Theory Uncertainties

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Gluon Fusion Production

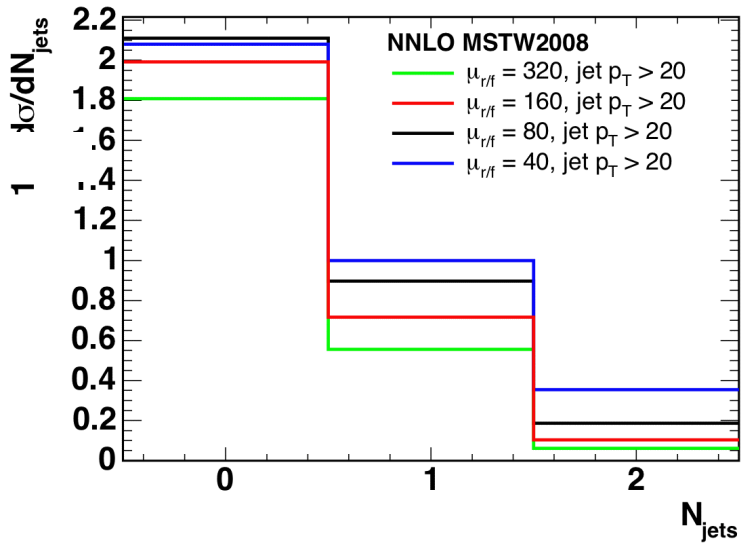
- Use cross section calculations of de Florian and Grazzini (arXiv:0901.2427v2) to normalize MC
  - Soft-gluon resummation to NNLL
  - Proper treatment of b-quarks to NLO
  - Inclusion of two-loop electroweak effects
  - MSTW2008 Parton Density Functions
  - $\mu_F = \mu_R = m_H$
- In good agreement with calculations of Anastasiou, Boughezal, and Petriello (arXiv:0811.3458v2)
  - $\mu_F = \mu_R = m_H/2$

Cross Section Uncertainties

- Higher-order QCD radiative corrections
  - Independently vary μ_F and μ_R between $0.5m_H$ and $2.0m_H$, within the constraint $0.5 < \mu_F/\mu_R < 2.0$
- PDF model
  - Use 40 alternative grids associated with MSTW2008 NNLO PDF to evaluate
- An additional complication at CDF is that cross section uncertainties coming from scale changes are topology dependent (e.g. dependent on number of jets criteria used to define channels) Anastasiou et al., arXiv:0905.3529v2

Cross Section Uncertainties (cont.)

- CDF relies on differential cross section uncertainties versus # of jets from Anastasiou et al.
  - 0 jets : +5%, -9%
  - 1 jet : +24%, -22%
  - 2+ jets : +78%, -41%
- Frank has pointed us to higher-order calculation of the 2+ jet bin uncertainties which gives smaller values



CDF reproduction of the calculations used in determining these uncertainties (using HNNLO program)

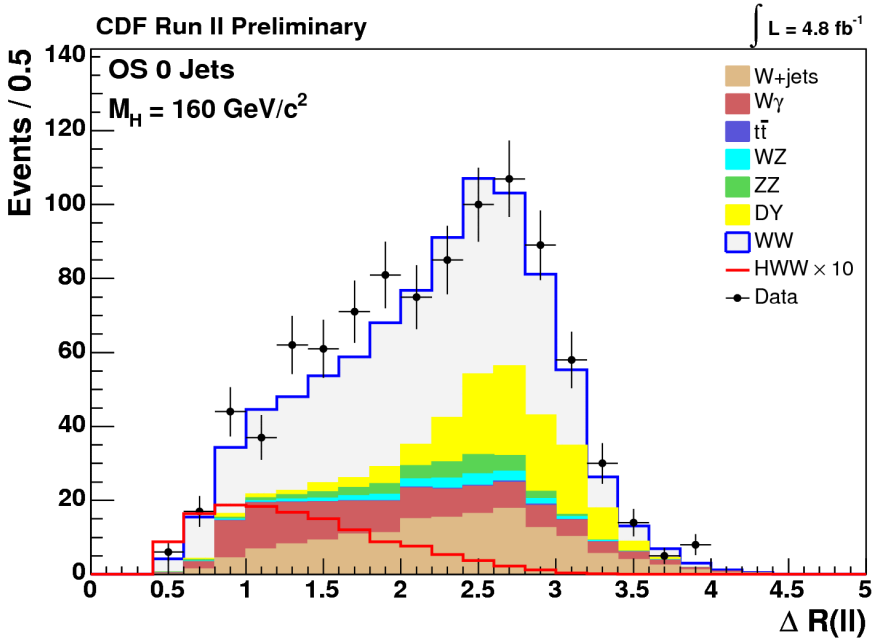
Cross Section Uncertainties (cont.)

