My Interests

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CERN Theory Group Retreat
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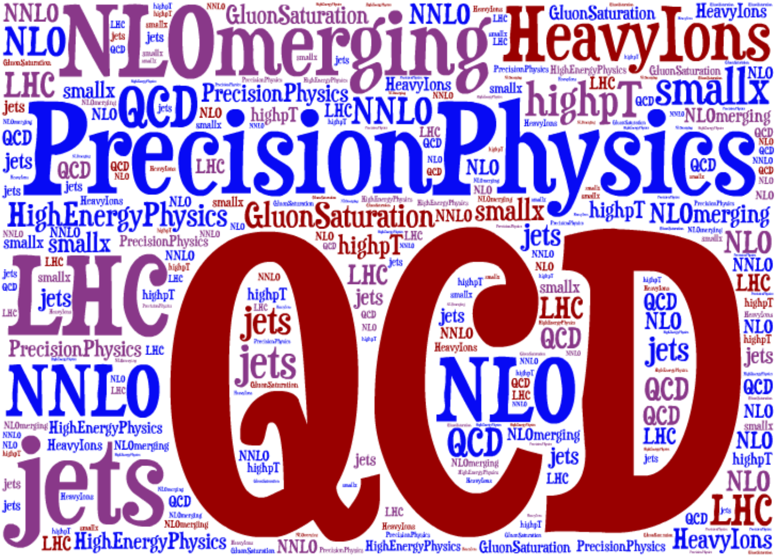
My Interests



Higher order QCD corrections

Fixed order perturbative expansion in α_s:

$$\sigma = \underbrace{\sigma_0}_{\text{LO}} + \underbrace{\alpha_s \sigma_1}_{\text{NLO}} + \underbrace{\alpha_s^2 \sigma_2}_{\text{NNLO}} + \cdots$$

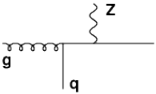
Naively, if $\sigma_i \simeq 1$ and $\alpha_s \ll 1$, this should all be nicely convergent.

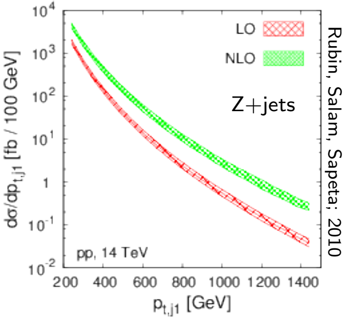
In real life however...

Huge K-factor! $K = \sigma_{\rm NLO}/\sigma_{\rm LO} \simeq 5$
(and this is not the most extreme case)

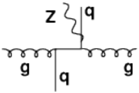
But why?

LO





NLO

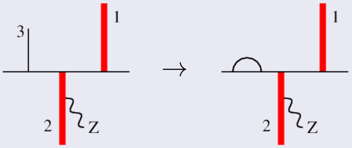


$\Rightarrow$ new incoming channels and new topologies
(though formally NLO diagrams for Z+jet, these are in fact leading contributions)

What can we do to improve the situation?

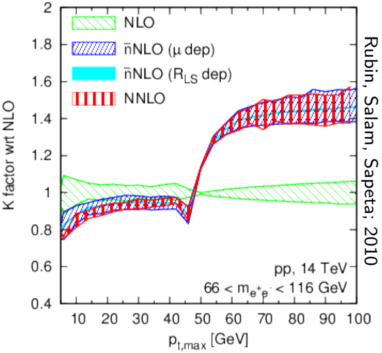
- Compute exact NNLO, N^3LO, etc. corrections.
  $\rightarrow$ Very respectable activity, but at the same time very hard, hence, slow progress.
- Determine dominant part of corrections coming from new topologies and new channels that open up at higher orders.
  $\rightarrow$ Works for broad class of processes and provides bulk of missing higher order corr.

LoopSim [M. Rubin, G. Salam, S.S.]



$$\sigma_{\bar{n}\text{NLO}} - \sigma_{\text{NNLO}} = \mathcal{O}\left(\frac{\alpha_s^2}{K_{\text{NNLO}}}\right)$$

$$K_{\text{NNLO}} \gtrsim K_{\text{NLO}} \gg 1$$



Current agenda (LoopSim-related)

LoopSim has been tested/used for a number of processes:
Drell-Yan, dijets, Z+jets (Tevatron, LHC), W+jets (LHC), WZ, WW

Next phase: get better understanding, improve.

- For a set of most common processes ($e^+e^- \to$ jets, DY, DIS, $gg \to H$), at the level of the total cross section, is it possible to understand the pattern of the NLO corrections?
- What are the key elements that are responsible for the large K-factors? Could one organize the perturbative expansion in a better way?
- Which of those elements could be included in LoopSim to partially account for non-singular terms of the higher order corrections? Which of them could be useful for MCs?

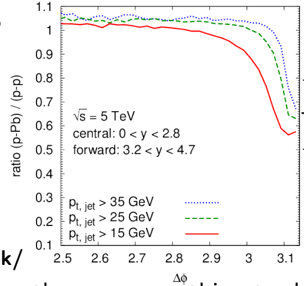
Independently of that:

- Phenomenological studies of processes where QCD corrections beyond NLO can be relevant: $gg \to H$, heavy quarks, diphotons.

Current agenda (other projects)

Studying saturation of gluon density with forward jets

- At low x, gluon density $g(x, k_t^2)$ is expected to be suppressed below $k_t \sim Q_s(x)$, where $Q_s(x)$ is the saturation scale.
- This can be studied with forward dijet configurations.
- The effect is enhanced in p-Pb collisions.



Kutak, Sapeta; 2013

NLO-PS matching /with Cracow group and A. Siódmok/

- Apart from computing corrections at fixed α_s, another common thing to do, in order to improve QCD predictions, is to combine NLO results with the parton shower. The latter resums multiple collinear emissions.
- Two well established approaches: MC@NLO and POWHEG.
- Somewhat less developed method, called KRKMC [*Jadach et al. Phys. Rev. D 87 (2013) 034029*], which has in principle several nice features: NLO correction of all PS vertices, no need for truncated shower, fully analytic PS, a well defined way to go one level higher, i.e. to NNLO+NLO PS (though still very hard).

References

- **"WW production at high transverse momenta beyond NLO"**
  F. Campanario, M. Rauch and S. Sapeta.
  arXiv:1309.7293 [hep-ph]
- **"Simulated NNLO for high-pT observables in vector boson + jets production at the LHC"**
  D. Maître and S. Sapeta.
  arXiv:1307.2252 [hep-ph]
- **"WZ production beyond NLO for high-pT observables"**
  F. Campanario and S. Sapeta.
  arXiv:1209.4595 [hep-ph]
  Phys. Lett. B **718**, 100 (2012)
- **"Gluon saturation in dijet production in p-Pb collisions at Large Hadron Collider"**
  K. Kutak and S. Sapeta.
  arXiv:1205.5035 [hep-ph]
  Phys. Rev. D **86**, 094043 (2012)