LHC Higgs Cross Section WG: VBF Status Report

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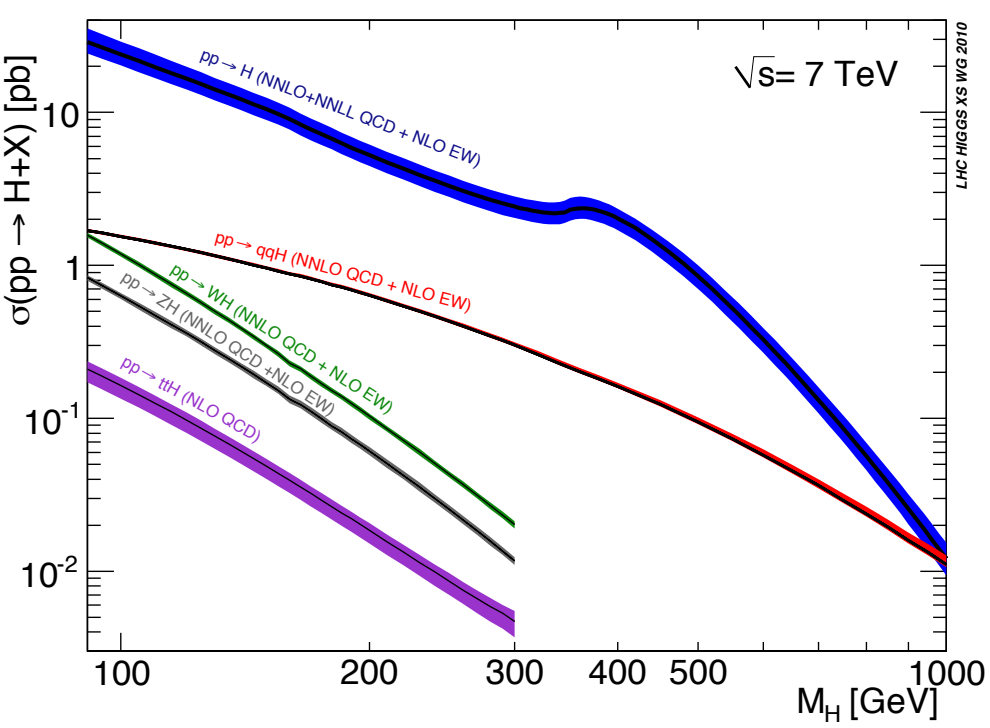
Collaborators: P. Bolzoni, S. Dittmaier, B. Quayle, F. Maltoni, C. Mariotti, S.-O. Moch, A. Mueck, P. Nason, S. Palmer, G. Passarino, R. Tanaka, G. Steele, M. Zaro

