Rare B Decays at BTeV

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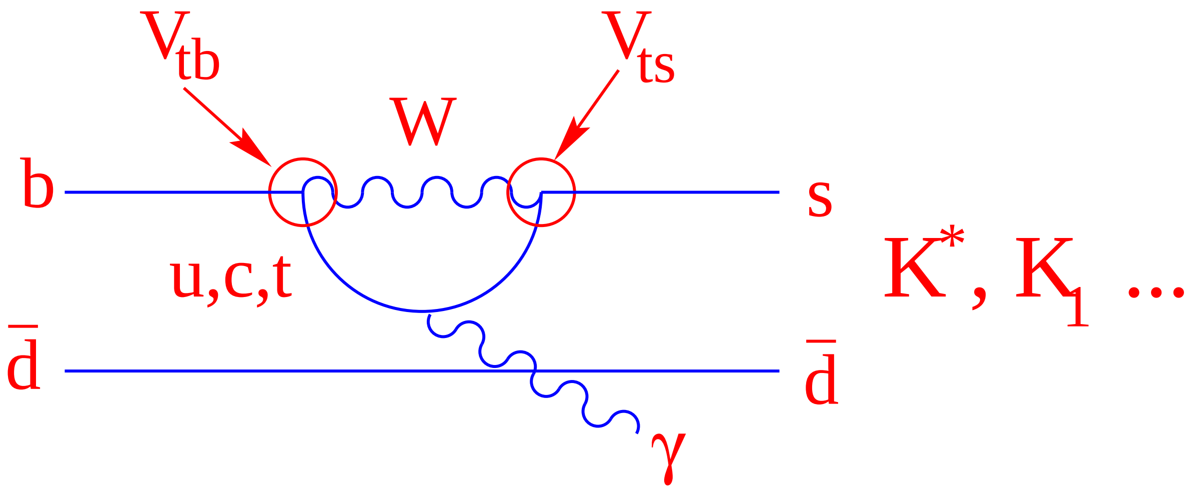
- $b \to s\,\gamma$.
- $b \to s\,\mu^+\mu^-$.
- One page on semileptonic decays.

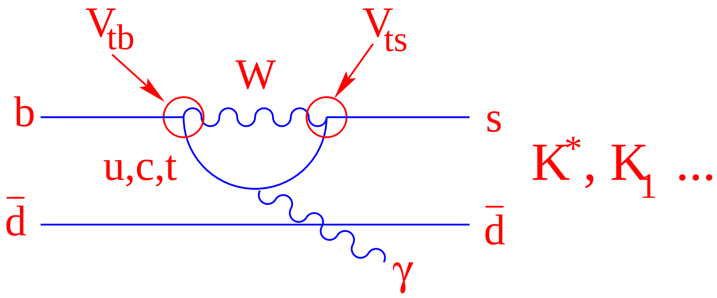
http://home.fnal.gov/~ kutschke/talks/BTeV/
010711_snowmass_p2.ps

Electromagnetic Penguins



- Inclusive rates:
  Easy to predict, hard to measure.
- Exclusive rates:
  Easy to measure, hard to predict.

CLEO II Results on EM Penguins



- $\mathcal{B}(B \to X_s\gamma) = (2.3 \pm 0.7) \times 10^{-4}$. (new: comparable number from Belle).
- $\mathcal{B}(B \to K^*(892)\gamma) = (4.2 \pm 0.6) \times 10^{-5}$.
- $\mathcal{B}(B \to K_2^*(1430)\gamma) = (1.7^{+0.6}_{-0.5}) \times 10^{-5}$.
- Rates in ball park predicted by theory.

$\Rightarrow$ Hard to see new physics.

Estimated BTeV Sensitivity

Mode	Events	S/B
$B^0 \to K^{*0}\gamma$	24000	> 1:"a few"

- Yields for one year of nominal running (2 fb^{-1}) with PDG BR (Self tagging).
- Yields include trigger efficiencies and $\mathcal{B}(K^{*0} \to K^+\pi^-)$.
- From BTeV Preliminary TDR, May 3 1999. (Not reevaluated for proposal.)

