NLO MC Group

Theory Status

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in collaboration with
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Main target

Provide the necessary support to the other lhc-higgs groups in terms of availability, documentation, and employment of the NLO MC tools for signal as well as backgrounds.

More in detail...

Unfolding our target

Target	Status
Provide (and keep it up-to-date) a short review of the generators available for each production channel.	done
Promote and support the use the best available MC tools in the experimental groups.	on-going
Review differences (possibly discrepancies) among generators and provide guidelines to the other groups.	ready-to-do
Provide guidelines for estimating uncertainties associated to different observables.	ready-to-do

Recommendation

Our recommendation (and target) for this group is to have all experiments use NLO+SMC as a default for Higgs signals (and possibly also for backgrounds when available)

THIS IS POSSIBLE ALREADY NOW FOR MOST HIGGS CHANNELS
(the only missing one, tth, is likely to be implemented soon).

NLO MC TH talk, Freiburg

Why? Example: ggF

Different differential calculations

$\sigma_{\rm acc}$ [fb] jet algorithm	$\mu = \frac{m_{\rm H}}{2}$ SISCone	$k_{\rm T}$	$\mu = 2\,m_{\rm H}$ SISCone	$k_{\rm T}$
LO	21.00 ± 0.02		14.53 ± 0.01	
HERWIG	11.16 ± 0.04	11.59 ± 0.04	7.60 ± 0.03	7.89 ± 0.03
NLO	22.40 ± 0.06		19.52 ± 0.05	
MC@NLO	17.42 ± 0.08	18.42 ± 0.08	13.60 ± 0.06	14.39 ± 0.06
$R^{\rm NLO}$(HERWIG)	19.79 ± 0.07	20.56 ± 0.07	14.61 ± 0.05	15.17 ± 0.05
NNLO	18.18 ± 0.43	18.45 ± 0.54	18.76 ± 0.31	19.01 ± 0.27
$R^{\rm NNLO}$(MC@NLO)	19.33 ± 0.09	20.43 ± 0.09	17.24 ± 0.07	18.24 ± 0.07
$R^{\rm NNLO}$(HERWIG)	22.02 ± 0.08	22.88 ± 0.08	18.65 ± 0.07	19.38 ± 0.07

Table 1: Cross-sections after the *signal cuts* of Ref. [33] are applied for different calculation methods. The statistical integration errors are shown expicitly. The MC@NLO and HERWIG cross-sections are evaluated with 1,000,000 generated events. The fixed-order results were computed in Ref. [33] and require the Monte-Carlo integration of multiple sectors [17].

- Good agreement between NNLO differential codes and MC@NLO, HERWIG rescaled to correct inclusive result

[see Petriello's tak today]

