Results of J/ψ weak decay searching at BESIII

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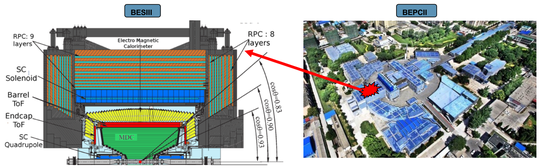
Introduction

- The decays of J/ψ are dominated by strong and electromagnetic interactions, which have been extensively studied.
- Few rare weak decays of J/ψ has been searched due to the small strength of the weak interaction.
- Searching for the J/ψ weak decays , which decay into single D meson can provide a experimental check of the standard model (SM) and may offer a unique opportunity to probe new physics beyond the SM.

BESIII Detector and BEPCII

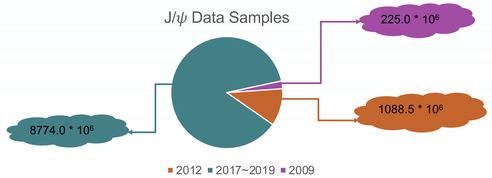
- Located and operated at IHEP, Beijing
- Symmetric e^+e^- collider
- Beam energy: 1.0 – 2.3 GeV (update to 2.45 GeV in 2020)
- Optimum energy: 1.89 GeV
- Design (and achieved) luminosity: $10^{33}\ \mathrm{cm^{-2}s^{-1}}$



Electromagnetic Calorimeter $\sigma_E/E(\%)$=2.5%/5% (barrel/endcap) at 1.0 GeV σ_{xy} = 6 / 9 (mm) (barrel/endcap)	**Muon Counter** σ_{xy} = 2 cm
Time of Flight σ_T(barrel)=80 ps and 68 ps (upgraded) σ_T(endcap)=110 ps and 60 ps (upgraded)	**Multiplayer Drift Chamber** dE/dx ~ 6% σ_p/p = 0.5% at 1 GeV

Data Sets

- J/ψ data samples are taken in three separate periods, and cumulated total 10087 million events.

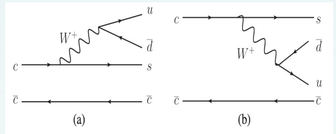


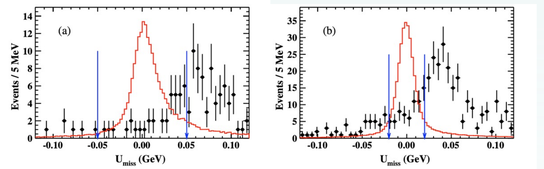
Results of $J/\psi \to D_S^- \rho^+$ and $J/\psi \to \bar{D}^0 \bar{K}^{*0}$

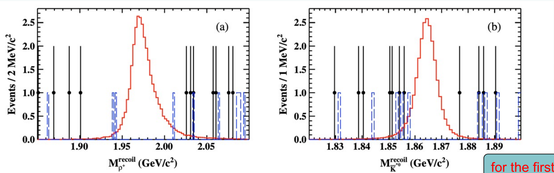
PRD 89, 071101(R) (2014)

- Based on 2009 J/ψ events
- Semi-leptonic decays of D meson have relatively clear background owing to the identification of e
- U_{miss} is a sensitive criterion to suppress backgrounds
- Signal yields are estimate by counting the events number in the recoiling mass
- Upper limits (90% C.L.):

$$B < \frac{N_{UL}}{N_{J/\psi}\epsilon B_{inter}(1-\sigma^{sys})}$$







for the first time!

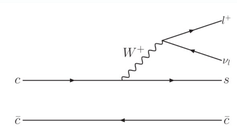
Decay mode	Intermediate decay	ε	$\mathcal{B}_{inter}$	σ^{sys}	N_{UL}	$\mathcal{B}$ (90% C.L.)
$J/\psi \to D_s^- \rho^+$	$D_s^- \to \phi e^- \bar{\nu}_e$, $\phi \to K^+K^-$, $\rho^+ \to \pi^+\pi^0$, $\pi^0 \to \gamma\gamma$	7.79%	1.20%	8.6%	2.5	$< 1.3 \times 10^{-5}$
$J/\psi \to \bar{D}^0 \bar{K}^{*0}$	$\bar{D}^0 \to K^+ e^- \bar{\nu}_e$, $\bar{K}^{*0} \to K^- \pi^+$	21.83%	2.37%	7.5%	2.7	$< 2.5 \times 10^{-6}$

Results of $J/\psi \to D_S^{(*)-} e^+ \nu_e$

PRD 90, 112014 (2014)

- Based on 2009 J/ψ events
- D mesons are reconstructed through four hadronic decays
- A simultaneous unbinned maximum likelihood fit is used to determine the event yields
- Upper limits (90% C.L.)

