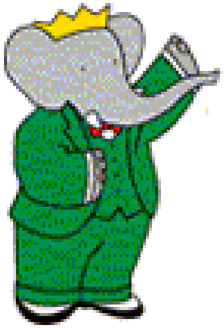
Branching Fraction Measurement of

$$B^+ \rightarrow (a_1\pi)^+$$



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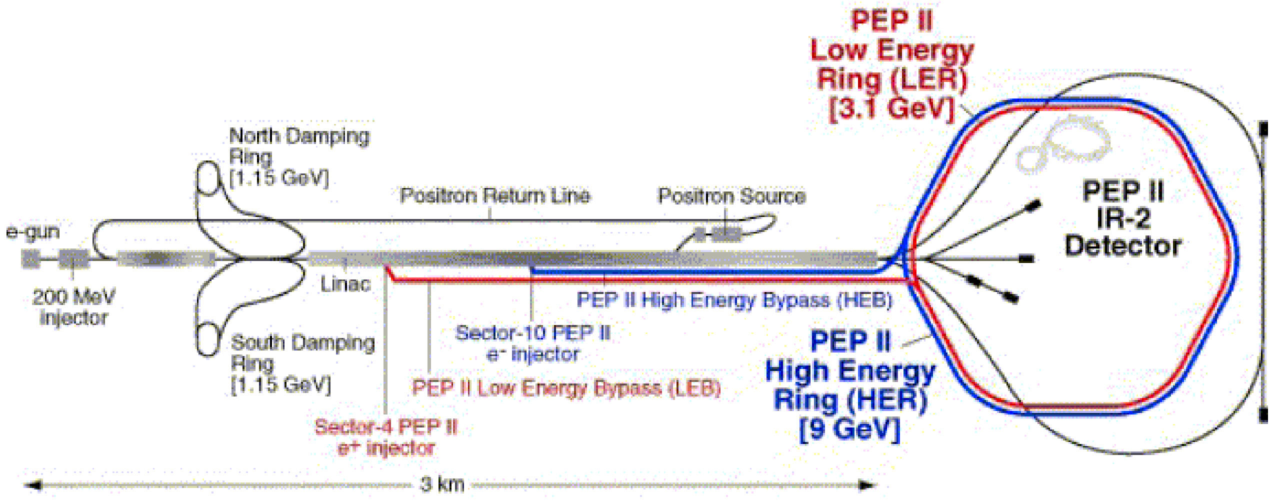
Overview

- Babar Detector
- Motivation
- Reconstruction
- Maximum Likelihood Analysis Technique
- Plans for the future

The Linear Accelerator

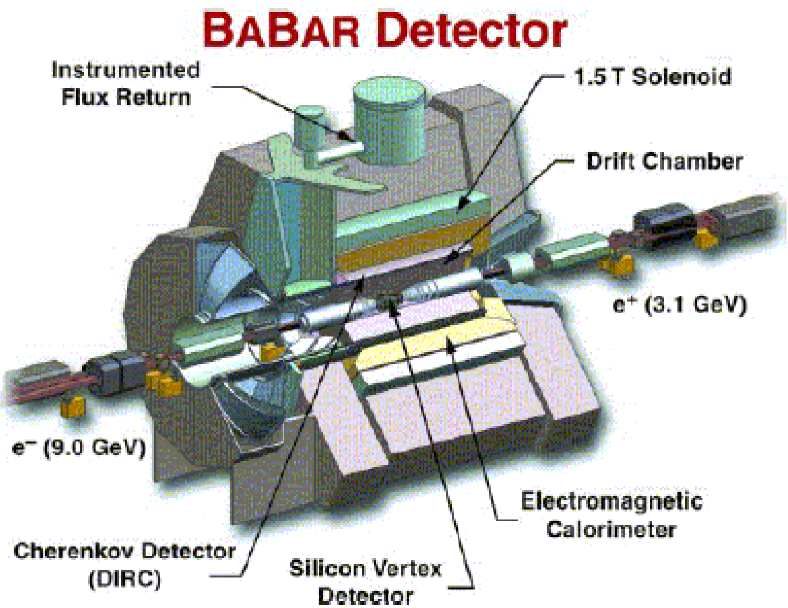
- 2 mile long linear electron and positron accelerator
- Electrons and positrons are fed into separate storage rings
- Electron ring is of a higher energy



