$b \to s\tau\tau$ status and prospects

Beyond the Flavour Anomalies 2026

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$b \to s\tau\tau$ - Theory motivation

- Flavour-changing neutral-current transition probing couplings to 3rd-generation leptons
- In the SM, branching fractions are typically of order 10^{-7}
- New-physics scenarios linked to the $R(D^{(*)})$ anomalies can enhance rates by up to $\mathcal{O}(10^3)$ [JHEP 08, 050 (2021), PRL 120, 181802 (2018)]
- Interplay with $b \to s\nu\bar{\nu}$ through couplings to τ-neutrinos [PLB 848, 138411 (2024)]

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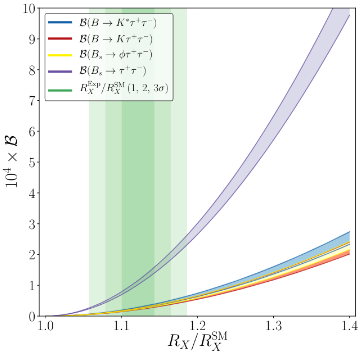
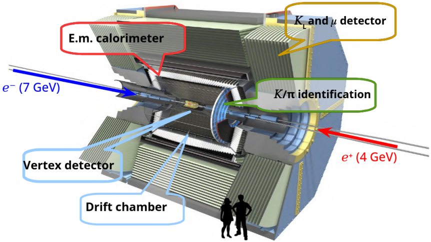


Experimentally difficult: low rates, large backgrounds, and at least two neutrinos from the τ decays.

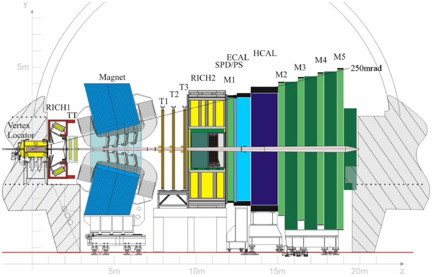
Belle II and LHCb are complementary

Belle II @ SuperKEKB



- Cylindrical spectrometer, covering $\sim 4\pi$ solid angle

LHCb @ LHC



- Single-arm spectrometer, covering pseudorapidity range $2 < \eta < 5$

Belle II and LHCb are complementary

Belle II @ SuperKEKB

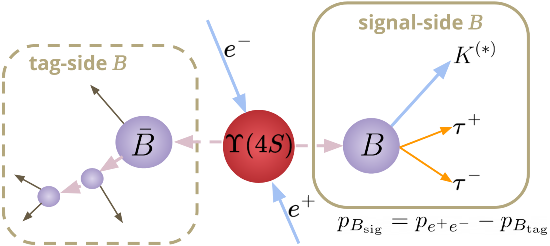
- Clean e^+e^- environment, but smaller $B\bar{B}$ production rate
- Efficient reconstruction of both photons and charged particles.
- Hermetic detector and precise initial-state kinematics. Well suited to final states with missing energy.

LHCb @ LHC

- Huge b-hadron production rate, with correspondingly larger backgrounds
- Excellent tracking, vertexing and muon identification
- Strong for charged final states and displaced-vertex topologies

Belle II is naturally advantaged for modes with several neutrinos; LHCb benefits from the vertex information.

Signal reconstruction at Belle II

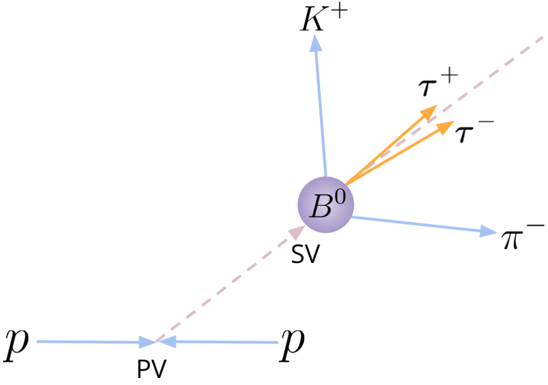


ML algorithm improves the tagging performance with respect to Belle/BaBar [Comput Softw Big Sci 3, 6 (2019)]

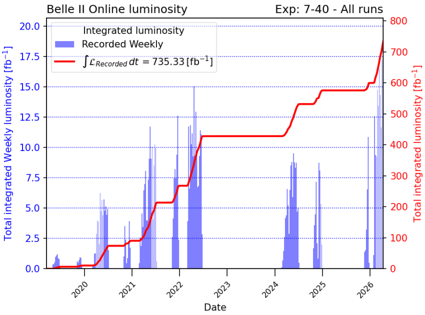
- Reconstruct the companion $B_{\rm tag}$ to constrain the signal-side kinematics, even when $B_{\rm sig}$ decays to neutrinos
- Hadronic tagging used so far for $B \to K^{(*)}\tau\tau$
- Typical hadronic-tag performance at Belle II: $\varepsilon_{\rm tag}(B^0) \sim 0.2\%$, $\varepsilon_{\rm tag}(B^+) \sim 0.3\%$, with purity of order 40%

