NEW R VALUES FROM 2-5 GEV FROM THE BESII AT BEPC

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We report preliminary R values for all 85 energy points scanned in the energy region of 2-5 GeV with the upgraded Beijing Spectrometer (BESII) at the Beijing Electron Positron Collider (BEPC). The typical uncertainties on the R values we measured are $\sim 7\%$. The new R values have a significant impact on the predicted mass of the Higgs (m_H) coming from the global fit to the electroweak data, and will also contribute to the interpretation of the E821 $g-2$ experiment.

1. Introduction

The QED running coupling constant evaluated at the Z pole, $\alpha(M_Z^2)$, and the anomalous magnetic moment of the muon, $a_\mu = (g-2)/2$, are two fundamental quantities to test the Standard Model(SM).[1,2] $\alpha(M_Z^2)$, as one of the three input parameters in the global fit to the electroweak data, is sensitive to the predicted mass of the Higgs. Theoretically, a_μ is sensitive to large energy scales and high order radiative corrections.[3] Any deviation between the SM predicted value of a_μ and that from the experimentally measured one may hint at new physics. However, the uncertainties in both $\alpha(M_Z^2)$ and a_μ^{SM} are dominated by hadronic vacuum polarization, which cannot be reliably calculated but can be related to R values through a dispersion relation.[2] Here R is defined as the ratio of lowest order QED cross-sections, $R = \sigma(e^+e^- \to \text{hadrons})/\sigma(e^+e^- \to \mu^+\mu^-)$.

Since the uncertainties in $\alpha(M_Z^2)$ and a_μ^{SM} are dominated by the errors of the values of R in the cm energy range below 5 GeV,[2] it is crucial to significantly reduce the uncertainties in the R values measured about 20 years ago with a precision of about 15-20% in the energy region of 2-5 GeV.[1,3]

2. R scan with BESII at BEPC

Following the first R scan with 6 energy points in the 2.6-5 GeV range done in 1998,[4] the BES collaboration did a finer R scan with 85 energy points in the energy region of 2-4.8 GeV. To understand the beam associated background, separated beam running was done at 24 energy points and single beam running for both e^- and e^+ was done at 7 energy points distributed over the scan region. The scan was done with BESII, a conventional detector described in detail in Ref. 5.

3. Data Analysis

The R values from the BESII scan data are measured by observing the final hadronic events inclusively, i.e. the value of R is determined from the number of observed hadronic events (N_{had}^{obs}) by the relation

$$R = \frac{N_{had}^{obs} - N_{bg} - \sum_l N_{ll} - N_{\gamma\gamma}}{\sigma_{\mu\mu}^0 \cdot L \cdot \epsilon_{had} \cdot (1+\delta)}, \tag{1}$$

where N_{bg} is the number of beam associated background events; $\sum_l N_{ll}$, $(l = e, \mu, \tau)$ and $N_{\gamma\gamma}$ are the numbers of misidentified lepton-pairs from one-photon and two-photon processes events respectively; L is the integrated luminosity; δ is the radiative correction; and ϵ_{had} is the detection efficiency for hadronic events.

The hadronic event selection selects true hadron production from all other possible contamination mechanisms. Cosmic rays, lepton pair production, two-photon processes and beam associated processes are the potential backgrounds considered. Hadronic events are selected based on charged track information. Cuts are applied on the vertex, track fit quality, maximum and minimum energy deposition, momentum, and time-of-flight in order to select hadronic events. Special attention is paid to two-prong events, where extra cuts are used to remove non-hadrons.[4]

The cosmic rays and part of the lepton pair events are directly removed by the event selection. The remaining background from lepton pair production and two-photon processes is then subtracted out statistically using a MC simulation.

Most of the beam associated background events are rejected by the vertex cut. The remaining events are subtracted out by fitting the event vertex along the beam direction with a Gaussian for real hadronic events and a second degree polynomial for the background. The vertex fitting method is checked with an analysis of separated-beam data. The differences obtained using these two methods are about $(0.3 \sim 2.3)\%$, depending on the energy and are factored into the systematic error.

