Evidence for $B \to K^{*} l^{+} l^{-}$ and Measurement of $B \to K l^{+} l^{-}$

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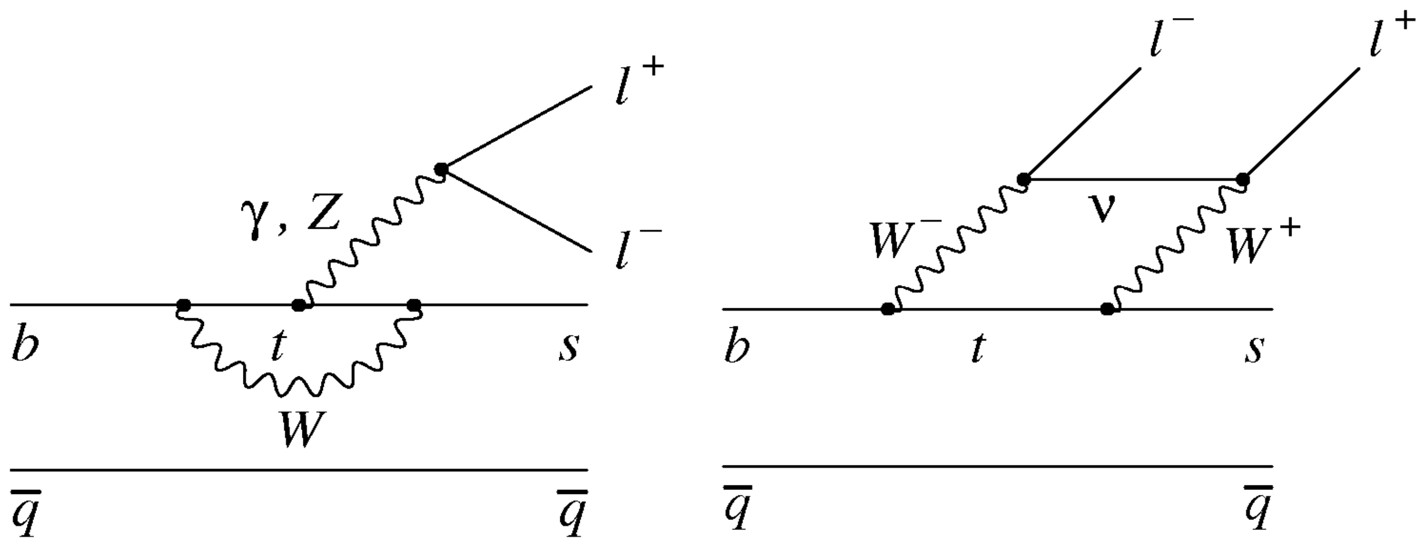
Outline:

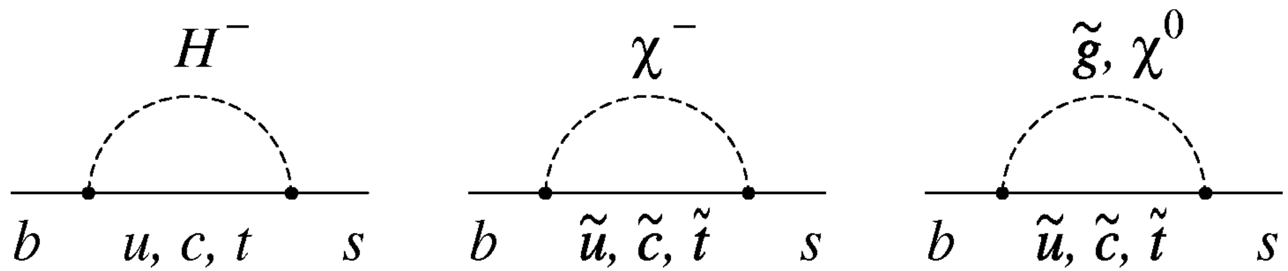
- Physics motivation
- Analysis strategy
- Results and conclusions

Flavor changing neutral currents $b \to s l^+ l^-$

- These decays are highly suppressed: in the SM they are forbidden at tree level and proceed via loop diagrams



