Search for Charmonium weak decay at BESIII

Yong-Hua Zhan (詹永华), Sun Yat-sen University

On behalf of BESIII Collaboration

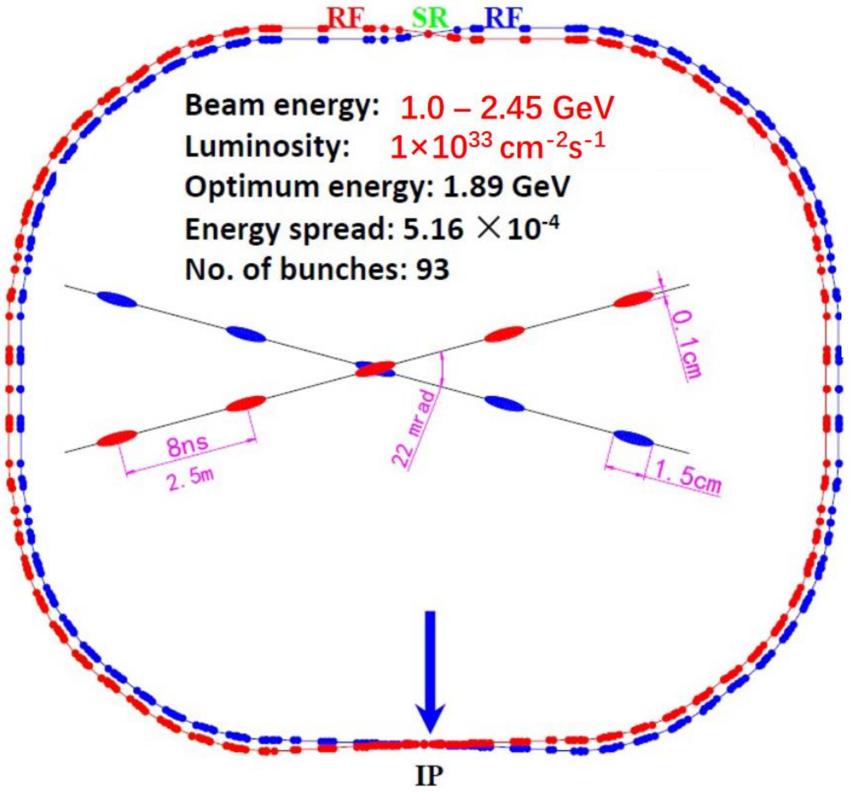
NPG Workshop 2024

Outline

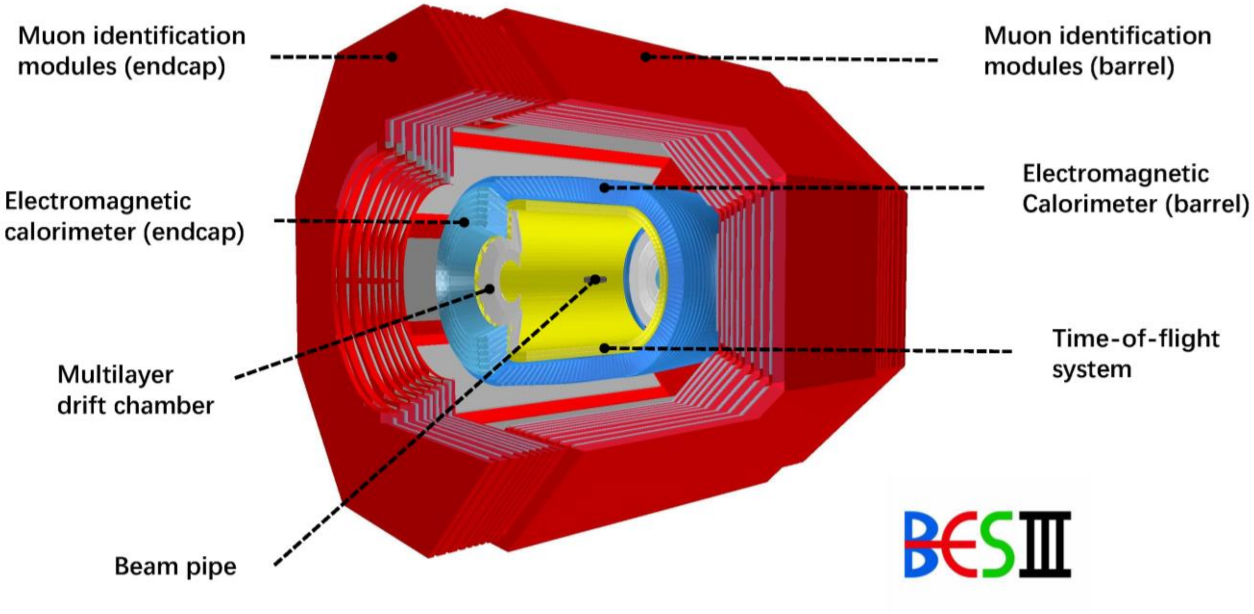
- BEPCII and BESIII
- BESIII data samples
- Charmonium weak decays
- $J/\psi \to D^- e^+ \nu_e$
- $J/\psi \to D^- \mu^+ \nu_\mu$
- $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
- Ongoing analyses
- Summary

BEPCII and BESIII

Beijing Electron Positron Collider II



BESIII Detector



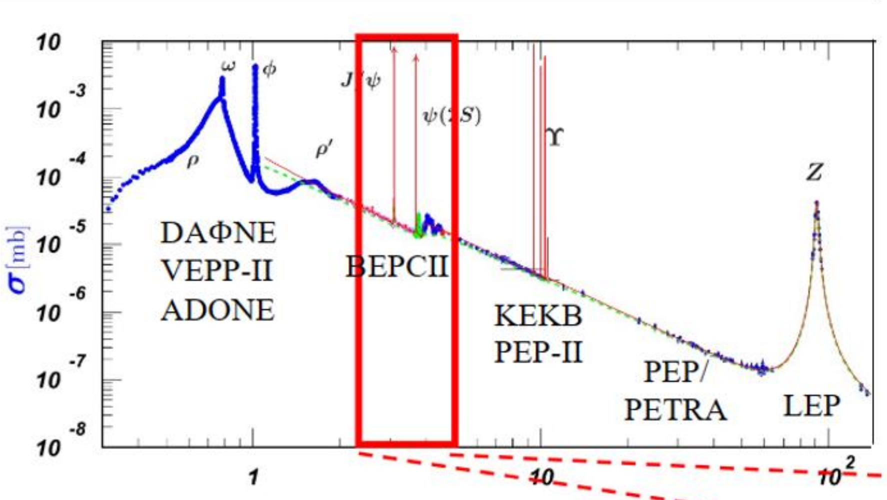
- Multilayer drift chamber (MDC)
  - The momentum resolution: 0.5% @ 1GeV/c
  - dE/dx resolution: 6%
- Time-of-flight (TOF) system
  - The time resolution: 68ps(barrel)/60ps(endcap)
- CsI(Tl) Electromagnetic calorimeter (EMC)
  - The energy resolution: 2.5%(barrel)/5.0%(endcap) @1GeV
- Supercon-ducting solenoidal magnet (1.0 T magnetic field)
- Muon chamber (MUC) system

