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von Humboldt Stiftung/Found

Gluon fusion H+3j as a background to VBF

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In collaboration with:

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H+jets in gluon-gluon fusion

- Dominant channel of Higgs production
- Large background makes it a prohibitive channel to directly study the Higgs boson
- Nonetheless precise knowledge of GGF-channel is crucial:
  - When applying vetoes to jets

  ➔ H+jets cross section needed to estimate untertainties in efficiencies

  - When studying VBF production channel

  ➔ Estimate contamination in VBF sample of events coming from gluon-gluon fusion channel

  ➔ H+2j sample can describe further radiation only at LO

H+jets in gluon-gluon fusion

H+3 jets

- Calculation setup so far:
  - B amplitudes: Sherpa (Amegic)
  - V amplitudes: GoSam

  } PS integration: Sherpa (BLHA)

  - IRS amplitudes: MG4/MadDipole

  } PS integration: MadEvent

  → Full NLO

- New ongoing calculation:
  - B amplitudes: Sherpa (Comix)
  - V amplitudes: GoSam
  - IRS amplitudes: Sherpa (Comix)

  } PS integration: Sherpa (BLHA)

  → Full NLO + merging + shower

H+jets in gluon-gluon fusion

H+3 jets

- New possibilities:
  - ✓ Generation of Ntuples for H+2j and H+3j jets [Should be ready early next year]
  - ✓ Will allow PDF / Scale / Cut variation (ΔR, jet algo, pt, eta)
  - ✓ Study impact of typical GGF and VBF cuts (similar to LH2013 study)
    - ✓ Easy comparison of VBF signal and GGF background
      - ✓ Using different selection for leading jets (leading pt / most forward-backward)
    - ✓ Merging of H+2j and H+3j sample and application of jet vetos

H+3 jets

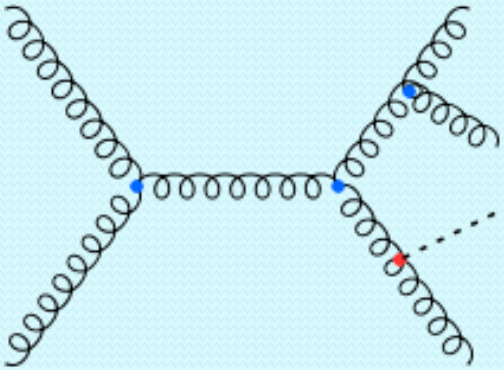
[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter, LH2013]

- Computed using GoSam + Sherpa + MadGraph4/MadDipole/MadEvent
  - Physical setup: LHC 8 TeV with ATLAS cuts

anti-kt: R=0.4 p_T>30 GeV $|\eta| < 4.4$

PDFs: cteq6L1 @ LO CT10nlo @ NLO

scales: $\mu_F = \mu_R = \frac{\hat{H}_T}{2} = \frac{1}{2}\left(\sqrt{m_H^2 + p_{T,H}^2} + \sum_i |p_{T,i}|\right)$



$$\alpha_s^5 \longrightarrow \alpha_s^2(m_H)\alpha_s^3(\hat{H}_T/2)$$

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter, LH2013]

- Inclusive cross section:

