Electroweak and radiative penguin *B* meson decays at Belle and Belle II

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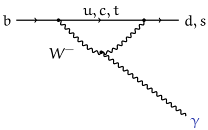
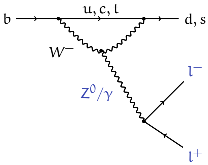
on behalf of the Belle and Belle II collaborations

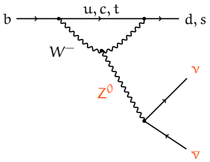
Moriond QCD 2024

Electroweak and radiative penguin *B* decays

- Flavour changing neutral currents present only at loop level in the Standard Model
- Formidable place to look for New Physics that could interfere with radiative and electroweak penguin loops

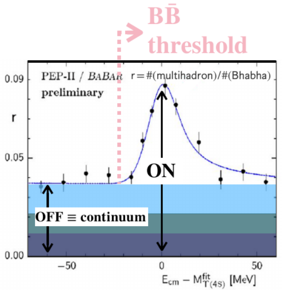


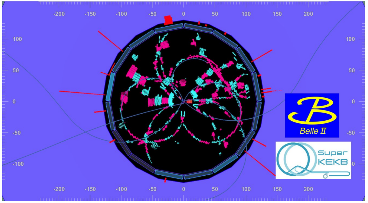


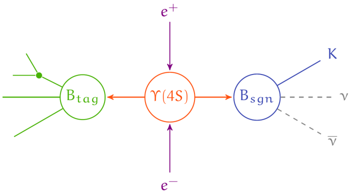


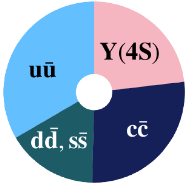
Advantages of an $e^+ e^-$ flavour factory

- Known initial kinematics and good hermeticity
  - possible to fully reconstruct events with invisible particles
- Run at the $\Upsilon(4S)$ mass just above $B\bar{B}$ threshold
  - Relatively low background
  - Data off-resonance provide control sample without $B\bar{B}$
- Clean environment (average 11 tracks per event)
  - efficient detection of neutrals (γ, π^0, η, ...)







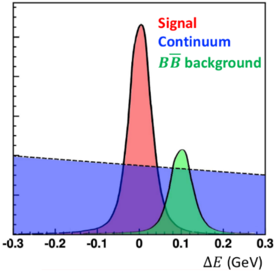


Hadronic cross-section
@ $\sqrt{s} = 10.58$ GeV

Tools at an $e^+ e^-$ flavour factory

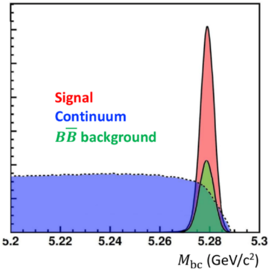
- Optimised variables to exploit information on initial kinematics
- Exploit different event shape to separate $B\bar{B}$ from continuum background

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

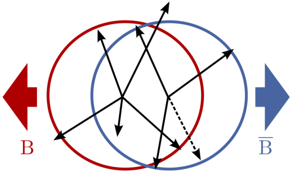


Expected $\Delta E \simeq 0$

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

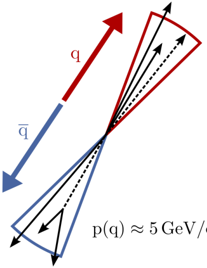


Expected $M_{bc} \simeq m_B$



$p(B) \approx 0.3\,\mathrm{GeV}/c$

$e^+e^- \to \Upsilon(4S) \to B\bar{B}$

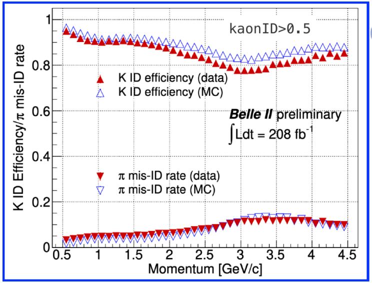


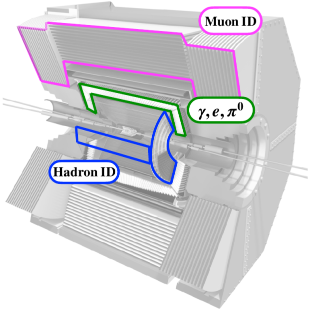
$p(q) \approx 5\,\mathrm{GeV}/c$

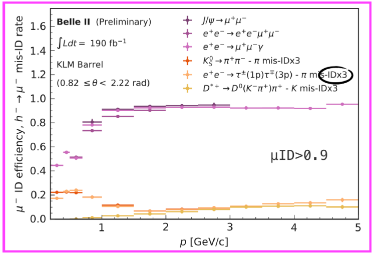
$e^+e^- \to q\bar{q} \quad (q \in \{u, d, s, c\})$

