Hadron track in jets purity study

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Track PID purity study from jet

- Goal: check PID purity for tracks in jets with the track longitudinal momentum fraction (z) from the jet.
  - Check PID purity with different (x,Q^2).
  - Track longitudinal momentum fraction (z) from jet : $z = \frac{\vec{p}_{track} \cdot \vec{p}_{jet}}{\vec{p}_{jet}^{\,2}}$
- Check for 3 PID system:
  - dualRICH_aerogel: $1 < \eta < 3.5$
  - dualRICH_c2f6: $1 < \eta < 3.5$
  - barrelDIRC: $-1 < \eta < 1$

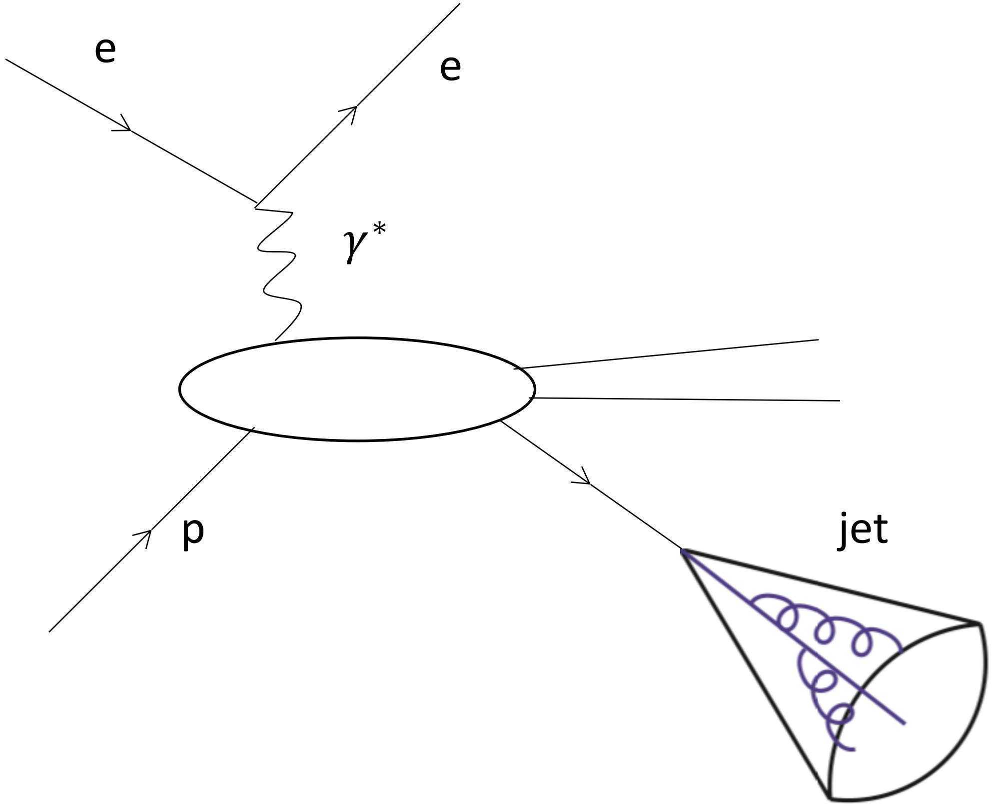
Jet finding algorithm:

Anti-kT , R=1.0 , P_T > 3 GeV

- Merge the dualRICH system by the track momentum:
  - dualRICH_aerogel: P < 12 GeV
  - dualRICH_c2f6: P > 12 GeV
- Check for Pion, Kaon and Proton tracks.

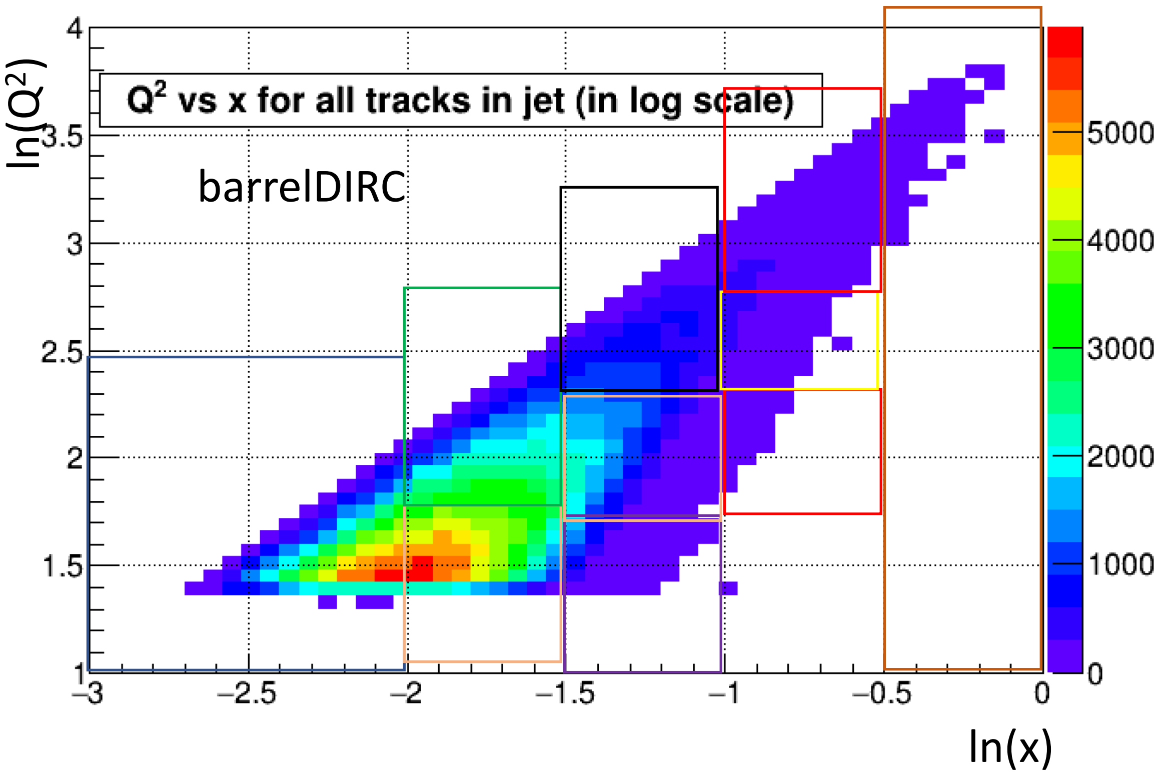
Data set

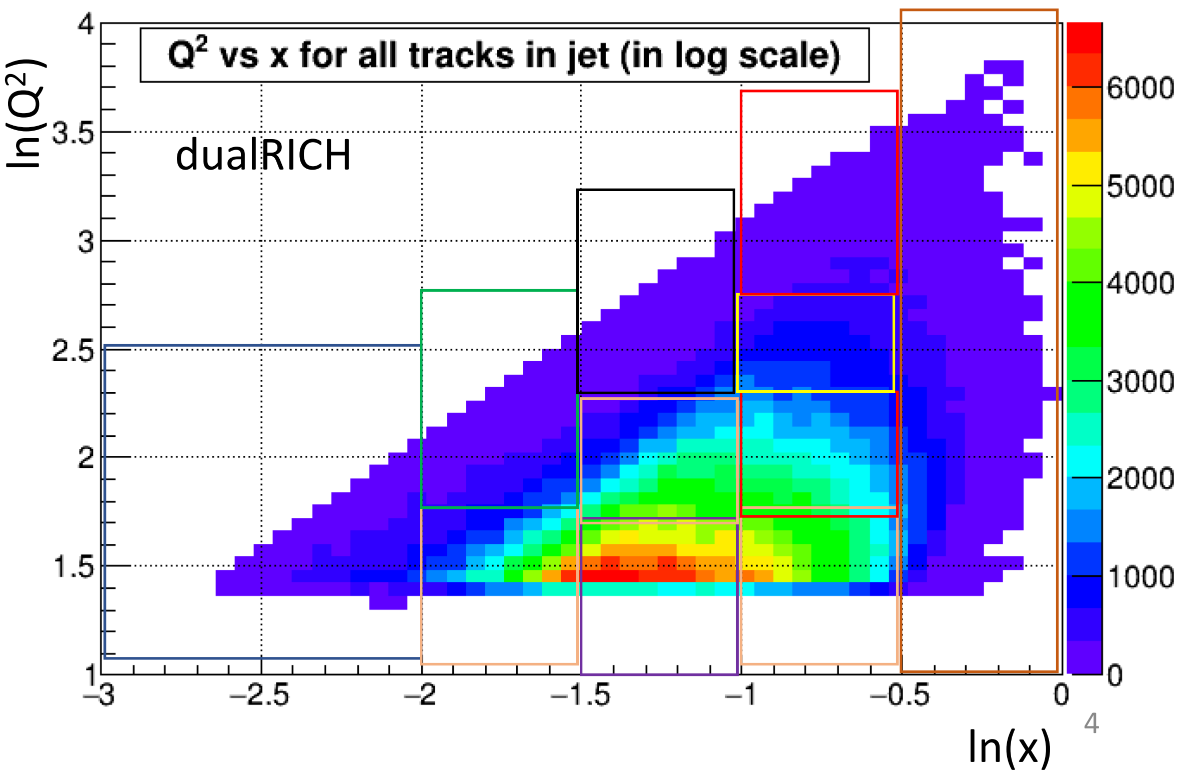
- Use Pythia8 to simulate Deep Inelastic Scattering (DIS) process
- Use Delphes to do the EIC detector respond simulation
  - Delphes card: **ATHENA.tcl** , where PID hypothesis is implemented for calorimeter systems.
- Number of event generated: 1 M
- E_{proton} = 275 GeV
- $E_{electron}$ = 10 GeV
-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



Event Q^2 vs x for all the tracks in the jet

- We plot event Q^2 vs x in log scale.
  - Note: each track in the jet will give an entry, so there will be multiple counting for each event.
  - Choose 10 area for barrelDIRC system and 11 area for dualRICH system.





