ALICE-India Meeting, VECC Kolkata

Study of angular correlations between D^0 and charged particles in pp @7TeV with ALICE

Somnath Kar
VECC, Kolkata

- Date: 06.02.2016

Outline

- Physics motivation
- ALICE detector
- Technical details of analysis
- Analysis procedure
- Results update:
  - Correlations in pp-pass4 data
  - Comparison with pp-pass2 data
- Summary & Future plan

Physics motivation

Heavy flavor as a probe to study QGP:

Heavy quarks (charm and beauty) are produced via hard scattering (dominantly via gluon-gluon fusion at LHC energy) before the formation of QGP.

- Energy loss in the QGP (high p_T)
- Thermalization in the QGP (low p_T)

Heavy flavour production in pp collisions:

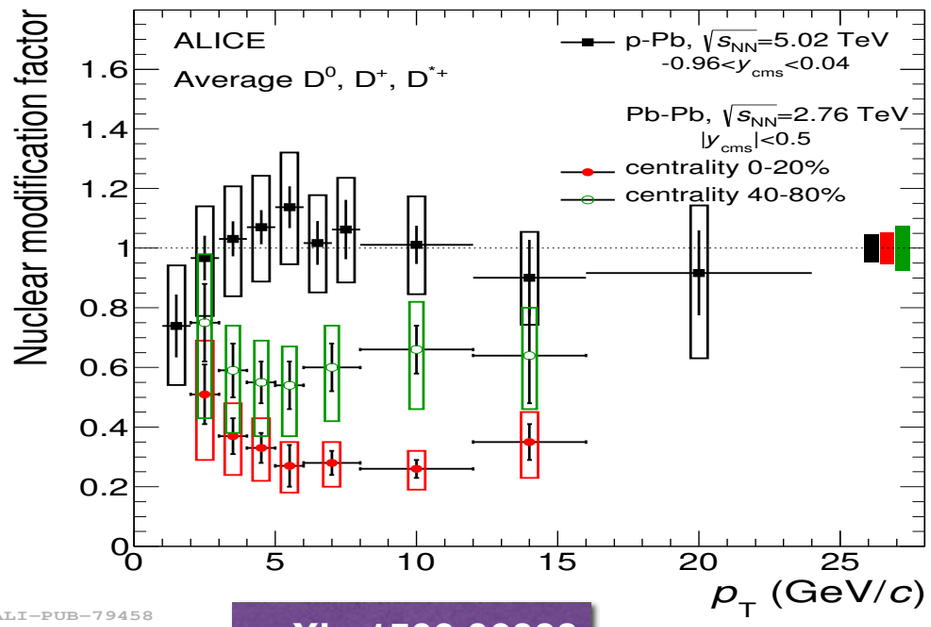
- Address charm and beauty fragmentation properties
- Reference for comparison with Pb-Pb and p-Pb data

Heavy flavour production in p-Pb Collisions:

Necessary to disentangle the initial state effects due to the presence of a nucleus.

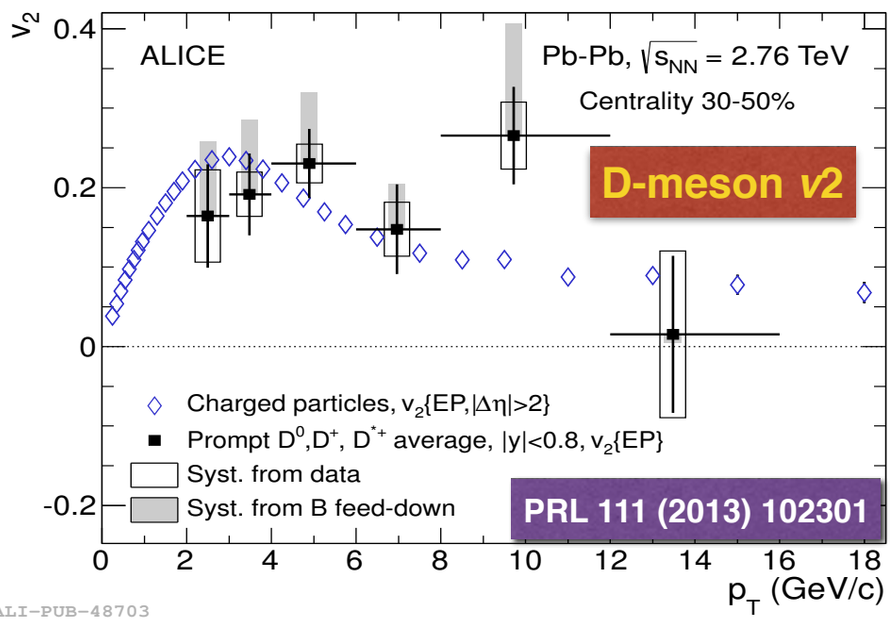
ALICE Observations:

Nuclear modification factor p-Pb and Pb-Pb



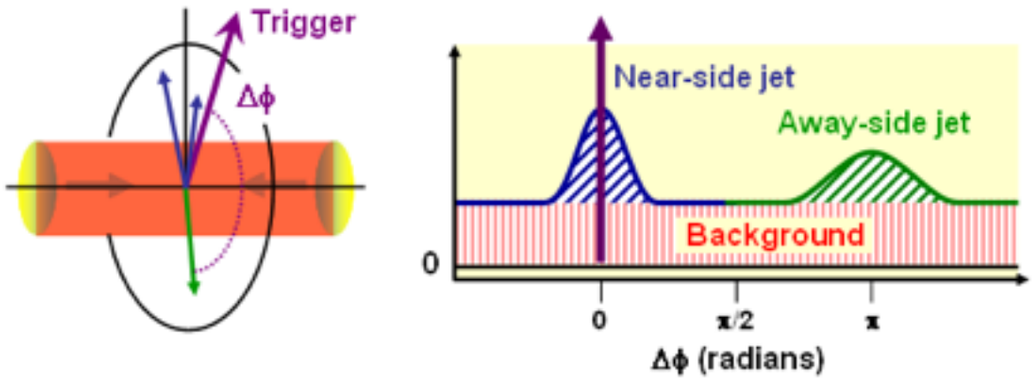
arXiv:1509.06888

heavy flavours participate to the collective expansion of the system



PRL 111 (2013) 102301

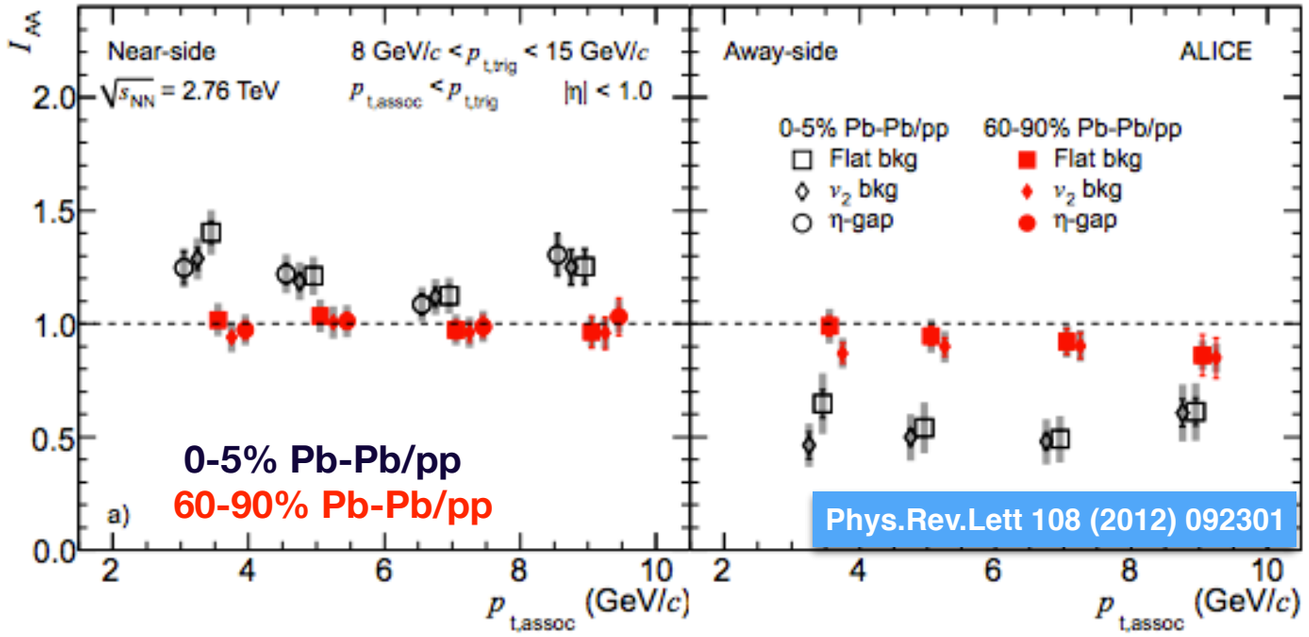
Physics motivation



Address recoiling jet properties

- ✤ **Away-side partons**
  - travel longer path through the medium
  - interact more with the medium
  - lose energy and get quenched
  - Quenching depends on the amount of energy loss
- ✤ **Study of the near side**
  - to investigate possible medium related modifications to jet properties and parton fragmentation
  - can also be interesting to understand the trigger biases

From di-hadron correlation study:



Phys.Rev.Lett 108 (2012) 092301

Near side: 20% enhancement
Away side: 50% suppression

Study the azimuthal angular correlation of particle yields in heavy-ion and pp collisions

- **Relative associated yield**

$$I_{AA} = Y_{AA} / Y_{pp}$$

where Y_{AA} and Y_{pp} are the yields in Pb-Pb and pp collisions.

$$Y = \frac{1}{N_{trig}} \int \frac{dN^{assoc}(\Delta\varphi)}{d\Delta\varphi} d\Delta\varphi$$

- **Provide experimental input on the path-length dependence of energy loss**

Similar effect in heavy-flavour correlations? I_{AA} for heavy flavours?

ALICE detector

ALICE (A Large Ion Collider Experiment)

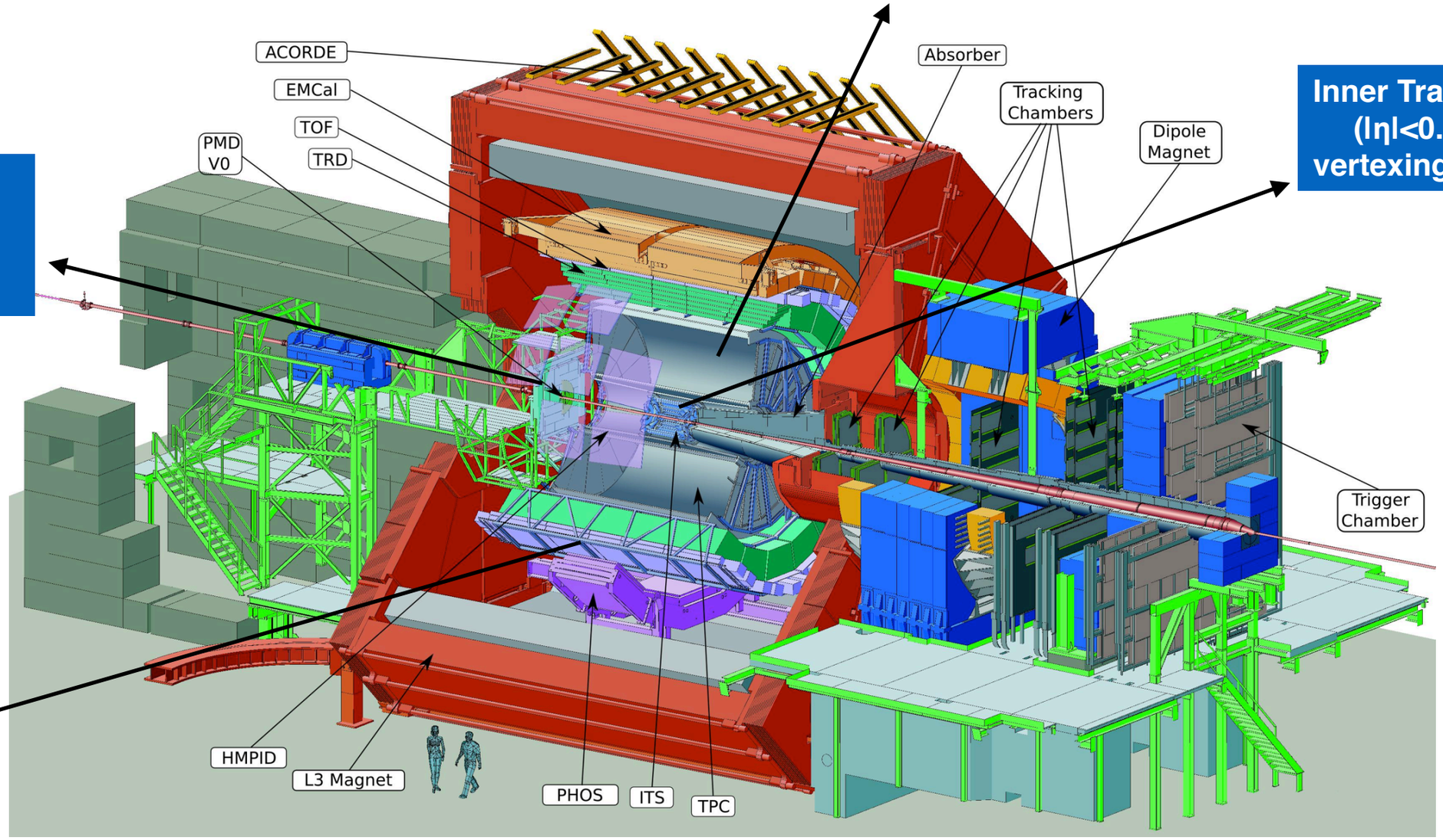
Heavy-flavour detection with ALICE:

Time Projection Chamber (|η|<0.9) used for tracking and PID

Inner Tracking System (|η|<0.9) used for vertexing and tracking

V0 detector used for triggering and multiplicity determination

Time of Flight used for PID



Data Sets:

pp minimum bias at $\sqrt{s}$ = 7 TeV: ~300M events

p-Pb minimum bias at $\sqrt{s_{NN}}$ = 5.02 TeV: ~100M events

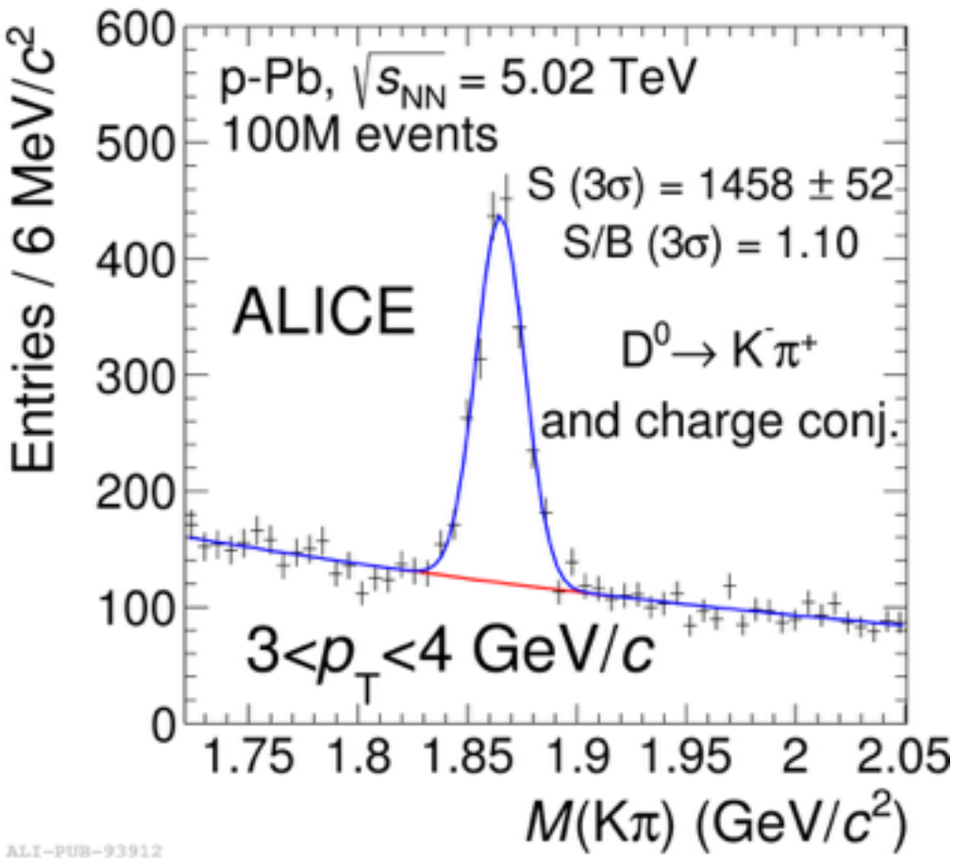
Integrated Luminosity: 5 nb^{-1} for pp collisions and 50 μb^{-1} for p-Pb collisions

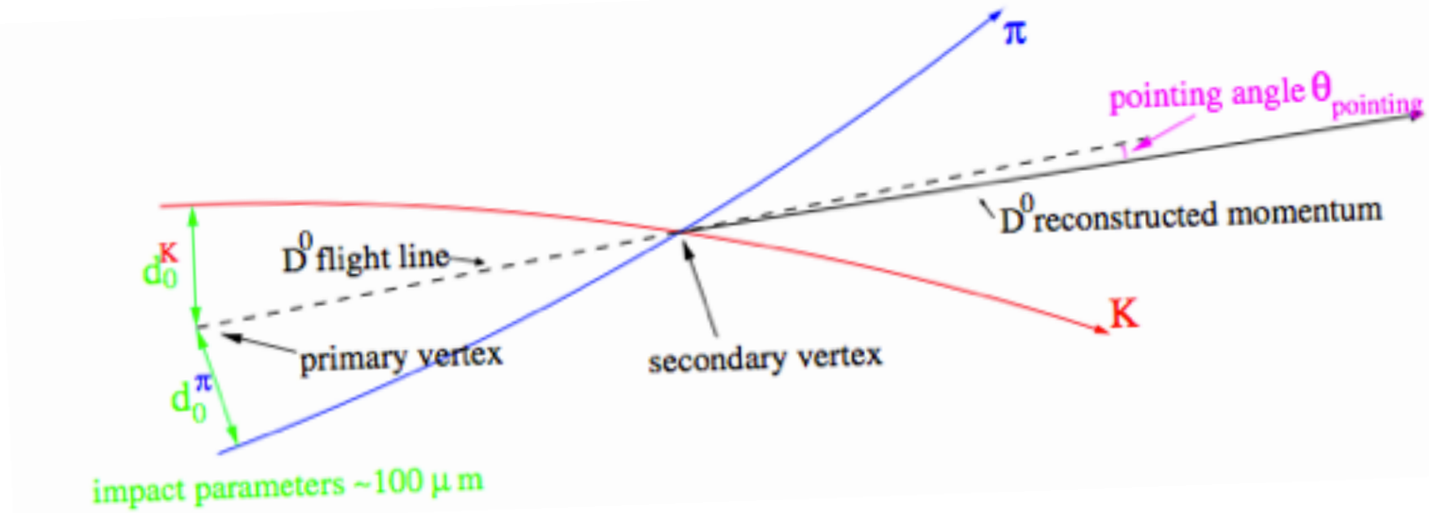
D meson-charged particle angular correlation analysis

D-meson signal extraction

- Invariant mass analysis of D-meson candidates.
- Displaced vertices selected via topological cuts
- PID on decay products

Decay Channel	Branching Ratio
$D^0 \rightarrow K^- \pi^+$	3.88 ± 0.05%



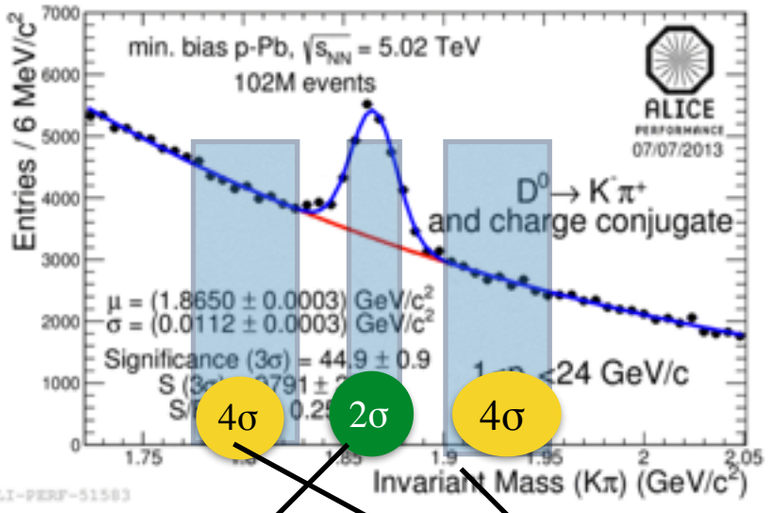


Challenges for D-meson analyses

- Large statistics needed
- High combinatorial background (in the reconstruction of D-meson hadronic decays)
- Contamination due to D from B decays

D meson-charged particle angular correlation analysis

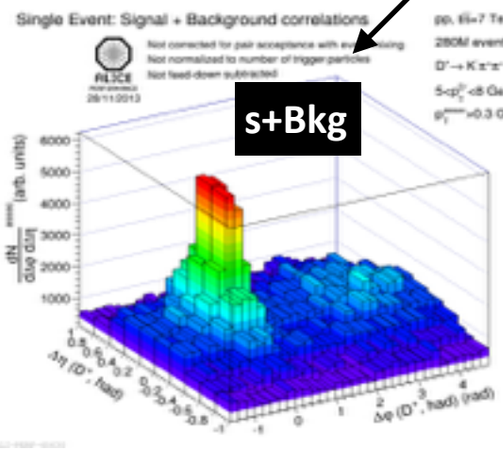
Correlation via Same Event analysis

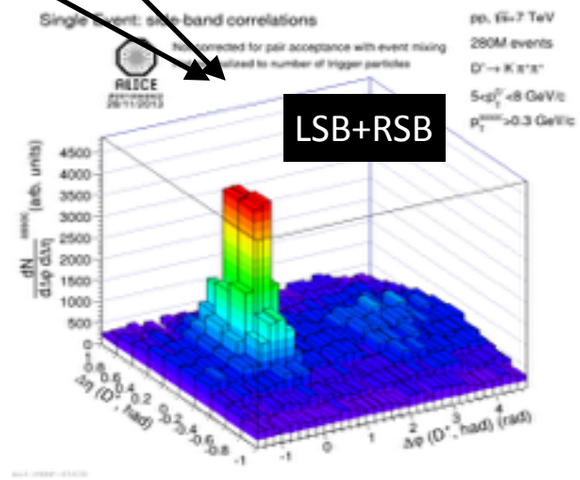


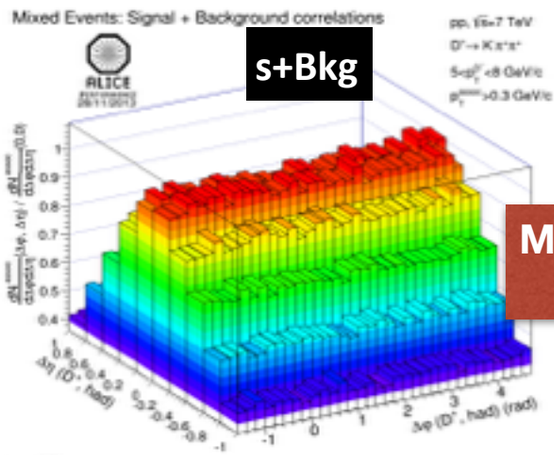
Left side-Band (LSB)

Right side-Band (RSB)

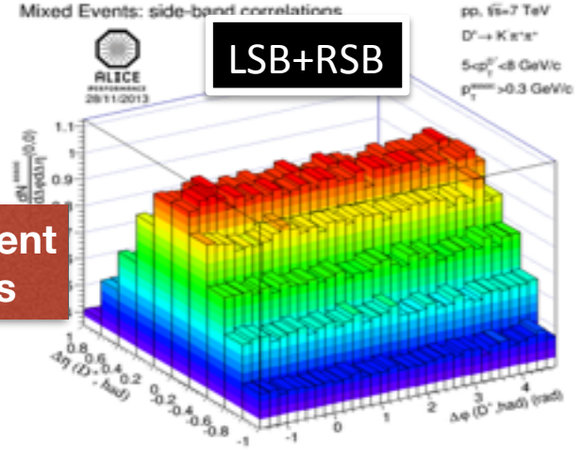
4σ 2σ 4σ







Mixed Event analysis



1. **Same Event** (SE) D meson-charged particle angular correlations evaluated for D-meson candidates in the signal-peak range as well as in the right and left side-band regions

   ➥ **raw Δφ-Δη correlation**

2. **Mixed Event** (ME) analysis for both the signal (s)+background (bkg) and LSB+RSB regions.

3. **Dividing SE/ME**: Correct for detector inhomogeneities and acceptance effect.

4. Remove the background in the signal region as estimated from the side bands (**Side-Band Technique**).

$$\left(\frac{d^2N^{corr}}{d\Delta\varphi d\Delta\eta}\right) = \left(\frac{d^2N^{corr}}{d\Delta\varphi d\Delta\eta}\right)_{s+bkg} - \frac{B}{B_{sb}}\left(\frac{d^2N^{corr}}{d\Delta\varphi d\Delta\eta}\right)_{LSB+RSB}$$

where
B => Background under the signal mass peak that we estimate from the invariant mass fit
B_{sb} => Integral of the invariant mass distribution in the side-band region

Results:

Last Alice-India meeting:

New treatment of the pools:
The SE and ME correlations have to be kept separated among the various event classes (pools)
The SE/ME ratio is performed pool-by-pool. The corrected results from each pool are then summed to obtain the final results.

$$SE/ME = SE1/ME1 + \ldots + SE9/ME9$$

This allows to take correctly into account possible differences among the various event classes.

This Alice-India meeting result update:

- Continue with new pool setting
- D^0-hadron correlation analysis in pp 7TeV with pass4.

