charm hadronic physics at BESIII

27th Rencontres de Blois
Particle Physics and Cosmology
May 31 — June 05

Y. Huang Nanjing University

charm hadronic physics at BESIII

Huang Yong
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BEPC II collider

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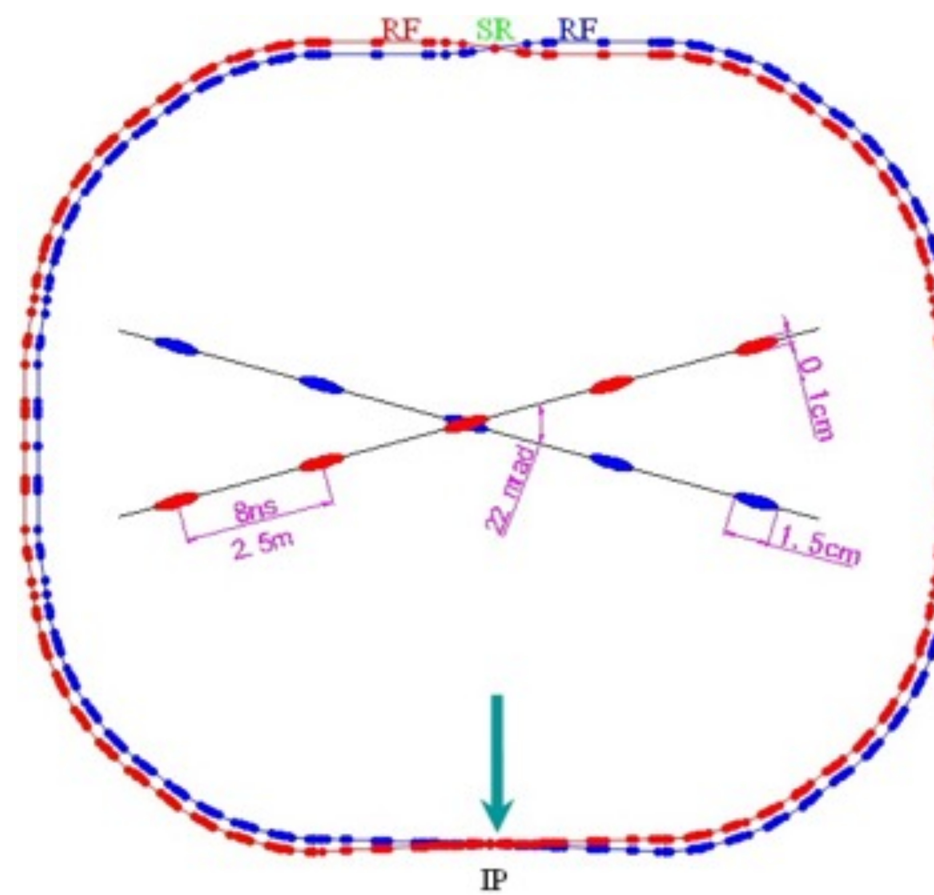

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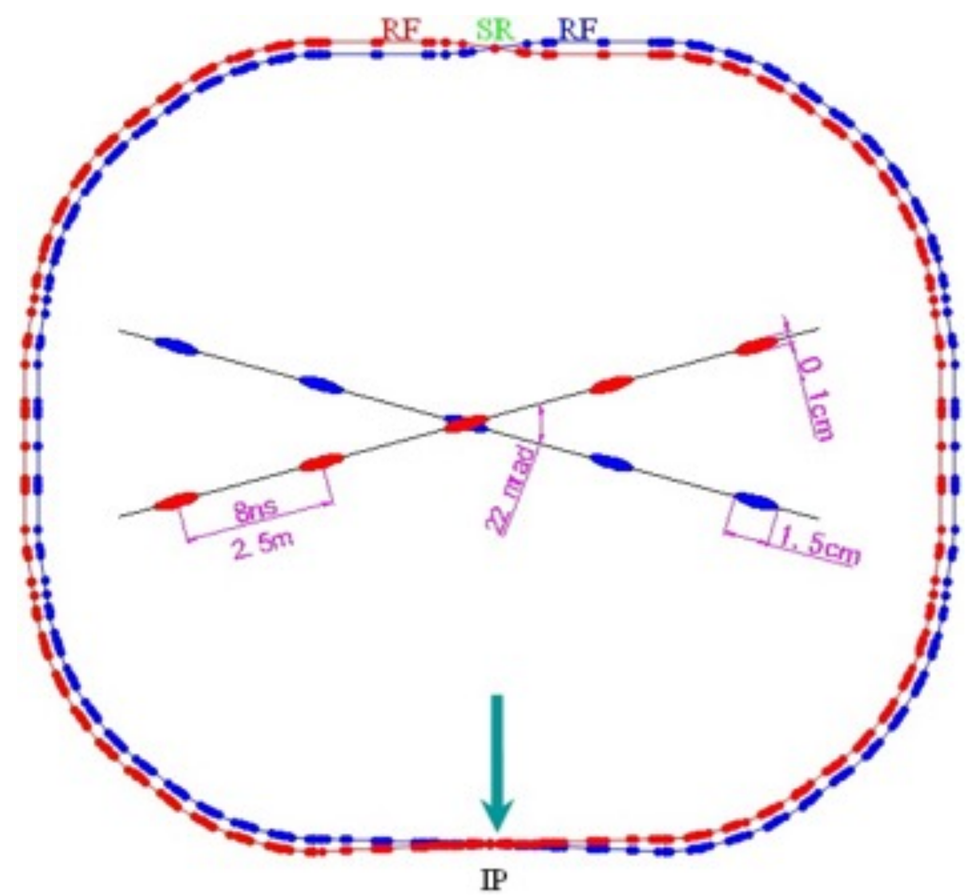

Institute of High Energy Physics (IHEP)
Beijing, P.R.China

BES III detector

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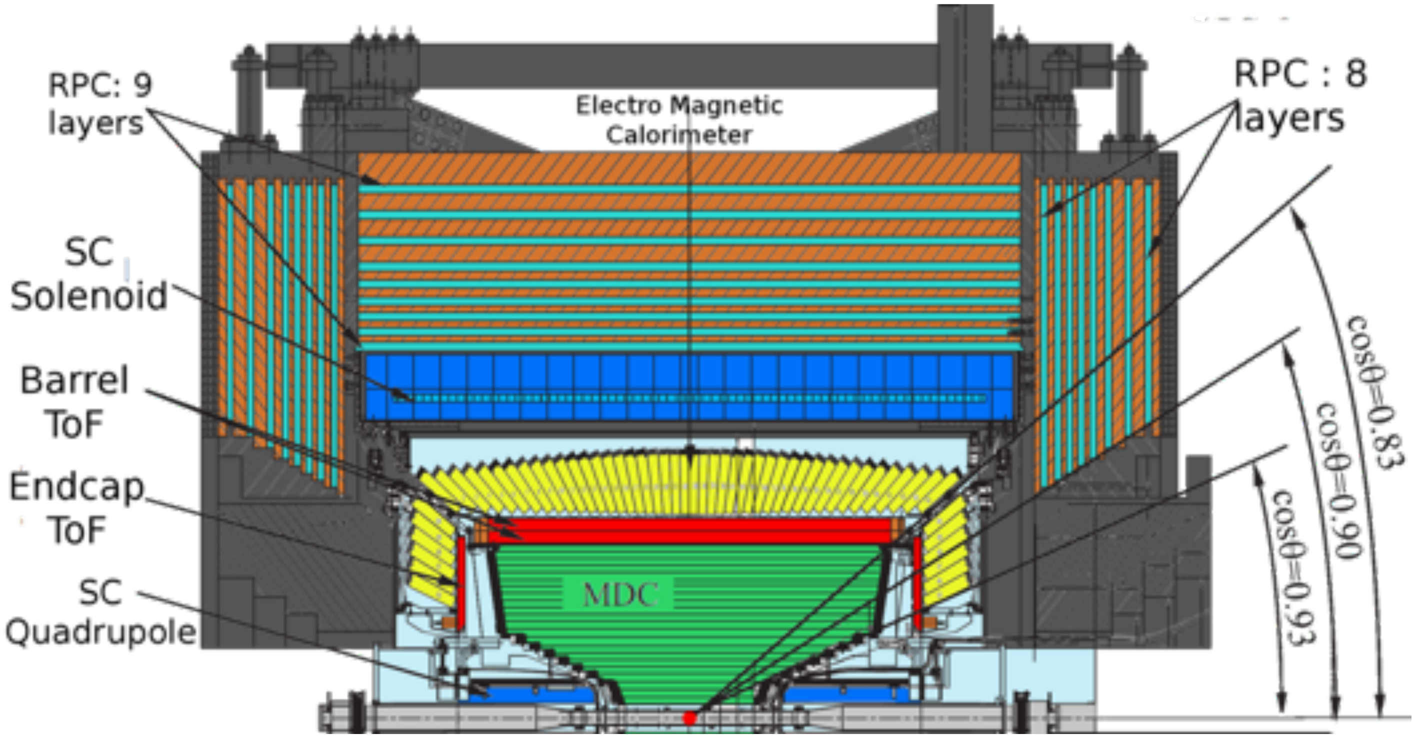
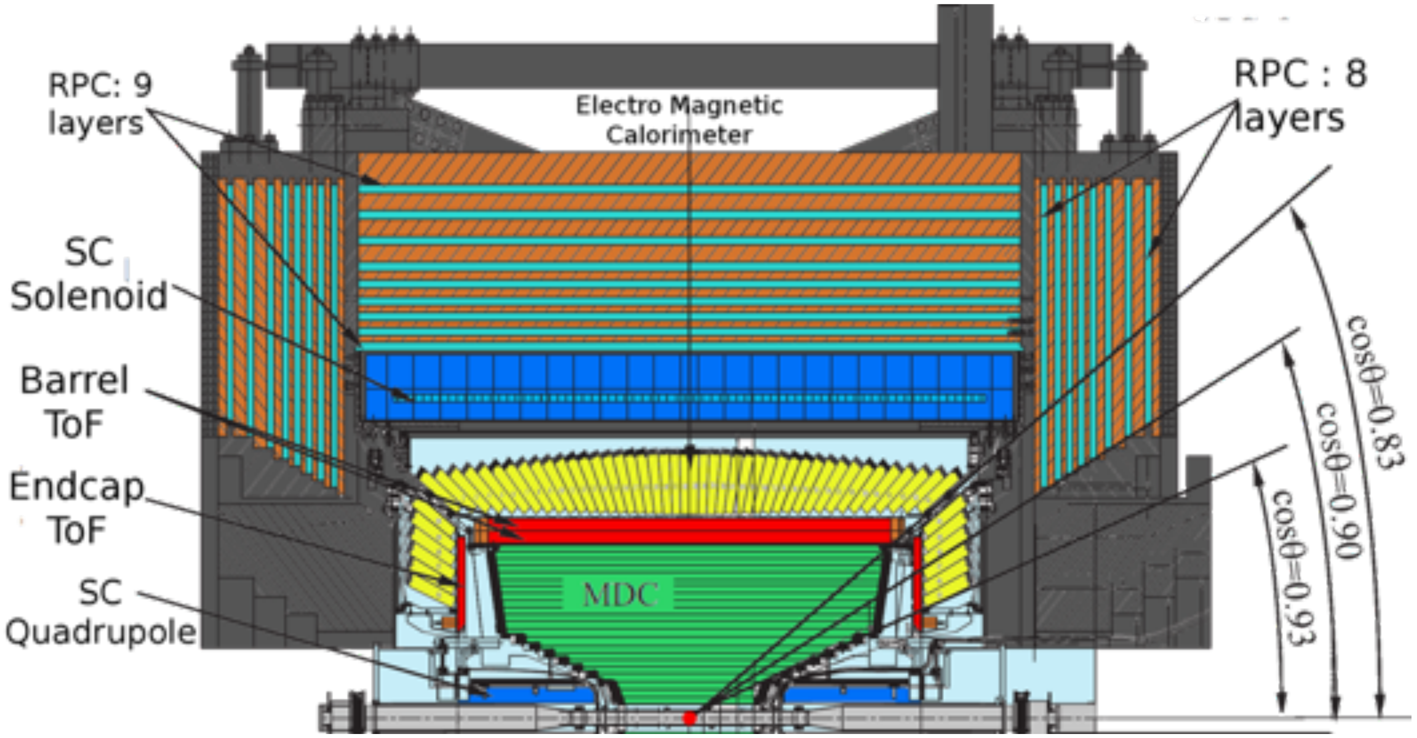


