Searches for dark sector particles at Belle II and Belle

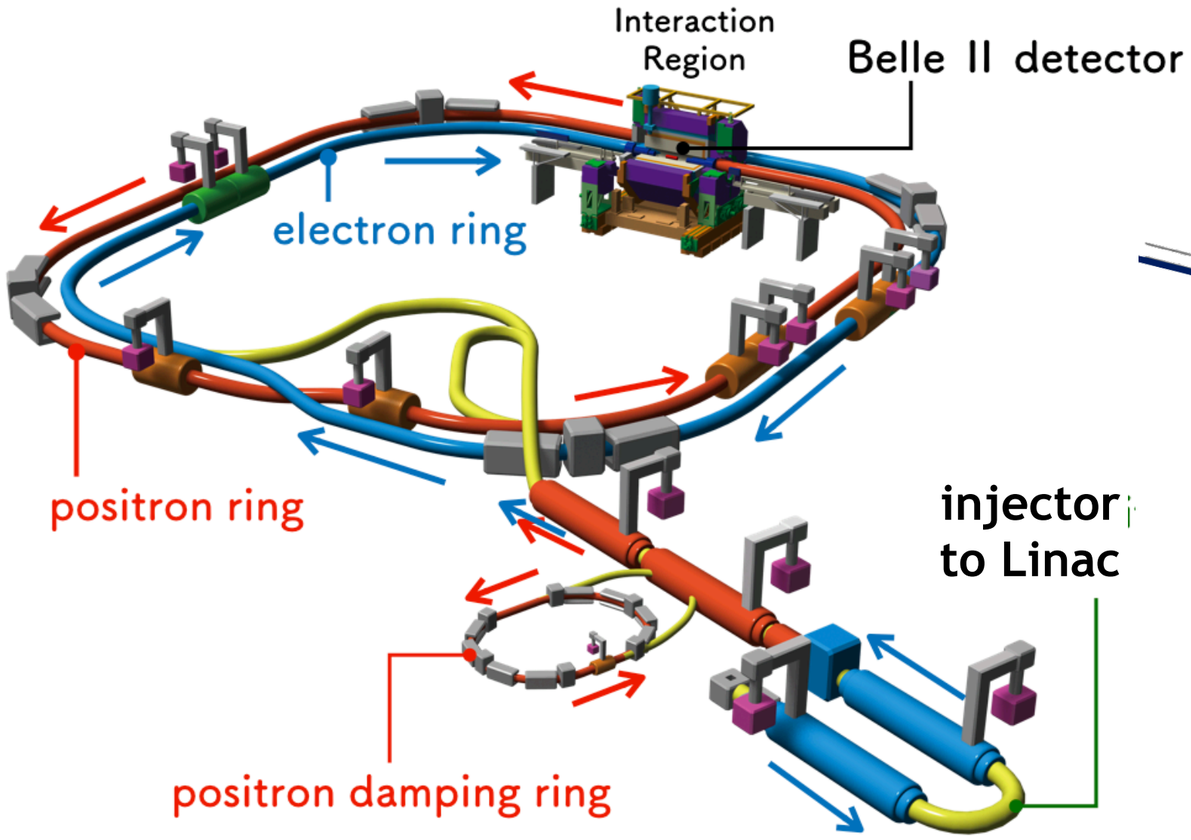
Youngjoon Kwon (Yonsei U.)

CPNR Workshop @ CAU, Oct. 26, 2026

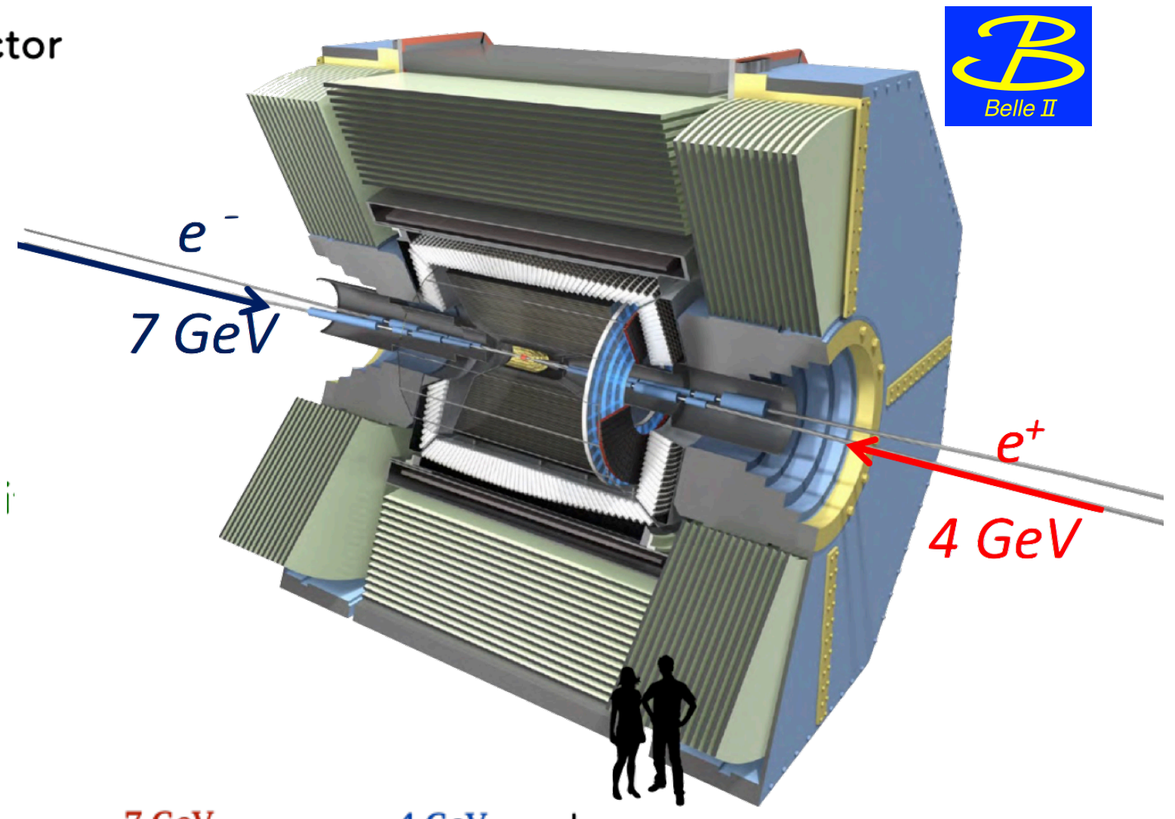
Overview

- A quick intro. to Belle II
- Recent results of dark sector particle search
  - ✓ Dark Higgs in association w/ inelastic DM (Belle II) PRL 135, 131801 (2025)
  - ✓ Dark photon search in $e^+e^- \to \gamma[\mu^+\mu^-]$ (Belle II) *Preliminary*
  - ✓ ALP search in $e^+e^- \to \gamma a$ (Belle II) arXiv:2607.07800 *submitted to PRL*
  - ✓ $B \to K^{(*)}\gamma\gamma$ for ALP search (Belle) JHEP 12 (2025) 109
  - ✓ Feebly-interacting particle search in B (Belle) PRL 136, 231802 (2026)
- Closing remarks

SuperKEKB



Belle II

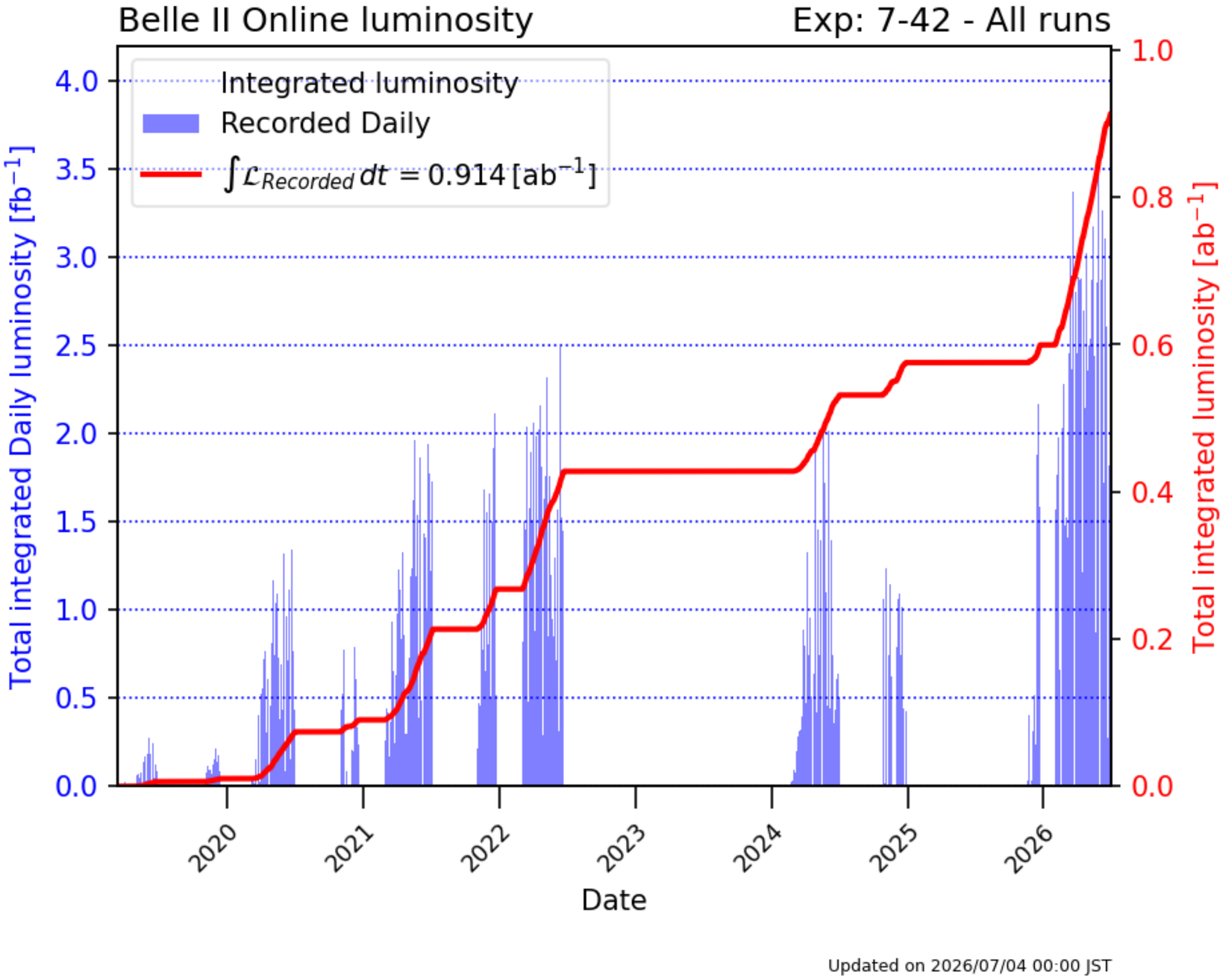


$$e^- \xrightarrow{7\ \text{GeV}} (\star) \xleftarrow{4\ \text{GeV}} e^+$$

$$\sqrt{s} = 10.58\ \text{GeV} = m_{\Upsilon(4S)}c^2$$

We also have data taken off-resonance as well as energy scan around $\Upsilon(5S)$

- $\mathcal{B}(\Upsilon(4S) \to B\overline{B}) > 96\%$, with $p_B^{CM} \sim 0.35$ GeV/c
- nothing else but $B\overline{B}$ in the final state
  $\therefore$ if we know $(E, \vec{p})$ of one B, the other B is also constrained "B-tagging" *unique to e^+e^- B-factory*

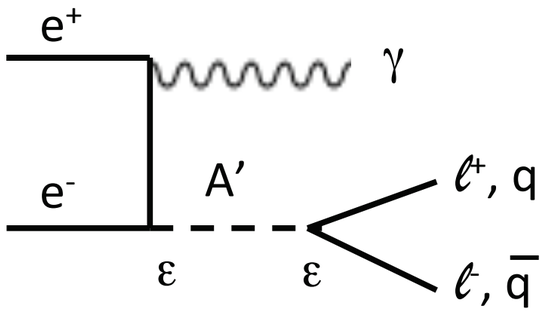


- $\mathscr{L}_{\mathrm{peak}} = 5.2 \times 10^{34}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$ (world record)
- Now, world's largest sample of $B\bar{B}$ from e^+e^- collision

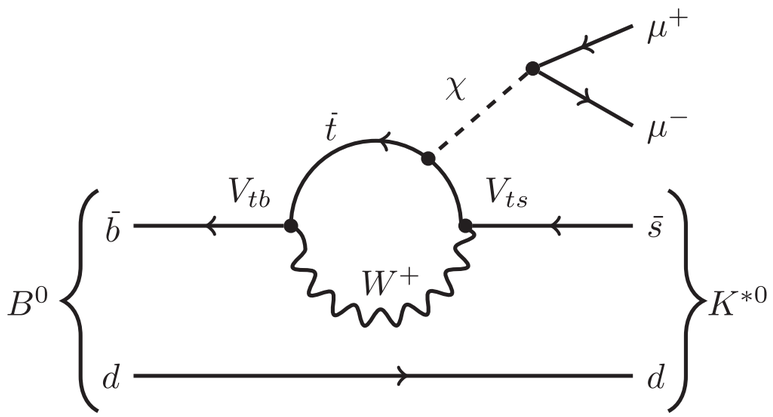
Belle (1999-2010)
Luminosity

- $\int \mathscr{L}_{\mathrm{total}} = 1\ \mathrm{ab}^{-1}$
- $\int \mathscr{L}_{\Upsilon(4S)} = 711\ \mathrm{fb}^{-1}$

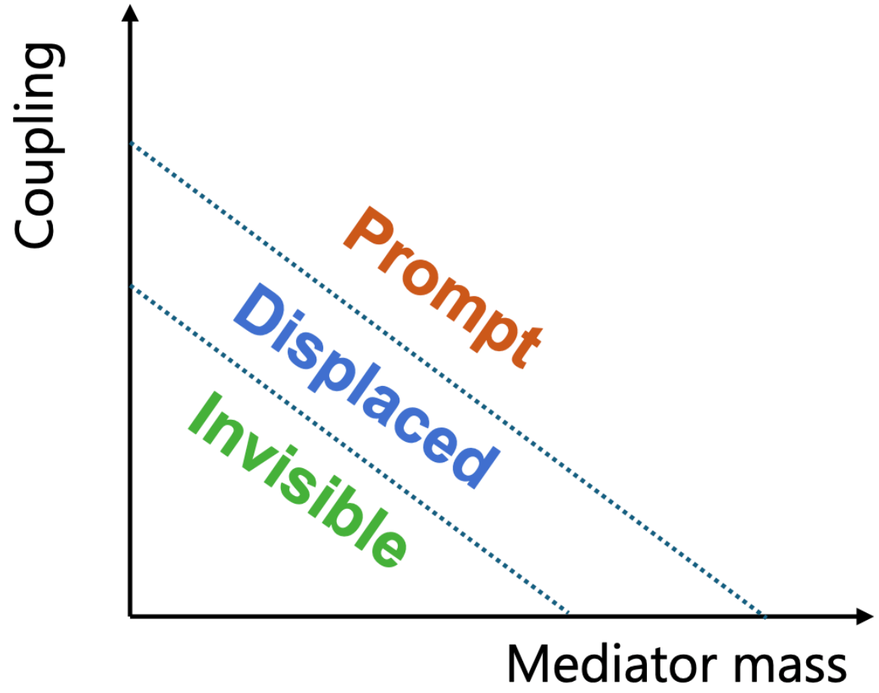
how to look for dark sector at Belle II



ISR



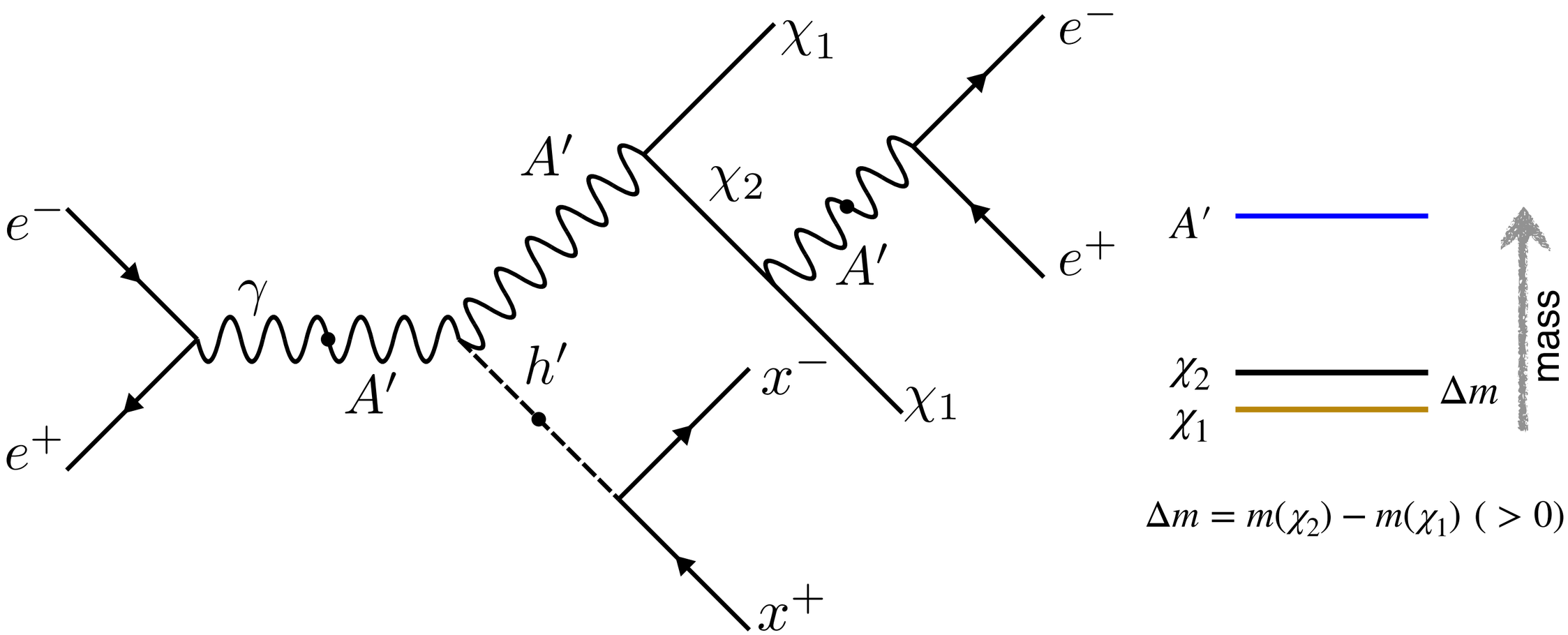
B decays



- For invisible final states
  - use missing $(E, \vec{p})$ — we are NOT testing energy-momentum conservation
- For visible final states

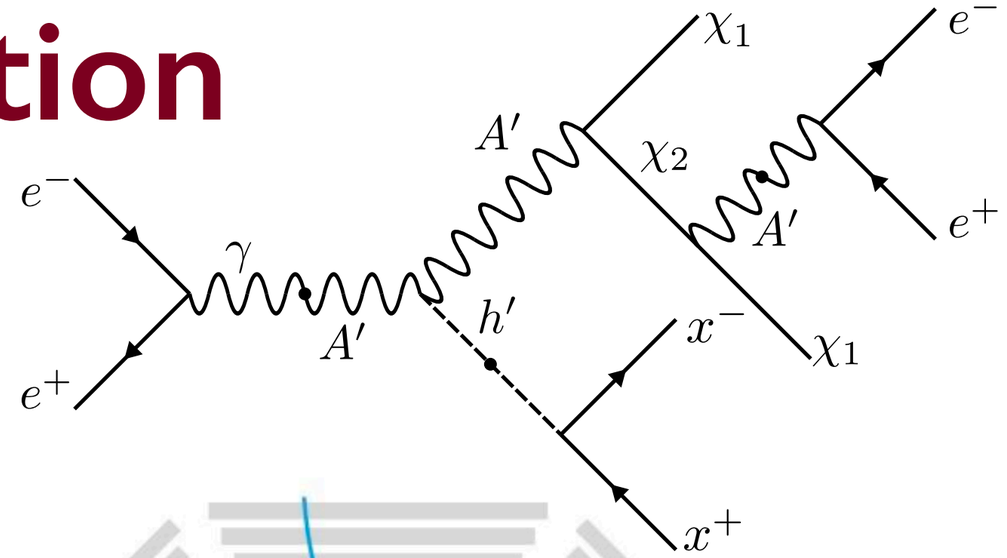
  (Q) how to distinguish them from SM particles?
  - search for resonant and/or kinematic features (e.g. displaced vertex) unknown in the SM

Dark Higgs in association with Inelastic DM

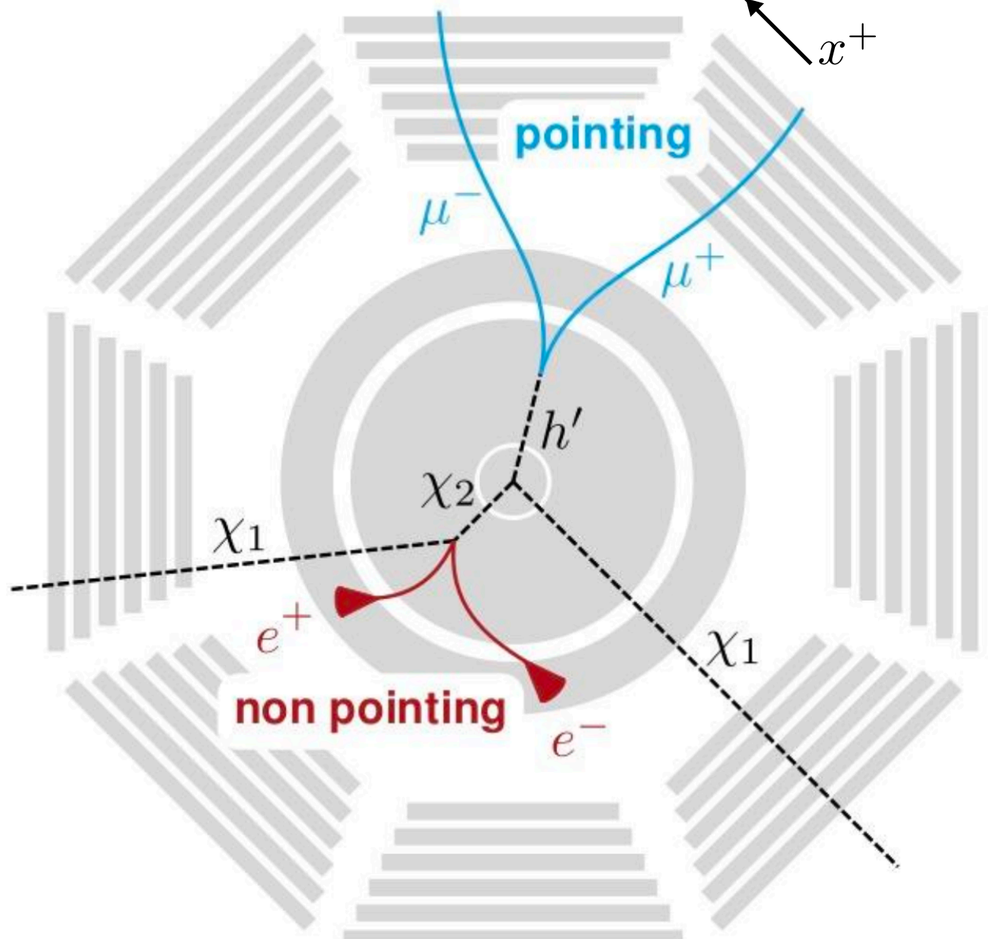


Inelastic DM, Introduction

- Dark sector (DS) with dark Higgs h', dark photon A' [#]
  - DM particles χ_2, χ_1 with $\Delta m = m(\chi_2) - m(\chi_1)$ (> 0)
  - χ_1 (lightest DS particle) — stable & relic DM candidate
  - Focus on $m(A') > m(\chi_2) + m(\chi_1)$ for $A' \to \chi_1\chi_2$



- Experimental Signature
  - challenging for tracking (displaced), trigger
  - Four tracks in the final state
  - (up to) two displaced vertices
    - ✓ $h' \to x^+x^-$ $(x = \mu, \pi, K)$ **"pointing"**
    - ✓ $\chi_2 \to \chi_1 A'(\to e^+e^-)$ **"non-pointing"**
  - missing energy due to stable χ_1
  - very small SM background ("smoking gun")



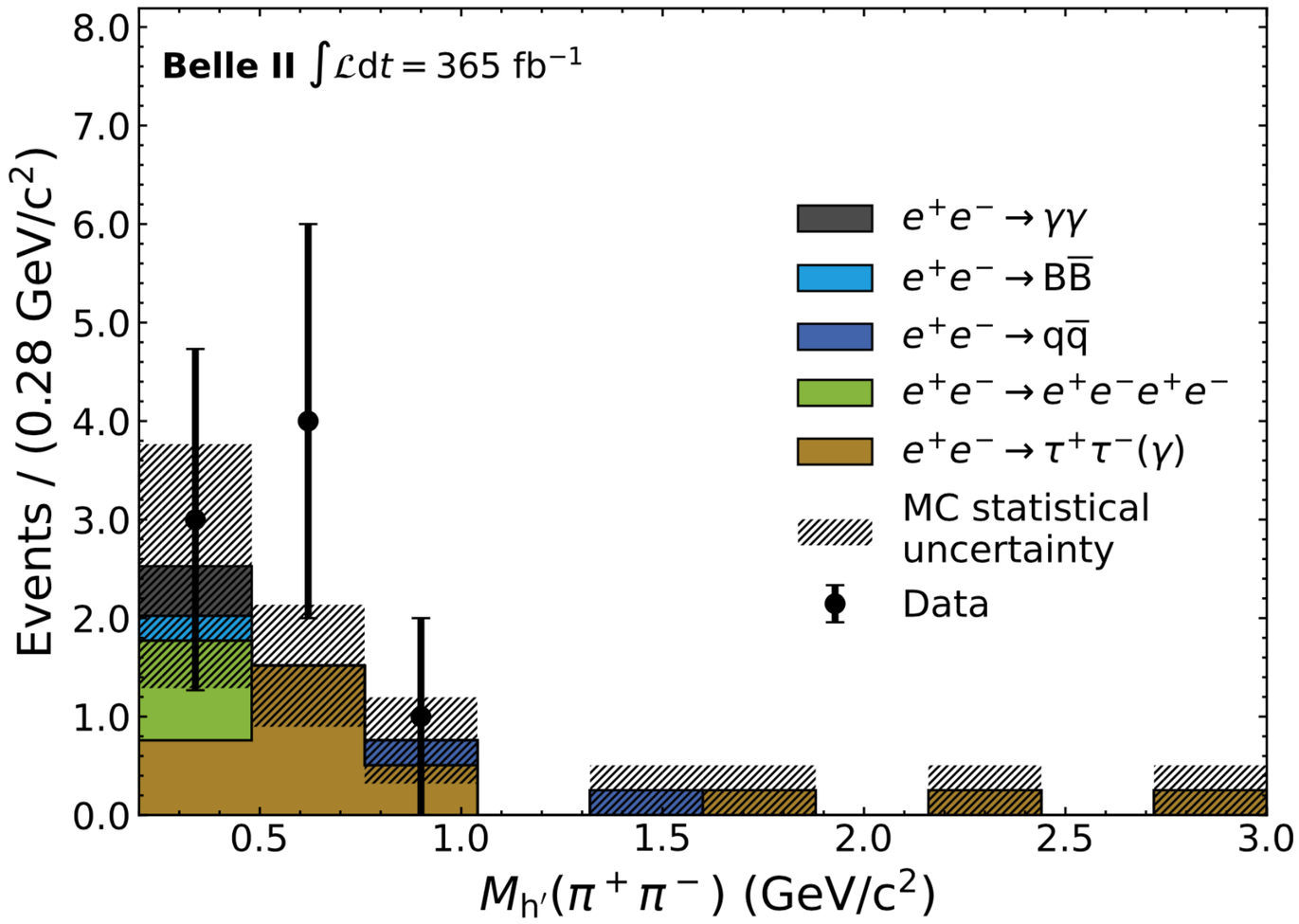
adapted from Duerr, Ferber et al, JHEP04 (2021) 146

[#] D. Smith and N. Weiner, *Inelastic dark matter*, PRD 64, 043502 (2001).

