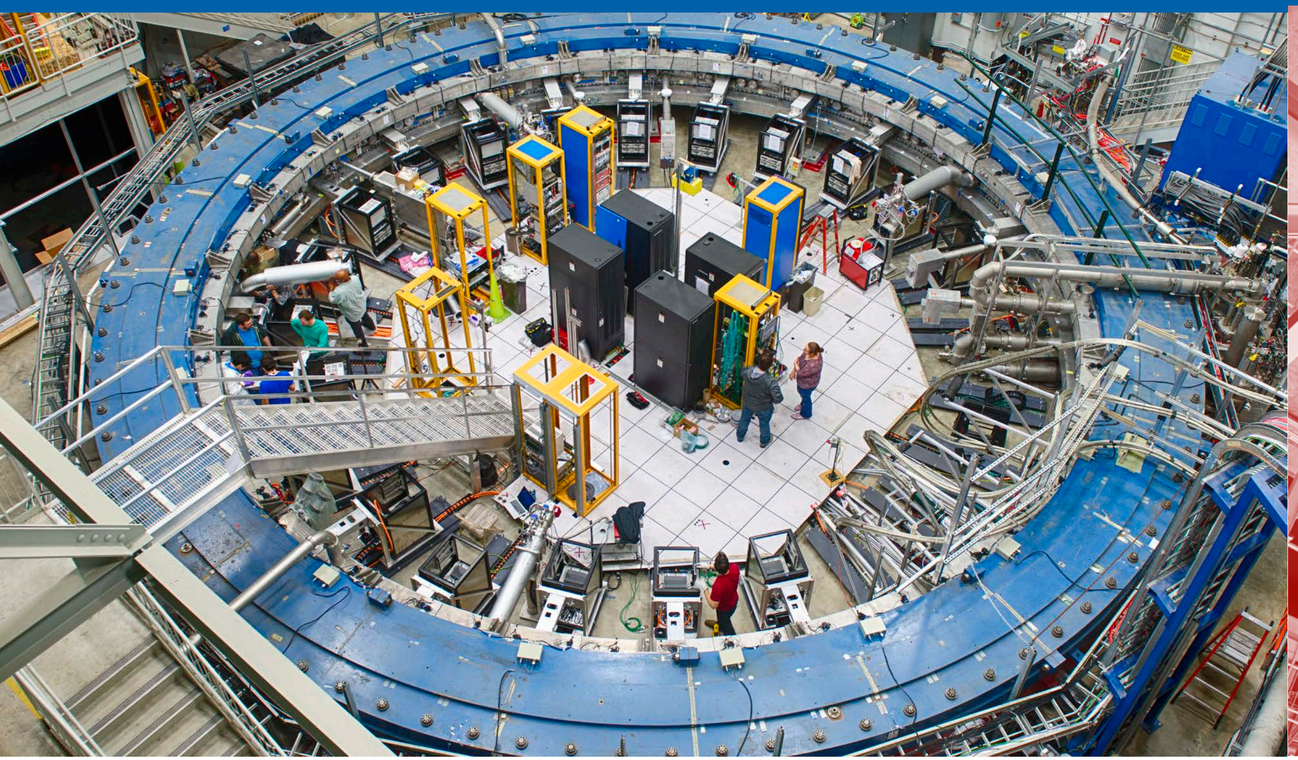

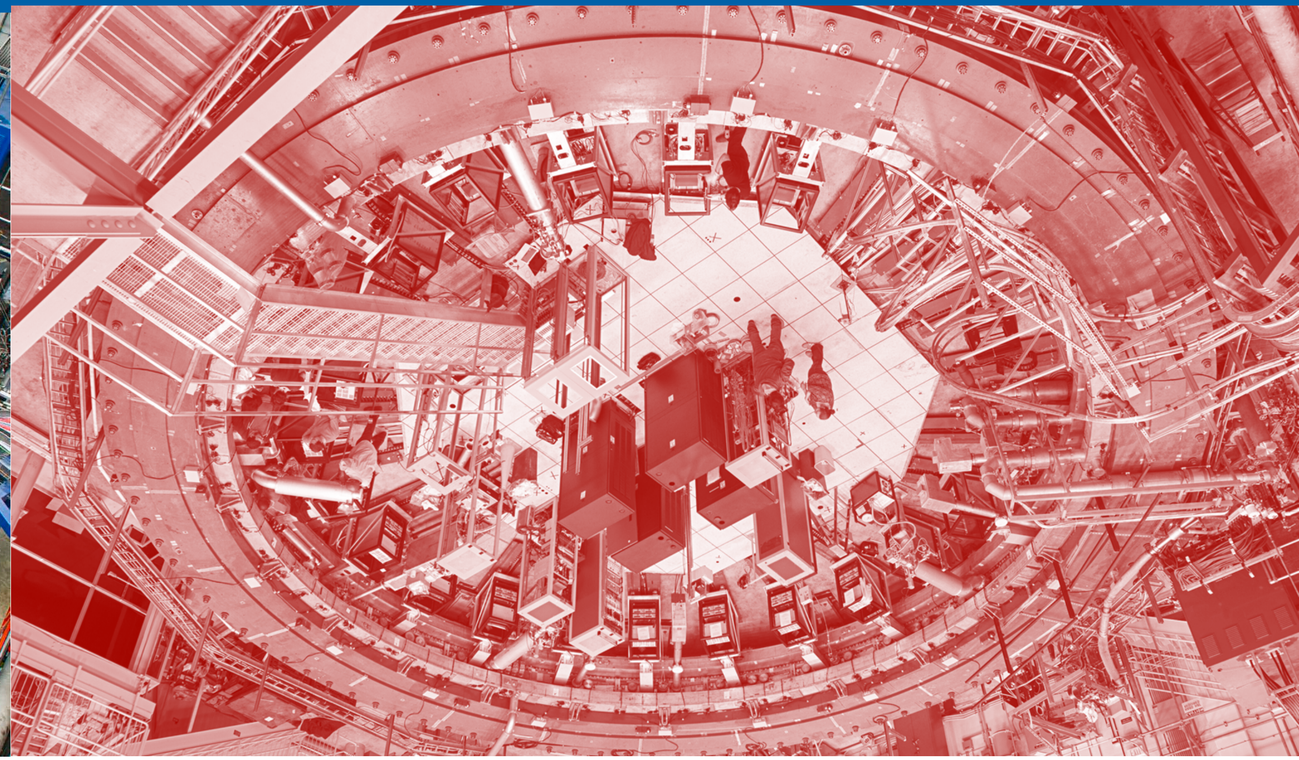

Muon g-2 μ^- Run Physics

Breese Quinn, University of Mississippi

Potential Fermilab Muon Campus & Storage Ring Experiments Workshop

May 24, 2021

CPTLV: SME and Muon g-2

- SME Lagrangian (Kostelecký et.al.):

$$\mathcal{L}' = -a_\kappa \bar{\psi}\gamma^\kappa\psi - b_\kappa \bar{\psi}\gamma_5\gamma^\kappa\psi - \frac{1}{2}H_{\kappa\lambda}\bar{\psi}\sigma^{\kappa\lambda}\psi$$
$$+\frac{1}{2}ic_{\kappa\lambda}\bar{\psi}\gamma^\kappa \overleftrightarrow{D^\lambda}\psi + \frac{1}{2}id_{\kappa\lambda}\bar{\psi}\gamma_5\gamma^\kappa \overleftrightarrow{D^\lambda}\psi$$

  - All terms violate Lorentz invariance
  - a_κ, b_κ are CPT-odd; others are CPT-even

- Predicts two CPT/Lorentz violating signatures for muon g-2:
  - Sidereal (or annual) variation in ω_a (with μ^+ or μ^-) $\rightarrow b_T$
  - Difference in ω_a between μ^+ / μ^- $\rightarrow b_Z, H_{XY}, d_{Z0}$

