

MITP workshop

The Evaluation of the Leading Hadronic Contribution to the Muon $g-2$: Toward the MUonE Experiment

Report from the N³LO Workstop






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16 NOVEMBER 2022

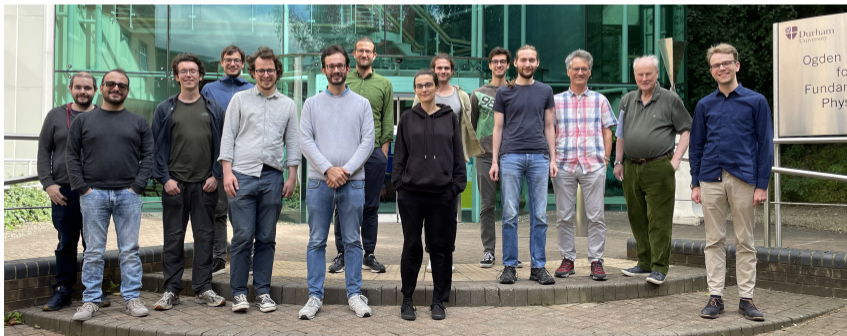
physical $2 \rightarrow 2$ cross section

$$\begin{aligned}
 \sigma = & \int d\Phi_2 \left| \begin{array}{c} \text{tree} \\ + \\ \text{1-loop} \\ + \\ \text{2-loop} \\ + \\ \text{3-loop} \\ + \dots \end{array} \right|^2 \\
 & + \int d\Phi_3 \left| \begin{array}{c} \text{1-loop} \\ + \\ \text{2-loop} \\ + \\ \text{3-loop} \\ + \dots \end{array} \right|^2 \\
 & + \int d\Phi_4 \left| \begin{array}{c} \text{2-loop} \\ + \\ \text{3-loop} \\ + \dots \end{array} \right|^2 \\
 & + \int d\Phi_5 \left| \begin{array}{c} \text{3-loop} \\ + \dots \end{array} \right|^2
 \end{aligned}$$

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 • \sim three-loop heavy quark form factor \rightarrow Matteo's talk
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 • \sim really difficult, see later
- 
 • \sim OpenLoops \oplus NTS stabilisation \rightarrow nasty but doable
- 
 • \sim tree level but difficult phase space \rightarrow (hopefully) easy enough
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 • $\int d\Phi_5 \left| \dots \right| \sim$ FKS³ subtraction

small workstop in Durham (3 – 5 Aug)

- VVV: Lange, Schönwald, Fael
- RVV: Ronca, Moodie
- RRV: Lindert, Schär
- assembly & dirty tricks: Engel, Rocco



the most difficult part: four scales (m , Q^2 , s_{12} , $s_{1\gamma}$)

using approximations

- massless integrals known (three-jet @ NNLO)
- massification, NTS stabilisation, jettification
- + fast evaluation (fully analytic), stable by construction, not **too** difficult
- introduces difficult-to-quantify systematic error

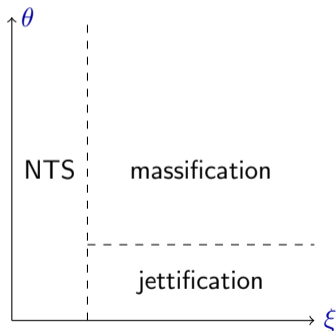
using brute-force

- numerical evaluation of full integrals (eg. DiffExp)
- ⇒ need to find master integral basis (KIT group)
- + no new systematic error
- slow evaluation, potentially very unstable, extremely difficult

the most difficult part: four scales ($m, Q^2, s_{12}, s_{1\gamma}$)

using approximations

using brute-force



- starting point: $\frac{d\vec{F}}{dx_i} = A_i \vec{F}$
- know integrals at some point (eg. boundary conditions)
- find a line to where you want it $0 < y < 1$
- solve $d\vec{F}/dy = A_y \vec{F}$ using power series in y
- repeat
- highly efficient implementation in DiffExp [Hidding 20]

- the N^3 LO calculation will be very difficult
 - ... but it will be doable for the dominant corrections
 - ... using **all** the tools
- ⇒ whitepaper will be written to demonstrate this to the community
- ⇒ provide input for Strong2020 Workstop in Zurich (Summer 23)