第 31 卷 第 9 期
2007 年 9 月

高 能 物 理 与 核 物 理
HIGH ENERGY PHYSICS AND NUCLEAR PHYSICS

Vol. 31, No. 9
Sep., 2007

Improvement on Hadronic Event Selection in *R* Measurement*

HU Hai-Ming[1] WENG Yao[1;1)] GUO Yi-Qing[1] JIN Yi[1,2] ZHANG Bing-Xin[1]
HU Jun-Hui[1,3] GAO Yuan-Ning[4]

1 (Institute of High Energy Physics, CAS, Beijing 100049, China)
2 (Institute of Science, Jinan University, Jinan 250022, China)
3 (College of Physics and Electronic Engineering, Guangxi Normal University, Guilin 541004, China)
4 (Department of Engineering Physics, Tsinghua University, Beijing 100084, China)

Abstract Hadronic event selection and hadronic detection efficiency are two main sources of systematic error for the R measurement at BES/BEPC. If only the hadronic events with 2-prong and higher prong are selected as done in the previous measurements, the lost events with 0-prong and 1-prong will cause the systematic error for both of the number of hadronic events and the detection efficiency. This paper aims to present a new method to select the 1-prong hadronic events. It will be helpful to tune the parameters in hadronic events generator LUARLW more reasonably, and decrease the systematic errors of hadronic efficiency in R measurement.

Key words R value, hadronic event, systematic error, event generator

1 Introduction

The R value directly relates to the measurement of the inclusive hadronic cross section in the process of $\mathrm{e}^+\mathrm{e}^-$ annihilation, which contains the contributions of all hadronic production channels. In experiment, R is measured with the following formula

$$R=\frac{N_{\text{had}}}{\sigma^0_{\mu\mu}\cdot L\cdot\epsilon_{\text{trg}}\cdot\bar{\epsilon}_{\text{had}}\cdot(1+\delta)}\ , \tag{1}$$

where, N_{had} is the number of the selected hadronic events in data, L is the integrated luminosity, ϵ_{trg} and $\bar{\epsilon}_{\text{had}}$ are the trigger and detection efficiency of hadronic events respectively, $(1+\delta)$ is the factor of the initial state radiative correction, and $\sigma^0_{\mu\mu}$ is the theoretical Born cross section of $\mathrm{e}^+\mathrm{e}^-\to\mu^+\mu^-$.

In 1998 and 1999, the R scan data were collected with the upgraded BES detector[1], and the typical systematic errors of the measured R were 5%—8%[2, 3]. In 2004, data samples at E_{cm}=2.2, 2.6, 3.07, and 3.65GeV with about 10pb^{-1} integrated luminosity were taken. The purpose is to measure the R value with higher precision, and provide some useful experiences in the future experiment at BEPCII/BESIII.

In this work, a new method is suggested to select the hadronic sample including 1-prong events, and the method of the parameters tuning is improved, which will be helpful to obtain a set of more reasonable parameters of the hadronic generator LUARLW[4, 5], and to reduce the systematic errors of the hadronic efficiency $\bar{\epsilon}_{\text{had}}$ and R value effectively.

2 Dominant Errors of *R* Measurement

The error of R value arises from the contributions of all quantities in Eq. (1). In this section, some errors related to the hadronic efficiency are described.

2.1 Total error

In the measurement of R value, the fraction of the lost hadronic events is compensated by the efficiency

---

Received 19 October 2006, Revised 22 March 2007
* Supported by National Natural Science Foundation of China (10491300)
1) E-mail: wengy@ihep.ac.cn

$$\bar{\epsilon}_{\text{had}}=\frac{N_{\text{obs}}^{\text{MC}}}{N_{\text{gen}}^{\text{MC}}}\ , \tag{2}$$

where, $N_{\text{gen}}^{\text{MC}}$ is the total number of the inclusive hadronic events generated by generator, and $N_{\text{obs}}^{\text{MC}}$ is the observed number of events after the detector simulations and the event selection. The consistence between data and Monte Carlo (MC) is crucial for the measurement precision.

