PID purity study on simulation tracks

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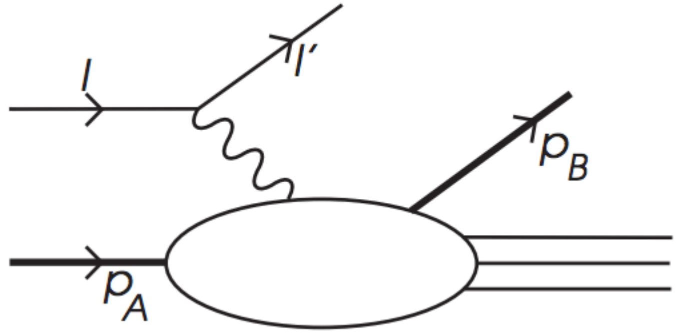
Goal and definition

- Goal: check PID purity for tracks in jets and observe how the purity change with different track energy and the track momentum fraction (z) from the jet.
- PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system}{number\ of\ all\ track\ within\ PID\ system\ coverage}$ for certain kind of particle (Pion, Kaon, proton).
  - "Correctly identified track": 4-momentum and PID of the track are same (matched) between the track in PID system and track from jet.
  - Code : TrackA->Particle.GetObject() == TrackB->Particle.GetObject()
  - dualRICH_aerogel: $1 < \eta < 3.5$, $P < 12\ GeV$
  - dualRICH_c2f6: $1 < \eta < 3.5$, $P > 12\ GeV$
  - barrelDIRC: $-1 < \eta < 1$
  - ~~mRICH: $-3.5 < \eta < -1$~~

Data set

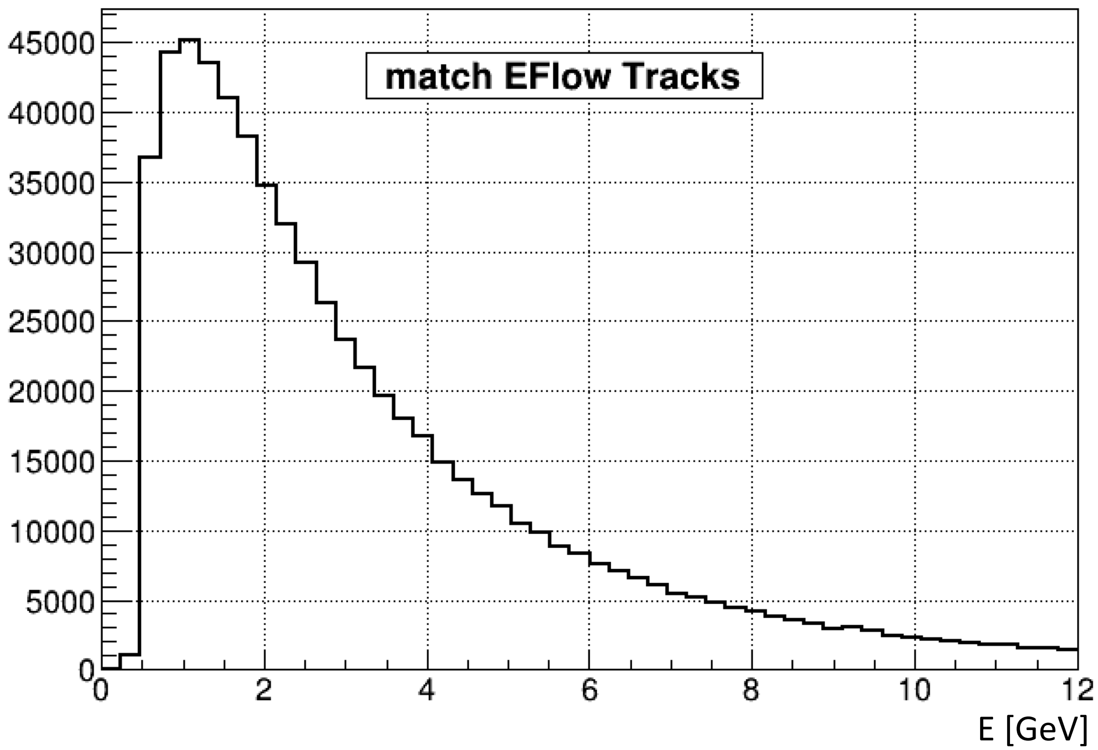
- Use Pythia8 and Delphes to simulate DIS process
- Delphes card: **delphes_card_allsilicon_3T.tcl** . Based on EIC Delphes card.
- Number of event generated: 200 k
- E_{proton} = 100 GeV
- $E_{electron}$ = 10 GeV
- Q^2 > 100 GeV
- Jet finding: Anti-kT algorithm, R<1

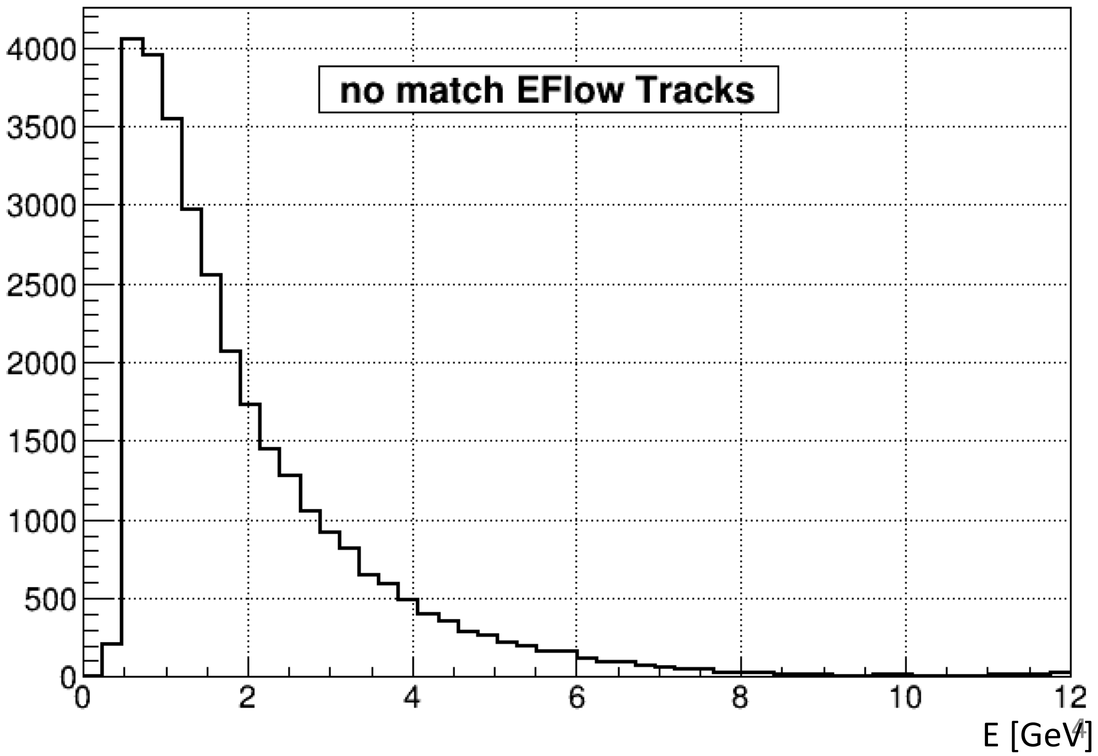


- The input track list for jet finding is: Eflow track.
  - Include Ecal photons, Hcal tracks and Hcal neutral hadrons.
- The input track list for PID system is: Smearing Track

Check Eflow track with dualRICH_aerogel

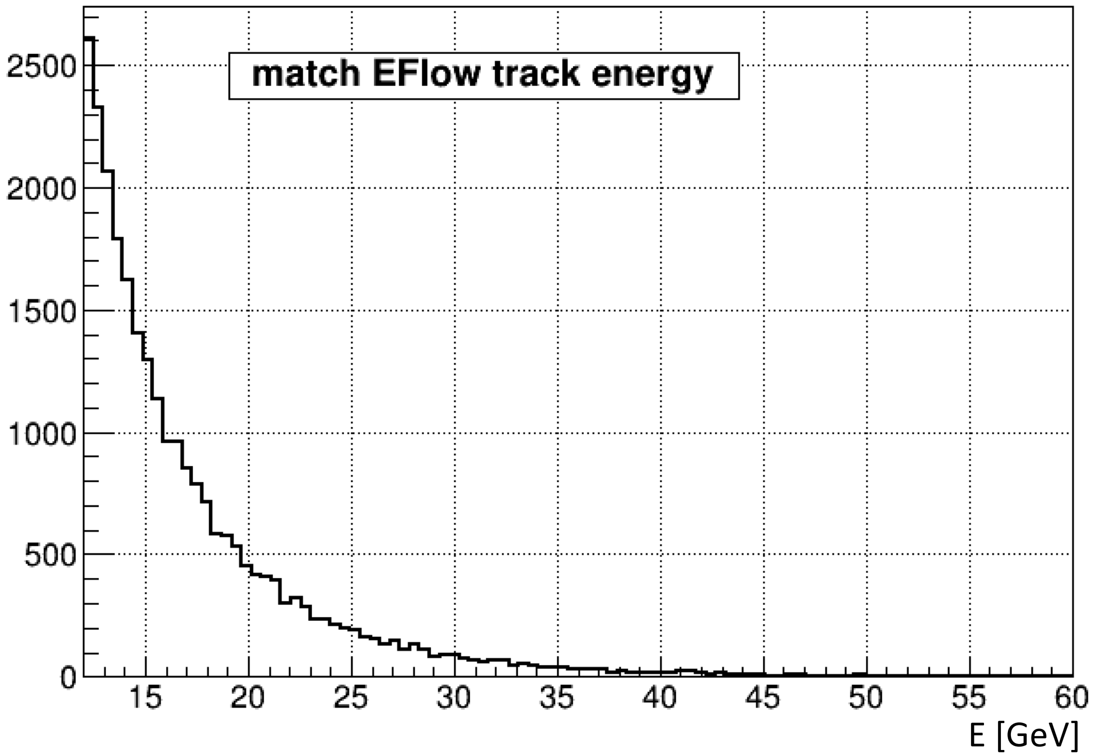
- Range of Eflow tracks for checking matching with dualRICH_aerogel tracks.
  - Particle type: Pion, Kaon, proton (from PID number)
  - $1 < \eta < 3.5$, $P < 12\ GeV$

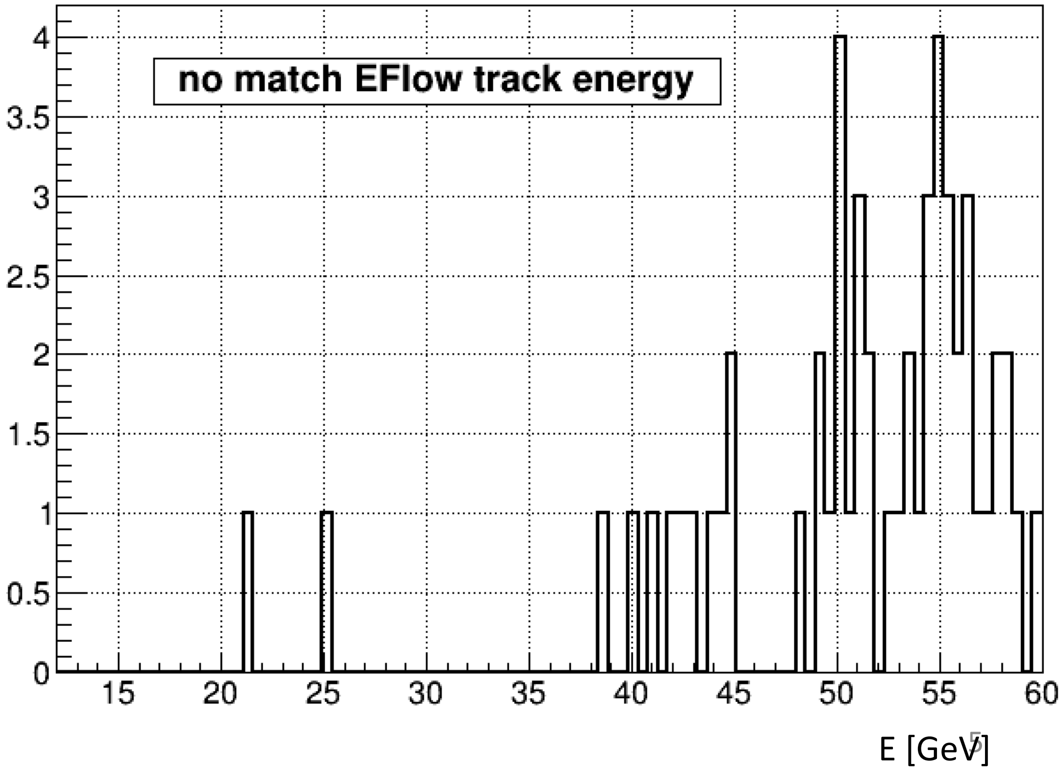




Check Eflow track with dualRICH_c2f6

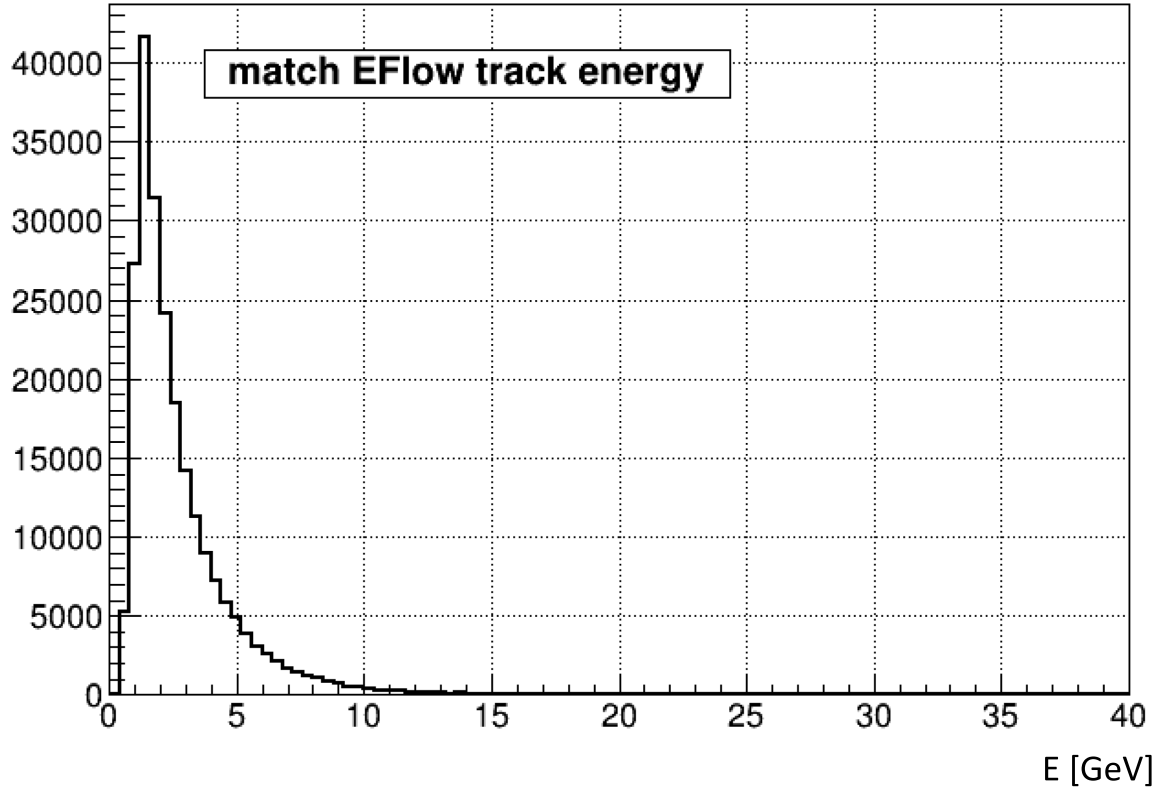
- Range of Eflow tracks for checking matching with dualRICH_c2f6 tracks.
  - Particle type: Pion, Kaon, proton (from PID number)
  - $1 < \eta < 3.5$, $P > 12\ GeV$
- Surprisingly, few Eflow tracks can not match with dualRICH_c2f6 tracks.

