Charmless Hadronic B Decays with CLEO II and II.V

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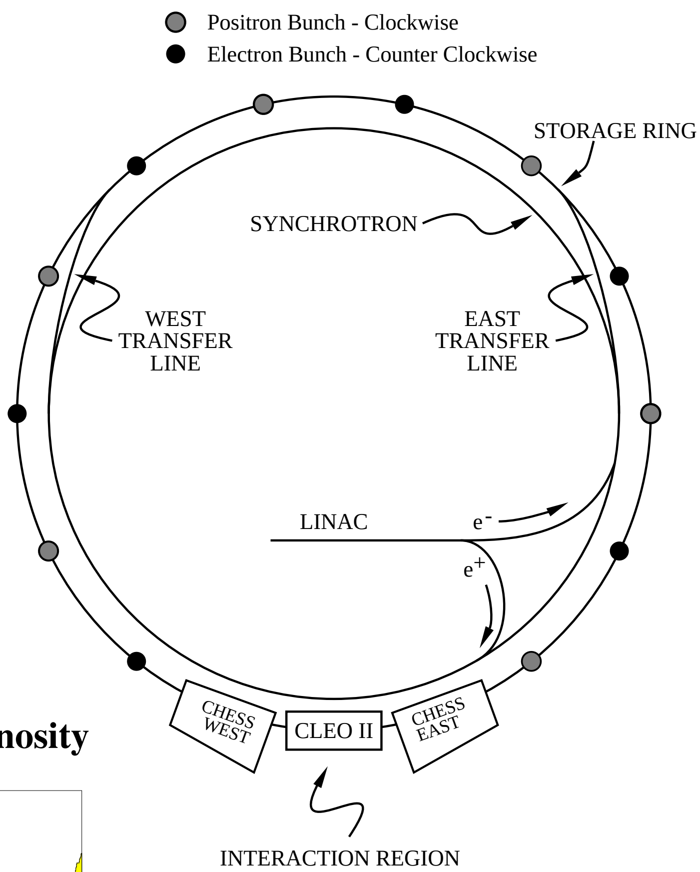
Charmless B Decays With CLEO

- An introduction to CLEO and CESR
- Physics goals in rare B decays:
  - penguins vs. trees vs. ??
  - constrain unitarity triangle
- Present signals in several channels:
  - $B \to K\pi, KK, \pi\pi$
  - $B \to (\rho/K^*) + (\pi/K)$
  - $B \to \eta' K, \eta(K^*/\rho)$
  - $B \to \omega(K/\pi)$
- Prospects for the future

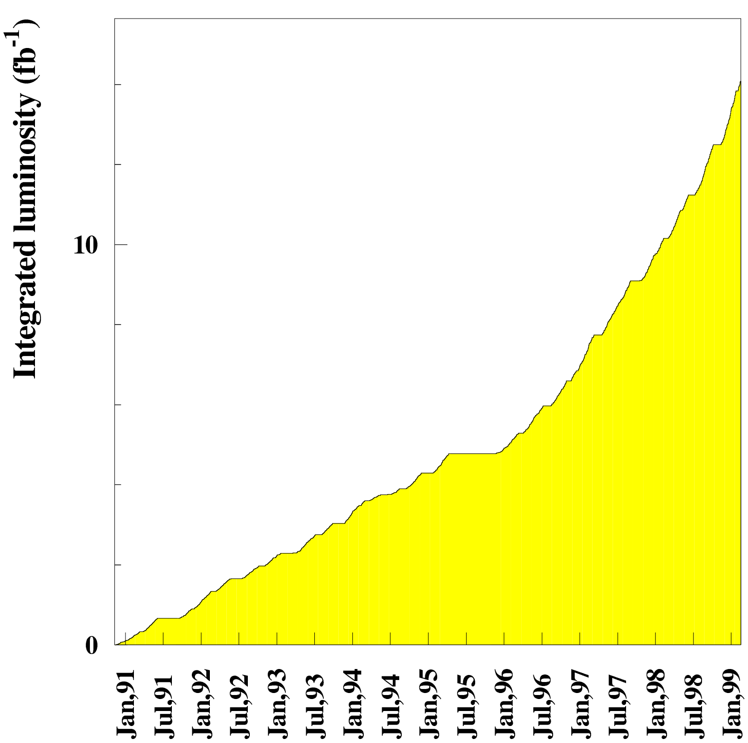
Cornell Electron Storage Ring (CESR) for CLEO II and II.V

Luminosity:

- Peak: $8.5 \times 10^{32} cm^2 s^-1$
- Daily: 40 pb^{-1}
- Monthly: 750 pb^{-1}
- Yearly: 4400 pb^{-1}
- Maximum current: 260 mA (9 trains by 4 bunches)

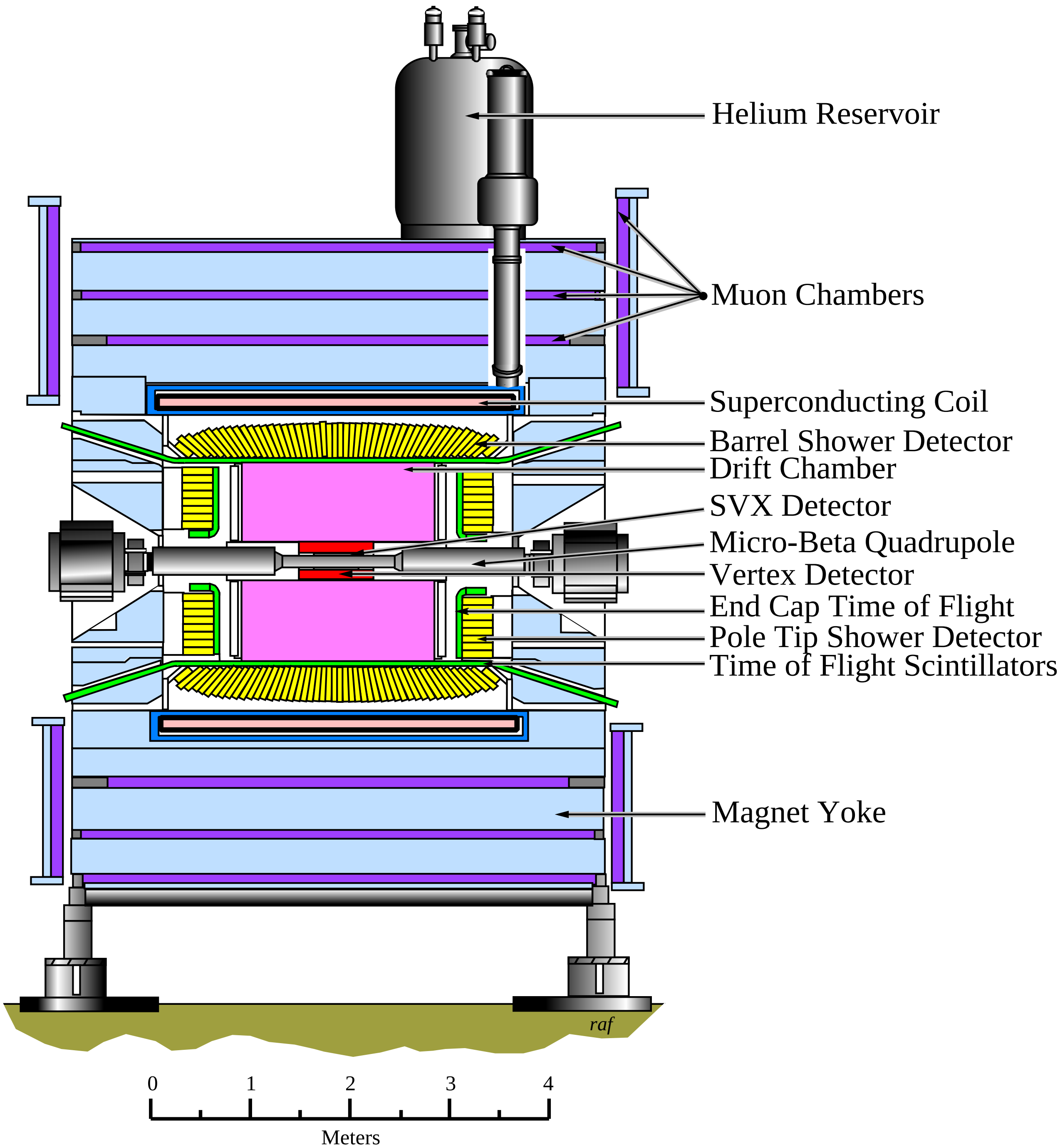


Total CLEO II + CLEO II.V Luminosity



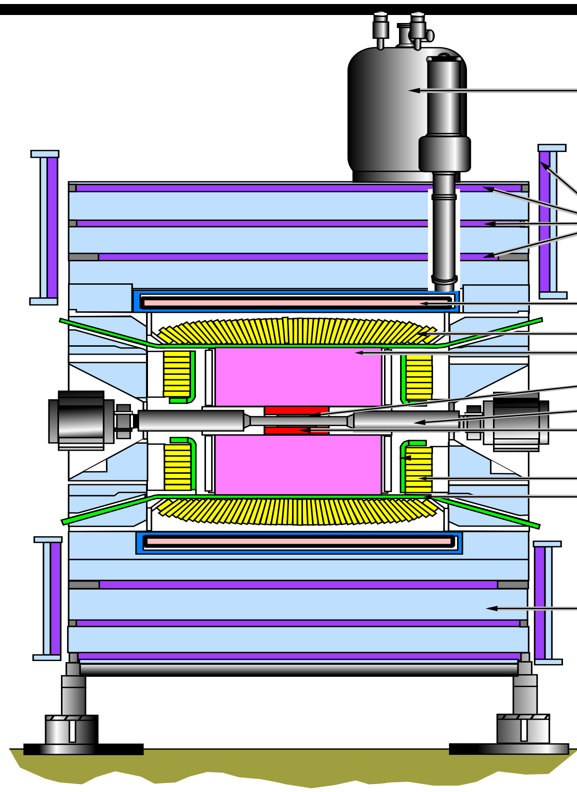
Luminosity	$\Upsilon 4S$	$e^+e^- \to q\bar{q}$
CLEO II	3.0	1.6
CLEO II.5	6.1	2.8
Total	9.1	4.4

CLEO


Helium Reservoir
Muon Chambers
Superconducting Coil
Barrel Shower Detector
Drift Chamber
SVX Detector
Micro-Beta Quadrupole
Vertex Detector
End Cap Time of Flight
Pole Tip Shower Detector
Time of Flight Scintillators
Magnet Yoke
raf
0
1
2
3
4
Meters

CLEO II

- 1989-1995
- $4.6\,\mathrm{fb}^{-1}$ total
- $3.0\,\mathrm{fb}^{-1}$ on $\Upsilon(4s)$
- 1.5T $\vec{B}$
- 67 tracking layers
- strawtube Precision Tracker (6 layers)
- CsI calorimeter

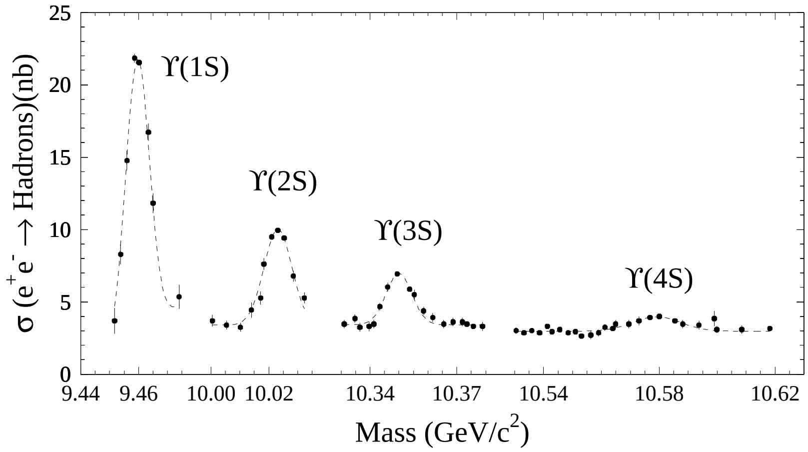


- $\sigma(m_{\pi_0}) \sim 10\,\mathrm{MeV/c^2}$ at 2.6 GeV
- Barrel (85% of 4π): $\frac{\sigma_E}{E}[\%] = \frac{0.35}{E^{\frac{3}{4}}} + 1.9 - 0.1E$, E in GeV
- Endcap (10% of 4π): $\frac{\sigma_E}{E}[\%] = \frac{0.26}{E} + 2.6$, E in GeV
- $\frac{\sigma_{p_T}}{p_T} = \sqrt{(0.0015p_T)^2 + (0.005)^2}$ $\delta P \approx 15MeV$ at 2.5 GeV
- dE/dx,ToF particle identification: $K\pi$ separation $\approx 1.7\sigma$ at 2.6 GeV

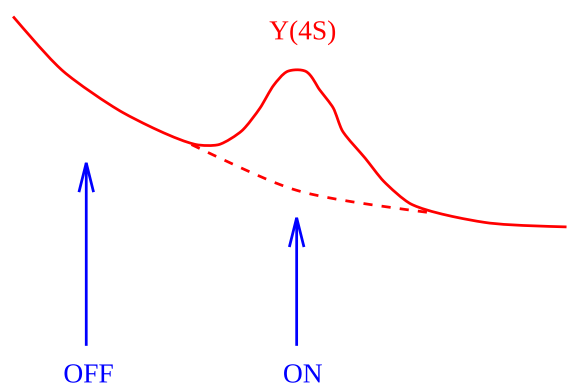
CLEO II.V

- 1995-1999
- $9.1\,\mathrm{fb}^{-1}$ total ($6.1\,\mathrm{fb}^{-1}$ on $\Upsilon(4s)$)
- 3-layer double-sided silicon vertex detector replaces the PT
- He/Propane replaces Ar/Ethane in trackers
- vertex resolution is 2-4 times better in $r\phi$, 8 times better in Z.

B Meson Production at the $\Upsilon(4s)$ (10.58 GeV)



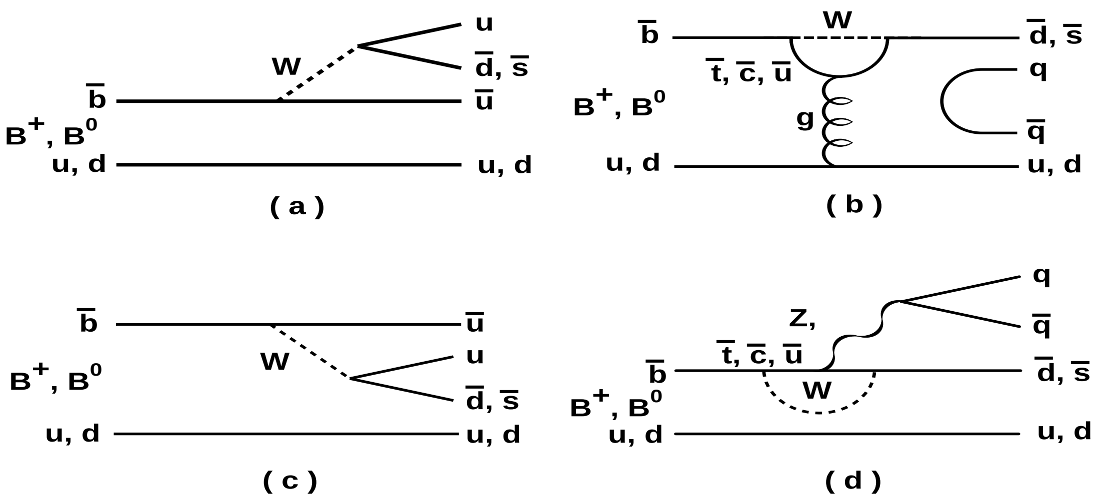
- A total of 13.5 fb^{-1} of luminosity available with CLEO II
- For Continuum processes, $\sigma(e^+e^- \to q\bar{q},\, q = u, d, s, c) \sim 3.3\,\mathrm{nb}$.
  3 times greater than $B\overline{B}$ production.
- $\sigma(\Upsilon(4\mathrm{S}) \to \mathrm{B\bar{B}}) = 1.07$ nb
- $\sim 1/3$ of data is taken about 55 MeV below the $\Upsilon(4s)$ to allow study of the continuum.
- 9.7 million $B\bar{B}$ pairs



- The collider environment also allows useful constraints:
  - $E(B) = E_{beam}$ (B mesons have the energy of the $e^{\pm}$ beams).
  - $M_{beam}(B) = \sqrt{E^2_{beam} - \mathbf{p_B^2}}$ = "Beam-constrained mass"
- $\sigma(M_{beam}(B)) = (2.5 \sim 4)\,\mathrm{MeV/c^2}$, $\sigma(\Delta E) = (20 - 80)\,\mathrm{MeV}$

