

## Example: H+2 jets MiNLO at next-to-leading order

- To extend from LO 'MiLO' example to NLO apply the same all orders shower corr<sup>n</sup>s to the conventional NLO HJJ computation

The chalkboard contains the following equations:

$$d\sigma_{HJJ}^{\text{MiNLO}} \equiv d\sigma_{HJJ}^{\text{NLO}} \times \frac{d\sigma_{HJJ}^{\text{P.S.}}}{\left[ d\sigma_{HJJ}^{\text{P.S.}} \right]_{\text{LO}}}$$
$$- d\sigma_{HJJ}^{\text{LO}} \times \left[ \frac{d\sigma_{HJJ}^{\text{P.S.}}}{\left[ d\sigma_{HJJ}^{\text{P.S.}} \right]_{\text{LO}}} \right]_{\alpha_s\text{-term only}} \times \frac{d\sigma_{HJJ}^{\text{P.S.}}}{\left[ d\sigma_{HJJ}^{\text{P.S.}} \right]_{\text{LO}}}$$

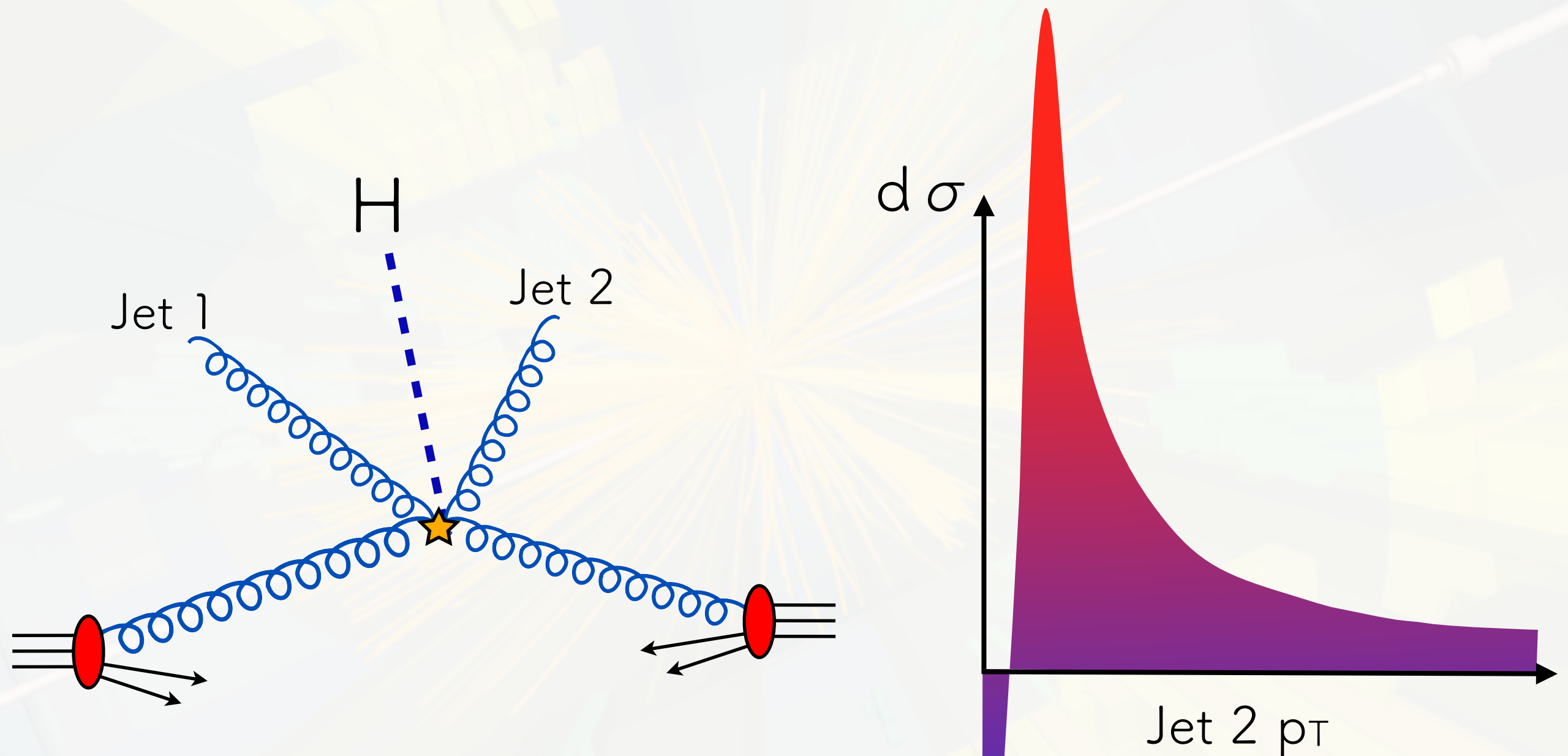
A red dotted arrow points from the text "conventional NLO HJJ computation" to the first fraction in the first equation. A green dotted arrow points from the text "unchanged to NLO" to the second fraction in the second equation.

