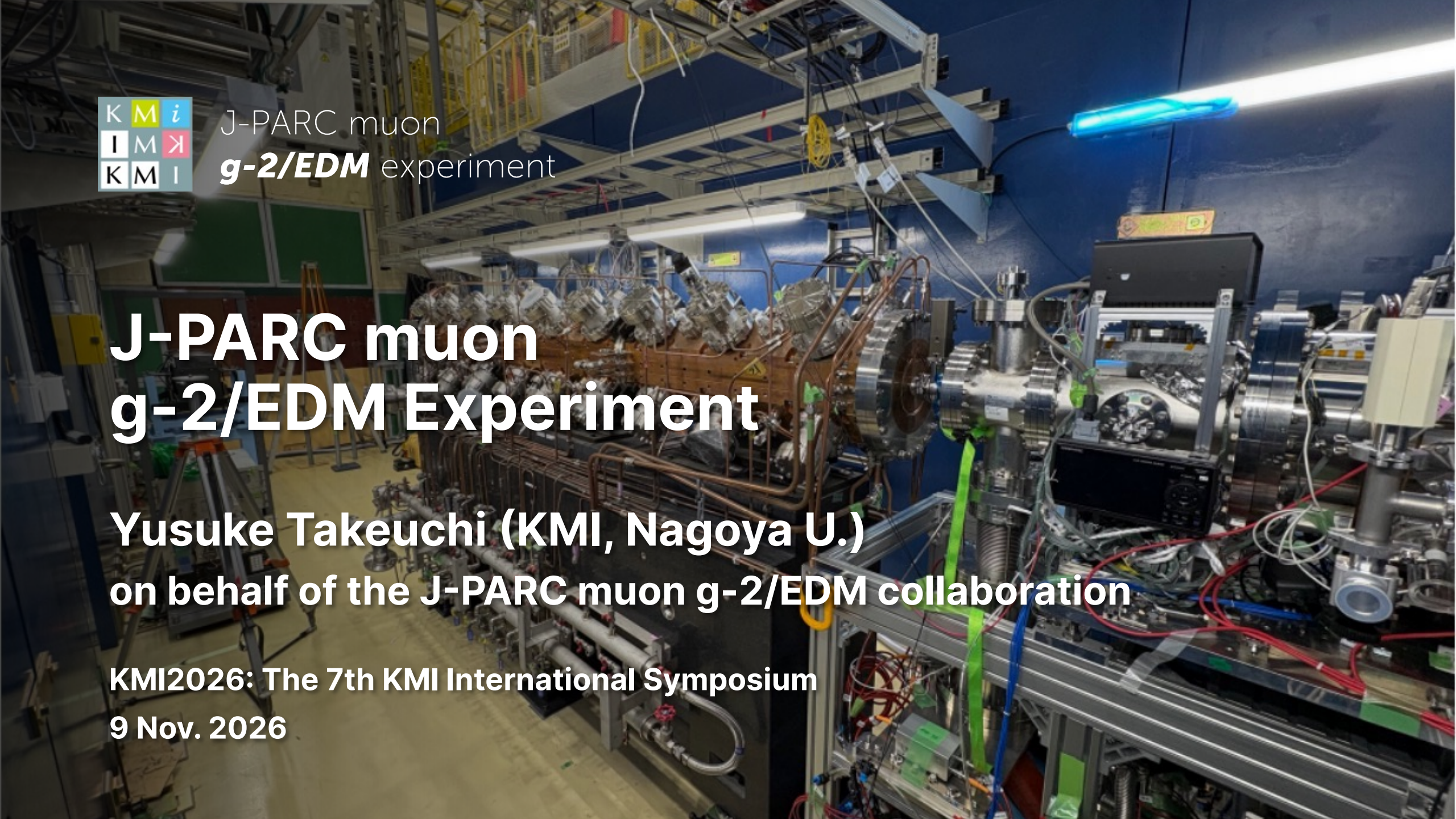


J-PARC muon g-2/EDM Experiment

Yusuke Takeuchi (KMI, Nagoya U.)
on behalf of the J-PARC muon g-2/EDM collaboration

KMI2026: The 7th KMI International Symposium
9 Nov. 2026

Muon g–2 and EDM

J-PARC muon
g-2/EDM experiment

Phys. Rev. D (accepted, 2026), arXiv:2606.17323

Muon anomalous magnetic moment (g–2)

- Final result from Fermilab E989 (2025): **127 ppb precision**
- WP25 lattice-QCD-based prediction agrees with experiment
- Tensions among hadronic vacuum polarization calculations remain

Theory details: Miura-san's talk

Muon electric dipole moment (EDM)

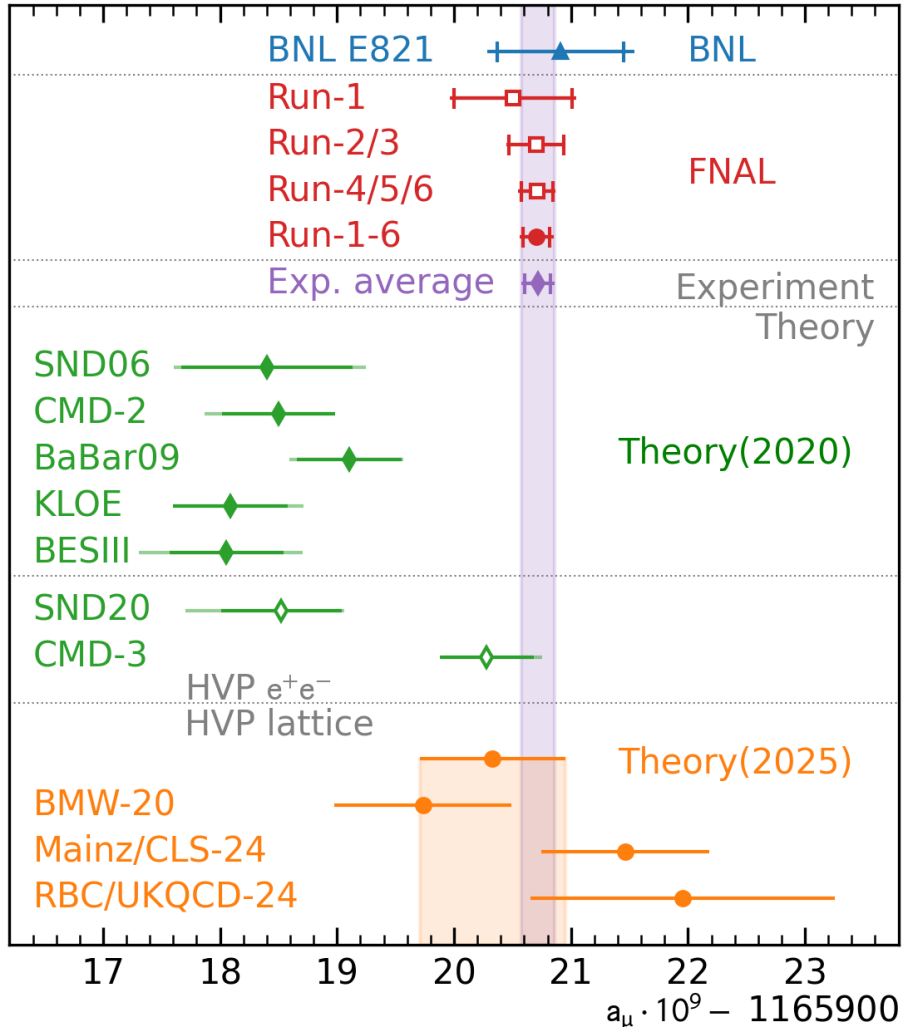
- A nonzero muon EDM would violate P and T symmetries, implying CP violation if CPT is conserved
- The SM predicts an extremely small EDM $|d_\mu^{\mathrm{SM}}| \sim 10^{-38}\, e \cdot \mathrm{cm}$, far below current experimental sensitivity
- **New direct limit (arXiv:2608.11124, 2026)**
  - **Fermilab E989 (90% CL):**

$$|d_{\mu^+}| < 0.98 \times 10^{-19}\, e \cdot \mathrm{cm}$$

  - **Combined with BNL (90% CL, assuming CPT):**

$$|d_\mu| < 0.86 \times 10^{-19}\, e \cdot \mathrm{cm}$$

  - **2.3-fold improvement in measurement precision compared with BNL (with 25% of the dataset (Runs 2–3).)**



How g–2 and EDM are measured

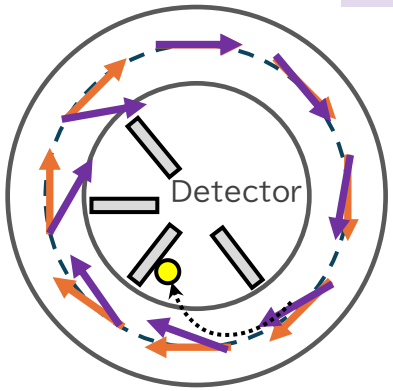
J-PARC muon **g-2/EDM** experiment

spin precession (ω_s) $\vec{\omega}_s$ — $\vec{\omega}_c$ cyclotron motion (ω_c)

muon momentum

muon spin

in a uniform B-field



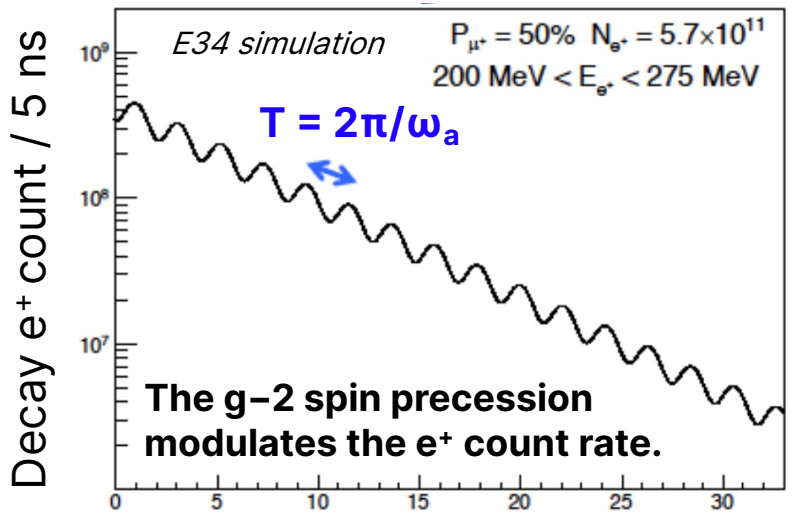
T-BMT equation: assuming $\vec{\beta}\cdot\vec{B}=\vec{\beta}\cdot\vec{E}=0$

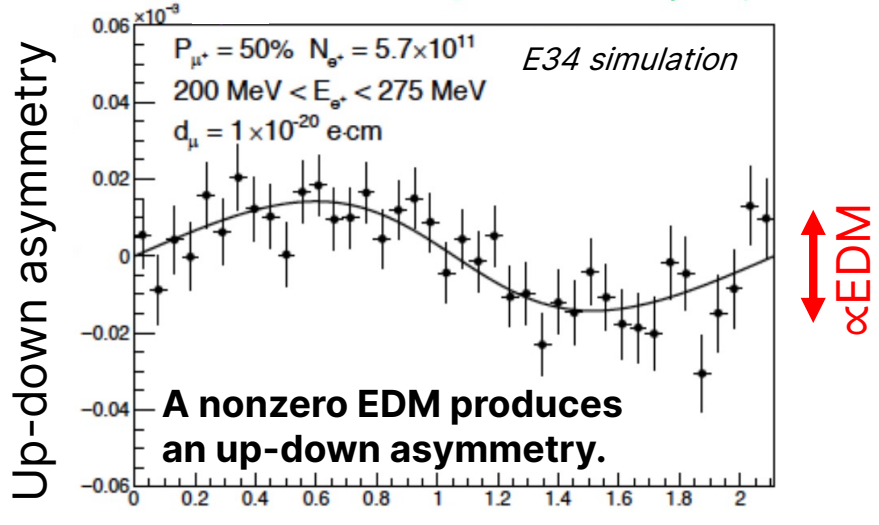
$$= -\frac{e}{m_\mu}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2-1}\right)\frac{\vec{\beta}\times\vec{E}}{c} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B}+\frac{\vec{E}}{c}\right)\right]$$

