The Suppressed Decay of B-$\bar{B}$ to $K_sK^{\pm}\pi^{\pm}$ - Searching For A Needle In A Haystack

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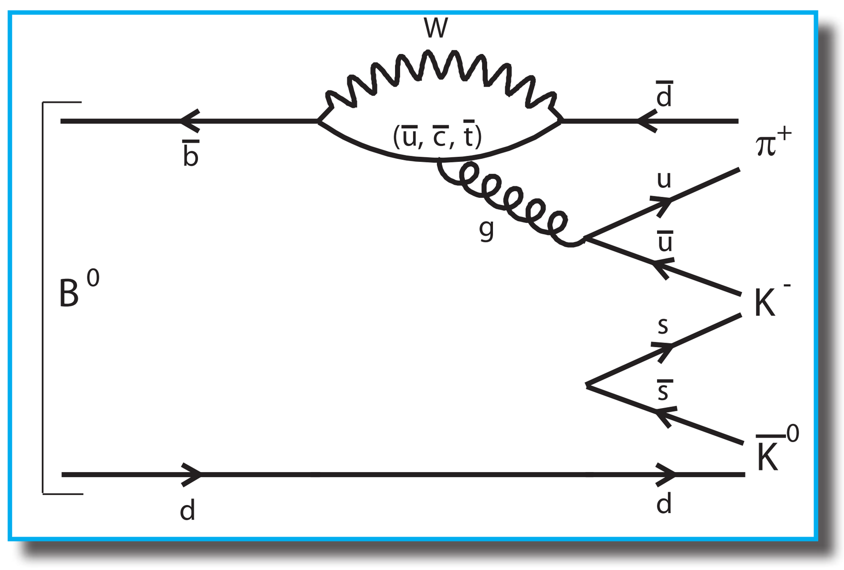
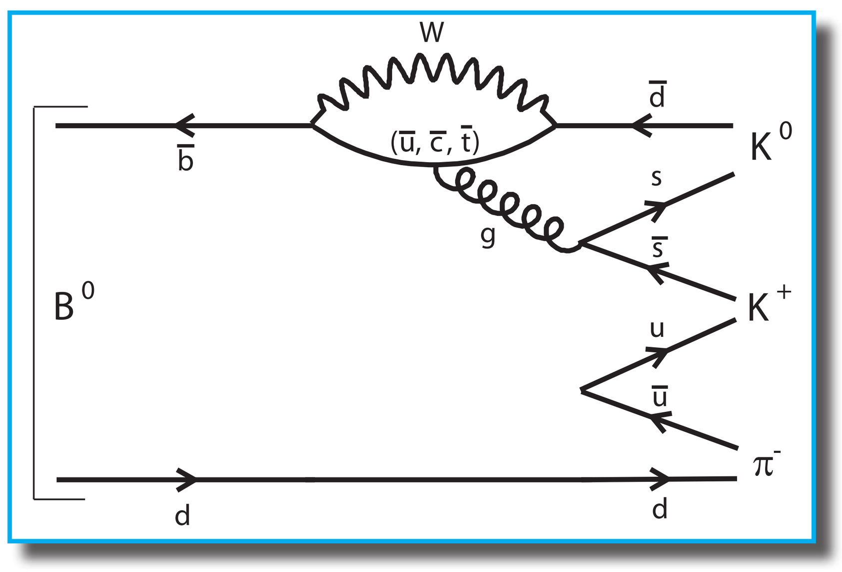
The Decay

A single B^0 or $\bar{B}^0$ particle can decay into a K_s, $K^{+/-}$ and a $\pi^{-/+}$. The schematic diagrams below (Feynman Diagrams) illustrate this.





These decays without a charm quark (charmless decays) are very rare, with an upper limit of 3 decays in one million. If we can determine exactly how many times this occurs out of a given total, we can deduce an exact value for the branching fraction.

