Searching for FCNC decays

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Outline

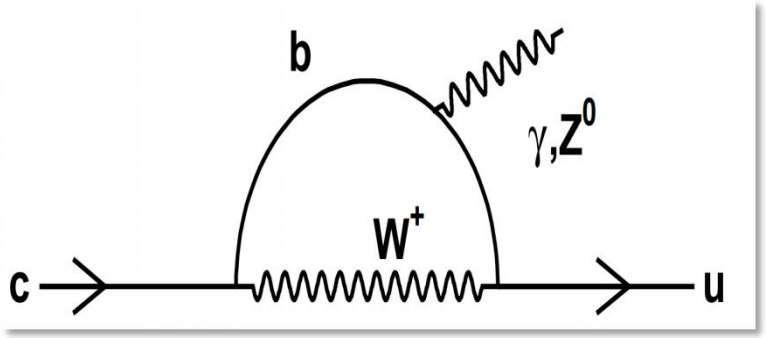
- ✓ **Motivation**
- ☐ **Current status**
- ☐ **Charmonium FCNC decay**
  - $J/\psi \to D^0\mu^+\mu^-,\ J/\psi \to \gamma D^0$
- ☐ **Charm FCNC decay**
  - $D_s^+ \to h(h')e^+e^-, D \to h(h')e^+e^-, D^0 \to \pi^0\nu\bar{\nu}$
- ☐ **Prospect**
- ☐ **Summary**

Motivation

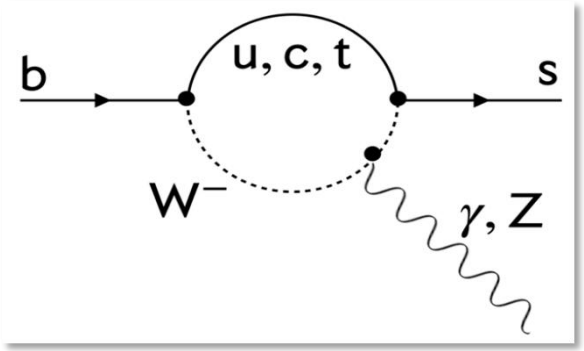
- Flavor Changing Neutral Current (FCNC) processes refer to transitions between different flavors within the same type of quark, such as c -> u, b -> s.

- Strongly suppressed by the GIM mechanism.
- The SM-predicted branch fraction (BF) for c -> u are in the range of $10^{-8}\sim10^{-14}$.
- Contributions from new physics may enhance the BF by $2\sim3$ orders of magnitude.

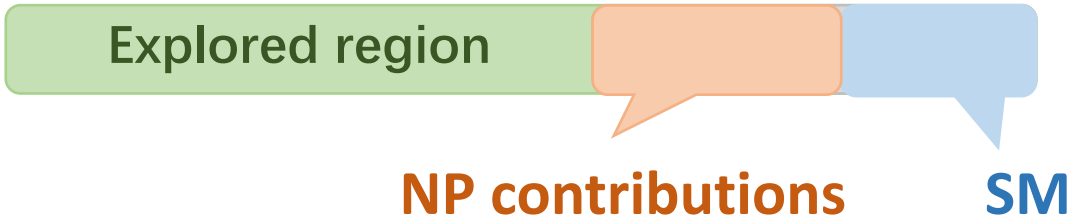
Natl.Sci.Rev. 8 (2021) 11



Phys. Rev. D 96, 111101



PoS(FPCP2023)008



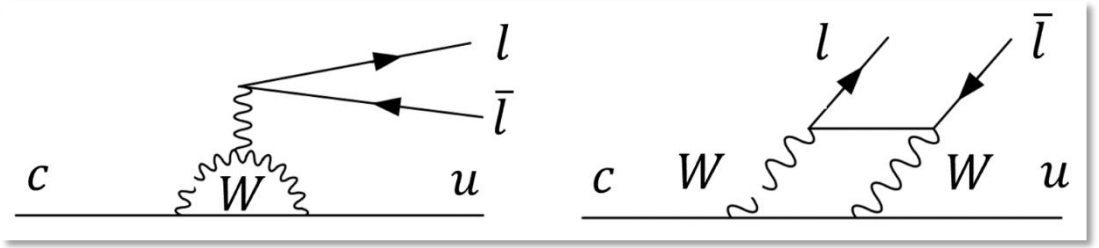
Motivation

- There are three types that need to be distinguished.

arXiv:2403.11597

Short-distance (SD), proceed via the SM loop diagrams, BF~$10^{-8}\sim10^{-14}$.

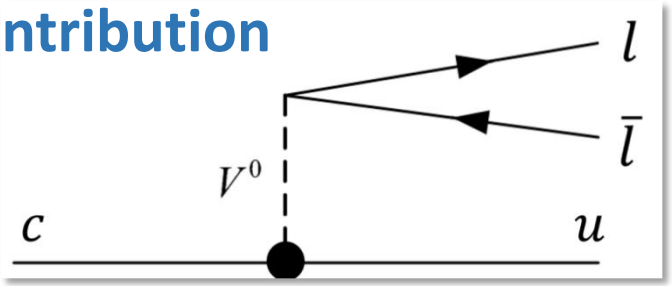
SD Contribution



Conf.Proc.C 060726 (2006) 811-814

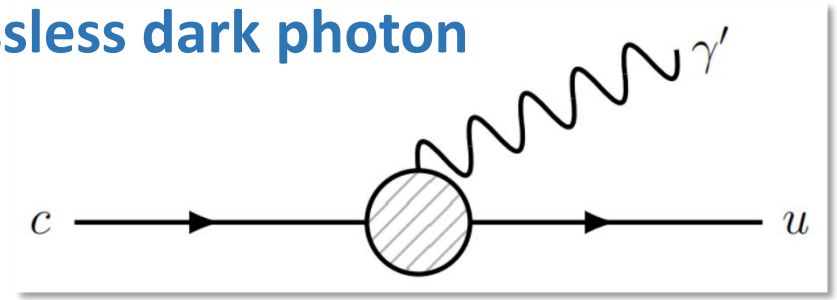
Long-distance (LD) can be dominant, such as Vector Meson Dominance (VMD), and BF~$10^{-6}\sim10^{-11}$.

LD Contribution



New physics contribution, such as **Top-color model**, **two-Higgs doublet model**, **massless dark photon**, and **QCD axion**, enhance the BF 2-3 orders.

NP Contribution, such as massless dark photon



PRD 15 (1977) 1858. PLB 119 (1982) 136. PLB 345 (1995) 483. PRD 102 (2020) 11.

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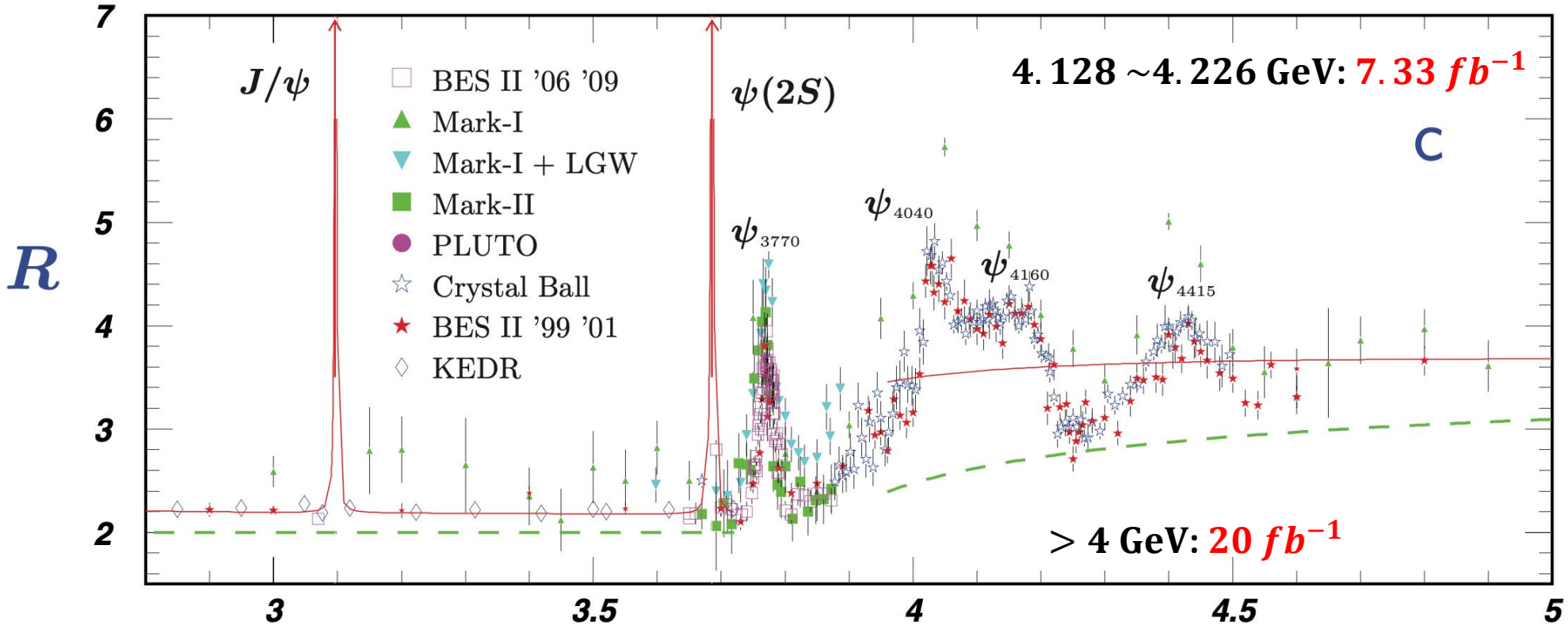
  - $D_s^+ D_s^+ \to h(h')e^+e^-,\ D \to h(h')e^+e^-,\ D^0 \to \pi^0\nu\bar{\nu}$
- ☐ Prospect
- ☐ Summary

BESIII Data Samples

- BESIII has collected the largest data samples of J/ψ and $\psi(3686)$ on the threshold in the world. New data has been collected at higher energy points, such as for $\psi(3770)$, where the integrated luminosity has increased from 2.93 fb^{-1} to 20 fb^{-1}.

