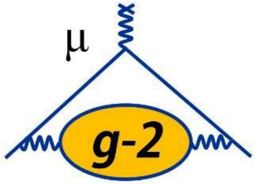
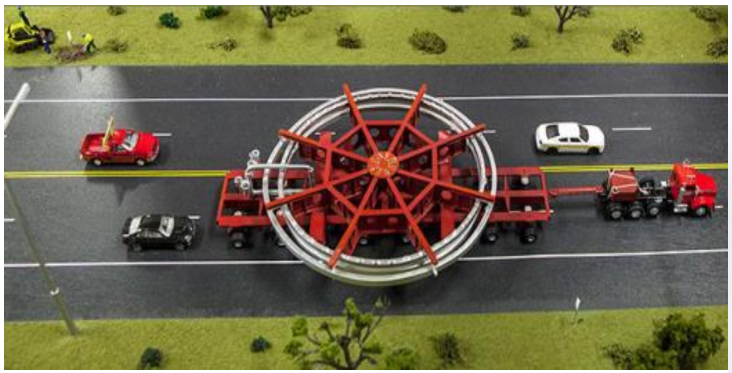
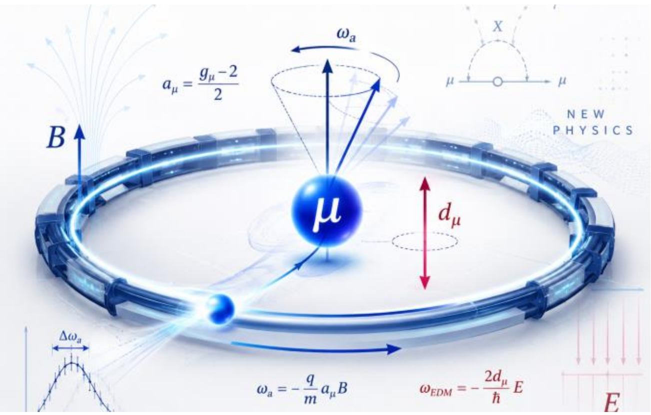
中国物理学会高能物理分会第十二届全国会员代表大会暨学术年会（CHEP 2026）



Muon g-2 and EDM: Precision Tests of Fundamental Symmetries and New Physics





2013

First g−2 talk at SPCS
The ring was still on the road

2018-2023

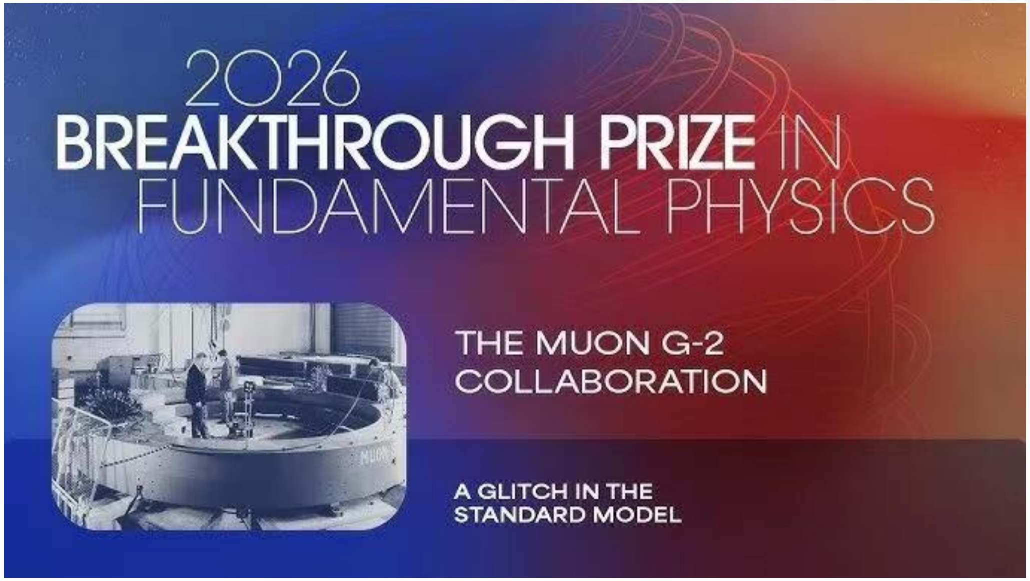
Physics running
Precision data taking at Fermilab

2026

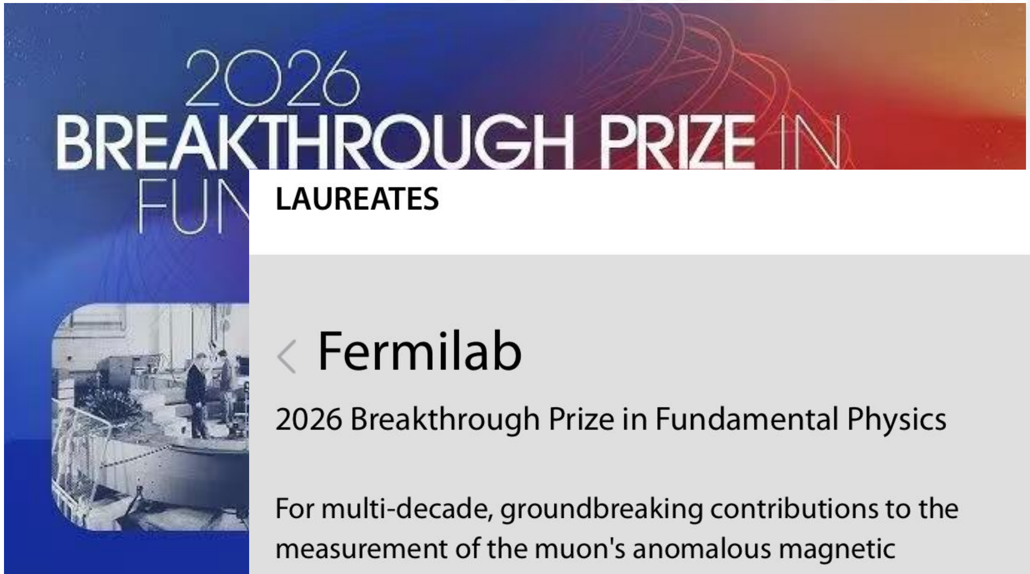
Breakthrough Prize
SJTU share the honor

Liang Li
Shanghai Jiao Tong University

Breakthrough Prize in Fundamental Physics



Breakthrough Prize in Fundamental Physics



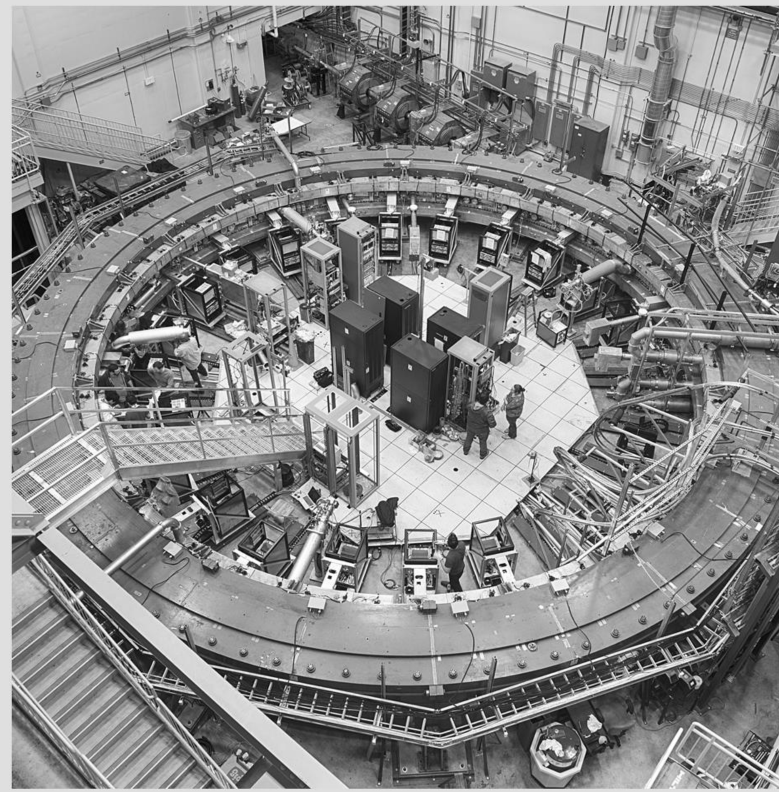
LAUREATES

Fermilab

2026 Breakthrough Prize in Fundamental Physics

For multi-decade, groundbreaking contributions to the measurement of the muon's anomalous magnetic moment, pushing the boundaries of experimental precision and igniting a new era in the quest for physics beyond the Standard Model.

The prizewinners are the living co-authors of the publications that reported the results from the measurement campaigns at CERN, BNL, and Fermilab. The names are listed below.



Breakthrough Prize in Fundamental Physics

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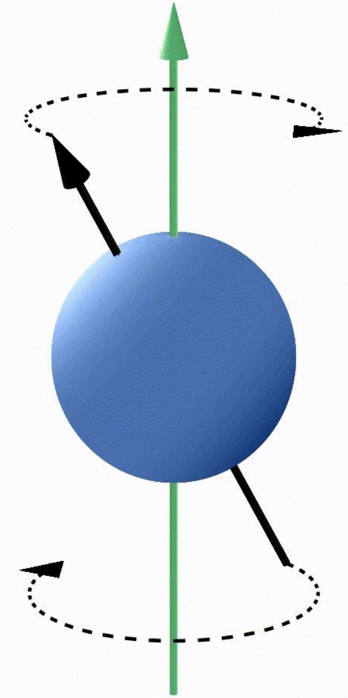
April 18, 2026: $3M prize shared by 368 collaborators world wide
SJTU Muon g-2 team: 14 laureates

What is Muon g-2?

$$\vec{\mu} = g \frac{e}{2m} \vec{s}$$



In the quantum world, particles have spin

- **Fermions have half integer spins, bosons have integer spins**
- **Muon's magnetic moment is closely related to spin and internal structure**
- **Muon's intrinsic magnet interacts with external magnetic field: precess!**
  - **Muon's precession frequency can be influenced by (virtual) particles**
  - **Anomalous magnetic moment can be measured and calculated**

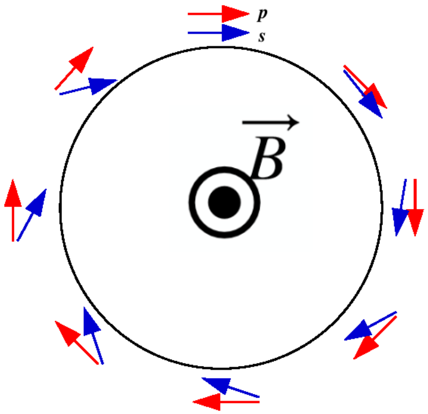
Discrepancy between experiment and theory leads to new physics

$$a_\mu^{SM} = a_\mu^{QED} + a_\mu^{had} + a_\mu^{EW} + \boldsymbol{a_\mu^{NP}}\textbf{?}$$

- **New particles, fifth force, or new structure?**

Experimental Principle

$$\vec{\omega} = -\frac{e}{m_\mu}\left[\underbrace{a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2 - 1}\right)\frac{\vec{\beta} \times \vec{E}}{c}}_{\omega_a\text{ : g–2 term}} + \underbrace{\frac{\eta}{2}\left(\vec{\beta} \times \vec{B} + \frac{\vec{E}}{c}\right)}_{\omega_\eta\text{ : EDM term}}\right]$$

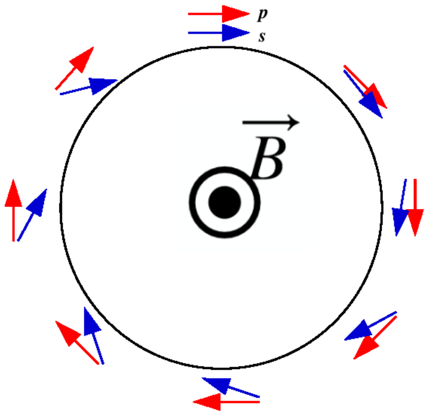


Experimental Principle

$$\vec{\omega} = -\frac{e}{m_\mu}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2-1}\right)\frac{\vec{\beta}\times\vec{E}}{c} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$

ω_a : g–2 term

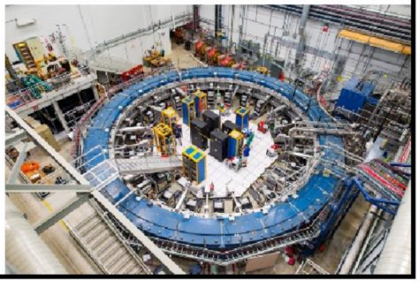
ω_η : EDM term



Approach1 : $a_\mu - \frac{1}{\gamma^2-1} \approx 0$

$$\vec{\omega} = -\frac{e}{m_\mu}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$

- Adopted at BNL/FNAL
- Electric field is used for beam focusing (Strong beam focusing)



Approach2 : $\vec{E} = 0$

$$\vec{\omega} = -\frac{e}{m_\mu}\left[a_\mu \vec{B} + \frac{\eta}{2}\vec{\beta}\times\vec{B}\right]$$

- Adopted at J-PARC
- Magnetic field is used for beam focusing (Weak beam focusing)
- EDM term is orthogonal to g-2 term

Muon g-2 Experimental Measurement

Frequency measurements can be done in very high precision

Muon g-2 Experimental Measurement

Frequency measurements can be done in very high precision

- **Measure frequency ratio and extract from several measurements**

$$a_\mu \sim \frac{\omega_a}{<B>} = \frac{g_e}{2}\frac{\omega_a}{\varpi_p}\frac{m_\mu}{m_e}\frac{\mu_p}{\mu_e}$$

  - ω_p **is proton Larmor precession frequency in water sample (**$\omega_p \sim |B|$**)**
  - ϖ_p **is the weighted magnetic field folded with muon distribution**
  - **All other values from Committee on Data for Science and Technology (CODATA), uncertainty < 25 ppb**
    - **E.g. muon-to-electron mass ratio by muonium hyperfine structure experiment**

