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New developments in NLOwPS

7^{th} meeting, Higgs cross section WG

CERN, 6/12/2012

New means whatever has happened since the 6^{th} meeting (May 2012)

My interpretation of the scope of the NLO-MC subgroup (which I find not clearly defined): present new tools and techniques as they become available, raise awareness of issues under scrutiny by theorists

Other, mostly process-specific things belong to the various physics subgroups, and are best discussed there – and the same strategy should be applied to YR's

Note

A three-day ATLAS+CMS+LPCC meeting has taken place at CERN on Nov 19^{th}–21^{st}, and (most of) the relevant topics have been discussed in great details

`https://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=212`

See the slides there for more information

New things of interest

- MINLO
- NLO merging
- Public releases
- Scale and PDF uncertainties through reweighting
- SM Higgs p_T with exact m_b, m_t dependence

MINLO (Multi-leg Improved NLO)

Hamilton, Nason, Zanderighi 1206.3572

- Motivation: define an "optimal" scale choice for NLO computations, that is not based on stability considerations, and that takes into account production dynamics in multi-scale processes (ie, that involve jets)
- The latter requirement implies the necessity of multiplying by Sudakov form factors
- Can be viewed as a prescription for the virtual and real contributions, which is consistent with the underlying Born being computed according to CKKW

Comments on MINLO

- Can be applied to both NLO and NLOwPS
- Sudakov form factors help tame Sudakov logs that appear in the short-distance cross sections: hence, the difference wrt standard approaches is dramatic in Sudakov regions
  (with MINLO being better behaved)
- The claim is that in the Sudakov regions the MINLO prescription is always beneficial in the context of NLOwPS
- MINLO is not a merging procedure. However, it may facilitate merging

NLO merging

Terminology

- An NLO *matching* procedure is MC@NLO or POWHEG
- An LO *merging* procedure is CKKW or MLM

Hence, with NLO merging I mean the extension of techniques such as CKKW or MLM to simulations whose individual results are accurate to NLO. There may thus exist different NLO mergings for the same matching strategy, and not only for different types of matching

Up and running, not public just yet

Sherpa (Hoeche, Krauss, Schonherr, Siegert + Gehrmann) 1207.5030, 1207.5031

FxFx (aMC@NLO) (Frederix, SF) 1209.6215

- Both use MC@NLO-type matching
- Basic idea is that of reconstructing a shower history that defines nodal values, used then to "split" matrix elements between samples, and to assign scales and shower initial conditions
- Many implementation differences (eg Sudakovs, matrix-elements weights, and core MC@NLO)
- Sherpa claim formal NLO and log accuracy (and Q_{cut} at $1/N_C \alpha_S^2 L^3$), FxFx do not (but rather compare to un-merged results)

Formalism defined, implementation to come

UNLOPS, NL^3 (Pythia8) (Lönnblad, Prestel) 1211.7278

Herwig++ (Plätzer) 1211.5467

Geneva (Alioli, Bauer, . . .) 1211.7049

- UNLOPS and HW++ approaches strongly rely on unitarity constraints
- UNLOPS extends UMEPS (1211.4827) to NLO, while NL^3 upgrades CKKW-L (and violates unitarity)
- Geneva emphasise control on subleading logs, and claim better overall accuracy
- Current implementation of UNLOPS require hacking third-party matrix-element codes. Actions must be taken for systematic progress

Better understanding of the various methods, and systematic comparisons, will come in due time. The pattern will be similar to that of LO mergings, but possibly more painful: *this stuff is very new, and not easy*

My main concern at the moment: merging should not become a complicated way to justify our prejudices on which matrix elements contribute to which observables

In other words, the interplay between MC and ME's must be thoroughly explored. This may of course lead to unpleasant surprises

Public releases

Recently, both aMC@NLO and Sherpa-with-NLO have released public (beta) versions. See:

`http://amcatnlo.cern.ch`

`https://sherpa.hepforge.org/trac/wiki/SherpaDownloads/Sherpa-2.0.beta`

Sherpa needs interfacing with external one-loop provider – there are a few on the market now (GoSam, OpenLoops, BlackHat). aMC@NLO is self-contained, but will also be linked to external codes

General high level of automation – up to the user to figure how much of it in the various codes. Feedback to developers is essential at this stage