The two largest error sources of the R value measurement arise from N_{had} and $\bar{\epsilon}_{\text{had}}$ in Eq. (1), and there is a strong correlation between them. Based upon the principle that the systematic error of the hadronic efficiency is estimated by comparing the difference between data and MC, the equivalent number of hadronic events is defined as

$$\tilde{N}_{\text{had}}=\frac{N_{\text{had}}}{\bar{\epsilon}_{\text{had}}}=N_{\text{gen}}^{\text{MC}}\frac{N_{\text{had}}}{N_{\text{obs}}^{\text{MC}}}\ , \tag{3}$$

where, $N_{\text{gen}}^{\text{MC}}$ is set to be a large constant in MC simulation, N_{had} and $N_{\text{obs}}^{\text{MC}}$ depend on the hadronic criteria, and the latter also depends on the hadronic generator and the values of the parameters of the Lund model. According to Eq. (1), the main systematic error of R value is estimated as

$$\frac{\Delta R}{R}\cong \sqrt{\left(\frac{\Delta\tilde{N}_{\text{had}}}{\tilde{N}_{\text{had}}}\right)^2+\left(\frac{\Delta L}{L}\right)^2+\left(\frac{\Delta\epsilon_{\text{trg}}}{\epsilon_{\text{trg}}}\right)^2+\left(\frac{\Delta(1+\delta)}{(1+\delta)}\right)^2}, \tag{4}$$

in which, $\Delta\tilde{N}_{\text{had}}$ is the error caused by the discrepancy between data and MC sample. The error caused by the uncertainty of the parameters in the hadronization model has been included in $\Delta\tilde{N}_{\text{had}}$.

2.2 Influence of MC parameters

In the simulation, the generated event with n_{hd} hadrons contains n_{ch} charged and n_{nu} neutral particles. The distribution of the total multiplicity $f(n_{\text{hd}};\alpha)$, the ratio of the n_{nu} and n_{ch}, and the distribution of the momentum $g(\boldsymbol{p};\alpha)$ are governed by the generator LUARLW based on the Lund area law and the set of the phenomenological parameters, which are signed as α. The detailed descriptions of the parameters set α may be found in Refs. [4, 5]. In the measurement of R value, only the number of the good charged tracks n_{gd} is accounted, which can be categorized into $n_{\text{gd}}=0$-prong, 1-prong, 2-prong and multi-prong according to the number of good charged tracks in each event. In principle, the relationship between the observed probability $P(n_{\text{gd}})\equiv N(n_{\text{gd}})/N_{\text{had}}$ (the ratio of the events with n_{gd} good charged tracks to the total observed hadronic events N_{had}) and the values of the parameter set α in LUARLW may be expressed as

$$P(n_{\text{gd}})=\sum_{n_{\text{hd}}}f(n_{\text{hd}};\alpha)G(n_{\text{hd}},n_{\text{gd}})\ , \tag{5}$$

where, $G(n_{\text{hd}},n_{\text{gd}})$ is the probability matrix where n_{hd} initial hadrons are generated at the collision vertex and n_{gd} good charged hadrons are observed in the final state. And the observed distribution of the momentum is[6]

$$F(\boldsymbol{p})=\int g(\boldsymbol{p}';\alpha)D(\boldsymbol{p}',\boldsymbol{p})\mathrm{d}^3\boldsymbol{p}'\ . \tag{6}$$

The meaning of $D(\boldsymbol{p}',\boldsymbol{p})$ is similar to $G(n_{\text{hd}},n_{\text{gd}})$. Due to the measurement error and the limited resolution of the detector, the generated $\boldsymbol{p}'$ is different from the observed $\boldsymbol{p}$. The latent and nonanalytical transformation functions $G(n_{\text{hd}},n_{\text{gd}})$ and $D(\boldsymbol{p}',\boldsymbol{p})$ are determined by the detector simulation and the selected criteria for the observed hadronic events.

2.3 Efficiency

The ideal hadronic generator and the detector simulation should give the consistent distributions related to the hadronic events criteria with those of the data. But in the practice case, the differences always exist. The task of the parameter tuning of the hadronic events generator is to deduce a set of reasonable values of the parameters by comparing the observed distributions of the data and MC. The process of tuning the values of the parameter set is to compare the distributions $P(n_{\text{gd}})$ and $F(\boldsymbol{p})$ between data and MC. The error of the average efficiency arises from the weighted sum of the errors of the $P(n_{\text{gd}})$ and $F(\boldsymbol{p})$. Among these errors, the biggest one comes from the multiplicity distribution $f(n_{\text{hd}};\alpha)$, which will influence the average detection efficiency in the following manner[7]

$$\bar{\epsilon}_{\text{hd}}=\frac{N_{\text{obs}}^{\text{MC}}}{N_{\text{gen}}^{\text{MC}}}=\frac{\sum M(n_{\text{gd}})}{\sum N(n_{\text{hd}})}\ , \tag{7}$$

where,

$$M(n_{\rm gd})=\sum_{n_{\rm hd}}N(n_{\rm hd})\epsilon(n_{\rm hd};n_{\rm gd})\ , \tag{8}$$

and $N(n_{\rm hd})=N_{\rm gen}^{\rm MC}f(n_{\rm hd};\alpha)$ is the number of the generated events with total multiplicity $n_{\rm hd}$. The efficiencies $\epsilon(n_{\rm gd};n_{\rm hd})$ are determined by MC simulation of the production and detection of the final states

$$\epsilon(n_{\rm hd};n_{\rm gd})=\frac{N_{\rm obs}^{\rm MC}(n_{\rm gd})}{N_{\rm gen}^{\rm MC}(n_{\rm hd})}, \tag{9}$$

where, $N_{\rm gen}^{\rm MC}(n_{\rm hd})$ is the number of events generated with multiplicity $n_{\rm hd}$, and $N_{\rm obs}^{\rm MC}(n_{\rm gd})$ is the number of events observed with $n_{\rm hd}$ good charged tracks after the simulation and event selection.

