Higgs Searches at DØ

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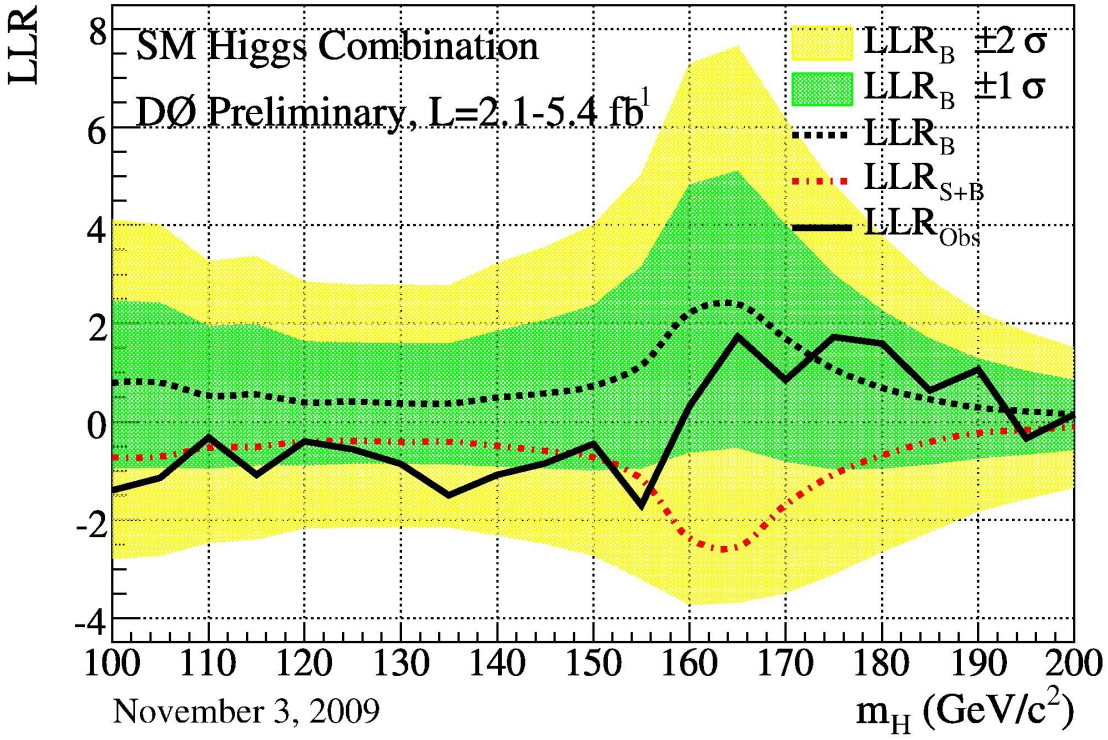
DISCLAIMER

Will not discuss analyzes
Will describe current practices
Will definitely cause some rise in blood pressure among theorists
Will say almost nothing about PDFs

The end result



At m_H=115 GeV

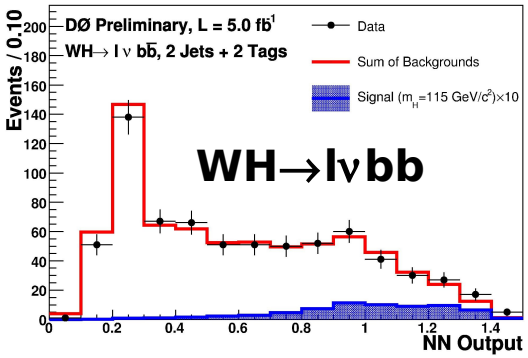
σ/SM<2.8 (expected)

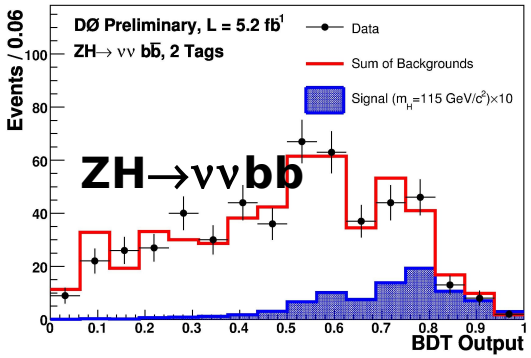
σ/SM<4.0 (observed)