Beijing Electron Spectrometer

BES III detector



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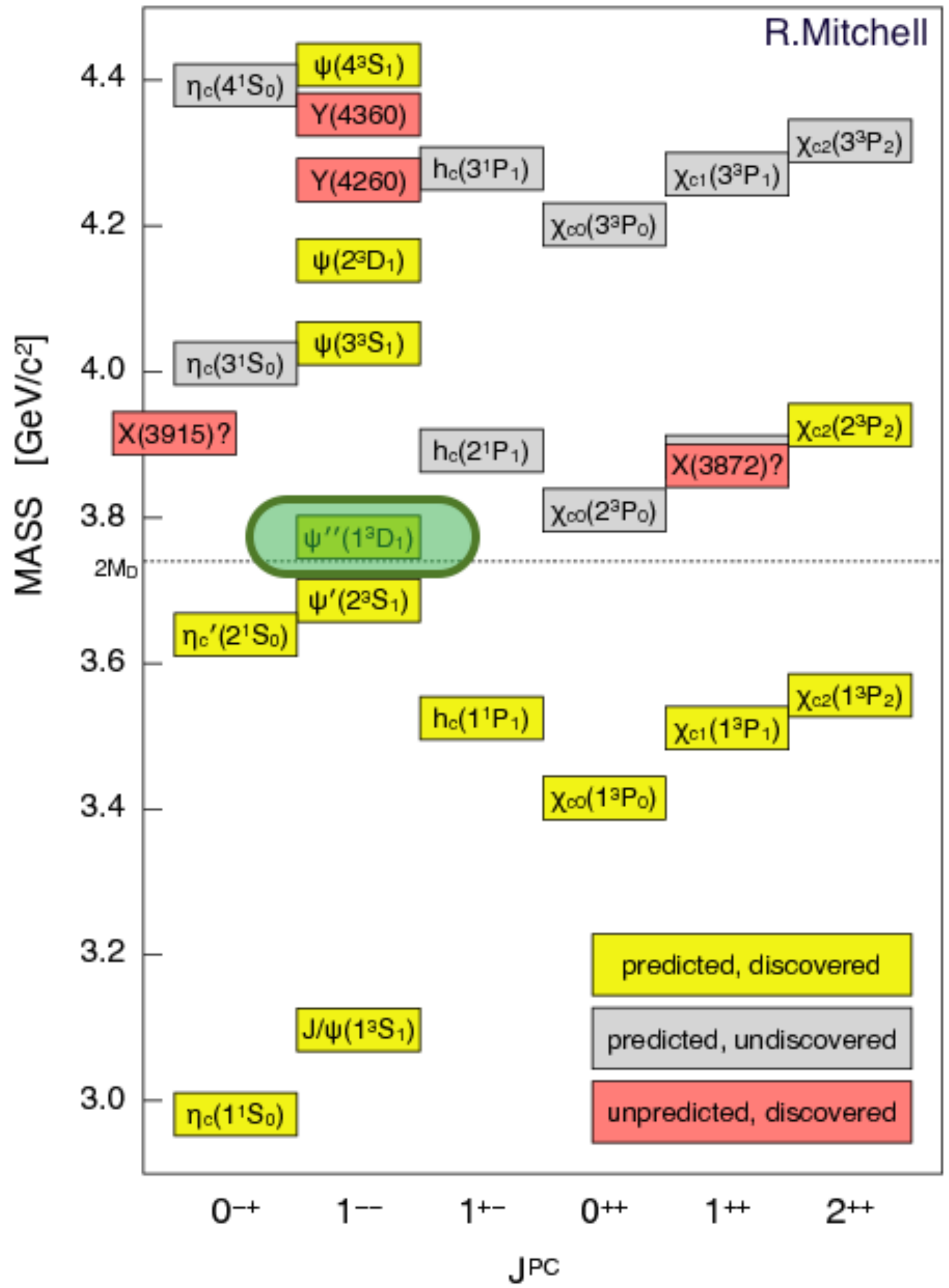

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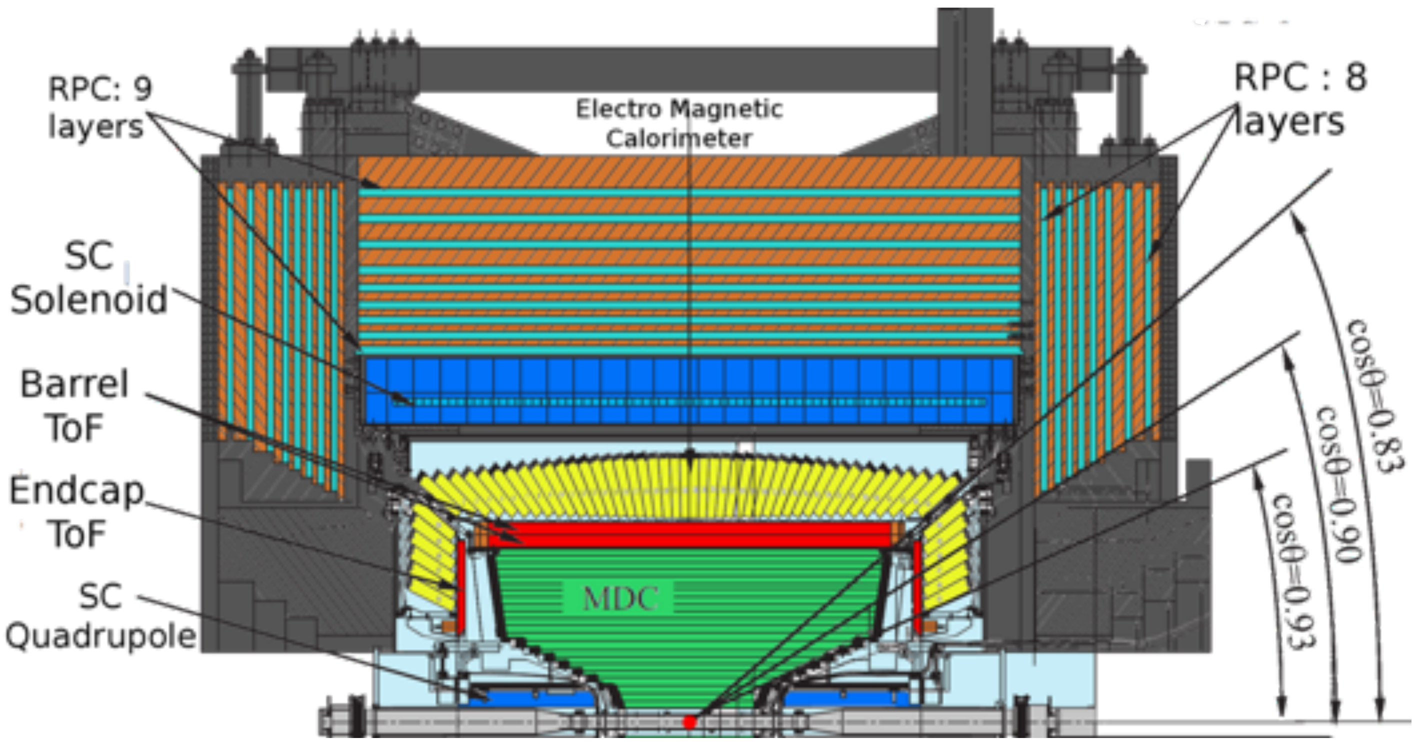

