Search for $B^+ \to K^+ l^+ l^-$ and $B^0 \to K^{*0} l^+ l^-$

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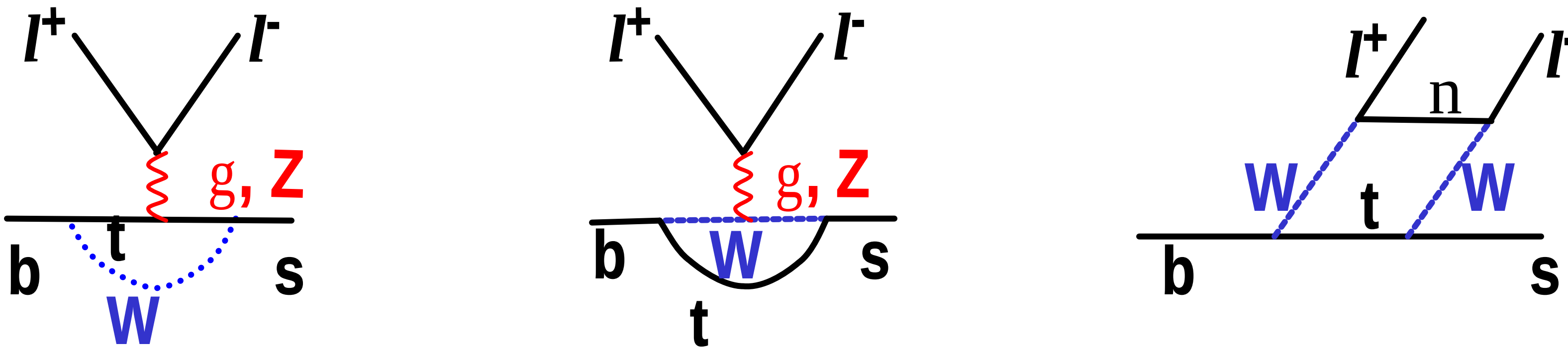
On behalf of the BaBar Collaboration

- Theoretical predictions and experimental status
- Analysis methods
- Signal properties
- Main background categories
  - J/ψ [$\psi(2S)$] K and J/ψ [$\psi(2S)$] K* events
- Results

Theoretical issues



Mode	Predicted Br. Fr.* (~35% uncertainty)	Product Br. Fr.	# produced events / 10 fb^{-1}
$B^+ \to K^+ l^+ l^-$	5.7×10^{-7}	5.7×10^{-7}	12.0
$B^0 \to K^{*0} e^+ e^-$ ($K^{*0} \to K^+ \pi^-$)	2.3×10^{-6}	1.5×10^{-6}	16.1
$B^0 \to K^{*0} \mu^+ \mu^-$ ($K^{*0} \to K^+ \pi^-$)	1.9×10^{-6}	1.3×10^{-6}	13.3
TOTAL events produced			**41.4**

➡ For now, we are only looking at 3.15 fb^{-1} of data

- this is the first stage of a blind analysis
- we expect to have 20 fb^{-1} by the end of the year

*A.Ali *et al*., Phys. Rev. D. **61,** (2000), 074024 (form factors from Light Cone QCD Sum Rules).

Experimental status

- 90% CL limits from **CLEO** (3.33×10^6 $B\bar{B}$ data set) and **CDF** ($88\ pb^{-1}$):

Mode	CLEO*	CDF**
$K^{+}m^{+}m^{-}$	$< 9.7 \times 10^{-6}$	$< 5.2 \times 10^{-6}$
$K^{0}m^{+}m^{-}$	$< 31.0 \times 10^{-6}$	
$K^{*+}m^{+}m^{-}$	$< 33.0 \times 10^{-6}$	
$K^{*0}m^{+}m^{-}$	$< 9.5 \times 10^{-6}$	$< 4.0 \times 10^{-6}$
$K^{+}e^{+}e^{-}$	$< 11.0 \times 10^{-6}$	
$K^{0}e^{+}e^{-}$	$< 17.0 \times 10^{-6}$	
$K^{*+}e^{+}e^{-}$	$< 38.0 \times 10^{-6}$	
$K^{*0}e^{+}e^{-}$	$< 14.0 \times 10^{-6}$	