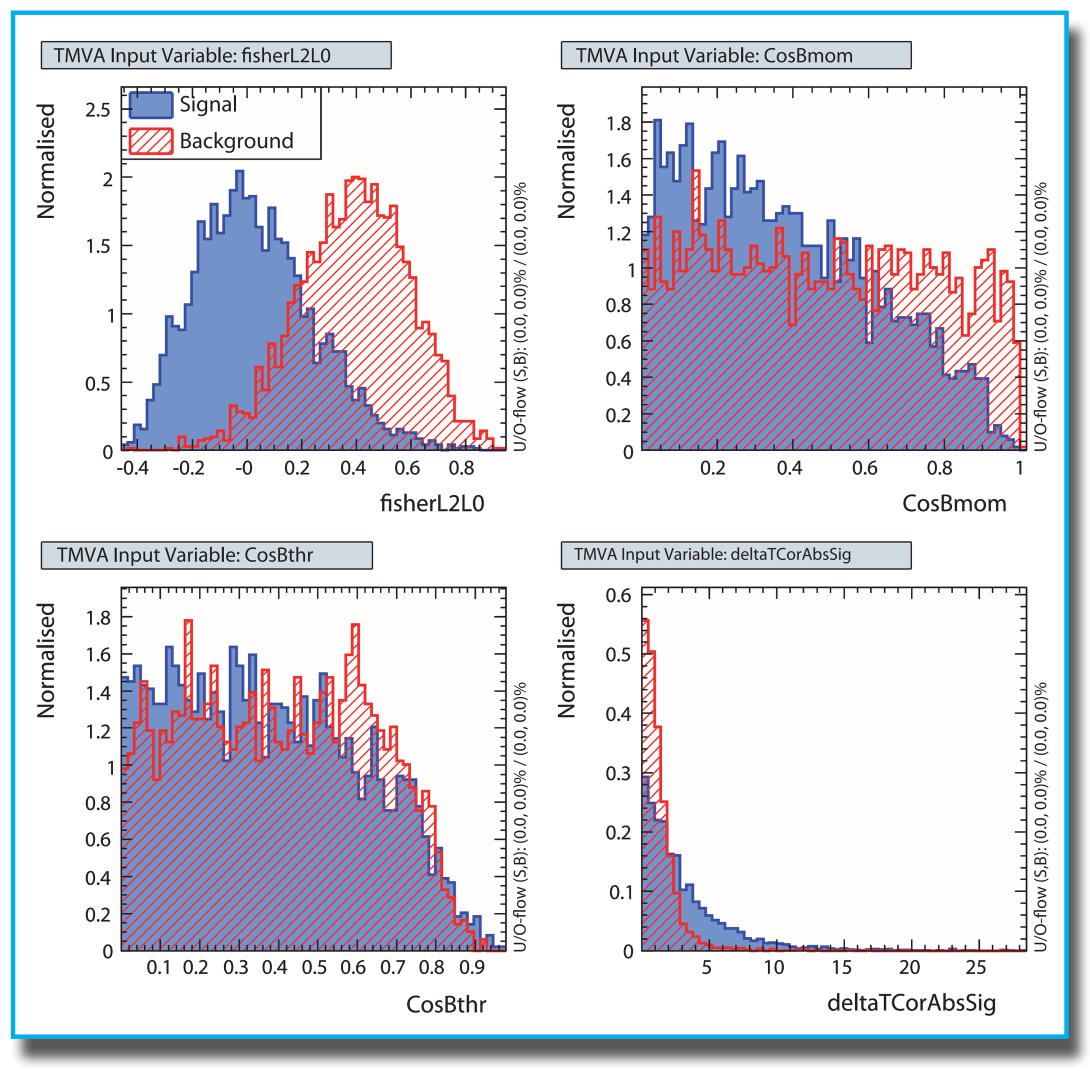


Fig 1 - Plots of the four input variables used. Moving from the top left clockwise:
- FisherL2L0, the ratio of the 2nd order Fisher polynomial to the zeroth.
- CosBmom, a measure of the cosine of the momentum. Note the constant nature of the background.
- deltaTCorAbsSig, the corrected time of flight. Signal events come from second decay, therefore are displaced further from the origin, resulting in larger values.
- CosBthr, the cosine of the thrust.

