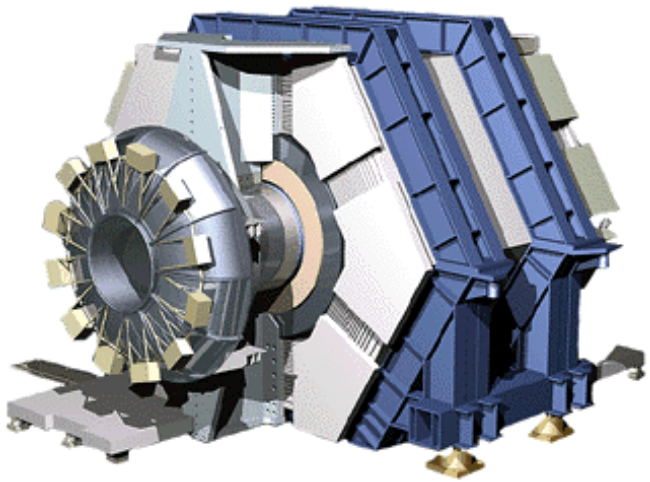
Leptonic B Decays at BaBar

Thomas Moore
University of Massachusetts, Amherst

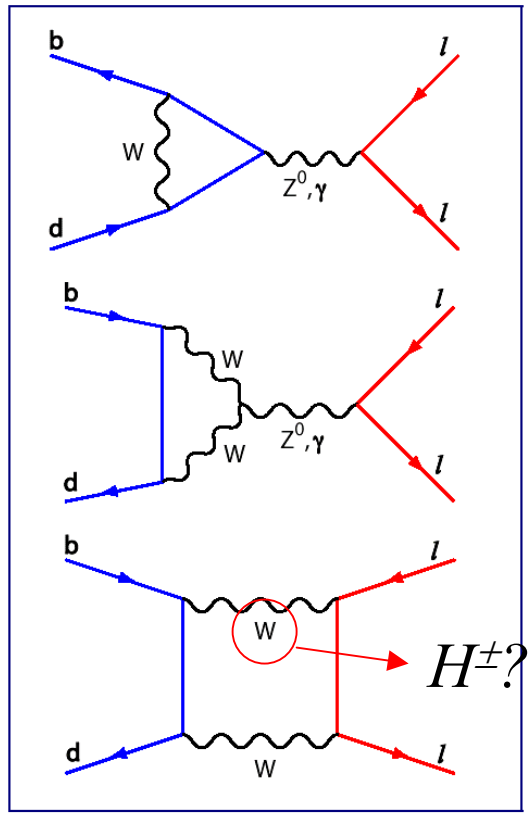
31st International Conference on High Energy Physics
July 24-31 2002



- $B^0 \to \ell^+\ell^-$
- $B^+ \to K^+\nu\bar{\nu}$

$B^0 \to \ell^+ \ell^-$

- $B^0 \to \ell^+ \ell^-$ is highly suppressed in the Standard Model:
  - CKM suppression ($b \to d$ transition)
  - helicity suppression $(m_\ell / m_B)^2$
- Sensitive to new physics:
  - multi-Higgs-doublet models
  - leptoquarks, R-parity violating SUSY…
- Standard Model BR predictions (Ali, Greub, Mannel) and experimental upper limits:



	SM BR	CLEO(9.1 fb^{-1})	Belle(21.3 fb^{-1})
$B^0 \to e^+e^-$	$\approx 10^{-15}$	8.3×10^{-7}	6.3×10^{-7}
$B^0 \to \mu^+\mu^-$	$\approx 10^{-10}$	6.1×10^{-7}	2.8×10^{-7}
$B^0 \to e^+\mu^-$	-	15.0×10^{-7}	9.4×10^{-7}