- And subtract a term to render the expansion in  $\alpha_s$  unchanged to NLO



# Example: H+2 jets MiNLO at next-to-leading order

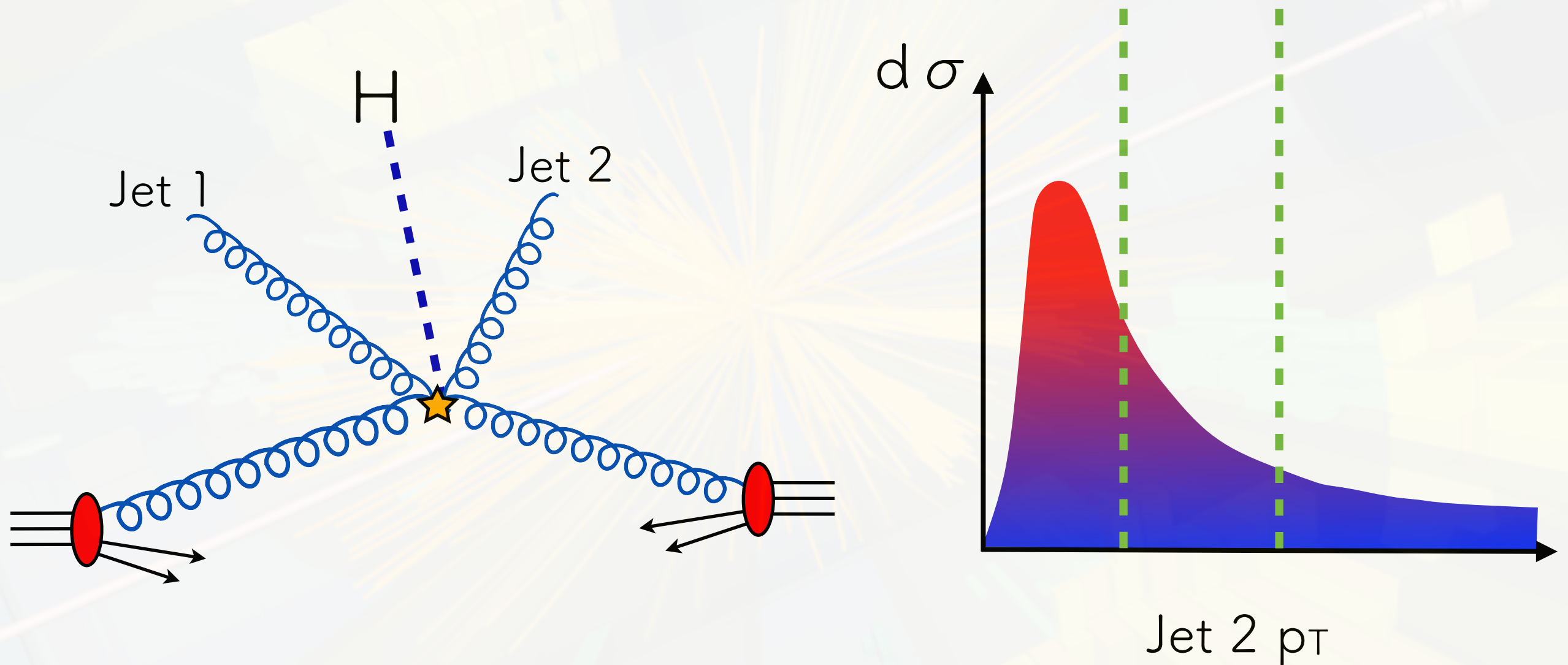
- Conventional NLO when underlying Born configs  $\rightarrow$  singular regions



\* For real emission underlying Born is H+2-jets def<sup>n</sup>d w. excl.  $k_T$  jet alg.

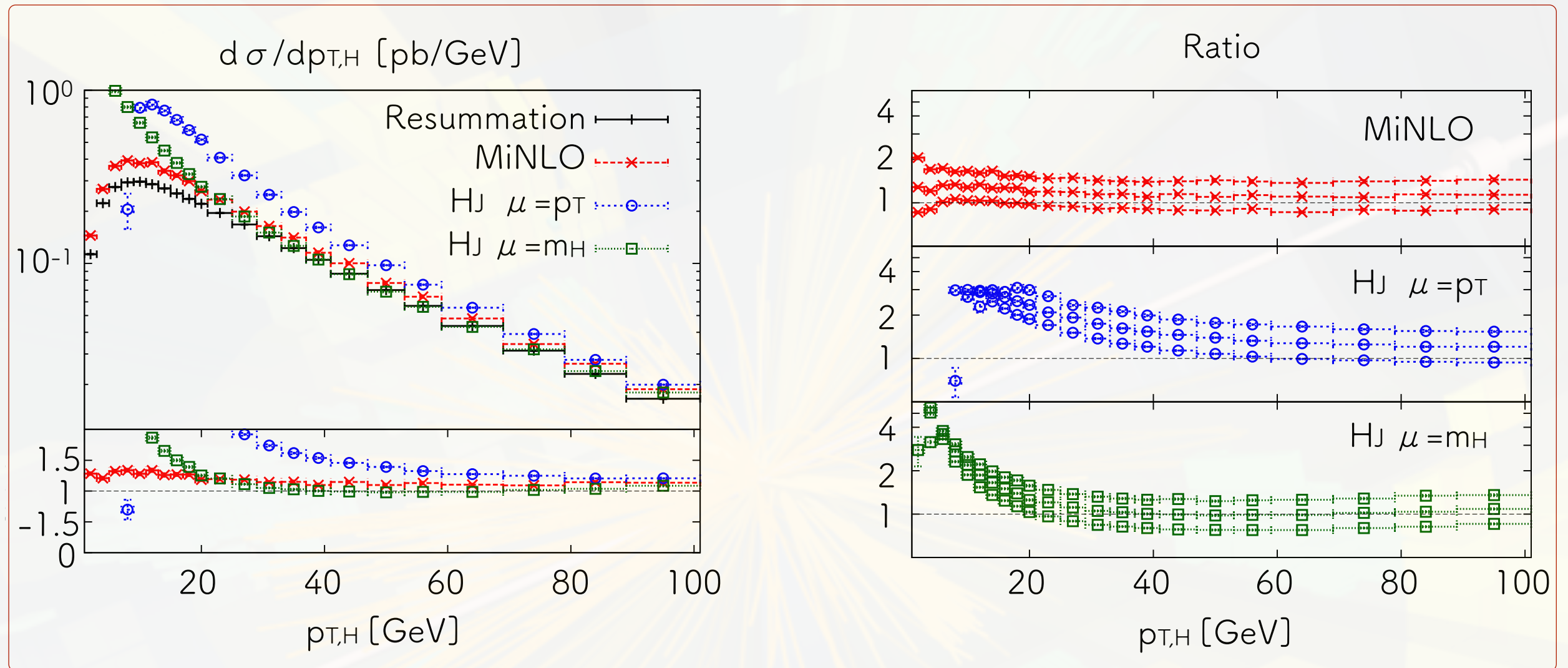
# Example: H+2 jets MiNLO at next-to-leading order

