$B_s \to \phi l X \nu$ 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 & #4787.

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 BBBAR_TWO_CMUP3 Trigger

The Di-Muon trigger path.

- L1_TWO_CMU1.5_PT1.5
  - CHARGE_PRODUCT = No Requirement
  - CMU_XFT_PT $\geq$ 1.52 GeV/c
  - CMU_STUB_PT $\geq$ 1.5 GeV/c
- L2_CMUP1.5_PT3_&_CMU1.5_PT1.5
  - XFT_PT $\geq$ 3.04 GeV/c
  - MUON_TYPE = 3
  - XFT_PT2 $\geq$ 1.52 GeV/c
  - MUON_TYPE2 = 1
  - DELTA_PHI6_MAX = 180 degrees
  - CHARGE_PRODUCT = No Requirement
- L3_BBAR_TWO_CMUP3_v-2
  - minPt $\geq$ 3.0
  - nMuon = 2
  - selectCMUP = true
  - 5 $<$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 I	Our Cuts
μ	$p_T > 2$ GeV	$p_T > 2$ GeV
K	$p_T > 1$ GeV $\Delta R(K, l) < 1$ dE/dx: $L(K_1, K_2) > 0.25$	$p_T > 1.0$ GeV $\Delta R(K, l) < 1$ not yet implemented
ϕ	$p_T > 2.7$ GeV	$p_T > 2.7$ GeV
$\phi\mu$	$2.0 < m_{\phi l} < 5.0$ $p_T(\phi l) > 5.0$ GeV $p_T^{rel} > 1.0$ GeV	$2.0 < m_{\phi l} < 5.0$ $p_T(\phi l) > 5.0$ GeV not yet implemented
ϕ h	$\Delta R(h, \phi l) < 1$ $1.0 < m_{\phi h} < 2.0$ $L_{xy} > 0.0$ Prob $(\chi^2) > 0.01$	$\Delta R(h, \phi l) < 1$ $1.0 < m_{\phi h} < 2.0$ $L_{xy} > 0.0$ Prob $(\chi^2) > 0.01$
ϕ h μ	$m_{\phi h\mu} < 5.0$ GeV Prob $(\chi^2) > 0.01$	$m_{\phi h\mu} < 5.0$ GeV Prob $(\chi^2) > 0.0001$
$\mu\mu$	$\Delta R(l_{tag}, l) > 2$	$\Delta R(l_{tag}, l) > 2$

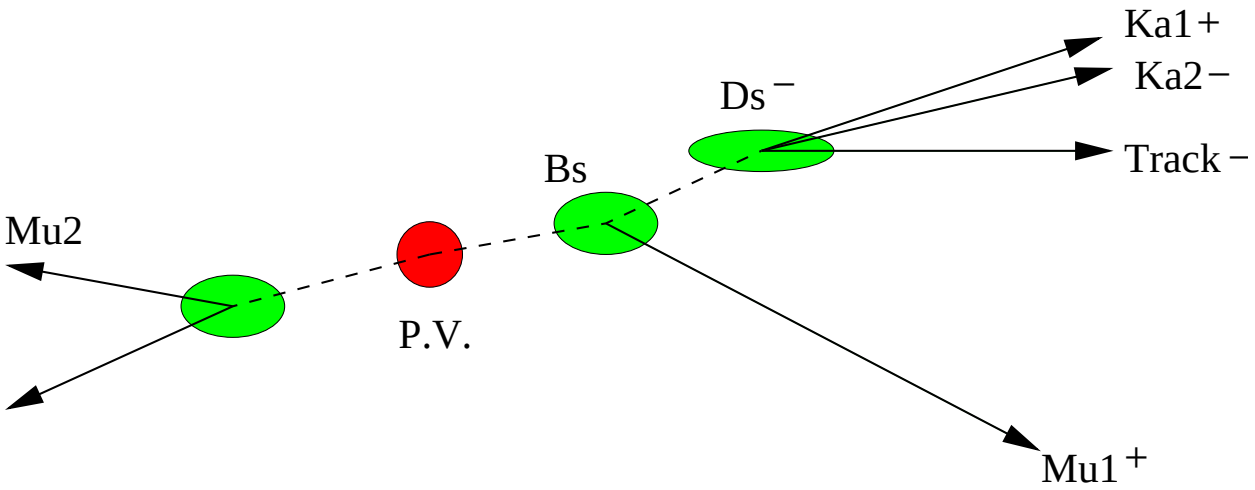
Adding Extra Hadron Track

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.

