

Breaking Walls To The Unknown: The 18th Particle?

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substituted by

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**Falling Walls Circle – Wilhelm and Else Heraeus Symposium
for Breakthroughs in Physical Sciences**

November 8th, 2021

JOHANNES GUTENBERG
UNIVERSITÄT MAINZ



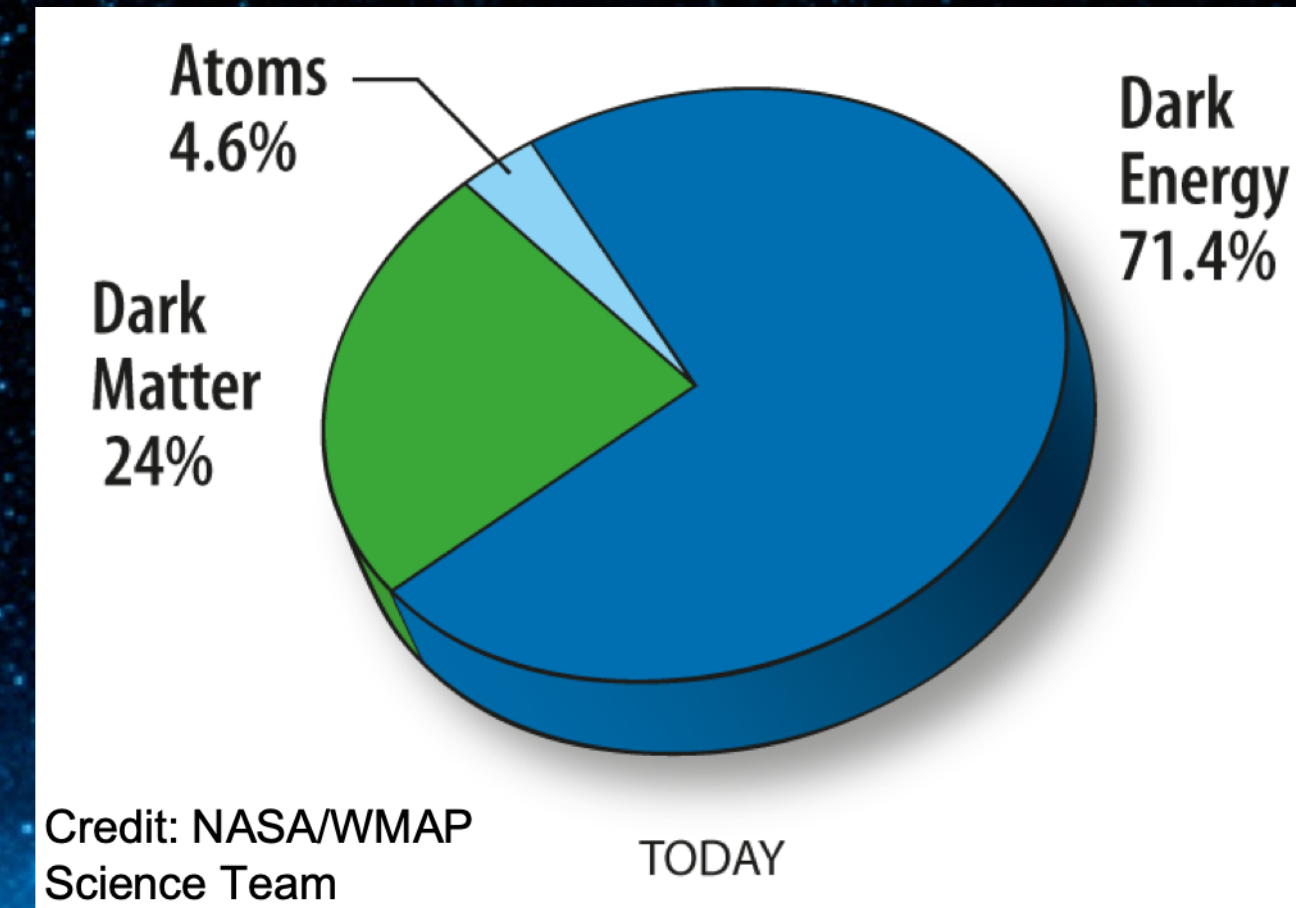
The 17 Elementary Particles of the Standard Model

three generations of matter (elementary fermions)			interactions / force carriers (elementary bosons)		
QUARKS	I	II	III		
	mass charge spin $\approx 2.2 \text{ MeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ u up	$\approx 1.28 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ c charm	$\approx 173.1 \text{ GeV}/c^2$ $\frac{2}{3}$ $\frac{1}{2}$ t top	0 0 1 g gluon	$\approx 124.97 \text{ GeV}/c^2$ 0 0 H higgs
	$\approx 4.7 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ d down	$\approx 96 \text{ MeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ s strange	$\approx 4.18 \text{ GeV}/c^2$ $-\frac{1}{3}$ $\frac{1}{2}$ b bottom	0 0 1 γ photon	
LEPTONS	$\approx 0.511 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ e^- electron	$\approx 105.66 \text{ MeV}/c^2$ -1 $\frac{1}{2}$ μ^- muon	$\approx 1.7768 \text{ GeV}/c^2$ -1 $\frac{1}{2}$ τ^- tau	$\approx 91.19 \text{ GeV}/c^2$ 0 1 Z Z⁰ boson	
	$< 0.8 \text{ eV}/c^2$ 0 $\frac{1}{2}$ ν_e electron neutrino	$< 0.17 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_μ muon neutrino	$< 18.2 \text{ MeV}/c^2$ 0 $\frac{1}{2}$ ν_τ tau neutrino	$\approx 80.39 \text{ GeV}/c^2$ -1 1 W^- W⁻ boson	
				GAUGE BOSONS VECTOR BOSONS	SCALAR BOSONS

Figure adapted and updated from https://commons.wikimedia.org/wiki/File:Standard_Model_of_Elementary_Particles_Anti.svg

Fundamental Questions

Baryon asymmetry of the Universe:
Why is there not more anti-matter?
Why are we even here?



Dark energy:
What is it?

What is Dark Matter made of ?

How does gravity fit
into a common
framework with the
other three forces?

Neutrinos do have mass!
How heavy are they?
How do they obtain mass?

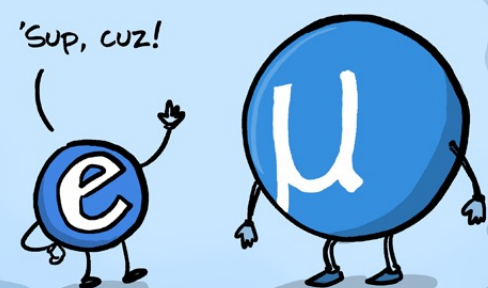
The Standard Model of Particle Physics
does not provide any answers
to these fundamental questions!

THE MUON g-2 ANOMALY EXPLAINED



THE MUON IS THE ELECTRON'S HEAVIER COUSIN.

JUST LIKE THE ELECTRON, IT HAS A MAGNETIC MOMENT THAT COMES FROM ITS CHARGE AND QUANTUM SPIN.

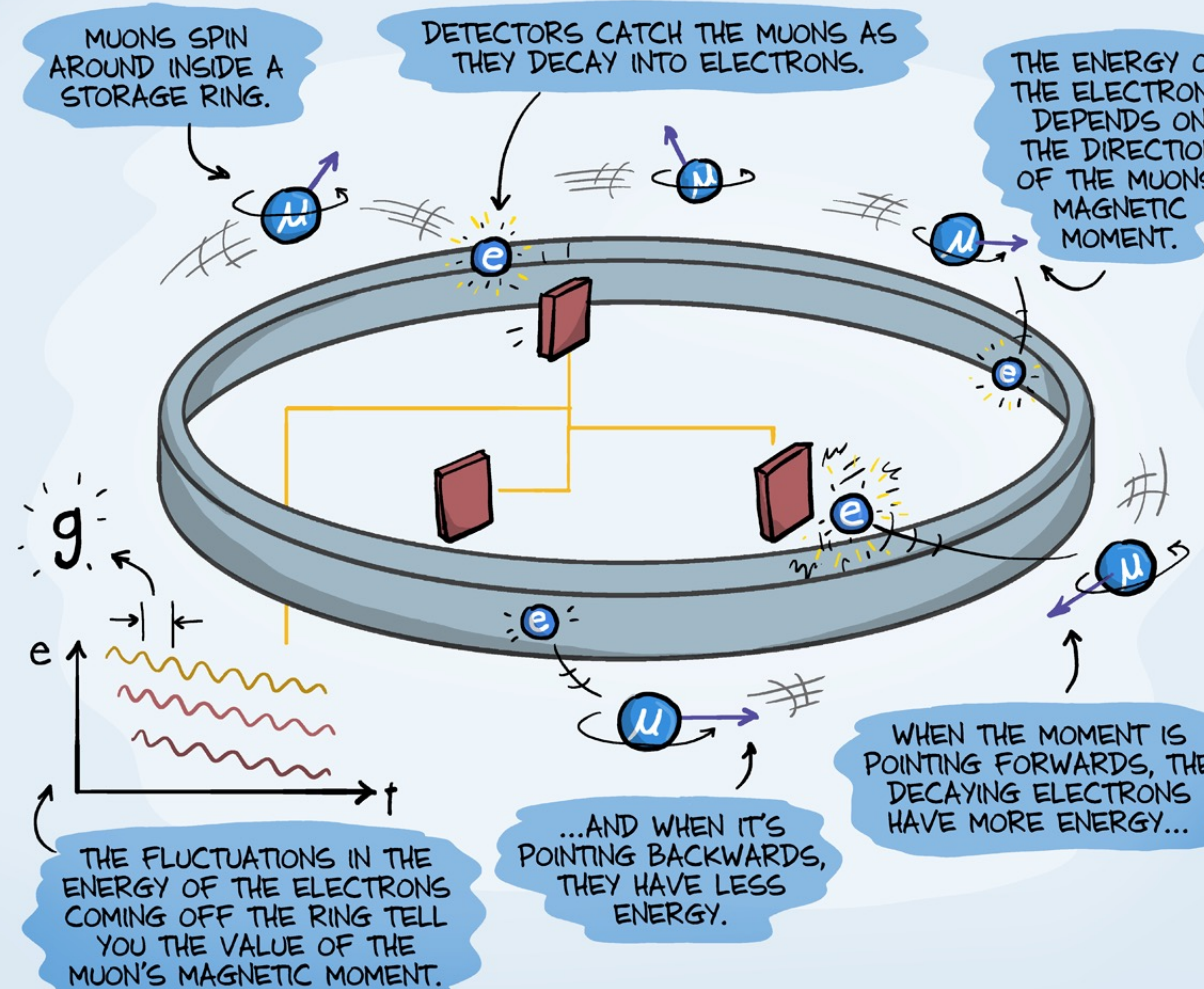


BY USING OUR CATALOG OF KNOWN PARTICLES, WE CAN PREDICT WHAT THIS CHANGE SHOULD BE...

...AND COMPARE IT TO EXPERIMENTAL MEASUREMENTS OF IT.

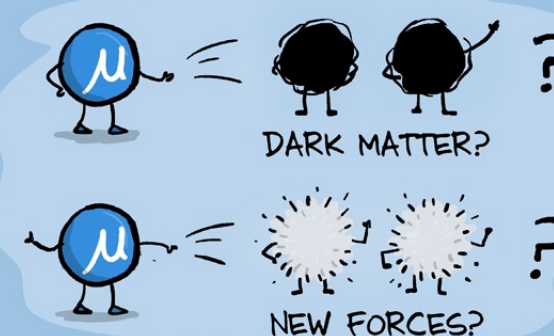


SINCE THEN, THE THEORETICAL VALUE HAS GOTTEN MORE PRECISE, AND NOW FERMI NATIONAL LAB HAS MADE AN EVEN MORE ACCURATE MEASUREMENT OF IT:



COULD IT BE THAT THE MUON IS CREATING PARTICLES WE DON'T KNOW ANYTHING ABOUT, BUT WHICH MIGHT SOLVE OTHER MYSTERIES IN PHYSICS?

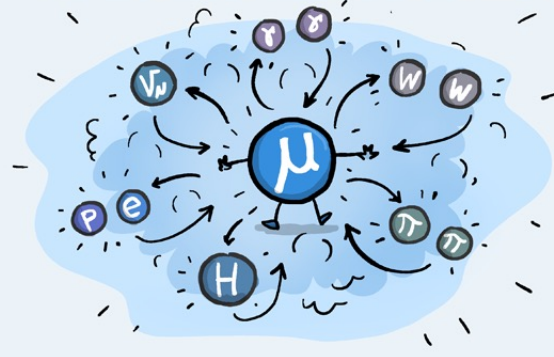
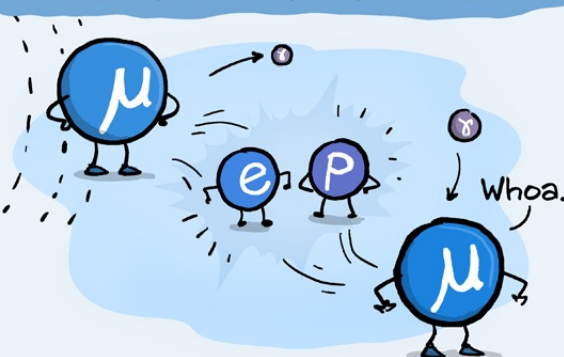
IT'S ALL PART OF OUR SEARCH TO DISCOVER HOW THE UNIVERSE WORKS.



WE ALL LOOK AROUND AND WONDER: HOW CAN THIS ALL BE? WHY DO WE EXIST?

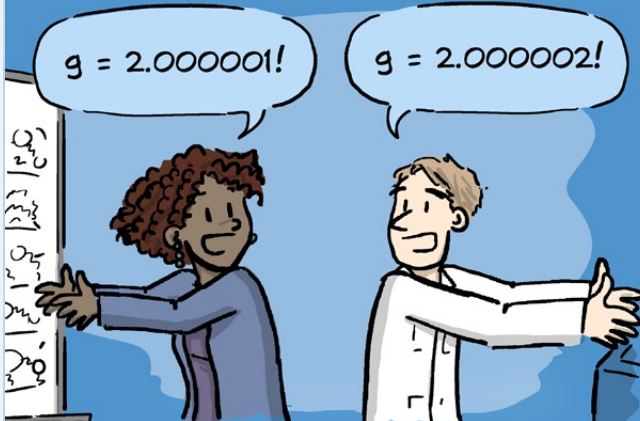
LIKE ALL CHARGED PARTICLES, IT TENDS TO INTERACT WITH ITSELF IN A MAGNETIC FIELD, AND IN THE PROCESS IT CREATES OTHER PARTICLES THAT EXIST FOR A BRIEF MOMENT IN TIME.

IT DOES THIS IN A QUANTUM MECHANICAL WAY, WHICH MEANS IT CREATES MANY COMBINATIONS OF PARTICLES ALL THE TIME, AND ALL AT THE SAME TIME.