ω_a (g-2): In-plane spin precession

ω_η (EDM): Out-of-plane spin motion

High-energy positrons are preferentially emitted along the muon spin direction





Independent approach: Fermilab vs J-PARC

J-PARC muon
g-2/EDM experiment

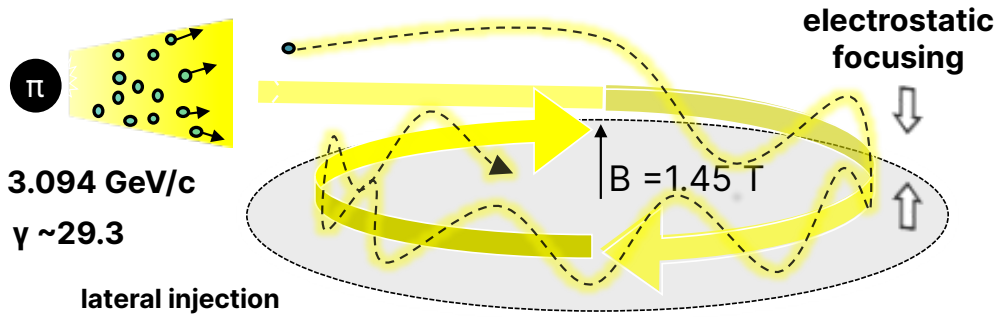
$$\vec{\omega} = \vec{\omega}_a + \vec{\omega}_\eta = \vec{\omega}_s - \vec{\omega}_c$$

T-BMT equation:
assuming $\vec{\beta} \cdot \vec{B} = \vec{\beta} \cdot \vec{E} = 0$

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

ω_a ω_η

BNL/Fermilab



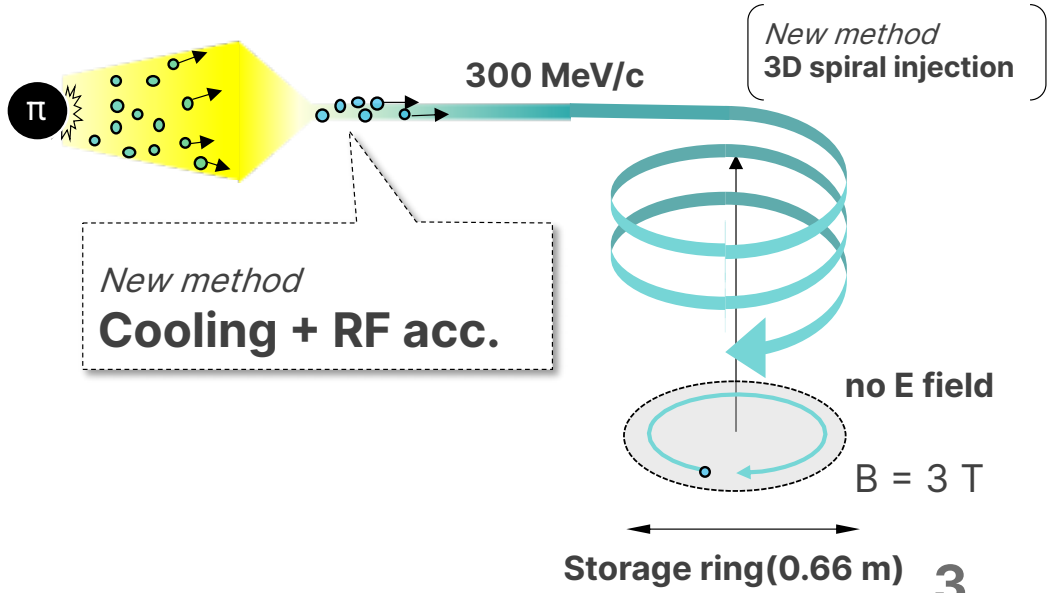
$$a_\mu - \frac{1}{\gamma^2 - 1} = 0$$

$$(\gamma_{\text{magic}} \simeq 29.3)$$

Storage ring(14 m)

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

J-PARC



Independent approach: Fermilab vs J-PARC

J-PARC muon
g-2/EDM experiment

$$\vec{\omega} = \vec{\omega}_a + \vec{\omega}_\eta = \vec{\omega}_s - \vec{\omega}_c$$

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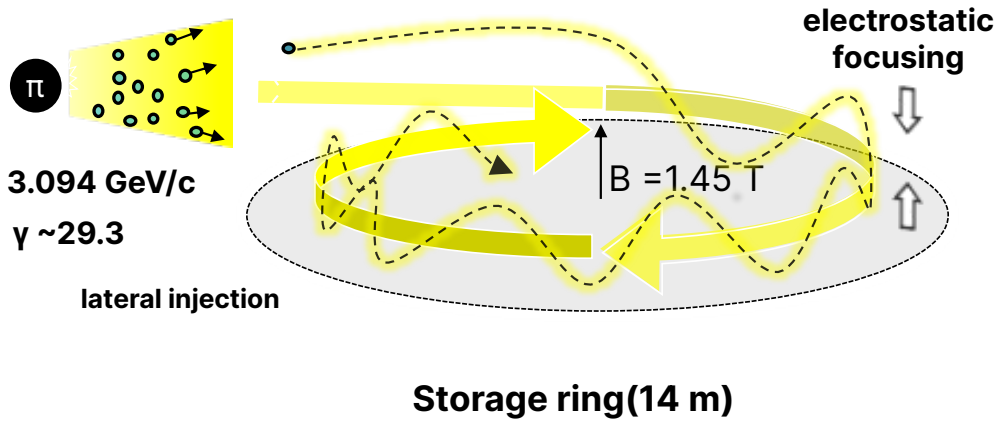
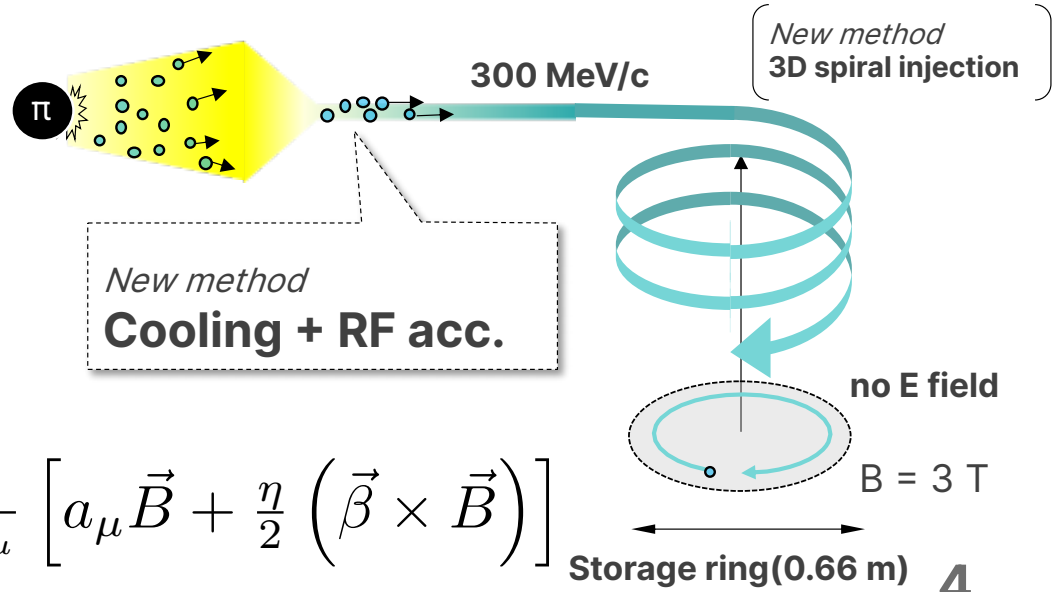
ω_a ω_η

BNL/Fermilab



J-PARC



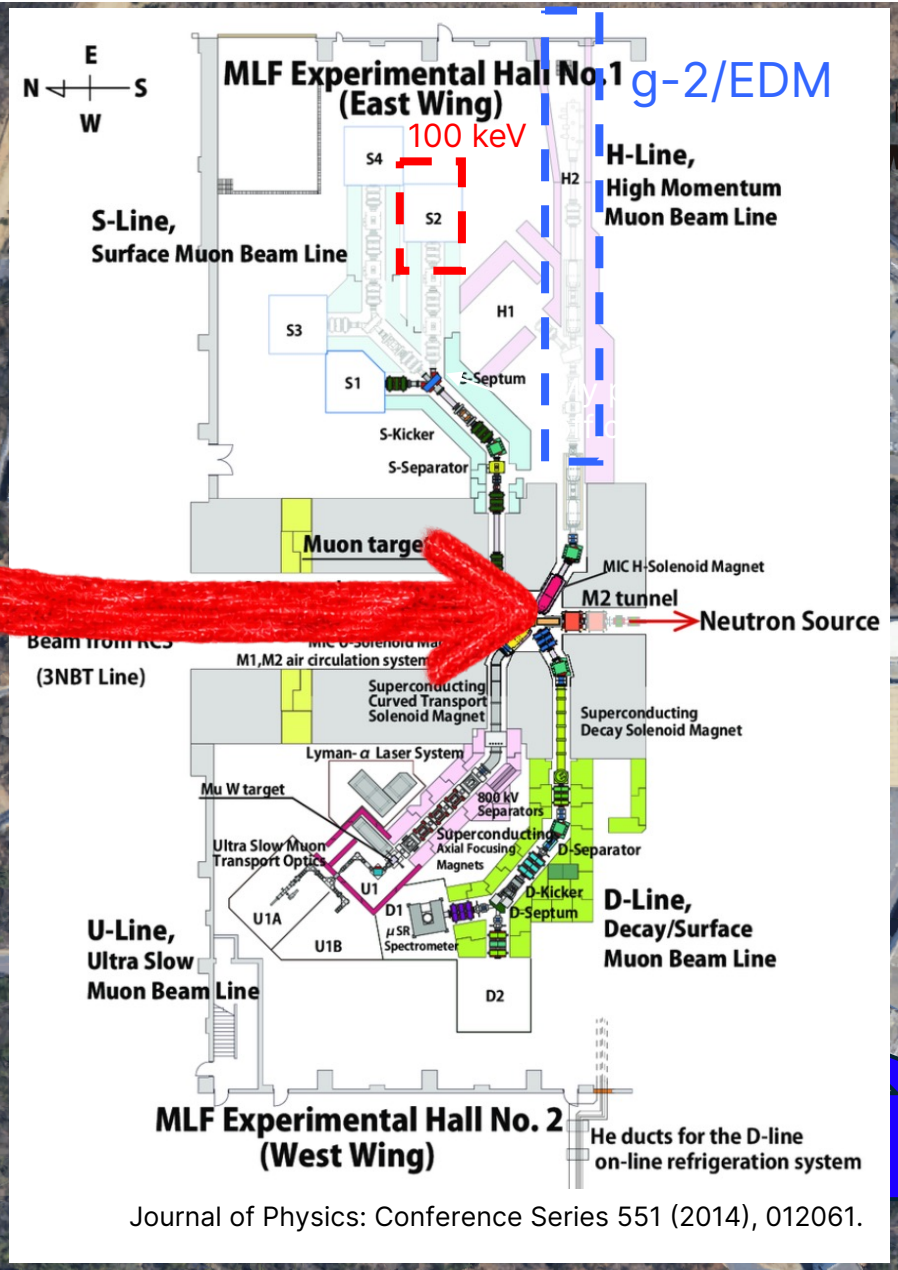
$$\vec{\omega} = -\frac{e}{m_\mu}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta} \times \vec{B}\right)\right]$$

