Search for the decay τ-$e\gamma$ using the *BABAR* detector

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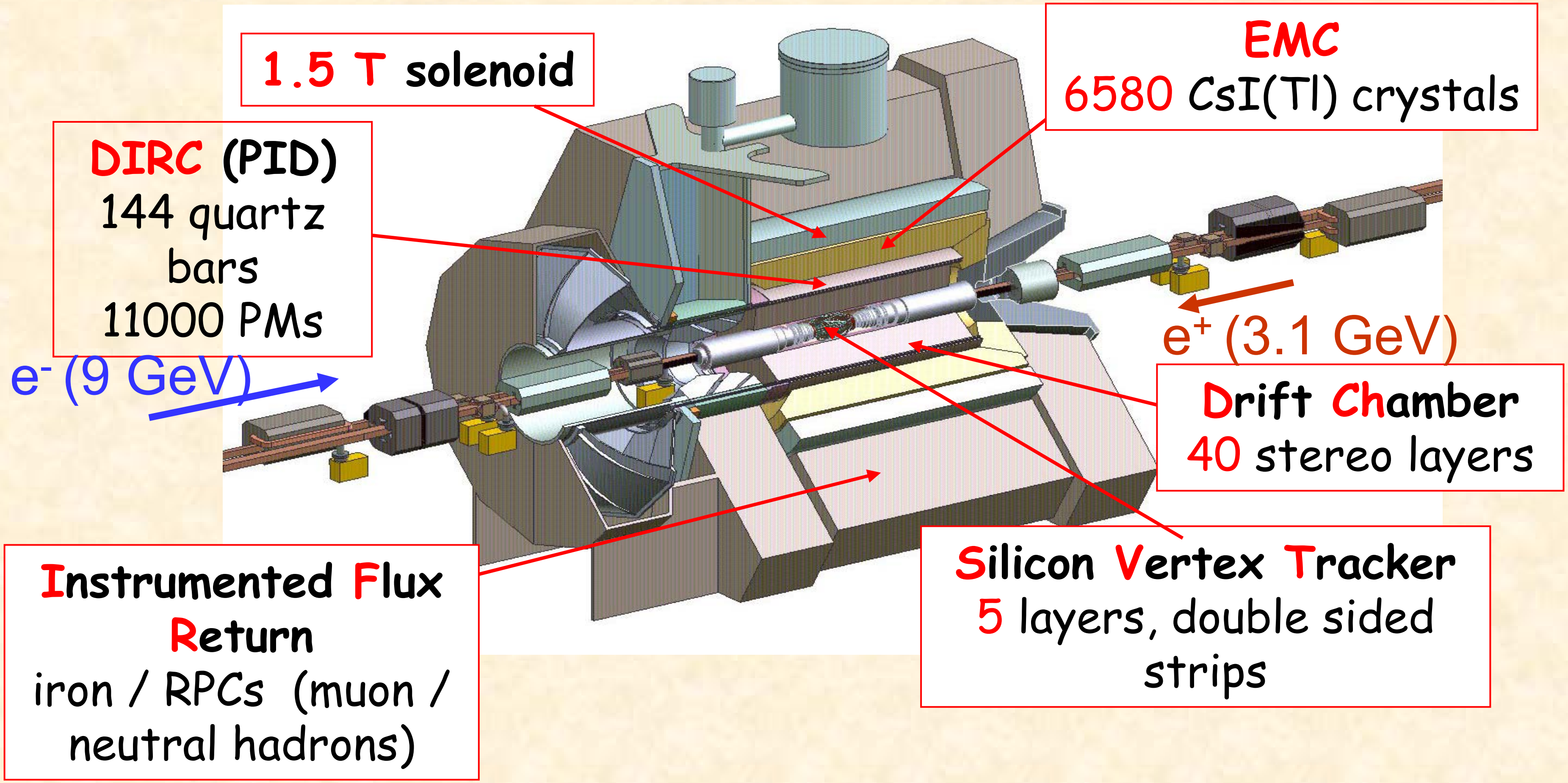
Motivation: Conservation of Lepton Number

Lepton number conservation in electro-weak processes is an assumption within the Standard Model.

Recent confirmation of neutrino oscillations supports the argument that conservation may be violated and has intensified the search for an extension to the Standard Model, which would incorporate such a violation and allow neutrinoless decays.

Stringent limits have thus far been set for μ-decays of the order of 10^{-12}. Many theoretical models with mass-dependent couplings enhance the branching fraction and make it reach-able by the size of the *BABAR* data set.

