# Charm Jet Substructure PID Studies

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# Reminder

- Last Update 07/27/2020
  - Statistical projections and resolution of hadronization and jet substructure variables were shown for $D^0$s in jets with truth PID used for $D^0$ reconstruction
- This update
  - Effect of using default vs requested PID parametrizations for $D^0$ reconstruction rather than truth PID is investigated
- Analysis code is available on Github
  - Inclusive jet analysis code found here -- managed by Joe Osborn
  - Heavy flavor jet analysis code found here -- managed by Dillon Fitzgerald

# Analysis Chain

**Truth Level**

1. Generate sample of 100 million e+p events for 18x275 GeV and 10x100 GeV collisions
    a. PYTHIA 6, all e+p sub processes included (MSEL=2 option)
2. Use truth level information to filter out events that satisfy the following criteria
    a. $\gamma^*c \rightarrow c \rightarrow D^0 \rightarrow \{K\pi, K^+K^-, \pi^+\pi^-\}$ -- KK and ππ are negligible contribution (**note:** $\gamma^*q \rightarrow q$ is PYTHIA process number 99)
    b. $D^0$ decay products are within detector acceptance
3. Replace $D^0$ decay products with $D^0$, cluster particles into jets (anti $k_T$ R = 1), only write out those containing a $D^0$

**Reco Level**

1. Check smear particle p and η against PID matrix parametrizations for 2 cases {default PID, requested PID}
    a. use truth mass and smeared momentum to calculate smeared energy if PID detection criteria is satisfied
2. Perform $D^0$ reconstruction with particles in PID acceptance
3. Replace $D^0$ decay products with $D^0$, cluster particles into jets (anti $k_T$ R = 1), only write out those containing a $D^0$

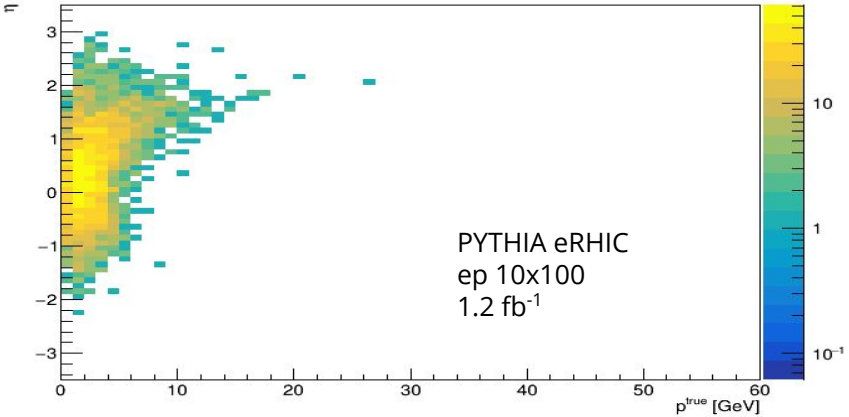
# Truth η vs p for Kπ

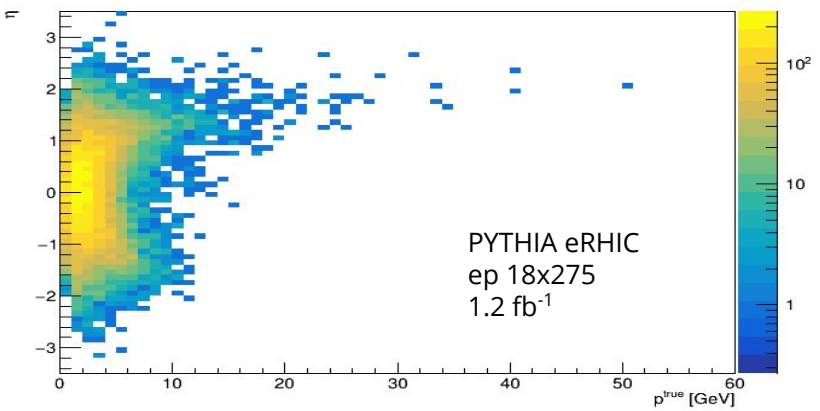
- Pseudorapidity vs momentum of charged $D^0$ decay products in jets
- Majority of decay products within requested and default coverage

