

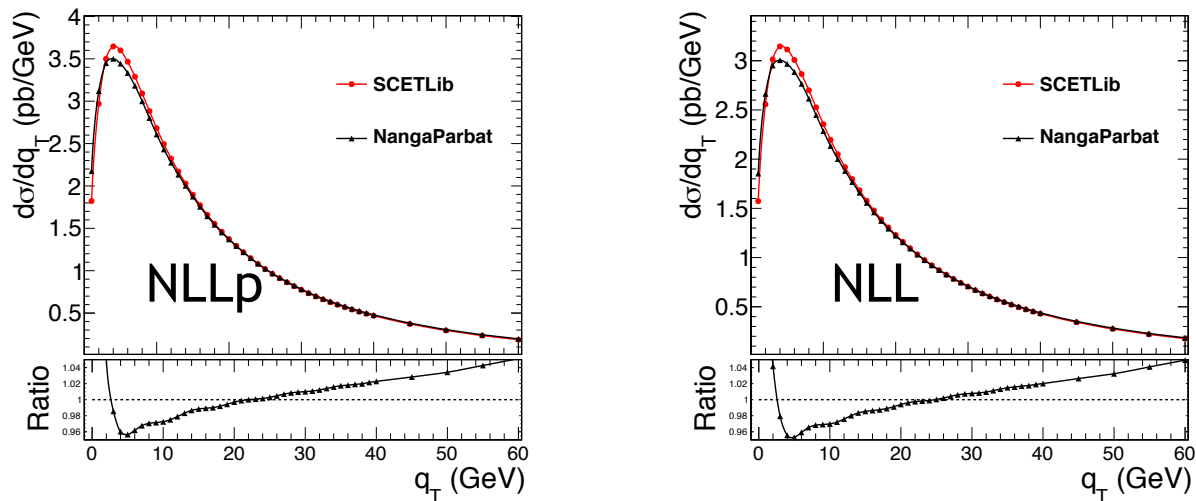
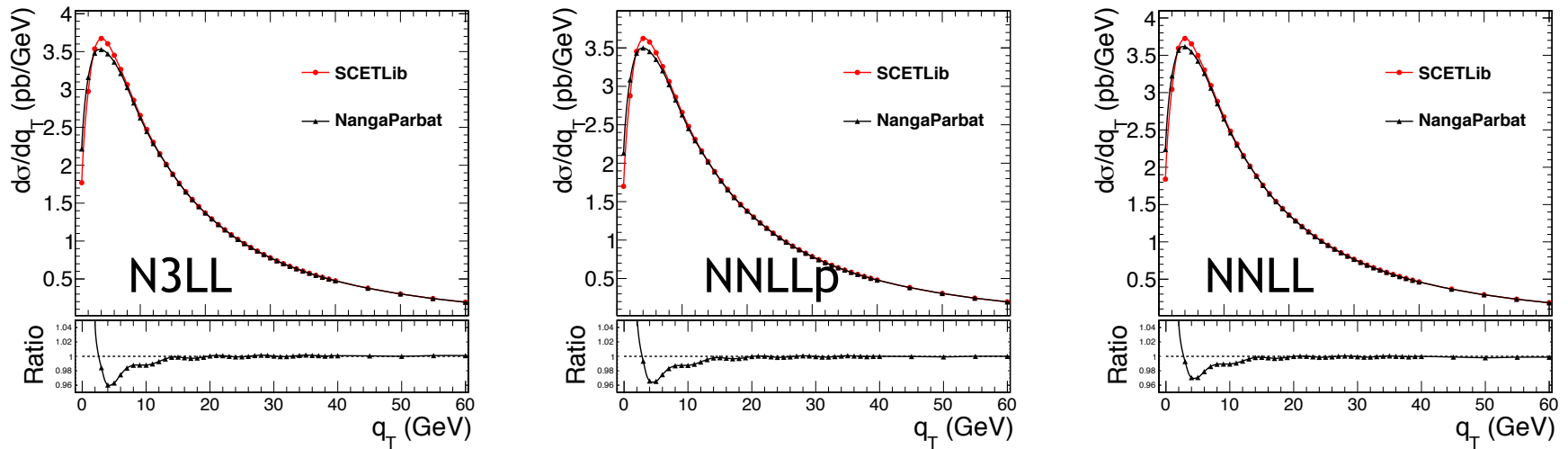
Resummation benchmarking