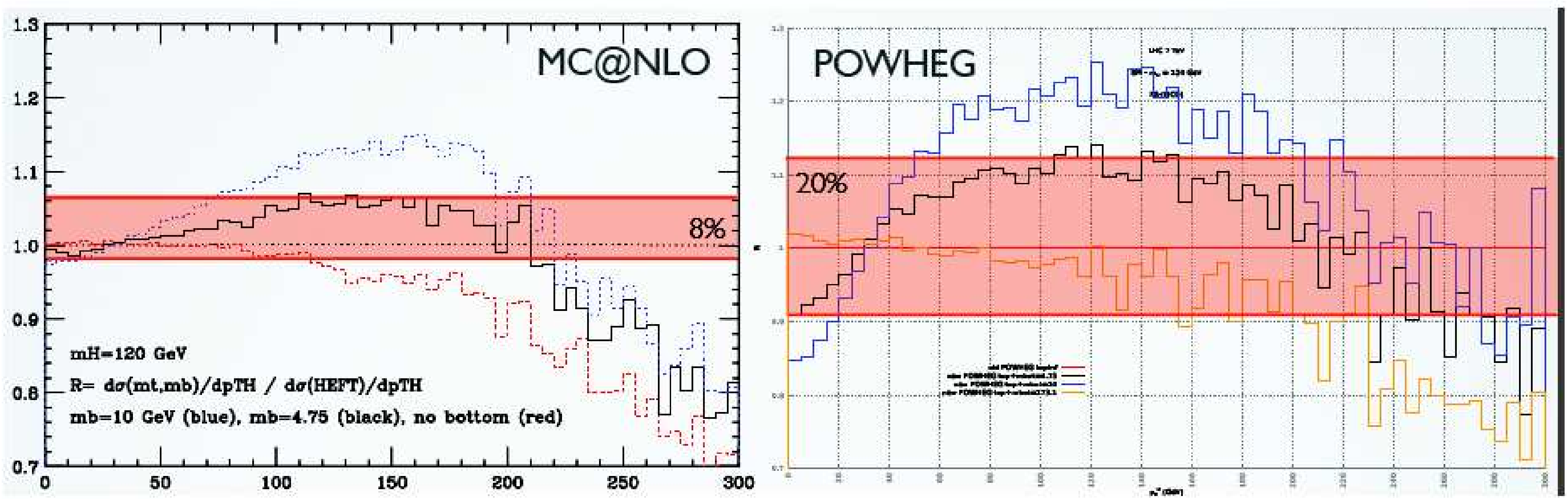
Scale and PDF uncertainties

aMC@NLO and POWHEG can save in the LH event file the information on the cross sections computed with scales and/or PDF different wrt those used in the current run

The implication is that it is not necessary to re-run such codes in order to obtain theoretical "error bands"

Beware: the MC@NLO and POWHEG short-distance cross sections are not the same, and one must not expect the uncertainties predicted by the two codes to be exactly the same