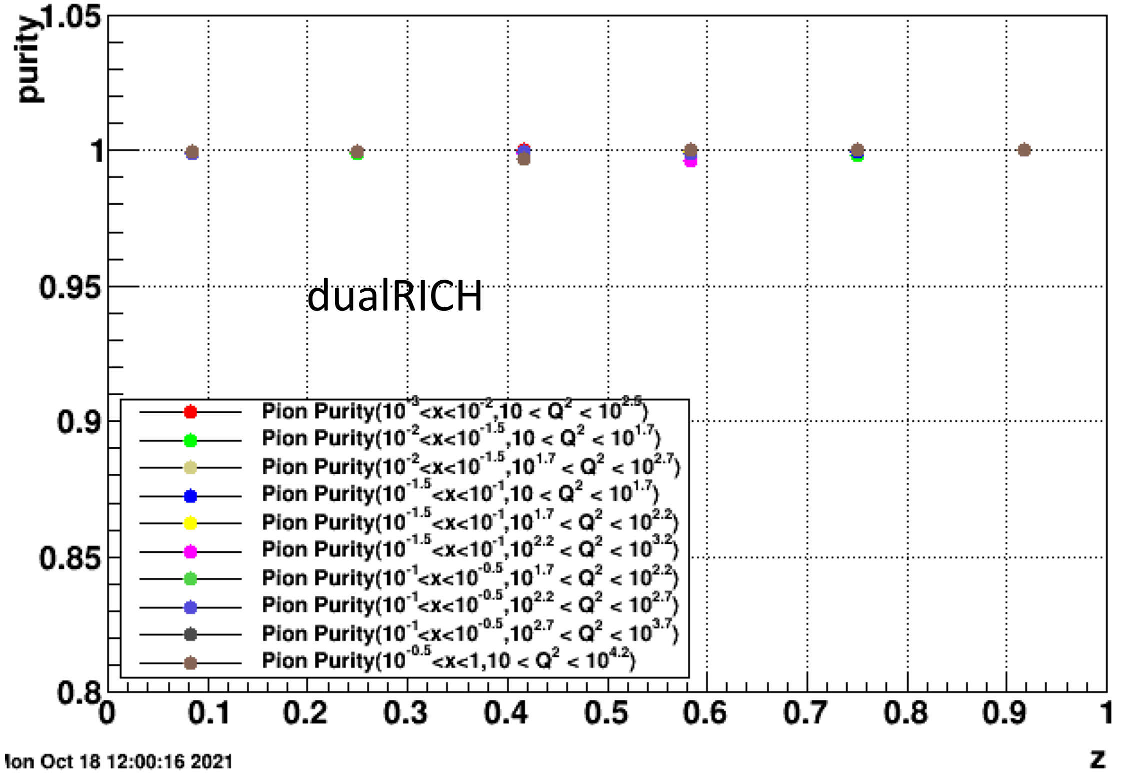
Pion track purity result for different z

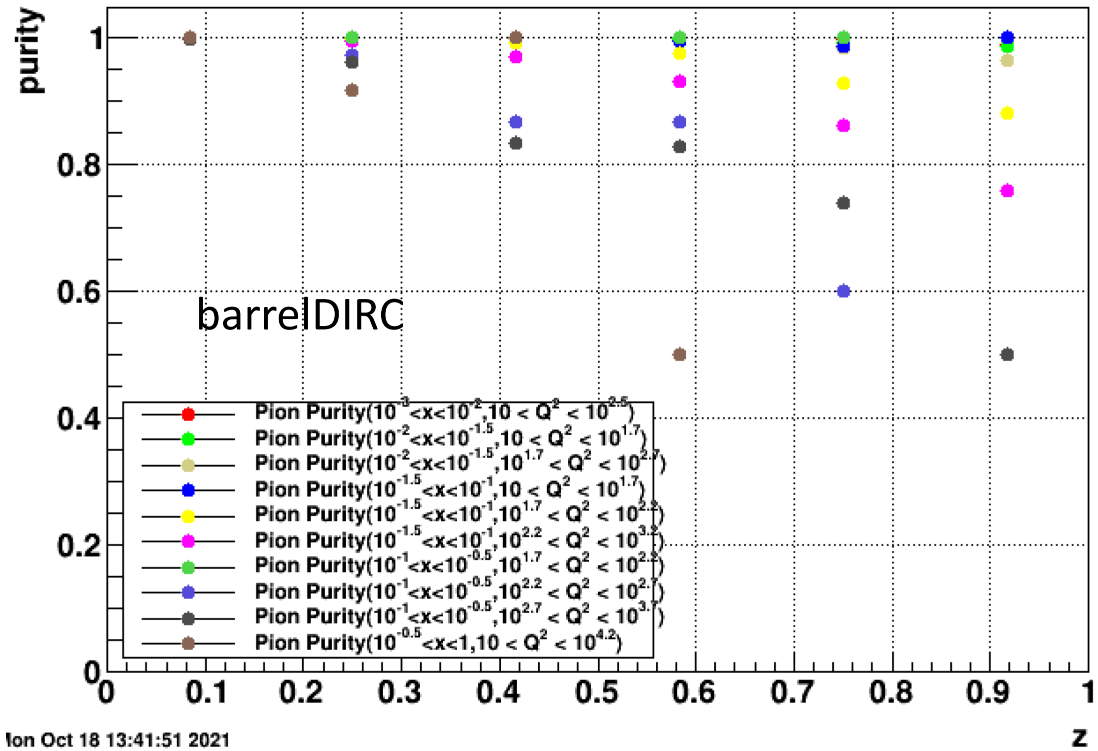
6 bins

dualRICH_aerogel: P < 12 GeV
dualRICH_c2f6: P > 12 GeV

- purity: $\frac{number\ of\ correctly\ identified\ tracks\ in\ PID\ system}{number\ of\ all\ tracks\ in\ jet\ within\ PID\ system\ coverage}$
  - "Correctly identified track": PID value for track in jet same as the PID value for the corresponding track in PID system hypothesis.
  - Z: track longitudinal momentum fraction from the jet
  - Combine dualRICH systems results by hadronic track momentum.

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





Kaon track purity result for different z

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dualRICH_c2f6: P > 12 GeV

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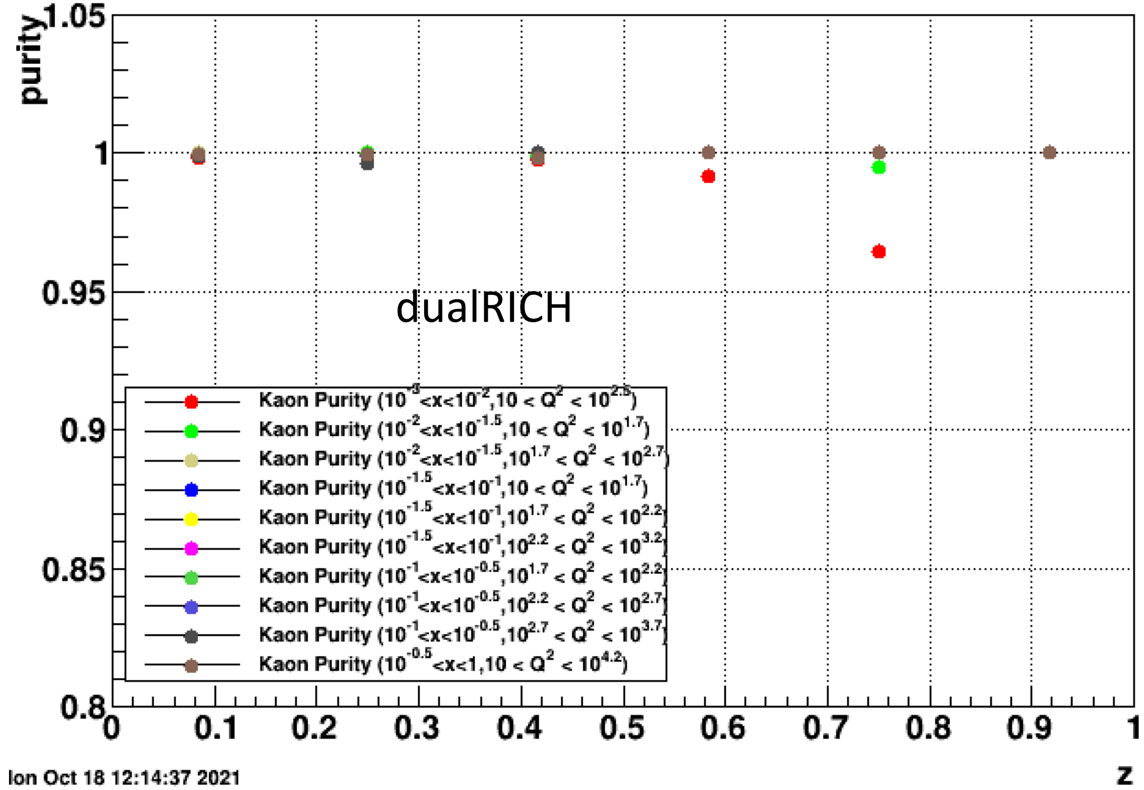