LHC EW precision group workshop

November 18, 2019

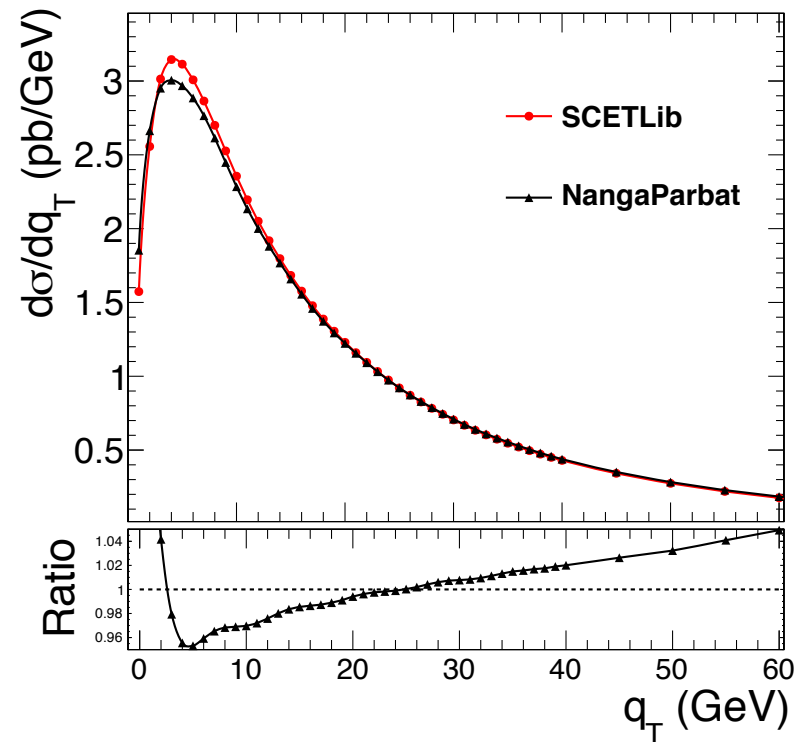
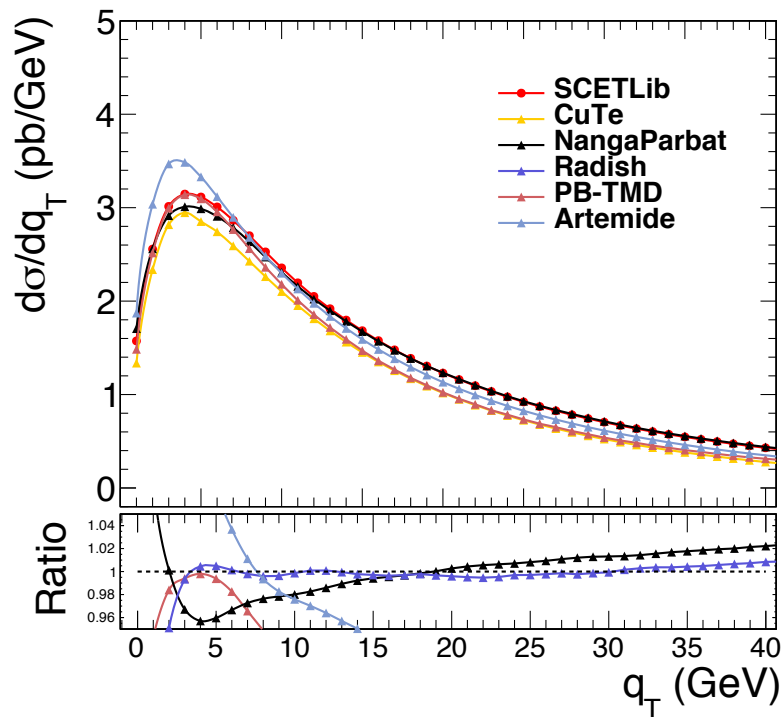
Q=mZ, Y=0, level-1, gen=5

• SCETLib vs. NangaParbat



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

- NLL comparisons: SCETlib, CuTe, NangaParbat, Radish, PB-TMD, Artemide
- ReSolve PDF evolution is not through LHAPDF

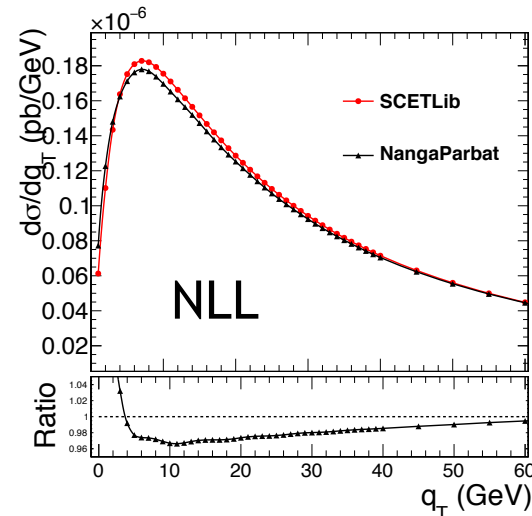
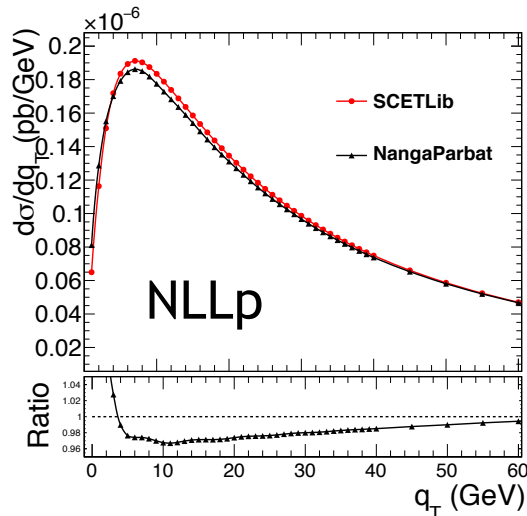
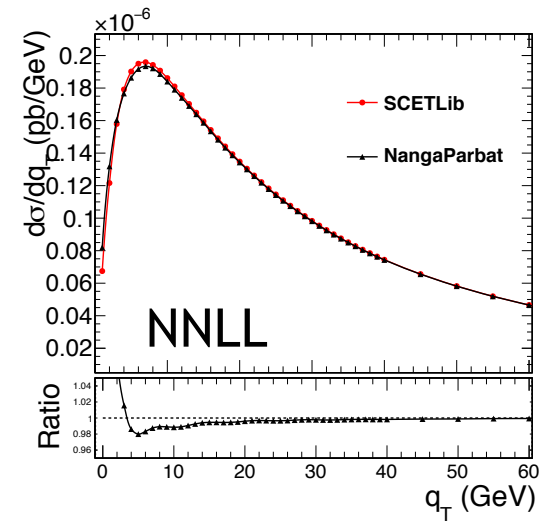
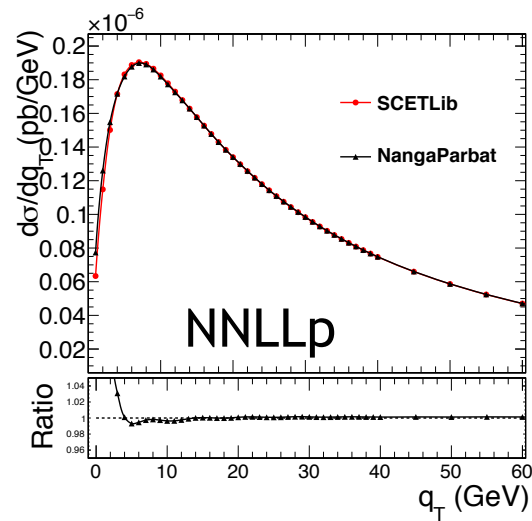
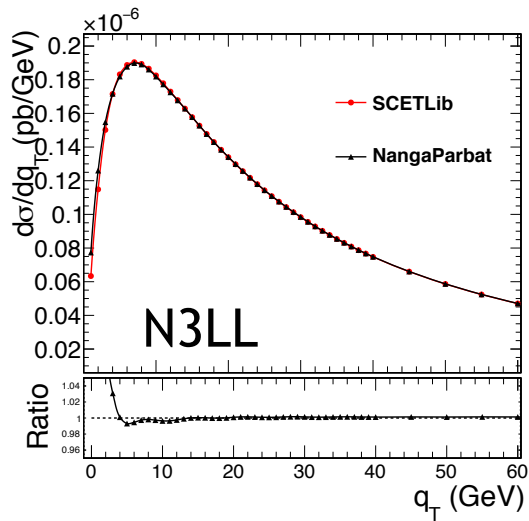