$B^0 \to \ell^+ \ell^-$ Analysis

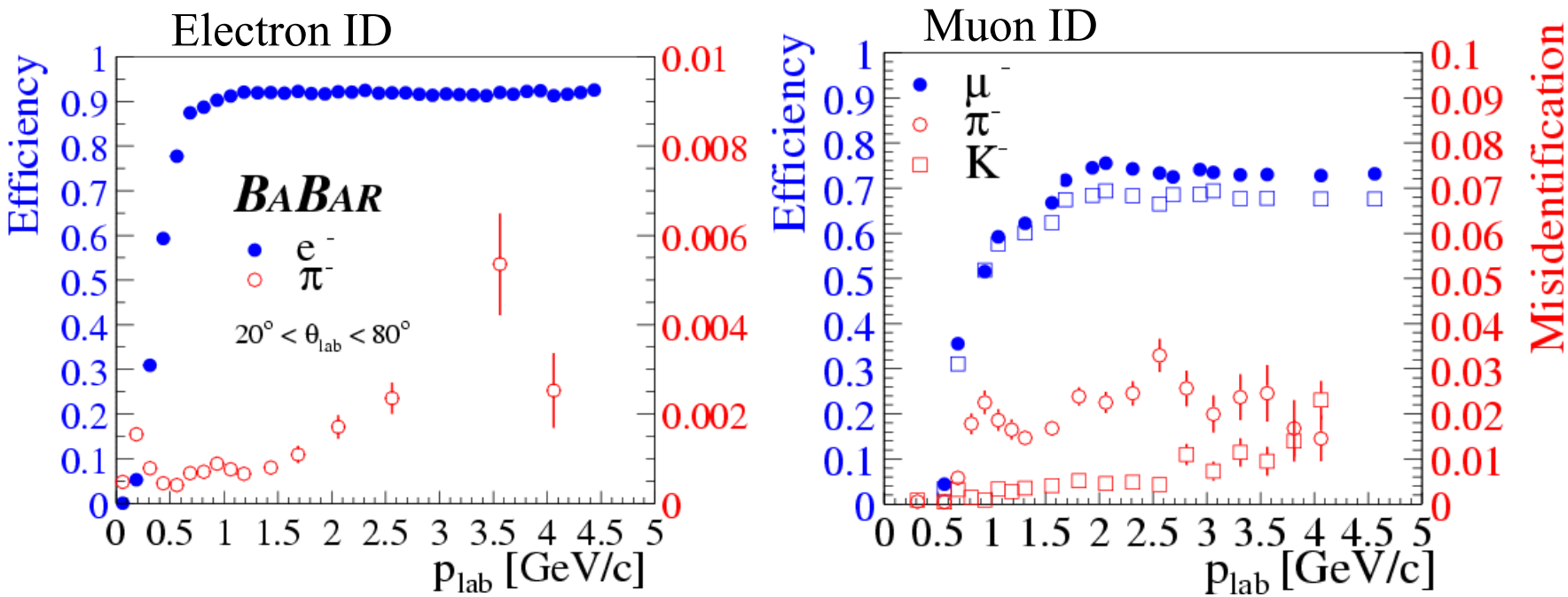
- *Event Preselection:*
  - total energy $E_{Tot} < 11.0$ GeV
  - missing momentum $p_{Miss} < 3.0$ GeV
  - multiplicity $N_{Mult} = N_{Trk} + \frac{1}{2} N_{\gamma} \geq 6$
- *Signal Reconstruction:*
  - locate B decay vertex with two high p leptons ($P_{vtx} > 0.1\%$)
  - define a signal box in ΔE vs m_{ES} ,

$$\Delta E = \sum_i \sqrt{m_i^2 + (p_i^*)^2} - E_{beam}^* \qquad m_{ES} = \sqrt{(E_{beam}^*)^2 - (\sum_i p_i^*)^2}$$

- *Continuum Suppression:* event shape variables
- *Analysis is performed blind:*

  54.4 fb^{-1} of data (60 M $B\bar{B}$ events) collected at the $\Upsilon(4S)$.