2.4 Error of tracking efficiency

The error of the events selection has been estimated in Eq. (4). In the data analysis, the hadronic events are classified by their charged tracks. Therefore, except for the systematic errors mentioned above, the error of the tracking efficiency $\sigma_{\rm trk}$, which reflects the difference of the track reconstruction between data and MC, will cause the extra error $\Delta\epsilon_{\rm trk}$. The probability that $n_{\rm er}$ tracks are wrongly constructed in $n_{\rm gd}$-prong event ($n_{\rm er}\leqslant n_{\rm ch}$) can be considered to roughly obey the binomial distribution $B(n_{\rm er};n_{\rm gd},\sigma_{\rm trk})$, where, $\sigma_{\rm trk}$ is the tracking-error. $\sigma_{\rm trk}$ is dependent on many factors, such as the type of the particle and the momentum. Considering the distribution of the multiplicity $P(n_{\rm gd})$, the effective error of the tracking efficiency is estimated to be

$$\Delta\epsilon_{\rm trk}=\sum_{n_{\rm gd}}P(n_{\rm gd})B(n_{\rm er};n_{\rm gd},\sigma_{\rm trk})\ . \tag{10}$$

For the measurement of the inclusive cross section with $n_{\rm good}\geqslant 1$, only the cases that all $n_{\rm gd}$ tracks in an event are wrongly reconstructed (i.e. $n_{\rm er}=n_{\rm gd}$) will induce the error from the track reconstruction. Therefore, the influence of the error of the tracking efficiency is smaller than the measurement of the exclusive process. In the data analysis of J/ψ and ψ′ physics at BES, the value of $\sigma_{\rm trk}$ is taken as 2%. One may estimate the order of $\Delta\epsilon_{\rm trk}$ in R measurement by varying $\sigma_{\rm trk}$ within a reasonable range.

3 Event selection

In the BEPC energy region, the processes that occur in the beam pipe are $e^+e^-\to e^+e^-$, $\mu^+\mu^-$, $\tau^+\tau^-$, $\gamma\gamma$, e^+e^-X (X means any of the possible final states in two photon processes), hadrons (including continuous and resonant states) and the beam associated background. The observed final state particles are e, μ, π, K and p. Different types of final states can be identified with the following criteria[8].

$e^+e^-(\gamma)$ or $\gamma\gamma$:

1) $2\leqslant N_{\rm chrg}\leqslant 10$;
2) $E_{\rm sum}\geqslant 1.15E_{\rm b}$;
3) $E_{\rm max1}\geqslant 0.6E_{\rm b}$, $E_{\rm max2}\geqslant 0.45E_{\rm b}$, $E_{\rm max3}>0$;
4) $|\theta_2-\theta_3|\leqslant 0.7$ (37.8°) (in BSC);
5) $|\phi_2-\phi_3|\leqslant 0.7$ (37.8°) (in BSC);
6) $|(\theta_1-\theta_2)-180^\circ|<15^\circ$;
7) $2^\circ<|\phi_1-\phi_2|\leqslant 20^\circ$;
8) $|z_1|$ and $|z_2|\leqslant 1.4$m.

The track with the largest energy is assigned to be track 1, the track with the second largest to be track 2, and so on. θ_i and ϕ_i are the polar and azimuthal angles of the ith track. z is the z-coordinate of the event vertex. $E_{\rm b}$ is the beam energy.

Cosmic ray:

1) $Q=\pm1$;
2) $M_{\rm fit}=2$;
3) $p>1.5E_{\rm b}$;
4) $|t_{1\ \rm tof}-t_{2\ \rm tof}|>4$ns;
5) $|\phi_1-\phi_2|<3^\circ$;
6) $t_{\rm tof}\leqslant 2$ns or $t_{\rm tof}>t_{\rm p}+1$ns.

Q is the charge of every track, $M_{\rm fit}$ expresses the one track fit quantity and $t_{\rm p}$ is the time of flight of proton with momentum p.