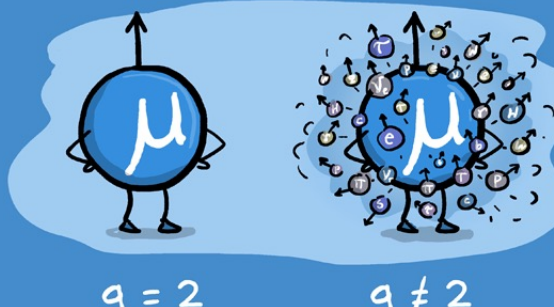
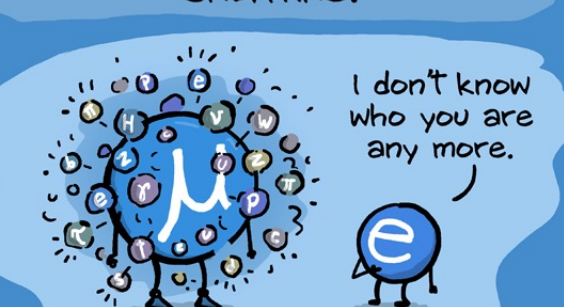
BUT WHAT IF THOSE TWO NUMBERS ARE NOT THE SAME?

COULD WE BE WRONG ABOUT WHICH PARTICLES THE MUON CAN CREATE? OR IS OUR WHOLE FORMULATION OF PHYSICS INCORRECT?



THAT MEANS THAT WHEN YOU LOOK AT A MUON, YOU DON'T JUST SEE THE MUON; YOU ALSO SEE THE INFINITE NUMBER OF VIRTUAL PARTICLES IT IS CONSTANTLY CREATING.

EACH OF THESE PARTICLES AFFECTS THE MUON'S MAGNETIC MOMENT IN A MEASURABLE WAY, CHANGING ITS VALUE.

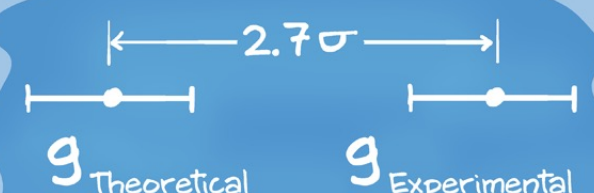


THAT IS THE MYSTERY OF THE MUON'S MAGNETIC MOMENT.

20 YEARS AGO, BROOKHAVEN NATIONAL LAB MEASURED IT, AND FOUND IT TO BE DIFFERENT THAN THE THEORETICAL VALUE BY 2.7σ .

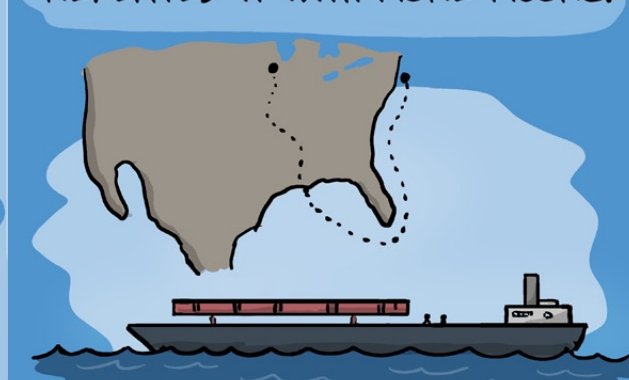
$$g_{\text{Brookhaven}} = 2.00233184178 \pm 0.00000000126$$

IT IS ONE OF THE MOST PRECISELY TESTED PHYSICAL QUANTITIES IN HUMAN HISTORY.

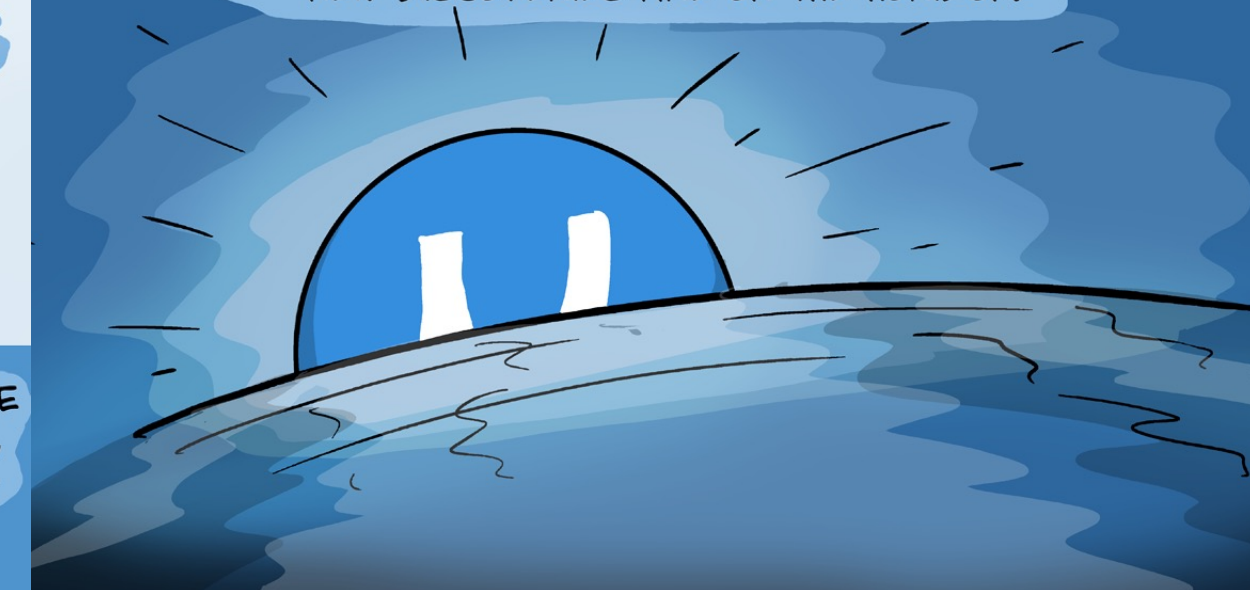


FERMILAB SHIPPED THE GIANT MAGNET FROM BROOKHAVEN, NEW YORK TO CHICAGO, UPGRADED THE EXPERIMENT SIGNIFICANTLY, AND REPEATED IT WITH MORE MUONS.

WITH THIS NEW MEASUREMENT, THE DIFFERENCE IN g IS NOW 4.2σ , PROVIDING STRONGER EVIDENCE THAT SOMETHING IS AMISS.



ONE THING IS FOR SURE: THE HUNT IS ON, AND NEW DISCOVERIES ARE ON THE HORIZON.



APS
physics

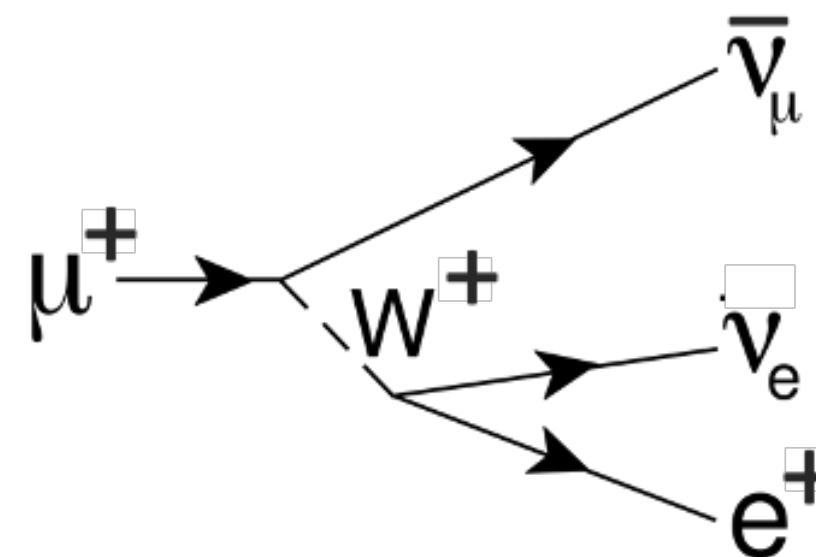
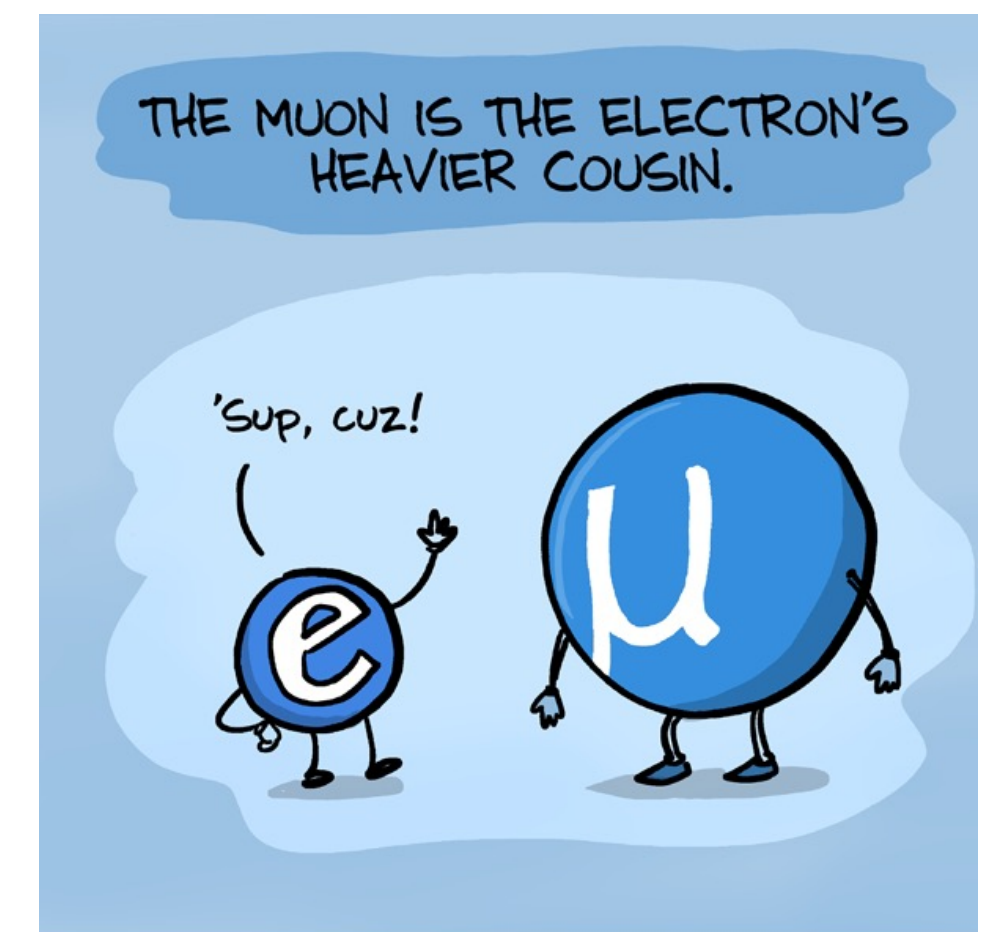
Written and drawn by Jorge Cham
for Physics Magazine physics.aps.org
Thanks to Chris Polly and Fermilab!

What are muons?

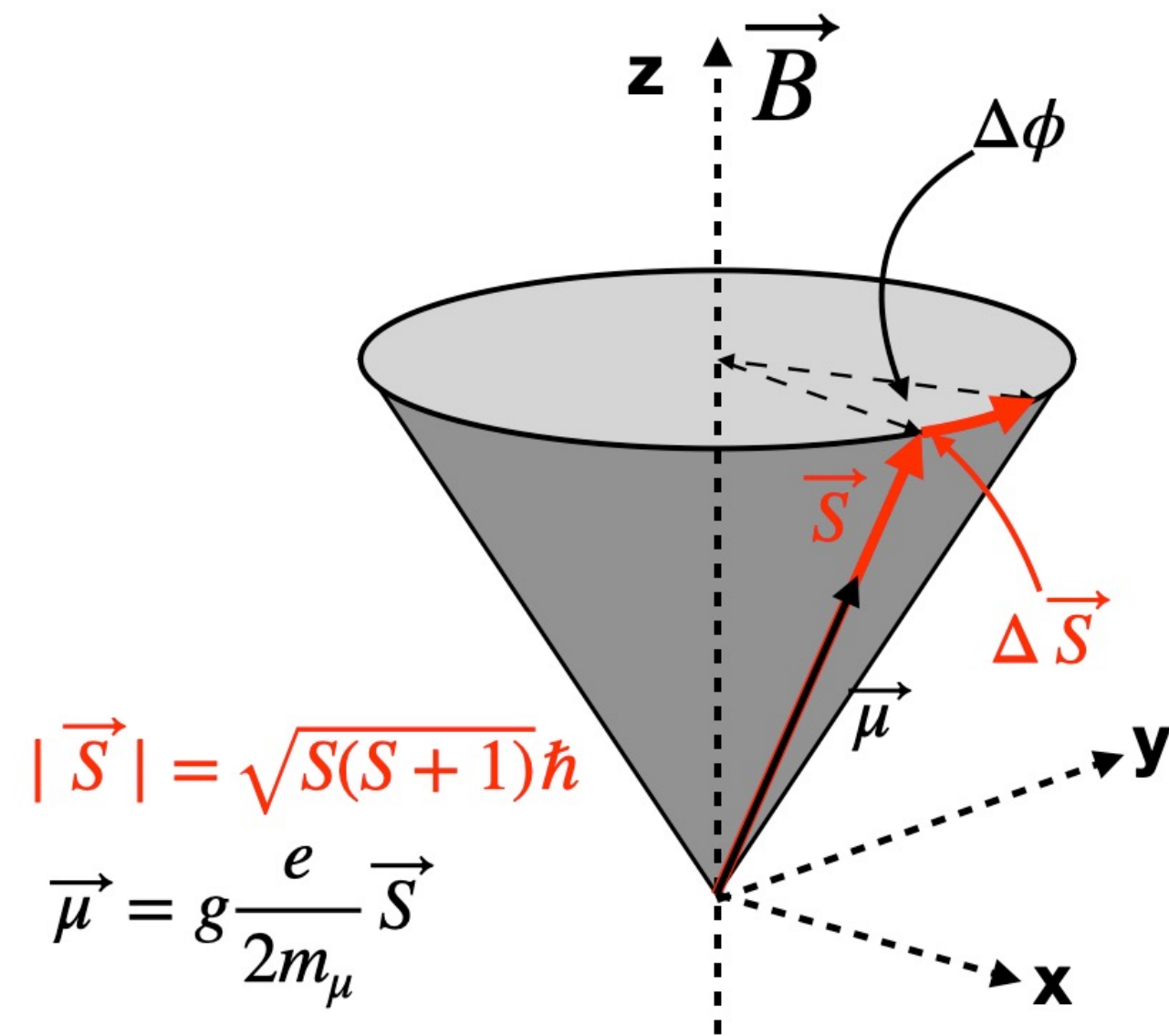
three generations of matter (elementary fermions)			
	I	II	III
QUARKS	mass $\approx 2.2 \text{ MeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ u up	mass $\approx 1.28 \text{ GeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ c charm	mass $\approx 173.1 \text{ GeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ t top
	mass $\approx 4.7 \text{ MeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ d down	mass $\approx 96 \text{ MeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ s strange	mass $\approx 4.18 \text{ GeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ b bottom
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LEPTONS	mass $< 0.8 \text{ eV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_e electron neutrino	mass $< 0.17 \text{ MeV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_μ muon neutrino	mass $< 18.2 \text{ MeV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_τ tau neutrino