- MiNLO when underlying Born configs  $\rightarrow$  singular regions



- NLO accuracy in perturbative region
- Improved description of transition region
- Parton shower all-orders corrections in resummation region

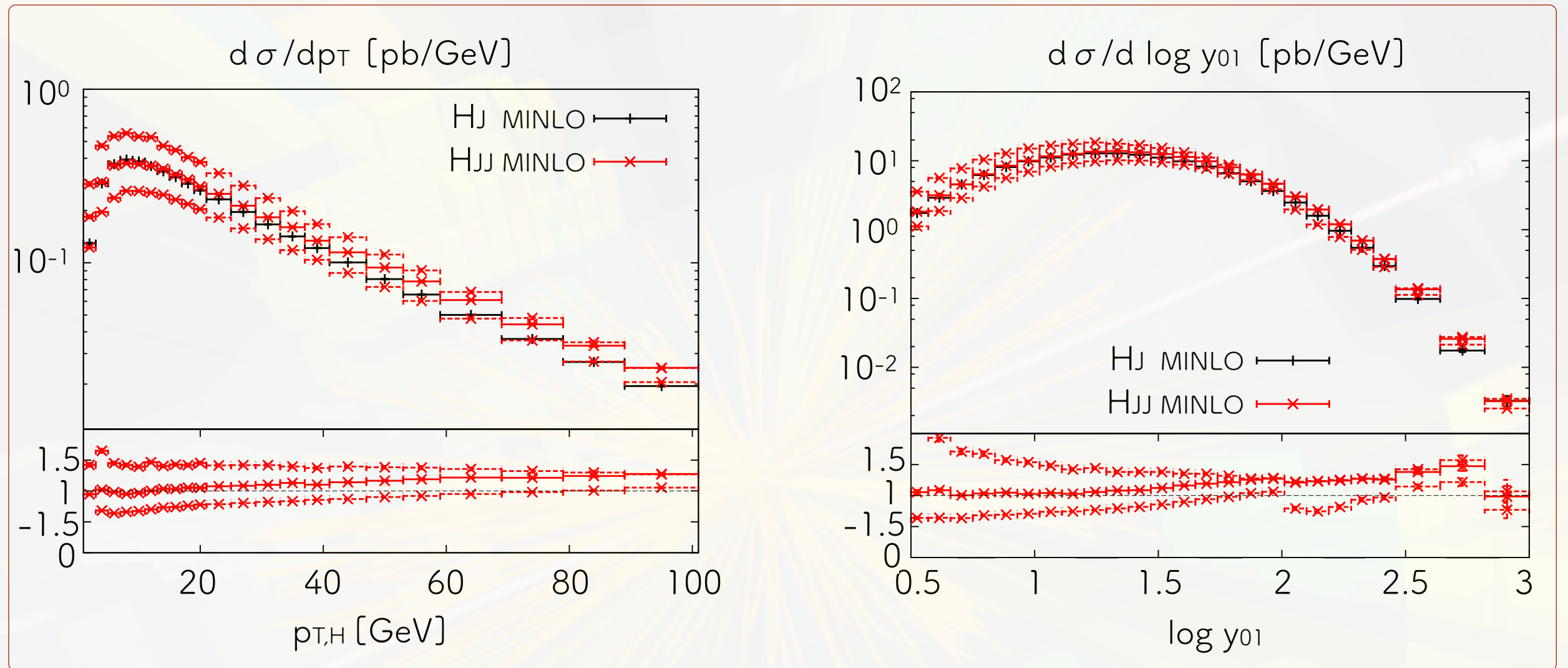
# Application: H+1 jet MiNLO at next-to-leading order



- Resummation matched to NLO inclusive  $gg \rightarrow H$  xsec<sup>n</sup> [  $\equiv 1$  in ratios ]
- **HJ RUN**: NLO H + 1 jet with  $\mu_R = \mu_F = p_{T,H}$
- **HJ FXD**: NLO H + 1 jet with  $\mu_R = \mu_F = M_H$
- **HJ-MiNLO**  $\rightarrow$  conventional NLO H + 1 jet at high  $p_T$
- **HJ-MiNLO**  $\rightarrow$  resummation result at low  $p_T$
- **HJ-MiNLO**  $\rightarrow$  sensible scale unc. band [doesn't shrink as  $p_T \rightarrow 0$ ]

