

PERTURBATIVE QCD

“THEORY FOR EXPERIMENTALISTS”,
IOP HALF-DAY MEETING, FEBRUARY 20, 2008.

JOHN CAMPBELL



University
of Glasgow

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➔ Perturbative QCD basics.

➔ Scales choices, PDFs and theoretical uncertainties.

➔ Progress in pQCD.

➔ Expectations for the near future.

➔ Disclaimer: some material borrowed from recent review article.

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Hard interactions of quarks and gluons: a primer for LHC physics

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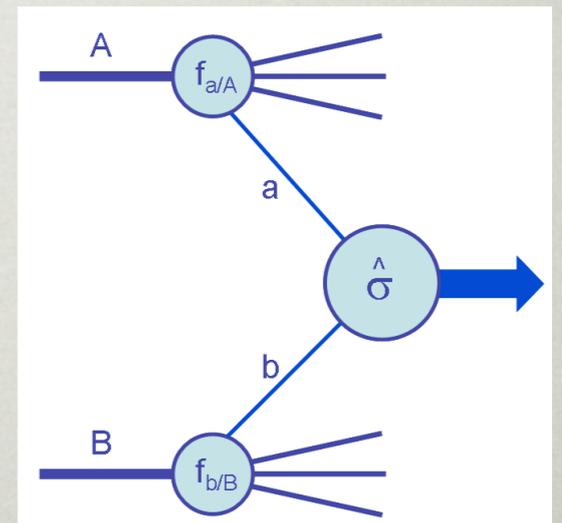
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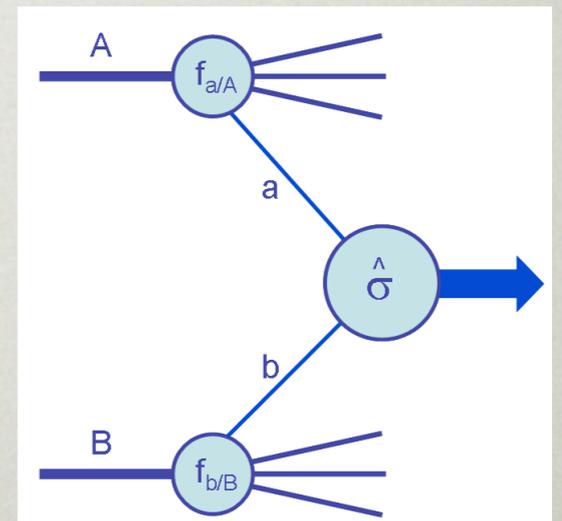
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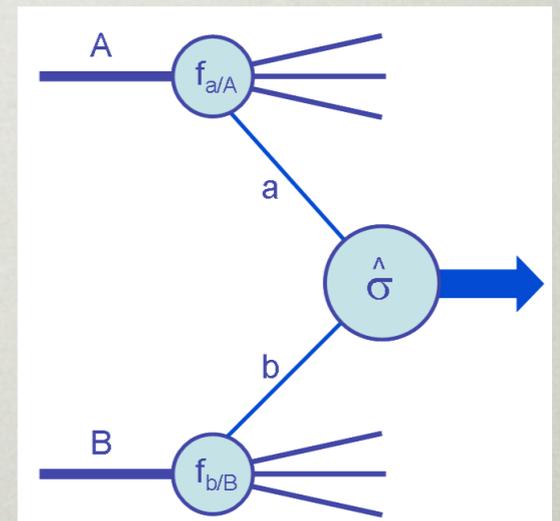
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- Cross section factorizes into a part describing the partons inside hadrons (*universal*) and another part describing the scattering of those partons (calculated case-by-case).



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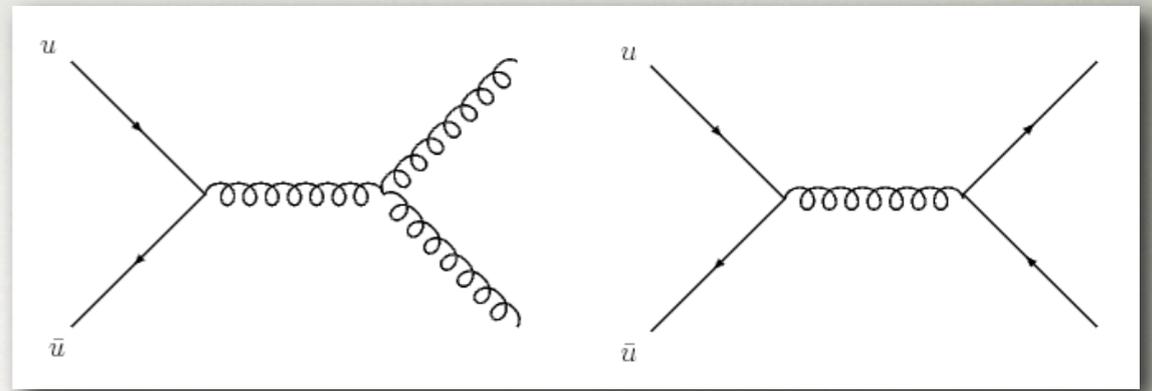
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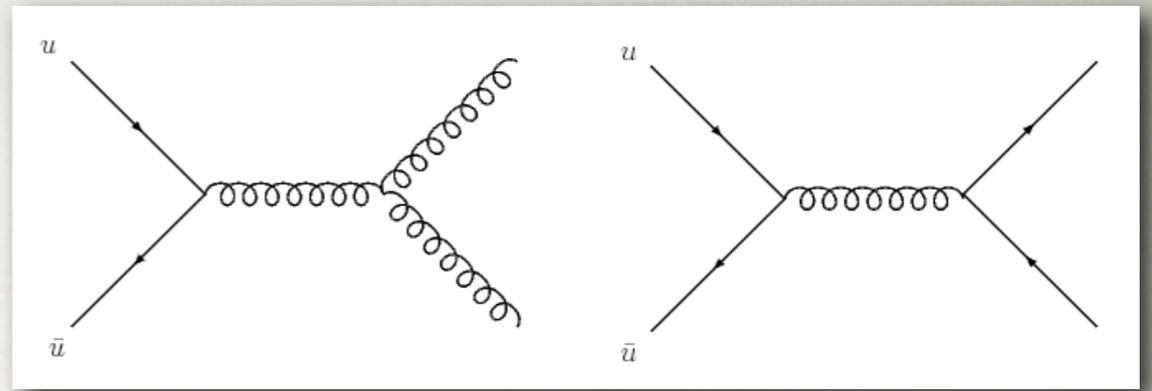
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- The dependence on both scales is an artefact of pQCD and should be reduced in higher orders.
- Typically, one might vary both these scales to try to estimate the effect of neglected higher order corrections / quantify theoretical uncertainty.

- A simple example is provided by the single-jet inclusive distribution at the Tevatron. At high E_T it is dominated by the quark-antiquark initial state.



