An event generator for J/ψ and $\psi(2S)$ decay

J.C. Chen*, G.S. Huang , X.R. Qi, D.H. Zhang, Y.S. Zhu,
Institute of High Energy Physics, Beijing 100039, China

Abstract

We have built a Monte-Carlo generator for simulating charmonium J/ψ and $\psi(2S)$ inclusive decay. In the model, charmonium decay via gluons is described by the QCD partonic theory, and the partonic hadronization is handled by the LUND shower string model. C parity and G parity conservation and abnormal suppression effect of charmonium decay are included in the charmonium decay. This model reproduce the properties of hadronic events produced in the charmonium inclusive decay, such as the branching ratios of hadronic resonance, ratios of stable hadrons and the radiative products, as well as global properties of hadronic events.

1 INTRODUCTION

Although charmonium resonance J/ψ and $\psi(2S)$ were found more than twenty years, research of their properties is still an active field and a model used to simulate the charmonium inclusive decay is appealed. The discovery of charmonium resonance makes us a new view to observe the structure of particle. Since charmonium has been found, many theoretical efforts have been made toward understanding the spectrum and decay properties of charmonium family [16, 17, 28, 26, 27, 32]. Existence of the non-Abelian gluon field is the key hypothesis of QCD, and the discovery of the glueballs and hybrids will be the direct and essential proof for the validity of QCD. It is an ideal place to search for glueballs and hybrids in the J/ψ decay process, because the perturbative QCD predicts that low-lying glueballs(with spin-parity 0^{++}, 2^{++}, 0^{-+}) and hybrids can be produced in J/ψ decay. Therefore the systematic studies of the J/ψ and $\psi(2S)$ decays and measurements of branching ratios of their decays, angular distributions and other properties precisely are important ways to search for glueballs and hybrids. Although more than hundred decay modes of J/ψ and about thirty decay modes of $\psi(2S)$ are observed, most of their uncertainties are more than 10-30%. In order to enhance the precision of the measurement, it is needed that an event generator which can reproduce precisely global properties of J/ψ and $\psi(2S)$ decays. It will be very important to the calculation of acceptence for the hadronic inclusive processes(for example, for the measurment of resonance cross section in $J/\psi, \psi(2S) \to hadrons$), as well as in the estimation of the background in the exclusive processes which related with J/ψ and $\psi(2S)$ decay. Those calculations and estimations were usually depended on the simulation by the

*e-mail: chenjc@alpha02.ihep.ac.cn

phase space model at before, and the main system errors origin from the obvious discrepancy between the experimental data and the Monte Carlo generator. This case limited us to perform the precise measurement for the charmonium decay. If a model which can reproduce global properties of the charmonium inclusive decay quantitatively, the acceptance will be calculated more precise than it before, and charmonium decay modes will be measured precisely.

The direct goal of our work are as follows:

1. Study inclusive processes in the $J/\psi, \psi(2S) \to hadrons$, and providing the precise calculation of the acceptence;

2. study exclusive processes in the $J/\psi, \psi(2S) \to hadrons$, and providing the reliable estimation to their background.

3. study exclusive processes in those decays which can produce J/ψ or $\psi(2S)$, such as in the χ_{cJ} or Υ decays, and providing the reasonable estimation to the background.

The main characters of this model are : (1) the main measured modes of charmonium decay are included in the model; (2) flavor generation machinery of the LUND model is applied for the quark hadronization (3) gluon fragmentation are performed by the LUND shower string model[30]; (4) C parity and G parity conservation are included in the interactions; (5) unstable particle's decays are handled by the LUND model to produce the final states; (6) both Particle Data Group(PDG) and BEijing Spectrometer(BES) results are full used to check and tune parameters of the model; (7) not only are the branching ratios of most modes of J/ψ and $\psi(2S)$ decay reproduced by this generator, but also global properties hadronic events consist with the experimental data, such as, the charged multiplicity, KNO scaling distribution, Feynman scaling distribution, rapidity distribution, sphere distribution, transverse momentum distribution, ... and so on.

In the following parts, the method of the model is introduced at first. And than the generator is used to simulate J/ψ and $\psi(2S)$ decay. A full checking is presented by comparing model with data of the PDG and the BES experiment. The last part is a conclusion.

2 METHOD

2.1 Partonic production in the Charmonium inclusive decay

As it is shown in the figure 1. charmonium decay via four ways. These ways can be divided into two types according to they are completely measured or incompletely measured. The completely measured modes are those modes of charmonium decay through transition(such as, $J/\psi \to \gamma\eta_c$, $\psi(2S) \to J/\psi + X, \gamma\chi_{cJ}, \gamma\eta_c$) and the modes of charmonium decay into lepton pairs by a virtual photon(such as, $J/\psi \to e^+e^-, \mu^+\mu^-$, or $\psi(2S) \to e^+e^-, \mu^+\mu^-, \tau^+\tau^-$). These charmonium decay modes have been measured by many experiments and their properties are full listed in the PDG. In our simulation, these decay modes are included into the generator directly by listing theirs measured branching ratios from PDG [34, 33, 21].

The incompletely measured modes are those which measured partly, for instance, such as charmonium decay into hadrons via a virtual photon, or through γgg, or by the way of