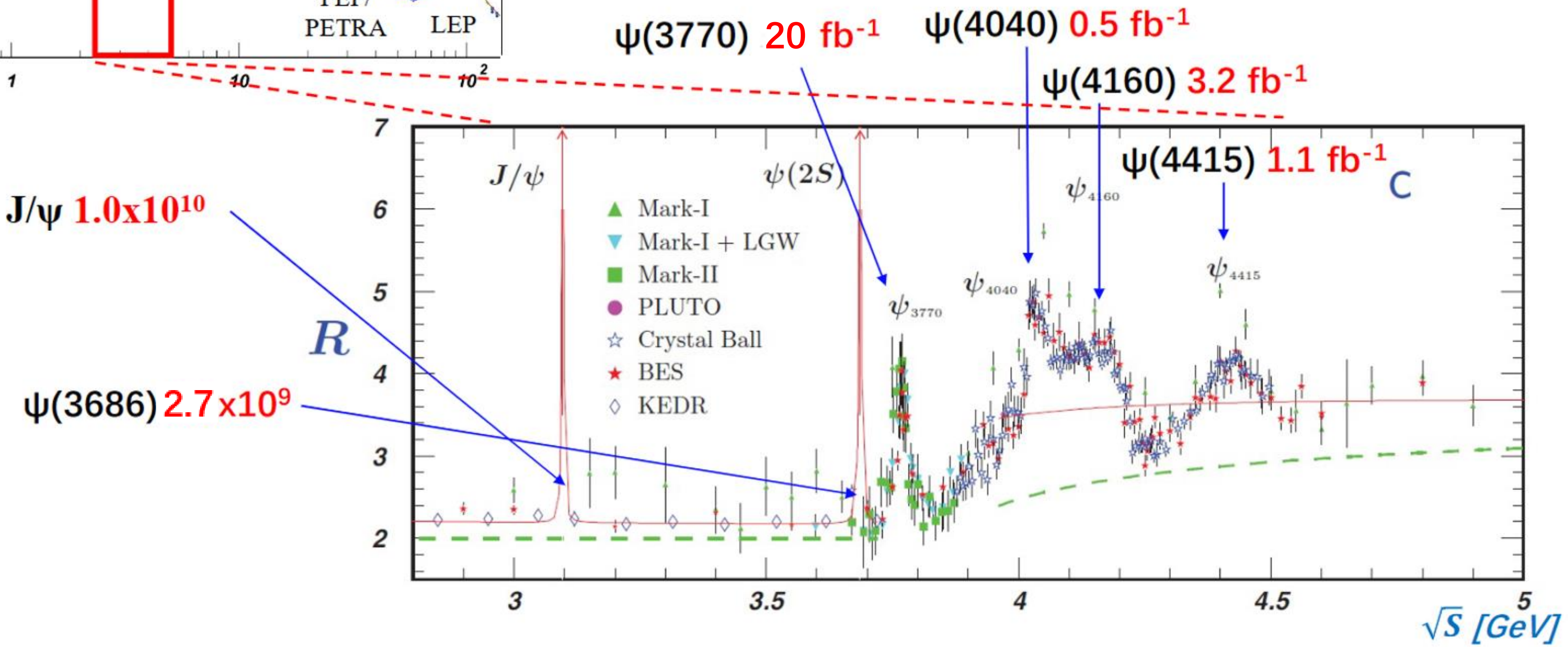
Outline

- BEPCII and BESIII
- BESIII data samples
- Charmonium weak decays
- $J/\psi \to D^{-}e^{+}\nu_{e}$
- $J/\psi \to D^{-}\mu^{+}\nu_{\mu}$
- $J/\psi \to D^{-}+\pi^{+}/\rho^{+}$ and $J/\psi \to \bar{D}^{0}+\pi^{0}/\rho^{0}/\eta$
- Ongoing analyses
- Summary

BESIII data samples

- BESIII has collected the largest data samples of J/ψ & $\psi(3686)$ on the threshold in the world.





Outline

- ◆BEPCII and BESIII
- ◆BESIII data samples
- ◆Charmonium weak decays
- ◆ $J/\psi \rightarrow D^{-}e^{+}\nu_{e}$
- ◆ $J/\psi \rightarrow D^{-}\mu^{+}\nu_{\mu}$
- ◆ $J/\psi \rightarrow D^{-}+\pi^{+}/\rho^{+}$ and $J/\psi \rightarrow \bar{D}^{0}+\pi^{0}/\rho^{0}/\eta$
- ◆Ongoing analyses
- ◆Summary

SM contribution is dominant

New Physics	Standard Model

Good sensitivity to NP

SM contribution is highly suppressed

New Physics	Standard Model

- Charmonium weak decays — This work
- FCNC (flavor-changing neutral current) — 27th, Sun Liang
- High order
- …

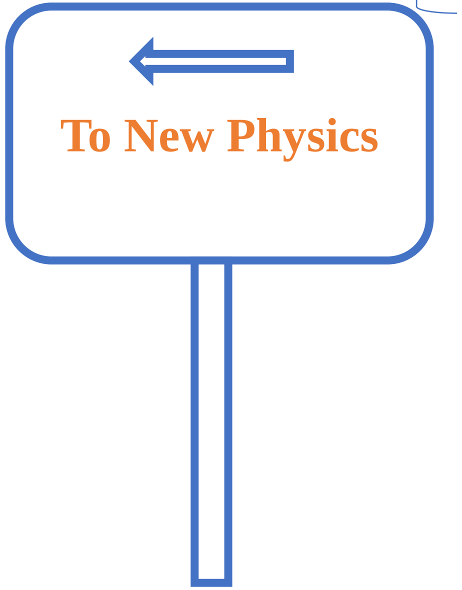
SM contribution is forbidden

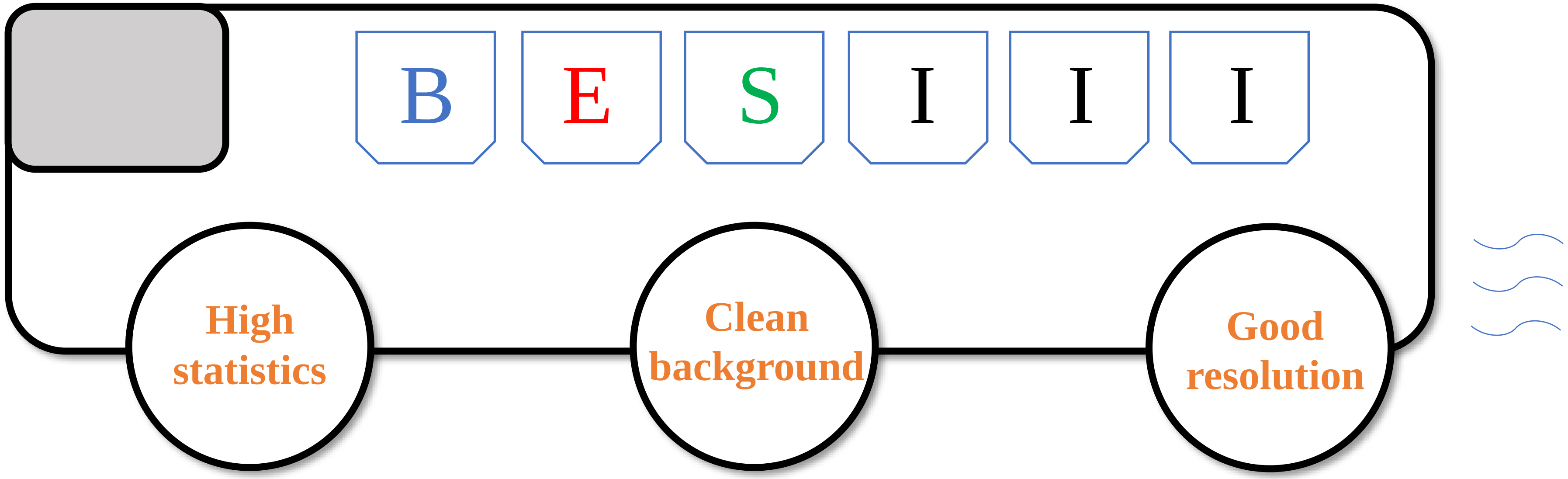
New Physics

28th, Hao Xiqing, Wang Tengjiao

- BNV/LNV (baryon and lepton number violation)
- CLFV (charged lepton flavor violating)
- …

28th, Yuan Mingkuan





Charmonium weak decays

- With a collection of 10^{10} J/ψ events, BESIII is now able to conduct searches for Charmonium weak decays with higher statistics.
- The inclusive branching fraction of these rare weak decays is predicted to be 10^{-8} in the standard model.
- If the branching fractions for weak decays of J/ψ are found to be within the range of 10^{-8} to 10^{-6}, it would suggest the presence of new physics beyond the Standard Model.

Top-color model [1]
The Minimal Super-symmetric SM with or without R-parity [2]
Two-Higgs doublet model [3]
...

Charmonium weak decay	Experimental upper limit (@90% C.L.)	Number of J/ψ or $\psi(3686)$ data events
$J/\psi \to D^- e^+ \nu_e$	$< 7.1 \times 10^{-8}$ [4]	BESIII (1.01×10^{10})
$J/\psi \to D^- \mu^+ \nu_\mu$	$< 5.6 \times 10^{-7}$ [5]	BESIII (1.01×10^{10})
$J/\psi \to D_s^- e^+ \nu_e$	$< 1.3 \times 10^{-6}$ [6]	BESIII (2.25×10^8)
$J/\psi \to D_s^{*-} e^+ \nu_e$	$< 1.8 \times 10^{-6}$ [6]	BESIII (2.25×10^8)
$J/\psi \to D^0 e^+ e^-$	$< 8.5 \times 10^{-8}$ [7]	BESIII (13.11×10^8)
$\psi(3686) \to D^0 e^+ e^-$	$< 1.4 \times 10^{-7}$ [7]	BESIII (44.81×10^7)

Charmonium weak	Experimental upper limit (@90% C.L.)	Number of J/ψ or $\psi(3686)$ data events
$J/\psi \to D_s^- \rho^+$	$< 1.3 \times 10^{-5}$ [8]	BESIII (2.25×10^8)
$J/\psi \to \bar{D}^0 \bar{K}^{*0}$	$< 2.5 \times 10^{-6}$ [8]	BESIII (2.25×10^8)
$J/\psi \to D_s^- \pi^+$	$< 1.3 \times 10^{-4}$ [9]	BESII (5.77×10^7)
$J/\psi \to \bar{D}^0 \bar{K}^0$	$< 1.7 \times 10^{-4}$ [9]	BESII (5.77×10^7)
$J/\psi \to D^- \rho^+$	$< 6.0 \times 10^{-7}$ [10]	BESIII (1.01×10^{10})
$J/\psi \to D^- \pi^+$	$< 7.0 \times 10^{-8}$ [10]	
$J/\psi \to \bar{D}^0 \rho^0$	$< 5.2 \times 10^{-7}$ [10]	
$J/\psi \to \bar{D}^0 \eta$	$< 6.8 \times 10^{-7}$ [10]	
$J/\psi \to \bar{D}^0 \pi^0$	$< 4.7 \times 10^{-7}$ [10]	
$\psi(3686) \to \Lambda_c^+ \bar{\Sigma}^-$	$< 1.4 \times 10^{-4}$ [11]	BESIII (44.81×10^7)

