

MUonE: Theory Update

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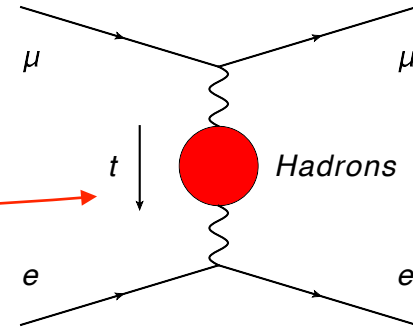


MUonE meeting
Pisa
29-30 January 2018

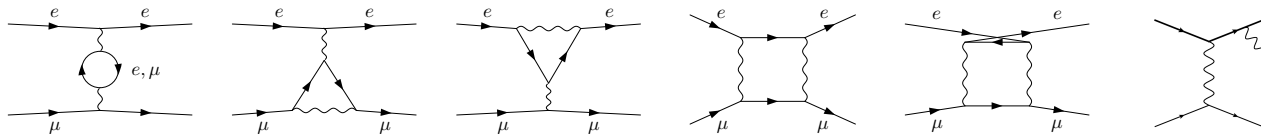
- The SM prediction for mu-e scattering must be known with an accuracy of 10 ppm → **a full NNLO QED MC generator is needed!**

$$a_{\mu}^{\text{HLO}} = \frac{\alpha}{\pi} \int_0^1 dx (1-x) \Delta\alpha_{\text{had}}[t(x)]$$

$$t(x) = \frac{x^2 m_{\mu}^2}{x-1} < 0$$

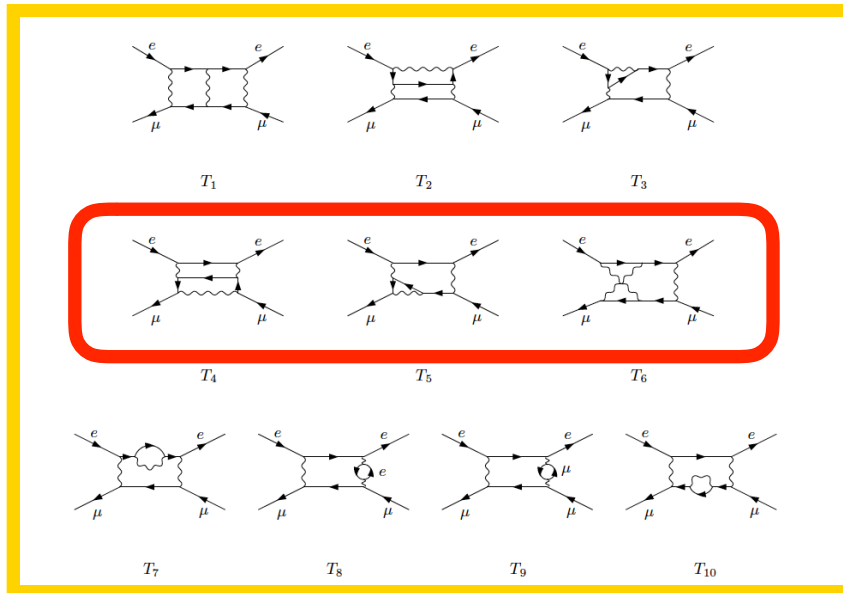


- NLO QED corrections known & checked.**



- An NLO MC generator with full mass dependence has already been developed by the **Pavia group**. It's ready & double-checked!
- EW NLO corrections are also in the pipeline (Pavia group).**

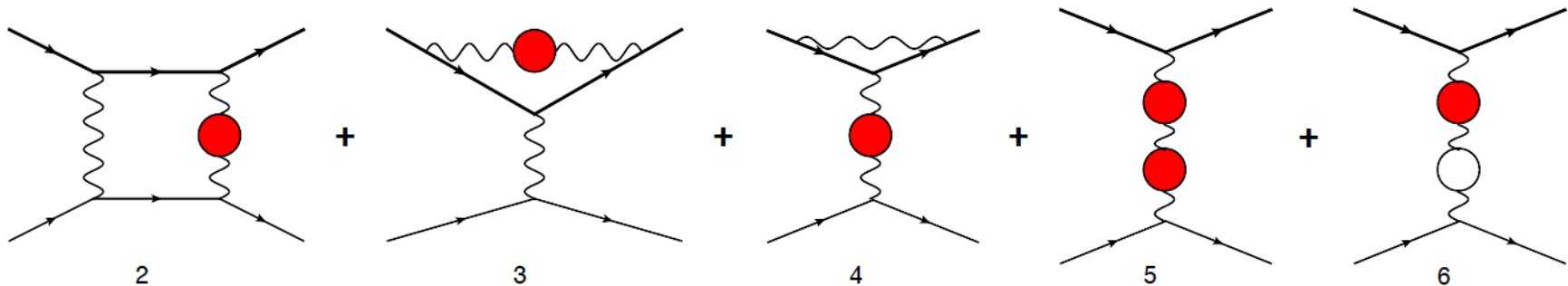
- The NNLO QED corrections to μe scattering are unknown.
- State-of-the-art methods required to calculate the 2-loop diagrams.
- First results in 2017 for the 2-loop box diagrams (Padova group):



Mastrolia, MP, Primo & Schubert, JHEP 1711 (2017) 198

- Work in progress for the non planar diagrams (Padova group).
- Then build an amplitude, add real emission, subtractions, etc etc...
It's a long way to go! Many theorists are joining the effort.