$$B < \frac{N^{up'}_{total}}{N_{J/\psi}(1-\sigma^{sys}_{common})}$$

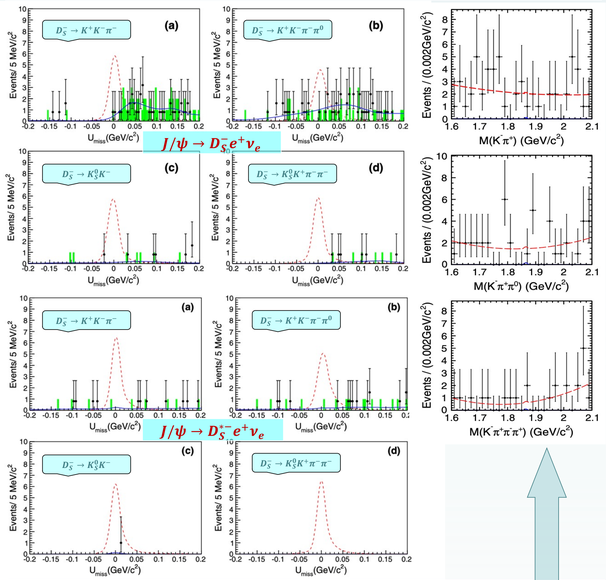


	$J/\psi \to D_s^- e^+ \nu_e$	$J/\psi \to D_s^{*-} e^+ \nu_e$
N^{up}_{total}	244	335
σ_{total}	31	43
$N^{up'}_{total}$	275	378
σ^{sys}_{common}	3.3%	3.9%
$N_{J/\psi}$	2.25×10^8	
$\mathcal{B}$(90% C.L.)	$< 1.3 \times 10^{-6}$	$< 1.8 \times 10^{-6}$

30 times more strict than the previous result

for the first time!

Results of $J/\psi \to D_S^{(*)-} e^+ \nu_e$



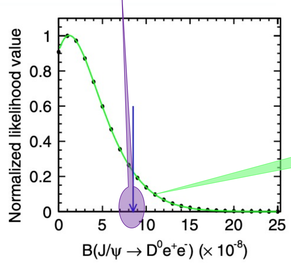
$J/\psi \to D_s^- e^+ \nu_e$

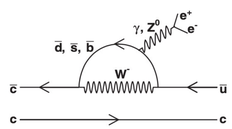
$J/\psi \to D_s^{*-} e^+ \nu_e$

Result of $J/\psi \to D^0 e^+ e^-$

PRD 96, 111101(R) (2017)

- Based on 2009 + 2012 J/ψ events
- D mesons are reconstructed through three hadronic decays
- Signal yields are estimated by a simultaneous unbinned maximum likelihood fit on the distributions of invariant mass of D
- Upper limits (90% C.L.):
  - $B < 8.5 \times 10^{-8}$ (more stringent by 2 orders in magnitude compared to the previous results)



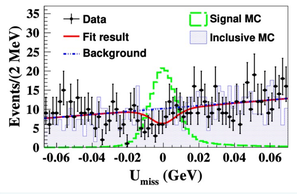


Corrected and un-correlated systematic uncertainties are incorporated in likelihood function

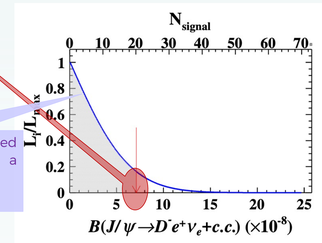
Result of $J/\psi \to D^- e^+ \nu_e$

JHEP 06, (2021) 157

- Based on full J/ψ events
- Hadron candidates $K^+K^-\pi^-$ to form the D meson
- Event yields are determined by the unbinned maximum fit on U_{miss} distributions
- Upper limits (90% C.L.)
  - $B < 7.1 \times 10^{-8}$ (improve this limit by a factor of 170, and is the most sensitive search of this channel)



- The distribution of the normalized smeared likelihood values as a function of the BF



Summary

- Several searches of weak decays of J/ψ have been performed at BESIII .
- These measurements are roughly compatible with the SM theoretical predictions, but with striking difference between different new physics models.
- With the more and more searches are studied based on unprecedented J/ψ samples in future, the more precise results would also be applied to constrain the parameter spaces of some new physics models.

References

1. M. Ablikim et al. [BESIII collaboration], Phys. Rev. D **89**, 071101 (2014).
2. M. Ablikim et al. [BESIII collaboration], Phys. Rev. D **90**, 112014 (2014).
3. M. Ablikim et al. [BESIII collaboration], Phys. Rev. D **96**, 111101 (2017).
4. M. Ablikim et al. [BESIII collaboration], arXiv:2104.06628 [hep-ex].

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