The lightest pseudoscalar (π^0, η, η') exchange contribution to the light-by-light scattering piece of the muon g-2

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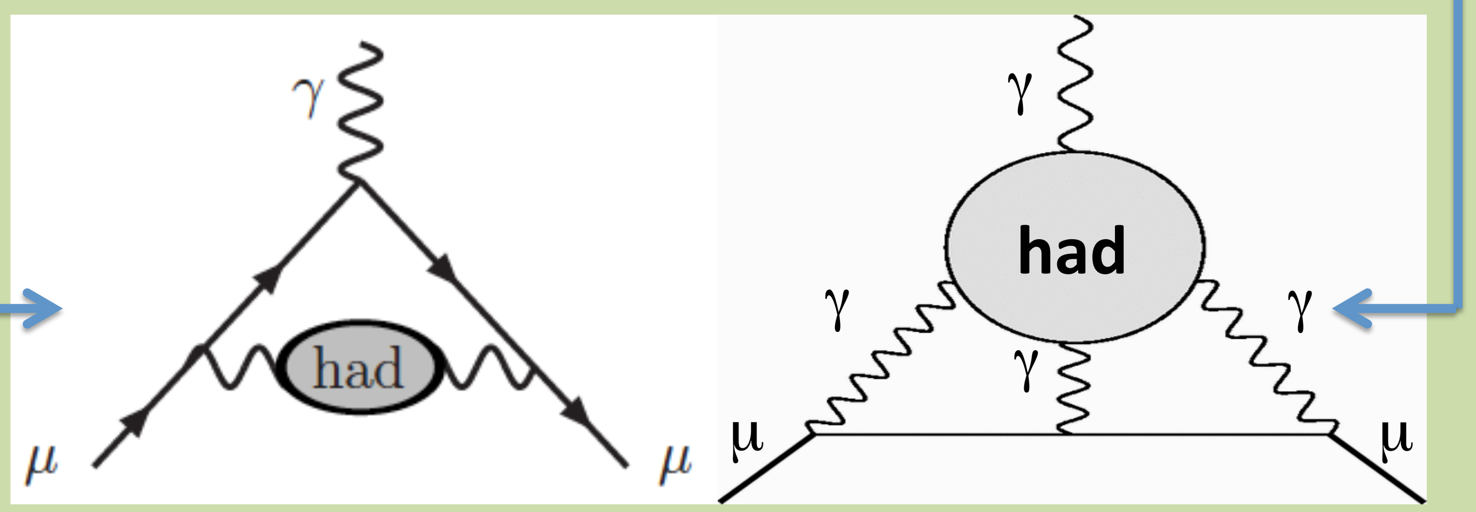
PROBLEM:

The anomalous magnetic dipole moment of the muon, $\mathbf{a_\mu=(g_\mu-2)/2}$, is one of the most precisely measured[1] and theoretically predicted observables.[2] Since 2000 there is a persistent discrepancy between both at the **3 σ** level, which must be understood.

$$a_\mu^{\rm exp} - a_\mu^{\rm th} = (293 \pm 88) \times 10^{-11} \qquad (3.3\sigma)$$ [2]

DIFFERENT CONTRIBUTIONS TO $a_\mu \times 10^{11}$: [2]

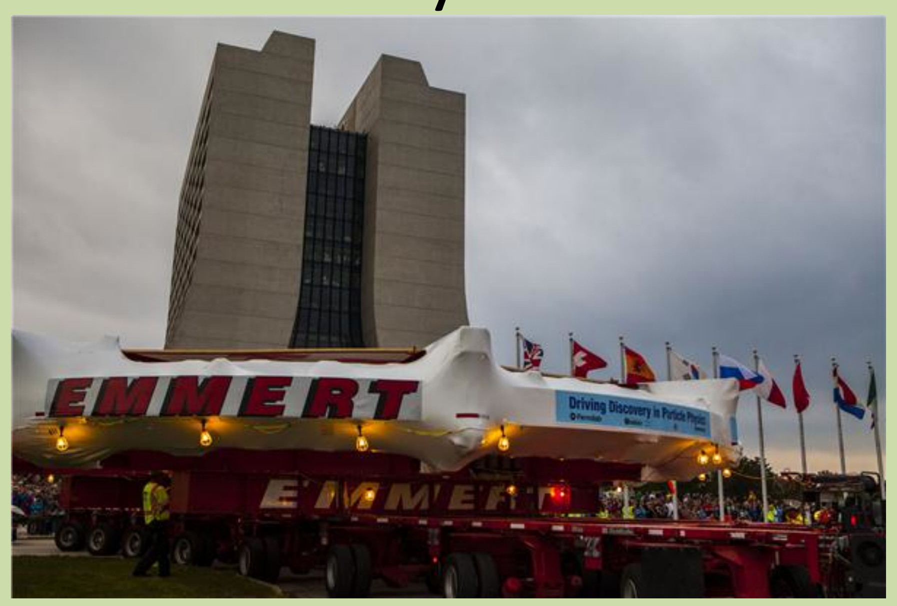
Contribution	Value	Error
QED	116 584 718.853	0.036
Weak	153.6	1.0
Leading order HVP	6 907.5	47.2
Higher order HVP	-100.3	2.2
HLbL	116	40
Theory (total)	116 591 796	62
Experiment	116 592 089	63
Experiment - Theory (3.3σ)	293	88



