--- a part of ---

RIKEN J-PARC CENTER PROJECT

RNC

M. IWASAKI

--- a part of ---

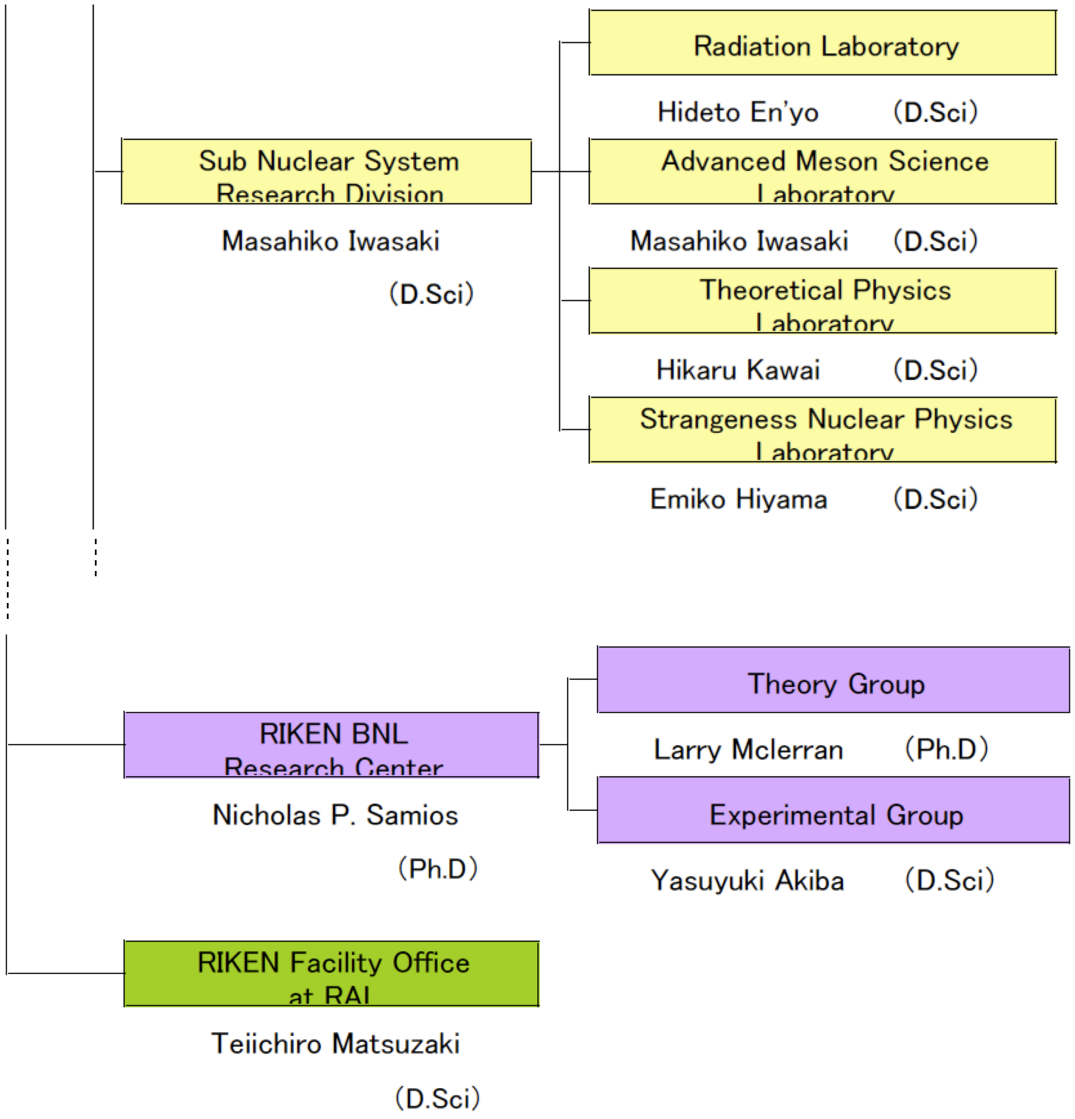
Future Project

of the

Sub Nuclear System Research Division

Proposal of Muon g-2 R&D as a New Pillar at RIKEN-RAL

Organization structure for Riken-RAL Branch



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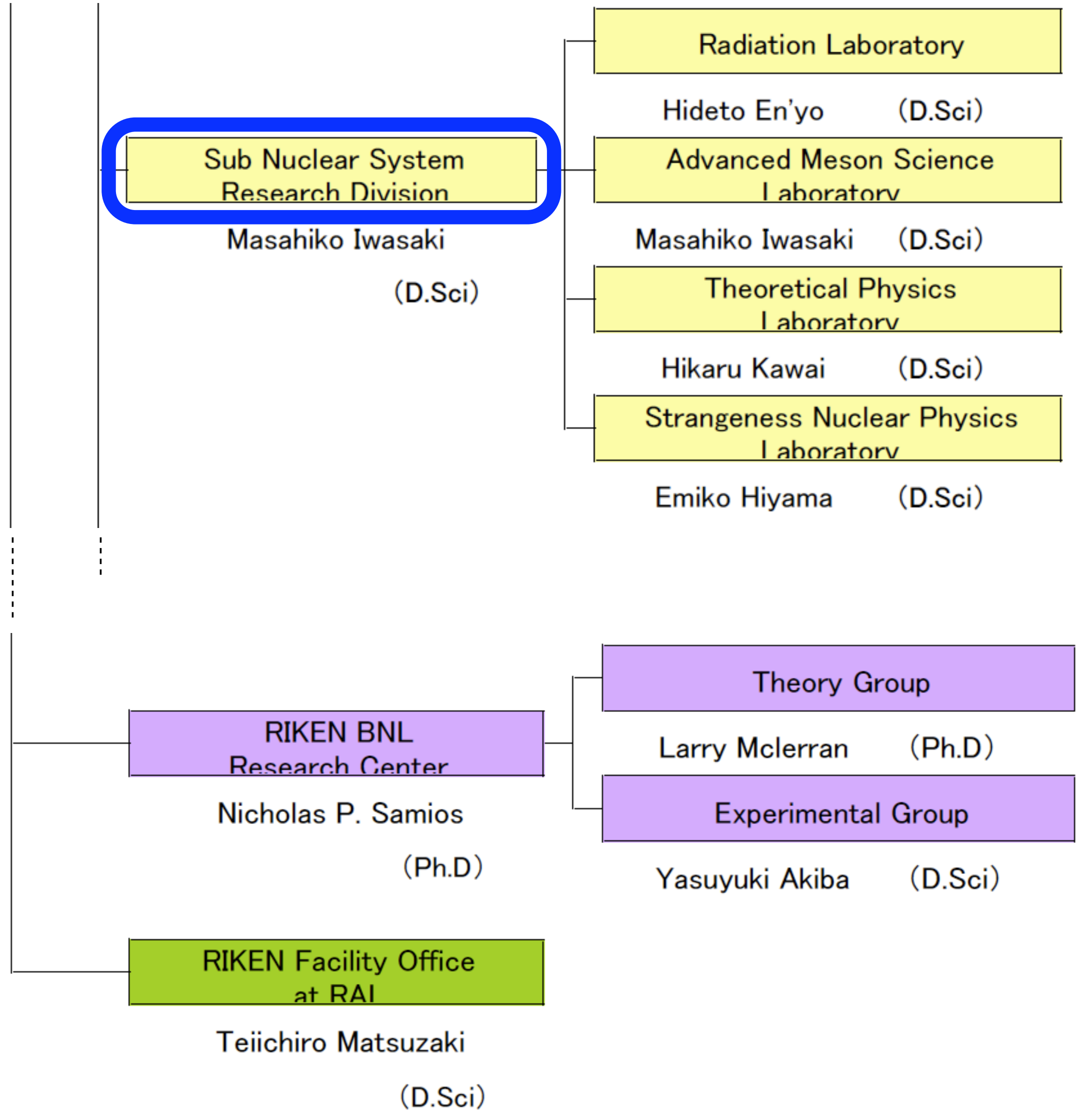