J-PARC MLF

3 GeV RCS (25 Hz)

400 MeV proton linac

Main Ring



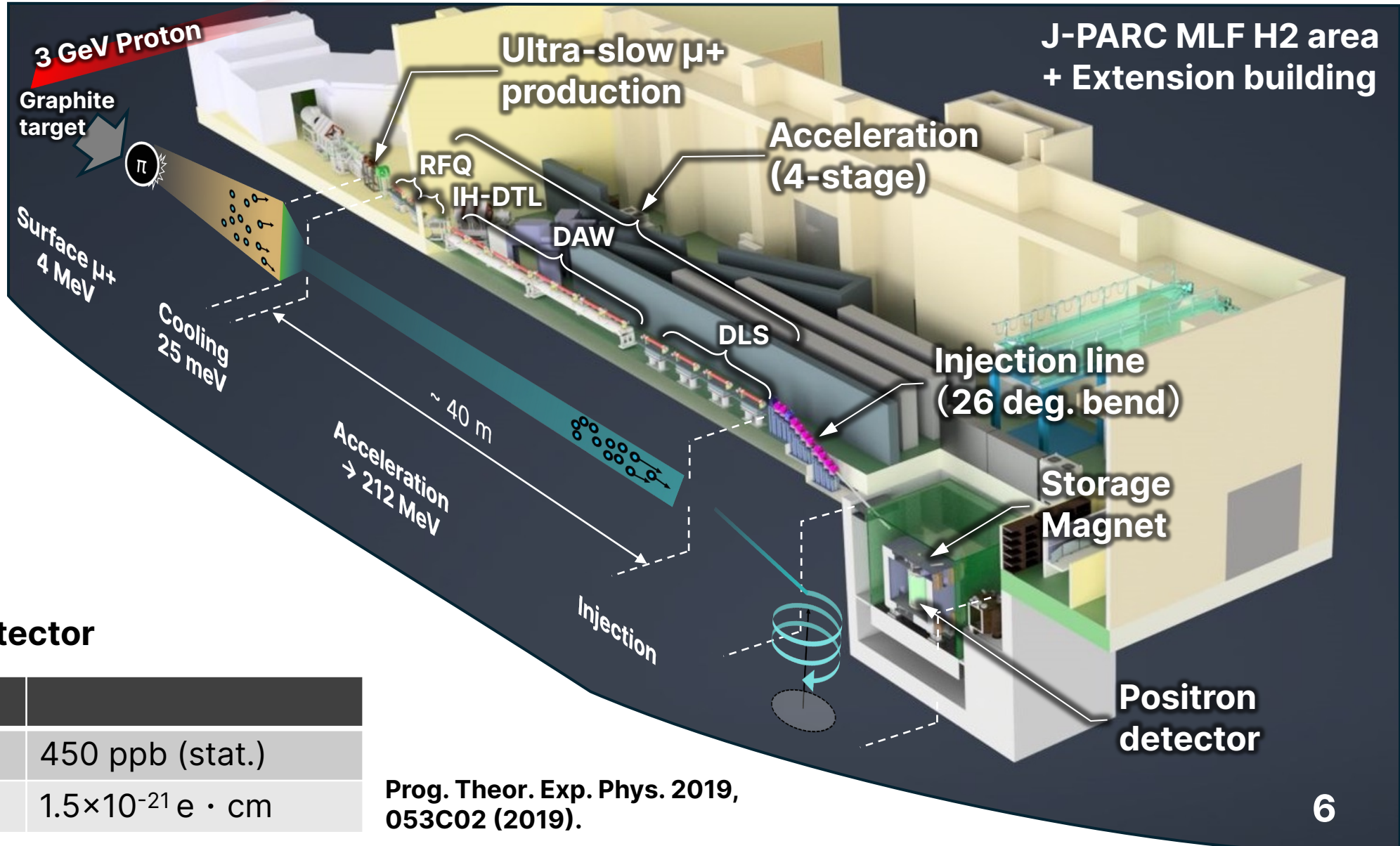
Journal of Physics: Conference Series 551 (2014), 012061.

Google Maps
Imagery ©2026 Google, Map data ©2026 100 m

J-PARC muon g-2/EDM experiment

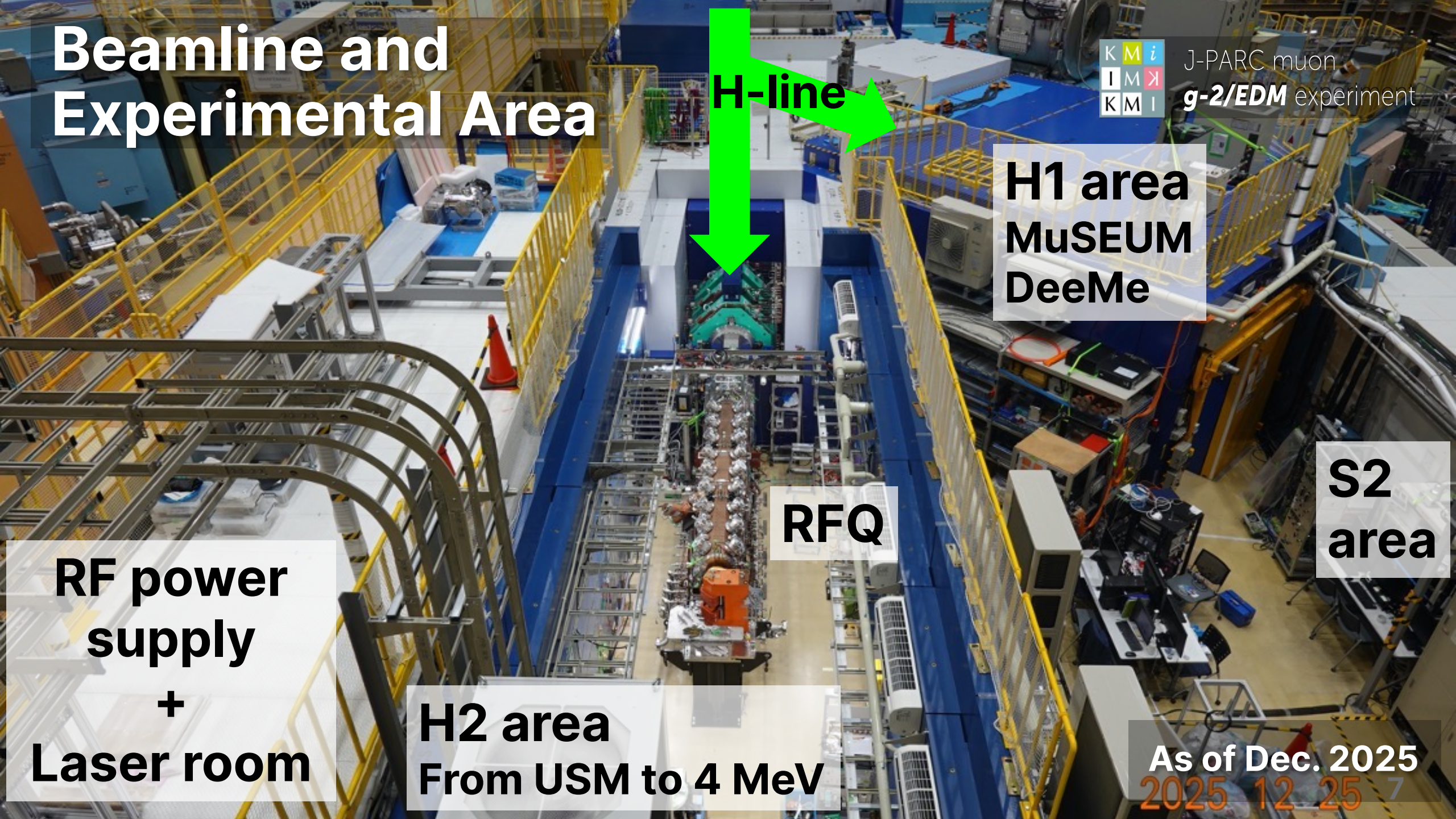
J-PARC muon
g-2/EDM experiment

1. Muon beamline and experimental area
2. Ultra-slow muon production
3. Acceleration
4. 3D spiral injection
5. Storage magnet
6. Positron tracking detector



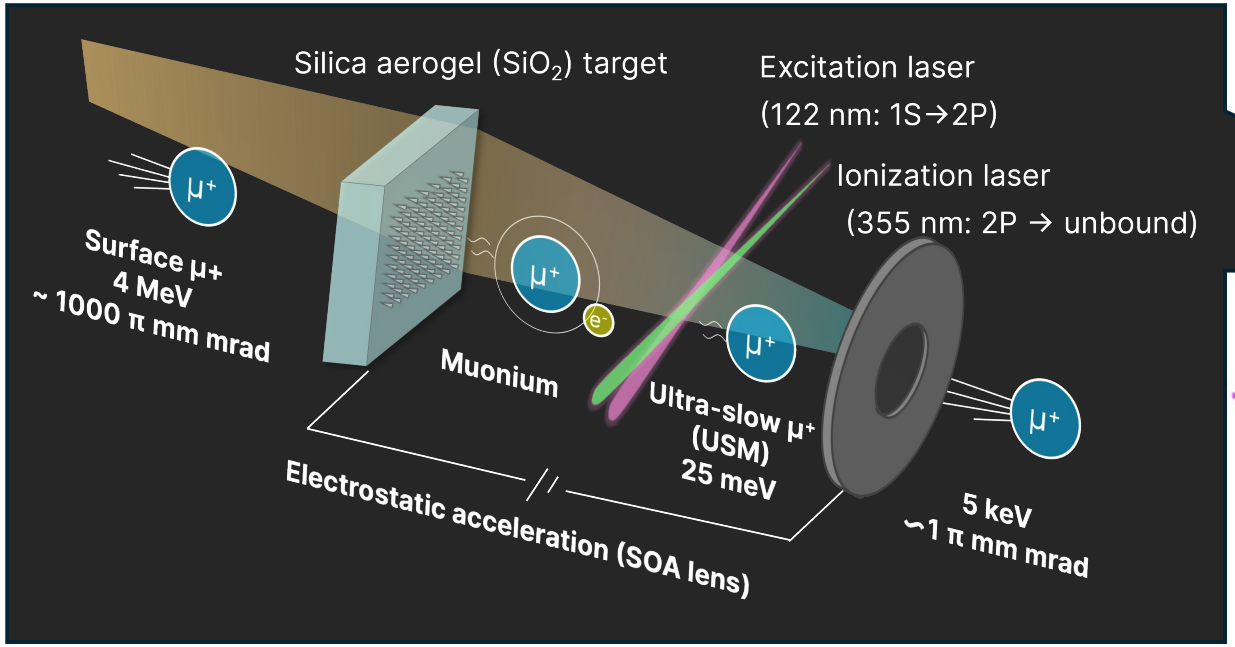
Baseline physics goals	
Muon g-2	450 ppb (stat.)
Muon EDM	1.5×10^{-21} e・cm

Prog. Theor. Exp. Phys. 2019, 053C02 (2019).


