Precise Predictions for Electroweak H+Jets Production

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DESY

with F. Campanario, T. Figy & M. Sjödahl

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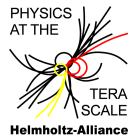


Outline.

- Motivation.
- Outline of the calculation.
- Numerical results.
- Conclusions & Outlook.

Motivation.

VBF Higgs production is an important Higgs production channel.

Extraction of a VBF signal requires precise understanding of H plus three jets production.

- Jet vetoes needed to push for the VBF signature
- QCD and EW channels need to be considered, ideally with interferences

Fixed-order calculations of three jet production as a first step into assessing jet veto cross sections.

- Needs to be supplemented by resummation and/or parton showers
- Important to keep track of full QCD dynamics

Outline of the Calculation.

H plus three jets production at $\mathcal{O}(\alpha^3\alpha_s^2)$.

- Previously considered in t-channel (VBF) approximation

  [T. Figy, V. Hankele, D. Zeppenfeld – JHEP 0802 (2008) 076]

- The full process includes s, t, u-type diagrams and all interferences
  $\rightarrow$ VBF and Higgs-Strahlung with hadronically decaying vector boson
- Virtual corrections range up to six-point functions
- Also provide H plus two jets as cross check to HAWK

  [M. Ciccolini, A. Denner, S. Dittmaier – Phys.Rev. D77 (2008) 013002]

We use a setup based on the Matchbox module of Herwig++.
Matching/merging with parton shower is directly in reach.

NLO Calculations with Matchbox.

$$\sigma_{\text{NLO}} = \int_n \mathrm{d}\sigma_{\text{LO}} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}_{n,0}|^2 \end{pmatrix} + \int_n \left[\mathrm{d}\sigma_{\text{V}} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle, |\mathcal{M}_{n,1}\rangle \\ 2\text{Re}(\langle \mathcal{M}_{n,0} | \mathcal{M}_{n,1} \rangle) \end{pmatrix} + \int_1 \mathrm{d}\sigma_{\text{A}} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}^{ij}_{n,0}|^2 \end{pmatrix} \right]$$
$$+ \int_{n+1} \left[\mathrm{d}\sigma_{\text{R}} \begin{pmatrix} |\mathcal{M}_{n+1,0}\rangle \\ |\mathcal{M}_{n+1,0}|^2 \end{pmatrix} - \mathrm{d}\sigma_{\text{A}} \begin{pmatrix} |\mathcal{M}_{n,0}\rangle \\ |\mathcal{M}^{ij}_{n,0}|^2 \end{pmatrix} \right]$$

Interfaces at amplitude level

- Color bases provided, including interface to `ColorFull`. [M. Sjödahl, SP]
- Spinor helicity library and caching facilities.
- Some in-house calculations and parts of `HJets++`. [F. Campanario, T. Figy, SP, M. Sjödahl]

Interfaces at squared amplitude level

- Dedicated interfaces. [nlojet++ & J. Kotanski, J. Katzy, SP]
- BLHA2. [GoSam & J. Bellm, S. Gieseke, SP, C. Reuschle] [NJet & SP] [VBFNLO & K. Arnold, S. Gieseke, SP]

Matchbox infrastructure based on [SP & S. Gieseke – Eur.Phys.J. C72 (2012) 2187]

- Process generation and bookkeeping, integration, analysis.
- Automatic crossing if required, various caching facilities.
- Automated Catani-Seymour dipole subtraction, alternative choices possible.
- Diagram-based mutli-channel phase space, straightforward interface for alternatives.

HJets++

HJets++ provides electroweak H+2,3 jet production at NLO QCD.

Matchbox

[SP & S. Gieseke – Eur.Phys.J. C72 (2012) 2187]

- Tree-level amplitudes using builtin spinor helicity library
- Automatic dipole subtraction

ColorFull

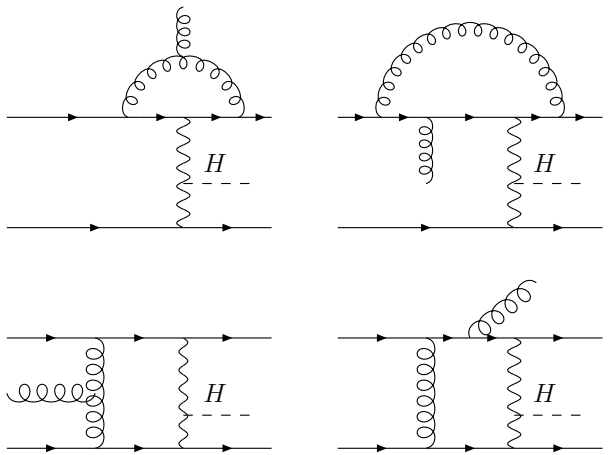
[M. Sjödahl – colorfull.hepforge.org]

- color sums and color correlations

Tensor reduction

[F. Campanario – JHEP 1110 (2011) 070]

- automated generation of amplitudes, stable tensor reduction
- scalar integrals from OneLOop [A. van Hameren – CPC 182 (2011) 2427-2438]



Full complex mass scheme, Higgs decays via Herwig++ decayer framework with sophisticated line shape modelling.

