

NLO QCD+EW CORRECTIONS FOR HV AND HV +JET IN THE POWHEG BOX RES

Carlo Oleari

Università di Milano-Bicocca, Milan

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In collaboration with: **F. Granata, J. Lindert and S. Pozzorini**

arXiv:1706.03522

- ✗ NLO QCD+EW HV and HVj production
- ✗ The POWHEG BOX RES code
- ✗ HVj + MiNLO
- ✗ A few results
- ✗ Conclusions

HV and HVj production

We have computed, using [OpenLoops](#) and [MadGraph 4](#), the NLO QCD+EW **corrections** to the following processes

$$pp \rightarrow HW^+(j) \rightarrow H \ell^+ \nu_\ell(j)$$

$$pp \rightarrow HW^-(j) \rightarrow H \ell^- \bar{\nu}_\ell(j)$$

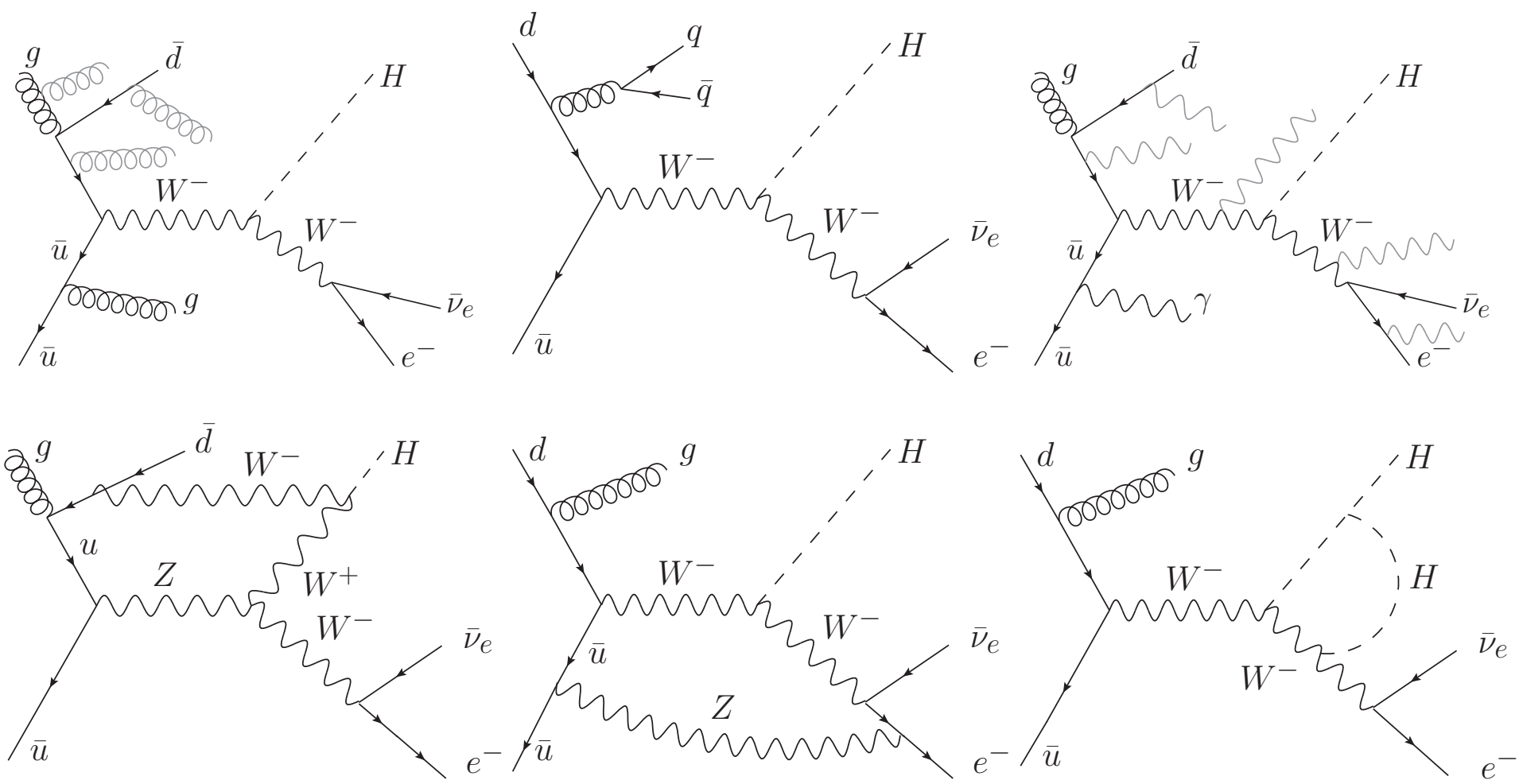
$$pp \rightarrow HZ(j) \rightarrow H \ell^+ \ell^-(j)$$