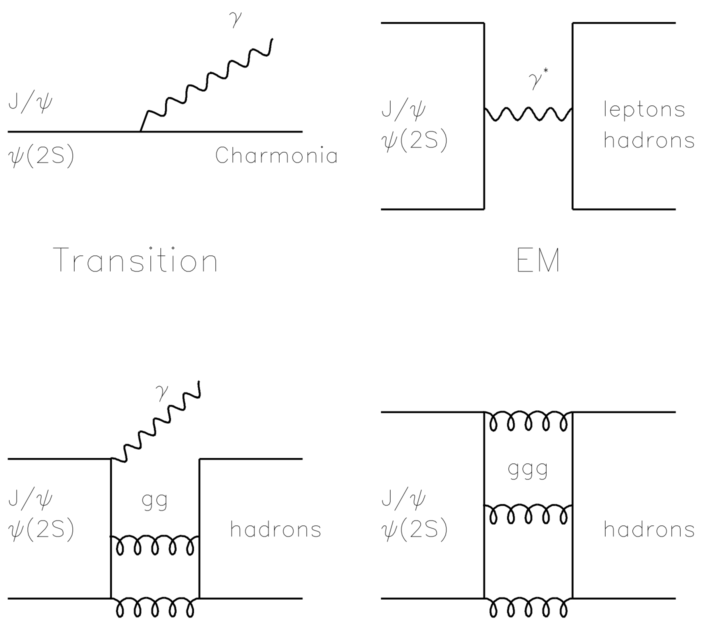

Figure 1: Charmonia Decay: Br($c\bar{c}$)+$Br(\gamma^*)$+$Br(\gamma gg)$+Br(ggg)=1

ggg. In our model, the total branching ratio of charmonium decay into hadrons via a virtual photon are included directly by the data of PDG [34], 0.17 for J/ψ and 0.029 for $\psi(2S)$. The virtual photon decaying into hadrons via $q\bar{q}$ is performed by the Jetset7.4 generator.

As to the charmonium decay into hadrons by γgg or ggg, their properties have been full studied by many theorists [19, 1, 25, 26, 12]. According to QCD, the $J^{PC} = 1^{--}$ states should decay primarily into three gluons and another allowed mode is two gluons and a photon, but it is suppressed by a factor α_{em}/α_s. To order a_s^2, Brodsky et al. proved that the branching ratio for a quarkonia producing $gg\gamma$ or ggg follows the equation 1 [12]:

$$\Gamma(q\bar{q}(1S) \to gg\gamma)/\Gamma(q\bar{q}(1S) \to ggg) = \frac{36e_q^2}{5}\frac{\alpha_{em}}{\alpha_s}\{1 + (2.2 \pm 0.6)\frac{\alpha_s}{\pi}\} \tag{1}$$

In the J/ψ decay, the value of this ratio is about 10% [27]. The fractional energies of γgg or ggg, $x_i = 2E_i/E_{CM}$, is given in the equation 2 [19, 1, 26]:

$$\frac{1}{\sigma_{ggg}}\frac{d\sigma_{ggg}}{dx_1 dx_2} = \frac{1}{\pi^2 - 9}\{(\frac{1-x_1}{x_2 x_3})^2 + (\frac{1-x_2}{x_1 x_3})^2 + (\frac{1-x_3}{x_1 x_2})^2\} \tag{2}$$

For massless gluon and photon, the region of values of x_i(i=1,2,3) are

$$0 \leq x_i \leq 1 \tag{3}$$

$$x_1 + x_2 + x_3 = 2 \tag{4}$$

with high accuracy, the equation 2 can be approximated by a constant 2 [19].

$$\frac{1}{\sigma_{ggg}}\frac{d\sigma_{ggg}}{dx_1 dx_2} \simeq 2 \tag{5}$$

In order to simulate parton hadronization, flavor generation machinery of the LUND model is applied for the $q\bar{q}$ fragmentation, and LUND string model is applied for the gluon shower developing and fragmentation. Those parameters which relate with the ratio of baryon and the ratios of pseudoscalar meson, vector meson and tensor meson in the Jetset7.4 are tuned(shown in the Table 1). When LUND model works in the low energy region, for example in the charm region, some of parameters in the model should be adjusted. The minimum masses of quark string and gluon string are reduced. According the transverse momentum distribution of hadronic events observed in the BES experiment, width of the Gaussian distribution for the Px and Py is added. Those tuned parameters are listed in the Table 1 too.

Table 1: Parameters of Jetset7.4 tuned in the charmonium generator

Dynamic parameter				Particle ratio			
Parameter	Def	Tune	Description	Parameter	Def	Tune	Description
PARJ(21)	0.36	0.5	σ, width of Gaussian	parj(11)	0.5	0.64	V/P ratio of u&d
PARJ(33)	0.8	0.6	diquark minium mass	parj(14)	0	0.62	axial Vector ratio
parj(126)	2GeV	1GeV	gg minimum mass	parj(15)	0	0.15	scalar meson ratio
parj(25)	1.0	0.5	η extra suppression	parj(16)	0	0.15	another axial Vector
				parj(17)	0	0.12	tensor meson
				parj(1)	1	0.07	p(qq)/p(q)
				parj(2)	0.3	0.4	p(ss)/p(uu)

2.2 C parity and G parity conservation in the model

It is because the LUND model is used in the high energy region usually, so that C-parity and G-parity conservation are ignored in the model. However, C-parity and G-parity conservation are known to play an important role in the hadronic decay at the low energy, their effects are included into our generator.

C commutation is defined as an internal symmetry transformation of interchange particle and antiparticle. It is known that only a neutral non-strange meson is the eigenstate of the unitary operator C with the eigenvalue +1 or -1. C-parity conservation works in both electromagnetic interaction (i.e. decay to $q\bar{q}$ via a virtual photon) and strong interaction(i.e. decay via gluons). The C parity of a cluster of neutral mesons is assigned as $\prod C_{nutral}$, the multiplication of those C parities of neutral mesons in the cluster. A charged particle is not the eigenstate of C commutation and it is not assigned a fix C parity. However, a cluster system of charged particles is possible assigned the C parity, $C = (-1)^J$, depending on the J, the angular momentum of the cluster system. In our work, the contribution of the ith charged particle to the C parity of the cluster system is assumed to depend on two parameters. The first parameter is J_i, the contribution of the ith charged particle to the total angular momentum of the cluster system. The total angular momentum of the particles cluster system is the sum of J_i. The C parity of the multiparticle cluster system is assigned as

$$C_{cluster} = \prod C_{nutral} \times (-1)^{\Sigma J_i} \tag{6}$$

The second parameter R_J^i is the probability of the ith particle's contribution whose value taking J_i or $J_i + 1$. Parameters J_i and R_J^i of an anti-particle are same as the particle's.

