V+jet at NNLO

Frank Petriello

QCD, EW and Tools at 100 TeV

October 8, 2015

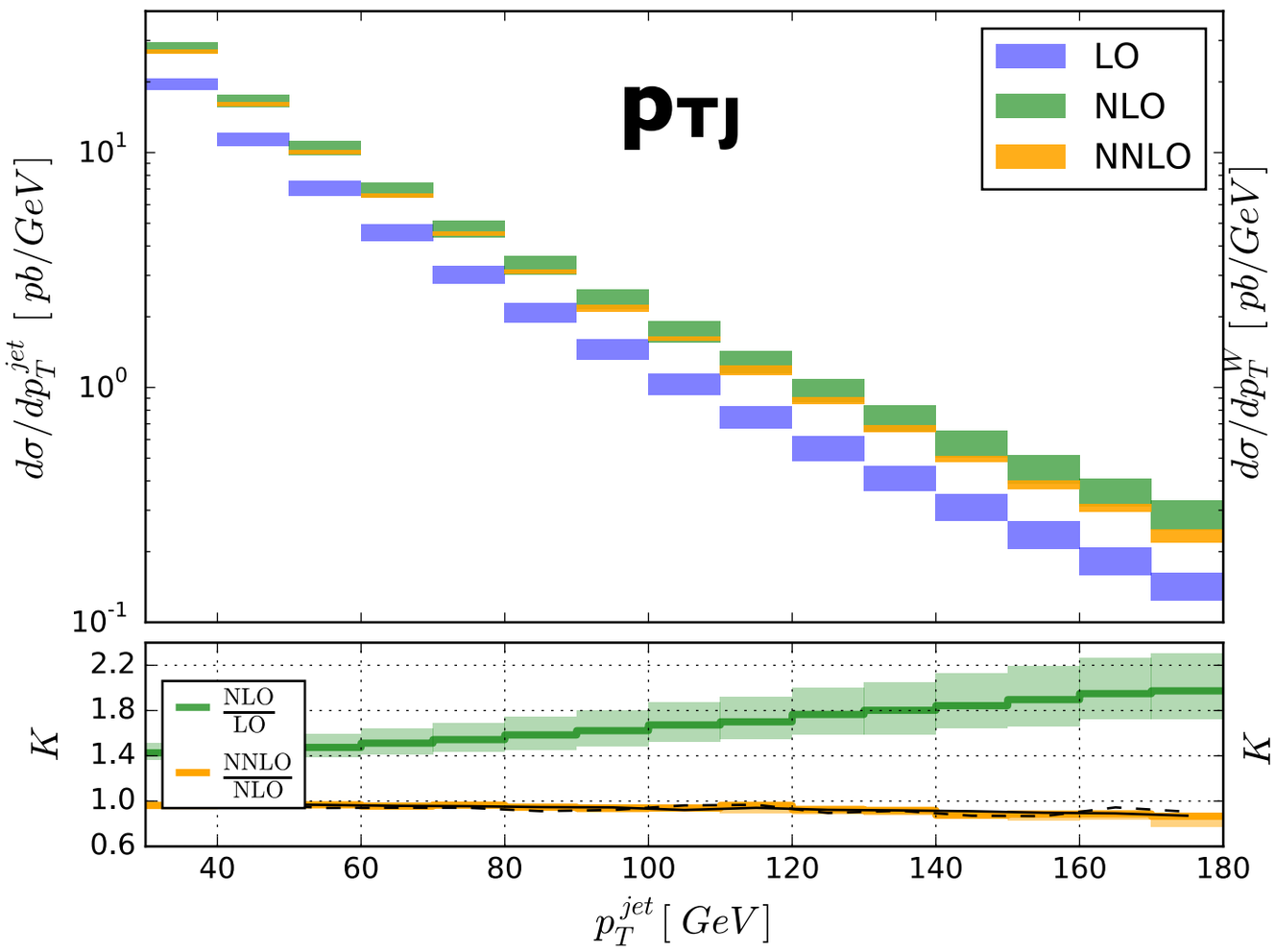
Outline

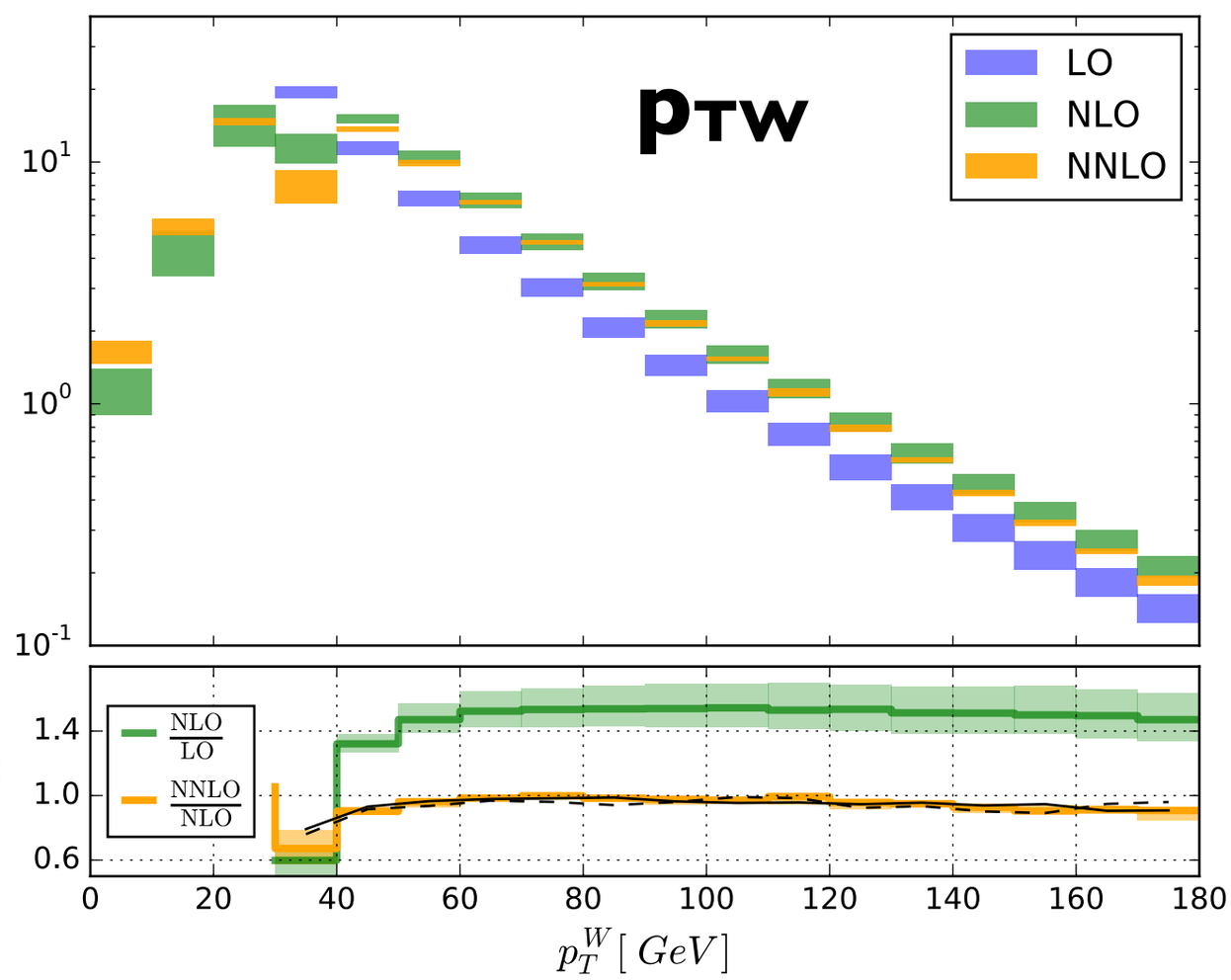
- Review of Wj phenomenology at 8 TeV
- Wj phenomenology at 100 TeV
- All Wj@NNLO results based on the following calculation:
  1504.021131 (Boughezal, Focke, Liu, FP)
- Comparison of exact NNLO with LoopSim (preliminary)

(in collaboration with Daniel Maître)

Phenomenology at 8 TeV

- Results are for CT14 PDFs, central scale $\mu=M_W$, estimate error with a factor-of-2 variation around this central scale