Charmless Hadronic B Decays

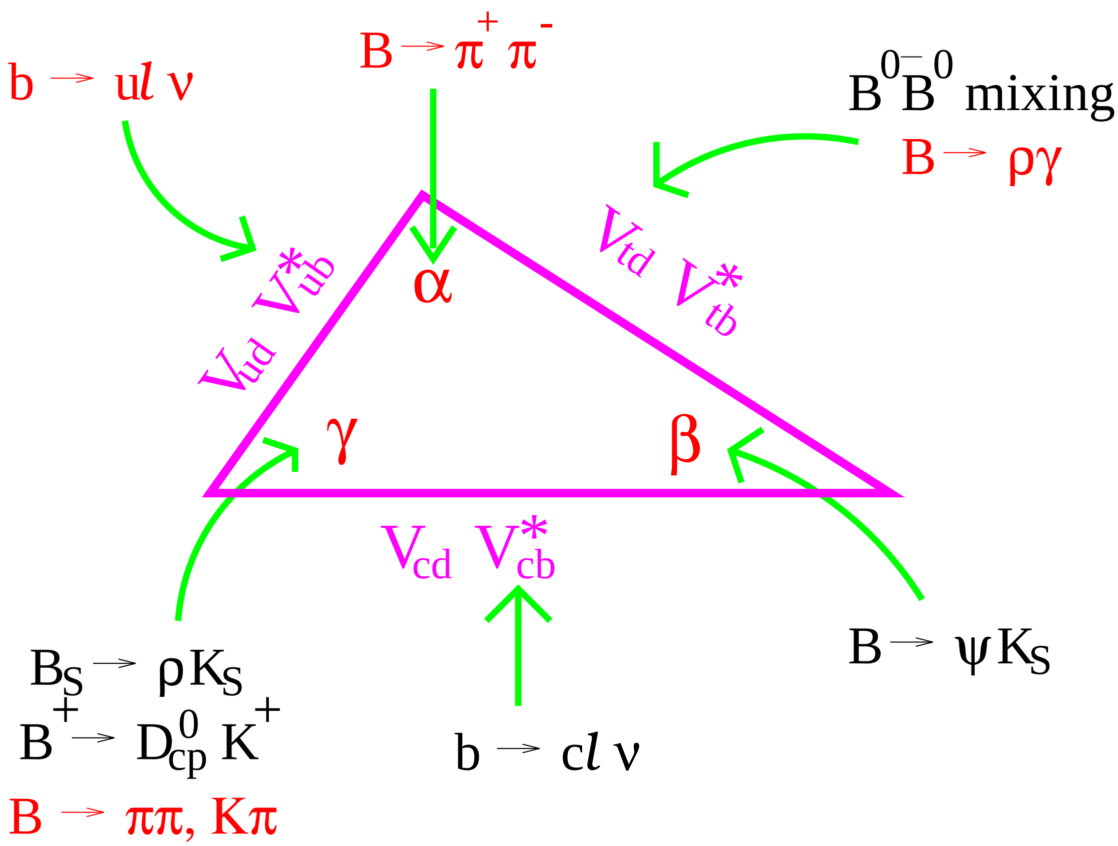
- A major goal of B physics is to determine the CKM matrix elements; the weak couplings of the quarks and their phases.



- Interference between different rare processes is important in charmless B-decays.
- Understanding the competing processes will be essential in translating future measurement into constraints on the unitarity triangle and CKM matrix.
- Penguin pollution obscures measurements of α at B factories but encourages searches for direct CP violation .

Charmless Hadronic B Decays

- By studying rates and CP asymmetries in related channels one will be able to measure α, β, γ



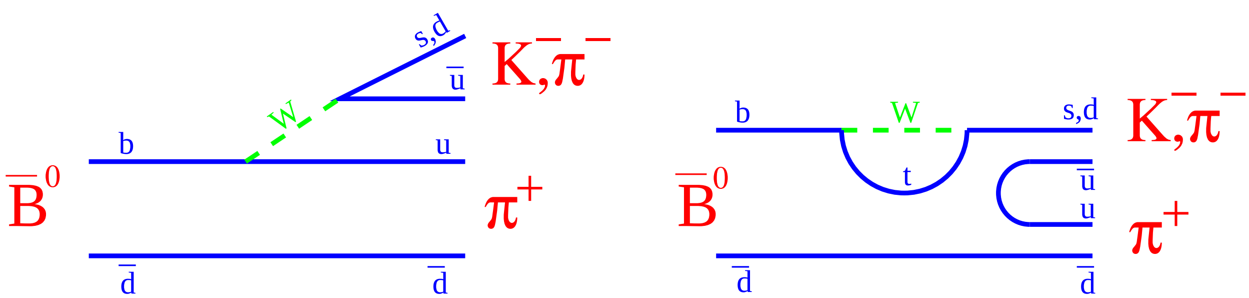
- Penguins are the only contribution to $b \to s\gamma$.
  CLEO discovered the first evidence for their existence.

- The relative contribution of Penguins is greatest in B decays: $|V_{tb}V^*_{ts}/V_{cb}|^2 \sim 1$, in K decays $|V_{ts}V^*_{td}/V_{us}|^2 \sim 10^{-6}$.

- Things get rarer with B physics.

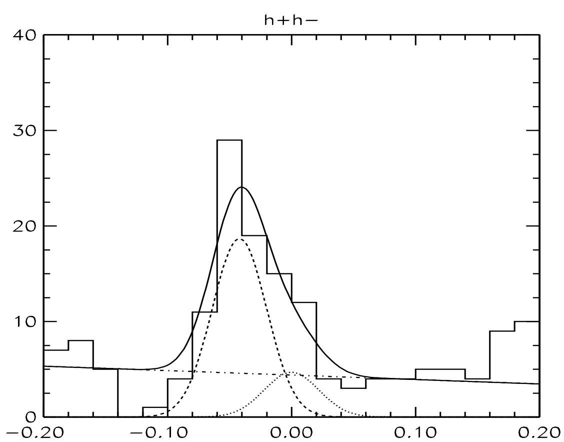
Charmless Hadronic B Decays

- Cabibbo-allowed tree, $b \to u(\bar{u}d)$, + Cabibbo-suppressed penguin, $b \to d(\bar{u}u)$: $B \to X_{u,d} X'_{u,d}$, $X = \pi, \rho, \eta, \omega$
- Cabibbo-suppressed tree $b \to u(\bar{u}d)$ + Cabibbo-allowed penguin $b \to s(\bar{u}u, \bar{d}d)$: $B \to X_{u,d} Y_s$, $X = \pi, \eta, \rho, \omega$, $Y = K^{(*)}$

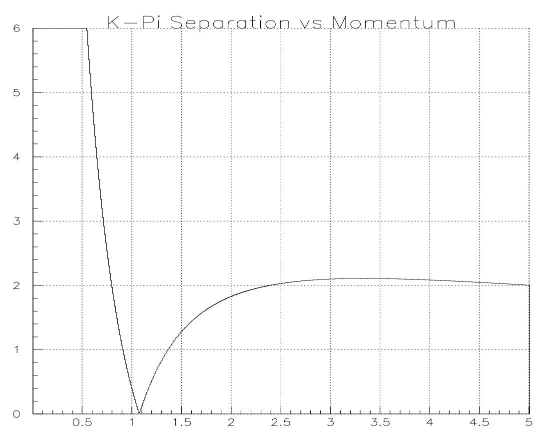


- K/π separation is critical.

	$\sigma_{\Delta E}$	ΔE	dE/dX
CLEO II	25 MeV	1.7σ	1.7σ
CLEO II.5	20 MeV	2.1σ	2.0σ

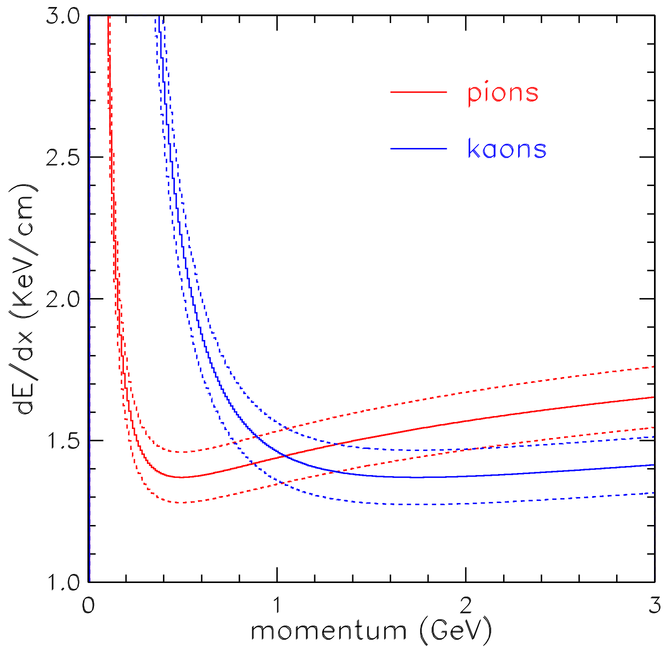


$\Delta \mathbf{E}_{\mathbf{K}\pi}$ separation

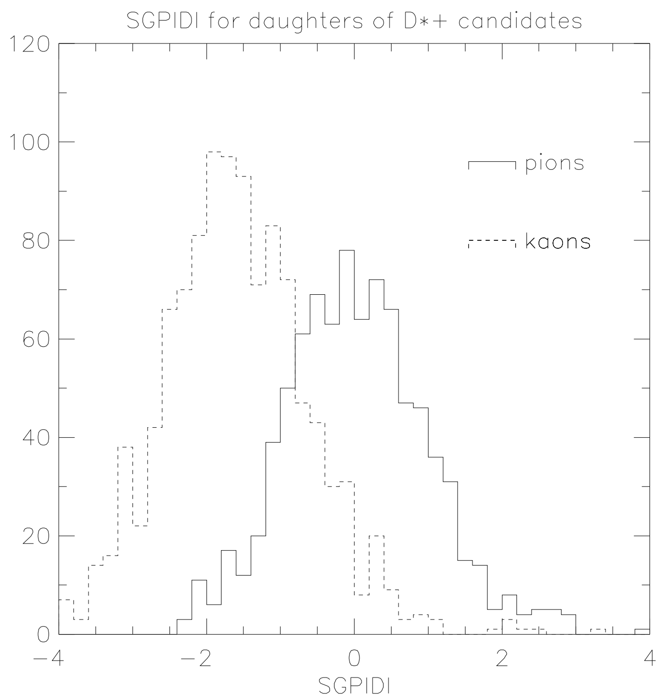


dE/dx Kπ separation vs. p

dE/dX



3.0
2.5
2.0
1.5
1.0
0
1
2
3
dE/dx (KeV/cm)
momentum (GeV)
pions
kaons

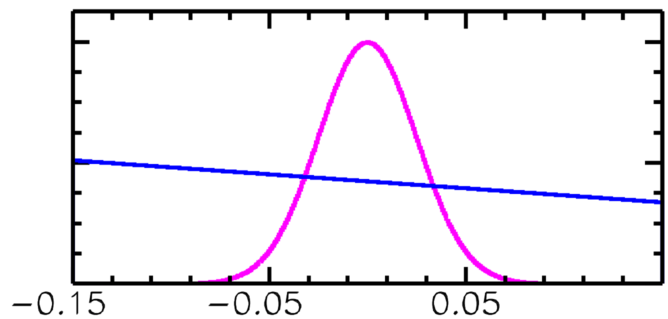


SGPIDI for daughters of D*+ candidates
120
100
80
60
40
20
0
−4
−2
0
2
4
SGPIDI
pions
kaons

B Meson Reconstruction

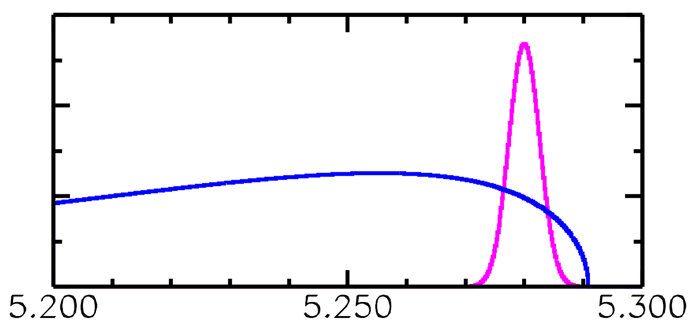
$$e^+e^- \to \Upsilon(4S) \to B\overline{B}$$

- Reconstructed B meson energy must be the same as the beam energy:
  - $\Delta E = E_B - E_{beam} = 0.0$
  - $\sigma(\Delta E) = 20 - 30$ MeV



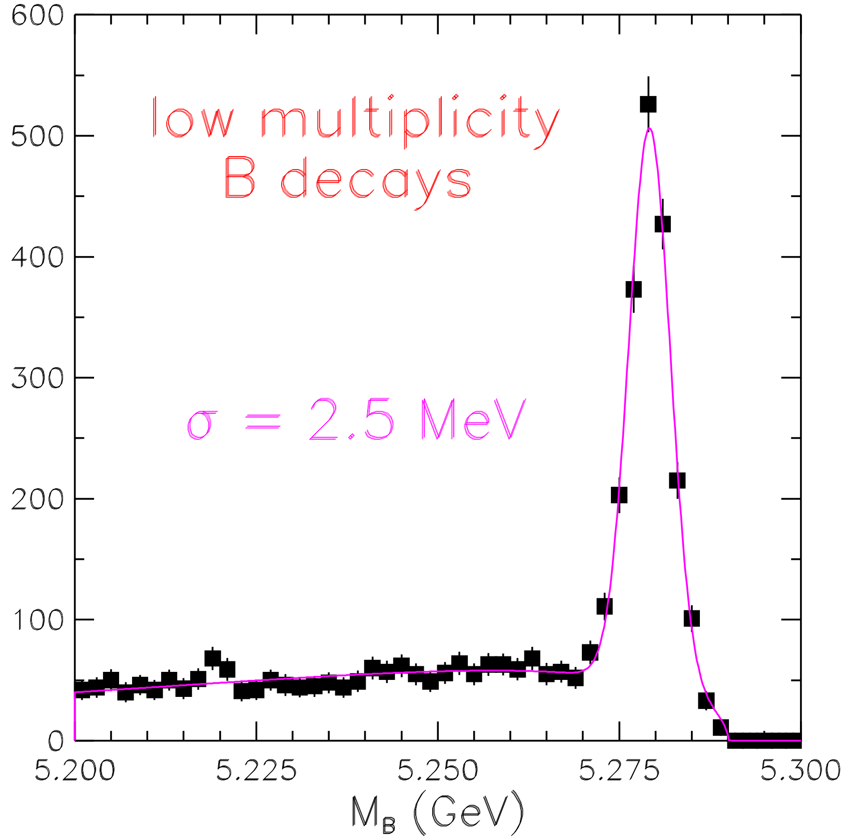
ΔE in GeV.

- Beam-constrained mass: use beam energy and momentum sum of B decay products to reconstruct mass.
  - $M_B = \sqrt{E_{beam}^2 - |\sum_i^n \vec{P}_i|^2}$
  - $\sigma(M_B) = 2.7$ MeV



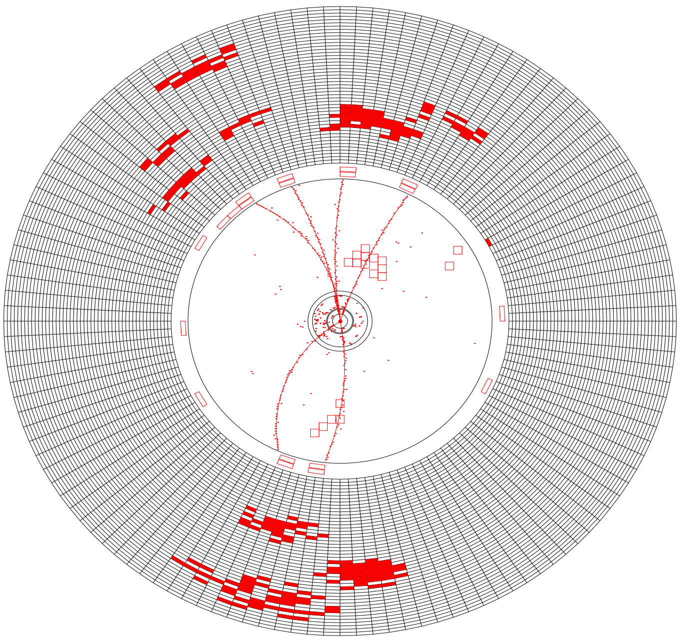
M_B in GeV.