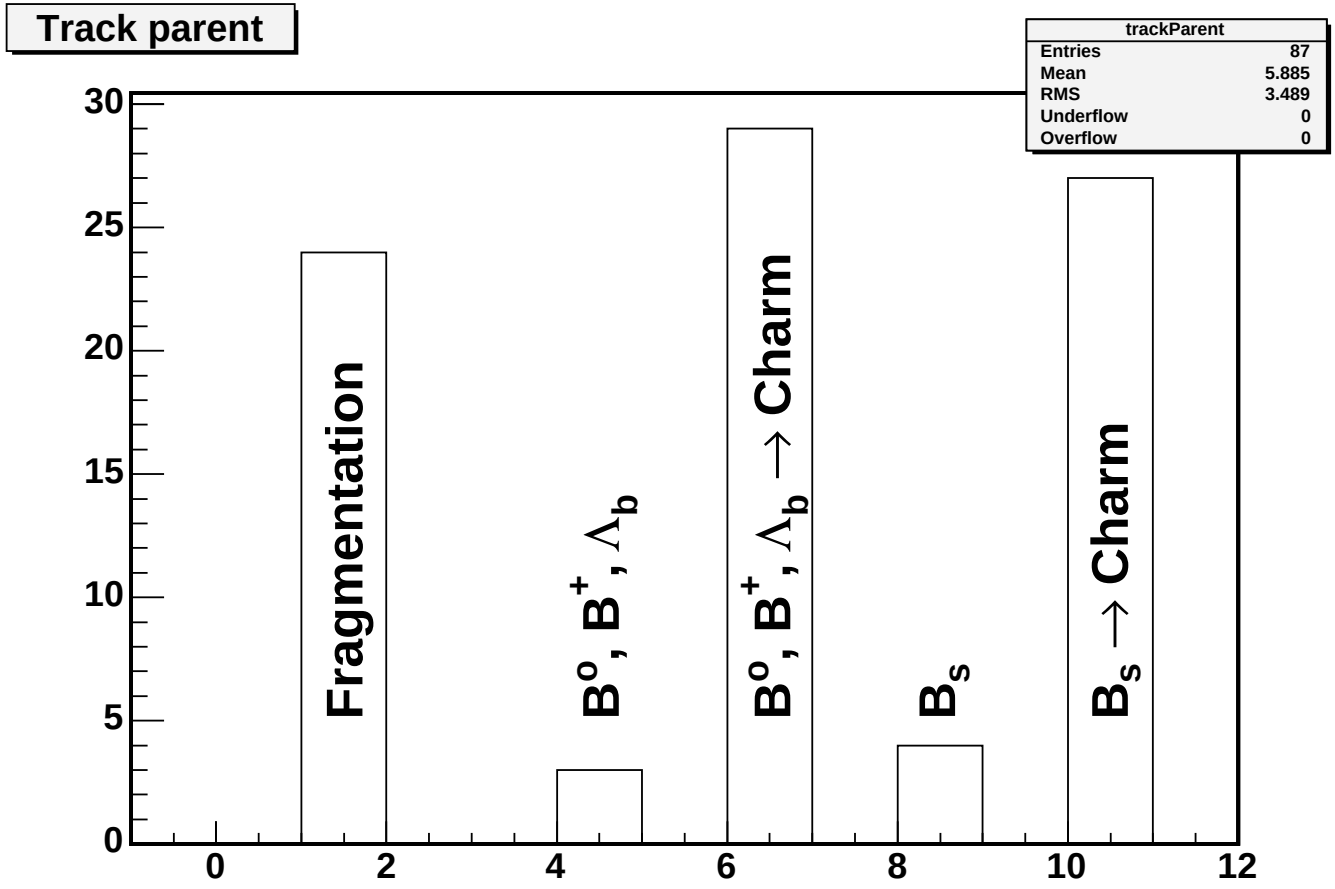
We require that:

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



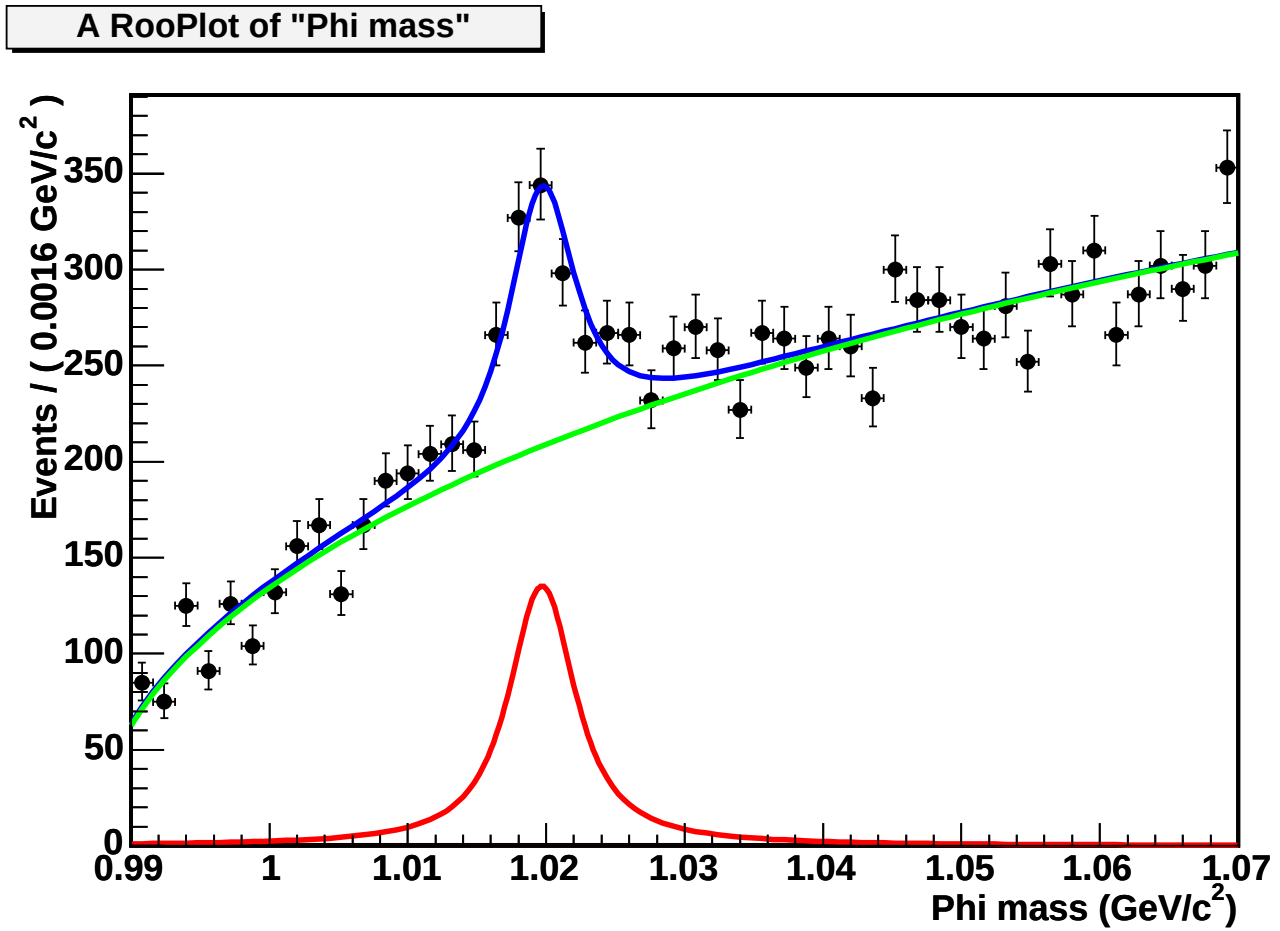
Efficiency for added Track

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



Efficiency is only $\sim 72\%$ for this analysis.

The Run 2 ϕ Yield Using Run 1-like Cuts



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

Run 2 Yield: 705 (on $\sim 360pb^{-1}$). Includes only $\mu - \mu$ events.

Closer Look at the Yield

Monte Carlo Sample

- Generic B, $msel = 5$, 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

$\rightarrow$ **Yields 487 events.**

Run 2 Di-Muon Trigger cuts:

- $p_T(\mu) > 3.0$ GeV
- CMUP-CMUP muons

$\rightarrow$ **Yields 104 events.**

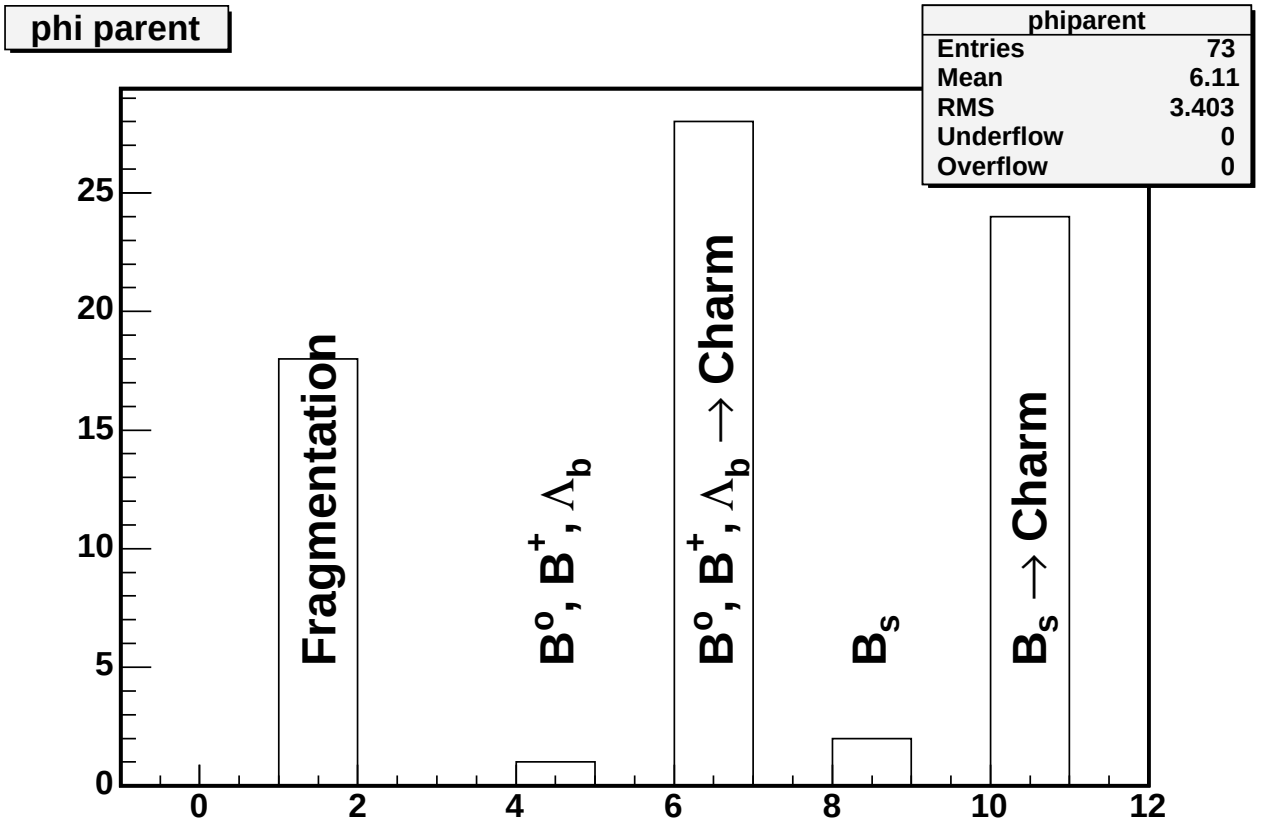
Run 2 trigger yields only $\sim 21\%$ of Run 1.

1068	Run 1 Events in $110pb^{-1}$
802	$\mu - \mu$ events (75%)
266	$e - \mu$ events (25%)
705	Run 2 Events in $360pb^{-1}$
705	$\mu - \mu$ events

Scaling to Run 1: $705 * \frac{487}{104} * \frac{110pb^{-1}}{360pb^{-1}} = \mathbf{1009}$

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:

$\sim 32\%$ $B_s \rightarrow \phi l X \nu$

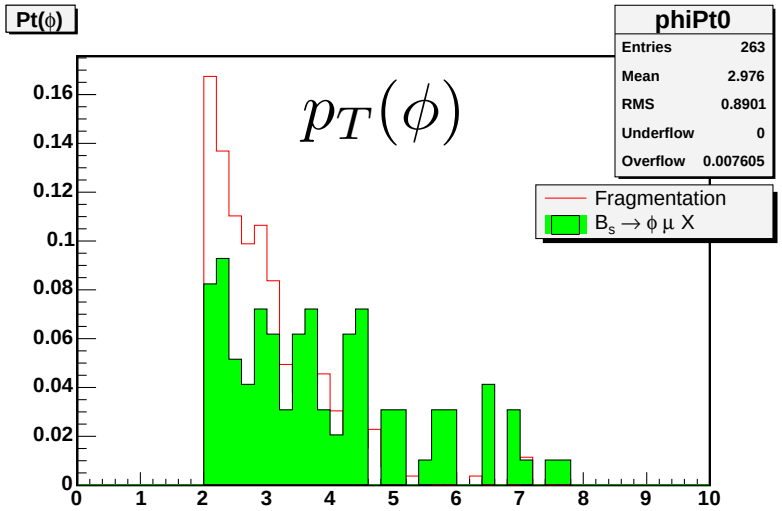
$\sim 38\%$ $B^0, B^+ \rightarrow \phi l X \nu$