The heavier cousin of the electrons:

- 200 x heavier than an electron
- Same “spin” (intrinsic angular momentum)
- Same electric charge than e
- Unstable: lifetime $\approx 2 \mu\text{s}$
- Production in large numbers at accelerators
- Decay: Prototype of weak interaction

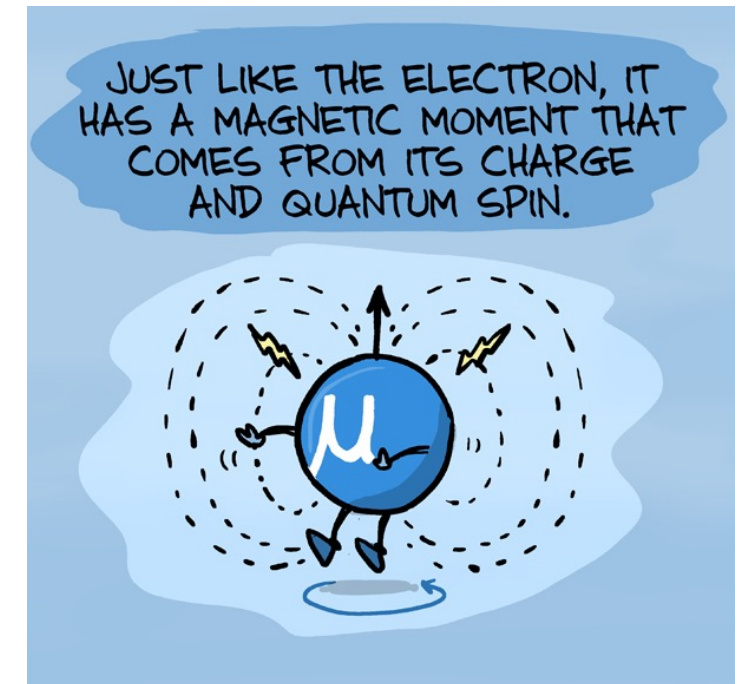


The g factor of a charged lepton



Charged particle with magnetic dipole moment and spin

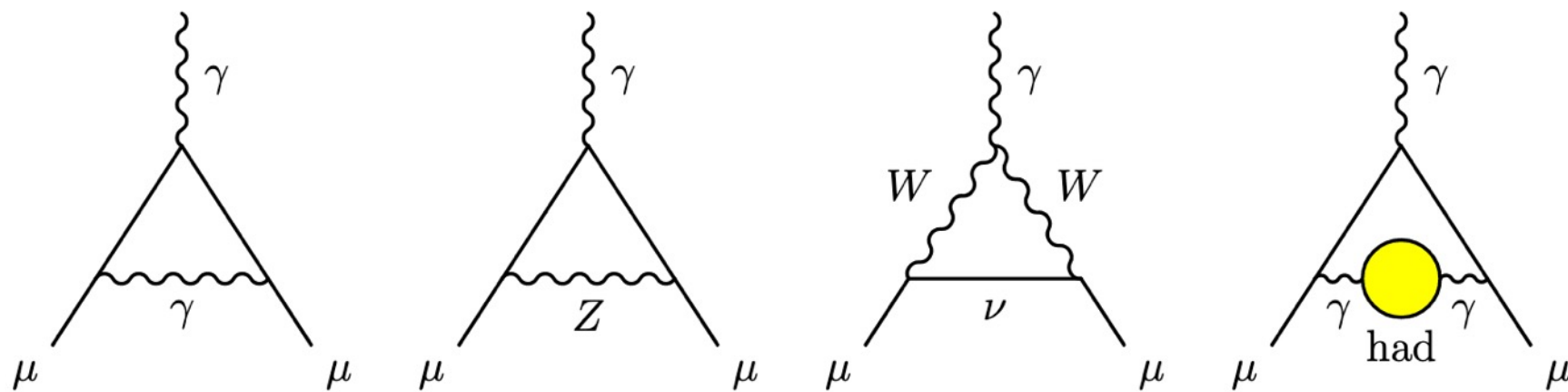
$$\vec{\mu} = g \frac{q}{2m} \vec{S}$$



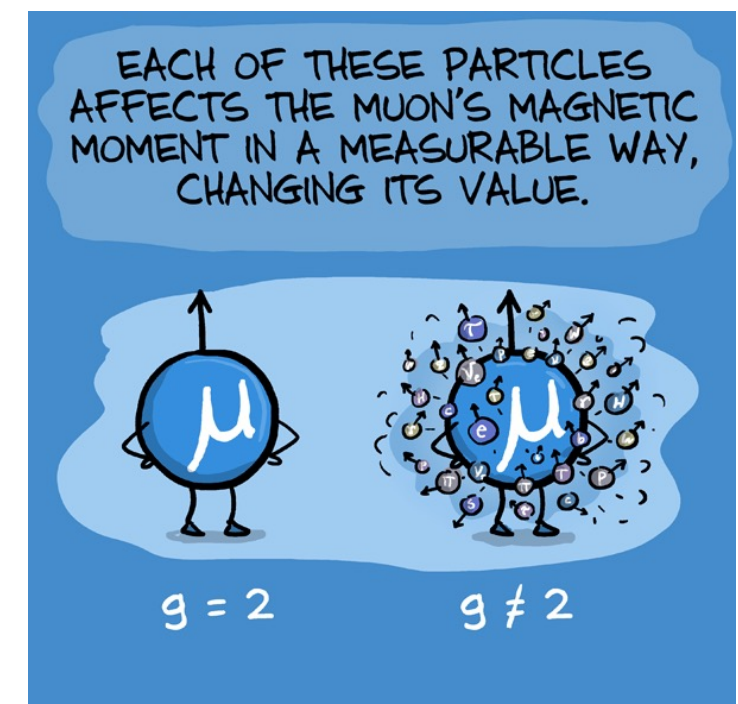
For a point-like charged lepton with spin 1/2 Dirac predicts $g = 2$

(P. Dirac, The Quantum Theory of the Electron, Proc. R. Soc. Lond. A 1928 117)

Interactions with virtual particles cause the “anomalous magnetic moment”

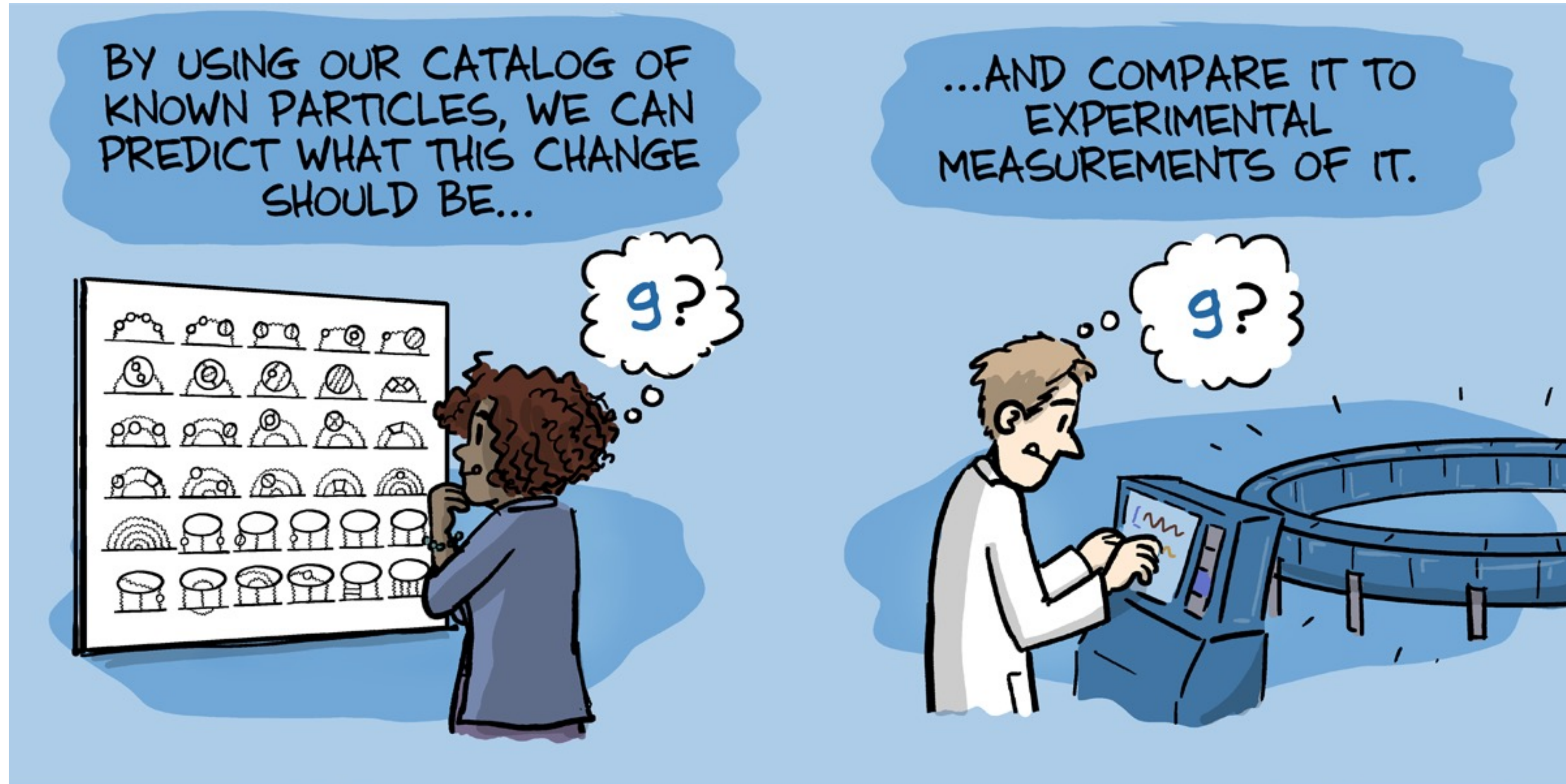


$$a_\mu = \frac{g_\mu - 2}{2} = a_{\text{QED}} + a_{\text{weak}} + a_{\text{had}} (+a_{\text{BSM}})$$

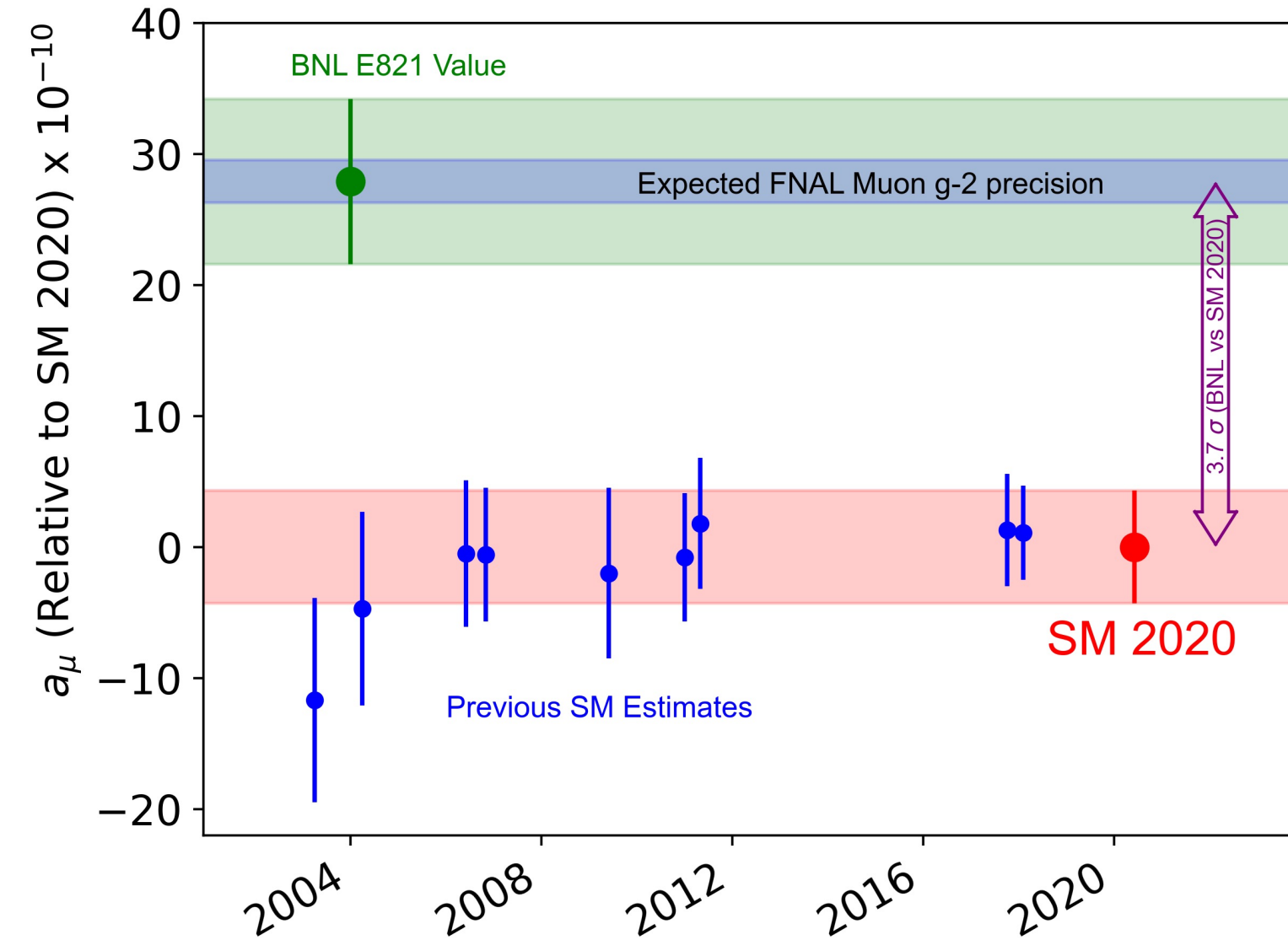


Feynman diagrams: M. Tanabashi et al. (Particle Data Group), Phys. Rev. D98, 030001 (2018)

Prediction meets the experiment !?



Prediction meets the experiment



Total SM prediction: $a_{\mu}^{\text{SM}} = 11659\textcolor{red}{1810} \pm 43$ (368 ppb)

Phys. Rept. 887 (2020) 1-166

Experiment (BNL E821): $a_{\mu}^{\text{BNL}} = 11659\textcolor{red}{2089} \pm 63$ (540 ppb)

Phys. Rev. D 73, 072003, 2006

Discrepancy: $\Delta a_{\mu} = a_{\mu}^{\text{exp}} - a_{\mu}^{\text{SM}} = (279 \pm 76) \times 10^{-11}$

3.7 σ deviation



Check the experiment:
Reduce uncertainty
by a factor of 4 @ FNAL
with 20x more muons!

Check the prediction:
Are all interactions and
particles accounted for?

Or is this a hint for #18
lurking to be discovered?

