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RECENT MEASUREMENTS OF THE AVERAGE LIFETIME OF HADRONS CONTAINING B-QUARKS FROM PEP EXPERIMENTS AT SLAC*

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Recent precise results from several experiments have confirmed the early evidence that the lifetime of hadrons containing B-quarks is rather long, implying that the third generation of quarks is more decoupled from the first two than the second is from the first. The average of the measurements performed by the experiments at PEP is 1.08 ± 0.13 ps.

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In recent years several groups [1] have published results on the measurement of the lifetime of particle containing b-quarks. This measurement provides information on two elements of the Cabibbo Kobayashi Maskawa matrix which define the strength of the b→u (V_{bu}) and b→c (V_{bc}) transition [2].
In this contribution we will report on recent precise measurement done at PEP by the MAC[3], DELCO[4] and HRS[5] collaboration.

Sample selection.

At PEP energies only 1/11 of the multihadrons is from b-b events but it is easy to tag semileptonic decays of B-hadrons by requiring a lepton with high tranverse momentum with respect to the initial quark direction (approximated by one of the principal axis of the event -tipically the Thrust or the sphericity axis). In this way it is possible to have a sample that contains ≥ 65% b-b events with ≥ 10% efficiency. Table 1 contains the list of the cuts and the sample composition for the three experiments.

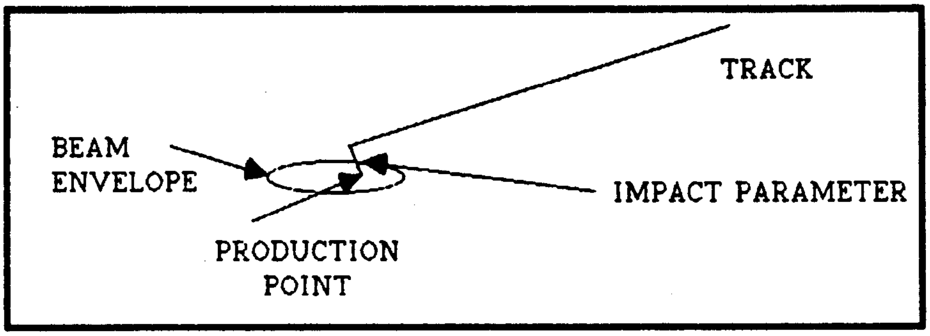
Table 1: sample selection.

Expt	Enrichment cuts	% b-b events
MAC e,μ	P ≥ 2. GEV/C PT ≥ 1.5 GEV/C	69 %
DELCO e	PT ≥ 1. GEV/C	79 %
HRS e	P ≥ 2. GEV/C PT ≥ 1.1 GEV/C	54 %

Electrons are selected by MAC and HRS by requiring consistency between the momentum of a track measured by the tracking system and the corresponding energy measured by the EM calorimeter.
DELCO has superior electron identification thanks to the very good Π rejection of their Cerenckov counters.
MAC is a very good μ detector: the μ track is sampled in the central trackers, in the hadron calorimeter and in muon chambers which are located inside and outside of the hadron calorimeter. The information from each detector is combined to form a χ^2 which is used to select well measured muons.

The Method

All three experiments estimate the lifetime from the impact parameter distribution. As can be seen from the figure the impact parameter is the distance of closest approach of a decay track to the estimated production point. This distance is given a sign depending on whether the decay appear to be forward or backward respect to the parent quark flight direction.



The primary quark flight direction is approximated by the thrust axis -MAC, HRS- or the sphericity axis -DELCO. All experiments work only with the projection on the XY plane -the plane perpendicular to the beam direction (Z)- as the beam envelope is very eleongated along Z; typically the width of the beam envelope is 70 μm along Y, 350 μm along X and 1.5 mm along Z.

In what follows, a well measured track is a track which satisfies certain quality requirements, like having many hits, a good fit etc.; the reader is anyway referred to the original papers[3,4,5] for detailed information.

While DELCO and HRS follow the standard procedure of using the beam centroid as determined from Bhabha's events on a run by run basis as the estimate for the production point, MAC uses all the well measured tracks of the event -other than the one for which the impact parameter is being measured- to determine an average vertex inside the beam envelope on an event by event basis. Montecarlo studies have shown that this procedure does not introduce biases when averaged over several events and increases the precision on the knowledge of the production point especially along X.

