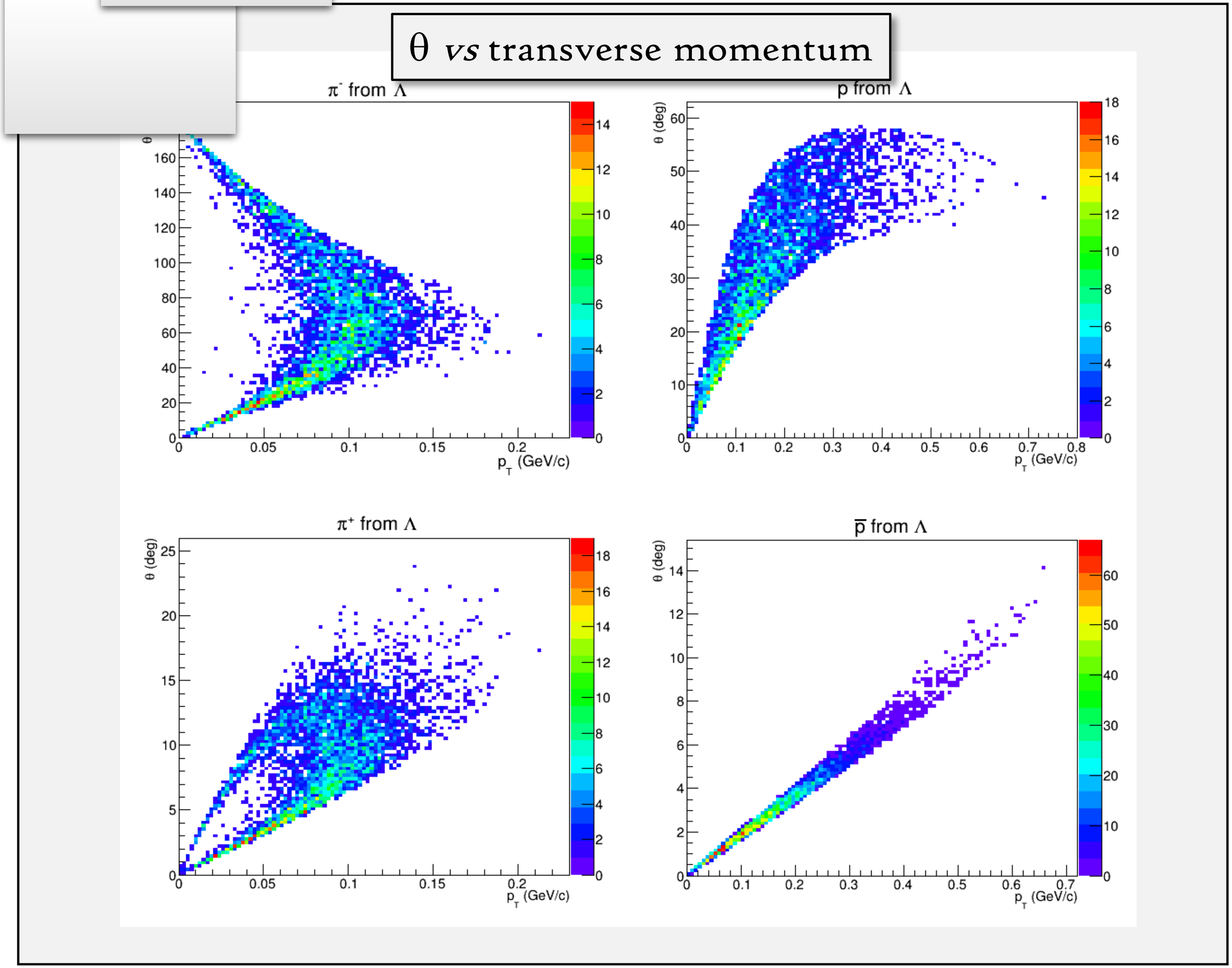
$\bar{p}p \to \overline{\Lambda}\Lambda$, boosted model