[1] Phys. Lett. B 345, 483 (1995)
[2] Phys. Lett. B 119, 136 (1982)
[3] Phys. Rev. D15, 1958 (1977)
[4] JHEP 06, 157 (2021)
[5] JHEP 01, 126 (2024)
[6] Phys. Rev. D 90, 112014 (2014)
[7] Phys. Rev. D 96, 111101(R) (2017)
[8] Phys. Lett. B 663, 297 (2008)
[9] Phys. Rev. D 89, 071101 (2014)
[10] Phys. Rev. D 110, 032020 (2024)
[11] Chin. Phys. C 47, no.1, 013002 (2023)

Outline

- BEPCII and BESIII
- BESIII data samples
- Charmonium weak decays
- $J/\psi \rightarrow D^{-}e^{+}\nu_{e}$
- $J/\psi \rightarrow D^{-}\mu^{+}\nu_{\mu}$
- $J/\psi \rightarrow D^{-} + \pi^{+}/\rho^{+}$ and $J/\psi \rightarrow \bar{D}^{0} + \pi^{0}/\rho^{0}/\eta$
- Ongoing analyses
- Summary

Search for decay $J/\psi \to D^- e^+ \nu_e$

$J/\psi \to D^- e^+ \nu_e$
JHEP 06,157(2021)

$J/\psi \to D^- \mu^+ \nu_\mu$
JHEP 01,126(2024)

- Using $(1.0087 \pm 0.0044) \times 10^{10} J/\psi$ events.
- $J/\psi \to D^- l^+ \nu, D^- \to K^+ \pi^- \pi^-$

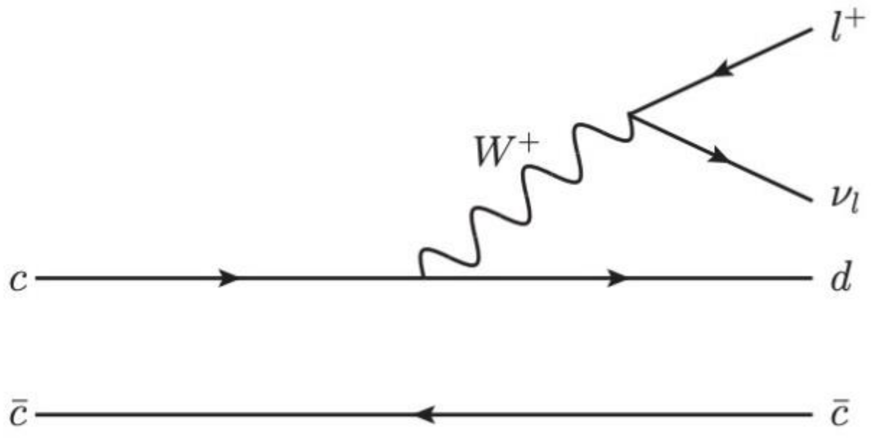


Figure: The Feynman diagram of $J/\psi \to D^- l^+ \nu$

[1] Adv. High Energy Phys. 2013 (2013) 706543
[2] Phys. Rev. D 92 (2015) 074030
[3] J. Phys. G 44 (2017) 045004
[4] Eur. Phys. J. C 84, no.1, 65 (2024)
[5] arXiv:2407.13568

Model	BSW [1]	CCQM[2]	BSM[3]	CLFQM[4]	LQCD[5]
$\mathcal{B}(J/\psi \to D^- e^+ \nu_e)(\times 10^{-10})$	$6.0^{+0.8}_{-0.7}$	1.71	$2.03^{+0.29}_{-0.25}$	$6.10^{+0.11+0.10+0.14}_{-0.11-0.12-0.19}$	0.121
$\mathcal{B}(J/\psi \to D^- \mu^+ \nu_\mu)(\times 10^{-10})$	$5.8^{+0.8}_{-0.6}$	1.66	$1.98^{+0.28}_{-0.24}$	$5.78^{+0.11+0.11+0.16}_{-0.10-0.13-0.11}$	0.118

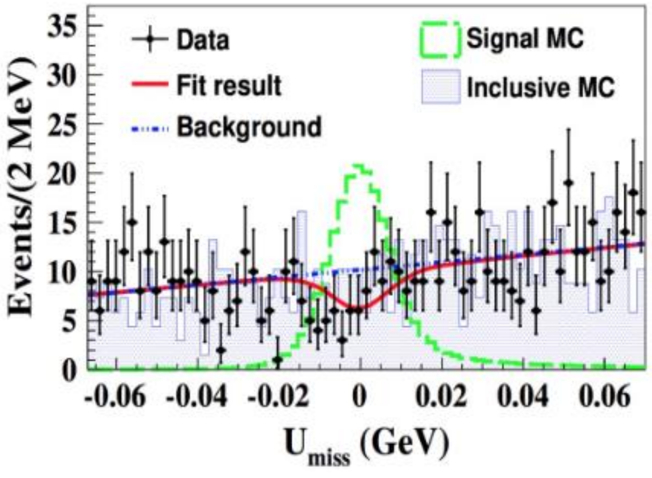
Table: Theoretical results for the BF of the semi-leptonic decay $J/\psi \to D^- l^+ \nu$ within the SM, where BSW is the Bauer-Stech-Wirbel model, CCQM is the confined covariant quark model, BSM is the Bathe-Salpeter-Mandelstam model, CLFQM is the covariant light-front quark model, and LQCD is the lattice QCD calculation.

zhanyh6@mail2.sysu.edu.cn

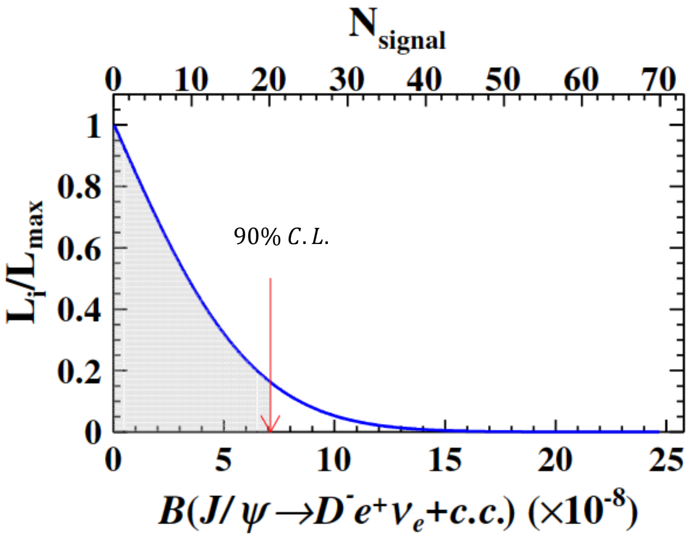
Search for decay $J/\psi \to D^- e^+ \nu_e$

$J/\psi \to D^- e^+ \nu_e$
JHEP 06,157(2021)

- Using $(1.0087 \pm 0.0044) \times 10^{10} J/\psi$ events.
- $J/\psi \to D^- e^+ \nu_e, D^- \to K^+ \pi^- \pi^-$
- Using a fit on $U_{miss} = E_{miss} - c|P_{miss}|$ to extract the signal.



Fig(a) Fitting in full data



Fig(b) Upper limit in full data

$$\mathcal{B}(J/\psi \to D^- e^+ \nu_e + c.c.) = \frac{N_{signal}}{N_{J/\psi} \times \epsilon \times \mathcal{B}_{sub}}$$

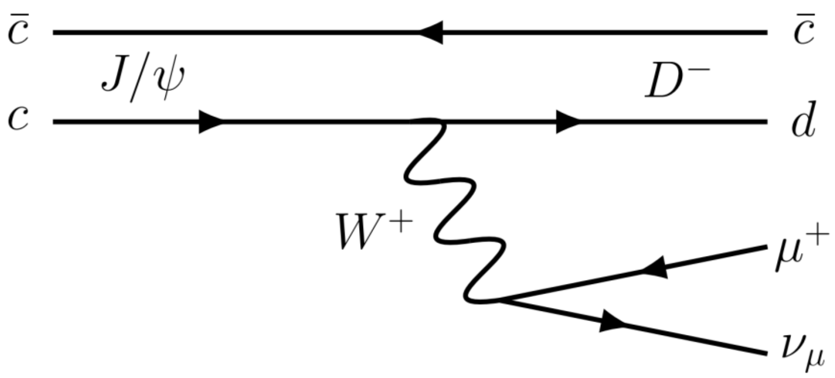
- where N_{signal} is the number of signal decays, $N_{J/\psi} = (10087 \pm 44) \times 10^6$ is the number of J/ψ events, ϵ is the signal detection efficiency, and $\mathcal{B}_{sub}$ is the BF of the intermediate decay $D^- \to K^+ \pi^- \pi^-$ quoted from PDG.
- $\mathcal{B}(J/\psi \to D^- e^+ \nu_e) < 7.1 \times 10^{-8}$ @90% C.L.
- Puts a stringent constraint on the parameter spaces for different new physics models predicting BFs at the order of 10^{-5} .