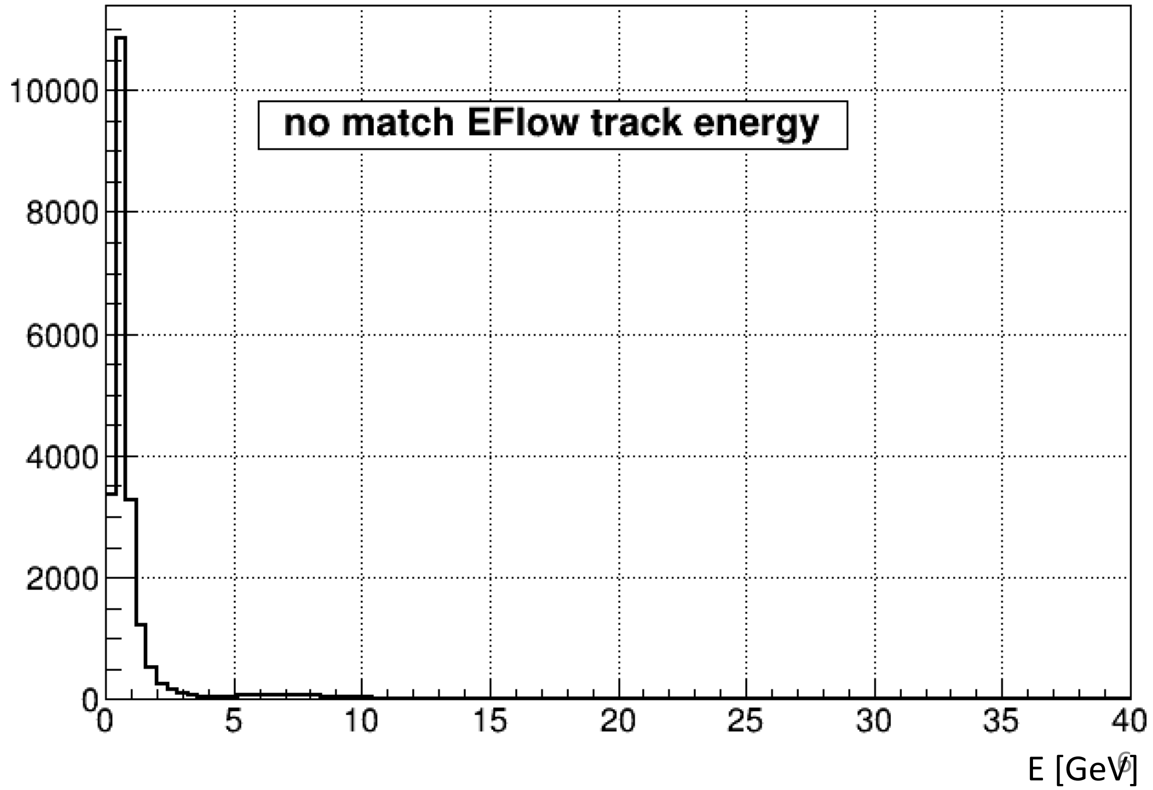




Check Eflow track with barrelDIRC

- Range of Eflow tracks for checking matching with barrelDIRC tracks.
  - Particle type: Pion, Kaon, proton (from PID number)
  - $-1 < \eta < 1$





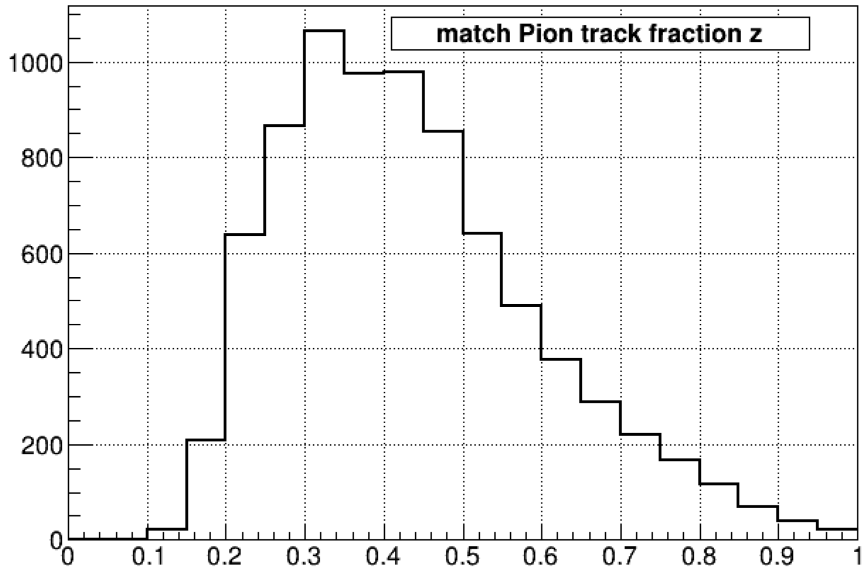
PID system dualRICH_c2f6

- dualRICH_c2f6: $1 < \eta < 3.5$, $P > 12\ GeV$
- PID efficiency: (obtain from Delphes simulation card, the exact identification efficiency is various by different η and E)
  - Pion to Pion: > 80%
  - Kaon to Kaon: > 80%
  - Proton to proton: ≈100%

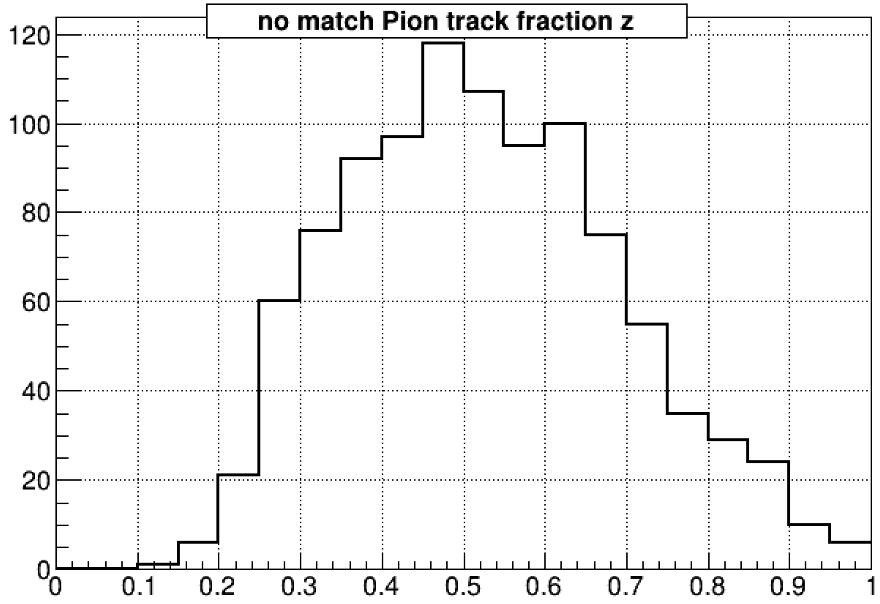
(no) match Pion track distribution with fraction z

- PID system: dualRICH_c2f6 ($1 < \eta < 3.5$, $P > 12\ GeV$)
- Match track: find out track in PID system with the same track in the simulation track list.
- No match track: can NOT find out track in PID system for the track within coverage with same type in the simulation track list.

Z: track momentum fraction from the jet



z

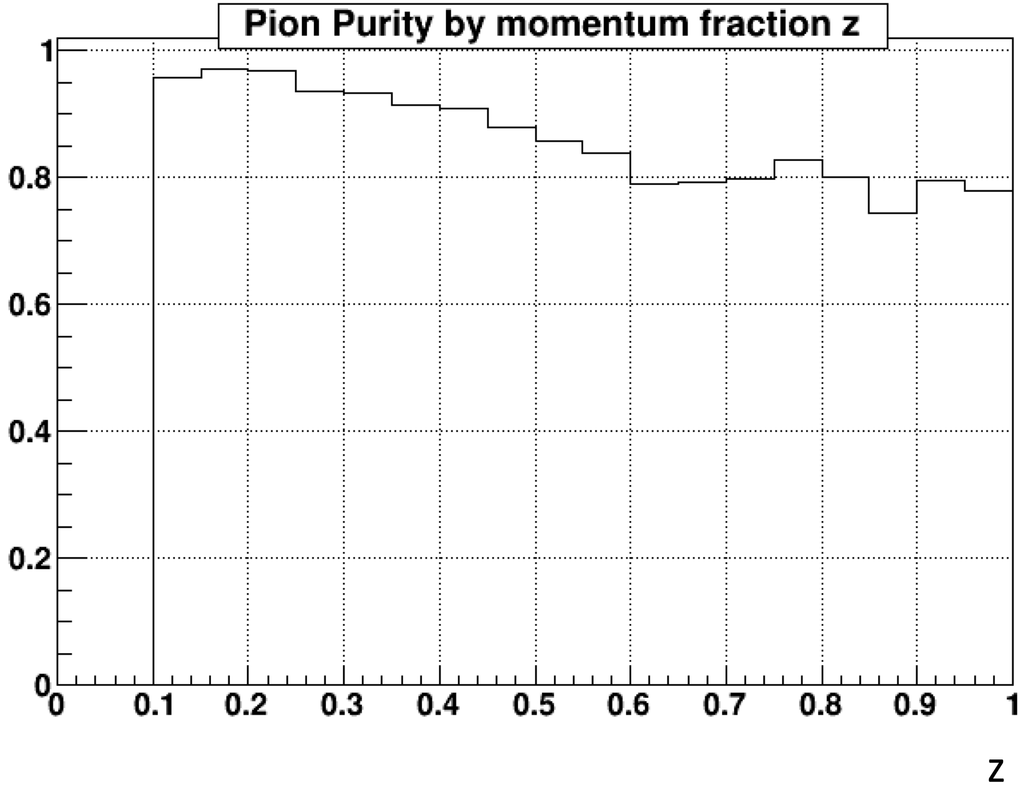


z

Pion purity by momentum fraction z

PID system: dualRICH_c2f6

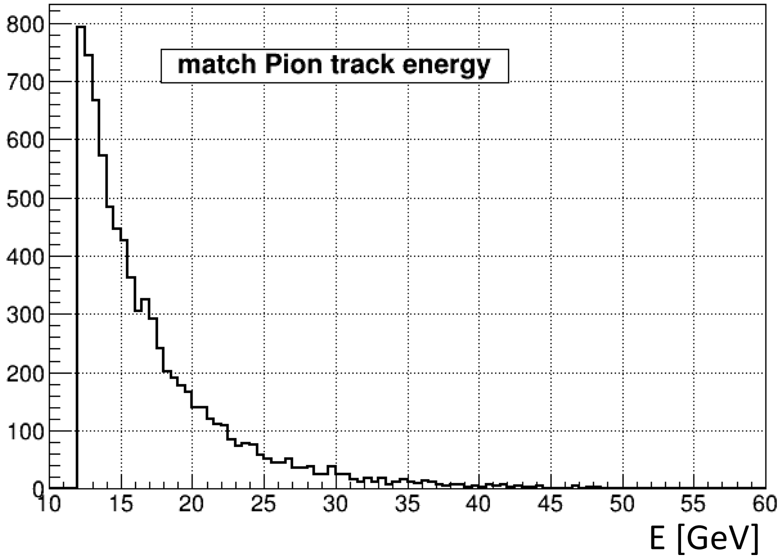
- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.

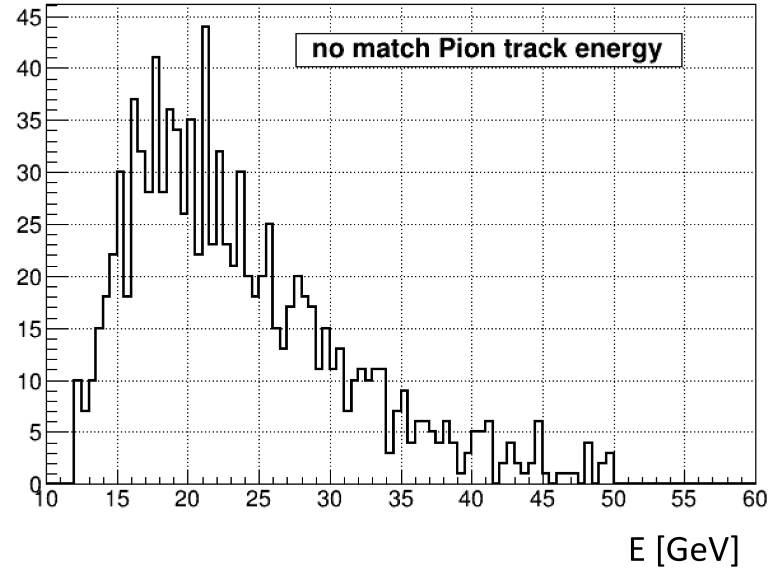


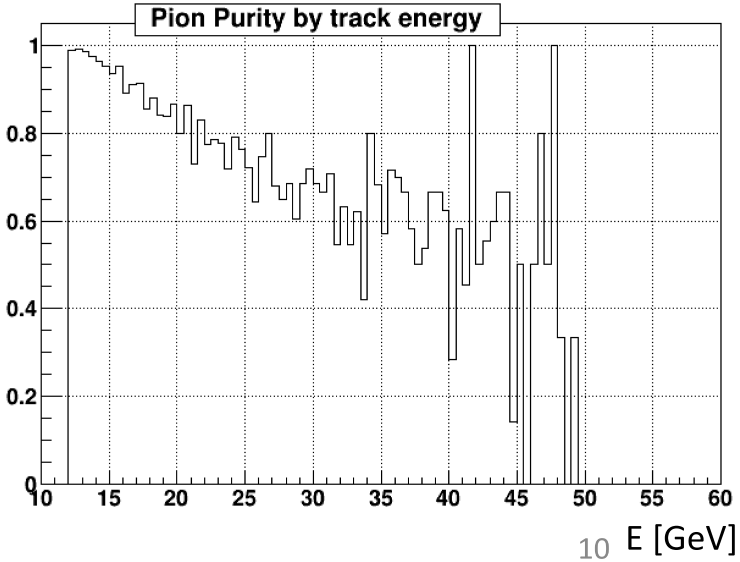
Pion purity by track energy

PID system: dualRICH_c2f6

- $purity = \frac{number\ of\ matched\ track\ within\ track\ energy\ range}{total\ number\ of\ track\ within\ track\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this jet energy range.
- For the relatively low purity at E > 20 GeV, there are still some tracks in jets that not match with PID system.