- *E.g.*, supersymmetric particles can contribute to the rate



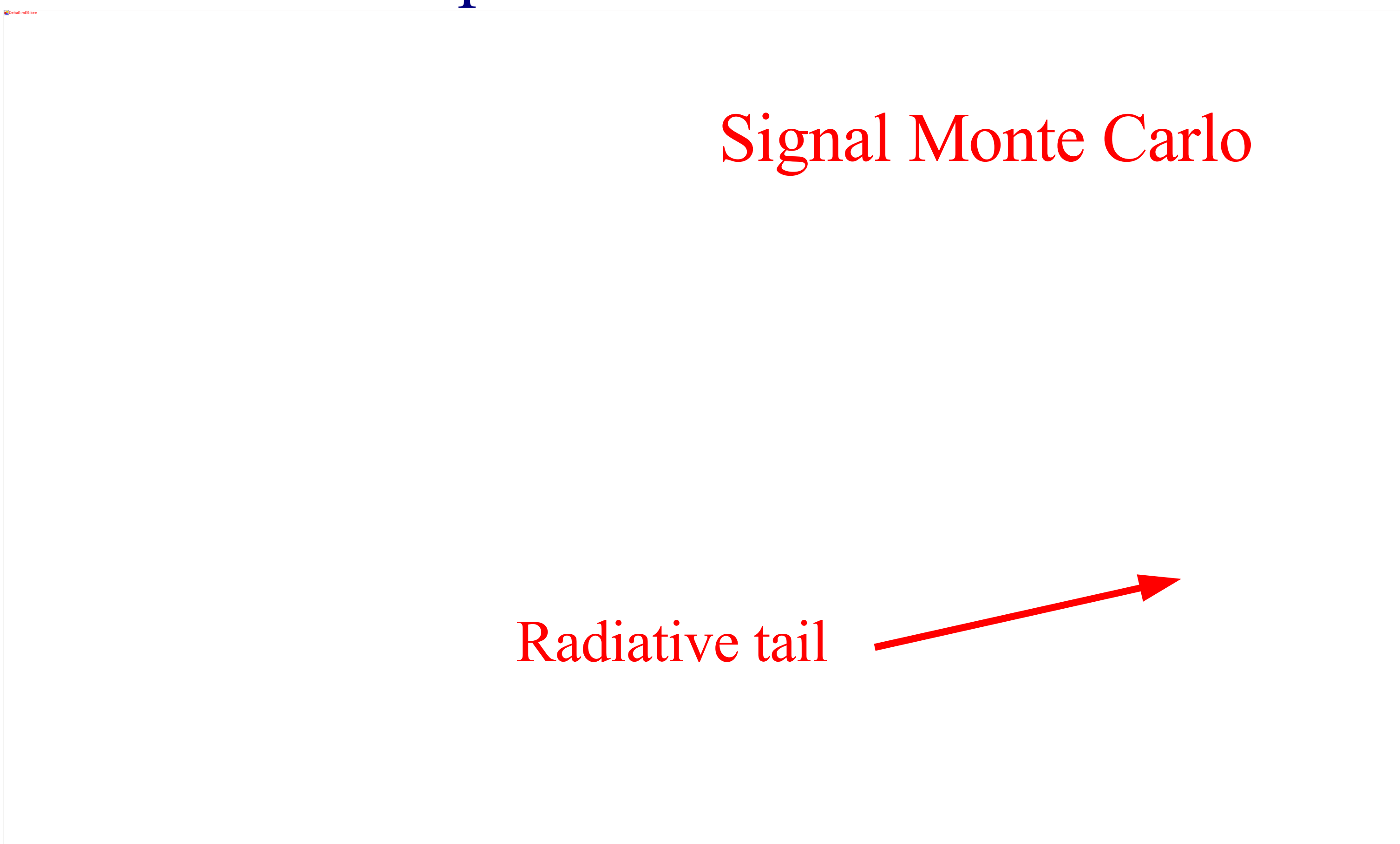
Theory predictions for $B \to K^{(*)} l^+ l^-$

