Track PID purity and efficiency study

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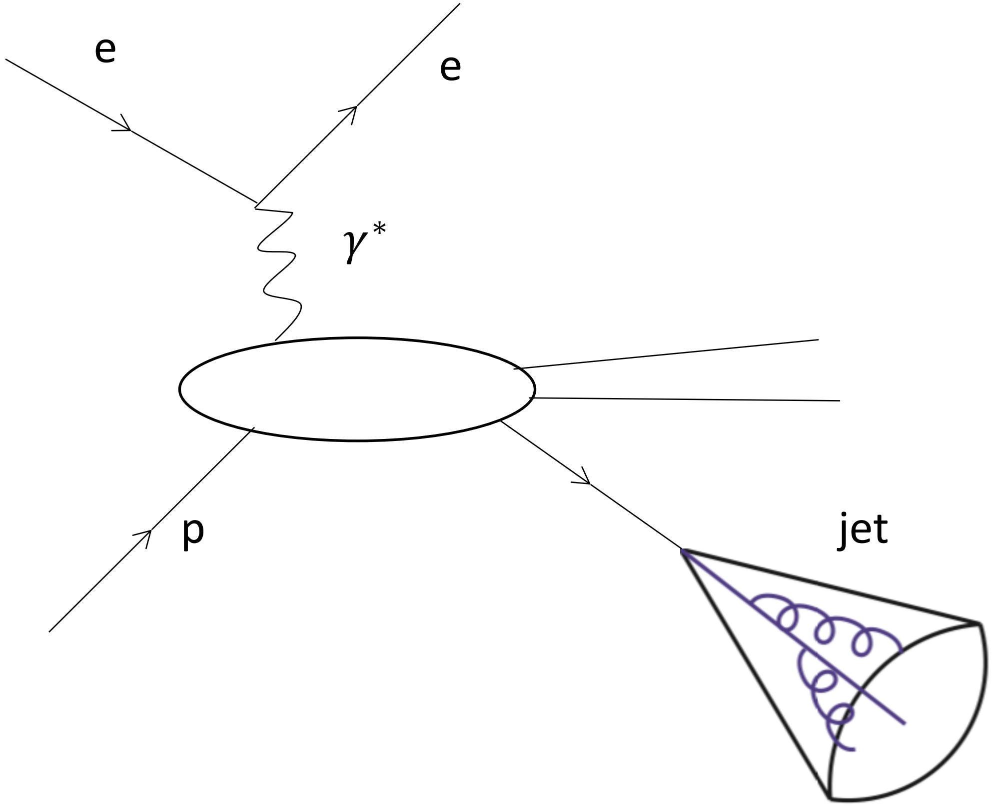
Goals

- Goals: check with PID system tracks PID purity and efficiency for Pion, Kaon and proton tracks.
  - PID efficiency: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ true\ level\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ PID\ hypothesis\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - Correctly identified track: PID value for track in PID system matches with the PID value for the corresponding true particle level.
- PID systems coverage:
  - dualRICH_aerogel: $1 < \eta < 3.5$
  - dualRICH_c2f6: $1 < \eta < 3.5$
  - barrelDIRC: $-1 < \eta < 1$

Simulation data set

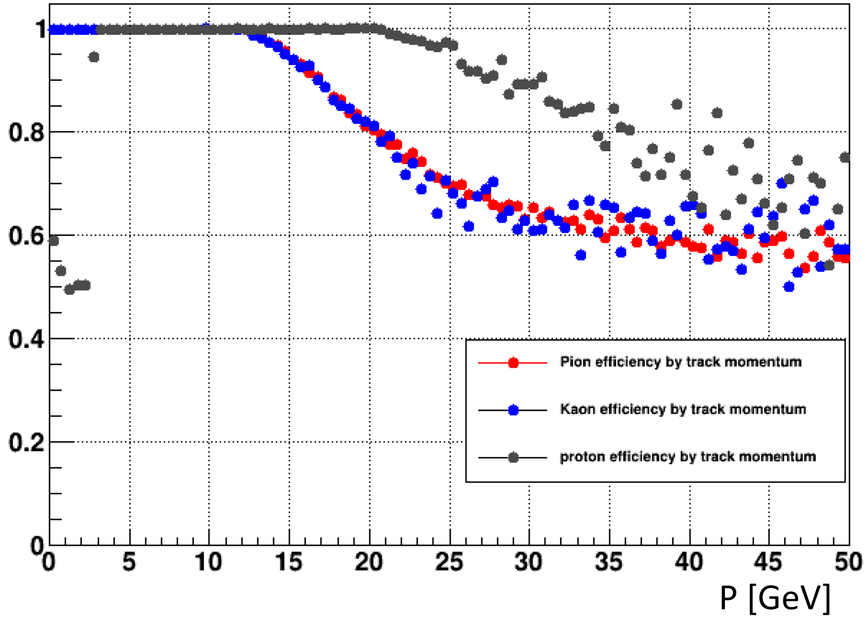
- Use Pythia8 to simulate Deep Inelastic Scattering (DIS) process
- Use Delphes to do the EIC detector response simulation
  - Delphes card: **ATHENA.tcl** , including PID simulation for calorimeter systems.
- Number of event generated: 1 M
- E_{proton} = 275 GeV
- $E_{electron}$ = 10 GeV
- Q^2 > 25 GeV
- Jet finding algorithm:
  - Anti-kT , R=1.0 , P_T > 3 GeV



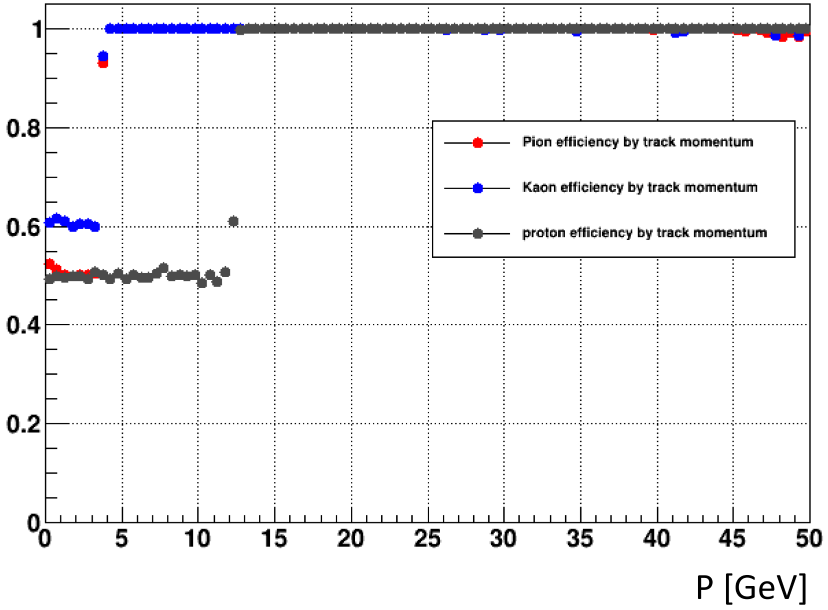
Efficiency study for 3 PID systems

- Particle type: Pion, Kaon, proton (from PID number)
- PID efficiency: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ {\color{red}true\ level\ track}\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π efficiency = $\frac{n(\pi\rightarrow\pi)}{n({\color{red}\pi}\rightarrow\pi)+n({\color{red}\pi}\rightarrow K)+n({\color{red}\pi}\rightarrow Pr)}$

