

reSolve Update – 24/04/2020

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LHC EW precision resummation benchmarking sub-meeting 24th April 2020

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Quick Update on reSolve results

- reSolve results available for level 1 canonical logs resummation at $Q=mZ$ inclusive γ , $\gamma=0$, $\gamma=2.4$ at LL, NLL', NNLL' in q_T and $\log q_T$ (as before).
- **reSolve results available for level 2 nominal logs resummation (central scales) at $Q=mZ$ inclusive γ , $\gamma=0$, $\gamma=2.4$ at LL, NLL', NNLL' in q_T and $\log q_T$ (as before).**
- **reSolve results for $Q=1\text{TeV}$ $\gamma=0$ at LL, NLL', NNLL' available, canonical and nominal (central scales).**
- reSolve result investigating effect of changing b_{lim} available (canonical NNLL', $Q=mZ$, $\gamma=0$).
- reSolve results for changing the resummation scale available for canonical vs nominal comparison ($Q=mZ$ and $Q=1\text{TeV}$, $\gamma=0$ at LL, NLL', NNLL') as before.
- reSolve results for ratios of different Q and γ results available as before.
- **reSolve step-by-step level 1 -> level 2 changes now available.**
- **reSolve scale variation results available for $Q=mZ$ $\gamma=0$ and $Q=1\text{TeV}$, $\gamma = 0$ at NNLL'.**

Preliminary!

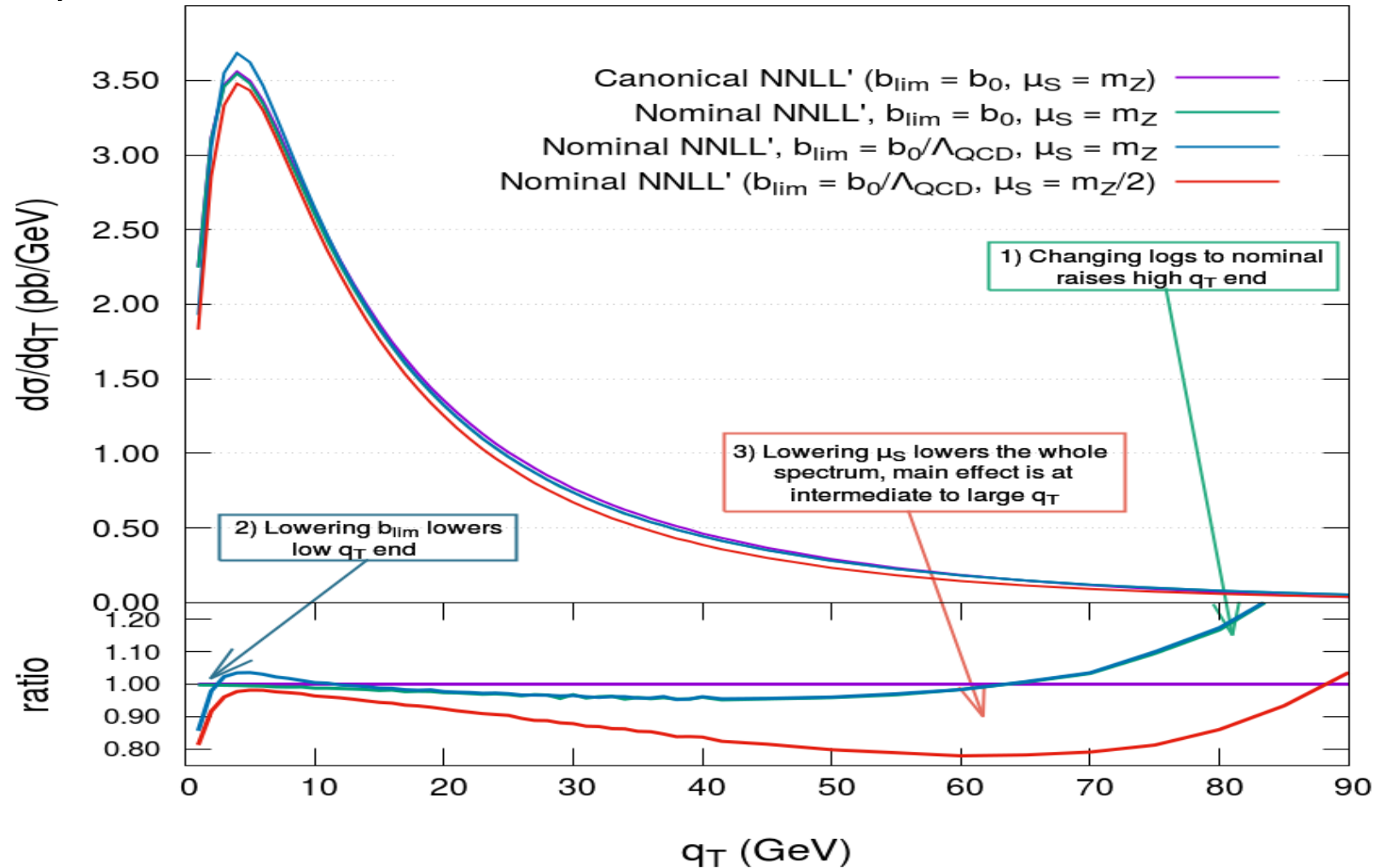
reSolve level 1 -> level 2 changes

- Changes in reSolve implementation between levels 1 and 2:

- changes**
1. **Canonical Logs -> Nominal Logs**: $\log\left(\frac{\mu_S^2 b^2}{b_0^2} + 1\right)$ - affects high q_T tail.
 2. **b* prescription -> b_{lim}** altered so freezes out at higher b, i.e. lower q_T closer to Landau pole – affects low q_T around peak:
$$b_{lim} = b_0 \exp\left(\frac{1}{2\alpha_s \beta_0}\right) \rightarrow b_{lim} \sim 1/\Lambda_{QCD}$$
 3. **Resummation scale** change -> typically use $\mu_s = m_Z/2$ as signals divide between resummed form factor and b-independent piece – affects whole spectrum, mainly intermediate q_T .
- not changed**
4. No change made to **non-perturbative form factor (\mathcal{S}_{NP})**, so still set to $\mathcal{S}_{NP} = 1$ – i.e. Gaussian smearing coefficient set to 0.
 5. No **further suppression of intermediate/high q_T** beyond modified logs, i.e. no transition or profile functions.
 6. No **Counter-term** included, just the pure resummed piece.

reSolve level 1 -> level 2 step by step changes

- $Q=m_Z, \gamma=0$ NNLL':

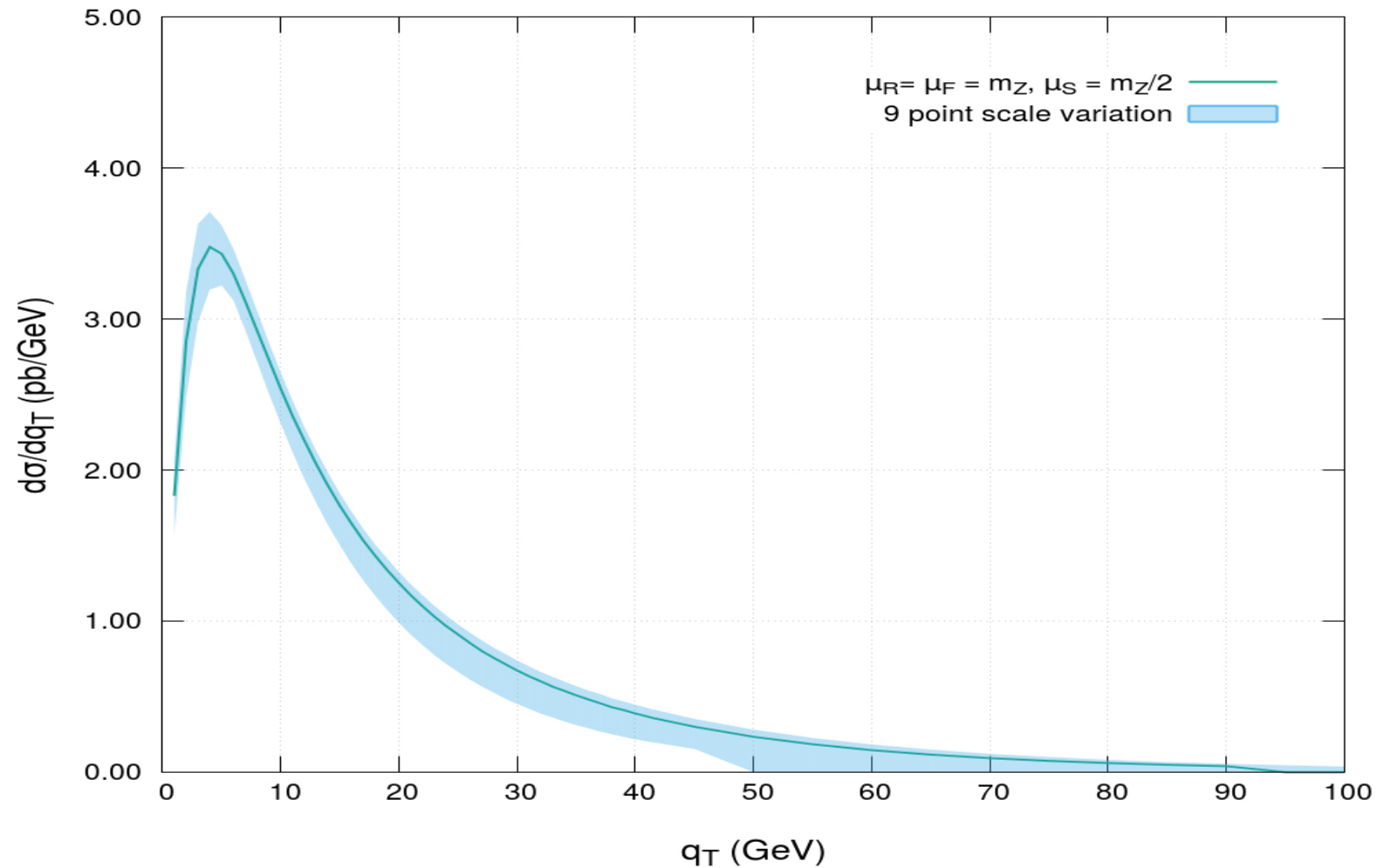


reSolve scale variation

- Perform a **9-point scale variation** varying renormalisation (μ_R), factorisation (μ_F) and resummation (μ_S) scales relative to their default scales ($m_Z, m_Z, m_Z / 2$) by the following factors:
- **(μ_R, μ_F, μ_S)**: (0.5, 0.5, 1), (0.5, 1, 1), (1, 0.5, 1), (1, 1, 0.5), (1, 1, 1), (2, 1, 1), (1, 2, 1), (2, 2, 1), (1,1,2).
- Performed so far for $Q = m_Z$ $y=0$ and $Q=1\text{TeV}$ $y=0$ NNLL' results **(preliminary)**.
- Unfortunately issues with UCL system currently so no further results beyond that (other y values or other invariant masses) produced yet.

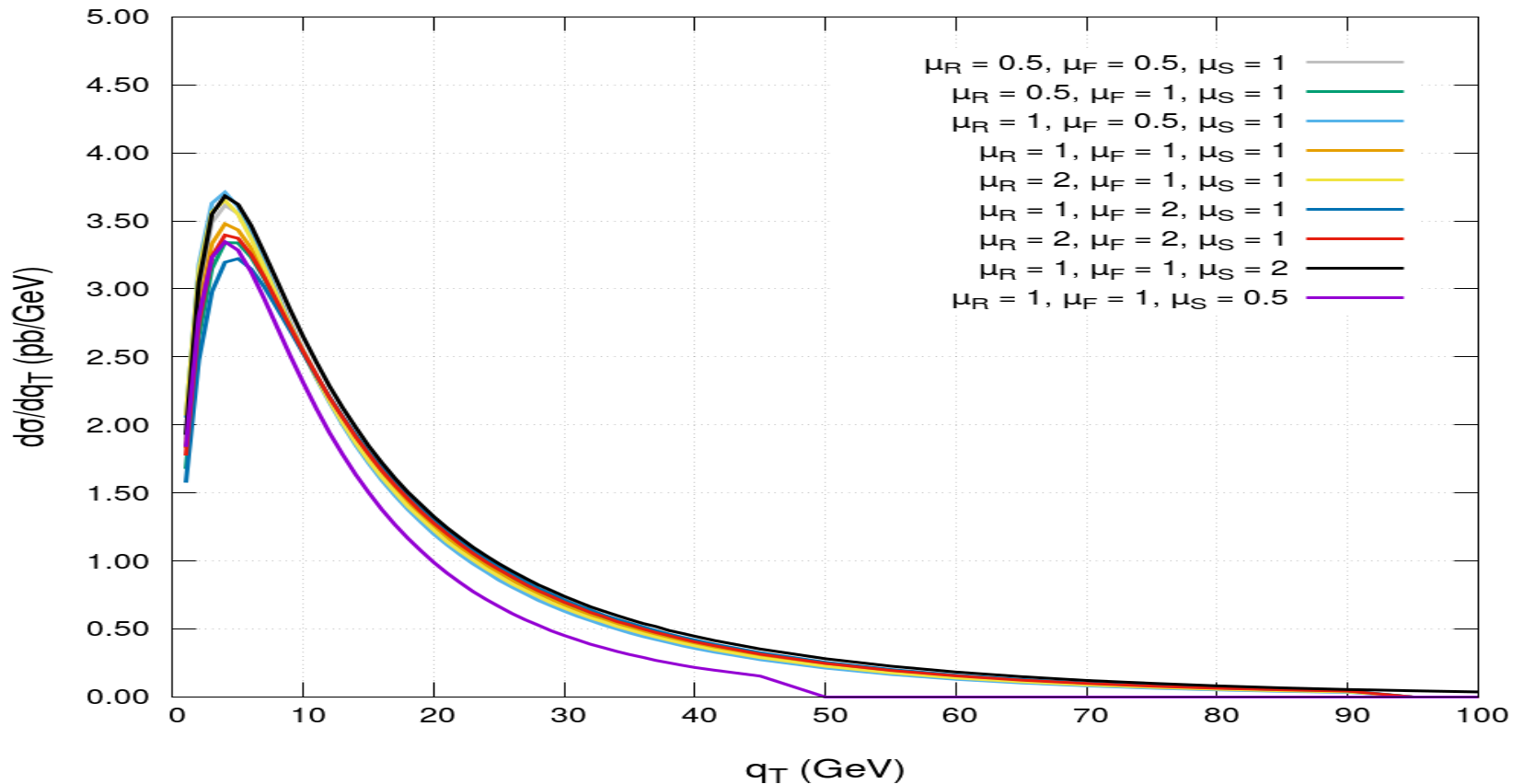
Level 2 results with scale variation bands

- $Q=m_Z, \gamma=0$, NNLL' nominal results at level 2 with scale variation (**preliminary**):