Recent evaluations of the SM prediction of a_μ

Units: $\text{xxx } 10^{-11}$

QED ($\mathcal{O}(\alpha^5)$, > 12000 digrams):

$$116584718.931 \pm 0.104$$

Electroweak:

$$153.6 \pm 1.0$$

LO hadronic vacuum polarization:

$$6931 \pm 40$$

NLO HVP:

$$-98.3 \pm 0.7$$

NNLO HVP:

$$12.4 \pm 0.1$$

LO hadronic light-by-light scattering:

$$92 \pm 19$$

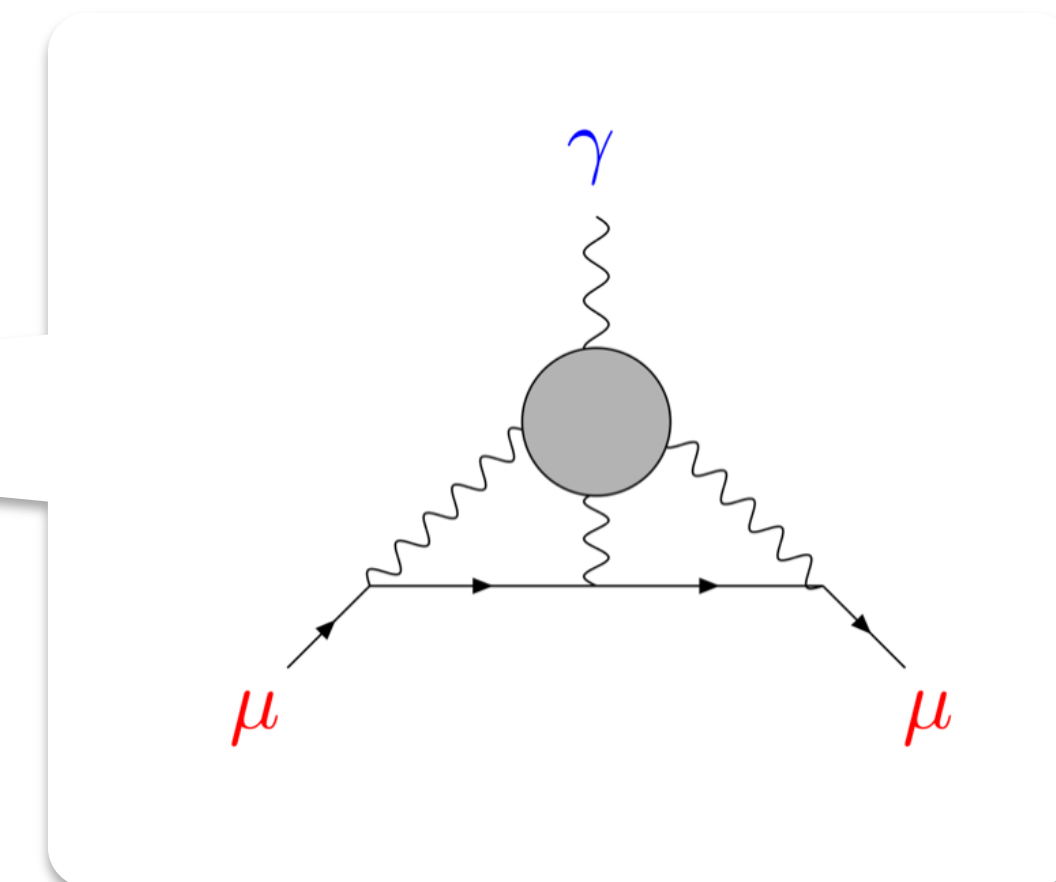
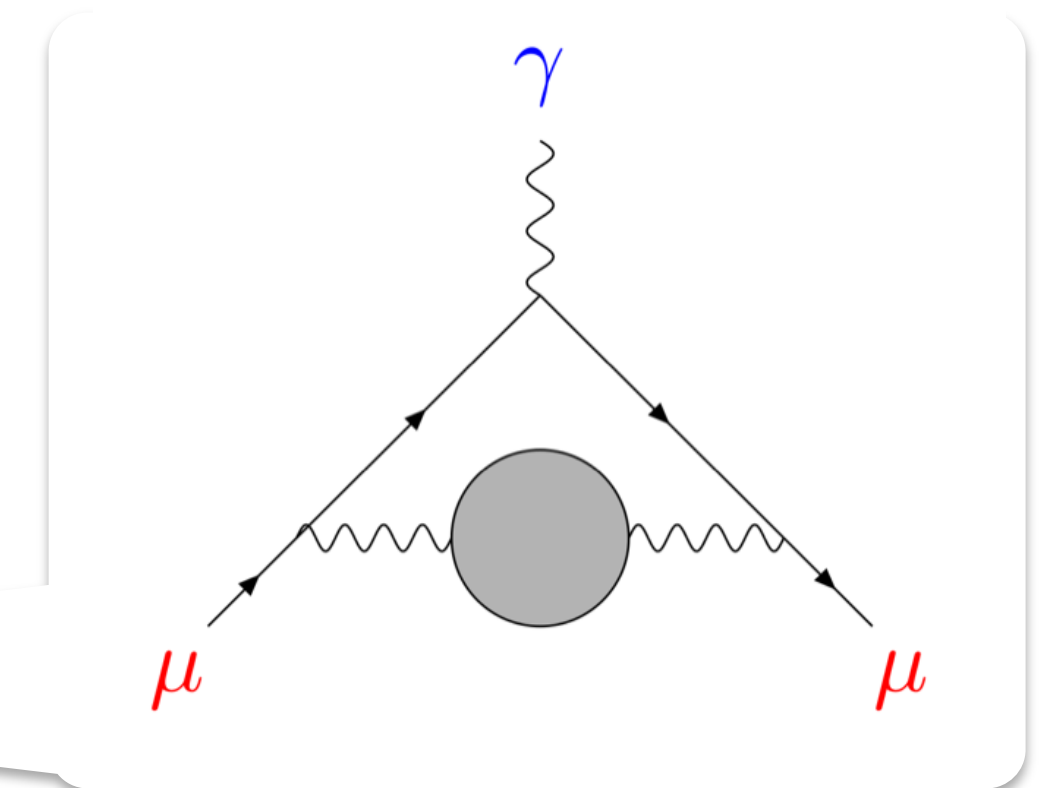
NLO hLbL scattering:

$$2 \pm 1$$

Uncertainty dominated by hadronic physics contributions!

Total SM prediction:

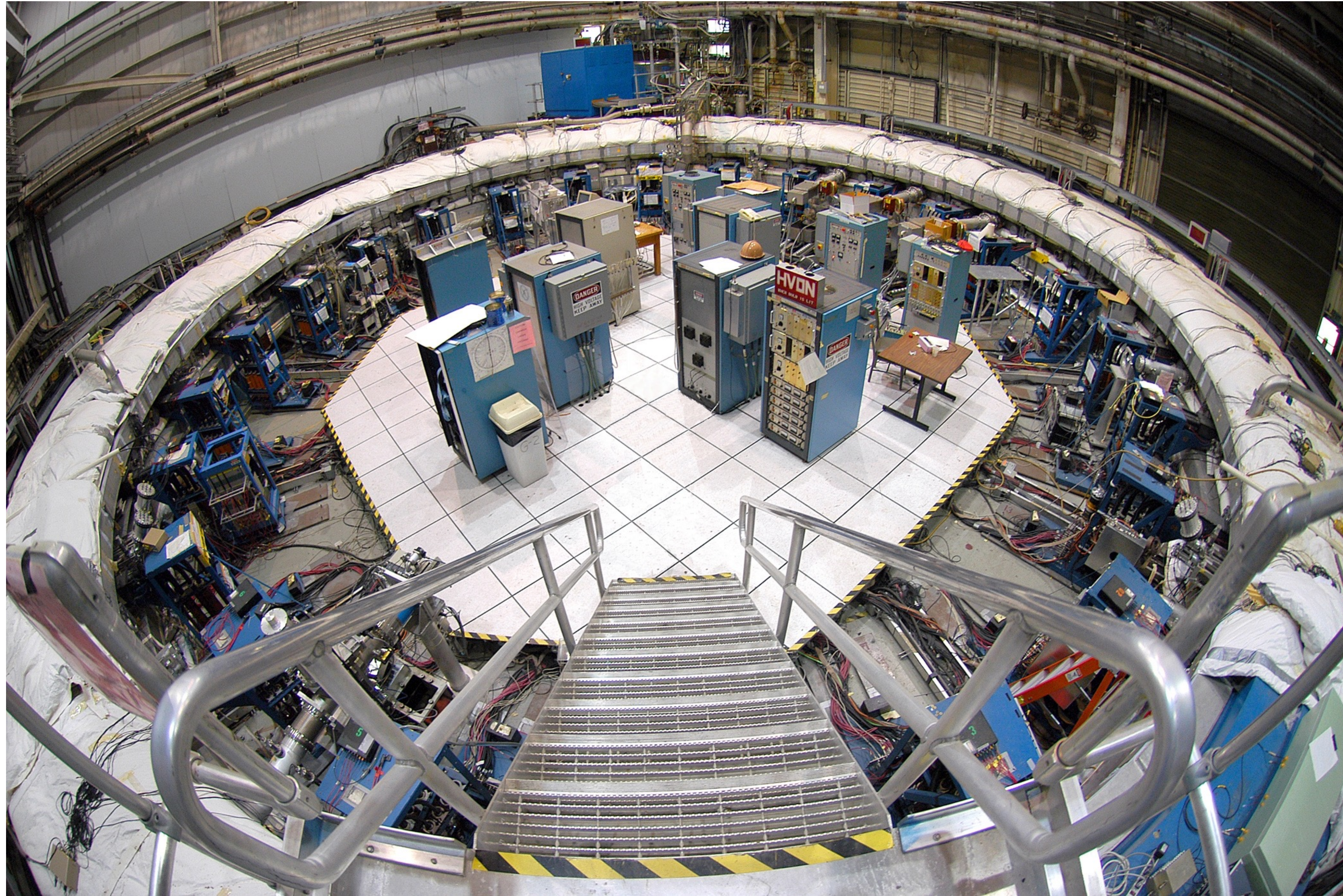
$$a_\mu^{\text{SM}} = 11659\textcolor{red}{1810} \pm 43 \text{ (368 ppb)}$$



Numbers taken from “Muon g-2 Theory Initiative White Paper”: Phys. Rept. 887 (2020) 1-166

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The muon g-2 experiment at Brookhaven



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The long journey from Brookhaven to Fermilab (2013) !

If the short route isn't feasible...

... a little detour is needed!



On the road ...



On the river ...

By the sea ...

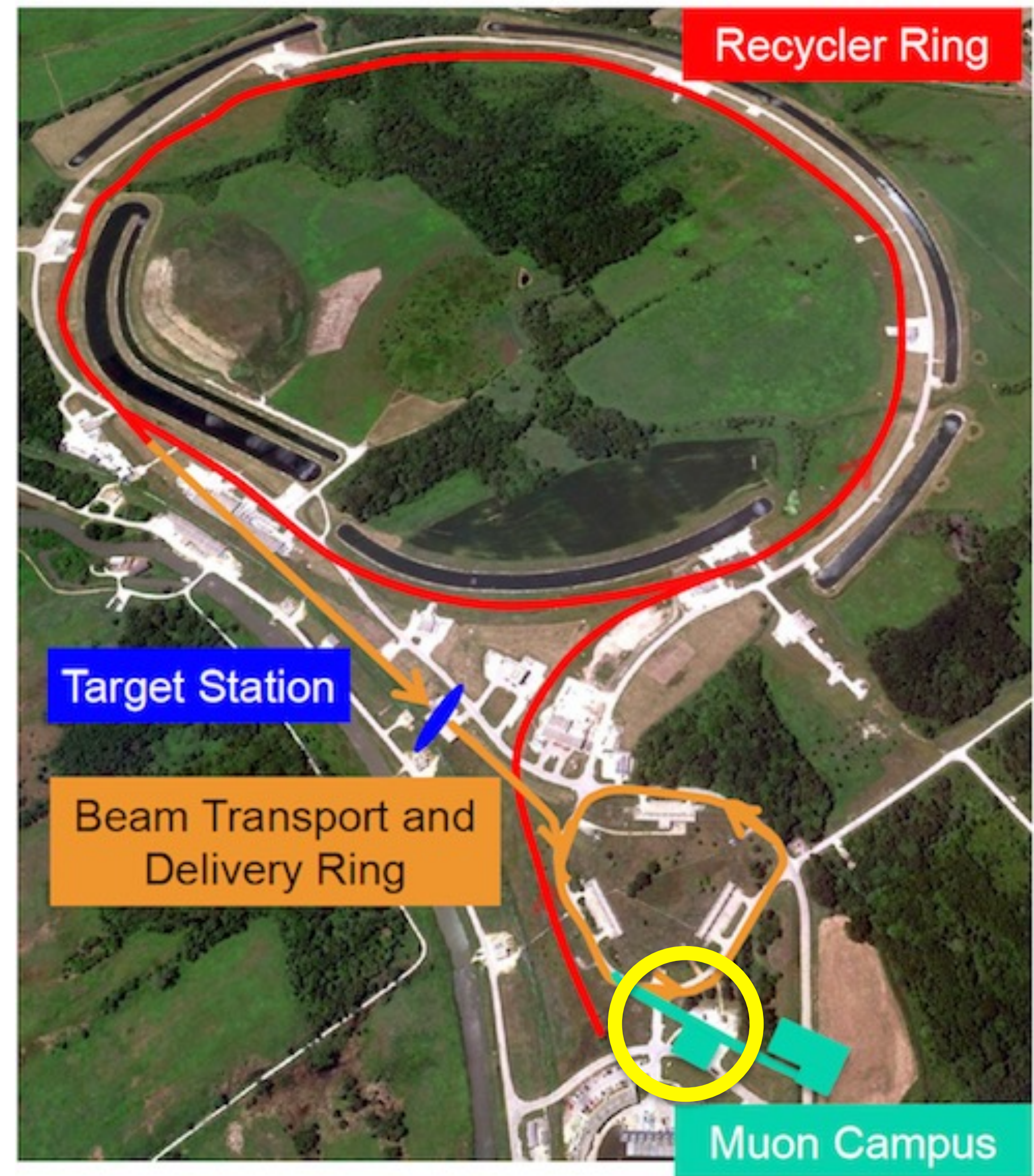


Making friends in Chicago!