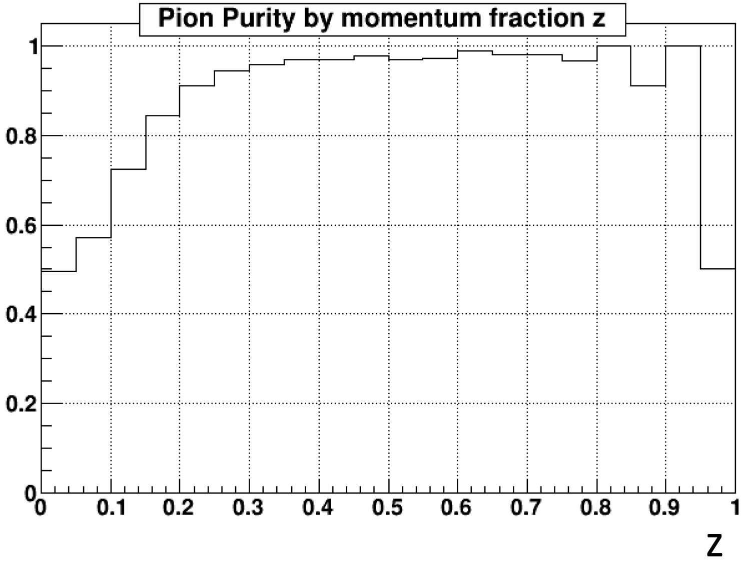
Compare with other PID system

- PID system track range:
  - dualRICH_aerogel: $1 < \eta < 3.5$, $P < 12\ GeV$
  - dualRICH_c2f6: $1 < \eta < 3.5$, $P > 12\ GeV$
  - barrelDIRC: $-1 < \eta < 1$
  - mRICH: $-3.5 < \eta < -1$

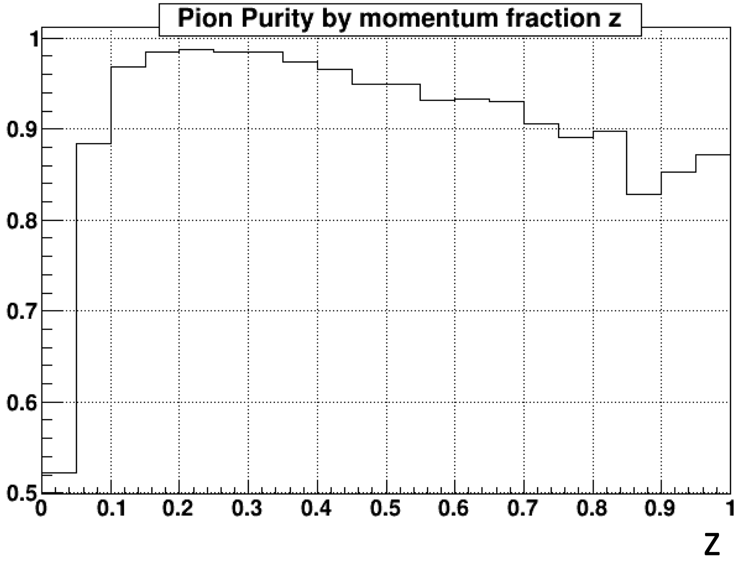
- All the track from jets need to satisfy for corresponding range when calculate for purity with each PID system.

Pion purity by z for different PID systems

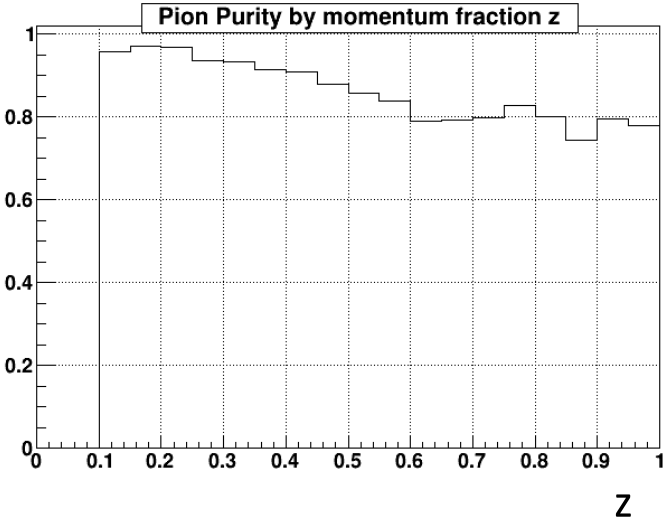
PID system: dualRICH_aerogel



PID system: barrelDIRC



PID system: dualRICH_c2f6

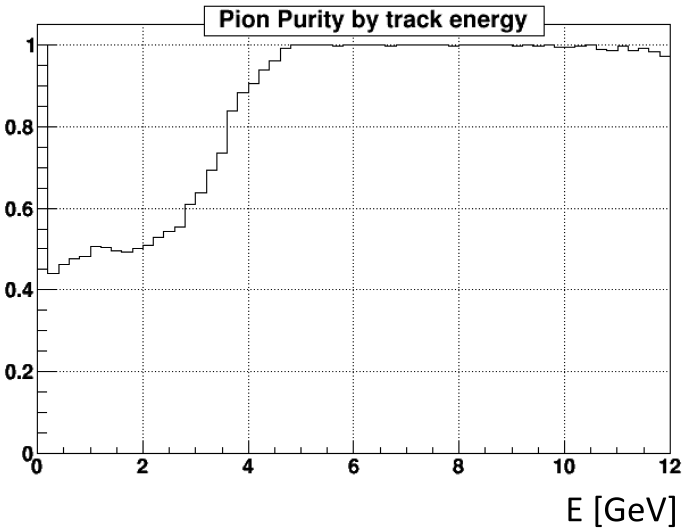


Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

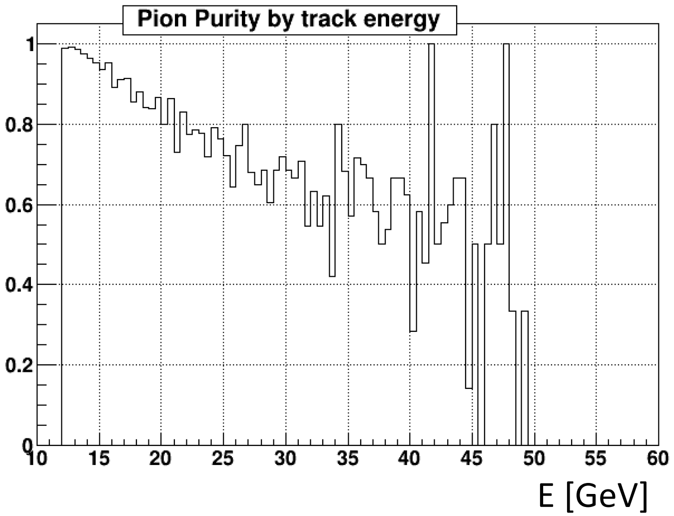
Z: track momentum fraction from the jet

Pion purity by track energy for different PID systems

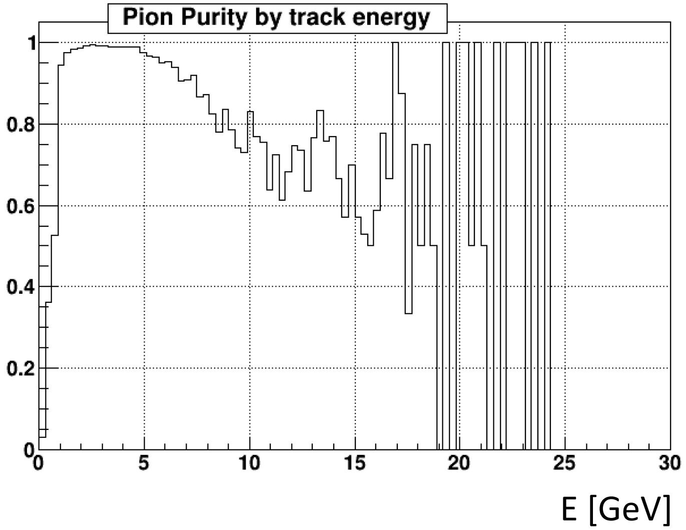
PID system: dualRICH_aerogel



PID system: dualRICH_c2f6



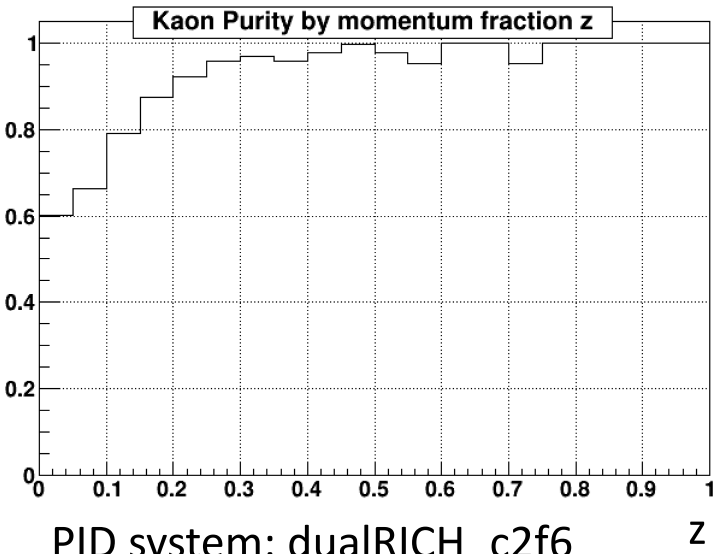
PID system: barrelDIRC



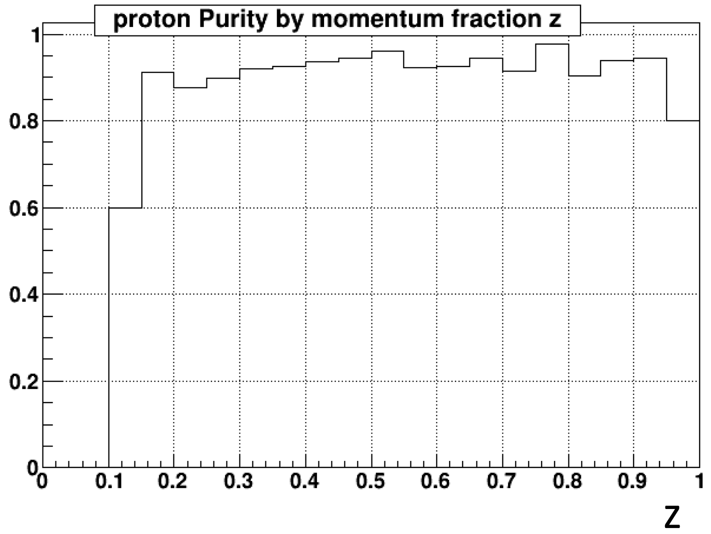
Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

Kaon purity by z for different PID systems

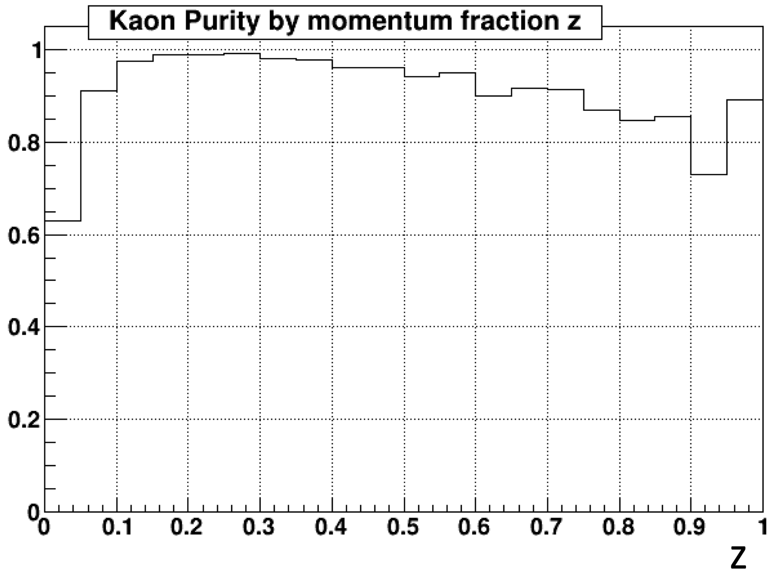
PID system: dualRICH_aerogel



PID system: dualRICH_c2f6



PID system: barrelDIRC

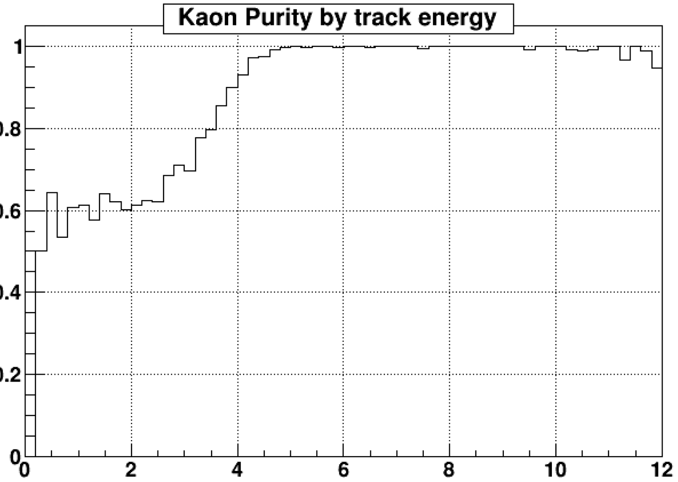


Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

Z: track momentum fraction from the jet

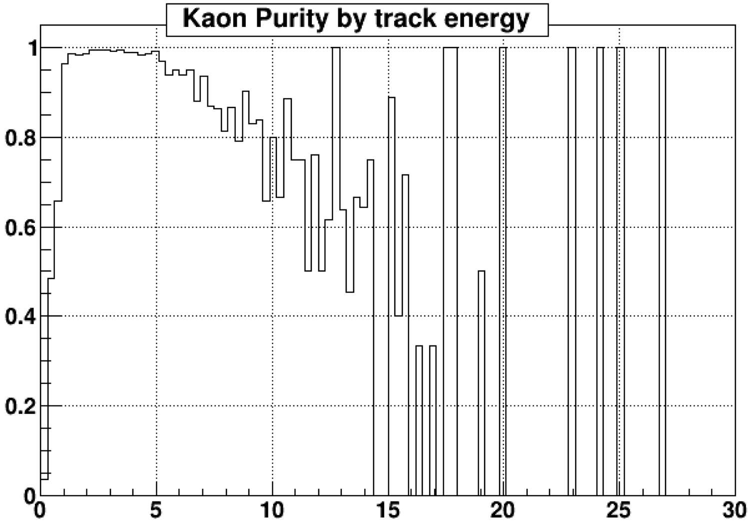
Kaon purity by track energy for different PID systems