Signal reconstruction at LHCb

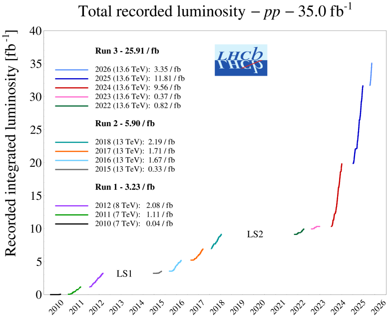
- Exploit the large boost and the displaced secondary vertex
- Infer the B flight direction from the PV–SV line
- Need visible charged tracks and typically a normalization channel



Datasets



Belle II online luminosity plots



LHCb Operations plots

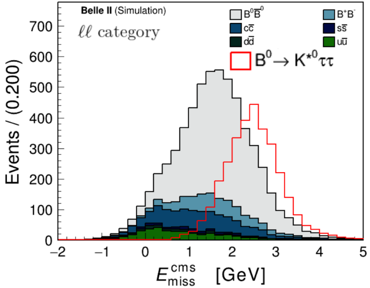
- This talk: $365\,\mathrm{fb}^{-1}$ at the $\Upsilon(4S)$ (Run 1)
- This talk: $5.4\,\mathrm{fb}^{-1}$ (Run 2)

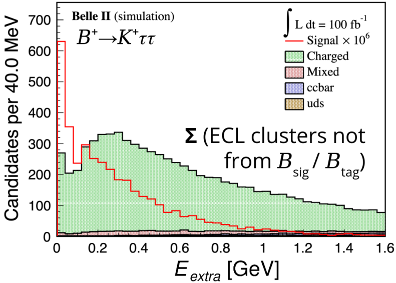
Rule of thumb: $\sim 1\,\mathrm{fb}^{-1}$ at LHCb corresponds to $\sim 1\,\mathrm{ab}^{-1}$ at Belle II

Belle II: $b \to s\tau\tau$ analysis strategy

Three results with hadronic tag: $B^+ \to K^+\tau\tau$, $B^0 \to K^{*0}\tau\tau$, $B^0 \to K^0_S\tau\tau$

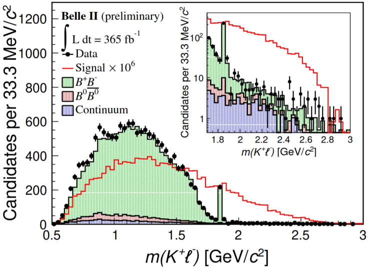
1. Reconstruct $K^{(*)}$ and the two τ candidates on the signal side
   - Leptonic τ modes give the cleanest signature
2. Main background handles: missing energy/momentum, charm vetoes, and extra calorimeter energy (E_{extra})
3. Backgrounds and efficiencies validated with control samples
   - data at $\sqrt{s}$ 60 MeV below $\Upsilon(4S)$ for non-$B\bar{B}$ backgrounds
   - Sidebands for residual $B\bar{B}$ background. Control sample for signal.
4. Signal extracted by counting or by a fit to a classifier output

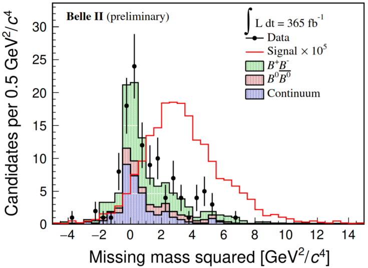




Belle II: $B^+ \to K^+\tau^+\tau^-$

- Previous UL from BaBar: 2.25×10^{-3} @ 90% CL [PRL 118, 031802 (2017)]
- Combine Belle II Run 1 with Belle dataset ($711\,\mathrm{fb}^{-1}$)
- Only $\tau \to \ell\nu\bar{\nu}$ decays are used ($\ell = e, \mu$)
- Cut-based optimisation
  - reject $\simeq 99\%$ of $B\bar{B}$ background requiring $m(K^+\ell^-) > 1.9\,\mathrm{GeV}/c^2$
  - further selection on lepton-momentum and missing-mass, optimised to minimize expected UL

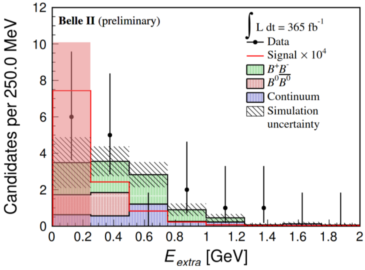




arXiv:2603.24437, submitted to PRL

Belle II: $B^+ \to K^+\tau^+\tau^-$

- Signal extracted by counting in the first bin of E_{extra}
- Backgrounds validated in control regions
  - use sidebands of q^2, M_{bc} and E_{extra} for $B\bar{B}$ background shape
- Statistical uncertainty dominates. Dominant systematic uncertainty: estimated background yield in the signal region from sidebands.



