LEPTON FLAVOR VIOLATING B-DECAYS AT LHCb AND B-FACTORIES

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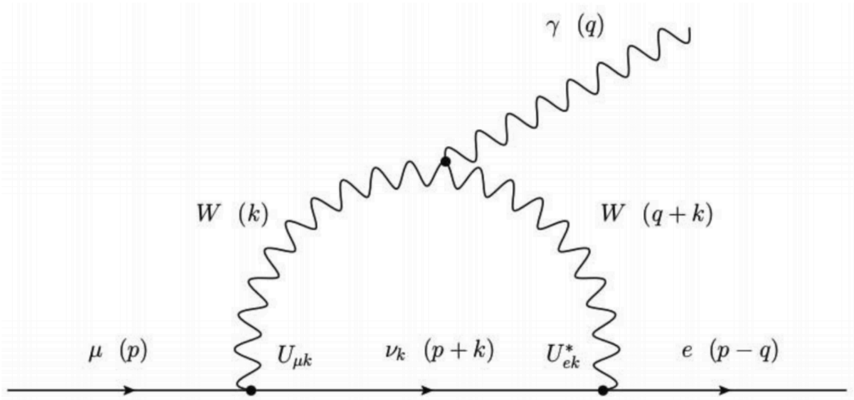
LEPTON FLAVOR VIOLATION

- Lepton flavour violation occurs in the Standard Model at very low rate, through neutrino oscillations (Br < 10^{-40})

  => **charged LFV decays in the SM have rates of the order of 10^{-54} !**



$$\mathcal{B}(\mu \to e\gamma) \simeq \frac{3\alpha}{32\pi} \left| \sum_{k=1,3} \frac{U_{\mu k} U^*_{ek} m^2_{\nu_k}}{M^2_W} \right|^2 \simeq 10^{-55} - 10^{-54}$$

- **A natural consequence of LFUV models is LFV in *B* decays:**

$$\mathcal{B}(B \to K \mu^{\pm} e^{\mp}) \sim 3 \cdot 10^{-8} \left(\frac{1 - R_K}{0.23} \right)^2, \; \mathcal{B}(B \to K (e^{\pm}, \mu^{\pm}) \tau^{\mp}) \sim 2 \cdot 10^{-8} \left(\frac{1 - R_K}{0.23} \right)^2,$$

$$\frac{\mathcal{B}(B_s \to \mu^+ e^-)}{\mathcal{B}(B_s \to \mu^+ \mu^-)_{\rm SM}} \sim 0.01 \left(\frac{1 - R_K}{0.23} \right)^2, \quad \frac{\mathcal{B}(B_s \to \tau^+ (e^-, \mu^-))}{\mathcal{B}(B_s \to \mu^+ \mu^-)_{\rm SM}} \sim 4 \left(\frac{1 - R_K}{0.23} \right)^2.$$

[Hiller, Loose, Schönwald (2016)]

Observation of a charged LFV decay would be a striking sign of new physics!

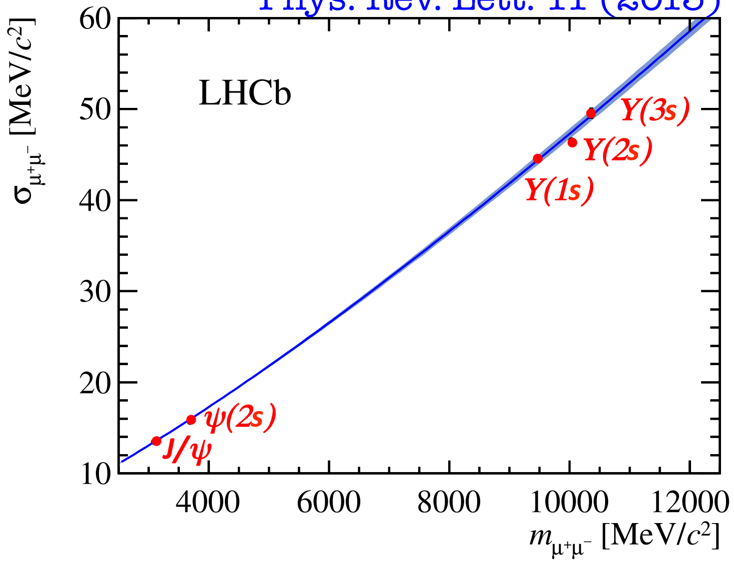
CHALLENGES

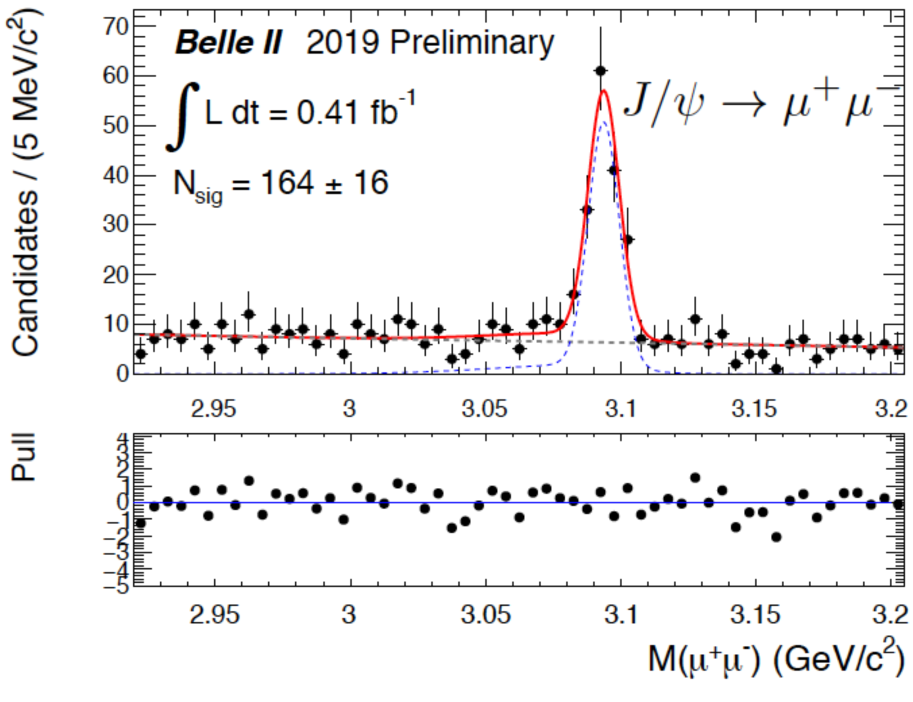
- Extremely rare decays: need **large samples** of *B* mesons.
- Need to reconstruct **two leptons of different flavors**.
  Electrons and taus are more difficult than muons.
- **Backgrounds**, for ex: double-semileptonic B and D decays;
  charmonium decays with mis-identification.
- Phase space is used to **model the signal**: need to provide information to interpret results in different models.

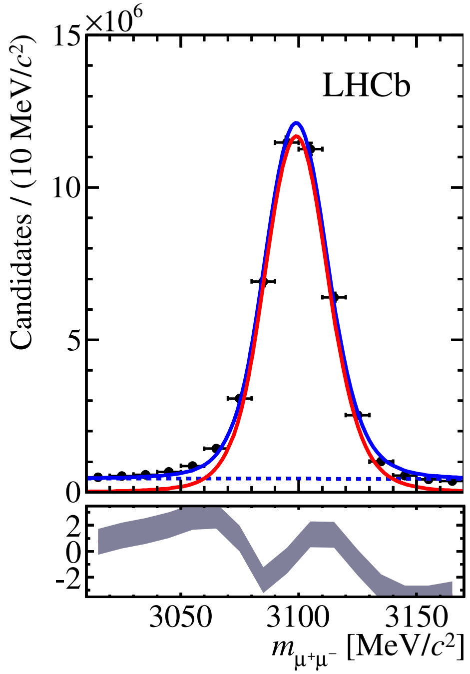
MUONS

- **Extremely performant in all experiments**, thanks to dedicated muon chambers.
- **Very good di-muon resolution.**
- **A muon is a clear trigger signature for LHCb**:
  ε(L0+HLT)= ~90% for di-muon channels
  ε(L0+HLT)= ~30% for multibody hadronic states

Phys. Rev. Lett. 11 (2013)







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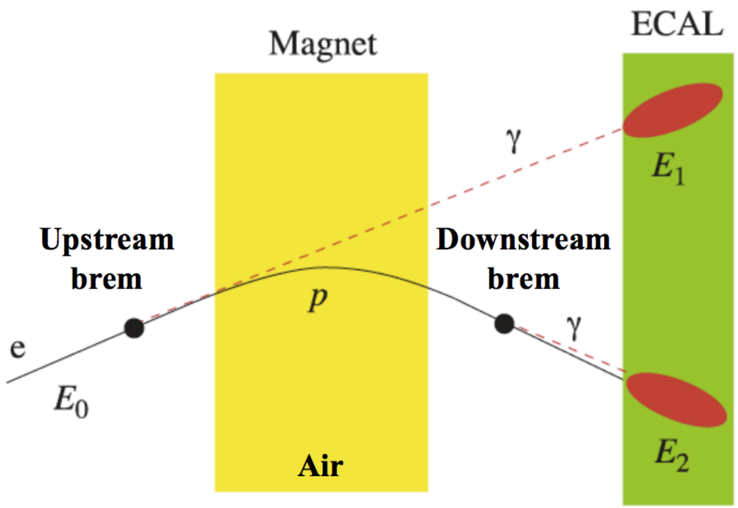
ELECTRONS @ LHCb

- Identified through the electromagnetic calorimeter, subject to high occupancy.

- High energy loss from **bremsstrahlung**.
  Brem photon **recovery** can not be 100% efficient due to the high occupancy:
  - **degradation of the *B* mass resolution**
  - **large partially reconstructed backgrounds**
  - **bin migration effects**

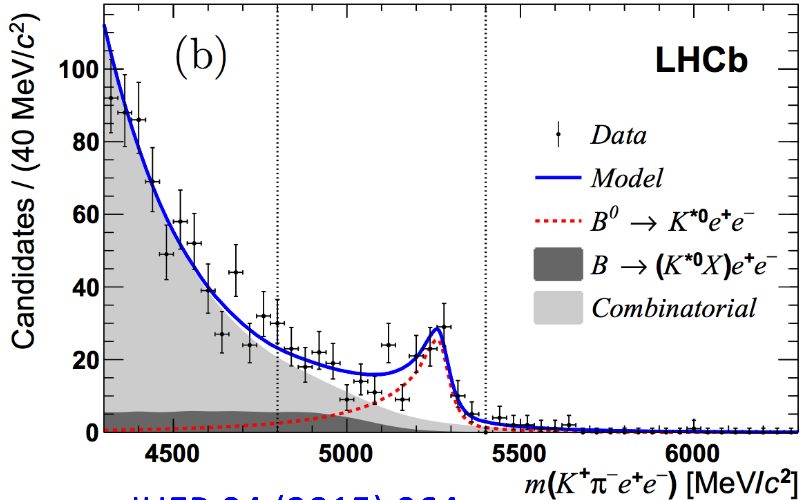
  Solution: use exclusive brem categories, accounting for different resolutions and purities.



