

# Physics @ BABAR

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Stanford Linear Accelerator Center

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# Physics Leadership Positions

## Analysis Working Groups

### Current or Former Conveners

- Charmless 2 Body      Cristinziani
- Charmless 3 Body      Dujmic
- SemiLeptonic      Luth
- Radiative Penguins      Libby, Jessop
- Leptonic decays      Robertson, Schindler
- Pentaquark Task Force      Halyo
- Inclusive Spectra      Muller, Ratcliff
- Particle Id      Aston

# Physics Analysis Topics

## Charmless B Decays

### Gluonic Penguins

$$B^0 \rightarrow \pi^0 \pi^0$$

$$B^0 \rightarrow K^+ K^- K_s^0$$

$$B \rightarrow p \bar{p} K$$

## Radiative Penguin B Decays

### Electro-weak Penguins

$$b \rightarrow s \gamma$$

$$B \rightarrow \rho \gamma$$

$$B \rightarrow K^* \gamma$$

## Semi-Leptonic B Decays

$$B \rightarrow \pi(\rho) \ell \nu$$

$$b \rightarrow c \ell \nu \text{ moments}$$

$$B \rightarrow D^* \ell \nu \text{ FormFactor}$$

## Spectroscopy

$$D_{sJ}(2317)$$

Pentaquarks?

## QCD & Taus

$$\tau \rightarrow 7 \pi^\pm \nu_\tau$$

$R_{HAD}$  with ISR events

Inclusive Hadronic Spectra

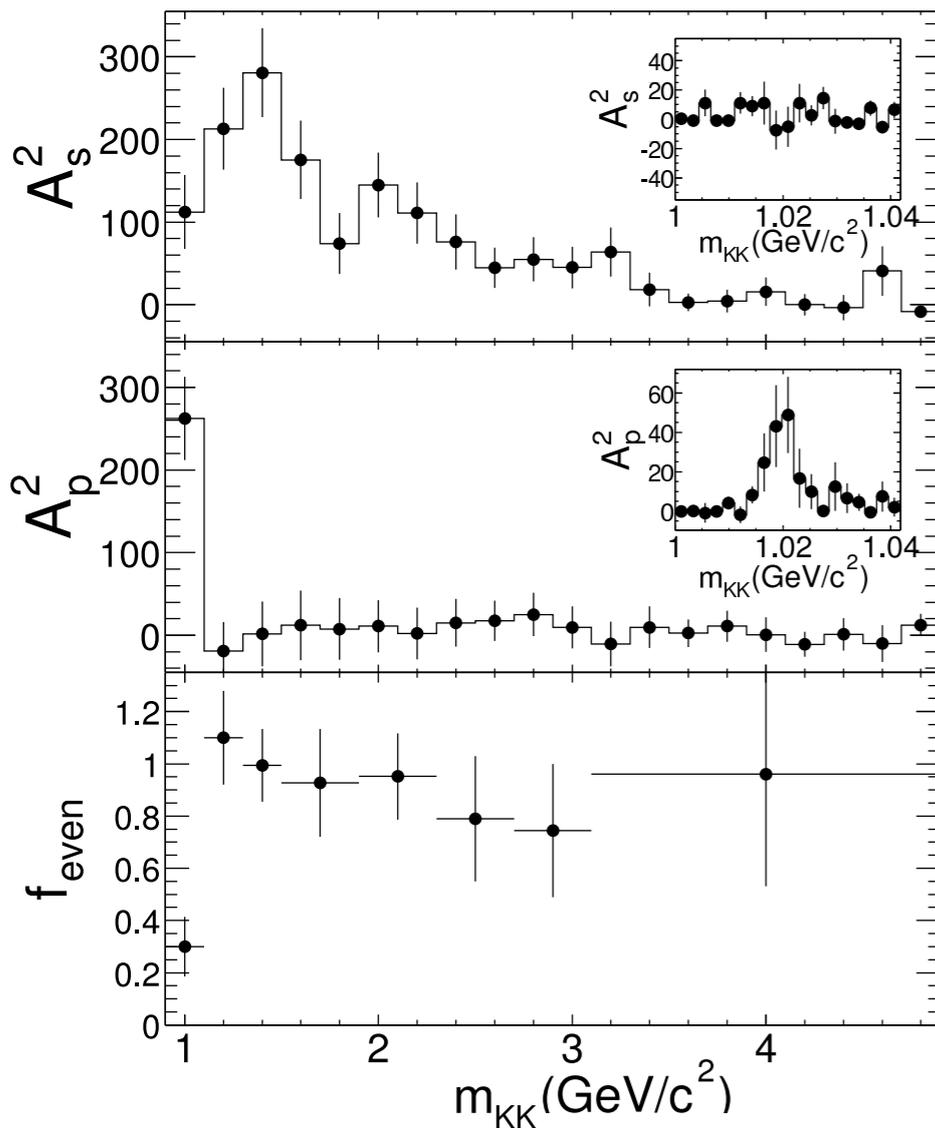
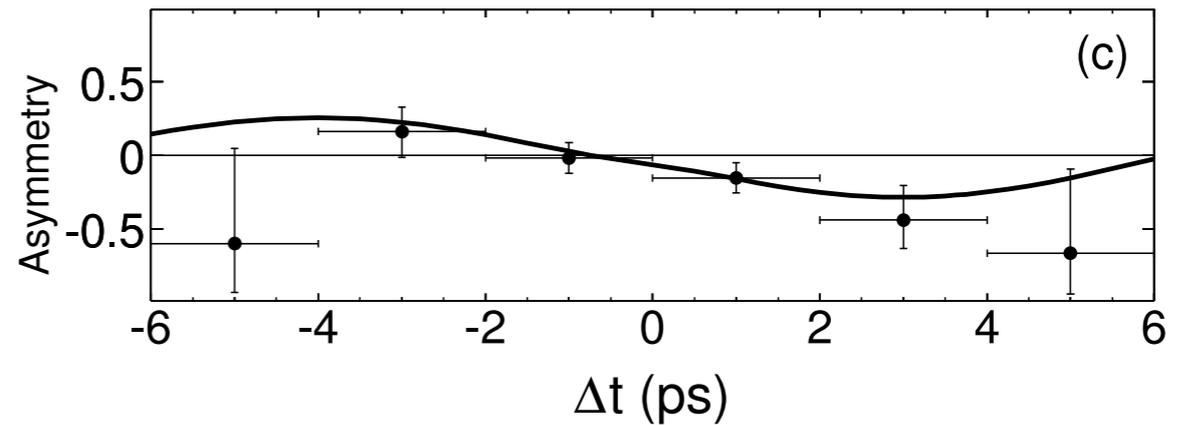
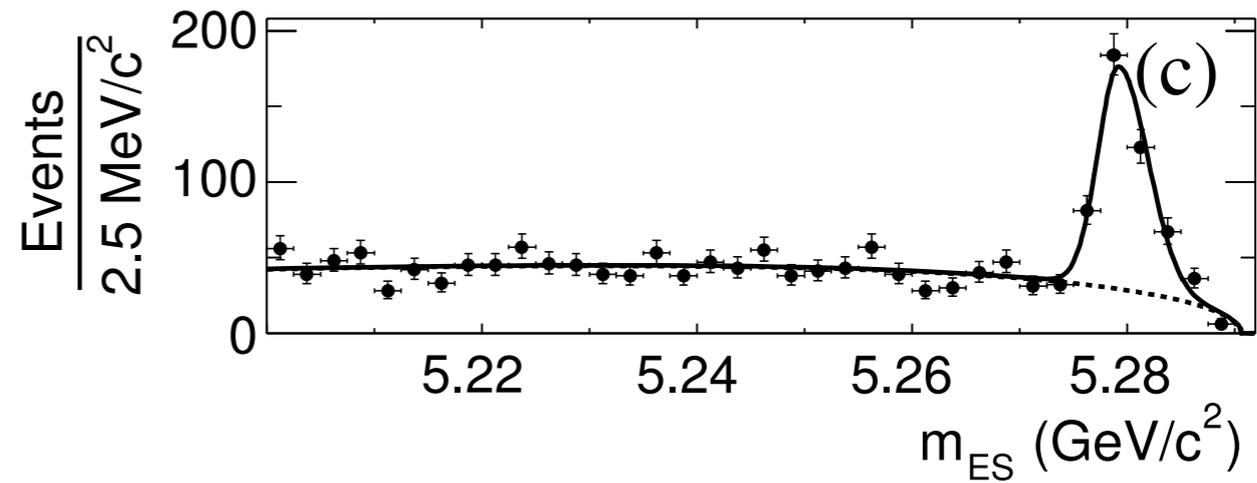
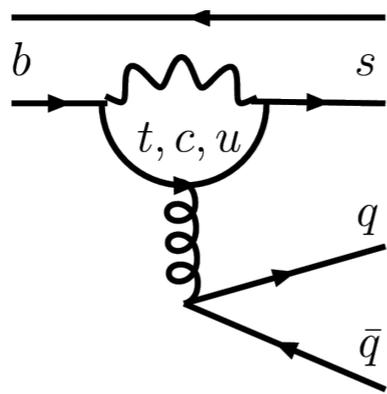
## Leptonic Decays

