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Precision Measurement of the Muon Magnetic Moment Anomaly at the Fermilab Muon g-2 Experiment

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The Fermilab Muon g-2 Experiment measured the muon magnetic moment anomaly to a precision of 200 parts per billion (ppb), after combining data from 2019 and 2020 with those from 2018. It involves high-precision measurements of the anomalous muon spin precession frequency ω_a, as well as the magnetic field experienced by the muons. ω_a is measured with polarized muons decaying in a dipole magnetic field inside a storage ring. The parity violation property of polarized muon weak decay causes the measured decay rate above an optimized energy threshold to fluctuate over time at a frequency ω_a, which is extracted through fitting. Additional corrections are applied to account for beam dynamics effects. On the other hand, the magnetic field is measured using Nuclear Magnetic Resonance (NMR) probes. Absolutely calibrated NMR probes mounted on a survey trolley measure the magnetic field inside the muon storage ring, and fixed NMR probes located at various locations around the ring track the field over time. The measurements are synchronized and interpolated, then averaged over space and time, and weighted by the muon density. Transient magnetic field influences are addressed by additional corrections. The uncertainty in the newly released data was improved over multiple aspects other than statistics. Better running conditions, more systematic studies, and analysis improvements all contributed to the 70-ppb systematic uncertainty of the new result, surpassing the 100-ppb proposal goal.

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