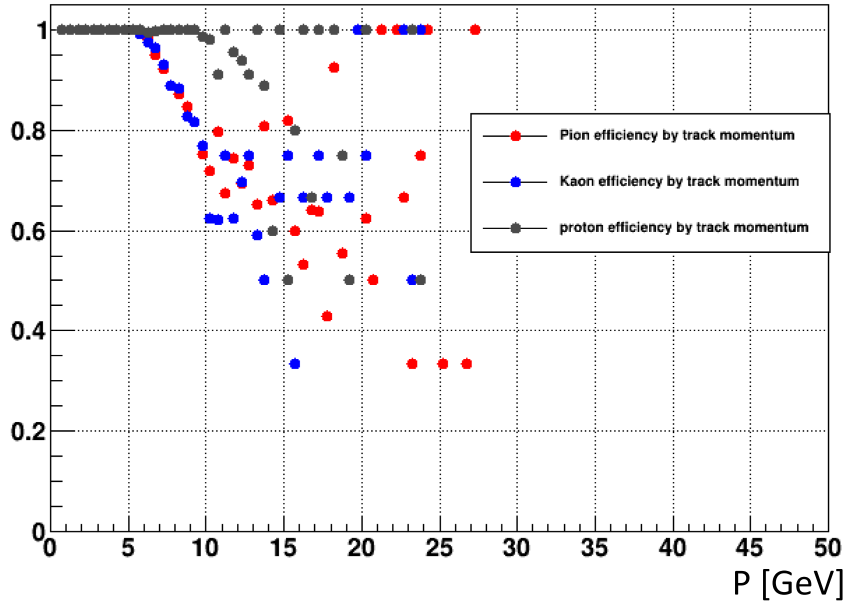
dualRICH_aerogel



dualRICH_c2f6



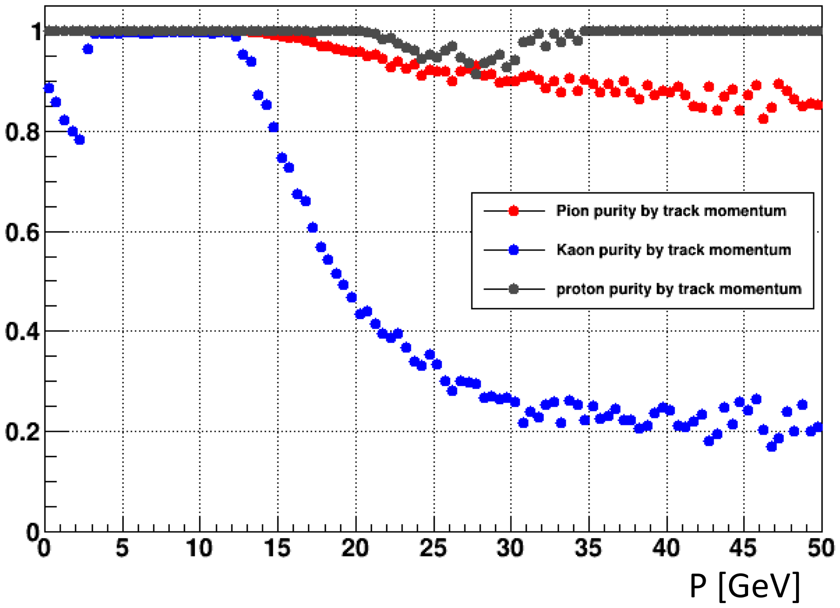
barrelDIRC



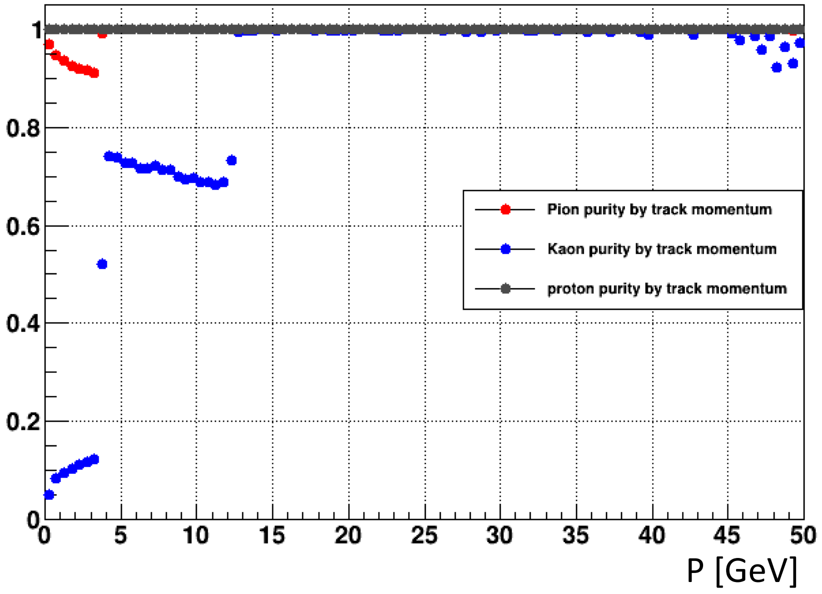
Purity study for 3 PID systems

- Particle type: Pion, Kaon, proton (from PID number)
- PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ PID\ hypothesis\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π purity = $\frac{n(\pi\to\pi)}{n(\pi\to\pi)+n(K\to\pi)+n(Pr\to\pi)}$

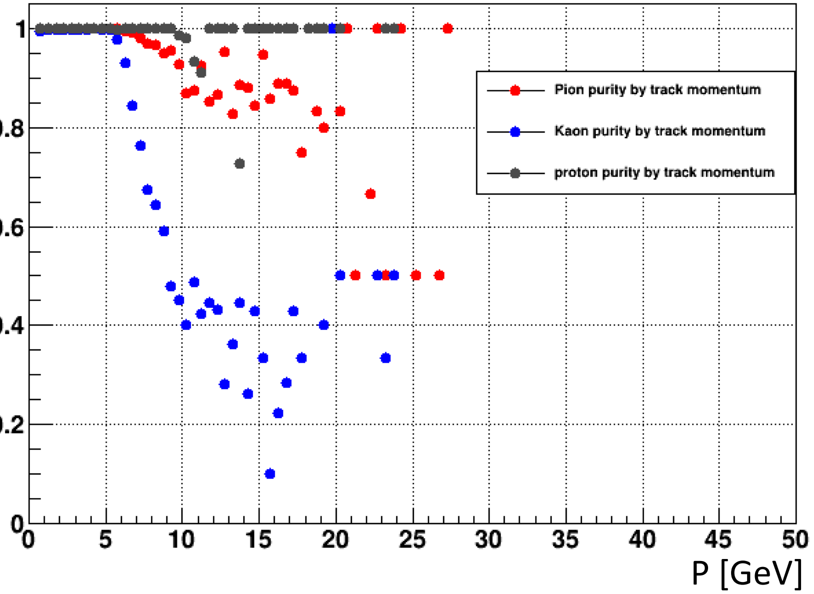
dualRICH_aerogel



dualRICH_c2f6



barrelDIRC



Track PID purity study from jet

- 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: $\frac{number\ of\ correctly\ identified\ track\ in\ jet}{number\ of\ all\ found\ track\ in\ jet}$ for each PID system for certain kind of particle. (Pion, Kaon, proton)
- Track momentum fraction (z) from jet : $\frac{\vec{p}_{track} \cdot \vec{p}_{jet}}{\vec{p}_{jet}^{2}}$
  - "Correctly identified track": PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.
  - dualRICH_aerogel: $1 < \eta < 3.5$
  - dualRICH_c2f6: $1 < \eta < 3.5$
  - barrelDIRC: $-1 < \eta < 1$

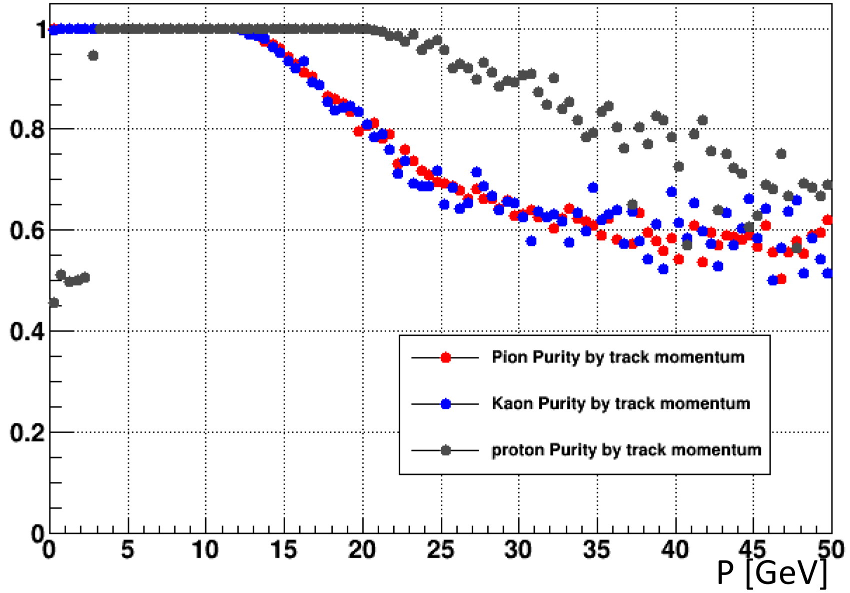
Input track list for jet finding and PID system

- I check the input track list for jet finding and PID system from the simulation.
- 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
- There are some tracks in the jet that can not found with tracks in PID system.

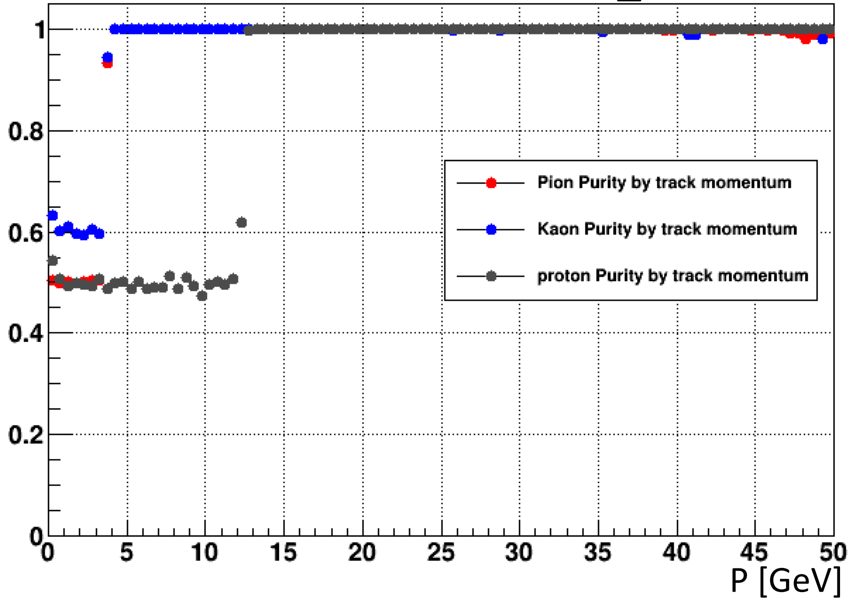
Track in jet purity result for different PID systems

- $purity = \frac{number\ of\ matched\ track\ within\ P\ range\ for\ each\ PID\ system}{total\ number\ of\ found\ track\ within\ P\ range\ for\ tracks\ in\ jets}$
  - Matched track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.
  - Found check: the track in jet matches with track in PID system hypothesis in particle level.
- The purity results distributions look similar when checking when Eflow tracks.

