

---

# W+jets observables

J. Huston

Michigan State University

LHC EWWG meeting

22/05/12

# Cuts on jets

- $p_T$  cuts on jets:
  - multiple jet thresholds
  - physics can be different for different thresholds (SCET resummation studies)
- Jet algorithms
  - antikT ( $kT$ , *SISCone*?)
  - physics is different for different algorithms
- Jet sizes
  - 0.4, 0.5, 0.6, 0.7
  - physics is different for different jet sizes
  - so far calibrations for 0.4 and 0.6; 0.5 and 0.7 will allow for direct comparisons to CMS

# Some observables

- ...in addition to what was included in the 2010 paper
- $m_T$  (transverse mass of all objects in event)
- $m_T^{(n)}$  (transverse mass of first  $n$  jets in the event, where  $n=2,3,4,\dots$ )
- $p_T^W$  (inclusive and for  $n_{\text{jet}}=0,1,2,3,4$  and  $\geq 0, \geq 1, \geq 2, \geq 3, \geq 4$ )
- $p_T^{\text{jet2}}/p_T^{\text{jet1}}$ 
  - in bins of  $p_T^{\text{jet1}}$
  - in bins of  $p_T^W$
- $\Delta y_{jj}$  (for  $n_{\text{jet}}=2,3,4, \geq 2, \geq 3, \geq 4$ )
- $M_{jj}$  vs  $\Delta y_{jj}$
- $N_{\text{jets}}$  vs  $\Delta y_{jj}$  (tests of NLO vs FKL summation)
- $N_{\text{jets}}$  with VBF-style cuts
  - testing ground for Higgs
  - testing ground for Poisson-like jet multiplicity distributions rather than 'staircase' distributions
- Beam thrust (for comparisons to SCET/future physics)

# Theory comparisons

---

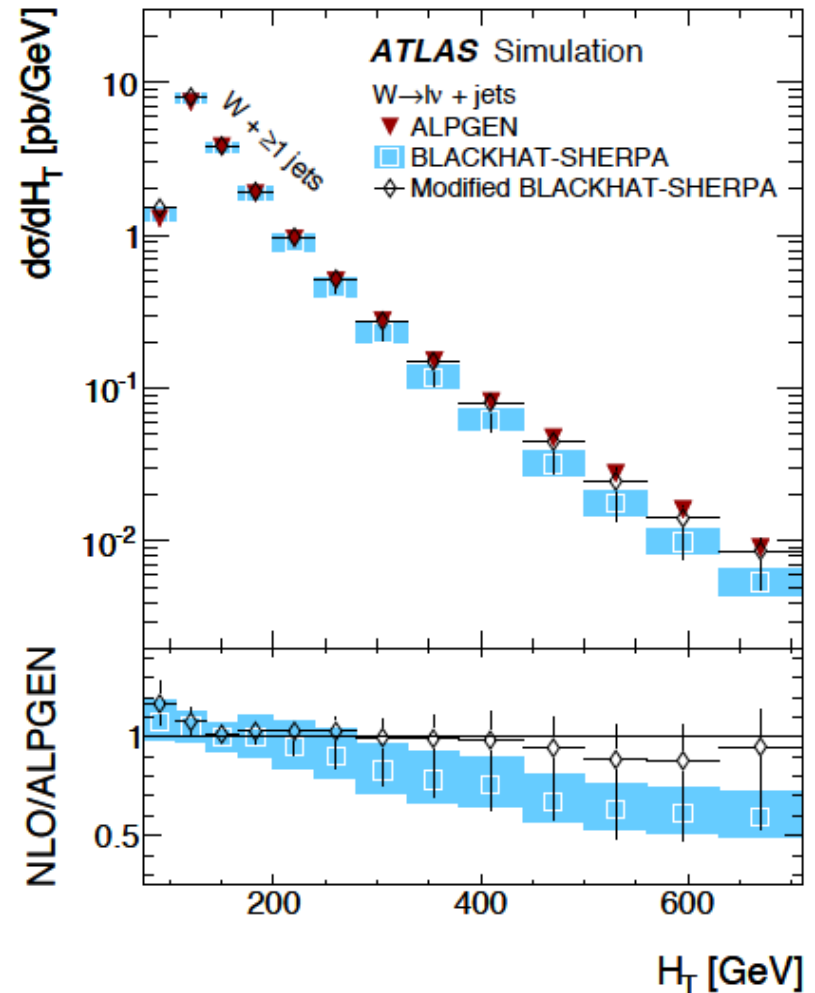
- We will be comparing data to predictions from
  - MCFM
  - Blackhat+Sherpa
    - using B+S ROOT ntuples
    - NLO inclusive and exclusive sums perhaps augmented by LoopSim (see Daniel's talk)
  - HEJ
  - SCET predictions (Stewart/Tackmann)
  - aMC@NLO, Sherpa+Blackhat
  - ...in addition to standard ME+PS predictions
- Analysis is within same framework for all programs