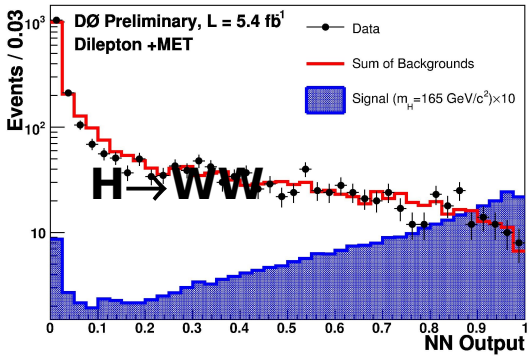
At m_H=165 GeV

σ/SM<1.35 (expected)

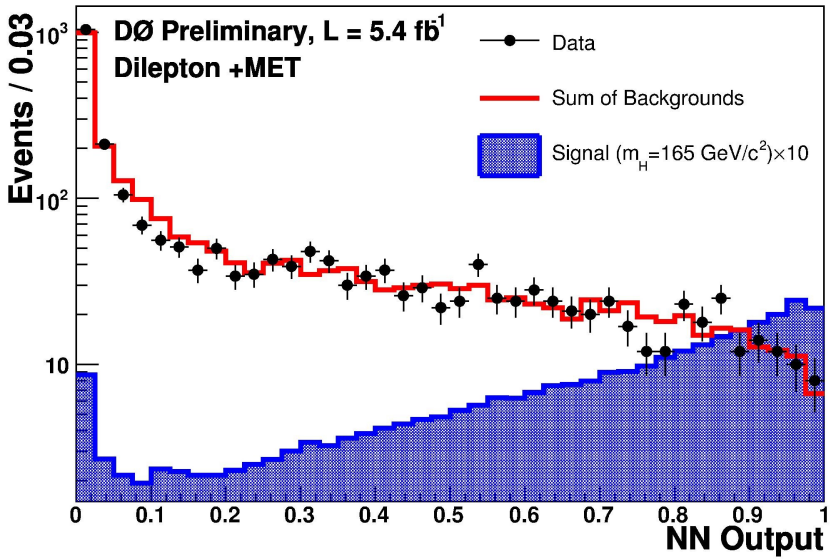
σ/SM<1.53 (observed)

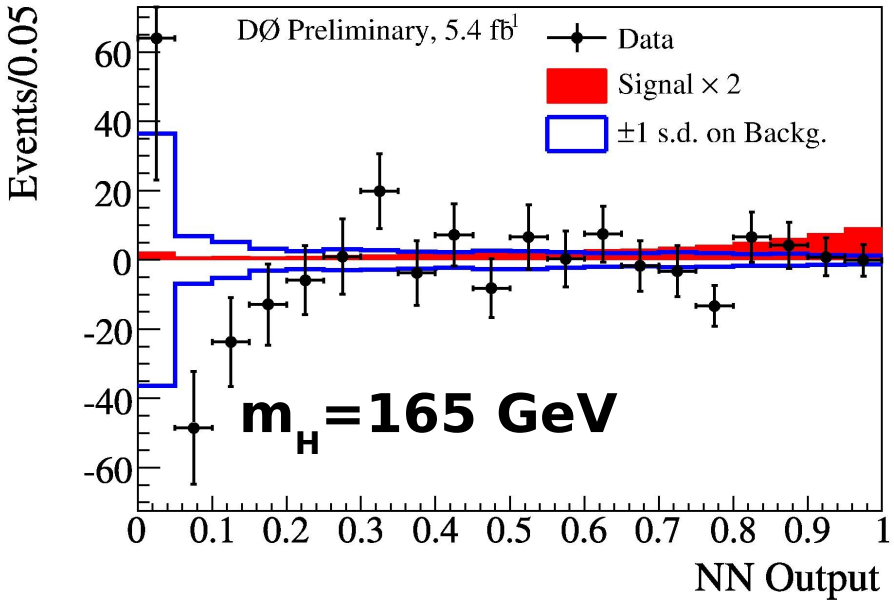






High mass SM Higgs





Main background: non resonant WW production
Systematics: cross sections for backgrounds, luminosity, lepton/trigger efficiencies
Difference wrt CDF: not yet using different discriminants in different jet bins (but n_{Jets} in NN input)