Level 2 results all scale variation lines

- $Q=mZ, \gamma=0$, NNLL' nominal results at level 2 with scale variation (**preliminary**):

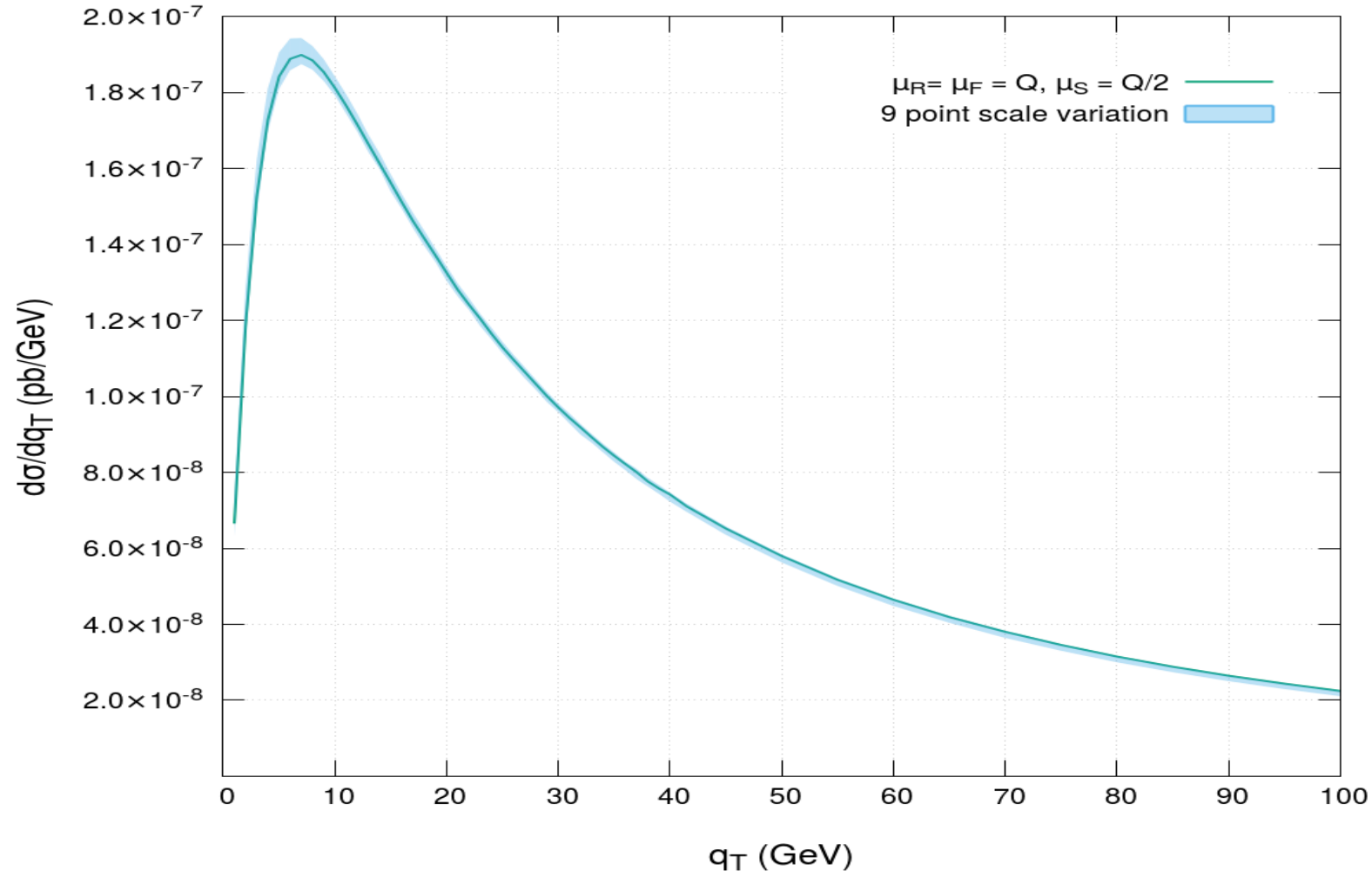


Resummation scale μ_S is dominant variation outside peak

-> variation down too large beyond small q_T , would be balanced by counter term in matching.