Editors' Suggestion PRL 135, 131801 (2025)

Dark Higgs, Results

- Signal extraction procedure
  - cut-and-count for signal extraction
    - ✓ count events in narrow window of $M(x^+x^-)$
  - Background estimation using data sideband in $M(x^+x^-)$, not to rely on MC
    - ✓ full mass range for $\mu^+\mu^-$ and K^+K^-
    - ✓ for $\pi^+\pi^-$, split the mass region at 1 GeV

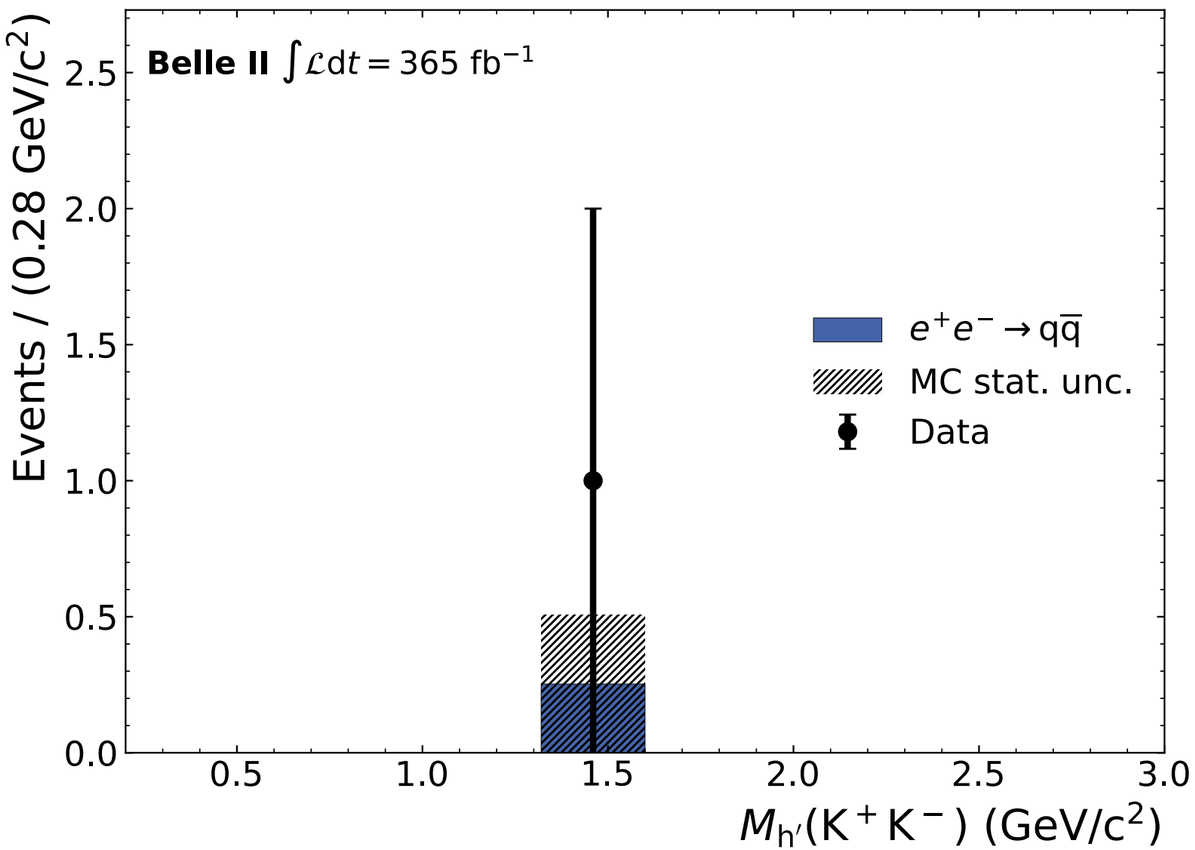


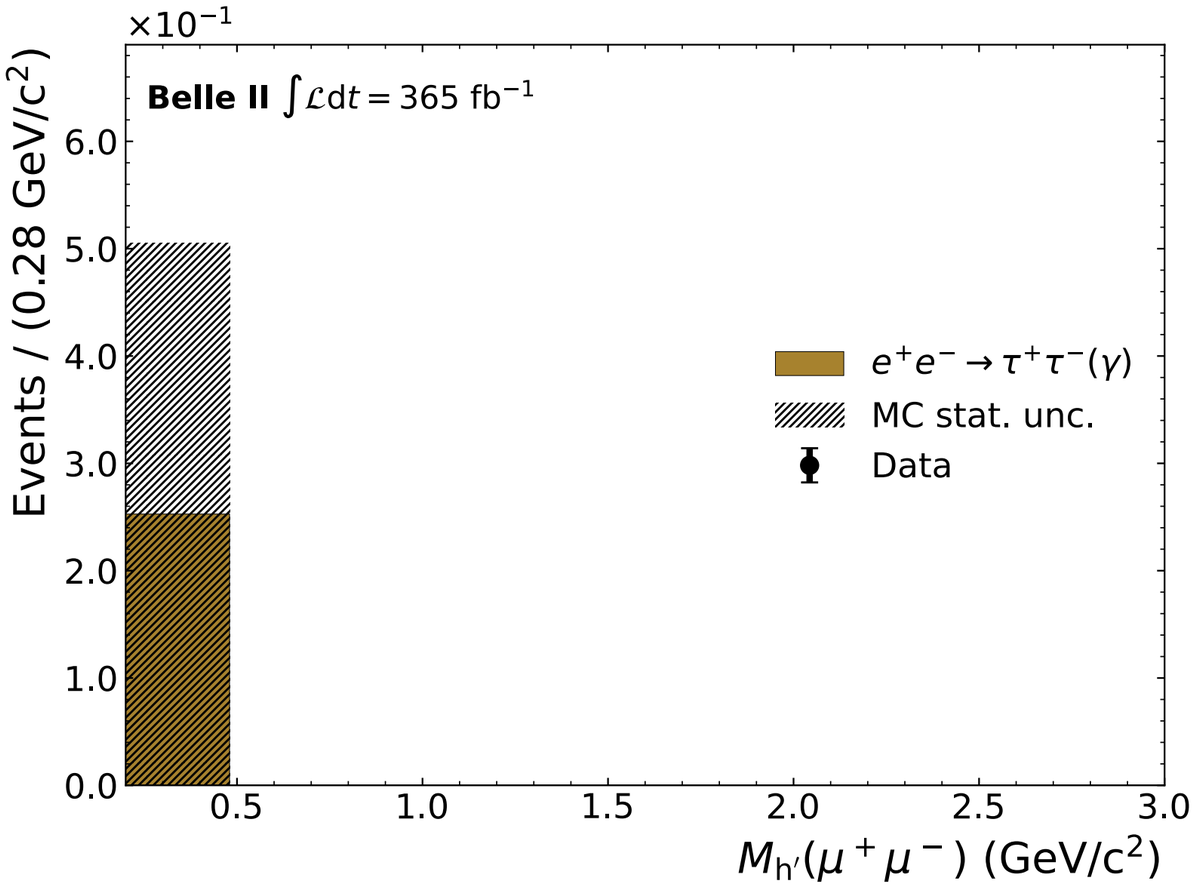
- No significant excess in any mode (or combined)
  - 8 events in $\pi^+\pi^-$ (consistent with background)
    - ✓ largest local significance of 2.9σ (1.1σ global) at $m(h') = 0.531$ GeV

Editors' Suggestion PRL 135, 131801 (2025)

Dark Higgs, Results

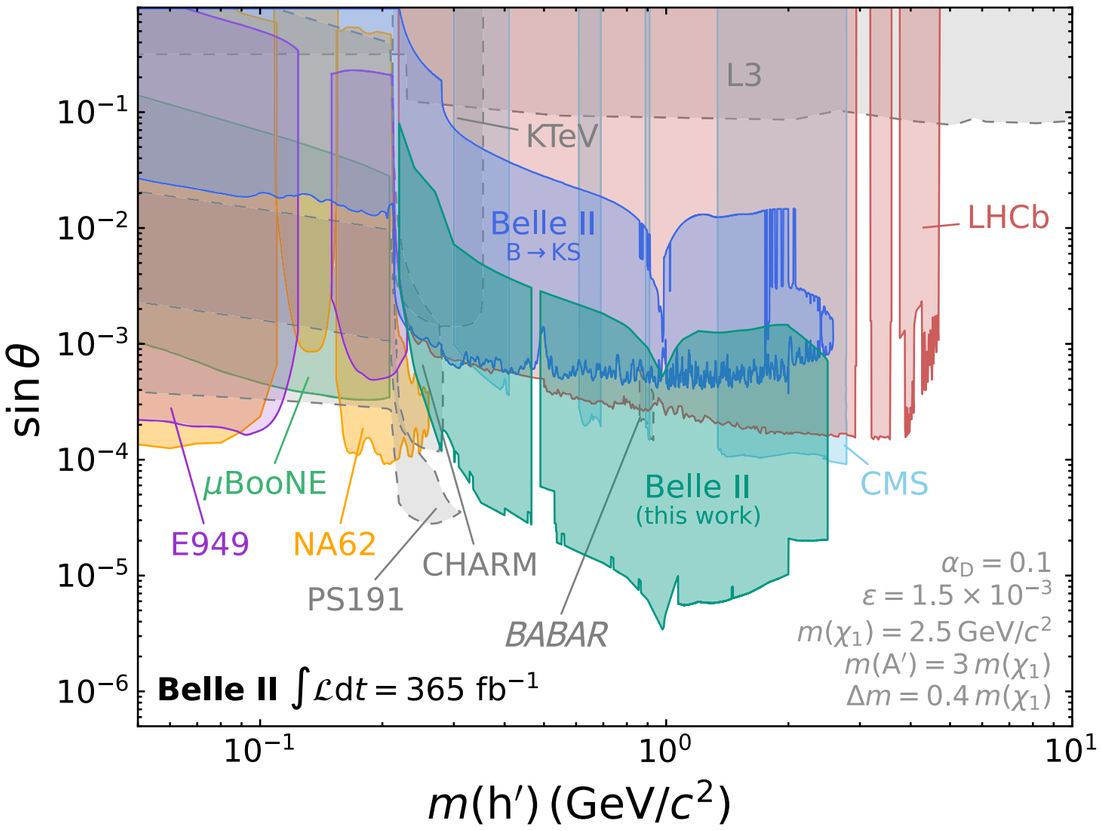
- No significant excess in any mode (or combined)
  - 8 events in $\pi^+\pi^-$ (consistent with background)
  - 1 event in K^+K^-, 0 events in $\mu^+\mu^-$

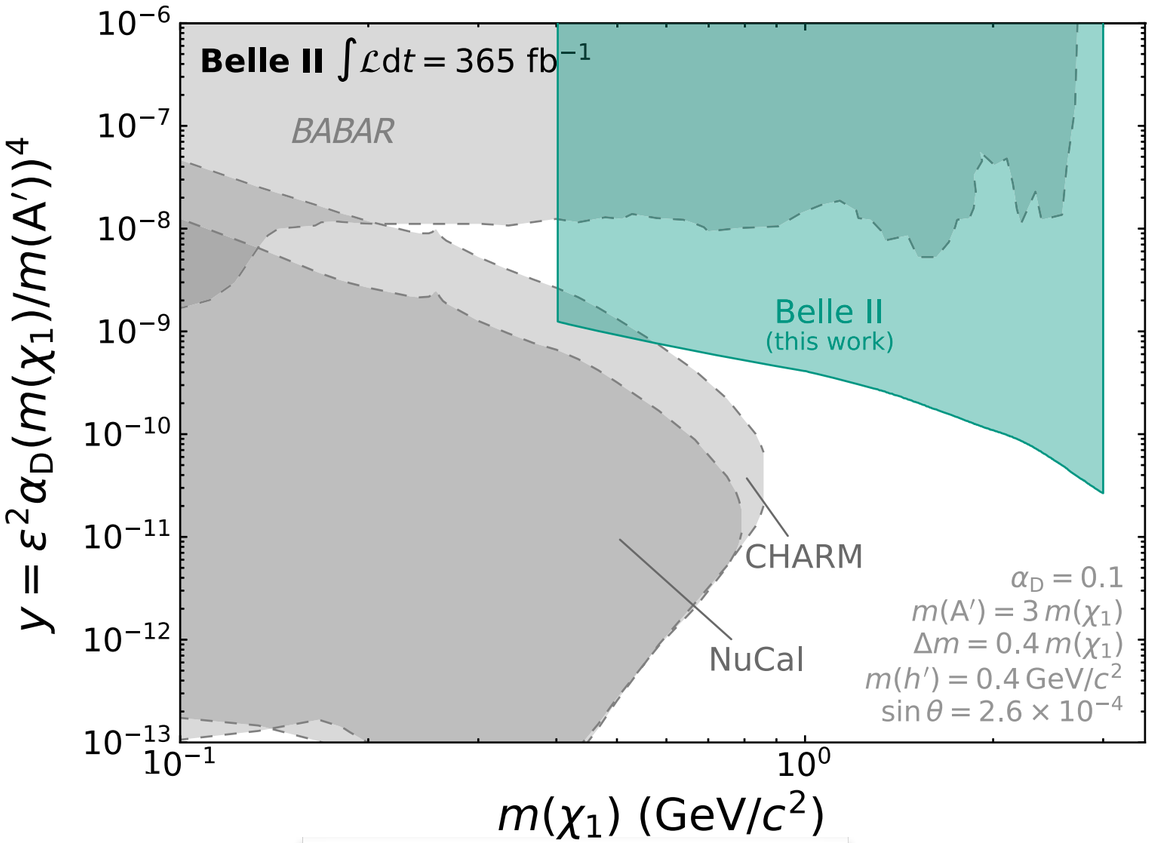




Editors' Suggestion PRL 135, 131801 (2025)

Inelastic DM, Results





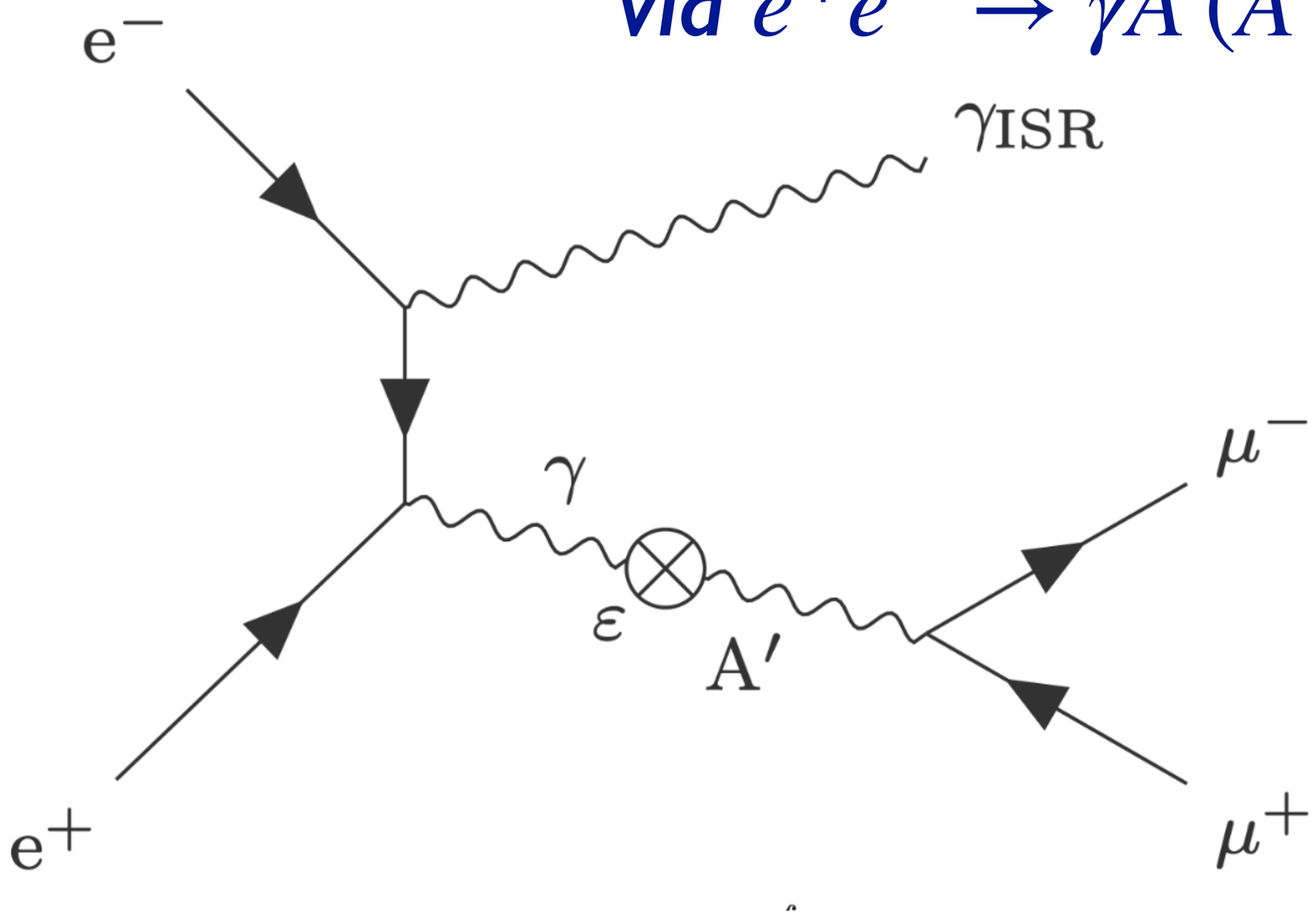
- Model-dependent limits on the coupling strengths and parameters
  - shown here for a specific choice
  - many more plots (~30), for different parameter sets
  - (Right plot) non-Belle II limits do not assume h', so less model-dependent

$$\alpha_D = 0.1$$
$$\varepsilon = 1.5 \times 10^{-3}$$
$$m(\chi_1) = 2.5\ \mathrm{GeV}$$
$$m(A') = 3m(\chi_1)$$
$$\Delta m = 0.4m(\chi_1)$$
$$\sin\theta = 2.6 \times 10^{-4}$$

See Back-up for meaning of the parameters

Dark photon search

via $e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$



Preliminary

$e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$

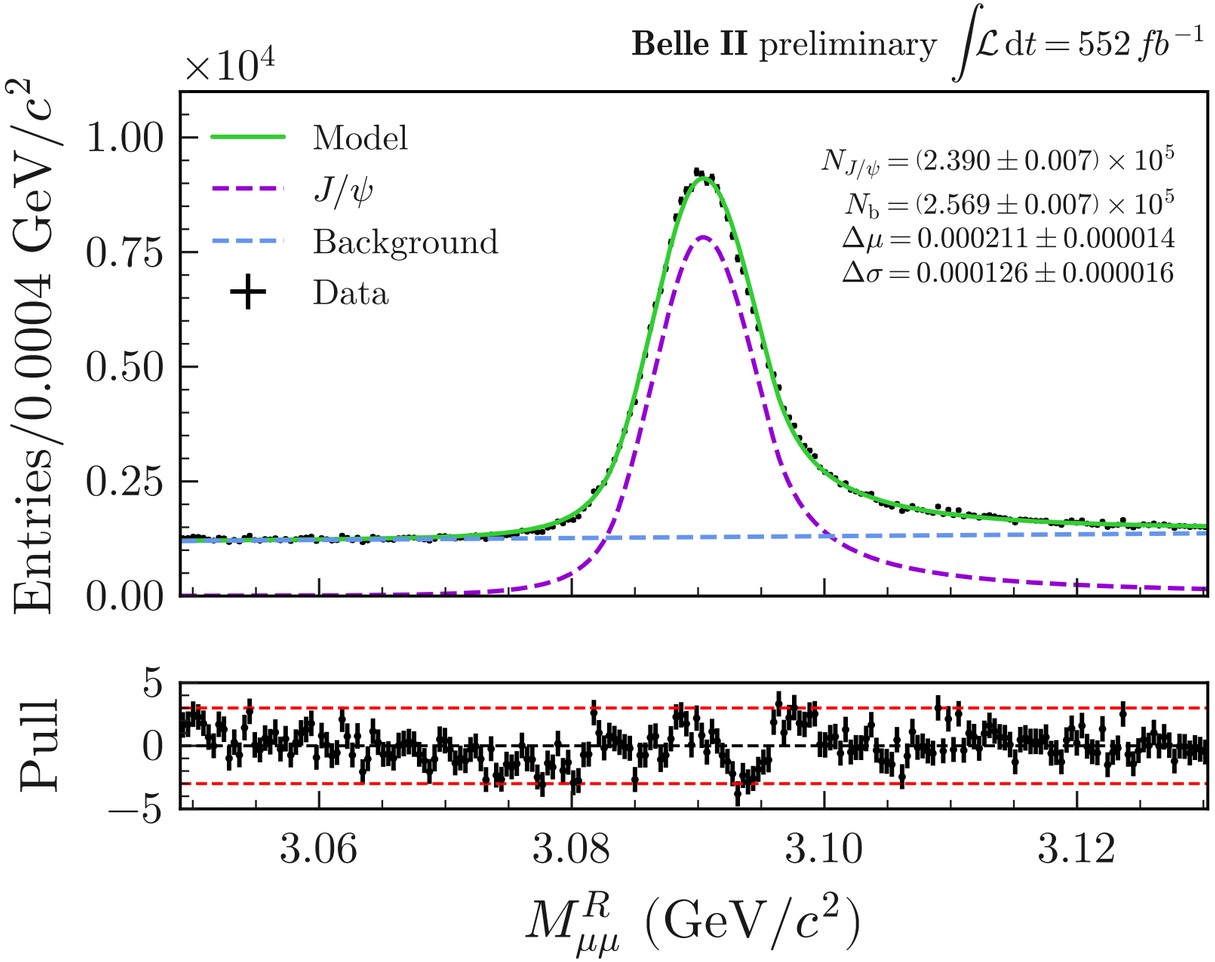
$$\int dt\ \mathscr{L} = 552\ \text{fb}^{-1}\ @\ 10.58\ \text{GeV}$$