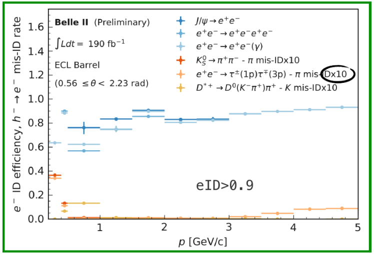
Key Belle II performances

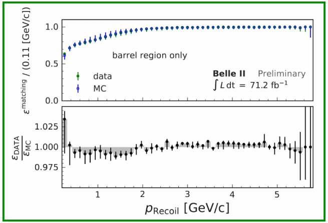
- Good kaon identification in full momentum range
  - $\varepsilon(K) \sim 90\%, \pi \to K \sim 6\%$
- High photon efficiency
  - $\varepsilon(\gamma) \sim 90\%$ ($p > 1.5$ GeV)
- Good lepton ID performance
  - $\varepsilon(\mu) \sim 90\%, \pi \to \mu \sim 7\%$
  - $\varepsilon(e) \sim 86\%, \pi \to e \sim 0.4\%$











New results since last Moriond QCD

- $\mathcal{B}$, A_{CP} and Δ_{+0} of $B \to K^*\gamma$
- $\mathcal{B}$, A_{CP} and A_{I} of $B \to \rho\gamma$
- Search for $B^0 \to \gamma\gamma$
- Search for rare $b \to ll$ decays
- First evidence of $B^+ \to K^+\nu\bar{\nu}$

Datasets

	on-resonance	off-resonance
BELLE	711 fb^{-1}	90 fb^{-1}
Belle II	362 fb^{-1}	42 fb^{-1}

$$B \to K^* \gamma$$

$B \to K^*\gamma$: motivation

- Flavour changing neutral current decays sensitive to new physics
- CP (A_{CP}) and isospin (Δ_{+0}) asymmetries are theoretically clean thanks to form factor cancellations
- Latest Belle measurement found evidence of isospin asymmetry at 3.1σ [Phys. Rev. Lett. 119, 191802 (2017)]

$$A_{CP} = \frac{\Gamma(\overline{B} \to \overline{K^*}\gamma) - \Gamma(B \to K^*\gamma)}{\Gamma(\overline{B} \to \overline{K^*}\gamma) + \Gamma(B \to K^*\gamma)}$$

$$\Delta_{+0} = \frac{\Gamma(B^0 \to K^{*0}\gamma) - \Gamma(B^+ \to K^{*+}\gamma)}{\Gamma(B^0 \to K^{*0}\gamma) + \Gamma(B^+ \to K^{*+}\gamma)}$$

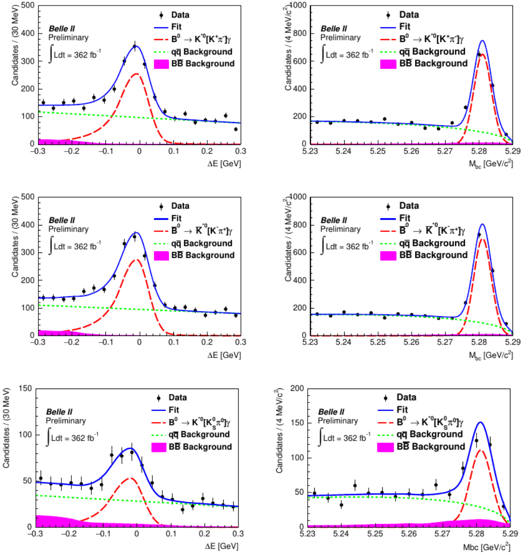
Goal

Using the 362 fb^{-1} Belle II run 1 dataset

- Measure $\mathcal{B}(B^{\pm,0} \to K^{*\pm,0}\gamma)$ with $K^* \to K^+\pi^-$, $K_S^0\pi^0$, $K^+\pi^0$ and $K_S^0\pi^+$
- Measure A_{CP} for all modes except $B^0 \to K^{*0}(\to K_S^0\pi^0)\gamma$

$B \to K^*\gamma$: analysis strategy

- Reconstruct 4 K^* modes: $K^+\pi^-$, $K^0_S\pi^0$, $K^+\pi^0$ and $K^0_S\pi^+$
- 2 MVA classifiers to reject
  - photons from asymmetric $\pi^0 \to \gamma\gamma$ and $\eta \to \gamma\gamma$ decays
  - continuum events
- Improve M_{bc} resolution and reduce correlation with ΔE by replacing magnitude photon momentum with $E^*_{\text{beam}} - E_{K^*}$
- 2D M_{bc}-ΔE fit to extract
  - Simultaneously yields of B and anti-B for self-tagged modes for A_{CP} and $\mathcal{B}$
  - Yield of $B \to K^{*0}(\to K^0_S\pi^0)\gamma$ for $\mathcal{B}$



