Measurements of $B \rightarrow X_s l^+ l^-$ and $B \rightarrow K^{(*)} l^+ l^-$ at *Belle*

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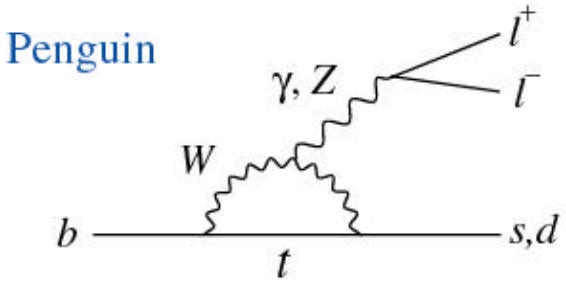
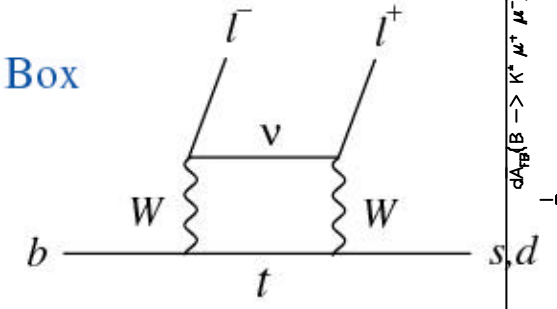
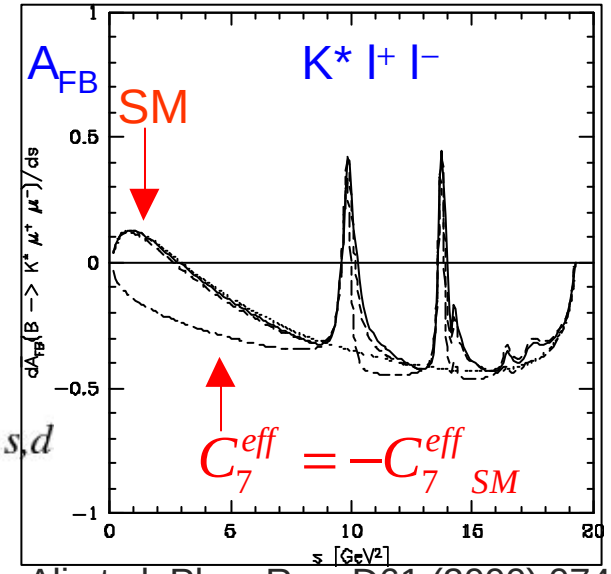
Introduction

- b→s l^+l^-
  - First observed by Belle in B→Kll
  - Proceed through γ penguin, Z penguin and W box diagrams
  - Sensitive to new physics $H^+, A^0, \tilde{\chi}^+, \tilde{\chi}^0, \tilde{g}, \tilde{t}, \tilde{b}$
  - Sign of Wilson coeffient C_7 as well as C_9 and C_{10} can be obtained from q^2 distribution and $A_{FB}(q^2)$.
  - BF is low compared with b→s γ, suppressed by additional α_{em} →need large statistics







Ali et al. Phys.Rev. D61 (2000) 074024

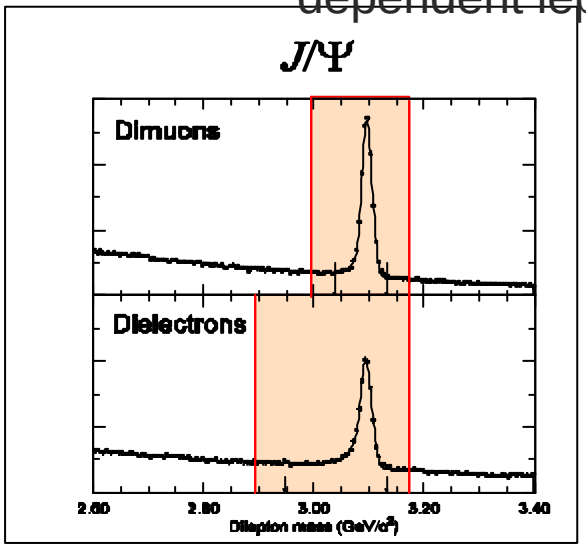
Measurement of $B \rightarrow X_s l^+ l^-$