- Has to apply **hardware trigger thresholds on electron E_T higher than on muon p_T**

  Solution: use hadron and independent-of-signal triggers, analized in different categories.

$0.002 < q^2 < 1.120\ GeV^2/c^4$



JHEP 04 (2015) 064

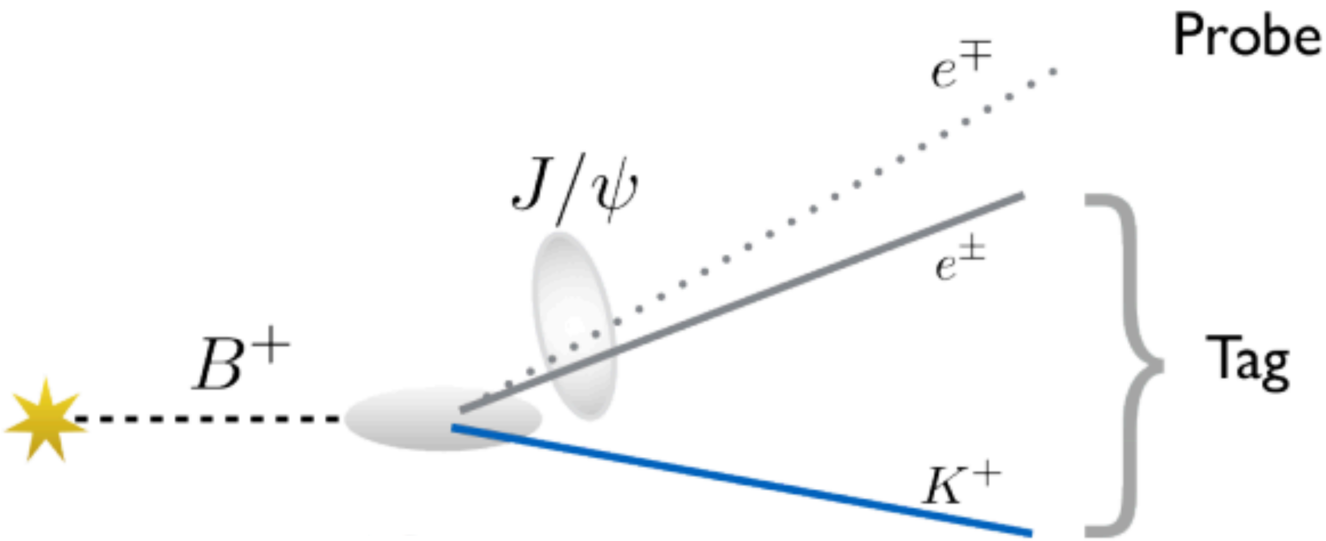
CONSOLIDATING MASTERY OF ELECTRONS @ LHCb

LHCB DP 2019 003 001 (to appear soon)

Bremsstrahlung decreases electron reconstruction efficiency downstream of the VELO.

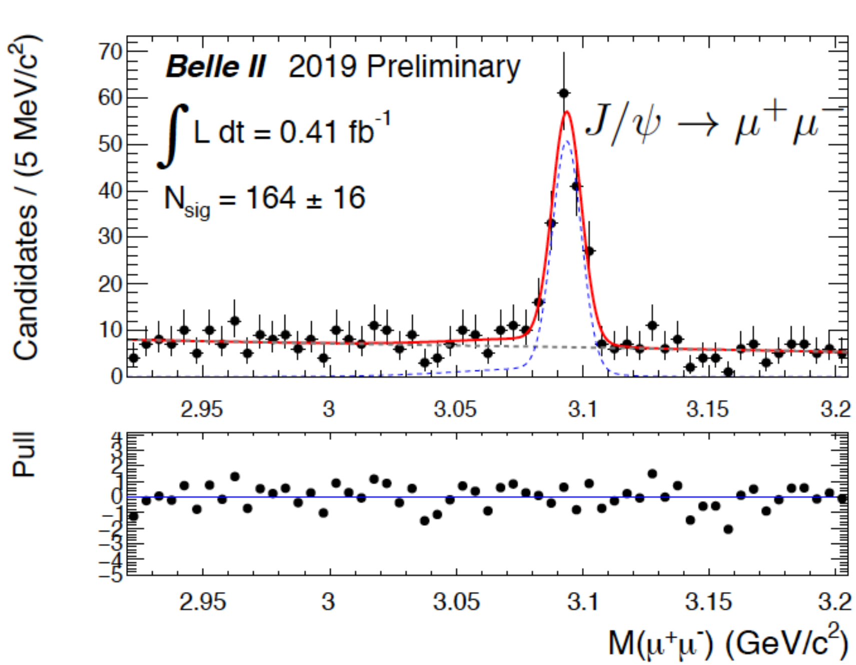
A **new data driven method for measuring electron reconstruction efficiency** has been developed, using kinematically constrained VELO tracks from $B^+ \to J/\psi\,(ee)\,K^+$:

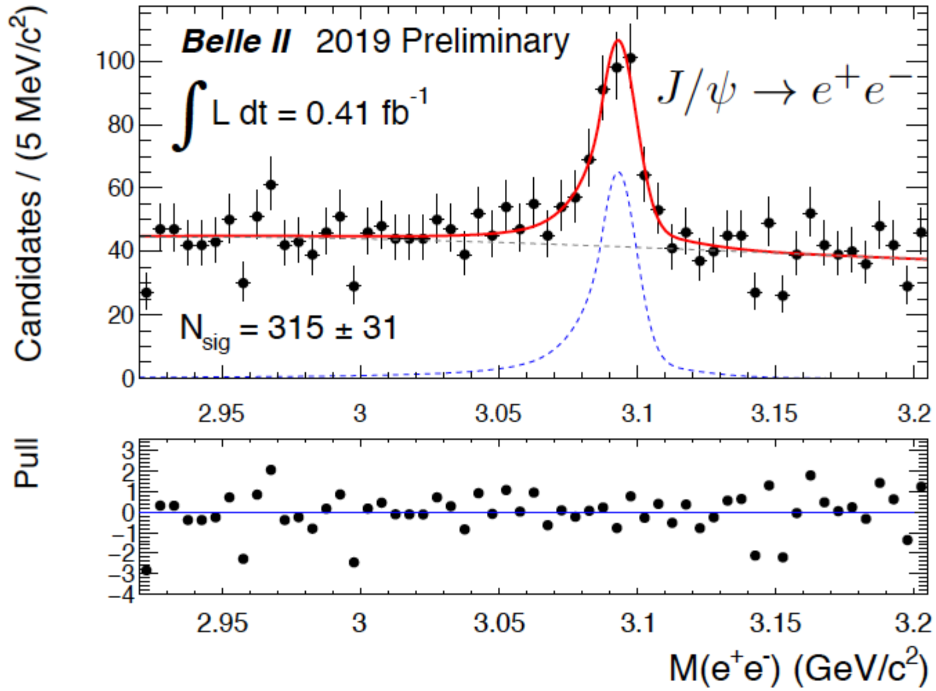
- direction inferred from VELO segment;
- probe momentum inferred from J/ψ mass constraint;
- B mass with J/ψ mass constraint used to extract signal.



ELECTRONS @ B-factories

- Bremsstrahlung is present, but the effect is less prominent: **similar resolution and efficiencies as muons**!





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TAUS

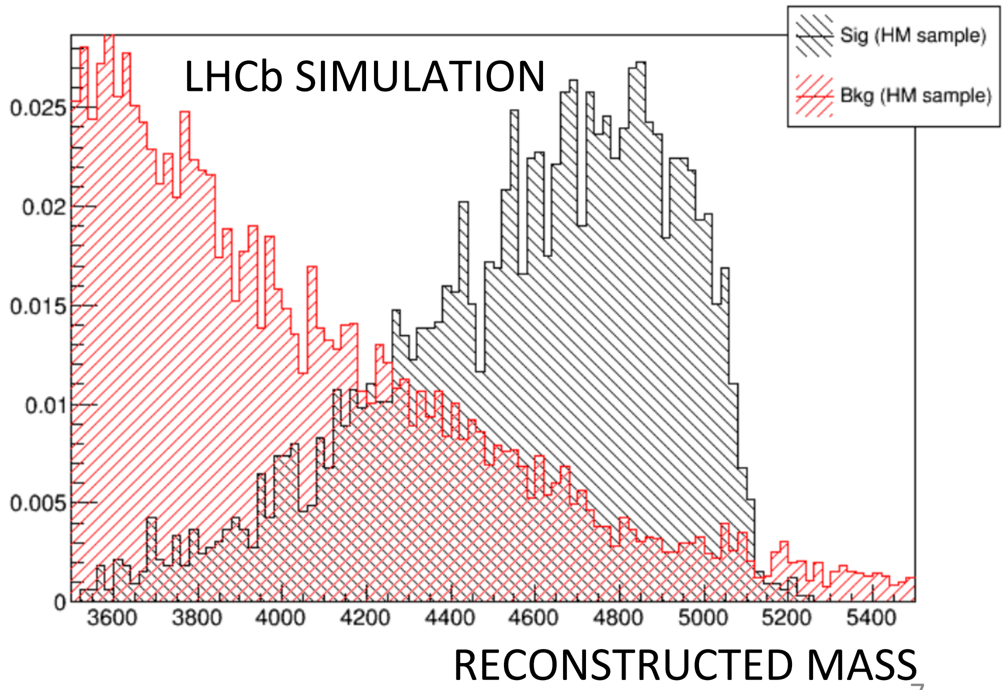
- Taus are **reconstructed through their decays**.
- Accompanied by neutrinos: **missing energy** and degradation of the *B* mass resolution
- Tau **decay vertex not always identified**
- ***Solutions:***
  - Reconstruction techniques exploiting the kinematics;
  - B_{tag} technique in B-factories.