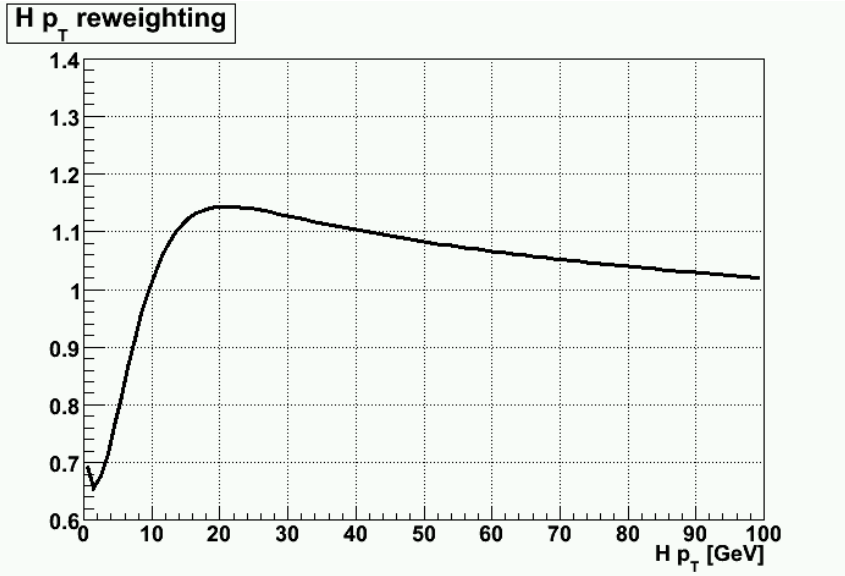
Signal MC (I)

Higgs signal generated with Pythia (includes gluon fusion, vector boson fusion, WH/ZH) using CTEQ6L PDFs

Normalized to NLO or NNLO calculations (deFlorian and Grazzini, PLB 674, 291 (2009), Anastasiou et al, JHEP0904 (2009) 003), use MSTW2008 PDFs

Corrections to the p_T(H) spectrum:

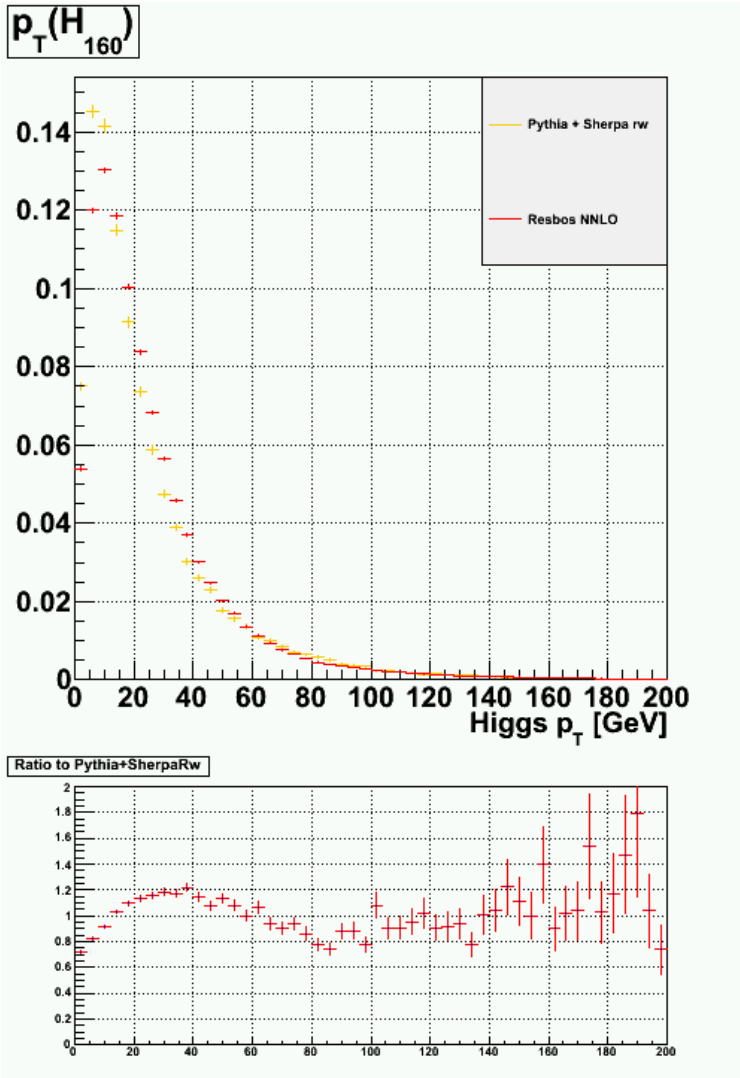
- **Should use NLO at high p_T and Resbos at low p_T (see next slide)**
- **Use Sherpa (minor effect)**