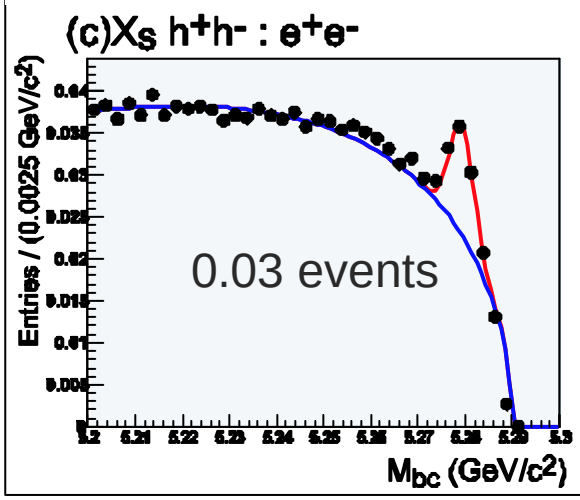
- Theoretically clean, ~15% uncertainty on BF.
- Experimentally challenging
  - fully-inclusive di-lepton ← impossible with current statistics
  - semi-inclusive Xs reconstruction ← possible!
- X_s hadron is reconstructed semi-inclusively
  - One K^+ or K_s + 0~4 pions (allow at most one π^0)
  - 18 decay modes covering 52% of X_s final states. (80% with K_L)
- With di-electron or di-muon
  - Electron ID efficiency ~ 95%, fake rate 0.2% @ 1.5GeV
  - Muon ID efficiency ~ 90%, fake rate 1.0% @1.5GeV
  - M_{ee}> 0.2 GeV to suppress Dalitz decays and converted photons
- Signal extraction
  - Fit to beam constrained mass distribution
- 140/fb data containing 152 million $B\bar{B}$ is used for this analysis

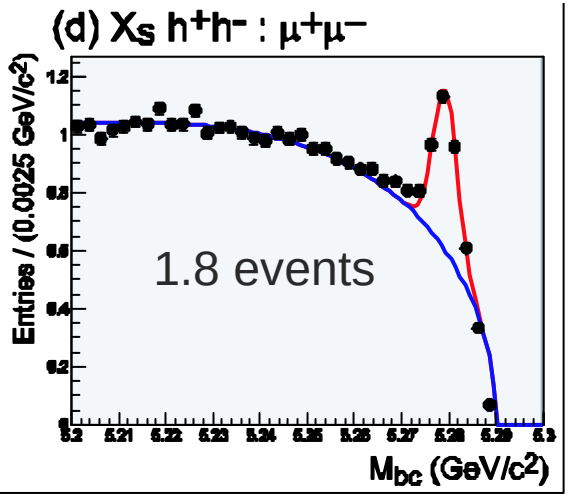
Measurement of $B \rightarrow X_s l^+ l^-$ cont'd

- Background suppression is most important in this analysis.
- Four background sources
  - dilepton events from continuum, mostly from charm events.
  - dilepton events from $B\bar{B}$: $B \rightarrow Xl\nu$, $B \rightarrow Yl\nu$

  } Dominant backgrounds
  - $B \rightarrow J/\Psi\ X_s$ events
    - Veto J/Ψ with dilepton invariant mass
  - $B \rightarrow X_s\ h^+\ h^-$ events (h refers kaon or pion)
    - Reconstruct $X_s\ h^+\ h^-$ and multiply momentum and angular dependent lepton ID fake rate.