- NangaParbat predictions changed
 - Valerio will double check

10/14/19 • Changed to internal evolution of α_s instead of LHAPDF

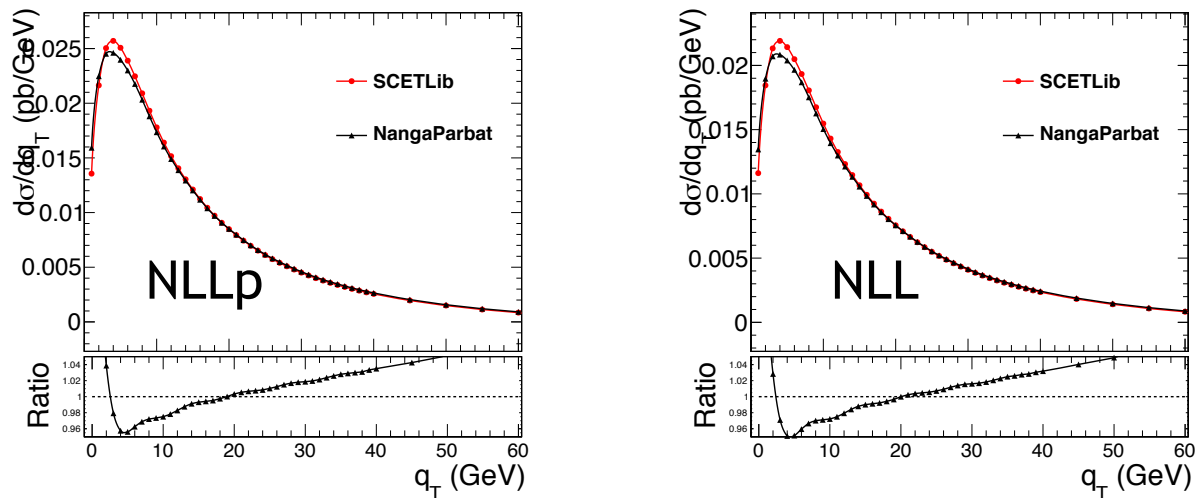
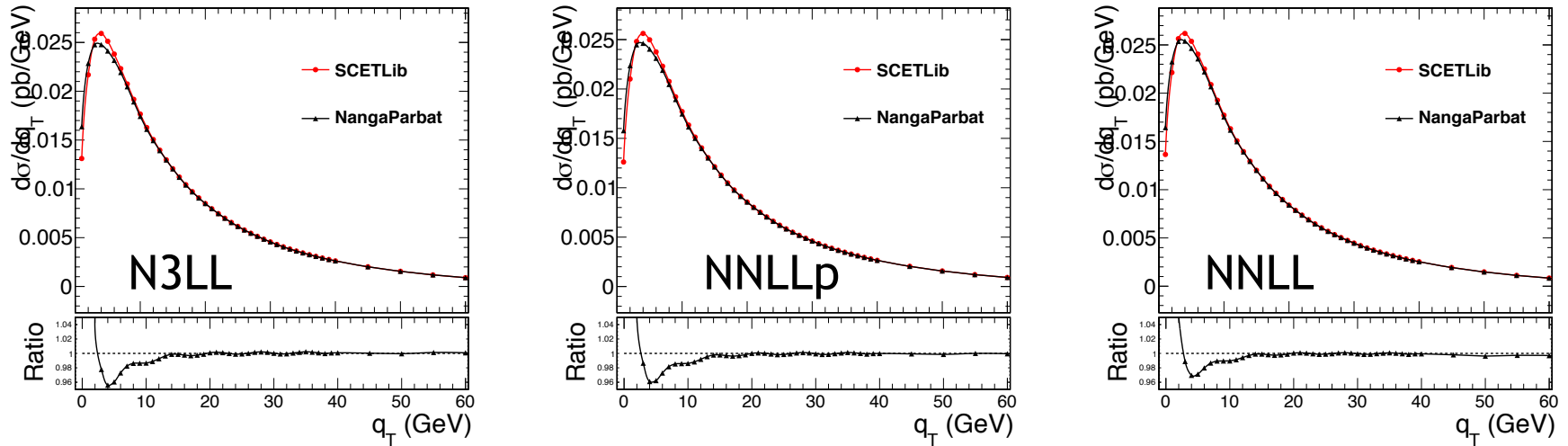
Q=1000, Y=0, level-1, gen=5

