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New Measurements of the $\pi^+ \to e^+ \nu_e$ Branching Ratio

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Study of rare decays is an important approach to search for new physics beyond the Standard Model. The branching ratio of charged pion decays, $R = \Gamma(\pi^+ \to e^+ \nu_e(\gamma))/\Gamma(\pi^+ \to \mu^+ \nu_\mu(\gamma))$ is one of the most precisely calculated processes involving quarks with $R_{SM} = (1.2352 \pm 0.0001) \times 10^{-4}$. Precise measurement of R provides one of the most stringent tests of the hypothesis of electron-muon universality in weak interactions. The current experimental values of the branching ratio are $R_{EXP} = (1.2265 \pm 0.0034(stat) \pm 0.0044(syst)) \times 10^{-4}$ (TRIUMF, 1992) and $R_{EXP} = (1.2346 \pm 0.0035(stat) \pm 0.0036(syst)) \times 10^{-4}$ (PSI, 1993), which indicate that there is a room for improvement by two orders of magnitude in precision. The goal of PIENU experiment at TRIUMF is to improve the accuracy of the branching ratio measurement by a factor of 5, to $< 0.1\%$. This precision allows potential access to new physics up to the mass scale of 1000 TeV for pseudoscalar interactions. Examples of the new physics probed include R-parity violating SUSY, heavy neutrino mixing, excited gauge bosons, leptoquarks, compositeness, and the effects of charged Higgs bosons.

The PIENU experiment collected about 4.5×10^5 $\pi^+ \to e^+ \nu_e$ events, which corresponds to about 30 times higher statistics than in the previous TRIUMF experiment. The time and energy of decay positrons from decays of pions at rest were measured in a spectrometer employing plastic scintillators, tracking detectors, and NaI(Tl) and pure CsI crystals. The branching ratio is obtained from the ratio of the positron yields from $\pi^+ \to e^+ \nu_e$ decays ($E_e = 69.8$ MeV) and $\pi^+ \to \mu^+ \nu_\mu$ decays followed by $\mu^+ \to e^+ \nu_e \overline{\nu_\mu}$ decays ($\pi^+ \to \mu^+ \to e^+$, $E_e = 0.5$ to 52.8 MeV). Two energy regions, above and below the $\pi^+ \to \mu^+ \to e^+$ distribution were used to determine the time spectra of decay positrons. Data in the two regions are fitted simultaneously to extract the branching ratio to which corrections are applied. The most important corrections resulting in systemmatic uncertainties include the $\pi^+ \to e^+ \nu_e$ low energy distribution in the calorimeter due to shower leakage and the difference of positron acceptances between $\pi^+ \to e^+ \nu_e$ and $\pi^+ \to \mu^+ \to e^+$ events. The current analysis corresponds to approximately 10% of the statistics of the full data. Results will be presented.

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