Precision Measurement of the μ^+ Lifetime - the μLAN experiment

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*and the μLAN Collaboration**

The Fermi constant G_F is a fundamental parameter of the Standard Model which determines the strength of all weak processes. Due to recent theoretical efforts, the dominant uncertainty in G_F is from experiment only.

The goal of the μLAN (Muon Lifetime ANalysis) experiment is a 1 ppm measurement of the positive muon lifetime τ_{μ^+}, using a high intensity muon beam at the Paul Scherrer Institute (PSI). This would represent a 20-fold improvement over previous efforts, resulting in a G_F precision of 0.5 ppm.

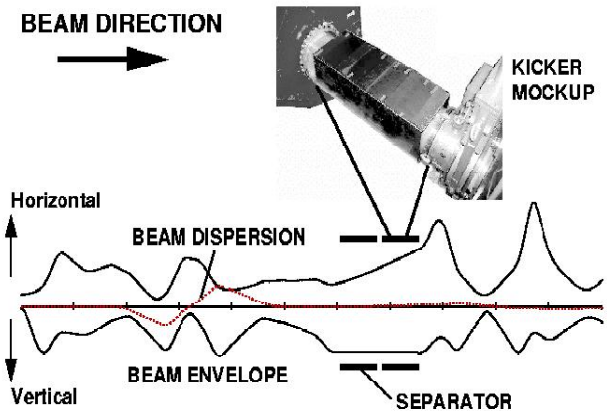

Figure 1: Beamline envelopes for the muon beam tune of PSI's πE3 area. The positions of the μ-e separator and the beam kicker are indicated.

The experiment requires a high-intensity pulsed muon beam, a nearly hermetic decay spectrometer, a high precision clock system, and a fast DAQ to obtain the high statistics.

Last year we made significant progress in developing a beam tune (Fig.1) which delivers a muon flux of up to 50 MHz, far better than the original design value of 11 MHz. Using a mockup of a fast switching electromagnetic kicker, which supplies muons on demand, we found a beam extinction factor (the ratio of beam-off to beam-on during kicker activation) of 3×10^{-4} at 15 MHz beam rate, which exceeds the design criteria.

The challenges of the decay positron measurement are in: (1) construction of a high efficiency detector, (2) cancellation of residual muon polarization effects (achieved by detector symmetry and the application of a magnetic field), and (3) the minimization of systematic uncertainties due to signal pile-up or beam straggling.

After several improvements, various detector subelements have been rigorously tested (Fig.2). 13 % of the detector has been comissioned and the remainder is under construction.

Prototypes of the newly-developed 500 MHz wave-form digitizers for ns pulse resolution have been tested.

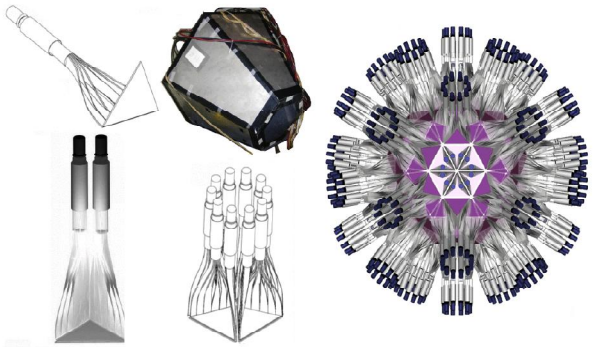

Figure 2: Matruschka type view of the μLAN detector: single scintillator, lightguide and photomultiplier housing; tile pair; pentagon and hexagon sub-elements; complete detector ball.

Our first test data, obtained with alternate sulfur and silver targets, yielded a τ_{μ^+} at 136 ppm precision, in excellent agreement with the PDG value. Installation and tuning of the final beamline, followed by a commissioning run with the full detector setup, is planned for 2003.

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