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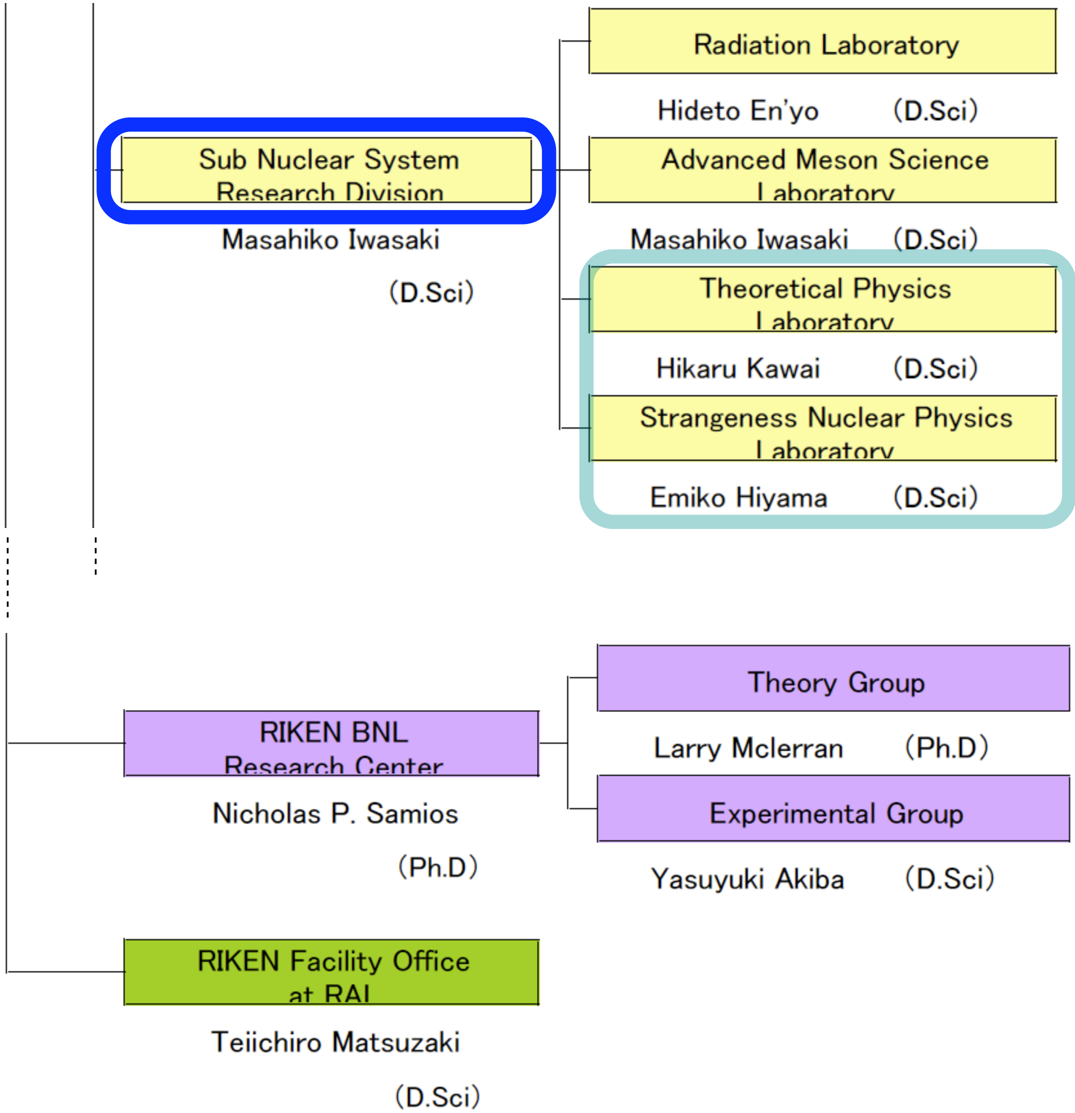

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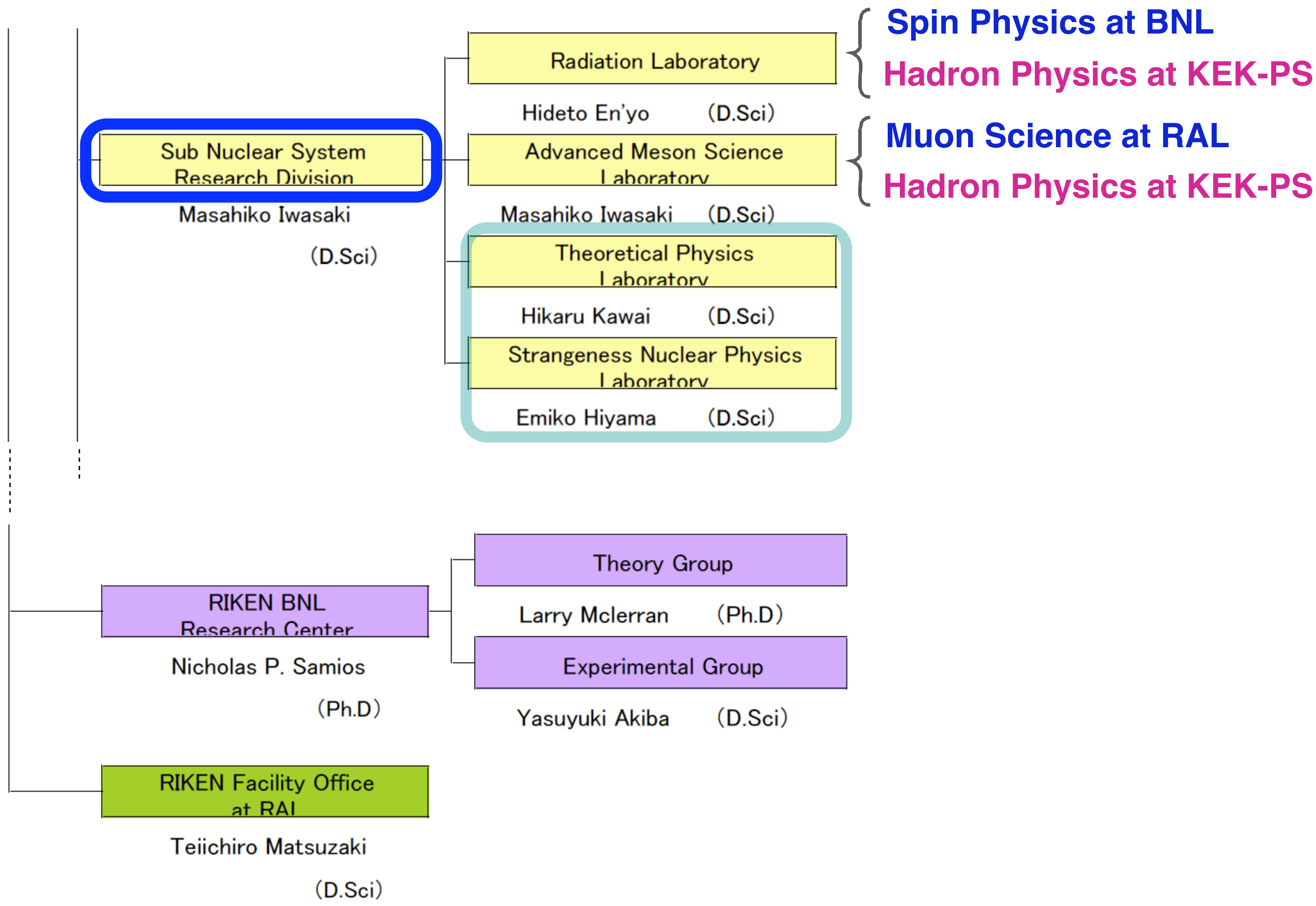