Leptonic:

- $BR(\tau^- \rightarrow \mu^- \nu\nu) = 17.41 \pm 0.04$ %
- $BR(\tau^- \rightarrow e^- \nu\nu) = 17.83 \pm 0.04$ %

Hadronic:

- $BR(\tau^- \rightarrow \pi^- \nu) = 10.83 \pm 0.06$ %
- $BR(\tau^- \rightarrow \pi^- \pi^0 \nu) = 25.52 \pm 0.09$ %
- $BR(\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu) = 9.30 \pm 0.11$ %
- $BR(\tau^- \rightarrow \pi^- \pi^+ \pi^- \nu) = 9.31 \pm 0.06$ %
- $BR(\tau^- \rightarrow \pi^- \pi^+ \pi^- \pi^0 \nu) = 4.62 \pm 0.06$ %



SELECTED SEARCHES

- $B_d \rightarrow K^*(892)^0 \, e \, \mu$ — *PR D98 071101* ***(2018)***
- $B_u \rightarrow K^+ \, e \, \mu$ — arXiv:1909.01010 **(2019)**
- $B_{d,s} \rightarrow e \, \mu$ — *JHEP 1803* ***(2018)*** *078*
- $B_{d,s} \rightarrow \tau \, \mu$ — *arXiv:1905.06614* ***(2019)***
- $B^+ \rightarrow h^+ \, \tau \, l \quad (h = K, \pi \, ; \, l = e, \mu)$ — *PR D86 012004* ***(2012)***

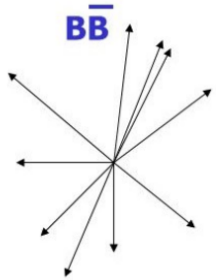
$B_d \rightarrow K^*(892)^0\, e\, \mu$

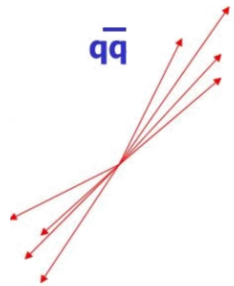
- **Belle full dataset.**

- **Discriminating variables typical of B-factories:**

$$M_{bc} = \sqrt{(E_{beam}/c^2)^2 - (p_B/c)^2} \qquad \Delta E = E_B - E_{beam}$$

- **Backgrounds:**
  - Continuum *ee->u,d,s,c* removed through:
    => topology (*bb* at rest in *ee* CM frame)
    => B tagging
    combined in a NN





  - both semileptonic *B* and B^- decays;
  - $B \rightarrow D^{-(*)} X \ell^+ \nu$ and $D^{-(*)} \rightarrow X \ell^- \nu^-$;
  - hadronic B decays with mis-ID into leptons.

  Dedicated NN using topology and kinematics

  - $B^0 \rightarrow K^{*0}(\rightarrow K^+\pi^-)\, J/\psi(\rightarrow \ell^+\ell^-)$ decays with one lepton misidentified and swapped with one hadron **=>** *vetoes accounting for mis-ID*

  - $B^0 \rightarrow K^{*0}\pi^+\pi^-$ with pions misidentified as leptons **=>** *only 0.01 event*

$B_d \to K^{*}(892)^0\, e\, \mu$

Belle: PR D98 071101

Compatible with back only hypothesis

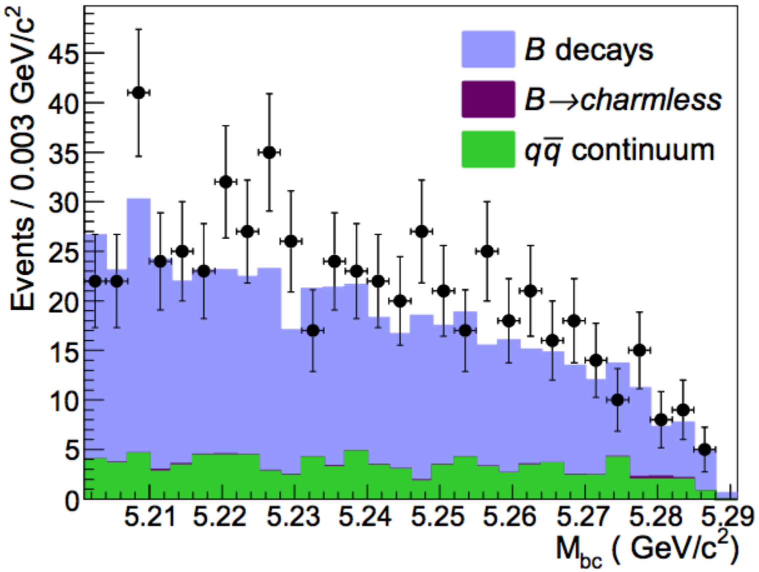
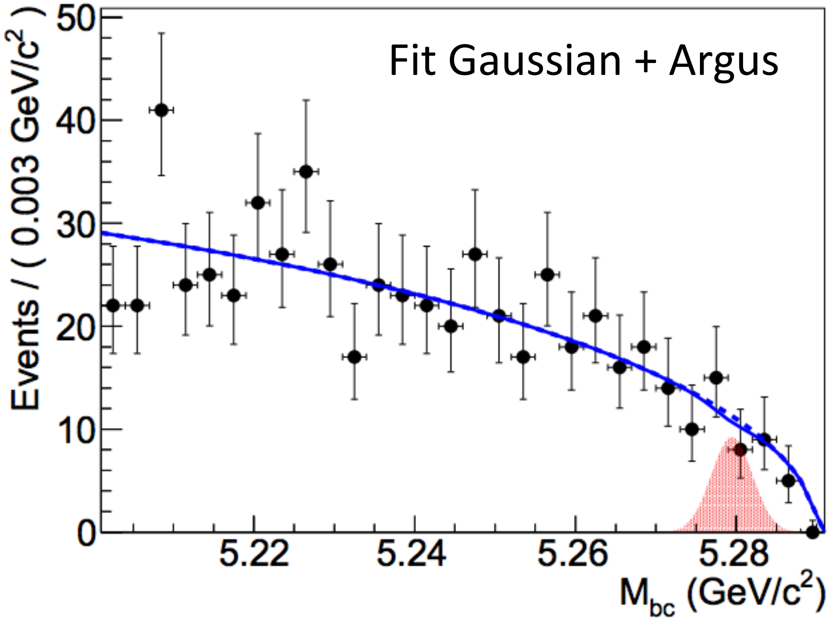


TABLE II: Systematic uncertainties included in calculating the upper limits.

Source	Systematic uncertainty (%)		
	$K^{*0}\mu^+e^-$	$K^{*0}\mu^-e^+$	$K^{*0}\mu^\pm e^\mp$
Reconstruction efficiency	±0.3	±0.3	±0.3
Number of $B^0\bar{B}^0$ pairs	±1.4	±1.4	±1.4
f^{00}	±1.2	±1.2	±1.2
Track reconstruction	±1.4	±1.4	±1.4
Particle identification	±2.8	±2.8	±2.8
$\mathcal{O}_{\rm NN}^{q\bar{q}}$ and $\mathcal{O}_{\rm NN}^{\rm BB}$	±2.8	±2.8	±2.8
PDF shape parameters	$^{+2.1}_{-3.0}$	$^{+8.2}_{-8.1}$	$^{+4.5}_{-4.5}$
$B \to$ charmless decays	±0.5	±2.2	±1.4
K^{*0} polarization	$^{+2.7}_{-1.4}$	$^{+3.8}_{-1.9}$	$^{+3.2}_{-1.6}$
Total	$^{+5.7}_{-5.6}$	$^{+10.3}_{-9.7}$	$^{+7.2}_{-6.7}$



Mode	ε (%)	$N_{\rm sig}$	$N_{\rm sig}^{\rm UL}$	$\mathcal{B}^{\rm UL}$ (10^{-7})
$B^0 \to K^{*0}\mu^+e^-$	8.8	$-1.5^{+4.7}_{-4.1}$	5.2	1.2
$B^0 \to K^{*0}\mu^-e^+$	9.3	$0.4^{+4.8}_{-4.5}$	7.4	1.6
$B^0 \to K^{*0}\mu^\pm e^\mp$ (combined)	9.0	$-1.2^{+6.8}_{-6.2}$	8.0	1.8

- Previous BaBar result improved by factor 3.
- Conservative limits, since $q^2 \equiv M^2(\ell^+\ell^-)$ peaks at low values, where efficiency is low.

$B_u \rightarrow K^+ e\, \mu$

- LHCb **Run1 data** (3 fb^{-1})
- **Trigger on a high-pT μuon**
- Three tracks with common, displaced vertex.

- Double semileptonic background:

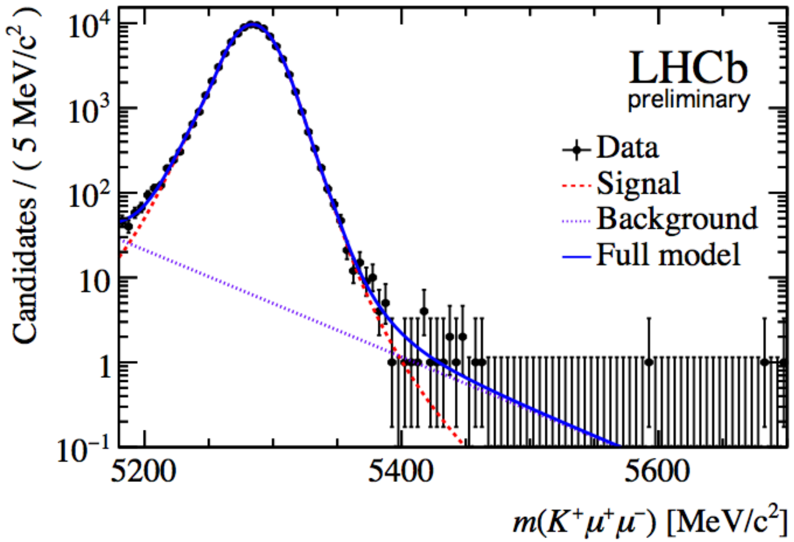
$$B^+ \rightarrow \overline{D}^0 (\rightarrow K^+ Y l^- \overline{\nu}_l) X l^+ \nu_l$$

=> ***D* mass veto**: m(K^+l^-)>1885 MeV

- Charmonium with lepton mis-ID:
  => **charmonium mass vetoes** accounting for mis-ID

Normalization channel

$B^+ \rightarrow J/\psi(\mu^+\mu^-)K^+$



- Selection based on **two stages BDT**
  => **Combinatorial background**: dedicated BDT exploiting topology and isolation, trained on high mass sideband.
  => **Partially reconstructed B decays**: dedicated BDT exploiting topology, isolation and kinematic, trained on lower mass sideband.