Signature

- peak in the $\mu^+\mu^-$ invariant mass, $M_{\mu\mu}$

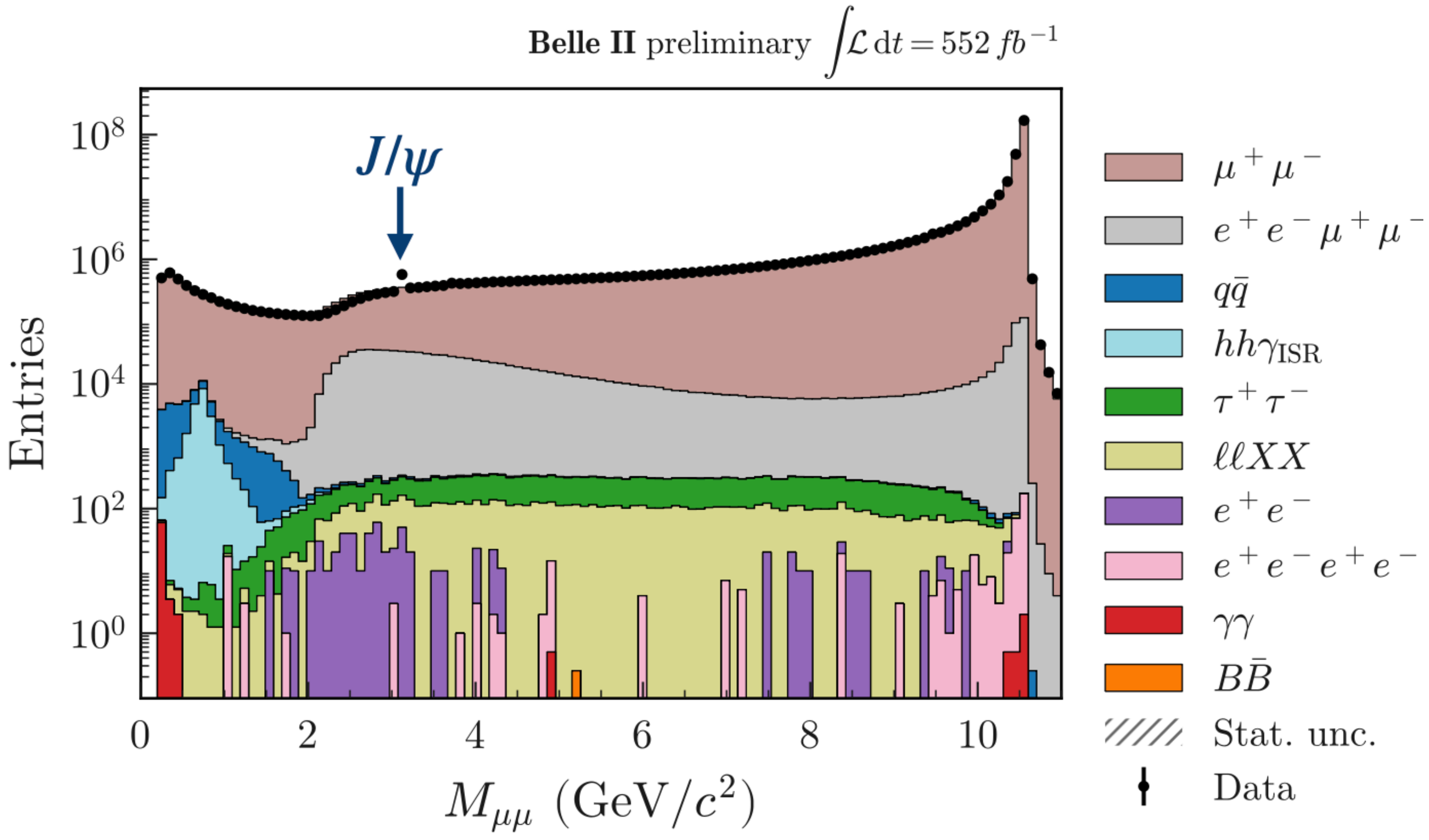
Strategy

- no explicit reconstruction of γ_{ISR}
- 4C kinematic fit to $[\mu^+\mu^- X]$ with massless X
- strict 4C fit helps suppressing the background



Preliminary

$e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$



Preliminary

$e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$

$$\frac{\mathrm{d}\sigma(e^+e^- \to A'\gamma_{\mathrm{ISR}} \to \mu^+\mu^-\gamma_{\mathrm{ISR}})}{\mathrm{d}\sigma(e^+e^- \to \gamma^*\gamma_{\mathrm{ISR}} \to \mu^+\mu^-\gamma_{\mathrm{ISR}})} = \varepsilon^2 \cdot \left(\frac{3\pi m_{A'}\mathcal{B}(A' \to \mu^+\mu^-)}{2\alpha\delta_m}\right)$$

$$\Gamma_{\mu^+\mu^-} = \frac{\alpha\varepsilon^2}{3{m_{A'}}^2}\left({m_{A'}}^2 + 2m_\mu^2\right)\sqrt{{m_{A'}}^2 - 4m_\mu^2},$$

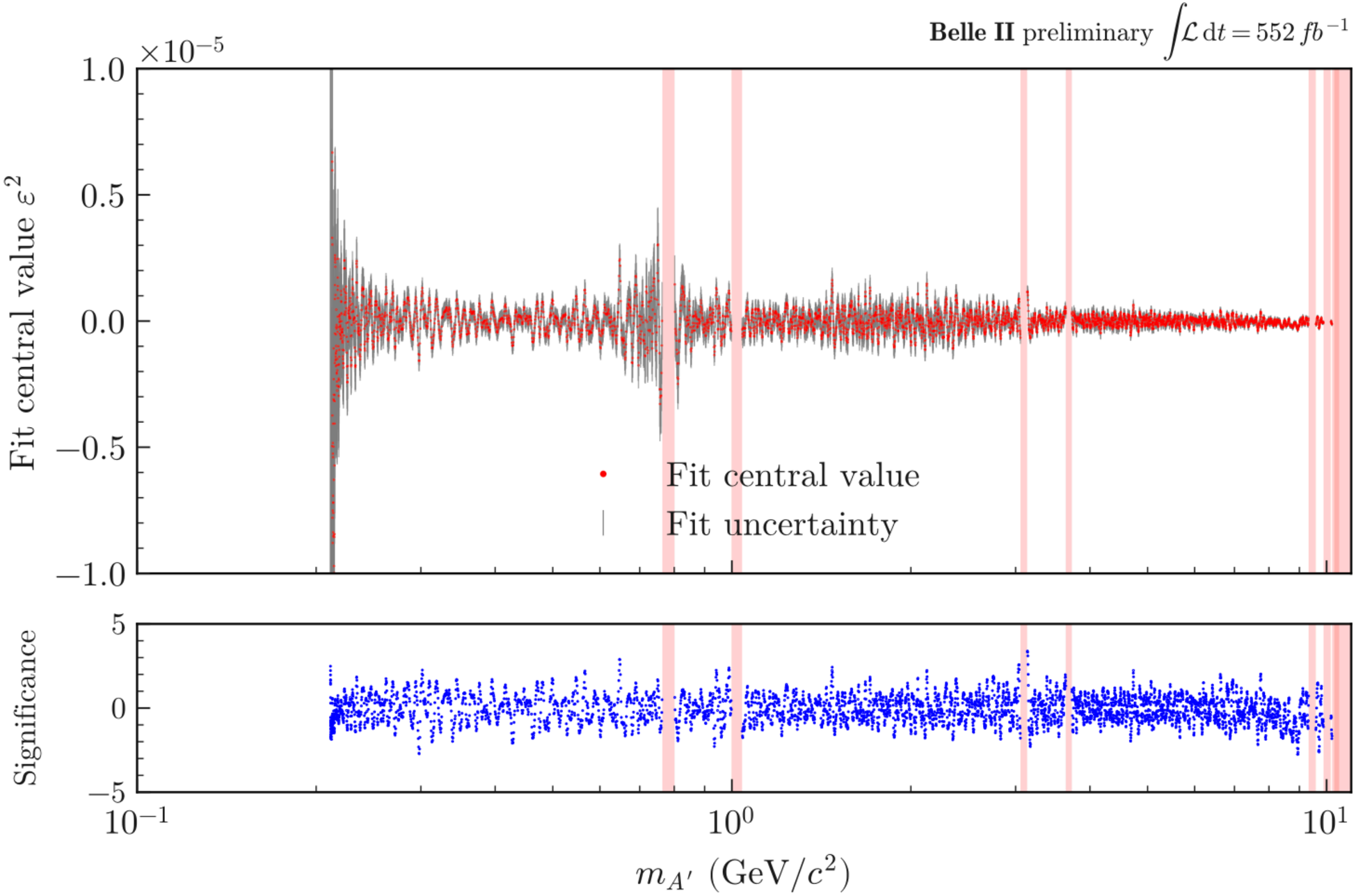
$$\Gamma_{\mathrm{tot}} = \Gamma_{e^+e^-} + \Gamma_{\mu^+\mu^-} \cdot (1 + R(\sqrt{s})) + \Gamma_{\tau^+\tau^-}$$

$$\varepsilon^2 = \frac{N_s/\lambda_s}{pN_b} \cdot \frac{2\alpha\delta_m}{3\pi m_{A'}\mathcal{B}(A' \to \mu^+\mu^-)}$$

- Taking the ratio for ε^2 cancels
  - signal efficiency dependency, and
  - many systeamatic uncertainties, e.g. in
    - trigger efficiency,
    - μ-ID efficiency, etc.

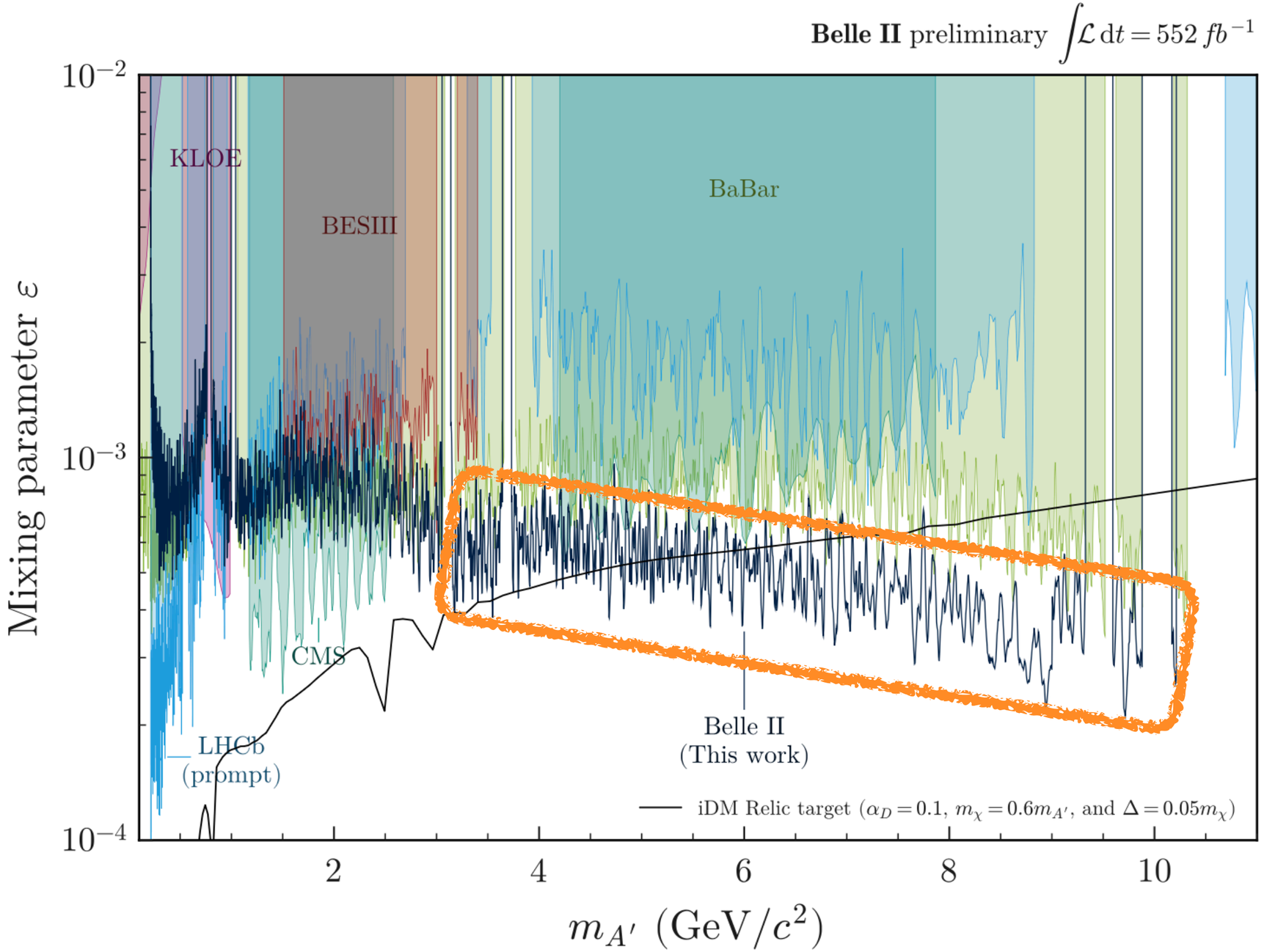
Preliminary

$e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$



Preliminary

$e^+e^- \to \gamma A'(A' \to \mu^+\mu^-)$

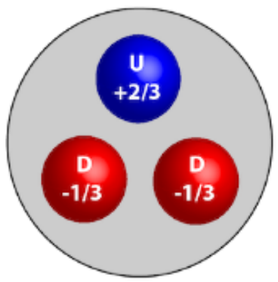


World-leading limit on ε^2 in the range ~[3, 10] GeV

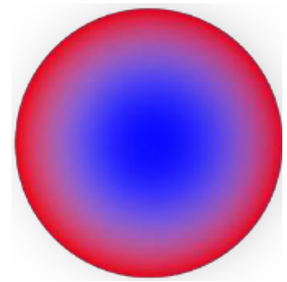
Axion-like particle (ALP)

- Axion as solution to Strong CP problem
  - Peccei-Quinn mechanism (1977)
  - QCD axion: $m_a^2 f_a^2 \sim m_\pi^2 f_\pi^2$ (cf. ALP)
- Cosmological implication
  - Accounting for dark matter (1983)
  - or, can be a portal to dark sector
- Detection principle
  - Sikivie effect (1983)

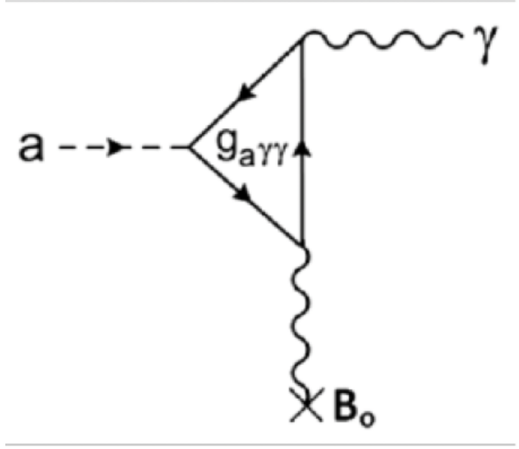
Absence of n-EDM

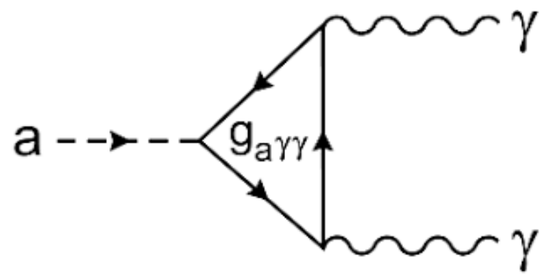


vs.



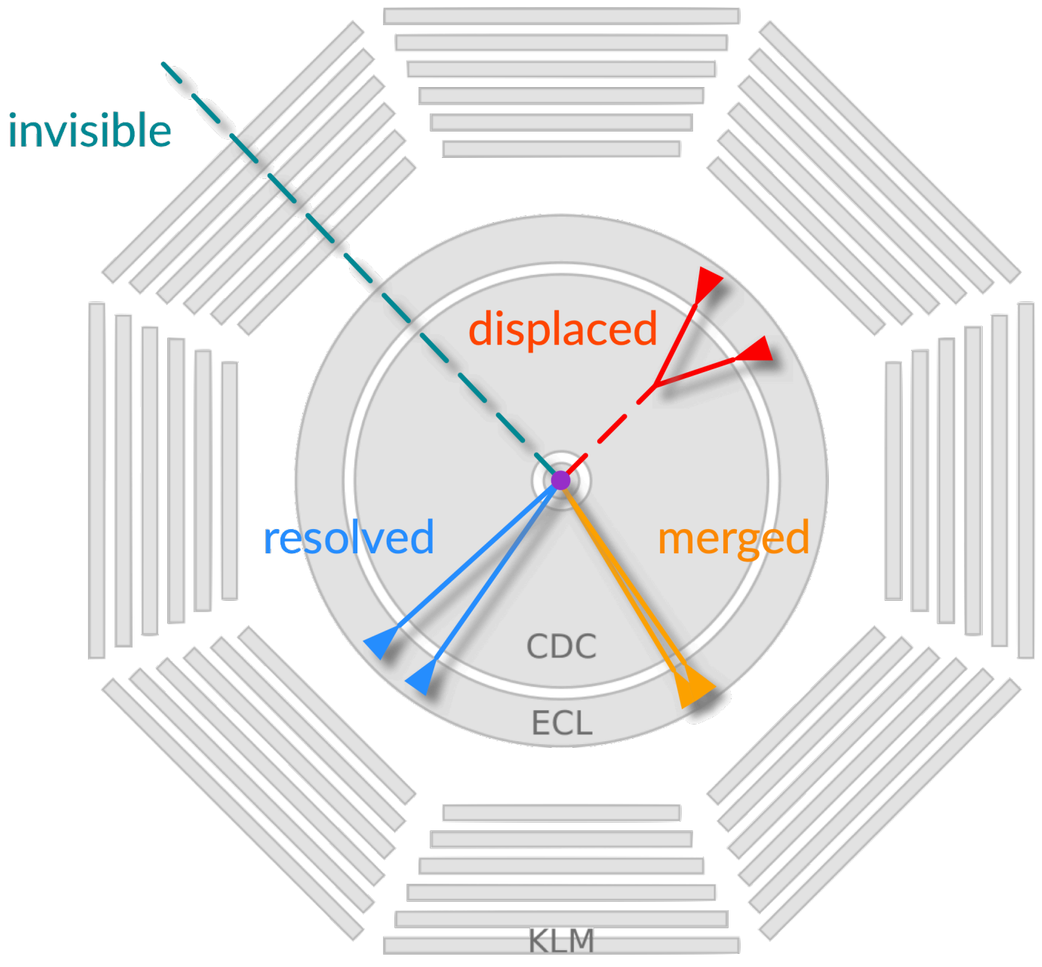
$$L_{QCD} \ni \theta \frac{\alpha_s}{32\pi} G\tilde{G} \quad \Rightarrow \quad \left[\theta - \frac{a(x)}{f_a}\right] \frac{\alpha_s}{32\pi} G\tilde{G}$$

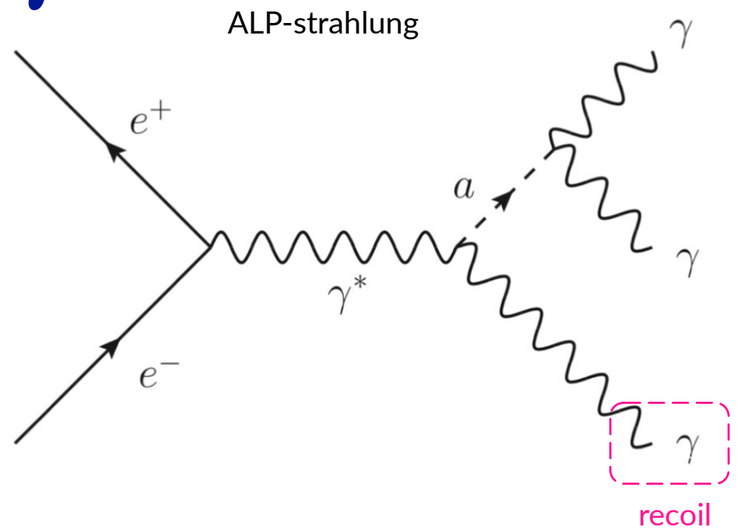


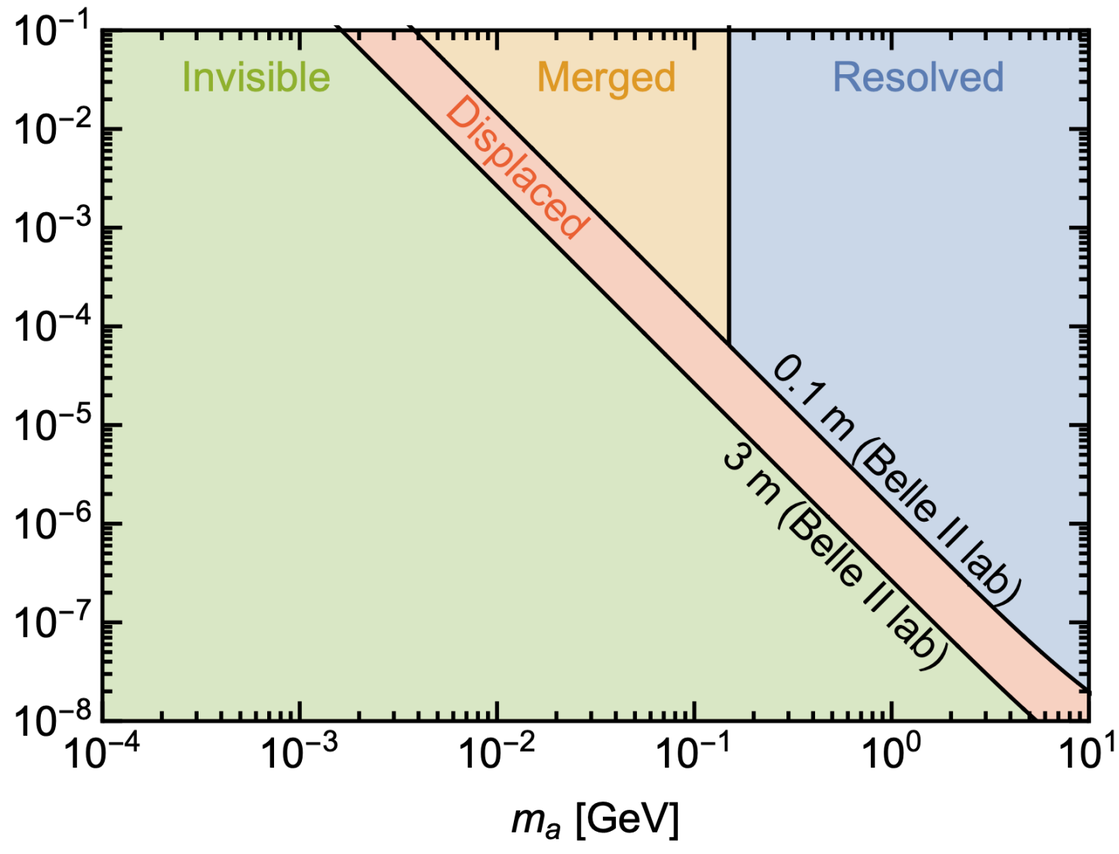


ALP search (1) in $e^+e^- \to \gamma a$

- Search for ALP in $e^+e^- \to \gamma a$ for $a \to \gamma\gamma$ (i.e. 3γ final state)