- The NLO hadronic contributions must be subtracted. They're unknown.



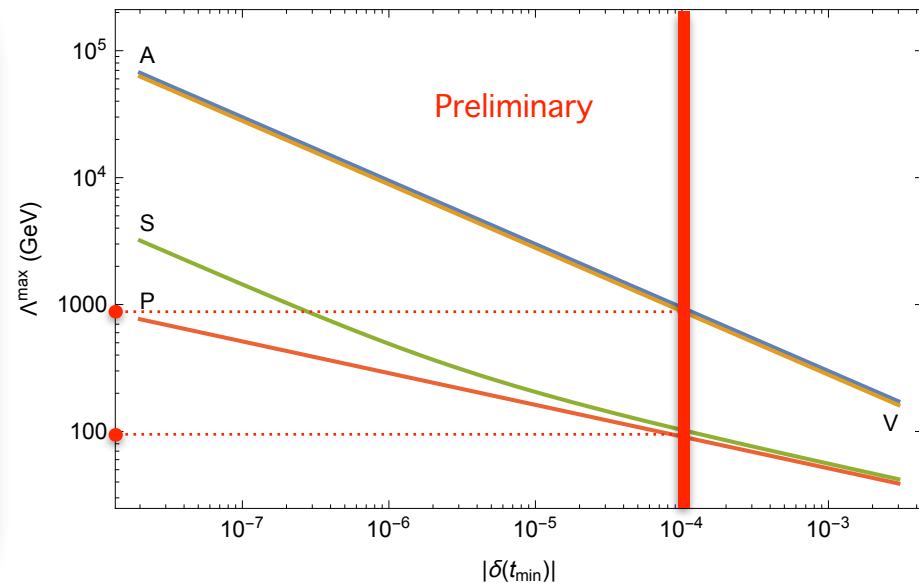
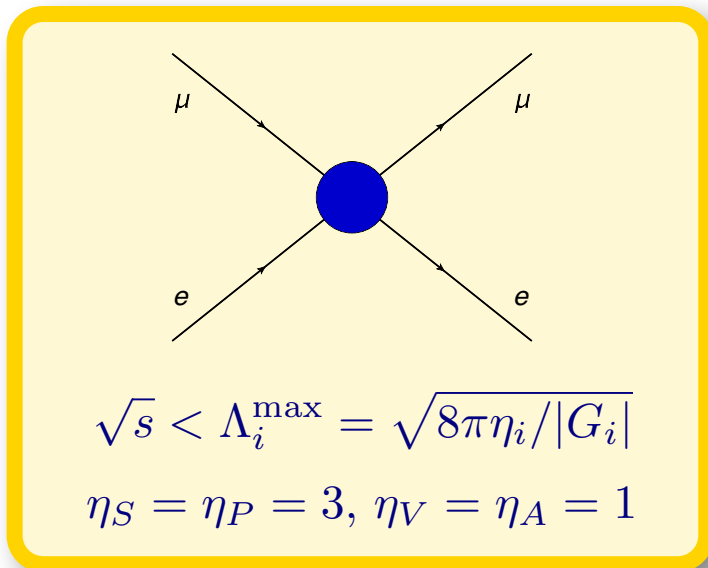
Matteo Fael, MP

- Calculation in progress (M. Fael + Padova group). Two alternatives:
 - Traditional calculation via dispersive approach. Uses timelike data.
 - Hyperspherical approach (Gegenbauer polynomials technique).
- The hadronic light-by-light contributions do not appear at NLO!! 😊

- Possible contributions to the μe scattering cross section of heavy spin-0 or 1 mediators at a scale Λ can be described via an effective Lagrangian if $\Lambda^2 \gg |q|^2 \sim (1\text{GeV})^2$ (Padova group).

$$\mathcal{L}_H = \sum_{i=S,P,V,A} G_i (\bar{\psi}_e \Gamma_i \psi_e) (\bar{\psi}_\mu \Gamma_i \psi_\mu) + \text{h.c.} \quad \longrightarrow \quad \frac{d\sigma}{dt} = \frac{d\sigma_{\text{QED}}}{dt} \left[1 + \sum_i \delta_i(s, t) \right]$$

- To probe these effects with a given experimental sensitivity, the values of G_i should be sufficiently large. Is perturbative unitarity respected?



