

A photo of the status of the BESIII experiment

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Summary. — The Beijing Spectrometer III (BESIII) operates with the collisions provided by the Beijing Electron Positron Collider II (BEPCII), which is hosted at the Institute of High Energy Physics (IHEP) of Beijing, China. Since 2009, BESIII has collected the world's largest sample of J/ψ , $\psi(2S)$, and $\psi(3770)$. In 2016 BEPCII has reached the design luminosity of $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$, setting a world record for e^+e^- accelerators in this energy regime. Moreover, since BEPCII can provide collisions with center-of-mass energies between 2 and 4.6 GeV, BESIII has unique datasets to investigate the properties of the new exotic XYZ states, open charm decays, hadron spectroscopy and new physics searches, with no direct competitor in the τ -charm energy region. In this paper, an overview on the status of the BESIII experiment and of its more recent results is presented.

1. – Introduction

Among all high-energy physics experiments, BESIII has a clear opportunity to collect data in an almost background-free environment in the energy range between 2 and 4.6 GeV, the so-called τ -charm regime, with no direct competitors. The collisions are provided by the BEPCII, a symmetric double-ring electron-positron collider, hosted at the Institute of High Energy Physics of Beijing, China. The possibility to scan the center-of-mass energy of the collision has allowed to collect the world largest sample of charmonia, in particular 1.3 billions J/ψ , roughly 500 millions $\psi(2S)$ and 2.9 fb^{-1} $\psi(3770)$.

The BESIII spectrometer is a classical central onion-like detector optimized for flavour physics. Most of the choices in the detector scheme are made following the examples of CLEO-c, Belle and BaBar [1]. More details on the detector scheme can be found in ref. [1].

The physics program of BESIII covers a very broad range of fields, that goes from charmonium spectroscopy to exotic searches, open charm meson and baryon decays, light hadron spectroscopy, and precise QCD measurements. In the next sections, a brief description of the most interesting latest results of BESIII is presented.

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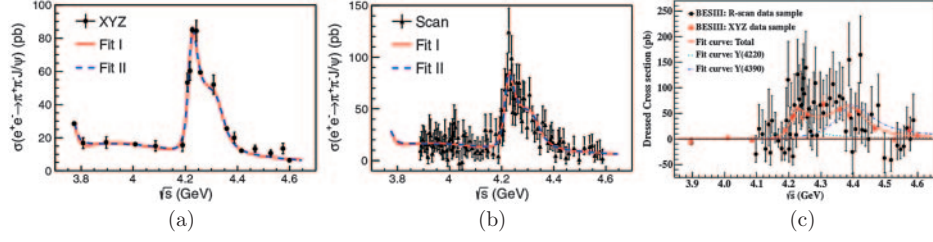


Fig. 1. – Results of the studies with the two samples. (a) $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ cross section with the high statistics sample. The red line represents the best fit. (b) $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ cross section with the low statistics sample. The red line represents the best fit. (c) $\pi^+\pi^- h_c$ cross section. The red line represents the final fit. The two resonances are represented as dashed lines.

2. – Update on the exotic states Y

One of the most interesting feature of BESIII is to have a direct window on the Y states. Differently from Belle [2] or BaBar [3] it can produce these states directly, with a huge increase in precision and statistics compared to B-factories.

Recently, BESIII has collected two sets of data from 3.7 to 4.6 GeV. One set has nine energy values with higher statistics (40 pb^{-1} per energy), while the other has several values with lower statistics ($7 - 9 \text{ pb}^{-1}$ per energy), used for R measurements. Their combination allows to have a clearer indication of the cross sections in this energy region. Benefiting from these datasets, two independent studies were performed on two different final states.

The first study intended to measure the cross section of $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ [4]. The results are shown in figs. 1(a) and (b), where the two datasets are fit simultaneously. The fit lineshapes show that the classical description of $Y(4260)$ as a single resonance is no more sufficient, but two resonances are needed to describe correctly the lineshapes. Moreover $Y(4008)$, as seen by Belle [2], has not been found. The second study shows a measurement of $e^+e^- \rightarrow \pi^+\pi^- h_c$ [5]. Here, the two datasets are combined. The results are shown in fig. 1(c), where the low- and high-statistics samples are identified with black and red markers, respectively. Two resonances are needed to fit the combination of the two data samples.

Mode	This work (%)	PDG (%)	BELLE \mathcal{B}
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30	
$pK^- \pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S^0 \pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50	
$pK_S^0 \pi^+ \pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^- \pi^+ \pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0	
$\Lambda \pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28	
$\Lambda \pi^+ \pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3	
$\Lambda \pi^+ \pi^- \pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7	
$\Sigma^0 \pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28	
$\Sigma^+ \pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34	
$\Sigma^+ \pi^+ \pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0	
$\Sigma^+ \omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0	

Fig. 2. – Table of the results of the direct measurements and comparison with PDG and BELLE results, when available.

The results of these two studies show much information: the higher-mass state in $e^+e^- \rightarrow \pi^+\pi^-h_c$, *i.e.* $Y(4360)$, is compatible with a similar state observed in $e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$; the higher-mass state in $e^+e^- \rightarrow \pi^+\pi^-J/\psi$, so-called $Y(4390)$, was never observed before and is indeed a possible new state; the lightest states in both channels show similar masses and widths; the observation of similar states in two different channels strengthens the $Y(4220)$ hypothesis. Additional studies are needed to shed more light on these states and BESIII can be the main actor of these searches.

3. – Λ_c studies at threshold

In 2013 data taking BEPCII extended the center-of-mass energy range up to 4.6 GeV: BESIII collected data at four energy values above the threshold for the Λ_c pairs production for a total of 500 pb⁻¹. The production at threshold has many advantages: *e.g.*, a background-free environment, close kinematics that allows unprecedented precise measurement of the branching fraction, etc.

BESIII opened a new season for the charmed baryon precision studies. It has measured twelve different final states, by means of a simultaneous fit to improve the single results [6]. Eleven channels were measured directly for the first time, with a natural increase in the precision with respect to the standard measurements, where the branching fractions were extracted compared to the $\Lambda_c \rightarrow pK^-\pi^+$ one. Moreover, the precision in the measurement of $\Lambda_c \rightarrow pK^-\pi^+$ is compatible with the one by Belle and will improve the PDG [7] estimate. In fig. 2, the results of the measurements are reported.

4. – Final comments and outlook

The BESIII physics program is very rich and wide. The results shown in this contribution give just a small idea of the BESIII capabilities in the τ -charm energy region and in terms of measurement precision and discovery opportunities.

BESIII will run until 2022, with a possible extension up to the end of the 2020s: new data taking for the XYZ states are planned in the next few years to shed new light on these states; more data on charmonia will help the understanding process of the light hadron spectroscopy; recently concluded $D_S^*D_S$ data taking will provide essential information to the B decays, and new precise measurements on the branching fractions; improvements of the inner tracker and of BEPCII will allow BESIII to compete with B -factories and give complementary indications to their observations in the future years.

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