Development of gas and RF system for the MuSEUM experiment

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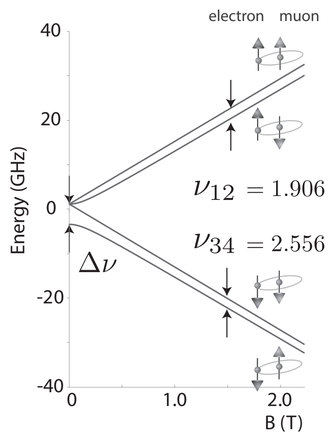
Background

measurement



Energy of muonium hyperfine splitting is obtained by sum of $\nu_{12} + \nu_{34}$.

Magnetic moment and mass of muon is calculated by ν_{12} and ν_{34} .

values

search for new particle

values

muonium HFS

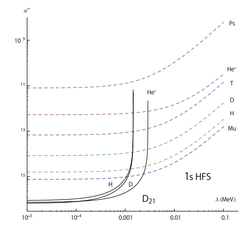
experimental	theory
ν_{HFS}(exp.) $= 4\,463.302\,765(53)$ MHz [12 ppb]	ν_{HFS}(theory.) $= 4\,463.302\,891(272)$ MHz [63 ppb]
W. Liu et al., PRL, 82, 711 (1999)	D. Nomura and T. Teubner, Nucl. Phys. B 867, 236 (2013)

magnetic moment $\frac{\mu_\mu}{\mu_p} = 3.183345107(84)$

mass $\frac{m_\mu}{m_e} = 206.7682823(52)$

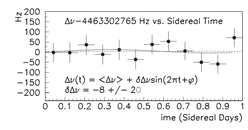
contributions

search for new particles
Suitable tool for new light particle search, inspired by proton radius puzzle (dark photon etc.).
PRL 104, 220406 (2010)



proton radius puzzle
Zemach radius can be obtained from muonium HFS.

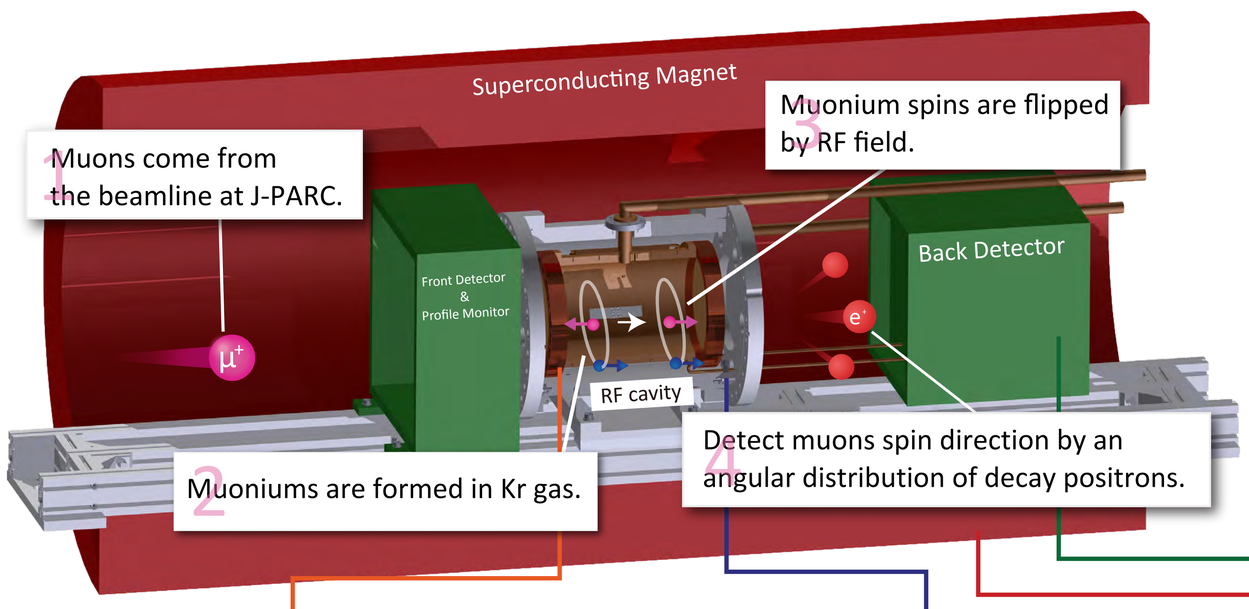
Test of CPT and Lorentz Invariance
Sidereal oscillation of transition frequency.
R. Bluhm, V. A. Kostelecký, and C. Da Lane, Phys. Rev. Lett. 84, 1098 (2000)
V.W. Hughes et al., Phys.Rev.Lett.87, 111804 (2001)



