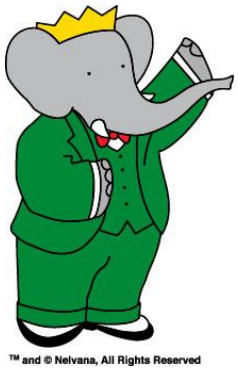
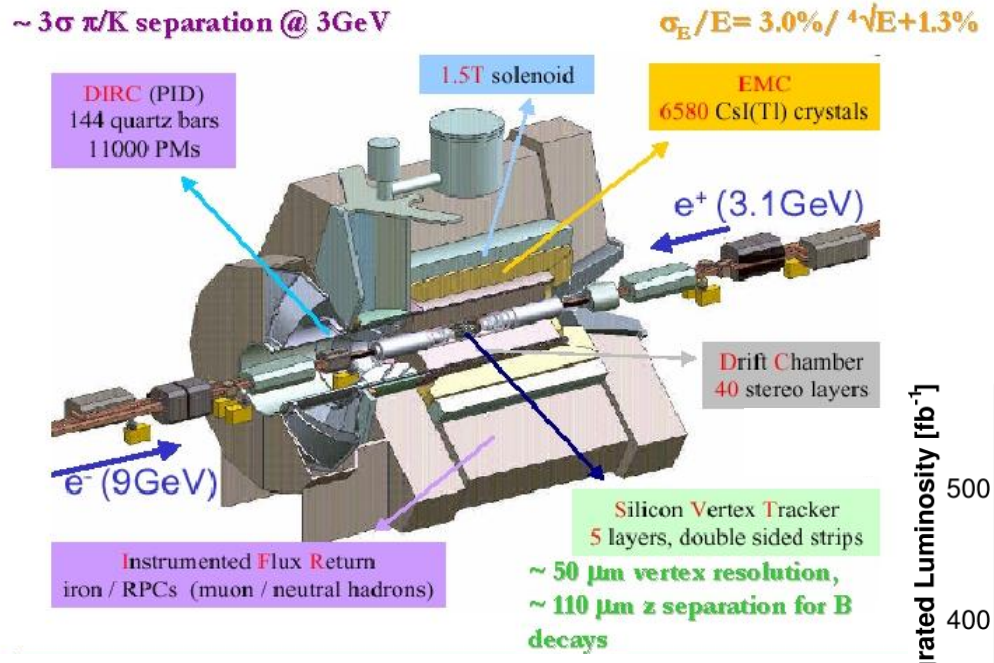
New Babar Results in FCNC Decays:

Search for $B^+ \rightarrow K^+ \tau^+ \tau^-$
Search for $B^0 \rightarrow \gamma\gamma$

Kevin Flood
Univ. of Wisconsin
(representing the Babar Collaboration)



The BABAR Detector



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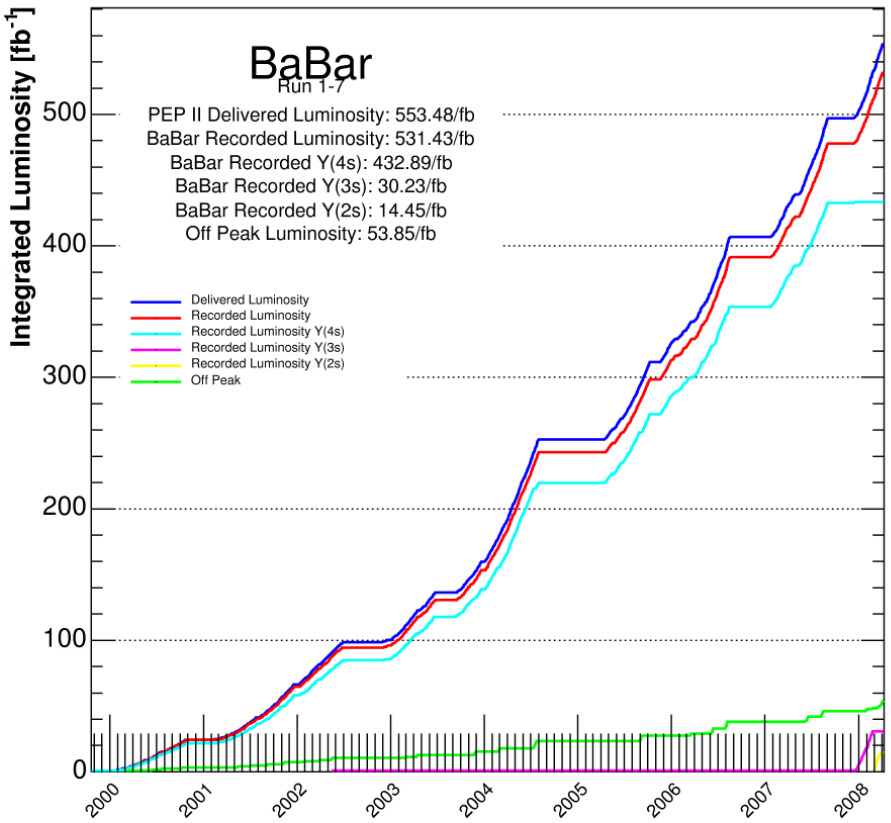
Final Babar dataset

426 fb^{-1} @ Υ(4S)