$$\mathcal{B}(B^+ \to K^+\tau\tau) < 5.6 \times 10^{-4} \text{ @ } 90\% \text{ CL}$$

About $\times 4$ better than the previous BaBar limit

Belle II: $B^0 \to K^{(*)0}_{(S)}\tau^+\tau^-$

PRL 135, 151801 (2025)

$B^0 \to K^{*0}\tau\tau$

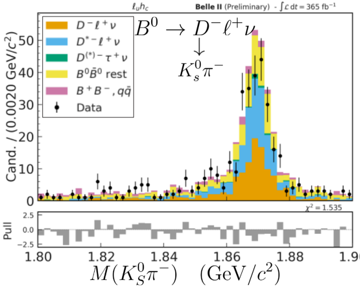
- Previous UL by Belle 3.1×10^{-3} @ 90% CL [PRD 108, L011102 (2023)]
- Belle II Run 1 dataset
- Reconstruct $K^{*0} \to K^+\pi^-$ with $m_{K^+\pi^-} \in (800, 990)\,\mathrm{MeV}/c^2$

$B^0 \to K^0_S\tau\tau$

- No previous searches
- Combine Belle II Run 1 with Belle dataset ($711\,\mathrm{fb}^{-1}$)
- Reconstruct clean $K^0_S \to \pi^+\pi^-$
  - relative K^0_S selection eff. $\simeq 85\%$ with $\simeq 98\%$ purity

Common analysis strategy:

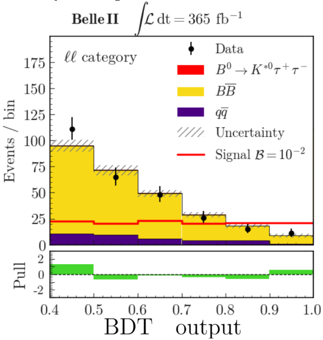
- Both τ decay to 1-prong. Group $\tau\tau$ categories by number of neutrinos
- A BDT combines kinematics, missing energy, charm suppression and E_{extra}
- Several control samples to validate BDT output for signal and backgrounds

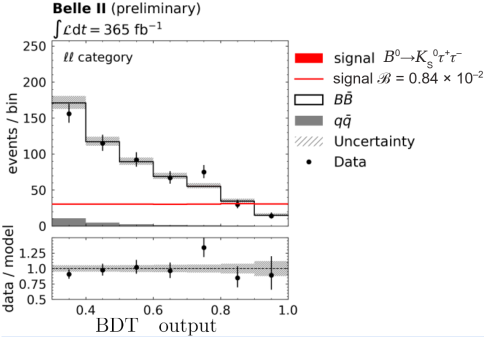


Belle II: $B^0 \to K^{(*)0}_{(S)}\tau^+\tau^-$

PRL 135, 151801 (2025)

- Simultaneous binned fit of the BDT output across the $\tau\tau$ categories
- Results dominated by stat. uncertainty. Dominant systematic from poorly modeled B decays



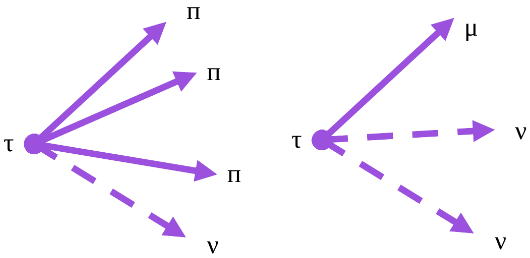


$\mathcal{B}(B^0 \to K^{*0}\tau\tau) <$ 1.8×10^{-3} @ 90% CL. Significant improvement over Belle despite $\sim$half the data size.

$\mathcal{B}(B^0 \to K^0_S\tau\tau) <$ 0.84×10^{-3} @ 90% CL (Belle + Belle II). First search for this channel. To be submitted soon.

LHCb results

- Two types of end-states investigated by LHCb so far
  - $B_s^0 \to \tau^+\tau^-$, with $\tau^+ \to \pi^+\pi^+\pi^-(\pi^0)\bar{\nu}_\tau$
  - $B_{(s)}^0 \to h_1^+ h_2^- \tau^+\tau^-$, with $\tau^+ \to \mu^+\nu_\mu\bar{\nu}_\tau$



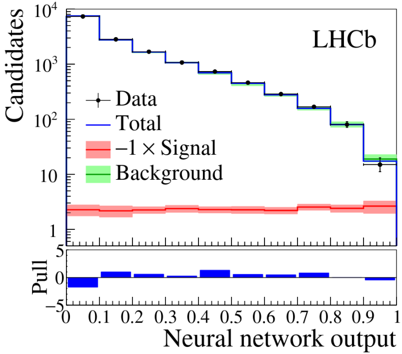
3-prong tau decays allow to reconstruct the tau decay vertex, but are associated with much more background.