$B \to K^*\gamma$: results

- Consistent with World average and SM
- Similar sensitivity as Belle despite smaller sample

$$\mathcal{B}[B^0 \to K^{*0}\gamma] = (4.16 \pm 0.10 \pm 0.11) \times 10^{-5},$$

$$\mathcal{B}[B^+ \to K^{*+}\gamma] = (4.04 \pm 0.13 \pm 0.13) \times 10^{-5},$$

$$\mathcal{A}_{CP}[B^0 \to K^{*0}\gamma] = (-3.2 \pm 2.4 \pm 0.4)\%,$$

$$\mathcal{A}_{CP}[B^+ \to K^{*+}\gamma] = (-1.0 \pm 3.0 \pm 0.6)\%,$$

$$\Delta\mathcal{A}_{CP} = (2.2 \pm 3.8 \pm 0.7)\%, \text{ and}$$

$$\Delta_{0+} = (5.1 \pm 2.0 \pm 1.5)\%,$$

BELLE + Belle II

$$B \to \rho\gamma$$

$B \to \rho\gamma$: motivation

- Flavour changing neutral current decays sensitive to new physics,
- SM $\mathcal{B}$ suppressed by $|V_{td}/V_{ts}| \simeq 0.04$ with respect to $B \to K^*\gamma$
- Previously observed at Belle [Phys.Rev.Lett.101:111801,2008] and BaBar [Phys.Rev.D78:112001,2008]
- Almost 2σ tension between current word average $A_I = (30^{+16}_{-13}\%)$ and SM $(5.2 \pm 2.8)\%$ [Lyon, Zwicky '13]

$$A_{CP}(B \to \rho\gamma) = \frac{\Gamma(\overline{B} \to \overline{\rho}\gamma) - \Gamma(B \to \rho\gamma)}{\Gamma(\overline{B} \to \overline{\rho}\gamma) + \Gamma(B \to \rho\gamma)}$$

$$A_I = \frac{2\Gamma(\overset{(-)}{B^0} \to \rho^0\gamma) - \Gamma(B^\pm \to \rho^\pm\gamma)}{2\Gamma(\overset{(-)}{B^0} \to \rho^0\gamma) + \Gamma(B^\pm \to \rho^\pm\gamma)}$$

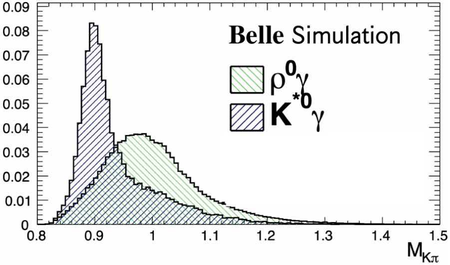
Goal

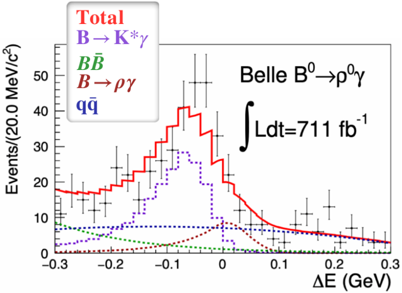
Using the 362 fb^{-1} Belle II run 1 dataset

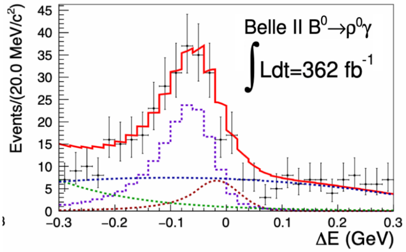
- Measure $\mathcal{B}(B^{\pm,0} \to \rho^{\pm,0}\gamma)$ with $\rho^0 \to \pi^+\pi^-$, and $\rho^\pm \to \pi^\pm\pi^0$
- Measure $A_{CP}(B^+ \to \rho^+\gamma)$ and $A_I(B \to \rho\gamma)$

$B \to \rho\gamma$: analysis strategy

- 2 MVA classifiers against photons from π^0/η and continuum events
- Improve M_{bc} resolution for $B^0 \to \rho^0\gamma$ replacing magnitude photon momentum with $E^*_{\text{beam}} - E_{\rho^0}$
- Large background from $B \to K^*\gamma$ ($K \to \pi$ misID)
- Belle+Belle II simultaneous 3D fit of M_{bc}, ΔE and $M_{K\pi}$







$B \to \rho\gamma$: results

- Obtain most precise measurements to date
- A_I consistent with SM at 0.6σ

$$\mathcal{B}\left(B^+ \to \rho^+\gamma\right) = \left(13.1^{+2.0+1.3}_{-1.9-1.2}\right) \times 10^{-7},$$
$$\mathcal{B}\left(B^0 \to \rho^0\gamma\right) = \left(7.5 \pm 1.3^{+1.0}_{-0.8}\right) \times 10^{-7},$$
$$A_{\mathrm{CP}}\left(B^+ \to \rho^+\gamma\right) = \left(-8.2 \pm 15.2^{+1.6}_{-1.2}\right)\%,$$
$$A_{\mathrm{I}}\left(B \to \rho\gamma\right) = \left(10.9^{+11.2+6.8+3.8}_{-11.7-6.2-3.9}\right)\%,$$