$N(B\bar{B}) = (467.8 \pm 5.2) \times 10^6$

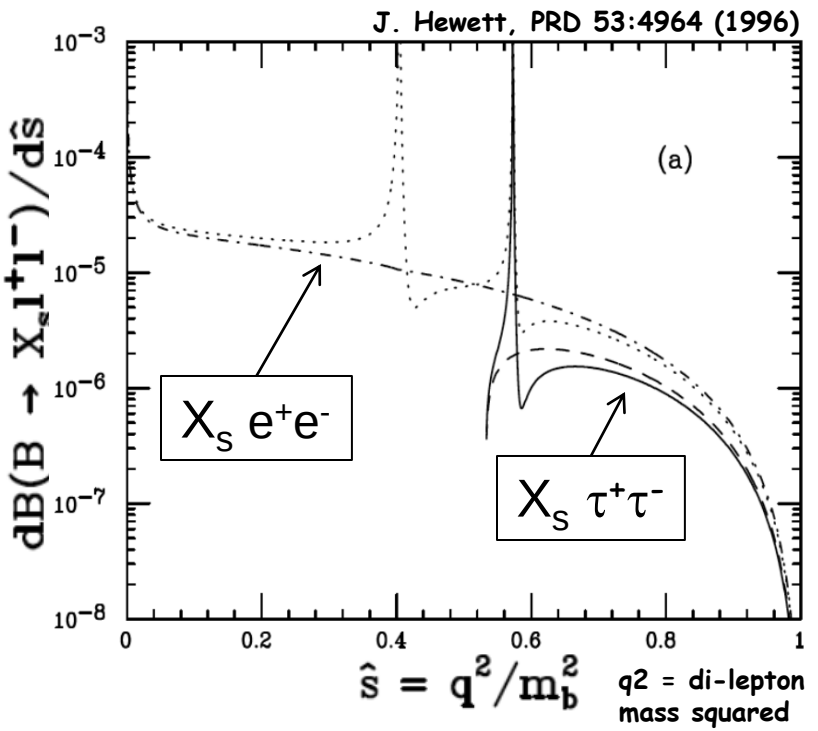


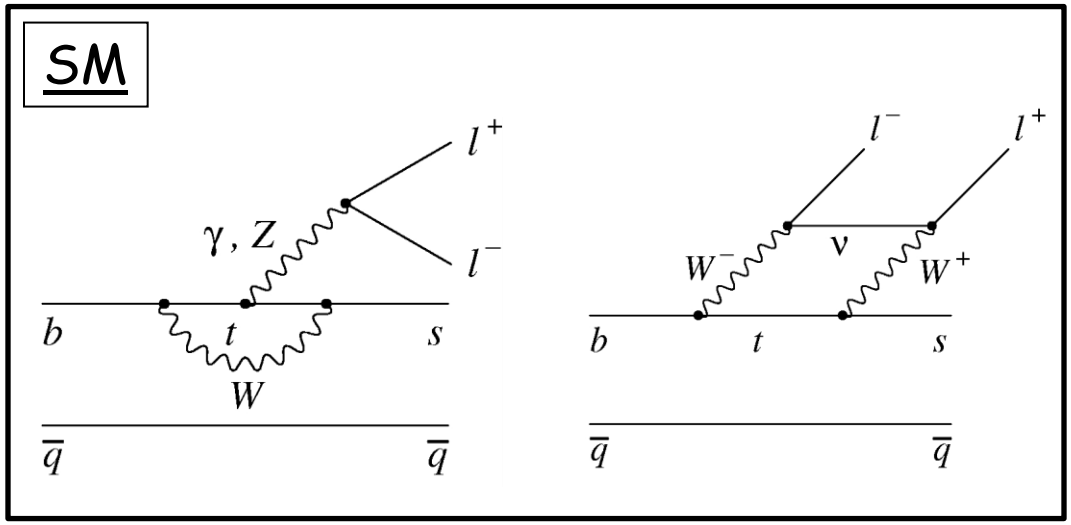
Search for $B^+ \to K^+ \tau^+ \tau^-$

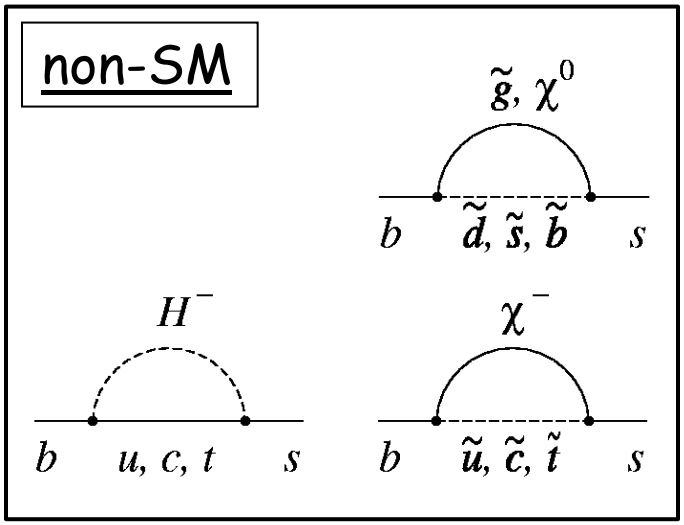
- $B \to X \tau^+ \tau^-$ SM rate similar to $B \to X l^+ l^-$ ($l = e, \mu$) in the kinematic region accessible to all

Lepton	$0.6 \leqslant \hat{s} \leqslant 1$
Electron	8.5×10^{-7}
Muon	8.5×10^{-7}
Tau	4.3×10^{-7}

- **$B^+ \to K^+ \tau^+ \tau^-$ ~50% of total inclusive rate**
- NMSSM rate enhancements could be proportional to $(M_\tau^2/M_\mu^2) \sim 280$

