Resummation benchmarking

LHC EW precision group meeting

September 11, 2019

Benchmarking levels

1) Canonical logarithms (as much as possible)
   - Strictly $\ln(Qb_T/b_0)$, $\ln(q_T/Q)$, i.e. $\mu_H = Q_{\rm res} = Q$, $\mu_r = \mu_f = Q$
   - Including b^* or equivalent prescription, but no nonpert. form factor etc.
   - Result in b_T space (if possible)
   - Result in q_T space

2) Nominal, favourite logarithms
   - Including turning off resummation at large q_T, e.g. $Q_{\rm res} = Q/2$, profile scales, $\ln(b_T) \to \ln(1 + b_T)$, etc. ...
   - Result in q_T space

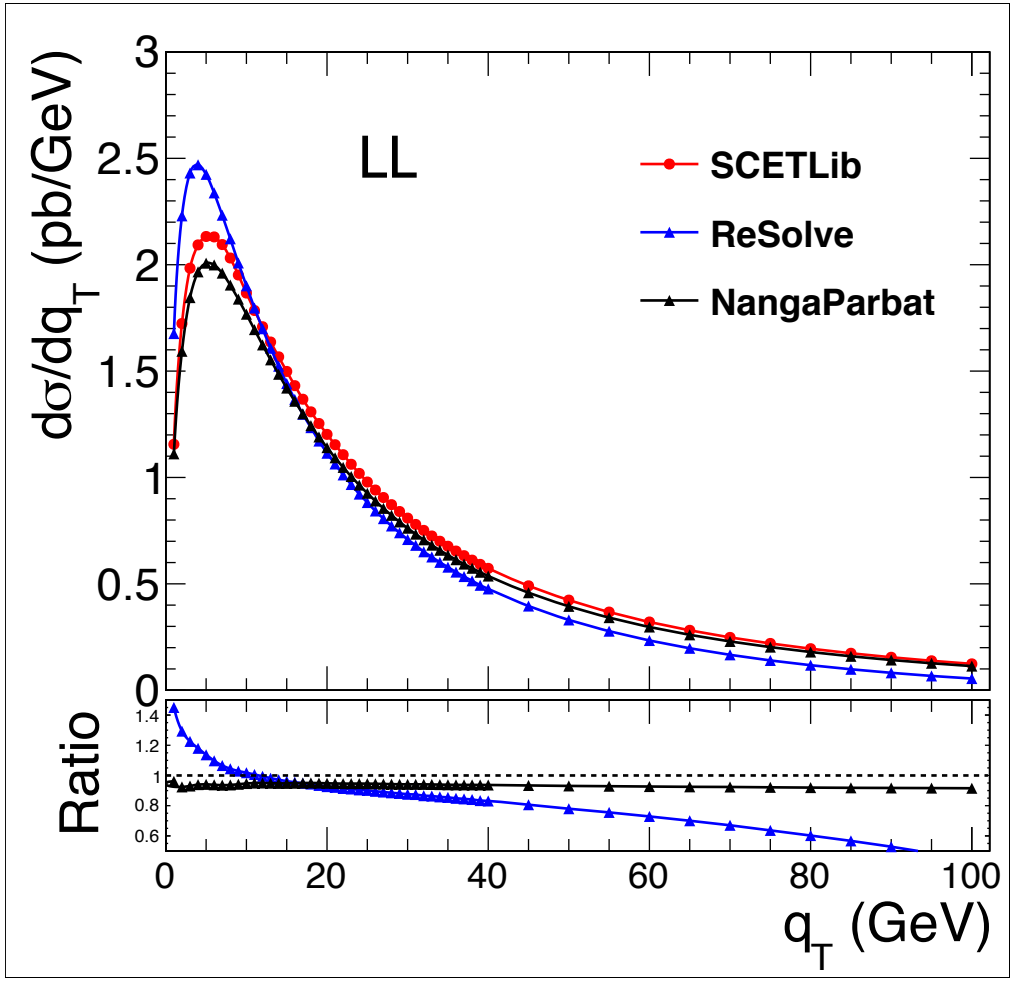
3) Resummation as in 2) plus matching nonsingular FO correction

Practical considerations

- Benchmarking of resummed $p_T Z$, $p_T W/p_T Z$:
  - Document with specifics attached to the agenda
  - Inputs: https://gitlab.cern.ch/arapyan/pt-comparison
- What is the status of inputs:
  - Raddish, Resbos2, and Dyres/Dyturbo didn't upload their inputs yet and the plots will not include these codes
  - SCETlib: level-1 inputs (5gen, 2gen), (mZ,|Y|=0)
  - NangaParbat: level-1?, 5gen, different mll and Yll bins (input format needs to be fixed)
  - CuTe: level-1 inputs (5gen, 2gen), (mZ,|Y|=0,2.4, inc)
  - ReSolve: level-1 and 2 inputs (5gen), (mZ,|Y|=0,2.4, inc). One extra bin in qT (41.5GeV)
  - PB-TMD: level-1 and 2 (5 gen). |Y|=0,2.4, inc, but 66<mll<116 GeV