Glover, 2002

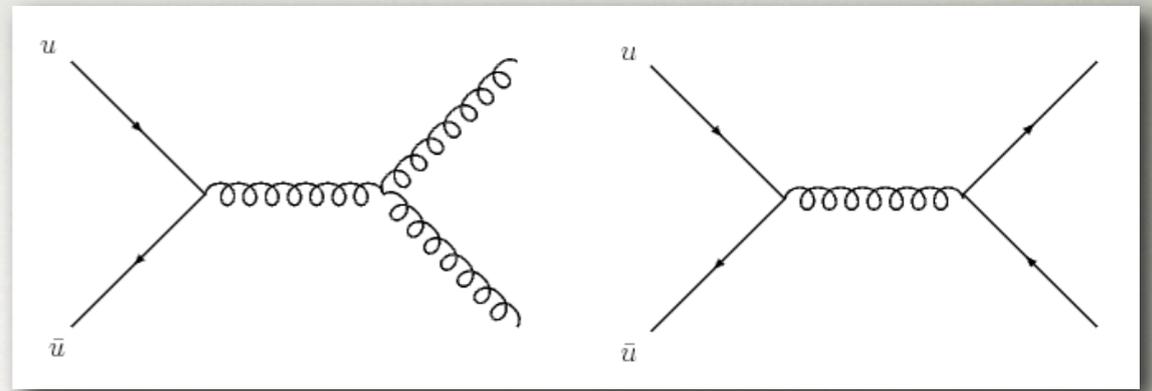
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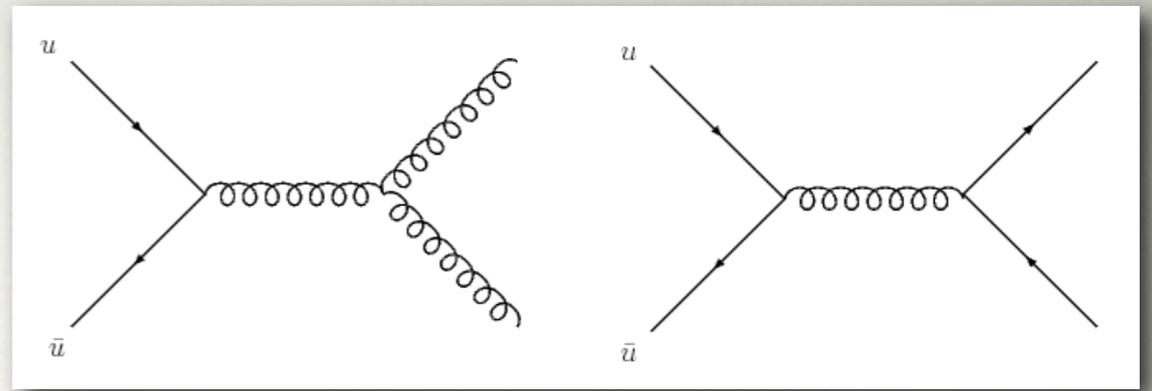
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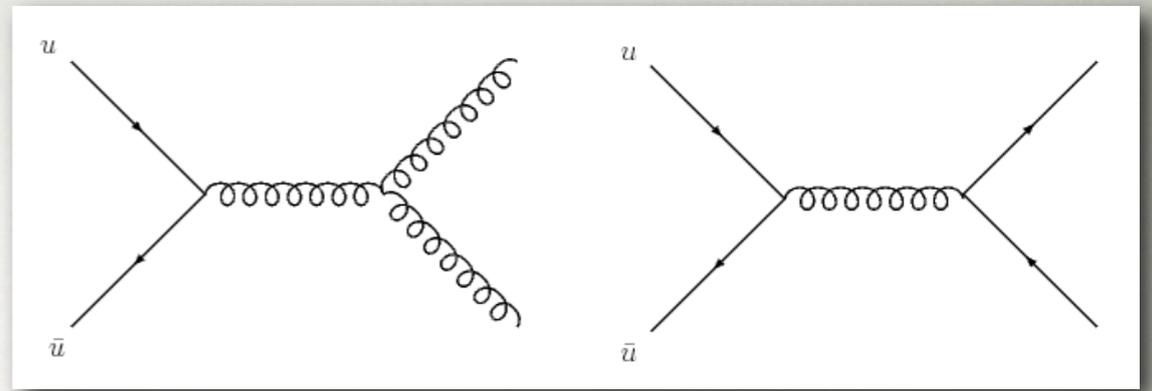
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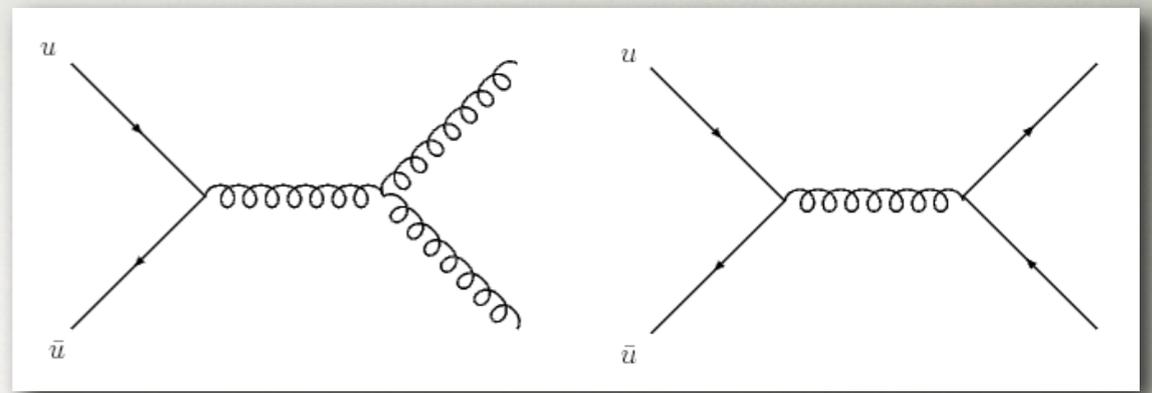
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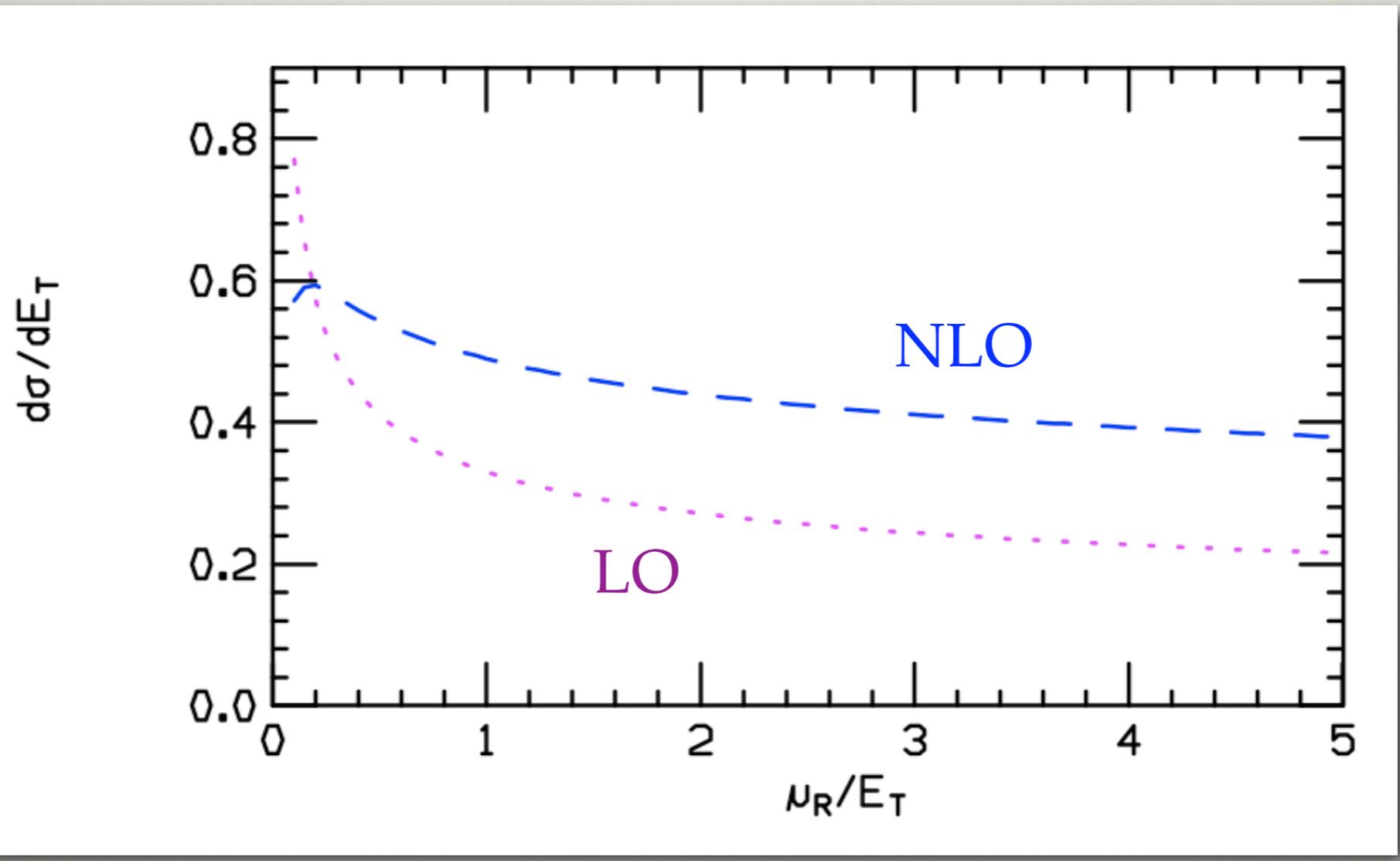
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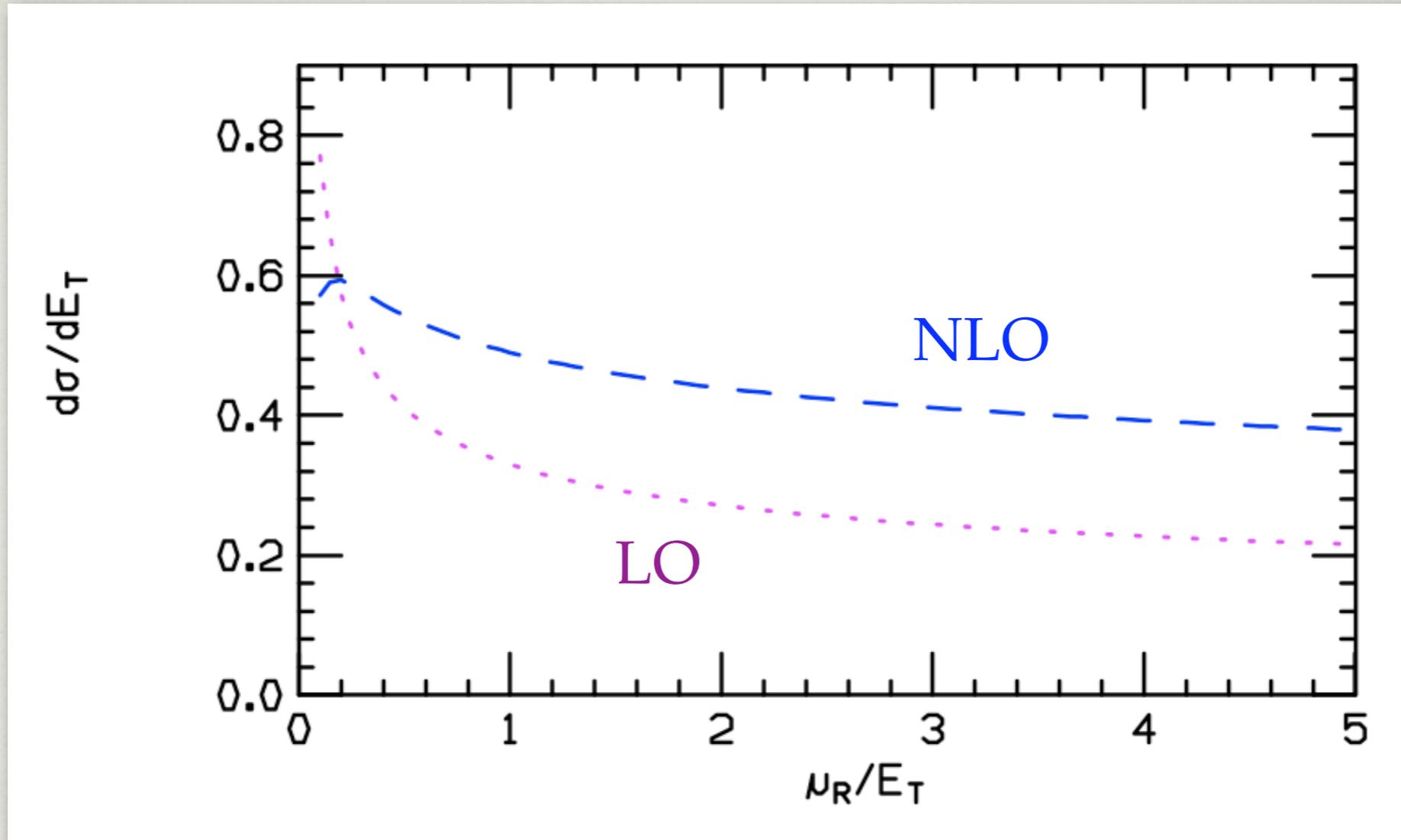
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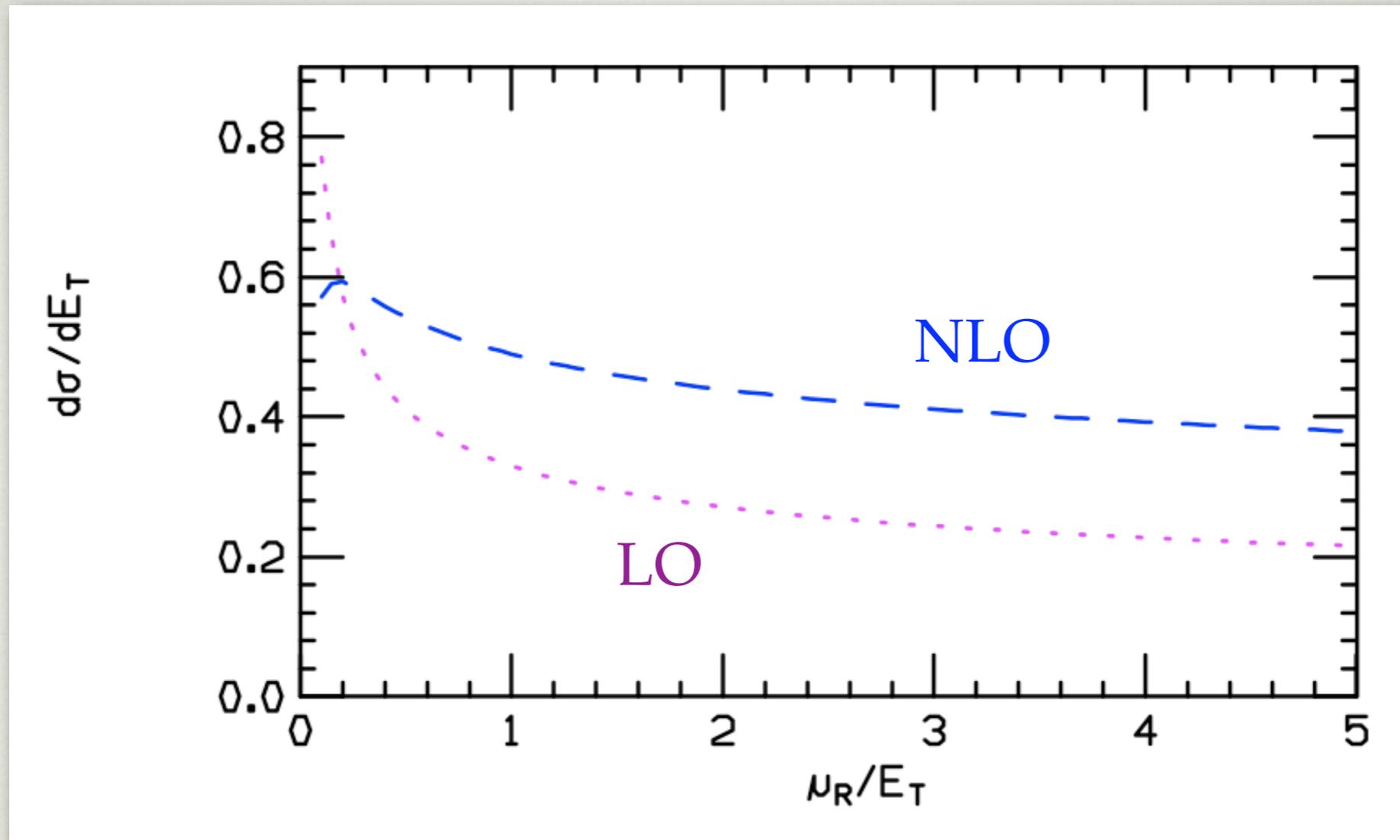
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- Independence is only formal: have to check real dependence case-by-case.