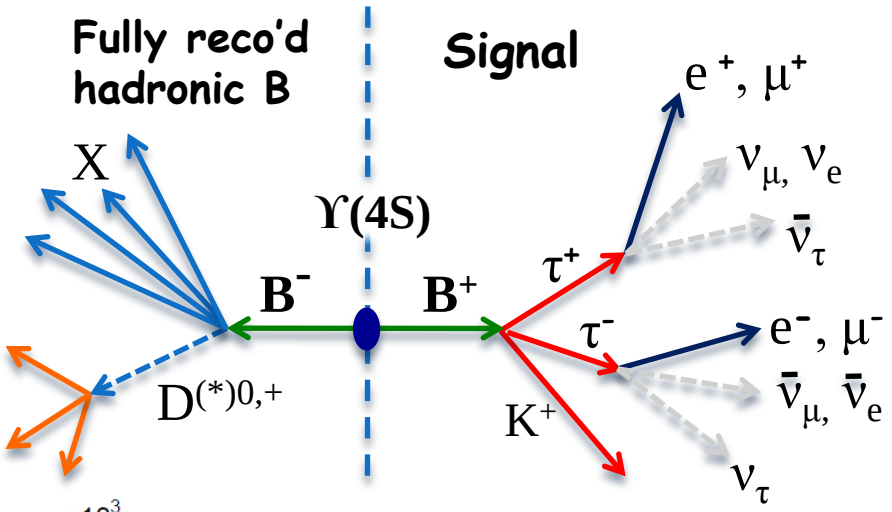


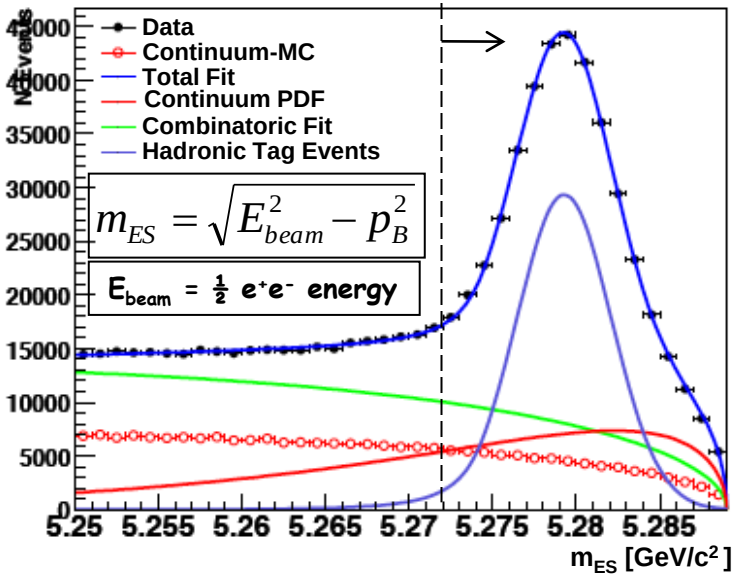


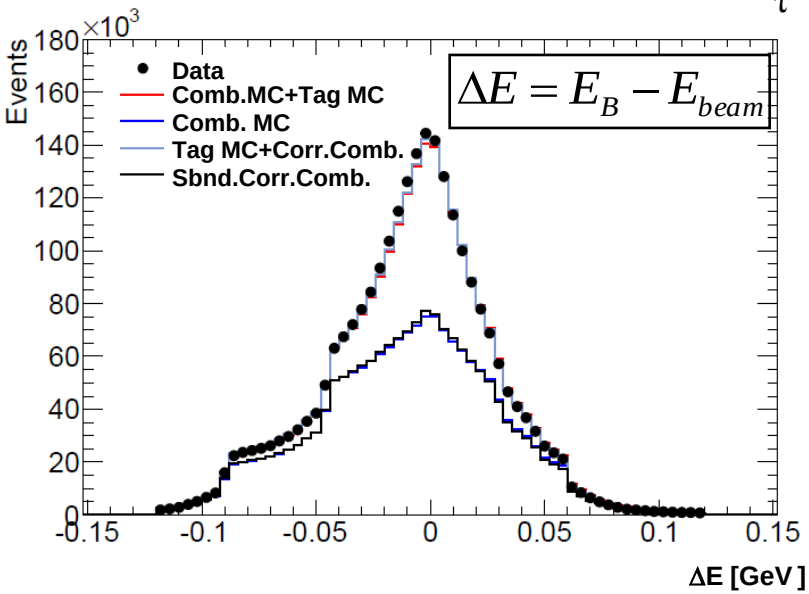


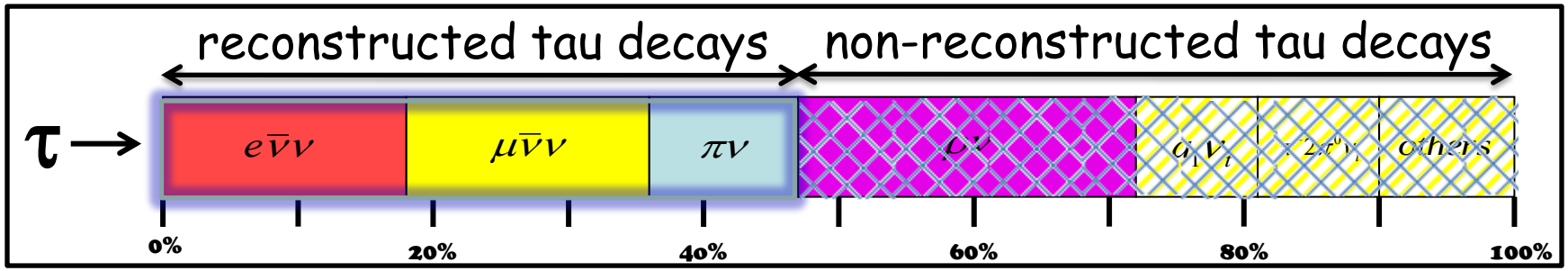
Search for $B^+ \to K^+ \tau^+ \tau^-$

- 2-4 neutrinos in signal final state
- Backgrounds controlled by reconstructing recoiling B- in many fully hadronic final states
  - $B^- \to D^{(*)0,+} + X$
    - X = up to total of six π^0, π^+, KS, K^+
  - Tag efficiency < ~0.2%



