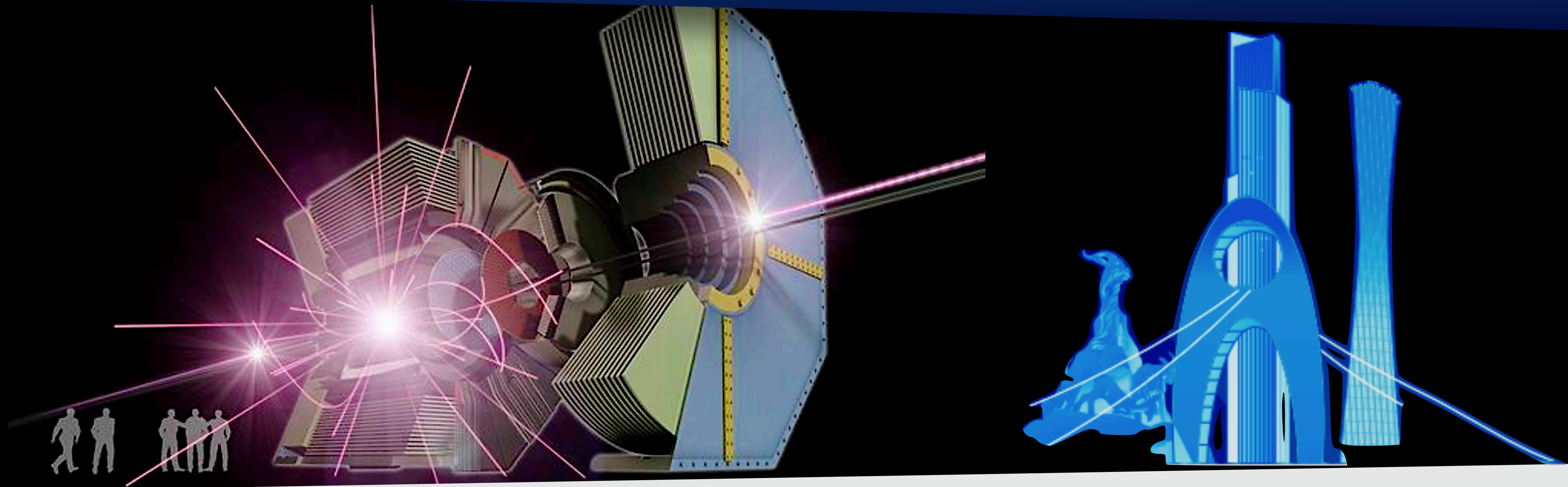


Highlights of B Physics Results from Belle II



曹璐

2026年7月15日

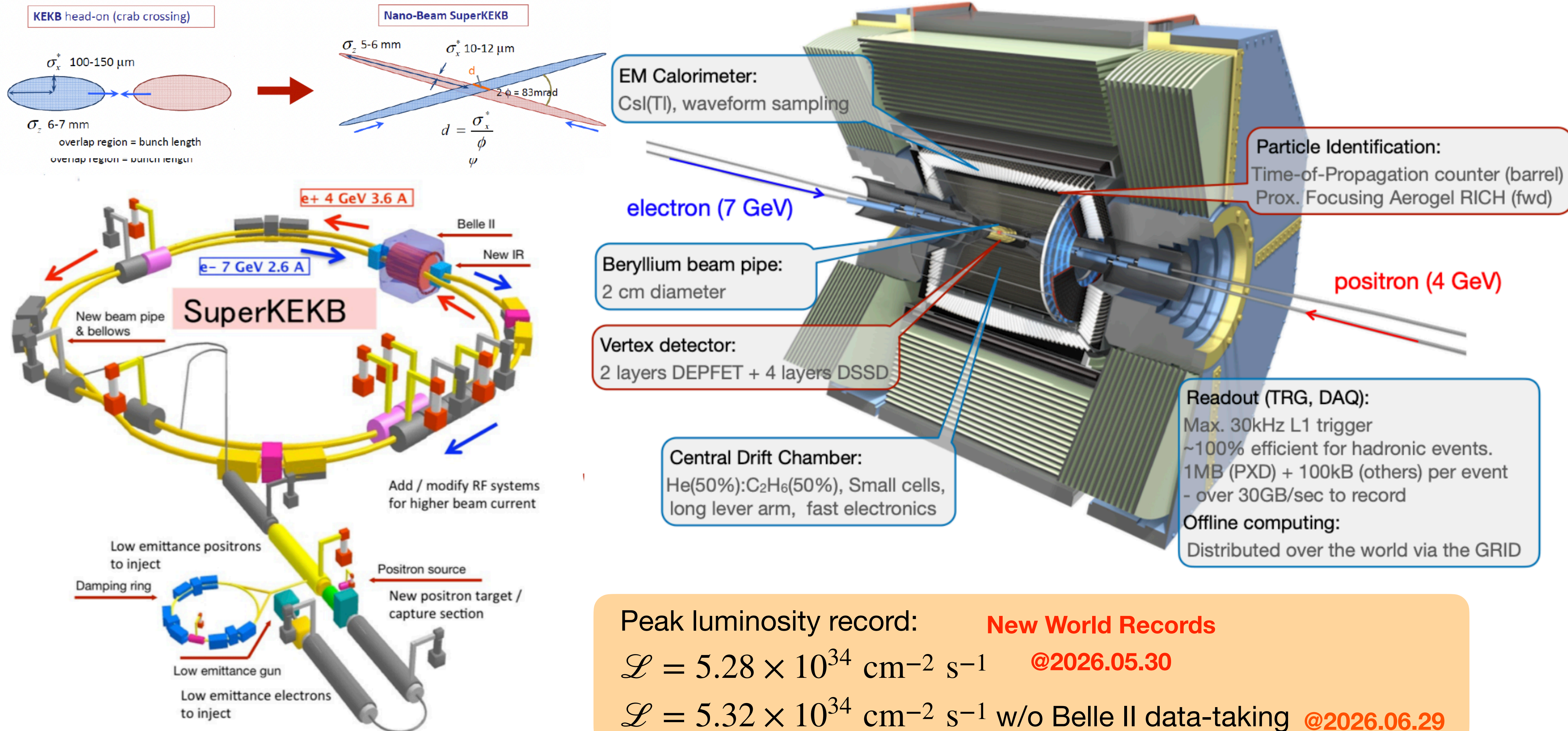
中国物理学会高能物理分会
HIGH ENERGY PHYSICS BRANCH OF CPS



华南师范大学

中国物理学会高能物理分会
第十二届全国会员代表大会暨学术年会

Belle II Experiment @ SuperKEKB



Belle II Luminosity

Recorded Luminosity

427.8 fb⁻¹
Run1
(offline)

151.4 fb⁻¹
2024abc
(offline)

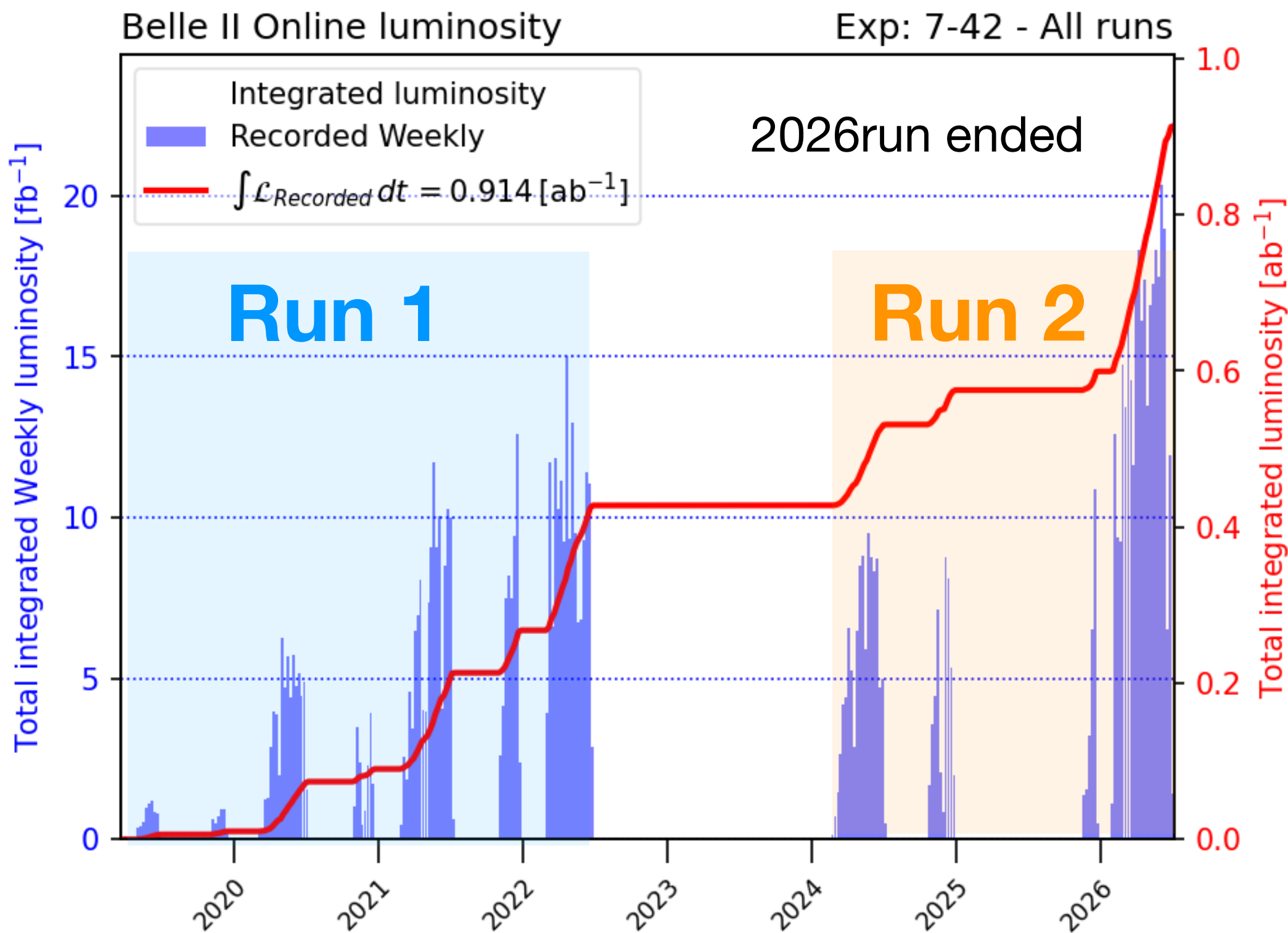
+ 338.5 fb⁻¹
2025c, 2026ab
(online)

= 917.7 fb⁻¹

365 fb⁻¹

~444 fb⁻¹

=> Tot. 809 fb⁻¹ at $\Upsilon(4S)$
Belle 711 fb⁻¹



Belle II accumulates the world's largest $\Upsilon(4S)$ dataset

for more precise searches for new physics beyond the Standard Model



Topics Covered in This Talk

Recent highlights in B physics:

- $R(D^{(*)})$ with had. tag *preliminary*
- $B \rightarrow \mu\nu$ [PRD 113, 112012 \(2026\)](#)
- $B \rightarrow X_u \ell \nu$ [PRD 113, 032004 \(2026\)](#)
- $B \rightarrow \pi^0 \pi^0$ [2606.20797](#) *preliminary*
- $B^+ \rightarrow \Sigma_c(2455)^{++} \bar{\Xi}_c'^-, B^0 \rightarrow \Sigma_c(2455)^0 \bar{\Xi}_c'^0$ [2606.12905](#) *preliminary*

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- $B^+ \rightarrow \Sigma_c(2455)^{++} \bar{\Xi}_c'^-, B^0 \rightarrow \Sigma_c(2455)^0 \bar{\Xi}_c'^0$



Belle II实验的进展

👤 XiaoLong Wang (Fudan University)

🕒 7/17/26, 8:30 AM

分会邀请报告

分会2: 强子物理与味物理

周五



tau physics at Belle II

👤 Chunhua Li (Nanjing Normal Uni...)

🕒 7/16/26, 9:35 AM

分会报告

分会2: 强子物理与味物理

周四



Recent Charm Results at Belle II

👤 Dr Longke 龙科 Li 李 (Hunan Normal Univ...)

🕒 7/17/26, 9:50 AM

分会报告

分会2: 强子物理与味物理

周五

Lepton-Flavor Universality Test

- In SM, the W boson couples equally to $\tau, \mu, e \Rightarrow$ **Lepton-Flavor Universality (LFU)**
- Semileptonic B decays are sensitive to new physics beyond SM
- **Ratio measurements** provide stringent LFU tests: branching fractions, angular asymmetry, etc.
 - Normalization ($|V_{xb}|$) cancels
 - Part of theoretical, experimental uncertainties cancels

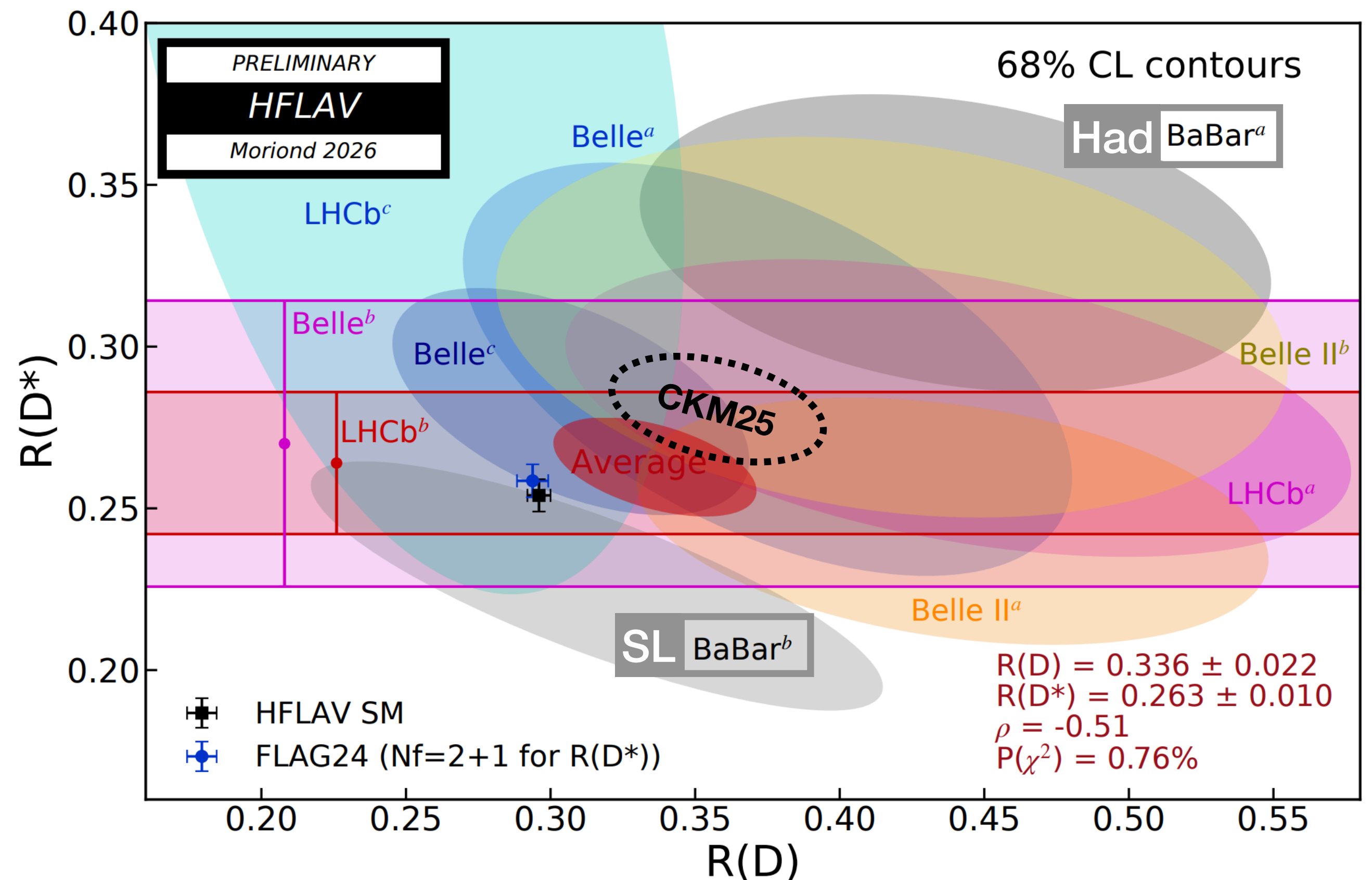
$$R(H_{\tau/\ell}) = \frac{\mathcal{B}(B \rightarrow H\tau\nu)}{\mathcal{B}(B \rightarrow H\ell\nu)}$$

$$H = D, D^*, X, \pi, \text{etc.} \quad \ell = e, \mu$$

final state can involve different hadrons

Tension of $R(D^{(*)})$ with $\text{SM}_{\text{HFLAV}} \sim 2\sigma$

including new preliminary BaBar results



Lepton-Flavor Universality Test

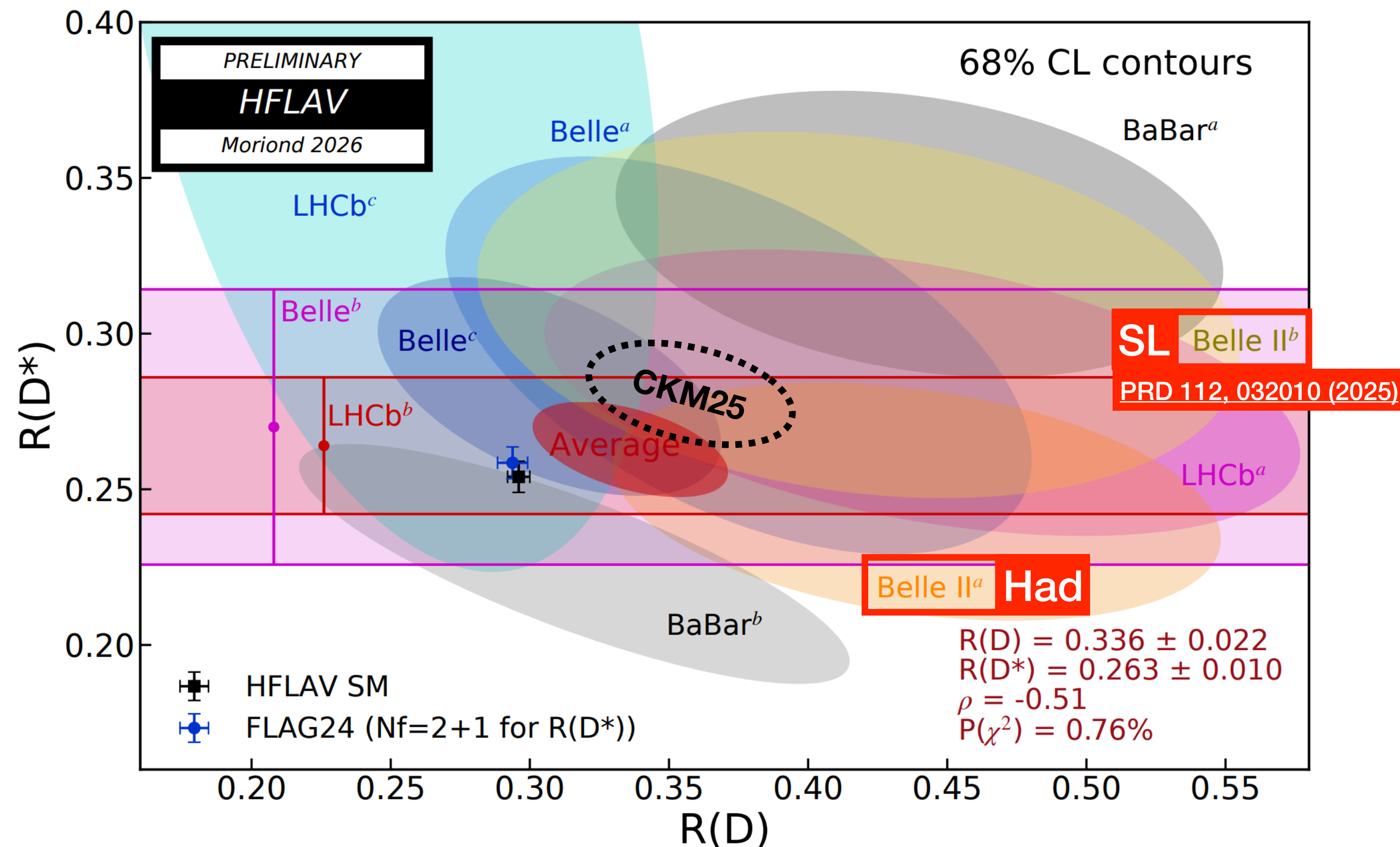
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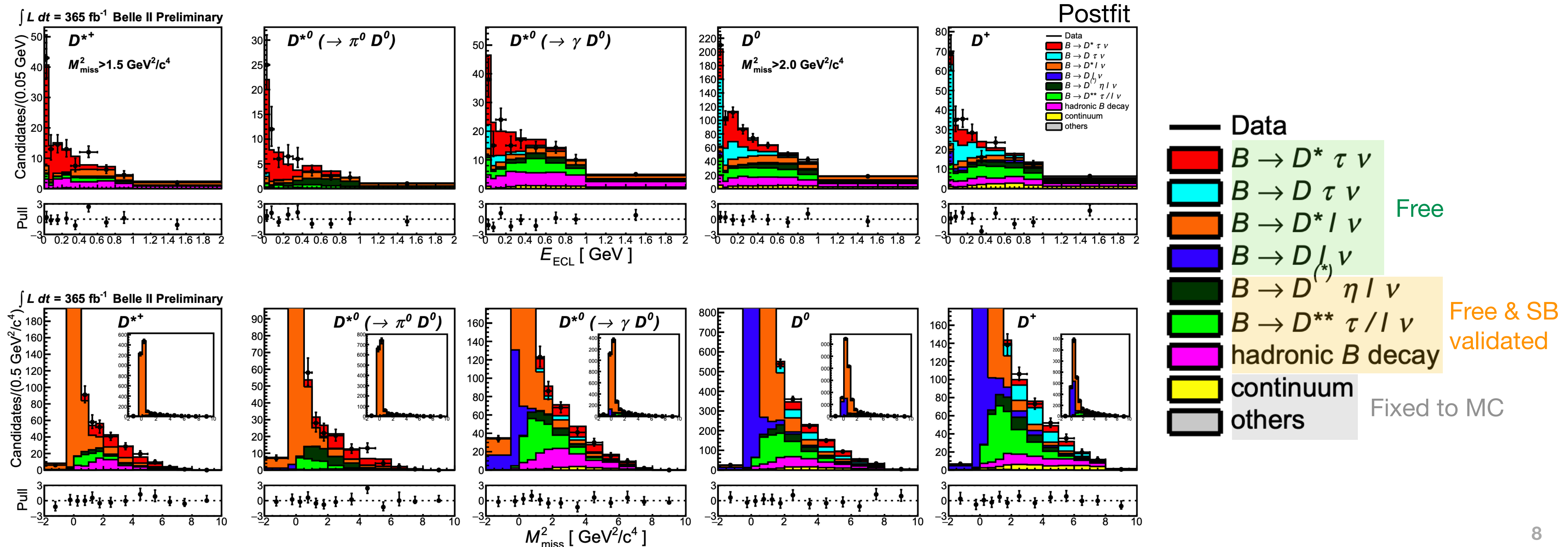
Tension of $R(D^{(*)})$ with $\text{SM}_{\text{HFLAV}} \sim 2\sigma$
including new preliminary BaBar results