Outline

- ◆BEPCII and BESIII
- ◆BESIII data samples
- ◆Charmonium weak decays
- ◆ $J/\psi \to D^- e^+ \nu_e$
- ◆ $J/\psi \to D^- \mu^+ \nu_\mu$
- ◆ $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
- ◆Ongoing analyses
- ◆Summary

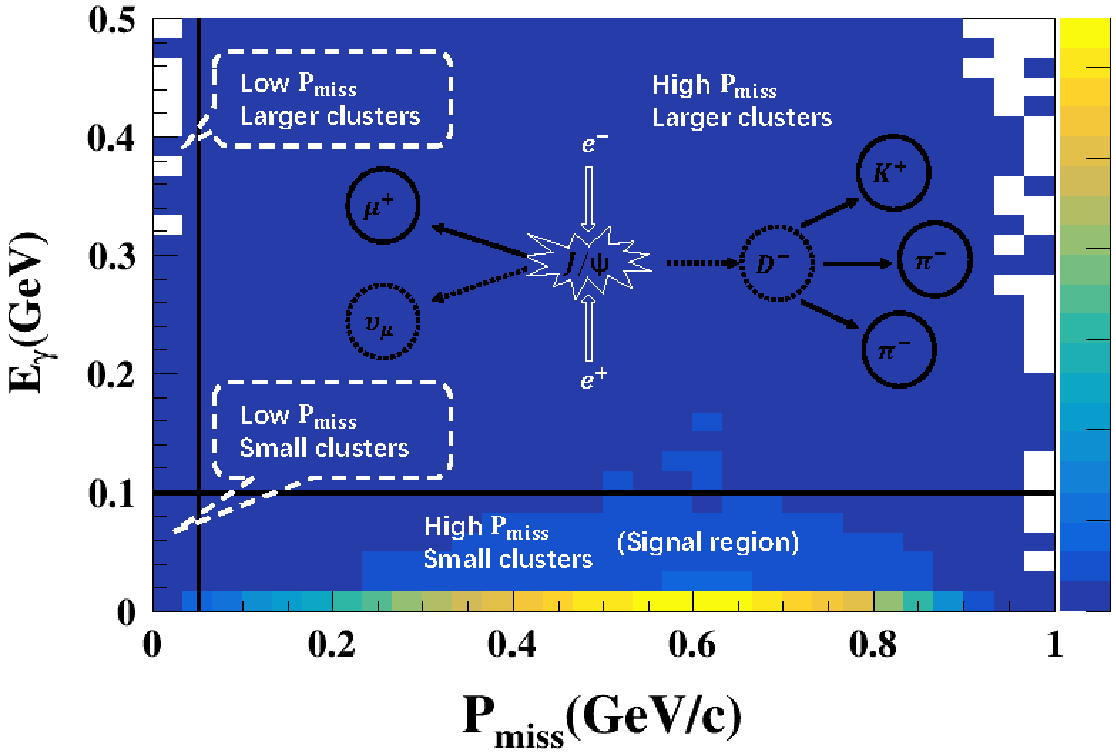
Search for decay $J/\psi \to D^-\mu^+\nu_\mu$

$J/\psi \to D^-\mu^+\nu_\mu$
JHEP 01,126(2024)



Fig(a) The Feynman diagram of $J/\psi \to D^-\mu^+\nu_\mu$

- Thus far, the search for weak semi-leptonic charmonium decays has only covered the electron channel.
- A search for the weak decay of charmonium with a muon in the final state is therefore desirable.
- Using $(1.0087 \pm 0.0044) \times 10^{10} J/\psi$ events.
- $J/\psi \to D^-\mu^+\nu_\mu, D^- \to K^+\pi^-\pi^-$
- Since the missing neutrino ν_μ and no extra hard photon in the final state, a large missing momentum P_{miss} and a clean cluster unassociated with the charged track are required.

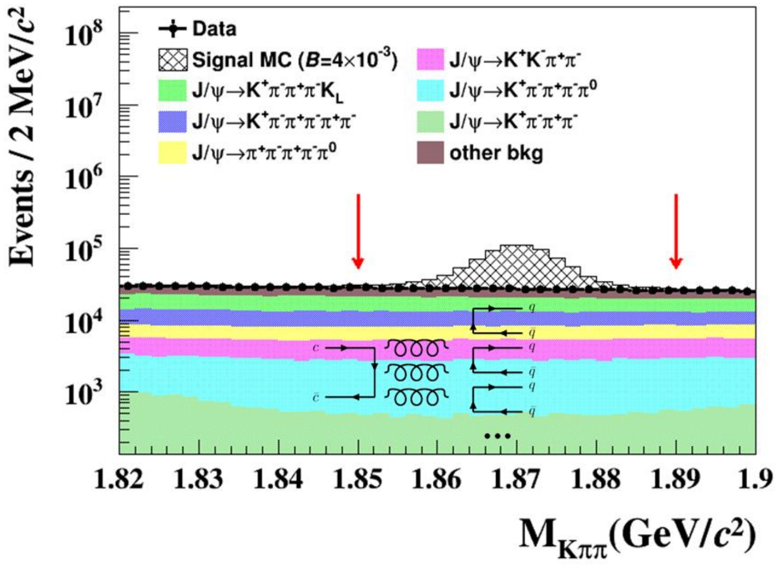


Fig(b) Event selections associated with missing momentum and clusters

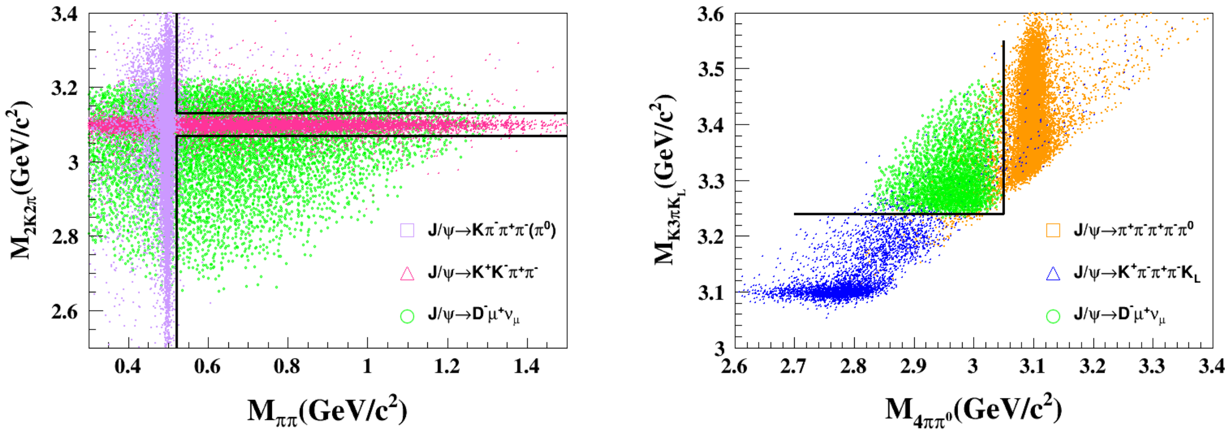
Search for decay $J/\psi \to D^-\mu^+\nu_\mu$

$J/\psi \to D^-\mu^+\nu_\mu$
JHEP 01,126(2024)

- Compare to electrons, muons are more difficult to be identified due to the muon-pion misidentification.
- Most muons do not provide effective information in the muon identifier because of the low momentum of muons in the three-body decay, leading to a significant background from muon-pion misidentification.



Fig(b) The reconstruction of the D meson, which still includes a huge background in the D mass range.



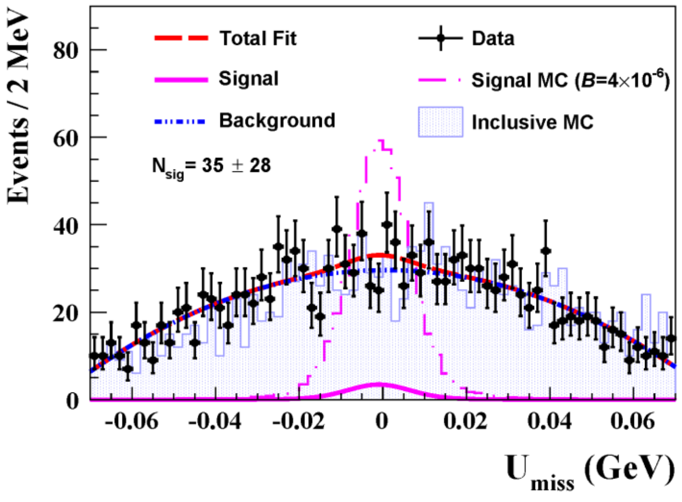
Fig(a) Kinematic-based PID is used to suppress the background further, where the green dots are the signal events from the simulation.

- The differences in particle mass can manifest as distinct kinematic characteristics in the entire event, leading to the developing of a kinematic-based PID method to further identify particles and effectively suppress misidentified hadronic background.