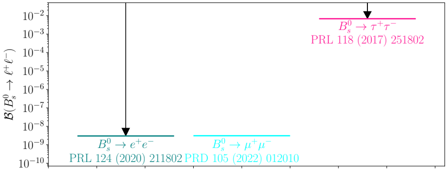
LHCb: $B_s^0 \to \tau^+\tau^-$

PRL 118 (2017) 251802

- Using 3-prong tau decays, leading to two missing neutrinos $\Rightarrow$ isolation is important
- Using neural network to separate (simulated) signal from (data-derived) background – final fit is on neural network output

$$\mathcal{B}(B_s^0 \to \tau^+\tau^-) < 6.8\,(5.2) \times 10^{-3} \text{ @ } 95\% \ (90\%) \text{ CL} \qquad (1)$$





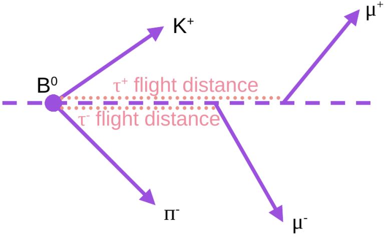
Analysis carried out with Run 1 LHCb data (3 fb^{-1}) $\Rightarrow$ improvements in sensitivity expected only by using Runs 2 and 3!

LHCb: $B^0_{(s)} \to h_1^+ h_2^- \tau^+ \tau^-$

- LHCb Run 2 (2016-2018) analysis searching for $B^0 \to K^+\pi^-\tau^+\tau^-$ and $B_s^0 \to K^+K^-\tau^+\tau^-$, separating dihadron mass the spectrum in bins to account for regions dominated by resonances
- Small amount of the τ branching fraction covered, as only $\tau \to \mu\nu\nu$ decays used in the analysis
  - Tau end-vertex cannot be reconstructed, but B-meson end-vertex is reconstructed from vertex formed by two hadrons

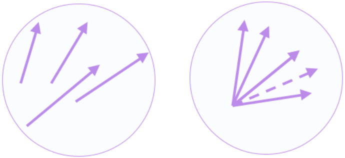
Table: Dihadron mass bins for the $K^+\pi^-$ and K^+K^- final states.

Mass range (MeV)	
$792 < m_{K^+\pi^-} < 992$	$980 < m_{K^+K^-} < 1060$
$992 < m_{K^+\pi^-} < 1330$	$1060 < m_{K^+K^-} < 1200$
$1330 < m_{K^+\pi^-} < 1530$	$1200 < m_{K^+K^-} < 1400$
$1530 < m_{K^+\pi^-} < 1726$	$1400 < m_{K^+K^-} < 1600$
–	$1600 < m_{K^+\pi^-} < 1813$



LHCb: $B^0_{(s)} \to h_1^+ h_2^- \tau^+\tau^-$ – main background types

- $B \to DDX$ (where $X \to h_1^+ h_2^-$) – reduced with cuts on reconstructed $m^2_{\tau\tau}$ and squared missing mass
  - Most signal-like background: D-meson flies and can decay to μ and invisibles (K^0, neutrinos, etc.)
- Combinatorial and semileptonic backgrounds – reduced with multi-class BDT
  - Isolation features and estimated flight distance of the tau candidate useful in separating signal from background

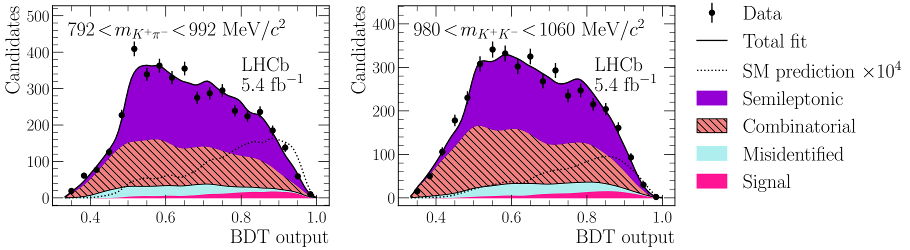


- Misidentified backgrounds – reduced with PID cuts
  - Remaining misidentified background represented in final fit with data-driven technique