Muon g-2 Experimental Measurement

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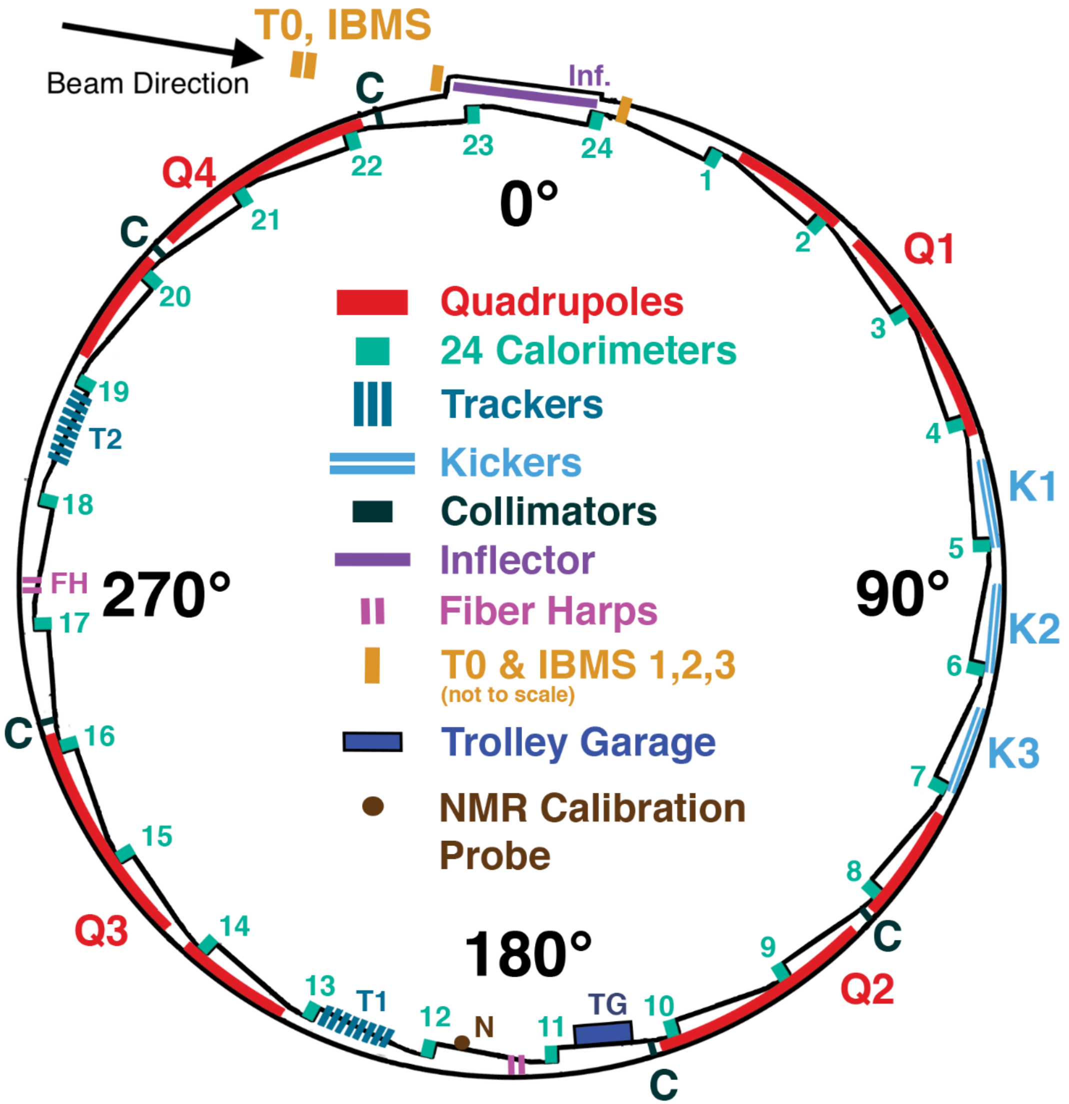
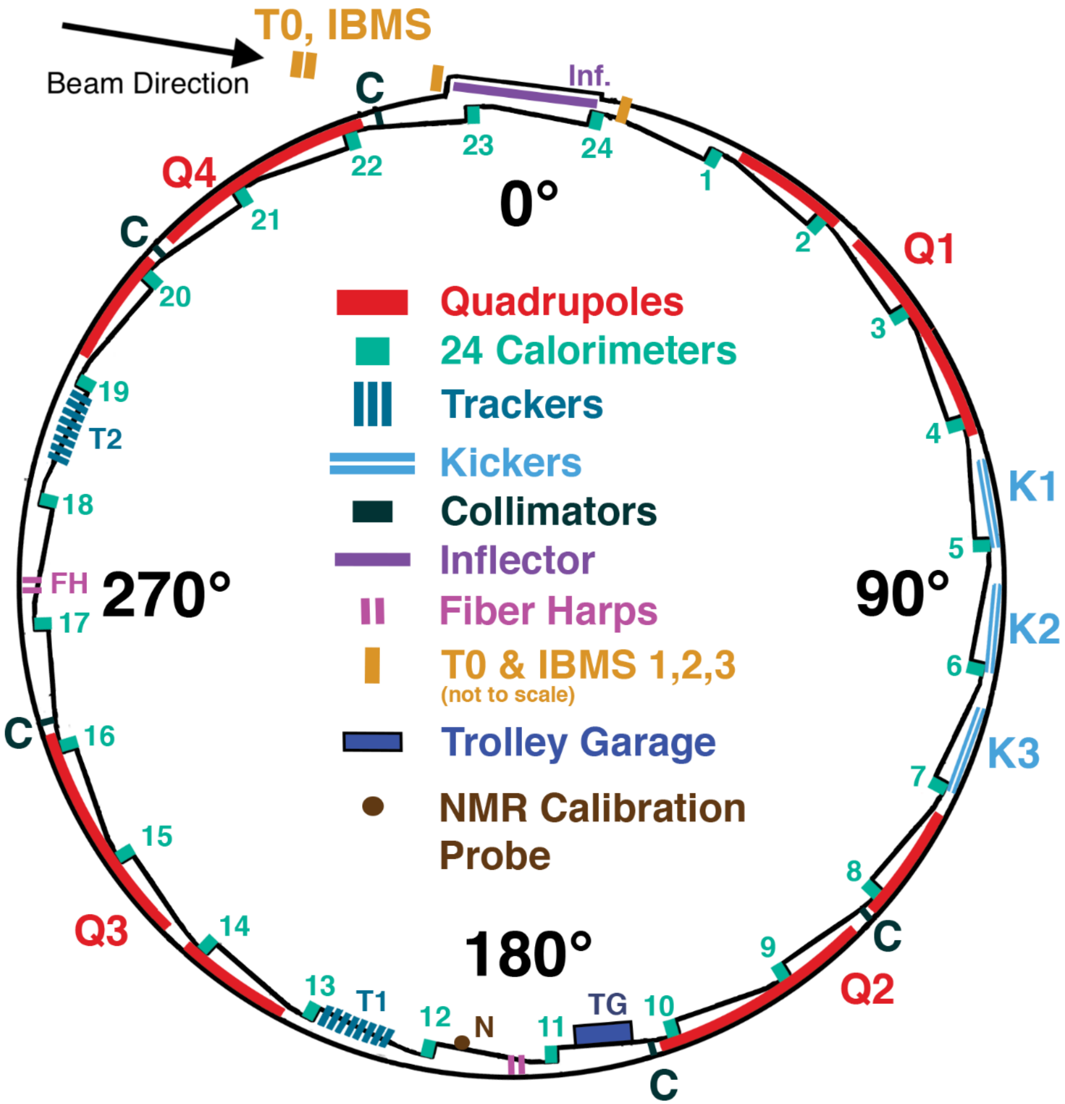
  - **All other values from Committee on Data for Science and Technology (CODATA), uncertainty < 25 ppb**
    - **E.g. muon-to-electron mass ratio by muonium hyperfine structure experiment**
- **Final measurements done in three steps**
  - **Inject muons into a ring with uniform magnetic field**
  - **Measure muon frequency difference ω_a**
  - **Measure proton precession frequency ω_p and muon distribution**
  - **Blind analyses: measurements and correction factors done *independently* before final answer**

Fermilab Muon g-2 Detector System



- 15 meter wide dipole superconducting magnet
- Inflector, kickers, quadrupoles, collimators for beam insertion
- 386 NMR probes
- Moving trolley with 17 probes
- 24 calorimeters
- Laser calibration system
- 2 tracker stations
- Auxiliary detectors: T0, IBMs, Fiber harps

Fermilab Muon g-2 Detector System



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MiniSciFi added in Run6
QuadRF added in Run5

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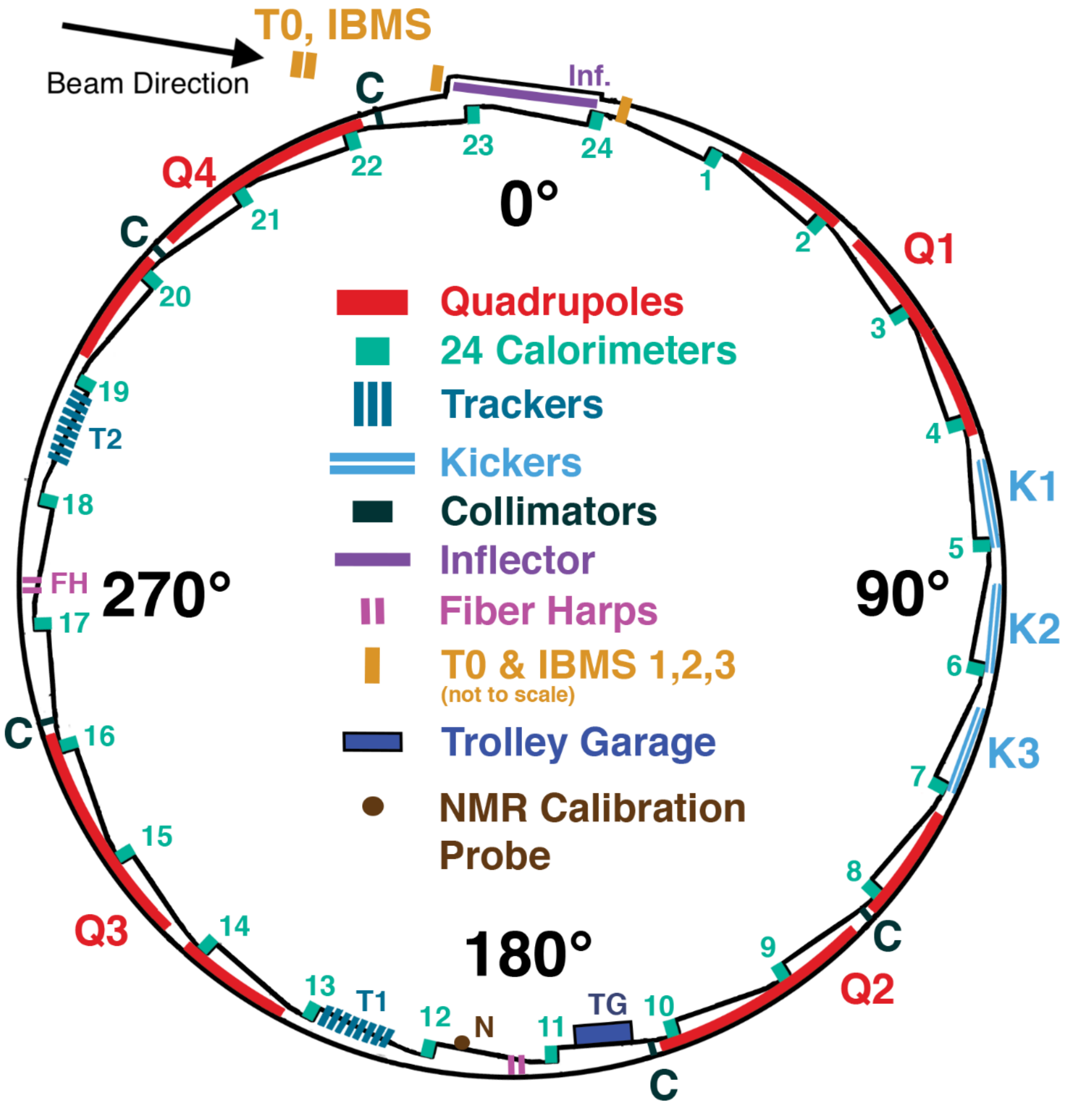

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MiniSciFi added in Run6
QuadRF added in Run5

9 PB of Raw Data!

Milestones for Muon g-2 Experiment

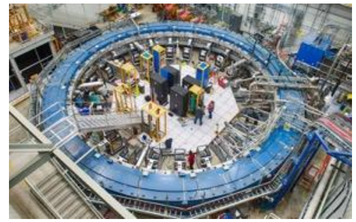
2008 — **Proposal**

The New (g – 2) Experiment:
A Proposal to Measure the Muon Anomalous
Magnetic Moment to ±0.14 ppm Precision

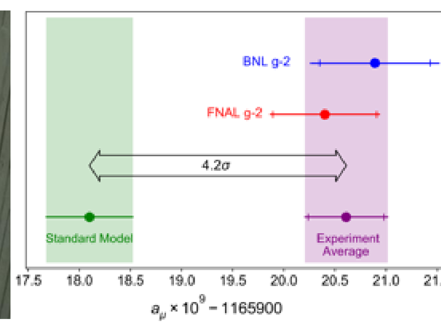
2012 — **Muon g-2 Critical Decision-0**

2013 — **The Big Move**

2017 — **1st Muon Beam**

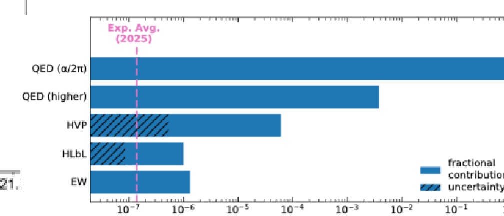


2021 — **First Run1 Result**



2023 — **End of Data Taking Second Run2/3 Result**

2025 — **Final Run1-6 Result**

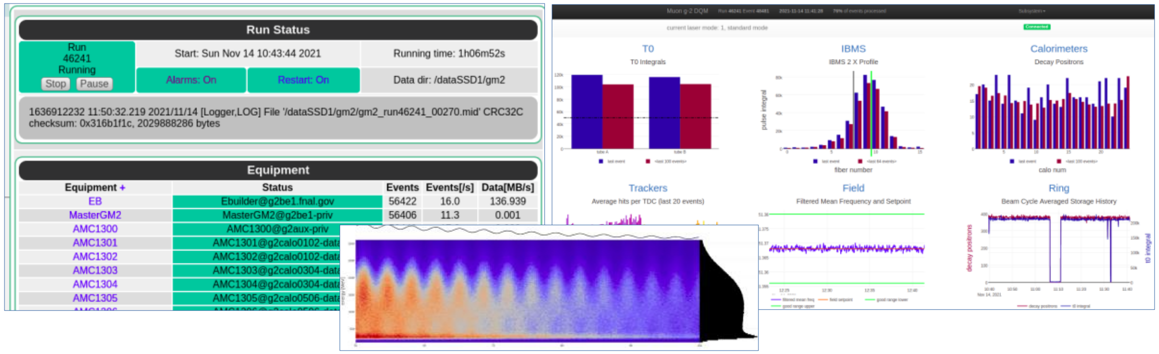


Data Flow

Raw data

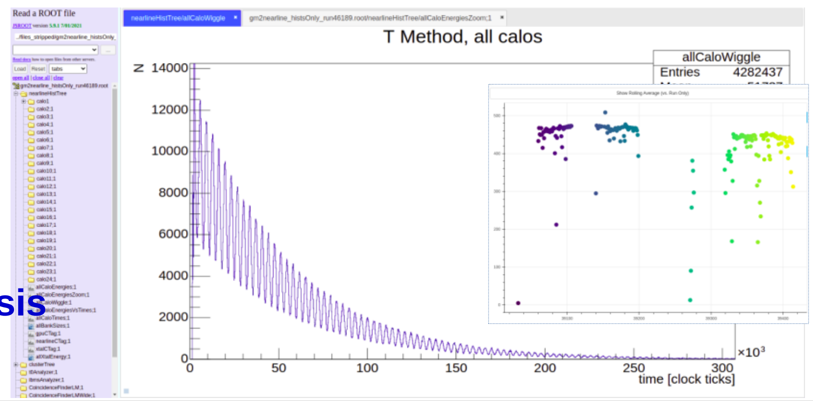
Online

Fraction of data
Instantaneous plots
DAQ and DQM



Nearline

Full data analyzed and plotted
Standard calibration
Useful for quick physics analysis
Results in ~ 30 min