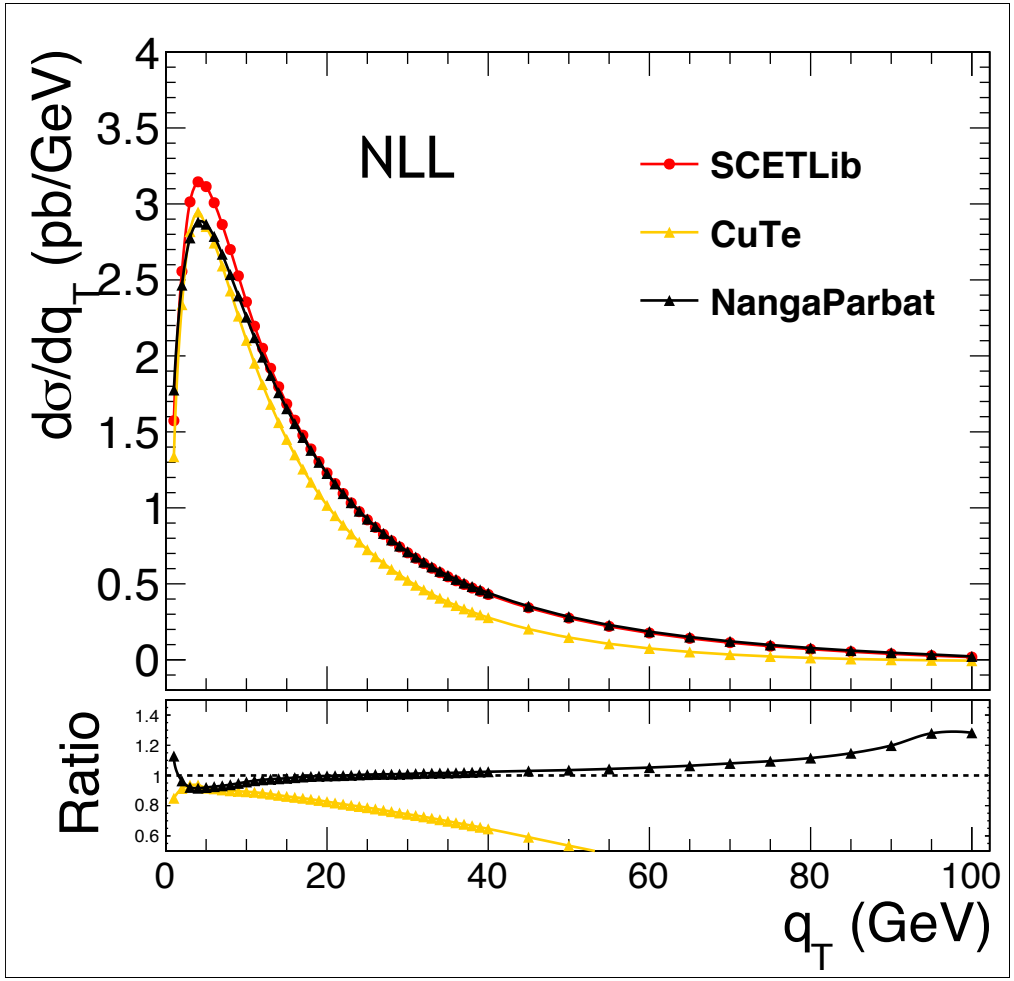
Q=MZ, Y=0, level-1, gen=5

- LL comparisons: SCETlib, ReSolve, and NangaParbat



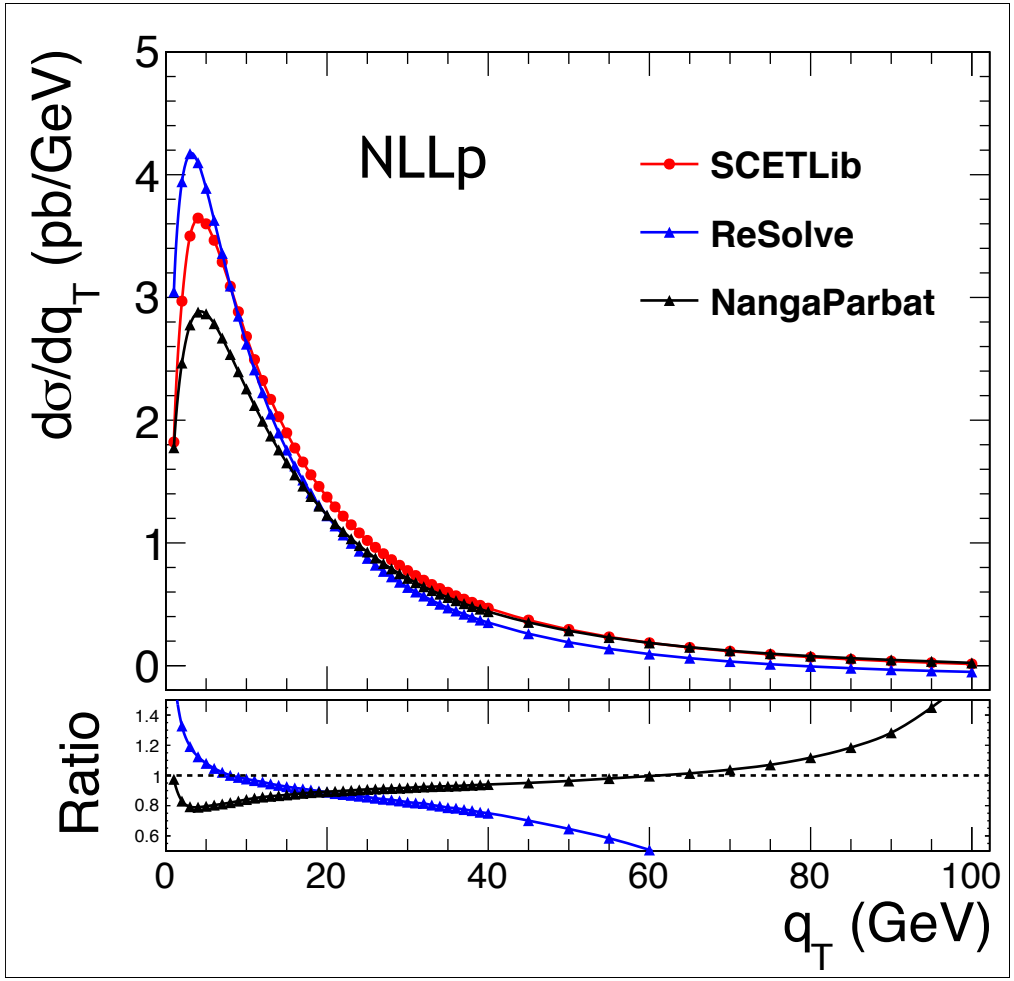
Q=MZ, Y=0, level-1, gen=5

- NLL comparisons: SCETlib, CuTe, and NangaParbat



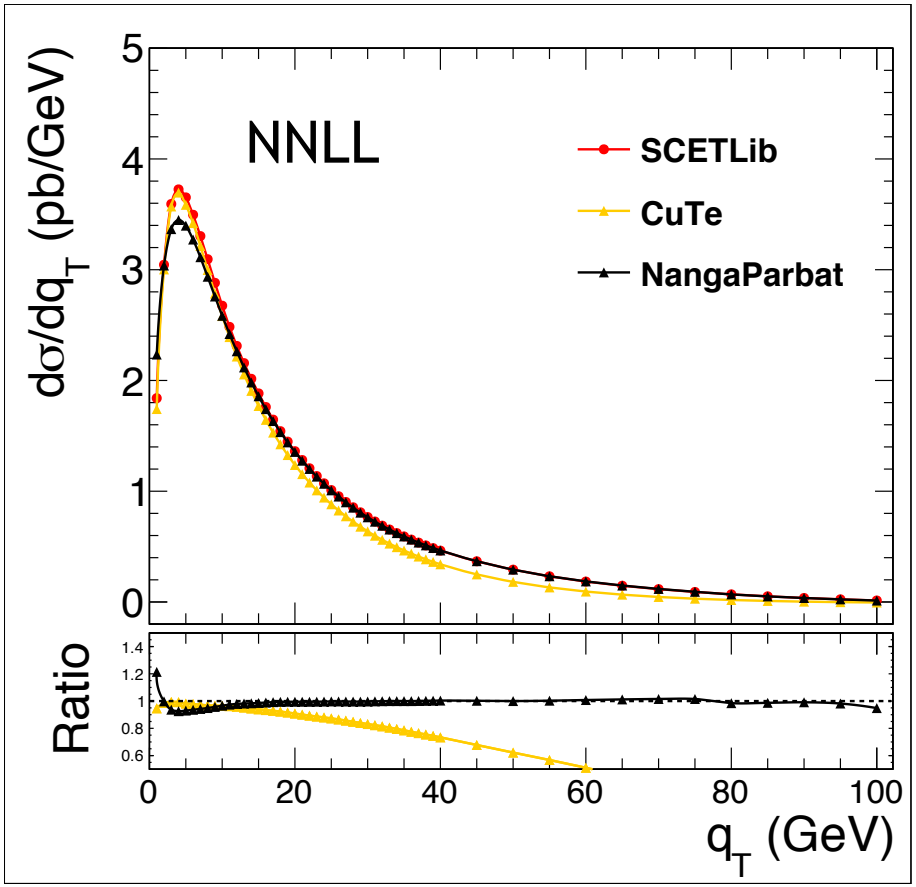