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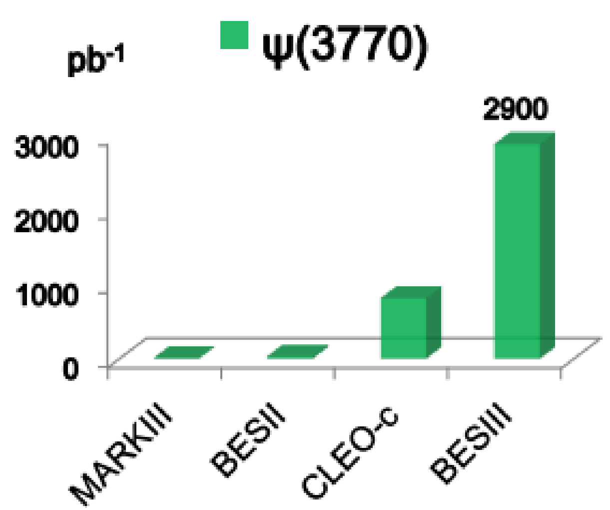
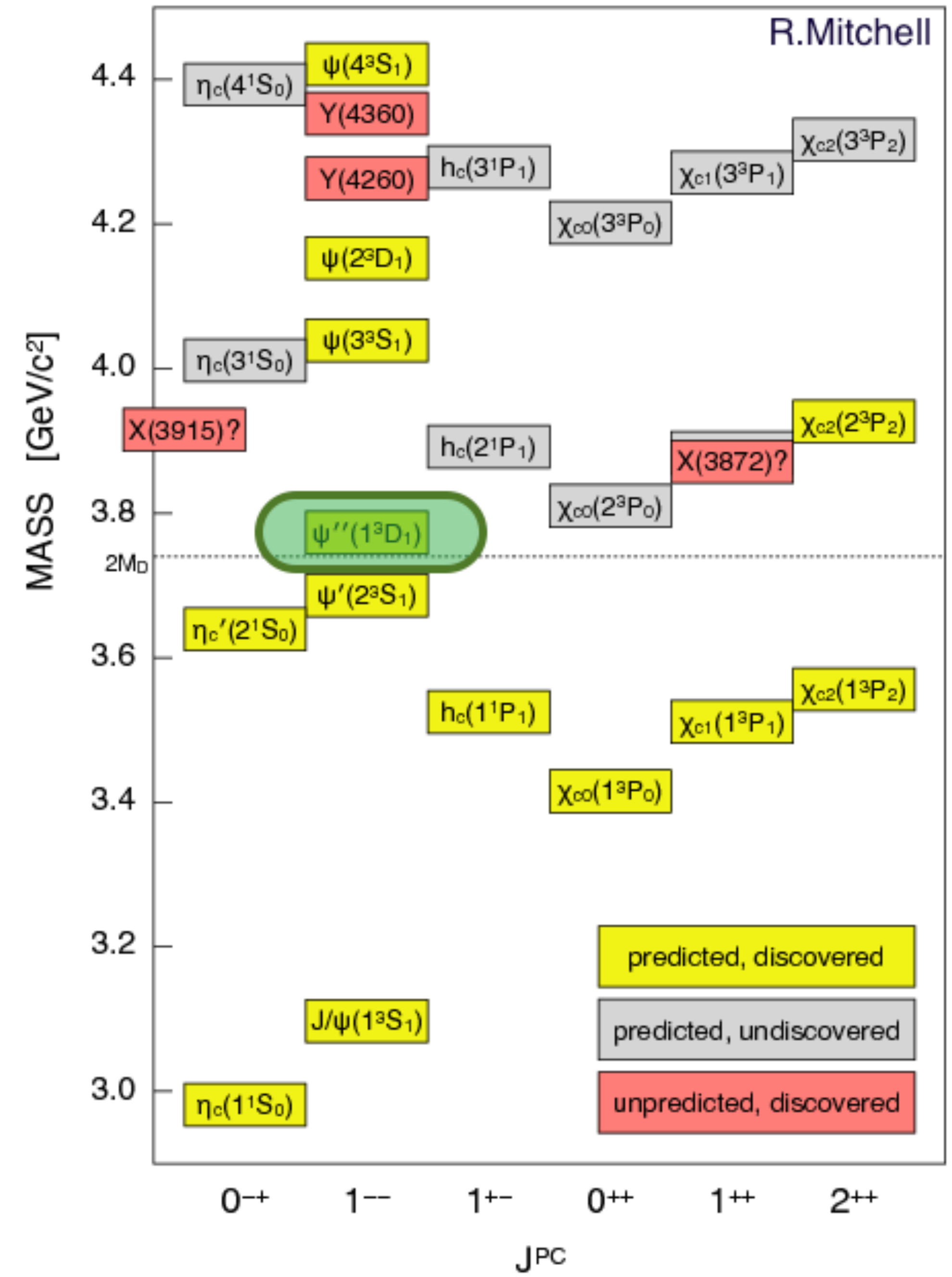


about 3.5 times than CLEO-c



D Tagging

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D Tagging is used for selecting events.

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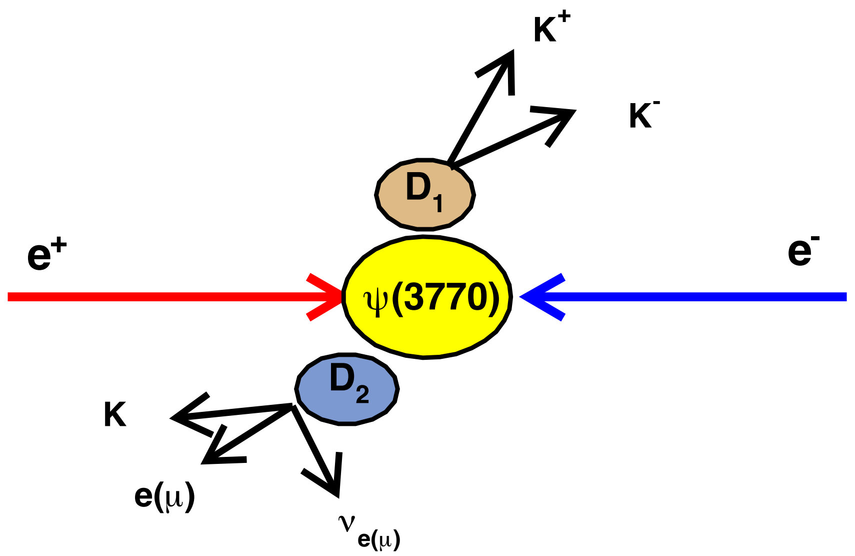

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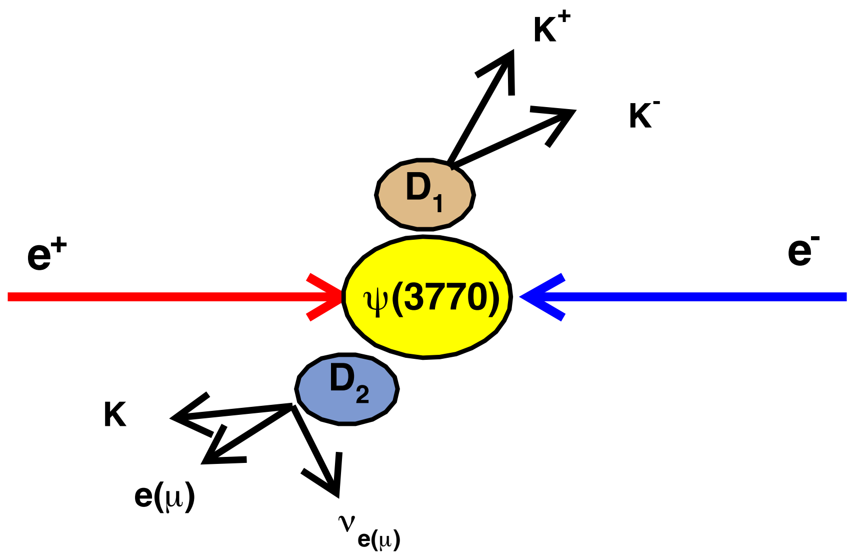
D Tagging is used for selecting events.

Single Tag (ST):

Tag modes are reconstructed requiring a certain window for the ΔE variable and M_{bc} distribution is fit to calculate tag yields.



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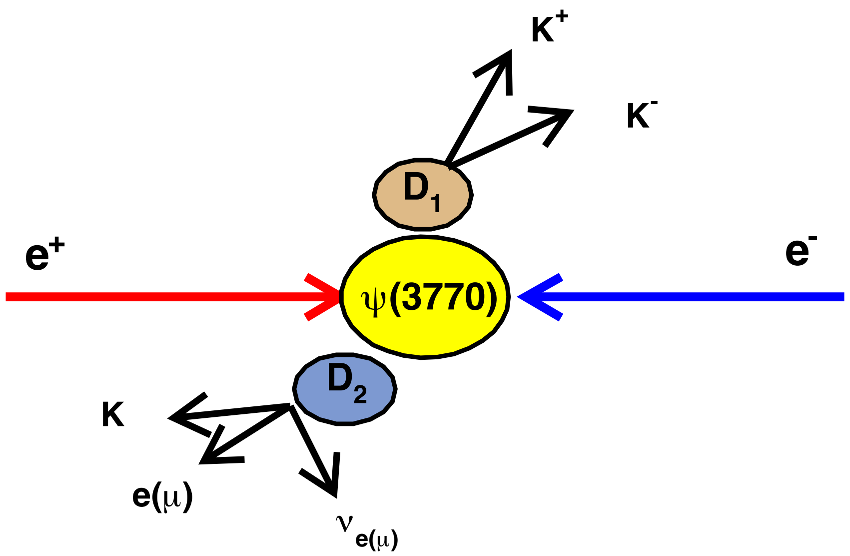

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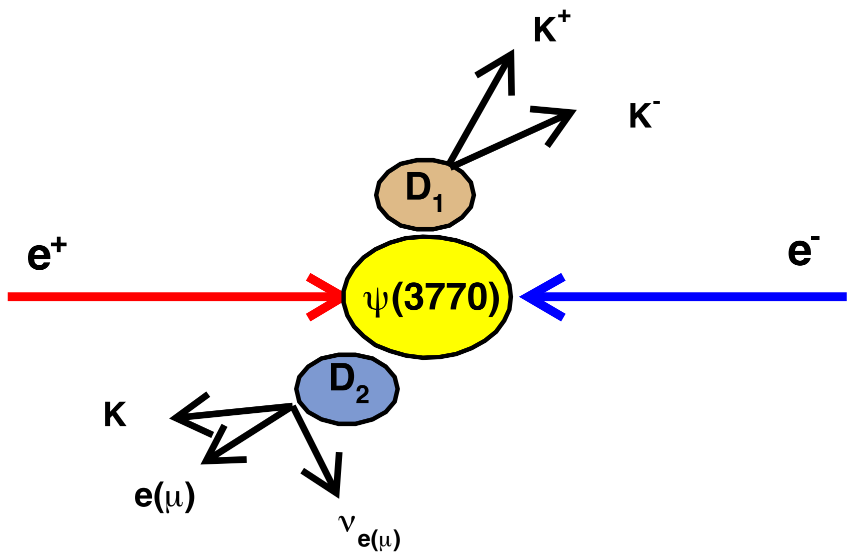

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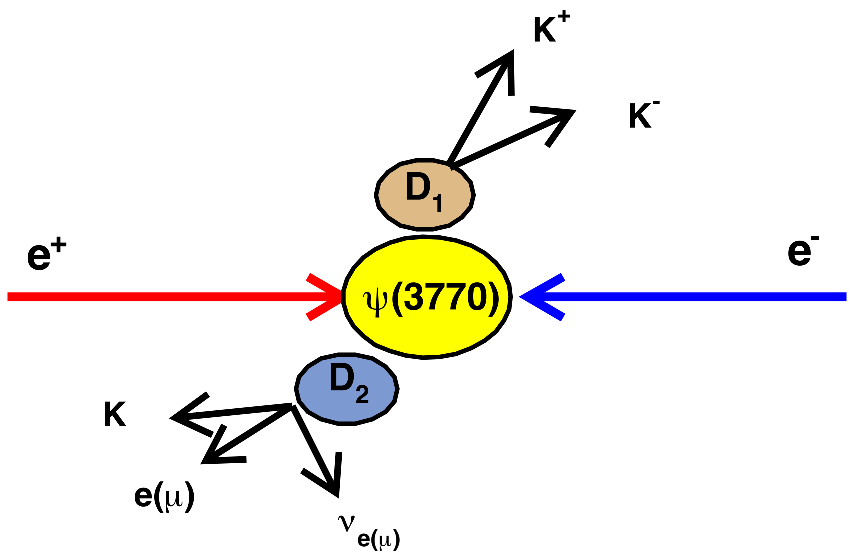

Double Tag (DT):

Depending on the D decay that is being studied M_{bc} or some other variable will be used to calculate double tag yields.

