



## 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  $B\bar{B}$  pairs and is summarized in the physics note BELLE2-NOTE-PH-2019-025.

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#### 1. $R_2$ DEFINITION AND PLOT

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

$$H_l = \sum_{i,j} \frac{|P_i||P_j|}{E_j^{vis}} P_l(\cos\theta_{ij}) \quad (1)$$

where  $\theta_{ij}$  is the opening angle between charged tracks or photons  $i$  and  $j$ ,  $E_{vis}$  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<sup>-1</sup>)
- exp 8,  $\Upsilon(4S)$ : runs 43-1022, 1036-1554 (integrated luminosity: 1982.3 pb<sup>-1</sup>)
- exp 8, off-resonance: runs 1703-1835 (integrated luminosity: 827.0 pb<sup>-1</sup>)

for a total luminosity of 2624.2 pb<sup>-1</sup> (rounded to 2.62 fb<sup>-1</sup>) on-peak. On-peak and off-resonance data have been reprocessed and calibrated, the used global tags are `data_reprocessing_proc9`.

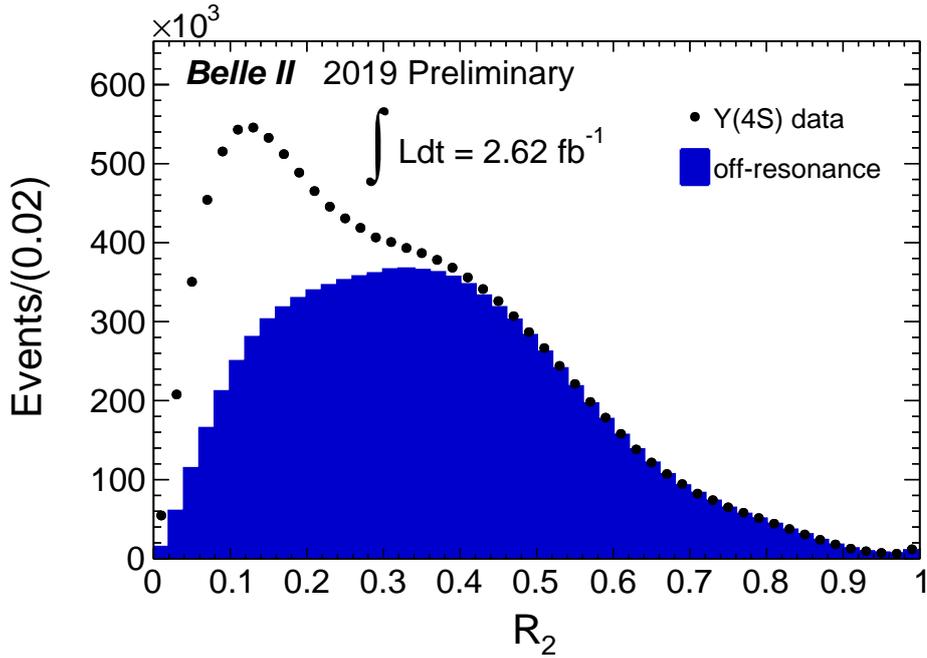


FIG. 1:  $R_2$  distribution for  $\Upsilon(4S)$  data and off-resonance data. The event selection requires at least three tracks and two clusters in the event, with transverse momentum greater than 100 MeV/ $c$  and cluster energy greater than 100 MeV, respectively. Additional requirements on tracks, clusters and event variables are described in detail in the note BELLE2-NOTE-PH-2019-025. The overall selection efficiency on the  $B\bar{B}$  sample is 98.8%. The MC and off-resonance contributions are normalized to the yields obtained from a template fit to this variable.