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Search for B meson decays to four baryons at BaBar

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Summary. — B mesons are the lightest mesons which can decay to various final states containing baryons. The measurement and comparison of exclusive branching fractions of baryonic B decays, as well as studies on the dynamic of the decay, may allow better understanding of baryon production in B decays and, more generally, hadron fragmentation into baryons. We present here a search for the decay of a B meson in four baryons: $B^0 \to pp\bar{p}\bar{p}$, not yet observed. The data set consists of about 470 million $B\bar{B}$ pairs collected with the BaBar detector at the SLAC National Accelerator Laboratory.

1. – Introduction

Due to its large mass, the B meson decays also into final states containing baryons and, therefore, it is an optimal tool to study the mechanism of baryonic fragmentation of hadrons, only poorly understood. The inclusive branching fraction (BF) of B mesons decaying into baryonic final states is approximately 7% [1] and it is not covered by the sum of so far measured exclusive baryonic channels of the B meson. Indeed, this puzzle motivates the search for unmeasured B meson decays to baryons. Main open issues in baryonic B decays are related to the hierarchy of the branching fractions, due to resonant subchannels, and the threshold enhancement effect. So far, the only four-baryon final state studied by the BaBar Collaboration is the decay mode $\bar{B}^0 \to \Lambda_c^+ p\bar{p}\bar{p}$ [2], for which no event was observed and the upper limit on the branching fraction at a 90% CL was set to 2.8×10^{-6}. From this measurement, for the search of $B^0 \to pp\bar{p}\bar{p}$ (see footnote([1])) we assume as working hypothesis $BF = 10^{-7}$, which is used for optimizing the selection.

([1]) The charge conjugate is always implied throughout the article.

2. – The BaBar experiment

The data sample analysed corresponds to an integrated luminosity of $424\,\mathrm{fb}^{-1}$ electron-positron collisions at the centre-of-mass (CM) energy of the $\Upsilon(4S)$ resonance, $\sqrt{s} = 10.58\,\mathrm{GeV}/c^2$, collected with the BaBar detector [3] at the asymmetric-energy collider PEP-II. Charged-particle tracks momenta are precisely measured by means of a five-layer double-sided silicon vertex tracker and a 40-layer multiwire drift chamber, both operating in the 1.5 T magnetic field of a superconducting solenoid. The particle identification (PID) for protons, kaons and pions uses the specific energy loss measured in the tracking devices and the Cherenkov radiation measurement provided by the internally reflecting, ring-imaging Cherenkov detector.

3. – Method and results

This study is performed as a *blind* analysis, which means that all cuts are optimized without looking at the data in the region where the signal is expected. The event is reconstructed combining 4 oppositely charged tracks identified as protons and antiprotons and kinematically fitted to a common vertex, with a fit probability larger than 0.1%. Cuts are also applied to the kinematic variables $m_{ES} = \sqrt{(E^*_{beam})^2 - (\vec{p_B}^*)^2}$ and $\Delta E = E^*_B - E^*_{beam}$ [4], related to the momentum, $\vec{p_B}^*$, and the reconstructed energy, E^*_B, of the B-candidate and to the beam energy, E^*_{beam}, in the CM reference frame. PID efficiency for protons is excellent for this analysis ($> 99\%$) and mis-identification rates for wrongly assigning the proton identity to kaons and pions are lower than 1%. Real protons coming from continuum hadronization processes ($e^+e^- \to q\bar{q}$) are expected to be the main source of combinatoric background. Further background is rejected by cutting on the output of a multivariate analysis method, the Boosted Decision Tree (BDT), whose response is evaluated on the input variable distributions ΔE, $\cos\theta^*_B$(2), and two event-shape variables which discriminate between the spherical shape of a signal event ($e^+e^- \to B\bar{B}$) and a jet-like $q\bar{q}$ event. The signal efficiency, computed on the signal MC sample as the ratio of the number of selected to generated events, is assessed to be $\epsilon = 0.2068 \pm 0.0005$. The signal yield is extracted from an extended unbinned maximum likelihood fit to the selected events in the range $5.2 < m_{ES} < 5.3\,\mathrm{GeV/c^2}$. The shape of the signal and of the background components is fixed in the fit to the results of the modeling studies performed on both MC samples and on the side band region data. From a pseudo-experiment on the full MC sample scaled to the BaBar integrated luminosity, the expected signal yield is $N_{sig} = 10.0 \pm 4.5$, from which we determine an upper limit on the BF of 2×10^{-7} at a 90% CL, consistent with the working hypothesis of $BF = 10^{-7}$.

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[4] BaBar and Belle Collaborations (Bevan A. J. *et al.*), *Eur. Phys. J. C*, **74** (2014) 3026, pp. 84–87.

(2) θ^*_B the flight polar angle of the B meson in the centre-of-mass frame.