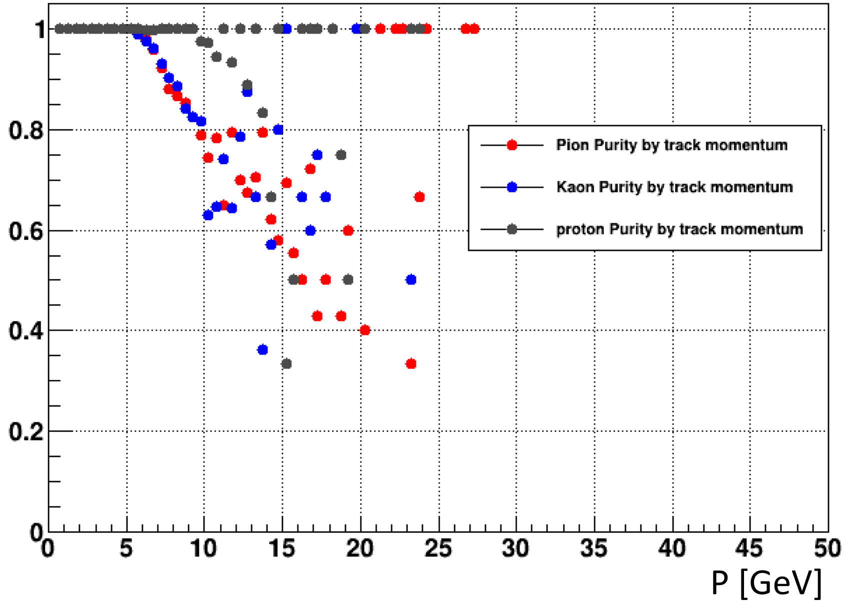
dualRICH_aerogel



dualRICH_c2f6



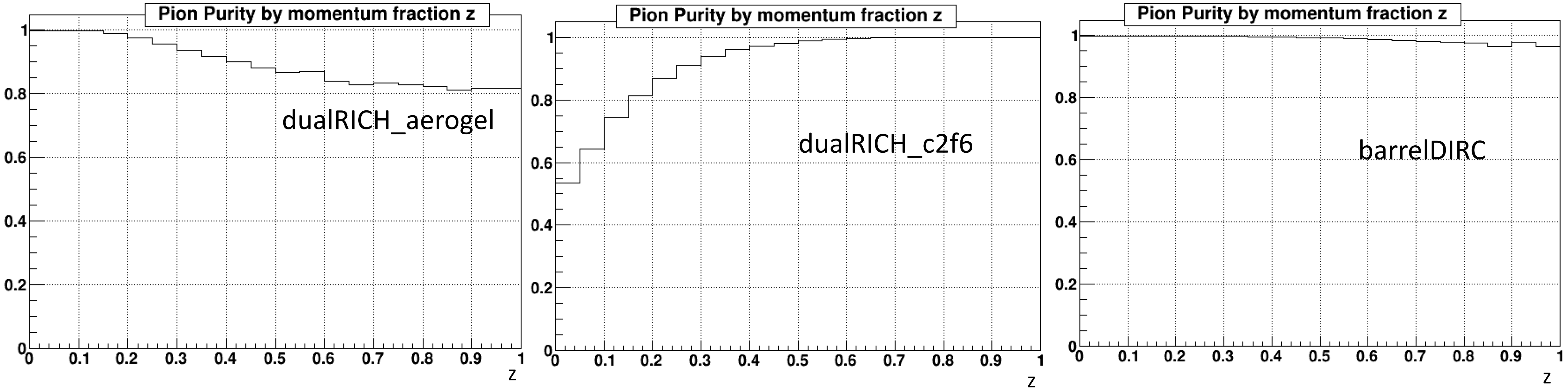
barrelDIRC



Pion track purity result for different PID system

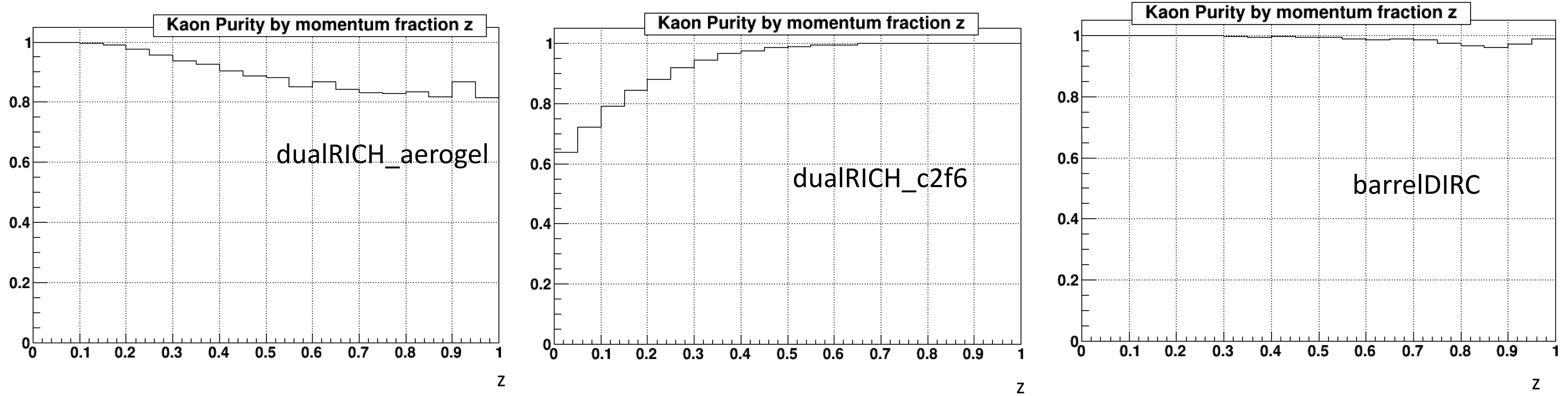
$z = \frac{\vec{p}_{track} \cdot \vec{p}_{jet}}{\vec{p}_{jet}^{\,2}}$

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range\ for\ each\ PID\ system}{total\ number\ of\ found\ track\ within\ z\ range\ for\ tracks\ in\ jets}$
  - Matched track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.
  - Found check: the track in jet matches with track in PID system hypothesis in particle level.



Kaon track purity result for different PID system

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range\ for\ each\ PID\ system}{total\ number\ of\ found\ track\ within\ z\ range\ for\ tracks\ in\ jets}$ z=$\frac{\vec{p}_{track}\cdot\vec{p}_{jet}}{\vec{p}_{jet}^{2}}$
  - Matched track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.
  - Found check: the track in jet matches with track in PID system hypothesis in particle level.

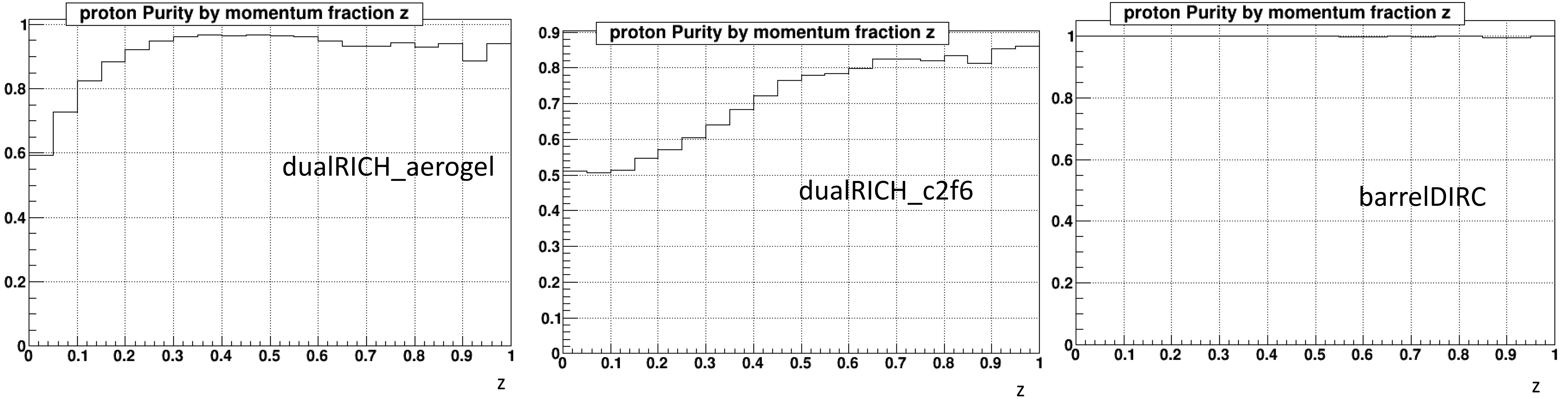


Proton track purity result for different PID system

- $purity = \frac{number\ of\ matched\ track\ within\ z\ range\ for\ each\ PID\ system}{total\ number\ of\ found\ track\ within\ z\ range\ for\ tracks\ in\ jets}$

$z = \frac{\vec{p}_{track} \cdot \vec{p}_{jet}}{\vec{p}_{jet}^{2}}$

  - Matched track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.
  - Found check: the track in jet matches with track in PID system hypothesis in particle level.