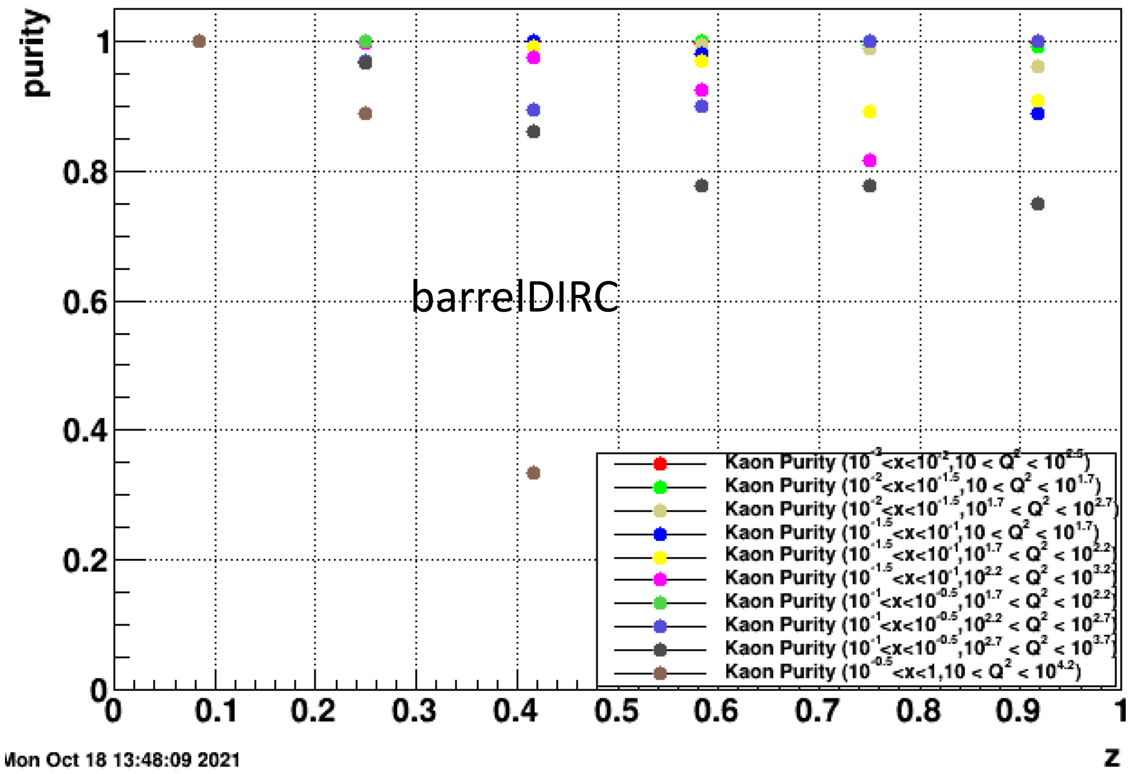

Proton track purity result for different z

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dualRICH_c2f6: P > 12 GeV

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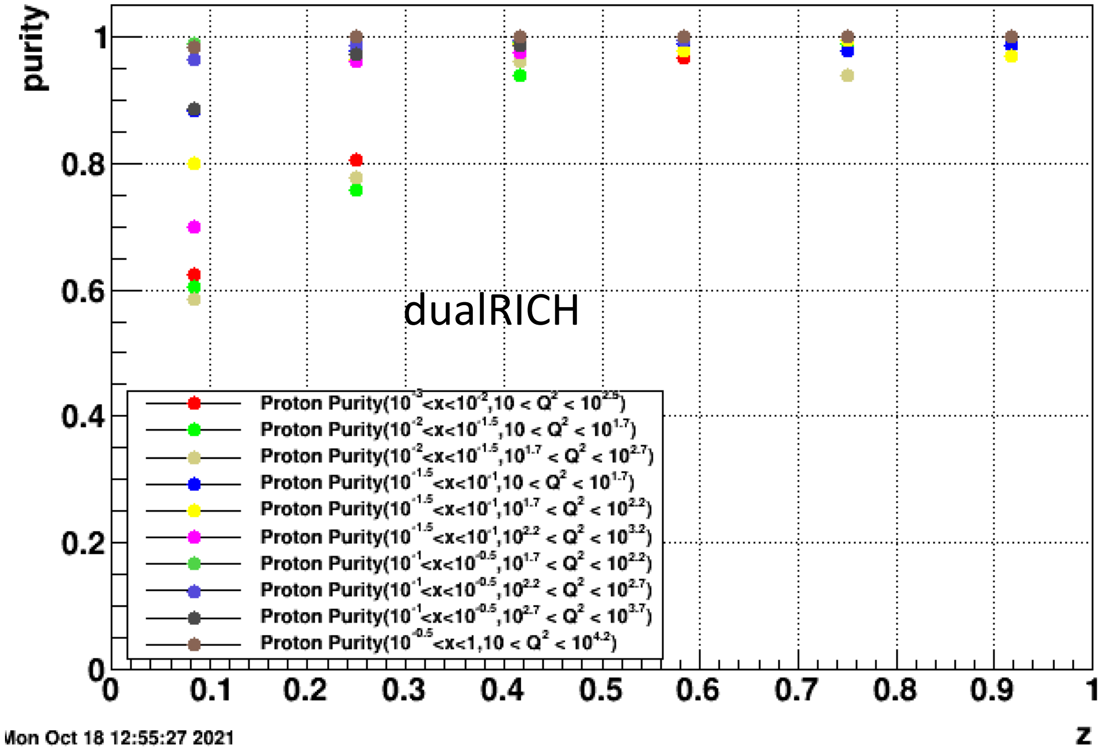
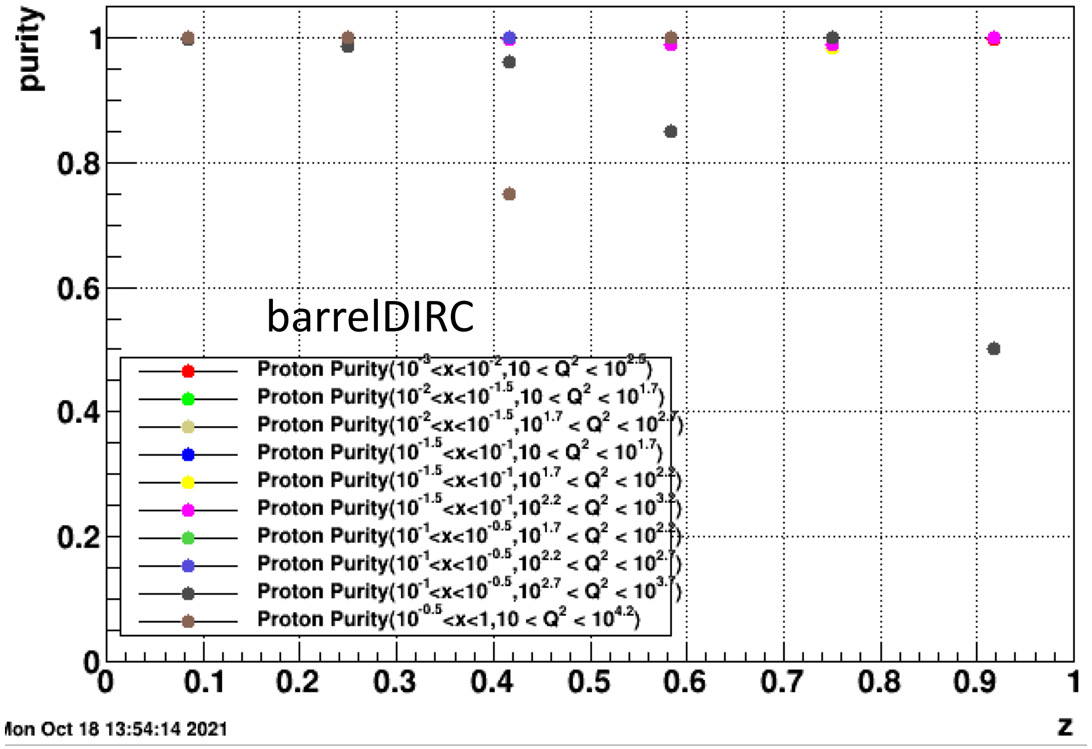


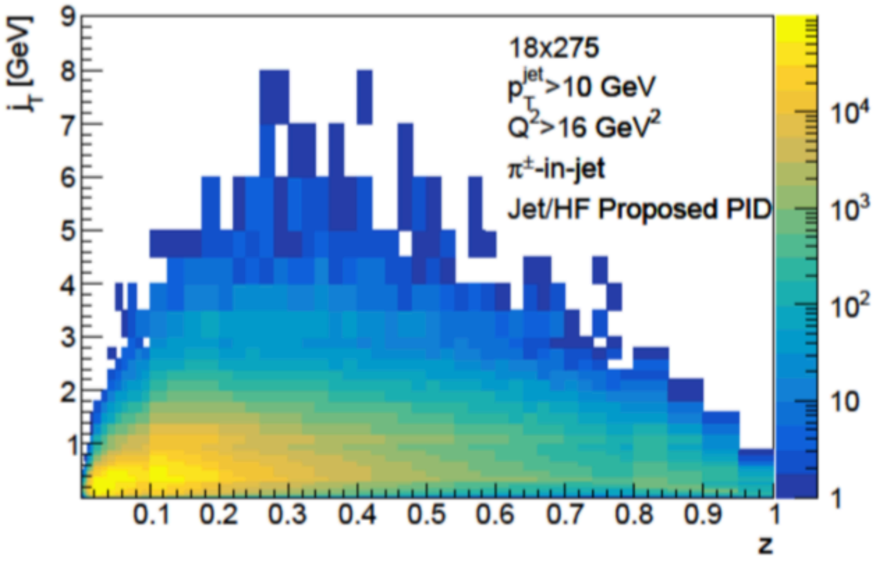


Conclusion

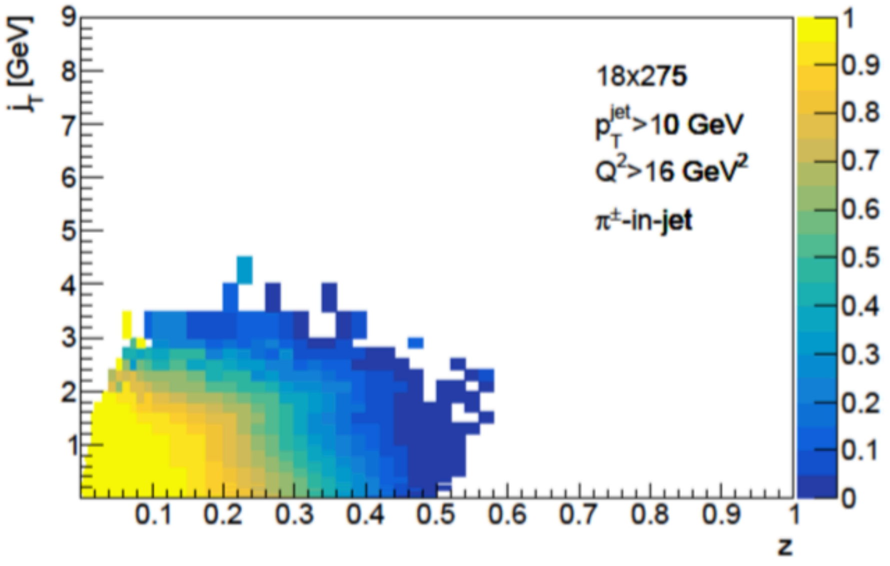
- When we combine the dualRICH PID systems to calculate the purity, the Pion and Kaon purity is close to 1 for most of the (x,Q^2) ranges.
- The proton purity are high for dualRICH systems at high longitudinal momentum fraction z ranges.
- For barrelDIRC system, the purity are high at low longitudinal momentum fraction z. Lower Q^2 ranges seems to bring high purity.

Motivation on PID purity with limited phase space

- The restricted momentum coverage (right plot) taken based on pseudorapidity range will limit the phase space and cause the high z range to be inaccessible.
  - The restricted momentum coverage is based on expected performance range.
- Our current step is to investigate how the PID purity change in limited phase space by choosing different (x,Q^2).