g-2 experiment
MuHFS is one-half of the experimental input

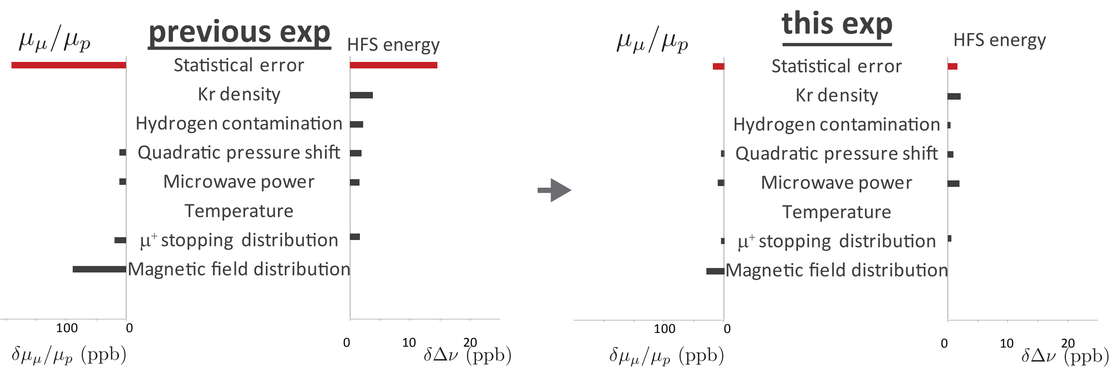
$$g - 2 = \frac{R}{\lambda - R}$$
$$\lambda \equiv \frac{\mu_\mu}{\mu_p}$$

High Field Measurement



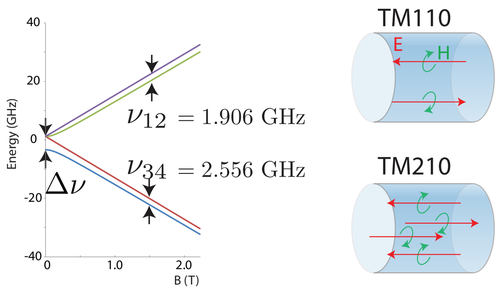
uncertainties

The total uncertainties were determined using the statistical uncertainties. We will achieve an accuracy more than 10 times greater than that of the latest experiment by using the H-line at J-PARC.



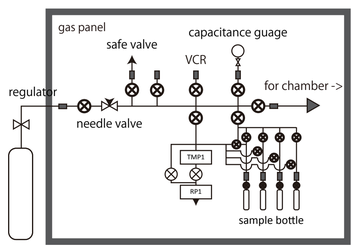
RF Cavity

Resonance frequencies are tuned for two transitions.



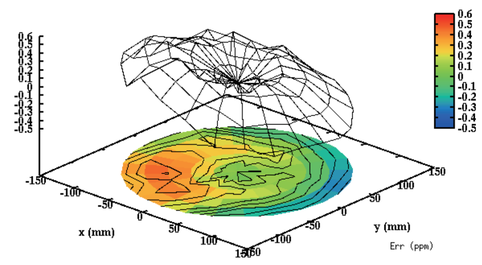
Gas System

pressure: 0.3 atm, 1.4 atm
stability of pressure: <0.02 %
purity: <ppm



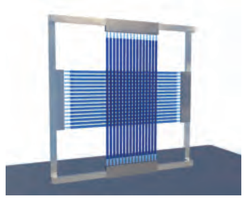
Magnet

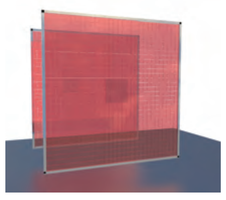
Homogeneity of B field was achieved at the 0.3 ppm level at shimming test by putting iron pieces.