R(D^{*}) with Hadronic Tag

Preliminary

- Run1 dataset: 365 fb⁻¹, supersedes previous had. R(D^{*}) using 189 fb⁻¹ [PRD 110, 072020 (2024)]
- Reconstruct **leptonic** tau decays
- 2D (E_{ECL} : M²_{miss}) binned simultaneous fit in 5 channels



$R(D^{(*)})$ with Hadronic Tag

Preliminary

$$R(D^{*}) = 0.242 \pm 0.019(\text{stat}) \pm 0.016(\text{syst})$$

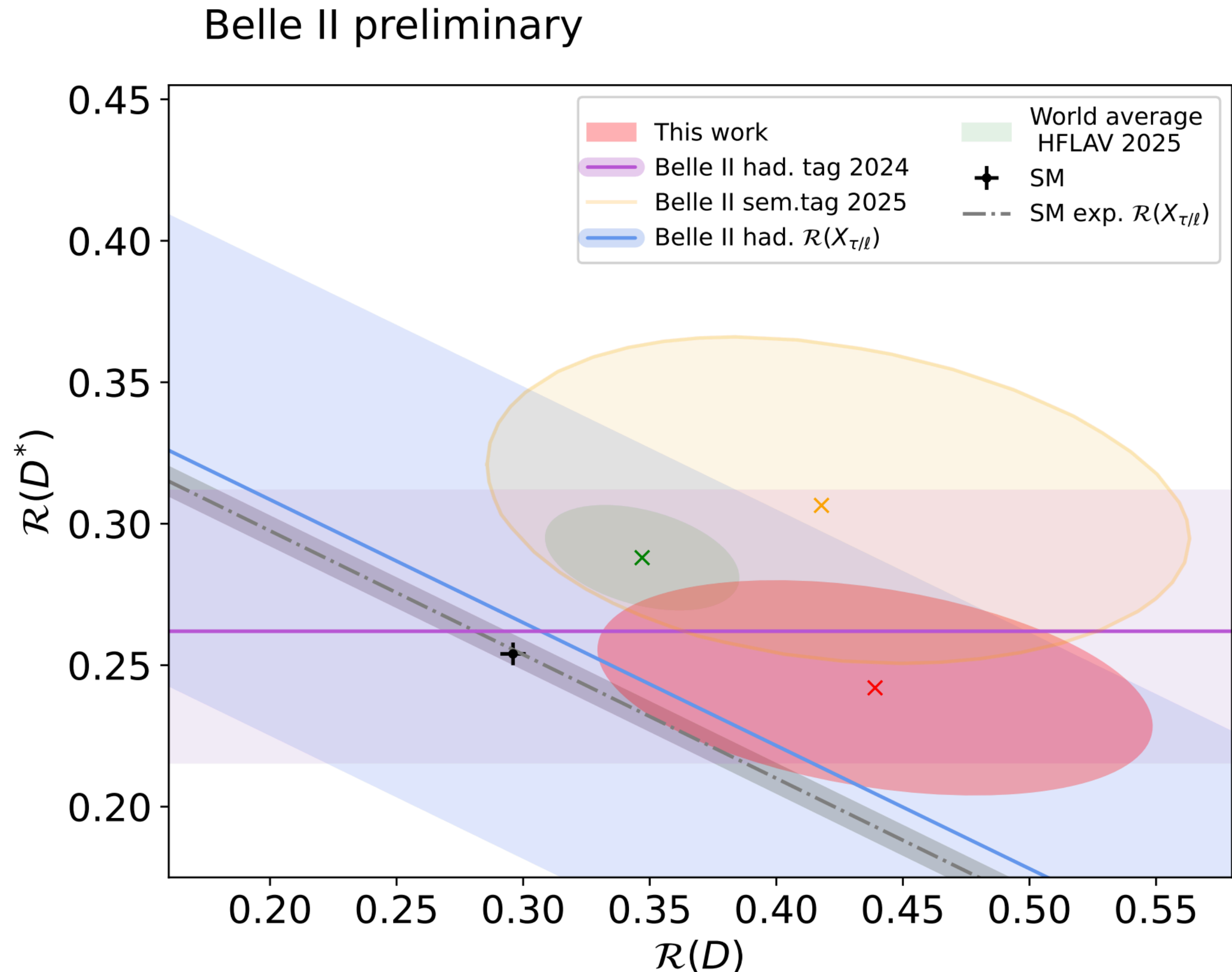
$$R(D) = 0.439 \pm 0.055(\text{stat}) \pm 0.046(\text{syst})$$

Preliminary

$$\rho_{\text{stat}} = -0.40, \rho_{\text{syst}} = -0.20$$

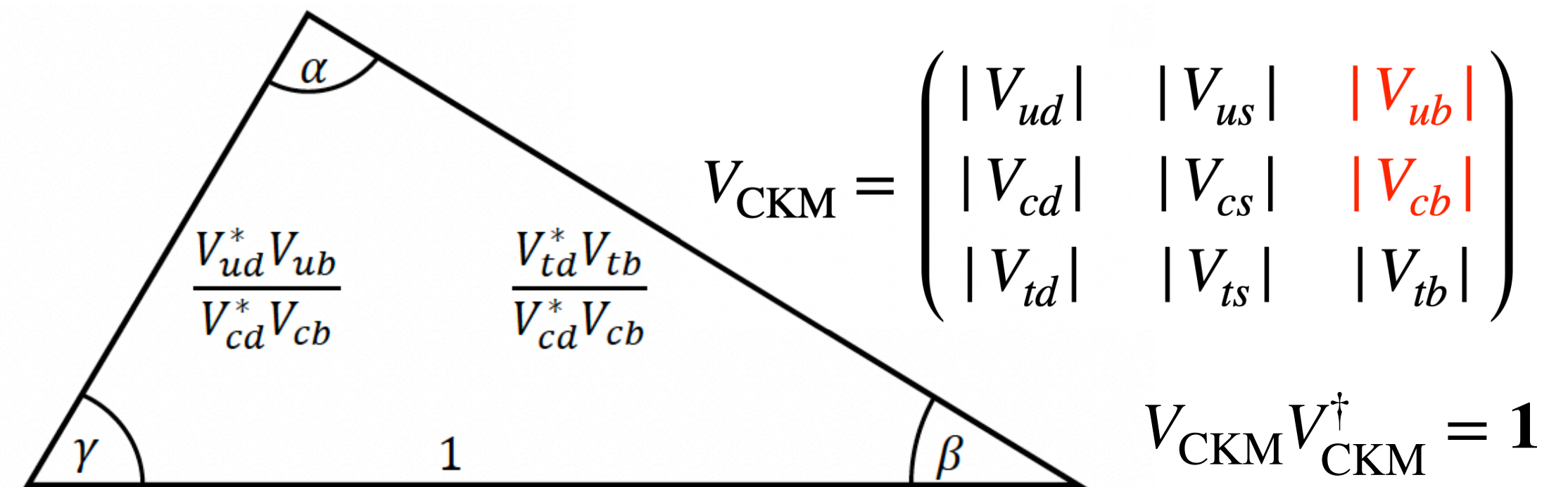
- Compatible with current world average within 1.3σ
- **Agrees with SM within 1.5σ**
 - 0.5σ for $R(D^{*})$
 - 2.0σ for $R(D)$
- Dominant syst. uncertainties: MC size, Xc gap modes, continuum bkg

✓ **Most precise $R(D^{(*)})$ with Had. tag**



$|V_{cb}|$ & $|V_{ub}|$

- Important to constrain CKM unitarity triangle & test SM
- Determinations via **inclusive** or **exclusive** semileptonic B decays
- Long-standing “**Vxb-puzzle**”: discrepancy btw. inclusive and exclusive determinations



Exclusive

$B \rightarrow \pi \ell \nu, B \rightarrow \rho \ell \nu, B \rightarrow D^{(*)} \ell \nu, \Lambda_b \rightarrow p \ell \nu$, etc.

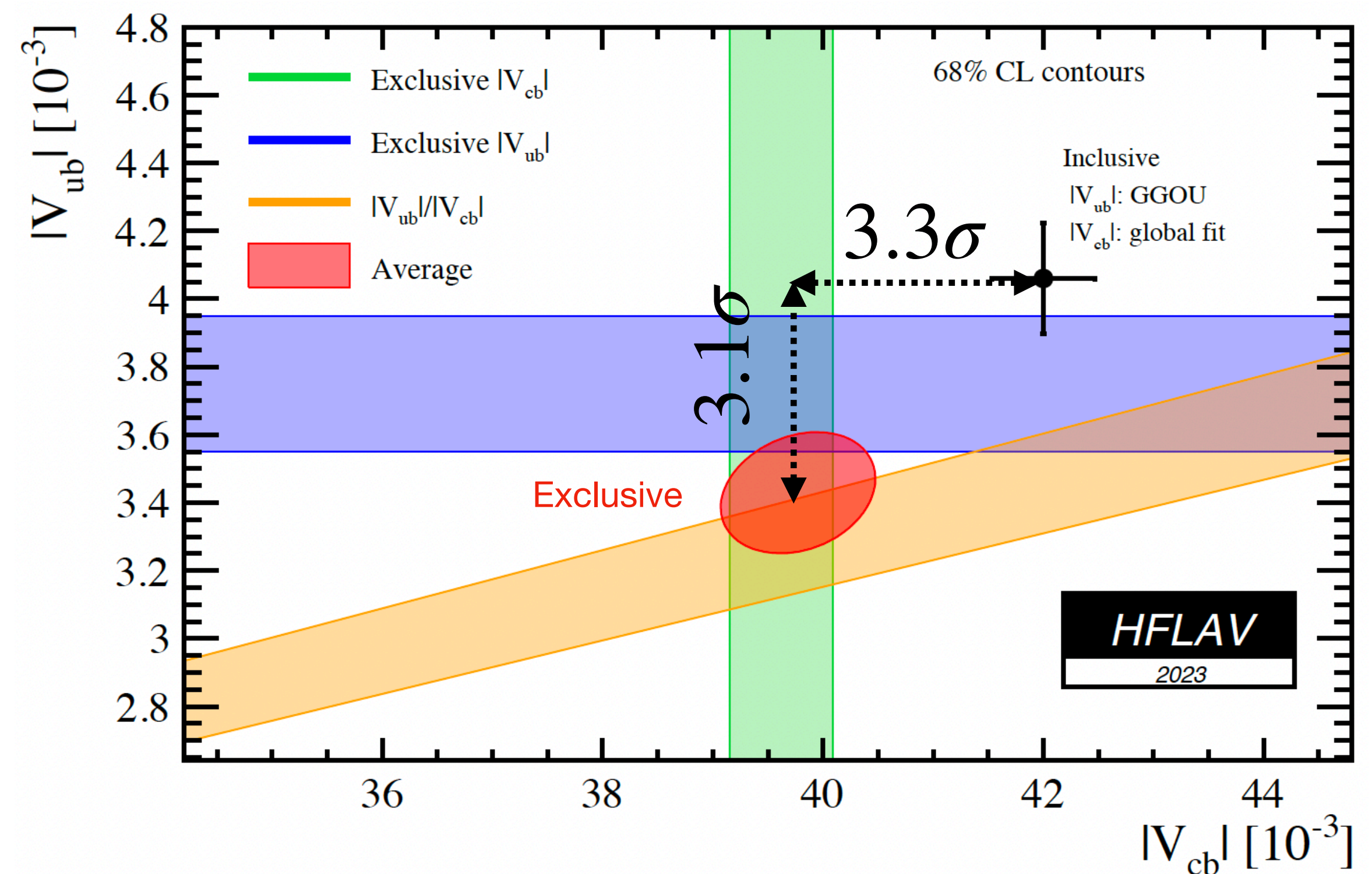
$$\mathcal{B} \propto |V_{xb}|^2 f^2 \quad \text{Form factor } f \text{ (LCSR, LQCD)}$$

Inclusive

$B \rightarrow X_u \ell \nu, B \rightarrow X_c \ell \nu$

$$\mathcal{B} \propto |V_{xb}|^2 \left[1 + \frac{c_5(\mu) \langle O_5 \rangle(\mu)}{m_h^2} + \frac{c_6(\mu) \langle O_6 \rangle(\mu)}{m_h^3} + O(m_b^4) \right] \quad |V_{xb}| = \sqrt{\frac{\Delta \mathcal{B}}{\tau_B \cdot \Delta \Gamma}}$$

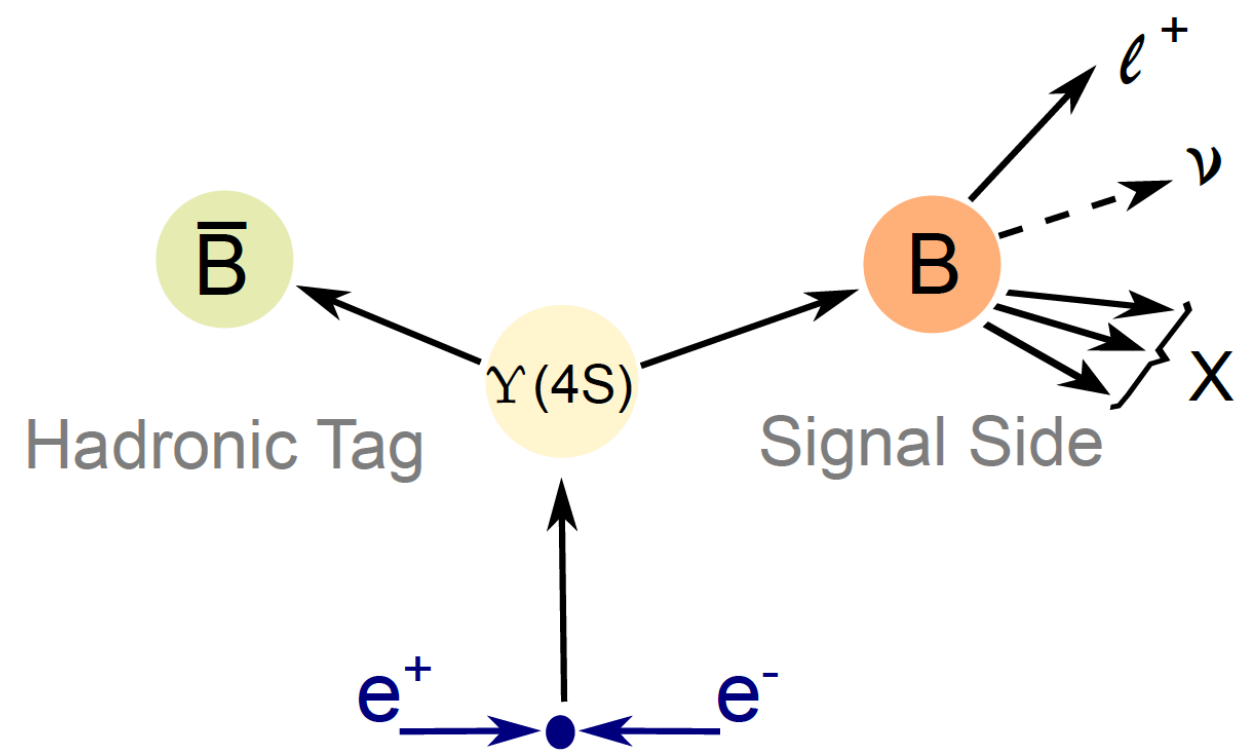
+ Shape Function / Fermi Motion (OPE)



$B \rightarrow X_u \ell \nu$ and Inclusive $|V_{ub}|$

PRD 113, 032004 (2026)

- Run1 dataset: 365 fb⁻¹
- Use hadronic tag to fully reconstruct B_{tag}
- Two classifiers used to suppress continuum, $B \rightarrow X_c \ell \nu$
- Observed poor modelling of $B \rightarrow X_c \ell \nu \Rightarrow$ **data-driven correction from sideband**
- Extract signal on (q^2, E_ℓ^B) in 3 partial phase spaces



Can fully assign each final state particle to either the tag or signal side

Allows to reconstruct inclusive X

- Hadronic system X :

$$p_X = \sum_i (\sqrt{m_\pi^2 + |\mathbf{p}_i|^2}, \mathbf{p}_i) + \sum_i (E_i, \mathbf{k}_i)$$

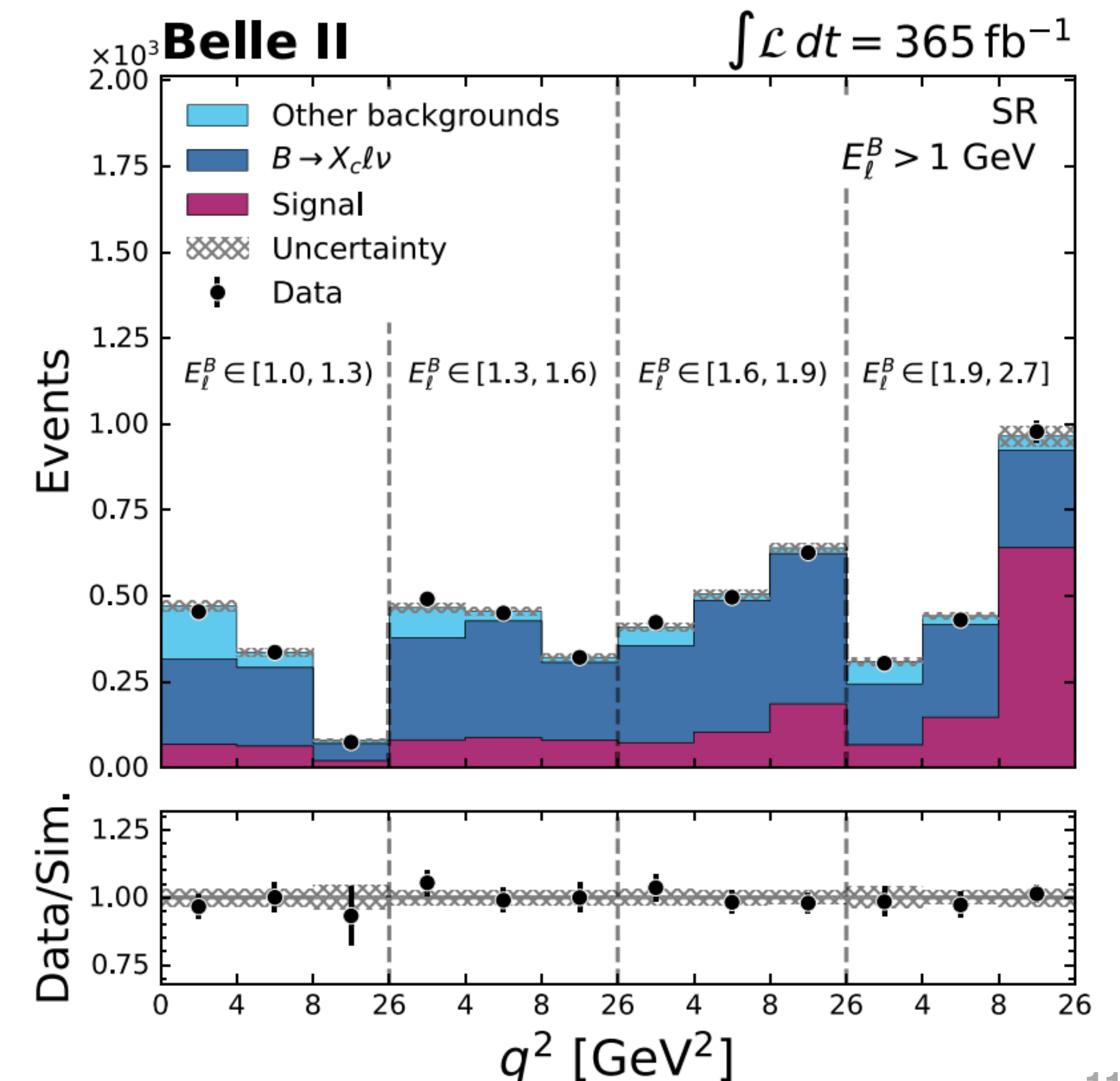
- Missing mass squared:

$$MM^2 = (P_{Y(4S)} - P_{\text{tag}} - P_X - P_\ell)^2$$

- Leptonic system:

$$q^2 = (P_B - P_X)^2 = (P_\ell + P_\nu)^2$$

$p\text{-value} = 0.79$



$B \rightarrow X_u \ell \nu$ and Inclusive $|V_{ub}|$

- Measured $\Delta\mathcal{B}$ of 3 partial phase spaces:

$$\Delta\mathcal{B}(B \rightarrow X_u \ell \nu)_1 = (1.54 \pm 0.08 \pm 0.12) \times 10^{-3}$$