# Extra



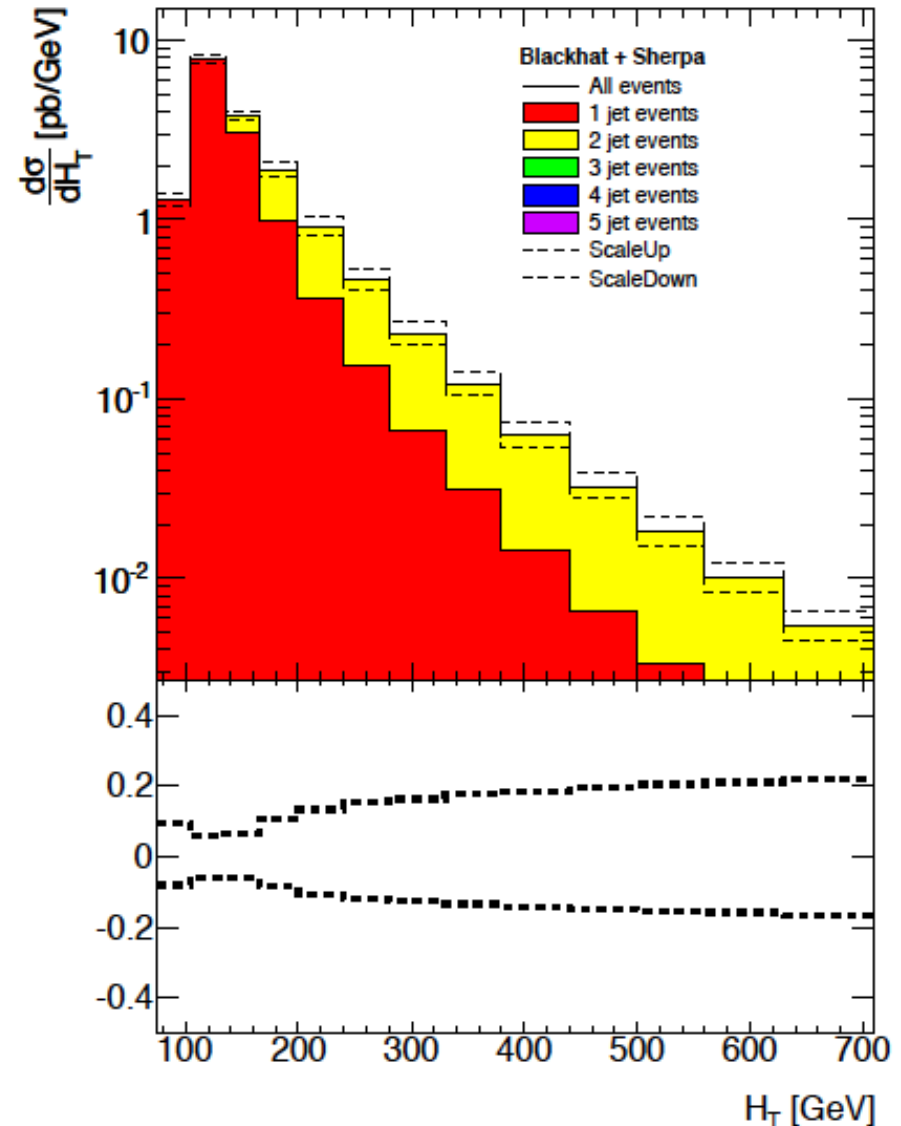
# Going beyond NLO inclusive

- In the 2010 data, we saw that the  $H_T$  distribution for  $W+\geq 1$  jet was not well-described by the NLO  $W+1$  jet prediction
- However, it was better described when additional information was included from  $W+2,3,4$  jets at NLO
- This is very tricky to do many of you may be offended