(a)

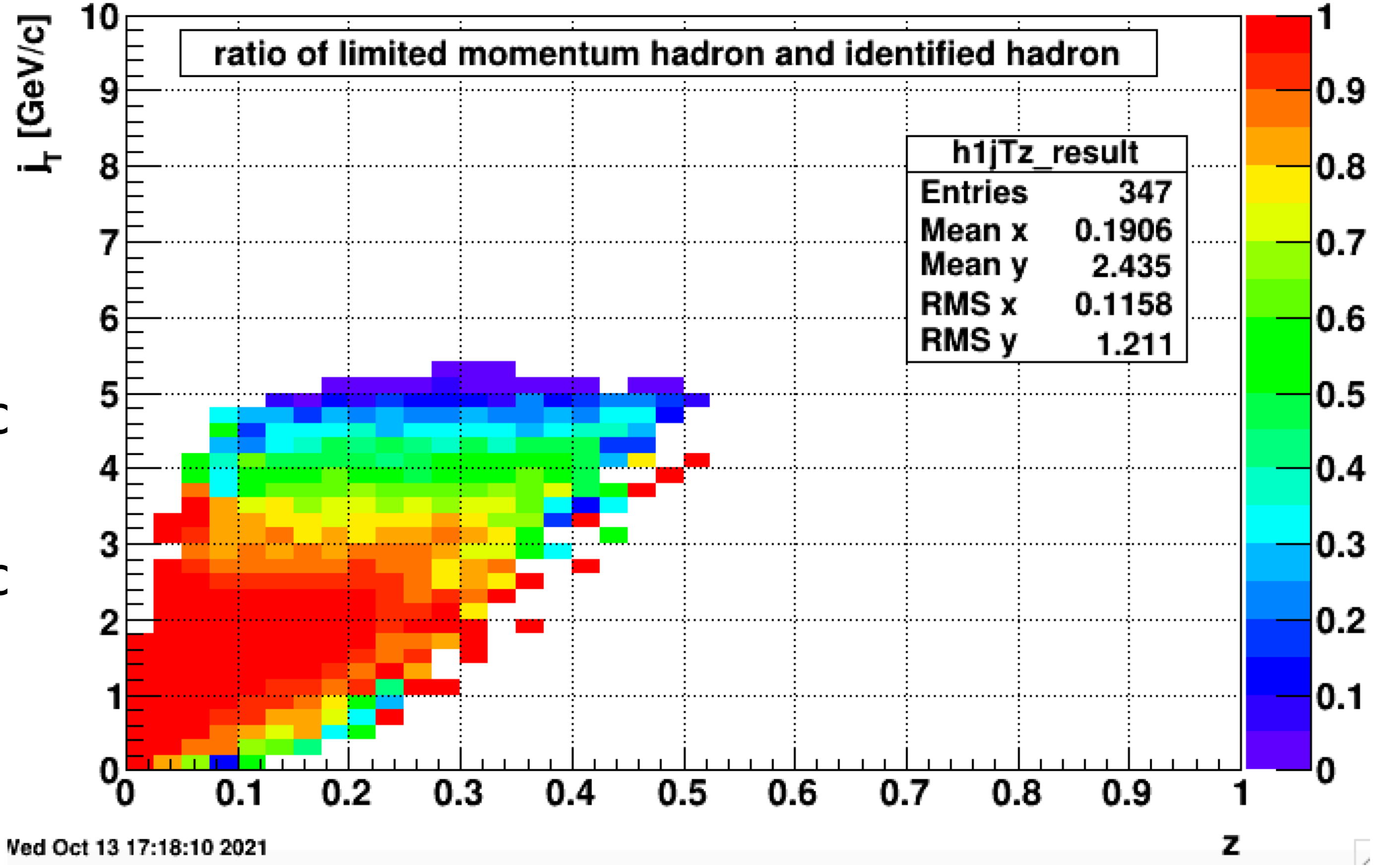


(b)

Ref: EIC Yellow Report arXiv:2103.05419

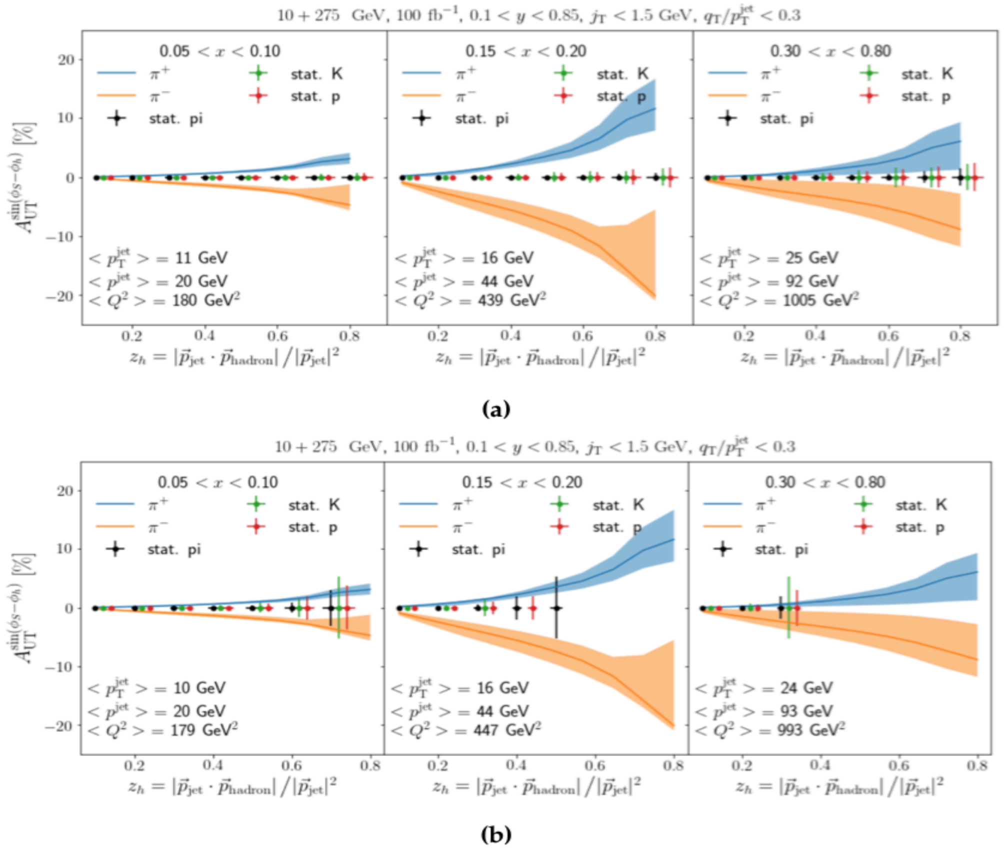
Repeat the result for ratio for limited momentum coverage distribution

- Electron E: 18GeV
- Proton E : 275 GeV
- $Q^2 > 16$ GeV
- Limited momentum:
  - $-1.0 < \eta < 1.0$: P < 5GeV/c
  - $1.0 < \eta < 2.0$: P < 8GeV/c
  - $2.0 < \eta < 3.0$: P < 20GeV/c
  - $3.0 < \eta < 3.5$: P < 35GeV



Impact on physics measurement with restricted momentum coverage

- Top row plots are Collins asymmetry with hadrons in perfect expected PID.
- Bottom row plots are Collins asymmetry with hadrons in restricted momentum reach PID.
- Our current step is to investigate how the PID purity change in limited phase space by choosing different (x,Q^2).



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M. Arratia, Z. Kang, A. Prokudin, F. Ringer Phys.Rev.D 102 (2020) 7, 074015

Pion track purity result for different z

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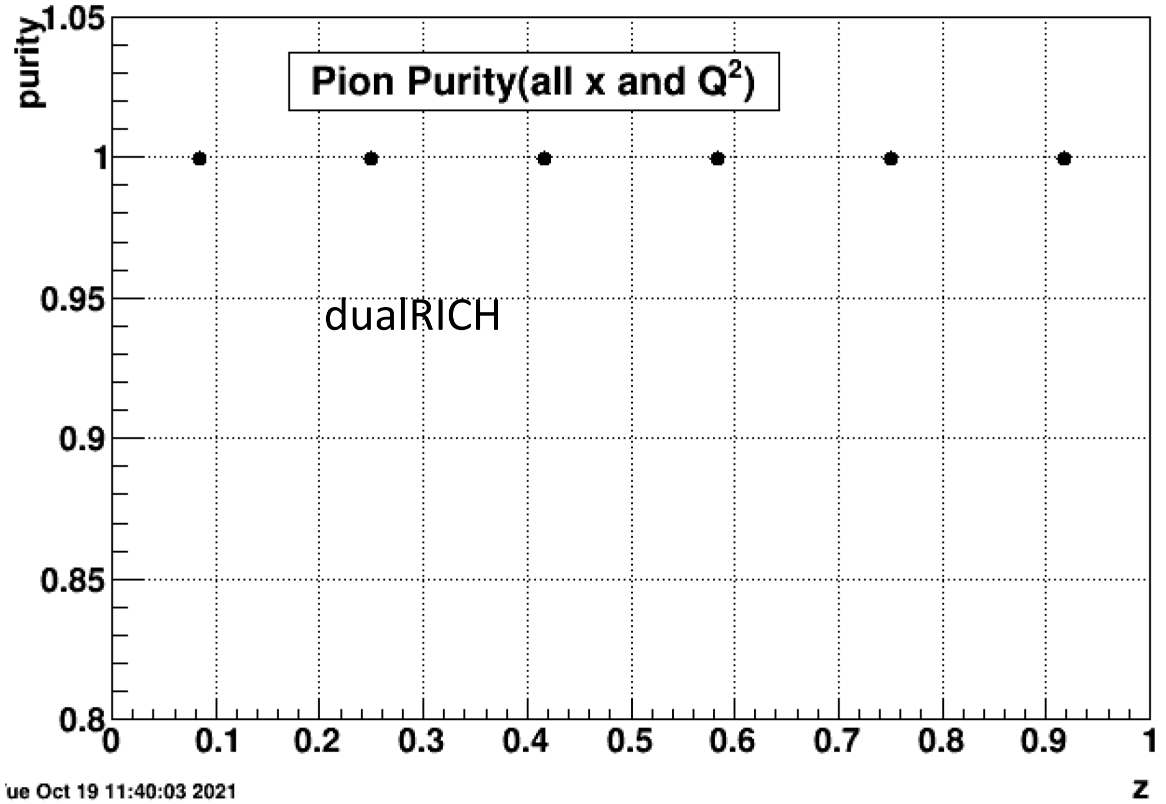
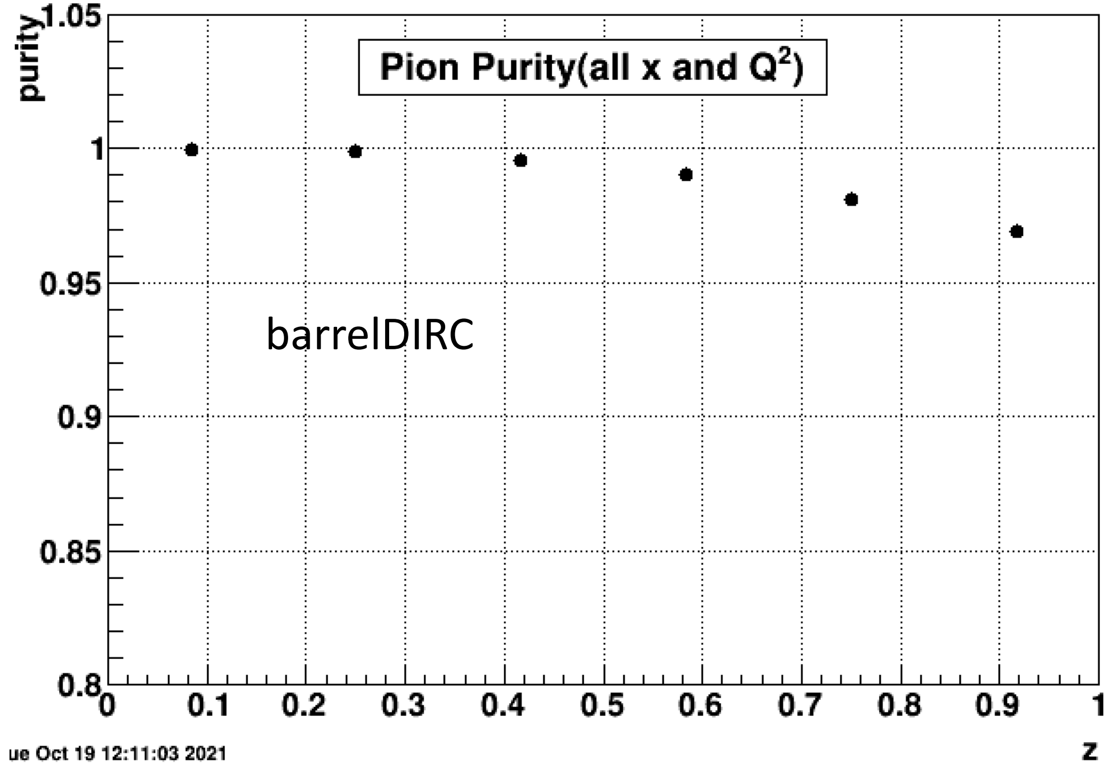
  - "Correctly identified track": PID value for track in jet same as the PID value for the corresponding track in PID system hypothesis.
  - Z: track longitudinal momentum fraction from the jet
  - Plots are for all the hadron tracks.