The *BABAR* Detector

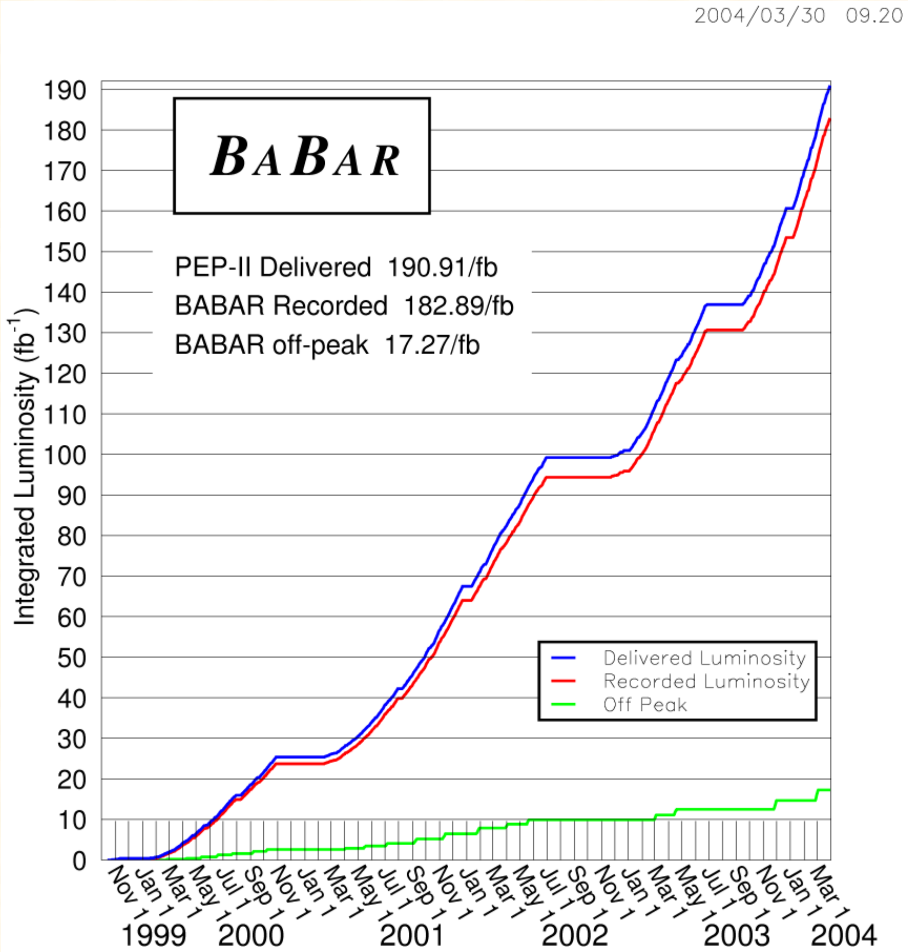


Recorded Data

At the operating energy of the *BABAR* detector the cross-section of e^+e^- to tau pair 0.89nb.

Therefore 163 million tau pairs decays have been recorded.

110 million tau pairs will be used for this analysis and comprises the data recorded up to July 2003.



Event Selection

85% of τ-decays have a single charged track .
Therefore 71.6% of τ-pairs will have a 1-1 topology.
The event will be divided into 2 hemispheres with one charged track on each side.

Signal hemisphere

- ✓ Good electron
- ✓ 1 photon
- ✓ $Mass_{e\gamma} = mass_{\tau}$
- ✓ No missing energy

Non-signal hemisphere

- ✓ Electron Veto
- ✓ Want missing energy

Pre-selection

The initial data volume is very large and the pre-selection reduces it by 80%.

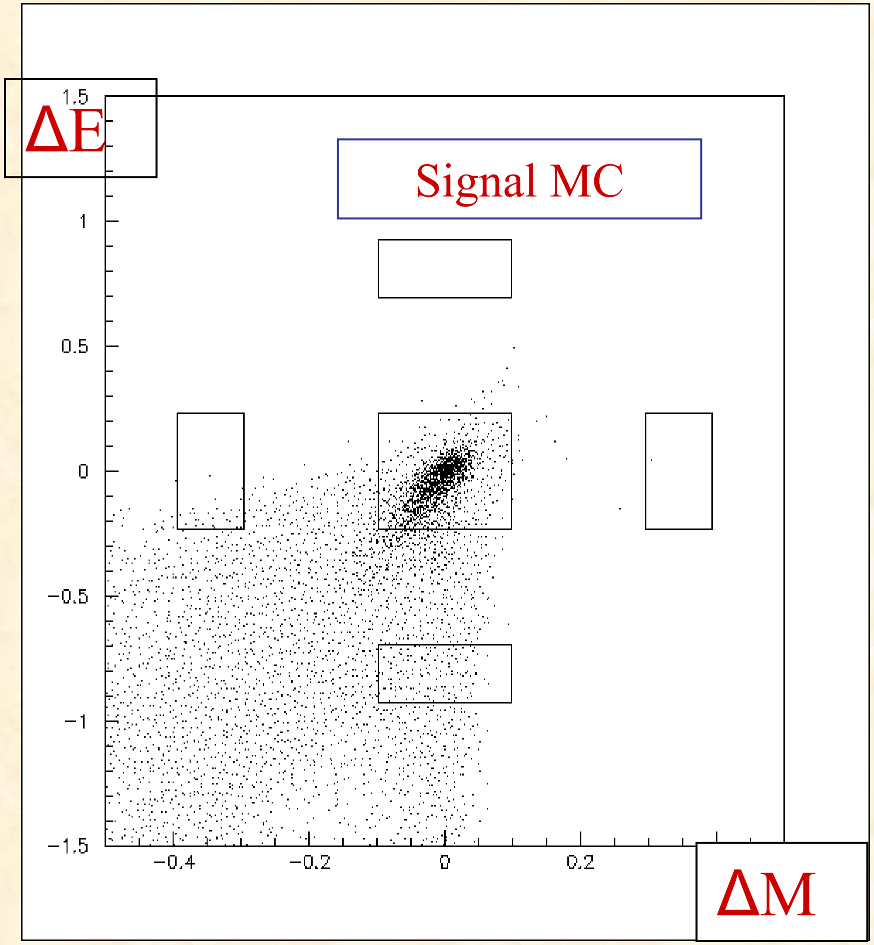
- All tracks fall within the acceptance of the calorimeter.
- Each event has only two charged tracks with total charge equals zero.
- Each event must have at least one photon.
- One charged track had to be identified as a good electron using the electron pid algorithm (signal side); the other had to be identified as not an electron (tag side).

