

$B_s \rightarrow \phi l X \nu$ in Dilepton Trigger Data for B_s Mixing

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Introduction

Best limit on B_s mixing in CDF Run I came from a sample of B_s semileptonic decays collected using Run I dilepton triggers.

Ting Miao CDF Note #4485.

Analysis Summary

- Use partially reconstructed decay of $B_s \rightarrow \phi l X \nu$
- A soft lepton opposite to the ϕl pair as a flavor tag.
- Found 1068 ± 70 candidates with a B_s purity of 61% (652 B_s).
- limit of $\Delta m_s > 5.8 ps^{-1}$

How well would this method work in Run II data?

- The mode is self-tagged.
- The di-muon trigger is not prescaled

The BBAR_TWO_CMUP3 Trigger

The Di-Muon trigger path.

- L1_TWO_CMU1.5_PT1.5
 - CHARGE_PRODUCT = 0
 - CMU_XFT_PT = 1.52 GeV/c
 - CMU_STUB_PT = 1.5 GeV/c
- L2_CMUP1.5_PT3_&_CMU1.5_PT1.5
 - XFT_PT = 3.04 GeV/c
 - MUON_TYPE = 3
 - XFT_PT2 = 1.52 GeV/c
 - MUON_TYPE2 = 1
 - DELTA_PHI6_MAX = 180 degrees
 - CHARGE_PRODUCT = 0
- L3_BBAR_TWO_CMUP3_v-2
 - minPt = 3.0
 - nMuon = 2
 - selectCMUP = true
 - $5 < \text{TwoTrackMass} < 9999$

Run 1 Trigger Differences:

CMU-CMU di-muon trigger

One muon also required to be CMP

Ting's analysis:

No offline trigger confirmation

Any muon pair is used

Also used electron-muon pairs.

Run 1 Cuts on the Run 2 Di-Muon Sample

Using [5.3.4 UniversalFinder \(Sin2BetaMods\)](#)

strip a sample from 5.3.1 dimuon data ([xbmm0d](#) and [xbmm0e](#)).

Particle	Run 1	Our Cuts
μ	$p_T > 2 \text{ GeV}$	$p_T > 2 \text{ GeV}$
K	$p_T > 1 \text{ GeV}$ $\Delta R(K, l) < 1$ $dE/dx: L(K_1, K_2) > 0.25$	$p_T > 1.0 \text{ GeV}$ $\Delta R(K, l) < 1$ not yet implemented
ϕ	$p_T > 2.7 \text{ GeV}$	$p_T > 2.7 \text{ GeV}$ Prob (ϕ) > 0.0001
$\phi\mu$	$2.0 < m_{\phi l} < 5.0$ $p_T(\phi l) > 5.0 \text{ GeV}$ $p_T^{rel} > 1.0 \text{ GeV}$	$2.0 < m_{\phi l} < 5.0$ $p_T(\phi l) > 5.0 \text{ GeV}$ not yet implemented
ϕh	$\Delta R(h, \phi l) < 1$ $1.0 < m_{\phi h} < 2.0$ $\text{Prob}(\chi^2) > 0.01$	$\Delta R(h, \phi l) < 1$ $1.0 < m_{\phi h} < 2.0$ $\text{Prob}(\chi^2) > 0.01$
$\phi h \mu$	$m_{\phi h \mu} < 5.0 \text{ GeV}$ $\text{Prob}(\chi^2) > 0.01$	$m_{\phi h \mu} < 5.0 \text{ GeV}$ Prob (χ^2) > 0.0001
$\mu\mu$	$\Delta R(l_{tag}, l) > 2$	$\Delta\phi(l_{tag}, l) > 2$

