

$R(D)$ and $R(D^*)$ Analysis

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University of Mississippi

17th Semi-tauonic Meeting

Tuesday, Dec. 19th, 2017

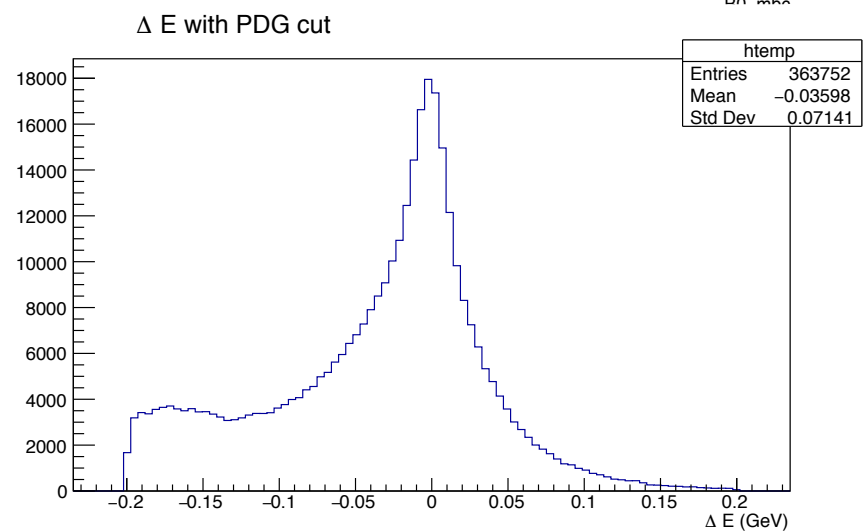
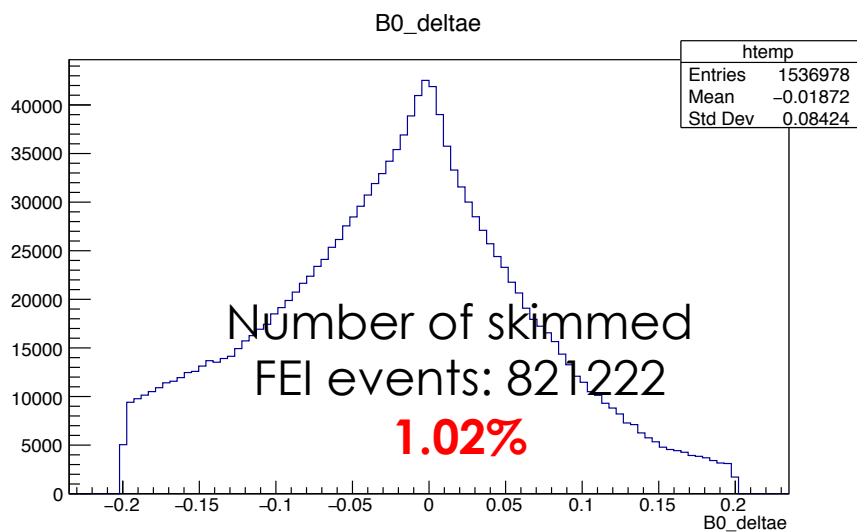
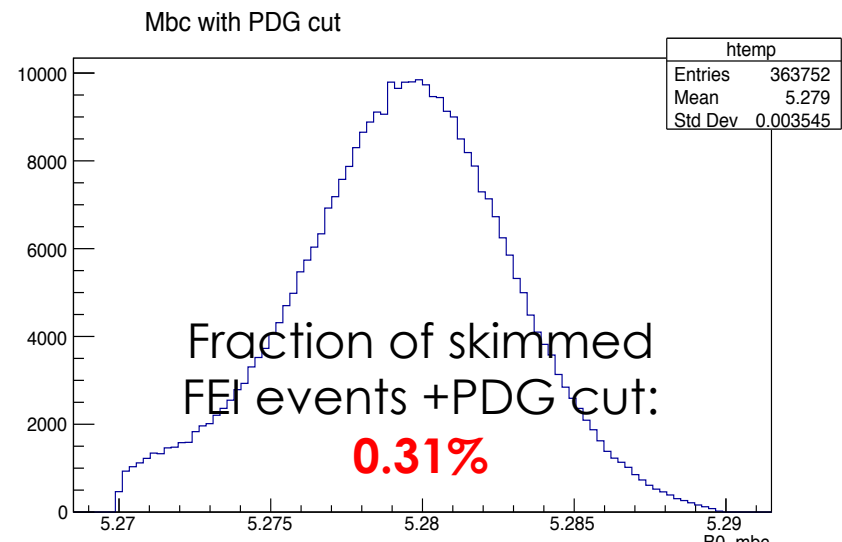
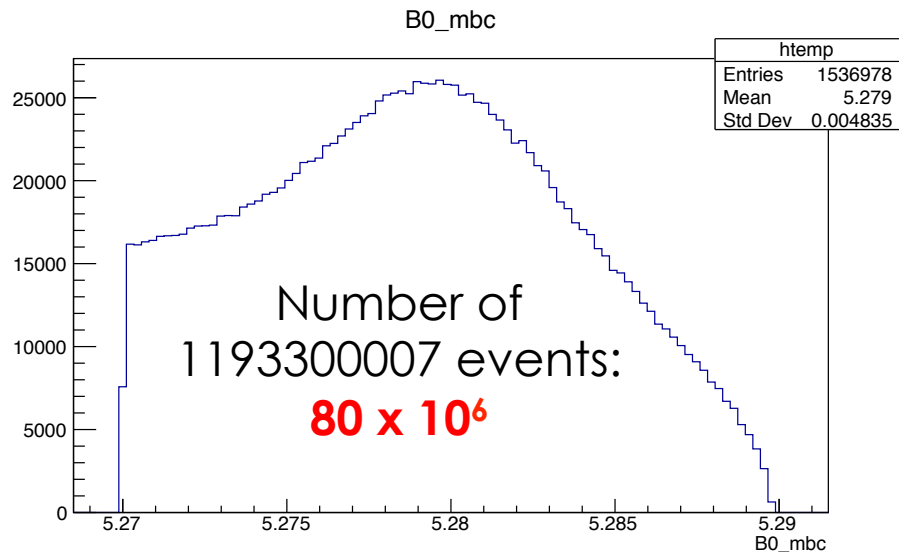


