



Higgs + Jets at ATLAS

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Jet Vetoes and Multiplicity Observables 20 Sep 2016 Durham

Content

- Higgs production categorisation and coupling results
- jet binning in H→γγ, H→ZZ, H→WW
- differential and fiducial cross sections in $H \rightarrow \gamma \gamma$, $H \rightarrow ZZ, H \rightarrow WW$

Higgs Measurements



- Many results analysing Run 1 dataset
- discovery
- couplings
- properties
- cross sections

Jets in Run 2 at 13 TeV

"not all jets are created equal"

- MVA-based Jet Vertex
 Tagger to suppress pileup
 jets replaces JVF
- ~80% efficient for jets in





New Higgs Measurements



Cross sections











Simplified cross sections

- measure in exclusive regions of phase space
- reduces model dependence
- separates measurements from interpretation
- staged introduction of "bins"





Simplified cross sections



"bins"



Simplified cross sections NNLO calculations vs time

W/Z total, H total, Harlander, Kilgore VBF total, Bolzoni, Maltoni, Moch, Zaro H total, Anastasiou, Melnikov H total, Ravindran, Smith, van Neerven WH diff., Ferrera, Grazzini, Tramontano WH total, Brein, Djouadi, Harlander y-y, Catani et al. H diff., Anastasiou, Melnikov, Petriello Hi (partial), Boughezal et al. H diff., Anastasiou, Melnikov, Petriello ttbar total, Czakon, Fiedler, Mitov W diff., Melnikov, Petriello Z-γ, Grazzini, Kallweit, Rathlev, Torre W/Z diff., Melnikov, Petriello ji (partial), Currie, Gehrmann-De Ridder, Glover, Pires H diff., Catani, Grazzini ZZ, Cascioli it et al. W/Z diff, Catani et a Ο Ο ZH diff., Ferrera, Grazzini, Tramontano 00 O WW, Gehrmann et al. 0 ଚ ttbar diff., Czakon, Fiedler, Mitov Z-y, W-y, Grazzini, Kallweit, Rathlev explosion of calculations Hj, Boughezal et al. Wj, Boughezal, Focke, Liu, Petriello in past 18 months Hj, Boughezal et al. VBF diff., Cacciari et al. Zi. Gehrmann-De Ridder et al. 2002 2006 2016 2004 2008 2010 2012 2014 ZZ, Grazzini, Kallweit, Rathlev Hj, Caola, Melnikov, Schulze Zj, Boughezal et al. compare "old" results WH diff., ZH diff., Campbell, Ellis, Williams y-y, Campbell, Ellis, Li, Williams WZ, Grazzini, Kallweit, Rathlev, Wiesemann to new predictions WW, Grazzini et al. MCFM at NNLO, Boughezal et al.

p_{tZ}, Gehrmann-De Ridder et al.



Higgs production modes





Jet categories



separate Higgs production modes by using



g GOOQ

g QQQQQ

Simplified σ per channel



Parameter value norm. to SM value

Simplified σ



Parameter value norm. to SM value

normalised to prediction, but measured σ quoted in Note ATLAS-CONF-2016-081

Uncertainties in VBF category

- both channels use BDT to select VBF category
- using variables sensitive to presence of 3rd jet
- can dramatically increase ggF+2jet XS uncertainty here 15%-25% on σ_{VBF}
- use ST method with NLO inclusive jet XS



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- very clean signature: narrow resonance against continuum background
- simultaneous fit of Signal+Background in many categories
- categories sensitive to ggF, VBF, VH, ttH



Jet Counting



Higgs Kinematics 13 TeV



Jet Kinematics







- clean signature against non-resonant ZZ* background
- fit M₄₁ distribution to extract signal yield



Jet Counting



Jet Counting



D. Hohn

Higgs Kinematics 870V



$\overset{\text{Paper August 2016}}{H \rightarrow WW} \rightarrow ev\mu v$

- 2I + MET signature
- 3 main backgrounds: non-resonant WW, W+jet, top estimated from data in control regions, enriched by exclusive NJet bins





Jet Counting

fiducial σ

normalised to σ_{LHC-XS}



Jet Veto Efficiency



Outlook

- already collected 2x data since ICHEP and potentially 2x again next year
- naive extrapolation with todays theory uncertainties
- theory unc. becomes limiting is some cases
- precision measurements ahead



 $\begin{array}{ccc} 0 & 0.2 & 0.4 \\ relative uncertainty \ \Delta \mu / \mu \end{array}$

hatched: with theory unc. solid: without theory unc.

<u>ATL-PHYS-PUB-2014-016</u>

Summary

- jet binning is powerful tool to increase significance in "complicated" channels, and is *indispensable* for accessing production mode couplings
- multiplicative signal strengths are now *legacy*
- already using Simplified Template Cross sections
- differential cross section measurements agree well with theory