INTRODUCTION

Two recent publications, from the MAC[1] and Mark II[2] collaborations, have reported the somewhat surprising result that the lifetime of particles made up of b quarks is in the 1 to 2 picosecond range, or somewhat longer than the lifetimes of charm particles. Although the charm decays are favored transitions while those of b particles depend upon off-diagonal elements of the weak flavor mixing matrix, the smallness of the b decay rates in face of the large available phase space indicates that the off-diagonal elements are indeed very small. The possibility for complete determination of the mixing matrix was brought significantly nearer by the availability of the lifetime information; what is needed now is to reduce the uncertainty of the measurements, which was about 33% for both experiments. We describe here an extension of the b lifetime study with the MAC detector, incorporating some new data and improvements in the analysis.

THE MAC EXPERIMENT

The decay length for short-lived particles is inferred from the distribution in the impact parameter, or distance of closest approach to the beam, of tracks that have been identified as products of the decay. Muons and electrons, which can be identified in the detector, are used in the analysis; the method for isolating leptons born in b decay is described below.

The MAC detector[3] was designed with emphasis on large acceptance and the use of calorimeters to measure energy flow, identify electrons, and filter hadrons to facilitate muon identification. It
includes a cylindrical central drift chamber for tracking charged particles which consists of ten layers of drift wires in the 5.7 kG magnetic field of the surrounding solenoid coil. The layers, extending from 12 cm to 45 cm, each provide point measurement accuracy of about 200 μm. The smallness of the inner radius helps the precision of impact parameter measurements; the relatively short tracking length, on the other hand, limits the precision because it leads to a fairly large curvature error (6p/p \approx 0.065p), which in turn affects the extrapolation to the production point.

The drift chamber is surrounded by electromagnetic and hadron calorimeters, which provide energy-flow information (used to pick out multihadron events and to define their thrust axis) and identification of electrons. Layers of lead interspersed with proportional wire chambers constitute the electromagnetic shower chamber, amounting to 16 radiation lengths of material. In the hadron calorimeter, layers of steel alternate with proportional wire chambers, such that normally incident particles traverse 91 cm of steel. The calorimeter steel in both the central and endcap regions is magnetized to about 17 kgauss by toroid coils. The entire calorimetric detector is surrounded by drift chambers for muon identification and tracking. These chambers determine the radial and axial components of the location and direction of particles penetrating the hadron calorimeters.

EVENT SELECTION

The parent sample for this analysis consists of approximately 75000 multihadron events having five or more charged prongs and calorimetric energy flow consistent with production by single photon annihilation. Cuts on the total energy, its component perpendicular to the beam, and the net energy imbalance eliminate two photon annihilation events[4],[5]. The muon (electron) sample corresponds to an integrated luminosity of 160 (127) pb⁻¹ at a center-of-mass energy of 29 GeV. This sample is about 1.5 times as large as the one used in ref. 1.

Considering first the muon selection, candidates were reconstructed and momentum-analyzed by interpolation between isolated track segments in the outer drift chambers and the primary event vertex, through the toroidal magnetic field of the calorimeter, taking into account the ionization energy loss of the particle in the calorimeter. It was required that the resulting track be matched within typically 1° in polar angle and 30% in momentum to a track reconstructed in the central drift chamber, and within 2 to 10 degrees to a segment reconstructed from the energy deposited in the central or endcap calorimeter. (The actual cuts were made on the appropriate χ², computed with inclusion of all measurement errors and the effect of multiple scattering, and are momentum dependent.) It was required that the calorim-