Conclusion

- The purity for dualRICH_aerogel, dualRICH_c2f6 system and barreDIRC system match well with the PID efficiency.
  - dualRICH_aerogel system has a good efficiency and purity at low momentum.
  - dualRICH_c2f6 system has a good efficiency and purity at high momentum.
  - barrelDIRC system looks well at low momentum.
- The purity for the tracks in jet simulation also roughly match with what we see for PID efficiency study.

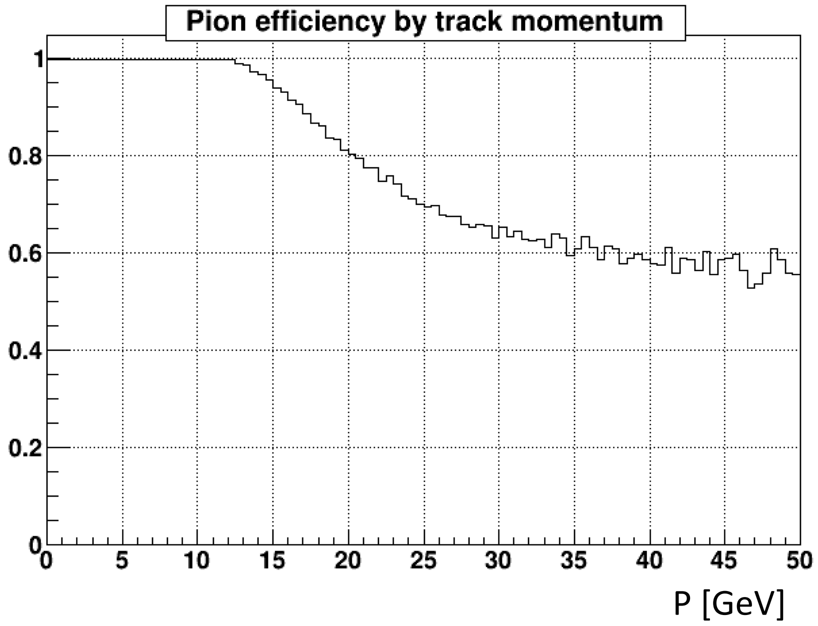
Back up

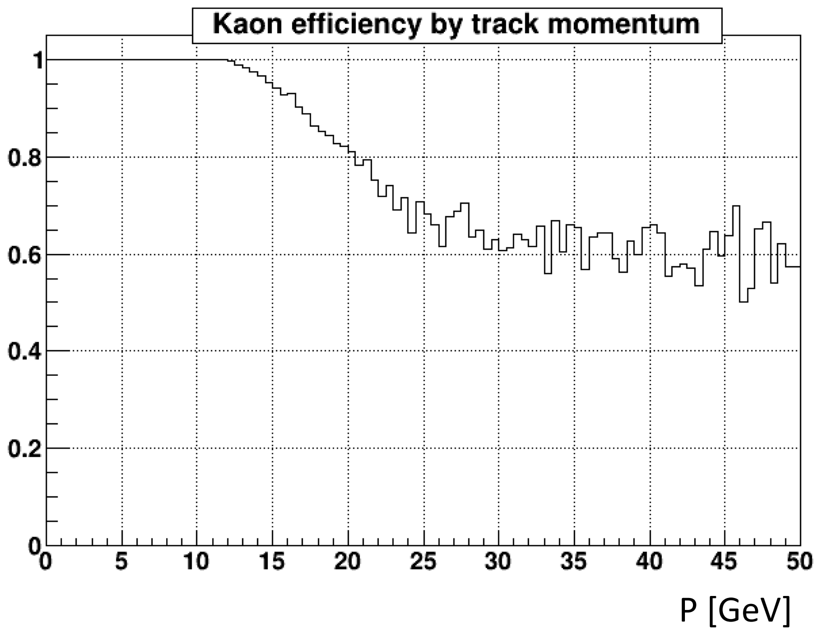
Basic idea for PID system

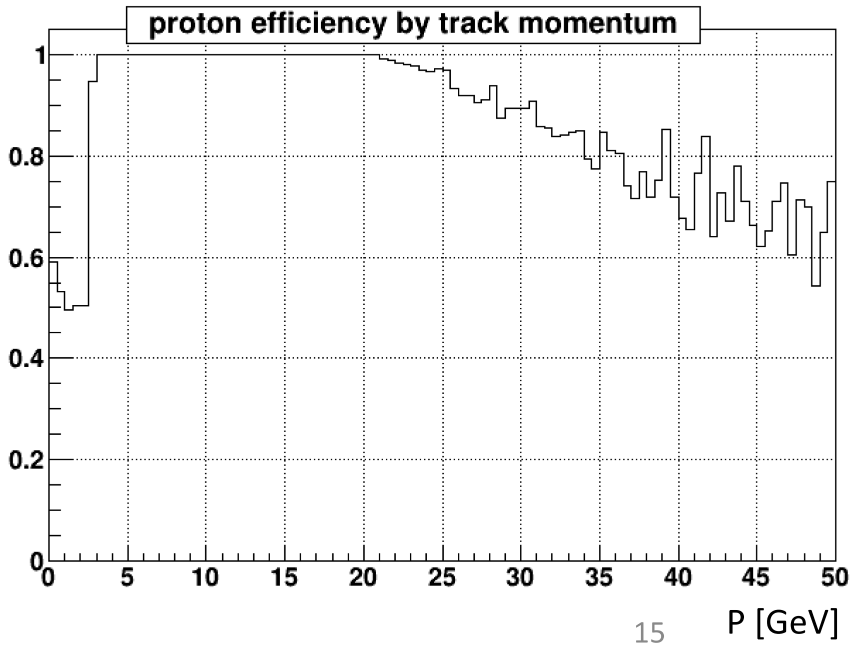
- For tracks, they have given the PID number for common particles to indicate their particle species.
- The particle identification systems are implemented in Delphes as identification maps that encode the probability which a track with truth identity A will be identified as PID hypothesis B.
  - The PID efficiency based on assumption that two species should separate by "n sigma" (will be different by different species), which comes from EICUG PID group and Yellow Report.
  - Track eta, momentum also serve as another aspect in identify hadrons.
- Check 3 different PID system :
  - barrelDIRC , dualRICH_aerogel , dualRICH_c2f6

Efficiency for dualRICH_aerogel tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $1 < \eta < 3.5$
- PID efficiency: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ true\ level\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
    - π efficiency = $\frac{n(\pi\rightarrow\pi)}{n(\pi\rightarrow\pi)+n(\pi\rightarrow K)+n(\pi\rightarrow Pr)}$