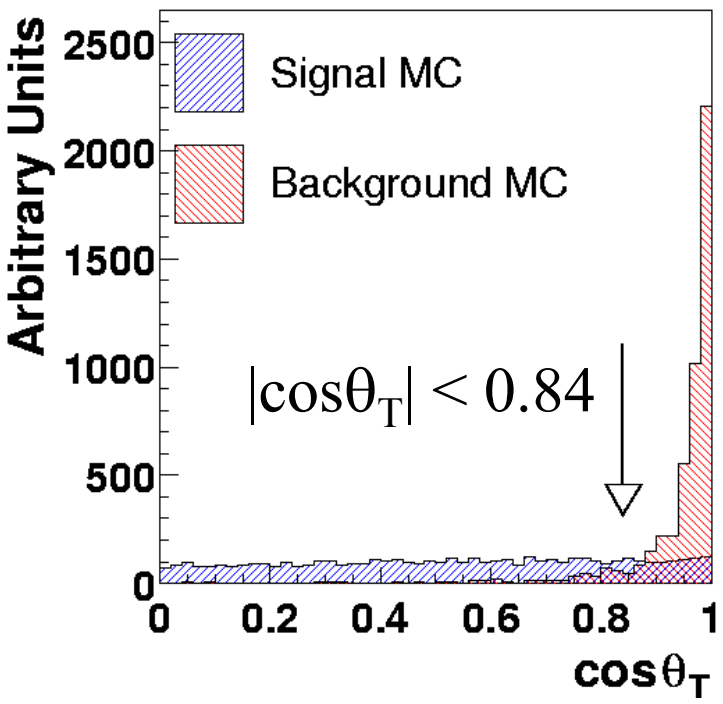
Lepton Identification

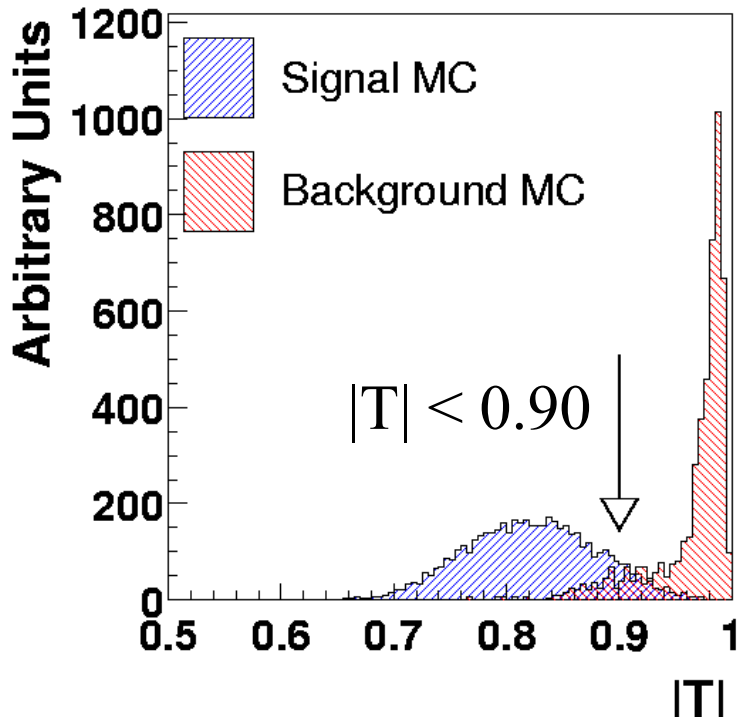


- electrons identified with EMC
- high efficiency (>90%)
- low π mis-id (≈10^{-3})

- muons identified with IFR
- tight selection efficiency ≈ 70%
- π mis-id ≈ 2.5%

Continuum Suppression





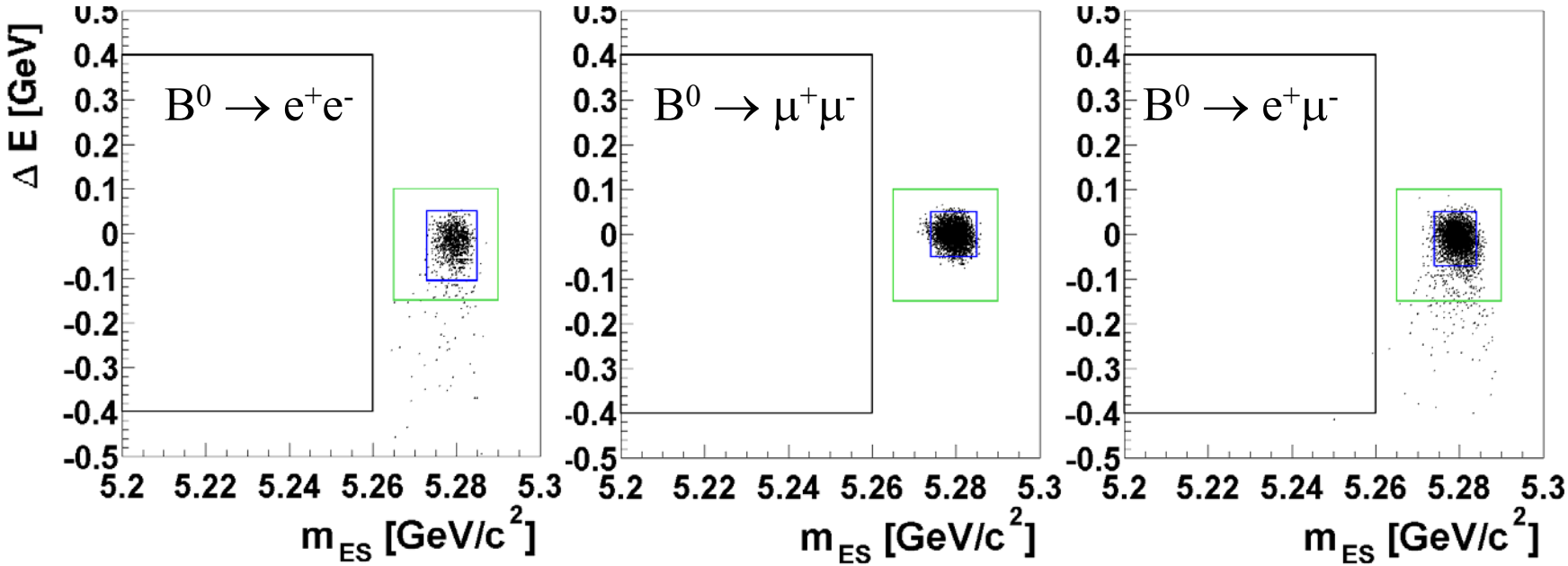
$\cos\theta_T$: angle between B momentum and thrust axis of the rest of the event