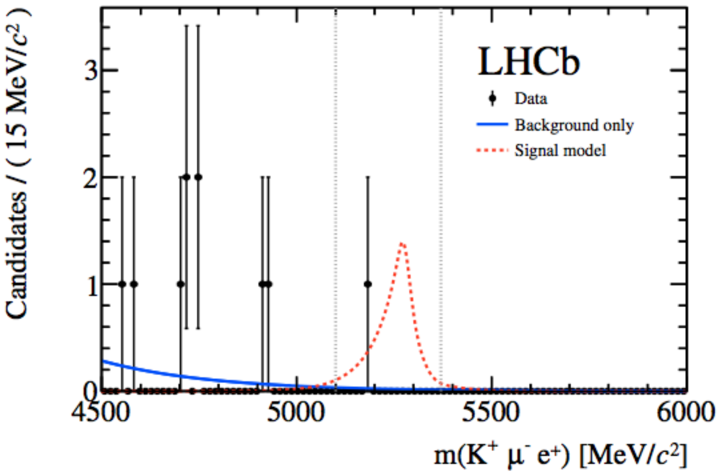
- Fully or partially reconstructed B decays with at least one mis-ID (ex *B->Kll*) => **PID cuts**

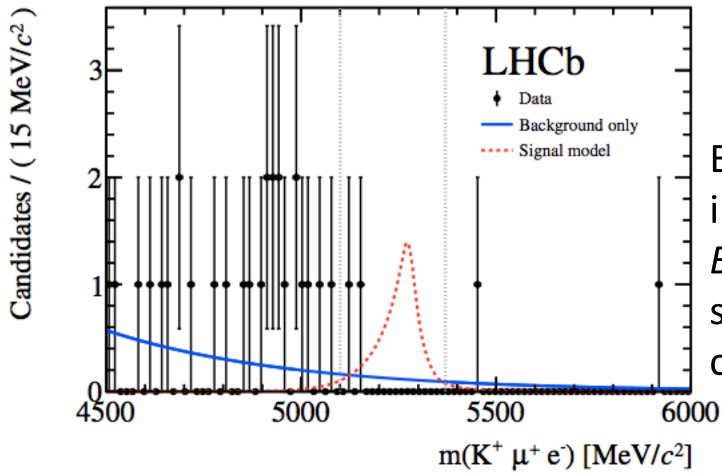
- **Background crosschecked to be negligible via simulation.**

$B_u \to K^+ e\ \mu$

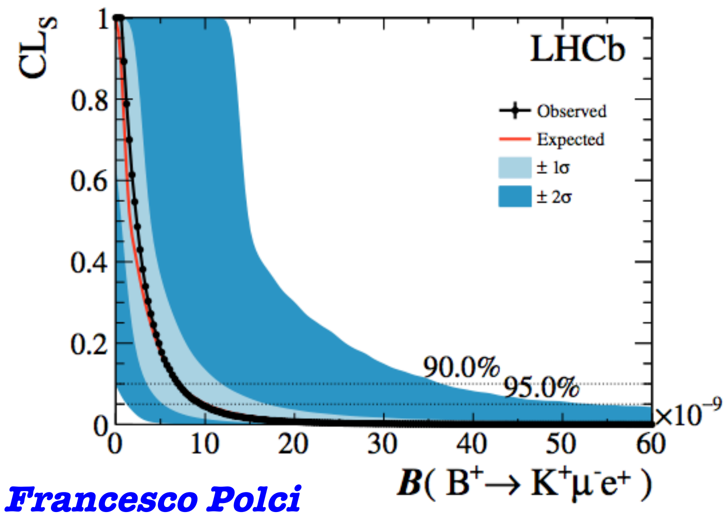
	90% C. L.	95% C. L.
$\mathcal{B}(B^+ \to K^+\mu^-e^+)/10^{-9}$	7.0	9.5
$\mathcal{B}(B^+ \to K^+\mu^+e^-)/10^{-9}$	6.4	8.8

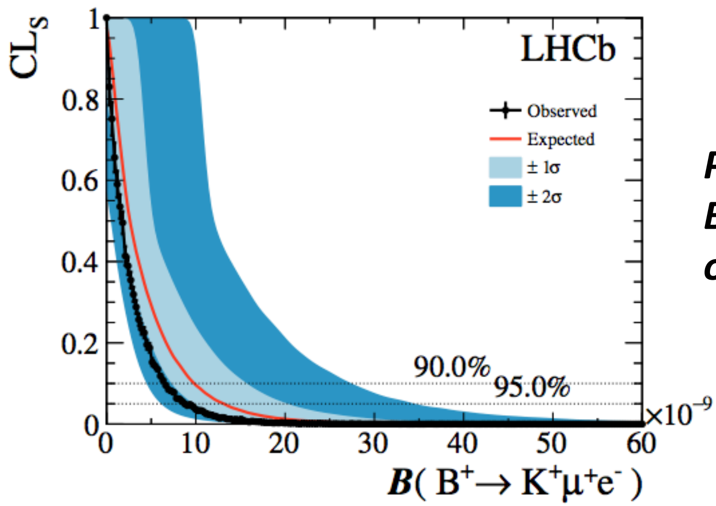
Systematics less than 7%





Expected signal shape inferred from MC and *B->Kee*, *B->Kμμ* data, separately for two brem categories.





Previous limits from BaBar improved by one order of magnitude!

Efficiencies in the phase space provided to help interpretations in different models.

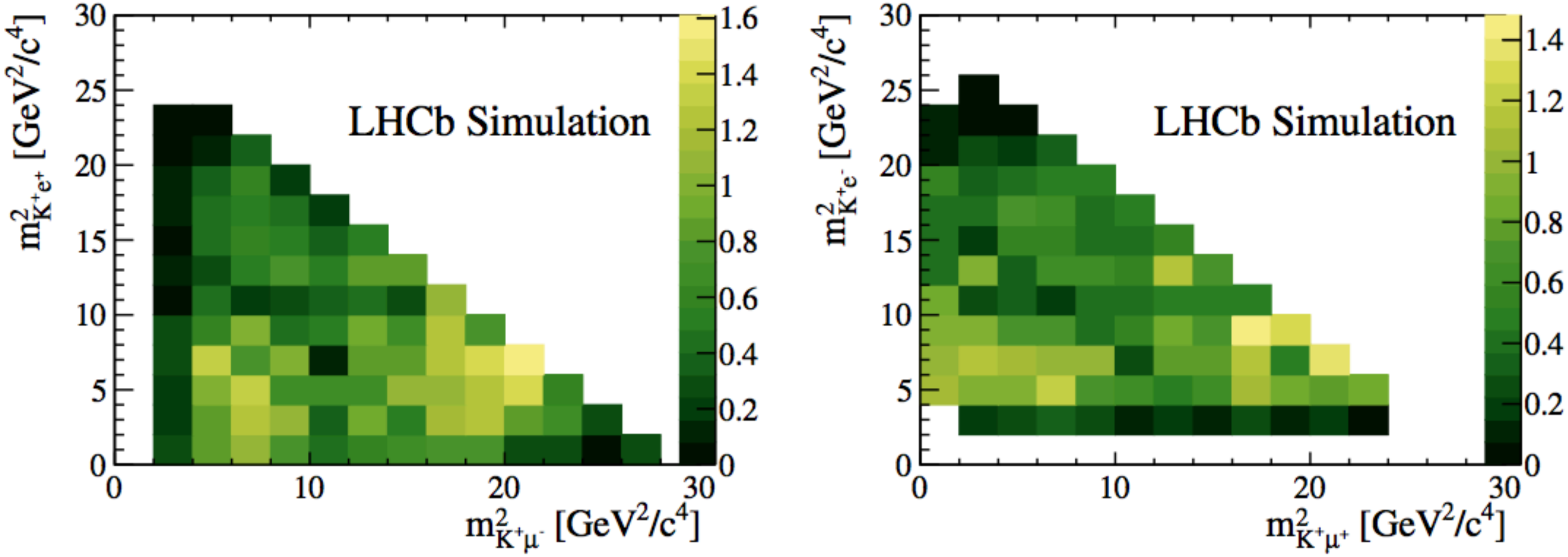
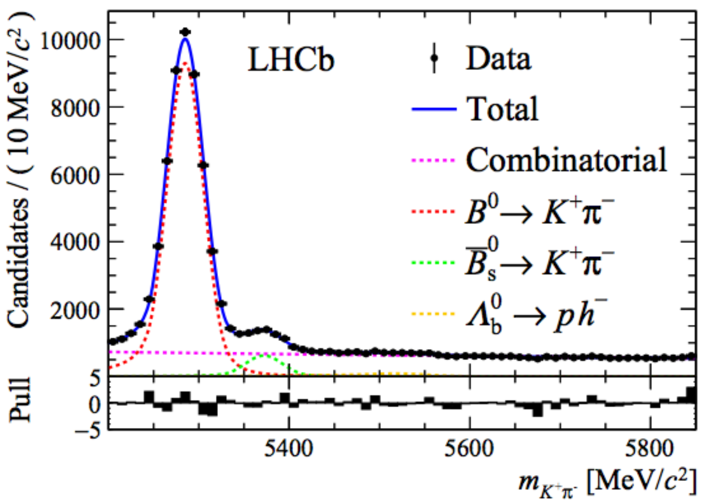


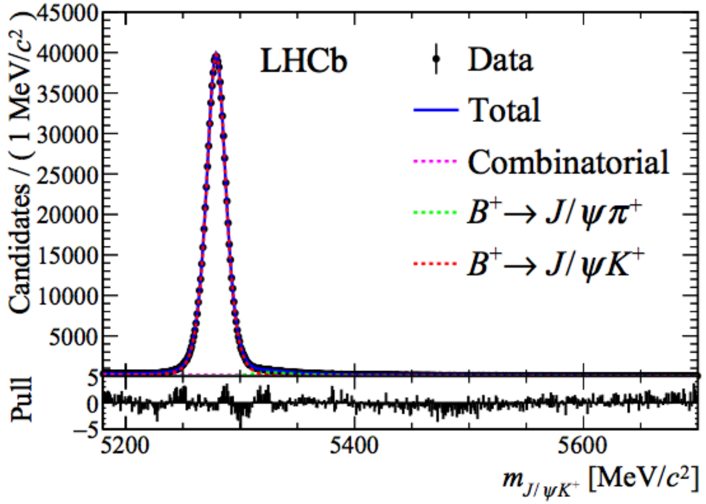
Figure 2: Efficiency of (left) $B^+ \rightarrow K^+\mu^-e^+$ and (right) $B^+ \rightarrow K^+\mu^+e^-$ as function of the invariant masses of the particles in the final state $m^2_{K^+e^\pm}$ and $m^2_{K^+\mu^\mp}$. The efficiency numbers are given in per mille.

