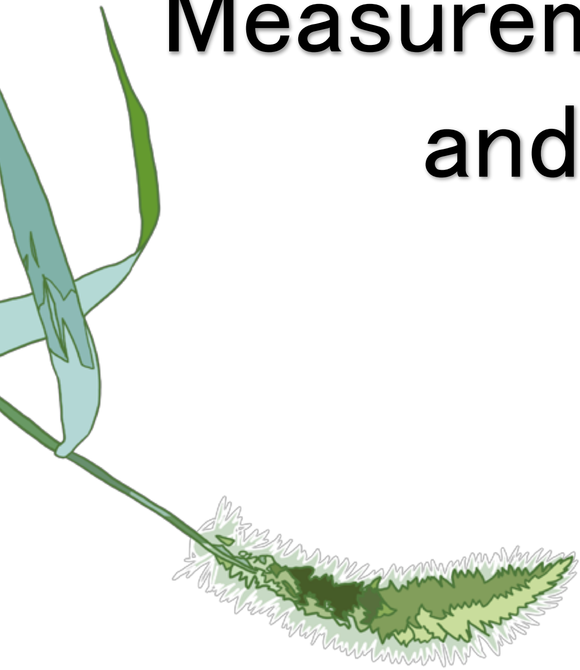
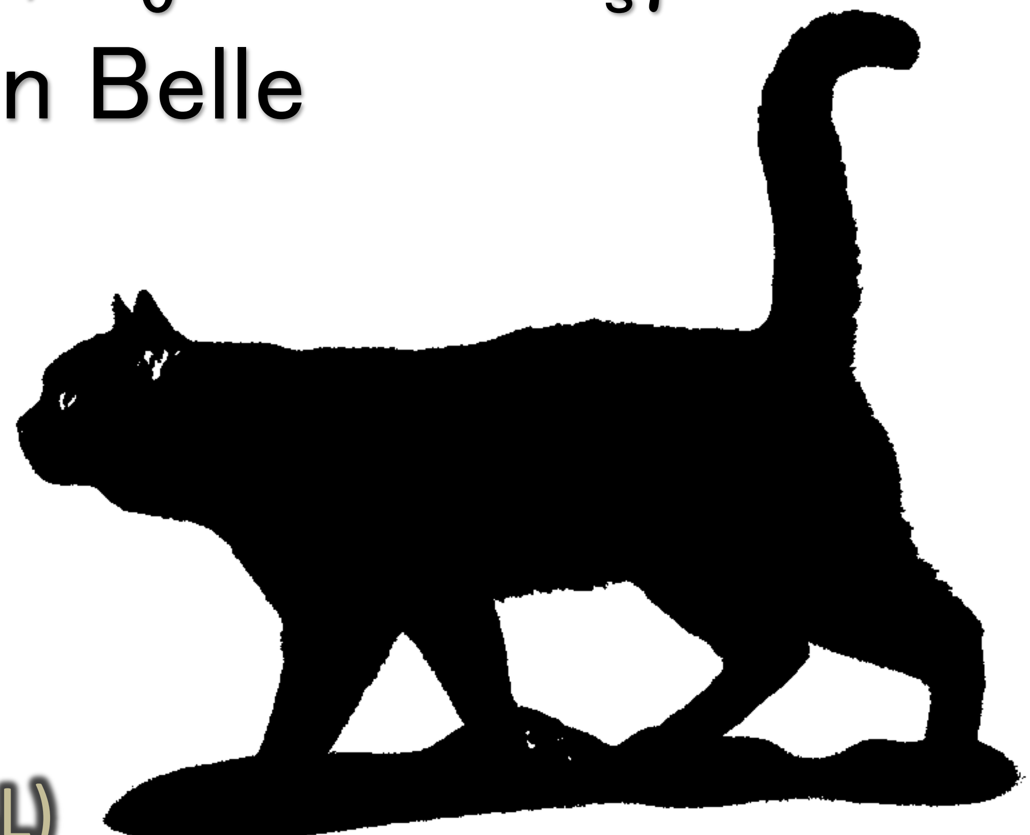
BEAUTY 2019 — 18th INTERNATIONAL CONFERENCE ON B-PHYSICS AT FRONTIER MACHINES
Ljubljana, Slovenia
September 30 - October 4, 2019

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

BELLE

Measurements of $R_{K(*)}$ of $B\to K^{(*)}l^+l^-$, and ΔA_{CP}, Δ_{0-} of $B\to X_s\gamma$ in Belle

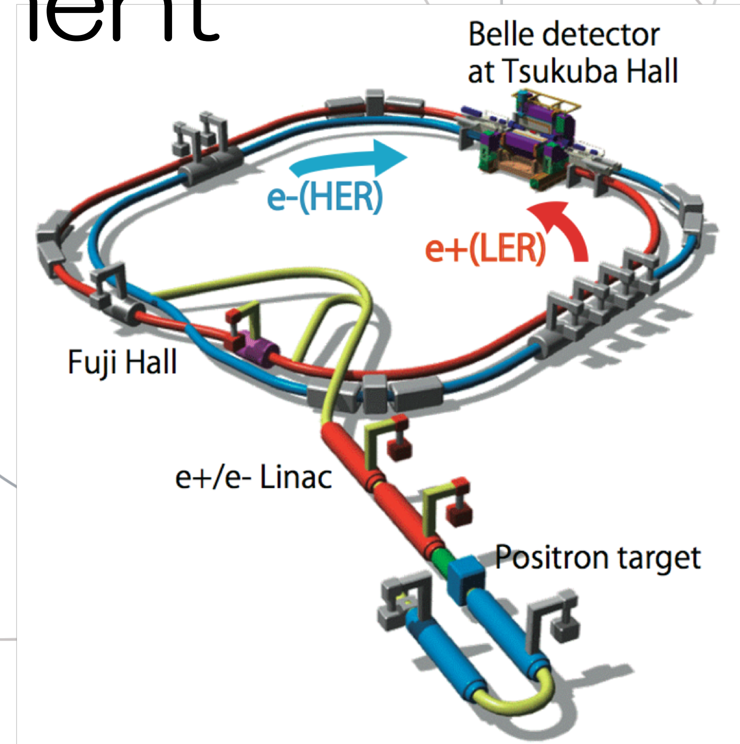


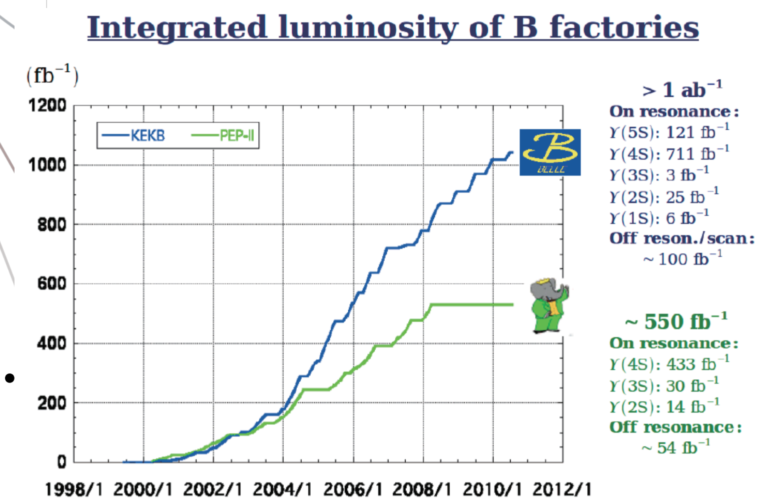


S. Watanuki (LAL)
for Belle Collaboration

Belle experiment

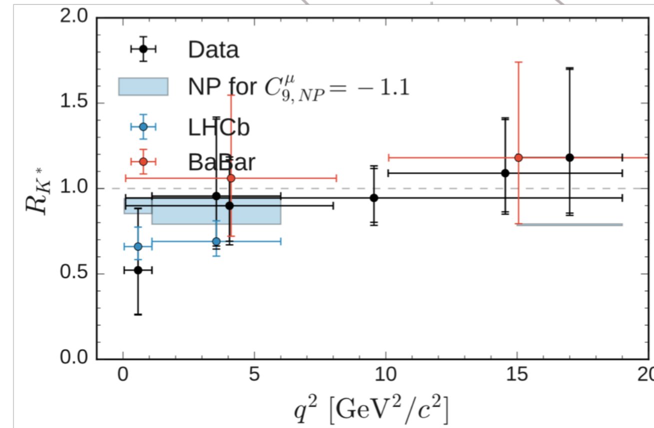
- Belle recoded 711fb-1 on resonance (=772M BB pairs)
- Very clean environment
- Many successes
  - Observation of CP violation
  - Determination of CKM angles
- Upgraded Belle II started.

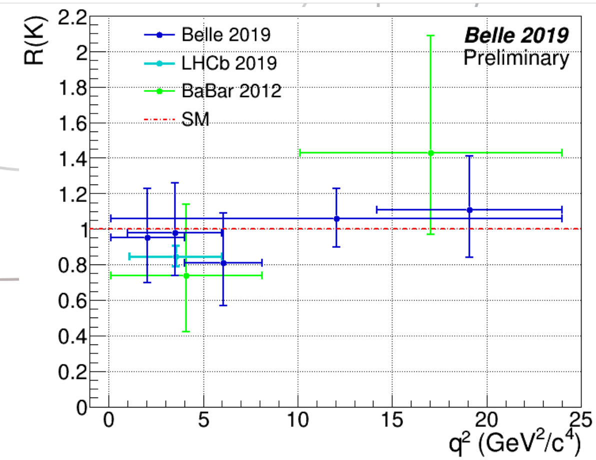


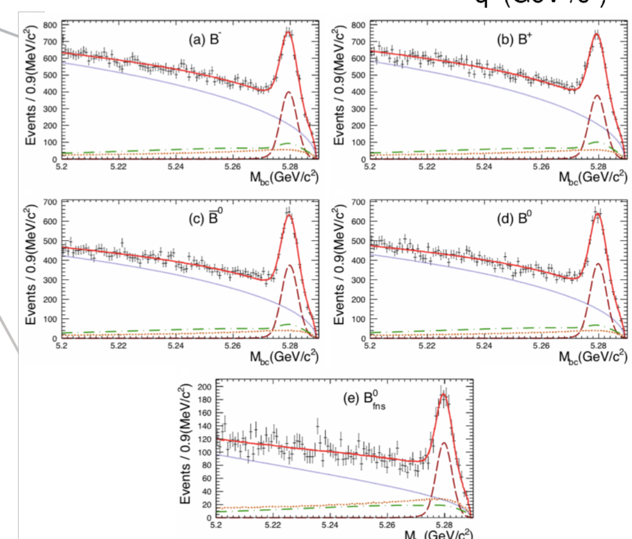


Topics

- $B \to K^* l^+ l^-$
  - arXiv:1904.02440v2
  - Lepton flavor universality test (R_{K*})
- $B \to K l^+ l^-$
  - arXiv:1908.01848
  - R_K, branching ratio, and A_I
- $B \to X_s \gamma$
  - Phys.Rev. D99 (2019) no.3, 032012
  - CP asymmetries difference between B^+ and B^0 (ΔA_{CP}) and isospin asymmetry (Δ_{0-})