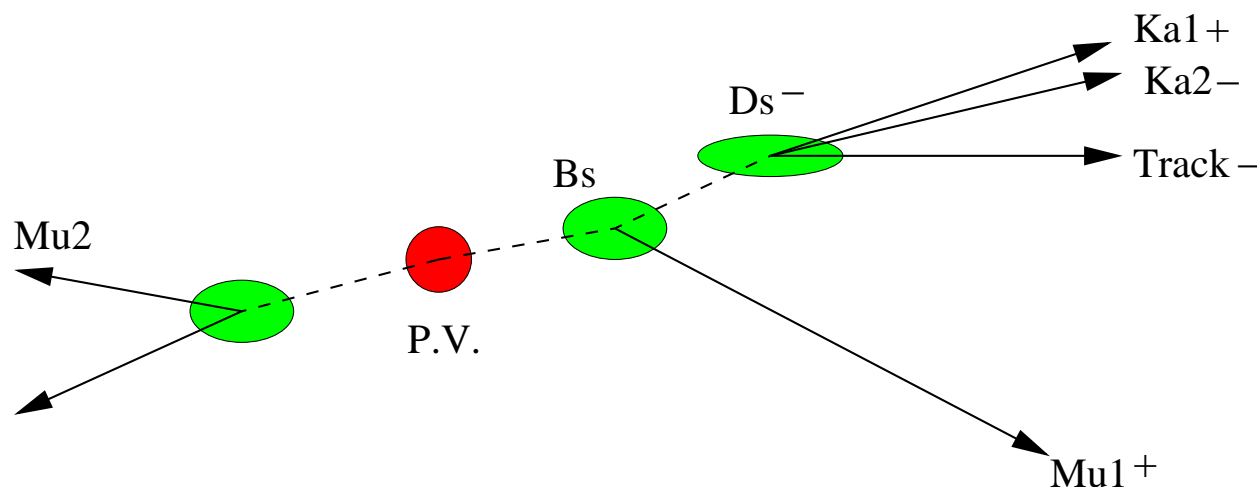
Adding Hadron Tracks: PickOne Finder

Copy of Run I method to add an extra hadron track to the D_s vertex.

- Tracks within a cone of 1 around the reconstructed ϕ are considered.
- Track has opposite charge as the Muon.
