VBF/VH discussion

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Point of discussions

Few Common issues

- Uncertainties due to PS, matching, merginig
- EWK correction and uncertainties

VH signal generators

VBF signal generators

ggH contamination in VBF analysis categories

EFT tools for HVV vertex

VVjj

Matching/Merging and PS

Powheg+Pythia8 and **main31**

In run 1 we did not make extended use of main31, but the collaboriation has already checks and studies on it.

Is **hdamp** expected to be an important variable in powheg for VBF/VH sample?

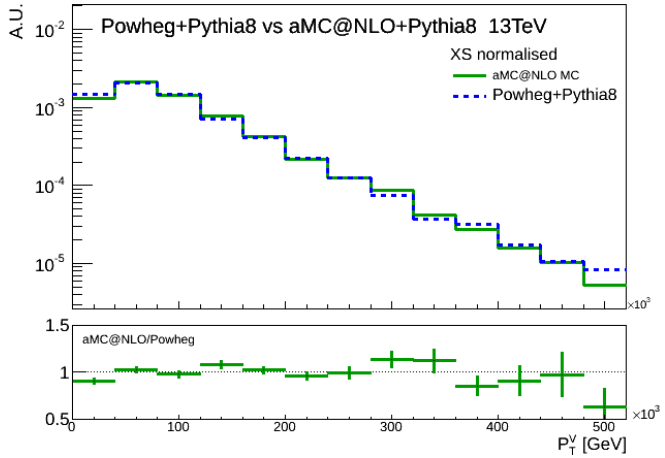
If so, **which is the favorite scale for it?**

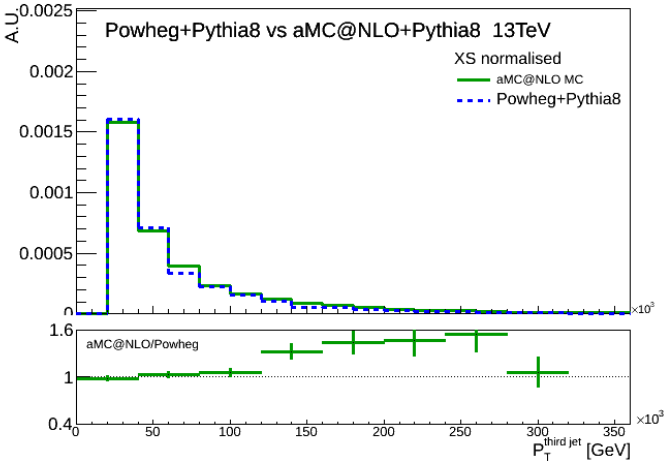
How to estimate the systematics?

Matching/Merging schemes:

Are the size of the differences seen before on the first additional jet expected?

(NOTE: Powheg MiNLO HZJ and Powheg HZ show differences for the second additional jet in the event)





Common source of uncertainties

Matching Uncertainty:

How do we estimate uncertainties on this? compare POWHEG VS aMC@NLO(0,1,2 jets) with same PS

or/and powheg with different matching schemes?

UE/PS Uncertainty:

during Run1 estimated in different ways:

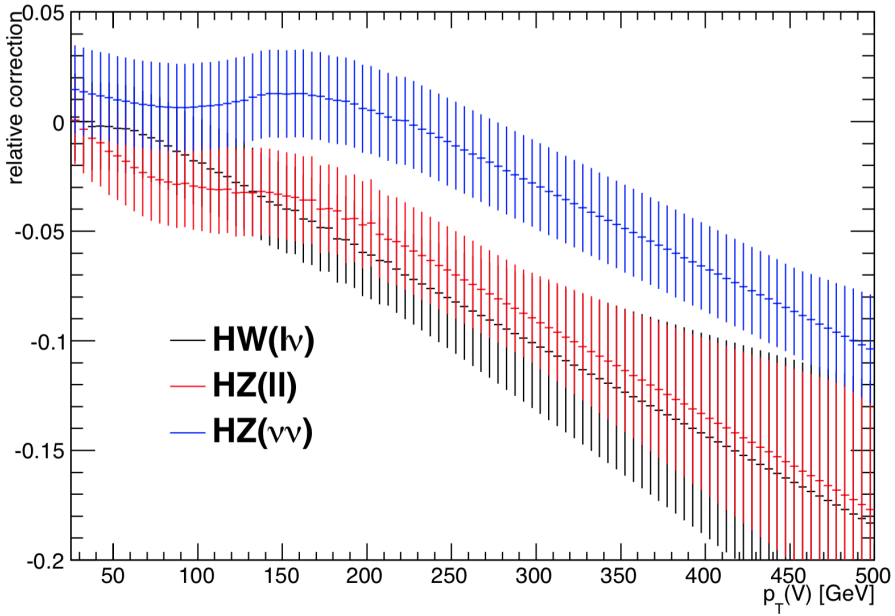
- compare acceptance to two different tunes
- switch off MPI
- compare acceptance with two different PS (need to be careful not to double count QCD scale unc)
- for Run2: compare effect of different eighentunes?