MC information

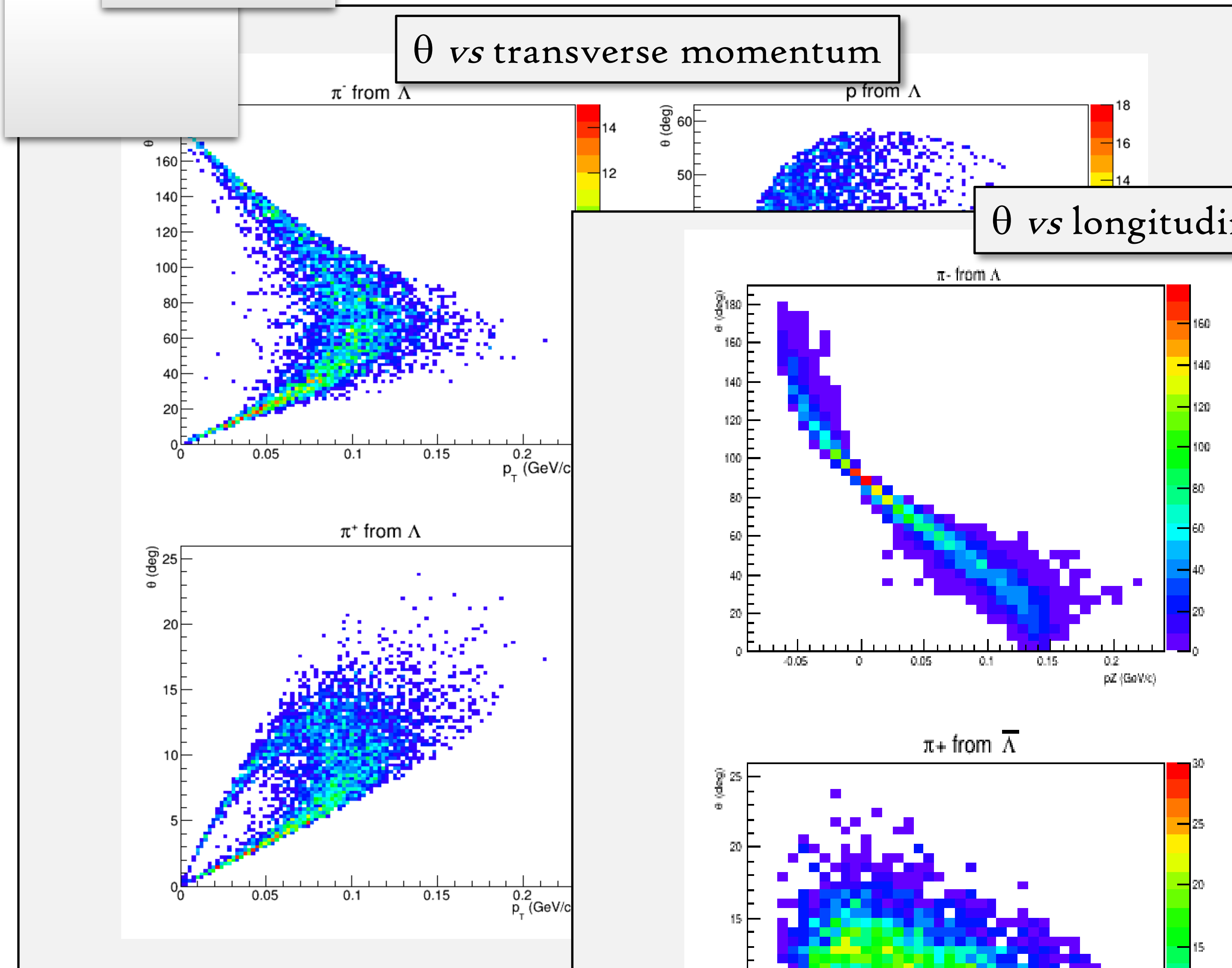
Decay vertex position

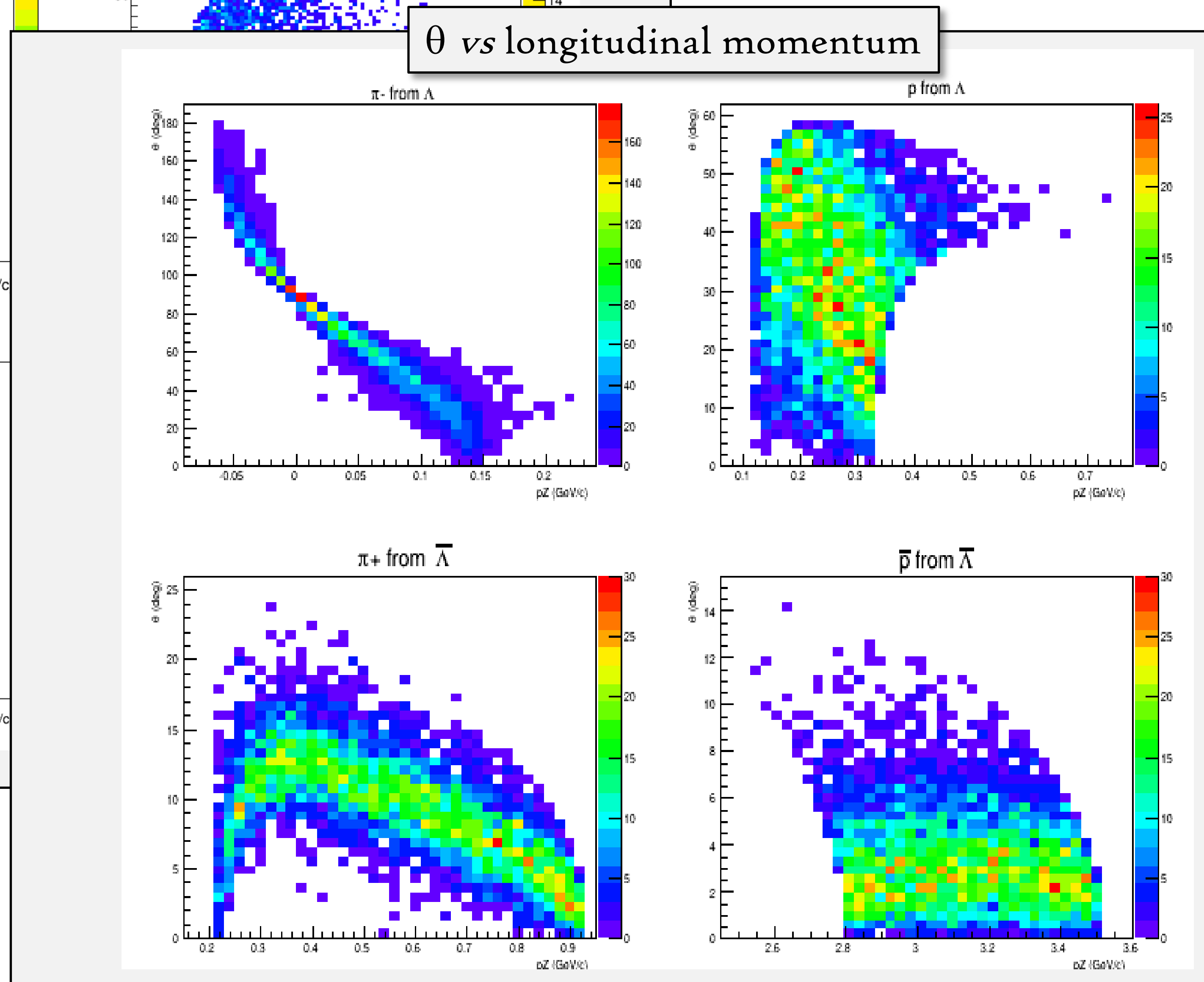


MC information



MC information

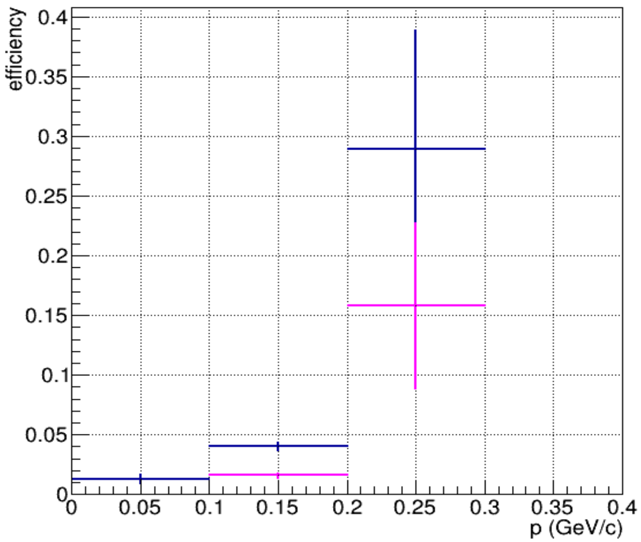


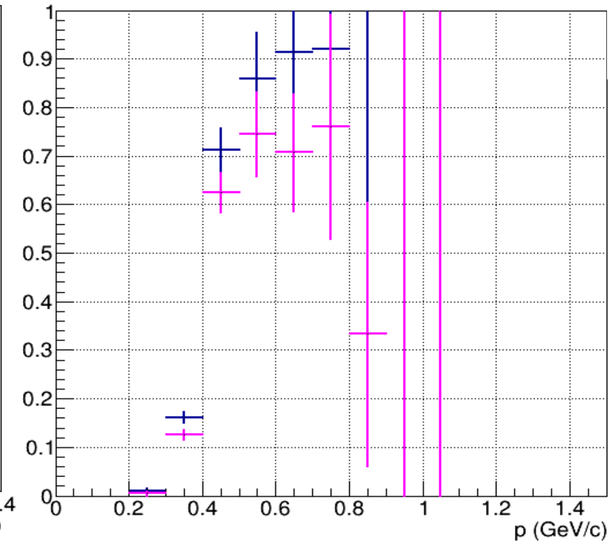


Efficiency vs momentum boost

EFFICIENCY = # TRUE TRACKS WITH > 80% CORRECTLY ASSIGNED HITS / # MC RECONSTRUCTABLE TRACKS