D Tagging

D Tagging

D^-

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

$D^- \to K^+\pi^-\pi^-\pi^0$

$D^- \to K_S^0\pi^-$

$D^- \to K_S^0\pi^-\pi^0$

$D^- \to K_S^0\pi^-\pi^+\pi^-$

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

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

D^0

$$D^0 \to K^-\pi^+$$
$$D^0 \to K^-\pi^+\pi^0$$
$$D^0 \to K^-\pi^+\pi^+\pi^-$$

$$K_S^0 \to \pi^+\pi^-$$
$$\pi^0 \to \gamma\gamma$$

D Tagging

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$$D^0 \to K^-\pi^+\pi^+\pi^-$$

$$K_S^0 \to \pi^+\pi^-$$
$$\pi^0 \to \gamma\gamma$$

Charge-conjugate modes are implied. Tag yields obtained by fitting M_{bc} distribution, about 1.5 million for D^+D^- and 2.2 million for $D^0\bar{D}^0$.

D Tagging

D^-

$$D^- \to K^+\pi^-\pi^-$$
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D^0

$$D^0 \to K^-\pi^+$$
$$D^0 \to K^-\pi^+\pi^0$$
$$D^0 \to K^-\pi^+\pi^+\pi^-$$

$$K^0_S \to \pi^+\pi^-$$
$$\pi^0 \to \gamma\gamma$$

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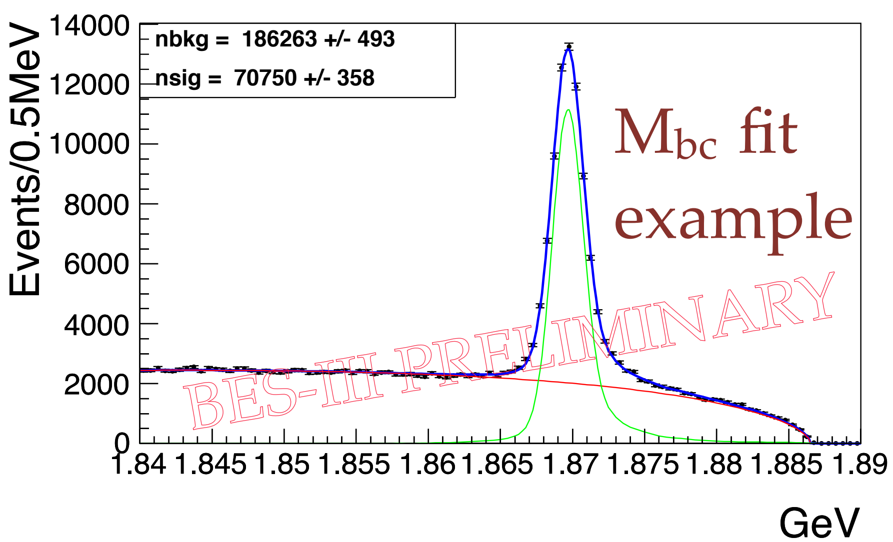

M_{bc} fit example

$\sigma(e^+e^- \to D\bar{D})$ line shape

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Fit the measured cross sections simultaneously using the theoretical cross section

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Fit the measured cross sections simultaneously using the theoretical cross section

$$\sigma^{\mathrm{RC}}_{D\bar{D}}(W) = \int z_{D\bar{D}}(W\sqrt{1-x})\sigma_{D\bar{D}}(W\sqrt{1-x})\mathcal{F}(x, W^2)dx$$

$\sigma(e^+e^- \to D\bar{D})$ line shape

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Coulomb Interaction

$\sigma(e^+e^- \to D\bar{D})$ line shape

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Coulomb Interaction   Born Level

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Coulomb Interaction Born Level ISR

$$\sigma_{D\bar{D}}(W) = \frac{\pi^2\alpha}{3W^2}\beta_D^3|F_D(W)|^2,\ \ F_D(W) = F_D^{\rm R}(W)e^{i\phi_{\rm R}} + F_D^{\rm NR}(W)$$

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Breit-Wigner formula for resonate component

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$$F_D^{\mathrm{R}}(W) = \frac{6W\sqrt{(\Gamma_{ee}/\alpha^2)(\Gamma_{D\bar{D}}(W)/\beta_D^3)}}{M^2 - W^2 - iM\Gamma(W)}, \; \Gamma_{D\bar{D}}(W) = \Gamma(W) \times (1 - \mathcal{B}_{nD\bar{D}})$$

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Two models for non-resonant component

$\sigma(e^+e^- \to D\bar{D})$ line shape

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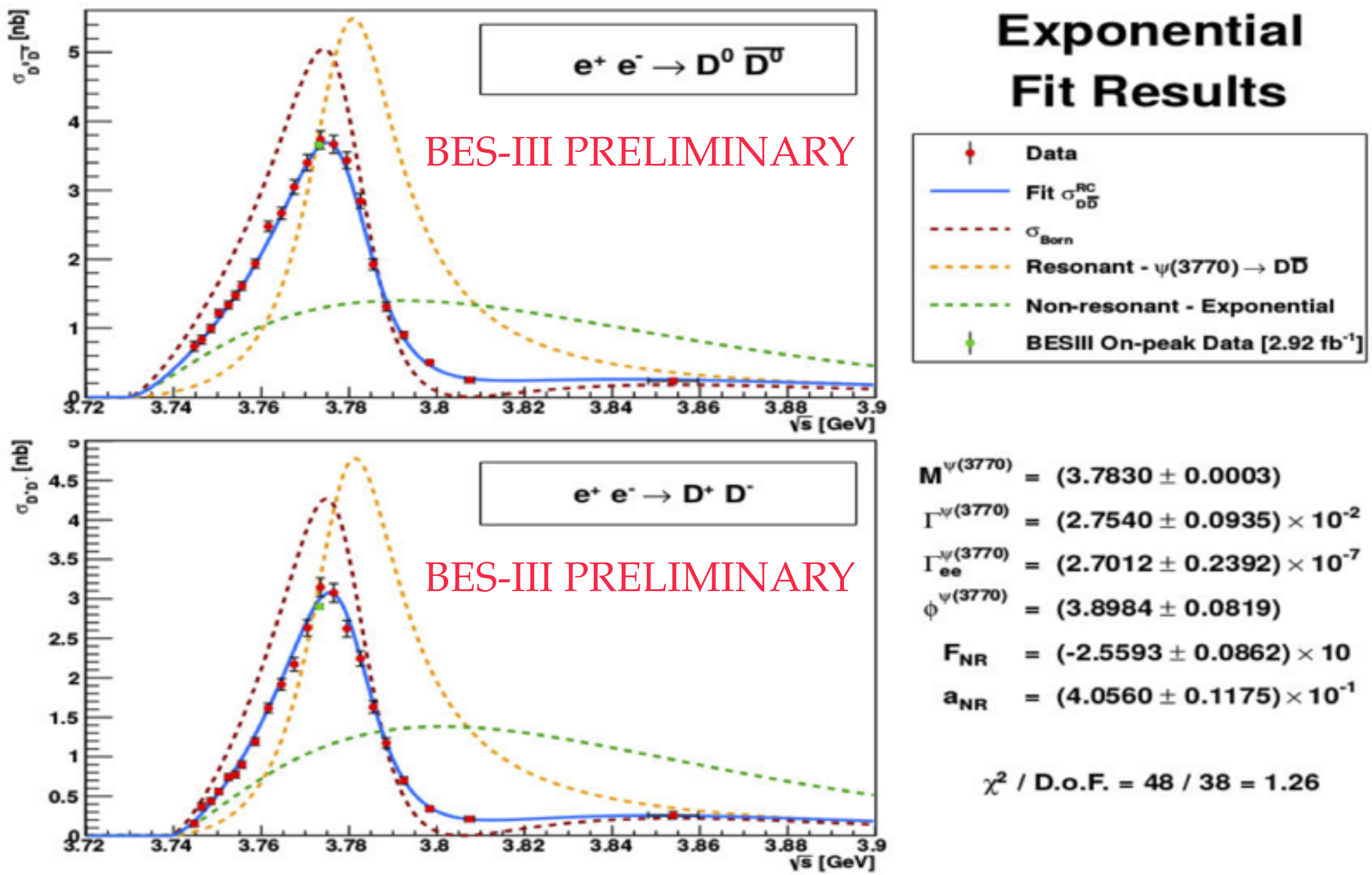
Two models for non-resonant component

- Exponential Model: $F_D^{\rm NR}(W) = F_{\rm NR}\exp(-q_D^2/\alpha_{\rm NR}^2)$
- Vector Dominance Model: $F_D^{\rm NR}(W) = F_D^{\psi(2S)}(W) + F_0$