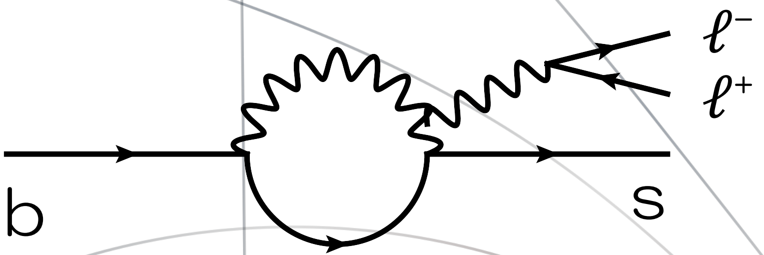




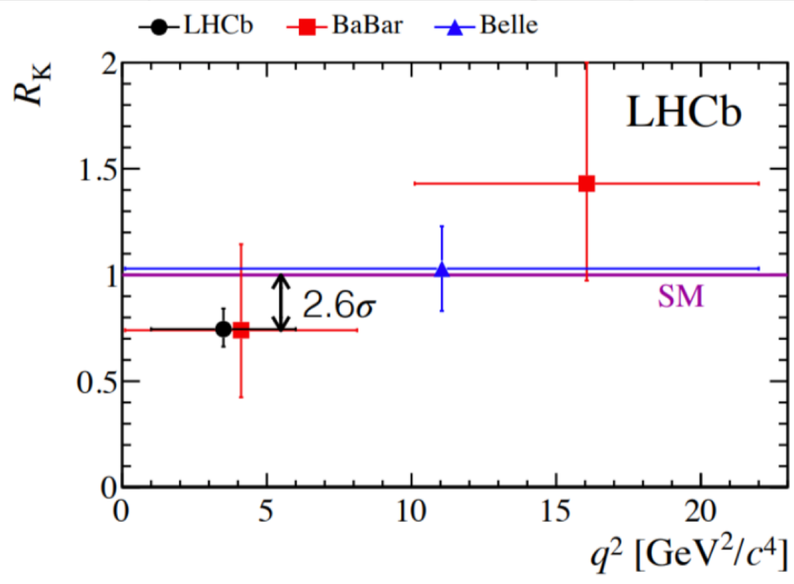


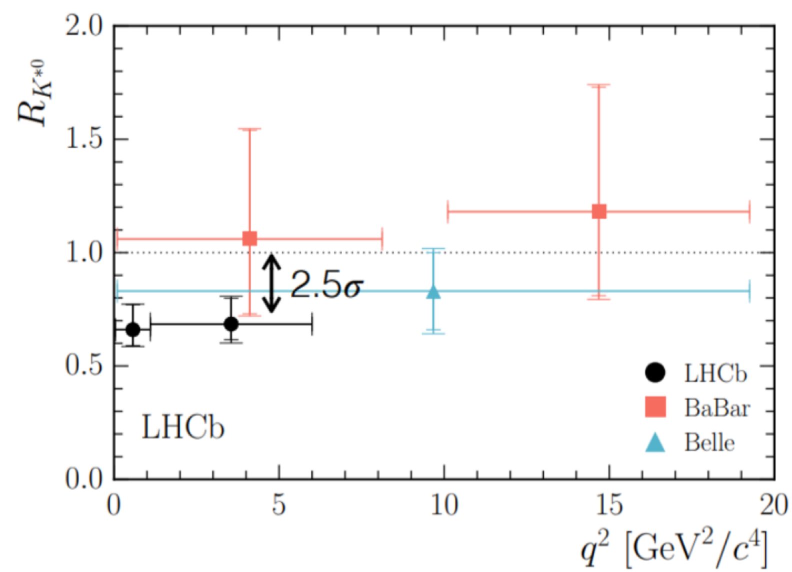
$B \to K^* l^+ l^-$
($K^+\pi^0$, $K_S{}^0\pi^+$, $K^+\pi^-$, $K_S{}^0\pi^0$)

$R_{K^{(*)}}$ measurements



$$R_{K^{(*)}} = \frac{\int \frac{d\Gamma}{dq^2}(B \to K^{(*)}\mu^+\mu^-)dq^2}{\int \frac{d\Gamma}{dq^2}(B \to K^{(*)}e^+e^-)dq^2} \approx 1(SM)$$





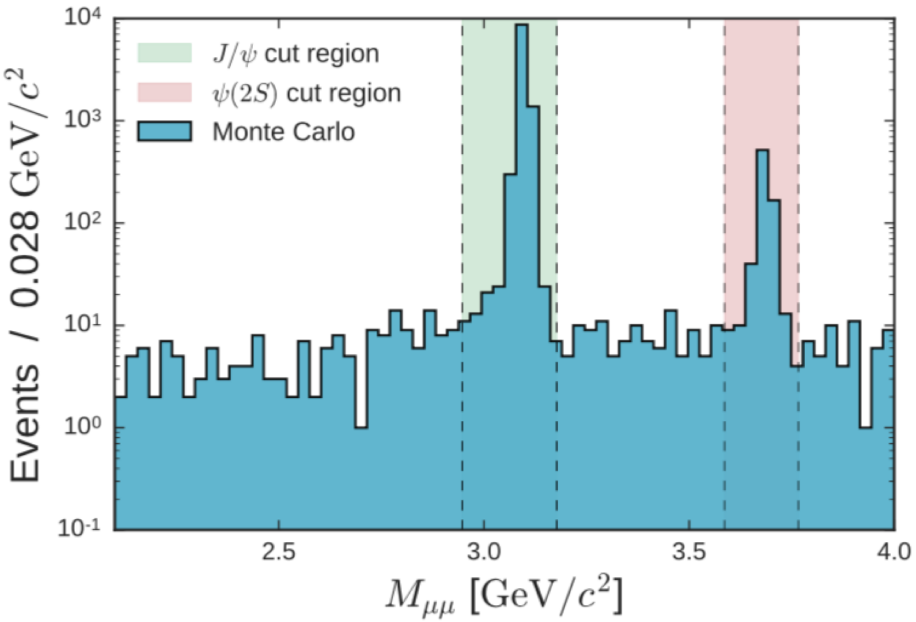
- LHCb showing anomaly of lepton flavor universality.
  - Even after combined data with 2fb^{-1} of Run-2 data, R_K is still below SM expectation at the level of 2.5σ.
- Belle measurement was done by partial data in whole q^2 region.

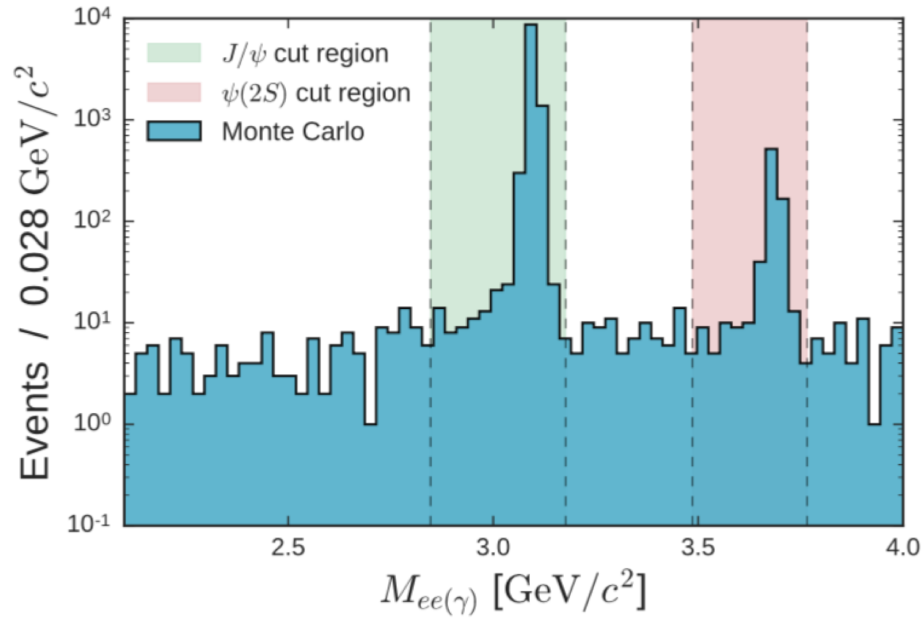
→ Update is needed

BG of $K^*l^+l^-$

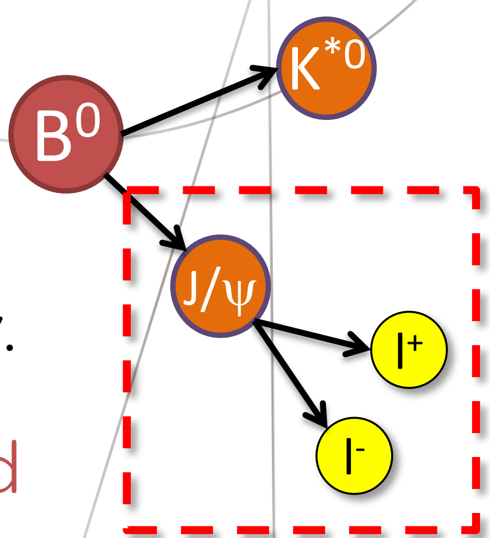
- **Continuum**
  - $q\bar{q}$ BG
  - Back to back jet-like events
- **Combinatorial**
  - Wrong combination of tracks in B decays
  - Dominant source of BG
- **Peaking**
  - Charmonium BG($J/\psi K^*$ and $\psi(2S)K^*$) leakage after veto
  - Double miss-identified BG of $K^*\pi^+\pi^-$
- **Cross-feed**
  - Miss reconstruction of children particles
  - Treated as systematic uncertainty

Charmonium veto



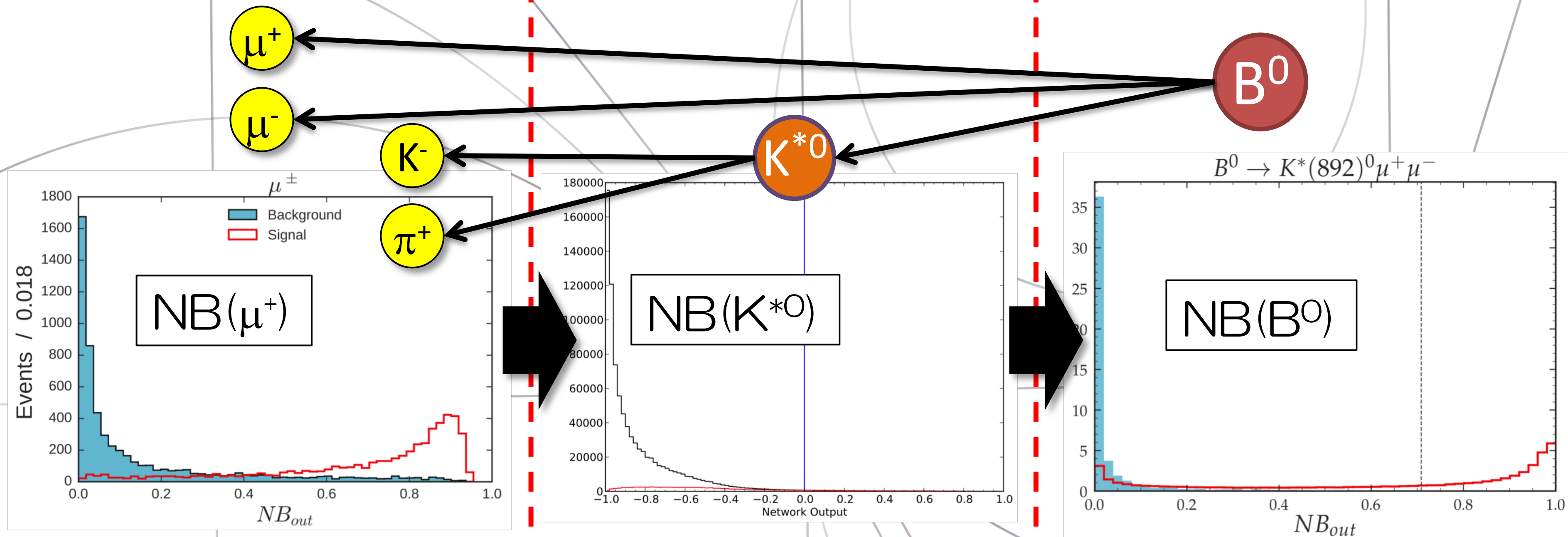


- $K^*J/\psi(l^+l^-)$ and $K^*\psi(2S)(l^+l^-)$ are irreducible.
  - Above regions are rejected (**charmonium veto**).
  - In $K^*e^+e^-$ mode, the veto was applied both before and after bremsstrahlung recovery.
- The veto region would be used as sideband to determine signal shape and evaluate data/MC discrepancy.



BG suppression with Neural Network

1st stage | 2nd stage | Final stage



1st stage
- Kinematic variables
- Particle ID information

etc.

2nd stage
- P_{tot} of children
- Product of NB_{child}
- χ^2 of vertex fit

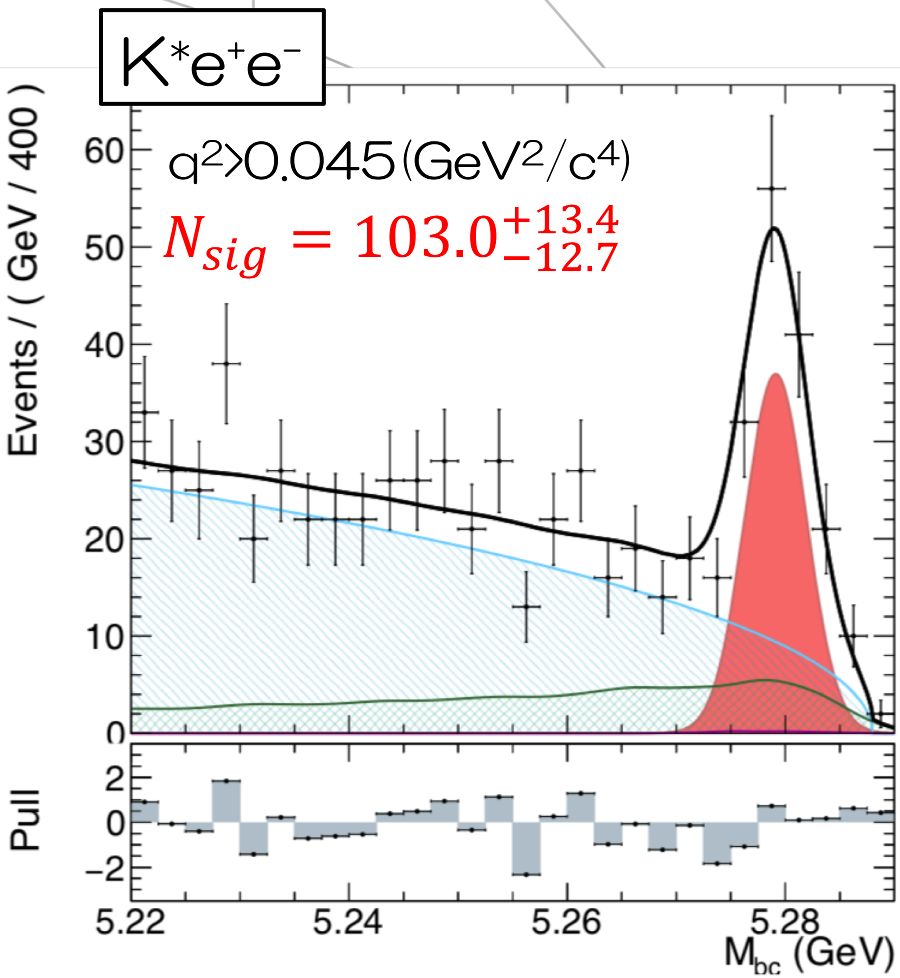
etc.