- SCETLib vs. NangaParbat



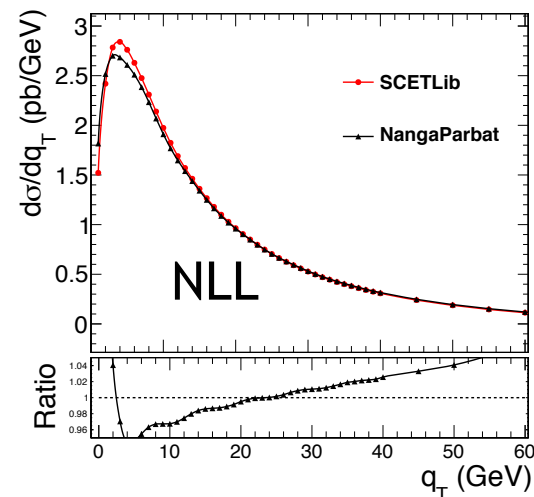
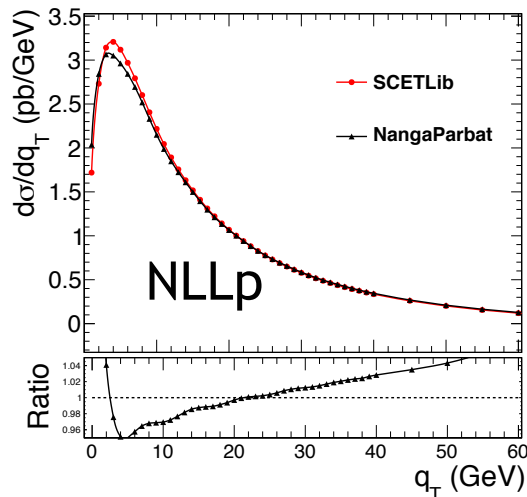
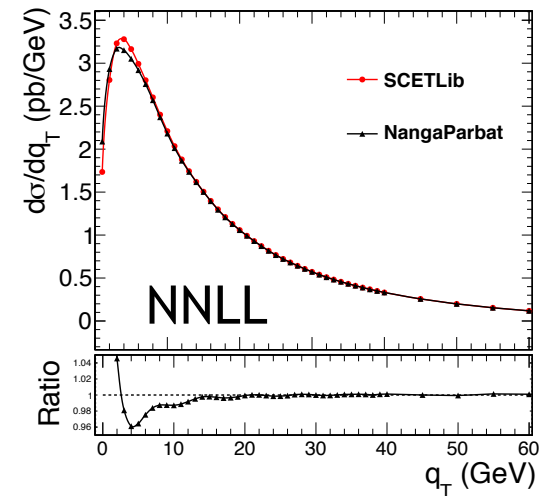
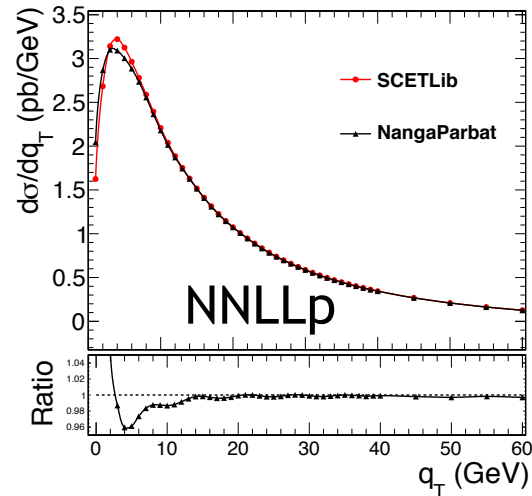
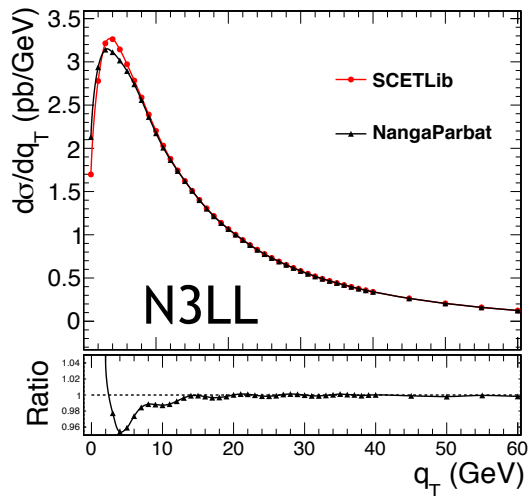
Q=66, Y=0, level-1, gen=5

- SCETLib vs. NangaParbat



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

- SCETLib vs. NangaParbat



ADDITIONAL MATERIAL

Benchmarking levels

- Benchmarking of resummed p_{TZ} , p_{TW}/p_{TZ} :
 - Document with specifics attached to the agenda
 - Inputs: <https://gitlab.cern.ch/arapyan/pt-comparison>
- 1) Canonical logarithms (as much as possible)
 - ▶ Strictly $\ln(Qb_T/b_0)$, $\ln(q_T/Q)$, i.e. $\mu_H = Q_{\text{res}} = Q$, $\mu_r = \mu_f = Q$
 - ▶ 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. $Q_{\text{res}} = Q/2$, profile scales, $\ln(b_T) \rightarrow \ln(1 + b_T)$, etc. ...
 - ▶ Result in q_T space
- 3) Resummation as in 2) plus matching nonsingular FO correction