$$B^0 \rightarrow \ell^+ \ell^- \quad D_s^+ \rightarrow \mu^+ \nu_\mu$$

$$B^+ \rightarrow \tau^+ \nu_\tau$$

# Charmless B Decays - Gluonic Penguins

$$B^0 \rightarrow K^+ K^- K_S^0$$

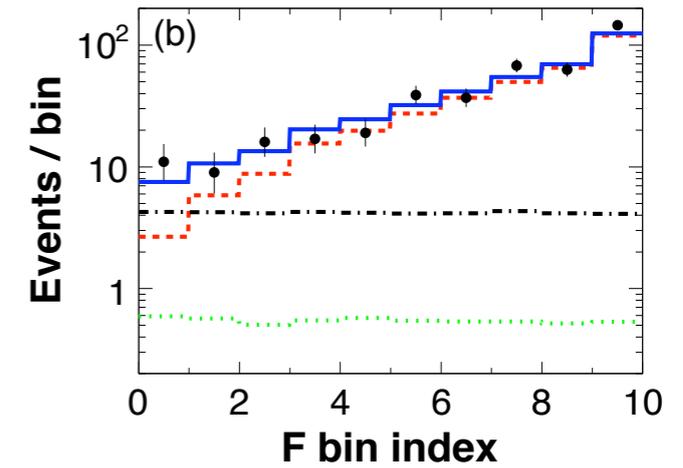
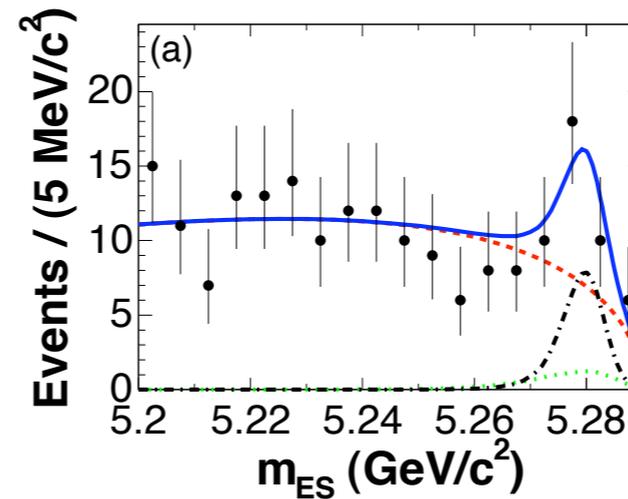
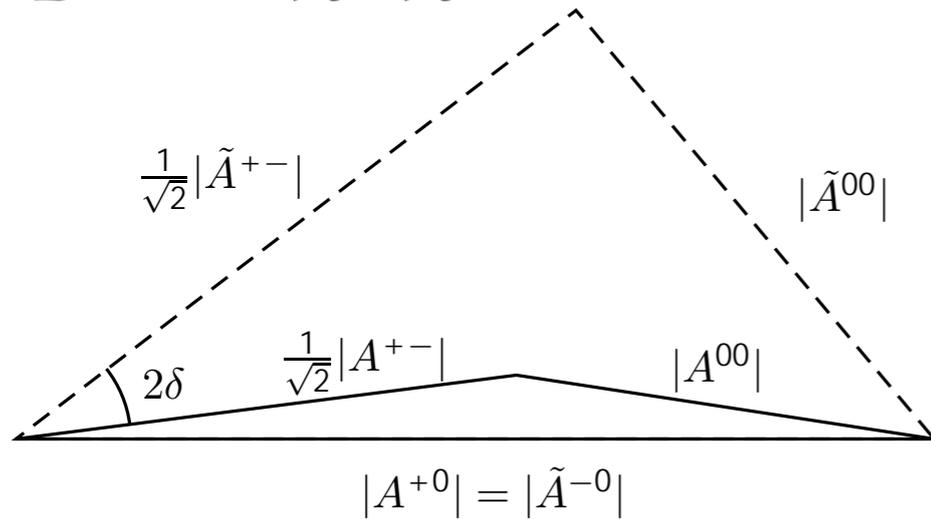


	$\phi K^0$	$K^+ K^- K_S^0$
	$\phi K_S^0$	$\phi K_L^0$
	(no $\phi K_S^0$ )	
$\sin 2\beta_{\text{eff}}$	$+0.50 \pm 0.25^{+0.07}_{-0.04}$	$+0.55 \pm 0.22 \pm 0.04 \pm 0.11$
$f_{\text{even}}$	0	1
$S$	$+0.50 \pm 0.25^{+0.07}_{-0.04}$	$-0.42 \pm 0.17 \pm 0.03$
$C$	$0.00 \pm 0.23 \pm 0.05$	$+0.10 \pm 0.14 \pm 0.04$
Yield	$114 \pm 12$	$98 \pm 18$
		$452 \pm 28$

Dujmic, Thompson

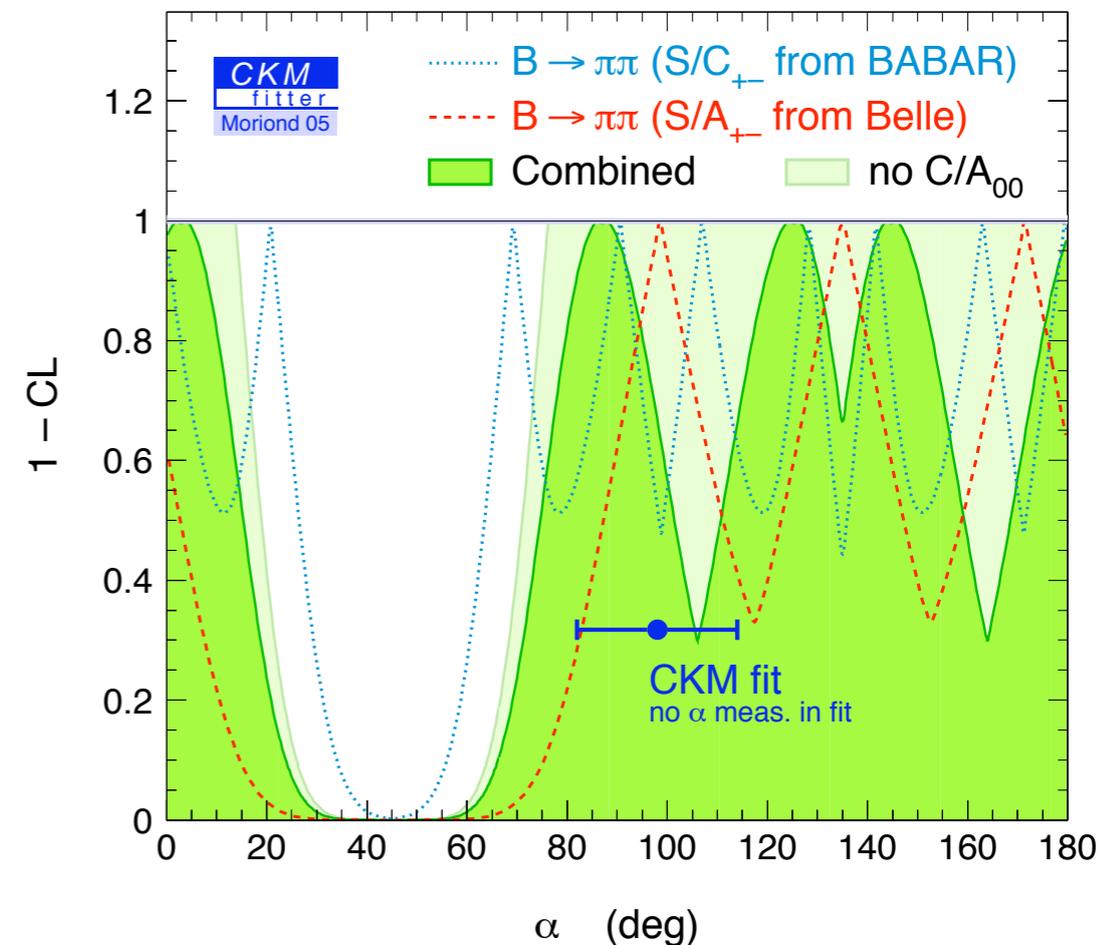
# Charmless B Decays - CKM Angle $\alpha$

$$B^0 \rightarrow \pi^0 \pi^0$$



Mode	$N$	$N_S$	$\epsilon$ (%)	$\mathcal{B}(10^{-6})$	Asymmetry (90% C.L.)
$B^0 \rightarrow \pi^0 \pi^0$	8153	$61 \pm 17$	$23.5 \pm 1.4$	$1.17 \pm 0.32 \pm 0.10$	$-0.12 \pm 0.56 \pm 0.06$ $[-0.88, 0.64]$

MODEL	$C_{\pi^0 \pi^0}$
SCET	$0.5 \pm 0.25$
Diagramatic (Gronau & Rosner etal)	$-0.52^{+0.20}_{-0.07}$
Diagramatic (Buras & Fleisher etal)	$-0.28^{+0.37}_{-0.21}$
FSI (Soni etal)	$+0.30^{+0.04}_{-0.01}$
QCDF (Beneke & Neubert)	$0.19(S4)$