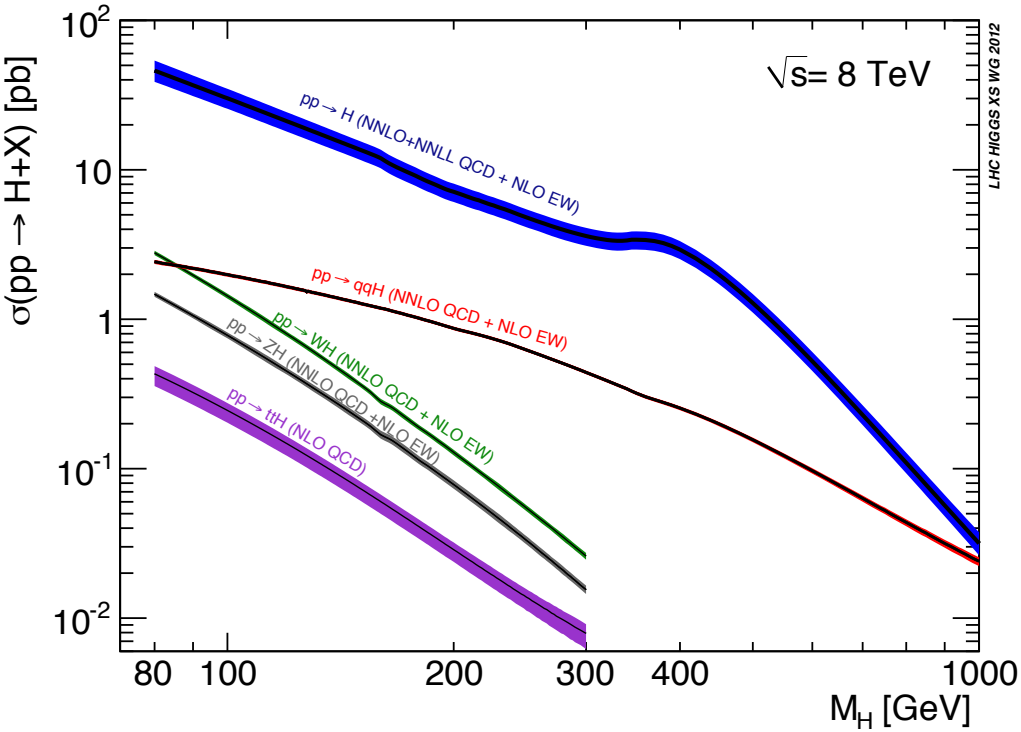
VBF calculations and programs

- **VV2H** [M. Spira]: only t-channel, NLO QCD http://people.web.psi.ch/spira/vv2h/
- **VBFNLO** [D. Zeppenfeld et al.]: only t-channel, NLO QCD + NLO EW arXiv:1107.4038
- **MCFM** [J. M. Campbell, R. K. Ellis, C. Williams]: only t-channel, NLO QCD hep-ph/0403194
- **HAWK** [M. Ciccolini, A. Denner, A. Dittmaier, A. Mück]: NLO QCD and NLO EW, s- and t-channel (s-channel can be switched off), CPS reweighting arXiv:0707.0381
- **VBF@NNLO** [P. Bolzoni, F. Maltoni, S.-O. Moch, M. Zaro] only t-channel, CPS reweighting arXiv:1003.4451
- **POWHEG** [C. Oleari, P. Nason]: only t-channel, NLO QCD + PS, CPS reweighting arXiv:0911.5299
- **aMC@NLO** [S. Frixione et al.] t-channel only, s-channel can be included *paper to appear*
- **Sherpa**: [F. Krauss et al.] automatically includes s-channel https://sherpa.hepforge.org/trac/wiki
- **PHANTOM**: [A. Ballestrero, E. Maina et al.] full calculation @ LO for six fermions final state arXiv:0801.3359
- **Pythia/Fortran-Herwig**: only t-channel

new cross-sections @ 8 TeV

- 7 TeV and 8 TeV cross-sections produced this summer with finer binning
- complex pole scheme applied over the full mass range (it was zero-width below 290 GeV beforehand)
- QCD scale and PDF+alpha$_S$ uncertainties estimated





VBF in aMC@NLO

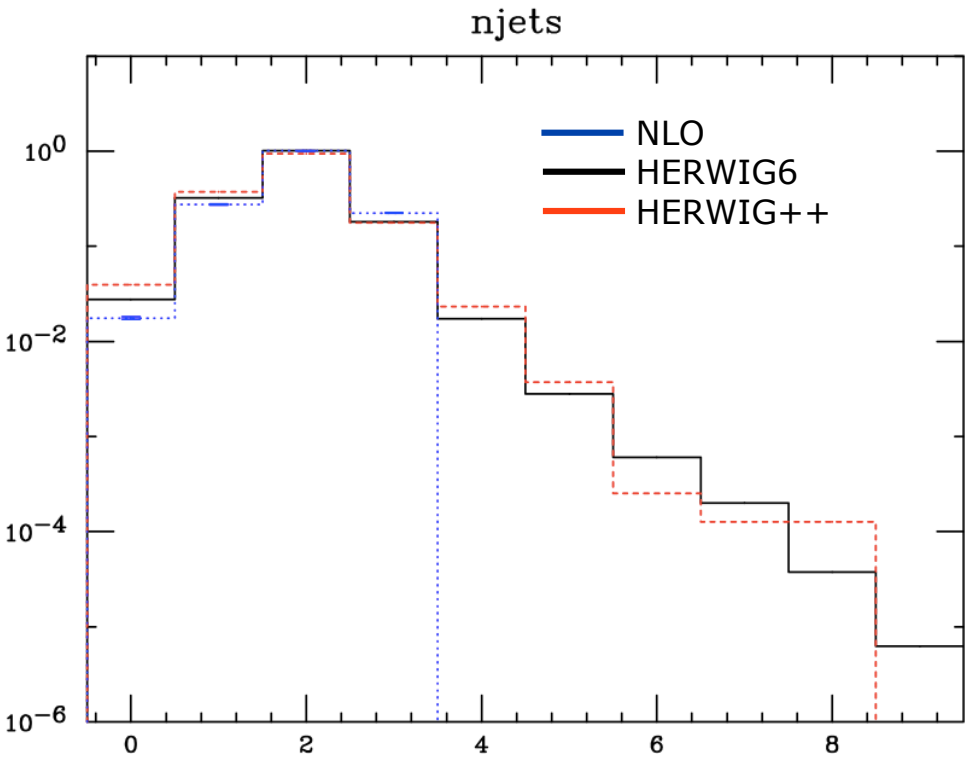
- comparing fixed-order NLO to herwig6 and herwig++ hadronization
- min jets p_T = 20 GeV, kT jets with cone size = 0.7
- same VBF selections as the POWHEG paper (arXiv:0911.5299)

