SPC: muon g-2 session

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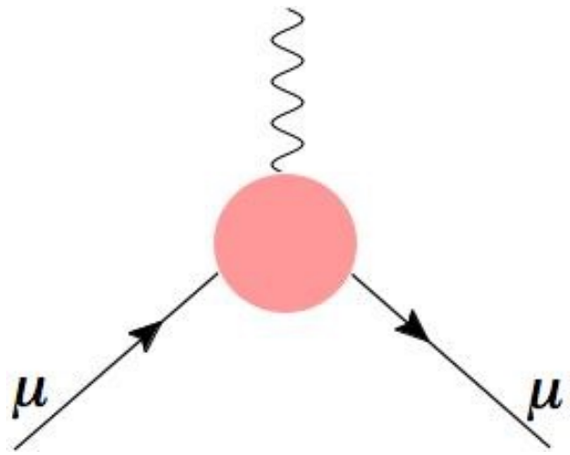
USQCD All Hands meeting, JLab, 28-29 April 2017

Introduction



$$= (-i\,e)\,\bar{u}(p')\left[\gamma^{\mu}F_1(q^2) + \frac{i\sigma^{\mu\nu}q_{\nu}}{2m}F_2(q^2)\right]u(p)$$

✦ muon anomalous magnetic moment: $a_\mu = F_2(0)$
receives contributions from QED, EW, and QCD corrections.

✦ QED + EW correction are known precisely:

$$a_\mu^{\rm QED} \times 10^{11} = 116584718.853 \pm 0.036$$
$$a_\mu^{\rm EW} \times 10^{11} = 153.6 \pm 1.0$$

✦ QCD corrections are the dominant source of error in the SM prediction:

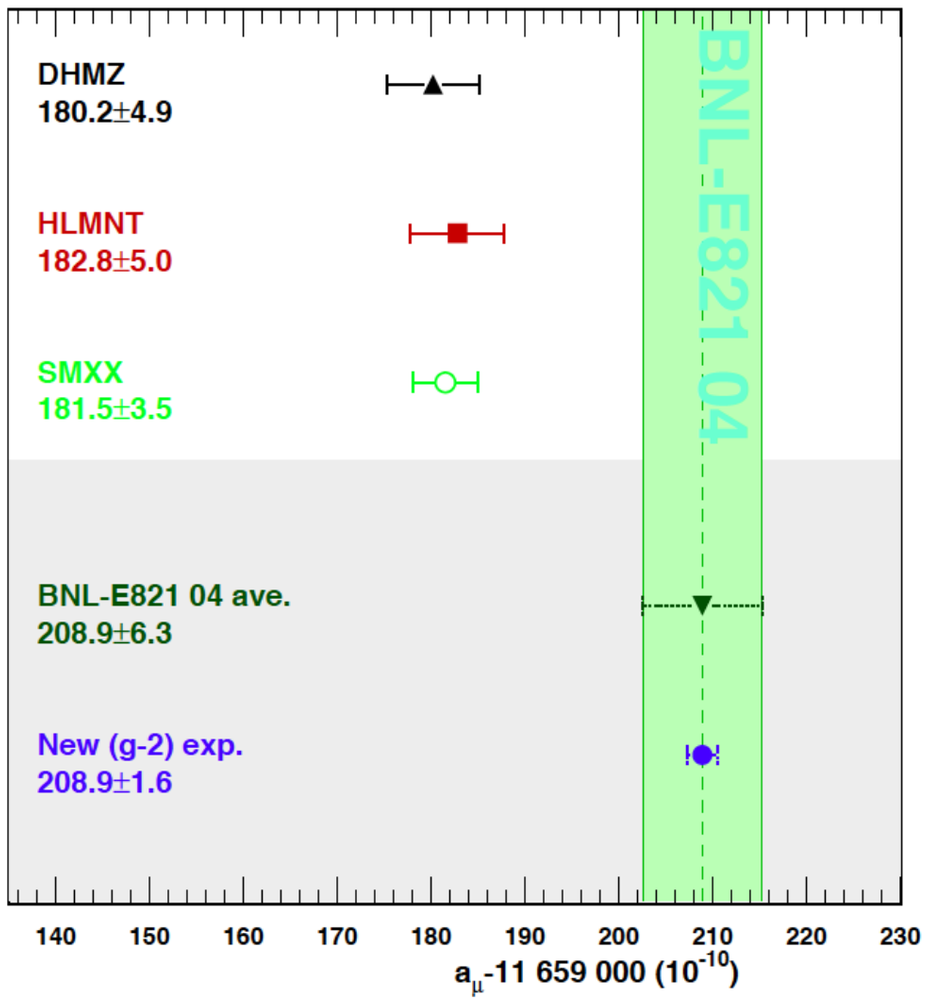
$$a_\mu^{\rm had} \times 10^{11} = 6945 \pm 49$$

