ttbb with MadGraph5_aMC@NLO

ttH subgroup periodic meeting
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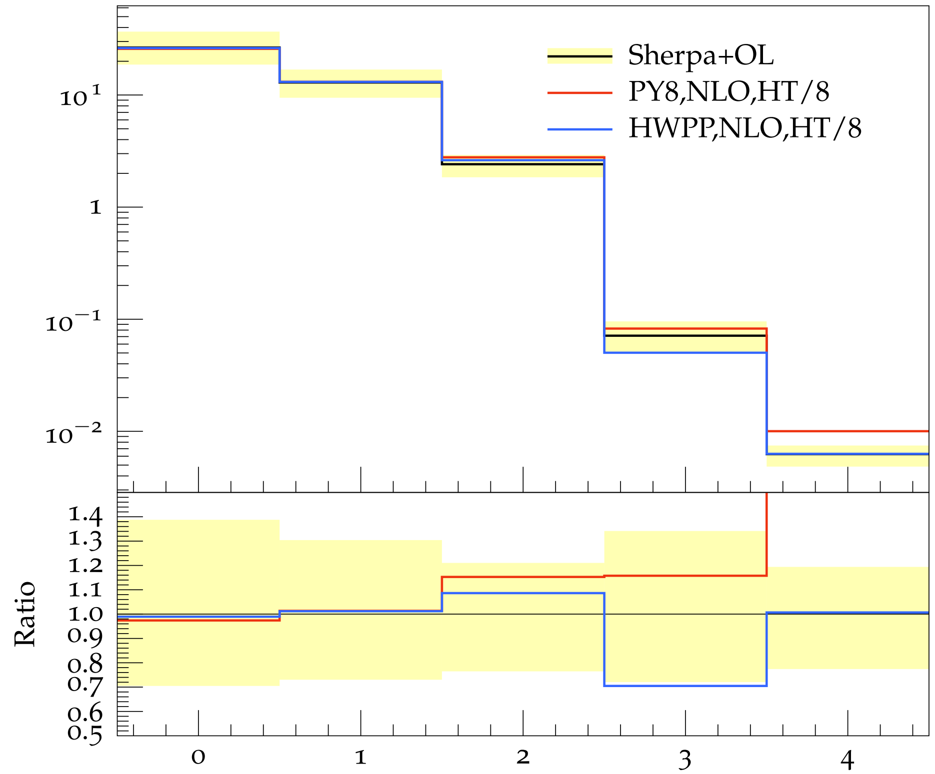
Setup

- Comparisons of results obtained with:
  - Three reference shower scales (sqrt(s)/4, $H_T/2$, $H_T/8$)
  - Two MCs (PY8, HW++)
  - NLO+PS and LO+PS
- Settings follow https://twiki.cern.ch/twiki/bin/view/LHCPhysics/ProposalTtbb (PY8 + sqrt(s)/4 is the same as in YR4)

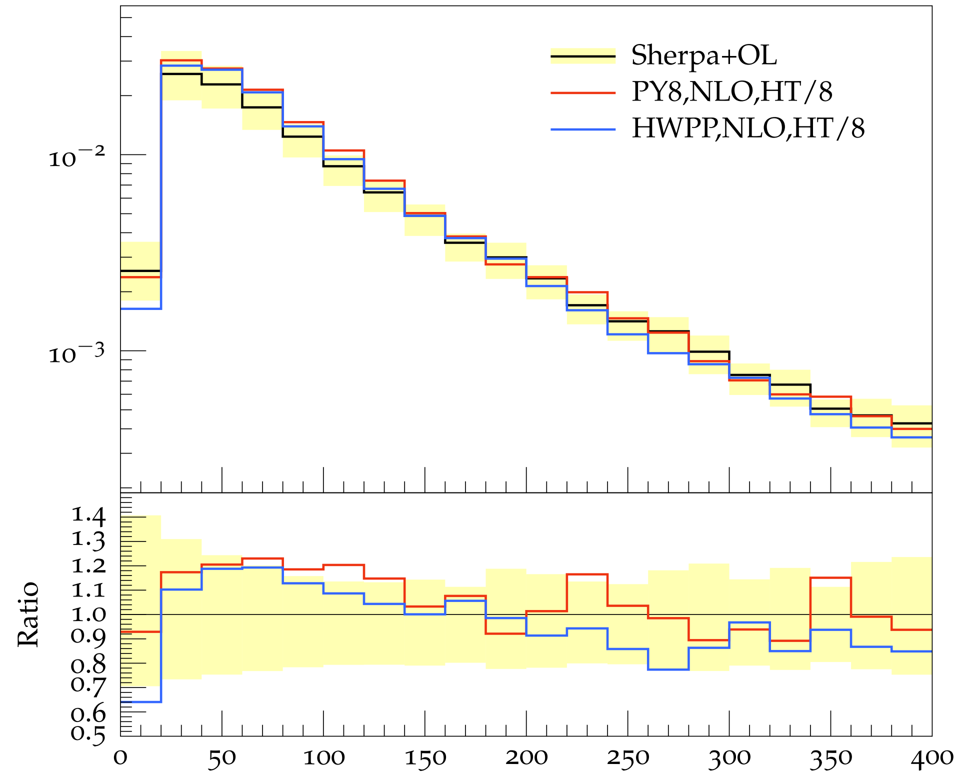
- How do these results compare among themselves and with Sherpa+OL?

Results: $\mu_{sh}=H_T/8$ vs Sherpa+OL

- Disclaimer: by no means we consider $\mu_{sh}=H_T/8$ a better scale for physics
- Using a very constrained shower scale, predictions from MG5_aMC (with PY8, HW++) are closer to Sherpa+OL, and fall within the scale uncertainty of the latter.
- Still, differences remains, mostly in the shape of distributions