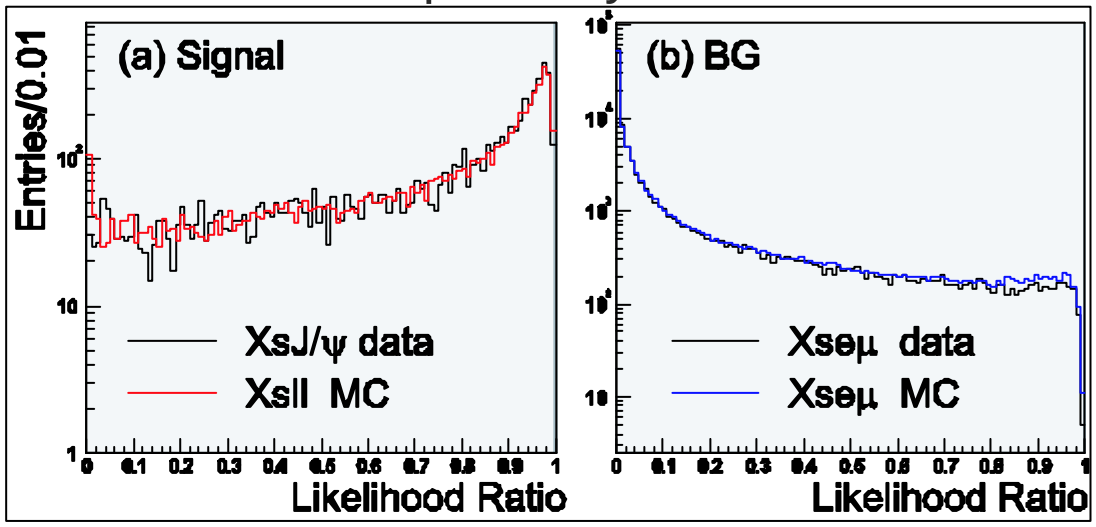






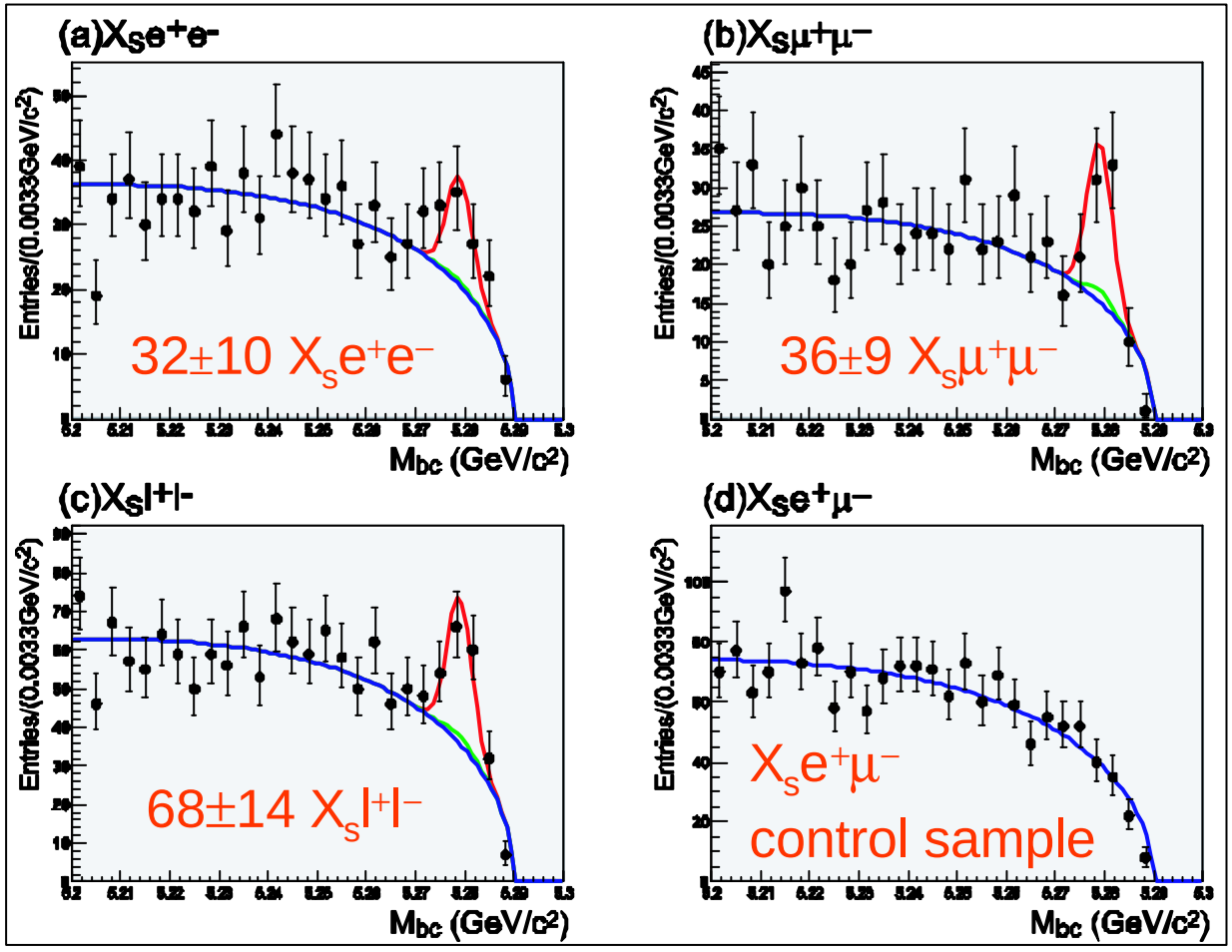
Dilepton Background suppression

- 5 variables into likelihood ratio(LR)
  - Event shape, angular distribution of B candidate momentum
  - Missing mass, energy and χ^2 of vertexing
- LR shape of real data in good agreement that of MC
- LR >0.9(>0.6 for M<1.1) cut retains 71% signal while removes 90% BG.
- Reconstruction Efficiencies for electron and muon modes are 2.6% and 2.9% respectively.