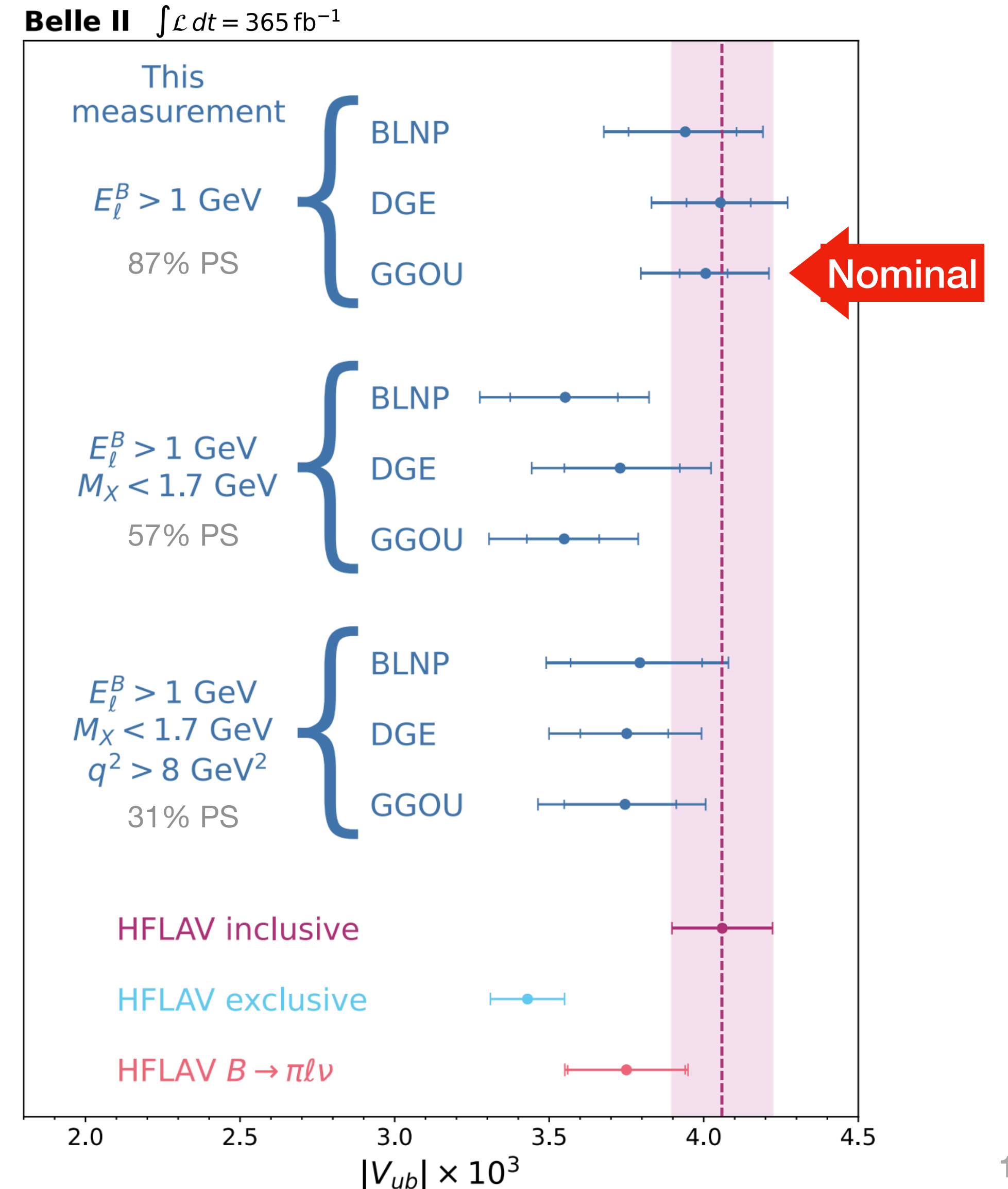
$$\Delta\mathcal{B}(B \rightarrow X_u \ell \nu)_2 = (0.95 \pm 0.05 \pm 0.10) \times 10^{-3}$$

$$\Delta\mathcal{B}(B \rightarrow X_u \ell \nu)_3 = (0.55 \pm 0.03 \pm 0.05) \times 10^{-3}$$

Consistent with previous measurements

- Leading syst. uncertainties are from inclusive X_u modelling, fragmentation, $B \rightarrow X_c \ell \nu$ normalisation correction, fit bias correction
- Achieved **similar precision** as the previous Belle measurement using 711fb^{-1} [PRD 104 , 012008 (2021)]
 - Higher tagging efficiency
 - Better D^* reconstruction and discrimination

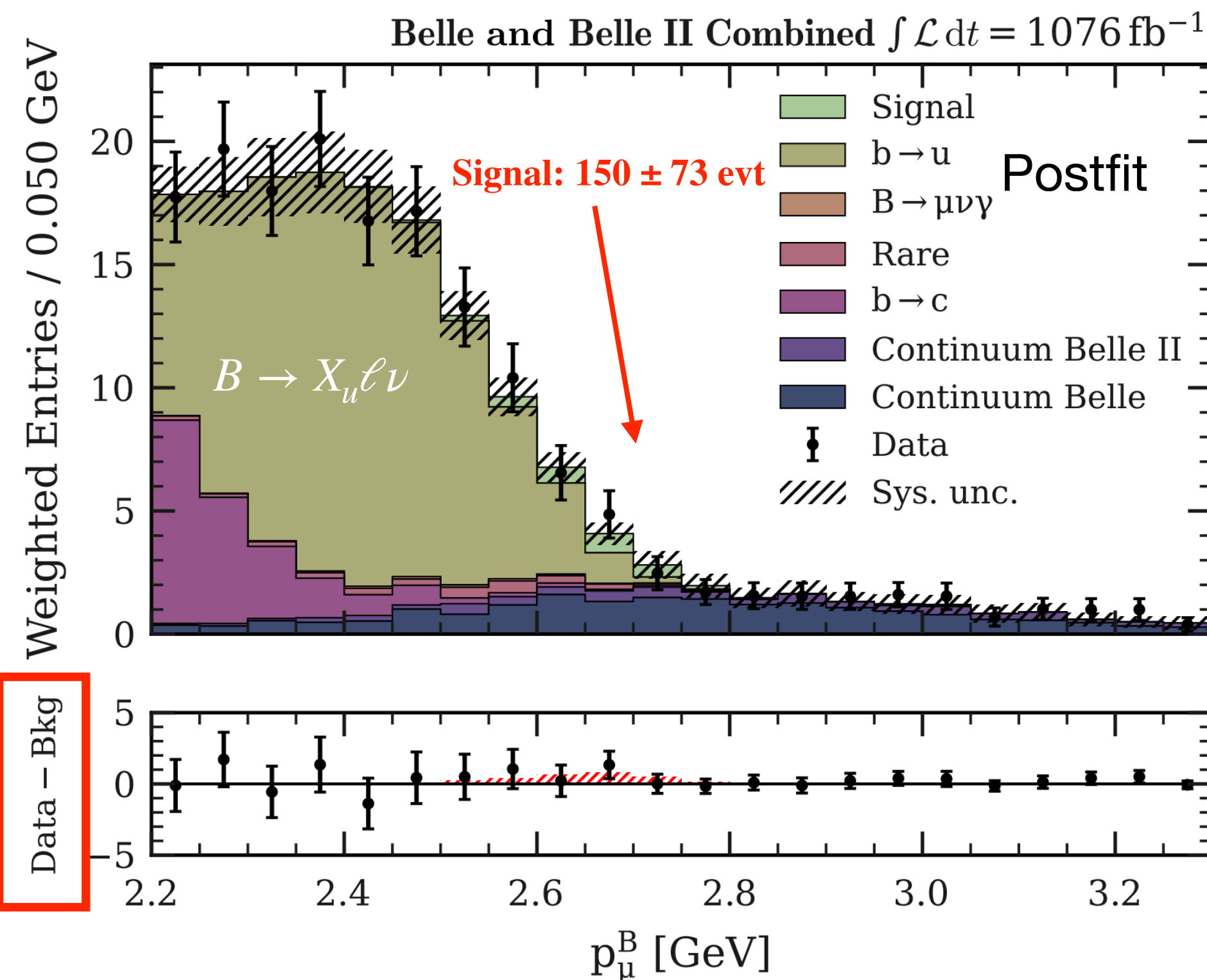
PRD 113, 032004 (2026)



$B \rightarrow \mu\nu$ with Inclusive Tag at Belle+Belle II

- Combine **Belle II** 365 fb⁻¹ and **Belle** published result from 711 fb⁻¹ [PRD 101, 032007(2020)]
- Inclusive tag**: tracks and clusters in the rest of event (ROE) used to reconstruct B_{tag}
- Signal extraction on p_{μ}^B after boosting muon to B_{sig} rest frame
- Further investigation**: type II & III 2HDM, heavy neutrinos search in 0~1.5 GeV, $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$ with $p_{\mu}^B > 2.2$ GeV and weak annihilation contribution

PRD 113, 112012 (2026)



Observed significance relative to bkg-only hypothesis: 2.4σ

$$\mathcal{B}(B^+ \rightarrow \mu^+ \nu_{\mu}) = (4.4 \pm 1.9 \pm 1.0) \times 10^{-7}$$

Upper limits (most stringent to date):

$$\mathcal{B}(B^+ \rightarrow \mu^+ \nu_{\mu}) < 7.2 \times 10^{-7} \quad \text{Bayesian}$$

$$|V_{ub}| = (3.92^{+0.77}_{-0.96} \text{ (stat.)} \pm 0.44 \text{ (sys.)} \pm 0.03 \text{ (theo.)}) \times 10^{-3}$$

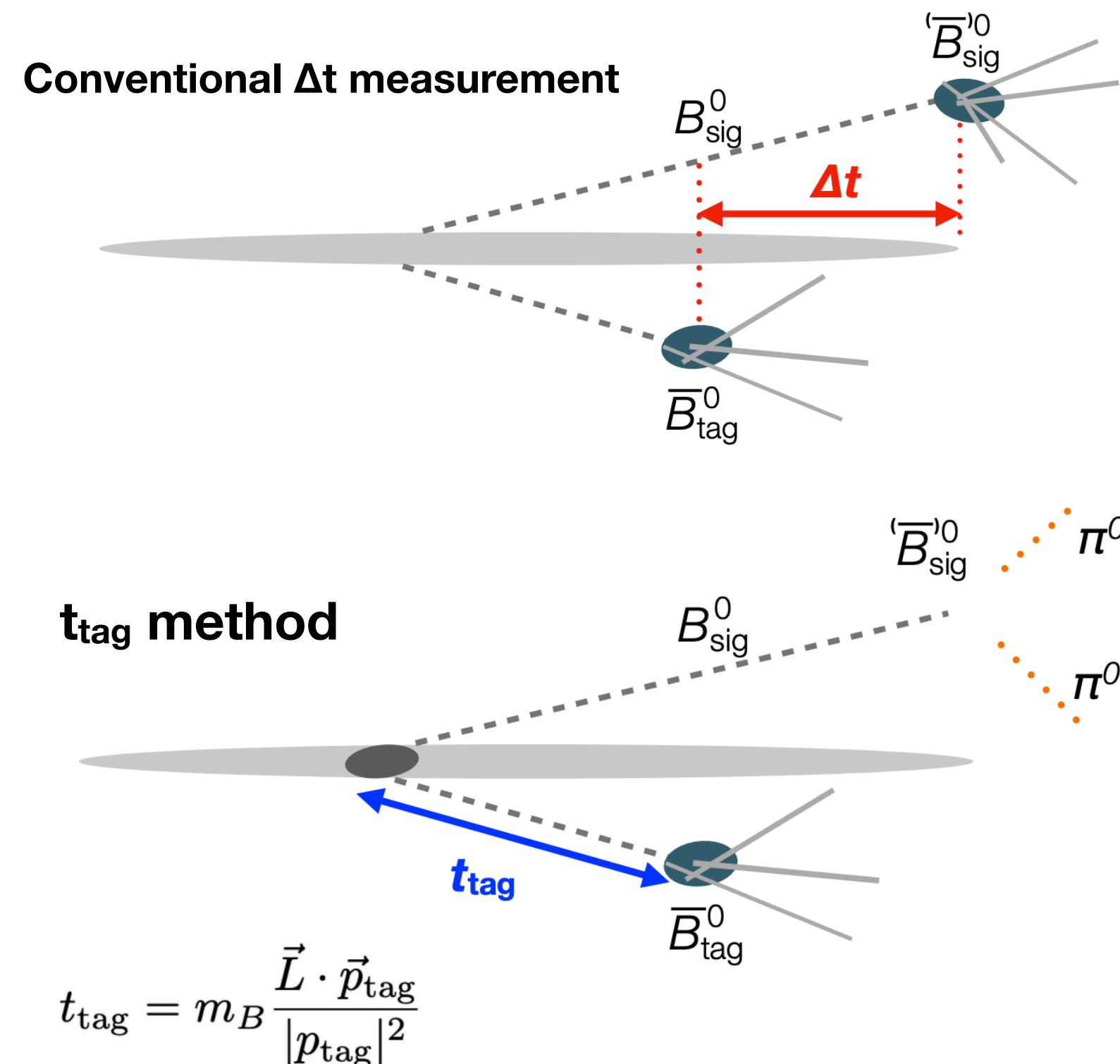
dominated by $b \rightarrow u$ modelling, continuum modelling

Mixing-Induced CP Violation in $B^0 \rightarrow \pi^0 \pi^0$

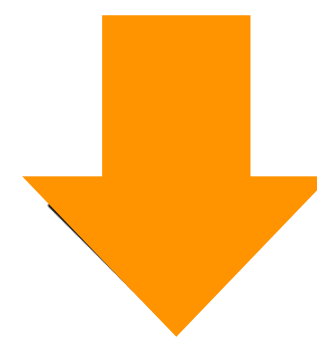
2606.20797

Preliminary

- Measure time-dependent asymmetry in B decays $A_{CP}(t) = \frac{N(\bar{B}^0(t) \rightarrow f) - N(B^0(t) \rightarrow f)}{N(\bar{B}^0(t) \rightarrow f) + N(B^0(t) \rightarrow f)}$ $f = \pi^0 \pi^0$
- Built upon previous time-integrated Belle II analysis [PRD 111, L071102(2025)]
- Use novel approach to access TDCPV w/o vertex [PRD 112, 032011(2025)] => **measure B-tag decay time instead**

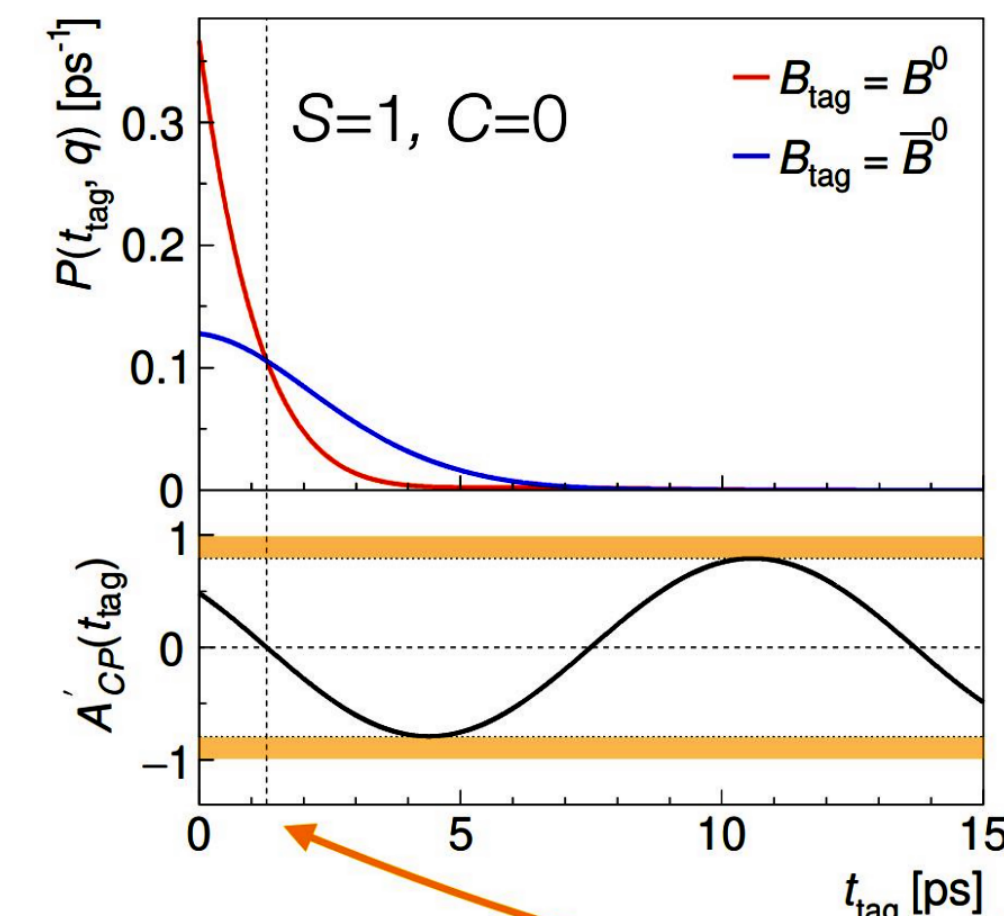


$$\mathcal{P}(t_{\text{tag}}, t_{CP}, q) = \frac{e^{-\frac{t_{CP} + t_{\text{tag}}}{\tau}}}{2\tau^2} \left(1 + q \left[S \sin \Delta m (t_{CP} - t_{\text{tag}}) - C \cos \Delta m (t_{CP} - t_{\text{tag}}) \right] \right)$$



Marginalizing
over t_{CP}

$$\mathcal{P}(t_{\text{tag}}, q) = \frac{e^{-t_{\text{tag}}/\tau}}{2\tau} \left(1 + q \left[S' \sin \Delta m (t_{\text{tag}} - \hat{t}) - C' \cos \Delta m (t_{\text{tag}} - \hat{t}) \right] \right),$$



$$A'_{CP}(t_{\text{tag}}) = S' \sin \Delta m (t_{\text{tag}} - t_0) - C' \cos \Delta m (t_{\text{tag}} - t_0)$$

$$S' = -\frac{S}{\sqrt{1 + (\tau \Delta m)^2}} \approx -0.8 S$$

$$C' = \frac{C}{\sqrt{1 + (\tau \Delta m)^2}} \approx 0.8 C$$

$$t_0 = \frac{1}{\Delta m} \arctan(\Delta m \tau) \approx 1.3 \text{ ps}$$

- High t_{tag} precision: 1.5 ps @ Belle II with PXD
- Technique validated with $B^0 \rightarrow J/\psi K_s^0$ for ϕ_1

