"Hot Topics" from BaBar

Vasia Shelkov
Lawerence Berkeley National Laboratory

BaBar Collaboration

"Hot Topics" from BaBar

$B \to \eta' K^{(*)}$

- $B^0 \to \eta' K^{*0}$
- $B \to \eta' K$
  - $B^0 \to \eta' K^0$
  - $B^+ \to \eta' K^+$

$B^\pm \to h^\pm h^\mp h^\pm$

- $B^\pm \to \pi^\pm \pi^\mp \pi^\pm$
- $B^\pm \to \pi^\pm \pi^\mp K^\pm$
- $B^\pm \to \pi^\pm K^\mp K^\pm$
- $B^\pm \to K^\pm K^\mp K^\pm$

Common Analyses Features

Source of Bs

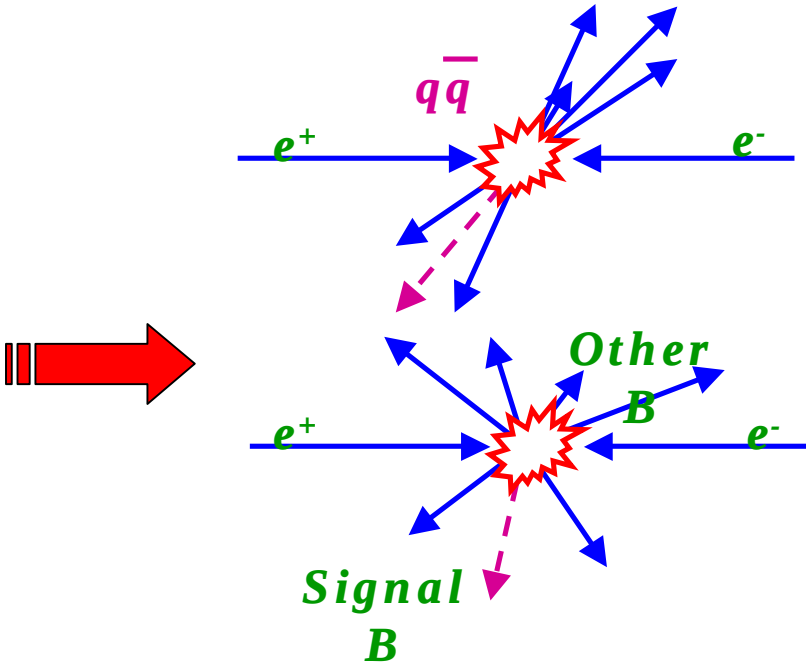
$$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\overline{B}$$

Approach

all analyses are blinded

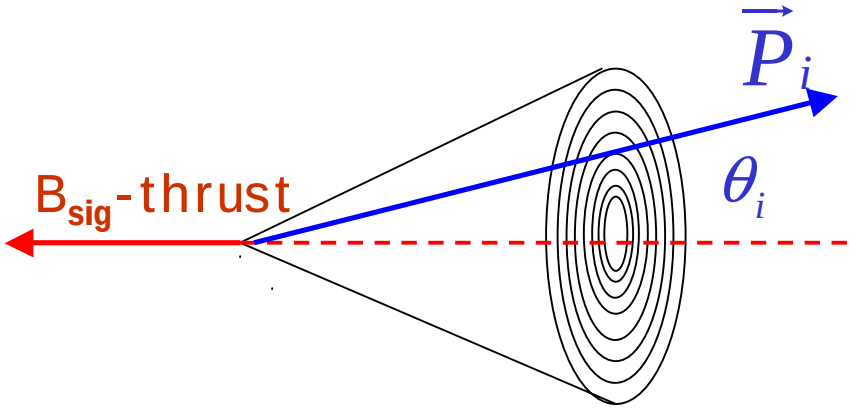
Variables

- $\Delta E = \sum_i \sqrt{p_i^{*2} + m_i^2} - E_{beam}^*$
- $m_{ES} = \sqrt{E_{beam}^{*2} - (\sum_i p_i^*)^2}$
- event shape variables:
  - $\cos(\vec{T}_{\text{B-sig}}, \vec{T}_{\text{B-other}})$, $\cos(\vec{P}_{\text{B-sig}}, \vec{Z}_{\text{Beam}})$
  - energy flow around B-thrust axis



Energy flow around B-thrust axis

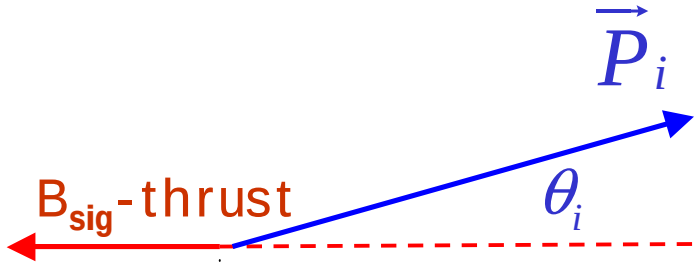
Numerical approach



$$I_j^{CONE} = \sum_{i=1}^{unused\ tracks,bumps} P^i$$

$$F = \sum_{j=1}^{9} \alpha_j I^j$$

Analytical approach



$$F = \sum_{i=1}^{unused\ tracks,bumps} (\alpha \cdot L_0(\theta_i) + \beta \cdot L_2(\theta_i) + ...) P^i$$

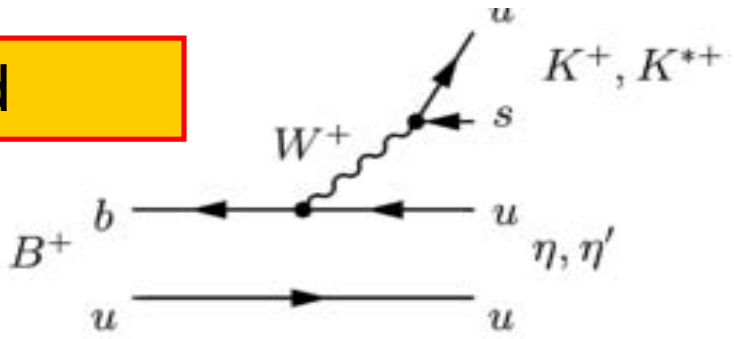
Ln – Legendre polynomial of n^{th} power

$$(e.g.\ L_2(\theta_i) = 3\cos^2\theta_i - 1)$$

We found that S/B discriminating power of 9-cone Fisher is identical to using a single polynomial L_2

Analyses of $B \to \eta^{(\prime)} K^{(*)}$ decays

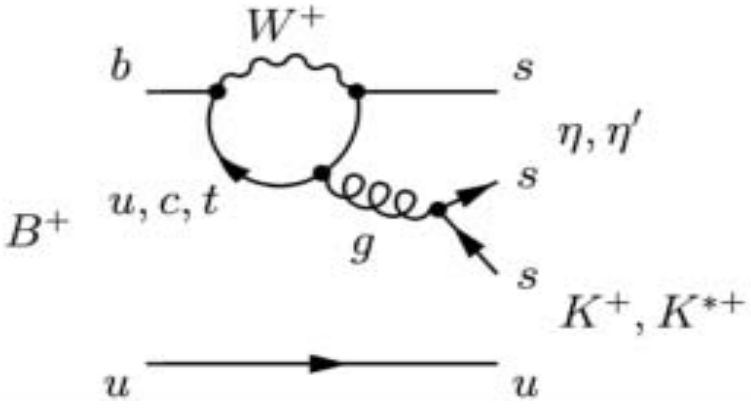
"tree" is Cabibbo suppressed

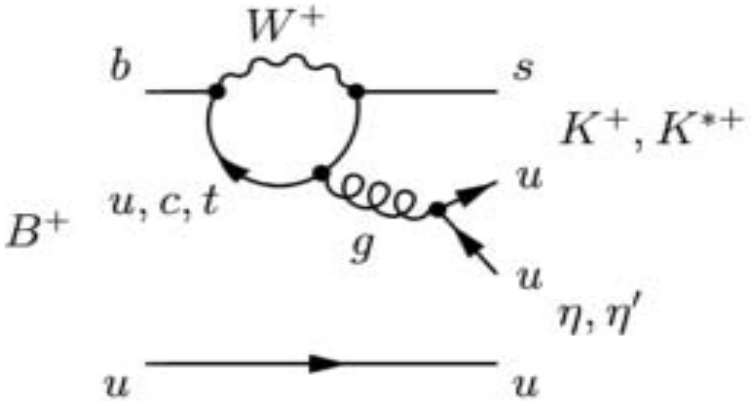


Interference between "penguins":

