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Tracking Efficiency

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Analysis goal

Reconstruction of two possible chains:

Two body decay: $D^{*+} \to D0\ \pi^+ \to k^-\ \pi^+$

Four body decay: $D^{*+} \to D0\ \pi^+ \to k^-\ \pi^+\ \pi^-\ \pi^+$

Extraction of the ratio:

$$\mathbf{R} = \frac{N_{K3\pi}\epsilon_{K\pi}}{N_{K\pi}\epsilon_{K3\pi}}.$$

R divided by the world-average value of the

BR fraction is sensitive to **pion relative tracking efficiency**:

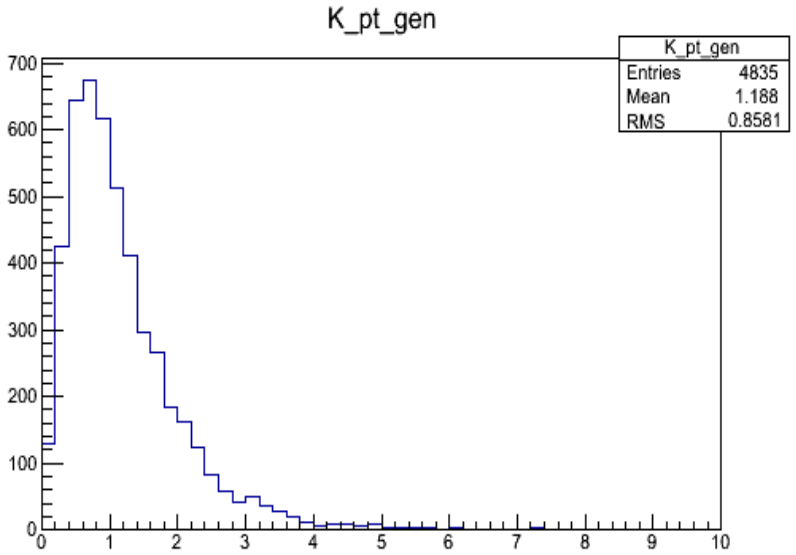
$$\frac{R}{R(PDG)} = \left(\frac{\epsilon_\pi^{DATA}}{\epsilon_\pi^{MC}}\right)^2$$

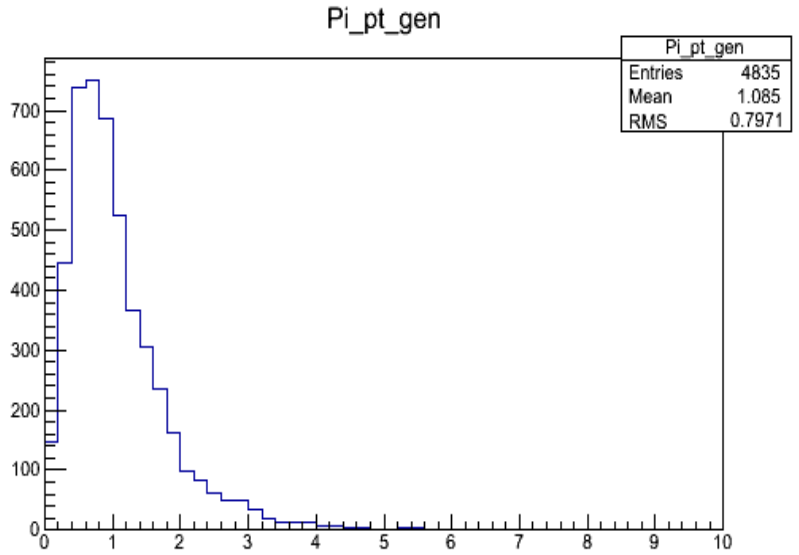
Two body decay

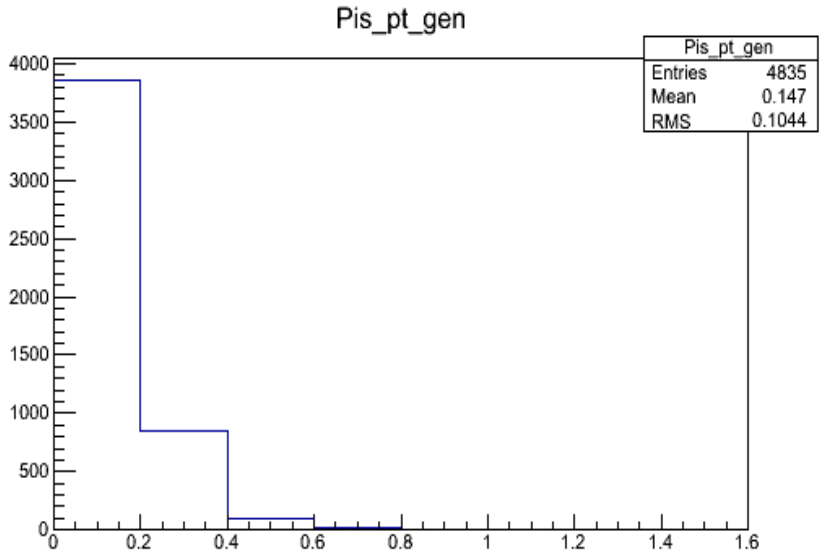
MC preliminary samples:
4835 D^{*+} events without pile up from a sample of 9715 total events.

Each event is required to have:
one D* + one π^+ + one D0 + one K^- + one π^+

Gen Level: kinematics

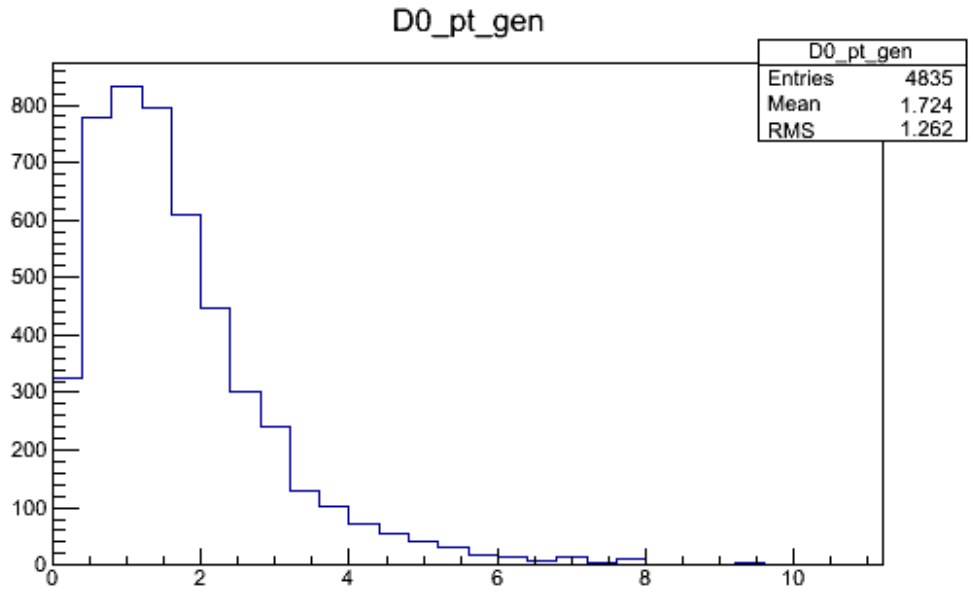


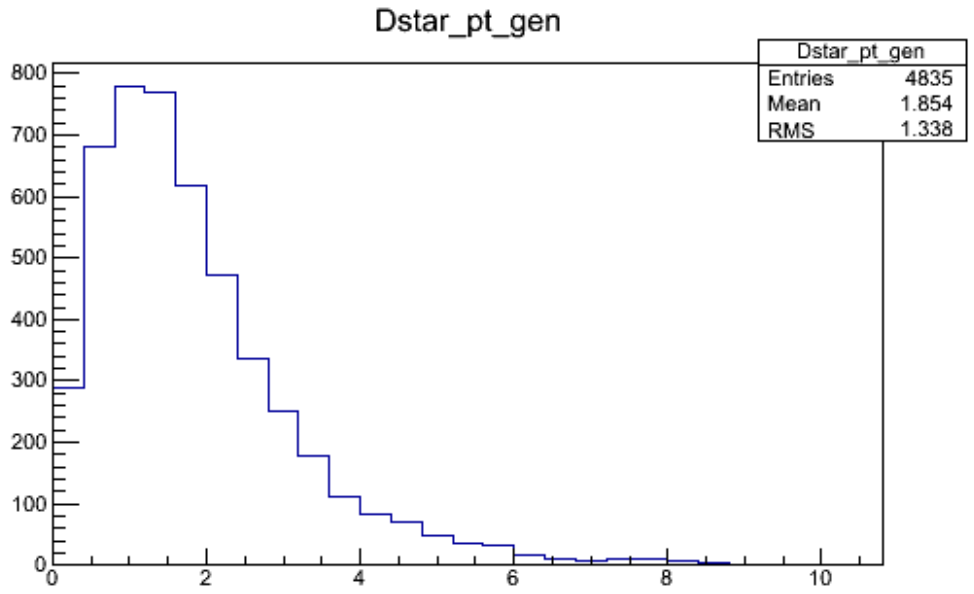




P_T distributions (GeV) for K (left), π (centre) and π_{slow} (right)