CPTLV: Sidereal Results

- BNL E821 Results (2008)

Amplitude of sidereal oscillation: $A^{\mu} = 2b_T^{\mu} \sin\chi$

$$A^{\mu^-} < 4.2 \text{ ppm}$$

$$A^{\mu^+} < 2.2 \text{ ppm}$$

Preliminary Run 2 result:

$$A^{\mu^+} < 2.0 \text{ ppm}$$

(Meghna Bhattacharya dissertation)

$$b_T^{\mu^+} = \sqrt{(\check{b}_X^{\mu^+})^2 + (\check{b}_Y^{\mu^+})^2} \leq 1.4 \times 10^{-24} \text{ GeV}$$

$$\check{b}_T^{\mu^-} = \sqrt{(\check{b}_X^{\mu^-})^2 + (\check{b}_Y^{\mu^-})^2} \leq 2.6 \times 10^{-24} \text{ GeV}$$

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CPTLV: μ^+/μ^- ω_a Difference

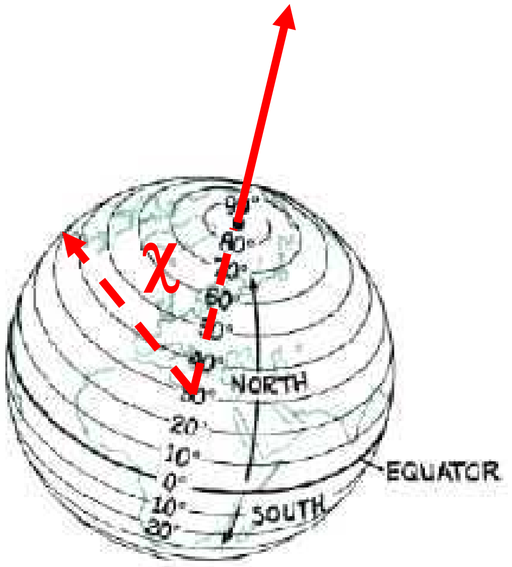
$$\Delta\omega_a \equiv \langle\omega_a^{\mu^+}\rangle - \langle\omega_a^{\mu^-}\rangle = \frac{4b_Z}{\gamma}\cos\chi$$

- However, the magnetic field can vary, so when comparing frequencies, instead of ω_a, we use $\mathcal{R} = \omega_a/\omega_p$

- BNL E821 Results (2008)