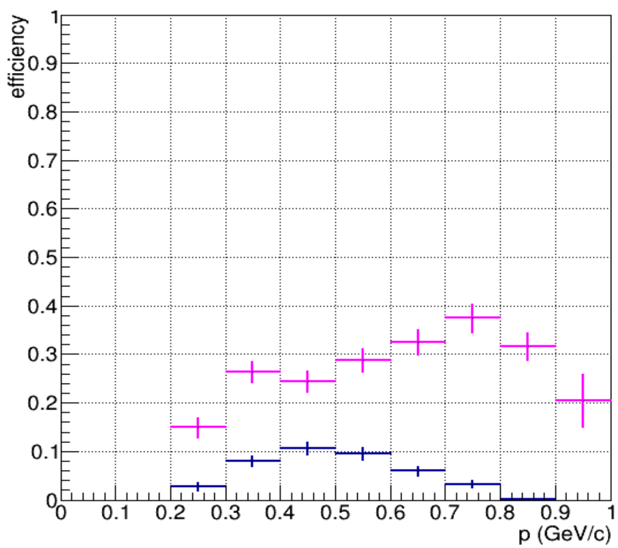
NEGATIVE PIONS

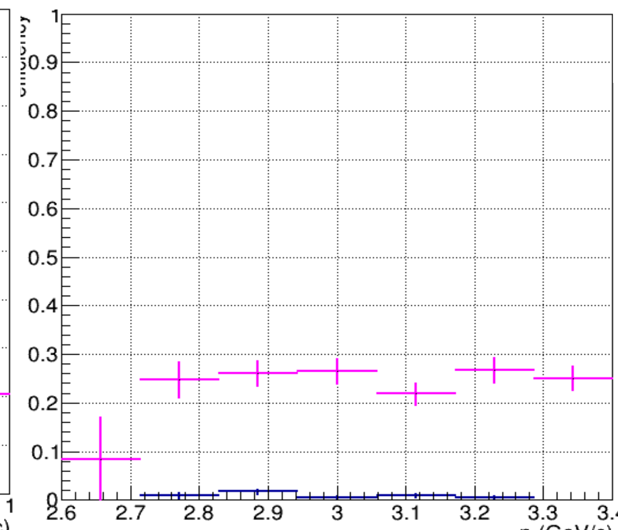




PROTON

POSITIVE PIONS

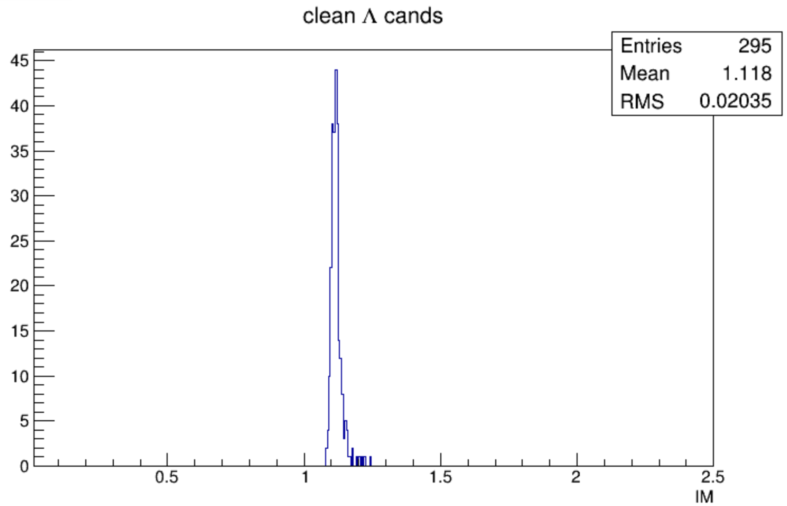


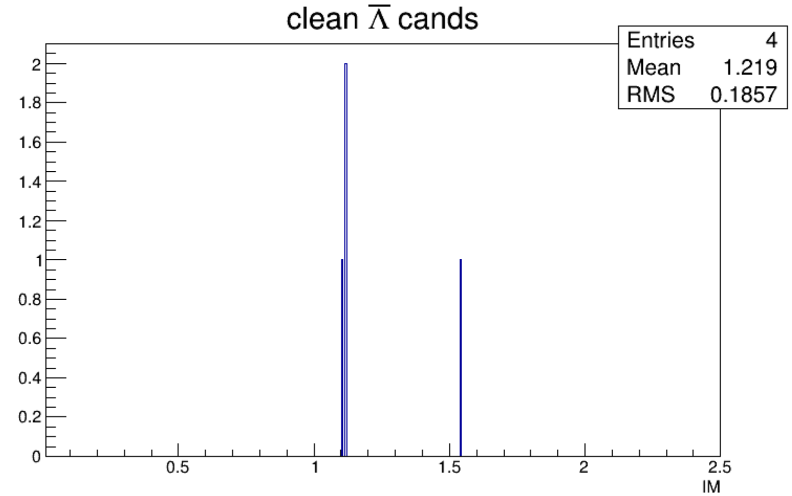


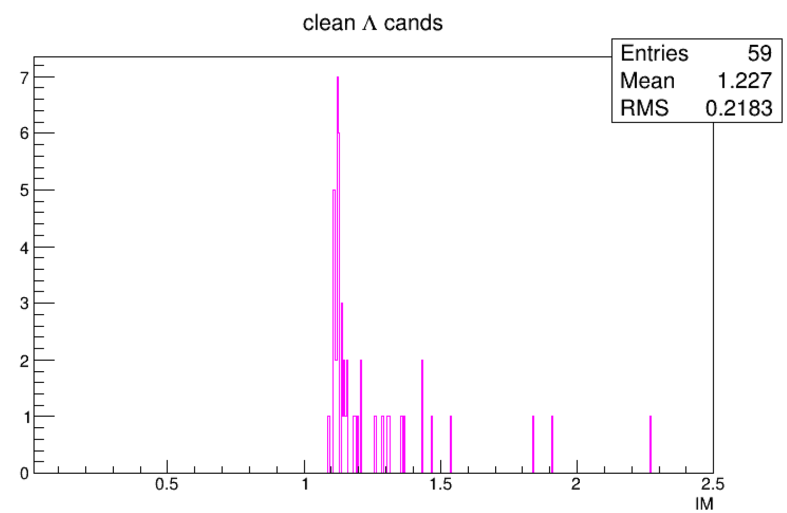
ANTIPROTON

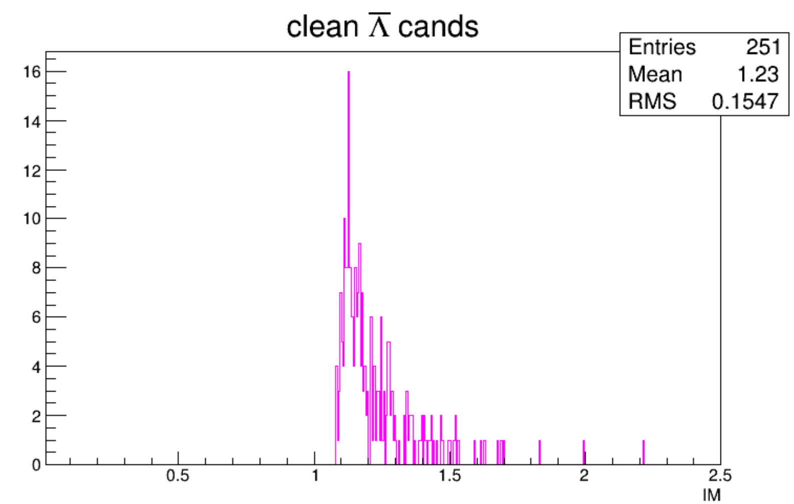
- Primary TF
- Secondary TF

IM for clean tracks









- **Primary TF**
- **Secondary TF**

Clean

- PID from Monte Carlo
- only one true track
- primaries only

Conclusions

- In the tests with formation/decay vertex @ 0, 10 cm in x and/or z direction, the primary TF shows better results in an area of some cm around (0, 0, 0).
- Far from the IP the secondary TF shows better performances.
- The secondary TF covers in a better way the low θ region (still to be improved).
- The secondary TF algorithm needs an improvement in the $z\phi$ plane, to avoid the peak and tails in the momentum distribution.

- In the $\Lambda\Lambda_{bar}$ events - phase space model, the distribution of the secondary vertex positions is peaked @ (0, 0, 0), thus giving better results with the primary TF.

- In the $\Lambda\Lambda_{bar}$ events - boosted model, the distribution of the secondary vertex positions of the Λ_{bar} is forward peaked, thus giving better results with the secondary TF; the Λ is still better with the primary TF.

- **WARNING!** The looping particles are still left unfound (code needed)

Thanks to Stefano and Karin and… **THANK YOU**

FOR YOUR ATTENTION