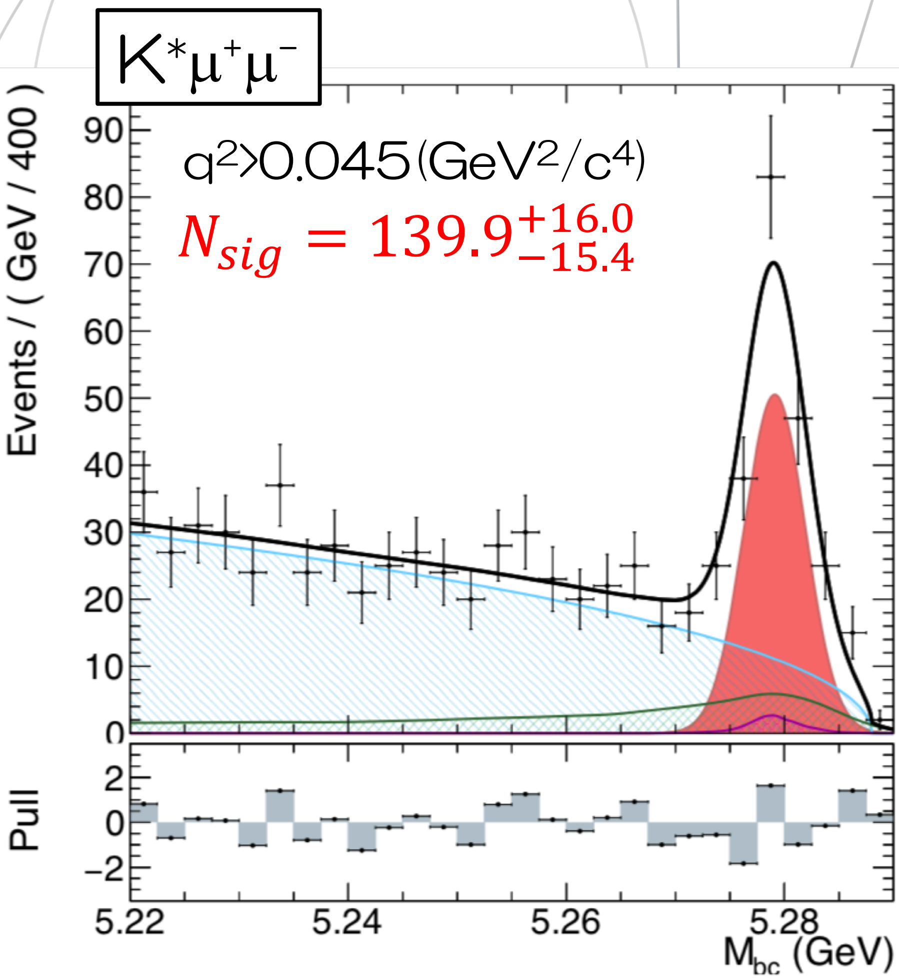
Final stage
- Super Fox-Wolfram moments(KSFW)
- Product of NB_{child}
- Distance b/w l^+l^- (Δ_{zll})

etc.

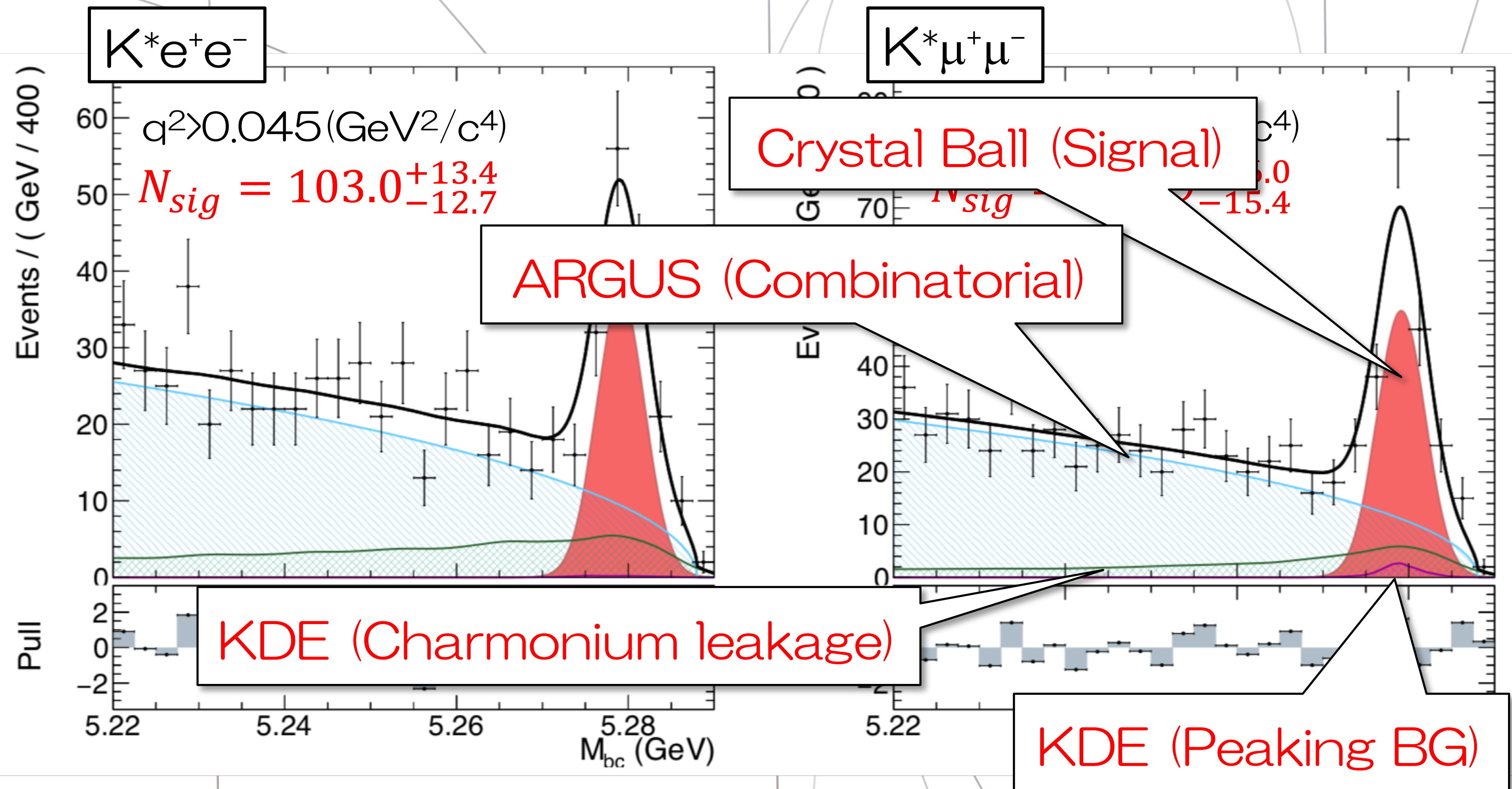
The candidate with the largest NB output was selected as the best.
(2 candidates per event on average)

Fitting of $K^*l^+l^-$





Fitting of K*l+l−



- Signal yields, ARGUS yields and shape parameters are floated.
- Other parameters are determined by vetoed q^2 sideband and MC.

※ KDE=
Kernel Density Estimation

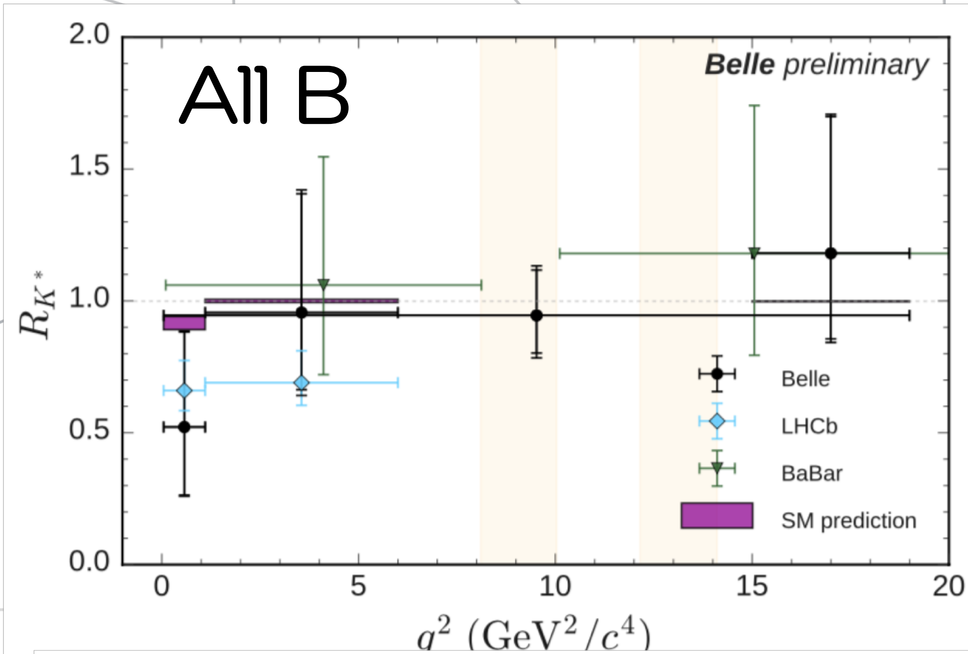
Systematic uncertainty

TABLE I. Systematic uncertainties on R_{K^*} for different q^2 regions.

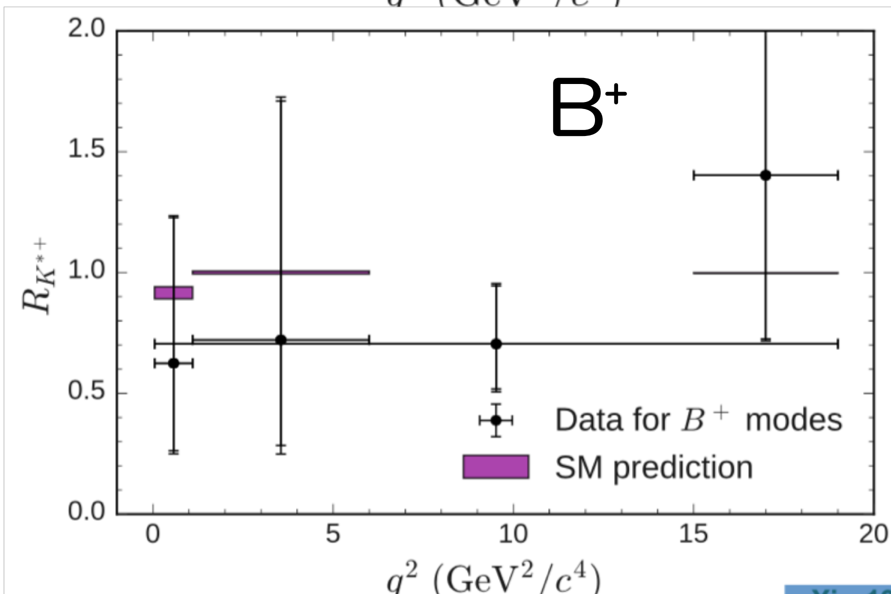
q^2 in GeV^2/c^4	e, μ eff.	MC size	Classifier	Sig. shape	Tracking	Peaking bkg.	$c\bar{c}$ bkg.	Total
all modes								
[0.045, None]	0.061	0.004	0.013	0.008	0.016	0.031	0.023	0.075
[0.1, 8]	0.058	0.005	0.029	0.002	0.016	0.054	0.051	0.100
[15, 19]	0.090	0.012	0.012	0.014	0.020	0.003	0.003	0.095
[0.045, 1.1]	0.027	0.006	0.008	0.025	0.009	0.026	0.001	0.047
[1.1, 6]	0.065	0.008	0.048	0.033	0.017	0.070	0.013	0.114
B^0 modes								
[0.045, None]	0.073	0.006	0.030	0.018	0.022	0.031	0.021	0.092
[0.1, 8]	0.058	0.006	0.040	0.019	0.017	0.033	0.018	0.084
[15, 19]	0.091	0.013	0.007	0.012	0.022	0.007	0.001	0.096
[0.045, 1.1]	0.024	0.007	0.044	0.005	0.009	0.049	0.001	0.071
[1.1, 6]	0.082	0.010	0.040	0.062	0.021	0.070	0.012	0.133
B^+ modes								
[0.045, None]	0.044	0.005	0.032	0.018	0.010	0.025	0.023	0.068
[0.1, 8]	0.060	0.010	0.039	0.040	0.014	0.048	0.107	0.144
[15, 19]	0.089	0.028	0.016	0.041	0.021	0.008	0.002	0.106
[0.045, 1.1]	0.033	0.013	0.067	0.060	0.009	0.006	0.000	0.097
[1.1, 6]	0.045	0.010	0.137	0.060	0.011	0.086	0.009	0.179

