



$B \rightarrow D^{(*)} \ell \nu$ Decays From Phase II Data at Belle II

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$B \rightarrow D^* \ell \nu$ Motivation

Discovering The Signal Side

Selecting the D^*

Lepton Selection

Background Rejection

B^0 Signal Selection

Further Work

- Learn how to analyse Phase II data
- Crosscheck untagged analysis by M. Nayak rediscovering this decay in Phase II data (BELLE2-NOTE-PH-2018-018)
- Release: release-01-02-09
- Data: prod4
- Monte Carlo: MC9, Phase II
- Signal monte carlo selected from MC9 generic mixed MC (118 200 events)



Used selections from M. Nayak's analysis for cross checking purposes.

Value	Cut
Impact Parameter	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	$1.85 \text{ GeV} < m_D < 1.88 \text{ GeV}$
$p_{\pi^+}^*$ from D^*	$p_{\pi^+}^* < 0.4 \text{ GeV}$
Slow/ "soft" D^*	$p_{D^*}^* < 2.5 \text{ GeV}$
Electron momentum	$1.2 \text{ GeV} < p_{e^-}^* < 2.4 \text{ GeV}$
Electron selection	$E_{\text{ECL}}/p > 0.8$ and $E9/E21 > 0.94$
Continuum rejection	$R2 > 0.25 \text{ GeV}$



Reconstructing the D^0

Discovering
The Signal
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B^0 Signal
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Further
Work

We looked at the $D^0 \rightarrow K^- \pi^+$ channel only, because:

- It is the cleanest decay; charged, hadronic final states
- most frequent single K hadronic decay of D^0 .



Discovering
The Signal
Side

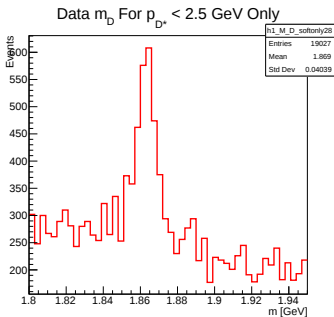
Selecting the
 D^*

Lepton
Selection

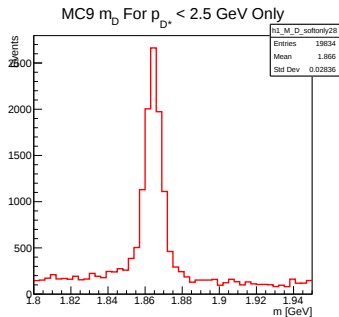
Background
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Further
Work



(a) Data m_{D^0}



(b) signal MC m_{D^0}

Comparison of m_{D^0} in signal MC9 and Phase II data.



Discovering
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Selecting the
 D^*

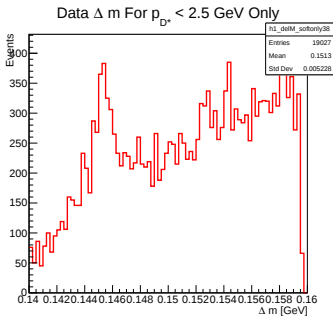
Lepton
Selection

Background
Rejection

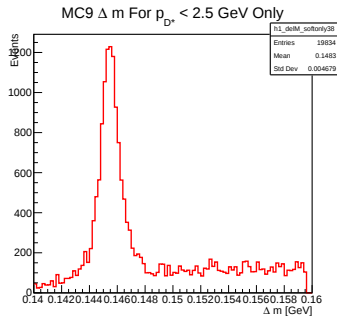
B^0 Signal
Selection

Further
Work

Define $\Delta m = m_{D^*} - m_{D^0}$



(a) data Δm



(b) signal MC Δm

Comparison of Δm in signal MC and Phase II data.