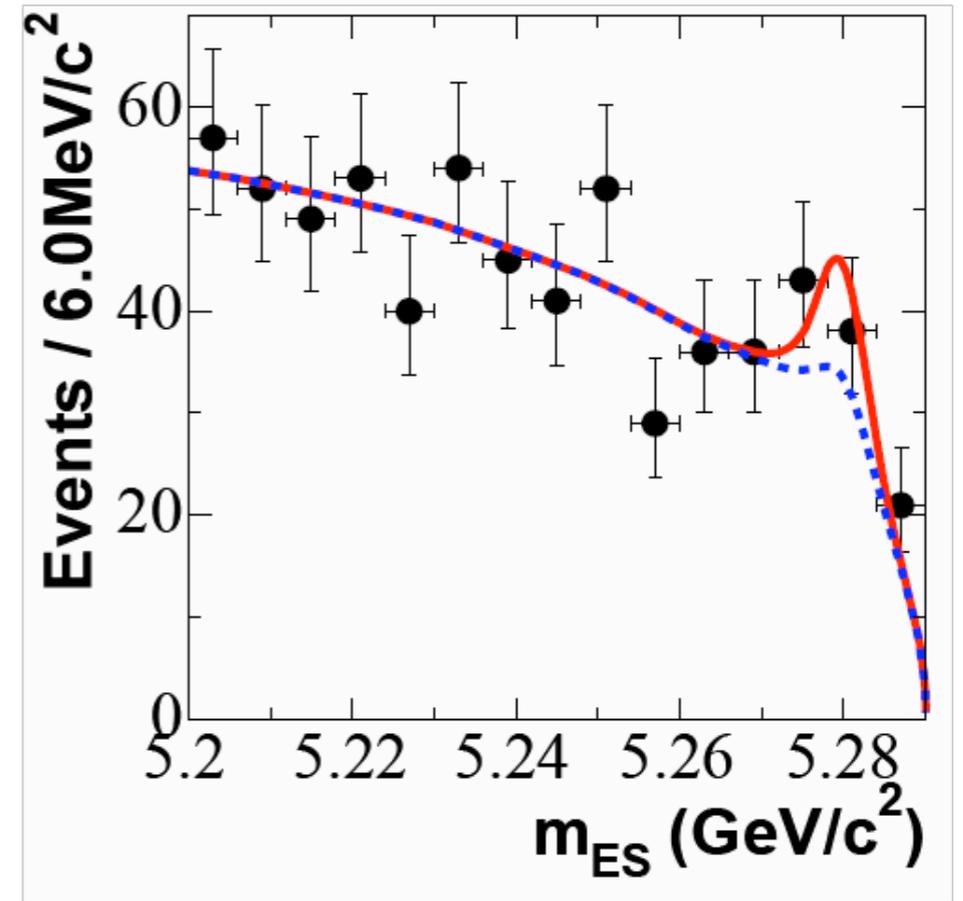
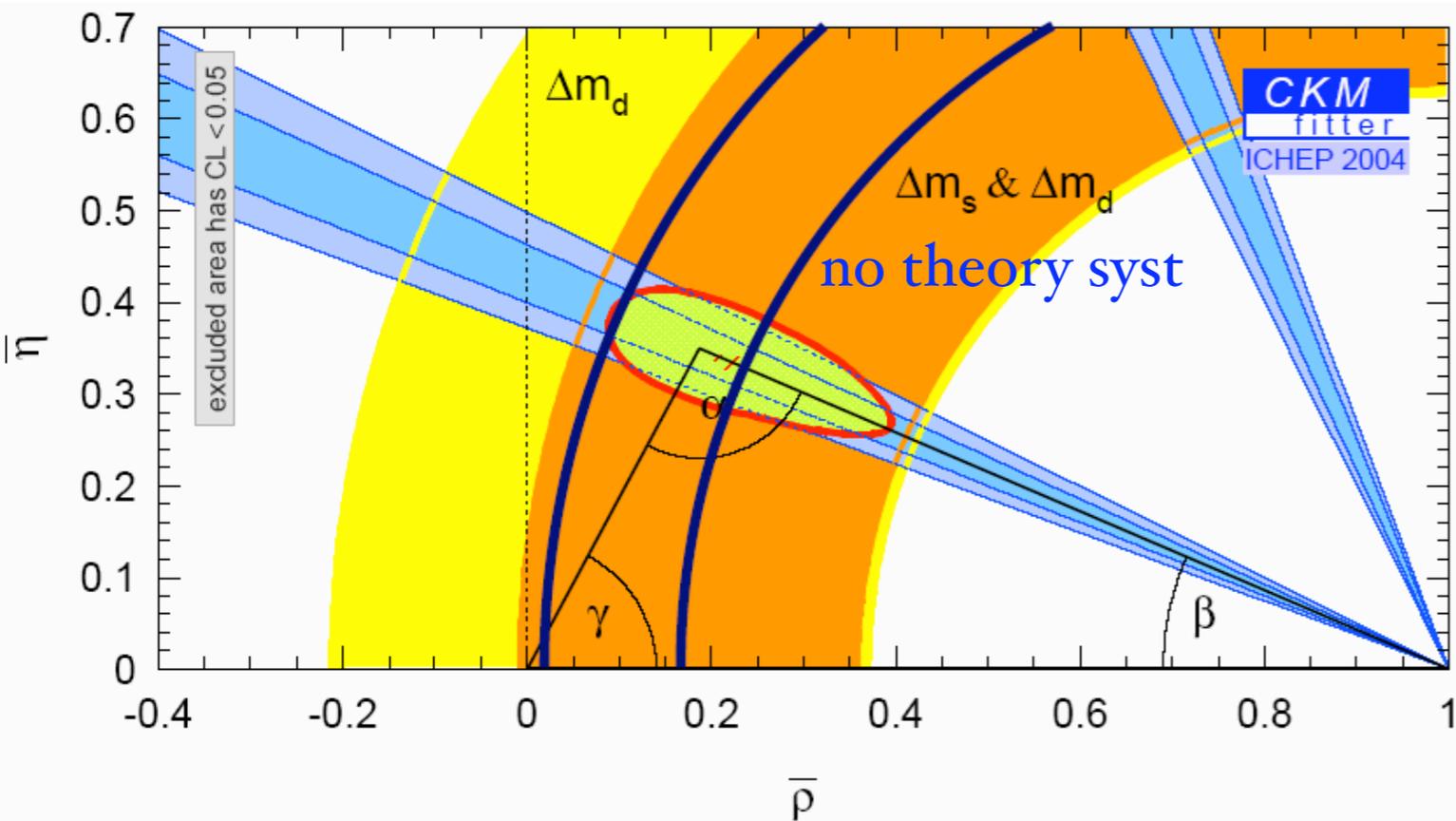
Cristinziani, Roodman, Allen

# Radiative B Decays EWK Penguins

$$\frac{\overline{\mathcal{B}}[B \rightarrow (\rho/\omega)\gamma]}{\mathcal{B}(B \rightarrow K^*\gamma)} = \left| \frac{V_{td}}{V_{ts}} \right|^2 \left( \frac{1 - m_\rho^2/M_B^2}{1 - m_{K^*}^2/M_B^2} \right)^3 \zeta^2 [1 + \Delta R]$$

$$\zeta = F^{B \rightarrow \rho} / F^{B \rightarrow K^*} \quad \text{SU(3) breaking}$$

$\Delta R(\rho/K^*)$  annihilation etc.

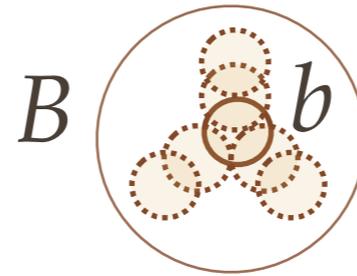
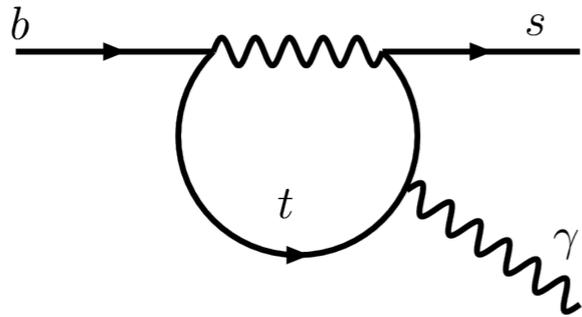


Mode	$n_{\text{sig}}$	$\mathcal{B}(10^{-6})$	90% C.L.
$B^+ \rightarrow \rho^+ \gamma$	$26^{+15+2}_{-14-2}$		$< 1.8$
$B^0 \rightarrow \rho^0 \gamma$	$0.3^{+7.2+1.7}_{-5.4-1.6}$		$< 0.4$
$B^0 \rightarrow \omega \gamma$	$8.3^{+5.7+1.3}_{-4.5-1.9}$		$< 1.0$