MC samples + FEI

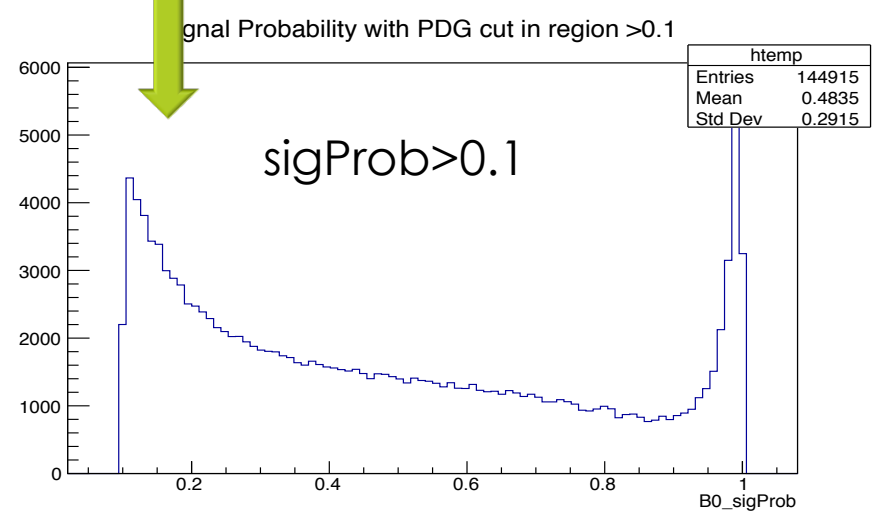
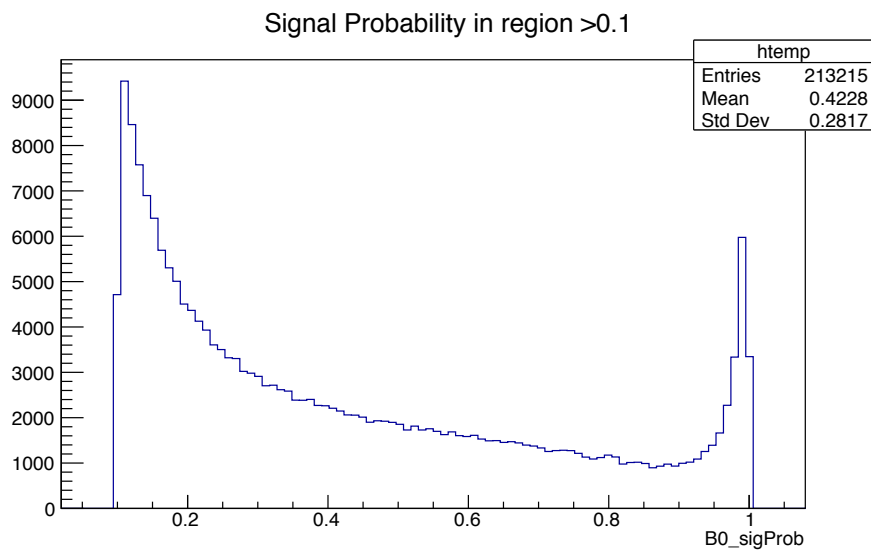
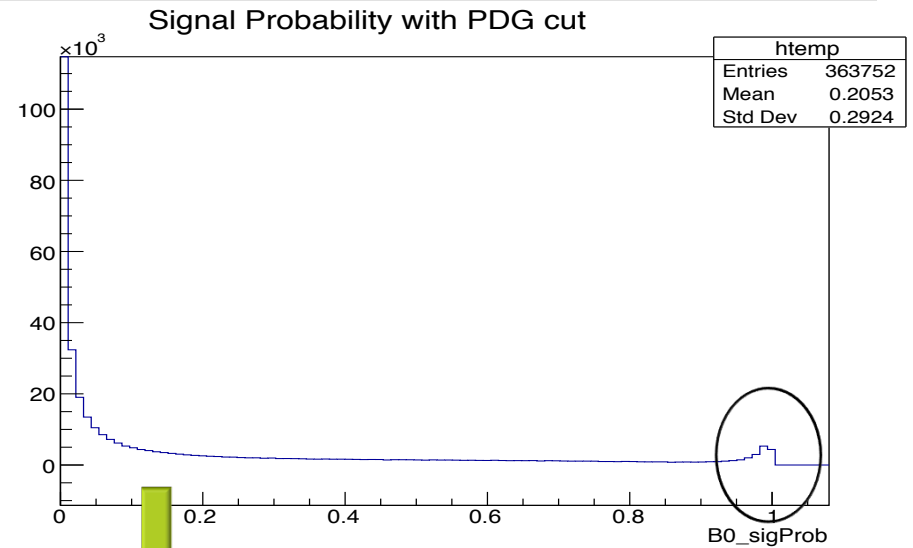
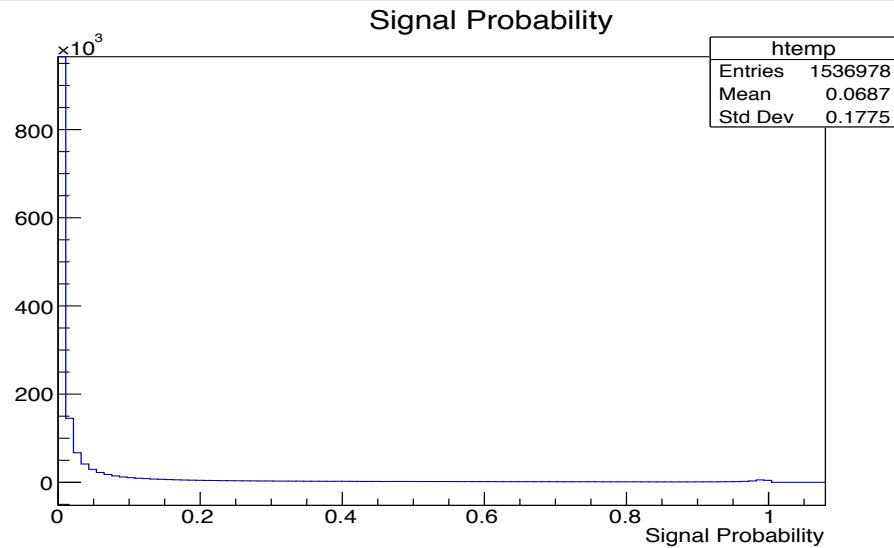
- New cocktail MC samples are ready and have been skimmed with FEI:
 - [https://confluence.desy.de/display/BI/Data+Production+MC9 - DataProductionMC9-PhaseIIY\(4S\)signalsamples](https://confluence.desy.de/display/BI/Data+Production+MC9+DataProductionMC9-PhaseIIY(4S)signalsamples)
 - Currently being skimmed with FEI on the grid:
- FEI skimmed samples of MC9 Bd_Xctaunu and Bu_Xctaunu signal MC is available on the grid:
 - /belle/user/rachac/dplustaunu05_hadronicSkim1_BGx1 →CHARGED
 - /belle/user/rachac/dplustaunu07_hadronicSkim1_BGx1 →CHARGED
 - /belle/user/rachac/dplustaunu08_hadronicSkim1_BGx1 →CHARGED
 - /belle/user/rachac/dtaunu05_hadronicSkim1_BGx1 →Neutral
 - /belle/user/rachac/dtaunu07_hadronicSkim_BGx1 → Neutral
 - /belle/user/rachac/dtaunu08_hadronicSkim_BGx1 → Neutral
- Scratch space at KEKcc has been made available to the semi-tauonic group:
/ghi/fs01/belle2/bdata/groups/physics/semitauonic
- FEI skimmed samples are being transferred to KEKcc and will become available in the semi-tauonic scratch space.
 - Problematic connection drops in file transfers.. Any volunteers?

FEI B0:

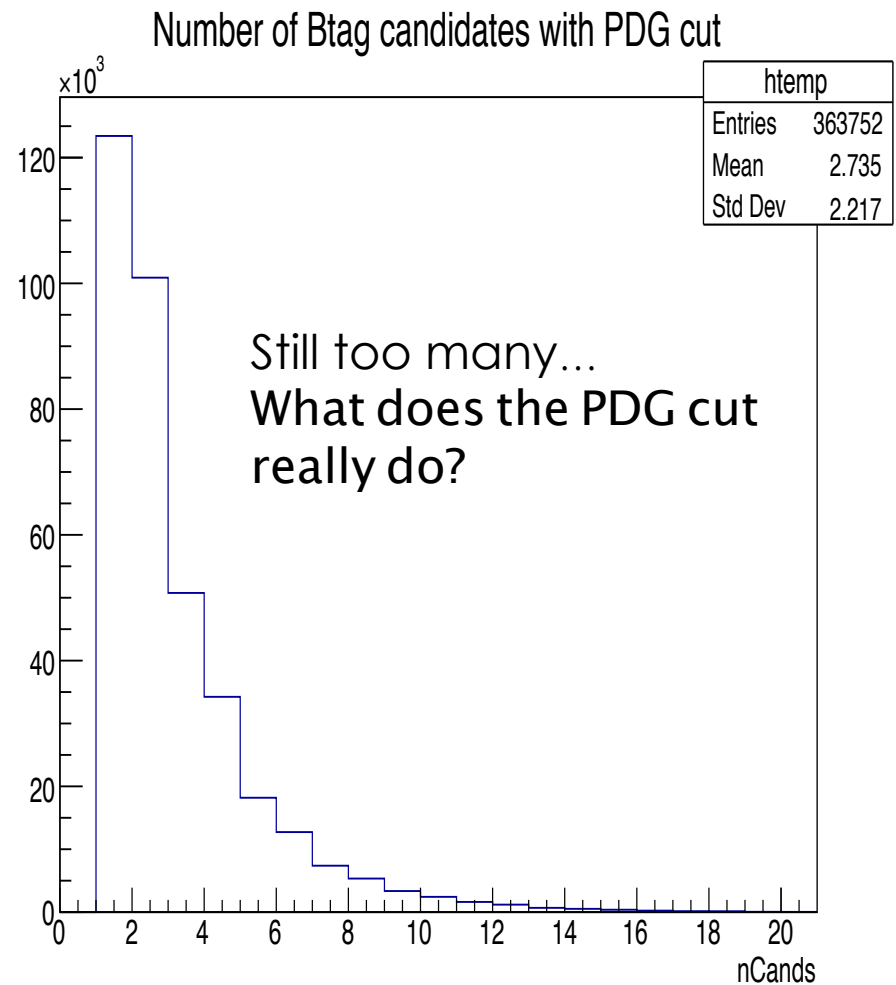
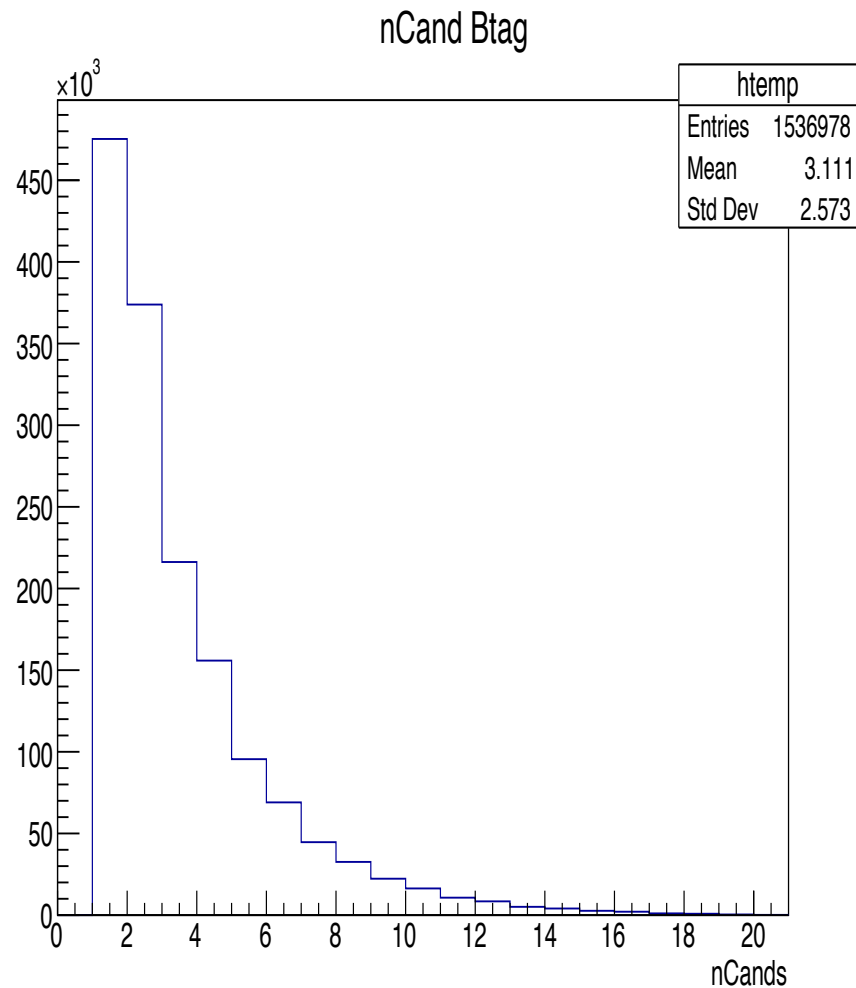
Cuts: $M_{bc} > 5.27$, $abs(\Delta E) < 0.2$, $sigProb > 0.001$