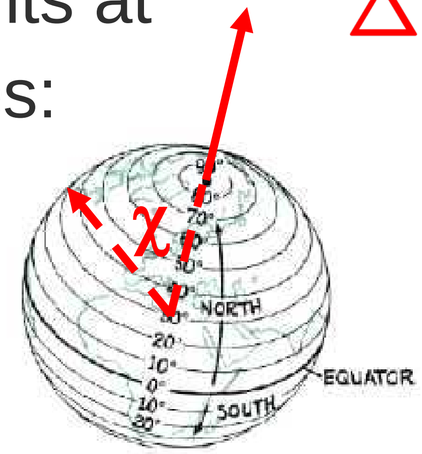
$$\Delta\mathcal{R} = -(3.6 \pm 3.7) \times 10^{-9}$$

$$b_Z = -(1.0 \pm 1.1) \times 10^{-23}\ \text{GeV}$$



CPTLV: μ^+/μ^- ω_a Difference

- For two experiments at different colatitudes:
  - e.g. BNL & CERN, ***FNAL & J-PARC***



$$\Delta\mathcal{R} = \frac{2b_Z}{\gamma}\left(\frac{\cos\chi_1}{\omega_{p1}} + \frac{\cos\chi_2}{\omega_{p2}}\right) + 2(m_\mu d_{Z0} + H_{XY})\left(\frac{\cos\chi_1}{\omega_{p1}} - \frac{\cos\chi_2}{\omega_{p2}}\right)$$

- BNL E821 Results (2008):
  - BNL & CERN

$$(m_\mu d_{Z0} + H_{XY}) = (1.6 \pm 5.6 \times 10^{-23})\ \text{GeV}$$

But J-PARC can't do μ^-…
E989 is the only and last shot at this!

CPTLV: μ^+/μ^- ω_a Difference

- Also note that Muon g-2 with μ^- essentially gives you ***3*** new experimental results here, not just 1!
- What we have:
  - BNL($\chi = 49.2$) μ^+/μ^- (700 ppb) & CERN ($\chi = 43.8$) μ^+/μ^- (7300 ppb) $\quad \Delta cos\chi = 0.07$
- What we would get:
  - FNAL ($\chi = 48.2$) μ^+ (140 ppb) & BNL μ^- (700 ppb)
  - FNAL μ^- (350 ppb) & BNL μ^+ (700 ppb) } $\Delta cos\chi = 0.01$
  - FNAL μ^- (350 ppb) & J-PARC ($\chi = 53.5$) μ^+ (450 ppb) - *Dominates* $\quad \Delta cos\chi = 0.07$
- *Potentially about 15x improvement*

SME Muon Sector Current Limits (Kostelecký et.al.)

With μ^+

Table D21. Muon sector, $d = 3$

Combination	Result	System	Ref.
$\lvert\mathrm{Re}\, H_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Re}\, g_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, g_{011}^{\mathrm{NR}(0B)}\rvert$	$< 2 \times 10^{-22}$ GeV	Muonium spectroscopy	[20]*
$\lvert\mathrm{Re}\, H_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Re}\, g_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, g_{011}^{\mathrm{NR}(1B)}\rvert$	$< 7 \times 10^{-23}$ GeV	”	[20]*
b^T/m_μ	$(7.3 \pm 5.0) \times 10^{-7}$	Muon decay	[184]*
b_Z	$-(1.0 \pm 1.1) \times 10^{-23}$ GeV	BNL $g_\mu - 2$	[185]
$\sqrt{(\check{b}_X^{\mu^+})^2 + (\check{b}_Y^{\mu^+})^2}$	$< 1.4 \times 10^{-24}$ GeV	”	[185]
$\sqrt{(\check{b}_X^{\mu^-})^2 + (\check{b}_Y^{\mu^-})^2}$	$< 2.6 \times 10^{-24}$ GeV	”	[185]
$\sqrt{(\tilde{b}_X)^2 + (\tilde{b}_Y)^2}$	$< 2 \times 10^{-23}$ GeV	Muonium spectroscopy	[186]
$b_Z - 1.19(m_\mu d_{Z0} + H_{XY})$	$(-1.4 \pm 1.0) \times 10^{-22}$ GeV	BNL, CERN $g_\mu - 2$ data	[187]
b_Z	$(-2.3 \pm 1.4) \times 10^{-22}$ GeV	CERN $g_\mu - 2$ data	[187], [188]*
$\lvert\mathrm{Re}\, H_{011}^{(3)(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{(3)(0B)}\rvert$	$< 5 \times 10^{-23}$ GeV	”	[20]*
$\check{H}_{010}^{(3)}$	$(-1.6 \pm 1.7) \times 10^{-22}$ GeV	BNL, CERN $g_\mu - 2$ data	[20]*
$\lvert\mathrm{Re}\, \check{H}_{011}^{(3)}\rvert$, $\lvert\mathrm{Im}\, \check{H}_{011}^{(3)}\rvert$	$< 2.0 \times 10^{-24}$ GeV	BNL $g_\mu - 2$	[20]*
$m_\mu d_{Z0} + H_{XY}$	$(1.8 \pm 6.0) \times 10^{-23}$ GeV	”	[185]

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SME Muon Sector Current Limits