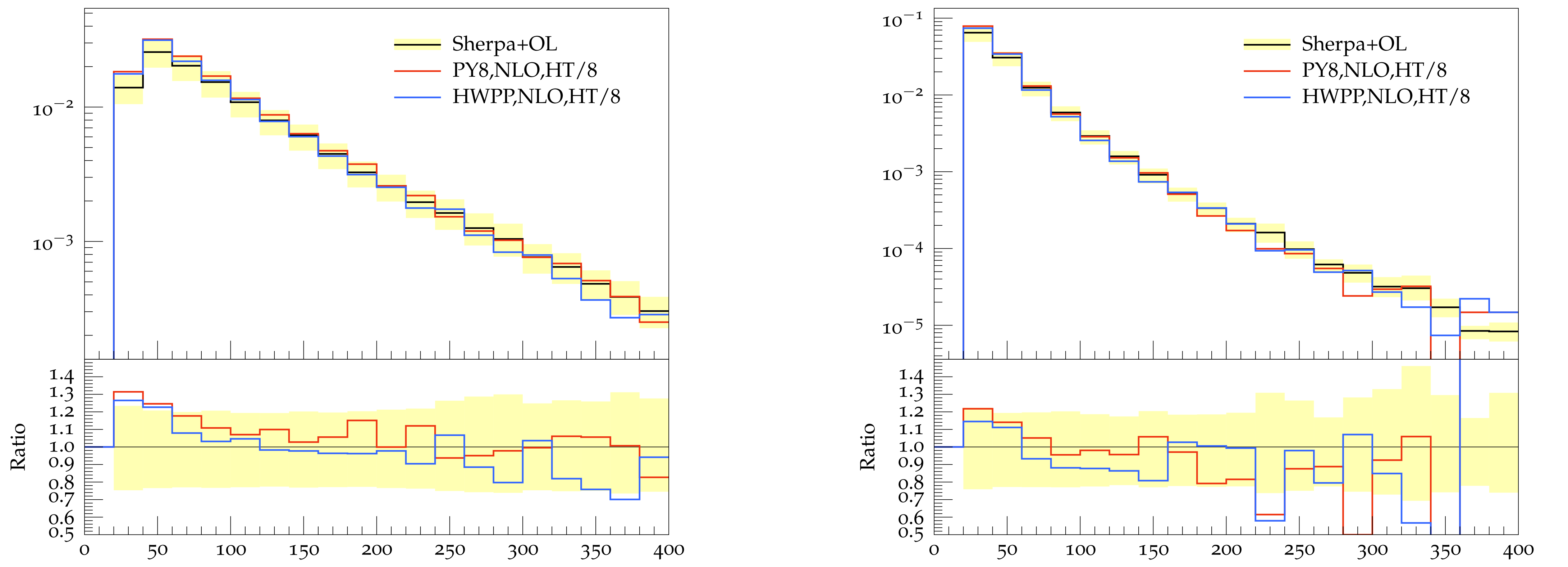


N b jets



$M(b_1,b_2)$

Results:
$\mu_{sh}=H_T/8$ vs Sherpa+OL

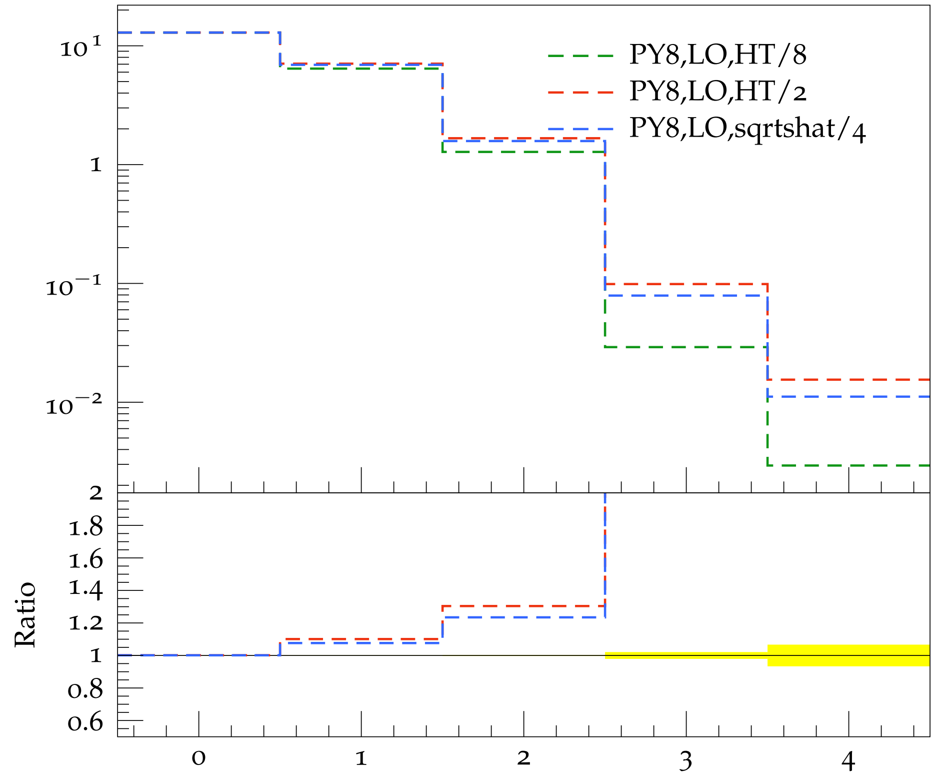


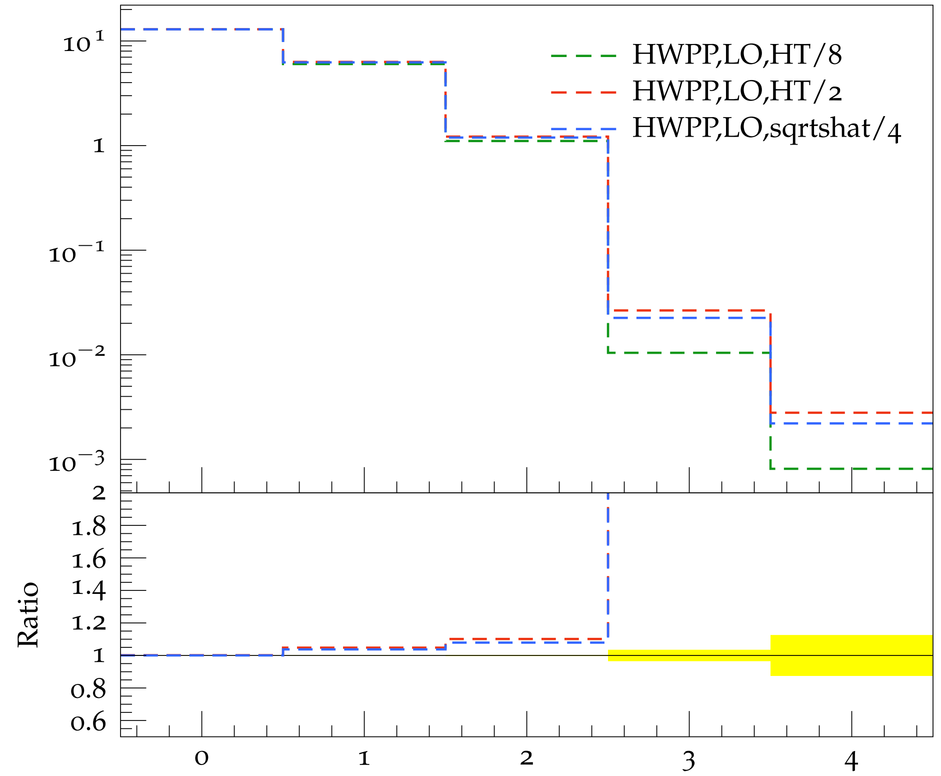
$P_T(b_1)$ $P_T(b_2)$

- The largest differences are for those observables which involve j_1. However, they are described only at LO accuracy