|T|: thrust magnitude

Cut values are optimized simultaneously for best upper limit

ΔE vs m_{ES} (Signal MC)

Signal box dimensions are optimized for best upper limit.



	efficiency[%]	$\sigma(m_{ES})$ [MeV]	$\sigma(\Delta E)$ [MeV]
$B^0 \to e^+e^-$	19.3±0.4	3.0±0.2	29.3±0.9
$B^0 \to \mu^+\mu^-$	18.8±0.3	2.6±0.1	24.7±0.3
$B^0 \to e^+\mu^-$	18.3±0.4	2.7±0.1	26.8±0.4

Expected Background

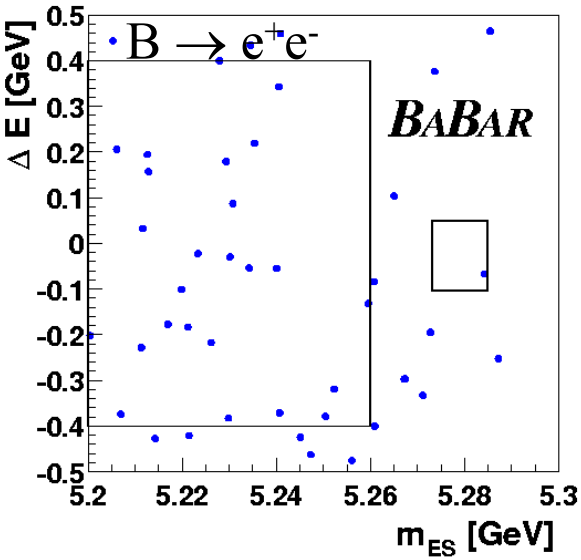
- Backgrounds are expected from:
  - real leptons from continuum $c\bar{c}$ decays
  - $\pi \rightarrow \mu$ misidentification in $B \rightarrow \mu^+\mu^-$ and $B \rightarrow e^+\mu^-$ channels
  - 2-photon processes in $B \rightarrow e^+e^-$ and $B \rightarrow e^+\mu^-$ channels

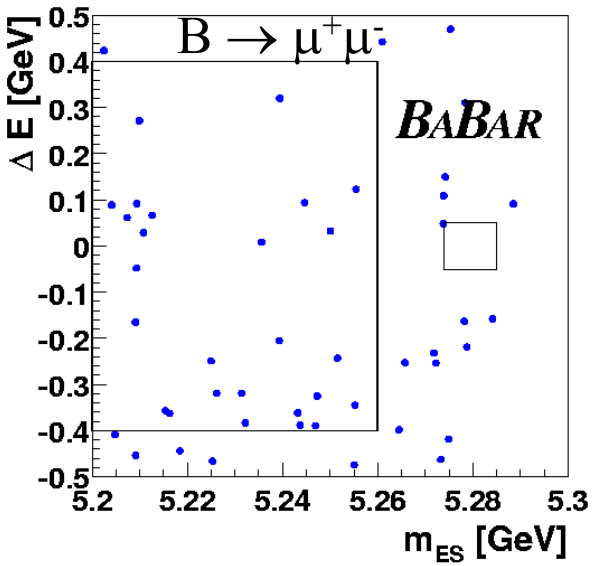
- Backgrounds are estimated from the data sidebands by extrapolating into the signal box. Normalization is taken from the data in the sideband.