- These uncertainties are treated as correlated across jet bins and as correlated with the inclusive cross section uncertainty taken by D0
- Note that since the perturbative calculation used to determine the differential cross section uncertainties does not have all the bells and whistles associated with the inclusive cross section calculation, there is a resulting mismatch in the inclusive cross section uncertainty obtained from the two approaches
  - Inclusive calculation (at m_H=160) : +9.1%,-7.7%
  - Differential calculation (at m_H=160) : +13.9%,-14.2%

Recent Developments

- Now also have the ability to determine differential PDF uncertainties versus # of jets
- Are able to use the same HNNLO framework to run over MSTW2008 PDF eigenvectors including α_S variations
- These numbers were not available from the Anastasiou et al. paper from which the scale variation uncertainties were taken
- Will be included in next iteration of the analysis

Shape uncertainties

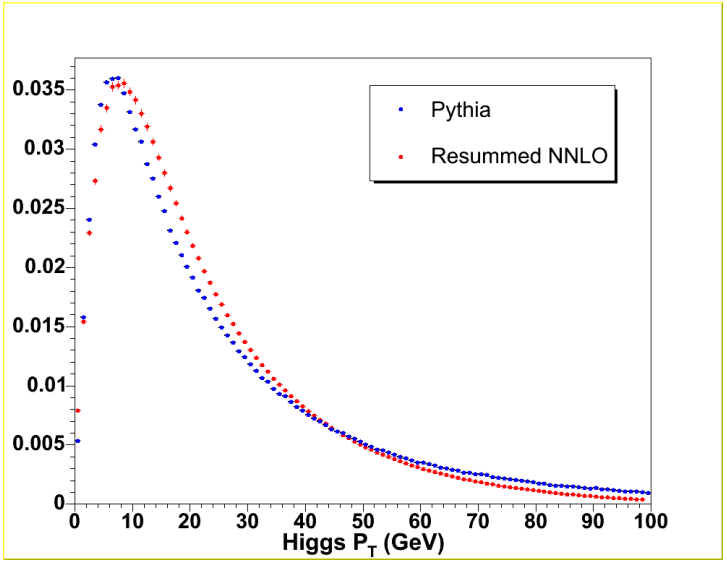


A variety of kinematic variables are used as inputs to the multi-variant techniques used to separate signal and backgrounds

In the end, variables describing the angular separation between the leptons are most important

We believe that to model these variables properly, the most important things to get correct in the simulation are spins and boost (Higgs p_T)

Simulation of gg to H

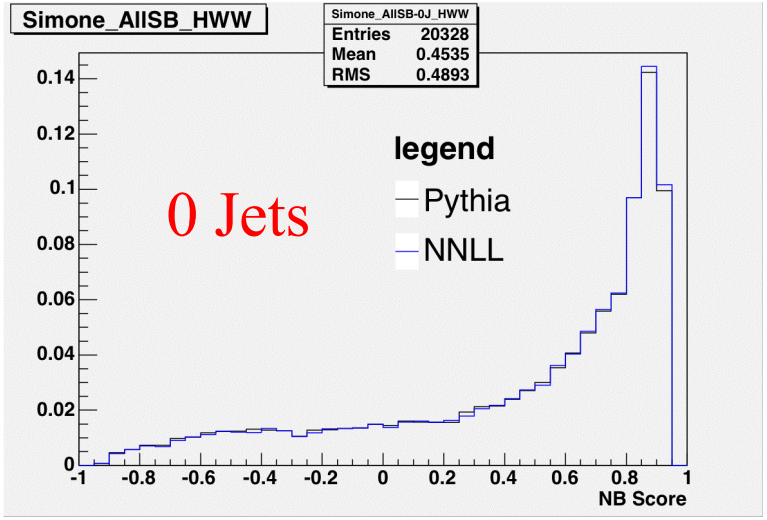


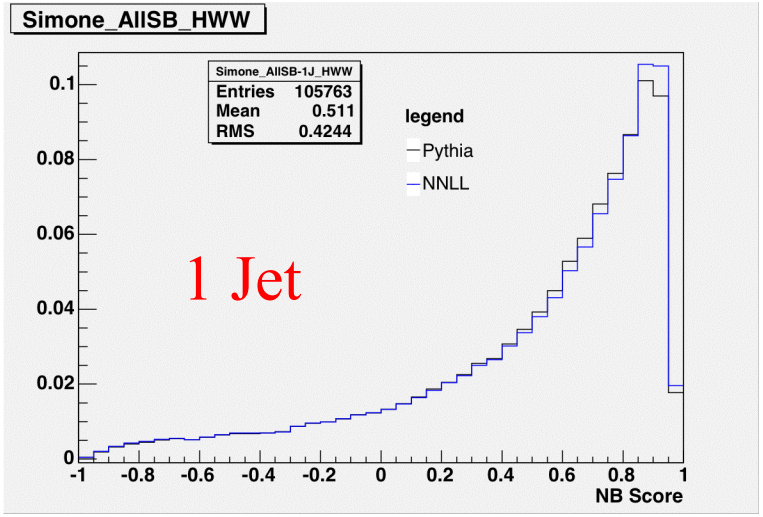
We use PYTHIA to simulate gluon fusion Higgs production (believe that spins are properly modeled)