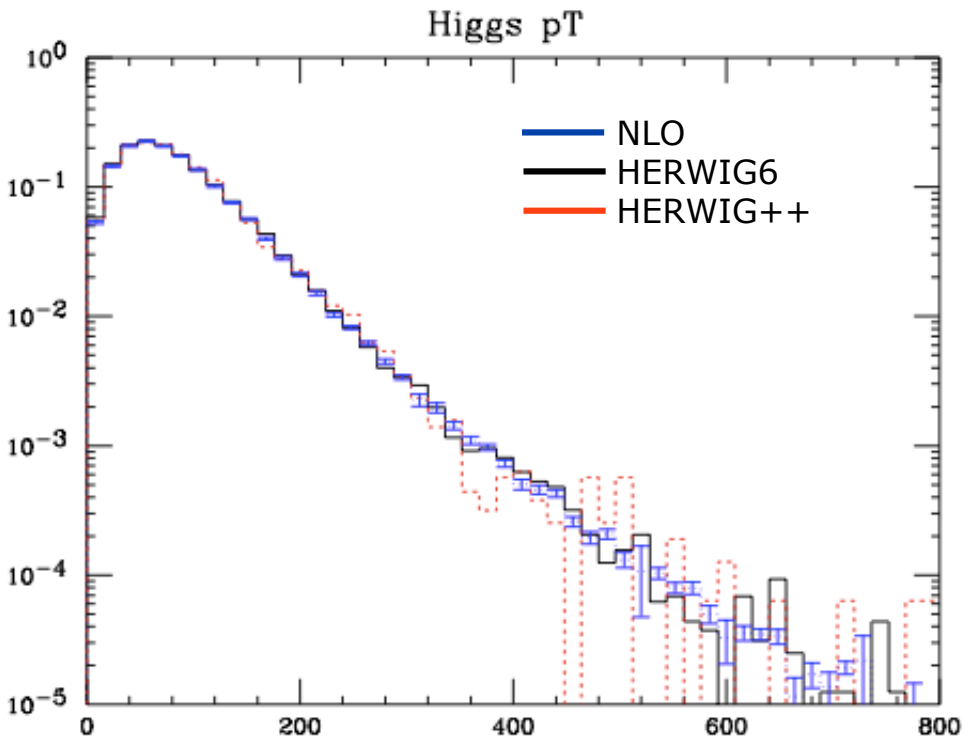
$$p_{\mathrm{T}j} > 20\ \mathrm{GeV}, \qquad |y_j| < 5\,.$$

$$p_{\mathrm{T}}^{\mathrm{tag}} > 30\ \mathrm{GeV}, \qquad |y_{j_1} - y_{j_2}| > 4.2\,, \qquad y_{j_1} \cdot y_{j_2} < 0\,, \qquad m_{jj} > 600\ \mathrm{GeV}\,,$$

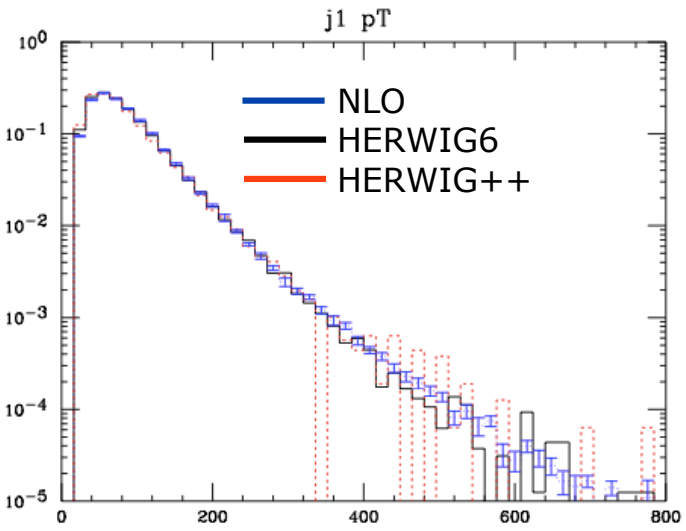
- next steps:
  - compare HERWIG and PYTHIA hadronizations
  - compare to POWHEG
- work is ongoing