Quantitative understanding of these types of uncertainties in systematic way.
Are there other cross sections (W/Z+jets) that can be used to test these differences with well-known (and large) cross sections?

EW corrections:

Very nice to get these for run 1: probably we should start working to get the new corrections for 13 TeV (if not there yet)

Maybe there are already some groups working to get the EW corrections already available for in the MC generators (including PS/hadronization/UE)?



NNLO, parton level and particle level

We already use the **NNLO+NLO(EW) calculation to get the overall normalization for our samples**.

It comes with dedicated systematics on scale and PDF (Yellow report).

But for the analysis we need to get event generators (i.e. listed in slide 2).

There are already NNLO partonic prediction on the differential cross sections.

Can these predictions be used to weight or to estimate systematics the events generated ?

[*NNLOPS-like approach for VH?]*

For VH the NNLO differential calculation predicts a reduction of the cross section by ~ 15% when one try to cover the phase space used by the LHC analyses (with jet veto).
Is this already taken into account to some level in the generators?

What about the scale variation?

NNLO, parton level and particle level

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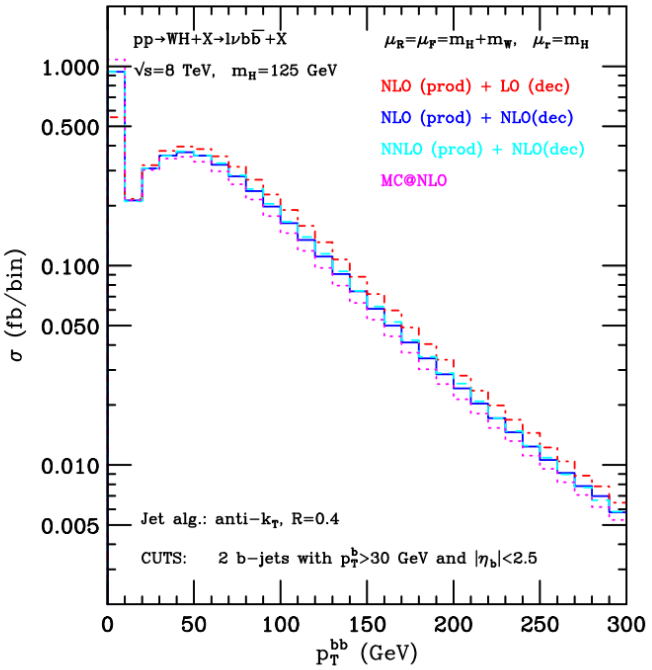