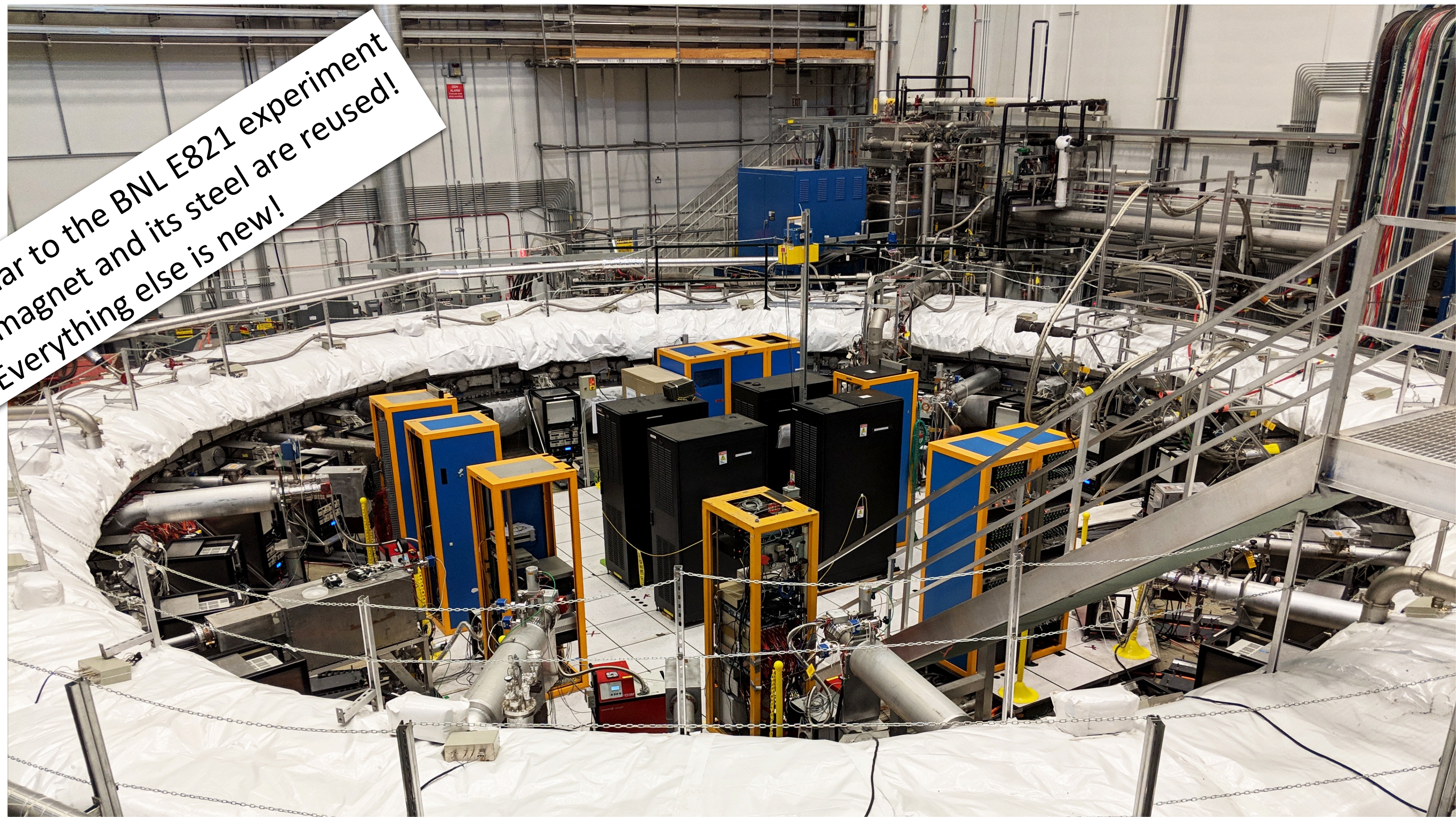
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12

FNAL muon campus: the new home base!

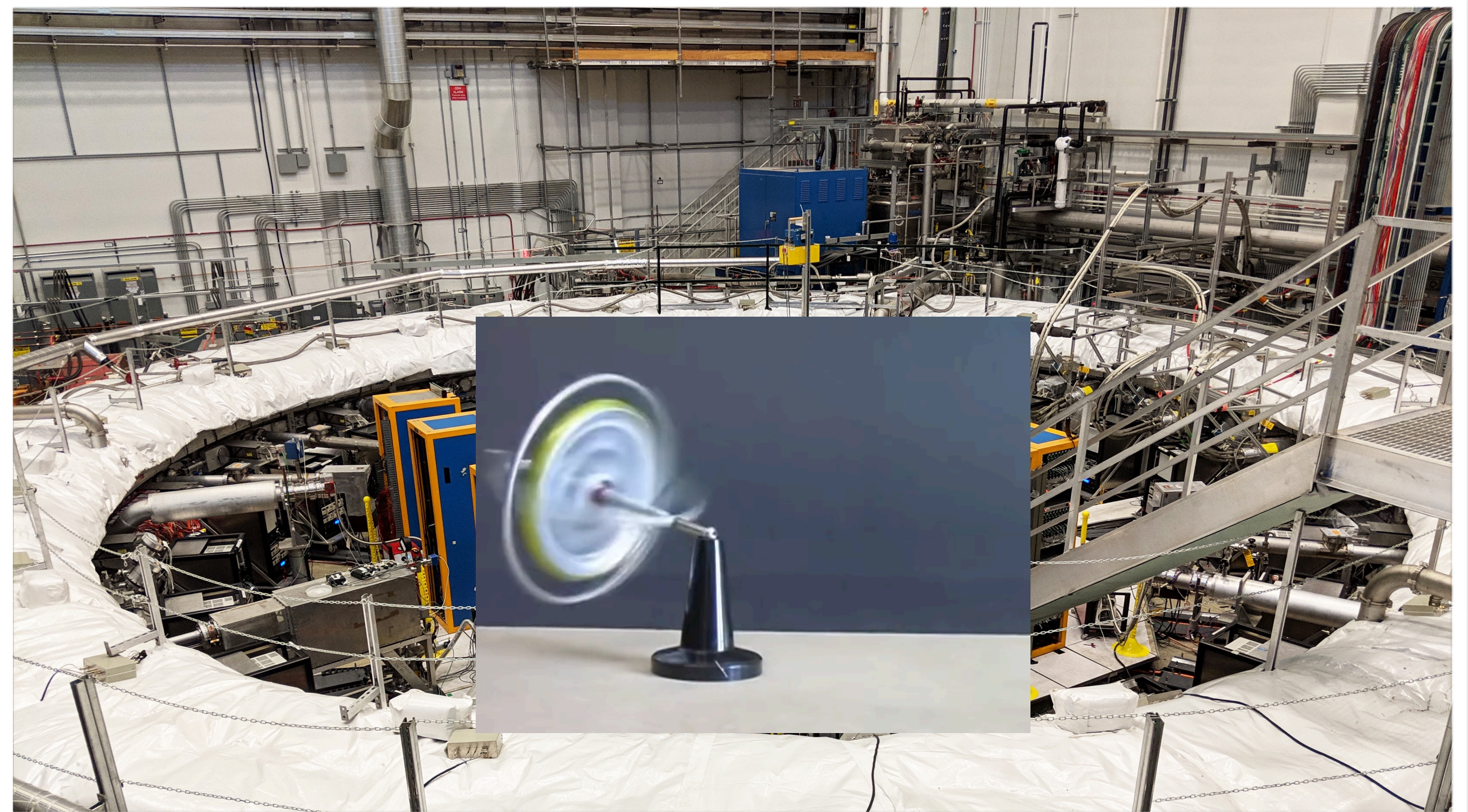


The muon g-2 experiment at Fermilab



Looks very similar to the BNL E821 experiment
But only the magnet and its steel are reused!
Everything else is new!

Muons spin like elementary tops in the storage ring



Precessing top: cropped from Hill Science videos
https://www.youtube.com/watch?v=cquvA_lpEsA

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The two clocks of a charged lepton

A *relativistic* charged lepton circulating a homogenous magnetic field experiences two effects:

Cyclotron motion

Spin precession

Equilibrium between centrifugal and Lorentz force

Coupling of magnetic moment and field

Cyclotron frequency

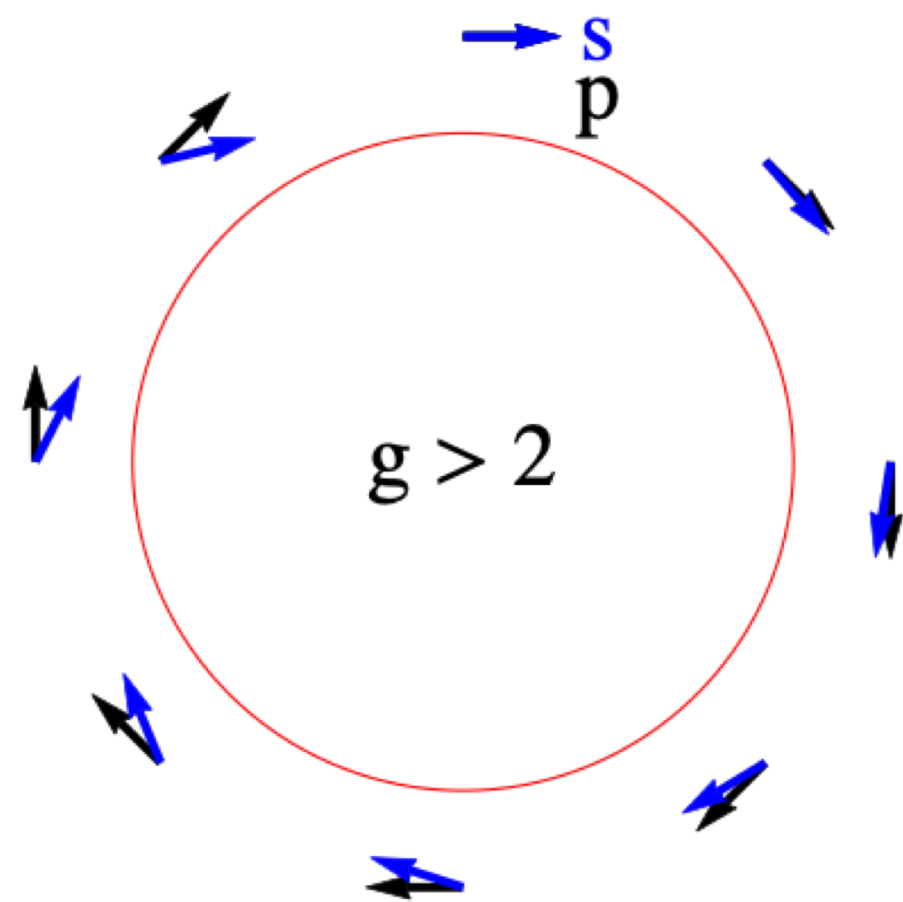
Larmor frequency

$$\vec{\omega}_c = -\frac{Qe}{m\gamma} \vec{B}$$

$$\vec{\omega}_s = -g \frac{Qe}{2m} \vec{B} - (1 - \gamma) \frac{Qe}{\gamma m} \vec{B}$$

Anomalous spin precession frequency:

$$\vec{\omega}_a = \vec{\omega}_s - \vec{\omega}_c = -\left(\frac{g-2}{2}\right) \vec{B} = -a \frac{Qe}{m} \vec{B}$$



Independent of
particle momentum!

Clock frequency shifts for muons in motion

Evolution of muon's longitudinal polarization in a superposition of electric and magnetic fields

$$\frac{d}{dt}P_L = \frac{d}{dt}(\hat{\beta} \cdot \vec{s}) = -\frac{e}{m} \vec{s}_{\perp} \cdot \left[a_{\mu} \hat{\beta} \times \vec{B} + \left(a_{\mu} - \frac{1}{\gamma^2 - 1} \right) \beta \vec{E} \right]$$

By virtue of
the parity violation
of weak interactions

Spin component
perpendicular to
velocity

Non-relativistic and
circular motion limit

Relativistically generated magnetic fields
“electric field correction”
“pitch correction”

Accurate reconstruction
of decay positrons
for frequency extraction

Magnetic field
maps and temporal
interpolation

Reconstruction
of complex beam
dynamics

FNAL E989: $E \neq 0$
suppressed at $\gamma = 29.3$
“magic momentum”

Extracting a_μ - the external ingredients

Anchor B , e and m_μ to other high-precision measurements and calculations

$$a_\mu = \frac{\omega_a}{\tilde{B}} \frac{m_\mu}{e} = \frac{\omega_a}{\tilde{\omega}'_p(T_r)} \frac{\mu'_p(T_r)}{\mu_e(H)} \frac{\mu_e(H)}{\mu_e} \frac{m_\mu}{m_e} \frac{g_e}{2}$$

Extracting a_μ - the external ingredients

Anchor B , e and m_μ to other high-precision measurements and calculations

$$\frac{\mu'_p(T_r)}{\mu_e(H)}$$

10.5 ppb uncertainty
at $T_r = 34.7^\circ\text{C}$
Metrologia 13, 179 (1977)

$$\frac{\mu_e(H)}{\mu_e}$$

Bound state QED calculation
exact
Rev. Mod. Phys. 88, 035009 (2016)

$$a_\mu = \frac{\omega_a}{\tilde{B}} \frac{m_\mu}{e} = \frac{\omega_a}{\tilde{\omega}'_p(T_r)} \frac{\mu'_p(T_r)}{\mu_e(H)} \frac{\mu_e(H)}{\mu_e} \frac{m_\mu}{m_e} \frac{g_e}{2}$$

Total uncertainty
from external quantities:
24 ppb

$$\frac{m_\mu}{m_e}$$

Muonium hyperfine splitting
22 ppb uncertainty
Phys. Rev. Lett. 82, 11 (1999)

$$\frac{g_e}{2}$$

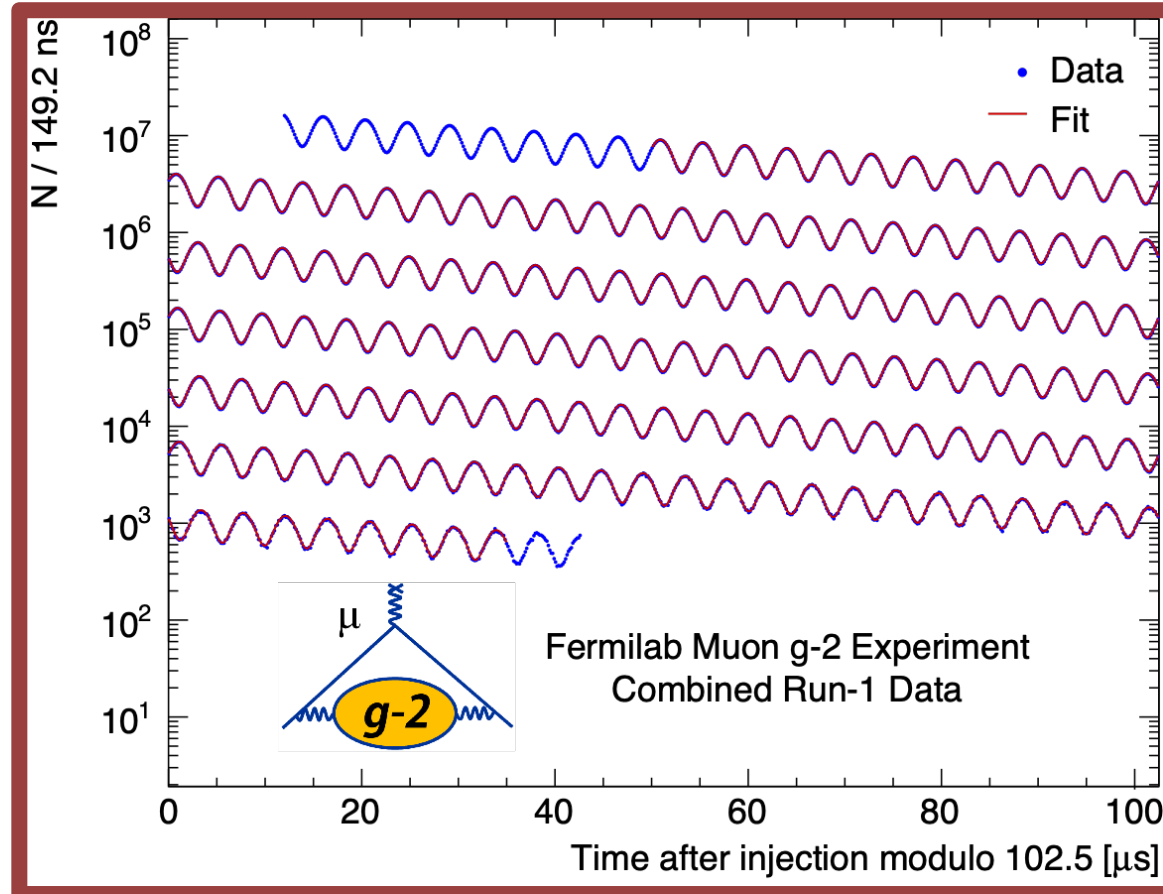
Measurement with
0.28 ppt uncertainty
Phys. Rev. A 83, 052122 (2011)