With μ^+

With μ^-

Table D21. Muon sector, $d = 3$

Combination	Result	System	Ref.
$\lvert\mathrm{Re}\, H_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Re}\, g_{011}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, g_{011}^{\mathrm{NR}(0B)}\rvert$	$< 2 \times 10^{-22}$ GeV	Muonium spectroscopy	[20]*
$\lvert\mathrm{Re}\, H_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Re}\, g_{011}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, g_{011}^{\mathrm{NR}(1B)}\rvert$	$< 7 \times 10^{-23}$ GeV	”	[20]*
b^T/m_μ	$(7.3 \pm 5.0) \times 10^{-7}$	Muon decay	[184]*
b_Z	$-(1.0 \pm 1.1) \times 10^{-23}$ GeV	BNL $g_\mu - 2$	[185]
$\sqrt{(\check{b}_X^{\mu^+})^2 + (\check{b}_Y^{\mu^+})^2}$	$< 1.4 \times 10^{-24}$ GeV	”	[185]
$\sqrt{(\check{b}_X^{\mu^-})^2 + (\check{b}_Y^{\mu^-})^2}$	$< 2.6 \times 10^{-24}$ GeV	”	[185]
$\sqrt{(\tilde{b}_X)^2 + (\tilde{b}_Y)^2}$	$< 2 \times 10^{-23}$ GeV	Muonium spectroscopy	[186]
$b_Z - 1.19(m_\mu d_{Z0} + H_{XY})$	$(-1.4 \pm 1.0) \times 10^{-22}$ GeV	BNL, CERN $g_\mu - 2$ data	[187]
b_Z	$(-2.3 \pm 1.4) \times 10^{-22}$ GeV	CERN $g_\mu - 2$ data	[187], [188]*
$\lvert\mathrm{Re}\, H_{011}^{(3)(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{(3)(0B)}\rvert$	$< 5 \times 10^{-23}$ GeV	”	[20]*
$\check{H}_{010}^{(3)}$	$(-1.6 \pm 1.7) \times 10^{-22}$ GeV	BNL, CERN $g_\mu - 2$ data	[20]*
$\lvert\mathrm{Re}\, \check{H}_{011}^{(3)}\rvert$, $\lvert\mathrm{Im}\, \check{H}_{011}^{(3)}\rvert$	$< 2.0 \times 10^{-24}$ GeV	BNL $g_\mu - 2$	[20]*
$m_\mu d_{Z0} + H_{XY}$	$(1.8 \pm 6.0) \times 10^{-23}$ GeV	”	[185]

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SME Muon Sector Current Limits

With μ^+

With μ^-

Table D22. Muon sector, $d = 4$

Combination	Result	System	Ref.
$c_{TT} + 0.35(c_{XX} + c_{YY}) + 0.28c_{ZZ}$	$< 8.5 \times 10^{-11}$	BNL $g_\mu - 2$	[189]*
$\lvert c_\mu - c_\gamma \rvert$	$< 3 \times 10^{-11}$	Astrophysics	[48]*
$c^{TT} - 0.05c^{ZZ}$	$(4.9 \pm 1.1) \times 10^{-8}$	Muon decay	[184]*
$\lvert c \rvert$	$< 10^{-11}$	Astrophysics	[68]*
$\lvert \mathrm{Re}\, g_{011}^{(4)(0B)} \rvert,\ \lvert \mathrm{Im}\, g_{011}^{(4)(0B)} \rvert$	$< 5 \times 10^{-22}$	Muonium spectroscopy	[20]*
$\lvert \mathrm{Re}\, \breve{g}_{011}^{(4)} \rvert,\ \lvert \mathrm{Im}\, \breve{g}_{011}^{(4)} \rvert$	$< 6.6 \times 10^{-25}$	BNL $g_\mu - 2$	[20]*
$\breve{g}_{010}^{(4)}$	$(-2.3 \pm 2.4) \times 10^{-25}$	”	[20]*
$m_\mu g_{XYT}^{(\mathrm{M})}$	$-(7.8 \pm 8.5) \times 10^{-27}$ GeV	”	[20]*
$m_\mu \sqrt{(g_{XZT}^{(\mathrm{M})})^2 + (g_{YZT}^{(\mathrm{M})})^2}$	$< 1.1 \times 10^{-27}$ GeV	”	[20]*

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SME Muon Sector Current Limits