B Meson Reconstruction, cont'd.



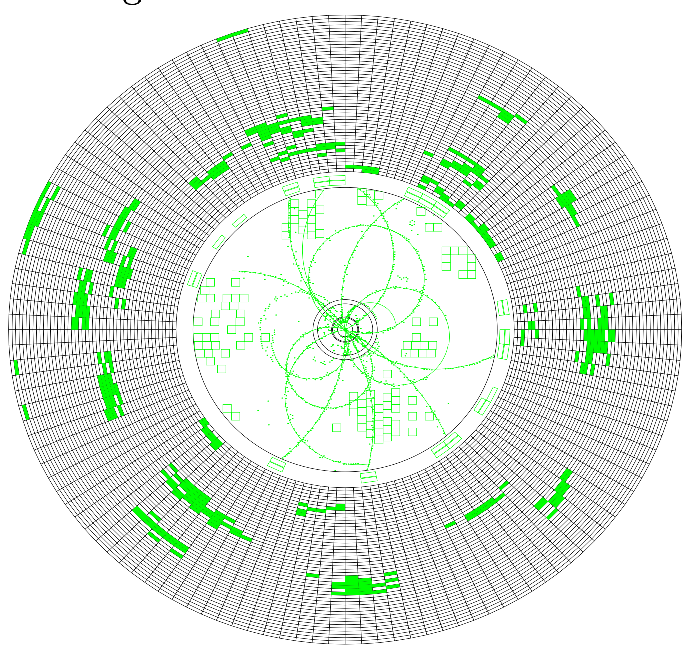
$B \to \pi\pi, \pi K, KK$

- CLEO has searched for $B \to \pi\pi, \pi K, KK$ in all eight charge states.
- $b \to cX$ $B\bar{B}$ decays do not produce as energetic daughter particles.



A Continuum ($q\overline{q}$) Event

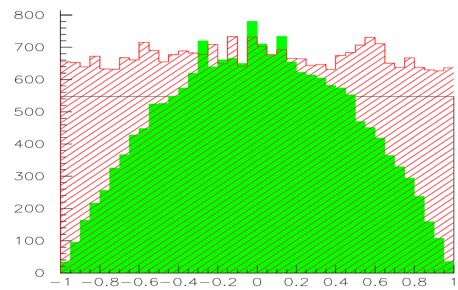
- The main background is continuum : $e^+e^- \to q\bar{q},\ q = u, d, s, c$.
- The jetlike nature of continuum events is very useful in suppressing their background contribution.
- $B\bar{B}$ events are much more isotropic.



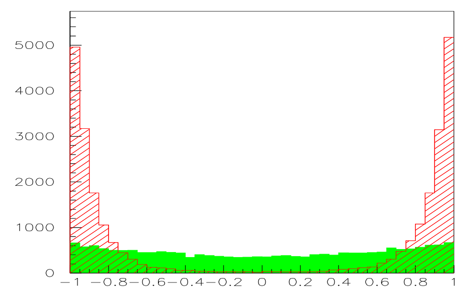
A $B\overline{B}$ Event

Observables For Continuum Suppression

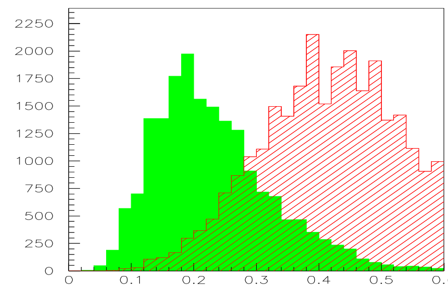
- $\cos\theta_B$: angle between the B and the beam axis ($\propto \sin^2\theta_B$ for B-decays, flat for continuum backgrounds)



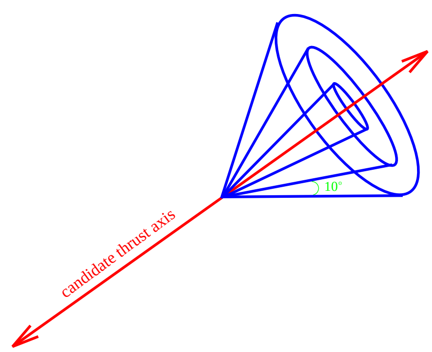
- $\cos\theta_{sphericity}$: angle between the B candidate sphericity axis and the sphericity axis of the rest of the event (continuum peaks near ±1, signal candidates produce flat distributions)



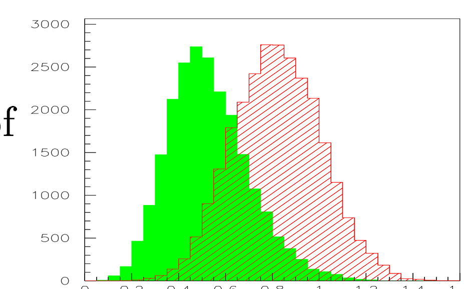
- 2nd Fox-Wolfram Moment R_2 (peaks at 1 for continuum, 0 for $B\overline{B}$)



- Sums of charged and neutral momenta in 9 10^o double cones about the candidate thrust axis (virtual calorimeter).



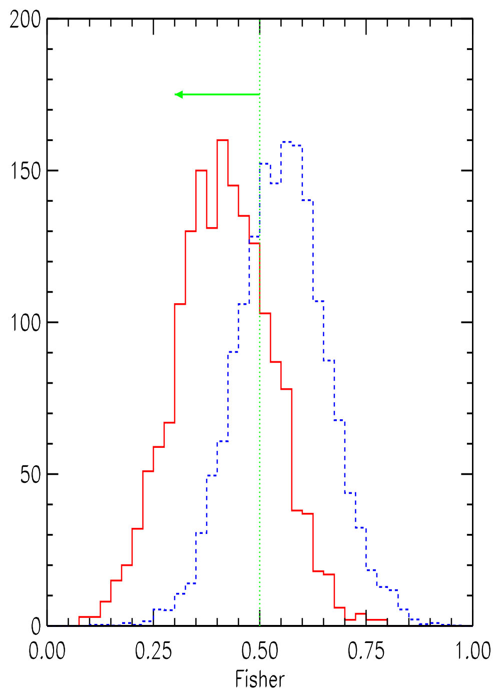
- Fisher Discriminant (optimum combination of the above variables except $\cos\theta_B$)



Fisher Discriminant

A Fisher Discriminant is a linear combination of measurements with coefficients optimized such that it emphasizes the *differences* between two phenomena.

CLEO uses the 9 virtual calorimeter momentum sums, the B thrust-axis direction ($\propto (\vec{p}_1 - \vec{p}_2)$ in a two body decay),and the B direction ($\propto (\vec{p}_1 + \vec{p}_2)$).

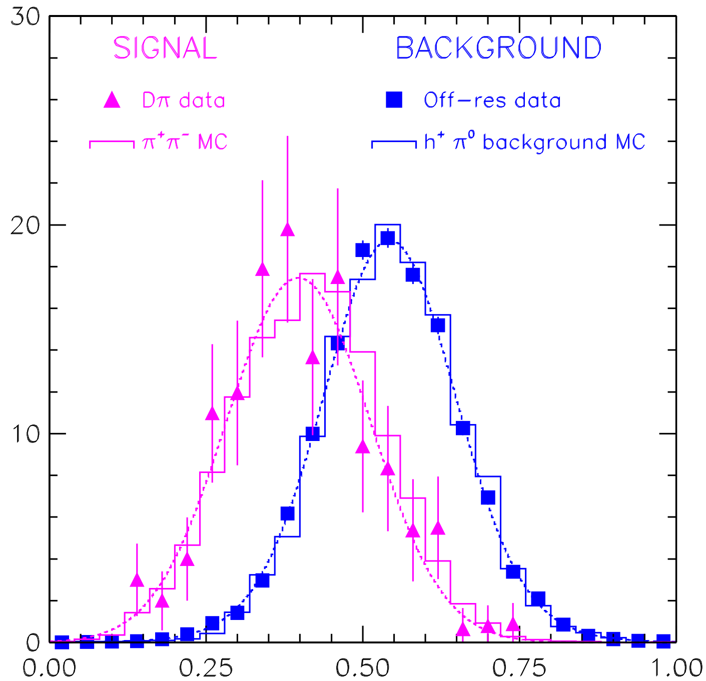


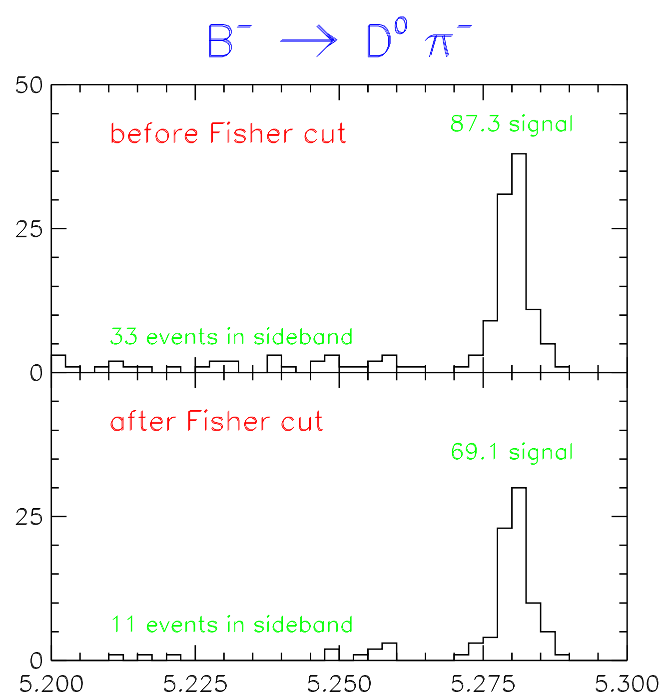
$$\mathcal{F} = \sum_{i=1}^{N} \alpha_i x_i$$

$$\alpha_j = \sum_{i=1}^{N} (\sigma_{ij}^{s} + \sigma_{ij}^{bkg})^{-1} \times (\mu^{bkg} - \mu_i^{s})$$

The Fisher discriminant is almost independent of the decay mode under study since it is determined by the behaviour of the rest of the event, whether miscellaneous B decay, or continuum. It assumes that the observables involved are Gaussianly distributed.

Fisher Discriminant





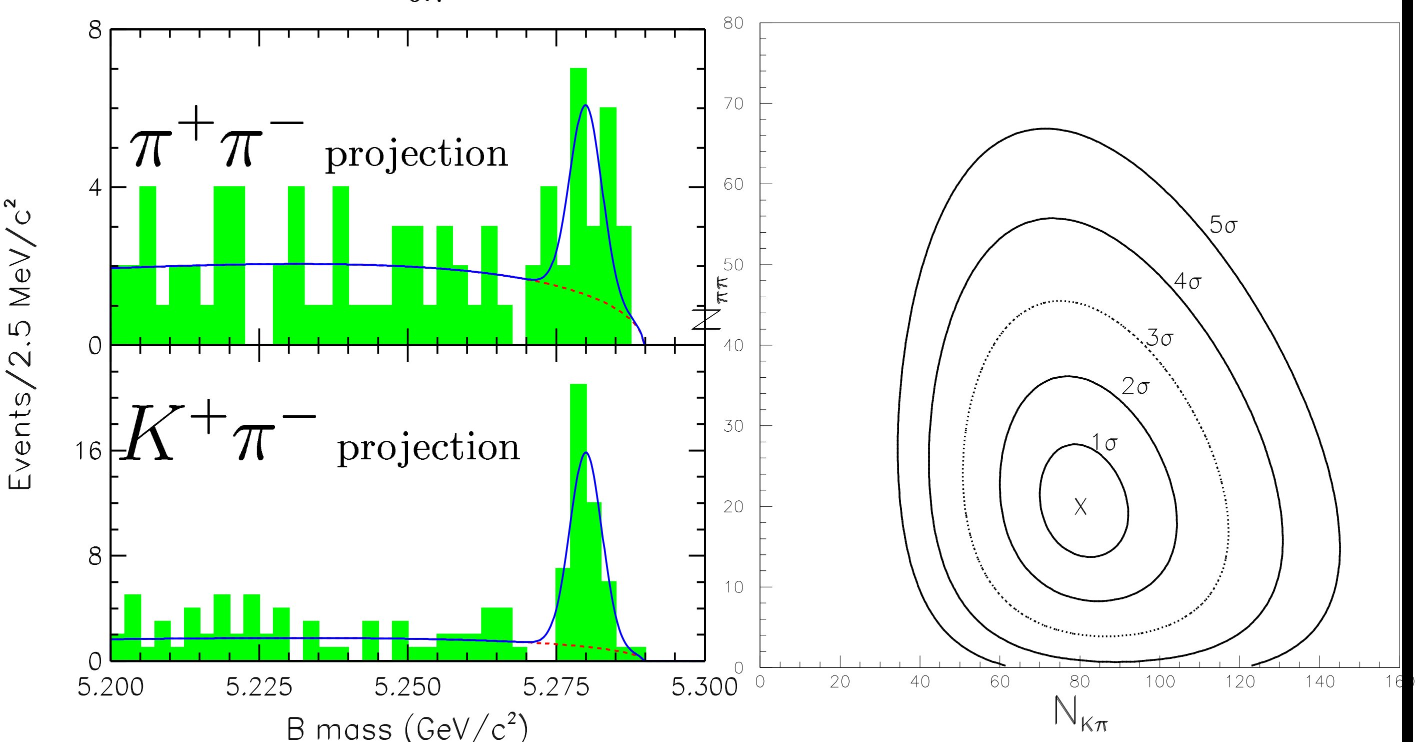
$B \to \pi\pi, \pi K, KK$ Analysis

Unbinned maximum-likelihood fit (more efficient than counting):

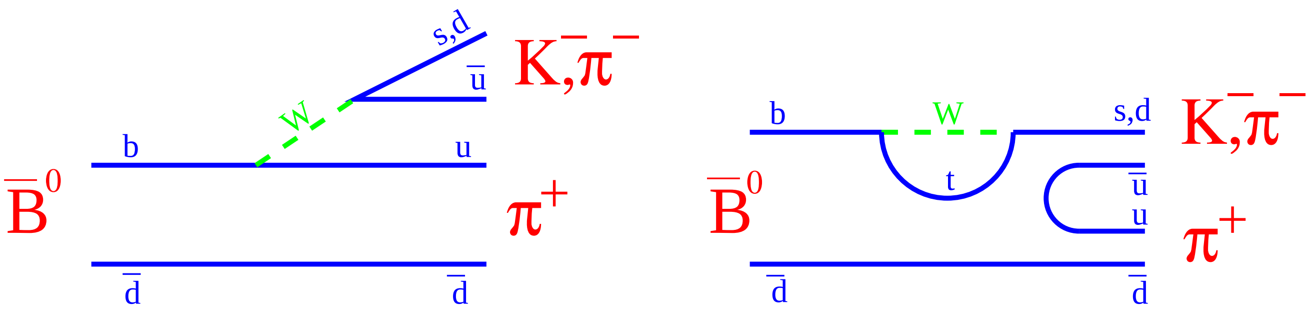
- uses probability distributions for continuum and signal for $M_{beam}(B)$, $\Delta E_{\pi\pi}$, dE_1/dX, dE_2/dX, $\mathcal{F}$, $\cos\theta_B$
- Fits for total rates for $B \to h^+h^-$, $h^+\pi^0$, $h^+K_s^0$, $K_s\pi^0$.
- Fits for π/K relative contribution in each channel.