The G commutation is defined as a complex transformation which first performing a rotation through π around the second axes in the isotopic-spin space, and then making the C transformation. In our model, G parity conservation effect is handled in the way similar as it for the C parity conservation. The differences between the G parity and the C parity are that the G parity is conserved only in the strong interaction, and both the neutral and charged normal mesons are the eigenstates of G operator. The G parity of a cluster of normal mesons is assigned as $\prod G_{normal}$, the multiplication of those G parities of normal mesons in the cluster. The strange meson and the baryon are not the eigenstates of G commutation and they are not assigned fixed the G parities. However, a cluster system of them is possible assigned the G parity as $(-1)^{(I+J)}$, where I and J are the isotopic-spin and total angular momentum of the cluster system. In our generator, the G parity of the multiparticle cluster system is assigned as

$$G_{cluster} = \prod G_{normal} \times (-1)^{\Sigma(I+J)_i} \tag{7}$$

Where $(I + J)_i$ is the parameter of the ith particle's contribution to the (I+J), the total isotopic-spin and angular momentum of the cluster system. The probability $R^i_{(I+J)}$ is another parameter for the ith particle's contribution whose value taking $(I + J)_i$ or $(I + J)_i + 1$.

Values of above parameters J_i, R_J^i, $(I+J)_i$ and $R^i_{(I+J)}$ are gotten by fitting the branching ratios of Monte-Carlo sample to the experimental data. Their values in the model are shown in the Table 2 and Table 3..

Table 2: Contribution of particles to the C parity of particles cluster

Particle	π^+	ρ^+	a_0^+	a_1^+	a_2^+	b_1^+	Λ	Σ^-	Σ^+	Σ^0
J_i	1/2	1	1/2	1/2	1/2	1/2	1	1	1	1
R_J^i	1	1	1	1	1	1	0.98	0.98	.98	.98
Particle	Σ^{*0}	Σ^{*-}	Σ^{*+}	Ξ^-	Ξ^0	Δ^+	Δ^-	Δ^0	Δ^{++}	K^+
J_i	1/2	1/2	1/2	1	1	1/2	1/2	1/2	1/2	1/2
R_J^i	1.	1.	1.	0.98	0.994	1.	1.	1.	1.	0.95
Particle	K^0	K^{*+}	K^{*0}	K_1^+	K_1^0	K_0^{*+}	K_0^{*0}	K_1^{*+}	K_1^{*0}	K_2^{*+}
J_i	1/2	1	1	0	0	1/2	1/2	1/2	1/2	1/2
R_J^i	0.95	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7	1.
Particle	K_2^{*0}	n	p							
J_i	1/2	1/2	1/2							
R_J^i	1.	0.99	0.99							

Table 3: Contribution of particles to the G parity of particles cluster

Particle	γ	Δ^+	Δ^-	Δ^0	$Delta^{++}$	K^+	K^0	K^{*+}	K^{*0}	K_1^+
$(I+J)_i$	1	1/2	1/2	0	1/2	1/2	0	0	0	0
$R^i_{(I+J)}$	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle	K_1^0	K_0^{*+}	K_0^{*0}	K_1^{*+}	K_1^{*0}	K_2^{*+}	K_2^{*0}	n	p	
$(I+J)_i$	0	0	0	1	1	1	1	1/2	1/2	
$R^i_{(I+J)}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.96	0.96	

2.3 Abnormal suppression decay effect

J/ψ and $\psi(2S)$ decay into hadrons via three gluons or by a virtual photon. According to the perturbative QCD(pQCD) , 1^{--} quarkonia decay width follows the equation 8 [2, 3, 4].

$$\Gamma(1^{--} \to l^+l^-) \simeq 4e_q^2\alpha_e^2 m\frac{|R_{q\bar{q}}(0)|^2}{M_{q\bar{q}}} \tag{8}$$

Where e_q is the charge of the quark, $R_{q\bar{q}}(0)$ is the bound-state wave function at the origin, $M_{q\bar{q}}$ is the mass of $q\bar{q}$. They appear in the equation 9 too.

$$\Gamma(1^{--} \to ggg) \simeq \frac{10}{9\pi^2}(\pi^2-9)\alpha_s^3\frac{|R_{q\bar{q}}(0)|^2}{M_{q\bar{q}}} \tag{9}$$

By equation 8 and equation 9, the branching ratios of J/ψ and $\psi(2S)$ decay into hadrons via ggg have the relation 10.

$$Q_h = \frac{B(\psi(2S) \to ggg)}{B(J/\psi \to ggg)} \simeq \frac{B(\psi(2S) \to e+e^-)}{B(J/\psi \to e^+e^-)} \tag{10}$$

According to e^+e^- branching ratio data of PDG in the 1998 [34], $Q_h \simeq 0.15$. J/ψ and $\psi(2S)$ decay into hadrons via the virtual photon following the similar relation.

Usually above relation is true. But some abnormal suppression decay modes are found by MARKII, it is the famous $\rho\pi/K^*\bar{K}$ puzzle, $\frac{Br(\psi(2S)\to\rho\pi)}{Br(J/\psi\to\rho\pi)} = 0.0063$, and $\frac{Br(\psi(2S)\to K^*\bar{K})}{Br(J/\psi\to K^*\bar{K})} < 0.00207$ [20].

Recent years, more and more abnormal decay suppression decay modes are found by BES experiment in the charmonium decaying into vector-pseudoscalar mesons or vector-tensor mesons [6, 7, 9]. Various theories are present to explain this abnormal suppression phenomenon [13, 22, 15, 35, 14, 29].

In order to handle these abnormal suppression decay modes, we assume that the $\psi(2S)$ decay by the normal rule and extra branching ratios of those modes are added in the J/ψ decay. These extra ratios are possible originated from the glueball contribution [22, 12]. The adding ratios, Br_{add}, are added according to the formula 11.

$$Br(J/\psi)_{add} = Br(J/\psi)_{Exp} - \frac{Br(\psi(2S))_{Exp}}{0.15} \tag{11}$$

Where Br_{Exp} is the branching ratio of experimental data which coming from the PDG [33, 34, 21] and the BES experiment [6, 7, 9].