Beamline and Experimental Area
H-line
J-PARC muon g-2/EDM experiment
H1 area
MuSEUM
DeeMe
RFQ
S2 area
RF power supply + Laser room
H2 area
From USM to 4 MeV
As of Dec. 2025

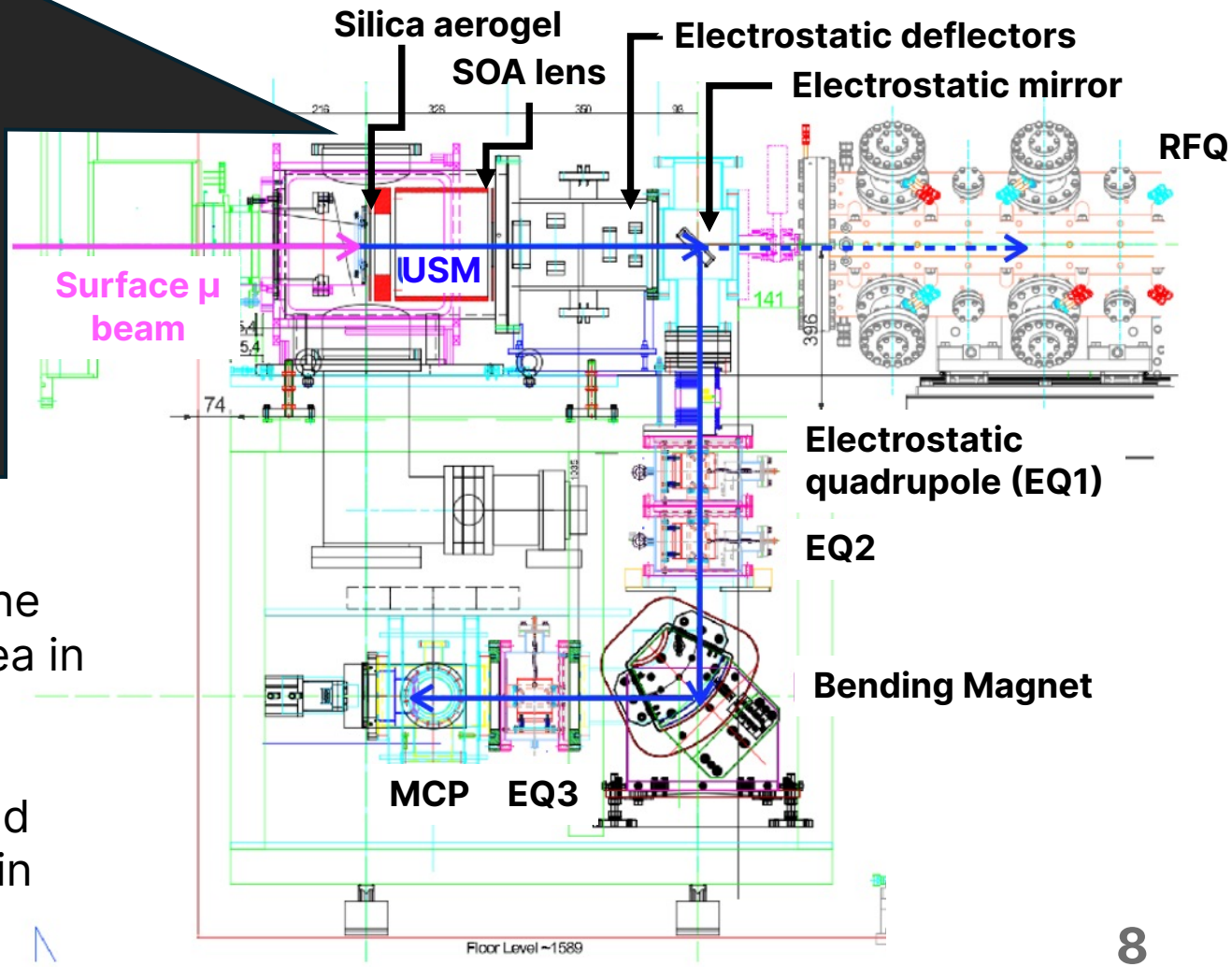
Ultra-slow muon production

J-PARC muon
g-2/EDM experiment



Ultra-slow Muon Diagnostic Line (UDL)

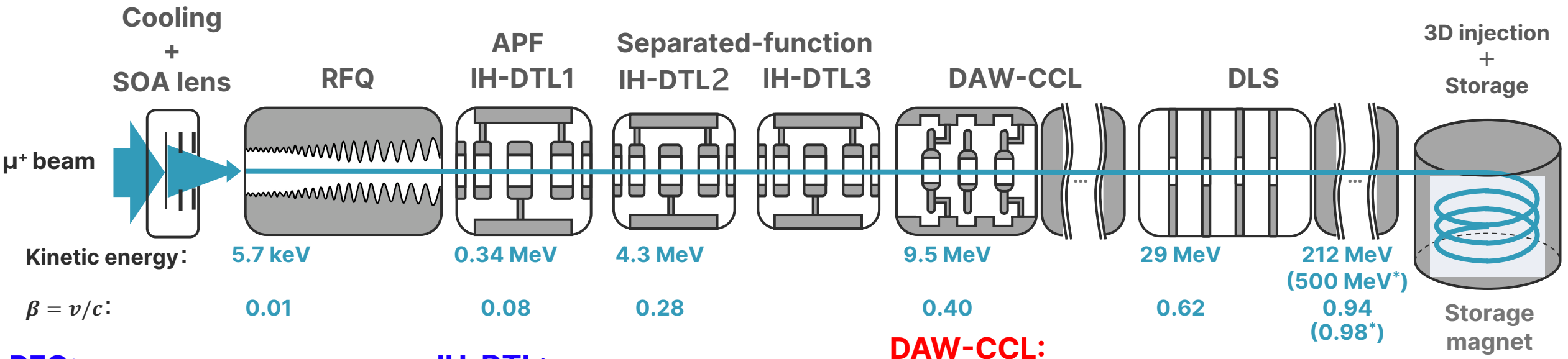
arXiv:2608.02706



- A dedicated 122/355-nm laser system enabled the first production of ultra-slow muons in the H2 area in December 2025.
- The newly developed UDL was commissioned and used for ultra-slow muon beam characterization in the H2 area.

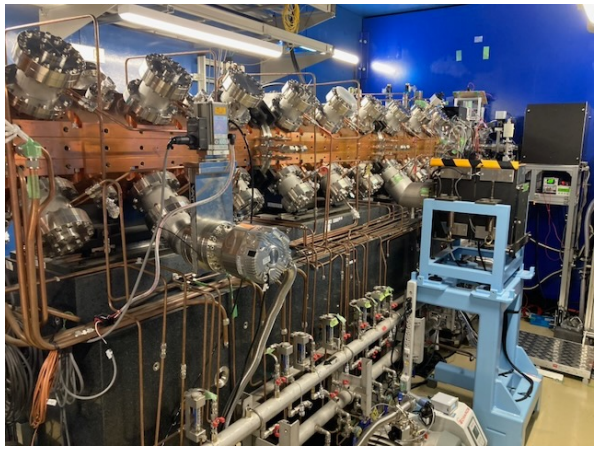
Acceleration

J-PARC muon
g-2/EDM experiment

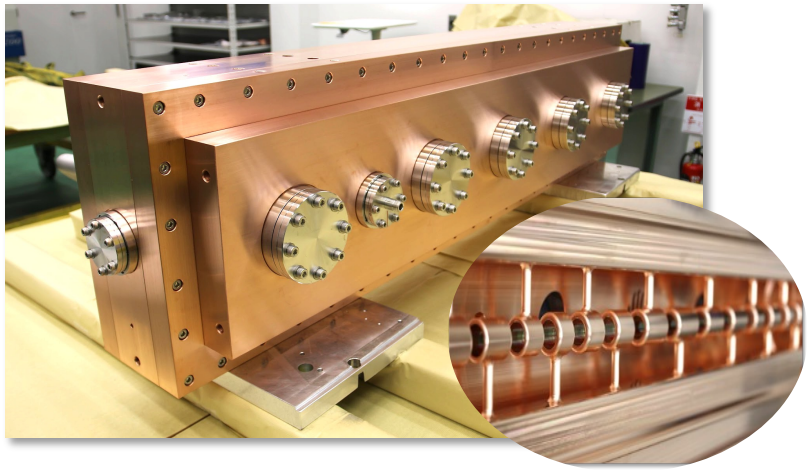


*Currently under consideration

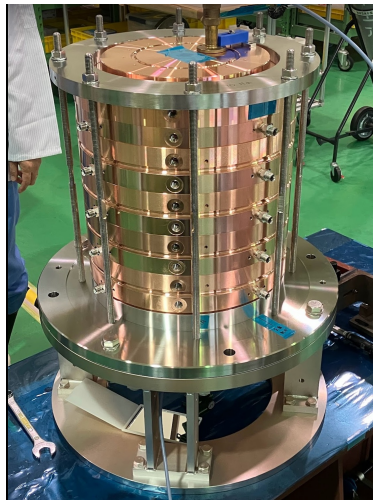
RFQ:
Acceleration demonstrated



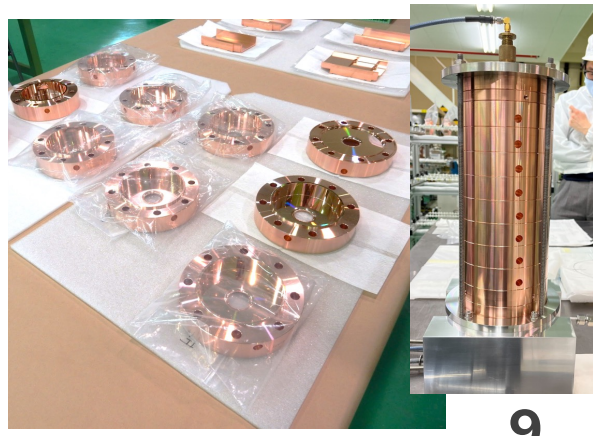
IH-DTL:
IH1 ready; IH2/3 in preparation



DAW-CCL:
Prototype completed



DLS: Prototype completed

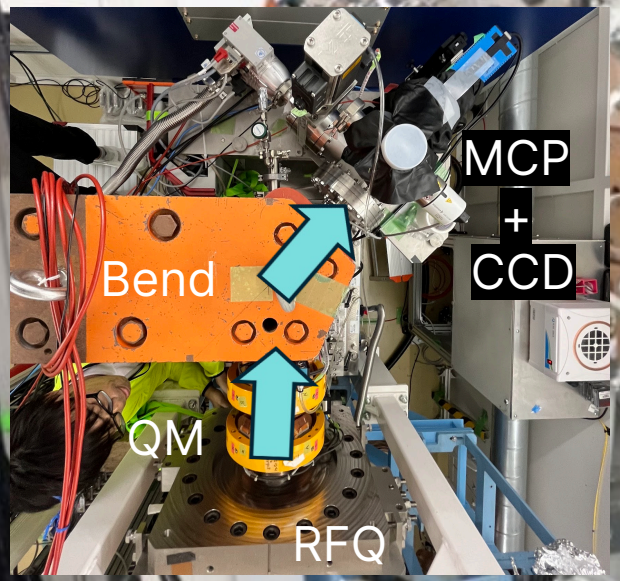


First demonstration of muon cooling and acceleration

© KEK IPNS

J-PARC muon
g-2/EDM experiment

S2 area (2024)