enhance: $B \to \eta K^*$ $B \to \eta' K$

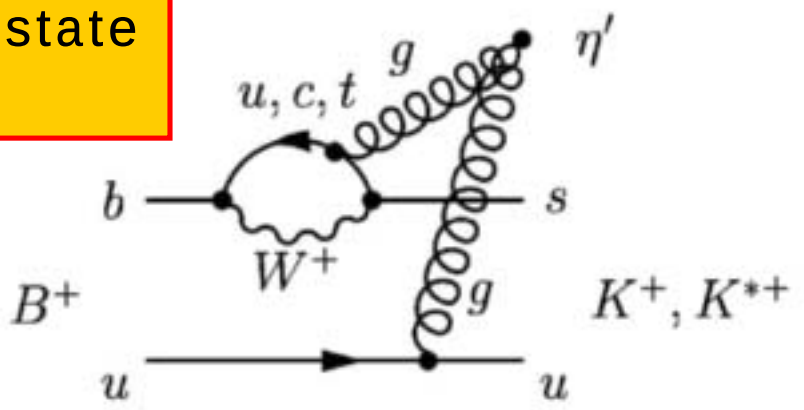
suppress: $B \to \eta K$ $B \to \eta' K^*$



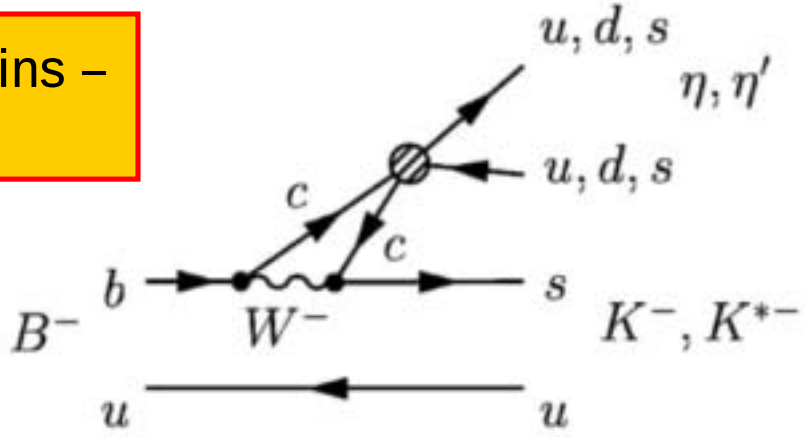


Large rate for $B \to \eta' K$ decays

- η' approximates a flavor singlet state
- QCD anomaly, glue coupling to η'



- "charming" penguins – **c** enhanced in loop

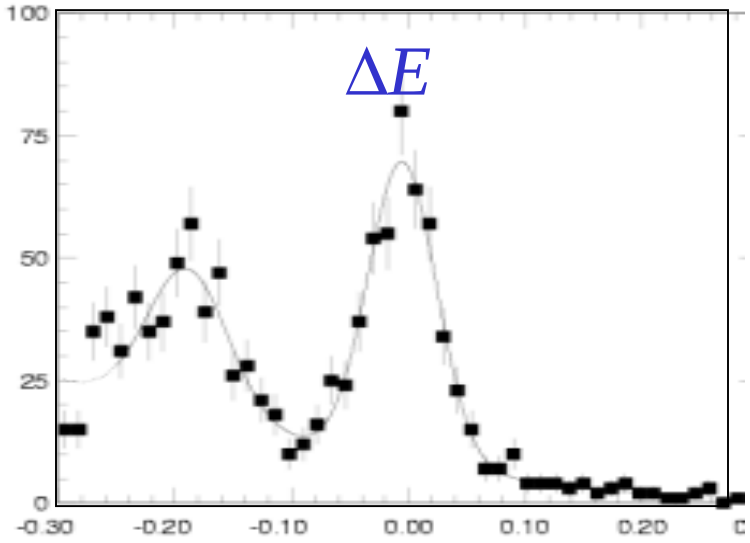


Event selection for $B \to \eta^{(\prime)} K^{(*)}$ decays

- selection of resonances: η, $\eta'(\pi\pi\eta, \rho\gamma)$, ρ, K^*, K^0_S
- suppress continuum with: $\cos(\vec{T}_{\text{B-sig}}, \vec{T}_{\text{B-other}}) < 0.9$
- extract signal with: $\max L(\Delta E, m_{ES}, F, m(\text{resonance}), H(PV))$
- PDFs were validated with independent sample of fully reconstructed events

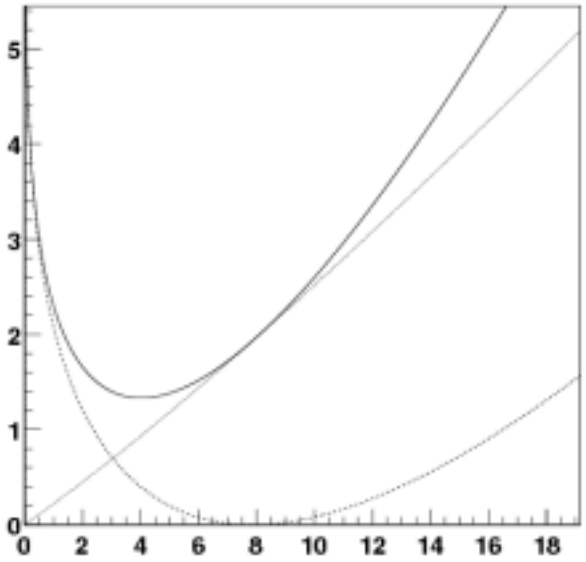
Example:

$B^- \to D^0(K^-\pi^+\pi^0)\pi^-$



Results for $Br(B \to \eta' K^*)$ measurement

ML fit quantity	2000($20fb^{-1}$)	2001($35fb^{-1}$)
Events to fit		
On resonance	659	1074
Off resonance	92	138
Signal yeild		
On resonance	$0.0^{+1.3}_{-0.0}$	$5.2^{+3.9}_{-2.8}$
Off resonance	$0.0^{+0.5}_{-0.0}$	$0.0^{+0.6}_{-0.0}$
MC ε(%)	16.9	16.9
Stat. sign.(σ)	–	1.9
B($\times 10^{-6}$)	$0.0^{+2.2}_{-0.0}$	$7.9^{+5.8}_{-4.2}$
UL(incl. syst.)	11.7×10^{-6}	23.5×10^{-6}



–2LnL-vs-BF

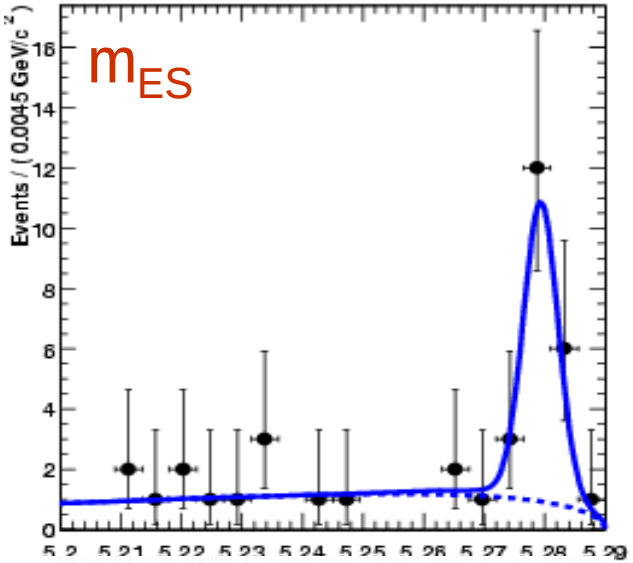
$$B(B \to \eta' K^*) = (4.0^{+3.5}_{-2.4} \pm 1.0)\times10^{-6} (<13\times10^{-6})$$