Result for B→ $X_s l^+ l^-$

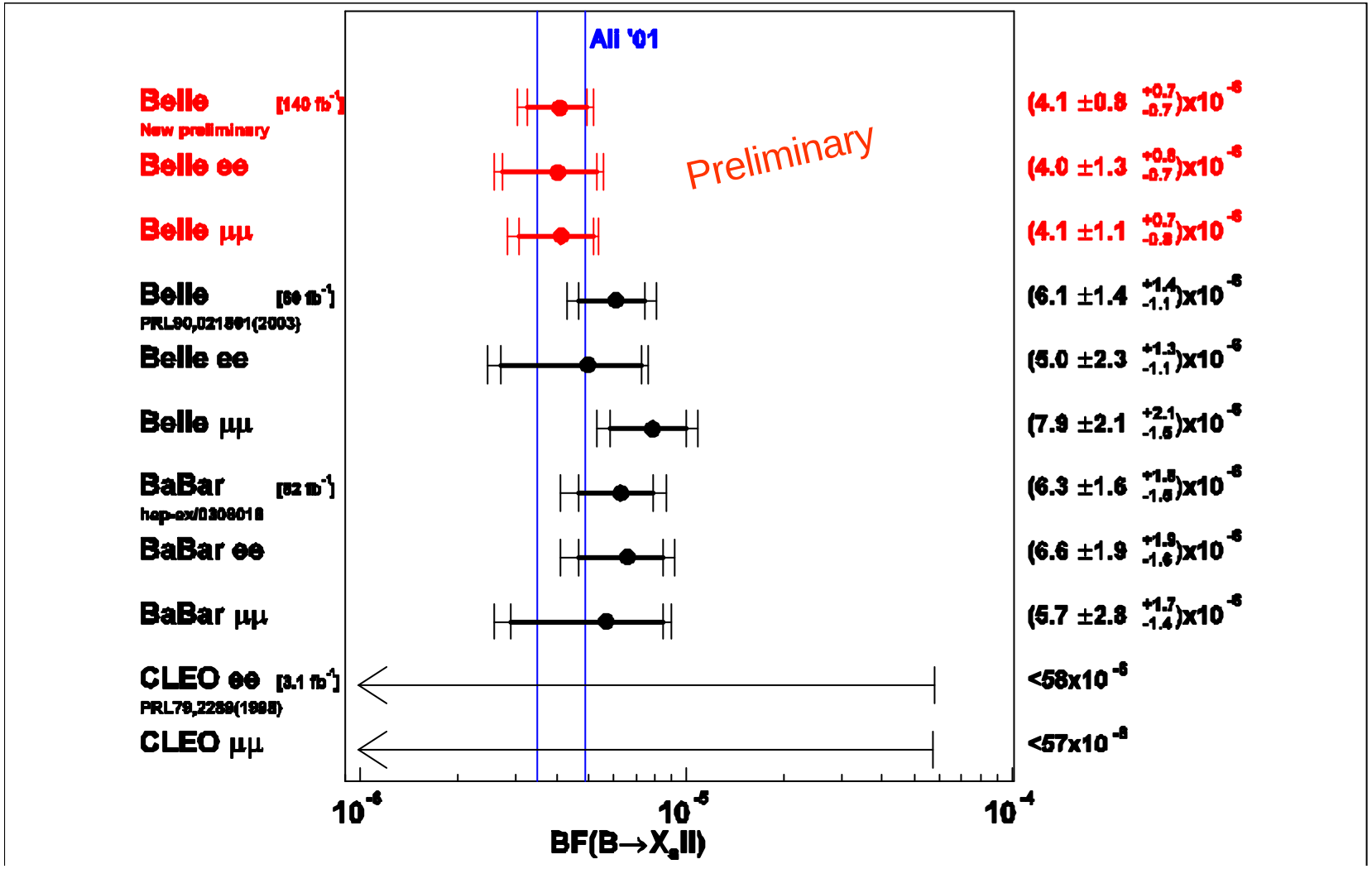
- 68±14 $X_s l^+ l^-$ signal events with 5.8σ significance