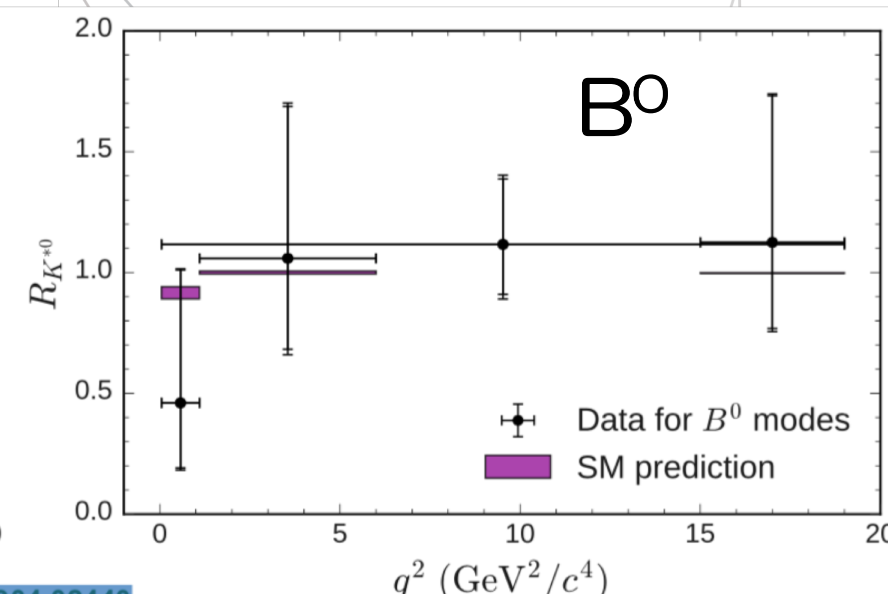
- The most dominant contribution comes from lepton efficiency uncertainty caused by correction of data/MC difference of lepton ID.
  - The correction is studied with ee → ee ee(μμ) sample.

Results of R_{K*}



- Consistent with both SM and LHCb, BaBar results.
- Statistical uncertainty dominant.
- This is the first result of R_{K*+} measurements.





arXiv:1904.02440

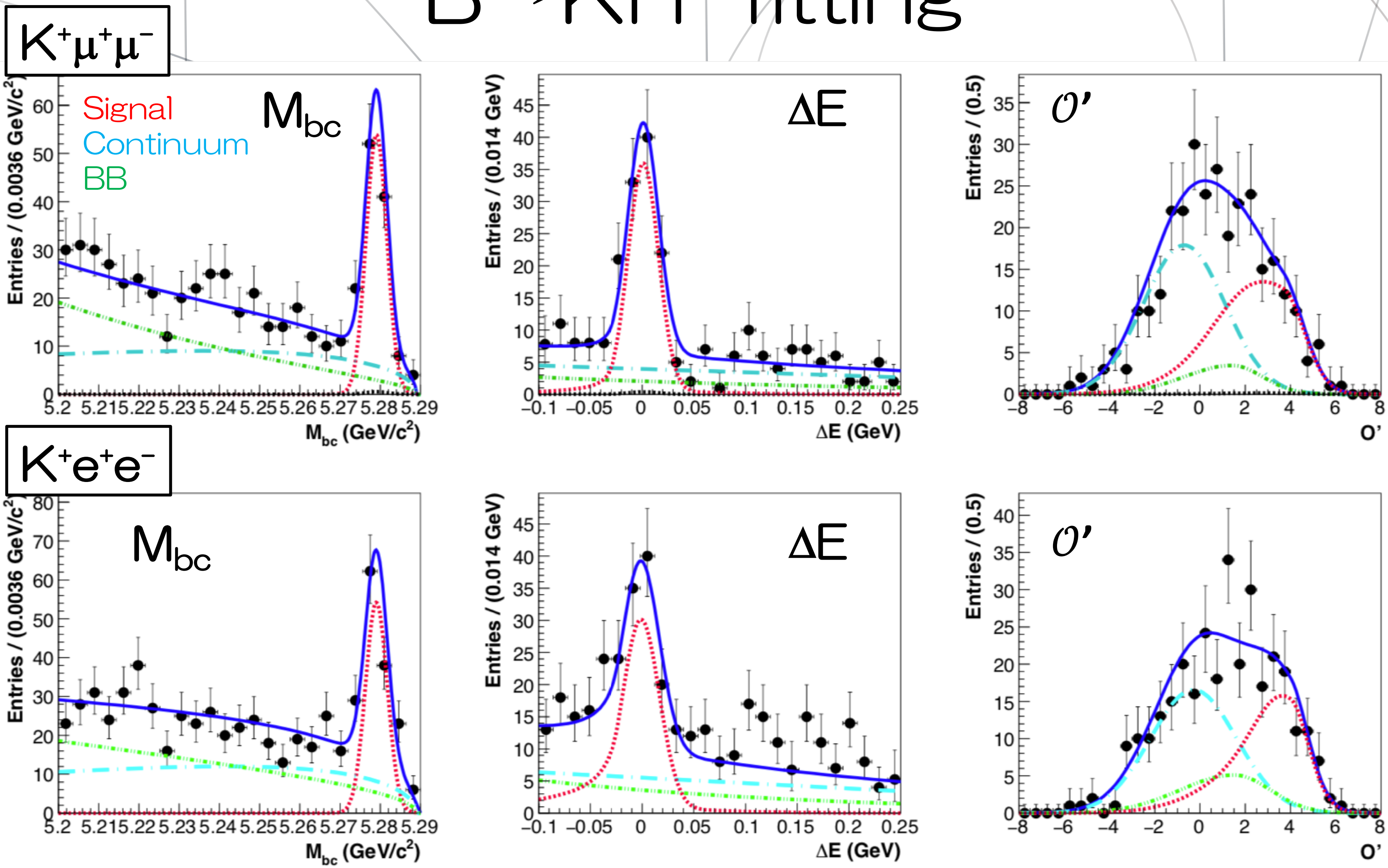
$B \to K l^+ l^-$
$(K = K_S^0, K^+)$

Analytical procedure $B \to K l^+ l^-$

- Selection criteria is changed
  - The values are optimized for Kl+l-
  - Different inputs for neural network to optimize sensitivity
- D veto
  - To suppress $B^- \to D^0(K^- \pi^+)\pi^-$ with double misidentification, which mimics signal
  - $M[K^+\mu^-] \notin (1.85, 1.88)$ GeV/c^2
- Additional J/ψ veto
  - To suppress $B^- \to K^- J/\psi(\mu^+\mu^-)$ with double misidentification($K^- \to \mu^-$, $\mu^- \to K^-$)
  - $M[K^+\mu^-] \notin (3.06, 3.13)$ GeV/c^2
- Fitting
  - 3 dimensional fit(M_{bc}, ΔE, $\mathcal{O}'$)

※ $\mathcal{O}' \equiv \log\left[\frac{\mathcal{O}-\mathcal{O}_{min}}{\mathcal{O}_{max}-\mathcal{O}}\right]$ is transformed Neural Network output for distribution modeling.

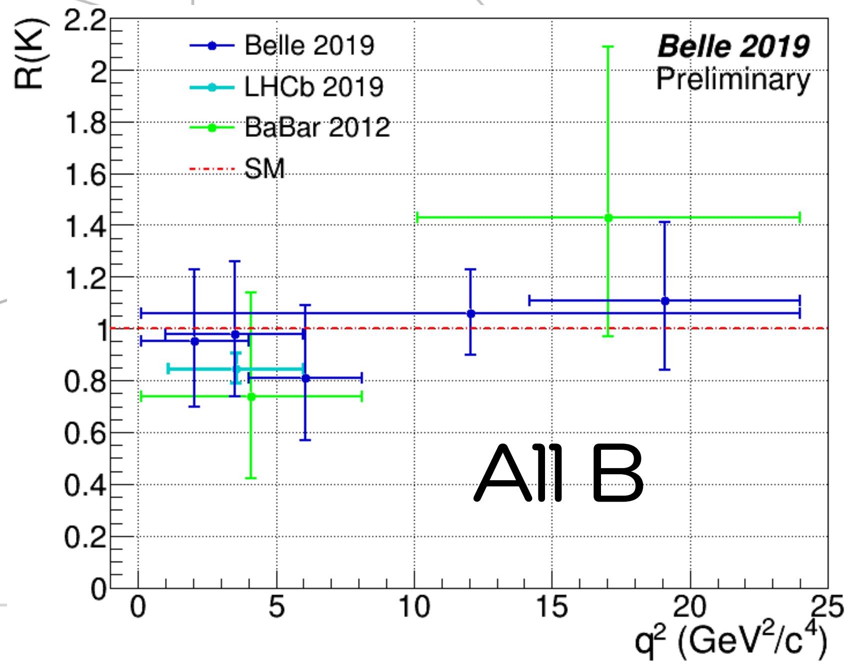
B→Kl$^+$l$^-$ fitting



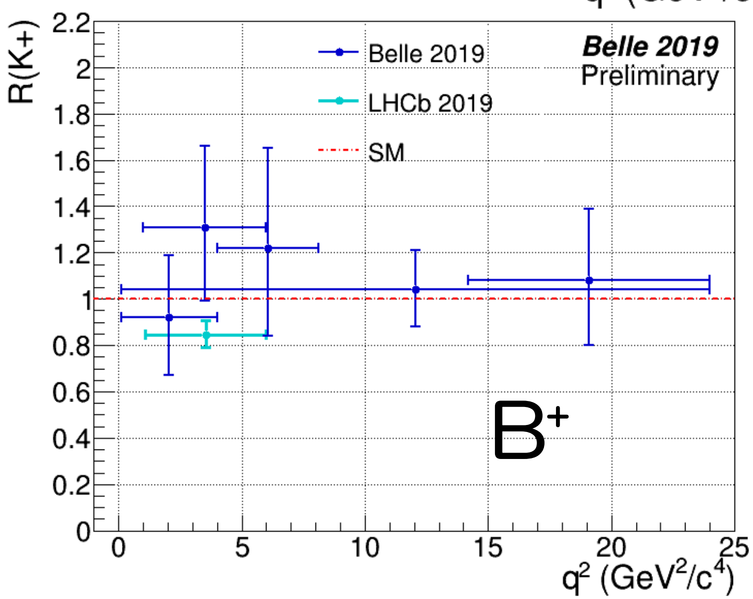
Signal enhanced distributions.

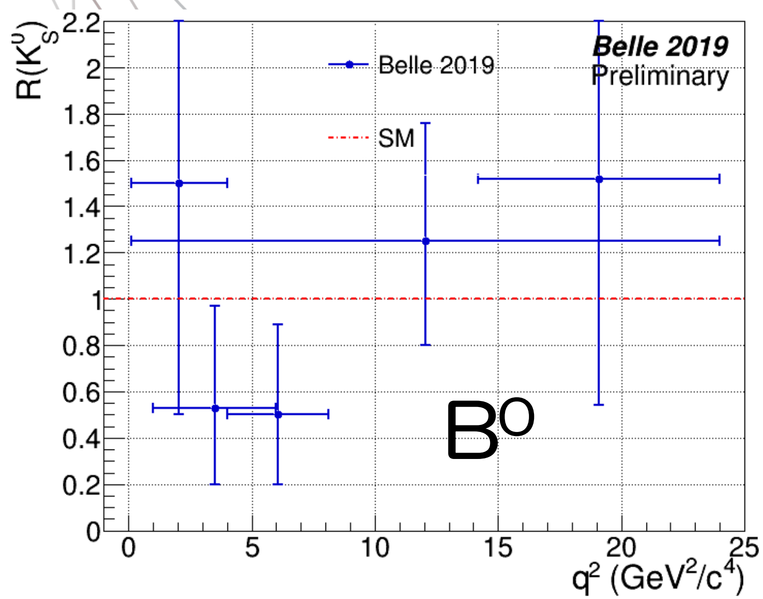
K$_S$l$^+$l$^-$ mode is as well.

