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# Status of and plans for aMC@NLO

LPCC MC Workshop

CERN, 19/11/2012

First public version available since 8<sup>th</sup> Nov 2012 at:

<http://amcatnlo.cern.ch>

Works like MadGraph: there is no pre-defined list of processes, all is computed on the fly

Very high level of parallelization: with a sufficient number of CPUs, a process will take as long to compute as its most demanding contribution  
(an integration channel of one partonic subprocess)

Computes QCD corrections to SM processes, with the exception of those that feature unstable coloured particles in the loops

These limitations will soon be removed, but already at present can be bypassed thanks to the modular structure of the code

(virtual computations – MadLoop – are completely independent)

Examples are available on the aMC@NLO web page: follow

Special Codes

at:

<http://amcatnlo.cern.ch>

# Special codes I

The project

- Home
- People
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- News

MC Tools  
(registration needed)

- Download aMC@NLO
- Help and FAQs
- Event samples DB
- Special Codes

Communication

- Citations
- Publications
- Talks & Seminars

Resources

- Useful links
- File Sharing

## aMC@NLO web page

### Optimized process-specific aMC@NLO codes

Here you find a collection of aMC@NLO codes dedicated to key processes at the LHC. In some cases, virtuals cannot yet be calculated by MadLoop (for example for Higgs production in the Higgs Effective Field Theory), while in others analytic expressions might be faster than MadLoop. We stress that all contributions to the cross sections except the finite part of the virtuals are still obtained with aMC@NLO, by generating the process with the [real=QCD] option. It is only the finite part of the virtuals that it is added "by hand". Therefore, the codes listed here provide explicit examples on how to interface aMC@NLO with BLHA-compliant external codes for one-loop corrections

Process	Codes	Plots	Extra info
<b>Higgs characterization.</b> Comparison plots: <a href="#">pt of the "Higgs" rapidity of the "Higgs" jet rates</a>			
$pp \rightarrow 0^+ + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Virtuals coded by hand by R. Frederix and M. Zaro from the known analytic results. Scalar resonance. Process generated in the HEFT model
$pp \rightarrow 0^- + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Virtuals coded by hand by R. Frederix and M. Zaro from the known analytic results. Pseudo scalar resonance. Process generated in the HEFT model
$pp \rightarrow 1^- + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Fully automatic in aMC@NLO. Vector resonance (Obtained from the Z using only vector coupling to quarks).
$pp \rightarrow 1^+ + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Fully automatic in aMC@NLO. Pseudo vector resonance (Obtained from the Z using only axial coupling to quarks).
$pp \rightarrow (2^- \rightarrow \gamma\gamma) + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Virtuals Provided by Frederix et al. <a href="#">arXiv:1209.4521</a> Code generated using the BS model. Spin 2 (graviton like)
More to come soon...			

Virtuals available from the literature ((pseudo)scalar, (pseudo)vector, graviton-like resonances), and included via BLHA interface

# Special codes II

aMC@NLO web page

$pp \rightarrow l^- + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Fully automatic in aMC@NLO. Vector resonance (Obtained from the Z using only vector coupling to quarks).
$pp \rightarrow l^+ + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Fully automatic in aMC@NLO. Pseudo vector resonance (Obtained from the Z using only axial coupling to quarks).
$pp \rightarrow (2^- \rightarrow \gamma\gamma) + X$	<a href="#">Code</a>	<a href="#">aMC@NLO+Pythia</a> <a href="#">aMC@NLO+Herwig</a>	Virtuals Provided by Frederix et al. <a href="#">arXiv:1209.6527</a> Code generated using the RS model. Spin 2 (graviton like)
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**Special Needs**

Here you find a collections of codes for special needs.