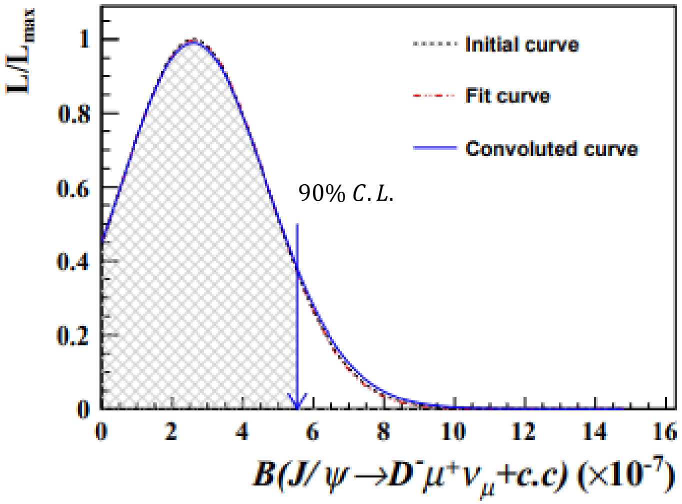
Search for decay $J/\psi \to D^-\mu^+\nu_\mu$

$J/\psi \to D^-\mu^+\nu_\mu$

JHEP 01,126(2024)

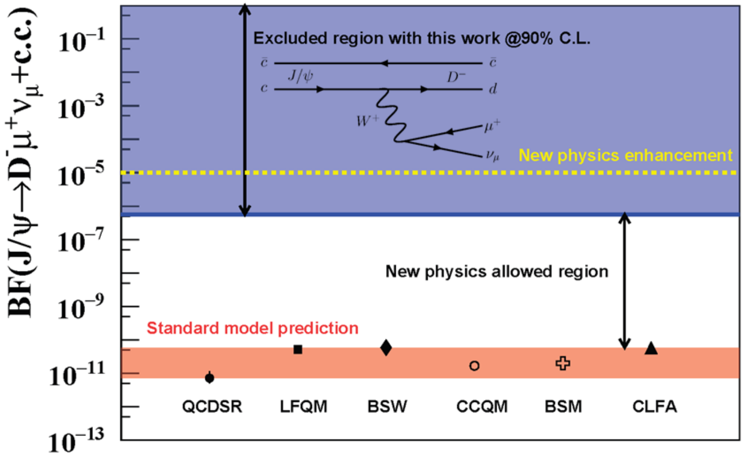


Fig(a) Fitting in full data



Fig(b) Upper limit in full data

- Using a fit on $U_{miss} = E_{miss} - c|P_{miss}|$ to extract the signal.
- No evidence of NP is found.
- $\mathcal{B}(J/\psi \to D^-\mu^+\nu_\mu) < 5.6 \times 10^{-7}$ @90% C.L.
- The first search of a charmonium weak decay with a muon in the final state.



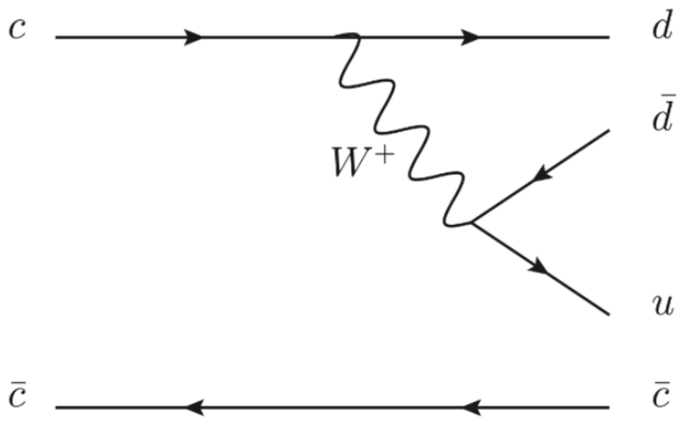
Fig(c) The excluded region of $J/\psi \to D^-\mu^+\nu_\mu + c.c.$ from this measurement.

Outline

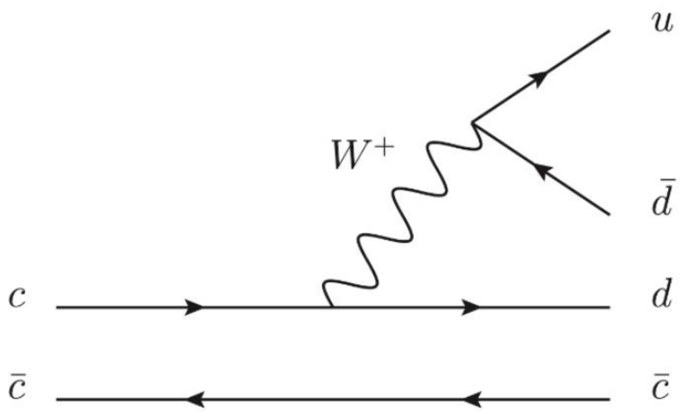
- ◆BEPCII and BESIII
- ◆BESIII data samples
- ◆Charmonium weak decays
- ◆ $J/\psi \to D^{-}e^{+}\nu_e$
- ◆ $J/\psi \to D^{-}\mu^{+}\nu_\mu$
- ◆ $J/\psi \to D^{-}+\pi^{+}/\rho^{+}$ and $J/\psi \to \bar{D}^{0}+\pi^{0}/\rho^{0}/\eta$
- ◆Ongoing analyses
- ◆Summary

Search for decay $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$

$J/\psi \to D^- + \pi^+/\rho^+$
and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
Phys. Rev. D 110, 032020(2024)



Fig(a) The leading-order Feynman diagram of $J/\psi \to \bar{D}^0\pi^0$, $J/\psi \to \bar{D}^0\eta$ and $J/\psi \to \bar{D}^0\rho^0$



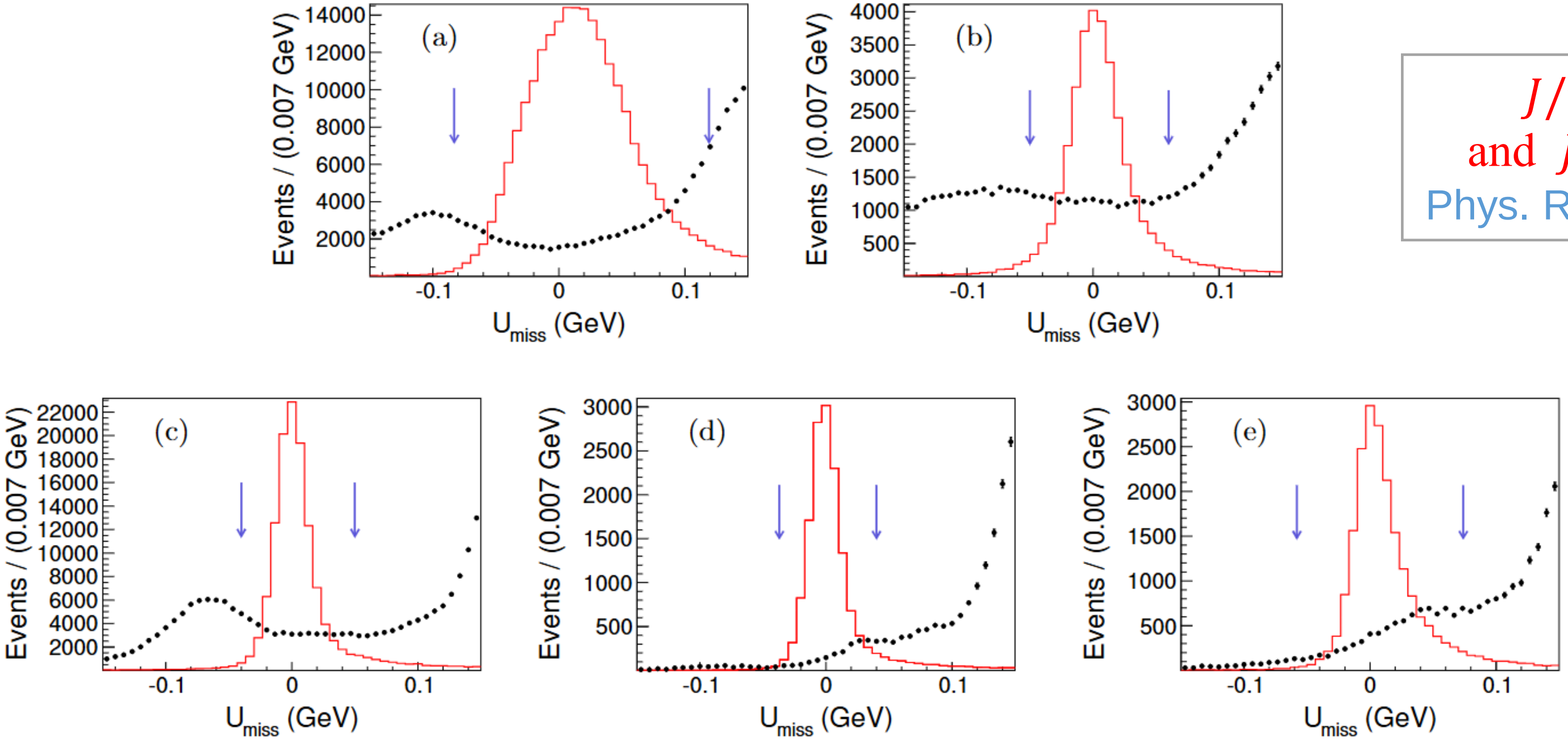
Fig(b) The leading-order Feynman diagram of $J/\psi \to D^-\pi^+$ and $J/\psi \to D^-\rho^+$

- Via the weak interaction, the J/ψ can potentially decay into a single charm meson such as D accompanied by some non-charm mesons.
- To avoid high background from conventional J/ψ hadronic decays, the $\bar{D}^0$ and D^- mesons are tagged by the semileptonic decays.