Almost all of known suppression branching ratios of modes can be handled by above way, except $\rho\pi$ mode. By the C parities and G parities of ρ and π, $\rho\pi$ mode should not be suppressed both in the J/ψ and $\psi(2S)$ decays according to the C-parity and G-parity conservation rule. However it is known that it is suppressed strongly in the $\psi(2S)$ decay. In order to reproduce $\rho\pi$ mode suppression, we had to assume that there is a strong suppression ($\sim$90%) to the $\rho\pi$ mode both in the J/ψ and $\psi(2S)$ decay at first, and then, the extra branching ratio is added into the J/ψ decay. This case is very different to other suppressed modes . All of extra branching ratios added in the J/ψ decay are shown in the Table 4.

Table 4: The extra branching ratio is added in the J/ψ decay

mode	$\rho\pi$	$a_2\pi$	$a_2\rho$	$\omega\eta$	ωf_2	$p\bar{p}\omega$	$b_1\pi$	$K\bar{K}^* + c.c.$
Br_{add}	0.0121	0.0057	0.009	0.0011	0.0036	0.0012	0.0026	0.0084
mode	$K^*\bar{K}_2^*$+c.c.	$\omega f_2'$	ϕK^+K^-					
Br_{add}	0.0112	0.00053	0.00114					

3 COMPRISON BETWEEN MONTE CARLO SIMULATION AND EXPERIMENTAL DATA

With our model, J/ψ and $\psi(2S)$ inclusive decay are simulated. Table 5 and Table 6 are the results of J/ψ decay and $\psi(2S)$ decay. In the Table 5 and Table 6, most experimental data are from PDG [33, 34, 21], and some of data come from BES [6, 7, 9] which marked with *.

As we pointed in the above section, charmonium decay modes can be divided into two types according to they are completely measured or incompletely measured. The completely measured decay modes are included into the generator directly by listing theirs measured branching ratios. From modes of charmonium decay through transitions and modes of charmonium decay into leptons listed in the Table 5 and Table 6, it is shown that their branching ratios are same as their input value, and it means that our generator works self-consistent.

As to the incompletely measured modes, they are simulated by the rule described in the above section. From Table 5 and Table 6, it is shown that the most branching ratios of decay modes consist with data about. We should point that not only are branching ratios of stable hadrons or radiative products reproduced, but although branching ratios of charmonium decays involving hadronic resonance are consist about with data. Both the final products and middle products of charmonium decay are simulated well by our generator, and the generator works well.

Properties of hadronic events can be described by distributions of their kinematics variables and kinetic parameters. Figure 2 and Figure 3 are such distributions of hadronic events which produced in the J/ψ decays and $\psi(2S)$ decay. In these Figures, shadows are the distributions of BES experimental data, and lines are the Monte Carlo sample generated by our model. The BES data used here are about 200000 events which collected in the 1993 for the study of J/ψ and about 1600000 events which collected in the 1995 for the $\psi(2S)$. Hadronic events are selected by the way similar as it in the project of R scan in the BES recently. about 100000 hadronic events with more than 2 charged tracks are selected from the J/ψ sample and 260000 hadronic events are selected from the $\psi(2S)$ sample.

In the figure 2 and figure 3, (a) is the charged multiplicity of events N_{ch}; (b) is the KNO scaling distribution [24]; (c) is the azimuth angle ϕ distribution; (d) and (e) are the spherier [10] and aplanarity distribution of events , and they show the features of partonic jet of the event; (f) is $cos\theta$ distribution of charged particles, where θ is the polar angle; (g), (h) and (i) are the thrust [11, 18], oblateness and jet axes polar angle $cos\theta_J$ distributions of events [31]; (j) is the distribution of Feynman scaling variable; Kinematics properties of events are illustrate by (k) pseudorapidity, (l) rapidity, and transverse momentum distributions in the (m), (n), (o).