Process	Codes	Info	Comments
Inclusive Heavy Higgs in $W \rightarrow 4$ leptons final states : codes for background-interference. MC@NLO code for the signal at NLO with full heavy quark dependence is available <a href="#">here</a> .			
$g g \rightarrow W^+ W^- \rightarrow e^+ \nu_e \mu^- \nu_{\mu^-}$	<a href="#">Code</a>	<a href="#">More info</a>	Virtual provided by MCFM and MadLoop. Features the interference of the Higgs with the continuum $WW$ background.
$g g \rightarrow e^+ e^- \mu^+ \mu^-$	<a href="#">Code</a>	<a href="#">More Info</a>	Virtual provided by MCFM and MadLoop. Features the interference of the Higgs with the continuum $ZZ$ background.
$g g \rightarrow e^+ e^- \nu_e \nu_{e^-}$	<a href="#">Code</a>	<a href="#">More Info</a>	Virtual provided by MCFM and MadLoop. Features the interference of the Higgs with the continuum $ZZ$ background.
$g g \rightarrow e^+ e^- \nu_e \nu_{e^-}$	Not yet available	<a href="#">More Info</a>	In progress. Features the interference of the Higgs with the continuum $WW/ZZ$ background.

$gg$ -induced  $\mathcal{O}(\alpha_s^2)$  four-lepton processes, including SM-Higgs exchange (these are “loop squared”). How to use them?  $\longrightarrow$

Call  $H$  whatever diagrams feature Higgs exchange, and  $R$  all the others

Study impact of interference by comparing

$$|H + R|^2 \quad |H|^2 + |R|^2$$

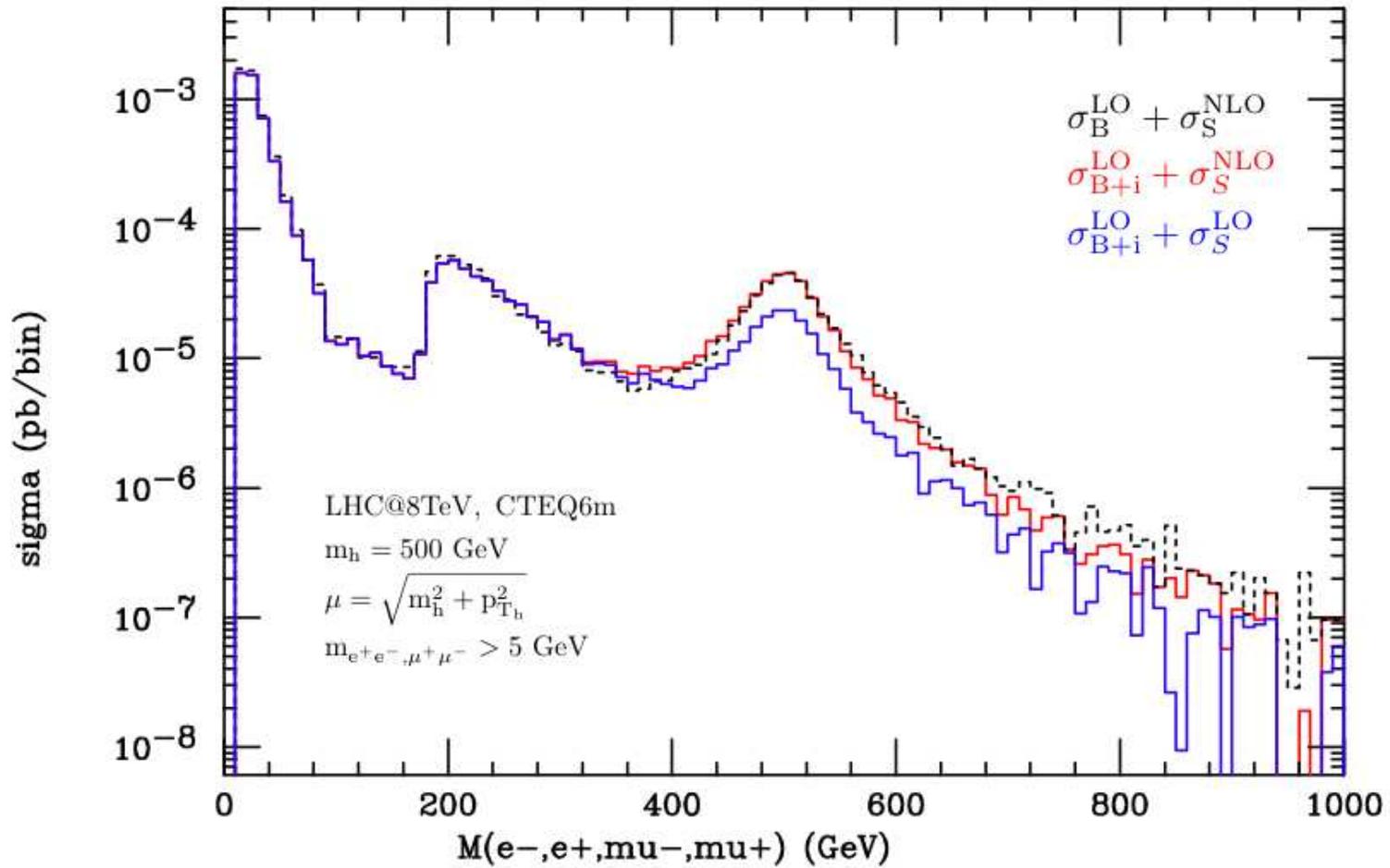
Each of these three terms can be obtained with the special codes