DELCO and HRS build the impact parameter distribution out of the well measured tagging-lepton tracks, MAC uses all the well measured tracks of the event -in average between 3 and 4- which have momentum greater than 500 Mev/c. Montecarlo studies have shown that the sample has 70% of tracks originating from b-parents, 16% from charm and 14% from light quarks. Table 2 shows the total number of tracks used and the average impact parameter obtained by the three experiments and some parameters describing the tracking precision of the various experiments. MAC has two entries as the data collected after the installation of a high precision vertex chamber is listed separately.

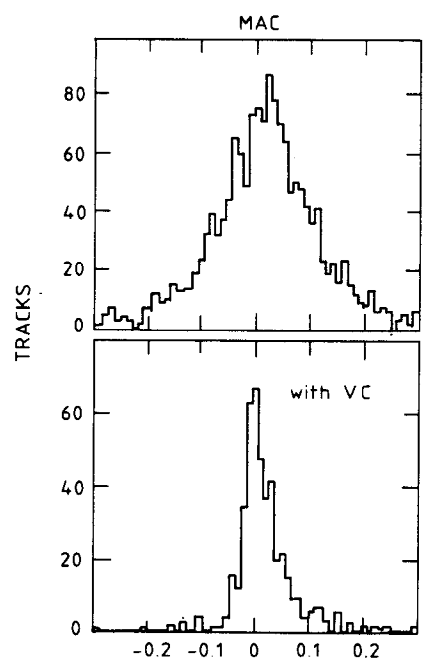
Table 2 : resolution parameters and statistics.

Expt	Point res (μm)	IP res (μm) Bhabha	# events	# tracks	Average IP (μm)
MAC	200	390	410	1558	156 ± 26
MAC (vc)	50	90	152	441	129 ± 19
DELCO	170	280	164	113	259 ± 49
HRS	100	140	312	301	80 ± 27

Lifetime Estimation.

The experimental distribution are shown in fig. 1,2,3. Each experiment uses its own method to estimate the lifetime from the distribution. DELCO and HRS build a likelyhood function using the experimental resolutions and the theoretical knowledge about what contributes to the distribution , leaving the b-lifetime as a parameter determined by maximizing the likelihood function. The reader is referred to the original papers[4,5] for the details of the fit and of the functions used. MAC has instead used the trimmed mean[b] as the estimator of the

Fig. 1: Mac I.P. Distributions



central value of the distribution and then unfolded the lifetime using the Montecarlo simulation to find which lifetime would reproduce the result. The trimmed mean is proven to be the most robust likelihood estimator when dealing with quasi gaussian resolution functions[6].

