

# About the efficiencies change

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## I. CHANGE OF MC SAMPLE

In the previous study, we used the “no- $P_{cs}^0(4459)$  MC sample” of  $\Upsilon(1, 2S)/e^+e^- \rightarrow \Lambda J/\psi + \bar{\Lambda} + q\bar{q}$  to simulate the process without resonance production. Both  $\Lambda$  and the  $\bar{\Lambda}$  from the inclusive part will be selected to combine with  $J/\psi$ , resulting in overestimation of the detection efficiencies. The reason for selecting such samples is that we think similar cases may exist in the experimental data. These samples allow for the most conservative estimation. However, such events are too few in data, only 2% (2/84) of the signal yield in our draft. It's not suitable to use the efficiencies from these samples in the calculations of Branching fractions and cross section.

To satisfy baryon number and strangeness number conservation, we choose another sample of  $\Upsilon(1, 2S)/e^+e^- \rightarrow \Lambda J/\psi + \bar{p} + K^+ q\bar{q}$ . The samples of  $\Upsilon(1, 2S) \rightarrow \Lambda J/\psi + \bar{p} + K^+ + q\bar{q}$  have lower detection efficiencies, which are  $\varepsilon_{\Upsilon(1S)} = (26.5 \pm 0.2)\%$  and  $\varepsilon_{\Upsilon(2S)} = (27.0 \pm 0.2)\%$  in  $\Upsilon(1S)$  and  $\Upsilon(2S)$  inclusive decays, and  $\varepsilon_{\text{cont}} = (26.6 \pm 0.2)\%$  in the  $e^+e^-$  annihilation. The efficiencies are calculated by:

$$\epsilon = N(\text{Reconstructed } J/\psi \Lambda/\bar{\Lambda} \text{ events})/N(\text{Generated } J/\psi \Lambda/\bar{\Lambda} \text{ events}) \quad (1)$$

Then the branching fractions and cross section will change to :

$$\begin{aligned} \mathcal{B}[\Upsilon(2S) \rightarrow \Lambda J/\psi + \text{anything}] &= (36.9 \pm 5.3 \pm 2.4) \times 10^{-6}; \\ \mathcal{B}[\Upsilon(2S) \rightarrow \Lambda J/\psi + \text{anything}] &= (22.3 \pm 5.7 \pm 3.1) \times 10^{-6}; \\ \sigma(e^+e^- \rightarrow \Lambda J/\psi + \text{anything}) &= (90 \pm 14 \pm 6) \text{ fb}; \end{aligned}$$

The calculation process are exactly the same as before; only the values of efficiencies have been replaced. Since there are still slight differences between the new efficiencies and the half of those obtained from the sample of  $\Upsilon(1, 2S)/e^+e^- \rightarrow \Lambda J/\psi + \bar{\Lambda} + q\bar{q}$ , we have incorporated the discrepancy into the systematic uncertainty.

The distribution of  $M_{\Lambda J/\psi}$  in this two samples are very close. And in estimating the systematic uncertainty for the measurement of the resonance parameters, we already take into account the differences between these two samples in the fitting results. So this change will have negligible impact on our fitting results.

## II. SYSTEMATIC UNCERTAINTY

The uncertainties of the efficiencies of “no- $P_{cs}^0(4459)$  MC samples” are estimated with different decay modes, for example,  $\Upsilon(1, 2S) \rightarrow \Lambda J/\psi + \bar{\Lambda} + q\bar{q}$  and  $e^+e^- \rightarrow \Lambda J/\psi + \bar{\Lambda} + q\bar{q}$ . We take the efficiency differences  $|\epsilon_1 - \epsilon_2|/\epsilon_1$  as the systematic uncertainties, where  $\epsilon_1$  and  $\epsilon_2$  represent the efficiencies obtained from the sample of  $\Upsilon(1, 2S)/e^+e^- \rightarrow \Lambda J/\psi + \bar{p} + K^+ + \text{any}$  and  $\Upsilon(1, 2S)/e^+e^- \rightarrow \Lambda J/\psi + \bar{\Lambda} + \text{any}$ , respectively. The systematic uncertainties of the decay model of “no- $P_{cs}^0(4459)$  MC sample” are determined to be 2.3% in  $\Upsilon(1S)$  decay, 3.5% in  $\Upsilon(2S)$  decay, and 1.9% in continuum production.