including all **spin-correlation** and **off-shell effects**

The NLO QCD corrections have been available for a while ([Luisoni, Nason, C.O., Tramontano, arXiv:1306.2542](#))

Only one leptonic generation, and all leptons are treated as massless.

QCD+EW corrections to HVj



Born: $\mathcal{O}(\alpha_s \alpha_{EM}^3)$

QCD real+virtual: $\mathcal{O}(\alpha_s^2 \alpha_{EM}^3)$

EW real+virtual: $\mathcal{O}(\alpha_s \alpha_{EM}^4)$

Sensitive to the **trilinear** Higgs boson coupling λ_{HHH} . There is the possibility to change λ_{HHH} , for studies on the anomalous triple Higgs boson coupling (λ_{HHH} in the powheg. input file).

The POWHEG BOX RES

The HV and HVj codes are implemented in the POWHEG BOX RES (Jezo, Nason, [arXiv:1509.09071](https://arxiv.org/abs/1509.09071)), a major revision of the POWHEG BOX V2 code able to deal with resonances.

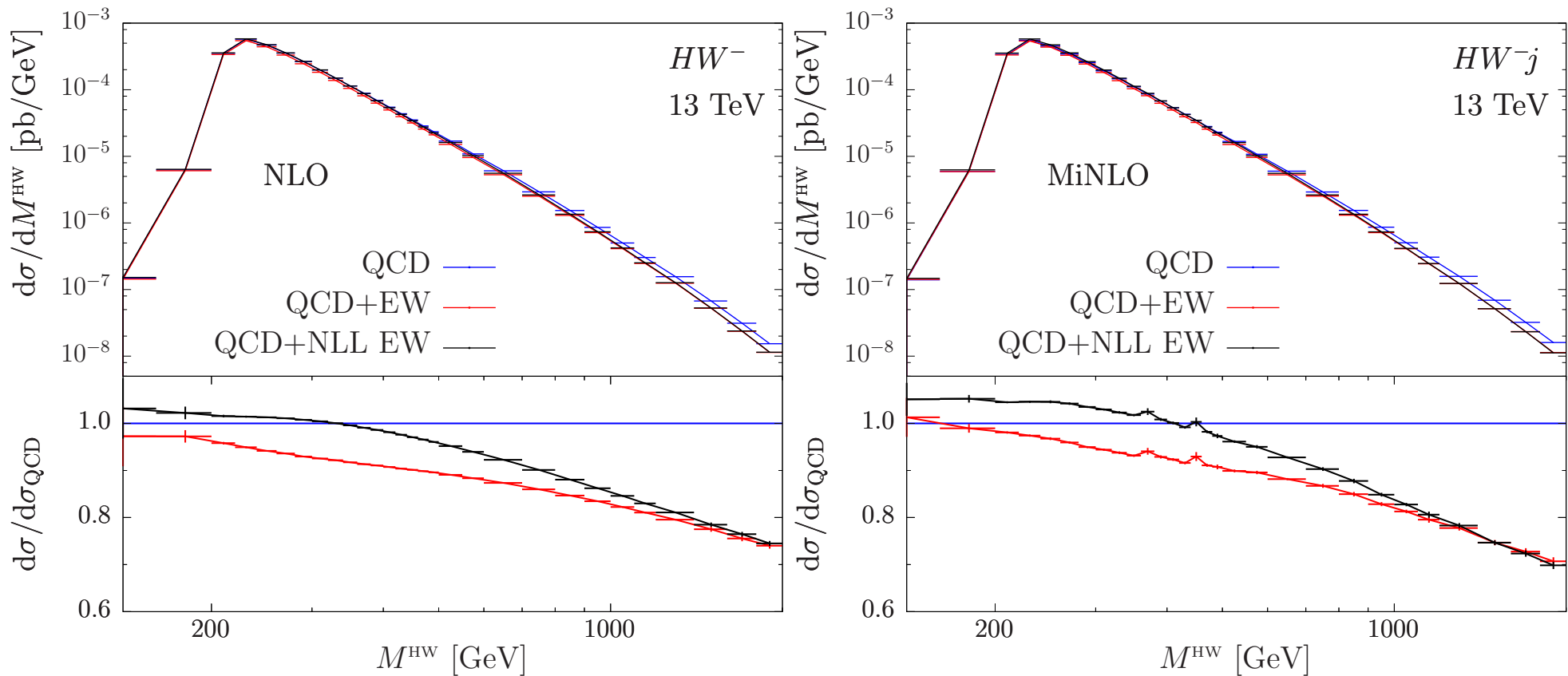
- The POWHEG BOX RES is able to generate radiation from each resonance, preserving their virtuality.
- It keeps track of all the decay chains, allowing to pass this piece of information to Pythia or Herwig, that can complete the shower by preserving the resonance virtualities.
- It can keep the hardest radiation in the decay of each resonance, for every generated event. In this way, an event has several QCD or QED radiations attached to it.