$B_{d,s} \to e\,\mu$

- BR could be enhanced up to 10^{-11}
- LHCb **Run1 data** (3 fb^{-1})
- **Trigger on high-p_T muons or high−E_T electrons**
- **Displaced vertex of electron and muon, PID** selections
- **Two normalization channels**:



$B^0 \to K^+\pi^-$: *similar reconstruction*



$B^+ \to J/\psi K^+$: *large yield, similar trigger*

- Efficiencies from MC except PID from control samples

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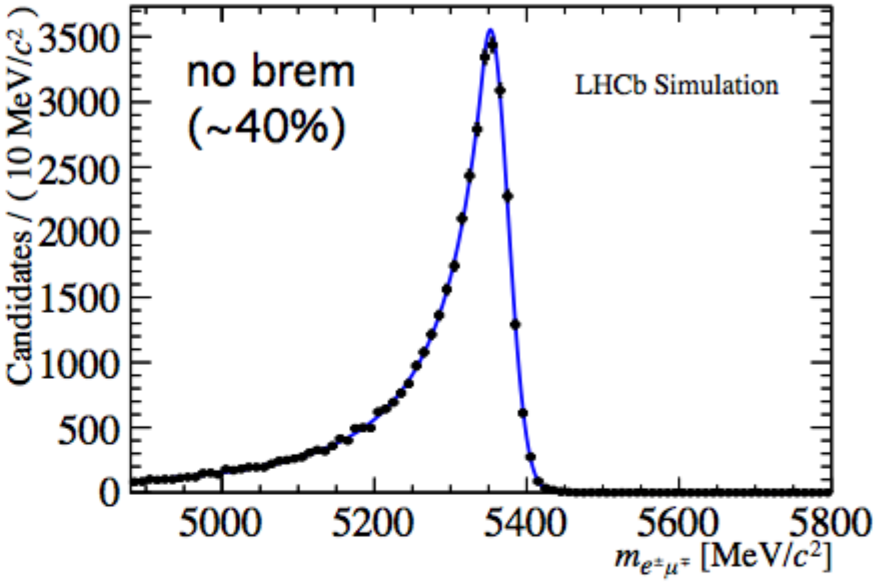
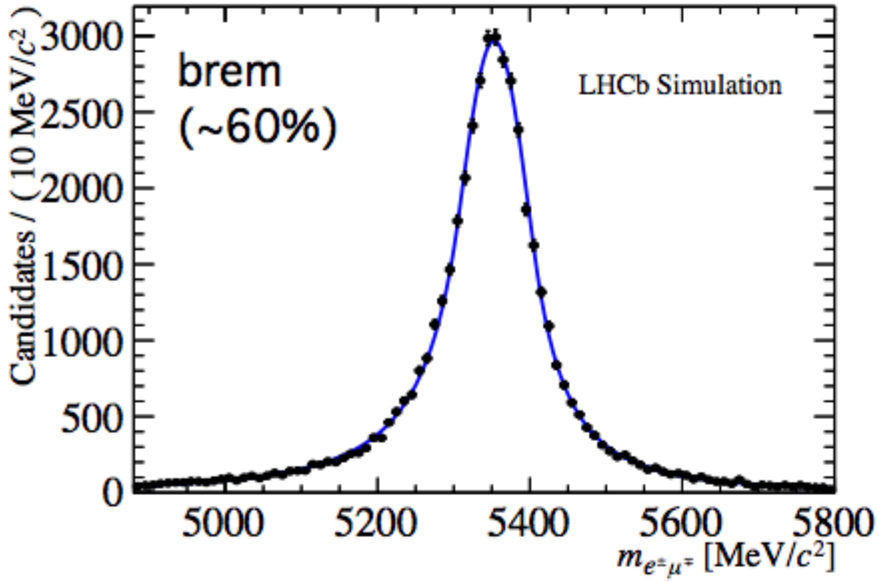
Selection efficiencies and mass shapes analyzed separately for

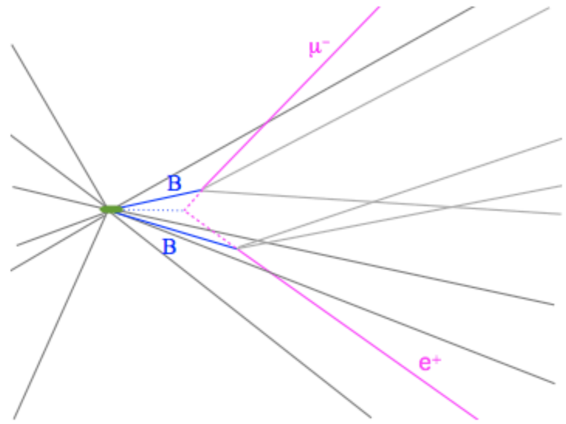
two bremsstrahlung categories



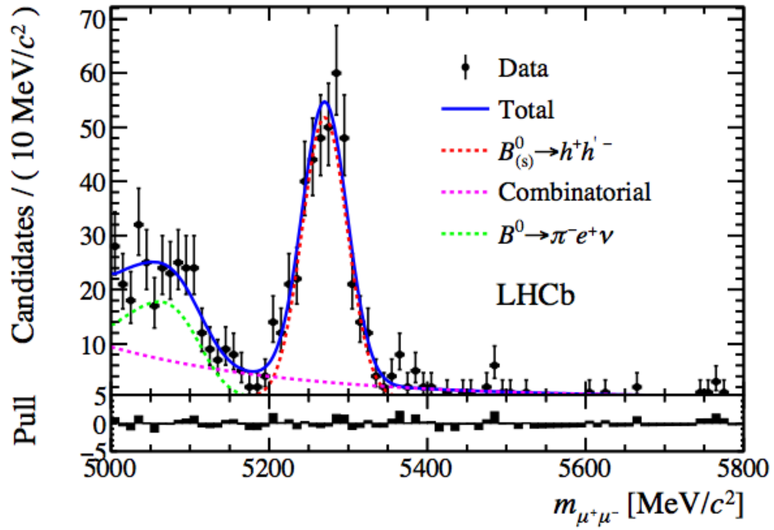


Backgrounds:

- Combinatorial:
  => rejected via a topological BDT,
  trained on signal MC (calibrated via B-Kπ data)
  and same-sign data,



- Peaking $B \to hh$ $(h=K,\pi)$ with two misID
  - *Normalised to* $B \to J/\psi K$
  - *Estimated from* $B \to hh \to \pi\, e$ *data (single misID)*
  => **0.1 event surviving**



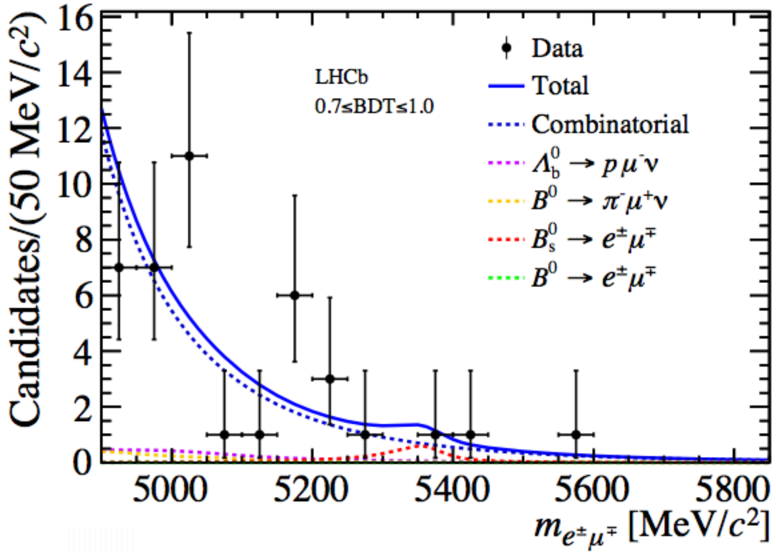
- $B_d \to \pi\mu\nu$ and $\Lambda_b \to p\mu\nu$ with $\pi,p \to e$ misID in the low mass region **included in the fit**

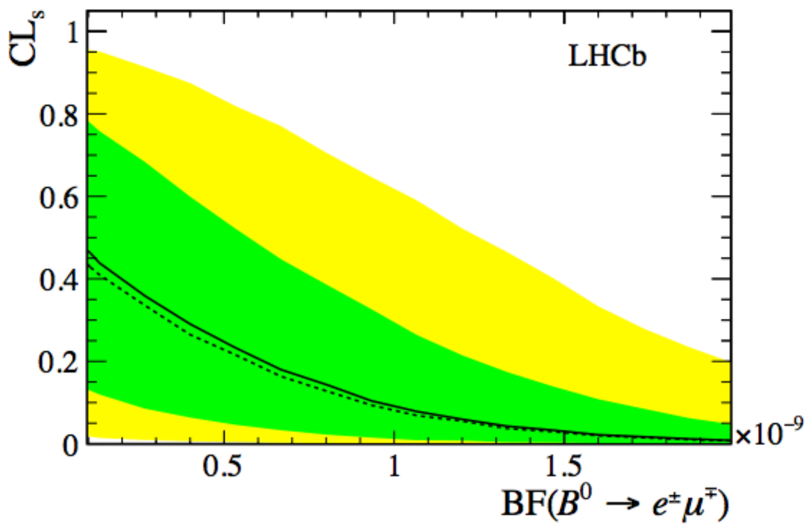
$B_{d,s} \to e\,\mu$

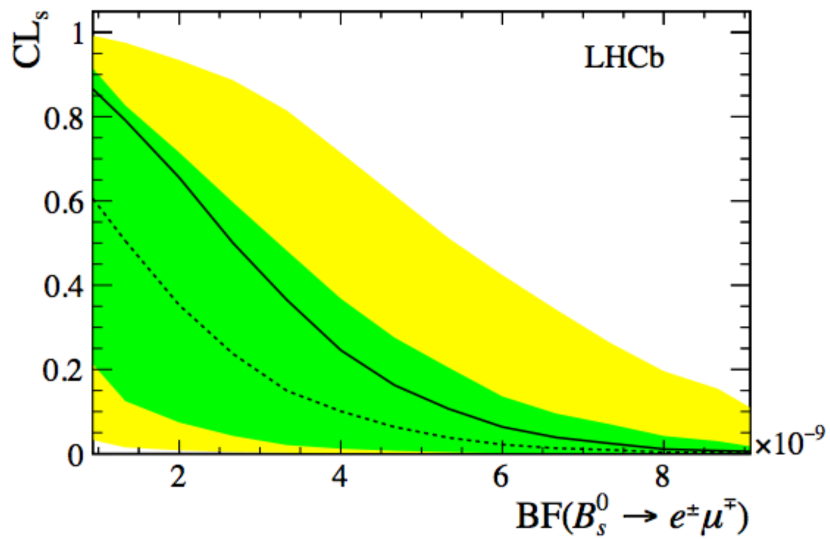
- Simultaneous fit to 14 categories of brem and BDT.
- No signal!
- Systematics below 5%
- CLs set at 95 (90)% CL:

channel	expected	observed
$\mathcal{B}(B_s^0 \to e^{\pm}\mu^{\mp})$	$5.0\,(3.9) \times 10^{-9}$	$6.3\,(5.4) \times 10^{-9}$
$\mathcal{B}(B^0 \to e^{\pm}\mu^{\mp})$	$1.2\,(0.9) \times 10^{-9}$	$1.3\,(1.0) \times 10^{-9}$

