
2nd MUonE collaboration meeting

Towards a NNLO Monte Carlo for MUonE

PSI side

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for the MCMULE collaboration

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- this is an **informal** and internal talk
 - many **preliminary** results
 - cross checks are on-going
- ⇒ everything could change at moments notice
- that being said, results from the MCMULE collaboration
(**M**onte **C**arlo for **M**uons and other **l**eptons)

very briefly

- calculate emissions from the electron to NNLO (electronic) with full m_e dependence
- $\mathcal{O}(90 - 95\%)$ of full NNLO
- out method: subtraction scheme FKS^2 [Engel, Signer, YU 2019] with $m_\gamma = 0$

$$\int d\Phi$$

divergent

very briefly

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$$\int d\Phi \left(\underbrace{\left(\text{diagram} - CT \right)}_{\text{integrable numerically}} \right) + \underbrace{\int d\Phi CT}_{\text{analytic}}$$

The diagram shows a fermion line with a wavy photon line branching off it. The fermion line has four external legs with arrows indicating direction. The photon line has two external legs, one of which is a curly line representing a soft photon emission.

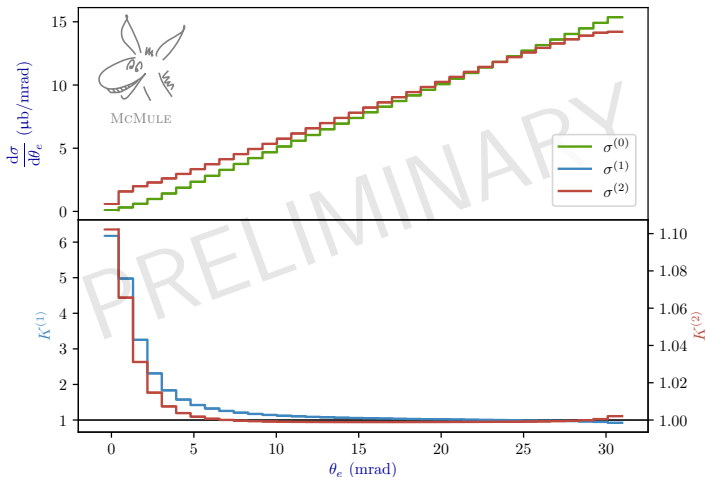
electronic NNLO (almost) done [Banerjee, Engel, Signer, YU very soon]

cross checks with...

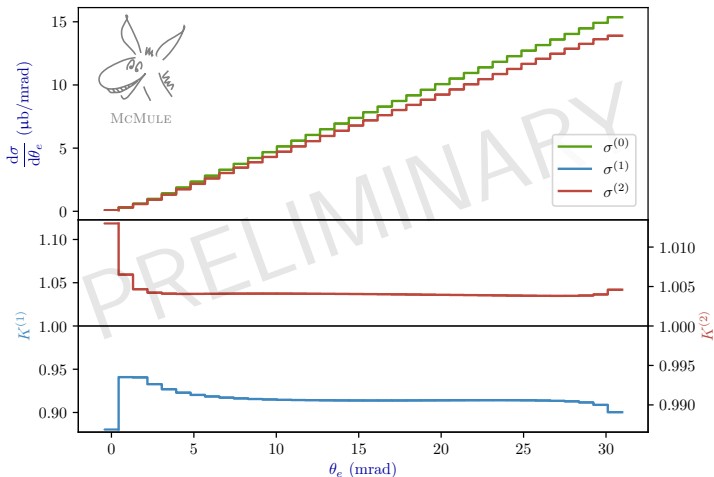
- ... PV group $e\mu \rightarrow e\mu + \gamma$ @ NLO very promising (cf. Carlo's talk)
 - ... Mainz group $ep \rightarrow ep$ @ NNLO **failed** (even NLO fails) [Bucoveanu, Spiesberger 2018]
- ⇒ numerical problems maybe?
- preliminary results presented @ PSI2019 [Engel 2019, YU 2019]

two MUonE configurations from [Alacevich, Carloni Calame, Chiesa, Montagna, Nicosini, Piccinini 2018]