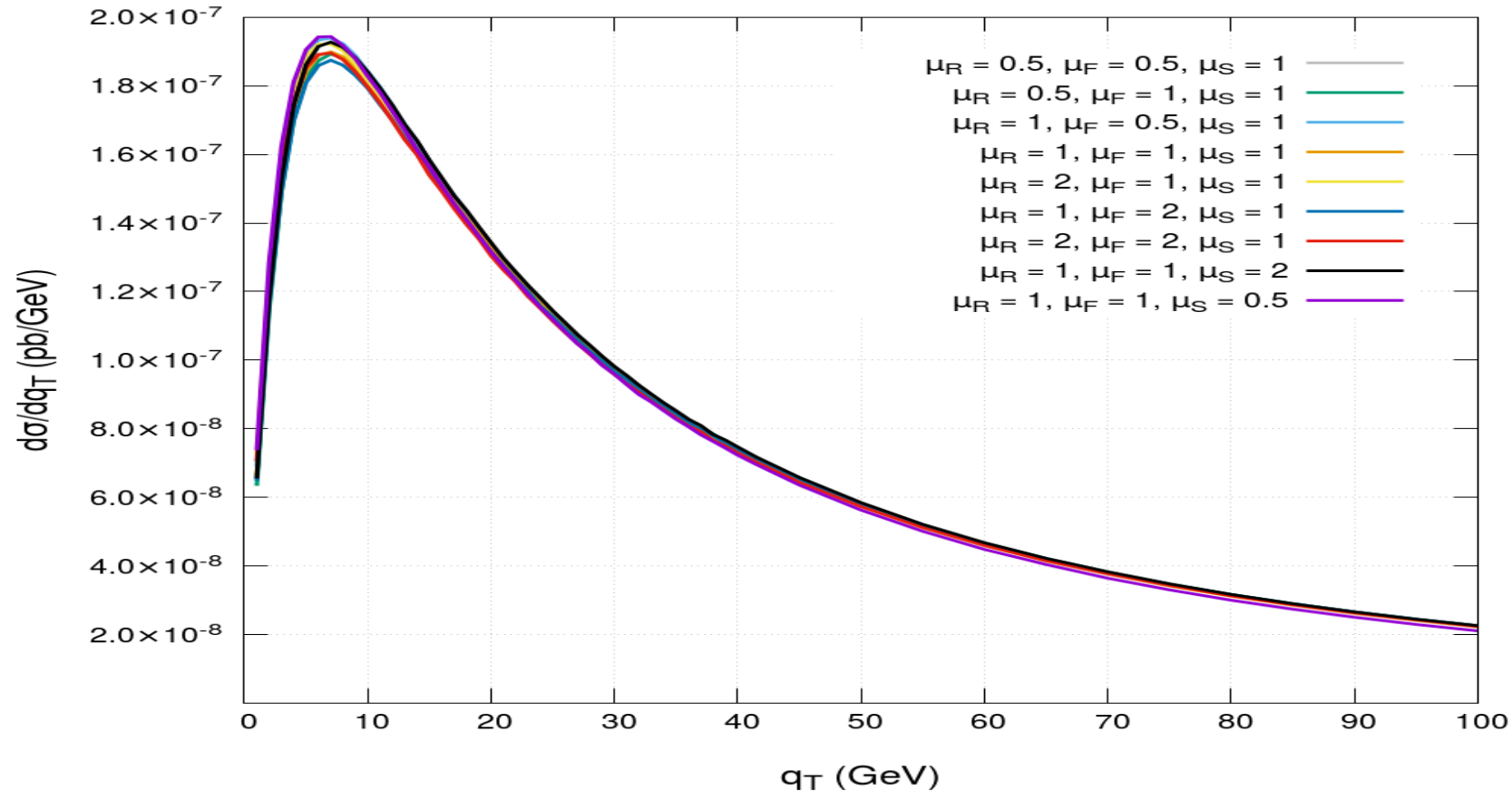
Level 2 results with scale variation bands

- $Q=1\text{TeV}$, $\gamma=0$, NNLL' nominal results at level 2 with scale variation (**preliminary**):



Level 2 results all scale variation lines

- $Q=1\text{TeV}$, $\gamma=0$, NNLL' nominal results at level 2 with scale variation (**preliminary**):



Much smaller resummation scale variation as q_T is a smaller fraction of Q so only resummed piece needed, no counter term required to remove any remnant resummation scale variation.

Next steps....

- As soon as I can access and run on the UCL system again...
- Check and confirm presented results, run longer runs for these (will then upload to git repository).
- Run LL and NLL' results to complete $Q = m_Z, 1 \text{ TeV}$ results at $y = 0$.
- Run further points in rapidity: $y = 2.4$ at least, also inclusive y probably.
- Compare with other codes to analyse and understand differences.
- Hopefully most of this will be available for next meeting. *