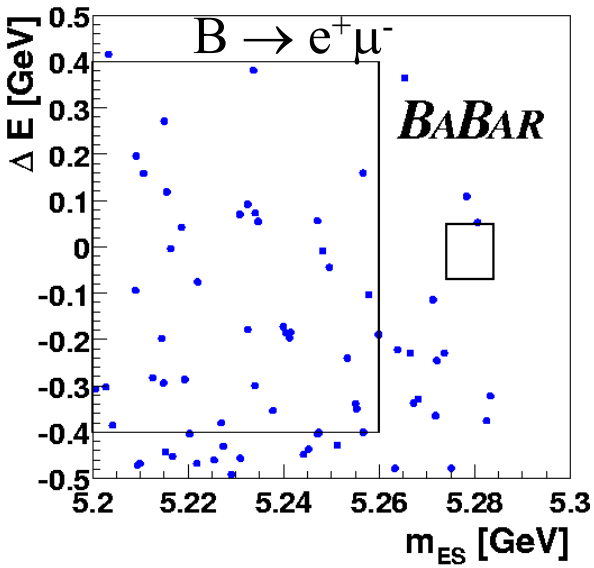
- No background subtraction is applied when extracting the upper limits.

$B^0 \to \ell^+ \ell^-$ Results

(Preliminary 54.4 fb^{-1})



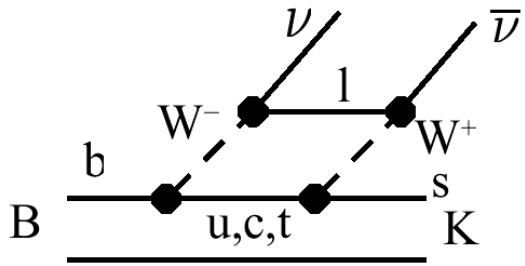


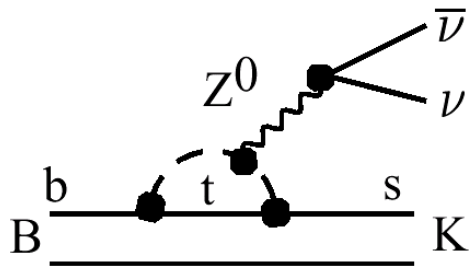


	N_{GSB}	N_{SigBox}	N_{BG}	90% CL Upper Limit
$B \to e^+e^-$	25	1	0.60±0.24	3.3×10^{-7}
$B \to \mu^+\mu^-$	26	0	0. 49±0.19	2.0×10^{-7}
$B \to e^+\mu^-$	37	0	0.51±0.17	2.1×10^{-7}

$B^+ \to K^+ \nu\bar{\nu}$

- $B^+ \to K^+ \nu\bar{\nu}$ involves flavor-changing neutral currents and is thus highly suppressed in the Standard Model,
  $\mathcal{B}(B^+ \to K^+ \nu\bar{\nu}) \approx 3.8 \times 10^{-6}$ (SM)
- $b \to s \nu\bar{\nu}$ is nearly free from strong interaction effects and has a small theoretical uncertainty.
- This decay is sensitive to new physics emerging in the loops:
  Fourth generation, extra vector-like down quark, R-parity violating SUSY, FCNC Z'
- The best experimental limit is from CLEO,
  $\mathcal{B}(B^+ \to K^+ \nu\bar{\nu}) < 2.4 \times 10^{-4}$ (90% CL)



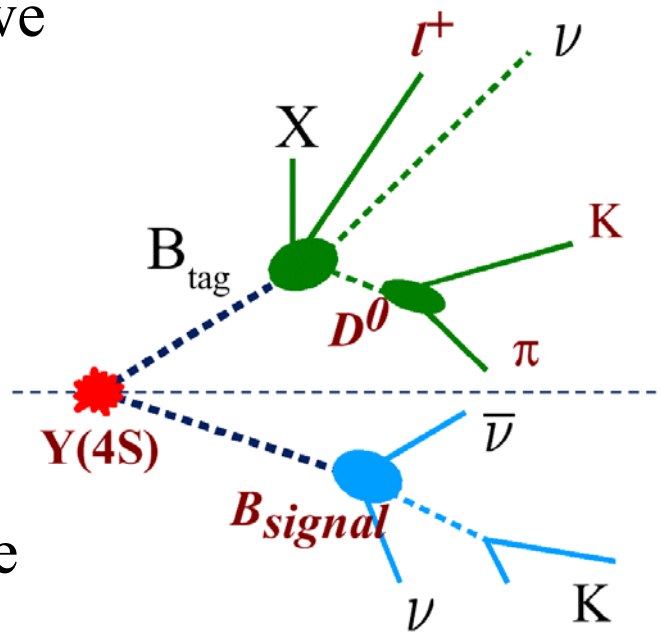


$B^+ \to K^+ \nu\bar{\nu}$ Analysis

- This decay includes 2 neutrinos so we must tag the other B and search the recoil system for the signal.
- The other B is tagged by partial reconstruction of:

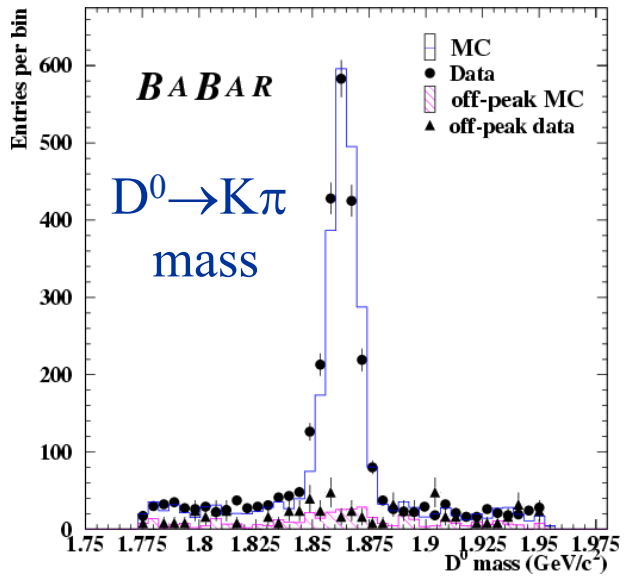
  $B^- \to D^0 \ell^- \nu(X)$

  $\hookrightarrow K^-\pi^+, K^-\pi^+\pi^+\pi^-, K^-\pi^+\pi^0$
- Tagging efficiency is estimated to be 0.55% from MC.



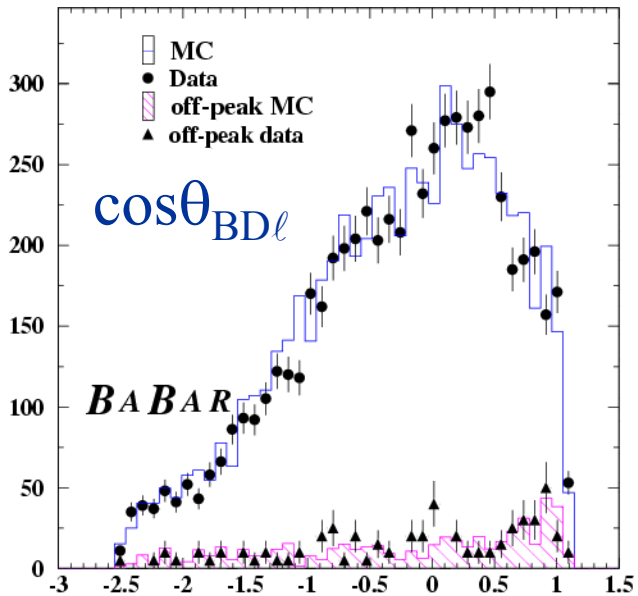
- We look for events with one remaining high momentum Kaon (identified by DIRC) and little remaining neutral energy.
- A blind analysis was performed using 50.7 fb^{-1} (56.3 M $B\bar{B}$) of data collected at the $\Upsilon(4S)$.

$B^- \to D^0 \ell^- \nu(X)$ Tag Selection



We have ≈ 2500 tags per fb^{-1} compared to ≈ 350 for fully reconstructed hadronic modes

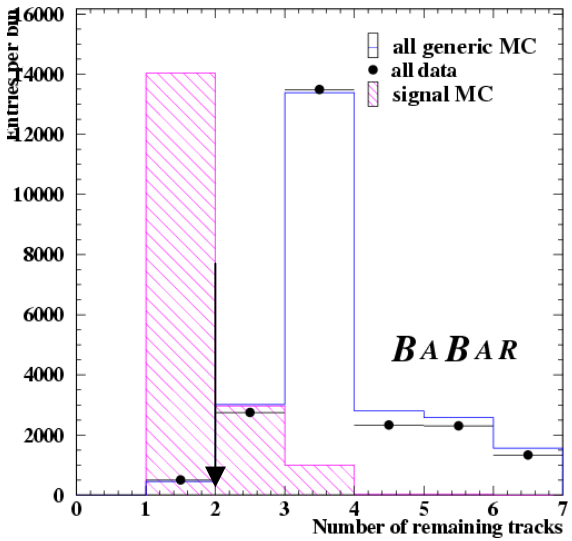
$$\cos\theta_{BD\ell} = \frac{2E_B E_{D\ell} - m_B^2 - m_{D\ell}^2}{2\,|\,\vec{p}_B\,|\,|\,\vec{p}_{D\ell}\,|}$$