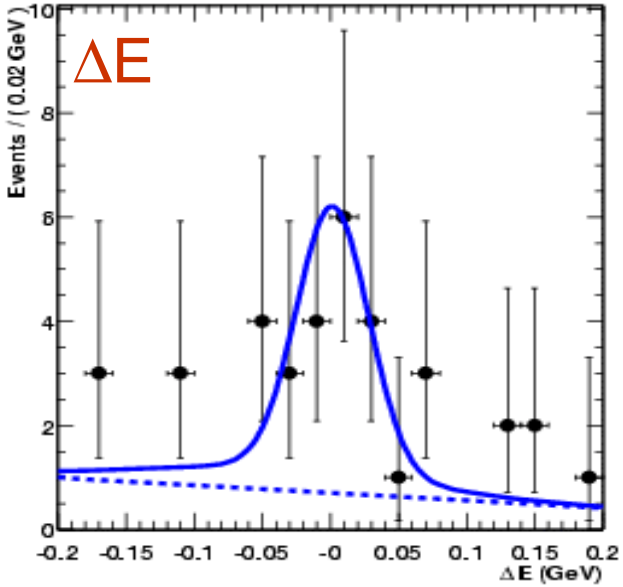
Results for $Br(B \to \eta' K)$ measurements

Quantity	$\eta'_{\eta\pi\pi} K^+$	$\eta'_{\rho\gamma} K^+$	$\eta'_{\eta\pi\pi} K^0$	$\eta'_{\rho\gamma} K^0$
Events to fit				
On-resonance	2199	34992	665	7400
Off-resonance	254	3847	59	790
Signal Yield				
On-res data	152^{+14}_{-13}	293^{+23}_{-22}	29^{+7}_{-6}	106^{+14}_{-13}
Off-res data	$-1.6^{+1.8}_{-0.9}$	$-1.3^{+4.0}_{-2.9}$	$0.0^{+0.7}_{-0.0}$	$0.0^{+2.8}_{-0.0}$
$B\bar{B}$ BG subtraction	0.0	13 ± 6	0.0	4.1 ± 2.1
MC ε(%)	23.1	24 ± 0	23.5	24.5
Stat. sign.(σ)	26	20	10	15
B(10^{-6})	65 ± 6	71 ± 6	32 ± 7	67 ± 9

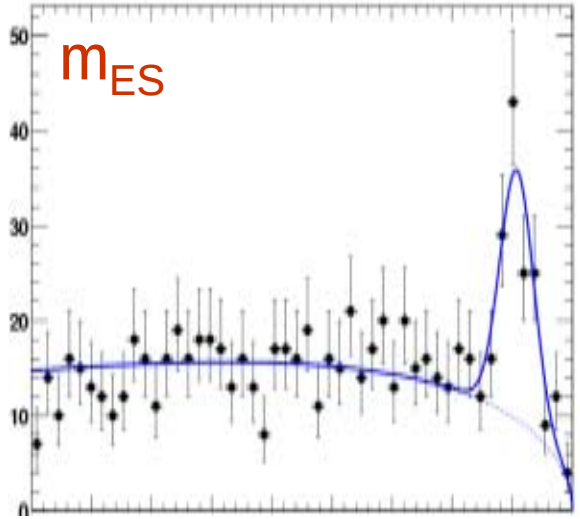
Projections for $B \to \eta' K^0$ fit

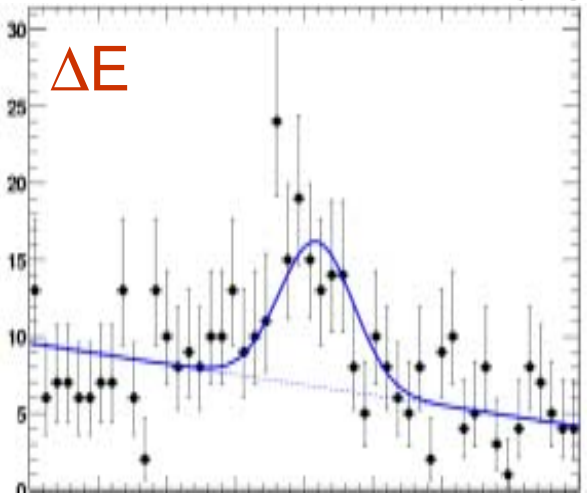
$\eta' \to \eta\pi\pi$





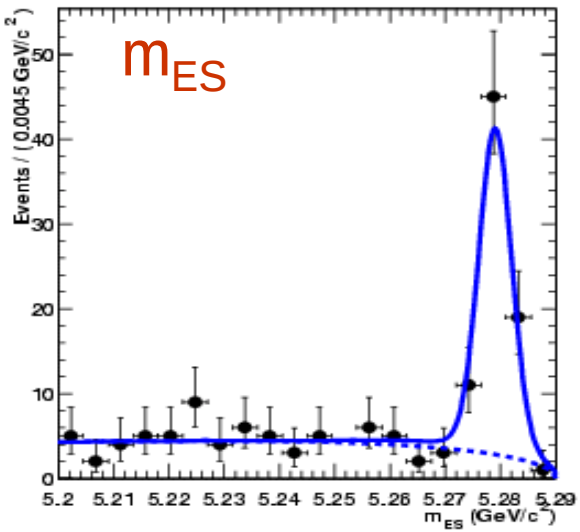
$\eta' \to \rho\gamma$

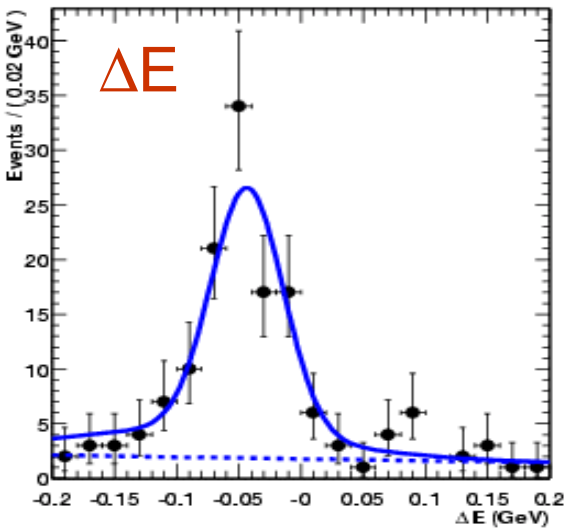




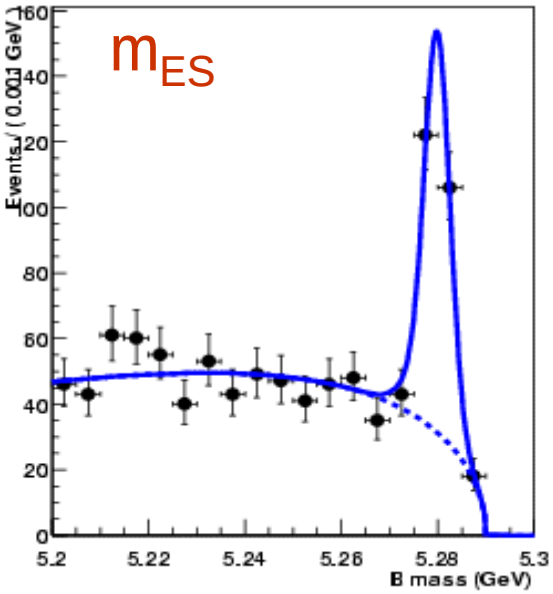
Projections for $B \to \eta' K^+$ fit

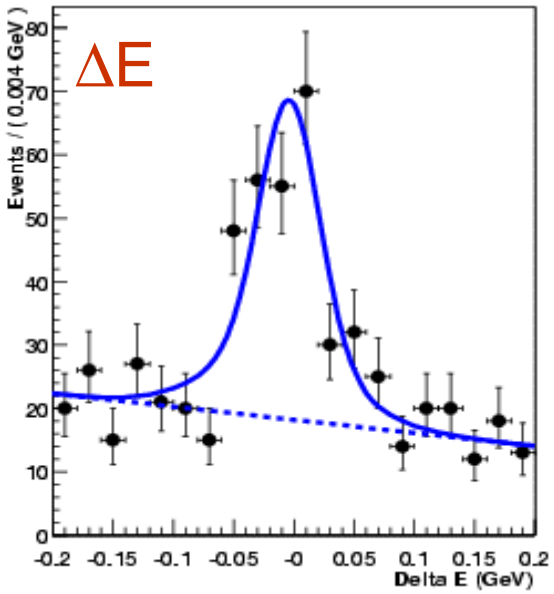
$\eta' \to \eta\pi\pi$





$\eta' \to \rho\gamma$





All $Br(B \to \eta' K^{(*)})$ results

in units of 10^{-6}

Mode	CLEO	BaBar(2001)	BaBar(2002)
$\eta' K^+$	$80^{+10}_{-9} \pm 7$	$70 \pm 8 \pm 5$	$67 \pm 5 \pm 5$
$\eta' K^0$	$89^{+18}_{-16} \pm 9$	$42^{+13}_{-11} \pm 4$	$46 \pm 6 \pm 4$
$\eta' K^{*0}$	$7.8^{+7.7}_{-5.7} (<24)$		$4.0^{+3.5}_{-2.4} \pm 1.0 (<13)$