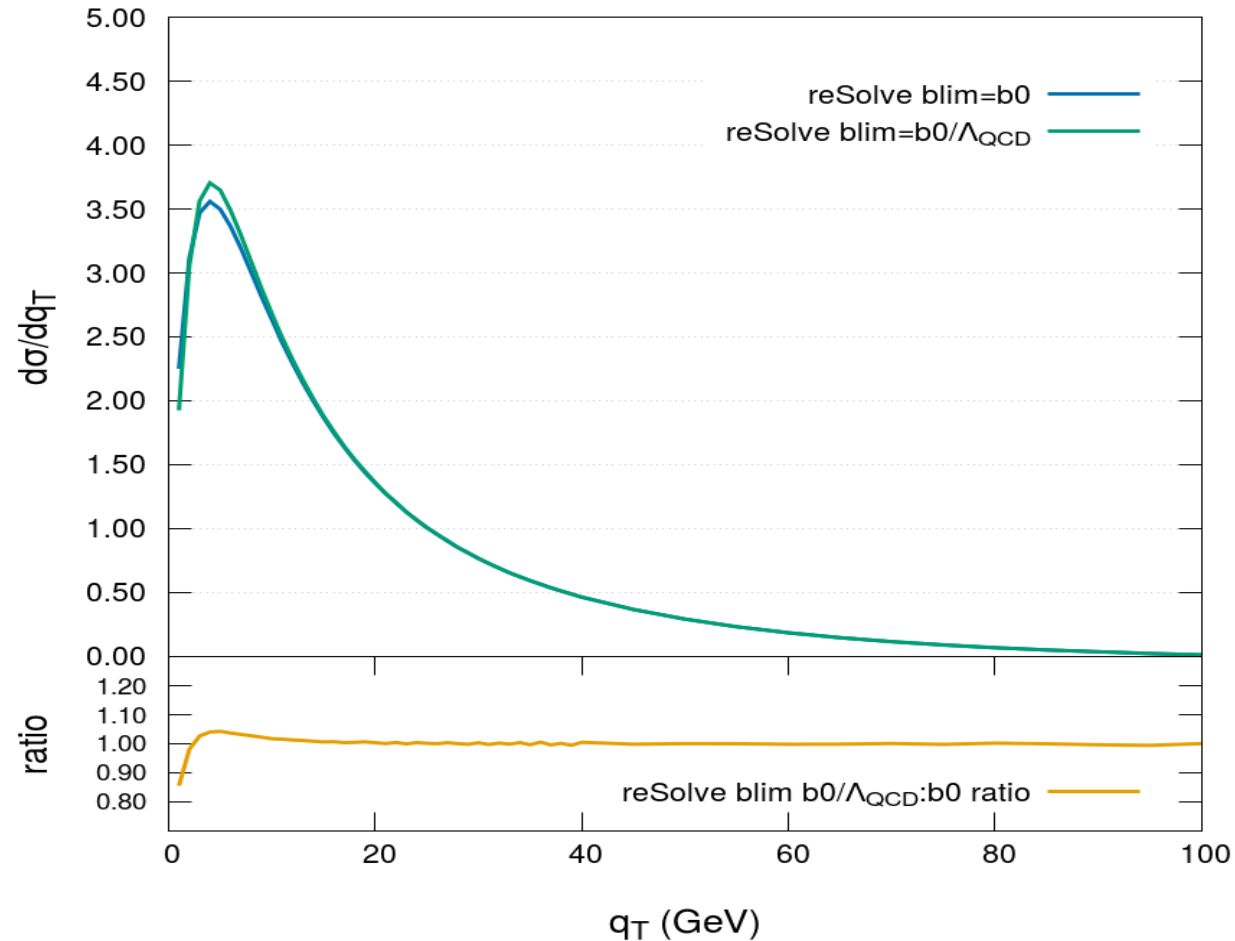
* (computing access dependent!)