Gen Level: kinematics

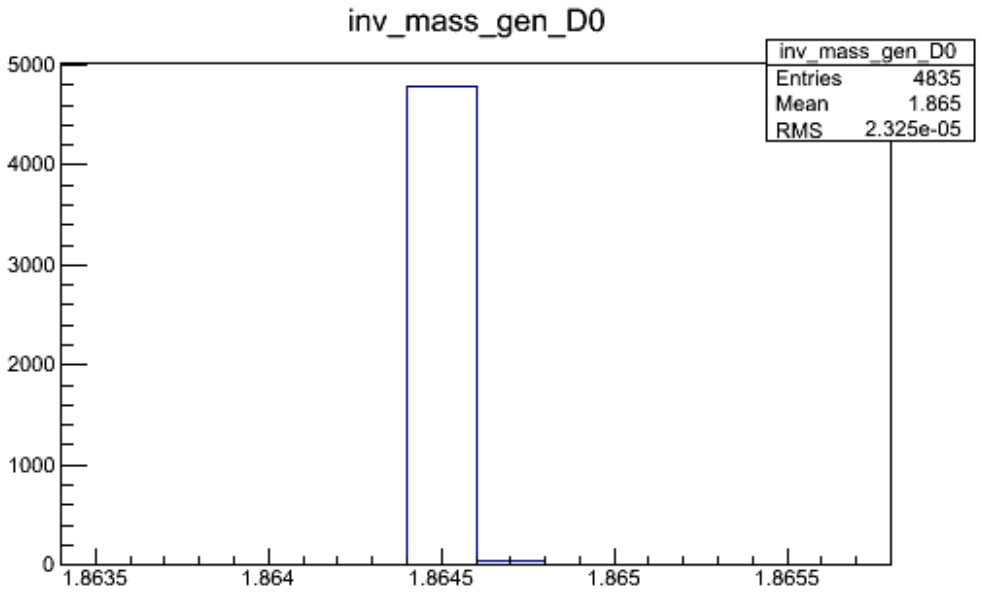




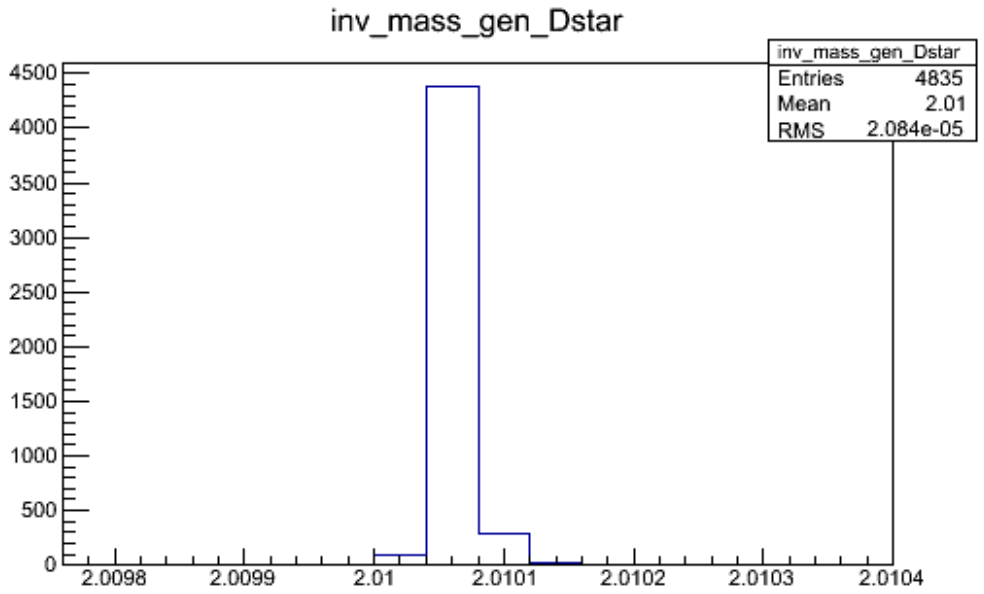
P_T distributions (GeV) for D0 (left) and D^{*+} (right)

Gen Level

As expected both invariant mass distributions are in agreement with the world-average values



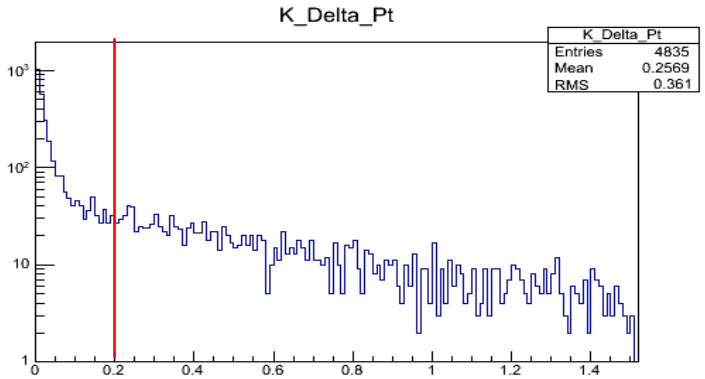
D0 invariant mass distribution (GeV)

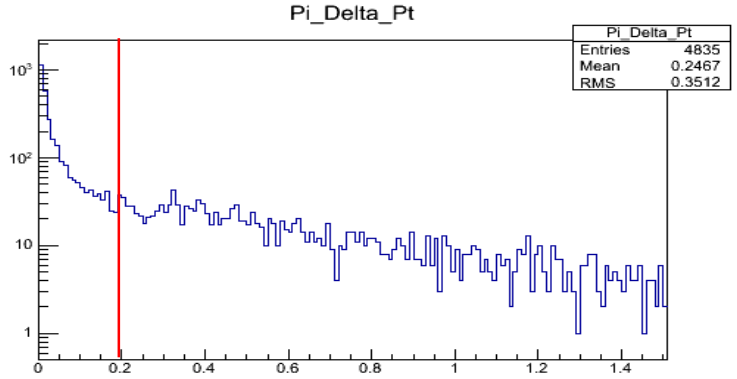


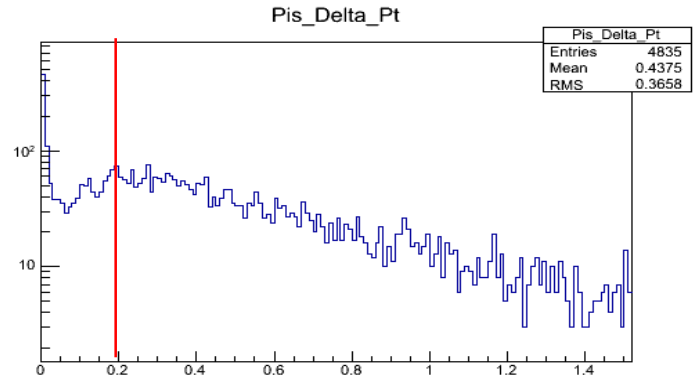
D*⁺ invariant mass distribution (GeV)

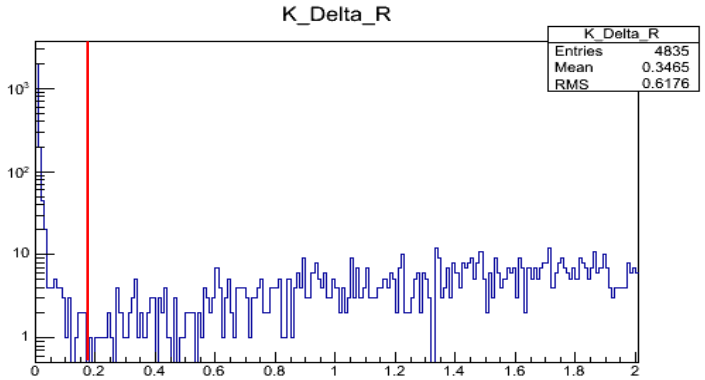
Delta R & Delta Pt

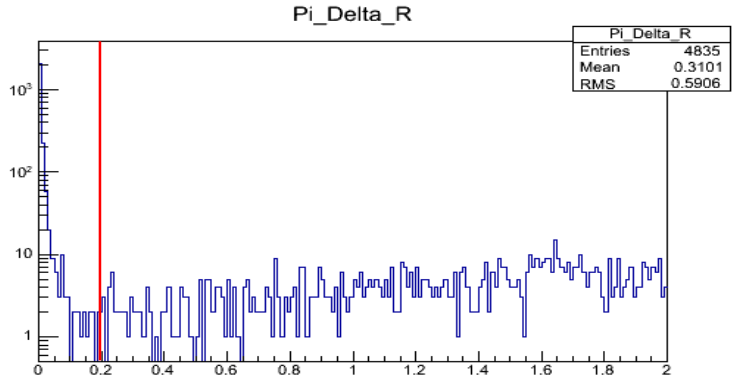
Δp_T and ΔR distributions are peaked at zero; red lines show the cuts for the matching

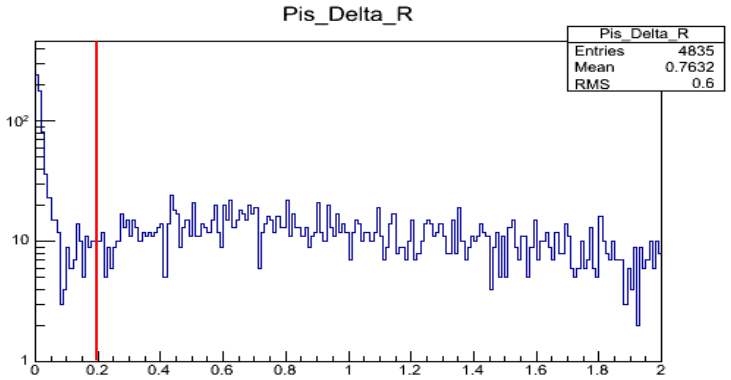






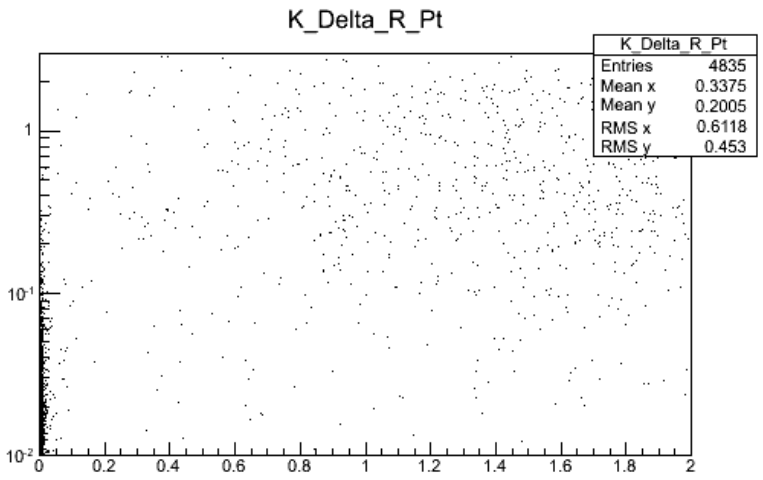


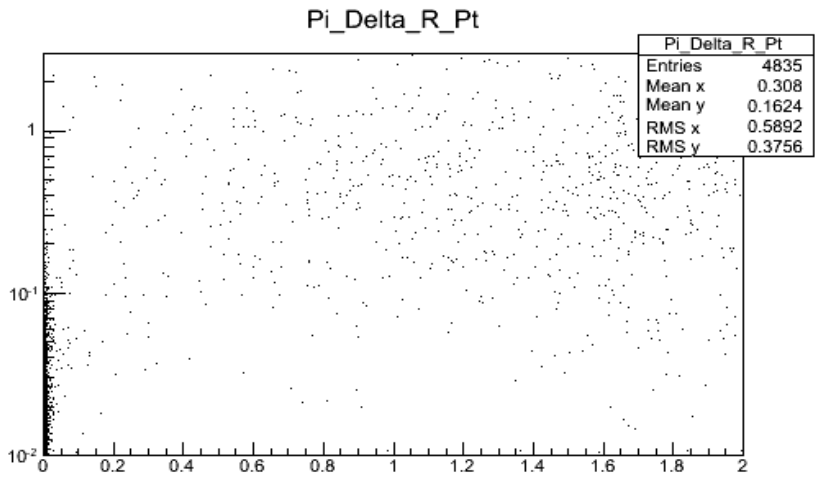


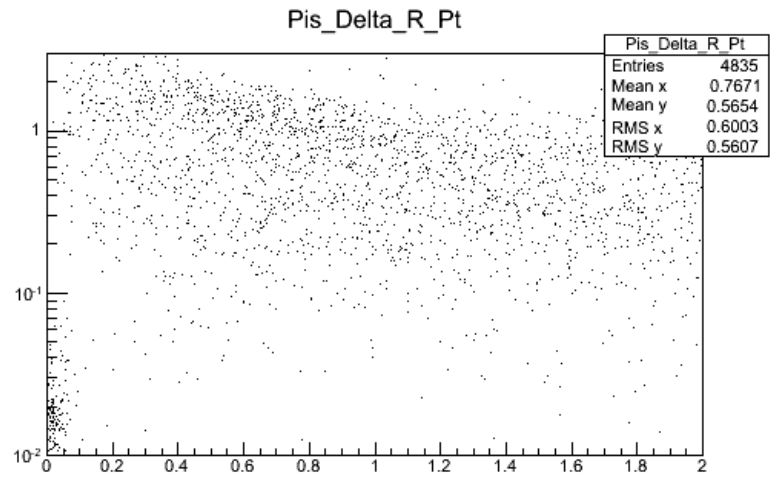


Δp_T and ΔR distributions for K (l), π (c) and π_{slow} (r)