Why? Example: ggF

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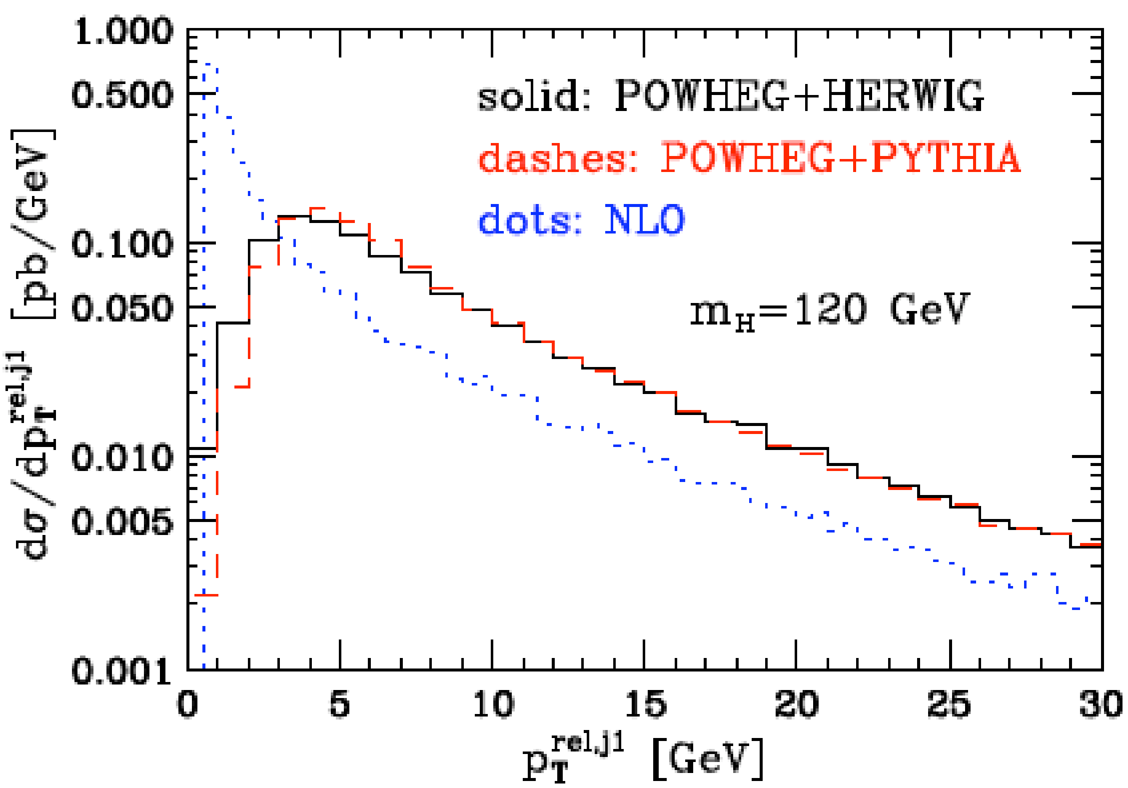
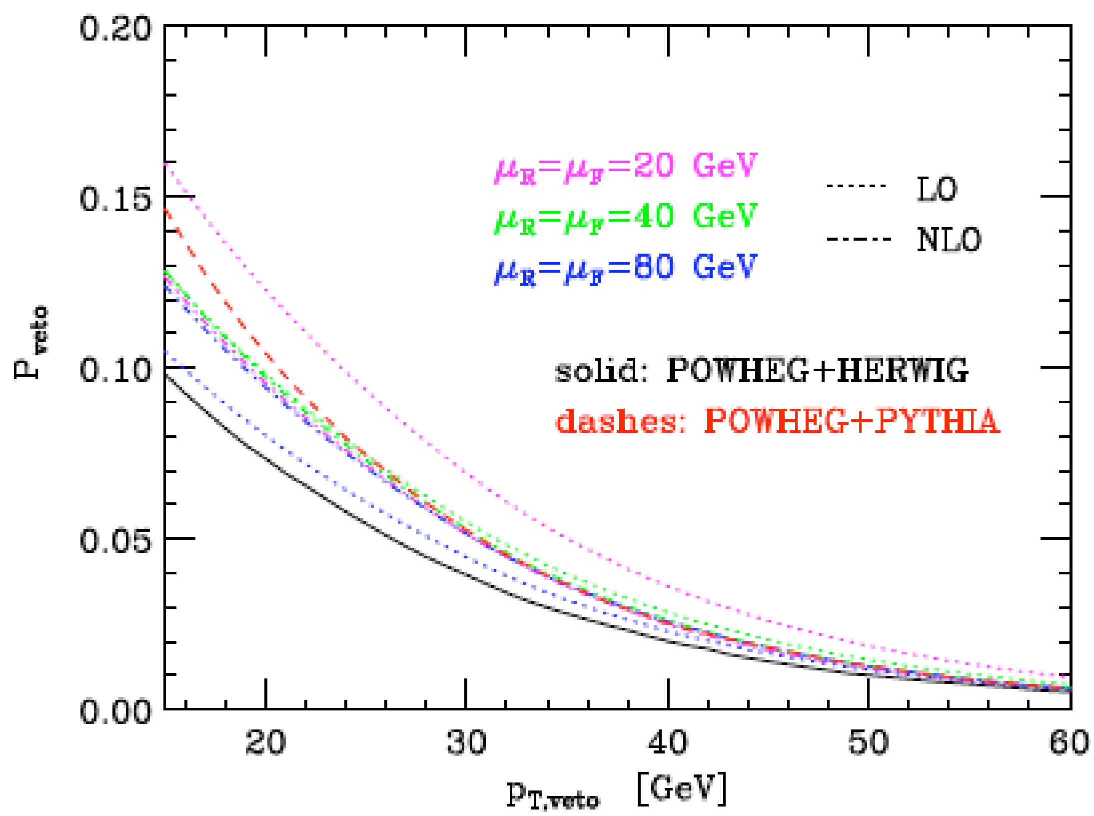
Why? Example:VBF

See also Farrington's talk..