  - by definition the inclusive  $W+1$  jet NLO calculation includes explicit  $W+2$  jet information (at LO) and implicitly, through DGLAP evolution, information from  $3,4,5,\dots$  additional jets (in the collinear limit)
  - ...and the real correction for  $W+1$  jet is the same as the born term for  $W+2$  jets...so double-counting is a problem

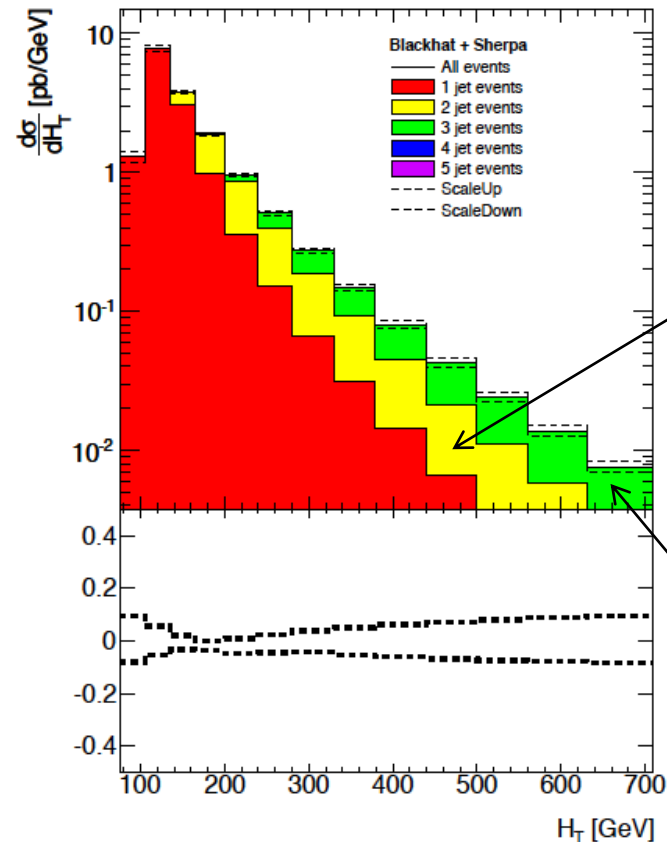
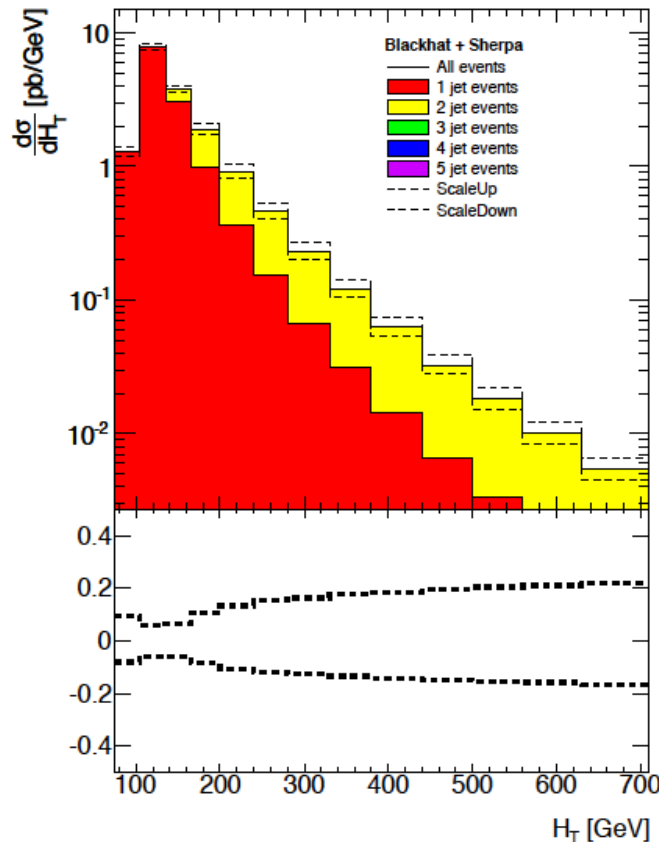