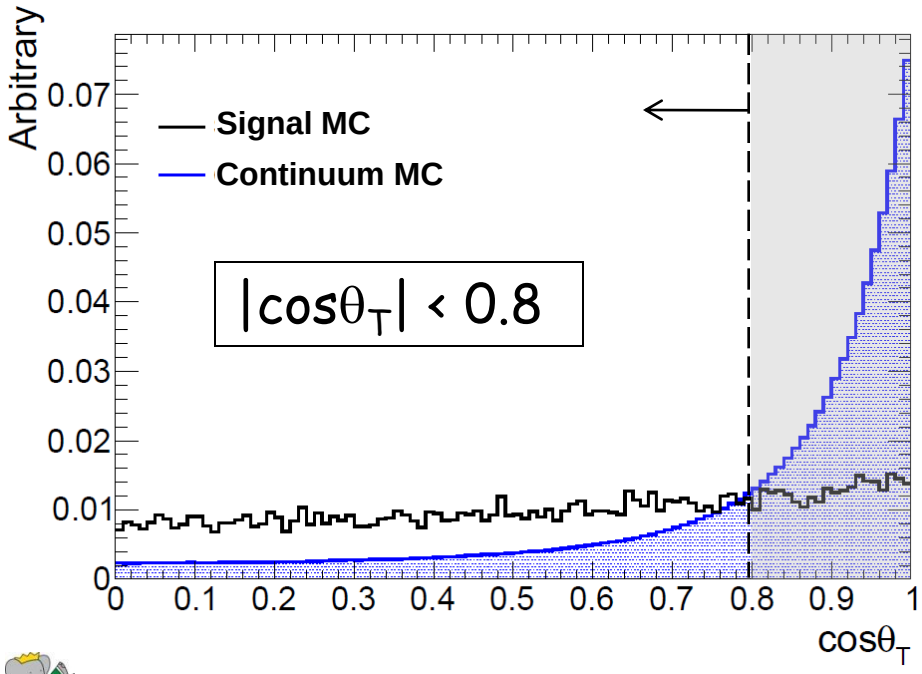






Search for $B^+ \to K^+ \tau^+ \tau^-$: Signal Selection

- Continuum backgrounds are suppressed using $|\cos\theta_T|$, the cosine of the opening angle between the tag B thrust and the rest-of-the-event thrust
  - All signal-side event selection is done subsequent to applying the $|\cos\theta_T|$ selection



- Three charged tracks only
  - **one particle ID K+**
    - $0.44 < p < 1.4$ GeV/c
    - charge opposite B_{tag}
  - **one neutral pair of PID e, μ, π**
    - $p < 1.59$ GeV/c
    - $M_{pair} < 2.89$ GeV/c^2
- $q^2 = (p_{\Upsilon 4S} - p_{tag} - p_K)^2 > 14.23$ GeV^2
- Missing energy calculated from $(p_{\Upsilon 4S} - p_{tag} - p_K - p_{\tau 1} - p_{\tau 2})$ 4-vector
  - $1.39 < E_{miss} < 3.38$ GeV
- Extra neutral energy < 0.74 GeV

- $B \to D+X$ decays are the largest remaining background, and are suppressed by combining the signal K+ with the signal tau daughter of opposite charge assigned a pion mass hypothesis and requiring the resulting invariant mass to be
  - $M(K\pi) > 1.96$ GeV/c^2

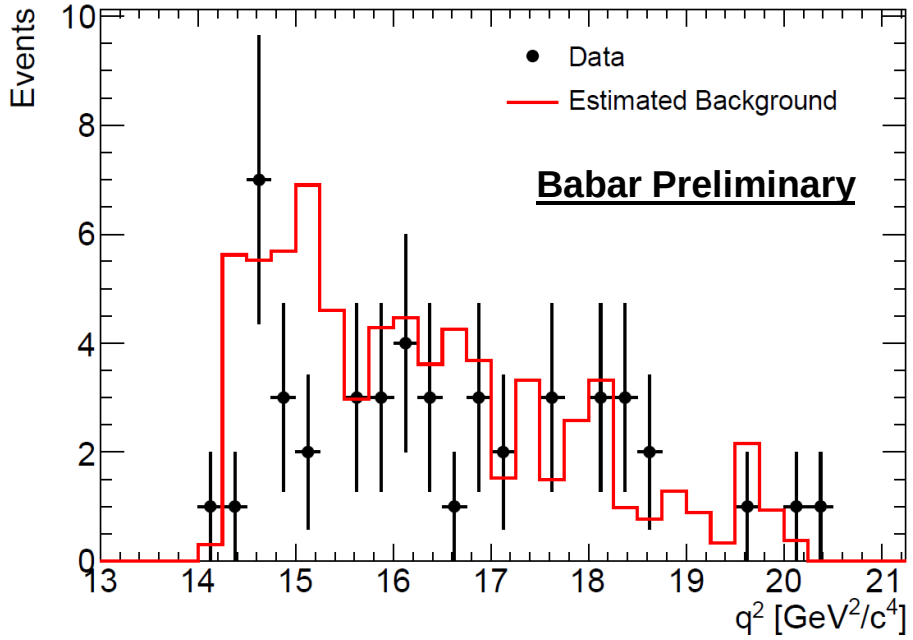
Search for $B^+ \to K^+ \tau^+ \tau^-$: Systematics, Results