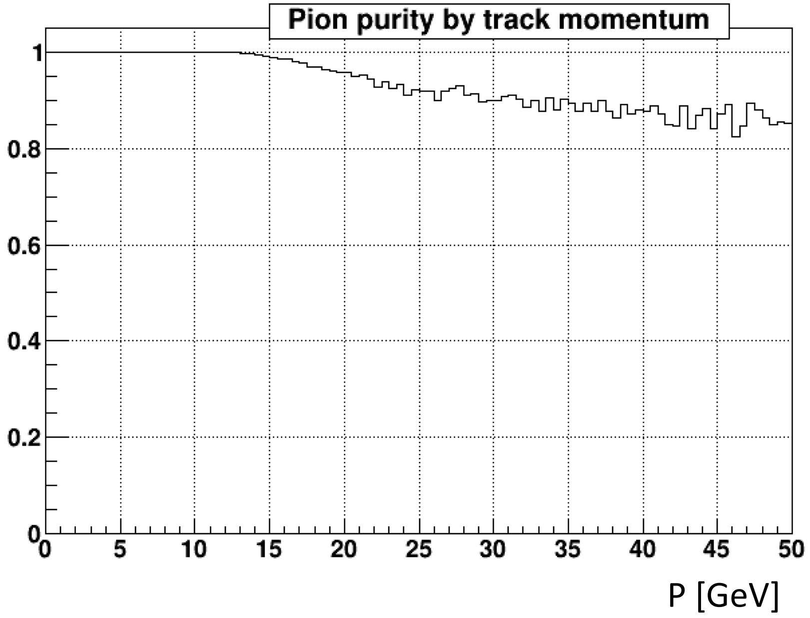


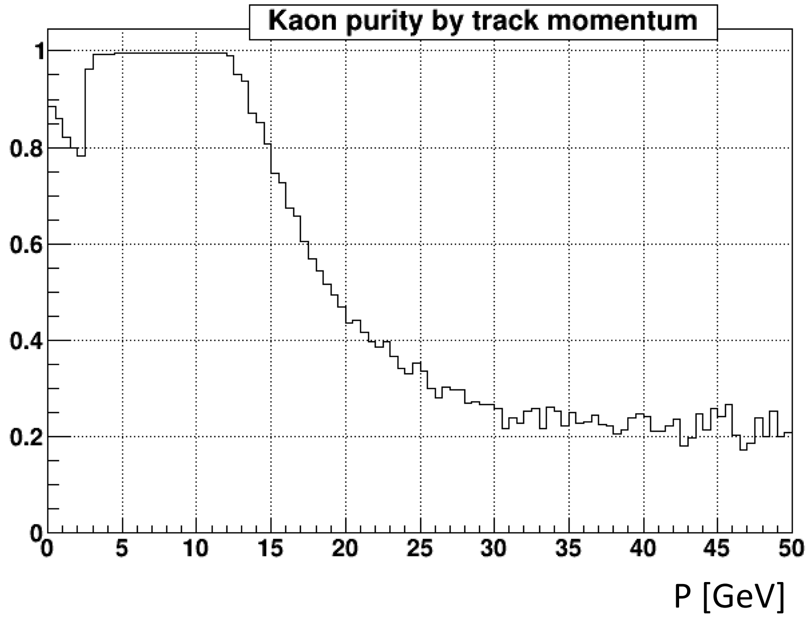


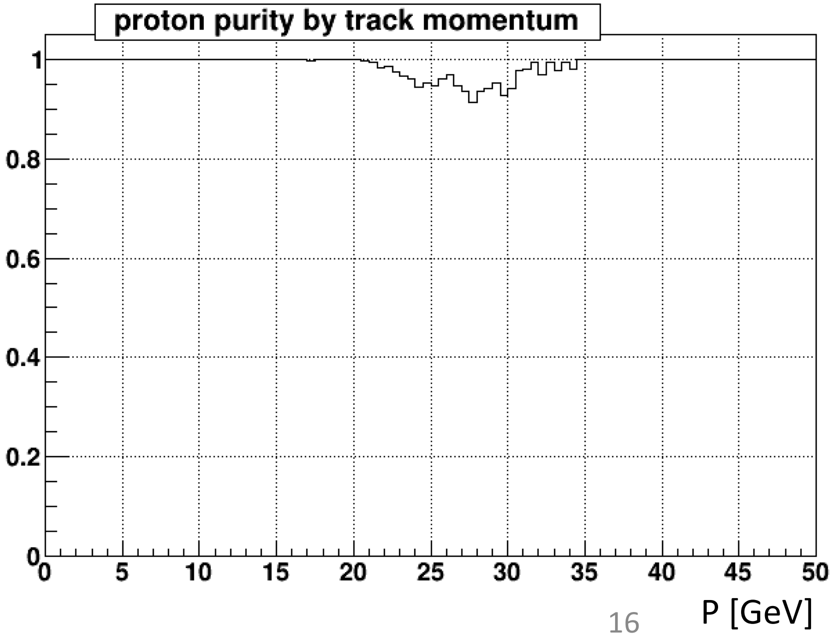


Purity for dualRICH_aerogel tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $1 < \eta < 3.5$
- PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ PID\ hypothesis\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π purity = $\frac{n(\pi \rightarrow \pi)}{n(\pi \rightarrow \pi)+n(K \rightarrow \pi)+n(Pr \rightarrow \pi)}$

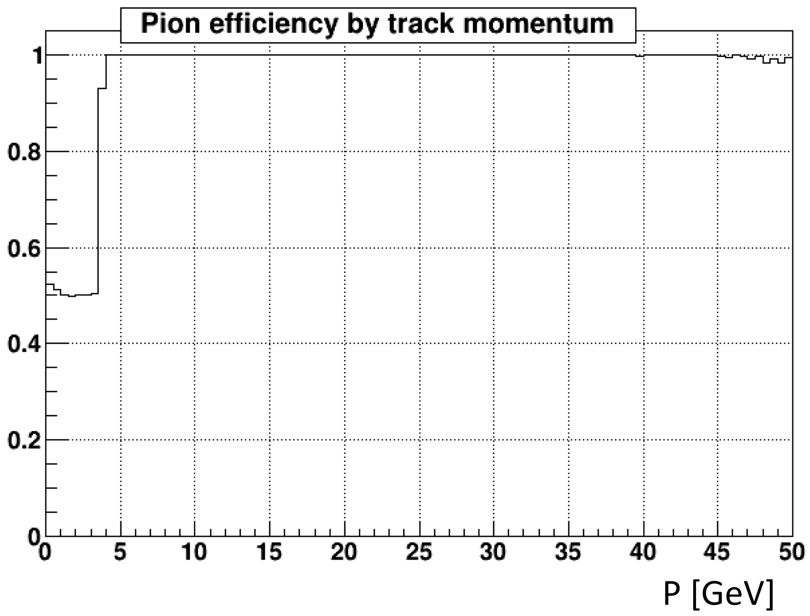


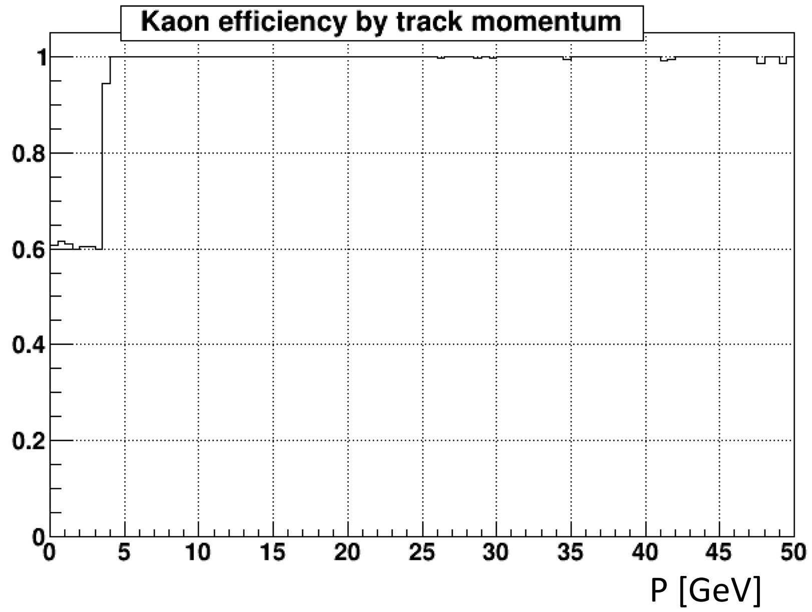


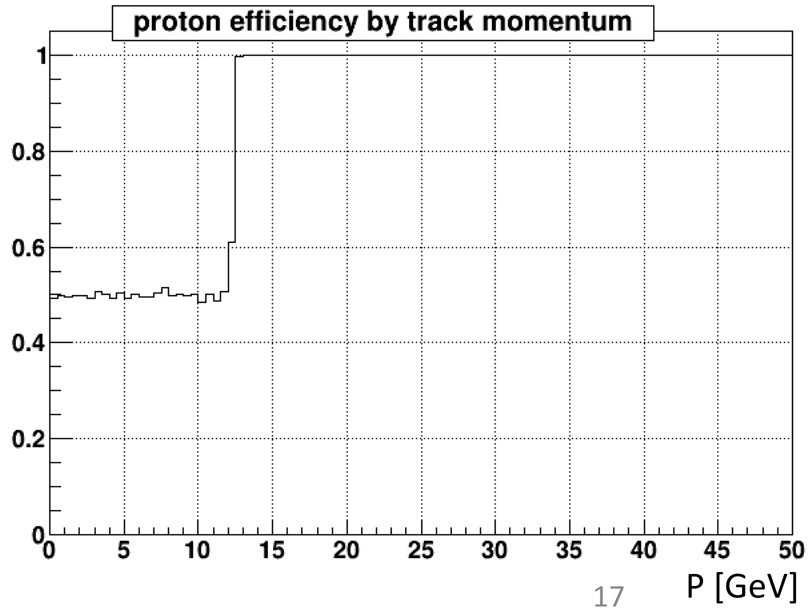


Efficiency for dualRICH_c2f6 tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $1 < \eta < 3.5$
- PID efficiency: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ true\ level\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π efficiency = $\frac{n(\pi\rightarrow\pi)}{n(\pi\rightarrow\pi)+n(\pi\rightarrow K)+n(\pi\rightarrow Pr)}$