Q=MZ, Y=0, level-1, gen=5

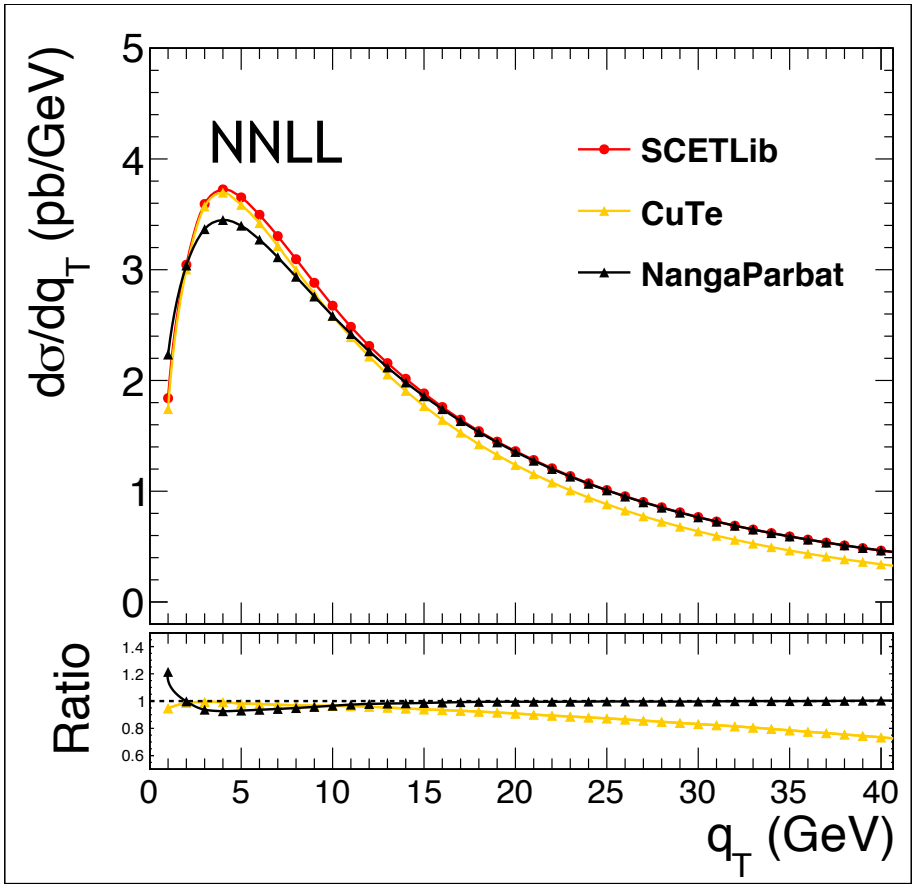
- NLLp comparisons: SCETlib, ReSolve, and NangaParbat



Q=MZ, Y=0, level-1, gen=5

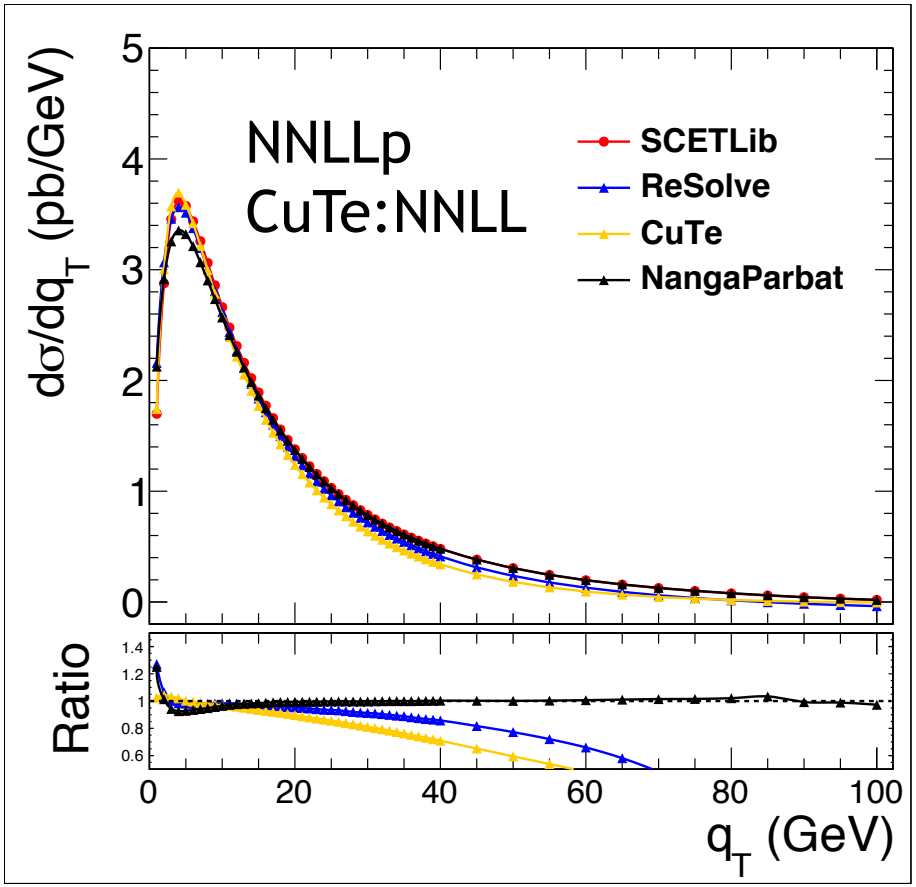
- NNLL comparisons: SCETlib, CuTe, and NangaParbat