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





Kaon track purity result for different z

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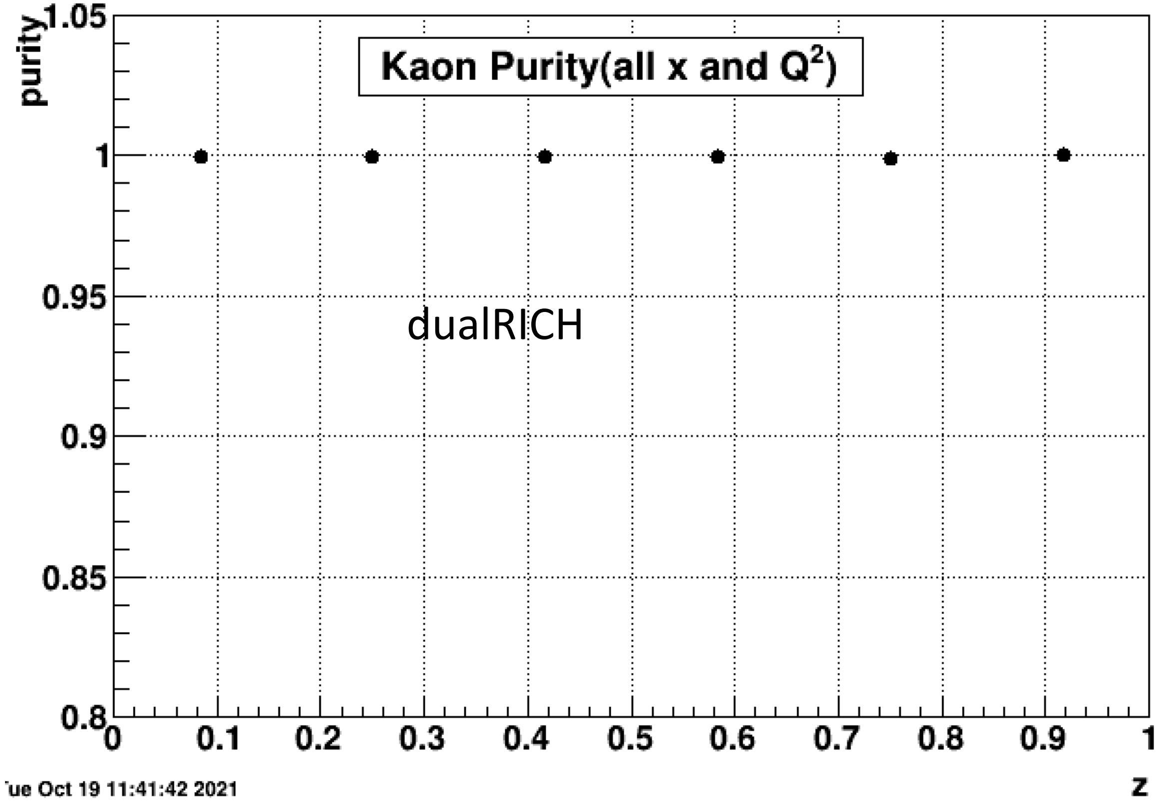

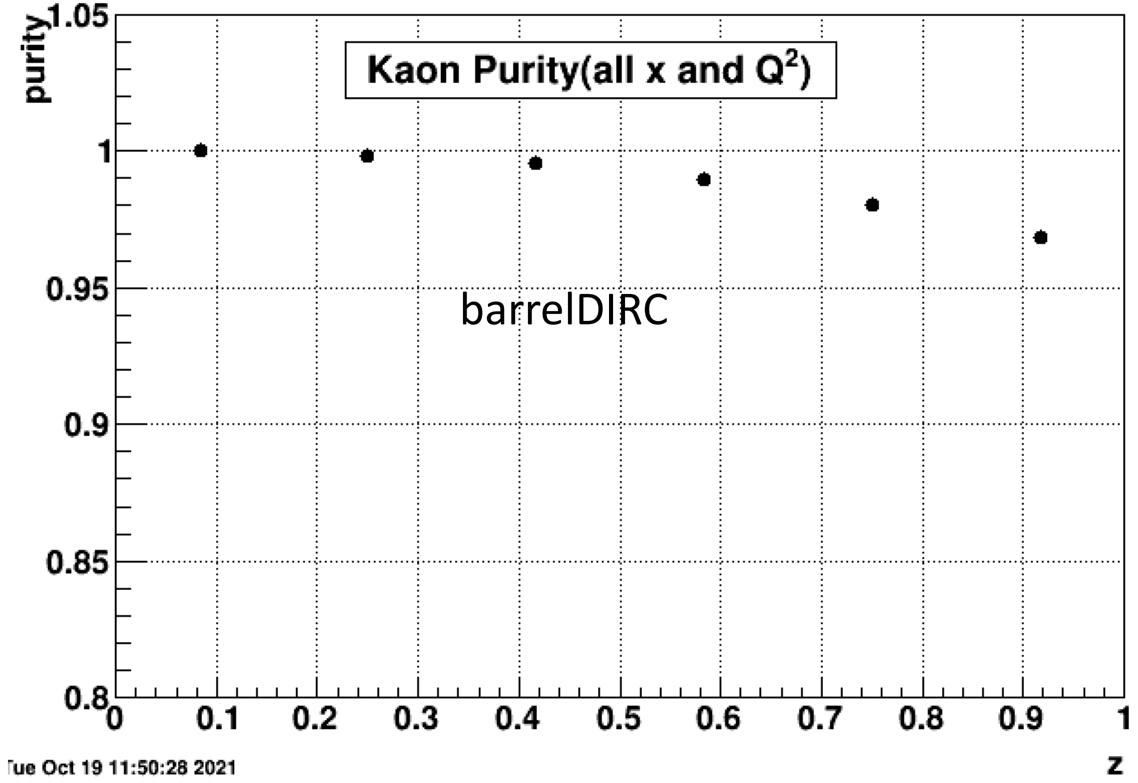

Proton track purity result for different z

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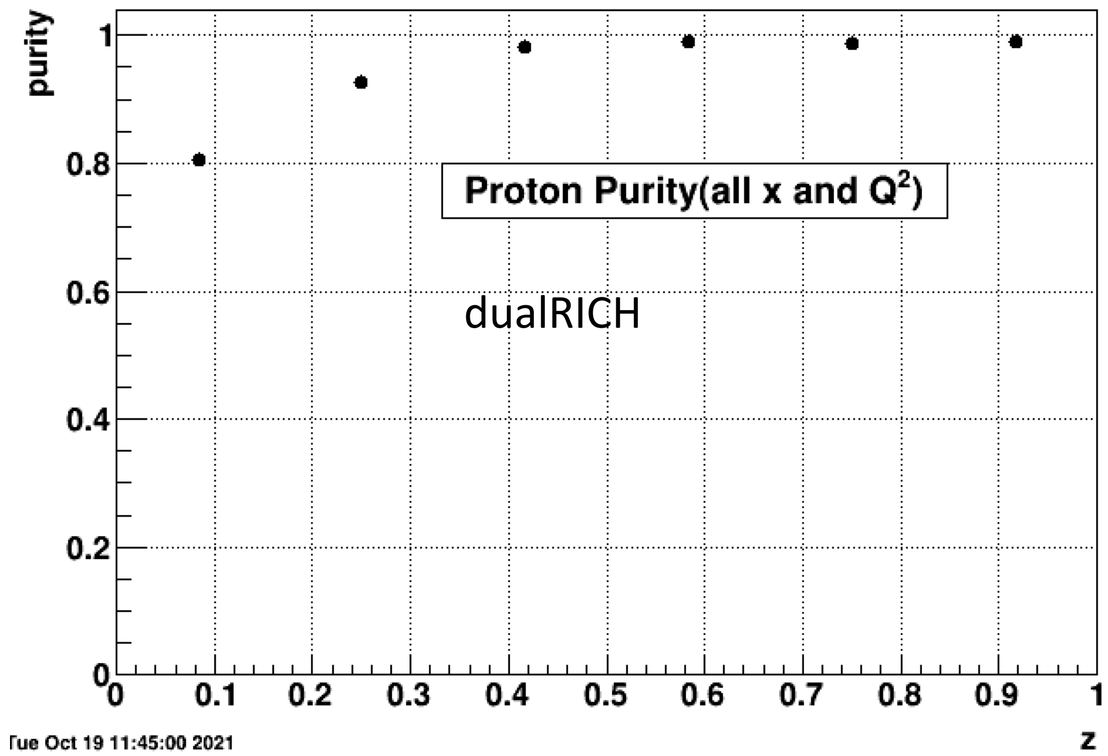