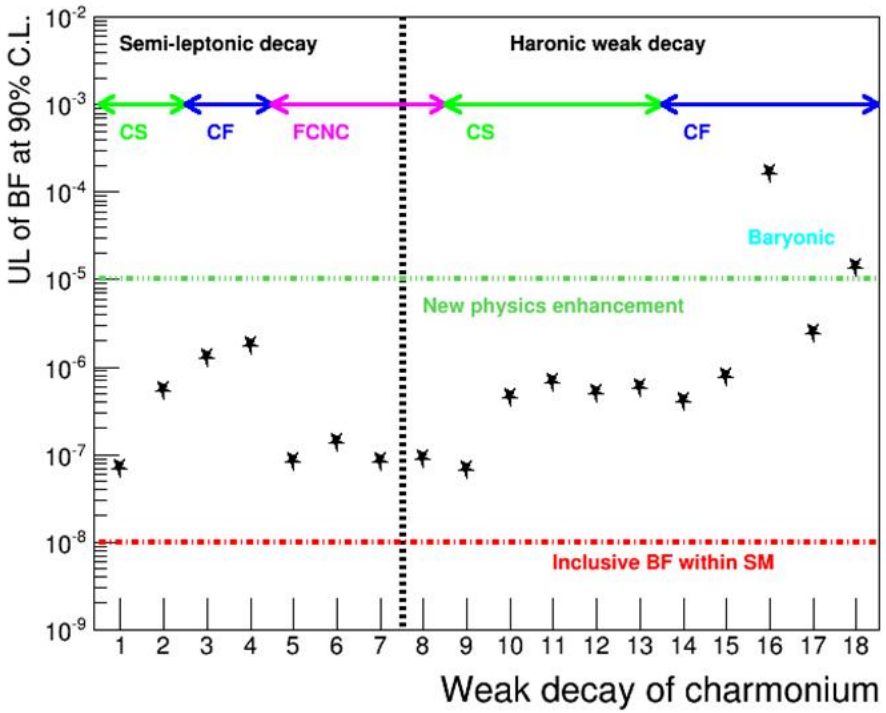
J/ψ resonance: 10^{10} $\psi(3686)$: 2.7×10^{9} $\psi(3770)$: $20\ fb^{-1}$



Charmonium FCNC decay

- For the $J/\psi\,(\psi(3686)) \to D^0 e^+ e^-$, it is based on the $\sim$1.3 B J/ψ (0.45 B $\psi(3686)$) events. Phys. Rev. D 96 (2017) 111101
- New results at the 90% C.L.: JHEP04(2025)061
  - $B(J/\psi \to D^0 \mu^+ \mu^-) < 1.1 \times 10^{-7}$, it is based on the $\sim$10 B J/ψ events.
  - $B(J/\psi \to \gamma D^0) < 9.1 \times 10^{-8}$, it is based on the $\sim$10 B J/ψ events.

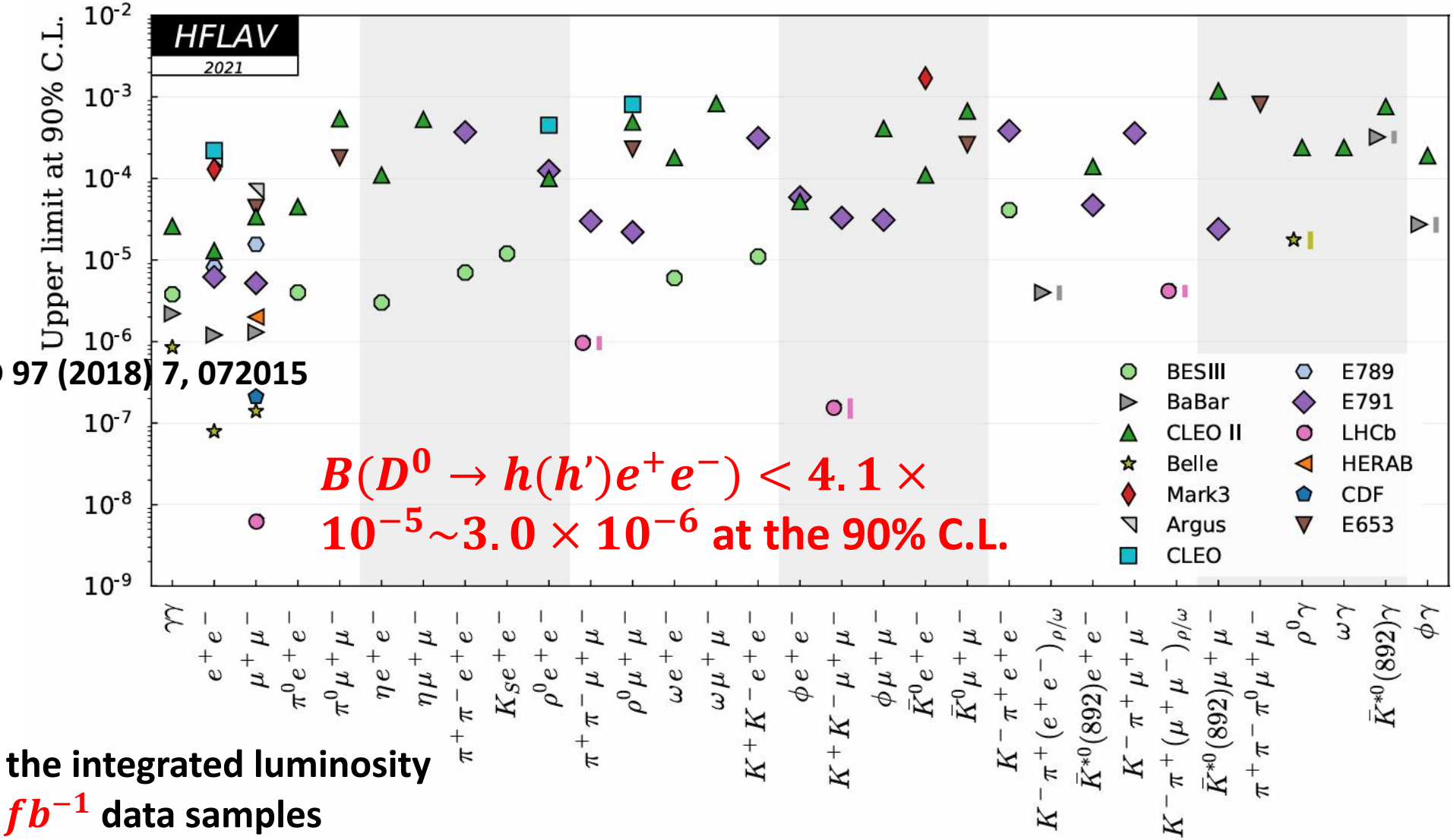
Phys. Rev. D 110 (2024) 112012



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: $J/\psi \to D^0 \mu^+ \mu^-$+c.c.
8: $J/\psi \to \gamma D^0$+c.c.
9: $J/\psi \to D^- \pi^+$+c.c.
10: $J/\psi \to D^0 \pi^0$+c.c.
11: $J/\psi \to D^0 \eta$+c.c.
12: $J/\psi \to D^0 \rho^0$+c.c.
13: $J/\psi \to D^- \rho^+$+c.c.
14: $J/\psi \to D_s^- \pi^+$+c.c.
15: $J/\psi \to D_s^- \rho^+$+c.c.
16: $J/\psi \to D^0 K^0$+c.c.
17: $J/\psi \to D^0 K^{*0}$+c.c.
18: $\psi(2S) \to \Lambda_c^+ \bar{\Sigma}^-$+c.c.

arXiv:2403.11597

Charm meson FCNC decay



Phys.Rev.D 97 (2018) 7, 072015

- Basd on the integrated luminosity of $2.93\ fb^{-1}$ data samples

https://hflav-eos.web.cern.ch/hflav-eos/charm/rare/Spring2021/rare_D0_2021.pdf

Charm meson FCNC decay

Phys.Rev.D 97 (2018) 7, 072015

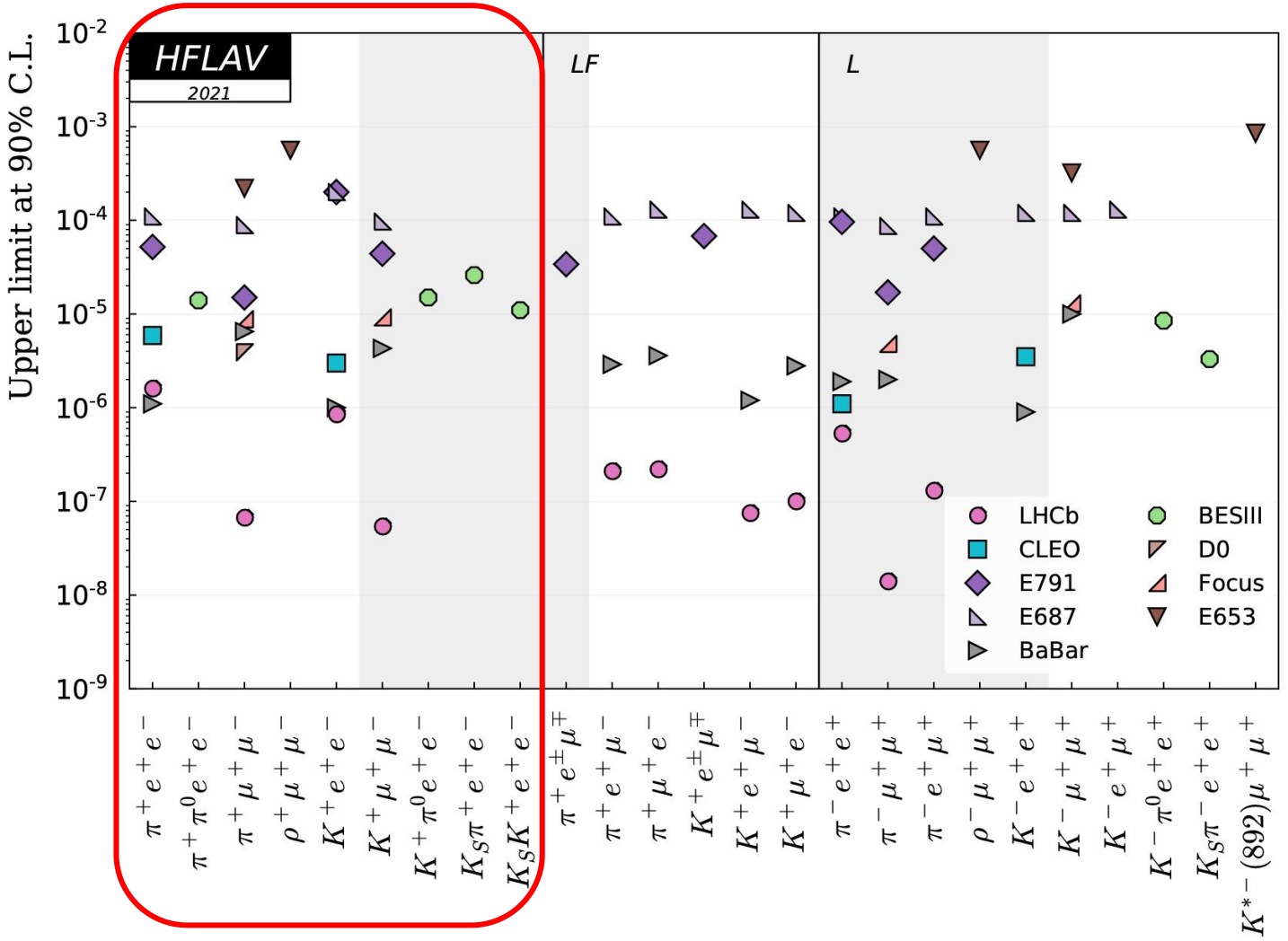
- Basd on the integrated luminosity of $2.93\ fb^{-1}$ data samples
- At the 90% C.L., upper limit of BF:

$$B(D^+ \to \pi^+ K_S e^+ e^-) < 2.6 \times 10^{-5}$$

$$B(D^+ \to \pi^+ \pi^0 e^+ e^-) < 1.4 \times 10^{-5}$$

$$B(D^+ \to K^+ K_S e^+ e^-) < 1.1 \times 10^{-5}$$

$$B(D^+ \to K^+ \pi^0 e^+ e^-) < 1.5 \times 10^{-5}$$



https://hflav-eos.web.cern.ch/hflav-eos/charm/rare/Spring2021/rare_Dplus_2021.pdf

D_s FCNC decay

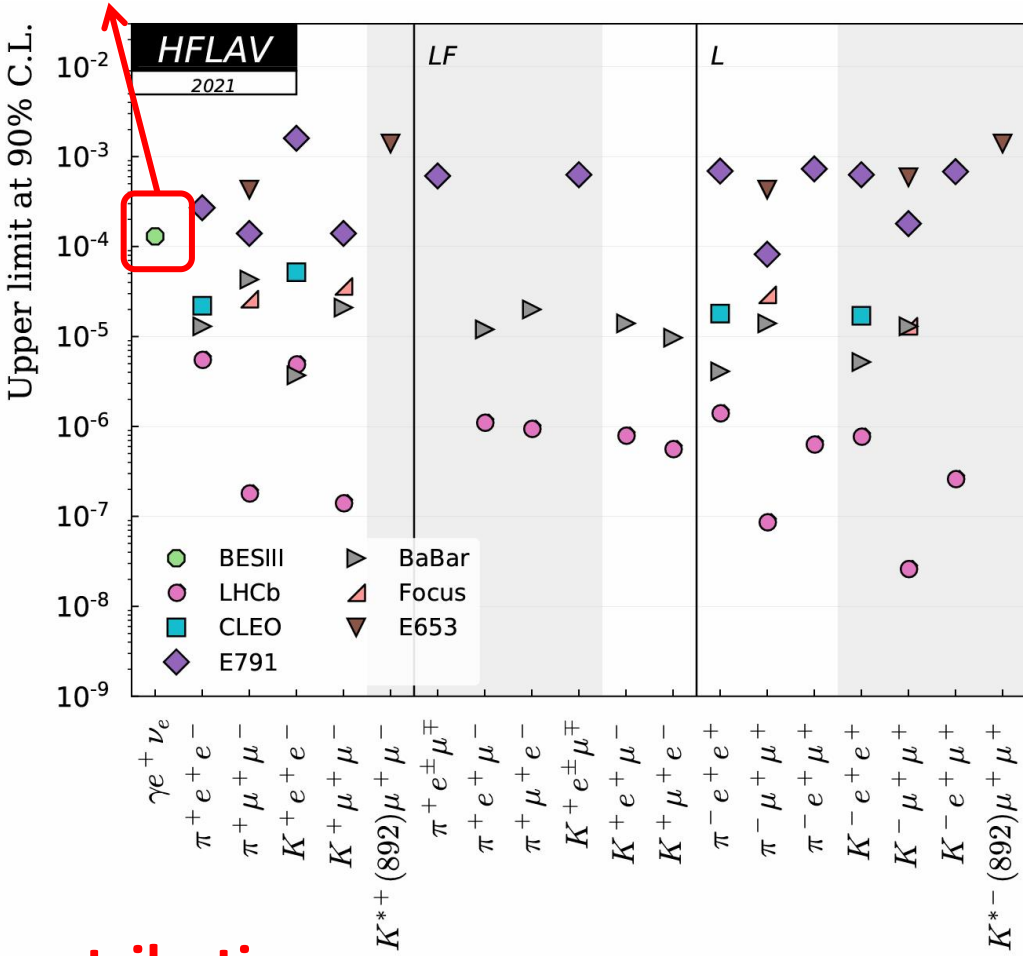
Phys.Rev.Lett. 133 (2024) 12, 121801

- New results ($7.33\ fb^{-1}$), at the 90% C.L.:
  - $B(D_s^+ \to \pi^+\pi^0 e^+ e^-) < 7.0 \times 10^{-5}$
  - $B(D_s^+ \to K^+\pi^0 e^+ e^-) < 7.1 \times 10^{-5}$
  - $B(D_s^+ \to K_S\pi^+ e^+ e^-) < 8.1 \times 10^{-5}$
  - $B(D_s^+ \to \pi^+\phi) \times B(\phi \to e^+e^-) =$

    $(1.17^{+0.23}_{-0.21} \pm 0.03) \times 10^{-5}$
  - $B(D_s^+ \to \rho^+\phi) \times B(\phi \to e^+e^-) =$

    $(2.44^{+0.67}_{-0.62} \pm 0.16) \times 10^{-5}$

Only one before 2021



Discovery of LD contributions

https://hflav-eos.web.cern.ch/hflav-eos/charm/rare/Spring2021/rare_Dsplus_2021.pdf

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- ☐ Prospect
- ☐ Summary

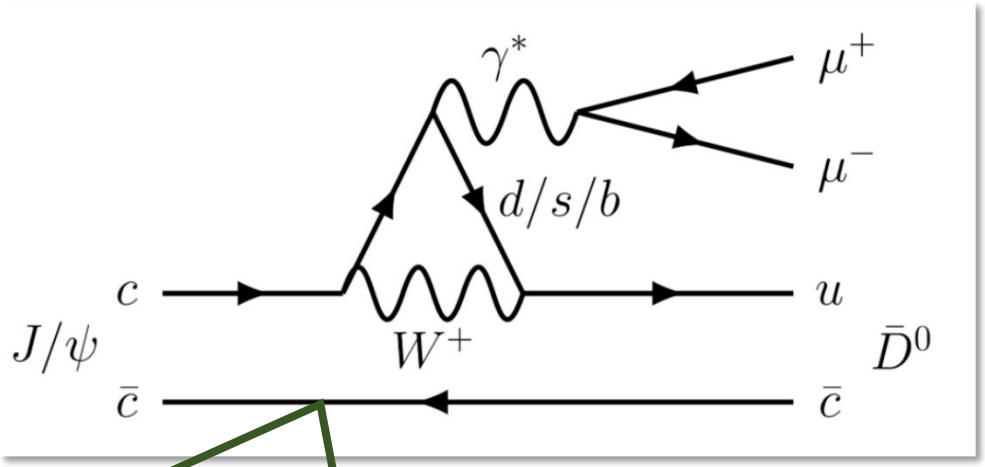
Search for $J/\psi \to D^0\mu^+\mu^-$ decay

JHEP 04 (2025) 061

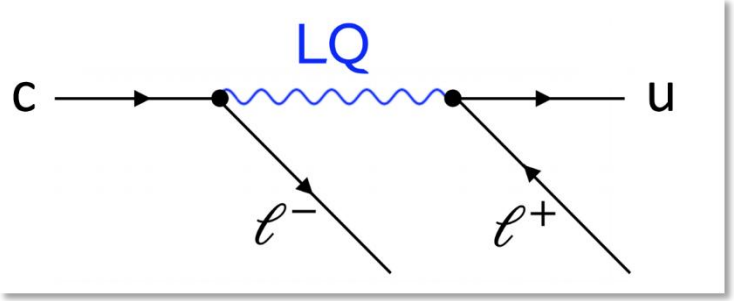
- Using $(1.0087 \pm 0.0044) \times 10^{10}$ events.
- Decay chain:
  - $J/\psi \to D^0\mu^+\mu^- + c.c$
  - Mode1: $D^0 \to K^-\pi^+$
  - Mode2: $D^0 \to K^-\pi^+\pi^0, \pi^0 \to \gamma\gamma$
  - Mode3: $D^0 \to K^-\pi^+\pi^+\pi^-$
- Based on the QCD sum rule, the result of theoretical calculation:

J.Phys.G 36 (2009) 105002

$$\mathrm{BR}(J/\psi \to \bar{D}^0 e^+ e^-) = 1.14^{+0.71}_{-0.35} \times 10^{-13}, \quad \mathrm{BR}(J/\psi \to \bar{D}^0 \mu^+ \mu^-) = 1.08^{+0.67}_{-0.33} \times 10^{-13},$$
$$\mathrm{BR}(J/\psi \to \bar{D}^{*0} e^+ e^-) = 6.30^{+3.61}_{-2.30} \times 10^{-13}, \quad \mathrm{BR}(J/\psi \to \bar{D}^{*0} \mu^+ \mu^-) = 5.94^{+3.36}_{-2.15} \times 10^{-13},$$



For new physics, some new particles that modulate FCNC processes



Search for $J/\psi \to D^0\mu^+\mu^-$ decay

JHEP 04 (2025) 061

- In the three-body decay $J/\psi \to D^0\mu^+\mu^-$, due to the low energy of muons (<0.4 GeV), there is insufficient information to identify muon, resulting in the main background being the μ/π misidentification.
- Correction Method:
- such as μ^- are corrected to π^-

$$\vec{p}_\pi = \vec{p}_\mu, E_\pi = \sqrt{\vec{p}_\mu^2 c^2 + m_\pi^2 c^4}$$

Background: $J/\psi \to \pi^+ \pi^- \pi^0 \pi^+ \pi^-$

Identified as: $J/\psi \to K^+ \pi^- \pi^0 \mu^+ \mu^-$

- Using a similar method, the analysis also constructs $M(4\pi)$, $M(\pi^+\pi^-)$, $M(\pi^\pm\pi^0)$, and $M(\pi^\pm\pi^+\pi^-)$.
- Due to the mass differences between particles, these variables has distinct kinematic features, which can effectively distinguish signals from backgrounds.

