MultiJet Predictions and Higgs Studies

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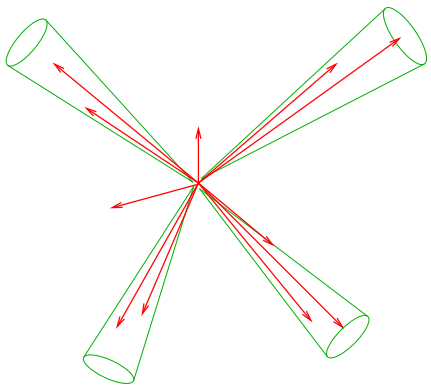

Tallahassee

13 May, 2013

MultiJet Studies at the LHC

- The LHC is throwing down the gauntlet to theory...
  Have plenty of data to work on... and TeVatron too!
- Multijet production is complex multi-scale process
- Key opportunity to tune analyses for Higgs-plus-jets:
  jet vetoes, angular correlations etc.
- Many theoretical descriptions with different specialities
  (and combinations!).

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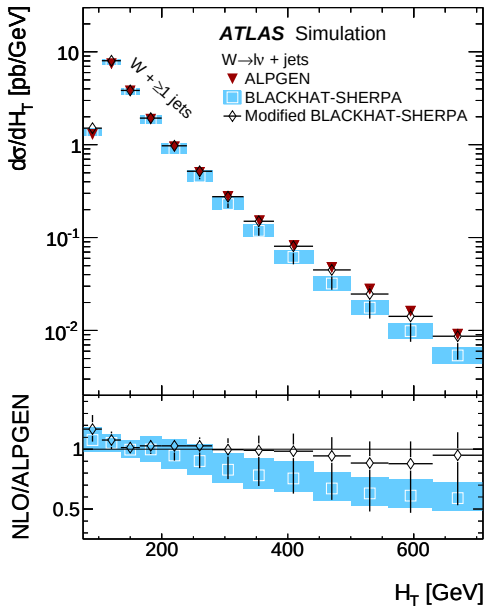
TODAY: High Energy Jets, W+jet analyses, Higgs+jets comps.

Importance of Higher Orders

- $(n+1)$-jet rates are not small compared to n-jet rates
  e.g. ATLAS Z+jets: $\frac{\sigma(n+1)}{\sigma(n)} \simeq 0.2$, $n = 1, \ldots, 6(!)$
  AND increases to 0.3 in VBF selection arXiv:1304.7098

- NLO is only one more emission
  ATLAS W+jets had to introduce 'exclusive sums' to describe e.g. H_T
  arXiv:1201.1276

  Confirmed in Z+jets.



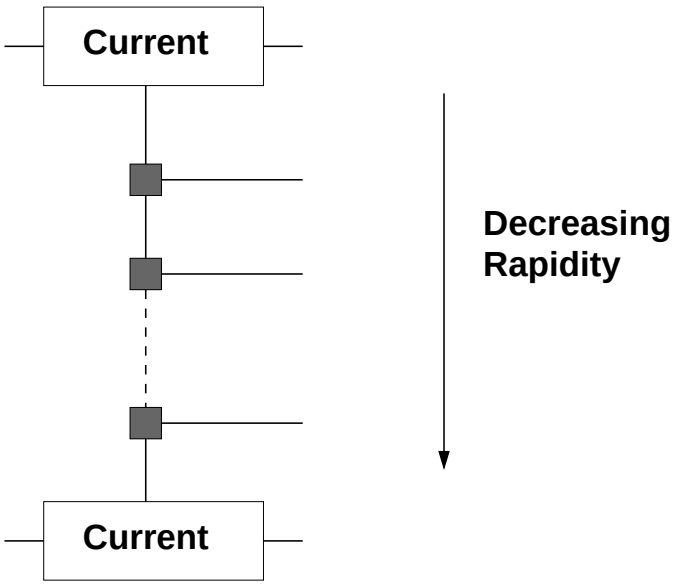
High Energy Jets systematically resums hard QCD emissions

High Energy Jets

Andersen & JS – arXiv:0908.2786, 0910.5113, 1101.5394, 1206.6763 (+Hapola)

Scattering amplitudes factorise in the High Energy limit:

$$s_{ij} \to \infty,\ p_{\perp_i} \text{ fixed},\ \forall \text{ partons } i, j$$



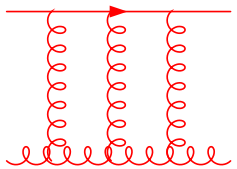
- Exploit this to approximate ME
- $2 \to n$ for any n is simply
$$j^\mu j_\mu \prod V^\nu$$
- Exact for $2 \to 2$

High Energy Jets

Andersen & JS – arXiv:0908.2786, 0910.5113, 1101.5394, 1206.6763 (+Hapola)

Factorisation also applies to *a*ll higher loops

(also necessary to regulate soft real emissions)


,...