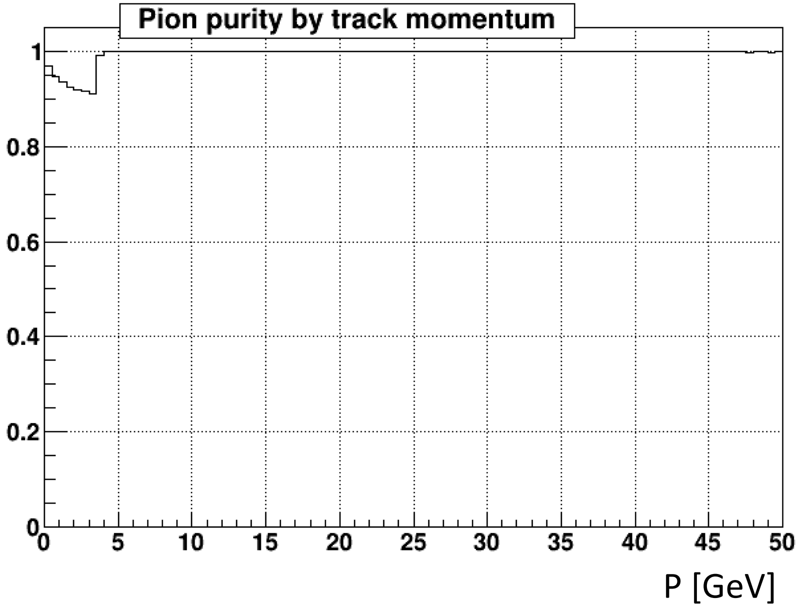


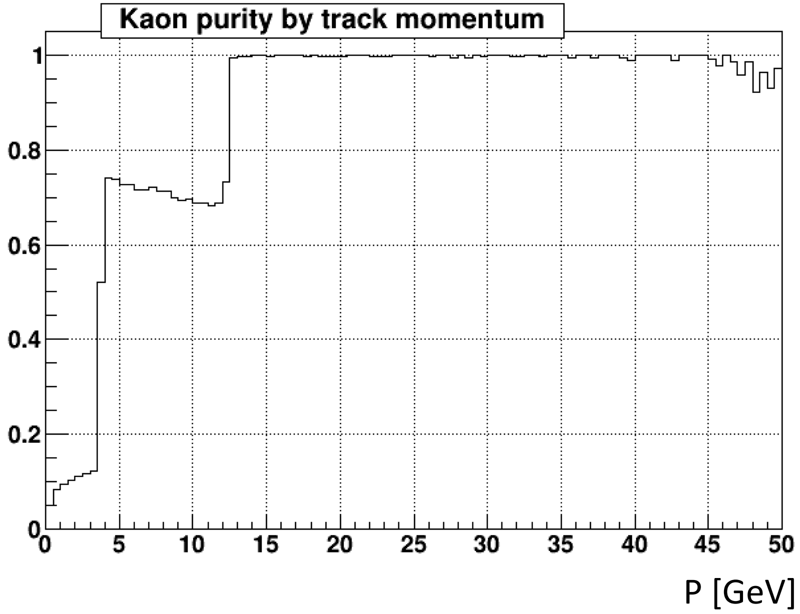


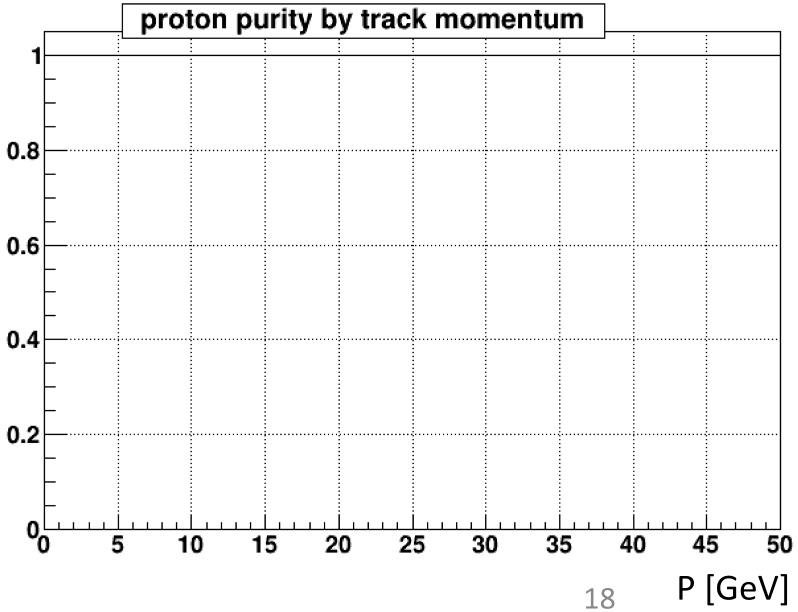


Purity for dualRICH_c2f6 tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $1 < \eta < 3.5$
- PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ PID\ hypothesis\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π purity = $\frac{n(\pi\rightarrow\pi)}{n(\pi\rightarrow\pi)+n(K\rightarrow\pi)+n(Pr\rightarrow\pi)}$

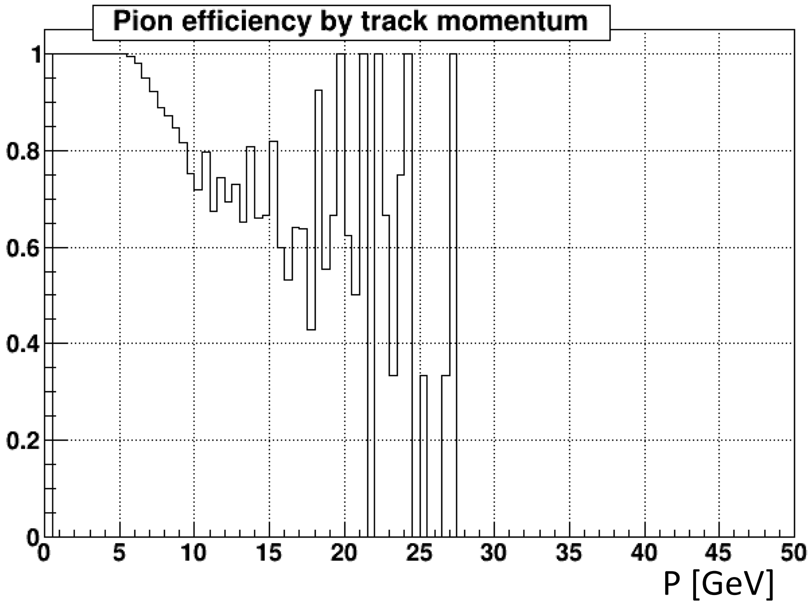


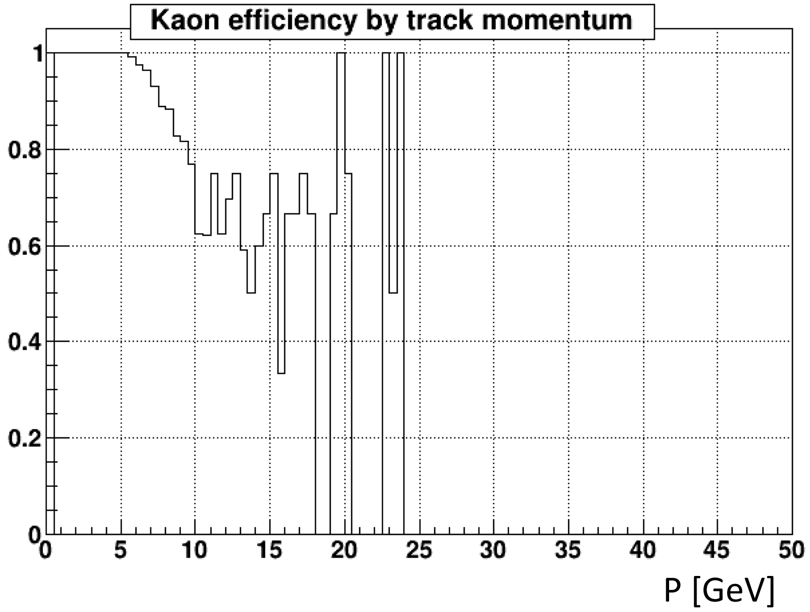


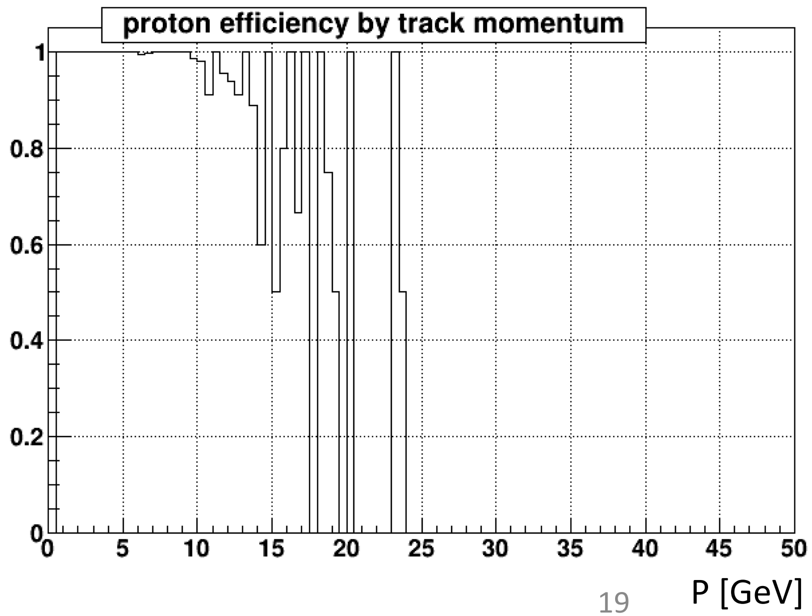


Efficiency for barrelDIRC tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $-1 < \eta < 1$
- PID efficiency: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ true\ level\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π efficiency = $\frac{n(\pi\to\pi)}{n(\pi\to\pi)+n(\pi\to K)+n(\pi\to Pr)}$

