Prospects on V+Jets @ 7TeV with the CMS Detector

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on behalf of the CMS collaboration

V+jets: Backgrounds for new physics and testing ground for QCD
09-09-2010
Motivations for V+jets studies

Observables
  - What are we starting with?
  - Precision studies

MC generators for V+jets in CMS
  - What we use
  - What we would like

What is the best way of presenting data

Plans
Motivations

- Important test of perturbative QCD
  - Compare rates to NLO predictions (MCFM, BlackHat, Rocket)
  - Compare shapes and relative rates to matrix element + parton shower calculations
- Final states with a vector boson plus jets are useful for searches, i.e.:
  - Normalization of SM backgrounds ($Z \rightarrow \nu\nu$, $W \rightarrow \tau\nu$)
  - Direct search of significant deviations in ($W+n$ jets)/($Z+n$ jets) or [$V+(n+1)$jets]/[$V+n$ jets]
- Important for detector commissioning
  - Jet energy scale calibration
What is a jet?

- Only infrared-collinear safe algorithms used in CMS
  - Anti-kt is our default
- Where to put the pt cut?
  - Low $p_T$ cut makes the measurement sensitive to the Underlying event
  - High $p_T$ cut is sensitive to higher order corrections
  - We are currently using two thresholds:
    - 15 GeV
    - 30 GeV

plots from Sherpa web page
Short term plan, $O(50 \text{ pb}^{-1})$:

- Measure the rate of jet production in association with a weak boson
  
  - $\frac{1}{\sigma_0} \frac{d\sigma}{dN_j}$, $\frac{\sigma[V+N_j]}{\sigma[V+(N+1)j]}$, $d\sigma/dN_j$
  
  - Comparison of rates, $\frac{\sigma(W+N_j)}{\sigma(Z+N_j)}$
Program for measuring rates

- Start with ratios
  - Z/W + n jets absolute cross section suffers from experimental uncertainties (luminosity, jet energy scale, acceptance...)
  - Check Berends-Giele scaling
    - Many systematics cancel out
  - Measure the W/Z ratio and the double ratio
    - Keeping W and Z selections in sync allows almost complete cancellation of reconstruction efficiency
- Unfold detector effects
- Deliver cross section measurements

MC study @ 10 TeV for O(100 pb⁻¹)
Precision studies: differential distributions

Longer term plan:
- Characterize $V + \text{jets}$ in greater detail
  - $d\sigma/dE_T$ for each jet, $d\sigma/dR_{jj}$, $d\sigma/dM_{jj}$, $d\sigma/d\Delta y_{jj}$
- Events shapes
  - Differential jet rates
    - Very challenging
    - Usually, for jets:
      * Cluster uncorrected energy
      * Apply a global correction
  - For differential jet rates we need to enter the clustering step with objects that have the correct energy scale
  - $\rightarrow$ Particle Flow
Underlying event and V+jets

- We can use V+soft jets to study Underlying Event
  - E.g. using 15 GeV threshold, a not negligible fraction of jets come from UE
  - $Z$ pT in events with at least 1 jet

Missing shower from MPI partons in old model based tunes.
The low momentum shoulder of this distribution could give us a handle to tune the UE

- Tuning status of ME+PS tools?
Rapidity gaps in V+jets

Rapidity gaps:
- Average number of jets VS rapidity gap between the forward and the backward jets
- Similar pattern in W+di-jets and in gluon fusion Higgs
- We can exploit W+di-jet to study the gg contamination to VBF

arXiv:1003.1241 [hep-ph], pag 72 and 130
Monte Carlos for V+jets

What are the desirable features?
- Describe multi jet topologies
  - ME + PS techniques
- Describe angular separation between jets and leptons
  - Our selections rely on isolation
- Refined treatment of QED fsr
  - FSR photons can fake jets
- Light and heavy flavor jets
  - We have both in the data
- It has to be tuned to data
  - Extremely important for a good understanding of isolation efficiencies
Parton level calculations

- FEWZ, DYNNLO, MCFM
  - To compute overall k-factors
- BlackHat and Rocket
  - We are in contact with the authors to get ntuples for $W+1,2,3$ jets at NLO 7TeV
  - samples produced with at least two scale choices
  - Parton level ntuples, so that we can re-cluster partons with different algorithms/cuts
Comparing data and theory

- How to present data to be most effectively comparable to theory predictions?
  - Unfold detector effects to particle level
    ▪ Best solution to compare to MC particle level programs
  - Acceptance can be different as a function of the number of jets
    ▪ Quote results both with and without acceptance corrections
- How to compare with parton level calculations?
  ▪ Unfold hadronization effects?
  ▪ Apply corrections for the UE?
Comparisons to Tevatron data

- Need for a clear picture of how different generators compare to Tevatron
- Example: Comparison to Z + jets @D0 for Sherpa

plots from Sherpa web page
Conclusion

- Our plan for V+jets can be summarized as:
  - Short term: measure ratio of rates, rates
  - Longer term: measure differential distributions, event shapes
- We are using all the most popular particle level MC for our simulations
  - Status of tuning
  - Clear picture of how they compare to Tevatron
  - Need a good description of observables related to isolation and QED fsr
- We have a well established strategy for early analysis:
  - data driven techniques
  - unfolding of detector effects
Backup