Table 5: J/ψ Br. sorted by modes:Lepton,Resonance,Stable,Radiative

Decays into lepton								
Mode	B_{Exp}	B_{MC}	Mode	B_{Exp}	B_{MC}	Mode	B_{Exp}	B_{MC}
e^+e^-	6.02E-2	6.04E-2	$\mu^+\mu^-$	6.01E-2	6.0E-2			
Involving hadronic resonances			Decays into stable hadrons			Radiative decays		
Mode	Br_{Exp}	Br_{MC}	Mode	Br_{Exp}	Br_{MC}	Mode	Br_{Exp}	Br_{MC}
$\rho\pi$	1.27E-2	1.26E-2	$2(\pi^+\pi^-)\pi^0$	3.37E-2	4.2E-2	$\gamma\eta_c$	1.3E-2	1.3E-2
$\rho^0\pi^0$	4.2E-3	4.1E-3	$3(\pi^+\pi^-)\pi^0$	2.9E-2	3.3E-2	$\gamma\pi^+\pi^-2\pi^0$	8.3E-3	5.3E-3
$a_2\rho$	1.09E-2	1.1E-2	$\pi^+\pi^-\pi^0$	1.5E-2	1.6E-2	$\gamma\rho\rho$	4.5E-3	4.6E-3
ωf_2	4.3E-3	4.0E-3	$K^+K^-\pi^+\pi^-\pi^0$	1.2E-2	1.3E-2	$\gamma\eta'$	4.31E-3	0.0
$b_1^\pm\pi^\mp$	3.0E-3	3.3E-3	$K^+K^-\pi^+\pi^-$	7.2E-3	7.5E-3	$\gamma 2(\pi^+\pi^-)$	2.8E-3	2.1E-3
$b_1^0\pi^0$	2.3E-3	2.1E-3	$K\bar{K}\pi$	6.1E-3	3.5E-3	$\gamma\omega\omega$	1.59E-3	9.2E-4
$K^{*0}\bar{K}_2^{*0}+c.c.$	6.7E-3	6.3E-3	$p\bar{p}\pi^+\pi^-$	6.0E-3	4.4E-3	γf_2	1.38E-3	0.0
$K^+\bar{K}^{*-}+c.c.$	5.0E-3	6.6E-3	$2(\pi^+\pi^-)$	4.0E-3	3.0E-3	$\gamma\eta$	8.6E-4	0.0
$K^0\bar{K}^{*0}+c.c.$	4.2E-3	5.2E-3	$3(\pi^+\pi^-)$	4.0E-3	1.9E-3	γf_1	6.5E-4	0.0
$\omega\pi^0\pi^0$	3.4E-3	3.4E-3	$n\bar{n}\pi^+\pi^-$	4.0E-3	3.6E-3	$\gamma f_2'$	4.7E-4	0.0
$\omega K^*\bar{K}+c.c.$	5.3E-3	5.2E-3	$\Sigma^0\bar{\Sigma}^0$	1.27E-3	.8E-3	$\gamma\phi\phi$	4.0E-4	2.0E-3
$\phi K^*\bar{K}+c.c.$	2.04E-3	3.9E-3	$K^+K^-2(\pi^+\pi^-)$	3.1E-3	4.1E-3	$\gamma p\bar{p}$	3.8E-4	2.3E-4
$\Delta^{++}\bar{p}\pi-$	1.6E-3	2.7E-4	$p\bar{p}\pi^+\pi^-\pi^0$	2.3E-3	4.5E-3	$\gamma\pi^0$	3.9E-5	0.0
$\omega\eta$	1.58E-3	1.3E-3	$p\bar{p}$	2.14E-3	2.3E-3	$\gamma K\bar{K}$	8.5E-4	7.8E-4
$\phi K\bar{K}$	1.48E-3	1.6E-3	$p\bar{p}\eta$	2.09E-3	2.4E-3	$\gamma K\bar{K}\pi$	1.7E-3	7.5E-4
$p\bar{p}\omega$	1.3E-3	1.2E-3	$p\bar{n}\pi^-$	2.0E-3	2.3E-3			
$\Delta^{++}\bar{\Delta}^{--}$	1.1E-3	.72E-3	$n\bar{n}$	1.9E-3	2.34E-3			
$\Sigma^{*-}\bar{\Sigma}^{*+}$	1.03E-3	3.9E-3	$\Xi\bar{\Xi}$	1.8E-3	.7E-3			
$p\bar{p}\eta'$	9.0E-4	4.8E-4	$\Lambda\bar{\Lambda}$	1.35E-3	2.3E-3			
$\phi f_2'$	8.0E-4	1.5E-3	$p\bar{p}\pi^0$	1.09E-3	1.5E-3			
ωf_1	6.8E-4	7.2E-4	$\Lambda\bar{\Sigma}^-\pi^+$	1.06E-3	2.0E-5			
$\phi\eta$	6.5E-4	8.0E-4	$pK^-\bar{\Lambda}$	8.9E-4	3.0E-4			
$\Xi^{*-}\bar{\Xi}^+$	5.9E-4	2.6E-4	$2(K^+K^-)$	7.0E-4	1.2E-3			
$pK^-\bar{\Sigma}^{*0}$	5.1E-4	4.0E-5	$pK^-\bar{\Sigma}^0$	2.9E-4	1.0E-5			
$\omega\pi^0$	4.2E-4	1.0E-3	K^+K^-	2.37E-4	3.6E-4			
$\phi\eta'$	3.3E-4	6.0E-4	$\Lambda\bar{\Lambda}\pi^0$	2.2E-4	2.0E-5			
ϕf_0	3.2E-4	0.0	$\pi^+\pi^-$	1.47E-4	6.8E-4			
$\Xi^{*0}\bar{\Xi}^0$	3.2E-4	2.6E-4	$\Lambda\bar{\Sigma}+c.c.$	<1.5E-4	6.1E-4			
$\Sigma^{*-}\bar{\Sigma}^+$	3.1E-4	3.3E-4						
ϕf_1	2.6E-4	0.0						
$\rho\eta$	1.93E-4	2.8E-4						
$\omega\eta'$	1.67E-4	2.1E-4						
ωf_0	1.4E-4	7.5E-4						
$\rho\eta'$	1.05E-4	2.1E-4						
$p\bar{p}\phi$	4.5E-5	0.0						
$a_2^\pm\pi^\mp$	<4.3E-3	4.5E-3						
$K\bar{K}_2^*+c.c.$	<4.0E-3	0.8E-3						
$K_2^{*0}\bar{K}_2^{*0}$	<2.9E-3	1.1E-4						
$K^{*0}\bar{K}^{*0}$	<5.0E-4	4.3E-4						
ϕf_2	<3.7E-4	0.0						
$p\bar{p}\rho$	<3.1E-4	2.7E-4						
$\omega f_2'$	<2.2E-4	0.0						
$\Sigma^{*0}\bar{\Lambda}$	<2.0E-4	7.5E-4						
$\Delta^+\bar{p}$	<1.0E-4	1.2E-4						
$\Sigma^0\bar{\Lambda}$	<9.0E-5	3.1E-4						
$\phi\pi^0$	<6.8E-6	0.0						

