

# *Charmonium Contribution to $B \rightarrow X_s l^+ l^-$*

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Jack Jenkins (Indiana University)

## *Collaborators:*

Enrico Lunghi (Indiana University)

Tobias Hurth (MITP)

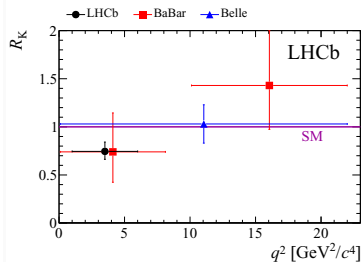
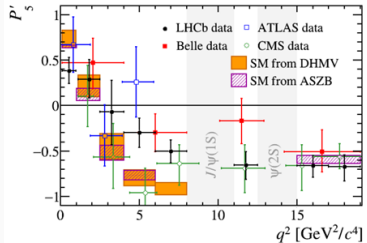
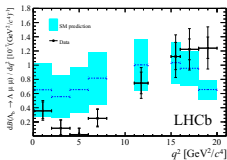
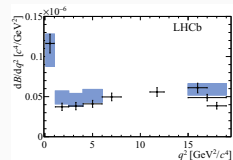
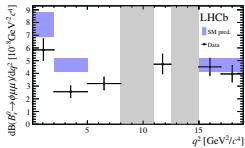
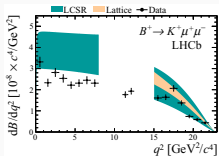
Tobias Huber (Siegen)

Keri Vos (Siegen)

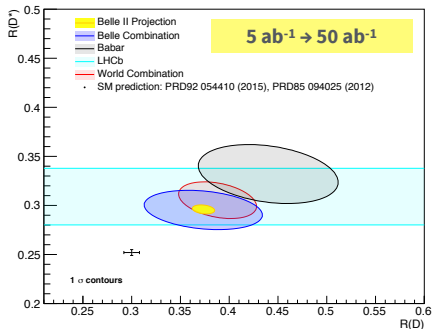
Qin Qin (Siegen)

# Anomalies in Exclusive Channels

- Anomalies in theoretically clean observables
- Region of interest is (1, 6) GeV
- Exclusive channels