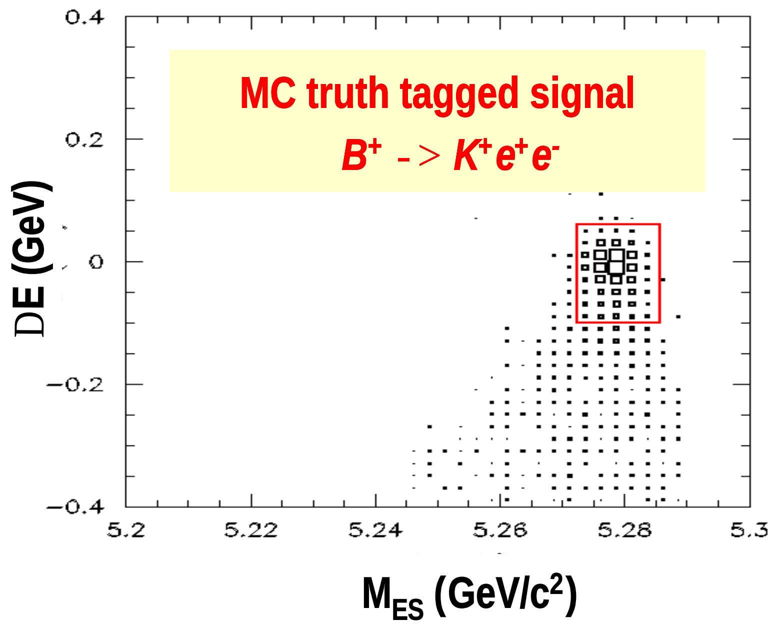
*CLEO CONF 98-22, ICHEP98 1012 (1998) (unpublished).
T. Affolder *et al.*, Phys. Rev. Lett. **83, (1999), 3378.

Analysis Methods (1)

- Basic ideas:
  - Perform a blind analysis
  - Select charged particle modes only:
    - $B^+ \to K^+e^+e^-$, $B^+ \to K^+\mu^+\mu^-$, $B^0 \to K^{*0}e^+e^-$, $B^0 \to K^{*0}\mu^+\mu^-$ (where $K^{*0} \to K^+\pi^-$)
  - use ΔE vs. m_{ES} plane to select signal region

$$m_{ES} = \sqrt{(\sqrt{s}/2)^2 - (p_B^*)^2}$$

$$\Delta E = E_B^* - \sqrt{s}/2$$



- $E_B^*(p_B^*)$ is the *B* candidate energy (momentum) in the CM frame
- $\sqrt{s}$ = center-of-mass energy

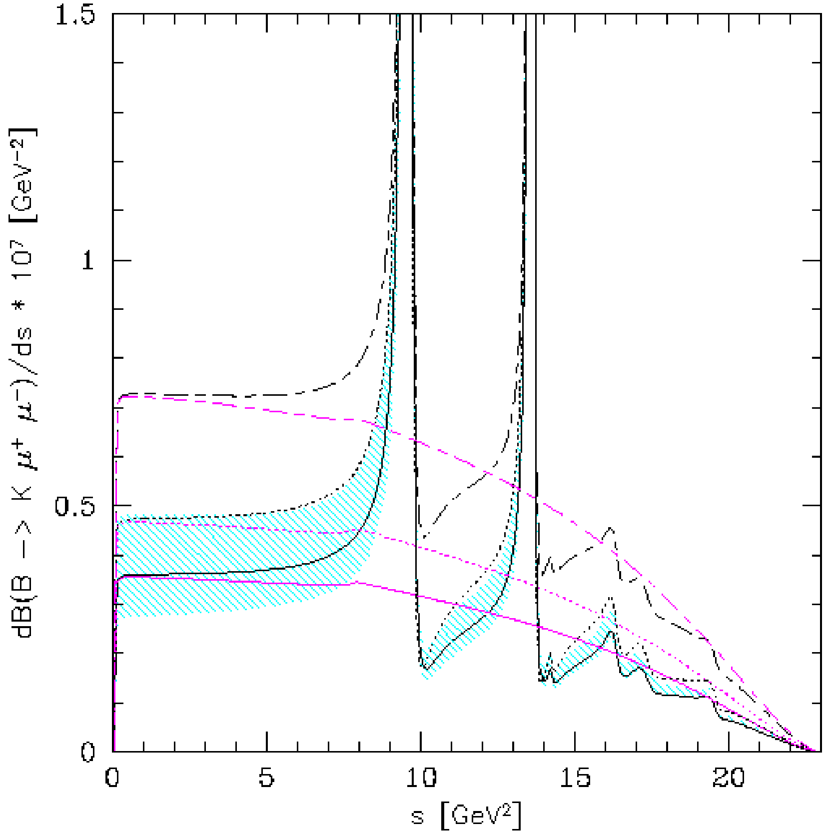
Analysis Methods (2)