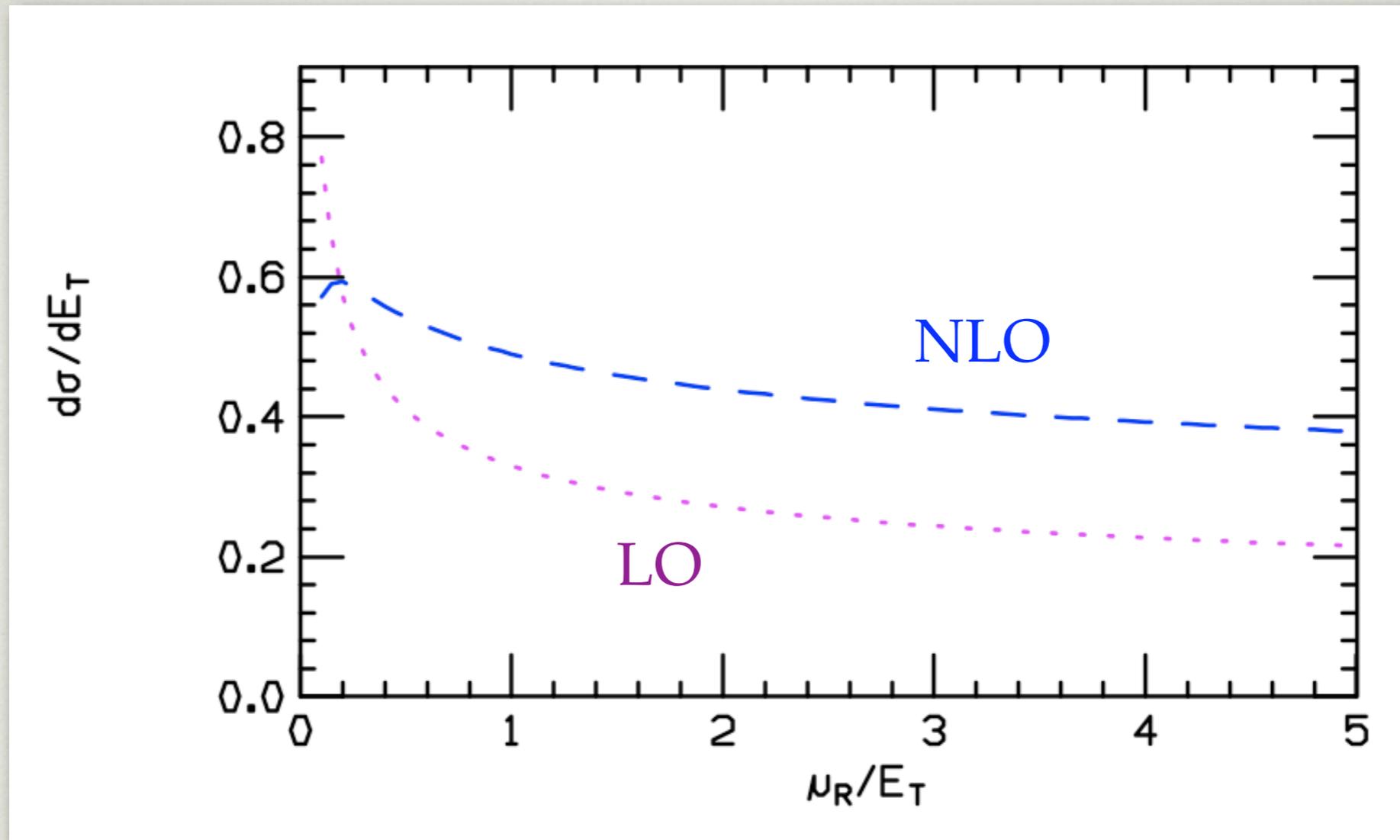




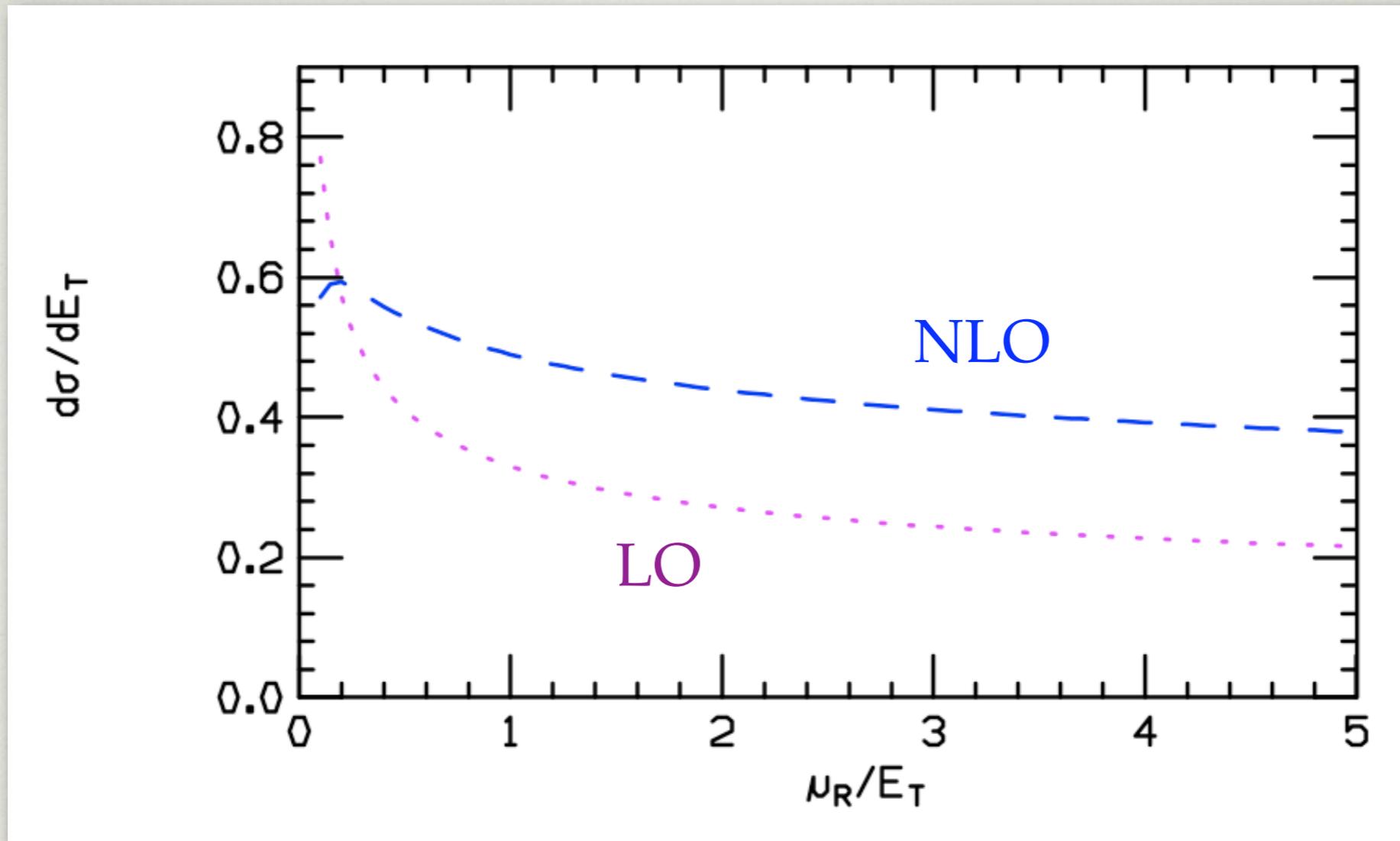
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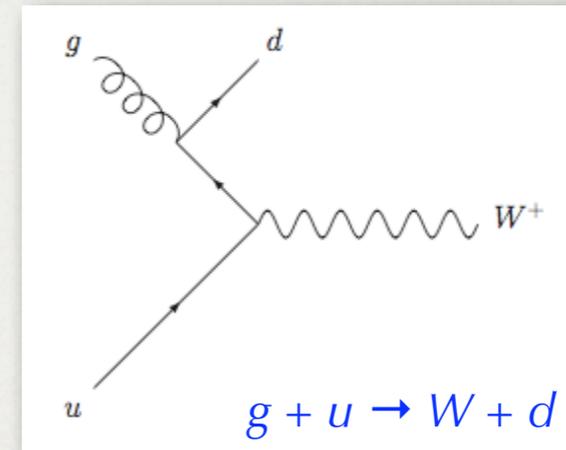
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- Not always true: sometimes clear that higher orders are important.

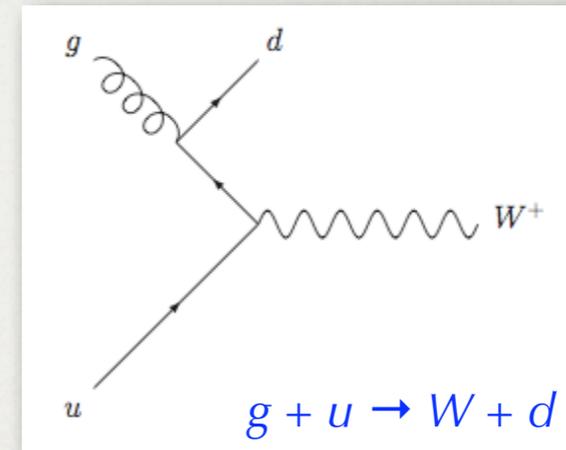
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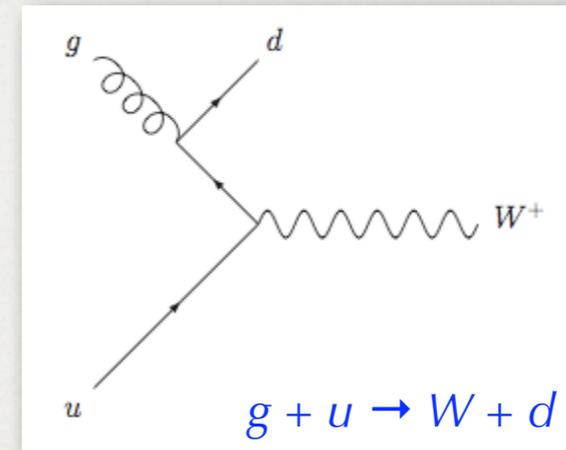
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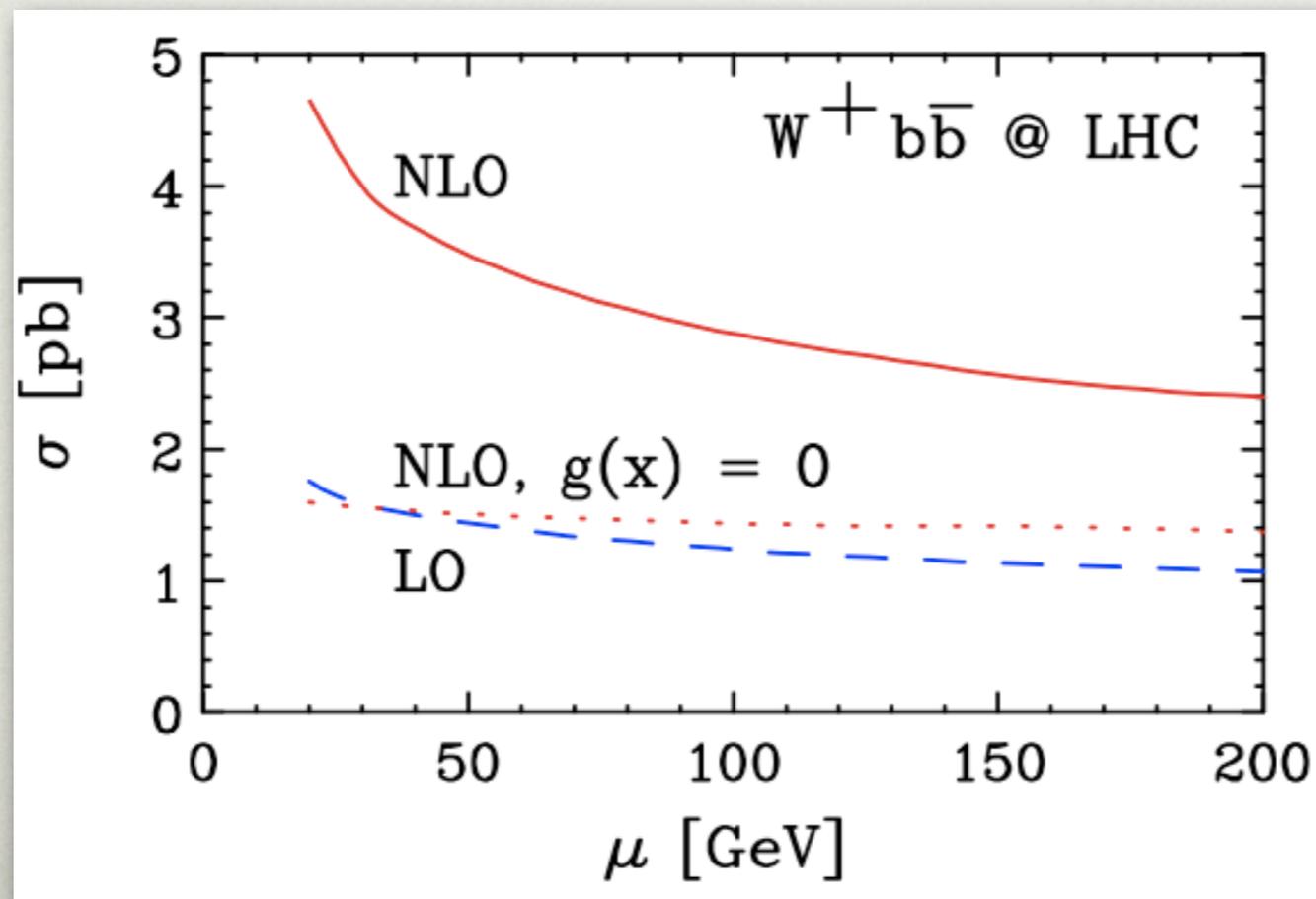
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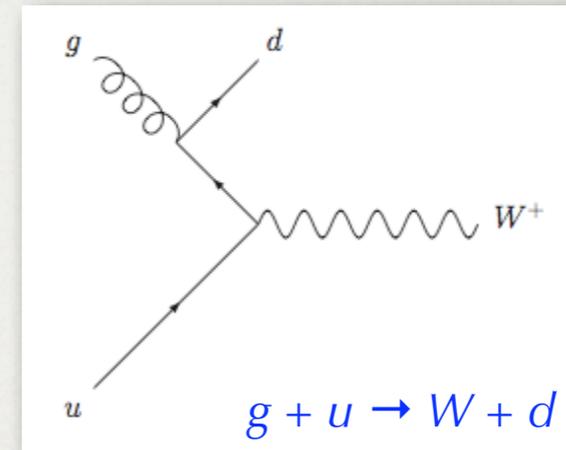


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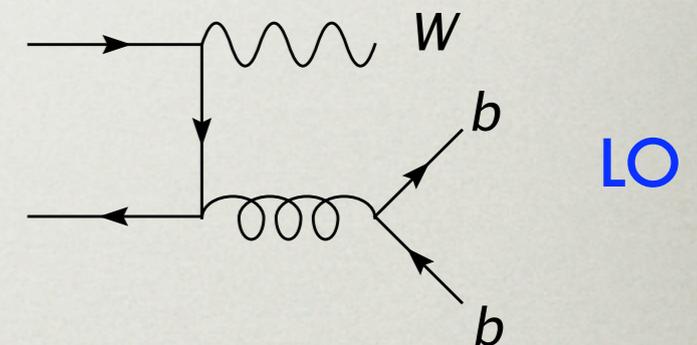
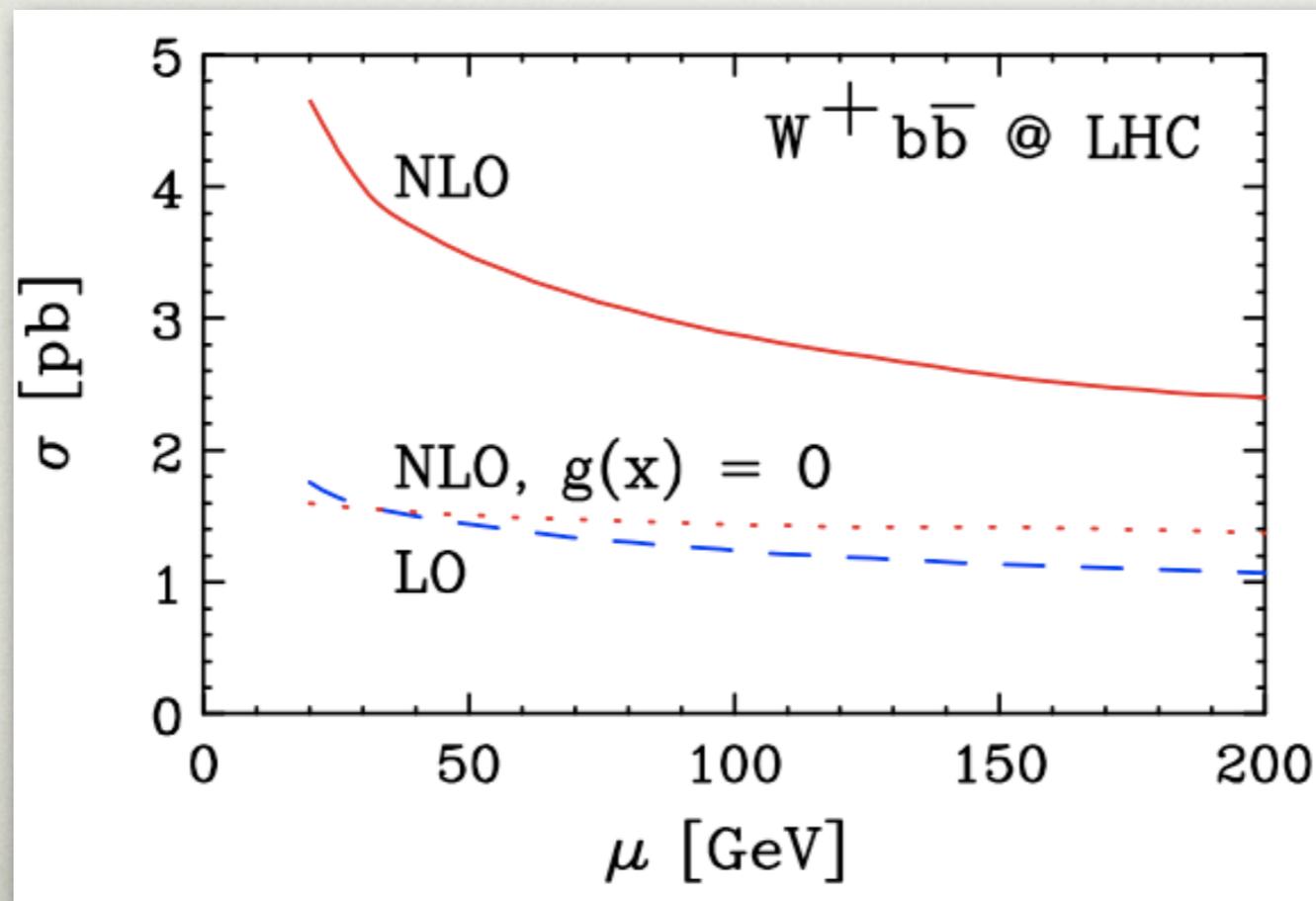


