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A New Part-Per-Million Measurement of the Positive Muon Lifetime and Determination of the Fermi Constant

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on behalf of the MuLan Collaboration

The Fermi constant, G_F, describes the strength of the weak force and is determined most precisely from the mean life of the positive muon, tau_mu. Advances in theory have reduced the theoretical uncertainty on G_F as calculated from tau_mu to a few tenths of a part per million (ppm). Until recently, the remaining uncertainty on G_F was entirely experimental and dominated by the uncertainty on tau_mu. We report the MuLan collaboration's recent 1.0 ppm measurement of the positive muon lifetime. This measurement is over a factor of 15 more precise than any previous measurement, and is the most precise particle lifetime ever measured. The experiment used a time-structured low-energy muon beam and an array of plastic scintillators read-out by waveform digitizers and a fast data acquisition system to record over 2 x 10ˆ12 muon decays. Two different in-vacuum muon-stopping targets were used in separate data-taking periods. The results from these two data-taking periods are in excellent agreement. The combined results give tau_{muˆ+}(MuLan)=2196980.3(2.2) ps. This measurement of the muon lifetime gives the most precise value for the Fermi constant: G_F(MuLan) = 1.1663788 (7) x 10ˆ-5 GeVˆ-2 (0.6 ppm). It is also used to extract the muˆ-p singlet capture rate, which determines the proton's weak induced pseudoscalar coupling g_P.

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