Search for $J/\psi \to D^0\mu^+\mu^-$ decay

JHEP 04 (2025) 061

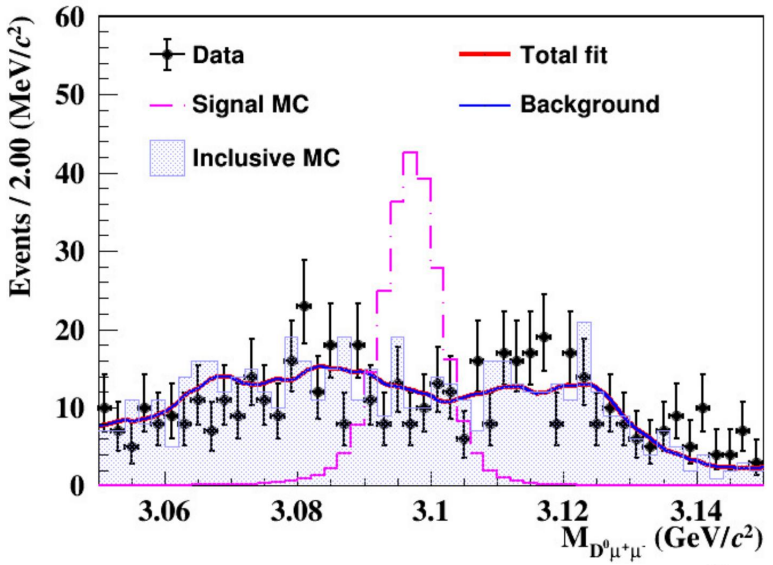
- The invariant mass of J/ψ is used for signal extraction.

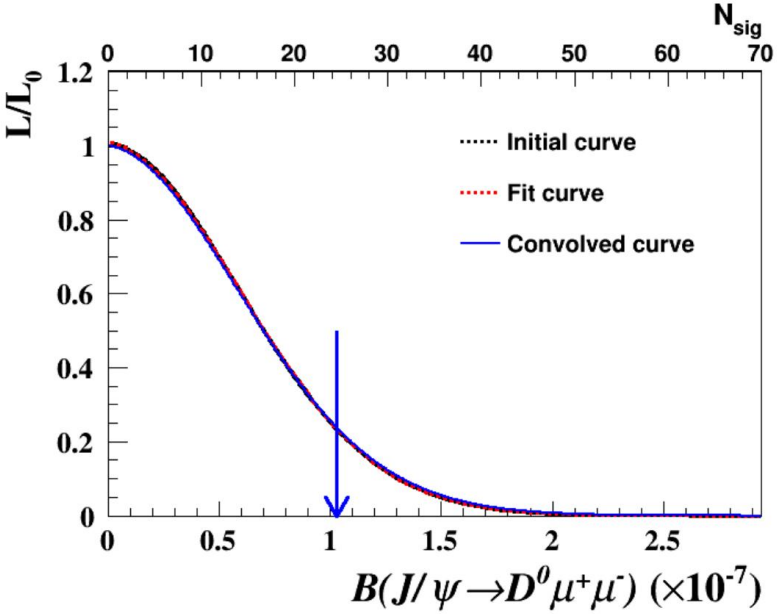
$$M(D^0\mu^+\mu^-) = \sqrt{(E_{D^0} + E_{\mu^+} + E_{\mu^-})^2 - |\vec{p}_{D^0} + \vec{p}_{\mu^+} + \vec{p}_{\mu^-}|^2}$$

$$B(J/\psi \to D^0\mu^+\mu^-) = \frac{N_{sig,\,fit}}{N_{J/\psi} \times \sum_i (\epsilon_{sig,\,i} \times B_{inter,\,i})}$$

where $N_{sig,\,fit}$ is the signal yield, $N_{J/\psi} = (10087 \pm 44) \times 10^6$, $\epsilon_{sig,\,i}$ and $B_{inter,\,i}$ are the signal efficiency and intermediate BF for the i-th reconstruction modes.

- This is the first measurement for $J/\psi \to D^0\mu^+\mu^-$, and no significant signal has been observed.
- $B(J/\psi \to D^0\mu^+\mu^-) < 1.1 \times 10^{-7}$ at the 90% C.L.

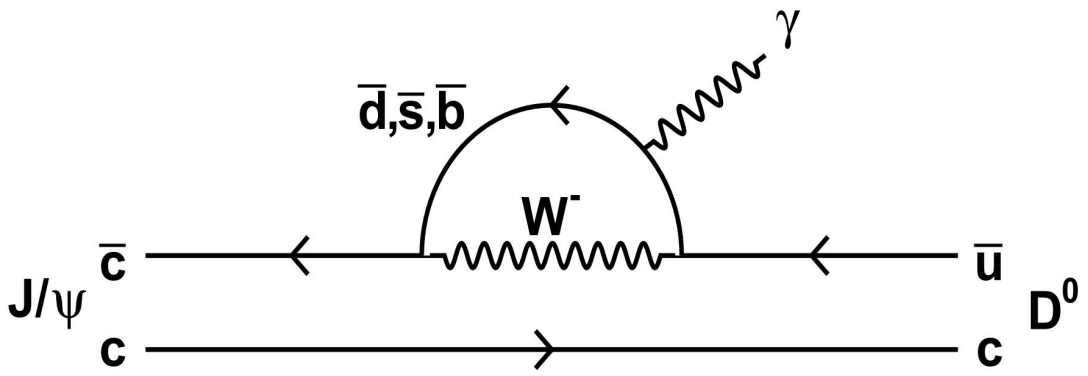




Search for $J/\psi \to \gamma D^0$ decay

Phys. Rev. D 110 (2024) 112012

- Using $(1.0087 \pm 0.0044) \times 10^{10}$ events.
- Decay chain:
  - $J/\psi \to \gamma D^0 + c.c$
  - Mode1: $D^0 \to K^-\pi^+$
  - Mode2: $D^0 \to K^-\pi^+\pi^0, \pi^0 \to \gamma\gamma$
  - Mode3: $D^0 \to K^-\pi^+\pi^+\pi^-$



- Theoretically, the expected BF is 1-2 orders of magnitude higher than that of $J/\psi \to D^0 l^+ l^-$, due to the presence of one fewer decay vertex.

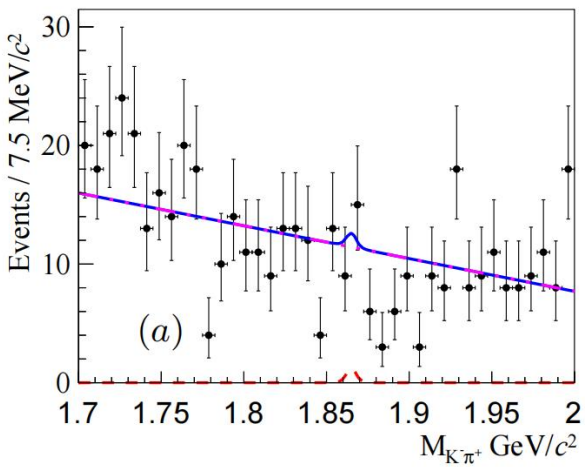
Search for $J/\psi \to \gamma D^0$ decay

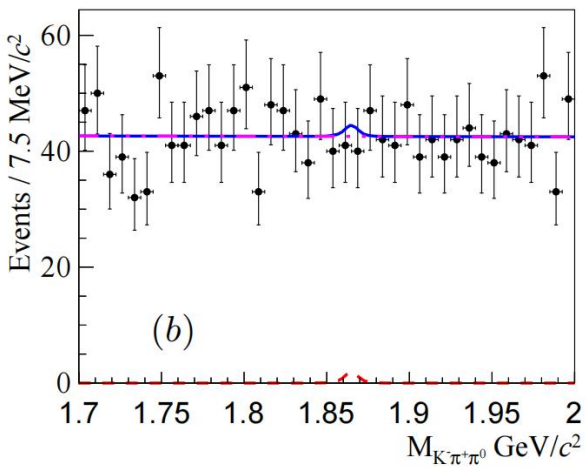
Phys. Rev. D 110 (2024) 112012

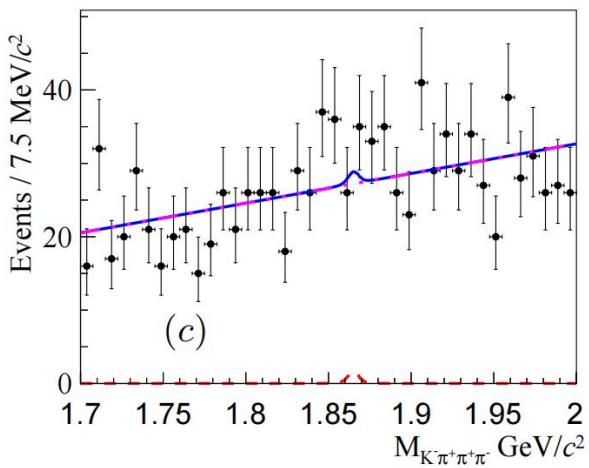
- The invariant mass of D^0 is used for signal extraction.

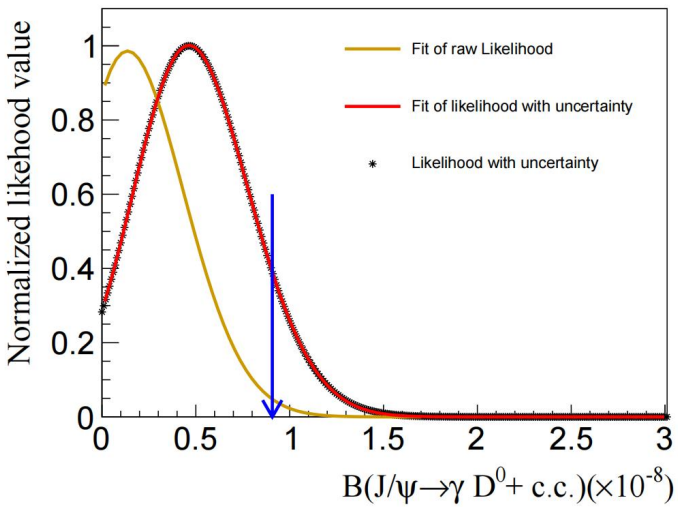
$$B(J/\psi \to \gamma D^0) = \frac{N_{sig,\,fit}}{N_{J/\psi} \times \sum_i (\epsilon_{sig,\,i} \times B_{inter,\,i})}$$

- This is the first measurement. No significant signal has been observed.
- $B(J/\psi \to \gamma D^0) < 9.1 \times 10^{-8}$ at the 90% C.L.