Estimated BTeV CP Sensitivity

- For definiteness, $S/B = 1/2$.

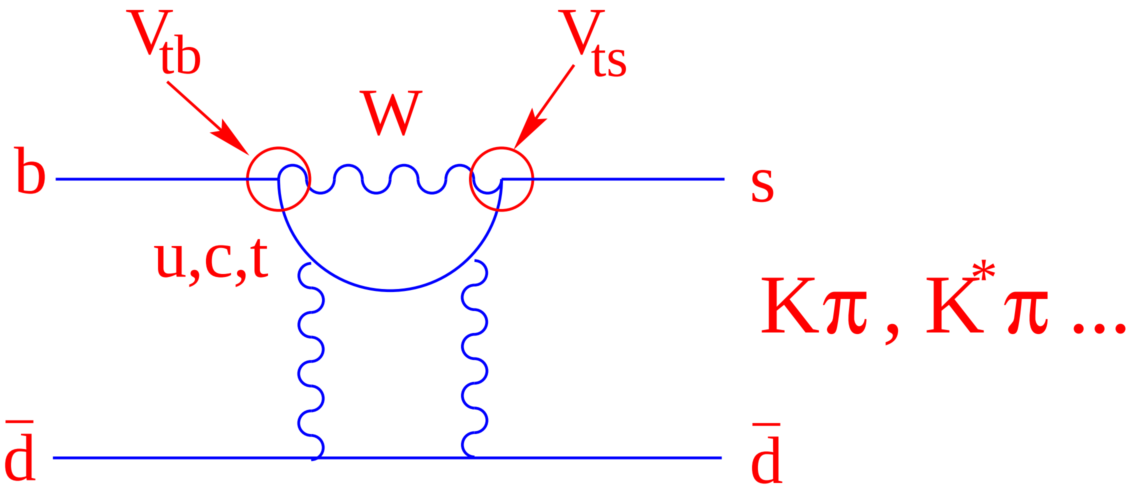
$$\begin{aligned} A_{CP} &= \frac{N_B - N_{\bar{B}}}{N_B + N_{\bar{B}}} \\ N_B + N_{\bar{B}} &= 24000 \pm 270. \\ N_B - N_{\bar{B}} &= x \pm 270. \end{aligned}$$

- For 5σ significance, $x = 1340$.

$\Rightarrow$ Statistical limit on $A_{CP} = 5.6 \pm 1.1\%$
$A_{CP} = 4.6 \pm 0.9\%$, for S/B=1:1.
$A_{CP} = 6.4 \pm 1.3\%$, for S/B=1:3.

- Have not yet evaluated systematics.

Gluonic Penguins



- Experiment:
  Exclusive OK, inclusive very hard.
- I have not recently checked state of theory. Vague recollections that inclusive is easy for theory and exclusive hard.