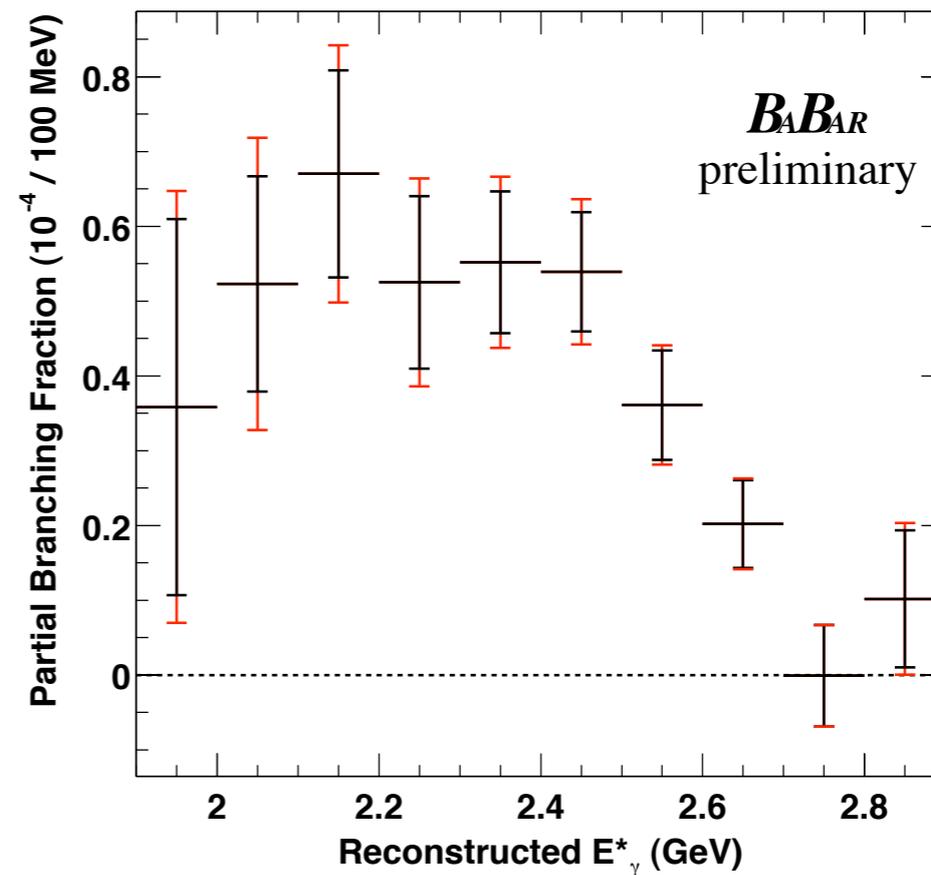
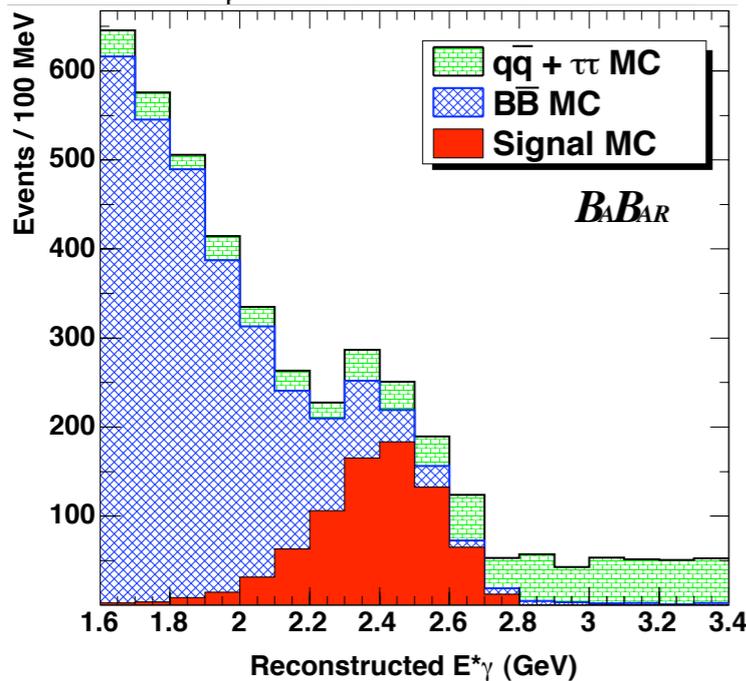
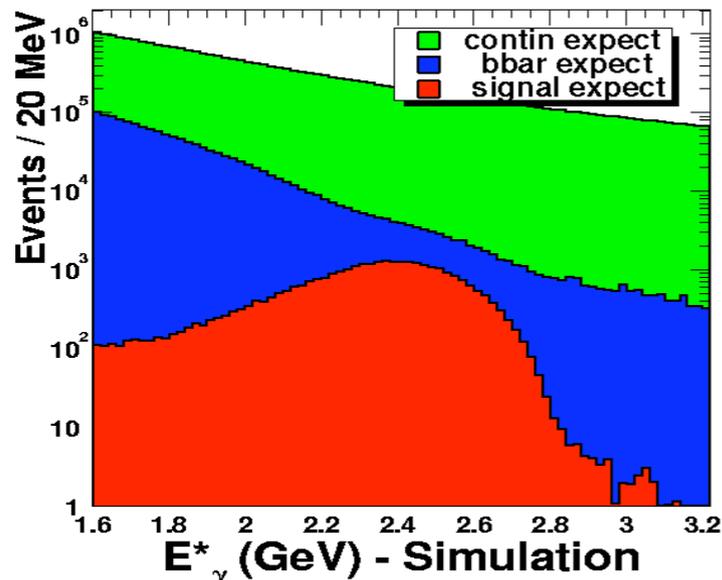
Convery, Hadig\*, Libby\*, Yarritu

# Radiative B Decays EWK Penguins

Inclusive  $b \rightarrow s \gamma$



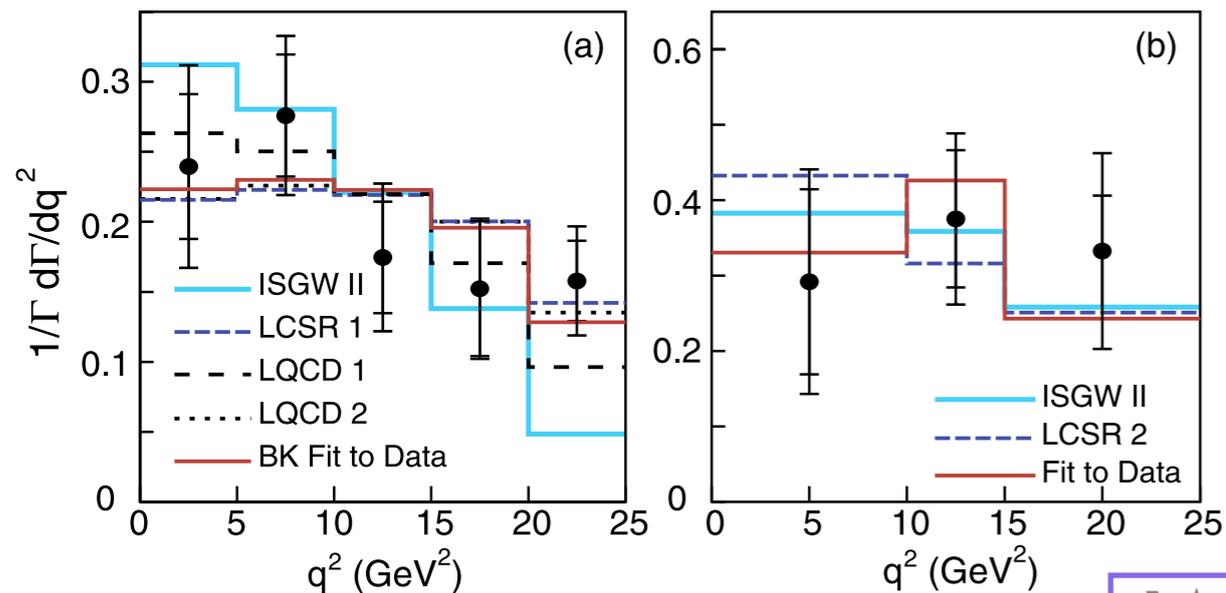
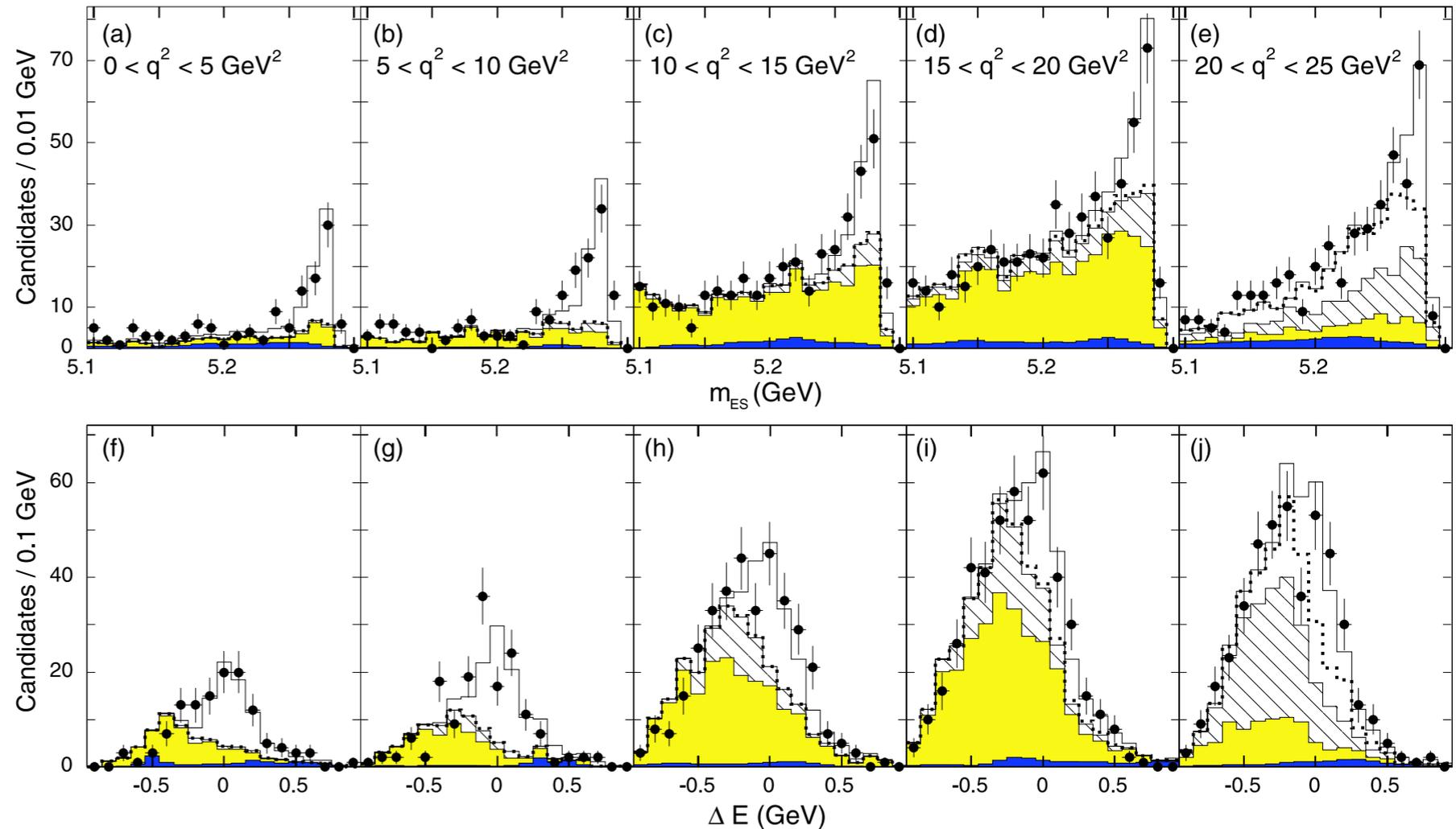
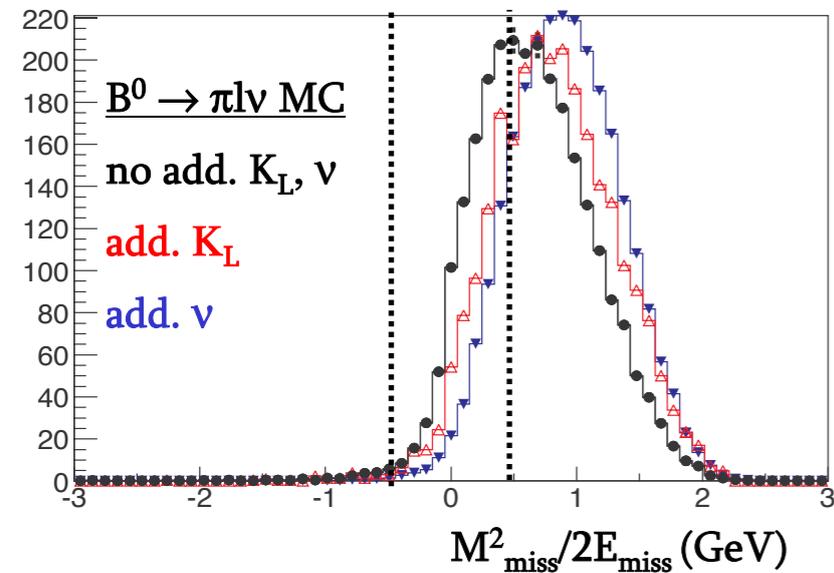
Fermi motion  
Shape Function