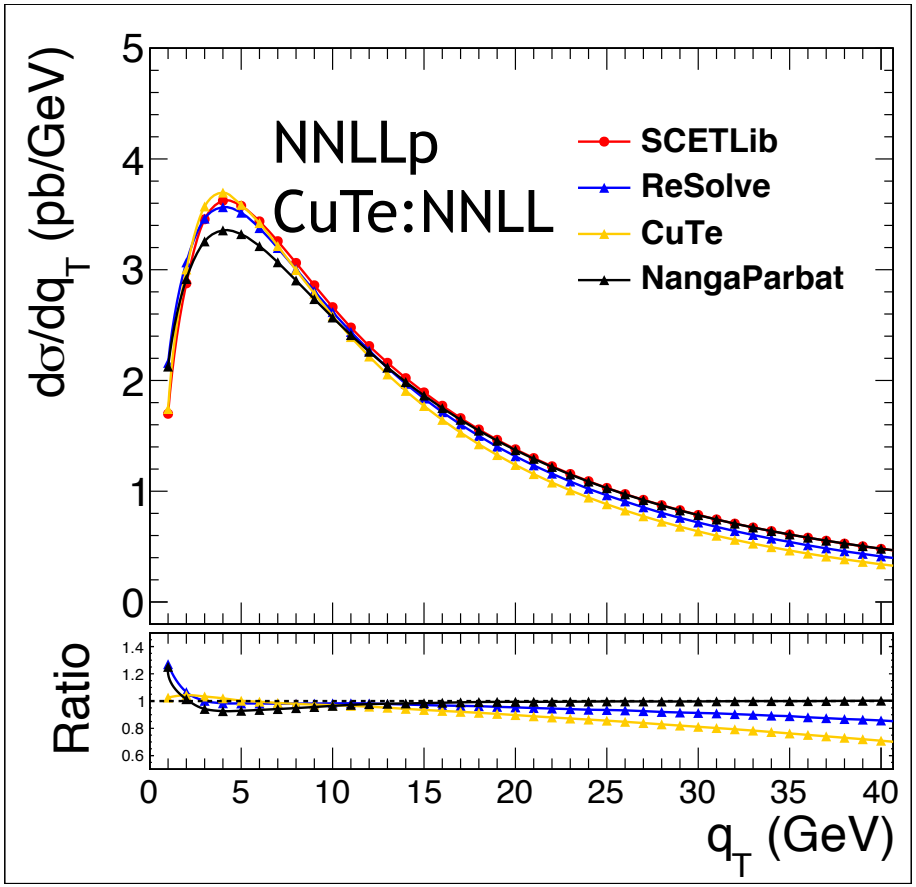




Q=MZ, Y=0, level-1, gen=5

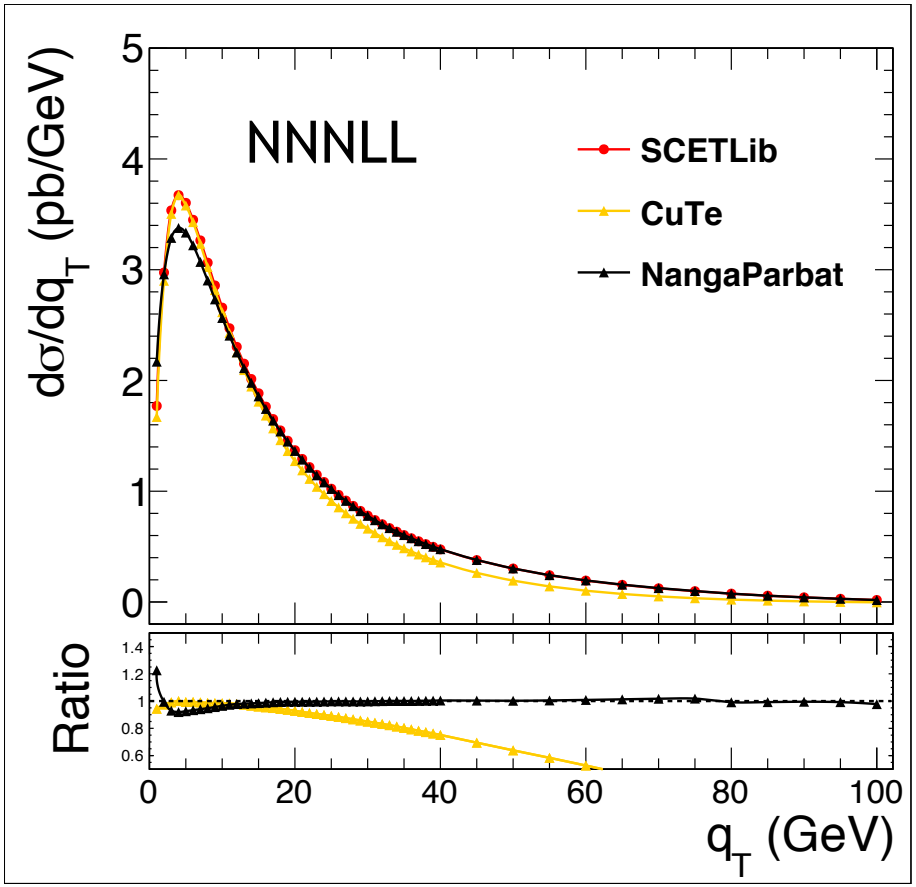
- NNLLp comparisons: SCETlib, CuTe(NNLL), ReSolve, and NangaParbat