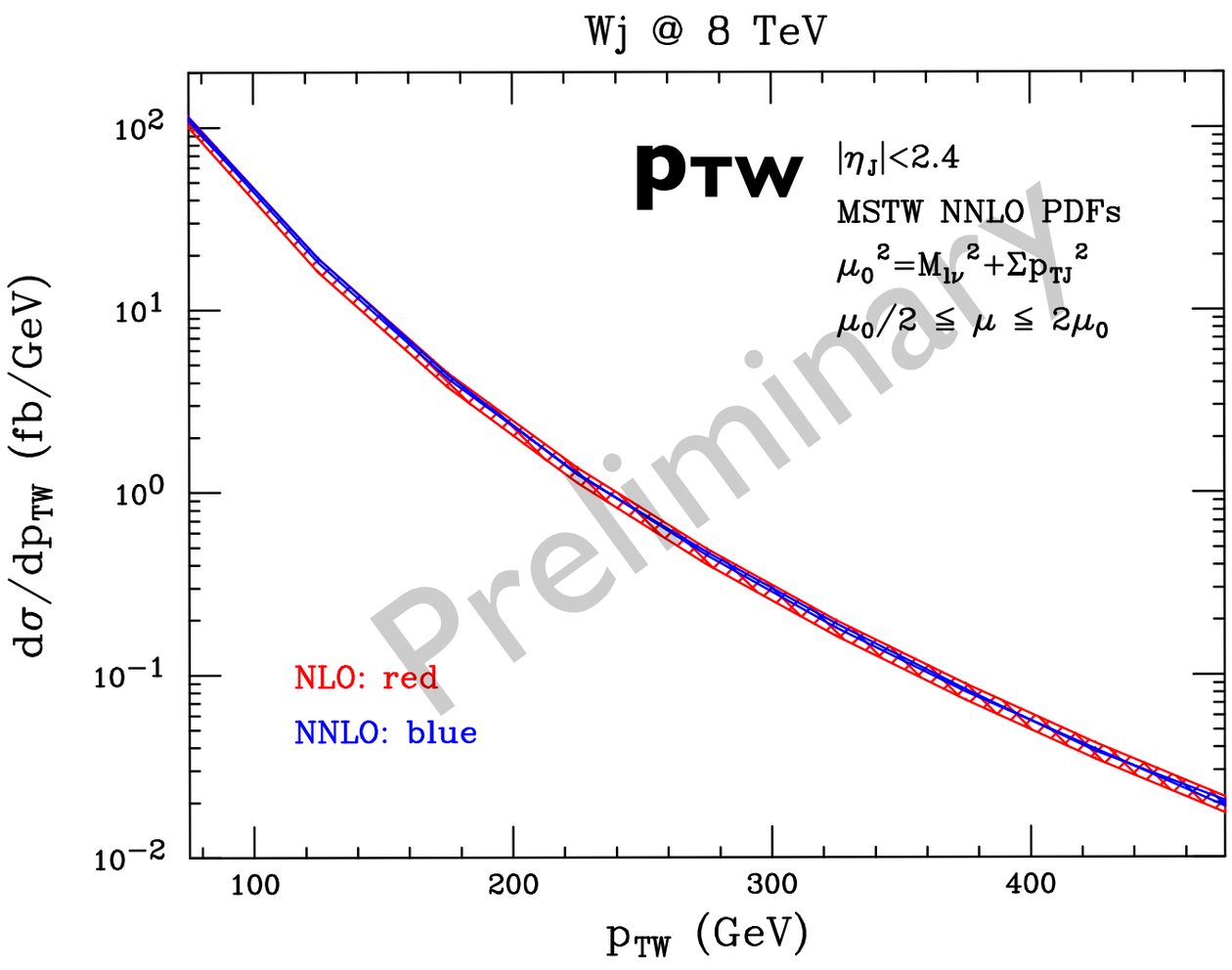


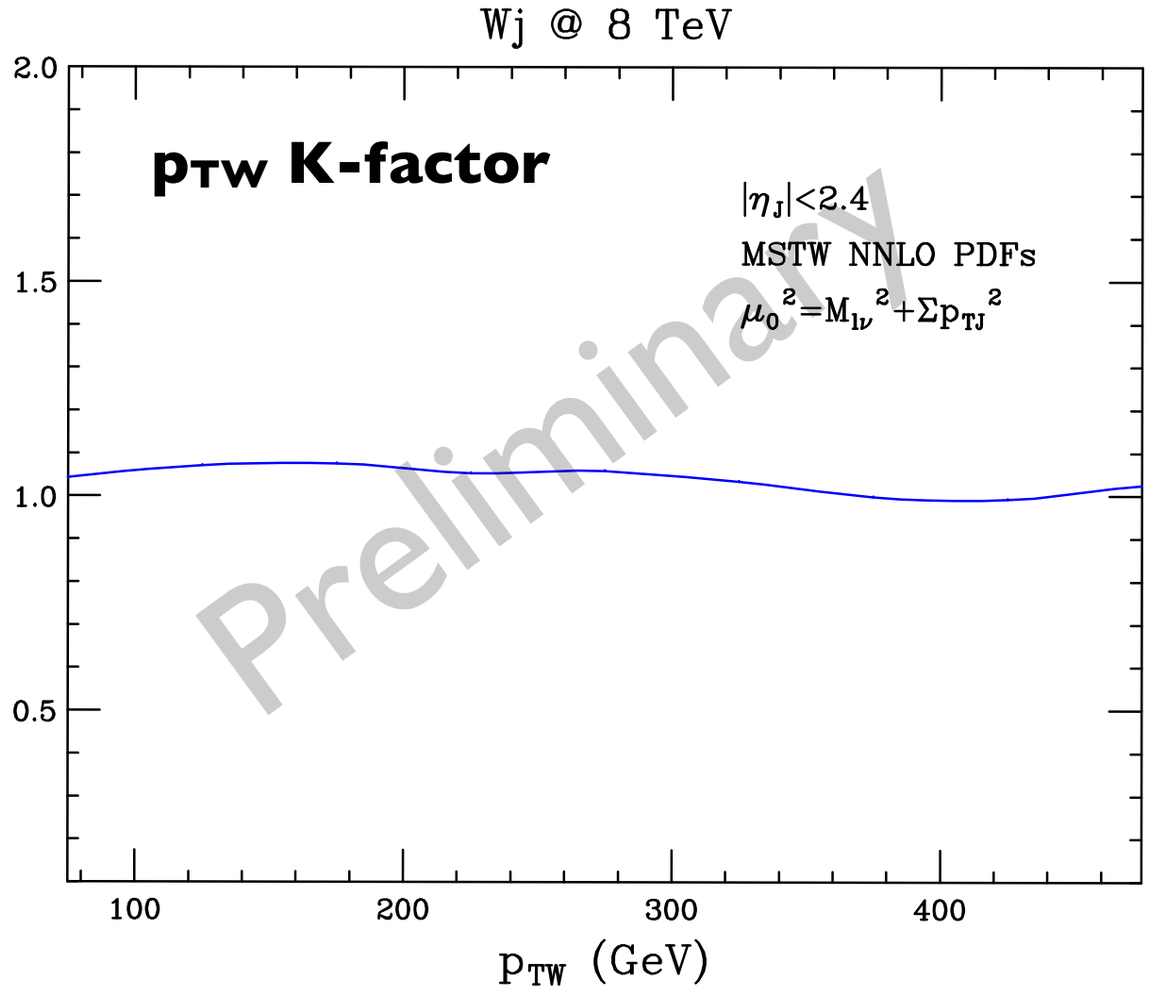


- NLO corrections large: 40% ranging to 80% for p_{TJ}<180 GeV with a dependence on p_{TJ}, 40% for p_{TW}<180 GeV
- NNLO corrections are ~1% with little dependence on kinematics