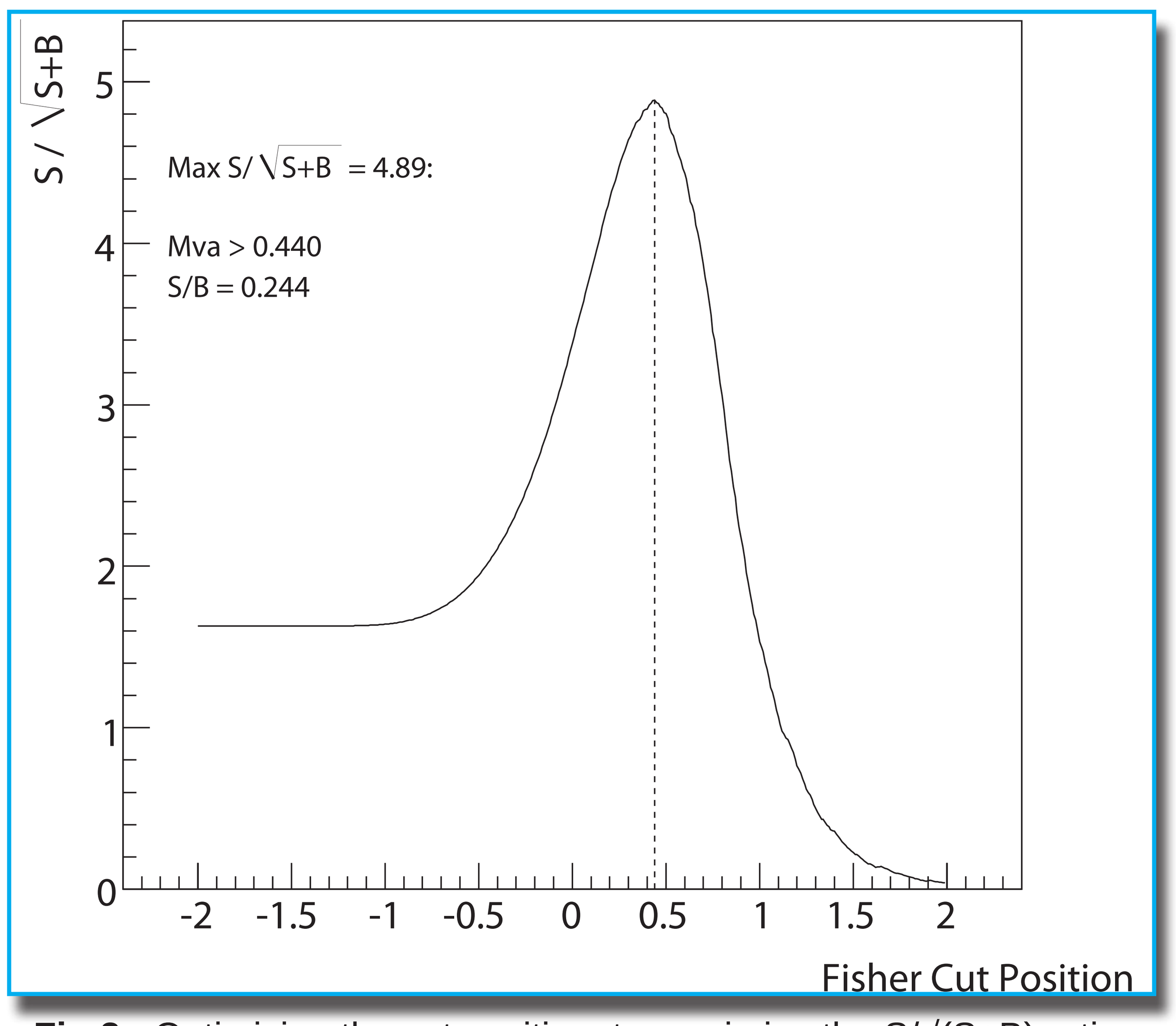


Fig 2 - Optimising the cut position, to maximise the S/√(S+B) ratio.

