

The muon anomalous magnetic moment and the search for new physics in the LHC era

Progress report

Laurent Lellouch for the collaboration

Starts Jan. 2015

Continuation of 2014 meeting project w/ same name

CPT Marseille
CNRS & Aix-Marseille U.



Context:

- today the experimental measurement and Standard Model prediction for $a_\mu \equiv (g_\mu - 2)$ disagree by more than 3σ with nearly matched errors
 - one of the largest particle physics indications of new fundamental physics
- \gtrsim 2017 new experiments at Fermilab and J-PARC plan to divide errors by 4
 - large discovery potential if theory precision follows

Main objectives:

- reduce uncertainties on the Standard Model prediction for a_μ to leverage experiment
 - in particular those coming from the hadronic vacuum polarization (HVP) and the hadronic light-by-light scattering (HLbyL) which dominate theory error
- design and explore New Physics models which may explain present and future a_μ measurements while accounting for present and future LHC constraints and discoveries
 - including full upgrade of community codes SuSpect and NMSSMTools

Methods and milestones:

- coordinate expertise of:
 - CPT in nonperturbative QCD (ab-initio and effective field theories) and Standard Model phenomenology (in particular a_μ and higher-loop calculations)
 - L2C in Renormalization group optimized perturbation theory (RGOPT), BSM phenomenology and SuSpect
 - LUPM in QCD sumrules, NMSSM phenomenology, and NSSMTools
- apply RGOPT and ab-initio lattice QCD calculations to HVP contribution to a_μ
 - calibration of methods against precise phenomenological determination
 - test of phenomenological determination
- combine techniques and insights from phenomenology, QCD sumrules, RGOPT and lattice QCD to calculate HLbyL contribution to a_μ
 - determine this contribution with fully reliable error bars for the first time
- study BSM models consistent with present and possible future deviations of Standard Model and experimental measurement of a_μ
 - initially non-universal SUSY models with large higher-loop contributions to a_μ
- update SuSpect and NMSSMTools and study complementarity with direct New Physics searches at LHC

People:

- **CPT:** M. Knecht (coord. \geq 2015) L Lellouch (coord. 2014), E de Rafael, R Malak (PhD Aix-Marseille U & Saclay, since Oct. 2012)
- **L2C:** JL Kneur, G Moulta
- **LUPM:** C Hugonie, S Narison
- OCEVU postdoc with initial focus on HLbyL and later on BSM aspects (localization Montpellier and/or Marseille)

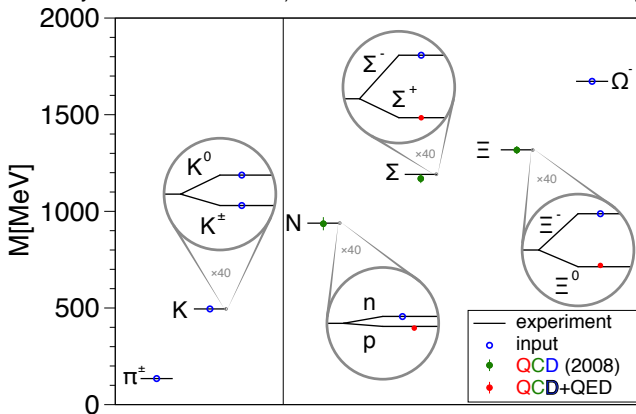
OCEVU funding:

- 1 PD expected from Oct. 2015 to Sept. 2018
- 4 k€ in 2014 for internal meetings and conference attendance
- ?? k€/year \geq 2015 for internal meetings and conference attendance

Ab-initio calculation of the n - p mass difference

Borsanyi, . . . , Lellouch et al, arXiv:1406.4088

Important in itself but also important validation of the entirely new generation of lattice QCD calculations (which fully include QED effects) and will be used for an ab-initio HLbyL calculation



(Comparison to some of our *Science* 322 (2008) light hadron mass determinations)

Publications:

- E. de Rafael, “Moment Analysis of Hadronic Vacuum Polarization - Proposal for a lattice QCD evaluation of $g_{\mu} - 2$,” arXiv:1406.4671 [hep-lat].
- S. Borsanyi, S. Durr, Z. Fodor, C. Hoelbling, S. D. Katz, S. Krieg, L. Lellouch and T. Lippert *et al.*, “Ab initio calculation of the neutron-proton mass difference,” arXiv:1406.4088 [hep-lat].
- E. B. Gregory, Z. Fodor, C. Hoelbling, S. Krieg, L. Lellouch, R. Malak, C. McNeile and K. Szabo, “Leading-order hadronic contributions to $g_{\mu} - 2$,” in proceedings of Lattice 2013, arXiv:1311.4446 [hep-lat].
- R. Malak for the Budapest-Marseille-Wuppertal collaboration, “Leading-order hadronic contribution to $g_{\mu} - 2$ from $N_f = 2 + 1$ simulations down to the physical pion mass,” talk at 32nd International Symposium on Lattice Field Theory” (Lattice 2014), June 23-28, 2014, Columbia University, USA, in preparation for the proceedings.
- M. Knecht, “The muon anomalous magnetic moment,” talk at “International conference on quantum chromodynamics” (QCD 2014), 30 June - 4 July, Montpellier, to appear in proceedings.
- J.L. Kneur, “Renormalization group optimized perturbation: α_s from f_{π} ,” talk at “International conference on quantum chromodynamics” (QCD 2014), 30 June - 4 July, Montpellier, to appear in proceedings.

Events and conference contributions:

- 2 collaboration meetings . . .
- . . . and additional exchanges in context of other meetings
- (Invited) talks at conferences, including: “Hadronic contributions to the muon $g-2$ ” (MK, LL, Mainz, 2014), “QCD 2014” (MK, JLK, Montpellier 2014), “Lattice 2014” (RM, New York)