$\mu^+\mu^-(\gamma)$:

1) $V_{\rm r}\leqslant 0.015$m, $|V_z|\leqslant 0.50$m;
2) $p\leqslant 1.4E_{\rm b}$;
3) $3\leqslant t_{\rm tof}\leqslant 6$ns;
4) $|\cos\theta|\leqslant 0.67$ (MDC);
5) $N_{\mu\ \rm hit}\geqslant 3$ (hit number muon counter);
6) $|t_{\rm tof}-t_{\rm exp}|\leqslant 1$ns.

Beam-associated backgrounds:

1) $M_{\rm fit}=2$;
2) $E_{\rm SC}>0.1$GeV (energy deposited in BSC);
3) all tracks of a event locate in the same side.

selecting procedure for hadronic events:

1) If the event is e^+e^- or $\gamma\gamma$ or $\mu^+\mu^-$, it is rejected;

2) The remained backgrounds are further removed by the hadronic criteria listed Table 1;

3) Energy deposit cut is needed.

The hadronic events with good charged tracks $n_{\rm gd} \geqslant 2$ may be selected by the criteria which are very similar to those used in the references[2, 3]. And for the 1-prong events, contaminations from the beam-associated background are serious, so stricter cut conditions are needed. We select only the 1-prong events which with one good charged track and containing at least one π^0. In order to avoid extra systematic error, no particle identification is used. The hadronic criteria may be divided into track level and event level, all of which are summarized in Table 1.

Table 1. The criteria for selecting hadronic events.

selection type		cut condition	explanatory note
track level	charged	$M_{\rm fit}$=2	good-track
		$V_{xy} < 2$cm	vertex limit in x-y plane
		$\lvert\cos\theta\rvert < 0.84$	angle limit in MDC
		$p < E_{\rm b}(1+0.1\sqrt{1+E_{\rm b}^2})$	momentum cut
		$t_{\rm tof} \leqslant t_{\rm proton} + 2/{\rm ns}$	TOF cut
		$E_{\rm BSC} \leqslant {\rm Min}(1, 0.6E_{\rm b})$	charged-track deposit energy
	neutral	—	no general request
event level	all tracks	$E_{\rm BSC}^{\rm sum} > {\rm Max}(0.5, 0.35E_{\rm b})$	total deposit energy in BSC
	⩾ 3-prong	$N_{\rm good} \geqslant 3$	3 good tracks
	2-prong	$N_{\rm good} = 2$	2 good tracks
		$\theta_{12} < 165°$	angle between two tracks
		$\lvert\Delta R\rvert \geqslant 34$ or $\lvert\Delta Z\rvert \geqslant 60/{\rm cm}$	neutral track in BSC
	1-prong	$N_{\rm good} = 1$	1 good track
		if ${\rm Xrate_e} > 0.5 \rightarrow {\rm e}$	judged as e
		if $p > 1$GeV, $\mu_{\rm hit} \geqslant 1 \rightarrow \mu$	judged as μ
		$N_\gamma \geqslant 2$	with multi-photons
		$E_\gamma > 0.1$GeV	reject out pseudo photon
		$N_{\rm hit\ layer} \geqslant 2$	hit layer in BSC
		$\theta_{\rm fc} < 30°$	angle between γ and shower region
		$\theta_{\gamma{\rm chgtrk}} > 25°$	angle between γ and charged track
		1-C fit, ${\rm Prob}(\chi^2) > 0.01$ for π^0	reconstruct π^0

Table 2. Trigger table used for data taking for R measurement in 2004.

TYPE CONDTN	BHABAA	CHARGED	2-MU	CHAR2	NEUTRAL	ENEU	EBB	BB2
active	N	Y	N	Y	Y	Y	Y	N
TOF B-B	-	-	-	-	-	-	-	-
$N_{\rm tof} \geqslant 1$	Y	Y	Y	-	-	-	-	-
$N_{\rm tof} \geqslant 2$	-	-	-	Y	-	-	-	Y
RADIAL	-	-	-	-	Y	-	-	-
$N_{\rm vc} \geqslant 1$	Y	Y	-	Y	-	-	Y	-
$E_{\rm radl}$	-	-	-	-	-	Y	-	Y
ETOF B-B	-	-	-	-	-	-	Y	-
$E_{\rm tof} \geqslant 1$	-	-	-	-	-	-	-	-
$N_{\rm vc} \geqslant 2$	-	-	-	-	-	-	-	-
$N_{\rm trk} \geqslant 1$	Y	Y	-	-	-	-	-	-
$N_{\rm trk} \geqslant 2$	-	-	-	Y	-	-	-	-
$N_{\rm trk} \geqslant 4$	-	-	-	-	-	-	-	-
MUON-OR	-	-	Y	-	-	-	-	-
$E_{\rm trk}$	-	-	-	-	-	-	-	Y
ESC-$\rm E_{tot}$	-	-	-	-	-	Y	Y	-
$E_{\rm tot.l}$	Y	Y	-	-	-	-	-	-
$E_{\rm tot.h}$	-	-	-	-	Y	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-