New_Threory_Table

B reconstruction

$$m_{\text{ES}} = \sqrt{E^{*\,2}_{\text{beam}} - \left(\sum_i p_i^*\right)^2} \qquad \Delta E = \sum_i \sqrt{p_i^{*\,2} + m_i^2} - E^*_{\text{beam}}$$

a * denotes quantities in the center-of-mass



Analysis overview

- This analysis is based on the Run 1 + Run 2 datasample of $(88.5 \pm 0.9) \times 10^6\, B\bar{B}$ pairs.
- We fully reconstruct B candidates in the modes

$$B^+ \to K^+ l^+ l^- \qquad B^0 \to K^{*0} l^+ l^-,\ K^{*0} \to K^+ \pi^-$$

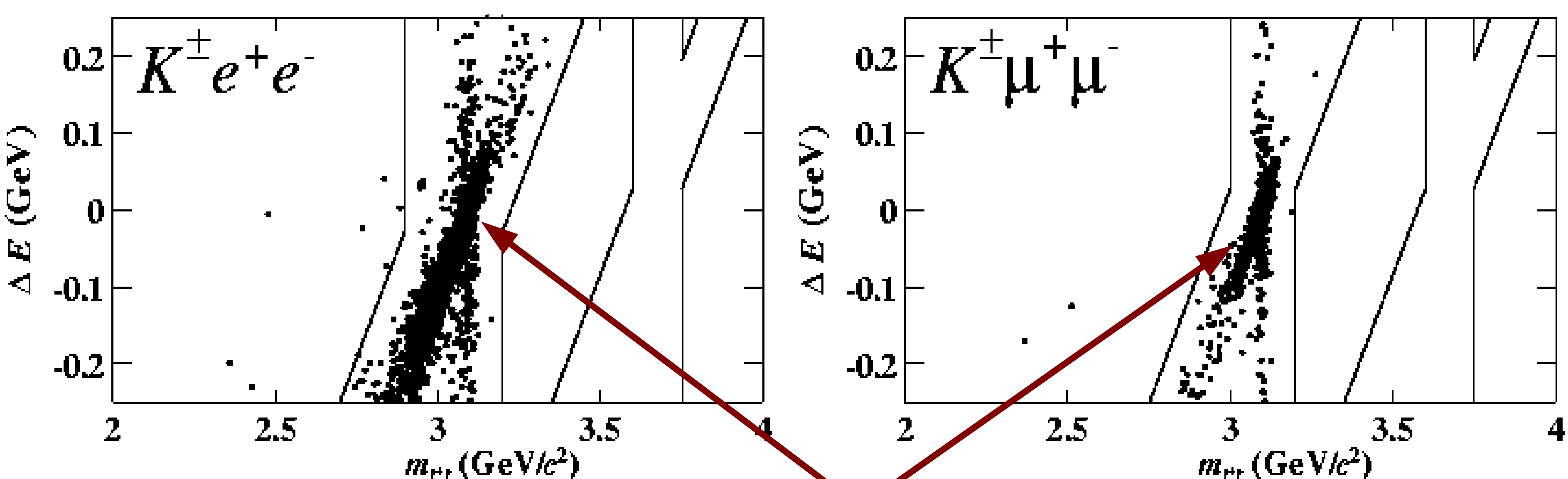
$$B^0 \to K^0_S l^+ l^- \qquad B^+ \to K^{*+} l^+ l^-,\ K^{*+} \to K^0_S \pi^+$$

where l is either an e or a μ and $K^0_S \to \pi^+ \pi^-$

- Leptons candidates are selected with tight particle identification
  - ~0.2% pion fake rate for electrons and ~2% pion fake rate for muons.
- For electrons we recover bremsstrahlung photons.
- Charged kaons are identified by the DIRC.
- The signal yields are extracted using an unbinned maximum likelihood fit in m_{ES} and ΔE.
  - In the K^* modes we in addition use the $K\pi$ mass in the fit.