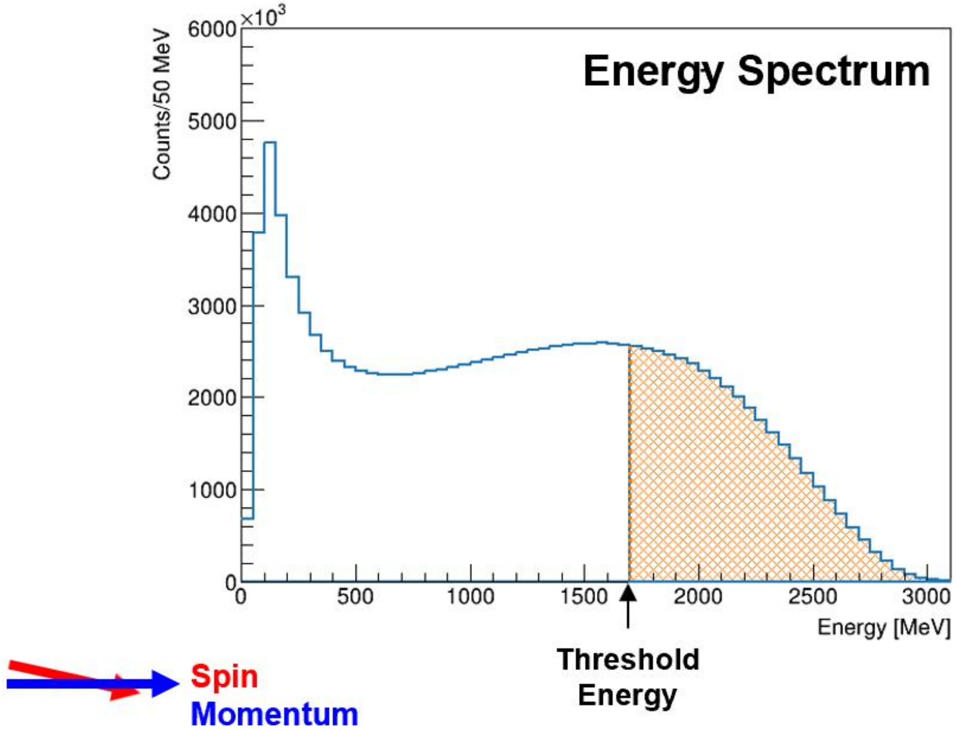
Offline

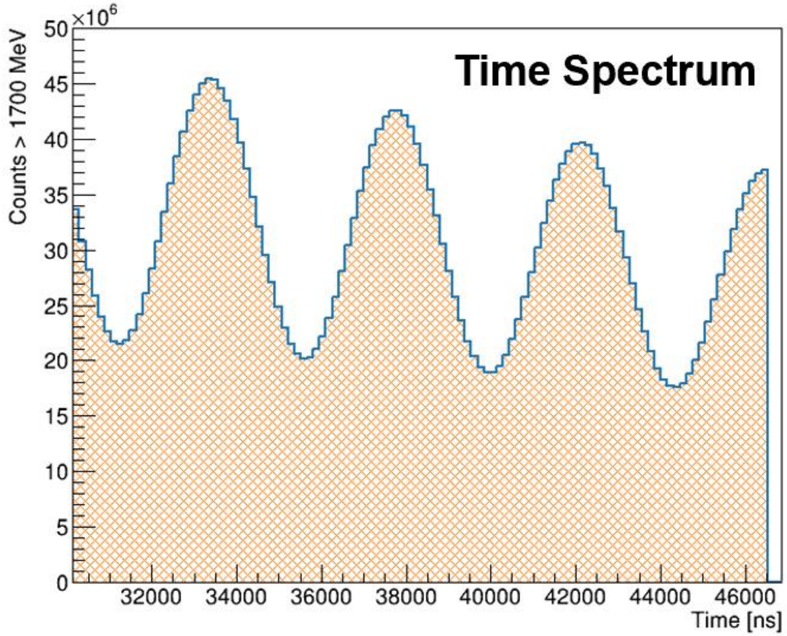
Pre-production → Calibration → Full-production → DQC

- Complete and fully calibrated reconstruction
- Involves pre- and full- productions
- Multiple reconstruction techniques
- Version-controlled, produced with POMS on grid
- Full results with DQC in ~ 1 year

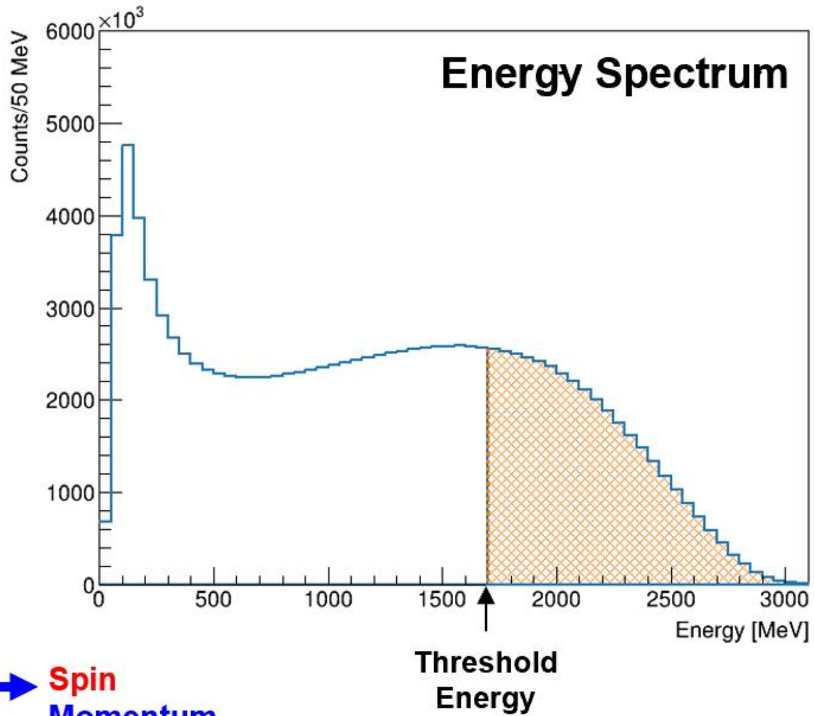
Production Operations Management System

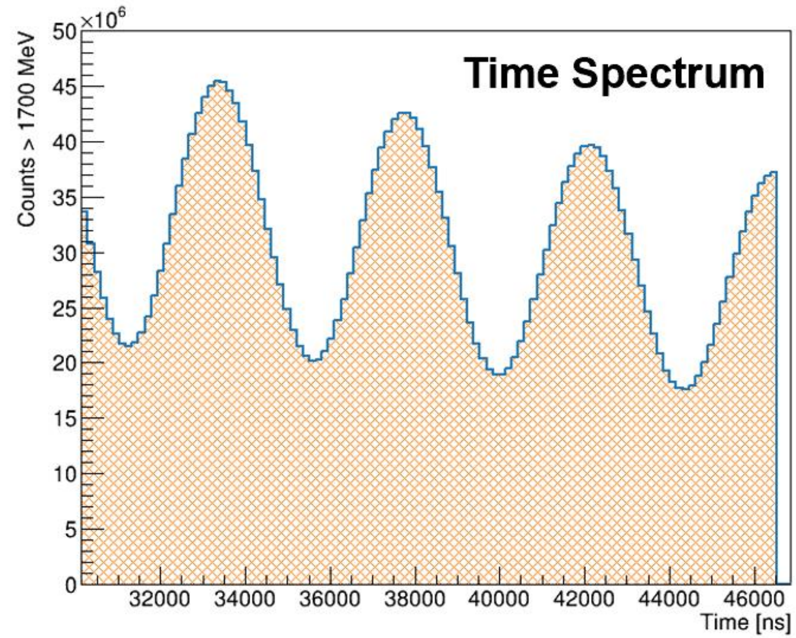
ω_a Measurement





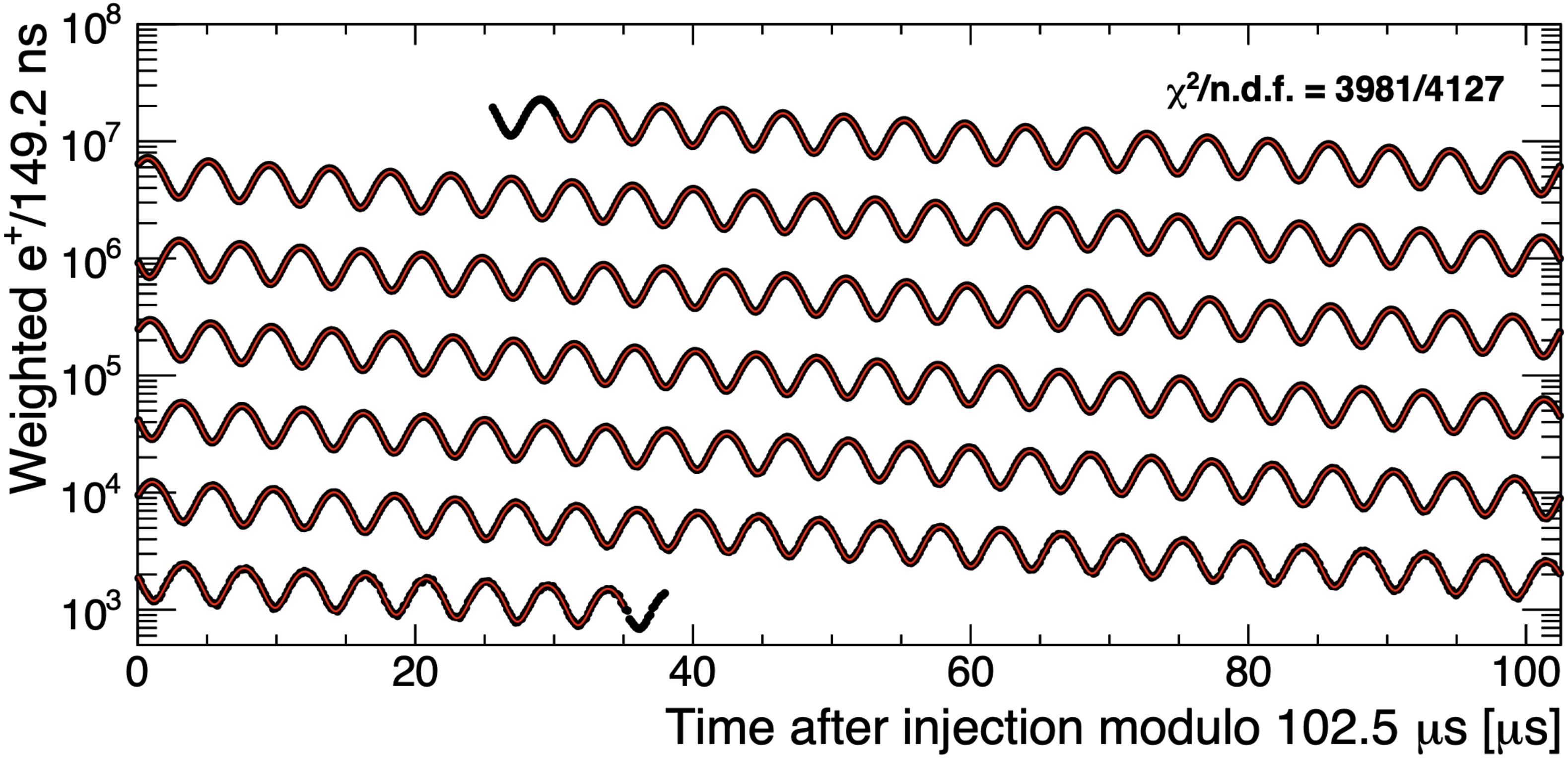
ω_a Measurement





- Energetic e+ oscillates as μ+ spin direction aligns or anti-aligns with momentum direction
- Count e+ hitting calorimeters above threshold (or weight the hits)
- Extract the oscillation frequency ω_a via fitting time spectrum

ω_a Measurement



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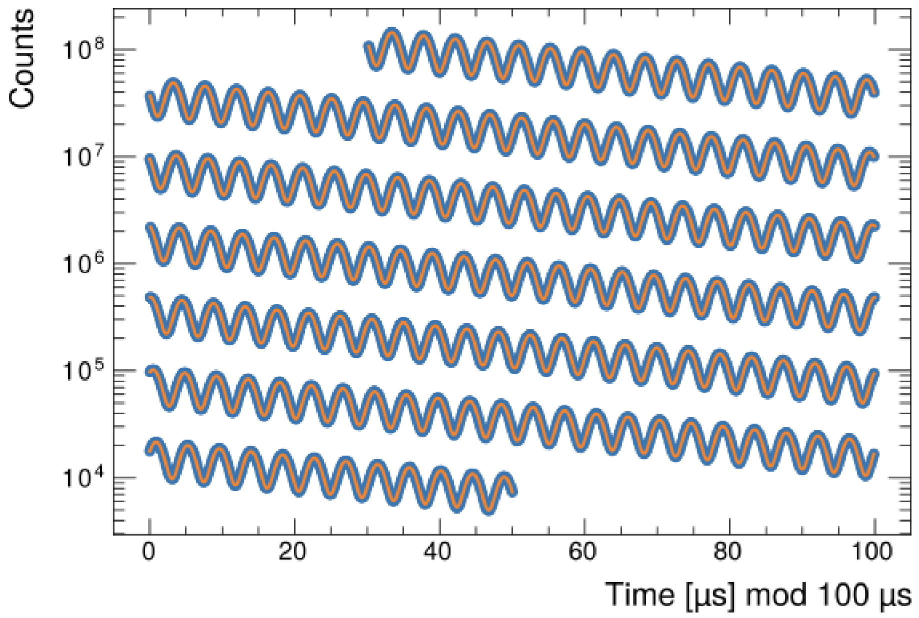
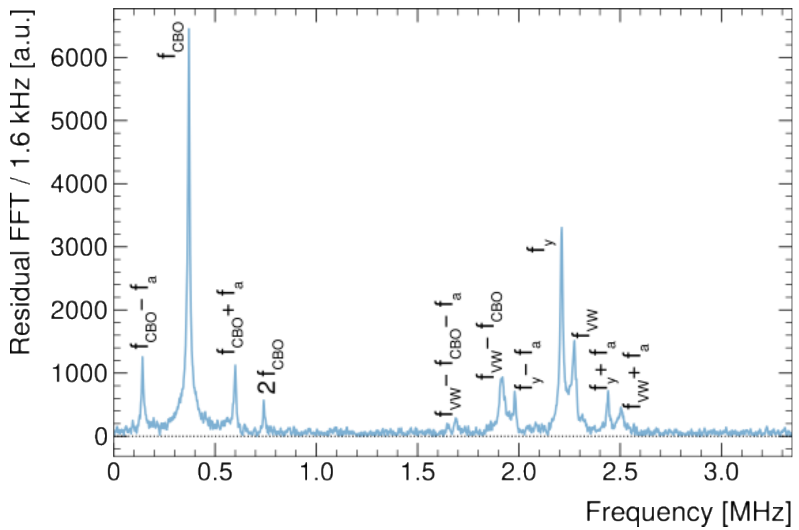
ω_a Measurement

Simplest fit model captures exponential decay & g-2 oscillation

$$N(t) = N_0\, e^{-t/\tau}\,[1 + A\cos(\omega_a t - \phi_0)]$$





Larger statistics reveal even more prominent frequency components.