BELLE + Belle II

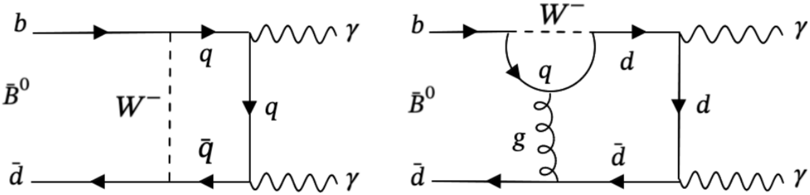
$$B^0 \to \gamma\gamma$$

$B^0 \to \gamma\gamma$: motivation

- Flavour changing neutral current decay sensitive to new physics
- Expected $\mathcal{B}(B^0 \to \gamma\gamma) = 1.4^{+1.4}_{-0.8} \times 10^{-8}$
  [Shen, Wang, Wei '09]
- Current best upper limit by BaBar
  $\mathcal{B}(B^0 \to \gamma\gamma) < 3.2 \times 10^{-7}$
  [Phys.Rev.D83:032006,2011]

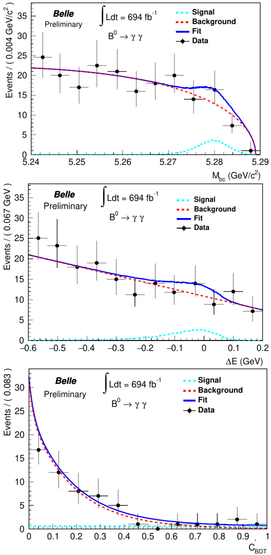
Goal

Search for the $B^0 \to \gamma\gamma$ decay using the 1.07 ab^{-1} Belle + Belle II dataset



$B^0 \to \gamma\gamma$: analysis strategy

- Combine two high energy photons from the barrel
- 2 MVA classifiers against photons from π^0/η and continuum events
- Photon timing cuts to suppress peaking background in M_{bc} from combinations of back-to-back off-time photons
- Belle+Belle II simultaneous 3D fit on M_{bc}, ΔE and output MVA classifier
  - Use KDE to model $M_{bc} - \Delta E$ correlation for signal
- Use $B^0 \to K^{*0}(\to K^+\pi^-)\gamma$ as control channel to derive data/MC efficiency corrections



$B^0 \to \gamma\gamma$: results

- $9.1^{+5.6}_{-4.4}/615 \pm 25$ and $1.9^{+4.2}_{-2.8}/317 \pm 18$ signal/background events in Belle and Belle II datasets
- 2.5σ combined significance
- 90% CL upper limit improved by a factor 5 over BaBar

	$\mathcal{B}(B^0 \to \gamma\gamma)$	$\mathcal{B}(B^0 \to \gamma\gamma)$ (at 90% CL)
Belle	$(5.4^{+3.3}_{-2.6} \pm 0.5) \times 10^{-8}$	$< 9.9 \times 10^{-8}$
Belle II	$(1.7^{+3.7}_{-2.4} \pm 0.3) \times 10^{-8}$	$< 7.4 \times 10^{-8}$
Combined	$(3.7^{+2.2}_{-1.8} \pm 0.7) \times 10^{-8}$	$< 6.4 \times 10^{-8}$

Rare $b \to ll$

Rare $b \to ll$: motivation

$b \to dll$ transitions

- FCNC sensitive to new physics complementary to $b \to sll$
- Extra CKM suppression $|V_{td}/V_{ts}|^2 \sim 0.04$ wrt $b \to sll$
- Typical $\mathcal{B} = \mathcal{O}(10^{-8})$ or smaller

Channel	UL or BR	Collaboration
$B^0 \to \eta ee$	$< 10.8 \times 10^{-8}$	BaBar
$B^0 \to \eta\mu\mu$	$< 11.2 \times 10^{-8}$	BaBar
$B^0 \to \pi^0 ee$	$< 8.4 \times 10^{-8}$	BaBar
$B^0 \to \pi^0\mu\mu$	$< 6.9 \times 10^{-8}$	BaBar
$B^+ \to \pi^+ ee$	$< 8.0 \times 10^{-8}$	Belle
$B^+ \to \pi^+\mu\mu$	$(1.78 \pm 0.22 \pm 0.03) \times 10^{-8}$	LHCb
$B^0 \to \rho^0\mu\mu$	$(1.98 \pm 0.53) \times 10^{-8}$	LHCb

Goal

Look for all the $B^{\pm,0} \to (\eta, \omega, \pi^{\pm,0}, \rho^{\pm,0})ll$ decays (except $B^+ \to \pi^+\mu\mu$ and $B^+ \to \rho^0\mu\mu$ already seen by LHCb)