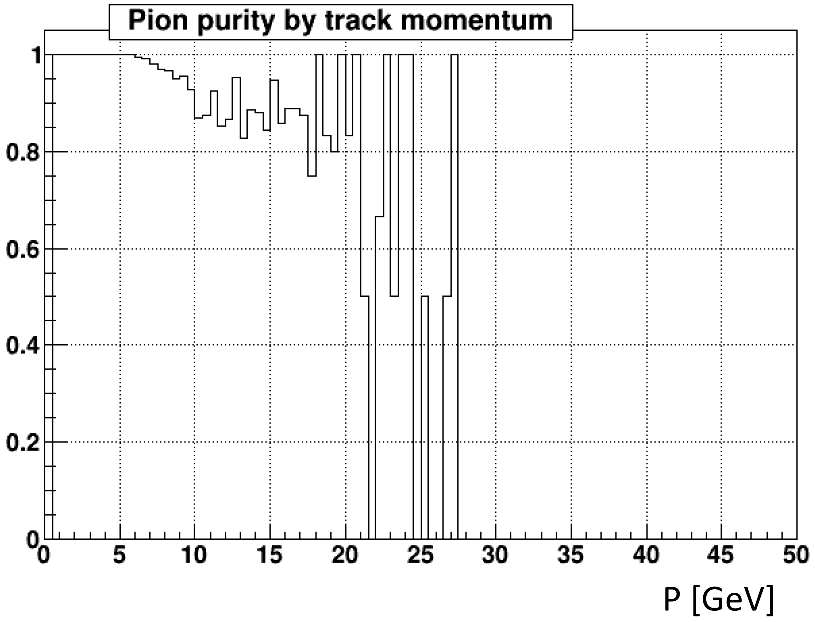


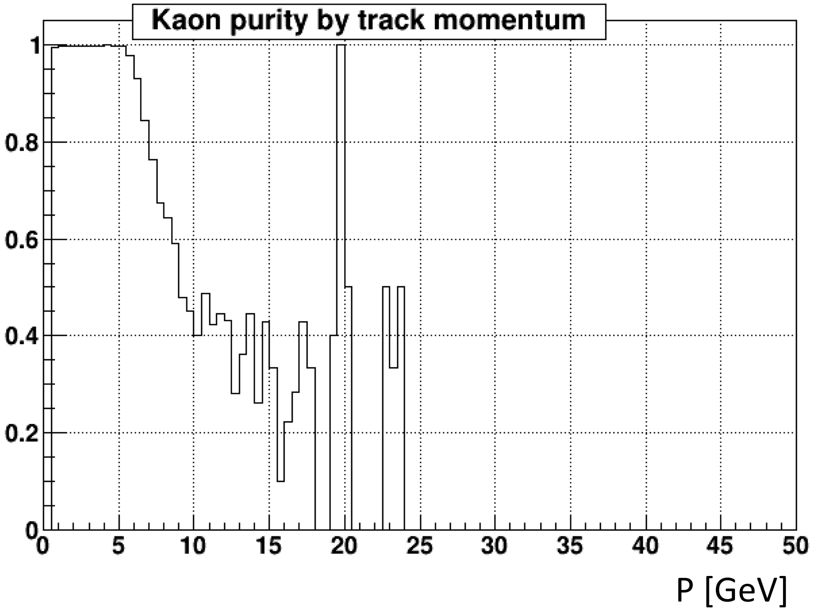


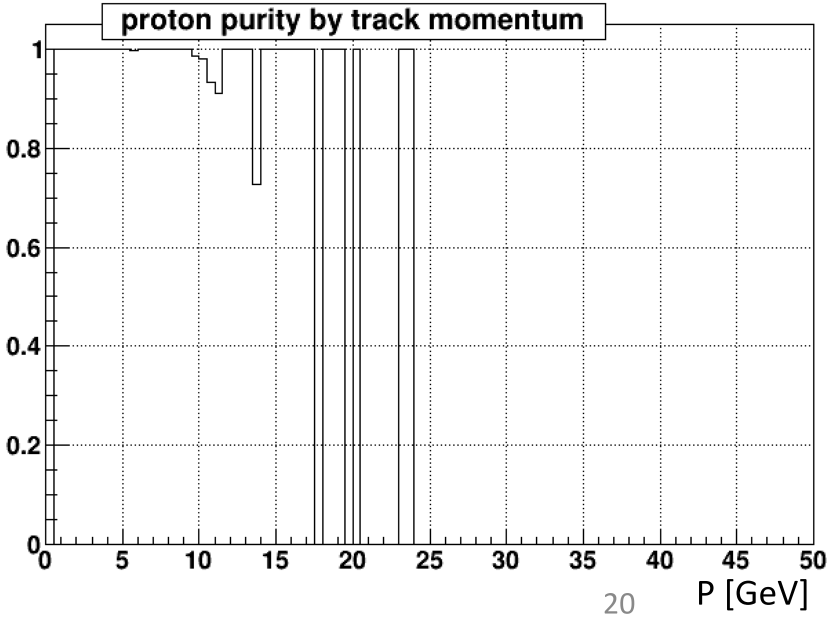


Purity for barrelDIRC tracks

- Particle type: Pion, Kaon, proton (from PID number)
- $-1 < \eta < 1$
- PID purity: $\frac{number\ of\ correctly\ identified\ track\ in\ PID\ system\ for\ each\ tyoe}{number\ of\ all\ PID\ hypothesis\ track\ in\ PID\ system\ coverage\ for\ each\ type}$
  - π purity = $\frac{n(\pi\rightarrow\pi)}{n(\pi\rightarrow\pi)+n(K\rightarrow\pi)+n(Pr\rightarrow\pi)}$