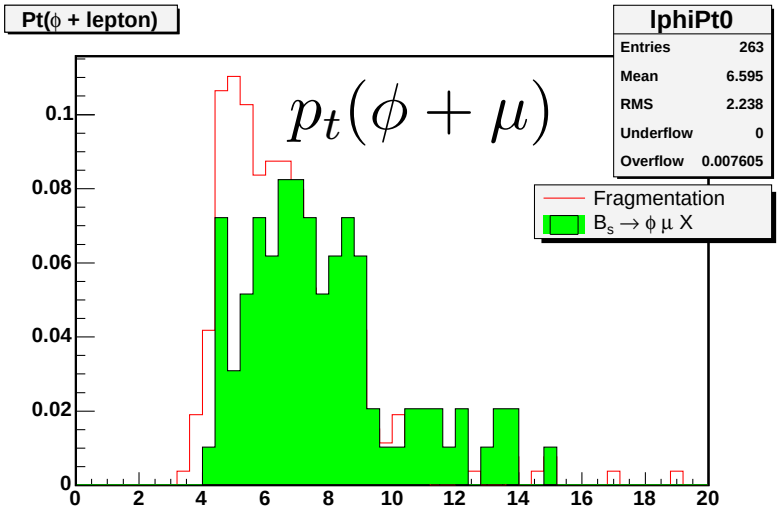
$\sim 25\%$ $b \rightarrow \phi B$; $B \rightarrow l X \nu$

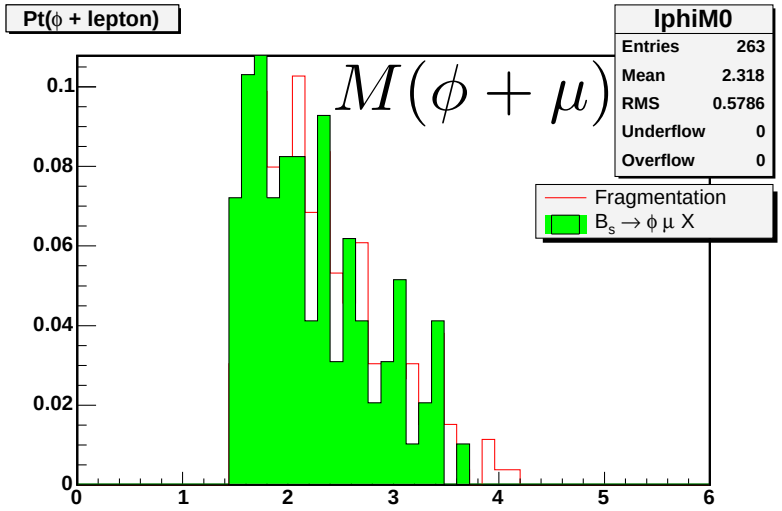
$\sim 5\%$ other

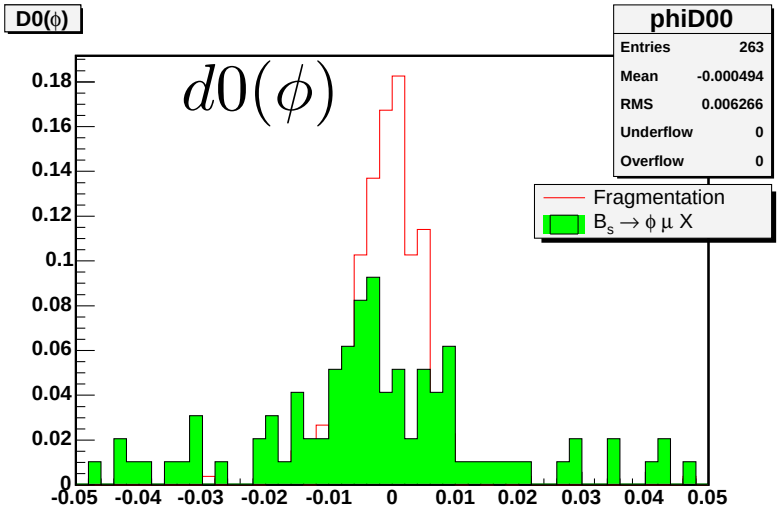
Possibilities for Improving Signal Purity