CLEO II Results on Gluonic Penguins

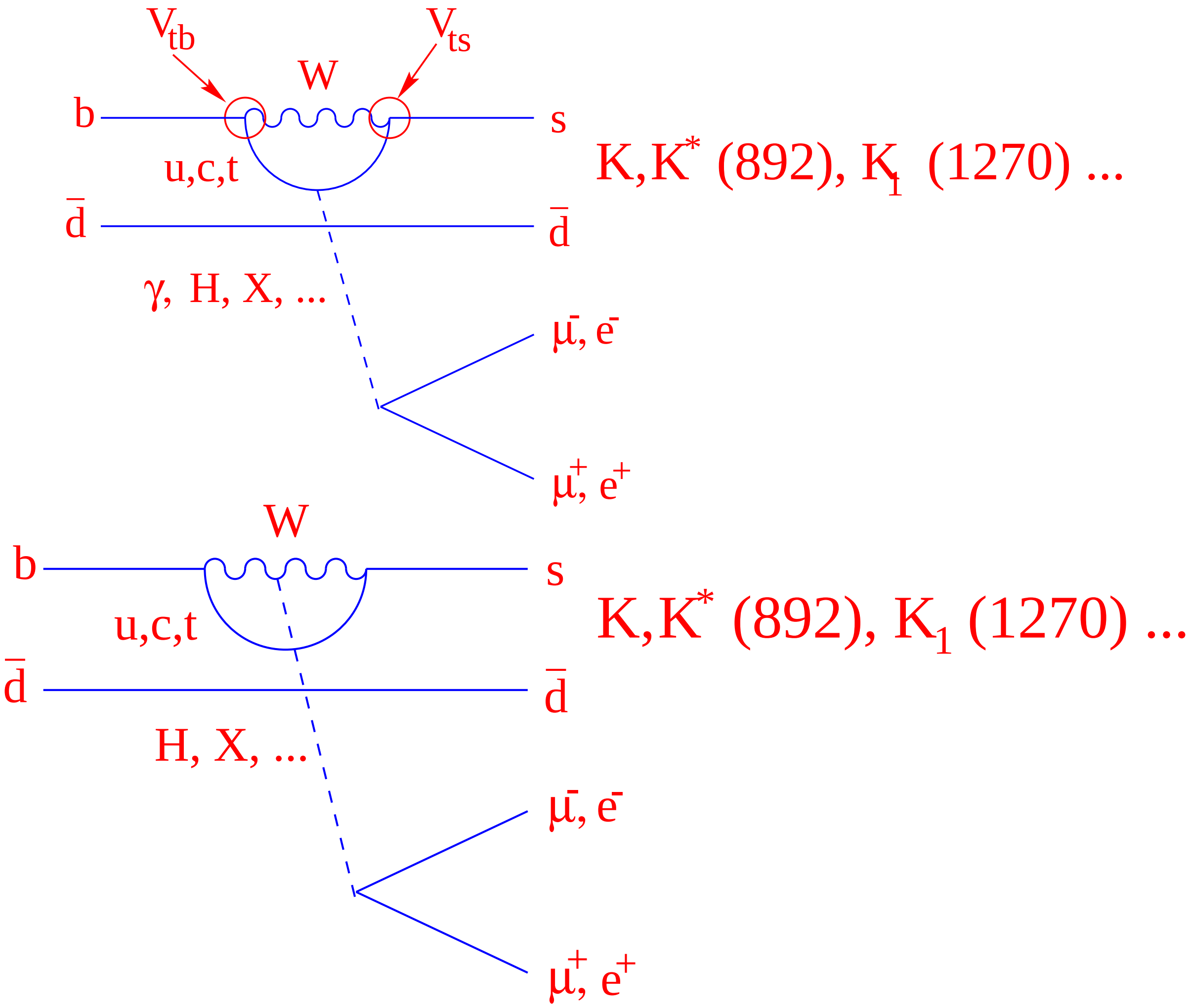
- $\mathcal{B}(B \to K^+\pi^-) = (1.72 \pm 0.27) \times 10^{-5}$.
  Penguin + CKM suppressed tree.
- $\mathcal{B}(B \to \pi^+\pi^-) = (4.3 \pm 1.6) \times 10^{-6}$.
  Tree + CKM suppressed penguin.

$\Rightarrow$ $B \to K^+\pi^-$ sets scale of gluonic penguins. In ballpark of theory predictions.

- $\mathcal{B}(B \to X_s\, g) < 0.068$ @ 90% CL.