RFQ

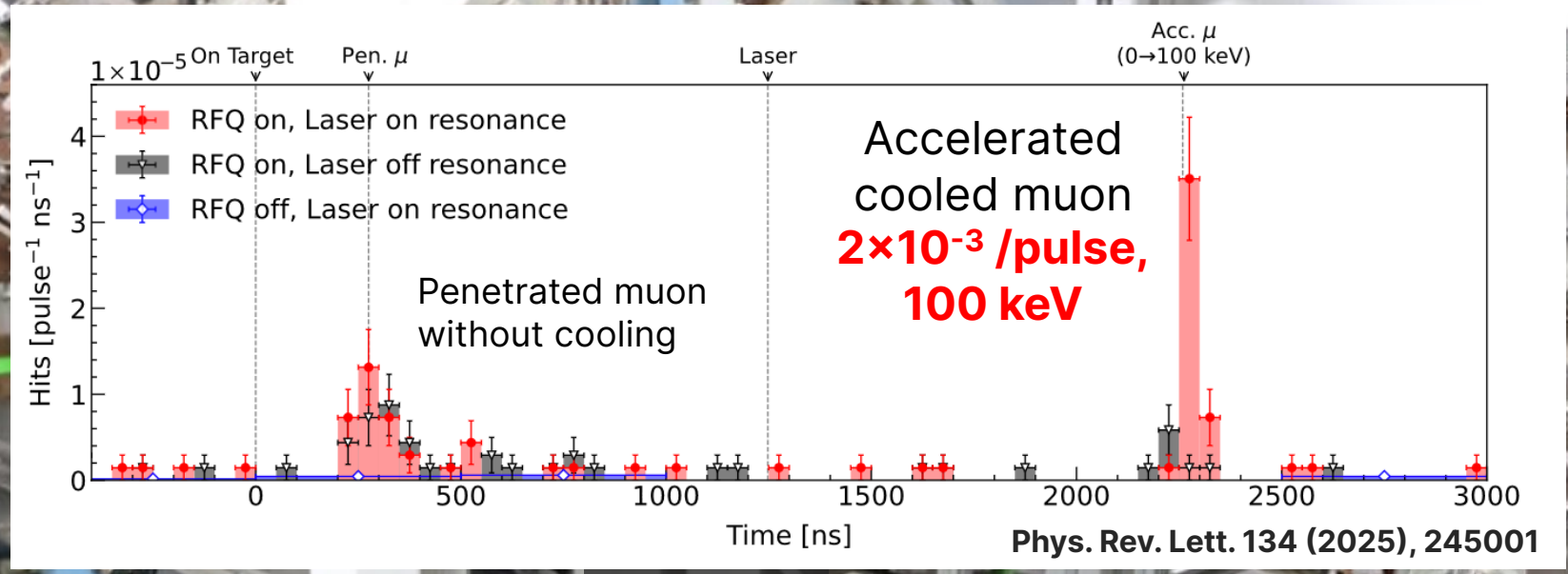
Cooling

First demonstration of muon cooling and acceleration

© KEK IPNS

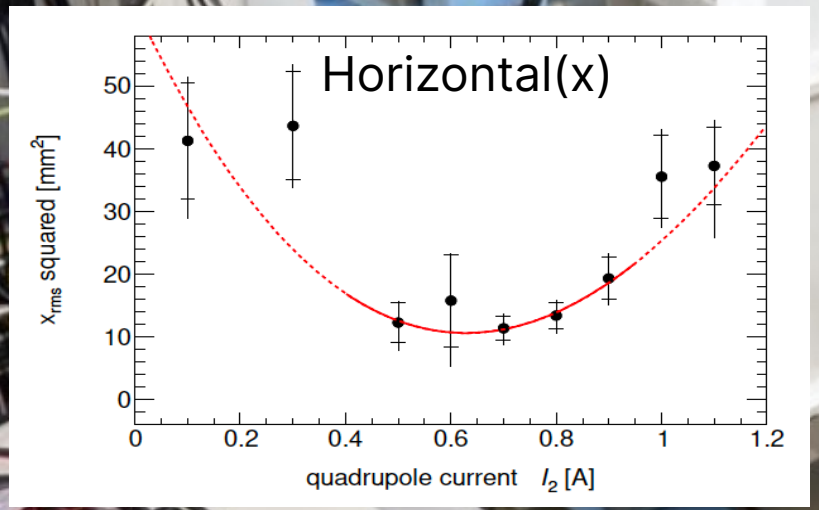
J-PARC muon *g-2/EDM* experiment

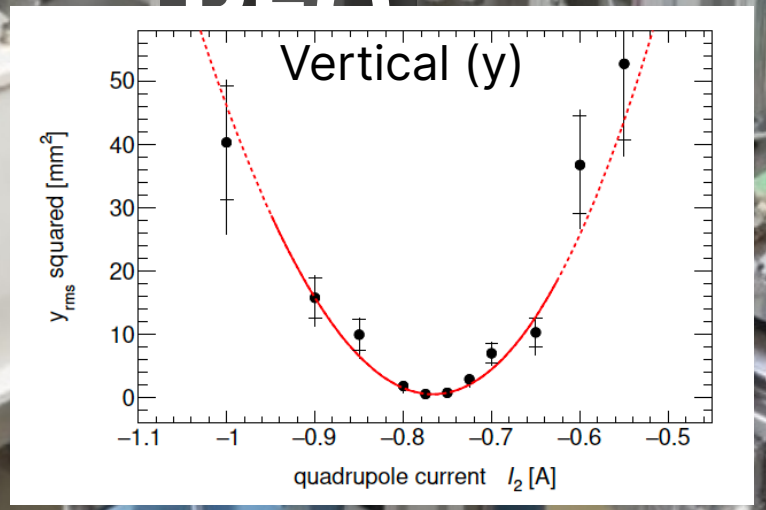
S2 area (2024)



Phys. Rev. Lett. 134 (2025), 245001

Cooling





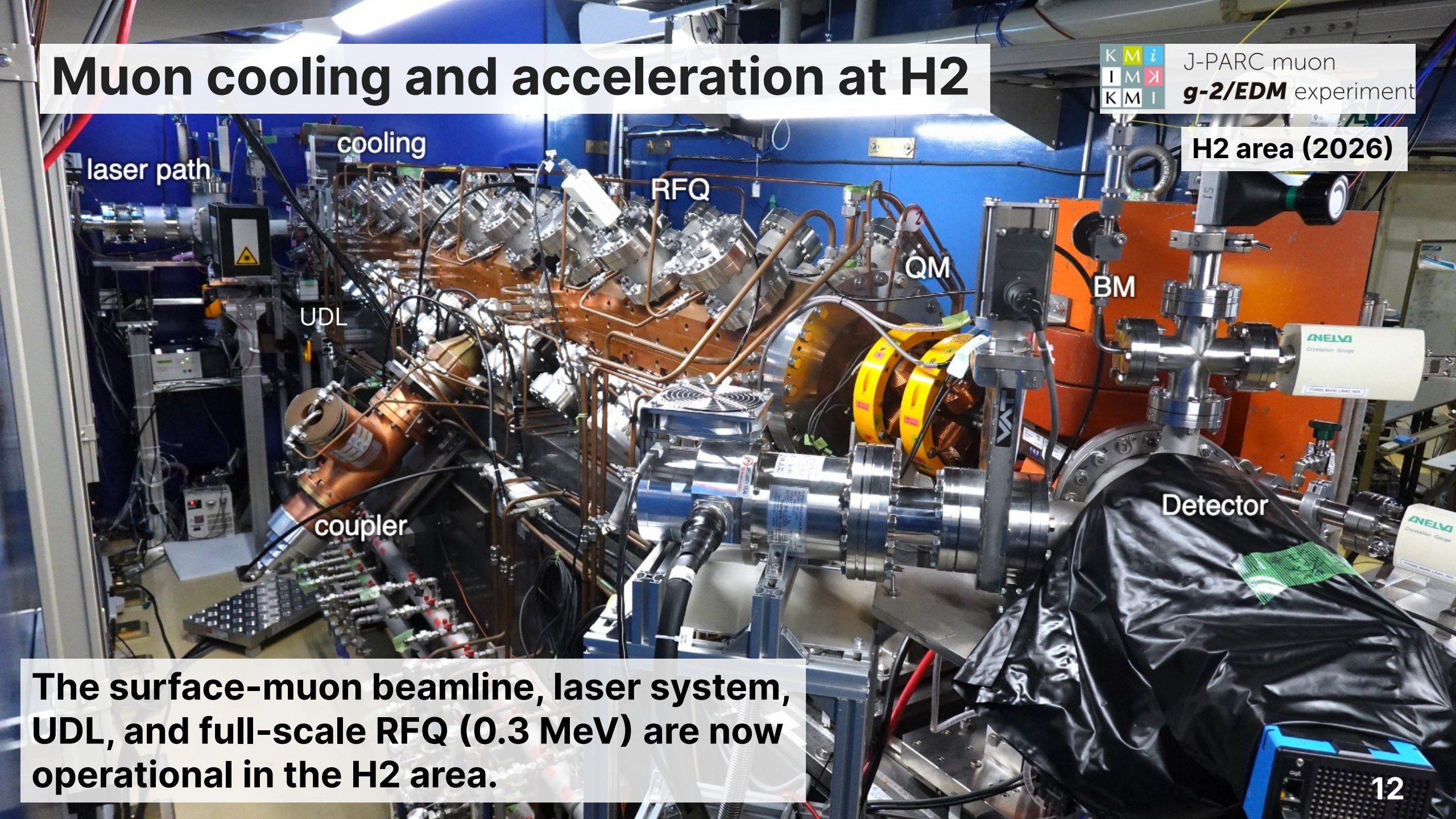
	Horizontal (x)	Vertical (y)
Before (surface muons)	170 ± 60	130 ± 10
After (RFQ acceleration)	$0.85 \pm 0.25^{+0.22}_{-0.13}$	$0.32 \pm 0.03^{+0.05}_{-0.02}$

> 100× lower transverse emittance than surface muons

Muon cooling and acceleration at H2

J-PARC muon
g-2/EDM experiment

H2 area (2026)



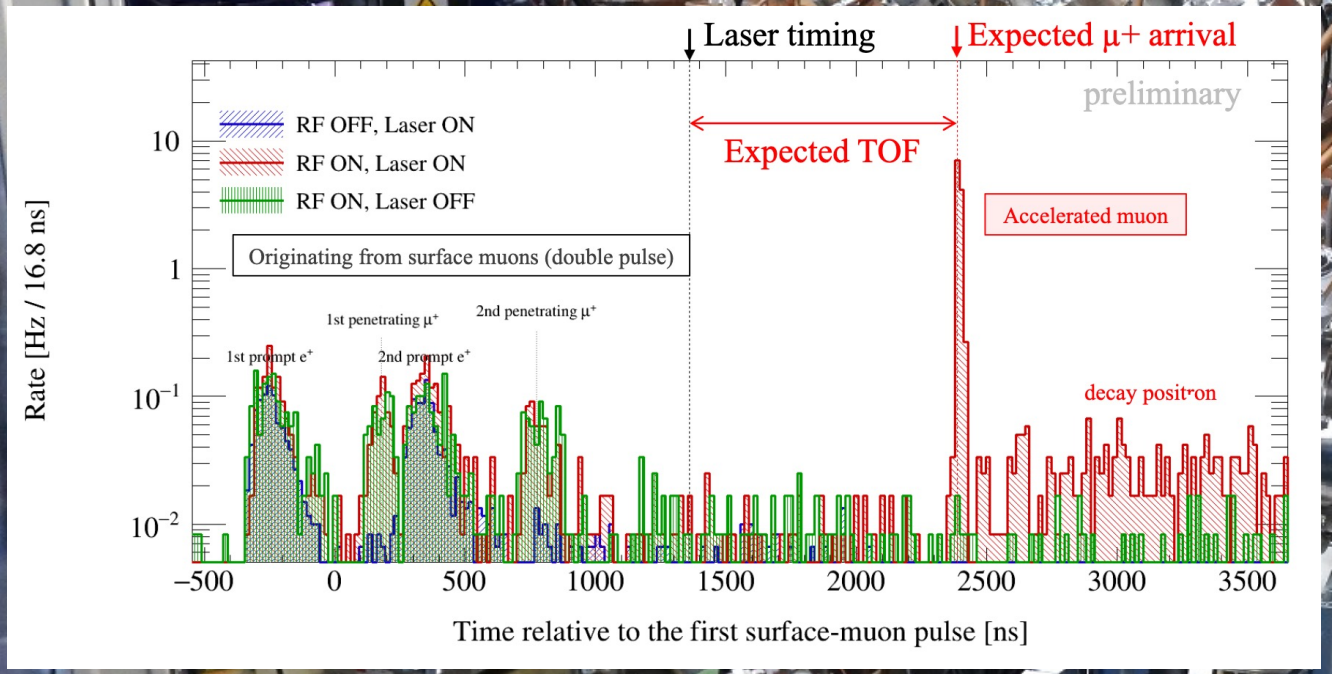
The surface-muon beamline, laser system, UDL, and full-scale RFQ (0.3 MeV) are now operational in the H2 area.