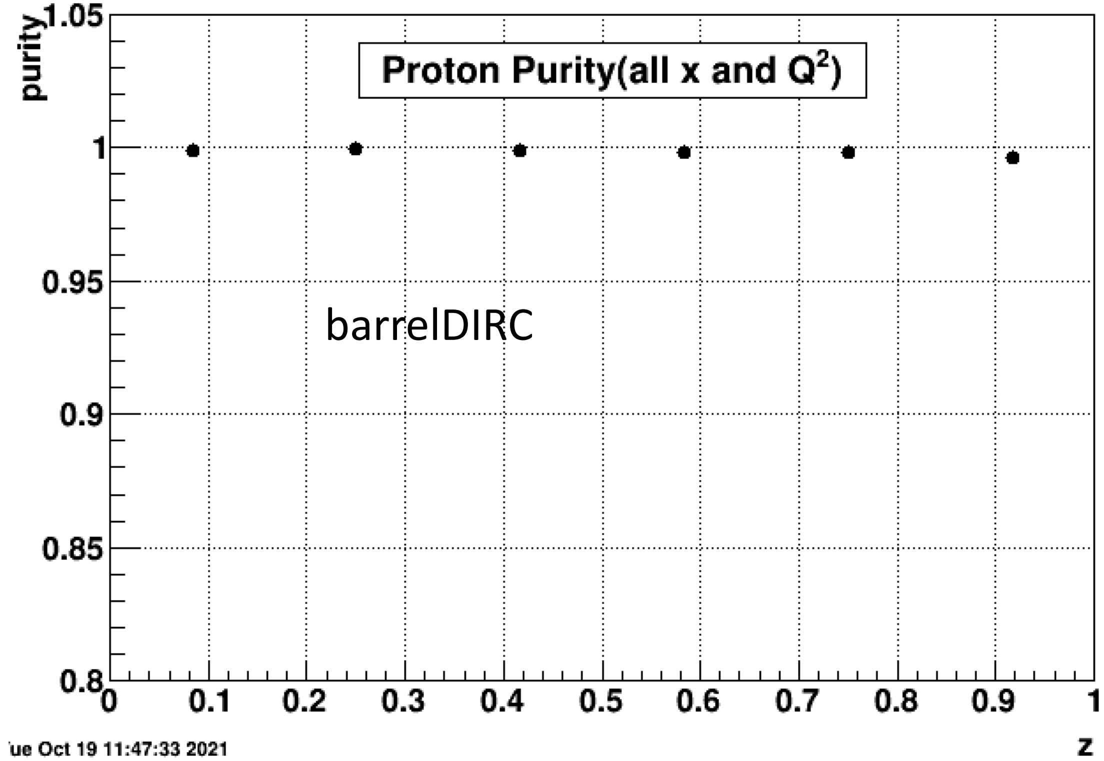

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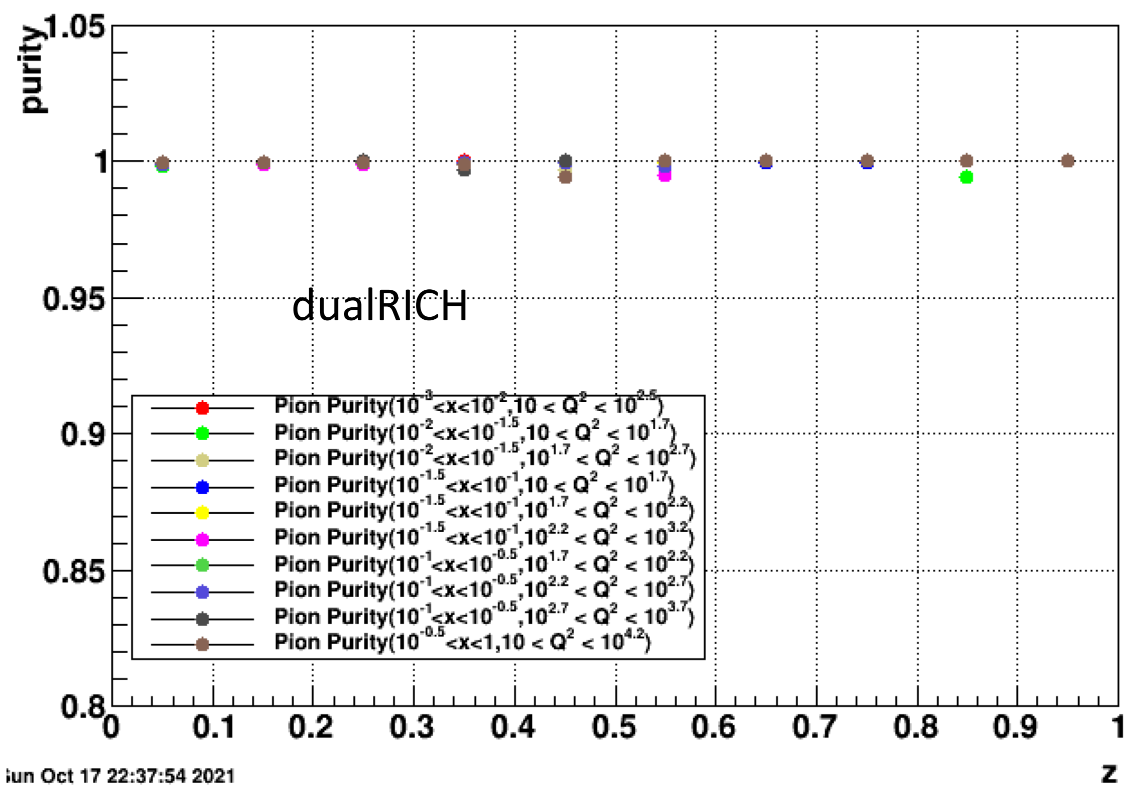

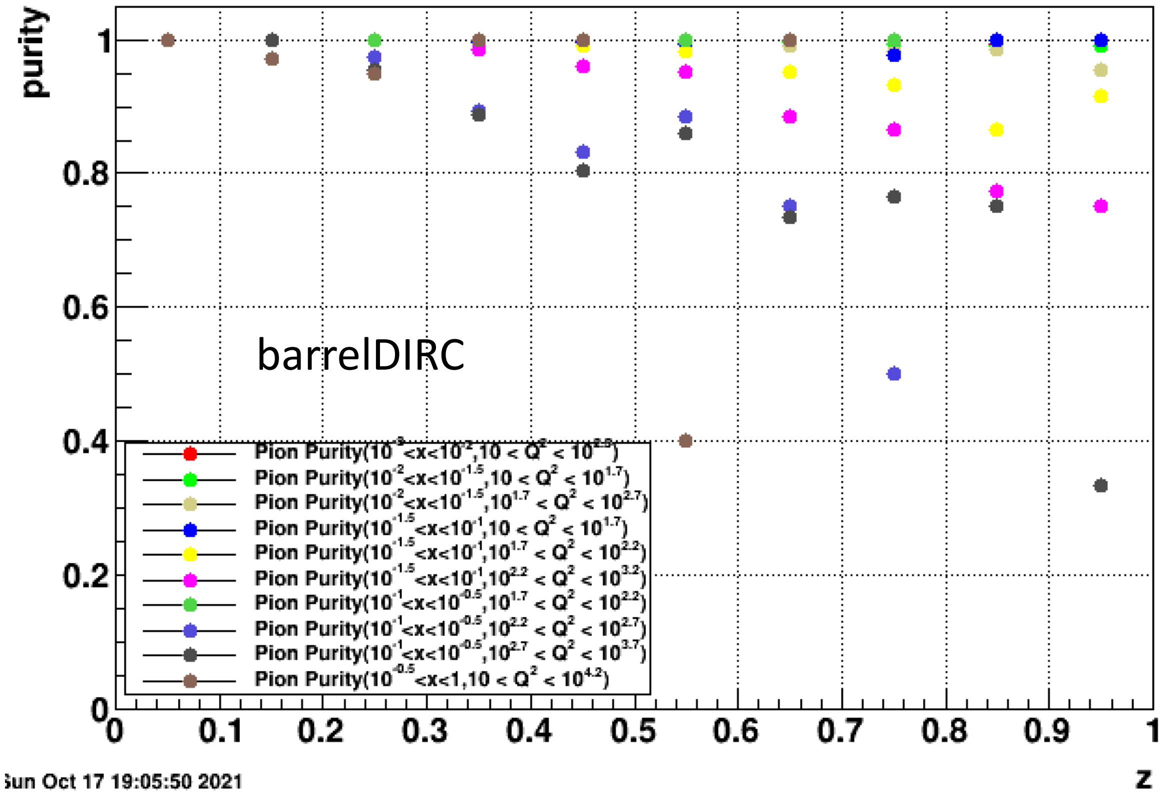

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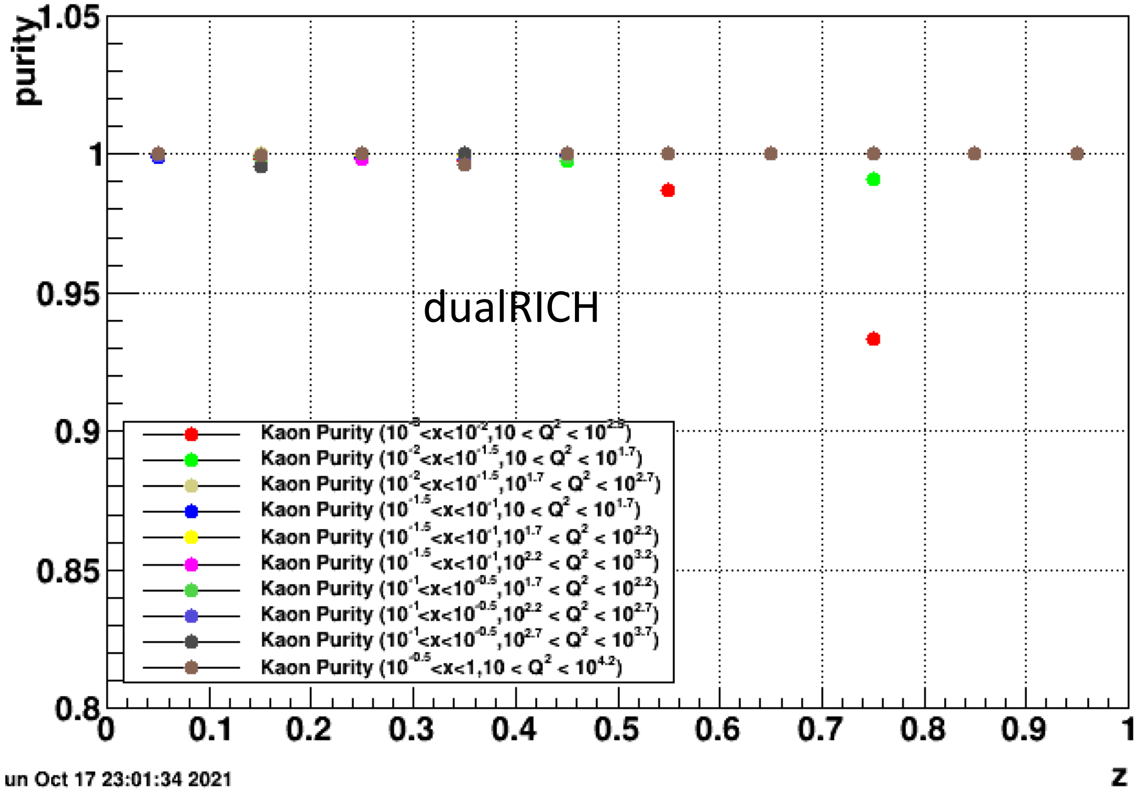