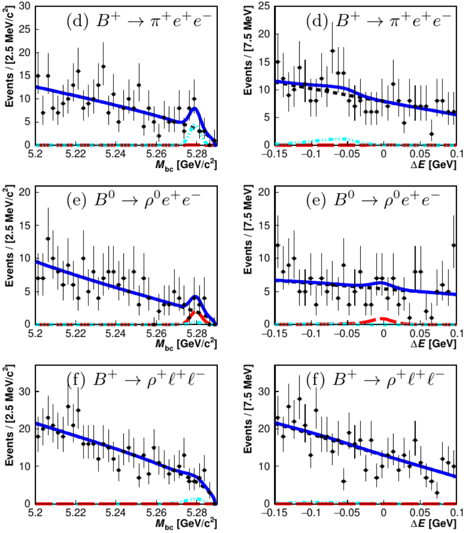
BaBar: [Phys.Rev.D 88 (2013) 3, 032012]
Belle: [Phys.Rev.D 78 (2008) 011101]
LHCb: [JHEP 10 (2015) 034, Phys.Lett.B 743 (2015) 46]

Rare $b \to ll$: analysis strategy

- Reconstruct 12 decay chains

$$B \to \{\pi, \rho, \eta, \omega\}\ell\ell \quad \begin{cases} \rho^{+,0} \to \pi^+\pi^{0,-} \\ \eta \to \gamma\gamma, \pi^+\pi^-\pi^0 \\ \omega \to \pi^+\pi^-\pi^0 \end{cases}$$

- MVA classifier against continuum background
- Suppress specific peaking backgrounds
  - Veto around J/ψ and $\psi(2S)$ masses
  - Veto 2-misID $D^0 \to K^+\pi^-$ in $B^+ \to \rho^+ ll$
  - $p_{\pi^0} > 1$ GeV and $p_{\pi^+} > 1$ GeV in $B^+ \to \pi^+ ll$ against 2-photon backgrounds
  - $q^2_{ee} > 0.045$ GeV^2 against photon conversions and π^0 Dalitz decays
- 2D fit on M_{bc} and ΔE to extract signal yields
  - Model remaining peaking background (charmless, $B^+ \to K^+e^+e^-$)



Rare $b \to ll$: results

No signal observed, set 90% CL upper limits

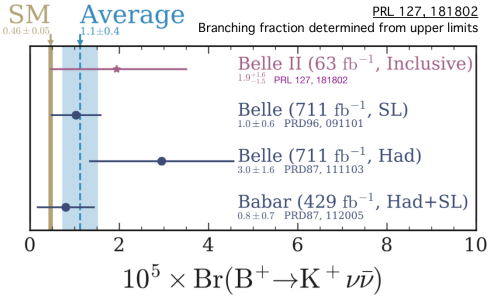
channel	N_{sig}	$N_{\mathrm{sig}}^{\mathrm{UL}}$	ε (%)	$\mathcal{B}^{\mathrm{UL}}$ (10^{-8})	$\mathcal{B}$ (10^{-8})
$B^0 \to \eta e^+e^-$	$0.0^{+1.4}_{-1.0}$	3.1	3.9	< 10.5	$0.0^{+4.9}_{-3.4} \pm 0.1$
$B^0 \to \eta \mu^+\mu^-$	$0.8^{+1.5}_{-1.1}$	4.2	5.9	< 9.4	$1.9^{+3.4}_{-2.5} \pm 0.2$
$B^0 \to \eta \ell^+\ell^-$	$0.5^{+1.0}_{-0.8}$	1.8	4.9	< 4.8	$1.3^{+2.8}_{-2.2} \pm 0.1$
$B^0 \to \omega e^+e^-$	$-0.3^{+3.2}_{-2.5}$	3.7	1.6	< 30.7	$-2.1^{+26.5}_{-20.8} \pm 0.2$
$B^0 \to \omega \mu^+\mu^-$	$1.7^{+2.3}_{-1.6}$	5.5	2.9	< 24.9	$7.7^{+10.8}_{-7.5} \pm 0.6$
$B^0 \to \omega \ell^+\ell^-$	$1.0^{+1.8}_{-1.3}$	3.6	2.2	< 22.0	$6.4^{+10.7}_{-7.8} \pm 0.5$
$B^0 \to \pi^0 e^+e^-$	$-2.9^{+1.8}_{-1.4}$	4.0	6.7	< 7.9	$-5.8^{+3.6}_{-2.8} \pm 0.5$
$B^0 \to \pi^0 \mu^+\mu^-$	$-0.5^{+3.6}_{-2.7}$	6.1	13.7	< 5.9	$-0.4^{+3.5}_{-2.6} \pm 0.1$
$B^0 \to \pi^0 \ell^+\ell^-$	$-1.8^{+1.6}_{-1.1}$	2.9	10.2	< 3.8	$-2.3^{+2.1}_{-1.5} \pm 0.2$
$B^+ \to \pi^+ e^+e^-$	$0.1^{+2.5}_{-1.6}$	5.0	11.5	< 5.4	$0.1^{+2.7}_{-1.8} \pm 0.1$
$B^0 \to \rho^0 e^+e^-$	$5.6^{+3.5}_{-2.7}$	10.8	3.2	< 45.5	$23.6^{+14.6}_{-11.2} \pm 1.1$
$B^+ \to \rho^+ e^+e^-$	$-4.4^{+2.3}_{-2.0}$	5.3	1.4	< 46.7	$-38.2^{+24.5}_{-17.2} \pm 3.4$
$B^+ \to \rho^+ \mu^+\mu^-$	$3.0^{+4.0}_{-3.0}$	8.7	2.9	< 38.1	$13.0^{+17.5}_{-13.3} \pm 1.1$
$B^+ \to \rho^+ \ell^+\ell^-$	$0.4^{+2.3}_{-1.8}$	3.0	2.0	< 18.9	$2.5^{+14.6}_{-11.8} \pm 0.2$