Resummation codes

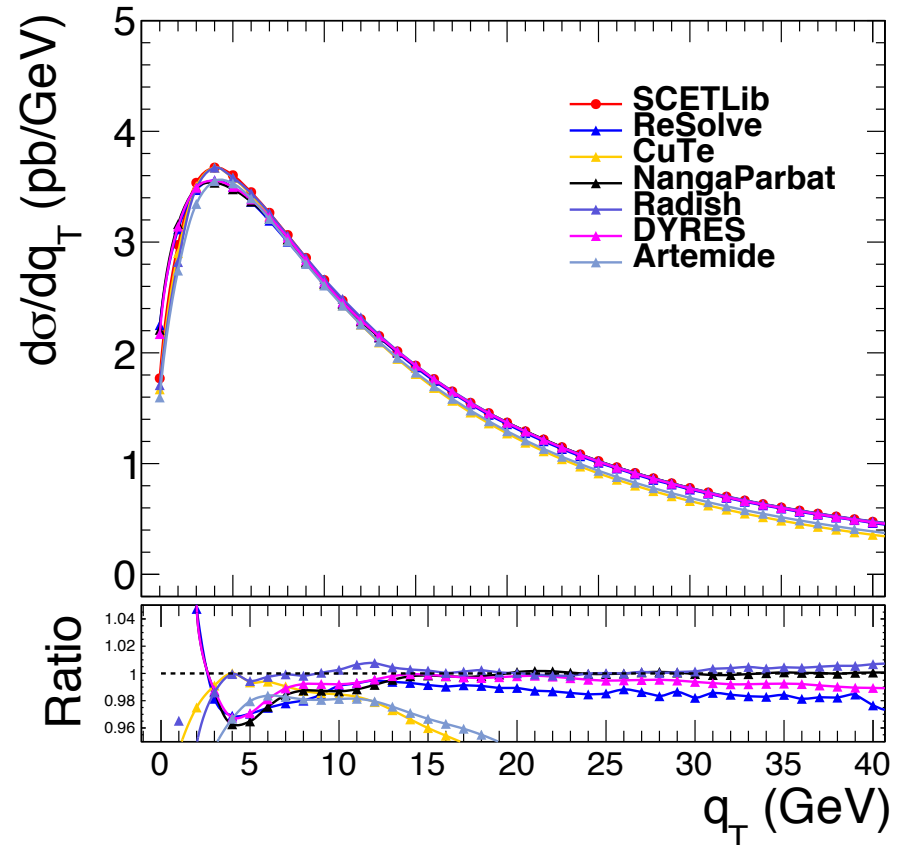
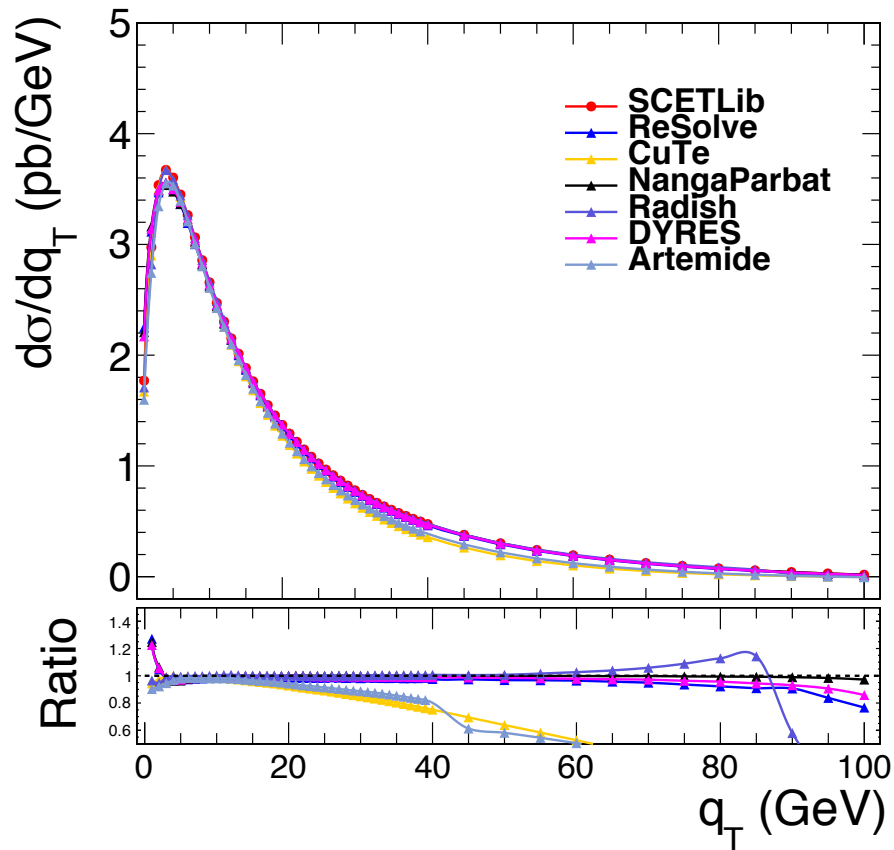
	<i>b</i> -space	<i>k_t</i> -space	add.	mult.	m. logs	profile	trans. fun	NP corr
PB-TMD		✓						✓
CuTe		✓	✓				✓	✓
DYres/DYTURBO	✓		✓		✓			(✓)
NangaParbat	✓		✓		✓			✓
RadISH		✓	(✓)	✓	✓			
ResBos2	✓		✓		✓			✓
Resolve	✓		✓		✓			✓
SCETLib	✓		✓			✓		

+Artemide

Order	Boundary cond. (FO singular)	Anomalous dimensions γ_i (noncusp)	$\Gamma_{\text{cusp}}, \beta$	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