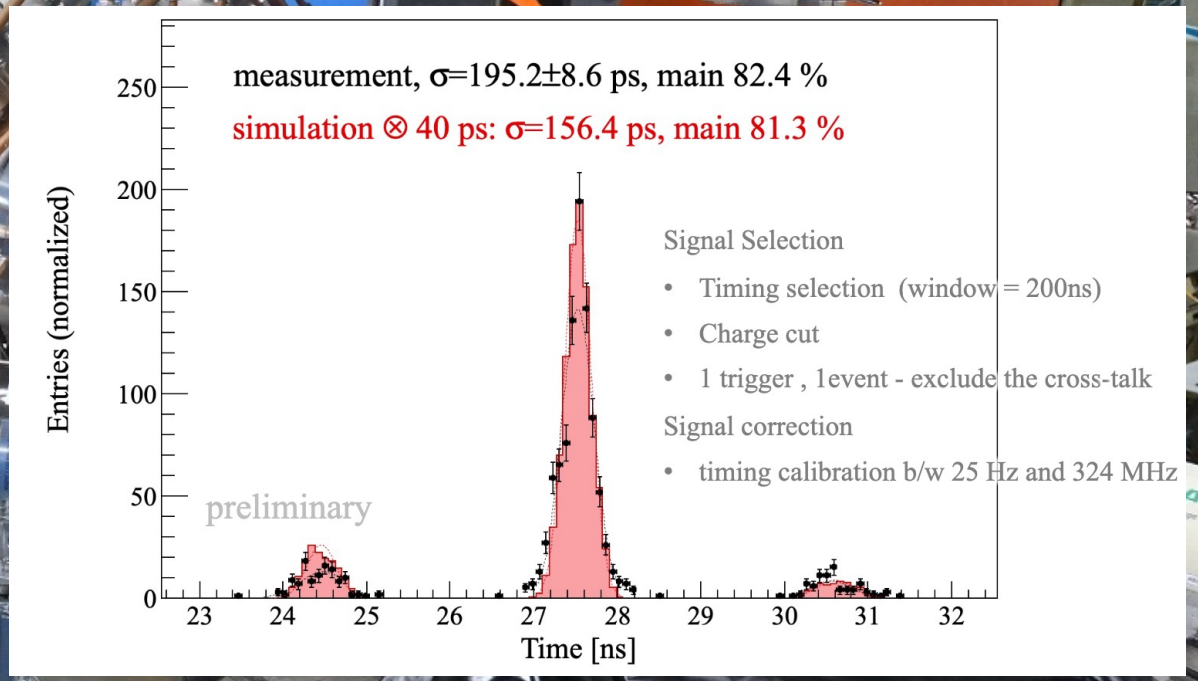
Muon cooling and acceleration at H2

J-PARC muon
g-2/EDM experiment

H2 area (2026)







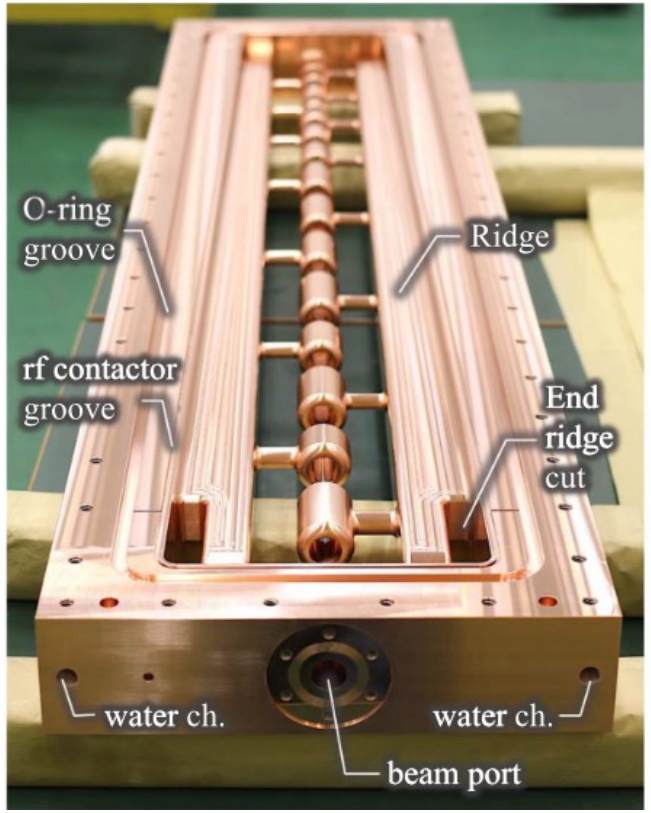
Successful muon acceleration to 0.3 MeV at H2 area, achieving a 200-fold increase in beam rate compared with S2 area.

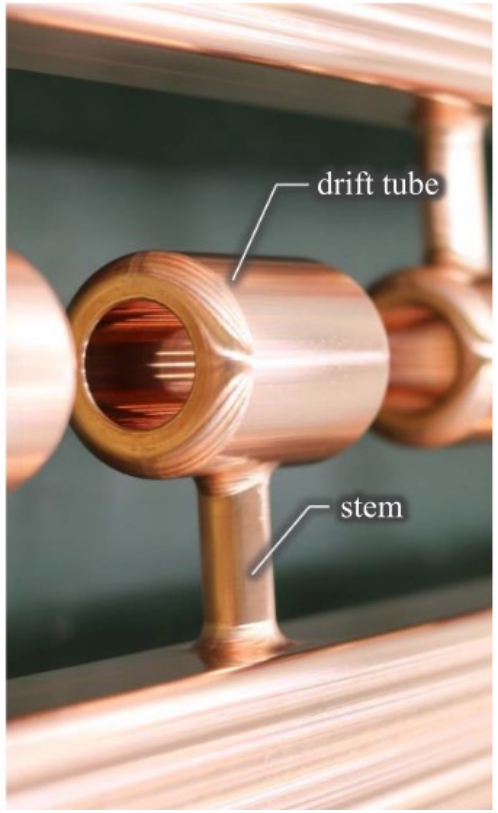
First measurement of the 324 MHz bunch structure (3.09 ns interval) of RFQ-accelerated muons.

Next Milestone: Muon acceleration to 4 MeV

J-PARC muon *g-2/EDM* experiment

- **324 MHz IH-DTL:** 0.34 → 4.26 MeV
- RF field tuning completed
- Stable high-power operation at 390 kW
- Muon acceleration test planned for FY2027

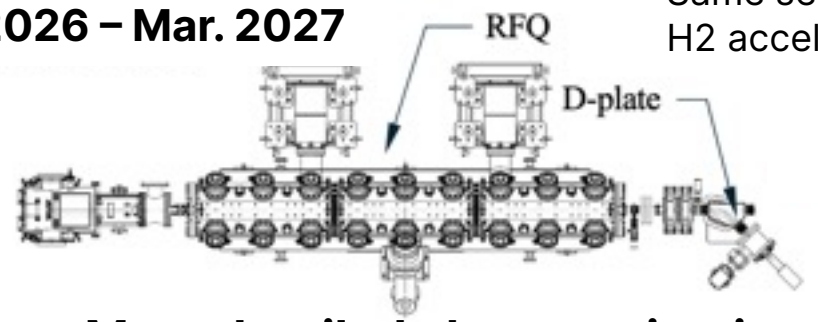




Phys. Rev. Accel. Beams 29, 093201 (2026).