LHCb: $B^0_{(s)} \to h_1^+ h_2^- \tau^+\tau^-$

- In total, 4 missing neutrinos $\Rightarrow$ not fitting the reconstructed mass. Instead, fitting the BDT output
  - Unbinned fit with templates represented with kernel density estimations
  - Uncertainty on data-derived background shape dominant systematic
- Upper limits are obtained in bins of dihadron mass and recast as limits on resonances, Wilson coefficients and $\mathcal{B}(B^0_s \to K^-\pi^+\tau^+\tau^-)$

$$\begin{aligned}\mathcal{B}(B^0 \to K^{*0}\tau^+\tau^-) &< 2.8\,(2.5)\times 10^{-4} \text{ @ } 95\% \text{ } (90\%) \text{ CL} \\ \mathcal{B}(B^0_s \to \phi\tau^+\tau^-) &< 4.7\,(4.1)\times 10^{-4} \text{ @ } 95\% \text{ } (90\%) \text{ CL}\end{aligned} \tag{2}$$



$b \to s\tau\tau$: status

- Searches are starting to get close to branching fractions predicted by new physics models
- Sensitivities on the order of 10^{-5} would be required to reject models

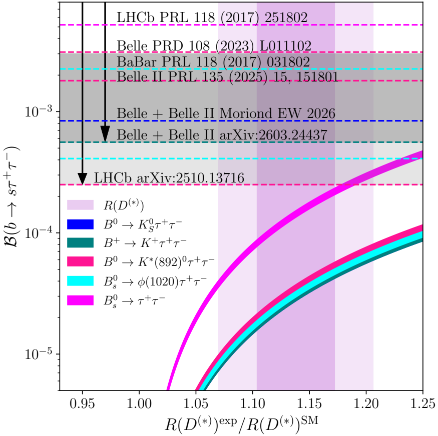


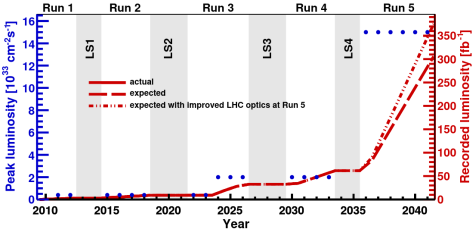
Figure: NP predictions from PRL 120 (2018) 181802, using latest results from HFLAV, with Belle, Belle II and LHCb limits overlaid.

$b \to s\tau\tau$ prospects

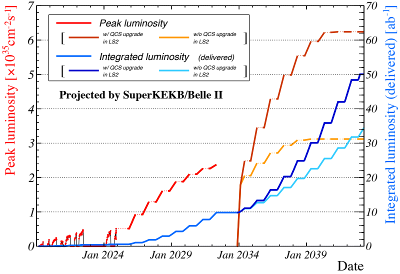
- Ways to improve the sensitivity
  - Increase the amount of data collected
  - Increase the number of decay modes considered
  - Update techniques to make searches more performant

Increase in statistics

- Belle II results dominated by statistical uncertainty
- Largest LHCb systematic uncertainty depends on data-derived background shapes



LHCB-TDR-026



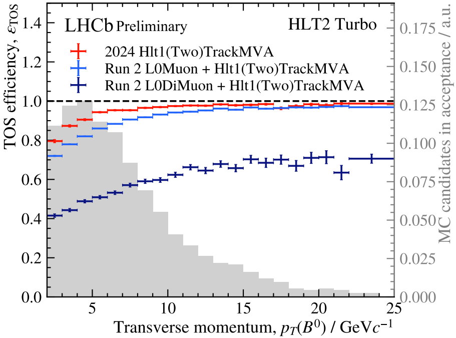
Belle II luminosity projection plot

Assuming similar detectors and techniques, increases by a factor of nearly 5 for LHCb Run 3 and a factor of 2 for Belle II in the same time period. Much larger increases in the 2030s.

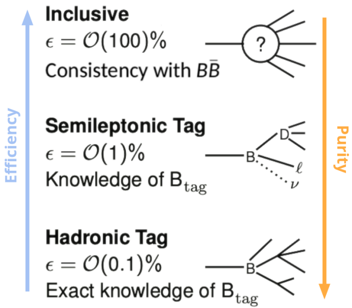
Data collection and tagging

- New fully software LHCb trigger in Run 3 with 40 MHz readout
  - Exclusive triggers allow for better fine-tuning to specific processes
  - Particles with lower $p_{(\mathrm{T})}$ can be selected much more effectively
- B-factories have so far used hadronic tagging: low efficiency but high purity
  - Additional tagging modes could increase efficiency (but lower purity)

LHCB-FIGURE-2024-030



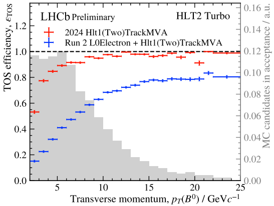
Efficiencies for $B^0 \to J/\psi(\to \mu^+\mu^-)K^{*0}$ as a function of $p_{\mathrm{T}}(B^0)$ for Run 2 triggers and Run 3