Strategy of the Analysis (1)

- One of the major backgrounds is the vast number of bhabhas produced due to its high cross-section.
- It is estimated that a sample of bhabha MC five times the size of the data set would be required, this is impracticable.
- Use the real data to produce a sample of bhabha events to evaluate the number expected from bhabha scattering.

Strategy of the Analysis (2)

- CLEO surmounted this problem by appealing directly to the data.
- In the spirit of a blind analysis we will use a sample of data (17%) to *ONLY* set the cuts and evaluate the expected backgrounds by extrapolating from the neighbouring regions into the signal box on a plot of ΔEvΔM.
- ΔM=invariant mass-tau mass
- ΔE=signal energy-beam energy
- As a check we will use a combination of background MC's and the bhabha control sample to evaluate the expected number of background events.

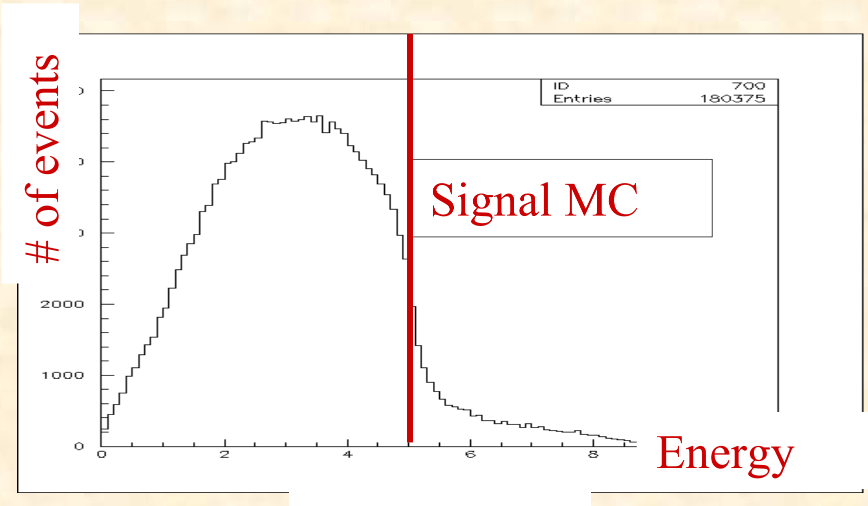


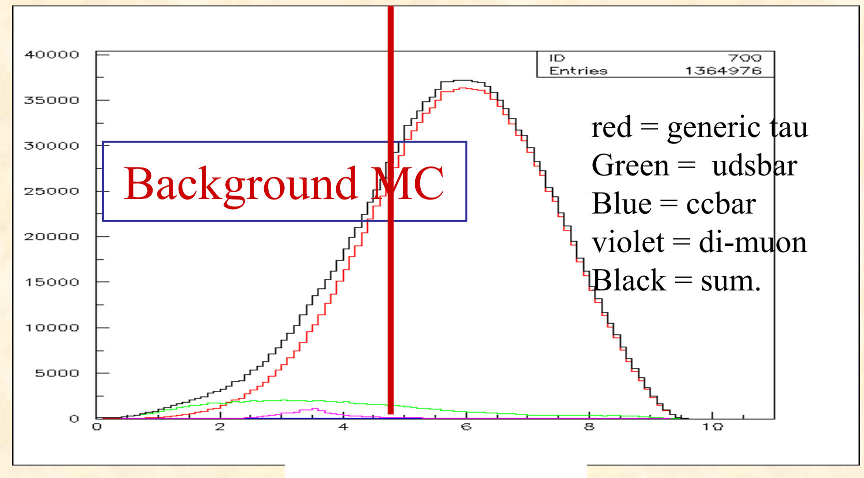
Strategy of the Analysis (3)

