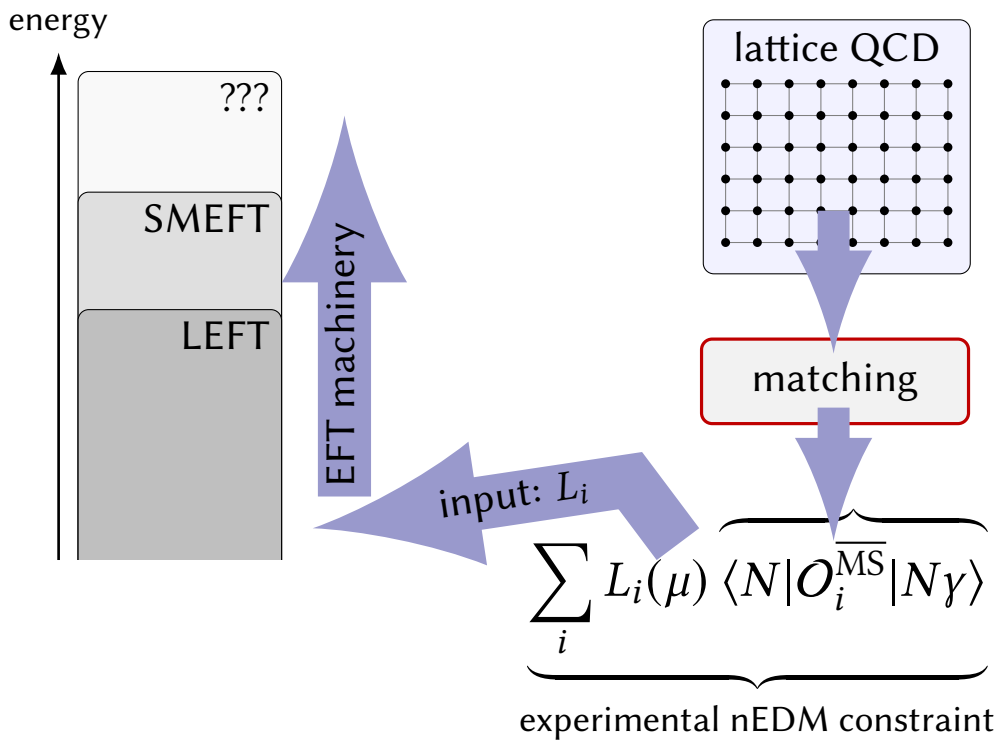
Low-energy footprints of heavy new physics

Indirect searches for new physics

- The Standard Model (SM) of particle physics (our best theory) is incomplete
- Unknown particles or forces must exist
- If they are too heavy, we cannot produce them directly in particle accelerators, since we may not reach the required energy $E = mc^2$
- Indirect searches can still detect footprints of new particles through the influence of their quantum corrections
- This requires precision calculations at low energies, which are agnostic w.r.t. UV theory



EFT machinery

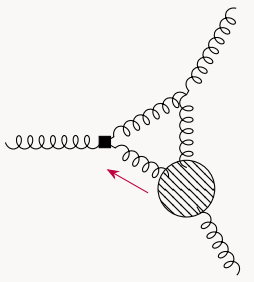
- The LEFT describes physics below $\Lambda_{\rm EW} \approx 100$ GeV

$$\mathcal{L}_{\rm LEFT} = \mathcal{L}_{\rm QED+QCD} + \sum_i L_i O_i.$$

- Above $\Lambda_{\rm EW} \approx 100$ GeV we can use the SMEFT
- Renormalization group & matching allows to evolve theory parameters to different energies
- Ultimate goal: translating low-energy experimental results into information on unknown more fundamental theories 🧐