Analysis of $B^{\pm} \to h^{\pm}h^{\mp}h^{\pm}$ decays

Motivation

charmless decays of charged Bs are interesting for direct-CP searches and extraction of CKM angle γ

Approach

- use all available PID information(DCH,SVT,DIRC) to separate πs and Ks
- explicitly veto D^0, J/Ψ, $\Psi(2S)$ decays into 2 charged hadrons
- efficiencies for signal and largest background contributions are calculated as a function of Dalitz plot
- perform Cut&Count analysis of the entire Dalitz plot

Analysis of $B^{\pm} \to h^{\pm}h^{\mp}h^{\pm}$ decays

PID cross-feeds in %

Selected as	Input Mode ππ	Kππ	KKπ	KKK
ππ	15.3	1.7	0.014	0.001
Kππ	0.4	15.1	3.2	0.04
KKπ	0.0	0.29	17.7	5.5
KKK	0.0	0.0	0.17	21.6

Charm Veto

➥ veto all possible combinations of K and π which end up within $\pm 3\sigma (30 \mathrm{MeV}/c^2)$ mass window of D^0 peak

➥ veto $m(\pi^+\pi^-)$ and $m(K^+K^-)$ mass combinations within $\pm 3\sigma (45 \mathrm{MeV}/c^2)$ of $J/\Psi, \Psi(2S)$ peaks

Analysis of $B^{\pm} \to h^{\pm}h^{\mp}h^{\pm}$ decays

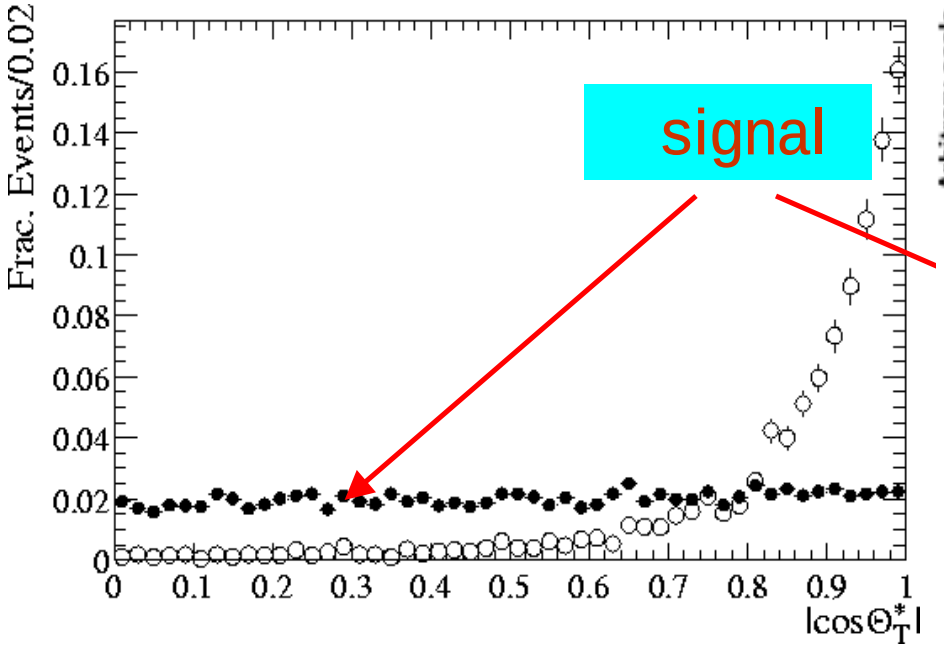
Continuum Suppression

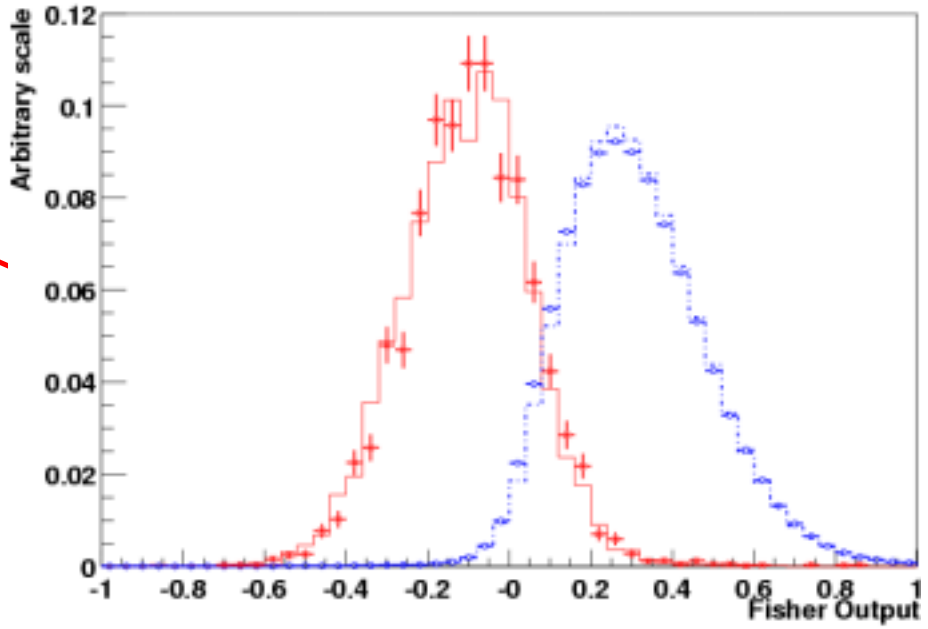
$\pi\pi\pi$: $\cos(\theta_T) < 0.575$ $F < -0.11$

$K\pi\pi$: $\cos(\theta_T) < 0.700$ $F < -0.03$

$KK\pi$: $\cos(\theta_T) < 0.725$ $F < +0.10$

KKK: $\cos(\theta_T) < 0.875$ $F < +0.30$





Analysis of $B^{\pm} \to h^{\pm}h^{\mp}h^{\pm}$ decays

Signal Box

$$|\Delta E - \langle \Delta E \rangle| < 60\ \text{MeV} \qquad |m_{ES} - m_B| < 8.0\ \text{MeV/c}^2$$