Cross sections & Scale Choices.

Complex multi-scale process. Scale choice not clear at all.

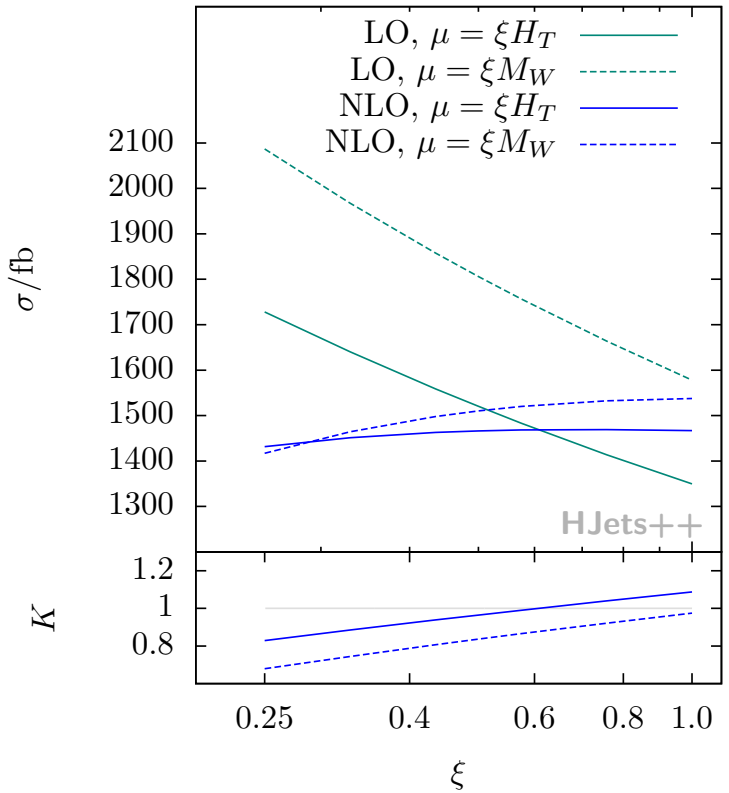
First consider inclsive cuts: three (anti-$k_\perp$) jets above 20 GeV.

$M_W/2$

- Motivated by previous VBF studies
- Larger scale dependence than for $H_\perp/2$
- Distributions show more variation in K factors

$H_\perp/2$

- Motivated by QCD EW+jets
- Strong reduction in scale dependence
- Most distributions with flat K factor
- Exception: jet $p_\perp$ spectra

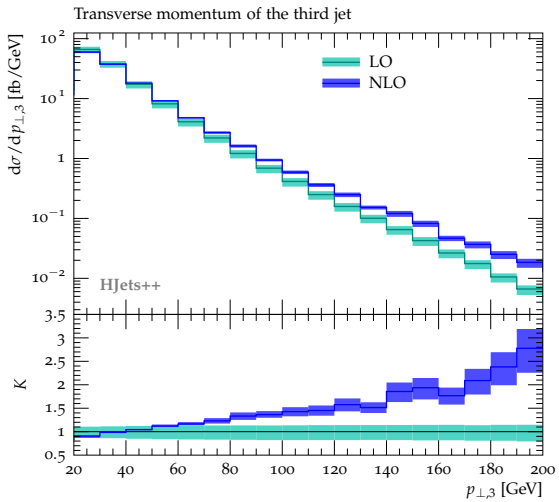


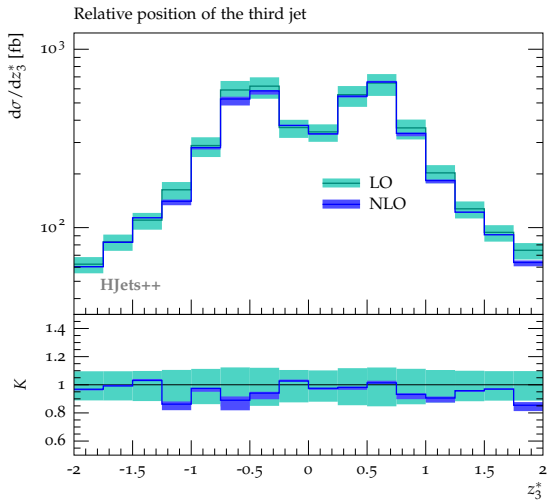
Neither of those may be the optimal one. Looking into 'clustering scales'.