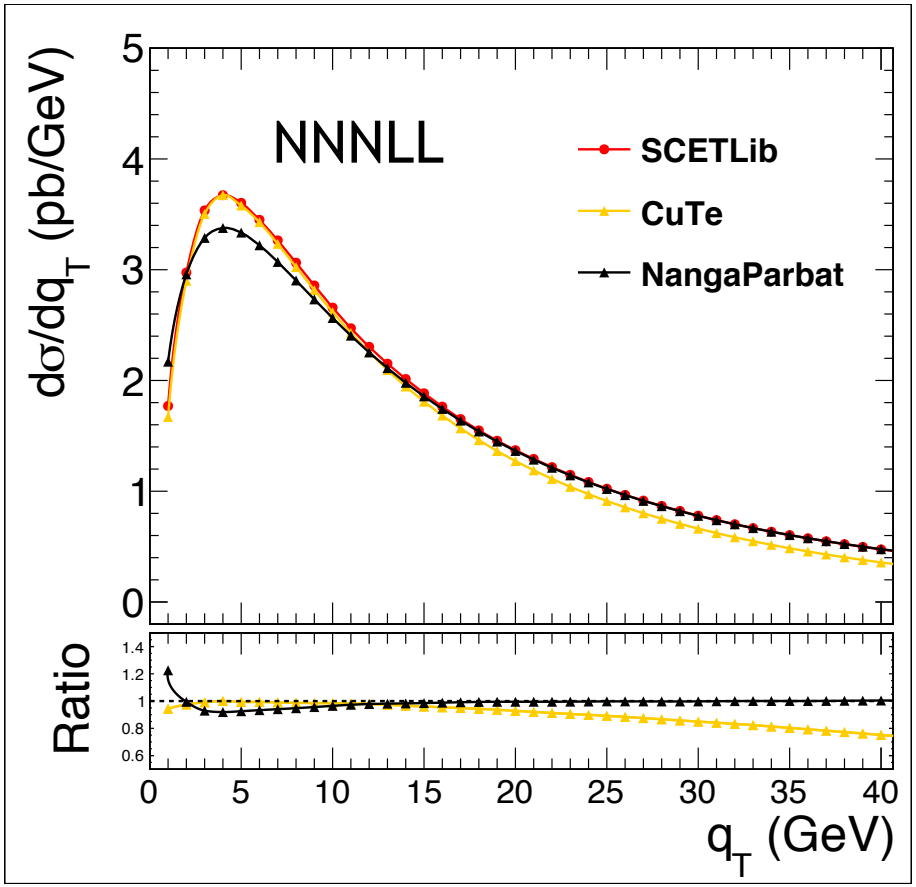




Q=MZ, Y=0, level-1, gen=5

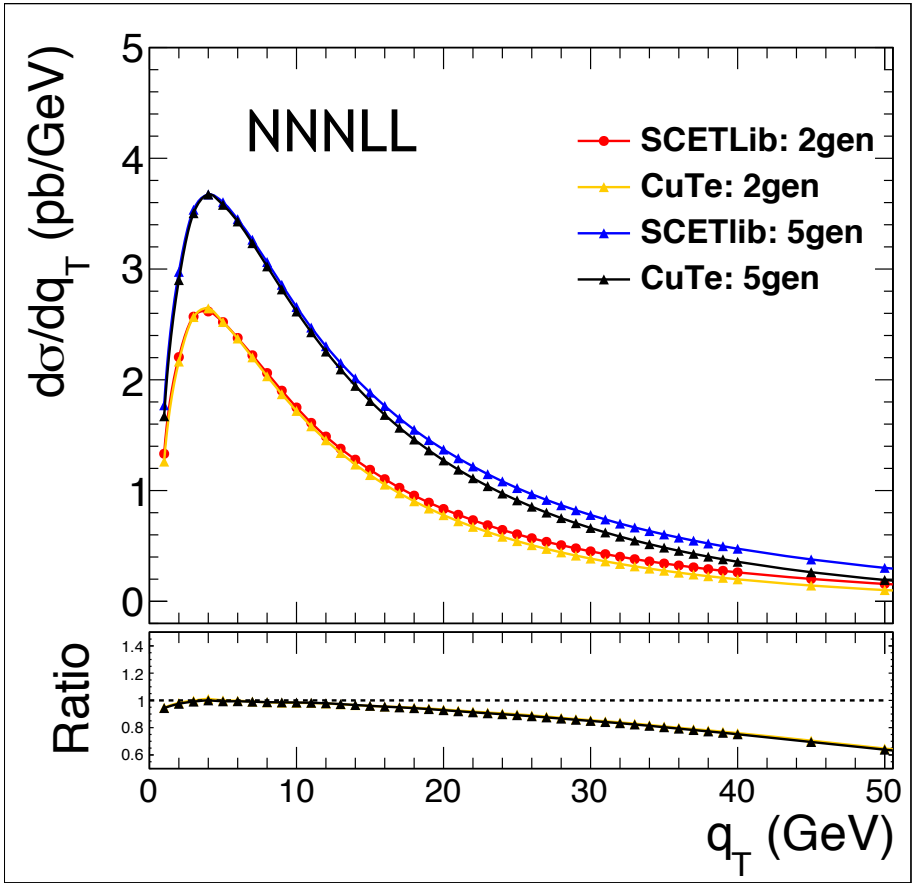
- NNNLL comparisons: SCETlib, CuTe, and NangaParbat