[Oleari, Nason,2009]





Jet structure

$$P_{\rm veto} = \frac{1}{\sigma_2^{NLO}} \int_{p_{T,\rm veto}}^{\infty} dp_{\rm T}^{j,\rm veto} \frac{d\sigma}{dp_{\rm T}^{j,\rm veto}}$$

The shower effects are more important than NLO QCD scale variations!

See also [Del Duca et al. 2006]

Recommendation

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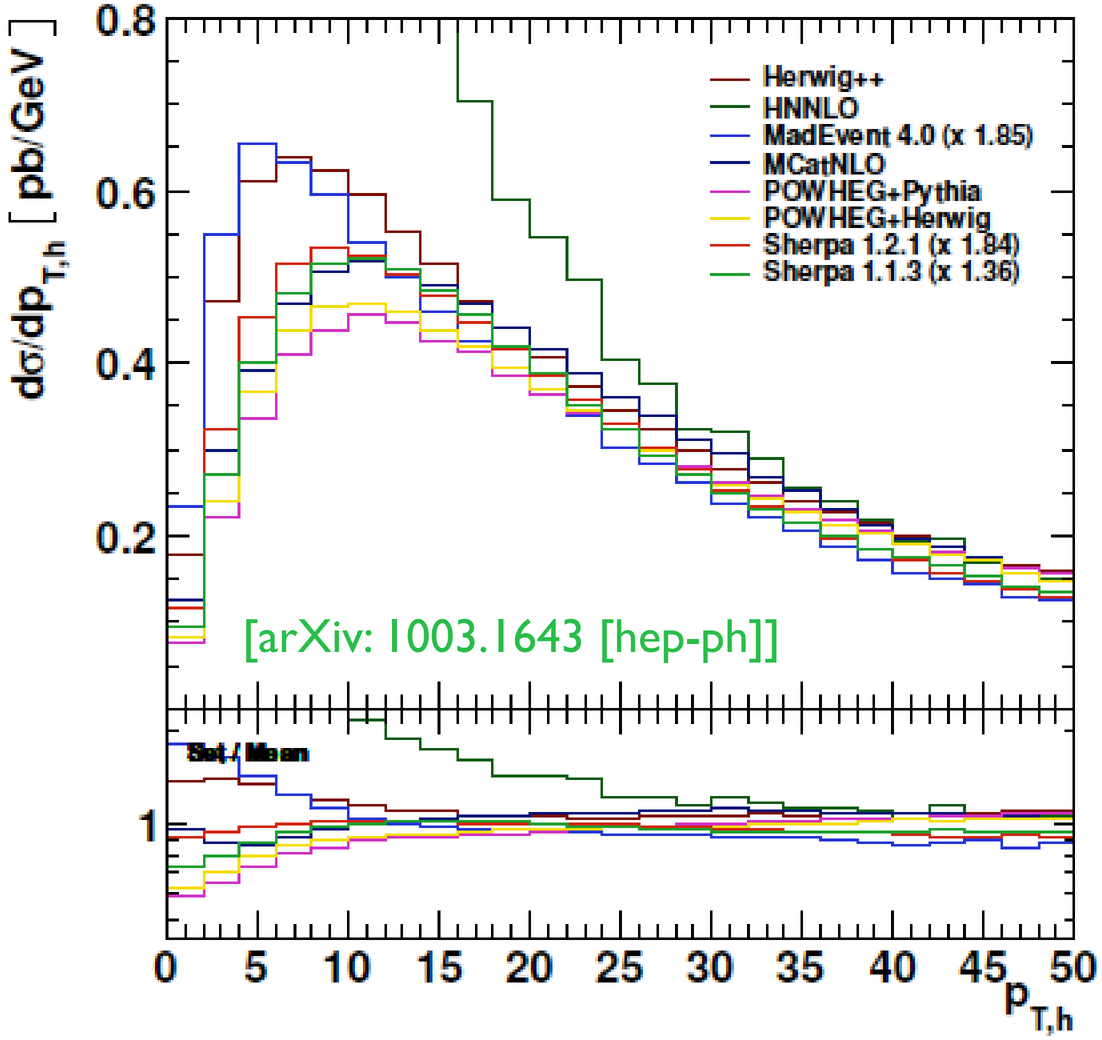
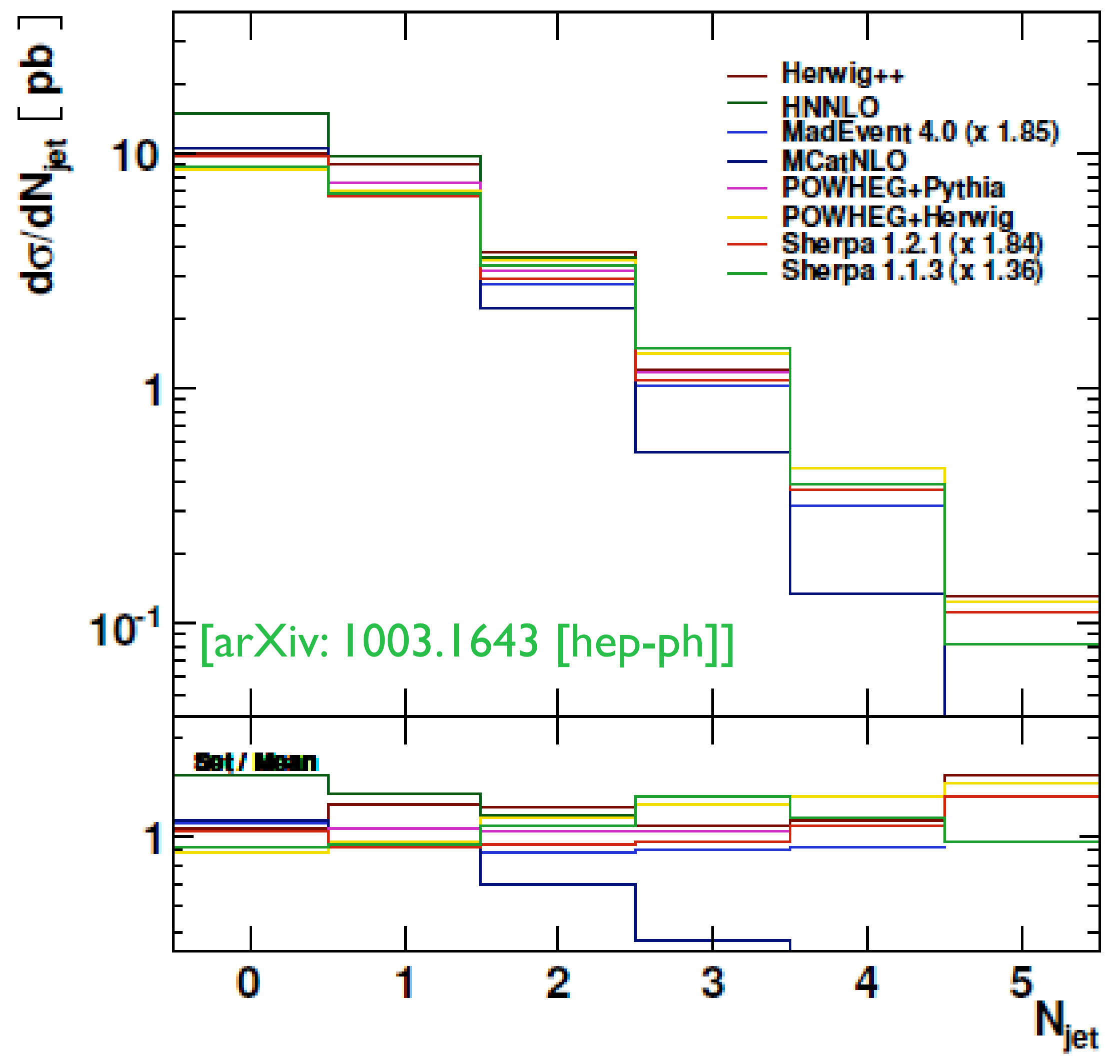
Channel	NLOwPS	MEwPS
ggF	MC@NLO, POWHEG	✓
VBF	POWHEG	✓
VH	MC@NLO, POWHEG	✓
ttH	NLO to be done	✓
BSM	tH^+, coupling rescaling	✓

Example : ggF





Les Houches comparison for ggF tools.

Signal : ready to go and compare with exp analyses

Example : ggF (Signal)

Status:

Main NLOwPS tools already employed by the exp collaborations.

Actions items:

1) Establish common CMS and ATLAS "MInimal but ReAlistiC AnaLysis Setups" (MIRACLES) for the first analyses (for example for WW) in each channel group.

