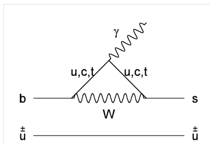
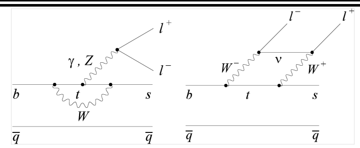
FCNC B decays

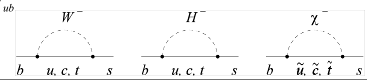
- Flavour changing neutral current (FCNC) decays appear only at the 1-loop level in the Standard Model
- Examples are the Penguin and W-box $b \to s l^+ l^-$ decays (right) and pure Penguin $b \to s\gamma$ decay (below)



- Preliminary results from *BABAR* are presented on $B \to K^{(*)} l^+ l^-$, $B \to X_s l^+ l^-$ and $B \to K_2^*(1430)\gamma$



- Excellent place to search for new physics because it appears at the same order as the Standard Model
- Some SUSY examples are shown in the figure below
- Theoretical predictions are more precise for inclusive modes than exclusive, due to hadronic uncertainties in the latter, however they are more challenging experimentally
- Measurement of the $b \to s\gamma$ photon energy spectrum leads to a more accurate simulation of the $b \to ul\nu$ lepton momentum spectrum, which is a major uncertainty in the determination of V_{ub}



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

Introduction

- The branching fraction for $B \to K l^+ l^-$ ($B \to K^* l^+ l^-$) is predicted to be around 0.5×10^{-6} (1.5×10^{-6}) with an accuracy of 35%
- 8 decay modes studied: $B^+ \to K^+ l^+ l^-$, $B^0 \to K^0_S l^+ l^-$, $B^+ \to K^{*+} l^+ l^-$ and $B^0 \to K^{*0} l^+ l^-$ ($l = e$ or μ)
- A data sample of 122.9×10^6 $B\bar{B}$ decays is used
- **Run 3 (2002-2003) data included**

Event selection

- B-candidates are formed by combining an oppositely charged lepton pair with a $K^\pm$ or K^0_S, and for the $B \to K^* l^+ l^-$ modes, a $\pi^\pm$ to form a K^* candidate
- Photons from Bremsstrahlung are recovered for electron tracks
- The K^+ are identified using the DIRC and dE/dx

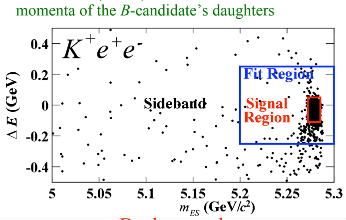
B-reconstruction

- The B-candidates are peaked strongly in two kinematic variables:

$$m_{ES} = \sqrt{E_b^{*2} - |\sum_i \mathbf{p}_i^*|^2}$$

$$\Delta E = \sum_i \sqrt{(m_i^2 + \mathbf{p}_i^{*2})} - E_b^*$$

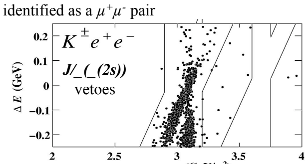
where E_b^* is the beam energy in the centre of mass frame, m_i and $\mathbf{p}_i^*$ are the masses and three-momenta of the B-candidate's daughters



Background

- Non-peaking background arises from random combinations of particles from $B\bar{B}$ and $q\bar{q}$ events
- Peaking background in m_{ES} and ΔE arises from:

1) $B \to J/\psi(\psi(2s))K^{(*)}$
2) $B \to K^*\gamma$ followed by photon conversion
3) Hadronic B-decays in which a $\pi^+\pi^-$ pair is identified as a $\mu^+\mu^-$ pair



- After cuts peaking background less than $\leq$ **0.7 events** in each mode

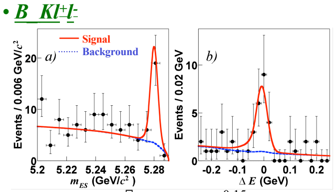
Fit

- Unbinned maximum likelihood fit is performed in m_{ES} and ΔE (m_{ES}, ΔE and $m_{K\pi}$) to extract signal yields of $B \to K l^+ l^-$ ($B \to K^* l^+ l^-$)
- Other signal parameters fixed to values from simulation or charmonium control samples
- Peaking background: same shape as signal with yields fixed
- Combinatorial background: empirical shape fitted to data with a floating normalization