(Davier et al. 2011, Hagiwara et al 2011, Kurz et al 2014, Prades et al 2009, Colangelo et al 2014, Jegerlehner 2015, Benayoun et al 2015,…)

Introduction

Experiment vs SM theory

T. Blum et al. (arXiv:1311.2198)



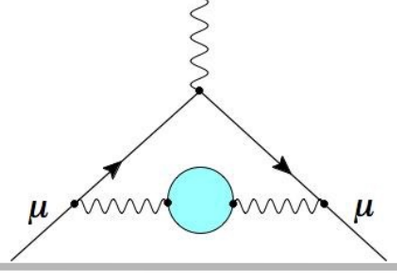
Fermilab g-2 experiment:

- ✦ reduce exp. error by a factor of 4
- ✦ first measurement with "Brookhaven level" uncertainty expected in 2018.
- ✦ Commissioning of beam has just started.

J-PARC experiment:

- ✦ complementary experiment
- ✦ expect measurement at 0.4 ppm level

Need to reduce and better control theory error for the hadronic corrections.

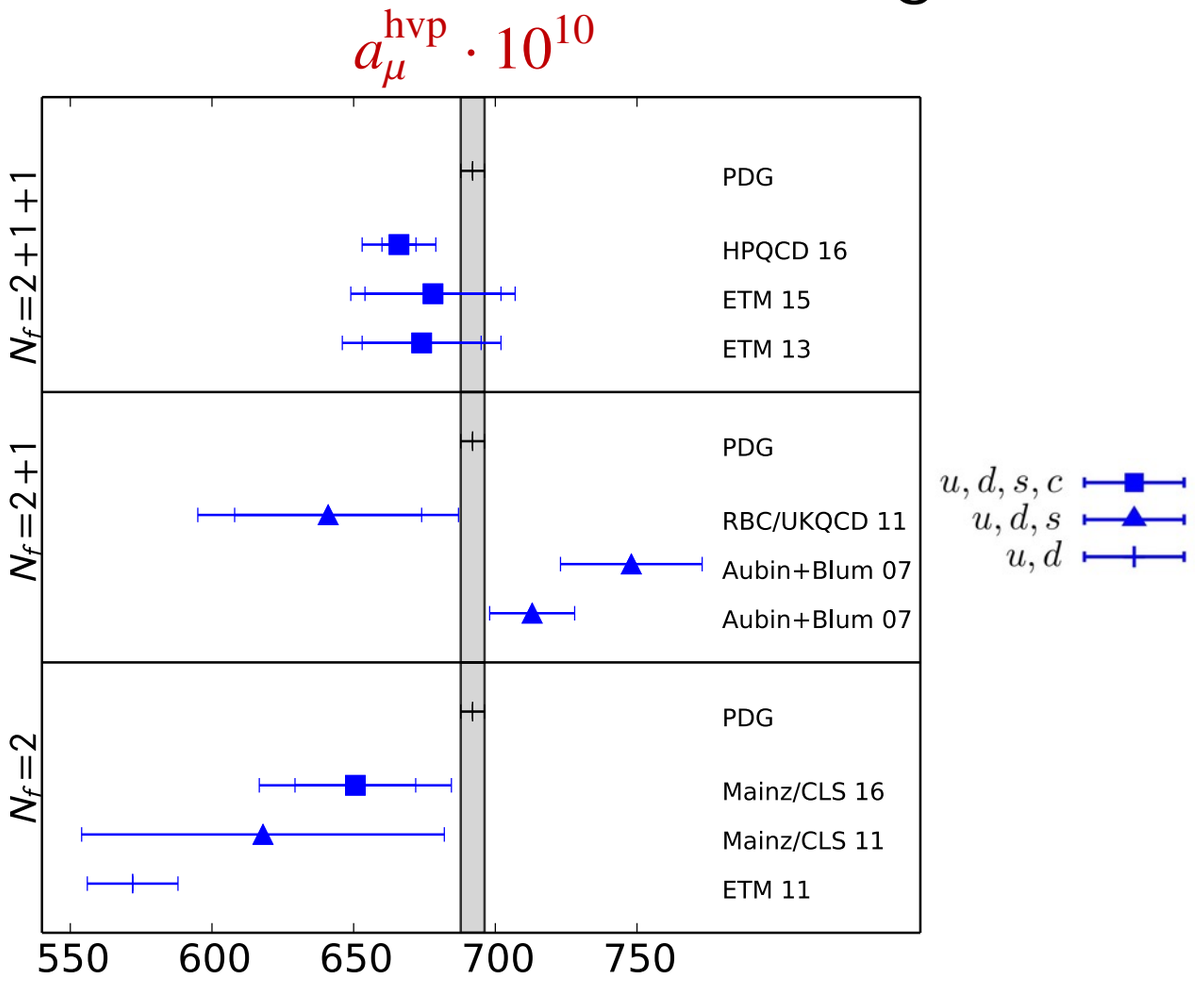


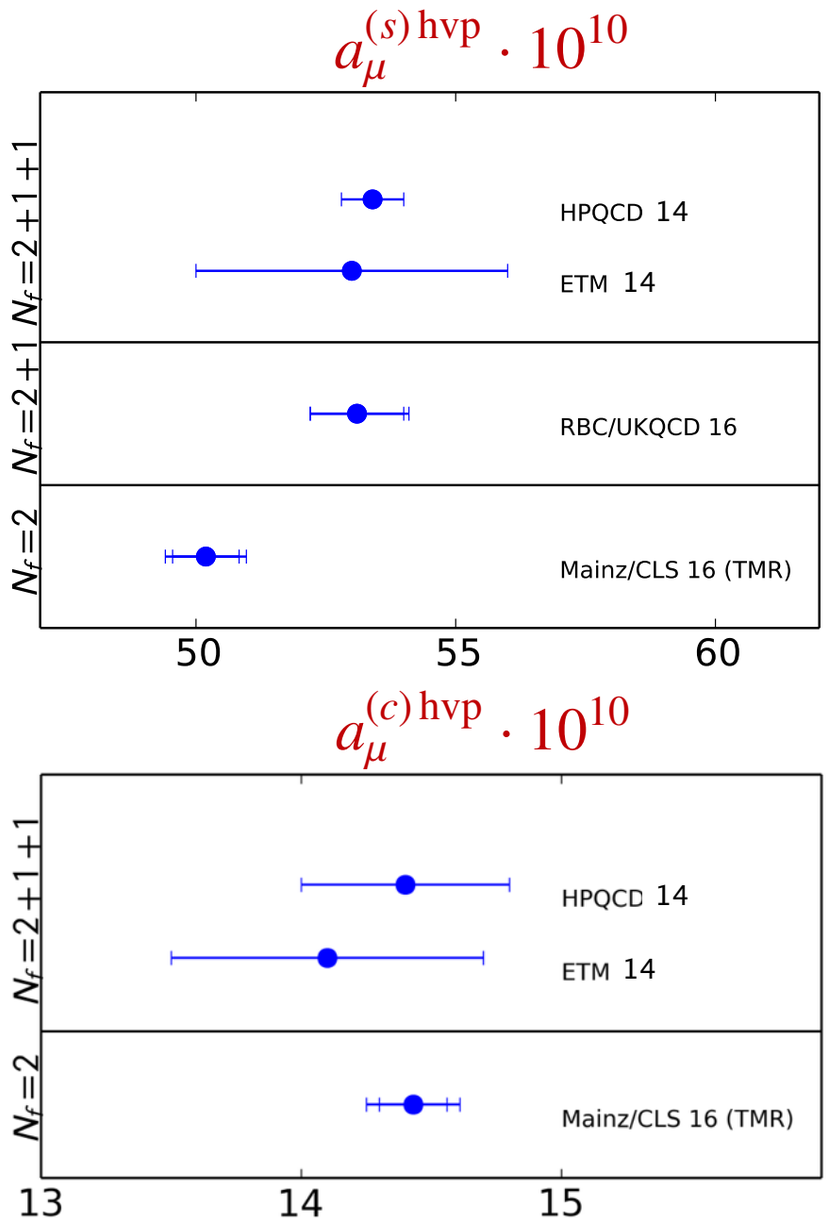
Hadronic vacuum polarization

- ✦ use dispersion relation + experimental data for $e^+e^- \to \text{hadrons}$
- ✦ current uncertainty ~0.6%
- ✦ can be improved with more precise experimental data
- ✦ new experimental measurements expected/ongoing at BES-III, VEPP-2000, Belle/Belle-II, ….
- ✦ lattice QCD:
  for (sub)percent precision, calculations of HVP correction need to include
  - physical mass ensembles
  - disconnected contributions
  - QED and strong isospin breaking corrections
  - Finite volume corrections
- ✦ Hybrid method: combine LQCD with experimental data to reduce errors
  (Lehner @ Lattice 2016)

HVP summary

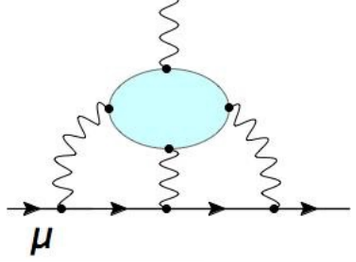