Leading order Hadronic Vacuum Polarization (**HVP**) Contribution.

Hadronic Light-by-Light (**HLbL**) scattering Contribution.

Uncertainty is saturated by hadronic contributions.



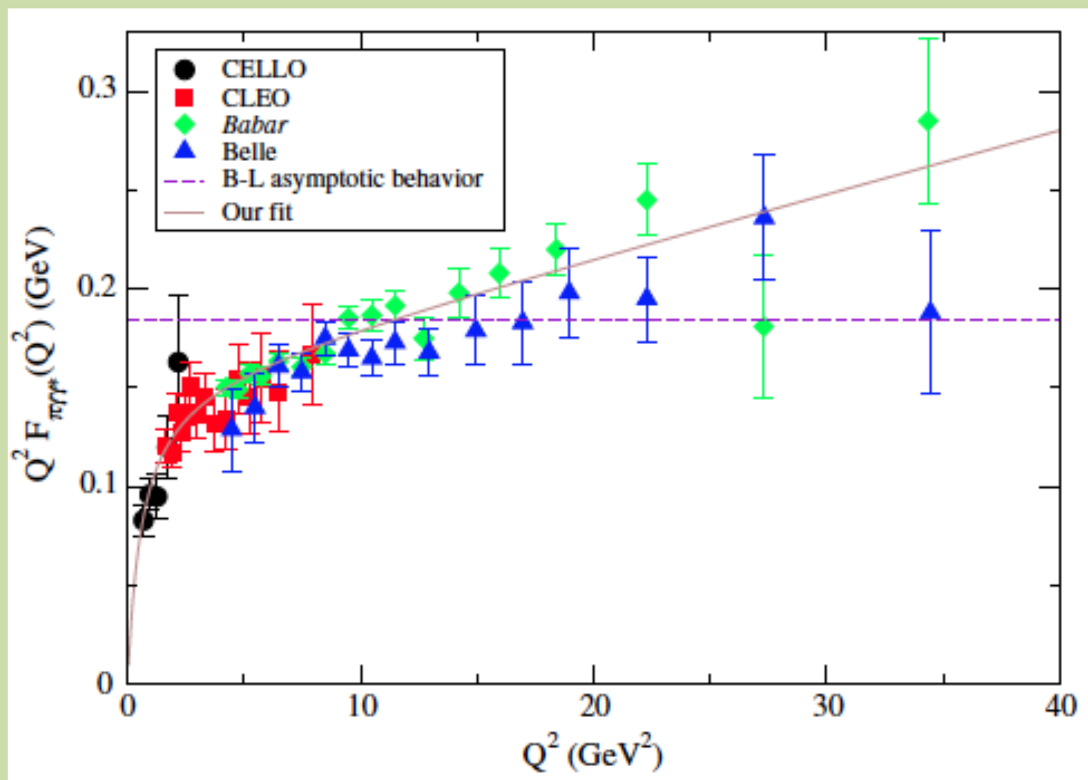
(Credit: Fermilab)

New experiments at **FNAL and J-PARC** will reduce the experimental uncertainty by a factor of 4 by **2017**.
Theory should catch up!

OUR WORK:

We have reconsidered the contribution of **π^0, η, η' exchange to** the **HLbL** piece of a_μ. This has been done in a **chiral Lagrangian** formalism including **resonances** as explicit degrees of freedom.[3] A satisfactory description of the **pseudoscalar transition form factors** (pTFF) is achieved by requiring the **QCD short-distance behaviour** to the **VVP** Green function.[4] Best agreement with data is found allowing for a tiny violation (below 5%) of one of the high-energy relations (involving P_2).