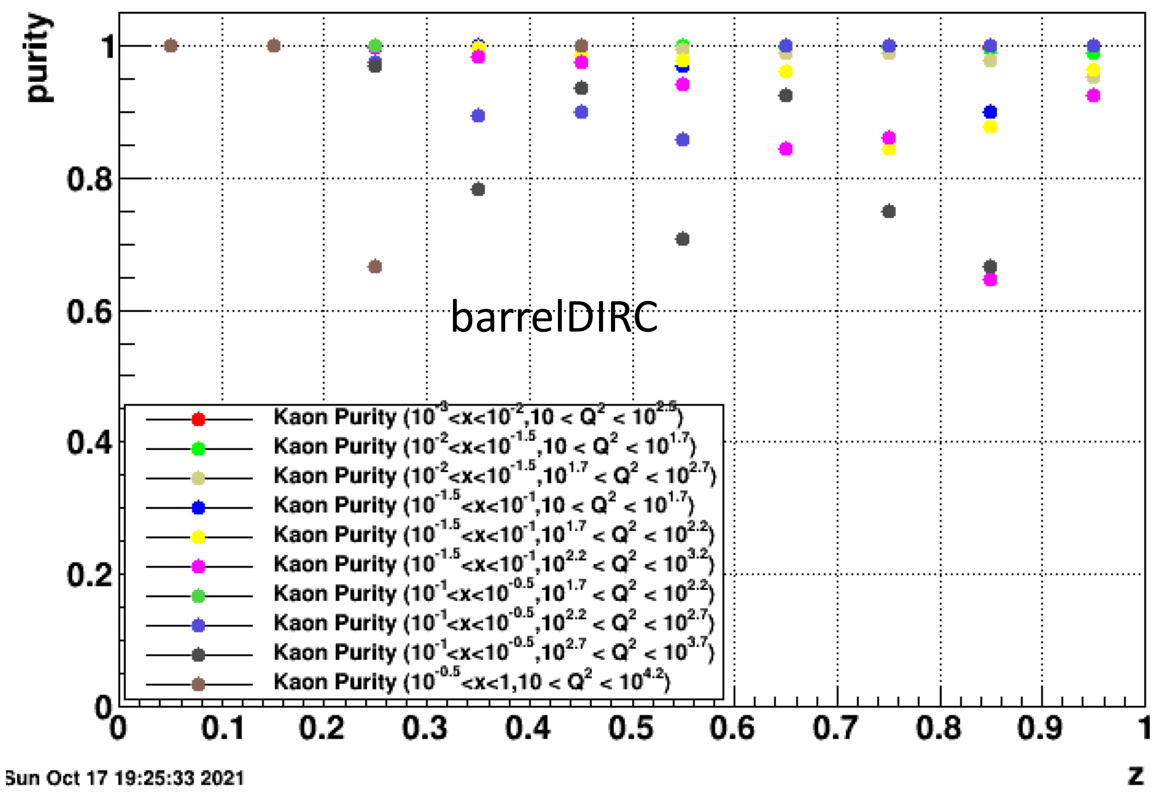

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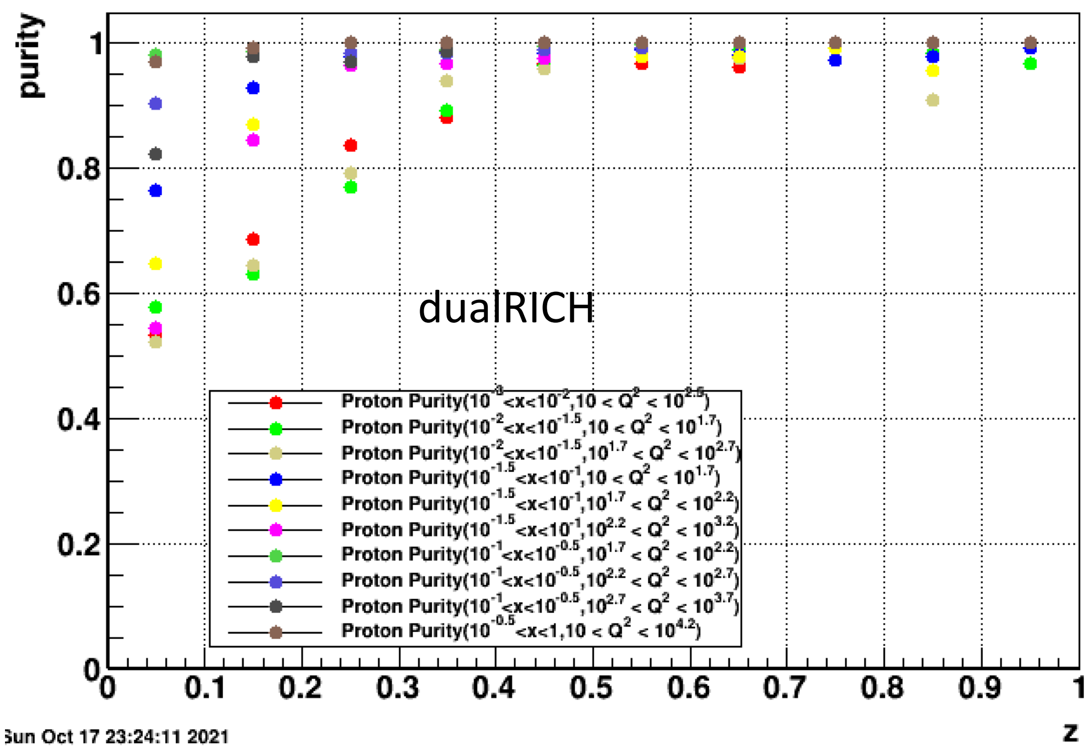