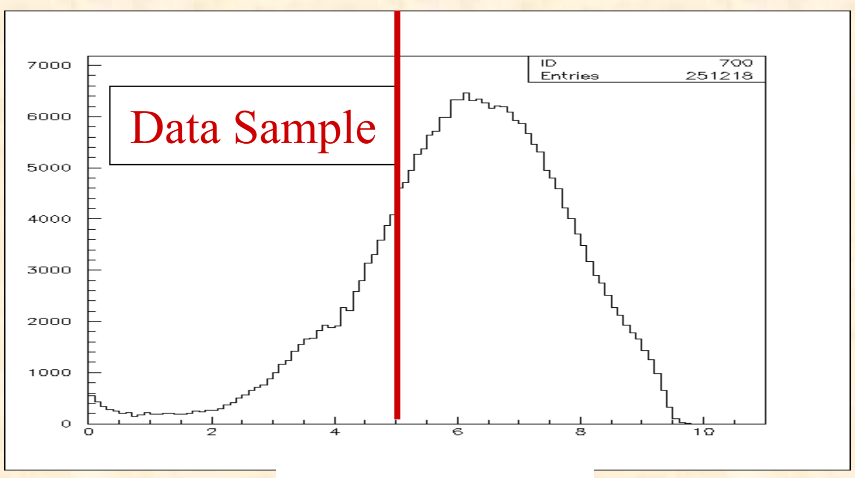
Thus, the expected number of background events can be evaluated by:

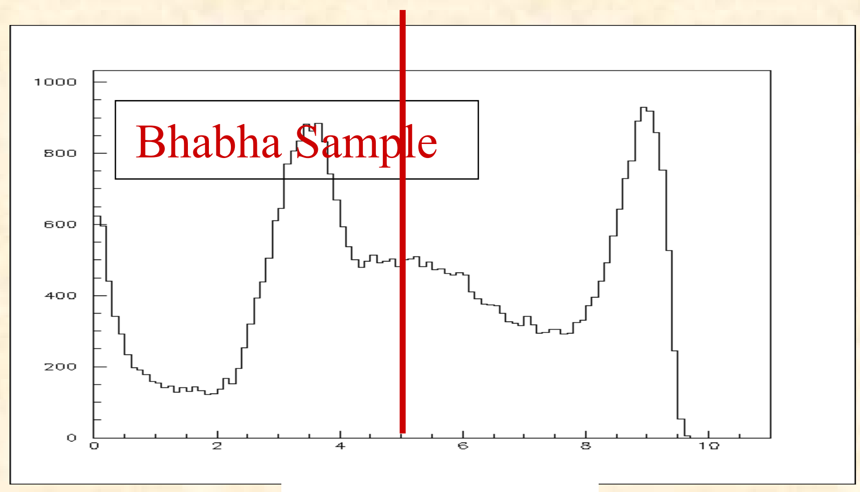
1. Data: Use the neighbouring regions.
2. A combination of background MC +bhabha control sample.
3. The background MC is a cocktail of generic tau, di-muon, ccbar and udsbar.

Missing energy in the whole event (5 GeV)

