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Production rates of hyperons and charmed baryons from e^+e^- annihilation near $\sqrt{s}$ = 10.52 GeV

Tatsuro Matsuda[∗†]
University of Miyazaki
E-mail: matsuda@phys.miyazaki-u.ac.jp

We have measured the inclusive production cross sections of hyperons and charmed baryons from e^+e^- annihilation using a $800\,fb^{-1}$ data sample taken near the Υ(4S)resonance with the Belle detector at the KEKB asymmetric-energy e^+e^- collider. The feed-down contributions from heavy particles are subtracted using our data, and the direct production cross sections are compared for the first time.

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∗Speaker.
†on behalf of the Belle Collaboration.

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1. Introduction

In e^+e^- annihilation, hadrons are produced after the $e^+e^- \to \gamma^* \to q\bar{q}$ creation and in the fragmentation process. The observed production cross sections (σ)[1] show a simple dependence on their masses: $\frac{\sigma}{\sigma_{had}(2J+1)} \propto e^{-\alpha m_{had}}$ as in the Fig.1, where σ_{had}, J, m_{had} and α are the hadronic cross section, the total spin, the mass of a hadron and a slope parameter, respectively. In fact the earlier measurements at $\sqrt{s}$ =10 GeV and $\sqrt{s}$ =90 GeV have shown that production rates of most non-strange baryons and hyperons follow an exponential mass dependence with a common slope parameter, but significant enhancements for Λ and $\Lambda(1520)$ baryons are observed in the Fig.2. However, the previous measurements of inclusive production cross sections might contain feed-down contributions from heavier resonances. And also the production cross sections of charmed baryons have an additional interest.

In this study, we report the production cross sections of hyperons and charmed bayrons. We study the feed-down contributions from heavy particles and measure the direct cross sections of hyperons and charmed baryons.

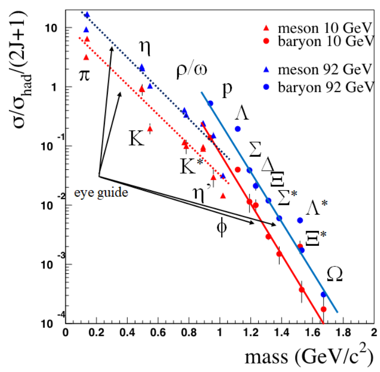

Figure 1: Hadron production rates in e^+e^- collision.

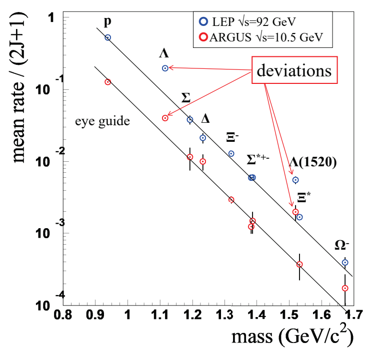

Figure 2: Baryon production rates in e^+e^- collision.

2. Belle data of KEK

We use Belle data recorded at the KEKB e^+e^- asymmetric-energy collider. For the study of hyperon production cross sections we use off-resonance data taken at $\sqrt{s} = 10.52$ GeV to avoid contamination from $\Upsilon(4S)$ decay. The integrated luminosity is $79.3 fb^{-1}$. In contrast, for charmed baryons we use both off- and on-resonance data of which integrated luminosity is $562 fb^{-1}$ at $\sqrt{s} = 10.58$ GeV because the production rates of charmed baryons, especially for the excited states, are small.

3. Reconstruction and inclusive differential cross sections of hyperons and charmed baryons

We reconstruct a $\Lambda \to p\pi^-$ decay candidate from a proton and a pion candidate. And a Σ^0 or a $\Sigma(1385)^+$ candidate is formed by combining a Λ with a photon or a π^-. For the reconstruction of $\Lambda(1520) \to K^- p$, a kaon and a proton tracks are identified and reconstructed.

We obtained the inclusive differential cross section ($d\sigma/dx_p$) as a function of hadron-scaled momentum, $x_p = \frac{p}{\sqrt{\frac{s}{4} - M^2}}$, where p and M are the momentum and the mass, respectively, of the particle. For obtaining the entire x_p regions of $S = -1$ hyperons we utilize a third-order Hermite interpolation describing the behavior in the measured x_p range. These distributions are corrected by the reconstruction efficiency and branching fractions, and are shown in Fig.3.

For the study of charmed baryons we use both off- and on-resonance data. For the on-resonance data we require the charmed baryon candidates to have $x_p > 0.44$ to eliminate the B-meson decay contribution. We reconstruct the Λ_c^+ baryon in the $\Lambda_c^+ \to \pi^+ K^- p$ decay mode. A $\Sigma_c^{(*)0}$ candidate or an excited Λ_c^{*+} candidate is formed by combining a Λ_c^+ candidate with a π^- or a $\pi^+\pi^-$ pair, respectively. For obtaining the entire x_p regions of excited Λ_c^+ and Σ_c^0 states we utilize the x_p dependence of cross sections obtained from MC using the Lund model[2] . These distributions are corrected by the reconstruction efficiency and branching fractions, and are shown in Fig.4.