Table 6: $\psi(2S)$ Br. sorted by modes:Lepton,Resonance,Stable,Radiative

Decays into lepton								
Mode	B_{Exp}	B_{MC}	Mode	B_{Exp}	B_{MC}	Mode	$B_{The.}$	B_{MC}
e^+e^-	8.5E-3	8.5E-3	$\mu^+\mu^-$	7.7E-3	7.9E-3	$\tau^+\tau^-$	3.15E-3	3.18E-3
Involving hadronic resonances			Decays into stable hadrons			Transition and Radiative		
Mode	Br_{Exp}	Br_{MC}	Mode	Br_{Exp}	Br_{MC}	Mode	Br_{Exp}	Br_{MC}
$\rho\pi$	<2.8E-5*	1.0E-5	$3(\pi^+\pi^-)\pi^0$	3.5E-3	5.0E-3	$J/\psi\pi^+\pi^-$	3.24E-1	3.24E-1
$a_2\rho$	<3.0E-4*	2.8E-4	$2(\pi^+\pi^-)\pi^0$	3.0E-3	2.9E-3	$J/\psi\pi^0\pi^0$	1.84E-1	1.84E-1
ωf_2	<1.1E-4*	6.0E-5	$K^+K^-\pi^+\pi^-$	1.6E-3	6.1E-4	$J/\psi\eta$	2.7E-2	2.7E-2
$b_1^\pm\pi^\mp$	3.0E-4*	2.4E-4	$K^+\bar{K}^{*0}\pi^- + c.c.$	6.7E-4	1.5E-4	$J/\psi\pi^0$	9.7E-4	9.7E-4
$K^{*0}\bar{K}_2^{*0} + c.c.$	<1.8E-4*	3.0E-5	$p\bar{p}\pi^+\pi^-$	8.0E-4	1.01E-3	$\gamma\chi_{c0}$	9.3E-2	9.3E-2
$K^+\bar{K}^{*-} + c.c.$	<5.4E-5	1.6E-4	$p\bar{p}$	1.9E-4	1.9E-4	$\gamma\chi_{c1}$	8.7E-2	8.7E-2
$K^0\bar{K}^{*0} + c.c.$	8.1E-5*	1.8E-4	$3(\pi^+\pi^-)$	1.5E-4	1.6E-4	$\gamma\chi_{c2}$	7.8E-2	7.8E-2
$\omega\pi^0$	4.4E-5*	8.0E-5	$p\bar{p}\pi^0$	1.4E-4	1.8E-4	$\gamma\eta_c$	2.8E-3	2.8E-3
$\omega\eta$	<7.1E-5*	3.0E-5	$\pi^+\pi^-$	<8.0E-5	7.0E-5	$J/\psi\mu^+\mu^-$	1.0E-2	1.0E-2
ϕK^+K^-	5.1E-5*	0.0	$\Lambda\bar{\Lambda}$	<4.0E-4	<0.0	$\gamma\eta'$	<1.1E-5	0.0
$\Delta^{++}\bar{\Delta}^{--}$	8.8E-5*	7.0E-5	$\Xi^{*0}\bar{\Xi}^{*0}$	<7.2E-5*	1.2E-4	γf_2	2.46E-4*	0.0
$\Sigma^{*-}\bar{\Sigma}^{*+}$	4.6E-5*	2.0E-5	$K^+K^-\pi^0$	<2.96E-5	8.0E-5			
$\Sigma^0\bar{\Sigma}^0$	1.17E-4*	0.0	$\Omega^-\Omega^+$	<7.1E-5*	6.0E-5			
$\phi f_2'$	<3.4E-5*	2.0E-5	$K_1\bar{K}$	7.6E-4*	5.0E-5			
$\Xi^-\bar{\Xi}^+$	1.03E-4*	5.0E-5	$K_1^*\bar{K}$	<2.7E-4*	2.0E-5			
ϕf_0	7.7E-5*	0.0						
$a_2^\pm\pi^\mp$	<8.3E-5*	7.0E-5						
$K^{*0}\bar{K}^{*0}$	<4.5E-5*	4.0E-5						
$\phi\phi$	<2.6E-5*	0.0						

From Figure 2 and Figure 3, it is shown that our model can full reproduce the global properties of hadronic events produced in the charmonium decay. Based on the consistent between the Monte Carlo sample and experimental data in the global properties of hadronic events, the acceptance can be calculated precisely for the process of charmonium decay into hadrons. This can improve the precision in the measurement of resonance width of J/ψ and $\psi(2S)$ decay, as well as improve the precision in the measurement of the total number of J/ψ or $\psi(2S)$ sample.

4 CONCLUSION

A new model of charmonium inclusive decay is presented. Charmonium decays are divided into two parts. One is the full measured decay modes, such as charmonium decay into leptons or decay into other charmonia via transition. They are simulated simply by including their well-measured branching ratios data into the generator. Another part of charmonium inclusive decay is incompletely measured, such as charmonium decay into hadrons via $q\bar{q}$ or $\gamma gg/ggg$. They are simulated by the assumed model. In this model, gluons showering development are handled by the LUND string model. Unstable particles decay are handled by the decay code of Jetset7.4. In addition, C-parity and G-parity conservation are considered by the simplified model. The most suppression effect of charmonium decay observed in the experiments can be described by the presuming that $\psi(2S)$ decays via normal way and adding some extra contribution into the J/ψ decay. It should be pointed that it is because $\rho\pi$ mode can not be suppressed by both the C-parity and the G-parity conservation in the J/ψ and $\psi(2S)$ decay, a special suppression effect had to be used for the $\rho\pi$ mode. It looks very different to the other suppressed decay modes.