With μ^+

With μ^-

Table D23. Nonminimal muon sector, $d \geq 5$

Combination	Result	System	Ref.
$\lvert\mathring{a}_2^{\mathrm{NR}}\rvert$	$< 8 \times 10^{-6}$ GeV^{-1}	Muonium spectroscopy	[20]*
$\lvert\mathring{c}_2^{\mathrm{NR}}\rvert$	$< 8 \times 10^{-6}$ GeV^{-1}	"	[20]*
$\lvert\mathrm{Re}\, H_{211}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{211}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Re}\, g_{211}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, g_{211}^{\mathrm{NR}(0B)}\rvert$	$< 1 \times 10^{-11}$ GeV^{-1}	"	[20]*
$\lvert\mathrm{Re}\, H_{211}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, H_{211}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Re}\, g_{211}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, g_{211}^{\mathrm{NR}(1B)}\rvert$	$< 6 \times 10^{-12}$ GeV^{-1}	"	[20]*
$\mathring{a}^{\mathrm{UR}(5)} - m_\mu \mathring{g}^{\mathrm{UR}(6)}$	$(-1 \text{ to } 1) \times 10^{-34}$ GeV^{-1}	Astrophysics	[73]*, [18]*
$\lvert\mathrm{Re}\, H_{011}^{(5)(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{011}^{(5)(0B)}\rvert$	$< 5 \times 10^{-21}$ GeV^{-1}	Muonium spectroscopy	[20]*
$\lvert\mathrm{Re}\, \breve{H}_{011}^{(5)}\rvert$, $\lvert\mathrm{Im}\, \breve{H}_{011}^{(5)}\rvert$, $\lvert\mathrm{Re}\, \breve{H}_{211}^{(5)}\rvert$, $\lvert\mathrm{Im}\, \breve{H}_{211}^{(5)}\rvert$	$< 2.1 \times 10^{-25}$ GeV^{-1}	BNL $g_\mu - 2$	[20]*
$\lvert\mathrm{Re}\, \breve{H}_{231}^{(5)}\rvert$, $\lvert\mathrm{Im}\, \breve{H}_{231}^{(5)}\rvert$	$< 1.3 \times 10^{-25}$ GeV^{-1}	"	[20]*
$\breve{H}_{010}^{(5)}$, $\breve{H}_{210}^{(5)}$	$(-1.7 \pm 1.7) \times 10^{-23}$ GeV^{-1}	BNL, CERN $g_\mu - 2$ data	[20]*
$\breve{H}_{230}^{(5)}$	$(2.9 \pm 3.0) \times 10^{-24}$ GeV^{-1}	"	[20]*
$\mathring{c}^{\mathrm{UR}(6)}$	$(-8.5 \text{ to } 0.0025) \times 10^{-20}$ GeV^{-2}	Astrophysics	[73]*, [18]*
$\lvert\mathrm{Re}\, g_{011}^{(6)(0B)}\rvert$, $\lvert\mathrm{Im}\, g_{011}^{(6)(0B)}\rvert$	$< 5 \times 10^{-20}$ GeV^{-2}	Muonium spectroscopy	[20]*
$\lvert\mathrm{Re}\, \breve{g}_{011}^{(6)}\rvert$, $\lvert\mathrm{Im}\, \breve{g}_{011}^{(6)}\rvert$, $\lvert\mathrm{Re}\, \breve{g}_{211}^{(6)}\rvert$, $\lvert\mathrm{Im}\, \breve{g}_{211}^{(6)}\rvert$	$< 6.8 \times 10^{-26}$ GeV^{-2}	BNL $g_\mu - 2$	[20]*
$\lvert\mathrm{Re}\, \breve{g}_{231}^{(6)}\rvert$, $\lvert\mathrm{Im}\, \breve{g}_{231}^{(6)}\rvert$	$< 4.3 \times 10^{-26}$ GeV^{-2}	"	[20]*
$\breve{g}_{010}^{(6)}$, $\breve{g}_{210}^{(6)}$	$(-2.4 \pm 2.5) \times 10^{-26}$ GeV^{-2}	"	[20]*
$\breve{g}_{230}^{(6)}$	$(-2.5 \pm 2.5) \times 10^{-26}$ GeV^{-2}	"	[20]*
$\lvert\mathring{a}_4^{\mathrm{NR}}\rvert$	$< 1 \times 10^{5}$ GeV^{-3}	Muonium spectroscopy	[20]*
$\lvert\mathring{a}_4^{\mathrm{NR}}\rvert$	$< 1 \times 10^{6}$ GeV^{-3}	"	[20]*
$\lvert\mathring{c}_4^{\mathrm{NR}}\rvert$	$< 1 \times 10^{5}$ GeV^{-3}	"	[20]*
$\lvert\mathring{c}_4^{\mathrm{NR}}\rvert$	$< 1 \times 10^{6}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, H_{411}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, H_{411}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Re}\, g_{411}^{\mathrm{NR}(0B)}\rvert$, $\lvert\mathrm{Im}\, g_{411}^{\mathrm{NR}(0B)}\rvert$	$< 2 \times 10^{-1}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, H_{411}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, H_{411}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Re}\, g_{411}^{\mathrm{NR}(1B)}\rvert$, $\lvert\mathrm{Im}\, g_{411}^{\mathrm{NR}(1B)}\rvert$	$< 8 \times 10^{-2}$ GeV^{-3}	"	[20]*

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SME Muon Sector Current Limits