Results: comparison of different scales in MG5_aMC at LO and NLO

- We compare results with PY8 (left) and HW++ (right) with the three different choices of μ_{sh}: sqrt(s)/4, $H_T/2$, $H_T/8$ (HT/8 is the baseline in the inset)





N b jets, LO

Results: comparison of different scales in MG5_aMC at LO and NLO

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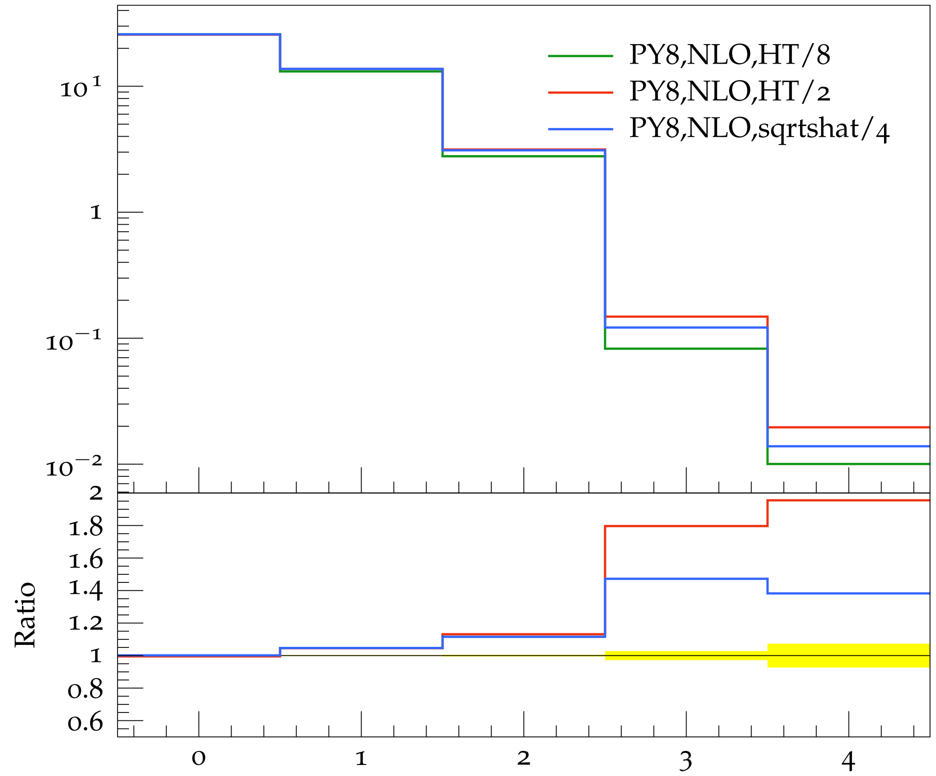

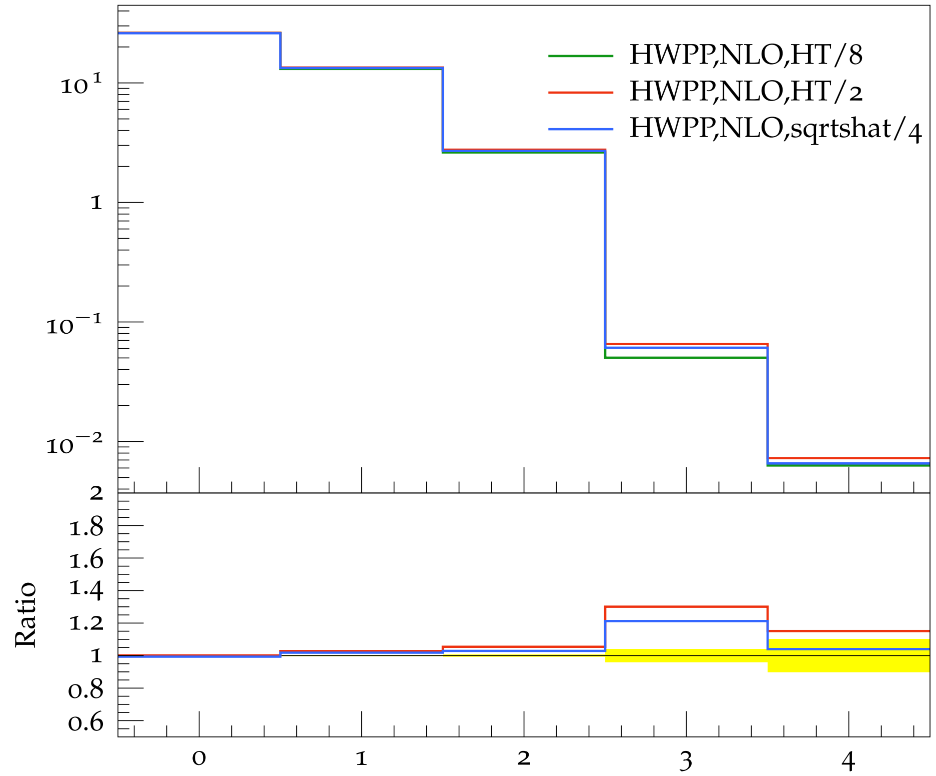

N b jets, NLO

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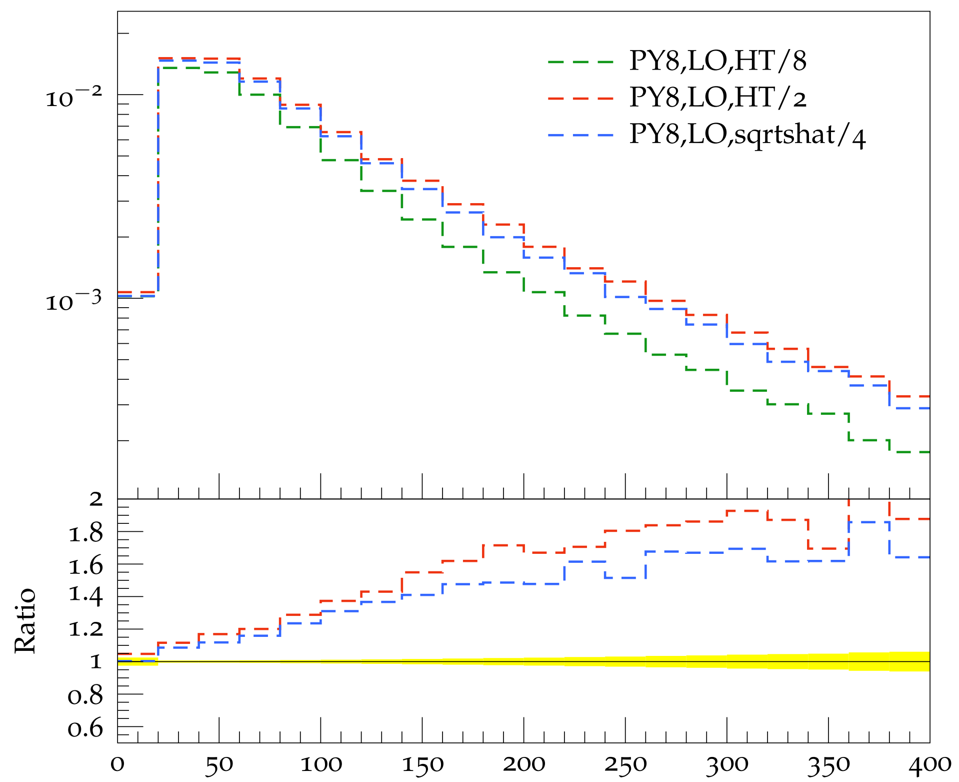