Signal MC (II)

Check with Resbos

Correction at low p_T(H) not yet included in analyzes (but effect is tiny)



WW background

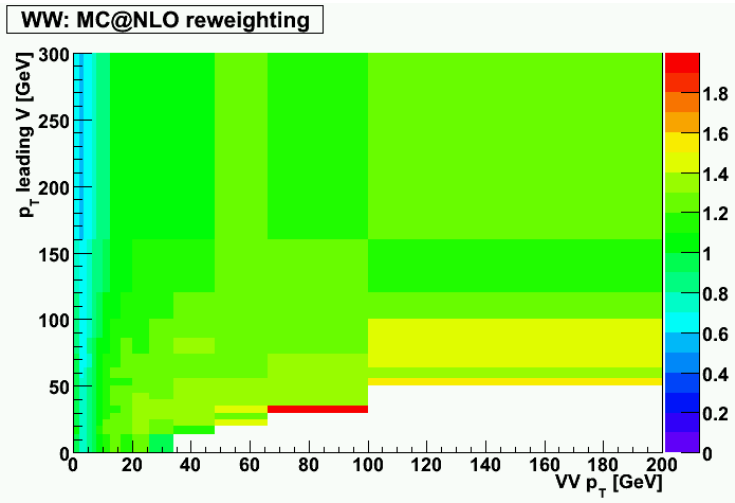
Main background: non-resonant WW production generated with Pythia (CTEQ6L PDFs), normalized to NLO calculation (Campbell and Ellis, PRD60, 113006 (1999))

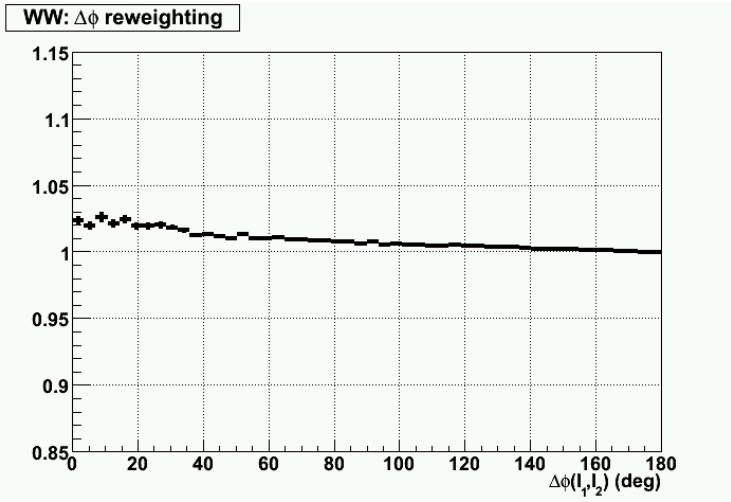
Corrections to the p_T(WW) spectrum:

- **No corrections at low p_T, does Resbos do WW now ?**
- **Reweight Pythia to MC@NLO (will get high p_T right)**

(Small) correction to the $\Delta\phi$(leptons) spectrum ($gg \rightarrow WW$)

- **Taken from Binoth et al (JHEP0612, 046 (2006))**





Other backgrounds

Other diboson final states generated with Pythia (cross sections from Campbell & Ellis)

Top pairs: ALPGEN (Pythia fragmentation), normalized to NNLO calculation (Moch et al. PRD78, 034003 (2008))

Single top generated with CompHEP

W/Z(+jets):

- **generated with ALPGEN (+Pythia) with CTEQ6L PDFs**
- **total cross section normalized to calculations of Hamberg et al (NPB359, 343 (1991))**
- **K-factors for heavy flavor production taken from MCFM**
- **reweight Z p_T distribution to D0 measurements**
- **transfer to W p_T distribution using calculations of Melnikov & Petriello (PRD 74, 114017 (2006))**

All of this applies also for low mass analyses (WH/ZH) !

Issues with Z(+jets) (high mass)

Veto on back-to-back leptons

Select preferably low mass, boosted lepton pairs
Well modeled in ALPGEN+Pythia ?