Results of R_K

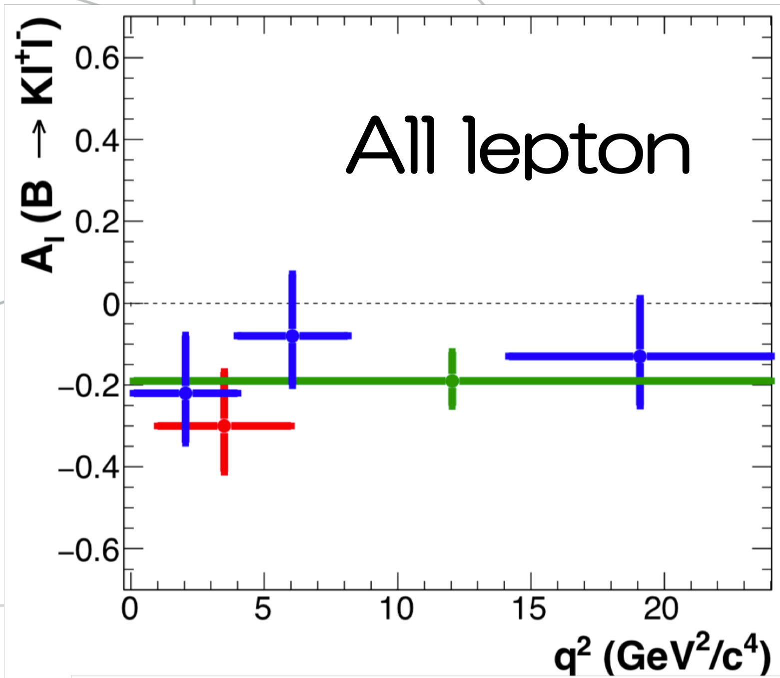


- Consistent with both SM and LHCb.
- Statistical uncertainty dominant.

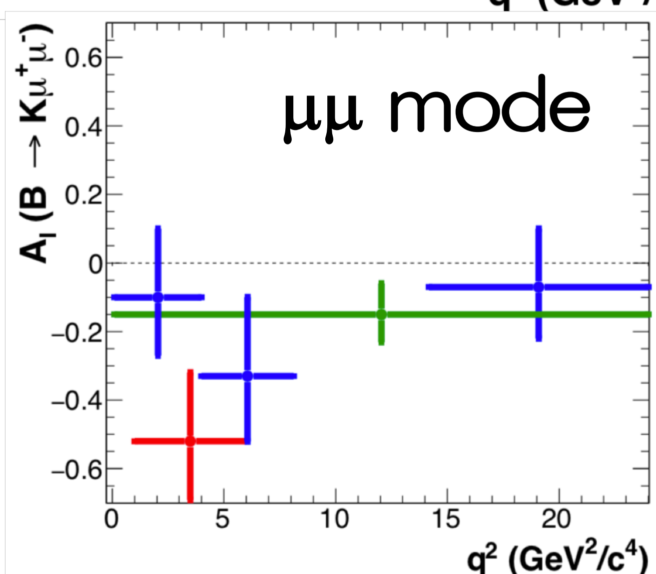


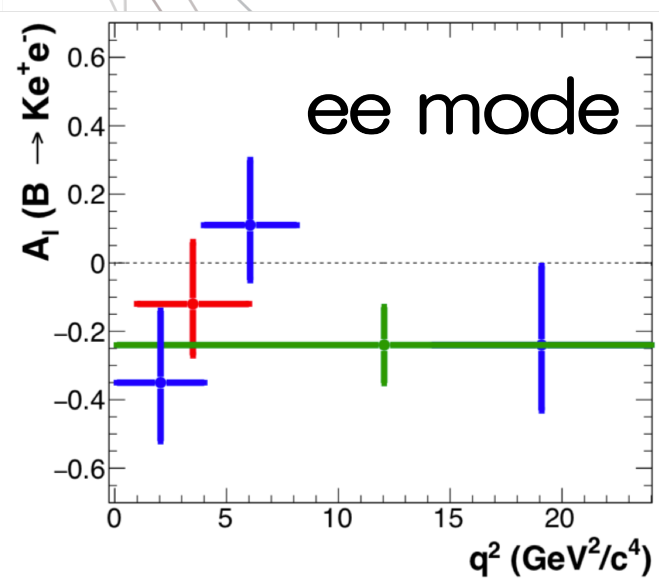


Results of A_l



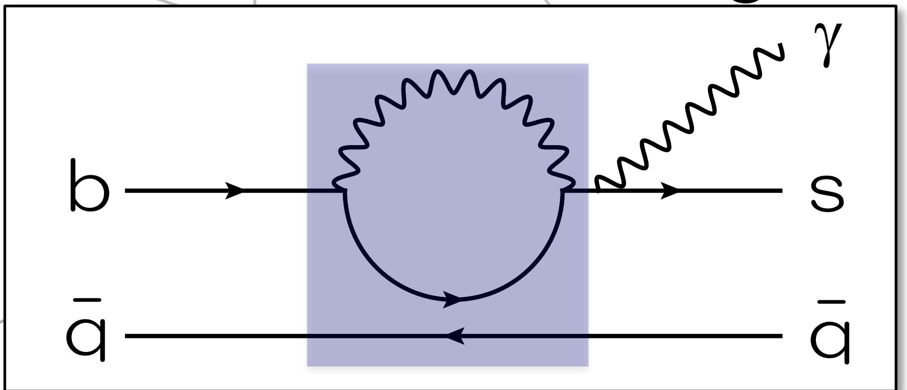
- Systematic deviation observed, which is consistent with recent measurement.
- $A_l(B \to K\mu^+\mu^-)$ in q^2(1.0, 6.0) GeV^2/c^4 deviates from 0 by 2.7σ.





$B \to X_s \gamma$

$B \to X_s \gamma$ in the Belle



- $b \to s\gamma$ is sensitive to NP contribution in the loop.
- Sum-of-exclusive = reconstruct as many X_s modes as possible

38 modes(~77%) are reconstructed

Tgt.1

$$\Delta A_{CP}(B \to X_s\gamma) \equiv A_{CP}(B^+ \to X_s^+\gamma) - A_{CP}(B^0 \to X_s^0\gamma)$$

$$\approx 4\pi^2\alpha_s \frac{\tilde{\Lambda}_{78}}{m_b} Im\left(\frac{C_8}{C_7}\right) \begin{cases} = 0 \text{ (SM)} \\ \neq 0 \text{ (NP)} \end{cases}$$

- In SM, it is 0%
- NP can enhance up to about 10%
- NULL test is provided

Tgt.2

$$\Delta_{0-}(B \to X_s\gamma) \equiv \frac{\Gamma(B^0 \to X_s^0\gamma) - \Gamma(B^\pm \to X_s^\pm\gamma)}{\Gamma(B^0 \to X_s^0\gamma) + \Gamma(B^\pm \to X_s^\pm\gamma)}$$

For BR($B \to X_s\gamma$) theory uncertainty reduction by $\frac{\Delta B_{s\gamma}^{RP78}}{B_{s\gamma}} \approx -\frac{1}{3}\Delta_{0-}$

Analysis

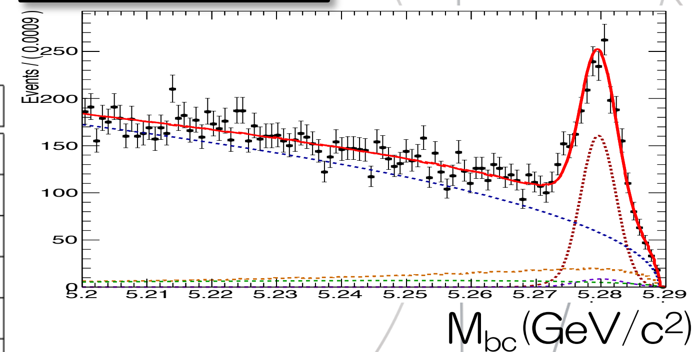
1. Reconstruction

Mode ID	Final state	Mode ID	Final state	Mode ID	Final state
1	$K^+\pi^-$	14	$K_S\pi^+\pi^+\pi^-\pi^-$	27	$K^+\eta\pi^0$
2	$K_S\pi^+$	15	$K^+\pi^+\pi^-\pi^-\pi^0$	28	$K_S\eta\pi^0$
3	$K^+\pi^0$	16	$K_S\pi^+\pi^+\pi^-\pi^0$	29	$K^+\eta\pi^+\pi^-$
4	$K_S\pi^0$	17	$K^+\pi^0\pi^0$	30	$K_S\eta\pi^+\pi^-$
5	$K_+\pi^+\pi^-$	18	$K_S\pi^0\pi^0$	31	$K^+\eta\pi^-\pi^0$
6	$K_S\pi^+\pi^-$	19	$K^+\pi^-\pi^0\pi^0$	32	$K_S\eta\pi^+\pi^0$
7	$K^+\pi^-\pi^0$	20	$K_S\pi^+\pi^0\pi^0$	33	$K^+K^+K^-$
8	$K_S\pi^+\pi^0$	21	$K^+\pi^+\pi^-\pi^0\pi^0$	34	$K^+K^-K_S$
9	$K^+\pi^+\pi^-\pi^-$	22	$K_S\pi^+\pi^-\pi^0\pi^0$	35	$K^+K^+K^-\pi^-$
10	$K_S\pi^+\pi^-\pi^-$	23	$K^+\eta$	36	$K^+K^-K_S\pi^+$
11	$K^+\pi^+\pi^-\pi^0$	24	$K_S\eta$	37	$K^+K^+K^-\pi^0$
12	$K_S\pi^+\pi^-\pi^0$	25	$K^+\eta\pi^-$	38	$K^+K^-K_S\pi^0$
13	$K^+\pi^+\pi^+\pi^-\pi^-$	26	$K_S\eta\pi^+$		

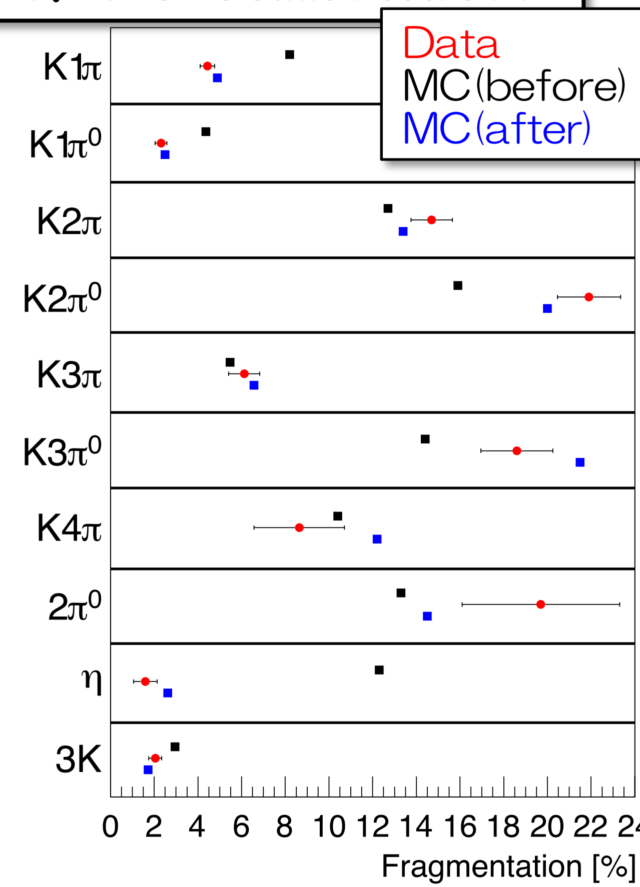
2. BG rejection

	Signal	CF	qq	BB BG
Rec.	45,786	106,599	7,524,916	905,933
π^0/η veto	30,385	61,202	1,316,842	239,962
D veto	29,256	50,344	1,032,962	173,099
NN	14,847	7,241	16,050	37,938
BCS	13,189	3,924	11,917	5,158
Eff.	28.8%	3.7%	0.2%	0.6%

