A PRECISION MEASUREMENT OF THE POSITIVE MUON LIFETIME USING A PULSED MUON BEAM AND THE μLAN DETECTOR

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The goal of PSI Experiment R-99.07.1 is to measure the positive muon lifetime to 1 ppm precision, thus determining the Fermi coupling constant, G_F to 0.5 ppm. The experiment requires a high-intensity pulsed muon beam, which can be obtained from the πE3 beamline at PSI and the use of a fast electrostatic kicker. A nearly hermetic spectrometer composed of 340 thin scintillators is used to measure the muon decays, and a fast data acquisition system featuring a bank of 500 MHz waveform digitizers (WFDs) is used to quantify the events.

In July 2002 we spent three weeks in the πE3 beam line, leading to several encouraging results:

- Several beam tunes were tested and refined to produce a kickable beam upstream and a small target spot size. Extending the πE3 beamline with two additional triplets and a slit system, we produced a target spot size from 1 to 3 cm RMS and flux of up to 50 MHz depending on slit settings.
- A box magnet was used to simulate the effects of the electrostatic kicker. Using the magnet to induce the same deflection on the muons as the kicker, the measured extinction factor exceeded 3000 at a beam rate of 15 MHz (see Fig. 1).
- A total of 44 detector elements (13% of the full system) were tested and were found to perform as expected. Additionally, the data obtained permitted a determination of the depolarization factor for stopped muons in sulfur relative to silver to be 11.5 (see Fig. 2). Lifetime data accumulated during tests resulted in a 140 ppm measurement of τ_μ.

In addition to the work during the run, we have made progress in all areas of the experiment:

- A contract has been signed with TRUIMF to build the fast HV switching electronics for the muon kicker and work has begun. The kicker will consist of two pairs of plates, operated in series, to give a 25 kV kick for 1.5 m. This kicker will be commissioned in 2003.
- A single-channel prototype waveform digitizer (WFD) has been built and shown to successfully reproduce a signal with a 500 MHz sampling rate. The design of a four-channel board with VME interface, external memory, and other necessary I/O signals has been completed. Final testing of these boards is expected by early Summer, 2003.
- Parts for the remaining 300 detector elements have been ordered and assembly is taking place. Design specifications are being completed for the detector mechanical support. The full detector is expected to be commissioned in Fall, 2003.
- A "mini-Mulan" DAQ was used during the 2002 summer run based on the Midas data acquisition package and ROOT analysis package. A VME crate was used to read 12 WFD and 1 MTDC modules from the BNL g-2 experiment at a rate of 1-2 MB/sec. We are currently working on an improved data compression algorithm in the MIDAS front-end, more efficient coupling between MIDAS and ROOT, and a means of storing 10 TB of partially processed data per run.

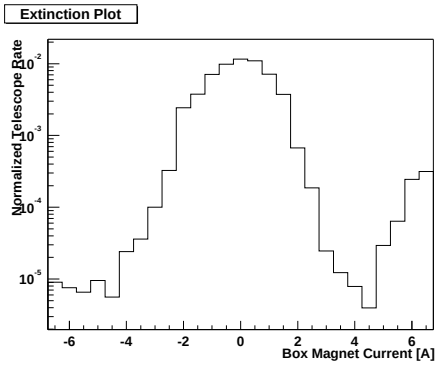

Figure 1: Muon flux as a function of box magnet current.

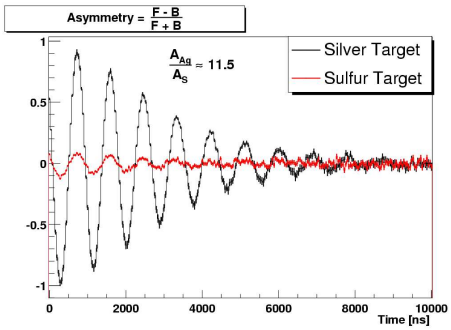

Figure 2: Forward - backward asymmetry for silver and sulfur targets.