Discovering
The Signal
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 D^*

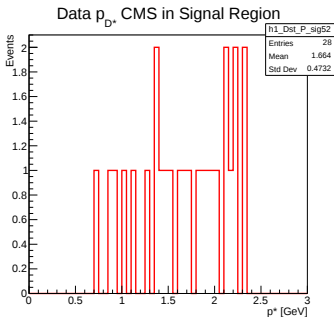
Lepton
Selection

Background
Rejection

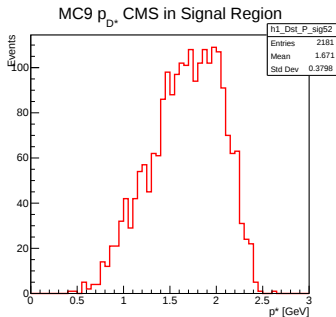
B^0 Signal
Selection

Further
Work

For signal events, we expect a slow D^*



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



(d) signal MC $p_{D^*}^*$



Discovering
The Signal
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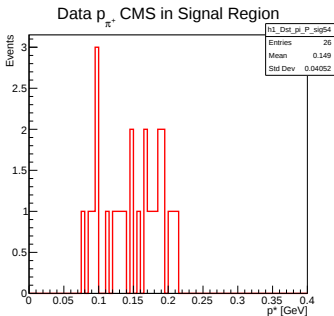
Selecting the
 D^*

Lepton
Selection

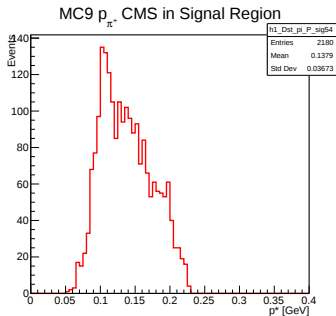
Background
Rejection

B^0 Signal
Selection

Further
Work



(e) Data p_{π^*}



(f) MC p_{π^*}



Selecting The Electron: E/p

Discovering
The Signal
Side

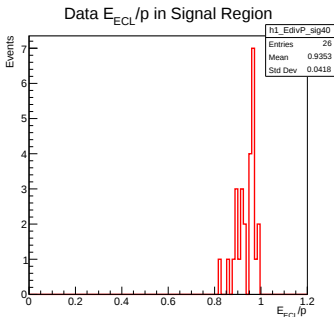
Selecting the
 D^*

**Lepton
Selection**

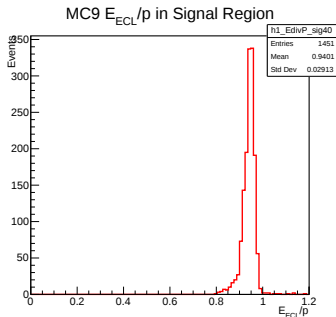
Background
Rejection

B^0 Signal
Selection

Further
Work



(a) In Data



(b) In MC9 Signal



Discovering
The Signal
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 D^*

**Lepton
Selection**

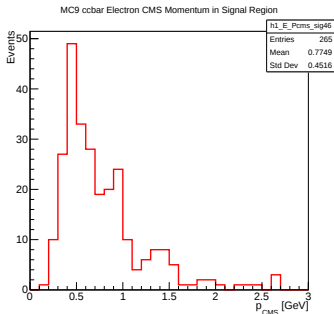
Background
Rejection

B^0 Signal
Selection

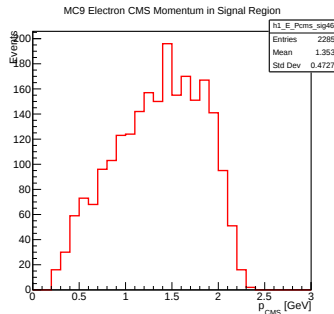
Further
Work



The analysis by M. Nayak cuts on $p_{e^-} > 1.2$ GeV. Used for background rejection



(c) signal MC $c\bar{c} p_{e^-}^*$



(d) MC signal $p_{e^-}^*$

Discovering
The Signal
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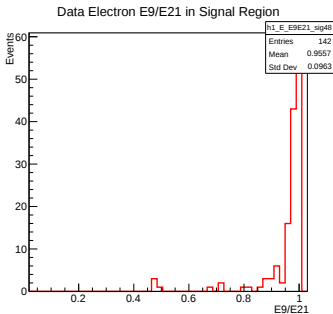
Selecting the
 D^*

Lepton
Selection

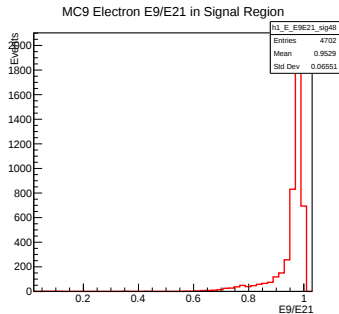
Background
Rejection

B^0 Signal
Selection

Further
Work



(e) Data electron E9/E21



(f) signal MC electron E9/E21



Discovering
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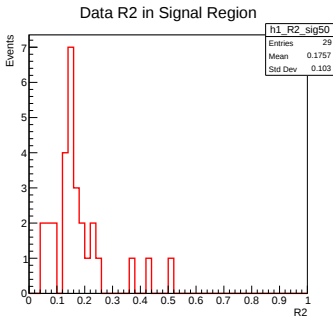
Selecting the
 D^*

