Beam dynamics corrections to the Run-1 measurement of the experiment Muon g-2 at Fermilab

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The Muon anomalous magnetic moment

The Muon g-2 experiment at Fermilab aims to measure the muon anomalous magnetic moment (a_μ). $R'_\mu = \frac{\omega_a}{\tilde{\omega}'_{p(T_r)}}$ is the ratio of the measured quantities and corrections:

$$R'_\mu \approx \frac{f_{clock}\omega_a^m\left(1 + C_e + C_p + C_{ml} + C_{pa}\right)}{f_{calib} < \omega'_p(x,y,\phi)\times M(x,y,\phi) > \left(1 + B_k + B_q\right)}$$

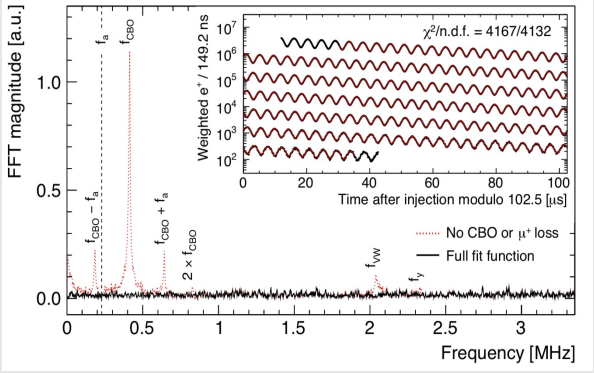
The numerator includes the precession frequency ω_a^m and the four beam dynamics corrections C_i. The denominator includes the magnetic field measurement.

Beam Dynamics motion in ω_a fit

The number of positrons as a function of time t is modelled as:

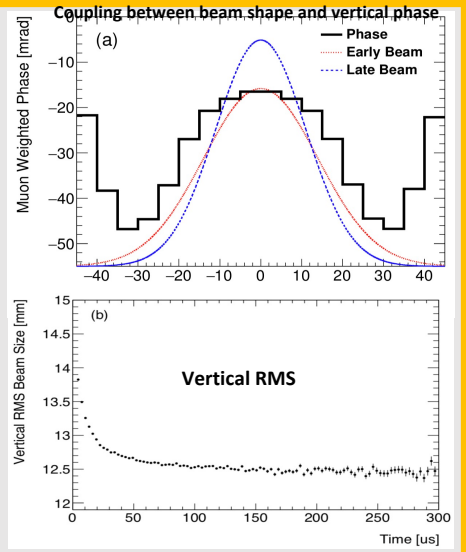
$$N(t) = N_0\eta_N(t)e^{-\frac{t}{\gamma\tau_\mu}}\times\left[1 - A\eta_A(t)\cos\left(\omega_a t + \phi_0 + \eta_\phi(t)\right)\right] (1)$$

The muon beam oscillates radially and vertically, its motion is measured via tracker stations. Fourier transforms of fit residuals show no unmodeled frequency components.



Phase Acceptance correction: C_{pa}

The phase for a given (x, y) decay coordinate depends on the orientation of the muon's spin that maximizes the acceptance. Its orientation is rotated respect to momentum causing an effective phase shift φ_{pa}. It is caused mainly by the beam vertical width variation during the muon *fill*. The net effect on ω_a is computed via toyMC simulation.



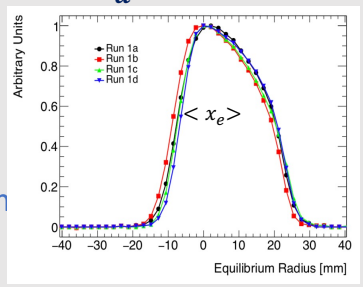
ω_a Beam Dynamics Corrections

Final **Run1** corrections on ω_a due to beam dynamics

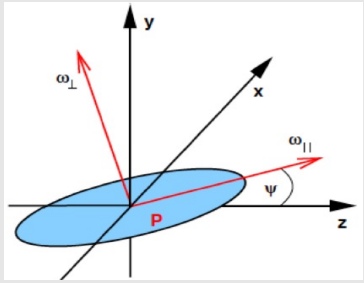
Quantity	Correction Term [ppb]	Uncertainty [ppb]
C_p	489	53
C_e	180	13
C_{lm}	-11	5
C_{pa}	-158	75

Beam Dynamics Corrections to ω_a

C_e:
The electric-field correction $C_e = 2n(1-n)\beta^2 x_e^2/R_0^2$ depends on the distribution of the equilibrium radii



C_p : The pitch correction $C_p = n < A_y^2 > /4R_0^2$ depends on the vertical betatron oscillations (A_y).



C_{lm} : It's caused by any bias in phase of muons that are lost compared to those that remain stored creating a time dependence to the phase factor ϕ_0 in Eq. 1.