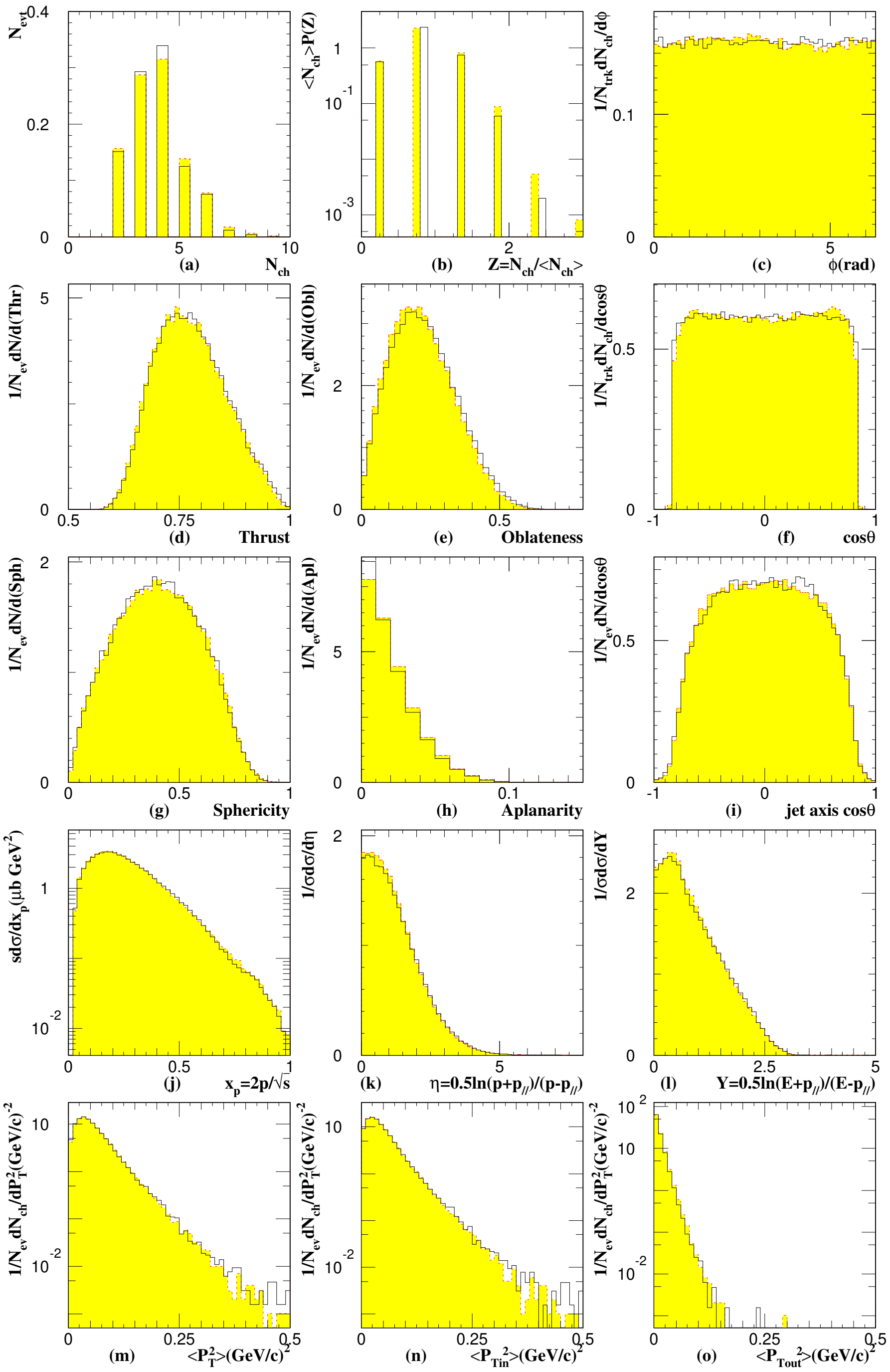

Figure 2: Global properties of hadronic events produced in the J/ψ decay. In the figure, shadows are the distribution of BES experimental data, lines are them of generated by our model. (a) The charged multiplicity of events, N_{ch}; (b) the KNO scaling [24]; (c) the azimuth angle ϕ distribution of charged particles; (d) the spherier distribution [10]; (e) aplanarity distribution; (f) polar angle $cos\theta$ distribution of charged particles; (g)thrust distribution [11, 18]; (h) oblateness distribution; (i)jet axes polar angle $cos\theta_J$ distributions of events [31]; (j) the distribution of Feynman scaling variable; (k) pseudorapidity; (l) rapidity; (m) transverse momentum of charged particles; (n)projection of p_T in the jet injection plane; (o)p_T projection out of the jet injection plane.