- Select electrons with $p^{LAB}_e > 0.5$ GeV/c and muons with $p^{LAB}_\mu > 1.0$ GeV/c
- Require high multiplicity events (with # of tracks > 4); veto γ conversions
- Veto J/ψ, $\psi(2S)$ resonance regions
- Suppress continuum background using Fisher discriminant
- Particle ID:
  - electron ID based on energy deposition in the CsI calorimeter
  - muon ID based on the penetration length in the Instrumented Flux Return
  - hadron ID based on combined drift chamber dE/dx and Cherenkov angle information

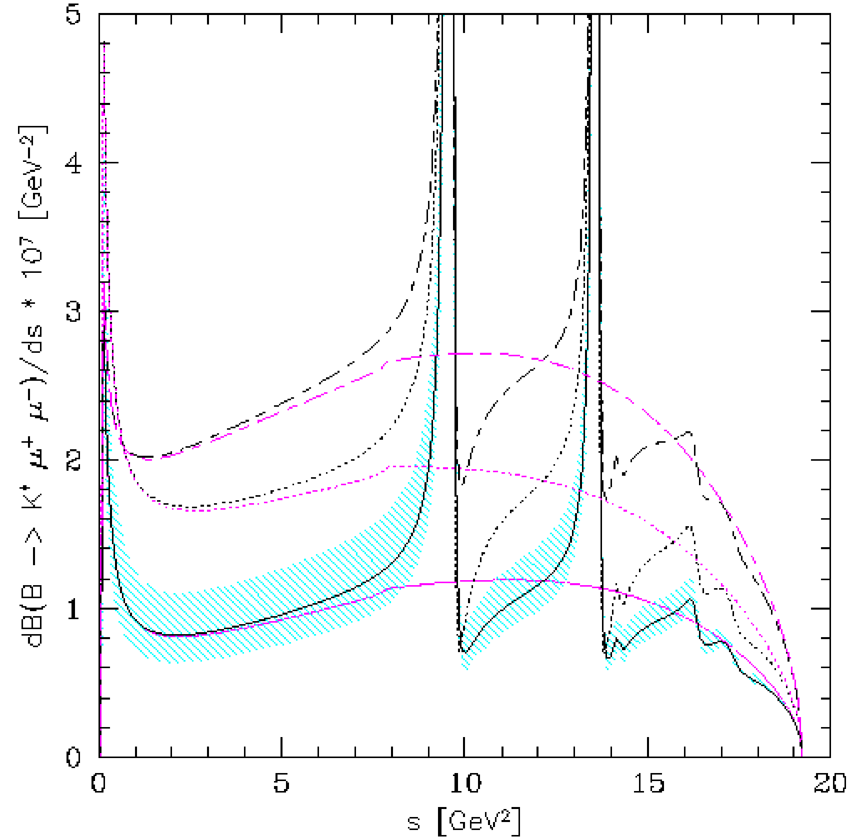
Mode	$K^+e^+e^-$	$K^+\mu^+\mu^-$	$K^{*0}e^+e^-$	$K^{*0}\mu^+\mu^-$
Efficiency, %	**13.1**	**8.6**	**7.7**	**4.5**

Predicted distributions for $q^2 = M^2_{l+l-}$

B -> K m^+m^- :



B -> K^{*0} m^+m^- (pole at $q^2 = 0$):