PID system: dualRICH_aerogel



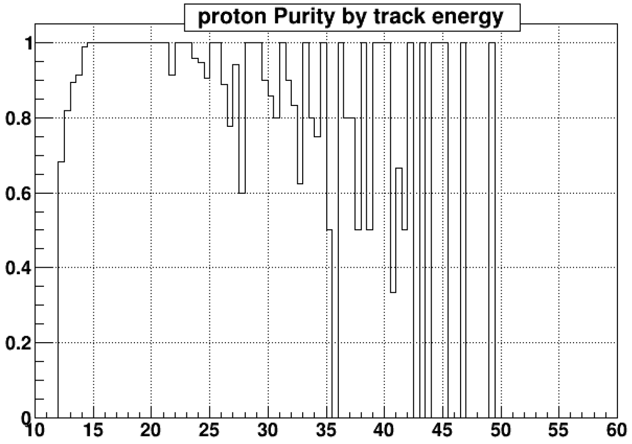
E [GeV]

PID system: barrelDIRC



E [GeV]

PID system: dualRICH_c2f6

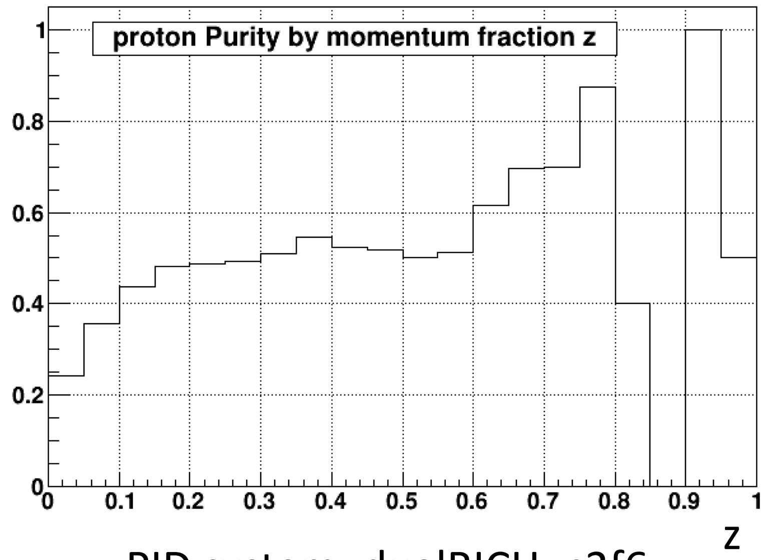


E [GeV]

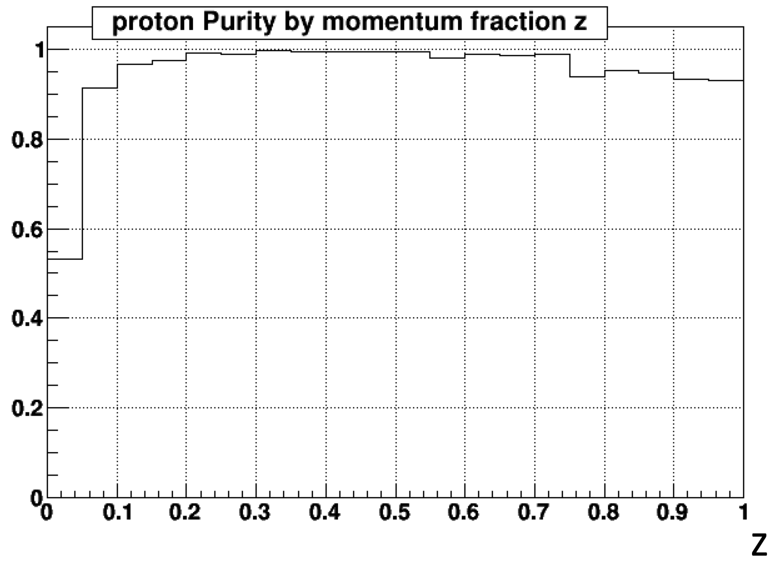
Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

Proton purity by z for different PID systems

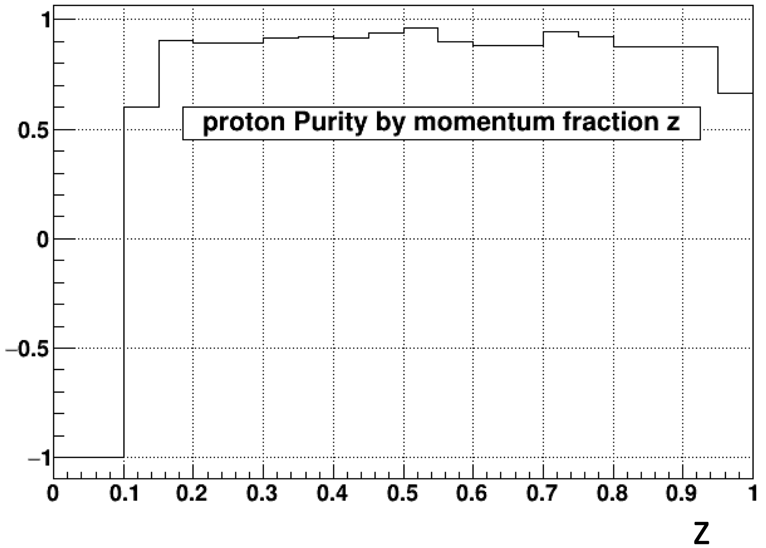
PID system: dualRICH_aerogel



PID system: barrelDIRC



PID system: dualRICH_c2f6

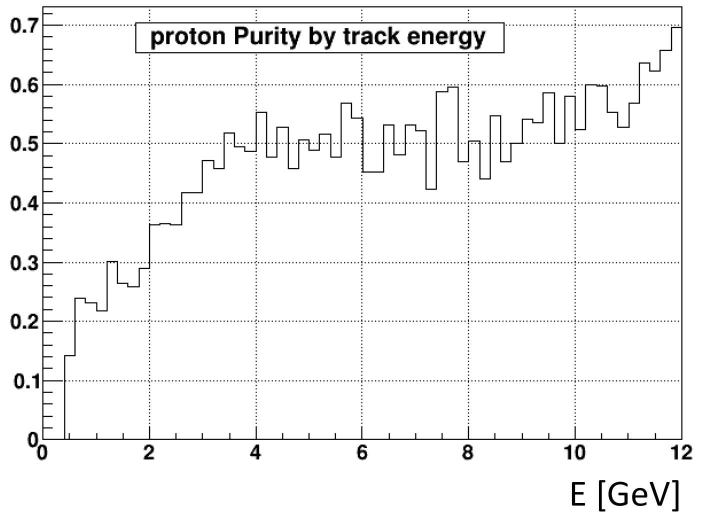


Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

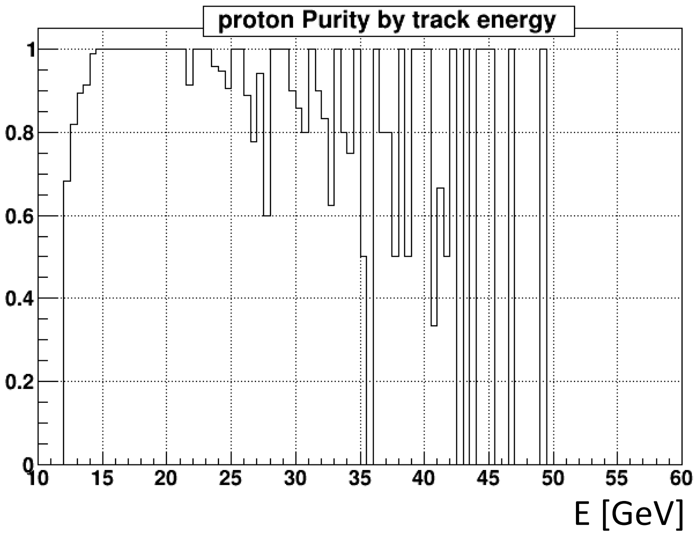
Z: track momentum fraction from the jet

Proton purity by track energy for different PID systems

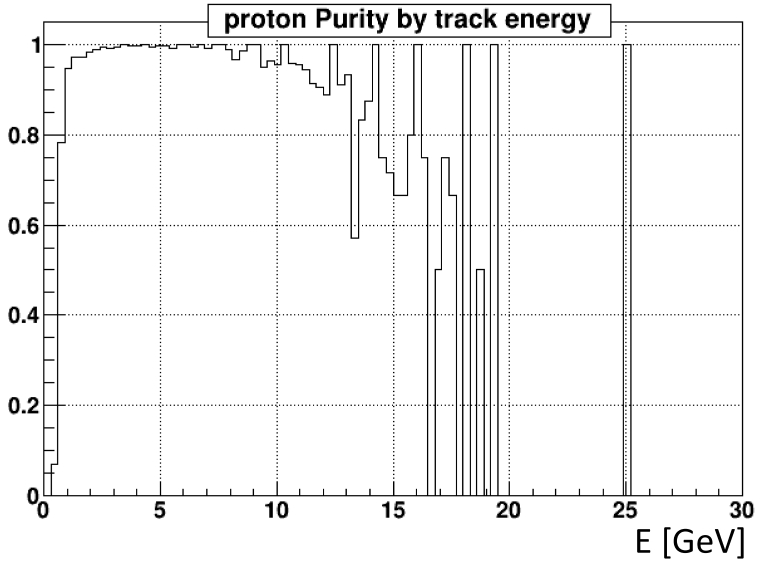
PID system: dualRICH_aerogel



PID system: dualRICH_c2f6



PID system: barrelDIRC



Not many tracks are within PID system mRICH coverage, so the purity is very low (close to 0).

Conclusion

- When we correct our track matching code based on expert's suggestion, we can get much more reasonable purity result.
- More detail for dualRICH_aerogel and barrel PID systems are in back up.

Back up

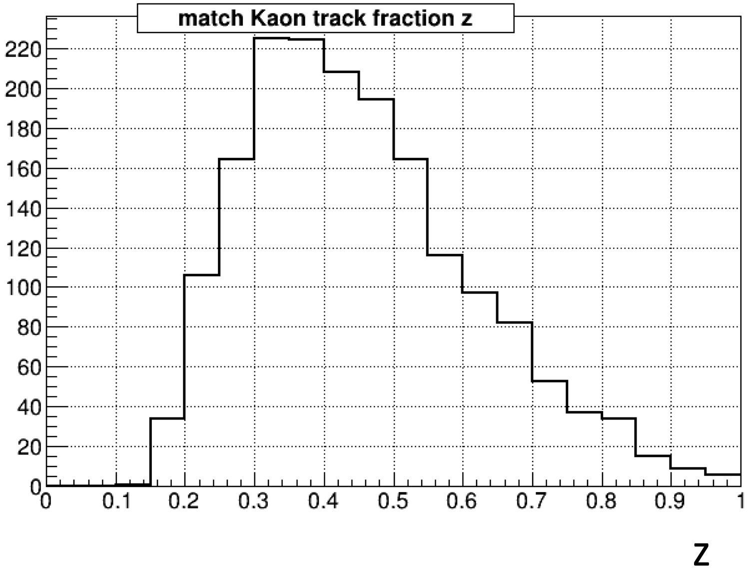
Basic idea for PID system

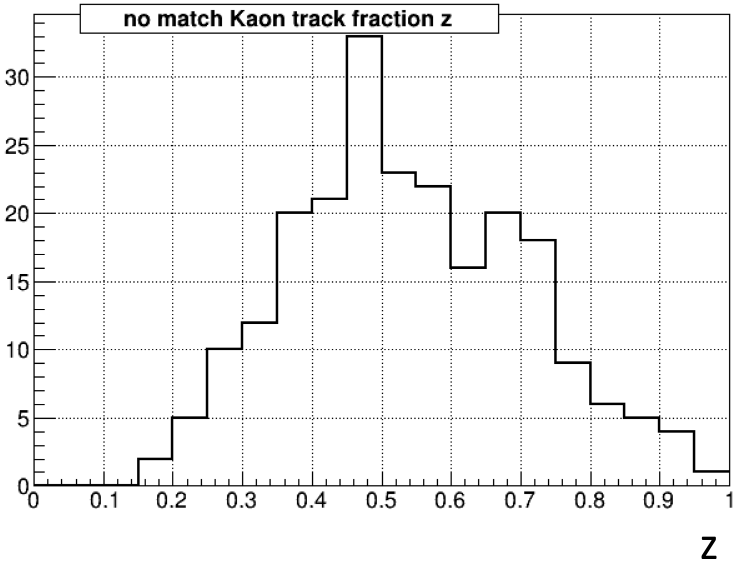
- For tracks, they have given the PID number for common particles to indicate their particle species.
- Implemented using Yellow Report-era EICUG tools ("PID Code") which returns nSigma separation for a particle with a given (P , eta) under a certain hypothesis pair (e.g. K/pi or K/proton).
  - This nSigma separation for particle pair give us the identification efficiency, which is probability that species A to identify as same species A. These have already set in Delphes simulation card.
- Check 4 different PID system purity:
  - mRICH , barrelDIRC , dualRICH_aerogel , dualRICH_c2f6

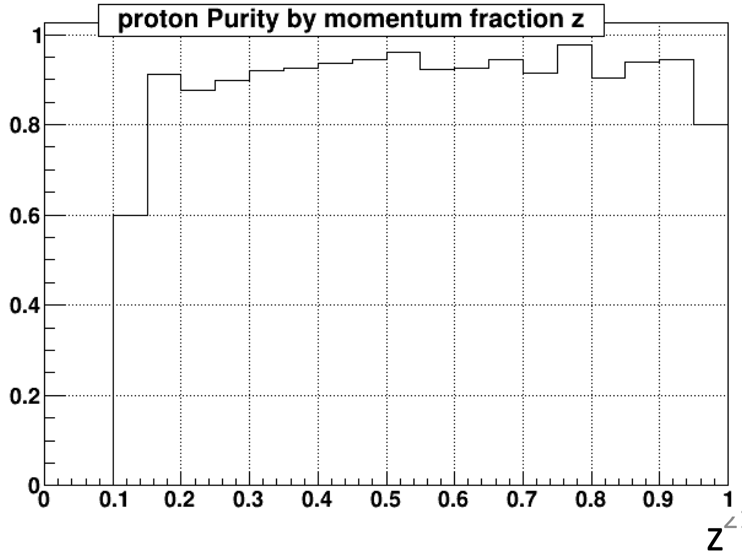
PID system: dualRICH_c2f6

Kaon purity by momentum fraction z

- $purity = \dfrac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.