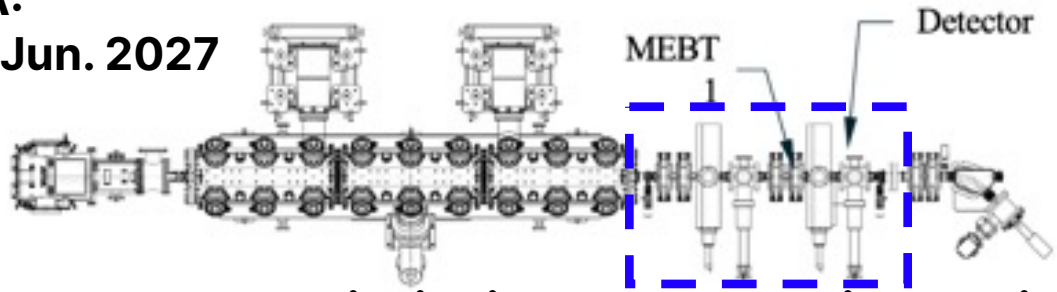
2026B:
Oct. 2026 – Mar. 2027

Same setup as the 2026 H2 acceleration test



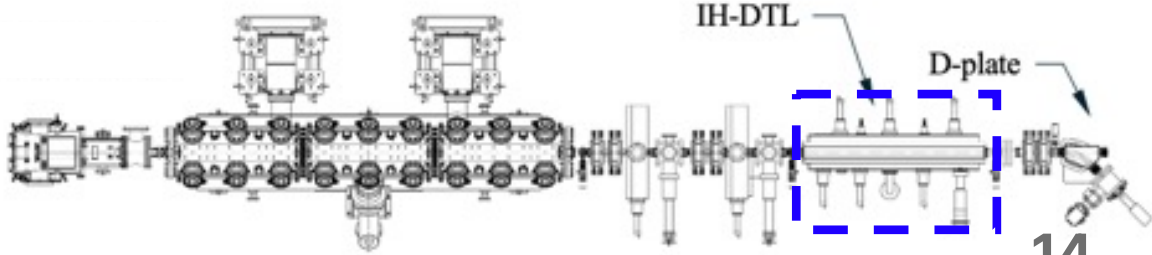
More detailed characterization RFQ beam

2027A:
Apr. – Jun. 2027



MEBT commissioning and beam diagnostics

2027B:
Oct. 2027 – Mar. 2028

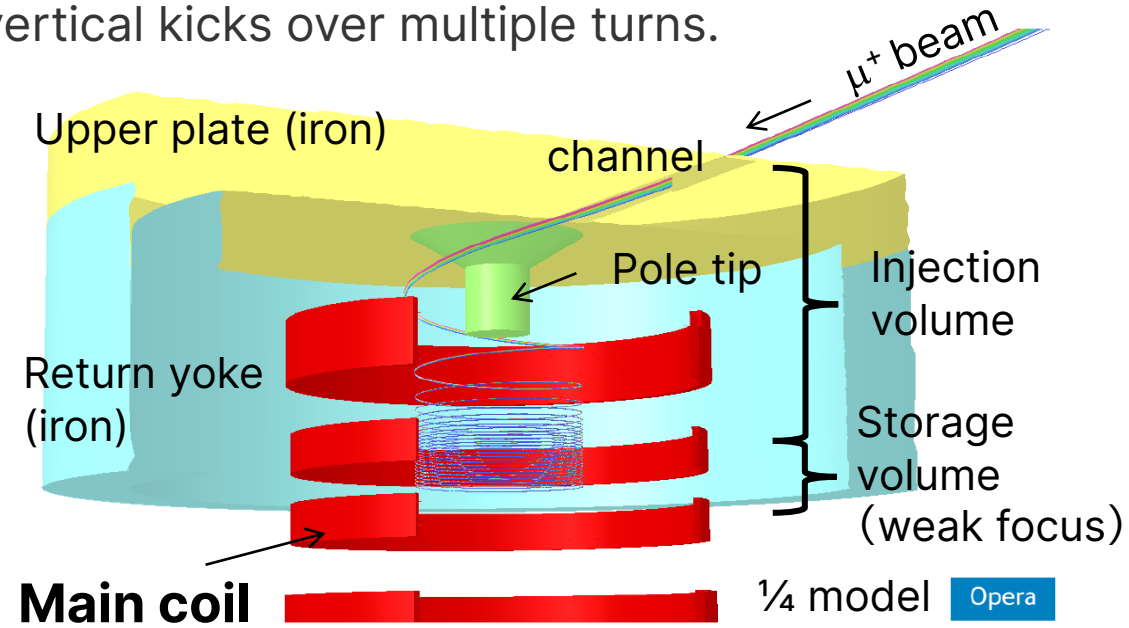


Muon acceleration to 4.26 MeV

3D spiral injection

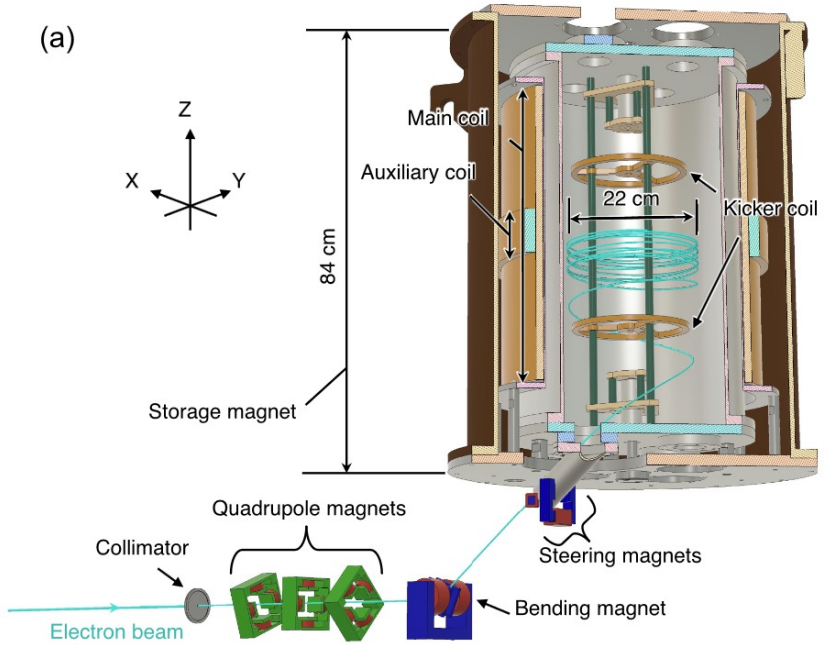
J-PARC muon
g-2/EDM experiment

- Conventional 2D injection requires a fast kicker operating within one revolution
  - 149 ns at Fermilab, but only 7.4 ns at J-PARC.
- **3D spiral injection** overcomes this limitation by applying vertical kicks over multiple turns.

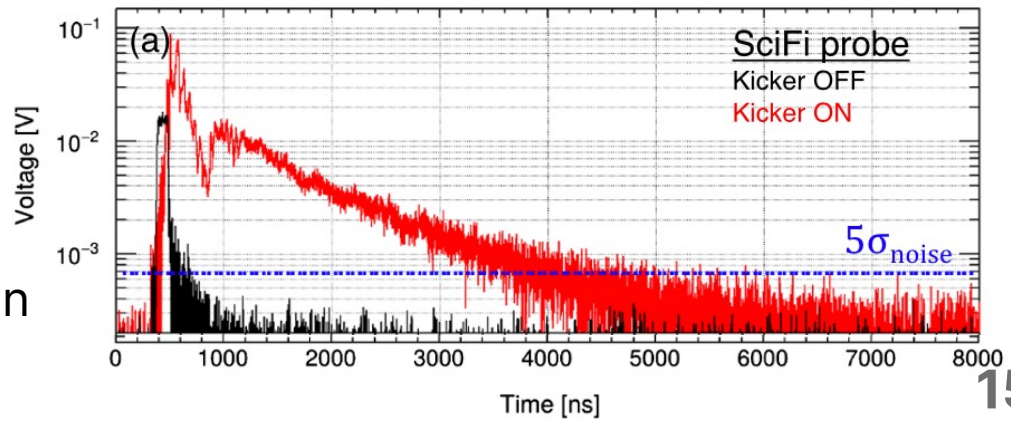


Nucl. Instrum. Methods Phys. Res. A 832 (2016), 51–62
arXiv:2607.14354 (2026)

Phys. Rev. Lett. 137 (2026), 025002



A vertically inserted SciFi probe detects electrons circulating in the storage region (Z=0-20 cm).

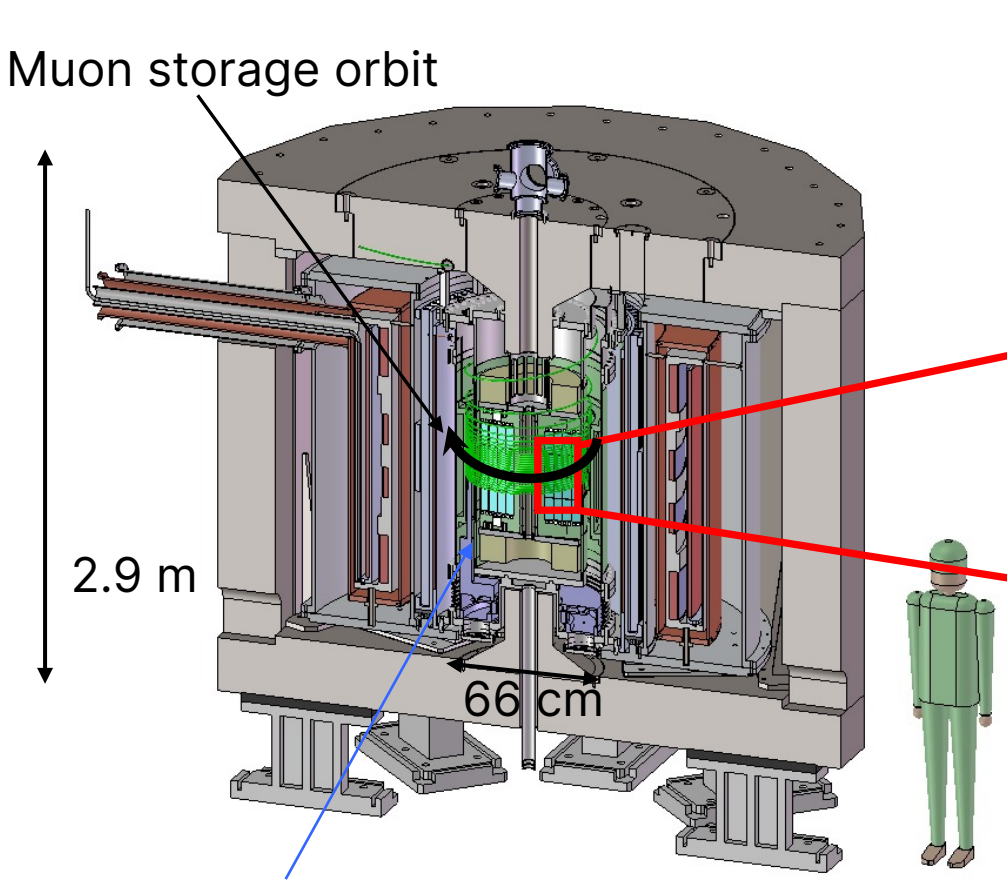


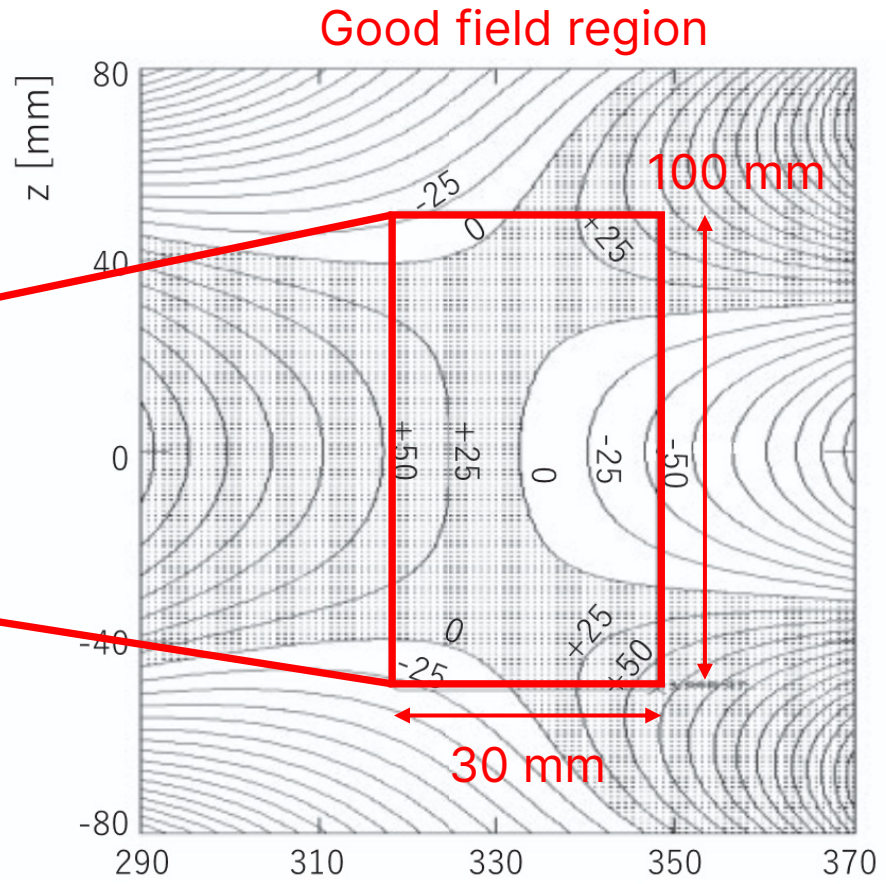
- First experimental demonstration of beam storage using an 80 keV electron beam.

