Approved plots of $R_2$ distribution in Early Phase 3 Data

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Abstract

We present the approved plots of the event shape variable $R_2$ represented by the ratio of the second and zeroth Fox-Wolfram moment. The variable $R_2$ is a good indicator to understand if the collision data of the SuperKEKB are occurring at the $\Upsilon(4S)$ resonance. The study on the shape variable $R_2$ is used to derive the total number of produced $B\overline{B}$ pairs and is summarized in the physics note BELLE2-NOTE-PH-2019-025.
1. $R_2$ DEFINITION AND PLOT

The Fox-Wolfram moments $H_l$, $l = 0, 1, 2, \ldots$ are defined by

$$H_l = \sum_{i,j} \frac{|P_i||P_j|}{E_{\text{vis}}^j} P_l(\cos\theta_{ij})$$

(1)

where $\theta_{ij}$ is the opening angle between charged tracks or photons i and j, $E_{\text{vis}}$ is the total visible energy of the event, $P_l$ are the Legendre polynomials and $|P_i|$ and $|P_j|$ are the momenta of the charged tracks or photons. $R_2$ is defined as the ratio of the second and zeroth moment, $H_2/H_0$.

Results presented here are obtained with Phase 3 data collected in 2019 corresponding to the following run numbers and luminosities:

- exp 7, $\Upsilon(4S)$: runs 1006-1155, 1372-4120 (integrated luminosity: 641.9 pb$^{-1}$)
- exp 8, $\Upsilon(4S)$: runs 43-1022, 1036-1554 (integrated luminosity: 1982.3 pb$^{-1}$)
- exp 8, off-resonance: runs 1703-1835 (integrated luminosity: 827.0 pb$^{-1}$)

for a total luminosity of 2624.2 pb$^{-1}$ (rounded to 2.62 fb$^{-1}$) on-peak. On-peak and off-resonance data have been reprocessed and calibrated, the used global tags are data_reprocessing_proc9.
FIG. 1: $R_2$ distribution for $\Upsilon(4S)$ data and off-resonance data. The event selection requires at least three tracks and two clusters in the event, with transverse momentum greater than 100 MeV/$c$ and cluster energy greater than 100 MeV, respectively. Additional requirements on tracks, clusters and event variables are described in detail in the note BELLE2-NOTE-PH-2019-025. The overall selection efficiency on the $\bar{B}B$ sample is 98.8%. The off-resonance contribution is normalized to the luminosity of the on-peak data.