2) Study and provide guidelines for estimating TH uncertainties (PDF, scales, LO vs NLO observables...) within the MIRACLES.

3) Start addressing more advanced questions: e.g., are there ways to use data to validate (at least for some features) of the signal MC's?

Example : ggF (Background)

Status:

To be addressed. Much wider scope and effort.
However, general principles and approaches can be studied on some urgent cases.

Actions items:

1) Focus on first-data analyses and identify the backgrounds for a given production+decay channel.

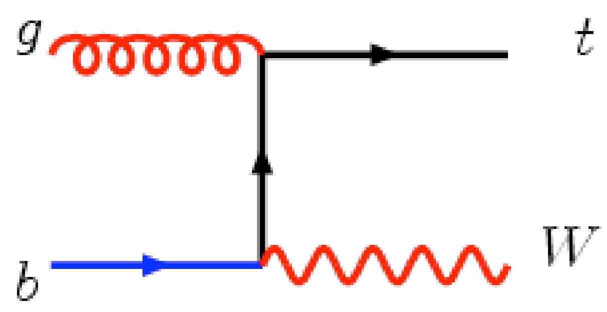
2) Within the MIRACLES address first the easy questions (guidelines for estimating TH uncertainties (PDF, scales, LO vs NLO observables...)) and then the key questions (how to use data to validate/tune the background MC estimations).

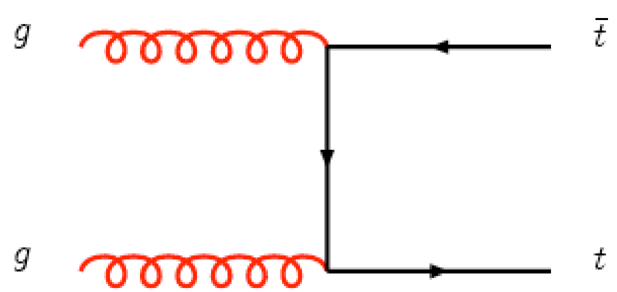
Example : $gg \rightarrow H \rightarrow W^+W^-$

- Signature : 2 opposite charge leptons + “no extra radiation”
- Signal very well studied, including comparisons between NNLO and MC@NLO.
- Main backgrounds:
  - ★ irreducible : WW continuous (see Nicolas’ talk...)
  - ★ reducible : top (tt and tW)
- Other backgrounds:
  - ★ reducible: W,Z,ZZ,WZ,QCD, bb, instrumental...

Example: top backgrounds to $gg \to H \to W^+W^-$

[White et al. , arXiv:0908.0631]





The MIRACLE:

1. There should be two opposite sign leptons satisfying $p_T > 25$ GeV and $|\eta| < 2.5$.
2. The invariant mass of the charged lepton pair should satisfy 12 GeV$< m_{ll} < 40$ GeV.
3. The azimuthal angle between the leptons (i.e. the angle in the transverse plane) should be less than $\pi/4$.
4. The lepton with the highest p_T should satisfy 30 GeV$< p_T <$55 GeV
5. There must be a missing transverse energy of at least 50 GeV.
6. There must be no jets (i.e. either b or light jets) with $p_T > 25$ GeV and $|\eta| < 2.5$. ☜ jet veto

Example: top backgrounds to gg→H→W$^+$W$^-$

[White et al. , arXiv:0908.0631]

Results:

Process	σ_{NLO}/fb	Code
$h \to WW$	81.8 ± 0.4	MC@NLO
$t\bar{t}$	12.25 ± 0.33	MC@NLO
Wt (DR)	6.91 ± 0.062	MC@NLO

Conclusions:

1. ttbar and tW are of similar order (and distinguishable) in this phase space region.
2. The whole analysis (including continuos WW) can be done within MC@NLO.
3. Background validation could be done in control regions (with complementary cuts) and in the 1 and 2 jet bins with similar cuts... (for this WW+1and 2 jets at NLO would be useful..)

Outlook

- We are ready to support the production channel groups in the next phase (beyond total cross sections).
- We strongly recommend the exps to use NLOwPS (and whenever it suitable also MEwPS) for both signal and, whenever possible, also for backgrounds. Comparison with “theoretical” (parton-level) calculations should start from there.
- For the background estimation, we would be happy to discuss/support data validation/extrapolation strategies.