P. Paradisi, MP



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User:Mpassera/MUonE Theory

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This page aims at describing the theoretical aspects of muon-electron scattering and, in particular, the theoretical studies of the MUonE project at [CERN](#). This is only a very preliminary set-up, to be improved in the near future.

The theory required for the MUonE project is being developed along six main lines of research:

1. [Monte Carlo](#) for [QED](#) at NLO, full mass dependence;
2. [Electroweak](#) corrections at NLO;
3. [QED](#) corrections at NNLO: Master integrals;
4. [QED](#) corrections at NNLO: Amplitudes;
5. Hadronic corrections at NLO;
6. Physics Beyond the [Standard Model](#).

Here is a link to a recent review of the theory status.^[1]

Links to dedicated theory workshops: [Padova 2017](#), [Mainz 2018](#).

1. [^] MUonE Meeting, Bologna, 14-15 december 2017 [link](#)

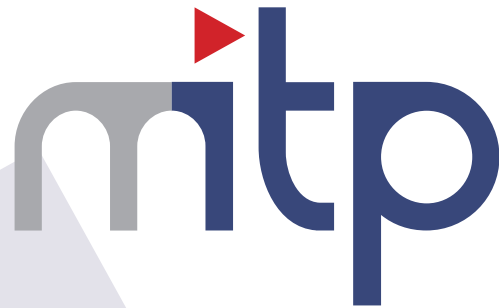
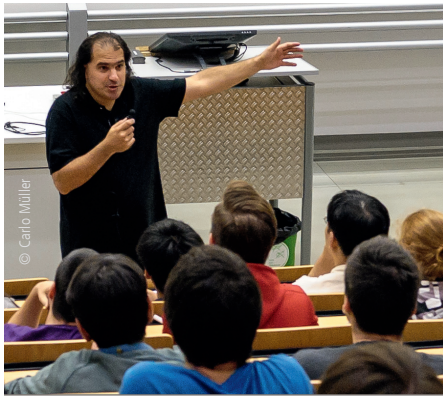
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https://en.wikipedia.org/wiki/User:mpassera/MUonE_Theory





Mainz Institute for Theoretical Physics

SCIENTIFIC PROGRAMS

Probing Physics Beyond SM with Precision
 Ansgar Denner [U Würzburg](#), Stefan Dittmaier [U Freiburg](#), Tilman Plehn [U Heidelberg](#)
February 26-March 9, 2018

Bridging the Standard Model to New Physics with the Parity Violation Program at MESA
 Jens Erler [UNAM](#), Mikhail Gorshteyn, Hubert Spiesberger [JGU](#)
April 23-May 4, 2018

Modern Techniques for CFT and AdS
 Bartłomiej Czech [IAS Princeton](#), Michal P. Heller
 MPI for Gravitational Physics, Alessandro Vichi [EPFL](#)
May 28-June 8, 2018

The Dawn of Gravitational Wave Science
 Rafael A. Porto [ICTP-SAIFR](#), Riccardo Sturani [IIP Natal](#)

TOPICAL WORKSHOPS

The Evaluation of the Leading Hadronic Contribution to the muon anomalous magnetic moment
 Massimo Passera [INFN Padua](#), Luca Trentadue [U Parma](#), Carlo Carloni Calame [INFN Pavia](#) Graziano Venanzoni [INFN Frascati](#)
February 19-23, 2018

Challenges in Semileptonic B Decays
 Paolo Gambino [U Turin](#), Andreas Kronfeld [Fermilab](#), Marcello Rotondo [INFN-LNF Frascati](#), Christof Schwanda [OEWA Vienna](#)
April 16-20, 2018

Tension in LCDM Paradigm
 Cora Dvorkin [U Harvard](#), Silvia Galli [IAP Paris](#), Fabio Iocco [ICTP-SAIFR](#), Federico Marinacci [MIT](#)
May 14-18, 2018

ACTIVITIES 2018

MITP Topical Workshop / February 19 – 23, 2018

indico.mitp.uni-mainz.de/e/MUonE

★ 30+ participants.

→ Monday

- General opening on the muon $g-2$ (Jegerlehner, Eidelman); MUonE project (Passera, Venanzoni); Lattice overview (Marinkovic); QED NNLO – Amplitudes (Signer, Ossola, Broggio, Torres, Greiner, ...)

→ Tuesday

- QED NNLO – Master Integrals (Primo, Laporta, ...); Monte Carlo Theory (Czyż, Alacevich, Carloni Calame, Montagna, Piccinini)

→ Wednesday

- Experimental day: Bernhard, Brizzolari, Ignatov, Ivantchenko, Keshavarzi, Marconi, Matteuzzi, Mersi, Tenchini, Venanzoni, ...

→ Thursday

- Hadronic corrections, BSM and more (Fael, Hagelstein, Knecht, Nesterenko, Pruna, Szafron, ...)

→ Friday (morning)

- Workshop summary: outlook & future work (Trentadue)

(The names of the speakers are only tentative)

The End