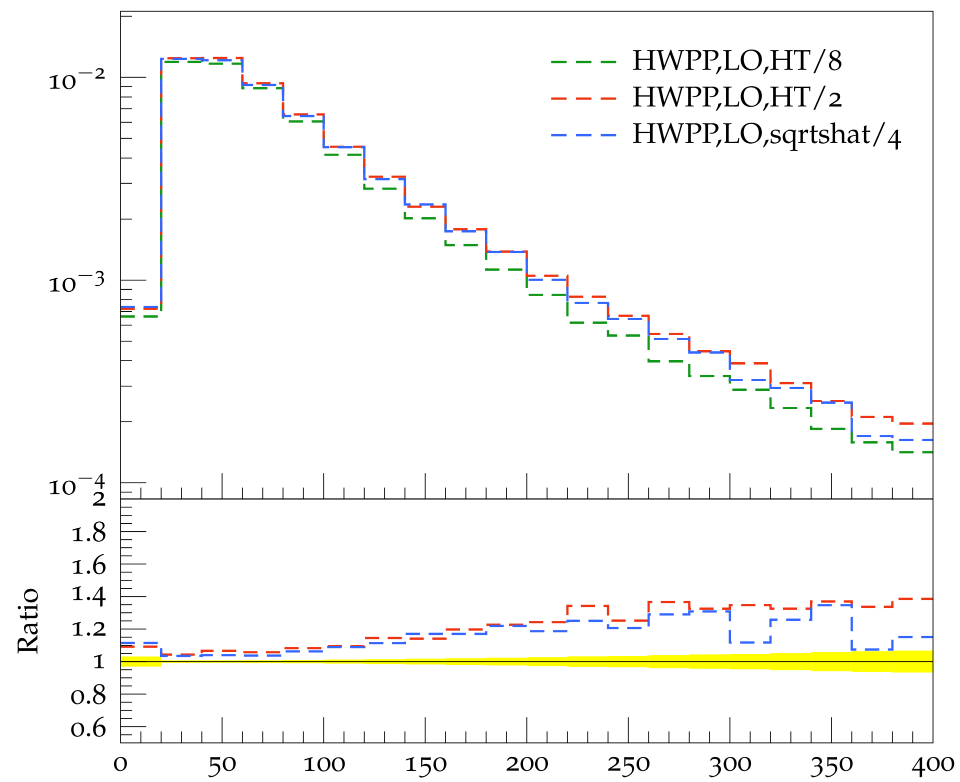

$M(b_1,b_2)$, LO

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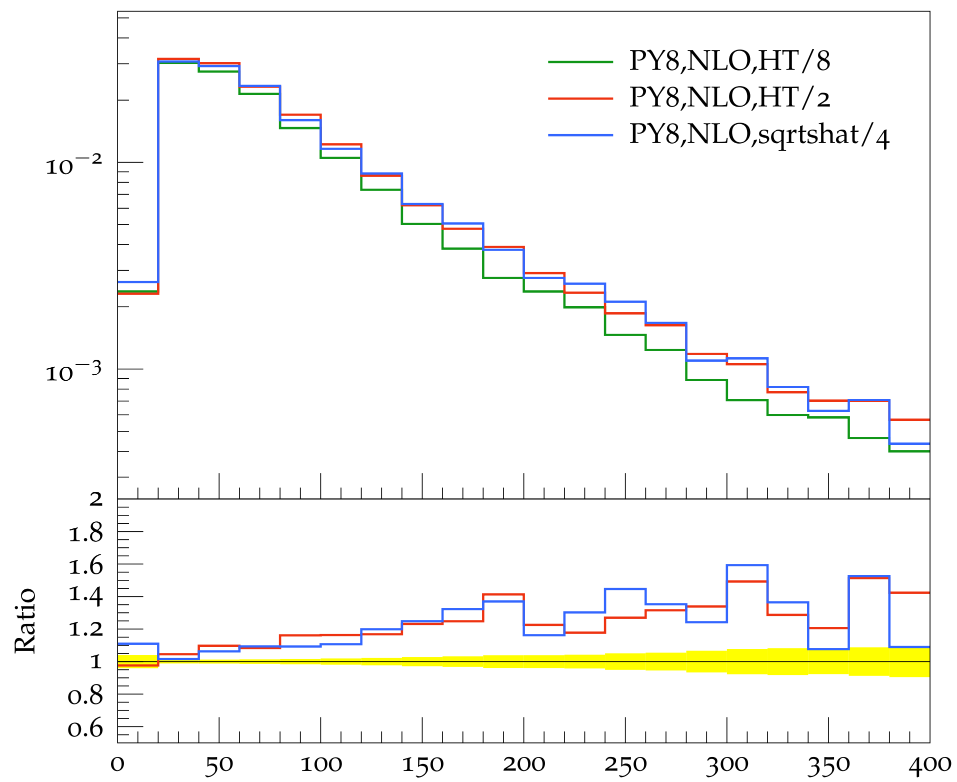

