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MuLan, a part-per-million measurement of the positive muon lifetime

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We report the results from a part-per-million measurement of the positive muon lifetime τ_μ, and a commensurate determination of the Fermi constant G_F, by the MuLan Collaboration. The Fermi constant governs the rates of all weak interaction processes and, together with the fine structure constant α and the Z-boson mass M_Z, fixes the electroweak sector of the Standard Model. Additionally, precise knowledge of the free muon lifetime τ_μ is necessary for interpreting the results from ongoing lifetime measurements of muonic hydrogen and deuterium atoms. The MuLan experiment was conducted at the Paul Scherrer Institute in Villigen, Switzerland using a pulsed surface muon beam, in-vacuum muon-stopping targets, and a large acceptance, finely segmented, fast timing, scintillator array. The scintillator pulses were recorded by 500 MHz, 8-bit waveform digitizers and stored by a high-speed data acquisition system. A total of $\sim 10^{12}$ decay positrons from muon stops in both a magnetized iron alloy target and a crystal quartz target were recorded. Thorough studies were conducted of systematic effects from positron pulse pileup, muon spin rotation, and other sources. The measured lifetimes from the two different targets are in excellent agreement and together yield a measurement of τ_μ to better than 1.3 ppm and a determination of G_F to better than 0.8 ppm.

[1]on behalf of the MuLan Collaboration