With μ^+

With μ^-

$\lvert\mathrm{Re}\, H^{(7)(0B)}_{011}\rvert,\ \lvert\mathrm{Im}\, H^{(7)(0B)}_{011}\rvert$	$< 4 \times 10^{-19}$ GeV^{-3}	Muonium spectroscopy	[20]*
$\check{H}^{(7)}_{010},\ \check{H}^{(7)}_{210},\ \check{H}^{(7)}_{410}$	$(-1.7 \pm 1.8) \times 10^{-24}$ GeV^{-3}	BNL, CERN $g_\mu - 2$ data	[20]*
$\check{H}^{(7)}_{230},\ \check{H}^{(7)}_{430}$	$(3.0 \pm 3.1) \times 10^{-25}$ GeV^{-3}	"	[20]*
$\check{H}^{(7)}_{450}$	$(2.6 \pm 2.6) \times 10^{-25}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, H^{(7)}_{011}\rvert,\ \lvert\mathrm{Im}\, H^{(7)}_{011}\rvert,\ \lvert\mathrm{Re}\, H^{(7)}_{211}\rvert,\ \lvert\mathrm{Im}\, H^{(7)}_{211}\rvert$	$< 2.2 \times 10^{-26}$ GeV^{-3}	BNL $g_\mu - 2$	[20]*
$\lvert\mathrm{Re}\, \check{H}^{(7)}_{411}\rvert,\ \lvert\mathrm{Im}\, \check{H}^{(7)}_{411}\rvert$	$< 2.2 \times 10^{-26}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, \check{H}^{(7)}_{231}\rvert,\ \lvert\mathrm{Im}\, \check{H}^{(7)}_{231}\rvert,\ \lvert\mathrm{Re}\, \check{H}^{(7)}_{431}\rvert,\ \lvert\mathrm{Im}\, \check{H}^{(7)}_{431}\rvert$	$< 1.4 \times 10^{-26}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, \check{H}^{(7)}_{451}\rvert,\ \lvert\mathrm{Im}\, \check{H}^{(7)}_{451}\rvert$	$< 1.1 \times 10^{-26}$ GeV^{-3}	"	[20]*
$\lvert\mathrm{Re}\, g^{(8)(0B)}_{011}\rvert,\ \lvert\mathrm{Im}\, g^{(8)(0B)}_{011}\rvert$	$< 4 \times 10^{-18}$ GeV^{-4}	Muonium spectroscopy	[20]*
$\check{g}^{(8)}_{010},\ \check{g}^{(8)}_{210},\ \check{g}^{(8)}_{410}$	$(-2.5 \pm 2.6) \times 10^{-27}$ GeV^{-4}	BNL $g_\mu - 2$	[20]*
$\check{g}^{(8)}_{230},\ \check{g}^{(8)}_{430}$	$(-2.6 \pm 2.6) \times 10^{-27}$ GeV^{-4}	"	[20]*
$\check{g}^{(8)}_{450}$	$(1.6 \pm 1.7) \times 10^{-27}$ GeV^{-4}	"	[20]*
$\lvert\mathrm{Re}\, \check{g}^{(8)}_{011}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{011}\rvert,\ \lvert\mathrm{Re}\, \check{g}^{(8)}_{211}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{211}\rvert$	$< 7.1 \times 10^{-27}$ GeV^{-4}	"	[20]*
$\lvert\mathrm{Re}\, \check{g}^{(8)}_{411}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{411}\rvert$	$< 7.1 \times 10^{-27}$ GeV^{-4}	"	[20]*
$\lvert\mathrm{Re}\, \check{g}^{(8)}_{231}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{231}\rvert,\ \lvert\mathrm{Re}\, \check{g}^{(8)}_{431}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{431}\rvert$	$< 4.5 \times 10^{-27}$ GeV^{-4}	"	[20]*
$\lvert\mathrm{Re}\, \check{g}^{(8)}_{451}\rvert,\ \lvert\mathrm{Im}\, \check{g}^{(8)}_{451}\rvert$	$< 3.6 \times 10^{-27}$ GeV^{-4}	"	[20]*
$\check{H}^{(9)}_{010},\ \check{H}^{(9)}_{210},\ \check{H}^{(9)}_{410},\ \check{H}^{(9)}_{610}$	$(-1.8 \pm 1.9) \times 10^{-25}$ GeV^{-5}	BNL, CERN $g_\mu - 2$ data	[20]*
$\check{H}^{(9)}_{230},\ \check{H}^{(9)}_{430},\ \check{H}^{(9)}_{630}$	$(3.2 \pm 3.3) \times 10^{-26}$ GeV^{-5}	"	[20]*
$\check{H}^{(9)}_{450},\ \check{H}^{(9)}_{650}$	$(2.7 \pm 2.7) \times 10^{-26}$ GeV^{-5}	"	[20]*
$\check{H}^{(9)}_{670}$	$(-1.1 \pm 1.1) \times 10^{-26}$ GeV^{-5}	"	[20]*
$\check{g}^{(10)}_{010},\ \check{g}^{(10)}_{210},\ \check{g}^{(10)}_{410},\ \check{g}^{(10)}_{610}$	$(-2.6 \pm 2.7) \times 10^{-28}$ GeV^{-6}	BNL $g_\mu - 2$	[20]*
$\check{g}^{(10)}_{230},\ \check{g}^{(10)}_{430},\ \check{g}^{(10)}_{630}$	$(-2.7 \pm 2.7) \times 10^{-28}$ GeV^{-6}	"	[20]*
$\check{g}^{(10)}_{450},\ \check{g}^{(10)}_{650}$	$(1.7 \pm 1.7) \times 10^{-28}$ GeV^{-6}	"	[20]*
$\check{g}^{(10)}_{670}$	$(1.3 \pm 1.4) \times 10^{-28}$ GeV^{-6}	"	[20]*