...but first, consider scale dependence for inclusive  $W+\geq 1$  jet

- Why does the scale dependence get worse as  $H_T$  increases?
- Large  $H_T \rightarrow$  more perturbative, so you might naively expect it to get better
- As  $H_T$  increases, most of cross section comes from  $W+2$  jets, which is present only at LO in the calculation



# Pretty well when adding W+2 jets



...note that the 2-jet information now comes in at NLO

the 3-jet contribution is now at LO

Fig. 1: The  $W$  + jets cross section, as a function of  $H_T$ , for the NLO inclusive  $W + \geq 1$  jet prediction (left) and for the exclusive sums approach, adding in  $W + 2$  jet production at NLO (right). The cross sections have been evaluated at a central scale of  $H_T/2$  and the uncertainty is given by varying the renormalization and factorization scales independently up and down by a factor of 2, while ensuring that the ratio of the two scales is never larger than a factor of 2.

# Not quite as well for adding 3 and 4 jets

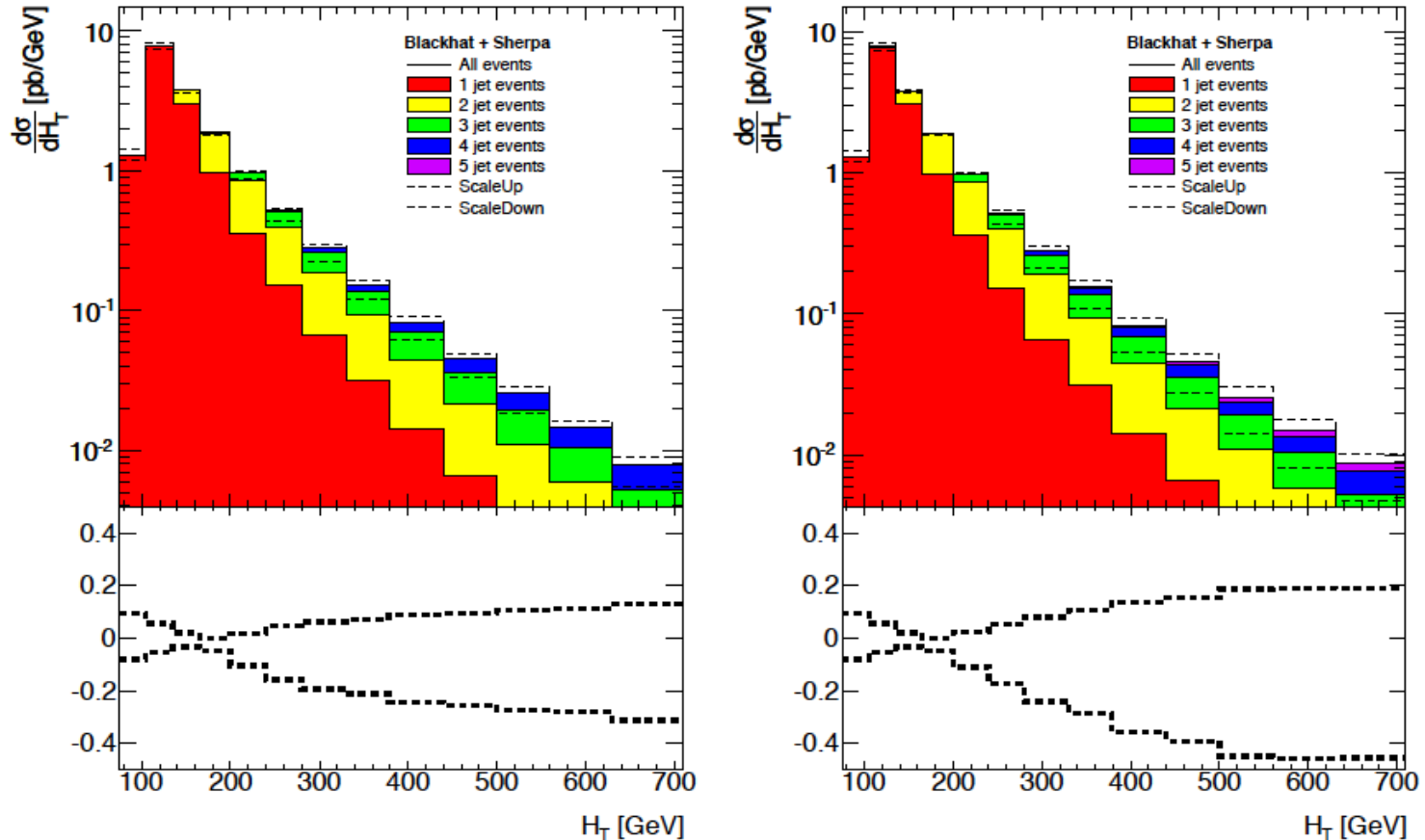


Fig. 2: The  $W +$  jets cross section, as a function of  $H_T$ , for  $W + \geq 1$  jet production using the exclusive sums approach, and adding up to 3 jets at NLO (left) and 4 jets at NLO (right). The cross sections have been evaluated at a central scale of  $H_T/2$  and the uncertainty is given by varying the renormalization and factorization scales independently up and down by a factor of 2, while ensuring that the ratio of the two scales is never larger than a factor of 2.