For a phenomenologically-realistic simulation, define:

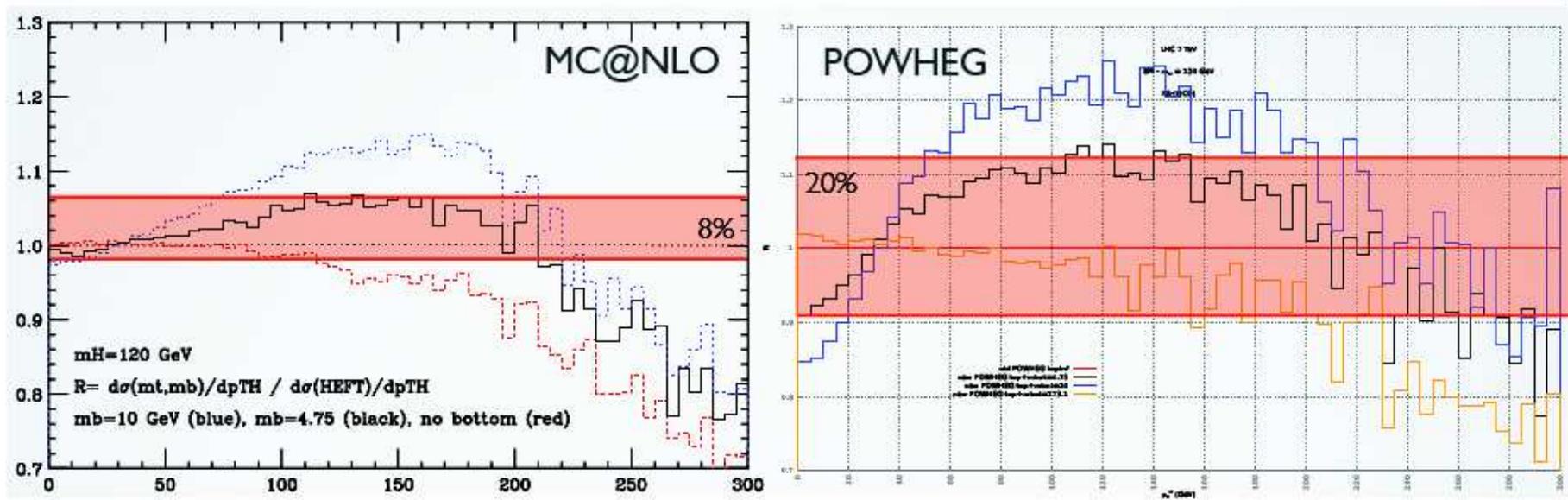
$$|H + R|^2 - |H|^2 + |H|^2_{\mathcal{O}(\alpha_S^3)}$$

that is, add the “signal” at the NLO. This should be computed with MC@NLO v4.08 or higher, since this features exact  $m_t$  and  $m_b$  dependences