$\sigma(e^+e^- \to D\bar{D})$ line shape



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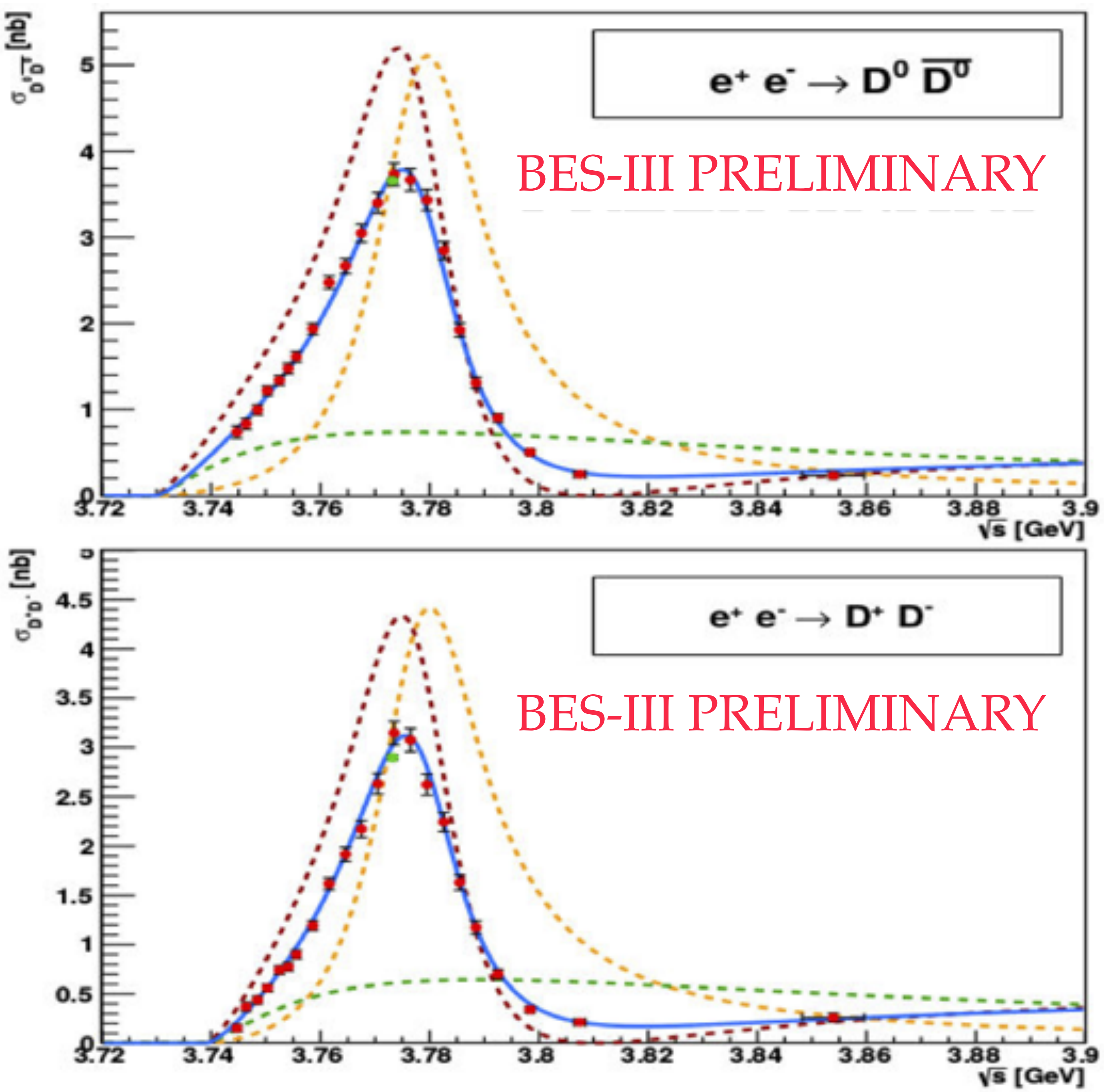
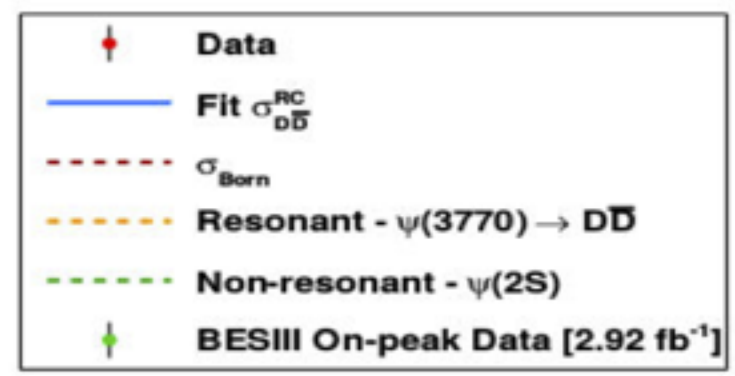


VDM Fit Results



$M^{\psi(3770)} = (3.7815 \pm 0.0003)$

$\Gamma^{\psi(3770)} = (2.5244 \pm 0.0683) \times 10^{-2}$

$\Gamma_{ee}^{\psi(3770)} = (2.2993 \pm 0.1800) \times 10^{-7}$

$\phi^{\psi(3770)} = (3.6388 \pm 0.0785)$

$\Gamma^{\psi(2S)} = (2.0895 \pm 0.1784) \times 10^{-2}$

$F_0 = (-1.8035 \pm 0.4623)$

χ^2 / D.o.F. = 50 / 38 = 1.33

$\sigma(e^+e^- \to D\bar{D})$ line shape

$$\Gamma_{ee}^{\psi(3770)\to D\bar{D}} = \Gamma_{ee}^{\psi(3770)} \times \mathcal{B}(\psi(3770) \to D\bar{D})$$

Source	$M_{\psi(3770)}$ [MeV/c²]	$\Gamma_{\psi(3770)}$ [MeV]	$\Gamma_{ee}^{\psi(3770)\to D\bar{D}}$ [eV]
Exponential	3783.0 ± 0.3	27.5 ± 0.9	270 ± 24
VDM	3781.5 ± 0.3	25.2 ± 0.7	230 ± 18
KEDR	$3779.3^{+1.8}_{-1.7}$	$25.3^{+4.4}_{-3.9}$	160^{+78}_{-58} 420^{+72}_{-80}
PDG	3773.2 ± 0.3	27.2 ± 1.0	$(262 \pm 18) \times \mathcal{B}_{D\bar{D}}$

BES-III PRELIMINARY

$\sigma(e^+e^- \to D\bar{D})$ line shape

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Our preliminary results are consistent with those measured at KEDR.