For more details, see the following contribution to Les Houches

arXiv: 1203.6803

## **W+jets production at the LHC: a comparison of perturbative tools**

*J. Andersen<sup>1</sup>, J. Huston<sup>2</sup>, D. Maître<sup>3,4</sup>, S. Sapeta<sup>5</sup>, G.P. Salam<sup>3,5,6</sup>, J. Smillie<sup>7</sup>, J. Winter<sup>3</sup>*

<sup>1</sup>CP<sup>3</sup>-Origins, Campusvej 55, DK-5230 Odense M, Denmark

<sup>2</sup> Physics and Astronomy Department, Michigan State University, East Lansing, MI, 48824 USA

<sup>3</sup>PH-TH Department, Case C01600, CERN, CH-1211 Geneva 23, Switzerland

<sup>4</sup>IPPP, University of Durham, Science Laboratories, South Rd, Durham DH1 3LE, UK

<sup>5</sup>LPTHE, UPMC and CNRS UMR 7589, 75252 Paris cedex 05, France

<sup>6</sup>Department of Physics, Princeton University, Princeton, NJ 08544, USA

<sup>7</sup>School of Physics and Astronomy, University of Edinburgh, Mayfield Road, Edinburgh EH9 3JZ, UK

### **Abstract**

In this contribution, we discuss several theoretical predictions for  $W$  plus jets production at the LHC, compare the predictions to recent data from the ATLAS collaboration, and examine possible improvements to the theoretical framework.

...plus some followup studies with Gavin Salam, Sebastian Sapeta, Daniel Maitre, Jan Winter et al on LoopSim treatment