H. Wittig review @ Lattice 2016





* Individual flavour contributions:

light (u,d)	≈ 90%
strange (s)	≈ 8%
charm (c)	≈ 2%



Hadronic Light-by-light

Hadronic light-by-light:

- ✦ current estimate "Glasgow consensus" based on different QCD models
- ✦ theory error not well known
- ✦ dispersion relations: more complicated than for HVP
  (Colangelo et al, arXiv:1702.07347)
  combine with exp. data and/or LQCD calculations

Direct lattice QCD calculations:

- ✦ QCD + stochastic QED
  (Jin et al, arXiv:1610.04603, 2016 PRL)
- ✦ QCD + exact QED kernel
  (Asmussen@ Lattice 2016; Green et al, arXiv:PRL 2015)
- ✦ dominant exclusive contributions (transition form factors)
  (Gerardin et al, arXiv:1607.08174, 2016 PRD, Lattice 2016)

USQCD g-2 proposals overview

- RBC/UKQCD:
  - HVP QED corrections
  - 34.5 M Jpsi; storage: 76 TB disk
- Aubin, Blum, Golterman, Peris:
  - LO HVP, focus on FV corrections
  - 63 M Jpsi CPU; storage: 96 TB disk + 96 TB tape
- FNAL/MILC/HPQCD:
  - HVP connected + disconnected, QED + IB corrections
  - 18 M Jpsi CPU; 421K GPU (BNL); 15% Mira ZPT, storage: 34 TB tape

First Workshop of the Muon g-2 Theory Initiative

3-6 June 2017
US/Central timezone

Search