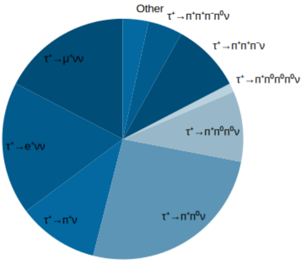
More tau decay modes

- $\sim 70\%$ and $\sim 35\%$ of tau decay modes covered by Belle and Belle II for $B^0 \to K^{(*)0}_{(S)}\tau^+\tau^-$ and $B^+ \to K^+\tau^+\tau^-$ respectively
  - Two tau decays: $\sim 50\%$ and $\sim 12\%$ of signal covered
- Around 17% of decay modes covered by LHCb Run 2 analysis
  - Two tau decays: $\sim 3\%$ of signal covered

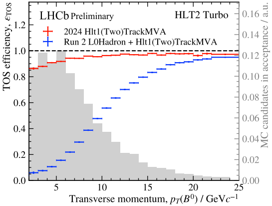
$B^0 \to J/\psi(\to e^+e^-)K^{*0}$



LHCB-FIGURE-2024-030



$B^0 \to D^-(\to K^+\pi^-\pi^-)\pi^+$



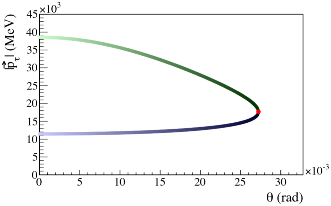
LHCB-FIGURE-2024-030

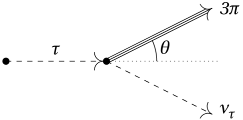
Despite larger backgrounds, expected increase in sensitivity by increasing the number of tau modes considered.

Additional improvements

- Possibility to reconstruct tau momentum from $\tau \to 3\pi$ with two-fold ambiguity (external constraints can reduce this ambiguity further)
  - Improved tracking in LHCb Run 3 $\Rightarrow$ improvements to this method

CERN-THESIS-2012-321





- Belle II: signal-background separation could be further improved by combining kinematic and vertex-related observable
- Multi-dimensional fits to additional features in LHCb could improve the overall sensitivity
- Belle II simulation
  - Run-dependent $\Rightarrow$ more reliable and feature dependent on beam background can be added with less systematic uncertainty
  - More data $\Rightarrow$ improvements in auxiliary background measurements

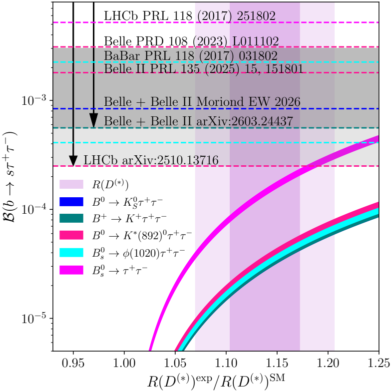
Additional modes

- Next potential step for Belle II: include additional exclusive channels, such as $B^+ \to K^{*+}\tau^+\tau^-$
  - In addition, possibly more inclusive approach exploiting the tag-side constraint
- LHCb has so far focused on a small amount of available end-states
  - End-states with 2 hadrons shown to work well, and less background expected in $\Lambda_b \to p^+K^-\tau^+\tau^-$
  - Work in CERN-THESIS-2012-321 indicates single solution for $B^+ \to K^+\tau^+\tau^-$ with 3-prong tau decay
    - Could alternatively try fully one-prong tau decay modes to estimate effect of loss of information from the b-hadron end-vertex

Investigating additional modes can help us determine where to look next.

Conclusion

- Recent results from Belle + Belle II and LHCb in the $\mathcal{O}(10^{-4})$ realm, but need to push further to reach $\mathcal{O}(10^{-6})$ – $\mathcal{O}(10^{-5})$, where new physics might lie
- A combination of upgraded detectors, larger data sets and updated techniques is likely to lead to at least an order of magnitude improvement compared to existing results



Backup

LHCb limits on $b \to s\tau\tau$ and Wilson coefficients

Table: Upper limits on $\mathcal{B}(b \to s\tau^+\tau^-)$ in bins of dihadron mass.

CL	Upper limit on $\mathcal{B}(B^0 \to K^+\pi^-\tau^+\tau^-)$				
$m_{K^+\pi^-}$ (MeV)	[792, 992]	[992, 1330]	[1330, 1530]	[1530, 1726]	
90%	1.4×10^{-4}	2.7×10^{-5}	1.0×10^{-5}	2.7×10^{-6}	
95%	1.6×10^{-4}	3.4×10^{-5}	1.1×10^{-5}	3.3×10^{-6}	
CL	Upper limit on $\mathcal{B}(B_s^0 \to K^+K^-\tau^+\tau^-)$				
$m_{K^+K^-}$ (MeV)	[980, 1060]	[1060, 1200]	[1200, 1400]	[1400, 1600]	[1600, 1813]
90%	2.0×10^{-4}	1.3×10^{-4}	1.2×10^{-4}	6.8×10^{-5}	3.2×10^{-5}
95%	2.3×10^{-4}	1.5×10^{-4}	1.4×10^{-4}	7.6×10^{-5}	3.6×10^{-5}

Table: Upper limit on Δ^2 at 90% and 95% CL, assuming $\mathcal{C}_{9(10)}^{\mathrm{NP}} = \mathcal{C}_{9(10)}^{\mathrm{SM}} \mp \Delta$ (see PRL 120 (2018) 181802).

