$\pi^0$ Skim Study in CM2

Minghui Lu

University of Oregon

For Fully Inclusive $b \rightarrow s\gamma$ group

Notre Dame-Oregon-Pisa-SLAC-UCSC
Outline

- Introduction
- $\pi^0$ skim cuts
- $\pi^0$ mass and energy spectrum
- The Comparison of $\pi^0$ mass spectrum between SP5 MC and run1 data
- Preliminary $\pi^0$ mass fit
- Outlook
Introduction

- $\pi^0$ is the dominant background for $b\rightarrow s\gamma$ signal in generic $B\bar{B}$ events
- $\pi^0$ correction receipe was provided by Neutral group based on $\tau\tau$ events for SP5 and SP6 (BAD870), but similar study is not done with inclusive events
- This is a first try to migrate current inclusive $b\rightarrow s\gamma$ analysis to CM2
- To understand $\pi^0$ spectrum in CM2, provide useful information for other CM2 analyses
$\pi^0$ skim

- **Skim Cuts**
  - BGFMultiHadron tag bit
  - $1.0 < e1\text{Mag} < 3.5$ GeV
  - 2nd Fox-Wolfram moment in overall CMS, $R2<0.9$
  - $n\text{Trk}>2$, from $n\text{GoodTrackLoose}$
  - $p1\text{Mag}<2.5$ GeV

- **Skim Efficiency**
  - $B^0\bar{B}^0$ MC events: $200k \rightarrow 25,393$, $12.7\%$
  - $B^+B^-$ MC events: $200k \rightarrow 26,417$, $13.2\%$
  - On-Peak run1 data: $500k \rightarrow 45,395$, $9.1\%$
  - Off-Peak run1 data: $100k \rightarrow 7,490$, $7.5\%$
Selection of $\pi^0$ Candidate

- $2\gamma$ Mass cut:
  - $E_{\gamma_1}^* > 1.0$ GeV, from user defined HE $\gamma$ List
  - $E_{\gamma_2} > 30$ MeV, from GoodPhotonLoose List
  - $50 < m_{2\gamma} < 250$ MeV
  - $1.0 < E_{2\gamma}^* < 3.5$ GeV

- Truth matching for MC:
  - GHit truth map
  - The mother <->daughter matching
$\pi^0$ spectrum (on-peak data)

Spectrum will be studied in 8 different $E_{\pi^0}^*$ bins:
1.0-1.2, 1.2-1.4, 1.4-1.6, 1.6-1.8,
1.8-2.0, 2.0-2.2, 2.2-2.4, 2.4-3.0
$M_{\pi^0}$ in different $E_{\pi^0}^*$ bins (on-peak data)
$\pi^0$ spectrum for $B^0\bar{B}^0$ MC

**Pi0Mass**
- Entries: 56111
- Mean: 0.1607
- RMS: 0.05082

**Pi0cmE**
- Entries: 56111
- Mean: 1.395
- RMS: 0.3076

**Mpi0 (Mpi0>0.05 && Mpi0<0.25)**
- Entries: 14254
- Mean: 0.1323
- RMS: 0.01784

$p^0$ Skim Study in CM2 – p.8
$M_{\pi^0}$ in 8 different $E^*_{\pi^0}$ bins ($B^0 \bar{B}^0$)
MC and Run1 data comparison

- on-off: On-peak - \( \frac{L_{on}}{L_{off}} \) off-peak

- Combine both \( B^0 \overline{B}^0 \) and \( B^+ B^- \), normalized to same number of Bs

\[ \pi^0 \text{ spectrum} \]

![Graph of \( \pi^0 \) spectrum with data entries and statistical properties.]

- Entries: 112222
- Mean: 0.1607
- RMS: 0.05082

\( \pi^0 \) Skim Study in CM2 – p.10
\( \pi^0 \) mass fit function

- **The signal Model:**

  \[
  f(m) = A_g [f_1 G(m, \mu_1, \sigma_1) + (1 - f_1) G(m, \mu_2, \sigma_2)], \quad m > m_0
  \]

  \[
  f(m) = N \left[ \frac{p \sigma_1 / \lambda}{(m_0 - m) + p \sigma_1 / \lambda} \right]^p, \quad m < m_0
  \]

  where \( m_0 = \mu_1 - \lambda \sigma_1 \)

  8 fit parameters: \( A_g, f_1, \mu_1, \sigma_1, \mu_2, \sigma_2, p \) and \( \lambda \).

- **Background:**

  \[
  f(m) = \frac{am^b}{(m^2 + c)^d}
  \]

  4 fit parameters: \( a, b, c, d \)
Preliminary $\pi^0$ mass fit

\begin{itemize}
  \item $\chi^2 / \text{ndf} = 114.5 / 42$
  \item Fraction: $0.9109 \pm 0.0066$
  \item Area: $43.76 \pm 0.71$
  \item Mean 1: $0.1347 \pm 0.0001$
  \item Sigma 1: $0.006113 \pm 0.000086$
  \item Mean 2: $-0.07278 \pm 0.02710$
  \item Sigma 2/Sigma 1: $15.61 \pm 0.45$
  \item Lambda: $1.246 \pm 0.043$
  \item Poly: $1.915 \pm 0.115$
\end{itemize}

\begin{center}
\includegraphics[width=\textwidth]{Mpi0Truth}
\end{center}
Summary and Outlook

- A simple data MC comparison was done on $\pi^0$ skim
- Preliminary Mass fits on truth matched $\pi^0$ mass spectrum were performed, more complete mass fits are expected
- Only skim samples were studied so far, more cuts will be implemented, such as photon quality cut, fisher cut, etc
- The mass fits now are done by my personal codes, John and Francesca’s complete $\pi^0/\eta$ mass fit package will be borrowed and migrated to CM2
- This study is intended to be done on full statistics (run1 to run4 data) once all cuts are finalized and codes are implemented