FEI B0:



FEI B0:



$$B^0 \rightarrow D^{*+} \tau \nu$$

□ $B^0 \rightarrow D^{*+} \tau \nu, \tau \rightarrow \mu \nu \nu$

□ $D^{*+} \rightarrow D^0 \pi^+, D^+ \pi^0$

□ $D \rightarrow K^- \pi^+ \pi^+, K^- \pi^+ \pi^+ \pi^0, K_S^0 \pi^+, K_S^0 \pi^+ \pi^- \pi^+, K_S^0 \pi^+ \pi^0 +, K_S^0 K^+$

□ $D \rightarrow K^- \pi^+, K^- \pi^+ \pi^0, K_S^0 \pi^0, K^- \pi^+ \pi^- \pi^+, K_S^0 \pi^+ \pi^-$

□ Particle Lists: loose photons, KS0_all, mu+:90eff, pi+:all, K+:all.

□ D+/D0 Mass cut = '1.7 < M < 2.0'

□ D* mass difference = '0.139 < massDifference(0) < 0.16'

□ ROEclusters = ('ROEclusters', '', 'abs(clusterTiming)<clusterErrorTiming and E>0.05')

□ ROETracks==0

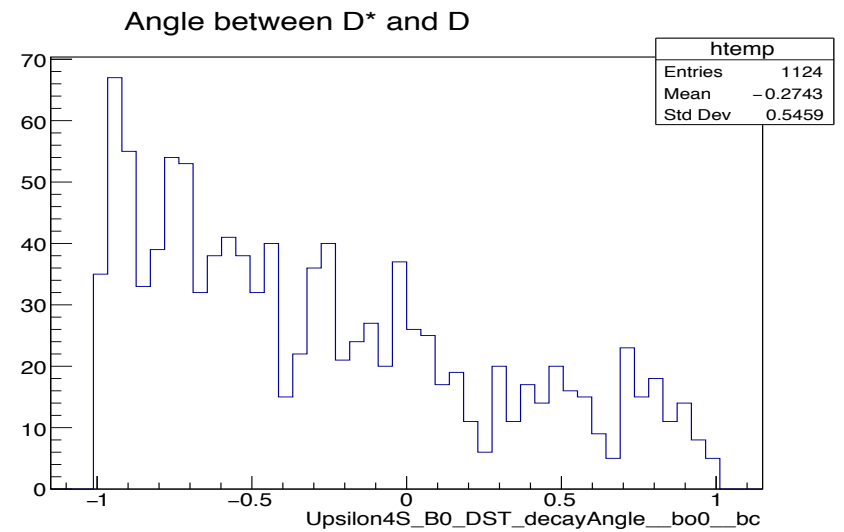
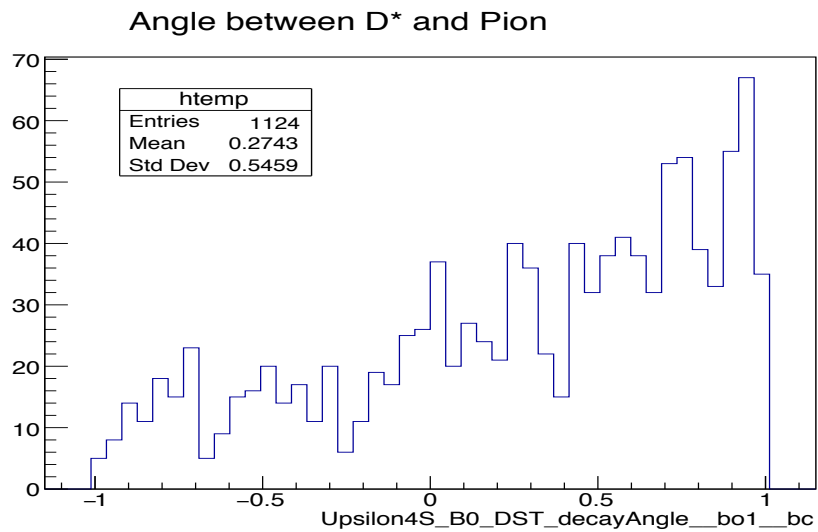
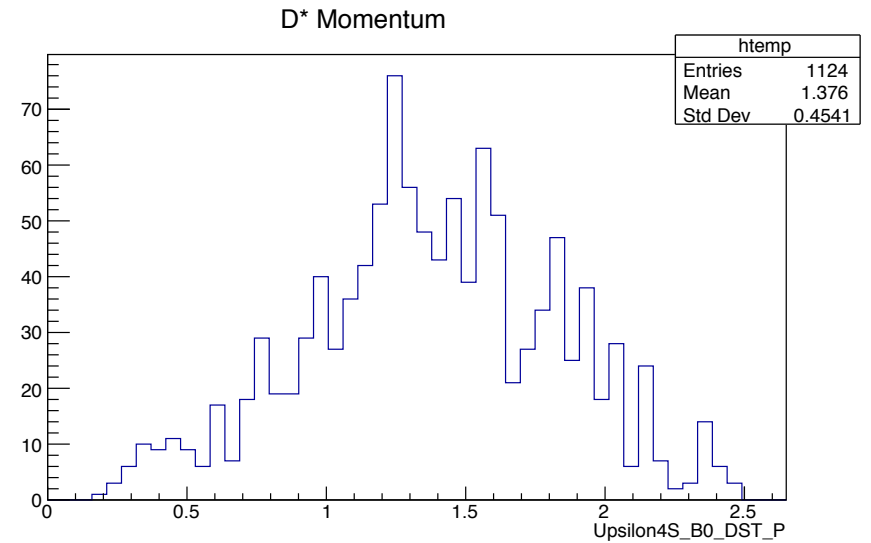
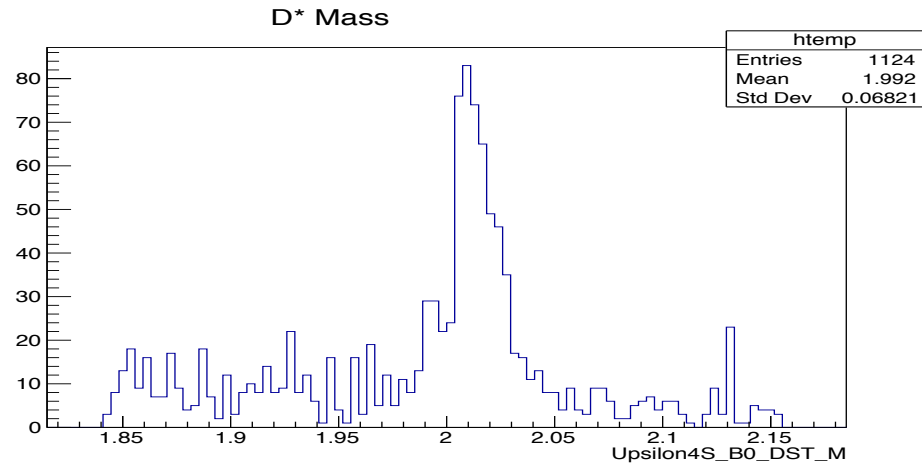
□ applyCuts('D*+:sigDstar','abs(genMotherPDG)==511')

□ applyCuts('D0:sigD','abs(genMotherPDG)==413')

□ applyCuts('D+:sigD','abs(genMotherPDG)==413')

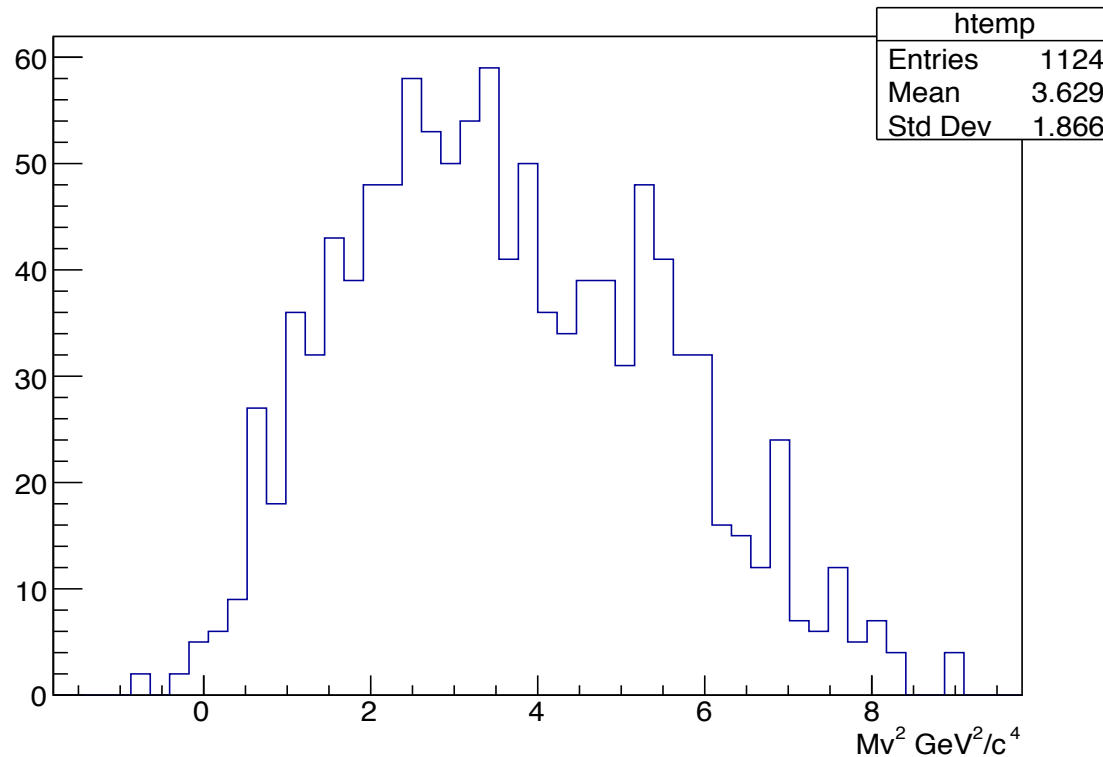
□ applyCuts('Upsilon(4S)', 'nAllROETracks==0')