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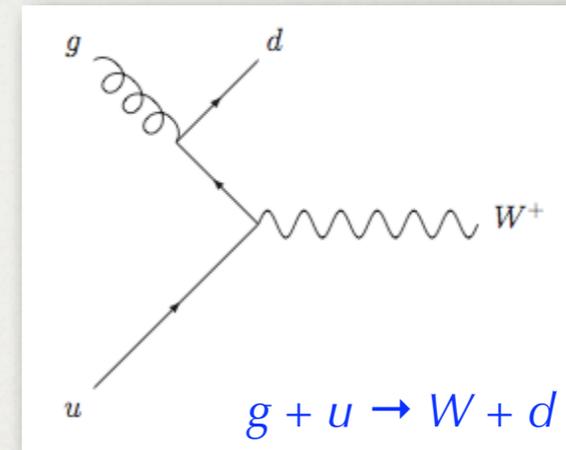


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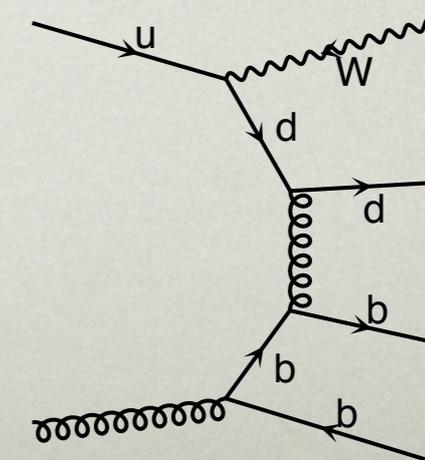
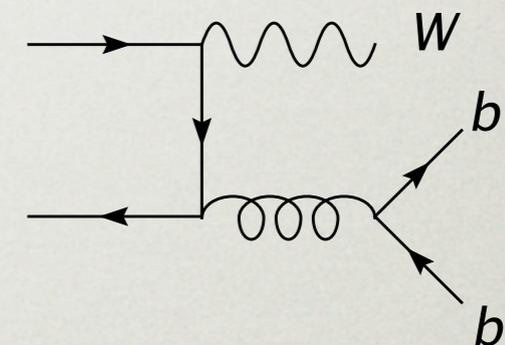
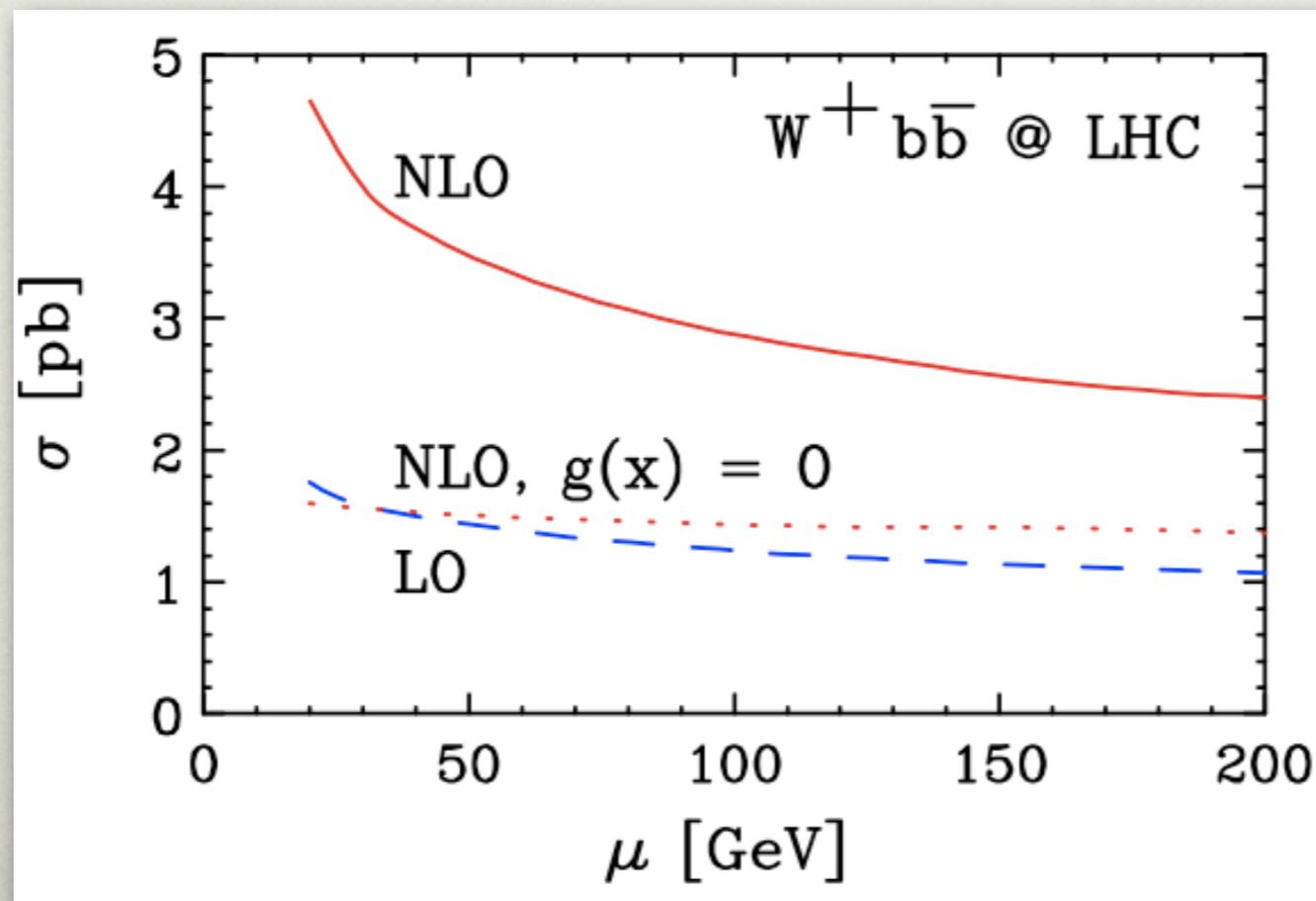


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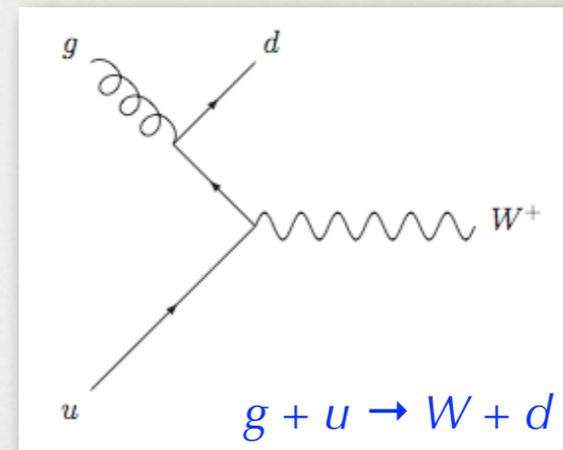