Delta R & Delta Pt



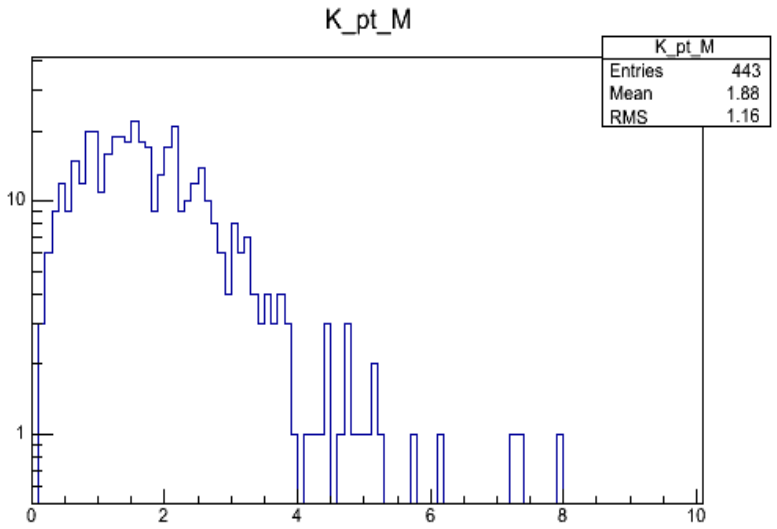


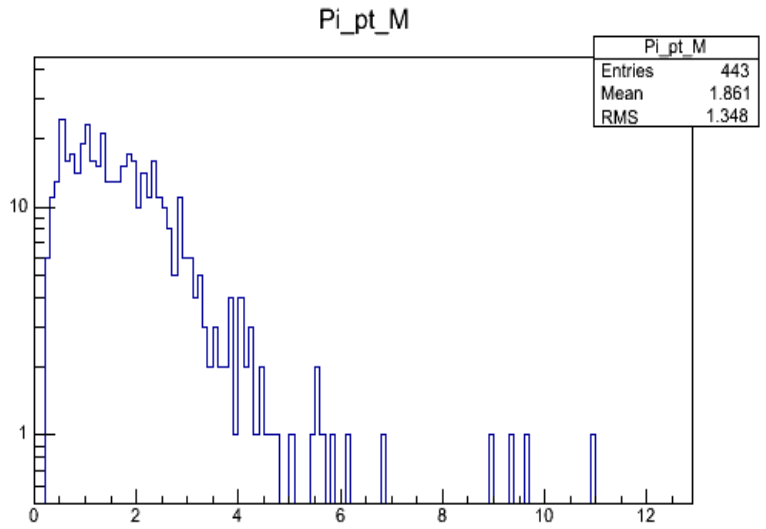


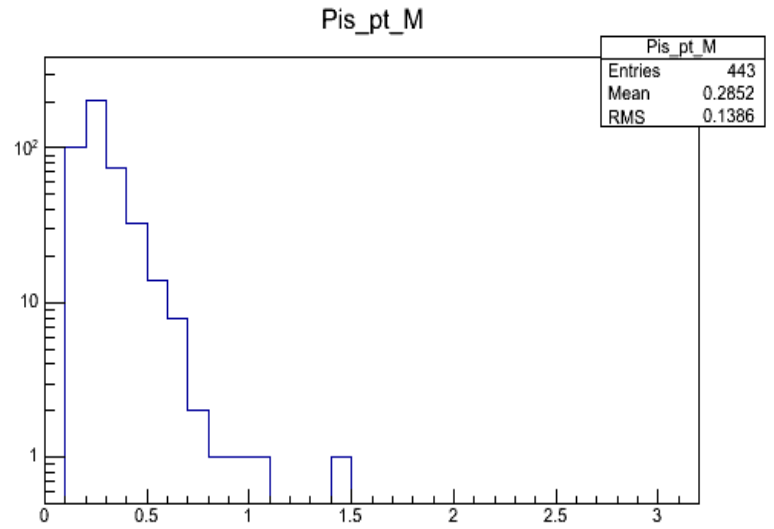
ΔR (x) vs Δp_T (y) for K (l), π (c) and π_{slow} (r)

Matched: kinematics

Delta R < 0.2 & Delta Pt < 0.2





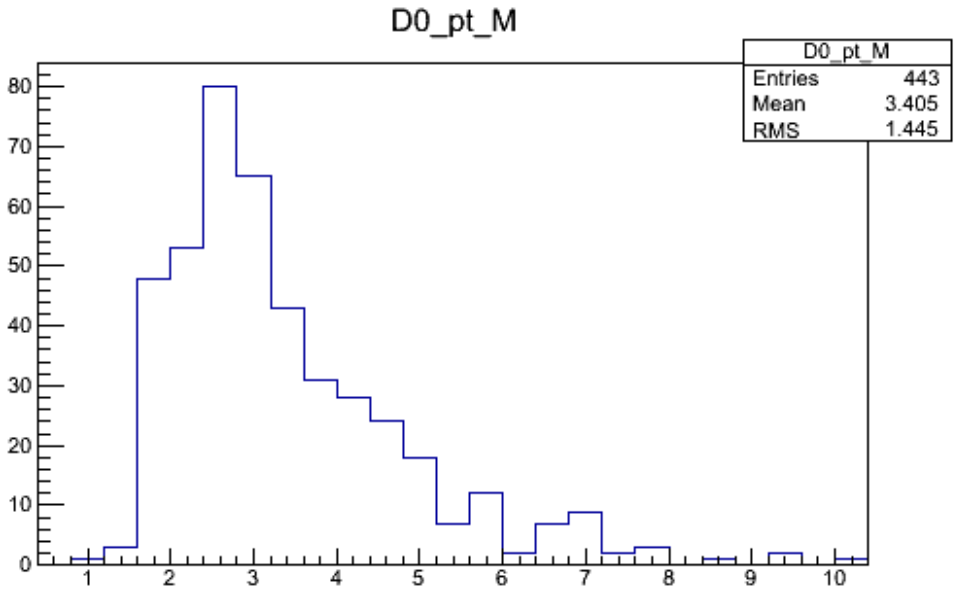


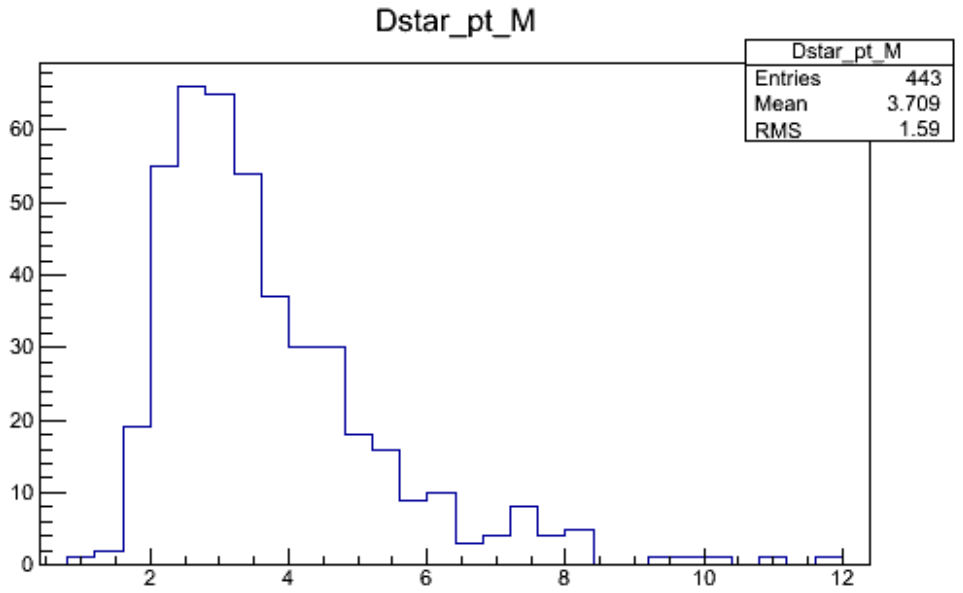
P_T distributions (Gev) for K (l), π (c) and π_{slow} (r)

Reco + Matching efficiency ≈ 10%

Matched: kinematics

Delta R < 0.2 & Delta Pt < 0.2

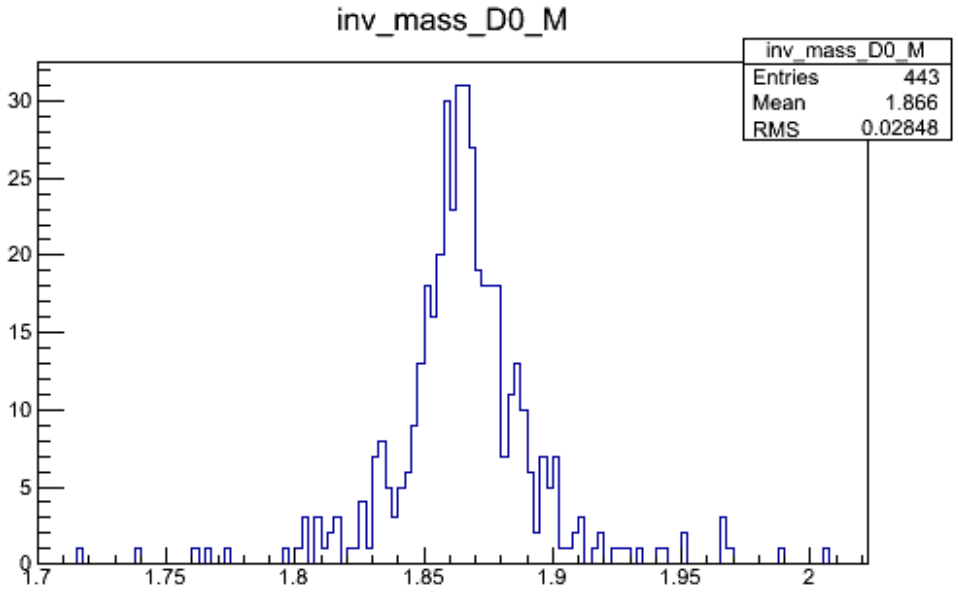


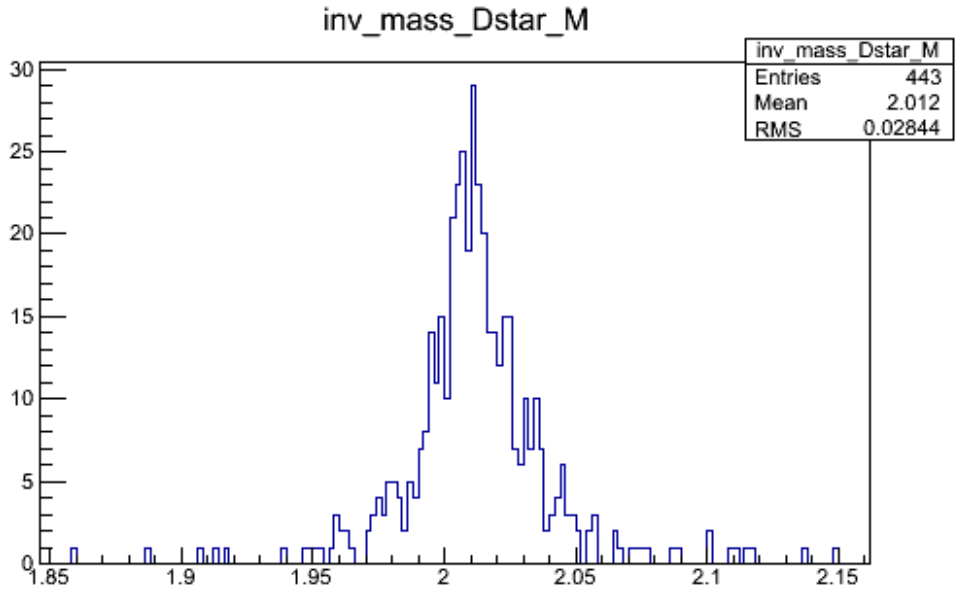


P_T distributions (GeV) for D0 (left) and D^{*+} (right)

Matched: D0 and D*

Delta R < 0.2 & Delta Pt < 0.2





D0 (left) and D^{*+} (right) invariant mass distributions and kinematics are in agreement with gen level information.