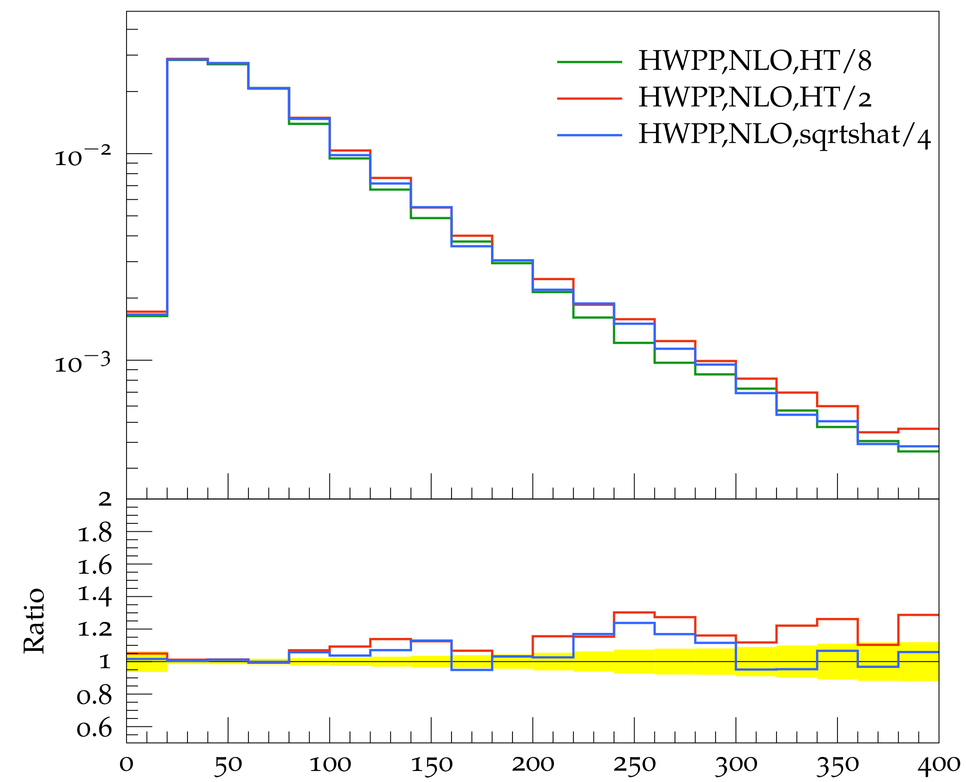

$M(b_1,b_2)$, NLO

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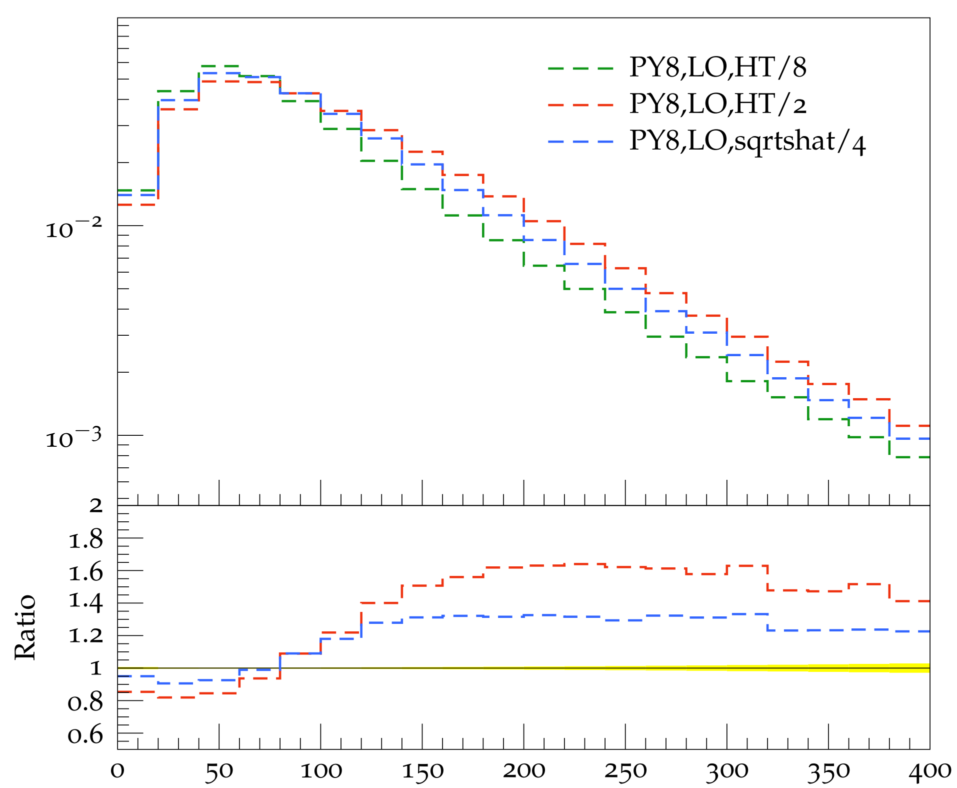