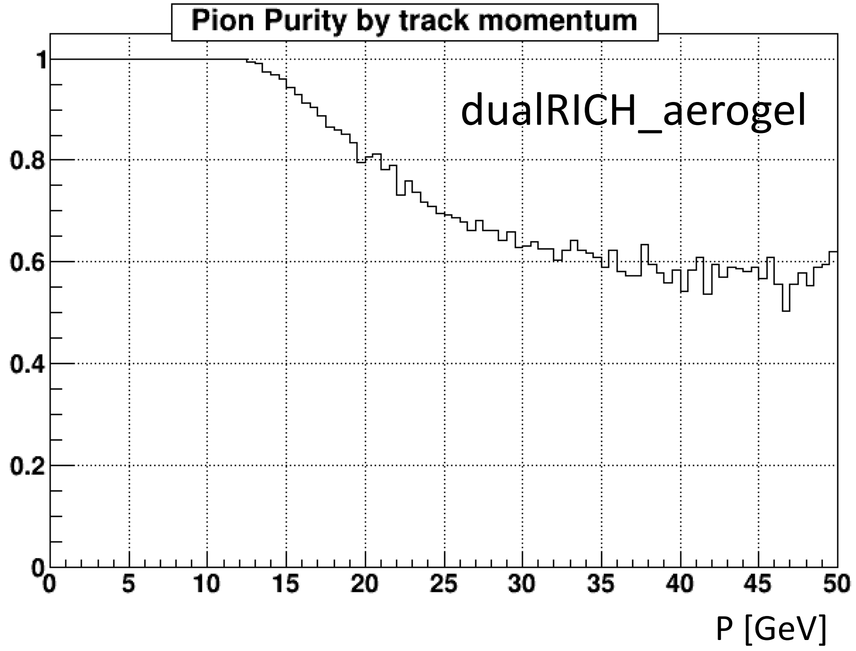


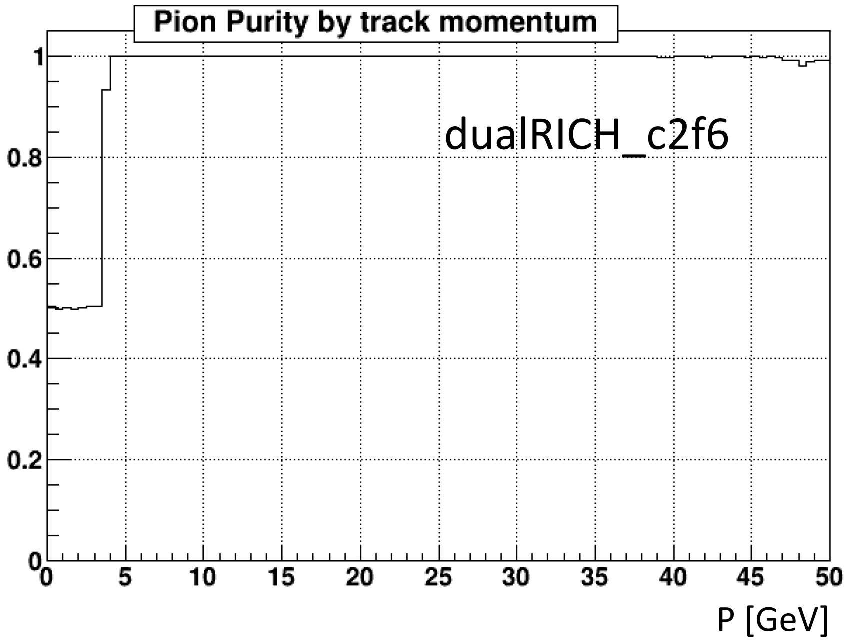


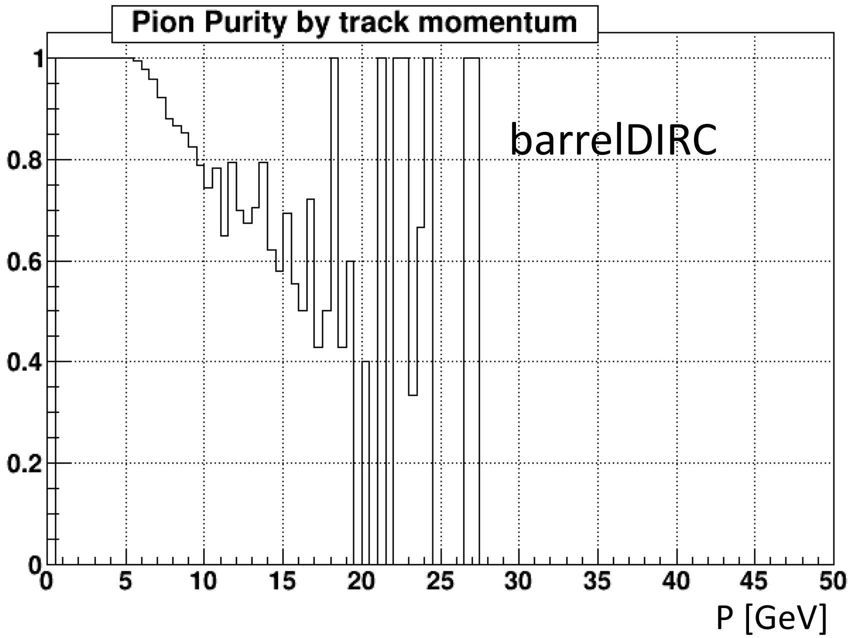
Check with hadronic tracks in jets

Pion track purity result for different PID system

- $purity = \frac{number\ of\ matched\ track\ within\ P\ range\ for\ each\ PID\ system}{total\ number\ of\ track\ within\ P\ range\ for\ tracks\ in\ jets}$
  - Correctly identified track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.

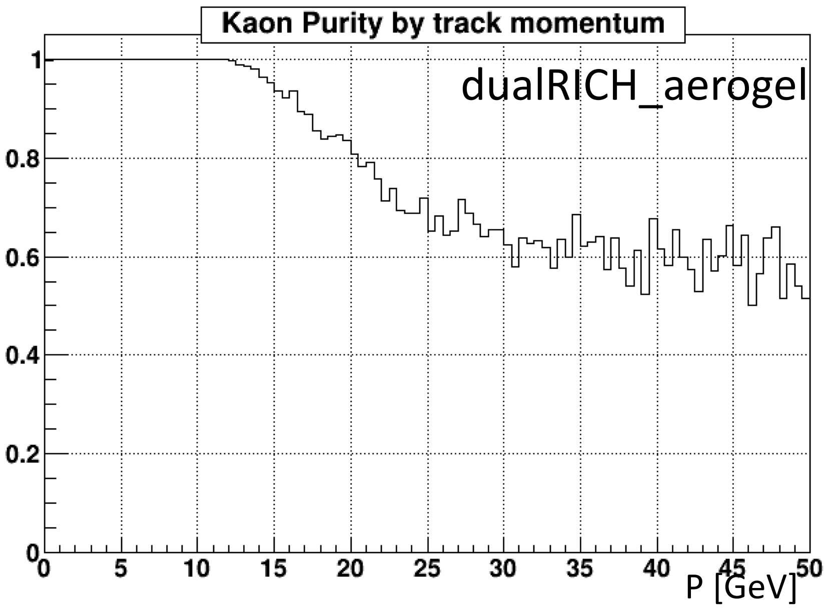


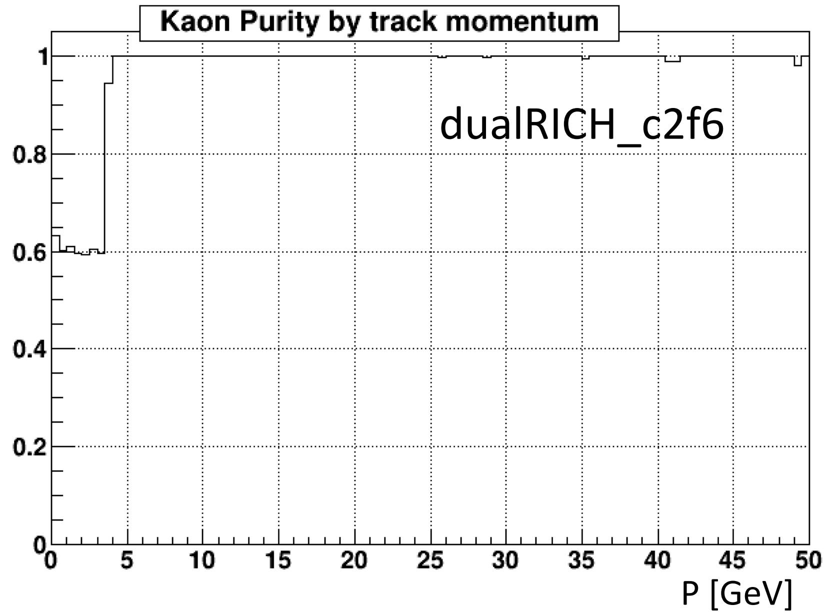


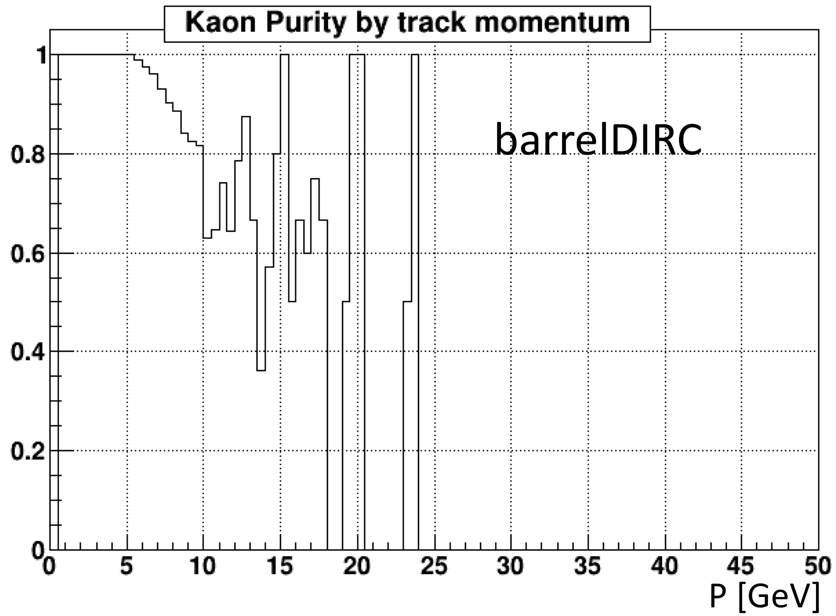


Kaon track purity result for different PID system

- $purity = \frac{number\ of\ matched\ track\ within\ P\ range\ for\ each\ PID\ system}{total\ number\ of\ track\ within\ P\ range\ for\ tracks\ in\ jets}$
  - Correctly identified track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.







Proton track purity result for different PID system

- $purity = \frac{number\ of\ matched\ track\ within\ P\ range\ for\ each\ PID\ system}{total\ number\ of\ track\ within\ P\ range\ for\ tracks\ in\ jets}$
  - Correctly identified track: PID value for track in jet matches with the PID value for the corresponding track in PID system hypothesis.