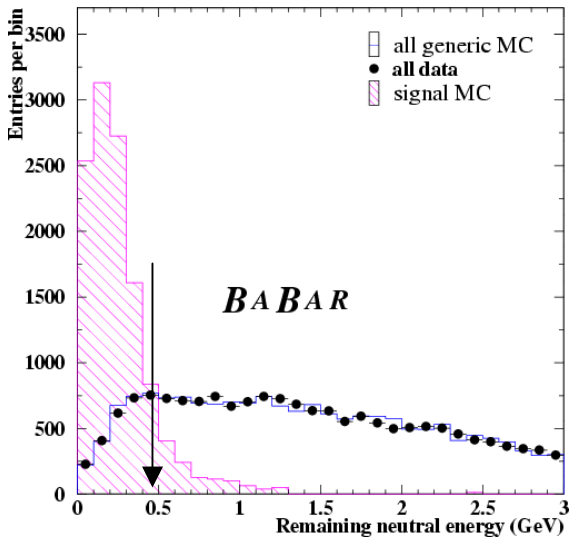
- p*(lepton) > 1.3 GeV/c
- p*(D^0) > 0.5 GeV/c
- m(D^0) within 3σ of PDG
- m($D^0\ell^-$) > 3.0 GeV/c^2
- $-2.5 < \cos\theta_{BD\ell} < 1.1$

Signal Selection

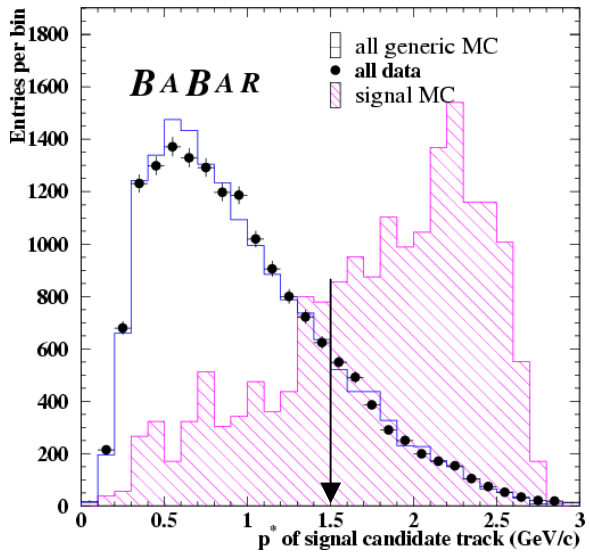
n remaining tracks



neutral E remaining(GeV)



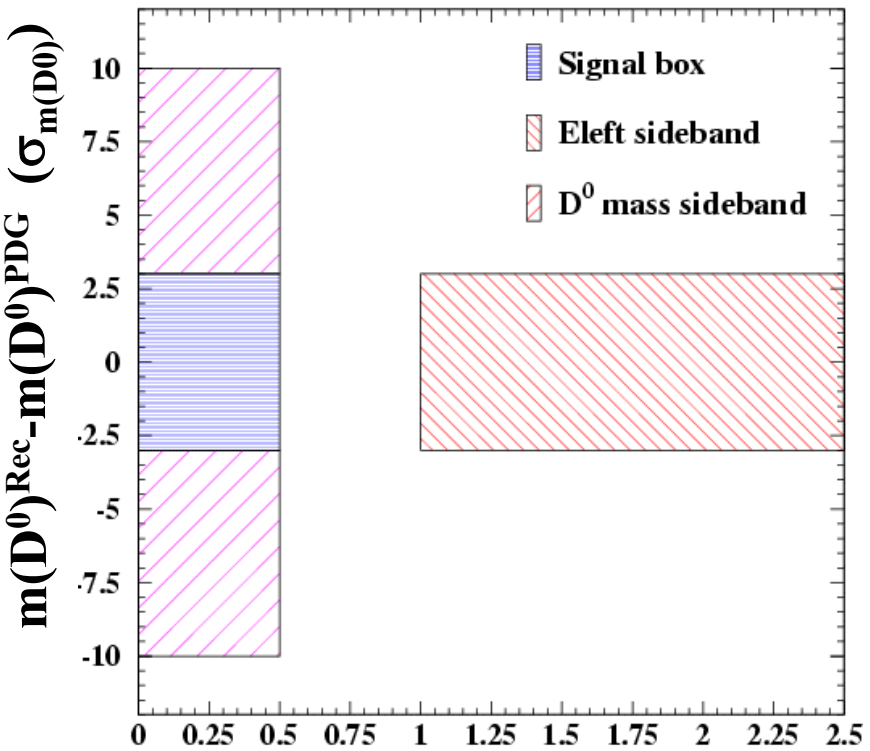
Kaon p* (GeV/c)