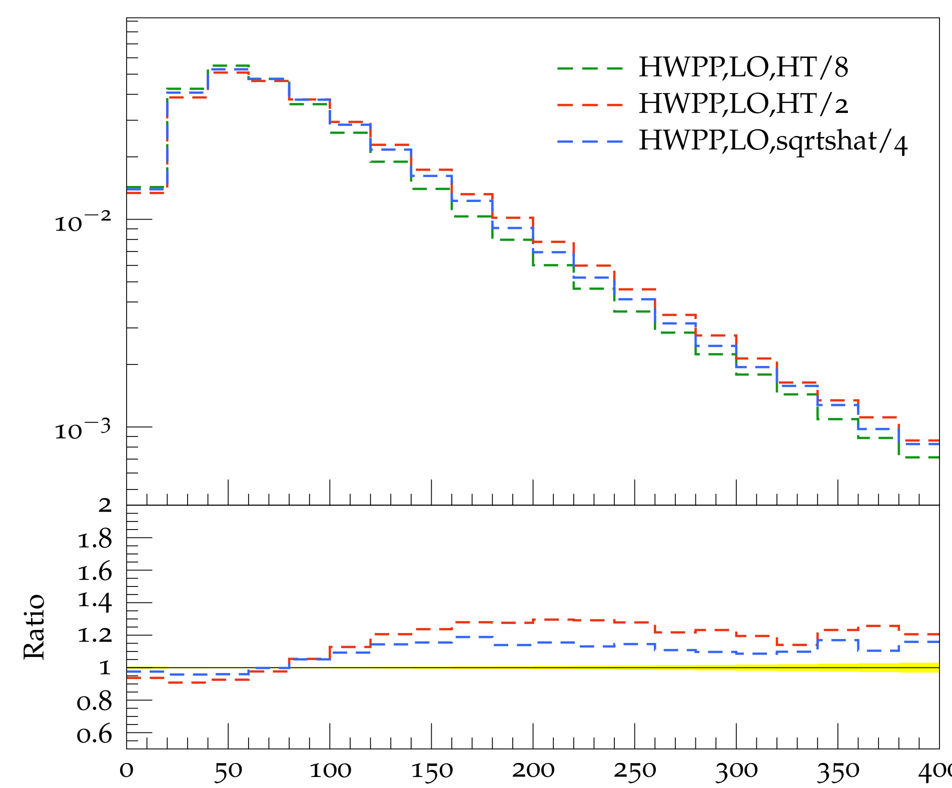

$P_T(t_1 t_2)$, 1-bjet bin, LO

Results: comparison of different scales in MG5_aMC at LO and NLO

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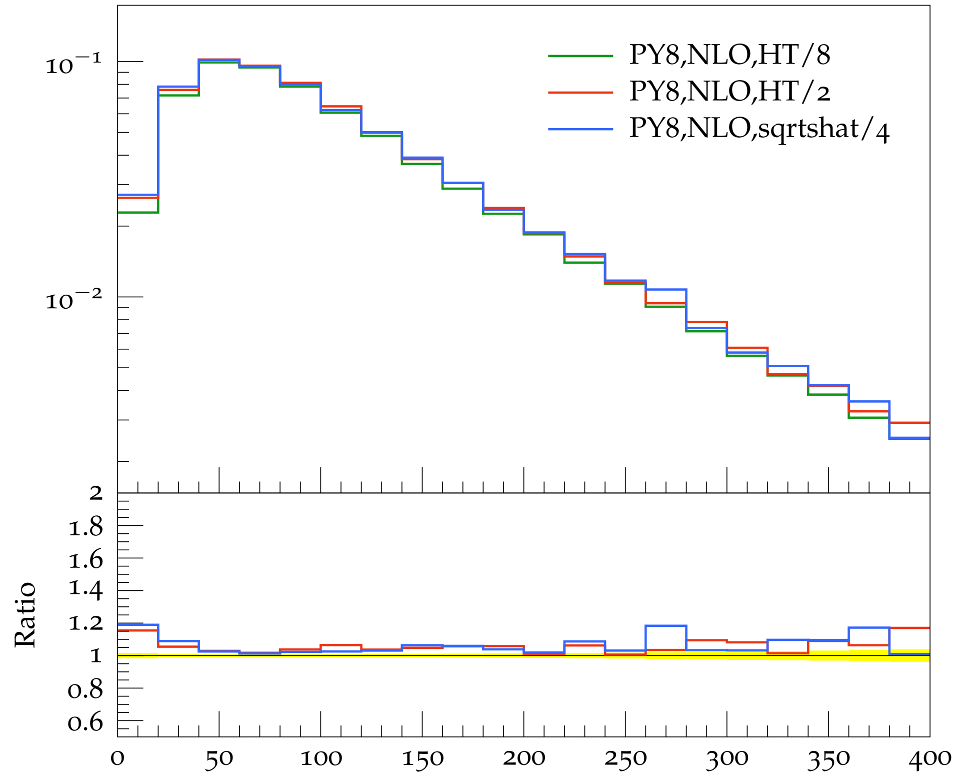

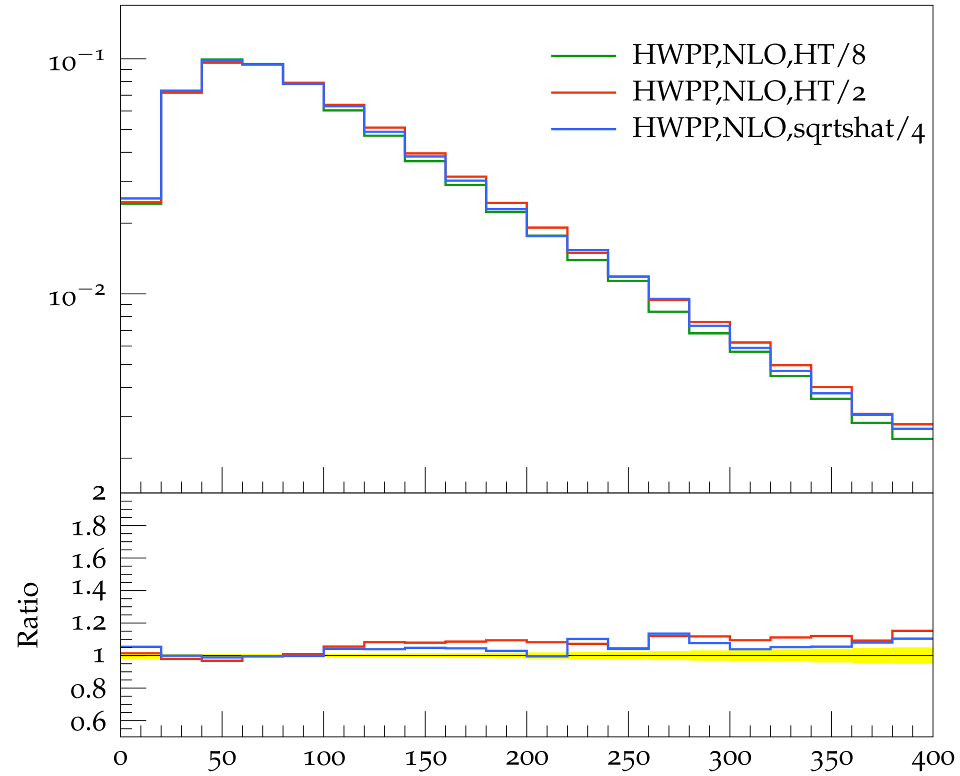

$P_T(t_1 t_2)$, 1-bjet bin, NLO

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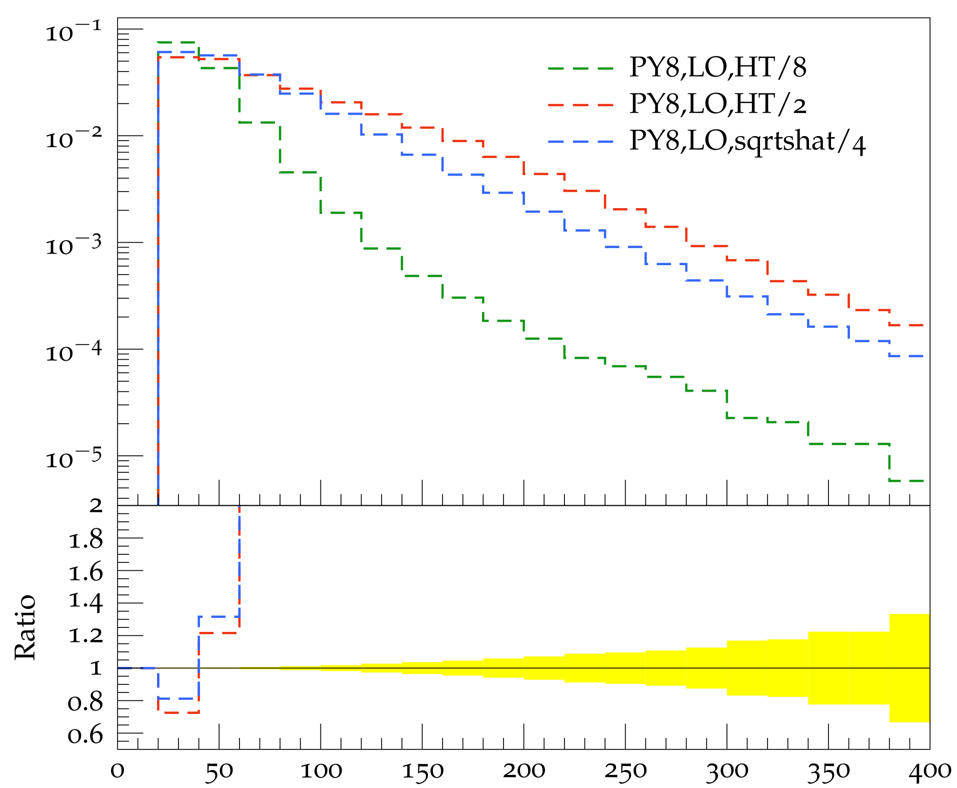