# ZZ invariant mass distribution



Both interference and NLO effects on “signal” are clearly visible

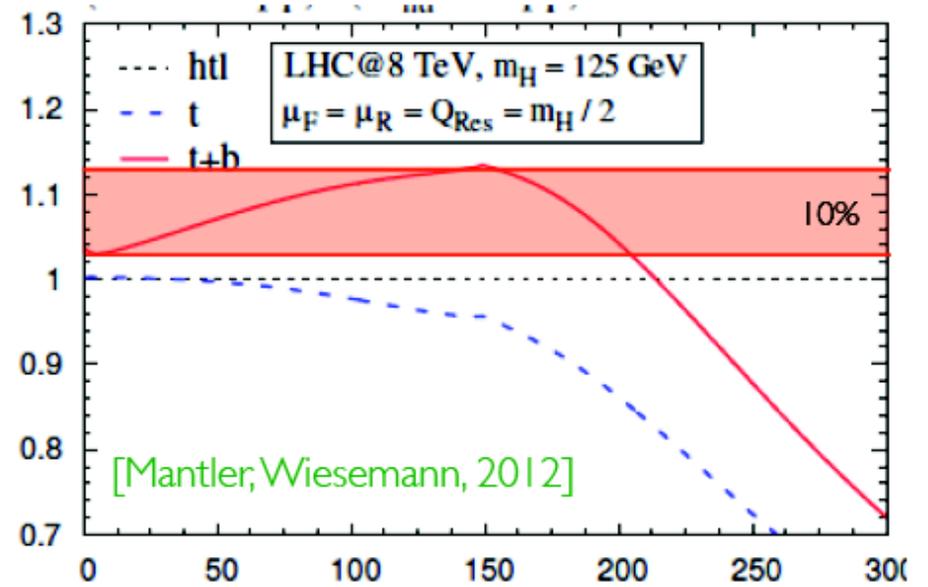
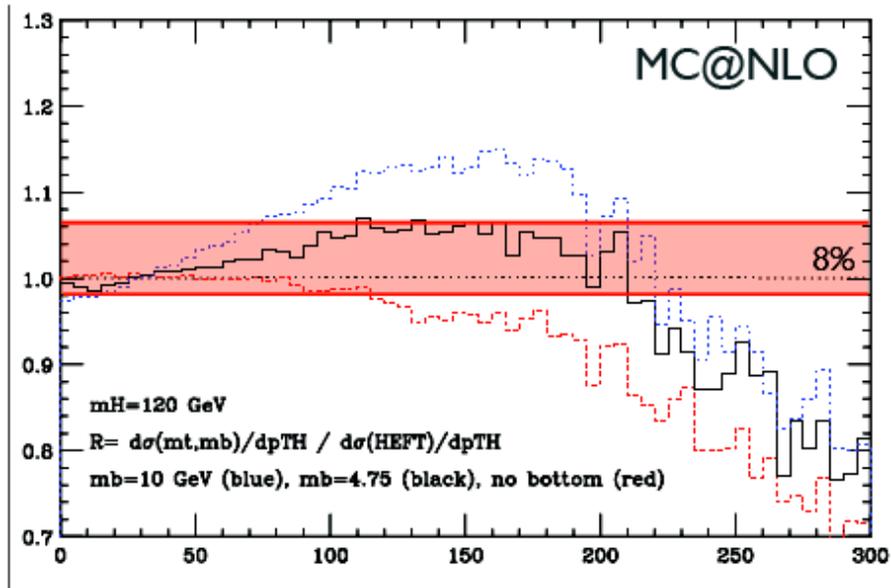


$m_t$  and  $m_b$  effects, relative to HEFT, in  $gg \rightarrow H^0$  at  $\mathcal{O}(\alpha_s^3)$

MC@NLO v4.08

POWHEG 1111.2854 (Bagnaschi, Degrandi, Slavich, Vicini)

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



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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

## Take-home message

aMC@NLO is even more flexible than it appears. It can be conveniently combined with existing calculations or tools for virtual matrix elements, in order to enlarge its present scope

This should be rather straightforward, thanks to standardization (BLHA). Please share with us your experience (and troubles)

## Physics-wise

aMC@NLO implements the MC@NLO formalism: what applies to the latter applies to the former. In particular (questions asked):

- ▶ We have never observed a significant dependence on the PDFs used in the shower phase. I suppose it shows up mainly at large rapidities. It can be checked systematically

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- ▶ Switch between MC- and ME-dominated regions accessible through inputs to some extent (new in aMC@NLO)