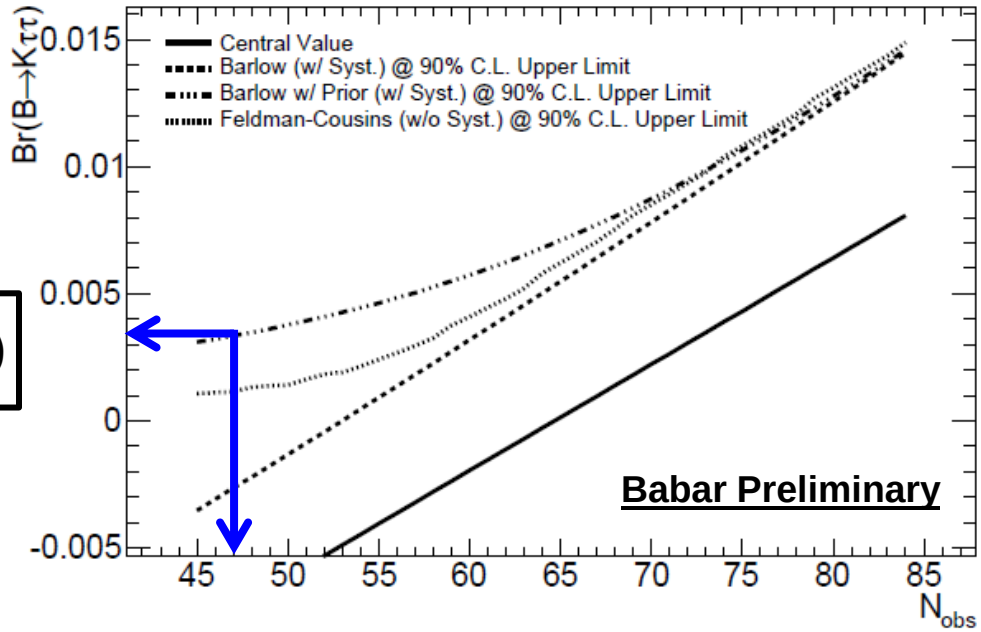
B counting	1.1%
Tag Efficiency	3.2%
Signal Efficiency	14.8%
- 13.9% MC Statistics	
Background Estimate	
- Correct Tags	5.2%
- 5.1% Particle ID	
- Incorrect Tags	14.8%
- 14.8% Data, MC statistics	

Expected Bkgd: 64.7 +/- 7.3

Data Events: 47

BF($B^+ \to K^+\tau^+\tau^-$) < 0.0033 (90% CL)

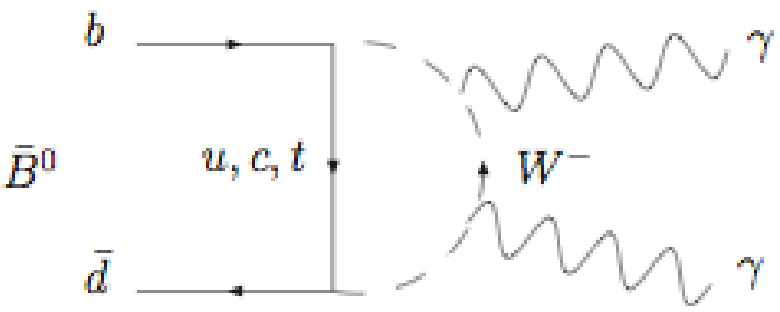


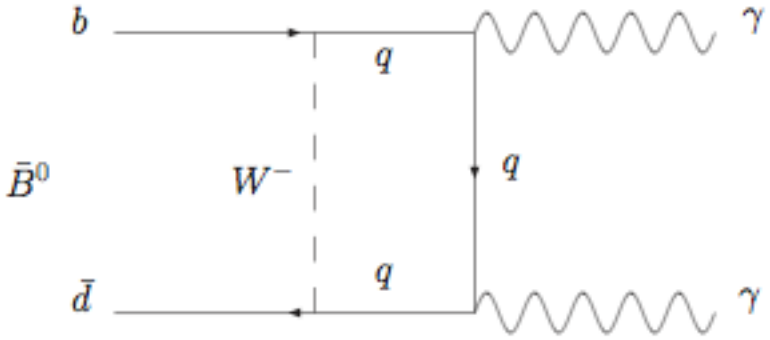


Search for $B^0 \to \gamma\gamma$

Search for $B^0 \to \gamma\gamma$: Motivation, Previous Results

- $B^0 \to \gamma\gamma$ is an "effective" FCNC decay which is suppressed by CKM and EM vertex factors compared to $b \to (s,d)\gamma$
- $B_{s,d}^0 \to \gamma\gamma$ constrained by $B \to X_{s,d}\gamma$
- $|V_{td}/V_{ts}|$ accessible in simple two-body non-hadronic final state
- SM BF ~ 3×10^{-8} [Bosch and Buchalla, JHEP 0208:054 (2002)]



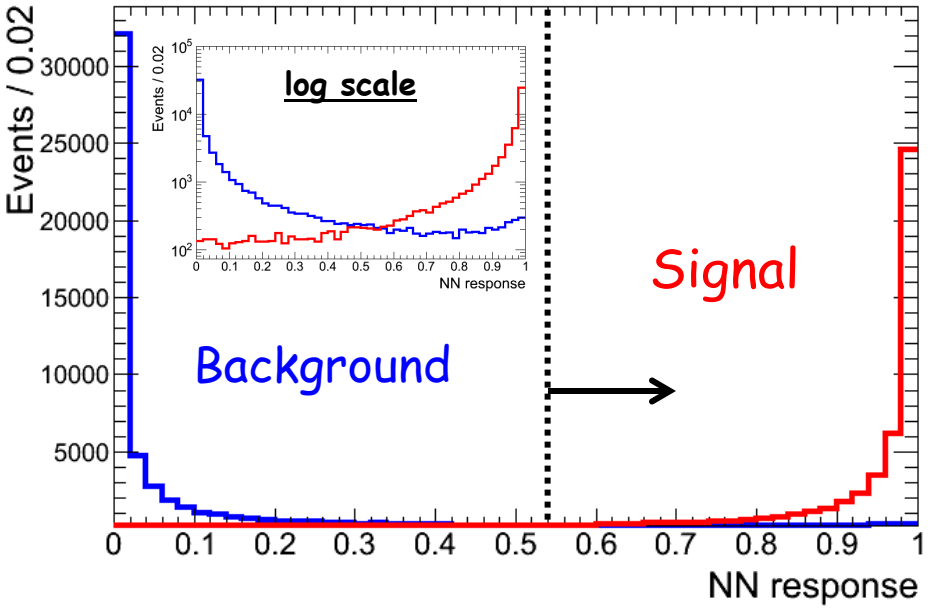


Experiment	BF (90% CL)	Dataset	Ref.
L3	$< 1.9 \times 10^{-5}$	2.95×10^6 ($Z \to$ had)	Acciarri et al. Phys. Lett. B, 363, 1995
BaBar	$< 1.7 \times 10^{-6}$	19 fb^{-1}	Aubert et al. PRL 87, 24, 2001
Belle	$< 6.1 \times 10^{-7}$	104 fb^{-1}	Villa et al. PRD 73, 2006