Phenomenology at 8 TeV: p_{TW}

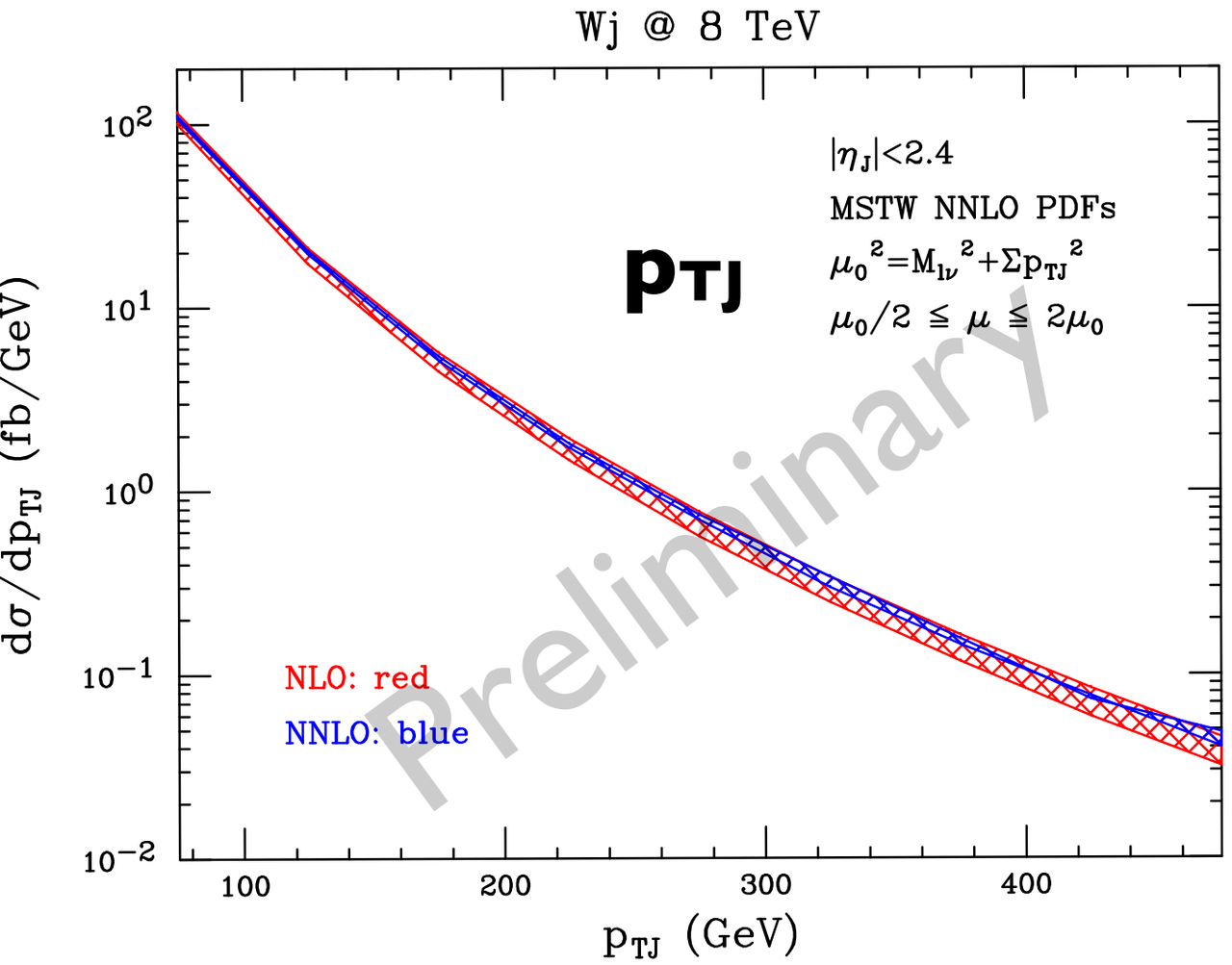
- How do the perturbative corrections change when an extended kinematic range is studied? Switch to a dynamical scale $\mu^2=M_{lv}^2+\sum p_{TJ}^2$

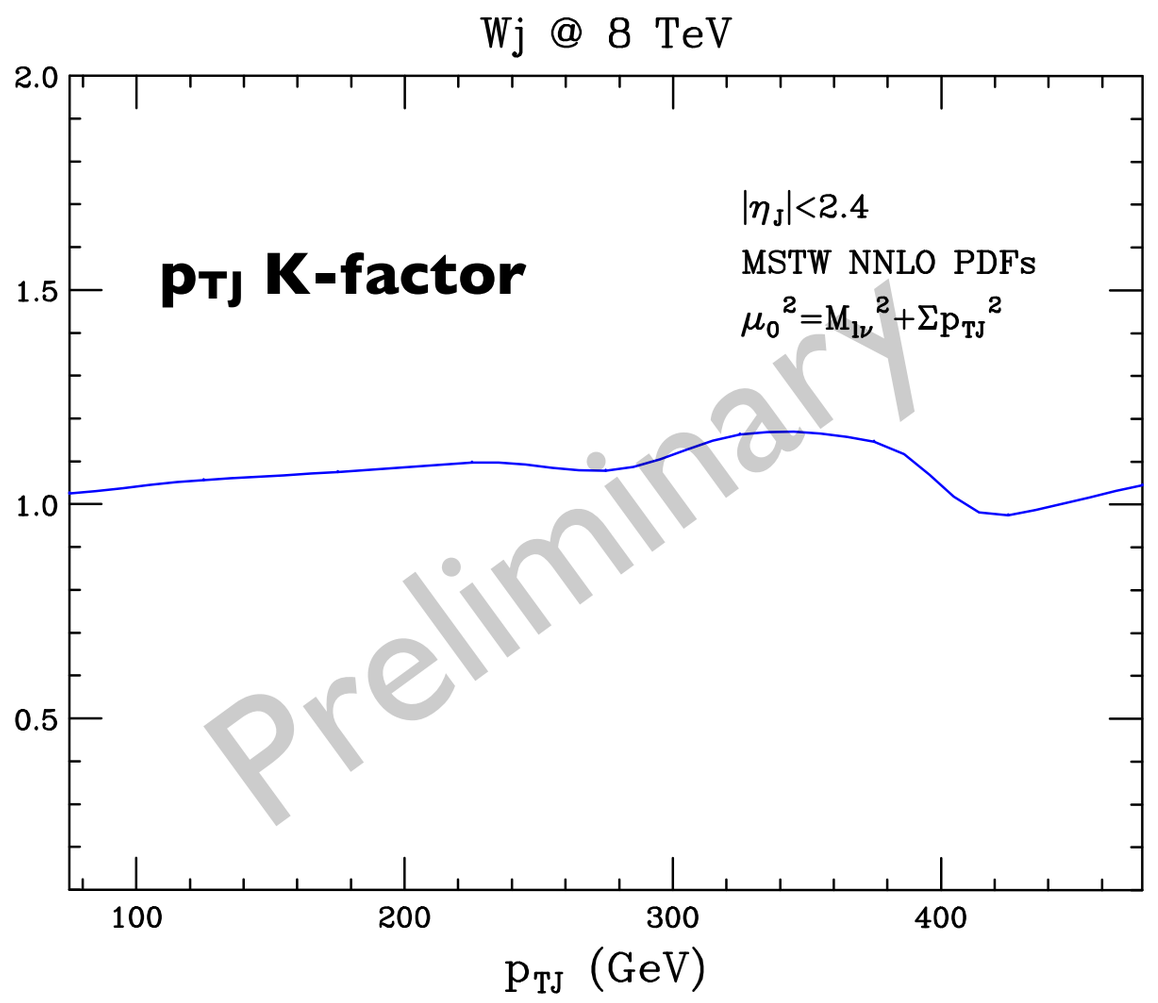




- NNLO corrections to the p_{TW} distribution remain small, ~few percent, over the entire studied range