140/fb data

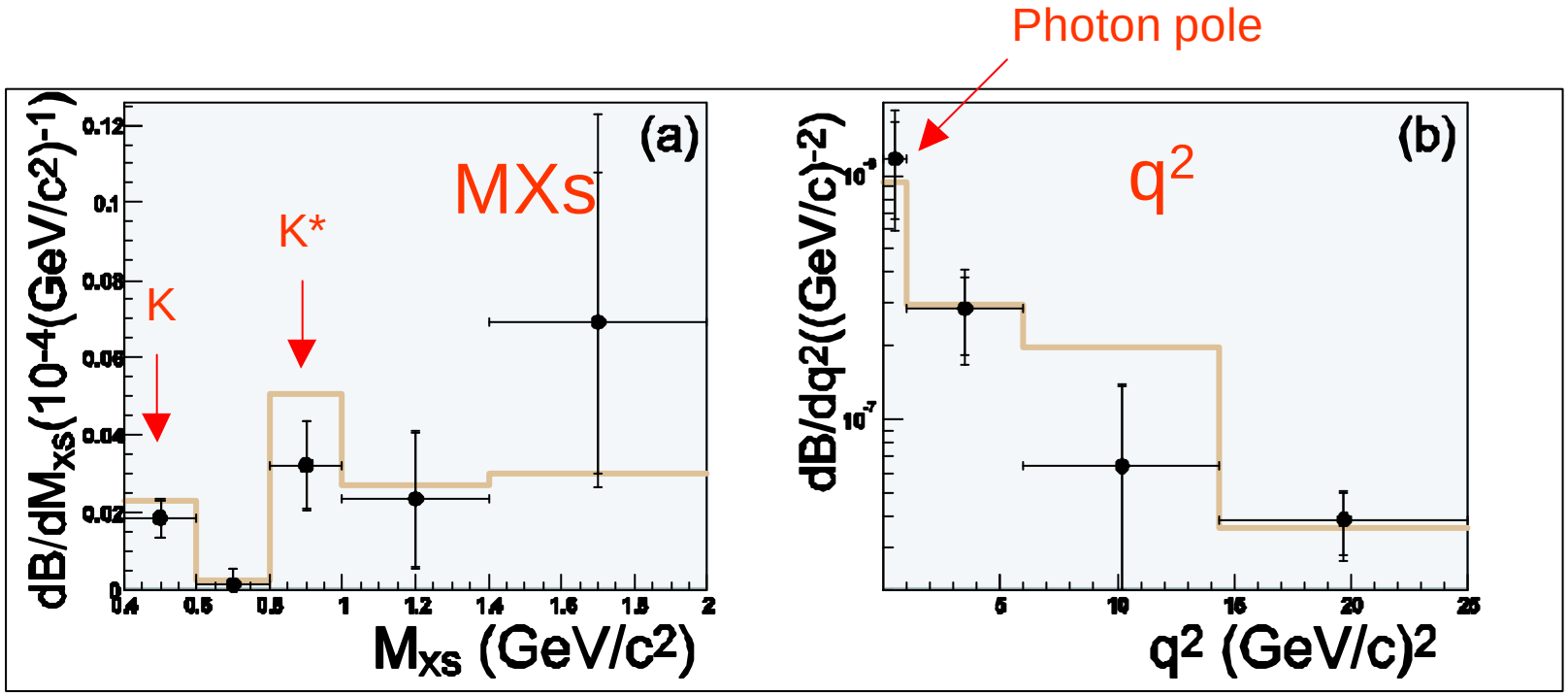
Branching Fraction for $B \rightarrow X_s l^+ l^-$

- BF is in good agreement with the SM prediction and previous results.



M_{Xs} and q^2 distributions in $B \rightarrow X_s l^+ l^-$

- M_{Xs} and q^2 distributions are measured.
- Kll and K*ll are clearly seen.
- q^2 distribution is consistent with the prediction by Ali et al.



Measurement of $B \rightarrow K^{(*)} l^+ l^-$

- Large theoretically uncertainty ~30% on BF.
  - Mostly from uncertainty in form factor model.
  - Experimental precision is already comparable to theoretical uncertainty.
  - Will be good calibration mode for QCD (form factor) in semi-leptonic B decays
- experimentally straightforward
  - clean→ more suitable to measure A_{FB} than inclusive decay
- Reconstruction method is almost same as semi-inclusive analysis.
- 253/fb data containing 273 million $B\bar{B}$ is used for this analysis

Result for B→ $K^{(*)}l^+l^-$

253/fb data

- 79 ± 10 Kll events and 82 ± 11 K*ll events are observed.
- BFs are consistent with theoretical prediction.

Results (x 10^{-7})