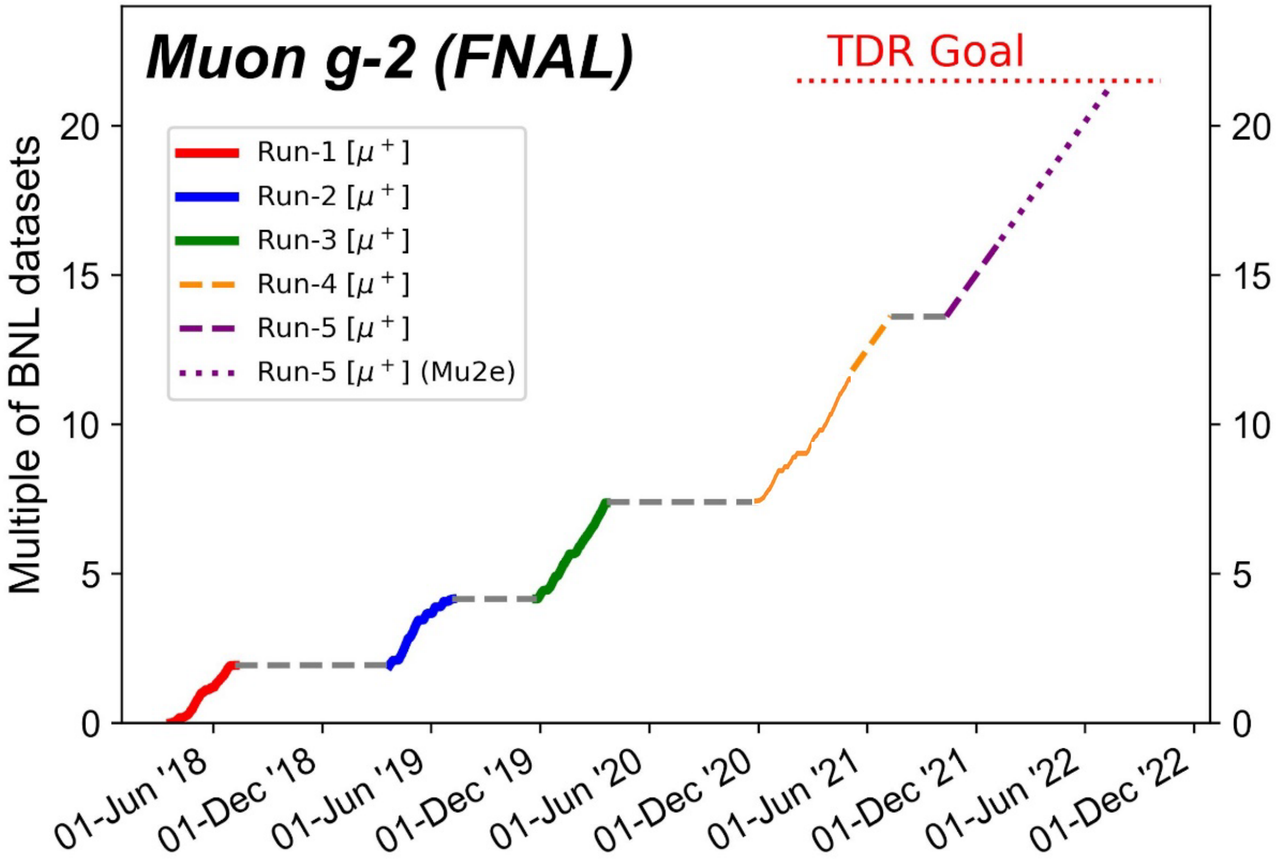
What else does an additional μ^- run give you?

- a_{μ^-}: improve by factor of 2

- Dark Matter search (Janish, Ramani)
  - Detect ultralight DM that couples predominantly to muons
  - Current *g*-2 anomaly can be explained by a spin torque applied to muons from a pseudoscalar dark matter background
  - Can cause a temporal modulation of ω_a with a frequency set by the DM particle mass
  - ***Longer run expands the mass range sensitivity***

Where we are with μ^+?