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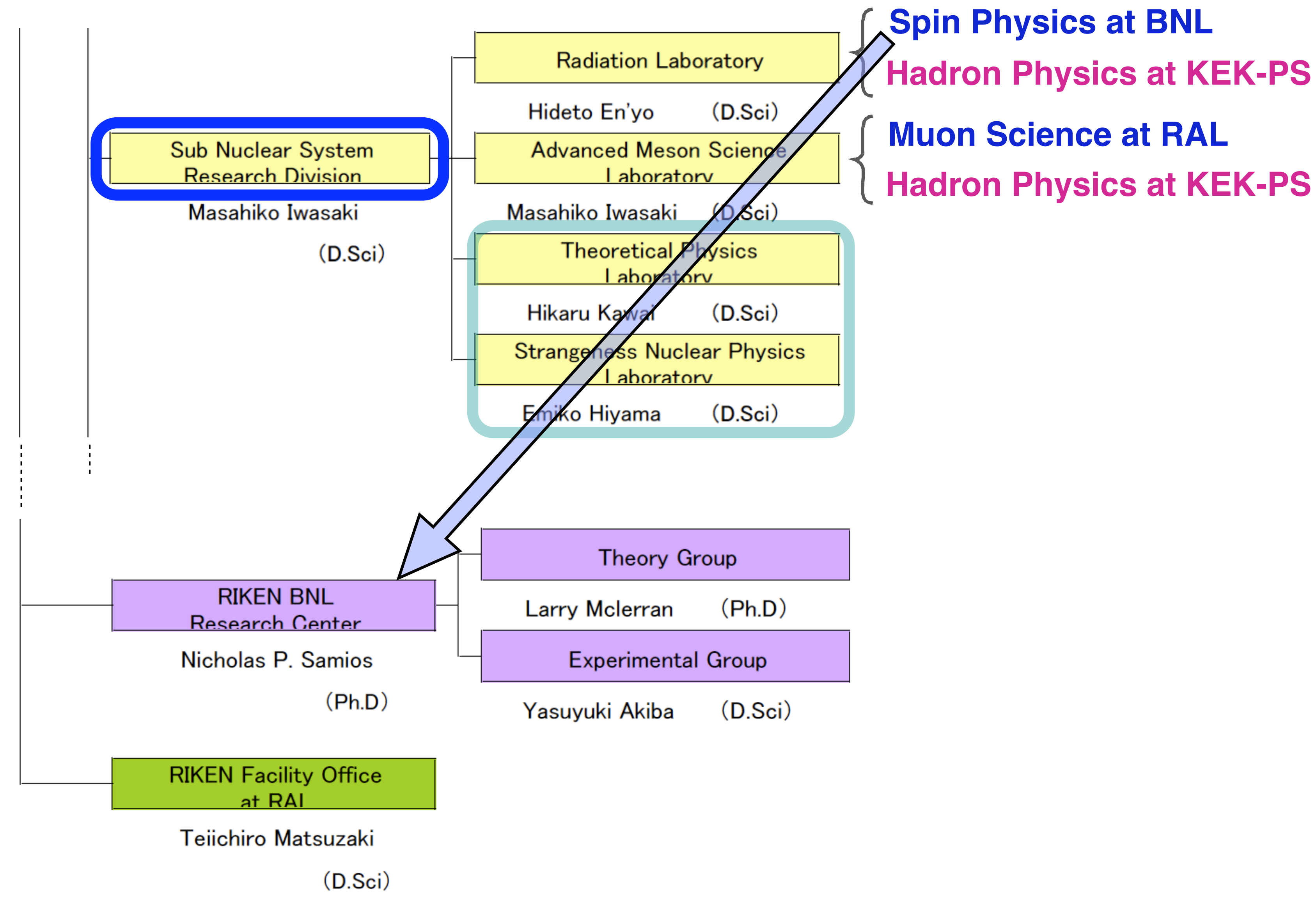

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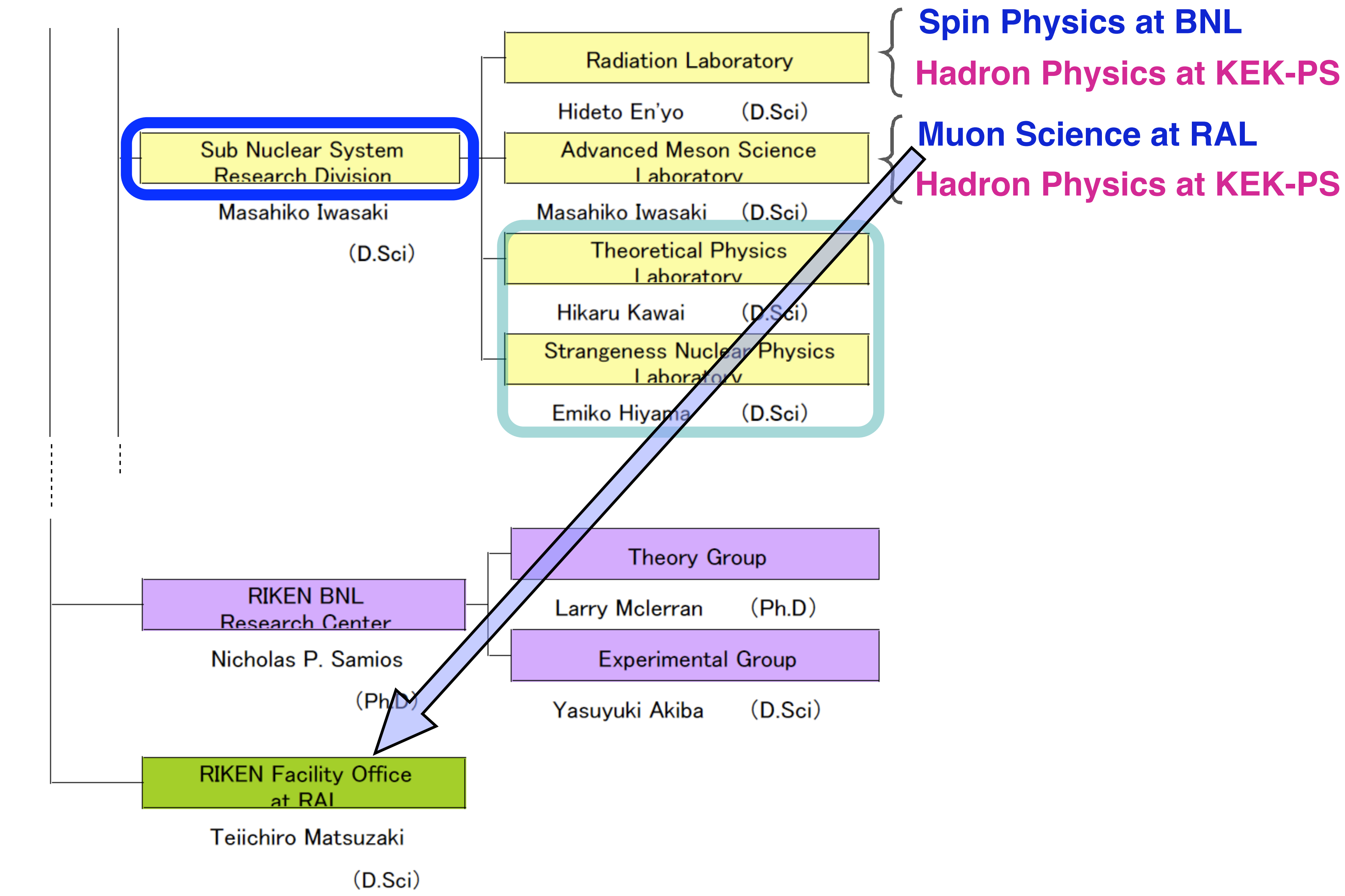