Backgrounds

- Combinatorial background from $B\bar{B}$ and $q\bar{q}$ events are suppressed using a likelihood and a Fisher discriminant respectively.
- Peaking backgrounds arise from several possible sources
  - Hadronic B decays where hadrons are misidentified as leptons
    - In the muon mode we veto $B \to D\pi$ decays.
  - Charmonium presents a large possible background and we veto these events in the m_{ll} vs. ΔE plane



$B \to J/\psi(\to l^+ l^-)K$

Hadronic peaking backgrounds

- Processed data without applying any lepton ID
- Weight histograms with fake rates and fit for background yields
  - Backgrounds neglible in the electron channels

$$B \to K\pi\pi\,,\,KK\pi\,,\,KKK\,,\,D\pi\,....$$

0.007 events

0.27 events

0.001 events

0.05 events

Peaking backgrounds

- We have considered the following sources of peaking backgrounds

Charmonium control samples

We reverse the charmonium veto and use the J/ψ events as a control sample for efficiency and checks of kinematic distributions

We find good agreement in our check using the charmonium control samples

ΔE vs. m_{ES} in the $B \rightarrow K l^{+} l^{-}$ modes

Preliminary

Combined $B \to K l^+ l^-$ fits

$-0.11 < \Delta E < 0.05\,\mathrm{GeV}$

$5.2724 < m_{\mathrm{ES}} < 5.2856\,\mathrm{GeV}$

Preliminary

$$Br(B \to K l^+ l^-) = (0.68^{+0.17}_{-0.15} \pm 0.04) \times 10^{-6} \quad (7\sigma)$$

Dilepton mass distributions

Preliminary

Charmonium vetoes

Preliminary

ΔE vs. m_{ES} in the $B \to K^{*} l^{+} l^{-}$ modes

Preliminary

Combined $B \to K^* l^+ l^-$ fits

Preliminary

$5.2724 < m_{\mathrm{ES}} < 5.2856\ \mathrm{GeV}$

$0.817 < m_{k\pi} < 0.967\ \mathrm{GeV}$

$-0.11 < \Delta E < 0.05\ \mathrm{GeV}$

$0.817 < m_{k\pi} < 0.967\ \mathrm{GeV}$

$5.2724 < m_{\mathrm{ES}} < 5.2856\ \mathrm{GeV}$

$-0.11 < \Delta E < 0.05\ \mathrm{GeV}$

$$Br\left(B \to K^* l^+ l^-\right) = \left(1.40^{+0.57}_{-0.49} \pm 0.21\right) \times 10^{-6} \qquad (3.0\,\sigma)$$

Combined $B \to K^* l^+ l^-$ fits

- For the combined fits in the *K** modes we use the constraint

$$\frac{Br\left(B \to K^* e^+ e^-\right)}{Br\left(B \to K^* \mu^+ \mu^-\right)} = 1.33$$

  as given by Ali *et al*. (2001).
- We quote the combined $B \to K^* l^+ l^-$ result for the electron channel.

Systematic uncertainties and significance

- Multiplicative systematic uncertainties do not affect the significance of the signal. We have considered:
  - Tracking and PID efficiencies
  - Model dependence, Monte Carlo statistics
- Additive systematic uncertainties arise from the fit and do affect the significance. Parameters for the background shape are determined in the fit to the data and do not contribute to a systematic uncertainty. Systematic effects that we have considered:
  - Signal shape parameters, mean and width
  - Radiative tail in electron modes
  - Background shape parametrization
  - Peaking backgrounds
- The significance was evaluated by combining the variations that lead to a decrease in the signal significance.