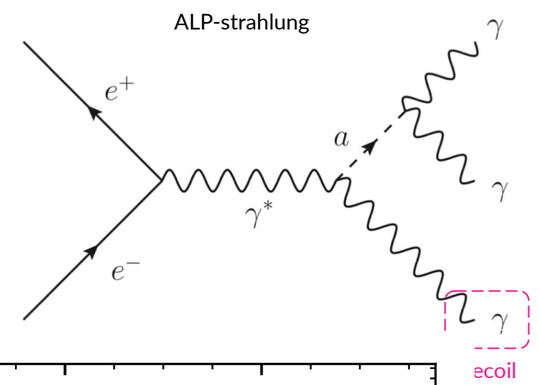


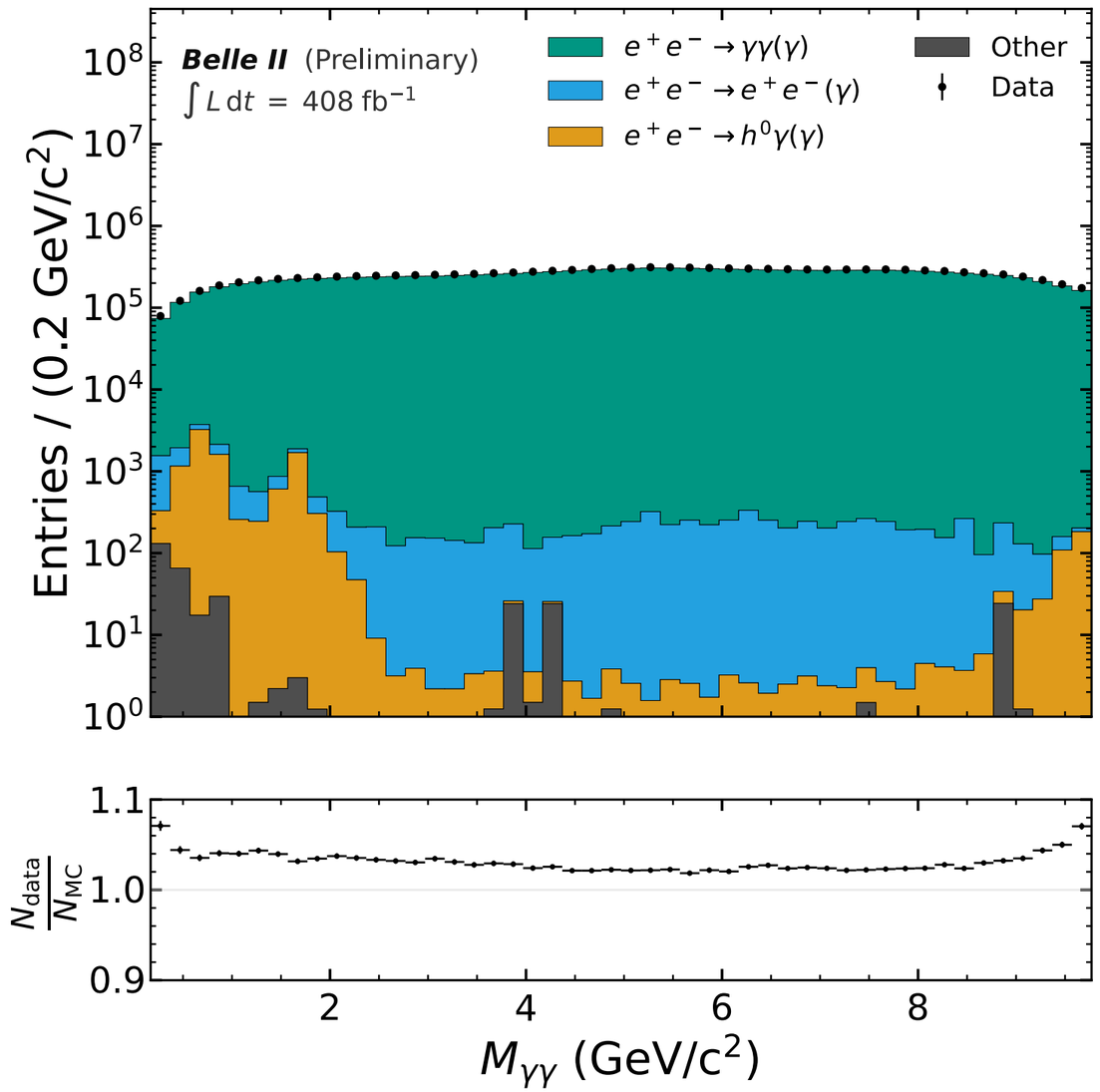


arXiv:2607.07800
submitted to PRL

ALP search (1) in $e^+e^- \to \gamma a$

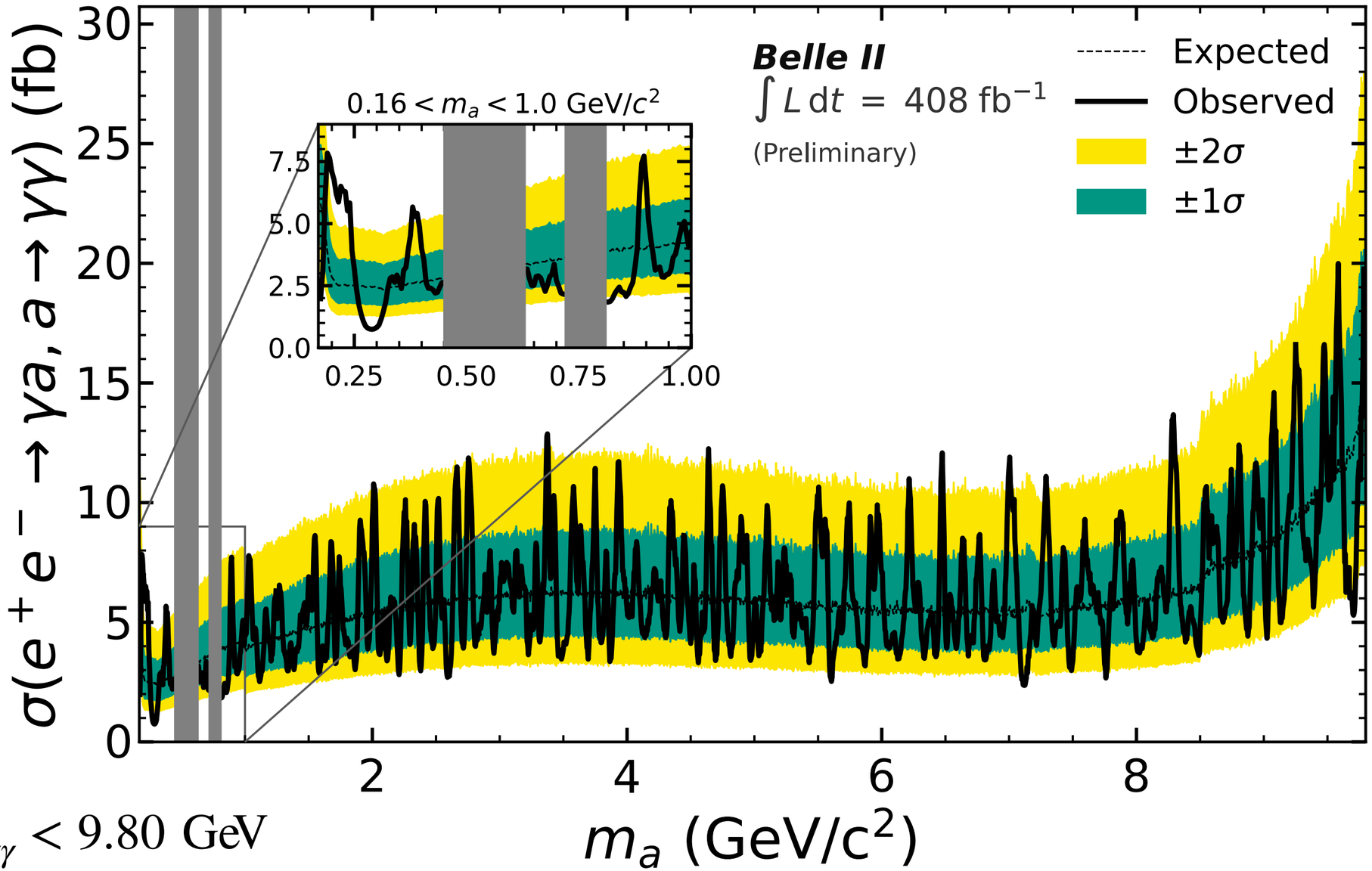
- Search for axion-like particle (ALP)
  - $a \to \gamma\gamma$ (assume dominant)
  - 3γ final state with p^μ constrained to colliding beams
- Background suppression
  - main bkgd. $e^+e^- \to \gamma\gamma(\gamma)$; veto ω, η
  - Further suppression by helicity angle & neural net
- Signal extraction
  - scan $M_{\gamma\gamma}$ and fit for resonance





arXiv:2607.07800
submitted to PRL

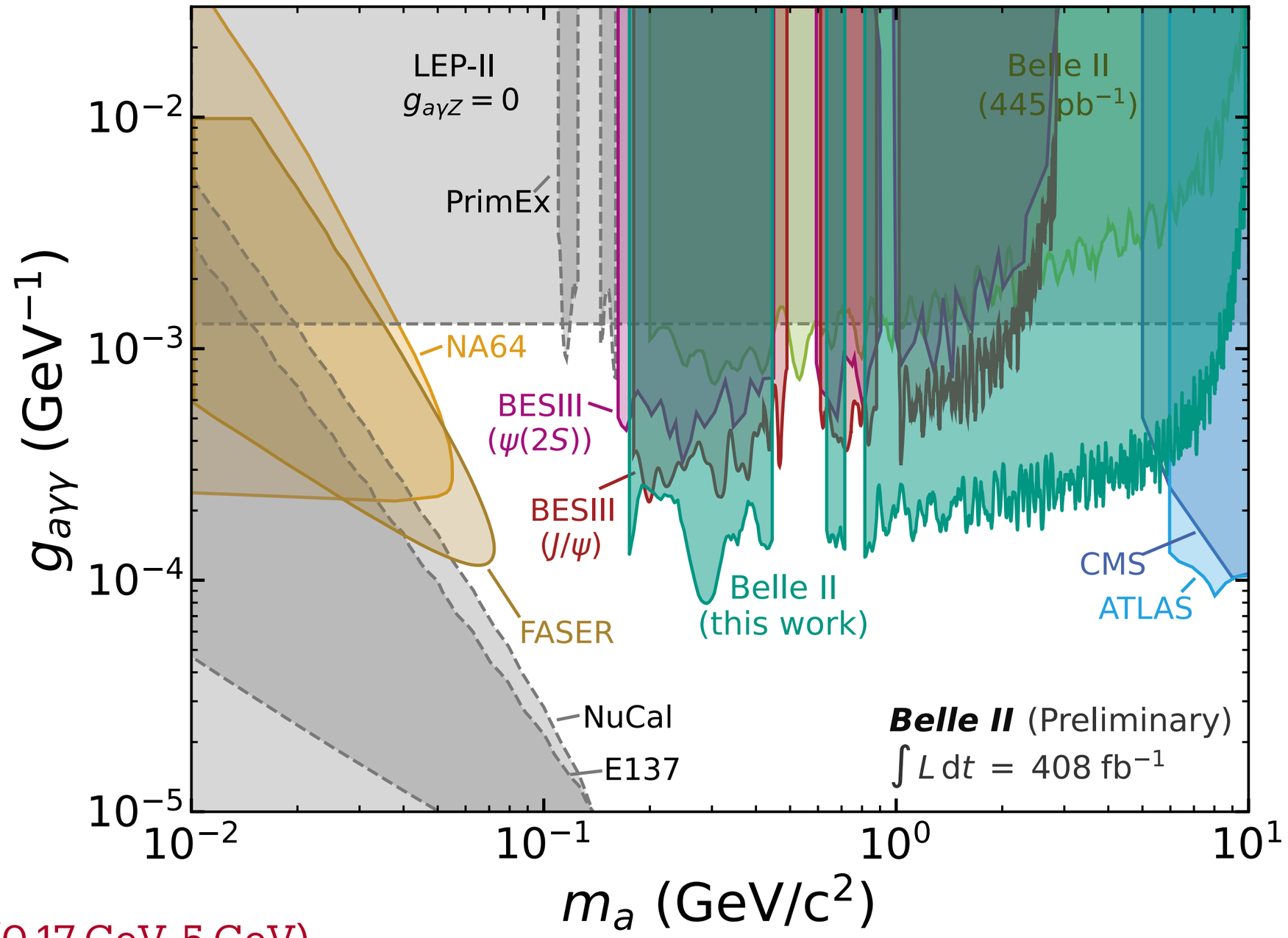
ALP search (1) in $e^+e^- \to \gamma a$



- Results
  - range: $0.17 < M_{\gamma\gamma} < 9.80$ GeV
  - no significant signal ➔ 95% CL upper limit
  - max. local sig. of 3.3σ (global 1.4σ with LEE) @ $m_a = 0.22$ GeV

arXiv:2607.07800
submitted to PRL

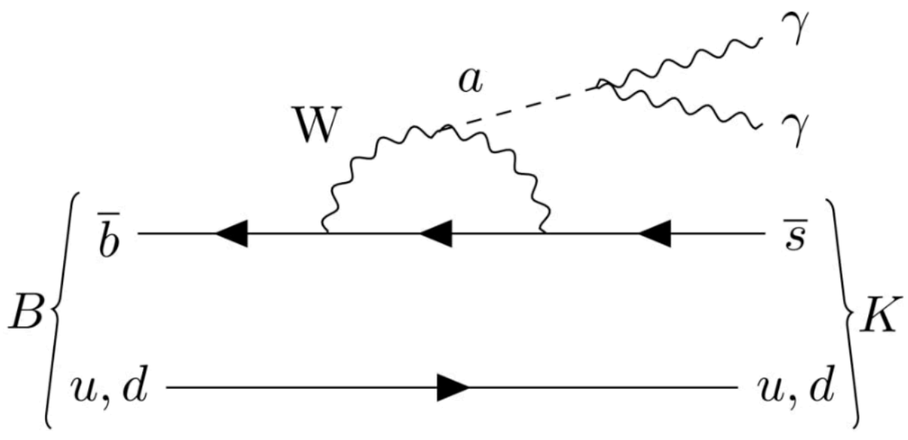
ALP search (1) in $e^+e^- \to \gamma a$



- Interpretation in $g_{a\gamma\gamma}$
  - world-leading limits in (0.17 GeV, 5 GeV)
  - factor 9 more stringent than previous Belle II (PRL 125, 161806 (2020))

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ALP search (2) in $B \to K^{(*)}\gamma\gamma$



- Search for axion-like particle (ALP)
  - $a \to \gamma\gamma$ (assume dominant)
  - also assume (mostly) prompt decay, but non-zero lifetime is considered for efficiency loss
  - if no signal, set upper limits on ALP-W coupling, g_{aW} [#]

[#] PRL 118, 111802 (2017)

- search region: $0.16 < m_a < 4.20\ (4.50)$ GeV
- no sensitivity for π^0, η, η' regions

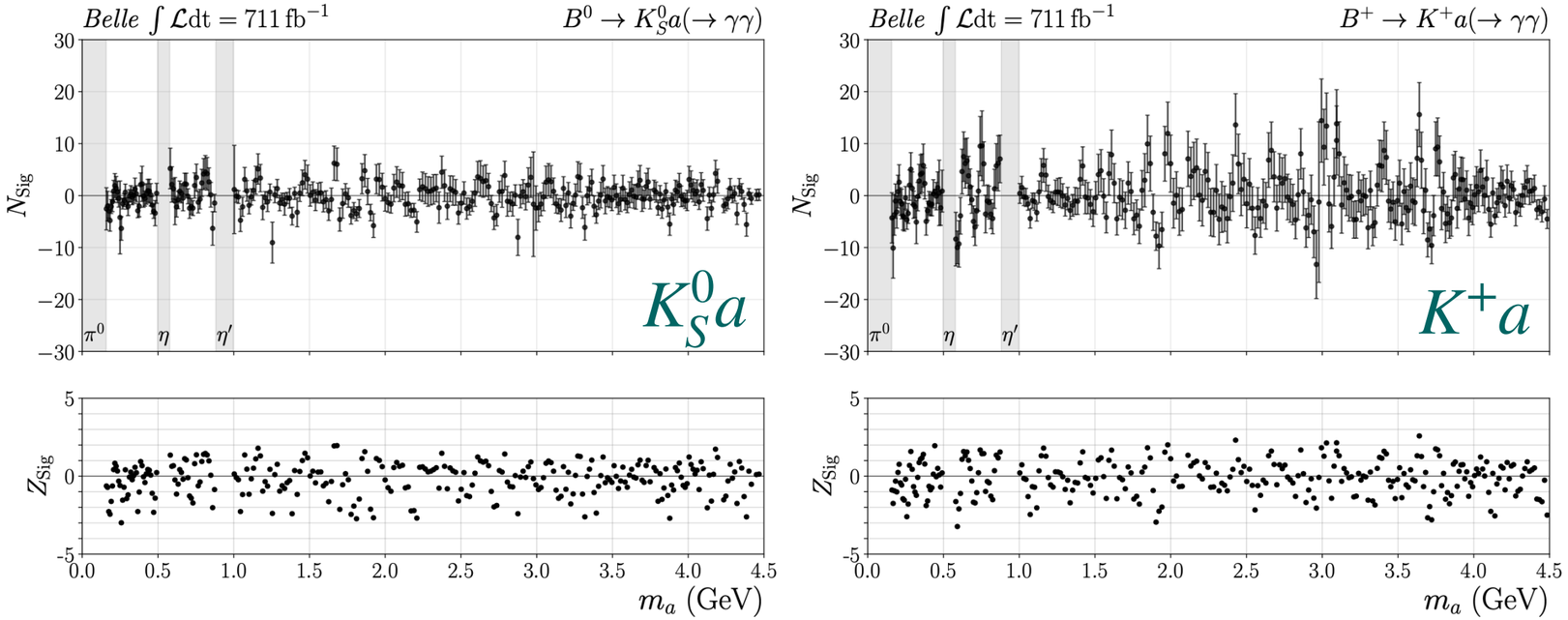
hadron veto

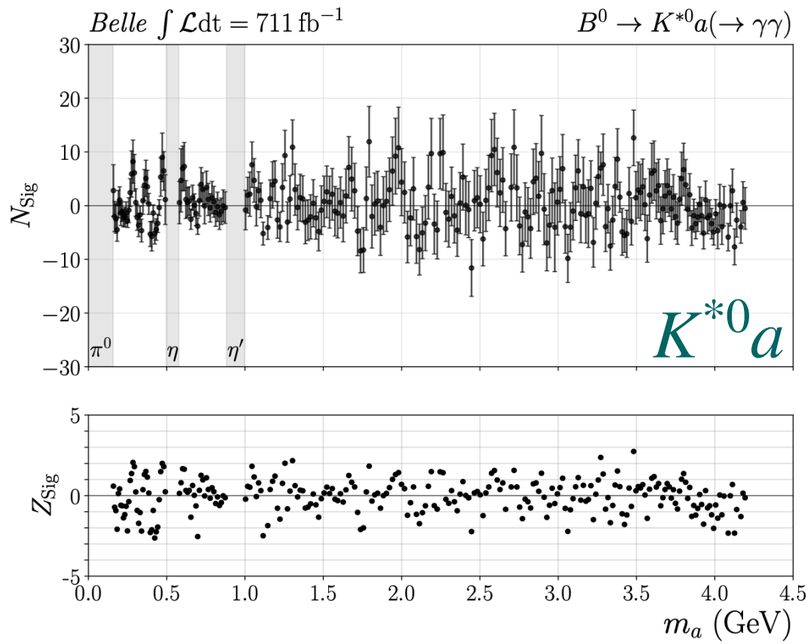
Type	3σ $M_{\gamma\gamma}$ region (GeV)
π^0	0.109 ~ 0.158
η	0.497 ~ 0.578
η'	0.882 ~ 0.997

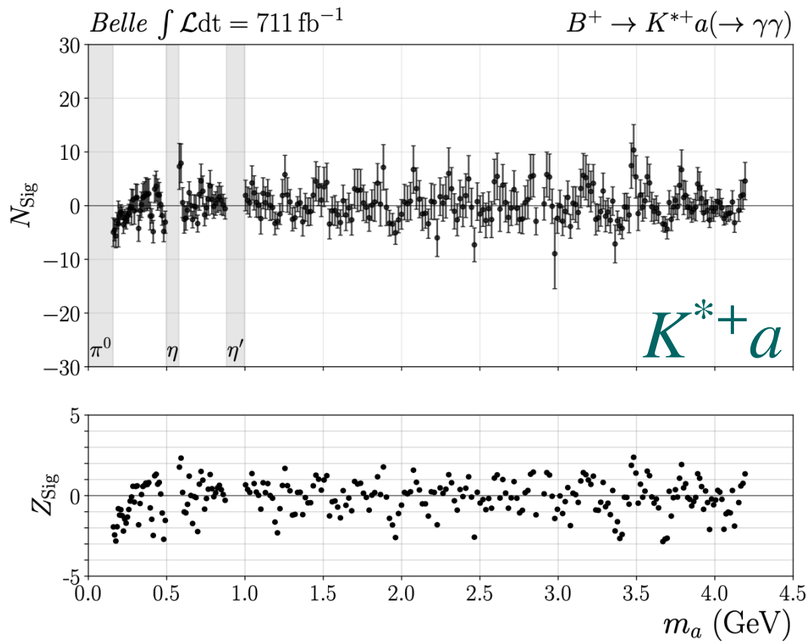
- Procedure
  - continuum suppression and $\pi^0 \to \gamma\gamma$ veto with separate Fast-BDT's (T. Keck, Comp Softw Big Sci 1, 2 (2017))
  - then apply extra cuts to suppress $B \to X_s\gamma$ background

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$B \to K^{(*)}\gamma\gamma$ for ALP, Results w/ Belle data



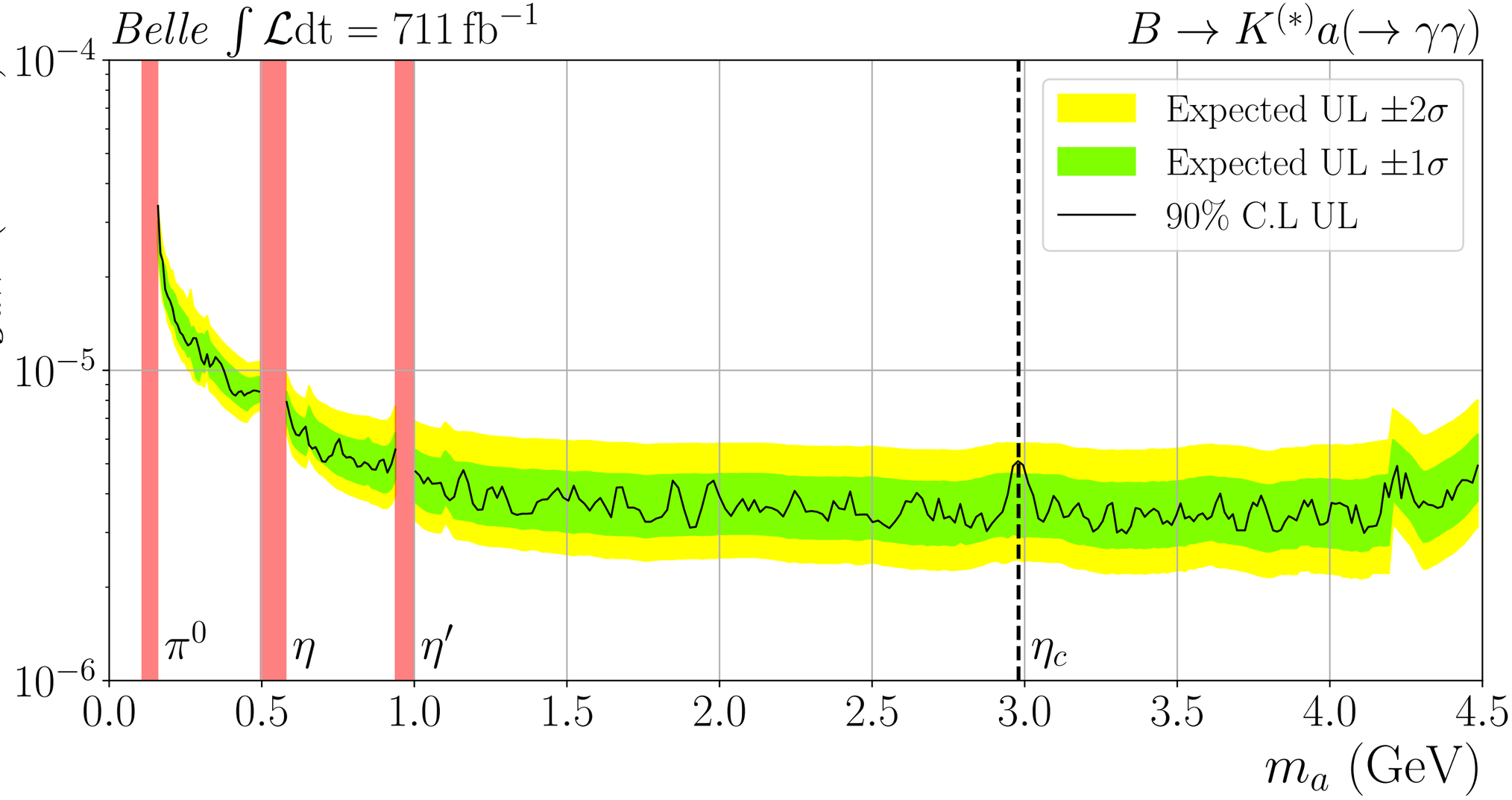




- Signal extraction by 1D max. likelihood fit to $M_{\gamma\gamma}$
- Results
  - for each $K^{(*)}$ mode
    - ✓ (top) signal yield
    - ✓ (bottom) significance level
  - the gray vertical bands correspond to π^0, η, and η' veto regions

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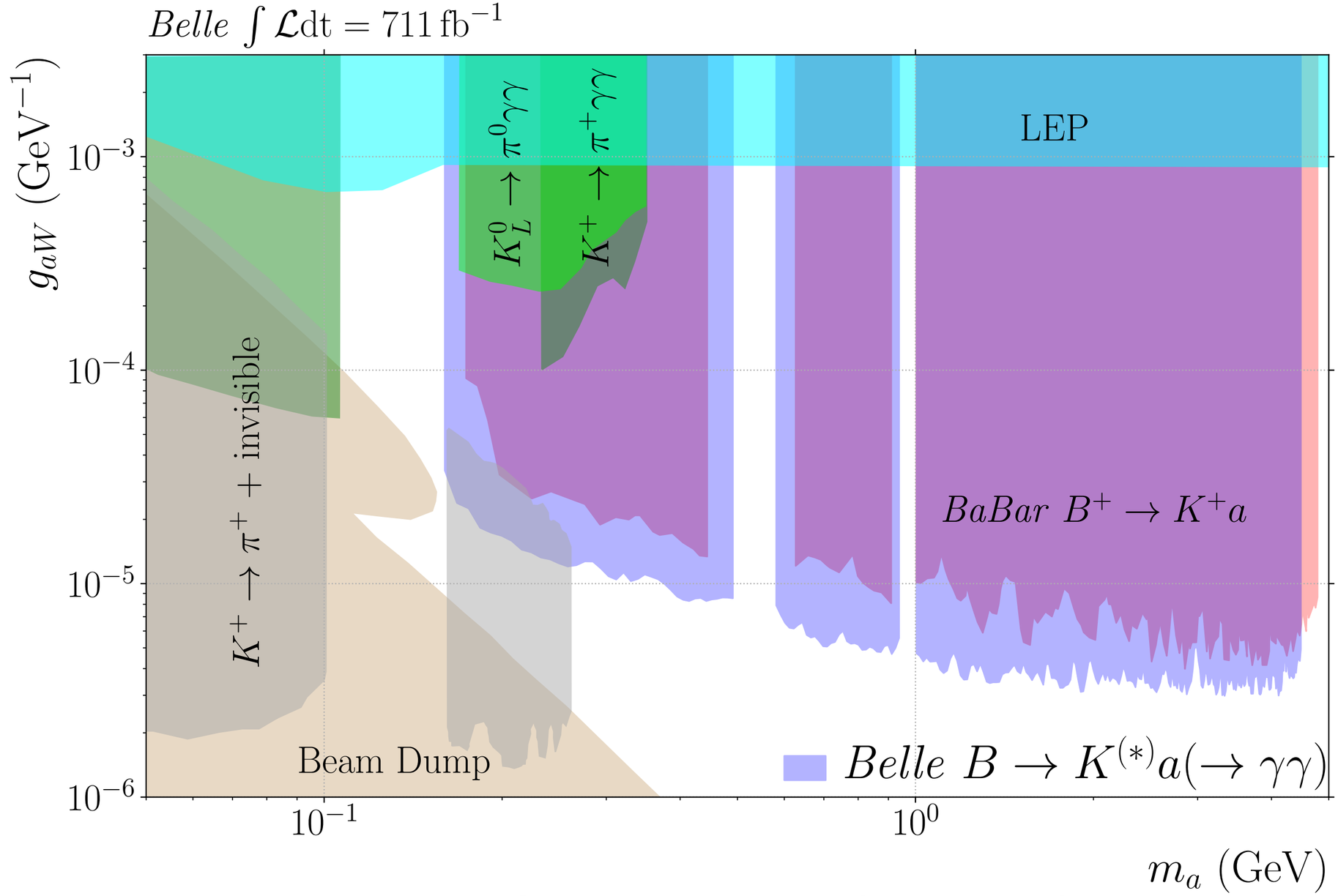
$B \to K^{(*)}\gamma\gamma$ for ALP, Upper limits on g_{aW}