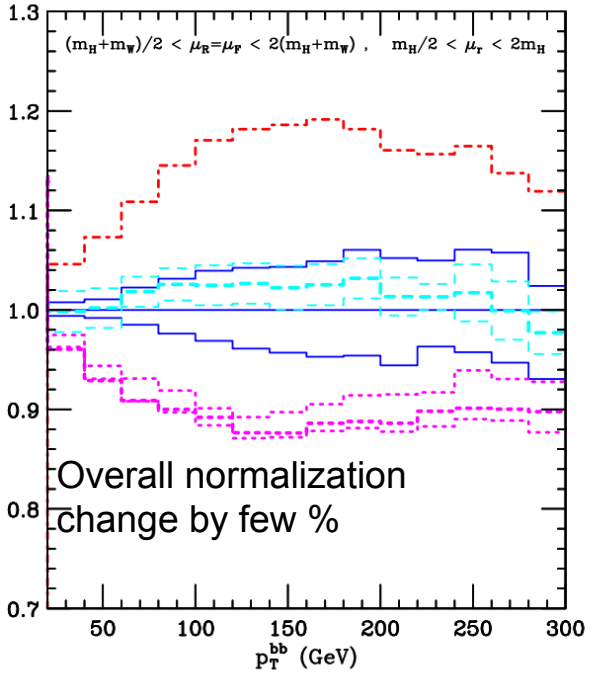

Ferrara,Grazzini,Tramontano arXiv:1312.1669

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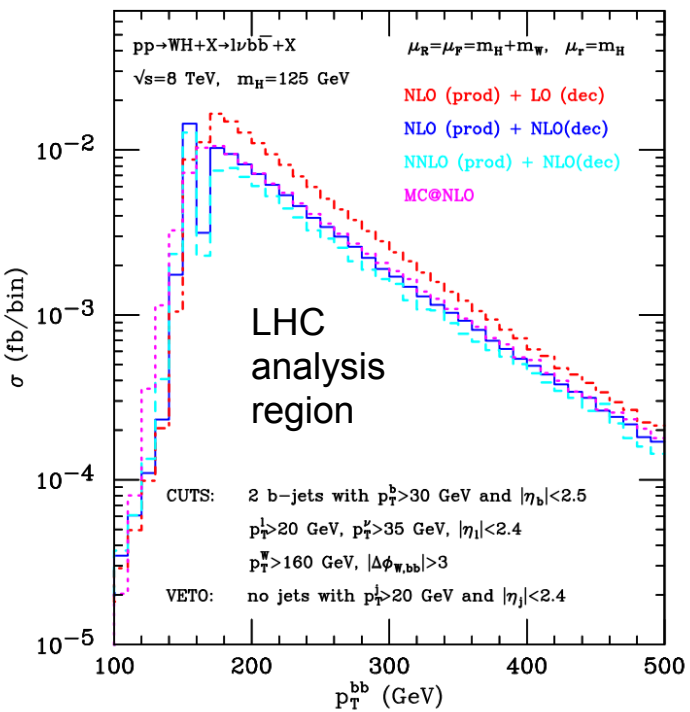

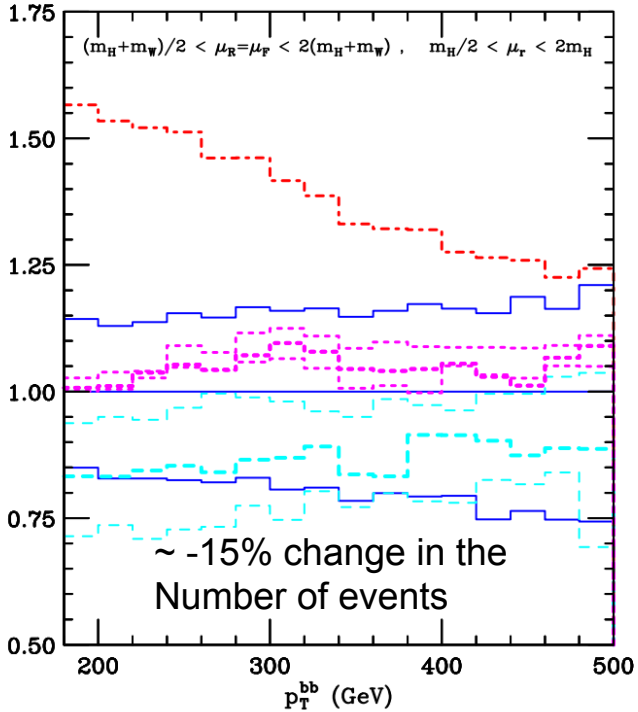

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Generators for VH (NLO, 0j, 1j, ...)

quark initiated: **Powheg(+MiNLO) , MADGRAPH5_aMC@NLO, Sherpa, PowhwgHerwig++**

gluon initiated: **Powheg, MADGRAPH5_aMC@NLO, Sherpa, Herwig++ ?**

It would be useful to have **all the decay modes for H and V available**, so that we have a **common signal setting for all the channels.**

For the moment, we got experiences with Powheg(+MiNLO), and we start to get experience with MADGRAPH5_aMC@NLO.
Next steps:

MADGRAPH5_aMC@NLO 0+1(+2?), and Sherpa

Other available?