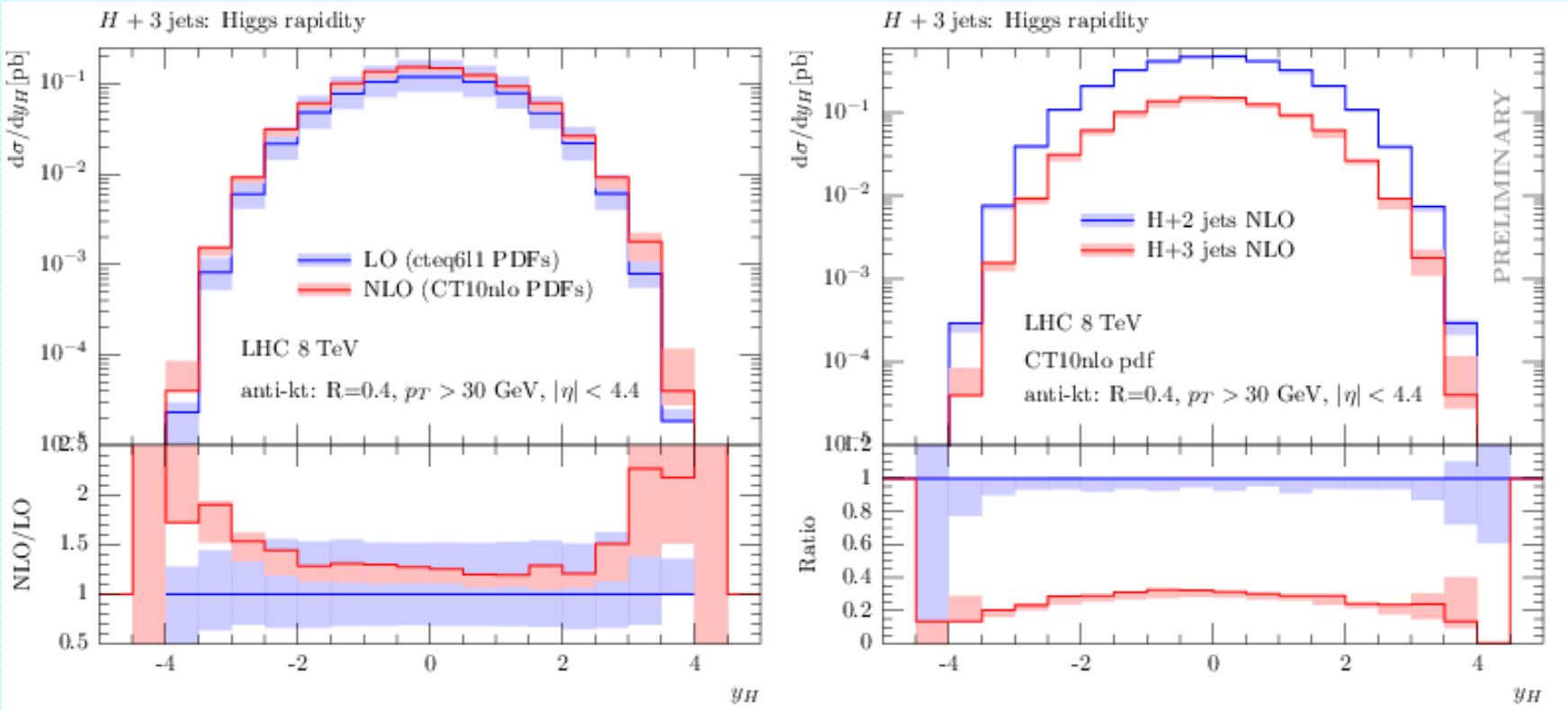
σ_n : inclusive cross section
f_3 : inclusive 3-jet fraction
$r_{(n+1)/n} = \sigma_{n+1}/\sigma_n$

Sample K-factor	Cross sections for Higgs boson plus ≥ 2 jets	f_3	≥ 3 jets	$r_{3/2}$
LO	[pb]		[pb]	
H+2-jets (LO PDFs)	$1.23\ ^{+37\%}_{-24\%}$			
H+3-jets (LO PDFs)	(0.381)	1.0	$0.381\ ^{+53\%}_{-32\%}$	$0.310\ ^{0.347}_{0.278}$
NLO				
H+2-jets	$1.590\ ^{-4\%}_{-7\%}$	0.182	$0.289\ ^{+49\%}_{-31\%}$	
H+3-jets	(0.485)	1.0	$0.485\ ^{-3\%}_{-13\%}$	$0.305\ ^{0.307}_{0.284}$
K_2, K_3 (LO PDFs for LO)	$1.29\ ^{0.911}_{1.59}$		$1.27\ ^{0.806}_{1.63}$	

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter, LH2013]

- Higgs rapidity distributions:

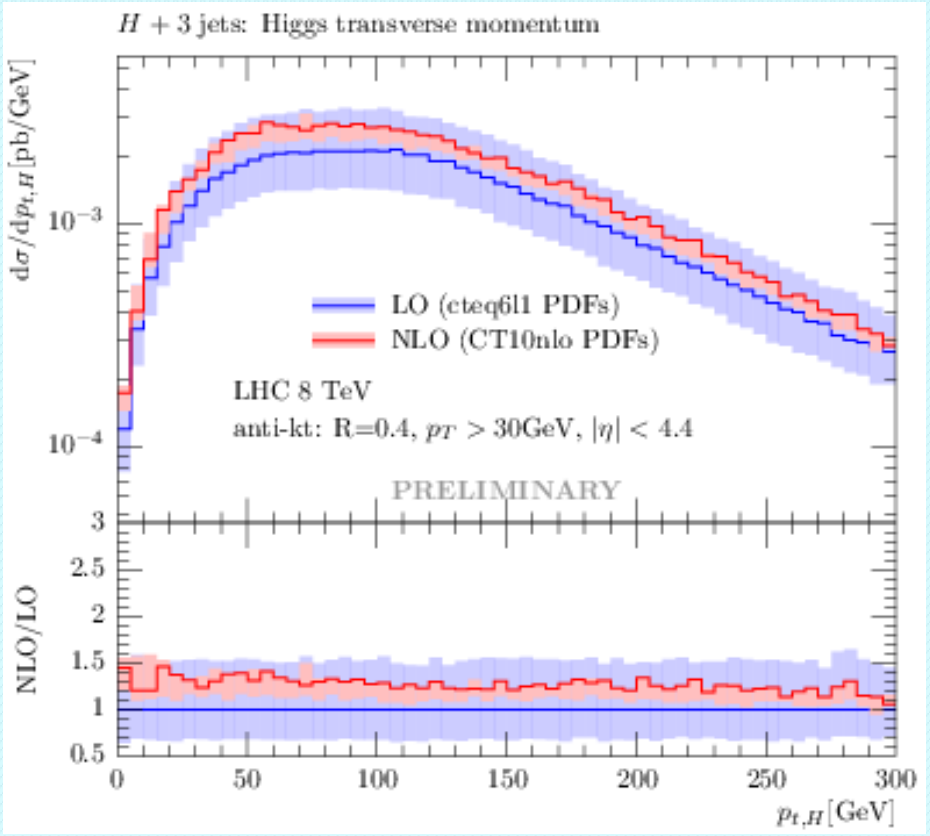


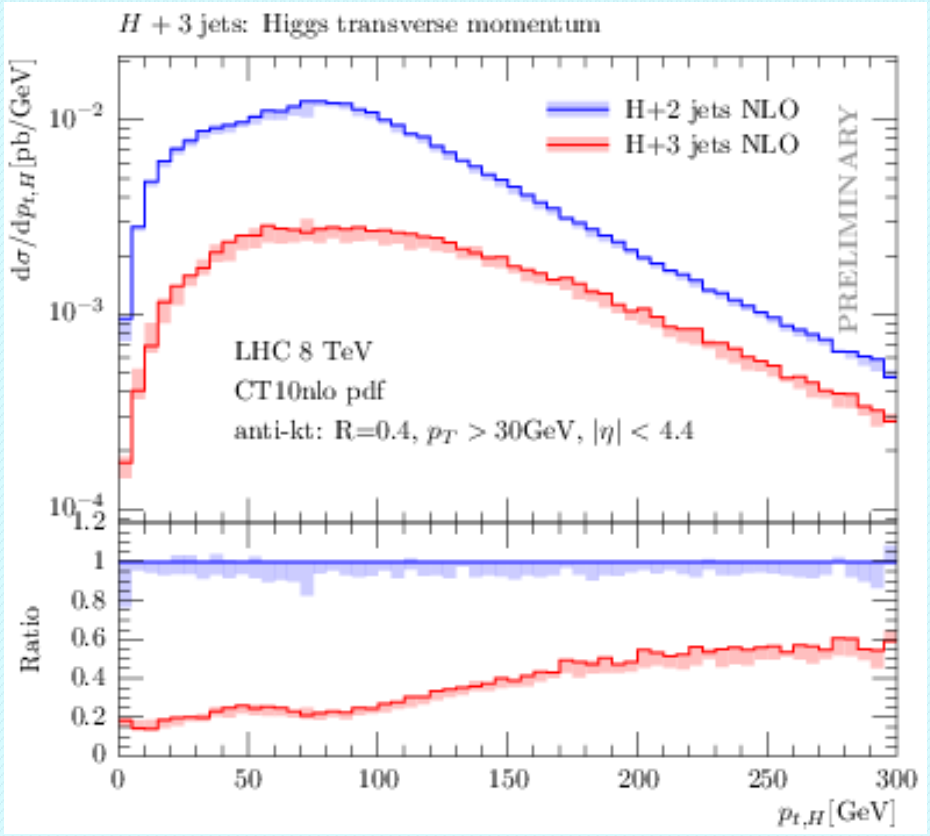
- Higgs in H+3j produced slightly more central

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter, LH2013]

- Higgs transverse momentum distributions:



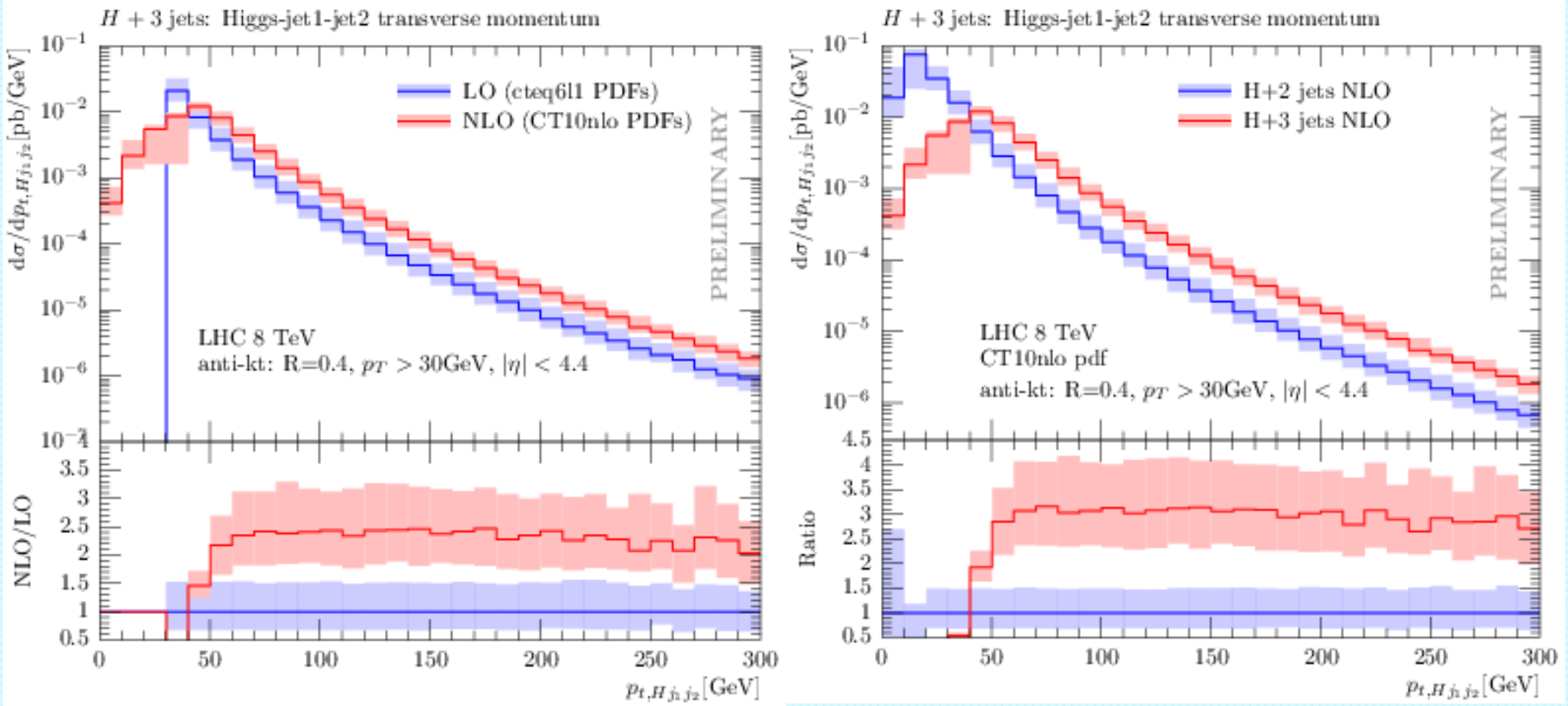


- H+3j sample particularly important at higher $p_{t,H}$

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter, LH2013]

- Hj_1j_2 transverse momentum:



- Hj1j2 first described at NLO (not over the full spectrum)

Conclusions & Outlook

- H+3 jets @ NLO in gluon-gluon fusion
  - Significant reduction of scale uncertainties
  - Important impact of NLO corrections on shapes with GGF
    ➔ interesting to see the relevance when applying VBF cuts
  - Pt of Hj_1j_2-system for the first time computed with NLO accuracy

- Work in progress
  - Generation of Ntuples with new setup
  - Impact of VBF-type cuts
  - Release code and NTuples files
  - Merging with smaller multiplicities / matching with parton shower
  - Any other format desired from experiments?