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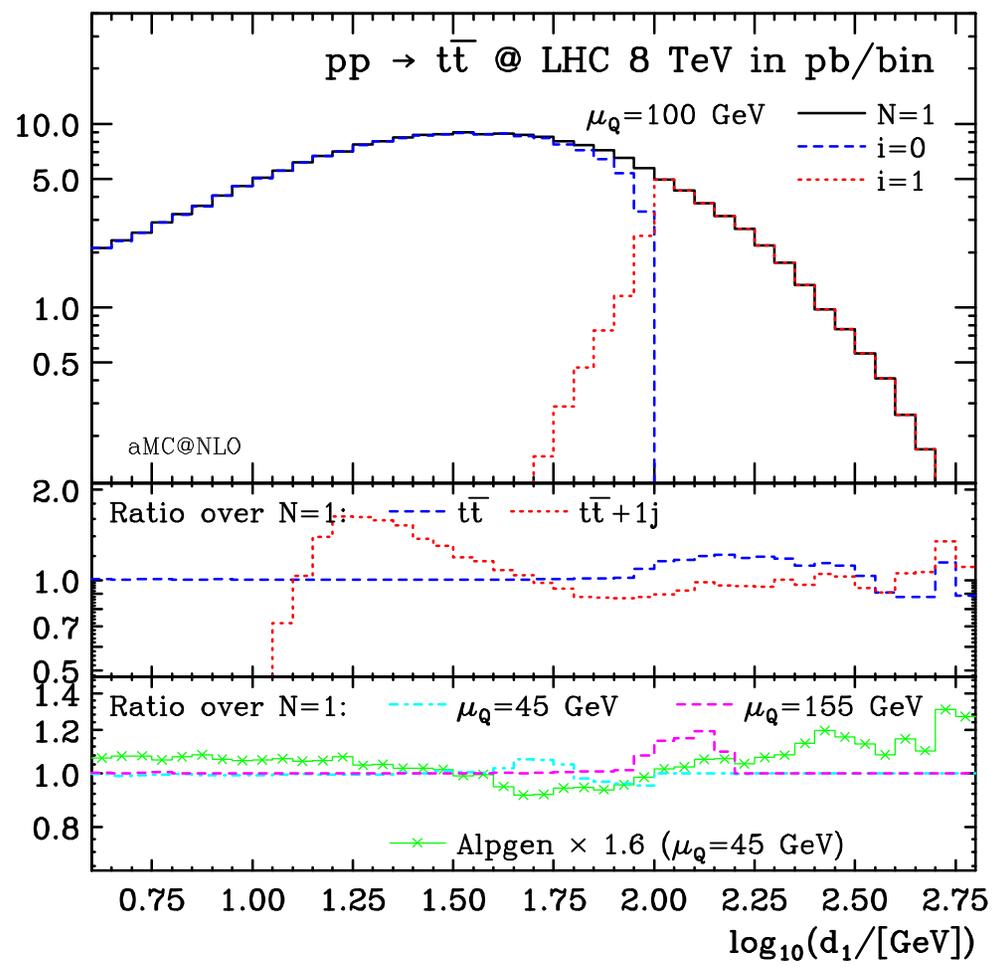
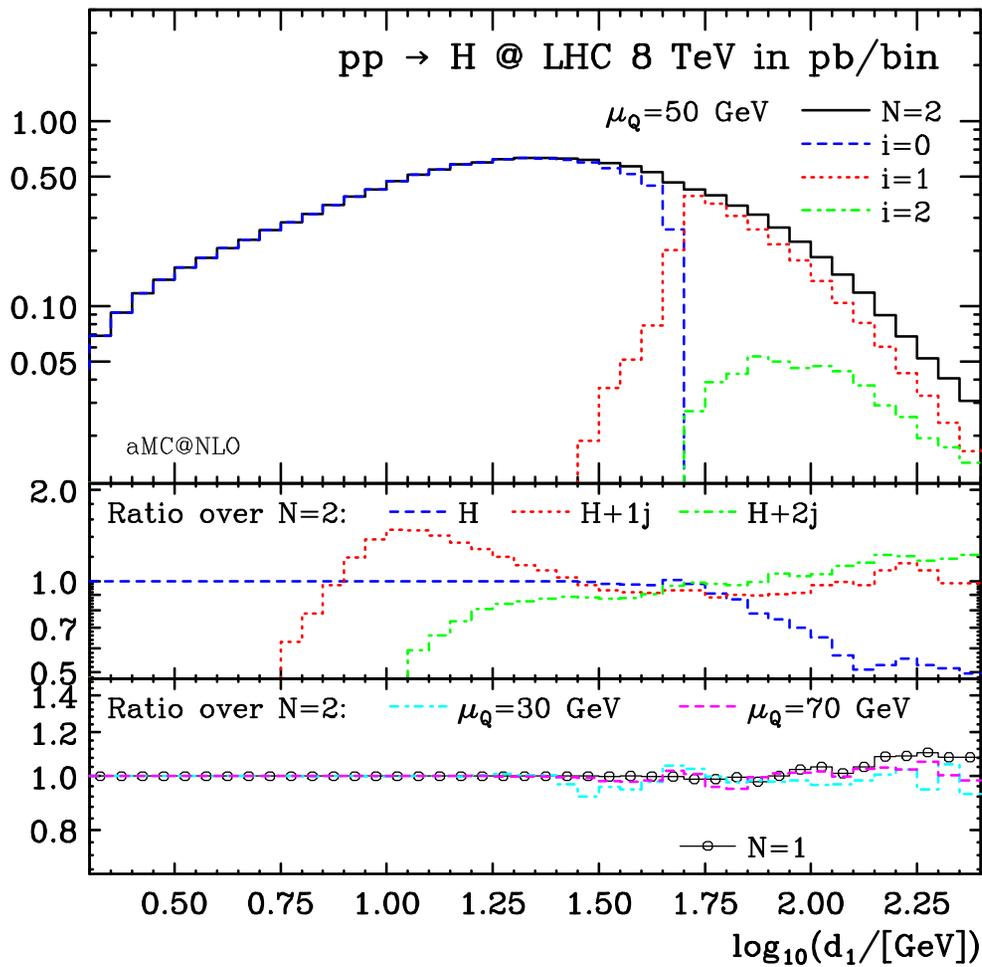
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