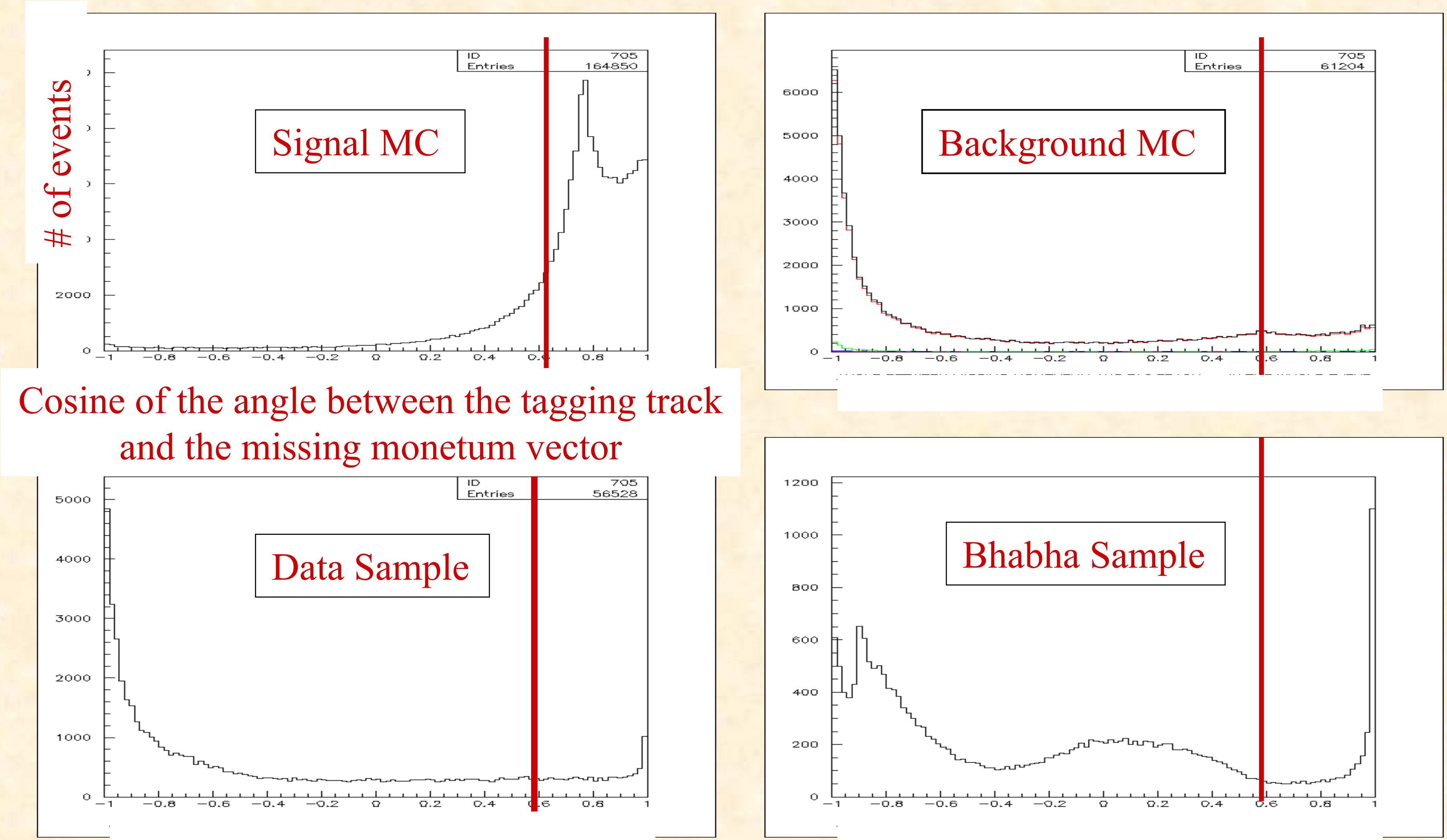




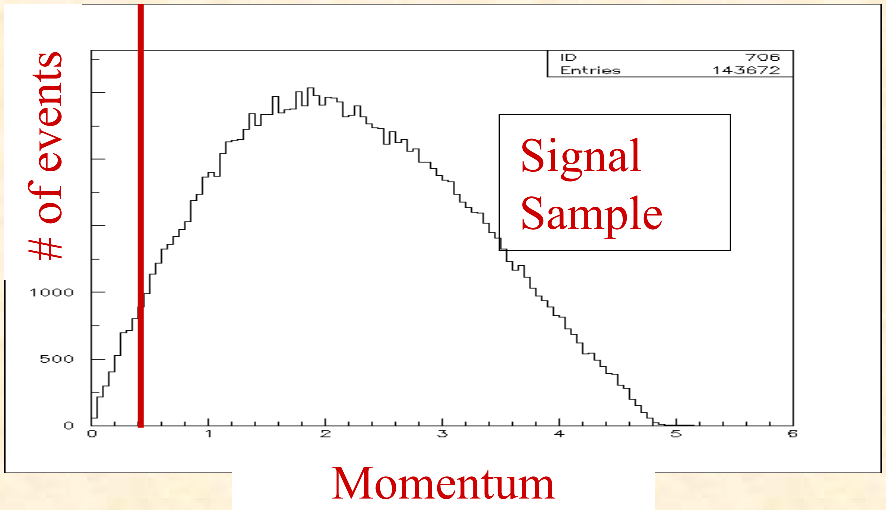


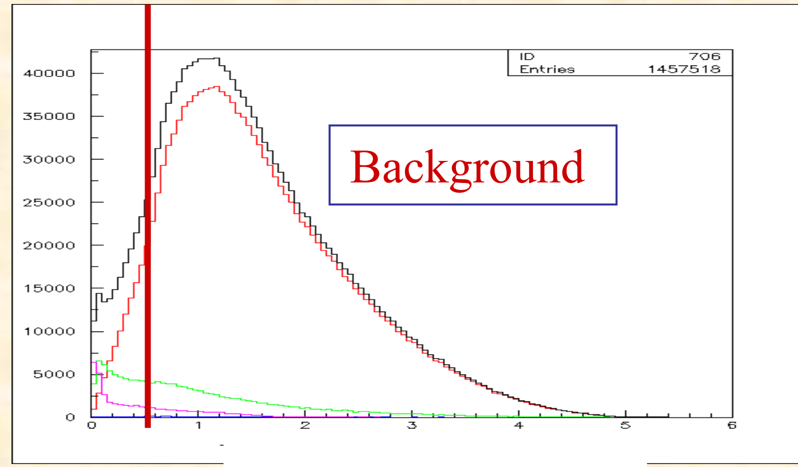