CL	$B^0 \to K^+\pi^-\tau^+\tau^-$	$B_s^0 \to K^+K^-\tau^+\tau^-$
90%	2.5×10^4	4.5×10^4
95%	2.9×10^4	5.2×10^4

LHCb $b \to s\tau\tau$: central values

Table: Central values for $\mathcal{B}(B^0 \to K^+\pi^-\tau^+\tau^-)$ and $\mathcal{B}(B_s^0 \to K^+K^-\tau^+\tau^-)$ decays. The first uncertainties are statistical, the second ones are systematic.

Central value for $\mathcal{B}(B^0 \to K^+\pi^-\tau^+\tau^-)$					
$m_{K^+\pi^-}$ (MeV)	[792, 992]	[992, 1330]	[1330, 1530]	[1530, 1726]	
	$(9.3 \pm 3.7 \pm 3.6) \times 10^{-5}$	$(-1.9^{+1.6}_{-1.5} \pm 2.4) \times 10^{-5}$	$(2.5^{+3.2}_{-3.1} \pm 4.7) \times 10^{-6}$	$(-1.2 \pm 1.1 \pm 1.9) \times 10^{-6}$	
Central value for $\mathcal{B}(B_s^0 \to K^+K^-\tau^+\tau^-)$					
$m_{K^+K^-}$ (MeV)	[980, 1060]	[1060, 1200]	[1200, 1400]	[1400, 1600]	[1600, 1813]
	$(1.1 \pm 0.5 \pm 0.8) \times 10^{-4}$	$(-3.4^{+5.4}_{-5.3} \pm 8.5) \times 10^{-5}$	$(5.3^{+3.3}_{-3.2} \pm 5.7) \times 10^{-5}$	$(4.6 \pm 1.3 \pm 1.9) \times 10^{-5}$	$(2.4 \pm 0.5 \pm 0.9) \times 10^{-5}$

LHCb $b \to s\tau\tau$: systematic uncertainties

Table: Sources of systematic uncertainty for the branching fractions of $b \to s\tau^+\tau^-$ decays, given as a percentage of the statistical uncertainty.

Systematic uncertainty for $\mathcal{B}(B^0 \to K^+\pi^-\tau^+\tau^-)$					
$m_{K^+\pi^-}$ (MeV)	[792, 992]	[992, 1330]	[1330, 1530]	[1530, 1726]	
Combinatorial shape	74%	128%	125%	124%	
Misidentified shape	39%	85%	78%	116%	
Semileptonic shape	45%	42%	28%	19%	
Signal shape	15%	12%	9%	11%	
Reweighting	21%	11%	6%	4%	
Known quantities	11%	5%	5%	4%	
Efficiency	11%	4%	5%	4%	
Systematic uncertainty for $\mathcal{B}(B_s^0 \to K^+K^-\tau^+\tau^-)$					
$m_{K^+K^-}$ (MeV)	[980, 1060]	[1060, 1200]	[1200, 1400]	[1400, 1600]	[1600, 1813]
Combinatorial shape	111%	140%	160%	141%	175%
Misidentified shape	44%	33%	40%	44%	35%
Semileptonic shape	69%	64%	53%	33%	17%
Signal shape	25%	13%	11%	10%	19%
Reweighting	15%	16%	14%	11%	12%
Known quantities	11%	5%	9%	18%	25%
Efficiency	9%	4%	8%	15%	21%

Belle II $B^+ \to K^+\tau^+\tau^-$

arXiv:2603.24437, submitted to PRL

	Belle	Belle II
$N_{\rm bkg}$	$14.1 \pm 1.6 \pm 1.9$	$3.5 \pm 0.7 \pm 0.9$
$N_{\rm obs}$	11	6
$\epsilon \times 10^5$	$1.45 \pm 0.05 \pm 0.18$	$1.26 \pm 0.04 \pm 0.18$
$\mathcal{B}(B^+ \to K^+\tau^+\tau^-) \times 10^4$	$-2.7^{+3.2}_{-2.6} \pm 2.2$	$5.1^{+5.6}_{-4.3} \pm 2.5$
Obs. (exp.) limit (10^{-3})	0.5 (0.7)	1.4 (0.9)

Figure: Expected background yields, observed event yields, signal efficiencies, observed branching fractions, and observed (expected) 90% CL exclusion limits.