From the combined fit for $B \to (\pi^+\pi^-) + (\pi^\pm K^\mp) + (K^+K^-)$:

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6	Significance
$\pi^+\pi^-$	$20.0^{+7.6}_{-6.5}$	48%	$4.3^{+1.6}_{-1.4} \pm 0.5$	4.2σ
$\pi^\pm K^\mp$	$80.2^{+11.8}_{-11.0}$	48%	$17.2^{+2.5}_{-2.4} \pm 1.2$	11.7σ
K^+K^-	$0.7^{+3.4}_{-0.7}$	48%	< 1.9	0.0σ



$B^0 \to \pi^+\pi^-, K^+\pi^-$



- Spectator W-emission

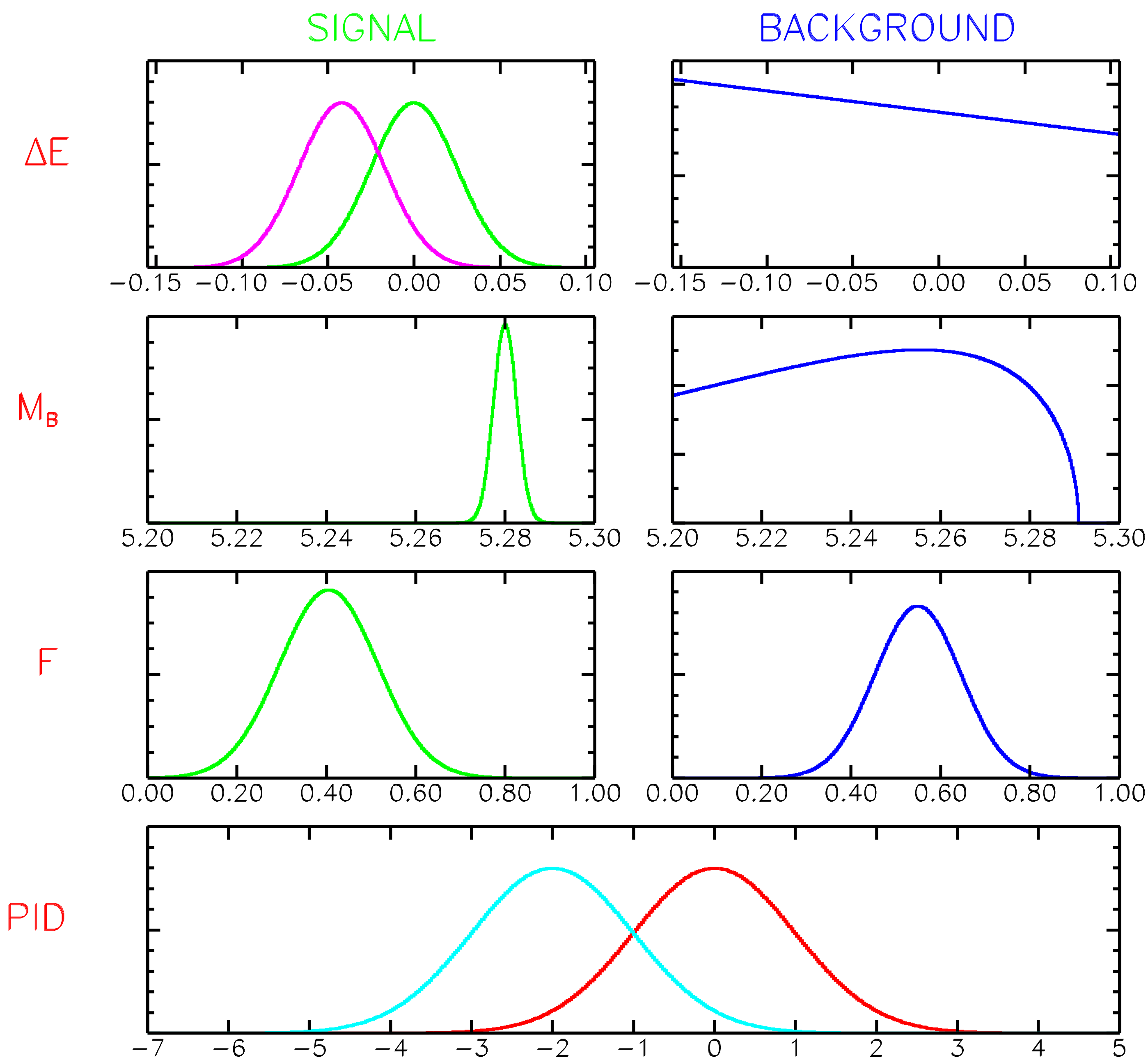
$$\pi^+\pi^- \quad \propto \quad V_{ub}$$
$$K^+\pi^- \quad \propto \quad V_{ub} \sin\theta_C$$

- Penguin

$$\pi^+\pi^- \quad \propto \quad V_{td}$$
$$K^+\pi^- \quad \propto \quad V_{ts}$$

- $\pi\pi$ Spectator $\sim$ $\pi\pi$ Penguin.
- $K\pi$ Penguin $\sim 10 \times \pi\pi$ Penguin.
- **K**π: Cabbibbo-allowed penguin dominant over Cabibbo-suppressed tree.
- $\pi\pi$: Cabbibbo-allowed tree dominant over Cabibbo-suppressed penguin.
- **KK**: Cabbibbo-suppressed penguin

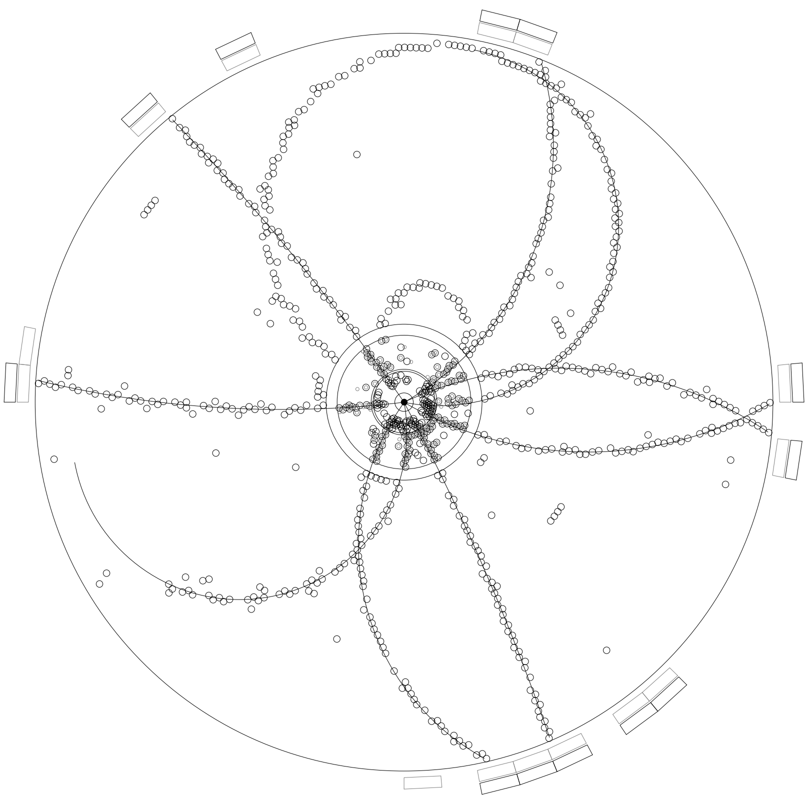
Maximum Likelihood Fit



CleoXD

Run: 42644 Event: 1000

$B^0 \to K^+\pi^-$



Gold-plated $K^+\pi^-$ Event

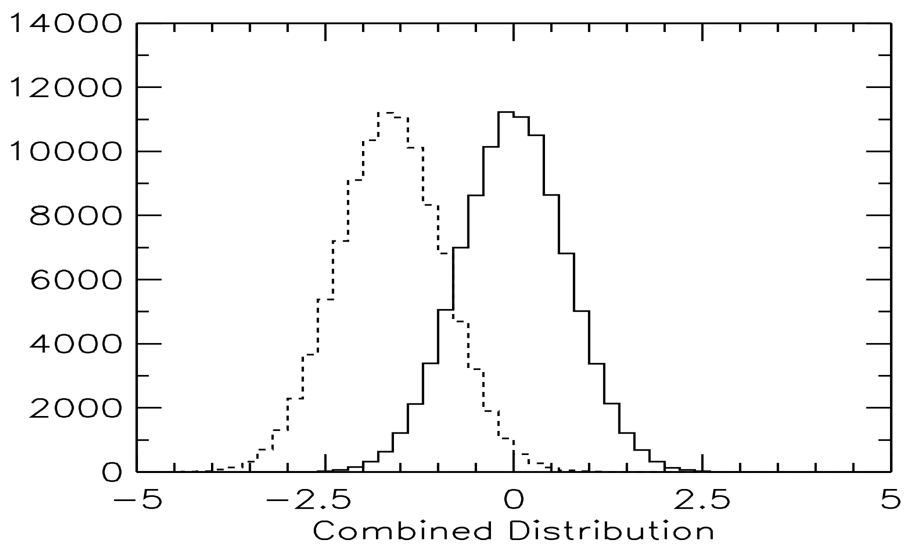
$B^0 \to \pi^+\pi^-, K^+\pi^-$

CLEO has already published a measurement of $B^0 \to h^-\pi^+$ (PRD53(1996)1039):

$$\mathcal{B}(B^0 \to \pi^+\pi^- + K^+\pi^-) = (1.8^{+0.6}_{-0.5}{}^{+0.2}_{-0.3} \pm 0.2) \times 10^{-5}$$

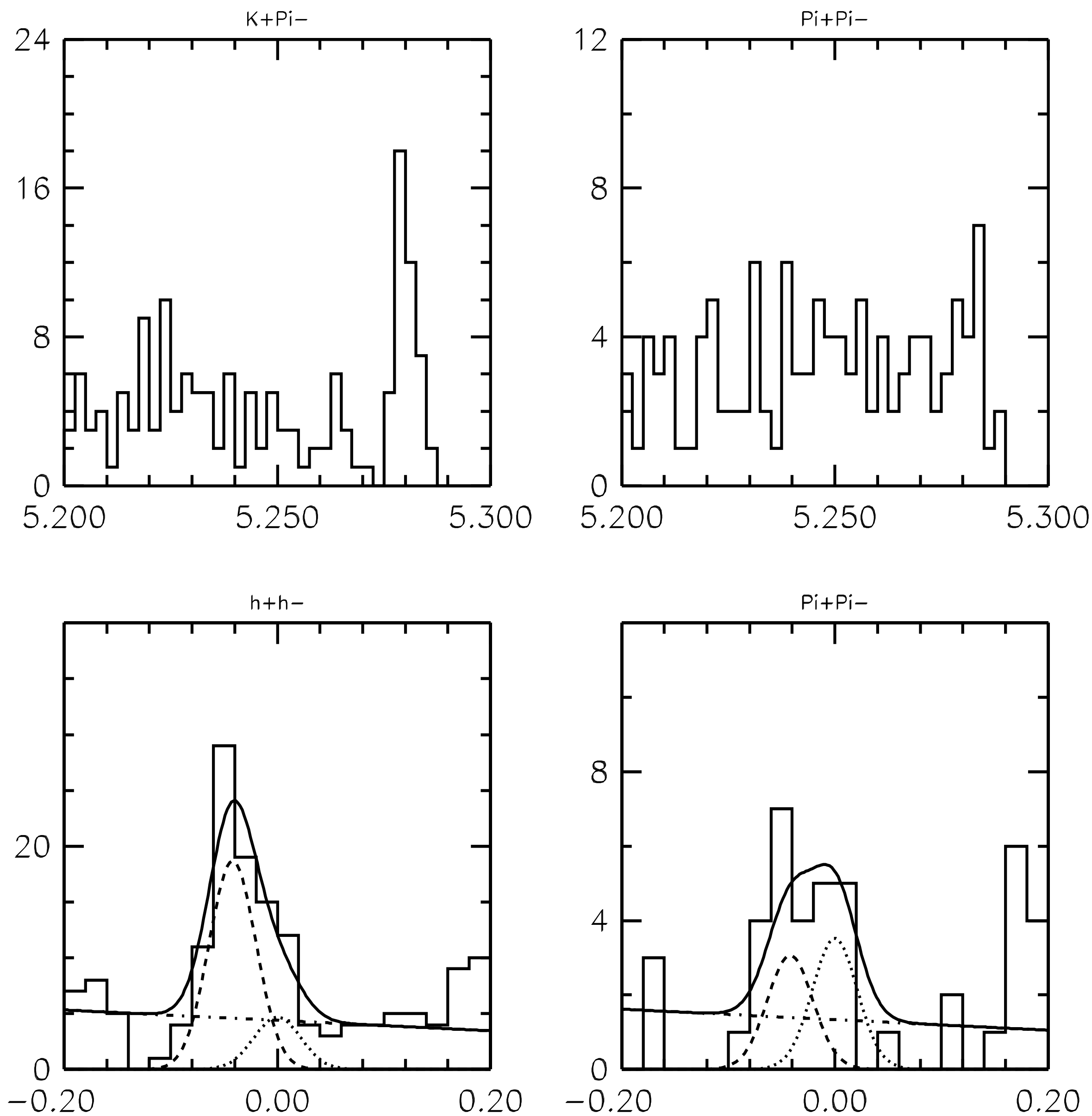
Several improvements:

- 5× more data
- Higher efficiency $44 \pm 3\%$
- Adjusted event shape variables
- loosen $|\cos\theta_{thrust}| < 0.8$
- Separate $K\pi$ and $\pi\pi$ contributions with a maximum likelihood fit (using M_B, ΔE , $\mathcal{F}$, dE/dx_+, dE/dx_-, $\cos\theta_B$).



CLEO II: 2.2 σ between K π and $\pi\pi$, 1.7σ from dE/dX, CLEO II.V 20% better.

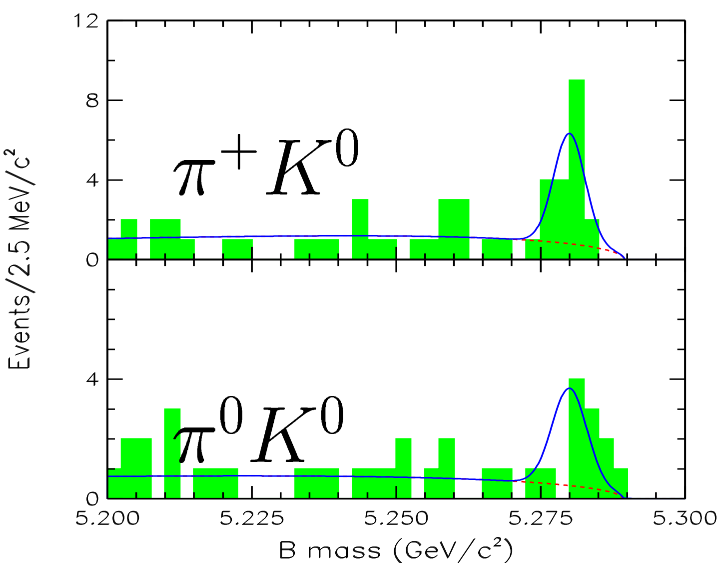
$B \to \pi^+\pi^-, \pi^\pm K^\mp$

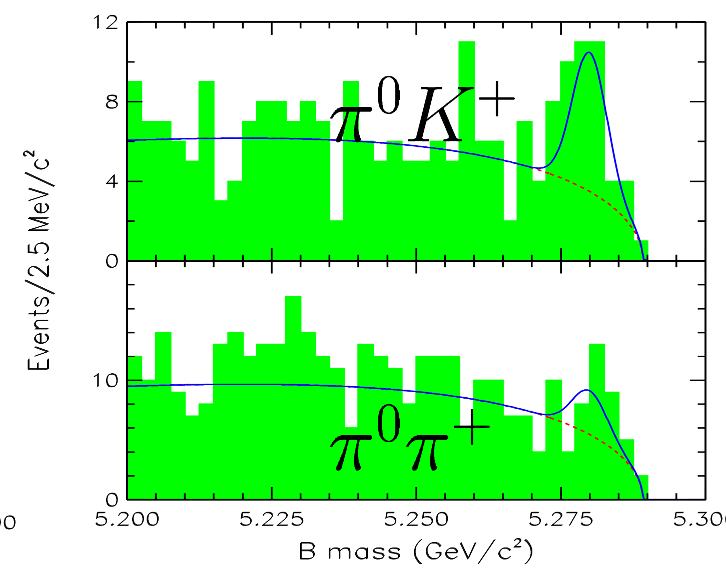


$B \to \pi\pi, \pi K, KK$: π^0/K^0 channels

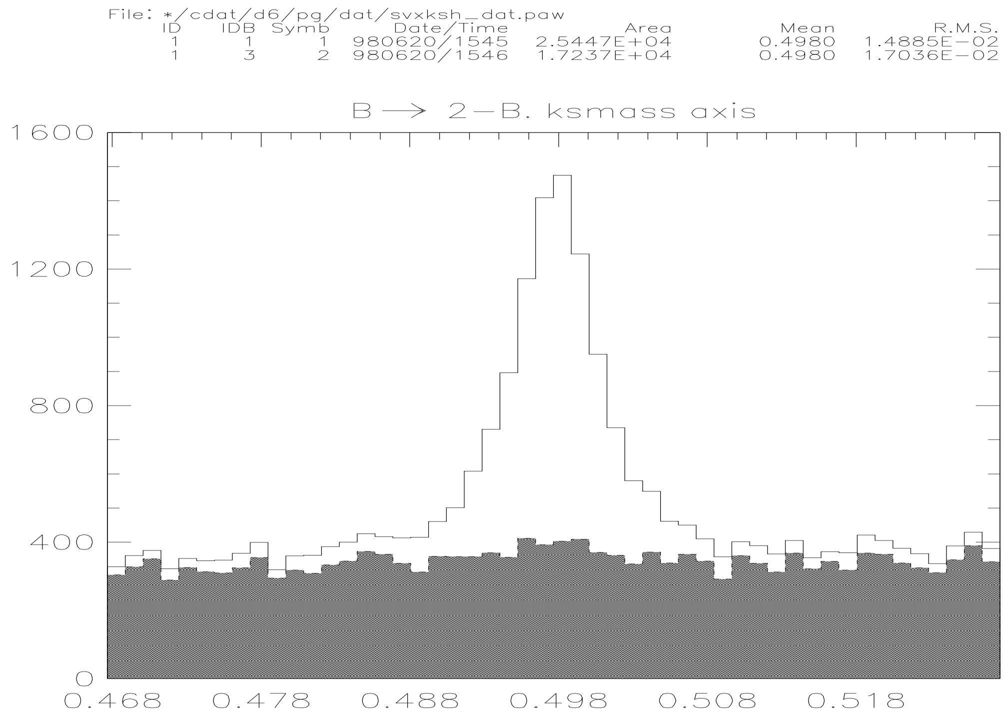
- Simultaneous fits for $(\pi^0 K^\pm) + (\pi^0\pi^\pm)$, and $(K^0\pi^\pm) + (K^0 K^\pm)$.
- CLEO observes $B^+ \to \pi^0 K^+, K^0\pi^+$ and $B^0 \to \pi^0 K^0$.
- $\pi^0\pi^0/K^0\bar{K}^0$ ULs based on $\sim 1/3$ of current data: PRL80(1998)3456.