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  - $D_s^+ \to h(h')e^+e^-,\ D \to h(h')e^+e^-,\ D^0 \to \pi^0\nu\bar{\nu}$
- ☐ Prospect
- ☐ Summary

Search for $D_s^+ \to h(h')e^+e^-$ decay

- Using $7.33\ fb^{-1}$ data @4.128 – 4.226 GeV. Phys.Rev.Lett. 133 (2024) 12, 121801
- The $D_s^{\pm}$ mesons are dominantly produced in the process $e^+e^- \to D_s^{*\pm}D_s^{\mp}$, $D_s^{*\pm} \to \gamma D_s^{\pm}$.
- The Single Tag (ST) method is used to search for $D_s^{\pm}$ candidates. The signal processes include:
  - $D_s^+ \to \pi^+\pi^0 e^+e^-$
  - $D_s^+ \to K^+\pi^0 e^+e^-$
  - $D_s^+ \to K_S\pi^+ e^+e^-$
  - $D_s^+ \to \pi^+\phi, \phi \to e^+e^-$
  - $D_s^+ \to \rho^+\phi, \phi \to e^+e^-$

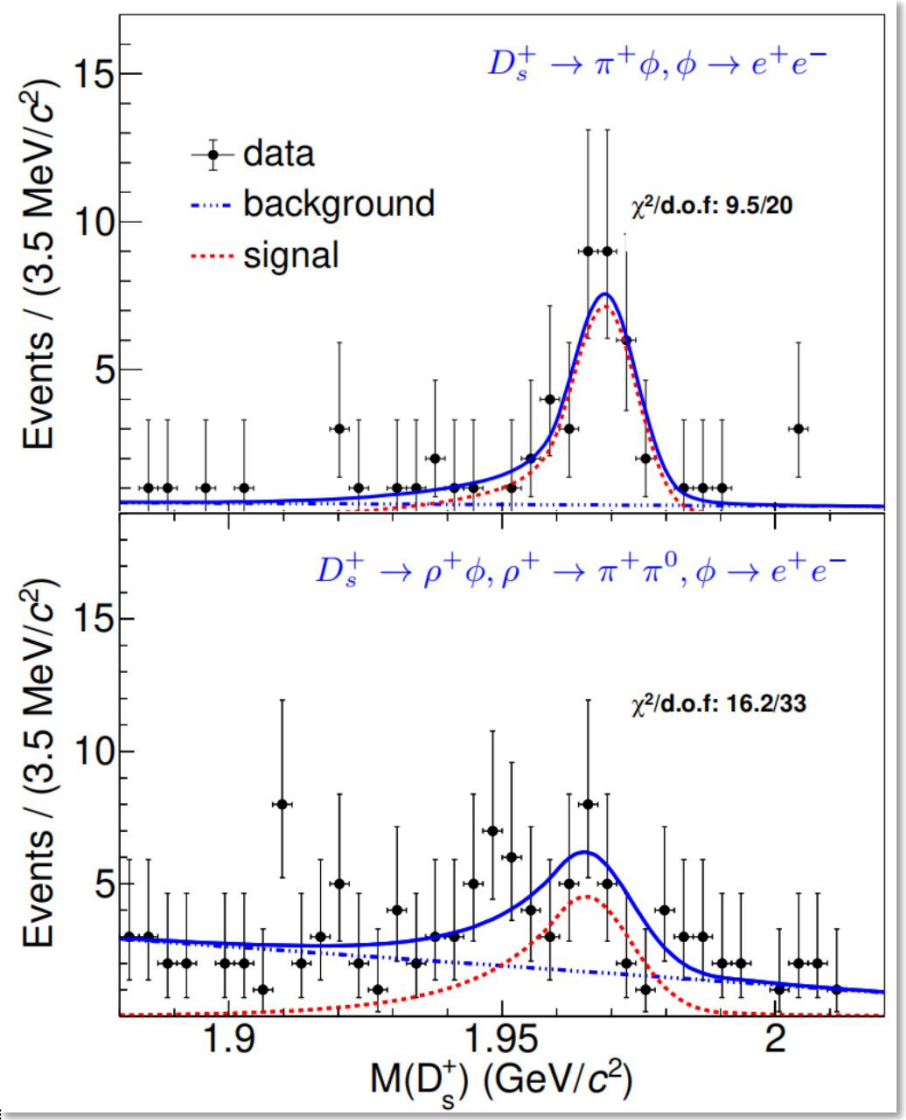
- Due to GIM suppression, the BF of SD contribution is $\sim 10^{-9}$. For LD contribution, the BF of $D_s^+ \to Ve^+e^-$ can reach $\sim 10^{-5}$.
- The yield of $D_s^{*\pm}D_s^{\mp}$ is $(64.72 \pm 0.28) \times 10^5$, which provides strong support for the discovery of LD contribution.

Search for $D_s^+ \to h(h')e^+e^-$ decay

- Single tag method requires one $D_s^+ \to h(h')e^+e^-$

$$B(D_s^+ \to h(h')e^+e^-) = \frac{N_{sig,\,fit}}{2 \times N_{D_s^{*\pm}D_s^{\mp}} \times \epsilon \times B_{inter}}$$

- $N_{D_s^{*\pm}D_s^{\mp}} = (64.72 \pm 0.28) \times 10^5$, $\epsilon = \sum_i (\epsilon_{sig}^i \times N_{D_s^{*\pm}D_s^{\mp}}^i / N_{D_s^{*\pm}D_s^{\mp}})$, where i represents different energy points.
- First evidence: $B(D_s^+ \to \rho^+\phi) \times B(\phi \to e^+e^-) = (2.44^{+0.67}_{-0.62} \pm 0.16) \times 10^{-5}$, significance is 4.4σ.
- Agreement with CLEO: $B(D_s^+ \to \pi^+\phi) \times B(\phi \to e^+e^-) = (1.17^{+0.23}_{-0.21} \pm 0.03) \times 10^{-5}$, significance is 7.8σ.



Phys.Rev.Lett. 133 (2024) 12, 121801

Search for $D_s^+ \to h(h')e^+e^-$ decay

- For the $D_s^+ \to K_S\pi^+e^+e^-/K^+\pi^0e^+e^-$, the LD contribution of $\phi \to e^+e^-$ is insignificant, BF is excepted about 10^{-8} order. Therefore, the upper limit of BF at 90% C.L. is as follows:

First limits

$$B(D_s^+ \to K^+\pi^0e^+e^-) < 7.1 \times 10^{-5}$$

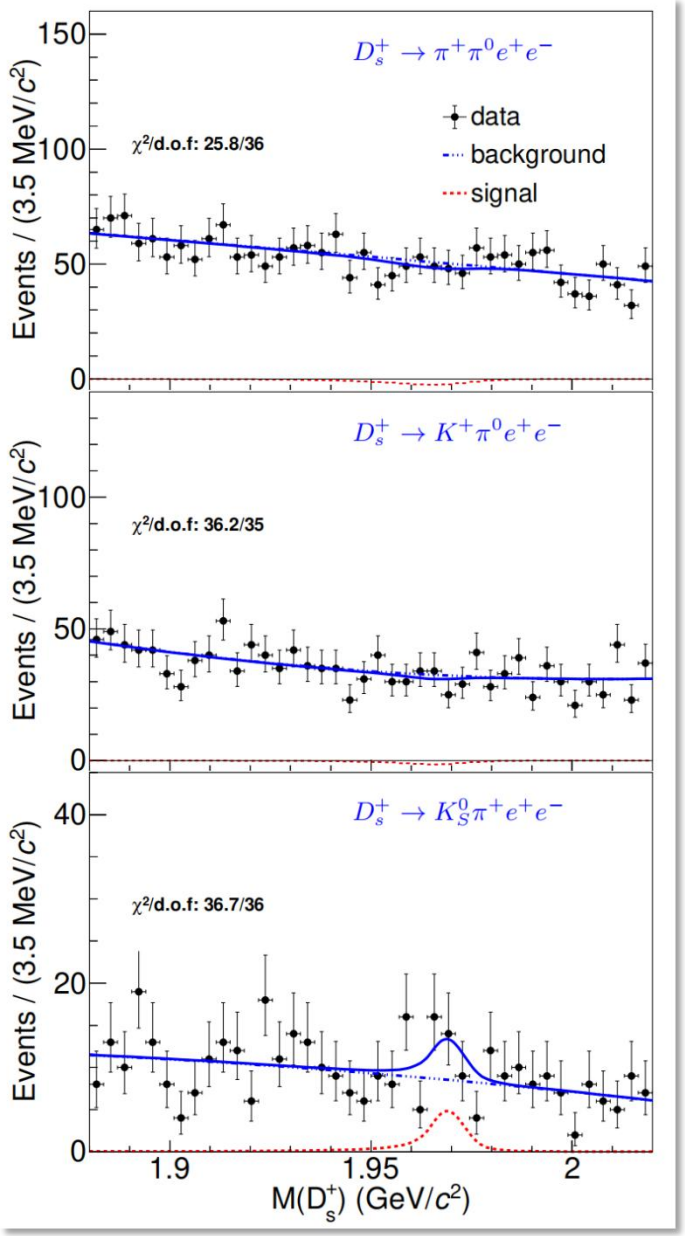
$$B(D_s^+ \to K_S\pi^+e^+e^-) < 8.1 \times 10^{-5}$$

- For the $D_s^+ \to \pi^+\pi^0e^+e^-$, it includes the LD contribution $D_s^+ \to \rho^+\phi$. Excluding the region $M(e^+e^-) \in (0.96, 1.05)\ \mathrm{GeV}/c^2$, the upper limit of BF at 90% C.L.:

First limits

$$B(D_s^+ \to \pi^+\pi^0e^+e^-) < 7.0 \times 10^{-5}$$

Phys.Rev.Lett. 133 (2024) 12, 121801



Search for $D \to h(h')e^+e^-$ decay

Phys.Rev.D 97 (2018) 7, 072015

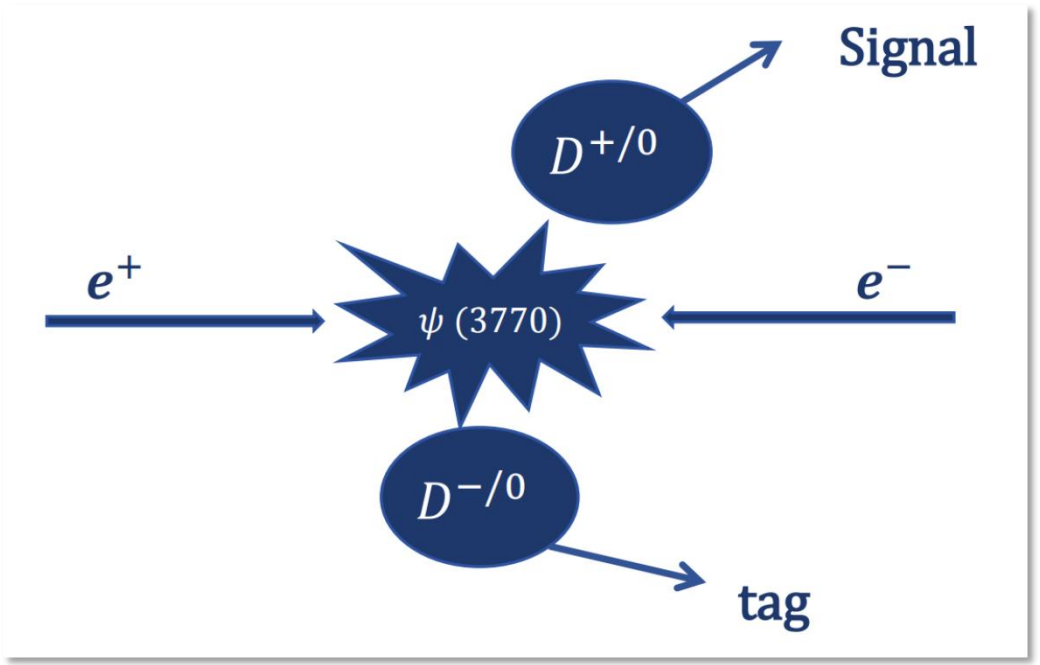
- Using $2.93\ fb^{-1}$ data @3.773 GeV.
- The pair of $D^0\bar{D}^0$ or D^+D^- is produced nearly at rest without any additional hadrons.
- The Double Tag (DT) method is used to search for signal candidates.
  - The single-tag side of D meson

    $$N_D^{ST} = 2 \times N_{D\bar{D}} \times B_{Tag} \times \epsilon_{ST}$$

  - Search for signals from other D meson decays

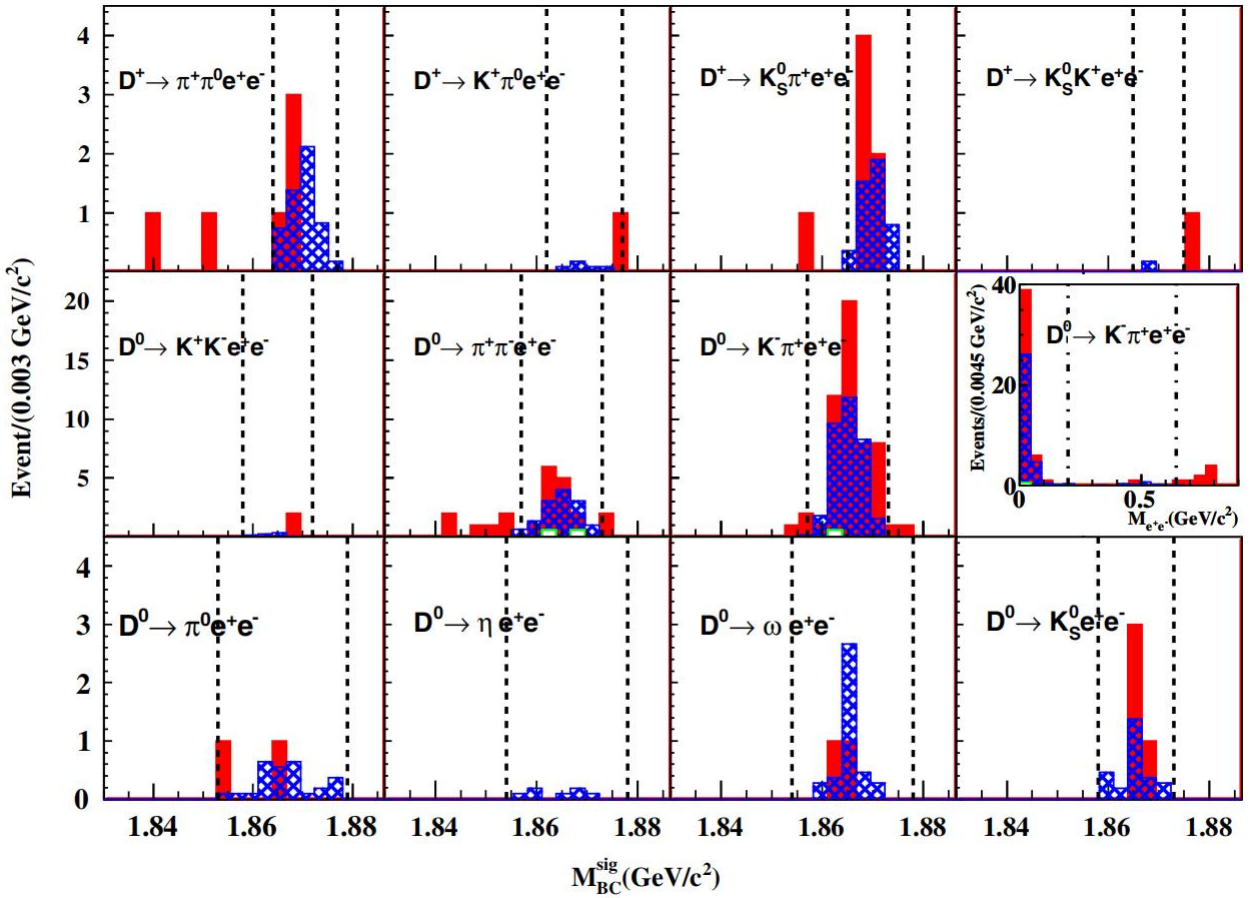
    $$N_D^{DT} = 2 \times N_{D\bar{D}} \times B_{Tag} \times B_{Sig} \times \epsilon_{DT}$$

  - $B_{Sig} = N_D^{DT} \times \epsilon_{ST} / N_D^{ST} \times \epsilon_{DT}$



Search for $D \to h(h')e^+e^-$ decay

Phys.Rev.D 97 (2018) 7, 072015



- The solid histograms are data, the hatched ones are the events in the inclusive MC.

First limits

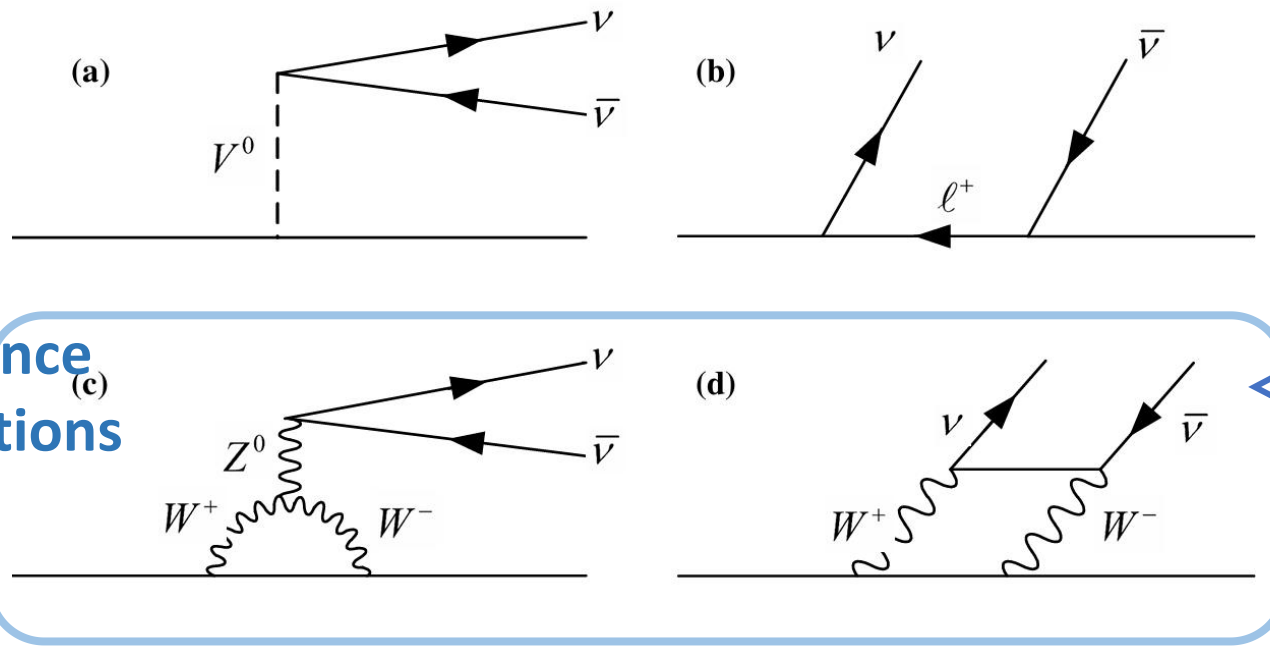
Signal decays	$\mathcal{B}$ ($\times 10^{-5}$)	PDG [9] ($\times 10^{-5}$)
$D^+ \to \pi^+\pi^0 e^+e^-$	<1.4	···
$D^+ \to K^+\pi^0 e^+e^-$	<1.5	···
$D^+ \to K^0_S\pi^+ e^+e^-$	<2.6	···
$D^+ \to K^0_S K^+ e^+e^-$	<1.1	···
$D^0 \to K^-K^+ e^+e^-$	<1.1	<31.5
$D^0 \to \pi^+\pi^- e^+e^-$	<0.7	<37.3
$D^0 \to K^-\pi^+ e^+e^-$ †	<4.1	<38.5
$D^0 \to \pi^0 e^+e^-$	<0.4	<4.5
$D^0 \to \eta e^+e^-$	<0.3	<11
$D^0 \to \omega e^+e^-$	<0.6	<18
$D^0 \to K^0_S e^+e^-$	<1.2	<11
† in $M_{e^+e^-}$ regions		
$[0.00, 0.20)$ GeV/c^2	$<3.0\ (1.5^{+1.0}_{-0.9})$	···
$[0.20, 0.65)$ GeV/c^2	<0.7	···
$[0.65, 0.90)$ GeV/c^2	$<1.9\ (1.0^{+0.5}_{-0.4})$	···

The current best limits

Search for $D^0 \to \pi^0 \nu\bar{\nu}$ decay

Phys.Rev.D 105 (2022) 7, L071102

- Using $2.93\ fb^{-1}$ data @3.773 GeV.
- The Double Tag (DT) method is used to search for signal candidates.
- Different points: The LD contribution of $D^0 \to \pi^0 \nu\bar{\nu}$ is insignificant, while the SD contributions from Z-penguin and box diagrams dominate, $B(D^0 \to \pi^0 \nu\bar{\nu}) \sim 10^{-15}$ in SM.