To suppress the background of the fake photons, 1-C fit of the invariant mass of two photons ($M_{\gamma\gamma}$) constrained to π^0 is applied. For the candidates with more than 2 photons, the $\gamma\gamma$ pair combination with the smallest χ^2 is chosen. Furthermore, the probability of χ^2 for 1-C fit is required to be larger than 0.01. Fig. 4 shows the $M_{\gamma\gamma}$ distribution after 1-C fit with the measured 4-momentum, and the Fig. 3 shows the vertex distributions of the 1-prong events in z direction. One can find that there is a good agreement between data and MC of LUARLW generator[4, 5].

In addition, the trigger efficiency is crucial for 1-prong selection. Table 2 shows the trigger conditions in data taking of 2004. For the condition type CHAR2, $N_{\rm trk} \geqslant 2$ is activated now, instead of using $\rm TOF_{BB}$ in 1999, so the sets of trigger conditions are looser than in the previous measurement of R value. Condition $N_{\rm trk} \geqslant 1$ means that an event could be recorded in raw data if it has at least one charged track and passes the online criteria, and it will not cause any extra loss for one charged track events. The 1-prong event mentioned before means that it contains one good charged track and at least one π^0, and may contains some neutral and bad charged tracks.

4 Parameter tuning

In principle, the physical meaning of the R value is the total cross section, including the contributions from the events with $n_{\rm gd} = 0, 1, 2, \cdots$. Due to the limited performance of BESⅡ, only the events with $n_{\rm gd} \geqslant n_0$ are selected. It is easy to believe that the more information and the more categories (i.e. the distributions about the quantities $\boldsymbol{p}$ and $n_{\rm gd}$ in Eq. (5) and Eq. (6)) of the events are used, the more reliable values of the parameters are set. In the previous measurement of R value, $n_0 = 2$ was adopted[2, 3]. The comparisons of the multiplicity between data and MC are illustrated in Fig. 1, in which only the events with $n_{\rm gd} \geqslant 2$ are selected and used to tune the parameters of LUARLW. Thus, the $P(n_{\rm gd} = 0, 1)$ were unknown, and they will bring larger uncertainty of the parameters tuning and larger error of $\bar{\epsilon}_{\rm had}$. In order to get the reliable $\bar{\epsilon}_{\rm had}$, the parameters of the LUARLW are tuned by the distributions including $n_{\rm gd} \geqslant$ 1-prong events.

The basic method of parameter tuning is to find a set of values of the parameters in LUARLW which make a group of distributions of MC agree with that of data well. In the previous experiment, the chosen distributions are multiplicity, momentum, event shapes, polar-angle, rapidity, jet axis, and only the events with $n_{\rm gd} \geqslant 2$ are selected and used to tune the parameters of LUARLW. Some of them have no direct relations with the hadronic events criteria, and are unsensitive to the selection criteria. The MC samples do not contain the contributions from the beam-associated backgrounds[4], so the types of the event in MC sample and in data are different. It is seen from Fig. 1 that the difference between data and MC become significant with the increase of the collision energy, the remained beam-associated backgrounds not being simulated is an important reason.

In the new measurement of R value with the data taken in 2004, the events with $n_{\rm gd} \geqslant 1$ are selected, and the distributions to be compared between data and MC are those which directly relate to the hadronic events criteria, see Table 1. They are distributions of multiplicity, space position, momentum, polar-angle, deposit energy, the ratio of $\pi/{\rm K}$, the fractions of the short life-time particle $\rm K_S$ and Λ (which will influence their secondary decay vertexes and then the detective efficiency), the fractions of the hadron and leptons (they will have different responses to the detector), the time of flight. Some comparisons of the sensitive distributions between data and LUARLW for the hadronic criteria are illustrated in Figs. 2—10 (dots and histograms represent data and MC respectively), in which the events with $n_{\rm gd} \geqslant 1$ are selected and used to tune the parameters of LUARLW, and MC samples contain the contributions from the beam-associated backgrounds. The dots with error bars are for the data, and the histograms are for the MC sample. In fact, the process of parameters tuning is to choose a set of parameters α in Eq. (5) and Eq. (6), and make those important distributions of the data and MC consistent at all energy points. Therefore, one may estimate the systematic error of hadronic efficiency (or called acceptance) by every criteria according to $\Delta\tilde{N}_{\rm had}/\tilde{N}_{\rm had}$ in Eq. (4).