Storage magnet

J-PARC muon
g-2/EDM experiment

- A compact **3-T MRI-type superconducting solenoid** is designed to store muons on a 66-cm-diameter orbit.
- **Field uniformity of 0.1 ppm** (azimuthally integrated) is required in the storage region.
- **Sub-ppm field uniformity** has been demonstrated by shimming the MuSEUM magnet at 1.2 T.



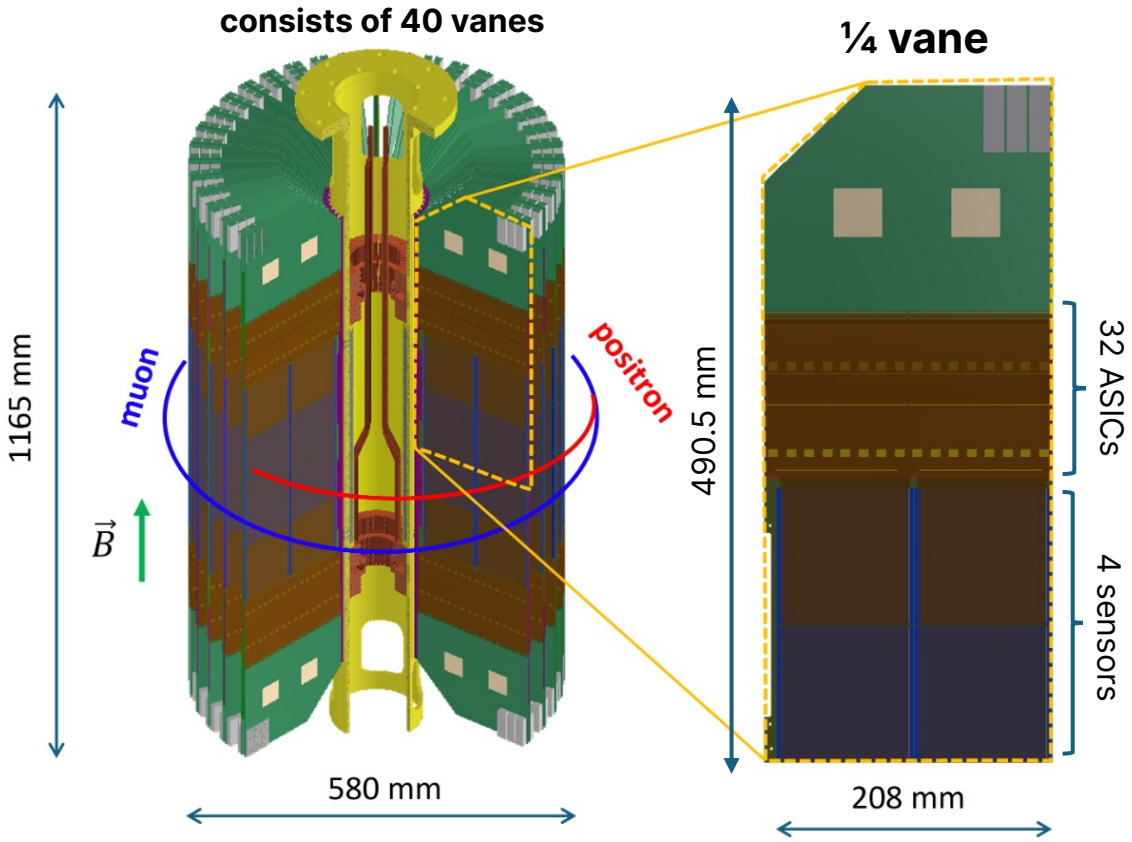


Contour interval: 25 ppb

PTEP 2019, 053C02 (2019), NIMA vol. 890 (2018) p. 51.

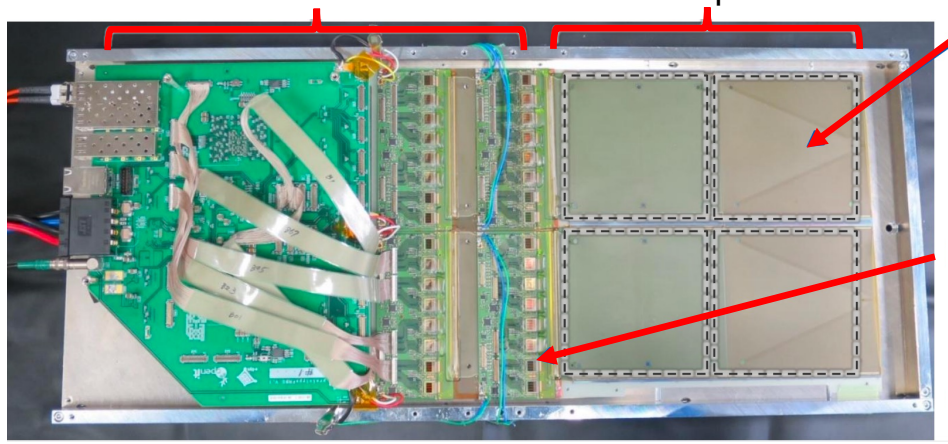
Positron tracking detector

J-PARC muon *g-2/EDM* experiment



Rigid printed circuit boards
Being prototyped and tested

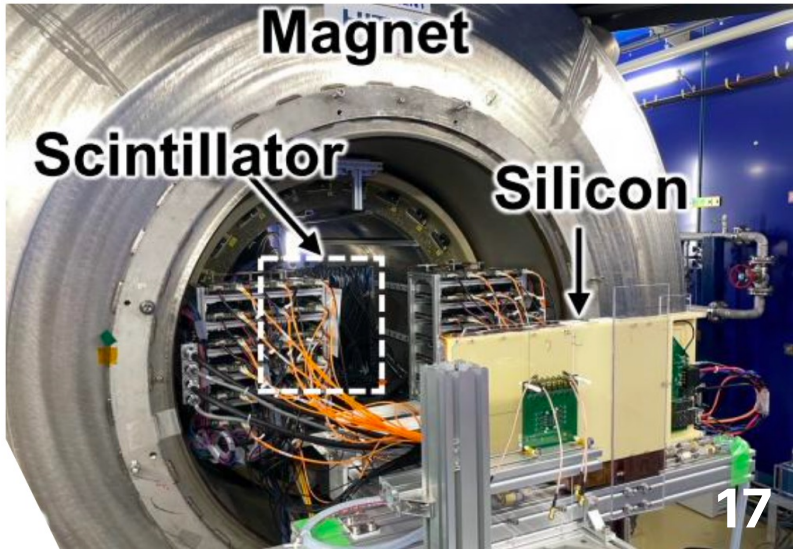
Flexible printed circuit boards
- Mass-production is done



Silicon-strip sensor
- Mass-production is ongoing

Readout ASIC (SliT)
- Mass-production and QA is done

Beam time setup



- Silicon-strip tracker for decay positrons (100–300 MeV/c).
- Designed for high instantaneous rates of up to **6 muon decays/ns**.
- Quarter-vane module successfully tested at the MuSEUM.
  - ~10% hit loss at 1.4 MHz/strip (expected peak hit rate)
  - Negligible impact on track reconstruction performance.

JINST 21 (2026), P07039

High-Sensitivity Option: Toward 100 ppb

The statistical precision on the ω_a

$$\frac{\delta\omega_a}{\omega_a} \simeq \frac{\sqrt{2}}{\omega_a \gamma\tau_\mu P A \sqrt{N}}$$

	Baseline	Under study	Gain
Magnet	**3 T**	**6 T**	**2**
Linac	**300 MeV/c**	**600 MeV/c**	**1.92**
Source	**P = 50%**	**P=70-80%**	**1.4-1.6**

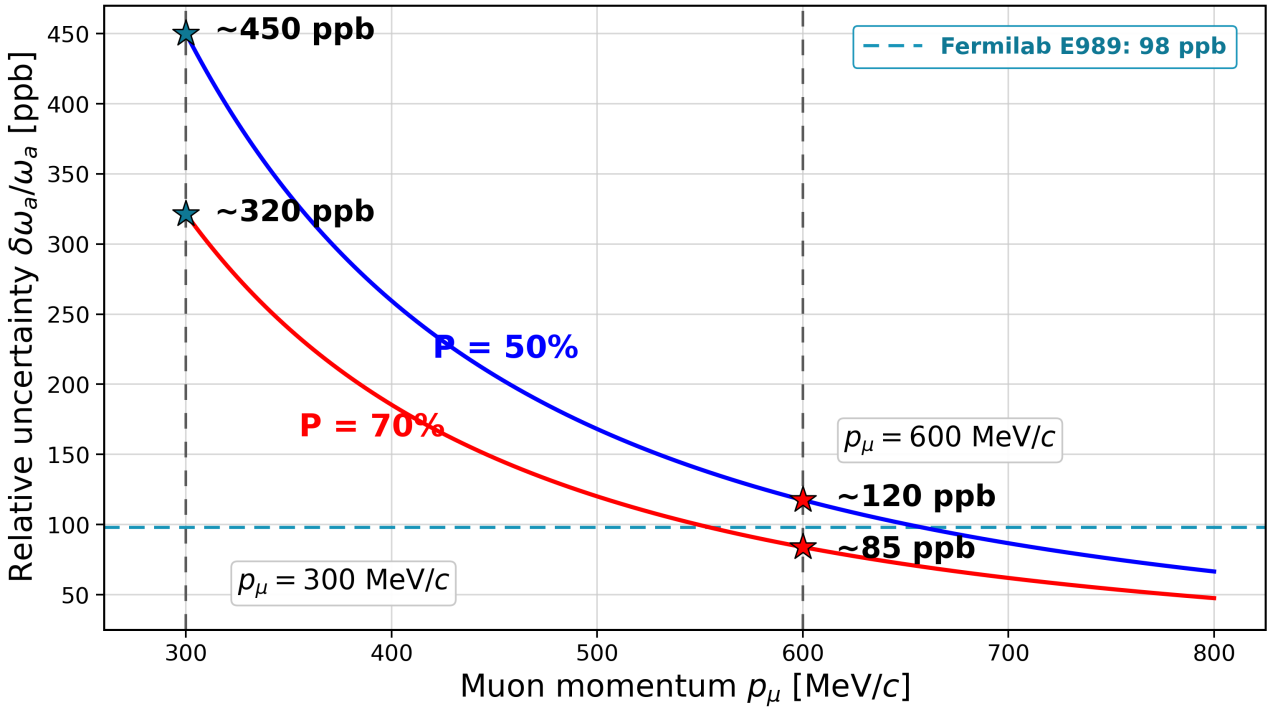
- A potential 5–6-fold improvement in statistical precision, assuming unchanged event statistics and analyzing power.

Systematic uncertainties

	Fermilab (Run456)	J-PARC (TDR)
$\delta a_{\mu(syst)}$	~78 ppb	~70 ppb

J-PARC muon *g-2/EDM* experiment

Potentially comparable to Fermilab E989



Feasibility studies toward higher sensitivity

- Optical pumping of muonium
- Linac reconfiguration and high-gradient acceleration
- 6 T storage magnet and injection

A new experimental proposal targeting ~100 ppb is planned for submission to the J-PARC PAC in May 2027.

Summary

J-PARC muon
g-2/EDM experiment

- J-PARC aims to provide an independent measurement of muon g−2 and a search for an EDM using low-emittance muons and a compact storage ring without electric-field focusing.
- Muon cooling and RF acceleration to 0.3 MeV have been demonstrated in the H2 area, with a 200-fold increase in beam rate compared with S2 area.
- Key technologies are progressing, including the IH-DTL, 3D spiral injection demonstrated with electrons, and the storage magnet and positron tracker.
- The baseline goal is 450 ppb (stat.) for g−2, while a higher-sensitivity option targeting ~100 ppb is under study.

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