443 D* matched events

Track selection

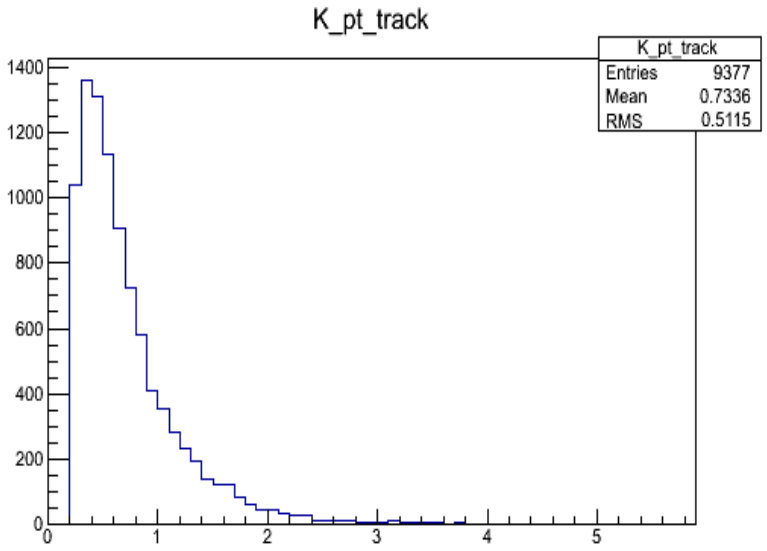
- pT > 200 MeV
- Reduced $\chi^2 < 3$
- Num hits > 3
- High purity tracks

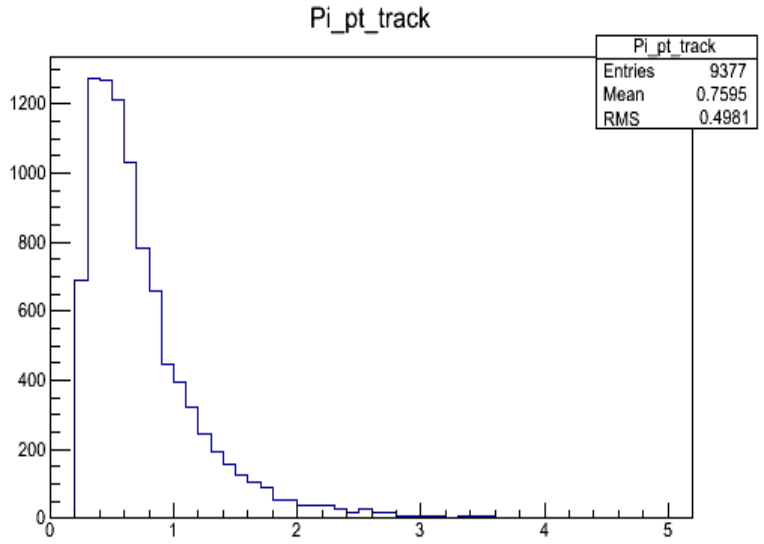
Candidates K and π are selected by combining two tracks coming from the same vertex (Kalman Fitter).

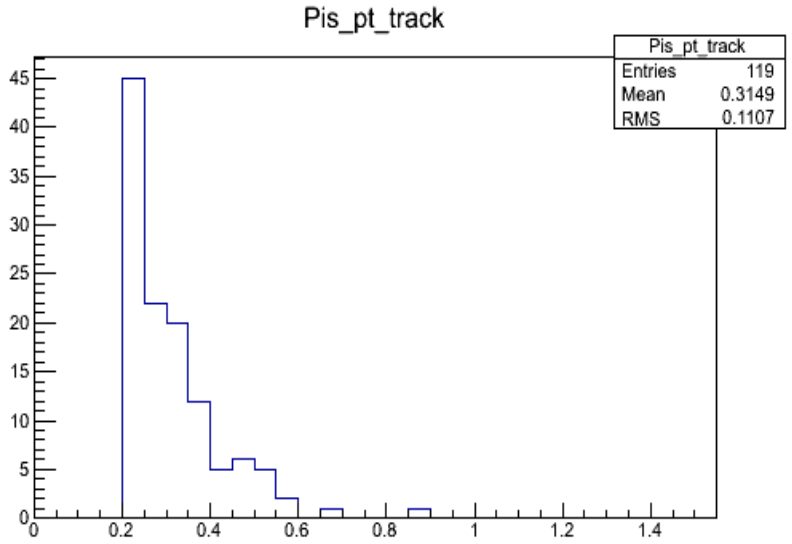
We assign K mass to the tracks with charge -1 and π mass to the tracks with charge +1 and choose the pair that best reproduces the D0 invariant mass.

We combine all the D0 candidates with an additional track with charge +1 (without any purity track request) and we reconstruct the D* invariant mass only if the inv mass of D0 differs from the world-average value by less than 25 MeV and if ΔM between D* and D0 candidates is less than 160 MeV.

Results: kinematics

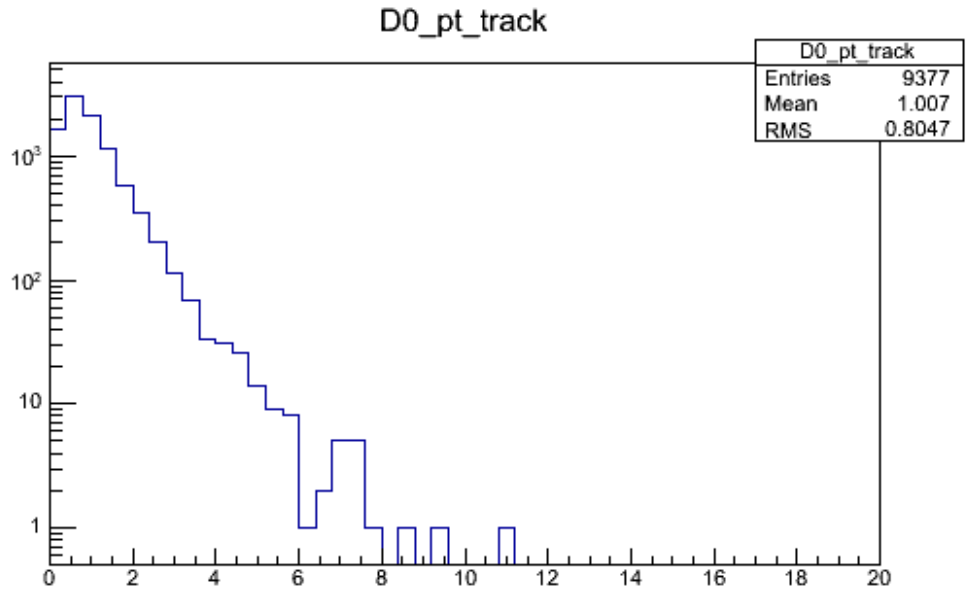


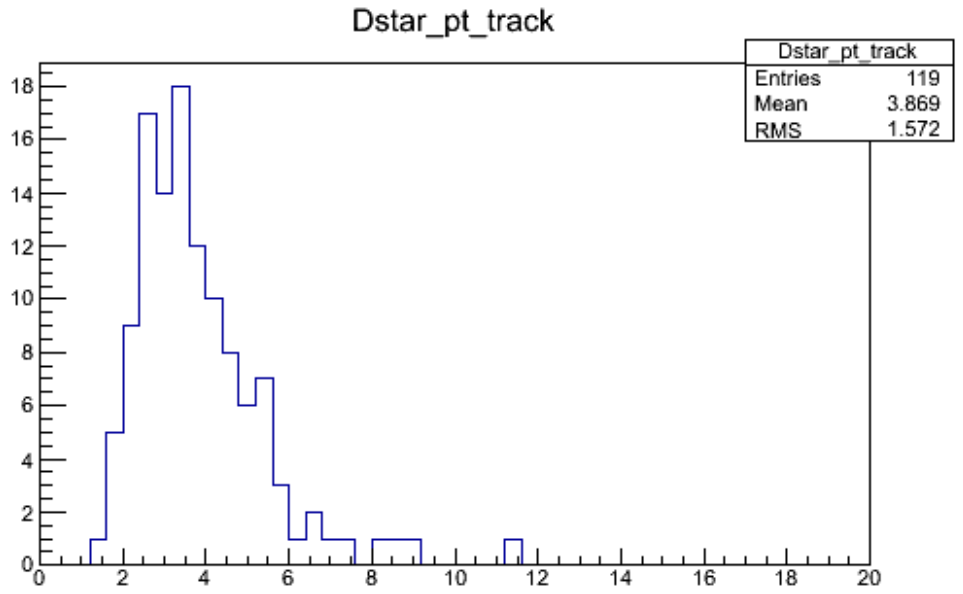




P_T distributions (GeV) for K (l), π (c) and π_{slow} (r) are similar to the gen-matched event shapes