Technical details of analysis

- Data set: LHC10/pass4-AOD
- Train output: 126(LHC10b), 127(LHC10c), 128(LHC10d), 129(LHC10e)
- Number of event analysed:
  LHC10b: 23.8M
  LHC10c: 72.M
  LHC10d: 124M
  LHC10e: 116M
  Total: 337M

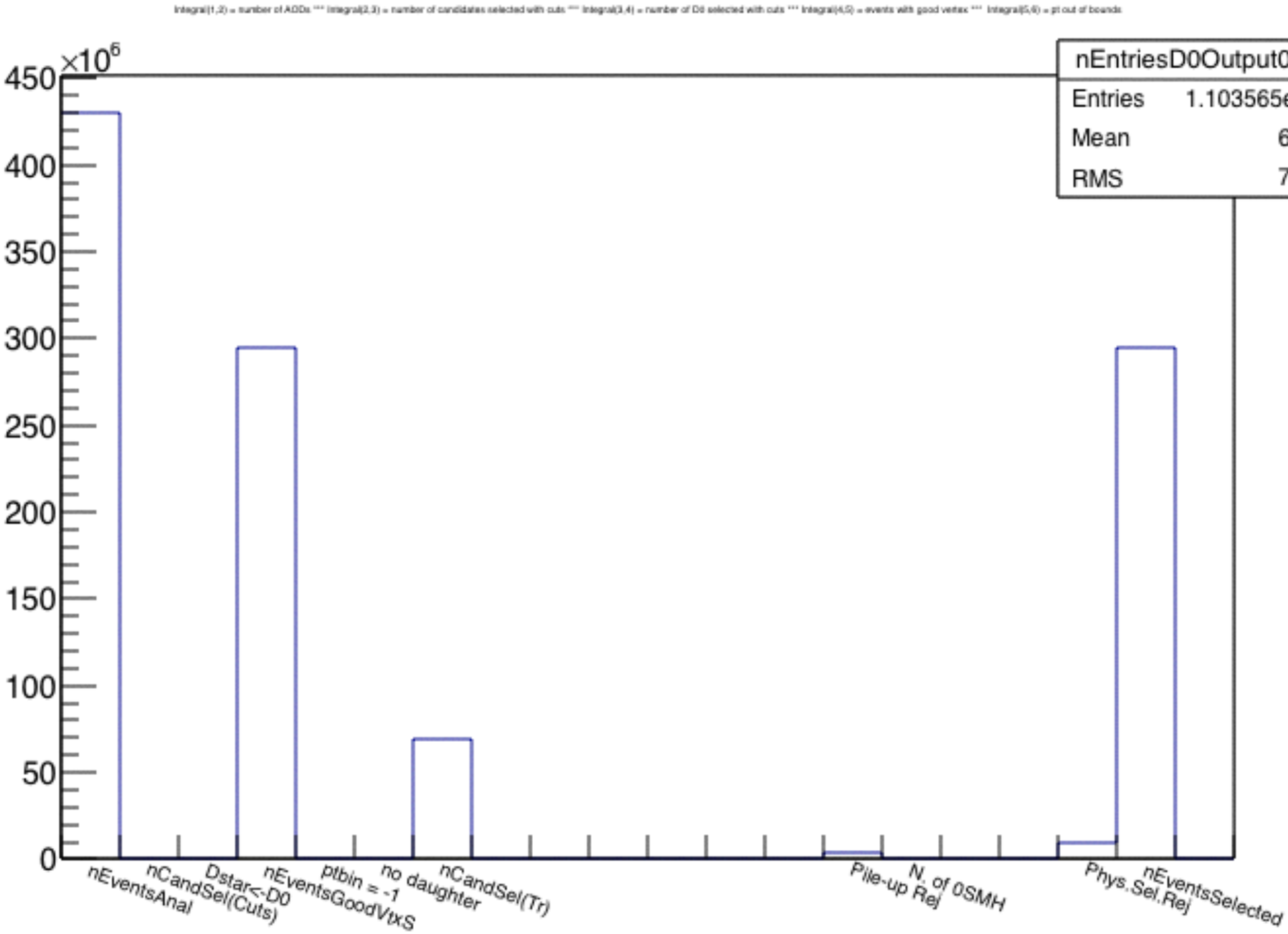
- D meson cut: Standard cuts pp2010
- Associated track cuts (info from train log file):

ITS Refit.....: No
TPC Refit.....: Yes
ITS SA.....: No
TPC SA.....: No
No Min number of ITS clusters.....: 3
Min number of TPC clusters.....: 70
SPD.....: kOff
Filter Bit.....: 1
Charge.....: 0

Event Pool settings:
Number of zVtx Bins: 3
zVtx Bins:
Bin 0.....: -10.0 - -2.5 cm
Bin 1.....: -2.5 - 2.5 cm
Bin 2.....: 2.5 - 10.0 cm
Number of Centrality(multiplicity) Bins: 3
Centrality(multiplicity) Bins:
Bin 0.....: 0.0 - 20.0
Bin 1.....: 20.0 - 35.0
Bin 2.....: 35.0 - 200.0

- D meson and track efficiencies are included in this analysis

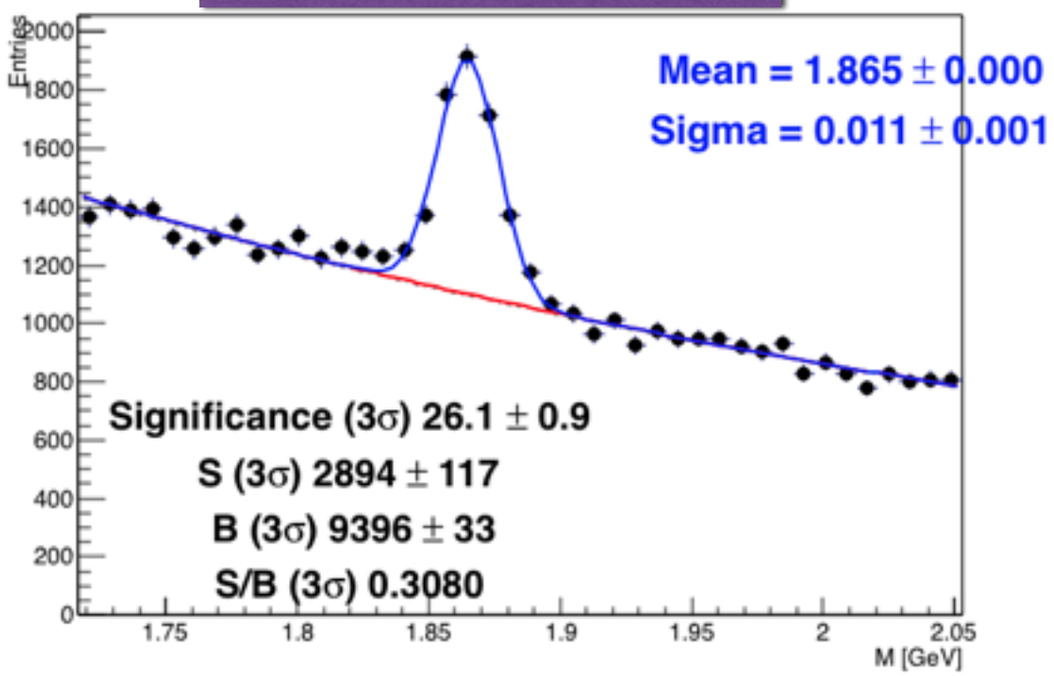
Result: nEntries for pass4



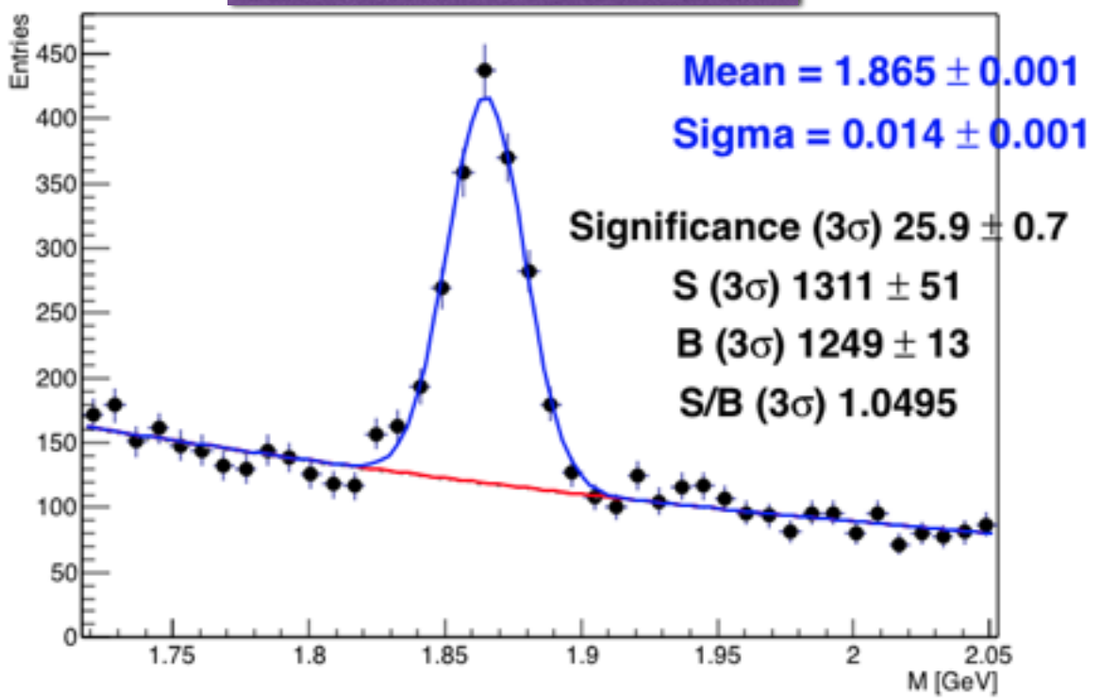
- ☑ Total events processed: 431M
- ☑ Selected events: ~337M
- ☑ Pileup rejection: 4M

D^0 Invariant mass distribution:

Low D^0 p_T 3-5 GeV/c



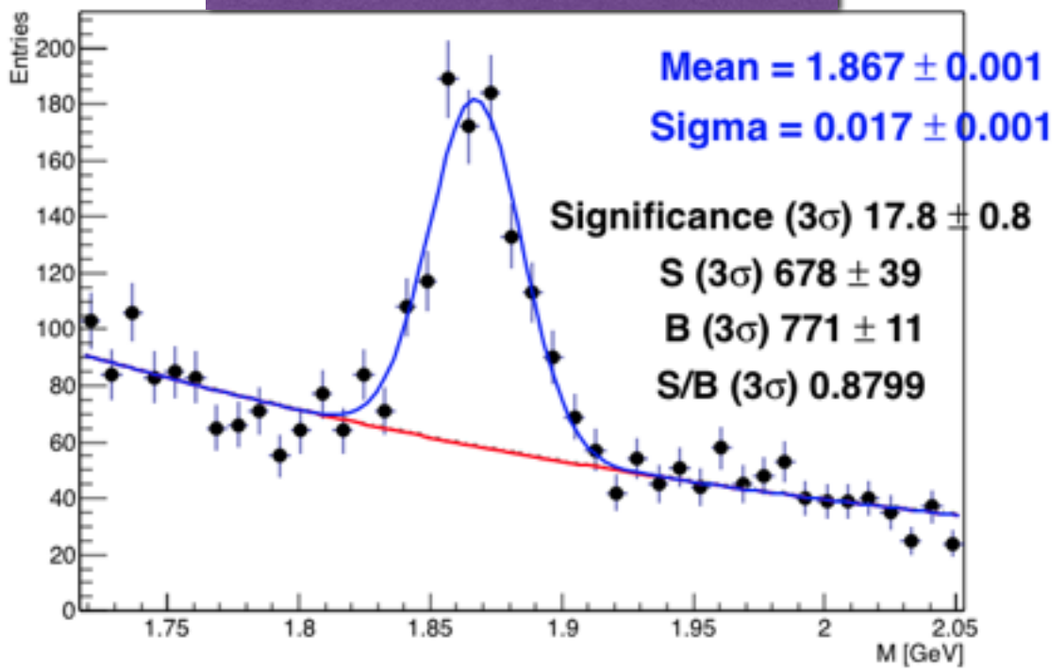
Mid D^0 p_T 5-8 GeV/c



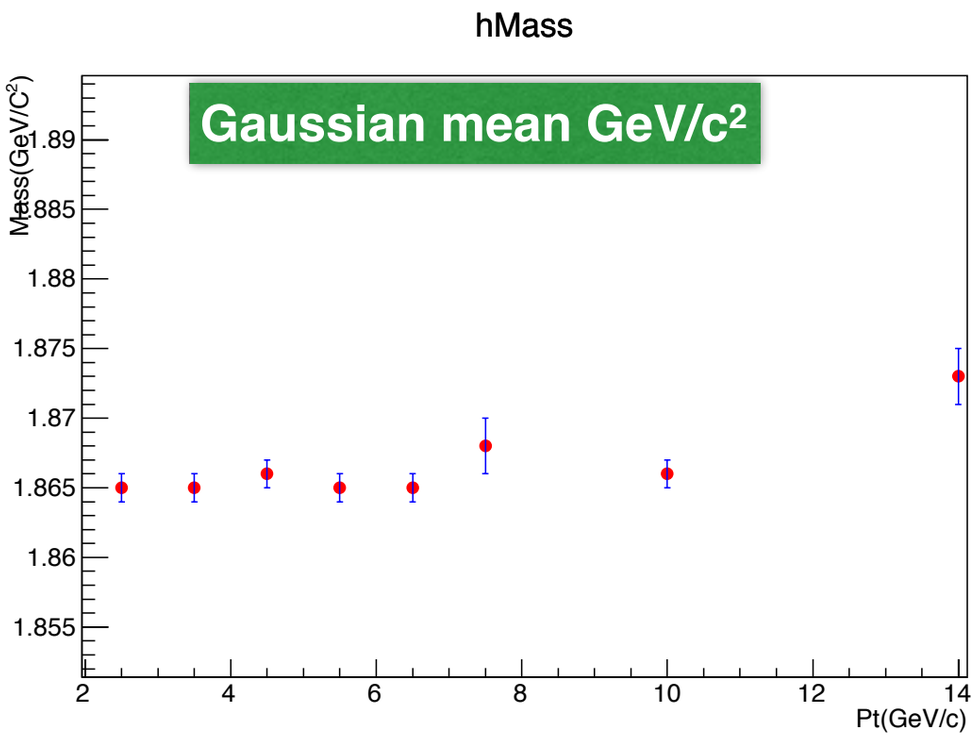
Without efficiency map only to display Inv mass.

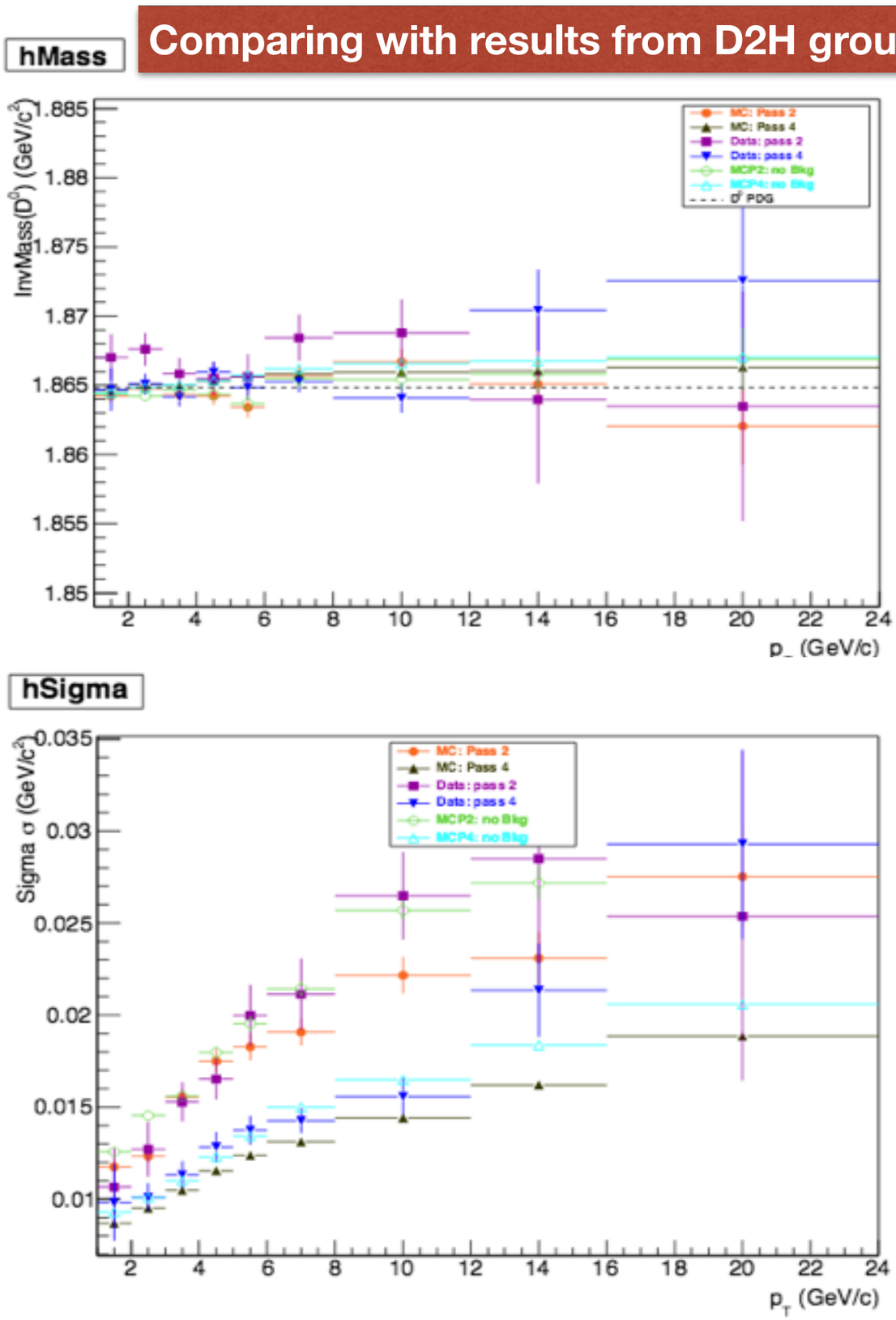
	3-5	5-8	8-16
Signal(s)	2894	1311	678
Bkg(B)	9396	1249	771
S/B	0.308	1.0495	0.8799
S/√S+B	26.01	25.91	18.19

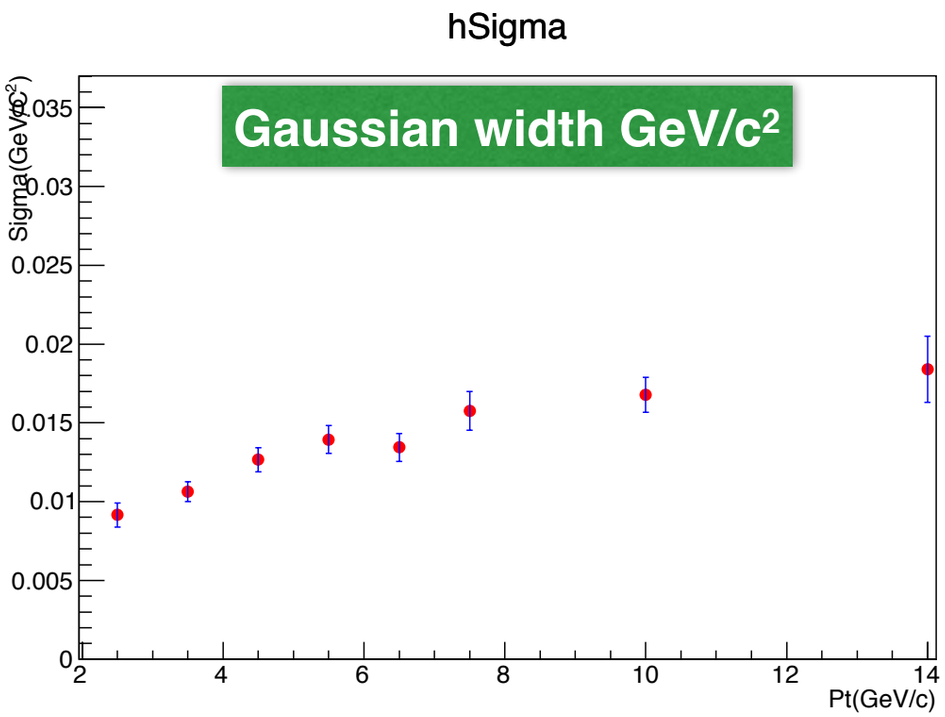
High D^0 p_T 8-16 GeV/c



D^0 Invariant mass distribution:





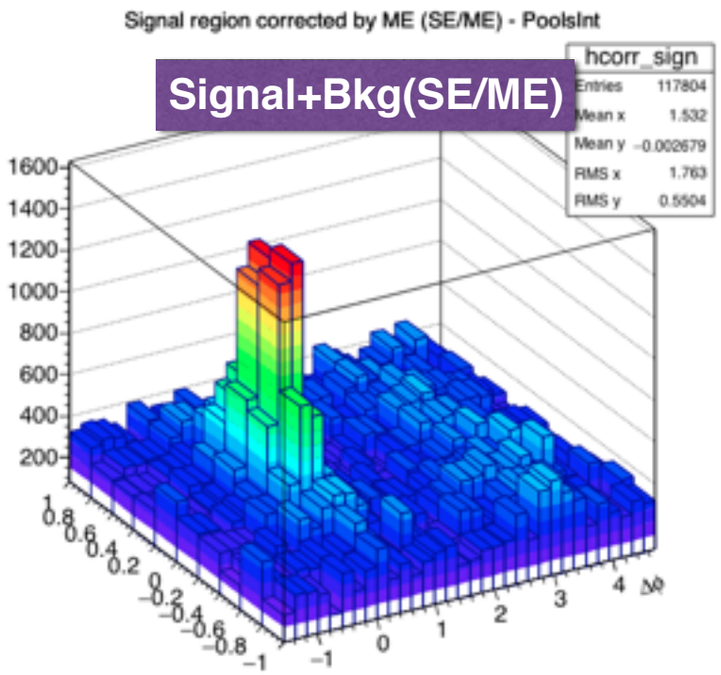


D^0 -hadron correlations:

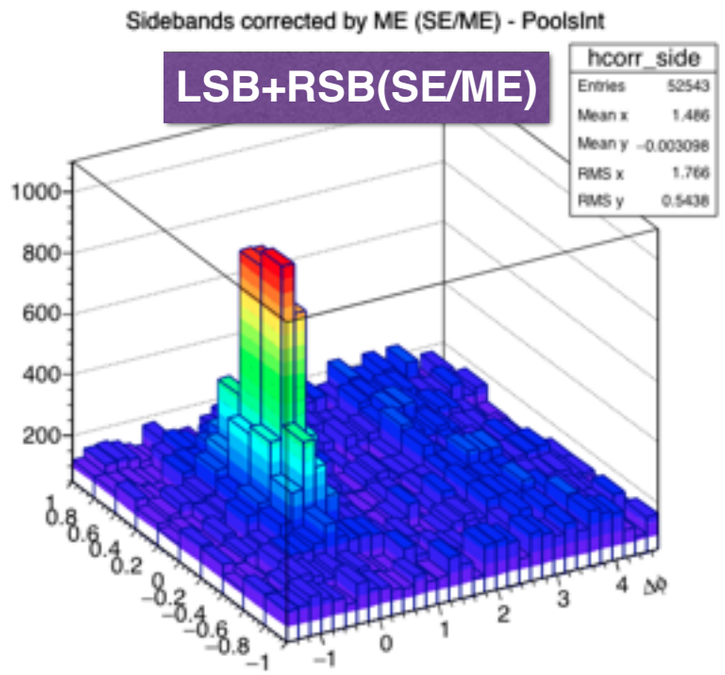
High D^0 p_T 8-16 GeV/c

Associated track p_T >0.3

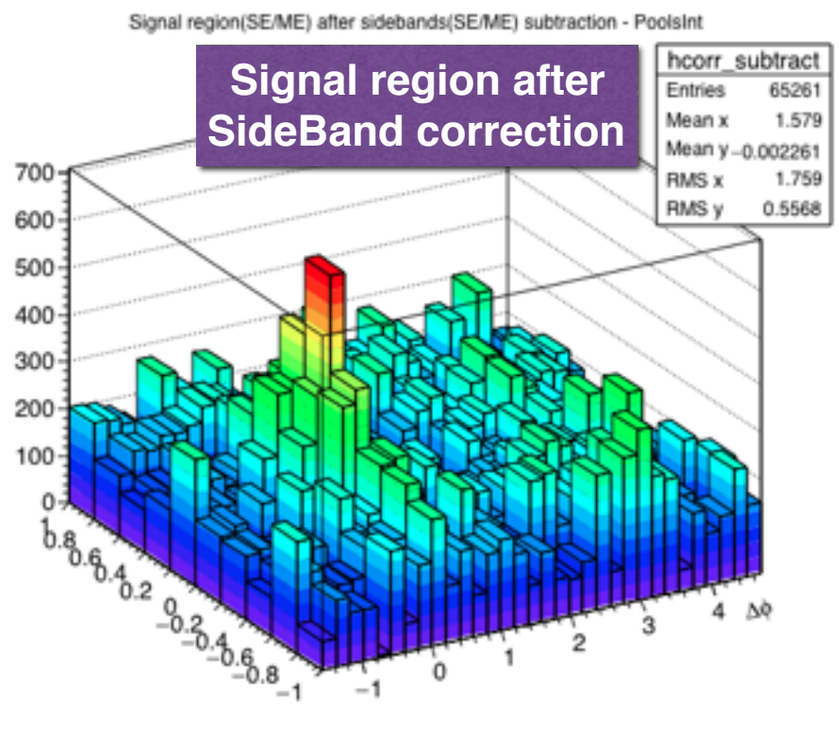
Signal+Bkg(SE/ME)

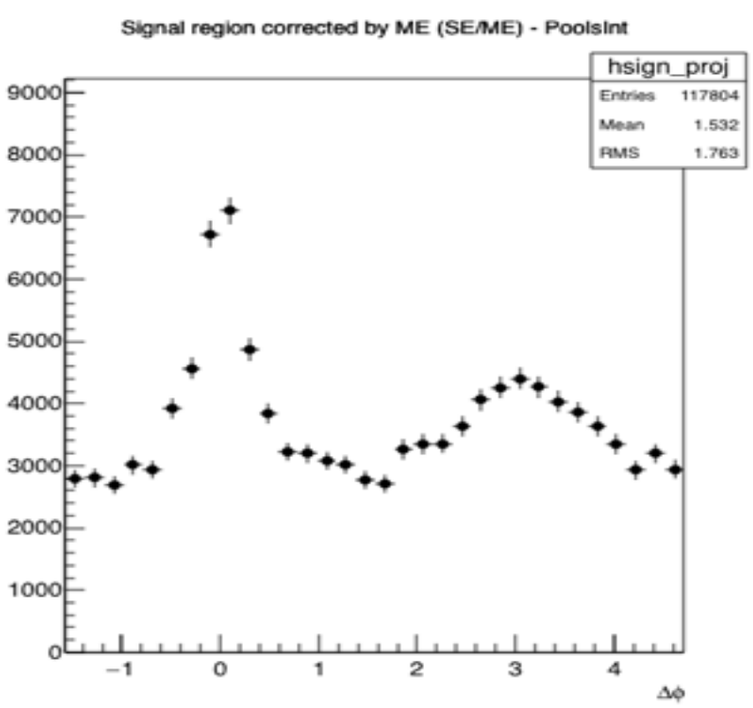


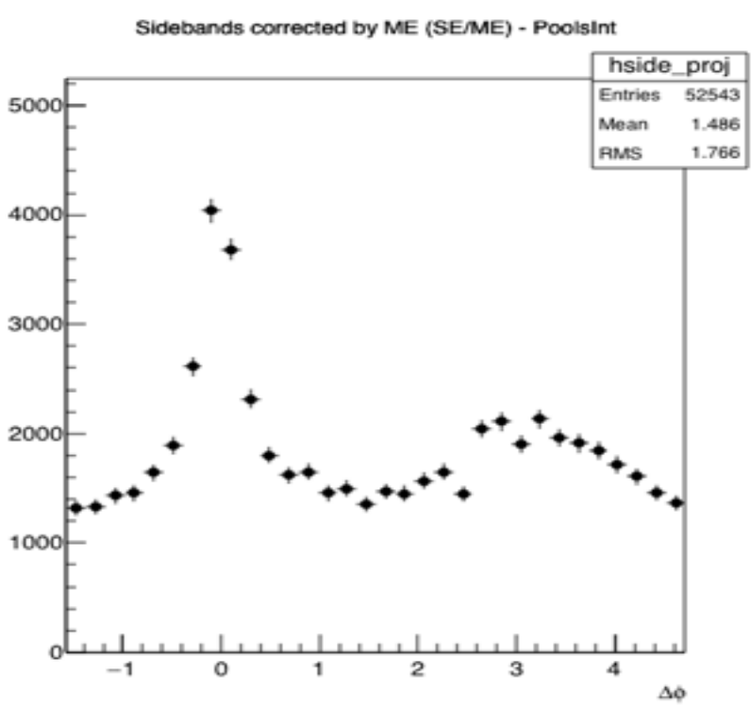
LSB+RSB(SE/ME)