$J/\psi \to \bar{D}^0\pi^0$ $\bar{D}^0 \to K^+e^-\bar{\nu}_e$ $\pi^0 \to \gamma\gamma$	$J/\psi \to \bar{D}^0\eta$ $\bar{D}^0 \to K^+e^-\bar{\nu}_e$ $\eta \to \gamma\gamma$	$J/\psi \to \bar{D}^0\rho^0$ $\bar{D}^0 \to K^+e^-\bar{\nu}_e$ $\rho^0 \to \pi^+\pi^-$	$J/\psi \to D^-\pi^+$ $D^- \to K_S^0e^-\bar{\nu}_e$ $K_S^0 \to \pi^+\pi^-$	$J/\psi \to D^-\rho^+$ $D^- \to K_S^0e^-\bar{\nu}_e$ $K_S^0 \to \pi^+\pi^-$ $\rho^+ \to \pi^+\pi^0$ $\pi^0 \to \gamma\gamma$

Search for decay $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$

- The kinematic quantity $U_{miss} = E_{miss} - c|\vec{p}_{miss}|$ is used to identify the missing neutrino and the criterion of U_{miss} is applied to suppress the backgrounds with multi-π^0/γ and the misidentification of electron/pion and kaon/pion in the final states.



$J/\psi \to D^- + \pi^+/\rho^+$
and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
Phys. Rev. D 110, 032020(2024)

Figure: Distribution of U_{miss} from $(a)\ J/\psi \to \bar{D}^0\pi^0, (b)\ J/\psi \to \bar{D}^0\eta, (c)\ J/\psi \to \bar{D}^0\rho^0, (d)\ J/\psi \to D^-\pi^+ and\ (e)\ J/\psi \to D^-\rho^+$. The black dots with error bars represent data and the red thick lines show the signal MC sample. The region between the two blue arrows marks the signal region of U_{miss}.

Search for decay $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$

- Select those events for which the recoiling mass against the $\pi^0, \eta, \rho^0, \pi^+$, and ρ^+ falls within the mass window $(1.80, 1.95)\ GeV/c^2$ for all decay modes.

$J/\psi \to D^- + \pi^+/\rho^+$
and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
Phys. Rev. D 110, 032020(2024)

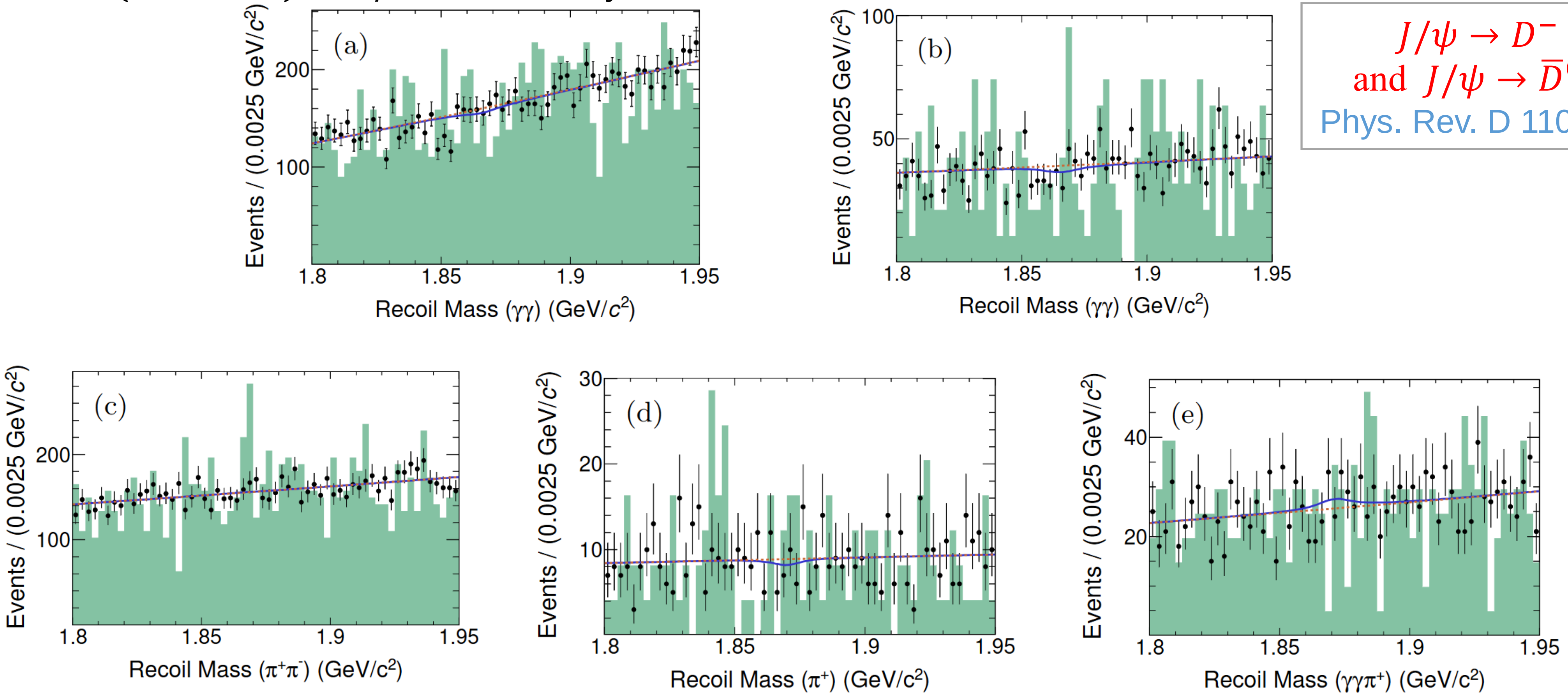


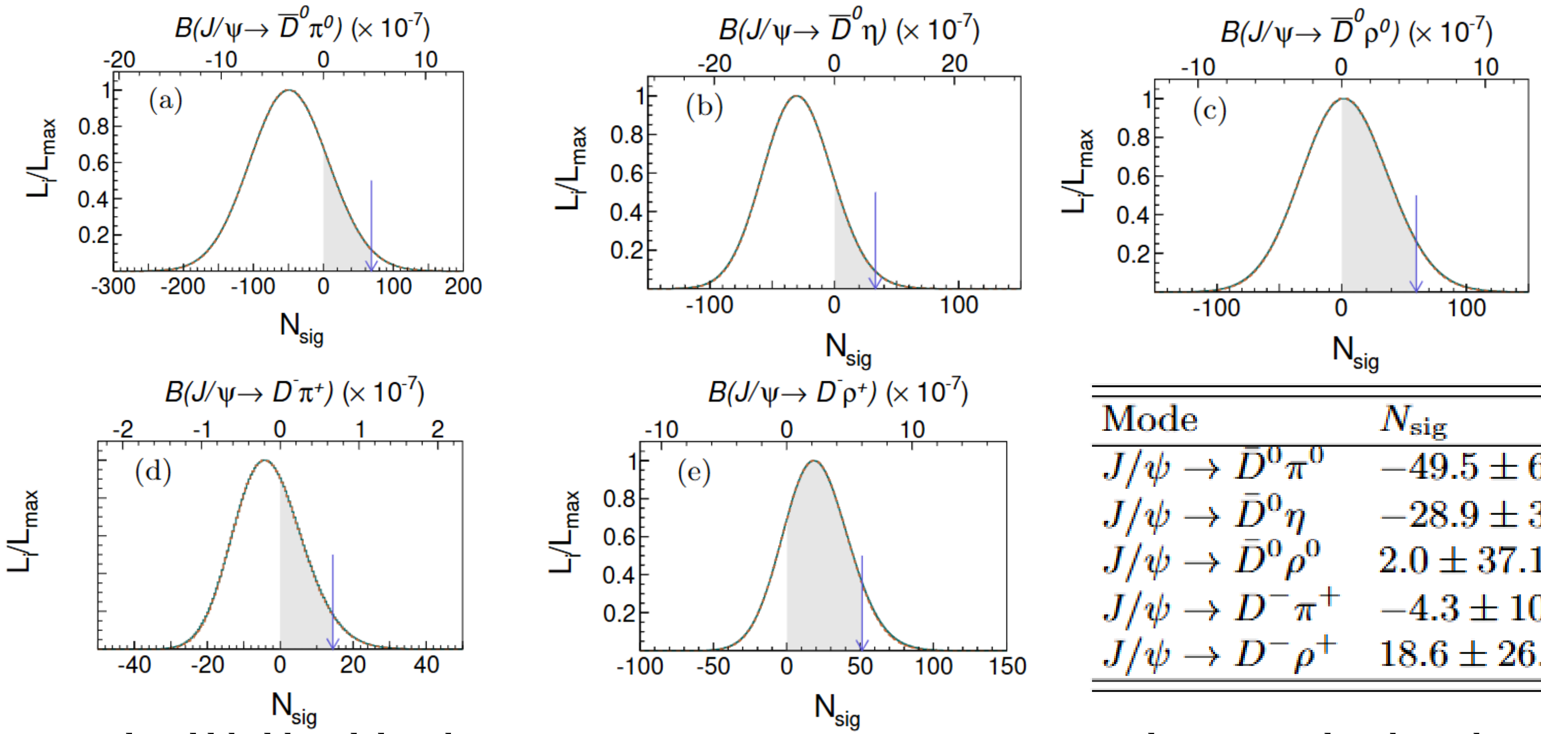
Figure: Fits of the accepted candidates to the recoiling mass spectra for $(a)\ J/\psi \to \bar{D}^0\pi^0$, $(b)\ J/\psi \to \bar{D}^0\eta$, $(c)\ J/\psi \to \bar{D}^0\rho^0$, $(d)\ J/\psi \to D^-\pi^+ and\ (e)\ J/\psi \to D^-\rho^+$. The dots with error bars are data and the orange dotted lines are polynomial functions describing the background. The blue solid curves are the total fits. The inclusive MC samples are shown by the green filled histograms.