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6	Significance
$\pi^0\pi^0$	$2.7^{+2.7}_{-1.7}$	29%	< 9.3	2.4σ
$\pi^0\pi^+$	$21.3^{+9.7}_{-8.5}$	39%	< 12.7	3.2σ
$\pi^0 K^\pm$	$42.1^{+10.9}_{-9.9}$	38%	$11.6^{+3.0}_{-2.7}{}^{+1.4}_{-1.3}$	6.1σ
$K^0\pi^0$	$16.1^{+5.9}_{-5.0}$	11%	$14.6^{+5.9}_{-5.1}{}^{+2.4}_{-3.3}$	4.9σ
$K^0\pi^\pm$	$25.2^{+6.4}_{-5.6}$	14%	$18.2^{+4.6}_{-4.0} \pm 1.6$	7.6σ
$K^0 K^\pm$	$1.4^{+2.4}_{-3.3}$	14%	< 5.1	1.1σ
$K^0\bar{K}^0$	0	5%	$< 17.$	0σ

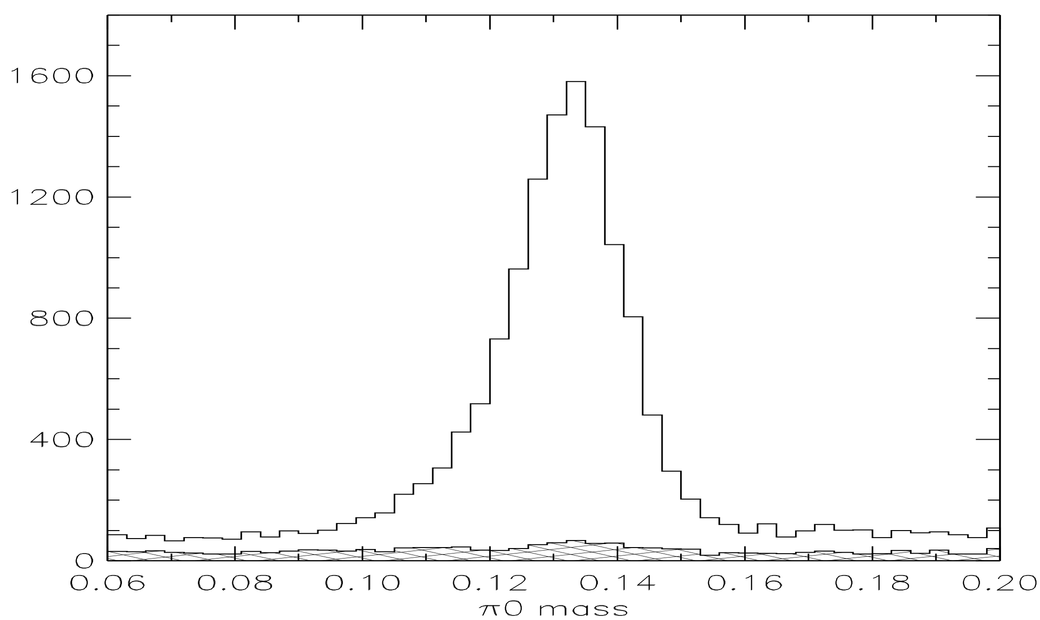




$B \to \pi\pi, \pi K, KK$: π^0/K^0 channels

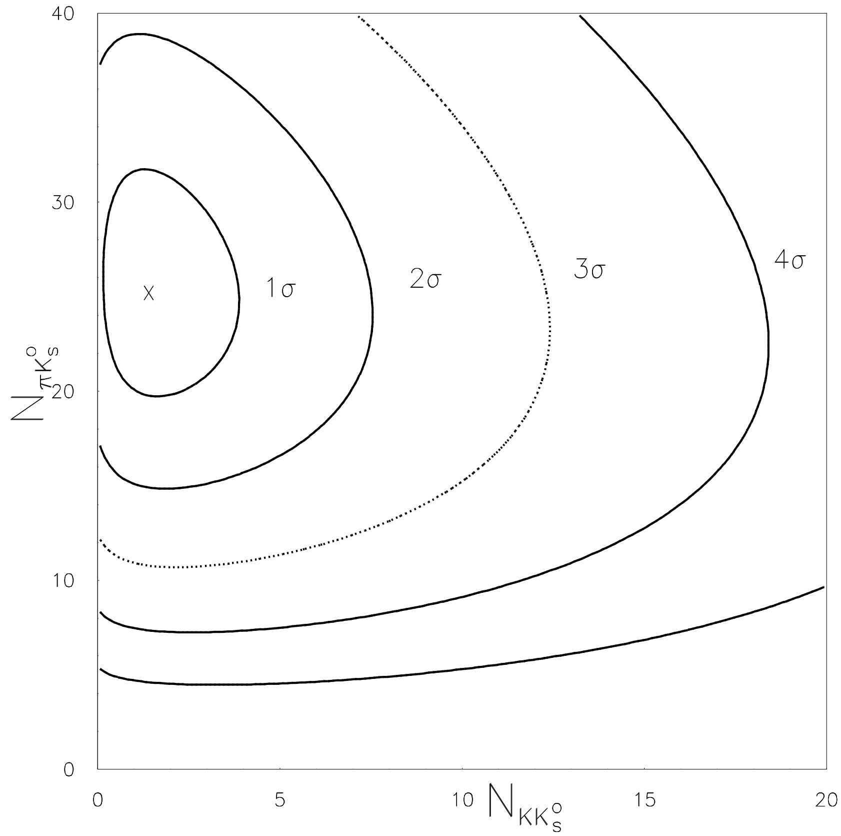


$m(K_s^0)$

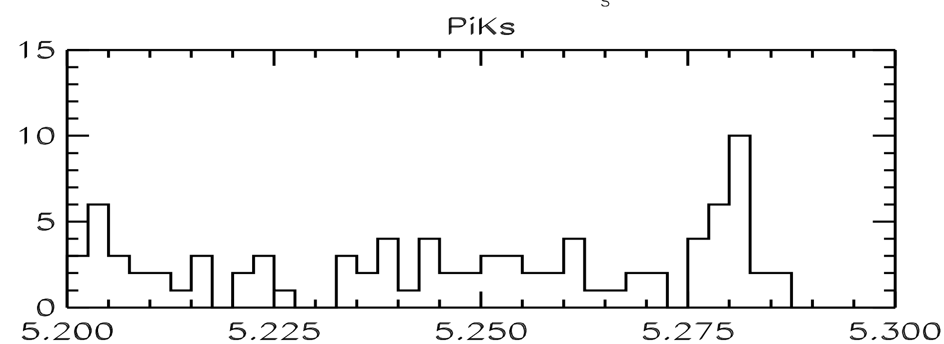


$m(\pi^0)$

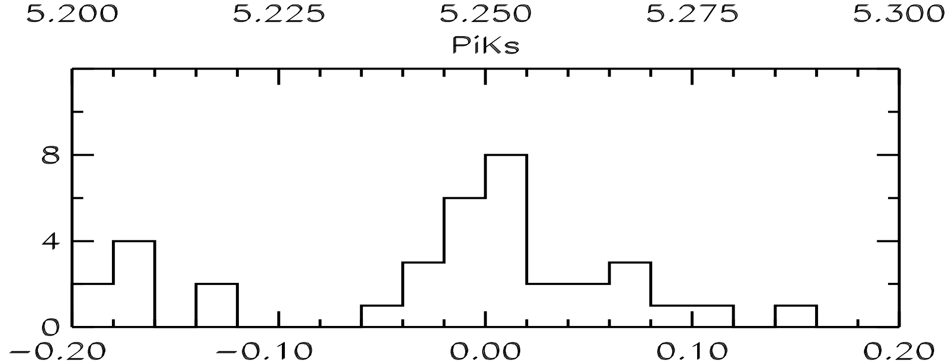
$B \to K^0(\pi^+, K^+)$



$M_{beam}(B)$



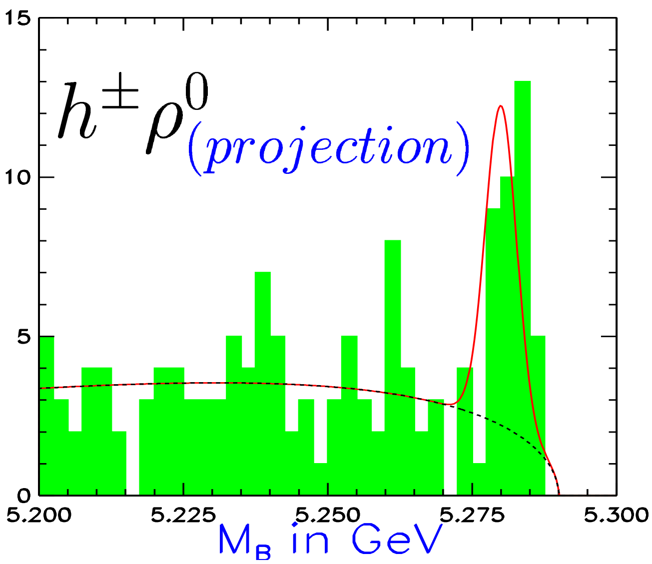
ΔE

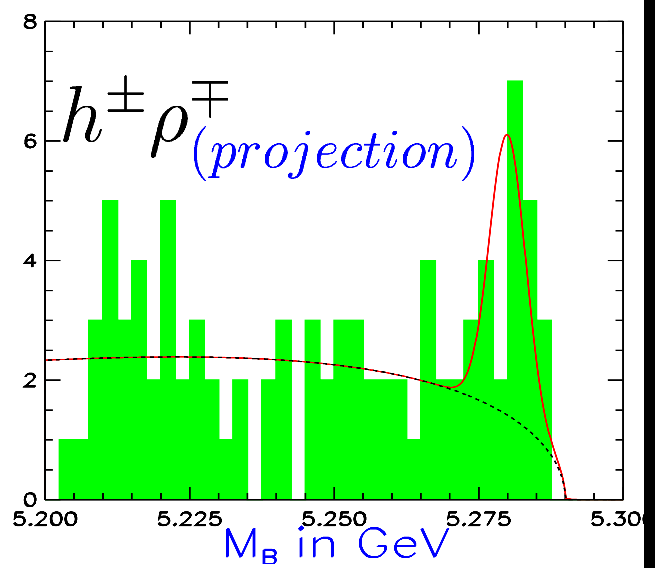


$B \to PV$: $(\pi^+, K^+) + (\rho^0, \rho^-, K^{*0})$

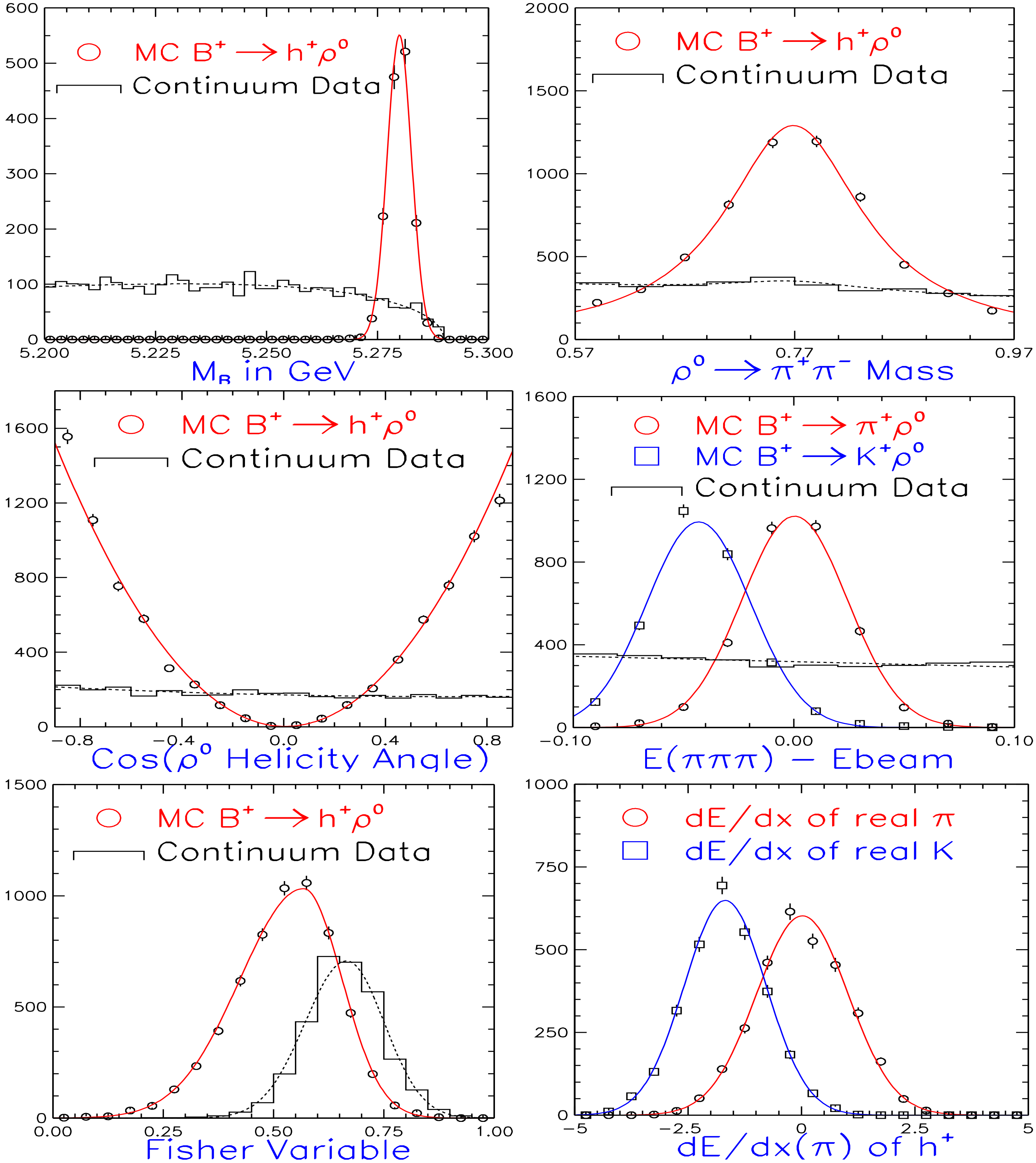
- First observation of hadronic $b \to u$: $B^+ \to \pi^+\rho^0$, $B^0 \to (\pi^\pm\rho^\mp)$
- Fit $(\pi^+\rho^0)/(K^+\rho^0)$, $(K^+K^{*0})/(\pi^+K^{*0})$, $(\pi^+\rho^-)/(K^+\rho^-)$
- More $B\bar{B}$ backgrounds (e.g $B^- \to D^0(K^-\pi^+)\pi^-$) but easily vetoable
- cross-feed from swapping "slow" π^+ and π^0
- helicity dependence of $P \to PV$ and $m(\rho^0)$, $m(K^{*0})$ in likelihood
- strong helicity cut in $\rho^\pm\pi^\mp$ to veto slow π^0s