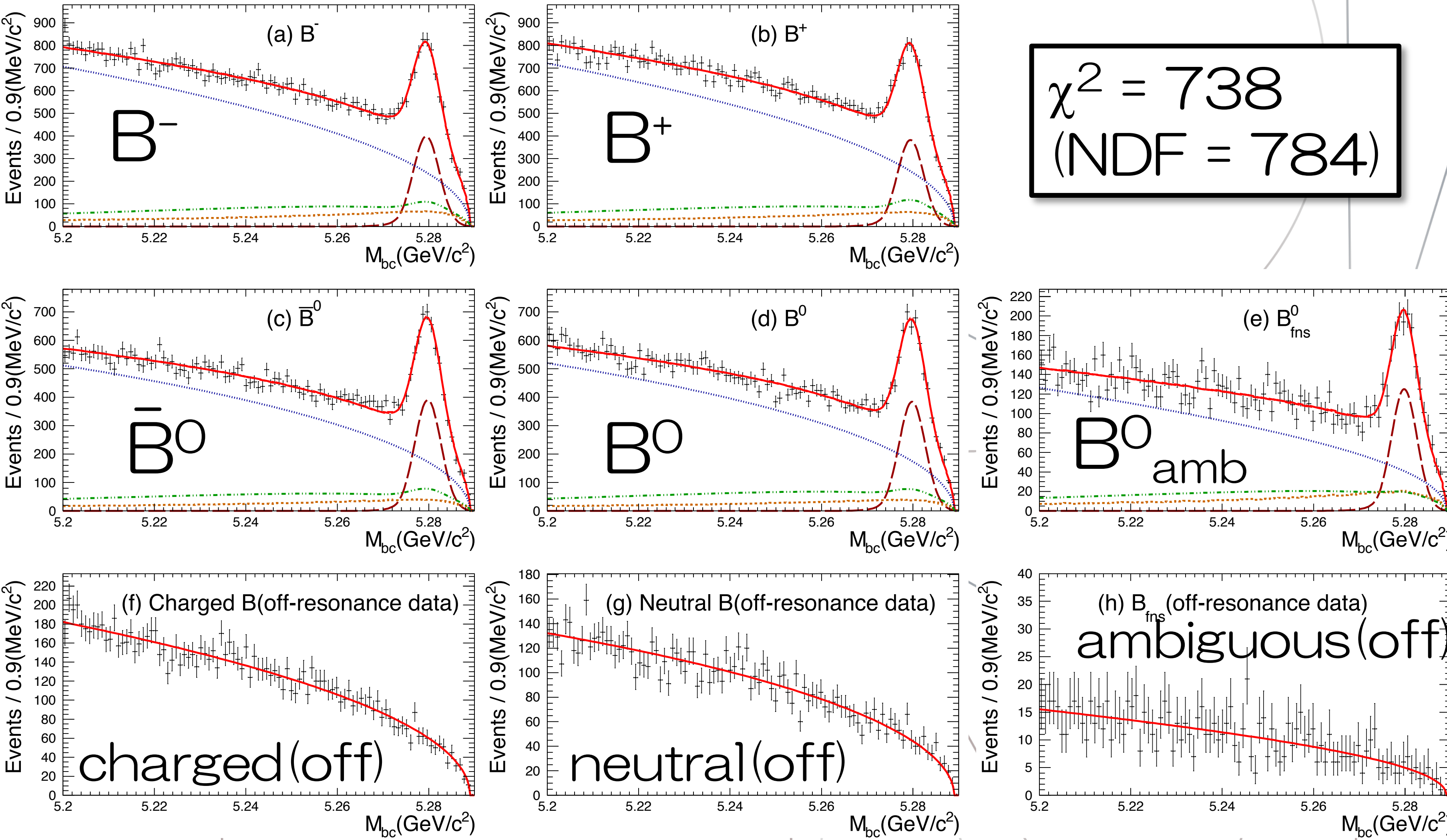
3. Fitting



4. MC calibration



Simultaneous Fitting for Asym.

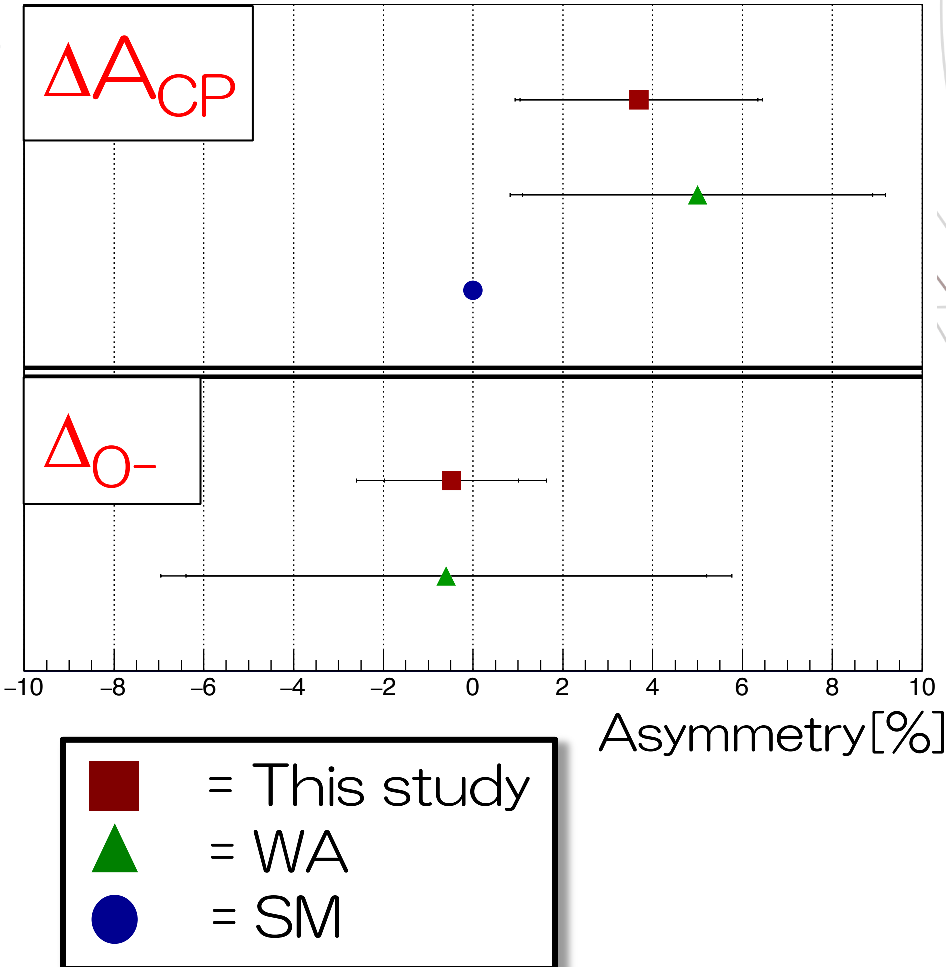


$\chi^2 = 738$
(NDF = 784)

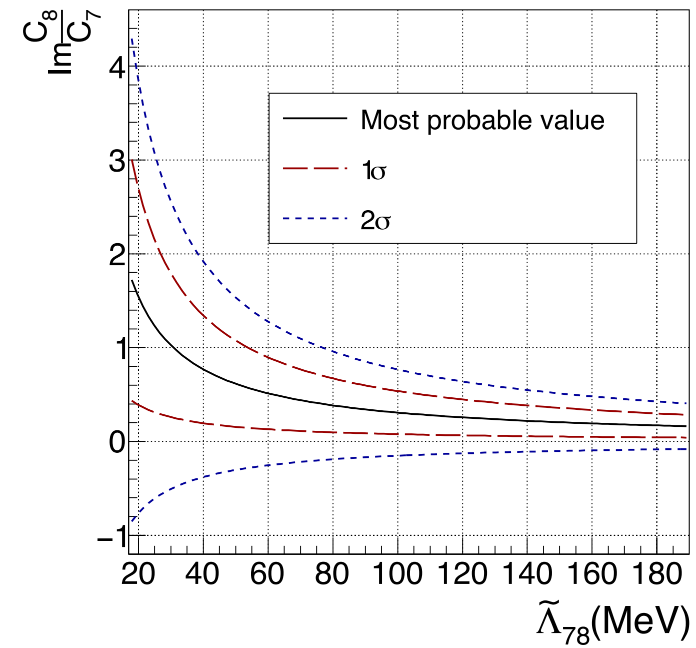
Results

※ BaBar : ΔA_{CP} by 429fb^{-1}
Δ_{0-} by 89.1fb^{-1}

Obs.	Our results(711fb^{-1})	World Average (BaBar)
ΔA_{CP}	$(3.69 \pm 2.65 \pm 0.76)\%$	$(5.0 \pm 3.9 \pm 1.5)\%$
Δ_{0-}	$(-0.48 \pm 1.49 \pm 0.97 \pm 1.15)\%$	$(-0.6 \pm 5.8 \pm 2.6)\%$



1.



2. $$\frac{\Delta BR^{RP78}_{s\gamma}}{BR_{s\gamma}} \approx -\frac{1 \pm 0.3}{3}\Delta_{0-}$$

→ evaluated 1.45%
which is smaller than others.

Summary

- $B \to K^{(*)} l^+ l^-$ study for the test of lepton universality $R_{K(*)}$ in several q^2 bins.
  - The results are all consistent with SM and LHCb.
  - Statistical uncertainty dominant.
- Isospin asymmetries are measured as well.
  - $A_I(B \to K\mu^+\mu^-)$ in $q^2(1.0, 6.0)$ GeV^2/c^4 is below 0 at the level of 2.7σ.

- $B \to X_s\gamma$ study for CP asymmetry difference ΔA_{CP} and isospin asymmetry Δ_{0-}.
  - ΔA_{CP} is consistent with both SM and BaBar, and limit $Im(C_8/C_7)$.
  - Δ_{0-} is consistent with 0 in high accuracy, which indicates small theoretical uncertainty ΔBR^{78} caused by resolved photon.


Thank you for listening!!

Backup

Particle selection criteria (K*l+l-)

Particle	Selection
Charged tracks	$\|dr\| < 1.0$ cm
	$\|dz\| < 5.0$ cm
	$p_T < 10.0$ GeV/c
$e^{\pm}$ candidate	$P_{eid}(e) > 0.9$
	$p_{lab} > 0.4$ GeV/c
	Bremsstrahlung recovery (in 0.05 rad.)
$\mu^{\pm}$ candidate	$p_{muid}(\mu) > 0.9$
	$p_{lab} > 0.7$ GeV/c
$K^{\pm}$ candidate	$P(K/\pi) > 0.1$
$\pi^{\pm}$ candidate	No selection
K_s candidate	good Ks
π^0 candidate	$E_\gamma > 30$ MeV
	$M_{\gamma\gamma} \in (115, 153)$ MeV/c^2

Exact values

	R_K	q^2	R_{K^*}	q^2
LHCb	$0.846^{+0.060}_{-0.054}{}^{+0.016}_{-0.014}$	(1.1, 6)	$0.66^{+0.11}_{-0.07} \pm 0.03$	(0.045, 1.1)
			$0.69^{+0.11}_{-0.07} \pm 0.05$	(1.1, 6)
BaBar	$0.74^{+0.40}_{-0.31} \pm 0.06$	(0.1, 8.12)	$1.06^{+0.48}_{-0.33} \pm 0.10$	(0.1, 8.12)
	$1.43^{+0.65}_{-0.44} \pm 0.12$	>10.11	$1.18^{+0.55}_{-0.37} \pm 0.11$	>10.11

TABLE I. Result for the branching fractions in $[10^{-7}]$ in the corresponding q^2 range in GeV^2/c^4.

Mode	$q^2 > 0.045$	$q^2 \in [0.1, 8]$	$q^2 \in [15, 19]$
$\mathcal{B}(B^0 \to K^{*0}\mu^+\mu^-)$	$10.3^{+1.3}_{-1.3} \pm 0.9$	$3.2^{+0.8}_{-0.8} \pm 0.3$	$2.2^{+0.5}_{-0.4} \pm 0.1$
$\mathcal{B}(B^0 \to K^{*0}e^+e^-)$	$9.2^{+1.6}_{-1.6} \pm 0.7$	$3.7^{+0.9}_{-0.9} \pm 0.4$	$2.0^{+0.6}_{-0.5} \pm 0.1$
$\mathcal{B}(B^+ \to K^{*+}\mu^+\mu^-)$	$9.9^{+2.4}_{-2.3} \pm 1.0$	$4.4^{+1.6}_{-1.4} \pm 0.4$	$2.9^{+1.0}_{-0.8} \pm 0.2$
$\mathcal{B}(B^+ \to K^{*+}e^+e^-)$	$14.1^{+3.1}_{-2.8} \pm 1.6$	$4.6^{+1.6}_{-1.5} \pm 0.7$	$2.1^{+1.2}_{-1.0} \pm 0.1$

BR($B \to K^* l^+ l^-$)

TABLE II. Result for R_{K^*}, $R_{K^{*0}}$ and $R_{K^{*+}}$. The first error is statistical and the second total systematic uncertainty.

q^2 in GeV^2/c^4	All modes	B^0 modes	B^+ modes
> 0.045	$0.94^{+0.17}_{-0.14} \pm 0.08$	$1.12^{+0.27}_{-0.21} \pm 0.09$	$0.70^{+0.24}_{-0.19} \pm 0.06$
$[0.1, 8]$	$0.90^{+0.27}_{-0.21} \pm 0.10$	$0.86^{+0.33}_{-0.24} \pm 0.08$	$0.96^{+0.56}_{-0.35} \pm 0.14$
$[15, 19]$	$1.18^{+0.52}_{-0.32} \pm 0.08$	$1.12^{+0.61}_{-0.36} \pm 0.09$	$1.40^{+1.99}_{-0.68} \pm 0.10$
$[0.045, 1.1]$	$0.52^{+0.36}_{-0.26} \pm 0.06$	$0.46^{+0.55}_{-0.27} \pm 0.07$	$0.62^{+0.60}_{-0.36} \pm 0.07$
$[1.1, 6]$	$0.96^{+0.45}_{-0.29} \pm 0.10$	$1.06^{+0.63}_{-0.38} \pm 0.12$	$0.72^{+0.99}_{-0.44} \pm 0.12$