Extracting a_μ - our challenge

$$a_\mu = \frac{\omega_a}{\tilde{B}} \frac{m_\mu}{e} = \boxed{\frac{\omega_a}{\tilde{\omega}'_p(T_r)}} \frac{\mu'_p(T_r)}{\mu_e(H)} \frac{\mu_e(H)}{\mu_e} \frac{m_\mu}{m_e} \frac{g_e}{2}$$

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

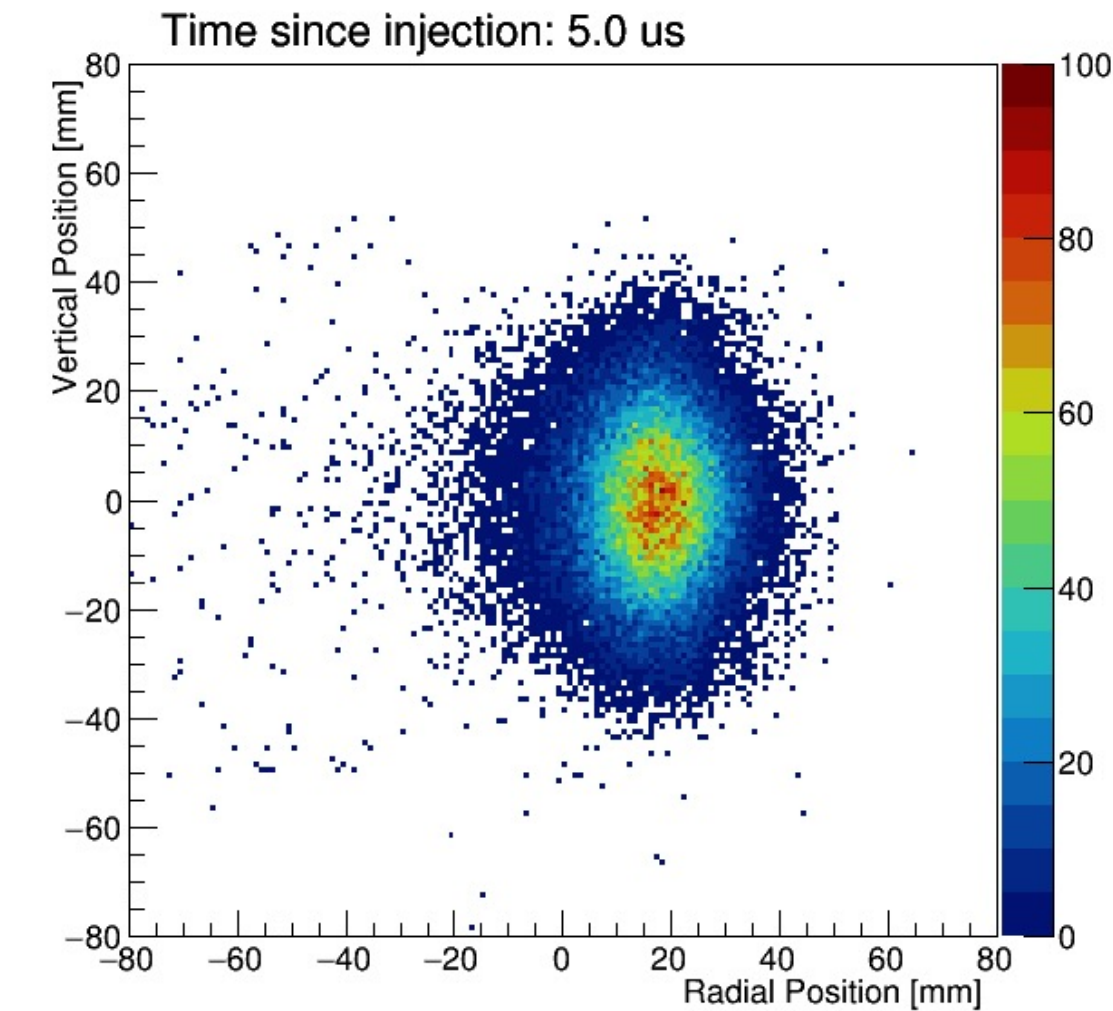
Extracting a_μ - our tools



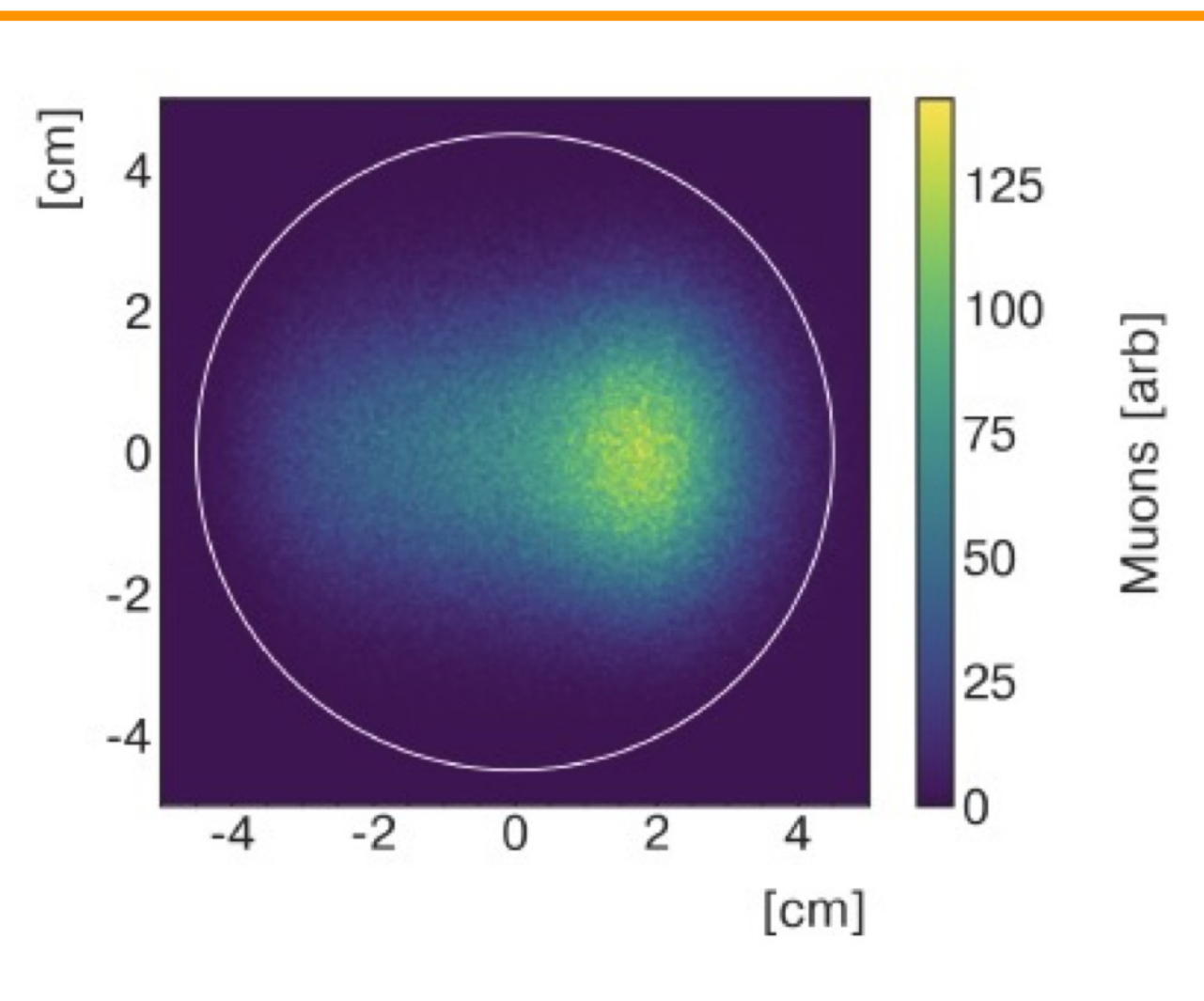
Anomalous spin precession
frequency

Muon beam dynamics
corrections

Clock blinding



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

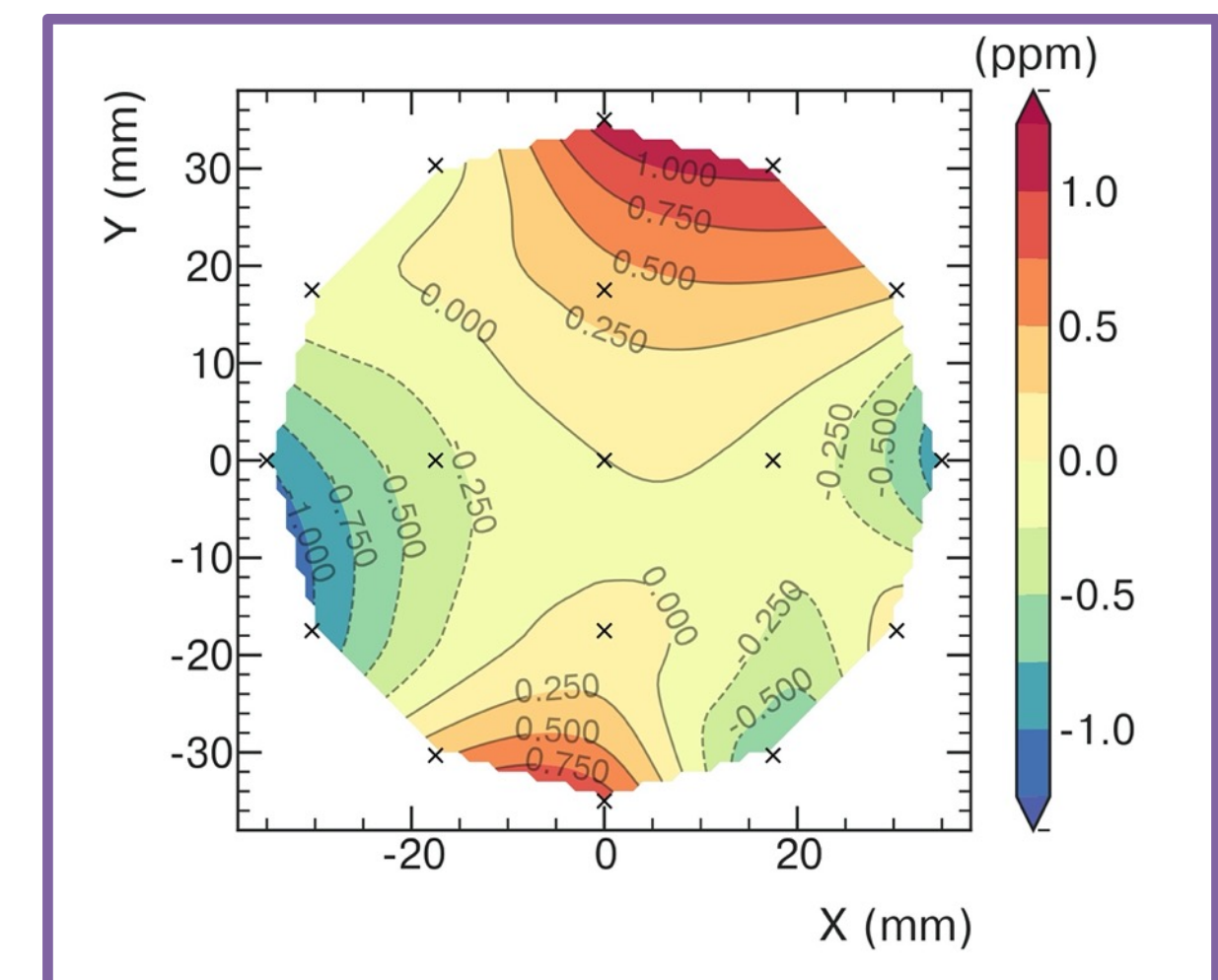


Spatial muon
distribution

Spatial distribution
of magnetic field

Transient magnetic
fields

Calibration



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The Muon g-2 collaboration ready to unblind ...

Domestic Universities

Boston
Cornell
Illinois
James Madison
Kentucky
Massachusetts
Michigan
Michigan State
Mississippi
Northern Illinois
Regis
UT Austin
Virginia
Washington

National Labs

Argonne
Brookhaven
Fermilab

China

Shanghai Jao Tong University

United Kingdom

Lancaster
Liverpool
University College London

Italy

Frascati
Molise
Naples
Pisa
Roma 2
Trieste
Udine

Germany

JGU Mainz
TU Dresden

Russia

JINR/Dubna
Novosibirsk

South Korea

CAPP/IBS
KAIST



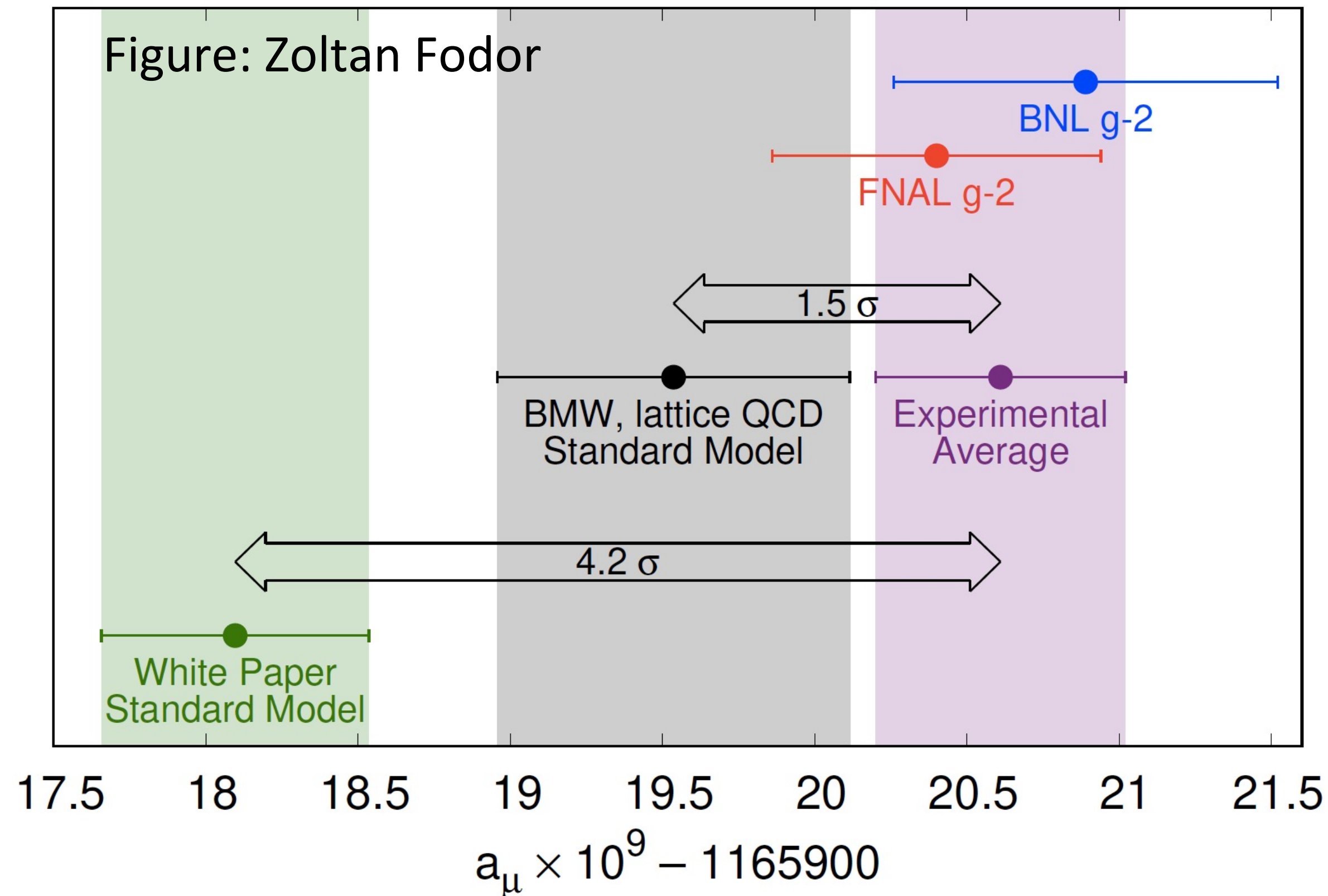
... on February 25th, 2021!