The total hadronic cross sections with and without inclusion of the initial state radiation and the vacuum polarization are studied by using PYTHIA[3], and they are indicated in Fig.3 and Fig.4, respectively.

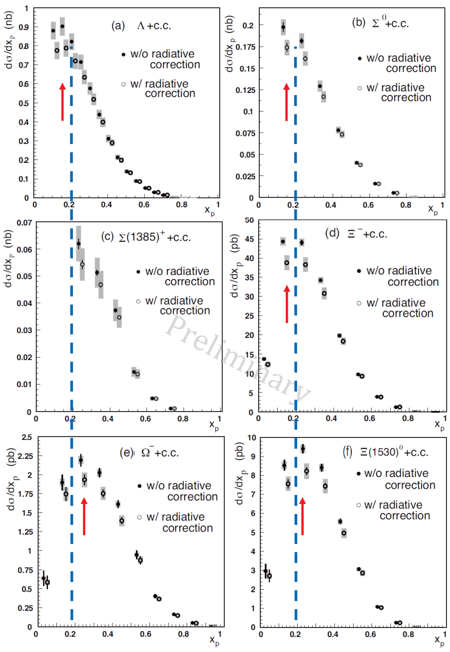

Figure 3: Differential inclusive cross sections of hyperons. The closed circles are shifted slightly to the left. Peak positions are indicated by arrows.

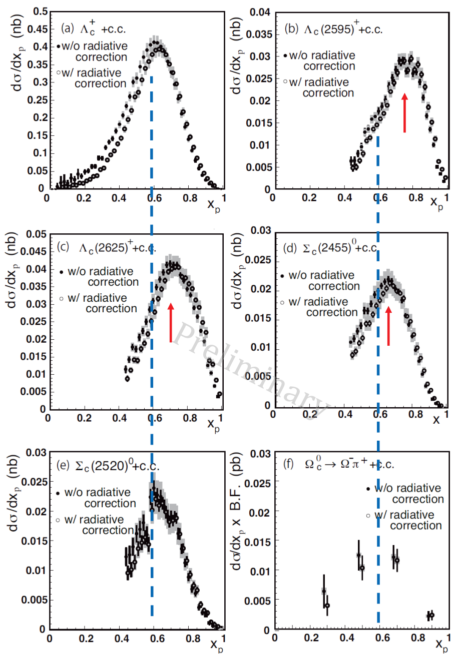

Figure 4: Differential inclusive cross sections of charmed baryons. The closed circles are shifted slightly to the left. Peak positions are indicated by arrows.

4. Feed-down subtracted (direct) cross section

We subtract the feed-down contributions from heavy particles in the inclusive cross sections. The amount of this feed-down is determined by the production cross sections of mother particles and the branching fractions. We use the world-average branching fractions for them. We comment that the inclusive cross sections before the feed-down subtraction are consistent with previous measurements, but with much higher precision.

5. Results and Discussion

The scaled direct cross section is derived from the direct production cross section divided by the number of spin state $(2J+1)$. In Fig.5 the scaled direct cross sections of hyperons are plotted as a function of baryon masses, and those of the charmed baryons are plotted in Fig.6. The production cross section of the $\Sigma_c(2800)$ measured by Belle(Ref. is there.) is also shown in Fig.6. We do not observe the enhancement of the direct cross section of Λ or $\Lambda(1520)$. The scaled direct cross section of $\Sigma(1385)^+$ is smaller than the exponential curve. $\Xi(1530)^0$ is suppressed with respect to the exponential curve. The production cross section of Ω^- shows further suppression. The production cross sections of the Λ_c^+ ground state is significantly higher than the exponential curve of hyperons extended to the corresponding mass. In contrast to hyperons where Λ and σ resonances lie on a common experimental curve, the production cross sections of Σ_c are smaller than those of excited Λ_c.

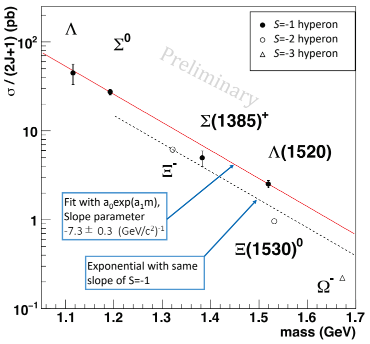

Figure 5: Scaled direct production cross section as a function of mass hyperons.

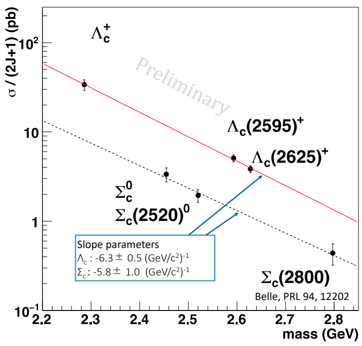

Figure 6: Scaled direct production cross section as a function of mass of charmed baryons.

6. Summary

We have measured the inclusive and direct production cross sections of hyperons and charmed baryons from e^+e^- annihilation near the $\Upsilon(4S)$ energy. The suppression of some baryons is observed and it may reflect the difference of their internal structures. The detailed explanation of our analyses and the comparison of our data with theories will be discussed in our forthcoming paper.

References

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