5 Conclusion

The selection of 0-prong and 1-prong events has been regarded as a long standing problem for the previous measurement of R value. 1-prong events account for 10%—20% depending on energy, so the treatment of 1-prong events is crucial for the R measurement with high precision (say 3% or better at BESIII). Especially, the fractions of low prong events in MC are very sensitive to average hadronic efficiency. In this paper, we try to develop a new method to select the 1-prong events from raw data, and it will be helpful to suppress the systematic error of $N_{\rm had}$ and to tune the phenomenological parameters of hadronic generator LUARW. Comparing Fig. 1 and Fig. 2, they illustrate that the improved event selection and the method of parameters tuning in new measurement of R value make data and MC in a better agreement. Other distributions related to the hadronic criteria of data and MC are also given in Figs. 3—10. It is desirable to obtain more reliable hadronic detector efficiency $\bar{\epsilon}_{\rm had}$ due to the good agreement between data and MC. And the results of R value for selecting $n_{\rm gd}\geqslant 1$ and $n_{\rm gd}\geqslant 2$ events also can be used as a cross check. Due to the limited resolution of BES II for the neutral tracks, the selection of 0-prong event (neutral events, such as $\pi^0\pi^0$) is unreliable, this issue will get significant improvement at the future BESIII.

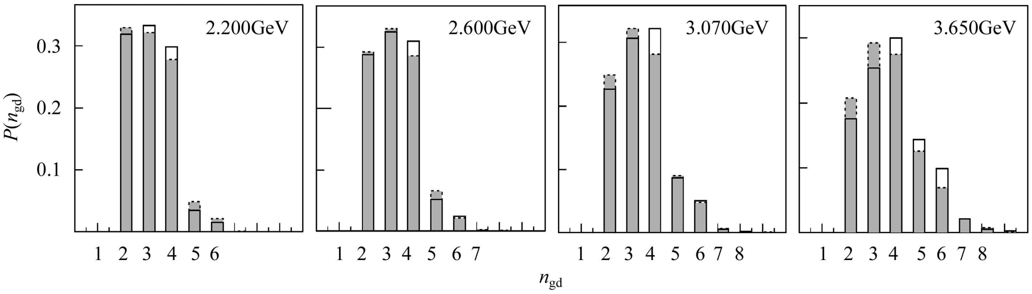

Fig. 1. The comparison of the multiplicity between data (grey region) and MC (black line histogram) in the previous R measurement with 1999 data, in which only the events with $n_{\rm gd}\geqslant 2$ are selected.

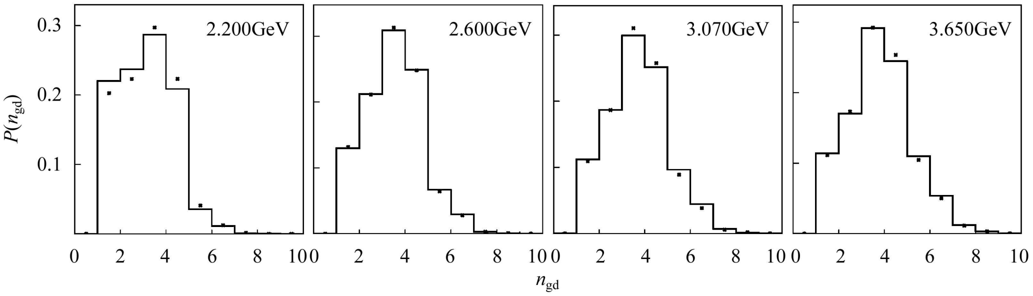

Fig. 2. The comparison of the multiplicity of good track between data (dots) and MC (histograms) for the new R measurement with 2004 data, in which the event with $n_{\rm gd}\geqslant 1$ are selected.

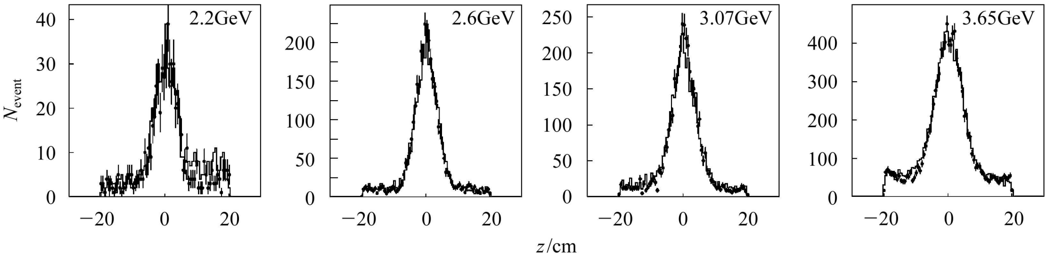

Fig. 3. The vertex distributions of the 1-prong events in z direction.