Phys. Rev. D 66, 014009 (2002)

dominance contributions

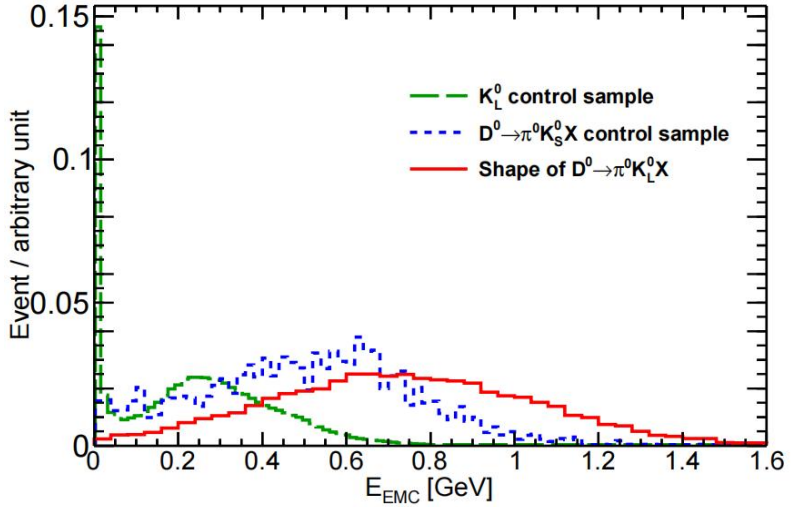
However, in some NP models, such as leptoquark model, Z' model, the BF can be enhanced by several orders of magnitude.

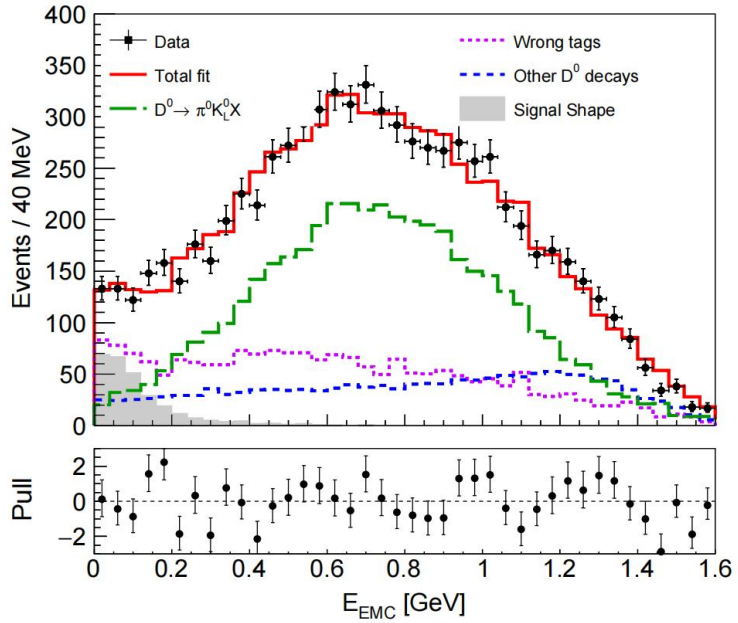
Phys. Rev. D 103, 015033 (2021)
Phys. Rev. D 104, 015014 (2021)
JHEP 04, 246 (2021)

Search for $D^0 \to \pi^0\nu\bar{\nu}$ decay

Phys.Rev.D 105 (2022) 7, L071102

- First measurement for $D^0 \to \pi^0\nu\bar{\nu}$.
- The summed EMC energy unassociated with signal and tag decays is used to signal extraction.
- The main background is K_L, and the estimation of its deposition energy spectrum is crucial. Data-driven method:
  - Model the K_L energy deposit $E_{EMC}^{K_L}$ using high-purity samples of $J/\psi \to \phi K^{\pm}\pi^{\mp}K_L$ and $J/\psi \to K^{\pm}\pi^{\mp}K_L$.
  - Model the energy deposit of E_{EMC}^{X} and the kinematics of K_L using the data sample of $D^0 \to \pi^0 K_S(\pi^+\pi^-)X$.
  - $E_{EMC} = E_{EMC}^{K_L} + E_{EMC}^{X}$



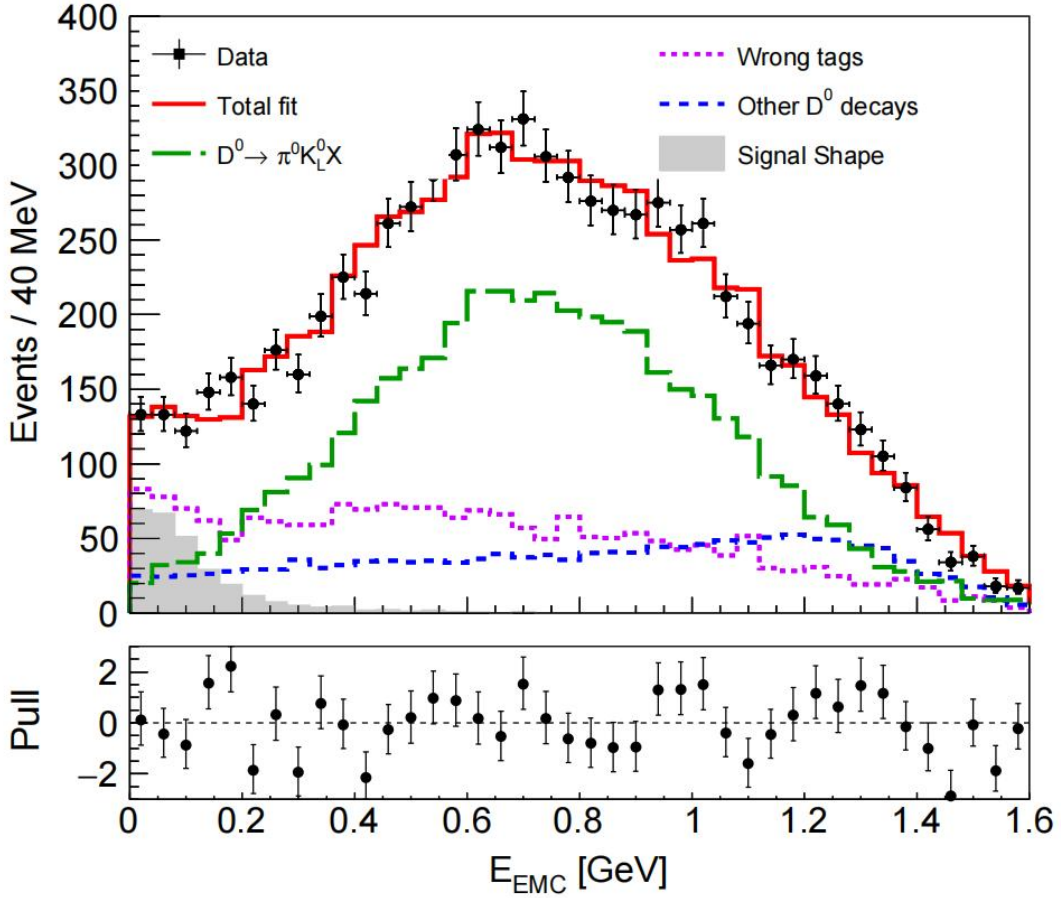


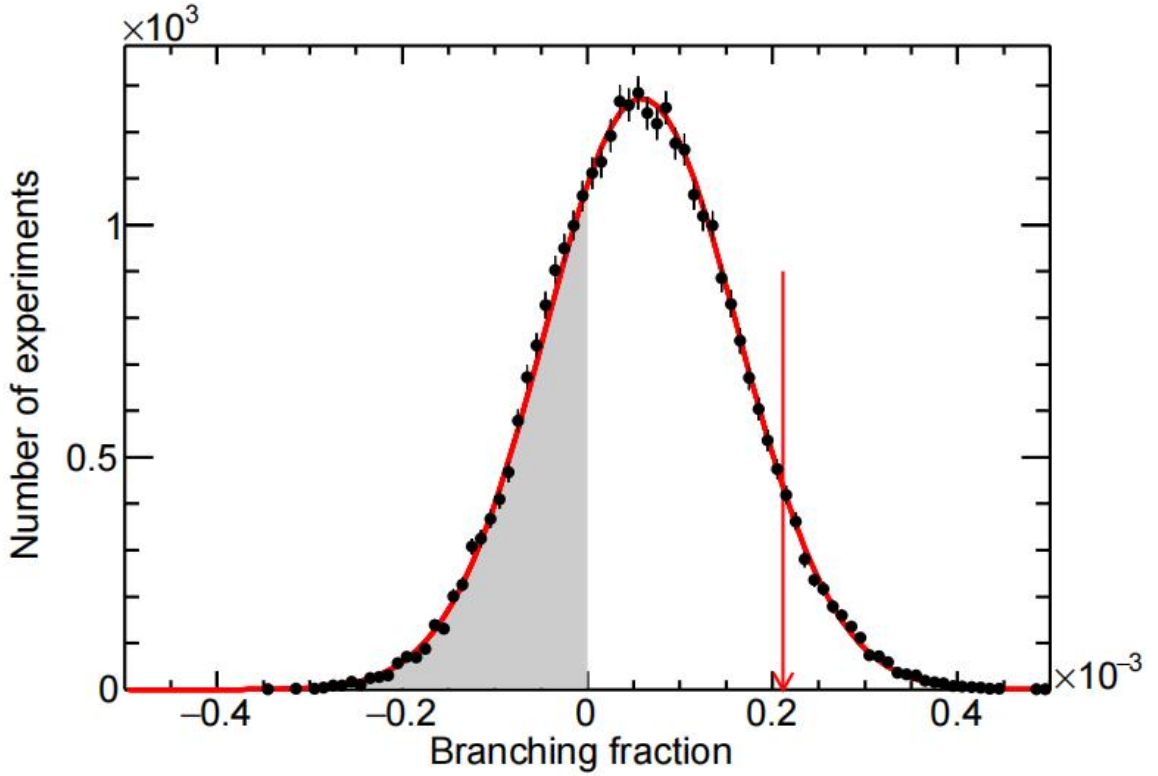
Search for $D^0 \to \pi^0 \nu\bar{\nu}$ decay