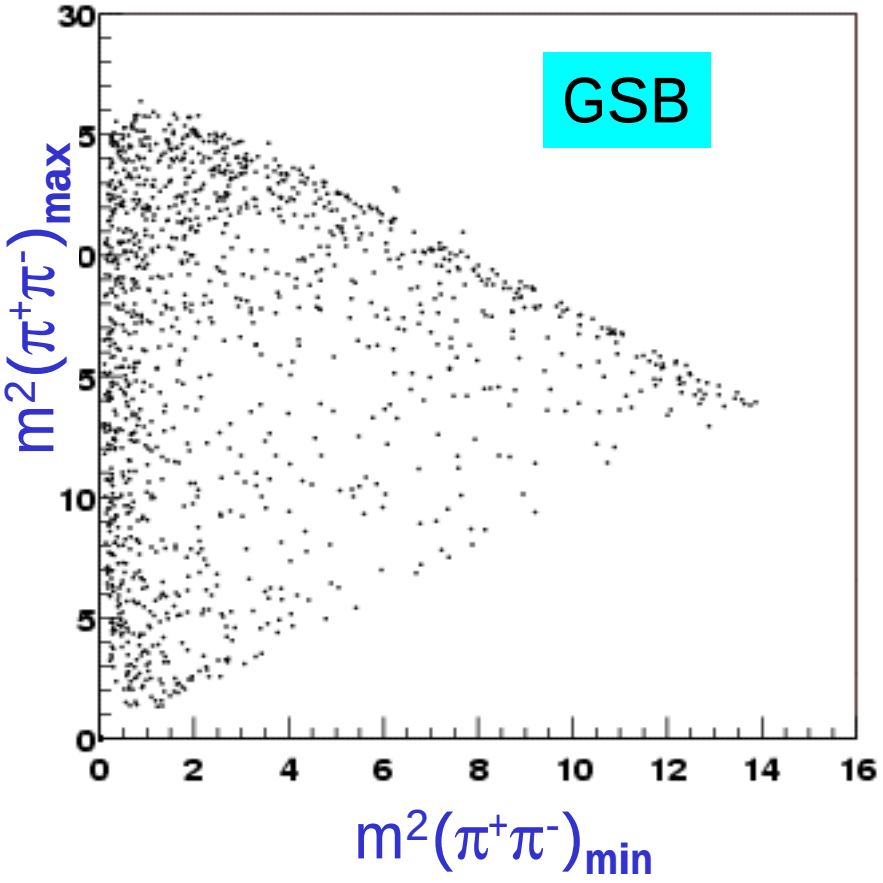
Grand Side Band

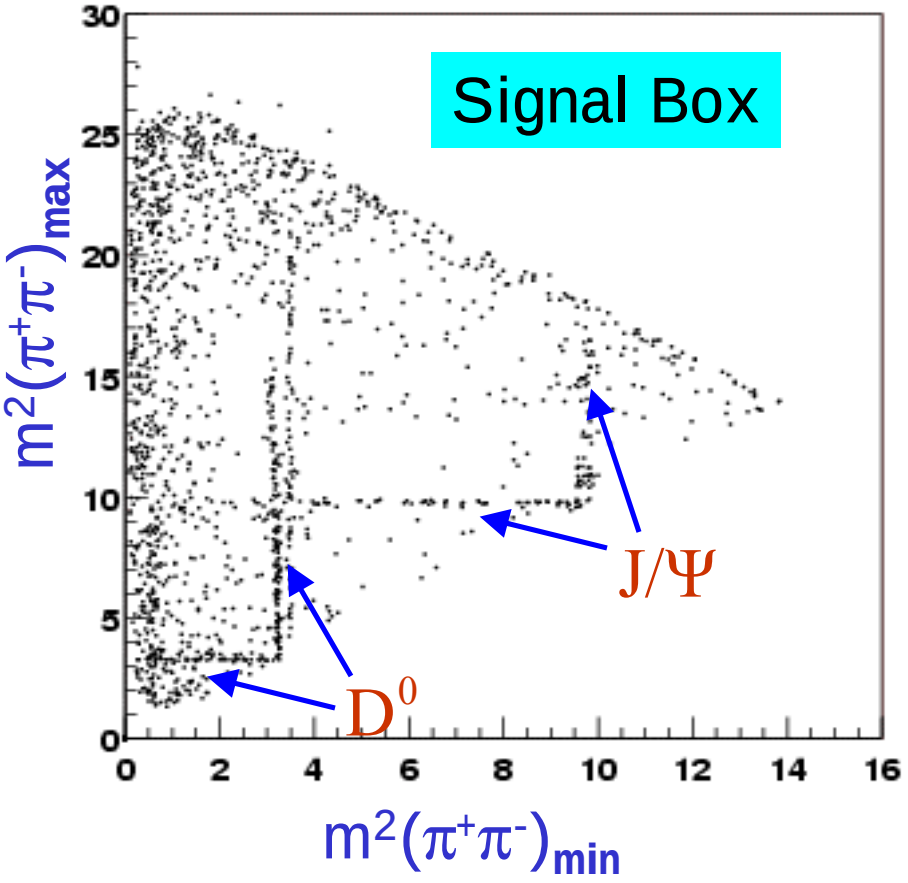
$$|\Delta E - \langle \Delta E \rangle| < 0.1\ \text{GeV} \qquad 5.21 < m_{ES} < 5.25\ \text{GeV/c}^2$$

Background propagation

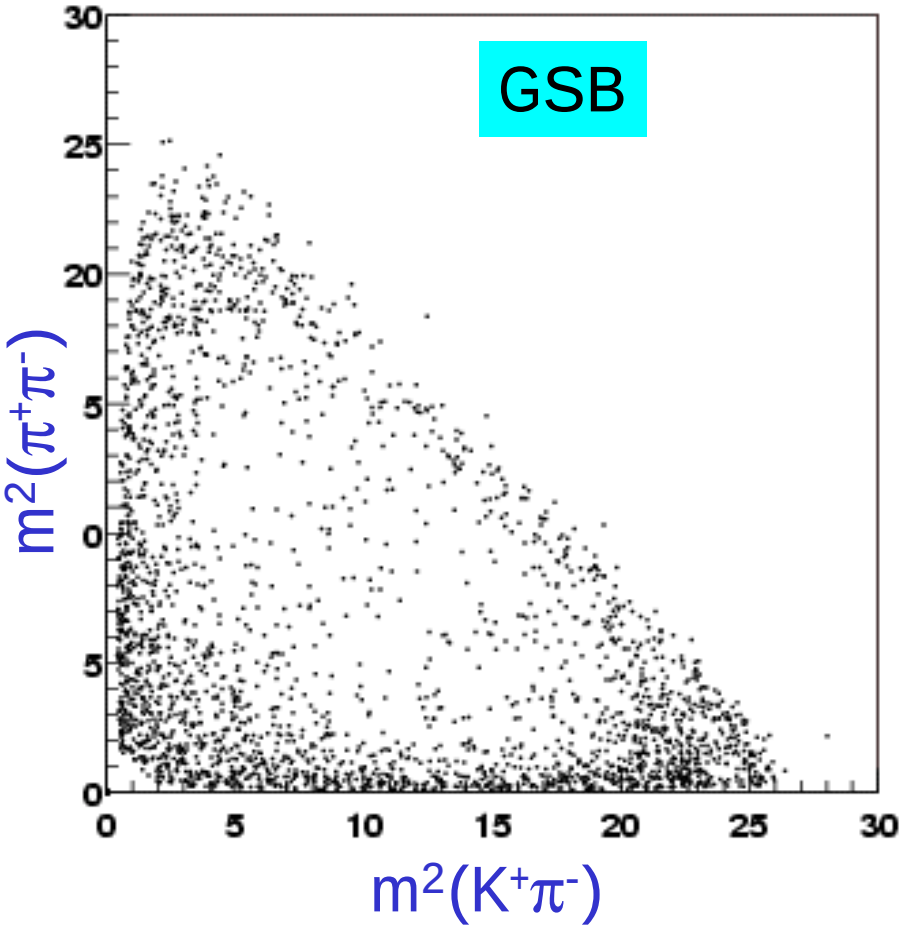
Using ARGUS shape of m_{ES}, and 2nd order polynomial for ΔE, the background from GSB is propagated into the Signal Box(using multiplicative factor R)