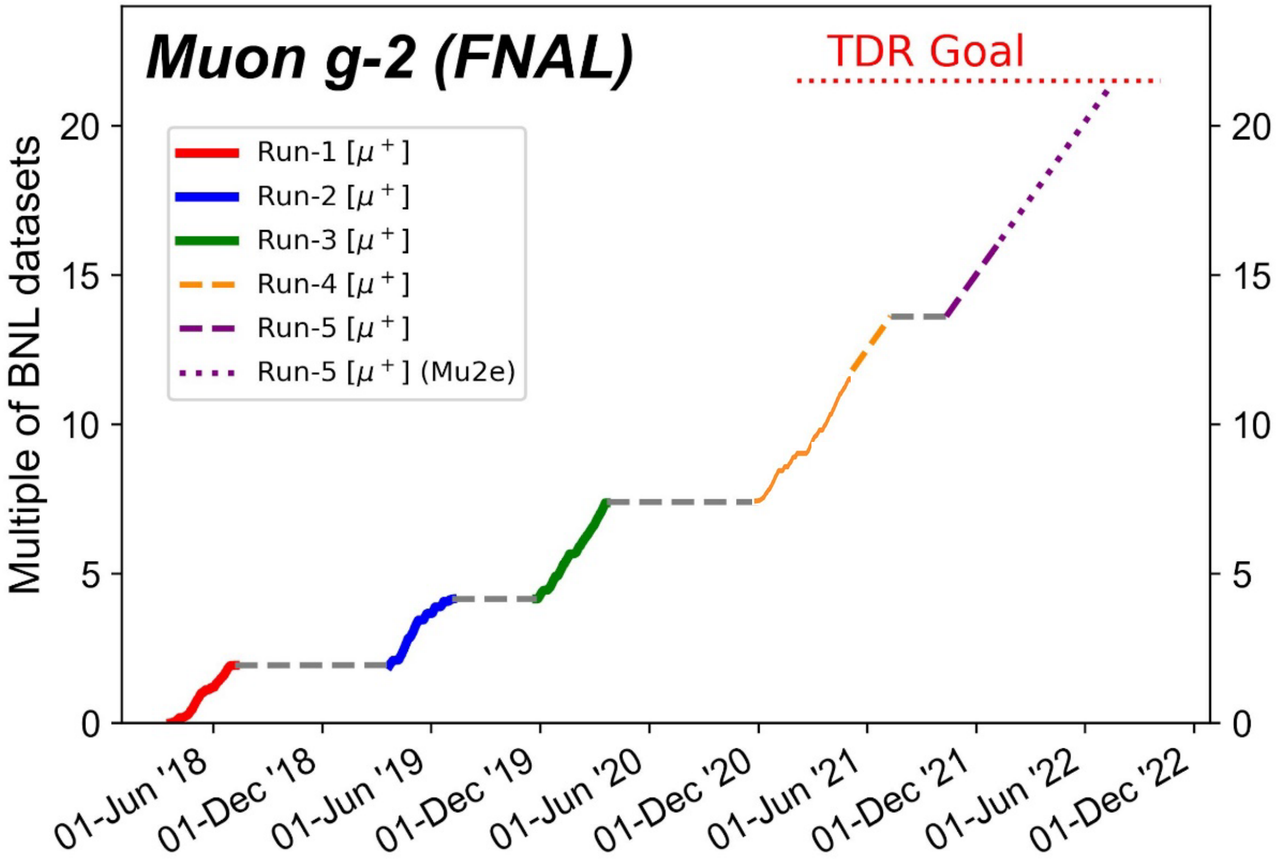
- Through Run 4…



Period	Usable Data (n x BNL)	Note
Run 1	0	Systematics deweighting
Run 2	1.3	DQC
Run 3	2.7	DQC
Run 4	6	Lost November
Total	10	Far from 20xBNL

What data *will* we have?

- With Run 5…



Period	Usable Data (n x BNL)	Note
Run 1	0	Systematics deweighting
Run 2	1.3	DQC
Run 3	2.7	DQC
Run 4	6	Lost November
Run 5	6	
Total	16	

- Need all of Run 5 for μ^+
  - Can't afford μ^- switching time and reduced flux

Potential Run 6

- Have been making case to keep magnet cold in Run 6 year (i.e. FY23)
  - Field mapping, possible systematic studies, ready to take data if opportunity arises
- Should a 20-week Run 6 be μ^+ or μ^-?

Physics	***μ^+ Run 6***	***μ^- Run 6***
Overall stats	***5xBNL*** ***1.14x stat. precision***	***2xBNL*** ***1.06x stat. precision***
μ^- stats	***-***	***4xBNL μ^-*** ***2x stat. precision***
Additional physics	***-***	$b_\perp^{\mu^-}$ b_z d_{Z0} H_{XY} ***many non-minimal, higher d***

Last chance anyone will have to make these!

- μ^- allows greater investigation of where *g-2* discrepancy might come from

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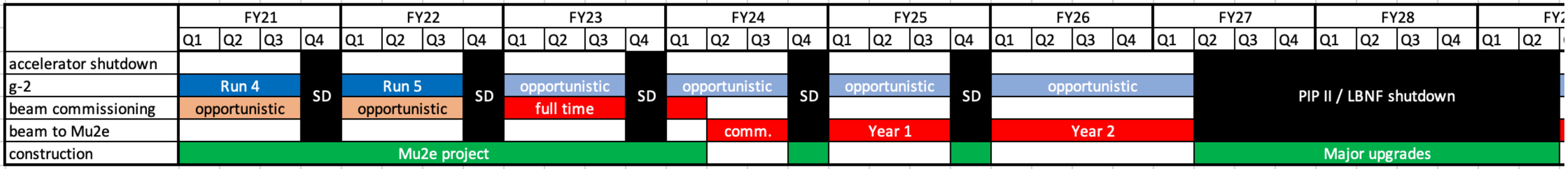
When Could We Run μ^-?



- We want opportunistic running beyond Run 5
- Two main scenarios:
  1. Mu2e stays on schedule – we run opportunistically by switching back and forth with Mu2e. Switching takes 1-2 days for μ^+, 1-2 weeks for μ^-. Mu2e Interruptions would need to be on order of 2 months to justify μ^- switch. Not likely to get regular opportunities of that length.
  2. Mu2e slips, opening an opportunity for a possible Run 6 in FY23. This is where a μ^-run would likely live.
     a) DR septum ready at start of FY23: 1st stage low intensity septum commissioning → 20 week Run 6 → 2nd stage high intensity septum commissioning
     b) DR septum not ready until mid FY23: 20 week Run 6 → septum commissioning