$$B^0 \rightarrow D^{*+} \tau \nu$$



$$B^0 \rightarrow D^{*+} \tau \nu$$

Mv2: M2recoil



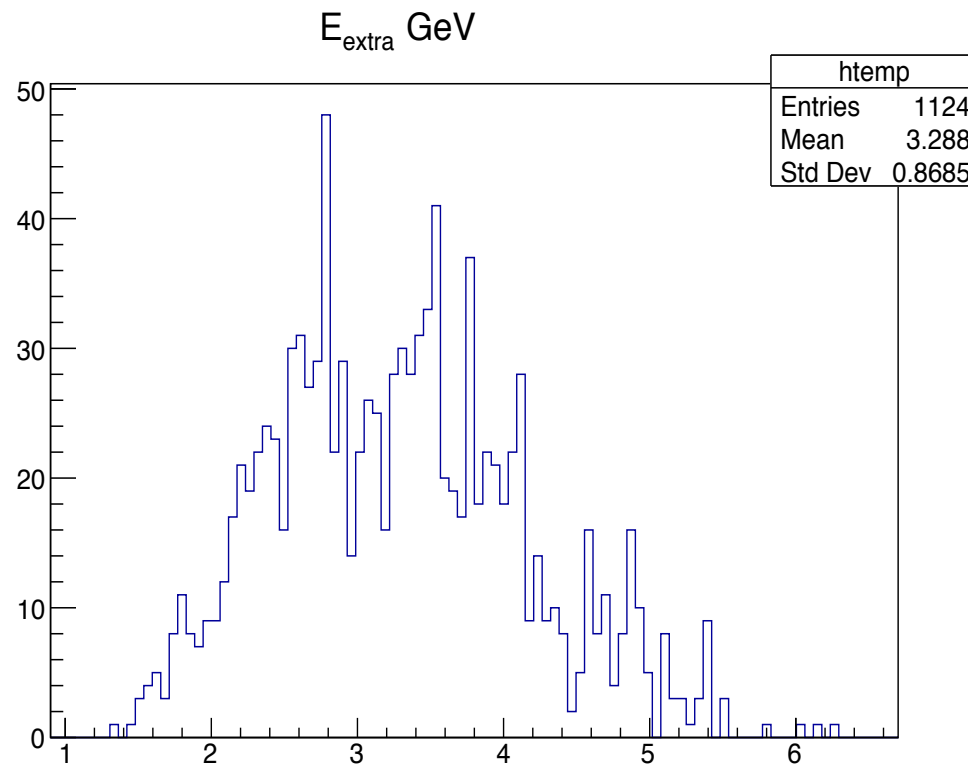
This variable
might be buggy.

Needs
examination..
Volunteers?

```
double recoilMassSquared(const Particle* particle)
{
    PCmsLabTransform T;
    // Initial state (e+e- momentum in LAB)
    TLorentzVector pIN = T.getBoostVector();
    return pIN - particle->get4Vector()).M2();
}
```

$$B^0 \rightarrow D^{*+} \tau \nu$$

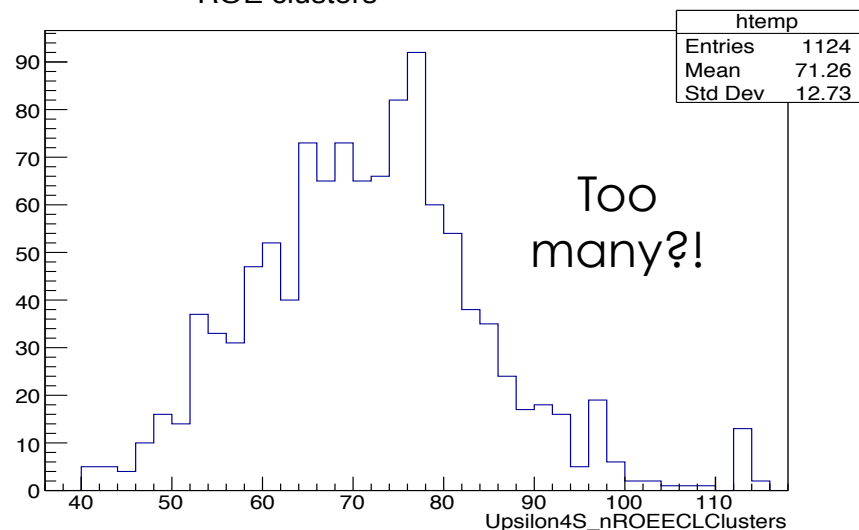
```
std::vector<const ECLCluster*> roeClusters = roe->getECLClusters(maskName);
double extraE = 0.0;
for (unsigned int iEcl = 0; iEcl < roeClusters.size(); iEcl++)
    extraE += roeClusters[iEcl]->getEnergy();
```



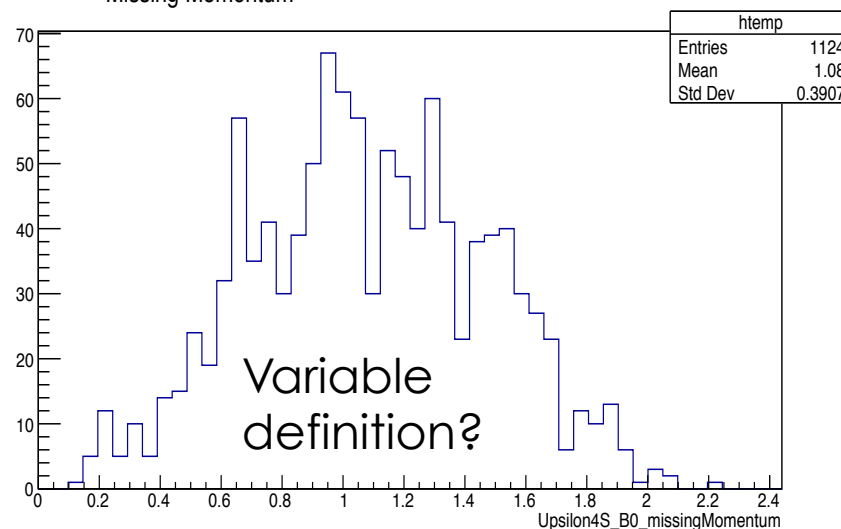
```
ROEclusters = ('ROEclusters', ", 'abs(clusterTiming)<clusterErrorTiming and  
E>0.05')
```