90% CL upper limits on g_{aW} as a function of m_a

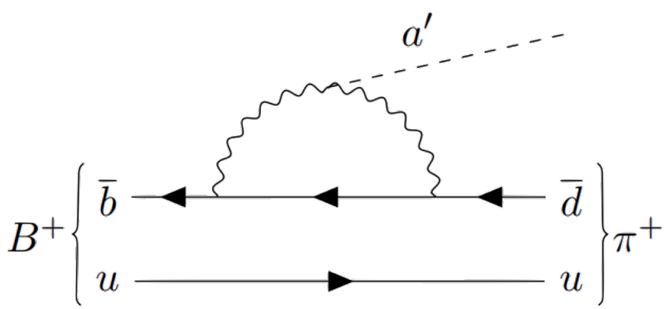
JHEP 12 (2025) 109

$B \to K^{(*)}\gamma\gamma$ for ALP, Upper limits on g_{aW}

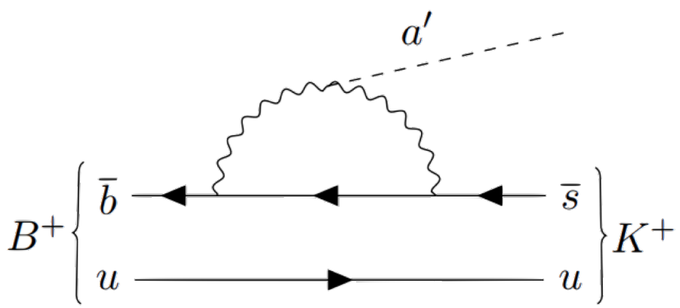


90% CL upper limits on g_{aW} as a function of m_a
in comparison with other existing results

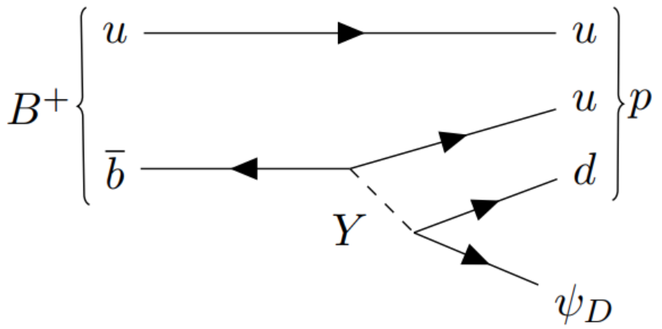
Feebly-interacting particle (FIP) in B decays



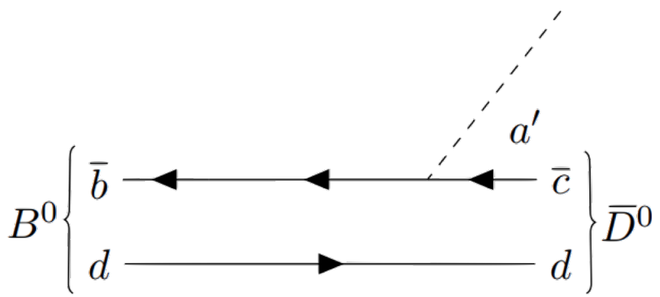
(a)



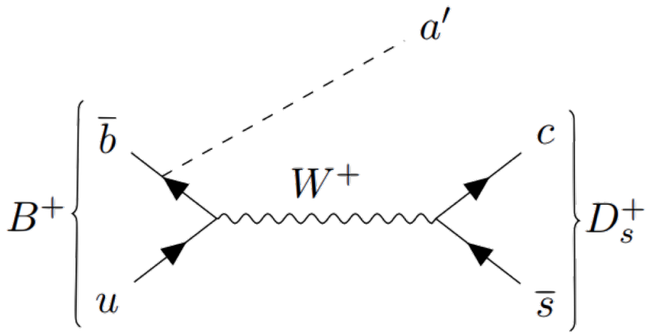
(b)



(e)



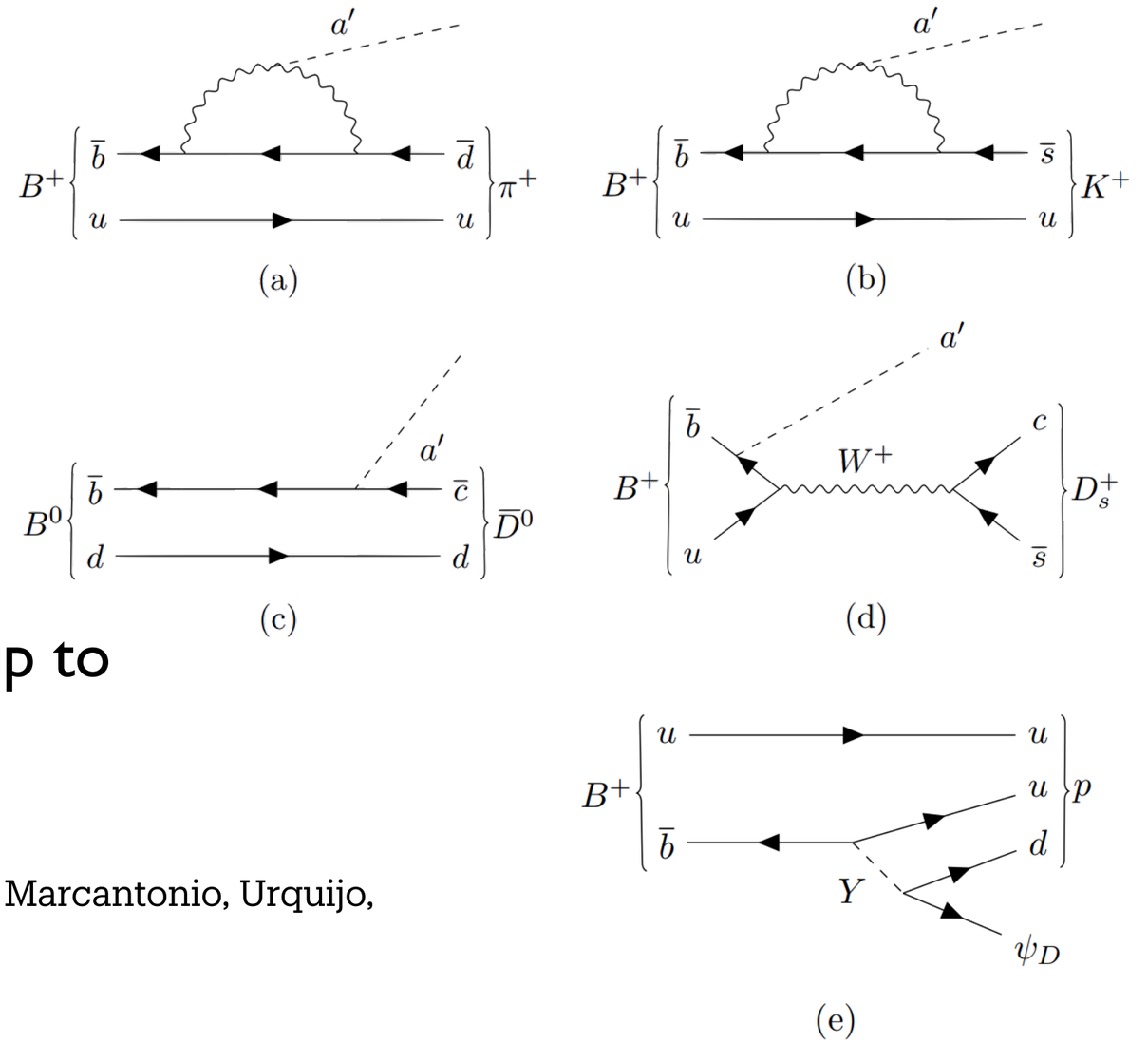
(c)



(d)

FIP in *B* decays, motivations

- ∃ many new physics models for X_{inv}, with $B \to hX_{\text{inv}}$
  - axion-like particle (1)
  - dark scalars (2)
  - dark photon, Z' (3)
  - dark baryons (B-mesogenesis) (4)



- Belle (II) can search for X_{inv} in mass region up to a few GeV

---

(1) Izaguirre, Lin, Shuve, PRL 118, 111802 (2017); Zhang, Ishikawa, Kou, Marcantonio, Urquijo, PRD 109, 016008 (2024)

(2) Filimonova, Schäfer, Westhoff, PRD 101, 095006 (2020)

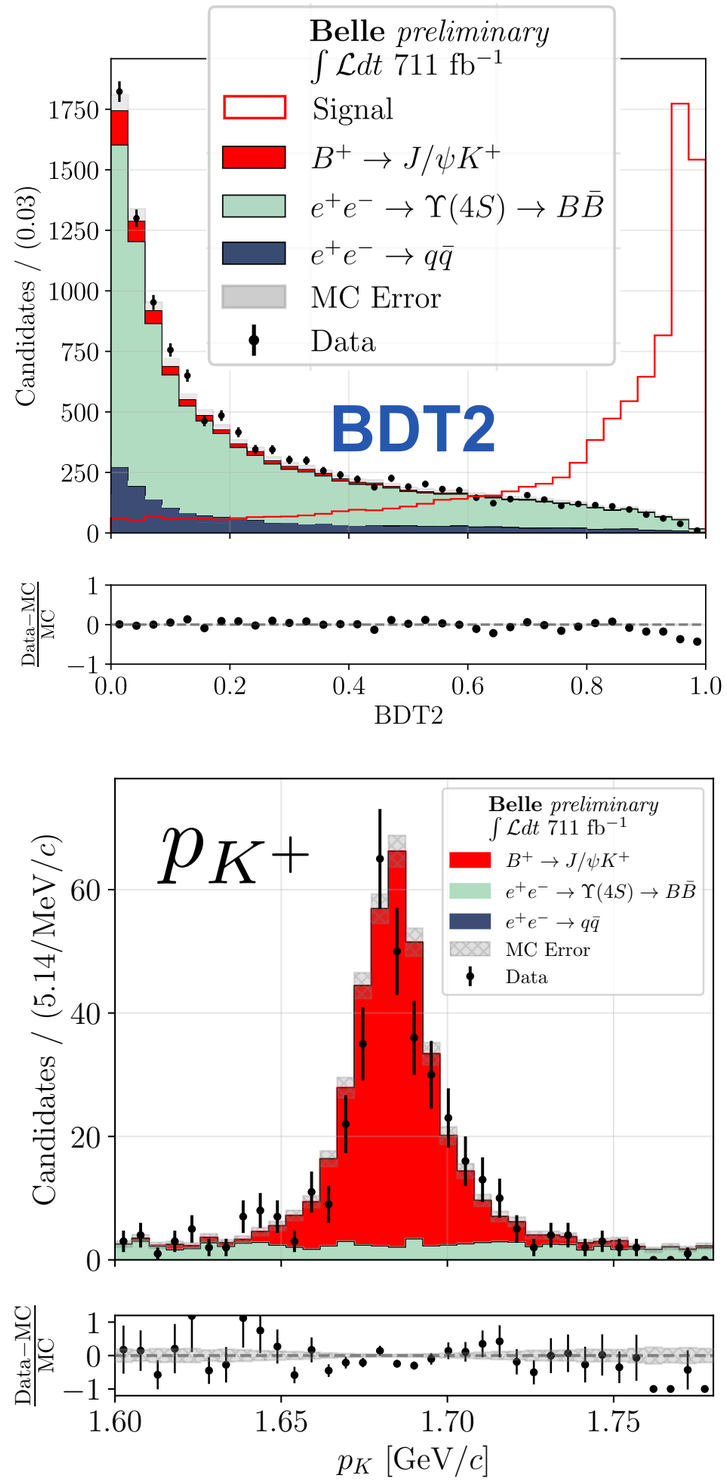
(3) Datta, Hammad, Marfatia, Mukherjee, Rashed, JHEP 2023, 108 (2023)

(4) Elor, Escudero, Nelson, PRD 99, 035031 (2019); Alonso-Álvarez, Elor, Escudero, PRD 104, 035028 (2021)

PRL 136, 231802 (2025)

$B \to hX_{\rm inv}$ search (Belle)

- model-agnostic approach as to why $X_{\rm inv}$ is invisible
  - a dark matter candidate
  - decays to a DM pair
  - long-lived, decays outside the detector
- analysis procedure
  - tag-side reconstruction using FEI (back-up, p.32)
  - identify h in the signal side
- background suppression using BDT in 2 stages
  - BDT1 to suppress $q\bar{q}$ continuum bkg.
  - BDT2 for remaining bkg.
- BDT calibration, by using 2-body B decays
  - $B^+ \to J/\psi K^+$ (for $h = K^+$)
  - $B^0 \to \overline{D}^0\pi^0$ (for $h = D^0$) with $E_{\rm ECL}$ sideband

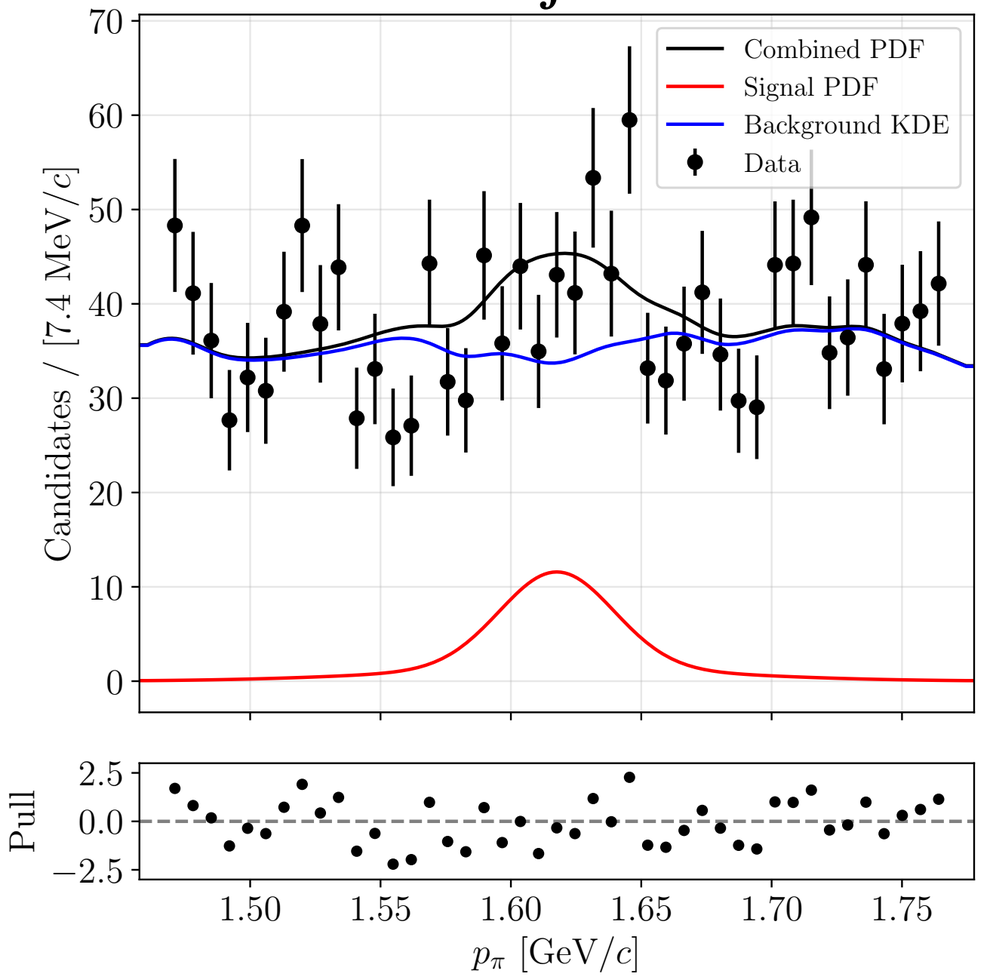


PRL 136, 231802 (2025)

$B \to hX_{\rm inv}$ signal extraction

- Signal extraction
  - 1D fit to p_h
  - by scanning $m_{X_{\rm inv}}$
  - scan step = 1/2 of the signal mass resolution
- No signal in any mode, any bin
  - max local significance $S_{\rm local}$=2.95σ for $h = \pi^+$ at 3.28 GeV ($S_{\rm global}$=0.65σ with LEE)
  - set 90% UL, using $\mathrm{CL_s}$ method, on $\mathscr{B}(B \to hX_{\rm inv})$
  - also set UL on $\mathscr{B}[B \to hX(\to \gamma\gamma)]$ where X decay particles are missing due to long lifetime

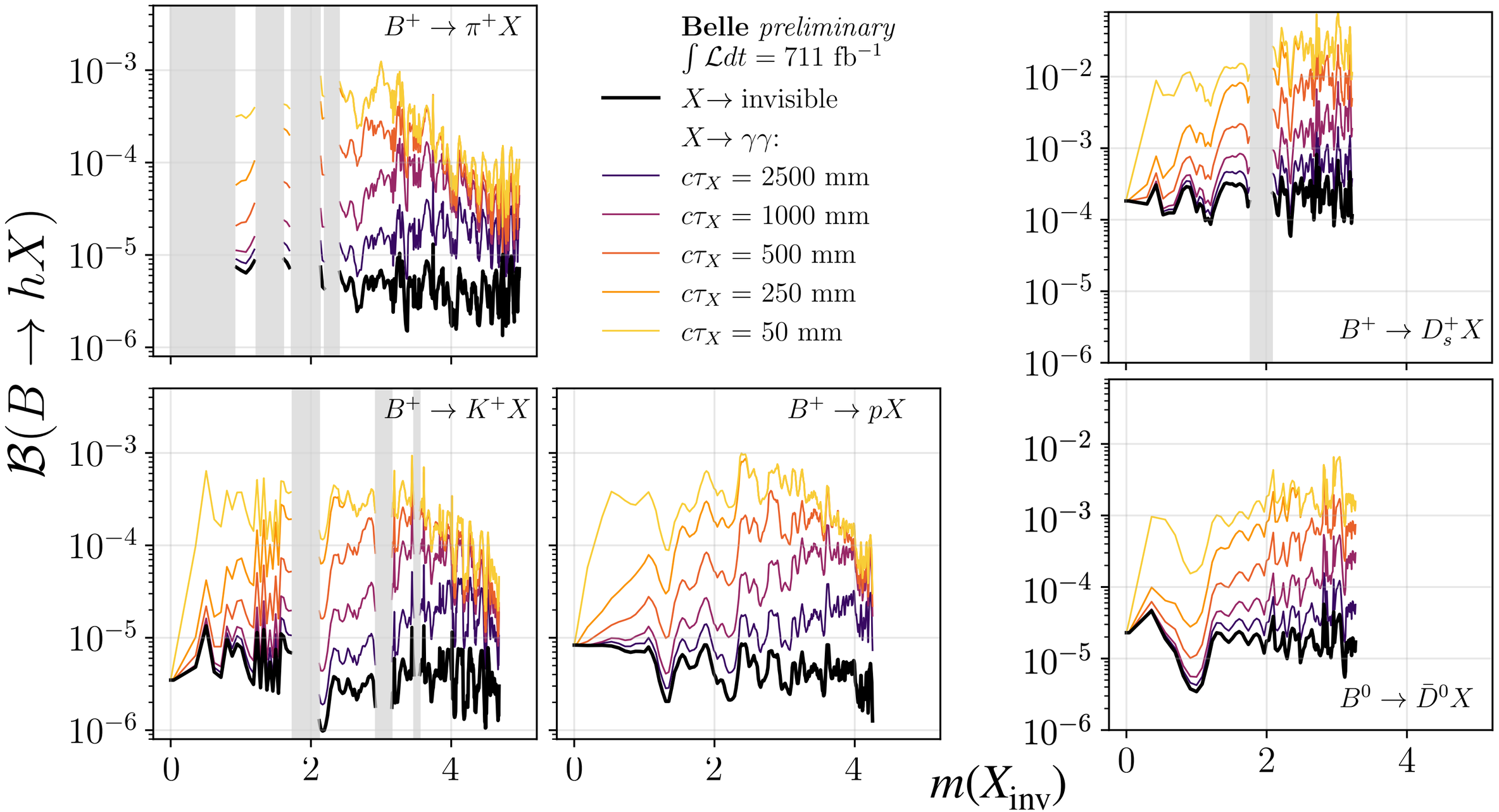
Belle preliminary $\int \mathscr{L} dt = 711\ \mathrm{fb}^{-1}$



p_π for $m(X_{\rm inv}) = 3.28$ GeV

PRL 136, 231802 (2025)

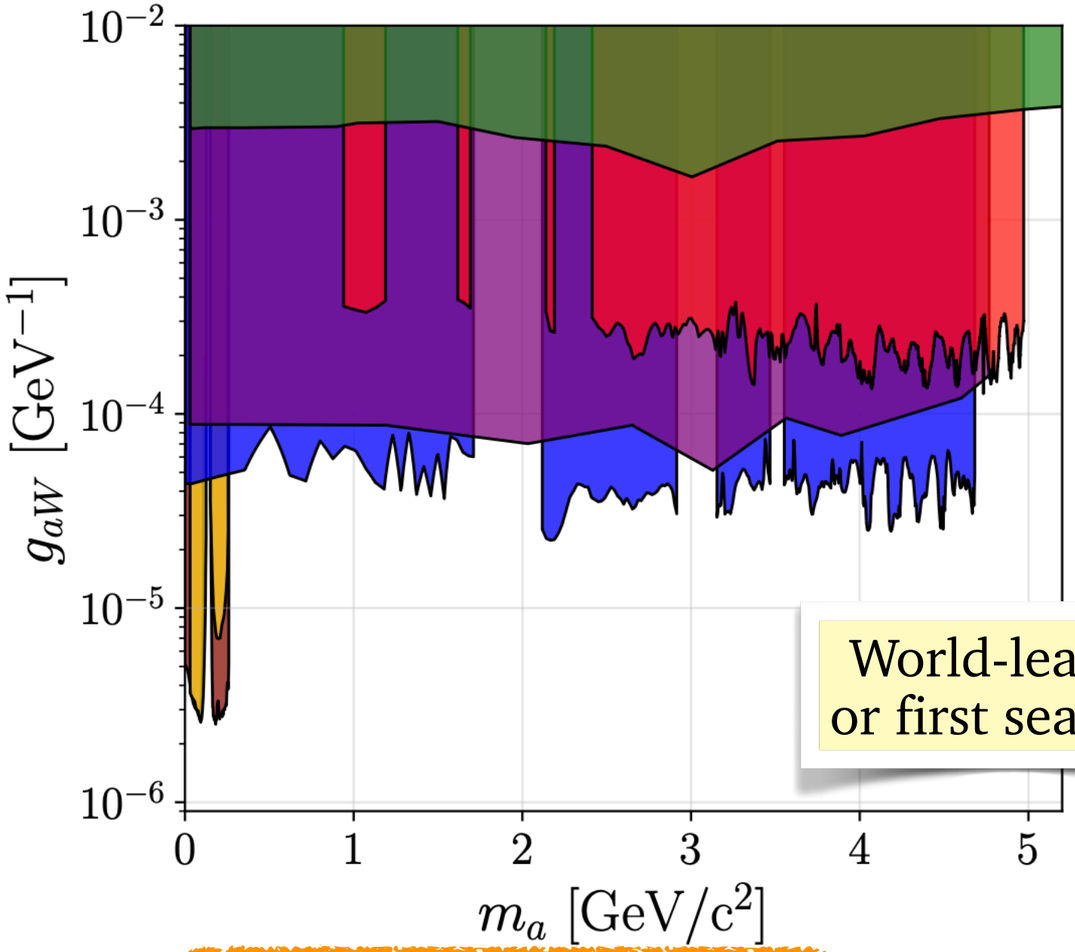
$\mathcal{B}(B \to hX_{\text{inv}})$ upper limits