- Track with the largest longitudinal momentum w.r.t the ϕ is chosen.
- The track and the ϕ are combined to form D_s vertex.
- The ϕ -Track vertex is projected back to the Muon to form the B_s vertex.

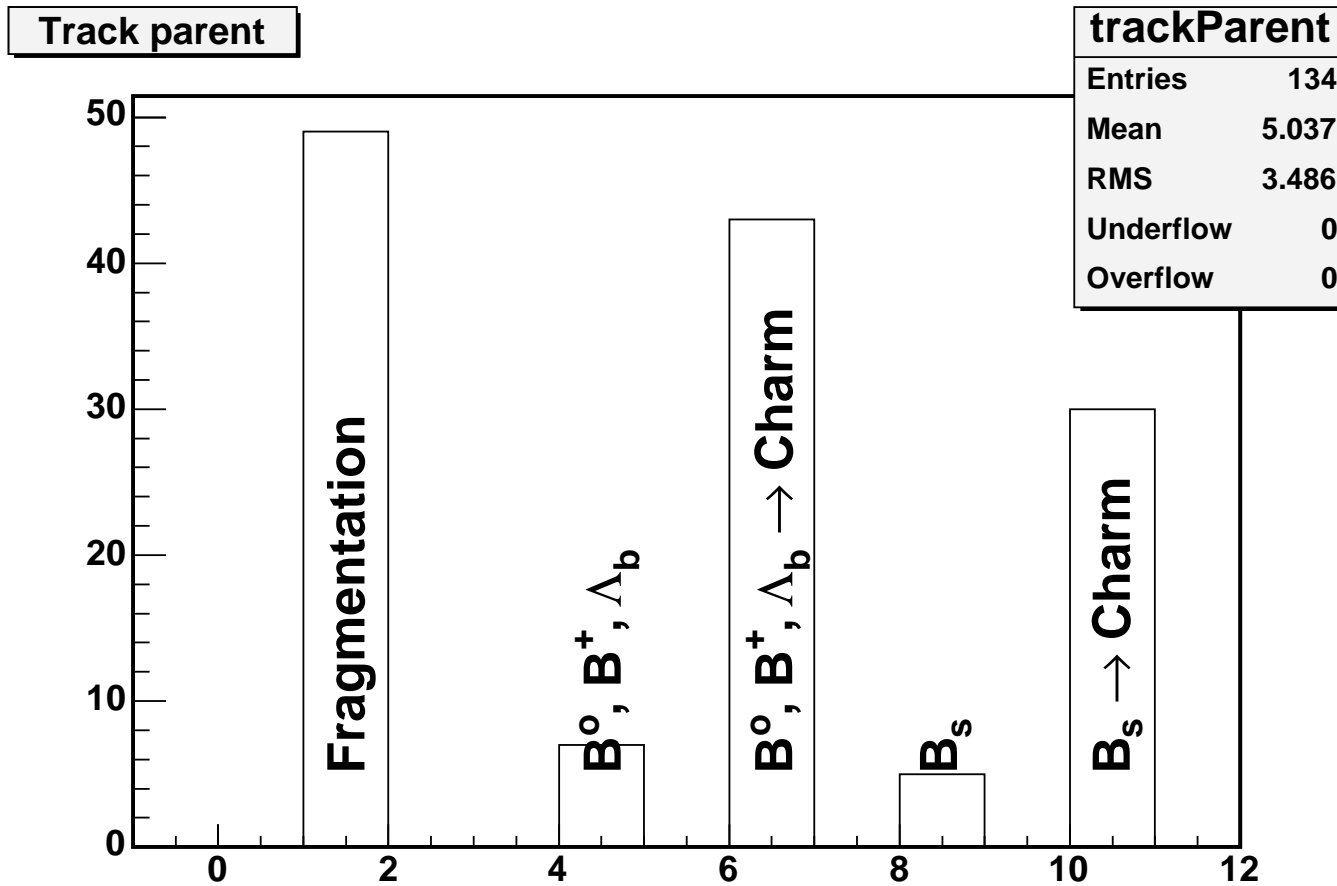
We require that:

- $1.0 < m_{\phi h} < 2.0$
- $m_{\phi\mu h} < 5\text{GeV}$
- $\Delta R(h, \phi\mu) < 1$



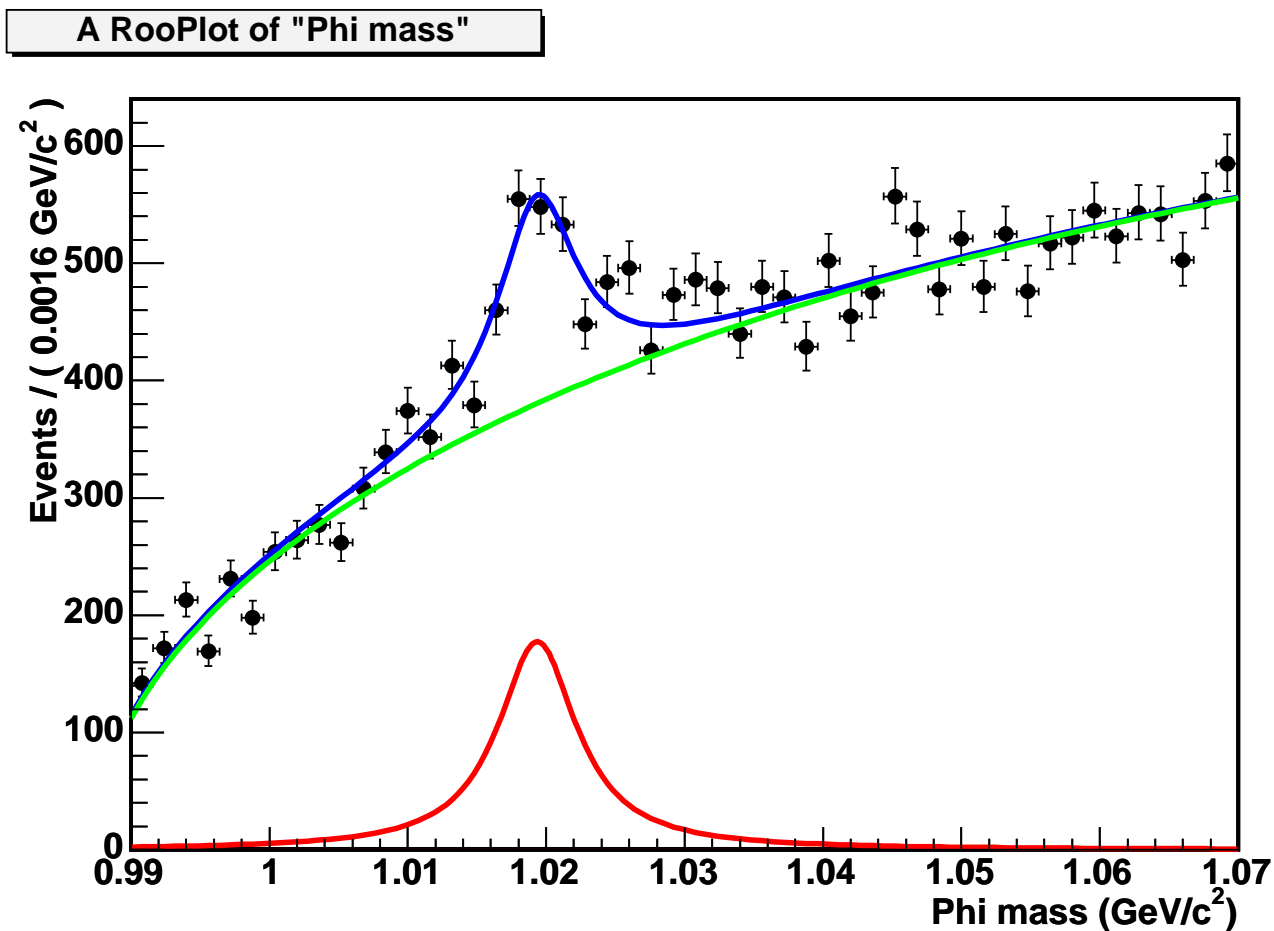
Efficiency for added Track

In Run 1: Probability for the selected track to be a B hadron track $> 97\%$.



Efficiency is only $\sim 64\%$ for this analysis.

The Run 2 ϕ Yield Using Run 1 Cuts



Run 1 Yield: 1068 (on $\sim 110pb^{-1}$). Includes $\mu - \mu$ and $e - \mu$ events

Run 2 Yield: 1137 (on $\sim 360pb^{-1}$). Includes only $\mu - \mu$ events.