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



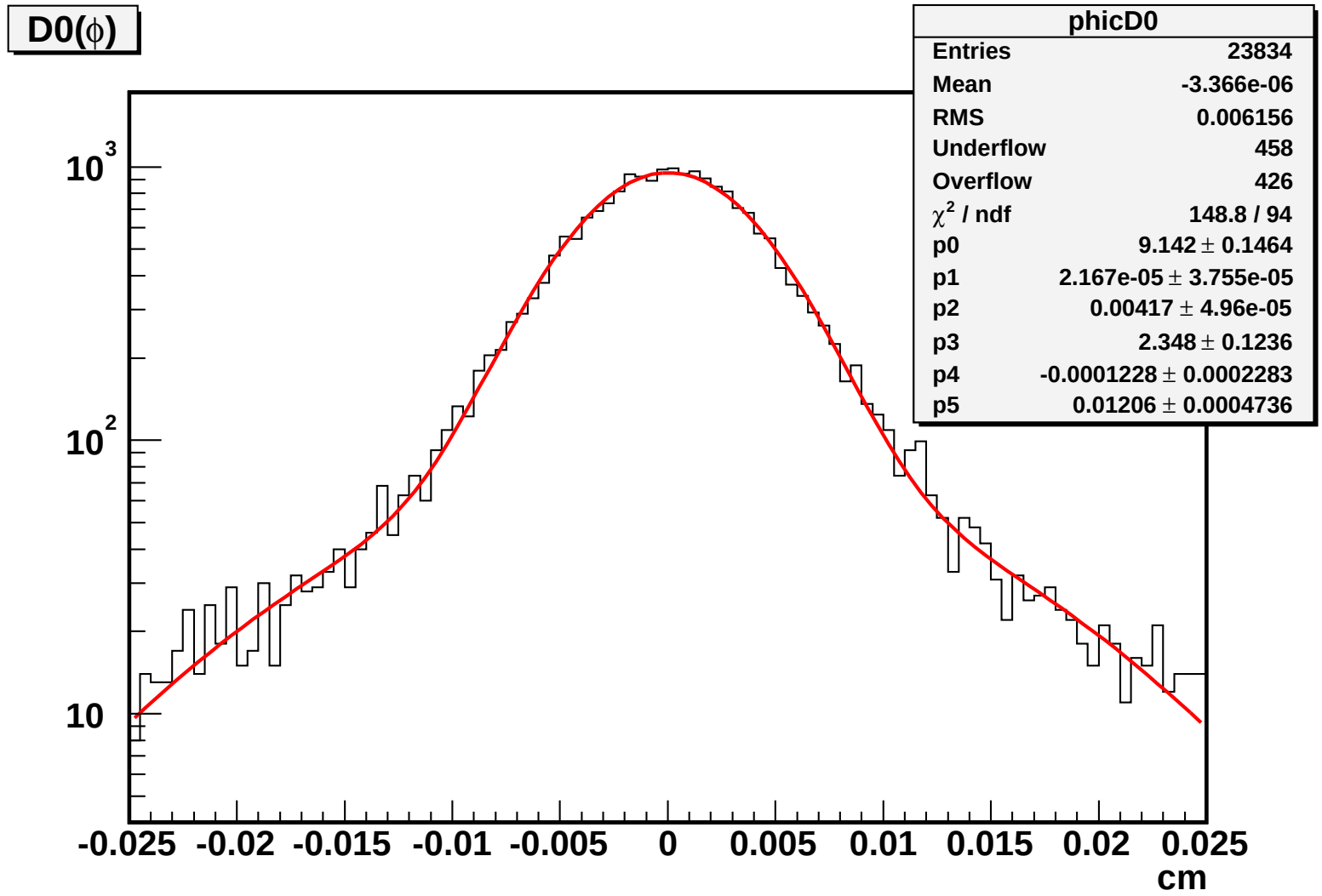






ϕ Impact Parameter

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 (to suppress fakes).
- Other kinematic cuts we could effectively use?

Sensitivity

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