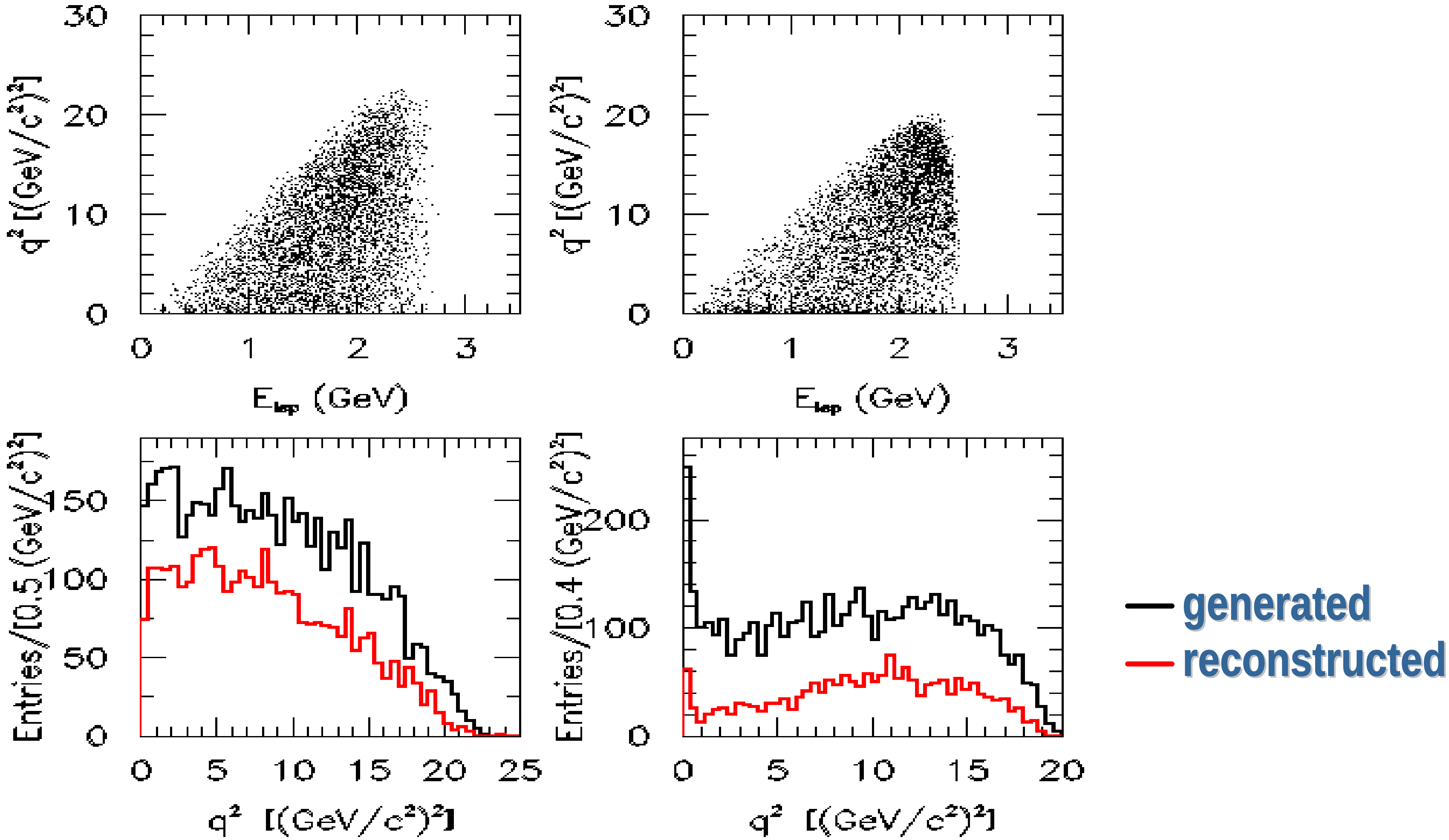


- Solid line + blue bands: SM range (± 35%); Ali et al. form factors
- Dotted line: SUGRA model (R_7 = -1.2, R_9 = 1.03, R_{10} = 1)
- Long-short dashed line: SUSY model (R_7 = -0.83, R_9 = 0.92, R_{10} = 1.61)

Generated distributions for $q^2 = M^2_{l+l-}$

We have implemented event generators using the model of Ali *et al.*

$B \to K\, m^+m^-$: **$B \to K^{*0}\, m^+m^-$ (pole at $q^2 = 0$):**



Background categories

- **$B \rightarrow J/\psi\ K(K^*)$, $\psi(2S)\ K(K^*)$ is the most serious background**
  - this background can be controlled by a cut in ΔE vs. m_{l+l-} plane
  - also possible to have $J/\psi\ (\rightarrow \mu^+ \mu^-)$ K with K and μ swapped
    - re-assign particle masses and cut on the J/ψ mass

