MITP workshop

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

Introduction to McMule

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McMule

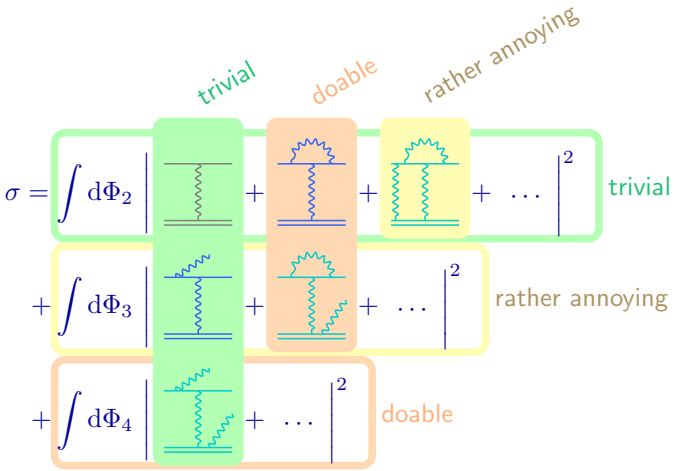
Monte Carlo for MUons and other LEptons
`https://mule-tools.gitlab.io`

- fixed-order QED corrections: some NLO, most NNLO, playing with N^3LO, some EW
- fully-differential Monte Carlo integrator, not an event generator (yet)
- playing with parton shower (not ready yet)
- whenever possible, steal QCD@LHC technology
  - dimensional regularisation
  - IBP reduction, integral calculations
  - subtraction schemes

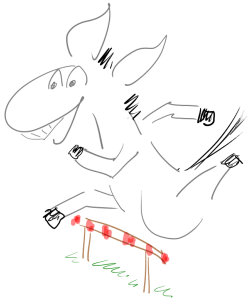
process	precision	experiment	physics motivation
$e\mu \to e\mu$	NNLO*	MUonE	HVP to $(g-2)_\mu$
	$\oplus$ NLO-EW		
$\ell p \to \ell p$	NNLO$^\#$	P2, Muse, Prad, ...	proton radius
$e^-e^- \to e^-e^-$	NNLO*	Prad 2	normalisation
		MOLLER, ...	$\sin\theta_W^2$ at low Q^2
$e^+e^- \to e^+e^-$	NNLO$^{*,\#}$	any e^+e^- collider	luminosity measurement
$ee \to \ell\ell$	NNLO†	VEPP, BES, Daphne, ...	R-ratio
	$\oplus$ NLO-EW	Belle	τ properties
$ee \to \gamma\gamma$	NNLO$^{*,\#}$	Daphne	dark searches
		any e^+e^- collider	luminosity measurement
$\mu \to \nu\bar{\nu}e$	NNLO	MEG	ALP searches
	$\oplus$ resum	DUNE	beam-line profiling

$*$: massification (cf. Tim's talk)
$\#$: some hadronic effects missing
$\dagger$: only dominant corrections

physical $2 \to 2$ cross section



- two-loop w/ full m-dependence: really difficult (cf. Tim's talk)
- VP diagrams for $e/\mu/\tau$/had/... numerically with full mass dependence (Matteo's method)
- real-virtual: really unstable for soft/collinear emission
- phase space integration: divergent



[Signer 22]

f.l.t.r.: F.Hagelstein (Mainz), A.Coutinho (PSI), N.Schalch (Bern), L.Naterop (Zurich & PSI), S.Kollatzsch (Zurich & PSI), A.Signer (Zurich & PSI), M.Rocco (PSI), T.Engel (→ Freiburg), V.Sharkovska (Zurich & PSI), Y.Ulrich (Durham), A.Gurgone (Pavia)

McMule

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for experimentalists

- event generator
- which observables / cuts should we use for tuning
- what can we share already now (i.e. $\mathrm{d}\sigma/\mathrm{d}\theta_e$)
- running with μ^+ or μ^- to check calculations
- ...

for theorists

- which observables have the hierarchy electr. $\gg$ mixd. $\gg$ muonic
- what can we resum up to NLL?
- N^3 LO $\rightarrow$ see later
- how good is the massification $\rightarrow$ Pavia calculation w/o approximation ongoing
- ...