Use in ATLAS of Electroweak NLO Corrections to VH Production

Jason Nielsen (UC Santa Cruz)
Giacinto Piacquadio (CERN)

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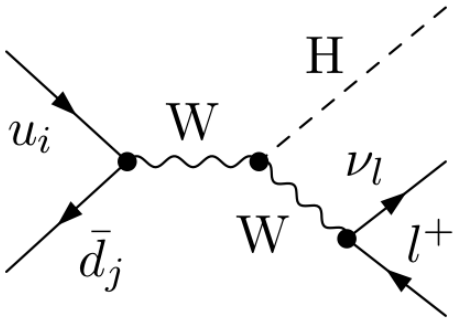
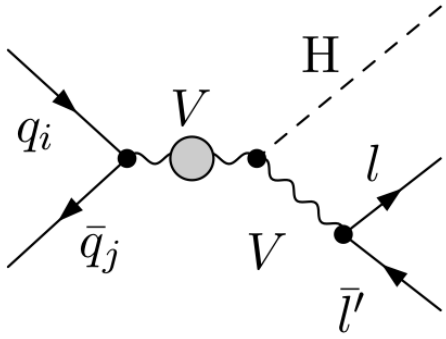
NLO Electroweak Corrections to VH

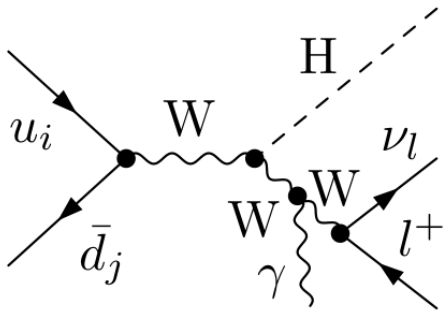
LO



Virtual NLO EW



Real NLO EW



- HAWK Monte Carlo program (Denner, Dittmaier, Kallweit, Mueck) calculates NLO QCD and NLO EW corrections for all VH processes [arXiv:1112.5142]
- Are there any other calculations (automatic?)
- Does it make sense to discuss relative contributions from processes detailed above?

WH and ZH Cross Sections @ 8 TeV

- From the CERN Yellow Report on Higgs Cross Sections
  - https://twiki.cern.ch/twiki/bin/view/LHCPhysics/WHZH

m_H	$\sigma(WH)$ [pb]	Scale [%]	PDF+α_s [%]	Δ_{EW} [%]
115 GeV	0.9165	+0.1-0.6	±3.9	-6.5
120 GeV	0.7966	+0.1-0.6	±3.4	-6.7
125 GeV	0.6966	+0.2-0.6	±3.5	-6.7
130 GeV	0.6095	+0.2-0.6	±3.5	-7.0
135 GeV	0.5351	+0.1-0.7	±3.4	-7.3

m_H	$\sigma(ZH)$ [pb]	Scale [%]	PDF+α_s	Δ_{EW} [%]
115 GeV	0.5117	+1.4-1.3	± 4.2	-5.1
120 GeV	0.4483	+1.5-1.4	± 3.5	-5.1
125 GeV	0.3943	+1.6-1.5	± 3.5	-5.1
130 GeV	0.3430	+1.7-1.6	± 3.7	-5.3
135 GeV	0.3074	+1.8-1.6	± 3.6	-5.3

Unfolding Inclusive EW Corrections

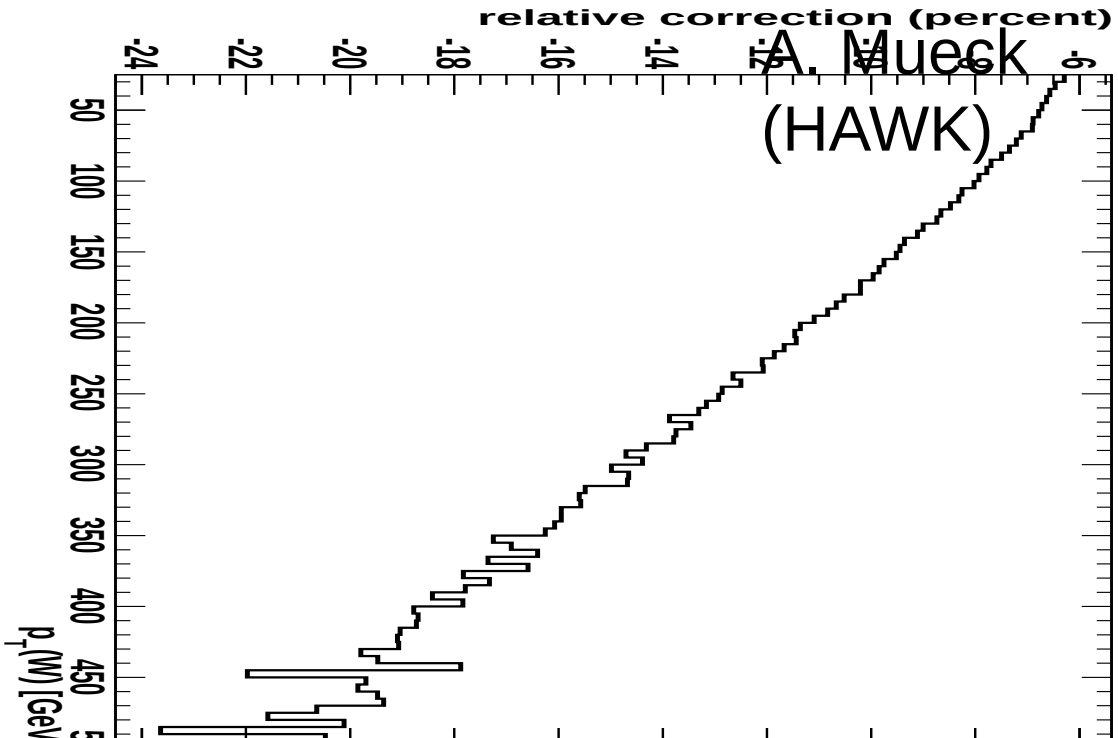
- The overall inclusive EW correction (Δ) does not give details on changes in the boson p_T distribution at NLO
  - Our analysis is divided into $p_T(V)$ bins, so that's important.
- We try to "unfold" the inclusive correction to see the residual dependence on boson p_T – call this δ
- This full δ is taken as a 100% uncertainty on the cross section. What could be considered reasonable?
- Calculate δ for each pT bin by reweighting with the NLO QCD cross section