The Babar Detector

•Electrons and positrons are collided at the Babar detector

•The collision results in pairs of B Mesons, the decays of which are studied via the detector



Analysis Overview

- I am studying decays of charged B Mesons to a_1 and π mesons.
- Final state for these decays are 3 charged and 1 neutral π
- Motivation for this analysis
  - $\rightarrow$ a_1 meson parameters are not widely known
  - $\rightarrow$ Branching fraction will be a valuable input to the measurement of the CKM angle α
- A recent Babar measurement of an a_1 channel, but of neutral B mesons to 4 charged π mesons was
  - $\rightarrow$ Branching Fraction, $B(B^0 \rightarrow a_1^{\pm}(1260)\pi) = (33.2 \pm 3.8 \pm 3.0) \times 10^{-6}$
  - $\rightarrow$ This was seen with a significance of 9.2σ

Reconstruction

•Final state is 3 charged tracks and 2 photons.

•Invariant mass constraints were placed on the reconstructed resonances

•Further selection cuts were applied to remove potential sources of background from the data

•Continuum light quark production is a dominant source of background.

$\rightarrow$Modelled using sidebands from data, i.e. away from the peak of the B resonance in the B mass-energy plane.

•Other sources of background are from other B decays that are incorrectly identified as signal

$\rightarrow$Model charmless B background decays

Maximum Likelihood Technique

- An extended Maximum Likelihood analysis is used. The likelihood for N events is defined as:

$$L = \exp\left(-\sum_j n_j \right) \prod_{i=1}^{N} \left[\sum_{k=1}^{m} n_k P_k \right]$$

- There are *m* components, and for each of these probability density functions (pdfs) are defined.
    - Signal, continuum and B background form different components
    - Obtain yields for the signal and background components from the fit.
- The exponential term ensures that the likelihood varies poissonially (extended likelihood)

ML Fit Variables

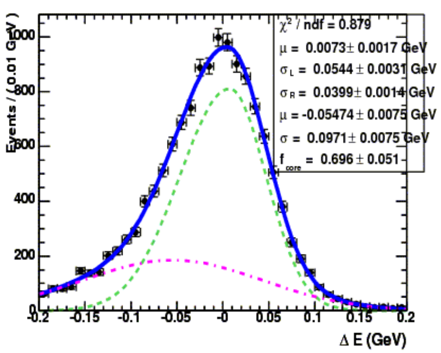
•B Mesons are characterised kinematically by the energy-substituted mass, M_{ES} and energy difference, ΔE

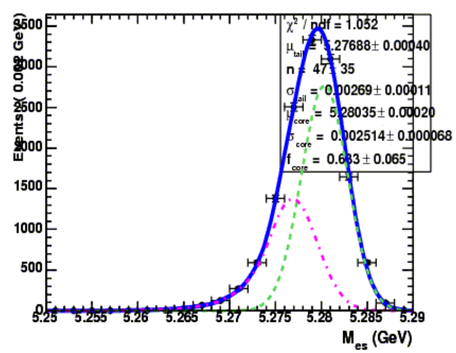
$$M_{ES} = \sqrt{\left(s/2 + \mathbf{p_0} \cdot \mathbf{p_B}\right)^2 / E_0^2 - \mathbf{p_B^2}}$$

$$\Delta E = E_B^* - \tfrac{1}{2}\sqrt{s}$$

Subscripts *0* and *B* refer to the initial Upsilon(4S) and to the B candidate in the lab-frame, respectively