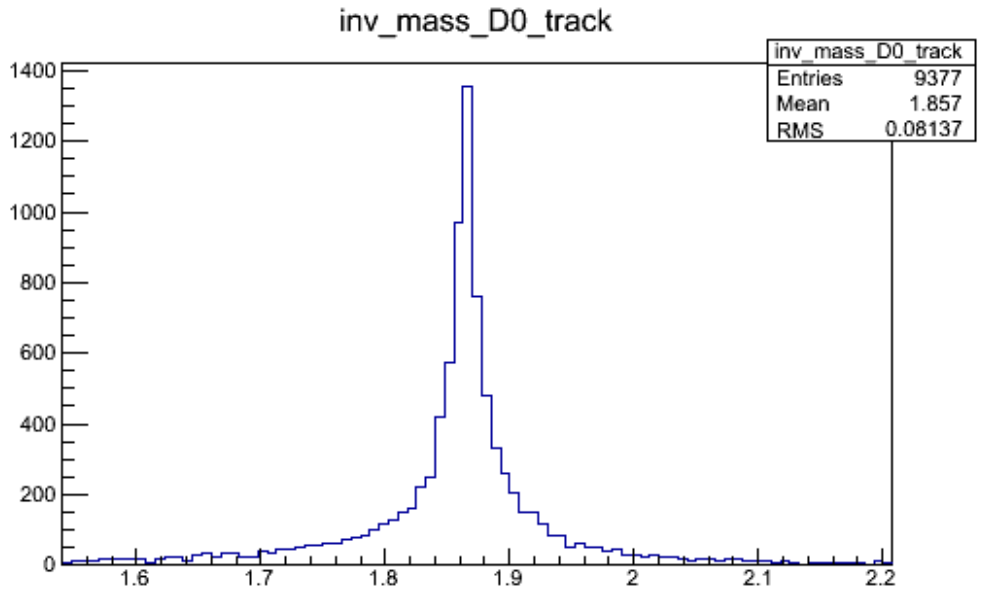
Results: kinematics



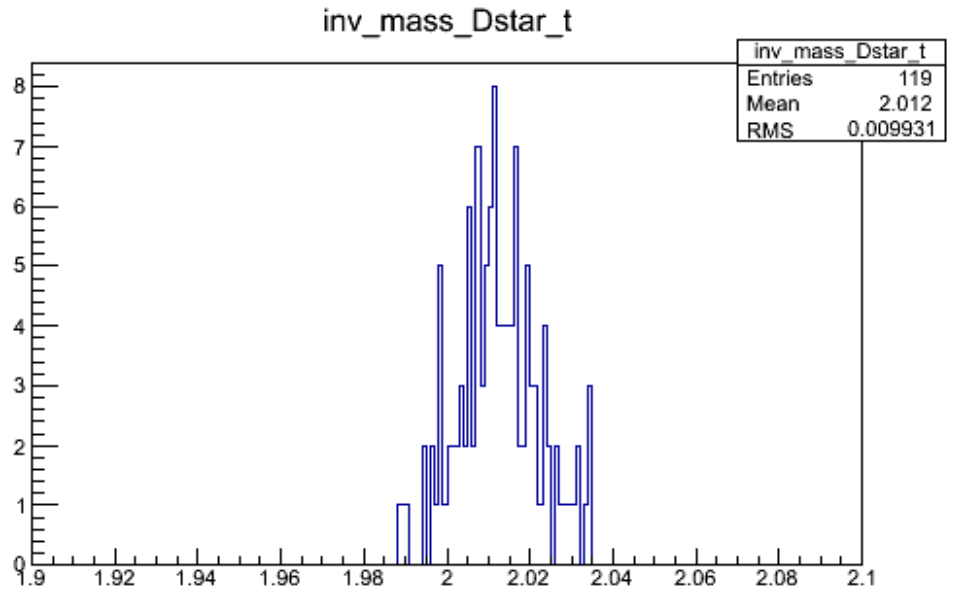


P_T distributions (GeV) for D0 (left) and D^{*+} (right)

Results



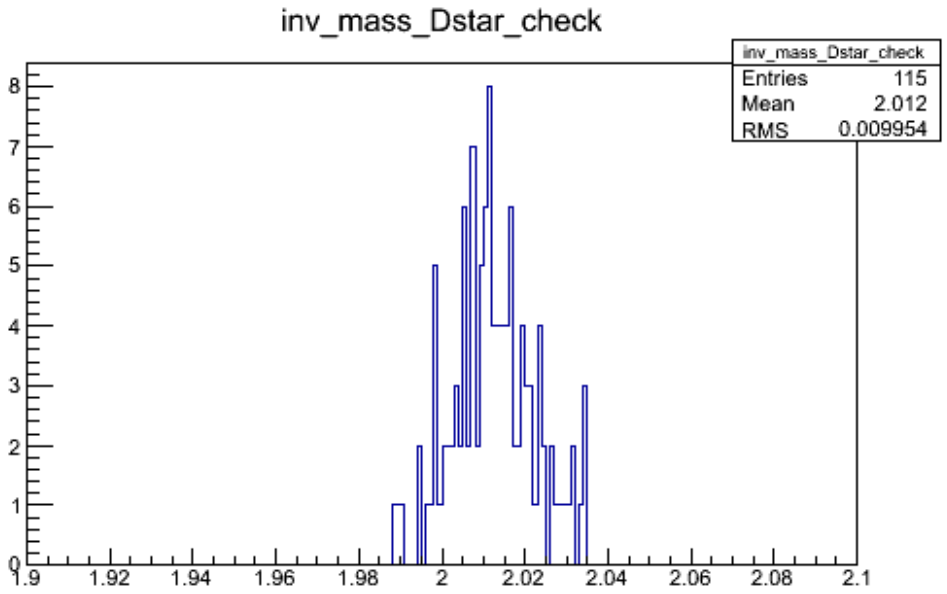
D0 invariant mass distribution



D*$^{+}$ invariant mass distribution

119 D* reconstructed events.

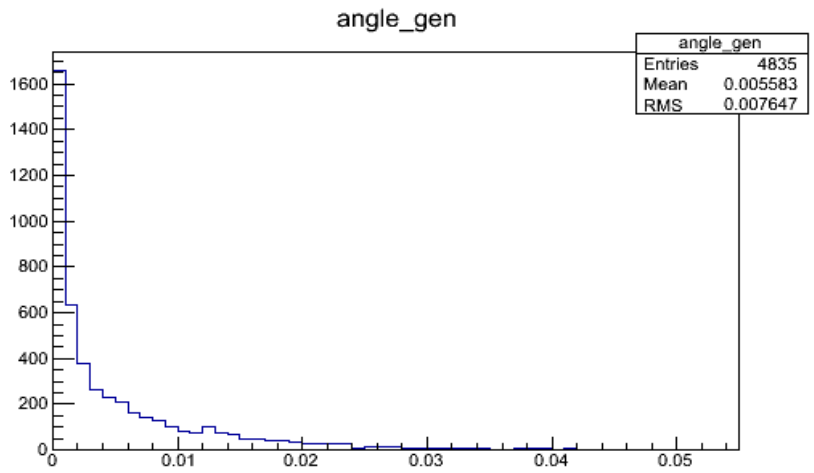
Results: check

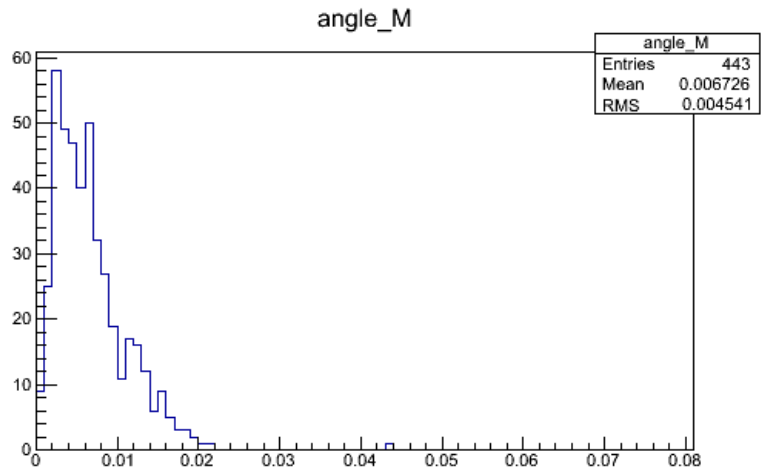


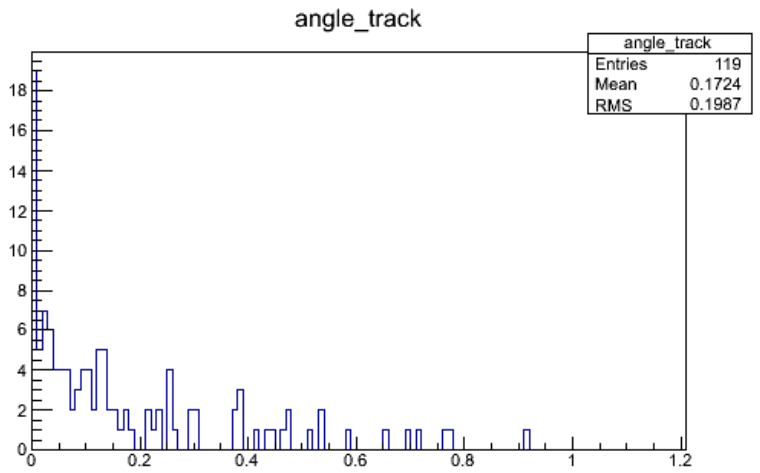
As check is shown D* invariant mass distribution when selected tracks coincide with matched tracks.

That confirms a good purity of the selection.

Check for D0 direction

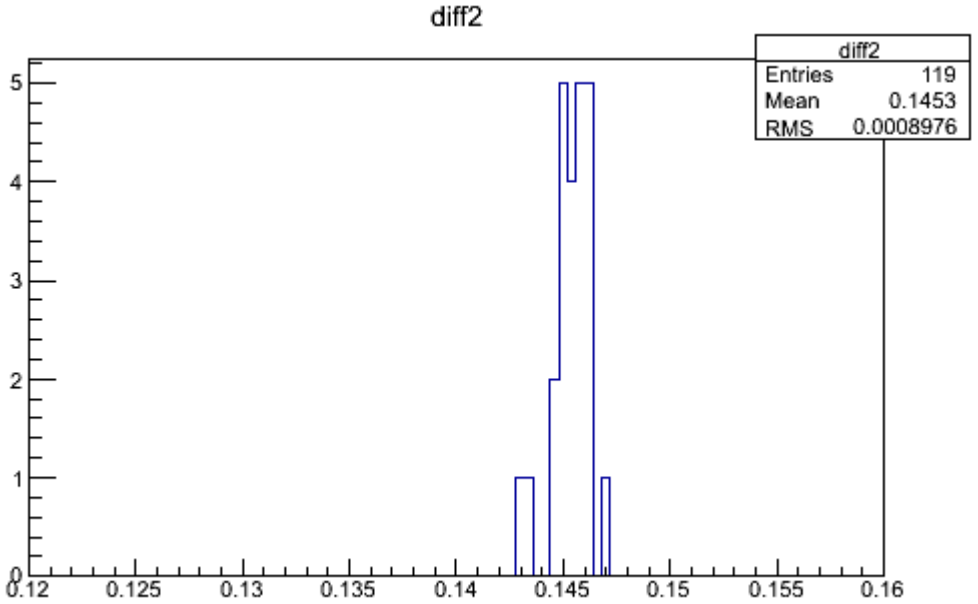






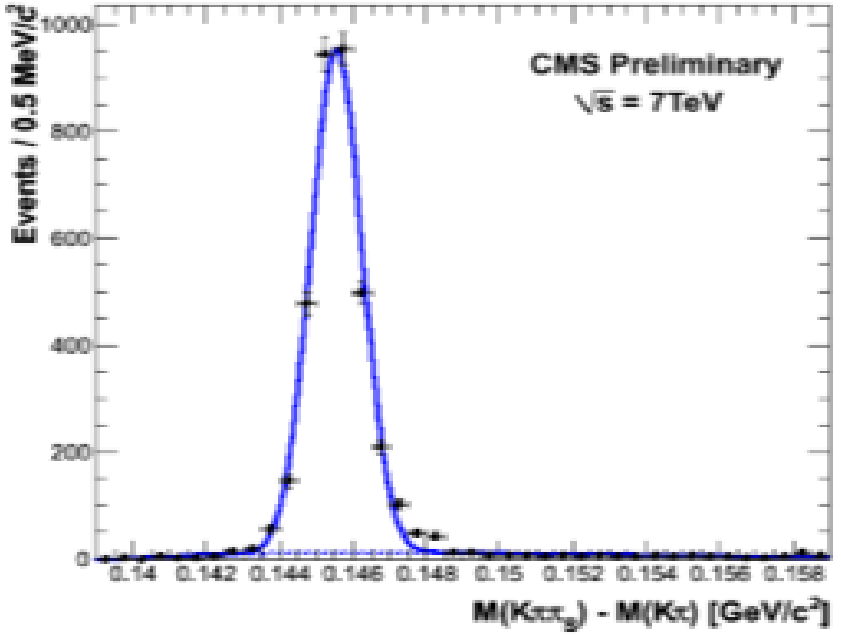
We expect D* and D0 to be almost aligned because of the lower mass of the π. The angle distributions between the two particles at gen level (left), after match (centre), reconstructed with tracks (right) are shown.