Mixing-Induced CP Violation in $B^0 \rightarrow \pi^0 \pi^0$

2606.20797

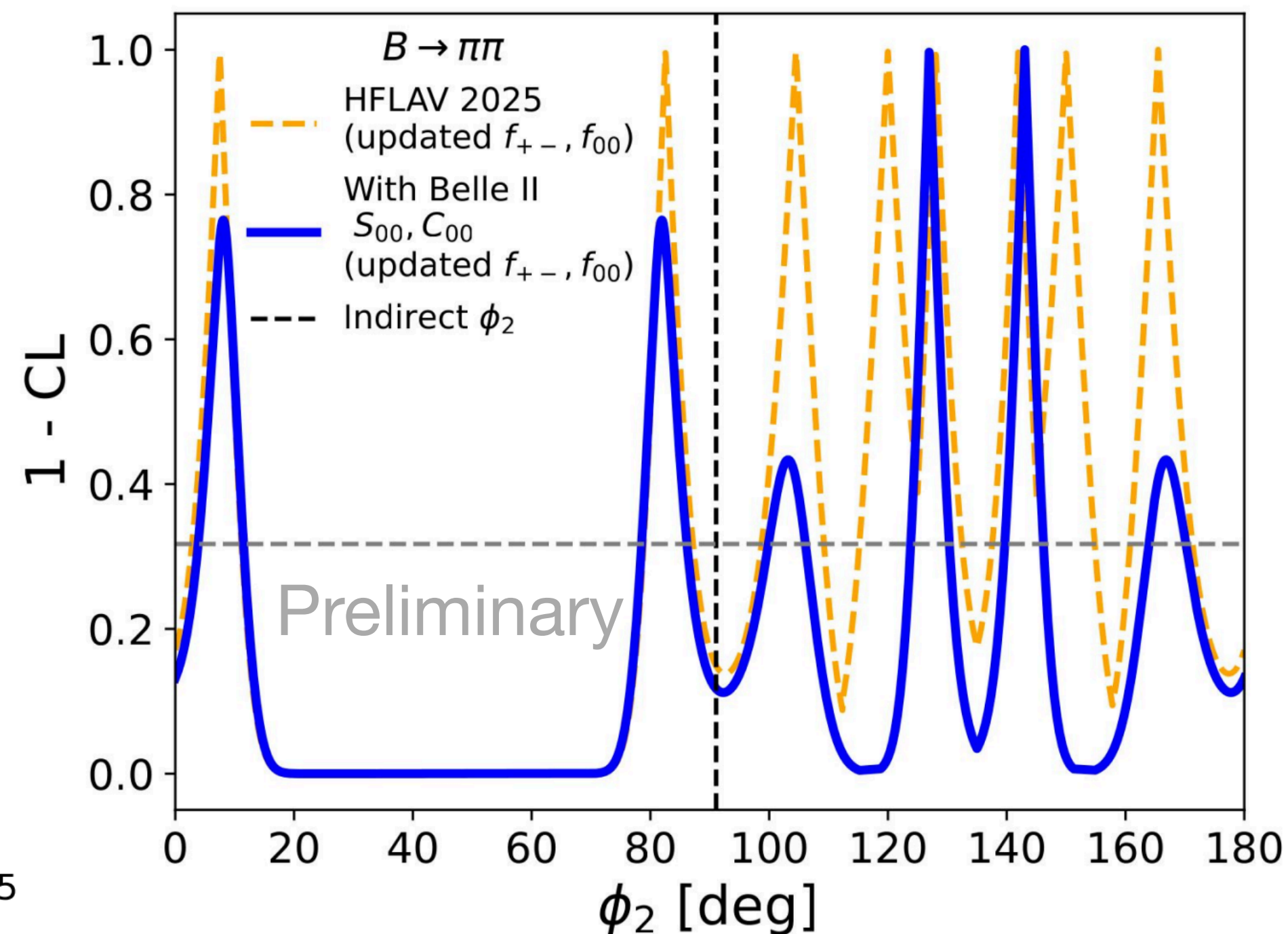
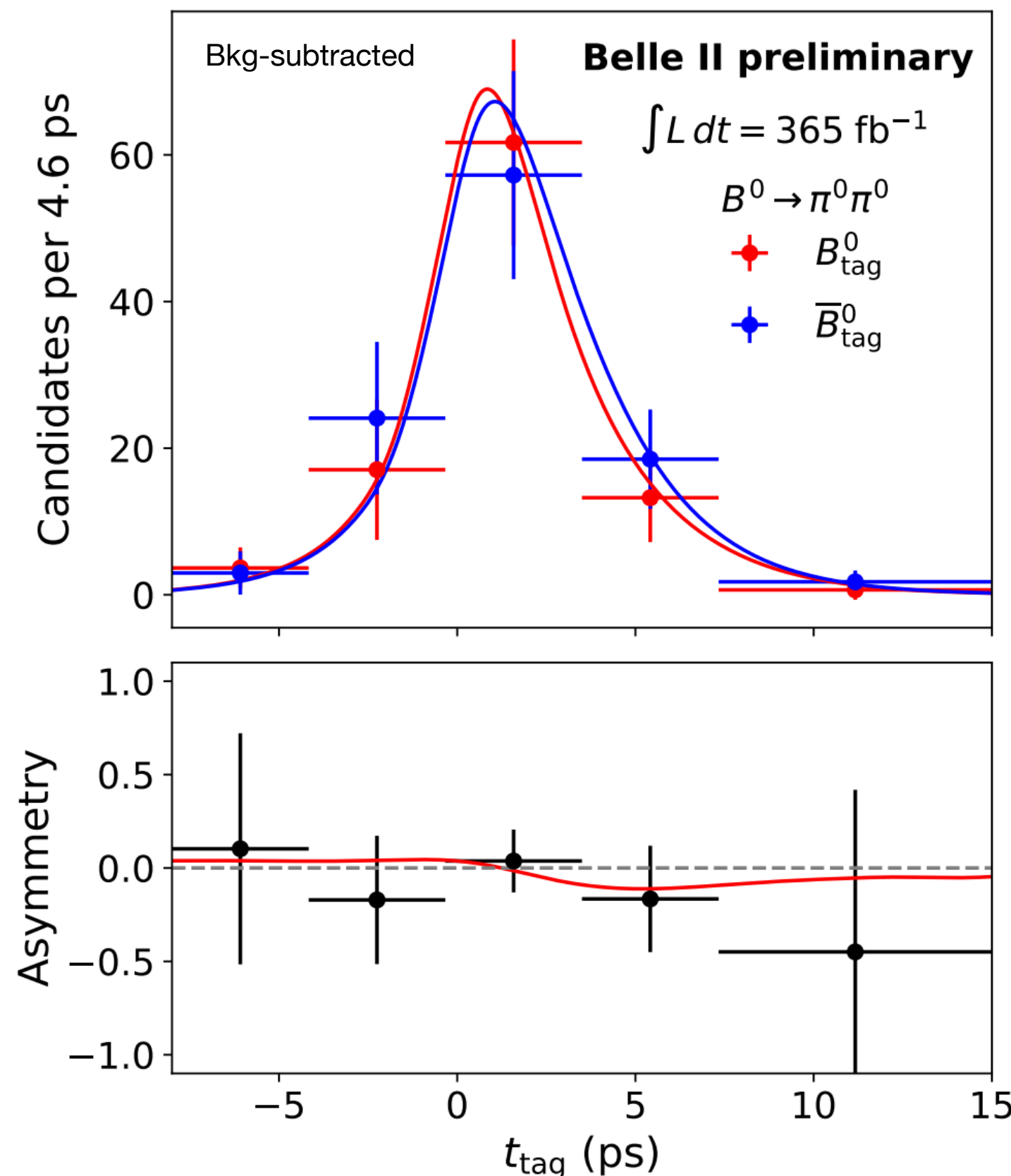
Preliminary

- First measurement of mixing induced CP-violation without signal vertex
- Would have required 20x more data if $A_{CP}(\Delta t)$, relies on π^0 modes with vertex info
- Consistent with previous Belle II time-independent $C_{\pi^0 \pi^0}$

Preliminary

$$S_{00} = 0.61^{+0.75}_{-0.79} (\text{stat}) \pm 0.11 (\text{syst}),$$

$$C_{00} = 0.05 \pm 0.28 (\text{stat}) \pm 0.07 (\text{syst})$$



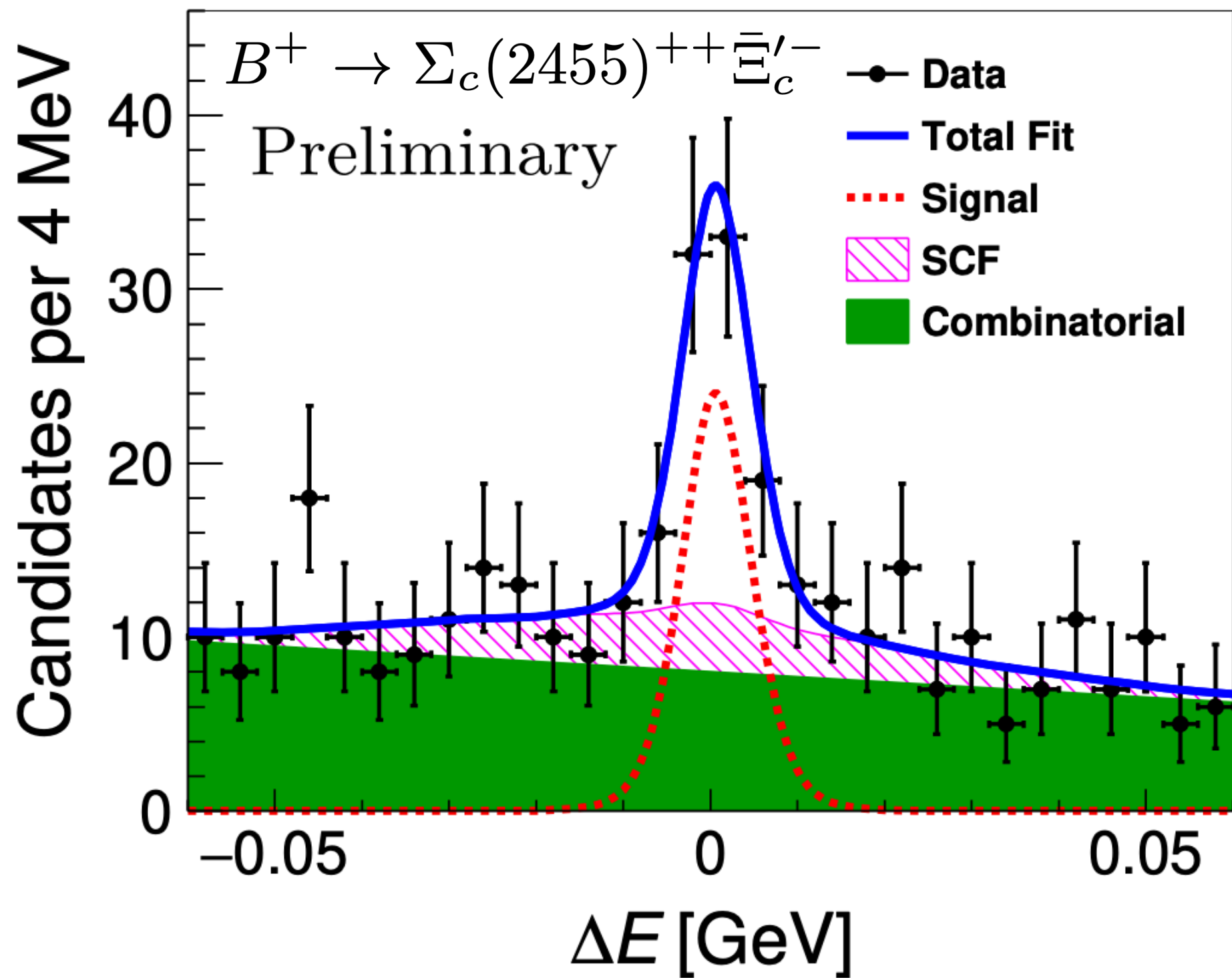
- Allowed 68% CL region interval in ϕ_2 from $B \rightarrow \pi\pi$ shrunk by 40%
- CKM-like ϕ_2 solutions from $\pi\pi$ and $\rho\rho$ are consistent with similar uncertainty

First Observation of $B \rightarrow \Sigma_c(2455)\bar{\Xi}'_c$

2606.12905

Preliminary

- Combine **Belle II** 492 fb⁻¹ and **Belle** 711 fb⁻¹
- Analysis strategy similar to previous measurement of $B \rightarrow \Sigma_c(2455)\bar{\Xi}_c$ [PRD 112, L051101 (2025)], requiring additional photon for $\bar{\Xi}'_c \rightarrow \bar{\Xi}_c\gamma$
- Observed significances: $6.4\sigma (B^+)$, $5.3\sigma (B^0)$



$B \rightarrow \Sigma_c(2455)\bar{\Xi}'_c$				
	N_{sig}	$\mathcal{B} (10^{-3})$		
B^+	62.3 ± 11.3	1.68 ± 0.31	± 0.12	$^{+1.49}_{-0.54}$
B^0	30.7 ± 7.6	1.28 ± 0.32	± 0.10	$^{+0.30}_{-0.21}$
		stat	syst	BRs of $\bar{\Xi}_c, \Sigma_c$
$B \rightarrow \Sigma_c(2455)\bar{\Xi}_c$				
	$N_{\text{ss}}^{\text{sig}}$	$\mathcal{B} (10^{-4})$		
B^+	52.8 ± 10.2	5.74 ± 1.11	± 0.42	$^{+2.47}_{-1.53}$
B^0	31.1 ± 7.2	4.83 ± 1.12	± 0.37	$^{+0.72}_{-0.60}$

Smaller phase space, but larger BF!

Any unknown mechanism?

Summary & Outlook

- $R(D^{(*)})$ tension alleviated; “Vub puzzle” remains
- Novel approach used to access $B \rightarrow \pi^0 \pi^0$ time evolution
- Many exciting new results are on the way using Belle II largest ever B-factory dataset

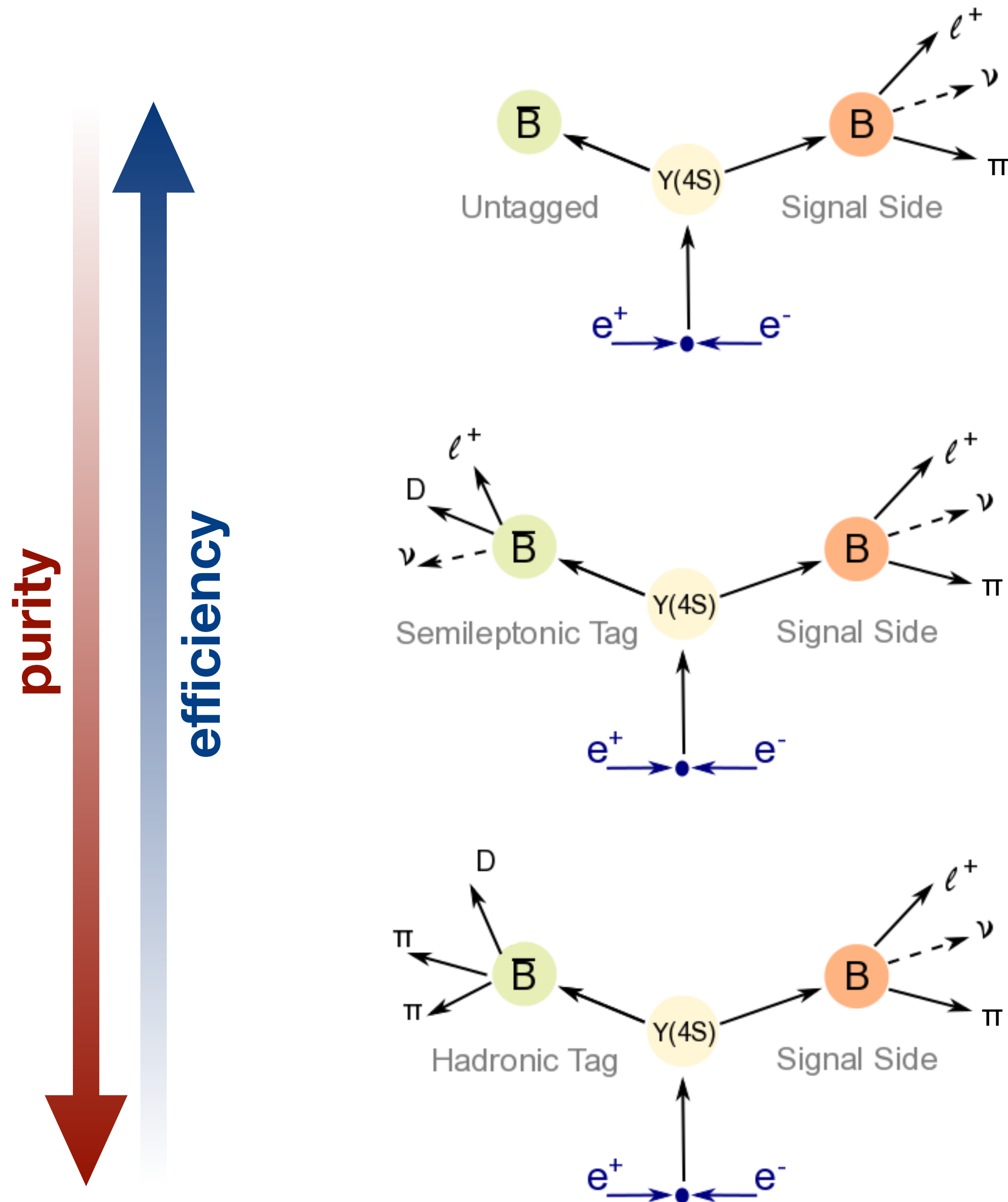
Upcoming:

- * $R(D^{*}), P_{\tau}(D^{*})$ with hadronic 1-prong τ decays and had. tag @ICHEP26
- * Combined $B \rightarrow D\ell\nu$ and $B \rightarrow D^{*}\ell\nu$
- * $B \rightarrow \tau\nu$ with SL tag

Recent highlights in B physics

- $R(D^{(*)})$ with had. tag
- $B \rightarrow X_u \ell \nu$
- $B \rightarrow \mu \nu$
- $B \rightarrow \pi^0 \pi^0$
- $B^{+} \rightarrow \Sigma_c(2455)^{++} \bar{\Xi}_c^{\prime -},$
 $B^0 \rightarrow \Sigma_c(2455)^0 \bar{\Xi}_c^{\prime 0}$

Backup: Tagging Techniques



- Untagged/Inclusive tag
 - Loose constraints on signal
 - Very large statistics, but also very large background
 - Efficiency $\epsilon \approx \mathcal{O}(100\%)$
- Semileptonic tag
 - Mid-range reconstruction efficiency
 - Due to multiple neutrinos, less information about B_{tag}
- Hadronic tag
 - Cleaner sample
 - Knowledge of $p(B_{\text{sig}})$
 - Low tag-side efficiency $\epsilon \approx \mathcal{O}(0.5\%)$

Backup: $R(D^{(*)})$ with Hadronic Tag

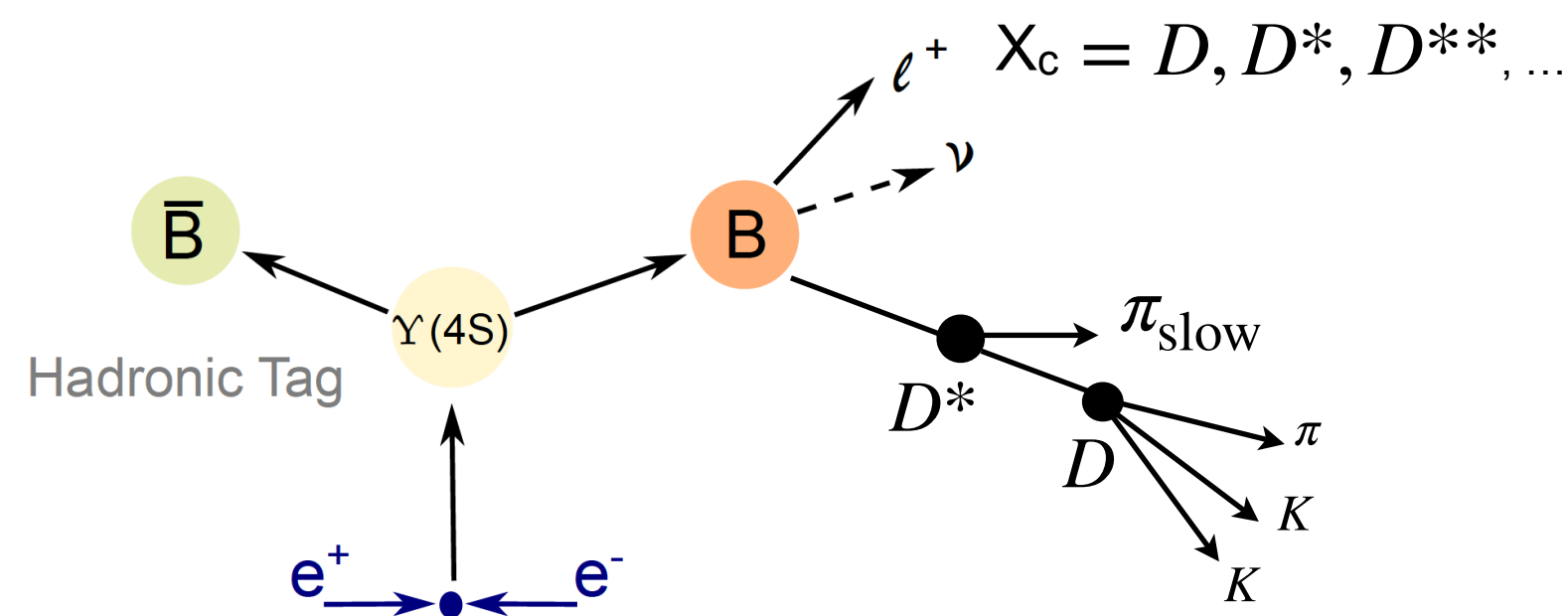
Preliminary

Table II. Summary of the systematic uncertainties on $R(D^{(*)})$ and their correlation (ρ). The description of each source is provided in the text.