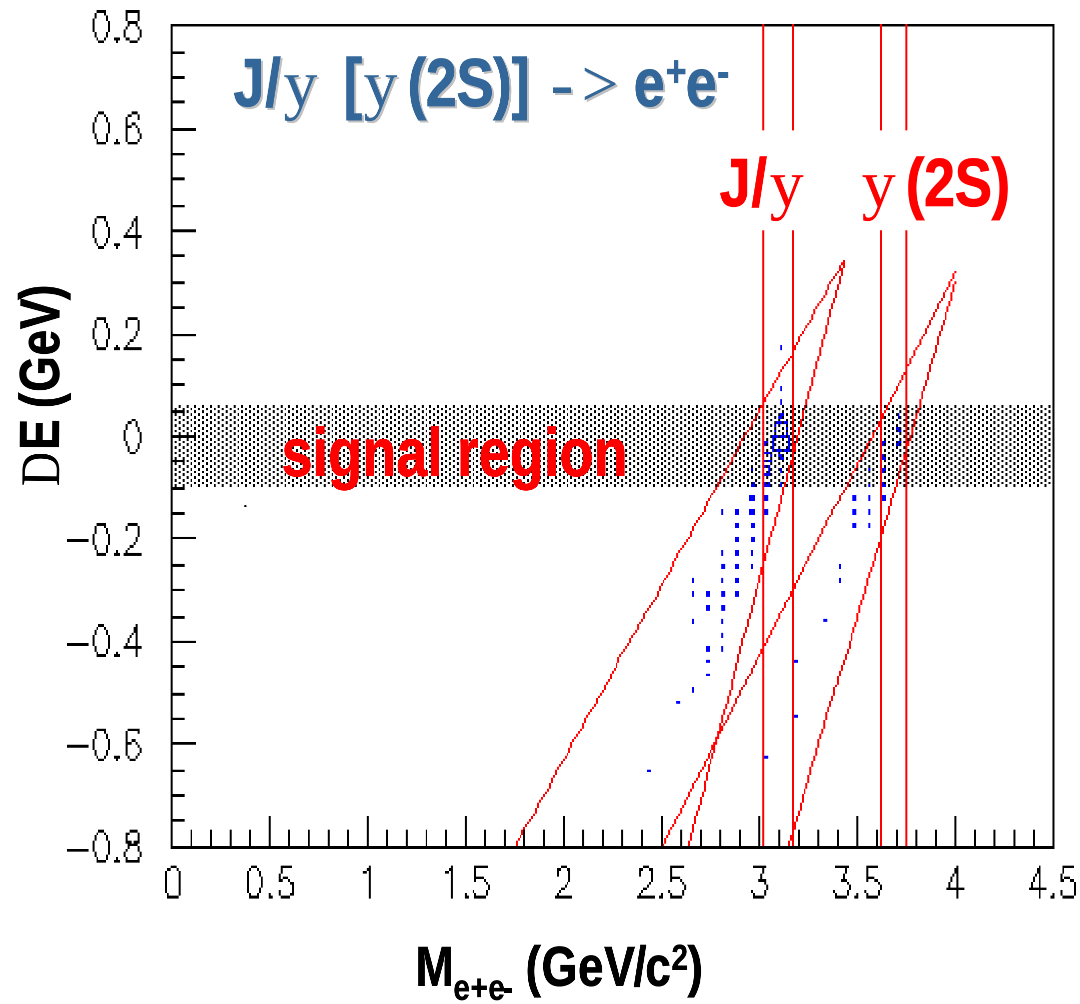
- **$B^+ \rightarrow D^0 (\rightarrow K^+ \pi^-) \pi^+$ with π^- misidentified as μ^- and K^+ as μ^+**
  - re-assign particle masses and veto the D^0

- **Continuum ($e^+e^- \rightarrow \bar{q}q$)**
  - suppressed by using a 4-variable Fisher discriminant

- **Combinatorial from $B\bar{B}$ events**
  - suppressed by using vertexing

B –> J/ψ [ψ(2S)] K$^{(*)}$ events (1)