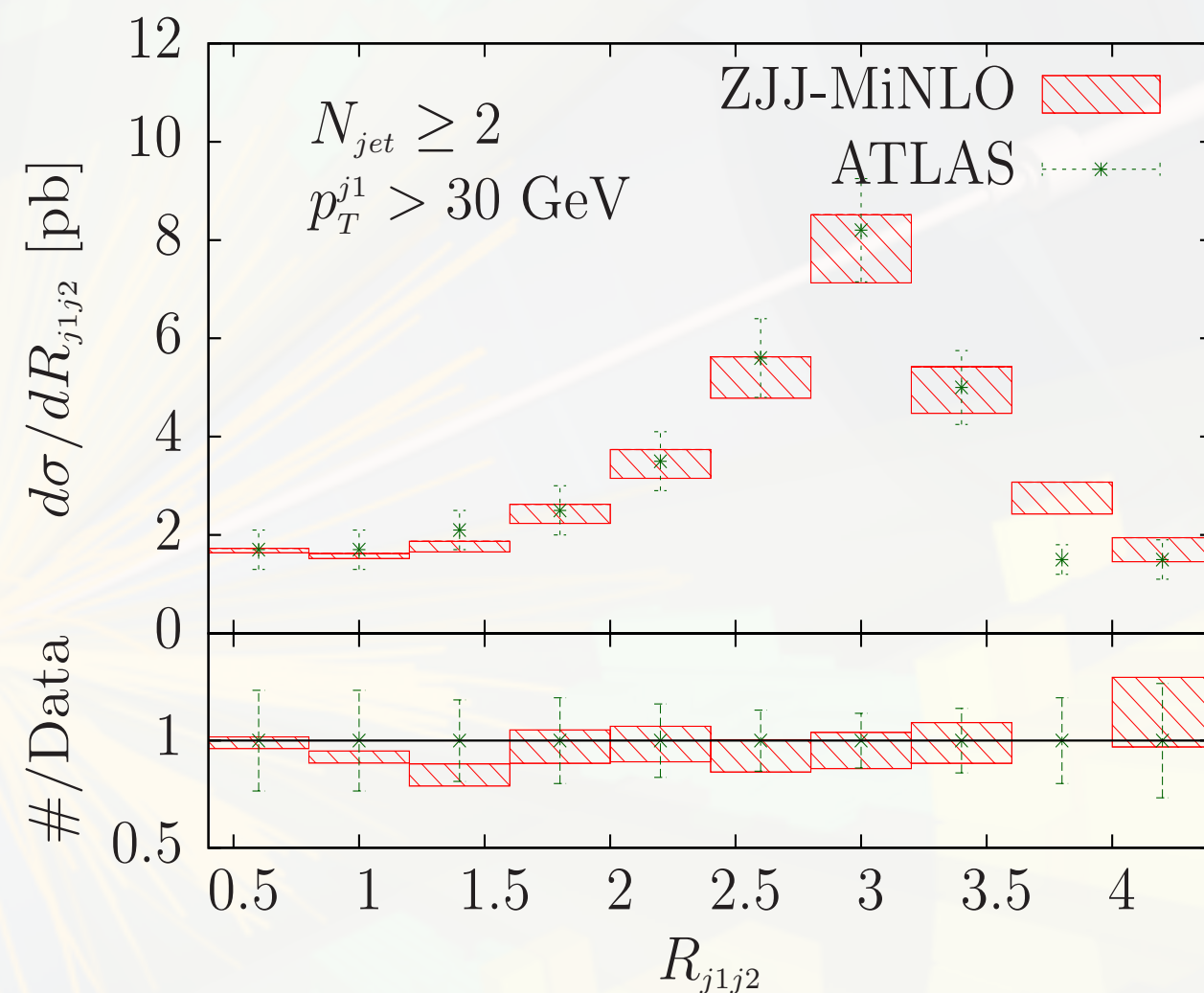
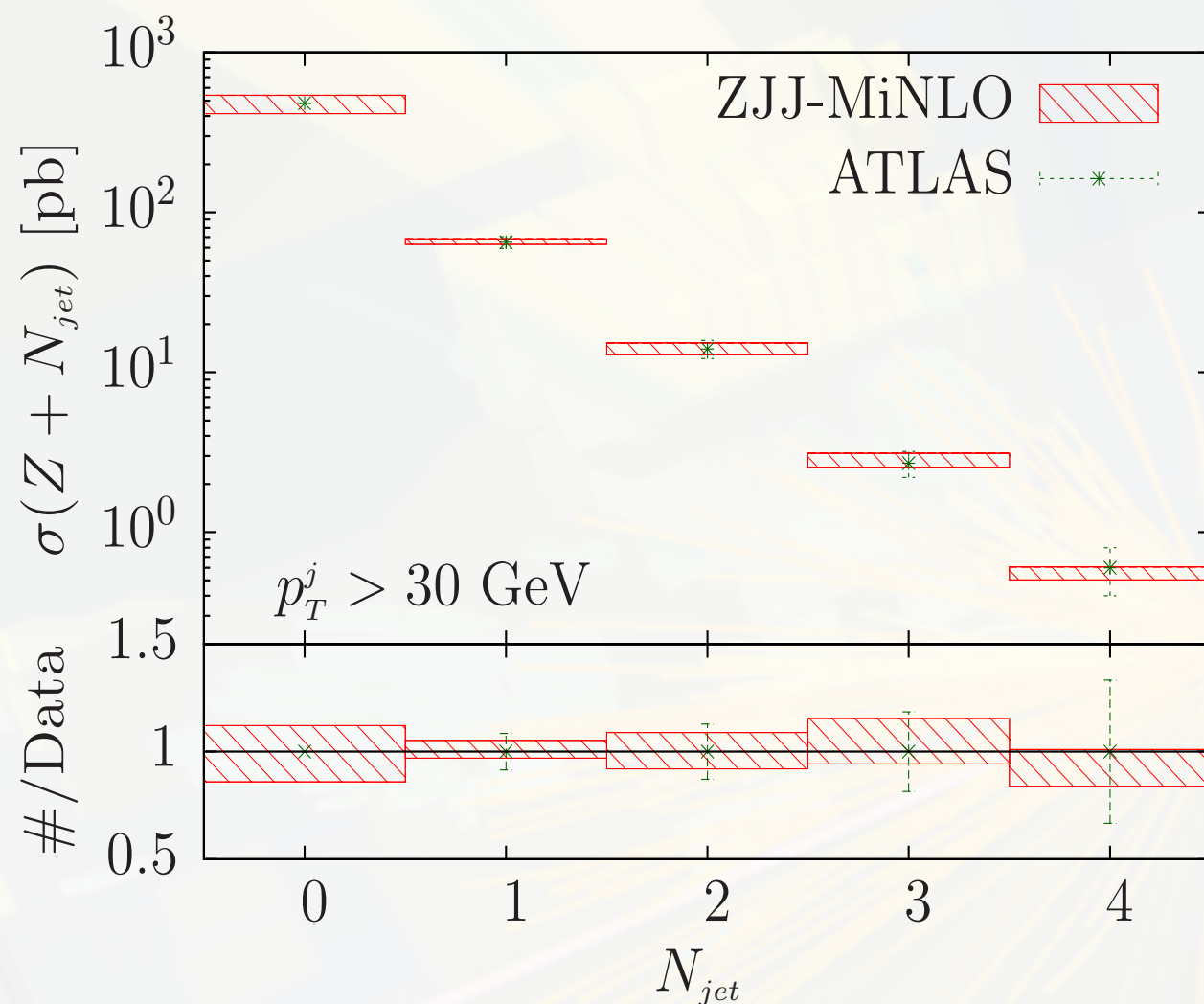