ω_a Measurement

Simplest fit model captures exponential decay & g-2 oscillation

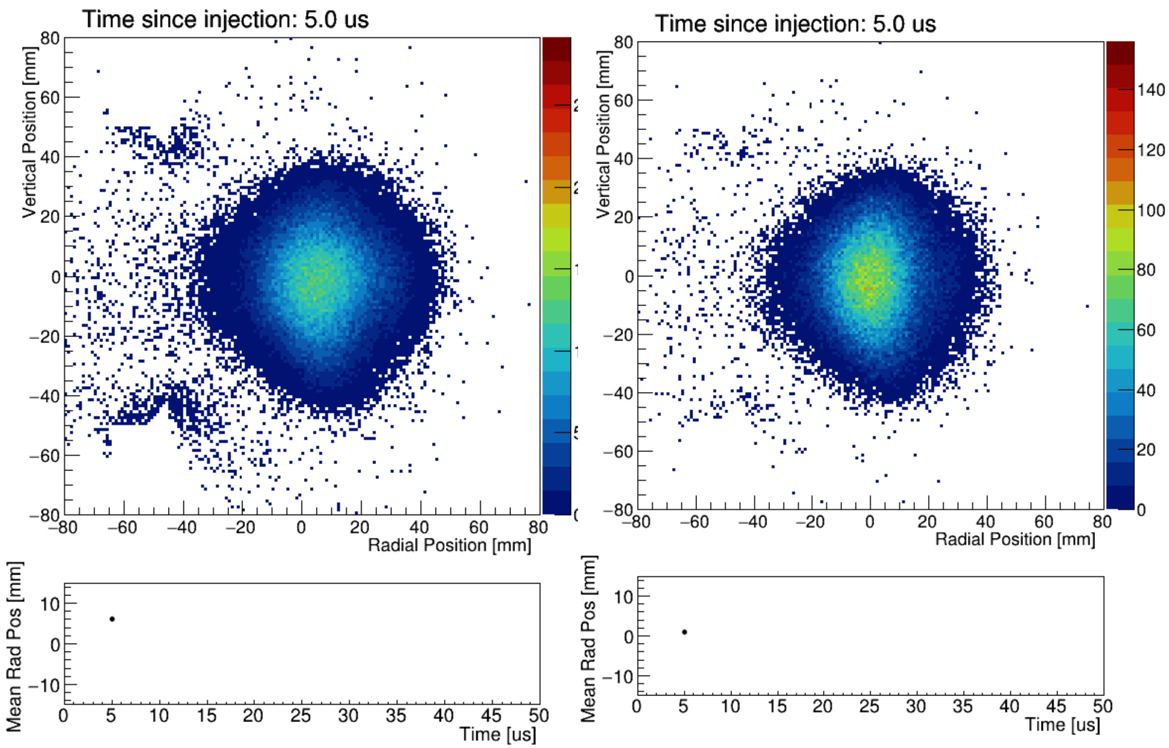
$$N(t) = N_0\, e^{-t/\tau}\,[1 + A\cos(\omega_a t\ - \phi_0)]$$

Must account for beam oscillations, muons losses, and detector effects

- **Final fit functions include 40+ additional parameters to model these effects!**

Beam dynamics modeling: CBO

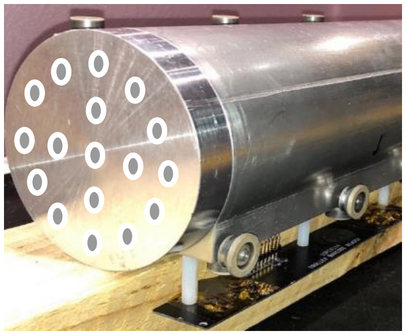
- **If not accounted for: ~800 ppb without the additional RF**
- **If not accounted for: ~80 ppb with the additional RF**



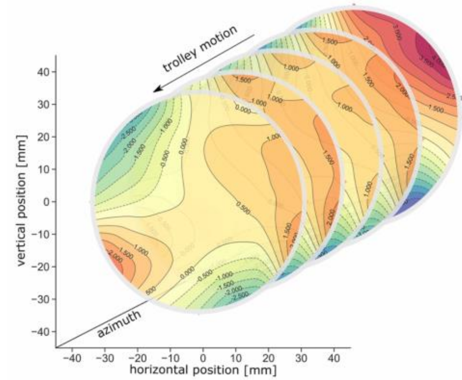
No Additional RF on ESQ **Additional RF on ESQ**

ω_p Measurement

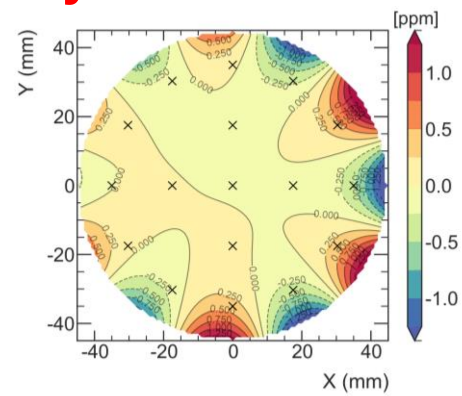
- **In-vacuum NMR trolley maps field every few days**



17 petroleum jelly NMR probes

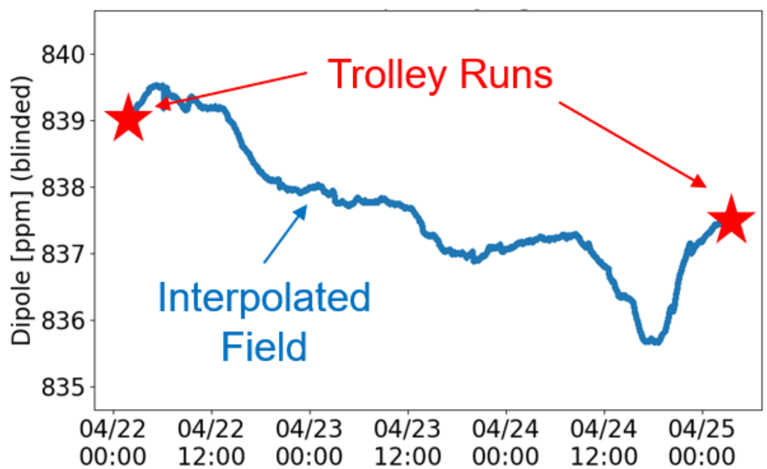


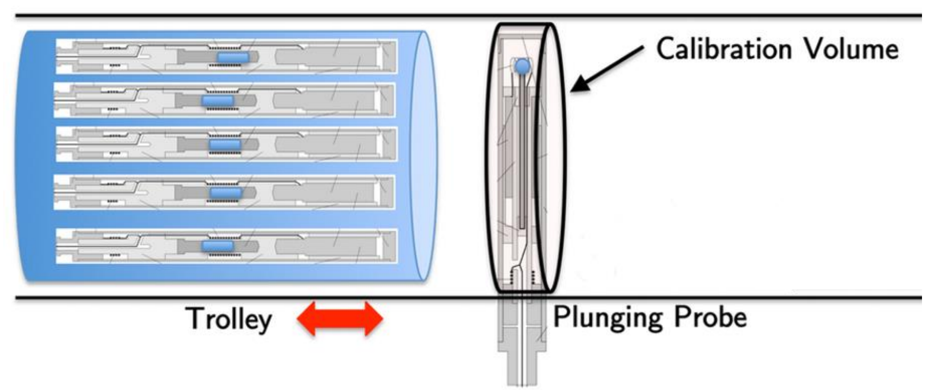
2D field maps (~8000 points)



Azimuthally-Averaged Variation < 1 ppm

- **378 fixed probes monitor field during muon storage at 72 locations**
- **Cross-calibrate using a cylindrical plunging H_2O probe**





Full Measurement with Corrections

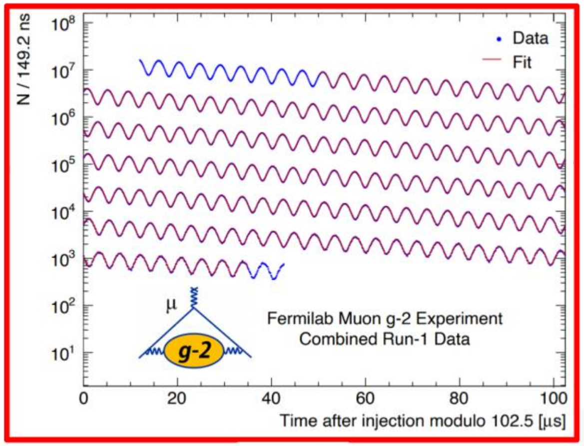
$$a_\mu = \frac{g_e}{2} \frac{\omega_a}{\tilde{\omega}_p} \frac{m_\mu}{m_e} \frac{\mu_p}{\mu_e}$$

Full Measurement with Corrections

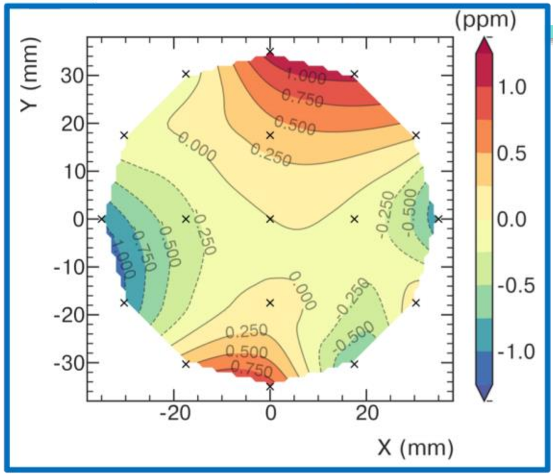
$$a_\mu = \frac{g_e}{2}\frac{\omega_a}{\widetilde{\omega}_p}\frac{m_\mu}{m_e}\frac{\mu_p}{\mu_e}$$

$$R_\mu = \frac{\omega_a}{\omega_p \otimes \text{Muon Dist}}$$

Full Measurement with Corrections



$$\mathcal{R}'_\mu = \frac{\omega_a}{\tilde{\omega}'_p(T_r)} = \frac{f_{\text{clock}}\, \omega_a^m\, (1 + C_e + C_p + C_{ml} + C_{pa})}{f_{\text{calib}}\, \langle\, \omega_p(x,y,\phi) \times M(x,y,\phi)\, \rangle (1 + B_k + B_q)}$$



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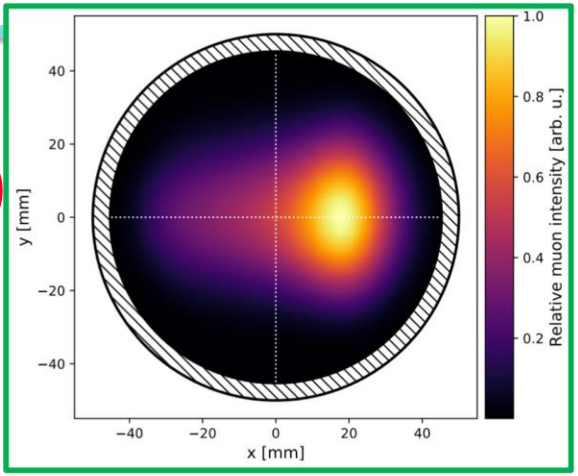

Full Measurement with Corrections

$$\frac{\omega_a}{\omega_p} = \frac{\omega_a^m}{\omega_p^m} \frac{1 + C_e + C_p + C_{pa} + C_{dd} + C_{ml}}{1 + B_k + B_q}$$

Measured Values

Full Measurement with Corrections

E-field & Up/Down motion: Spin precesses slower than in basic equation

$$\frac{\omega_a}{\omega_p} = \frac{\omega_a^m}{\omega_p^m} \frac{1 + C_e + C_p + C_{pa} + C_{dd} + C_{ml}}{1 + B_k + B_q}$$

Measured Values

Full Measurement with Corrections

E-field & Up/Down motion: Spin precesses slower than in basic equation

Phase changes over each fill: Phase-Acceptance, Differential Decay, Muon Losses

$$\frac{\omega_a}{\omega_p} = \frac{\omega_a^m}{\omega_p^m} \frac{1 + C_e + C_p + C_{pa} + C_{dd} + C_{ml}}{1 + B_k + B_q}$$

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Measured Values

Transient Magnetic Fields: Quad Vibrations, Kicker Eddy Current

Full Measurement with Corrections

E-field & Up/Down motion: Spin precesses slower than in basic equation

Phase changes over each fill: Phase-Acceptance, Differential Decay, Muon Losses

$$\frac{\omega_a}{\omega_p} = \frac{\omega_a^m}{\omega_p^m} \frac{1 + C_e + C_p + C_{pa} + C_{dd} + C_{ml}}{1 + B_k + B_q}$$

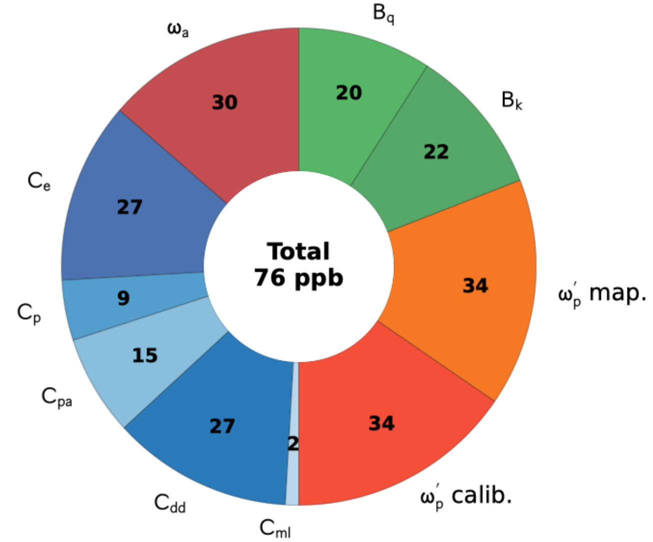
Measured Values

Transient Magnetic Fields: Quad Vibrations, Kicker Eddy Current

- **Total correction 572 ppb, dominated by E-field & Pitch**
  - ~350 ppb & 170 ppb, other ω_a correction ~ 30ppb
  - B_k ~ 30 ppb, B_q ~ 20 ppb

Total Uncertainties

Quantity	Correction (ppb)	Uncertainty (ppb)
ω_a^m (statistical)	$\cdots$	114
ω_a^m (systematic)	$\cdots$	30
C_e	347	27
C_p	175	9
C_{pa}	-33	15
C_{dd}	26	27
C_{ml}	0	2
$\langle \omega_p' \times M \rangle$	$\cdots$	48
B_k	-37	22
B_q	-21	20
μ_p'/μ_B	$\cdots$	4
m_μ/m_e	$\cdots$	22
Total systematic for $\mathcal{R}_\mu'$	$\cdots$	76
Total for a_μ	572	139



TDR goal : 100 ppb ✓

- **Evenly distributed**
- **No dominant source**
- **Further improving would require reducing in many categories**

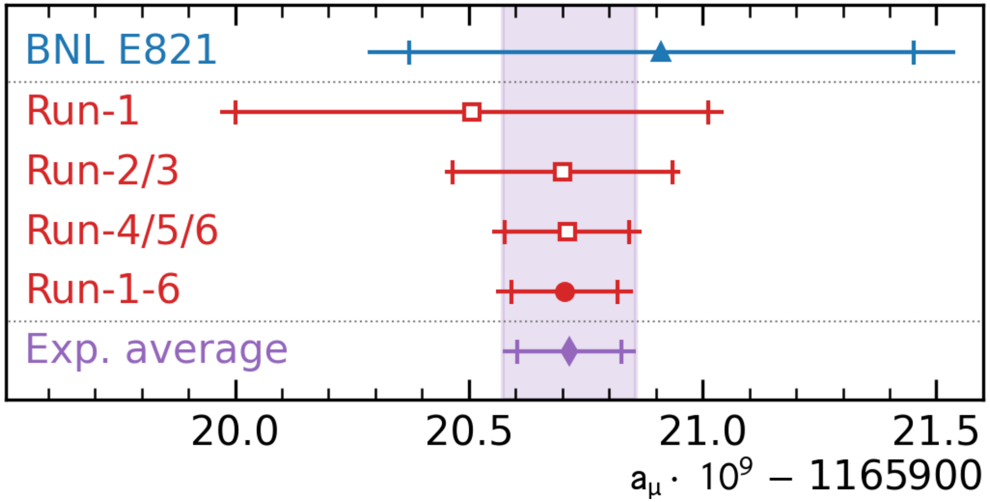
Total Uncertainties

$\frac{\omega_a}{\tilde{\omega}'_p}$	Stat. Uncertainty (ppb)	Syst. Uncertainty (ppb)	Total Uncertainty (ppb)
Run-1	434	159*	462
Run-2/3	201	78*	216
Run-4/5/6	114	76	137
Run-1-6	**98**	**78**	**125**
	TDR goal 100 ppb ✓	TDR goal: 100 ppb ✓	TDR goal: 140 ppb ✓

*corrected

A good example of precision measurements that actually exceeds the TDR design goal!