Higgs p_T spectrum

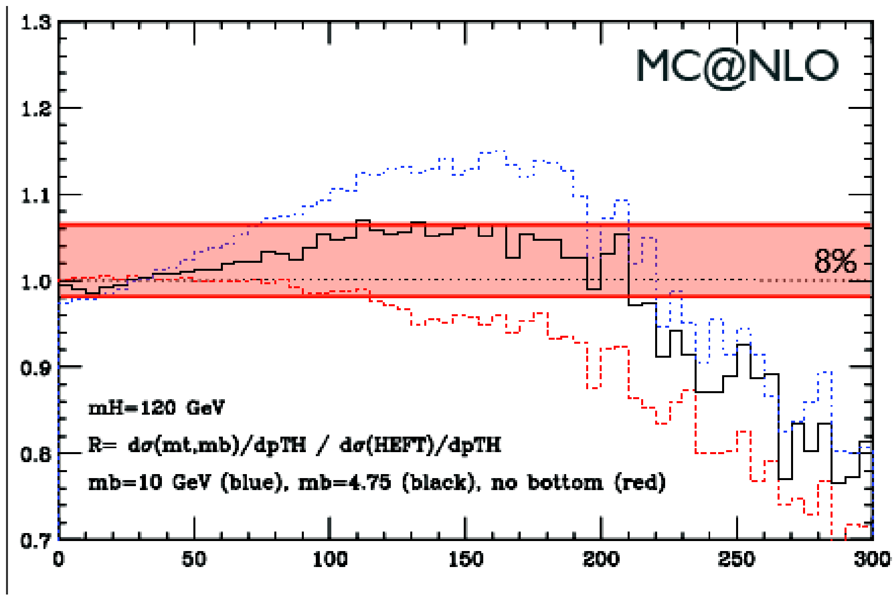


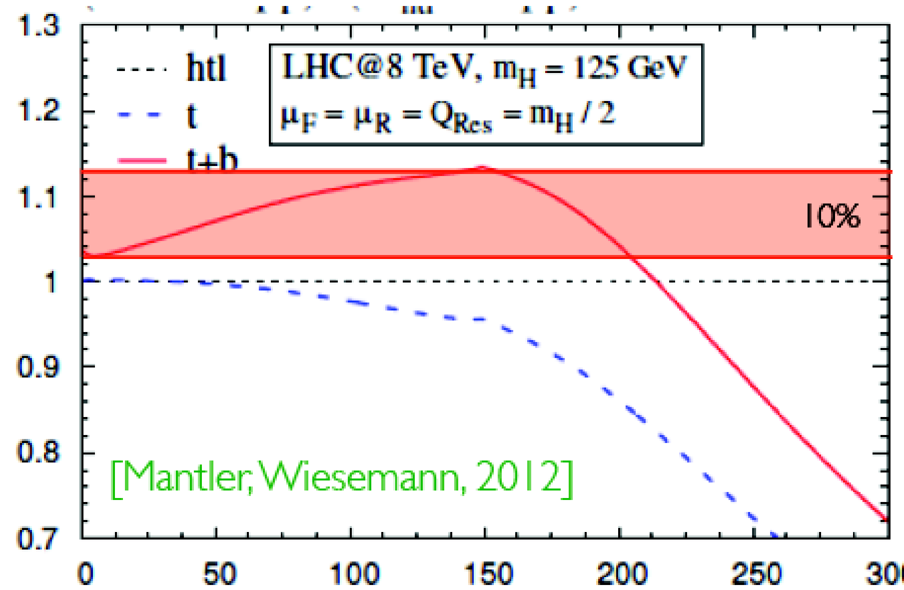
m_t and m_b effects, relative to HEFT, in $gg \to H^0$ at $\mathcal{O}(\alpha_S^3)$

MC@NLO v4.08

POWHEG 1111.2854 (Bagnaschi, Degrassi, Slavich, Vicini)

The two codes use the same matrix elements. Absolute normalization disregarded in this comparison





m_t and m_b effects, relative to HEFT, in $gg \to H^0$ at $\mathcal{O}(\alpha_S^3)$

MC@NLO v4.08

Analytic resummation 1210.8263 (Mantler, Wiesemann)

The two codes use the same matrix elements. Absolute normalization disregarded in this comparison. Choice of inputs in 1210.8263 not exactly the same as in MC@NLO and POWHEG

I stress again: the differences here are in shape.
Absolute normalization has not been taken care of

- Is this theoretical "systematics" included in experimental analysis? Note that on the theory side it is not clear what is going on

  (e.g., is the b-loop resolved? Does it lead to a smaller resummation scale?

  If so, I'd expect a softer, not harder, behaviour)

- Does `hfact` affect the POWHEG results?

- In general, are `hfact` variations treated as systematics?

YR3 activities I am aware of

aMC@NLO

- Higgs p_T with m_b and m_t: vs POWHEG vs analytical computations
- $gg \to H \to 4\ \ell$: signal+bckg+int additive, comparisons to other non-MC schemes
- VBF with HW/PY; comparisons to existing samples
- $t\bar{t}H$ and $t\bar{t}A$, including spin correlations
- $gg \to H$ and VH merged, and comparisons to NNLO
- Light Higgs with $0^{\pm}$, $1^{\pm}$, 2^{+}

Sherpa

- $gg \to H$ merged
- VBF at NLO
- Theoretical uncertanties, perturbative and non-perturbative
- Realistic analysis for specific channels ($H \to \gamma\gamma$)

To conclude, I have just one comment

The efforts of the experimental community towards adopting NLOwPS tools are remarkable. It seems to me not uncommon, however, that some of these attempts lead nowhere because of problems found along the generation-and-interfacing process, which *are not reported* back to the authors

If this is the case, it's an immense waste of resources. We are willing to help, but can do so only if informed promptly of things which are not working in the way you think they should