Search for $B^0 \to \gamma\gamma$: Strategy, Event Selection

- Blind analysis
- High-energy γ backgrounds
  - π^0, η vetos
  - Out-of-time photons
- Small peaking backgrounds characterized with MC
  - ~1.2 signal region events
- Continuum rejection with neural network using 19 event shape inputs
- Signal yield extracted from a 2-d fit to mES and DE

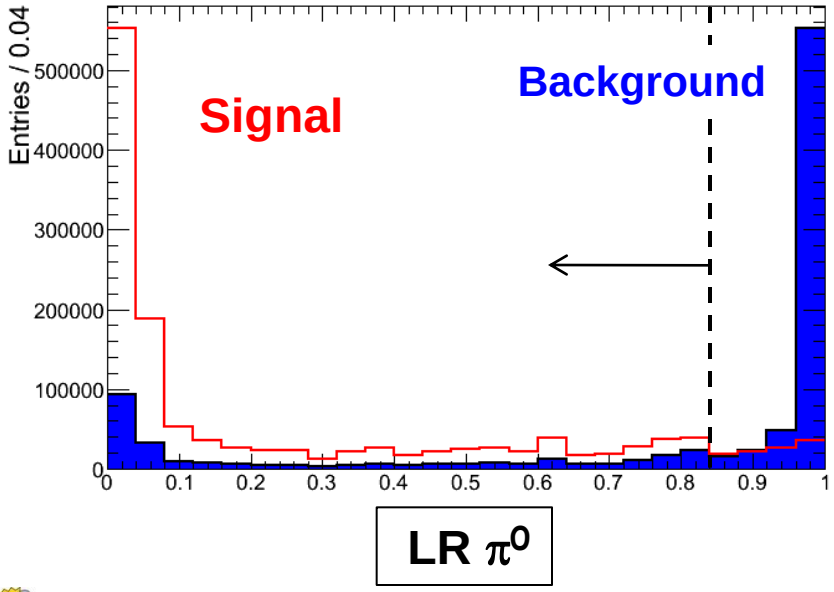
Selection	Value(s)
N Tracks / event	≥ 3
Total Event Energy	< 15.0 GeV
Cluster Timing	150 ns window
N cluster crystals	> 10
Cluster isolation	> 25 cm
Cluster Lateral Moment	0.15 ≤ LAT ≤ 0.5
π^0 Likelihood Ratio	≤ 0.84
η Likelihood Ratio	≤ 0.84
Neural Network	≥ 0.54

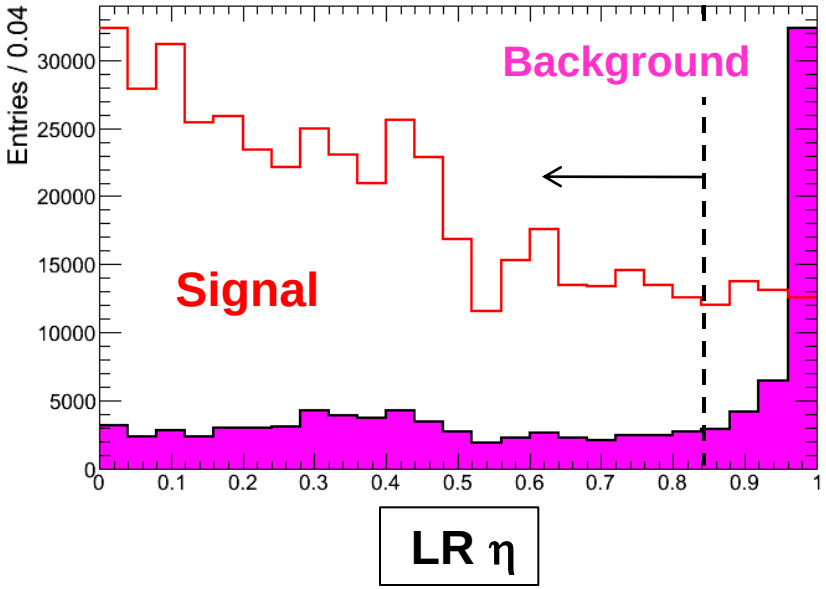


Search for $B^0 \to \gamma\gamma$: π^0, η Vetos

- Signal candidate photons (γ) are paired with lower energy photons (γ') in an event, and the pair's invariant mass $M(\gamma\gamma')$ and the soft photon's energy $E(\gamma')$ are used to construct a likelihood ratio with 2-d correlated likelihoods for signal events and background events obtained from simulated event samples

$$\mathcal{LR}_i = \frac{\mathcal{P}_i(m_{\gamma\gamma'}, E_{\gamma'})}{\mathcal{P}_{\rm sig}(m_{\gamma\gamma'}, E_{\gamma'}) + \mathcal{P}_i(m_{\gamma\gamma'}, E_{\gamma'})} \quad \Rightarrow \quad i = \pi^0 \text{ or } \eta$$