Preliminary

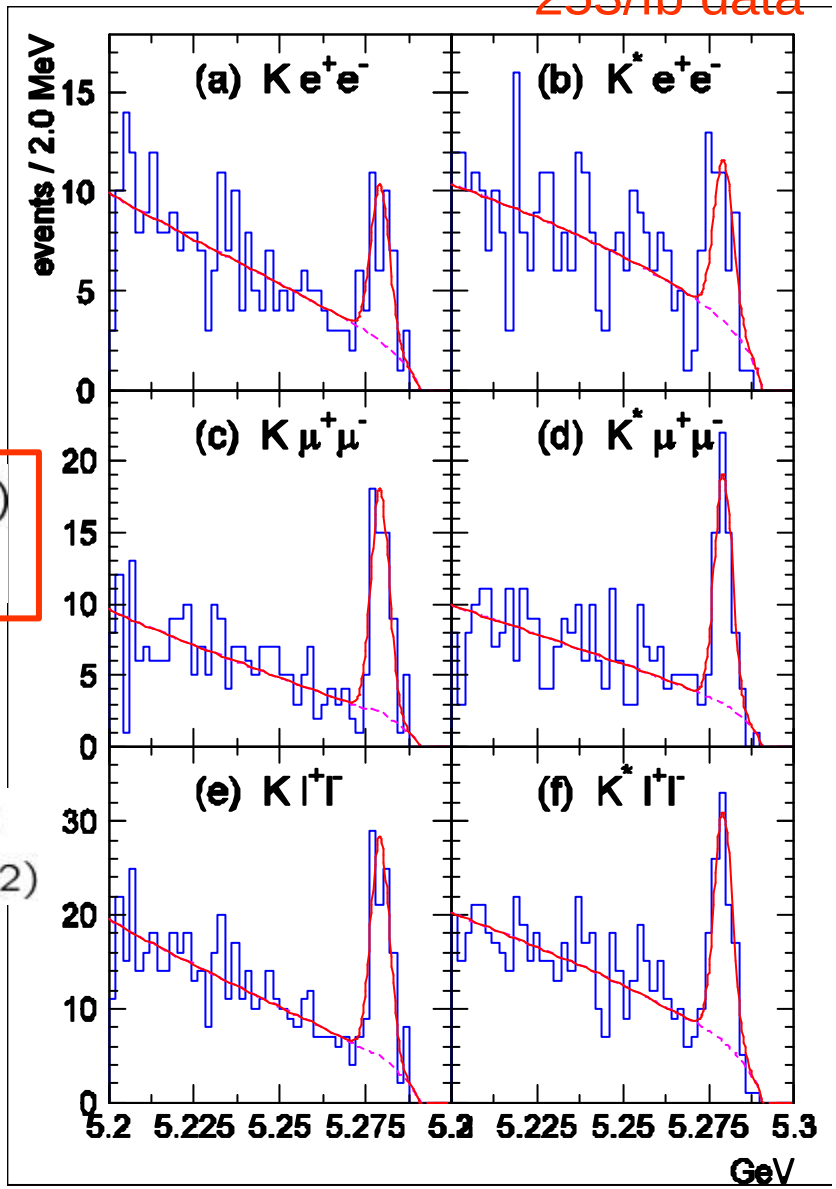
$$\mathcal{B}(B \to K\ell^+\ell^-) = (5.50^{+0.75}_{-0.70} \pm 0.27 \pm 0.02)$$
$$\mathcal{B}(B \to K^*\ell^+\ell^-) = (16.5^{+2.3}_{-2.2} \pm 0.9 \pm 0.4)$$

With NNLO calculation

Previous results with NLO calculation(x 10^{-7})

$$\mathcal{B}(B \to K\ell^+\ell^-) = (4.8^{+1.0}_{-0.9} \pm 0.3 \pm 0.1)$$
$$\mathcal{B}(B \to K^*\ell^+\ell^-) = (11.5^{+2.6}_{-2.4} \pm 0.8 \pm 0.2)$$

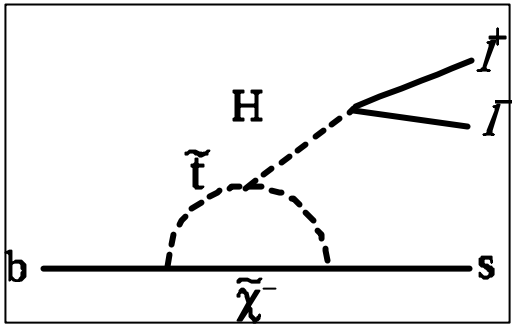
Since we now use NNLO precision effective Wilson coefficients, which gives larger C_7 than NLO calculation, efficiency of K*ll become smaller ~12%. With NLO efficiency, the BF of K*ll is 14.7 x 10^{-7}.



A Ratio of Branching fractions

- A ratio of BF of Kμμ to Kee is sensitive to neutral Higgs emission from internal loop in 2HDM with large tanβ. If Higgs contribution is large, this ratio is greater than unity.

  Y. Wang and D. Atwood Phys. Rev. D68(2003) 094016



- Same ratio for K*ll is sensitive to size of photon pole. In the SM, this ratio is about 0.75.