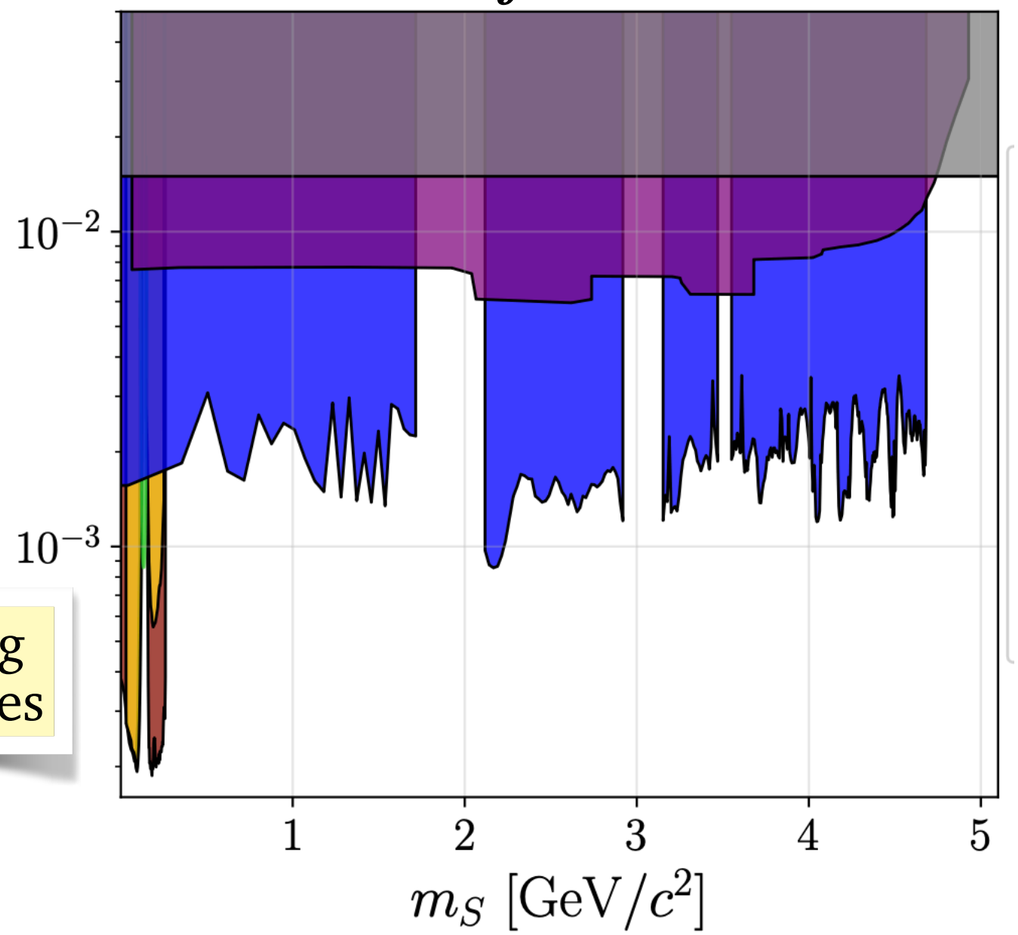


PRL 136, 231802 (2025)

$B \to hX_{\text{inv}}$ results in FIP coupling

Belle preliminary $\int \mathscr{L} dt = 711\ \text{fb}^{-1}$



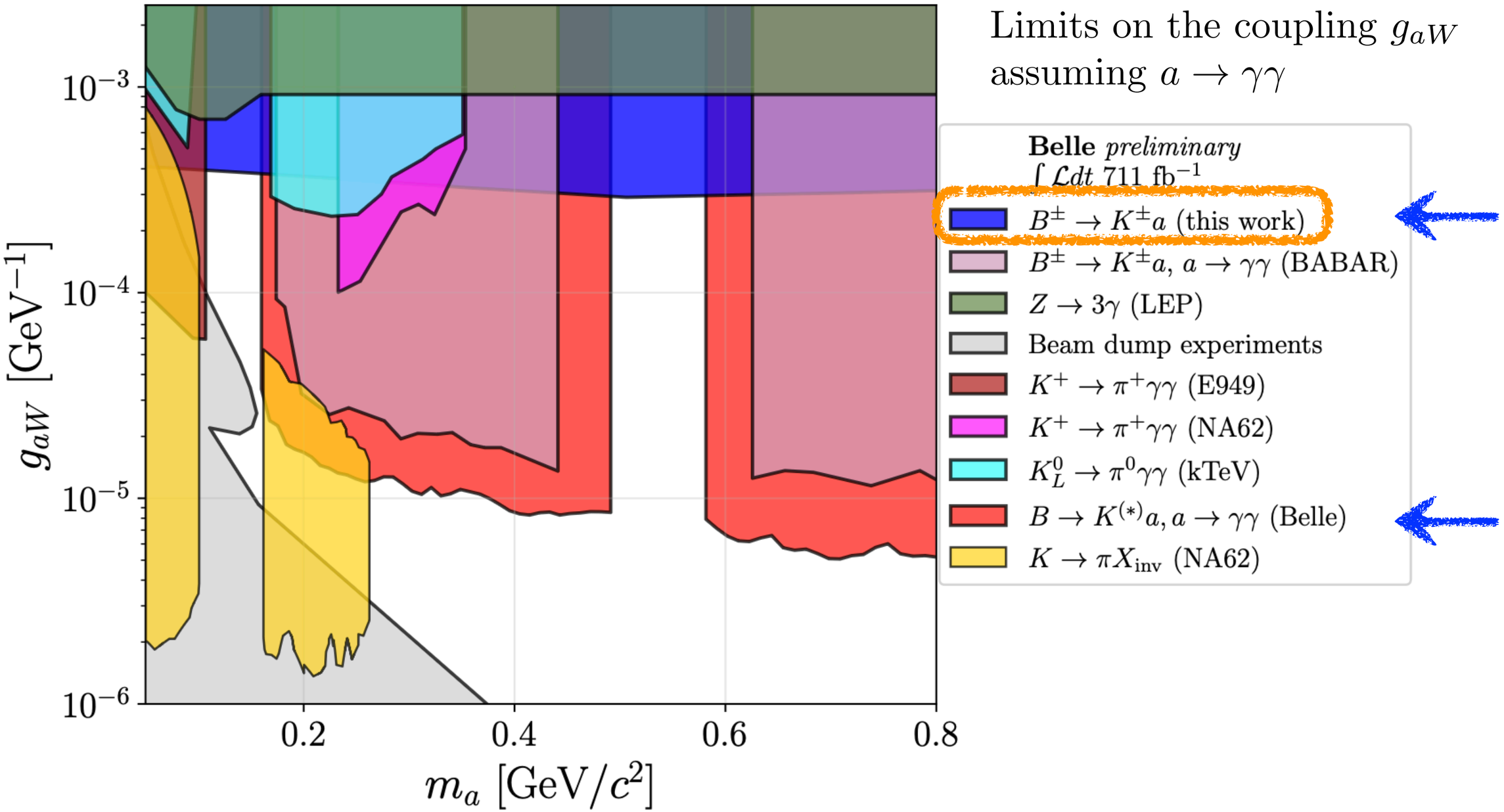


World-leading or first searches

$B^\pm \to K^\pm X$ (this work)
$B^\pm \to \pi^\pm X$ (this work)
mono-γ (BABAR)
$B \to K^\pm \nu\bar{\nu}$ (BABAR)
$K^+ \to \pi^+ X$ (NA62)
$K^+ \to \pi^+ \nu\bar{\nu}$ (E787+E949)
$h \to$ invisible (CMS)
$\pi^0 \to$ invisible (NA62)

PRL 136, 231802 (2025)

$B \to hX_{\text{inv}}$ results as $a \to \gamma\gamma$

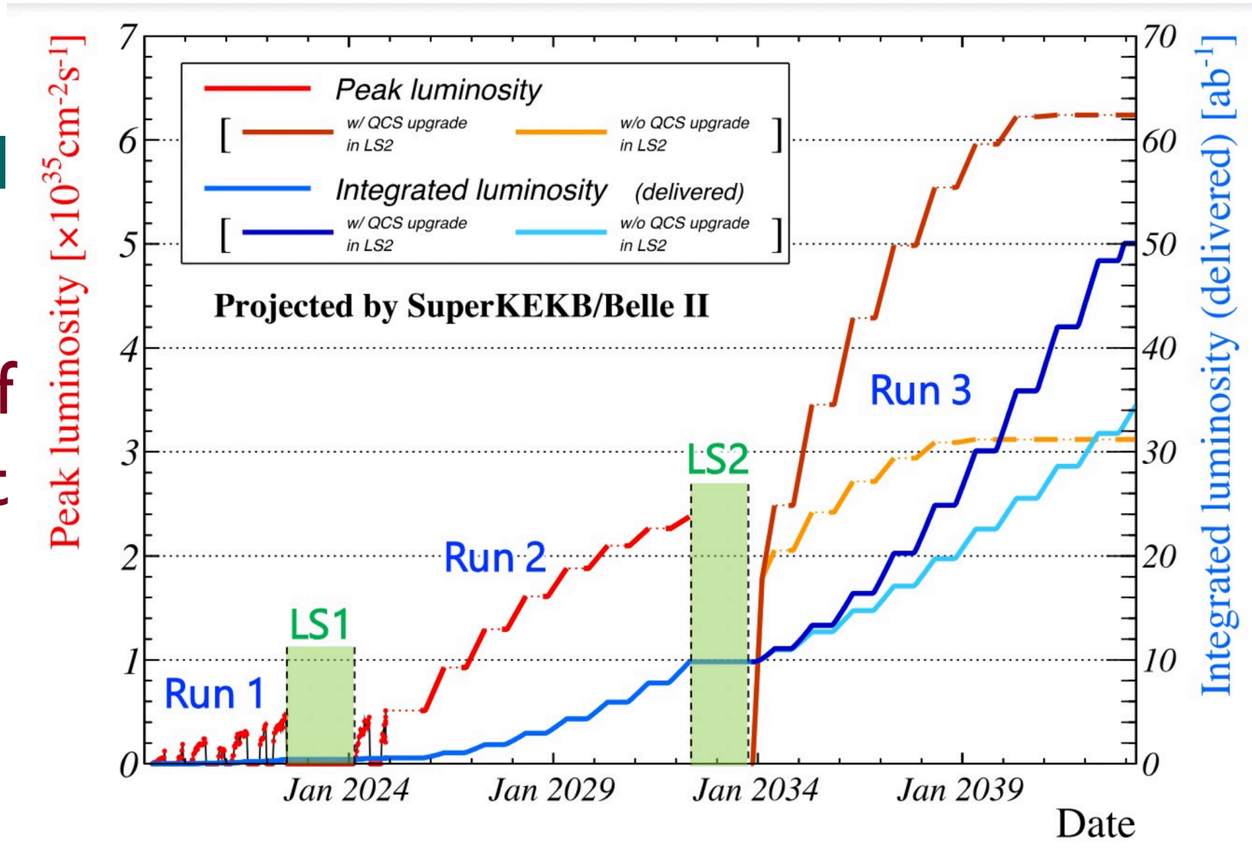


Closing remarks

- Although Belle II (and Belle) has been conceived and constructed mainly for studies of CP violation and heavy-flavor physics, it also provides an excellent probe for dark sector physics in $\mathcal{O}(1 \sim 10\ \mathrm{GeV})$ range.

- In this talk, we showed a few recent dark sector search results from Belle II and Belle.

- Belle II Run 2 is on-going with a goal of collecting several ab^{-1} data in the next few years. Please stay tuned!



Back-up slides

Quantum Entanglement in $\Upsilon(4S) \to B^0\overline{B}^0$

- QM is a non-local theory, with Bell inequality violation (2022 Nobel Physics prize)
- Entanglement observed in HEP from top quark pairs in ATLAS
- Belle Inequality is not testable in e^+e^- B-factories

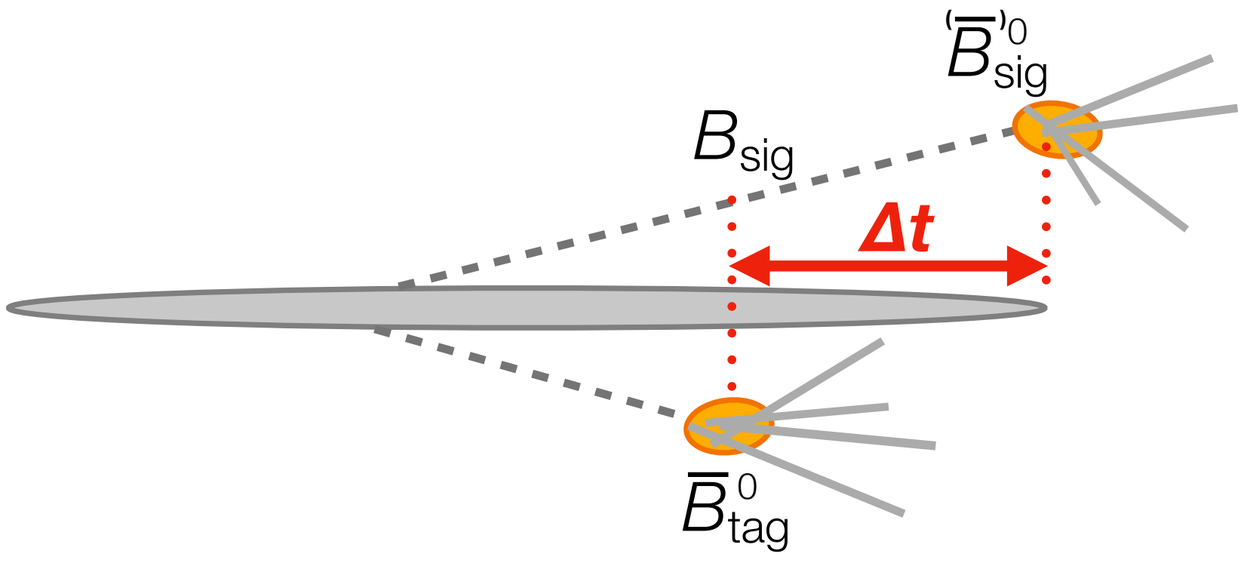
$$|\psi(t)> = \frac{e^{-t/\tau_{B^0}}}{\sqrt{2}}\left[|B^0(\vec{p})\bar{B}^0(-\vec{p})\rangle - |\bar{B}^0(\vec{p})B^0(-\vec{p})\rangle\right]$$

$\because$ passive decays, low oscillation rate, particle instability, microscopic separation of B^0 and $\overline{B}^0$

- But it can test quantum entanglement (QE) in $\Upsilon(4S) \to B^0\overline{B}^0$

Time-dependent CPV in $B^0 \to \pi^0\pi^0$

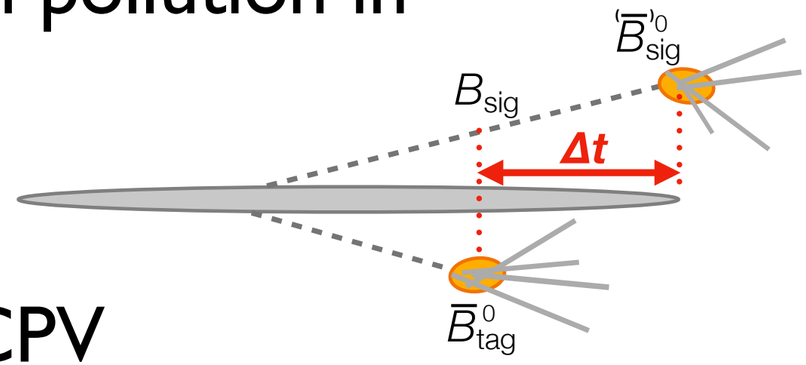
- why?
  - essential ingredient for a CKM angle $\phi_2(=\alpha)$ in $B \to \pi\pi$ decays
  - crucial for isospin analysis to resolve penguin pollution in $B^0 \to \pi^+\pi^-$
- main issue & key idea
  - traditionally, we need $\Delta t = t_{\rm CP} - t_{\rm tag}$ for TdCPV
  - but for … l vertex (∵ no charged …
    ✓ we m… statistics
  - exploit … CPV with $t_{\rm tag}$ alone, i.…



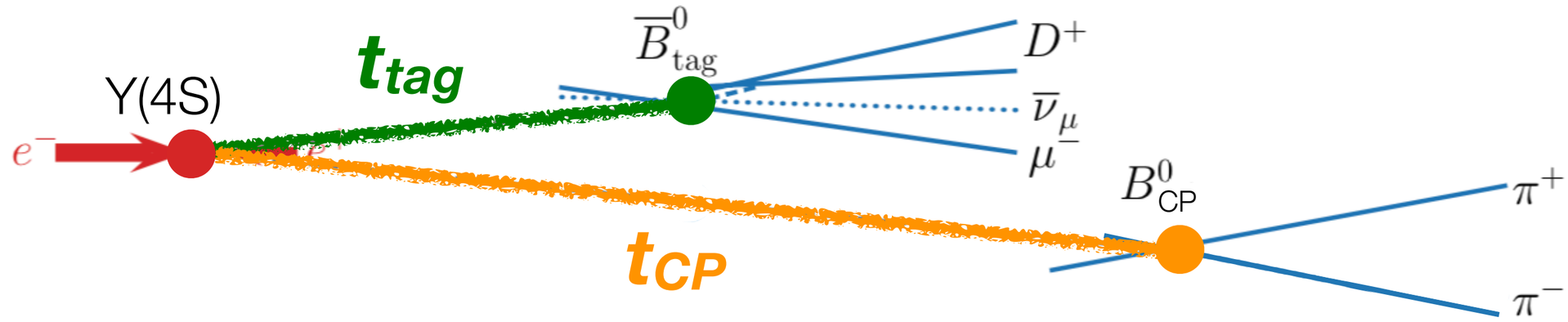
Time-dependent CPV in $B^0 \to \pi^0\pi^0$

- why?
  - essential ingredient for a CKM angle $\phi_2(=\alpha)$ in $B \to \pi\pi$ decays
  - crucial for isospin analysis to resolve penguin pollution in $B^0 \to \pi^+\pi^-$
- main issue & key idea
  - traditionally, we need $\Delta t = t_{\rm CP} - t_{\rm tag}$ for TdCPV
  - but for $B^0 \to \pi^0\pi^0$, we cannot measure the signal vertex ($\because$ no charged track with $\pi^0 \to \gamma\gamma$)

    ✓ we may turn to $\pi^0 \to e^+e^-\gamma$, but need $\mathcal{O}(10^2)$ statistics
  - exploit quantum entanglement for measuring TdCPV with $t_{\rm tag}$ alone, i.e. without having $t_{\rm CP}$



TdCPV in $B^0 \to \pi^0\pi^0$ using $t_{\rm tag}$ (QE)



$$P(t_{\rm tag}, t_{\rm CP}, q) = \frac{e^{-(t_{\rm tag}+t_{\rm CP})/\tau}}{4\tau^2}\Big\{1 + q\Big[S_f \sin\big(\Delta m(t_{\rm CP} - t_{\rm tag})\big) - C_f \cos\big(\Delta m(t_{\rm CP} - t_{\rm tag})\big)\Big]\Big\}$$

Integrating over $t_{\rm CP}$ as we don't measure it,

$$P(t_{\rm tag}, q) = \frac{e^{-t_{\rm tag}/\tau}}{4\tau}\Big[1 - qD\Big(S_{\pi^0\pi^0} \sin\Big[\Delta m(t_{\rm tag} - \hat{t})\Big] + C_{\pi^0\pi^0} \cos\Big[\Delta m(t_{\rm tag} - \hat{t})\Big]\Big)\Big]$$

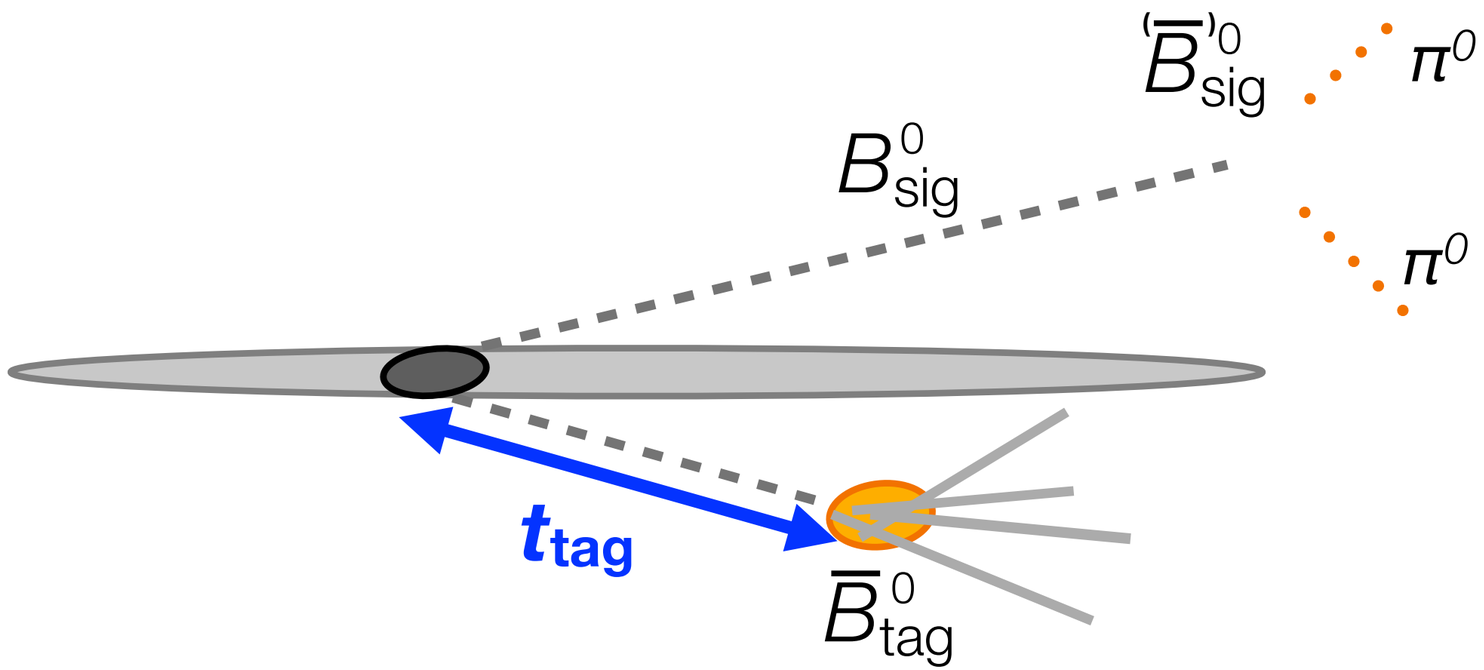
$\hat{t} = \arctan(\tau\Delta m)/\Delta m$

$D = 1/\sqrt{1 + (\tau\Delta m)^2}$

TdCPV in $B^0 \to \pi^0\pi^0$ using $t_{\rm tag}$ (QE)

$$t_{\rm tag} = m_B \frac{\vec{L} \cdot \vec{p}_{\rm tag}}{|\vec{p}_{\rm tag}|^2}$$

$$\vec{p}_{\rm CM} = \vec{p}_{\rm tag} + \vec{p}_{\rm sig}$$



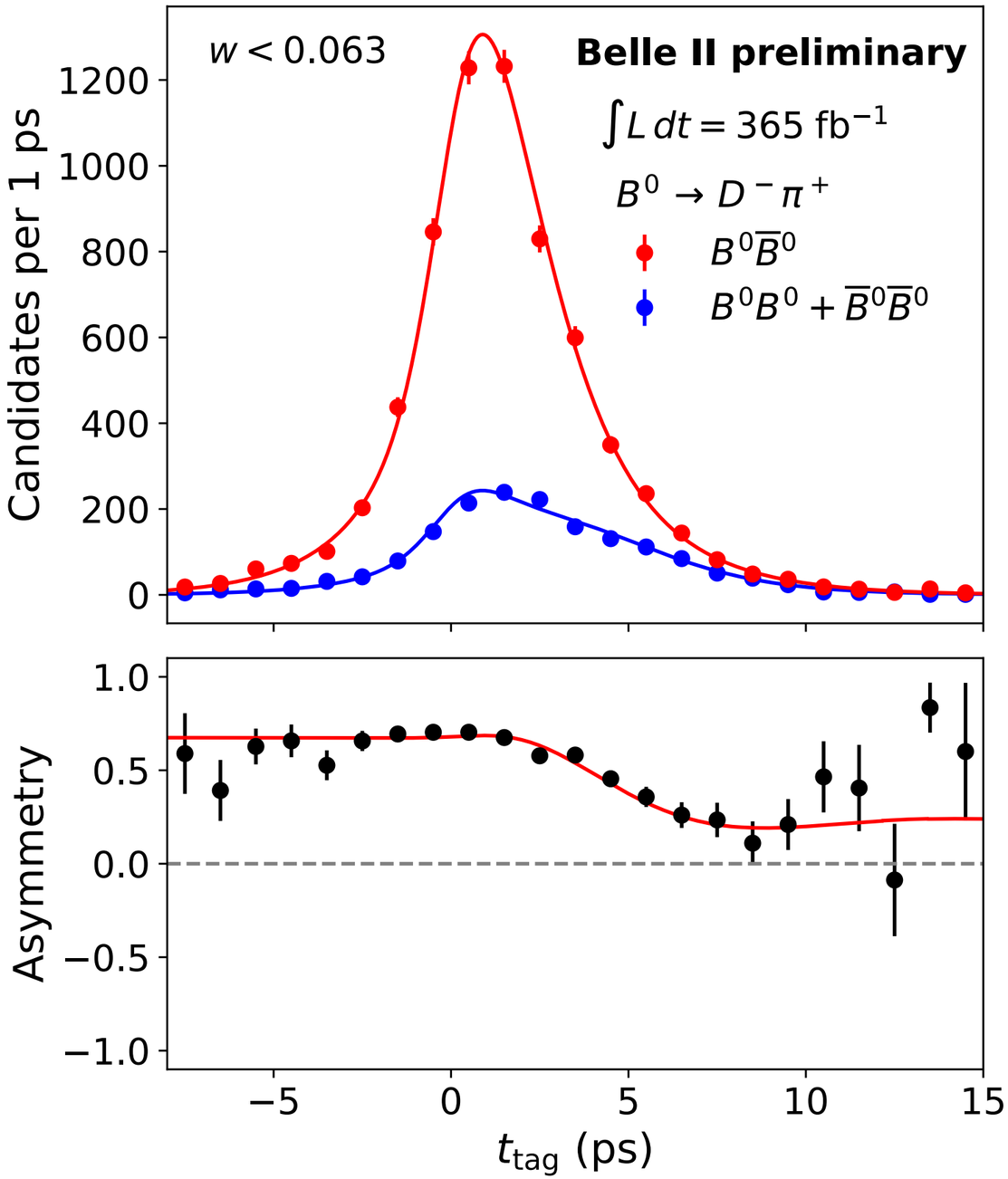
	Belle	BaBar	Belle II
Crossing angle [mrad]	22	0	83
Interaction region x width [μm]	70	148	13
Interaction region y width [μm]	1.0	6.9	0.2
Interaction region z width [μm]	6000	15150	350
$B_{\rm tag}$ vertex x-y resolution [μm]	80	80	30
$B_{\rm tag}$ vertex z resolution [μm]	100	125	30