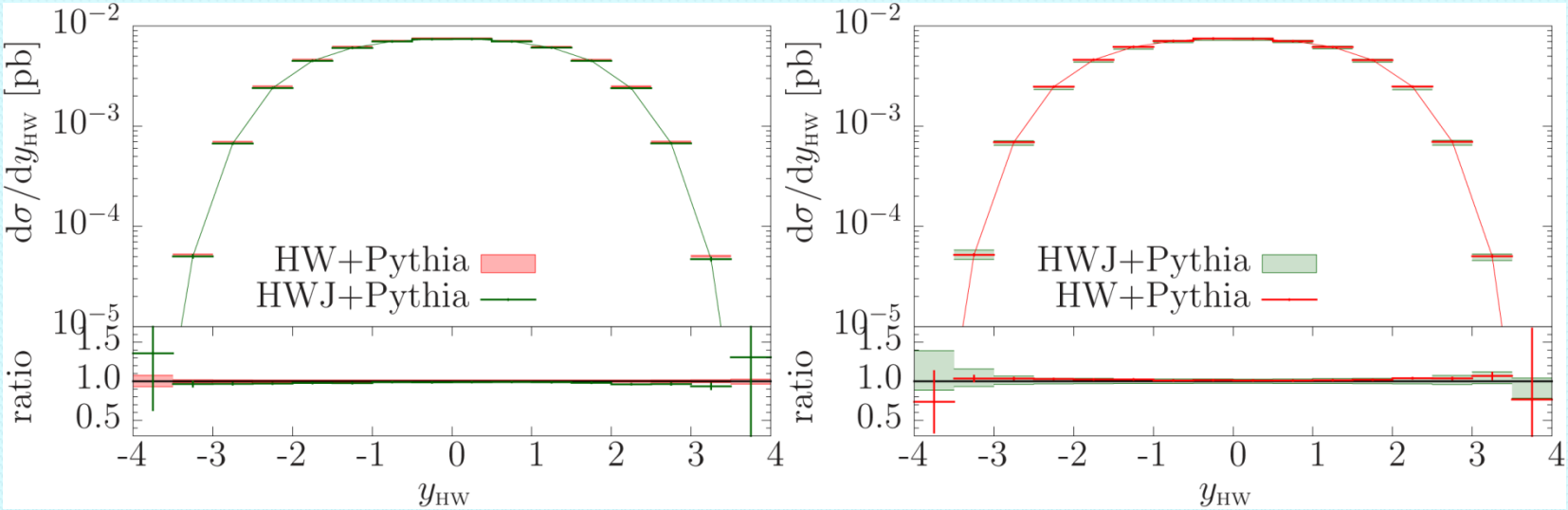
VH with GoSam+Powheg

[Luisoni, Nason, Oleari, Tramontano; **JHEP 1310 (2013) 083, arXiv:1306.2542**]

HV+1j with Powheg+GoSam

[Luisoni, Nason, Oleari, Tramontano]

- Results for LHC @ 8 TeV:
  - uncertainty band by varying independently K_R,K_F by factors of 0.5 and 2.