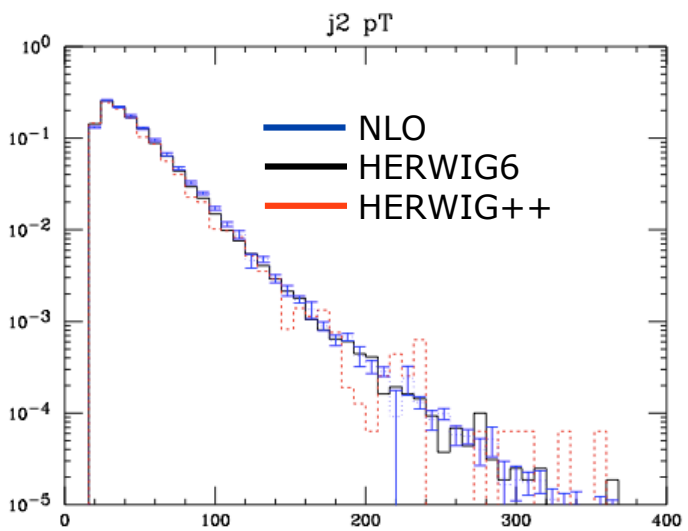
no VBF cuts

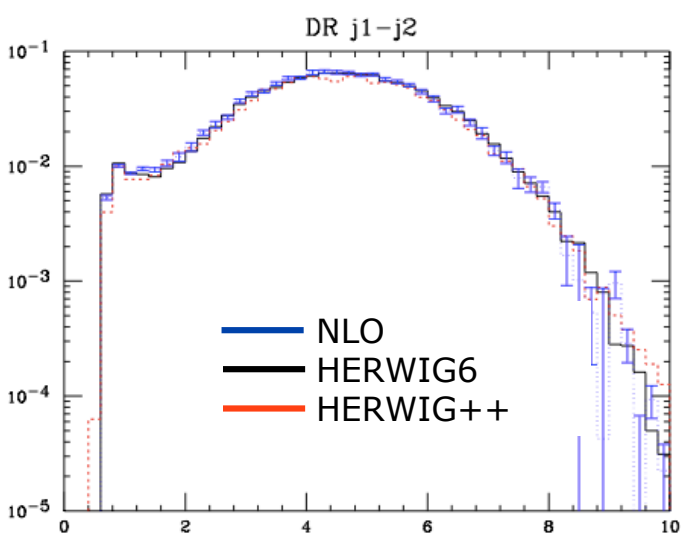

njets
NLO
HERWIG6
HERWIG++
10^{0}
10^{-2}
10^{-4}
10^{-6}
0
2
4
6
8

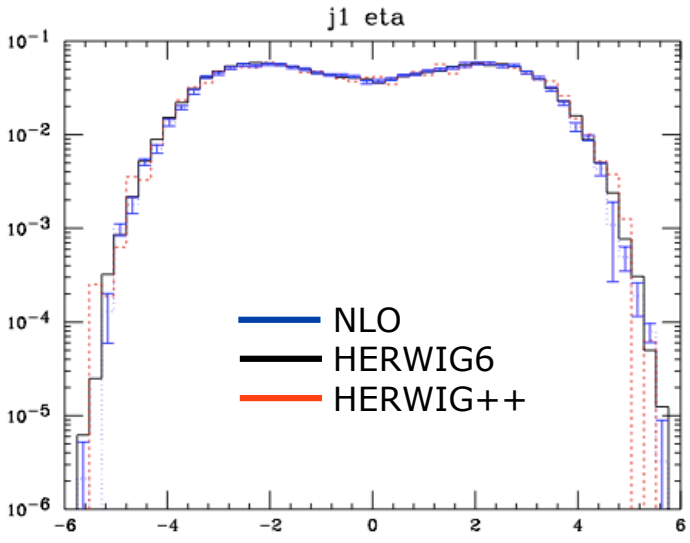

Higgs pT
NLO
HERWIG6
HERWIG++
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
200
400
600
800