Results: ΔM = D* - D0



Even with the low statistics we seem to reproduce previous analysis results quite well.

Analysis Note 2010/153



Cuts efficiency

Conditions	Efficiency (yields)
Events with one D^{*+} (gen level)	100% (5714)
One primary vertex	99% (5663)
One secondary vertex	96% (5497)
Tracks preselection, third track positive charged, vertex significance < 1	92% (5269)
1840 MeV< M_{D0} <1890 MeV	51% (2115)
$M_{D^*} - M_{D0}$ < 160 MeV	2% (119)

Selection strategy follows step by step previous analysis choices, since we need a preliminary workflow check.

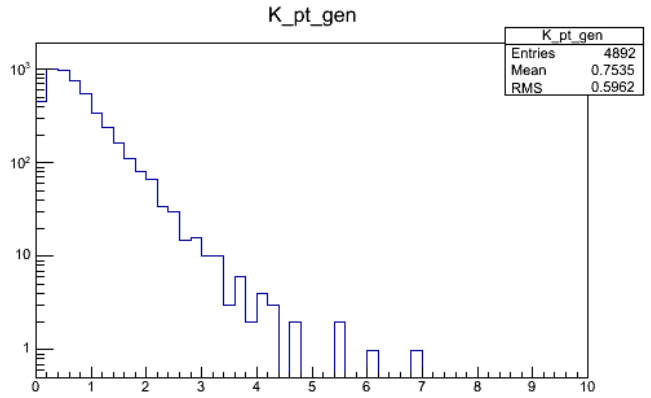
The final efficiency seems to be too low with respect to the previous analysis. We don't require a minimum p_T threshold, as first check we selected only events with D* p_T > 5.5 GeV and the efficiency increases (12/100) but we need a larger MC.

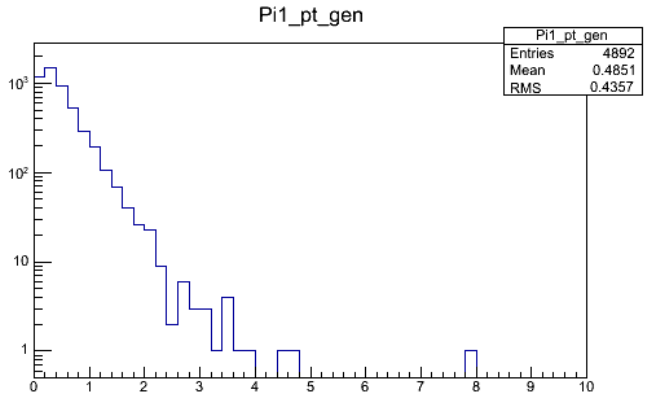
Four body decay

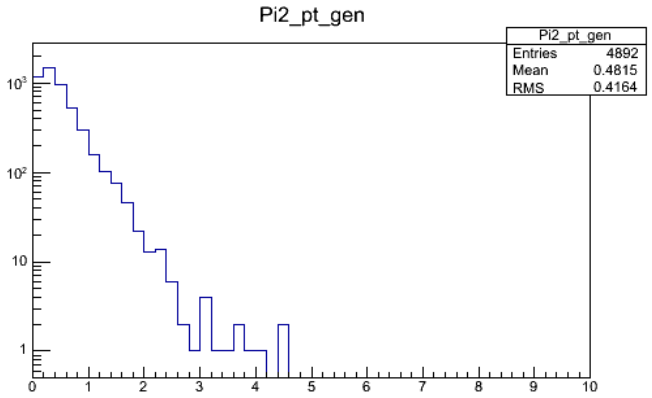
MC preliminary samples:
4892 D^{*+} events without pile up.

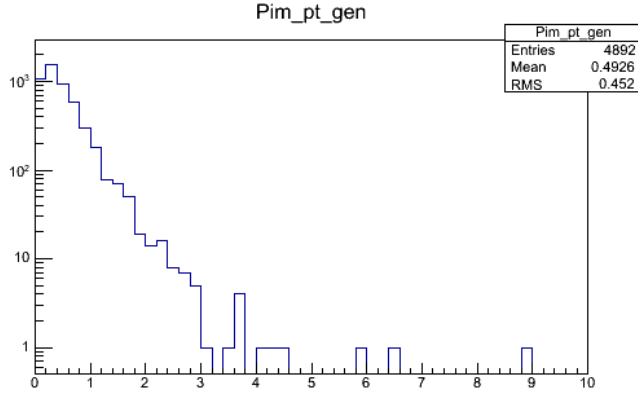
Each events is required to have:
one D* + one π^+ + one D0 + one K^- + two π^+ + one π^-

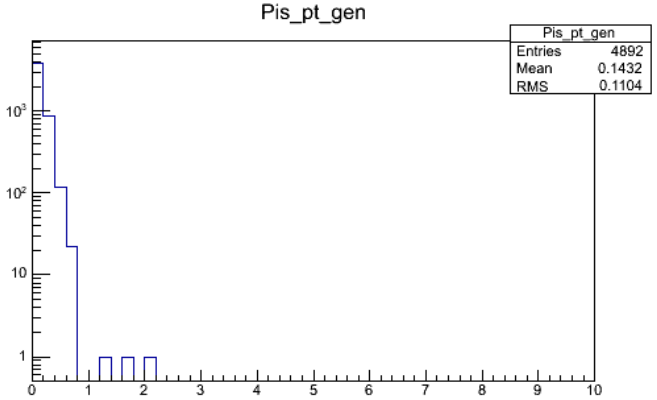
Gen Level: kinematics





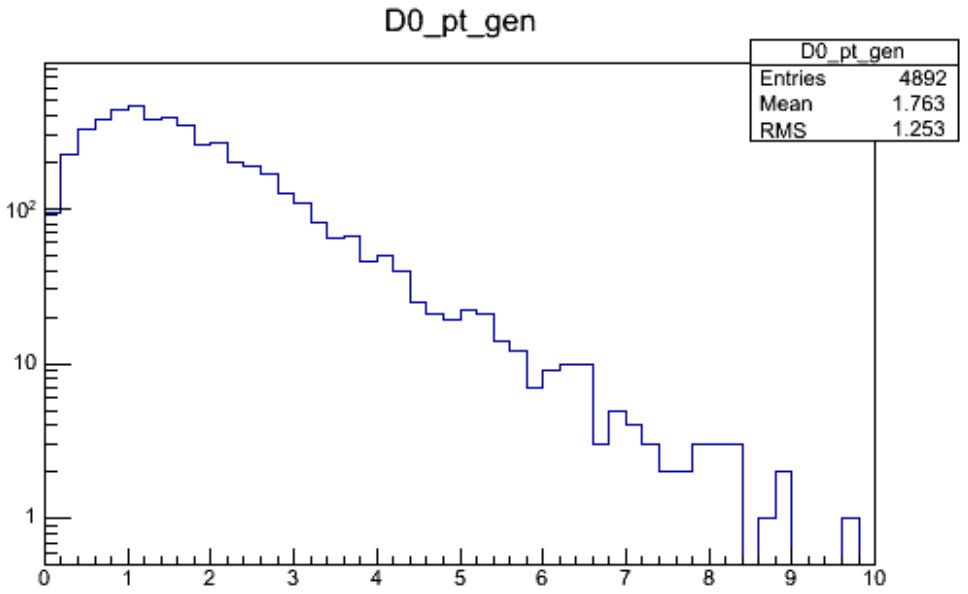


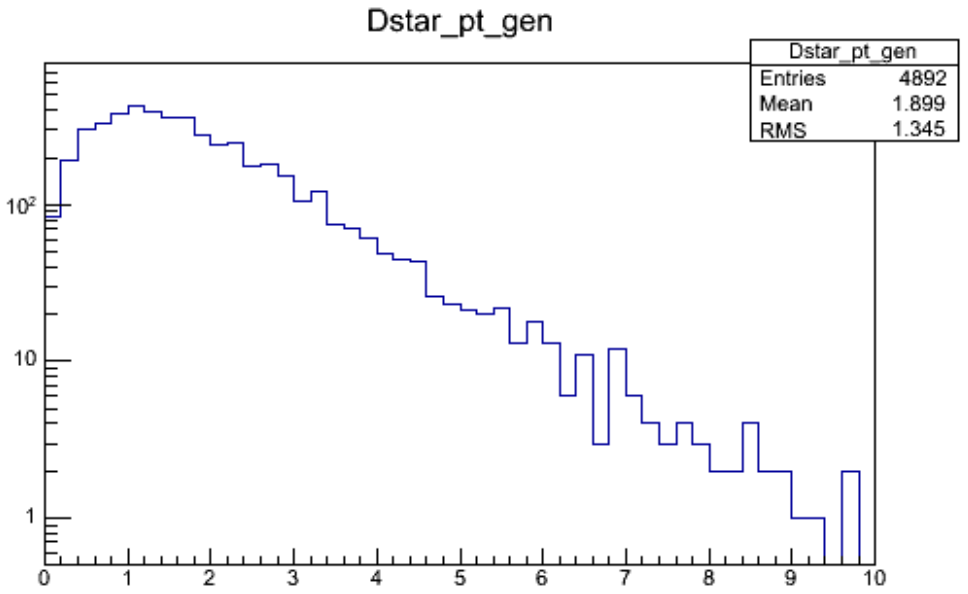




P_T distributions (GeV) for K and positive πs (above) and negative π and π_{slow} (below)