R_{K^*}

Exact values

TABLE I: Results from the fits. The columns correspond to the q^2 bin size, decay modes, reconstruction efficiency, signal yield, branching fraction, lepton-flavor-separated and combined A_I and R_K.

q^2 (GeV^2/c^4)	Mode	ε (%)	N_{sig}	$\mathcal{B}$ (10^{-7})	A_I (individual)	A_I (combined)	R_K (individual)	R_K (combined)
(0.1,4.0)	$B^+ \to K^+\mu^+\mu^-$	20.8	$28.4^{+6.6}_{-5.9}$	$1.72^{+0.4}_{-0.4} \pm 0.08$	$A_I(\mu\mu) =$	$-0.22^{+0.14}_{-0.12} \pm 0.01$	$R_{K^+} =$	$0.95^{+0.27}_{-0.24} \pm 0.06$
	$B^0 \to K^0_S\mu^+\mu^-$	14.7	$6.8^{+3.3}_{-2.6}$	$0.62^{+0.30}_{-0.23} \pm 0.03$	$-0.10^{+0.20}_{-0.17} \pm 0.01$		$0.92^{+0.27}_{-0.24} \pm 0.05$	
	$B^+ \to K^+e^+e^-$	27.8	$41.5^{+7.7}_{-7.0}$	$1.88^{+0.35}_{-0.31} \pm 0.08$	$A_I(ee) =$		$R_{K^0_S} =$	
	$B^0 \to K^0_Se^+e^-$	18.4	$5.5^{+3.6}_{-2.7}$	$0.40^{+0.26}_{-0.21} \pm 0.02$	$-0.35^{+0.21}_{-0.17} \pm 0.01$		$1.5^{+1.2}_{-1.0} \pm 0.1$	
(4.0,8.12)	$B^+ \to K^+\mu^+\mu^-$	29.2	$28.4^{+6.4}_{-5.7}$	$1.2^{+0.3}_{-0.2} \pm 0.06$	$A_I(\mu\mu) =$	$-0.08^{+0.15}_{-0.12} \pm 0.01$	$R_{K^+} =$	$0.81^{+0.28}_{-0.23} \pm 0.05$
	$B^0 \to K^0_S\mu^+\mu^-$	20.8	$4.2^{+4.2}_{-3.5}$	$0.27^{+0.18}_{-0.13} \pm 0.02$	$-0.33^{+0.23}_{-0.19} \pm 0.01$		$1.22^{+0.42}_{-0.37} \pm 0.07$	
	$B^+ \to K^+e^+e^-$	33.9	$26.9^{+6.9}_{-6.1}$	$1.00^{+0.26}_{-0.23} \pm 0.04$	$A_I(ee) =$		$R_{K^0_S} =$	
	$B^0 \to K^0_Se^+e^-$	22.8	$9.3^{+3.7}_{-3.0}$	$0.54^{+0.22}_{-0.18} \pm 0.03$	$0.11^{+0.19}_{-0.16} \pm 0.01$		$0.50^{+0.39}_{-0.30} \pm 0.03$	
(1.0,6.0)	$B^+ \to K^+\mu^+\mu^-$	23.5	$42.3^{+7.6}_{-6.9}$	$2.3^{+0.4}_{-0.4} \pm 0.1$	$A_I(\mu\mu) =$	$-0.30^{+0.13}_{-0.11} \pm 0.01$	$R_{K^+} =$	$0.98^{+0.27}_{-0.23} \pm 0.06$
	$B^0 \to K^0_S\mu^+\mu^-$	16.7	$3.9^{+2.7}_{-2.0}$	$0.31^{+0.22}_{-0.16} \pm 0.02$	$-0.52^{+0.20}_{-0.17} \pm 0.02$		$1.31^{+0.34}_{-0.31} \pm 0.07$	
	$B^+ \to K^+e^+e^-$	30.4	$41.7^{+8.0}_{-7.2}$	$1.74^{+0.33}_{-0.30} \pm 0.08$	$A_I(ee) =$		$R_{K^0_S} =$	
	$B^0 \to K^0_Se^+e^-$	20.1	$8.9^{+4.0}_{-3.2}$	$0.59^{+0.27}_{-0.21} \pm 0.03$	$-0.12^{+0.18}_{-0.15} \pm 0.01$		$0.53^{+0.44}_{-0.33} \pm 0.03$	
> 14.18	$B^+ \to K^+\mu^+\mu^-$	45.3	$47.9^{+8.6}_{-7.8}$	$1.34^{+0.24}_{-0.22} \pm 0.06$	$A_I(\mu\mu) =$	$-0.13^{+0.14}_{-0.12} \pm 0.01$	$R_{K^+} =$	$1.11^{+0.29}_{-0.26} \pm 0.07$
	$B^0 \to K^0_S\mu^+\mu^-$	25.3	$9.6^{+4.2}_{-3.5}$	$0.51^{+0.22}_{-0.18} \pm 0.03$	$-0.07^{+0.17}_{-0.15} \pm 0.01$		$1.08^{+0.30}_{-0.27} \pm 0.06$	
	$B^+ \to K^+e^+e^-$	44.2	$43.2^{+9.1}_{-8.3}$	$1.24^{+0.26}_{-0.24} \pm 0.05$	$A_I(ee) =$		$R_{K^0_S} =$	
	$B^0 \to K^0_Se^+e^-$	23.6	$5.9^{+4.0}_{-3.1}$	$0.33^{+0.23}_{-0.18} \pm 0.02$	$-0.24^{+0.23}_{-0.19} \pm 0.01$		$1.52^{+1.23}_{-0.97} \pm 0.10$	
whole q^2	$B^+ \to K^+\mu^+\mu^-$	27.8	$137.0^{+14.2}_{-13.5}$	$6.24^{+0.65}_{-0.61} \pm 0.31$	$A_I(\mu\mu) =$	$-0.19^{+0.07}_{-0.06} \pm 0.01$	$R_{K^+} =$	$1.06^{+0.15}_{-0.14} \pm 0.07$
	$B^0 \to K^0_S\mu^+\mu^-$	18.2	$27.3^{+6.6}_{-5.9}$	$2.0^{+0.5}_{-0.4} \pm 0.1$	$-0.15^{+0.09}_{-0.08} \pm 0.01$		$1.04^{+0.16}_{-0.15} \pm 0.06$	
	$B^+ \to K^+e^+e^-$	29.1	$138.0^{+15.5}_{-14.7}$	$6.00^{+0.7}_{-0.6} \pm 0.3$	$A_I(ee) =$		$R_{K^0_S} =$	
	$B^0 \to K^0_Se^+e^-$	18.2	$21.8^{+7.0}_{-6.1}$	$1.60^{+0.52}_{-0.45} \pm 0.08$	$-0.24 \pm 0.11 \pm 0.01$		$1.25^{+0.50}_{-0.44} \pm 0.08$	

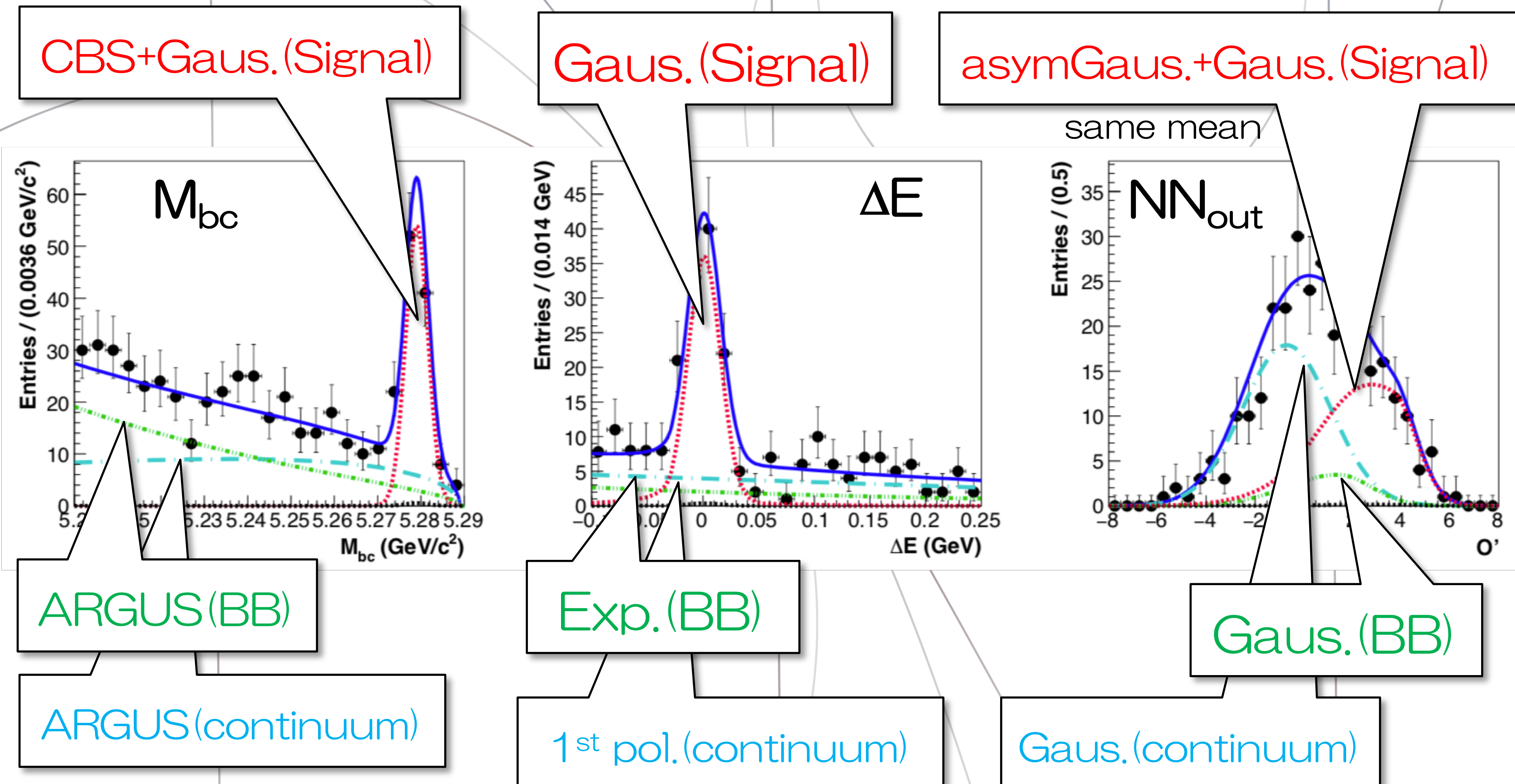
R_K

Systematic uncertainties ($R_{K^{(*)}}$)

- LID distribution difference between data and MC is dominant systematic uncertainty
- Peaking yields
  - Decided by MC.
  - Fluctuate +/-25%(50%) for charmonium leakage(rare decay)
- Less than statistical uncertainty

Fitting

Signal shapes are determined by MC.
(small offset and scale factors, obtained from q^2 sideband, is introduced)