Search for decay $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$

- No significant signal is observed in any of the decay modes. The branching fraction of signal decay is calculated as

$$\mathcal{B}(J/\psi \to DM(N)) = \frac{N_{\rm sig}}{N_{J/\psi} \times \epsilon \times \mathcal{B}_{\rm sub}}$$

- where N_{sig} is the number of signal events, $N_{J/\psi}$ is the total number of J/ψ events, ε is the signal detection efficiency, and B_{sub} is the product of the branching fractions of all possible intermediate decays.



$J/\psi \to D^- + \pi^+/\rho^+$
and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
Phys. Rev. D 110, 032020(2024)

Mode	$N_{\rm sig}$	$N_{\rm sig}^{\rm UL}$	$\mathcal{B}$ (90% C.L.)	$\mathcal{B}$ (90% C.L.)
$J/\psi \to \bar{D}^0\pi^0$	-49.5 ± 69.3	< 68.8	$< 4.7 \times 10^{-7}$	...
$J/\psi \to \bar{D}^0\eta$	-28.9 ± 34.5	< 32.9	$< 6.8 \times 10^{-7}$	...
$J/\psi \to \bar{D}^0\rho^0$	2.0 ± 37.1	< 59.9	$< 5.2 \times 10^{-7}$	...
$J/\psi \to D^-\pi^+$	-4.3 ± 10.3	< 14.4	$< 7.0 \times 10^{-8}$	$< 7.5 \times 10^{-5}$ [3]
$J/\psi \to D^-\rho^+$	18.6 ± 26.2	< 51.4	$< 6.0 \times 10^{-7}$	...

Figure: Normalized likelihood distributions for the fitted yields of signal events and corresponding branching fractions of $(a)\ J/\psi \to \bar{D}^0\pi^0$, $(b)\ J/\psi \to \bar{D}^0\eta$, $(c)\ J/\psi \to \bar{D}^0\rho^0$, $(d)\ J/\psi \to D^-\pi^+ and\ (e)\ J/\psi \to D^-\rho^+$, with (green solid curves) and without (orange dashed lines) smearing the systematic uncertainties. The blue arrows mark the upper limits at the 90% C.L..

Outline

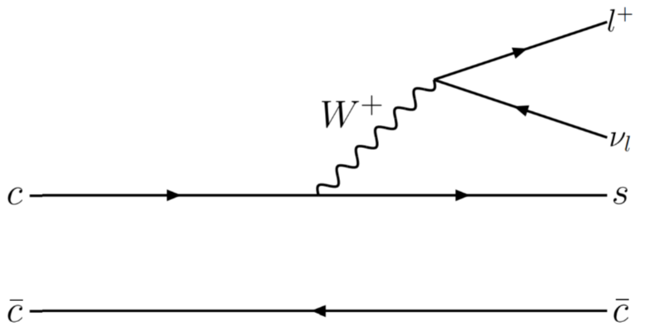
- ◆BEPCII and BESIII
- ◆BESIII data samples
- ◆Charmonium weak decays
- ◆ $J/\psi \to D^- e^+ \nu_e$
- ◆ $J/\psi \to D^- \mu^+ \nu_\mu$
- ◆ $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
- ◆Ongoing analyses
- ◆Summary

Ongoing analyses

Semileptonic weak decay

- $J/\psi \to D_s^- e^+ \nu_e + c.c$
- $\psi(3686) \to D_s^- e^+ \nu_e + c.c.$

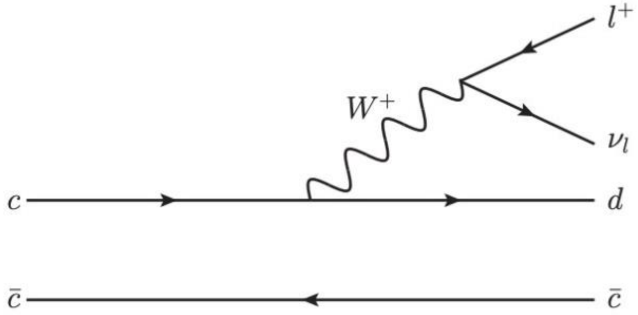
Tag mode:
- $D_s^- \to K_S^0 K^-$
- $D_s^- \to K^+ K^- \pi^-$
- $D_s^- \to K^+ K^- \pi^- \pi^0$
- $D_s^- \to K_S^0 K^- \pi^+ \pi^-$



Fig(a) The Feynman diagram of $J/\psi \to D_s^- l^+ \nu$ and $\psi(3686) \to D_s^- l^+ \nu$

- $\psi(3686) \to D^- e^+ \nu_e + c.c.$

Tag mode:
- $D^- \to K^+ \pi^- \pi^-$



Fig(b) The Feynman diagram of $J/\psi \to D^- l^+ \nu$ and $\psi(3686) \to D^- l^+ \nu$

Model	BSW [1]	CCQM[2]	BSM[3]	CLFQM[4]	LQCD[5]
$\mathcal{B}(J/\psi \to D_s^- e^+ \nu_e)(\times 10^{-10})$	$104^{+9.0}_{-7.5}$	33	$36.7^{+5.2}_{-4.4}$	$10.21^{+0.19+0.66+0.56}_{-0.18-0.61-1.41}$	1.90
$\mathcal{B}(\psi(3686) \to D_s^- e^+ \nu_e)(\times 10^{-10})$				$7.20^{+0.20+0.97+0.60}_{-0.19-0.44-0.92}$	
$\mathcal{B}(\psi(3686) \to D^- e^+ \nu_e)(\times 10^{-10})$				$3.45^{+0.10+0.49+0.23}_{-0.09-0.20-0.25}$	

[1] Adv. High Energy Phys. 2013 (2013) 706543
[2] Phys. Rev. D 92 (2015) 074030
[3] J. Phys. G 44 (2017) 045004
[4] Eur. Phys. J. C 84, no.1, 65 (2024)
[5] arXiv:2407.13568

Ongoing analyses

Nonleptonic weak decays

- $J/\psi \to D_s^- \rho^+ + c.c$
- $\psi(3686) \to D_s^- \rho^+ + c.c.$

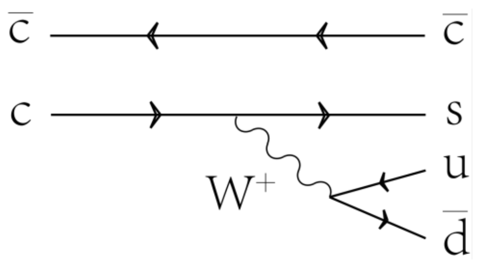
Decay chain:
- $D_s^- \to \phi e^- \bar{\nu}_e$
- $\rho^+ \to \pi^0 \pi^+$
- $\pi^0 \to \gamma\gamma$

- $J/\psi \to D_s^- \pi^+ + c.c$
- $\psi(3686) \to D_s^- \pi^+ + c.c.$

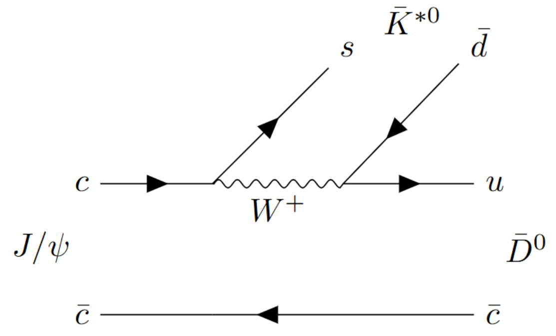
Decay chain:
- $D_s^- \to \phi e^- \bar{\nu}_e$

- $J/\psi \to \bar{D}^0 \bar{K}^{*0} + c.c.$

Decay chain:
- $\bar{D}^0 \to K^+ e^- \bar{\nu}_e$
- $\bar{K}^{*0} \to K^- \pi^+$



Fig(a) The Feynman diagram of $J/\psi \to D_s^- \rho^+, J/\psi \to D_s^- \pi^+, \psi(3686) \to D_s^- \rho^+$, and $\psi(3686) \to D_s^- \pi^+$