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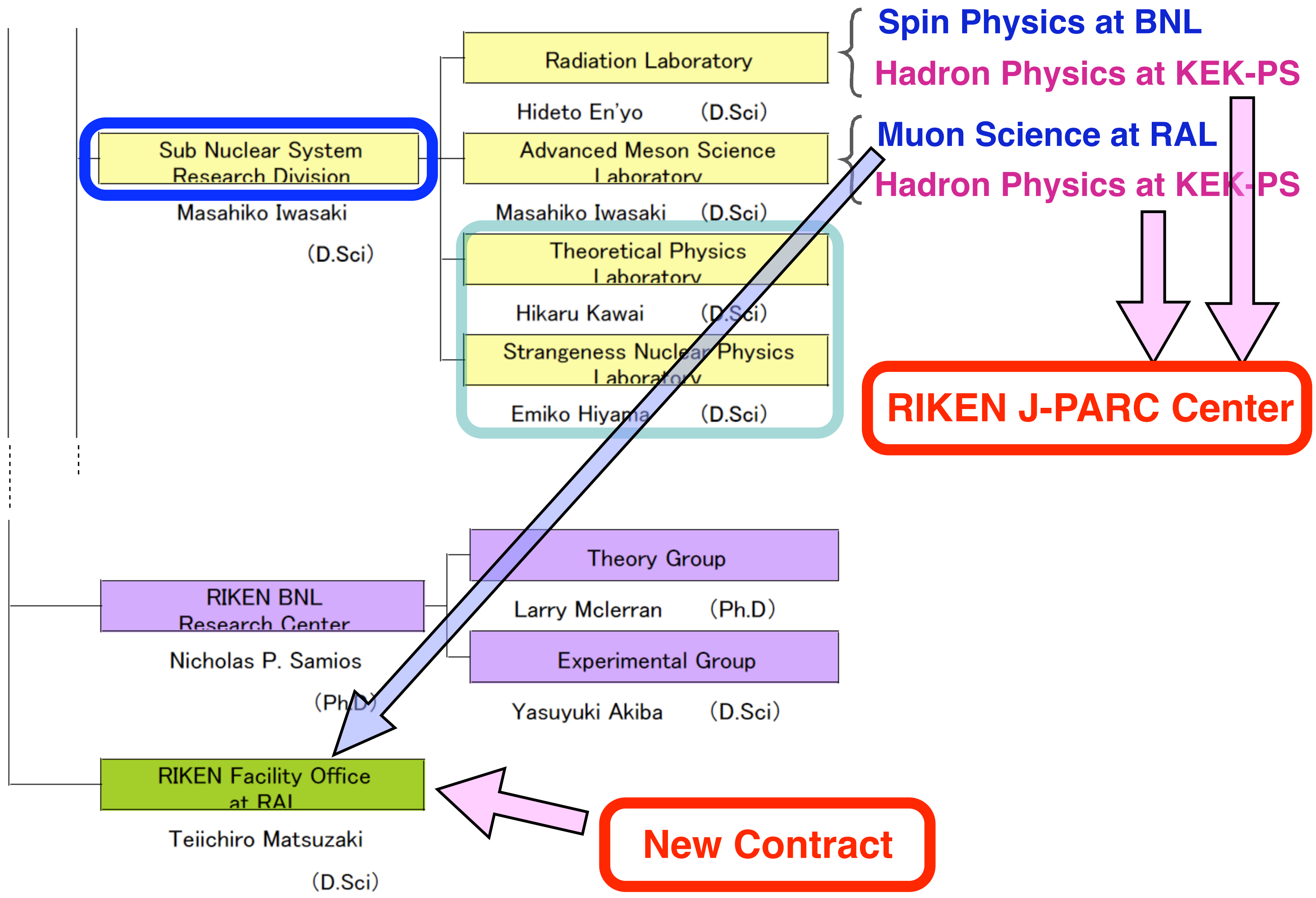


Sub-Nuclear System RD

Hadron Physics・Confinement

Origin of Hadron Mass

- 99. 95% of the Material Mass is from Nuclei
- Nuclei consist of proton and neutron
- quark mass is only 1% of proton and neutron

Where other 99% comes from？

Is Nanbu's Theory correct?

Major subject at J-PARC

Sub-Nuclear System RD

Particle Physics :
Standard Model

Precise muon g-2 measurement

— significant deviation from SM by 3.7σ

physics beyond the Standard Model?

Most crucial test

Even after LHC for Lepton sector

R & D only

Sub-Nuclear System RD

Particle Physics

New Muon Source development

New generation Slow μ・RIKEN-RAL

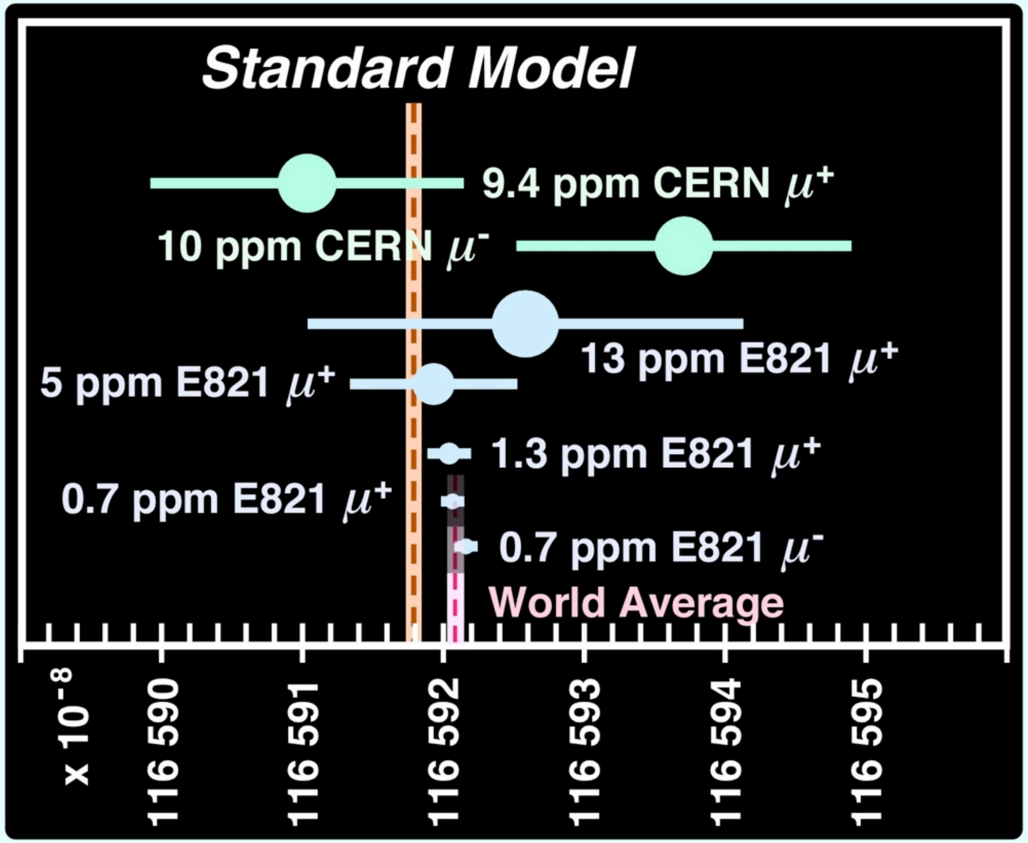
Ultra-low emittance muon beam
to realize g-2 : high dens. & low temp. & laser