Pythia and Herwig have then to be instructed not to produce any radiation harder than the one already present at the Les Houches level, for each resonance decay.

Improved MiNLO in HVj production

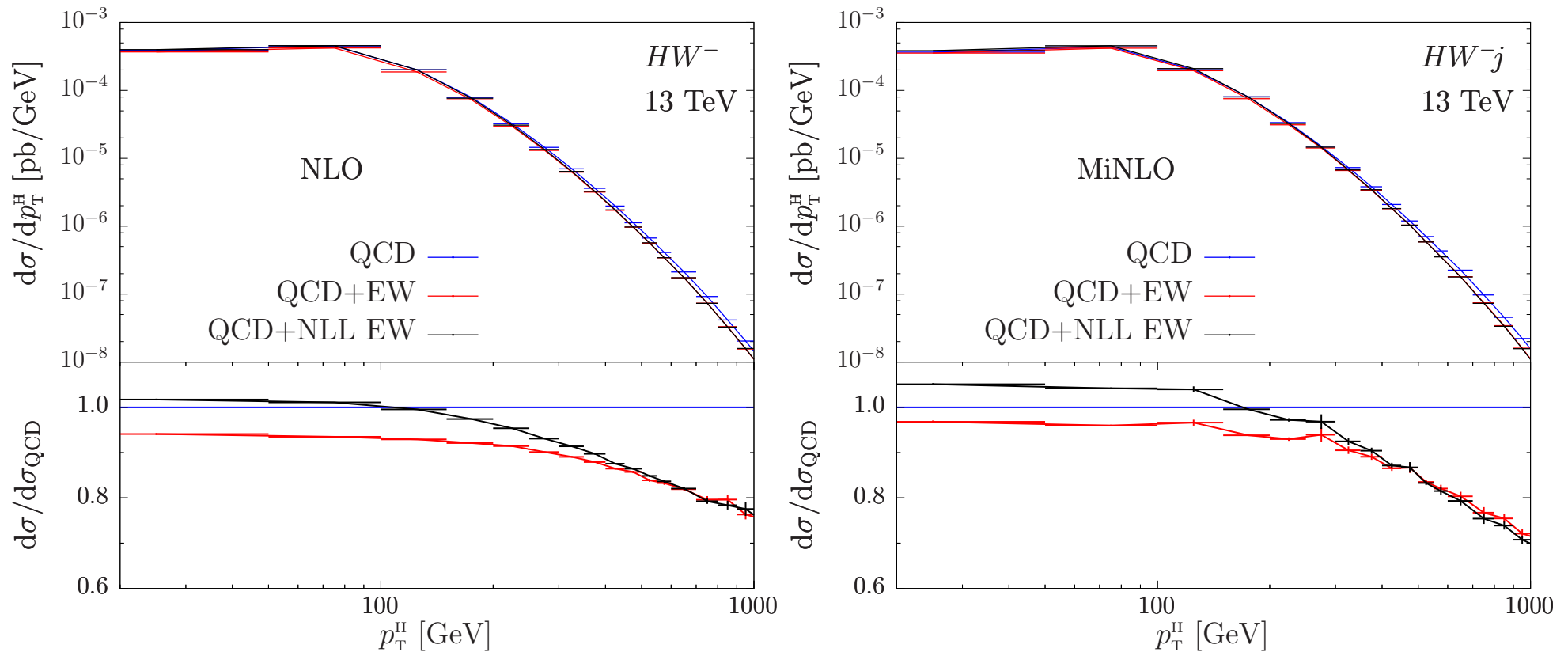
- ✗ The **fixed-order Born** cross section for HVj is **divergent** and, in general, a minimum transverse-momentum cut on the hardest jet is required.
- ✗ Related to this (at least in the POWHEG BOX), the question of **merging samples** with **different multiplicity**, i.e. HV , HVj , ... samples, preserving the good features of each sample in the “appropriate” region of validity.
- ✓ We deal with the divergent Born cross section and with the merging of samples using an **improved** version of **MiNLO** (**M**ulti-scale **i**mproved **NLO**), as described in [Hamilton, Nason, Zanderighi, arXiv:1206.3572](#).
- ✓ The resulting event sample is **NLO accurate** in **QCD+EW** both for inclusive distributions in HV production and for inclusive distributions in HVj .
For the **NLO QCD** accuracy, there exists a formal proof ([Hamilton, Nason, C.O., Zanderighi, arXiv:1212.4504](#)).
For the **NLO EW** accuracy, we have indications that it is correct.