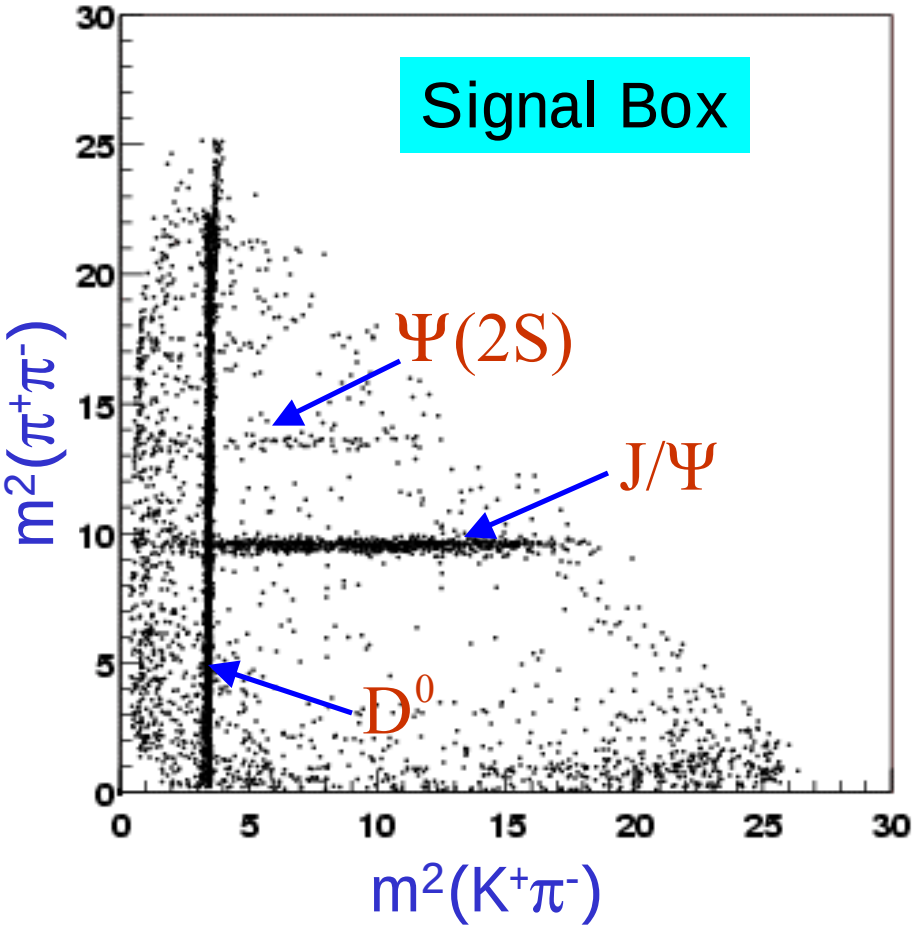
Dalitz plot for $B \to \pi\pi\pi$ decays