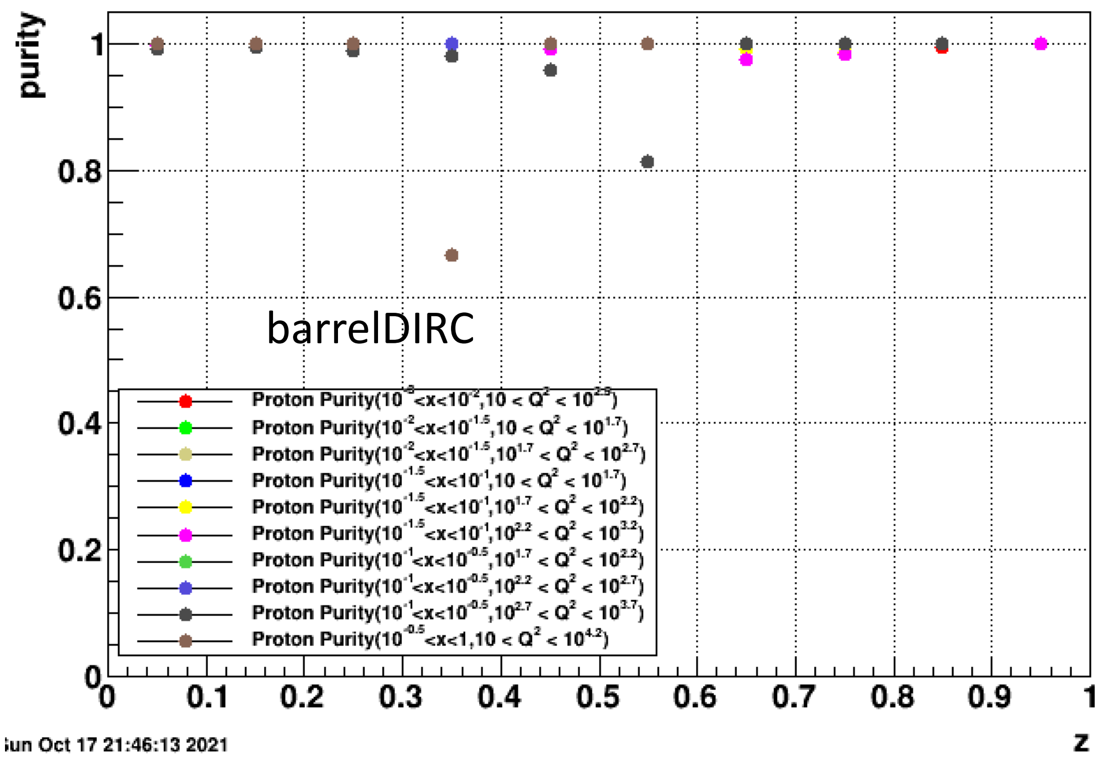

Pion track purity result for different z

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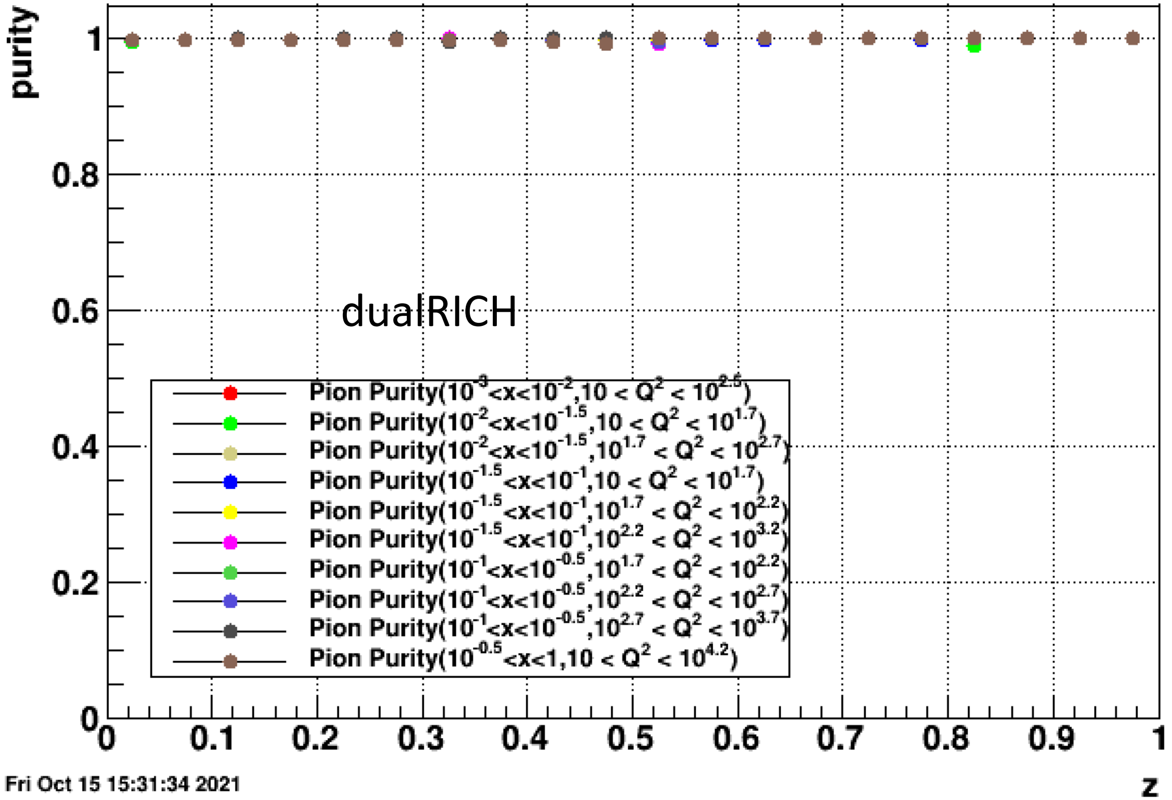

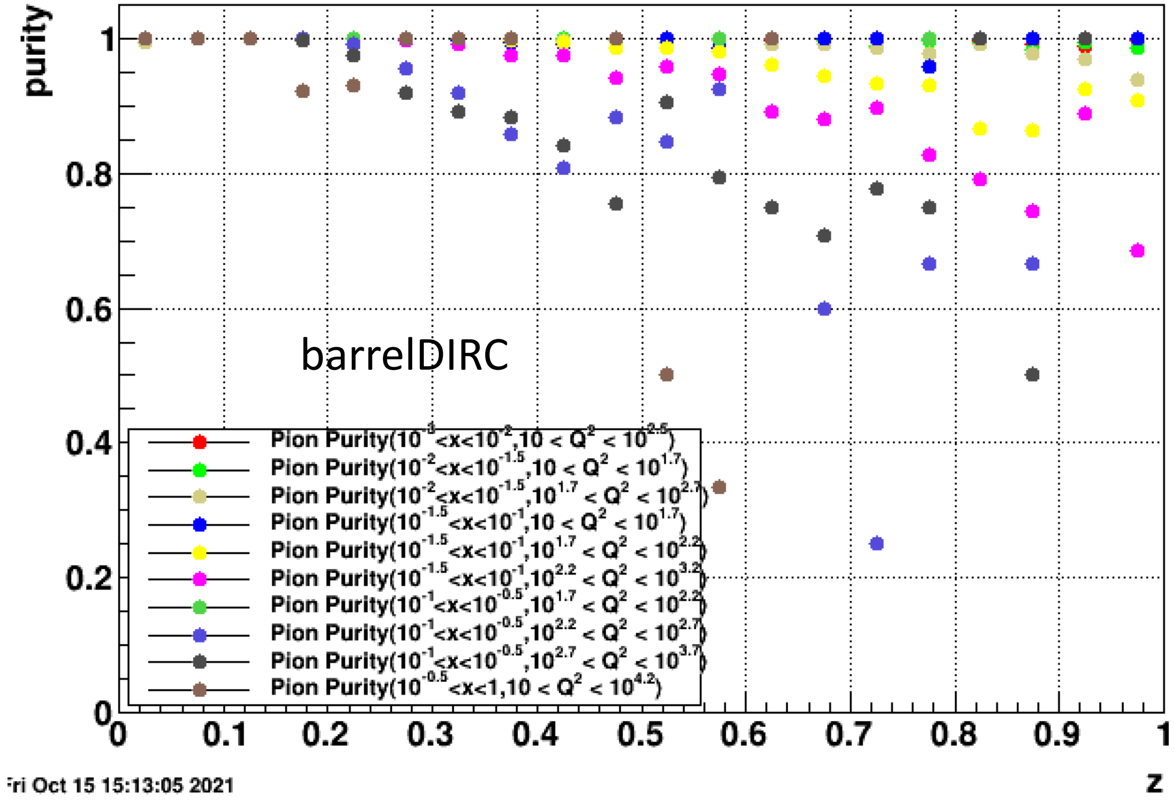

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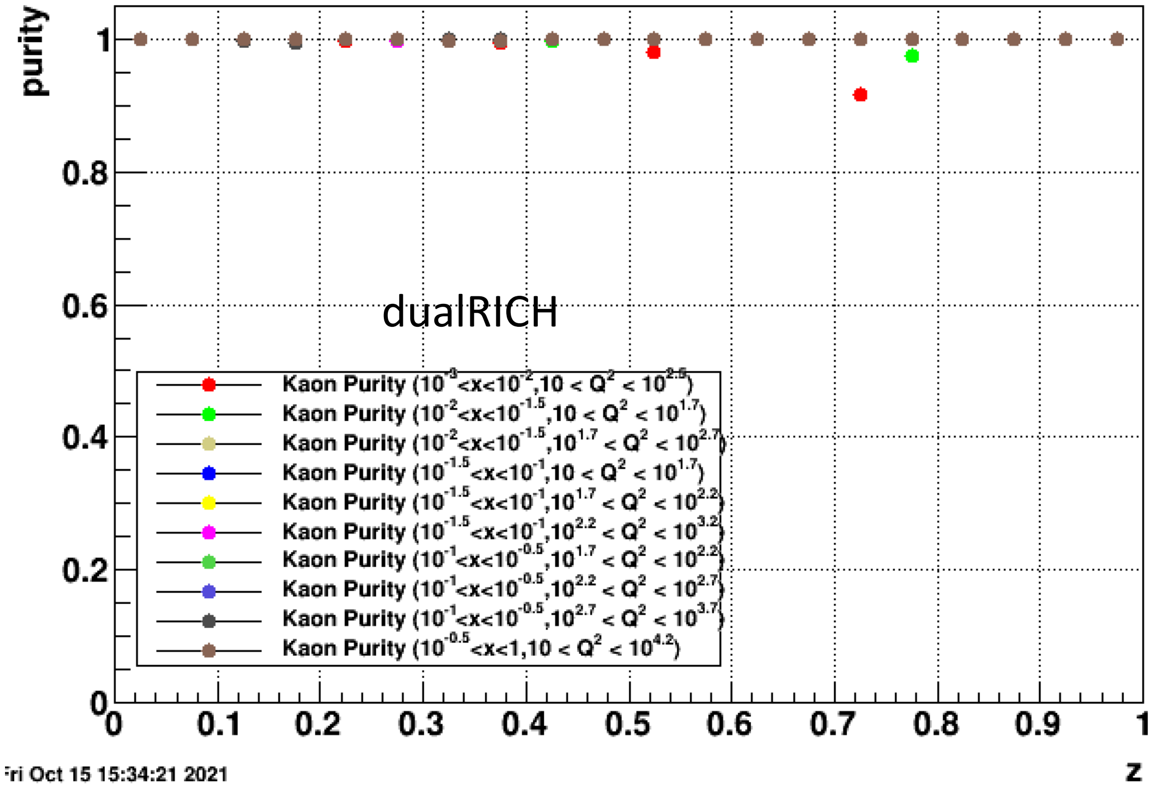

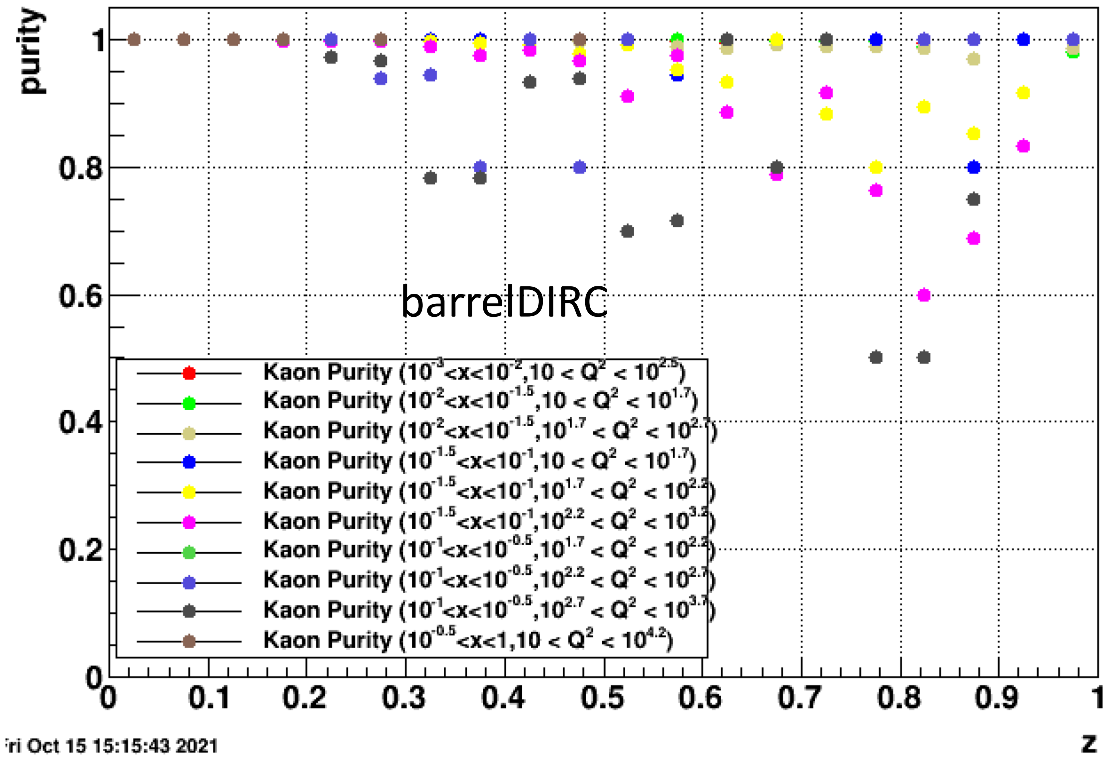

Proton track purity result for different z

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