Gen Level: kinematics

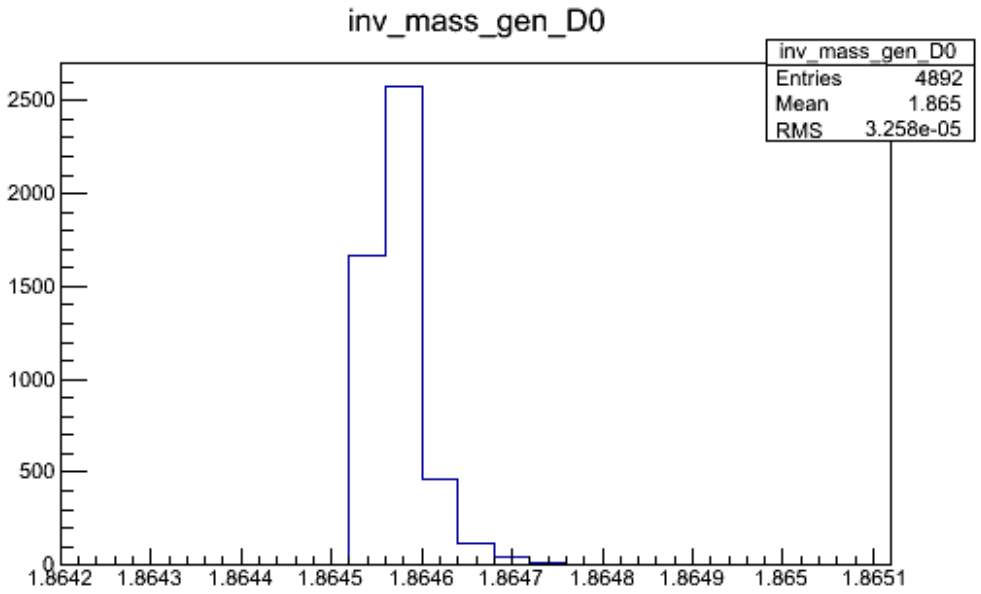




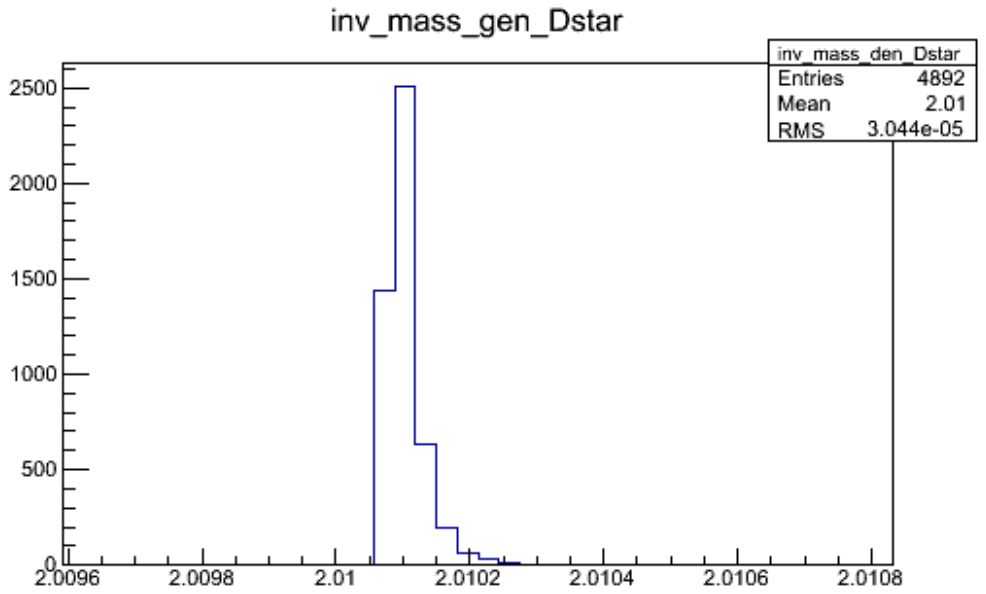
P_T distributions (GeV) for D0 (left) and D^{*+} (right)

Gen Level

As expected both invariant mass distributions are in agreement with the world-average values



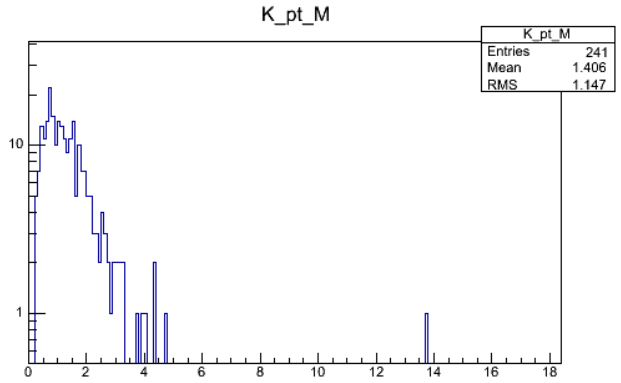
D0 invariant mass distribution

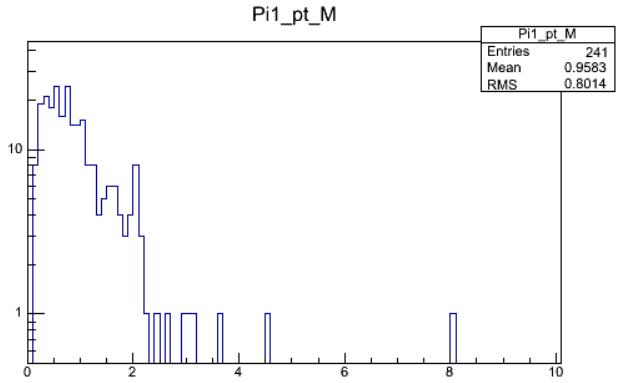


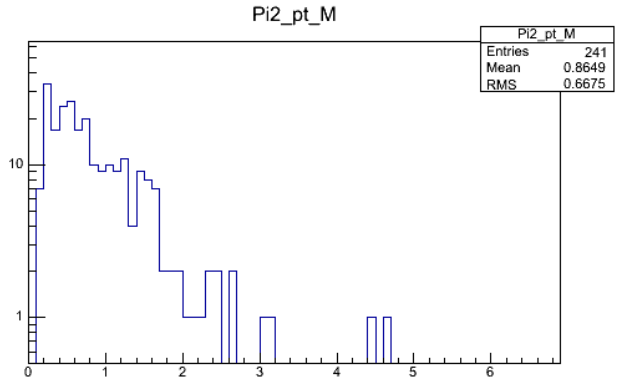
D*⁺ invariant mass distribution

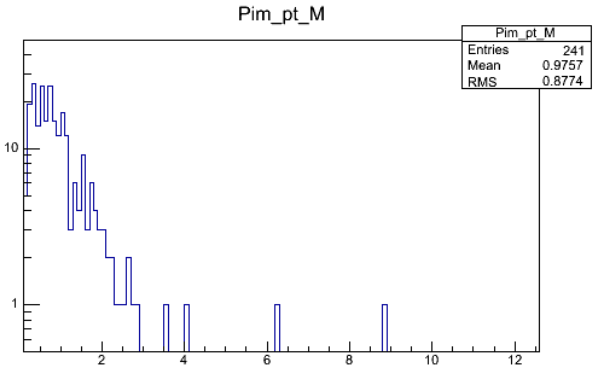
Matched: kinematics

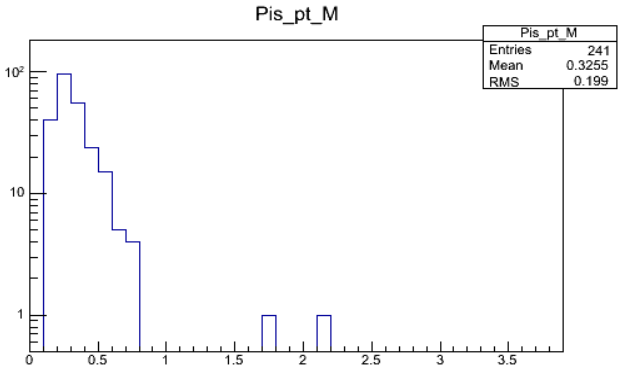
Delta R < 0.2 & Delta Pt < 0.2









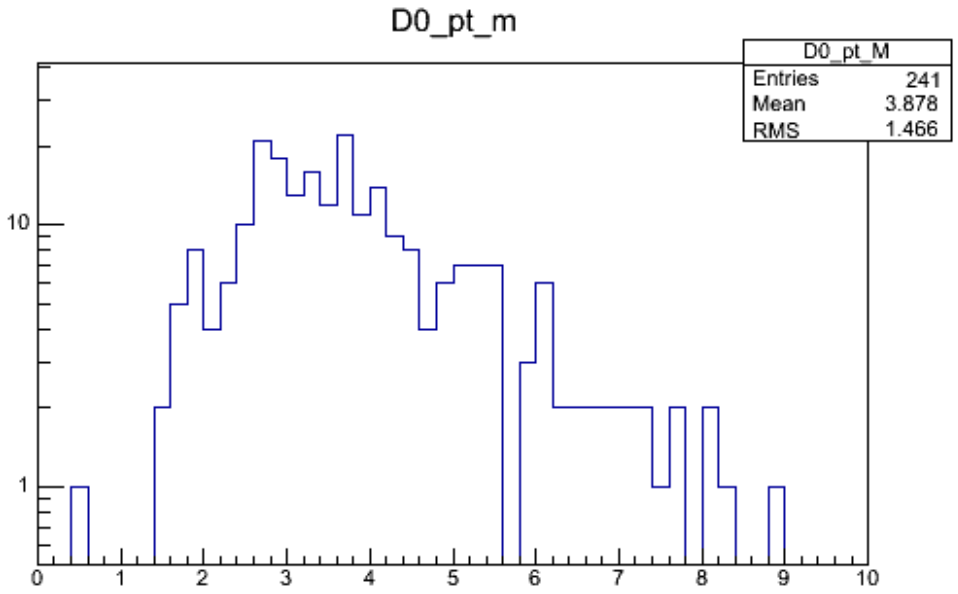


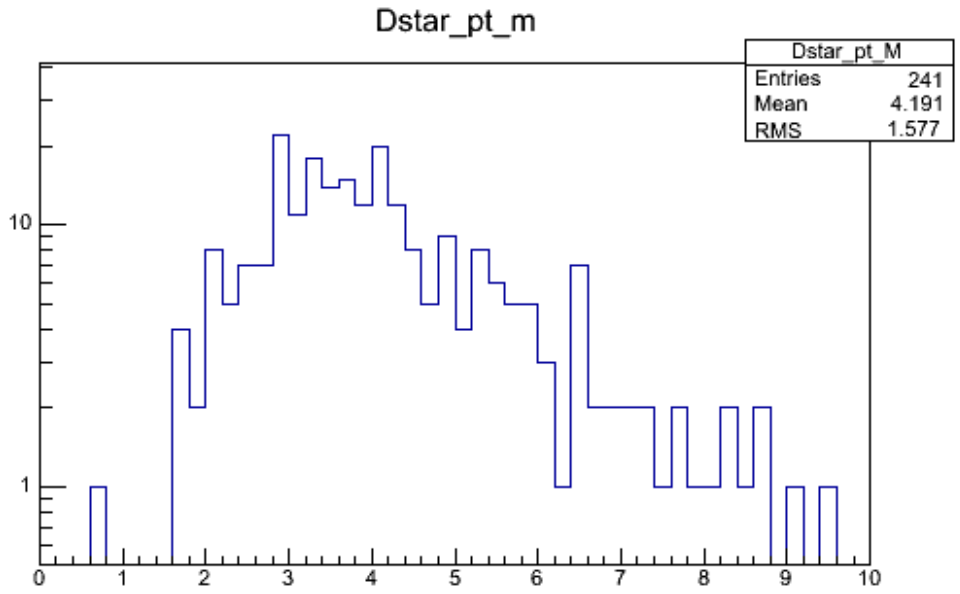
P_T distributions (GeV) for K and positive πs (above) and negative π and π_{slow} (below)