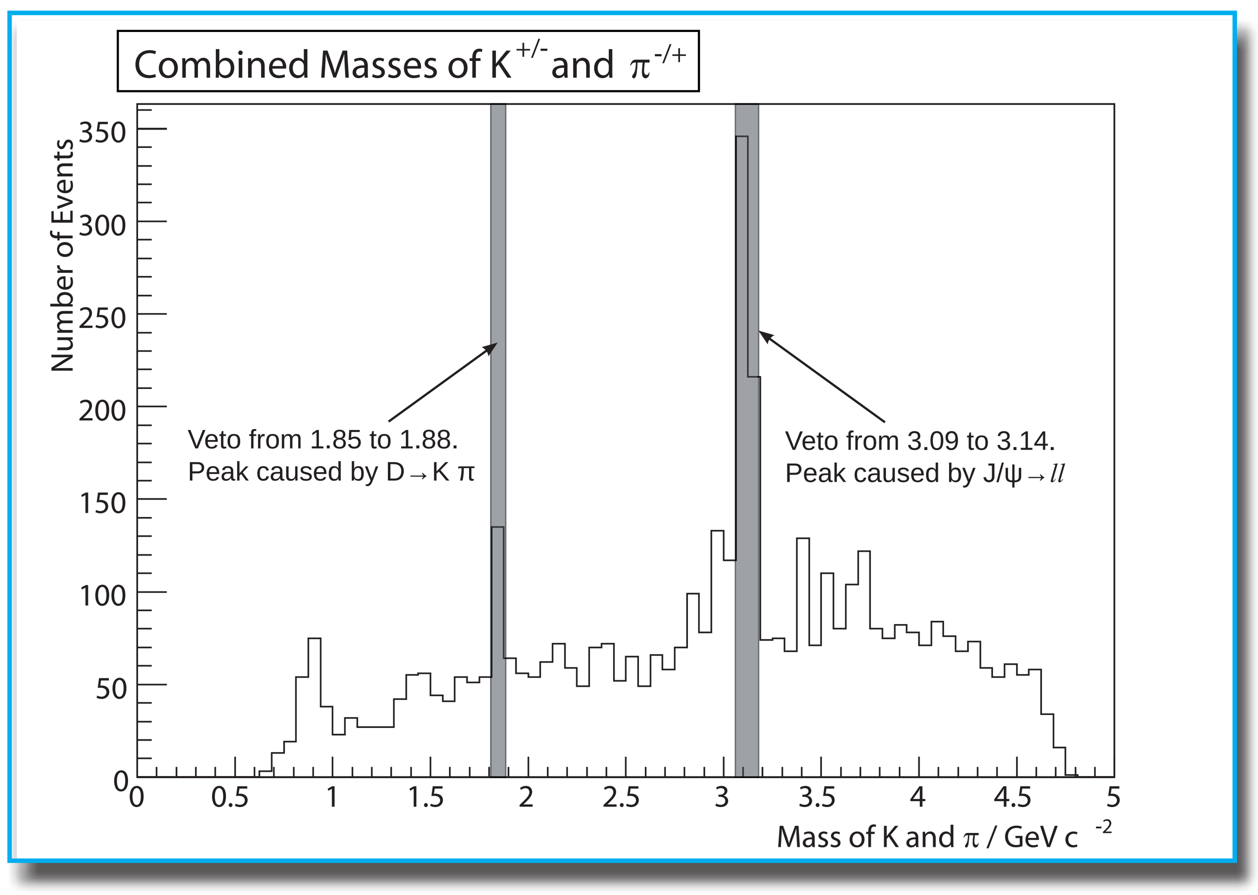


Fig 3 - A cut can be placed to remove the well defined peaks, and eliminate vast amounts of background easily.