Closer Look at the Yield

Monte Carlo Sample

- Generic B, $m_{sel} = 5$, Pythia Monte Carlo.
- Generator level filters select events with a ϕ and two muons.
- Prereq requires L1_TWO_CMU1.5_PT1.5 trigger.
- $\sim 13,000$ events.

Run 1 High Mass Di-Muon Trigger cuts:

- $p_T(\mu) > 2.0$ GeV
 - CMU-CMU muons
 - At least one CMUP muon
- **Yields 487 events.**

Run 2 Di-Muon Trigger cuts:

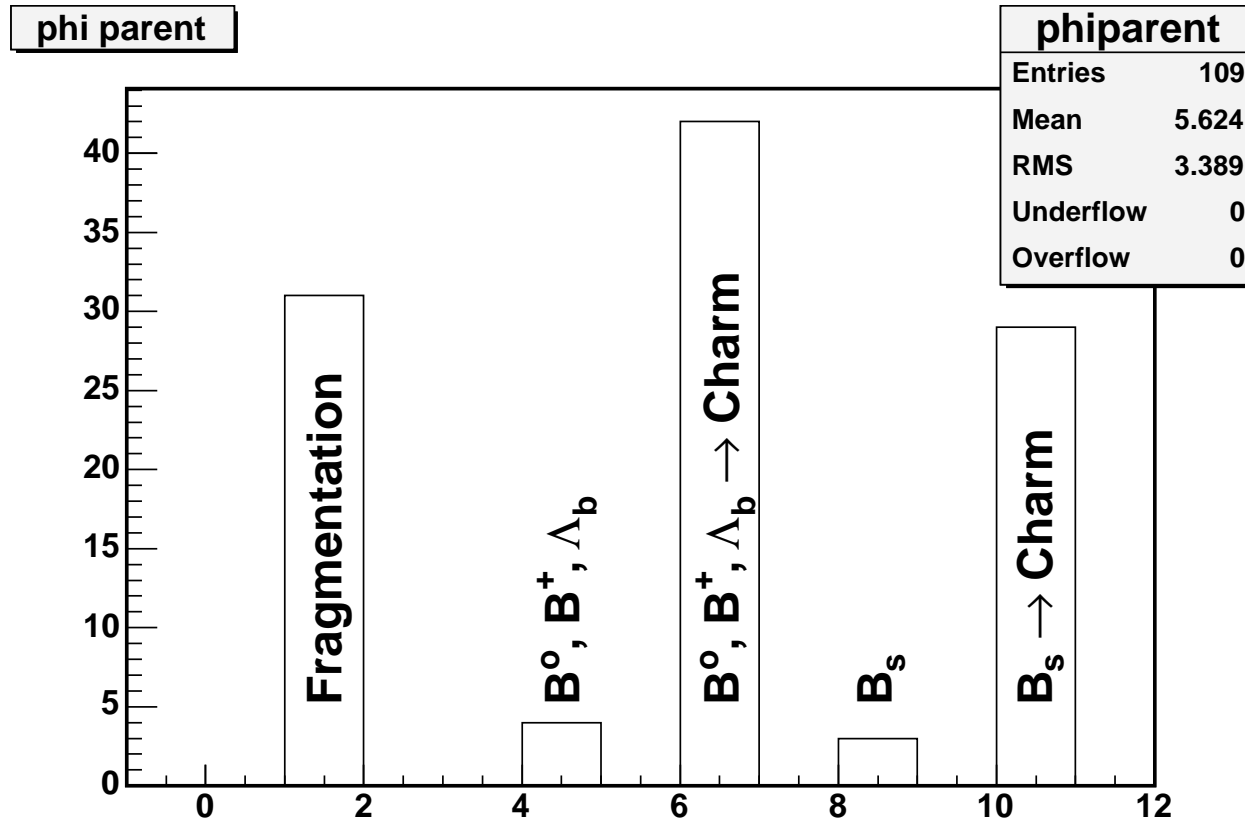
- $p_T(\mu) > 3.0$ GeV
 - CMUP-CMUP muons
- **Yields 104 events.**