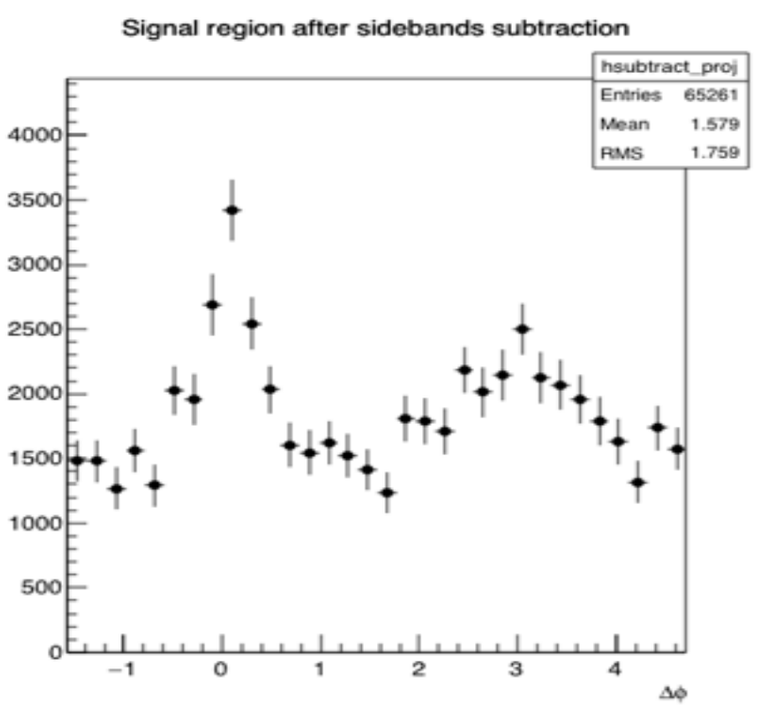


Signal region after SideBand correction





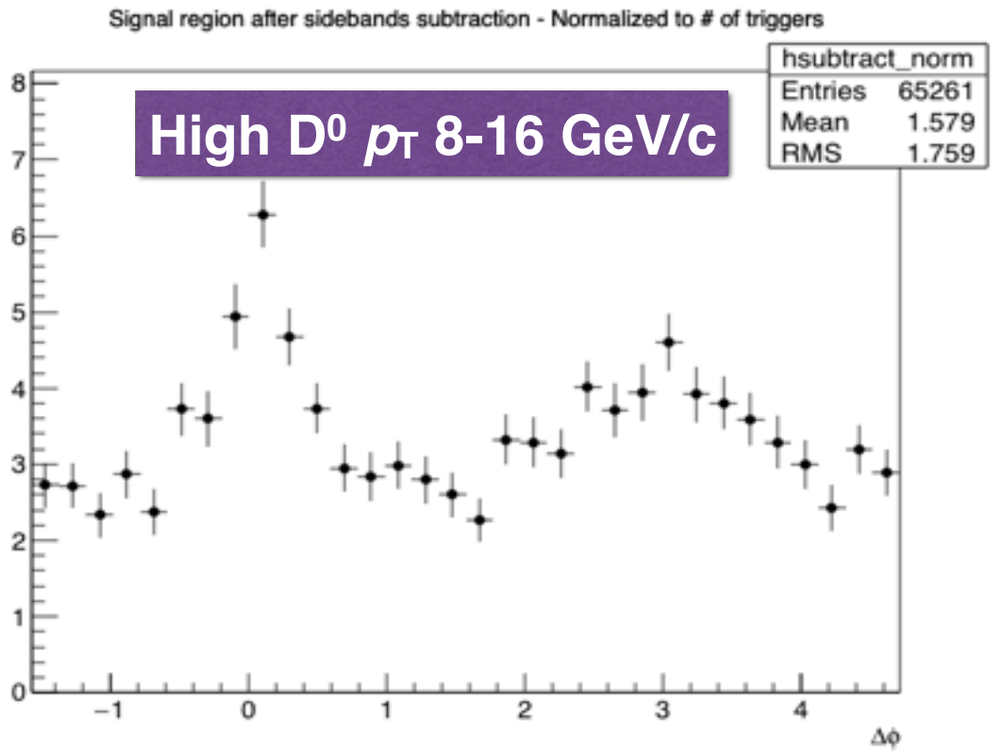


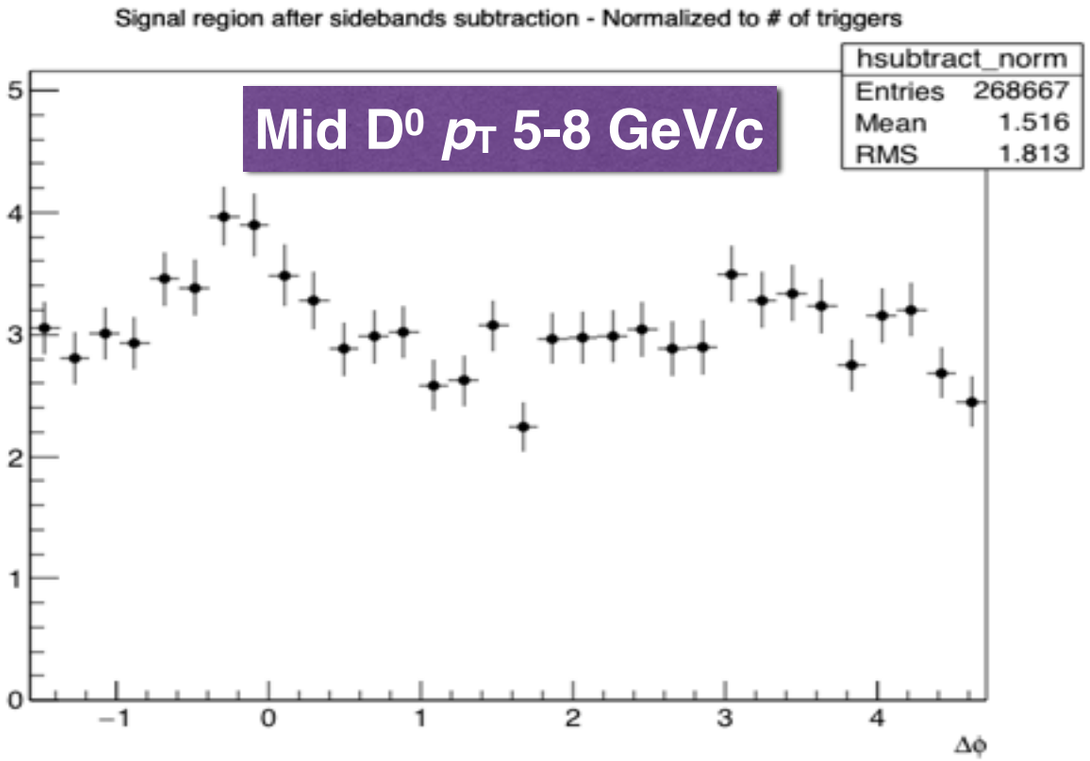


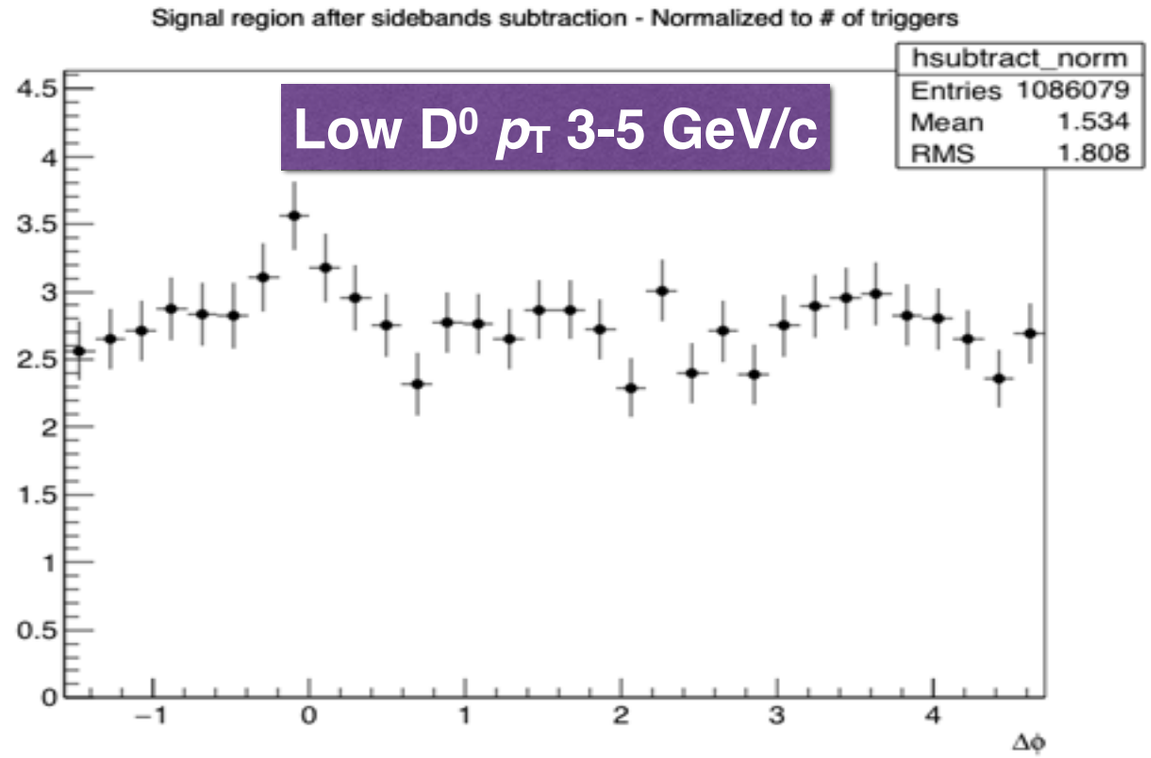
Other assoc p_T threshold 2D plots in backups

D^0 -hadron correlations:

Associated track p_T >0.3

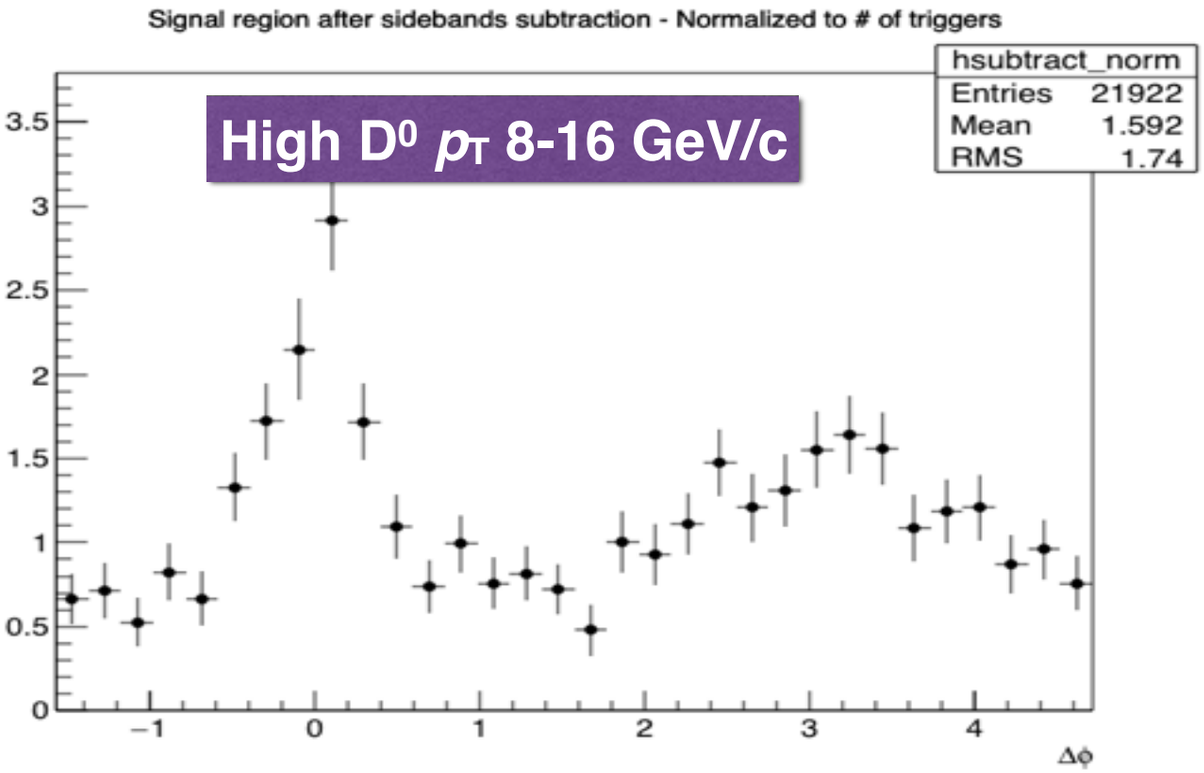


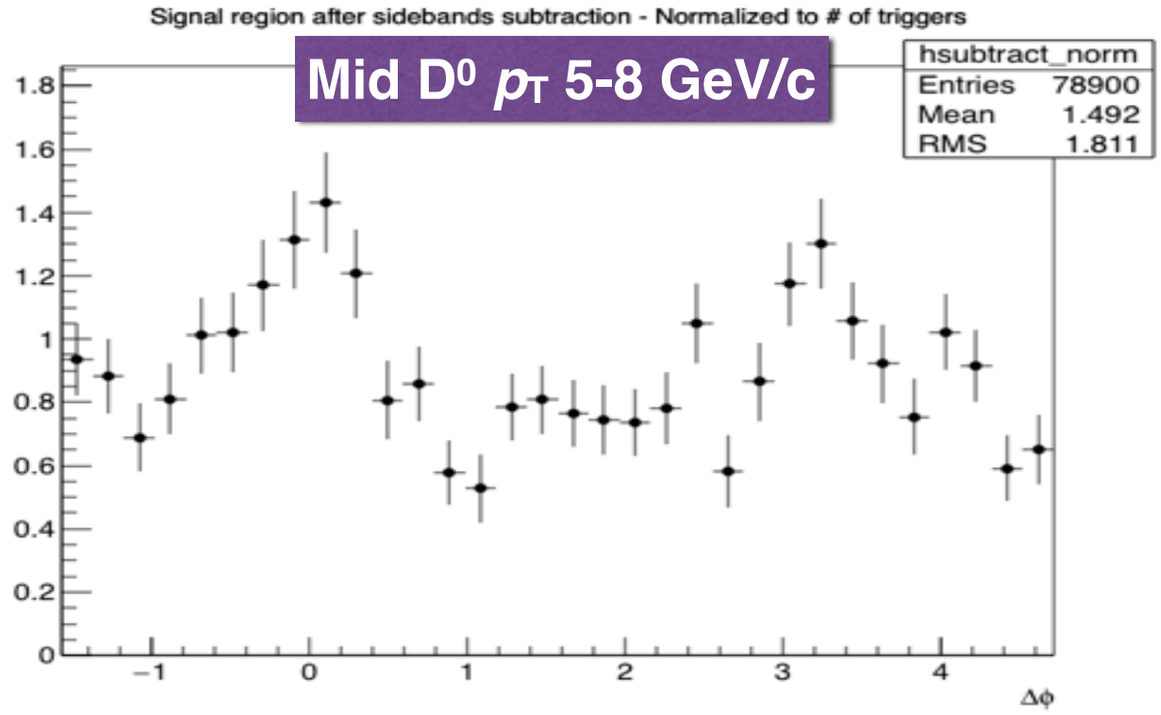


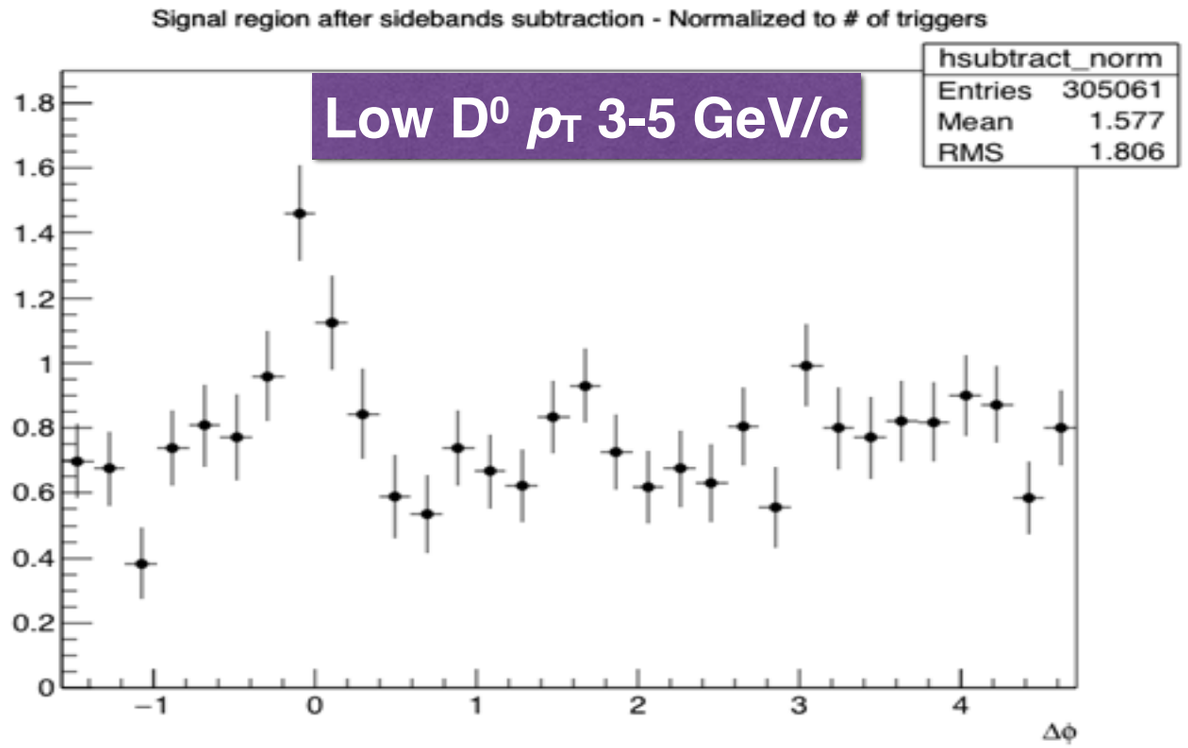


D^0 -hadron correlations:

Associated track p_T >1.0





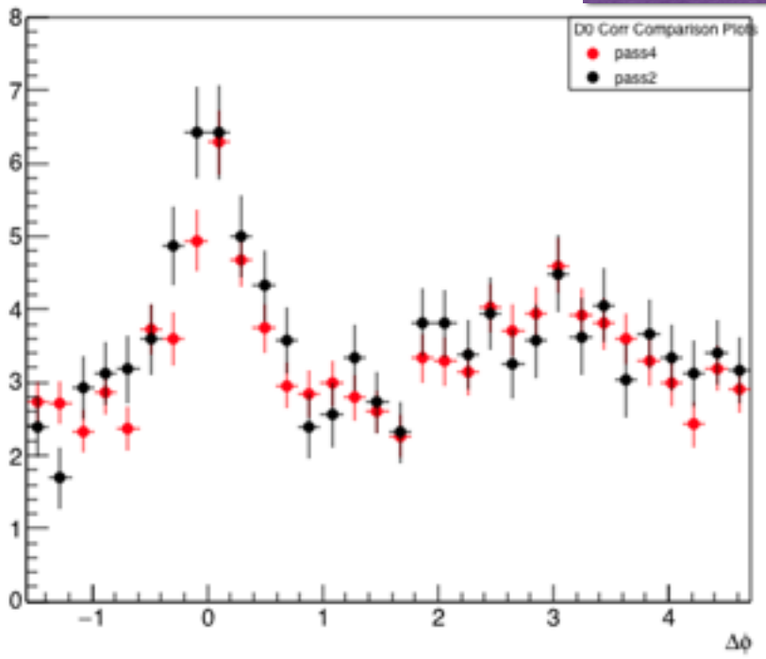


D^0 -hadron correlations: pass4 vs Pass2

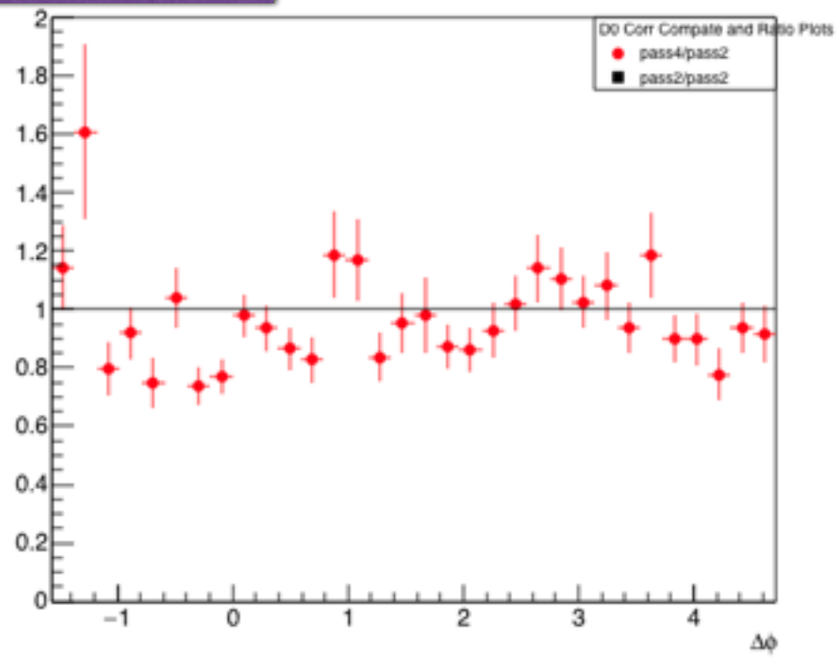
Associated track p_T >0.3

High D^0 p_T 8-16 GeV/c

Comparison pass4 & pass2

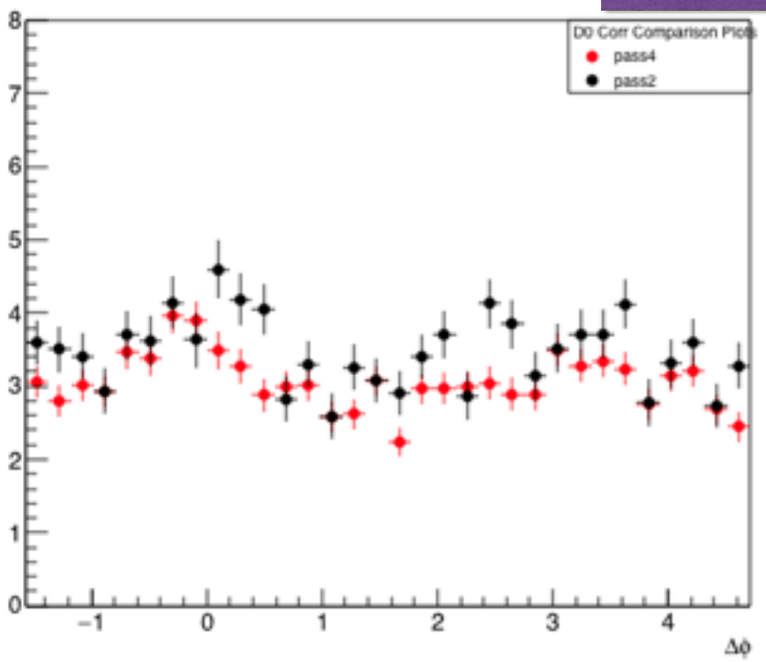


Ratio pass4 & pass2

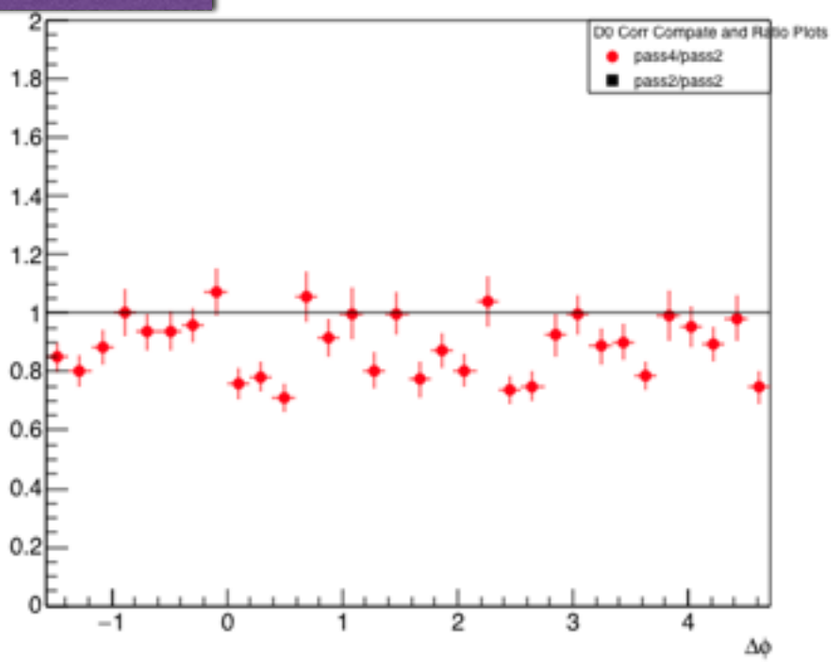


Mid D^0 p_T 5-8 GeV/c

Comparison pass4 & pass2



Ratio pass4 & pass2

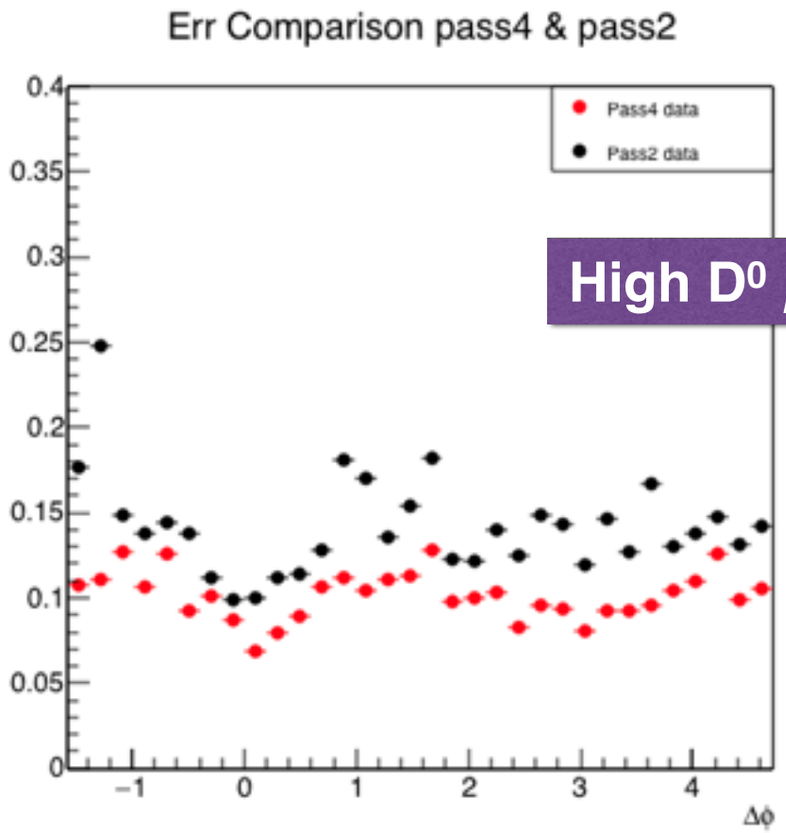


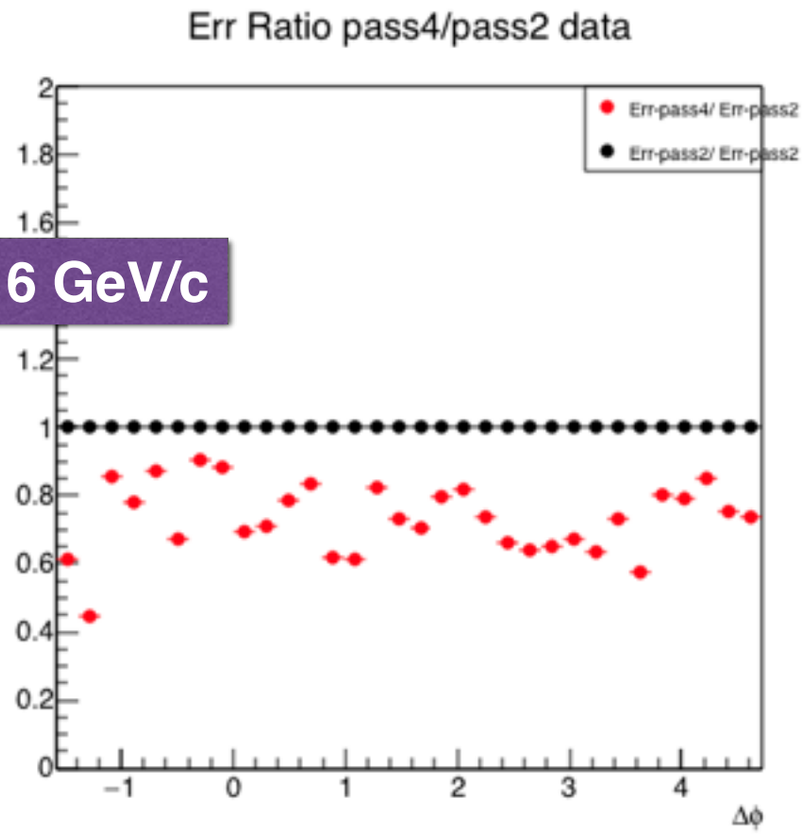
D^0 -hadron correlations: pass4 vs Pass2