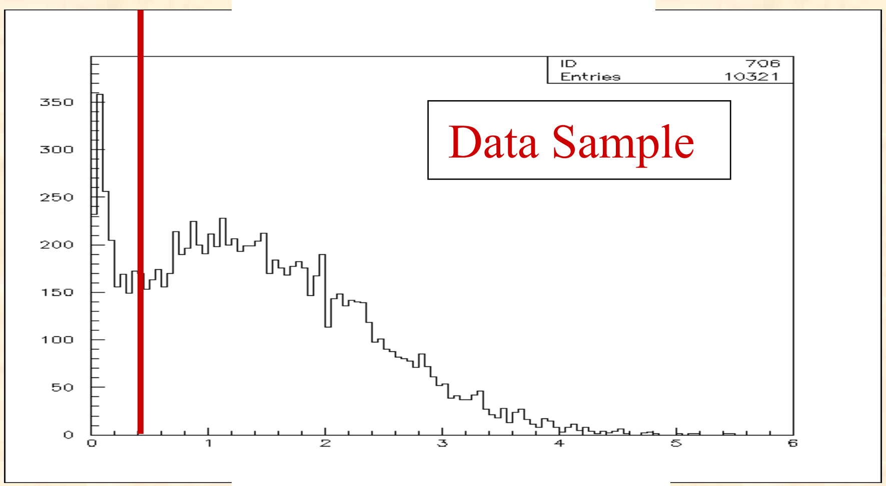
Missing momentum vector (0.6:0.988)

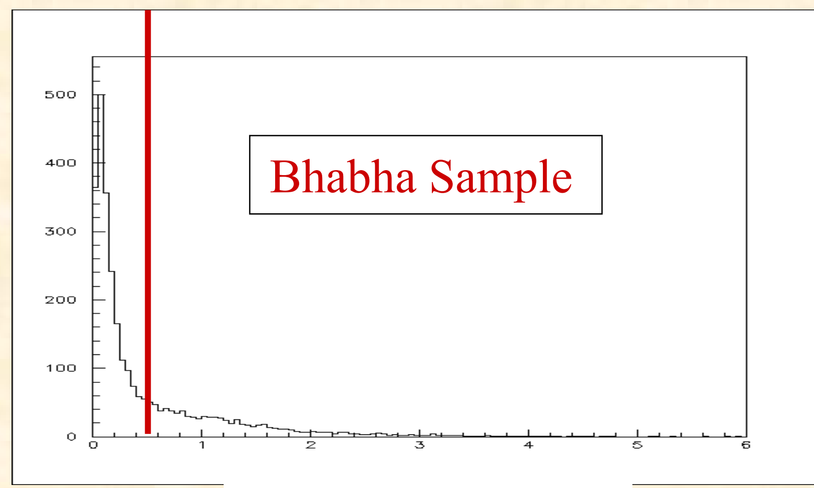


Transverse momentum of the whole event (0.5 GeV)