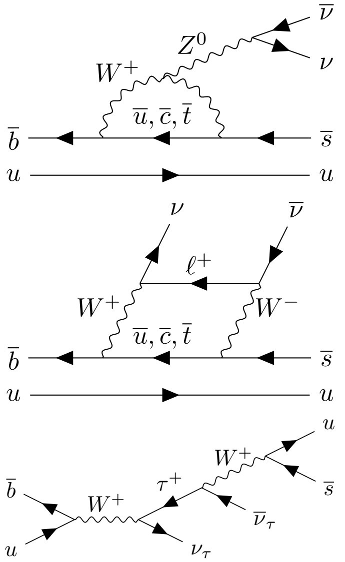
- Obtained upper limits in the range $(3.8 - 47) \times 10^{-8}$
- Best upper limit for all serched decay modes
- $B^0 \to \omega ll$, and $B^{\pm,0} \to \rho^{\pm,0} ll$ searched for the first time

$$B^+ \to K^+ \nu\bar{\nu}$$

[arXiv:2311.14647]

- $B^+ \to K^+\nu\bar{\nu}$ known with high accuracy in the SM
  - Clean SM computation (no charm loop contributions)
  - $\mathcal{B}_{SM} = (5.58 \pm 0.37) \times 10^{-6}$ [Parrott, Bouchard, Davies '23]
  - New physics could increase significantly the rate
  - Possible to recast to look for $B^+ \to K^+ X_{dark}$
- Very challenging experimentally, not yet observed
  - Low $\mathcal{B}$, high background contributions
  - 3-body kinematics, no good variable to fit

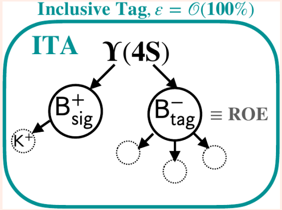




Evidence for $B^+ \to K^+ \nu\bar{\nu}$: analysis strategy [arXiv:2311.14647]

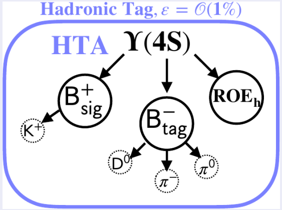
Inclusive tagged analysis (ITA): approach leading to the final sensitivity

- Select first signal kaon that minimises q^2_{rec} (computed as K^+ recoil)
- Two consecutive MVA classifiers
- Total efficiency $\sim$ 8%, purity $\sim$ 0.8%
- Binned fit to q^2_{rec} and output MVA classifier simultaneously for on and off resonance



Hadronically tagged analysis (HTA): Less sensitive but well-established

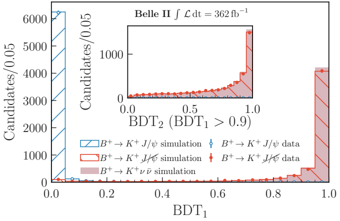
- Select first tag B decaying hadronically
- One MVA classifier to reject background
- Total efficiency $\sim$ 0.4%, purity $\sim$ 3.5%
- Fit output MVA classifier

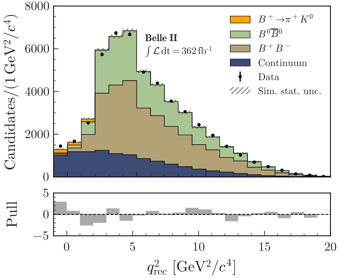


Evidence for $B^+ \to K^+\nu\bar{\nu}$: cross checks

[arXiv:2311.14647]