Search for $B^0 \to \gamma\gamma$: Fit Method

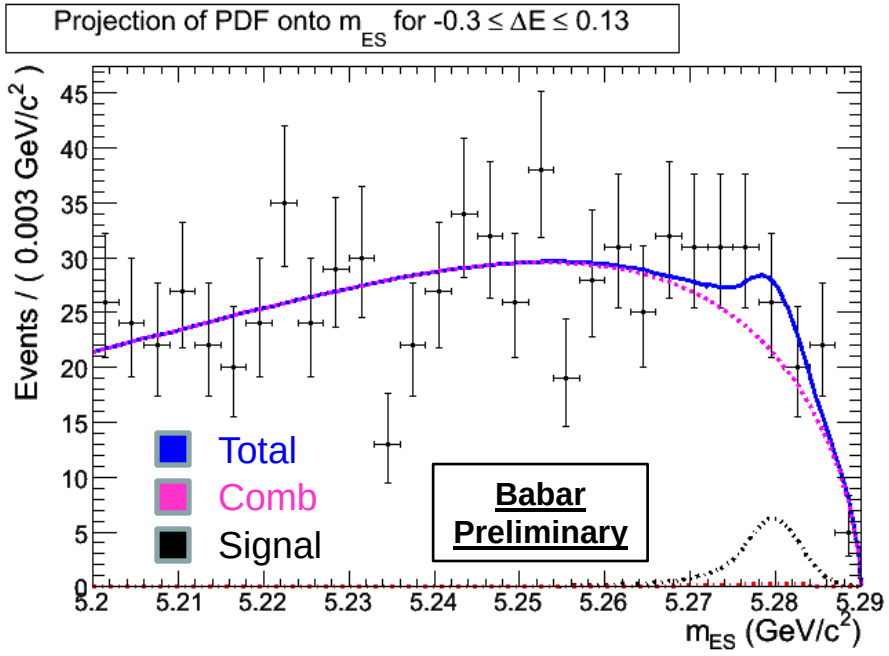
- Signal yield is extracted using a two-dimensional unbinned extended maximum likelihood fit in m_{ES} and ΔE
- Three components in fit
  - (1) Signal: pdf shapes from simulated events, normalization floated
  - (2) Combinatoric Background: shape and normalization floated
  - (3) Peaking Background: pdf shape and normalization from simulated events

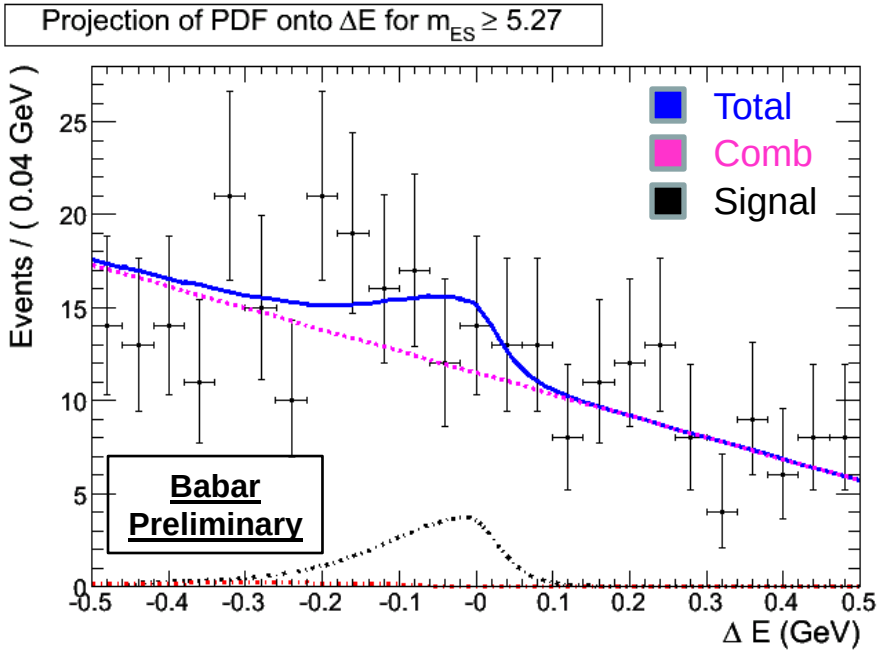
Component	mES	DeltaE
Signal	Crystal Ball	Asym Gaussian
Continuum Bkg	ARGUS	Polynomial O(1)
Peaking Bkg	2D Histogram PDF	

- All signal PDF parameters are fixed in the fit
- Peaking background shape and yield are fixed in the fit

Search for $B^0 \to \gamma\gamma$: Data Fit

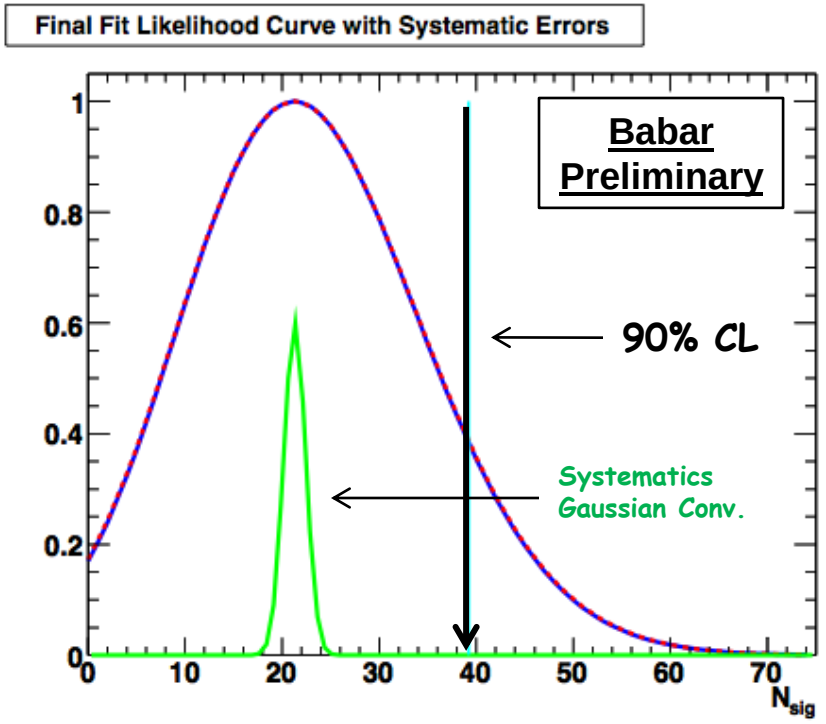
- Signal and combinatoric yields, and the slope of the combinatoric mES Argus PDF, are floated in the fit:
  - N signal = 21.3 (+12.8,-11.8)
  - BF($B^0 \to \gamma\gamma$) = (1.7 +/- 1.1) x 10^{-7}