Ozcan, Libby\*, Jessop\*

# Semi-Leptonic Decays

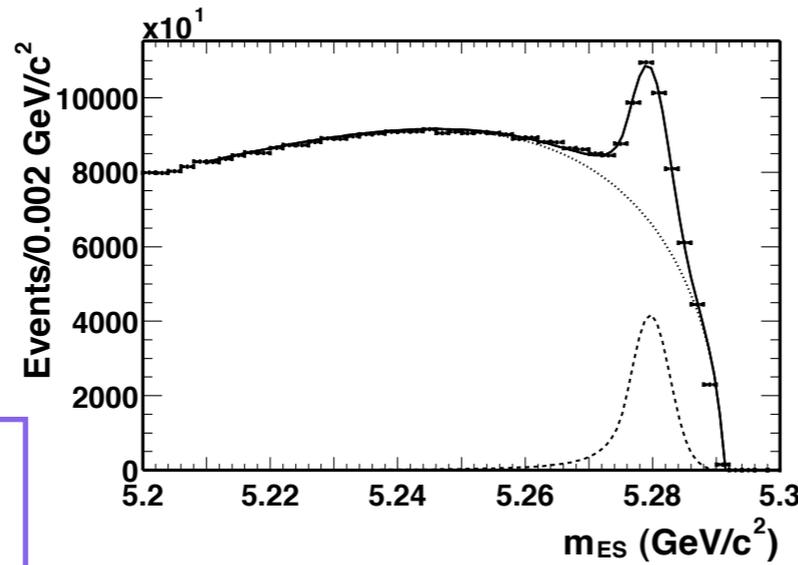
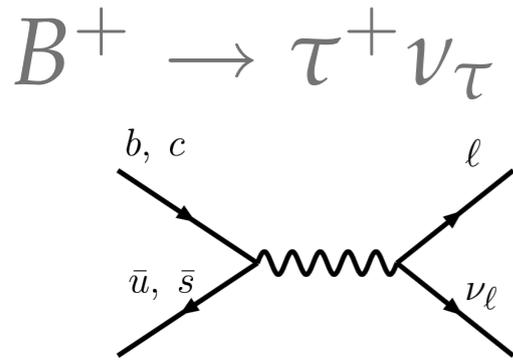
$$B \rightarrow \pi(\rho) \ell \nu$$



$$|V_{ub}| = (3.82 \pm 0.14 \pm 0.24 \pm 0.11^{+0.88}_{-0.52}) \times 10^{-3}$$

Weinstein, Dingfelder, Kelsey, Luth

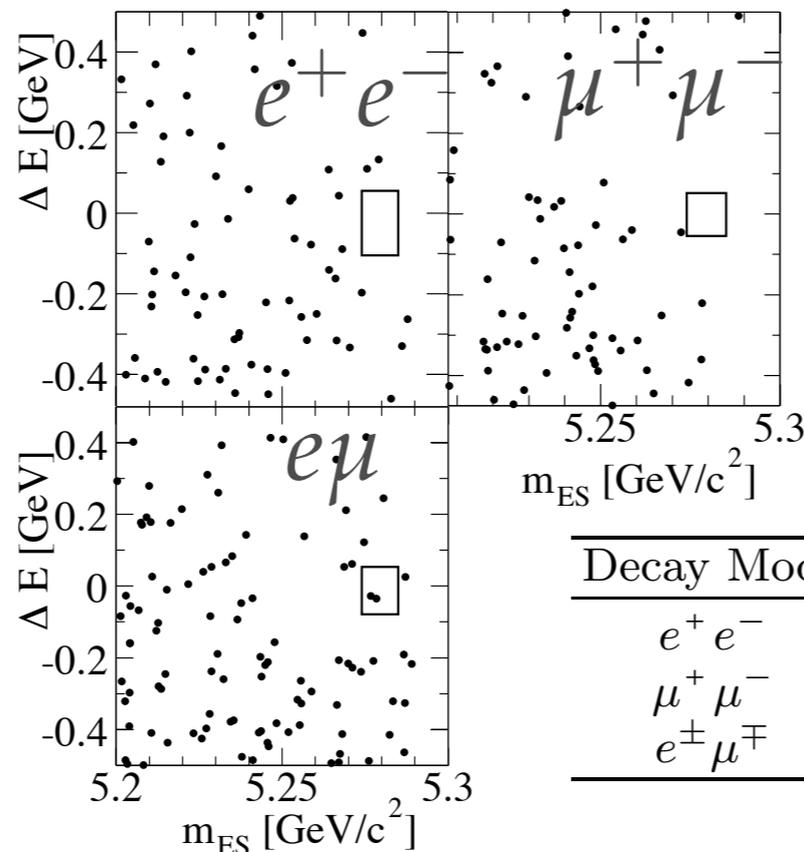
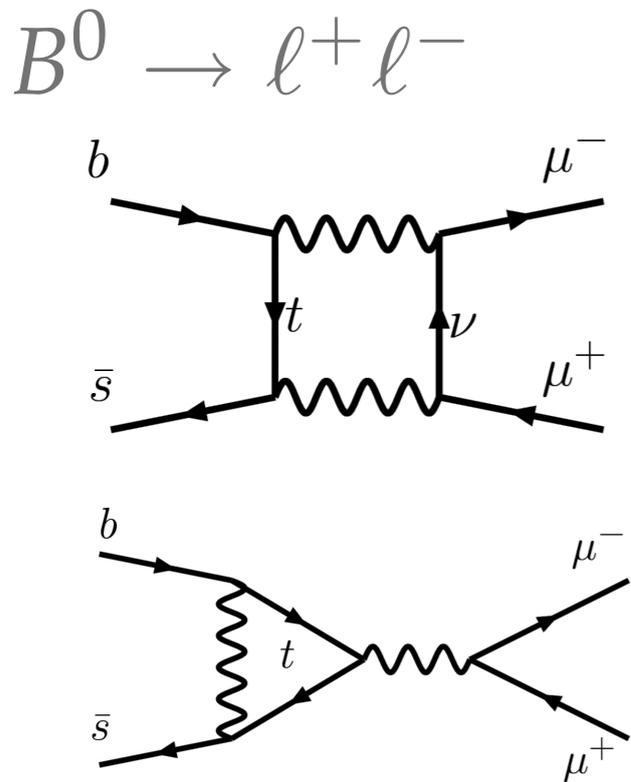
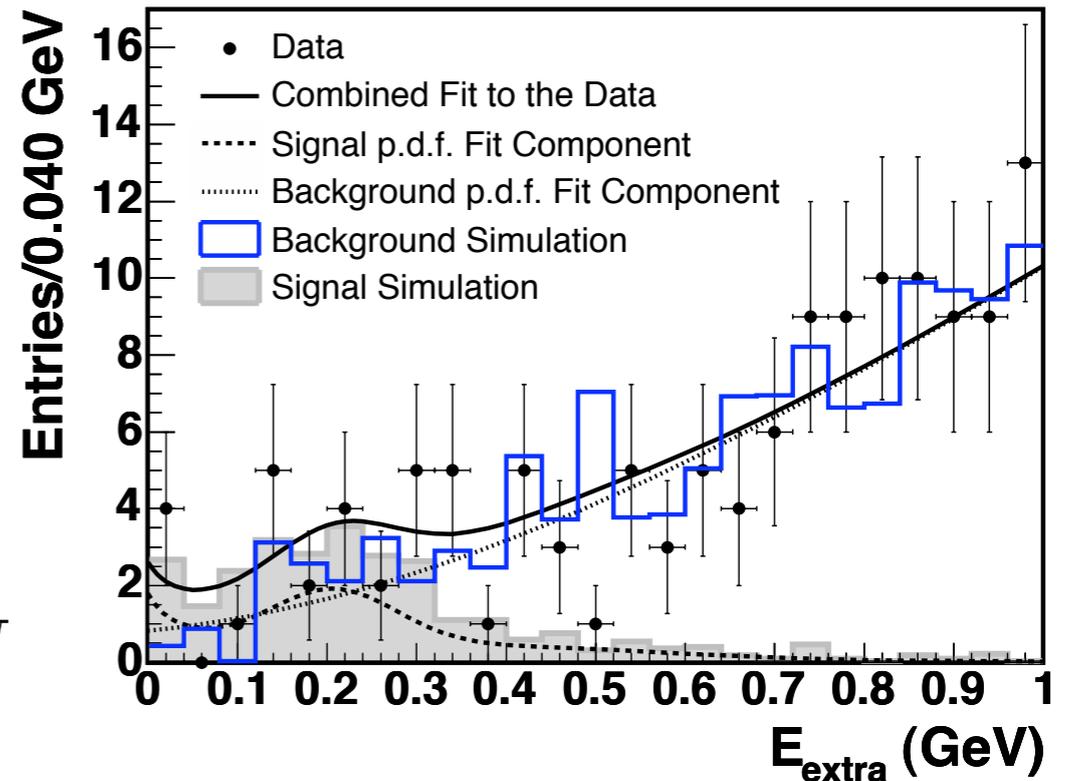
# Leptonic B Decays