Final Results



a_μ**(Run−1−6)** $= \mathbf{0.001165920710(162)}$

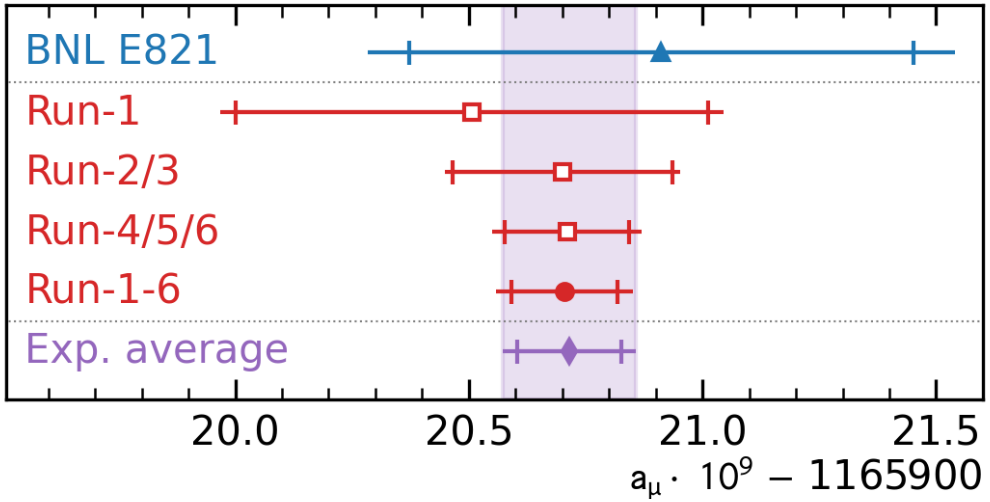
Total uncertainty: 127 ppb

a_μ**(Exp. Average)** $= \mathbf{0.001165920705(148)}$

Total uncertainty: 124 ppb

Final Results

- **Excellent agreement with Run-1/2/3 and BNL E821**
- **Uncertainty reduced by 1.8 times over Run-1/2/3**
- **Combined Run-1-6 reduces the uncertainty by a factor of 4.3 (compared to BNL E821)**
- **New world average reduces the uncertainty by a factor of 4.4 (compared to BNL E821)**



$$a_\mu(\text{Run−1−6}) = 0.001165920710(162)$$

Total uncertainty: 127 ppb

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Total uncertainty: 124 ppb

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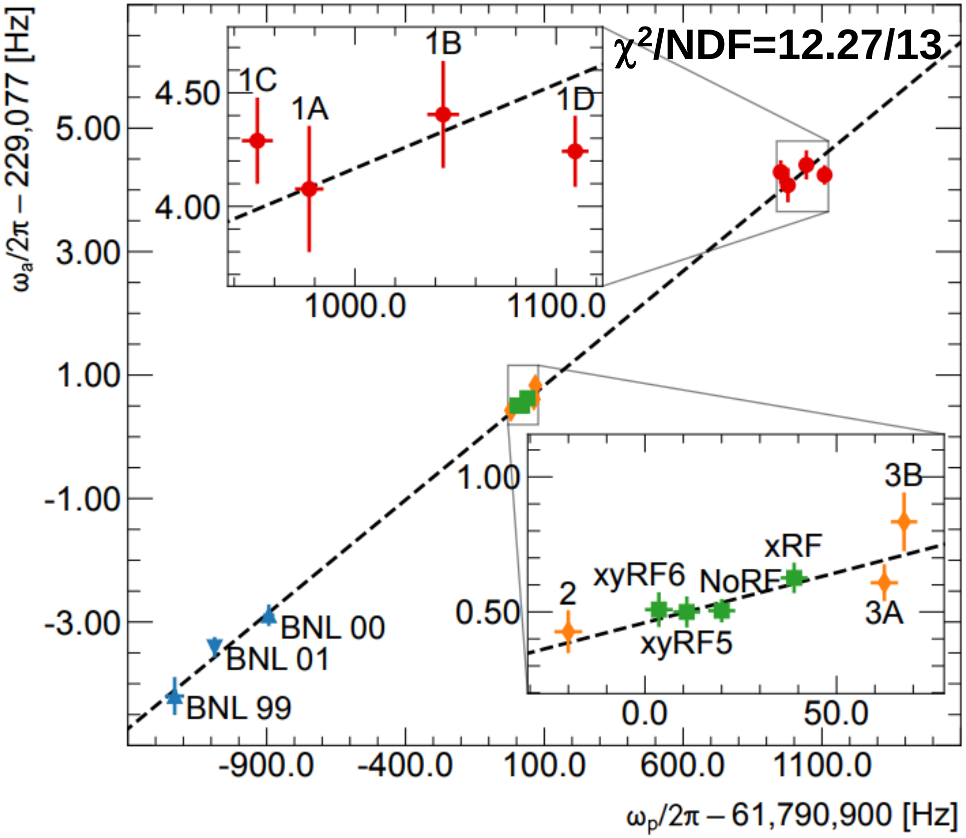
- **New world average reduces the uncertainty by a factor of 4.4 (compared to BNL E821)**

✓ **Consistency check of ω_a vs. ω_p**



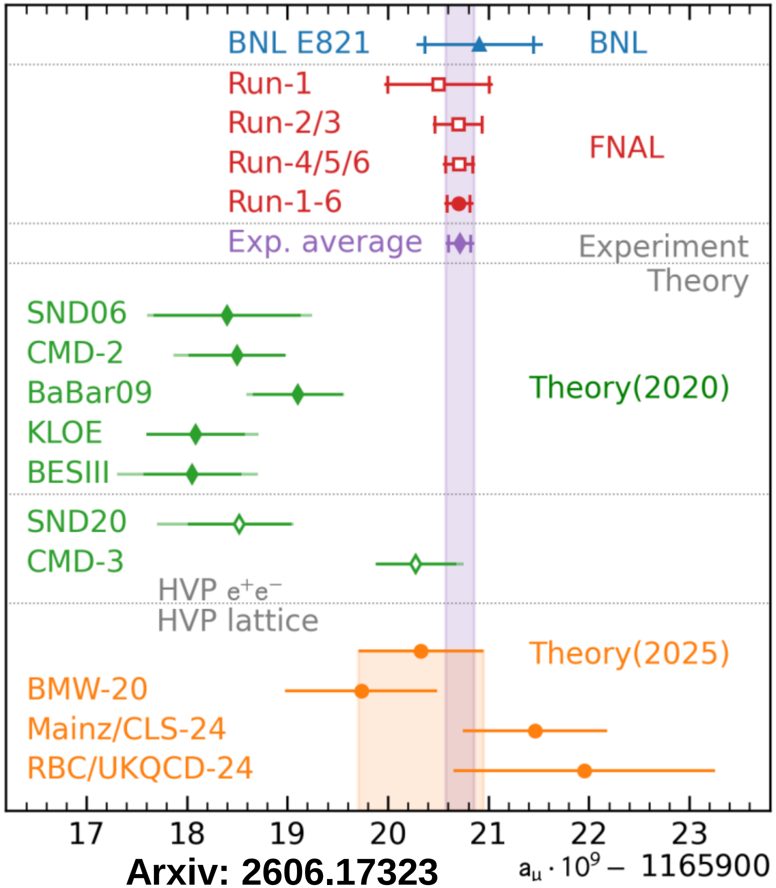
a_μ**(Run−1−6)** $= 0.001165920710(162)$

Total uncertainty: 127 ppb

a_μ**(Exp. Average)** $= 0.001165920705(148)$

Total uncertainty: 124 ppb

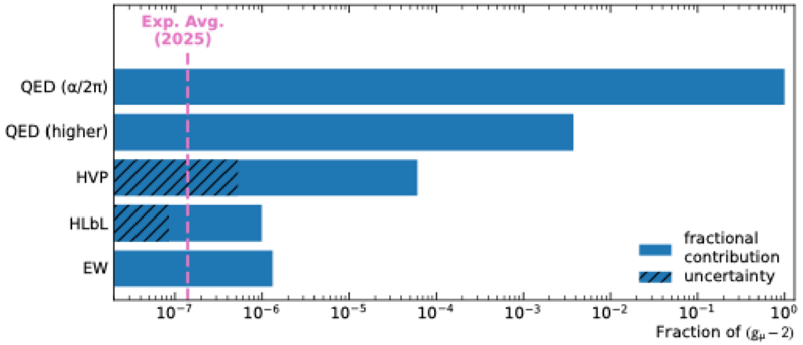
Final Results



Arxiv: 2606.17323

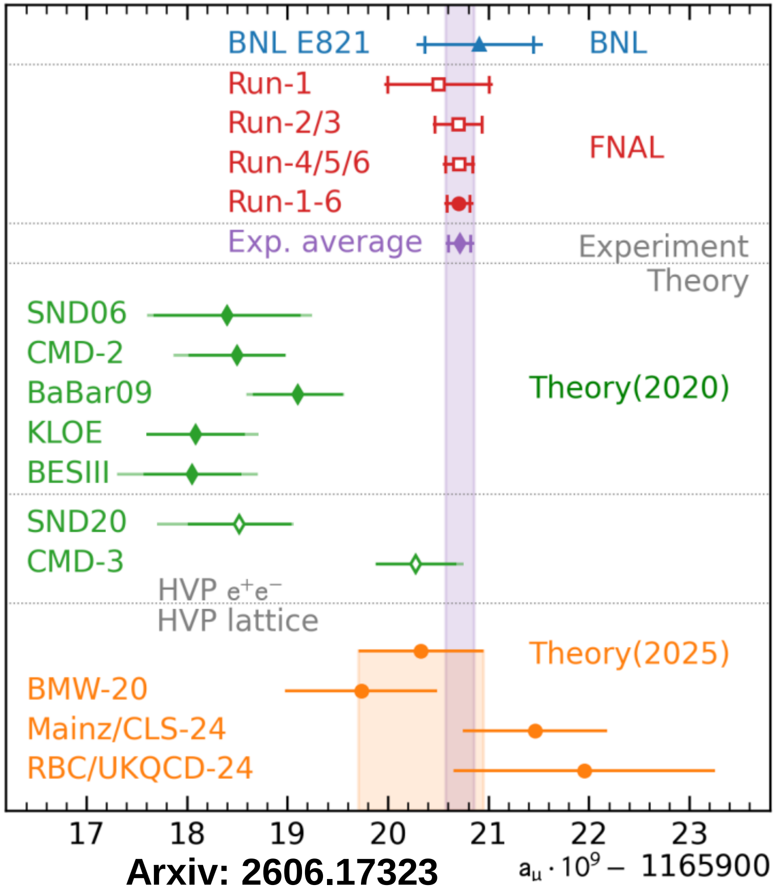
a_μ(Run−1−6) $= 0.001165920710(162)$

- Most precise determination of a_μ for many years to come
- 0.12 ppm measurement tests all Standard Model contributions



- Benchmark for models with new particles or forces

Final Results



Arxiv: 2606.17323

a_μ**(Run−1−6)** $= 0.001165920710(162)$

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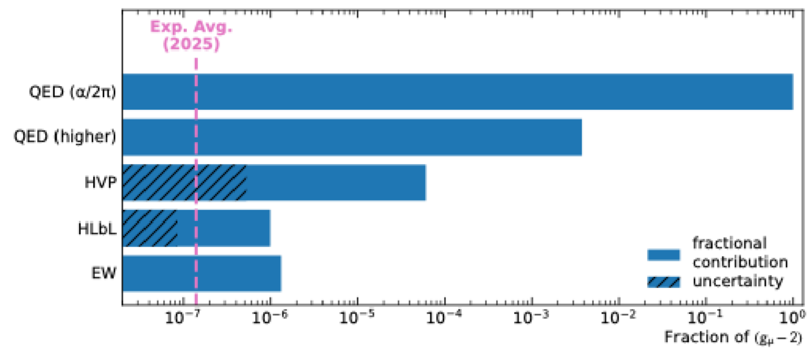
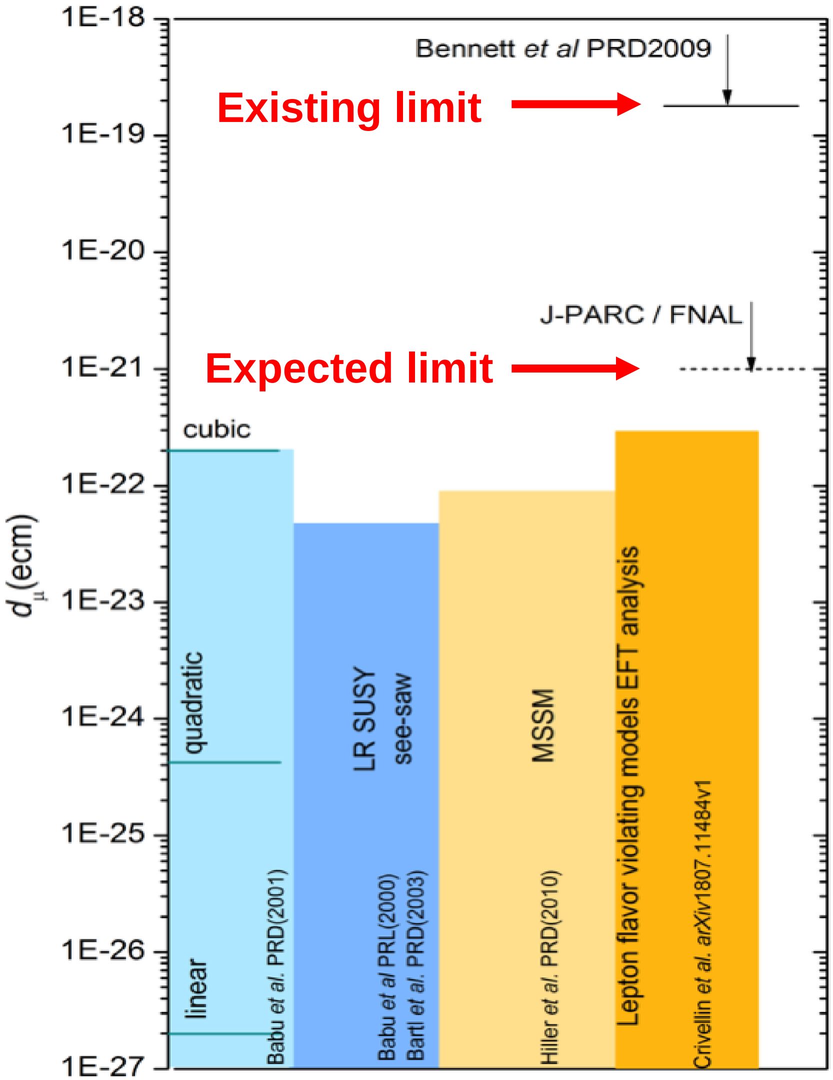


- **Benchmark for models with new particles or forces**

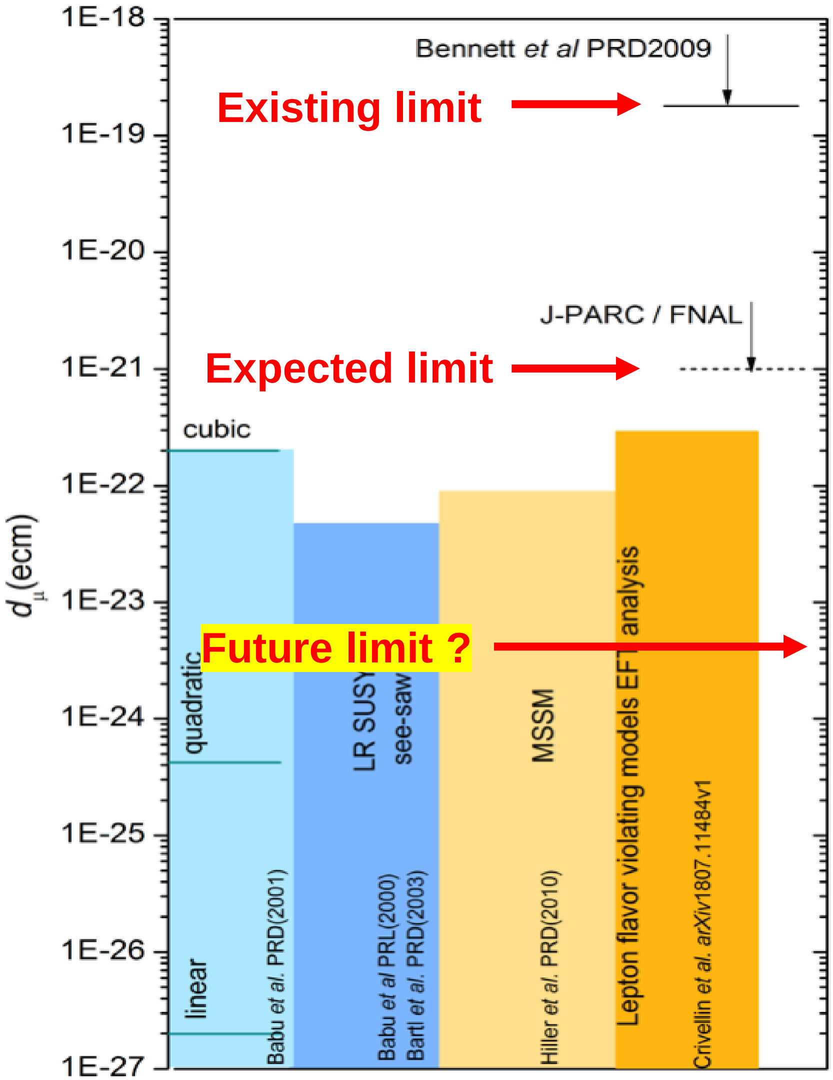
- **WP2025: LQCD LO HVP brings the SM prediction in agreement with experiment**
- **Unresolved puzzle: discrepancy between dispersive e^+e^- method and LQCD HVP**
  - **WP2020 theory uncertainty: 0.37ppm vs. WP2025 theory uncertainty: 0.53ppm**
- **Interesting contrast: ~1% agreement between LQCD LO HVP and e^+e^- results in tau and electron g-2!**