$\Rightarrow$ Together all pieces give leading behaviour in $\frac{s}{t}$ at all-orders

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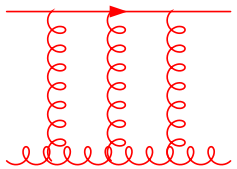
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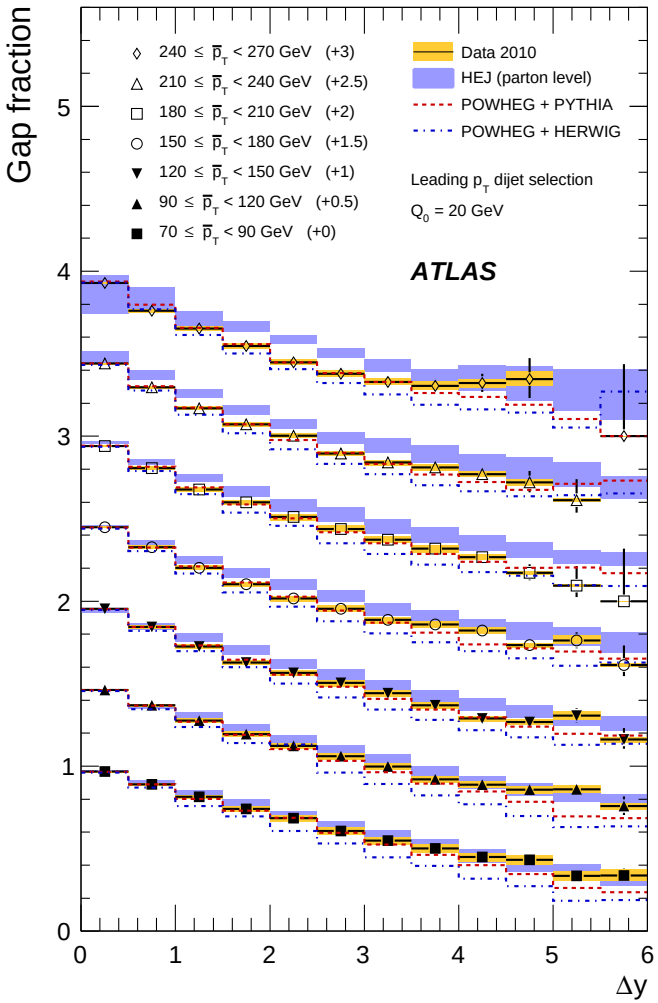
Fully flexible MC implementation available at

`http://cern.ch/hej`

for Higgs+jets (new!), W+jets, pure jets, HEJ+ARIADNE

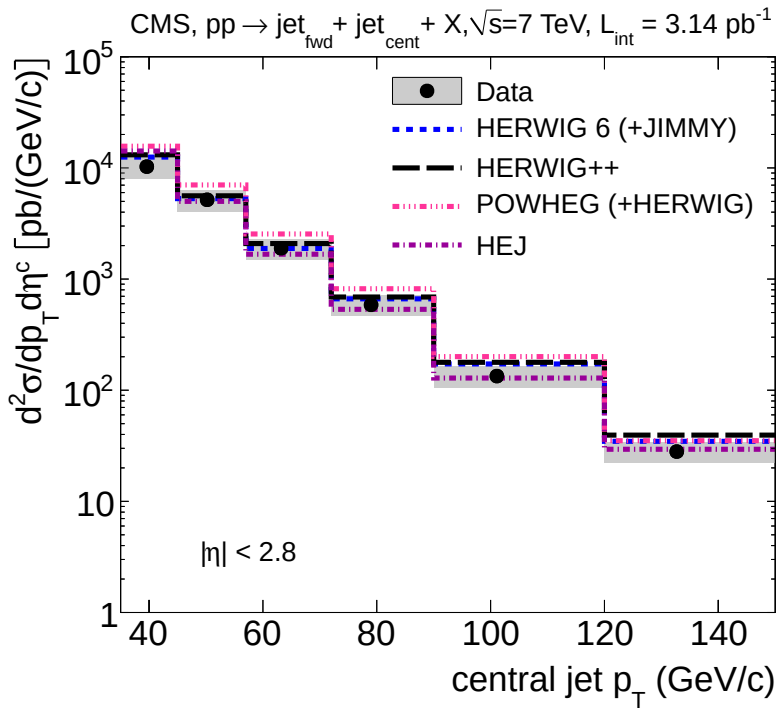
LHC Jet Analyses



Early jet analyses now well-known:

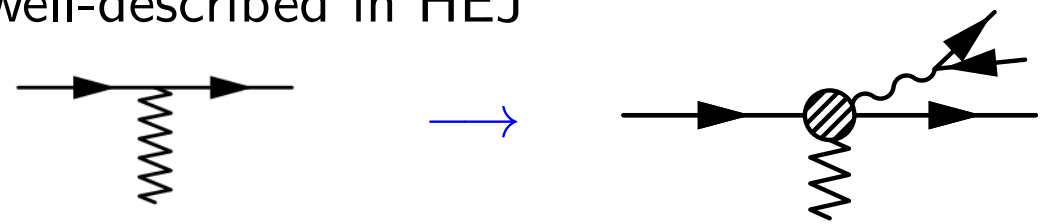
← ATLAS arXiv:1107.1641

↓ CMS arXiv:1202.0704,1204.0696



W Plus Jets

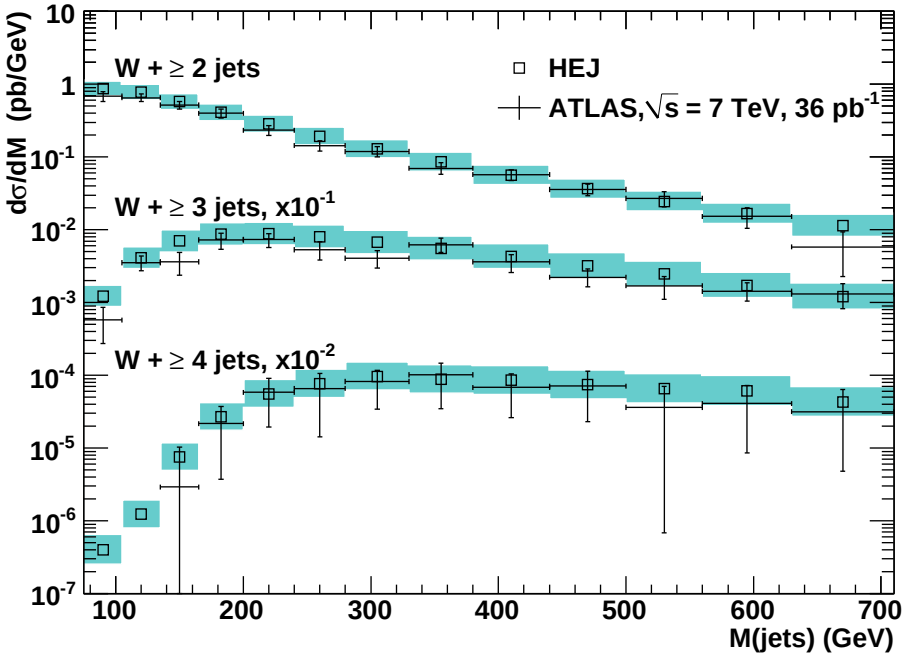
W+jets also well-described in HEJ



Andersen, Hapola & JS arXiv:1206.6763

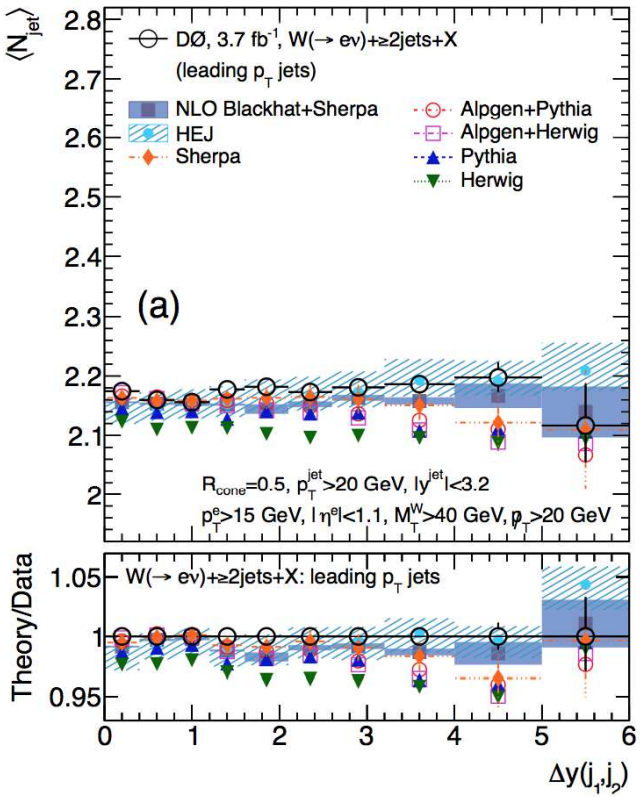
ATLAS data
arXiv:1201.1276

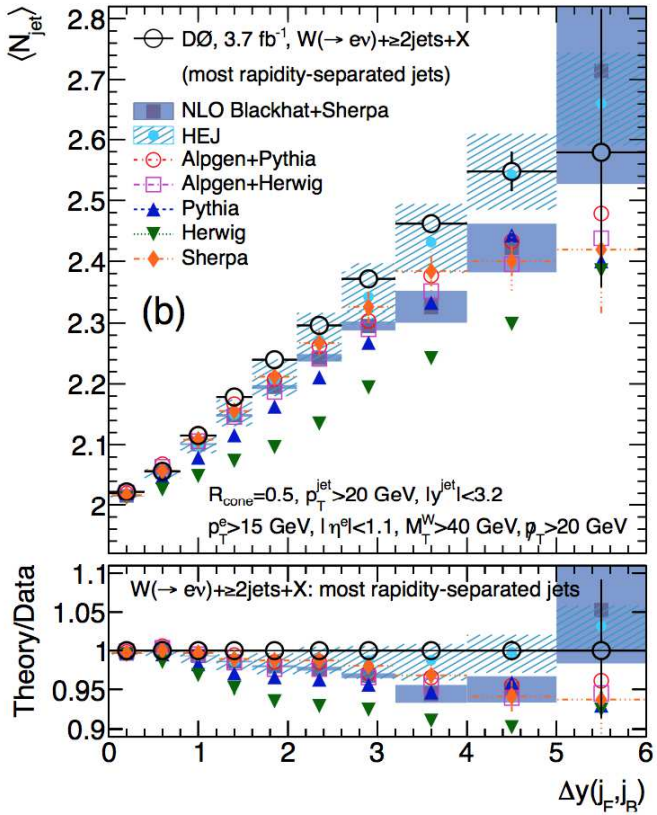