Run 2 trigger yields only $\sim 21\%$ of Run 1.

1068	Run 1 Events in $110pb^{-1}$
802	$\mu - \mu$ events (75%)
266	$e - \mu$ events (25%)
1140	Run 2 Events in $360pb^{-1}$
1140	$\mu - \mu$ events
1630	Scaled to Run 1 Trigger & \mathcal{L}

Sample Composition

Monte Carlo events reconstructed with page 3 cuts.



Run 1 Sample Composition:

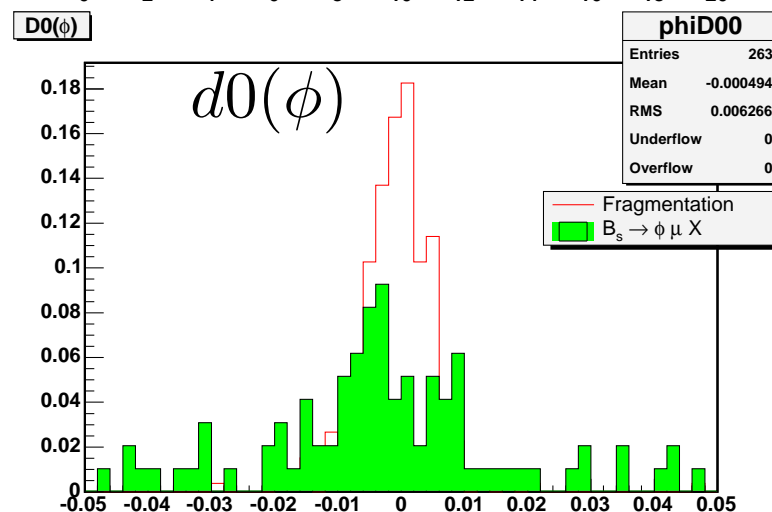
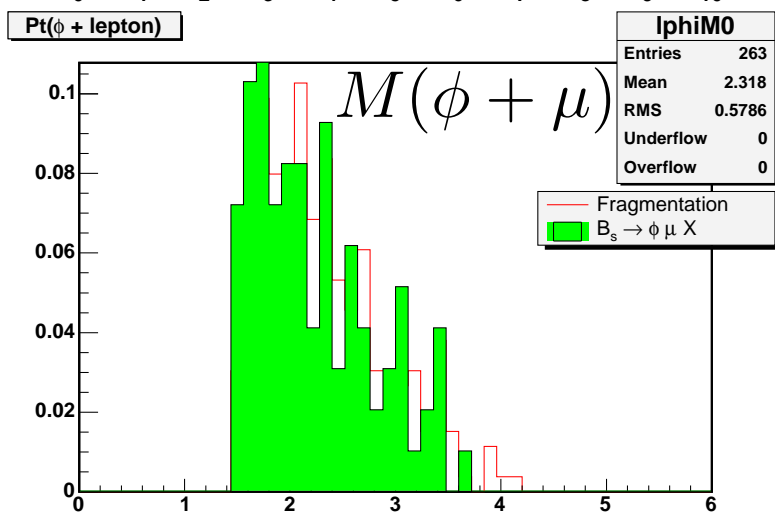
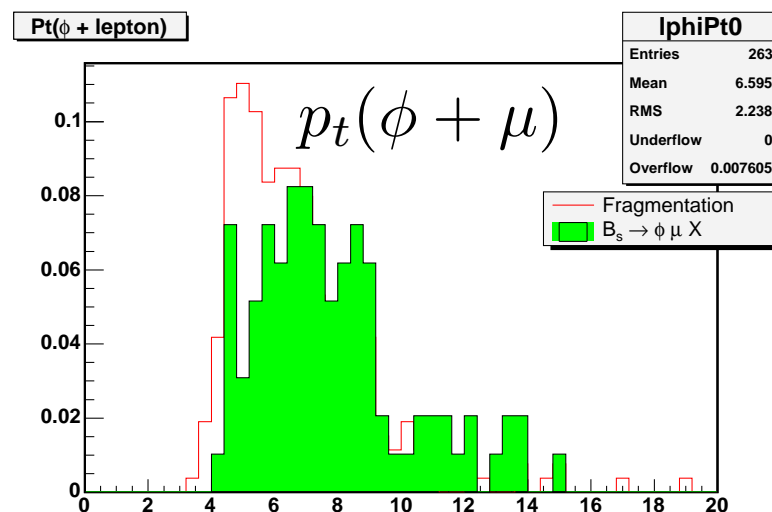
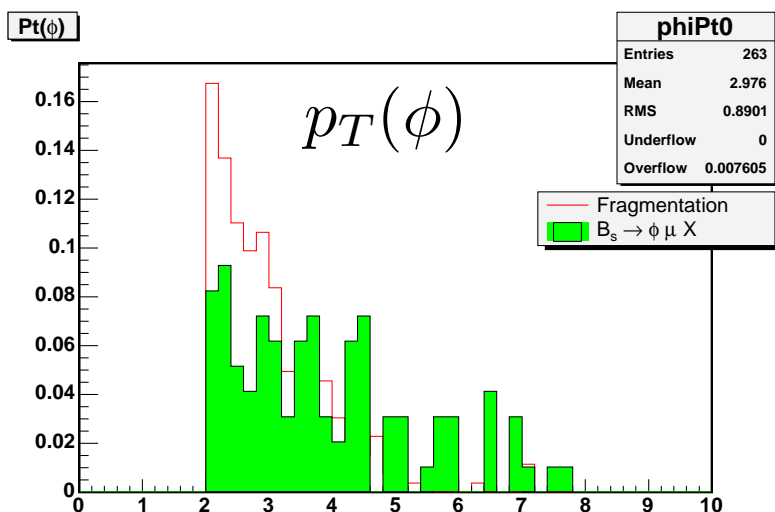
- $\sim 61\% B_s \rightarrow \phi l X \nu$
- $\sim 38\% B^0, B^+ \rightarrow \phi l X \nu$
- ~ 0 other

Run 2 Sample Composition:

- $\sim 25\% B_s \rightarrow \phi l X \nu$
- $\sim 39\% B^0, B^+ \rightarrow \phi l X \nu$
- $\sim 27\% b \rightarrow \phi B; B \rightarrow l X \nu$
- $\sim 8\%$ other

