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Measurement of the anomalous spin precession frequency ω_a in the Muon $g-2$ experiment at Fermilab

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The muon anomaly, $a_\mu = (g_\mu - 2)/2$, is a low-energy observable which can be both measured and computed to high precision, making it a sensitive test of the Standard Model (SM) and a probe for new physics. The current discrepancy between the experimental value and the Standard Model calculation from the Muon $g-2$ Theory Initiative [T. Aoyama et al. - Phys. Rep. 887, 1 (2020)] is $a_\mu^{exp} - a_\mu^{SM} = (251 \pm 59) \cdot 10^{-11}$, with a significance of $4.2\,\sigma$.
The Fermilab E989 experiment aims, with the full statistical power, to measure a_μ with a precision of 140 parts per billion (ppb), a four-fold improvement with respect to the previous measurement at the Brookhaven E821 experiment (1997-2001).
In April 2021 the FNAL E989 collaboration published their first result, based on the first year of data taking (2018 campaign) [B. Abi et al. (Muon $g-2$ Collaboration), Phys. Rev. Lett. 126, 141801 (2021)], and this year a new result is expected to be published, based on the datasets collected during Run-2 and Run-3 (2019 and 2020 campaigns).
A 3.1-GeV spin-polarized beam of muons is injected into a storage ring of 14 m of diameter, in the presence of a 1.45 T magnetic field. The anomaly a_μ can be extracted by accurately measuring the anomalous muon spin precession frequency, ω_a, and the magnetic field environment using Nuclear Magnetic Resonance techniques. The measurement of ω_a is based on the arrival time distribution of decay positrons in the high-energy tail of the spectrum, observed by 24 electromagnetic calorimeters that are placed around the inner circumference of the storage ring. The histogram of positron counts is fitted with a function that takes into account detector and beam dynamics effects.
This talk will present details about the improvements and upgrades to the positron reconstruction and to the ω_a analysis since the 2021 results, and it will describe the final statistical and systematic sources of uncertainty in the new result.

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