The integrated luminosity is determined by large-angle Bhabha events using only the energies deposited in the BSC. A cross check using only dE/dx information from the MDC to identify electrons was generally consistent with the BSC measurement; the difference was taken into account in the overall systematic error of 1.5-2.6%.

A great effort has been made by the Lund group and the BES collaboration to develop the formalism using the basic Lund Model Area Law directly for a Monte Carlo simulation, which removes the extreme high energy approximation and left-right symmetry in the string fragmentation in JETSET.[6]

The parameters in LUARLW are tuned with R scan data to reproduce distributions of kinematic variables such as multiplicity, sphericity, etc. We find that a single set of parameters can be applied to the energy region below open charm, and another set of parameters can be used for the energies above it. Parameters are also tuned point by point for the continuum region, and where the detection efficiencies determined are consistent within 2%, which is factored into the systematic errors.

Radiative corrections determined using four different schemes[4] agreed with each other to within 1% below charm threshold. Above charm threshold, where resonances are important, the agreement is within 1-3%. For the measurements reported here, we use the formalism of Ref. 9 and include the differences with the other schemes in the systematic error of less than 4%.

Table 1. Error contributions for E_{cm}=3.0 GeV. Adding the systematic and statistical errors in quadrature gives a total error of 5.8%.

Source	N_{had}	L	ϵ_{had}	$1+\delta$	Stat.
Err.(%)	3.3	2.3	3.0	1.3	2.5

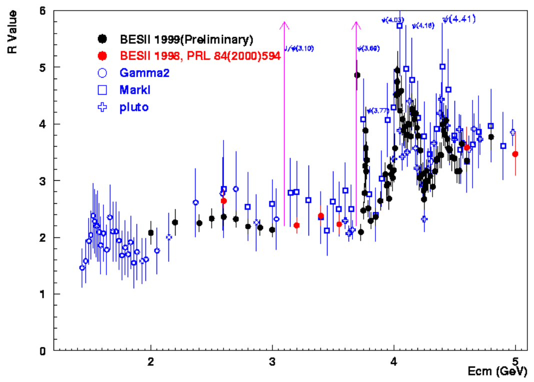

Fig. 1. R values below 5 GeV.

The preliminary R values obtained at all 85 energy are shown in Fig. 1, together with the 6 energy points measured in the first scan and those measured by several earlier experiments. The preliminary R values from BESII have an average uncertainty of about 7% and are slightly lower than those from previous measurements. The errors from different sources are listed in Table 1. The two to three factor improvement in precision of the R values from 2-5 GeV has a significant impact on the global fit to the electroweak data for the determination of m_H. The preliminary fit results show that the predicted m_H is significantly increased with the new preferred value lying just above the LEP2 excluded region, and the new χ^2 profile of the fit accommodates the LEP2 bound on the mass more comfortably.[7,8] BESII R values can also greatly contribute to the interpretation of the E821 $g-2$ measurement.[3]

1. A. Blondel, Proc. of the 28th Int. Conf. on High Energy Physics, Warsaw, Poland, July 1996.
2. Z. G. Zhao, Proc. of LP99, SLAC, USA, July 1999.
3. Robert Carey, "New Results from g-2 Experiment", talk given at ICHEP2000, Osaka, Japan, July 2000.
4. J. Z. Bai, et. al. the BES collaboration, *Phys. Rev. Lett.* **84**, 594 (2000).
5. J.Z. Bai *et al.*, (BES Collab.), *Nucl. Instrum. Methods* A **344**, 319 (1994); J.Z. Bai *et al.*, (BES Collab.), "The Upgraded Beijing Spectrometer", accepted by NIM.
6. B. Andersson and Haiming Hu, "Few-body States in Lund String Fragmentation Model" hep-ph/9910285.
7. B. Pietrzyk, "The Global Fit to the Electroweak Data", talk given at ICHEP2000, Osaka, Japan, July 2000.
8. A. Martin, et. al., hep-ph/0008078.