# Belle II: Experimental Outlook



Observables		Belle (2014)	Belle II 5 $ab^{-1}$	Belle II 50 $ab^{-1}$
UT angles	$\sin 2\beta$	$0.667 \pm 0.023 \pm 0.012$ [56]	0.012	0.008
	$\alpha$ [°]	$85 \pm 4$ (Belle+BaBar) [24]	2	1
	$\gamma$ [°]	$68 \pm 14$ [13]	6	1.5
Gluonic penguins	$S(B \rightarrow \phi K^0)$	$0.90^{+0.02}_{-0.01}$ [19]	0.053	0.018
	$S(B \rightarrow \eta K^0)$	$0.68 \pm 0.07 \pm 0.03$ [57]	0.028	0.011
	$S(B \rightarrow K_S^0 K_S^0)$	$0.30 \pm 0.32 \pm 0.08$ [17]	0.100	0.033
	$\mathcal{A}(B \rightarrow K_S^0 \pi^0)$	$-0.05 \pm 0.14 \pm 0.05$ [58]	0.07	0.04
UT sides	$ V_{cb} $ incl.	$41.6 \cdot 10^{-3} (1 \pm 1.8\%)$ [8]	1.2%	1.4%
	$ V_{cb} $ excl.	$37.5 \cdot 10^{-3} (1 \pm 3.0\%_{\text{ex}} \pm 2.7\%_{\text{th}})$ [10]	1.8%	3.0%
	$ V_{ub} $ incl.	$4.47 \cdot 10^{-3} (1 \pm 6.0\%_{\text{ex}} \pm 2.5\%_{\text{th}})$ [5]	3.4%	2.3%
	$ V_{ub} $ excl. (had. tag.)	$3.52 \cdot 10^{-3} (1 \pm 9.5\%)$ [7]	4.4%	2.3%
Missing $E$ decays	$\mathcal{B}(B \rightarrow \tau\nu)$ [ $10^{-6}$ ]	$96 (1 \pm 27\%)$ [26]	10%	5%
	$\mathcal{B}(B \rightarrow \mu\nu)$ [ $10^{-6}$ ]	$< 1.7$ [59]	20%	7%
	$R(B \rightarrow D\tau\nu)$	$0.440 (1 \pm 16.5\%)$ [29] <sup>†</sup>	5.2%	3.4%
	$R(B \rightarrow D^*\tau\nu)$	$0.332 (1 \pm 9.0\%)$ [29] <sup>†</sup>	2.9%	2.1%
	$\mathcal{B}(B \rightarrow K^{*+}\bar{\nu})$ [ $10^{-6}$ ]	$< 40$ [31]	$< 15$	20%
	$\mathcal{B}(B \rightarrow K^{*+}\nu)$ [ $10^{-6}$ ]	$< 55$ [31]	$< 21$	30%
Rad. & EW penguins	$\mathcal{B}(B \rightarrow X_s\gamma)$	$3.45 \cdot 10^{-4} (1 \pm 4.3\% \pm 11.6\%)$	7%	6%
	$A_{CP}(B \rightarrow X_s\ell\gamma)$ [ $10^{-2}$ ]	$2.2 \pm 4.0 \pm 0.8$ [60]	1	0.5
	$S(B \rightarrow K_S^0 \pi^0 \gamma)$	$-0.10 \pm 0.31 \pm 0.07$ [20]	0.11	0.035
	$S(B \rightarrow \rho\gamma)$	$-0.83 \pm 0.65 \pm 0.18$ [21]	0.23	0.07
	$C_7/C_9(B \rightarrow X_s \ell \ell)$	$\sim 20\%$ [37]	10%	5%
	$\mathcal{B}(B_s \rightarrow \gamma\gamma)$ [ $10^{-6}$ ]	$< 8.7$ [40]	0.3	-
	$\mathcal{B}(B_s \rightarrow \tau\tau)$ [ $10^{-3}$ ]	-	$< 2$ [42] <sup>‡</sup>	-
	-	-	-	-
Charm Rare	$\mathcal{B}(D_s \rightarrow \mu\nu)$	$5.31 \cdot 10^{-7} (1 \pm 5.3\% \pm 3.8\%)$ [44]	2.9%	0.9%
	$\mathcal{B}(D_s \rightarrow \tau\nu)$	$5.70 \cdot 10^{-7} (1 \pm 3.7\% \pm 5.4\%)$ [44]	3.5%	3.6%
	$\mathcal{B}(D^0 \rightarrow \gamma\gamma)$ [ $10^{-6}$ ]	$< 1.5$ [47]	30%	25%
Charm CP	$A_{CP}(D^0 \rightarrow K^+ K^-)$ [ $10^{-2}$ ]	$-0.32 \pm 0.21 \pm 0.09$ [61]	0.11	0.06
	$A_{CP}(D^0 \rightarrow \pi^+ \pi^0)$ [ $10^{-2}$ ]	$-0.03 \pm 0.64 \pm 0.10$ [62]	0.29	0.09
	$A_{CP}(D^0 \rightarrow K_S^0 \pi^0)$ [ $10^{-2}$ ]	$-0.21 \pm 0.16 \pm 0.09$ [62]	0.08	0.03
Charm Mixing	$x(D^0 \rightarrow K_S^0 \pi^+ \pi^-)$ [ $10^{-2}$ ]	$0.56 \pm 0.19 \pm 0.05$ [50]	0.14	0.11
	$y(D^0 \rightarrow K_S^0 \pi^+ \pi^-)$ [ $10^{-2}$ ]	$0.30 \pm 0.15 \pm 0.08$ [50]	0.08	0.05
	$ q/p (D^0 \rightarrow K_S^0 \pi^+ \pi^-)$	$0.90 \pm 0.16 \pm 0.08$ [50]	0.10	0.07
	$\phi(D^0 \rightarrow K_S^0 \pi^+ \pi^-)$ [°]	$-6 \pm 11 \pm 1$ [50]	6	4
Tau	$\tau \rightarrow \mu\gamma$ [ $10^{-9}$ ]	$< 45$ [63]	$< 14.7$	$< 4.7$
	$\tau \rightarrow e\gamma$ [ $10^{-9}$ ]	$< 120$ [63]	$< 39$	$< 12$
	$\tau \rightarrow \mu\mu\mu$ [ $10^{-9}$ ]	$< 21.0$ [64]	$< 3.0$	$< 0.3$