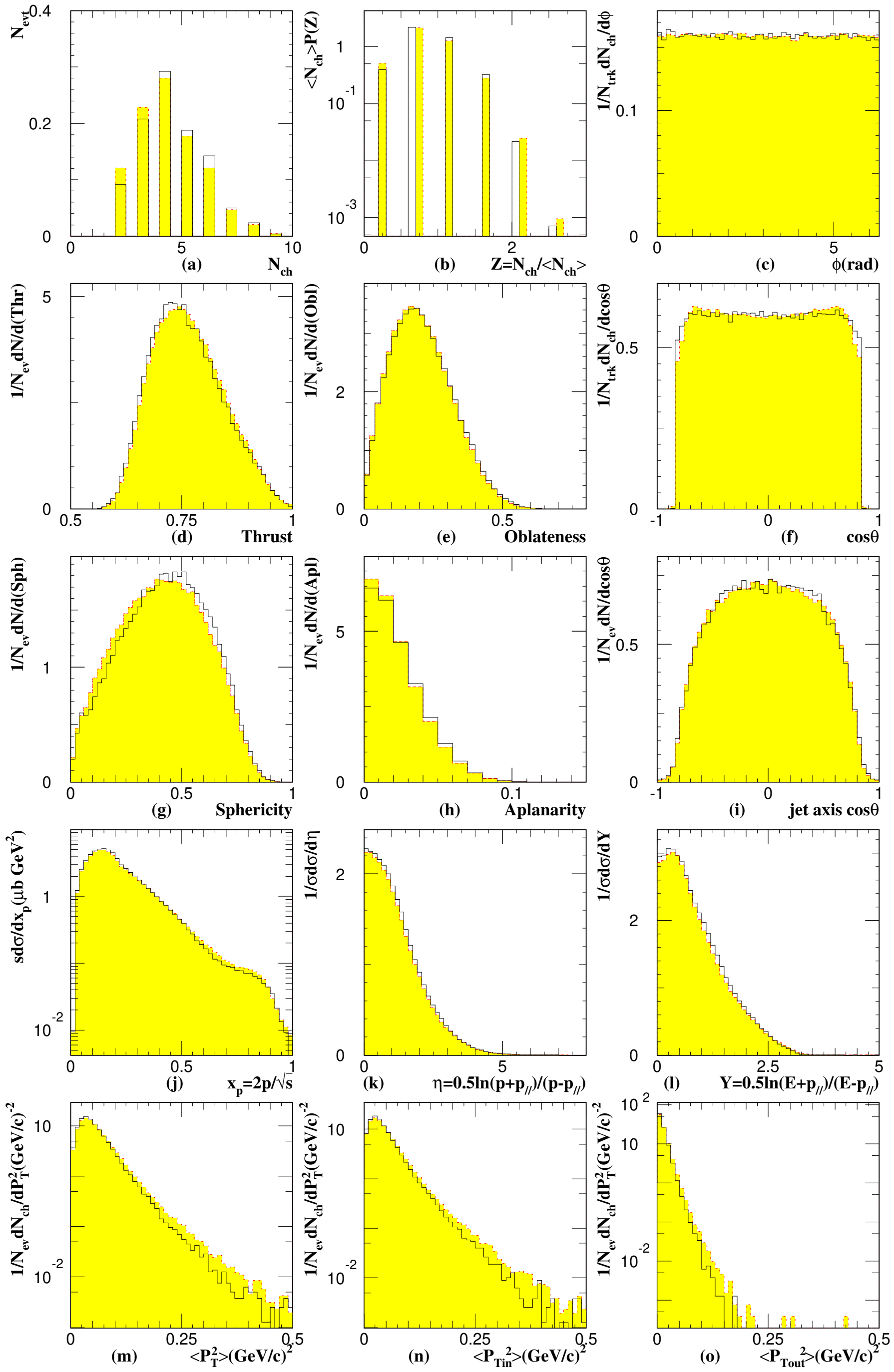

Figure 3: Global properties of hadronic events produced in the $\psi(2S)$ decay. Shadows are the distribution of BES experimental data, lines are them of generated by our model.

With our model, J/ψ and $\psi(2S)$ inclusive decays are simulated. The comparison results show that Monte Carlo results consist with data in the various properties, such as branching ratios of involving hadronic resonance's, stable hadrons or radiative products, as well as global properties of hadronic events. It is expected that our generator can contribute much to the improvement of the precision in the measurement of the branching ratios of charmonium decay.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to Dr. Xinhua Li who propose this work at first and provide us some helpful suggestions. We thank Dr. Torbjorn Sjostrand and Prof. B. Andersson and Dr. Tai An for helping us to apply LUND model in the BES experiment. Authors would like to express much thanks to all of members of BES collaboration, BES data and BES software are the results of their hard work. We specially thank to the Prof. Z.G. Zhao and Mr. Cheng Baosen and all of other members of R group, M.C. group and $\psi(2S)$ group of BES, for their various helpful discussions and contributions.

References

[1] Guido Altarelli, Phys. Rep. **81**,1(1982)

[2] T. Applequist and D. Polizter, Phys. Rev. Lett. **34**,43(1975)

[3] R. Barbieri, R. Gatto and R. Kogerler Phys. Lett. **60B**, 183(1976)

[4] R. Barbieri, R. Gatto and R. Remiddi Phys. Lett. **61B**, 368(1976)

[5] BES collaboration, Nucl. Instr. Meth, bf A334, 319(1994)

[6] BES collaboration, High Ener. Phys. and Nucl. Phys., bf 19, 93(1995)

[7] BES collaboration, High Ener. Phys. and Nucl. Phys., bf 21, 89(1997)

[8] BES collaboration group, High Energy Phys. and Nucl. Phys. **20**,481(1996)

[9] BES collaboration group, Phys. Rev. Lett. **81**,5080(1998)

[10] J.D. Bjorken and S.J. Brodsky, Phys. Rev. **D1**, 1416(1970)

[11] S. Brandt et al., Phys. Lett. **12**, 57(1964)

[12] S.J. Brodsky, G.P. Lepage and P.B. Mackenzie, Phys. Rev. **D28**,228(1983)

[13] S.J. Brodsky, G.P. Lepage and S.F. Tuan, Phys. Rev. Lett. **59**,621(1987)

[14] S.J. Brodsky and M. Karliner, Phys. Rev. Ltte. **78**, 4682(1997)

[15] M. Chaichian et al., Nucl. Phys. **B323**, 75(1989)

[16] E. Eichten, et al., Phys. Rev. Lett. **34**,369(1975)

[17] E. Eichten, et al., Phys. Rev. **D17**,3090(1978)

[18] E. Fahri, Phys. Rev. Lett. **39**, 187(1977)

[19] R.D. Field, Phys. Lett. **133B**,248(1983)

[20] M.E.B. Franklin et al., Phys. Rev. Lett. **51**,963(1983)

[21] Y.F. Gu and X.H. Li, Phys. Lett. **B449**,361(1999)

[22] Wei-Shu Hou and A. Soni, Phys. Rev. Lett. **50**,569(1983)

[23] G. Karl and W. Roberts, Phys. Lett. **144B**,263(1984)

[24] Z. Koba, H.B. Nielsen, P. Olesen, Nucl. Phys. **B40**,317(1972)

[25] K. Koller and T.F. Walsh, Phys. Lett. **72B**,227(1977)

[26] K. Koller and T.F. Walsh, Nucl. Phys. **B140**,449(1978)

[27] W. Kwong, et al., Phys. Rev. **D37**,3210(1988)

[28] L. M. Jones, et al., Phys. Rev. **D17**,2332(1978)

[29] X.Q. Li, D.V. Bugg and B.S. Zhou, Phys. Rev. **D55**, 1421(1997)

[30] B. Andersson, G. Gustafson and T. Sjostrand, Z. Phys. **C6**, 235(1980)
T. Sjostrand, Computer Phys. Comm. **27**, 243(1982)
T. Sjostrand, Computer Phys. Comm. **82**, 74(1994)

[31] R. Marshall, 1989, RAL-89-021. 3.10-3.17

[32] V. A. Novikov, et al., Phys. Rep. **41**,1(1978)

[33] Particle Data Group, Phys. Rev. **D54**, 1(1996)

[34] Particle Data Group, Eur.Phys. J. **C3**, 1(1998)

[35] S. S. Pinsky, Phys. Ltte. **B236**, 479(1990)