The 40 MHz clock was really set to:
39 997 784 MHz

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Result from combined Run 1 datasets



$$a_\mu(\text{BNL}) = 0.00116592089(63) \rightarrow 540 \text{ ppb}$$

$$a_\mu(\text{FNAL, R1}) = 0.00116592040(54) \rightarrow 463 \text{ ppb}$$

Both experiments uncertainty dominated by statistics:

$$a_\mu(\text{Exp}) = 0.00116592061(41) \rightarrow 350 \text{ ppb}$$

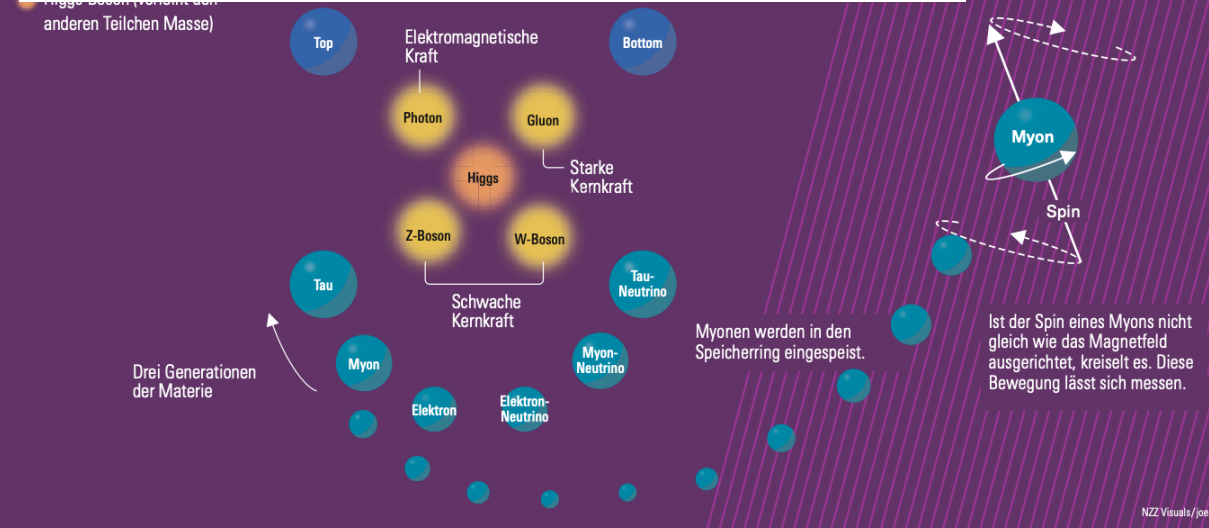
$$a_\mu(\text{SM}) = 0.00116591810(43) \rightarrow 350 \text{ ppb}$$

4.2 σ discrepancy between experiment and community approved SM prediction

BUT: the very recent results from IQCD vor HVP would reduce the tension to 1.5 σ !

*Borsányi et al., Nature **593**, 51–55, 2021
and arXiv:2002.12347*

Vor zwei Wochen bekam das Standardmodell der Teilchenphysik nasse Füsse. Jetzt steht ihm das Wasser bis zum Hals



Im Gebäck der Teilchenphysik kracht es

Eine Präzisionsmessung liefert die bisher überzeugendsten Hinweise auf «neue Physik»

4/9/2021 Starker Hinweis auf bisher unbekannte Kräfte oder Teilchen - Technik - derStandard.at | Wissenschaft

DER STANDARD

Startseite › Wissenschaft › Technik

NEUE PHYSIK

Starker Hinweis auf bisher unbekannte Kräfte oder Teilchen

Erneut lässt ein hochpräzises Experiment auf eine Physik abseits des gültigen Standardmodells schließen

9. April 2021, 06:00 80 Postings

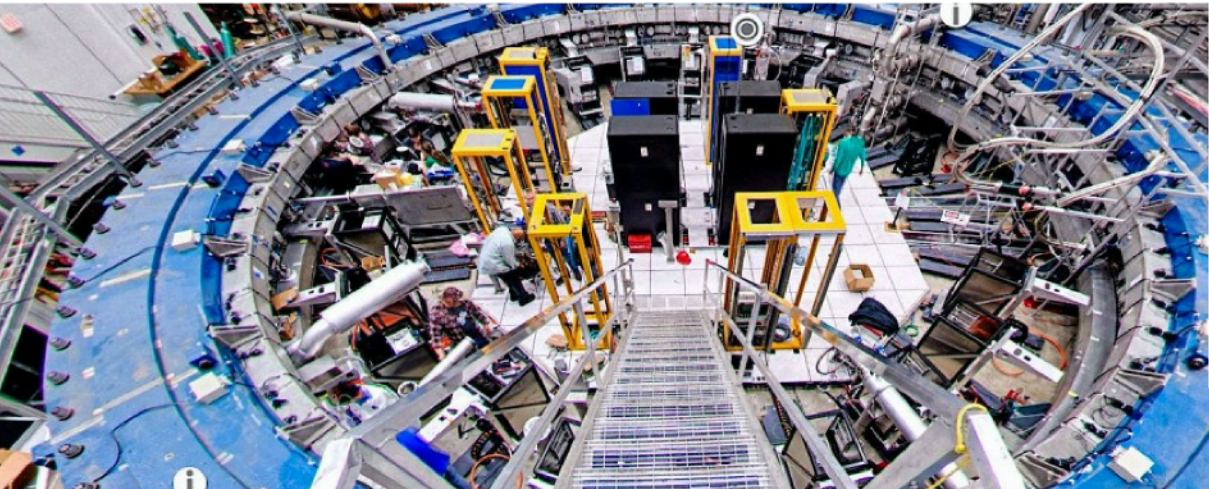
F+ PODCASTS BLOGS THEMEN TICKER ARCHIV STELLENMARKT
Wissen Physik & Mehr Das magnetische Moment des Myons ist größer als erwartet. Frühere Messungen bestätigen.

Sonderseite:
Coronavirus

HERAUSGEGEBEN VON GERALD BRAUNBERGER, JÜRGEN KAUBE, CARSTEN KNOP, BERTHOLD KOHLER

RÄTSELHAFTE MYONEN Abschied vom Standardmodell?

VON MANFRED LINDINGER · AKTUALISIERT AM 07.04.2021 · 18:55



Show mit Lava und Nordlicht

Vulkanausbruch auf Island wird zum Besuchermagnet

RUDOLF HERMANN

Frühdarstellung und Geldgadarad möglicherweise zungenbrecherische Flutman sein, doch inzwischen kennt sie die Welt: Sie beschreiben die Lokalität der westlich von Reykjavik in den Ne atlantik ragenden Halbinsel Reykja wo seit Mitte März die Erde Feuer sp Selber haben sich Tausende aufgem um das vulkanische Spektakel mit ein en Augen zu sehen. Nicht zur ungetr ten Freude der Behörden; diese versu ten anfangs nämlich, die Bevölker cher davon abzuhalten, den ein- bis zw stündigen Weg von der nächstgeleges Strasse durch unwegsames Gelände Stelle des Ausbruchs unter die Füße nehmen. Doch dieses Bemühen war geheiss: An Spitzentagen waren laut id dischen Medien bis zu fünf Tausend M schen in diesem Gebiet unterwegs.

Shuttlebus und Imbissbude

Die Behörden änderten deshalb ihre S tegie. Wenn die Neugierigen sowieso z Vulkan gingen, so dürfte man sich tüt legt haben, sei es besser, wenn sie einj massen unter Kontrolle blieben. So v den von den nächstgelegenen Stras zwei Zugangsrouten markiert, die abh gig von den herrschenden Verhältnis beganen werden können. Je nach Sit tion werden sie aber auch hin und wie gesperrt, etwa wenn, wie am Osternor geschehen, sich plötzlich eine neue Sp öffnet. Da hatten Zivilschutz und F tungsdienste alle Hände voll zu tun, zahlreichen Besucher zu evakuieren v das gesamte Gebiet abzuriegeln. Die Popularität des vulkanisch en Gebiets auf Reykjanen erklärt i nicht zuletzt dadurch, dass dieses

"All the News That's Fit to Print"

VOL. CLXX . . . No. 59,022

The New York Times

NEW YORK, THURSDAY, APRIL 8, 2021

Biden Tax Plan Aims to Curtail Use of Havens

Loophole Has Enriched Global Corporations

By JIM TANKERSLEY and ALAN RAPPAPORT

WASHINGTON — Large companies like Apple and Bristol Myers Squibb have long employed complicated maneuvers to reduce or eliminate their tax bills by sliding income on paper between countries. The strategy has enriched accountants and shareholders, while driving down corporate tax receipts for the federal government.

President Biden sees ending that practice as central to his \$2 trillion infrastructure package, pushing changes to the tax code that his administration says will ensure American companies are contributing tax dollars to help invest in the country's roads, bridges, water pipes and in other parts of its economic agenda.

On Wednesday, the Treasury Department released the details of Mr. Biden's tax plan, which aims to raise as much as \$2.5 trillion over 15 years to help finance the infrastructure proposal. That includes bumping the corporate tax rate to 28 percent from 21 percent, imposing a strict new minimum tax on global profits and cracking down on companies that try to move profits offshore.

The plan also aims to stop big companies that are profitable but have no federal income tax liability from paying no taxes to the Treasury Department by imposing a 15 percent tax on the profits they report to investors. Such a change would affect about 45 corporations, according to the Biden administration's estimates, because it would be limited to companies earning \$2 billion or more per year.

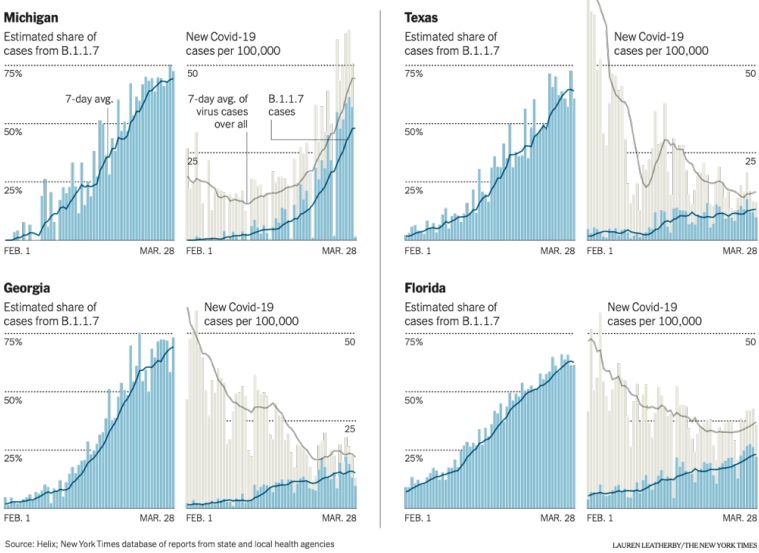
But two years after it suffered stinging defeats in Syria and Iraq, the terrorist group has found a new lifeline in Africa, where analysts say it has forged alliances with local militant groups in symbolic relationships that have pumped up their profiles, fundraising and recruitment.

Many of those homegrown insurgencies are only loosely connected to the Islamic State, also known as ISIS. Still, over the past year, as violence from Islamist extremists on the African continent would have added to companies with \$10 million or more in profits per year.

Continued on Page A18

Contagious Variant Is Fueling Surge in Infections Across the U.S.

Some states where new cases of the coronavirus are rising have been hit hard by the B.1.1.7 variant. Page A6.



ISIS and African Militants Join In a Marriage of Convenience

By CHRISTINA GOLDBAUM and ERIC SCHMITT

JOHANNESBURG — The Islamic State's self-declared caliphate has fallen, its fighters have dispersed and its leader, Abu Bakr al-Baghdadi, has been killed.

But two years after it suffered stinging defeats in Syria and Iraq, the terrorist group has found a new lifeline in Africa, where analysts say it has forged alliances with local militant groups in symbolic relationships that have pumped up their profiles, fundraising and recruitment.

Many of those homegrown insurgencies are only loosely connected to the Islamic State, also known as ISIS. Still, over the past year, as violence from Islamist extremists on the African continent would have added to companies with \$10 million or more in profits per year.

Still, its 15 percent tax is a narrower version of the one he proposed in the 2020 campaign that would have applied to companies with \$10 million or more in profits per year.

Continued on Page A18

4/8/2021

Is the standard model broken? Physicists cheer major muon result

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NEWS · 07 APRIL 2021

Is the standard model broken? Physicists cheer major muon result

The muon's magnetic moment is larger than expected — a hint that new elementary particles are waiting to be discovered.

DER SPIEGEL

Kryptowährung Vor 4 Min

Kindesmissbrauch vor Vor 8 Min

Europäer Vor 30 Min

Alle Artikel & digitales Magazin

Neue Erkenntnisse in der Teilchenphysik

Kundschafter ins Unbekannte

Seit 50 Jahren ersehnen Forscher Einblicke in die Welt jenseits der bekannten Naturgesetze. Mit den Erkenntnissen aus dem Myon-g-2-Experiment könnte sich das Tor zu einer neuen Physik öffnen. Von Johann Grolle

ZEIT ONLINE

Teilchenphysik

Neue Erkenntnisse stellen Standardmodell der Physik infrag

Datenauswertungen am Chicagoer Fermilab zeigen eine Abweichung vom Drehmoment des Myons, eines Elementarteilchens. Das könnte unser Verständnis von Physik verändern.