HV+1j with Powheg+GoSam

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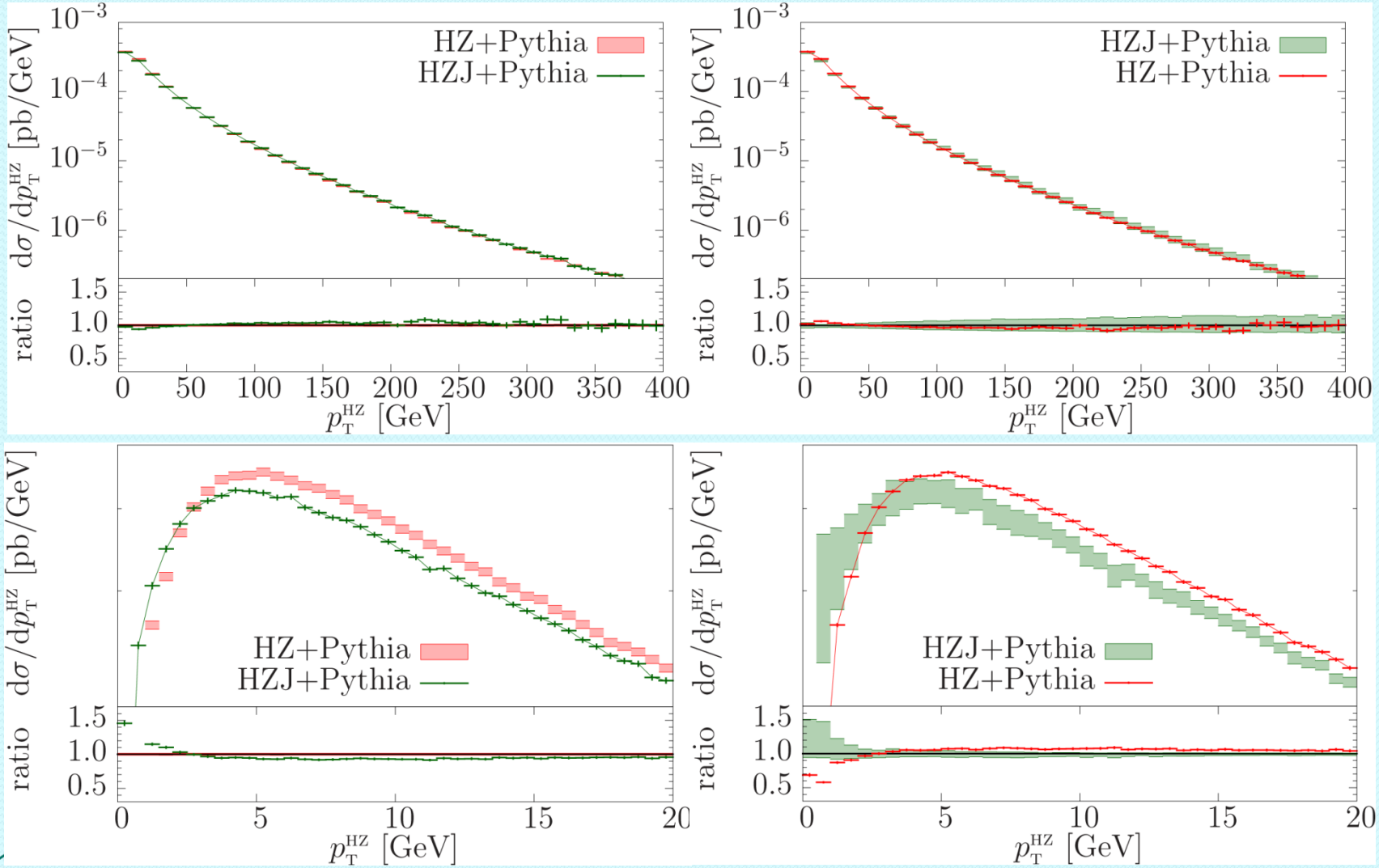
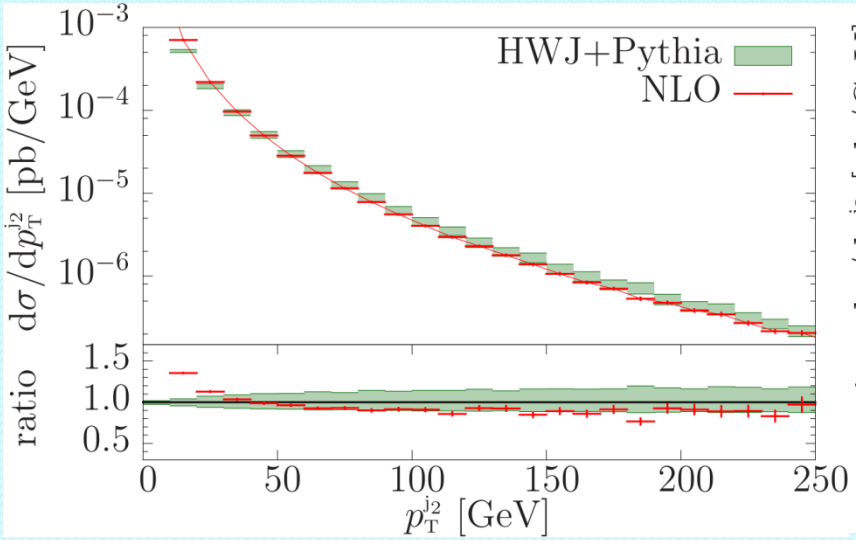
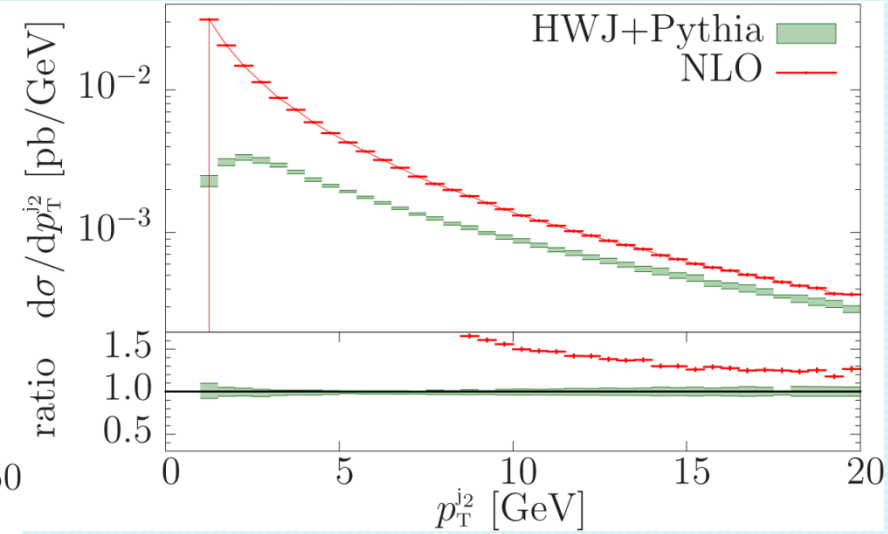


HV+1j with Powheg+GoSam

[Luisoni, Nason, Oleari, Tramontano]

- Effect of the Powheg formalism visible on the 2. jet:





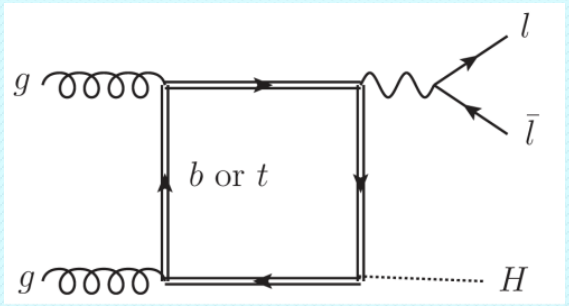
- Possibility to construct an NNLO+PS generator by reweighting with NNLO results.