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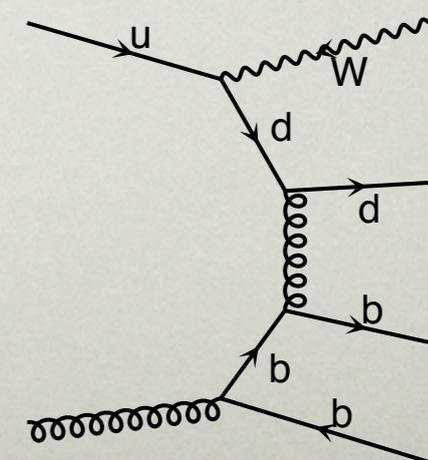
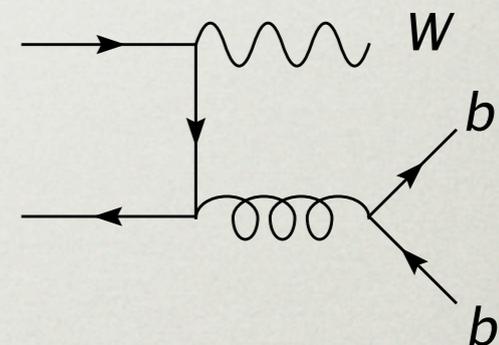
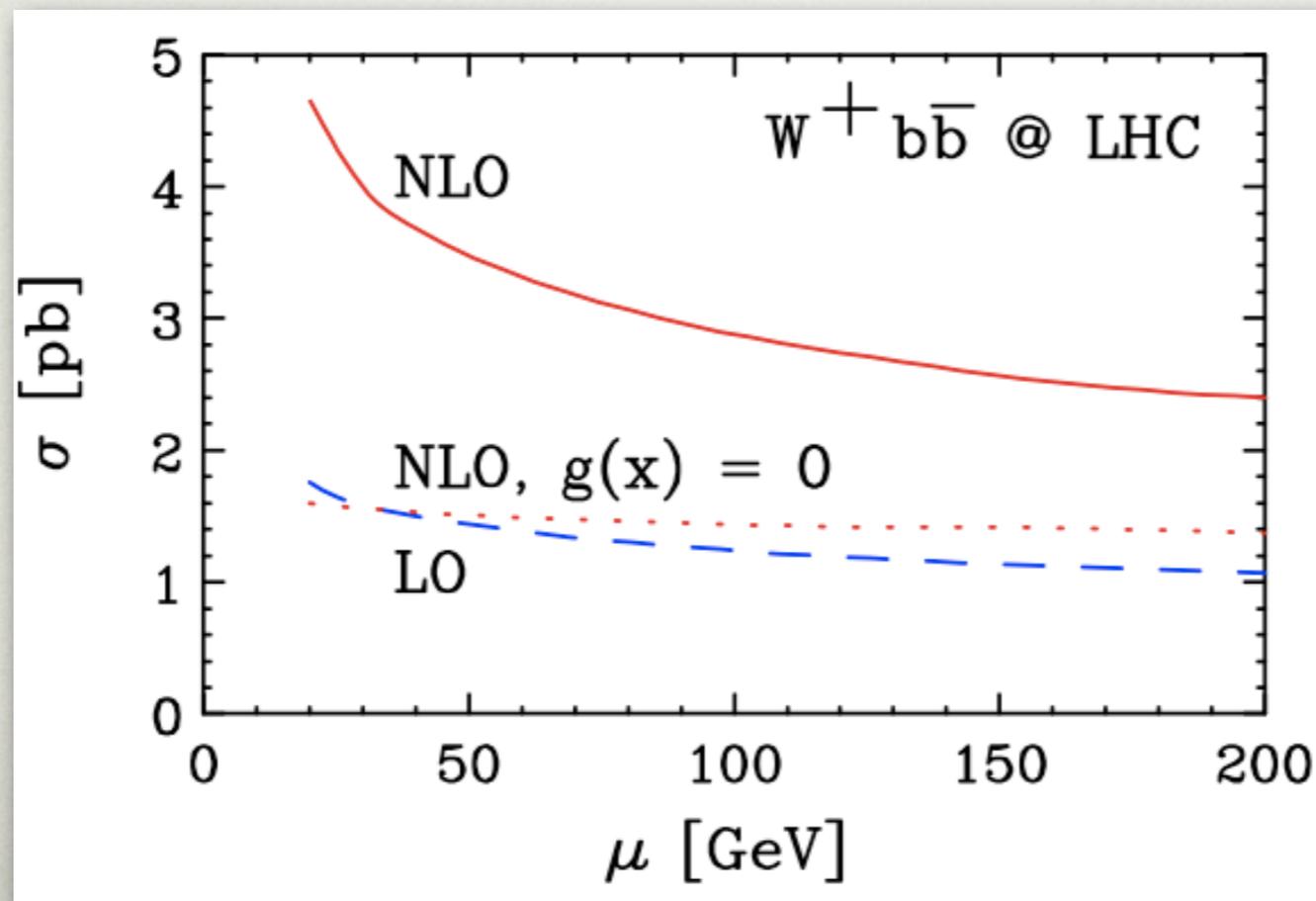
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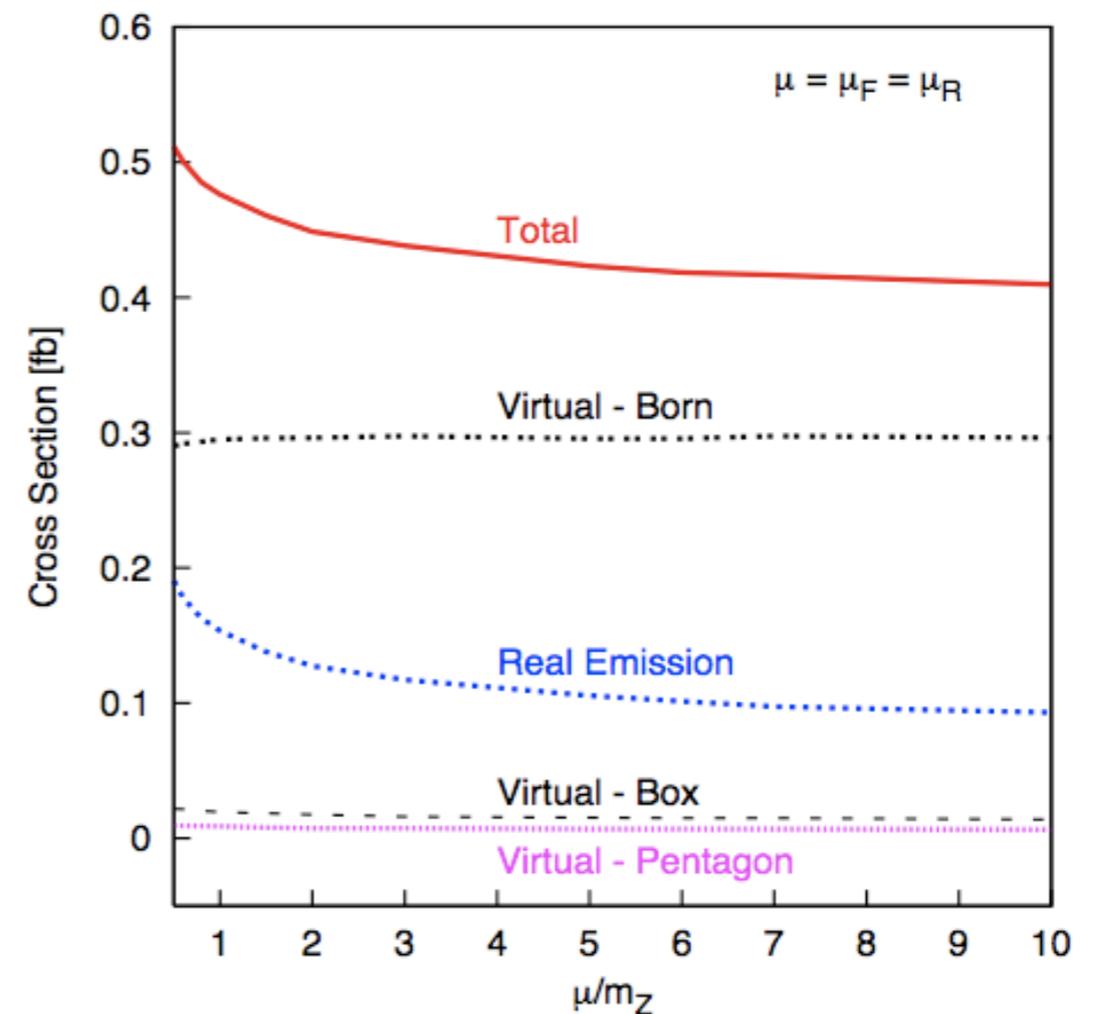
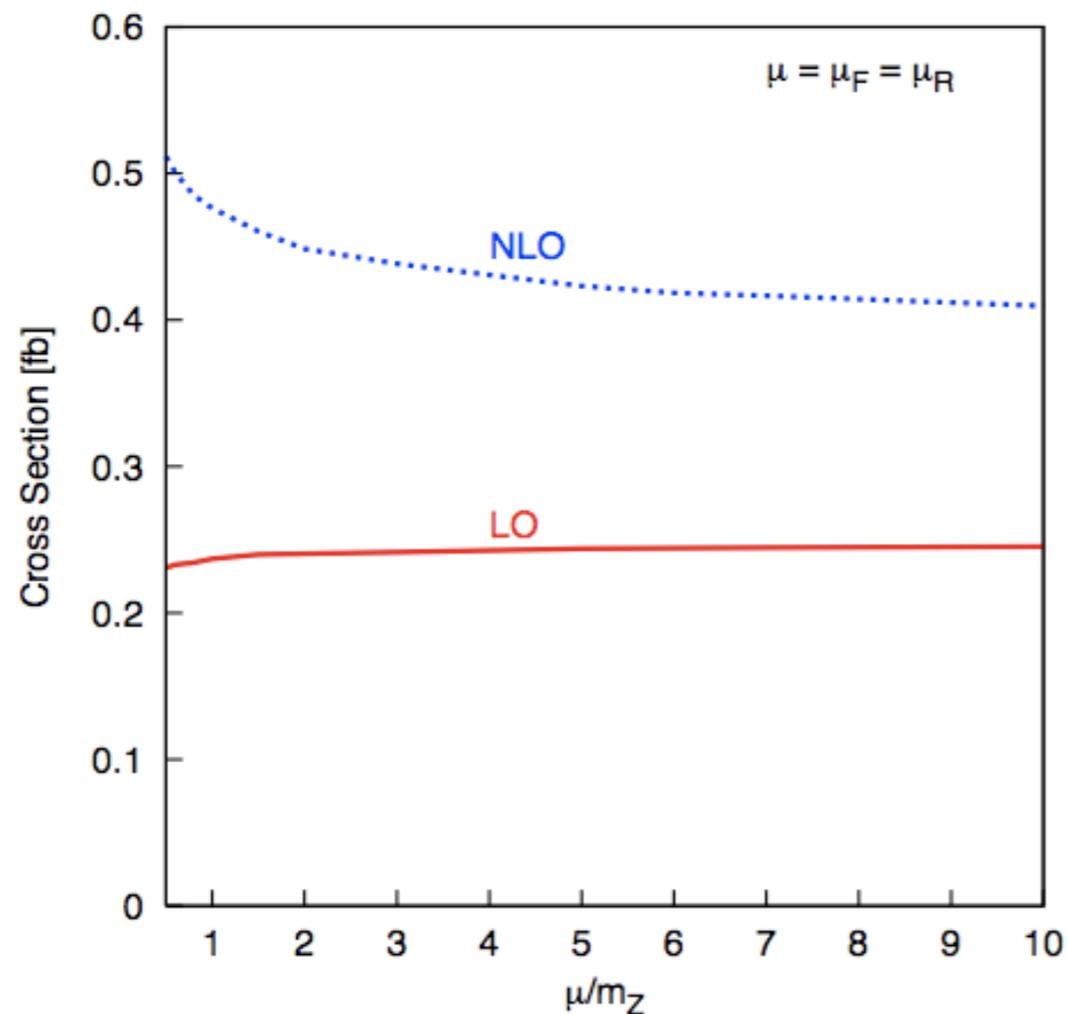
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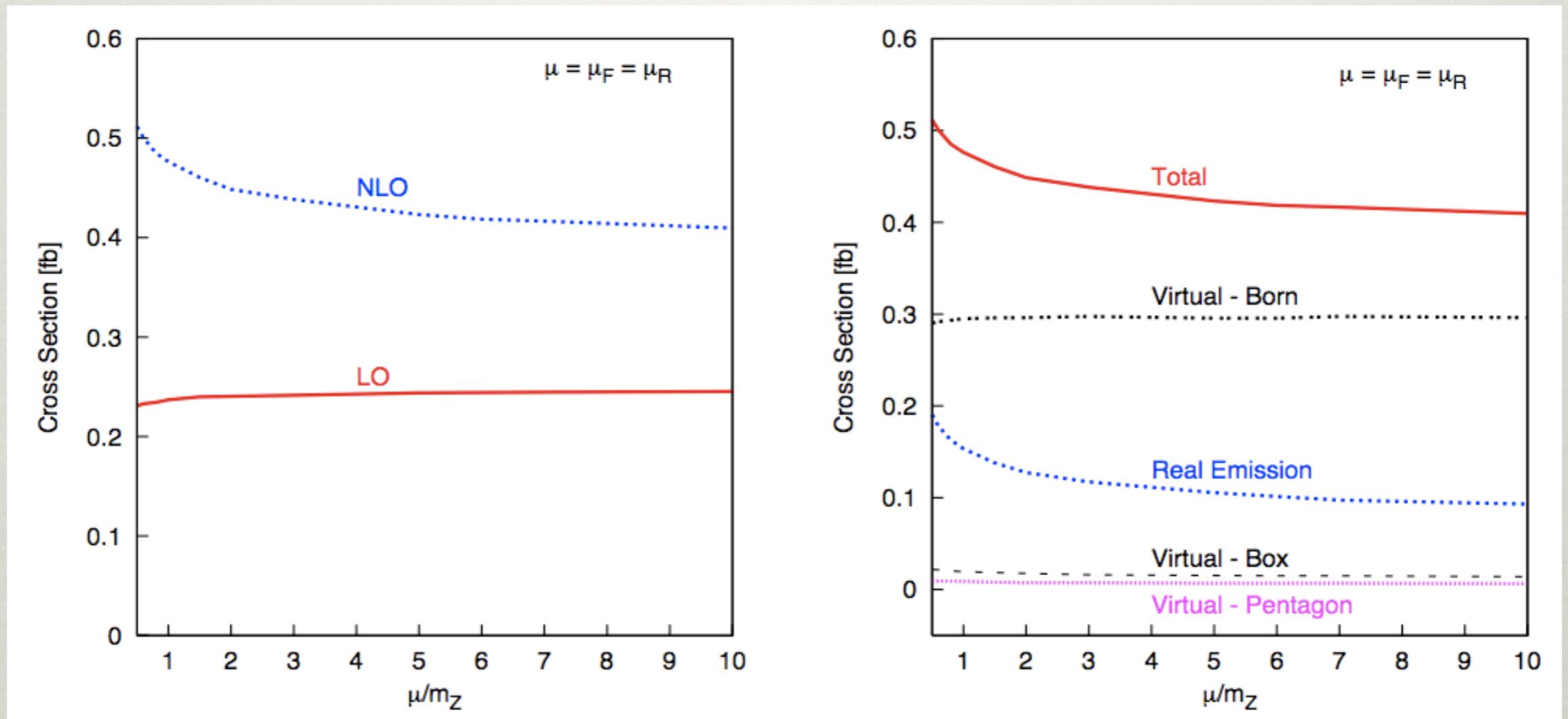
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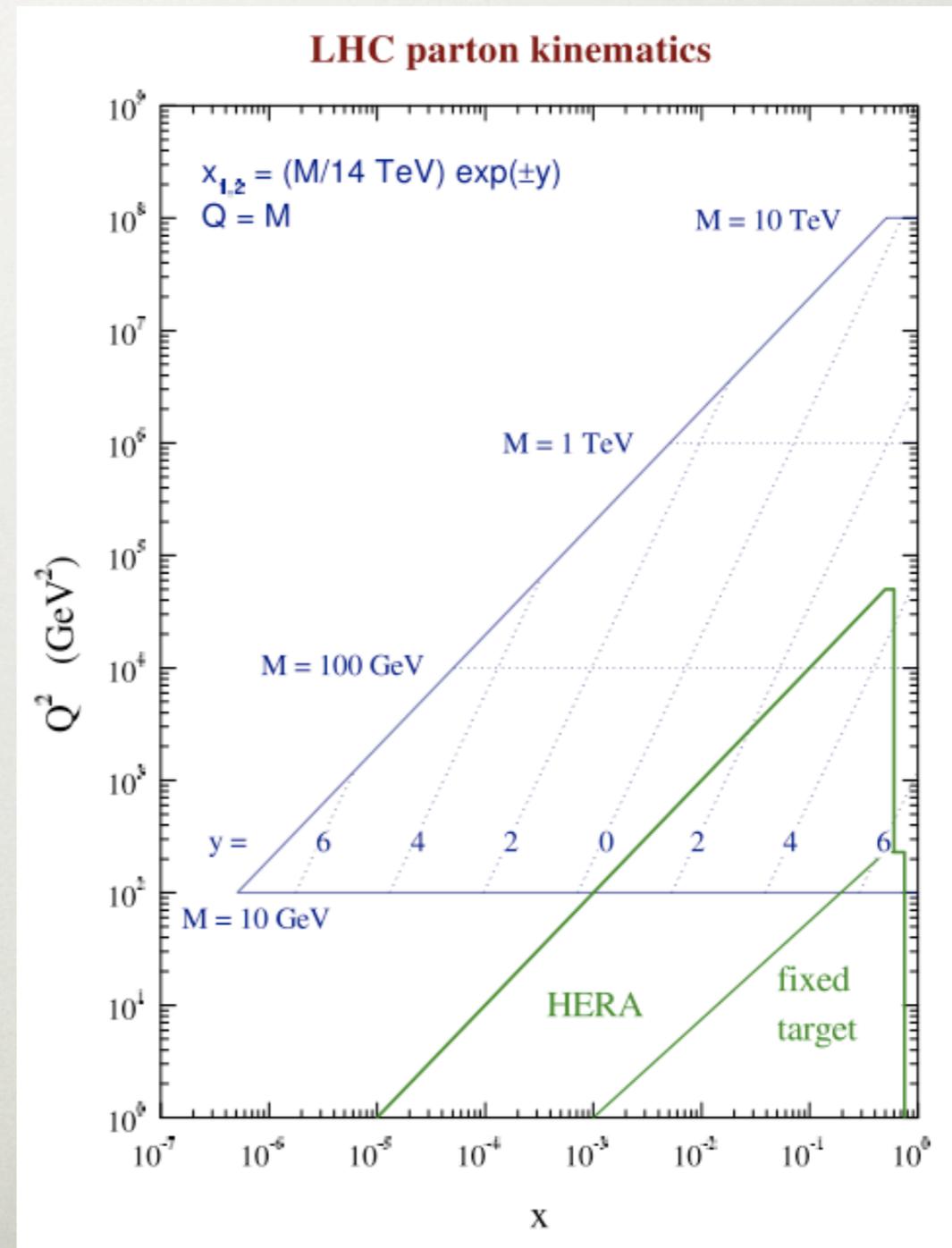