# Application: H+2 jet MiNLO at next-to-leading order



- Black: HJ MiNLO H + 1 jet feeding Powheg+Pythia
- Red: HJJ MINLO MiNLO H+2 jets
- Conventional NLO HJJ returns nonsense towards low  $p_T$
- HJJ MINLO follows MiNLO H+1 jet [w.shower] down to  $p_T = 0$

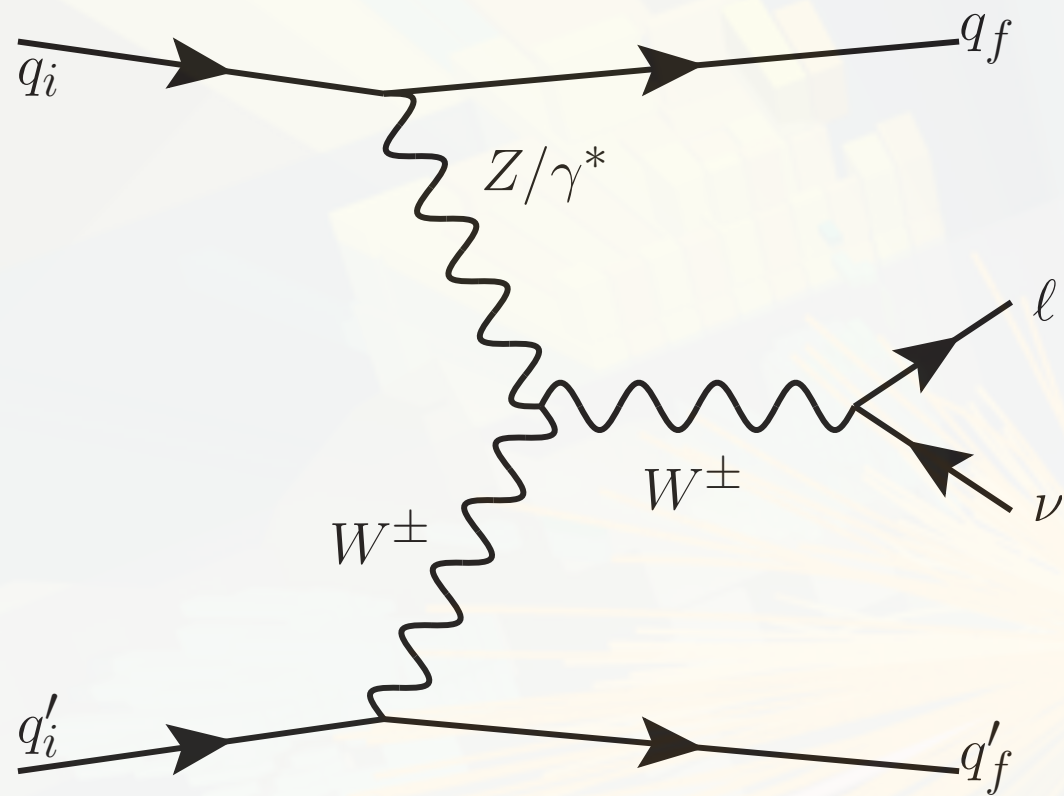
# Application: Z+2 jet MiNLO $\oplus$ Pythia vs ATLAS



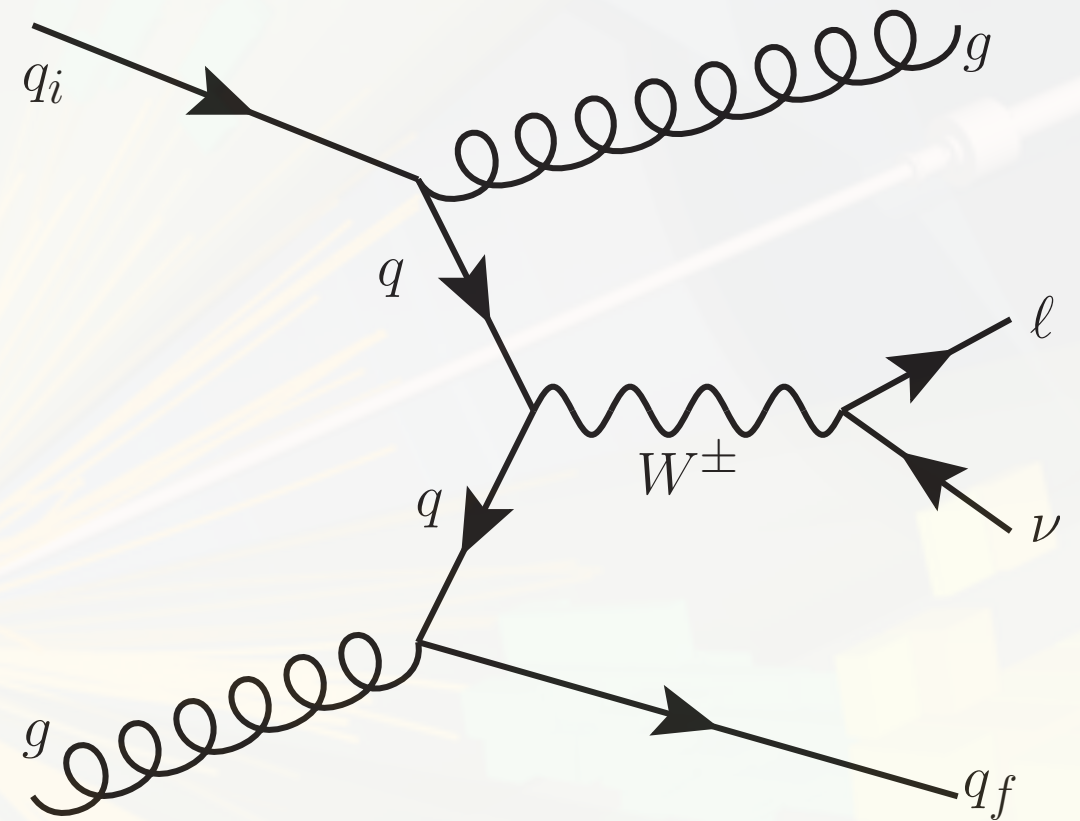
- Left: improves Z + 2 NLO s.t. gives even predict<sup>n</sup> for  $\geq 0$  jet evts!
- Right: NLO accuracy retained [& improved!] for  $\geq 2$  jet events
- Equally nice improvement & agreement for ATLAS W+jets data