Signal *B* -> J/y K and *B* ->y (2S) K Monte Carlo

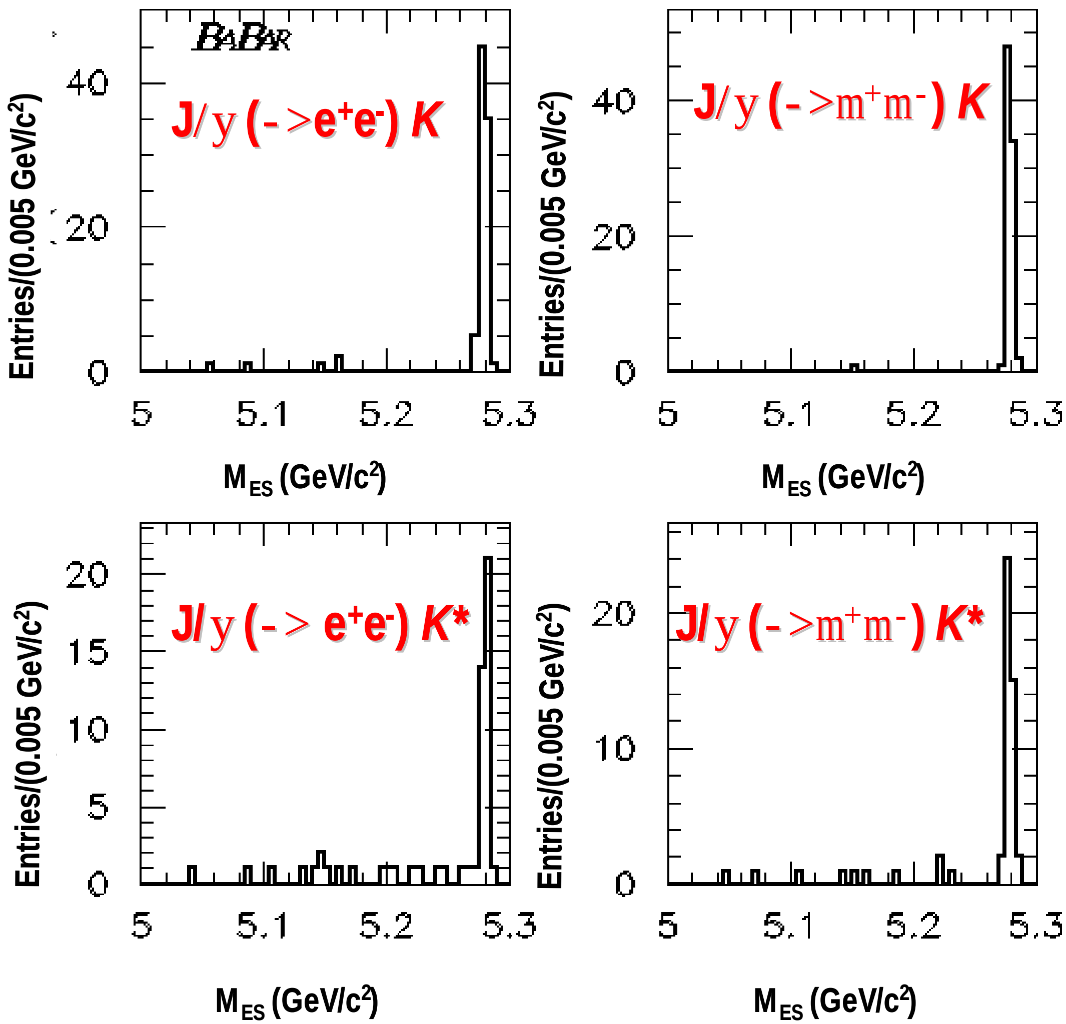


The most serious background for this analysis, **J/y [y (2S)] K$^{(*)}$** events, is suppressed by using a correlated selection in the **DE vs. m$_{l+l-}$** plane

- This is needed to account for bremsstrahlung and track mismeasurement

B –> J/ψ [ψ(2S)] $K^{(*)}$ events (2)