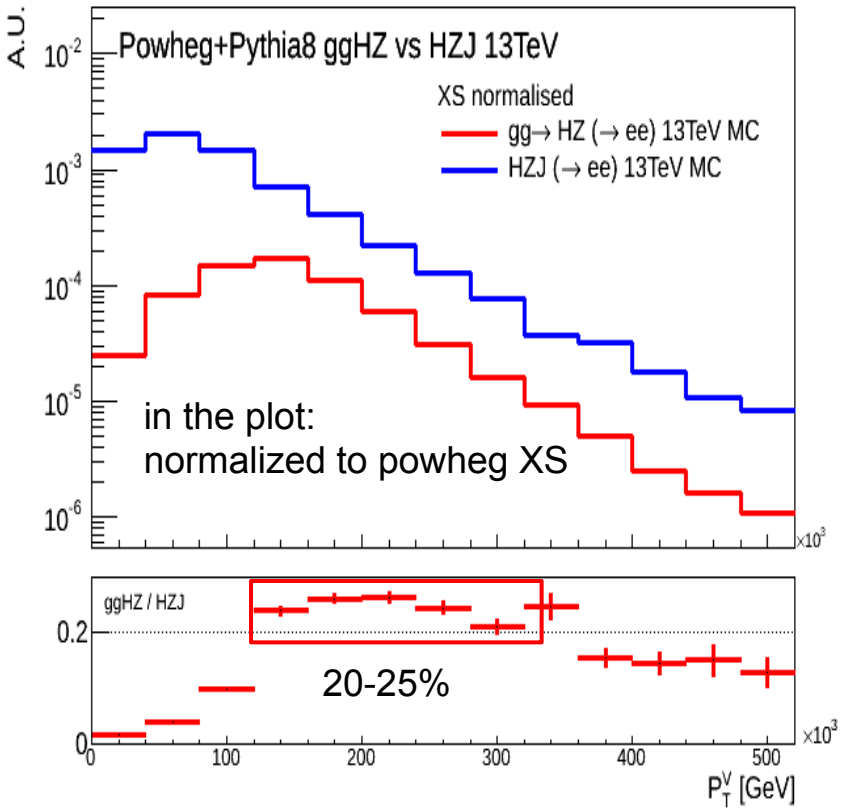
Apart the Powheg VS MC@NLO matching/merging differences, should we expect to have others?

ggZH

This process still have big uncertainties, and it will play a bigger role at 13 TeV.

Uncertainty in normalization in Run1 VHbb: ~50%.

Is there any chance to get a more robust estimate of this signal, so that the systematics can be reduced?



VBF Signal Generator

POWHEG BOX/aMC@NLO/HERWIG++ have implemented VBF HJJJ NLO production

- 3rd jet at NLO, improve description of CJV
- under study in ATLAS
- would a MINLO/FxFx procedure be feasible for HJJ and HJJJ?

Need LHE accord 3 implemented to easy calculation of scale variations and PDF unc

ggH contamination

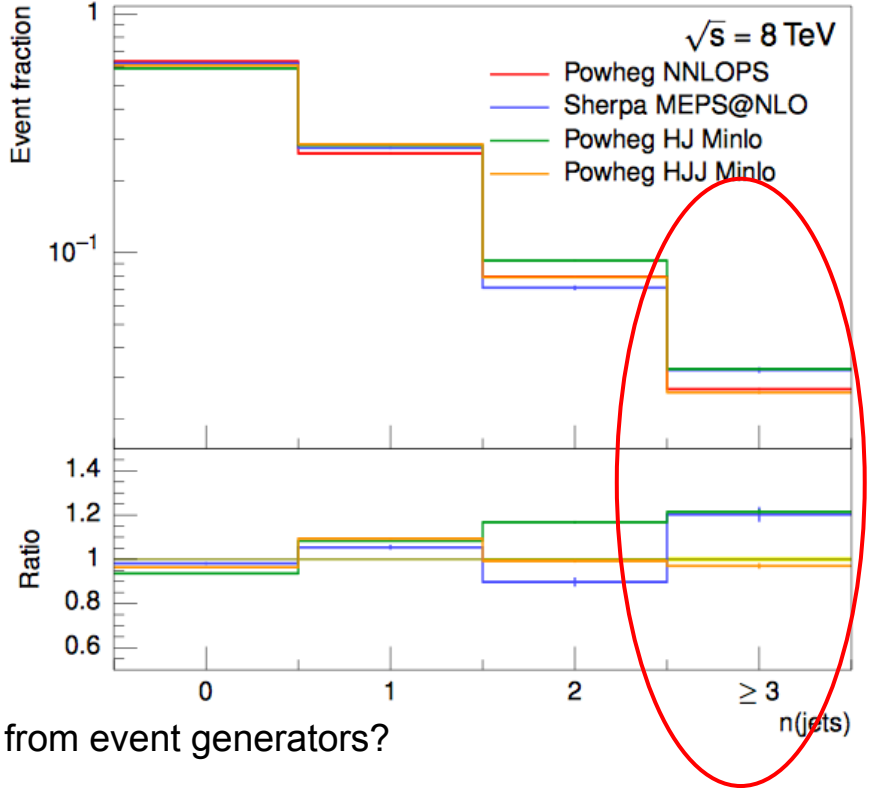
ggH in VBF-like region: H+2jets at NLO

- POWHEG-HJJ/MEPS@NLO/aMC@NLO

LO scale variations on σ(>=3 jets): ~ 70%

goSam: HJJJ NLO

- ntuples with differential cross sections
- plug-in to SHERPA (in development)



at ATLAS, we started to work with goSAM nutple! Thanks!