Associated track p_T >0.3

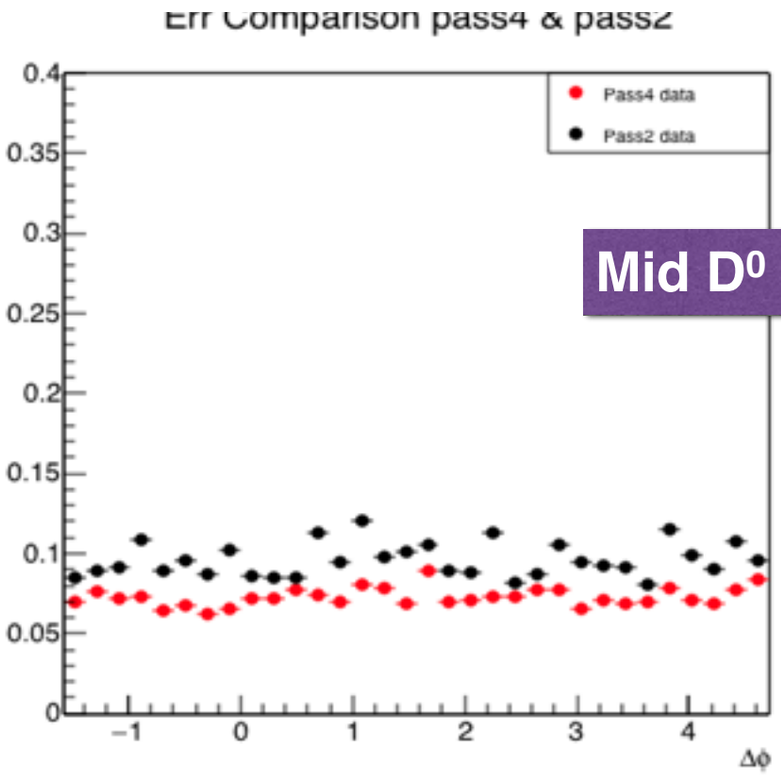
Comparison of weighted errors

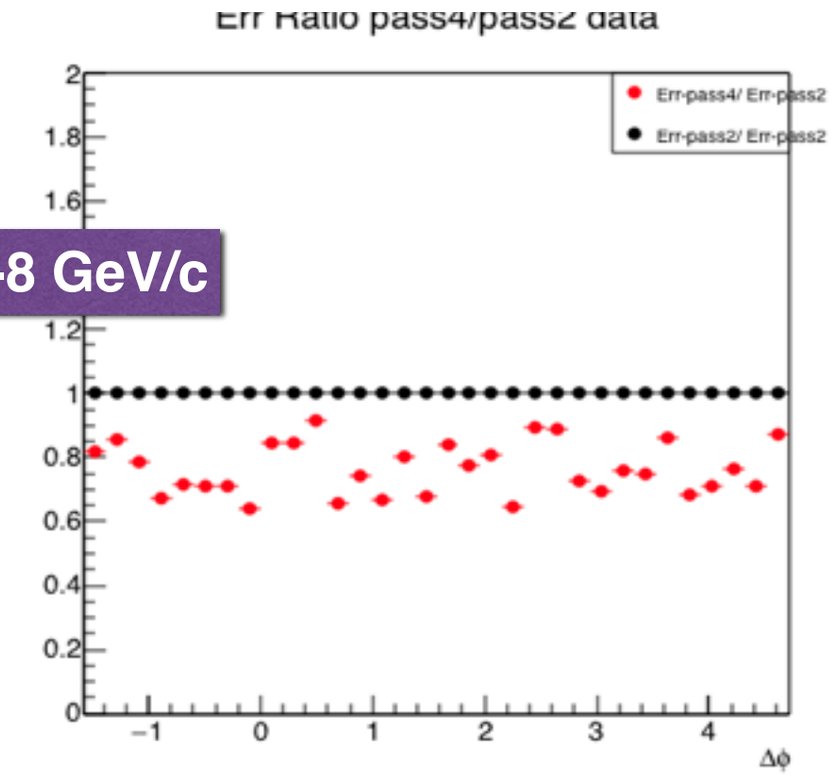
High D^0 p_T 8-16 GeV/c





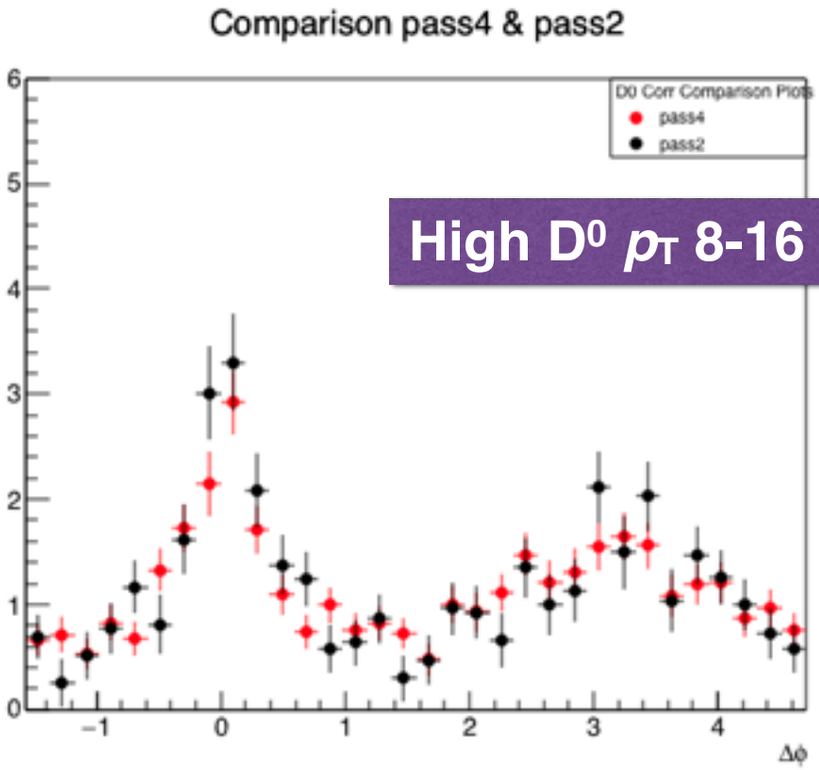
Mid D^0 p_T 5-8 GeV/c



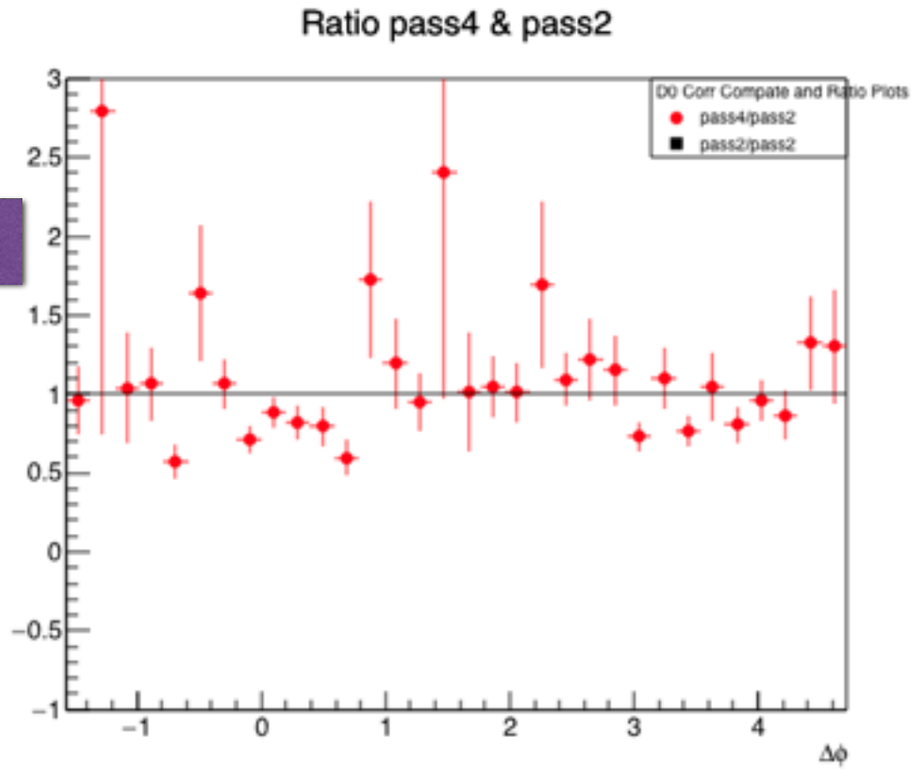


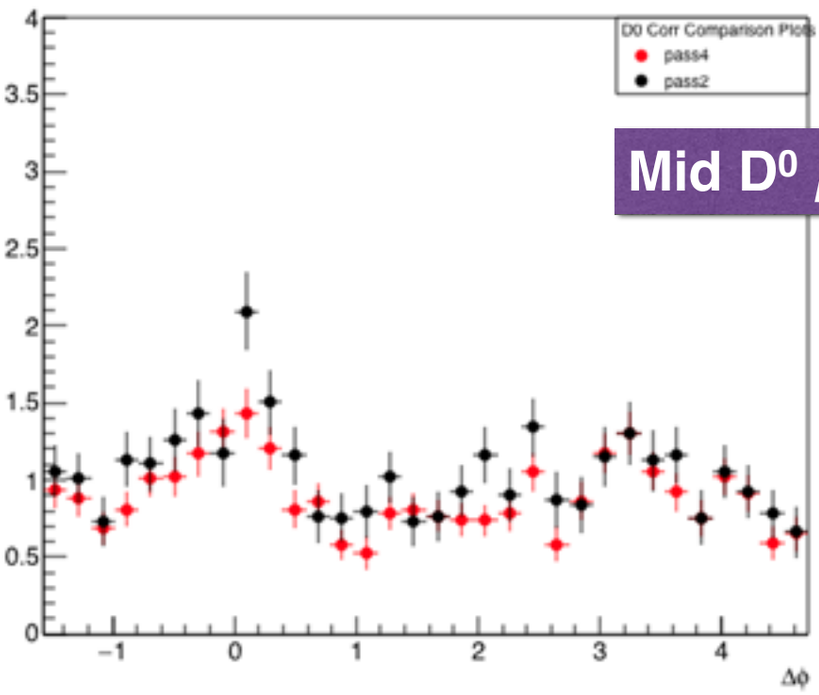
D^0 -hadron correlations: pass4 vs Pass2

Associated track p_T >1.0

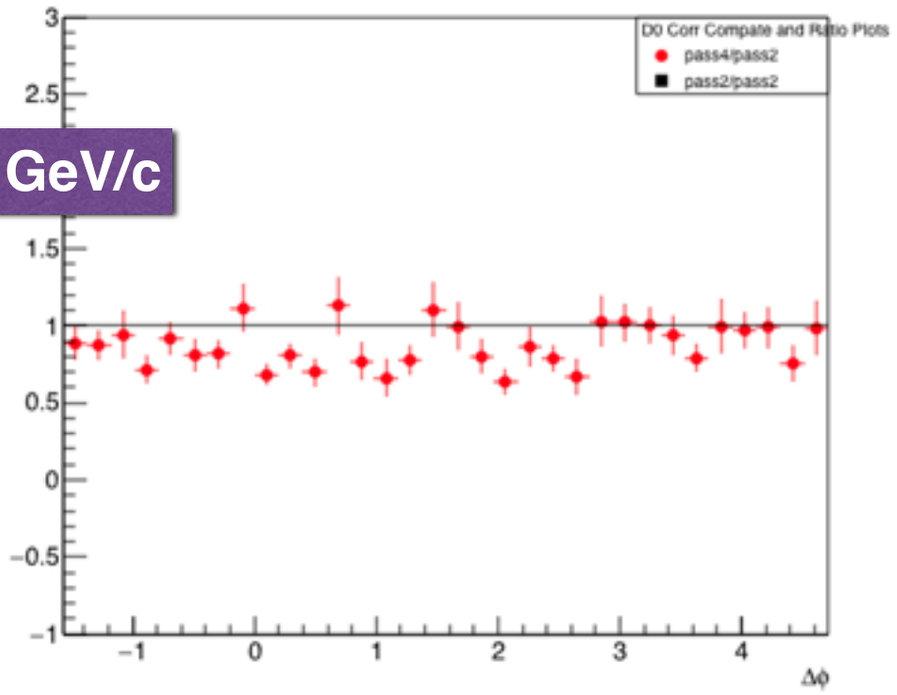


High D^0 p_T 8-16 GeV/c





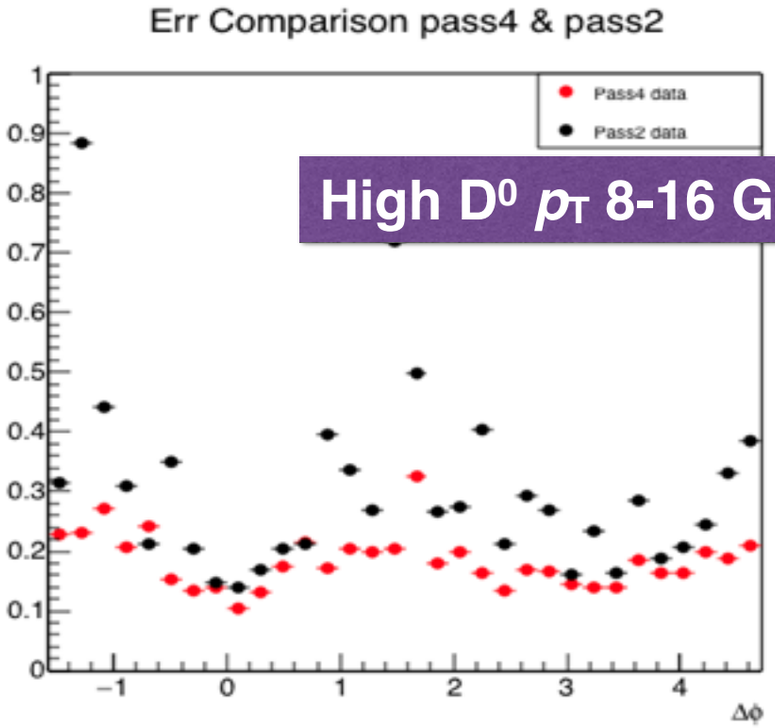
Mid D^0 p_T 5-8 GeV/c



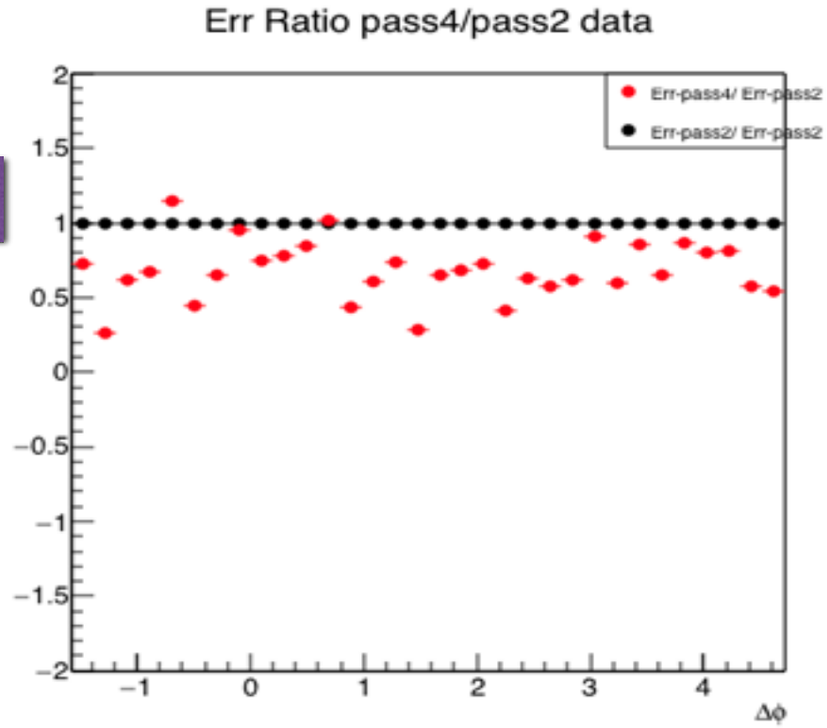
D^0 -hadron correlations: pass4 vs Pass2

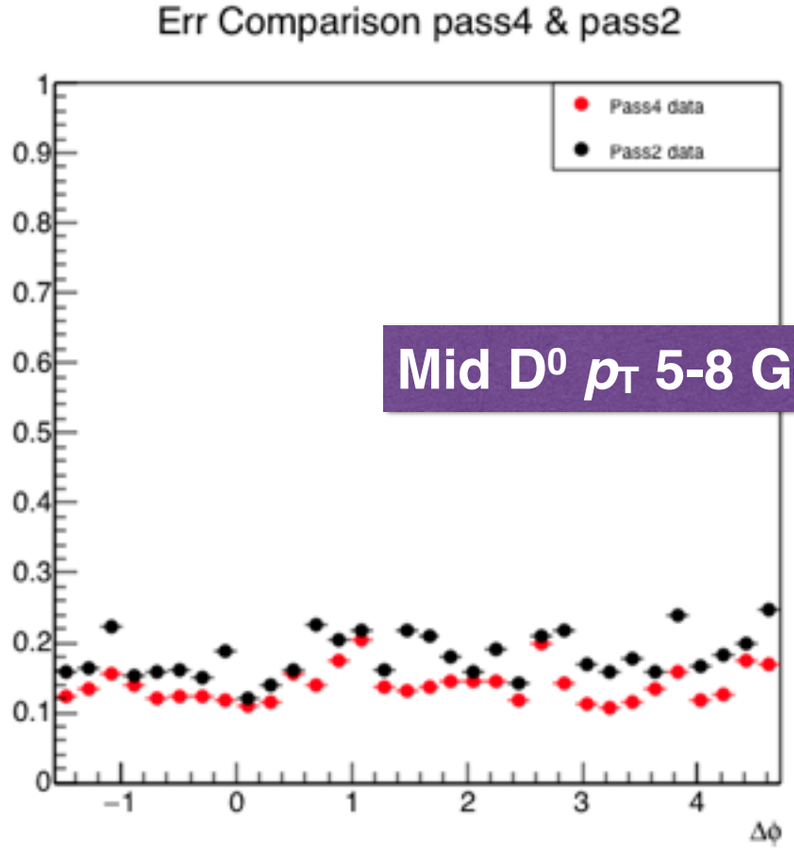
Associated track p_T >1.0

Comparison of weighted errors

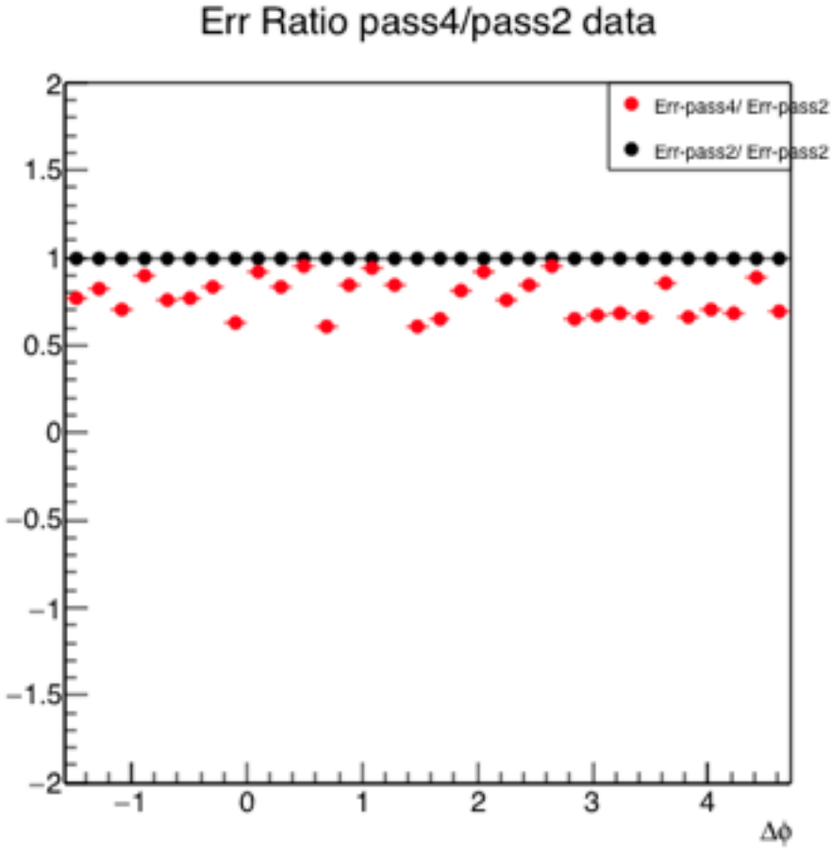


High D^0 p_T 8-16 GeV/c





Mid D^0 p_T 5-8 GeV/c



Low D^0 p_T in backups

Summary

- Checked for pass4 data pp@7TeV for different D^0 pT ranges and associated p_T thresholds with D meson and track efficiencies. Significance of inv. mass looks good for pass4.
- Comparison with pass2 data (plots are taken from Alice-twiki page, used for our upcoming paper).
- Comparison for the weighted error with pass2

Thanks to other collaborators of PWGHF-HFCJ group

Future plan:

- ☑ Continuation of data analysis for Run II data.
- ☑ We are making common correlation analysis structure for D^0, D^+, D^{*+} for future, trying to reduce the error coming from codes only.
- ☑ We are doing QA for Run II data along with PWGHF-D2H group.

Thank you :)

BackUps

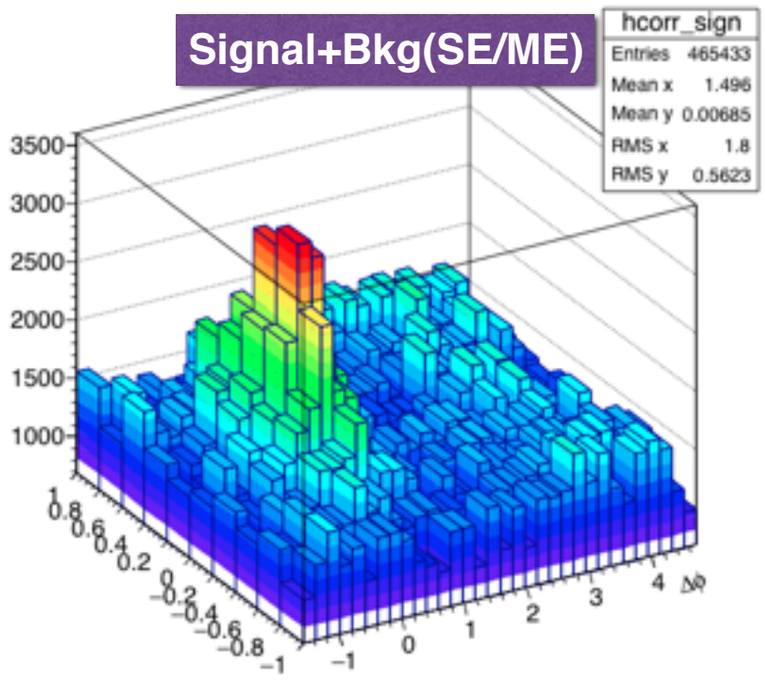
D^0 -hadron correlations:

Mid D^0 pT 5-8 GeV/c

Associated track pT>0.3

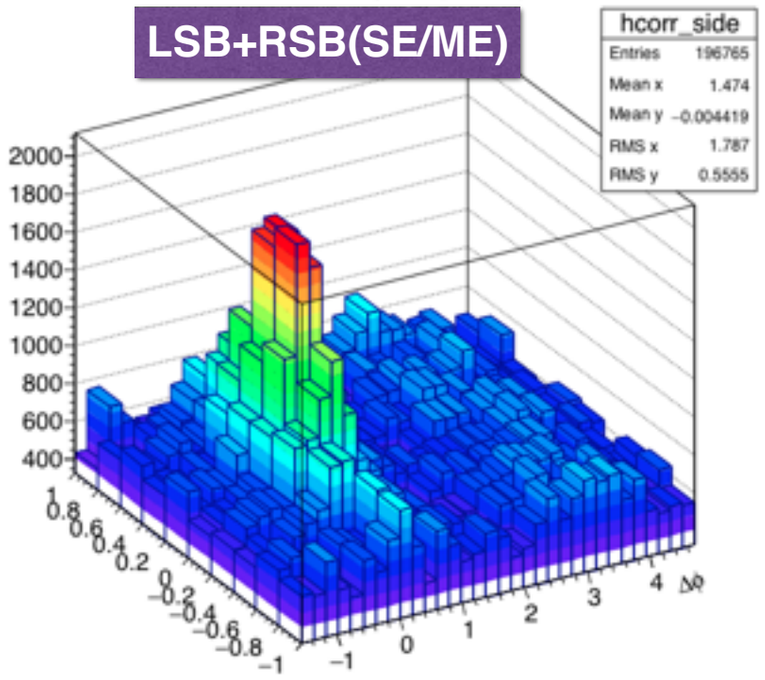
Signal region corrected by ME (SE/ME) - PoolsInt

Signal+Bkg(SE/ME)



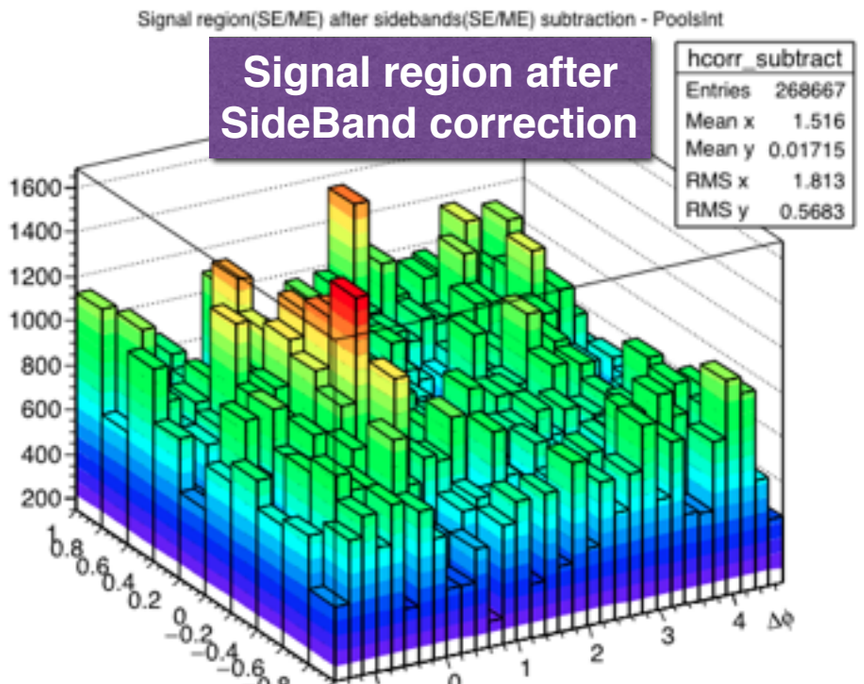
Sidebands corrected by ME (SE/ME) - PoolsInt

LSB+RSB(SE/ME)

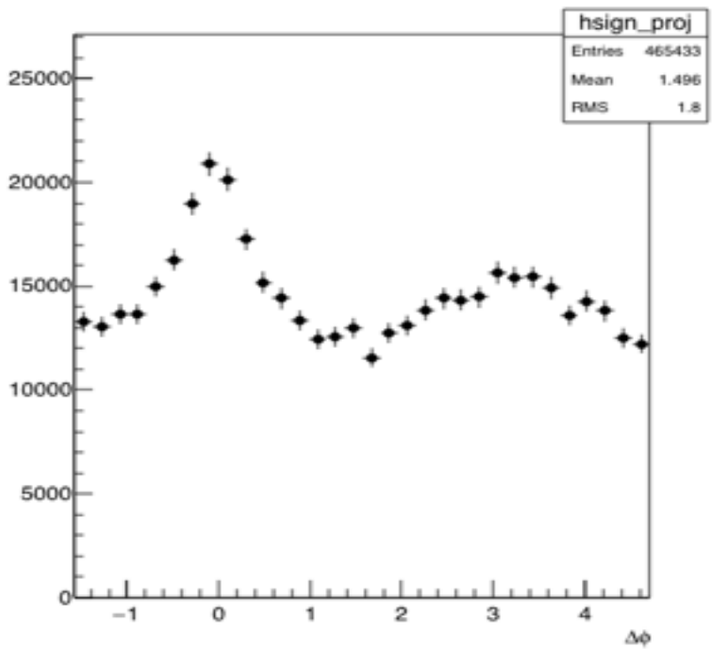


Signal region(SE/ME) after sidebands(SE/ME) subtraction - PoolsInt

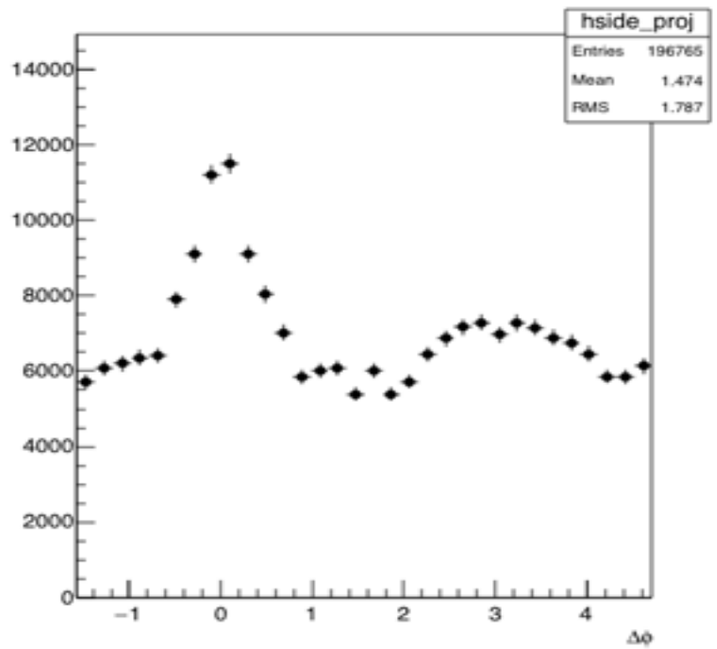
Signal region after SideBand correction



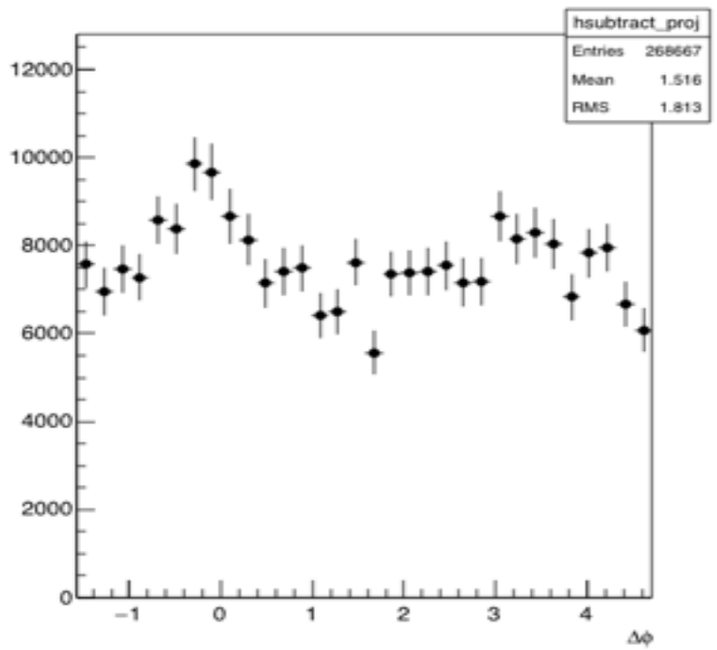
Signal region corrected by ME (SE/ME) - PoolsInt



Sidebands corrected by ME (SE/ME) - PoolsInt



Signal region after sidebands subtraction

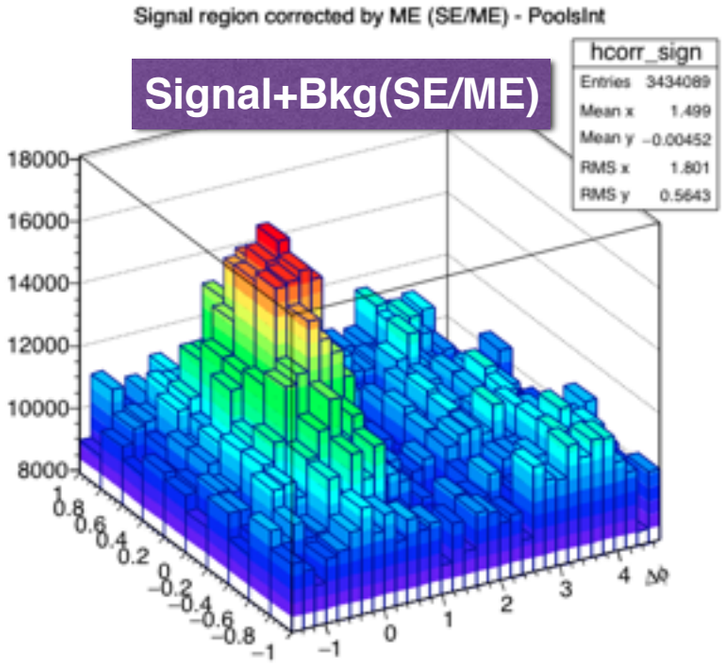


D^0 -hadron correlations:

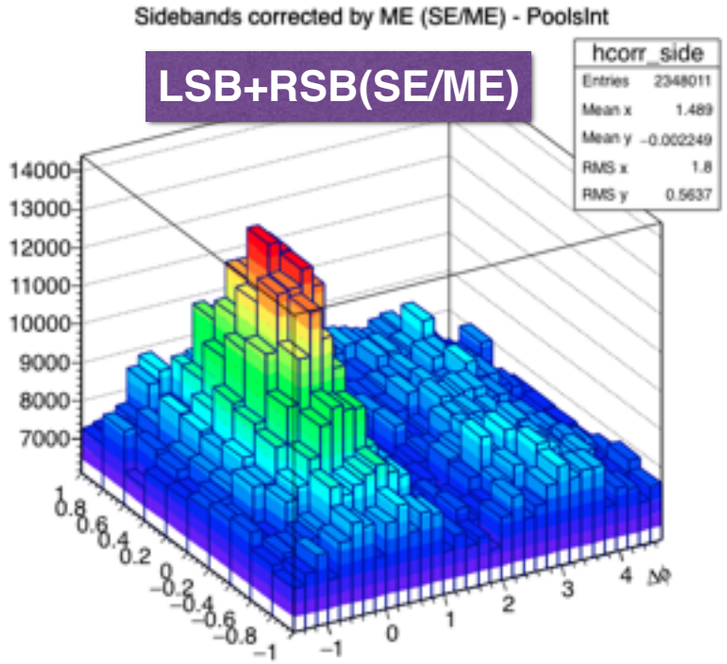
Low D^0 pT 3-5 GeV/c

Associated track pT>0.3

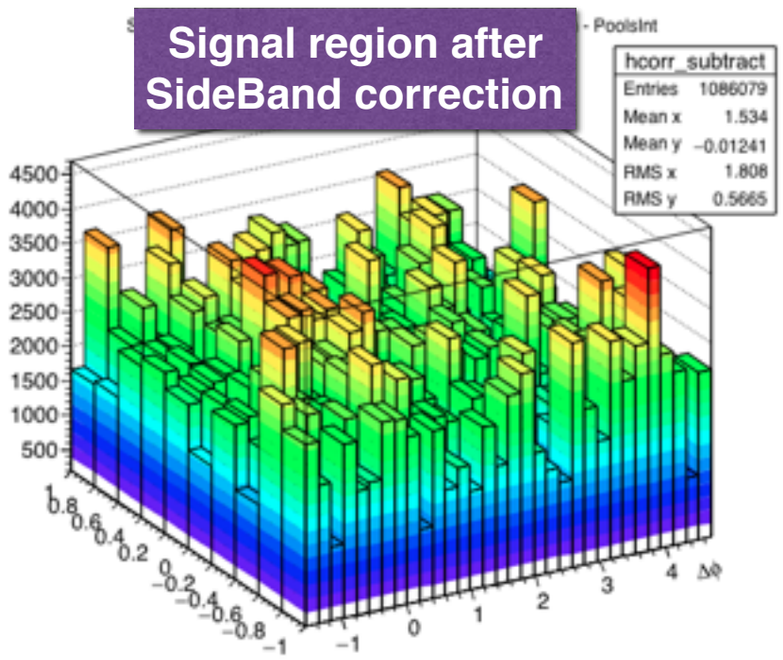
Signal+Bkg(SE/ME)

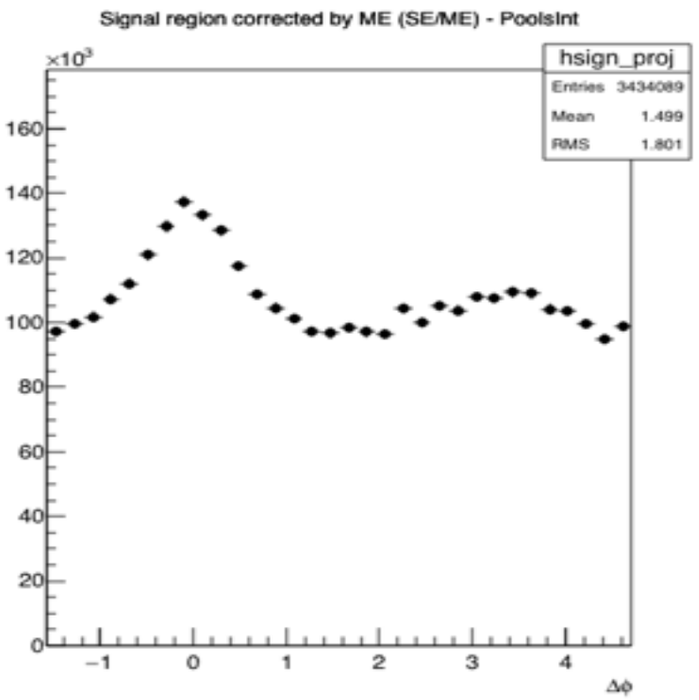


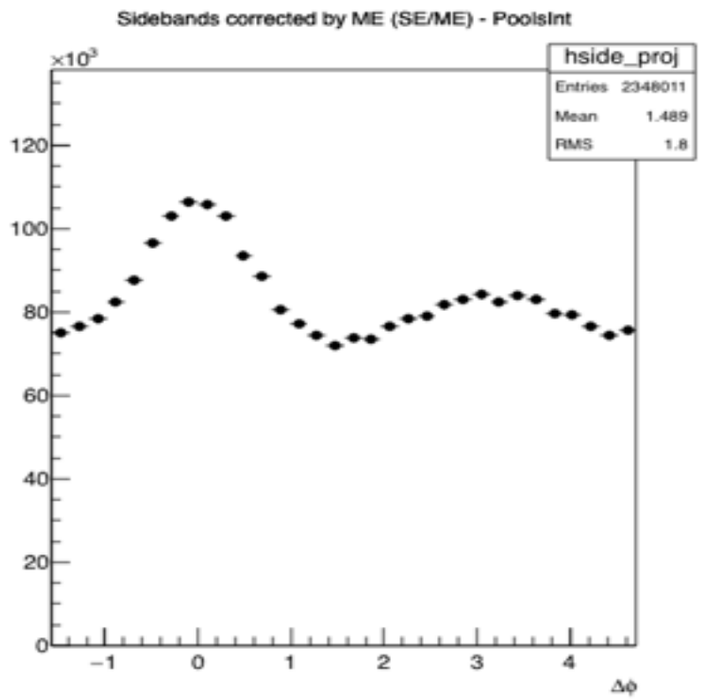
LSB+RSB(SE/ME)

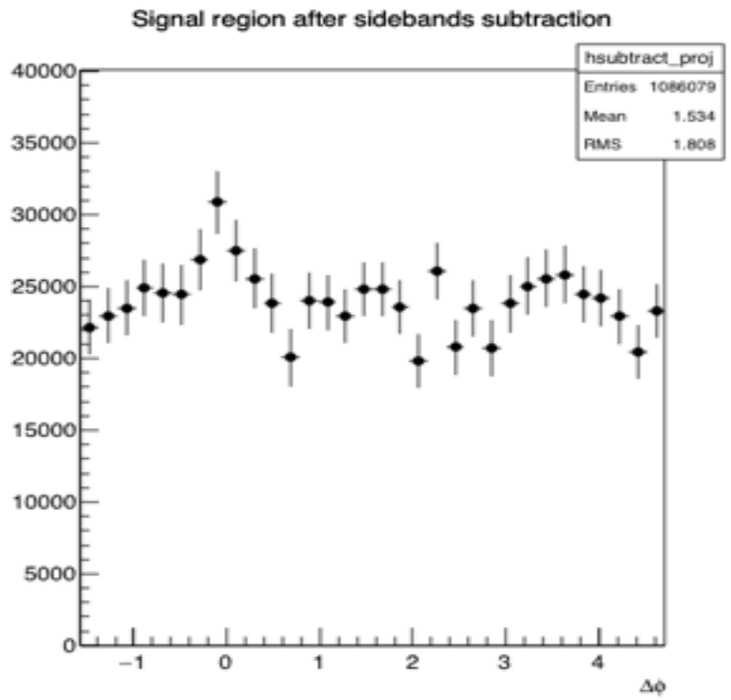


Signal region after SideBand correction



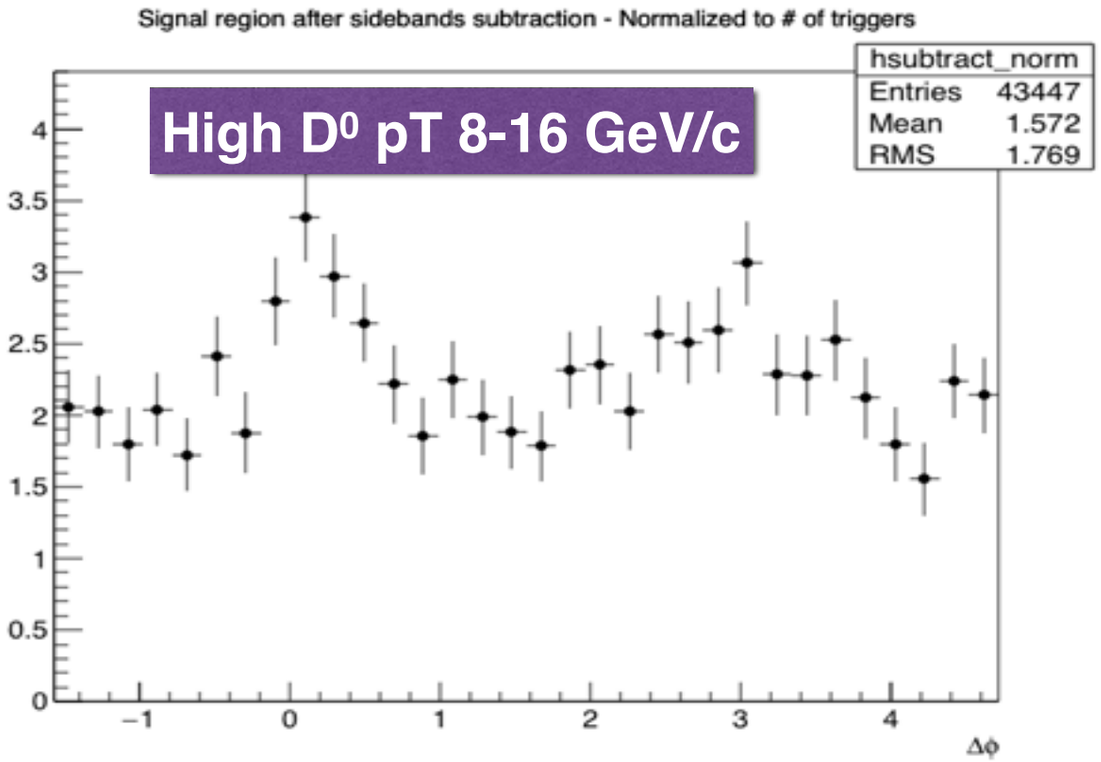


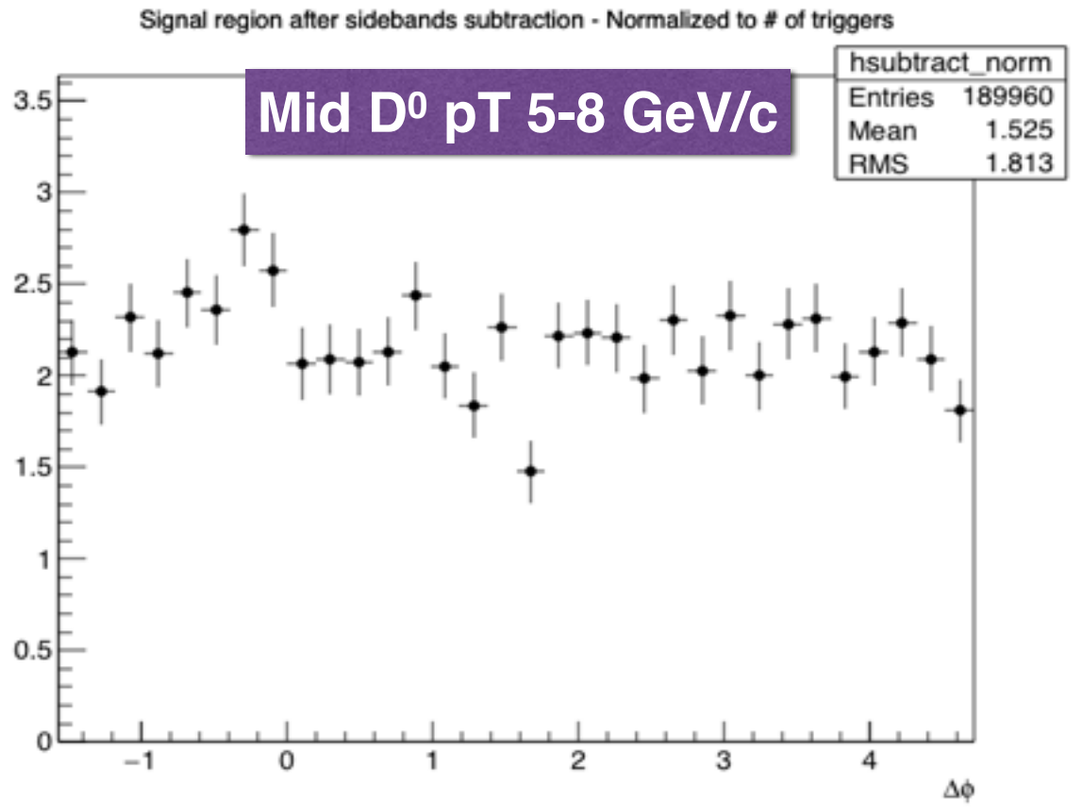


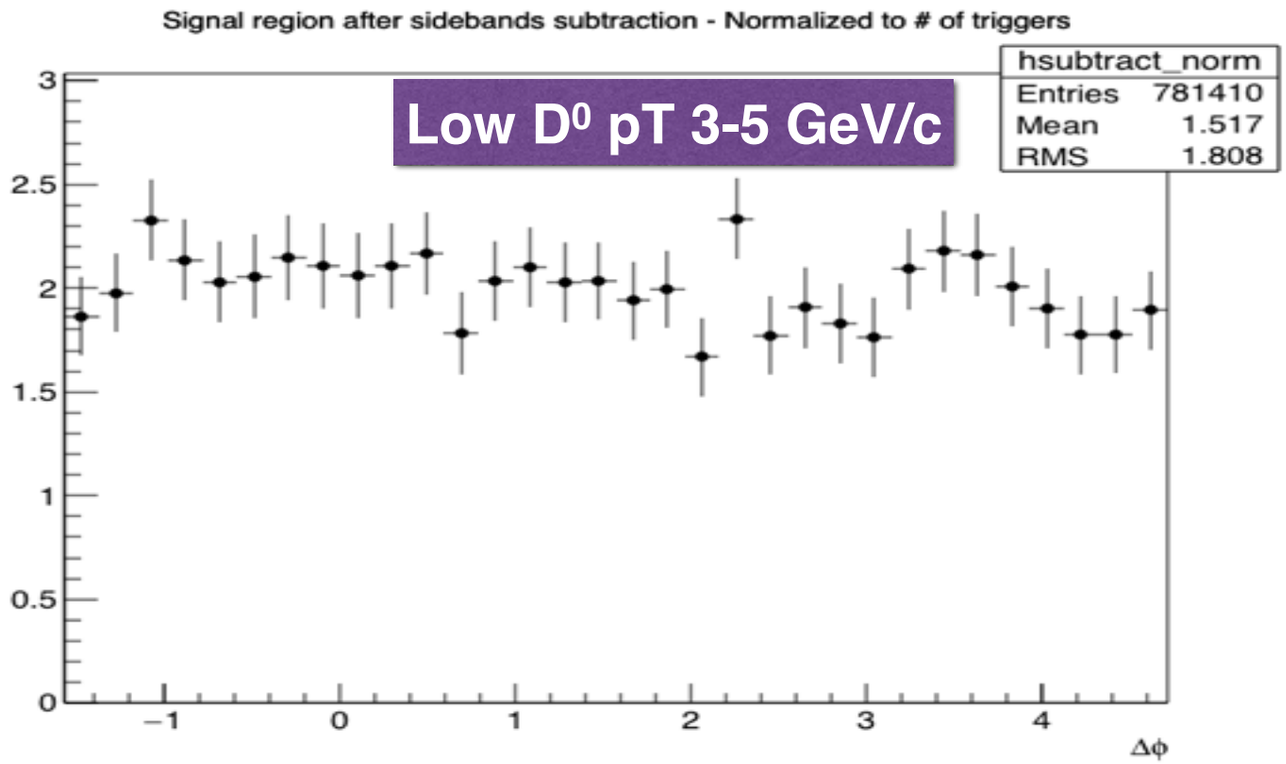


D^0 -hadron correlations:

Associated track 0.3<pT<1.0



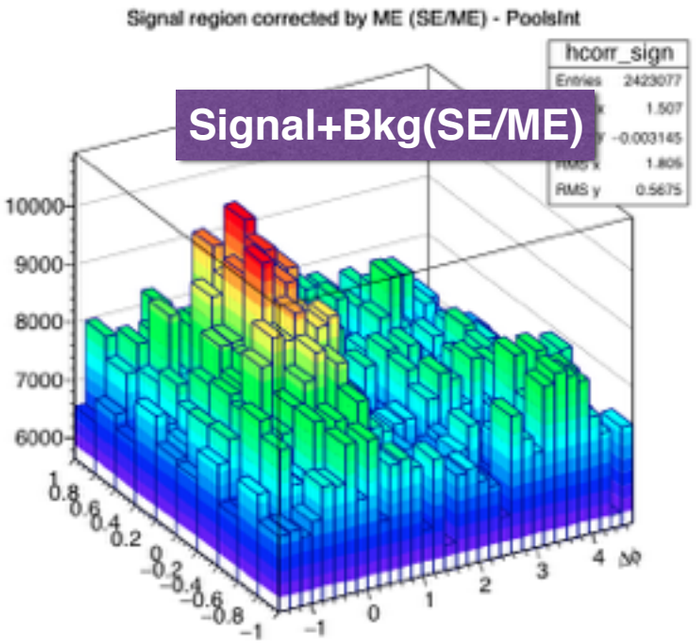


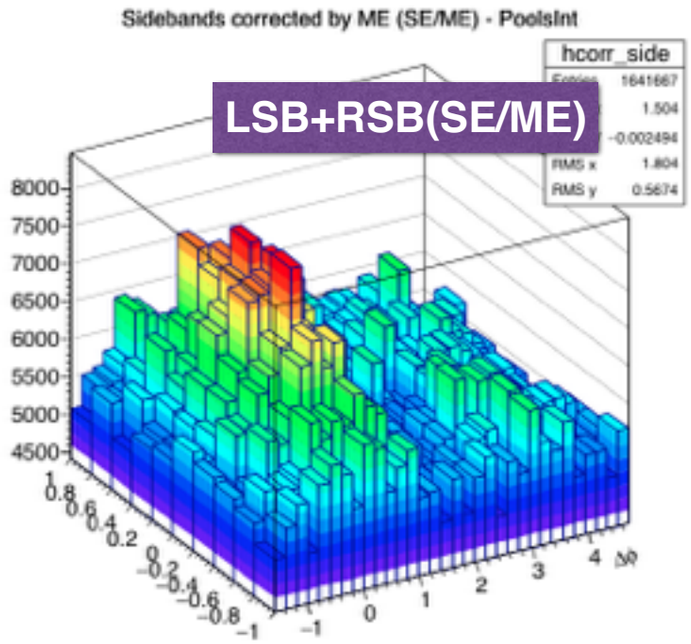


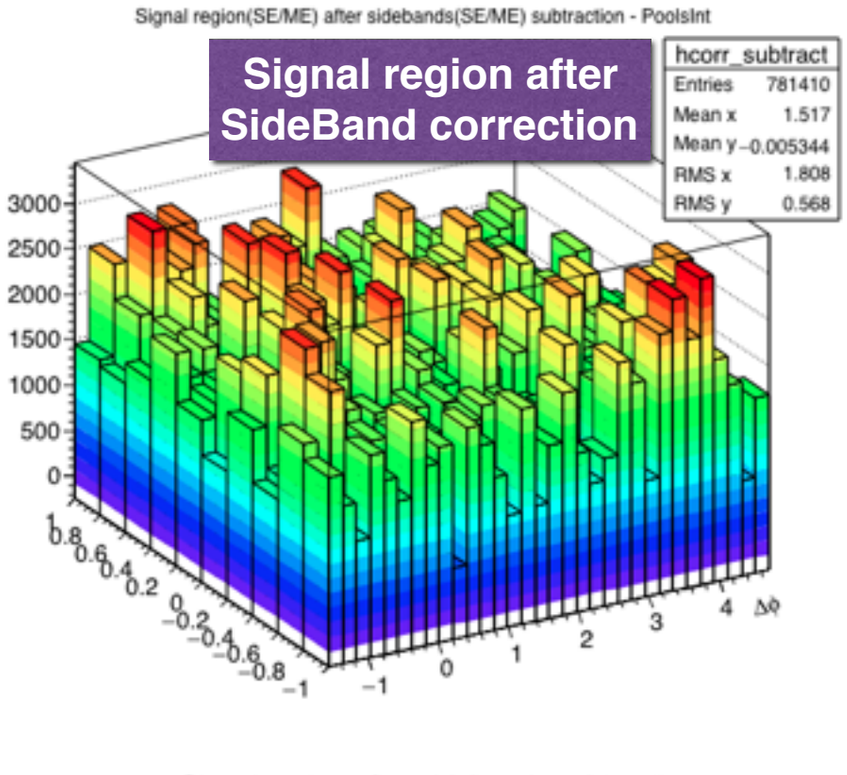
D^0 -hadron correlations:

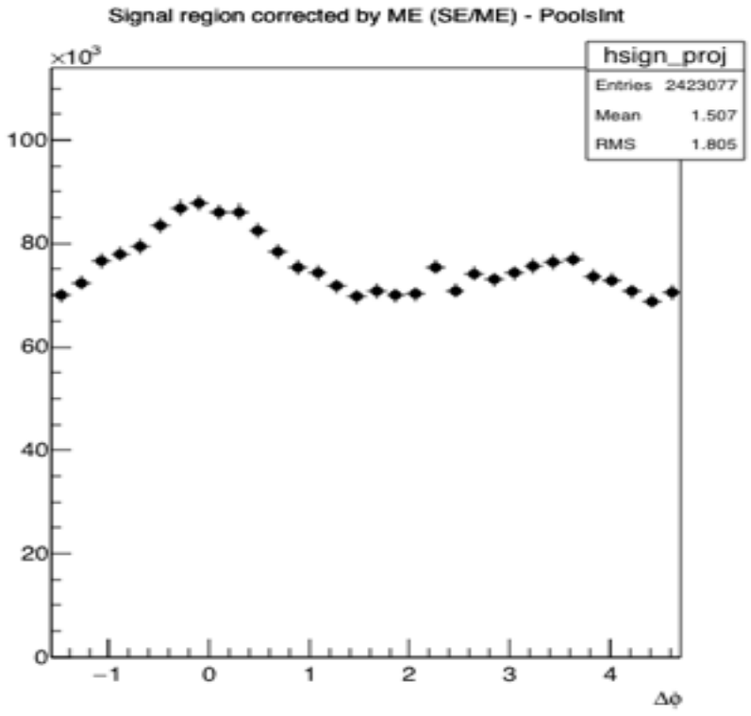
Low D^0 pT 3-5 GeV/c

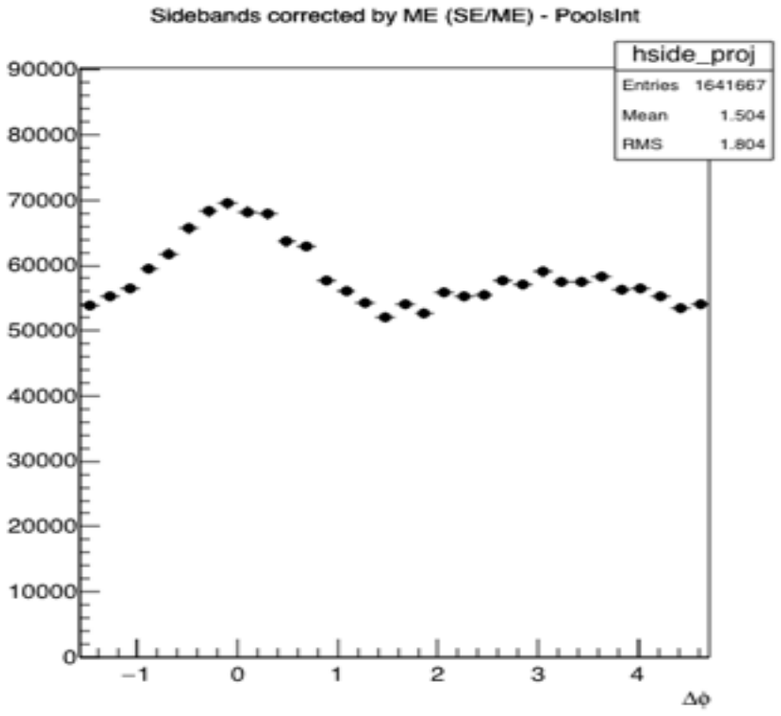
Associated track 0.3<pT<1.0

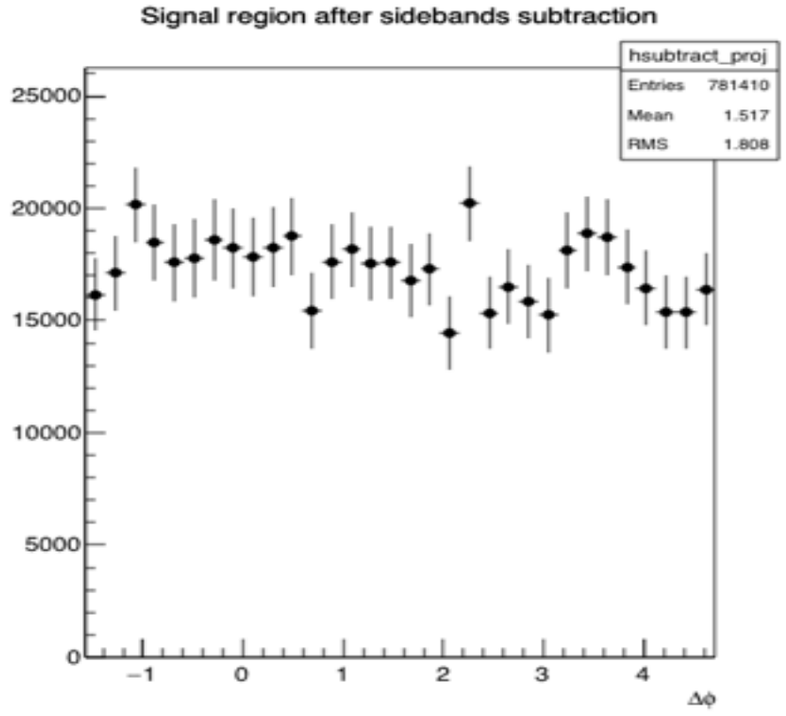








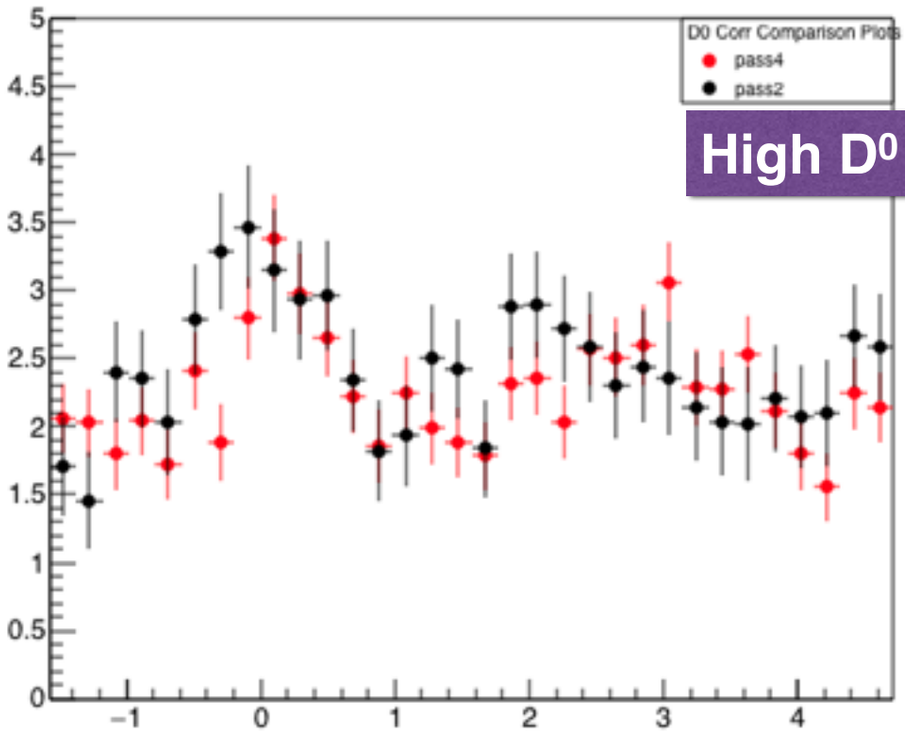


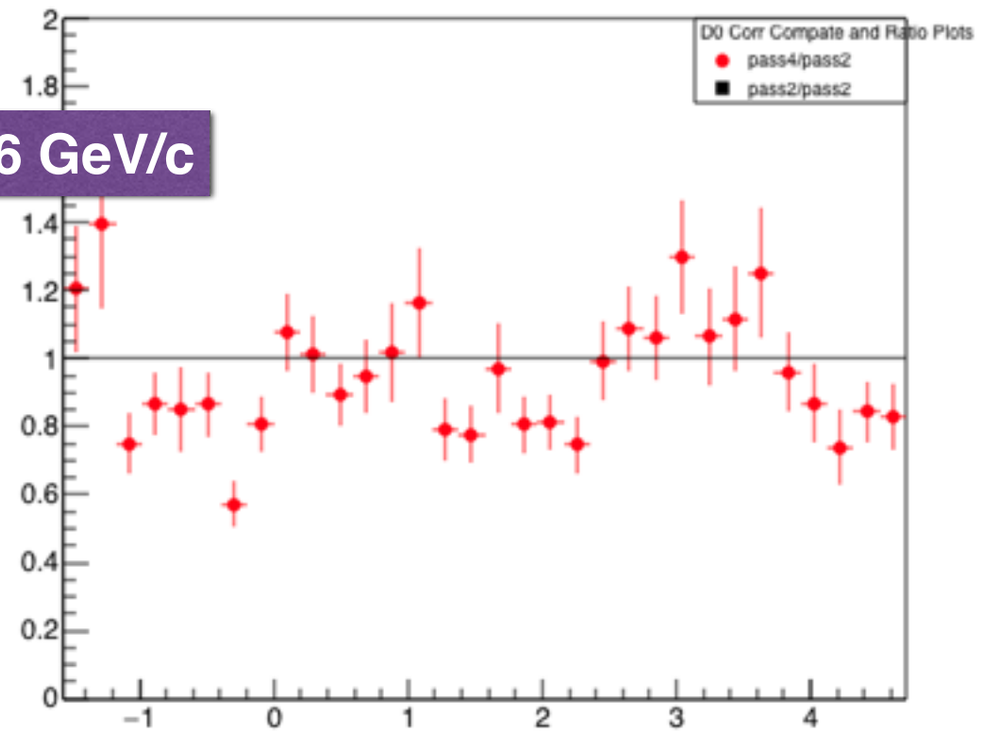


D^0 -hadron correlations: pass4 vs Pass2

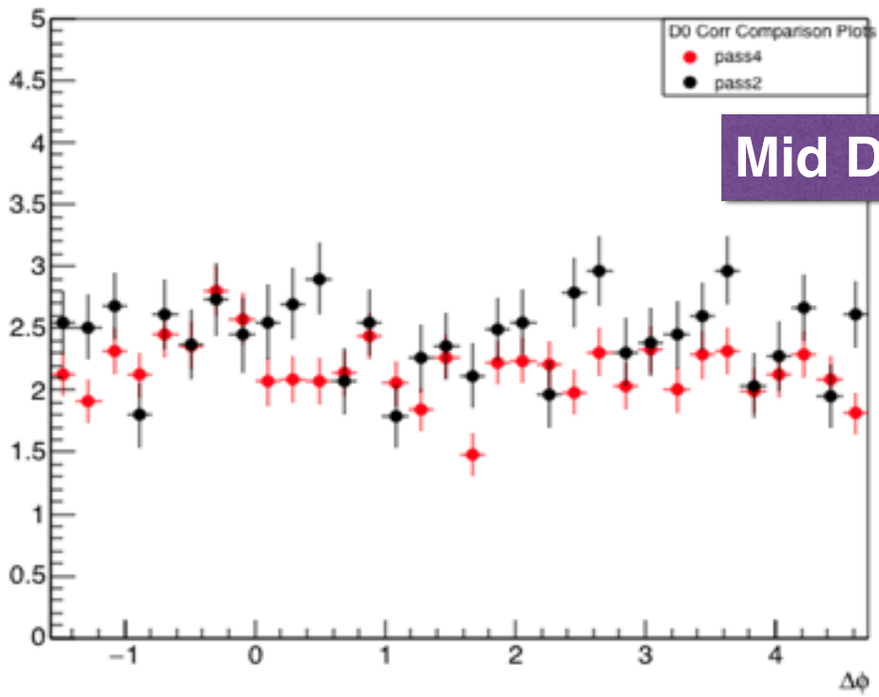
Associated track 0.3<pT<1.0

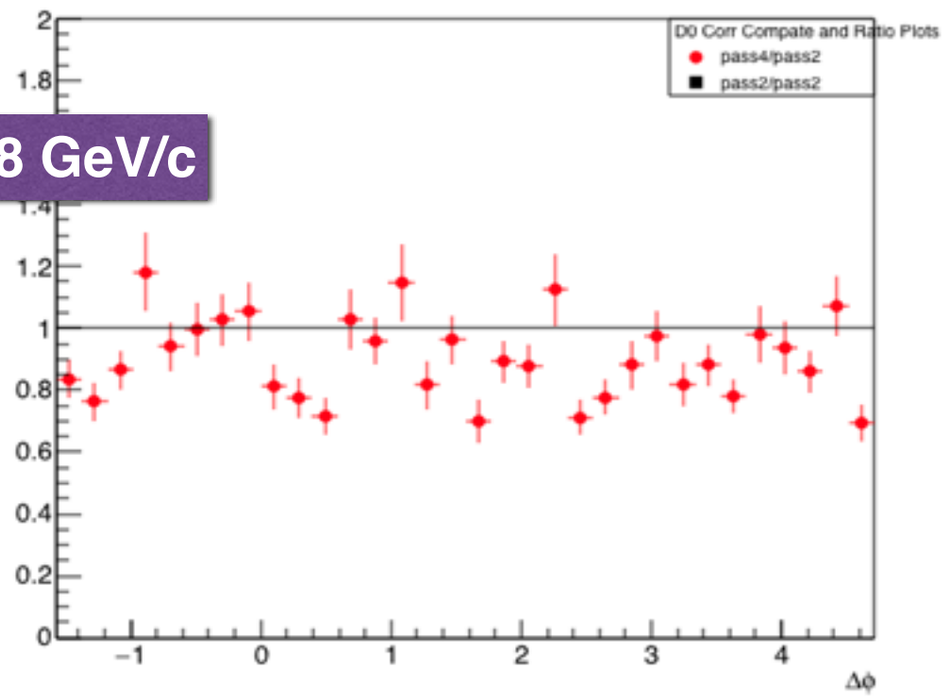
High D^0 pT 8-16 GeV/c





Mid D^0 pT 5-8 GeV/c

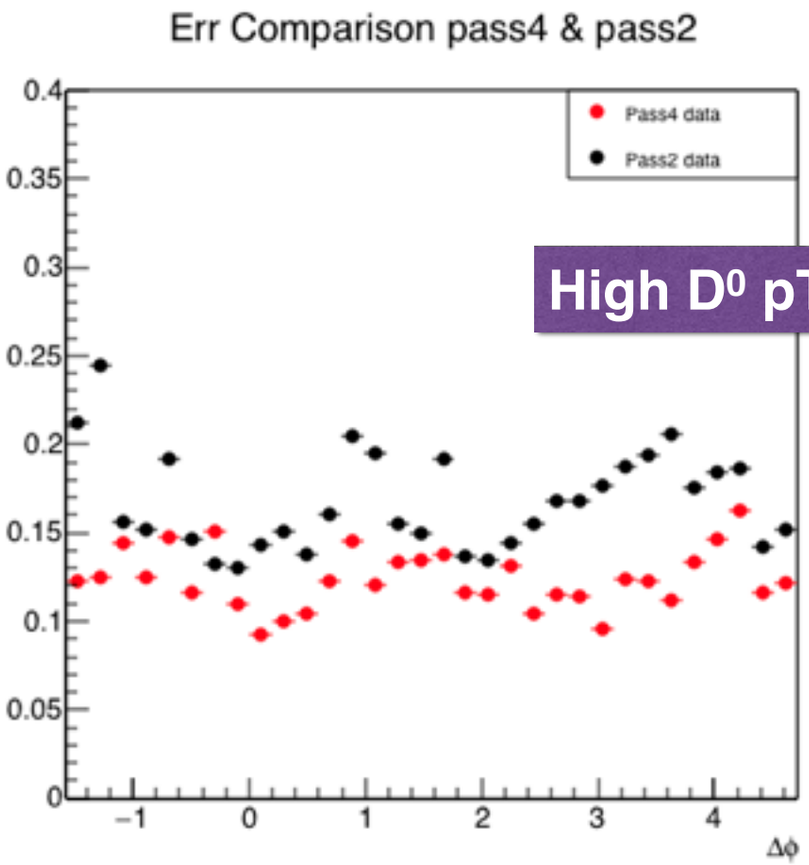


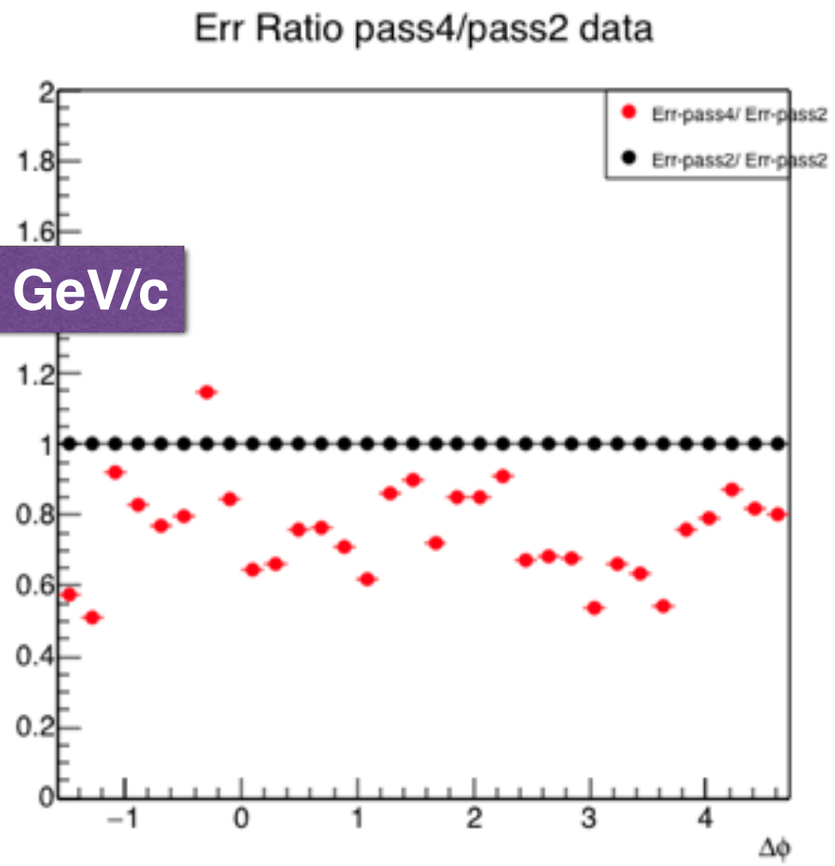


D^0 -hadron correlations: pass4 vs Pass2

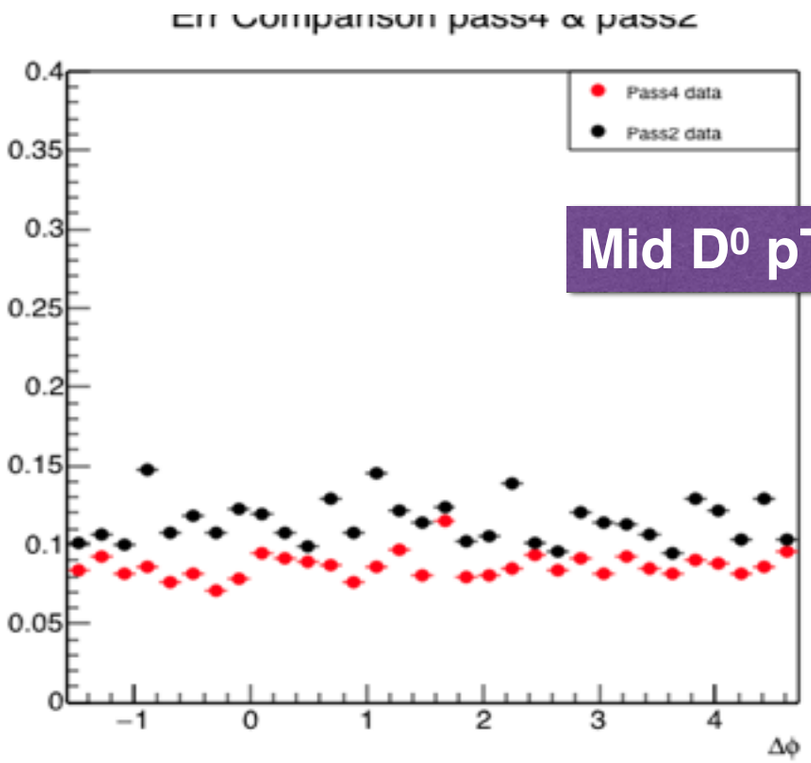
Associated track 0.3<pT<1.0

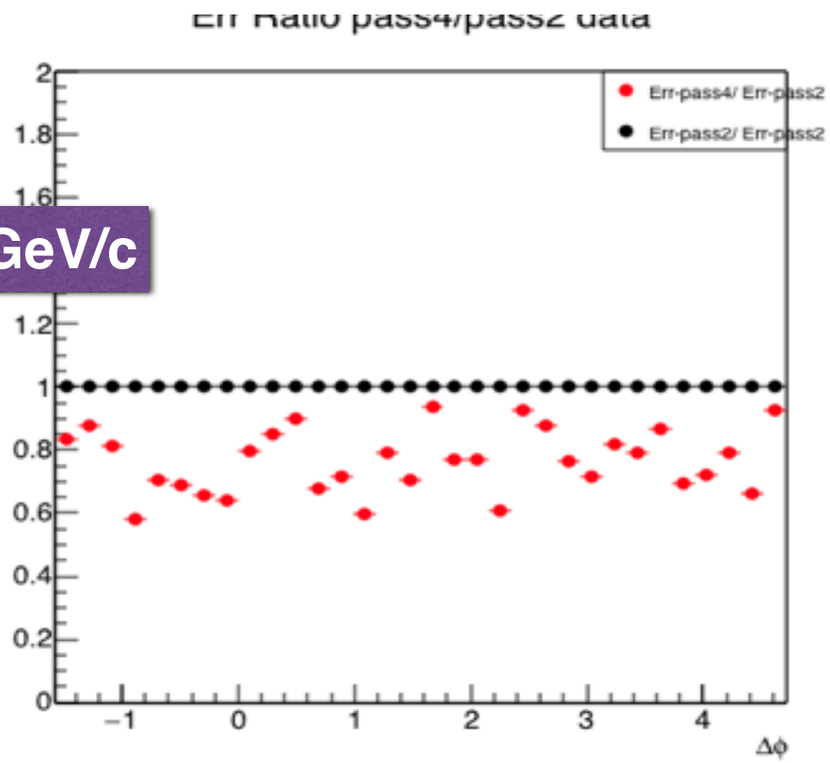
Comparison of wt. errors





High D^0 pT 8-16 GeV/c



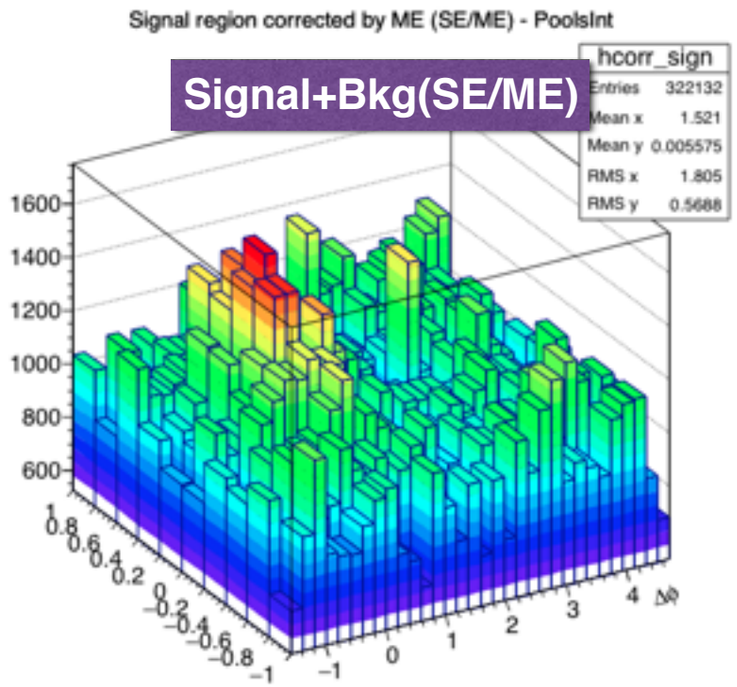


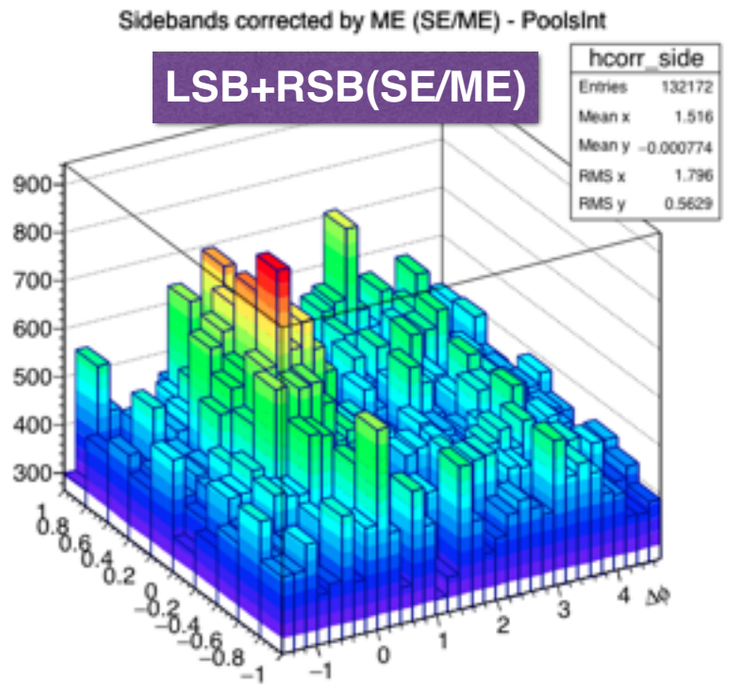
Mid D^0 pT 5-8 GeV/c

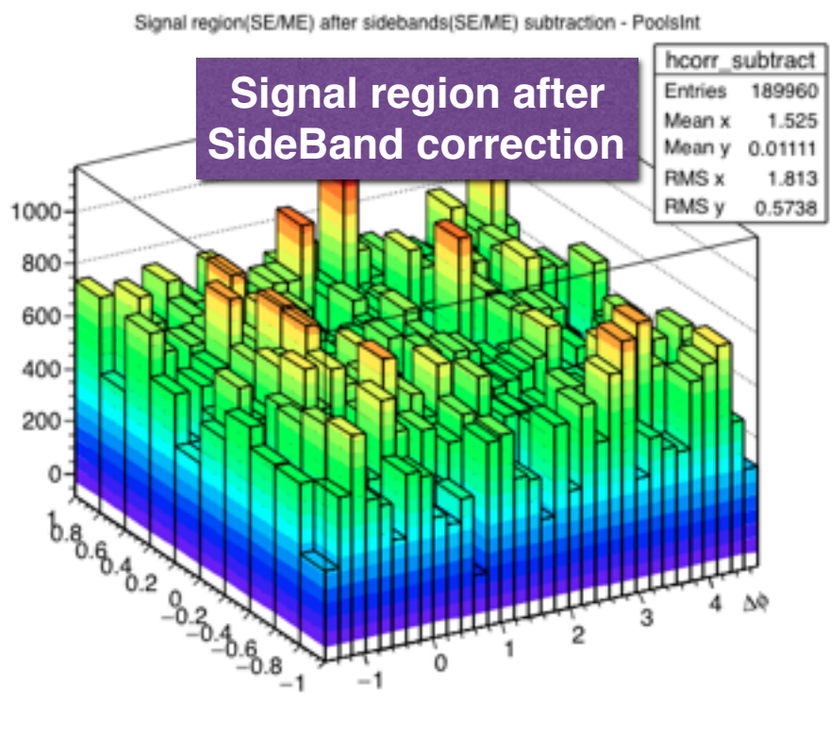
D^0 -hadron correlations:

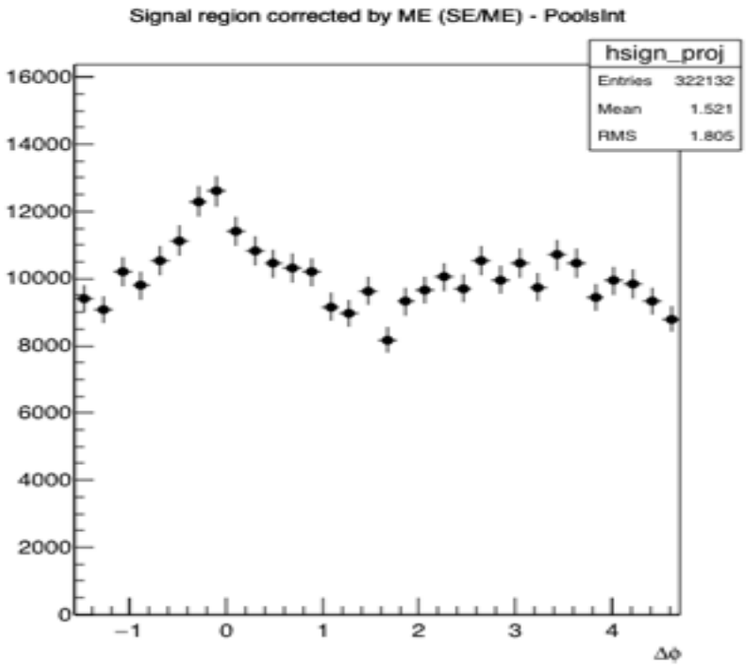
Mid D^0 pT 5-8 GeV/c

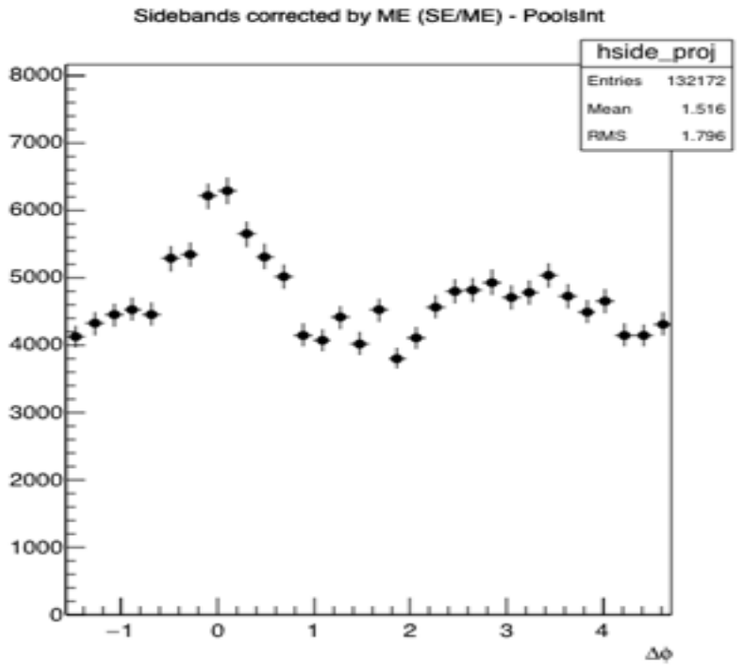
Associated track 0.3<pT<1.0

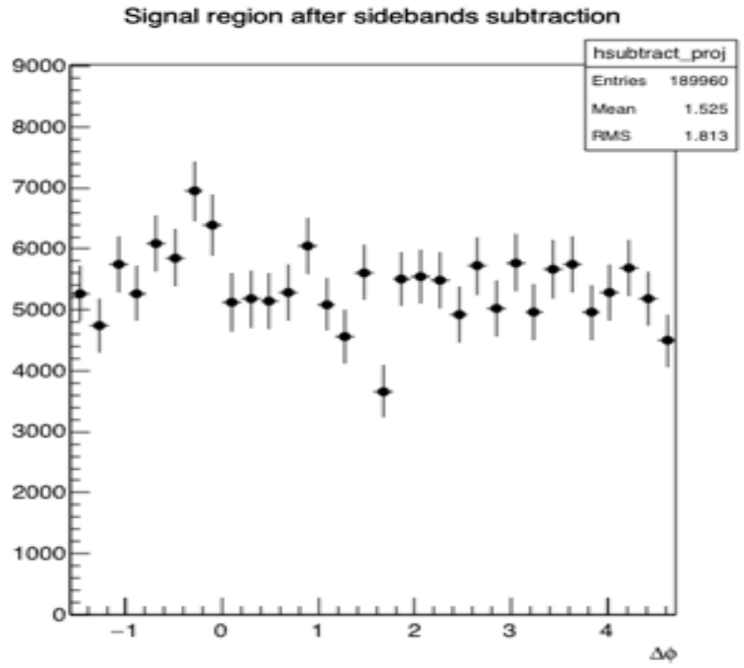










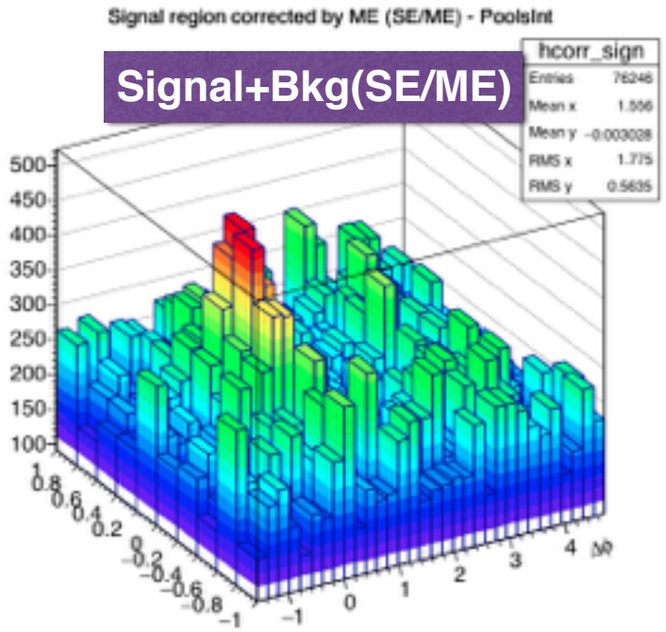


D^0 -hadron correlations:

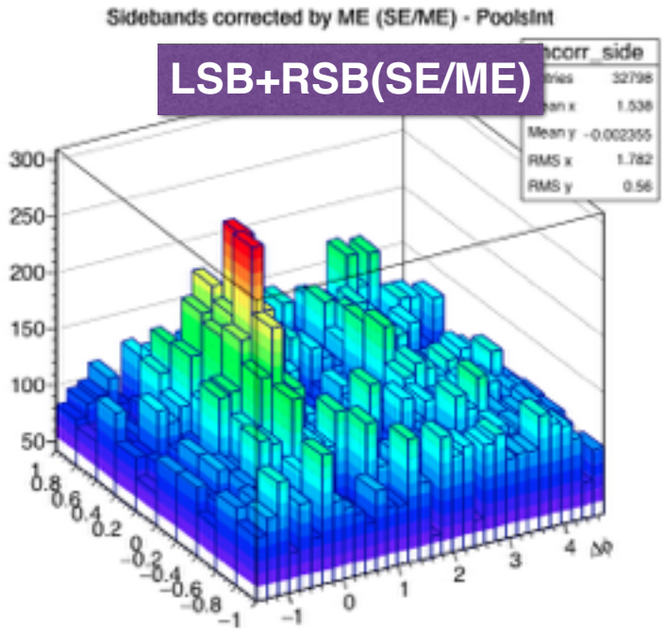
High D^0 pT 8-16 GeV/c

Associated track 0.3<pT<1.0

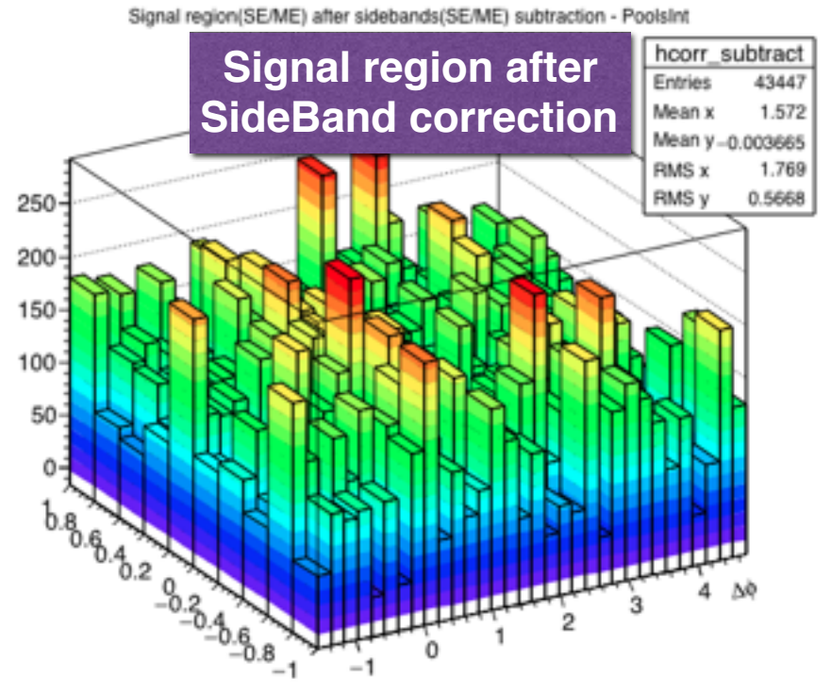
Signal+Bkg(SE/ME)