Muon Electric Dipole Moment (EDM)



- SM prediction for muon EDM is almost 0: $d_\mu < 10^{-38}$ e·cm
- Unambiguous new physics signal
- Muon is the best option
  - Direct measurement
  - Free of nuclear / molecular effects
- Note that $d_e \sim 10^{-29}$ e·cm
  - Current best result $d_\mu \sim 10^{-19}$ e·cm
  - $10\text{-}10^2$ improvement expected

Muon Electric Dipole Moment (EDM)



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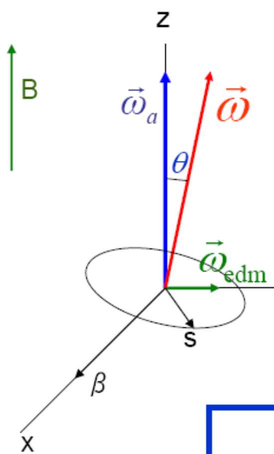
  - Current best result $d_\mu \sim 10^{-19}$ e·cm
  - $10\text{-}10^2$ improvement expected
- **Big discovery potential**

Muon EDM Searches

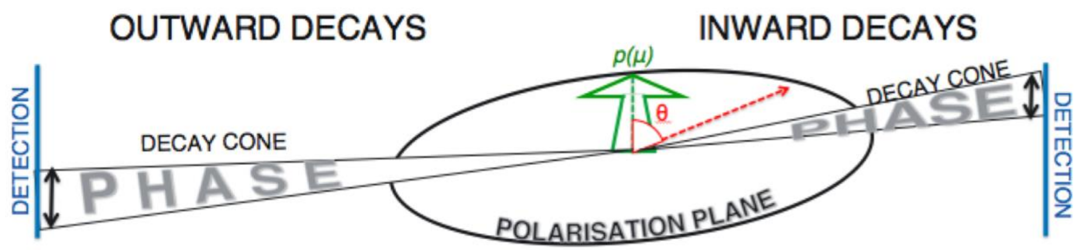


$$\vec{\omega} = \frac{e}{m}\left\{a\vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B}\right)\right\}$$

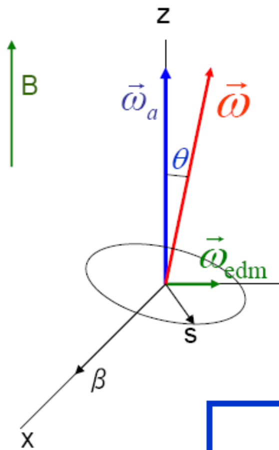
$$\vec{\omega} = \vec{\omega}_a + \vec{\omega}_{\rm edm}$$

$$\tan\theta = \frac{\omega_{edm}}{\omega_a}$$

Muon EDM Searches



Calorimeter-based
- Phase asymmetry and vertical position oscillation
- Systematically limited



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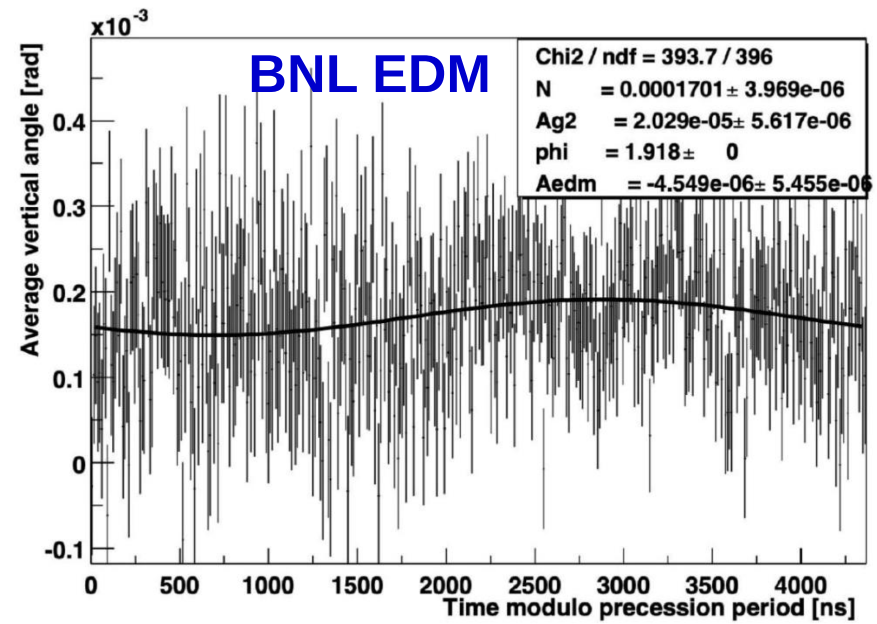
$$\vec{\omega} = \vec{\omega}_a + \vec{\omega}_{\text{edm}}$$

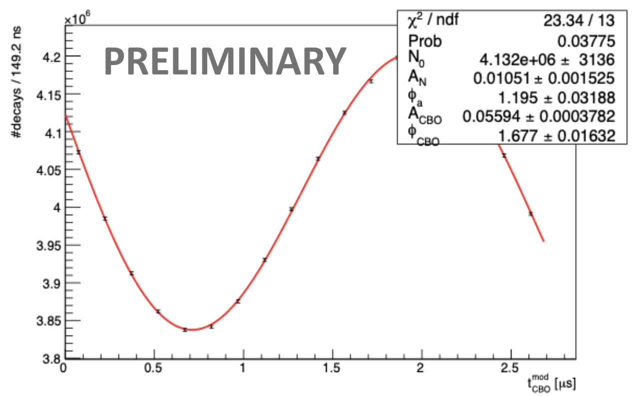
$$\tan\theta = \frac{\omega_{edm}}{\omega_a}$$

Tracker-based
- Vertical angle oscillation measurement
- Statistically limited at BNL

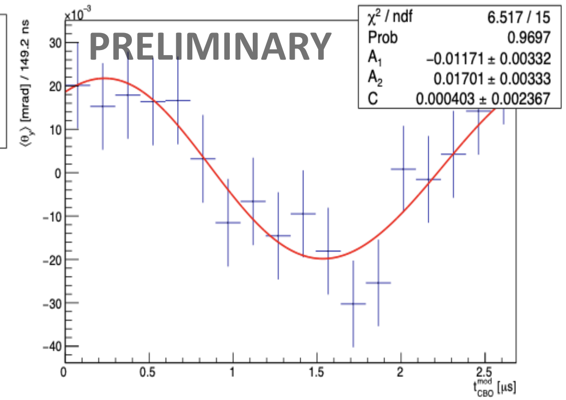


Muon EDM Searches

- **Blind analysis with large fake signal**
- **Fit the ω_a oscillation**
- **Fit the average vertical angle oscillation**



(a) $750 \leq p < 1000$ MeV

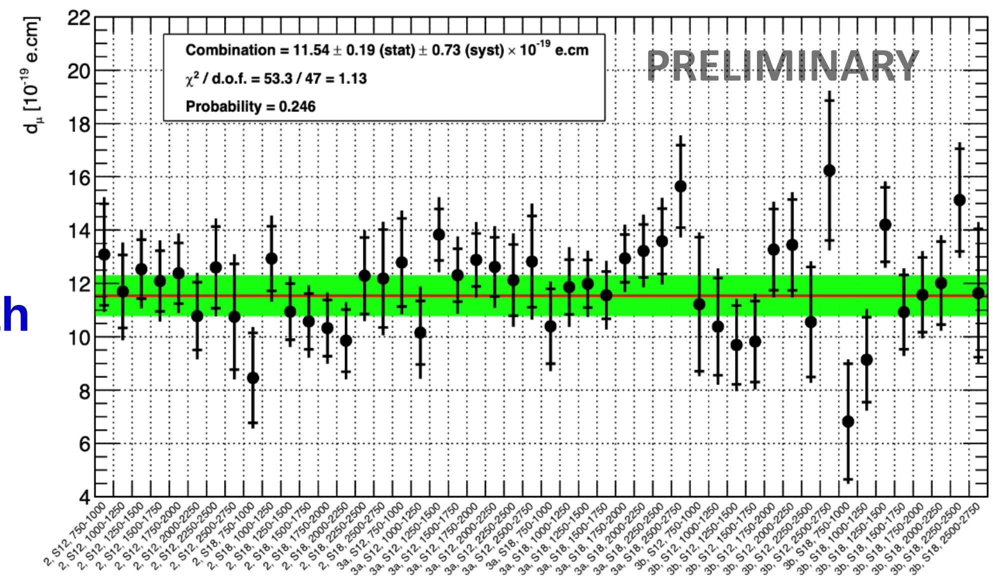


(a) $750 \leq p < 1000$ MeV

EDM Signal

$$\langle\theta_y\rangle(t) = \frac{A_{g-2}\cos(\omega_a t+\phi_a) + A_{\mathrm{EDM}}\sin(\omega_a t+\phi_a)}{(1+A_N\cos(\omega_a t+\phi_a^p))\,(1+A_{\mathrm{CBO}}\cos(\omega_{\mathrm{CBO}}t+\phi_{\mathrm{CBO}}))} + C$$

Fixed Term



- **Assuming central value at 0 after unblinding → limit of 9.2×10^{-20} e · cm**
- **2x improvement compared to BNL with Run-2/3 data**
- **$\sim 10^{-21}$ e · cm goal with Run1-6 data**

Canton-μ Proposal: Muon g-2 at HIAF

arXiv > hep-ex > arXiv:2512.11486

Search | Help

High Energy Physics – Experiment

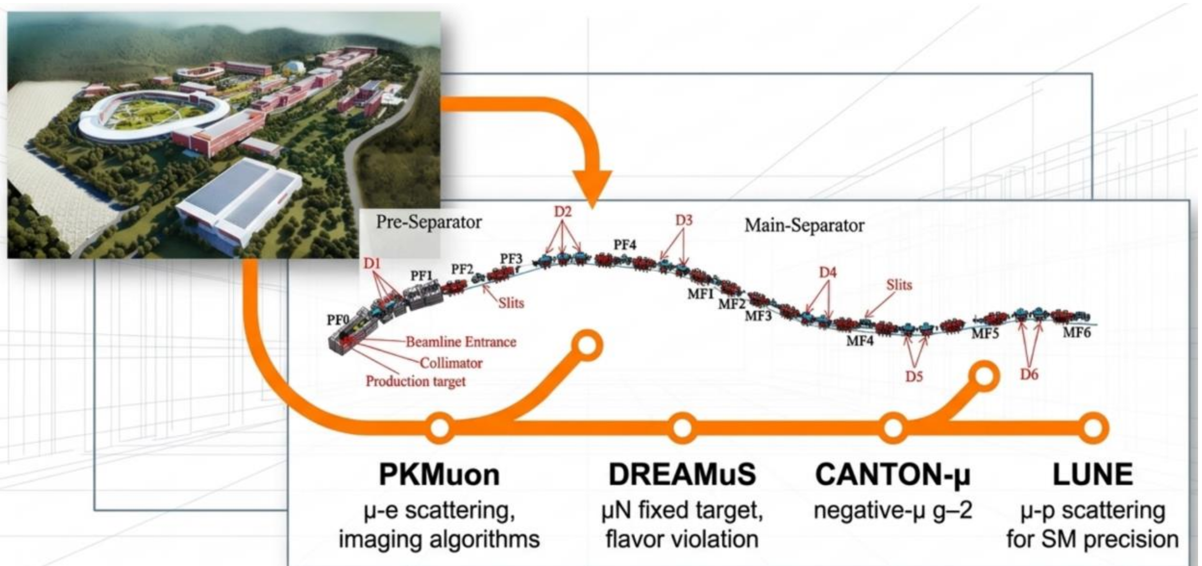
[Submitted on 12 Dec 2025]

CANTON-μ Proposal: A Next-Generation Muon $g-2$ Measurement at Sub-0.1 ppm Precision

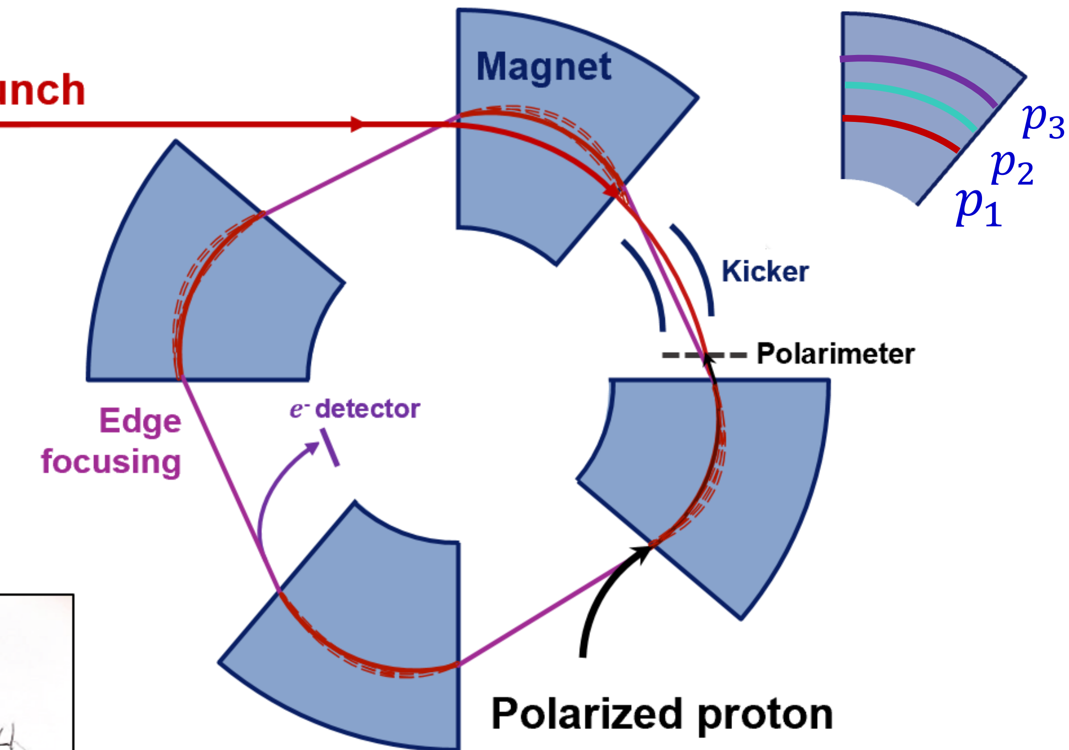
Ce Zhang, Yu Xu, On Kim, Bingzhi Li, Guodong Shen, Liangwen Chen, Fedor Ignatov, Liang Li, Qiang Li, Xueheng Zhang, Zhiyu Sun

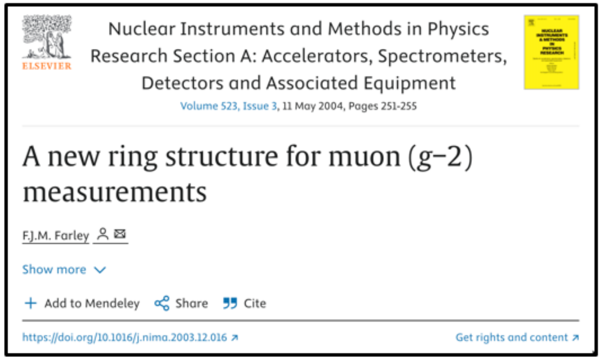
We propose a next-generation precision measurement of the muon anomalous magnetic moment $(g-2)$ at the High Intensity Heavy-Ion Accelerator Facility (HIAF) in Huizhou, China. The project, named CANTON-μ (Coherent Anomalous magNetic momenT ObservatioN with muon), describes novel experimental approaches based on HIAF's unique capability to produce intense pulsed muon beams at the GeV scale, particularly for negative-muon polarity. These approaches incorporate innovative focusing concepts such as the sector-magnet and weak-focusing ring designs, complemented by advanced magnetic-field calibration methods including a polarized-proton co-magnetometer. This independent measurement with distinct systematics is designed to achieve a precision of 0.1 ppm in Phase 1, matching the latest Fermilab result for μ^+, and 0.05 ppm in Phase 2 with the HIAF upgrade. Such precision will provide an exceptionally sensitive test of the Standard Model and a powerful probe of New Physics and CPT symmetry.