$$\sigma_{\mathrm{NLO}} = \sigma_0 \times (1 + \delta_{\mathrm{QCD}} + \delta_{\mathrm{EW}} + \delta_{\gamma})$$

- The real EW corrections δ_γ can be checked by comparing results with bare and recombined ("dressed") leptons

Differential EW Corrections -- WH

- Relative to "best estimate" with QCD corrections
  - Uses m_H=120 GeV, as in Yellow Reports (and Higgs pubs). Should this be updated? Does it matter?
- Total differential correction reweighted by cross section to find the inclusive correction Δ
  - Should we recover the full correction of -6.7%?



Calculating Δ and δ

- Integrate the relative differences between cross sections
  - Δ is relative difference between uncorrected NLO QCD xsec and full differential EW corrections (would be double-counting if included with inclusive xsec correction)
  - δ is rel diff between inclusive-corrected xsec and full differential EW corrrections
- Currently using the bare muon results only, ignoring tiny difference between bare and “recombined muons” due to real soft emission.

Summary Table of Differential Corrections

$WH \rightarrow \ell\nu bb$	[0-50]	[50-100]	[100-150]	[150-200]	[200-∞]
Δ_{EW}	-6.8%	-7.5%	-9.2%	-11.1%	-14.8%
δ_{EW}	-0.5%	-1.3	-3.2%	-5.2%	-9.1%
$ZH \rightarrow \ell\ell bb$	[0-50]	[50-100]	[100-150]	[150-200]	[200-∞]
Δ_{EW}	-5.8%	-7.3%	-8.1%	-8.8%	-12.2%
δ_{EW}	-1.0%	-2.6%	-3.4%	-4.1%	-7.7%
$ZH \rightarrow \nu\nu bb$		[90,120]	[120,160]	[160,200]	[200-∞]
Δ_{EW}		-4.4%	-4.0%	-4.1%	-6.5%
δ_{EW}		+ 0.4%	+ 0.9%	+ 0.8%	-1.7%

- Similar to 7 TeV (as expected)

Major Uncertainty on Final VH Results

From ATLAS-CONF-2012-161

Table 5: A summary of the size of the components of the systematic uncertainty on the signal with $m_H = 125$ GeV for the three channels of the $\sqrt{s} = 8$ TeV analysis. The dominant signal is shown for the 1 lepton and 2 lepton channels, while for the 0 lepton channel both ZH and WH signals are listed. The uncertainties are shown as a percentage, grouped together into broad categories and are calculated by summing in quadrature within each p_{T}^V bin and then averaging over all p_{T}^V bins in a channel.

Uncertainty [%]	0 lepton		1 lepton	2 leptons
	ZH	WH	WH	ZH
b-tagging	8.9	9.0	8.8	8.6
Jet/Pile-up/$E_{\mathrm{T}}^{\mathrm{miss}}$	19	25	6.7	4.2
Lepton	0.0	0.0	2.1	1.8
$H \to bb$ BR	3.3	3.3	3.3	3.3
VH p_T-dependence	5.3	8.1	7.6	5.0
VH theory PDF	3.5	3.5	3.5	3.5
VH theory scale	1.6	0.4	0.4	1.6
Statistical	4.9	18	4.1	2.6
Luminosity	3.6	3.6	3.6	3.6
Total	24	34	16	13

Questions for Discussion

- Is there an estimate of the uncertainty on the EW NLO corrections as a function of boson p_T?
  - Surely it cannot be only due to scale uncertainty on α.
  - Higher orders?
- Are there other calculations that could give a check?
  - If real emission dominates, could consider NLO generators.
- Updates for m_H=125 and specific selection criteria
  - Cuts on boson p_T
- Is there a smooth transition between inclusive results and “boosted selection”?