Results

Conclusions

- Analyzed the BABAR Run 1 and Run 2 data sample of $(88.5 \pm 0.9) \times 10^6\, B\bar{B}$ pairs.
- We have added the $K\pi$ mass to the likelihood fit for the $B \to K^* l^+ l^-$ modes and obtained the preliminary results:
- Clear signal (~7 σ) for $B \to K l^+ l^-$

$$Br(B \to K l^+ l^-) = (0.68^{+0.17}_{-0.15} \pm 0.04) \times 10^{-6}$$

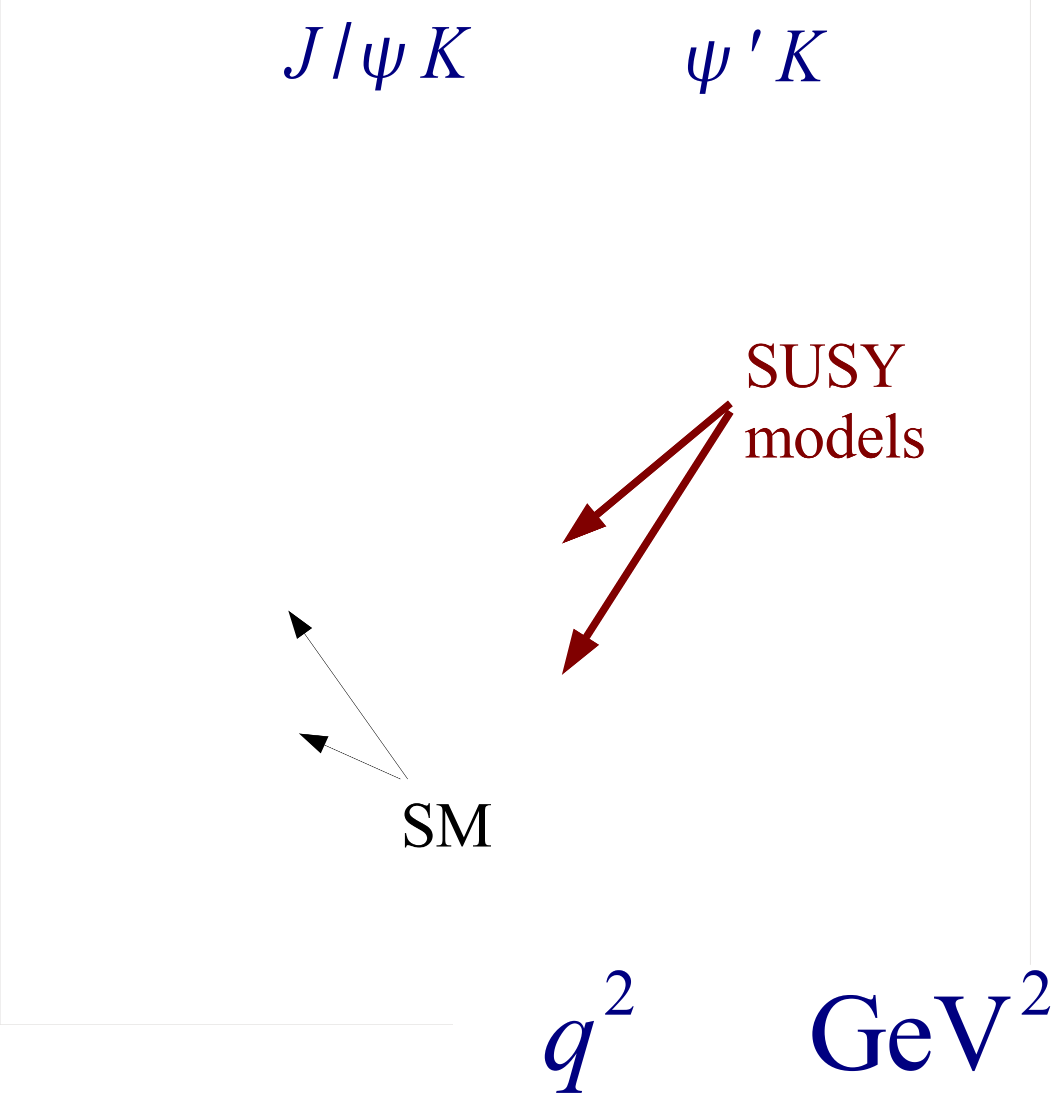
- Evidence (3.0 σ) for $B \to K^* l^+ l^-$