Reco + Matching efficiency ≈ 5%

Matched: kinematics

Delta R < 0.2 & Delta Pt < 0.2



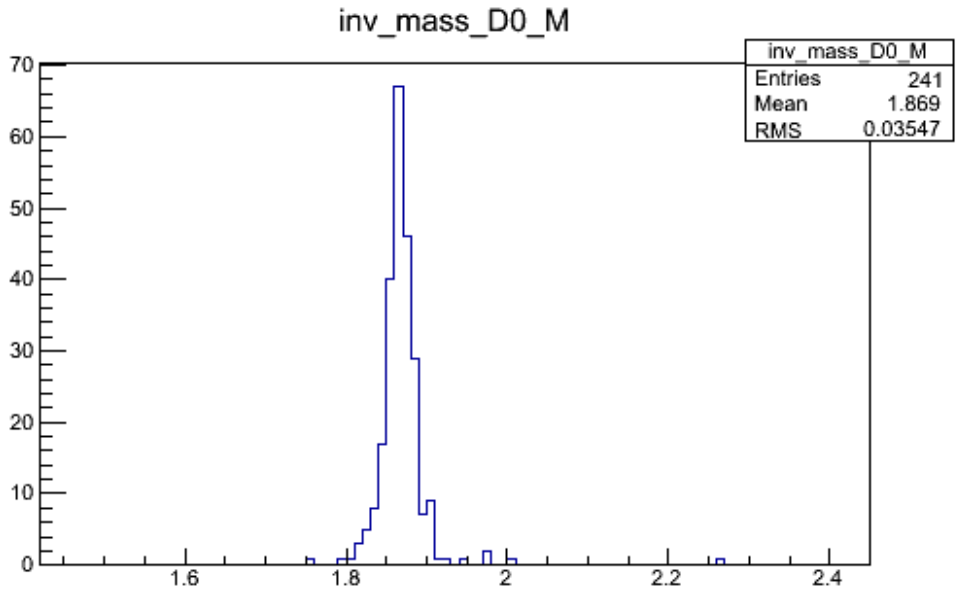


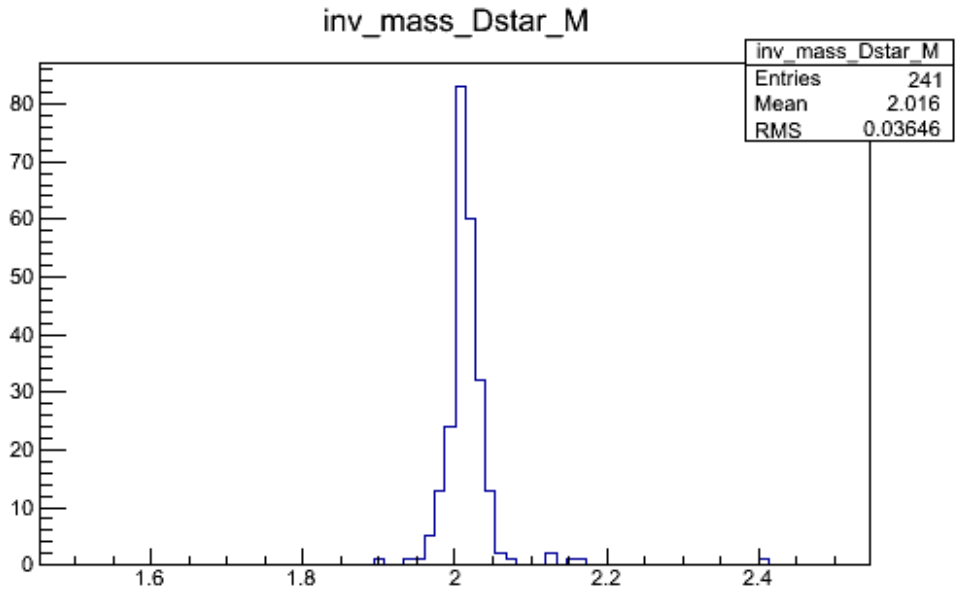
P_T distributions (GeV) for D0 (left) and D^{*+} (right)

Matched: D0 and D*

Delta R < 0.2 & Delta Pt < 0.2

241 D* matched events





D0 (left) and D^{*+} (right) invariant mass distributions and kinematics are in agreement with gen level informations.

Track selection

- pT > 200 MeV
- Reduced $\chi^2 < 3$
- Num hits > 3
- High purity tracks

To reconstruct the D0 mass we select four tracks with total charge zero and we combinate them to obtain the best invariant mass.

Positive charged tracks are associated with π, negative charged tracks can be associated to either π or K. We performed all possible combinations and we selected the set having the nearest value of invariant mass with respect to the D0 mass.

….On going…

Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

Resonant substructure not simulated by MC was considered in the previous analysis as systematic.

We would be interested in consider it in the extraction of the ratio $R = \frac{N_{K3\pi}}{N_{k\pi}} \frac{\epsilon_{k\pi}}{\epsilon_{k3\pi}}$.

We should obtain directly the yield with the efficiency correction event by event, in this way the efficiencies for each K3π sub-decay mode in the table (AN 2010/153) would not be source of uncertainty.

Decay Mode	EvtGen	PYTHIA
All	0.783 ± 0.011	0.807 ± 0.020
non-res	0.791 ± 0.036	0.759 ± 0.041
$a_1 K$	0.762 ± 0.016	0.828 ± 0.029
$K_1 \pi$	0.859 ± 0.052	0.953 ± 0.099
$K^{*0}\rho^0$	0.835 ± 0.032	0.819 ± 0.058
$K^{*0}\pi^+\pi^-$	0.781 ± 0.024	0.763 ± 0.054
$K^-\pi^+\rho^0$	0.760 ± 0.040	0.878 ± 0.076

Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

- The kinematics of a 3-body decay of a spinless particle is described in terms of 2 invariants, usually taken as the appropriate 2-body invariant masses squared.
- In 4-body decays the kinematics is described by 5 degrees of freedom, and one looks at the projections.
- A natural choice of invariants is the set of 2-body invariant masses squared:
  $s_{ij} = (p_i+p_j)^2$ where p_i and p_j are the 4-momenta.
- Because of two identical pions in the final state some cautions have to be taken into account, the 5 sij chosen are:

  1) $s_{24} = M^2(\pi^+\pi^-)_{high}$, high mass

  2) $s_{34} = M^2(\pi^+\pi^-)_{low}$, low mass

  3) $s_{13} = M^2(K^-\pi^+)_1$, where the π^+ is that not used in $M^2(\pi^+\pi^-)_{high}$

  4) $s_{12} = M^2(K^-\pi^+)_2$, the other π^+

  5) $s_{14} = M^2(K^-\pi^-)$

Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

The $D^0 \to K^-\pi^+\pi^+\pi^-$ (NR) Monte Carlo has been produced to access all the phase space.

Passing the generated MC events (each event is characterized by the 5 s_{ij} coordinates) through the entire analysis chain one can compute:

$$\mathrm{eff}(\{s_{ij}\}) = \mathrm{rec}(\{s_{ij}\}) / \mathrm{gen}(\{s_{ij}\})$$

This is a 5-D matrix, and for example partitioning each coordinate in 3 means 243 elements. But one could use a function of $\{s_{ij}\}$ (smooth function), instead.

The efficiency correction will be is used on an event by event basis.

Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

This is just the starting point of the efficiency determination for the decay mode $D^0 \to K^-\pi^+\pi^+\pi^-$.

- the 5 variables have been identified and the distributions at the generation level (GEN) shown
- a larger MC is probably necessary, but it it important first to establish the final cuts for the analysis
- the goal is to correct each (Data) $D^0 \to K^-\pi^+\pi^+\pi^-$ candidate by the proper efficiency. In this way the fit (used to determine the $D^0 \to K^-\pi^+\pi^+\pi^-$ Yield) will be on the "already corrected by efficiency" histogram.

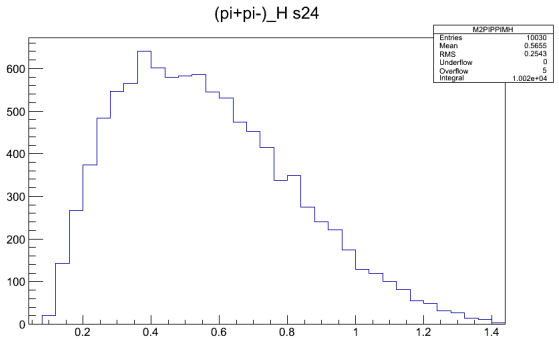
Conclusion / Next steps

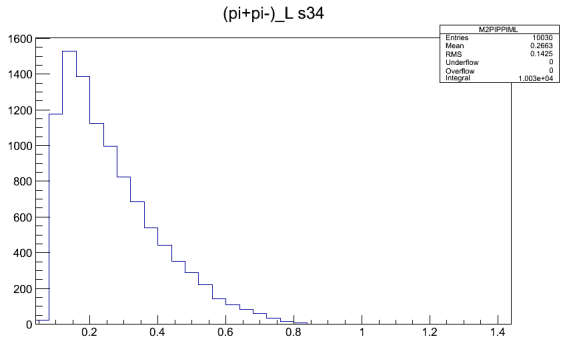
- Reconstruction of the whole chain in the four body decay mode.
- Use a larger MC sample, even with PU.
- More detailed study about the resonant substructure of D0 -> K3π

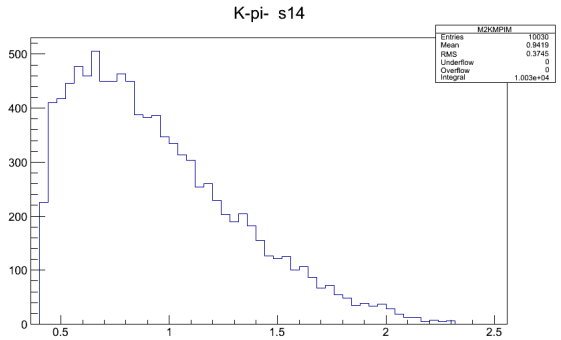
Backup

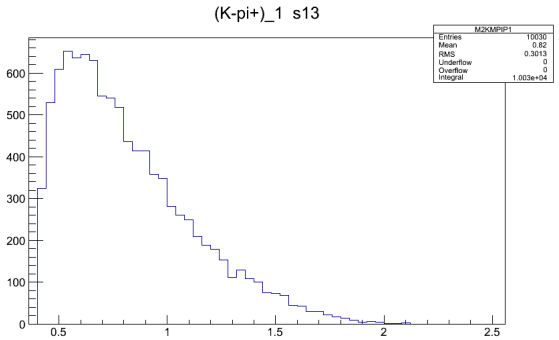
Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

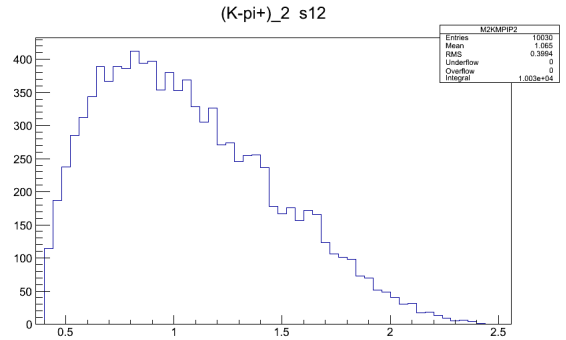
the 5 s_{ij}











Resonant substructure of $D^0 \to K^-\pi^+\pi^+\pi^-$

and some projections