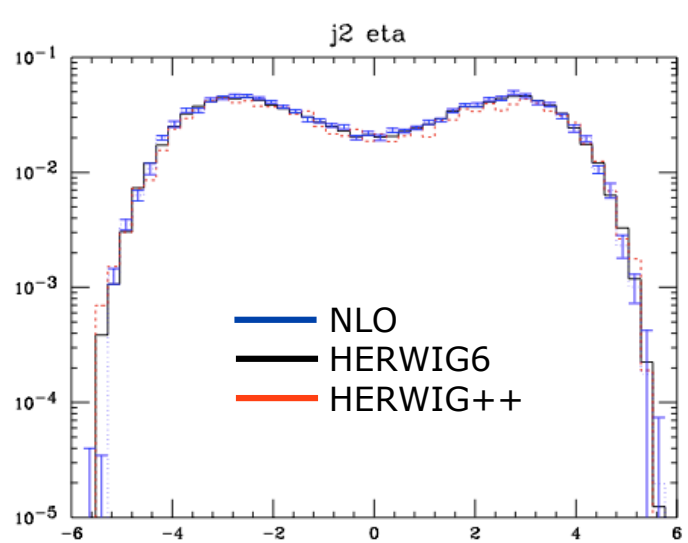
first two jets, no VBF cuts

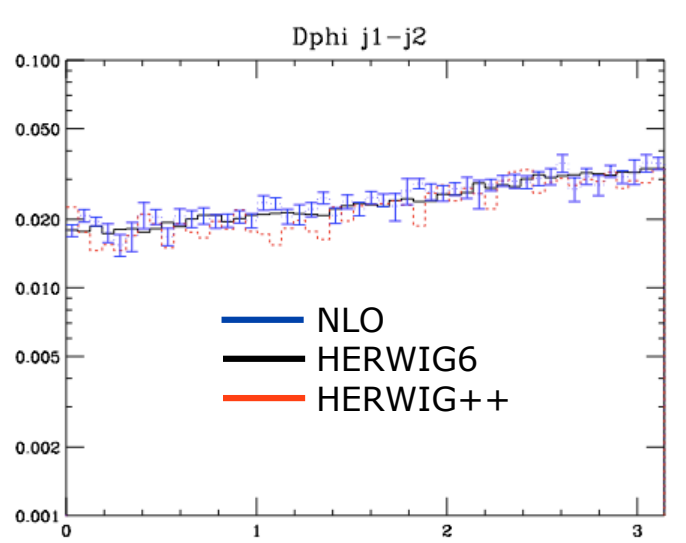




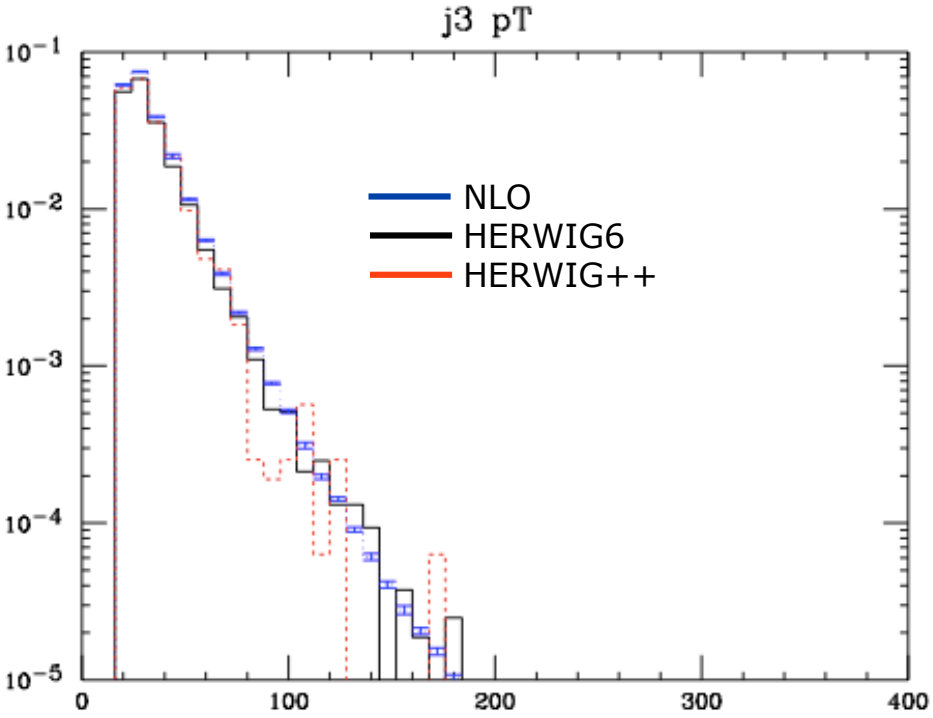


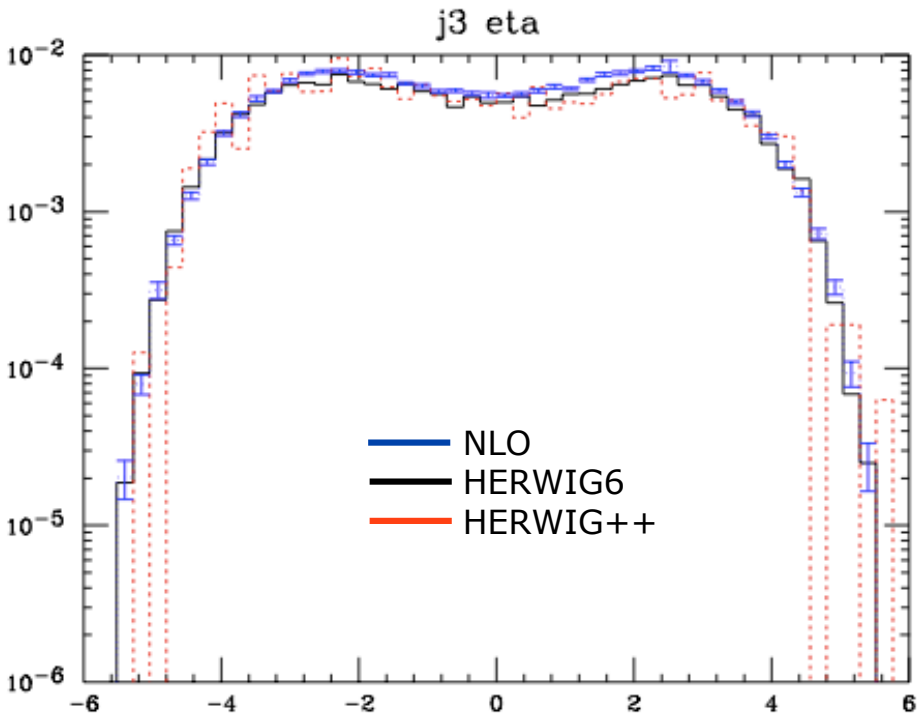




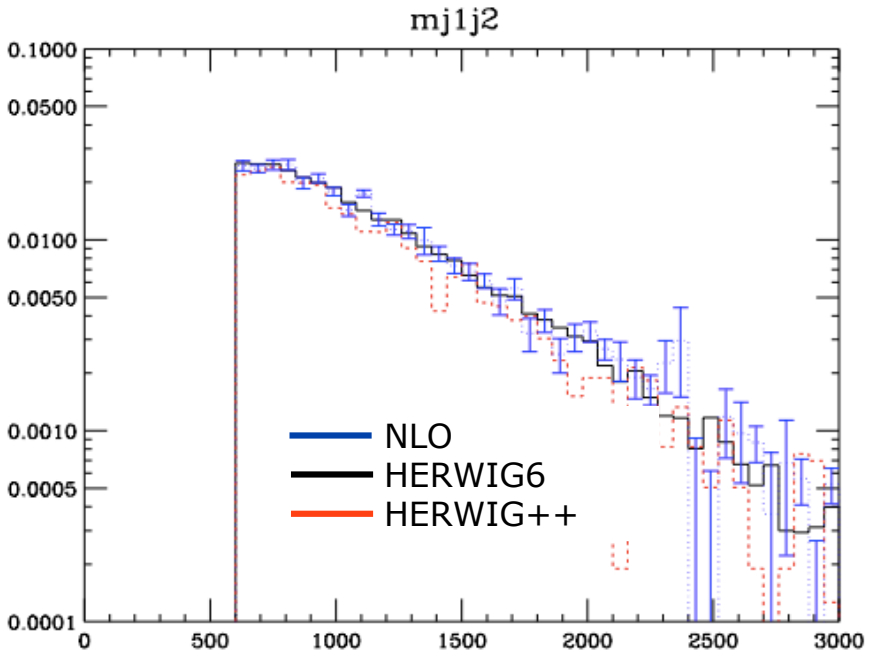