- 1 remaining track passes Kaon identification
- $E_{left} < 0.5$ GeV (remaining neutral energy)
- $p^*(K) > 1.5$ GeV/c
- $-0.9 < \cos\theta_{K\ell} < 0.8$ (angle between Kaon and tag lepton)

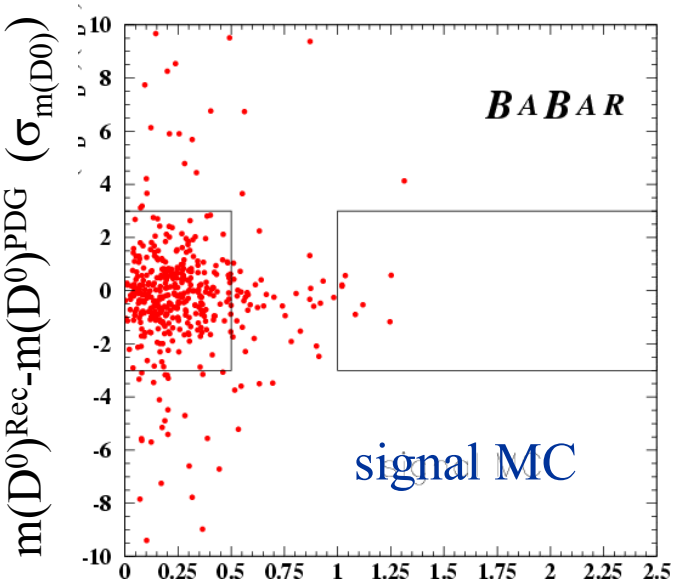
Signal Box

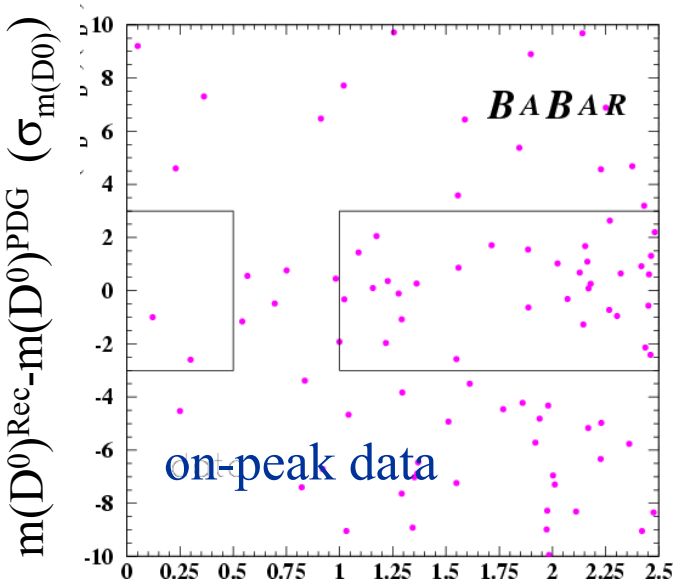
- Define signal and sideband regions in D^0 mass vs E_{left}.
- Check for data/MC consistency in the E_{left} and D^0 mass sidebands.
- The region below 1 GeV in E_{left} was blinded until the analysis was complete.



$B^+ \to K^+ \nu\bar{\nu}$ Results

(Preliminary 50.7 fb-1)





MC signal efficiency ≈ 0.1%

2 events observed in the data (2.2 expected)

$B(B^+ \to K^+ \nu\bar{\nu}) < 9.4 \times 10^{-5}$ (90% CL)

Conclusions

- With 54.4 fb^{-1}, BaBar has set the following upper limits on the B $\rightarrow \ell^+\ell^-$ branching ratios at 90% CL,

$$\mathcal{B}(B \rightarrow e^+e^-) < 3.3 \times 10^{-7}$$
$$\mathcal{B}(B \rightarrow \mu^+\mu^-) < 2.0 \times 10^{-7}$$
$$\mathcal{B}(B \rightarrow e^+\mu^-) < 2.1 \times 10^{-7}$$

- With 50.7 fb^{-1}, we set the following upper limit on the $B \rightarrow K\nu\bar{\nu}$ branching ratio at 90% CL,

$$\mathcal{B}(B^+ \rightarrow K^+\nu\bar{\nu}) < 9.4 \times 10^{-5}$$

The BaBar Detector

PEP-II delivers boosted e+e- $\rightarrow \Upsilon(4S) \rightarrow B\bar{B}$ ($\beta\gamma = 0.56$)