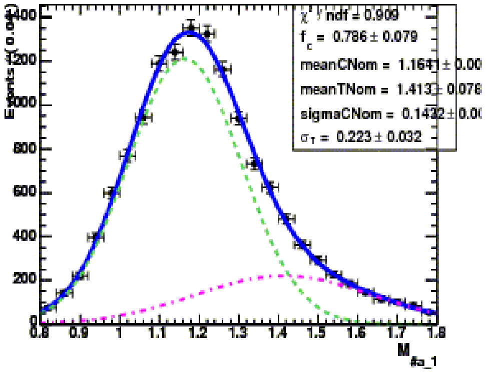
•Below are plots from simulated data, signal Monte Carlo here, for ΔE and M_{ES} .

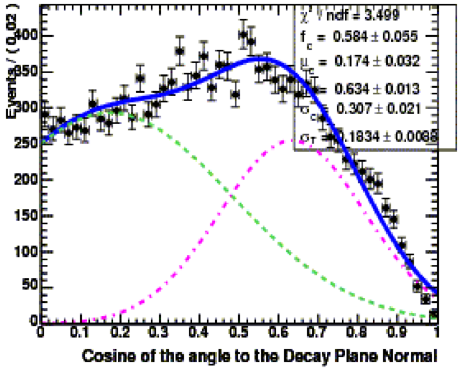


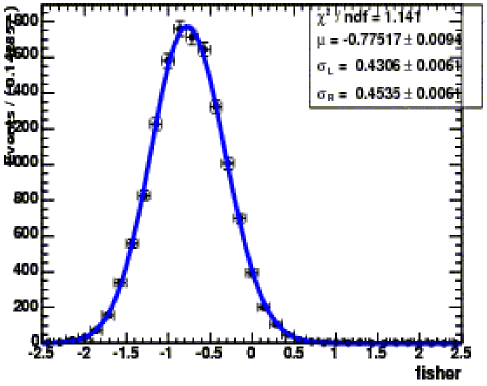


ML Fit Variables

- 3 other variables are used:
  - Legendre Fisher: This is optimised to differentiate between signal and background. This is made from Legendre polynomials of energy flow.
  - a_1 resonance mass: The reconstructed mass of the a_1 meson
  - a_1 decay plane normal: This is the cosine of the angle between the direction of the B, and the normal to the decay plane of the a_1, in the a_1 rest frame.
- These plots are for signal Monte Carlo.







Fit Validation

- Currently the analysis is blind, i.e. cannot run the fit on data.
- To determine if the fit will perform reliably, the fit is run on 'toy' Monte Carlo, which can be generated either from the pdf shapes or from simulated Monte Carlo
- As we know the number of signal events included in these samples, the fit result can be compared with what we expect

- Also can run a 'blind' fit, which scales and shifts the result by an unknown value. This tests the reliability of the fit

Other Issues

- The main issues that arose from studying the fit validation:

  - It was important to include a D Veto. This checks the 3π mass of the a_1 and if around the D mass, then the event is removed
  - Include extra components to model the charmless B backgrounds. There are about 15 different background modes. Splitting these modes up into independent components improves the fit model.
  - The signal component includes combinatorial background due to track or photon mis-identification, which has a different pdf shape. By including a 'self crossfeed' component, this improves the fit model

- These improvements were reflected in the improved results from the fit validation stage.

Conclusion and Outlook

- Analysis is currently blind
- I am finishing the validation off, so I can proceed with unblinding.
- Judging from the recent other babar result, I should hopefully be able to measure a signal. Due to my different final state, I would expect ~1/2 the number of signal events.

- Result from previous $B^0 \rightarrow a_1\pi$ analysis

$$B(B^0 \rightarrow a_1 \pm (1260)\pi) = (33.2 \pm 3.8 \pm 3.0) \times 10^{-6}$$