- Recent calculation of $pp \rightarrow WWZ$ at the LHC. Factorization scale dependence is small at LO. Hankele & Zeppenfeld, 2007
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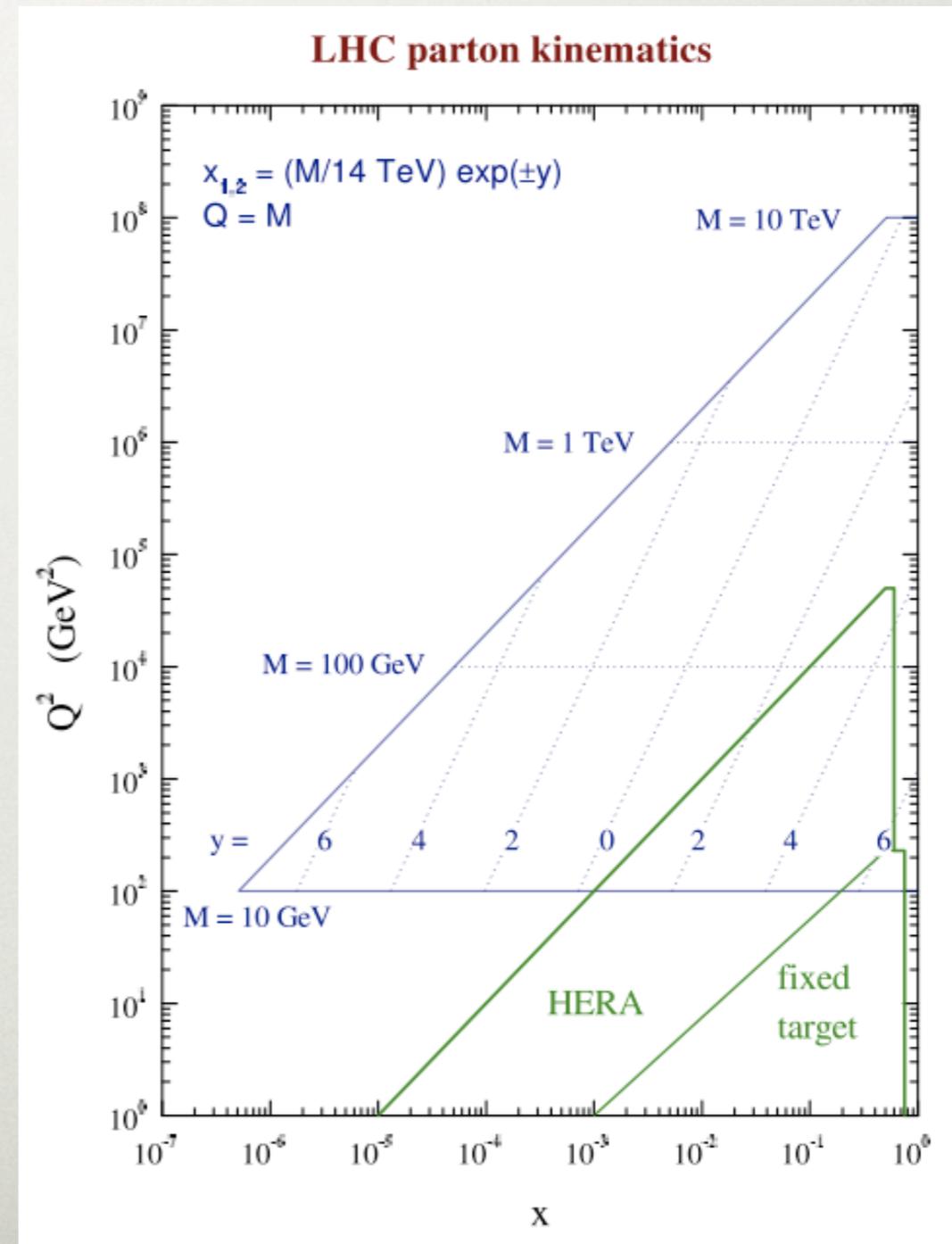
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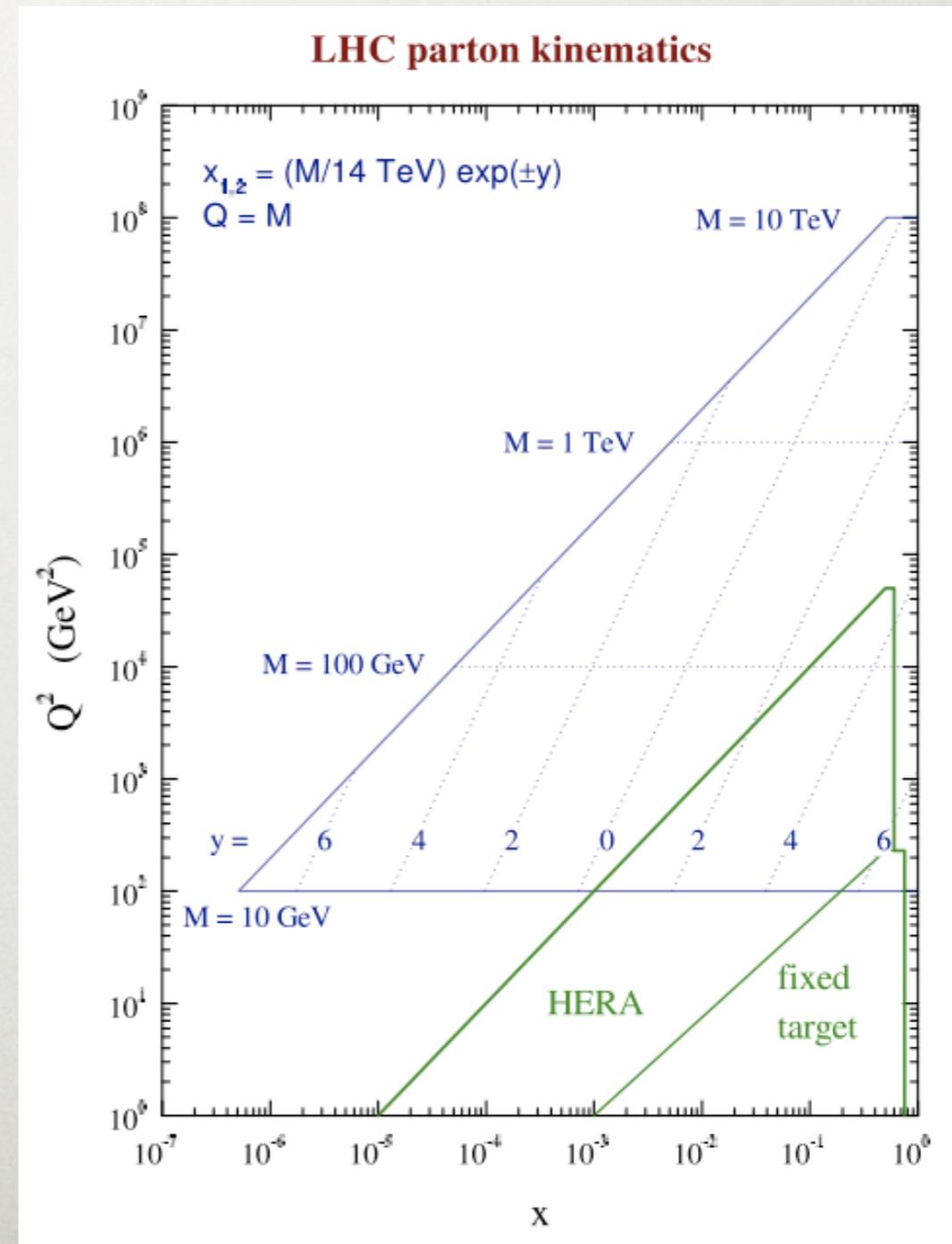
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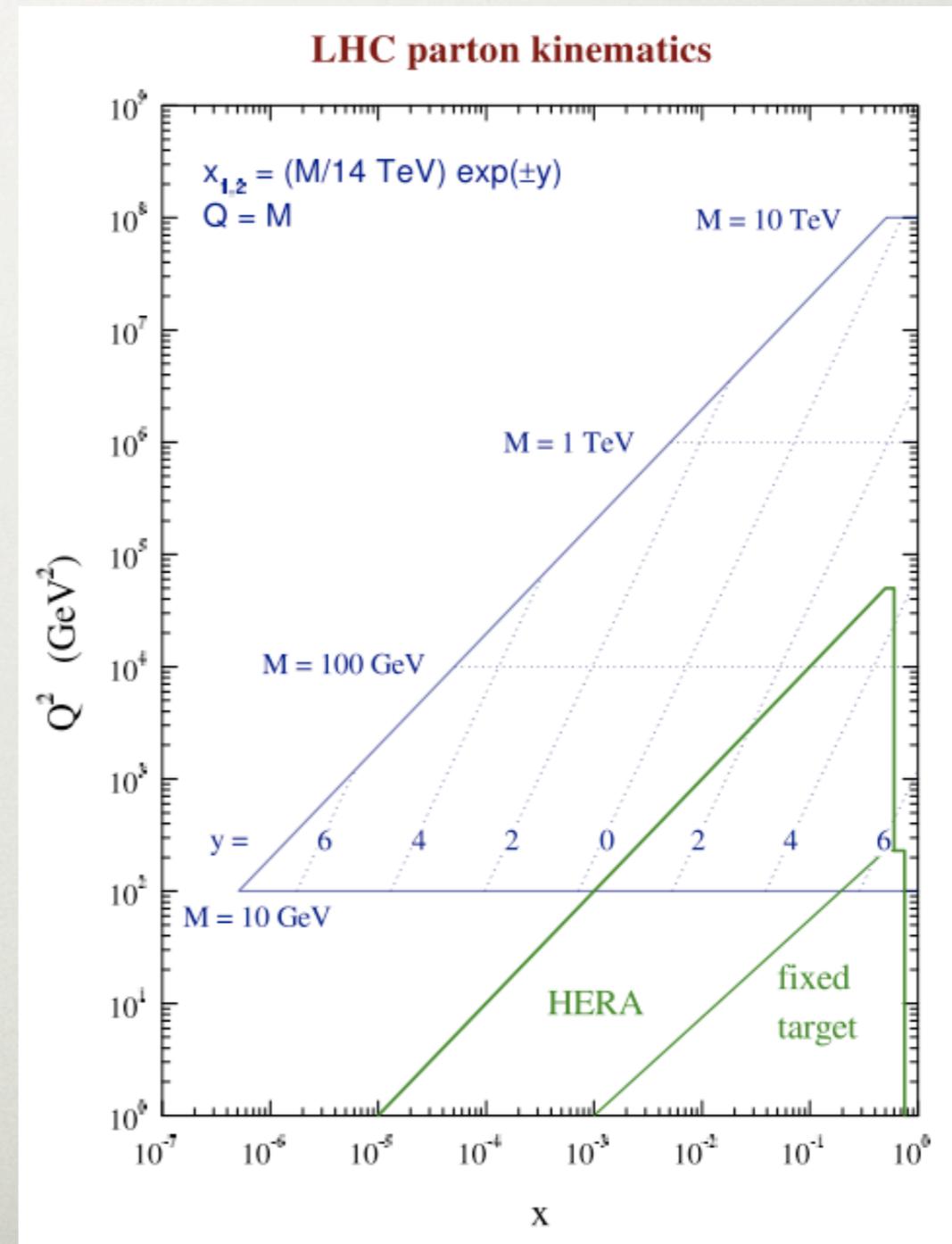
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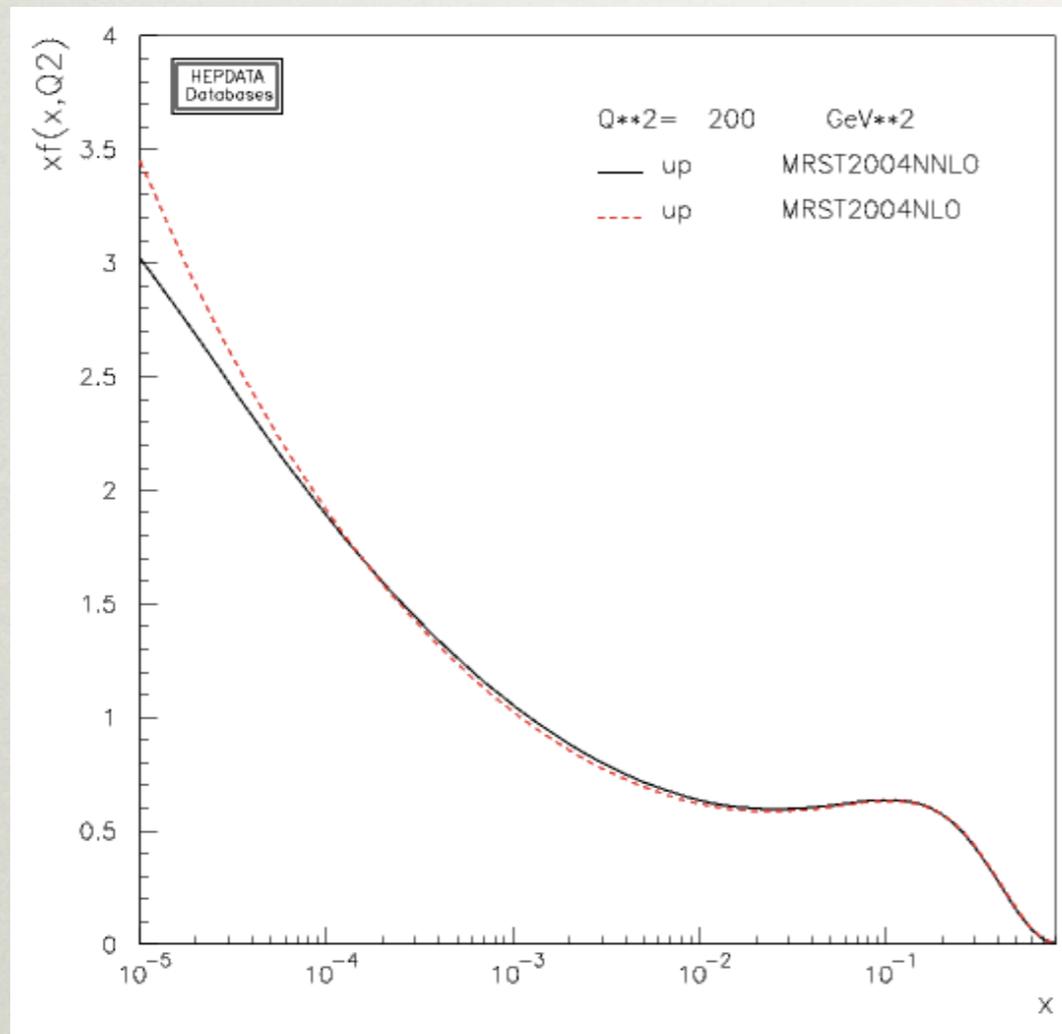