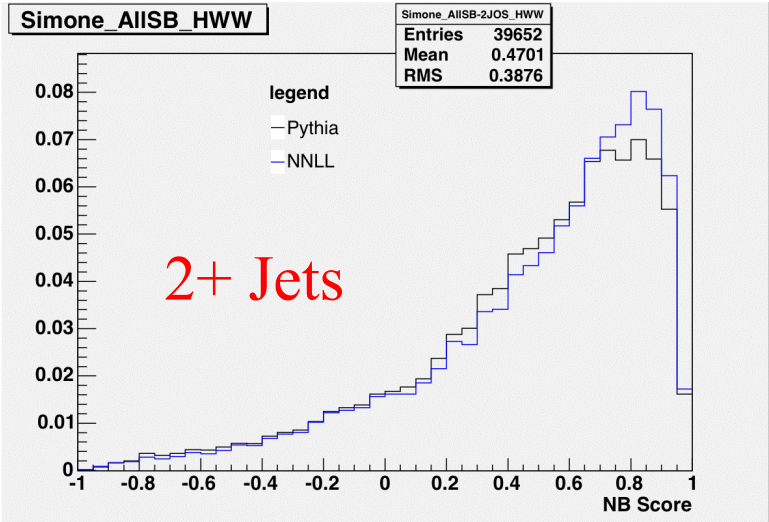
PYTHIA uses a parton shower model to simulate higher-order effects

In order to have the best possible modeling of the boost, we re-weight the PYTHIA events versus Higgs p_T to match the spectrum obtained from the calculations of Anastasiou et al.

Effect of Re-weighting







Criticism Received

- Baglio and Djouadi suggest that we should use central cross section values taken from NNLO calculations rather than those from the NNLL+NNLO calculations used currently. They argue that the additional contributions to the total cross section that arise in NNLL+NNLO will not survive experimental cuts and should therefore be ignored.

Response

- We disagree with the suggested approach. Our analyses incorporate a more accurate modeling of the effects of experimental cuts on the signal acceptance than what is obtainable via a parton-level calculation. Our acceptances are obtained using events generated with PYTHIA, which uses matrix element calculations followed by a parton shower to model higher-order radiative effects. In particular, the parton shower models "resummed" higher- order radiative corrections due to multiple emission of of soft and collinear partons. Although these higher-order contributions do not exactly match those included in the analytic resummed calculations, the parton shower model introduces soft and collinear effects beyond those contained within the customary fixed-order perturbative calculations. These simulated events are then re-weighted in order to match the PYTHIA generator-level Higgs p_T spectrum, both in shape and normalization, with that obtained directly from the NNLL+NNLO prediction. The Higgs p_T is the most important variable to model properly as the boost of the dilepton system directly translates into the efficiency of the selection cuts used in defining our search samples (lepton p_T, isolation, and missing E_T). The generated and re-weighted events are then passed through a full simulation of the detector response. Based on this approach, any changes in predicted yields as a function of the reconstructed jet multiplicity are modeled in a precise way, taking into account both physics and instrumental effects. We have also checked the effect an additional, subsequent re-weighting of our PYTHIA event sample to match the rapidity distribution for the Higgs obtained from a NNLO calculation and find that this results in negligible changes to the measured signal acceptances.