Hadron Physics

Hadron experiment Platform

Large Scale Detector at J-PARC

CURRENT PRECISION



$$\Delta a_\mu(\text{EXP-SM}) \sim (37 \pm 10) \times 10^{-10}$$

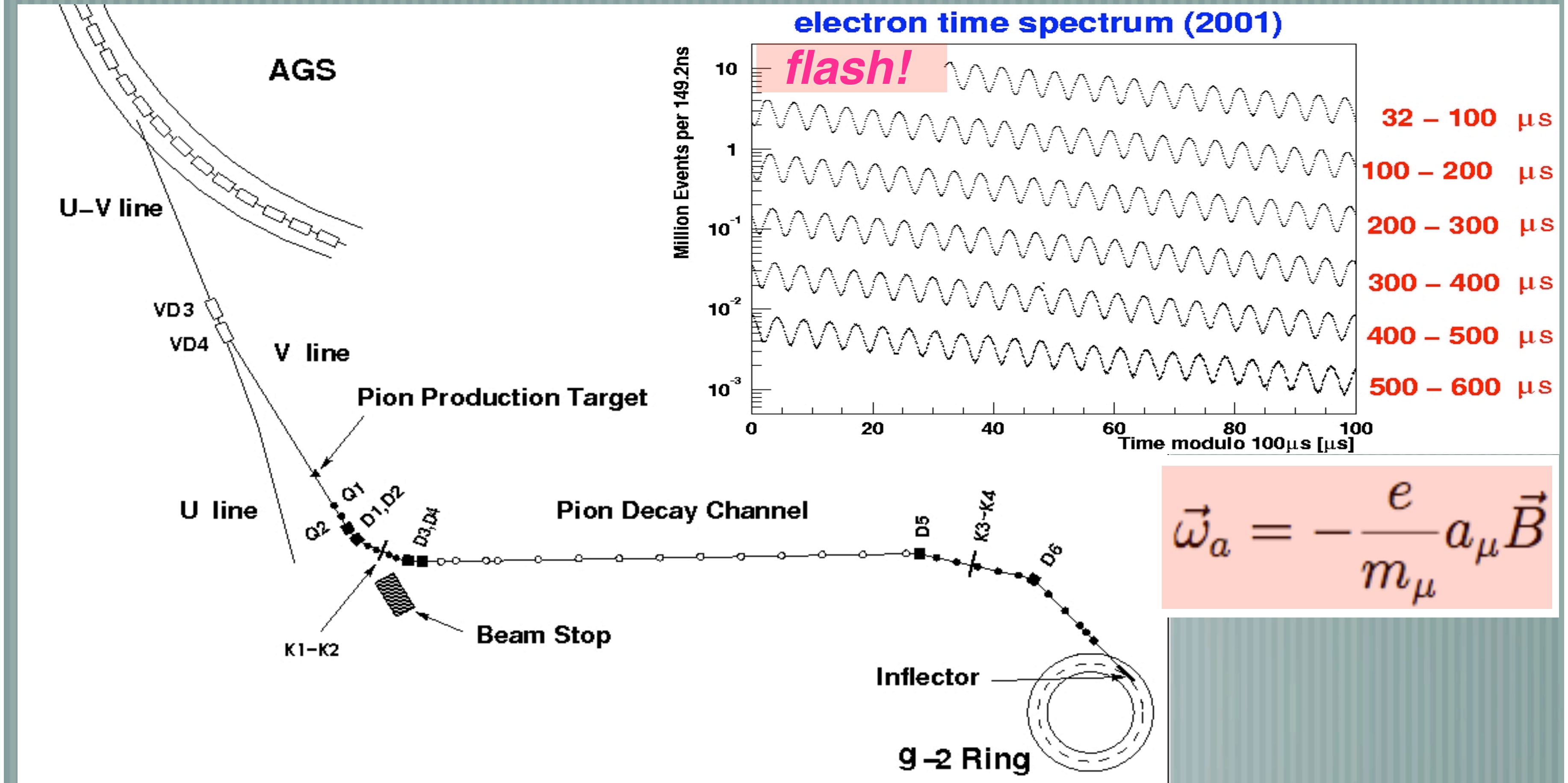
- E821 at BNL-AGS measured down to 0.7 ppm for both μ^+ and μ^-
- 3.7σ deviation from the SM
- ***Need to explore!***

BNL E821 EXPERIMENT

forward positron calorimeter

HOW WAS IT MEASURED?

- Precise frequency of muon ω_a in the storage ring was measured at ***the magic momentum***



$$\vec{\omega}_a = -\frac{e}{m_\mu} a_\mu \vec{B}$$

WHAT IS THE MAGIC MOMENTUM?

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

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0 @ 3 GeV/c

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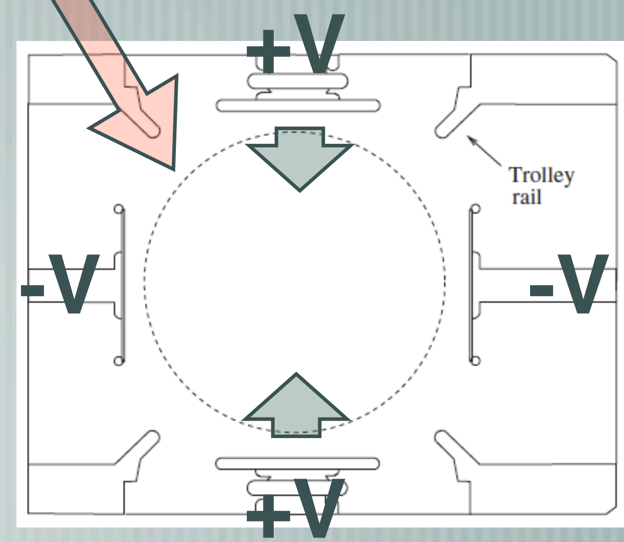
Electric field is the origin of CBO
Horizontal vibration!



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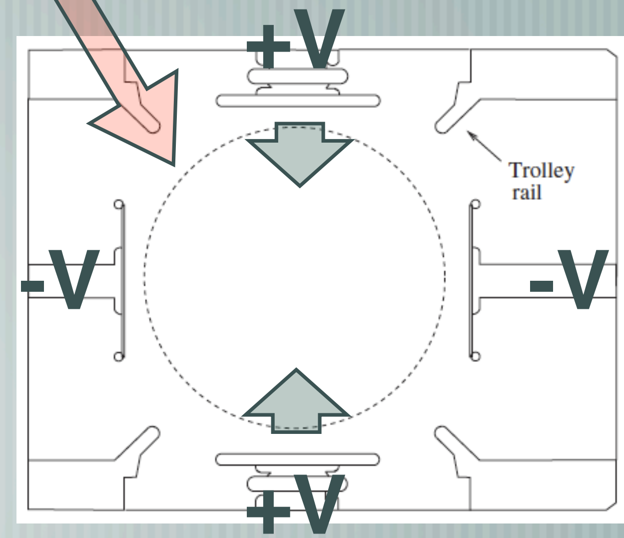
WHAT'S IF E=0?

No need for vertical focusing
if vertical divergence is extremely small!!



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$=$ 0 @ 3 GeV/c

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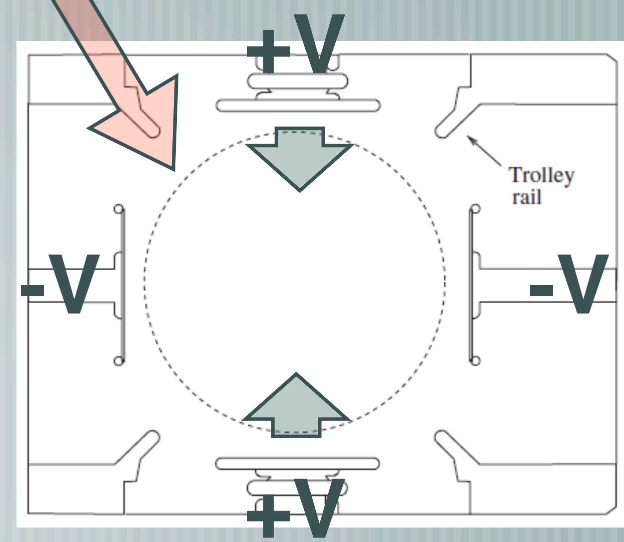
⇨ **Ultra-Slow Muon**

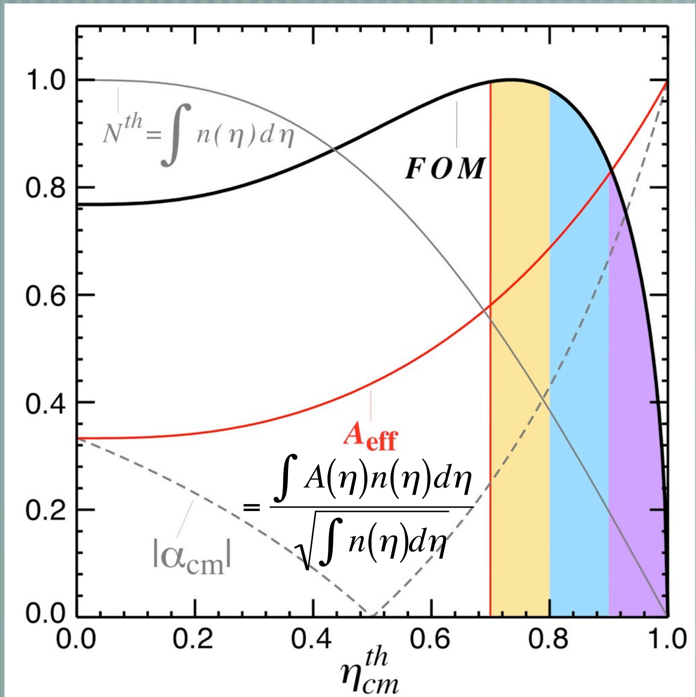


YIELD AND RE-ACCELERATION

$$\frac{\Delta a_\mu}{a_\mu} \approx 0.65 \frac{1}{A_{\text{eff}} \xi \gamma B\ [T]} \cdot \frac{1}{\sqrt{N_e}}$$