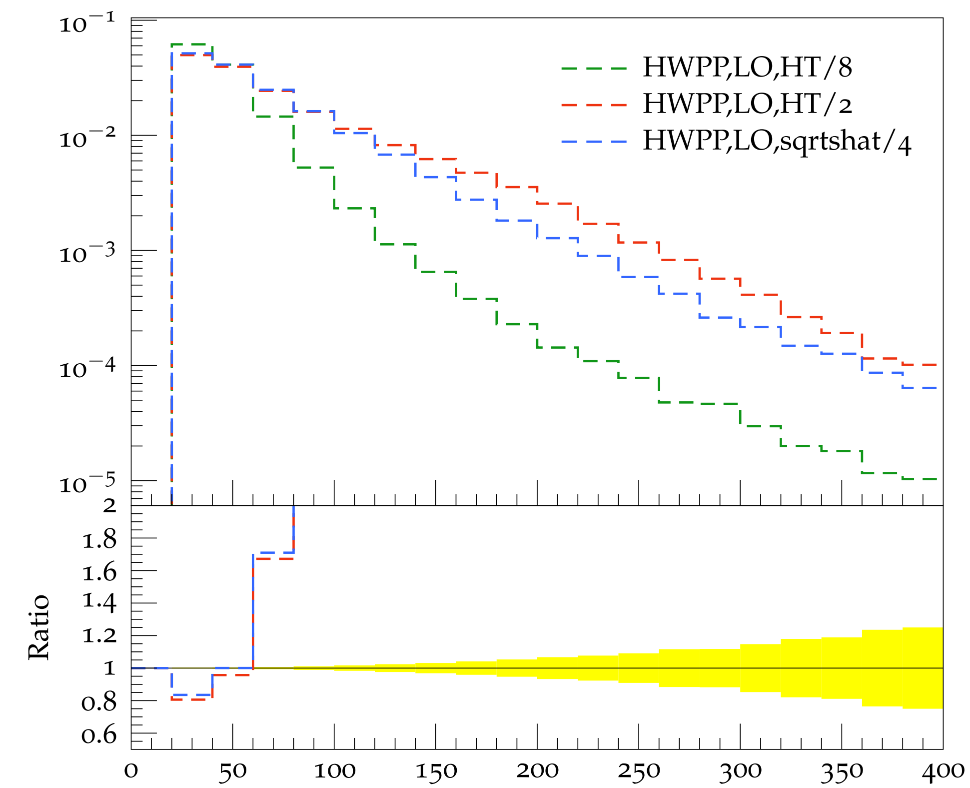

$P_T(j_1)$, 1-bjet bin, LO

Results: comparison of different scales in MG5_aMC at LO and NLO

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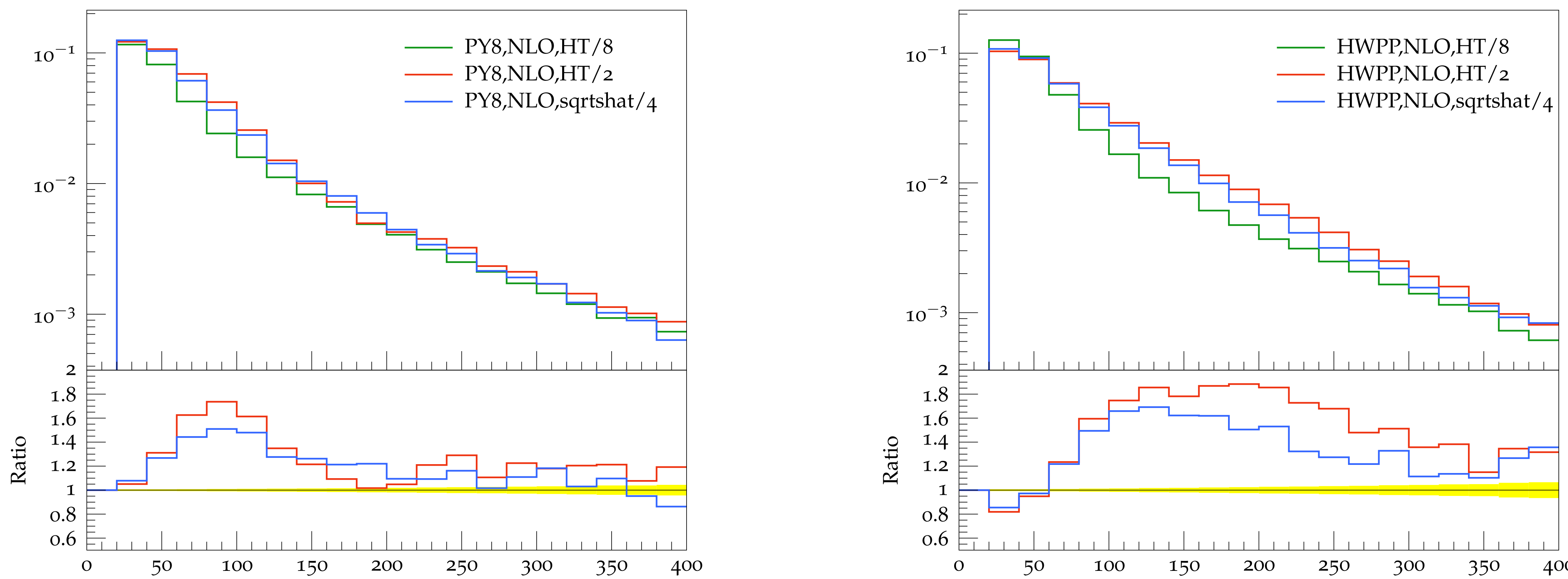