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6	Significance
$\pi^\pm\rho^0$	$29.8^{+9.3}_{-9.6}$	30%	$10.4^{+3.3}_{-3.4} \pm 2.1$	5.4σ
$K^\pm\rho^0$	$22.4^{+10.7}_{-9.1}$	28%	< 17.3	3.7σ
$\pi^\pm K^{*0}$	$13.4^{+6.2}_{-5.3}$	18%	< 15.9	3.6σ
$K^\pm K^{*0}$	$0.0^{+2.2}_{-0.0}$	17%	< 5.3	0.0σ
$\pi^\pm\rho^\mp$	$31.0^{+9.4}_{-8.3}$	12%	$27.6^{+9.4}_{-8.3} \pm 4.2$	5.6σ
$K^\pm\rho^\mp$	$16.4^{+7.8}_{-6.6}$	11%	< 32.3	3.5σ

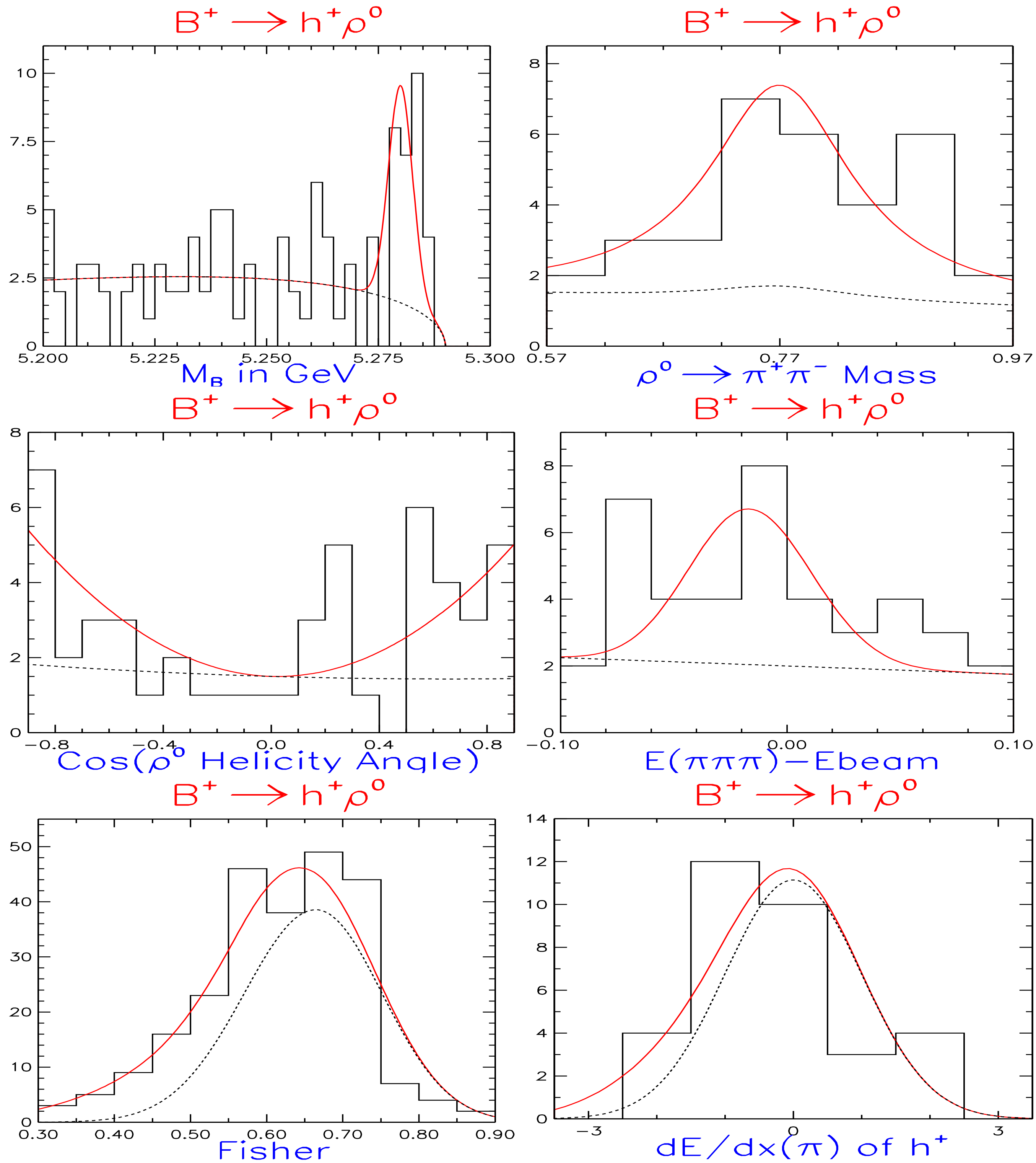




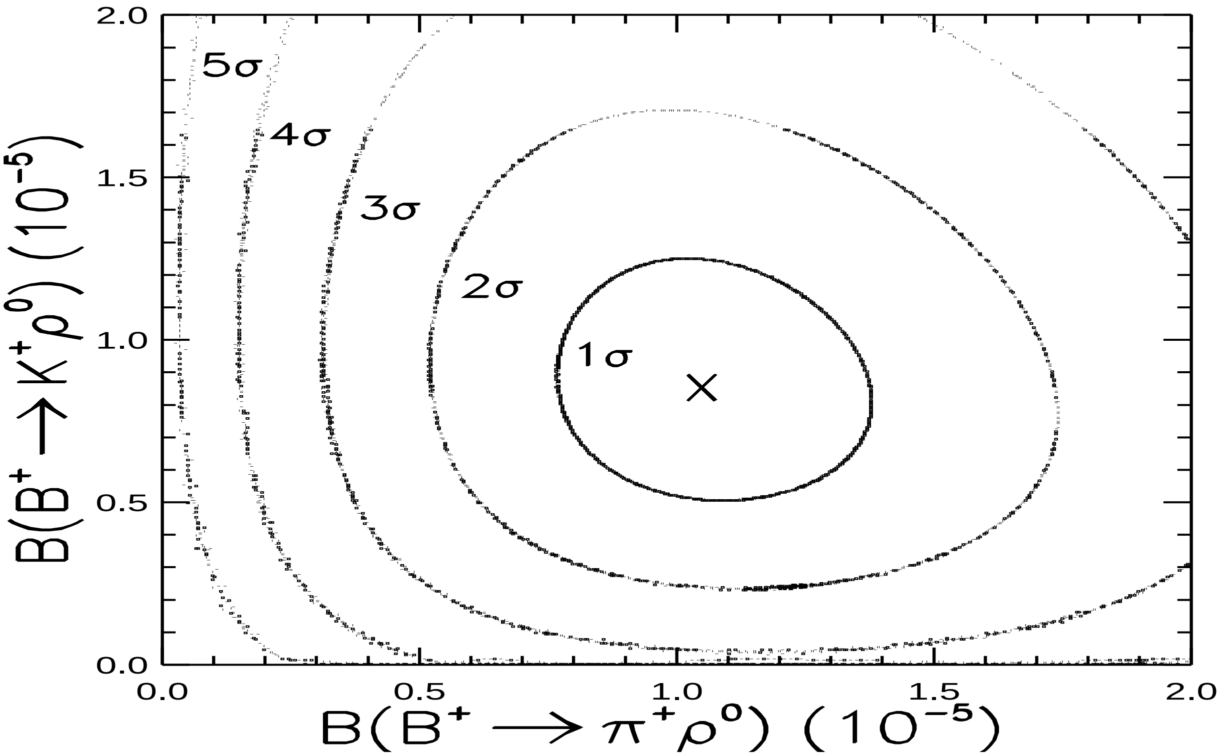
PDF distributions for $B \to PV$ $P = \pi^+, K^+$, $V = \rho^0$

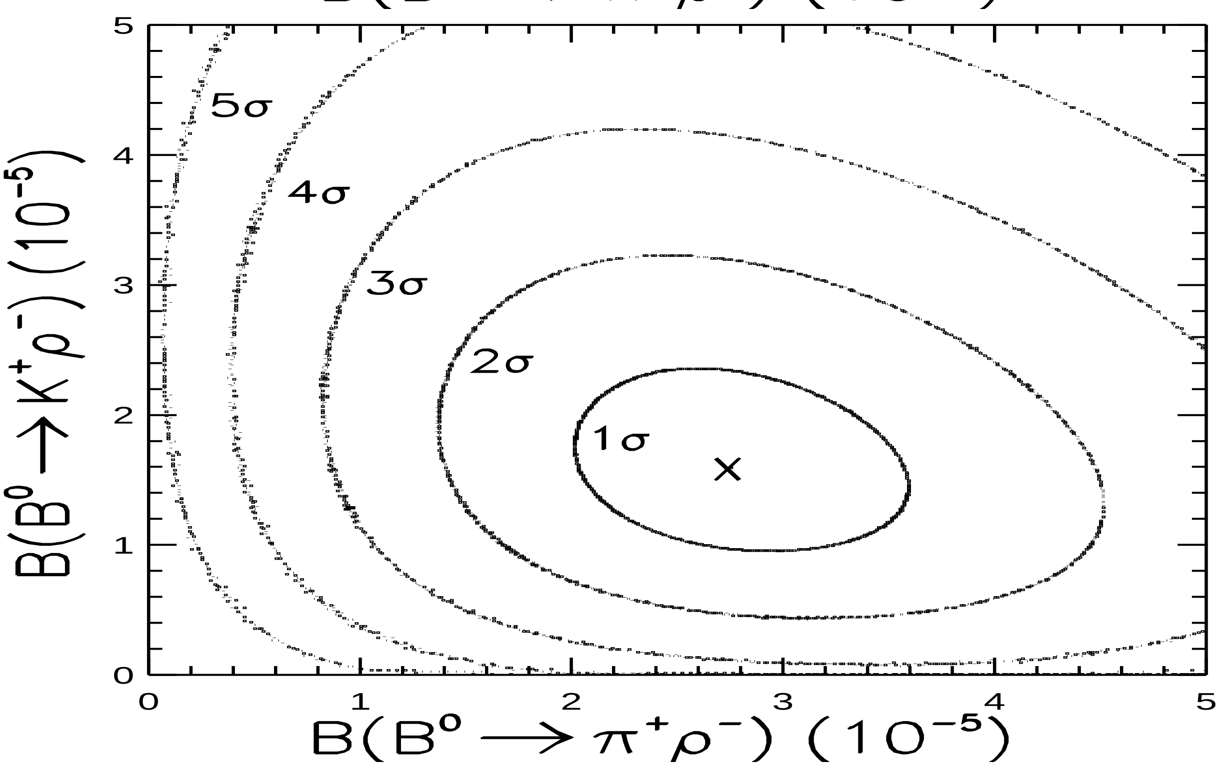


Projections for $B \to PV$ $P = \pi^+, K^+$, $V = \rho^0$



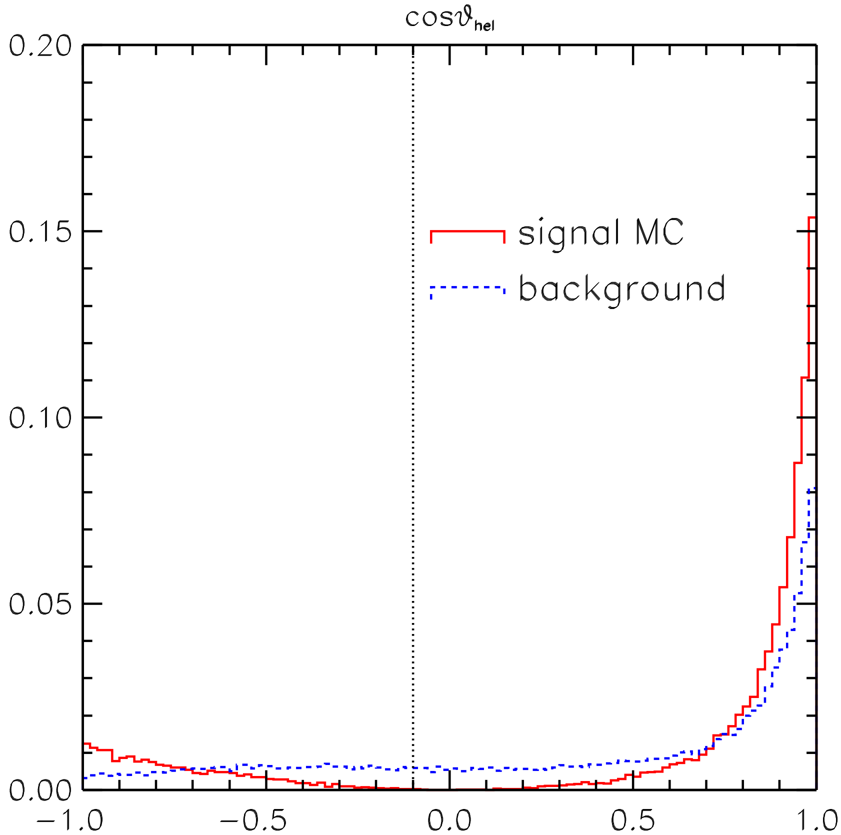
Likelihood Contours for $B \to PV$ $P = \pi^+, K^+$, $V = \rho^0, \rho^-$



