III.G1. LIFETIME FROM HYBRID EMULSION EXPERIMENTS

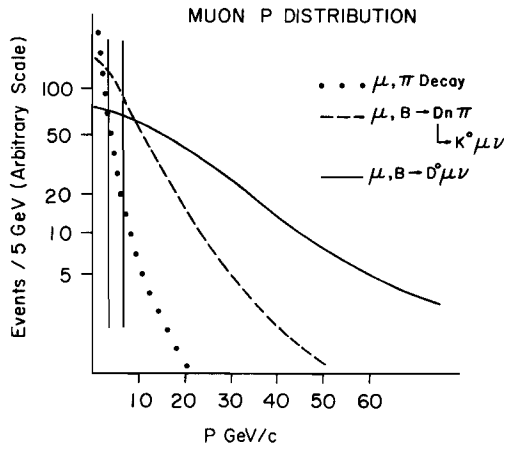
N. Stanton, Ohio State University

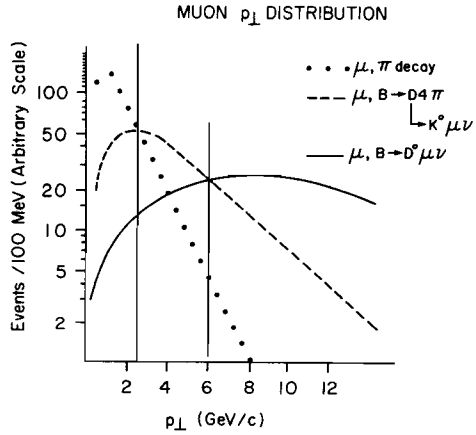
Nuclear emulsion is the only existing technique having position resolution $<1\mu$ and therefore capable of relatively bias-free measurement of lifetimes down to $\sim 10^{-15}$ s for decaying particles with $\gamma \gtrsim 25$. We note here that emulsion, coupled with a carefully designed tagging spectrometer, can provide[1] the first measurement of the B lifetime if hadronic production cross sections for $B\bar{B}$ pairs are $\gtrsim 10$ nb.

The ultimate sensitivity limit is the product of total emulsion volume ($\sim 50\ell$ is reasonable)[1,2] and maximum tolerable track density ($\sim 700\text{-}2000/mm^2$)[1,2] giving ~8-25 interactions per nb and $\sim 7\text{-}20\times 10^7$ total interactions. It is feasible to search for $\sim 2\times 10^4$ tagged events in the emulsion if the tagging is accurate and reliable. One thus needs a rejection factor of several $\times 10^3$ between total interactions and tagged candidates. The best reported finding efficiency for tagged events (Fermilab Experiment #531)[3] is 53% in a ν beam; higher efficiency can be expected in a charged beam if the beam track is unambiguously tagged and followed to the interaction.

Since the number of decays in the exposed emulsion is fixed and limited it is crucial not to waste the B events which are present by failing to find or reconstruct them. The associated spectrometer must have a high-yield signature for B events and excellent position resolution for tagging. It must be able to reconstruct high-multiplicity, collimated events with negligible losses and must have sufficient aperture, momentum resolution, and neutral detection capability to do kinematic reconstruction to obtain proper decay times. Such a spectrometer has been designed[1] using position-sensitive silicon detectors.

Event selection based on clean identification of a single muon can give the necessary background rejection while tagging an appreciable fraction of the B's in the emulsion (see Fig. 1). In addition to the stiff, high p_T muons from $B \to \mu X$, of which rather stringent cuts lose only 20%, one can also include most of the events with softer muons from $B \to D^{\pm}X$, $D^{\pm} \to \mu X$ provided the $D^{\pm}$ decay vertex can be reconstructed. This can be done with surprisingly good efficiency with high resolution detectors. Note that the $D^{\pm}$ are both long-lived ($\tau \sim 10^{-13}$ s)[3] and also the chief source of muons in charm decays. The product of branching ratios, muon acceptances and cut survival from these two muon sources give a tagging efficiency of 8% for B's in the emulsion.[1] Assuming that half of these are found and using 8-25 events/nb in the emulsion, one obtains a yield of 6-18 found B decays per 10 nb of $B\bar{B}$ cross section. Since the acceptance of the spectrometer for $B\bar{B}$ decays is ~60%, these events should suffice to determine the lifetime to better than ±50%.





Tagging Efficiency.[a]

Process	μ Cut	BR	Cuts and Acceptance	Net Efficiency
$B \to \mu X$	$p > 6$, $p_T > 0.6$ GeV	10%	60%	6%
$B \to D^{\pm}X$	$p > 3.5$, $p_T > 0.25$ GeV	7%	30%	2%
$\quad \vert \to \mu X$			Total 8%	

[a]Note that each event gives a pair of B's with 8% chance of tagging each one, or 16%/pair.

It should also be noted that the same apparatus can simultaneously obtain ~2000 found charm decays in the emulsion for high-statistics lifetime determinations.

References

1. N. Ushida et al., Fermilab Proposal #653, 1980.

2. G. Baroni, report on CERN NA-19 at this workshop.

3. N. Ushida et al., Measurement of the D^0 Lifetime, DOE/ER/01545-277, 1980; N. Ushida et al., Measurement of the D+, F+, and Λ_c^+ Charmed Particle Lifetimes, DOE/ER/01545-278, 1980.