SuperKEKB

Belle II pixels

$B\overline{B}$ mixing with t_{tag} method

arXiv:2606.20797
Preliminary



- Validation with $B^0 \to D^-\pi^+$

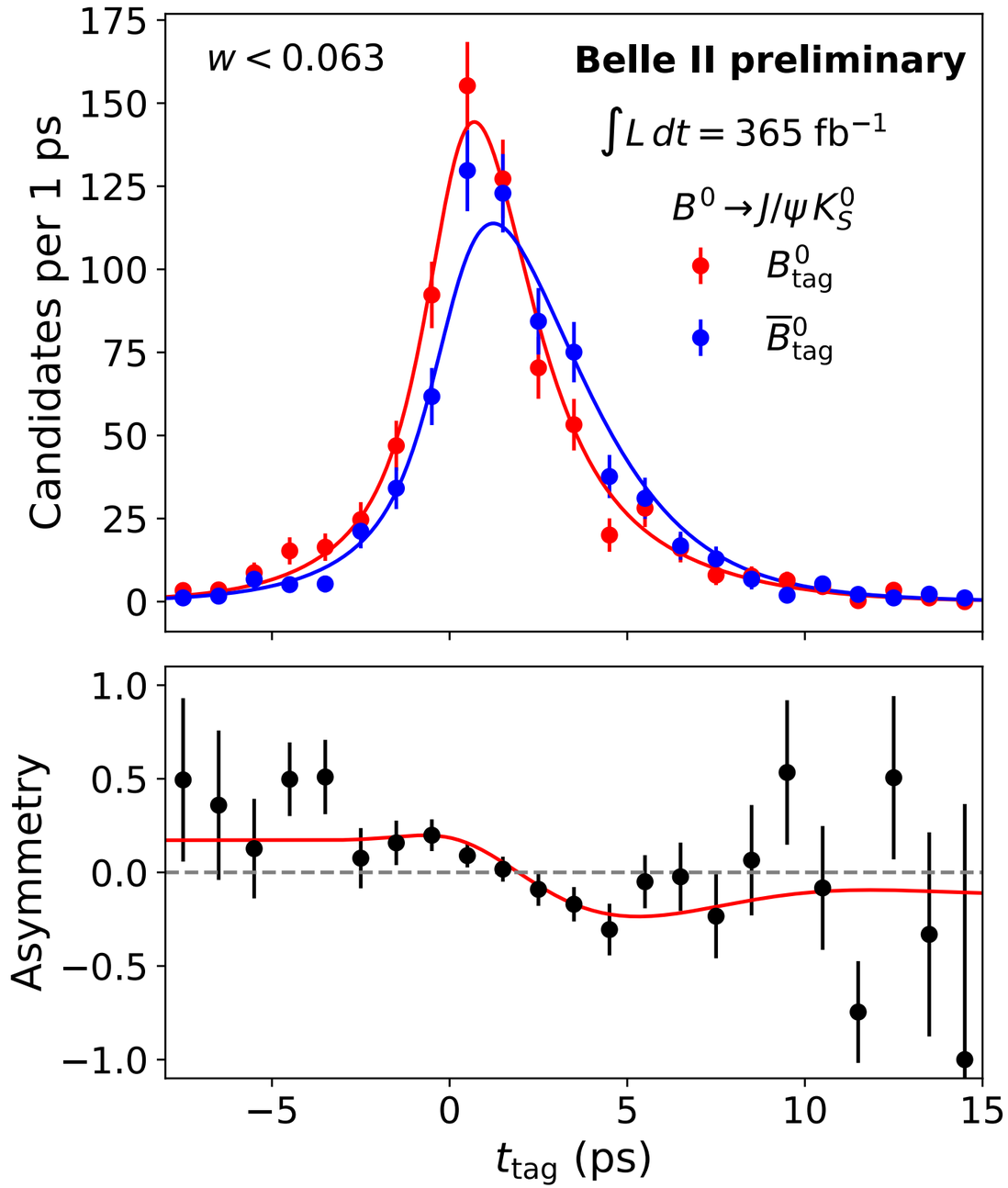
$$\tau = 1.524 \pm 0.026 \text{ ps}$$

$$\Delta m_d = 0.512 \pm 0.011 \text{ ps}^{-1}$$

  - consistent w/ the known values

TdCPV with t_{tag} method

arXiv:2606.20797
Preliminary



- CPV parameters for $B^0 \to J/\psi K^0_S$

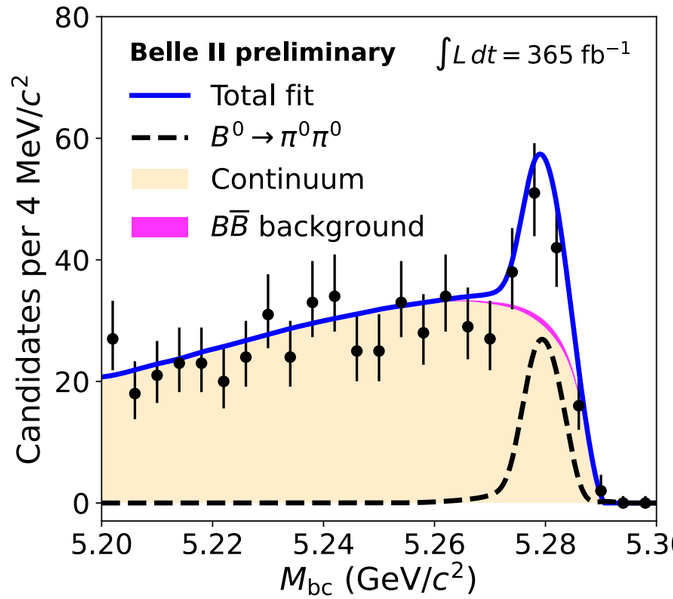
$$S_{J/\psi K^0_S} = 0.835 \pm 0.104$$

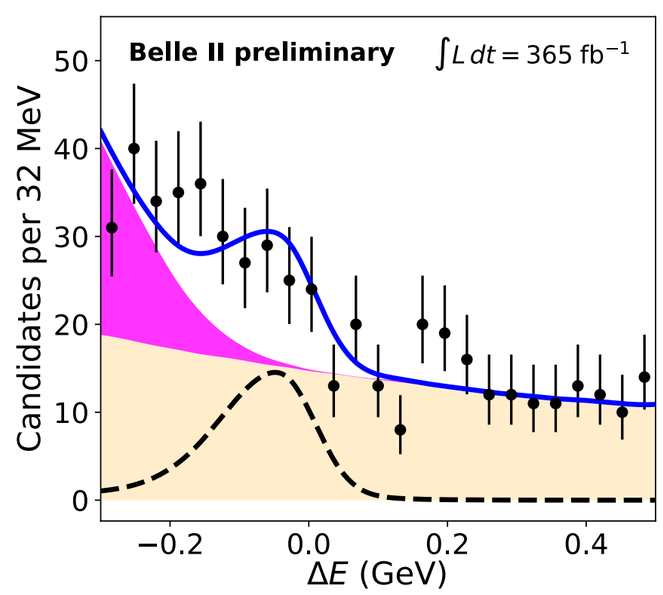
$$C_{J/\psi K^0_S} = -0.056 \pm 0.033$$

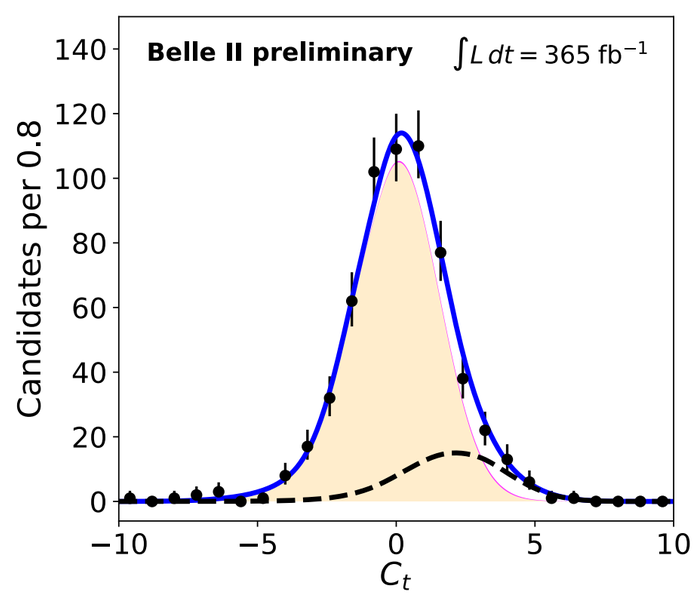
  - consistent w/ the known values from Δt-based measurement

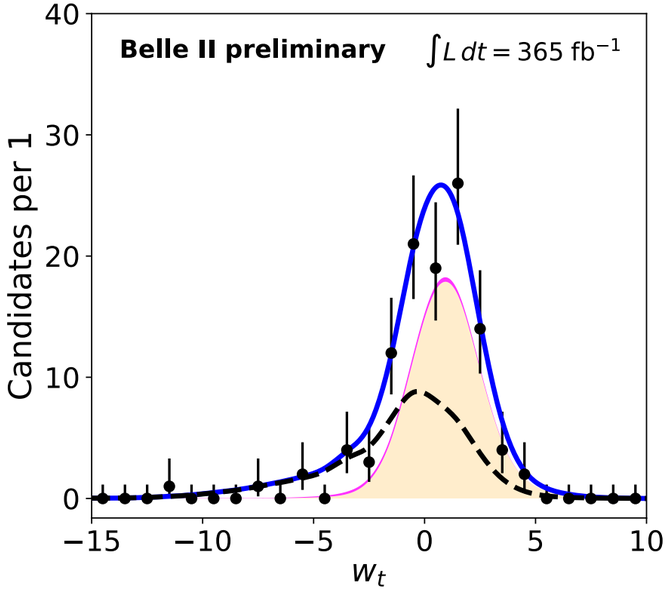
$B^0 \to \pi^0\pi^0$ using t_{tag}

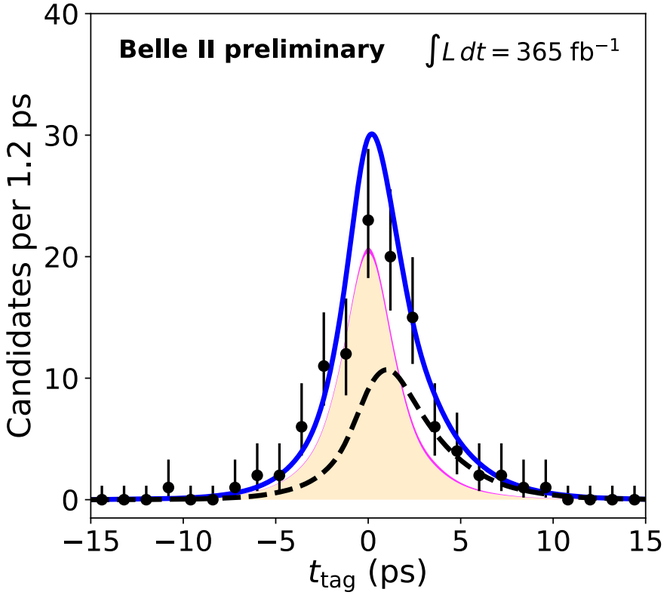
arXiv:2606.20797
Preliminary

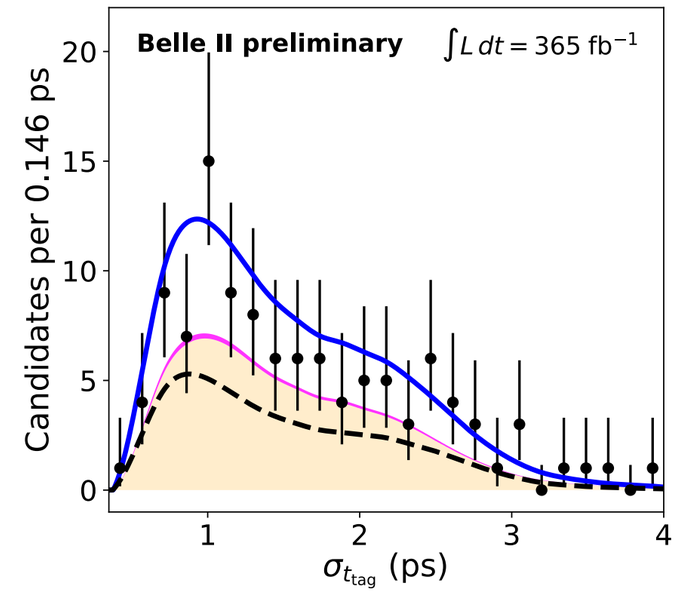












$B^0 \to \pi^0\pi^0$ using $t_{\rm tag}$ — Results

arXiv:2606.20797
Preliminary

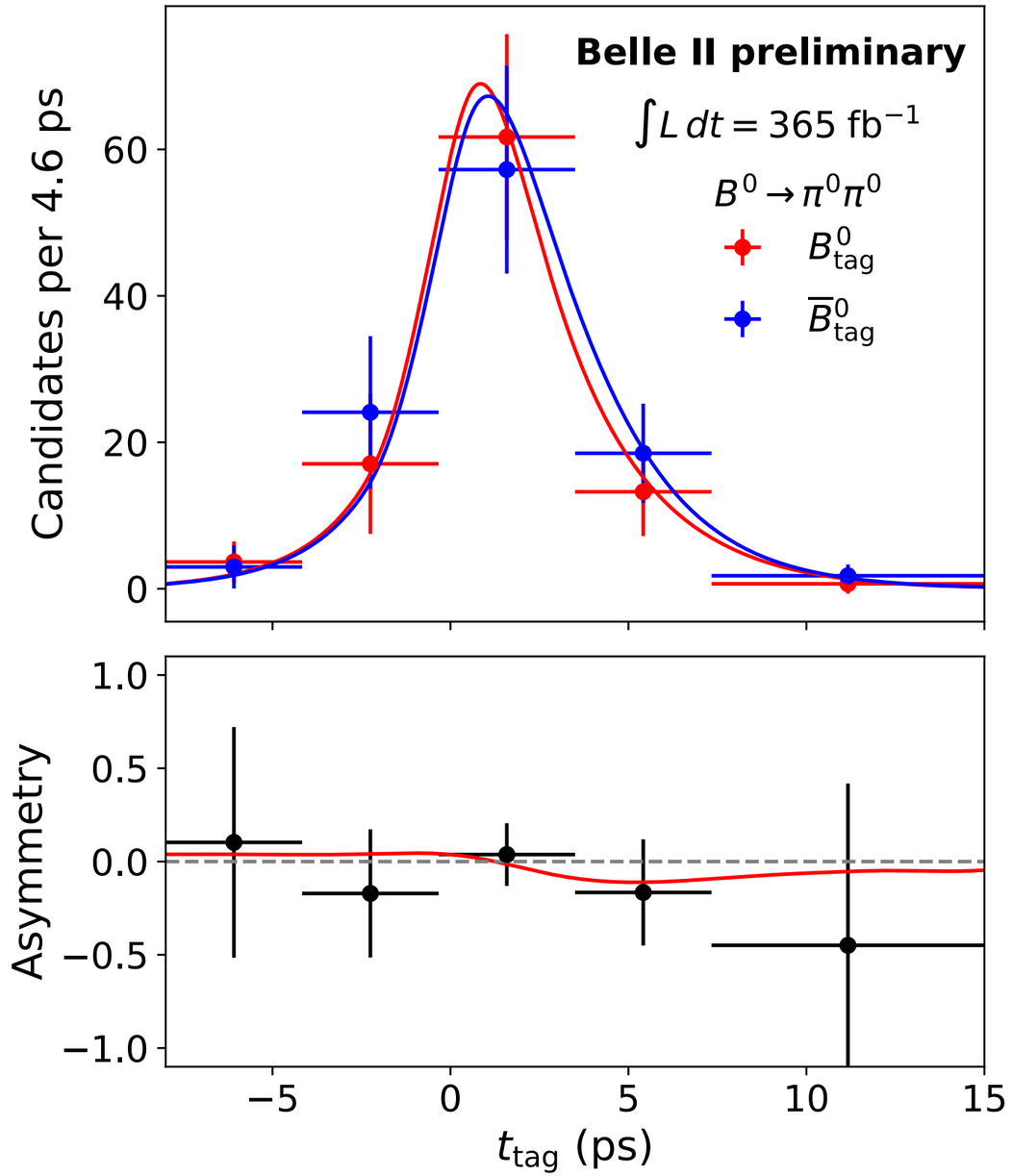
- CPV parameters w/ 171 ± 24 signal events

$$S_{\pi^0\pi^0} = 0.61^{+0.75}_{-0.79} \pm 0.11$$

$$C_{\pi^0\pi^0} = 0.05 \pm 0.28 \pm 0.07$$

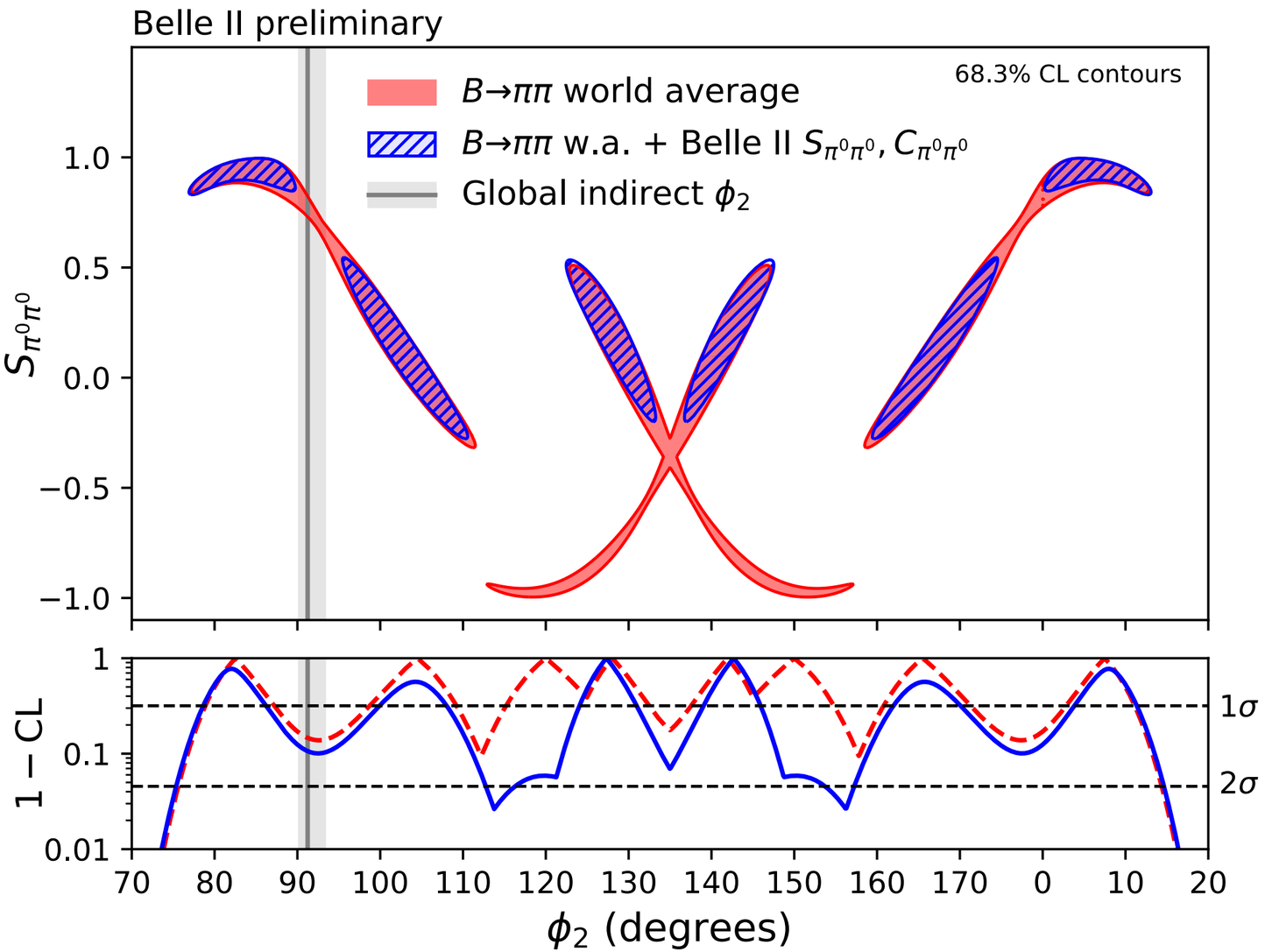
standard Δt method will need $\times 20$ more stat. to achieve similar sensitivity

- First measurement of mixing-induced CP violation in $B^0 \to \pi^0\pi^0$



$B^0 \to \pi^0\pi^0$ using $t_{\rm tag}$ — Impact on ϕ_2

arXiv:2606.20797
Preliminary

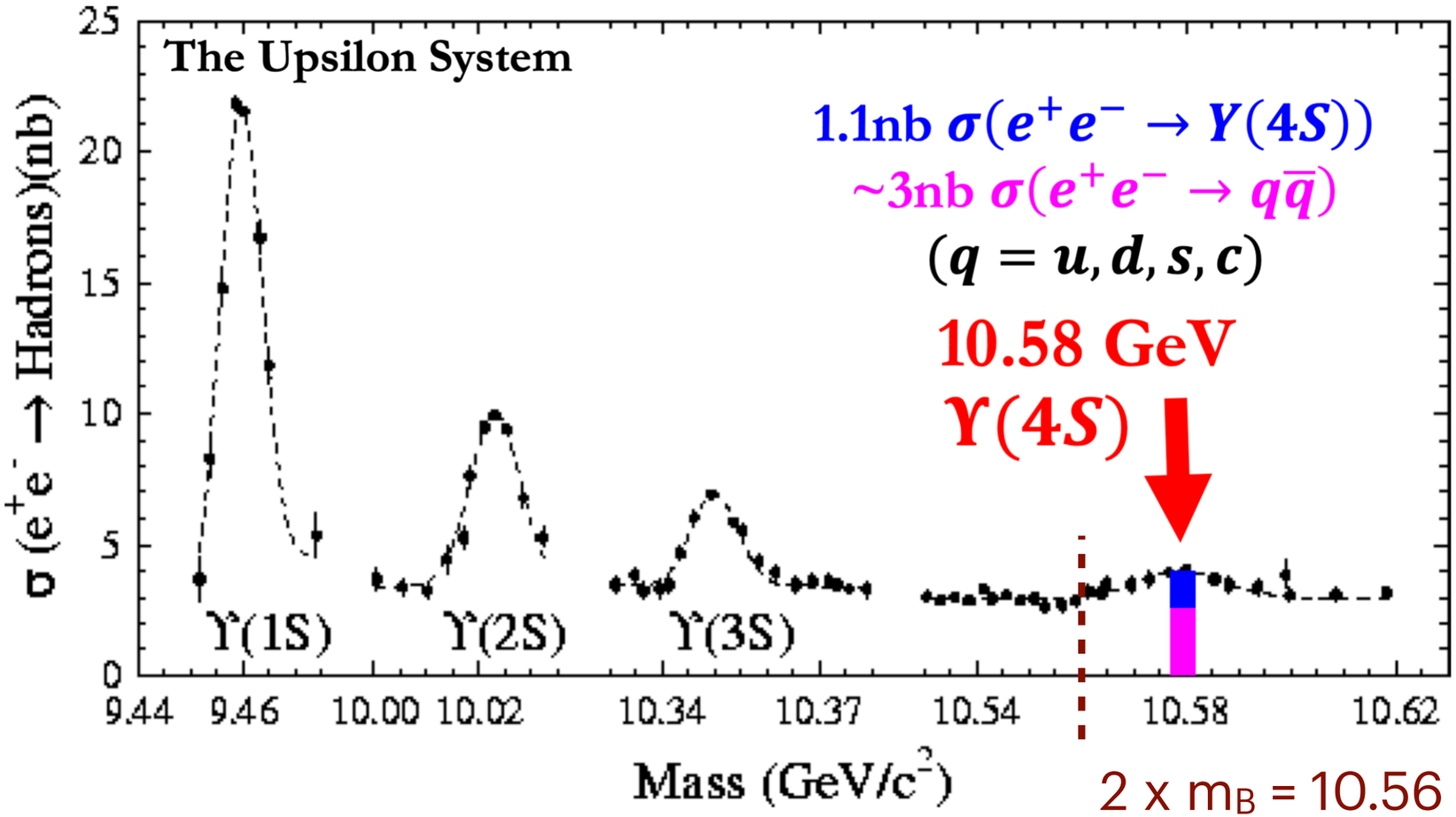


- Reduces discrete ambiguity, and 1σ interval got reduced by $\sim 40\,\%$
- CKM favored solution:

  $\phi_2 = \left(82.0^{+4.4}_{-3.5}\right)^\circ$

- dominated by statistics, hence anticipating much improved ϕ_2 from $B \to \pi\pi$ with more data at Belle II

$e^+e^- \to \Upsilon(4S)$ as a B-factory

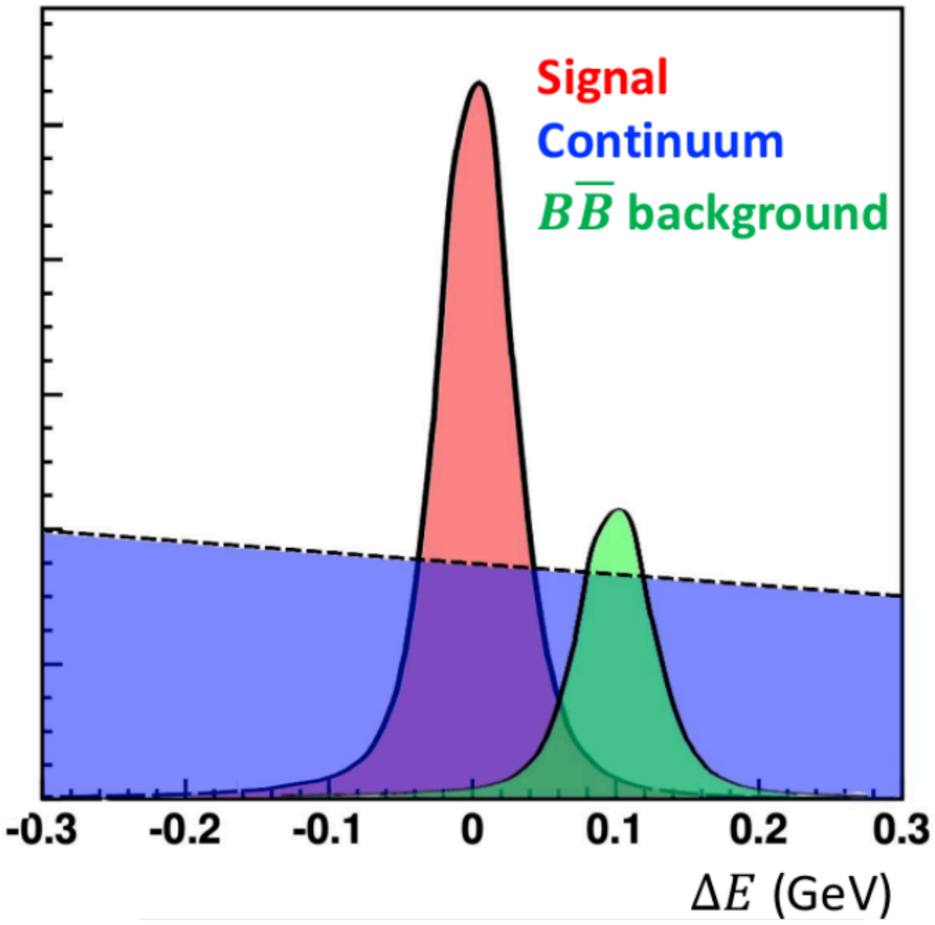


- $\mathcal{B}(\Upsilon(4S) \to B\overline{B}) > 96\%$, with $p_B^{CM} \sim 0.35$ GeV/c
- nothing else but $B\overline{B}$ in the final state

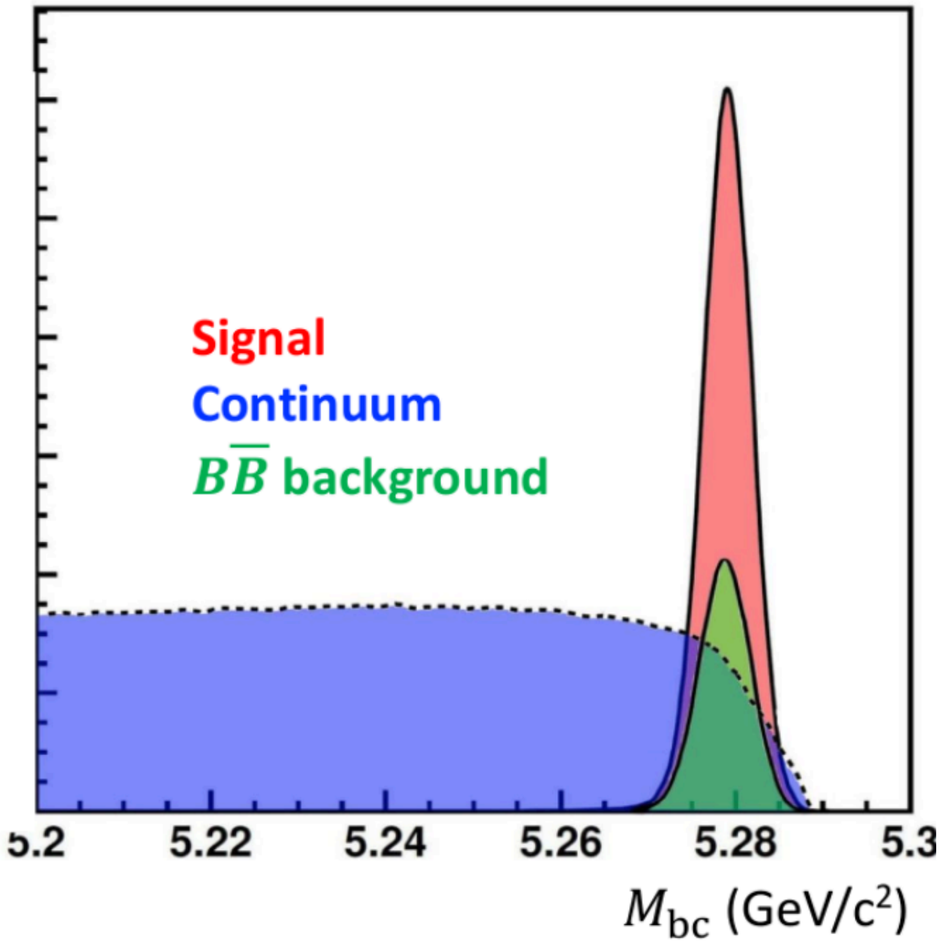
  $\therefore$ if we know $(E, \vec{p})$ of one B, the other B is also constrained

Key variables of *B* decays

$$\Delta E = E_B^* - \sqrt{s}/2$$

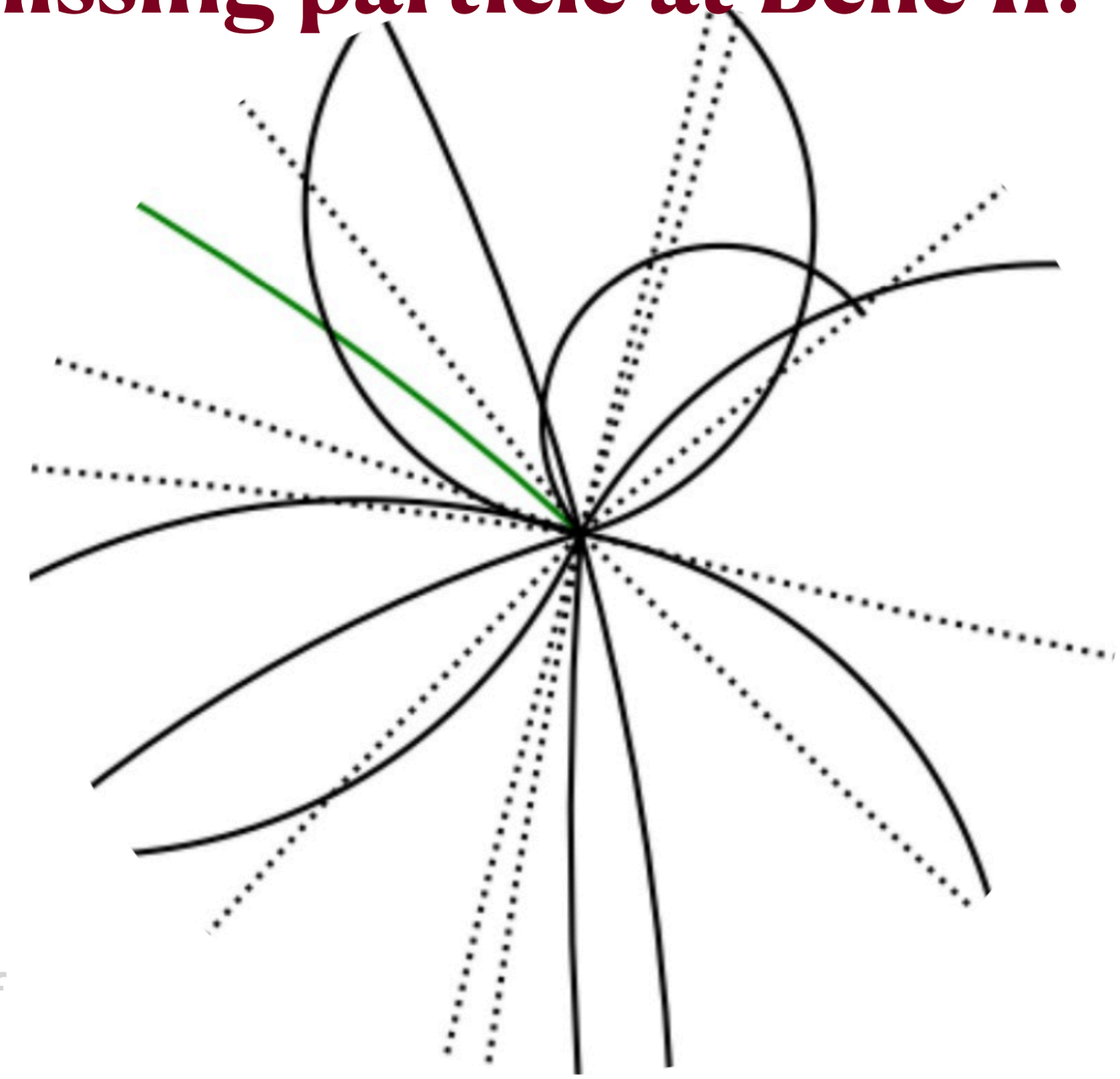


$$M_{bc} = \sqrt{(\sqrt{s}/2)^2 - \vec{p}_B^{*2}}$$



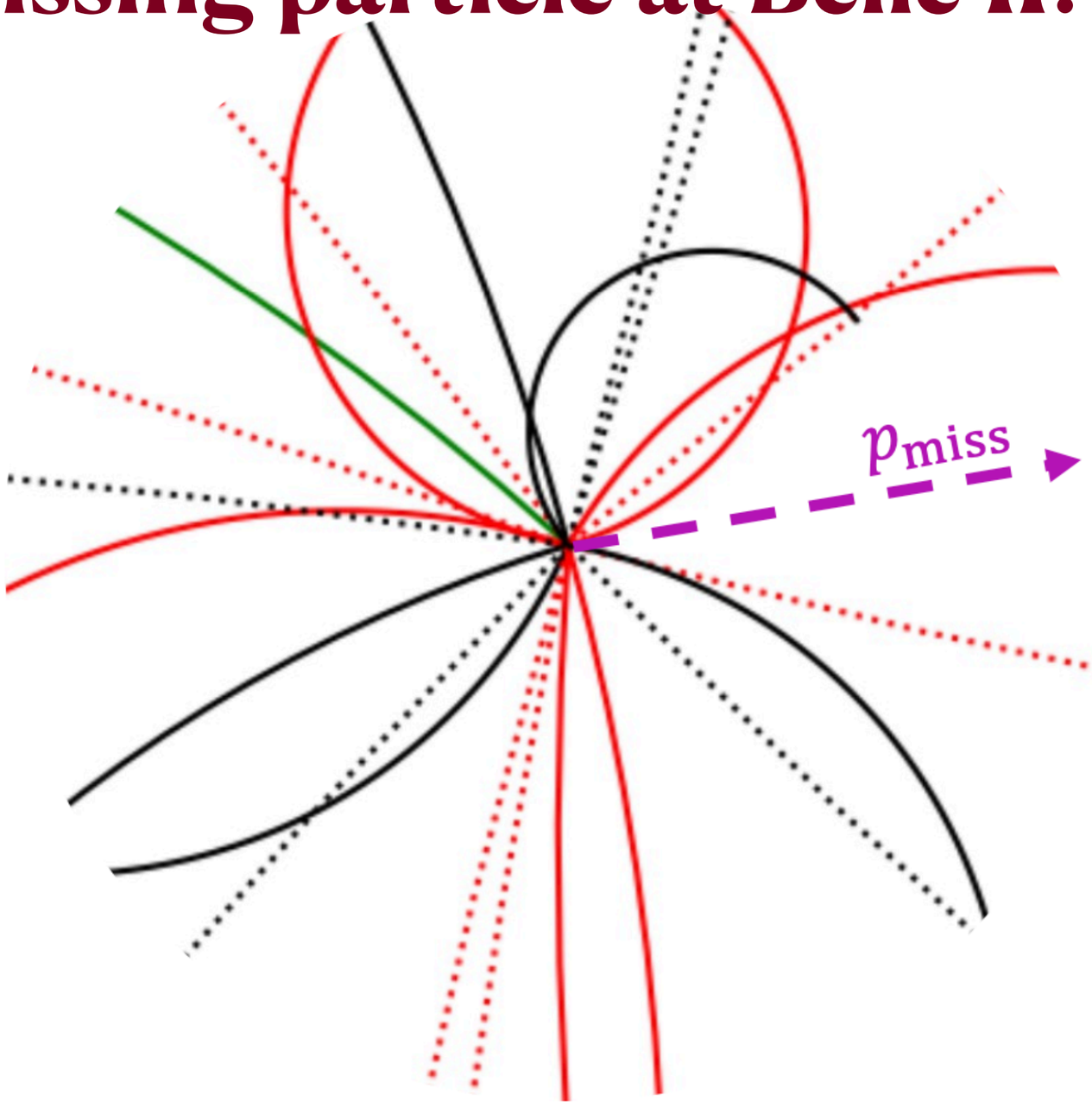
How to handle a missing particle at Belle II?

- $e^+e^- \to \Upsilon(4S) \to B\overline{B}$
  - only two B mesons in the final state
  - Since the initial state is clearly determined, fully accounting one B ($B_{\rm tag}$) makes it possible to constrain the accompanying B ($B_{\rm sig}$)
  - Having a single missing particle (e.g. ν) is usually as clean as getting all particles measured
  - The price to pay is a big drop of efficiency ($< \mathcal{O}(1\%)$)



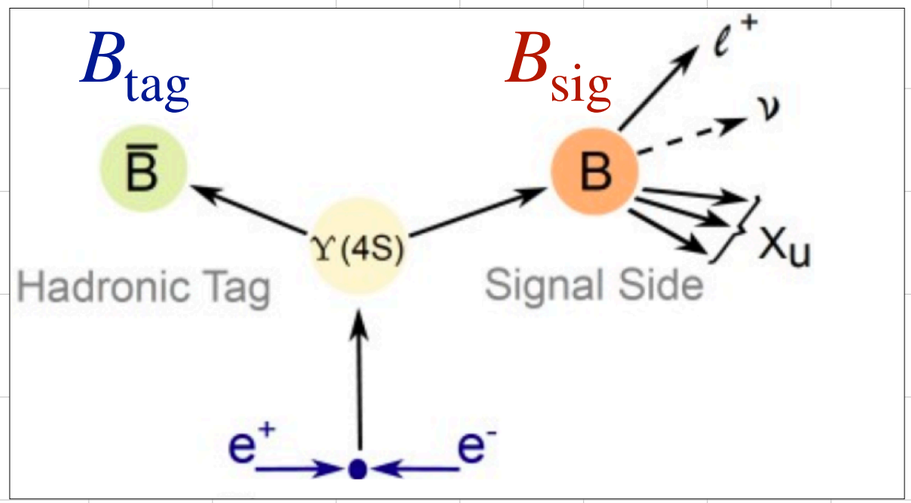
How to handle a missing particle at Belle II?

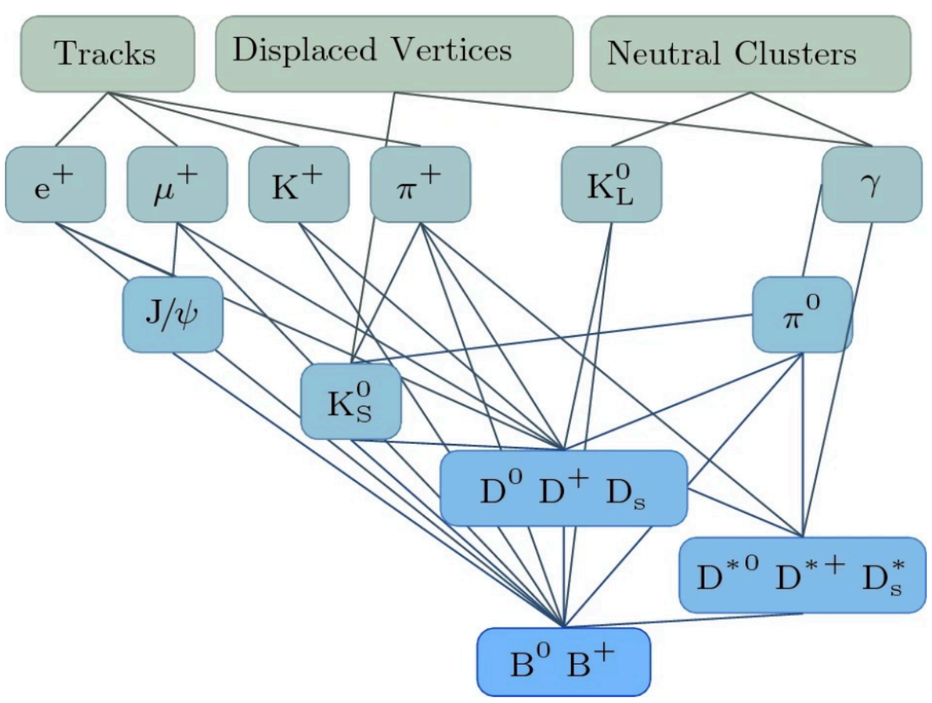
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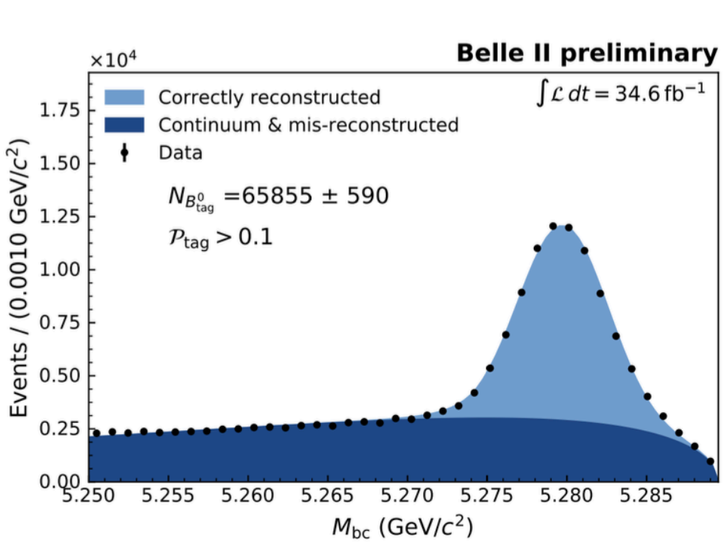


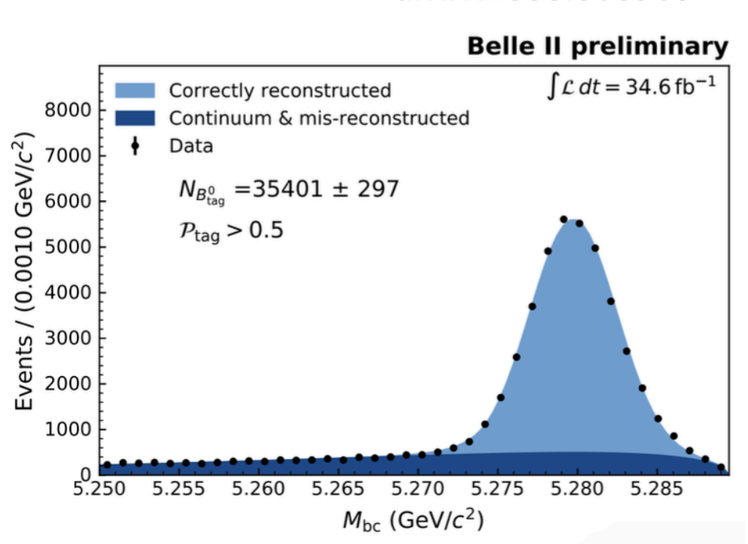
Full Event Interpretation (FEI)

- FEI algorithm to reconstruct B_{tag}
  - uses ~200 BDT's to reconstruct $\mathcal{O}(10^4)$ different B decay chains
  - assign signal probability of being correct B_{tag}





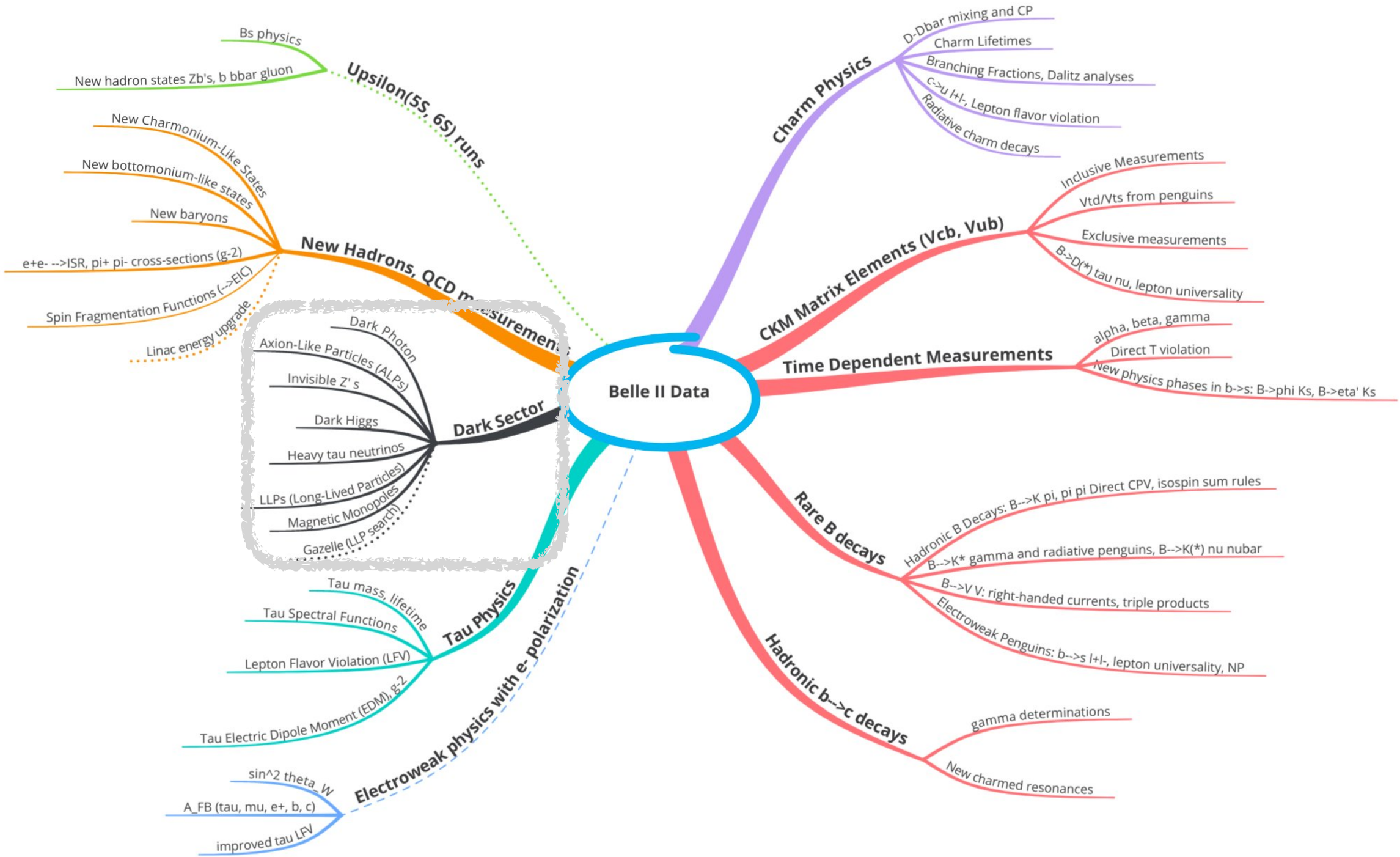




Comput Softw Big Sci 3, 6 (2019)

arXiv:2008.060965

Belle II Physics Mind-map



Parameters of dark sector with inelastic DM

- α_{D} = strength of dark-sector U(1) gauge interaction
- ε = mixing parameter between γ and A'
- θ = mixing angle between SM higgs h and dark higgs h'

$$\alpha_{\mathrm{D}} = 0.1$$
$$\varepsilon = 1.5 \times 10^{-3}$$
$$m(\chi_1) = 2.5\ \mathrm{GeV}$$
$$m(A') = 3m(\chi_1)$$
$$\Delta m = 0.4m(\chi_1)$$
$$\sin\theta = 2.6 \times 10^{-4}$$

a typical choice (p.10)