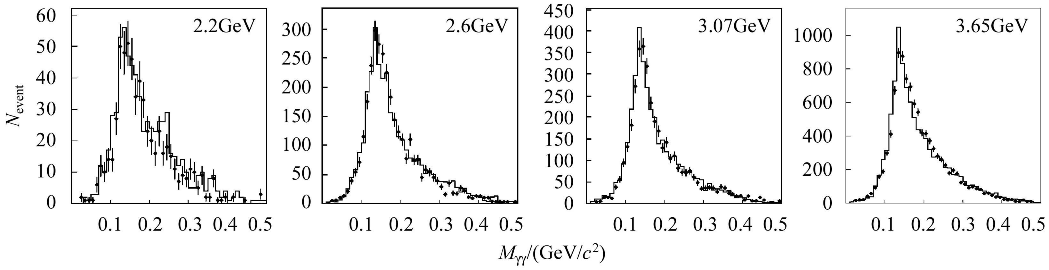

Fig. 4. The distributions of invariant mass of $\gamma\gamma$ in the decay $\pi^0 \rightarrow \gamma\gamma$ which pass 1C fitting.

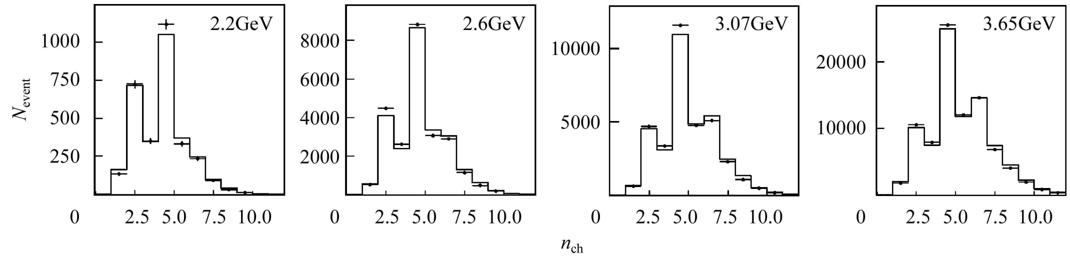

Fig. 5. The total multiplicity distributions with the number of charged tracks $n_{\rm ch}$.

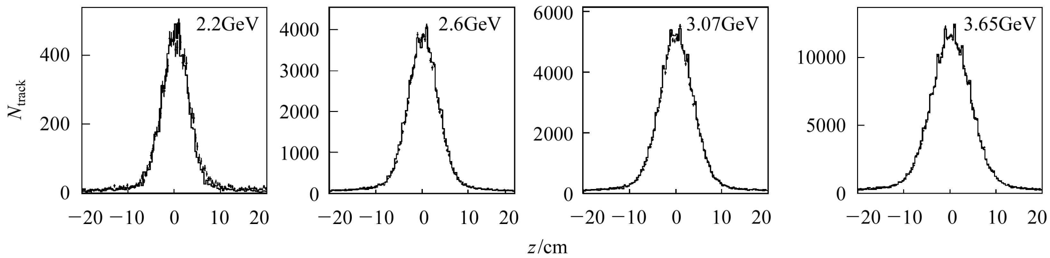

Fig. 6. The vertex distributions of good charged tracks in z direction.

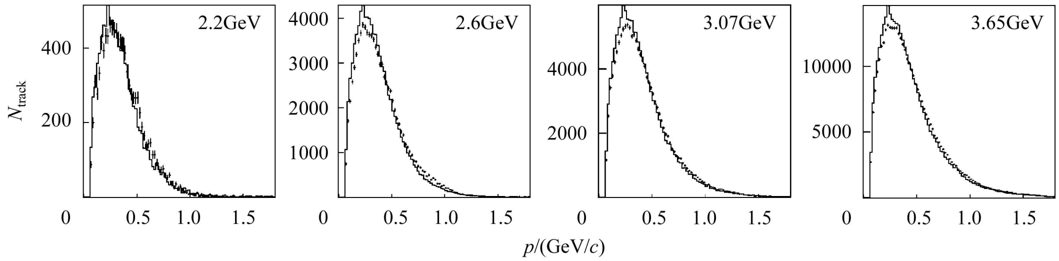

Fig. 7. The distributions of the momentum p of good charged tracks.

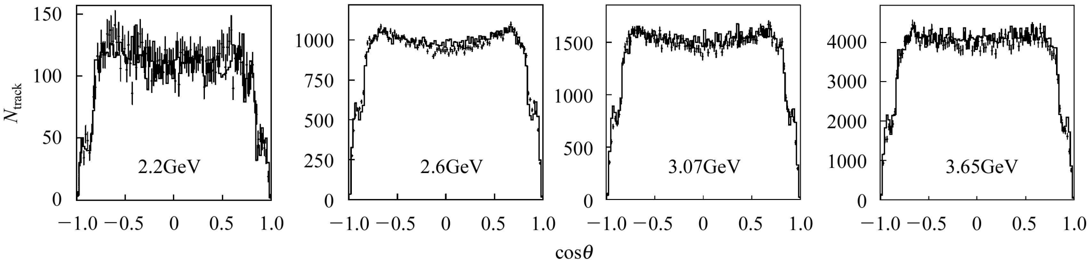

Fig. 8. The distributions of the polar-angle θ of the charged tracks.