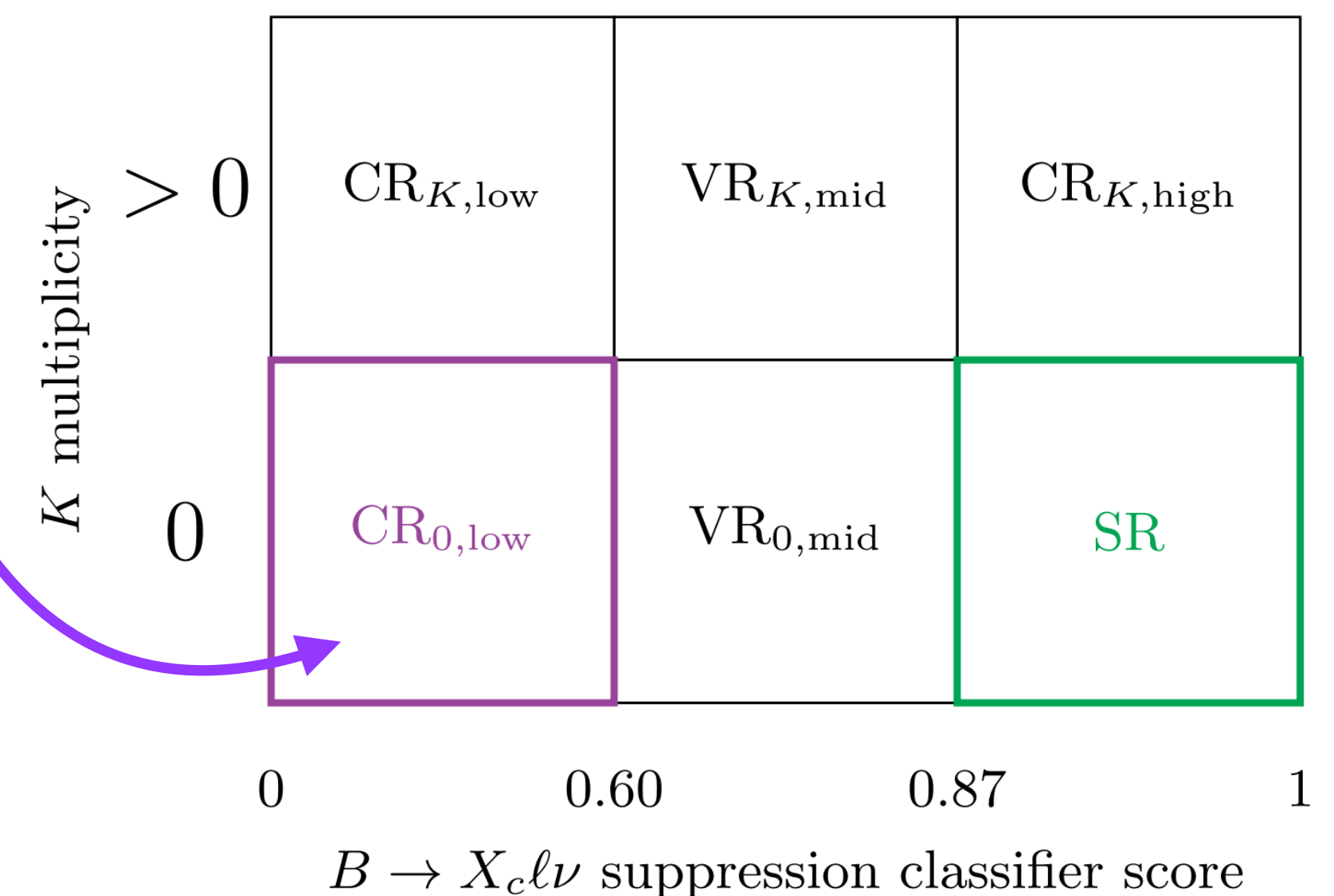
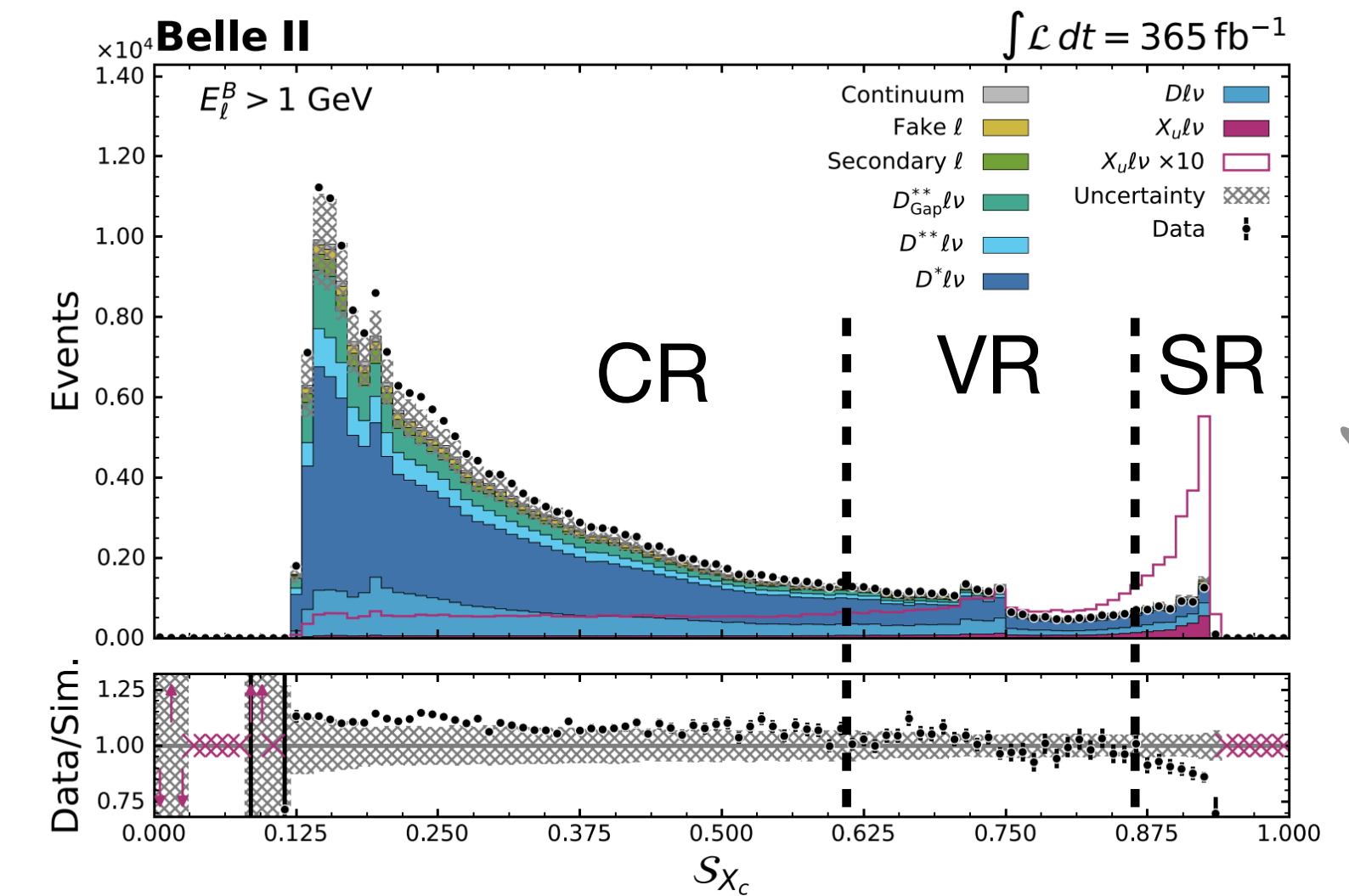
Source	$R(D^*)$	$R(D)$	ρ
Simulation sample size	4.8%	8.4%	-0.44
gap-mode branching fraction	2.7%	3.1%	0.00
$\bar{B} \rightarrow D^{**} \tau^- / (\ell^-) \bar{\nu}_\ell$ branching fractions	0.3%	1.3%	0.25
Hadronic B decay branching fractions	1.6%	1.5%	-0.26
Form factors	0.5%	0.9%	-0.70
Fraction of misreconstructed $D^{(*)}$	0.5%	1.2%	0.00
Continuum background	2.4%	2.1%	0.93
Fit biases	0.3%	1.2%	0.00
Low-momentum π^0, γ efficiency	2.2%	2.4%	0.99
Other efficiency corrections	0.7%	1.4%	0.92
B -tagging efficiency in data	0.9%	1.8%	-1.00
B -tagging efficiency of $B \rightarrow D\tau\nu$	0.1%	1.8%	1.00
M_{miss}^2 resolution	0.5%	0.8%	0.48
Total systematic uncertainty	6.7%	10.3%	-0.20
Statistical uncertainty	7.9%	12.5%	-0.40

Backup: $B \rightarrow X_u \ell \nu$ and Inclusive $|V_{ub}|$

- Based on $B \rightarrow X_c \ell \nu$ classifier, **Kaon veto** applied additionally to define validation/control regions
- MC normalisation of $B \rightarrow X_c \ell \nu$ in **SR** corrected via extrapolating CRs
- Simultaneous fit **CR** and **SR**, the high statistics of $B \rightarrow X_c \ell \nu$ in **CR** push the shape corrections to **SR**
- Systematics included as ~ 150 source-wise nuisances parameters and shared in **CR** & **SR**
- VR** used as pseudo-SR for validating the method



Data-driven correction
based on $B \rightarrow X_c \ell \nu$
enriched sideband



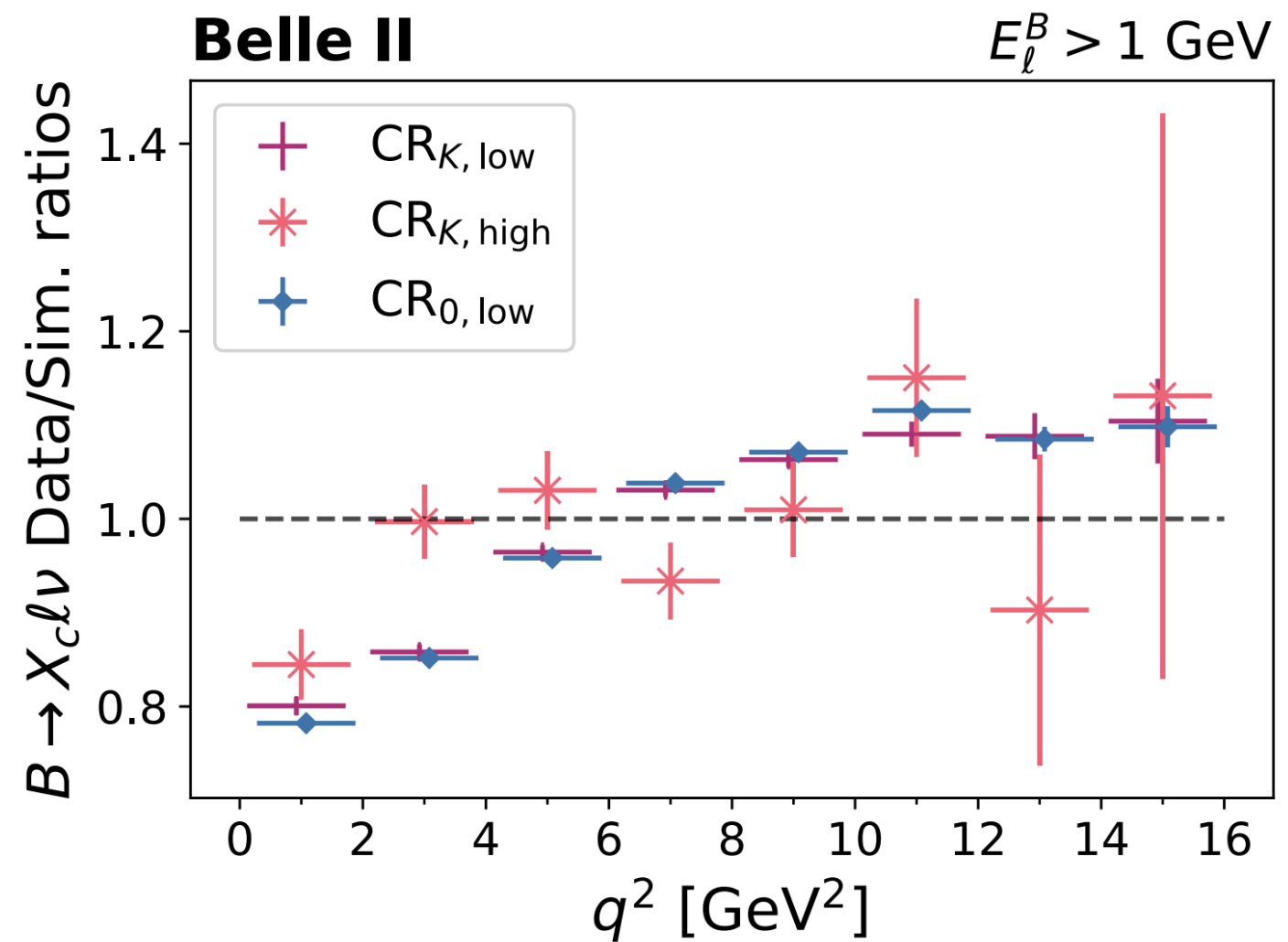
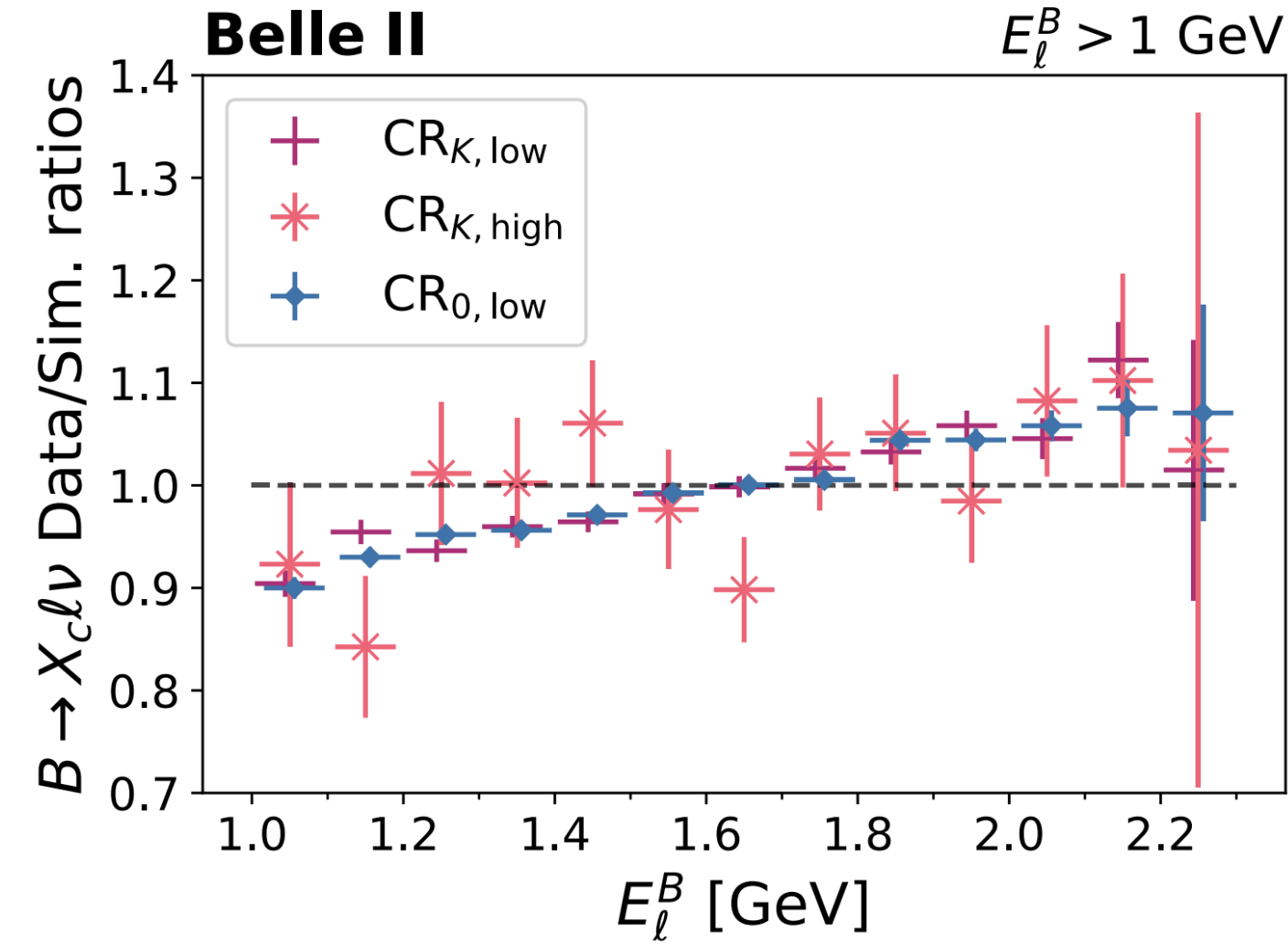
Backup: $B \rightarrow X_u \ell \nu$ and Inclusive $|V_{ub}|$

TABLE I. Assumed branching fractions used for simulated semileptonic B decays.

Decay mode	$\mathcal{B}$ (%)	
	B^+	B^0
Incl. $B \rightarrow X_u \ell \nu$	0.192 ± 0.024	0.176 ± 0.022
$B \rightarrow \pi \ell \nu$	0.0078 ± 0.0003	0.0150 ± 0.0006
$B \rightarrow \rho \ell \nu$	0.0158 ± 0.0011	0.0294 ± 0.0021
$B \rightarrow \omega \ell \nu$	0.0119 ± 0.0009	...
$B \rightarrow \eta \ell \nu$	0.0035 ± 0.0004	...
$B \rightarrow \eta' \ell \nu$	0.0024 ± 0.0007	...
Incl. $B \rightarrow X_c \ell \nu$	11.05 ± 0.16	10.27 ± 0.15
$B \rightarrow D \ell \nu$	2.27 ± 0.06	2.11 ± 0.05
$B \rightarrow D^* \ell \nu$	5.27 ± 0.12	4.90 ± 0.11
$B \rightarrow D_1 \ell \nu$	0.64 ± 0.10	0.59 ± 0.10
$B \rightarrow D_0^* \ell \nu$	0.13 ± 0.19	0.12 ± 0.18
$B \rightarrow D_1' \ell \nu$	0.28 ± 0.04	0.26 ± 0.04
$B \rightarrow D_2^* \ell \nu$	0.32 ± 0.03	0.30 ± 0.03
$B \rightarrow D_s K \ell \nu$	0.03 ± 0.01	...
$B \rightarrow D_s^* K \ell \nu$	0.03 ± 0.02	...
$B \rightarrow D \eta \ell \nu$	0.90 ± 0.90	0.86 ± 0.86
$B \rightarrow D^* \eta \ell \nu$	0.90 ± 0.90	0.86 ± 0.86
$B \rightarrow D \pi \pi \ell \nu$	0.07 ± 0.09	0.07 ± 0.08
$B \rightarrow D^* \pi \pi \ell \nu$	0.22 ± 0.10	0.20 ± 0.10

TABLE VIII. Breakdown of uncertainties added following the bias corrections described in Secs. VF and VG. In addition, we show the systematic, statistical, and total uncertainties of the corrected branching fractions.

	Relative uncertainty (%)		
	Fit 1	Fit 2	Fit 3
Fit bias	2.6	2.3	1.8
Composition uncertainty	1.3	5.7	0.2
$B \rightarrow X_c \ell \nu$ overestimation	2.6	0.4	1.3
correction			
Total systematic	7.9	10.5	9.7
Statistical	5.4	5.6	4.5
Total	9.6	11.9	10.7



PRD 113, 032004 (2026)

TABLE VII. Breakdown of the systematic uncertainties of the partial branching fraction obtained from each fit.