Phys.Rev.D 105 (2022) 7, L071102

- Based on the $2.93\ fb^{-1}$ data @3.773 GeV.

$$B(D^0 \to \pi^0 \nu\bar{\nu}) < 2.1 \times 10^{-4}\ at\ the\ 90\%\ C.L.$$



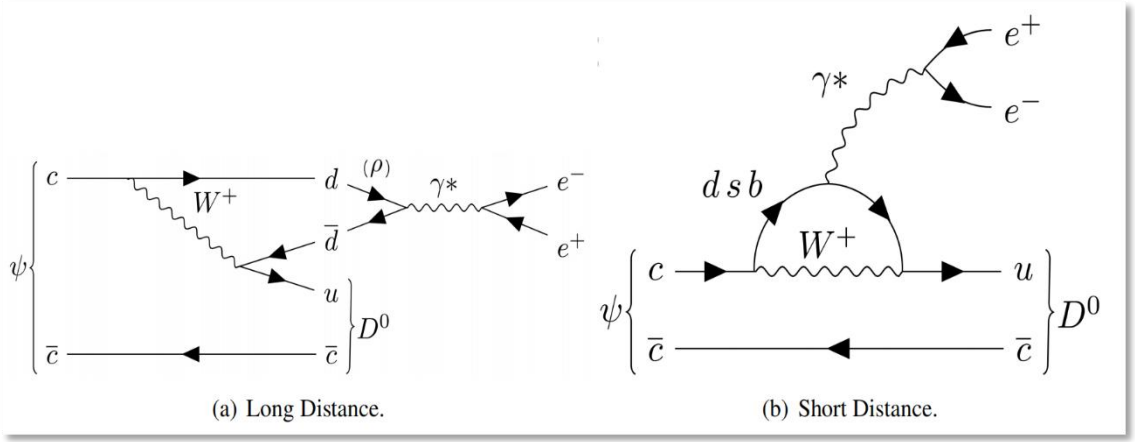


Outline

- ☐ Motivation
- ☐ Current status
- ☐ Charmonium FCNC decay
  - $J/\psi \to D^0\mu^+\mu^-,\ J/\psi \to \gamma D^0$
- ☐ Charm FCNC decay
  - $D_s^+ \to h(h')e^+e^-, D \to h(h')e^+e^-, D^0 \to \pi^0\nu\bar{\nu}$
- ✓ Prospect
- ☐ Summary

Ongoing analysis

- Currently, BESIII has accumulated 10 billion J/ψ events and 2.7 billion $\psi(3686)$ events, $20\ fb^{-1}$ data at @3.773 GeV, and has also collected $7.33\ fb^{-1}$ data at @4.128 – 4.226 GeV.
- Therefore, the FCNC decays can be searched for on the new data, and stronger constraints can be imposed.



- Charmonium:
  - $J/\psi\ (\psi(3686)) \to D^0 e^+ e^-$, BAM-952 Minghua Liao (SYSU)
  - Based on the 10 B J/ψ and 2.7 B $\psi(3686)$ data, expect best constraints on the charmonium FCNC decays.

Ongoing analysis

For the D meson FCNC decays:

- **Using $20\ fb^{-1}$ data @3.773 GeV.**

➢ **$D \to h(h')e^+e^-$ is ongoing, and studied by Qiang Lan(USC), Libo Liao (SYSU).**

- **$D^+ \to \pi^+\pi^0 e^+e^- / K^+\pi^0 e^+e^- / K_S\pi^+ e^+e^- / K_S K^+ e^+e^-$**
- **$D^0 \to \pi^+\pi^- e^+e^- / K^+K^- e^+e^-$**
- **$D^0 \to \pi^0 e^+e^- / \omega e^+e^- / \eta e^+e^- / K_S e^+e^-$**

➢ **$D^+ \to h^+e^+e^-$.**

- **$D^+ \to K^+e^+e^-$**
- **$D^+ \to \pi^+e^+e^-$**

- **Ran Ding (PKU/SYSU)**
- **Kaixin Fan (SYSU)**

$D \to Pl^+l^-$	Br^{SD}_{SM} $l=\mu,\ e$	$Br_{SM} \simeq Br^{LD}$ $l=\mu,\ e$	Br^{exp} $l=e$	Br^{exp} $l=\mu$
$D^0 \to \bar{K}^0 l^+l^-$	0	4.3×10^{-7}	$<1.1\times10^{-4}$	$<2.6\times10^{-4}$
$D_s^+ \to \pi^+ l^+l^-$	0	6.1×10^{-6}	$<2.7\times10^{-4}$	$<1.4\times10^{-4}$
$D^0 \to \pi^0 l^+l^-$	1.9×10^{-9}	2.1×10^{-7}	$<4.5\times10^{-5}$	$<1.8\times10^{-4}$
$D^0 \to \eta l^+l^-$	2.5×10^{-10}	4.9×10^{-8}	$<1.1\times10^{-4}$	$<5.3\times10^{-4}$
$D^0 \to \eta' l^+l^-$	9.7×10^{-12}	2.4×10^{-10}	$<1.1\times10^{-4}$	$<5.3\times10^{-4}$
$D^+ \to \pi^+ l^+l^-$	9.4×10^{-9}	1.0×10^{-6}	$<5.2\times10^{-5}$	$<7.8\times10^{-6}$
$D_s^+ \to K^+ l^+l^-$	9.0×10^{-10}	4.3×10^{-8}	$<1.6\times10^{-3}$	$<1.4\times10^{-4}$
$D^+ \to K^+ l^+l^-$	0	7.1×10^{-9}	$<2.0\times10^{-4}$	$<8.1\times10^{-6}$
$D^0 \to K^0 l^+l^-$	0	1.1×10^{-9}		

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Ongoing analysis

- For the D_s^+ meson FCNC decays:
  - Using $7.33\ fb^{-1}$ data @4.128 – 4.226 GeV.
  - $D_s^+ \to K^+\nu\bar{\nu}$, is ongoing and studied by Jiazhen Yan (PKU, WHU).
  - In some NP models, such as the Z' model and leptoquark model, under some parameter space, $B^{UL}(D_s^+ \to K^+\nu\bar{\nu}) \sim 10^{-5}$.

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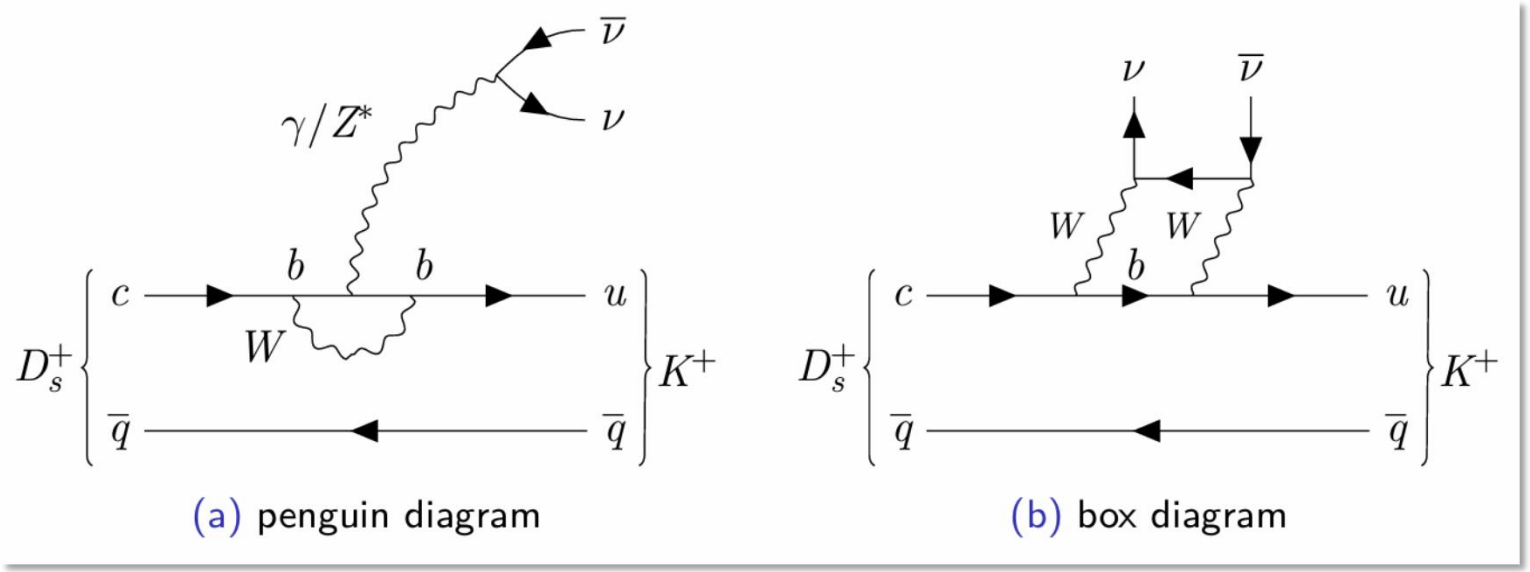

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- ☐ Prospect
- ✓ Summary

Summary

- For the FCNC decays, the contributions in the SM are extremely small $10^{-8}\sim10^{-14}$.

  The exploration of FCNC can serve as an channel for searching for new physics.

- At present, searches for $J/\psi \to D^0\mu^+\mu^-(2025)$, $J/\psi \to \gamma D^0(2024)$, $D_s^+ \to h(h')e^+e^-$ (2024), $D \to h(h')e^+e^-(2018)$, $D^0 \to \pi^0\nu\bar{\nu}(2022)$ have been completed.
  - For charm FCNC decay, $B^{UL}\sim10^{-5}$. The charmonium FCNC decay, $B^{UL}\sim10^{-7}$@90% C.L.
- Ongoing analysis, based on the 10 B J/ψ, 2.7 B $\psi(3686)$, 20 fb^{-1} data at @3.773 GeV, and 7.33 fb^{-1} data at @4.128 – 4.226 GeV:
  - $J/\psi \to D^0e^+e^-, D \to h(h')e^+e^-, D_s^+ \to K^+\nu\bar{\nu}$
- BESIII has great potential, with high-statistics datasets and low backgrounds.

Thank you for listening!