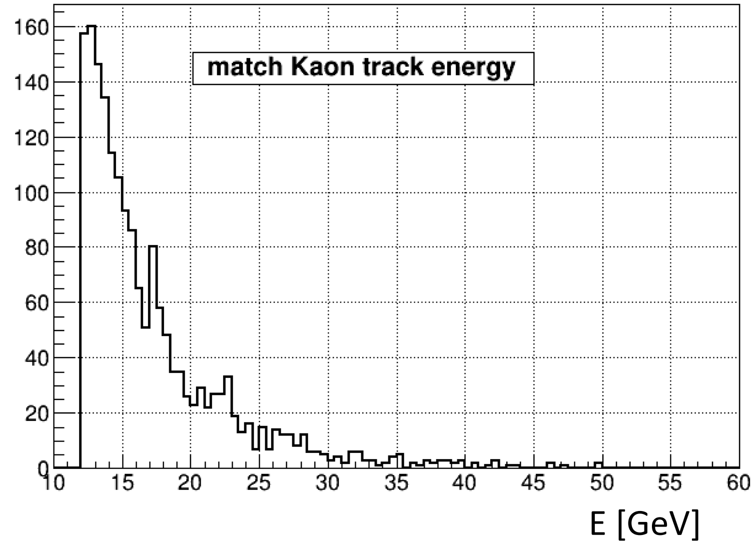


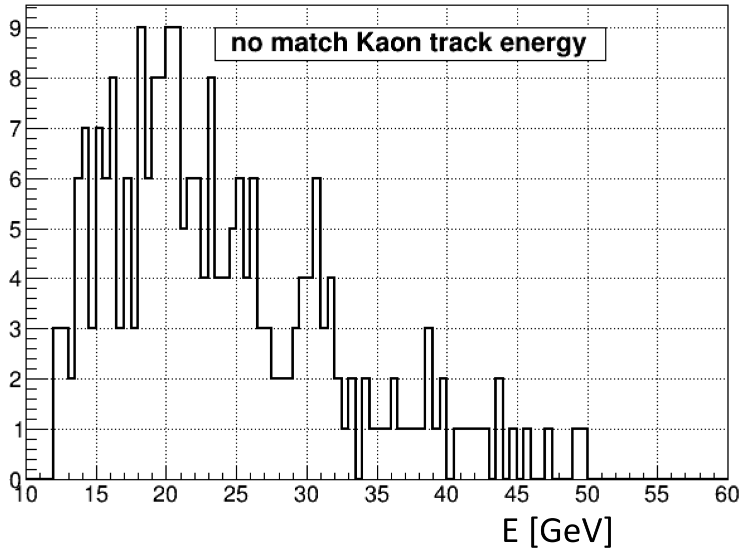


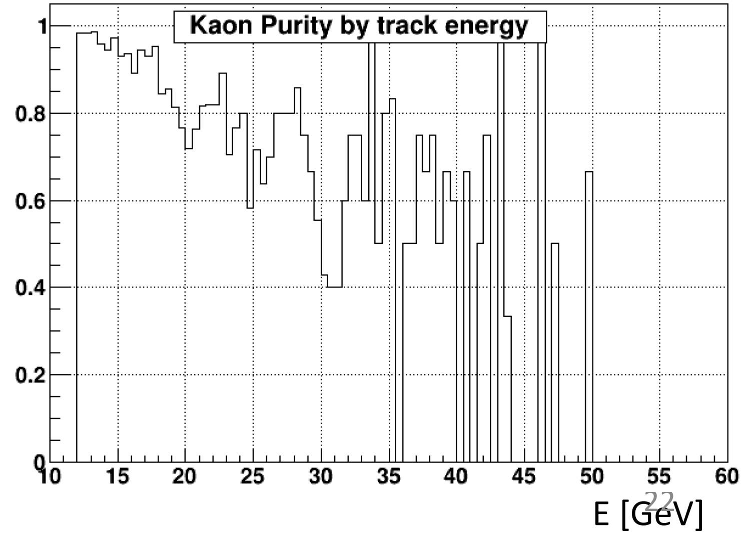
Kaon purity by track energy

PID system: dualRICH_c2f6

- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.



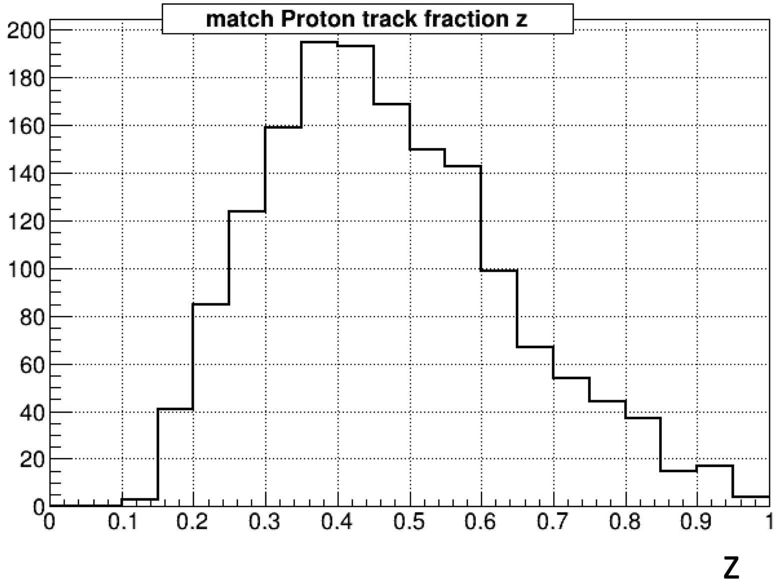


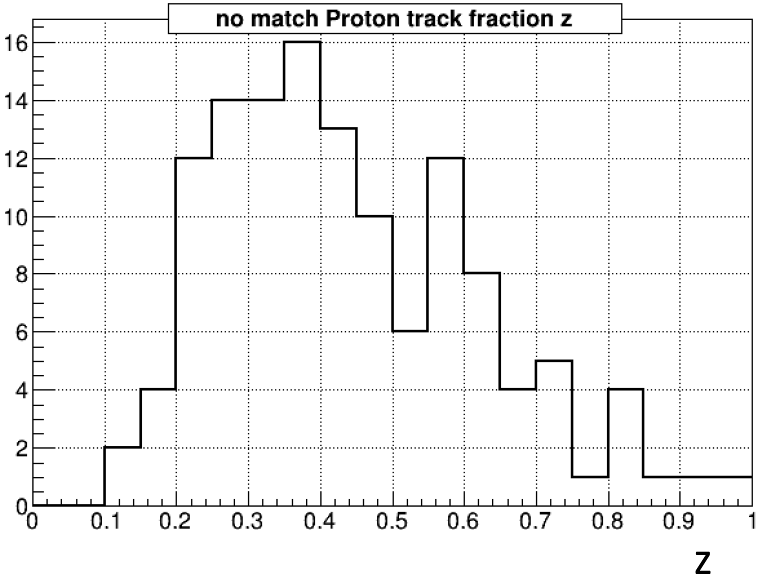


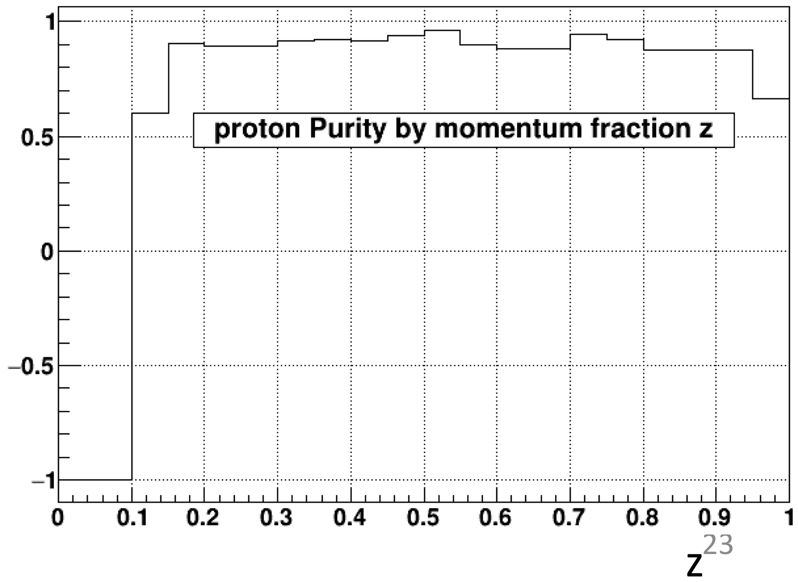
Proton purity by fraction z

PID system: dualRICH_c2f6

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.



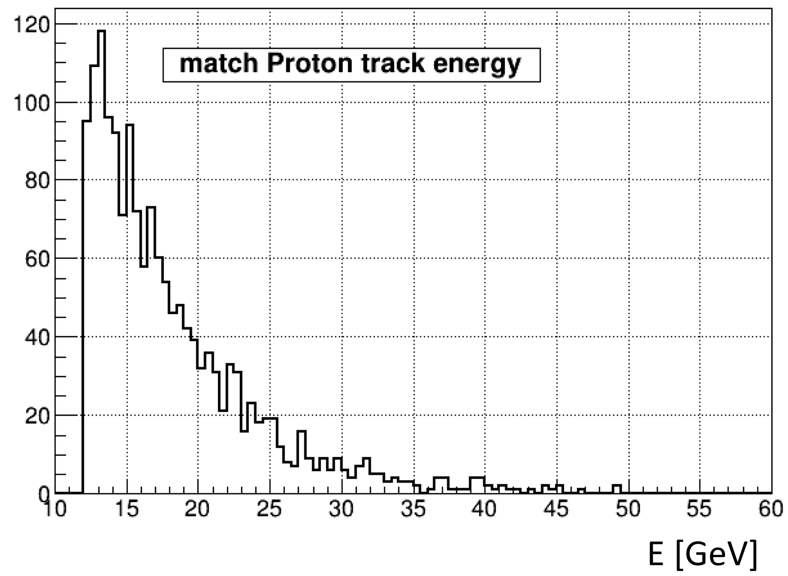


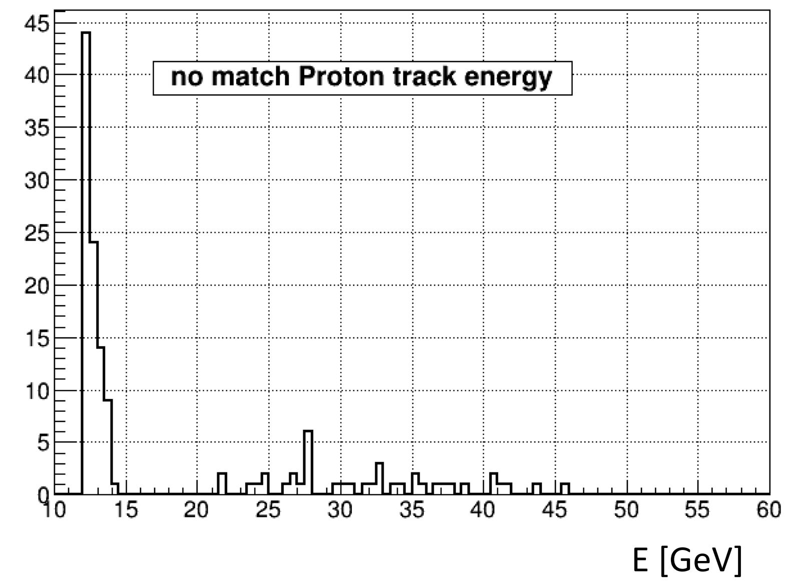


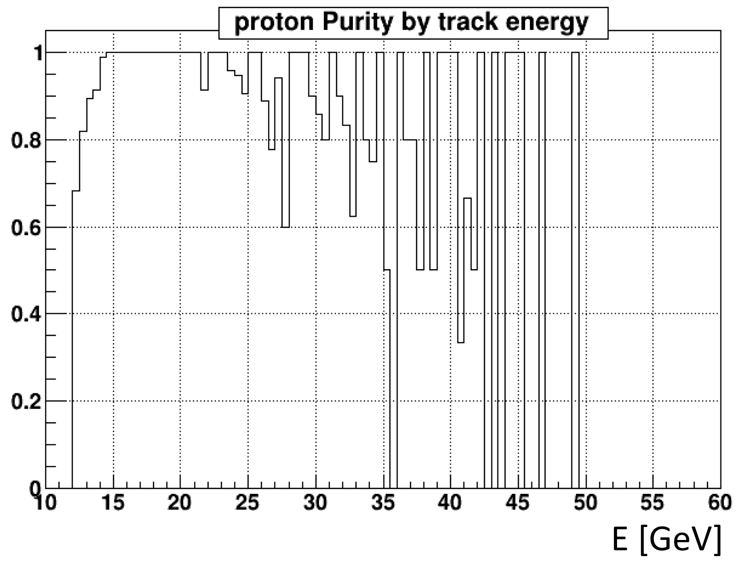
Proton purity by track energy

PID system: dualRICH_c2f6

- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.
- Proton energy less than 14 GeV are more likely to be not matched, maybe misidentified.





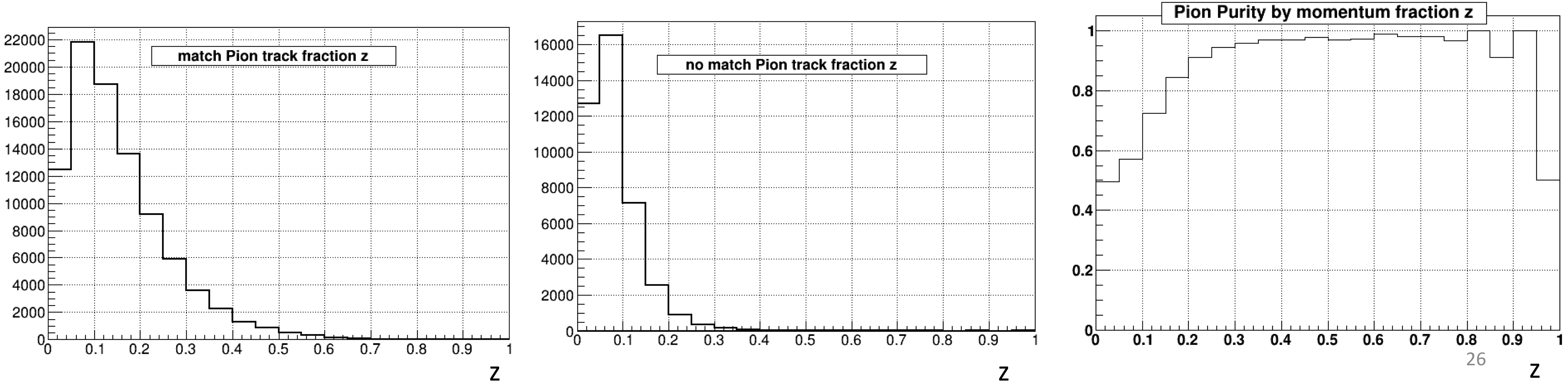


PID system: dualRICH_aerogel

- PID system: dualRICH_aerogel $(1 < \eta < 3.5\ , P < 12\ GeV)$
- PID efficiency:
  - Pion to Pion: > 60% (consider P < 20 GeV)
  - Kaon to Kaon: > 60% (consider P < 20 GeV)
  - Proton to proton: > 67% (consider P < 20 GeV)
  - For all, the lower energy range, the highest efficiency.