Results

Mode	Yield	ε(%)	$BF(10^{-6})$
$K^+e^+e^-$	$24.7^{+5.9}_{-5.2}$	19.2	$1.05^{+0.25}_{-0.22} \pm 0.08$
$K^+\mu^+\mu^-$	$0.7^{+2.0}_{-1.2}$	8.5	$0.07^{+0.19}_{-0.11} \pm 0.02$
$K^0e^+e^-$	$-1.8^{+2.0}_{-1.4}$	20.1	$-0.21^{+0.23}_{-0.16} \pm 0.08$
$K^0\mu^+\mu^-$	$5.9^{+3.0}_{-2.3}$	8.7	$1.63^{+0.82}_{-0.63} \pm 0.17$
$K^{*0}e^+e^-$	$12.4^{+6.3}_{-5.2}$	13.6	$1.11^{+0.56}_{-0.47} \pm 0.12$
$K^{*0}\mu^+\mu^-$	$4.5^{+4.1}_{-3.0}$	6.4	$0.86^{+0.79}_{-0.58} \pm 0.12$
$K^{*+}e^+e^-$	$0.6^{+3.8}_{-2.5}$	10.2	$0.20^{+1.34}_{-0.87} \pm 0.27$
$K^{*+}\mu^+\mu^-$	$4.2^{+3.5}_{-2.4}$	4.9	$3.07^{+2.58}_{-1.78} \pm 0.44$

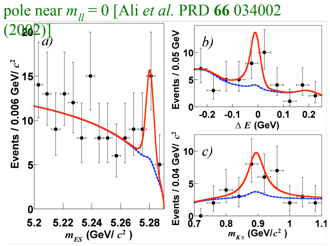
- **$B \to K l^+ l^-$**



$$BF(B \to K l^+ l^-) = (0.69^{+0.15}_{-0.13} \pm 0.06) \times 10^{-6}$$

Significance ~8σ

- **$B \to K^* l^+ l^-$**
- Assume $BF(B \to K^*e^+e^-)/BF(B \to K^*\mu^+\mu^-) = 1.33$ to account for contribution from photon penguin pole near $m_{ll} = 0$ [Ali *et al.* PRD **66** 034002 (2002)]

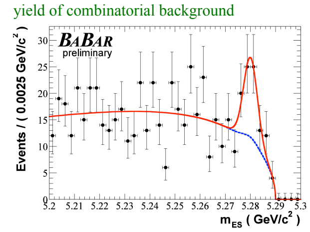


$$BF(B \to K^* l^+ l^-) = (0.89^{+0.34}_{-0.29} \pm 0.11) \times 10^{-6}$$

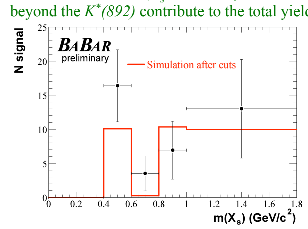
Significance ~3.3σ (including systematics)

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

- The inclusive branching fractions for $B \to X_s l^+ l^-$, where l is either an e or μ, are predicted to be $(4.2 \pm 0.7) \times 10^{-6}$ for $m_{ll} > 0.2$ GeV/c^2 [Ali, `hep-ph/0210183`]
- Sample of 88.9×10^6 $B\bar{B}$ events used
- Reconstruct ~50% of all final states by selecting oppositely charged electron or muon pairs combined with a $K^\pm$ or K^0_S, and up to 2 pions, one of which may be a π^0
- Event selection is optimized in 3 regions of $m(X_s)$ to enhance background rejection at higher $m(X_s)$
- Similar peaking backgrounds to $B \to K^{(*)} l^+ l^-$
- Unbinned extended maximum likelihood fit is performed to extract signal yields, and shape and yield of combinatorial background



- The distribution of $m(X_s)$ for e and μ shows states beyond the $K^*(892)$ contribute to the total yield



- **Signal yield 41.4±10.3±1.5, with a statistical significance of 4.6σ**

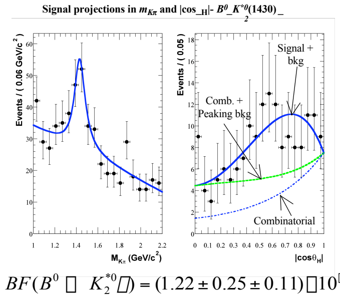
$$BF(B \to X_s l^+ l^-) = (6.3 \pm 1.6^{+1.8}_{-1.5}) \times 10^{-6}$$

- Dominant systematic uncertainties from the measured exclusive *BF*s and the Fermi motion model used for the b-quark in the meson
- With improved measurements of exclusive mode *BFs* and the Fermi motion the systematic uncertainty will **decrease significantly**

$B \to K_2^*(1430)\gamma$

- Branching fractions for the processes $B^+ \to K^{*+}_2(1430)\gamma$ and $B^0 \to K^{*0}_2(1430)\gamma$ have been measured
- Sub-modes $K^{*0}_2 \to K^+\pi^-$ and $K^{*+}_2 \to K^+\pi^0$, $K^0\pi^+_s$
- The spin-2 state is isolated from spin-1 background by fitting to the cosine of the helicity angle ($\cos\theta_H$) as well as ΔE and m_{ES}

Signal projections in $m_{K\pi}$ and $|\cos\theta_H|$- $B^0 \to K_2^{*0}(1430)\gamma$



$$BF(B^0 \to K_2^{*0}\gamma) = (1.22 \pm 0.25 \pm 0.11) \times 10^{-5}$$

$$BF(B^+ \to K_2^{*+}\gamma) = (1.44 \pm 0.40 \pm 0.13) \times 10^{-5}$$