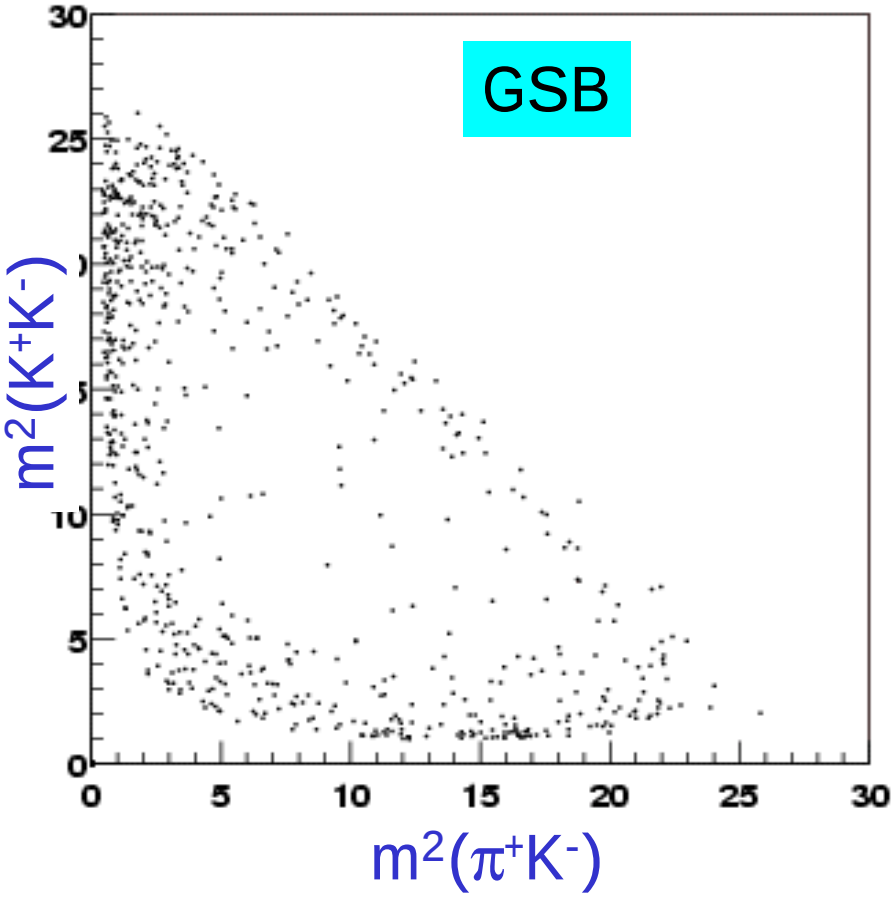


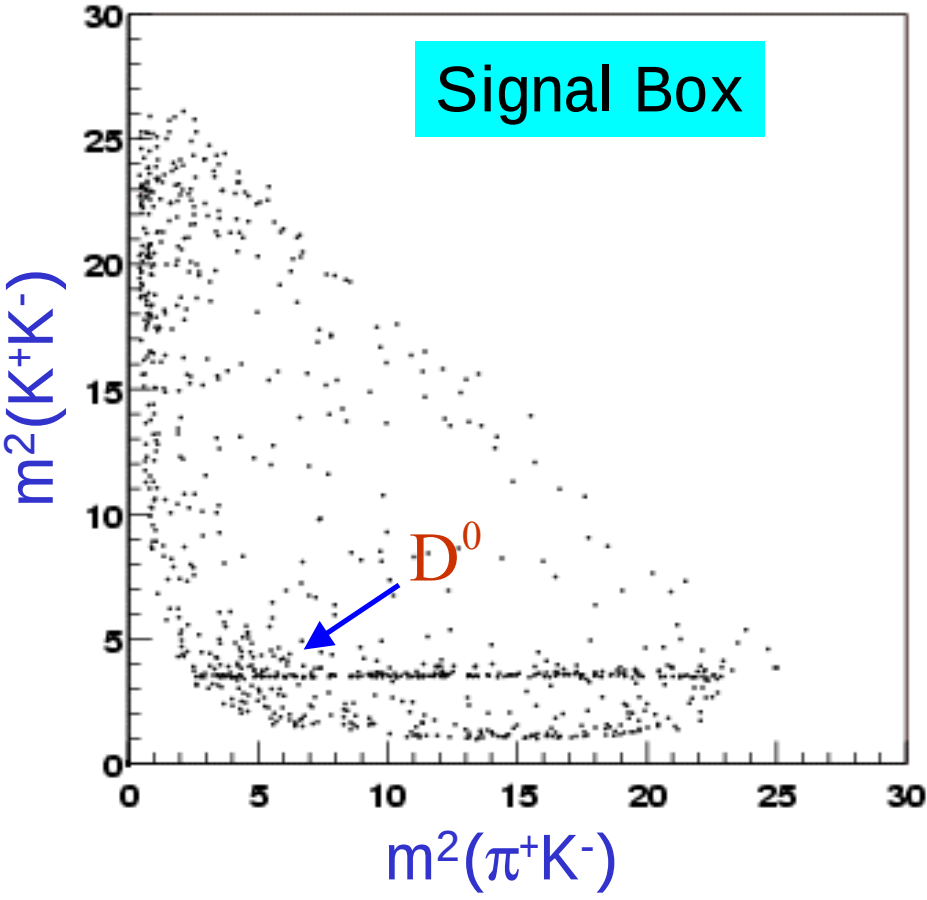
Dalitz plot for $B \to K\pi\pi$ decays



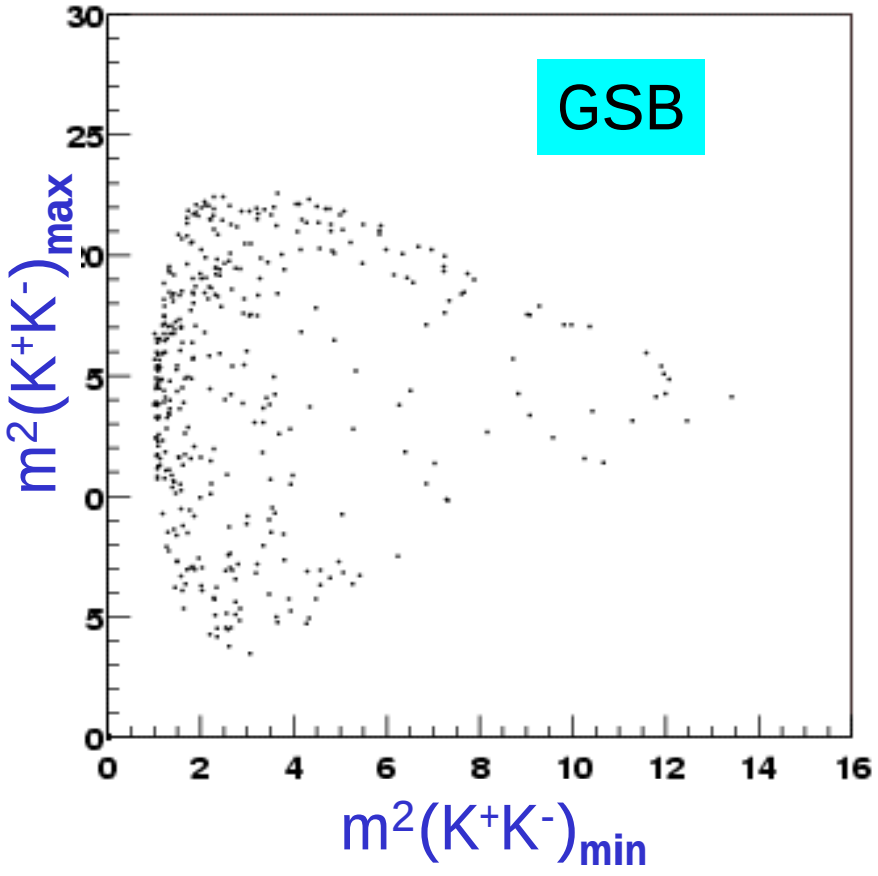


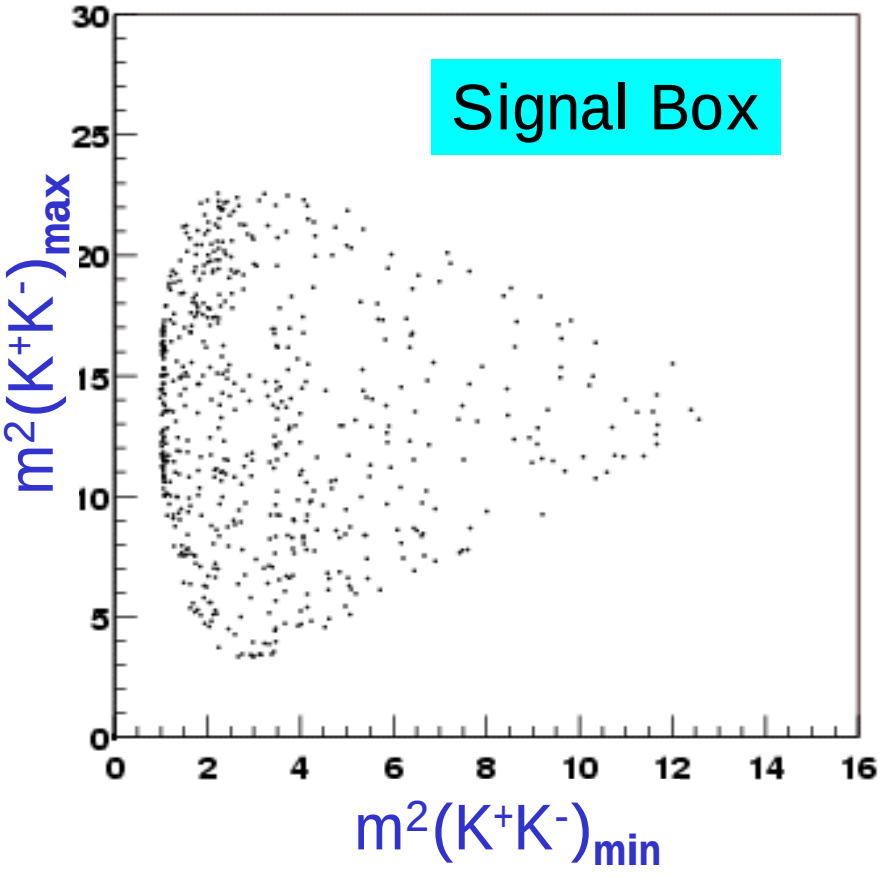
Dalitz plot for $B \to KK\pi$ decays





Dalitz plot for $B \to KKK$ decays

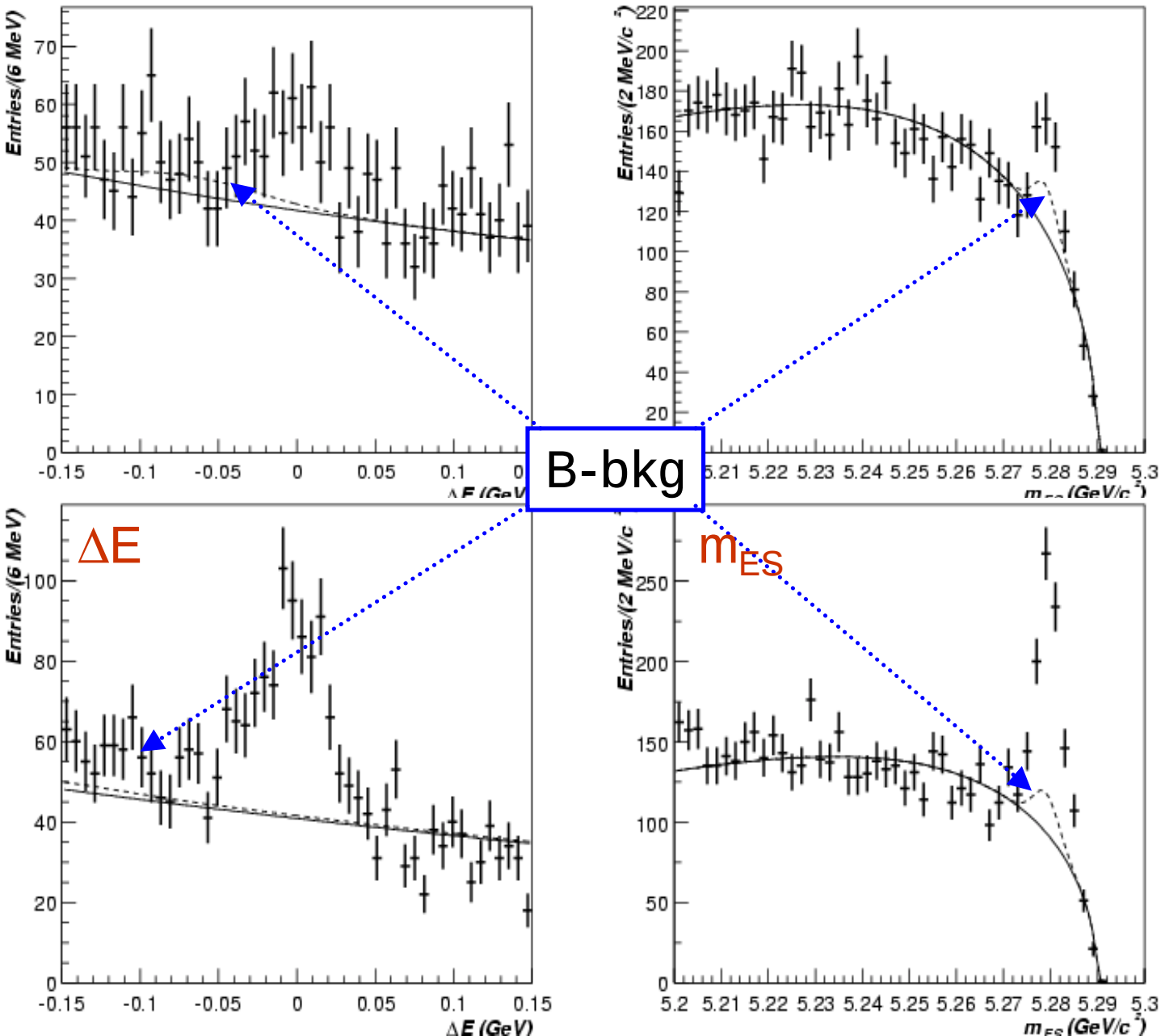




Results

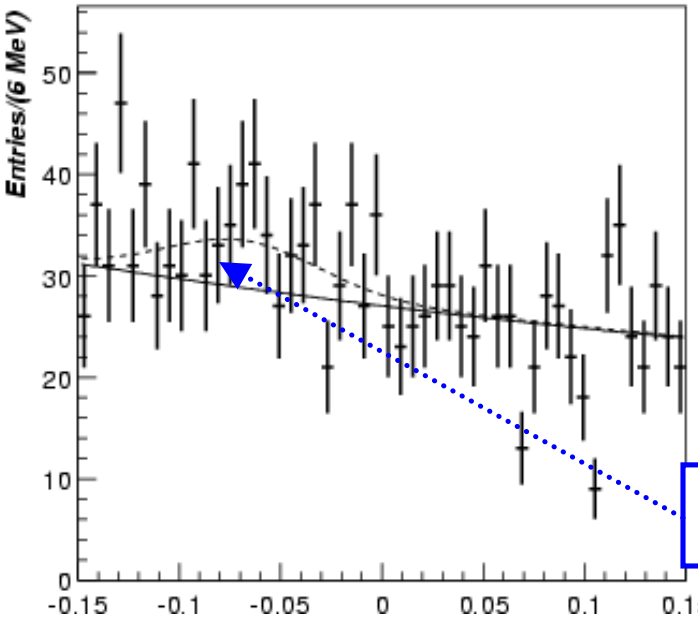
$B \to \pi\pi\pi$

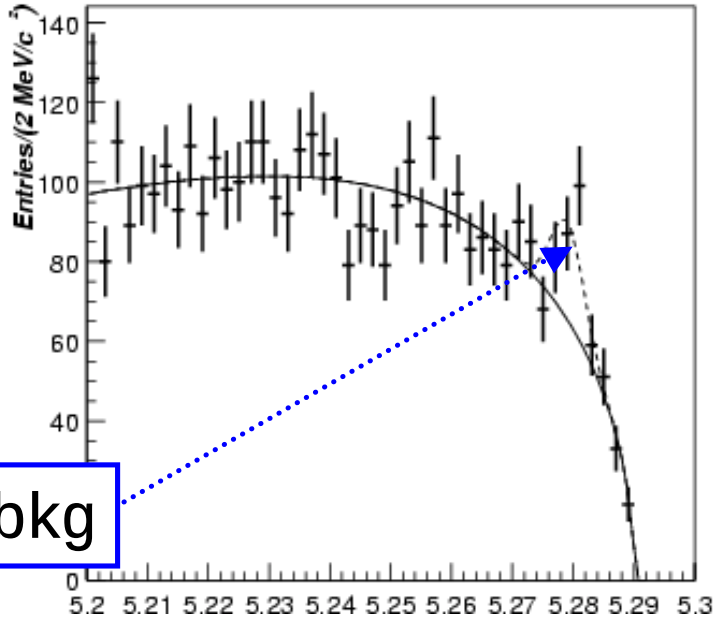
$B \to K\pi\pi$



Results

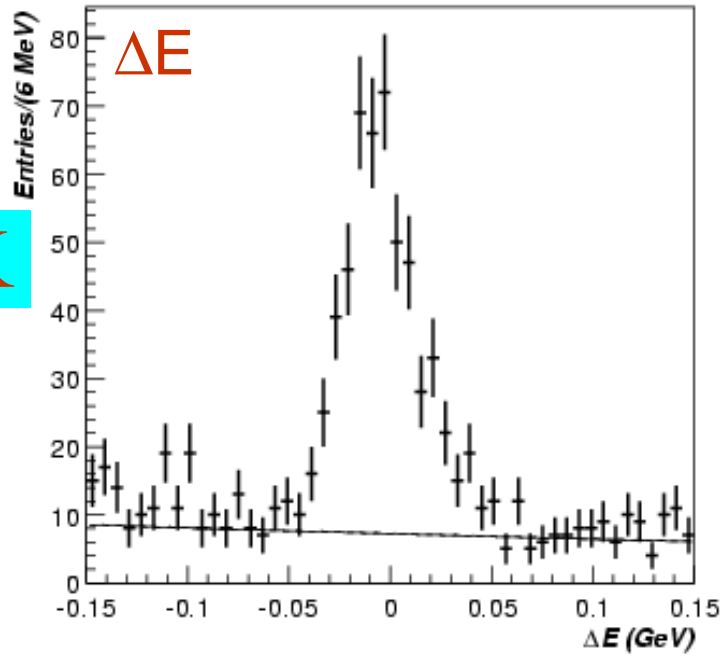
$B \to KK\pi$

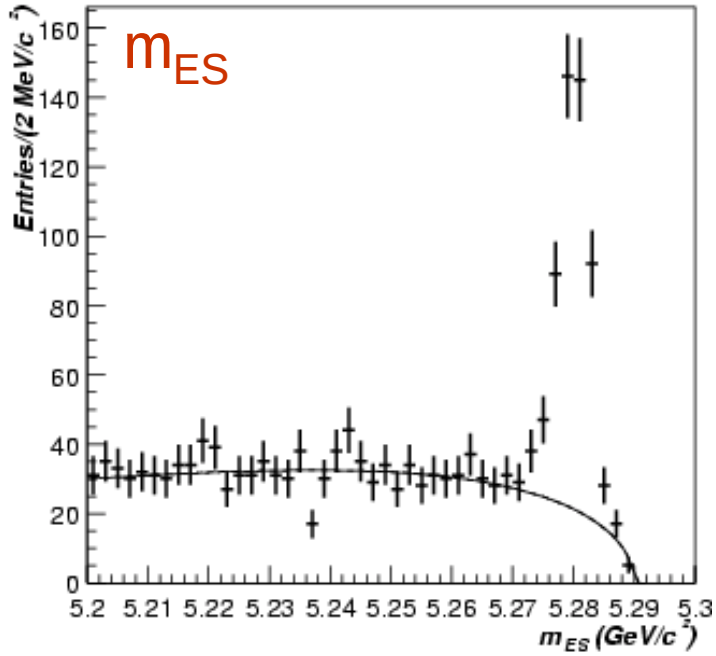




B-bkg

$B \to KKK$





Results

Signal Mode	πππ	K$\pi\pi$	KKπ	KKK
Signal Box	951	1269	573	603
GSB	5470	4652	3239	1100