- Analysis relies on simulation for background suppression and background templates for the fit
  - Simulation is validated via several control channels on data
- Signal validation
  - Total efficiency with $B^+ \to J/\psi K^+$, removing J/ψ and correcting the kaon kinematics to match the signal
  - Kaon ID selection validated with $B^+ \to \overline{D}^0(\to K^+\pi^-)K^+$
- Background validation
  - Off-resonance data to correct for data/MC differences in normalisation and shape
  - Size of $B \to X_c(K_L^0 X)$corrected using pion-enriched sideband
  - Modelling of K_L^0 detection efficiency in the calorimeter corrected using $e^+e^- \to \gamma\phi(\to K_S^0 K_L^0)$
  - Cross check $B^+ \to K^+ K_S^0 K_S^0$ to validate $B^+ \to K^+ K_L^0 K_L^0$
- Closure test measuring $\mathcal{B}(B^+ \to \pi^+ K^0) = (2.5 \pm 0.5) \times 10^{-5}$
  - compatible with PDG $(2.38 \pm 0.08) \times 10^{-5}$



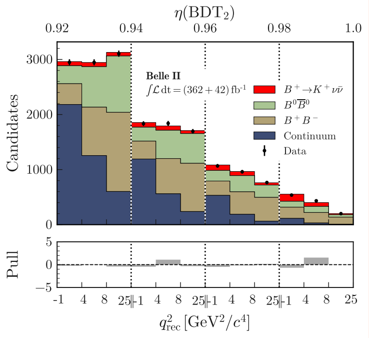


Evidence for $B^+ \to K^+\nu\bar{\nu}$: results

[arXiv:2311.14647]

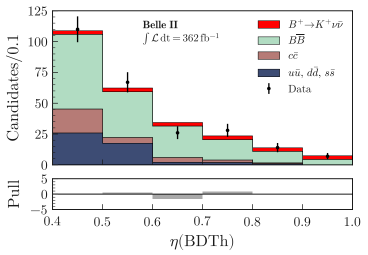
ITA

- $\mathcal{B} = (2.7 \pm 0.5 \pm 0.5) \times 10^{-5}$
- 3.5σ significance
- 2.9σ deviation from SM



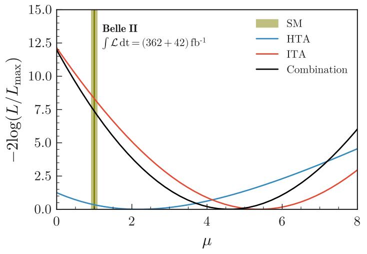
HTA

- $\mathcal{B} = (1.1^{+0.9+0.8}_{-0.8-0.5}) \times 10^{-5}$
- 1.1σ significance
- 0.6σ deviation from SM



Combination

- 1.2σ agreement between ITA and HTA, 2% common events
- $\mathcal{B} = (2.3 \pm 0.5^{+0.5}_{-0.5}) \times 10^{-5}$
- 3.5σ significance
- 2.7σ deviation from SM

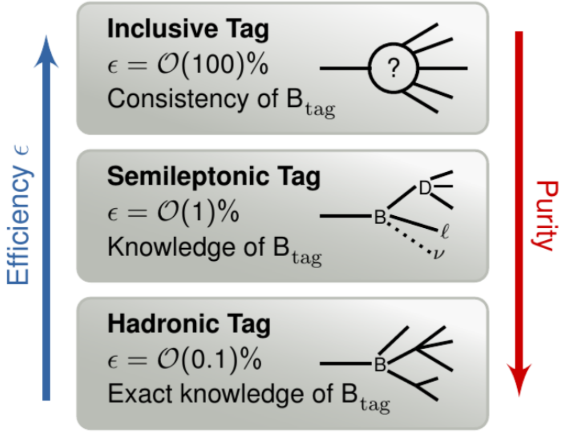


Conclusion

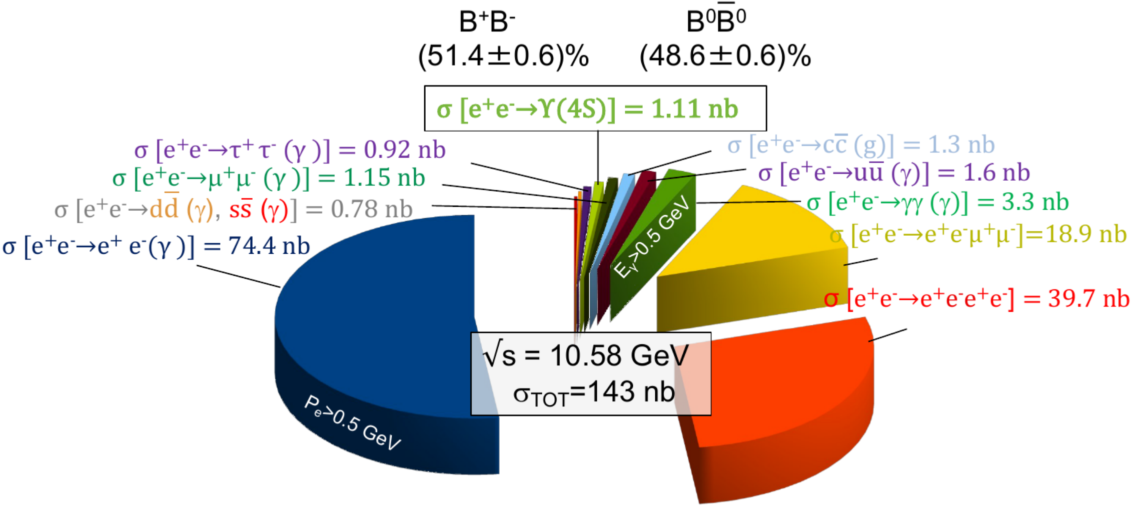
- Electroweak and radiative penguin B decays are promising place to look for New Physics
- Five Belle and Belle II new results since last Moriond
  - New measurements of $\mathcal{B}$, A_{CP} and Δ_{+0} of $B \to K^*\gamma$ with Belle II
  - Best measurements of $\mathcal{B}$, A_{CP} and A_{I} of $B \to \rho\gamma$ with Belle+Belle II
  - Best upper limit on $B^0 \to \gamma\gamma$ with Belle+Belle II
  - Best upper limits on rare $b \to ll$ decays with Belle
  - First evidence of $B^+ \to K^+\nu\bar{\nu}$ with Belle II
- Results statistically limited; Belle II Run 2 data taking just started, stay tuned for updates