Note large impact of higher orders!



Recent TeVatron W+Jets Results

D0 arXiv:1302.6508





Difference between:

Leading jets

Most forward/backward jets

Recent Tevatron W+Jets Results

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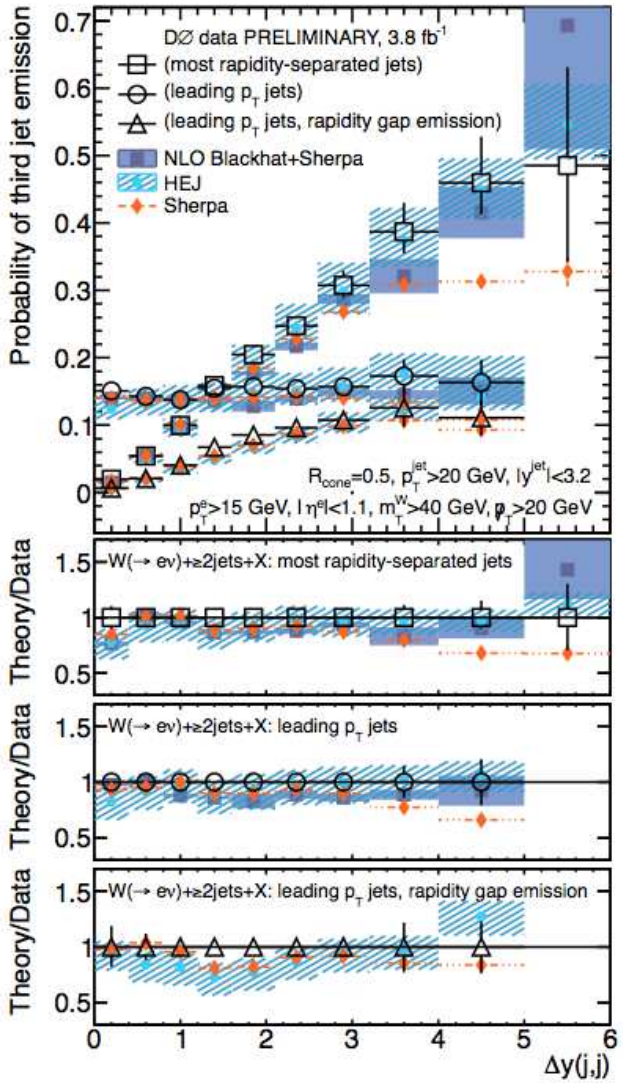
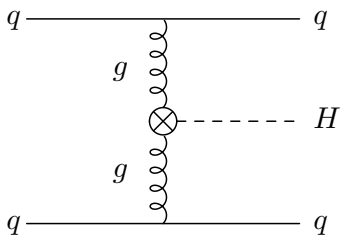
Probability of third jet emission vs. Δy of