Comments: 25 pages, 7 figures
Subjects: **High Energy Physics – Experiment (hep-ex)**
Cite as: arXiv:2512.11486 **[hep-ex]**
(or arXiv:2512.11486v1 **[hep-ex]** for this version)
https://doi.org/10.48550/arXiv.2512.11486



Canton-μ Proposal: Muon g-2 at HIAF




Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment
Volume 523, Issue 3, 11 May 2004, Pages 251-255

A new ring structure for muon (g−2) measurements

F.J.M. Farley

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https://doi.org/10.1016/j.nima.2003.12.016

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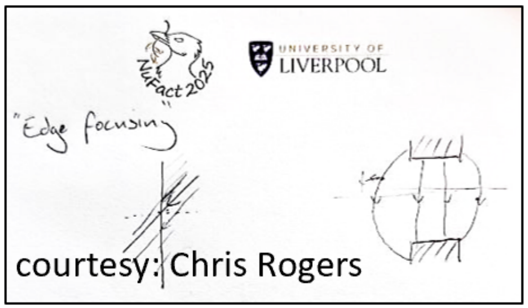


- Segmented sector magnet structure with fringe fields to focus the muons, no need for additional E field focusing.
- No restriction on magic muon momentum. Polarized protons experience the same magnetic field as muons for a direct calibration of the magnetic field.

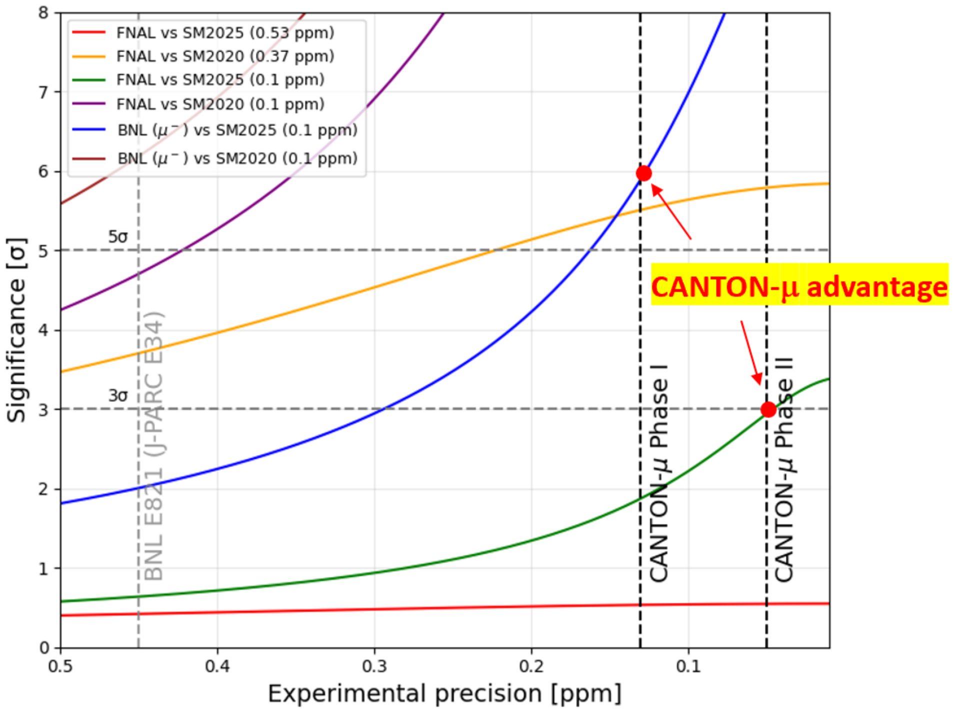
Canton-μ Proposal: Muon g-2 at HIAF

Muon g-2 theory and experiment comparison continues:

$$\Delta a_\mu^{\mathrm{Exp-WP2020}} = 26.2(4.5) \times 10^{-10},$$

$$\Delta a_\mu^{\mathrm{Exp-WP2025}} = 3.8(6.3) \times 10^{-10}$$

Canton-μ Phase-1 goal: 0.12ppm (FNAL precision)
Theory precision matches FNAL: 0.1ppm
Canton-μ Phase-2 goal: 0.05ppm



- **Canton-μ Phase-1 reaches 5σ in case of BNL central (μ^-) vs. WP2025**
- **Canton-μ Phase-2 reaches 3σ in case of FNAL central (μ^+) vs. WP2025**

Conclusion and Outlook

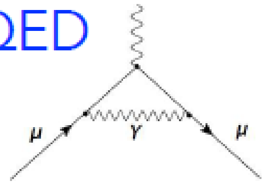
- ✓ **Breakthrough Prize for 3 generations of Muon g-2 exp.**
  - ✓ **Most precise measurement at 0.12ppm**
- ✓ **Puzzles remain to be solved and many new potentials**
  - ✓ **Tension between different methods to evaluate HVP contribution**
  - ✓ **Muon EDM ($\mathbf{O(10^{-21})\ e\cdot cm}$) , CPT/LV and Dark Matter searches**
- ✓ **J-PARC Muon g-2/EDM to take data in ca. 2030: $\mathbf{1.5\times10^{-21}\ e\cdot cm}$ EDM**
- ✓ **PSI MuEDM Phase I to take data from 2027: $\mathbf{3\times10^{-21}\ e\cdot cm}$ EDM**
- ✓ **Canton-μ Proposal: μ^{-} 0.05 ppm precision potential**
- ✓ **More exciting results from Muon g-2 and EDM sector underway!**

Backup

Muon g-2 Theory Prediction

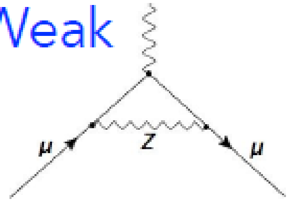
$$a_\mu = a_\mu(\mathrm{QED}) + a_\mu(\mathrm{Weak}) + a_\mu(\mathrm{Hadronic})$$

QED



$+\ldots$ $116\,584\,718.9\,(1) \times 10^{-11}$ 0.001 ppm

Weak

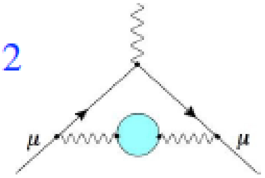


$+\ldots$ $153.6\,(1.0) \times 10^{-11}$ 0.01 ppm

Hadronic… **Muon g-2 Theory Initiative: Phys. Rept. 887 (2020) 1-166 (WP2020)**

…Vacuum Polarization (HVP)

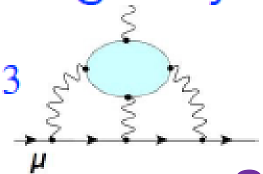
α^2



$+\ldots$ $6845\,(40) \times 10^{-11}$ 0.37 ppm [0.6%]

…Light-by-Light (HLbL)

α^3



$+\ldots$ $92\,(18) \times 10^{-11}$ 0.15 ppm [20%]

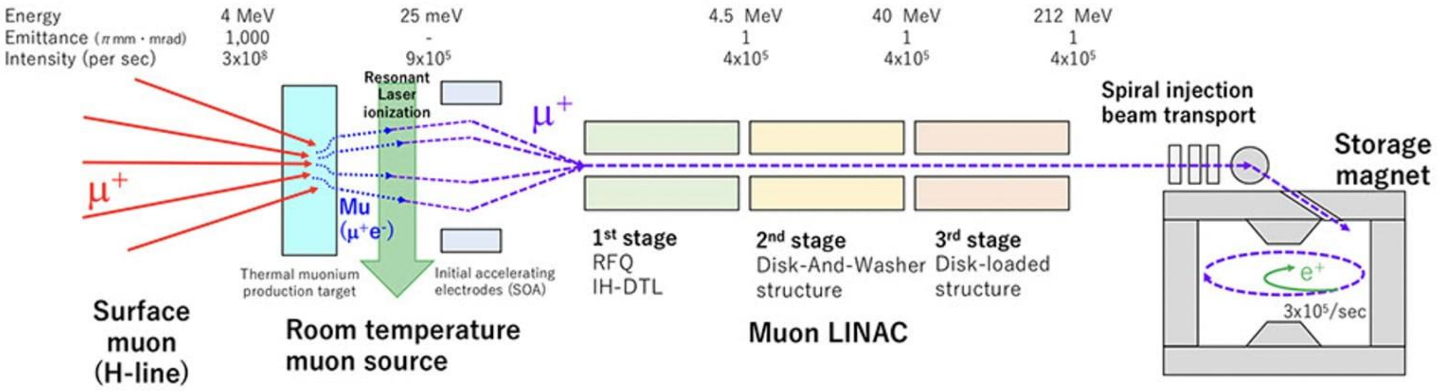
a_μ(SM) = 0.00 116 591 810(43) [370 ppb]

What makes them so different?

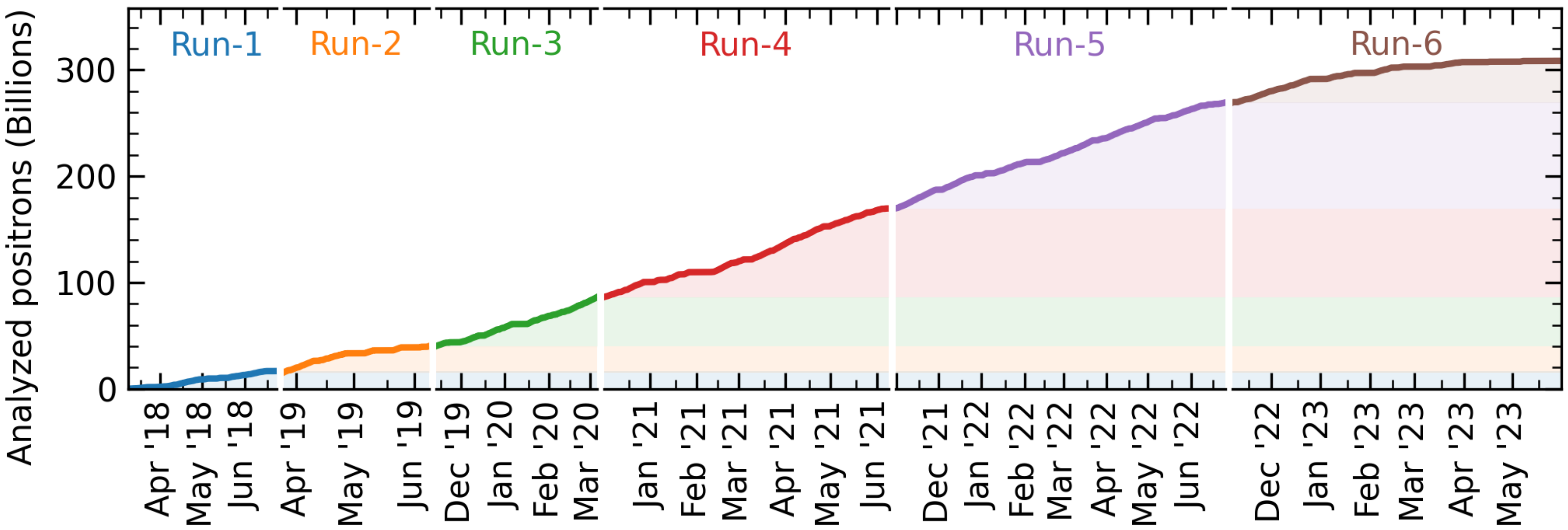
$$\vec{\omega_a} = \frac{e}{mc}\left[a\vec{B} - \left(a - \frac{1}{\gamma^2 - 1}\right)\vec{\beta}\times\vec{E}\right] + \frac{e\eta}{2mc}\left(\vec{E} + \vec{\beta}\times\vec{\boldsymbol{B}}\right)$$

g-2 **E=0** **EDM**

- **“Ultra-cold” muon source: low P_T muons**
  - **Not constrained to run at the “magic momentum”**
  - **Smaller magnet, Compact design**
  - **Low emittance beam, Intrinsically more uniform**
- **Challenges**
  - **Produce, accelerate and inject cold muons into storage ring**
  - **Overall low muon efficiency**

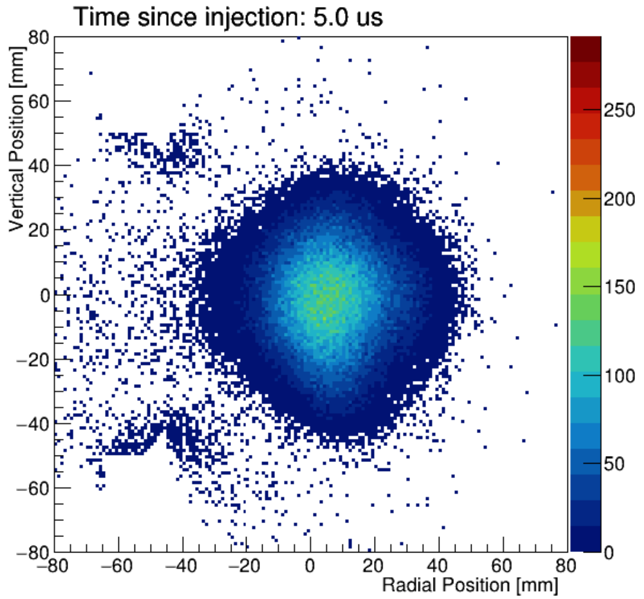


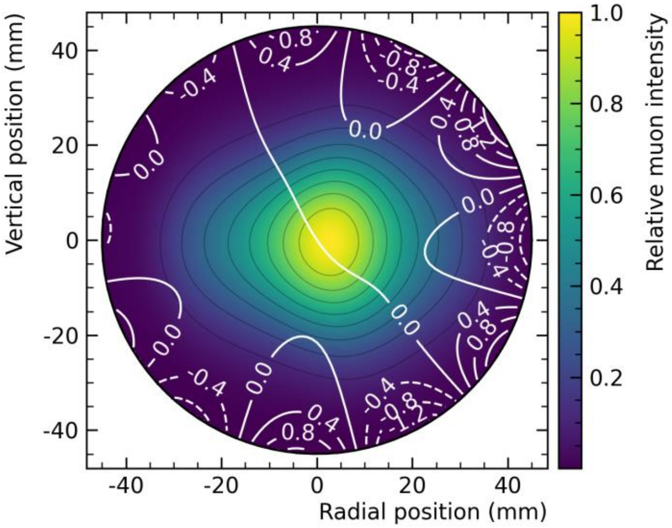
Data Collection



- ✓ **Apr. 2021: Run-1 Result (2018 data) Stat. 434ppb**
- ✓ **Aug. 2023: Run-2/3 Result (2019-20 data) Stat. 201ppb**
- ✓ **Jun. 2025: Run-4/5/6 Result (2021-23 data) Stat. 114ppb**
- ✓ **Run-2/3 ~ 4 times larger than Run-1**
- ✓ **Run-4/5/6 ~ 4 times larger than Run-2/3**