First Observation of
Singly Cabibbo-Suppressed decay

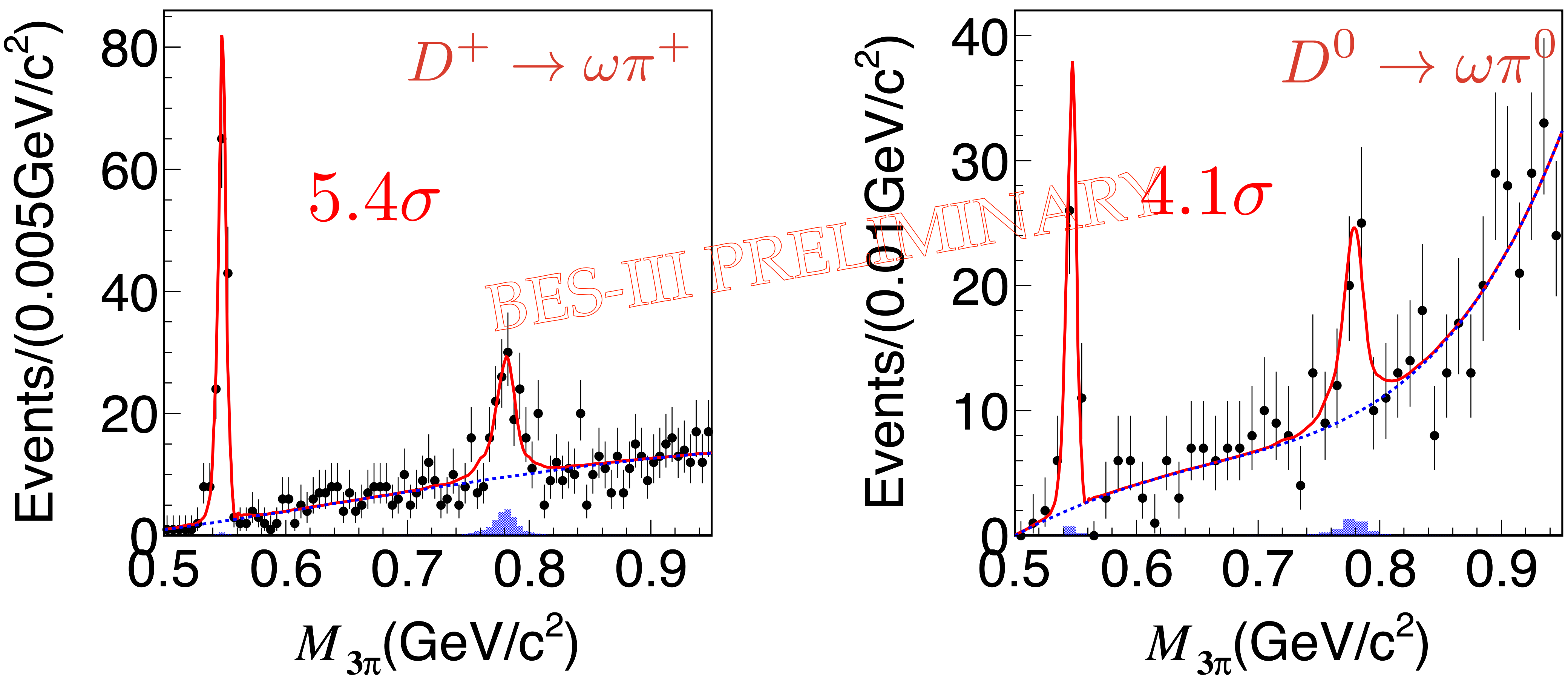
$D^+ \to \omega\pi^+$

and

Evidence in

$D^0 \to \omega\pi^0$

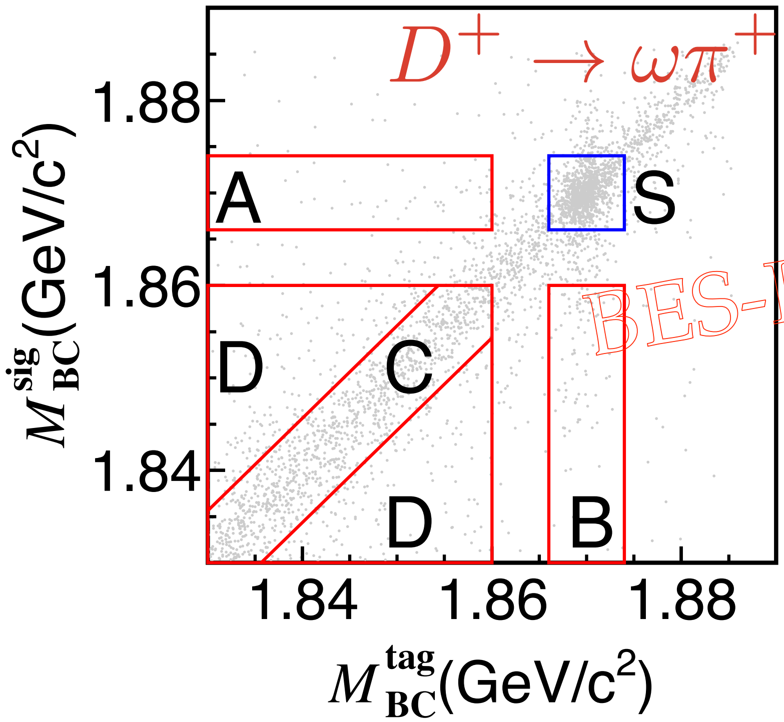
$D^{+(0)} \to \omega\pi^{+(0)}$

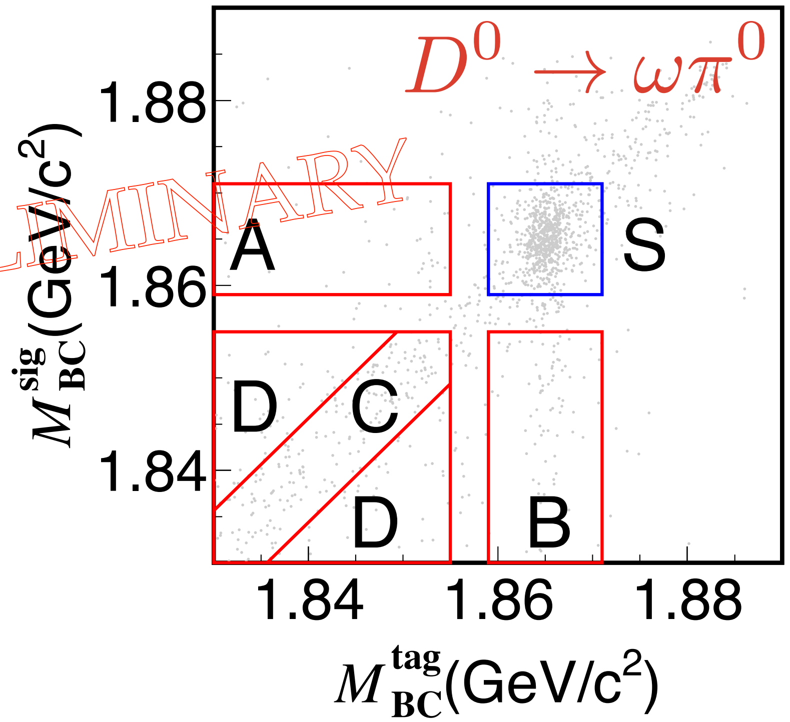


- Signal: MC shape convoluted with Gaussian
- Background: Polynomial (dashed line)
- Peaking background: Mainly come from $q\bar{q}$ process, estimated from 2D M_{bc} sidebands (filled histograms)

$D^{+(0)} \to \omega\pi^{+(0)}$

Peaking background estimated from sidebands (mainly come from q$\bar{\text{q}}$ process)





$$Y = (S - D \cdot \frac{AreaS}{AreaD}) - scaleA \cdot (A - D \cdot \frac{AreaA}{AreaD})$$
$$- scaleB \cdot (B - D \cdot \frac{AreaB}{AreaD}) - scaleC \cdot (C - D \cdot \frac{AreaC}{AreaD})$$
$$scale(A,B) = N_{Argus}(S)/N_{Argus}(A,B) \quad scaleC = (scaleA + scaleB)/2$$

$D^{+(0)} \to \omega\pi^{+(0)}$

Category	N_{sig}	$\mathcal{B}$ this work	$\mathcal{B}$ PDG
$D^+ \to \omega\pi^+$	76 ± 16	$(2.74 \pm 0.58 \pm 0.17) \times 10^{-4}$	$< 3.4 \times 10^{-4}$@90%CL
$D^0 \to \omega\pi^0$	36 ± 14	$(1.05 \pm 0.41 \pm 0.09) \times 10^{-4}$	$< 2.6 \times 10^{-4}$@90%CL
$D^+ \to \eta\pi^+$	256 ± 18	$(3.13 \pm 0.22 \pm 0.19) \times 10^{-3}$	$(3.53 \pm 0.21) \times 10^{-3}$
$D^0 \to \eta\pi^0$	68 ± 10	$(0.67 \pm 0.10 \pm 0.05) \times 10^{-3}$	$(0.68 \pm 0.07) \times 10^{-3}$

BES-III PRELIMINARY

$D^0 \to K_S^0 K^+ K^-$

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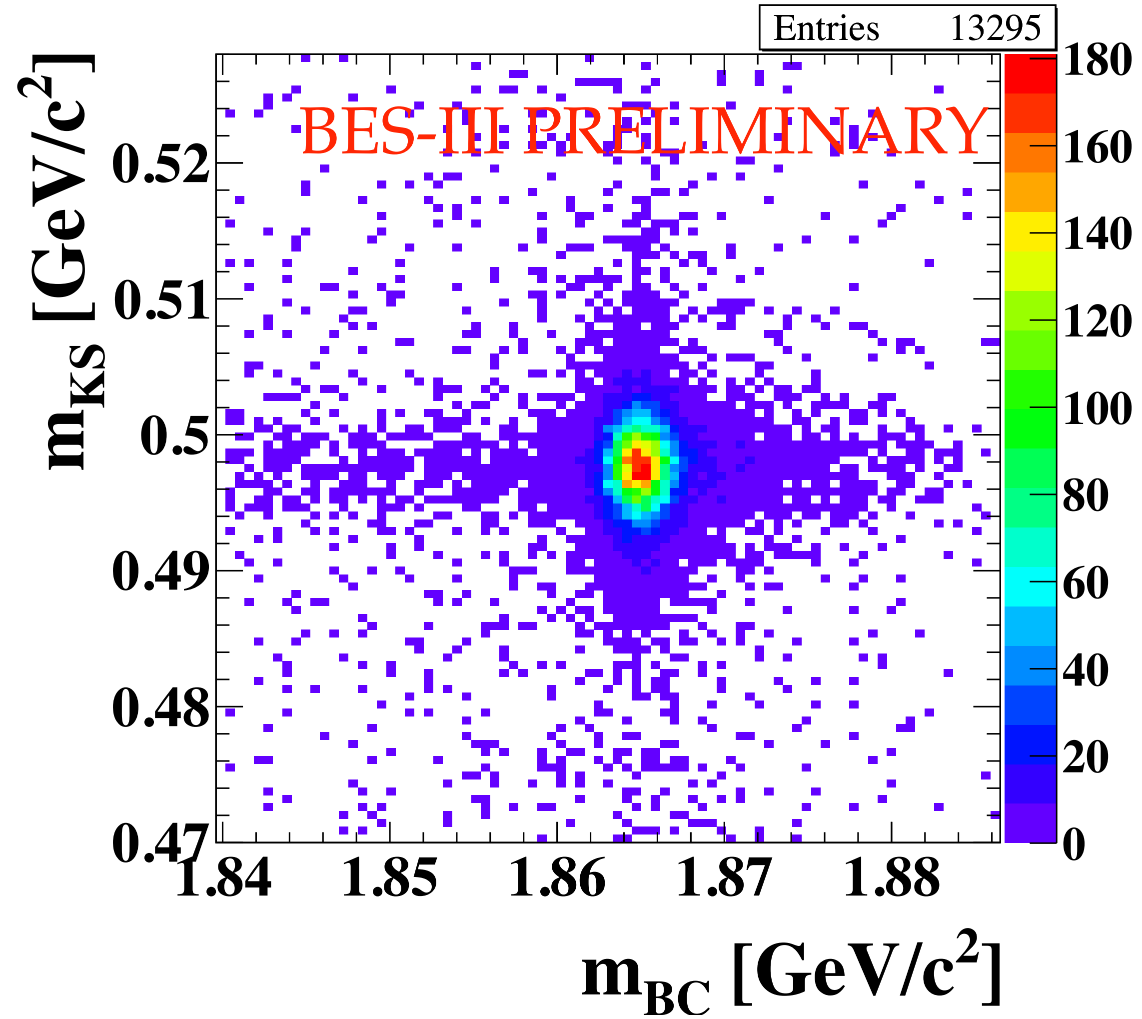
$$\mathcal{B}(D^0 \to K_S^0 K^+ K^-) = \frac{N_{sig}}{\epsilon \cdot \mathcal{B}(K_S^0 \to \pi\pi) \cdot \mathcal{L} \cdot 2\sigma_{D^0 \bar{D}^0}}$$

$D^0 \to K_S^0 K^+ K^-$

$$\mathcal{B}(D^0 \to K_S^0 K^+ K^-) = \frac{N_{sig}}{\epsilon \cdot \mathcal{B}(K_S^0 \to \pi\pi) \cdot \mathcal{L} \cdot 2\sigma_{D^0 \bar{D}^0}}$$

2 Dimensional plot
in the space of
M_{bc} and m_{Ks}



$D^0 \to K_S^0 K^+ K^-$

- 2 Dimensional fit is performed in the space of M_{bc} and m_{Ks}
- Signal and background modeling
  - Signal:

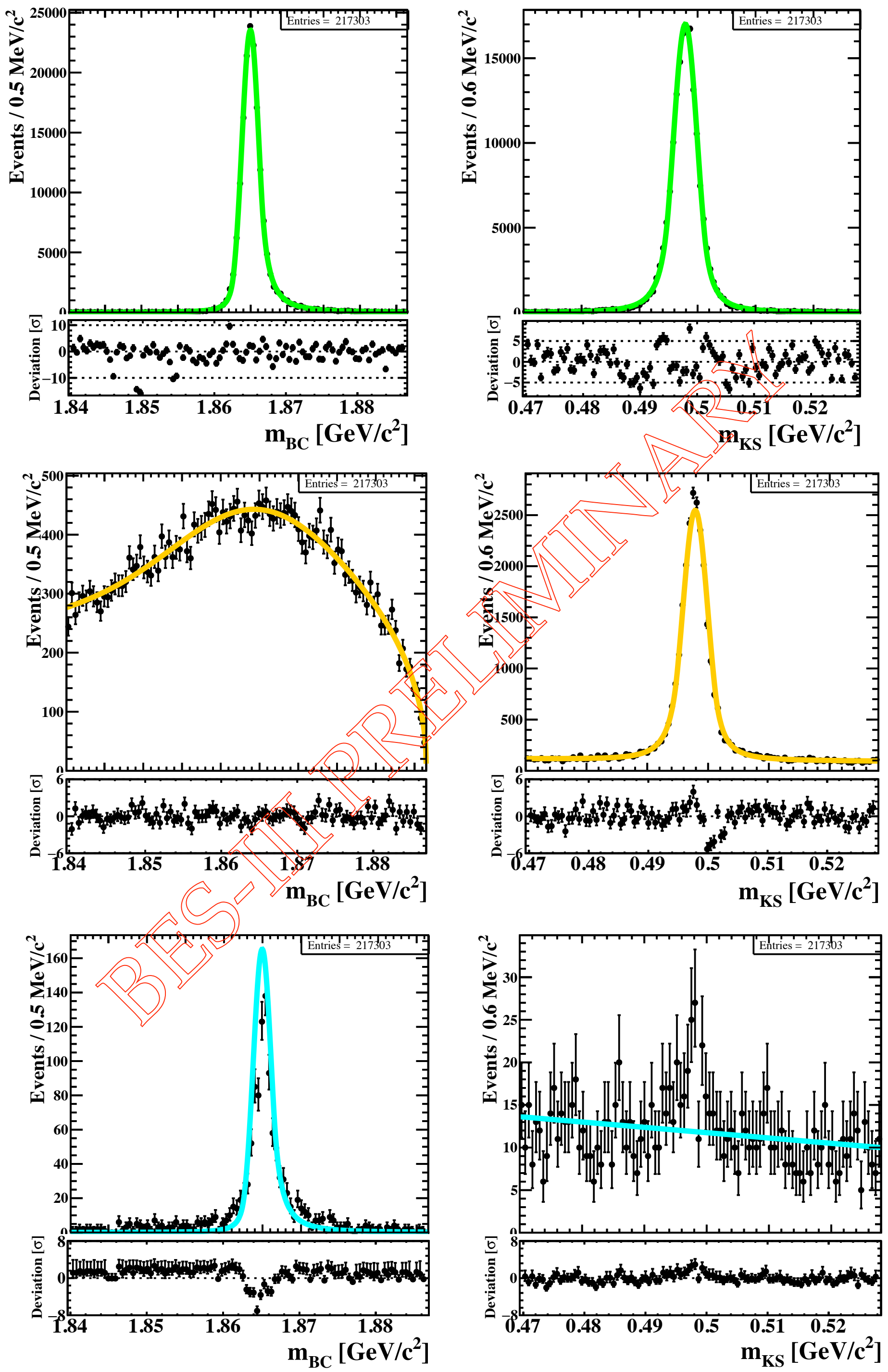
    $$\mathrm{CB}(\mathrm{M_{bc}}) \times \mathrm{Gauss}(\mathrm{m_{K_S^0}})$$

  - background (Ks):

    $$(\mathrm{Argus} + \mathrm{Gauss})(\mathrm{M_{bc}}) \times (\mathrm{Gauss} + \mathrm{Pol})(\mathrm{m_{K_S^0}})$$

  - background (non-Ks):

    $$\mathrm{CB}(\mathrm{M_{bc}}) \times \mathrm{Pol}(\mathrm{m_{K_S^0}})$$



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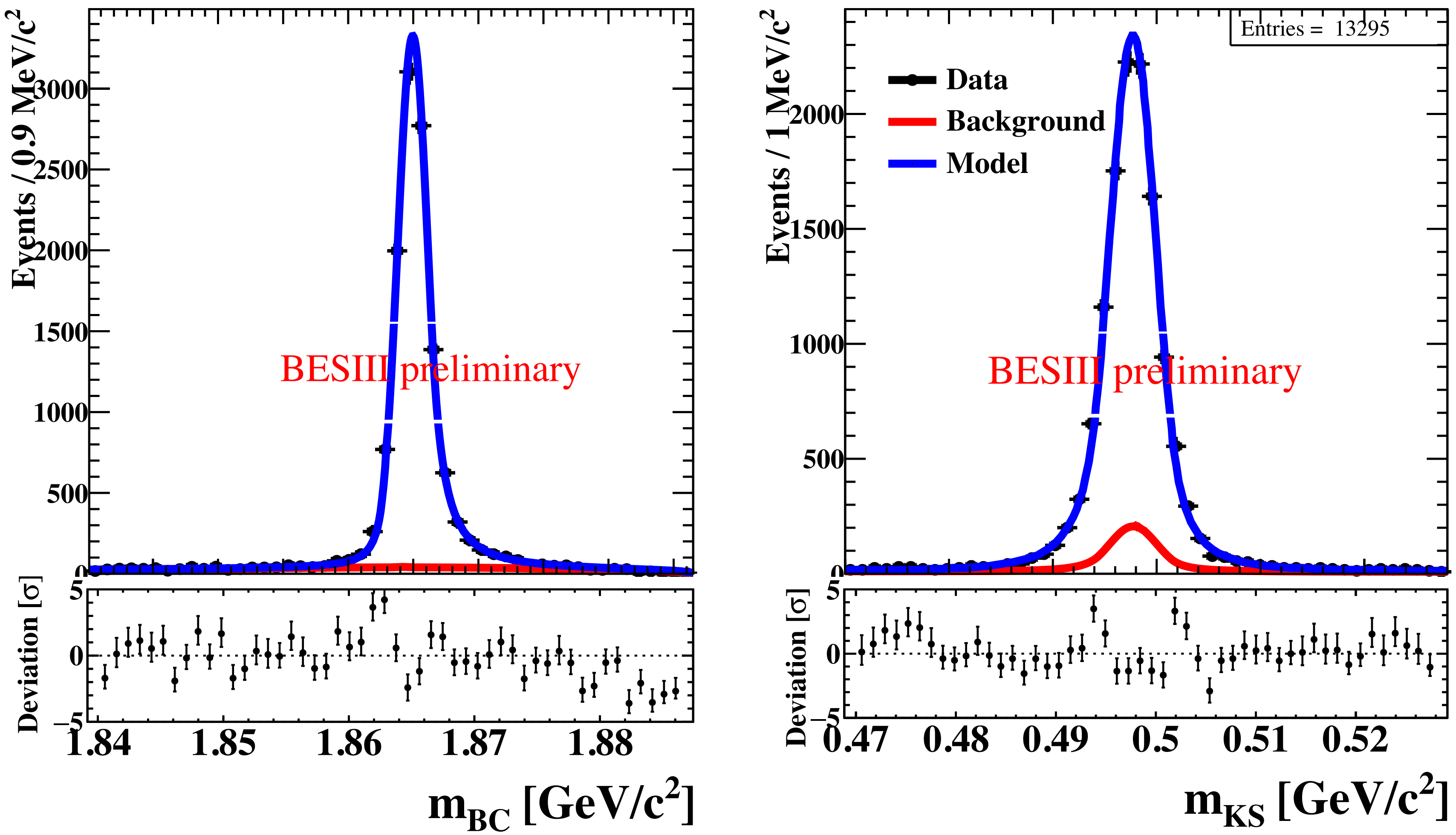
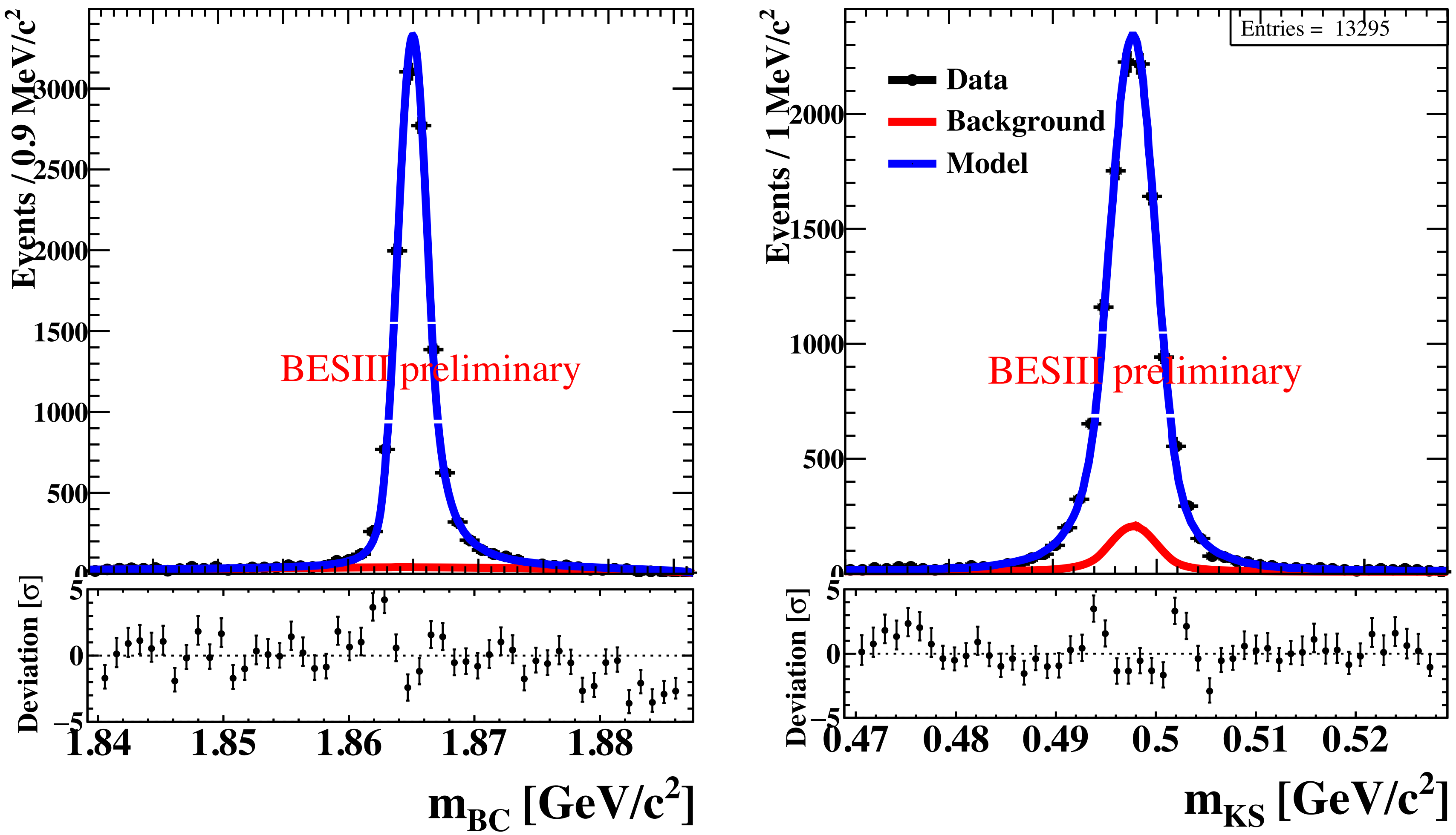