Z peak well modeled/understood
Validity of DØ reweighting procedure off Z peak ?

Evidence that have some modeling problems (impact on final result small, Z/γ^* not a large background, may lead us to be too conservative when assessing systematics)

Can we trust FEWZ to model low (15-60 GeV) invariant masses ? Down to what $p_T(\gamma^*)$?

Can we really use FEWZ to transfer our n_{Jets} dependent Z p_T reweighting to the W ?

Low mass Higgs searches

Search channels: WH/ZH
Backgrounds: W/Z+heavy flavors, diboson production
Same mixture of event generators discussed earlier

Understanding W+jets backgrounds

- **Use large sample of W/Z+2/3j prior to b-tagging to reweight ALPGEN samples (if needed)**
- **Assume that corrections needed to match MC with data are flavor independent (not the same diagrams !!!!), not a major source of uncertainty**
- **Normalization of W/Z+heavy flavor content from data (though initial NLO estimate not wildly off)**
- **Uncertainties on shapes more relevant than uncertainties on normalization**
- **Systematics ?**

Main discriminant is the dijet invariant mass

- **Systematics on the dijet mass from theory ?**

Angular distributions

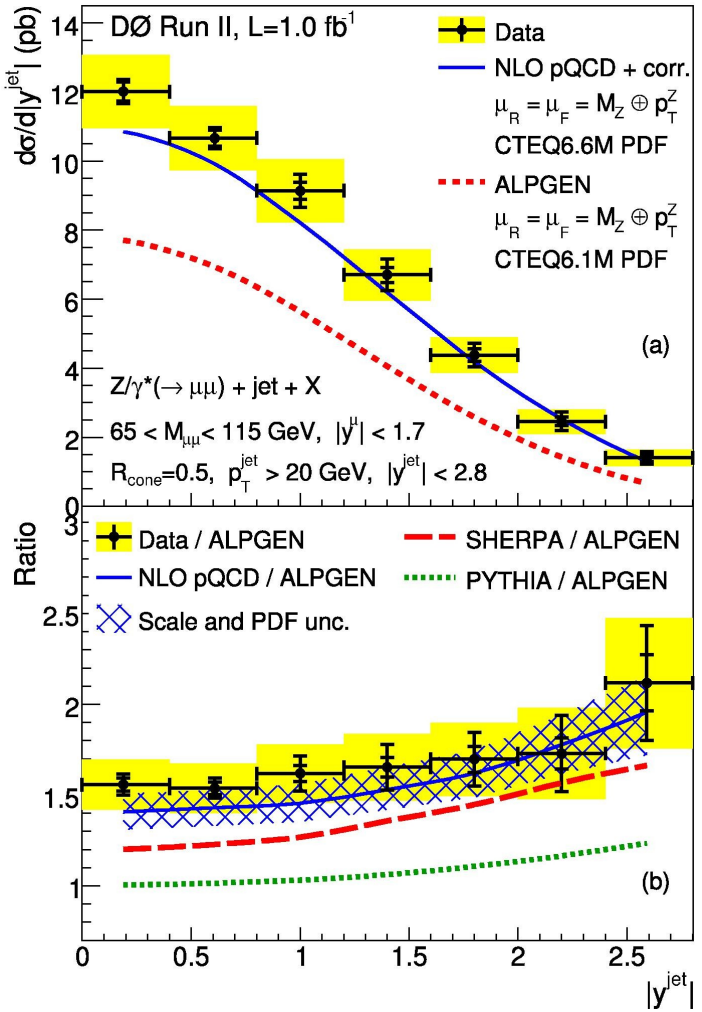
Data agree better with MCFM/ SHERPA than with ALPGEN (broader jet rapidity distribution)

Apply reweighting derived from data

DØ measurements:

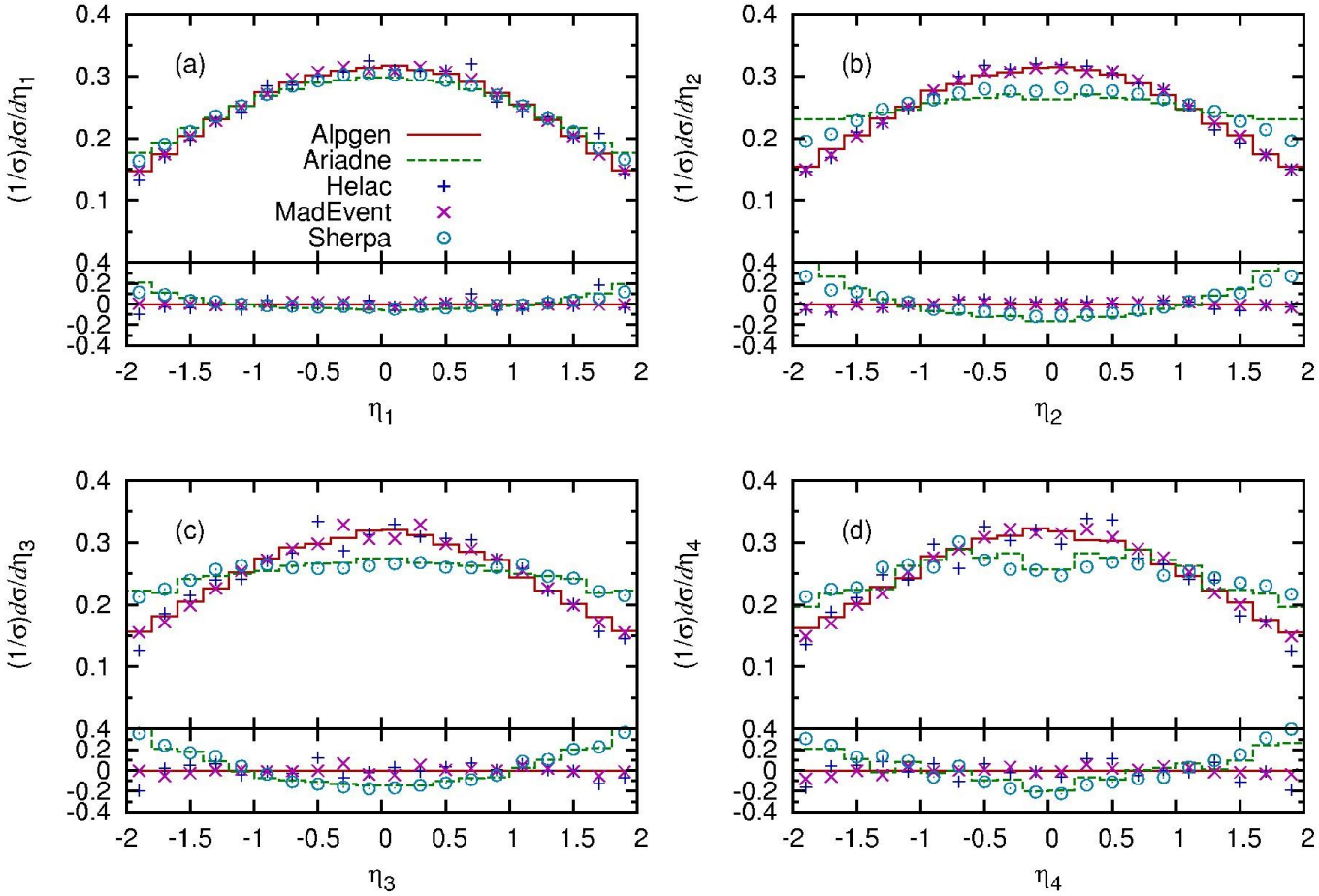
- **PLB 669, 278 (2008)**
- **Z+jet(s): inclusive p_T and rapidity**
- **PLB 678, 45 (2009)**
- **Z+1/2/3 jets: p_T**
- **arXiv:0907.4286 [hep-ex]**
- **Angular distributions in Z+1 jet**