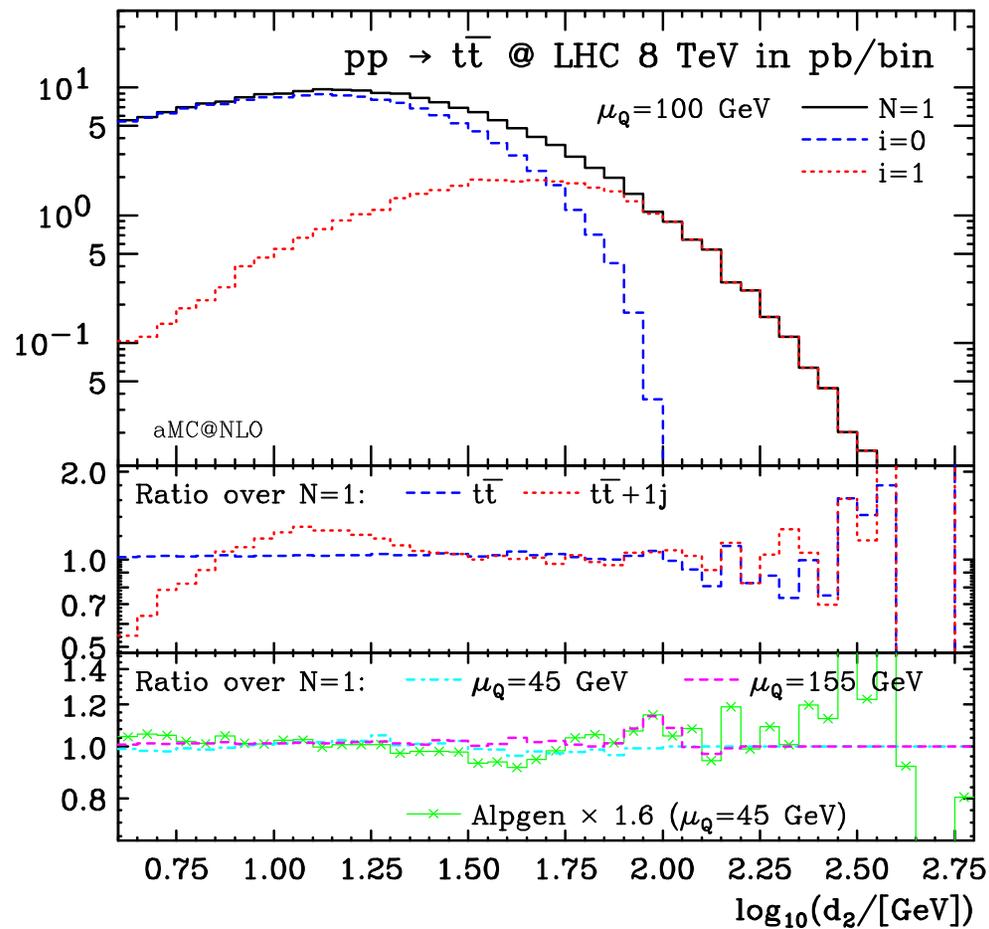
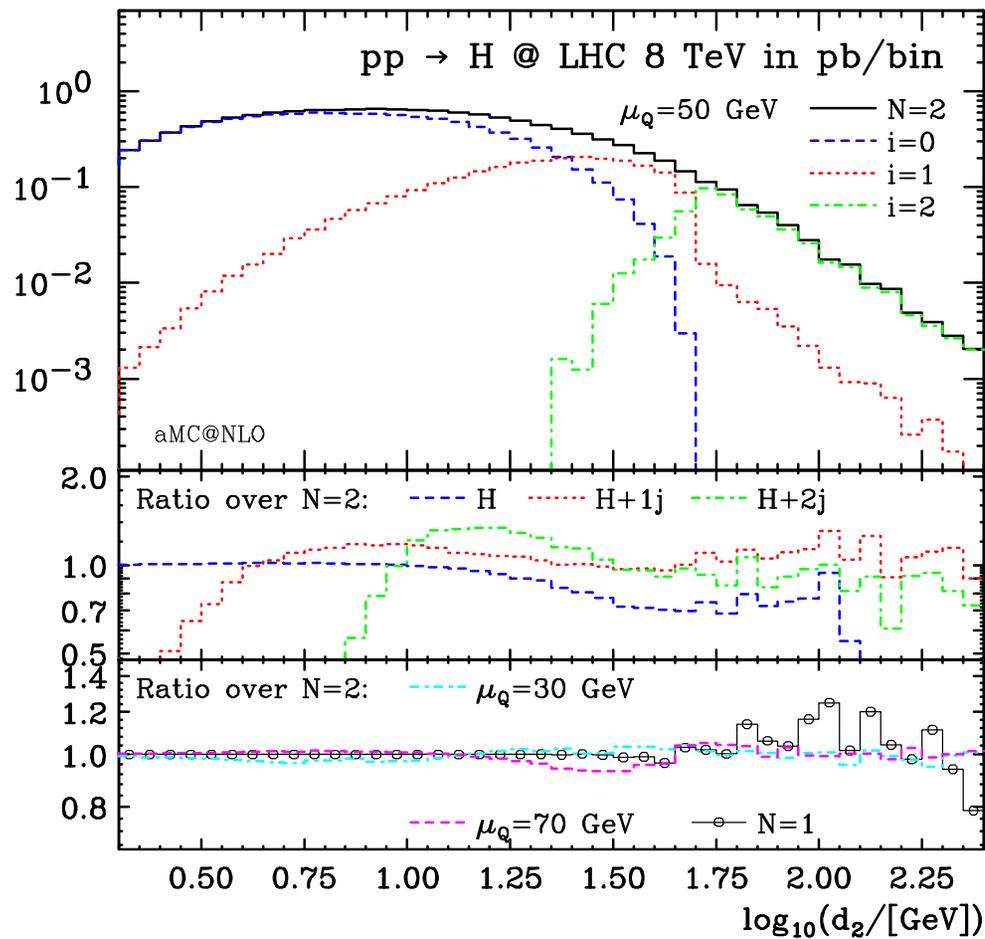
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$0 \rightarrow 1$  rates in  $H^0$  and  $t\bar{t}$  production



1 → 2 rates in  $H^0$  and  $t\bar{t}$  production

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- ▶ EW corrections, and their matching with showers
- ▶ Automation of loop-induced (finite) processes