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Selection

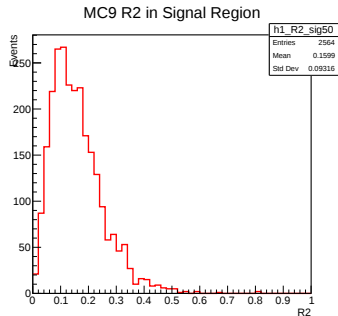
Background
Rejection

B^0 Signal
Selection

Further
Work



(a) Data R2



(b) MC R2



Discovering
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Selecting the
 D^*

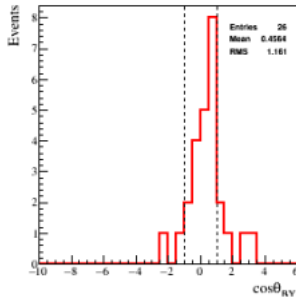
Lepton
Selection

Background
Rejection

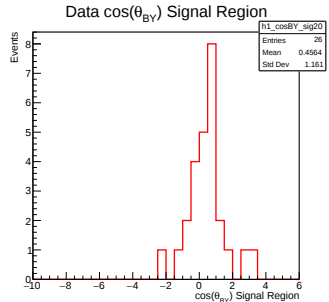
B^0 Signal
Selection

Further
Work

$$\cos(\theta_{BY}) = \frac{2E_B^* E_Y^* - m_B^2 - m_Y^2}{2p_B^* p_Y^*}$$



(a) Belle2 Note



(b) My Analysis

Select signal events in region $-1 < \cos(\theta_{BY}) < 1$.



Discovering
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Selecting the
 D^*

Lepton
Selection

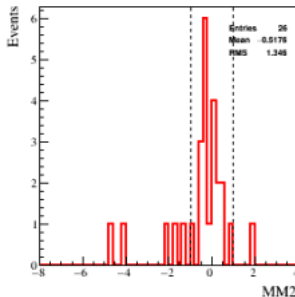
Background
Rejection

B^0 Signal
Selection

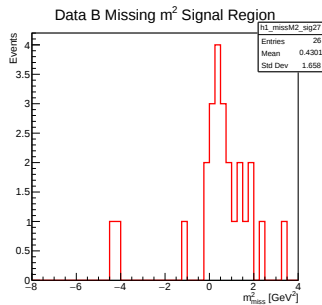
Further
Work

Define:

$$m_{miss}^2 := \left(\frac{m_{\Upsilon(4S)}}{2} - (E_{D^*} + E_{e^+}), -(\vec{p}_{D^*} + \vec{p}_{e^+}) \right)^2$$



(c) Belle2 Note



(d) My Analysis

Signal events in region $-1 \text{ GeV}^2 < m_{miss}^2 < 1 \text{ GeV}^2$



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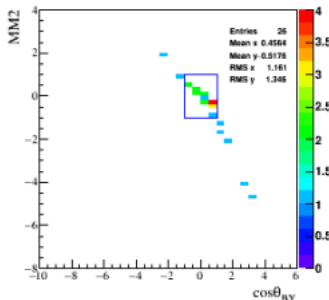
Lepton
Selection

Background
Rejection

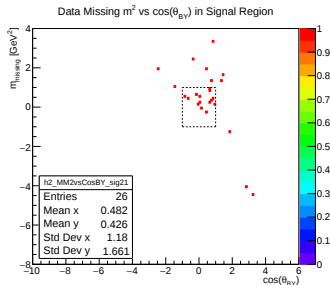
B^0 Signal
Selection

Further
Work

There are 19 events in the signal region overall,
consistent with Minakshi's results!



(e) Belle2 Note



(f) My Analysis





What's Next?

Discovering
The Signal
Side

Selecting the
 D^*

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Further
Work

- 1 Running a background MC analysis as well.
- 2 Possibly reconstructing Charged B and $B \rightarrow D^0 \ell \nu$.
- 3 Semileptonic tagging to find $B \rightarrow X \ell \nu$.



Thank You

Bernanda Telalovic