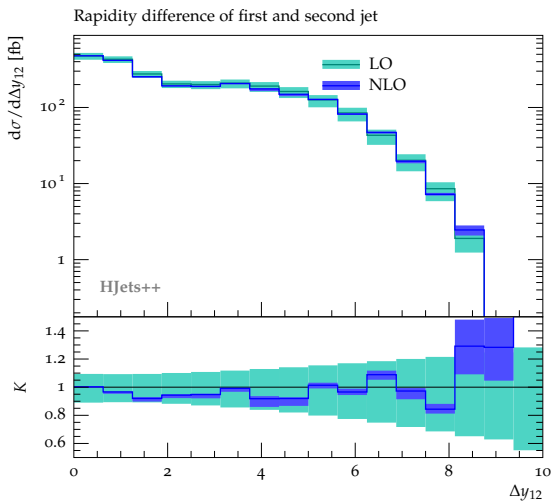
[R. Poncelet (DESY summer student) & SP – in progress]

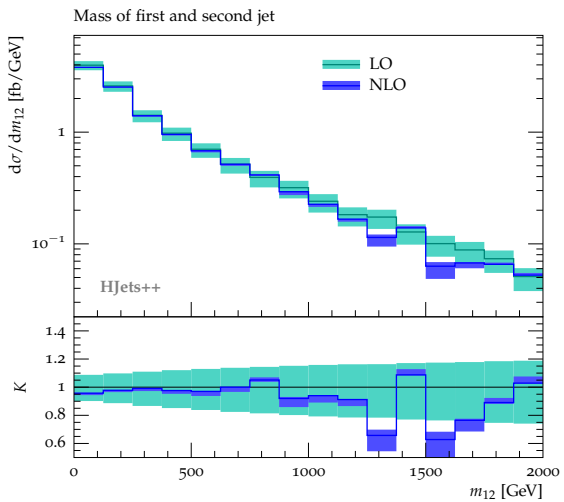
Distributions.

Inclusive cuts, $\mu = H_\perp/2$









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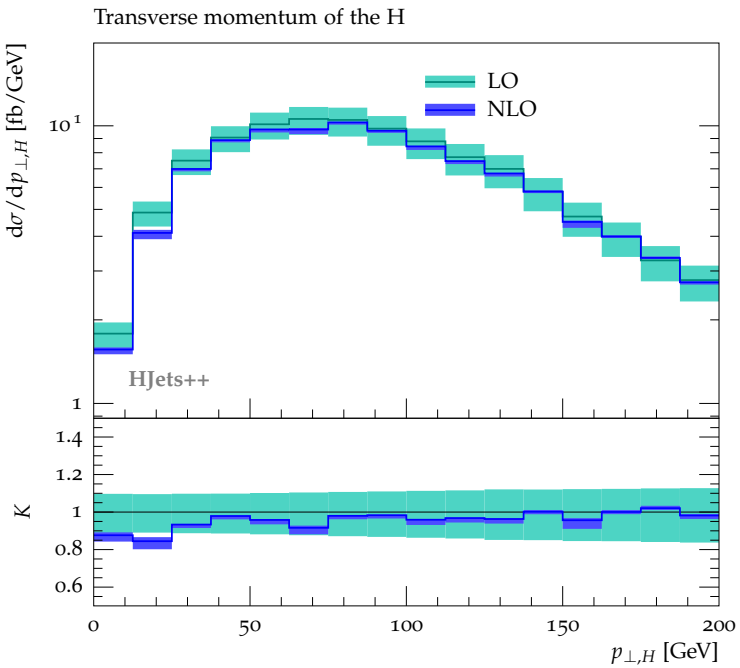

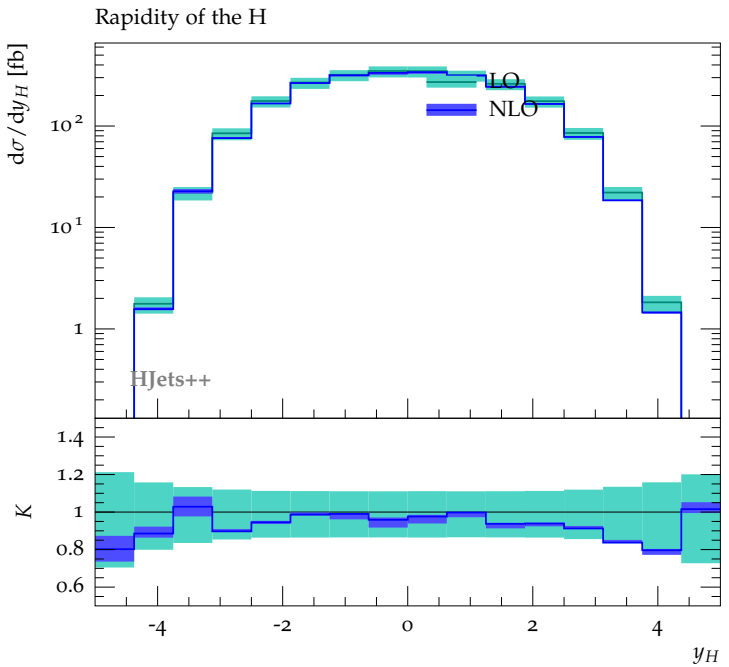

Conclusions & Outlook.

Electroweak H plus two and three jet production availabl in `HJets++`
Code based on the Matchbox framework of Herwig++.

All VBF and Higgs-Strahlung diagrams considered.

Important ingredient to assess jet vetoes.

Impact of VBF cuts, jet algorithms, test of VBF approximation and much more in progress.

Jet $p_\perp$ spectra need more understanding $\rightarrow$ new channels?