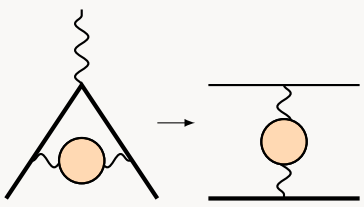
CP violation beyond the SM

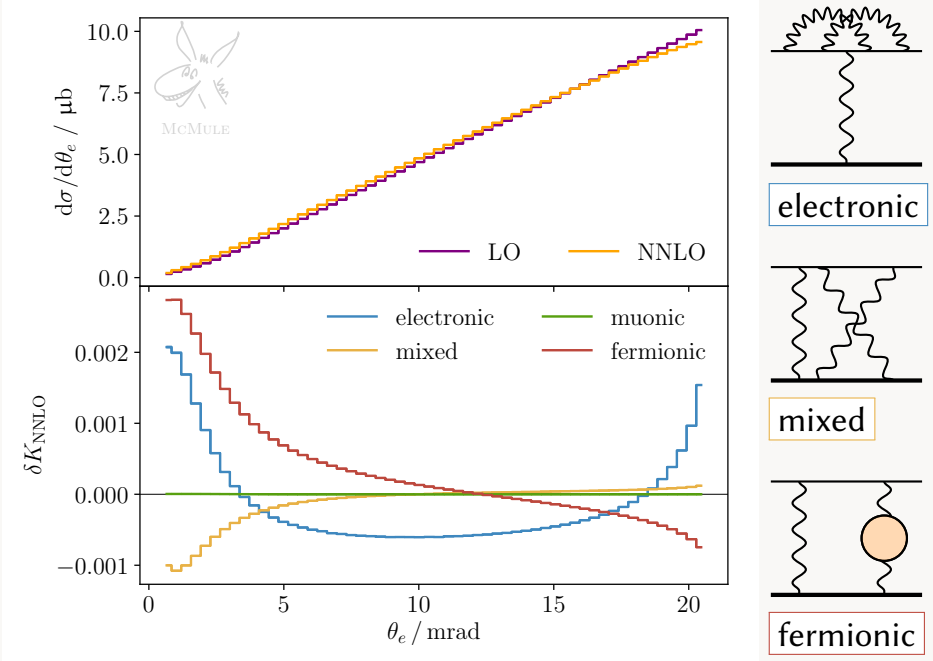
- Baryon asymmetry $\Longrightarrow$ we need more CP violation than the one we have in the Standard Model (CKM phase + possible θ-term) $\Longrightarrow$ strong interest in electric dipole moments (EDMs)
- Hadronic EDMs are non-perturbative quantities $\Longrightarrow$ we require matrix elements from lattice QCD
- The EFT tower requires results given in $D = 4 - 2\epsilon$ space-time dimensions. But lattice QCD is tied to integer dimensions 😢
- Our group is involved in making the translation between the lattice scheme (gradient flow) and the EFT tower scheme (minimal subtraction)



McMule mule-tools.gitlab.io

Independent prediction of $a_\mu^{\rm Had}$ from the MUonE experiment ($e\mu \to e\mu$) requires precise knowledge of the QED prediction.



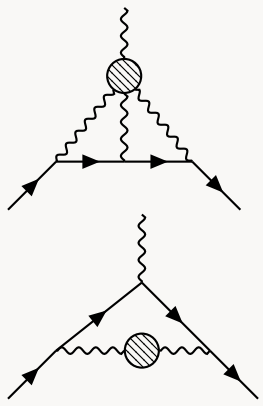


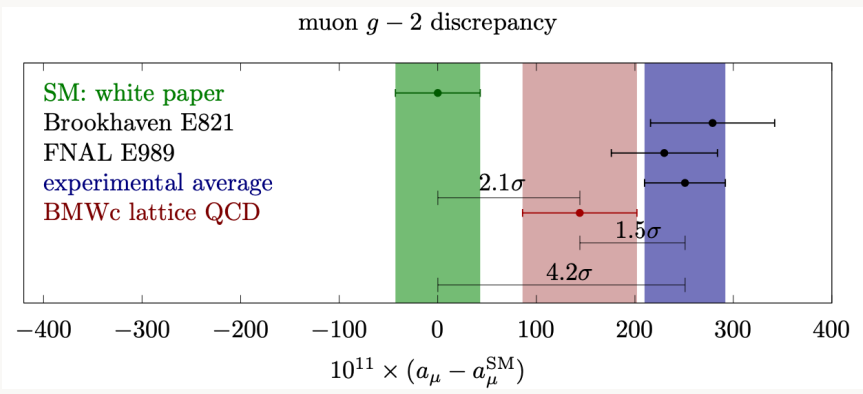
This can be calculated using the McMule framework:

· subtraction scheme for phase-space integration
· multi-scale loop integrals · EFT methods
· phenomenological studies · numerical challenges

Muon g-2

- Tension between measured value and SM prediction could indicate presence of new physics
- Requires control over hadronic uncertainties





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