Preliminary

$$\mathcal{R}_{K\ell\ell} = \frac{\mathcal{B}(B\to K\mu\mu)}{\mathcal{B}(B\to Kee)} = 1.38^{+0.39+0.06}_{-0.41-0.07} = 1.00$$

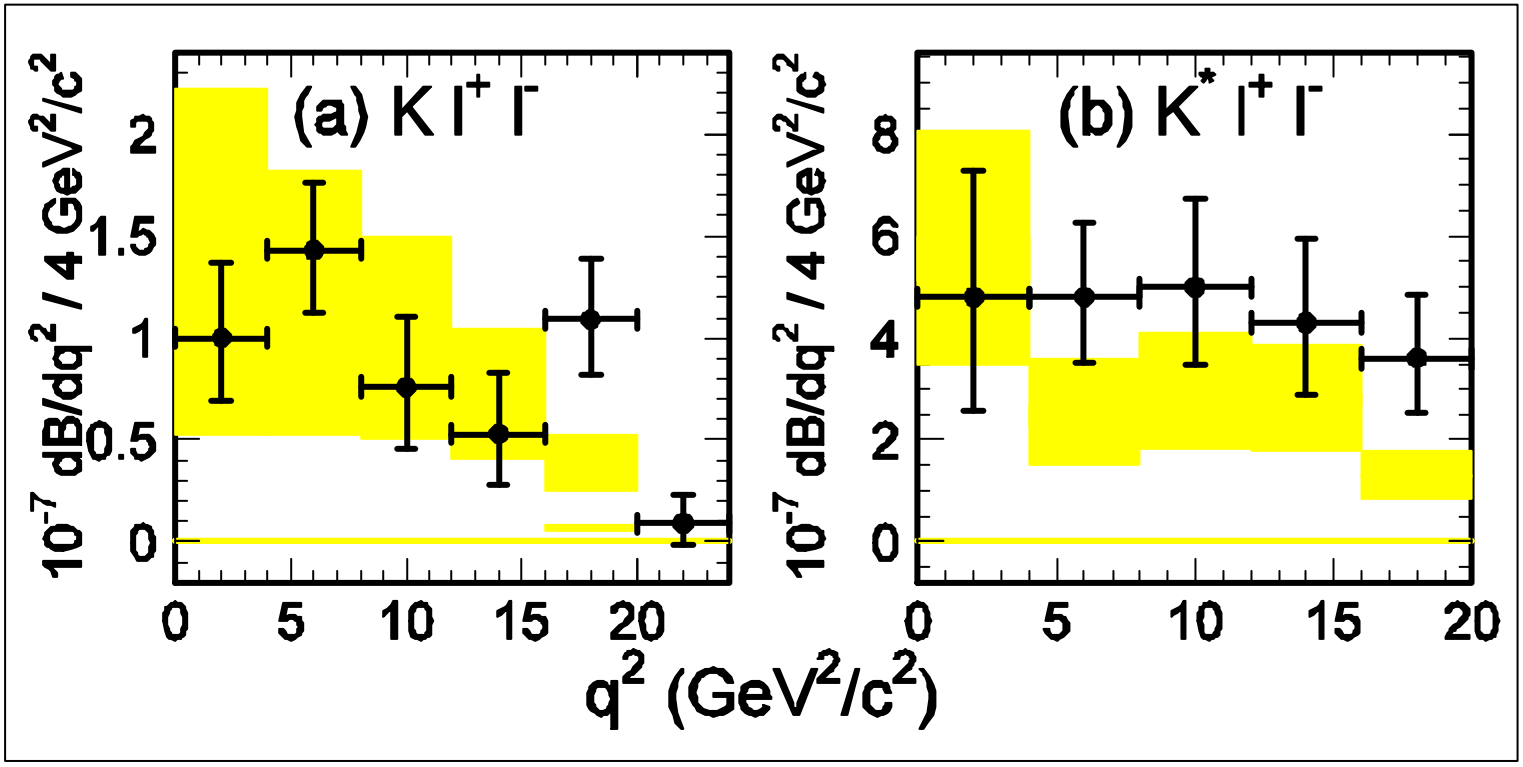
$$\mathcal{R}_{K^*\ell\ell} = \frac{\mathcal{B}(B\to K^*\mu\mu)}{\mathcal{B}(B\to K^*ee)} = 0.98^{+0.30}_{-0.31} \pm 0.08 \sim 0.75$$

in the SM.

- Both ratios are consistent with the SM prediction, so far.