- can use goSAM ntuples to benchmark cross sections from event generators?
- use goSAM input for JVE unc method?

NOTE: not all analysis use CJV, often loose selection, and MultiVariate discriminant

need way to propagate scale variations to full-sim samples: LHE accord 3?

CP-violation in HVV vertex:VBF

Cuts applied:
[pT(parton) > 20 GeV
Δη(parton1,parton2) > 2.8,
M(parton1,parton2) > 500 GeV]

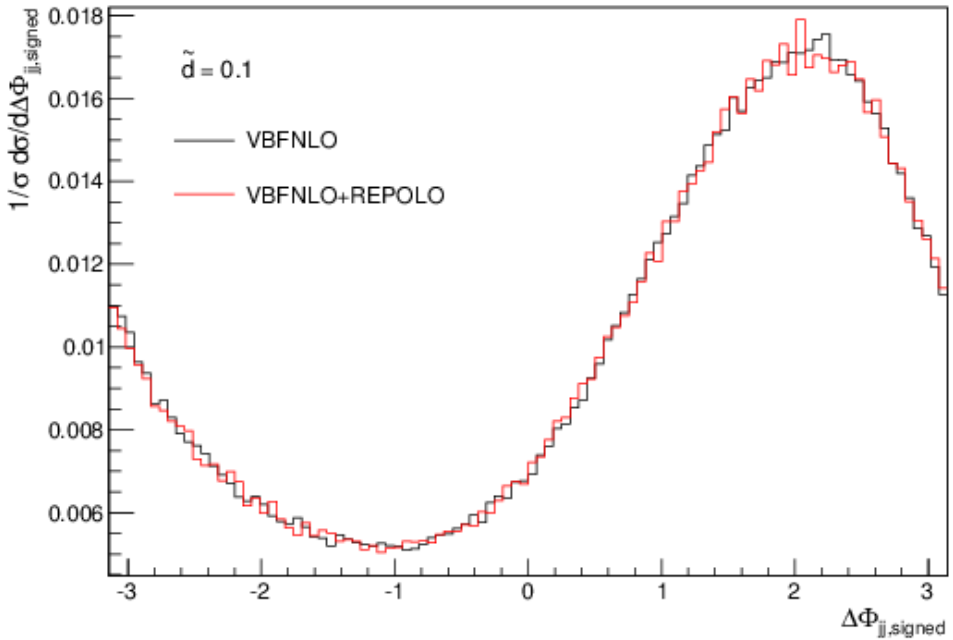
VBFNLO (SM LHE LO files)+ REPOLO (SM + d~=0.1)
versus VBFNLO (BSM, SM + d~=0.1)
→ closure test

note: no form factors used

where are the validity limits on VBF EFT?

- form factors
- Lambda scale

how do we determine them? how do we test if model violate unitarity?



CP-violation in Higgs sector: next steps

- use REPOLO with POWHEG LO events

- compare with aMC@NLO anomalous couplings
  - both LO and NLO anomalous coupling aMC@NLO with SM+REPOLO
  - test also re-weight from aMC@NLO

Similar studies will be performed for VH production mode as well

VVjj

$W^{\pm}W^{\pm}$ jj ATLAS analysis (see http://arxiv.org/abs/1405.6241)

Signal modelling:

- any progress on VBS EWK and Strong production NLO interference calculation?
- possible to move VBS into POWHEG v2? and include all the decay modes?

Background (and WZ signal):

- WZjj : no NLO implementation with PS. One of larger systematic uncertainties

Back Up

General scattering amplitude for spin zero boson decaying into two gauge bosons:

$$A(X \to V_1 V_2) = \frac{1}{v}\left(\underbrace{g_1^{(0)} m_V^2 \epsilon_1^* \epsilon_2^*}_{\text{SM}} + g_2^{(0)} f_{\mu\nu}^{*(1)} f^{*(2),\mu\nu} + g_3^{(0)} f^{*(1),\mu\nu} f_{\mu\alpha}^{*(2)} \frac{q_{2\nu} q_1^{\alpha}}{\Lambda^2} + \underbrace{g_4^{(0)} f_{\mu\nu}^{*(1)} \tilde{f}^{*(2),\mu\nu}}_{\text{CP-odd}}\right)$$

$$\frac{|g_4^{(0)}|}{|g_1^{(0)}|_{WW}} = \tilde{d}$$