8. April 2021, 7:47 Uhr / Aktualisiert am 8. April 2021, 8:50 Uhr / Quelle: ZEIT ONLINE
296 Kommentare /

Science

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Muons twirl as they circulate in this ring-shaped accelerator at Fermilab, like race cars perpetually spinning out. REIDAR HAHN/FERMI LAB

Particle mystery deepens, as physicists confirm that the muon is more magnetic than predicted

By Adrian Cho | Apr. 7, 2021, 11:00 AM

Le Monde

VENDREDI 9 AVRIL 2021

Une particule élémentaire polarise le monde de la physique

Une anomalie dans le comportement

FAS



Braut sich da was zusammen? Im Sommer 2013 wurde der Myonen-Speicherring (auf dem Lastwagen) am Fermilab nahe Chicago angeliefert. Jetzt wurden erste Ergebnisse verkündet.

Die Macht der Myonen

Ein Teilchen schickt sich an, eine beispiellos erfolgreiche Theorie zu sprengen. Viele Physiker freuen sich wie Bolle. Andere warnen, dazu sei es noch zu früh.

Von Ulrike von Rauchhaupt

Süddeutsche Zeitung

SZ.de Zeitung Magazin

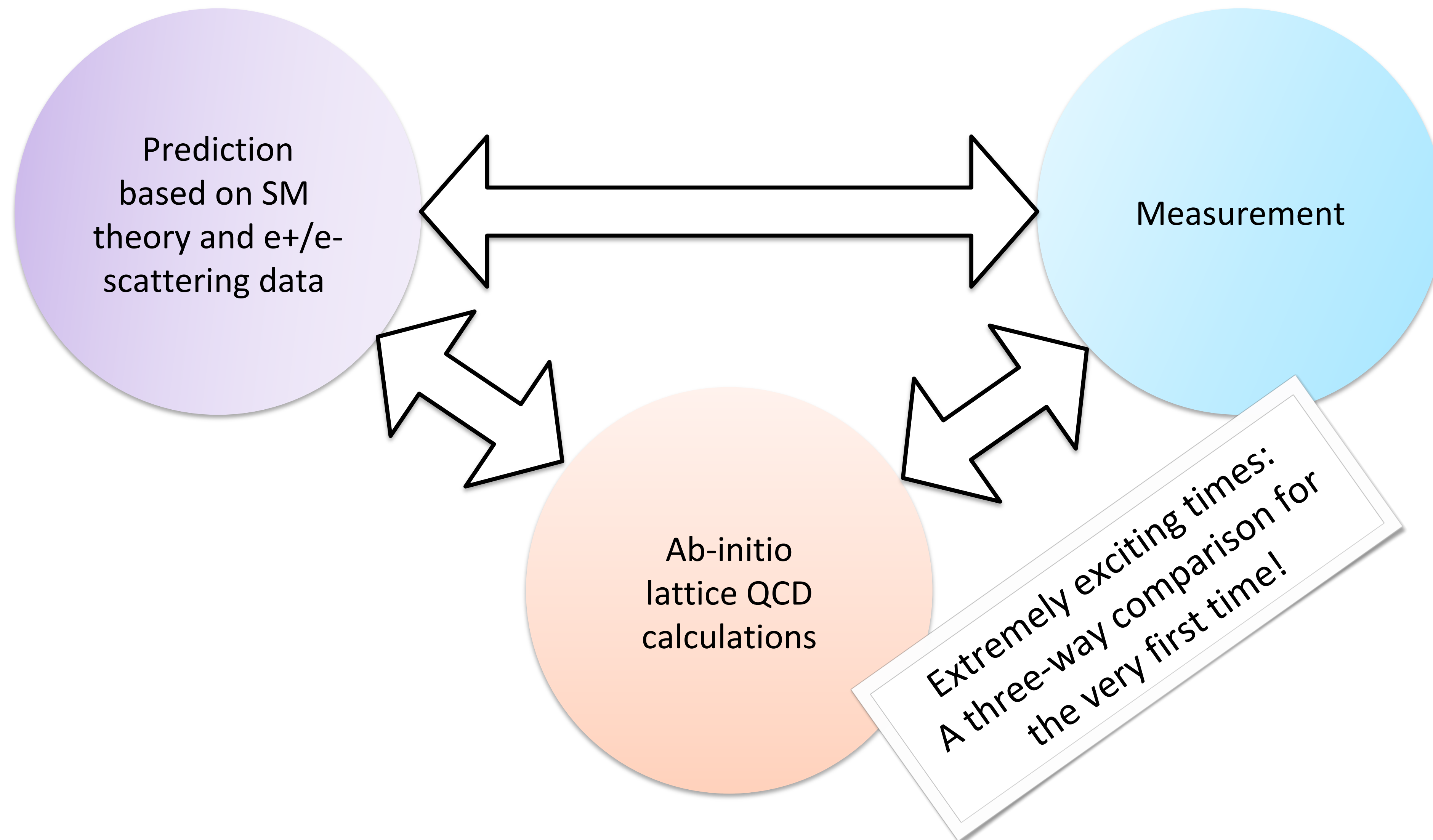
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Wie sieht es aus? Myonen-Experiment stellt Standardmodell der Physik infrage

8. April 2021, 15:54 Uhr Physik

Myonen-Experiment stellt Standardmodell infrage

A new era of a_μ comparisons



Particle #18: are you out there?

COULD IT BE THAT THE MUON IS CREATING PARTICLES WE DON'T KNOW ANYTHING ABOUT, BUT WHICH MIGHT SOLVE OTHER MYSTERIES IN PHYSICS?

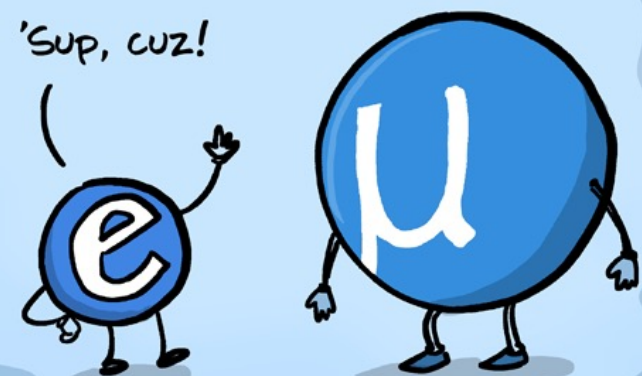


IT'S ALL PART OF OUR SEARCH TO DISCOVER HOW THE UNIVERSE WORKS.



WE ALL LOOK AROUND AND WONDER: HOW CAN THIS ALL BE? WHY DO WE EXIST?

THE MUON IS THE ELECTRON'S HEAVIER COUSIN.



Other mysteries: Hints for lepton flavour universality violation
 $b \rightarrow s\mu\mu$, Cabibbo angle anomaly

Muon really just the heavier cousin?

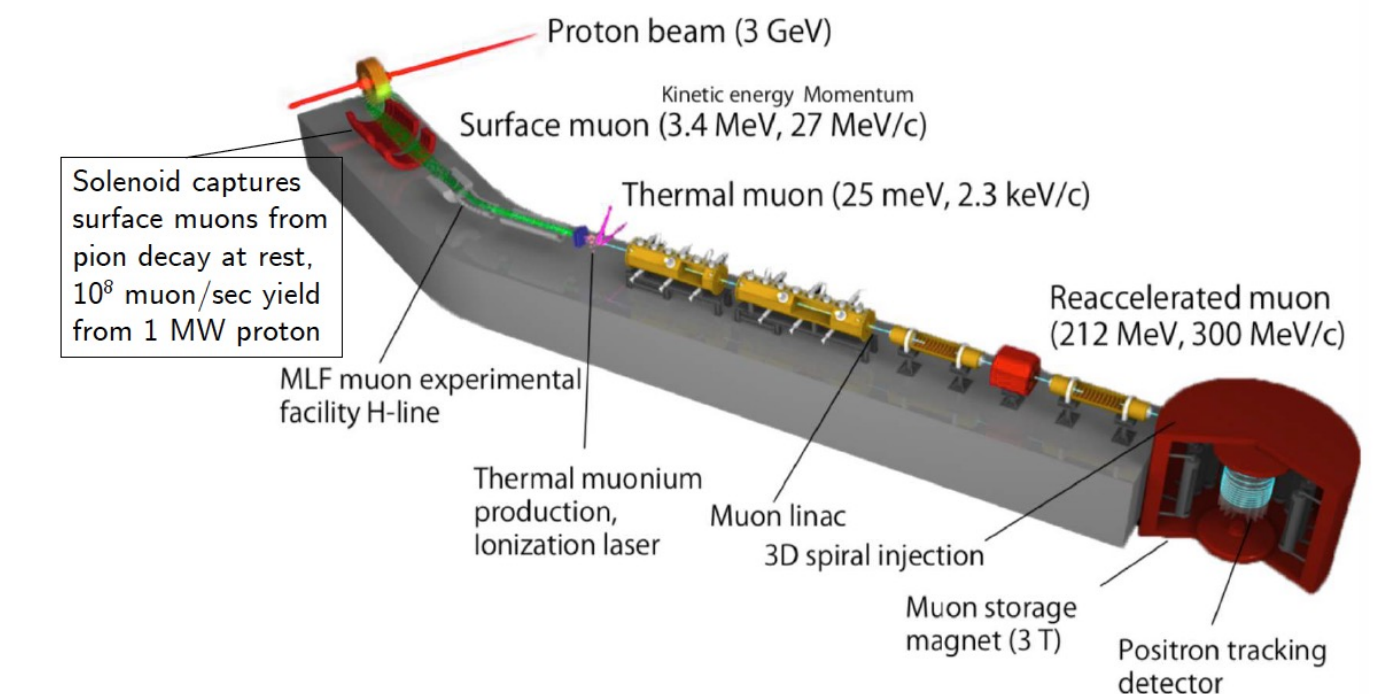
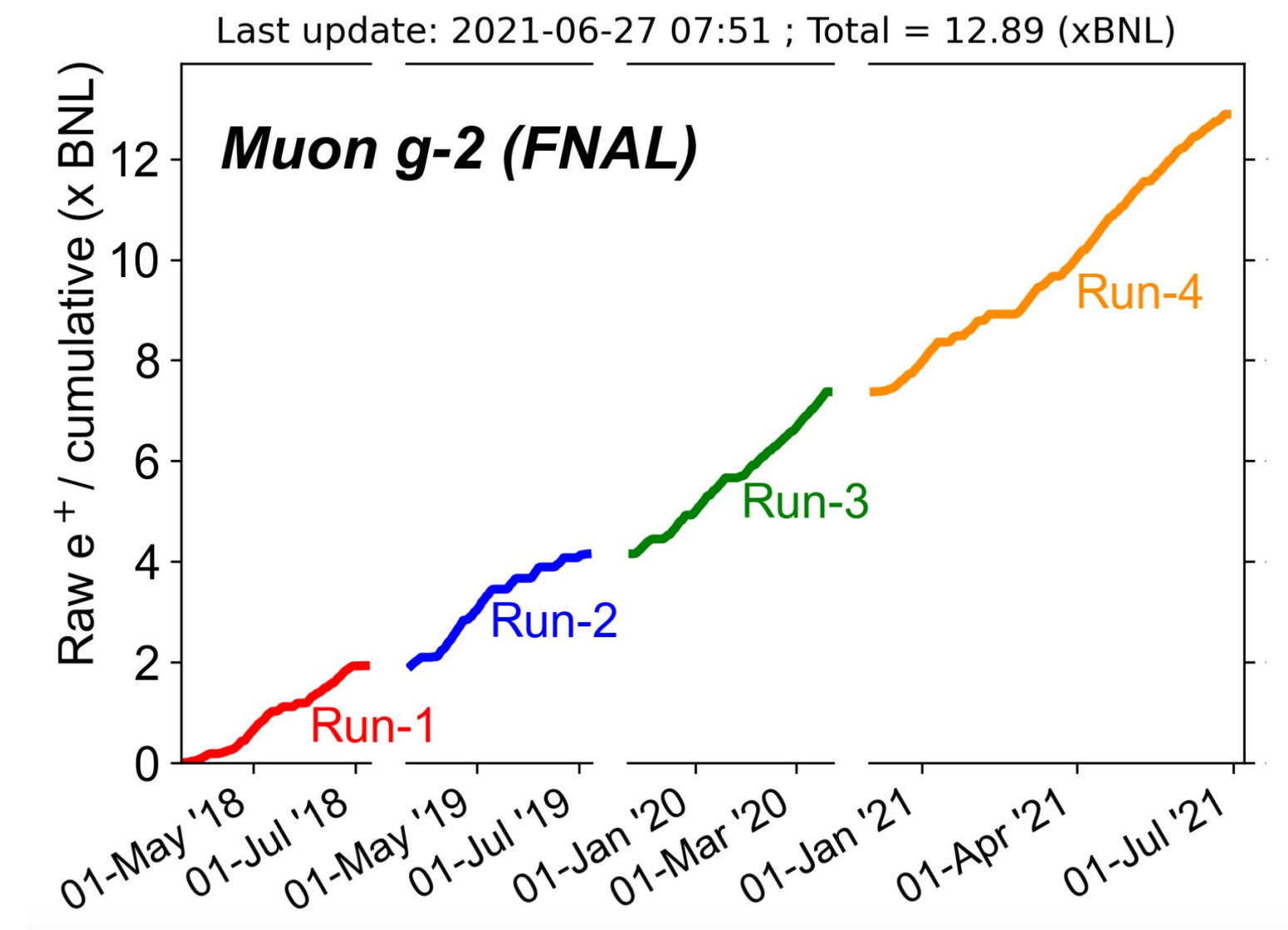
Extremely exciting times...

The near future:

- Fermilab experiment ongoing with much improved conditions → Factor 2 uncertainty reduction next year
- Intense scrutinizing of the IQCD calculation ongoing

The intermediate future:

- Independent measurement of muon $g-2$ at J-PARC
- Different experimental technique
- Different beam energy → Different magnetic field
- Proposed new data-driven HVP determination: MUonE at CERN



Thank you Chris for your leadership and congratulations!

Chris Polly is new Muon g-2 co-spokesperson

January 16, 2018 | Tom Barratt

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Chris Polly

79°F

☀️

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Chris Polly, center, project director for Fermilab, speaks during a safety briefing in Glen Ellyn, Ill., Thursday, July 25 before the final move of the electromagnet. The electromagnet is 50 feet ...



FERMILAB

CHRIS POLLY

WINNER 2021

2021

PHYSICAL SCIENCES

A full-length photo of Chris Polly standing in a laboratory or industrial setting. He is wearing a blue long-sleeved shirt and light-colored trousers, with his arms crossed. The background shows various pieces of equipment and machinery.

Thanks to the various funding agencies, in particular DOE, the excellence cluster PRISMA+ at JGU, and the WE Heraeus Foundation