$\Rightarrow$ Room for new physics in inclusive gluonic penguins but not in exclusive.

$$B \to X_s \, \ell^+ \ell^-, \, \ell = e \text{ or } \mu$$

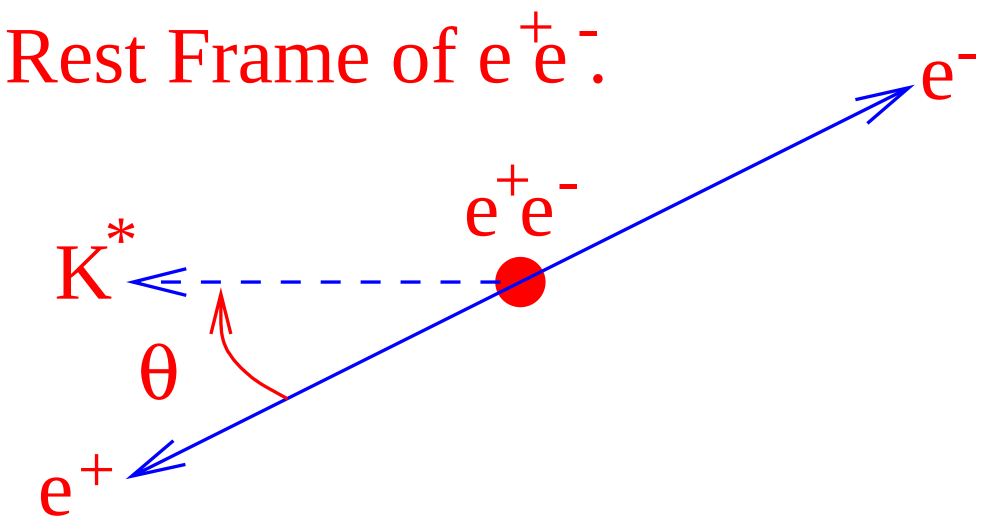


$B \to X_s \ell^+ \ell^-$

Decay Mode	Est. BR(SM)	Measurements and 90% CL upper limits
$(B_d, B_u) \to X_s \mu^+ \mu^-$	$(5.7 \pm 1.2) \times 10^{-6}$	$< 3.6 \times 10^{-5}$
$(B_d, B_u) \to X_d \mu^+ \mu^-$	$(3.3 \pm 1.9) \times 10^{-7}$	–
$(B_d, B_u) \to K \mu^+ \mu^-$	$(4.0 \pm 1.5) \times 10^{-7}$	$< 0.9 \times 10^{-5}$
$(B_d, B_u) \to K^* \mu^+ \mu^-$	$(1.5 \pm 0.6) \times 10^{-6}$	$< 2.5 \times 10^{-5}$
$B_s \to \mu^+ \mu^-$	$(3.5 \pm 1.0) \times 10^{-9}$	$< 8.4 \times 10^{-6}$
$B_d \to \mu^+ \mu^-$	$(1.5 \pm 0.9) \times 10^{-10}$	$< 1.6 \times 10^{-6}$
$(B_d, B_u) \to X_s e^+ e^-$	$(8.4 \pm 2.2) \times 10^{-6}$	–
$(B_d, B_u) \to X_d e^+ e^-$	$(4.9 \pm 2.9) \times 10^{-7}$	–
$(B_d, B_u) \to K e^+ e^-$	$(5.9 \pm 2.3) \times 10^{-7}$	$< 1.2 \times 10^{-5}$
$(B_d, B_u) \to K^* e^+ e^-$	$(2.3 \pm 0.9) \times 10^{-6}$	$< 1.6 \times 10^{-5}$
$B_s \to e^+ e^-$	$(8.0 \pm 3.5) \times 10^{-14}$	–
$B_d \to e^+ e^-$	$(3.4 \pm 2.3) \times 10^{-15}$	–