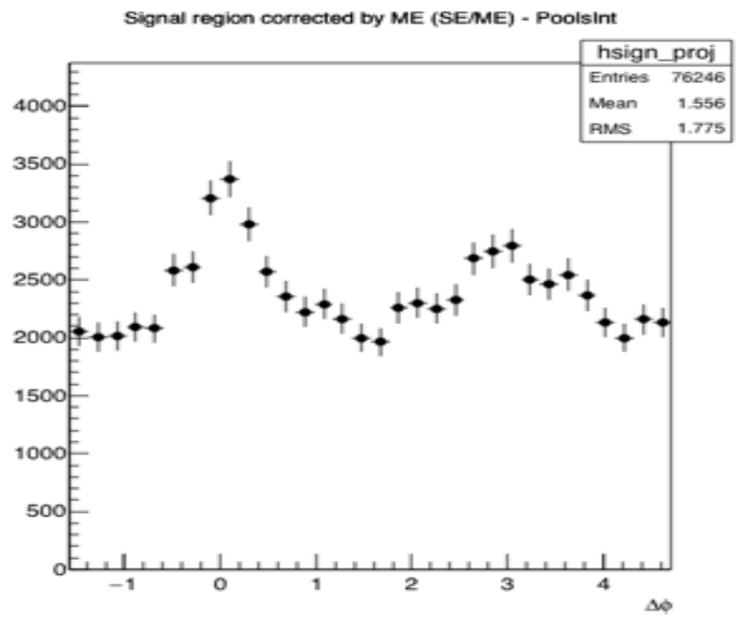


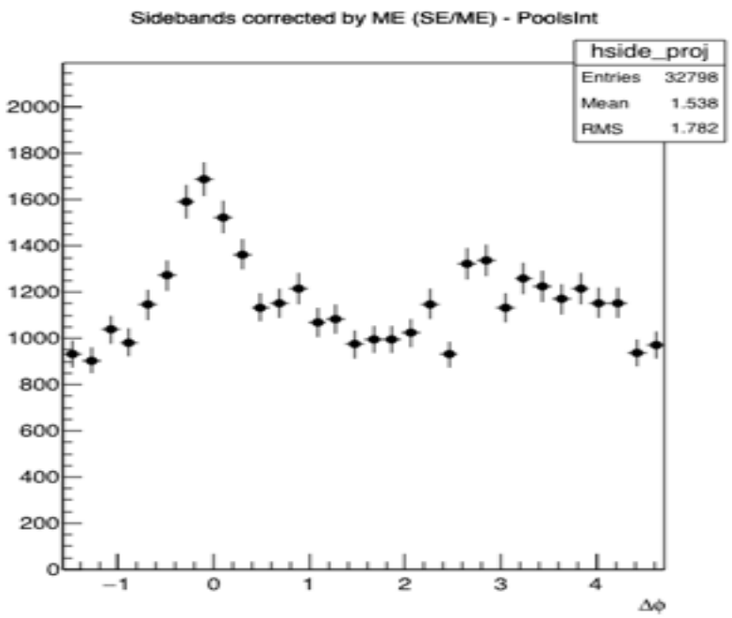
LSB+RSB(SE/ME)

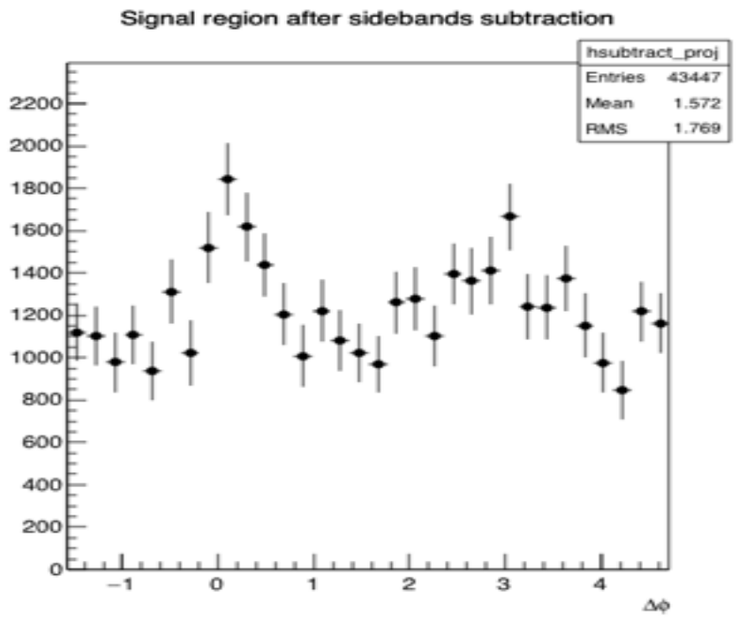


Signal region after SideBand correction





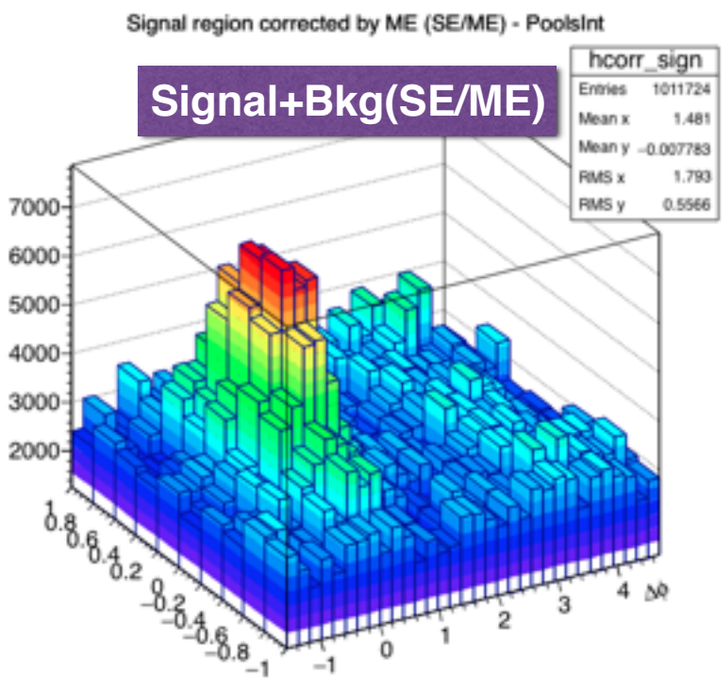


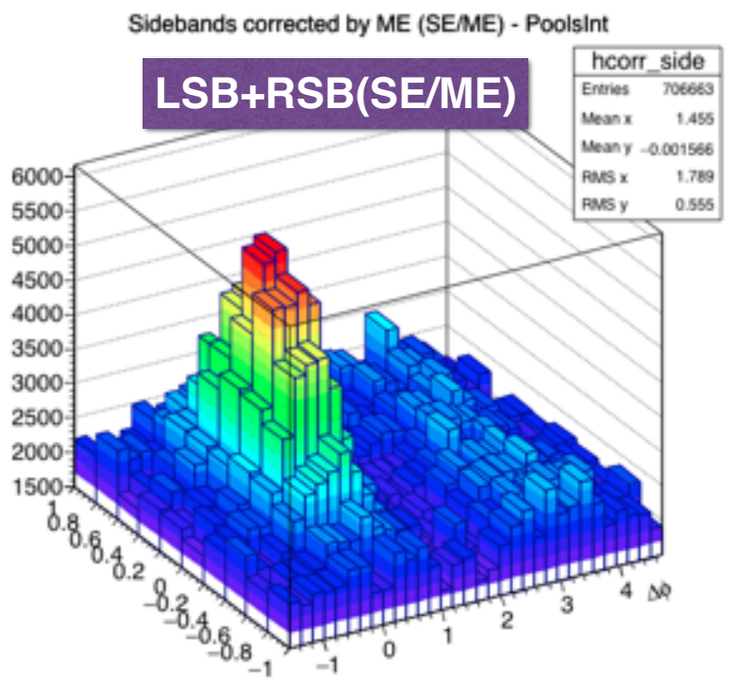


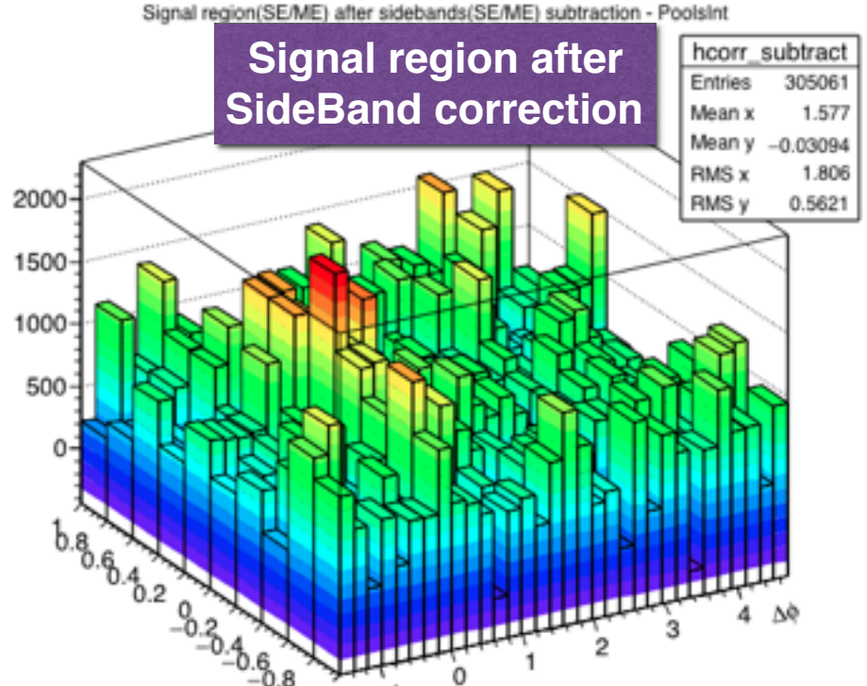
D^0 -hadron correlations:

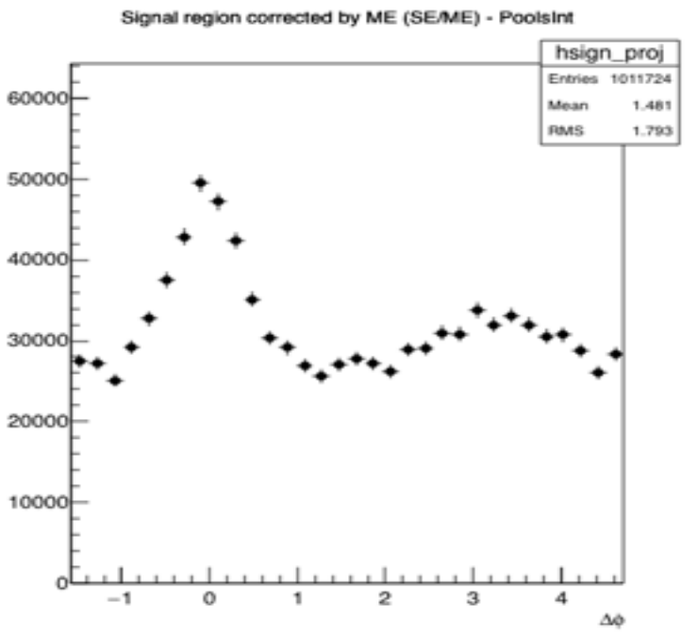
Low D^0 pT 3-5 GeV/c

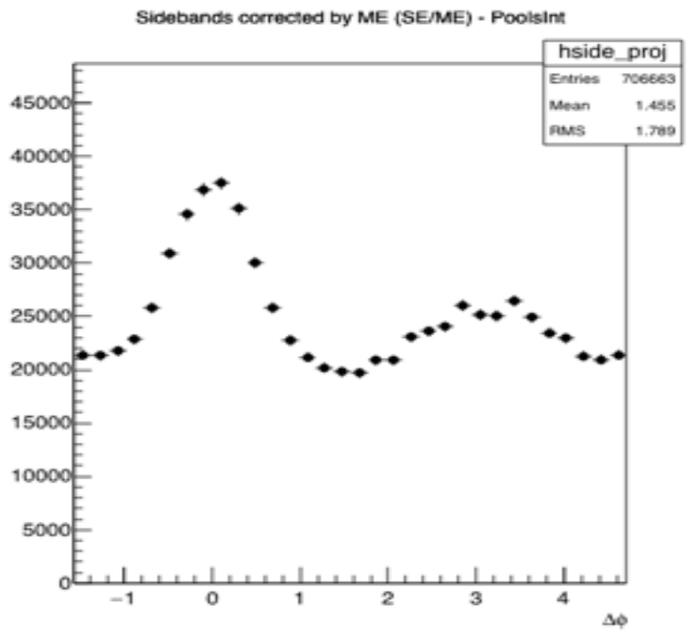
Associated track pT>1.0

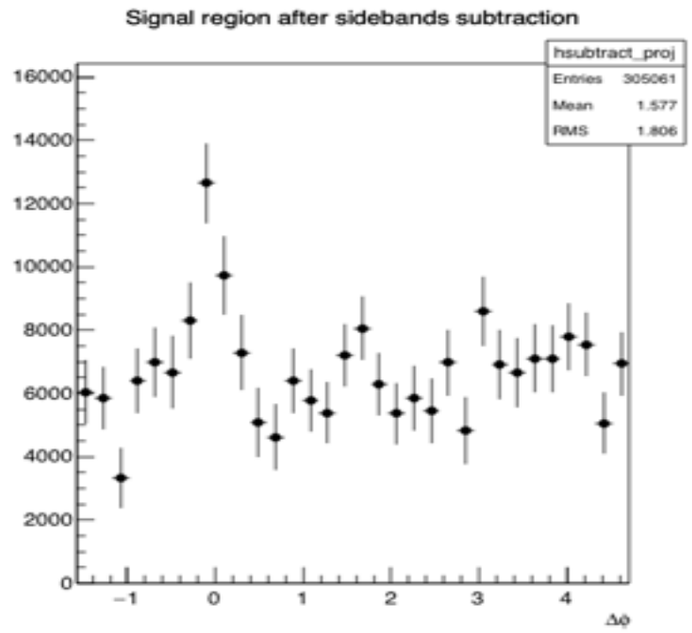








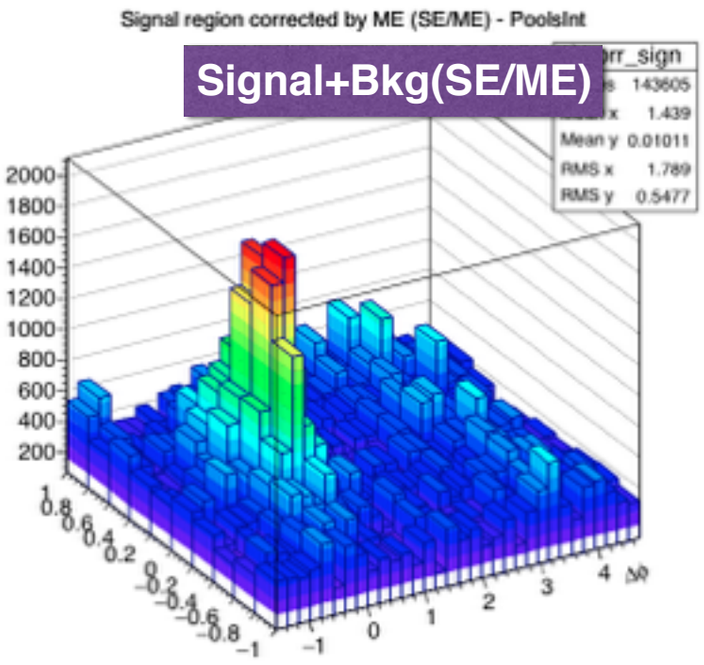


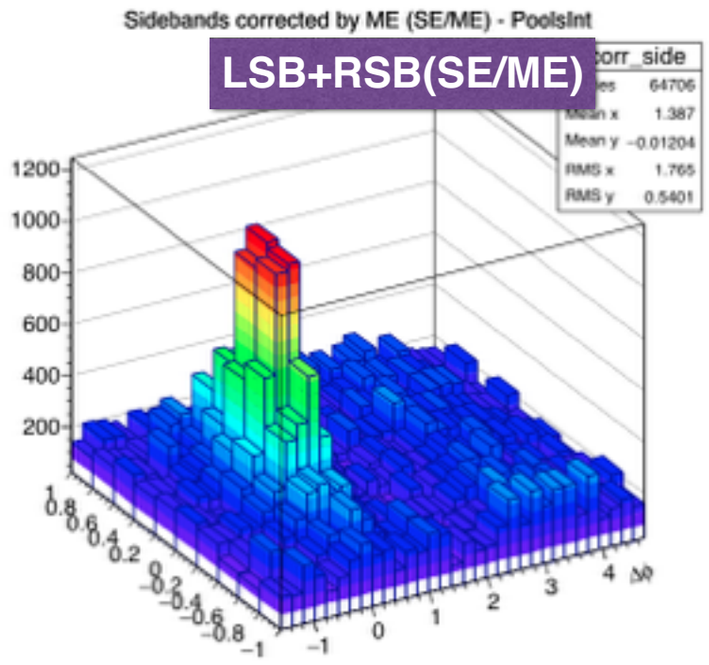


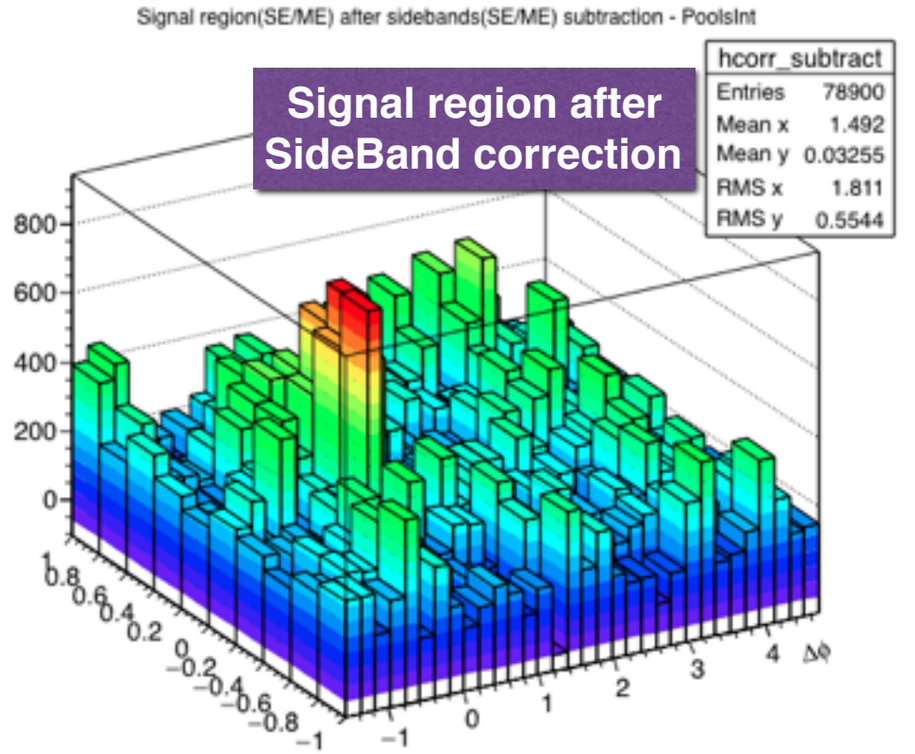
D^0 -hadron correlations:

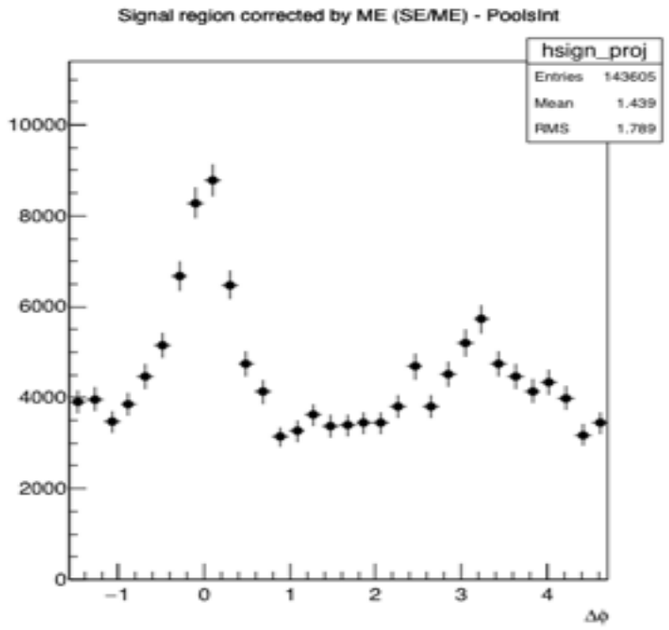
Mid D^0 pT 5-8 GeV/c

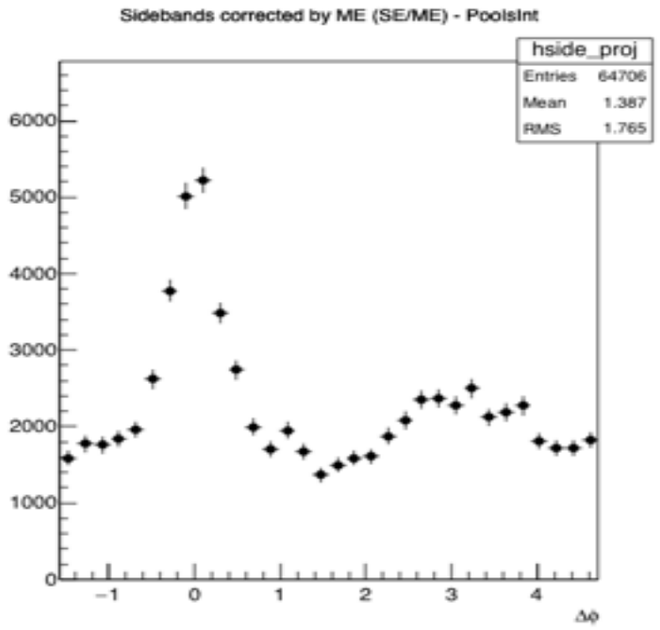
Associated track pT>1.0

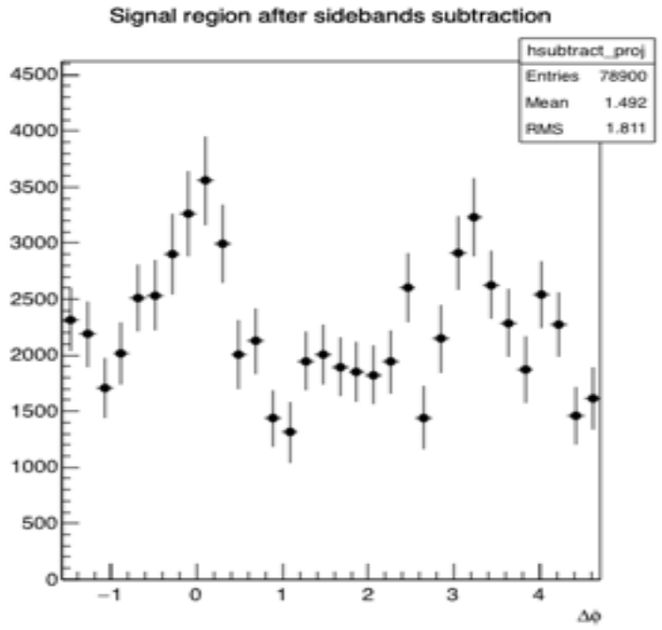










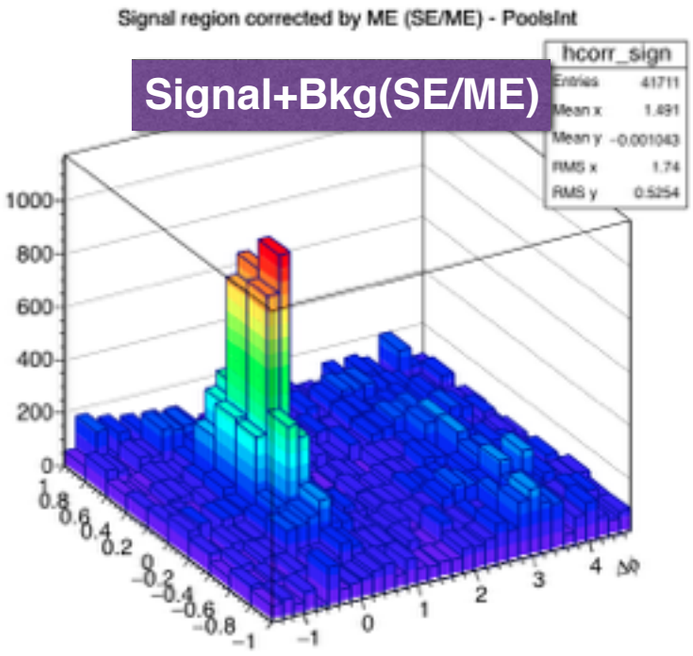


D^0 -hadron correlations:

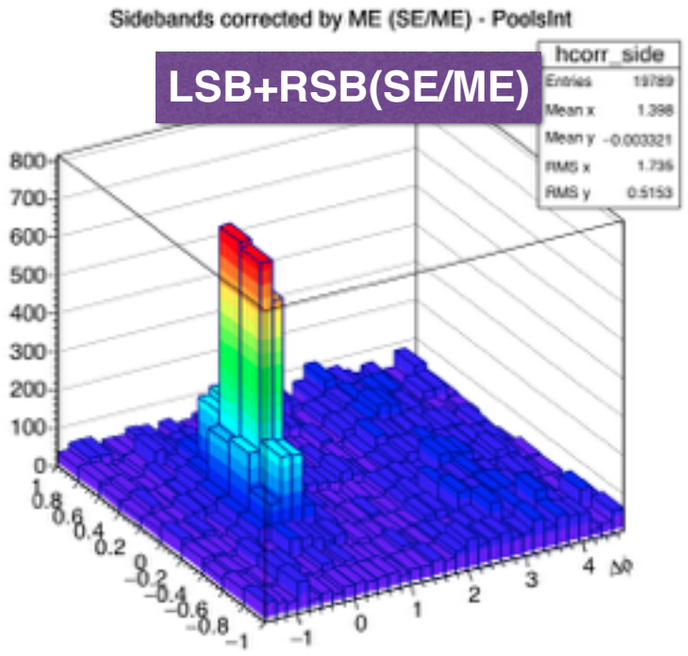
High D^0 pT 8-16 GeV/c

Associated track pT>1.0

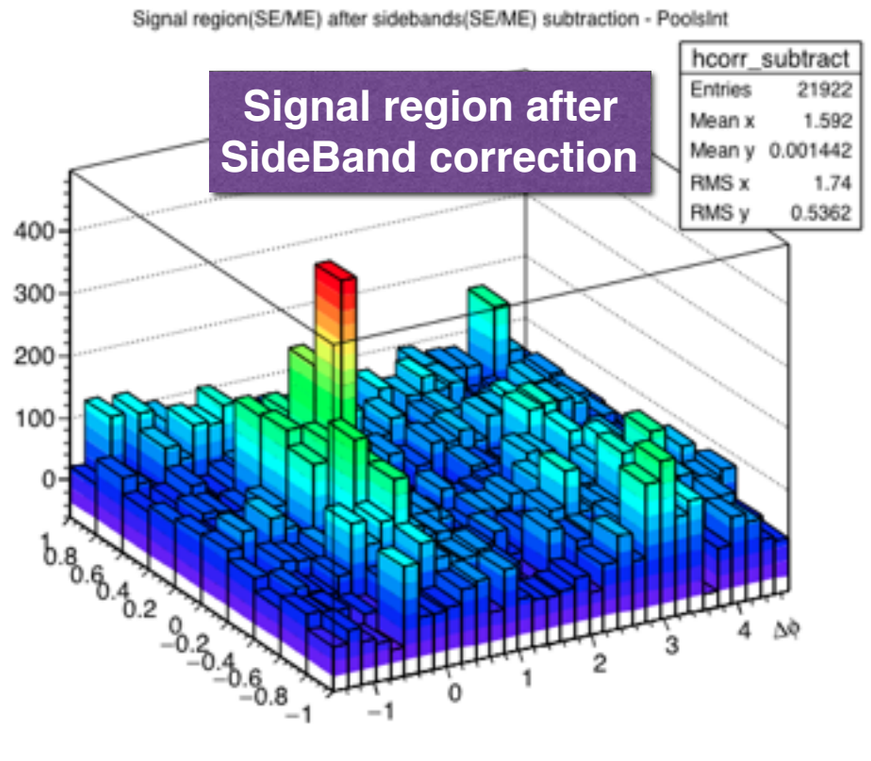
Signal+Bkg(SE/ME)