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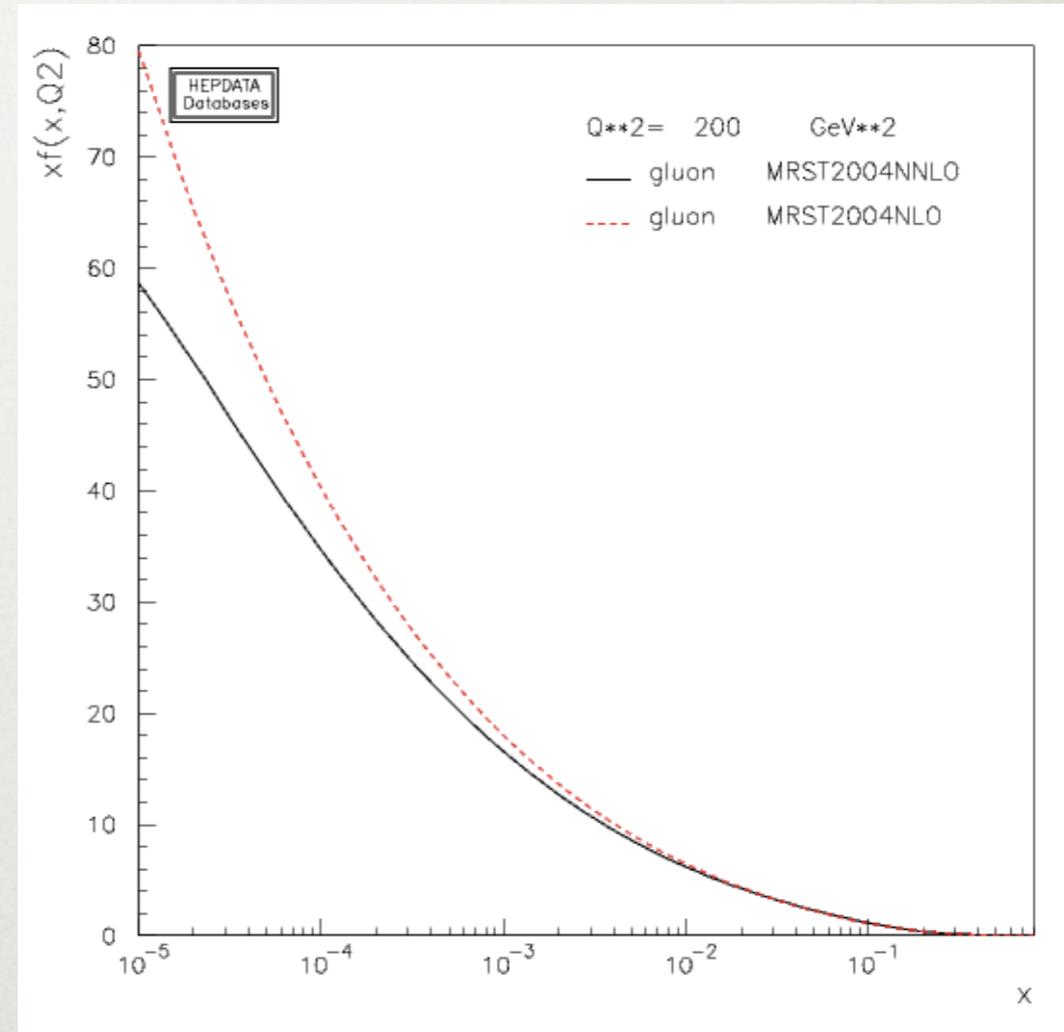
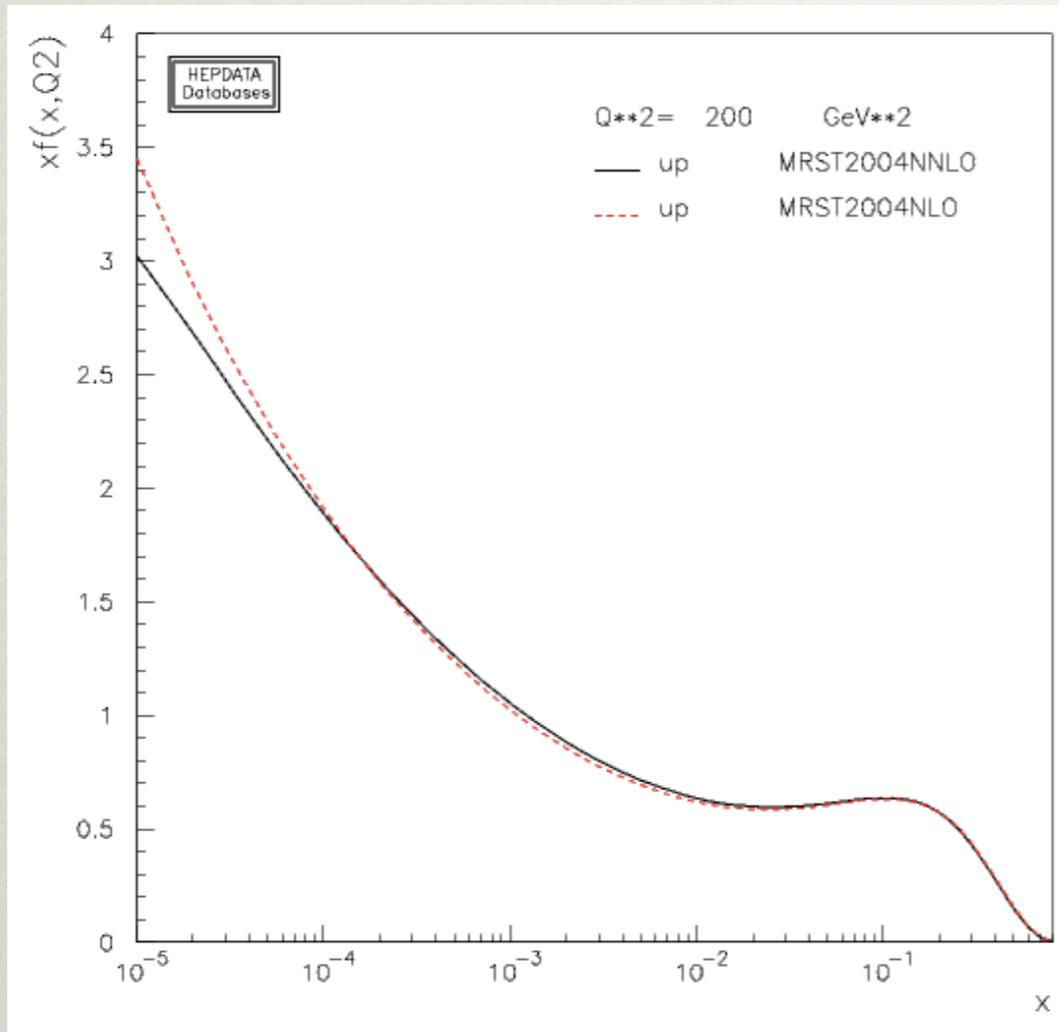
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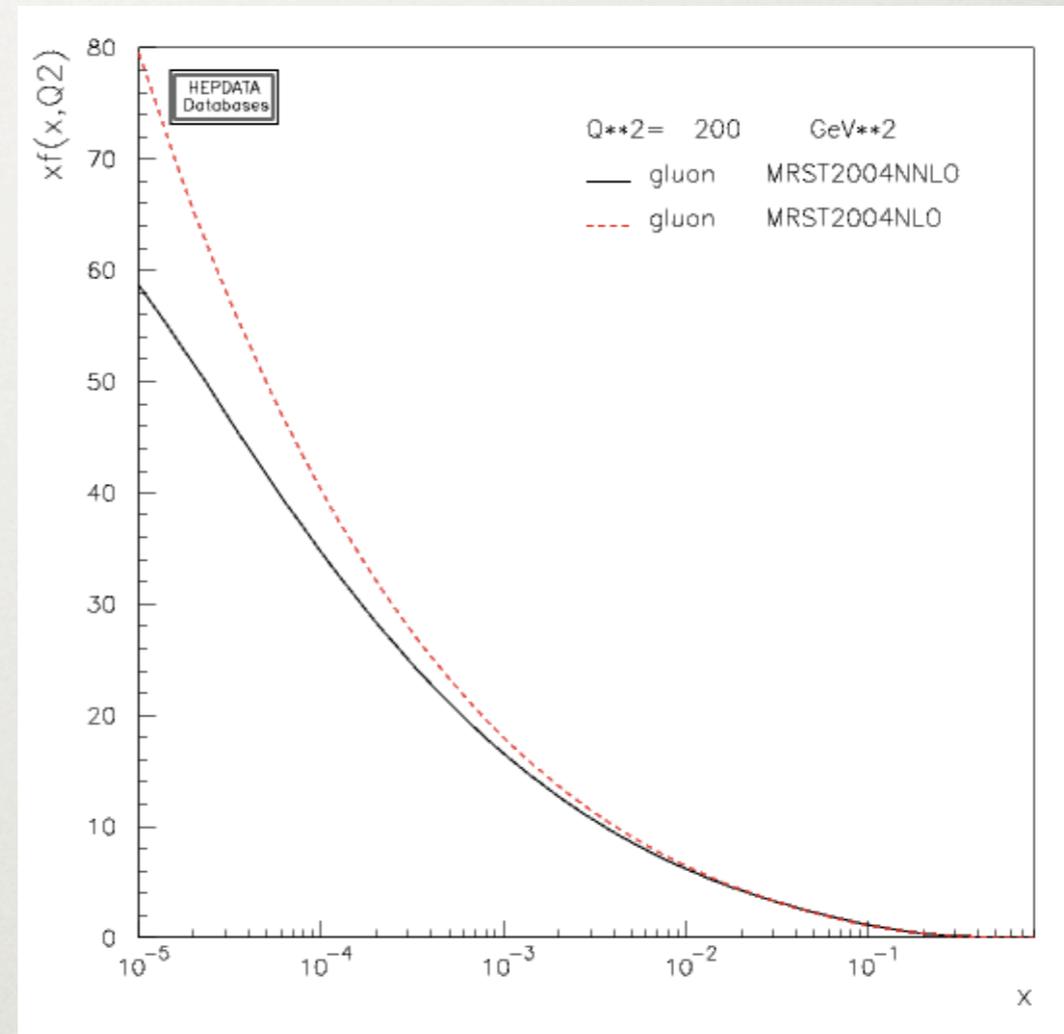
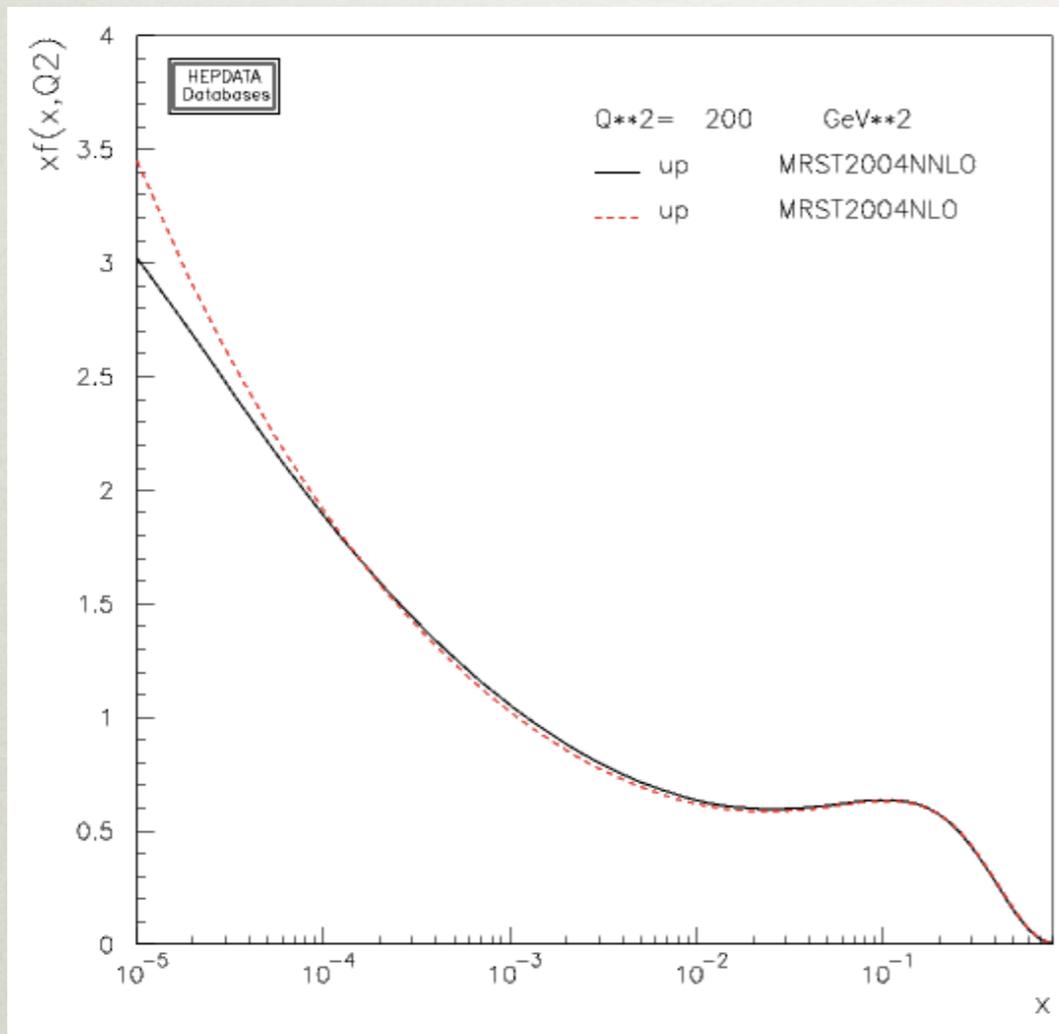
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- For truly NNLO global PDF fit, need all matrix elements to the same order. Some such information (D.-Y. at fixed target) is incorporated in e.g. MRST, although not complete (missing inclusive jets at Tevatron).