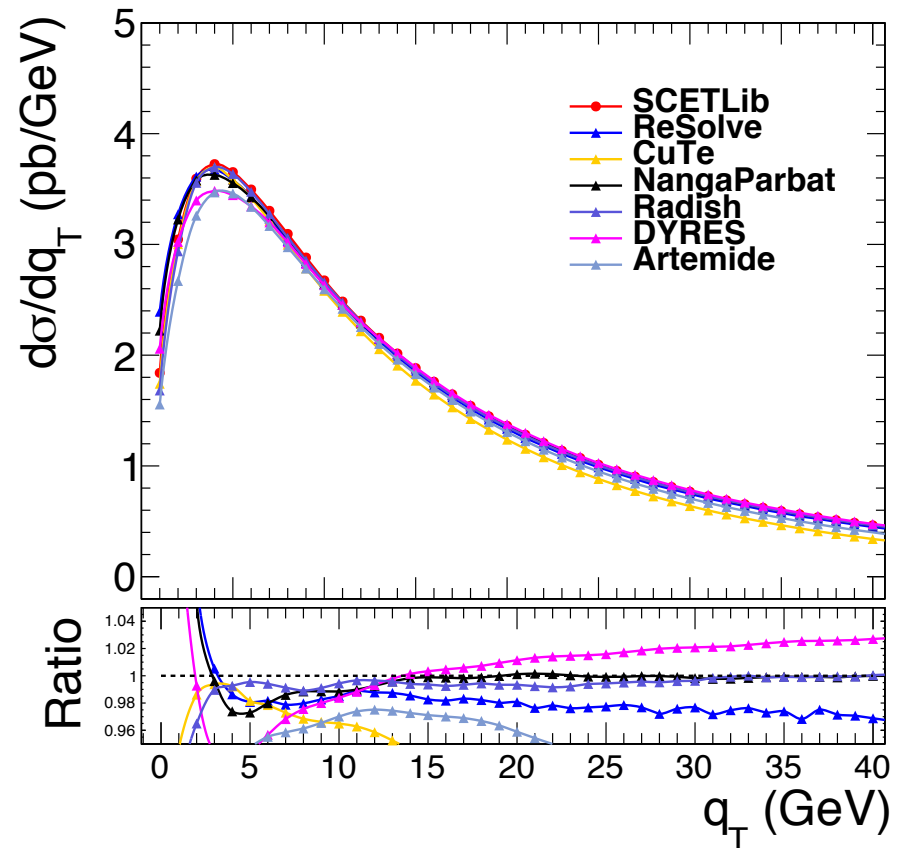
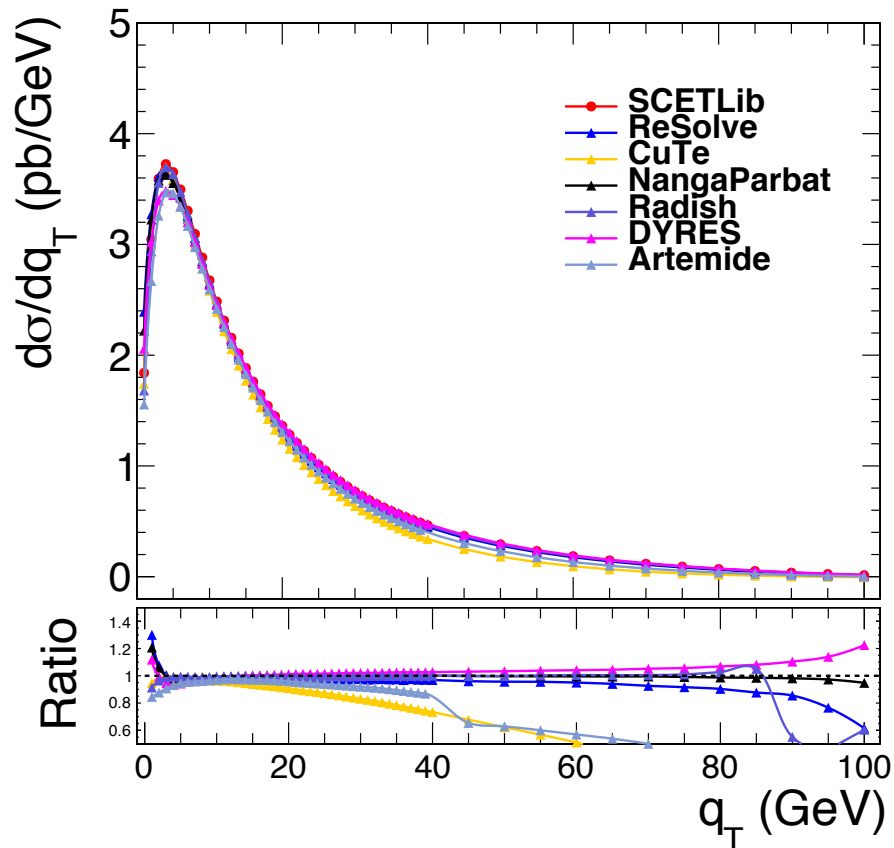
Q=MZ, Y=0, level-1, gen=5

- NNLL comparisons: SCETlib, ReSolve(NNLLp), CuTe, NangaParbat, Radish, DYRES (NNLLp?), Artemide
- ReSolve PDF evolution is not through LHAPDF



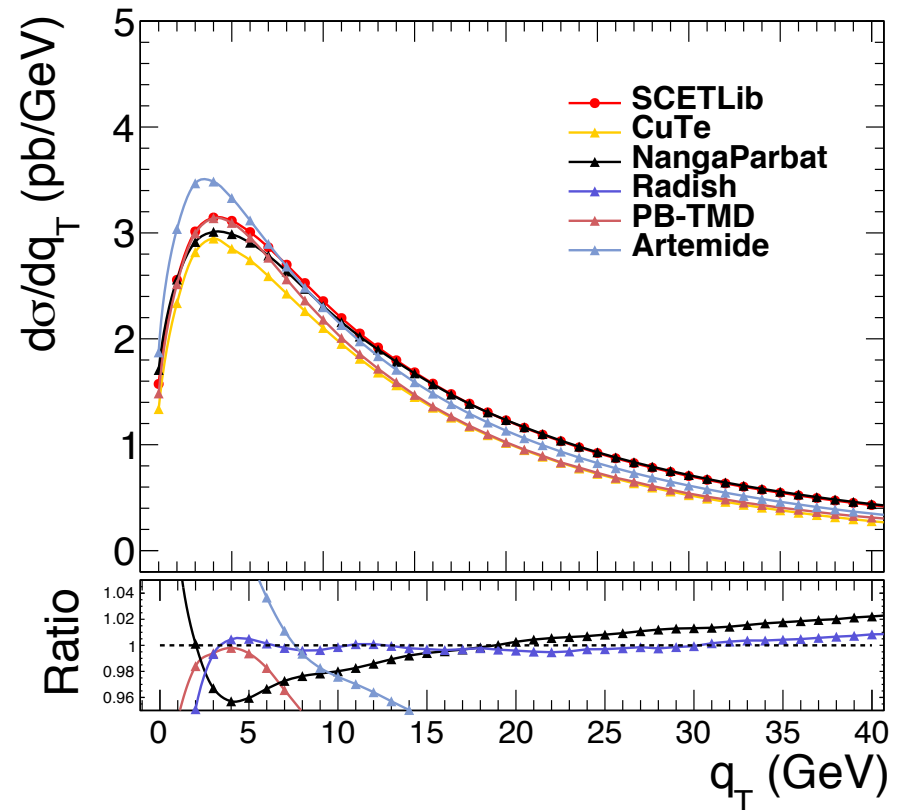
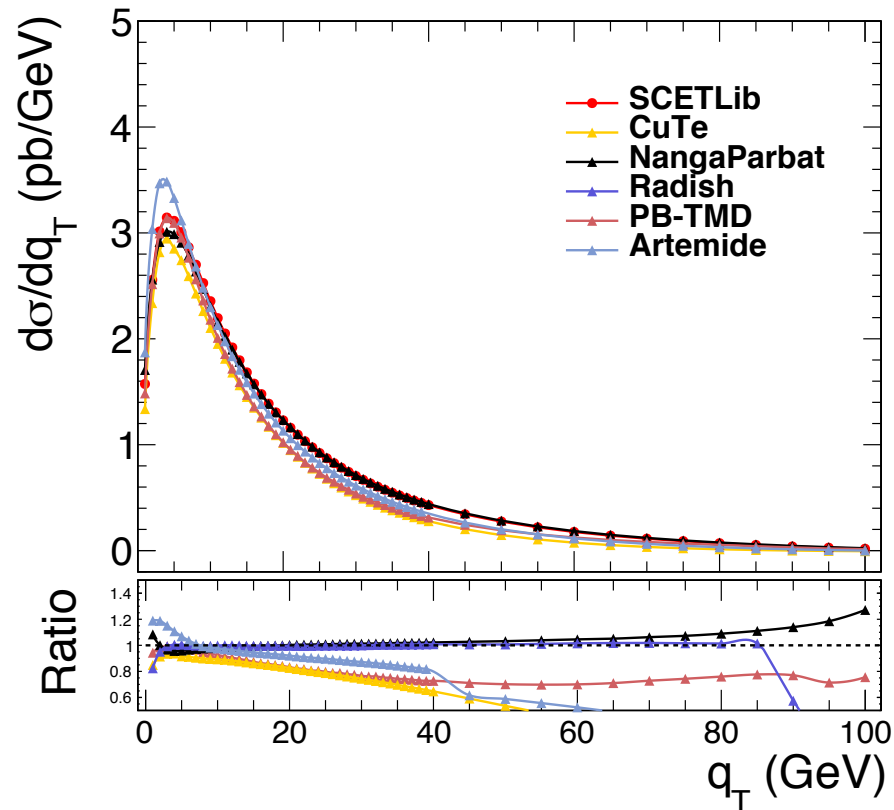
Q=MZ, Y=0, level-1, gen=5