[ Campbell, Ellis, Nason, Zanderighi - JHEP 2013 ]

# Application: $W+2$ jet MiNLO vs ATLAS in VBF kinematics



VBF WJJ

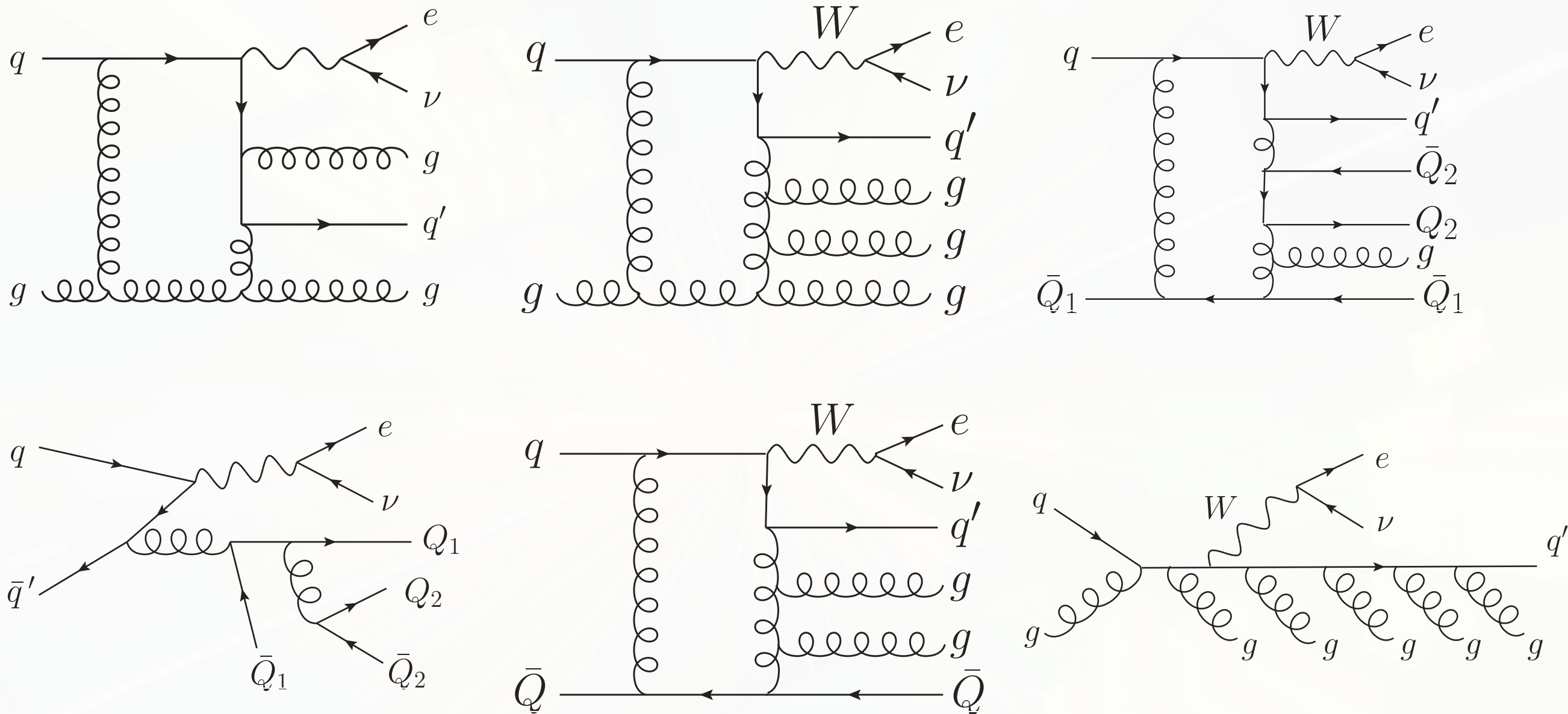


Strong WJJ

- WJJ/ZJJ MiNLO  $\oplus$  Pythia/Herwig heavily used in ATLAS VBF W/Z analyses
- Partly motivated to consolidate knowledge/methods for VBF Higgs studies
- Partly motivated to look for anomalous couplings
- Weird multi-scale multi-jet kinematics  $\rightarrow$  NLO+MC stress test