(B_s limit assumes pure heavy mass eigenstate)

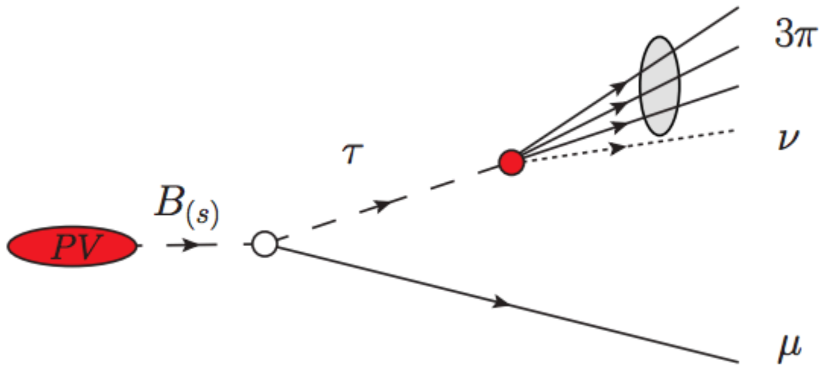




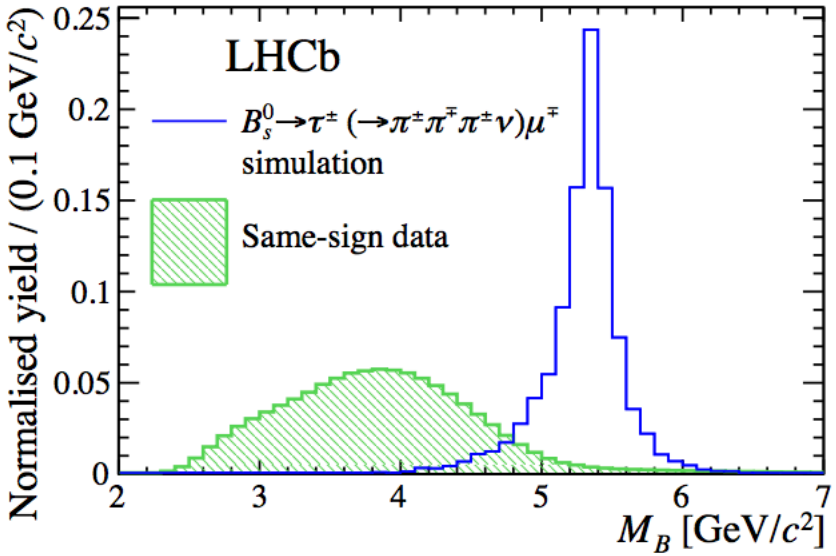


$B_{d,s} \to \tau\mu$

- **Trigger on high-pT muons**
- Tau reconstructed hadronically: $\tau \to 3\pi\nu$
- Kinematic constraints to compute analytically the ***B* mass with two-fold ambiguity**. Solution with highest S/B is kept.
- **Same sign data to model background**

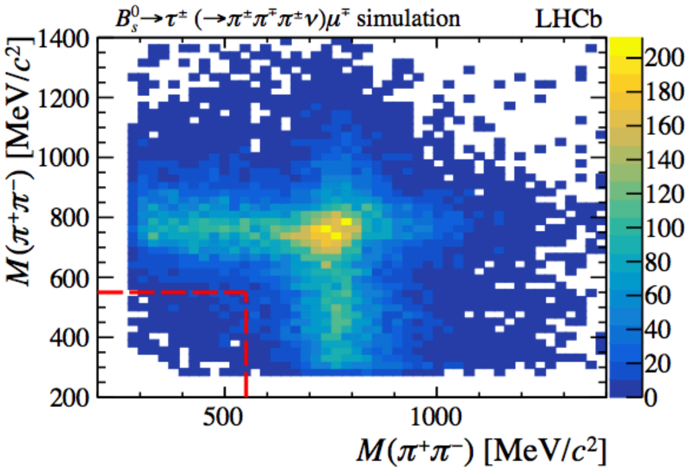


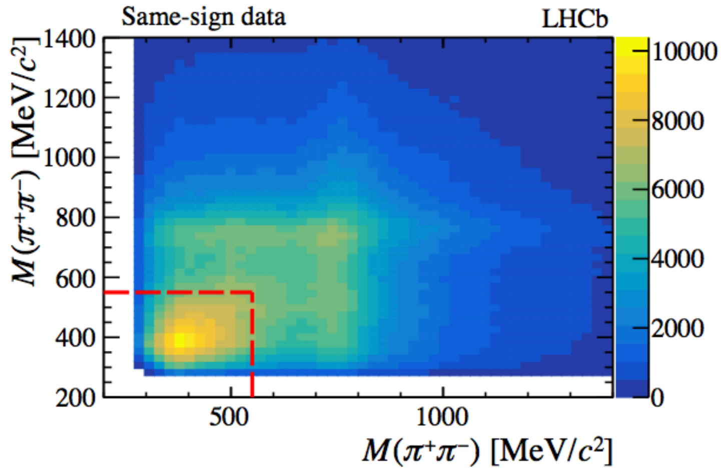
- Normalization channel with similar topology $B^0 \to D^-(K^+\pi^-\pi^-)\pi^+$



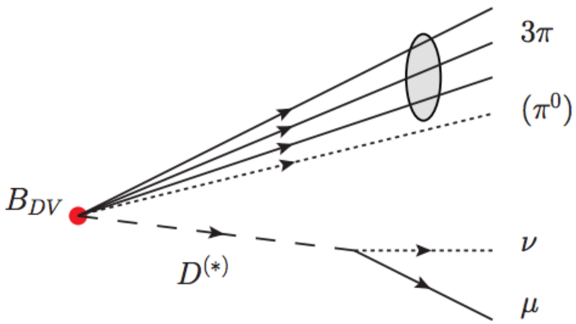
$B_{d,s} \to \tau\mu$

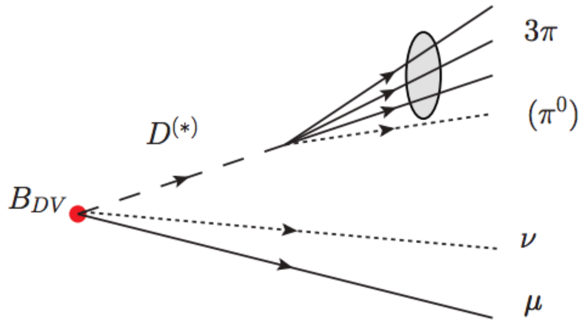
- Powerful tool for background rejection: **tau decays through *a1* and ρ**





- **Partially reconstructed**: cut with **decay time** (left) or **included in the fit** (right)





- **Combinatorial:** reduced by **BDT** (including **isolation**) on signal MC and upper mass sidebands of **SS data**