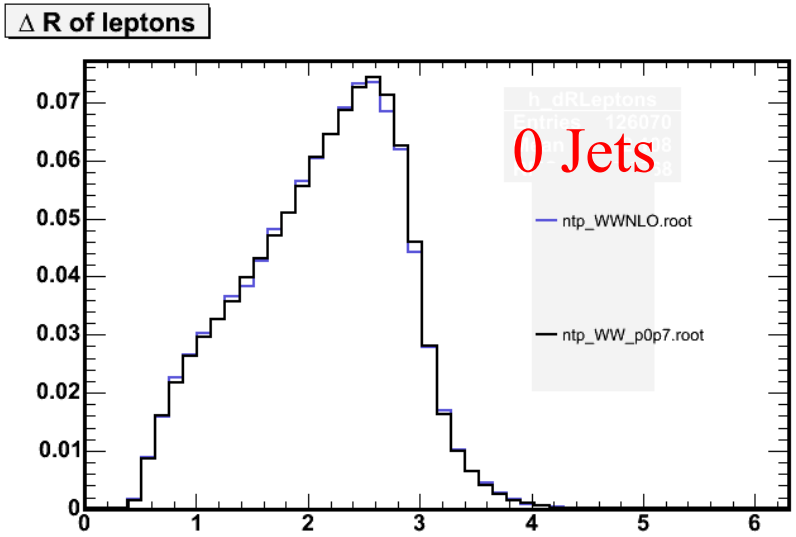
Cross-Check

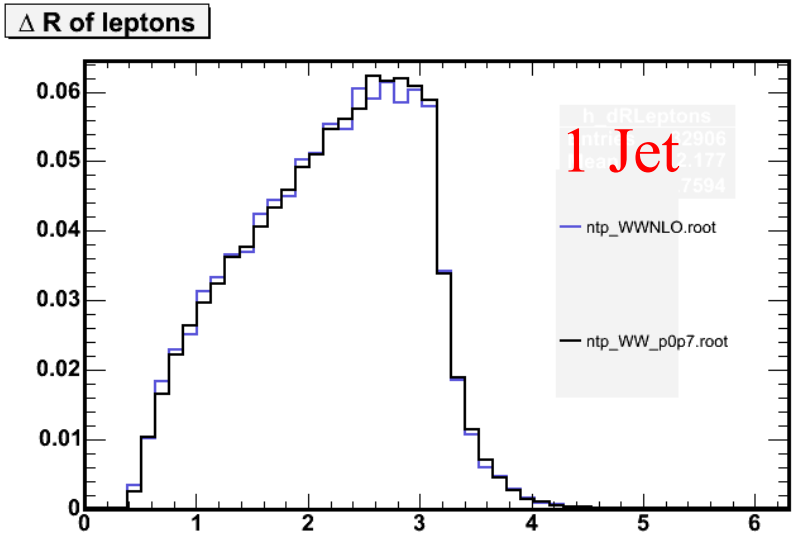
- Frank has suggested a good cross check which we still need to do
- Essentially, compare the current NNLO+NNNL cross section times the current acceptance with NNLO cross section (after basic selection cuts) times modified acceptance
- Acceptance is modified such that the denominator is PYTHIA events that satisfy basic selection cuts at generator-level

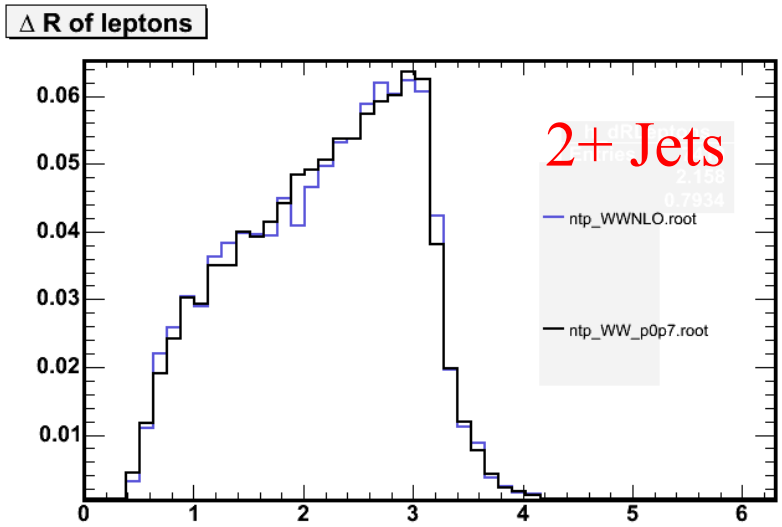
WW Background

- This is our most important background (most closely mimics the kinematics of Higgs signal)
- As with the Higgs signal, we want to correctly model spins and boost
- For modeling WW, we have put a significant amount of effort into interfacing the MC@NLO generator into our simulation package
  - Properly models spins as long as each potential lepton decay channel (9 total) are simulated separately
  - Currently, interfaces to HERWIG for showering (creating an interface to PYTHIA is on our wish list)

PYTHIA versus MC@NLO







Diboson Odds and Ends

- For normalizing simulated diboson samples, we use NLO MCFM calculations
- In the near future we want to take advantage of work being done by D0 and reweight events in the WW MC@NLO sample to match the WW p_T spectrum obtained from the resummed RESBOS calculation
- Would like to upgrade WZ simulation to MC@NLO also, but manual indicates that MC@NLO does not properly generate spin information for this process – told several months ago that this was coming soon – need to follow up