Phenomenology at 8 TeV: p_{TJ}

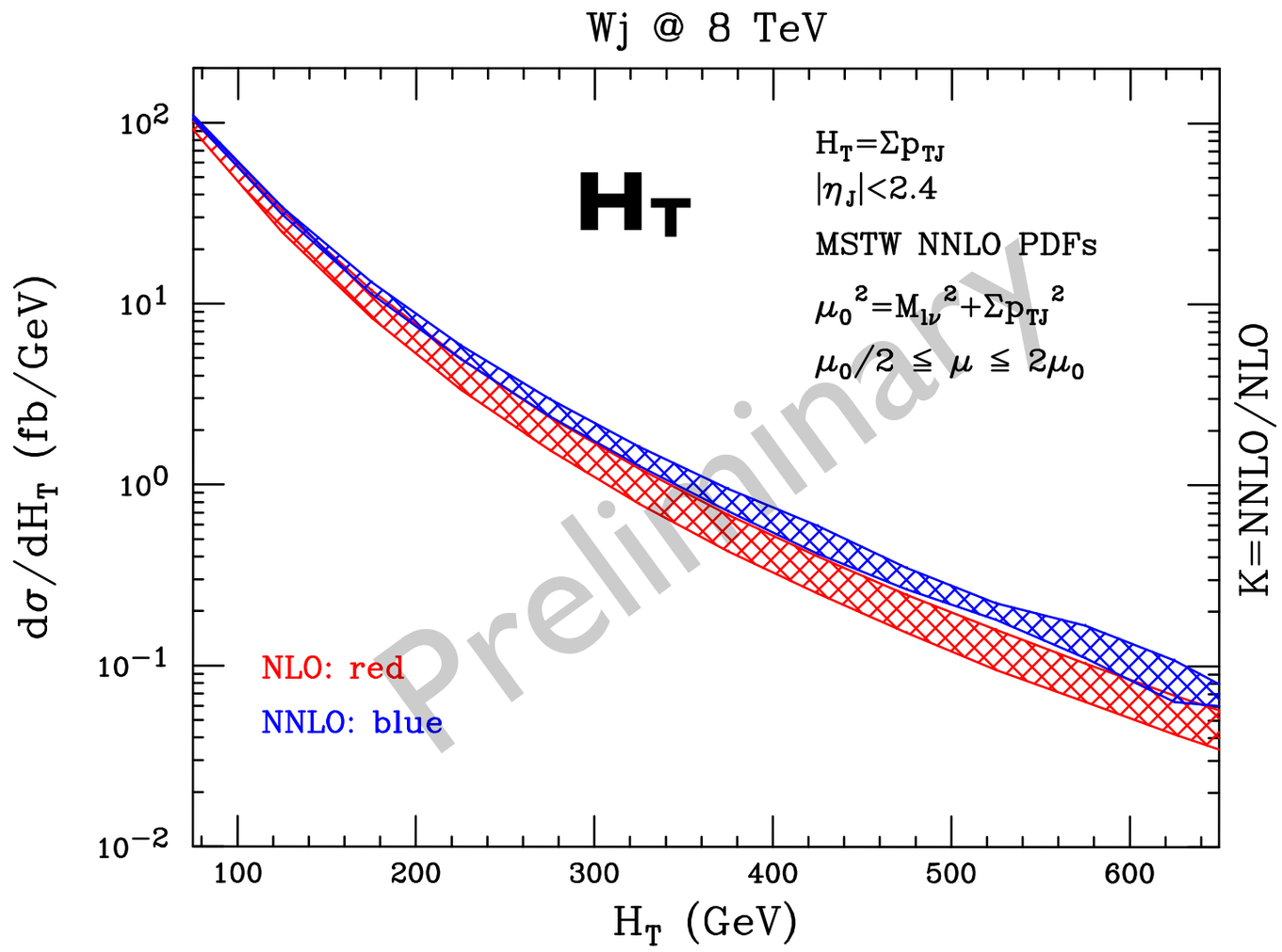


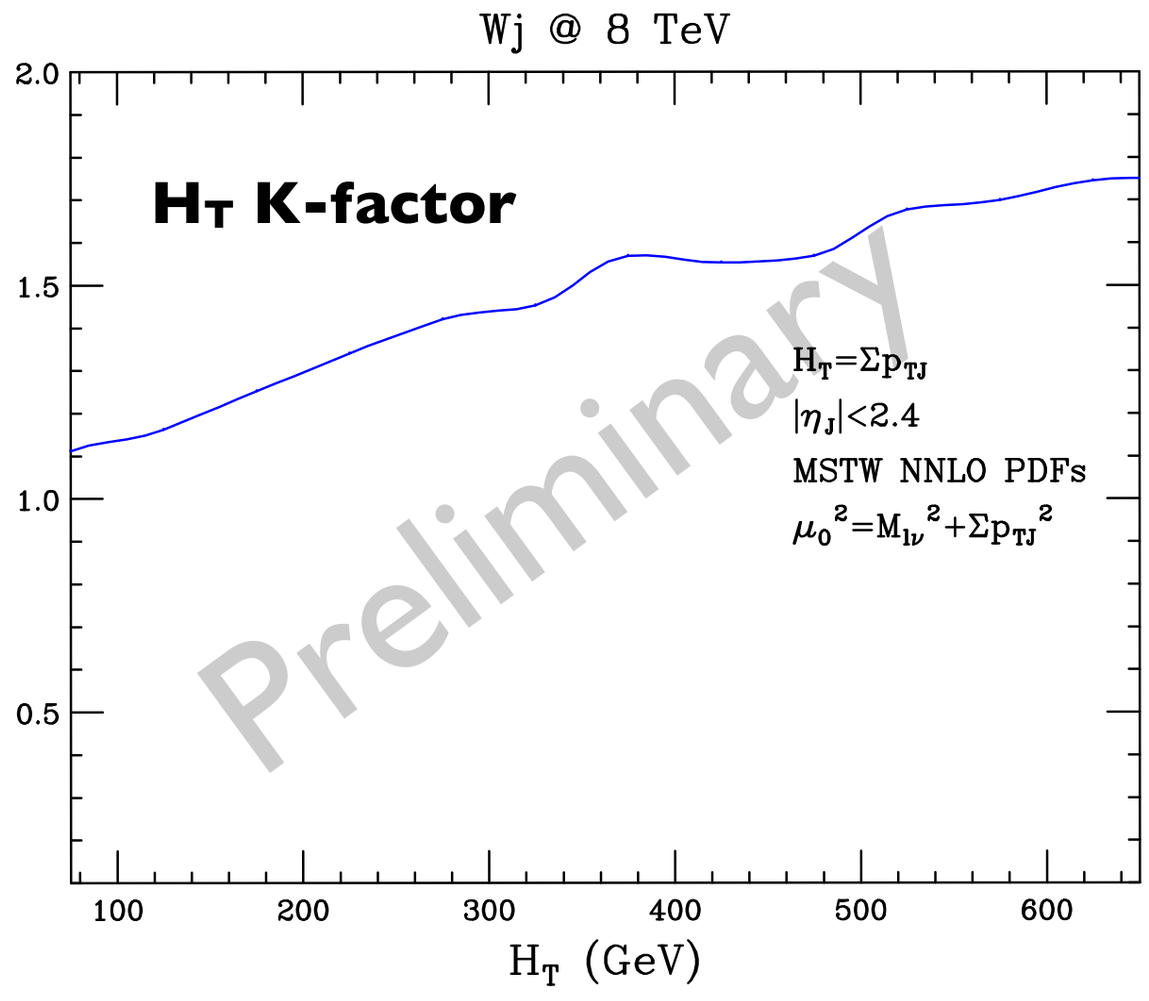


- NNLO corrections are again small for the p_{TJ} distribution over the entire studied range; slight rise for higher p_{TJ}

Phenomenology at 8 TeV: H_T

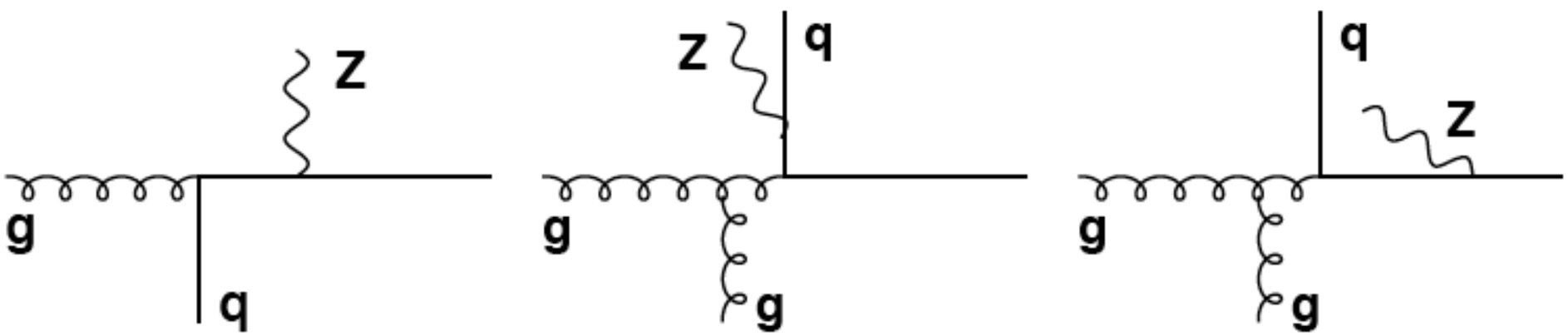
- Define $H_T=\sum p_{TJ}$. Larger corrections to this distribution; K-factor rises above 1.75 for H_T>600 GeV