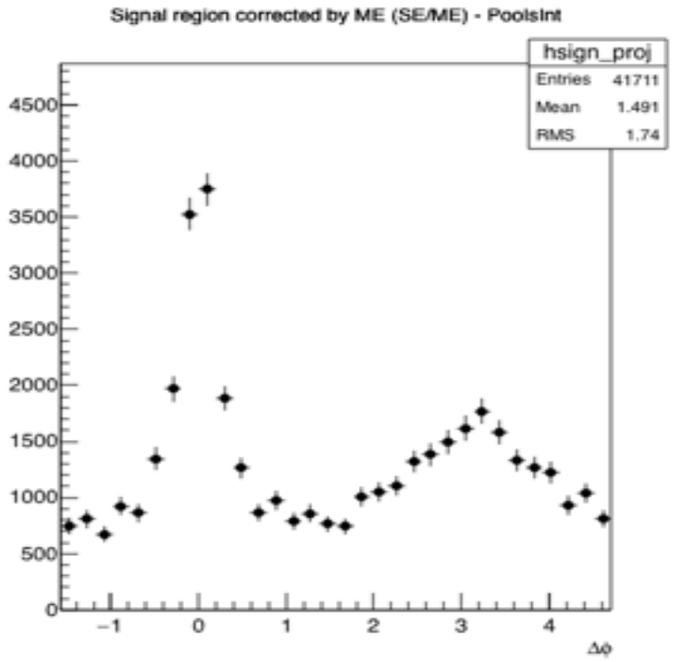


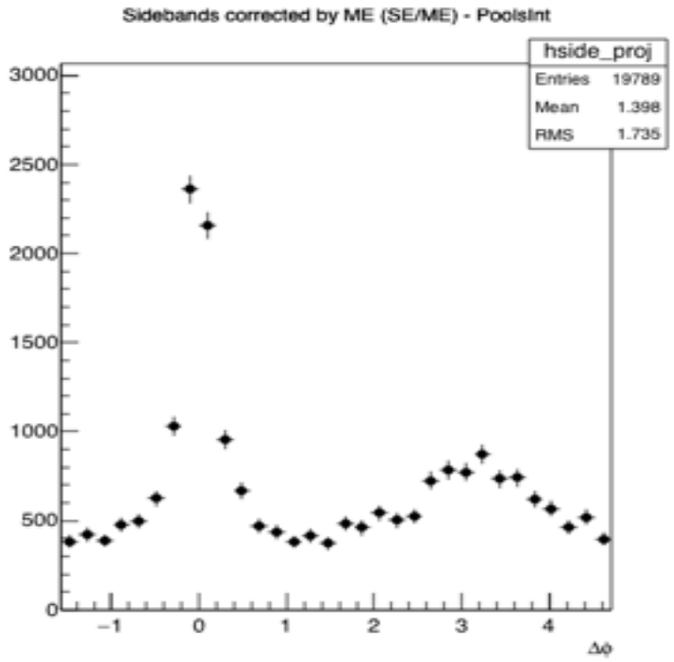
LSB+RSB(SE/ME)

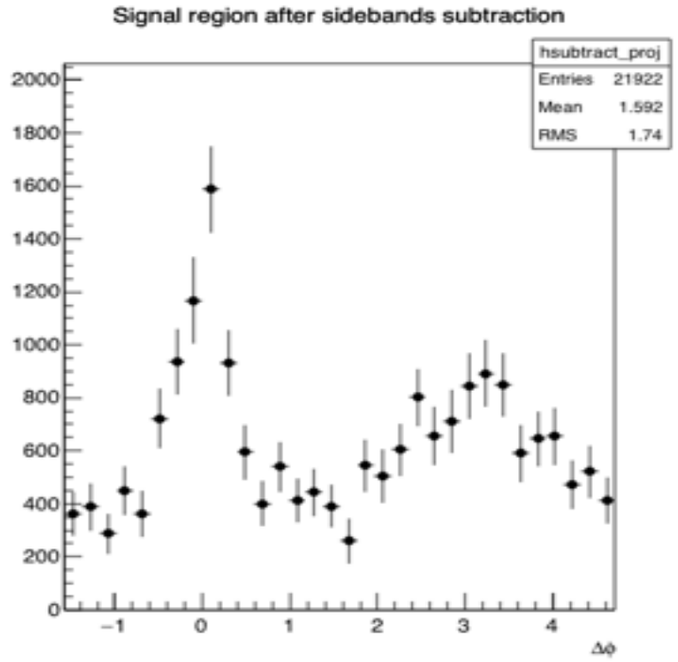


Signal region after SideBand correction





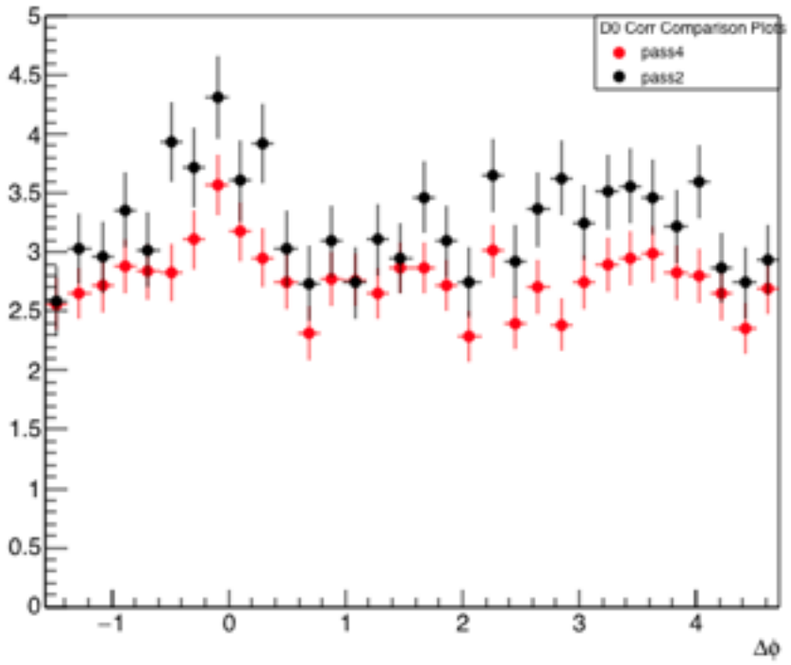


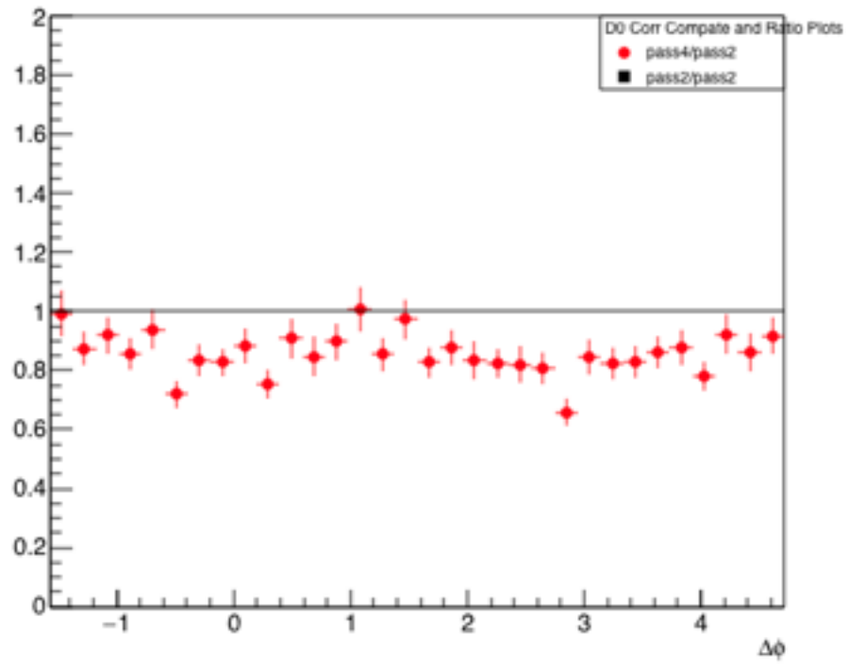


D^0 -hadron correlations: pass4 vs Pass2

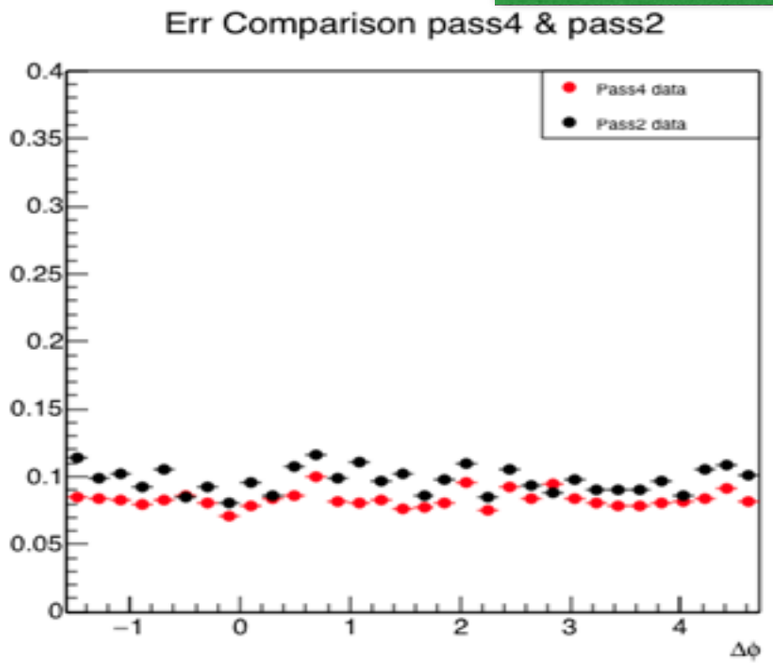
Associated track pT>0.3

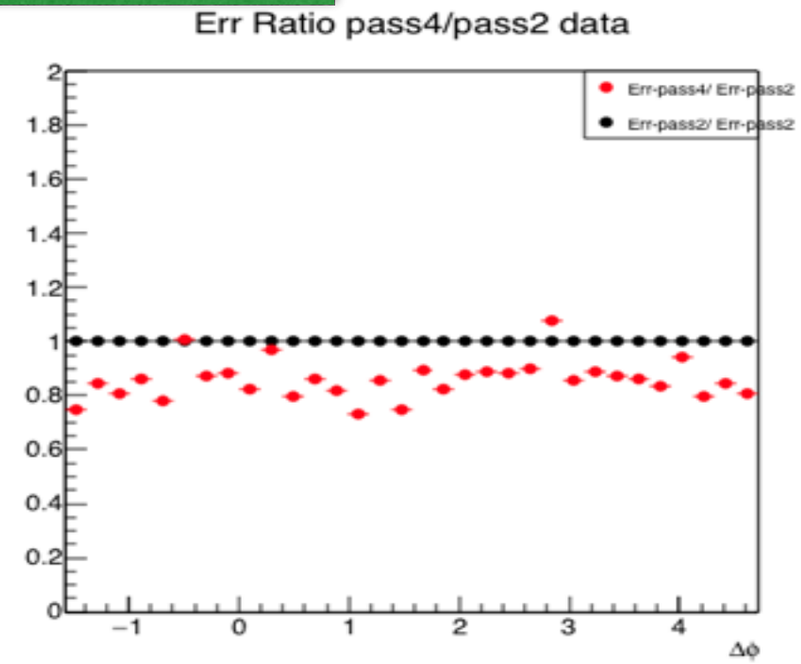
Low D^0 pT 3-5 GeV/c





Comparison of wt. errors



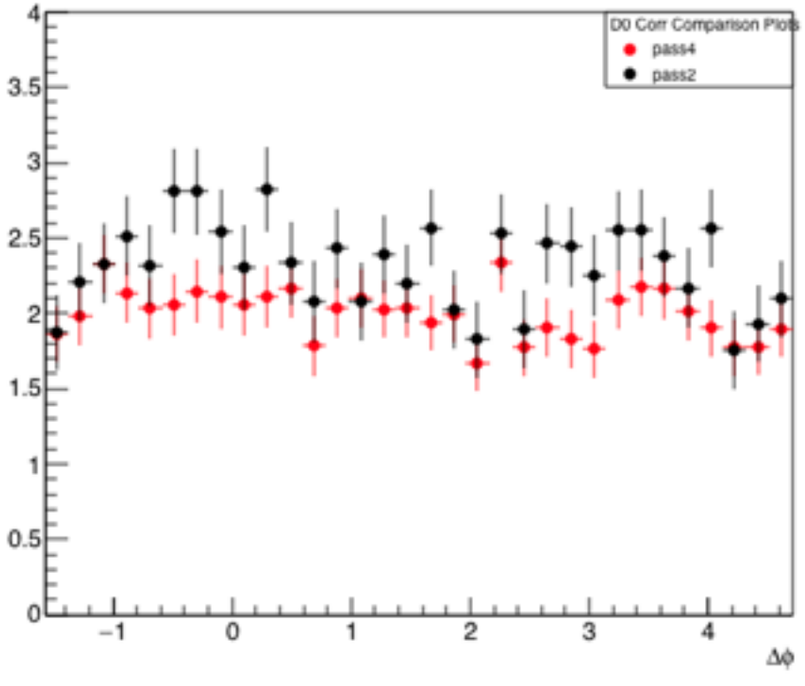


D^0 -hadron correlations: pass4 vs Pass2

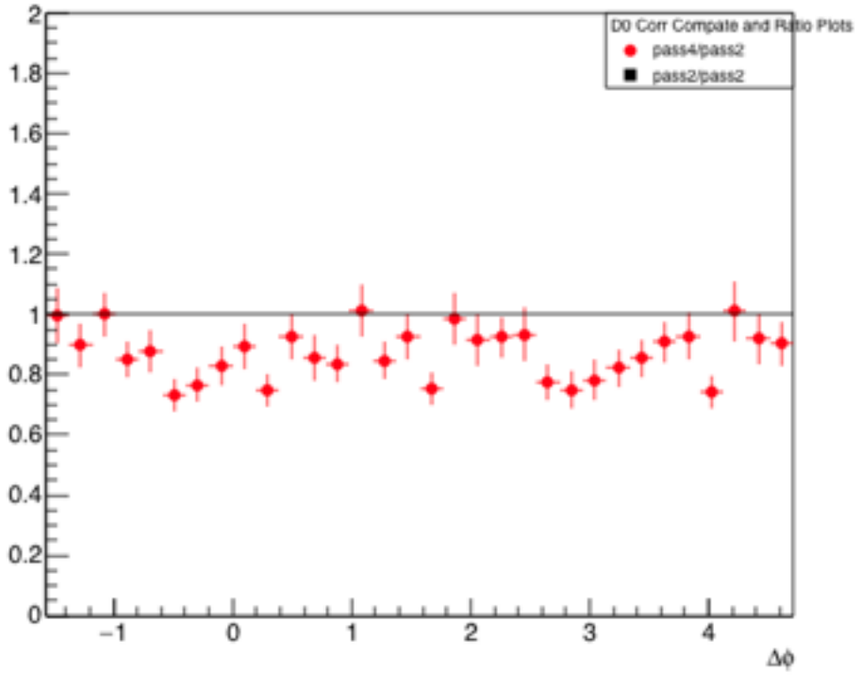
Associated track 0.3<pT<1.0

Low D^0 pT 3-5 GeV/c

Comparison pass4 & pass2

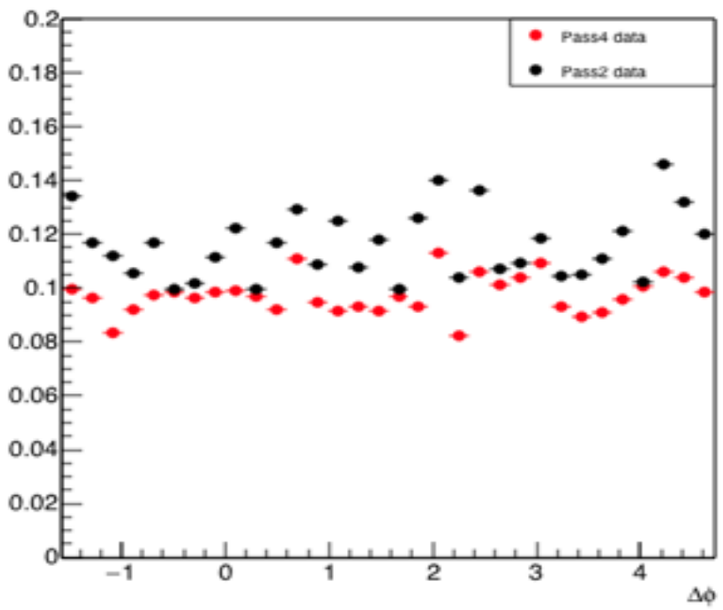


Ratio pass4 & pass2

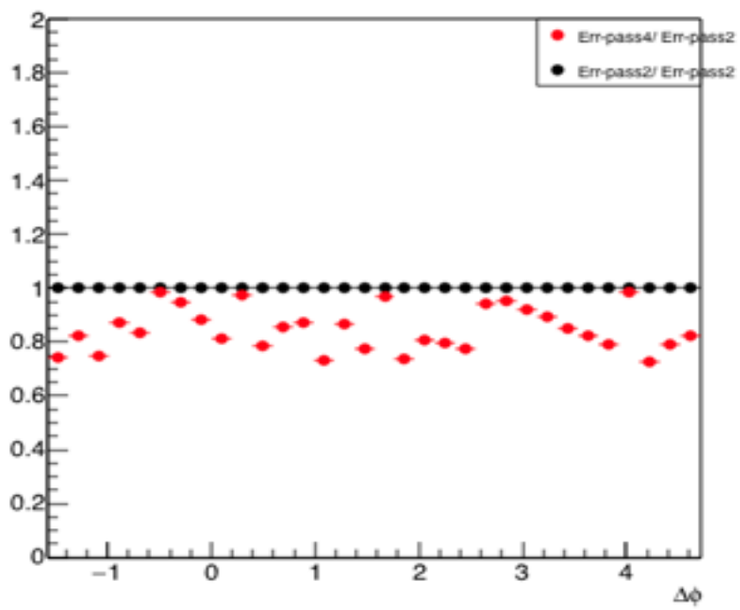


Comparison of wt. errors

Err Comparison pass4 & pass2



Err Ratio pass4/pass2 data

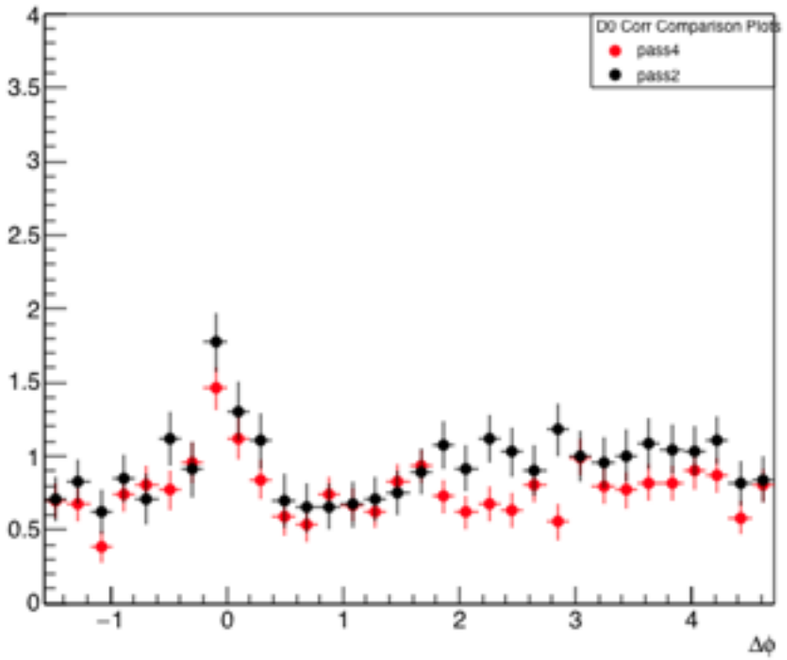


D^0 -hadron correlations: pass4 vs Pass2

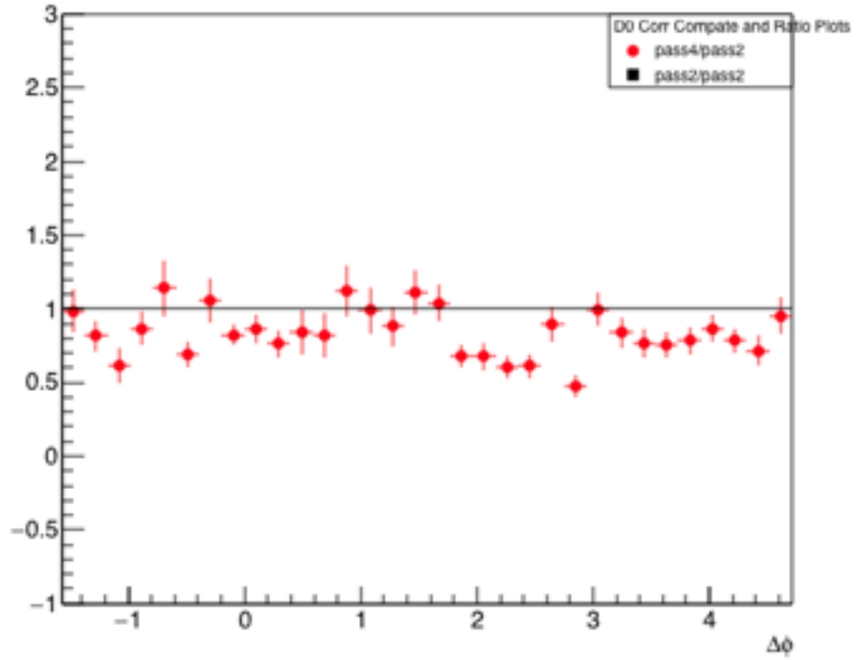
Associated track pT>1.0

Low D^0 pT 3-5 GeV/c

Comparison pass4 & pass2

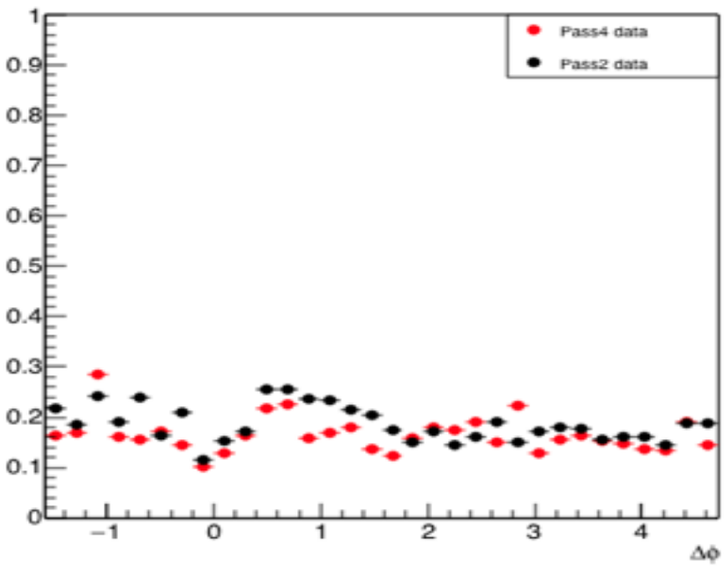


Ratio pass4 & pass2

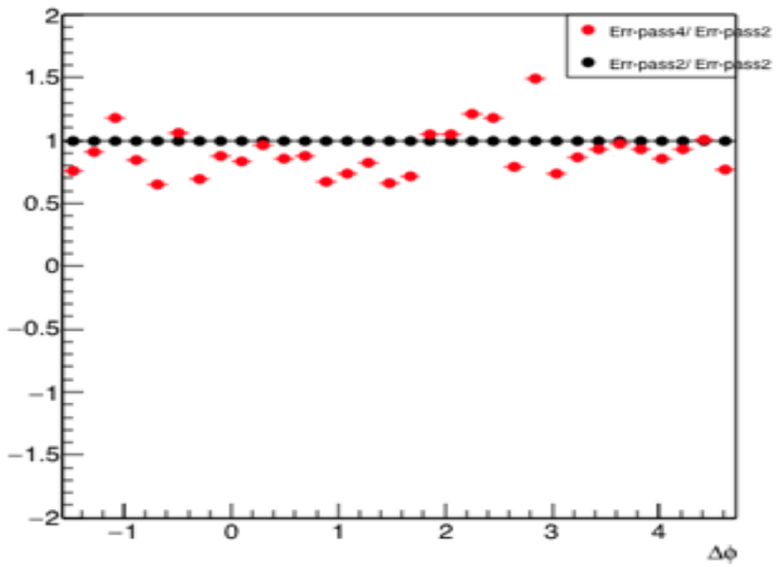


Comparison of wt. errors

Err Comparison pass4 & pass2



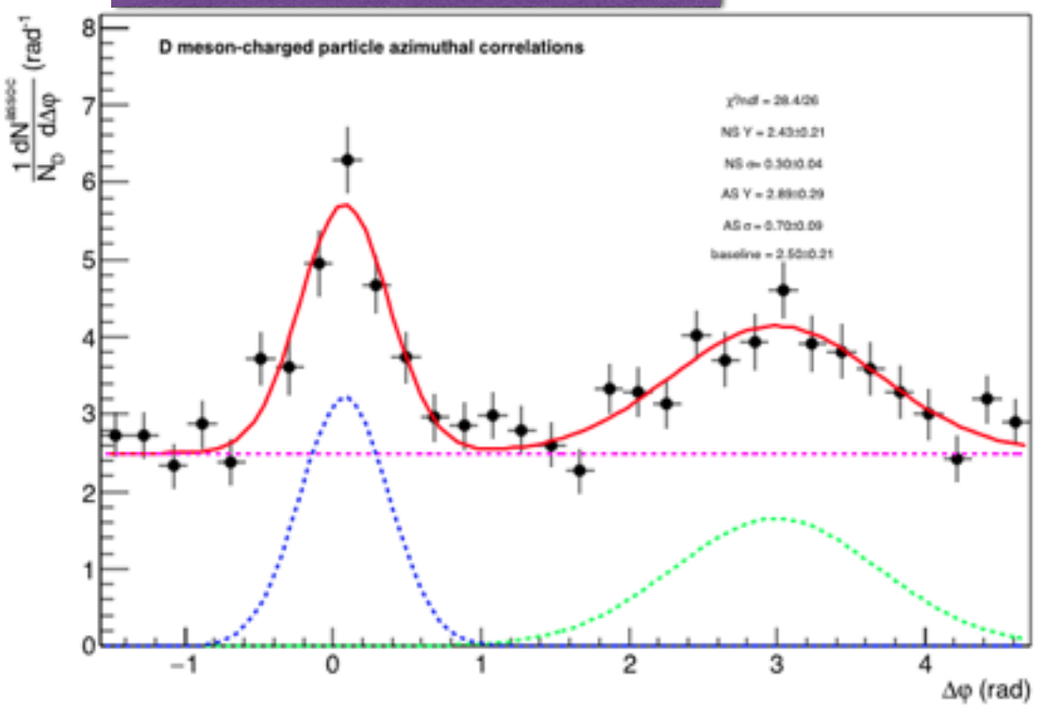
Err Ratio pass4/pass2 data



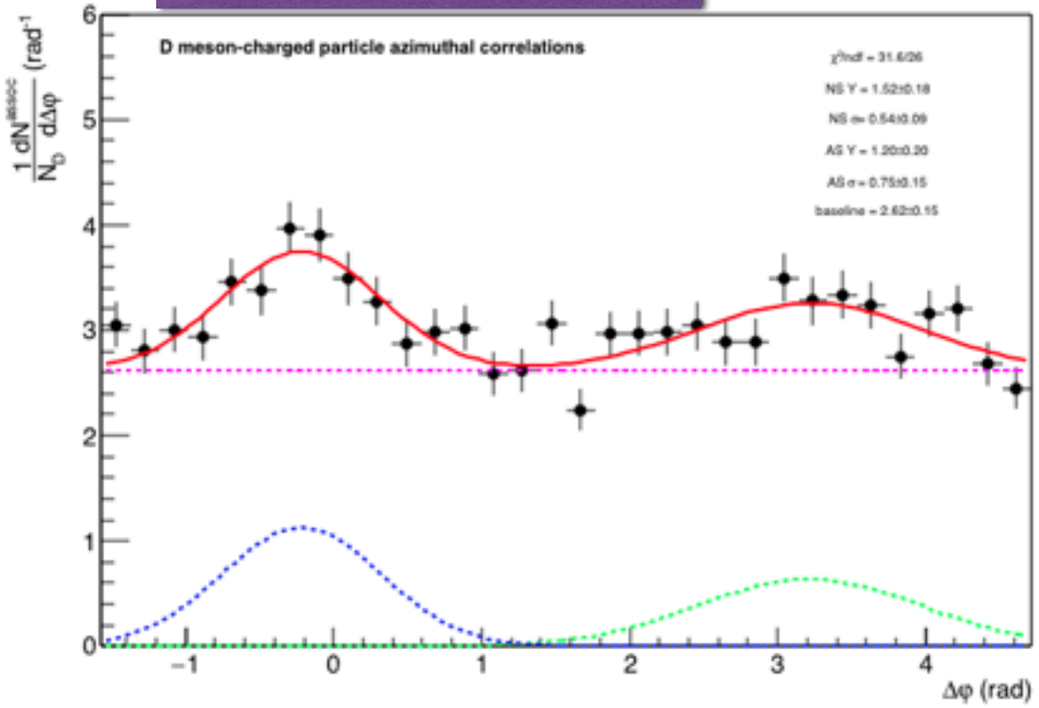
D^0 -hadron correlations: sample fitting

Associated track pT>0.3

High D^0 pT 8-16 GeV/c



Mid D^0 pT 5-8 GeV/c



Low D^0 pT 3-5 GeV/c