Little impact on dijet invariant mass



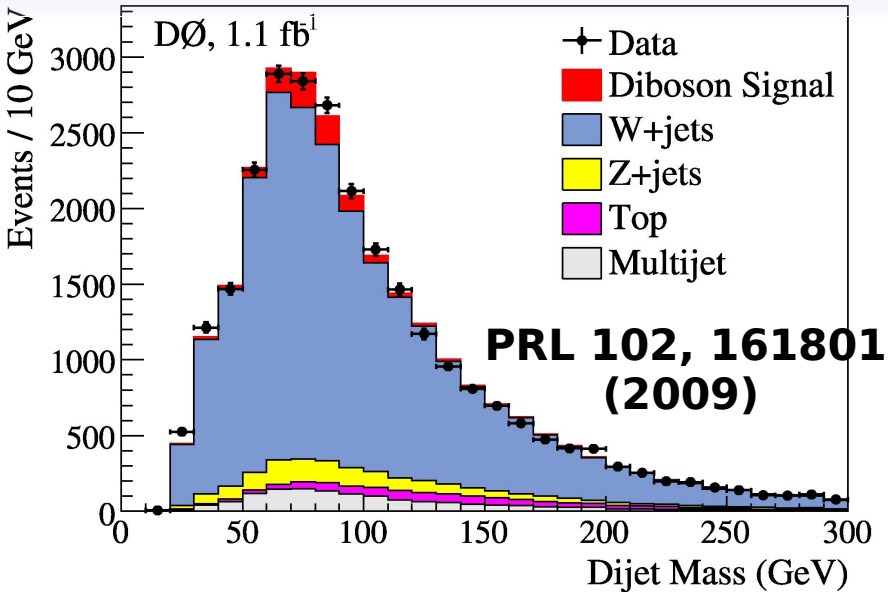
PLB 669, 278 (2008)

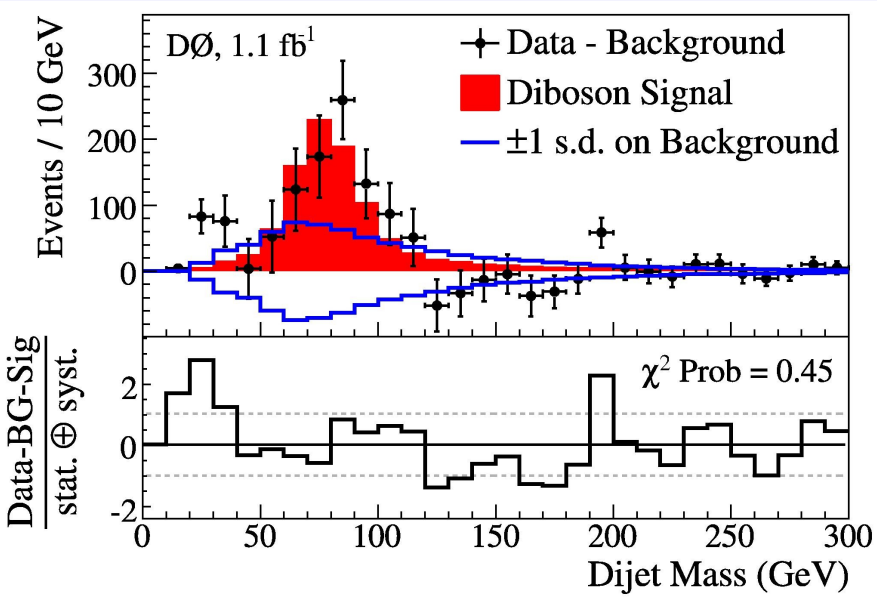
A known feature



Difference between ALPGEN/SHERPA already noticed in J.Alwall et al. EPJ C53, 473 (2008)

Dijet mass systematics





Possible Higgs boson sits on large W+jets continuum

Look at W/Z resonances from diboson production

Select signal with non-linear discriminant (includes mass information), if mass peak not at the known mass(es), wrong estimation of background

Dijet mass systematics

Apply methods from WW/WZ search also to Higgs searches

Tune ALPGEN parameters on data (and derive range for sytematic variations):

- **renormalization+factorization scale**
- **k_T factor (scale for α_s at each vertex)**
- **parton-matching pT threshold in MLM procedure**
- **parton-matching radius in MLM procedure**

Repeat these studies using NLO calculation and check for possible differences between light/heavy flavors

NLO calculations: check whether W+Q behave similar way as W+QQ (also using final states with only 1 b-tag)

Nice to hear that Resbos now does WH/ZH (please update web pages as well !!!)

Some conclusions

Experimentalists like event generators they can play with

When we don't have an event generator we use correction functions (parameterized in a few kinematic variables).

Correcting to (N)NLO at high p_T is easy.... but at low p_T this doesn't make sense, need resummed calculations

Phase space for tuning event generators grows with time (counter to expectations): Pythia, ALPGEN, PDFs (don't underestimate the resistance within the experiments to change tunes, PDFs, parameters, and the amount of time required to regenerate the MC samples we need)

Would need tunes done on Pythia+ALPGEN instead of being done on Pythia alone (ex when using p_T(Z) as input)