Giant K-factors and LoopSim

- The origin of these large corrections to the H_T distribution have been discussed in the literature (for example, see Salam, Rubin, Sapeta 1006.2144)

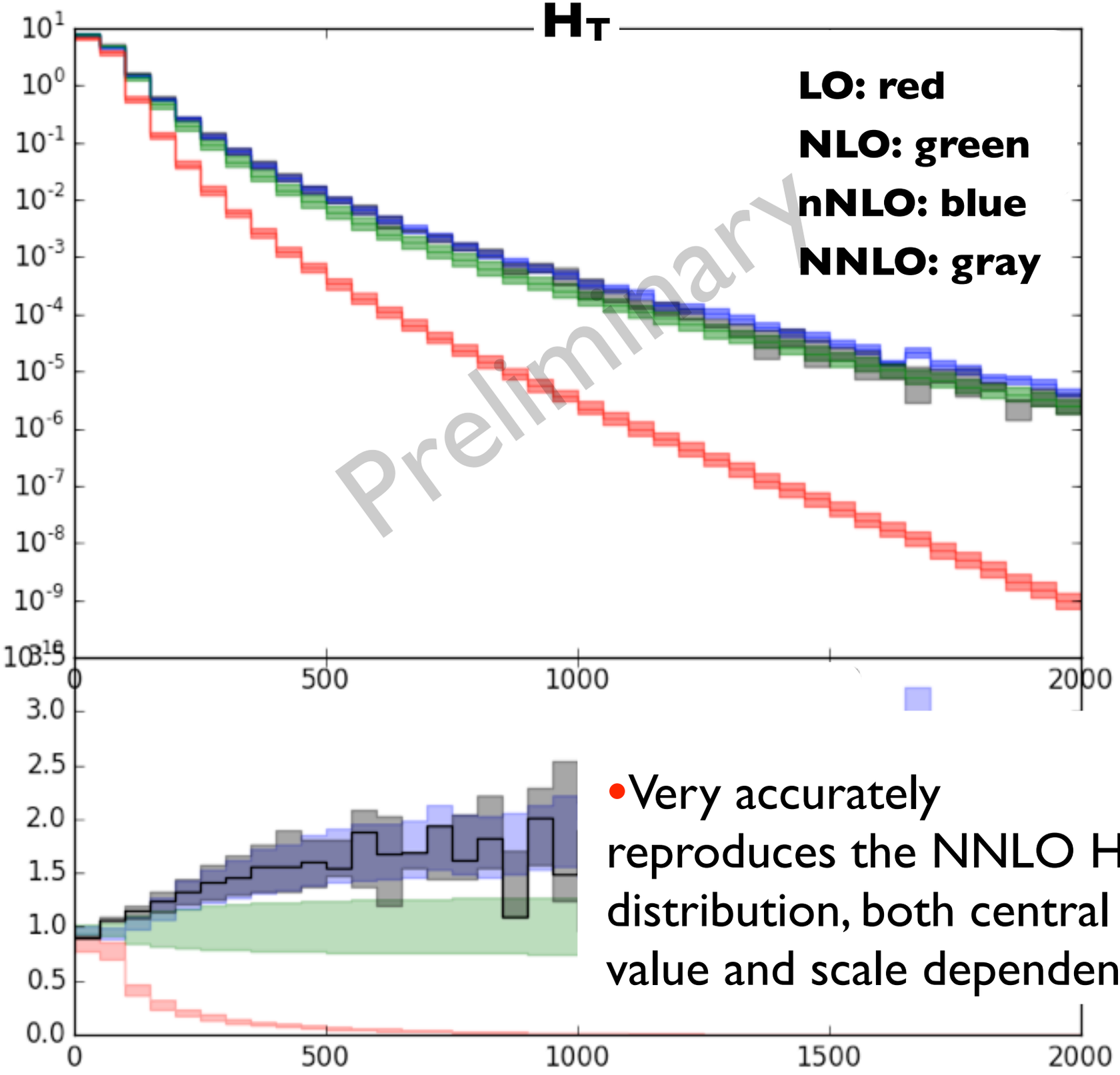


LO contribution to V+j; at large p_{TJ} or H_T, V must be a hard emission. Contributes $O(\alpha_S \alpha_{EW})$.

NLO contributions to V+j; at large p_{TJ} or H_T, can have soft +collinear V. Contributes $O(\alpha_S^2 \alpha_{EW} \ln^2(Q/M_V)$, with $Q=p_{TJ}$ or H_T, which becomes large at high energies.

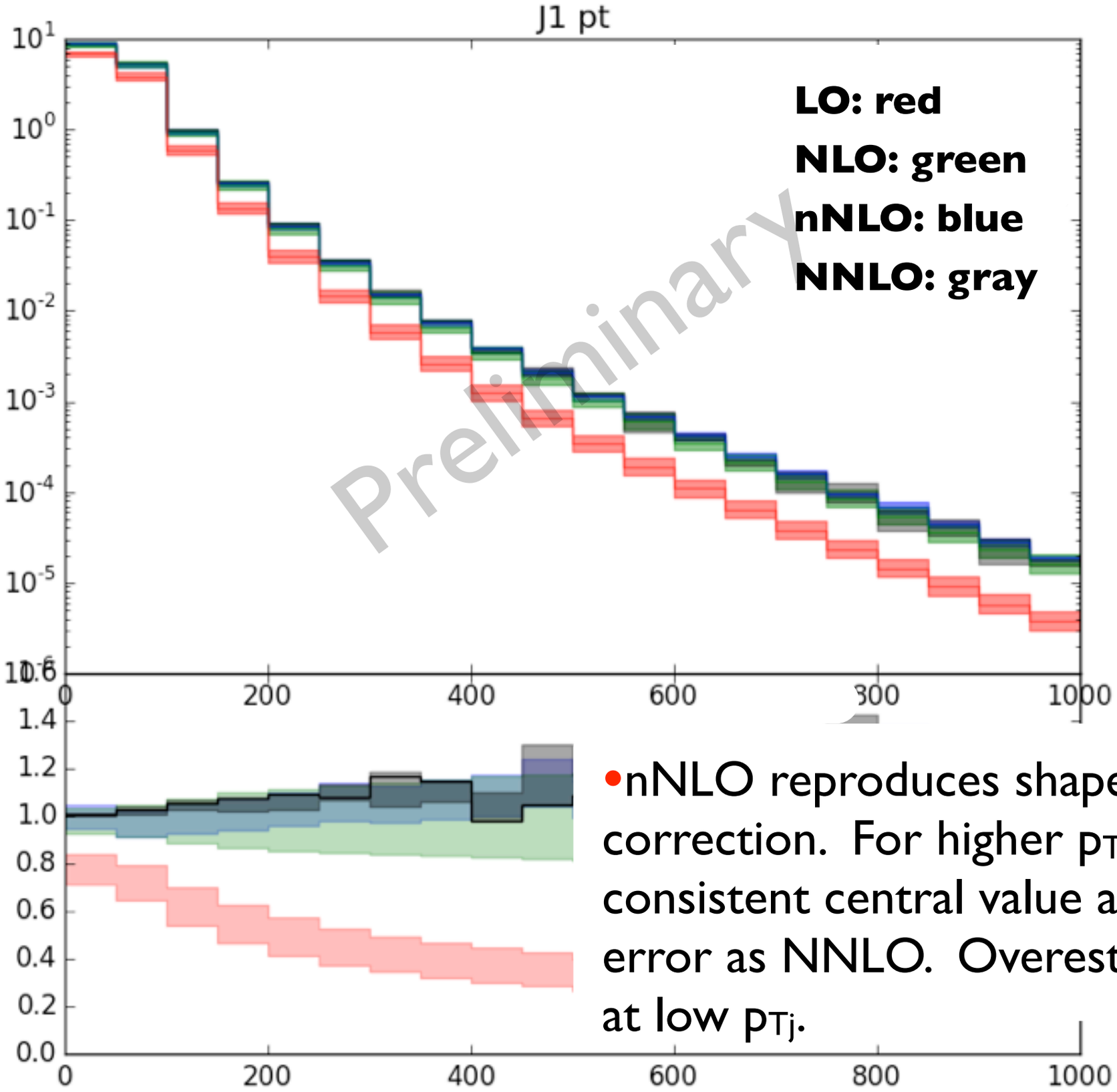
- LoopSim (nNLO) is an approximation of the full NNLO calculation that captures these large logarithmic corrections; nNLO has full NLO Vj, and in addition the logarithmically enhanced NNLO corrections