In the coming years, experiments at Fermilab and at J-PARC plan to reduce the uncertainties on the already very precisely measured anomalous magnetic moment of the muon by a factor of four. The goal is to resolve the current tantalizing tension between theory and experiment of three to four standard deviations. On the theory side the hadronic corrections to the anomalous magnetic moment are the dominant sources of uncertainty. They must be determined with better precision in order to unambiguously discover whether or not new physics effects contribute to this quantity.

There are a number of complementary theoretical efforts underway to better understand and quantify the hadronic corrections, including dispersive methods, lattice QCD, effective field theories, and QCD models. We have formed a new theory initiative to facilitate interactions between the different groups through organizing a series of workshops. The goal of this first workshop is to bring together theorists from the different communities to discuss, assess, and compare the status of the various efforts, and to map out strategies for obtaining the best theoretical predictions for these hadronic corrections in advance of the experimental results.

All sessions in this workshop will be plenary, featuring a mix of talks and discussions.

Dates: from June 3, 2017 08:00 to June 6, 2017 18:00
Timezone: US/Central
Chairs: Dr. Van de Water, Ruth
Dr. Lehner, Christoph
Prof. Roberts, Bradley Lee
Prof. El-Khadra, Aida
Dr. Izubuchi, Taku

https://indico.fnal.gov/conferenceDisplay.py?confId=13795