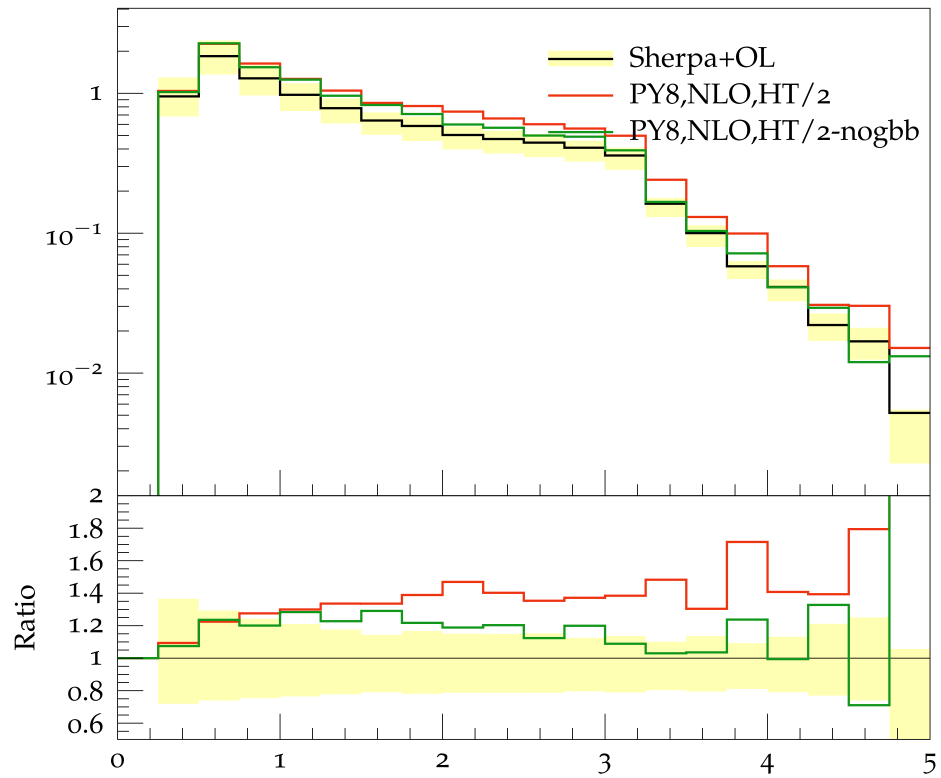
$P_T(j_1)$, 1-bjet bin, NLO

Results: comparison of different scales in MG5_aMC at LO and NLO

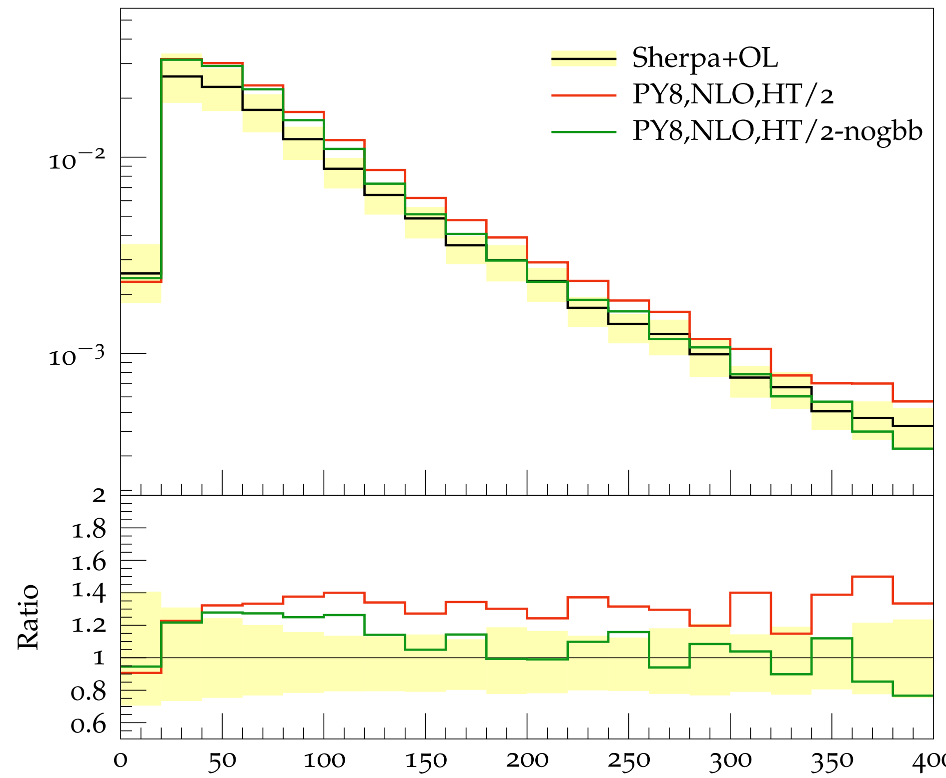
- Bottom line:
  - PY8 typically shows a larger dependence on the shower scale than HW++
  - NLO corrections provide a stabilisation of predictions, with a consequent reduction of their spread.
  - The impact of such a stabilisation is highly observable dependent
  - Observables related to j_1 have a LO-like behaviour at NLO +PS (and entirely MC-driven at LO+PS) confirmed by the very large shower-scale dependence.

Results: Effect of secondary g→bb splittings in PY8

- We have investigated what happens when g→bb splittings are vetoed in the shower.
- As it was shown with Sherpa, the effect of g→bb splittings is large (20-30%), in particular for the second b jet.



$M(b_1,b_2)$



$\Delta R(b_1,b_2)$

Running time statistics

- Each NLO sample consists in 4M LHE events. The statistics for the running time (excluding the showering step) are:

Step:	# jobs	Longest time (s)	Aggregated time (s)
Grid setup	49	12k	110k
Integration	49	75k	682k
Event generation	433 (*)	163k	14.8M

* the number of jobs for event generation can be increased (thus reducing the running time of each job) by setting the `nevt_job` variable in the `run_card` to a smaller number. Here `nevt_job=10000` was used.

Outlook

- A very low shower scale brings predictions from MG5_aMC close to those by Sherpa. However, the usage of such a scale is not physically motivated.
- NLO corrections show a clear stabilisation of the shower-scale dependence of predictions. The extent of this stabilisation is very observable dependent.
- The impact of $g \to bb$ splitting is found to be large, as expected. Further studies may regard the dependence on the form of the splitting function (can be changed in PY8).
- An assessment of *all* theoretical uncertainties, including those from the shower, is mandatory for this kind of processes.
- How do different tools compare at the hadronic level?