# Application: $W + 3, 4, 5$ jets NLO vs MiNLO vs ATLAS

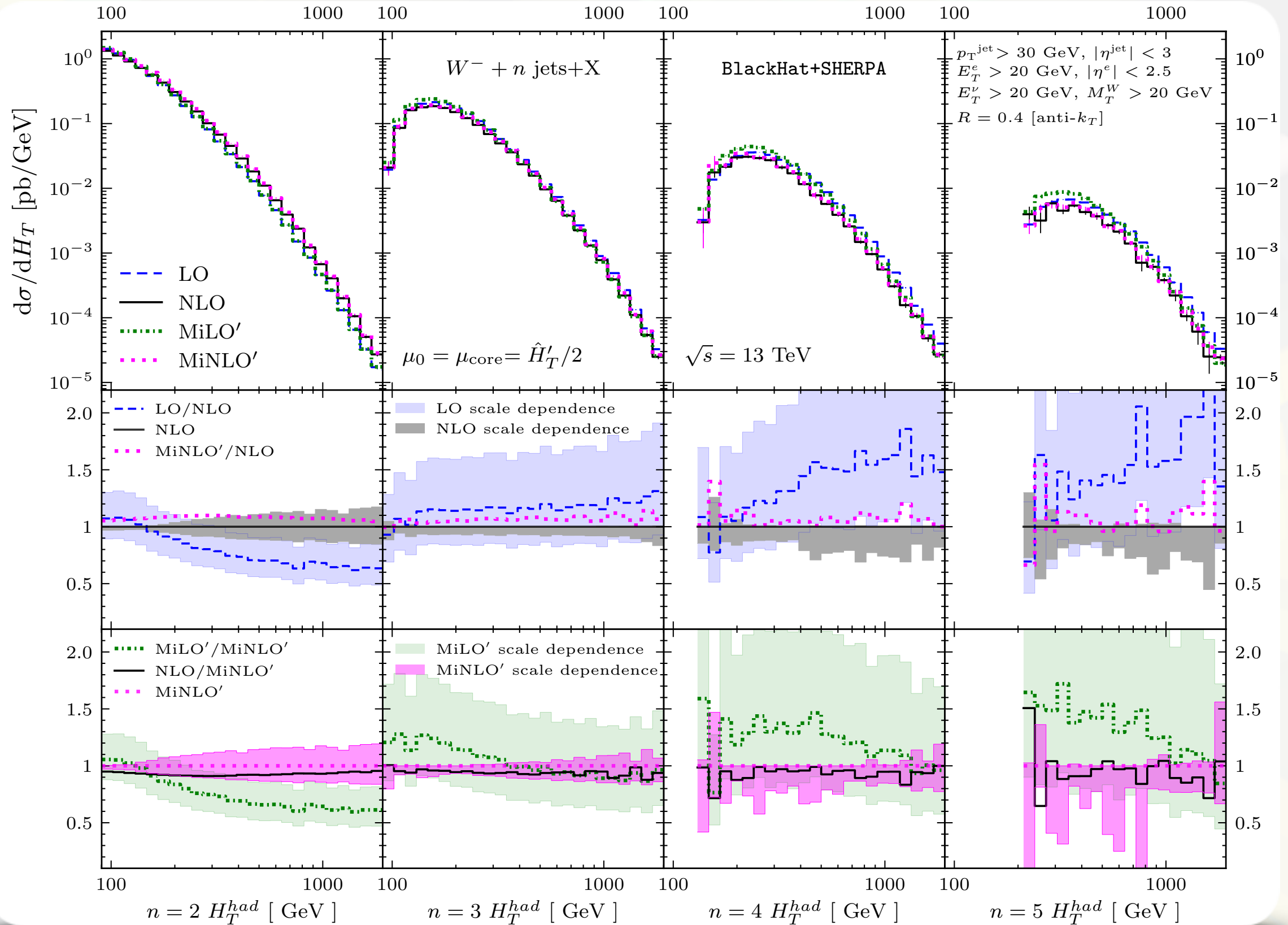


$W + N$  jets calc<sup>n</sup>s by BlackHat collaboration

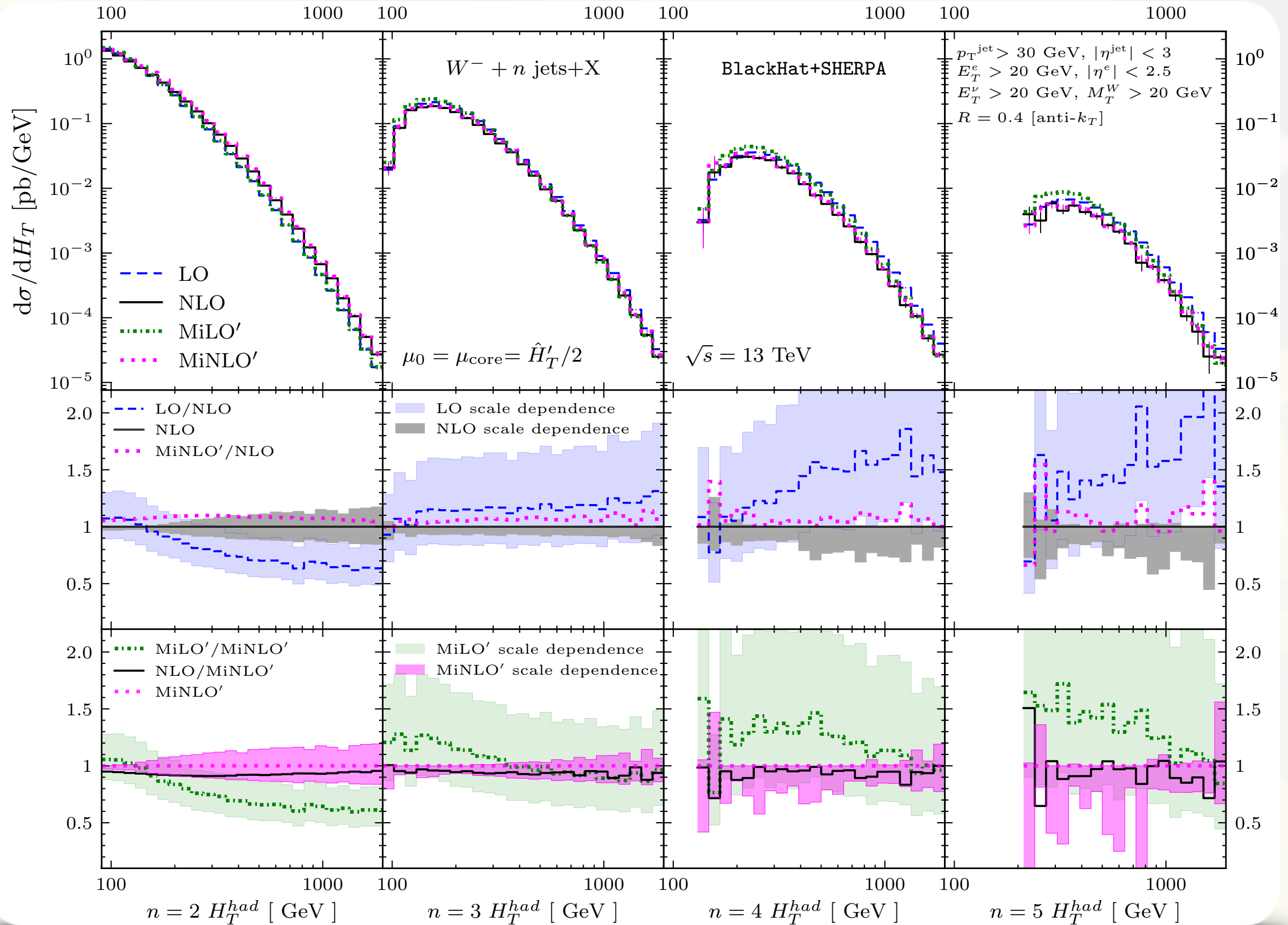
C. Berger, Z. Bern, L. Dixon, F. Febres Cordero,  
D. Forde, S. Höche, H. Ita, D. Kosower, D. Maître, K. Ozeren