Fig(b) The Feynman diagram of $J/\psi \to \bar{D}^0 \bar{K}^{*0}$

Model	QCDSR [1]	BSW [2]	CLFQM (2008) [3]	CLFQM (2024) [4]
$\mathcal{B}(J/\psi \to D_s^- \rho^+)(\times 10^{-10})$	$12.6^{+7.6}_{-6.0}$	$51.1^{+7.6}_{-6.0}$	28^{+0}_{-9}	$29.5^{+0.6+1.1+1.5}_{-0.5-1.4-1.9}$
$\mathcal{B}(J/\psi \to D_s^- \pi^+)(\times 10^{-10})$	$2.0^{+4.0}_{-0.2}$	$7.41^{+0.13}_{-0.23}$	$2.5^{+0.0}_{-0.1}$	$3.64^{+0.06+0.34+0.78}_{-0.06-0.38-0.96}$
$\mathcal{B}(\psi(3686) \to D_s^- \rho^+)(\times 10^{-10})$				$12.2^{+0.3+0.1+4.1}_{-0.3-1.0-1.9}$
$\mathcal{B}(\psi(3686) \to D_s^- \pi^+)(\times 10^{-10})$				$12.3^{+0.3+0.8+5.9}_{-0.3-1.8-5.1}$
$\mathcal{B}(J/\psi \to \bar{D}^0 \bar{K}^{*0})(\times 10^{-10})$	$1.54^{+0.68}_{-0.38}$	$7.61^{+1.6}_{-1.2}$		

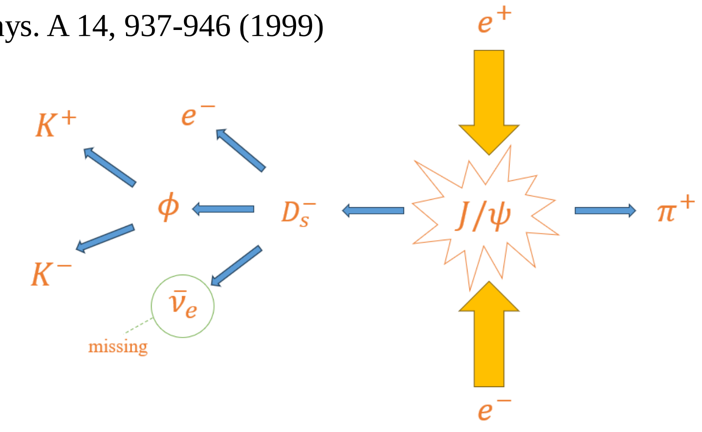
- ✓ QCDSR is the QCD sum rule model.
- ✓ BSW is the Bauer-Stech-Wirbel model.
- ✓ CLFQM is the covariant light-front quark model.

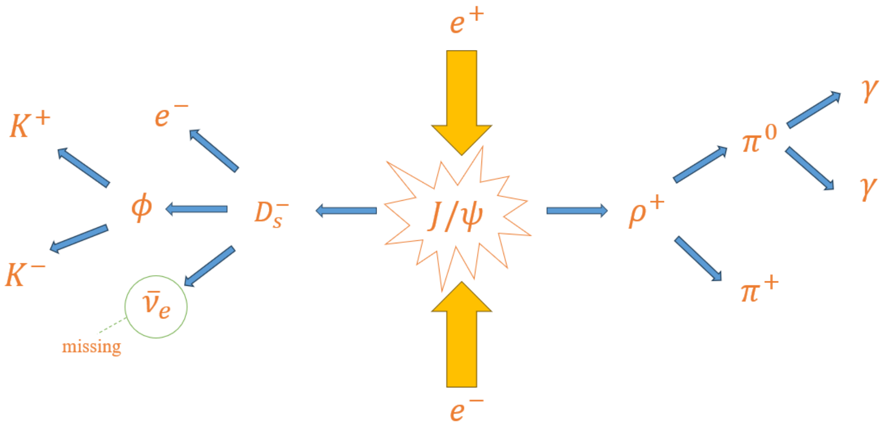
[1] Eur. Phys. J.C 55, 607-613 (2008)
[2] High Energy Phys. 2013, 706543 (2013)
[3] Phys. Rev. D 78, 074012 (2008)
[4] Eur. Phys. J.C 84, no.1, 65 (2024)

Ongoing analyses

- Decay： $J/\psi \to D_s^- \rho^+$ and $J/\psi \to D_s^- \pi^+$
- Predicted relative ratio[1]: $\frac{\mathcal{B}(J/\psi \to D_s^- \rho^+)}{\mathcal{B}(J/\psi \to D_s^- \pi^+)} = 4.2$

[1] Int. J. Mod. Phys. A 14, 937-946 (1999)





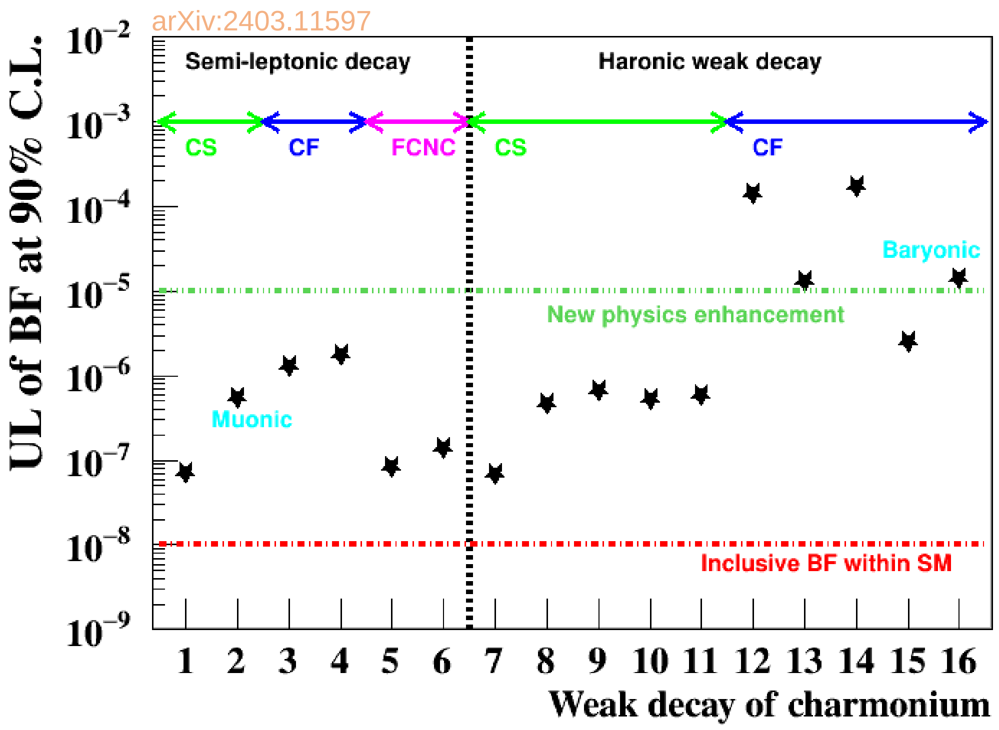
- The non-leptonic decay modes of D_s mesons do not provide good sensitivity due to the presence of J/ψ hadronic decay backgrounds.
- Therefore, the D_s candidates are reconstructed via semi-leptonic decay mode $D_s^- \to \phi e^- \bar{\nu}_e$.
- Since D_s^- cannot be reconstructed with their invariant mass due to the missing neutrino, the recoil momentum is used to reconstruct D_s^-.
- We use the ratio of EMC deposited energy E and MDC momentum P for charged particles and dE/dx information from MDC to suppress the main background due to e/π misidentification.

Outline

- ◆BEPCII and BESIII
- ◆BESIII data samples
- ◆Charmonium weak decays
- ◆ $J/\psi \to D^- e^+ \nu_e$
- ◆ $J/\psi \to D^- \mu^+ \nu_\mu$
- ◆ $J/\psi \to D^- + \pi^+/\rho^+$ and $J/\psi \to \bar{D}^0 + \pi^0/\rho^0/\eta$
- ◆Ongoing analyses
- ◆Summary

Summary

- BESIII performed a wide range study of new physics, with many first searches or best limits.
- The latest search results for rare Charmonium decays in BESIII are reported.
- BESIII has great potential with unique (and increasing) datasets and analysis techniques.



1: $J/\psi \to D^- e^+ \nu_e$+c.c.
2: $J/\psi \to D^- \mu^+ \nu_\mu$+c.c.
3: $J/\psi \to D_s^- e^+ \nu_e$+c.c.
4: $J/\psi \to D_s^{*-} e^+ \nu_e$+c.c.
5: $J/\psi \to D^0 e^+ e^-$+c.c.
6: $\psi(2S) \to D^0 e^+ e^-$+c.c.
7: $J/\psi \to D^- \pi^+$+c.c.
8: $J/\psi \to D^0 \pi^0$+c.c.
9: $J/\psi \to D^0 \eta$+c.c.
10: $J/\psi \to D^0 \rho^0$+c.c.
11: $J/\psi \to D^- \rho^+$+c.c.
12: $J/\psi \to D_s^- \pi^+$+c.c.
13: $J/\psi \to D_s^- \rho^+$+c.c.
14: $J/\psi \to D^0 K^0$+c.c.
15: $J/\psi \to D^0 K^{*0}$+c.c.
16: $\psi(2S) \to \Lambda_c^+ \bar{\Sigma}^-$+c.c.

Figure: The summary of charmonium weak decay

Thanks