Fig. 2 DELCO IP distribution

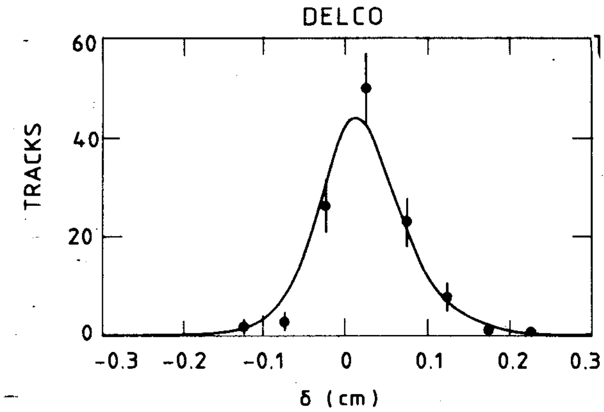
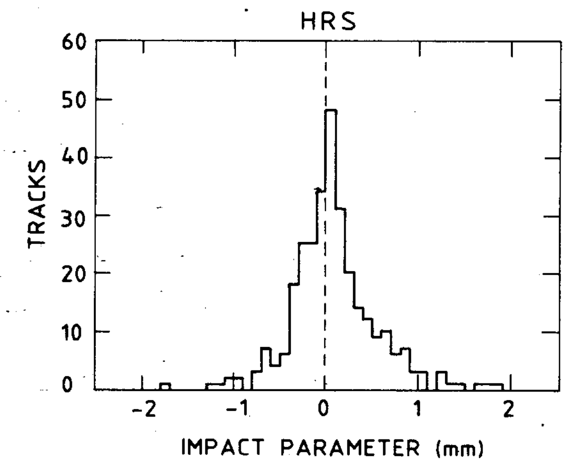
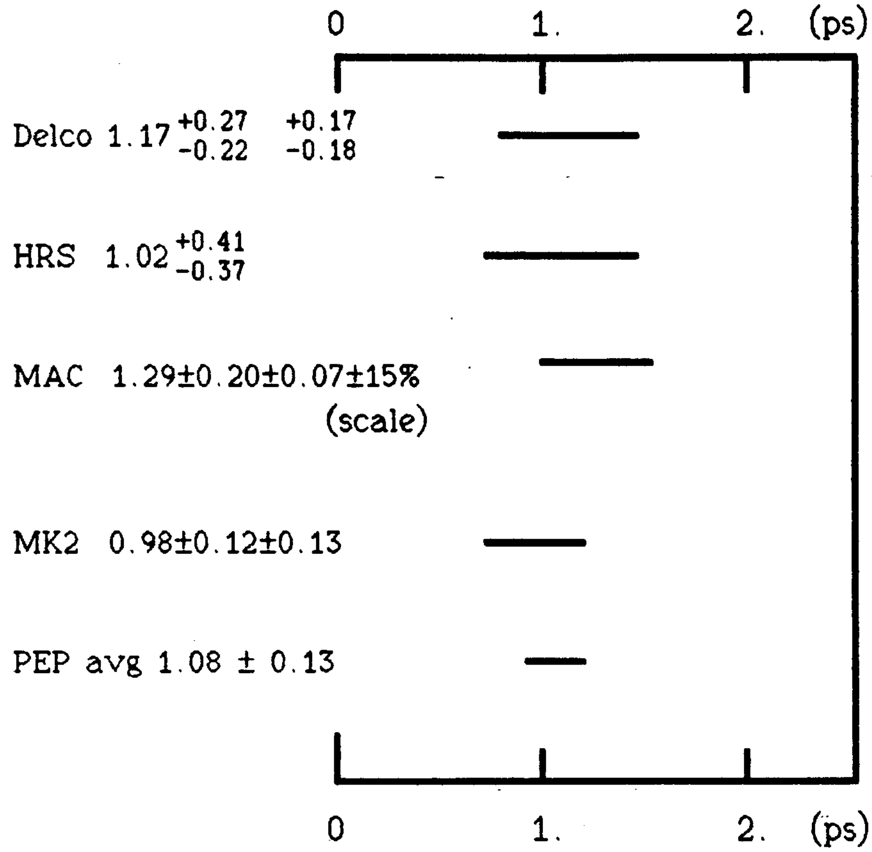


Fig. 3: HRS IP Distribution



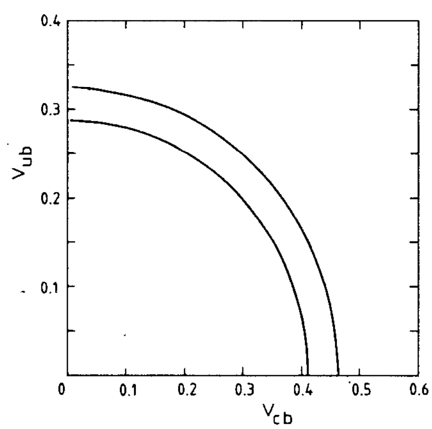
The final values, with the systematic uncertainty also specified, is shown below. The MAC collaboration has chosen to separate the systematic error into an additive part and a scale uncertainty (which is dominated by the uncertainty on the b fragmentation function) to enhance the significance of the measurement. The HRS collaboration has decided not to separate statistical and systematic contribution to the error. The final result from the MARK2[7] collaboration -which was not available at the time of the conference- is also included in the "PEP Average" which is the weighted average of the results obtained by the four experiment. The weights have been determined by adding in quadrature statistical and systematic errors -choosing the largest when having asymmetric errors. The fact that the experiments use different kinematical cuts, or like MAC include information from non semi-leptonic decays, might mean that the samples are enriched differently in neutral and charged B mesons and this might make the above average meaningless if the lifetime of the charged and neutral B mesons are very different -like for the charmed mesons. Assuming that the lifetimes are the same, fig. 4 shows how the average lifetime translates in terms of the values of the V_{bu} , V_{bc} elements of the Cabibbo, Kobayashi, Maskawa matrix using the computation of ref. [8].



Conclusions

There is firm evidence that the b is rather long-lived, or put in different words, that the coupling of the third generation of quarks to the first two is very weak. This type of experiment has reached its goal and task for forthcoming experiments will be to measure the lifetime of exclusive decay channels.

Fig. 4: Limits on V_{ub} and V_{cb} from the Average Lifetime measured by PEP Experiments.



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[b] The trimmed is defined as the mean of the distribution excluding a fraction f (trim) from the right and left tails of the distribution . For MAC the trim chosen was 5%.

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