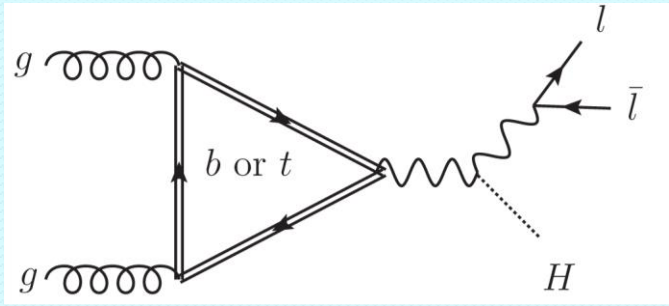
[Hamilton, Nason, Oleari, Re, Zanderighi]

gg->HZ with Powheg+GoSam

[Luisoni, Nason, Oleari, Tramontano; **JHEP 1310 (2013) 083**, arXiv:1306.2542]

- gg → HZ production:





- square of LO contribution to gg→HZ (via massive b/t loops) with GoSam
  - This is a LO generator, not a NLO one, the POWHEG-BOX does not generate any additional radiation

- possibility to modify the Higgs-top and Higgs-Z coupling by multiplicative factors κ_{Ht} , κ_{HZ} via reweighting of lhe event files:

$$g_{\mathrm{Ht}} = \kappa_{\mathrm{Ht}} \times g_{\mathrm{Ht}}^{SM}$$

$$g_{\mathrm{HZ}} = \kappa_{\mathrm{HZ}} \times g_{\mathrm{HZ}}^{SM}$$

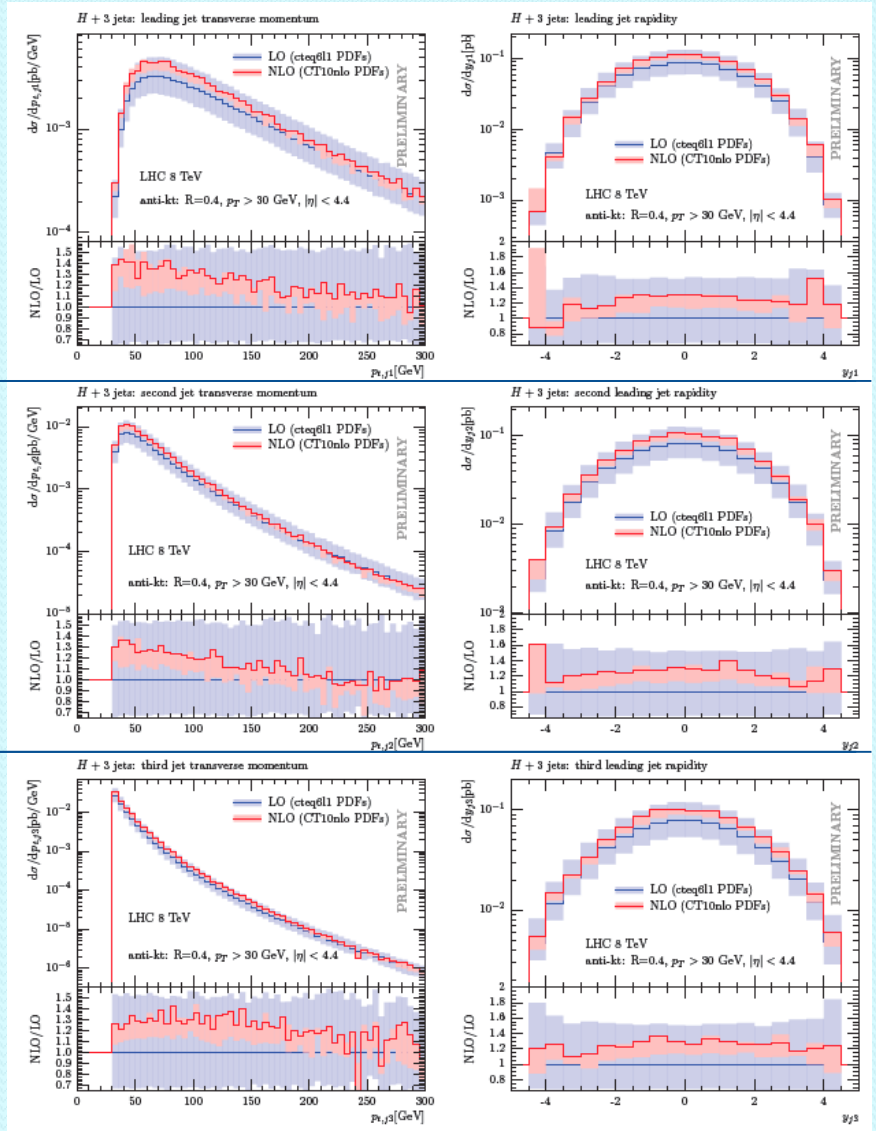
http://indico.cern.ch/event/330239/contribution/2/material/slides/0.pdf