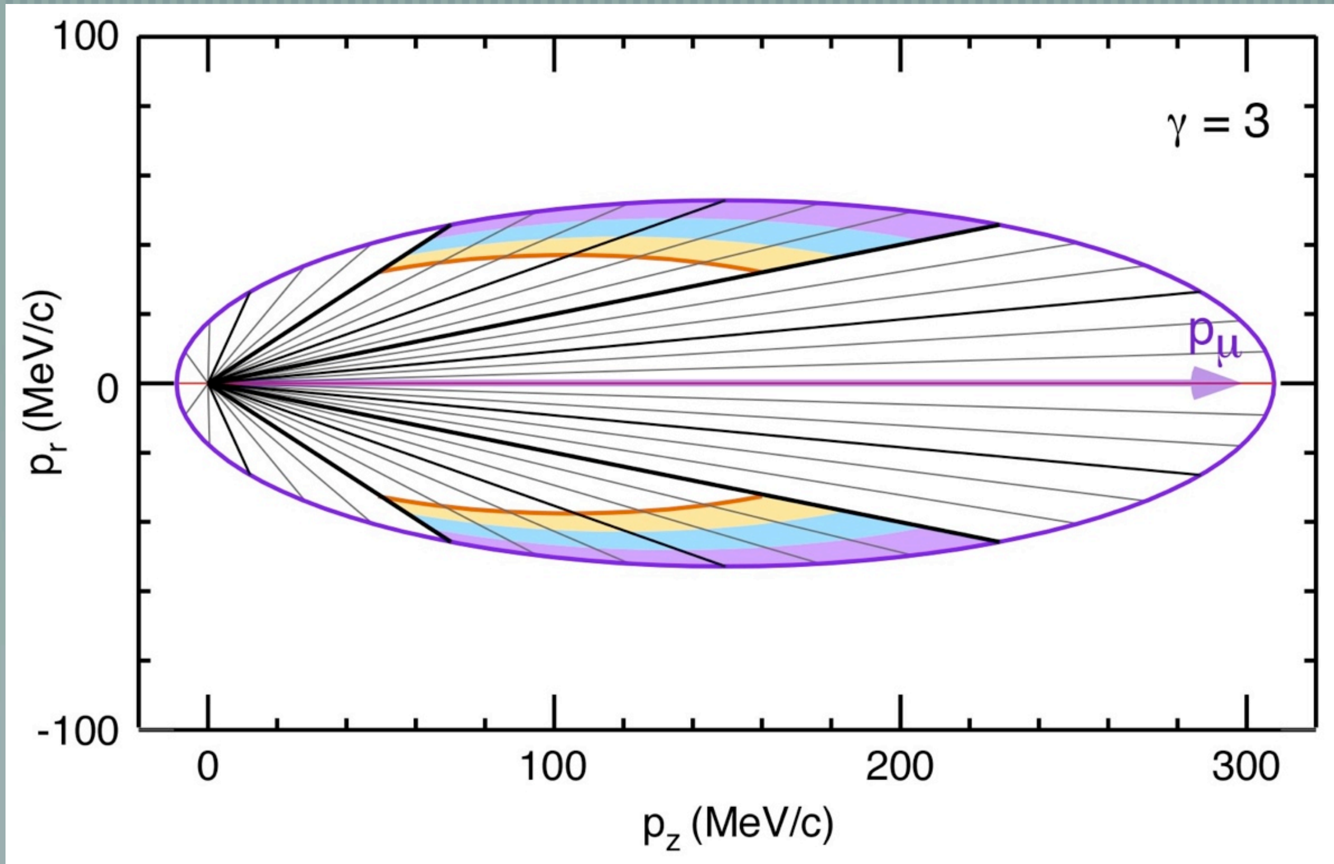
$$= \frac{\sqrt{2}}{\tau_\mu \left(\frac{e}{m_\mu}\right) a_\mu}$$

$$N_\mu \approx 4.2 \times 10^{11} \left(\frac{1}{x A_{\text{eff}} \xi \gamma B} \right)^2 \left(\frac{N^{th}}{N^{all}} \cdot \frac{\Delta\Omega}{\Omega} \right)^{-1}$$



T_n	γ	p_μ	B[T]	R[m]	ΔT_{cycle}	N_{life}	$N_{life}\gamma\tau_\mu$	$\Delta y'_{limit}$
			0.25	1.41	41.8 ns			
43.8 MeV	$\sqrt{2}$	106	0.5	0.70	20.9 ns	5	15.5 μs	15.2 μrad
			1.0	0.35	10.4 ns			
			1.0	0.61	14.7 ns			
106 MeV	2	183	1.5	0.41	9.8 ns	5	22.0 μs	8.8 μrad
			3.0	0.20	4.9 ns			
			1.0	1.00	22.2 ns			
211 MeV	3	299	1.5	0.66	14.8 ns	5	33.0 μs	5.4 μrad
			3.0	0.33	7.4 ns			
			1.0	1.36	29.5 ns			
317 MeV	4	409	1.5	0.91	19.7 ns	5	43.9 μs	3.9 μrad
			3.0	0.45	9.8 ns			

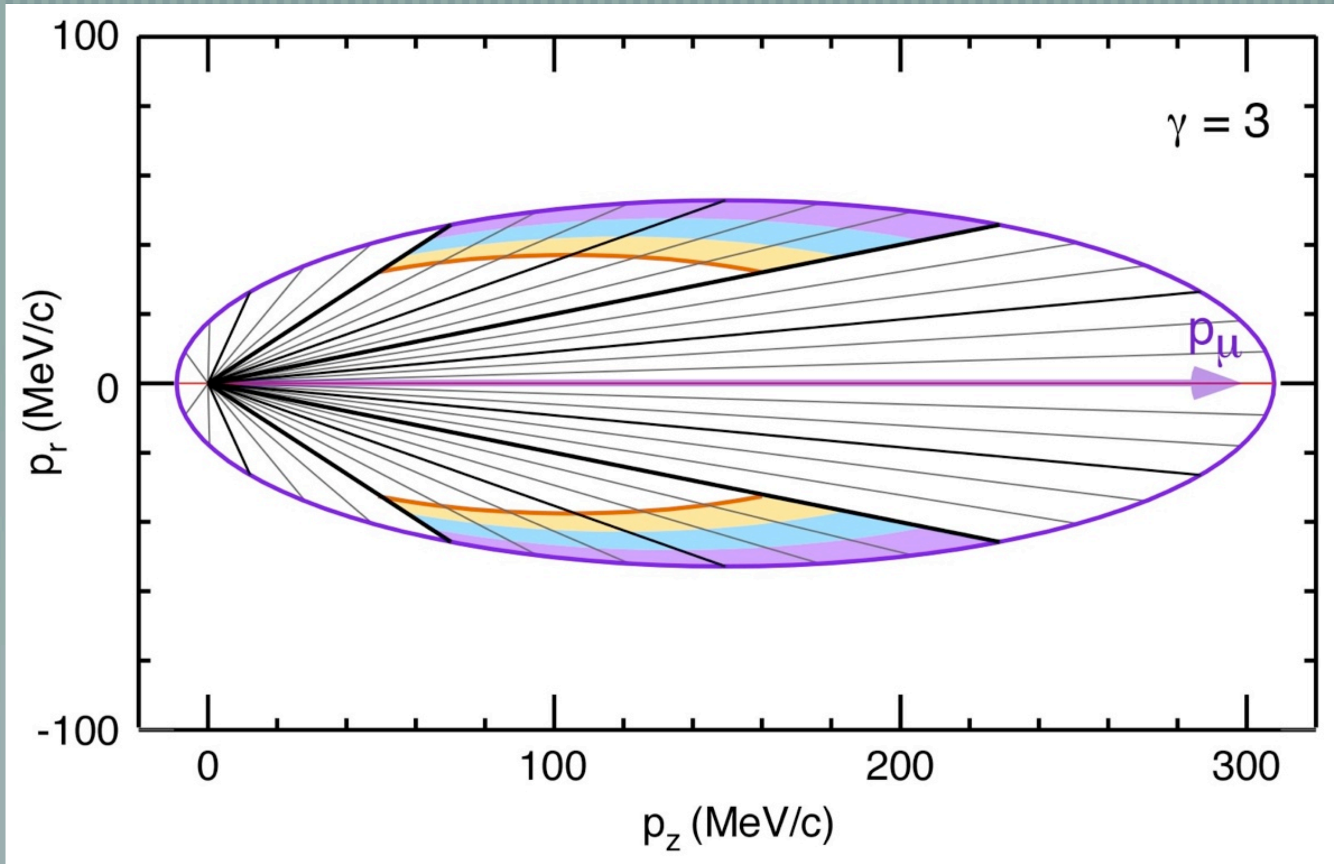
MUON G-2 MEASUREMENT



(~300MeV/c)