(no) match Pion track distribution with fraction z

- PID system: dualRICH_aerogel $(1 < \eta < 3.5\ , P < 12\ GeV)$
- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.



Pion purity by track energy

PID system: dualRICH_aerogel
$(1 < \eta < 3.5\ ,\ P < 12\ GeV)$

- $purity = \frac{number\ of\ matched\ track\ within\ track\ energy\ range}{total\ number\ of\ track\ within\ track\ energy\ range}$
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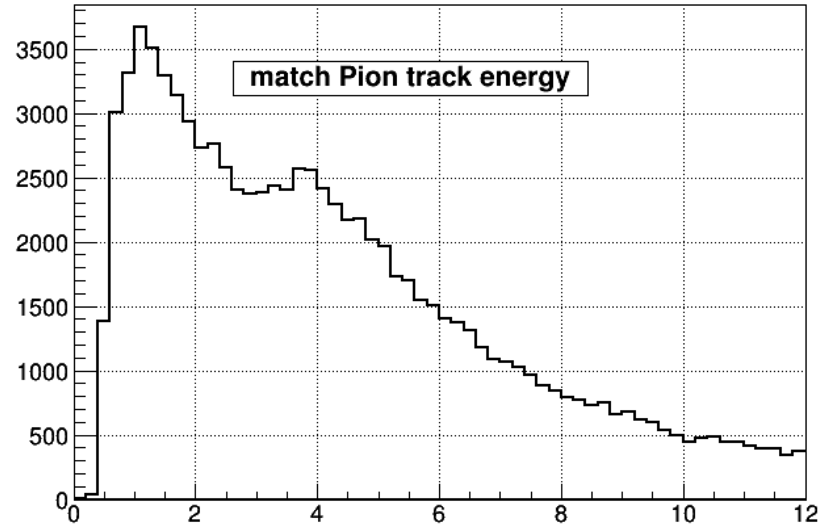
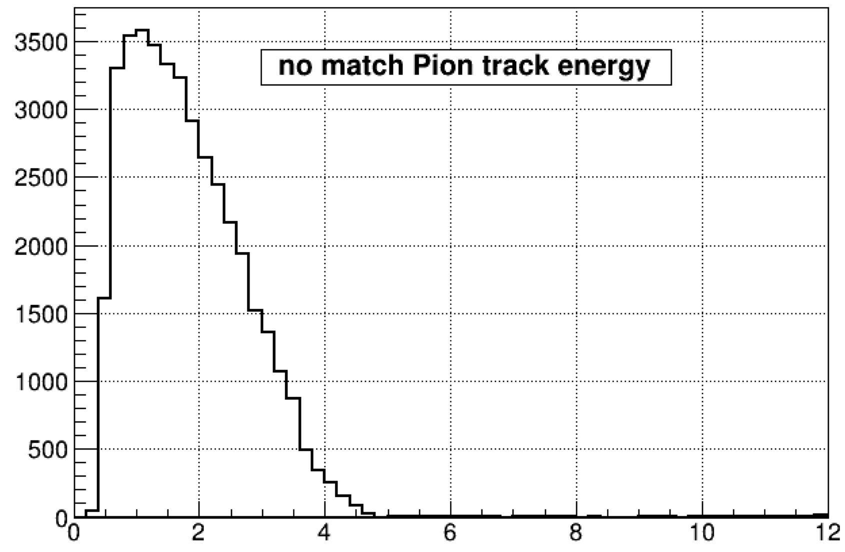
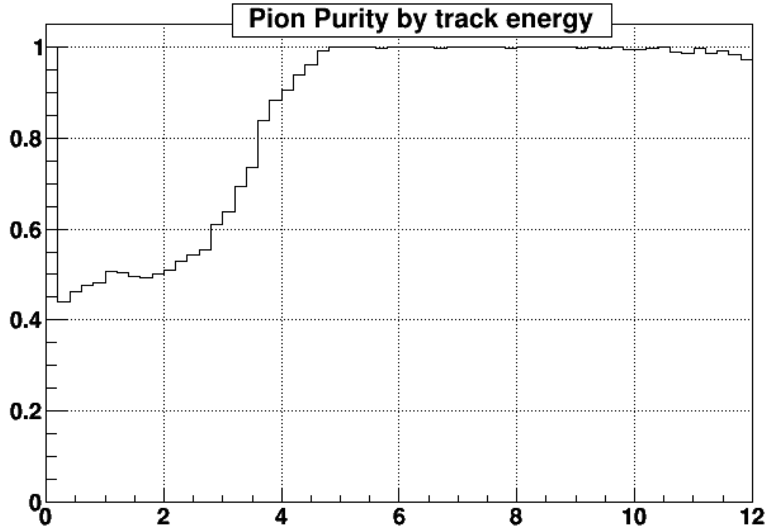


E [GeV]



E [GeV]



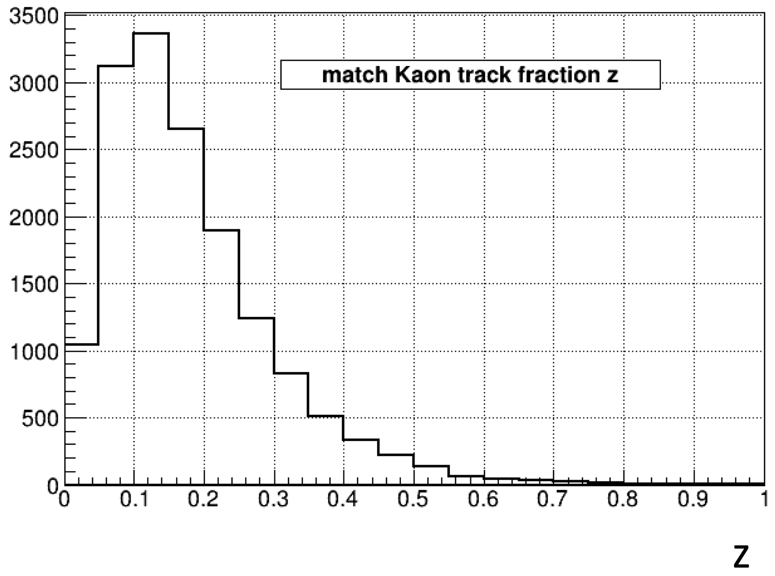
E [GeV]

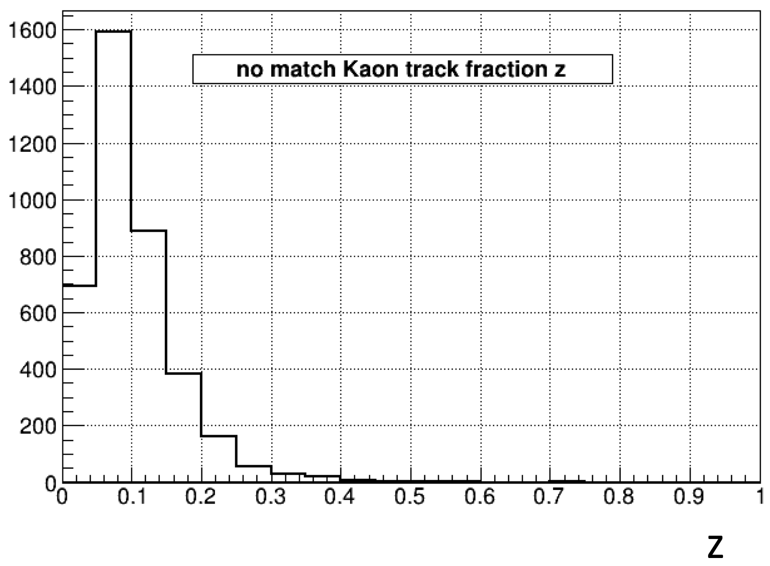
Kaon purity by momentum fraction z

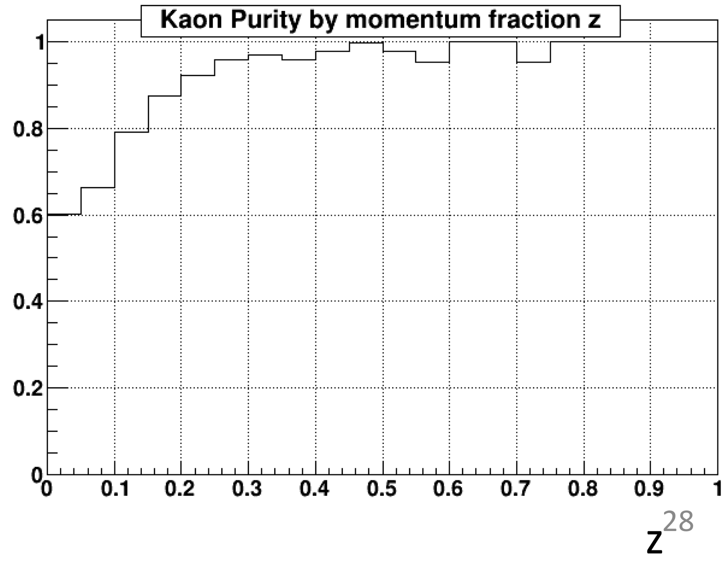
- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.

PID system: dualRICH_aerogel

$(1 < \eta < 3.5\ , P < 12\ GeV)$





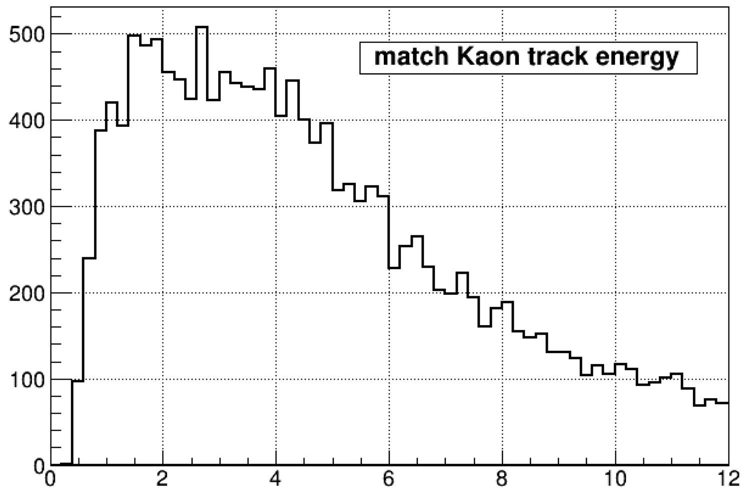


Kaon purity by track energy

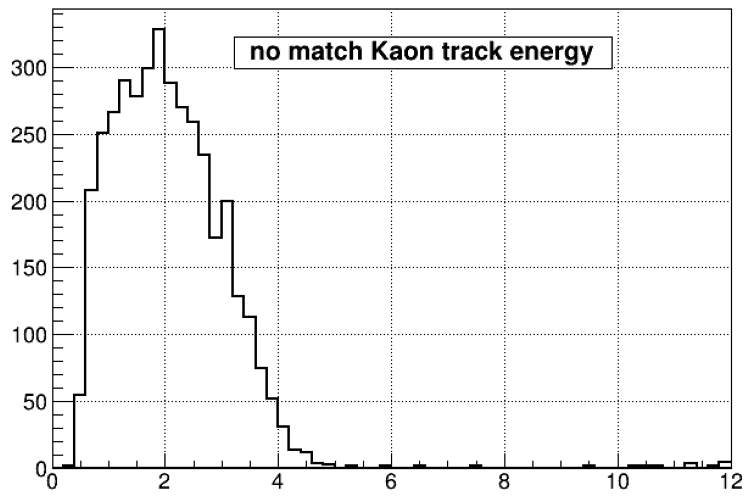
PID system: dualRICH_aerogel

$(1 < \eta < 3.5\ , P < 12\ GeV)$

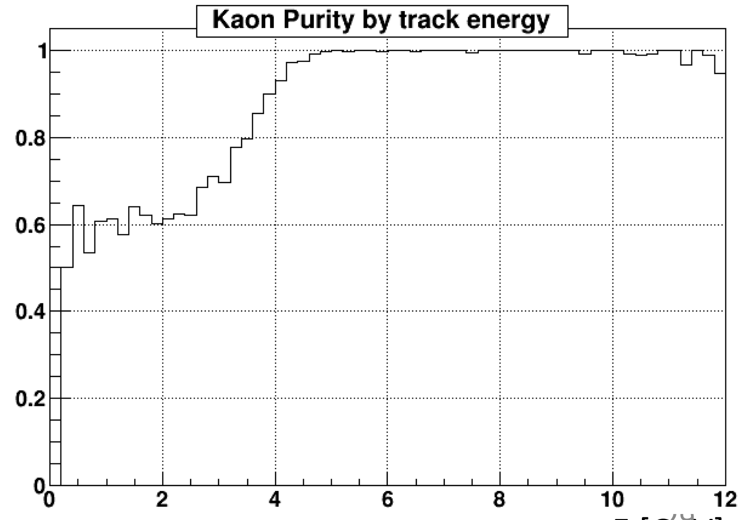
- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.