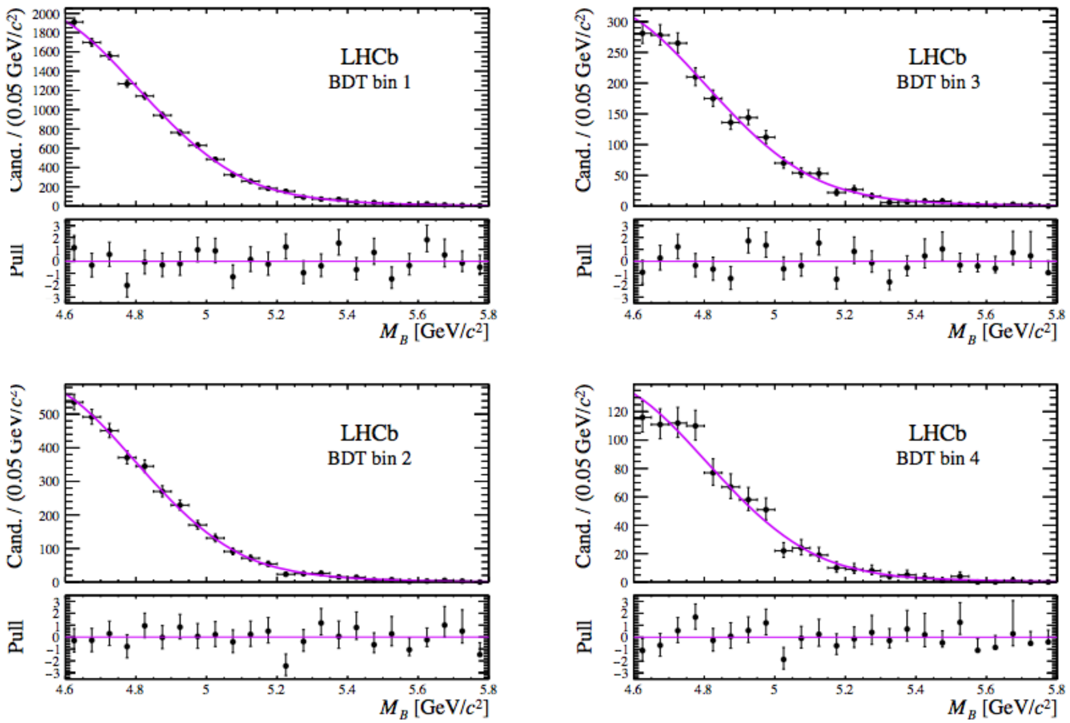
$B_{d,s} \to \tau\mu$

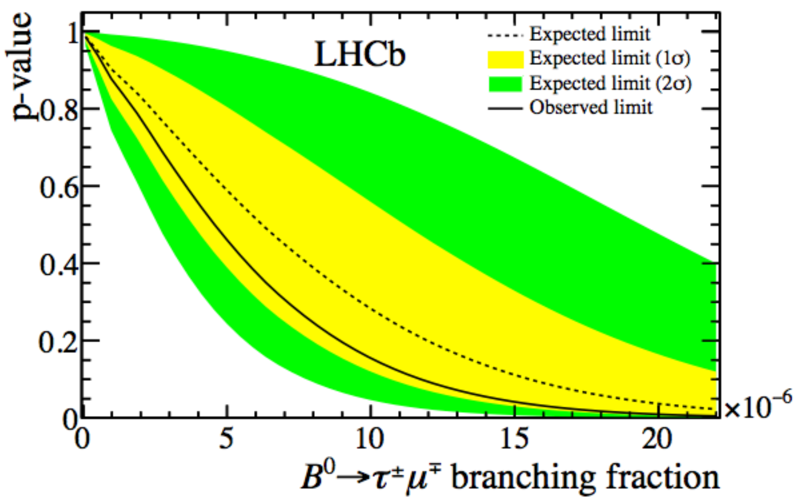
LHCb: arXiv:1905.06614

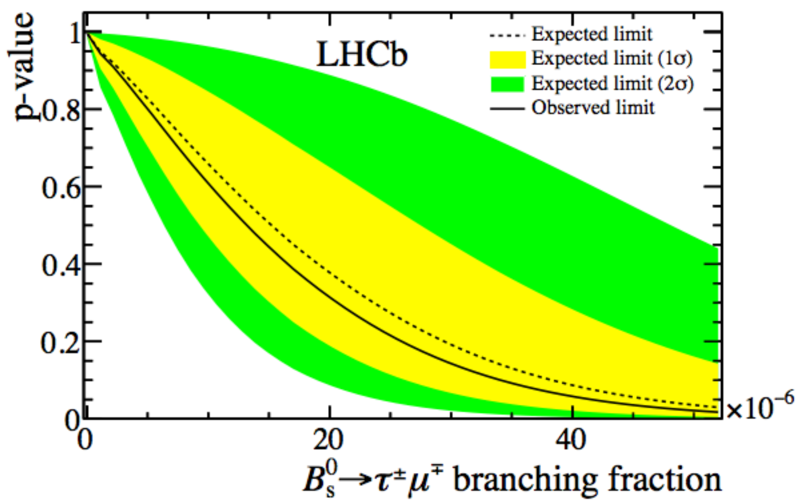
Simultaneous fit on 4 BDT bins.
Systematic on background model at 35%

Mode	Limit	90% CL	95% CL
$B_s^0 \to \tau^\pm\mu^\mp$	Observed	3.4×10^{-5}	4.2×10^{-5}
	Expected	3.9×10^{-5}	4.7×10^{-5}
$B^0 \to \tau^\pm\mu^\mp$	Observed	1.2×10^{-5}	1.4×10^{-5}
	Expected	1.6×10^{-5}	1.9×10^{-5}

Factor 2 improvement wrt BaBar and first ever result on B_s



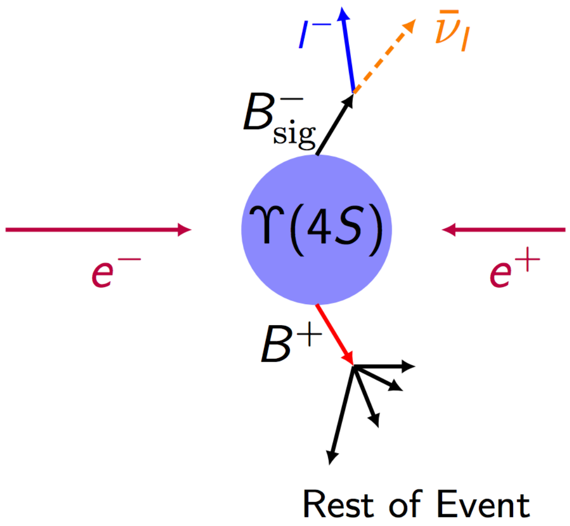




$B^+ \rightarrow h^+ \tau l$ $(h = K, \pi ; l = e, \mu)$

BaBar: PR D86 012004

- ***Y(4S)* → *BB* events** (whole BaBar data sample**: 472M *BB***)
- Detected tracks and neutral objects assigned to either the **tag *B* or** the **signal *B***.
- B_{tag} **fully reconstruct hadronically**: only events with B_{tag} purity > 10% are kept.



- **τ reconstructed indirectly**:
  - **B_{sig} and B_{tag} 3-momenta are opposite**
  - B_{sig} and B_{tag} energies are equal to the beam energy in the e^+e^- CM frame

$$\vec{p}_\tau = -\vec{p}_{\rm tag} - \vec{p}_h - \vec{p}_\ell,$$
$$E_\tau = E_{\rm beam} - E_h - E_\ell,$$
$$m_\tau = \sqrt{E_\tau^2 - |\vec{p}_\tau|^2},$$

- Signal candidates selected in **narrow reconstructed τ mass region.**
- **Requiring exactly 3 daughters => only one-prong τ decays** are selected (85% of the total). Exclusive assignment to $\tau \rightarrow e\nu\nu$, $\tau \rightarrow \mu\nu\nu$, $\tau \rightarrow (n\pi^0)\pi\nu$ (with $n \geq 0$)
- Backgrounds from semileptonic *B* or *D* decays (depending on the primary lepton charge) => **vetoes on *D***
- Branching fraction **normalized to $B^+ \rightarrow \bar{D}^{(*)0}\ell^+\nu$; $\bar{D}^0 \rightarrow K^+\pi^-$ events.**

$B^+ \rightarrow h^+ \tau l$ $(h = K, \pi ; l = e, \mu)$

BaBar: PR D86 012004

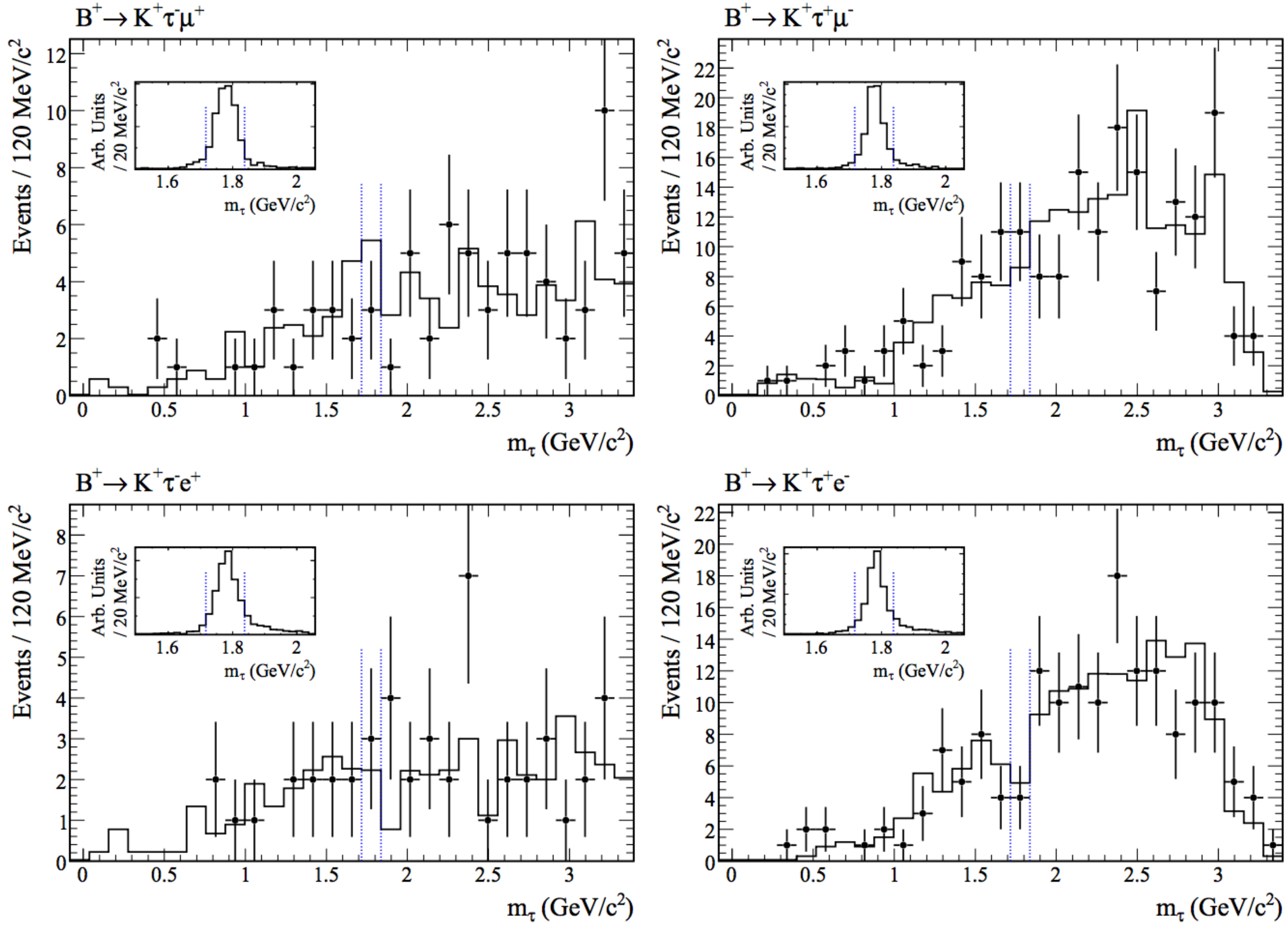


FIG. 6: Observed distributions of the τ invariant mass for the $B \rightarrow K\tau\ell$ modes. The distributions show the sum of the three τ channels (e, μ, π). The points with error bars are the data. The solid line is the background MC which has been normalized to the area of the data distribution. The dashed vertical lines indicate the m_τ signal window range. The inset shows the m_τ distribution for signal MC.

$B^+ \to h^+ \tau l$ $(h = K, \pi ; l = e, \mu)$

BaBar: PR D86 012004

TABLE IV: Results for the observed sideband events $N_{sb,i}$, signal-to-sideband ratio $R_{b,i}$, expected background events b_i, number of observed events n_i, signal efficiency $\epsilon_{h\tau\ell,i}$ (assuming uniform three-body phase space decays) for each τ channel i and $B \to h\tau\ell$ [9] branching fraction central value and 90% C.L. upper limits (UL). All uncertainties include statistical and systematic sources.