NLO results at fixed order for HW^- and HW^-j production



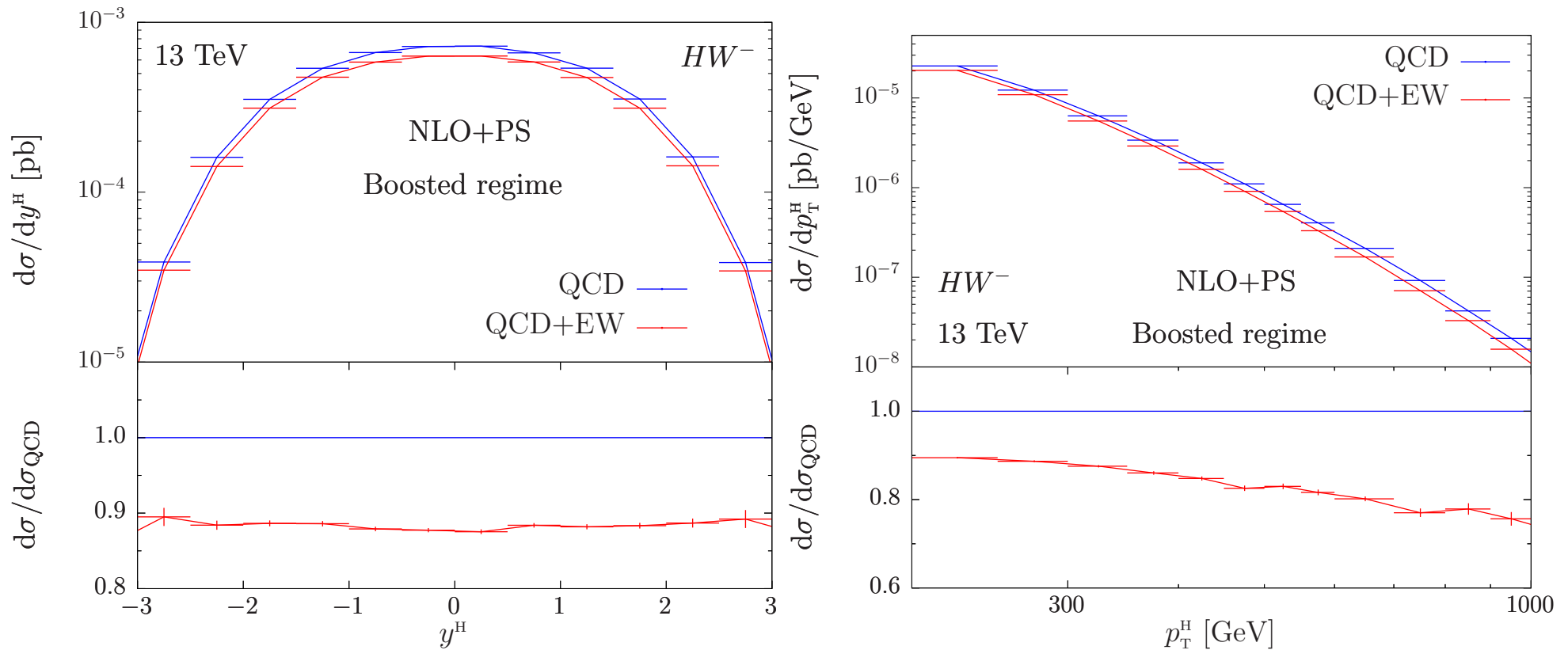
- **EW corrections** can largely exceed the ten percent level in the **high-energy** regions, where **Sudakov logarithms** become **dominant**.
- An example is the invariant mass of the HV pair in HV and HVj production, where the EW corrections reach -30% around 2 TeV.