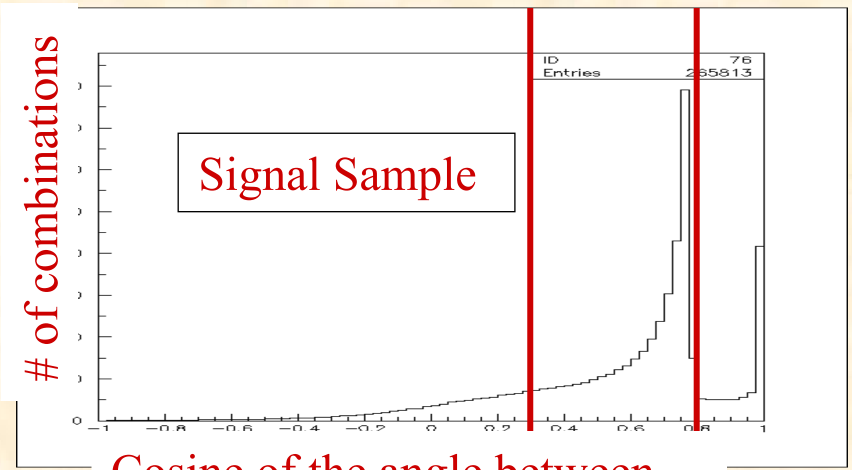


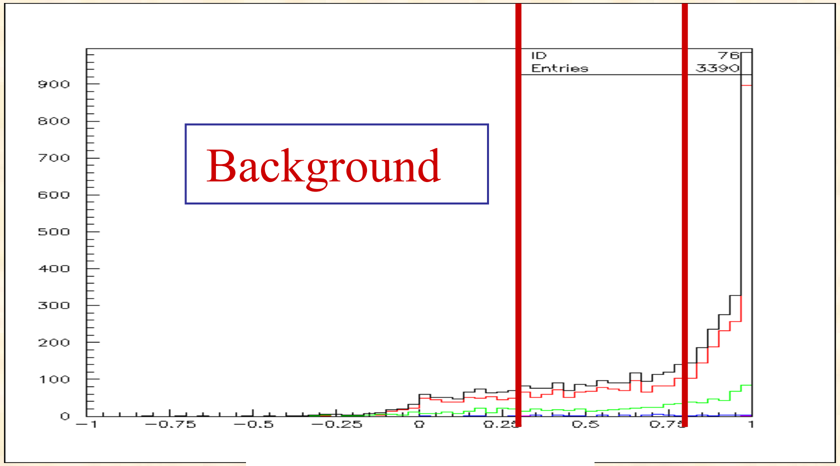




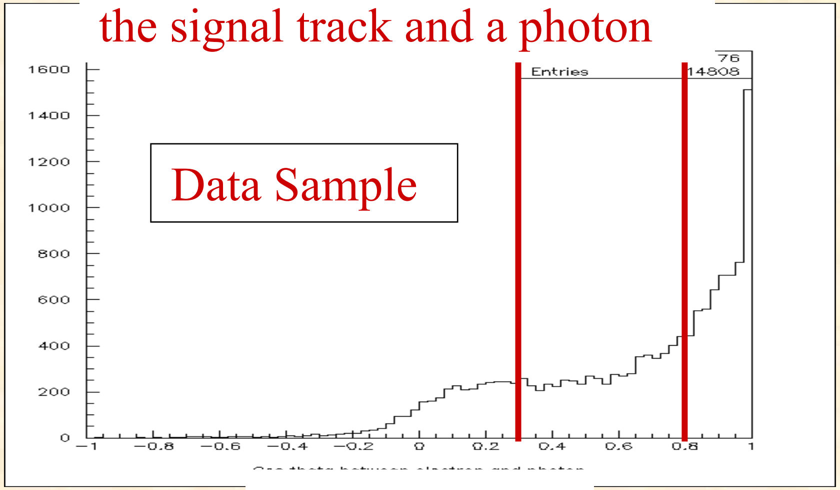


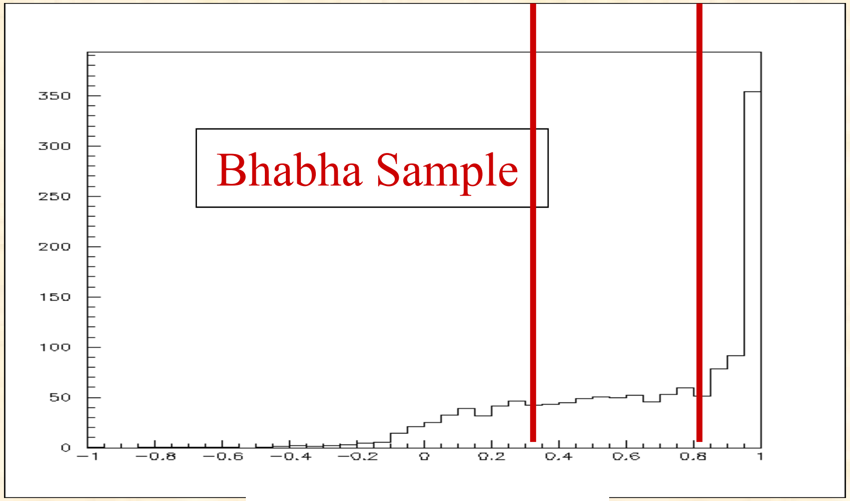
Cut to select the signal photon (0.3:0.8)





Cosine of the angle between the signal track and a photon





Mass and energy distributions

To optimise the size of the signal box CLEO used a simple gaussian fit to the mass and energy distributions.

Following this method a 5σ signal box was used.