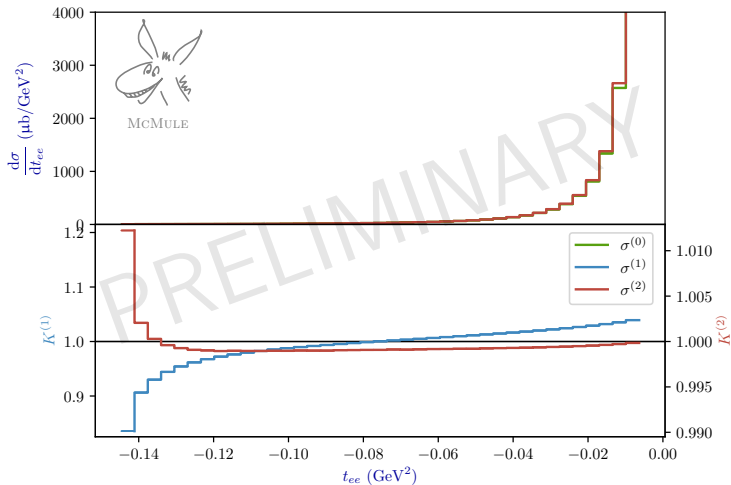
- $E_\mu = 150 \text{ GeV}$
- $E_e^{(\text{out})} > 1 \text{ GeV} \rightarrow t_{ee} \lesssim -1.02 \times 10^{-3} \text{ GeV}^2$
 - Setup 2: no further cuts
 - Setup 4: acoplanarity cut $|\pi - |\phi_e - \phi_\mu|| \leq 3.5 \text{ mrad}$

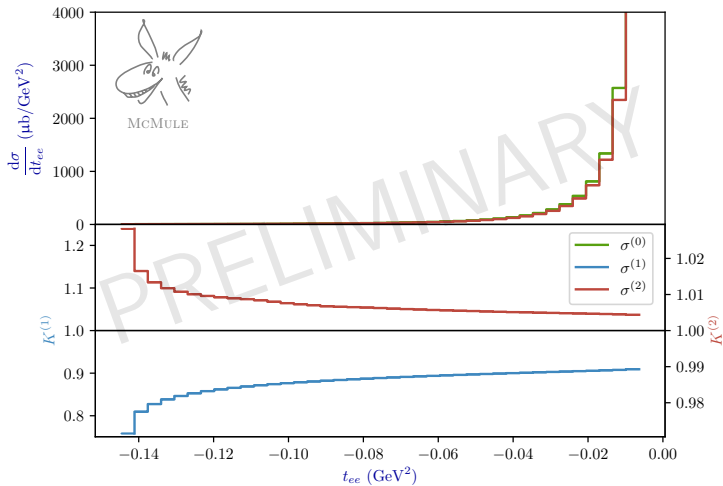


corrections extremely large for $\theta_e \rightarrow 0 \rightarrow$ fixable with PS



corrections flat-ish but large-ish \rightarrow resummation

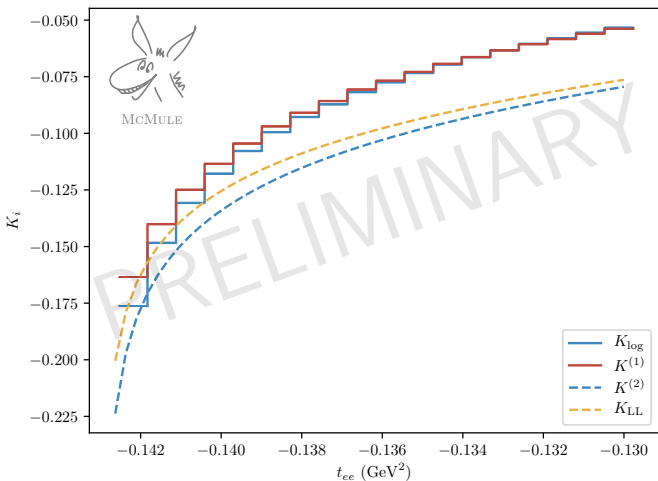




resummation is mission-critical

- leading-log (LL) through PS
 - strict NLL is observable dependent
- ⇒ exceedingly difficult for anything that could actually be measured
- something in-between might be possible

compare NNLO v. LL [Becher, Broggio, Passera 2019 (internal)]



extremely preliminary (as in, on the train)

near future

- validate electronic NNLO (very soon)
- real-virtual with massive electron
- full NNLO (mid 2021?) with massified two-loop (cf. Pierpaolo's talk)
- PS in MCMULE (202x)

cloud cuckoo land dreams

- NLL with something measurable
- electronic N^3LO is conceivable
 - important parts of three-loop virtual ($\gamma^* \rightarrow QQ$) known
 - massify two-loop $\gamma^* \rightarrow q\bar{q}g$ for real-virtual-virtual
 - automation of real-real-virtual & real-real-real

various workshops

- the Theory Kickoff Workshop, 4-5 September 2017, Padova,
- the MITP Workshop, 19-23 February 2018, Mainz, and
- the 2 nd WorkStop/ThinkStart, 4-7 February 2019 University of Zurich.

Theory for muon-electron scattering @ 10 ppm

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ABSTRACT: We review the current status of the theory predictions for elastic μ - e scattering, describing the recent activities and future plans of the theory initiative related to the proposed MUonE experiment.