Backup Slides

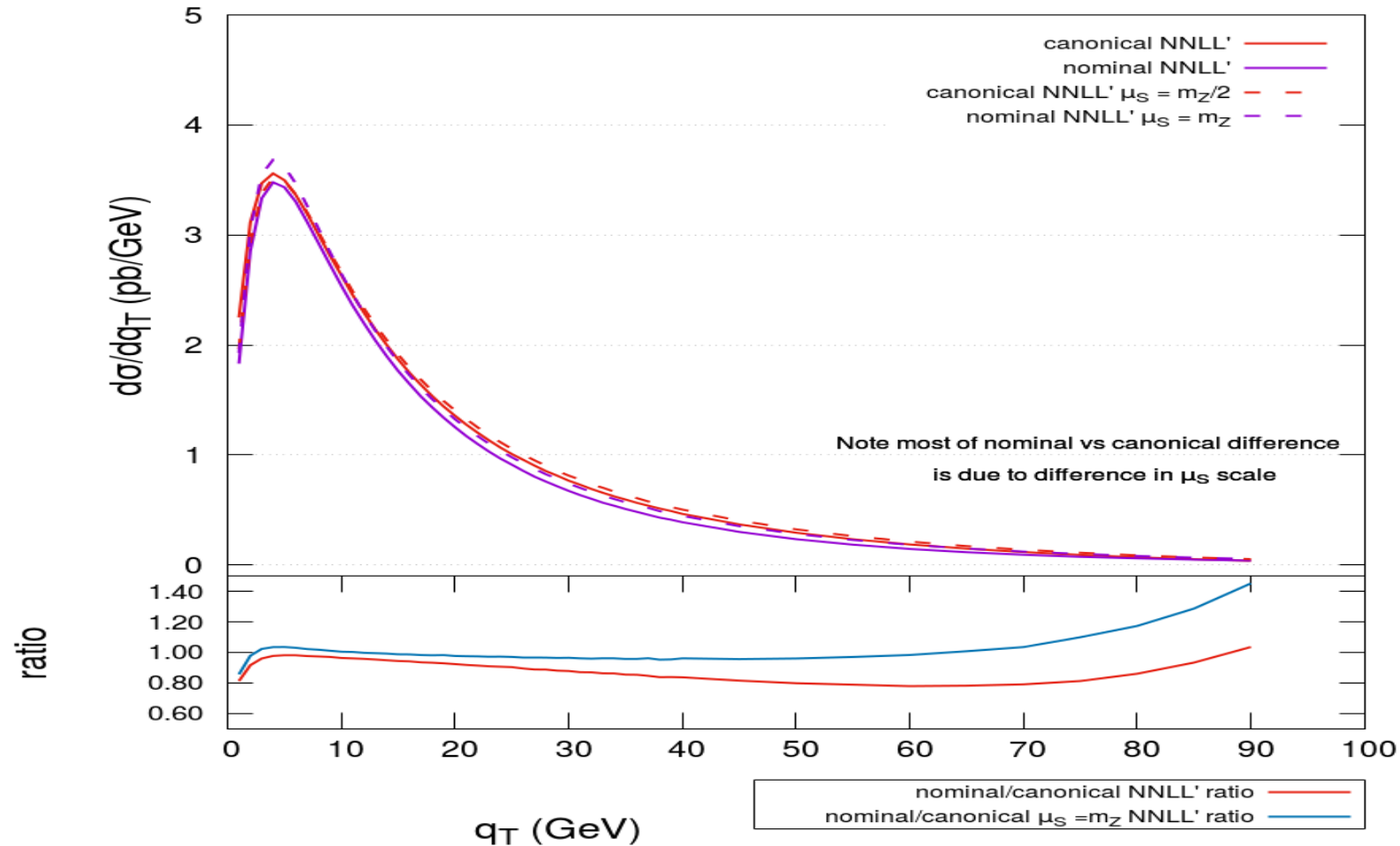
Reminder – effect of b_{lim}

- Canonical (level 1) $Q = m_Z, y = 0$ NNLL':



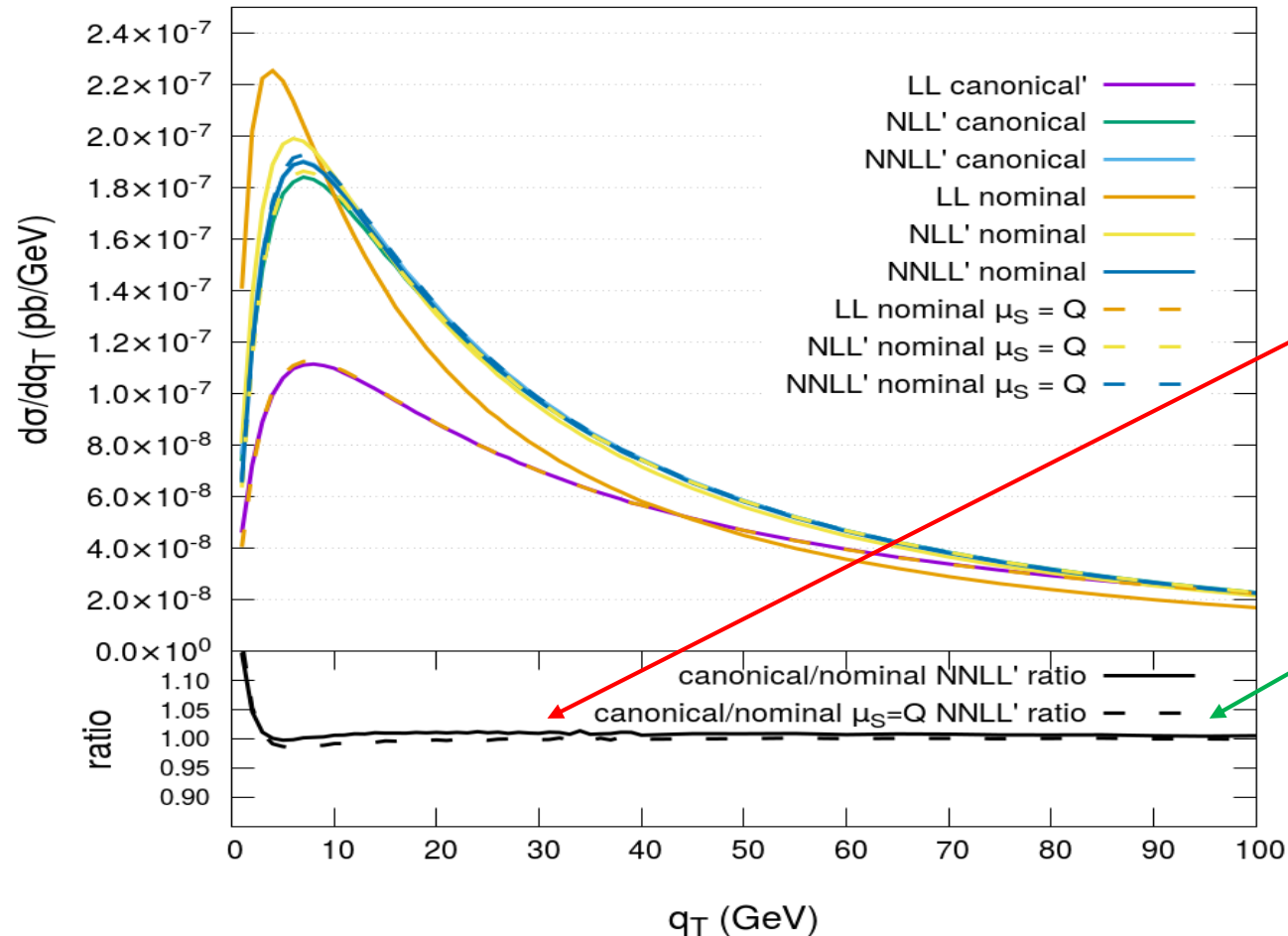
Reminder – resummation scale main difference