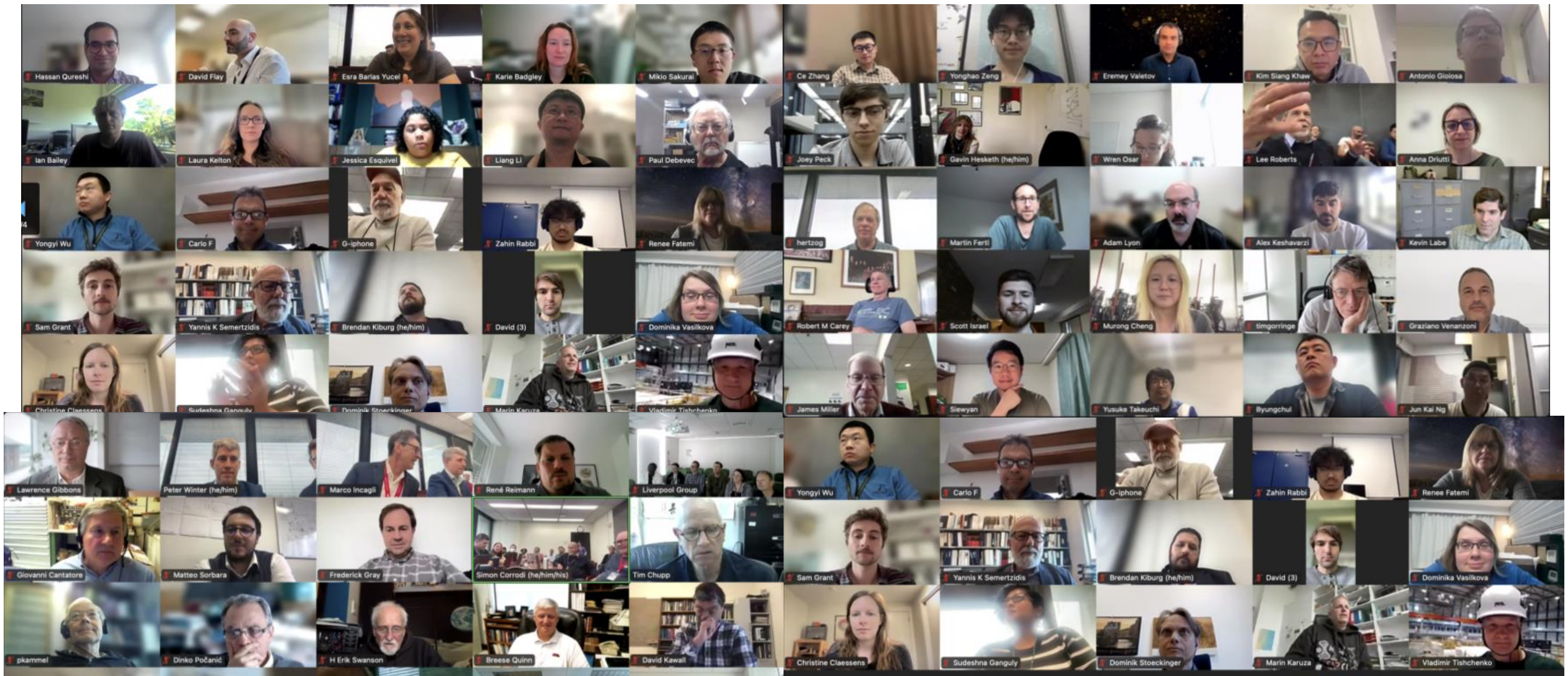
Muon Distribution Measurement





- **Trackers can measure beam oscillations directly**
  - **Beam-dynamics corrections**
  - **Tuning simulations**
  - **Optimizing experiment running conditions**
- **Use muon distribution to weight field maps by where the muons live**

Unblinding Ceremony



The Muon g-2 Collaboration:

176 collaborators, 34 institutes, 7 countries

Particle-, Nuclear-, Atomic-, Optical-, Accelerator-, and Theoretical-Physicists and Engineers

Improving Systematic Uncertainties

Identified an Intensity-Dependent Gain Sag

- with a magnitude below our stability design goal (10^{-4})
- however, phase-shifted oscillation at ω_a leads to larger sensitivity than orig. estimated
- Resolved puzzle of residual slow terms in ω_a-fits
- Run-2/3: +47 ppb $\pm$ 24 ppb
  (Run-1: +50 ppb $\pm$ 29 ppb)

Improved spatial-model of Kicker-Transients

- Additional, dedicated measurement after muon storage periods
- similar cross-checks for transient fields from ESQ (B_Q), confirmed used model
- Run-2/3: +19 ppb $\pm$ 23 ppb
  *on a_μ, correction on B_k has opposite sign

Identified and corrected a sign error

- in one (of three) contribution to the Differential Decay Correction ($C_{dd}^{beamline}$)
- Run-2/3: magnitude of $C_{dd}^{beamline}$: 12 ppb to 20 ppb
- Run-2/3: +32 ppb $\pm$17 ppb
  *uncertainty due to method not sign error

Simulation efforts allowed for many cross-checks and gain new insights

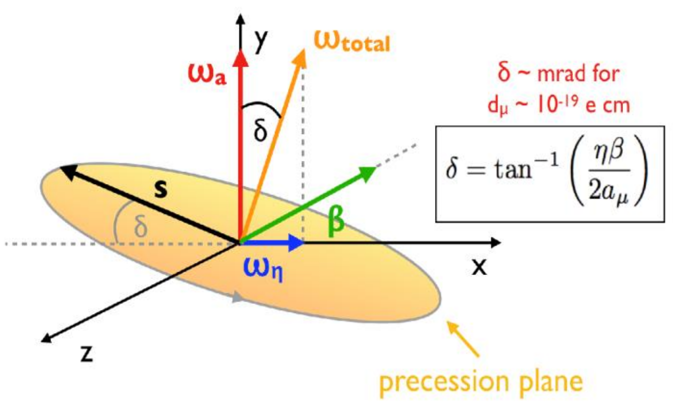
Use Run-4/5/6 knowledge for Run-1/2/3:

Run-2/3 central value: +89 ppb
Run-2/3 uncertainty: from 70 ppb to 78 ppb

BSM searches (EDM, CPT/LV, DM)

Muon Electric Dipole Moment (EDM)

- Spin precession plane is tilted in the presence of the EDM
- Run-2/3 analysis to be announced soon!
- BNL limit: $1.8 \times 10^{-19}\, e \cdot cm \rightarrow$
  FNAL Projected limit: $\sim \mathcal{O}(10^{-20}\, e \cdot \mathrm{cm})$



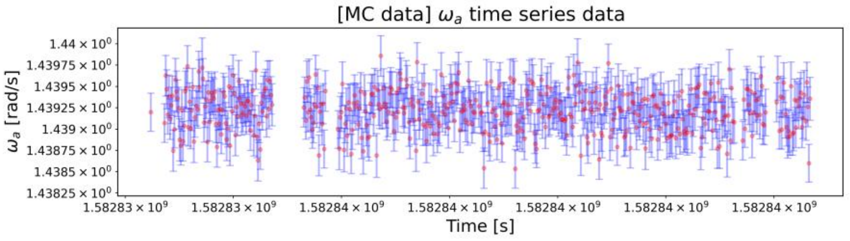
$$\delta = \tan^{-1}\left(\frac{\eta\beta}{2a_\mu}\right)$$

CPT and Lorentz Invariance Violation

- ω_a modulated at sidereal motion freq.
- Run-2/3 analysis in review
- BNL limit: 1.4×10^{-24} GeV →
  FNAL Projected limit: $\mathcal{O}(10^{-25})$ GeV

Ultralight Muonic Dark Matter (scalar)

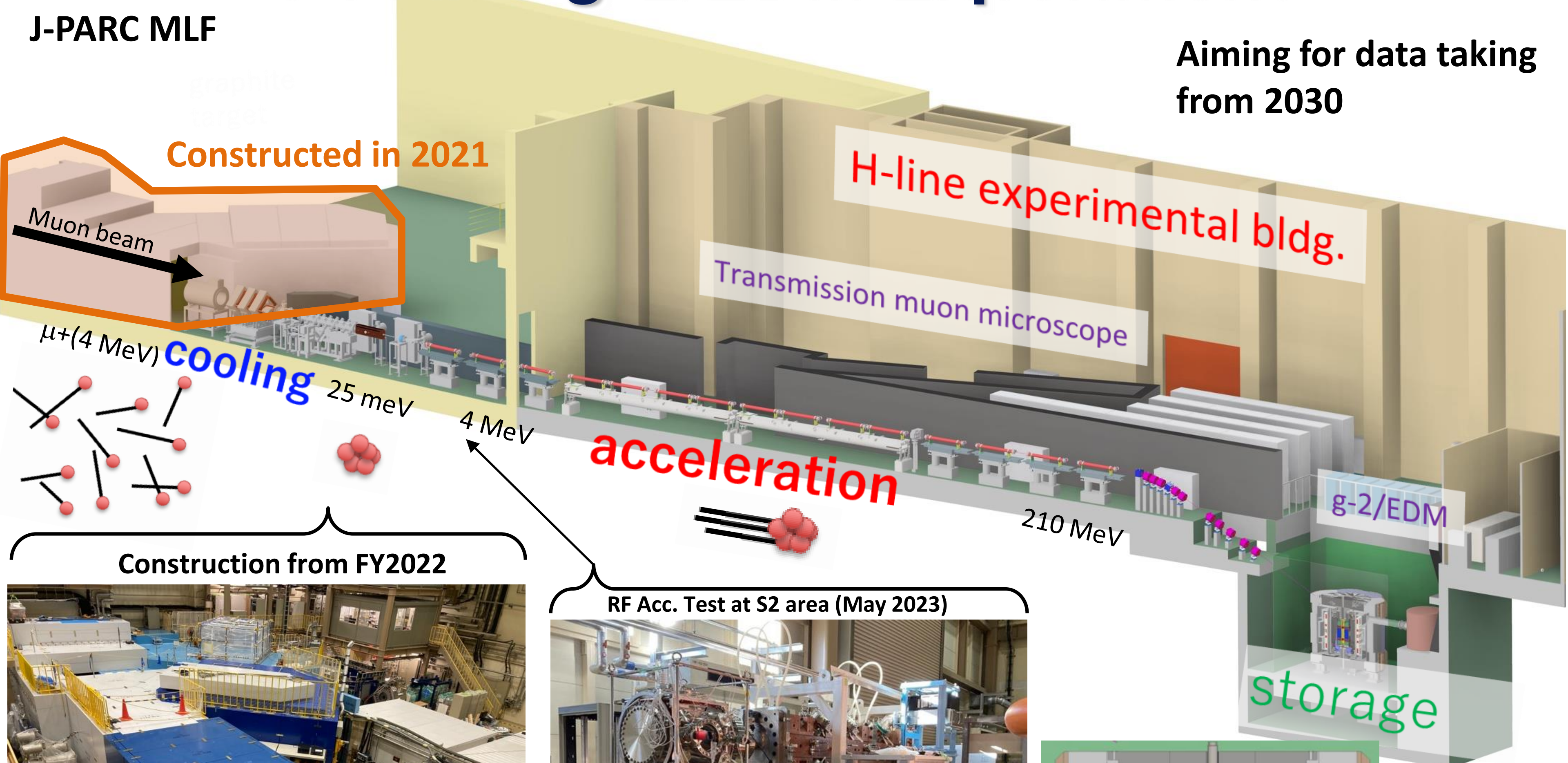
- ω_a modulated at the DM Compton frequency: $\omega_{DM} = c^2 m_{DM}/\hbar$
- Run-2/3 analysis in progress



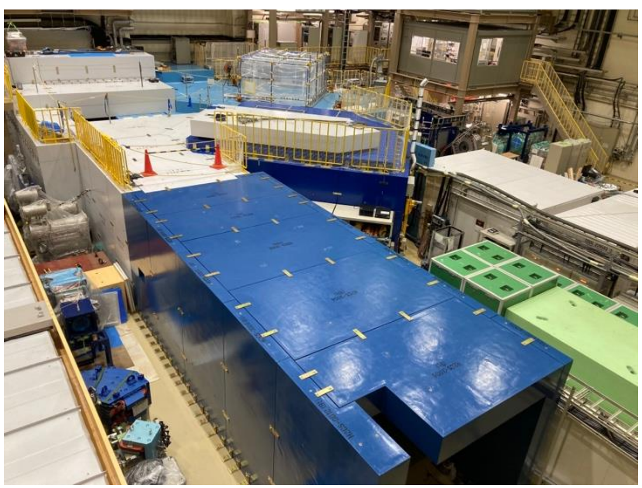
J-PARC g-2/EDM Experiment

J-PARC MLF

Aiming for data taking from 2030

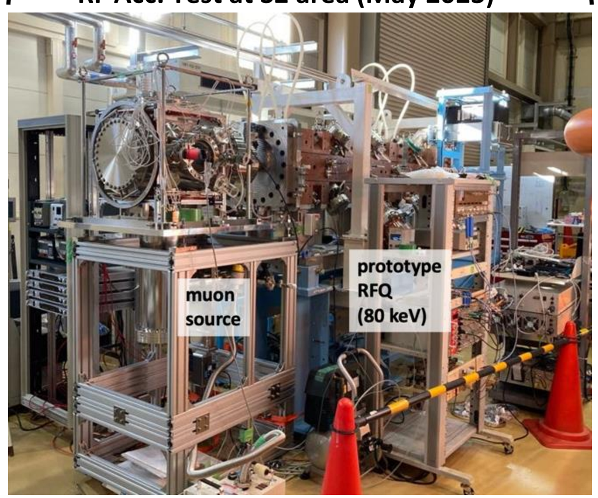


Construction from FY2022



Shields, area control (2022)

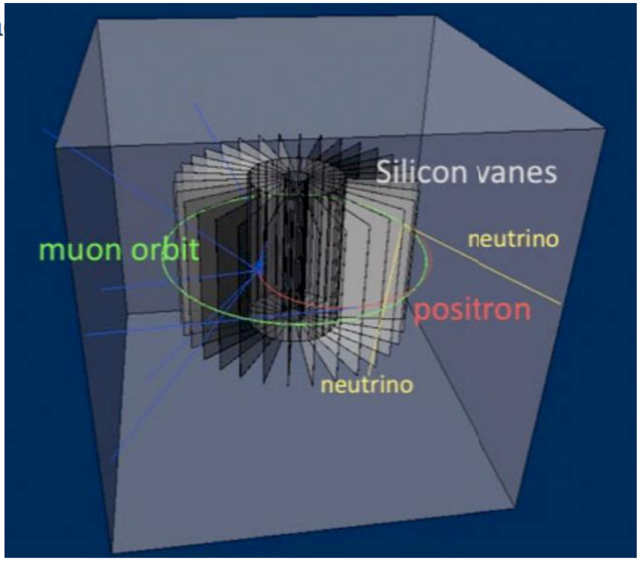
RF Acc. Test at S2 area (May 2023)



J-PARC g-2/EDM Expectation

Comparison of various parameters for the Fermilab and J-PARC $(g-2)$ Experim

Parameter	Fermilab E989	J-PARC E24
Statistical goal	100 ppb	400 ppb
Magnetic field	1.45 T	3.0 T
Radius	711 cm	33.3 cm
Cyclotron period	149.1 ns	7.4 ns
Precession frequency, ω_a	1.43 MHz	2.96 MHz
Lifetime, $\gamma\tau_\mu$	64.4 μs	6.6 μs
Typical asymmetry, A	0.4	0.4
Beam polarization	0.97	0.50
Events in final fit	1.8×10^{11}	8.1×10^{11}



Subsystem	Efficiency
Surface muon transportation	16%
Thermal muon generation	0.19%
Thermal muon transportation	72%
Acceleration	71%
Injection	78%
Energy window	12%
Detector acceptance	100%
Reconstruction	90%
Total	0.0013%

Aim to have comparable precision with FNAL Run-1 result

- **Assuming 1 year operation**
- **Statistical uncertainty dominated**
  - **$\delta\omega_a$ = 0.45 ppm, $\delta\omega_{a\_sys}$ = 0.07 ppm**
  - **δEDM = $1.5 \cdot 10^{-21}$ e·cm**