							$\mathcal{B}(B \to h\tau\ell)$ $(\times 10^{-5})$	
Mode	τ channel	$N_{sb,i}$	$R_{b,i}$	b_i	n_i	$\epsilon_{h\tau\ell,i}$	central value	90% C.L. UL
	e	22	0.02 ± 0.01	0.4 ± 0.2	2	$(2.6 \pm 0.2)\%$		
$B^+ \to K^+\tau^-\mu^+$	μ	4	0.08 ± 0.05	0.3 ± 0.2	0	$(3.2 \pm 0.4)\%$	$0.8\ ^{+1.9}_{-1.4}$	< 4.5
	π	39	0.045 ± 0.020	1.8 ± 0.8	1	$(4.1 \pm 0.4)\%$		
	e	5	0.03 ± 0.01	0.2 ± 0.1	0	$(3.7 \pm 0.3)\%$		
$B^+ \to K^+\tau^+\mu^-$	μ	3	0.06 ± 0.03	0.2 ± 0.1	0	$(3.6 \pm 0.7)\%$	$-0.4\ ^{+1.4}_{-0.9}$	< 2.8
	π	153	0.045 ± 0.010	6.9 ± 1.5	11	$(9.1 \pm 0.5)\%$		
	e	6	0.095 ± 0.020	0.6 ± 0.1	2	$(2.2 \pm 0.2)\%$		
$B^+ \to K^+\tau^-e^+$	μ	4	0.025 ± 0.010	0.1 ± 0.1	0	$(2.7 \pm 0.6)\%$	$0.2\ ^{+2.1}_{-1.0}$	< 4.3
	π	33	0.045 ± 0.015	1.5 ± 0.5	1	$(4.8 \pm 0.6)\%$		
	e	8	0.10 ± 0.06	0.8 ± 0.5	0	$(2.8 \pm 1.1)\%$		
$B^+ \to K^+\tau^+e^-$	μ	3	0.045 ± 0.020	0.1 ± 0.1	0	$(3.2 \pm 0.7)\%$	$-1.3\ ^{+1.5}_{-1.8}$	< 1.5
	π	132	0.035 ± 0.010	4.6 ± 1.3	4	$(8.7 \pm 1.2)\%$		
	e	55	0.017 ± 0.010	0.9 ± 0.6	0	$(2.3 \pm 0.2)\%$		
$B^+ \to \pi^+\tau^-\mu^+$	μ	10	0.11 ± 0.04	1.1 ± 0.4	2	$(2.9 \pm 0.4)\%$	$0.4\ ^{+3.1}_{-2.2}$	< 6.2
	π	93	0.035 ± 0.010	3.3 ± 0.9	4	$(2.8 \pm 0.2)\%$		
	e	171	0.012 ± 0.003	2.1 ± 0.5	2	$(3.8 \pm 0.3)\%$		
$B^+ \to \pi^+\tau^+\mu^-$	μ	89	0.04 ± 0.01	3.6 ± 0.9	4	$(4.8 \pm 0.3)\%$	$0.0\ ^{+2.6}_{-2.0}$	< 4.5
	π	512	0.050 ± 0.005	25 ± 3	23	$(9.1 \pm 0.6)\%$		
	e	1	0.050 ± 0.025	0.1 ± 0.1	1	$(2.0 \pm 0.8)\%$		
$B^+ \to \pi^+\tau^-e^+$	μ	16	0.025 ± 0.010	0.4 ± 0.2	1	$(2.8 \pm 0.3)\%$	$2.8\ ^{+2.4}_{-1.9}$	< 7.4
	π	172	0.035 ± 0.008	6.0 ± 1.4	7	$(5.8 \pm 0.3)\%$		
	e	31	0.033 ± 0.013	1.0 ± 0.4	0	$(2.9 \pm 0.3)\%$		
$B^+ \to \pi^+\tau^+e^-$	μ	247	0.012 ± 0.005	3.0 ± 1.2	2	$(4.6 \pm 0.4)\%$	$-3.1\ ^{+2.4}_{-2.1}$	< 2.0
	π	82	0.07 ± 0.03	5.7 ± 2.5	3	$(3.7 \pm 1.0)\%$		

Systematics at 1-2% level

FINAL STATES WITH eμ

DECAY	MAX NP EXPECT	BEST 90%CL	PAPER	EXPERIMENT/ YEAR	LUMINOSITY	LHCb 2023 ($23 fb^{-1}$)	Belle II 2027 ($50 ab^{-1}$)
$B^+ \to \pi^+ e \mu$		1.7×10^{-7}	PRL 99 051801	BABAR 2007	230M BB (209 fb^{-1})		
$B^0 \to \pi^0 e \mu$		1.4×10^{-7}					
$B^+ \to K^+ e^+ \mu^-$	10^{-8}	7.0×10^{-9}	arXiv:1909.01010	LHCb 2019	3 fb-1 (Run1)	$\sim 2 \times 10^{-9}$	
$B^+ \to K^+ e^- \mu^+$	10^{-8}	6.4×10^{-9}				$\sim 2 \times 10^{-9}$	
$B^+ \to K^*(892)^+ e \mu$	10^{-8}	1.4×10^{-6}	PR D73 092001	BABAR 2006	229M BB (208 fb^{-1})		
$B^0 \to K^*(892)^0 e^+ \mu^-$	10^{-8}	1.6×10^{-7}	PR D98 071101	Belle 2018	772M BB (711 fb^{-1})	$\sim 10^{-9}$	$\sim 2 \times 10^{-8}$
$B^0 \to K^*(892)^0 e^- \mu^+$	10^{-8}	1.2×10^{-7}				$\sim 10^{-9}$	$\sim 2 \times 10^{-8}$
$B^0 \to K^*(892)^0 e \mu$	10^{-8}	1.8×10^{-7}				$\sim 10^{-9}$	$\sim 2 \times 10^{-8}$
$B^0 \to K^0 e \mu$		2.7×10^{-7}	PR D73 092001	BABAR 2006	229M BB (208 fb^{-1})		
$B^0 \to e \mu$	10^{-11}	1.0×10^{-9}	JHEP 1803 078	LHCb 2018	3 fb-1 (Run1)	2×10^{-10}	
$B_s \to e \mu$	10^{-11}	5.4×10^{-9}				8×10^{-10}	

Official LHCb expectations from ***arXiv:1808.08865*** in ***blue***

Official Belle II expectations from ***arXiv:1808.10567*** in ***blue***

Naïve personal guess (from similar channels or extrapolation for luminosity) in **grey**

FINAL STATES WITH $\mu\tau$

DECAY	MAX NP EXPECT	BEST 90%CL	PAPER	EXPERIMENT/ YEAR	LUMINOSITY	LHCb 2023 ($23 fb^{-1}$)	Belle II 2027 ($50 ab^{-1}$)
$B^+ \to \pi^+ \tau \mu$		7.2×10^{-5}	PR D86 012004	BABAR 2012	472M BB		
$B^+ \to K^+ \tau \mu$	10^{-5}	4.8×10^{-5}	PR D86 012004	BABAR 2012	472M BB	$\sim 10^{-6}$	3.3×10^{-6}
$B^0 \to K^*(892)^0 \mu \tau$	10^{-5}					10^{-6}	$\sim 10^{-6}$
$B^0 \to \tau \mu$	10^{-5}	1.2×10^{-5}	*arXiv:1905.06614*	LHCb 2019	$3 fb^{-1}$ (Run1)	3×10^{-6}	1.3×10^{-5}
$B_s \to \tau \mu$	10^{-5}	3.4×10^{-5}				9×10^{-6}	$\sim 10^{-5}$

Official LHCb expectations from ***arXiv:1808.08865*** in ***blue***
Official Belle II expectations from ***arXiv:1808.10567*** in ***blue***
Naïve personal guess (from similar channels or extrapolation for luminosity) in **grey**

FINAL STATES WITH $e\tau$

DECAY	MAX NP EXPECT	BEST 90%CL	PAPER	EXPERIMENT/ YEAR	LUMINOSITY	LHCb 2023 ($23 fb^{-1}$)	Belle II 2027 ($50 ab^{-1}$)
$B^+ \to \pi^+ e \tau$		7.5×10^{-5}	PR D86 012004	BABAR 2012	472M BB		
$B^+ \to K^+ e \tau$		3.0×10^{-5}	PR D86 012004	BABAR 2012	472M BB		2.1×10^{-6}
$B^0 \to e \tau$		2.8×10^{-5}	PR D77 091104	BABAR 2008	378M BB ($342 fb^{-1}$)		1.6×10^{-5}

Official LHCb expectations from ***arXiv:1808.08865*** in ***blue***
Official Belle II expectations from ***arXiv:1808.10567*** in ***blue***
Naïve personal guess (from similar channels or extrapolation for luminosity) in **grey**

CONCLUSIONS

- Charged-lepton flavor violating decays have been and **are being extensively studied at B-factories and LHCb.**

- Final states with **electrons and muons** are easier: the sensitivities are touching **10^{-9}**

- Final states with **taus** are harder: the sensitivities are touching **10^{-5}** and can hopefully go down to 10^{-6}

- These limits are already **constraining the phase space of some NP models**.

- **LHCb is now catching up on these searches**, and recent results are showing its capabilities for two- and three-body decays, both containing an electron or a tau.
  Belle II has a competitive/complementary potential.

- **Large samples are needed to increase** current searches **by order of magnitudes** .

Bordone et al.
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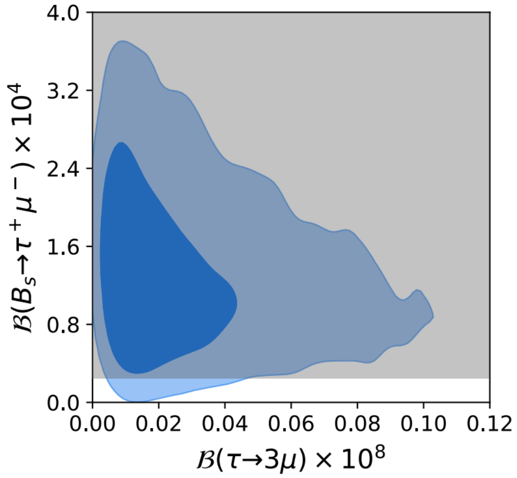

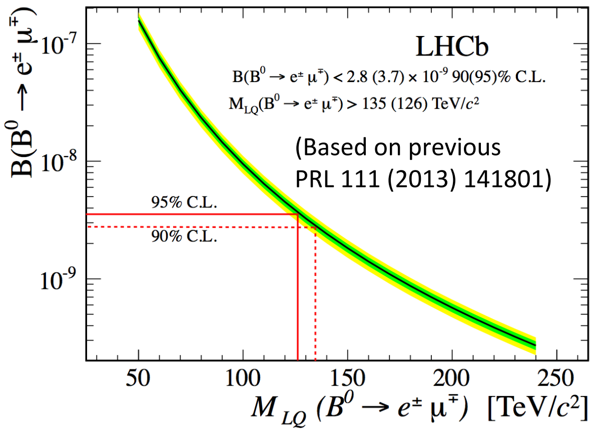

Francesco Polci

MY QUESTIONS

- Is the approach of providing **efficiencies as function of the phase space satisfactory**?

- Selection choices are unavoidably affected by the use of phase space Monte Carlo.
  Is there **any kinematic configuration that it is obviously worth to study independently**, in order to optimize the sensitivity into the phase space region it covers mostly?

- Is there **any additional information** that should be provided **for the interpretation?**

- In the past some results have been provided for the **two charge combinations** combined, but it seems it makes more sense to keep them independent both for theoretical and experimental reasons.

- Do **ATLAS and CMS** have any plans to have a look at these decays?
  If so, which are the **sensitivities expected**?