$$Br(B \to K^* l^+ l^-) = (1.40^{+0.57}_{-0.49} \pm 0.21) \times 10^{-6}$$

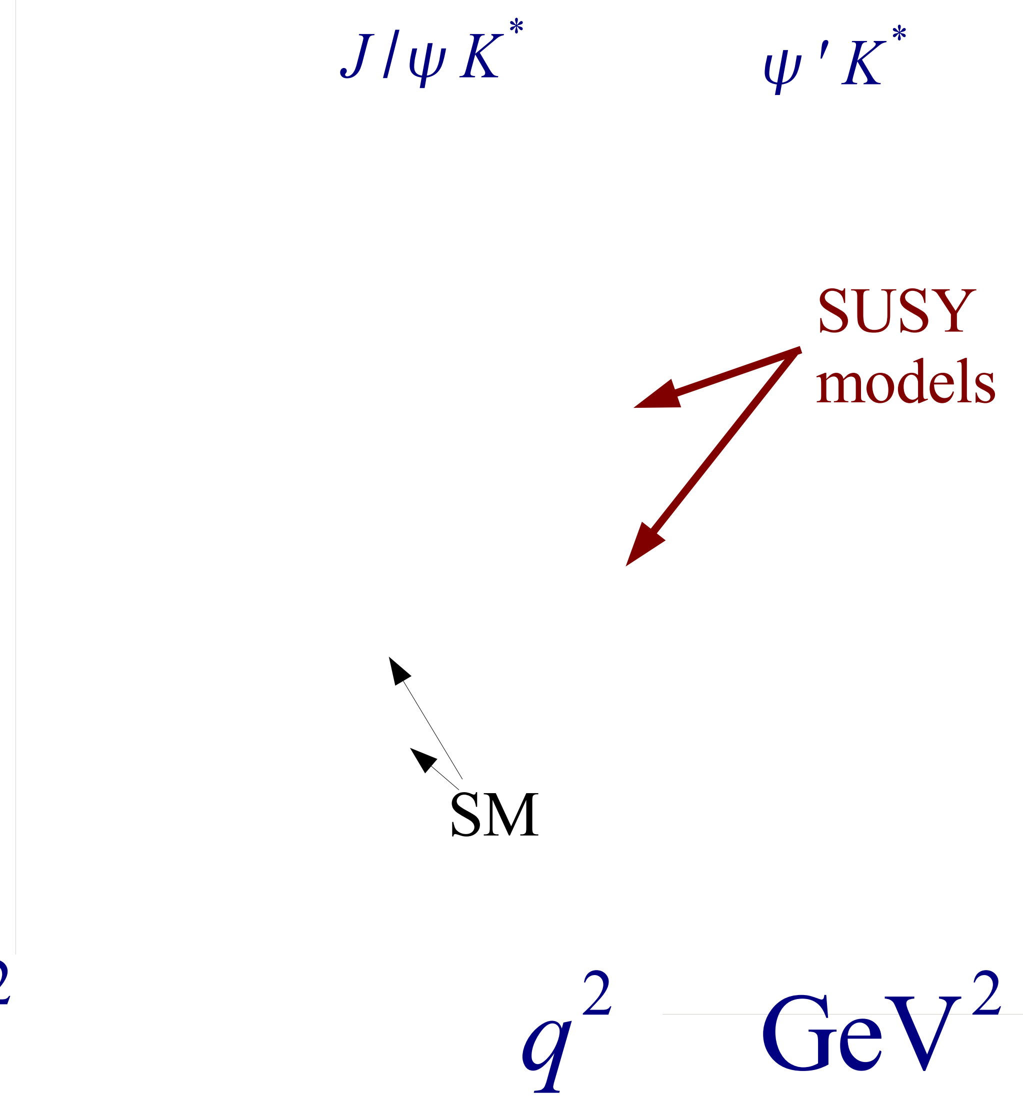
Backup slides

Contributions from new physics to $B \to K^{(*)} l l$

$B \to K \mu\mu$



$B \to K^{*} \mu\mu$



Multiplicative systematic uncertainties

- Particle ID systematics checked in our particle ID blind control samples