LoopSim at 8 TeV: H_T



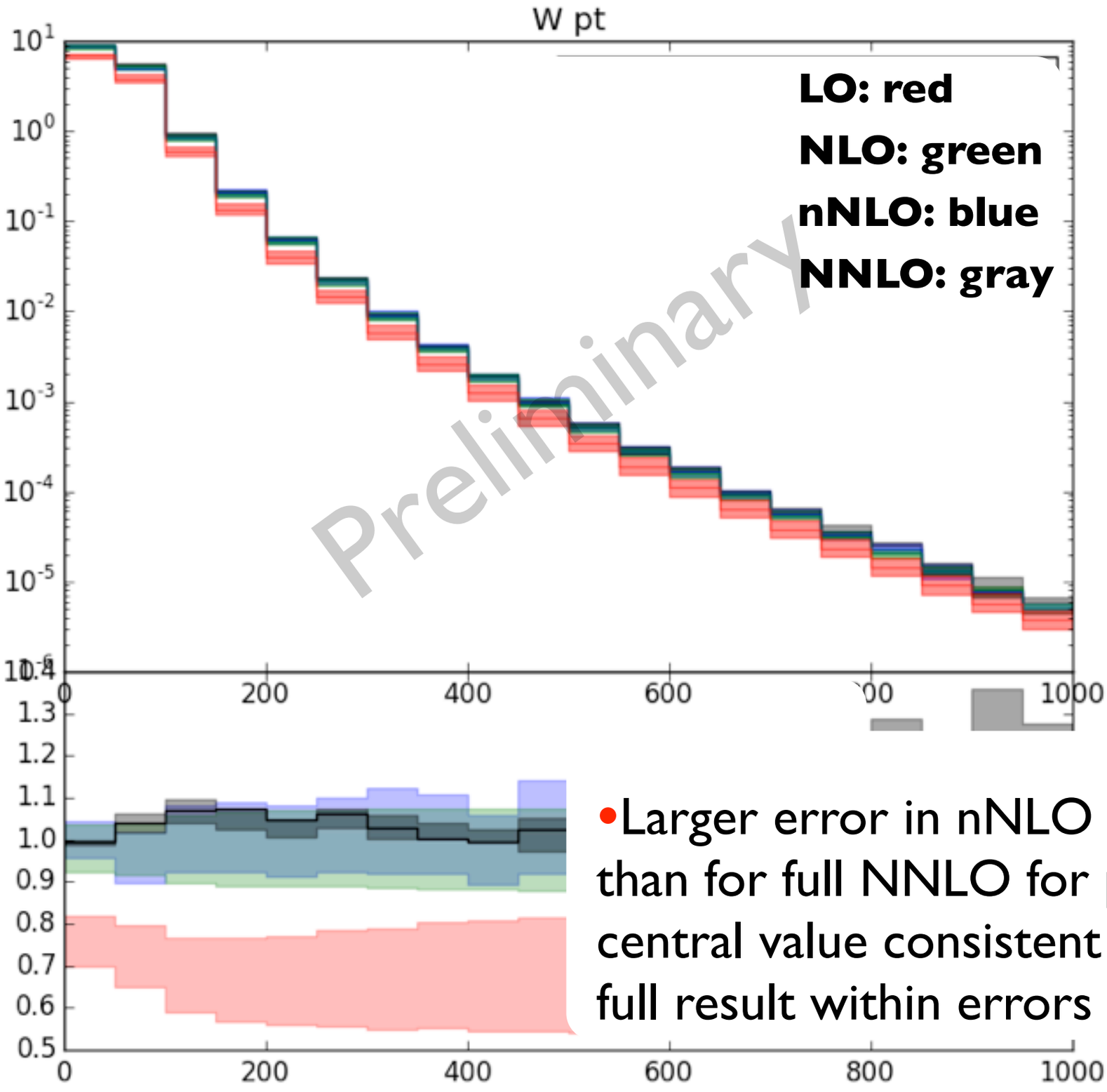
- Very accurately reproduces the NNLO H_T distribution, both central value and scale dependence

LoopSim at 8 TeV: p_{TJ}



- nNLO reproduces shape of NNLO correction. For higher p_{TJ} values, gives consistent central value and similar error as NNLO. Overestimates error at low p_{Tj}.