Detector

Online beam profile monitor is cross-configured fiber hodoscope. Positron detector is composed of segmented scintillator+SiPM.

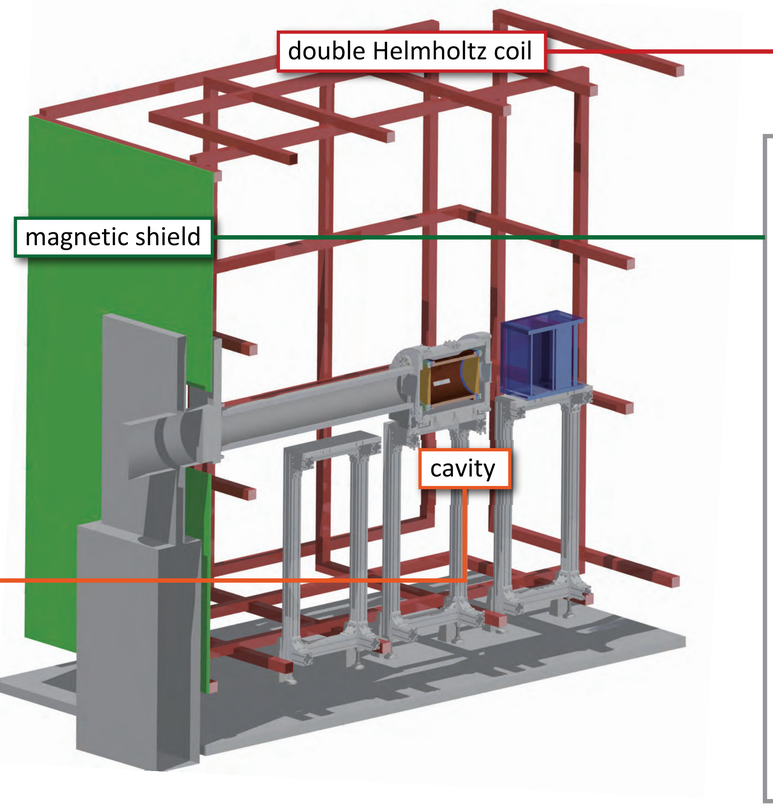

beam profile monitor


positron detector

Zero Field Measurement

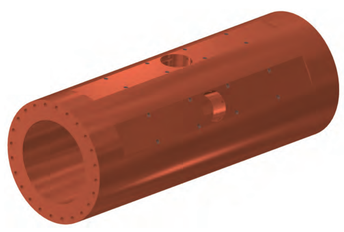
We are planning a measurement of munoium hyperfine splitting at zero field. Measurement at zero field has not measured since 1975 [1]. We can use same gas system and detectors (online beam profile monitor, positron detector) for high field experiment.

1 Physics Letters B, 59:397



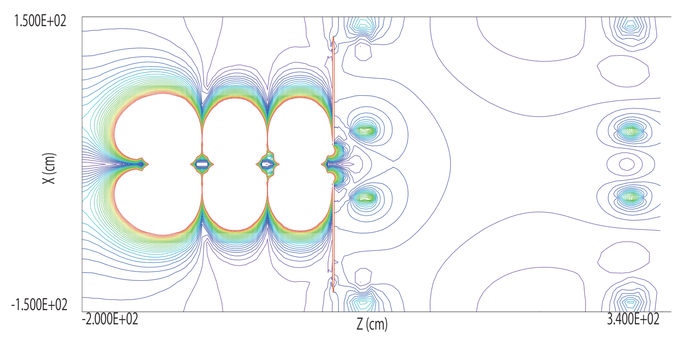
preparing for new cavity

The resonance frequency of the new cavity is 4.465 GHz corresponded to the transition frequency of muonium hyperfine at zero field.



preparing for zero field

For homogeneous (~mG) zero magnetic field, we are preparing the magnetic shield to suppress leakage field from beamline and double Helmholtz coil to correlate of the magnetic field.



Schedule

2012	2013	2014	2015	2016	2017
cavity test	detector test	TBPM test	shimming test	Zero Field exp	High Field exp