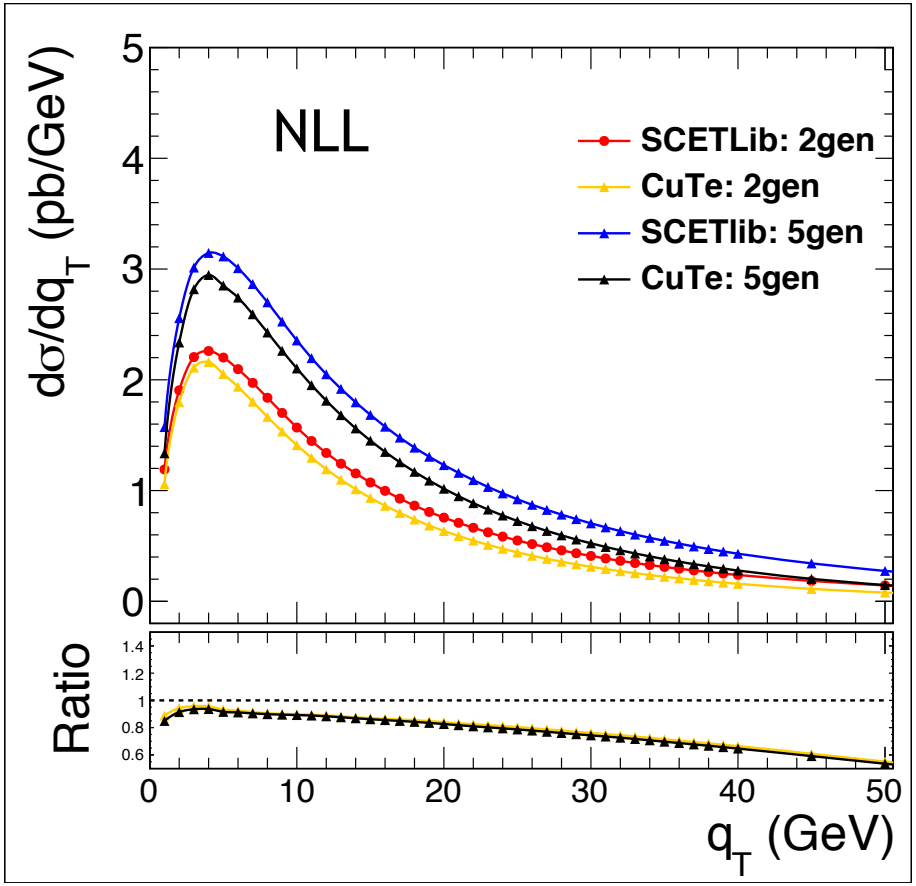




gen=2 vs. gen=5, mZ, Y=0

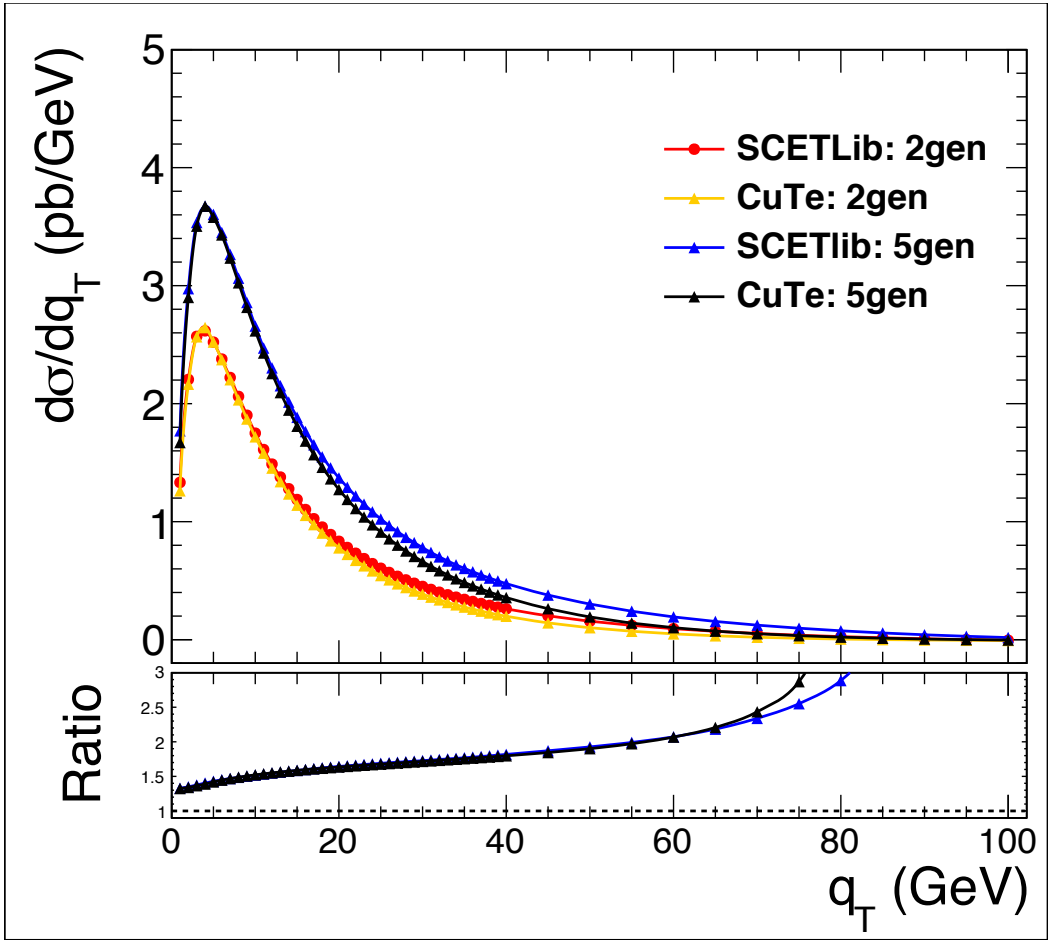
- The CuTe/SCETLib ratio appears to be the same for 2gen and 5gen in all orders. Probably no need to generate 2gen inputs.