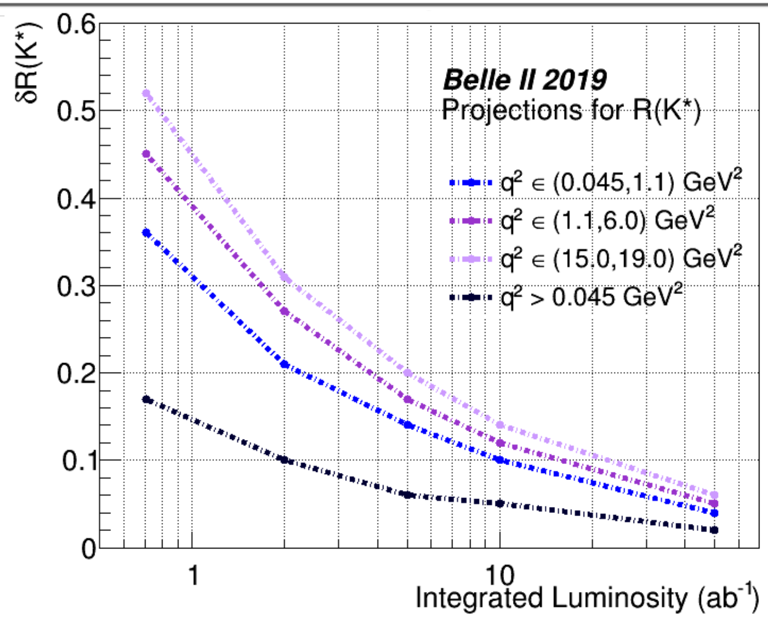


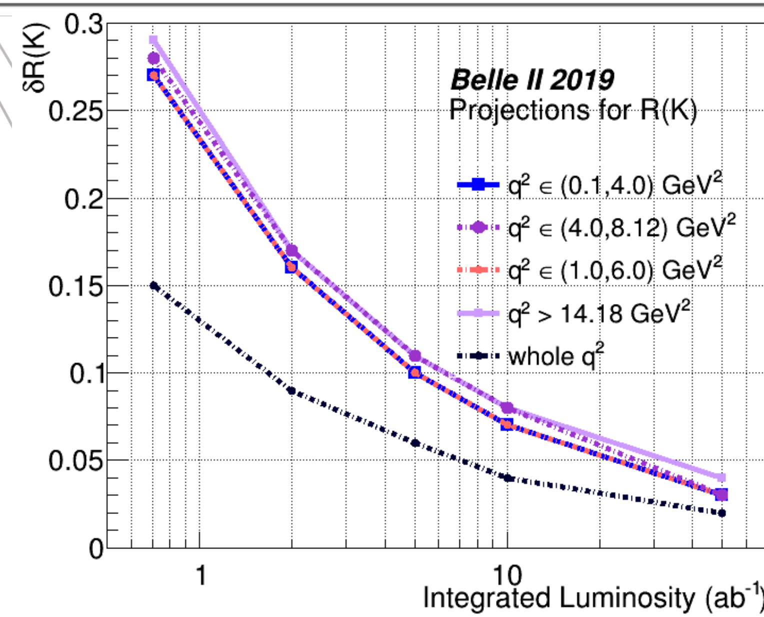
Prospects of b→sl⁺l⁻ in Belle II

FERMILAB-PUB-18-398-T

Observables	Belle $0.71\,ab^{-1}$	Belle II $5\,ab^{-1}$	Belle II $50\,ab^{-1}$
R_K ($[1.0, 6.0]$ GeV^2)	28%	11%	3.6%
R_K (> 14.4 GeV^2)	30%	12%	3.6%
R_{K^*} ($[1.0, 6.0]$ GeV^2)	26%	10%	3.2%
R_{K^*} (> 14.4 GeV^2)	24%	9.2%	2.8%
R_{X_s} ($[1.0, 6.0]$ GeV^2)	32%	12%	4.0%
R_{X_s} (> 14.4 GeV^2)	28%	11%	3.4%

Before recent measurements





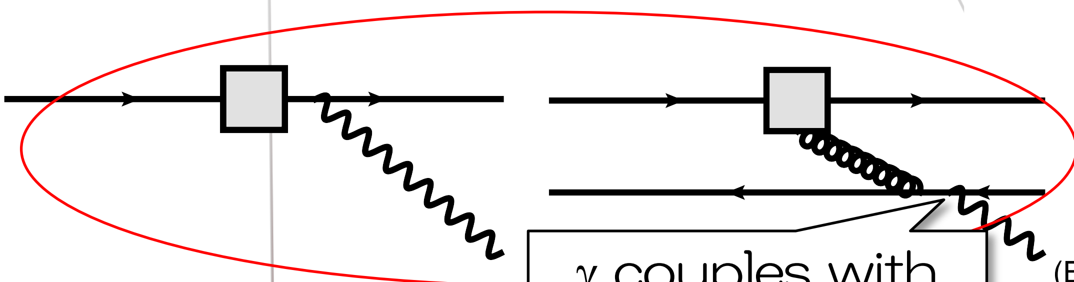
Motivation (Δ_{0-})

BR($B \to X_s\gamma$)

The strong constraint on charged Higgs $H^{\pm}$ in the low tanβ region.

ΔBR_{SM} and $\Delta BR_{ex.}$ are comparable
→ For Belle II, reduction of theoretical uncertainty is needed.

Dominant contribution comes from uncertainty of the resolved photon



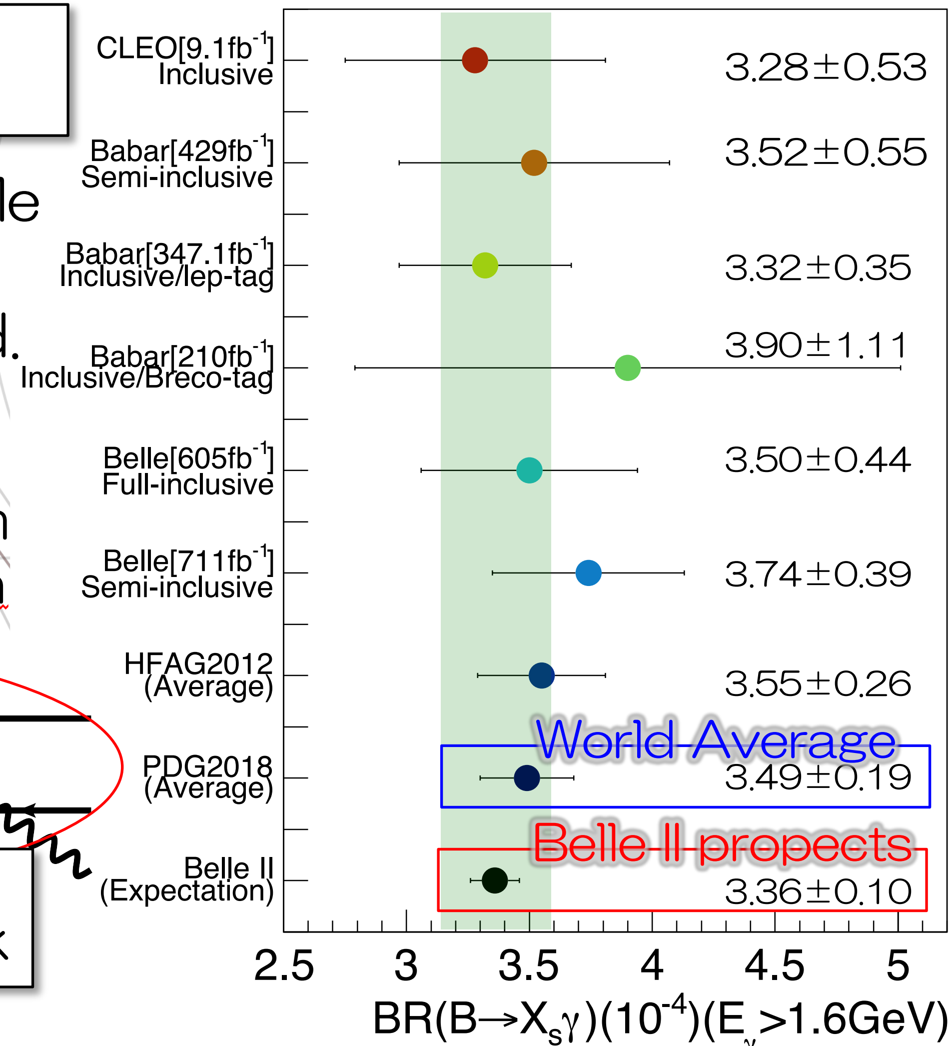
γ couples with spectator quark

$$\frac{\Delta B_{s\gamma}}{B_{s\gamma}} \approx \frac{Q_d + Q_u}{Q_d - Q_u} \Delta_{0-} = -\frac{1}{3}\Delta_{0-}$$

uncertainty is proportional to Δ_{0-}

BR($B \to X_s\gamma$) (10^{-4})

(SM) 3.36±0.23



Δ_{0-} is possibly to reduce ΔBR^{78} of resolved γ.

Sources of systematic error

Source	ΔA_{CP}[%]	Δ_{0-}[%]
Direct calibration	- -	0.576 -0.579
Missing fraction	- -	0.004 -0.004
Fixed parameters	0.530 -0.504	0.600 -0.472
Tracking	- -	0.019 -0.019
Pi0/Eta	- -	0.007 -0.007
Ks	- -	0.012 -0.012
PID	- -	0.044 -0.044
Detection asymmetry	0.388 -0.388	0.000 -0.000
$A^{\pm}_{CP}(X_s\eta)$	0.022 -0.022	0.001 -0.001
$A^{\pm}_{CP}(K\eta')$	0.000 -0.000	0.000 -0.000
$A^{\pm}_{CP}(\rho\gamma)$	0.001 -0.001	0.000 -0.000
$A^{0}_{CP}(X_s\eta)$	0.033 -0.033	0.002 -0.002
$\Delta_{0-}(\rho\gamma)$	0.003 -0.003	0.005 -0.005

Red : max

Blue : second max

⋮

	ΔA_{CP}	Δ_{0-}
τ+-/τ00	- -	0.186 -0.186
f+-/f00	- -	1.150 -1.150
ΔE modification	- -	0.030 -0.060
K*-Xs transition	- -	0.120 -0.120
MC statistics	- -	0.026 -0.026
Fitter bias	0.107 -0.107	0.080 -0.080
Total	0.667 -0.646	1.440 -1.396

Gluino mediated EWP

arXiv:1712.04959v3

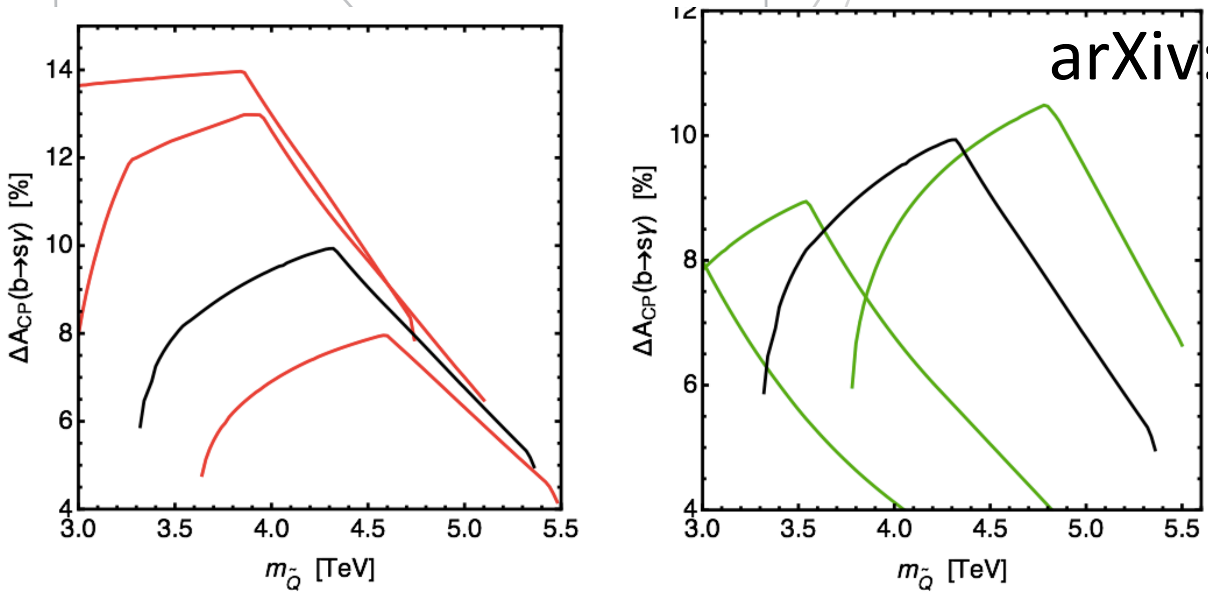


Figure 7. The maximum value of $\Delta A_{CP}(b \to s\gamma)$ as a function of $m_{\tilde{Q}}$. Here, $(\varepsilon'/\varepsilon_K)^{SUSY} = 10.0 \times 10^{-4}$ is fixed. The parameters are $\gamma_R/\beta_R = -\gamma_L/\beta_L = 1$ and $m_{\tilde{g}}/m_{\tilde{Q}} = 1$ on the black line. In the left plot, $\gamma_R/\beta_R = -\gamma_L/\beta_L = 0.6, 0.8, 1.2$ with $m_{\tilde{g}}/m_{\tilde{Q}} = 1$ from left to right of the red lines. In the right plot, $m_{\tilde{g}}/m_{\tilde{Q}} = 1.8, 1.4, 0.8$ with $\gamma_R/\beta_R = -\gamma_L/\beta_L = 1$ from left to right of the green lines.

- It can enhance ΔA_{CP} at most ~14%.
- The model was introduced to explain measured 2.8σ discrepancy of $\varepsilon'/\varepsilon_K$ from SM.

Future plan

- The same analysis can be performed at Belle II experiment.
- Since both ΔA_{CP} and Δ_{0-} are statistical error dominant, study at Belle II will be important.
- In addition, dominant systematic uncertainties are caused by statistical limitation of ctr. samples and sidebands.
  - π^0 probability sideband, m_{bc} sideband, off-resonance, and so on.
  - Thus almost all of systematic error for ΔA_{CP} can be reduced as well as statistical error.
- For example, 50 times statistics will reduce total error of ΔA_{CP} to under 0.4%.
  - More than 2% ΔA_{CP} can be an evidence of NP, while current measurement is 3.6%).