$B \to K^* \ell^+ \ell^-$

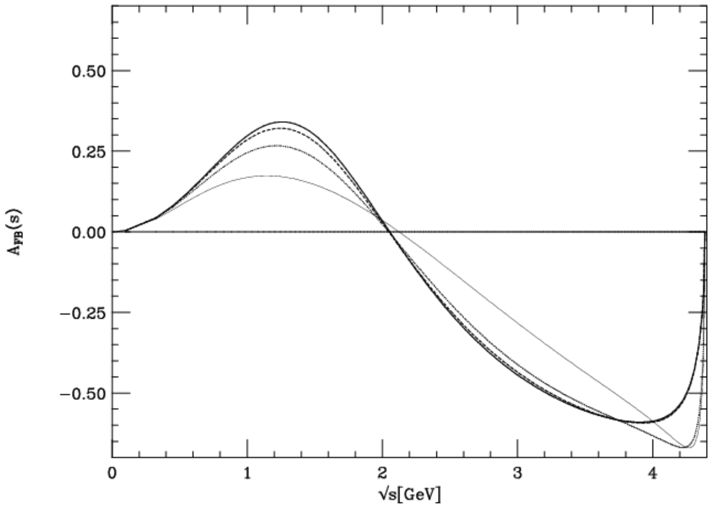
- Observables: Γ, $q^2 = m^2(\ell^+\ell^-)$, $\cos\theta$.



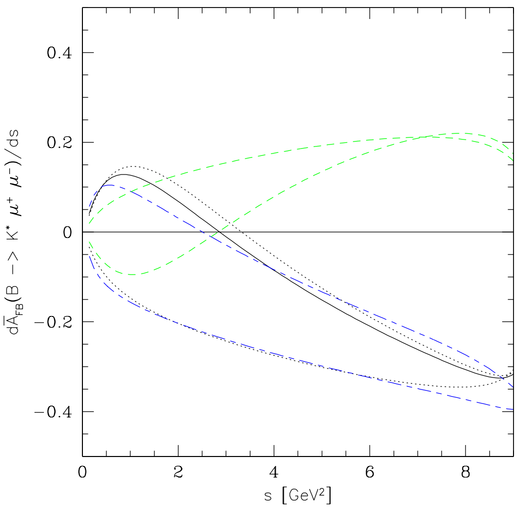
- $d\Gamma/d\cos\theta$ may be asymmetric.
- Asymmetry depends on q^2.
- All observables sensitive to new physics.

Asymmetry in $B \to K^{*0}\,\ell^+\ell^-$

SM: Burdman, Phys. Rev. D57 4254 (1998).



SUGRA(MIA-SUSY): Ali et al., Phys. Rev. D61 (2000).



BTeV Sensitivities, From BTeV Proposal

Mode	Events	S/B
$B^0 \to K^{*0}\mu^+\mu^-$	2200	11.
$B^+ \to K^+\mu^+\mu^-$	1280	3.2
$B \to X_s\,\mu^+\mu^-$	3600	0.13

- Yields for one year of nominal running (2 fb^{-1}) with SM predicted BR (Self tagging).
- Yields include trigger efficiencies and $\mathcal{B}(K^{*0} \to K^+\pi^-)$.
- To come: $\mu : \pi$ separation in RICH. Use $e^{\pm}$.
- It will be possible to measure the zero crossing in $A_{FB}(q^2)$.

Prospects for Semileptonic Decays

- Fixed target experiments have reconstructed $D \to K\ell\nu$ and $D \to K^*\ell\nu$.
- Method:
  - Reconstruct primary and secondary vertices: gives D flight direction.
  - Use P_T balance and m_D to close the kinematics: gives a quadratic ambiguity in the ν momentum.
- BTeV will evaluate this method for semileptonic B decays.

Conclusions

- Independent of experiment:
  - $b \to s\gamma$: Hard to see new physics.
  - $b \to s\, g$: Hard to see new physics in exclusive modes. Possibile for inclusive modes.
  - $b \to X_s\, \ell^+\ell^-$. Lots of room for new physics in rate, q^2 distributions and in angular distributions.
- BTeV can see CP Violation in $B^0 \to K^{*0}\gamma$ with $\delta(A_{CP}) \simeq 0.01$ and can see SM expectations for $b \to s\, \ell^+\ell^-$.
- BTeV is investigating semileptonic modes.