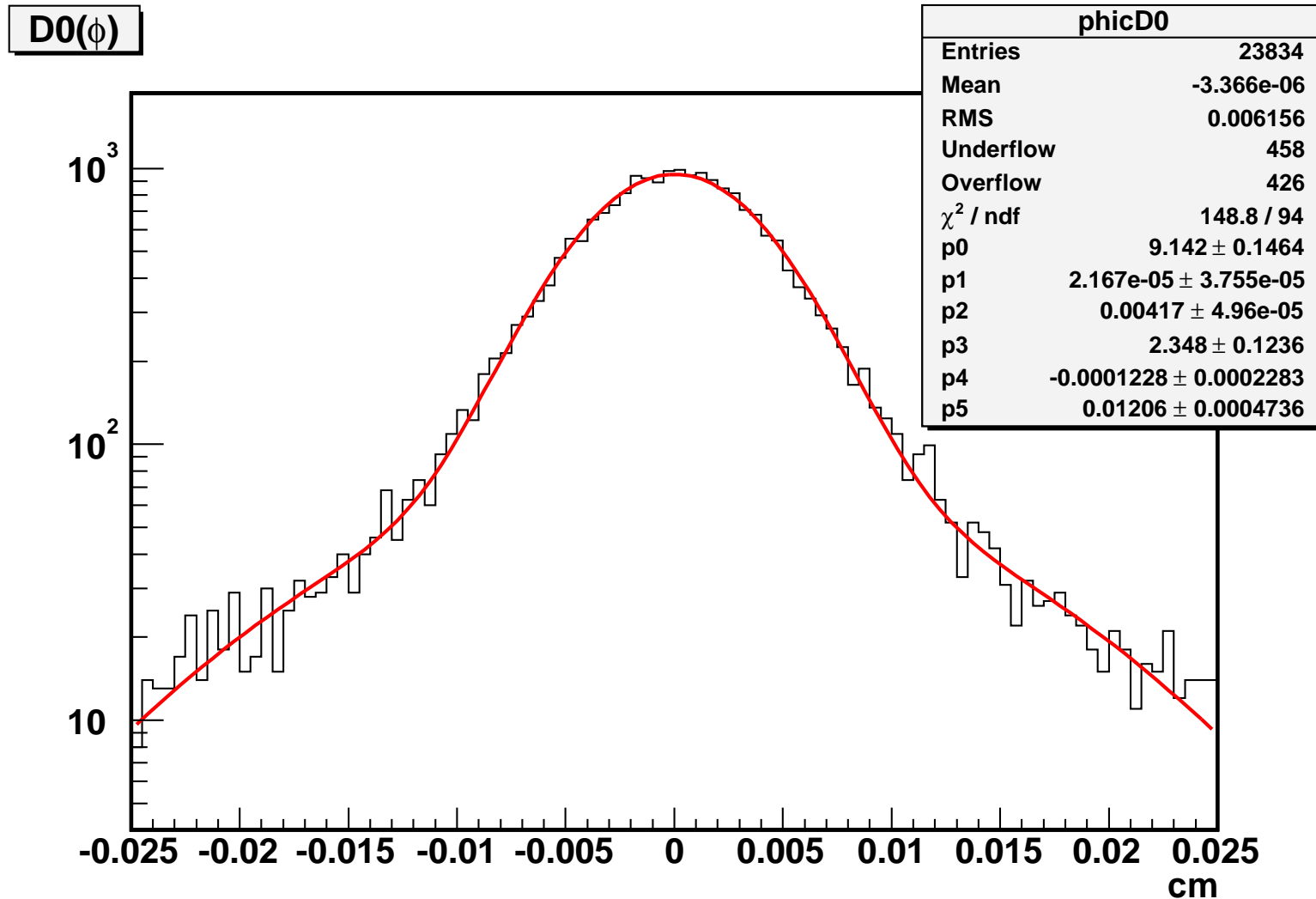
Improving Signal Purity

Run 1, used kinematic differences in $b \rightarrow \phi B$; $B \rightarrow \phi l$ and $B_s \rightarrow \phi l X \nu$ to reduce this background to about 2% of $B_s \rightarrow \phi l X$ signal.



ϕ Impact Parameter

Might be able to use the impact parameter to improve purity.



Clean up signal but introduce lifetime bias.

Summary and To Do List

Yield

- Run2 Trigger is much different compared to Run1
- Are there other samples we could try?
 - SUSY di-lepton triggers?
 - provide both $e - \mu$ and $\mu - \mu$ triggers
 - no lepton opening angle cuts

Adding Tracks

- more reliable way to find extra tracks from B decays?

Sample Composition

- dE/dx for Kaons from ϕ
- Other kinematic cuts we could effectively use?

Sensitivity

- NEED more MC for K-factor, L_{xy} resolution, etc.
- Estimate the sensitivity for this method