Sources	Impact on BF (Belle)	Impact on BF (Belle II)
Expected bkg yield	±2.5 events	±1.2 events
FEI scale factor	10.1%	12.6%
Simulated sample size	3.3%	3.5%
PID correction	1.0%	1.6%
pi0 veto	1.9%	2.9%
Tracking efficiency	1.1%	0.8%
Signal decay model	3.5%	4.3%
f+-	$^{+1.4}_{-2.1}$ %	$^{+1.4}_{-2.1}$ %
Number of BBbar pairs	1.4%	1.6%

Figure: Systematic uncertainties breakdown.

Belle II: $B^0 \to K_S^0 \tau^+ \tau^-$

To be submitted

	Belle					Belle II				
	$\ell\ell$	$\ell_C h_U$	$\ell_U h_C$	$\rho\ell$	no-ℓ	$\ell\ell$	$\ell_C h_U$	$\ell_U h_C$	$\rho\ell$	no-ℓ
N_{bg}	442	1459	2109	632	16186	618	1147	1317	925	6745
$\varepsilon^{\text{sig}}(10^{-5})$	3.4	8.0	8.2	3.1	28.2	6.8	10.8	10.4	7.4	30.3
N^{sig}	25 ± 196					50 ± 151				
$\mathcal{B}(B^0 \to K_S^0 \tau^+ \tau^-)$	$(0.07 \pm 0.41 \pm 0.31) \times 10^{-3}$					$(0.20 \pm 0.50 \pm 0.36) \times 10^{-3}$				
$\mathcal{B}_{\text{UL}}(B^0 \to K_S^0 \tau^+ \tau^-)$	$< 0.94 \times 10^{-3}$					$< 1.19 \times 10^{-3}$				

Figure: Expected background yields, observed event yields, signal efficiencies, observed branching fractions, and observed (expected) 90% CL exclusion limits.

Source	**Uncertainty type, parameters**	$\sigma_{\mathcal{B}}(\mathbf{10^{-3}})$
MC statistics	Uncorrelated shape, 140	0.18
Leading B-decay branching fractions	Correlated shape, 30	0.11
B-tagging efficiency	Correlated shape, 2	0.06
Combinatorial B^0_{tag} normalization	Correlated shape, 10	0.05
$D \to K_L^0$ modeling	Correlated shape, 2	0.05
Lepton ID	Correlated shape, 6	0.03
Signal efficiency uncertainty	Normalization, 2	0.03
f_{00}	Correlated shape, 1	0.02
π^0 efficiency	Correlated shape, 2	0.02
$q\bar{q}$ normalization	Normalization, 4	0.02
Signal model	Correlated shape, 1	0.02
K_S^0 efficiency	Correlated shape, 2	<0.01
Number of $\Upsilon(4S)$	Normalization, 2	<0.01
Luminosity uncertainty	Normalization, 2	<0.01
Tracking efficiency	Correlated Shape, 2	<0.01
Leading τ-decay branching fractions	Correlated shape, 10	<0.01
χ_d	Correlated shape, 1	<0.01
Total		**0.23**

Figure: Systematic uncertainties breakdown.

Belle II: $B^0 \to K^{*0}\tau^+\tau^-$

PRL 135, 151801 (2025)

- $\mathcal{B}(B^0 \to K^{*0}\tau^+\tau^-) = [-0.15 \pm 0.86(\text{stat}) \pm 0.52(\text{syst})] \times 10^{-3}$
- $\mathcal{B}(B^0 \to K^{*0}\tau^+\tau^-) < 1.8\,(1.7) \times 10^{-3}\,(\text{exp})$ @90% CL

Signal category	$\varepsilon \times 10^5$	$B\overline{B}$	$q\bar{q}$
$\ell\ell$	4.0 ± 0.6	275	39
$\pi\ell$	7.6 ± 1.1	1058	230
ρ	15.5 ± 2.2	3279	845
$\pi\pi$	4.0 ± 0.6	1077	424

Figure: Signal efficiencies and expected background yields.

Source	Impact on $\mathcal{B} \times 10^{-3}$
$B \to D^{**}\ell/\tau\nu$ branching fractions	0.29
Simulated sample size	0.27
$q\bar{q}$ normalization	0.18
ROE cluster multiplicity	0.17
π and K ID	0.14
B decay branching fraction	0.11
Combinatorial $B\overline{B}$ normalization	0.09
Signal and peaking $B^0\overline{B}^0$ normalization	0.07
Lepton ID	0.04
π^0 efficiency	0.03
f_{00}	0.01
$N_{\Upsilon(4S)}$	0.01
$D \to K_L^0$ decays	0.01
Signal form factors	0.01
Luminosity	< 0.01
Total systematics	0.52
Statistics	0.86

Figure: Systematic uncertainties breakdown.