Search for $B^0 \to \gamma\gamma$: Systematics, UL

Source	Systematic Error
Multiplicative Errors (%)	
B-counting	1.7
Track eff.	0.2
Photon eff.	4.0
Cluster time	0.7
π^0/η LR	2.8
Neural network	3.0
Additive Errors (nEvents)	
Fit sys.	0.74

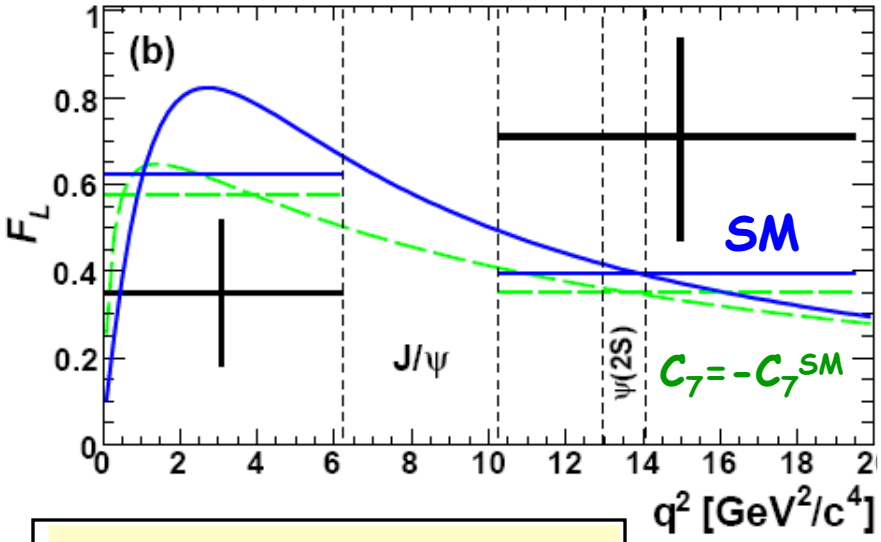


N signal = 21.3 (+12.8,-11.8) +/- 1.4

$$\mathcal{B}(B^0 \to \gamma\gamma) < 3.2 \times 10^{-7} \text{ (@ 90\% CL)}$$

$B \to K^* l^+ l^-$: FL and AFB Results (349 fb^{-1}, 390x10^6 $B\bar{B}$)

Longitudinal K* polarization



$$F_L^{\text{low } s} = 0.35 \pm 0.16 \pm 0.04$$

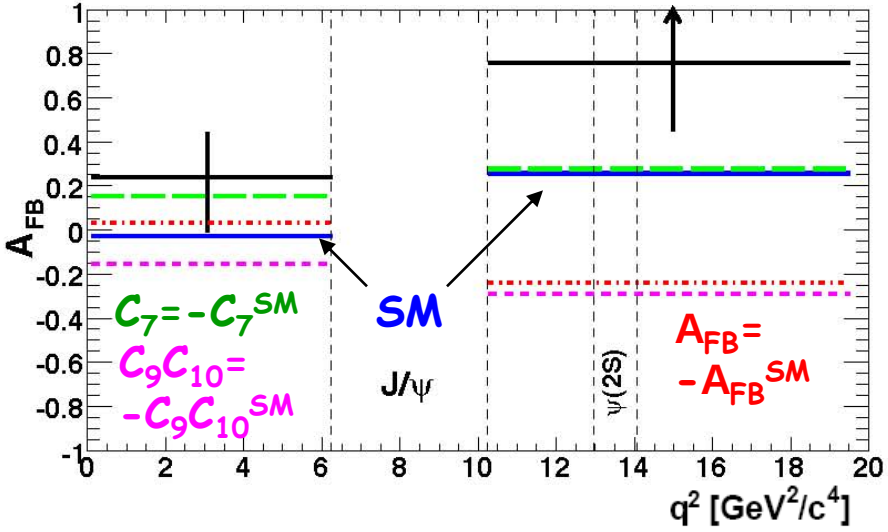
$$F_L^{\text{high } s} = 0.71^{+0.20}_{-0.22} \pm 0.05$$

PRD 79, 031102 (2009)

$$A_{FB}^{\text{low } s} = 0.24^{+0.18}_{-0.23} \pm 0.06$$

$$A_{FB}^{\text{high } s} = 0.76^{+0.52}_{-0.32} \pm 0.07$$

Lepton forward-backward asymmetry



Source of Error	F_L low q^2	F_L high q^2	A_{FB} low q^2	A_{FB} high q^2
m_{ES} fit yields	0.001	0.016	0.003	0.002
F_L fit error			0.025	0.022
Background shape	0.011	0.008	0.017	0.021
Signal model	0.036	0.034	0.030	0.038
Fit bias	0.012	0.020	0.023	0.052
Mis-reconstructed signal	0.010	0.010	0.020	0.020
Total	0.041	0.044	0.052	0.074

Summary

- Two new Babar results shown
- First limit on $B^+ \to K^+\tau^+\tau^-$
  - **BF($B^+ \to K^+ \tau^+ \tau^-$) < 0.0033% (90% CL)**
- Improvement of $B^0 \to \gamma\gamma$ upper limit by a factor of two
  - **BF($B^0 \to \gamma\gamma$) < 3.2 x 10^{-7} (90% CL)**
- Further progress in these modes only possible at a high-luminosity B Factory
  - $B^+ \to K^+\tau^+\tau^-$ sensitive to LFV effects, NMSSM
  - $B^0 \to \gamma\gamma$ can probe B meson QCD dynamics and provides a clean way to access $|V_{td}/V_{ts}|$
- $B \to K^*l^+l^-$ currently being updated to full Babar dataset
  - Results will be reported in a manner allowing trivial combination with recent Belle and CDF results