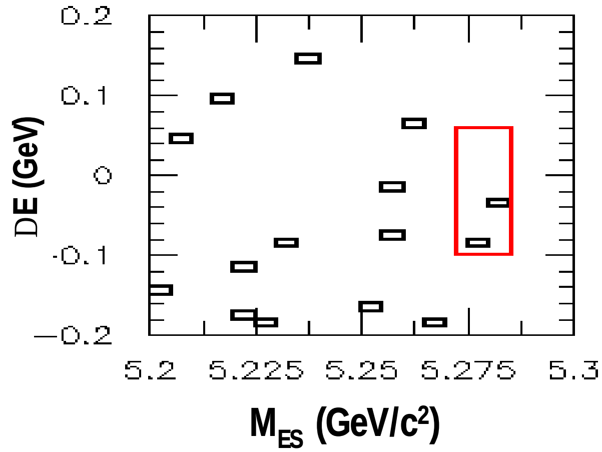
B -> J/y [y (2S)] $K^{(*)}$ control sample (8 fb^{-1} of data)

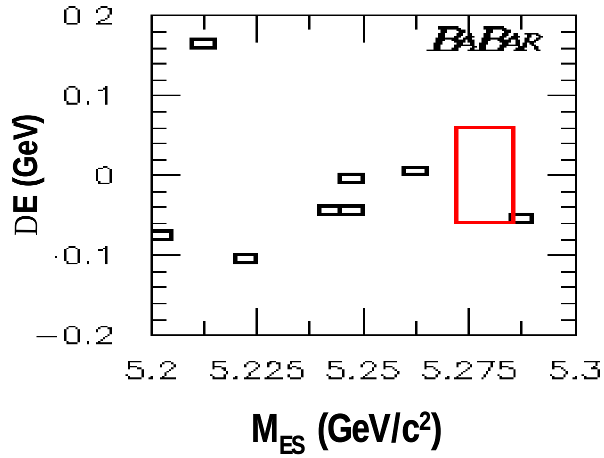


J/y [y (2S)] $K^{(*)}$ events are also used as a control sample to verify the analysis efficiency

Results (1)

