



$B^0 \rightarrow D^* \ell \nu$ Decays With Semileptonic Tags in Phase II

Honours Project Progress Report

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September 14, 2018

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$B \rightarrow D^* \ell \nu$ Semileptonic Tagging

Checking
Particle ID

Signal
Selection

Electron
Channel
Signal
Region

Muon
Channel
Signal
Region

Further
Work

- Release: release-02-00-00
- Data: prod5, 2.05 million events
- Monte Carlo: MC10 mixed, Phase II, beam background x 1, 4 500 000 events
- FEI version: FEIv4_2018_MC10_phase2-02-00-00
- 2.1 million semileptonic tags for MC10
- 520 000 tags for prod5
- All code is run on the local cluster; I don't have access to KEKCC



Checking Particle ID

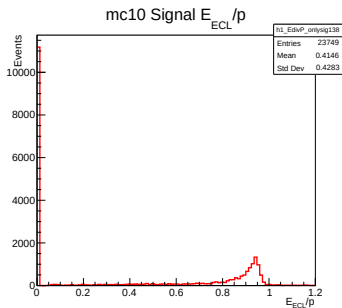
Signal Selection

Electron Channel Signal Region

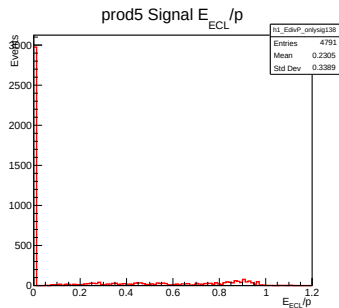
Muon Channel Signal Region

Further Work

With electron ID > 0.98 , all other particle IDs < 0.01 .



(a) MC10 E_{ECL}/p



(b) prod5 E_{ECL}/p



Checking Particle ID

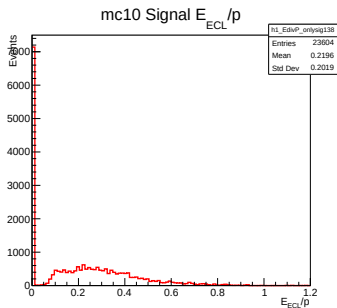
Signal Selection

Electron Channel Signal Region

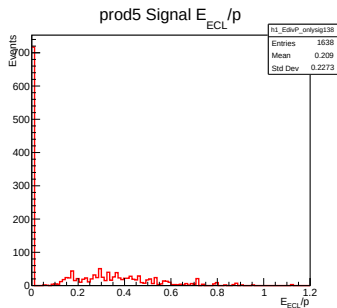
Muon Channel Signal Region

Further Work

Muon ID selected at > 0.9 , all other IDs < 0.01 .



(c) MC10 E_{ECL}/p



(d) prod5 E_{ECL}/p



Define the signal region for signal B^0 :

Value	Cut
Impact Parameters	leptons: $ d_0 < 2$ cm, $ d_z < 5$ cm mesons: $ d_0 < 0.5$ cm, $ d_z < 3$ cm
Energy released	$0.0 \text{ GeV} < Q_{D^*} < 0.02 \text{ GeV}$
Δm	$0.144 \text{ GeV} < \Delta m < 0.148 \text{ GeV}$
m_D	$1.85 \text{ GeV} < m_D < 1.9 \text{ GeV}$
$p_{\pi^+}^*$ from D^*	$p_{\pi^+}^* < 0.4 \text{ GeV}$
Slow D^*	$p_{D^*}^* < 2.5 \text{ GeV}$
Electron momentum	$1.2 \text{ GeV} < p_{e^-}^* < 2.5 \text{ GeV}$
Muon momentum	$0.1 \text{ GeV} < p_{\mu^-}^* < 2.3 \text{ GeV}$
Electron selection	$eID > 0.98; \pi ID, \mu ID, KID < 0.01$
Muon selection	$\mu ID > 0.9; \pi ID, eID < 0.01$
Continuum rejection	$R2 > 0.25 \text{ GeV}$