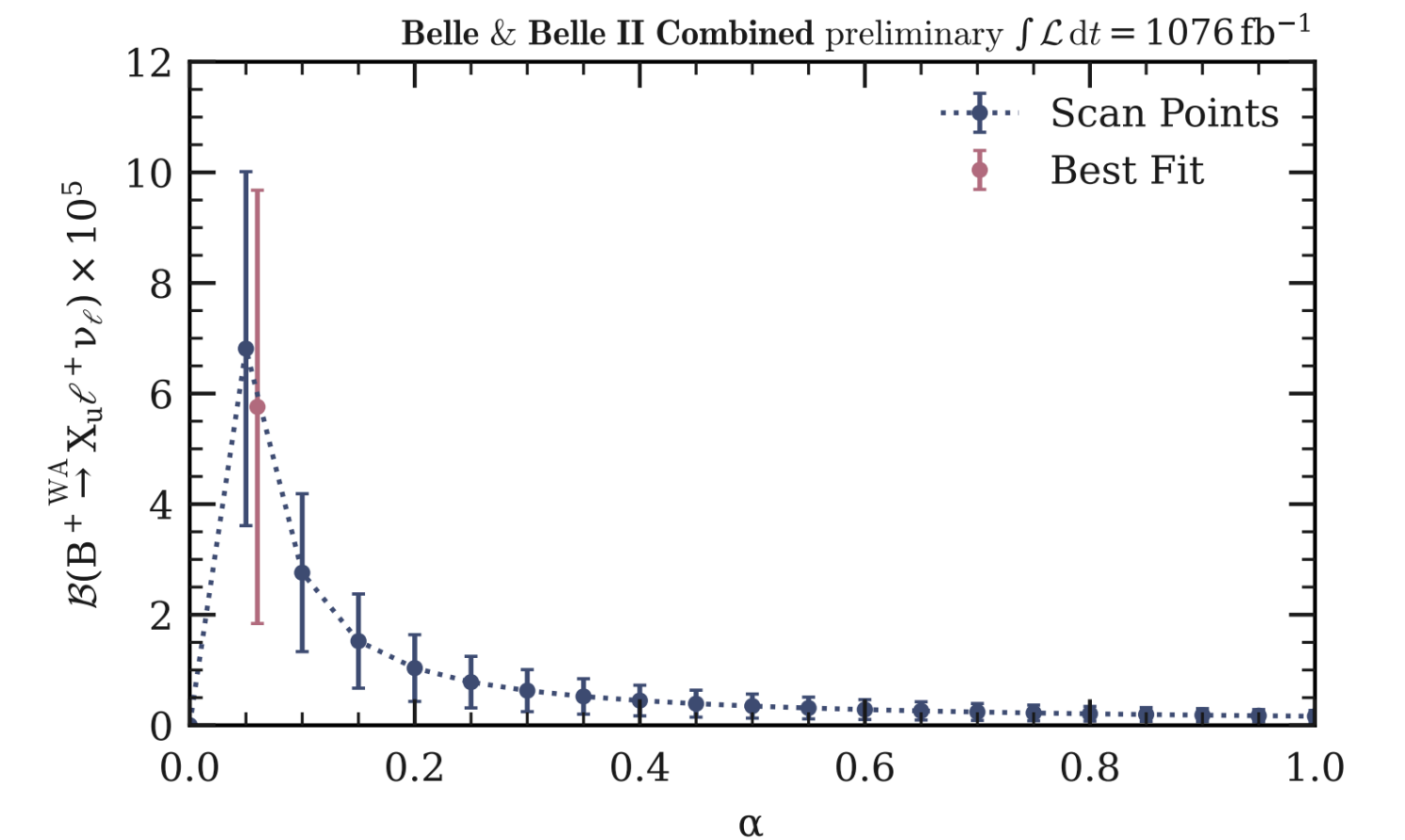
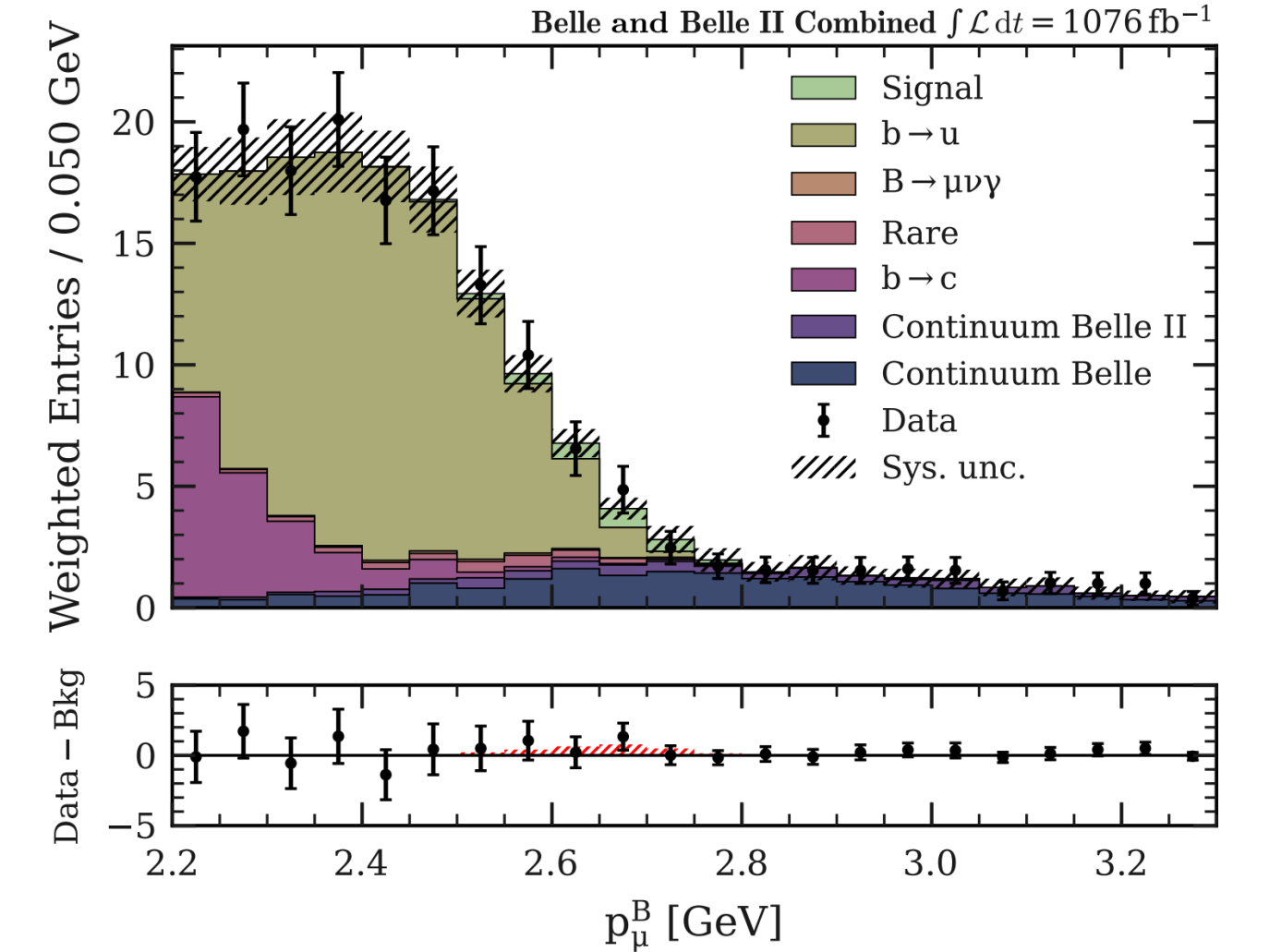
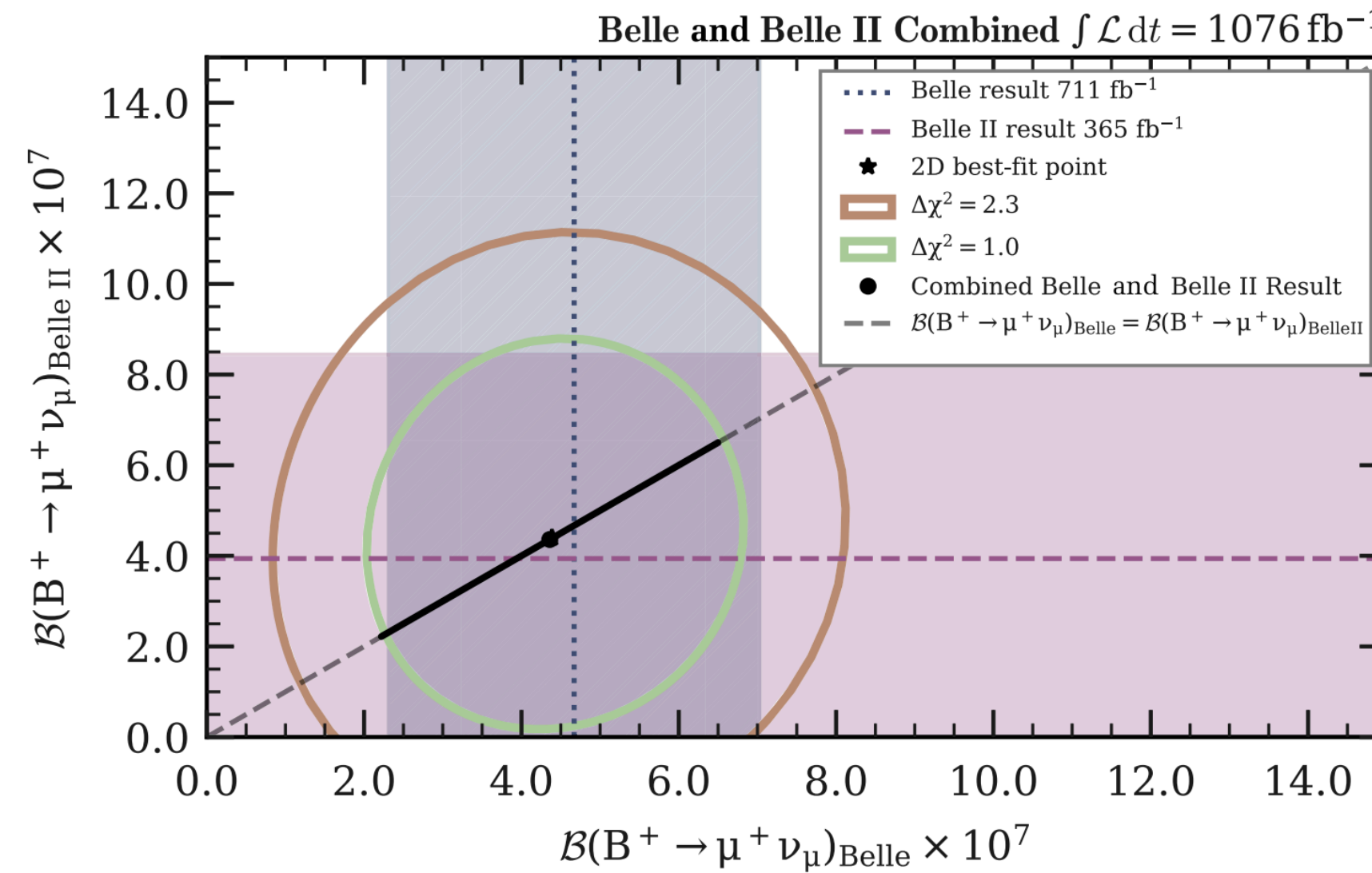
Uncertainty source	Relative uncertainty (%)		
	Fit 1	Fit 2	Fit 3
DFN parameters	4.4	4.5	5.7
DFN $\rightarrow$ BLNP	0.2	0.8	1.3
γ_s	1.7	2.1	2.1
$B \rightarrow \pi \ell \nu$ form factors	0.3	0.3	0.3
$B \rightarrow \rho \ell \nu$ form factors	0.3	0.3	0.2
$B \rightarrow \omega \ell \nu$ form factors	0.1	0.1	0.1
$B \rightarrow \eta/\eta' \ell \nu$ form factors	<0.1	<0.1	<0.1
$B^\pm \rightarrow X_u \ell \nu$ branching fractions	0.9	0.6	0.5
$B^0 \rightarrow X_u \ell \nu$ branching fractions	0.6	0.5	0.5
$B \rightarrow D_{\text{Broad}}^{**}$ form factors	0.5	0.1	0.2
$B \rightarrow D_{\text{Narrow}}^{**}$ form factors	0.1	<0.1	<0.1
$B \rightarrow D/D^* \ell \nu$ form factors	<0.1	<0.1	<0.1
$B^\pm \rightarrow X_c \ell \nu$ branching fractions	0.7	0.5	0.2
$B^0 \rightarrow X_c \ell \nu$ branching fractions	0.6	0.2	0.1
D decay branching fractions	0.1	0.3	0.1
SR $X_c \ell \nu$ normalization	1.6	3.5	3.4
CR $X_c \ell \nu$ normalization	0.9	1.1	0.4
Other backgrounds normalization	0.3	N/A	N/A
X_u fragmentation	0.3	4.4	3.9
$N_{Y(4S)}$	1.4	1.4	1.4
FEI	1.3	1.3	1.4
Slow pion efficiency	0.4	0.2	0.3
ℓ identification	0.7	0.7	0.6
$f^{\pm/00}$	0.6	0.7	0.6
Continuum calibration	0.2	0.2	0.2
Tracking	0.3	0.3	0.3
K_S^0 efficiency	0.1	0.1	<0.1
$K^\pm$ ID	<0.1	<0.1	<0.1
Simulated data statistics	1.1	1.1	0.8

Backup: $B \rightarrow \mu\nu$ with Inclusive Tag at Belle+Belle II

Table V: The uncertainties on the measured $B^+ \rightarrow \mu^+ \nu_\mu$ branching fraction are shown. For definitions of additive and multiplicative errors see the text. FF denotes form factor, and BF denotes branching fraction.

Source	Fractional uncertainty
Additive uncertainties	
$b \rightarrow u$ modeling	17.4%
$B \rightarrow \pi \ell^+ \nu_\ell$ FF	8.2%
$B \rightarrow \rho \ell^+ \nu_\ell$ FF	8.9%
$B^+ \rightarrow \omega \ell^+ \nu_\ell$ FF	4.5%
$B^+ \rightarrow \eta \ell^+ \nu_\ell$ FF	0.2%
$B^+ \rightarrow \eta' \ell^+ \nu_\ell$ FF	1.0%
$B \rightarrow \pi \ell^+ \nu_\ell$ BF	4.8%
$B \rightarrow \rho \ell^+ \nu_\ell$ BF	1.0%
$B^+ \rightarrow \omega \ell^+ \nu_\ell$ BF	0.2%
$B^+ \rightarrow \eta \ell^+ \nu_\ell$ BF	0.2%
$B^+ \rightarrow \eta' \ell^+ \nu_\ell$ BF	0.1%
$B \rightarrow X_u \ell^+ \nu_\ell$ BF	3.3%
DFN parameters	5.7%
Hybrid model	6.0%
MC sample size	5.6%
Continuum modeling	14.0%
Shape correction	4.1%
MC sample size	13.3%
$B^+ \rightarrow \mu^+ \nu_\mu \gamma$ modeling	4.8%
$b \rightarrow c$ modeling	2.4%
Rare decay modeling	1.5%
$B^+ \rightarrow \mu^+ \nu_\mu$ modeling	1.5%
Multiplicative uncertainties	
PID efficiency Belle	1.6%
Tracking efficiency Belle	0.3%
$N_{B\bar{B}}$ Belle	1.1%
PID efficiency Belle II	1.0%
Tracking efficiency Belle II	0.1%
$N_{B\bar{B}}$ Belle II	0.3%
f_{+0}	2.1%
Control channel efficiency ratios	3.2%
Total systematic uncertainty	23.6%
Total statistical uncertainty	42.9%

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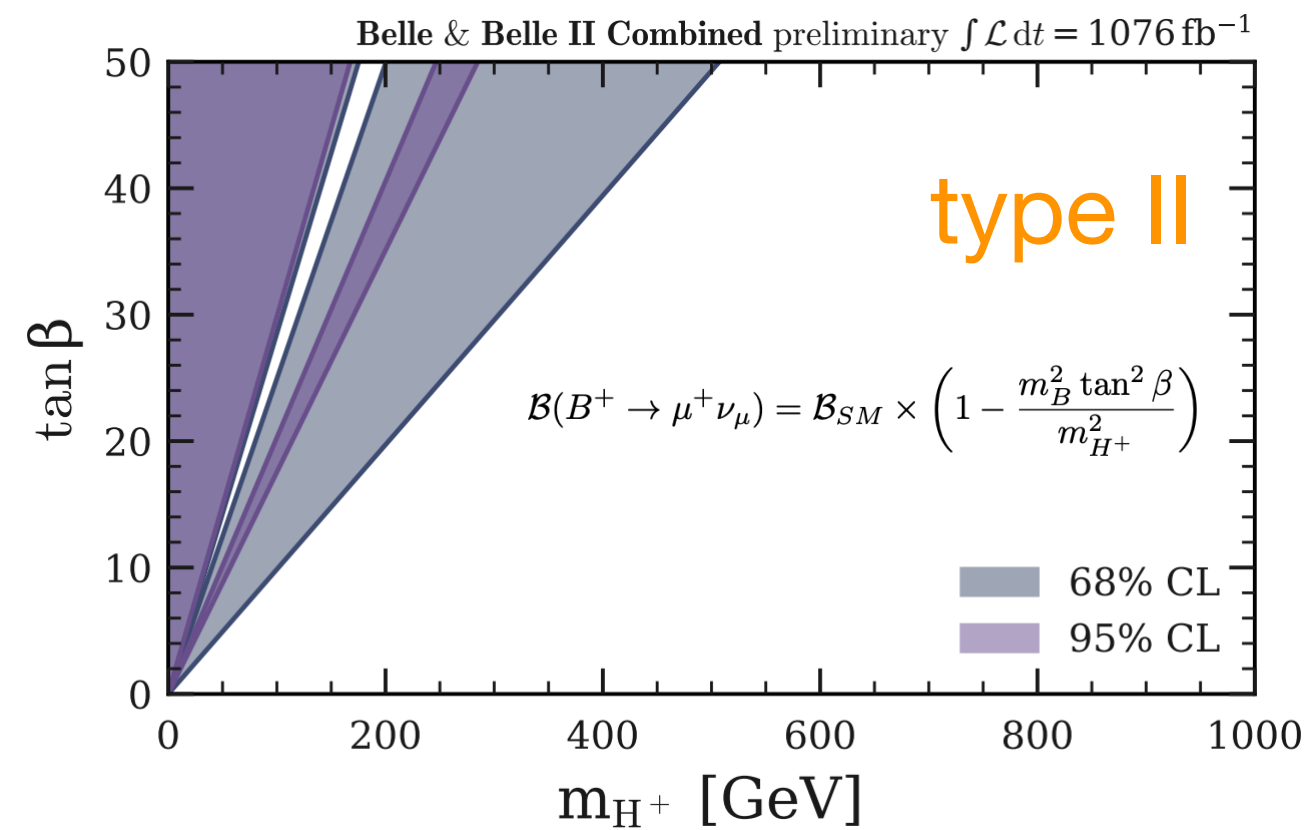


Backup: $B \rightarrow \mu\nu$ with Inclusive Tag at Belle+Belle II

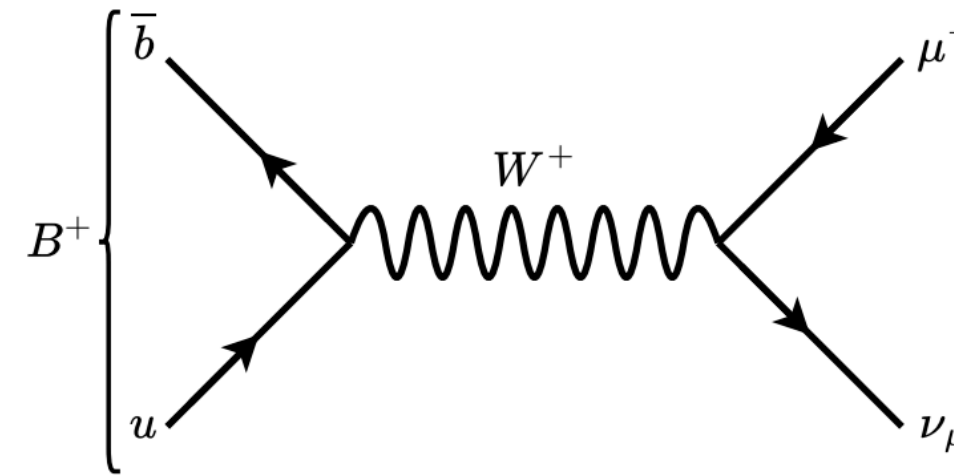
PRD 113, 112012 (2026)

Further investigation:

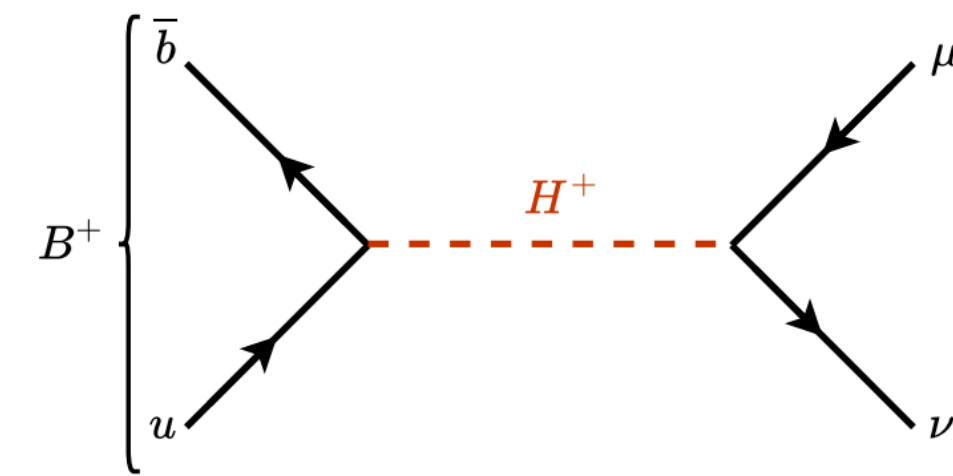
- Exclude parameter space for **type II & III 2HDM**
- Search for heavy neutrinos within $m_N=0\sim 1.5$ GeV
- Extract $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$ with $p_\mu^B > 2.2$ GeV
- Weak annihilation contribution in $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$



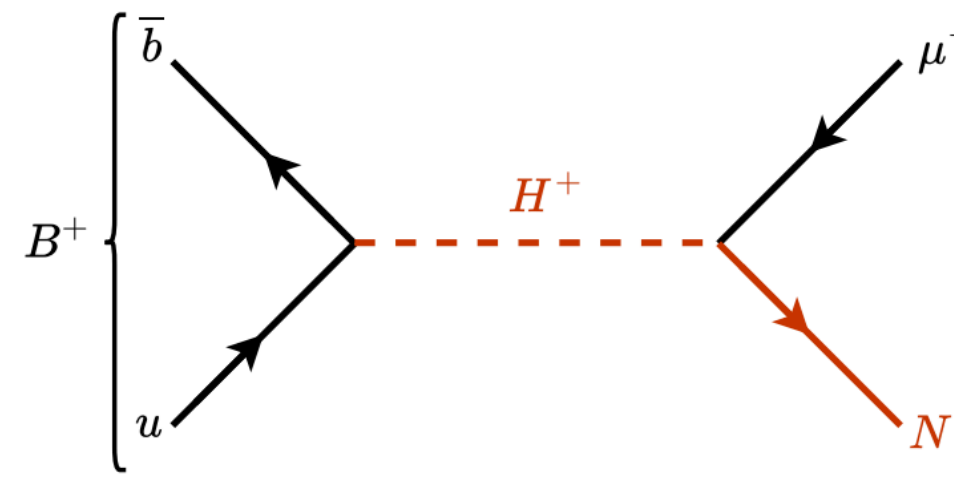
$$\mathcal{B}(B^+ \rightarrow \mu^+ \nu_\mu) = \frac{G_F^2 m_B m_\mu^2}{8\pi} \left(1 - \frac{m_\mu^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_{B^+}$$