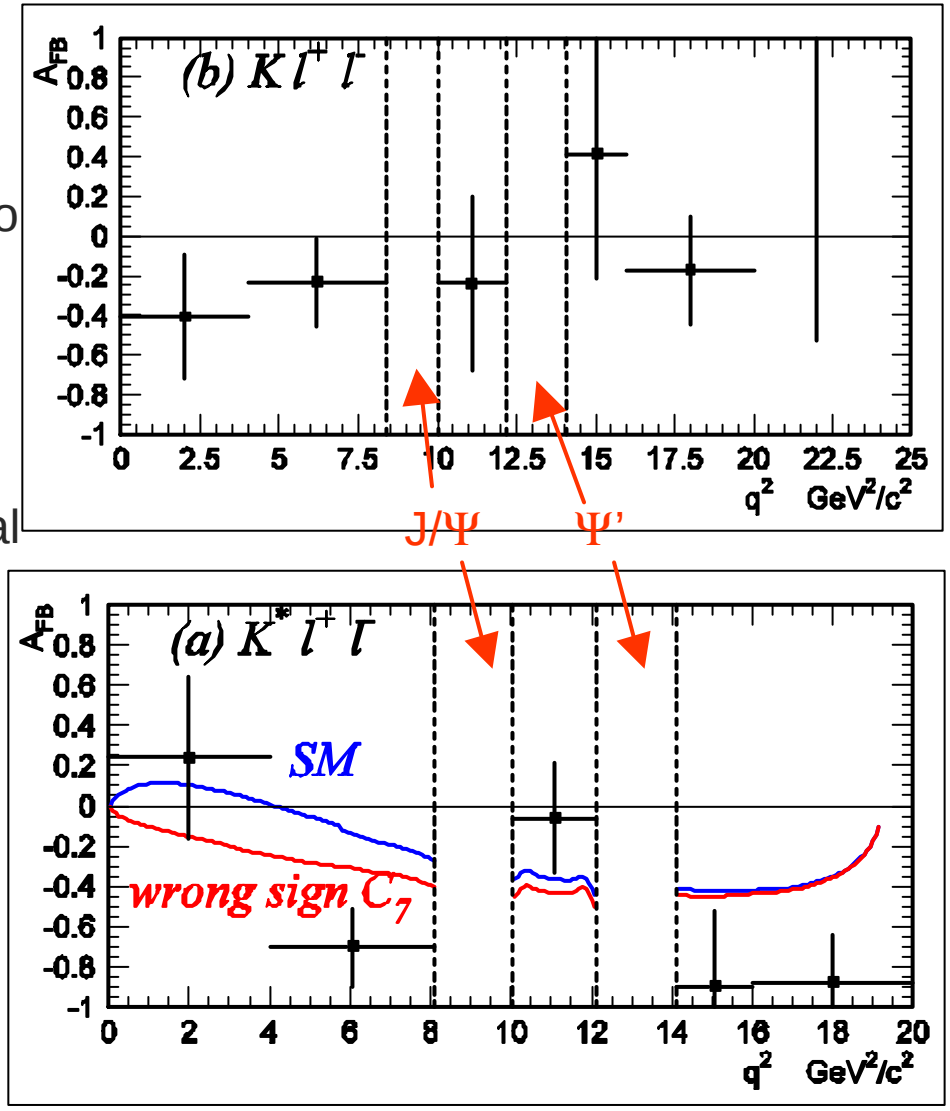
q^2 distributions for $B \rightarrow K^{(*)} l^+ l^-$

- Yellow bands show ranges of theoretical prediction.
- Both results are consistent with the SM prediction, so far.



First look at A_{FB}

- Raw A_{FB} in each q^2 region is extracted from M_{bc} fit.
- Dotted lines show charmonium veto windows.
- Kll has no asymmetry, so it is a good control sample.
- Curves show theoretical distributions including experimental efficiency effect (not fitted lines!).
- Both curves are in agreement with data, so far.



Summary

- improved measurements of inclusive B → Xs ll and exclusive B → Kll and K*ll.
- Measured BFs, ratios of BFs and q2 distributions are in good agreement with the SM theoretical prediction.

$$\mathcal{B}(B \to X_s \ell^+ \ell^-) = (41.1 \pm 8.3^{+7.4}_{-7.0}) \times 10^{-7}$$

$$\mathcal{B}(B \to K \ell^+ \ell^-) = (5.50^{+0.75}_{-0.70} \pm 0.27 \pm 0.02) \times 10^{-7}$$

Preliminary

$$\mathcal{B}(B \to K^* \ell^+ \ell^-) = (16.5^{+2.3}_{-2.2} \pm 0.9 \pm 0.4) \times 10^{-7}$$

$$\mathcal{R}_{K\ell\ell} = 1.38^{+0.39+0.06}_{-0.41-0.07}$$

$$\mathcal{R}_{K^*\ell\ell} = 0.98^{+0.30}_{-0.31} \pm 0.08$$

- First look at A_{FB}

cf.

$$\mathcal{B}(B \to X_s \ell^+ \ell^-) = 4.15 \pm 0.70) \times 10^{-7}$$

Ali et al. Phys.Rev.D66:034002,2002