- Canonical (level 1) $Q = m_Z, y = 0$ NNLL':



Reminder – Less μ_s variation at $Q=1\text{TeV}$

- Canonical (level 1) $Q = 1\text{TeV}, y = 0$ NNLL':

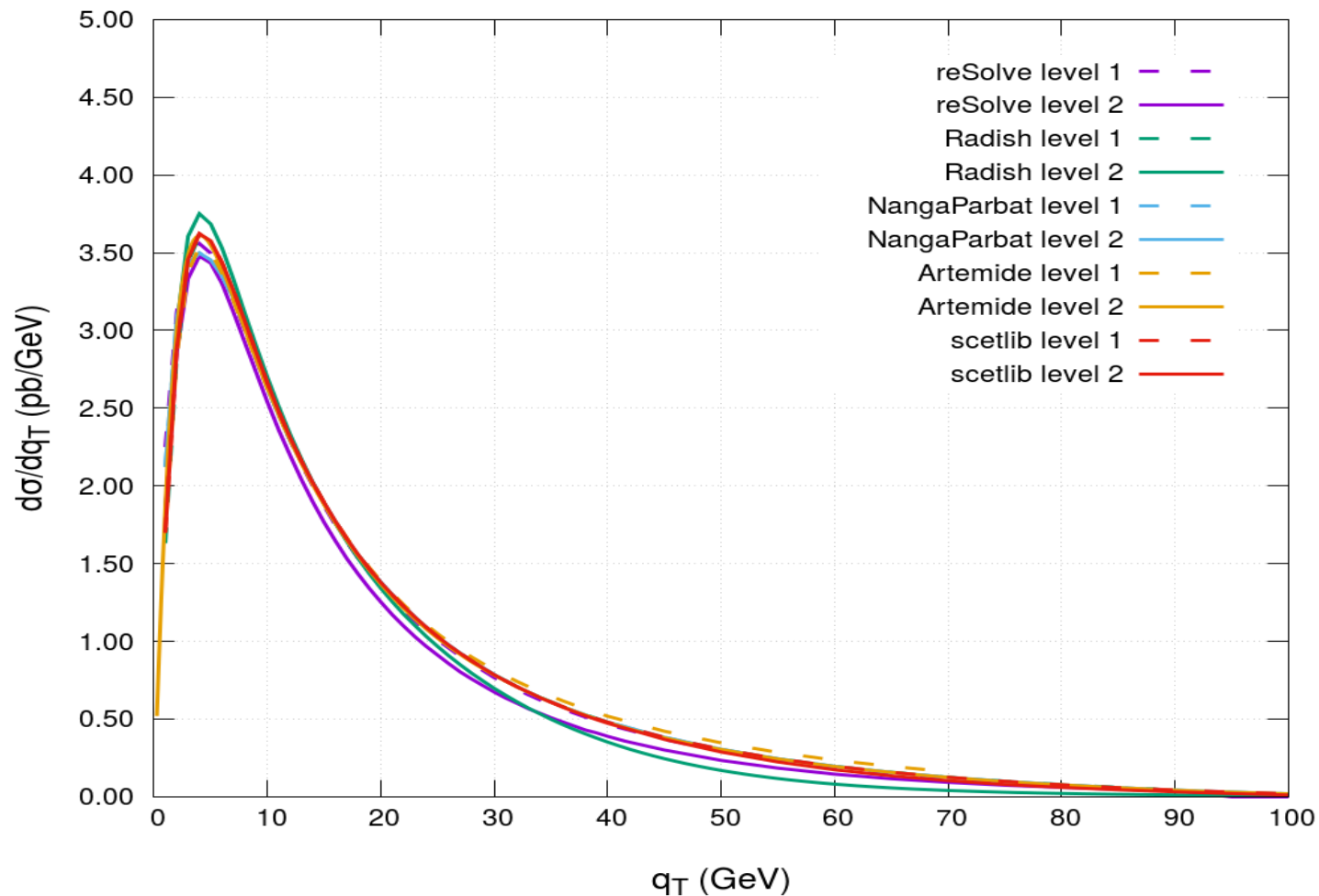


Less μ_s variation
at higher $Q=1\text{TeV}$
than $Q = m_Z$

Little difference
of modified logs
yet visible at
 $q_T = 100\text{GeV}$.

Comparison of results level 1 and level 2

- Level 1 vs Level 2 results so far for $Q = m_Z, y = 0$ NNLL' for codes that have provided them (no scale variation):



Preliminary!