PID Momentum Coverage

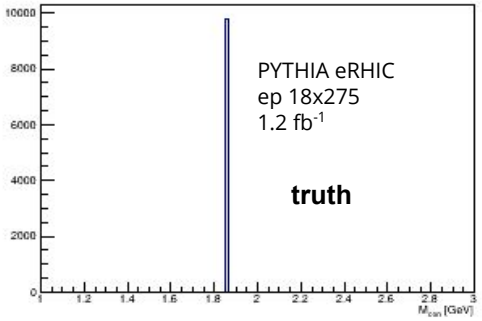
| Eta Range | Default Momentum Coverage | Requested Momentum Coverage |
|---|---|---|
| -3.5 < η < -1.0 | ≤ 7 GeV | Same |
| -1.0 < η < 0.0 | ≤ 5 GeV | ≤ 10 GeV |
| 0.0 < η < 0.5 | | |
| 0.5 < η < 1.0 | | ≤ 15 GeV |
| 1.0 < η < 1.5 | ≤ 8 GeV | ≤ 30 GeV |
| 1.5 < η < 2.0 | | ≤ 50 GeV |
| 2.0 < η < 2.5 | ≤ 20 GeV | |
| 2.5 < η < 3.0 | | ≤ 30 GeV |
| 3.0 < η < 3.5 | ≤ 45 GeV | Can tolerate ≤ ~20 GeV |

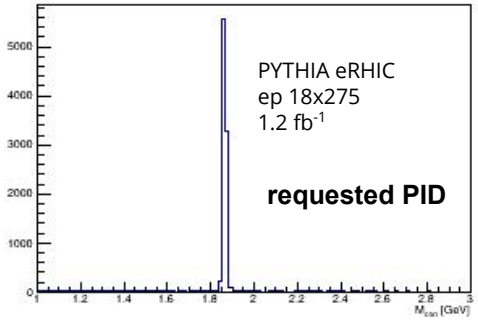
**$Q^2 > 16\ GeV^2$; $0.05 \leq y \leq 0.95$; Anti-$k_T$; R = 1.0; Jet $p_T > 4$ GeV**

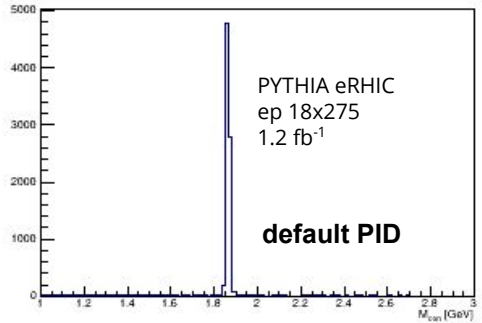


# $D^0$ in Jet Mass (18x275 GeV)



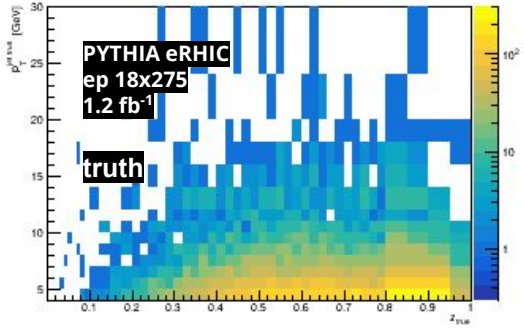

- Invariant mass for $D^0$ in jet shown for truth events, smeared events with requested PID and smeared events with default PID in 18x275 GeV e+p collisions
- Both $D^0$ decay products required to be in PID acceptance

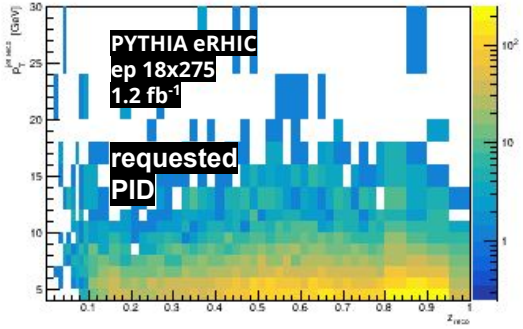
| Category | $N_{jets}$ | Losses due to PID |
|---|---|---|
| Truth | 9792 | -- |
| Requested PID | 9684 | 182 |
| Default PID | 8244 | 1458 |

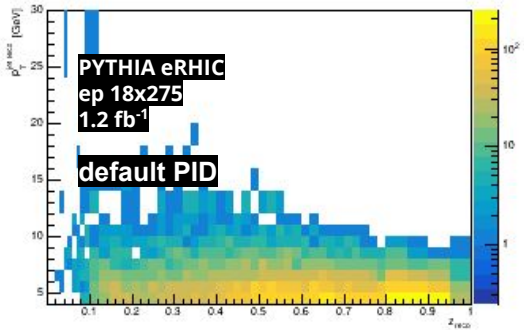
**Note: $N_{jets}^{true}$ != $N_{jets}^{smear}$ + PID losses**