NLO results at fixed order for HW^- and HW^-j production



- **Similar conclusions** for the transverse momentum of the Higgs boson. The **EW corrections** reach **-30%** around 1 TeV in HW^-j production.

NLO + Parton Shower results for HW^- production

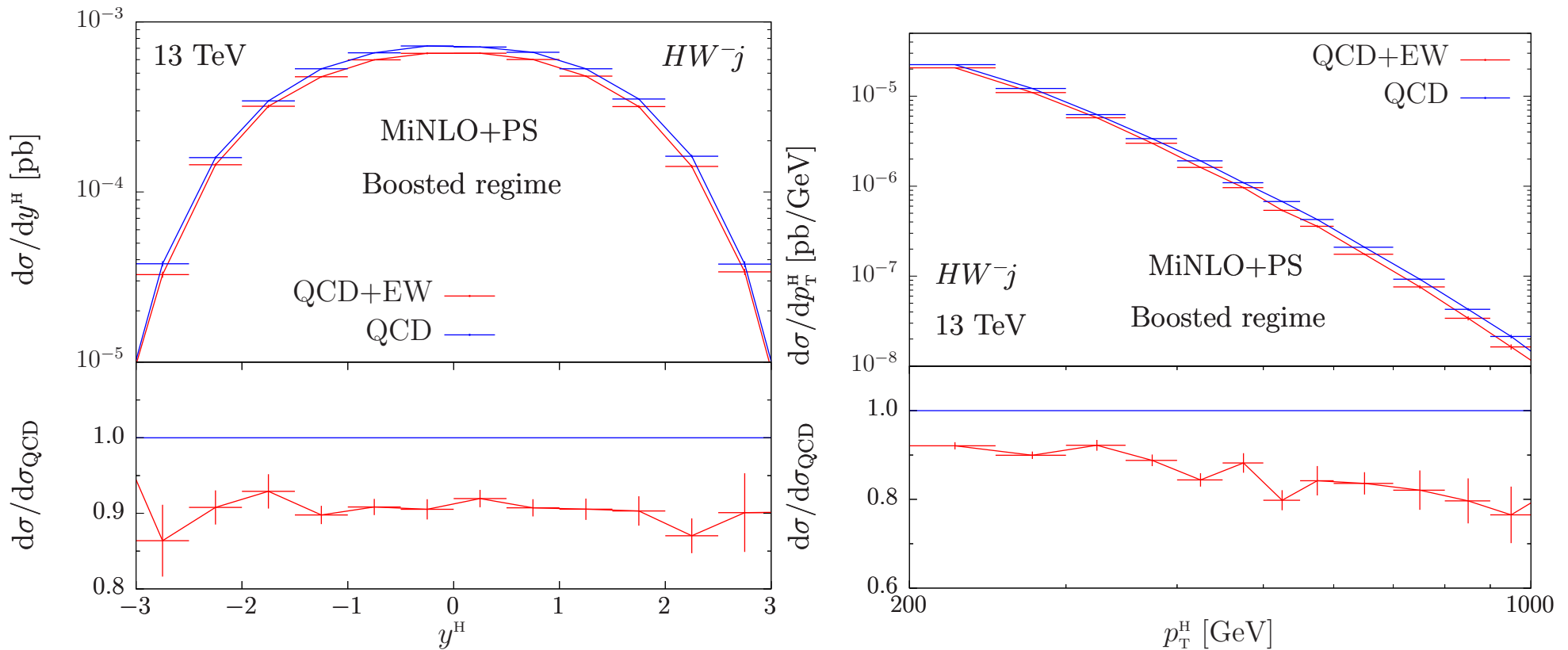


- Shower done by **Pythia 8.1**. The results have **NLO+PS QCD+EW** accuracy
- **Boosted regime** to improve the signal-over-background ratio in the $H \rightarrow b\bar{b}$ decay channel:

$$p_T^H \geq 200 \text{ GeV} \quad p_T^V \geq 190 \text{ GeV}$$

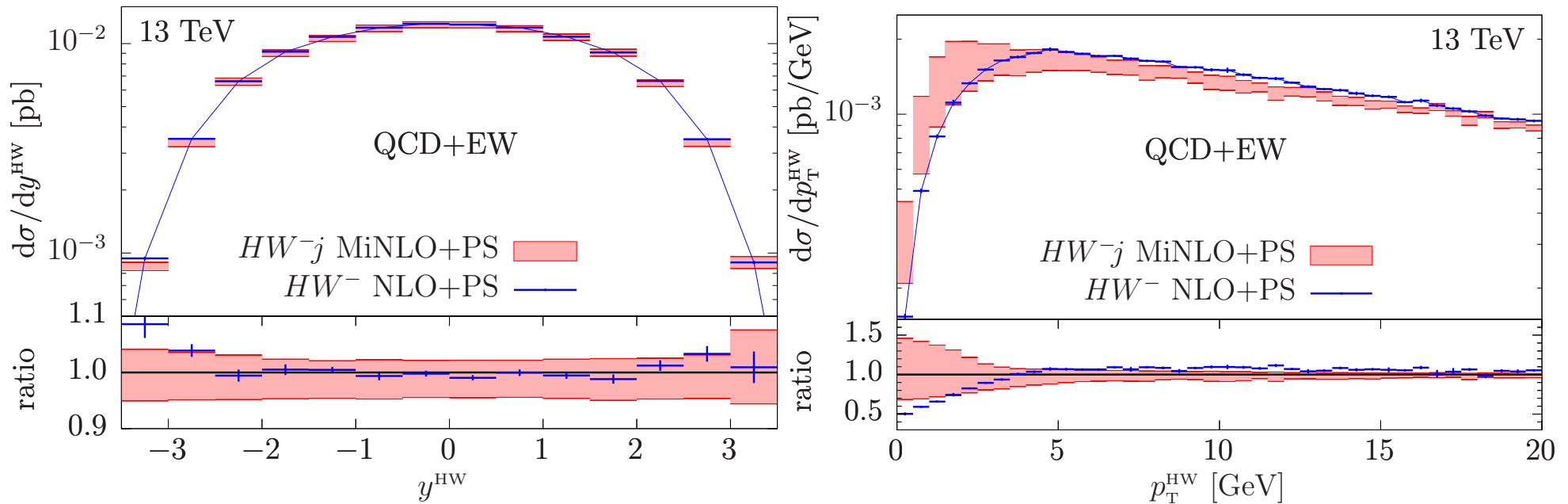
- Constant **negative** EW corrections around **10%** for y^H and corrections up to **-25%** for p_T^H around 1 TeV.

MiNLO + Parton Shower results for HW^-j production



- These results **closely agree** with the corresponding ones for HW^- production.
- This supports the fact that the **MiNLO** predictions for HVj should preserve **NLO QCD+EW** accuracy for **inclusive** (with respect to the jet) quantities.

HV vs. HVj generators



- **Scale variation** bands ([details in arXiv:1706.03522](https://arxiv.org/abs/1706.03522))
- With **MiNLO**, the y^{HW} and p_T^{HW} distributions computed with the HWj generator are **finite** and agree with the results for HW .
- y^{HW} has **NLO** accuracy both in HV and with HVj .
 p_T^{HW} has **LO** accuracy for HV and **NLO** accuracy for HVj .

Conclusions

- ✓ Electroweak corrections typically **lower** NLO+PS QCD predictions by **5 to 10%** at the level of **integrated cross sections** and in **angular distributions**.
- ✓ Due to **Sudakov logarithms**, EW corrections can be much **more sizable** in the **tails** of transverse-momentum and invariant-mass distributions, where their negative contributions reach **tens of percent**.

`http://powhegbox.mib.infn.it/`

```
svn co --username anonymous --password anonymous
```

```
svn://powhegbox.mib.infn.it/trunk/POWHEG-BOX-RES
```

```
svn co --username anonymous --password anonymous
```

```
svn://powhegbox.mib.infn.it/trunk/User-Processes-RES/XXX
```

where XXX = HW_ew, HZ_ew, HWJ_ew, HZJ_ew