Robertson\*

$$\mathcal{B}(B^- \rightarrow \tau^- \bar{\nu}_\tau) = \frac{G_F^2 m_B}{8\pi} m_\tau^2 \left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau$$

$$\mathcal{B}(B^- \rightarrow \tau^- \bar{\nu}_\tau) < 4.2 \times 10^{-4} \text{ (90\% C.L.)}$$



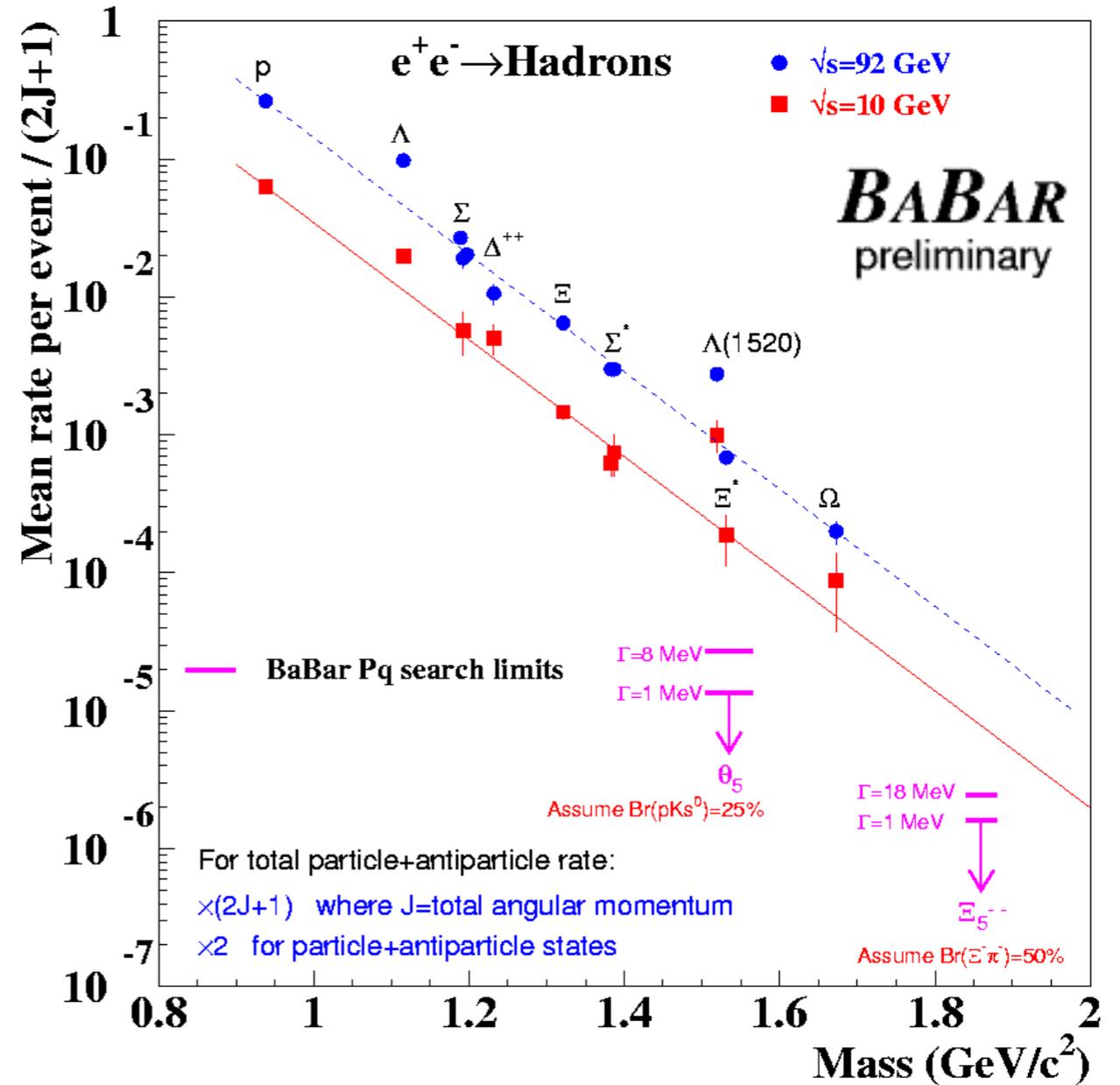
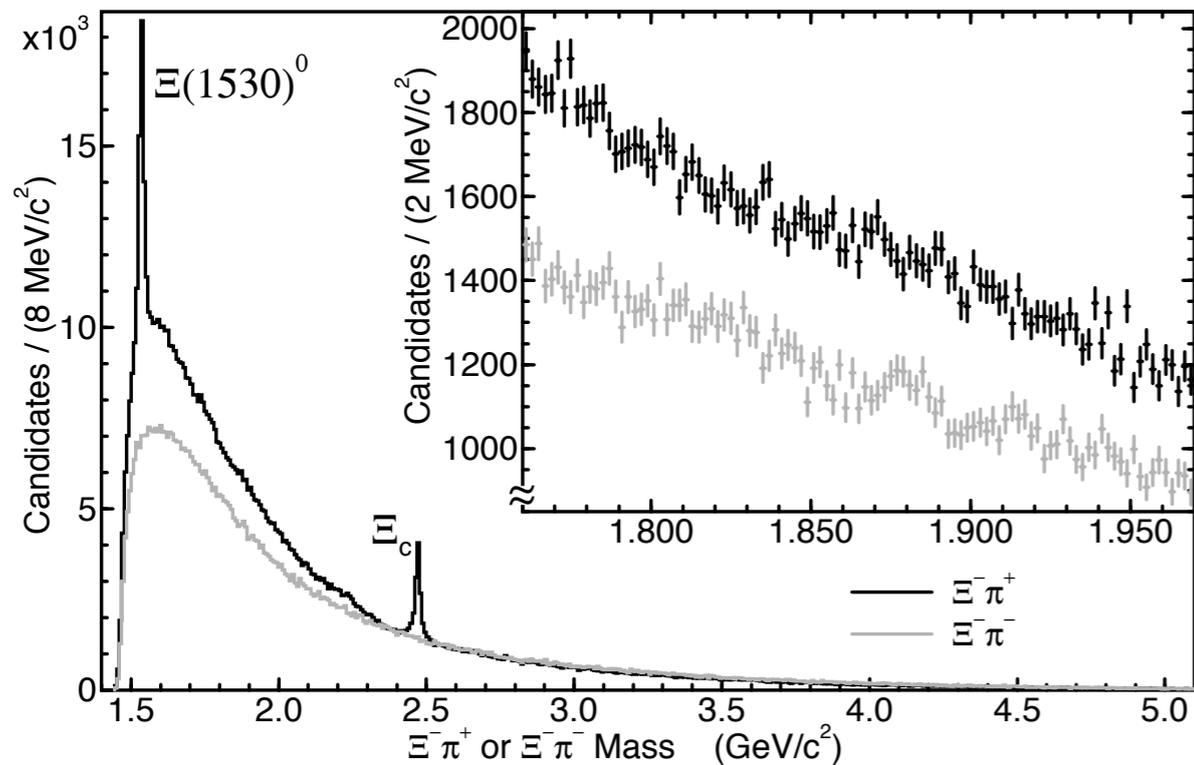
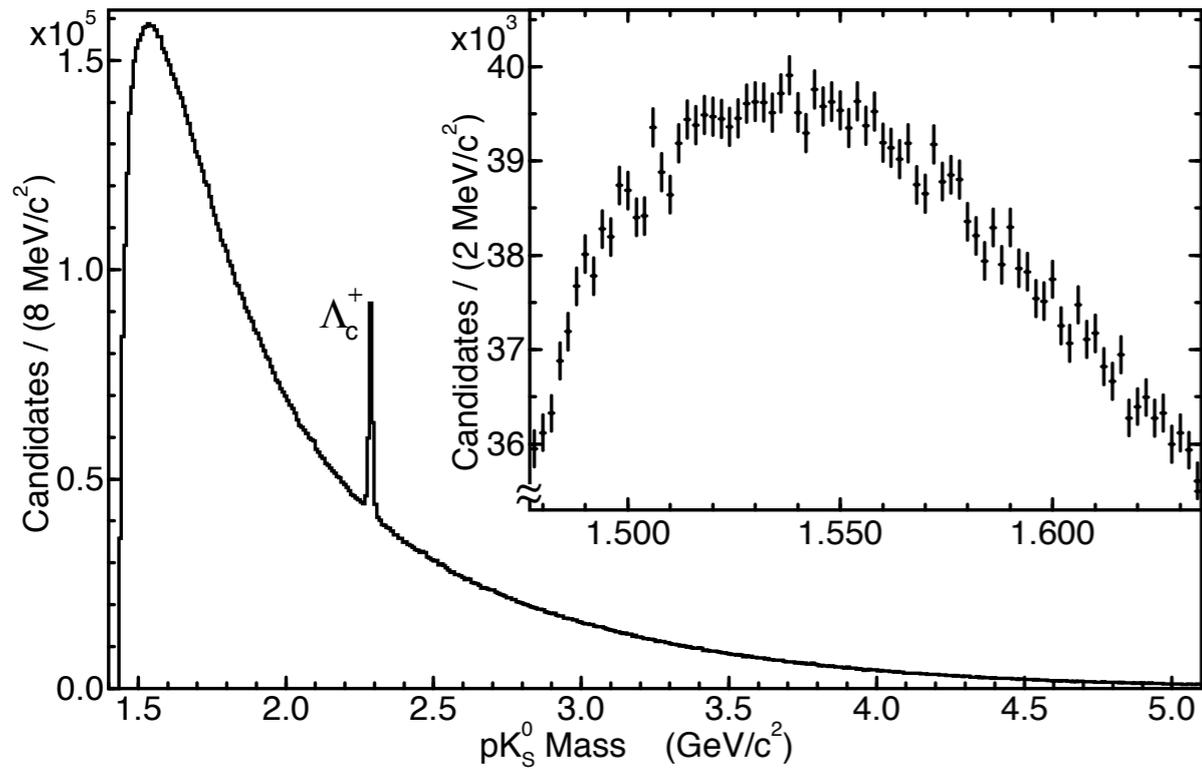
Halyo, Langenegger\*