Final signal region determined by $\cos \theta_{B D^* \ell}$



Checking
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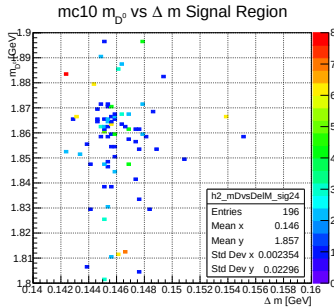
Signal
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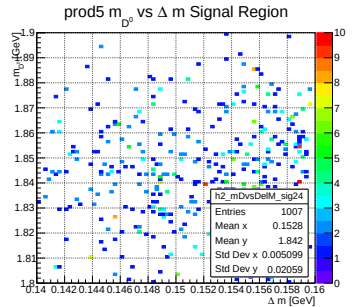
Muon
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Further
Work

D^0 lists taken from FEI constructed lists, then form a D^{*+} with a π^+ . Best D^* selection variables are m_{D^0} and $\Delta m = m_{D^*} - m_{D^0}$.



(a) MC10 Δm



(b) prod5 Δm



Checking
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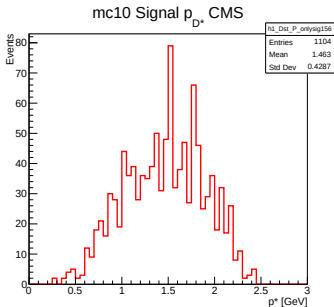
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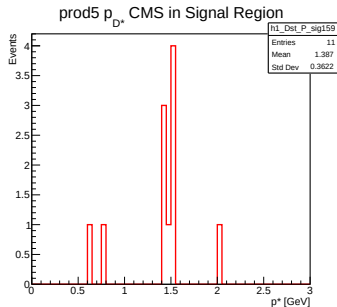
Muon
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Further
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Momentum selection made for $p^* < 2.5$ GeV. Higher momentum D^* rejected to reduce background.



(c) MC10 $p_{D^*}^*$



(d) prod5 $p_{D^*}^*$



Checking
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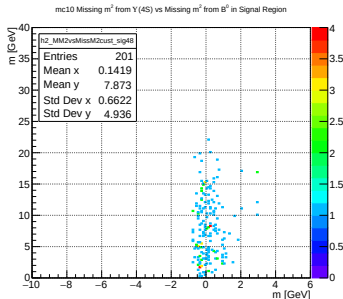
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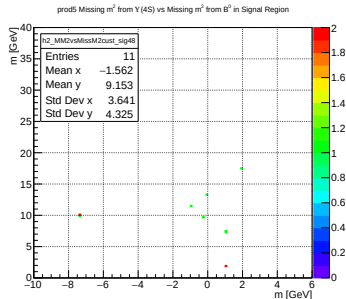
Muon
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Further
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Semileptonic tagging broadens the missing mass distribution. Missing mass under assumption B^0 is created at rest is a narrower distribution. In electron channel:



(e) truth matched MC10 Signal Cuts



(f) prod5 Signal Cuts



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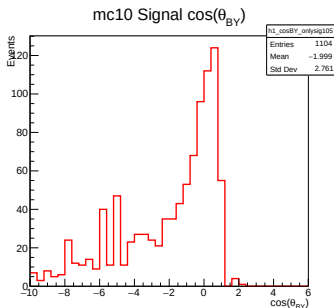
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Further
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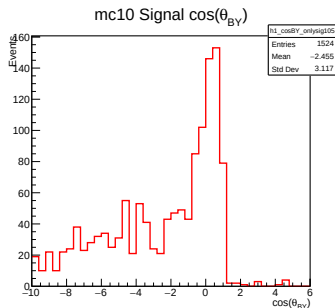


$$\cos \theta_{B D^* \ell} = \frac{2E_B^* E_{D^* \ell}^* - m_B^2 - m_{D^* \ell}^2}{2p_{B D^* \ell}^*}$$

In MC10, for truth matched events:



(g) MC10 electron channel



(h) MC10 muon channel

Checking
Particle ID

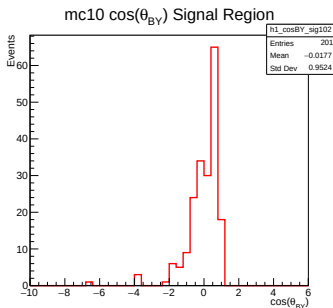
Signal
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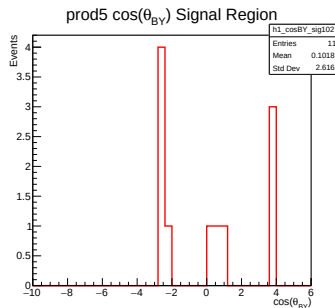
Muon
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Further
Work

With all signal selections applied, in the electron channel



(a) MC10 electron channel



(b) prod5 electron channel

Checking
Particle ID

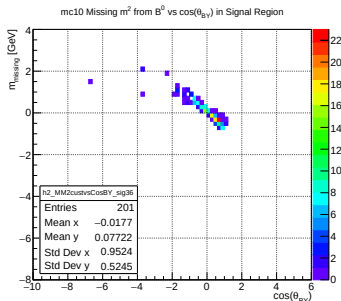
Signal
Selection

**Electron
Channel
Signal
Region**

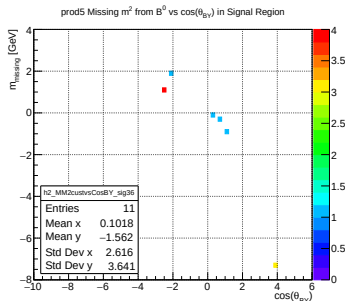
Muon
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Further
Work

The missing mass squared from the B^0 is also a signal distinguisher.



(c) MC10 electron channel



(d) prod5 electron channel

In physical region of $\cos \theta_{B D^* e}$, there are 2 events.
With a $\cos \theta_{B D^* e} < 2.0$ selection, 9 events.

Checking
Particle ID

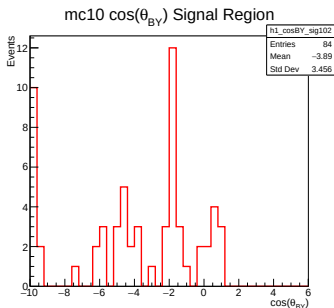
Signal
Selection

Electron
Channel
Signal
Region

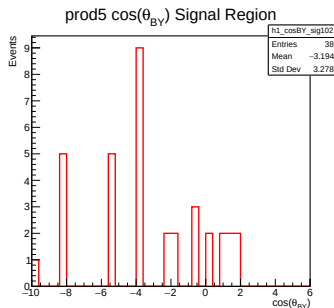
**Muon
Channel
Signal
Region**

Further
Work

With all signal selections applied, in the muon channel.
Will need more MC10 samples to improve statistics.



(a) MC10 muon channel



(b) prod5 muon channel



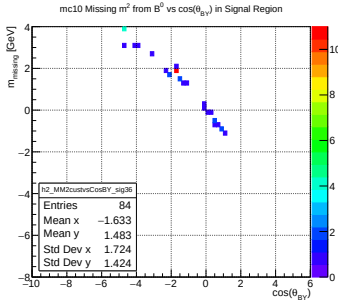
Checking
Particle ID

Signal
Selection

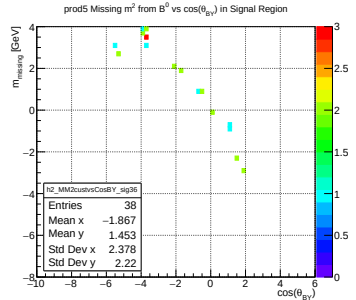
Electron
Channel
Signal
Region

Muon
Channel
Signal
Region

Further
Work



(c) MC10 muon channel



(d) prod5 muon channel

In physical region of $\cos \theta_{B D^* e}$, there are 5 events.
With a $-6.0 < \cos \theta_{B D^* e} < 2.0$ selection, 29 events.





What's next?

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Muon
Channel
Signal
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Further
Work

- Run FEI tagging on more mc10
- Incorporate background and normalise to data