MUON G-2 MEASUREMENT

$$\frac{F - B}{F + B}$$



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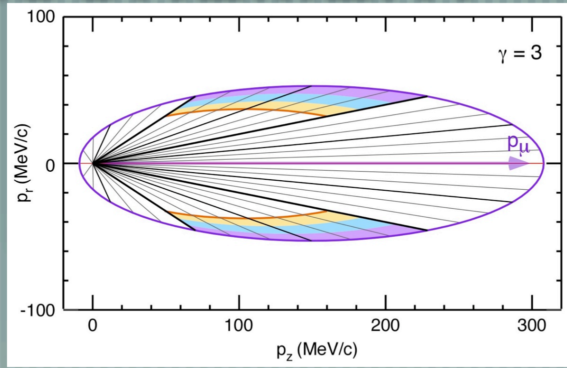
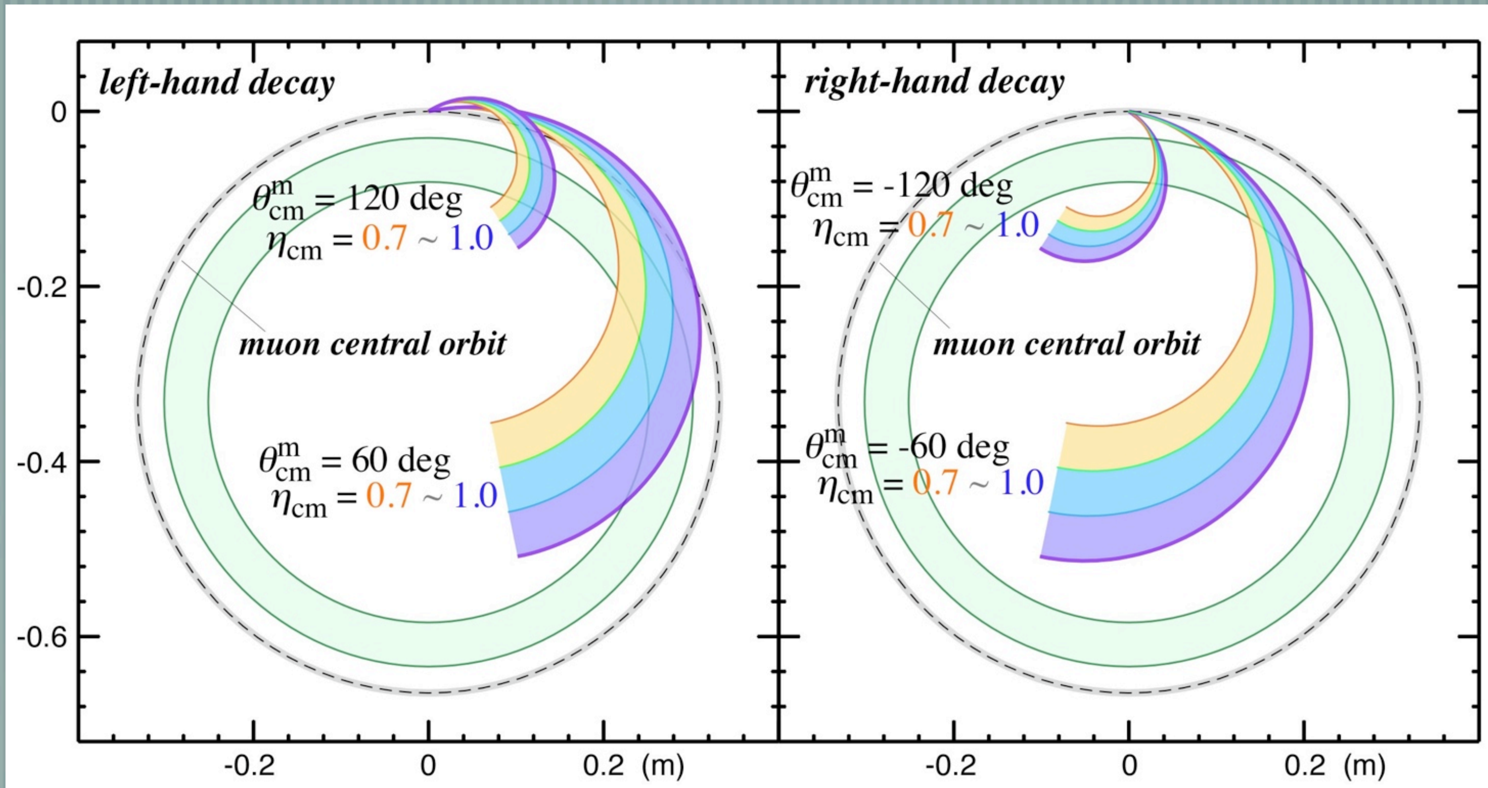


$$\frac{F - B}{F + B}$$

γ=3 @ 3T



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ADVANTAGE *How can we free from systematic error?*

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- **Momentum measurement with fine segmented detector**

  Free from pileup
- **Insensitive to gain drift**
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- **Small yield at present**

  Drastic improvements needed for Laser System
- **Need to reduce emittance even further**

  High density & low temperature muonium generation

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TO REALIZE g-2

- **Muon Yield**

x 10^4

x 10 : beam power

e.g. 1MW - 3GeV @ J-PARC

x 10 : solid angle

all solenoid beam channel

x 10^2 : laser power

- **Muonium Target**

< room temp.

better focus

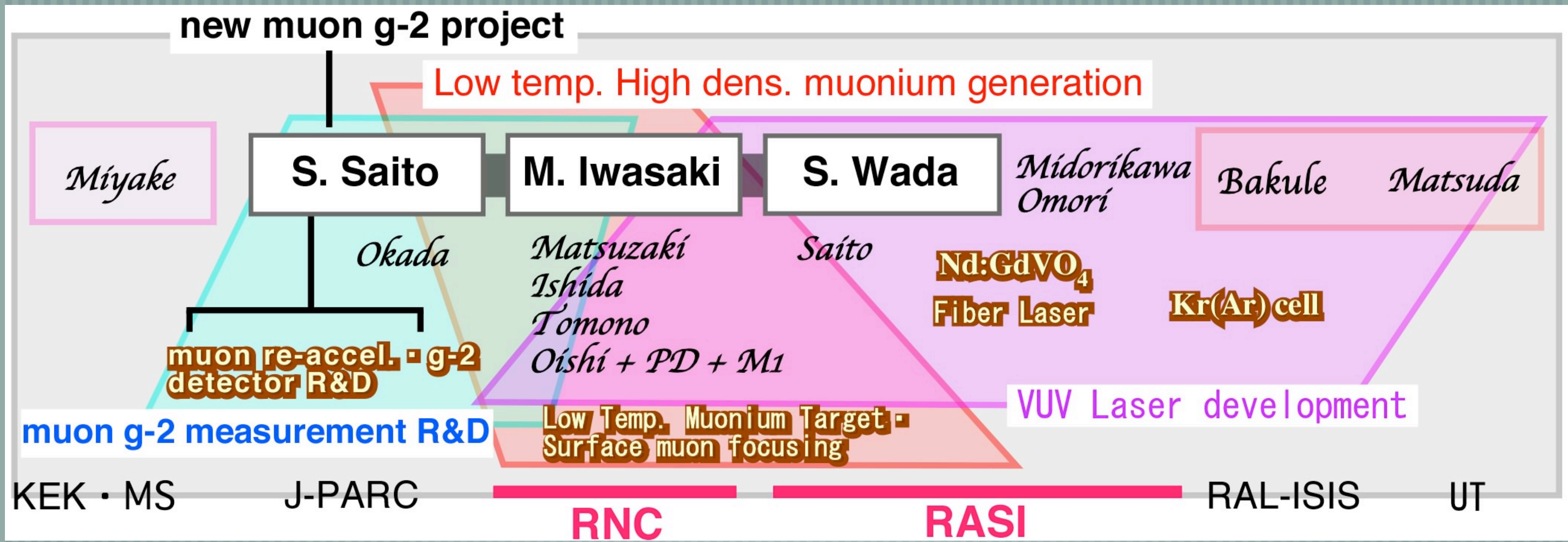
SiO_2 powder

Zeolite?