E [GeV]



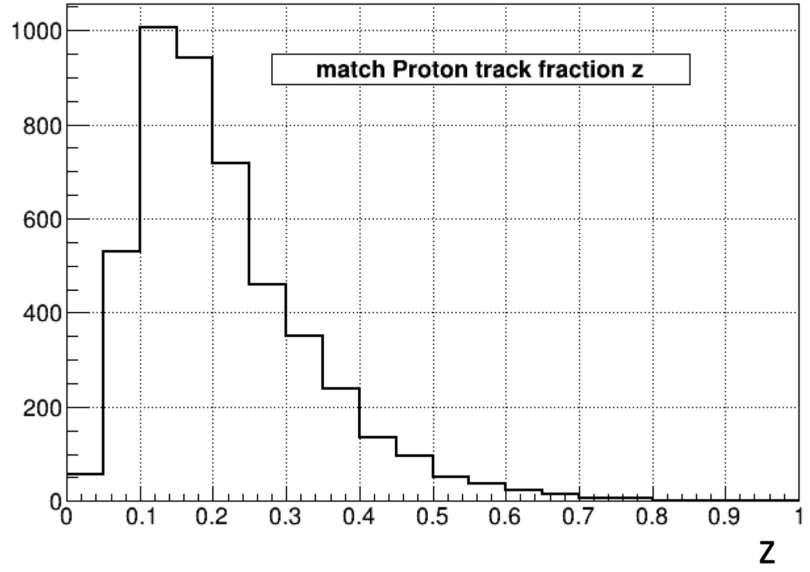
E [GeV]

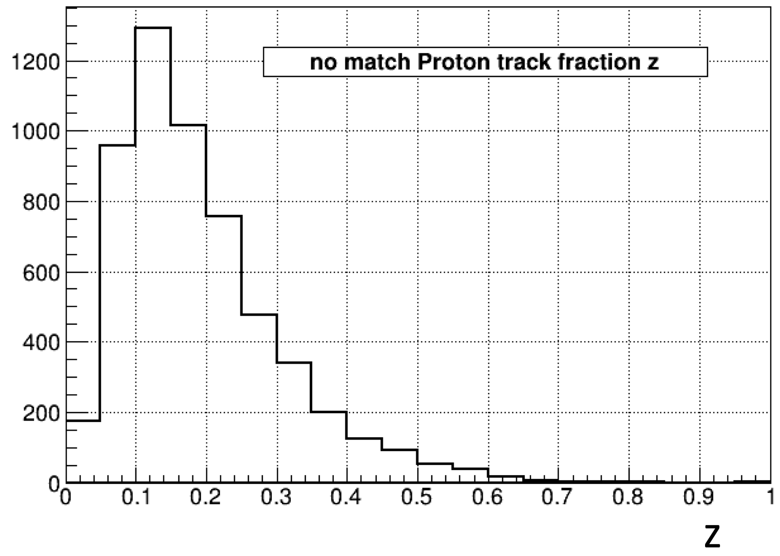


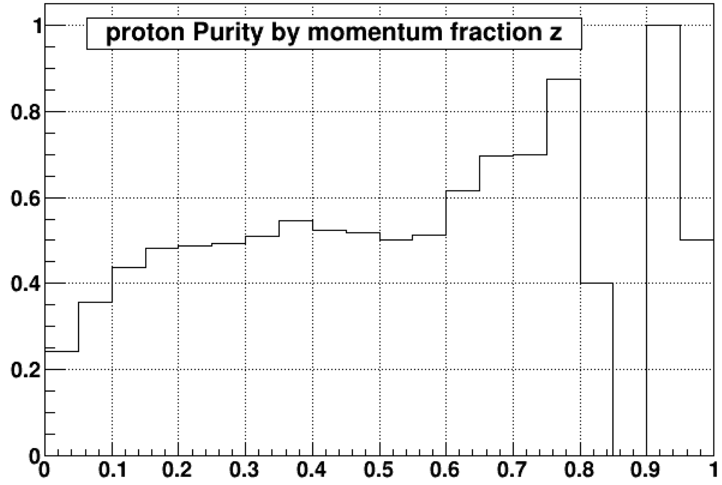
E [GeV]

Proton purity by momentum fraction z

- PID system: dualRICH_aerogel ($1 < \eta < 3.5$, $P < 12\ GeV$)
- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.





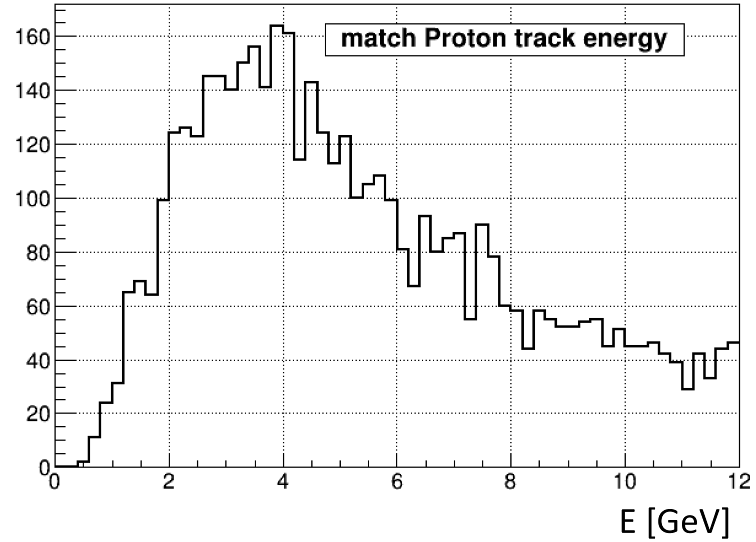


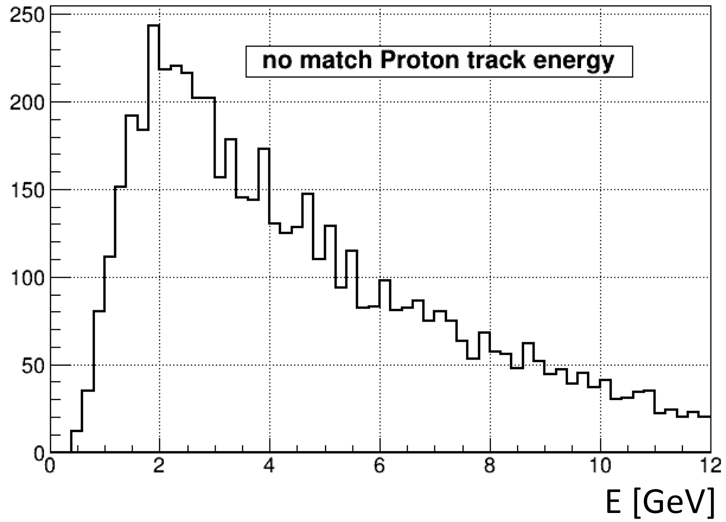
Proton purity by track energy

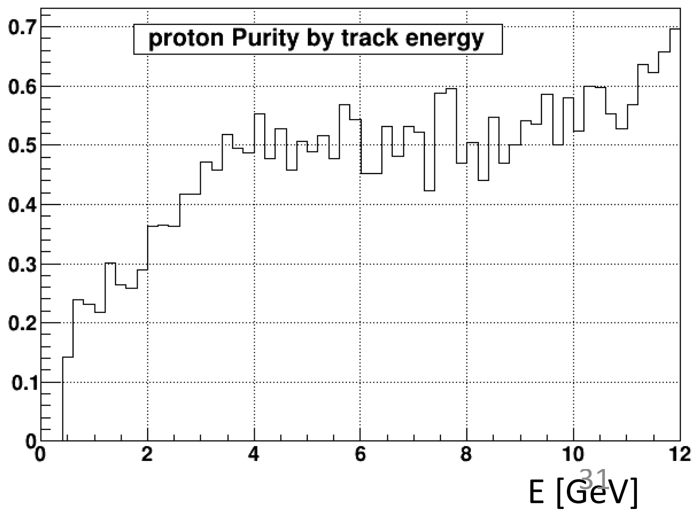
PID system: dualRICH_aerogel

$(1 < \eta < 3.5\ ,P < 12\ GeV)$

- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.





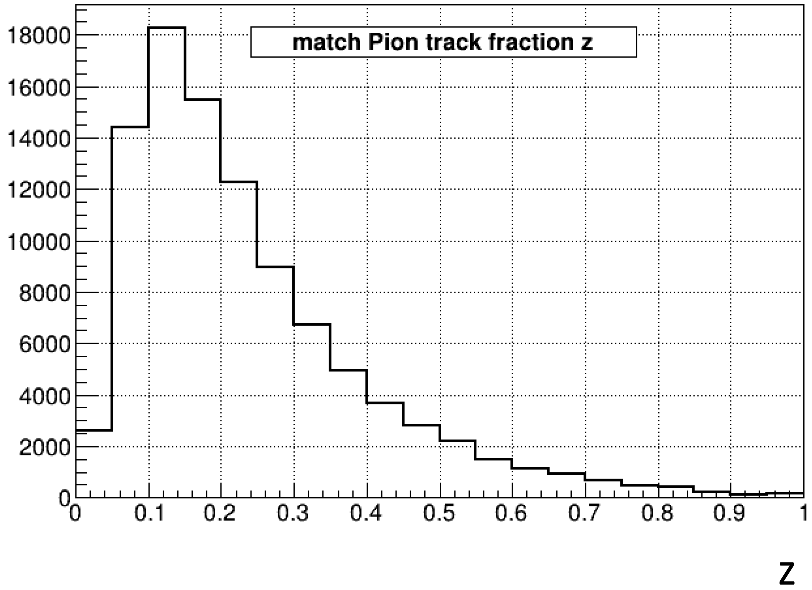


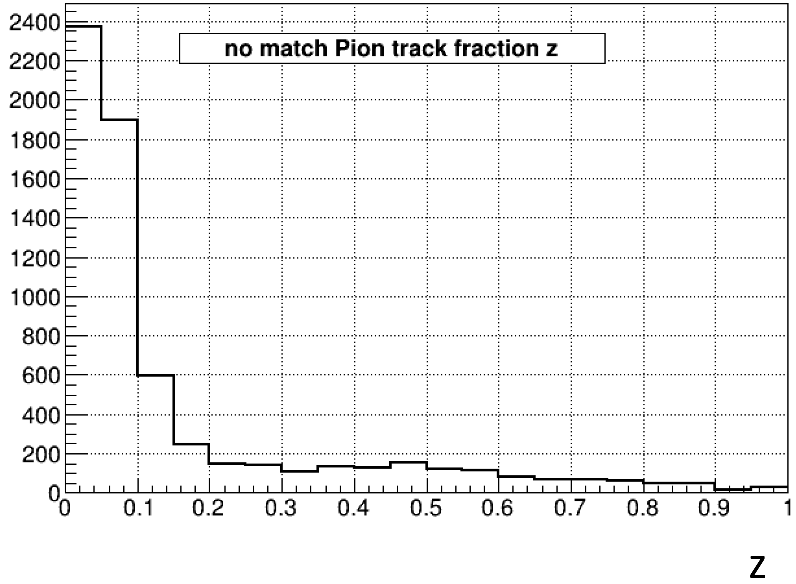
PID system: barrelDIRC

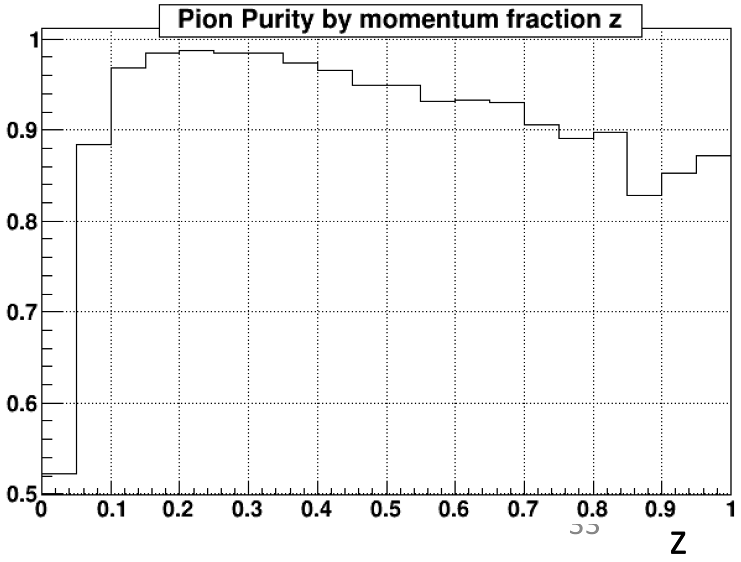
- PID system: barrelDIRC ($-1 < \eta < 1$)
- PID efficiency:
  - Pion to Pion: > 95%
  - Kaon to Kaon: > 95%
  - Proton to proton: 100% ($2.6 < P < 12\ GeV$); 60% ($0.4 < P < 2.6\ GeV$)

(no) match Pion track distribution with fraction z

- PID system: barrelDIRC ($-1 < \eta < 1$)
- $purity = \dfrac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.



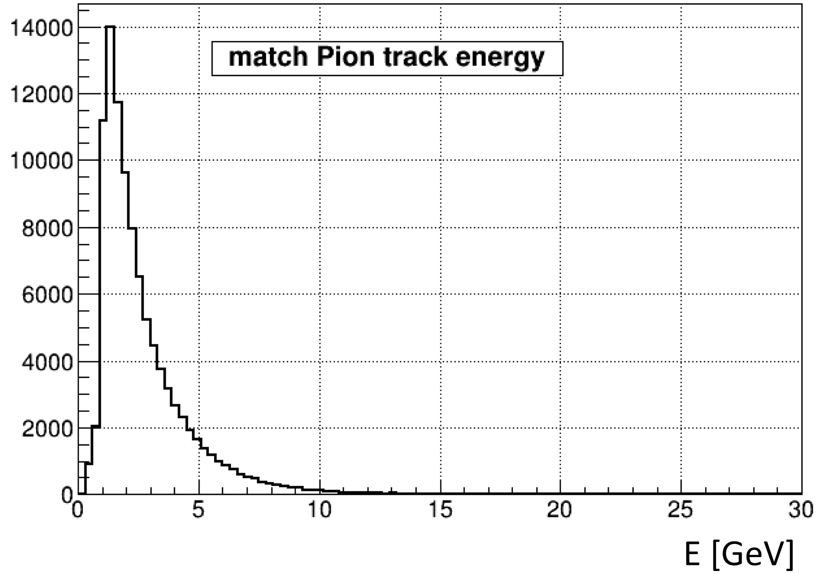


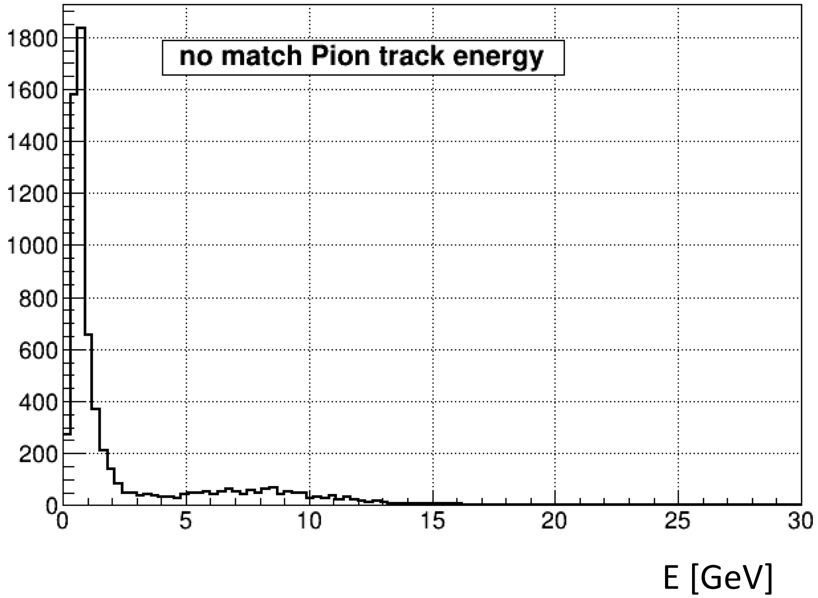


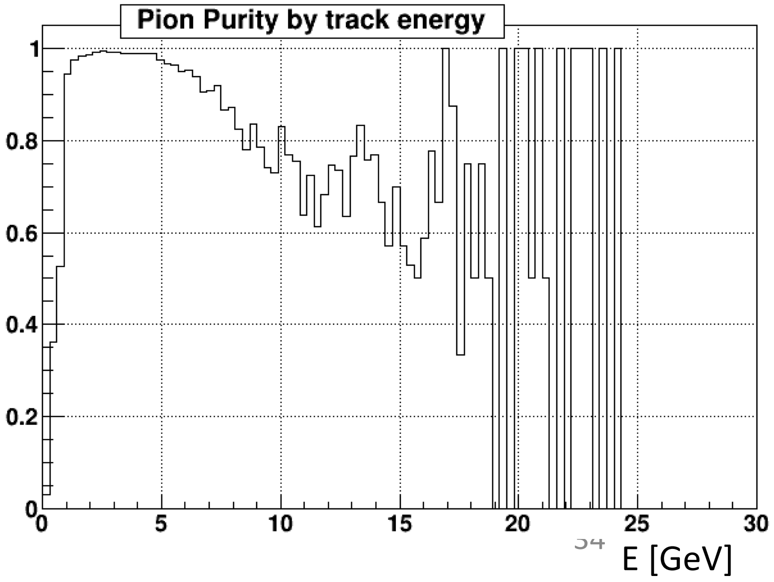
Pion purity by track energy

PID system: barrelDIRC ($-1 < \eta < 1$)

- $purity = \dfrac{number\ of\ matched\ track\ within\ track\ energy\ range}{total\ number\ of\ track\ within\ track\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.