Mass: mean = -5.3 MeV

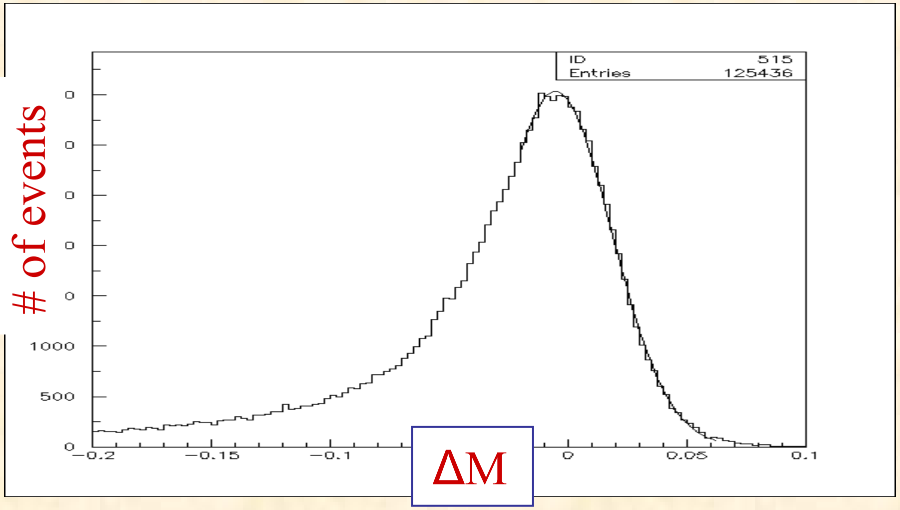
σ = 24 MeV

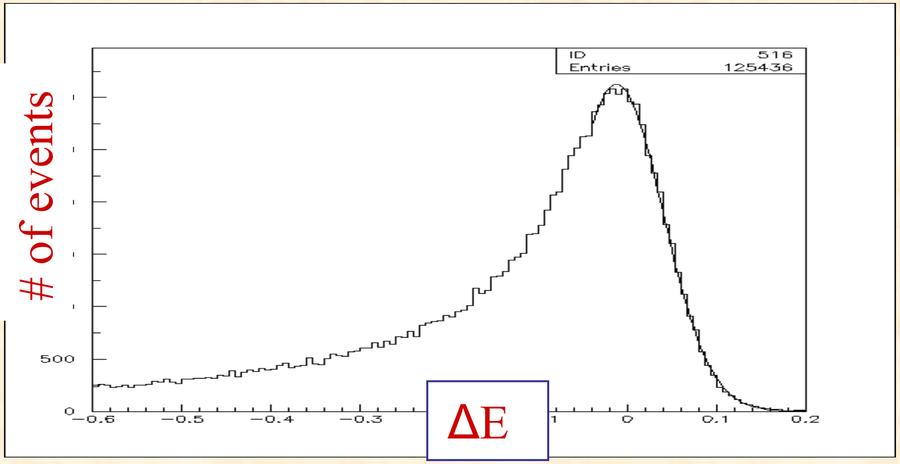
5σ = 120 MeV

Energy: mean = -12 MeV

σ = 53 MeV

5σ = 235 MeV



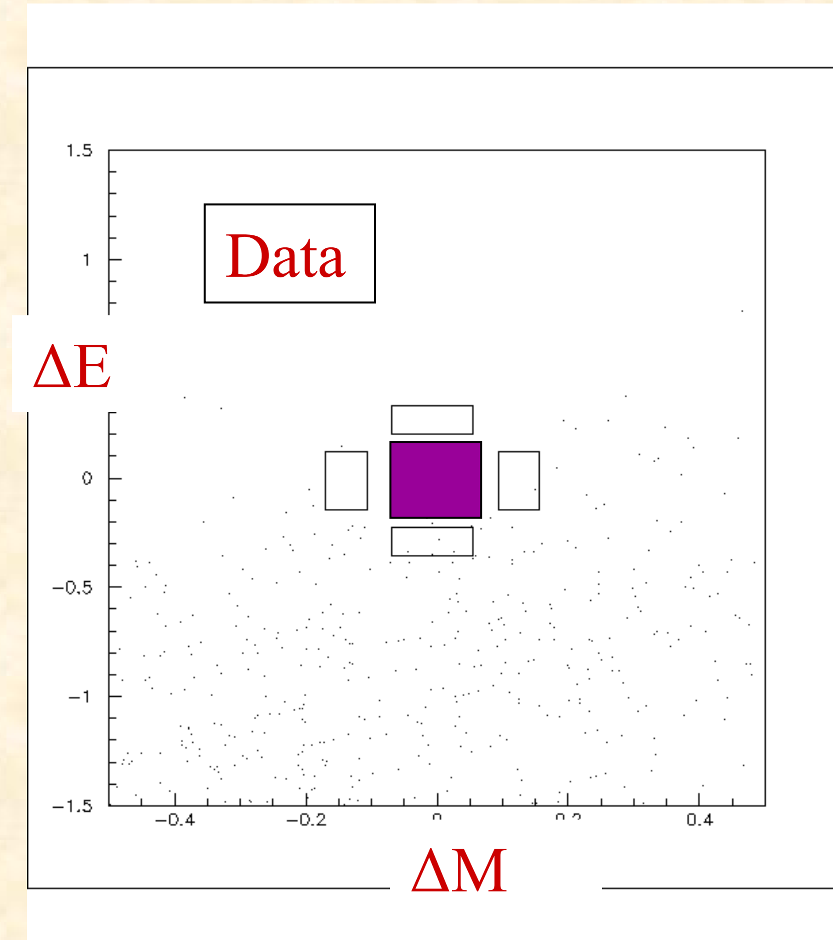


Data distribution and limit

A 5σ signal box was used with 2.5σ neighbouring regions.

2.5 background events are expected in the signal region for the 21.1 fb^{-1} sample of data with a signal efficiency of 6.4%.

There are many ways to calculate the upper limit on the expected number of signal events and thus calculate the upper limit for the branching fraction at 90% CL.



Comparison with others

Collaboration	Efficiency (%)	Luminosity (fb^{-1})	Observed	Background	Limit (10^{-7})
CLEO	10.1	4.64	0	2	27.0
BELLE	6.8	88.8	20	?	3.6
BABAR	6.4	21.1	TBA	2.5	TBA

The limit set by CLEO is the most recently published result.

BELLE reported their limit at a recent conference in Moscow.

Using 124.4 fb^{-1} the BABAR limit should be at least one order of magnitude better than CLEO and should be competitive with BELLE.

Conclusion

The cuts in their present form have been very successful in reducing the backgrounds, and enhancing the signal.

Several methods are being considered to improve the optimisation of the signal box.

The analysis will be applied to the entire runs 1, 2 and 3 data-set.

The statistical and systematic errors have yet to be studied.