$$B^0 \rightarrow D^{*+} \tau \nu:$$

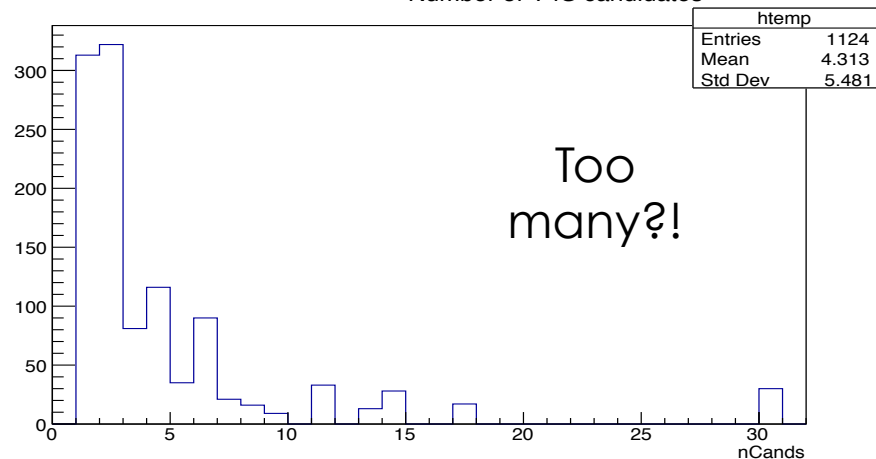
ROE clusters



Missing Momentum



Number of Y4S candidates



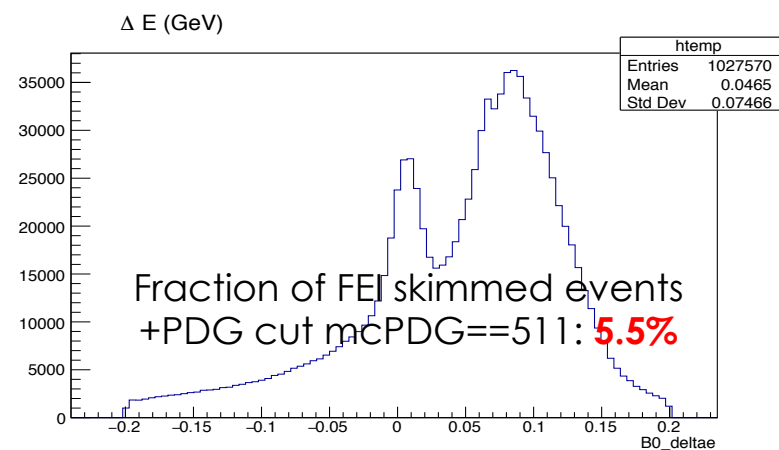
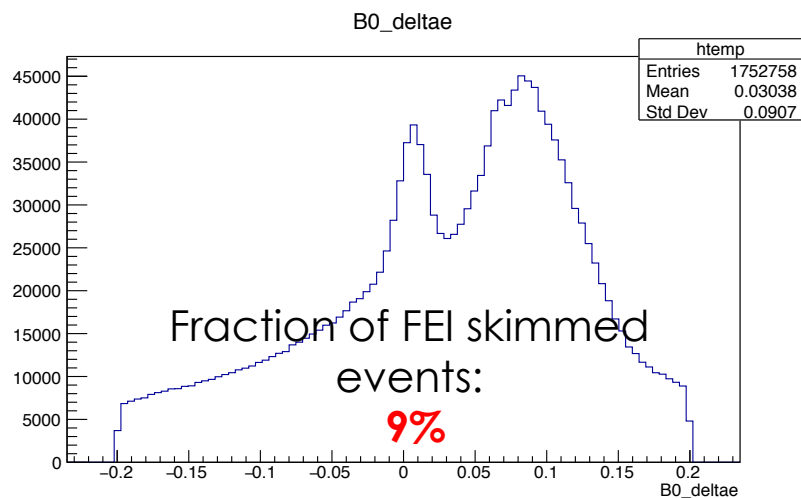
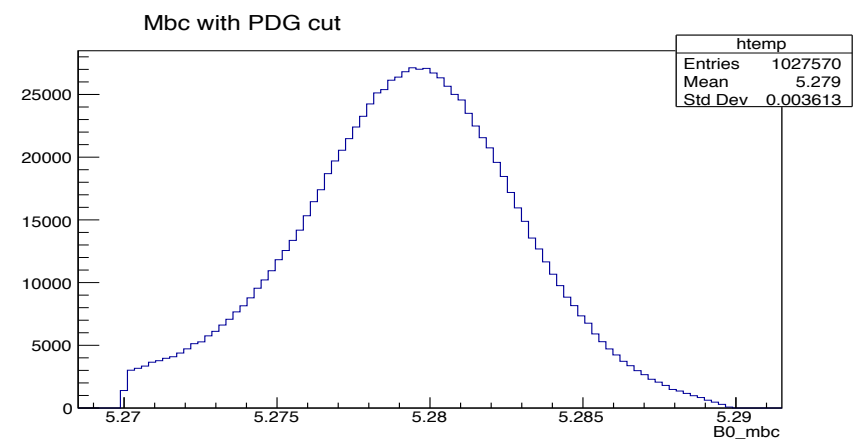
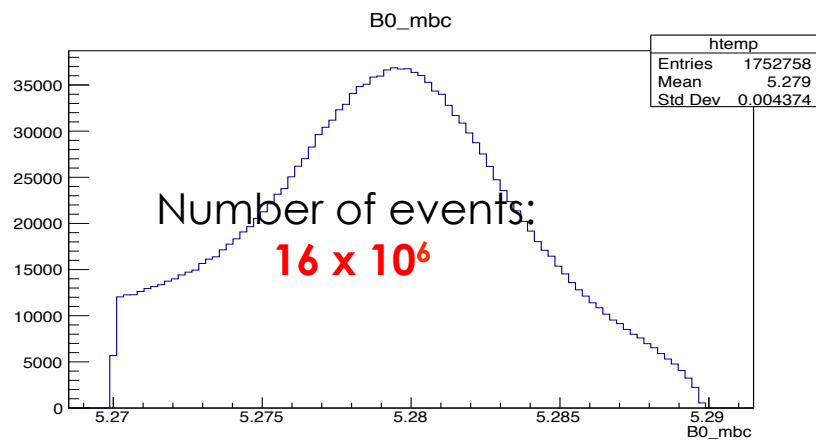
Number of surviving events:
 $566/80 \times 10^6 = 7.1 \times 10^{-6}$

Very low efficiency..
 Obviously no PDG cut will be used in
 the signal selection!

Cocktail sample: B0 FEI

■ $B^0 \rightarrow D^{*+} \tau \nu + \text{anti-}B^0 \rightarrow J/\psi K_s$

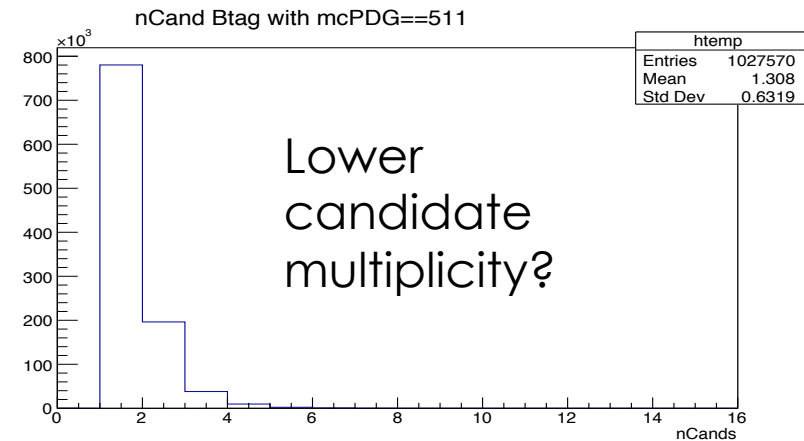
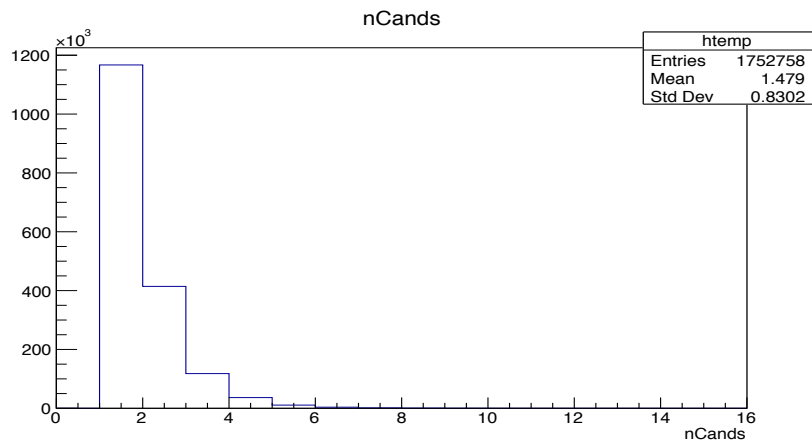
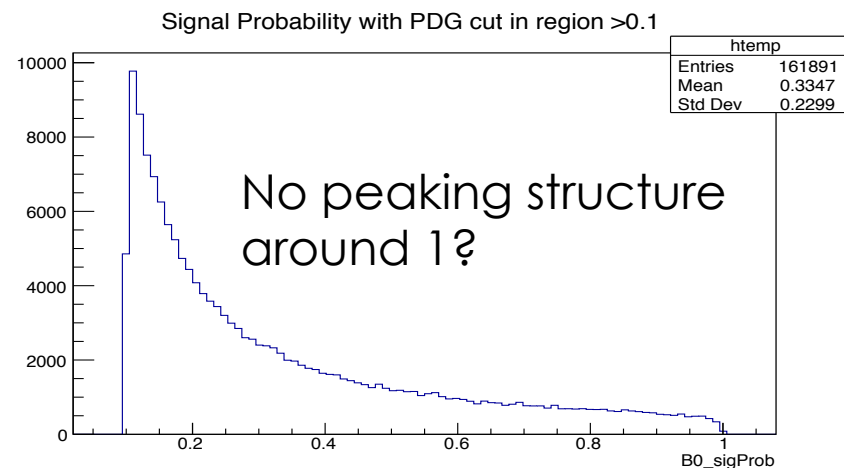
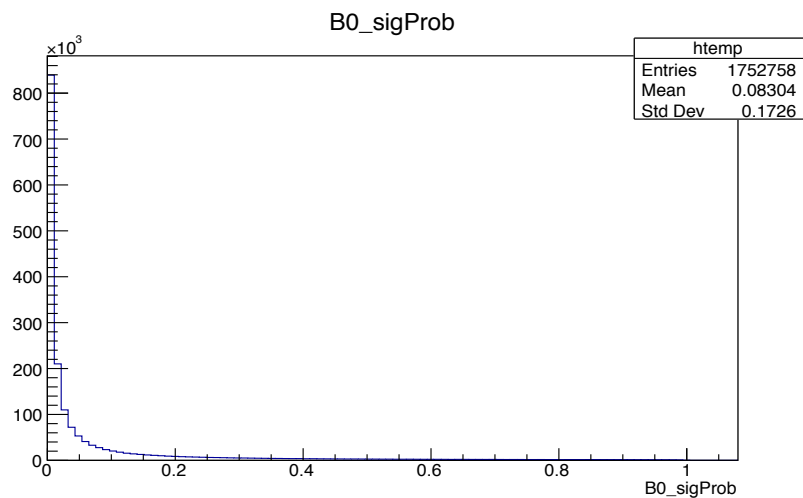
Cuts: $M_{bc} > 5.27$, $|\Delta E| < 0.2$, $\text{sigProb} > 0.001$