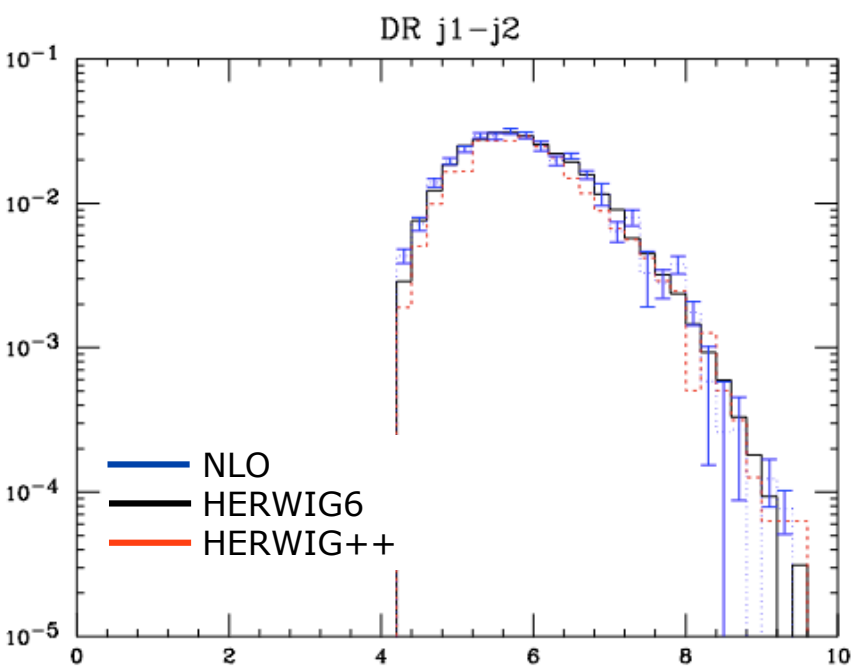
third jet, no VBF cuts

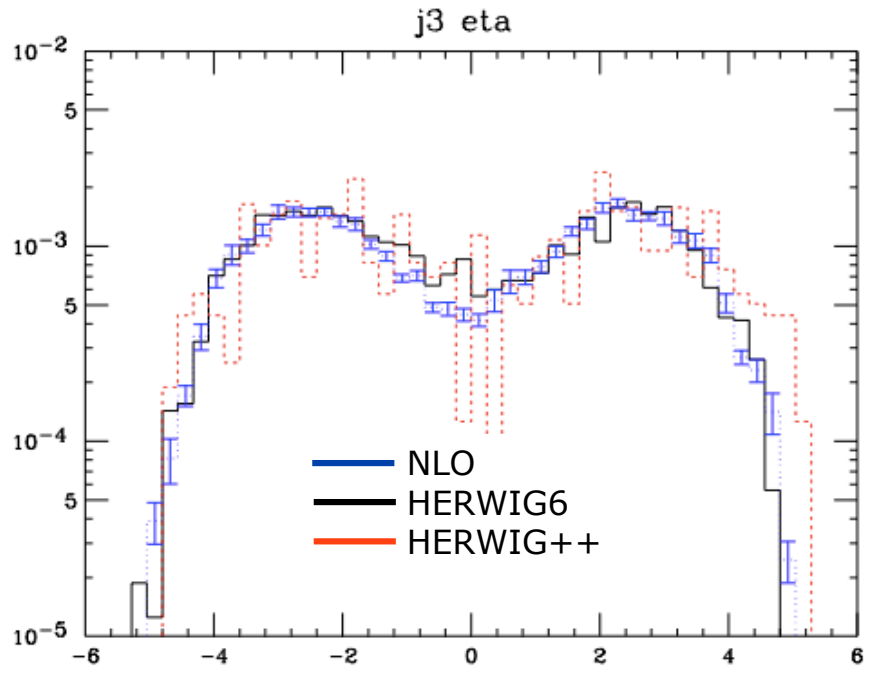


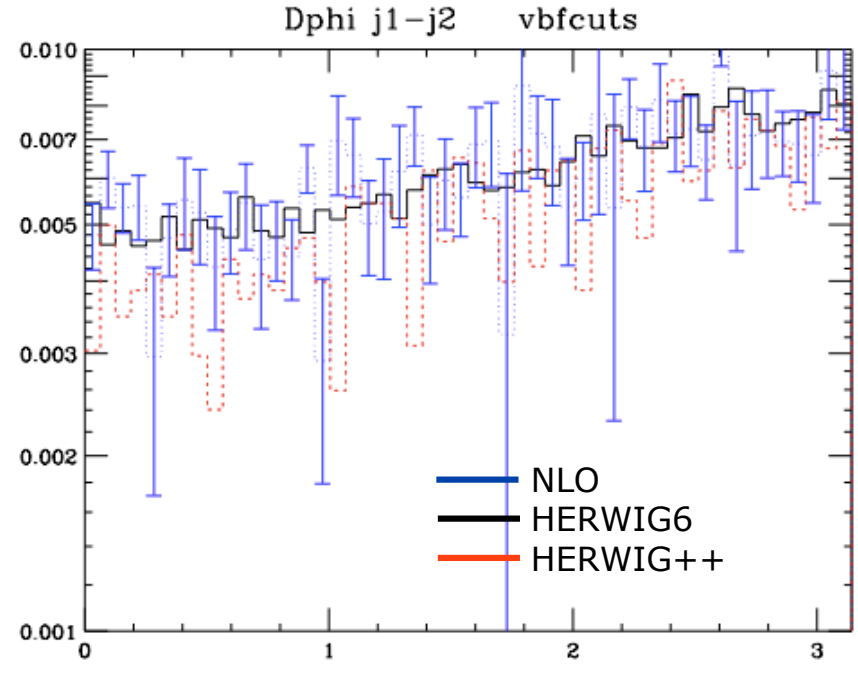


after VBF cuts









VBF cuts reminder

- min jets p_T = 20 GeV, kT jets with cone size = 0.7

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$$p_{\mathrm{T}}^{\mathrm{tag}} > 30\ \mathrm{GeV}, \qquad |y_{j_1} - y_{j_2}| > 4.2\,, \qquad y_{j_1} \cdot y_{j_2} < 0\,, \qquad m_{jj} > 600\ \mathrm{GeV}\,,$$