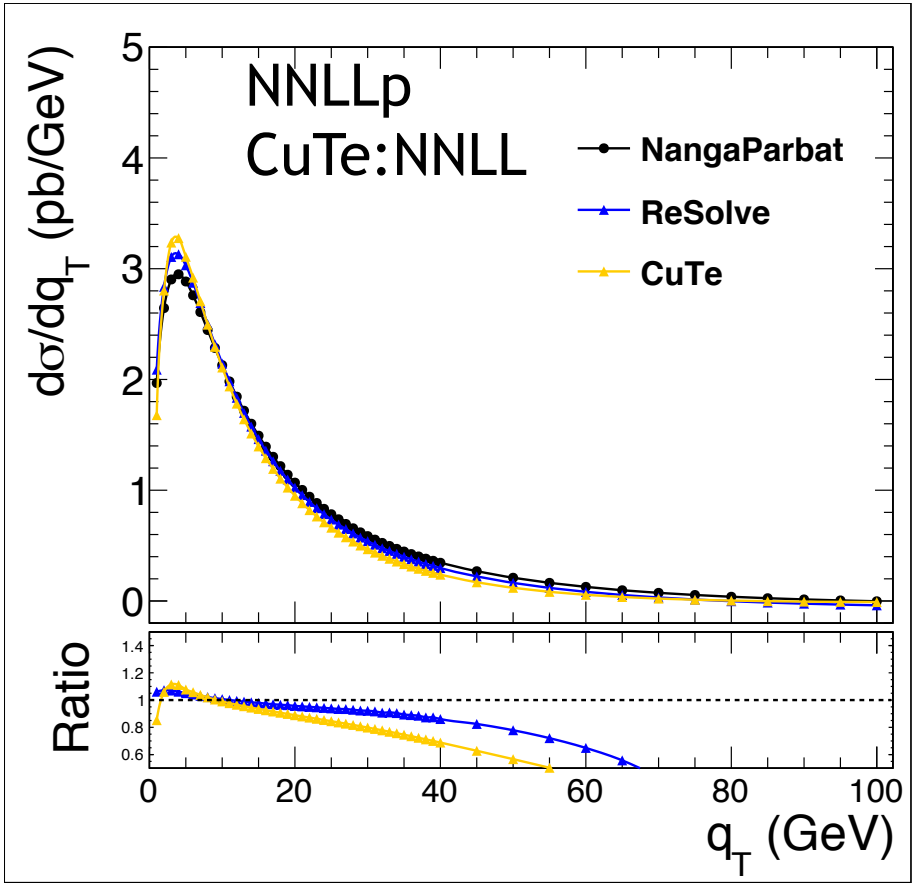
gen=2 vs. gen=5, mZ, Y=0

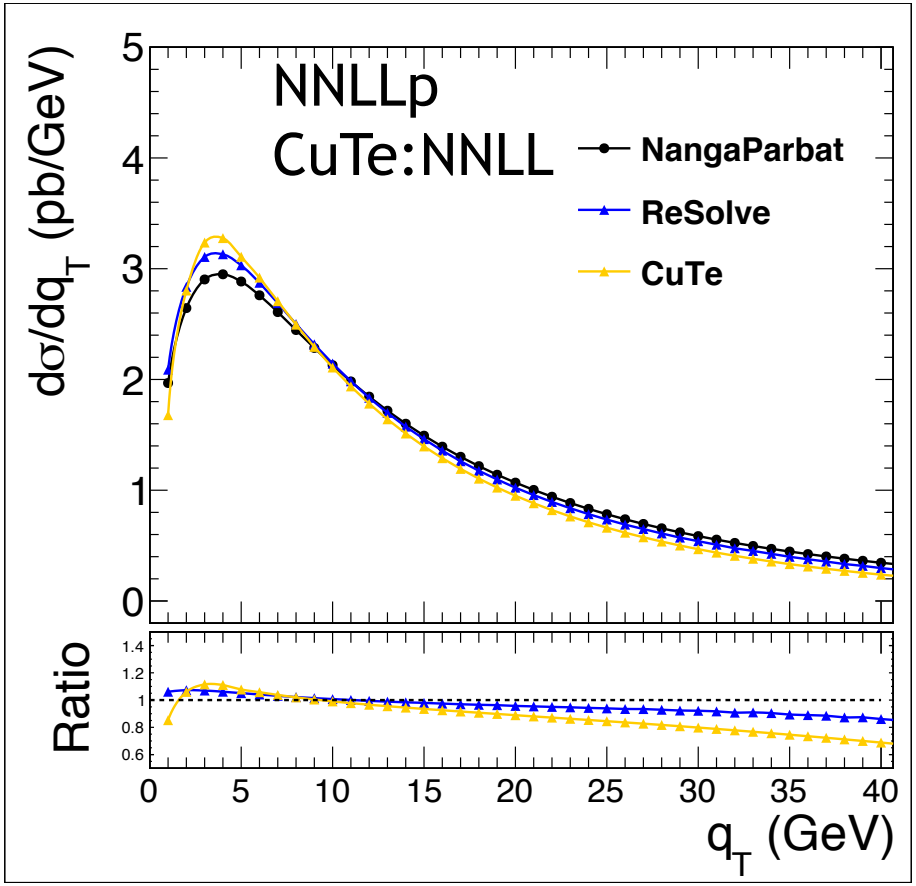
- Ratio plot: 5gen/2gen ratio (blue: scetlib, black: CuTe)



Q=MZ, Y=2.4, level-1, gen=5

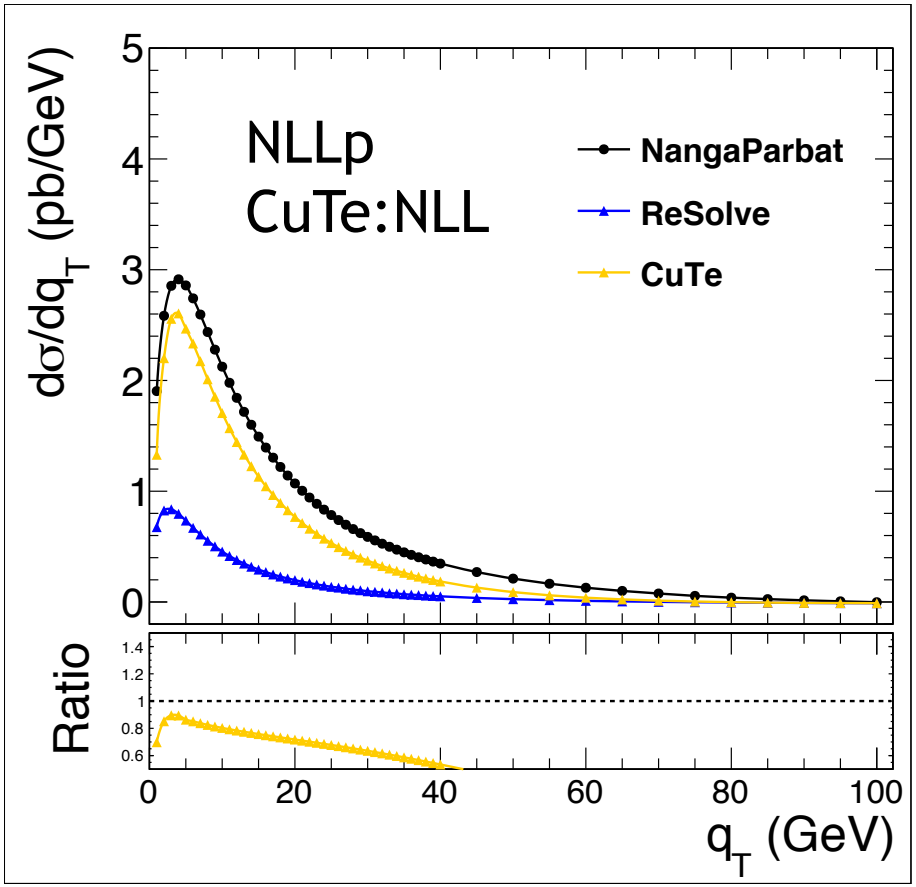
- NNLLp comparisons: ReSolve, CuTe, and NangaParbat
  - The picture is very similar to Y=0 case (slide 9)