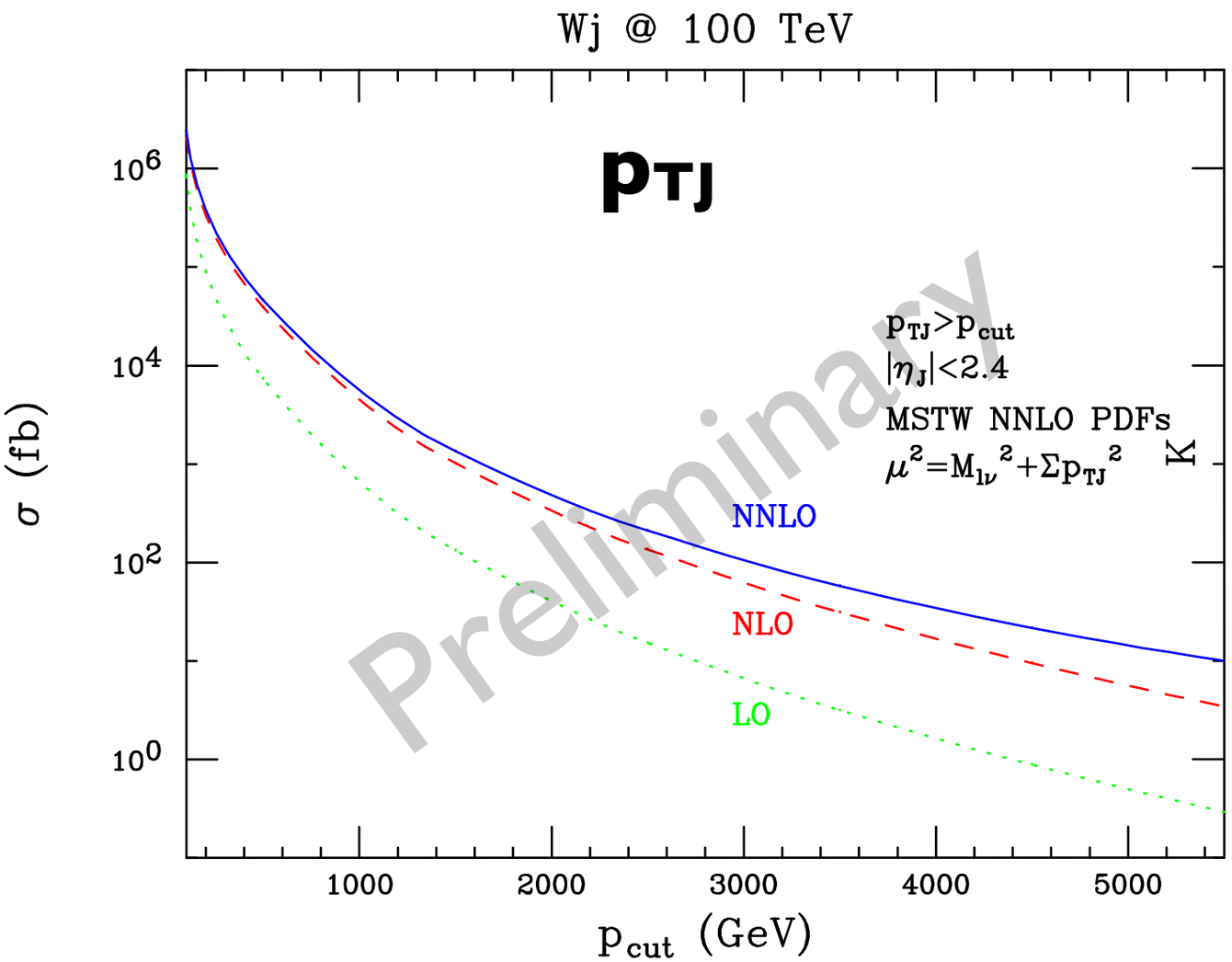
LoopSim at 8 TeV: p_{TW}

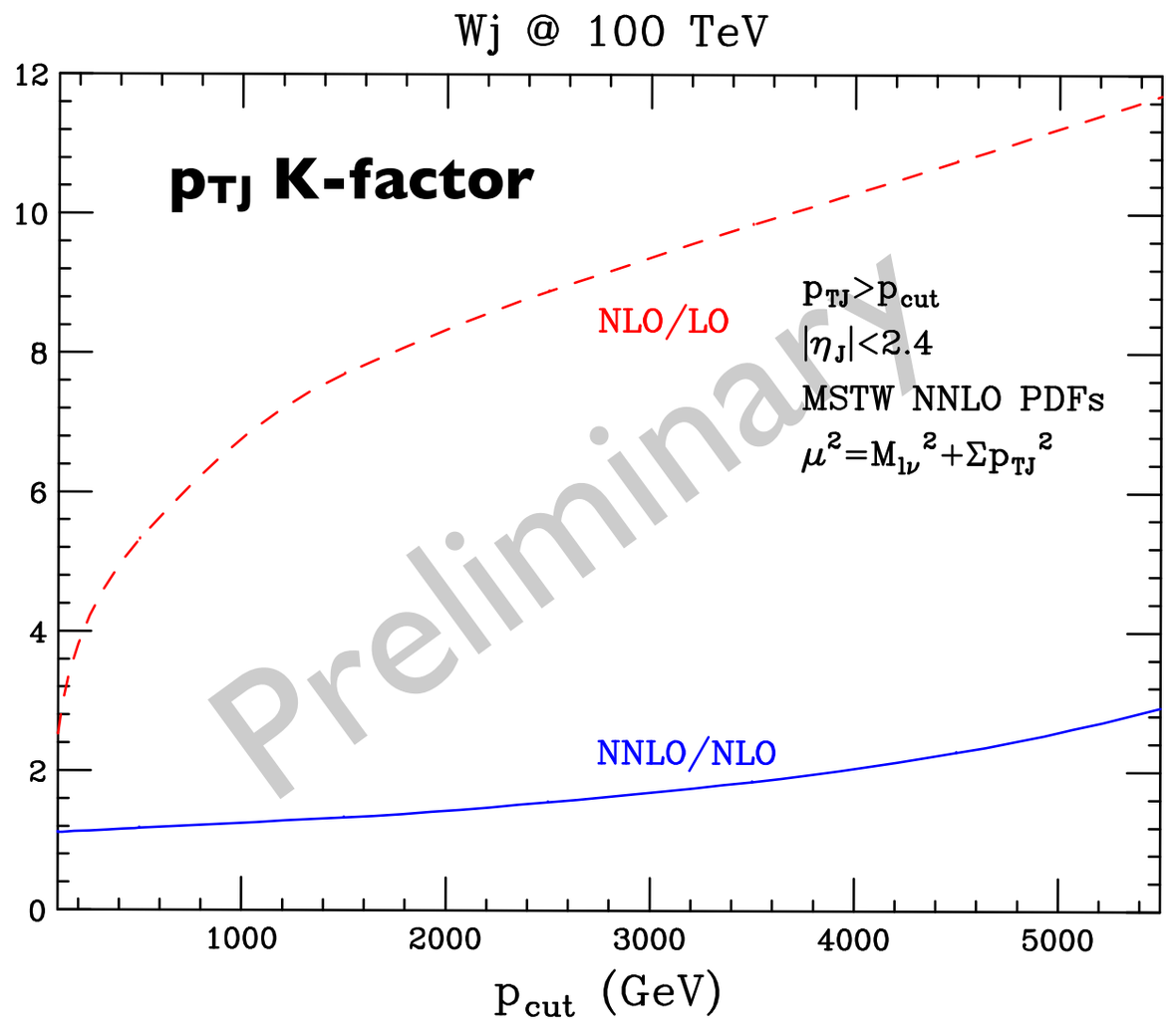


- Larger error in nNLO result than for full NNLO for p_{TW}; central value consistent with full result within errors

Phenomenology at 100 TeV: p_{TJ}

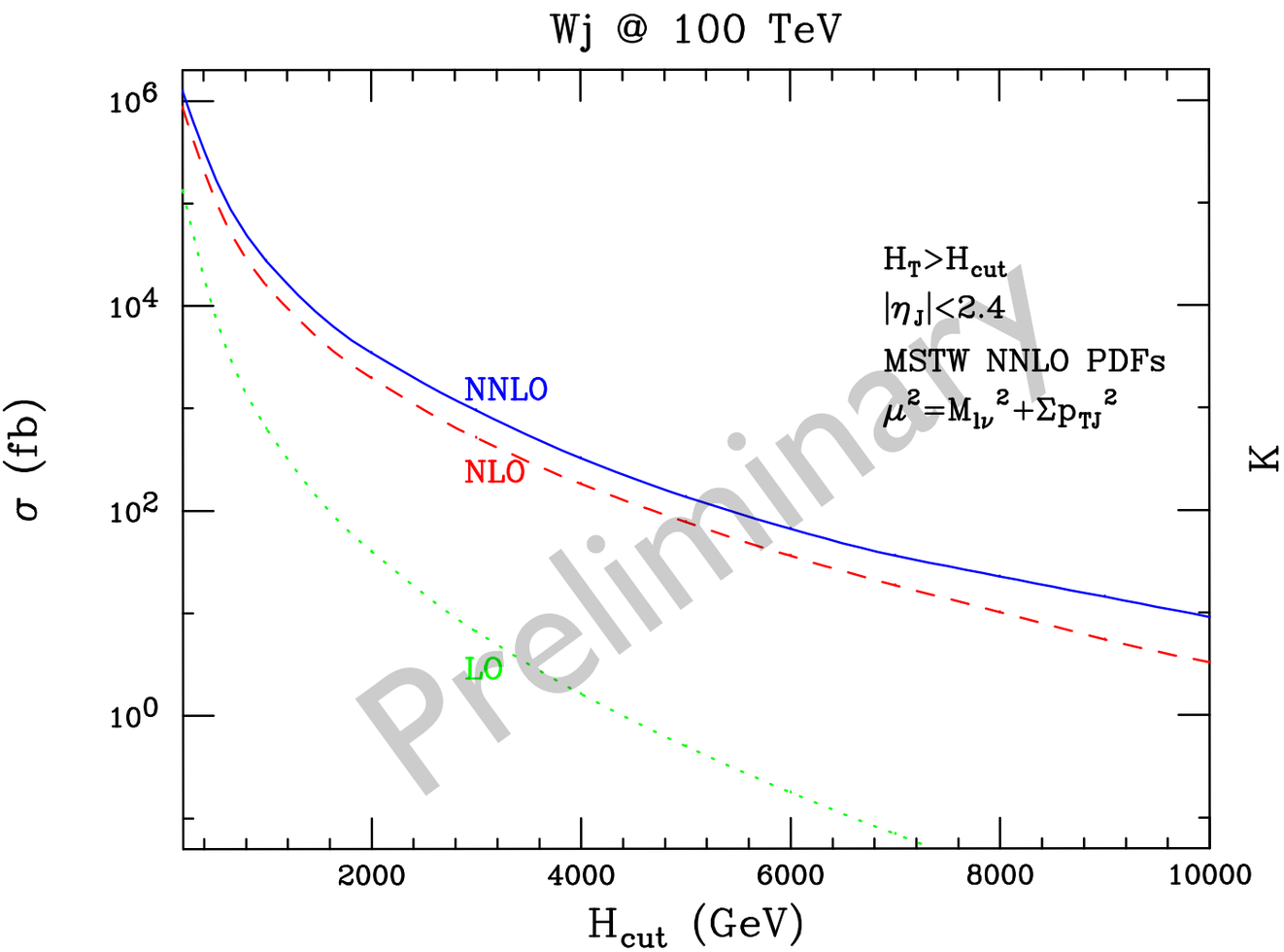
- Results are for MSTW PDFs, $\mu^2=M_{l\nu}^2+\sum p_{TJ}^2$