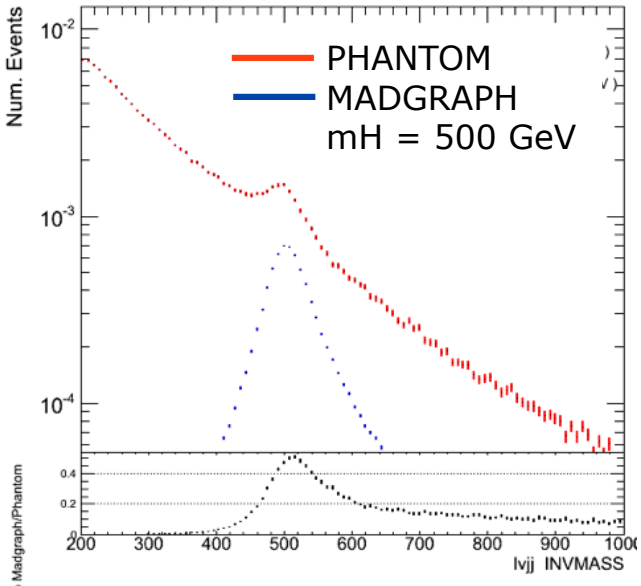
interference and VBF

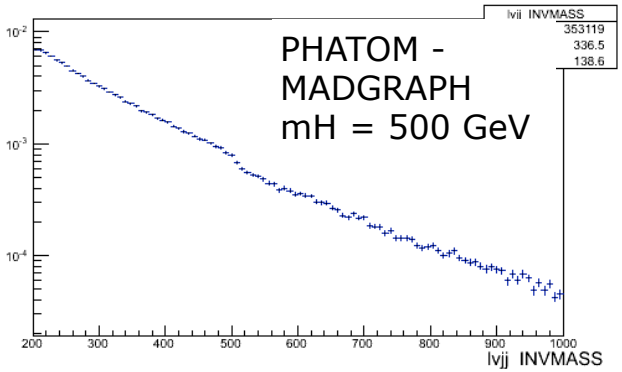
- evaluate the impact of the interference between Higgs and background in the standard model scenario
- not included in the POWHEG samples available to ATLAS and CMS
- need a final recipe (also for the uncertainty)
- see more in Sara&Sara's talk

PRELIMINARY STUDIES!

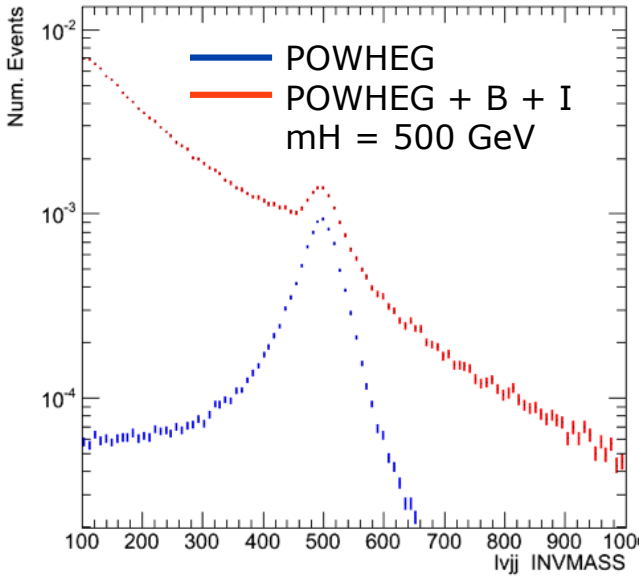
LO signal, bkg and interference from PHANTOM, subtract madgraph signal to get interference + a_{EW}^6 bkg

Add it to the POWHEG samples used by the analyses





A. Sznajder



gluon fusion contamination

- determine the contamination of gluon fusion in the VBF phase space and its uncertainty on the cross-section and shape (**need a recipe**)
- use the new tools on the market (MINLO, aMC@NLO, SHERPA)
- details in Gavin's talk tomorrow (Jets in Higgs Analysis)

- Theory error/systematics on ggF+2j large: in ATLAS is O(45%) $\rightarrow$ 13% on the extraction of VBF signal (leading systematic):

Source	ggF+2j	VBF
QCD scale	(*) 25% (30% with CJV)	~1%
Underlying event	30%	6%
Jet Energy Scale	19%	8%
Total	**45%**	**10%**

(*) Stewart-Tackmann recipe for the uncertainty + use of MCFM for the >= 2jets bin

YR3 chapter skeleton