This is because sometimes >1 jet is reconstructed with a single $D^0$ in a smeared event, and some $D^0$s are reconstructed but no jet is formed around them in the smeared event

# Jet $p_T$ vs $D^0$ z (18x275 GeV)

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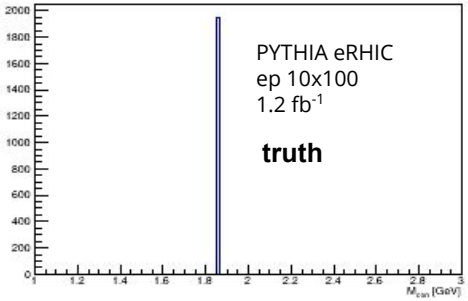
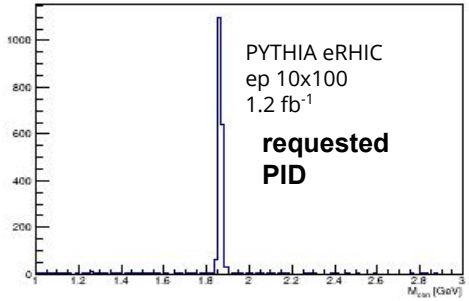
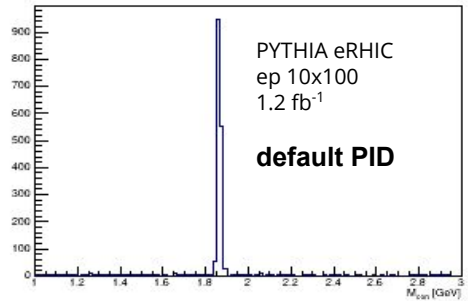
- $p_T$ vs z distributions for $D^0$ in jets for truth events, smeared events with requested PID, and smeared events with default PID in 18x275 GeV e+p collisions
- Signal lost from requested -> default PID is not too significant

# $D^0$ in Jet Mass (10x100 GeV)



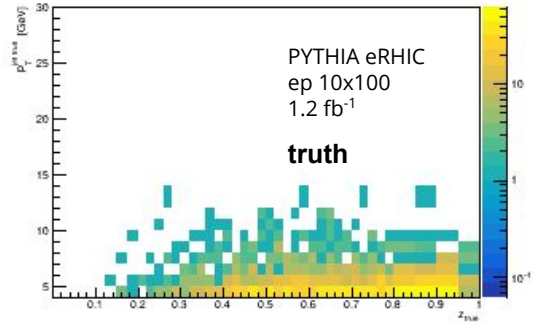



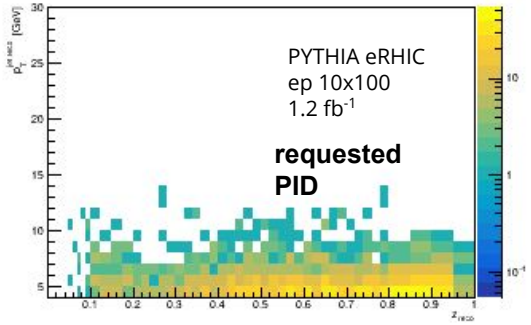



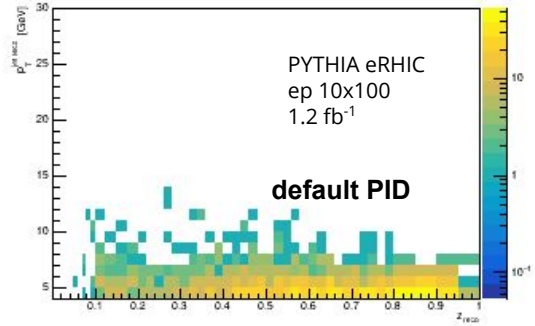

- Invariant mass for $D^0$ in jet shown for truth events, smeared events with requested PID and smeared events with default PID in 10x100 GeV e+p collisions
- Both $D^0$ decay products required to be in PID acceptance

| Category | $N_{jets}$ | Losses due to PID |
|---|---|---|
| Truth | 1949 | -- |
| Requested PID | 1935 | 7 |
| Default PID | 1672 | 252 |

# Jet $p_T$ vs $D^0$ z (10x100 GeV)

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- $p_T$ vs z distributions for $D^0$ in jets for truth events, smeared events with requested PID, and smeared events with default PID in 10x100 GeV e+p collisions
- Signal lost from requested -> default PID is again not too significant

# Conclusions

- Similarly to the inclusive jet substructure program, the largest loss of statistics is for high $p_T$ jets when using default PID requirements

- While high $p_T$ phase space is lost when going from requested to default PID requirements, most of the z phase space is preserved