Exp95-002: Direct Measurement of the Lifetime of the Heavy Hypernuclei at CEBAF

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The lifetime of heavy Λ hypernuclei is an especially interesting subject from the viewpoint of the weak-decay mechanism of the Λ in a nucleus. High precision measurements of hypernuclear lifetimes and their A dependence will provide valuable constraints in attempts to understand many fundamental issues in hypernuclear physics. Such issues include the effective YN interaction and its range, $\Lambda N \rightarrow N+N$ non-mesonic decay mechanism, and modification of the mesonic decay rate in the nuclear medium due to explicit quark effects.

A high precision hypernuclear lifetime measurement for various masses, especially in the heavy region, is indeed necessary and important. However, the presently available data are scarce, extremely poor in quality (about 100% relative error in most of cases), and no data are available for A>16.

Exp95-002 is designed to carry out a direct measurement of the lifetime of heavy Λ hypernuclei by fully utilizing the unique features of the CEBAF beam (2 ns beam bunch spacing and 1.67 ps bunch width) and fission fragment detection techniques. Since the hypernuclei will be produced by $(e,e'K^+)$ reactions, this experiment is designed to ensure Λ hypernuclear production once a kaon been detected by the SOS spectrometer. Since the nonmesonic decay of Λ dominantly determines the lifetime of the Λ hypernuclei and releases a large amount of energy (176 MeV), the probability of a time delayed fission ($\sim 10^{-10}$ sec) due to Λ hypernuclear decay is more than two orders of magnitude higher than that of prompt fission due to other sources. Thus, coincident detection of a kaon and delayed fission will select the decay of a Λ hypernucleus.

The fission fragments will be detected by a low pressure MWPC chamber systems (LPMWPC) mounted around target. The detected kaon will be used to select the event and, more importantly, to reconstruct the correct beam bucket during which the hypernucleus was produced. The timing resolution of SOS system is about 150 ps. Since the beam bunch width is only 1.67 ps, the reconstructed beam bucket provides an absolute zero time for the production of a Λ hypernucleus. The LPMWPC is a well known technique commonly applied in the nuclear fission experiments. Having excellent position and timing resolution (200 μm and 130 ps FWHM, respectively), sensitiving only to the desired Z range of fragments, and having 100% detection efficiency. With high count rate capability and radiation resistance, the position and timing information provided by the double plane system will allow reconstruction of the actual decay time with respect to the correct production beam pulse. Overall timing resolution for the decay time spectrum will be about 200 ps FWHM. The prompt fission time spectra from various channels will be measured simultaneously providing an accurate determination of the prompt background line shape parameters and an accurate absolute time-zero shift correction due to all possible systematic errors. The lifetime extraction accuracy can be about ±7 ps in this experiment and the first chosen target will be Bi.