111 fb<sup>-1</sup>

Decay Mode	$N_{\text{obs}}$	$N_{\text{exp}}^{\text{bg}}$	$\epsilon$ [%]	$\mathcal{B}_{\text{UL}}(B^0 \rightarrow l^+ l^-)$
$e^+ e^-$	0	$0.71 \pm 0.31$	$21.8 \pm 1.2$	$6.1 \times 10^{-8}$
$\mu^+ \mu^-$	0	$0.72 \pm 0.26$	$15.9 \pm 1.1$	$8.3 \times 10^{-8}$
$e^\pm \mu^\mp$	2	$1.29 \pm 0.44$	$18.1 \pm 1.2$	$18 \times 10^{-8}$

# Pentaquark Searches

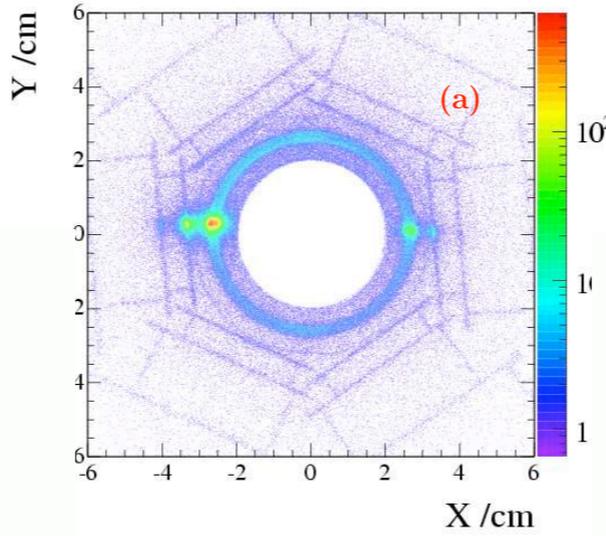
$$e^+e^- \rightarrow X$$



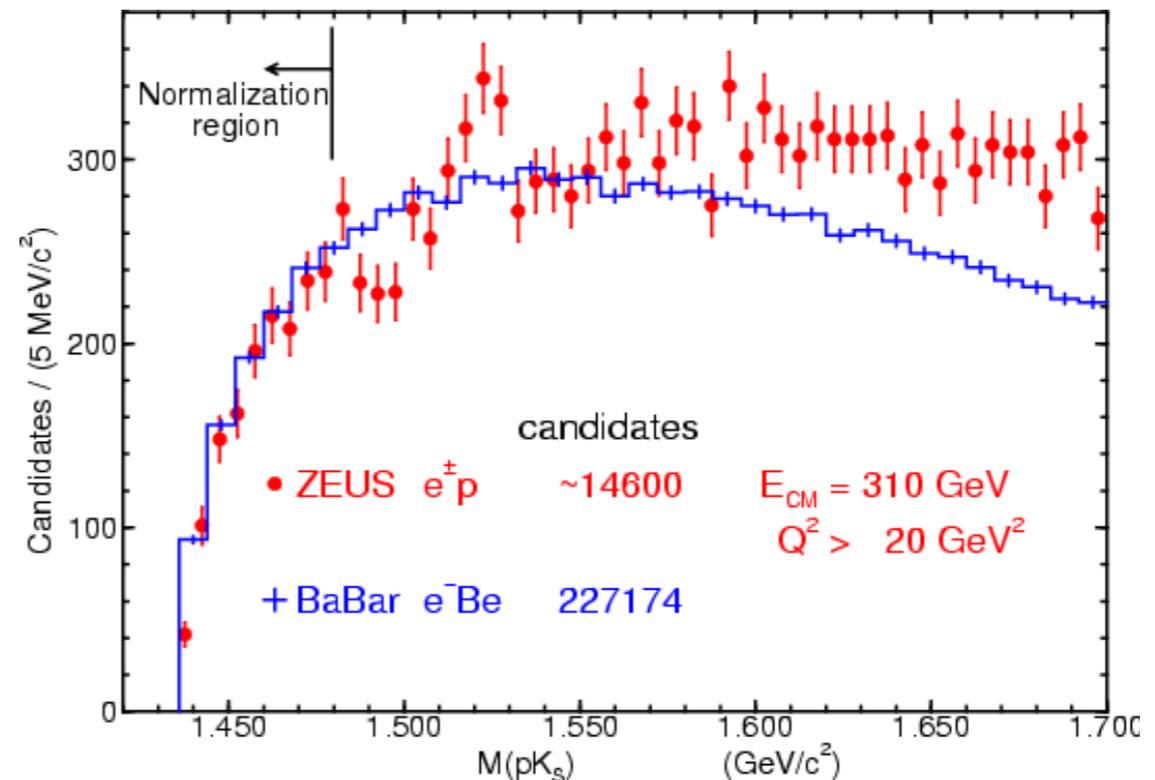
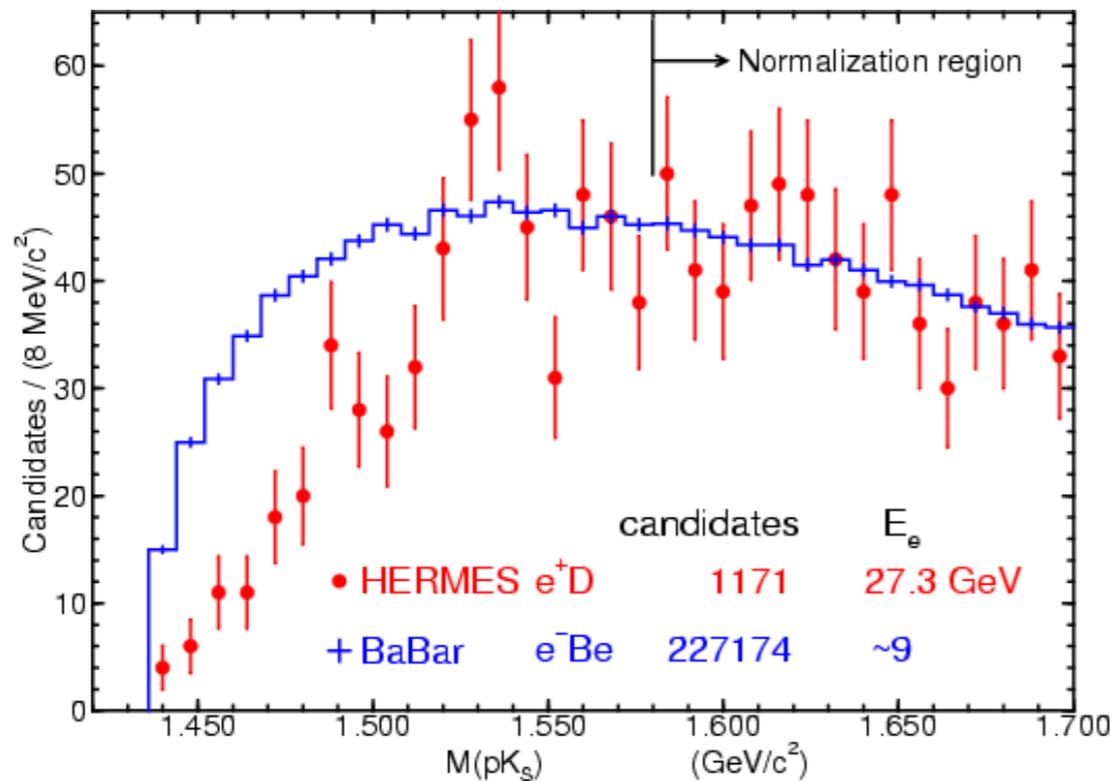
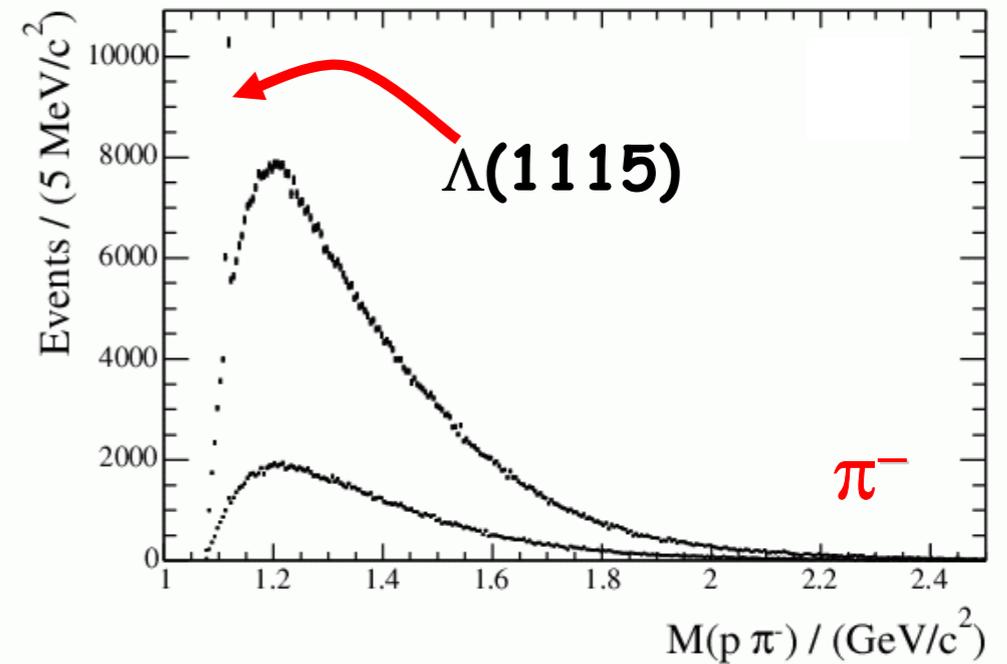
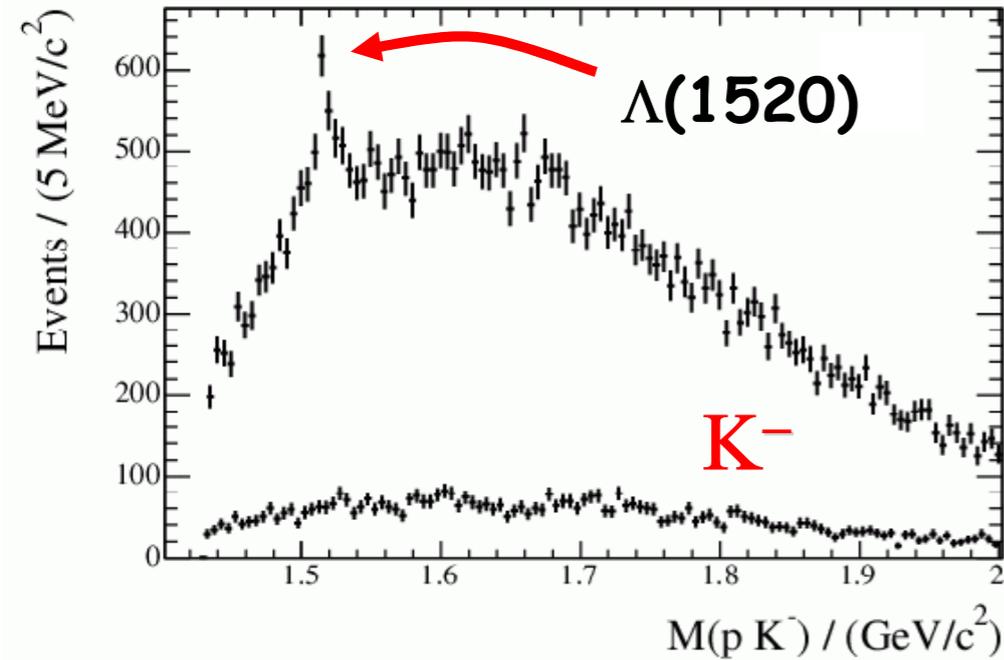
Halyo, Berger, Su Dong,  
Dunwoodie, Muller