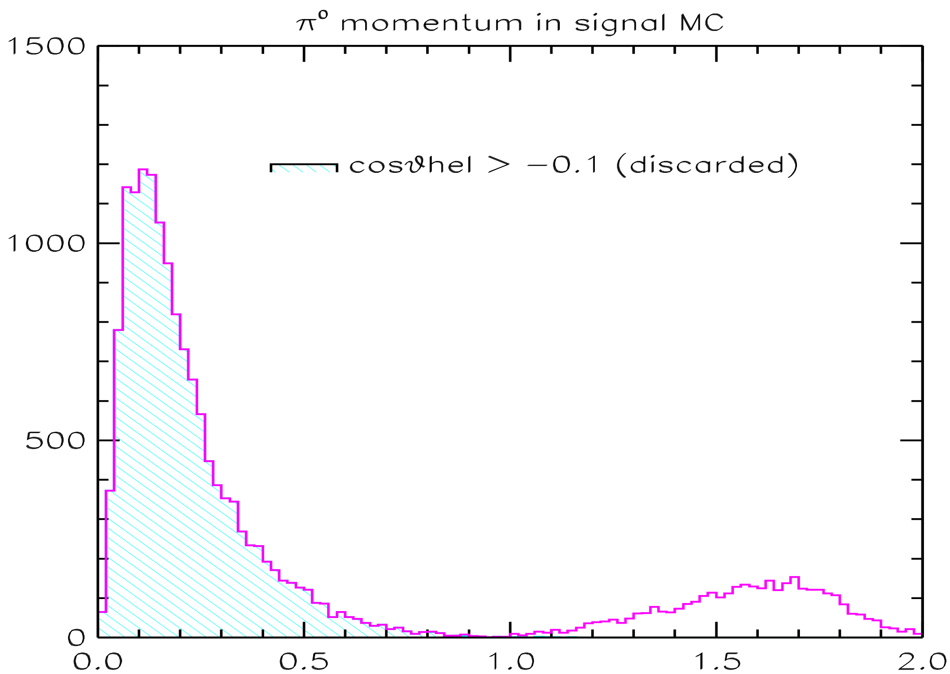


$B \to \rho^{\pm}\pi^{\mp}$

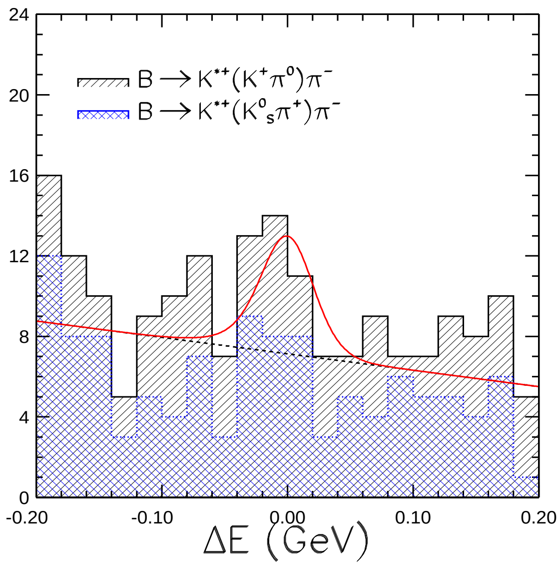
$\theta_{Helicity}(\rho^-)$

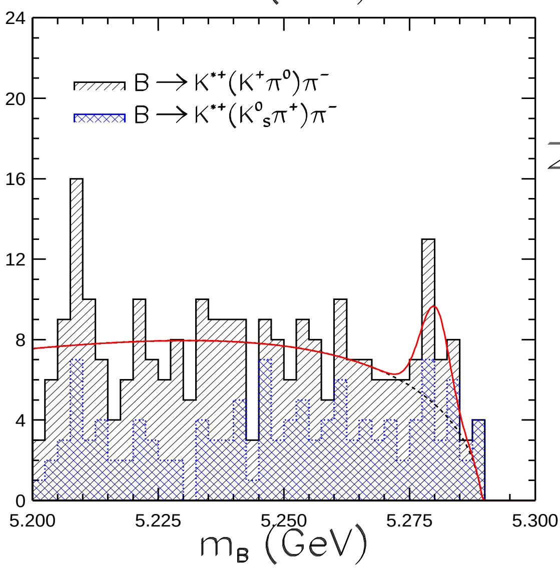


$P(\pi^0)$

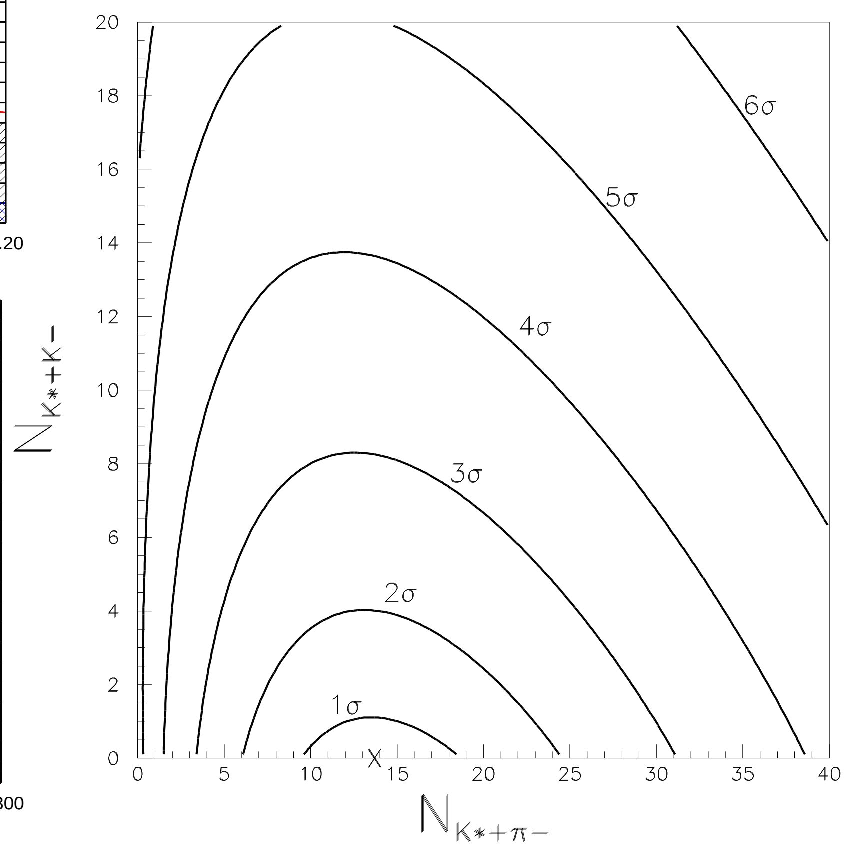


$B \to PV \;\; P = \pi^+, K^+, \; V = K^{*+}$





- Analysis combines $K^{*-} \to K^0\pi^-$ and $K^{\pm}\pi^0$.
- helicity angle and resonance masses added to likelihood fit

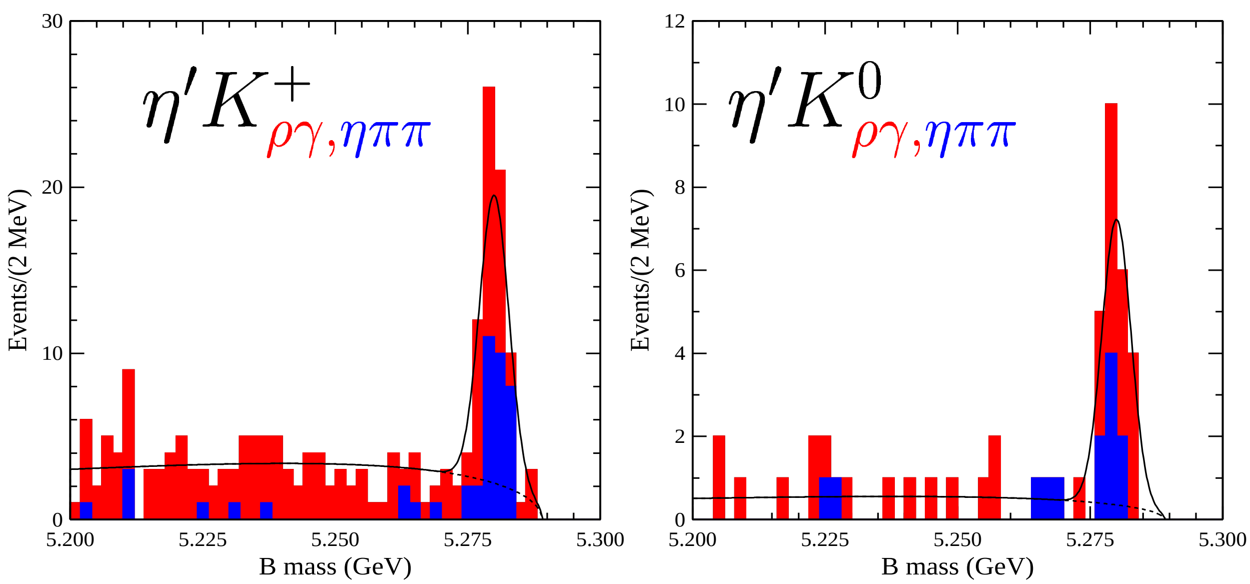


Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6	Significance
$K^{*\pm}(K^0_s\pi^{\pm})\pi^{\mp}$	$10.8^{+4.3}_{-3.5}$	31%x22%	$23^{+9}_{-7} \pm 3$	5.2σ
$K^{*\pm}(K^{\pm}\pi^0)\pi^{\mp}$	$5.7^{+4.3}_{-3.2}$	12%x33%	$20^{+15}_{-11}{}^{+3}_{-4}$	2.5σ
$K^{*\pm}\pi^{\mp}$			$22^{+8}_{-6}{}^{+4}_{-5}$	5.9σ
$K^{*\pm}K^{\mp}$	0		< 6	0σ

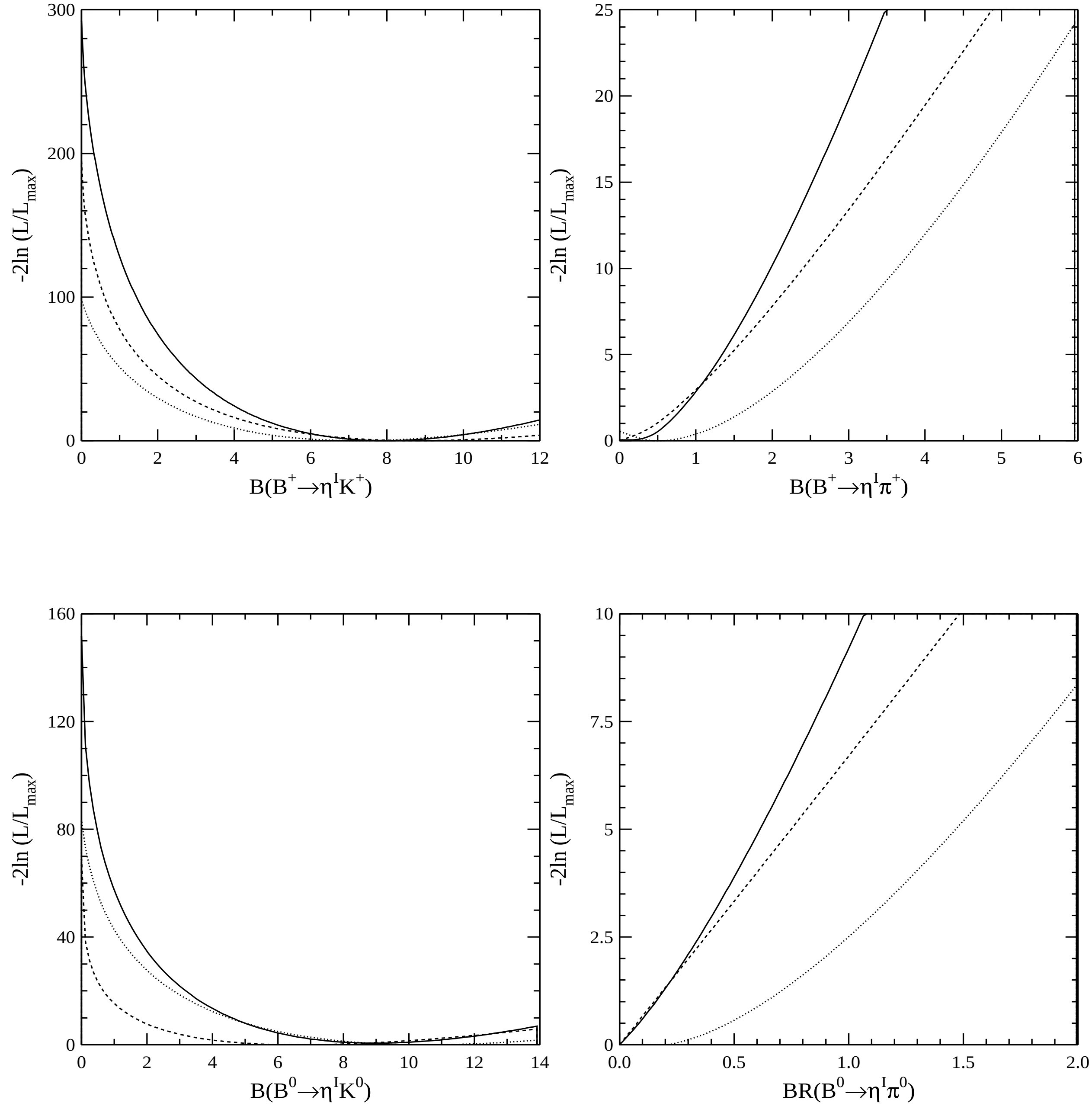
$B \to \eta'(K^+, K^0)$

- Unexpected large $B \to \eta' K$ rate confirmed with small error (14%).
- Many attempts at explaining this: $c\bar{c}$, gg content in η', QCD anomaly in $b \to sg^*$, possibly new physics.
- $\eta' P/\eta' V$ ratios reasonable theoretically
  $B^+ \to \eta' K^{*+} < 35 \times 10^{-6}$,$B^0 \to \eta' K^{*0} < 24 \times 10^{-6}$

Final State	efficiency	N(signal)	$\mathcal{B}$x10^6	Significance
$\eta'(\eta_{\gamma\gamma}\pi^+\pi^-)K^+$	4.7%	$39.6^{+7.0}_{-6.4}$	88^{+16}_{-14}	
$\eta'(\rho^0\gamma)K^+$	8.7%	61^{+11}_{-10}	72^{+13}_{-12}	
$\eta' K^+$ combined			$80^{+10}_{-9} \pm 7$	16.8σ
$\eta'(\eta_{\gamma\gamma}\pi^+\pi^-)K^0_s$	1.4%	$9.2^{+3.6}_{-2.9}$	67^{+26}_{-21}	
$\eta'(\rho^0\gamma)K^0_s$	2.9%	$29.6^{+7.0}_{-6.2}$	105^{+25}_{-22}	
$\eta' K^0_s$ combined			$89^{+18}_{-16} \pm 9$	11.7σ

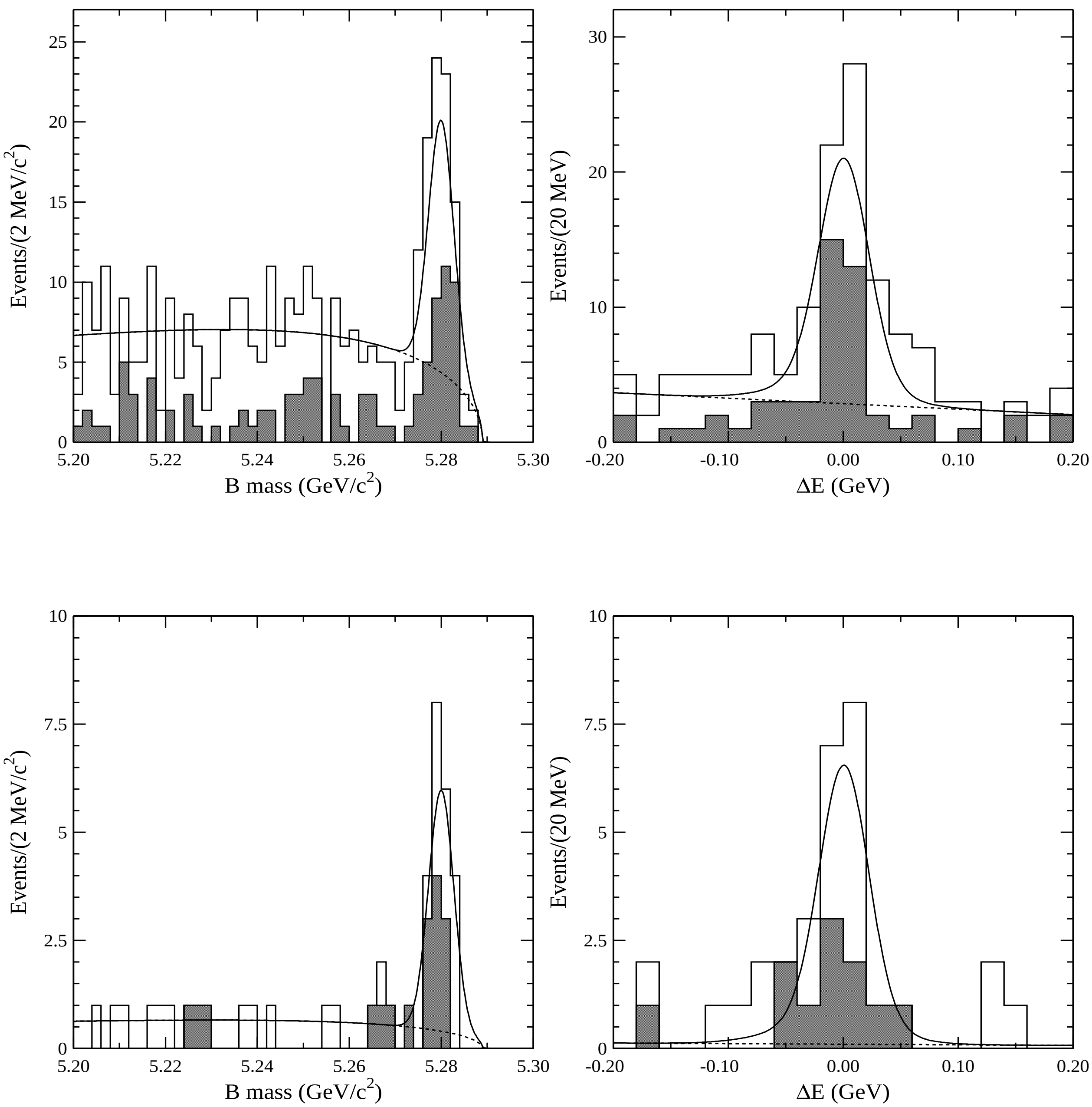


$B \to \eta'(K^+, K^0)$



-2ln (L/Lmax)
B(B+→η'K+)
0
2
4
6
8
10
12
100
200
300
B(B+→η'π+)
1
3
5
15
20
25
B(B0→η'K0)
14
40
80
120
160
BR(B0→η'π0)
0.0
0.5
1.0
1.5
2.0
2.5
7.5