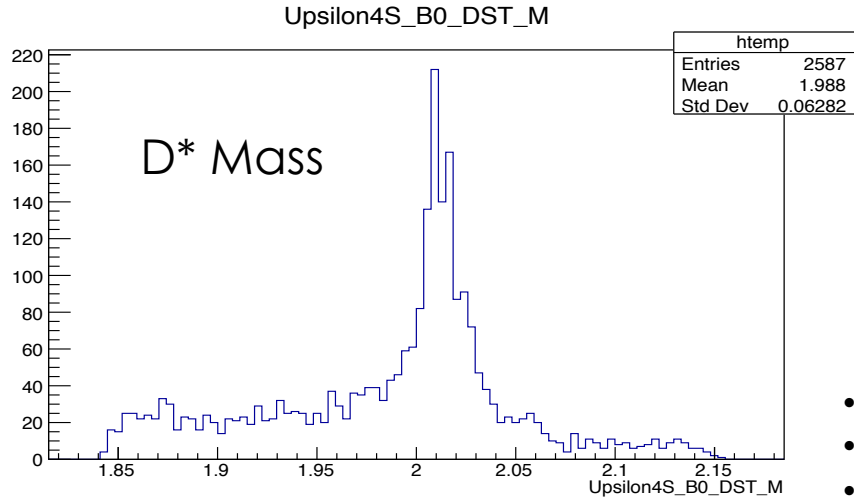
Cocktail sample: B0 FEI

■ $B^0 \rightarrow D^{*+} \tau \nu + \text{anti-}B^0 \rightarrow J/\psi K_s$

Cuts: $M_{bc} > 5.27$, $|\Delta E| < 0.2$, $\text{sigProb} > 0.001$



Cocktail Sample: $B^0 \rightarrow D^{*+} \tau \nu$:

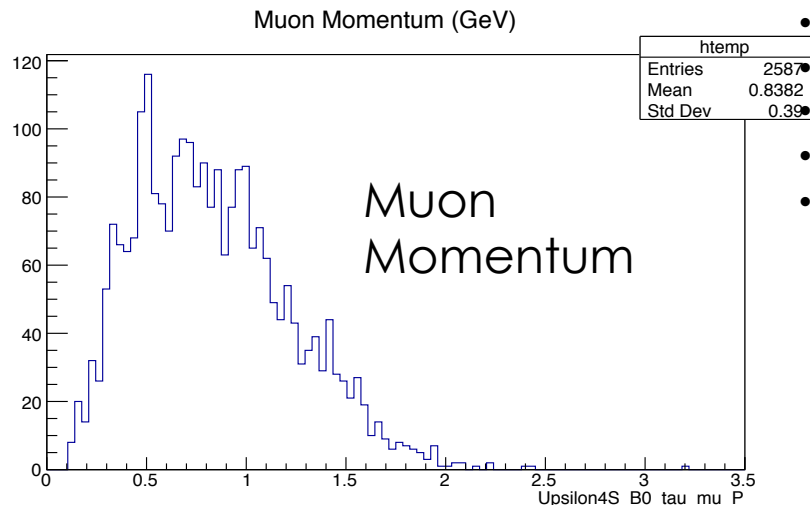


$B^0 \rightarrow D^{*+} \tau \nu, \tau \rightarrow \mu \nu \nu$

$D^{*+} \rightarrow D^0 \pi^+, D^+ \pi^0$

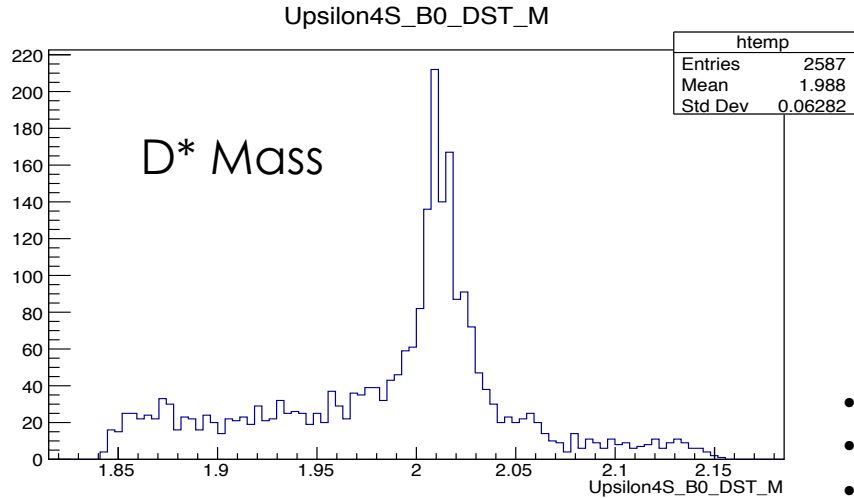
$D \rightarrow K^- \pi^+ \pi^+, K^- \pi^+ \pi^+ \pi^0, K_s^0 \pi^+, K_s^0 \pi^+ \pi^- \pi^{++},$
 $K_s^0 \pi^+ \pi^0 +, K_s^0 K^+$

$D \rightarrow K^- \pi^+, K^- \pi^+ \pi^0, K_s^0 \pi^0, K^- \pi^+ \pi^- \pi^+, K_s^0 \pi^+ \pi^-$



- D^+/D^0 Mass cut = ' $1.7 < M < 2.0$ '
- D^* mass difference = ' $0.139 < \text{massDifference}(0) < 0.16$ '
- ROEclusters = ('ROEclusters', '',
'abs(clusterTiming)<clusterErrorTiming and E>0.05')
- ROETracks==0
- applyCuts('D*+:sigDstar','abs(genMotherPDG)==511')
- applyCuts('D0:sigD','abs(genMotherPDG)==413')
- applyCuts('D+:sigD','abs(genMotherPDG)==413')
- applyCuts('Upsilon(4S)', 'nAllROETracks==0')

Cocktail Sample: $B^0 \rightarrow D^{*+} \tau \nu$:

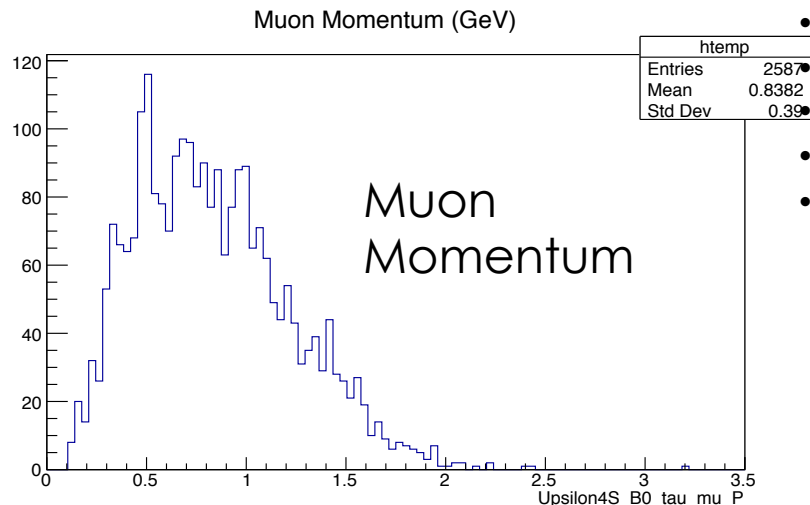


$B^0 \rightarrow D^{*+} \tau \nu, \tau \rightarrow \mu \nu \nu$

$D^{*+} \rightarrow D^0 \pi^+, D^+ \pi^0$

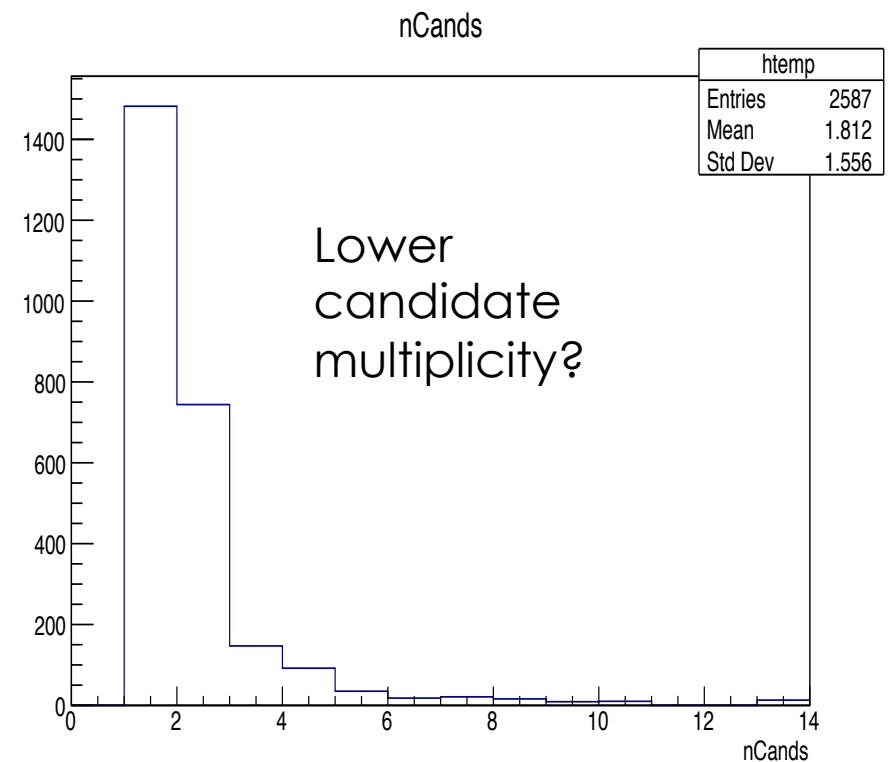
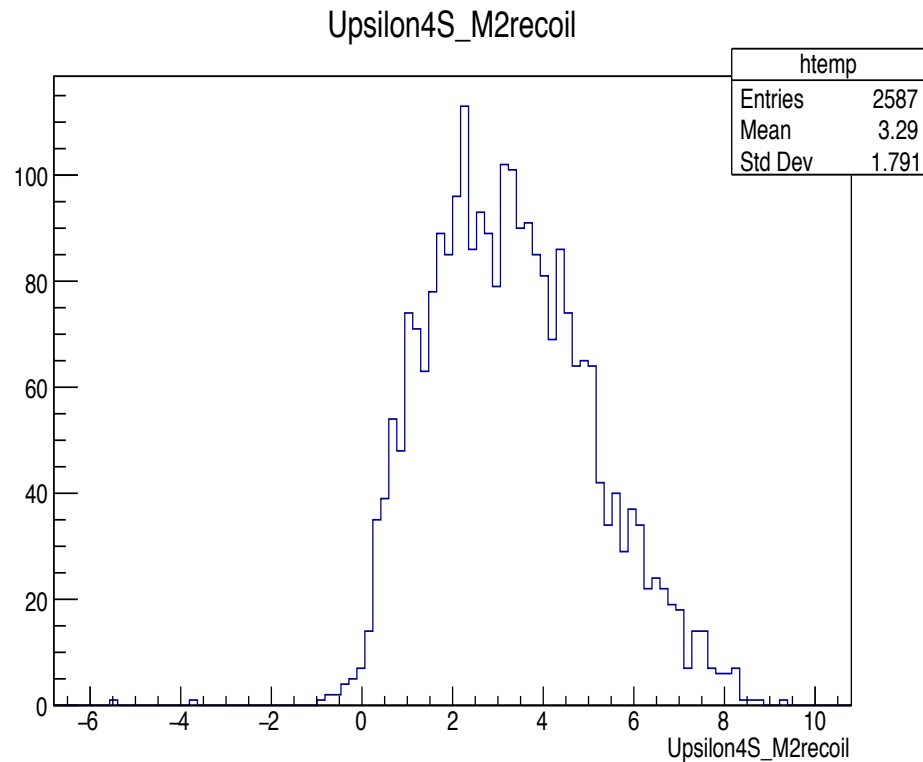
$D \rightarrow K^- \pi^+ \pi^+, K^- \pi^+ \pi^+ \pi^0, K_s^0 \pi^+, K_s^0 \pi^+ \pi^- \pi^+, K_s^0 \pi^+ \pi^0, K_s^0 K^+$

$D \rightarrow K^- \pi^+, K^- \pi^+ \pi^0, K_s^0 \pi^0, K^- \pi^+ \pi^- \pi^+, K_s^0 \pi^+ \pi^-$



- D^+/D^0 Mass cut = ' $1.7 < M < 2.0$ '
- D^* mass difference = ' $0.139 < \text{massDifference}(0) < 0.16$ '
- $\text{ROEclusters} = ('ROEclusters', ', 'abs(clusterTiming) < clusterErrorTiming \text{ and } E > 0.05')$
- $\text{ROETracks} == 0$
- $\text{applyCuts}('D^{*+}:\text{sigDstar}', 'abs(\text{genMotherPDG}) == 511')$
- $\text{applyCuts}('D^0:\text{sigD}', 'abs(\text{genMotherPDG}) == 413')$
- $\text{applyCuts}('D^{*+}:\text{sigD}', 'abs(\text{genMotherPDG}) == 413')$
- $\text{applyCuts}('Upsilon(4S)', 'nAllROETracks == 0')$

Cocktail Sample: $B^0 \rightarrow D^{*+} \tau \nu$:



Number of surviving events: 1944

Efficiency= 1.2×10^{-4}

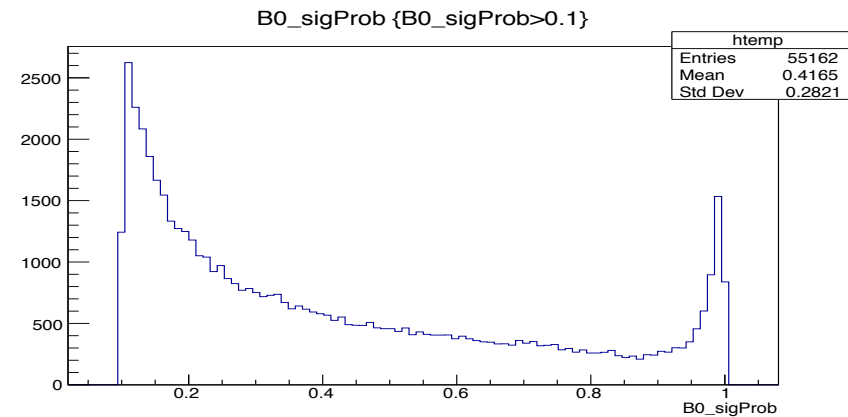
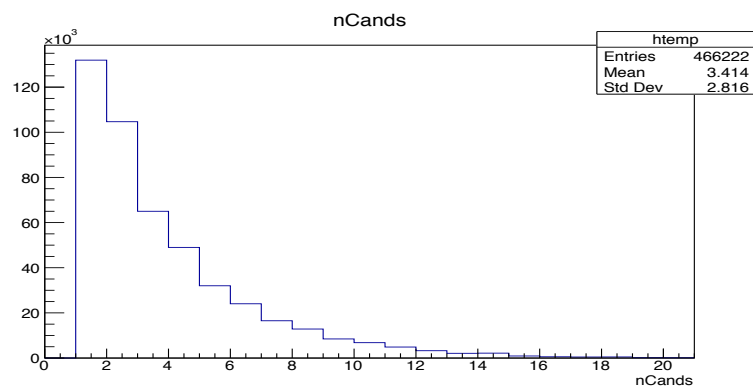
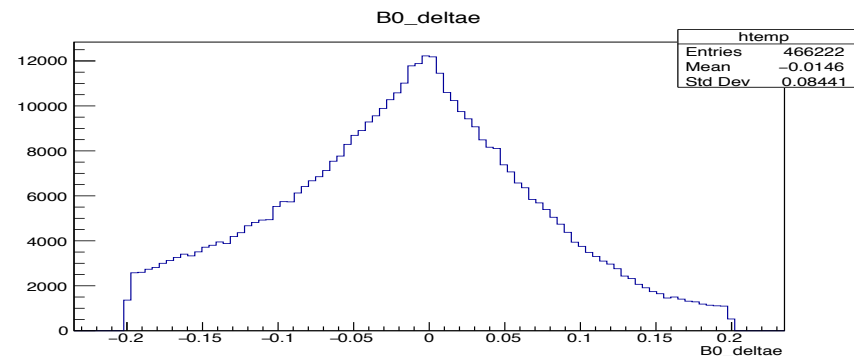
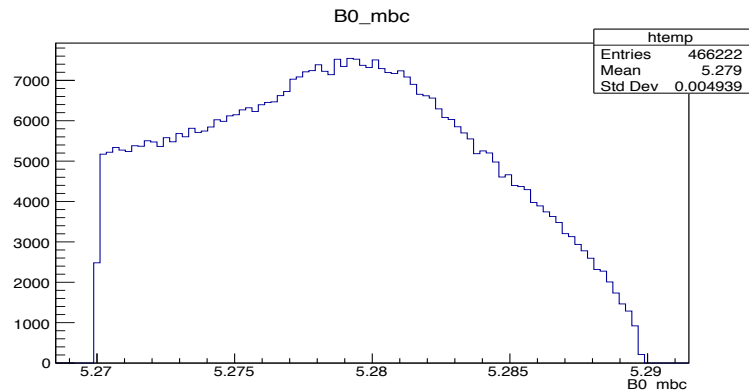
$B^0 \rightarrow D^{*+} \tau \nu$: Mixed MC

■ Using a subsample of mixed MC skimmed with FEI:

Approximately 10 million events:

Fraction of FEI skimmed: 2.1%

With truth PDG cut: 0.5%



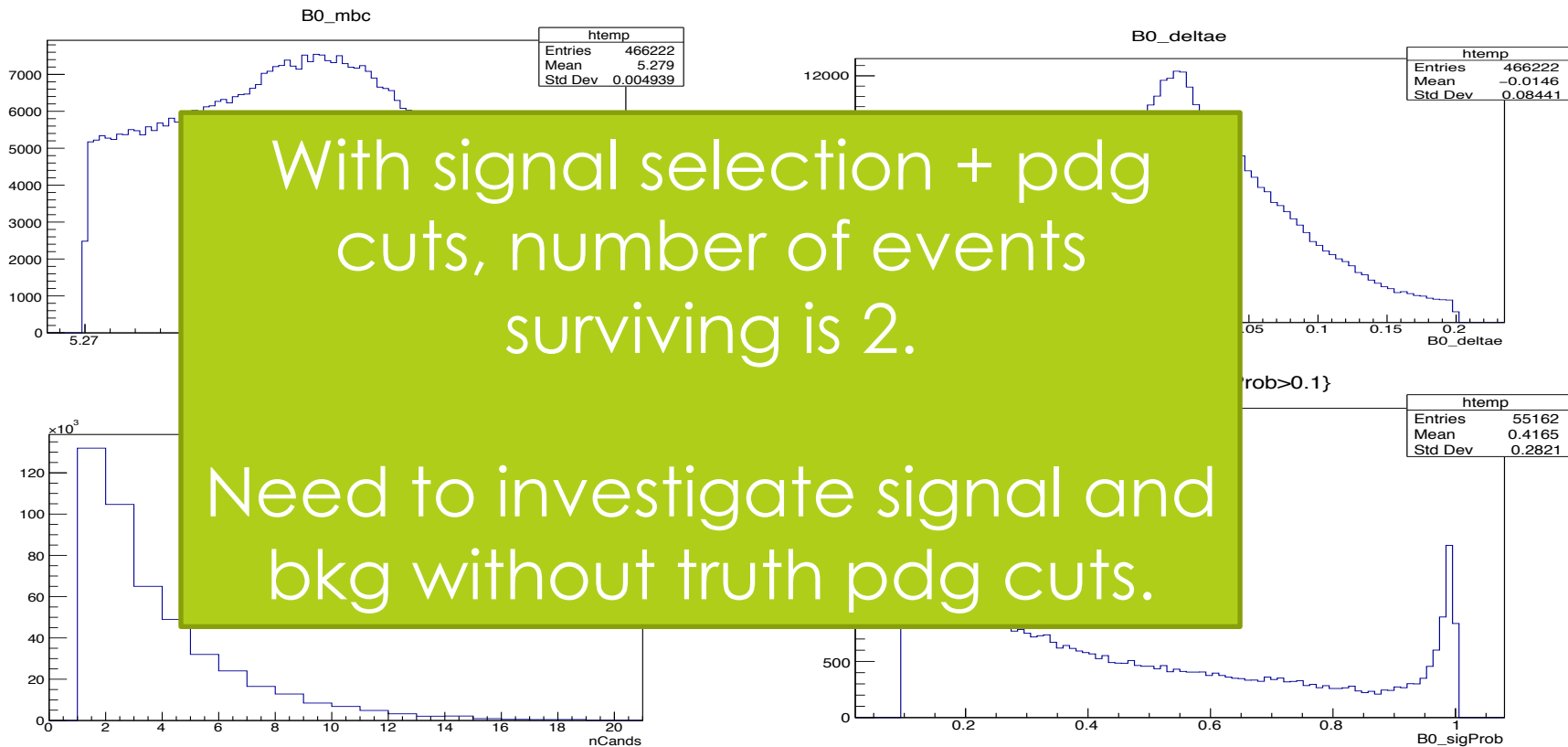
$B^0 \rightarrow D^{*+} \tau \nu$: Mixed MC

■ Using a subsample of mixed MC skimmed with FEL:

Approximately 10 million events:

Fraction of FEL skimmed: 2.1%

With truth PDG cut: 0.5%



$$B^0 \rightarrow D^{*+} \tau \nu$$

□ $B^0 \rightarrow D^{*+} \tau \nu, \tau \rightarrow \mu \nu \nu$

□ $D^{*+} \rightarrow D^0 \pi^+, D^+ \pi^0$

□ $D \rightarrow K^- \pi^+ \pi^+, K^- \pi^+ \pi^+ \pi^0, K_S^0 \pi^+, K_S^0 \pi^+ \pi^- \pi^+, K_S^0 \pi^+ \pi^0 +, K_S^0 K^+$

□ $D \rightarrow K^- \pi^+, K^- \pi^+ \pi^0, K_S^0 \pi^0, K^- \pi^+ \pi^- \pi^+, K_S^0 \pi^+ \pi^-$

□ Particle Lists: loose photons, KS0_all, mu+:90eff, pi+:90effl, K+:90eff.

□ Added momentum cuts for all tracks :between 300 MeV and 3 GeV.

□ D+/D0 Mass cut = '1.8 < M < 1.9', vertexKFit(D,0.001)

□ D* mass difference = '0.139 < massDifference(0) < 0.16', vertexKFit(D*, 0.001)

□ ROEclusters = ('ROEclusters', '', 'abs(clusterTiming)<clusterErrorTiming and E>0.05')

□ ROETracks==0

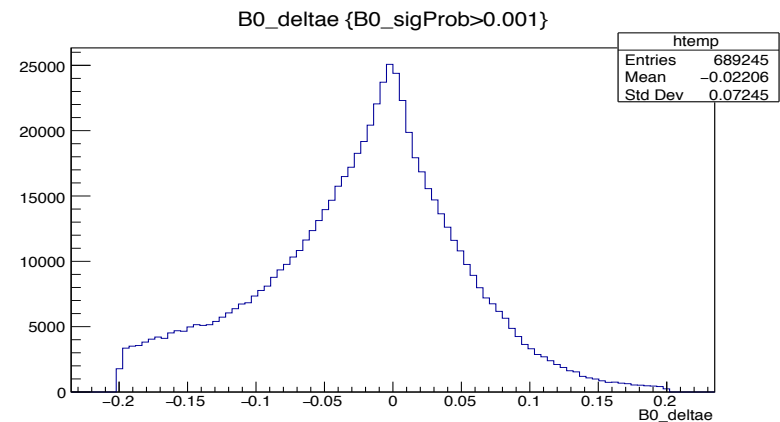
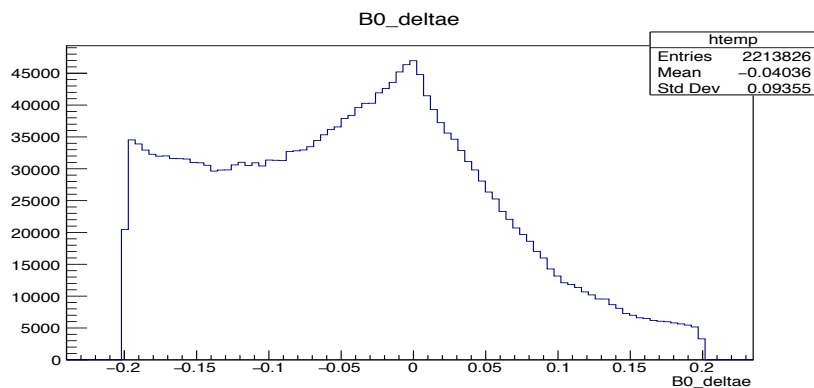
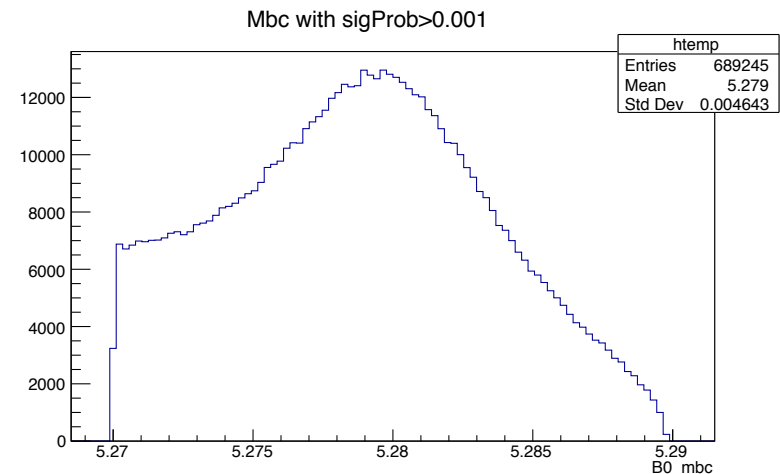
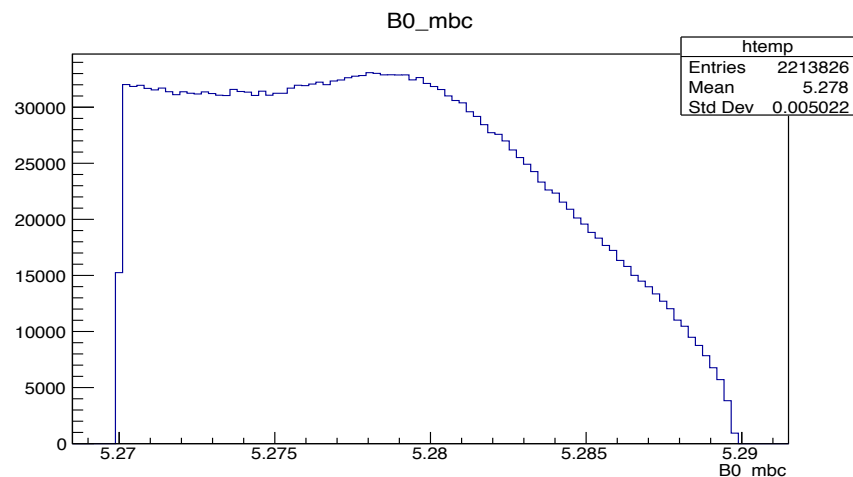
□ Removed PDG cuts.

Conclusion

- ▣ Continue signal selection development
- ▣ Investigate variables.
- ▣ Investigate cocktail sample distributions.
- ▣ Skim $D^{(*)}lv$ and see background survival rate.
- ▣ Repeat for D and D^{*+} modes.

FEI B0:

- rankByHighest('B0:generic','sigProb')
- cutAndCopyList('B0:tag','B0:generic','Mbc>5.27 and deltaE<0.2 and rank==1')



FEI B0:

- rankByHighest('B0:generic','sigProb')
- cutAndCopyList('B0:tag','B0:generic','Mbc>5.27 and deltaE<0.2 and rank==1')