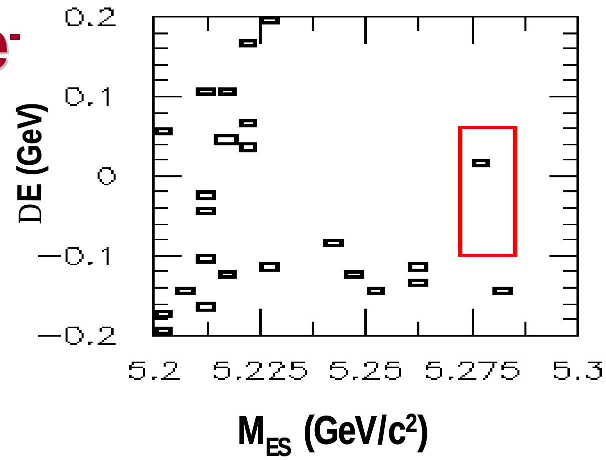
B^+ -> $K^+e^+e^-$

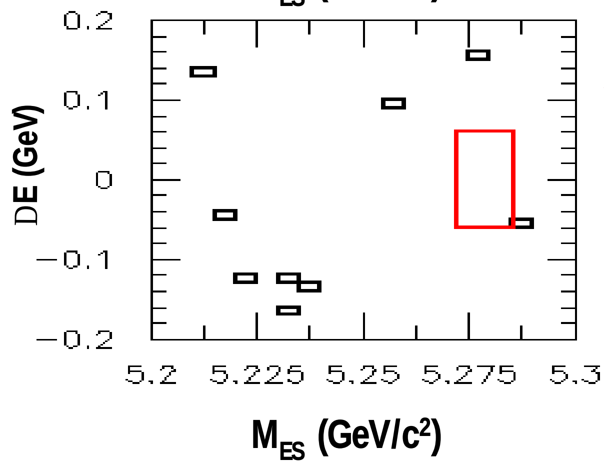




B^+ -> $K^+m^+m^-$

B^0 -> $K^{*0}e^+e^-$





B^0 -> $K^{*0}m^+m^-$

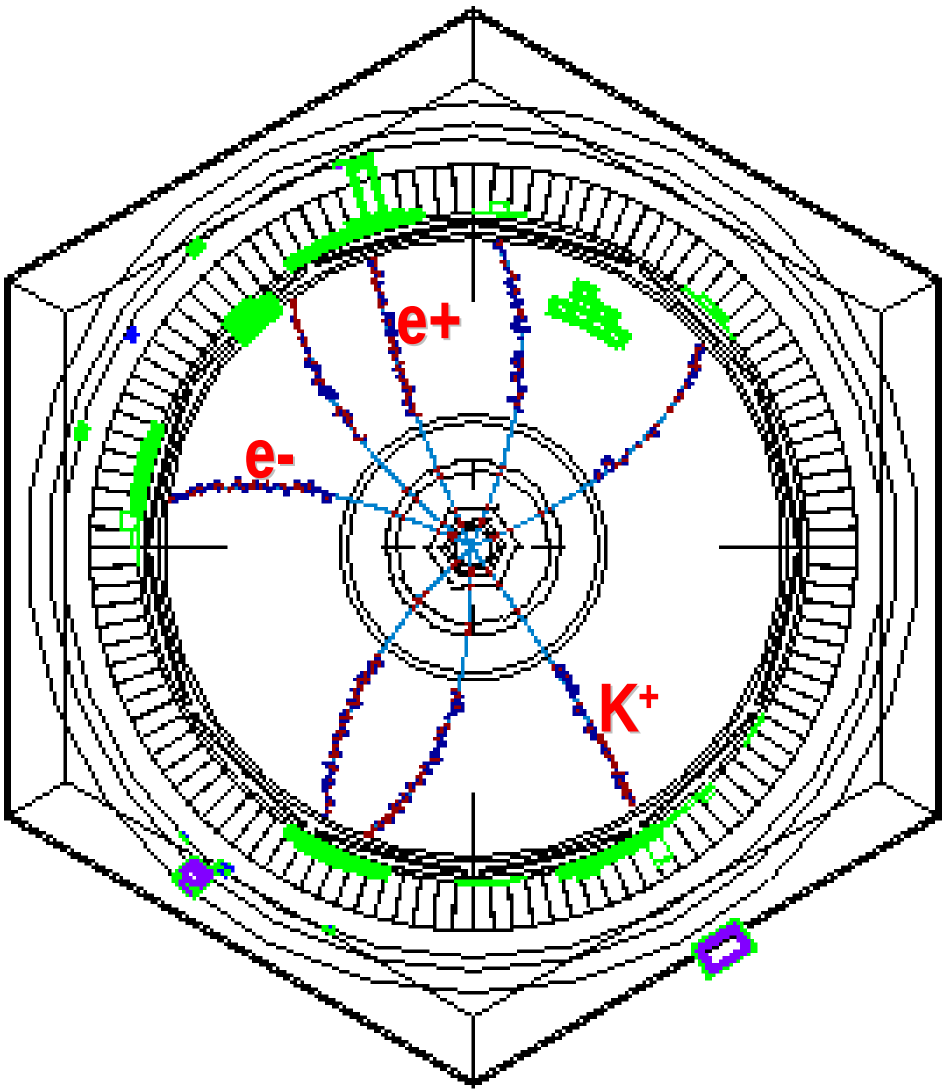
- For the purpose of setting the limit, we assume that **all** events in the signal region could be due to signal processes
  - Background is not subtracted

Results (2)

Mode	# obs. evts	# bkg. evts	Preliminary 90% C.L. limit
$K^+ e^+e^-$	2	0.20	$< 12.5 \times 10^{-6}$
$K^+ \mu^+\mu^-$	0	0.25	$< 8.3 \times 10^{-6}$
$K^{*0} e^+e^-$	1	0.50	$< 24.1 \times 10^{-6}$
$K^{*0} \mu^+\mu^-$	0	0.33	$< 24.5 \times 10^{-6}$
Total	**3**	**1.3**	

- The number of background events is extracted from sideband in data
  - Expect **1** signal event based on Geant MC (Ali *et al.* predictions).

A candidate $B^+ \to K^+ e^+ e^-$ event



Summary

- We have searched for the rare decays $B^+ \rightarrow K^+ l^+ l^-$ and $B^0 \rightarrow K^{*0} l^+ l^-$ using a sample of 3.67 x 10^6 $B\bar{B}$ events
  - We are using this sample to better understand our backgrounds
- We have found 3 candidate events total and set preliminary 90% C.L. limits
  - The limits for the $B \rightarrow K l^+ l^-$ modes are comparable to those set by other experiments
  - The limits for the $B \rightarrow K^{*0} l^+ l^-$ modes are less sensitive with this data sample
- We are planning to analyze substantially more data in the near future
  - BaBar will have 20 fb^{-1} by the end of the year and an extra 30 fb^{-1} by next year