$B \to \eta'(K^+, K^0)$

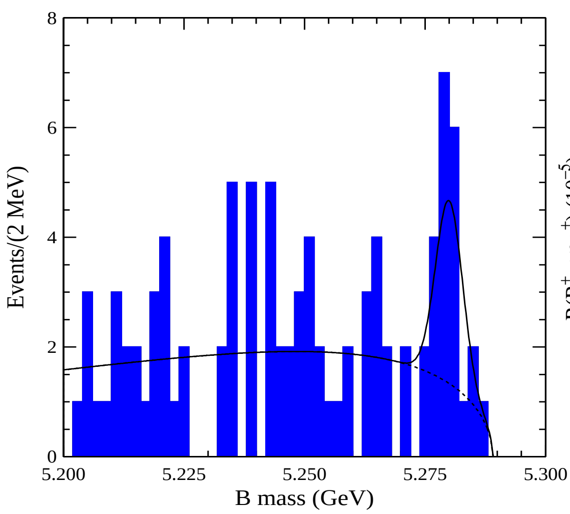


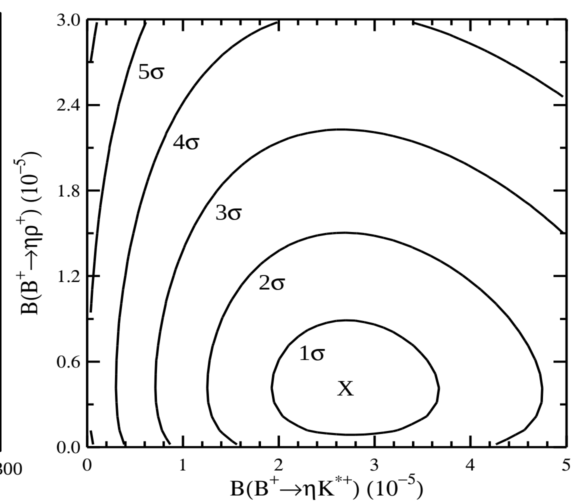
Events/(2 MeV/c²)
B mass (GeV/c²)
Events/(20 MeV)
ΔE (GeV)
5.20
5.22
5.24
5.26
5.28
5.30
-0.20
-0.10
0.00
0.10
0.20

$B \to \eta K^{*+}$

- 4.8σ signal
- Combined $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$
- Combined $K^{*+} \to K^+\pi^0$ and $K^0\pi^+$
- π/K separation unambiguous for daughter tracks

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6
$\eta(\gamma\gamma)K^{*+}(K^+\pi^0)$	$9.3^{+5.2}_{-3.5}$	2.8%	34^{+19}_{-13}
$\eta(\gamma\gamma)K^{*+}(K^0\pi^+)$	$3.3^{+3.0}_{-2.1}$	1.2%	16^{+14}_{-10}
$\eta(\pi^+\pi^-\pi^0)K^{*+}(K^+\pi^0)$	$3.6^{+3.1}_{-2.3}$	2.1%	32^{+28}_{-20}
$\eta(\pi^+\pi^-\pi^0)K^{*+}(K^0\pi^+)$	$3.0^{+2.7}_{-1.9}$	0.9%	34^{+30}_{-21}
ηK^{*+} combined			$26.4^{+9.6}_{-8.2} \pm 3.3$
$\eta\rho^+$ combined			< 15 (1.3σ)

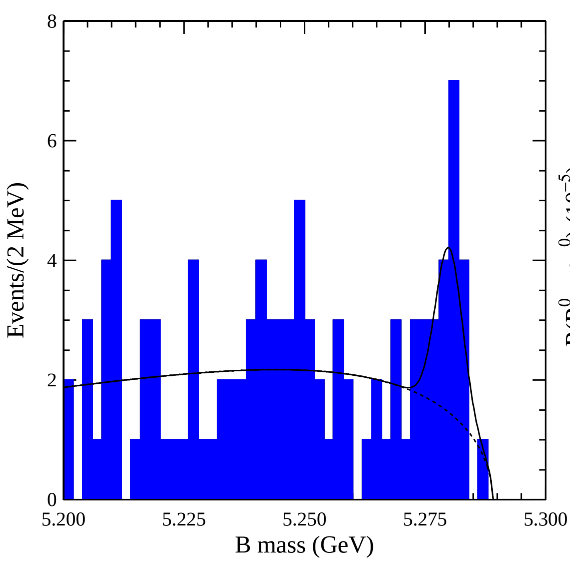


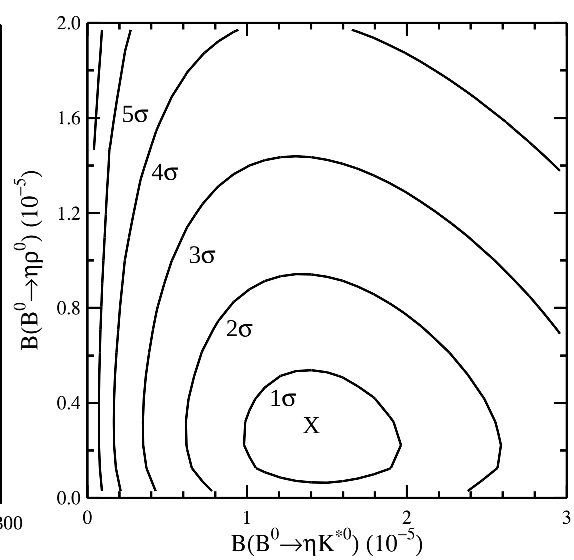


$B \to \eta K^{*0}$

- 5.1σ signal
- Combined $\eta \to \gamma\gamma$ and $\eta \to \pi^+\pi^-\pi^0$
- Decide $K^-\pi^+$ and $K^+\pi^-$ based on dE/dX+ToF
- ρ^0/K^{*0} simultaneously fit
- No signals in $\eta(K/\pi)$, consistent with theory

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6
$\eta(\gamma\gamma)K^{*0}(K^+\pi^-)$	$7.8^{+4.7}_{-3.1}$	8.3%	$9.7^{+5.8}_{-3.9}$
$\eta(\pi^+\pi^-\pi^0)K^{*0}(K^+\pi^-)$	$8.0^{+4.4}_{-3.5}$	3.3%	25^{+14}_{-11}
ηK^{*0} combined		12%	$13.8^{+5.5}_{-4.6} \pm 1.6$
$\eta\rho^0$ combined		15%	< 10 (1.3σ)

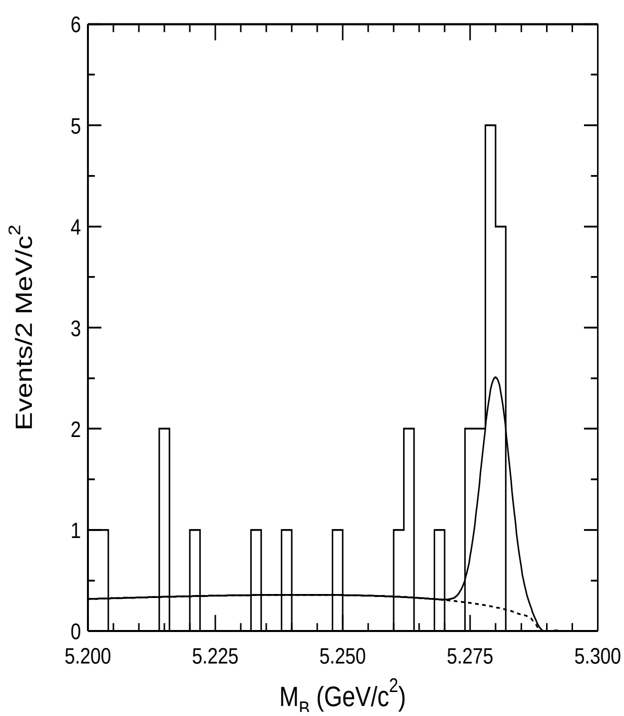


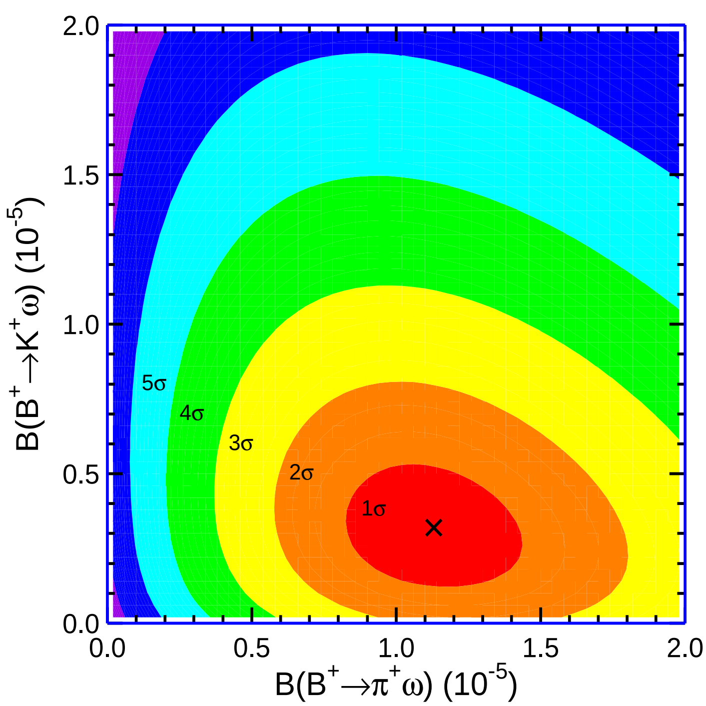


$B \to \omega(K/\pi)$

- $B \to \omega\pi^{\pm}$ comparable to $B \to \rho^0\pi^{\pm}$
- In $B \to PV$ the different contributions to the penguins cancel instead of reinforce (as in $\pi^-\pi^+/\pi^-K^+$).
- $B \to \omega K^0$ near detection threshold

Final State	Fitted signal	efficiency	$\mathcal{B}$x10^6	Significance
$\omega\pi^{\pm}$	$28.5^{+8.2}_{-7.3}$	26%	$11.3^{+3.3}_{-2.9} \pm 1.4$	6.2σ
$\omega K^{\pm}$	$7.9^{+6.0}_{-4.7}$	26%	< 7.9	2.1σ
$\omega\pi^0$	$1.5^{+3.5}_{-1.5}$	19%	< 5.6	0.6σ
ωK^0	$7.0^{+3.8}_{-2.9}$	7%	< 21	3.9σ

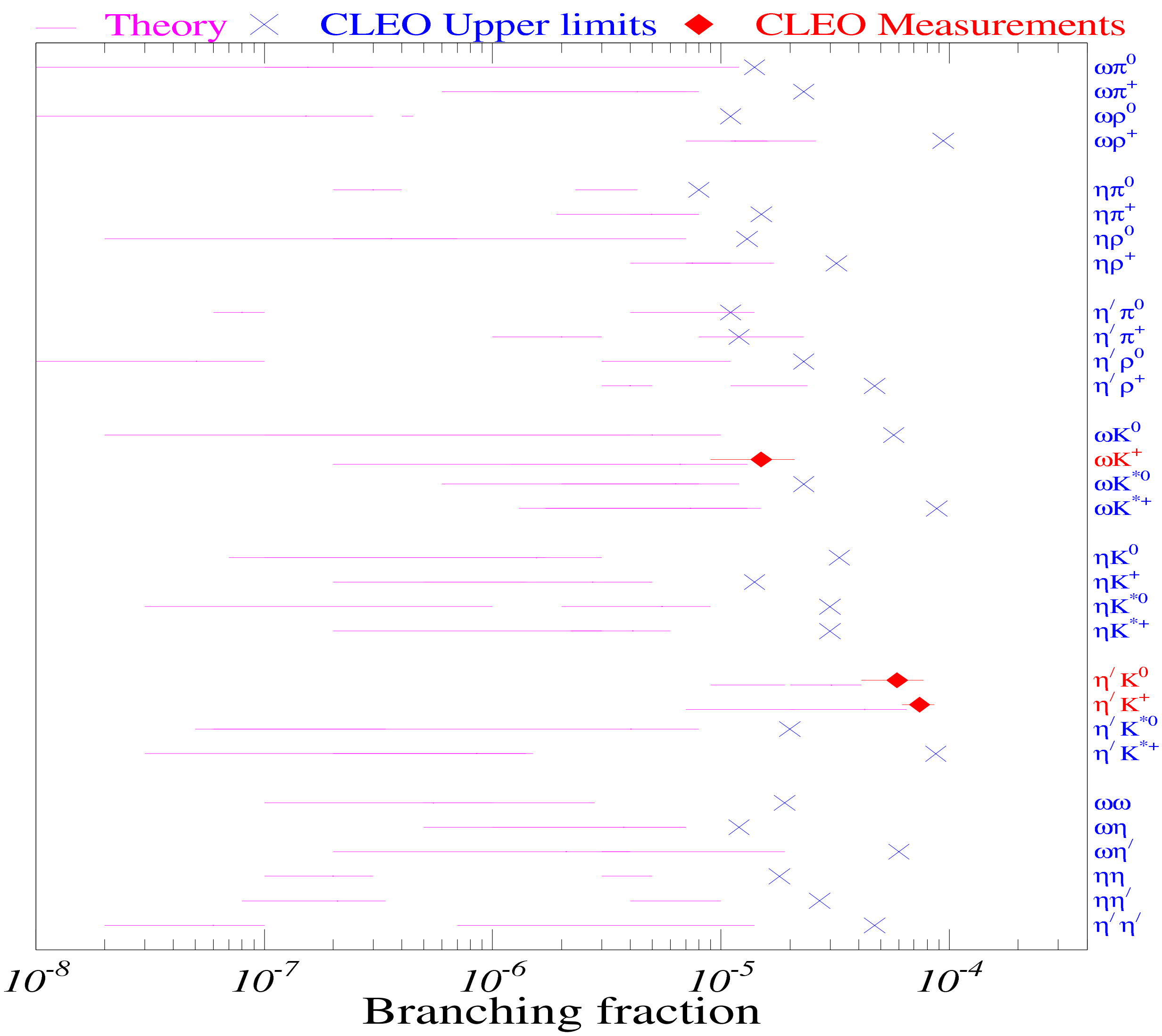




More Modes with $\eta, \eta', \omega, \phi$

- Reconstruct $\phi \to K^+K^-$, $\omega \to \pi^+\pi^-\pi^0$
- Combine $\eta \to \gamma\gamma, \pi^+\pi^-\pi^0$, $\eta' \to \pi^+\pi^-\eta, \rho\gamma$
- Combine with $\pi^\pm$, π^0, $K^\pm$, K^0, K^*, ρ to form B candidates.
- Total of ¿60 different decay chains (at least)

Summary of results



Summary: CLEO II and II.V

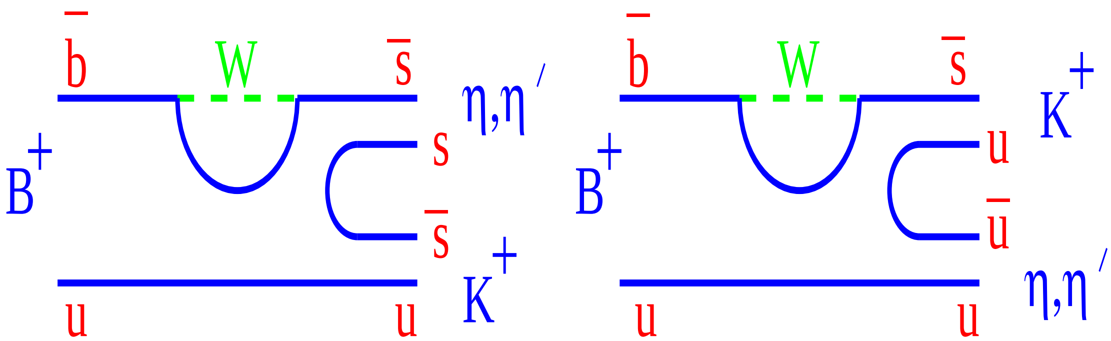
- CLEO has searched for O(100) charmless B decay modes
- Recent measurements for $B \to \pi^+\pi^-, \rho^0\pi^+, \rho^+\pi^-, \eta K^*, \eta' K, \omega\pi^+$
- a few charmless hadronic two-body modes to complete with the full dataset
- preliminary results on $B \to VV$, $b \to u(\bar{c}s)$ searches

The Future: CLEO III

- Currently taking data, expect $10\,\mathrm{fb}^{-1}$ analyzed by summer of 2001
- The new data should be more sensitive for rare B decays than the CLEO II.V data
- Ring Imaging Čerenkov Detector and dE/dX combined yield better than 4σ K/π separation at 2.6 GeV
- This will improve $\pi^+(P,V)/K^+(P,V)$ separation power as well as ρ, K^*.
- New drift chamber's performance already an improvement over CLEO II's chamber.
- Four layers of double-sided Si tracking.

Why is $B^+ \to \eta' K^+$ so large?

Large $\eta' K/\eta K$ ratio may be due in part to constructive interference between two Penguin diagrams (Lipkin, PLB254(1991)247, the interference should be destructive for $B^+ \to \eta' K^*$).



Other possible processes:

- Cabibbo-suppressed $b \to u$ transitions.
- OZI suppressed diagrams.
- Possible $c\bar{c}$ component to η'.
- Rescattering from $DD_s \to \eta_c K^+$ (FSI).
- $c\bar{c} \to g \to \eta'$ (Dunietz et al. hep-ph/9612421).