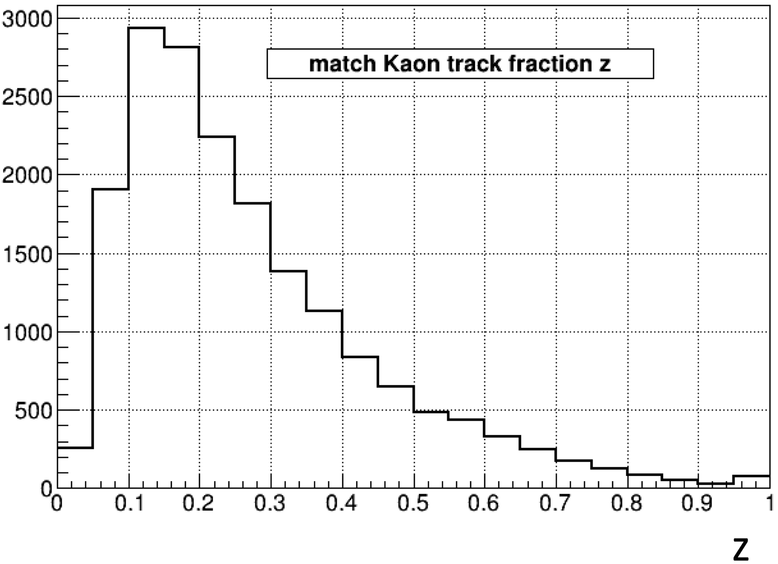


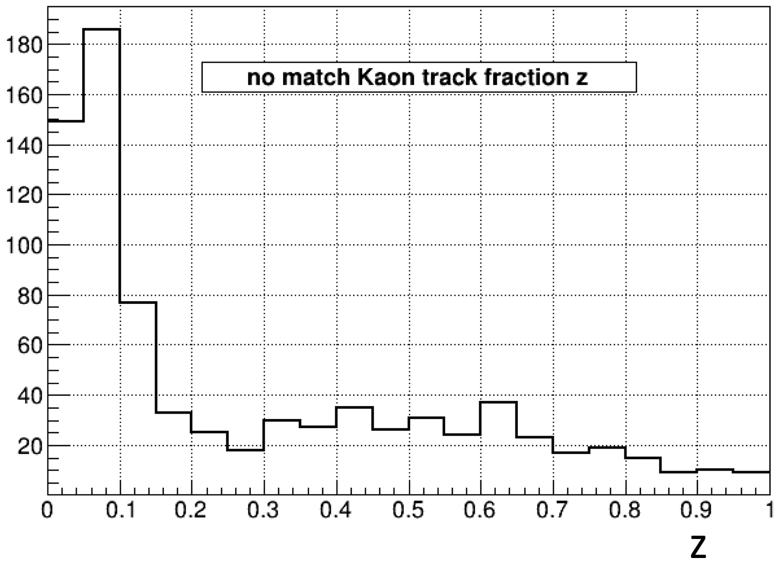


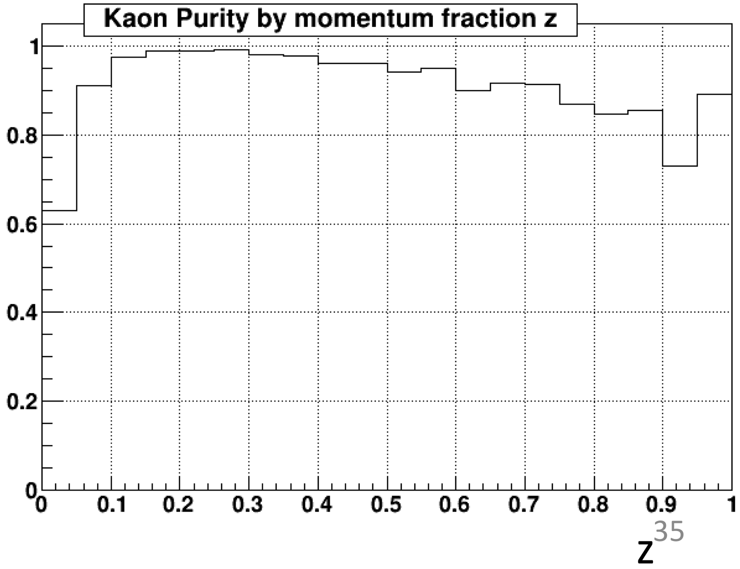


Kaon purity by momentum fraction z

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.







Kaon purity by track energy

PID system: barrelDIRC ($-1 < \eta < 1$)

- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
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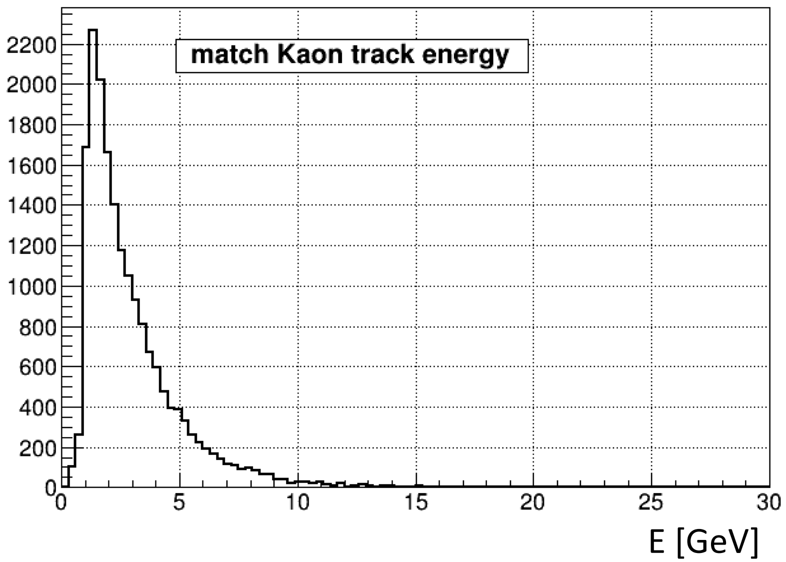
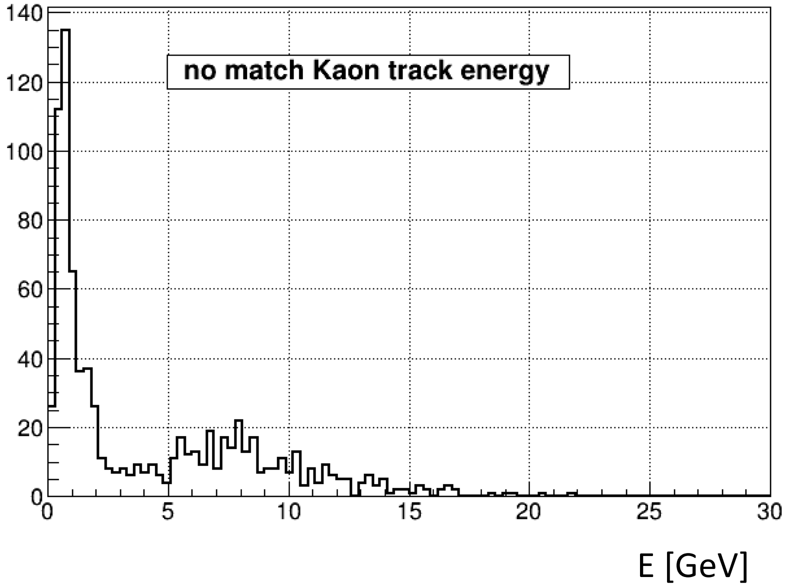
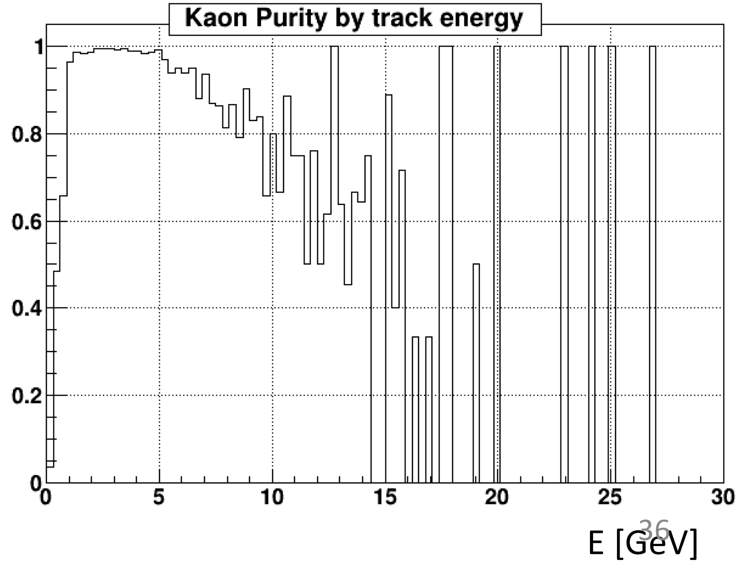


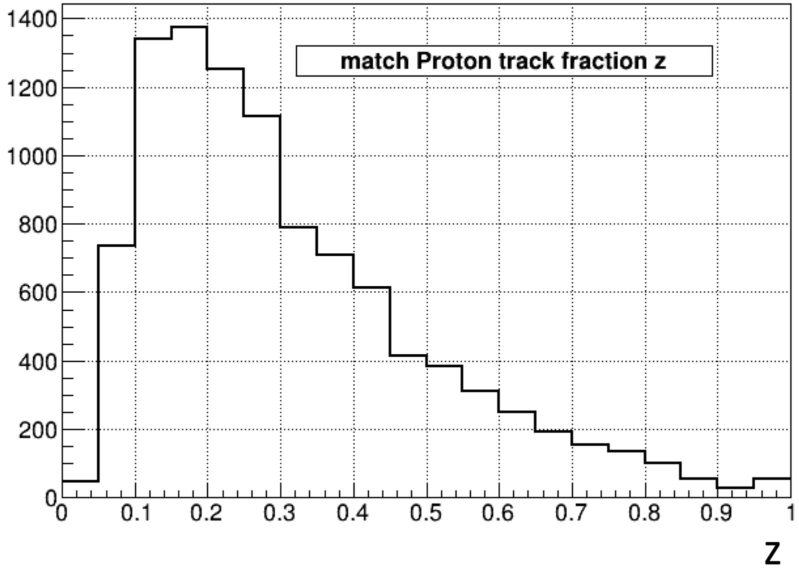


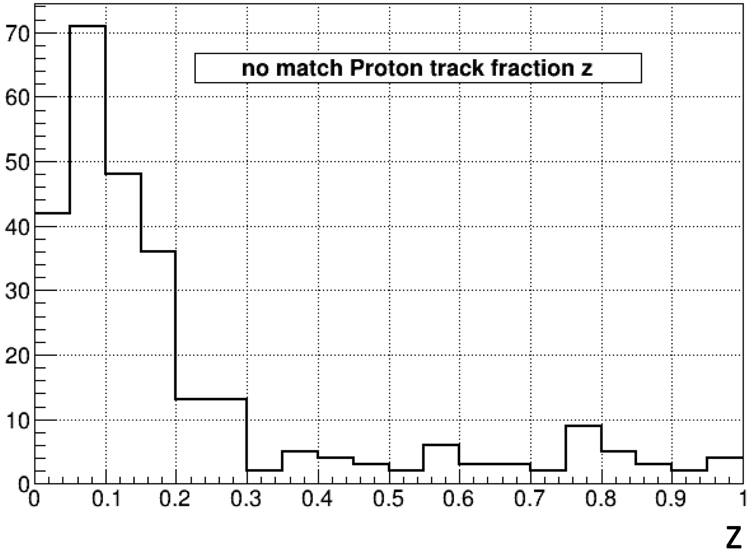


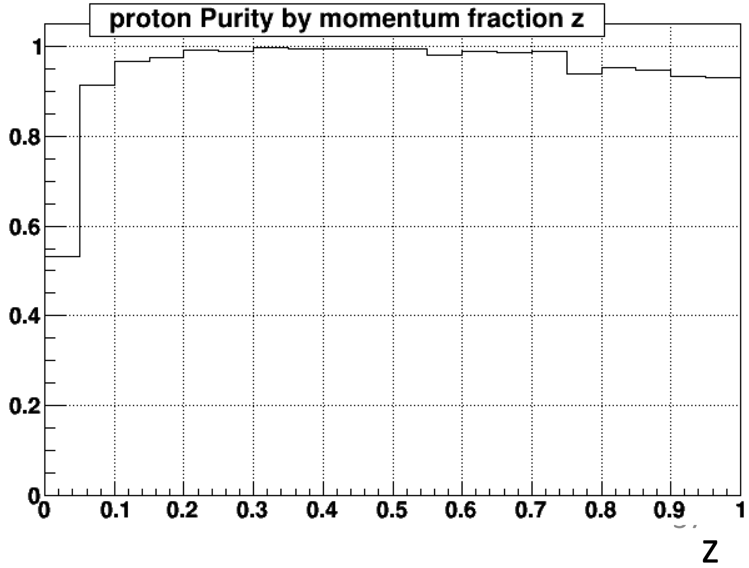
Proton purity by momentum fraction z

PID system: barrelDIRC ($-1 < \eta < 1$)

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range}{total\ number\ of\ track\ within\ z\ range}$
- Purity shown as 0 includes cases when no track is within this z range.







Proton purity by track energy

PID system: barrelDIRC ($-1 < \eta < 1$)

- $purity = \frac{number\ of\ matched\ track\ within\ energy\ range}{total\ number\ of\ track\ within\ energy\ range}$
- Purity shown as 0 includes cases when no track is within this track energy range.