capillary focus?

$$\langle v_{s\text{.v.eff}} \rangle \approx c \cdot \langle \Delta\theta_{\text{v.eff}} \rangle \cdot \frac{\sqrt{2kT}}{\sqrt{3m_\mu c^2}}$$

NEW FRAMEWORK



TIME SCALE FOR NEW SLOW MUON GENERATION

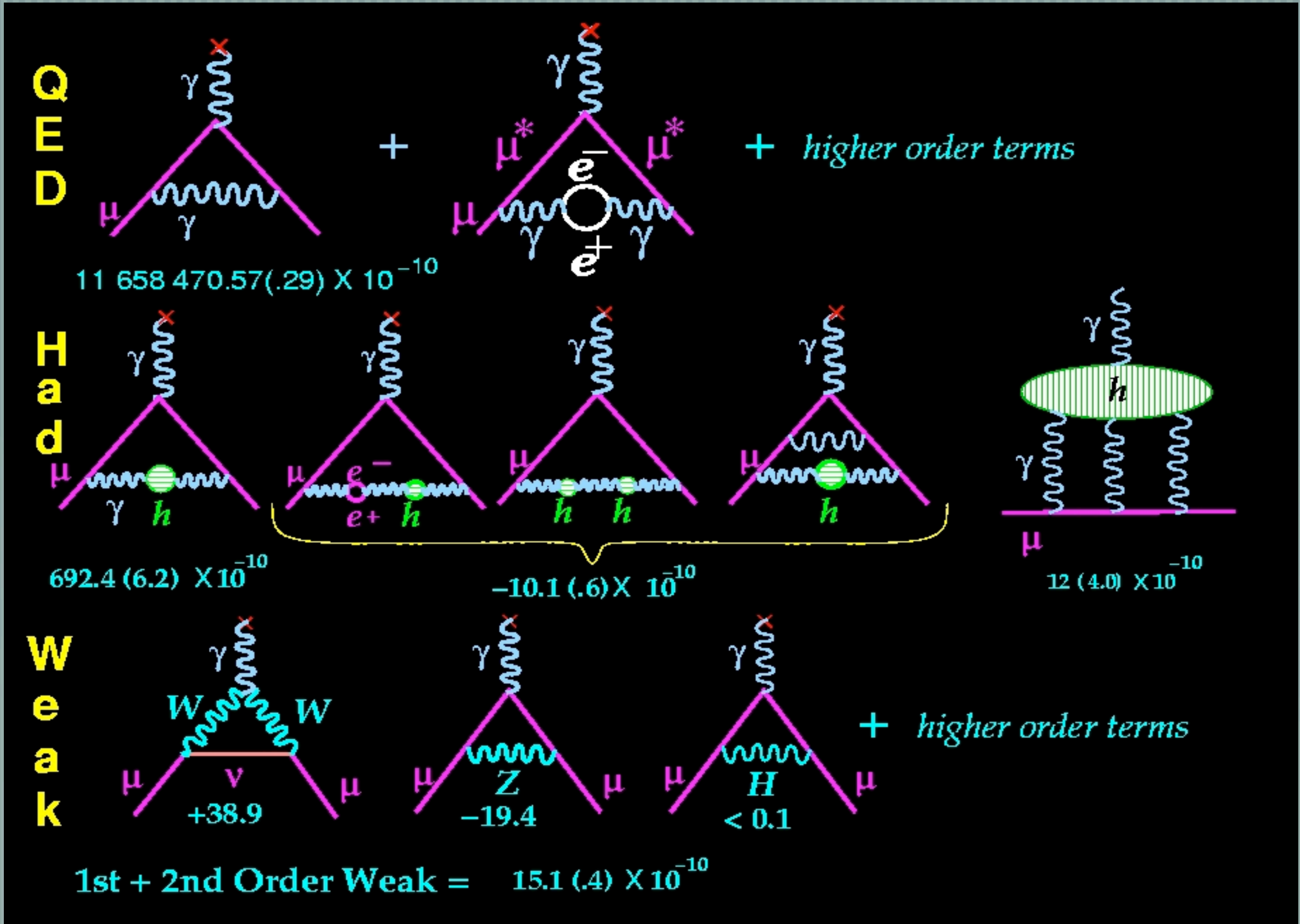
2~3 years

intensity x 100 or more / good emittance

IDEAL FOR μSR AT PULSE BEAM

Thank you

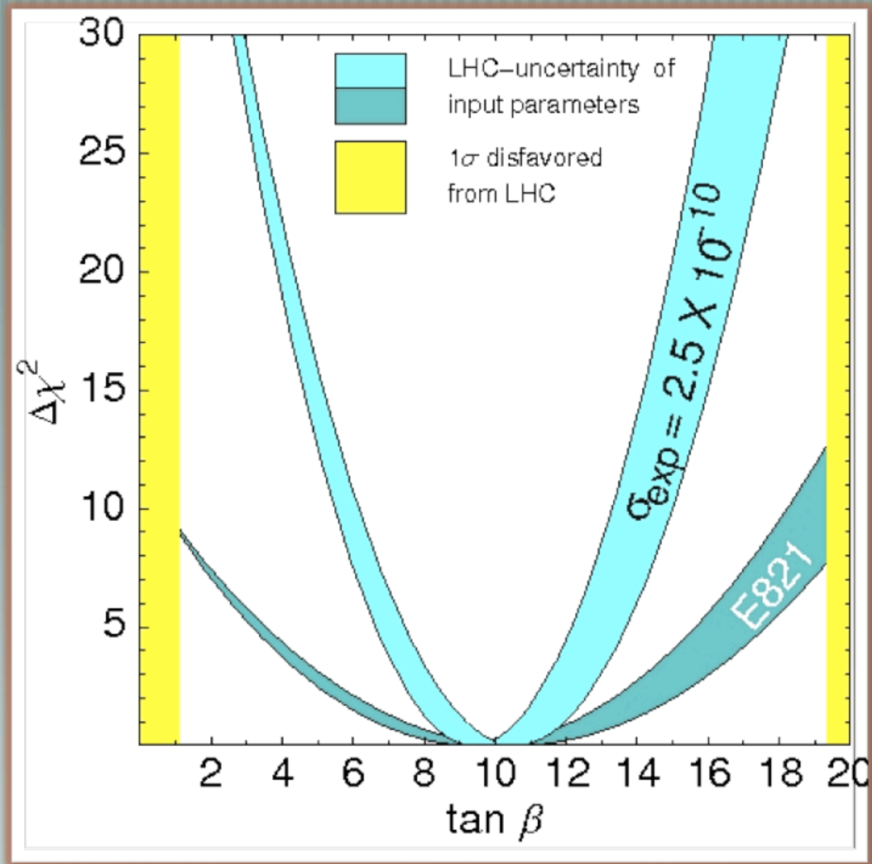
SM CONTRIBUTION TO $a \neq 0$



MUON G-2 IN THE LHC ERA

- Even the first SUSY discovery was made at LHC, the muon g-2 measurement remains unique to determine SUSY parameters:

  μ and $\tan\beta$



$$a_\mu(\mathrm{SUSY}) \approx (\mathrm{sgn}\,\mu) 13 \times 10^{-10} \tan\beta \left(\frac{100\ \mathrm{GeV}}{\tilde{m}}\right)^2$$