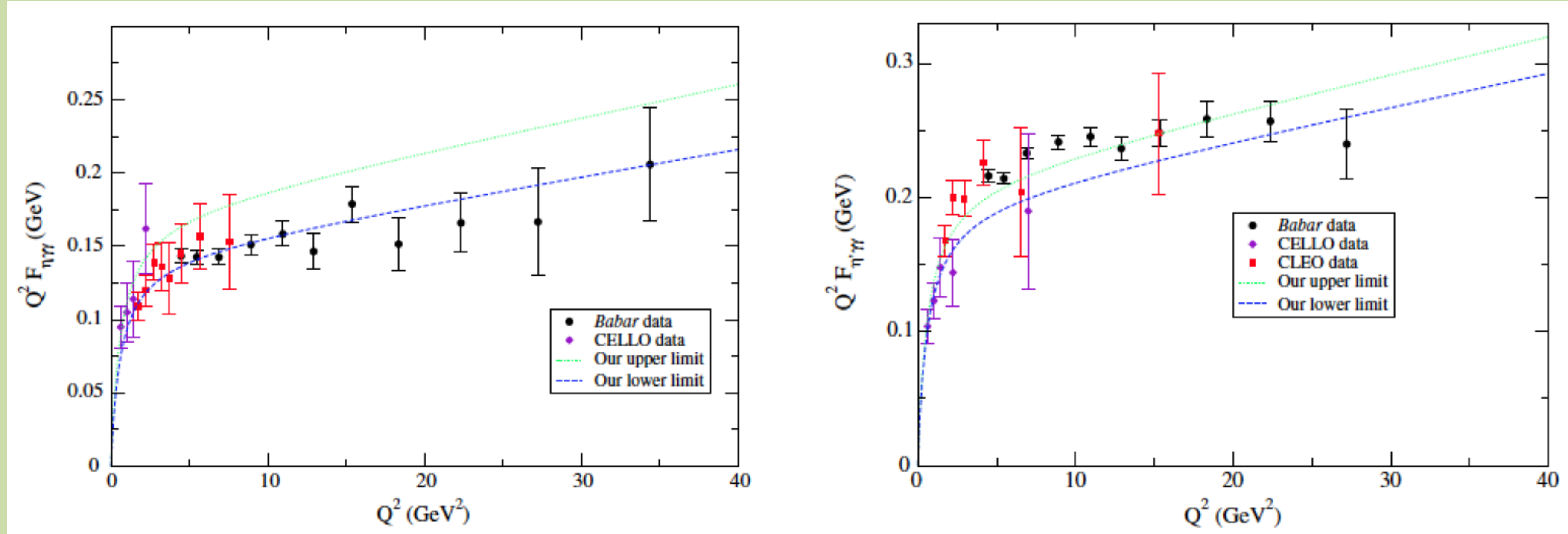
$$\mathcal{F}_{\pi^0\gamma\gamma}(Q^2) = -\frac{F}{3}\,\frac{Q^2\left(1+32\sqrt{2}\frac{P_2F_V}{F^2}\right) + \frac{N_C}{4\pi^2}\frac{M_V^4}{F^2}}{M_V^2(M_V^2+Q^2)}$$



Our result: $a_\mu^{\pi^0,\rm HLbL} = (6.66 \pm 0.21) \times 10^{-10}$

PREDICTION in terms of η-η' mixing.

$$\mathcal{F}_{\eta\gamma\gamma}(p^2,q^2,r^2) = \left(\frac{5}{3}C_q - \frac{\sqrt{2}}{3}C_s\right)\mathcal{F}_{\pi\gamma\gamma}(p^2,q^2,r^2),$$
$$\mathcal{F}_{\eta'\gamma\gamma}(p^2,q^2,r^2) = \left(\frac{5}{3}C_{q'} + \frac{\sqrt{2}}{3}C_{s'}\right)\mathcal{F}_{\pi\gamma\gamma}(p^2,q^2,r^2).$$



Our result: $a_\mu^{\eta,HLbL} = (2.04 \pm 0.44) \times 10^{-10}$, $a_\mu^{\eta',HLbL} = (1.77 \pm 0.23) \times 10^{-10}$

Jegerlehner & Nyffeler; Prades, de Rafael & Vainshtein:

$$a_\mu^{P,HLbL} = (10.9 \pm 2.2) \times 10^{-10}$$

Our result: $$a_\mu^{P,HLbL} = (10.47 \pm 0.54) \times 10^{-10}$$

Using the values in the literature for the remaining contributions to a_μ^{HLbL} yields:

$$a_\mu^{P,HLbL} = (11.8 \pm 2.0) \times 10^{-10}$$

$$\text{error}(a_\mu) = ^{+}_{-}5.1 \times 10^{-10}$$

CONCLUSION:

Our reduced error would increase the discrepancy to 3.6 σ. There is a strong case for new efforts on the theory side.

OTHER REFERENCES:

[1]MUON g-2 Coll., '06. [2]Reviews by Jegerlehner and Nyffeler and by Prades, de Rafael and Vainshtein '09. [3]Ecker et. al. '89. [4]Ruiz-Femenía, Pich and Portolés '03, Kampf and Novotny '11, Roig and Sanz-Cillero '13.