- NNLL comparisons: SCETlib, ReSolve(NLLp), CuTe, NangaParbat, Radish, DYRES (NLLp), Artemide
- ReSolve PDF evolution is not through LHAPDF



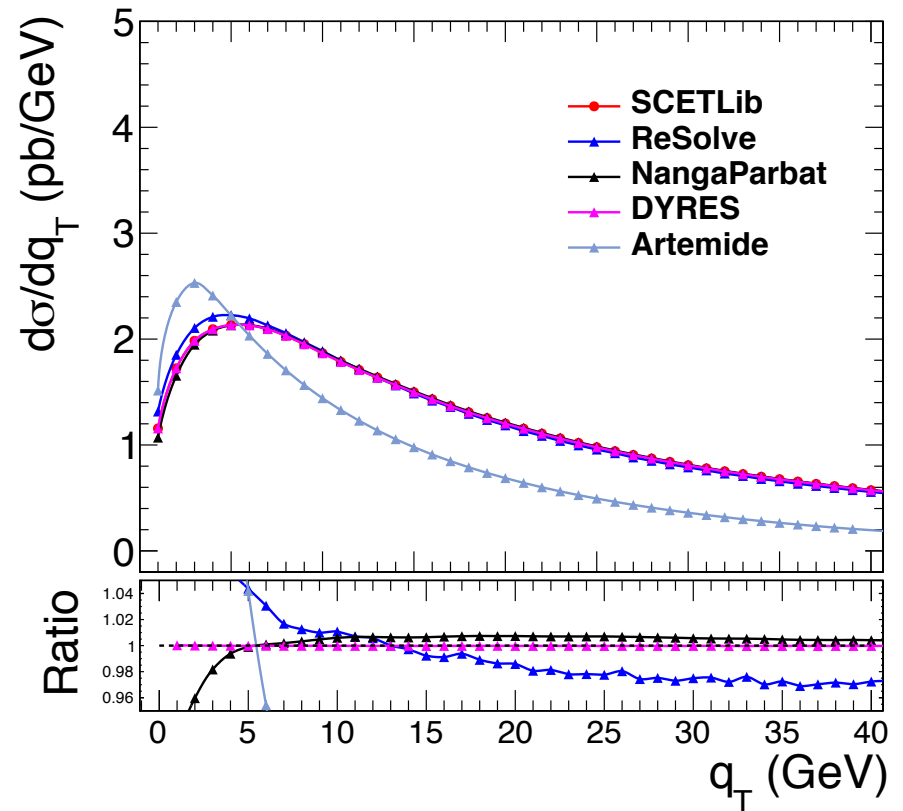
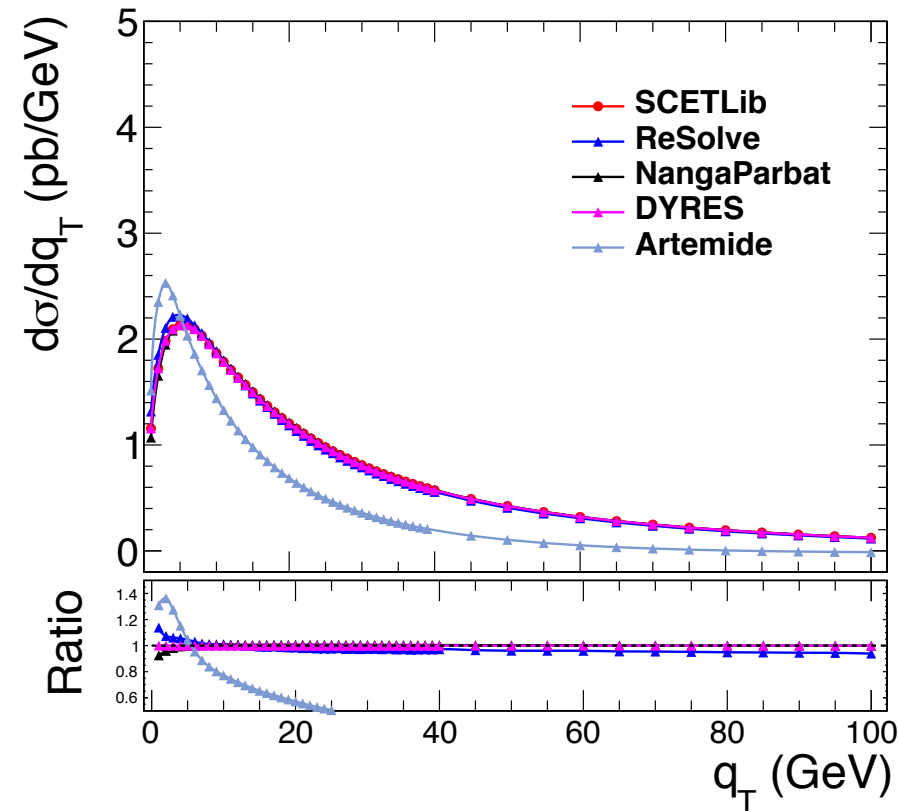
Q=MZ, Y=0, level-1, gen=5