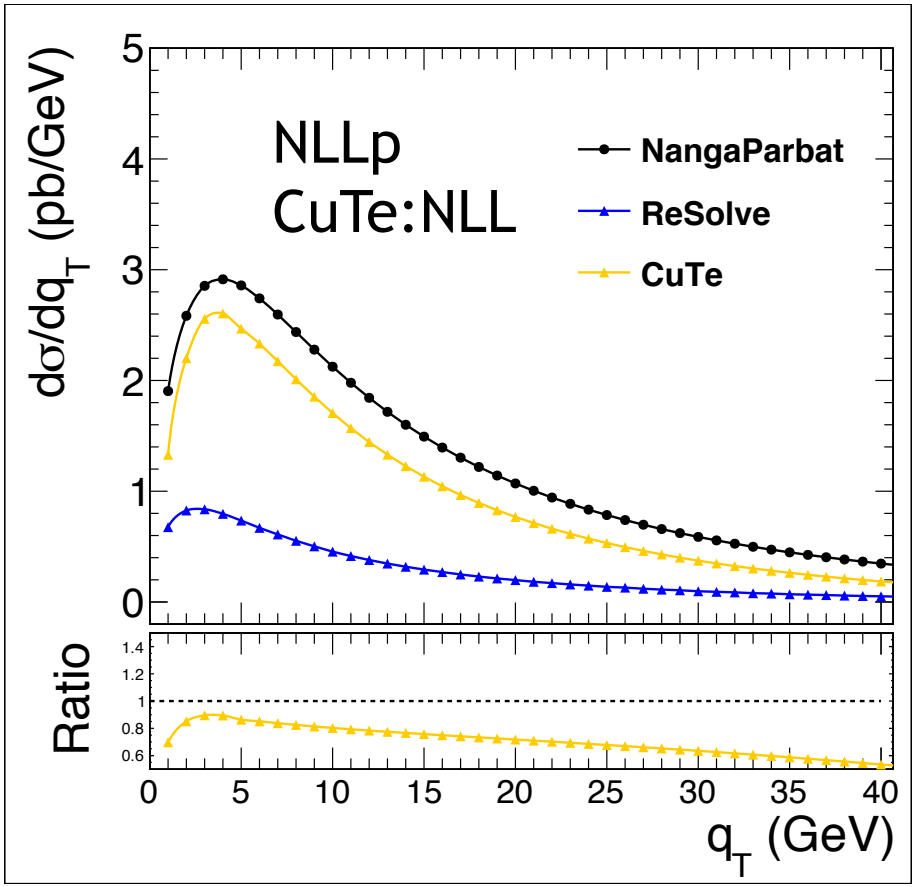




Q=MZ, Y=2.4, level-1, gen=5

- NLLp comparisons: ReSolve, CuTe, and NangaParbat





Next steps

- Continue making level-1 and level-2 comparisons as inputs come
  - For codes not shown today please upload your inputs

3.3 Step 2

- Add missing orders as well as missing results for level 2.
- Add points in $Y = 0, 1.2, 2.4, 3.6$.
- Add points in $Q = 66, 116, 300, 1000\,\mathrm{GeV}$.

- Hopefully we will have all the necessary inputs for step-2 (including level-2) discussion during the end of October workshop

Next steps

- We should think about uncertainties
- List of various sources of uncertainties to be quantified (as relevant for each step)
  1) Subheading logarithmic corrections
  2) Resummation uncertainties within each formalism
  3) Prescriptions to switch off the resummation at large pT, e.g. modified logarithms of some type, profile functions, etc.
  4) Matching schemes to combine resumed and FO results (relevant for the last step)

Next steps

- Time to discuss step 3:
  - Fixed order matching (nonsingular)
- Let's discuss and try to converge on the details soon
  - We can then update the benchmarking document to include this step
  - Using the same fixed order prediction for everyone
    - NNLOjet? FEWZ/DYNNLO, DYTurbo with fixed Q and Y

Order	Boundary cond. (FO singular)	Anomalous dimensions γ_i (noncusp)	$\Gamma_{\rm cusp}$, β	FO matching (nonsingular)
LL	1	-	1-loop	-
NLL	1	1-loop	2-loop	-
NLL′ (+NLO$_0$)	α_s	1-loop	2-loop	α_s
NNLL (+NLO$_0$)	α_s	2-loop	3-loop	α_s
NNLL′ (+NNLO$_0$)	α_s^2	2-loop	3-loop	α_s^2
N^{3}LL (+NNLO$_0$)	α_s^2	3-loop	4-loop	α_s^2
N^{3}LL′ (+N^{3}LO$_0$)	α_s^3	3-loop	4-loop	α_s^3
N^{4}LL (+N^{3}LO$_0$)	α_s^3	4-loop	5-loop	α_s^3

Timelines and documentation

- We agreed early this year to proceed in successive steps fo the benchmarking from pure resummation benchmarking to “full resummation+fixed order (FO)” benchmarking
  - Steps 1, 2, and 3
- From the Precision EW group the 3 steps will converge for the Yellow Report. it was also tentatively agreed:
  - There will be real added value in publishing the results of these comparisons (one can include a suitable version of such a publication in a Yellow Report). This would be jointly signed by all participating resummation groups.
- Possible timeline?
  - Digest steps 1 and 2 by the end of the year. We can also document these results by the end of the year.
  - Can we produce the step-3 results early next year?
  - Try to wrap up by Summer of next year?