# Application: $W + 3, 4, 5$ jets NLO vs MiNLO vs ATLAS



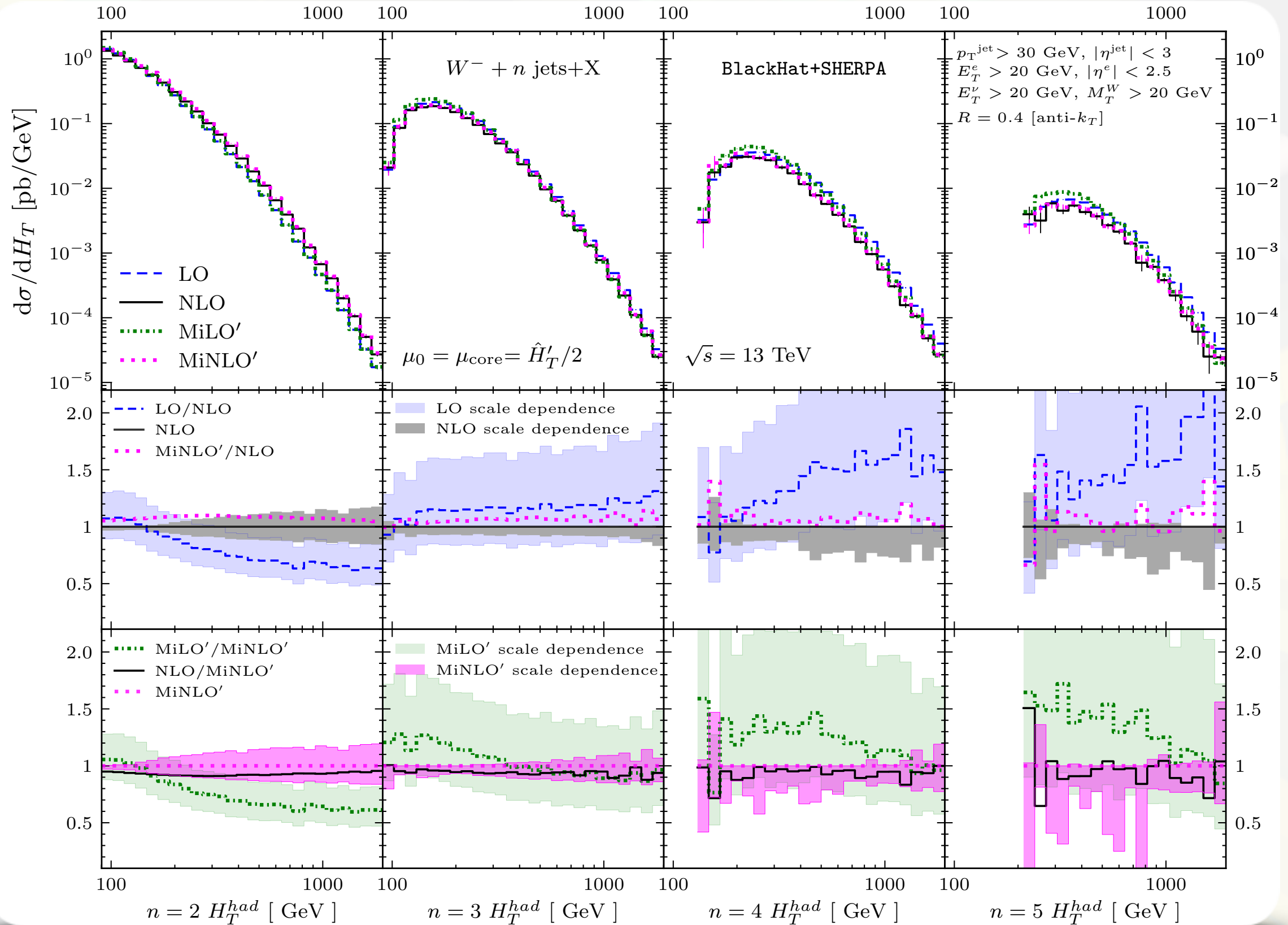
# Application: $W + 3, 4, 5$ jets NLO vs MiNLO vs ATLAS



MiNLO & conventional NLO agreeing well for complex multi-scale process



# Application: $W + 3, 4, 5$ jets NLO vs MiNLO vs ATLAS



MiNLO's larger  $\alpha_s$ 's & PDFs compensated by its Sudakov suppression

# Summary

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- MiNLO

- Motivations for NLO
- Renormalization and factorization scales
- Motivations for MiNLO
- MiNLO scale setting sketched with an example
- Applications