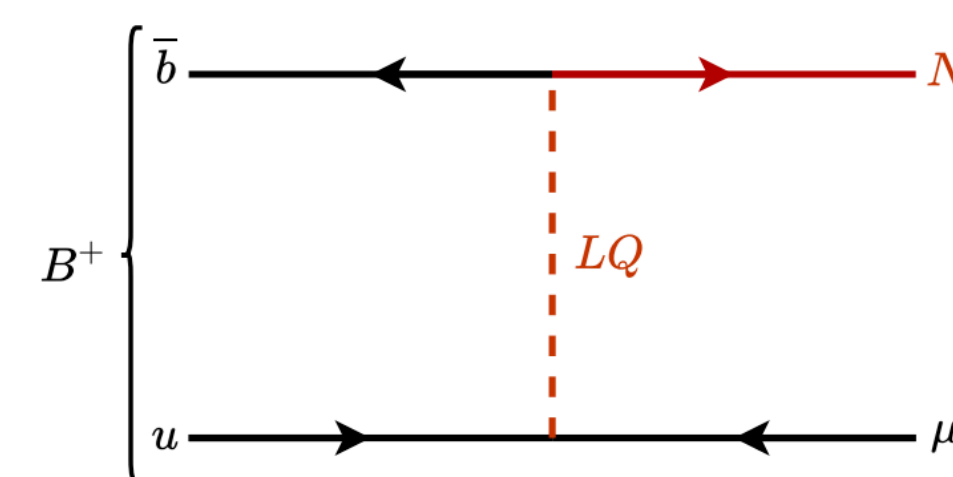
SM



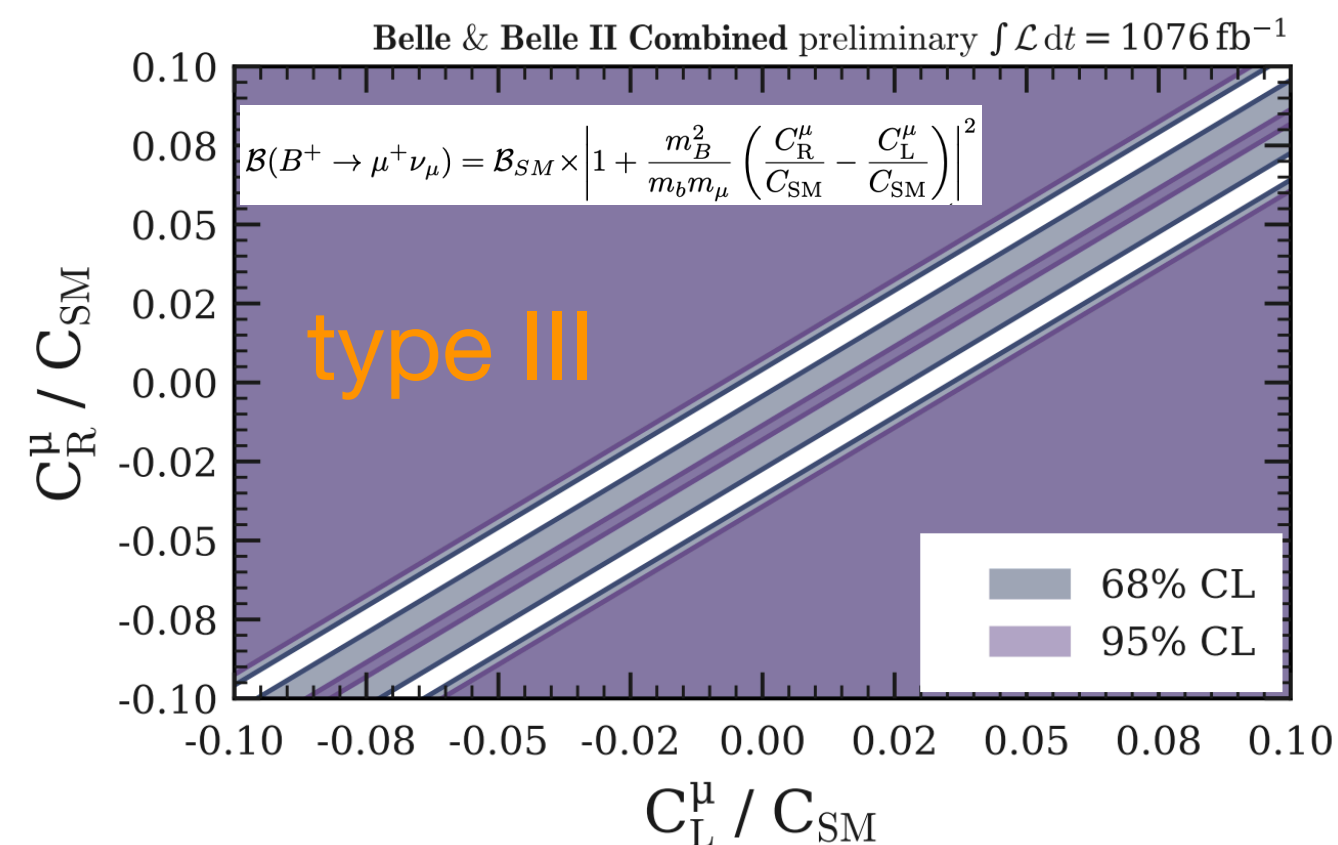
BSM



BSM



BSM

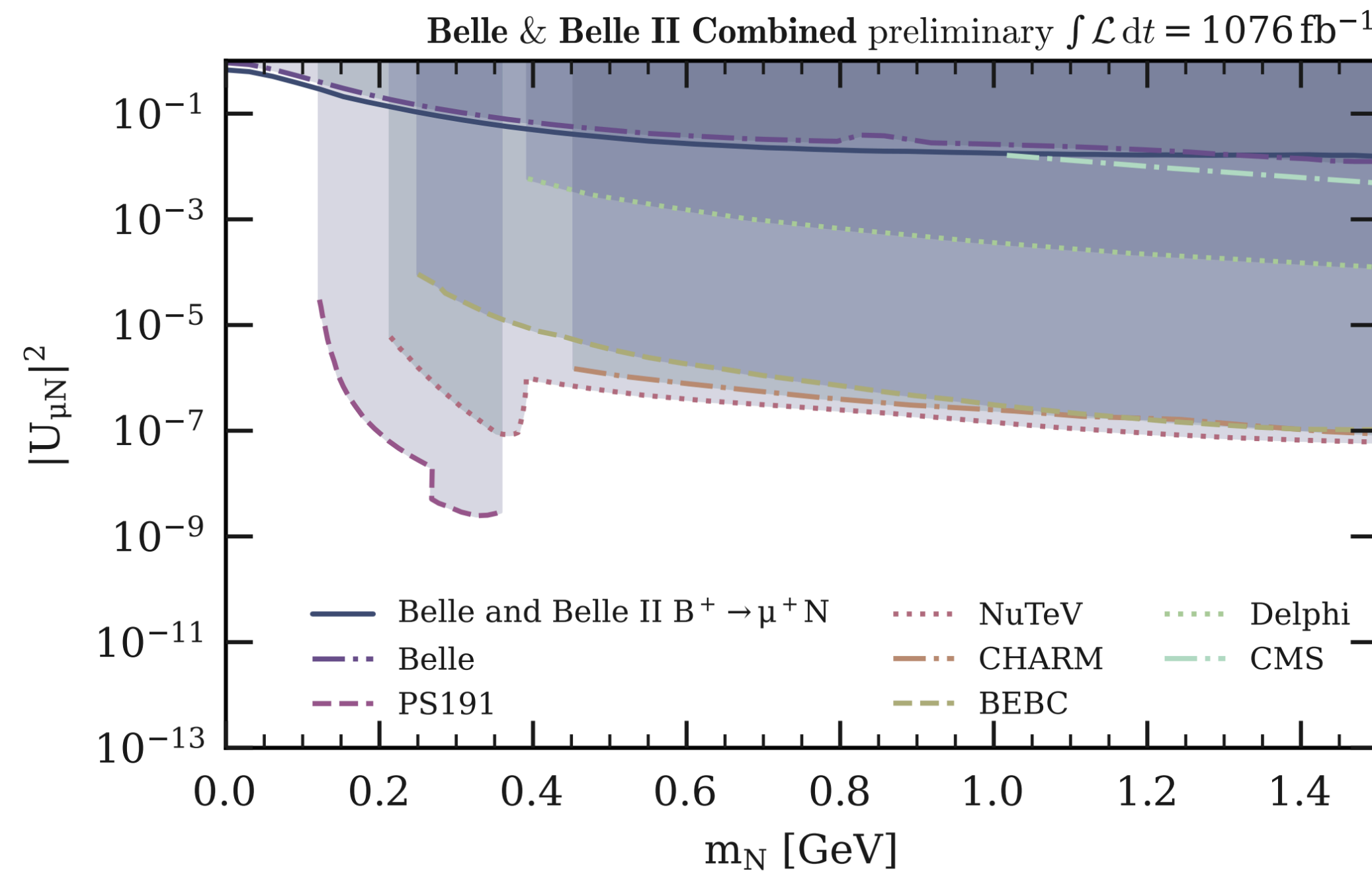
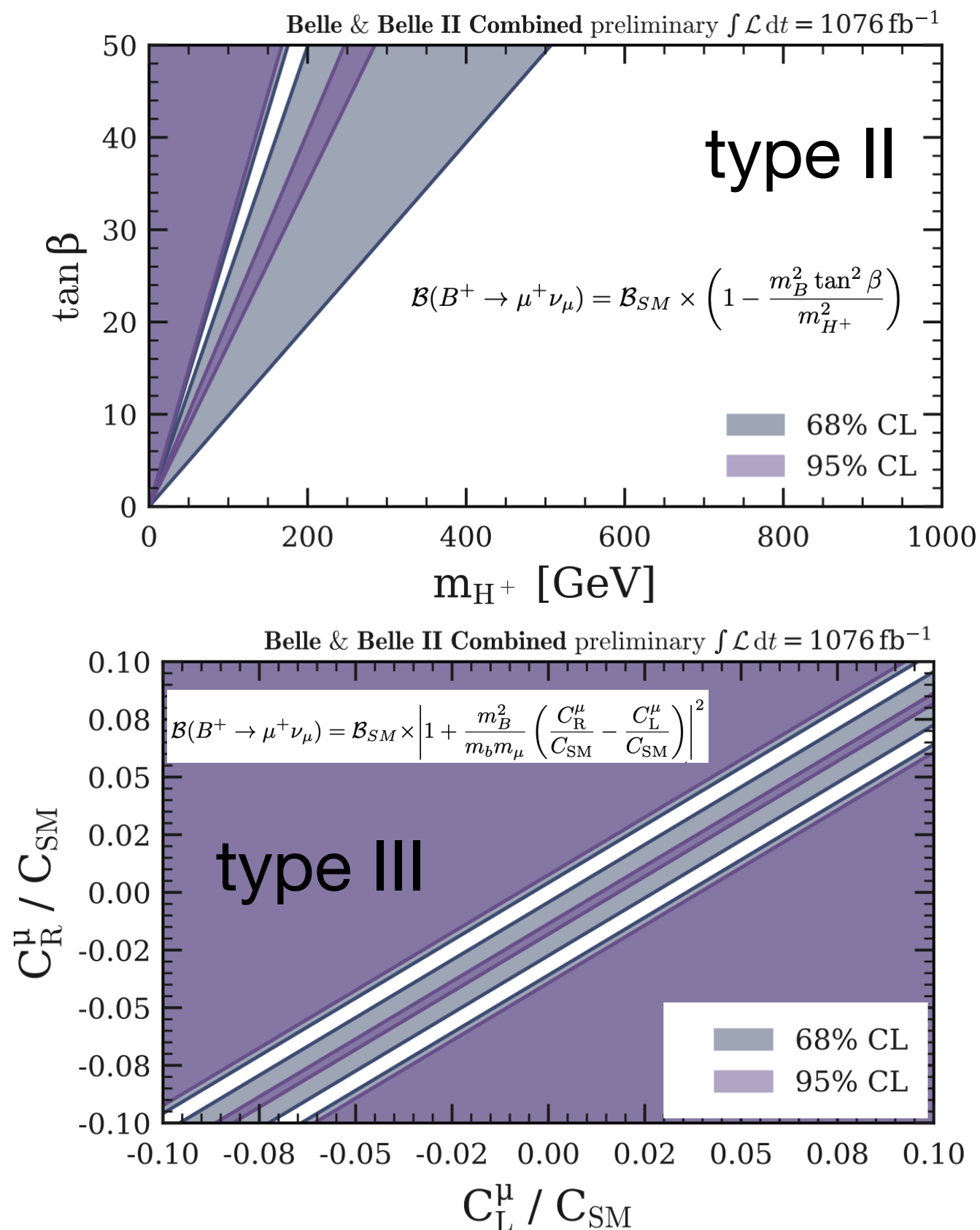


Backup: $B \rightarrow \mu\nu$ with Inclusive Tag at Belle+Belle II

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Further investigation:

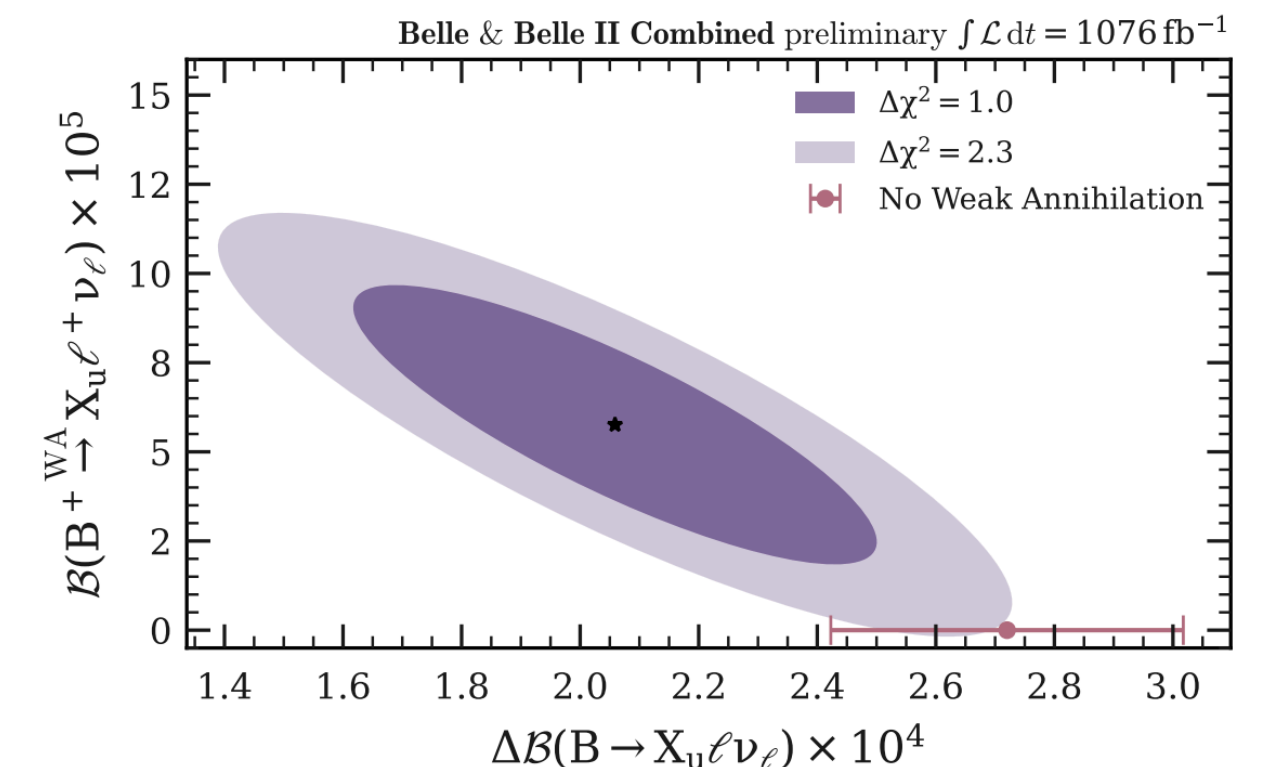
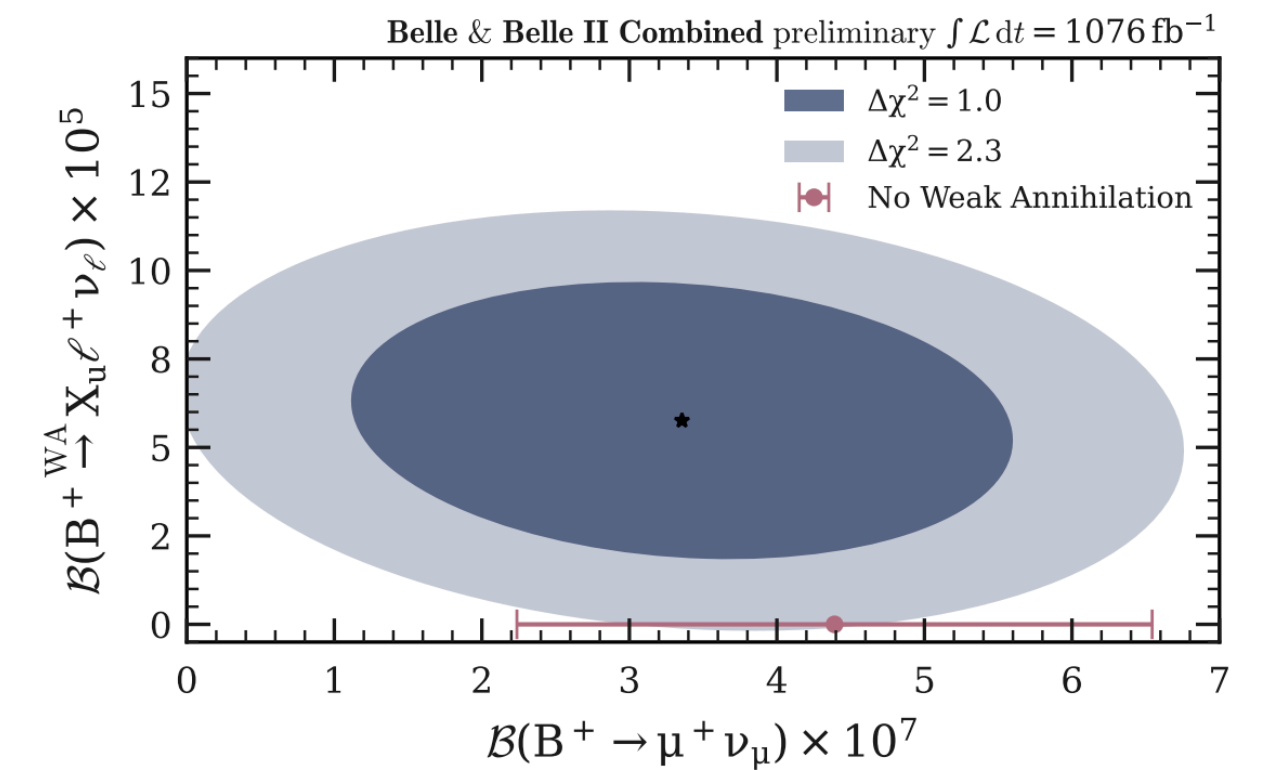
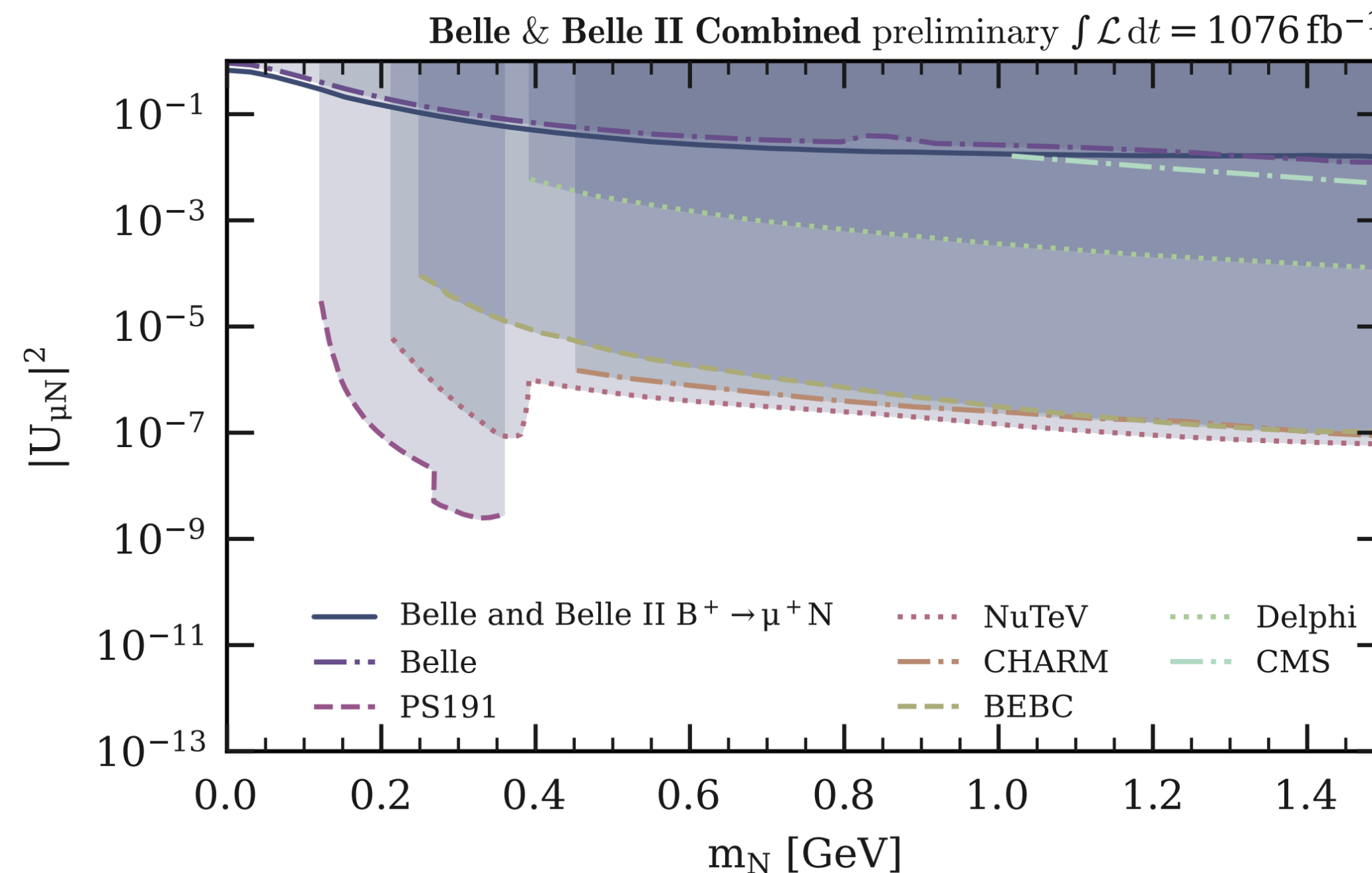
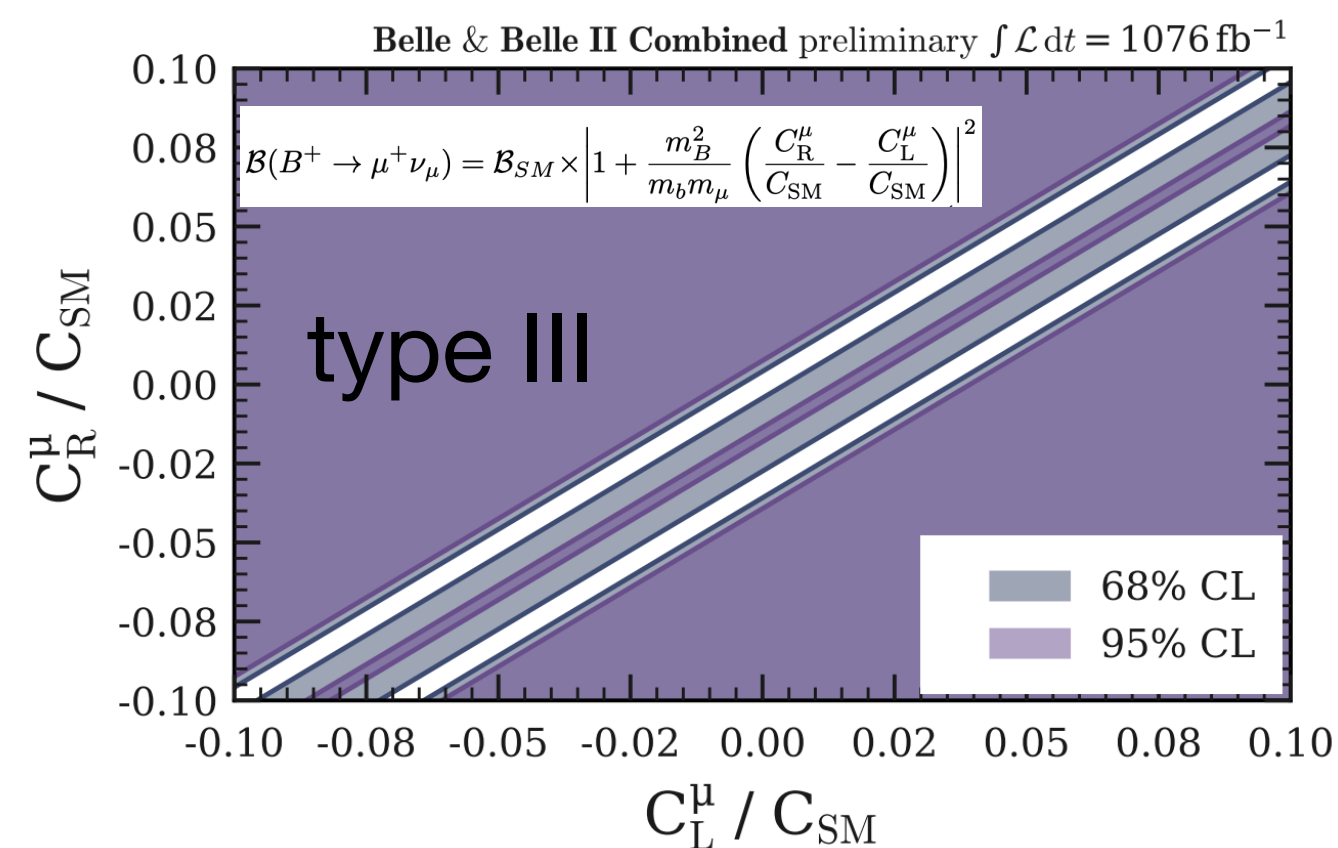
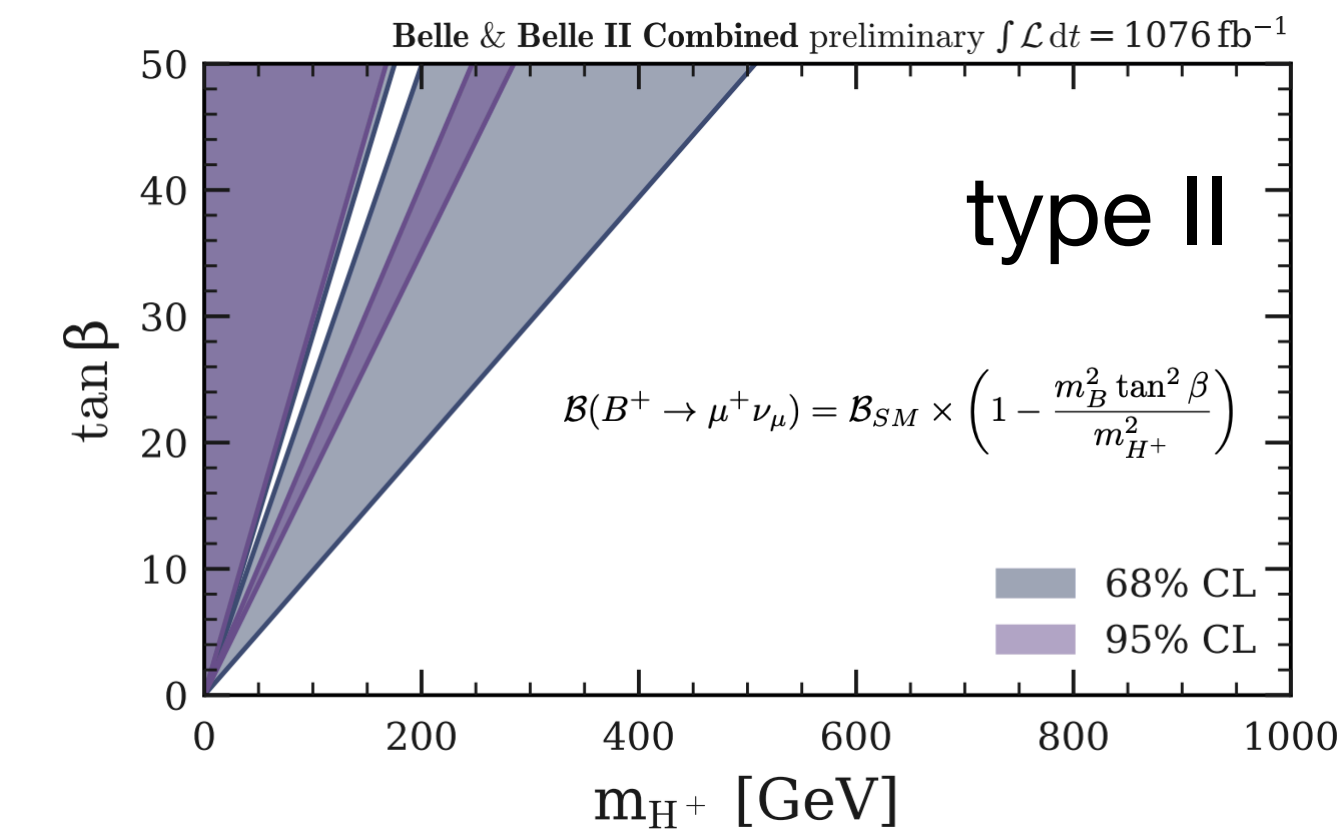
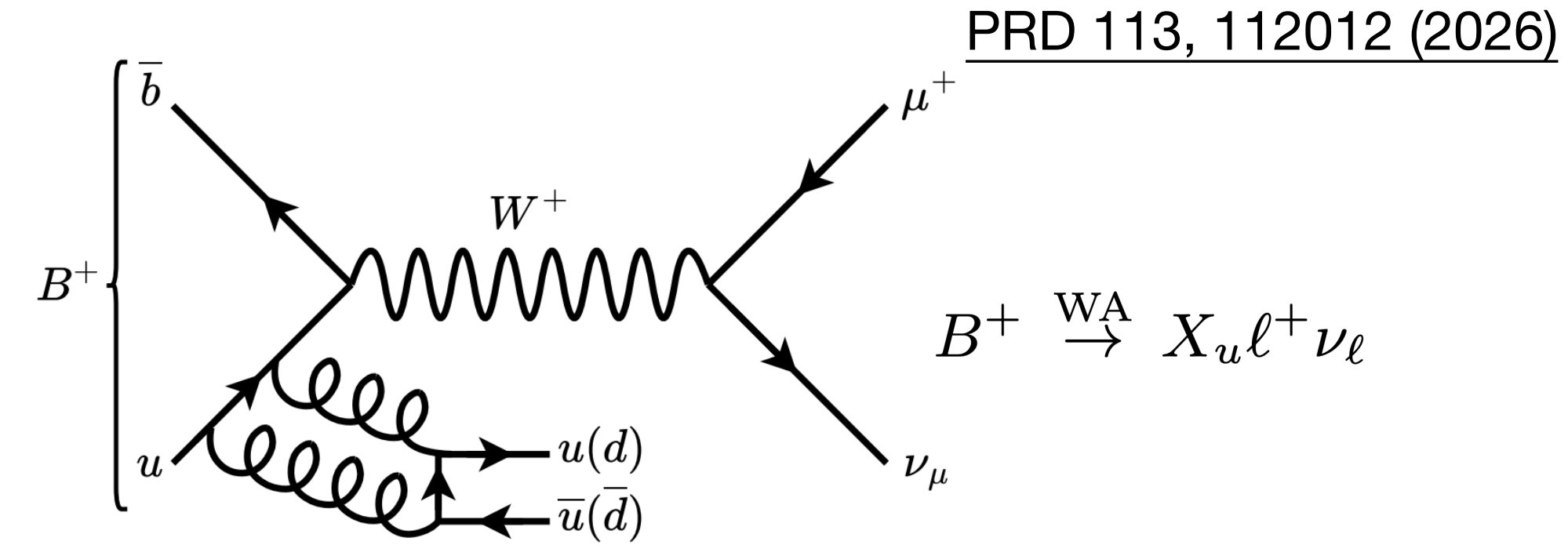
- Exclude parameter space for type II & III 2HDM
- Search for **heavy neutrinos within $m_N=0\sim 1.5$ GeV**
- Extract $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$ with $p_\mu^B > 2.2$ GeV
- Weak annihilation contribution in $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$