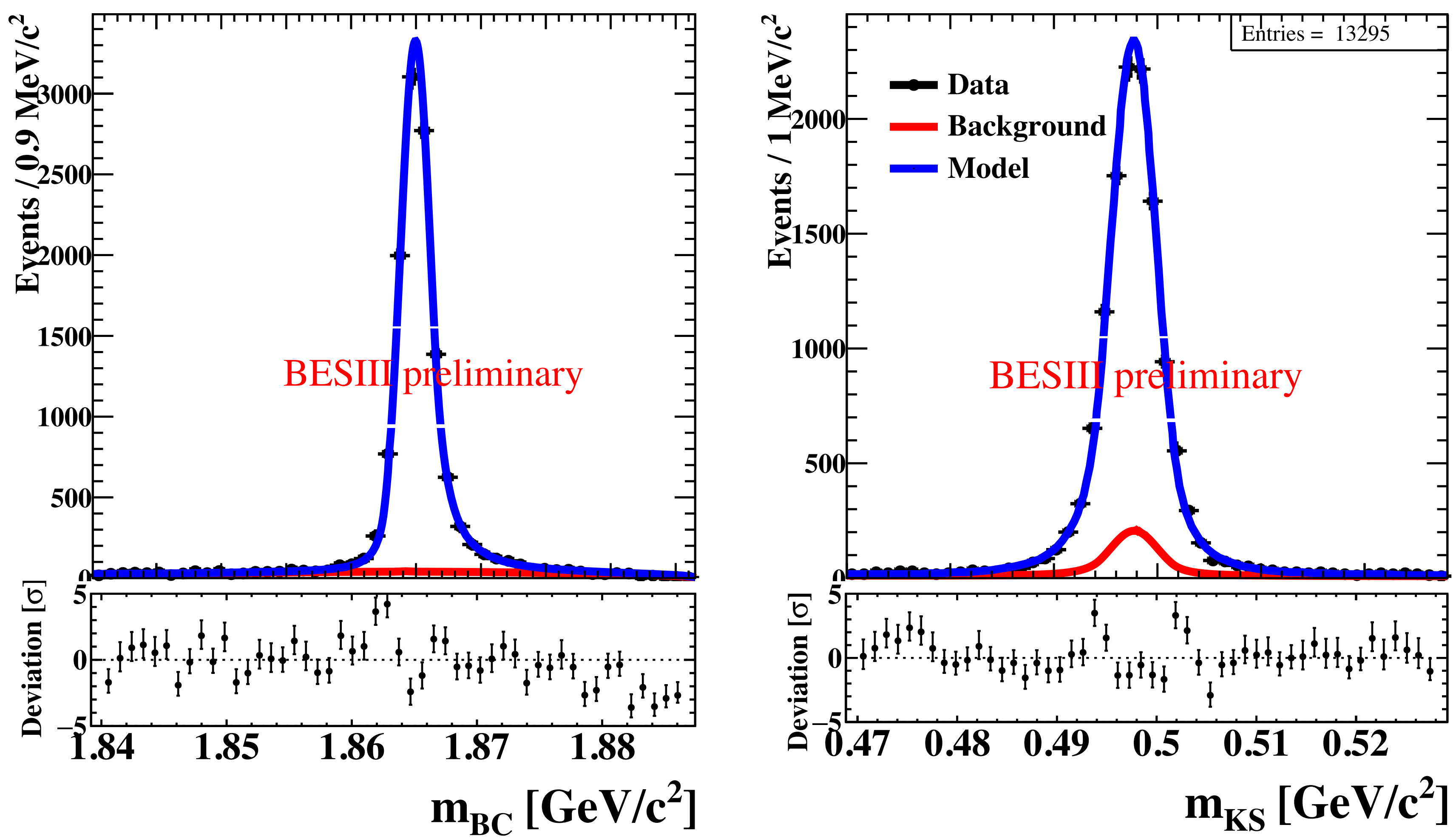
Events / 0.9 MeV/c²
BESIII preliminary
Deviation [σ]
m_BC [GeV/c²]
Events / 1 MeV/c²
Entries = 13295
Data
Background
Model
BESIII preliminary
m_KS [GeV/c²]

$D^0 \to K_S^0 K^+ K^-$



$$N_{\mathrm{sig}} = 11743 \pm 113$$

$D^0 \to K_S^0 K^+ K^-$



$$N_{\text{sig}} = 11743 \pm 113$$

$$\mathcal{B}(D^0 \to K_S^0 K^+ K^-) = (4.622 \pm 0.045 \pm 0.181) \times 10^{-3}$$

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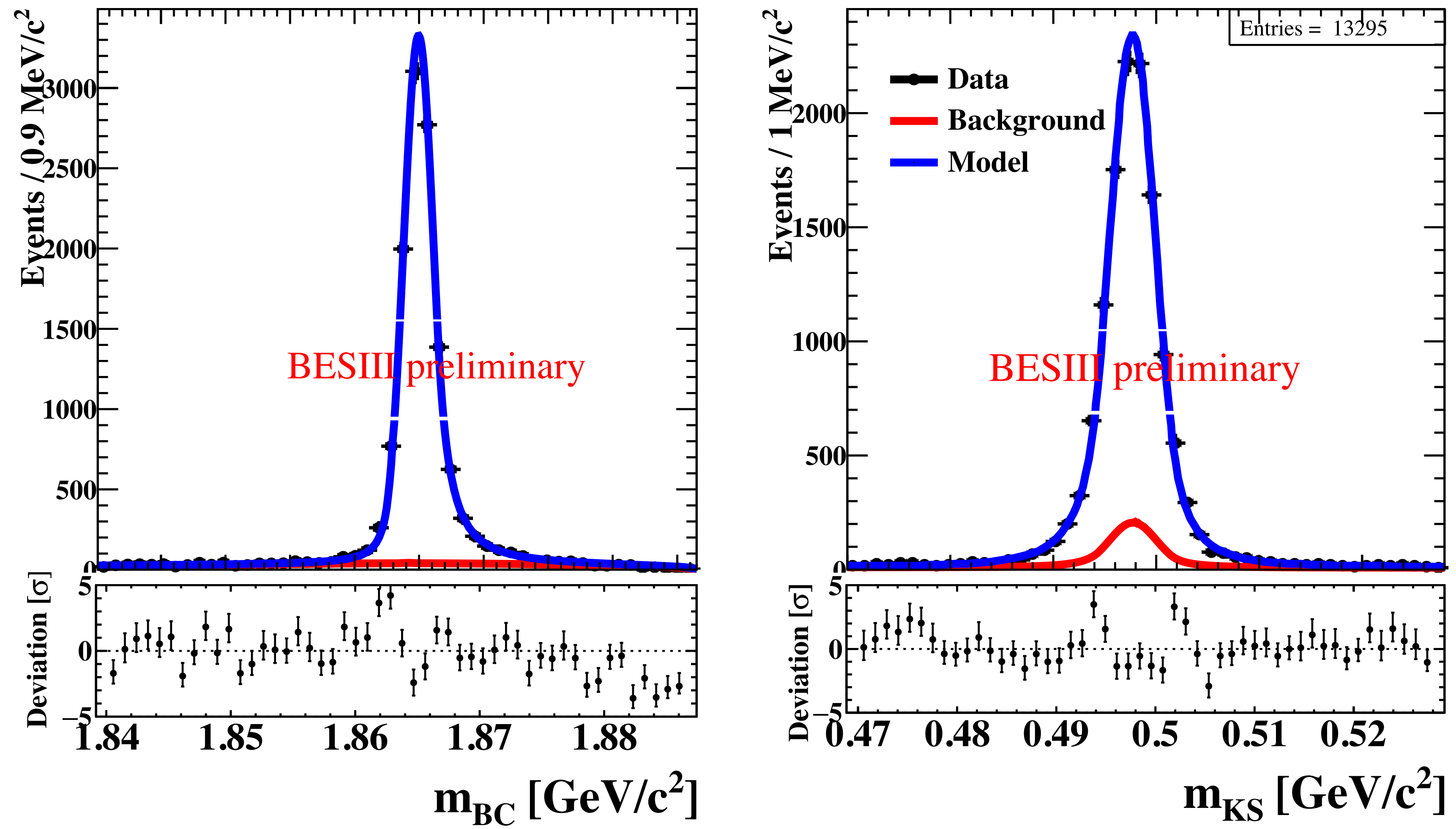

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PDG(2014): $(4.47 \pm 0.34) \times 10^{-3}$

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- Double tag method
- Observation of $D^+ \to \omega\pi^+$: 5.4σ
- Evidence of $D^0 \to \omega\pi^0$: 4.1σ
- $D^{+(0)} \to \eta\pi^{+(0)}$ consistent with PDG

Decay mode	This work
$D^+ \to \omega\pi^+$	$(2.74 \pm 0.58 \pm 0.17) \times 10^{-4}$
$D^0 \to \omega\pi^0$	$(1.05 \pm 0.41 \pm 0.09) \times 10^{-4}$
$D^+ \to \eta\pi^+$	$(3.13 \pm 0.22 \pm 0.19) \times 10^{-3}$
$D^0 \to \eta\pi^0$	$(0.67 \pm 0.10 \pm 0.05) \times 10^{-3}$

BES-III PRELIMINARY

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BES-III PRELIMINARY

$D^0 \to K^0_S K^+ K^-$

- Single tag method
- Preliminary result

$$\mathcal{B} = (4.622 \pm 0.045 \pm 0.181) \times 10^{-3}$$

- Dalitz plot analysis ongoing in order to study substructure: e.g. $a_0(980)$

Thank you!

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