Backup slide

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter]

- 1st jet
- 2nd jet
- 3rd jet



- Similar scale variations as Higgs rapidity
- y_j: +20% corrections from NLO
- Pt_j: important shape change due to NLO corrections

H+3 jets

[Cullen, van Deurzen, Greiner, Huston, G.L., Mastrolia, Mirabella, Ossola, Peraro,Tramontano, Yundin, Winter]

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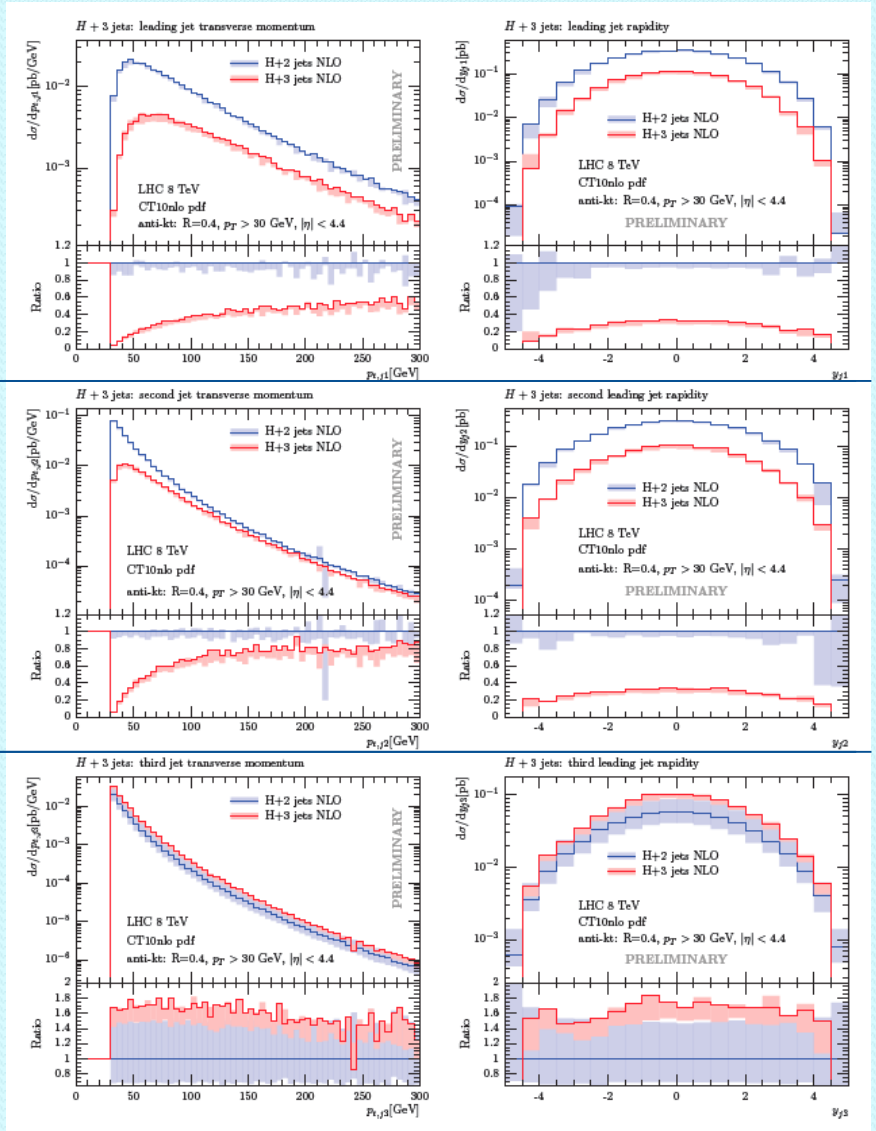

- $r_{3/2}$: flat for y_j distributions
- $r_{3/2}$: strong dependence in Pt_j distributions (50% at 100 GeV)

Higher jet multiplicity important

- $r_{3/2}$: different behaviour for hardest and 2nd hardest jet than for 3rd hardest one