# More Pentaquark Searches

$$e^- \text{Be} \rightarrow p K_S^0 K^- (\pi^-)$$



Dunwoodie, Coleman



# Ph.D. Theses

- Former Students
  - Hiro Tanaka, *Radiative Decays of the B Meson*, Aug 2002.
  - Aron Soha, *Branching Fraction and Time-Dependent CP Asymmetry in Neutral B Decays to Psi and a Neutral Pion*, May 2003.
  - Amanda Weinstein, *Study of Exclusive Charmless Semileptonic Decays of the B Meson*, Dec 2004.
- Current Students
  - Erkcan Ozcan, Inclusive decays Radiative Penguins decays  $b \rightarrow s\gamma$ , expected 2005
  - Tetiana Hryn'ova, Charmless Baryonic decay  $B \rightarrow p\bar{p}K$ , expected 2005
  - Nicolas Berger,  $R_{\text{HAD}}$  with ISR events, expected 2005
  - Joerg Stelzer, Leptonic Decay  $D_s^+ \rightarrow \mu^+ \nu_\mu$ , expected 2005
  - Kevin Yarritu, Radiative Penguin Decay  $B \rightarrow K^* \gamma$ , expected 2006
  - Mark Allen, CP Violation in  $B^0 \rightarrow \pi^0 \pi^0$
  - Joshua Thompson, CP Violation and Dalitz Analysis in  $B^0 \rightarrow K^+ K^- K_S^0$
  - Stephen Sun
- New Students
  - Wells Wulsin
  - Andrew Wagner
  - Christopher West

# SLAC @ BABAR

## People

T. Abe, M. T. Allen, D. Aston, N. Bakel, R. Bartoldus, N. Berger, A. M. Boyarski, O. L. Buchmueller, R. Claus, J. P. Coleman, M. R. Convery, M. Cristinziani, J. C. Dingfelder, D. Dong, J. Dorfan, D. Dujmic, W. Dunwoodie, S. Fan, R. C. Field, T. Glanzman, S. J. Gowdy, T. Hadig, V. Halyo, C. Hast, T. Hryn'ova, W. R. Innes, M. H. Kelsey, P. Kim, M. L. Kocian, D. W. G. S. Leith, J. Libby, S. Luitz, V. Luth, H. L. Lynch, H. Marsiske, R. Messner, D. R. Muller, C. P. O'Grady, V. E. Ozcan, A. Perazzo, M. Perl, B. N. Ratcli, A. Roodman, A. A. Salnikov, R. H. Schindler, J. Schwiening, A. Snyder, J. Stelzer, D. Su, M. K. Sullivan, K. Suzuki, S. Swain, J. M. Thompson, J. Va'vra, M. Weaver, W. J. Wisniewski, M. Wittgen, D. H. Wright, A. K. Yarritu, K. Yi, C. C. Young  
P Bechtle, S Li

Students

PostDocs

Faculty & BABAR Management

## Recent Publications

PUB-04/042	Branching Fractions and CP Asymmetries in $B_0 \rightarrow \pi_0\pi_0$ , $B^+ \rightarrow \pi^+\pi_0$ and $B^+ \rightarrow K^+\pi_0$ Decays and Isospin Analysis of the $B \rightarrow \pi\pi$ System	13-Dec-04	PRL 94, 181802 (2005)
PUB-03/028	Observation of the Decay $B_0 \rightarrow \pi_0 \pi_0$	05-Aug-03	PRL 91, 241801 (2003)
PUB-03/003	Study of Time-Dependent CP Asymmetry in $B_0 \rightarrow J/\psi \pi_0$ Decays	13-Mar-03	PRL 91, 061802 (2003)
PUB-04/051	Measurement of CP Asymmetries in $B_0 \rightarrow \phi K_0$ and $B_0 \rightarrow K^+K^-K_0$	09-Feb-05	PRD-RC 71, 091102 (2005)
PUB-04/015	Measurement of Branching Fractions and CP Asymmetries in $B_0 \rightarrow K^+K^-K_s$ and $B^+ \rightarrow K^+K_sK_s$ Decays	01-Jun-04	PRL 93, 181805 (2004)
PUB-03/017	Measurements of Branching Fractions in $B \rightarrow \phi K$ and $B \rightarrow \phi \pi$ and Search for Direct CP Violation in $B^+ \rightarrow \phi K^+$	05-Sep-03	PRD-RC 69, 011102 (2004)
PUB-04/007	Determination of the Branching Fraction for $B \rightarrow X_c \ell \nu$ Decays and of $ V_{cb} $ from Hadronic-Mass and Lepton-Energy Moments	11-Apr-04	PRL 93, 011803 (2004)
PUB-03/034	Measurements of Moments of the Hadronic Mass Distribution in Semileptonic B Decays		PRD69 111103 (2004)
PUB-03/012	Measurement of the Inclusive Charmless Semileptonic Branching Ratio of B Mesons and Determination of $ V_{ub} $	25-Jul-03	PRL 92, 071802 (2004)
PUB-04/019	Measurement of Branching Fractions, and CP and Isospin Asymmetries for $B \rightarrow K^* \gamma$	30-Jun-04	PRD-RC 70, 112006 (2004)
PUB-04/035	Search for $B^+ \rightarrow \rho^+ \gamma$ , $B_0 \rightarrow \rho^0 \gamma$ , and $B_0 \rightarrow \omega \gamma$	11-Aug-04	PRL 94, 011801 (2005)
PUB-03/008	Search for the Radiative Decays $B \rightarrow \rho \gamma$ and $B_0 \rightarrow \omega \gamma$	17-Jun-03	PRL 92, 111801 (2004)
PUB-04/021	Search for the Rare Leptonic Decay $B \rightarrow \tau \nu$	20-Jul-04	submitted to PRL
PUB-04/036	A search for the decay $B^+ \rightarrow K^+ \nu \bar{\nu}$	17-Nov-04	PRL 94, 101801 (2005)
PUB-04/008	B meson decays to $\eta(')K^*$ , $\eta(')\rho$ , $\eta(')\pi_0$ , $\omega \pi_0$ , and $\phi \pi_0$	17-Mar-04	PRD 70, 032006 (2004)
PUB-03/025	$J/\psi$ production via initial state radiation in $e^+e^- \rightarrow \mu^+\mu^- \gamma$ at an $e^+e^-$ center-of-mass energy near 10.6 GeV	14-Oct-03	PRD-RC 69, 011103 (2004)
PUB-04/047	Search for Strange-Pentaquark Production in $e^+e^-$ Annihilation at $\sqrt{s}=10.58$ GeV	01-Feb-05	submitted to PRL
PUB-03/030	Observation of a Narrow Meson Decaying to $D_s^+ \pi^0 \gamma$ at a Mass of 2.458 GeV/c <sup>2</sup>	24-Oct-03	PRD 69, 031101 (2004)
PUB-03/011	Observation of a Narrow Meson Decaying to $D_{s^*}^+ \pi^0$ at a Mass of 2.32 GeV/c <sup>2</sup>	11-Apr-03	PRL 90, 242001 (2003)
PUB-05/015	Search for the Decay $\tau$ to seven pions and one or zero pizeros	25-May-05	PRD-RC