Backup: $B \rightarrow \mu\nu$ with Inclusive Tag at Belle+Belle II

Further investigation:

- Exclude parameter space for type II & III 2HDM
- Search for heavy neutrinos within $m_N=0\sim 1.5$ GeV
- Extract $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$ with $p_\mu^B > 2.2$ GeV $\Rightarrow$ agrees with inclusive result
- **Weak annihilation** contribution in $\Delta\mathcal{B}(B \rightarrow X_u\mu\nu)$



Backup: Mixing-Induced CP Violation in $B^0 \rightarrow \pi^0 \pi^0$

Methodology: PRD 112, 032011(2025)

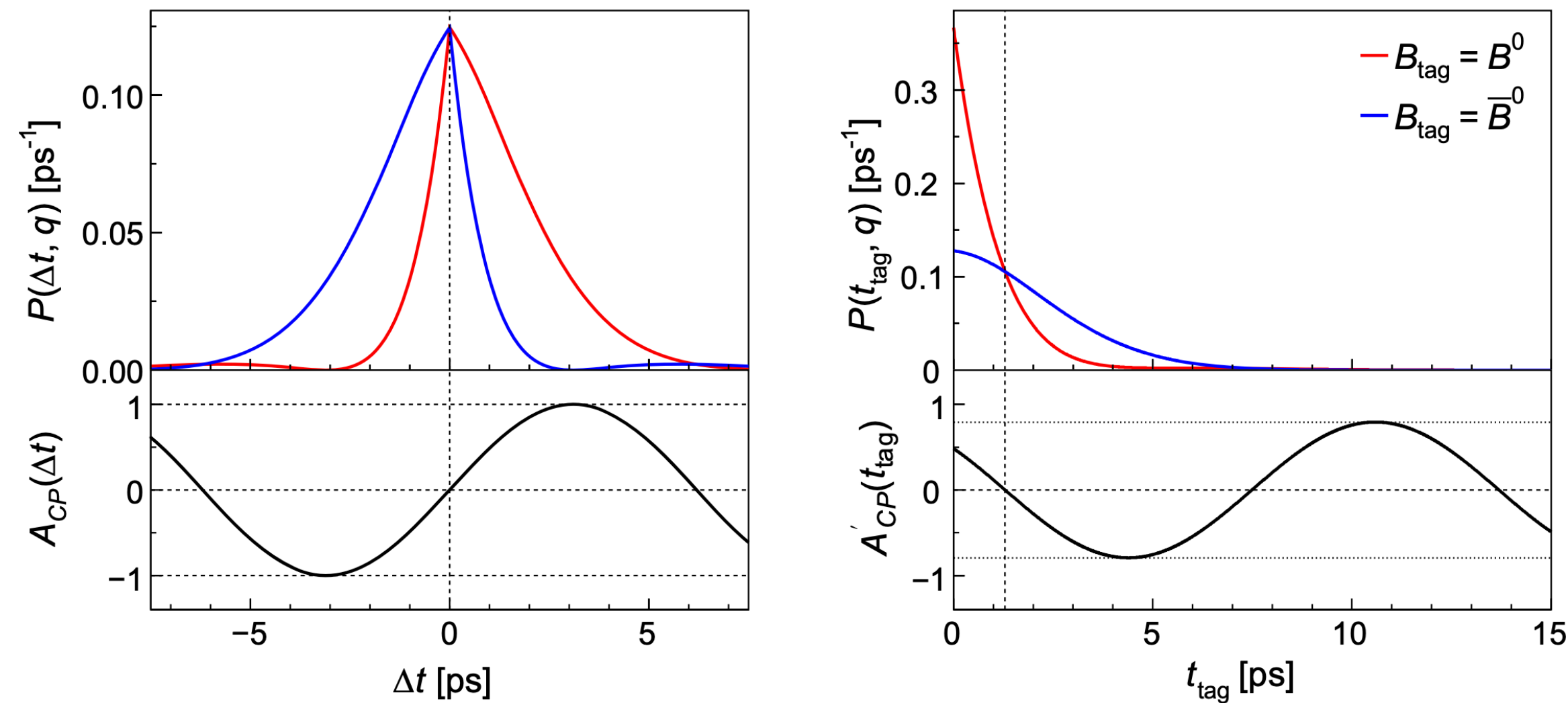


FIG. 1. Top panels: theoretical decay rates as a function of (left) Δt and (right) t_{tag} , for tagged (blue) B^0 and (red) $\bar{B}^0$ mesons assuming $S = 1.0$ and $C = 0.0$. Bottom panels: corresponding CP -violating decay-rate asymmetries (left) $A_{CP}(\Delta t)$ and (right) $A'_{CP}(t_{\text{tag}})$. The horizontal dashed lines show the maximum oscillation amplitudes. The vertical dashed line shows (left) the Δt origin and (right) the $\hat{t}$ value in Eq. (6). The decay time t_{tag} is non-negative by definition.

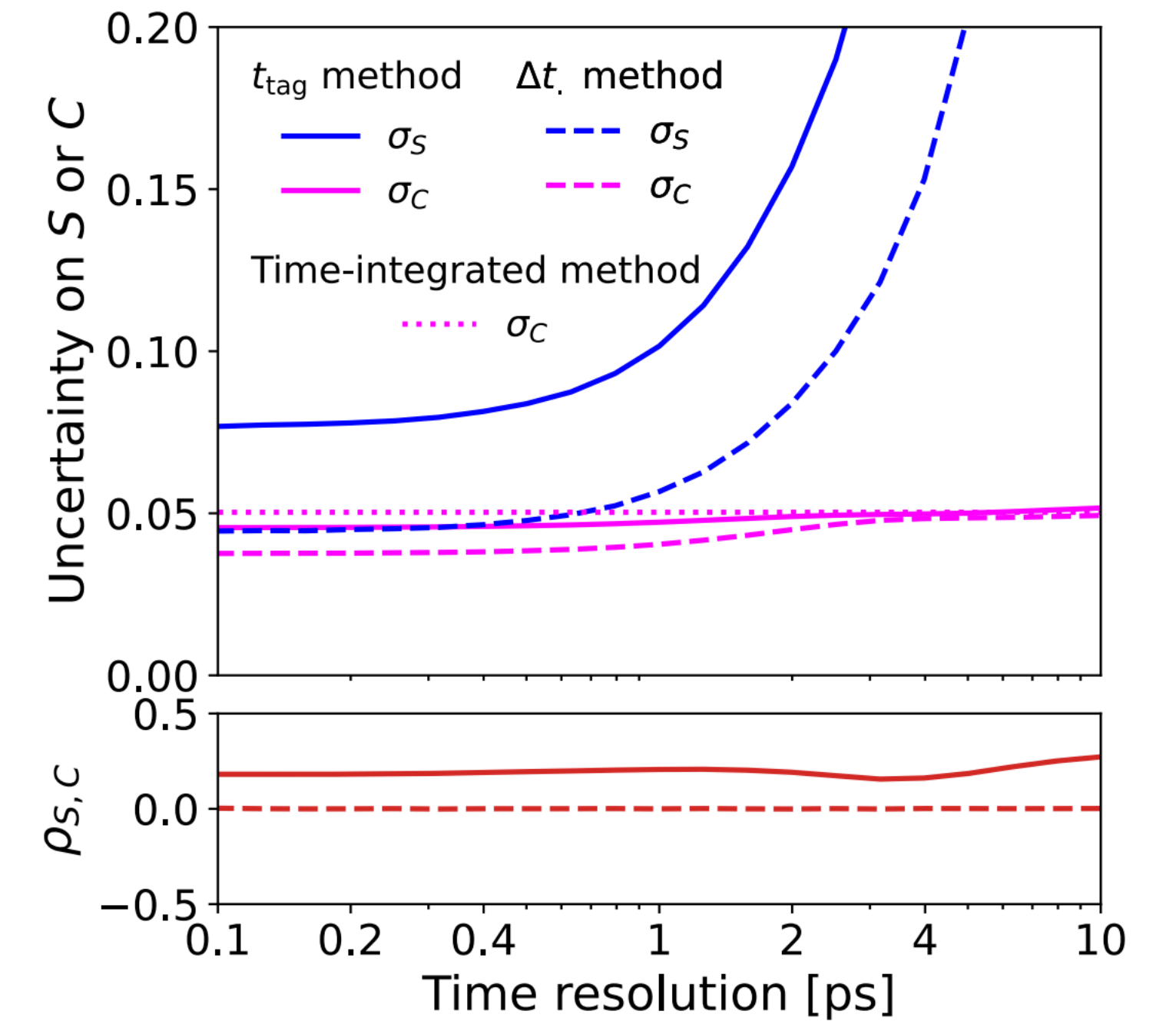


FIG. 2. Top panel: uncertainties on the CP -violating coefficients (blue) S and (magenta) C as functions of the resolution on (solid line) t_{tag} or (dashed line) Δt , for 10^3 perfectly tagged signal-only decays. Bottom panel: linear correlation between the coefficients.

Backup: First Observation of $B \rightarrow \Sigma_c(2455)\bar{\Xi}'_c$

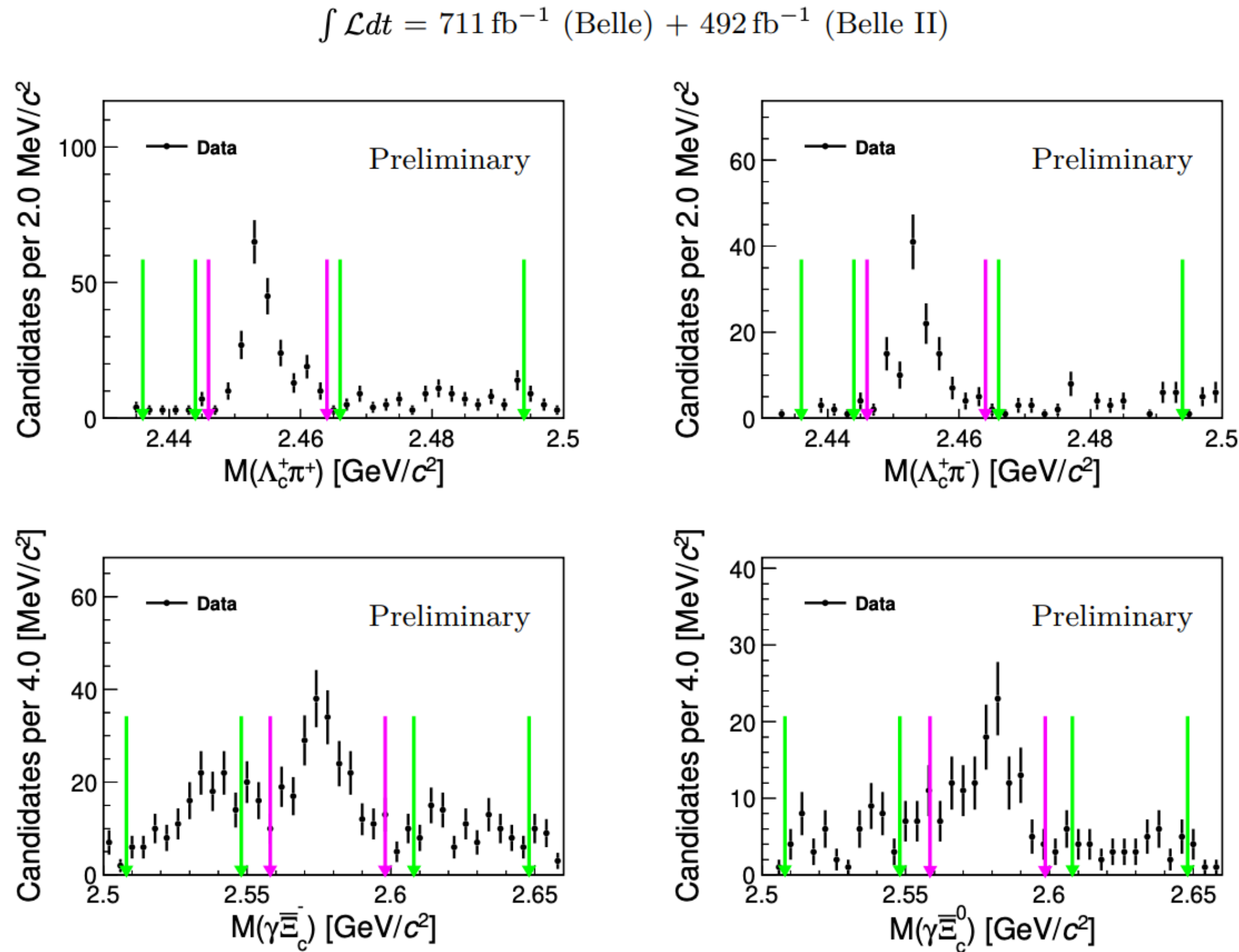


TABLE II: Summary of fractional systematic uncertainties (%) on the $\mathcal{B}(B^+ \rightarrow \Sigma_c(2455)^{++}\bar{\Xi}'_c^-)$ and $\mathcal{B}(B^0 \rightarrow \Sigma_c(2455)^0\bar{\Xi}'_c^0)$. The sources of all uncertainties are described in the text.

	σ_{DE}	σ_{eff}	$\sigma_{\mathcal{B}_i}$	$\sigma_{N_{\Upsilon(4S)}}$	$\sigma_{f_{+-/00}}$	σ_{BCS}	σ_{fit}	σ_{total}
B^+	2.7	1.0	3.5	1.0	2.1	2.5	4.3	7.2
B^0	2.4	1.0	3.5	1.0	1.7	3.6	4.9	7.8

FIG. 3: Distributions of (top) $M(\Lambda_c^+\pi^\pm)$ and (bottom) $M(\gamma\bar{\Xi}'_c^{-,0})$ for the reconstructed (left) $B^+ \rightarrow \Sigma_c(2455)^{++}\bar{\Xi}'_c^-$ and (right) $B^0 \rightarrow \Sigma_c(2455)^0\bar{\Xi}'_c^0$ candidates in the combined Belle and Belle II data. Points with error bars represent the data. The magenta arrows indicate the defined signal regions for the $\Sigma_c(2455)^{+,0}$ and $\bar{\Xi}'_c^{-,0}$ candidates, while the green arrows indicate the corresponding sideband regions.