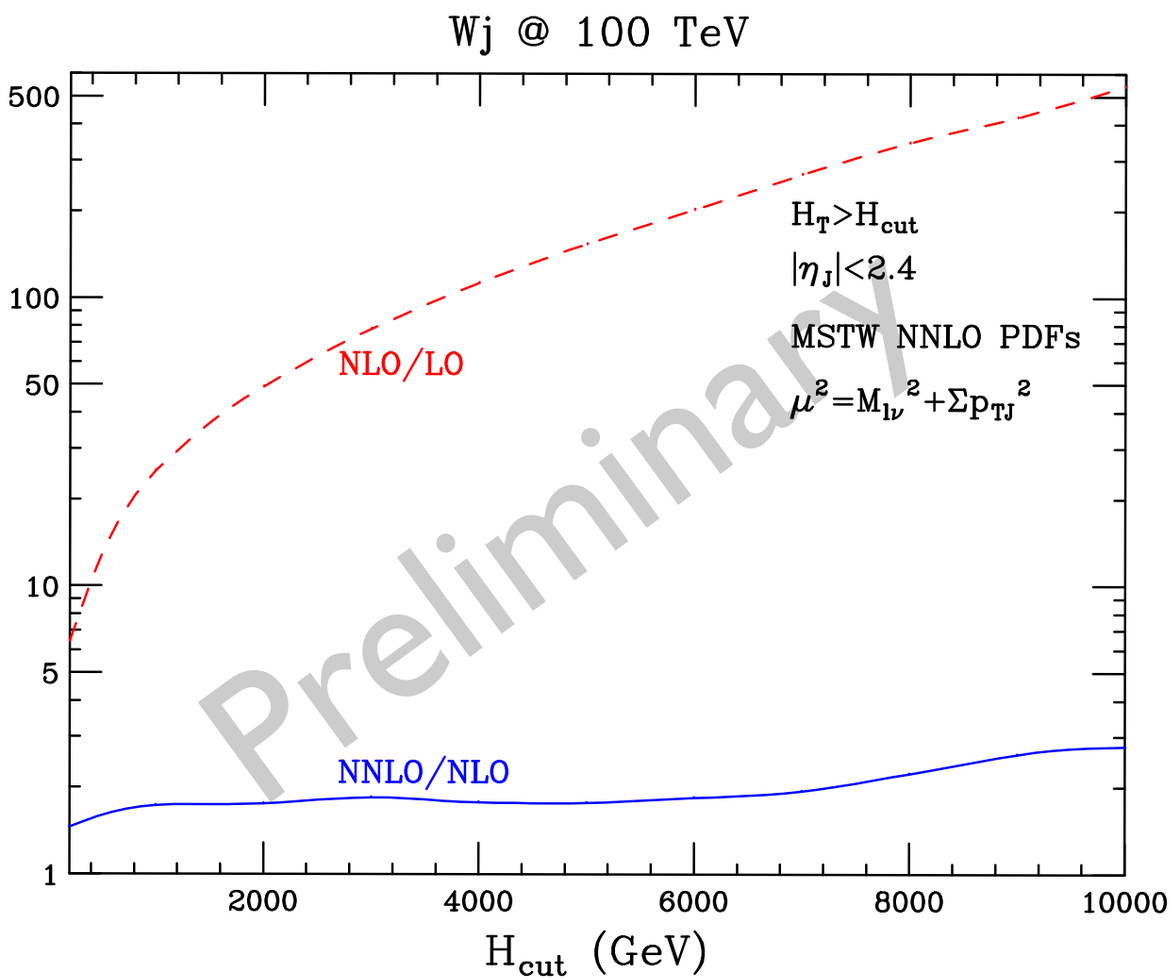




- K-factor at NLO grows above 10 for $p_{TJ}>4$ TeV
- While NNLO corrections are much milder than NLO corrections, the NNLO/NLO K-factor still grows to 3 for $p_{TJ}>5$ TeV.

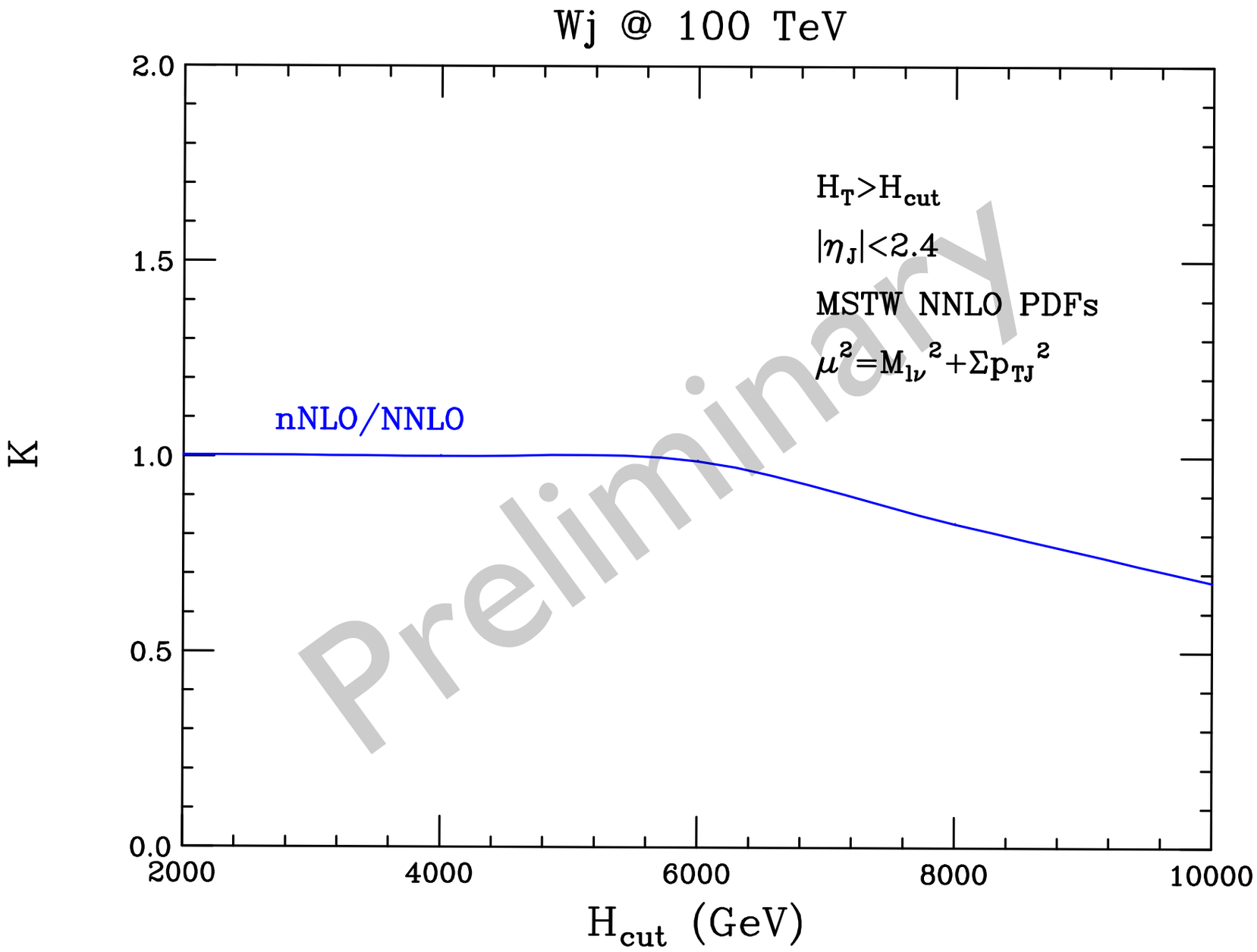
Phenomenology at 100 TeV: H_T





- Enormous K-factor at NLO; grows above 500 for H_T>10 TeV
- NNLO corrections similar to those found for p_{TJ}; milder than NLO, but still sizable and increasing with H_T. The K-factor grows to K=3 for H_T=10 TeV.

LoopSim at 100 TeV: H_T



- LoopSim agrees well with NNLO up to 6 TeV, then becomes smaller by 30% at H_T=10 TeV; this effect is under investigation

Conclusions

- NNLO corrections to Wj are large and observable-dependent, and should be studied to ensure accurate 100 TeV phenomenology
- NNLO corrections grow with p_{TJ} and H_T, and the K-factor rises to K=2-3 in the multi-TeV energy range. While large, these corrections are much smaller than found at NLO.
- The LoopSim approach is found to give a reasonably good approximation to the full NNLO result. For observables dominated by large logarithmic corrections such as the high H_T region, it reproduces the central value and scale variation.
- For observables such as p_{TW} or the low p_{TJ} region, where the logarithmic corrections do not dominate, it gets close to the correct central value and overestimates the scale variation.
- Given the large available phase space for radiation at 100 TeV, and the still-large NNLO corrections at high energies, applications of the LoopSim approach beyond NNLO should be studied