- NLL comparisons: SCETLib, CuTe, NangaParbat, Radish, PB-TMD, Artemide
- ReSolve PDF evolution is not through LHAPDF



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

- LL comparisons: SCETLib, Resolve, NangaParbat, DYRES, Artemide
- ReSolve PDF evolution is not through LHAPDF



Next steps for inputs

- So far seems ReSolve, NangaParbat, DYRES, Radish, SCETlib are within ~1% in $q_T > 10$ GeV and $q_T < 80$ GeV region
 - Cute, Artemide, and PB-TMD show larger differences (similar trend?)
- As discussed during the last meeting please upload the other Q points for level 1
 - Q=1TeV is a must
 - Q=66, 116, and 300 GeV points as many as possible
 - For example: NangaParbat already has all the Q and Y points
- Status of inputs for level 2 benchmarking
 - ReSolve and PB-TMD have already provided

Timelines and documentation

- We agreed early this year to proceed in successive steps for the benchmarking from pure resummation benchmarking to “full resummation+fixed order (FO)” benchmarking
 - Levels 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 (matched to FO) results early next year?
 - Try to wrap up by Summer of next year!

Theory uncertainties

- Discussion by Pier during the last meeting. Here re-iterating some of the discussion points for further discussion
 - Quantify systematic uncertainties in all-order calculations
 - **perturbative**: μ_R/μ_F scales, resummation scales, (difference in *resummation method* must be encoded too)
 - **unitarity constraint**: modified logarithms, profile functions, ...
 - **matching**: matching scheme, additional damping factors
 - **Non-perturbative corrections**: cutoffs (PDFs, α_s), NP models
 - **Heavy flavours & mass thresholds**: impact of bottom quark, thresholds in α_s and DGLAP evolution
- First 3 are the main/default objective of the benchmarking exercise. 4 and 5 are desirable but we have to see if there is time
- Theory uncertainties enter at L2 and L3. Of course provided that the differences in central values at L1 are understood

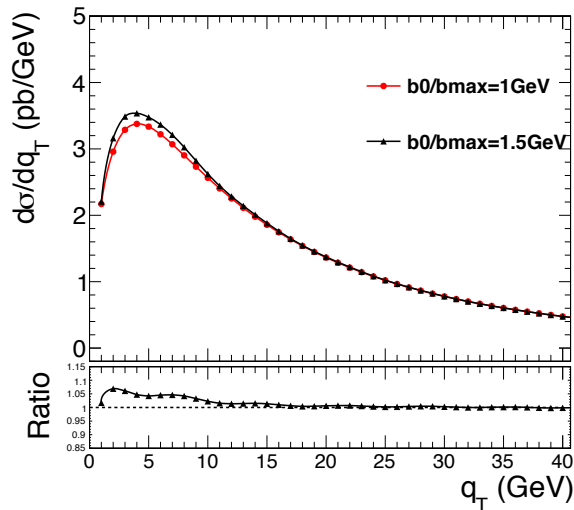
The objective

- The benchmarking exercise and W mass measurement
 - We benchmark Z, W, and W/Z ratio analytic resummed predictions
 - Has never been done before and there is already much to be learned
- Detailed study of how each of the uncertainty sources defined above impacts the W/Z ratio
- Final Goal: a list of uncertainties > what must be improved in the future
- As discussed during the last meeting the modeling of the correlations of the uncertainties in the pT W/Z ratio is outside of the scope of this first benchmarking result and documentation
 - This will be studied beyond Summer of 2020 within the LHC EW group

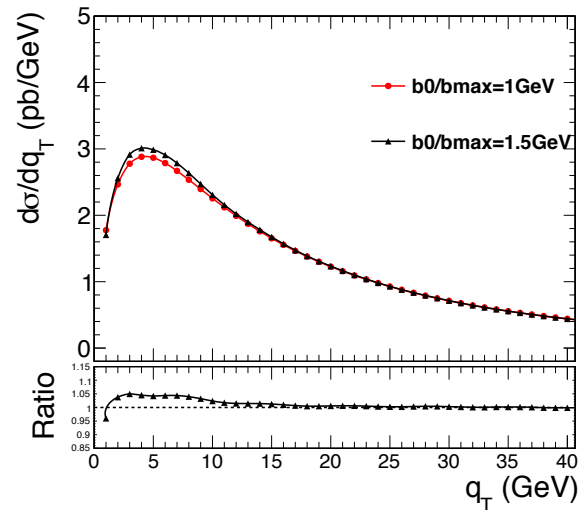
Non-perturbative cutoff

- NangaParbat had 1.65 GeV cut-off last round and has updated to 1.0 GeV
 - ~5% effect below 10GeV. What is happening with LL?

NNNLL



NLL



LL