BACKUP

Tagging strategies



Cross sections at the $\Upsilon(4S)$



$B \to \rho\gamma$: systematics

Source	$\mathcal{B}_{\rho^+\gamma} \times 10^8$	$\mathcal{B}_{\rho^0\gamma} \times 10^8$	A_{I}	A_{CP}
Reconstruction	4.1	1.3	1.4%	0.5%
Selection	9.0	3.4	4.0%	0.5%
Fixed PDF	1.1	2.7	1.8%	0.2%
Signal shape	4.7	3.0	3.1%	0.5%
Histogram PDF	1.0	0.6	0.5%	0.1%
$K^*\gamma$ yield	3.4	5.4	3.1%	0.1%
$B\overline{B}$ peaking yield	2.2	0.8	0.9%	0.2%
$B\overline{B}$ peaking A_{CP}	0.1	0.0	0.1%	1.0%
Number of $B\overline{B}$'s	1.7	1.4	0.3%	0.1%
Other parameters	4.0	3.6	3.9%	0.0%
Total	12.5	8.6	7.5%	1.4%

$B^0 \to \gamma\gamma$: systematics

TABLE I. Summary of systematic uncertainties on the signal yield.

Source	Belle (events)	Belle II (events)
Fit bias	$+0.16$	$+0.12$
PDF parameterization	${}^{+0.56}_{-0.48}$	${}^{+0.30}_{-0.32}$
Shape Modeling	$+0.06$	$+0.04$
Total (sum in quadrature)	${}^{+0.58}_{-0.48}$	${}^{+0.30}_{-0.32}$

TABLE II. Summary of systematic uncertainties on signal efficiencies.

Source	Belle (%)	Belle II (%)
Photon Detection Efficiency	4.0	2.7
Reconstruction Efficiency (ϵ_{rec})	0.6	0.5
Number of $B\overline{B}$	1.3	1.5
f^{00}	2.5	2.5
C_{BDT} requirement	0.4	0.9
π^0/η veto	0.3	0.4
Timing requirement efficiency	2.8	–
Total (sum in quadrature)	5.7	4.1

Rare $b \to ll$: systematics

source	ηee	$\eta\mu\mu$	ωee	$\omega\mu\mu$	$\pi^0 ee$	$\pi^0\mu\mu$	$\pi^+ ee$	$\rho^0 ee$	$\rho^0\mu\mu$	$\rho^+ ee$	$\rho^+\mu\mu$
μ	—	0.6	—	0.6	—	0.6	—	—	0.6	—	0.6
e	0.8	—	0.8	—	0.8	—	0.8	0.8	—	0.8	—
π^+	1.0	1.0	1.0	1.0	—	—	0.5	1.0	1.0	0.5	0.5
π^0	2.3	2.3	2.3	2.3	2.3	2.3	—	—	—	2.3	2.3
γ	4.0	4.0	—	—	—	—	—	—	—	—	—
BDT	7.1	6.6	7.1	6.6	7.1	6.6	1.4	1.4	0.8	7.1	6.6
MC	0.48	0.37	0.73	0.53	0.34	0.24	0.24	0.53	0.34	0.80	0.54
track	0.7-1.4	0.7-1.4	1.4	1.4	0.7	0.7	1.05	1.4	1.4	1.05	1.05
PDF	0.04	0.04	0.43	0.07	0.10	0.09	0.50	0.20	0.06	0.34	0.32
$f^{+-/00}$	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
$N_{B\bar{B}}$	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Total	9.27	8.87	8.25	7.78	8.06	7.60	3.50	3.72	3.47	8.15	7.68

$B^+ \to K^+\nu\bar{\nu}$