1. most forward/backward jets
2. hardests jets
3. hardests jets, counting only jets between

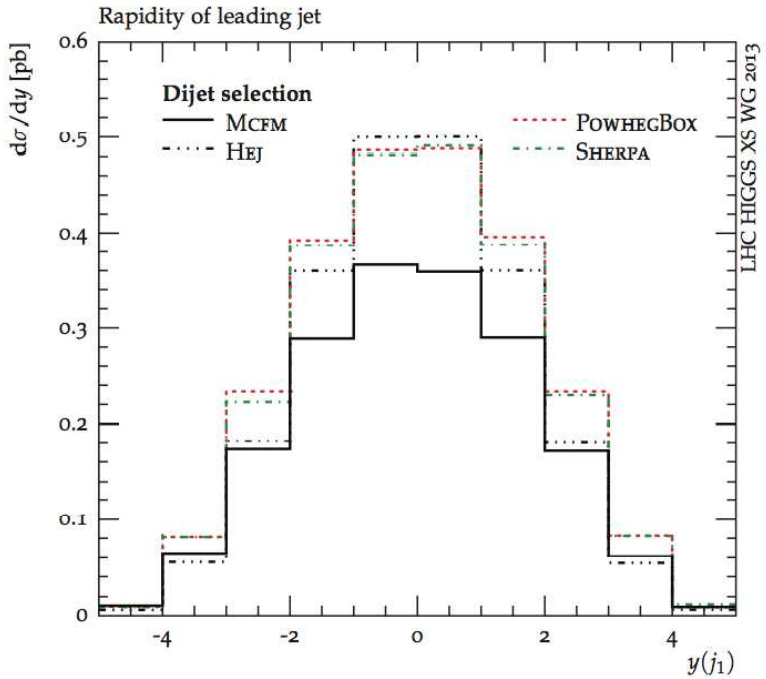


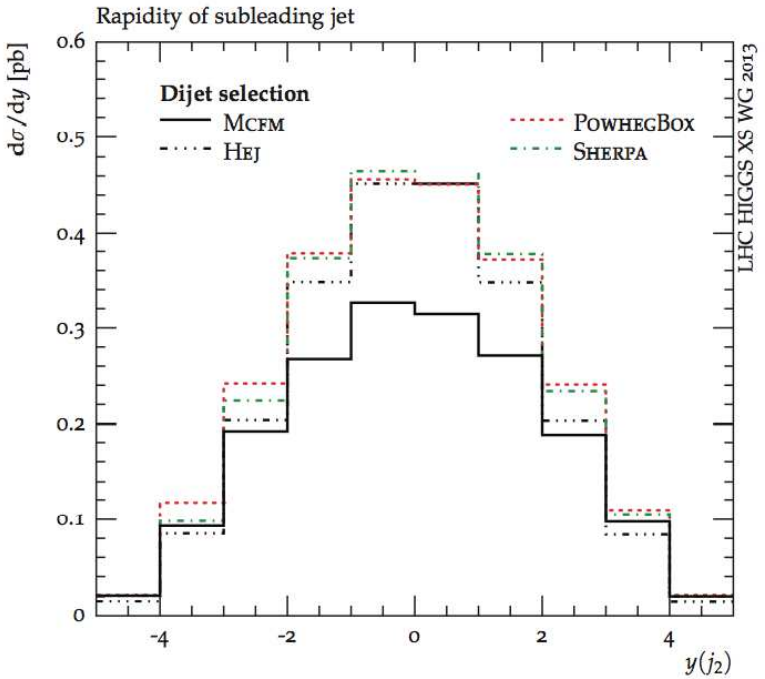
Preparation for Higgs+Jets Data



Have seen large rapidity spans = large jet activity

From YR3 Higgs XS WG 2013:





Inclusive 2 jets, $p_T > 25$ GeV, $|y| < 5$

Preparation for Higgs+Jets Data

Add weak boson fusion cuts, $|\Delta\eta_{jj}| > 2.8$, $m_{jj} > 400$ GeV

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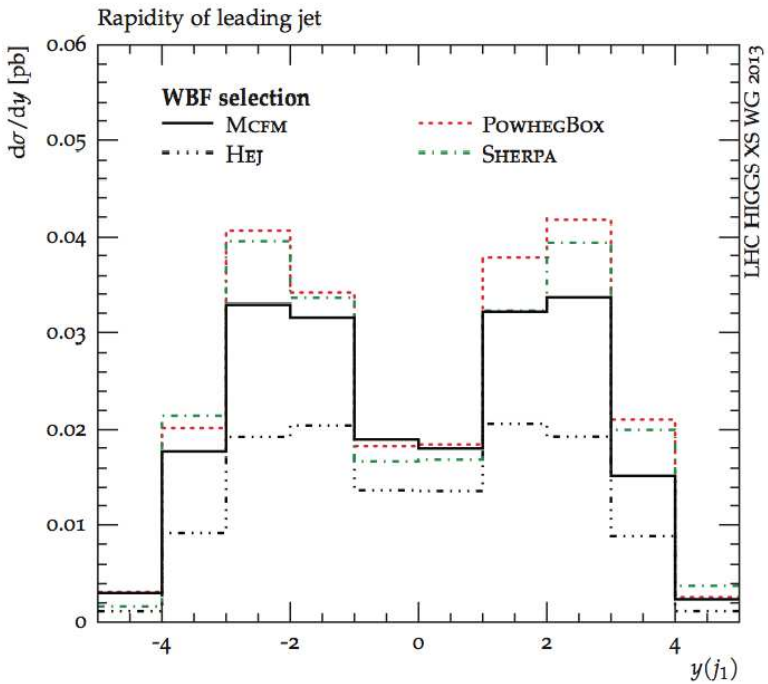

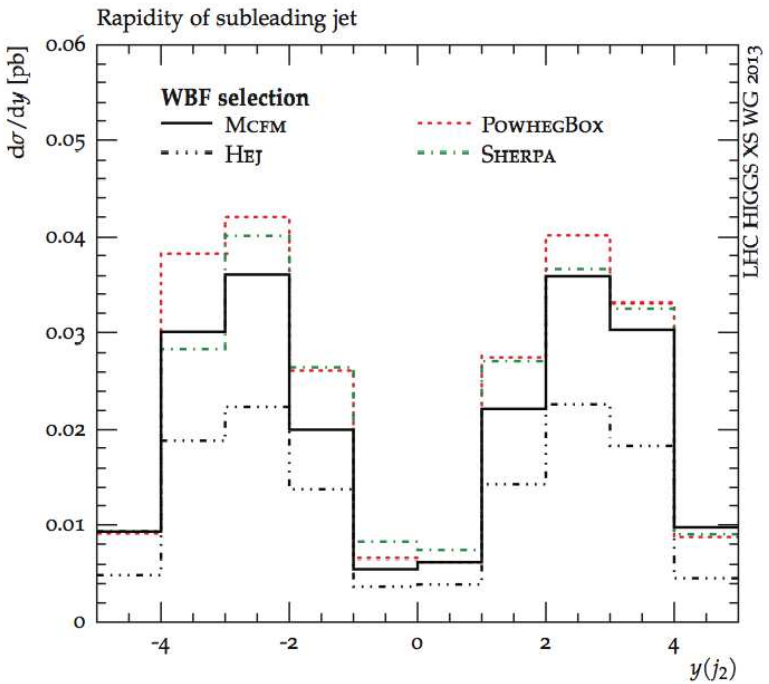

Roughly 10% for MCFM, POWHEG & SHERPA, 6% for HEJ.

See also Gavin Salam's Dec talk.

Summary

- Have already seen effect of hard QCD radiation in data
- High Energy Jets offers flexible MC description of this
- Recent and ongoing studies show effects of higher orders
- Important applications to Higgs-plus-jets studies:
  Currently see deviations in theoretical descriptions