Average Eff.	15.3±1.1	15.4±0.9	18.3±0.9	22.5±1.0
Bkg. Factor R	0.145±0.006	0.153±0.006	0.150±0.006	0.159±0.01
1) $\Sigma_i N_{1i}/\varepsilon_i$	5839 ± 212	8055 ± 255	3413 ± 156	2734 ± 111
2) $\Sigma_i RN_{2i}/\varepsilon_i$	4812 ± 73 ± 193	4434 ± 73 ± 171	2802 ± 54 ± 111	780 ± 23 ± 47
3) $\Sigma_i N_X\varepsilon''/\varepsilon_i$	391 ± 8 ± 2	14 ± 1 ± 1	435 ± 5 ± 8	–
4) $\Sigma_i n_{Di}/\varepsilon_i$	157±27	401±50	–	–
5) n_X	–	–124±55	56±11	–
6) $\Sigma_i \frac{(N_{1i}-RN_{2i}-N_X\varepsilon''-n_{Di})}{\varepsilon_i} - n_X$	478±224±195±34±26	3330±266±186±56±186	121±166±112±21±5	1954±114±47±13±82
Br. Ratio($\times10^{-6}$)	8.5±4.0±3.6	59.2±4.7±4.9	2.2±2.9±2.0	34.7±2.0±1.7
90% U ($\times10^{-6}$)	<15		<7	