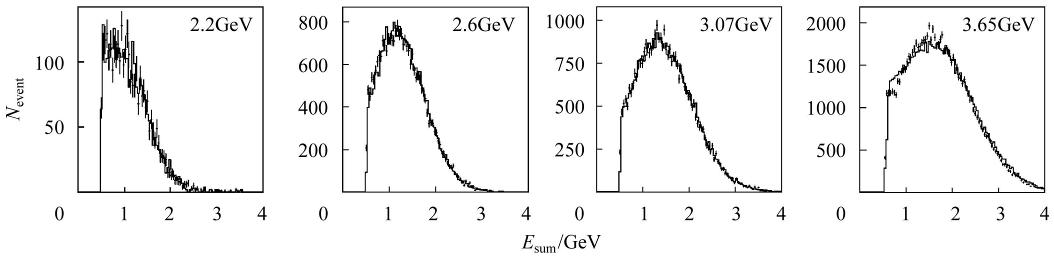

Fig. 9. The distributions of the energy deposit in barrel shower counter (BSC).

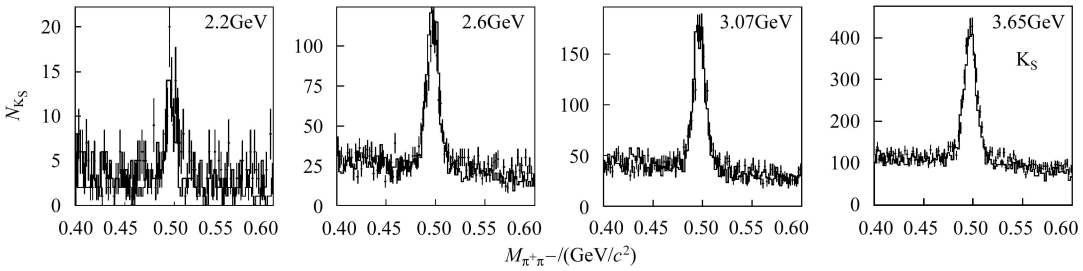

Fig. 10. The distributions of the invariant mass for the decay of $K_S \rightarrow \pi^+\pi^-$.

We would like to thank many BES colleagues for their helpful discussion and suggestions.

References

1 BES Collaboration(BAI J Z et al.). Nucl. Instrum. Methods Phys. Res., Sect., 2001, **A458**: 627
2 BES Collaboration(BAI J Z et al.). Phys. Rev. Lett., 2000, **84**: 594
3 BES Collaboration(BAI J Z et al.). Phys. Rev. Lett., 2002, **88**: 101802
4 HU Hai-Ming et al. HEP & NP, 2001, **25**(11): 1035—1043 (in Chinese)
(胡海明等. 高能物理与核物理, 2001, **25**(11): 1035—1043)
5 Torbjorn Sjostrand, CERN-TH.7112/93
6 ZHU Yong-Sheng. Probability and Statistics in Experimental Physics. Beijing: Science Press, 2006. 149
7 Siegrist J L et al. Phys. Rev., 1982, **D26**: 969
8 HUANG Guang-Shun. Post Dodctor Report, Chinese Center of Advanced Science of Technology, 2001

R值测量中强子事例选择的改进*

胡海明[1] 翁瑶[1;1)] 郭义庆[1] 金毅[1,2] 张丙新[1] 胡君辉[1,3] 高原宁[4]

1 (中国科学院高能物理研究所 北京 100049)
2 (济南大学理学院 济南 250022)
3 (广西师范大学物理与电子工程学院 桂林 541004)
4 (清华大学工程物理系 北京 100084)

摘要 强子事例的选择和强子探测效率是在BEPC/BES上进行R值测量的两项主要误差来源. 过去实验只选取等于或者大于2叉的强子事例, 因而0叉和1叉事例的丢失将导致强子事例数和强子探测效率的较大误差. 试图提出在R值测量中选取包含1叉强子事例在内的样本, 这将有助于更合理地调节强子事例产生器LUARLW的参数, 减小强子探测效率和R值测量的系统误差.

关键词 R值 强子事例 系统误差 事例产生器

2006 – 10 – 19 收稿, 2007 – 03 – 22 收修改稿
∗ 国家自然科学基金(10491300)资助

1) E-mail: wengy@ihep.ac.cn