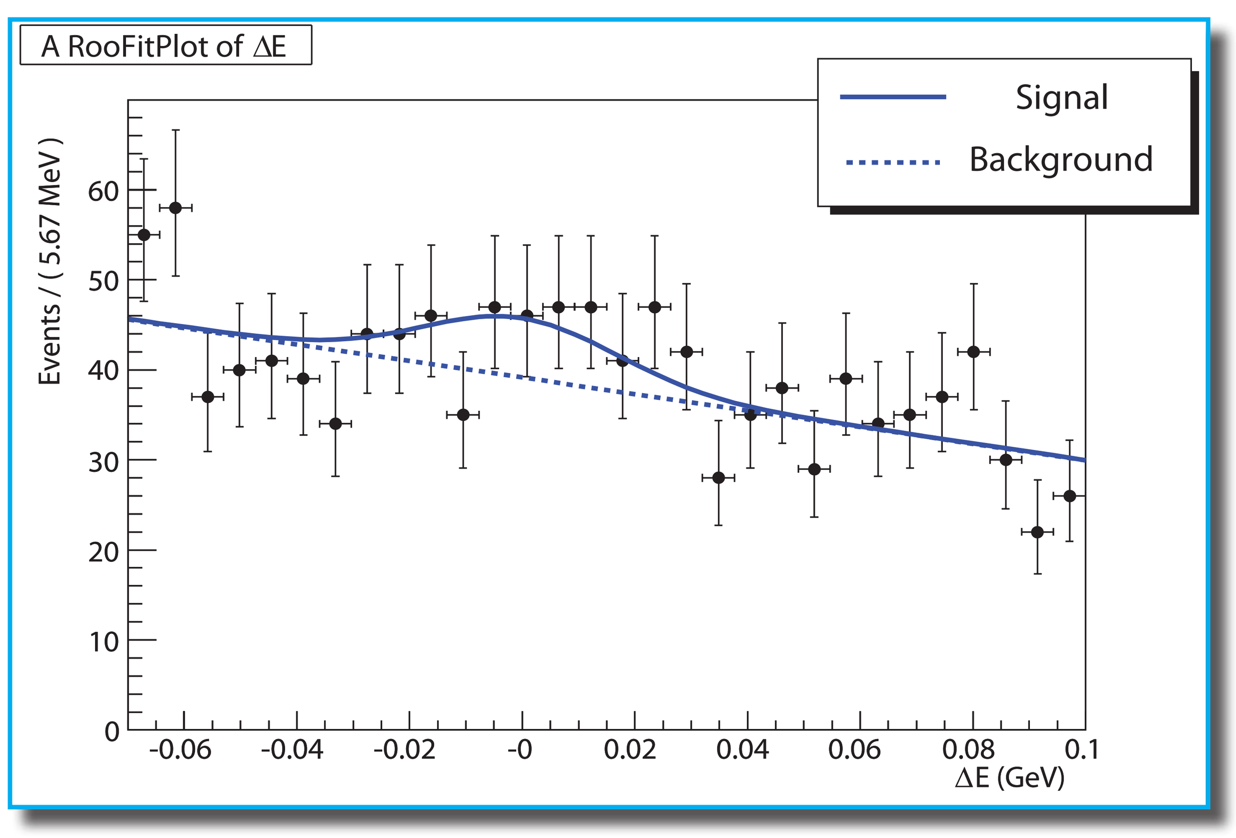


Fig 4 - A slight peak, corresponding to the $B^0 \rightarrow K_sK\pi$ signal decay, can be seen around ΔE=0.

Removing The Background Noise

There are three main different background sources: continuum, charmless, and charmed decay modes.

Since the background is huge compared to the signal, we must be incredibly accurate in removing the background, by removing as much as possible, without eliminating too much signal.

Continuum - use the difference in topology. Fisher L2L0, CosBmon, CosBthr, and deltaTCorAbsSig each provide orthogonal information, which can be used to reduce the continuum signal and increase the signal to background ratio (fig 1). A Fisher discriminant was then applied to the four data sets, to provide a distribution with maximum orthogonality.

Misidentification – use different combinations of PID selectors to reduce the chance of seeing misidentified particles. A very loose cut on kaon values with a loose cut on pion values provided the optimal signal to background ratio. The position of the cut in Fisher space was then optimised, to a position of 0.44 (fig 2).

Charmed – Since the mass peaks are well defined in areas with relatively low signal content, we can simply remove (veto) these masses from the data, and eliminate the vast majority of this type of background (fig 3).

Fitting The Data

Each ΔE distribution (the difference between the beam energy and the mass of the B^0 meson) after cuts and vetoes is plotted, and fitted as some simple function (linear, polynomial, trigonometric function, etc). These functions are then summed with variable weights, and fitted against the signal (fig 4). After taking these results, the branching fraction can be calculated at

$$(1.4 \pm 0.8) \times 10^{-6}$$

The uncertainty is due to statistical variations, and is not dependent on the characteristics of the detector, or any other experimental detail. This signal is not significant however, since there is a reasonable chance the peak is due to random variations. Steps need to be taken to enhance the signal strength and produce a conclusive result.

The Next Step...

Instead of a simple cut on the Fisher plot, use a more efficient method of reducing the background, without loosing a vast amount of signal. This would result in a greater efficiency, and a more accurate result.

When fitting the data, use three variables instead of only the single ΔE. Fitting in more than one dimension allows to not cut as tightly on mES and Fisher, and again results in a greater signal efficiency, resulting in a stronger overall signal.