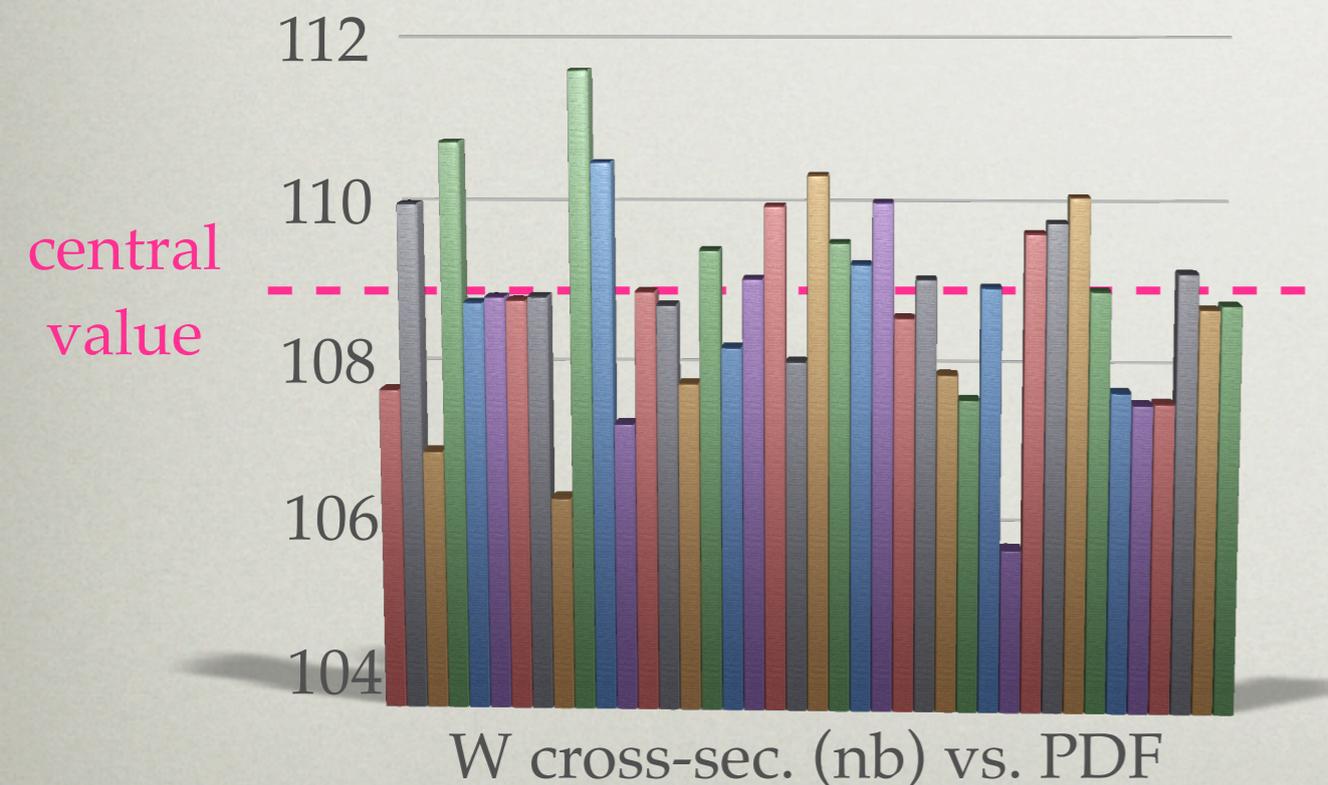
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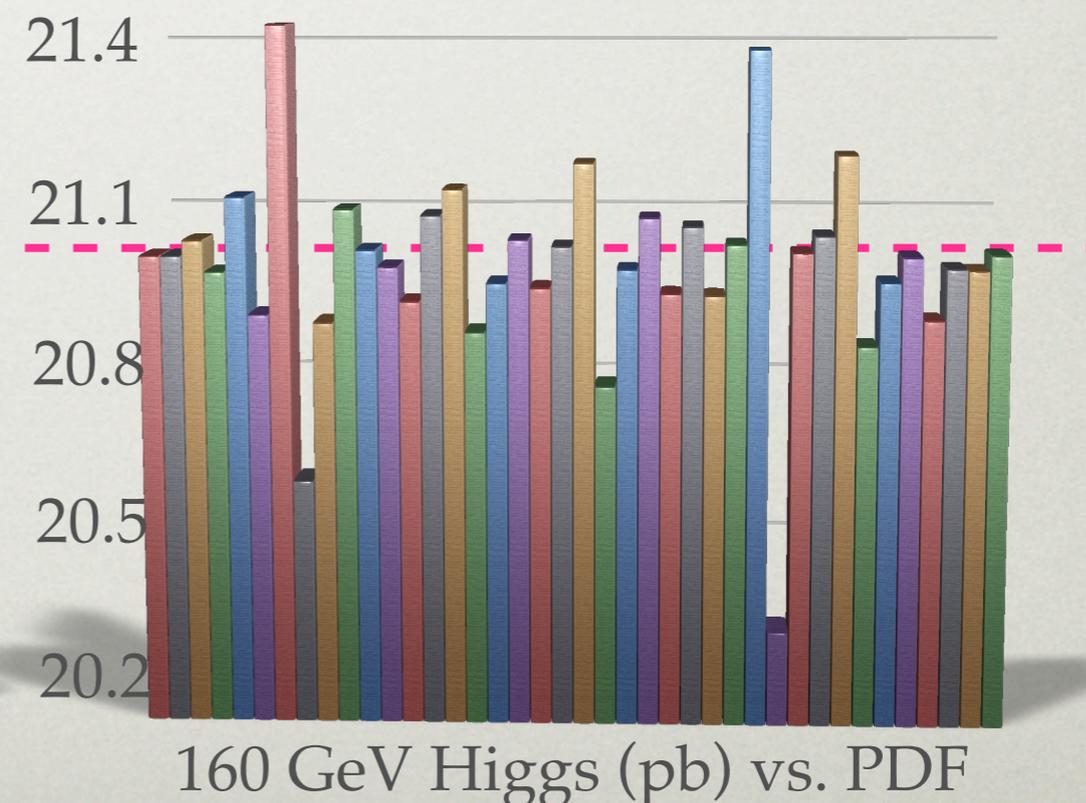
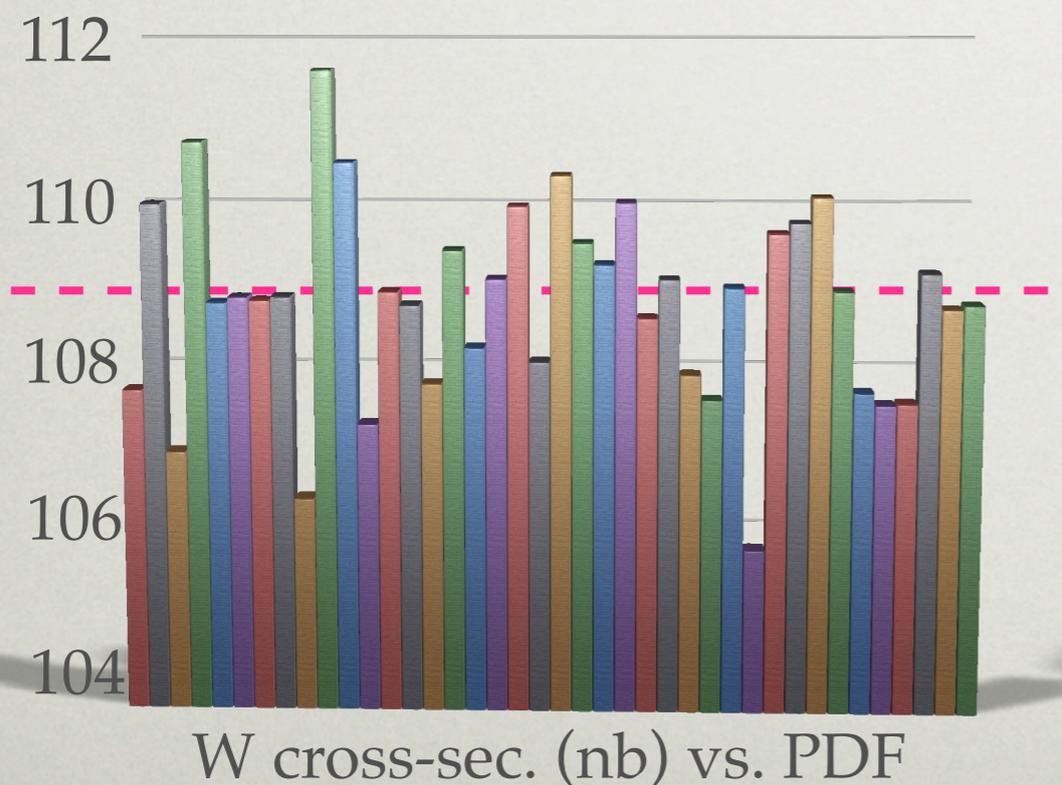
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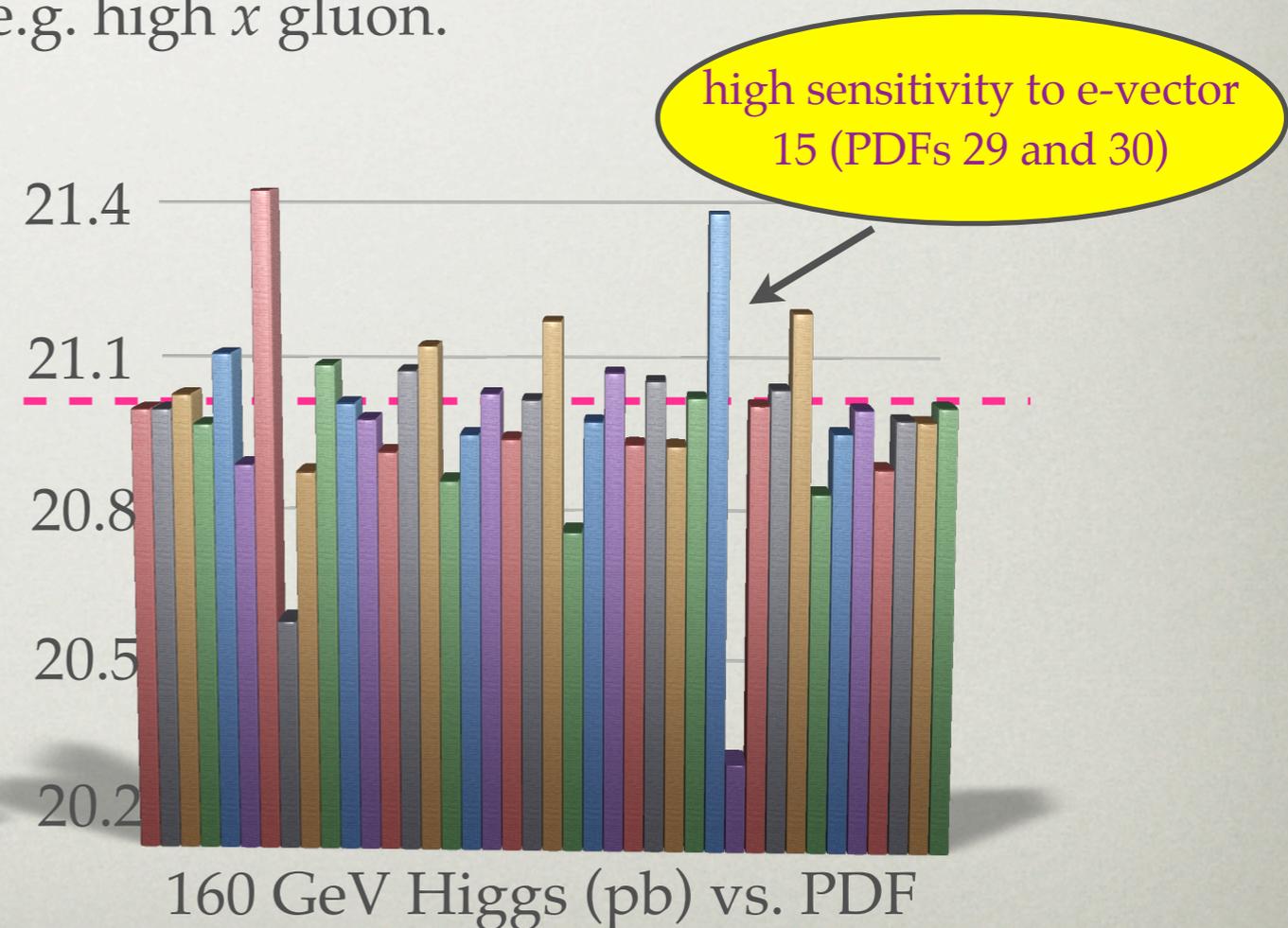
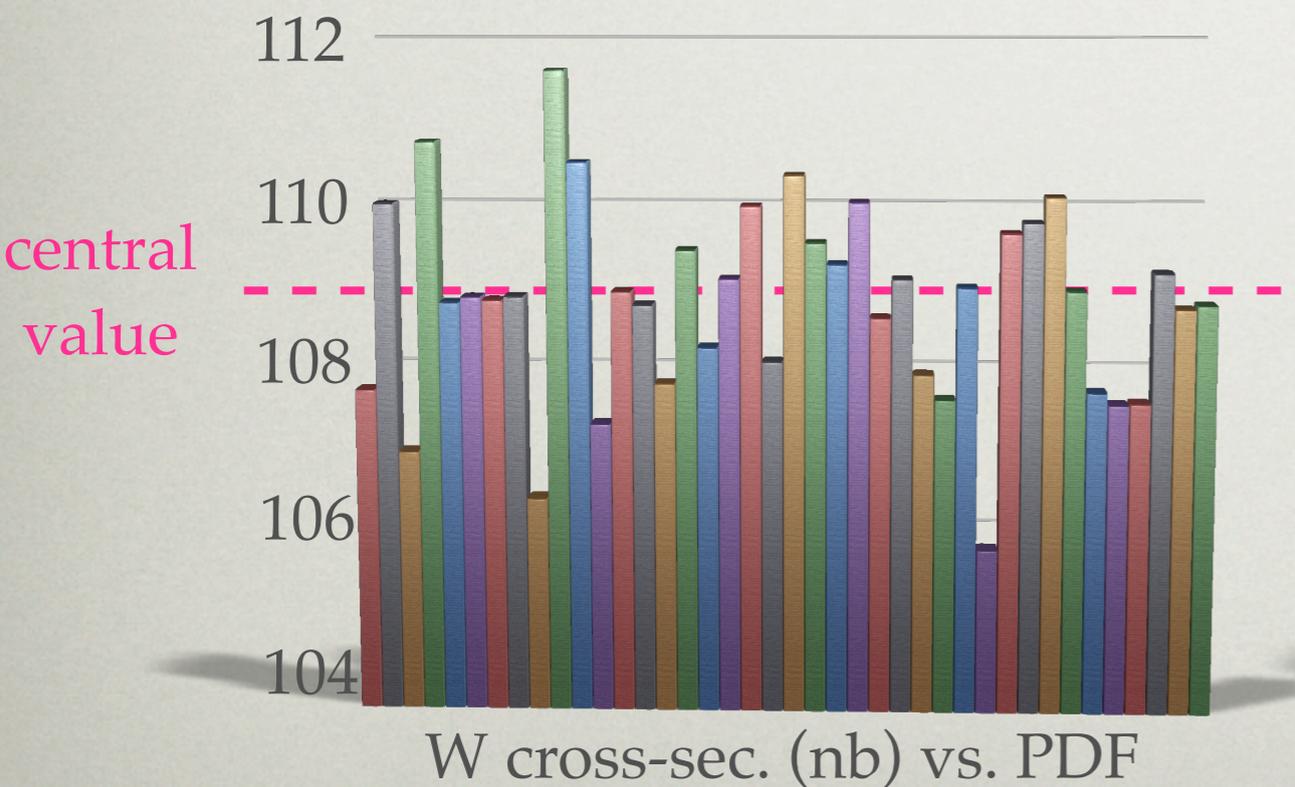
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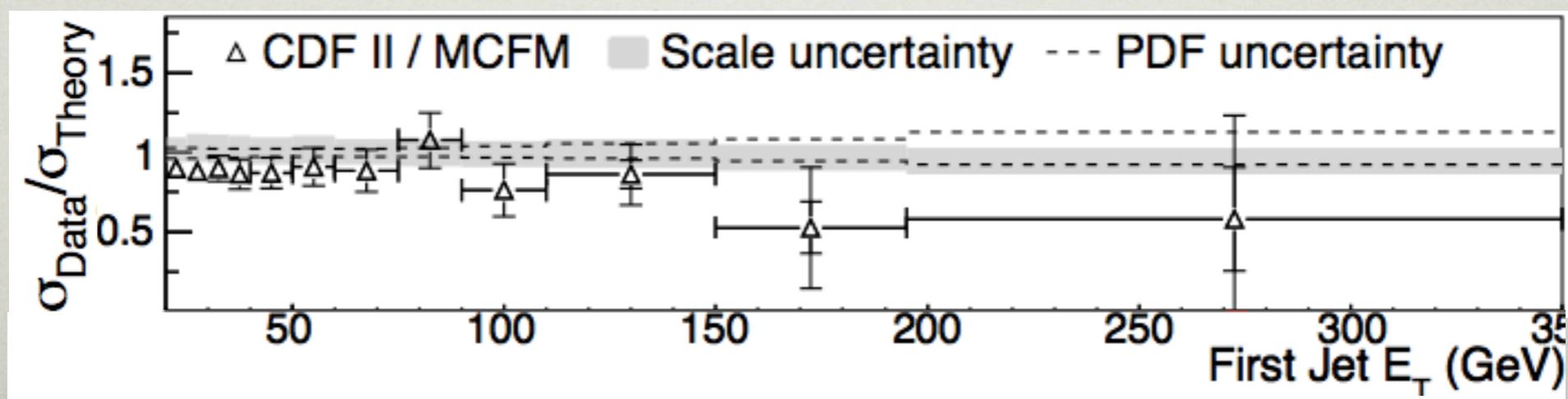
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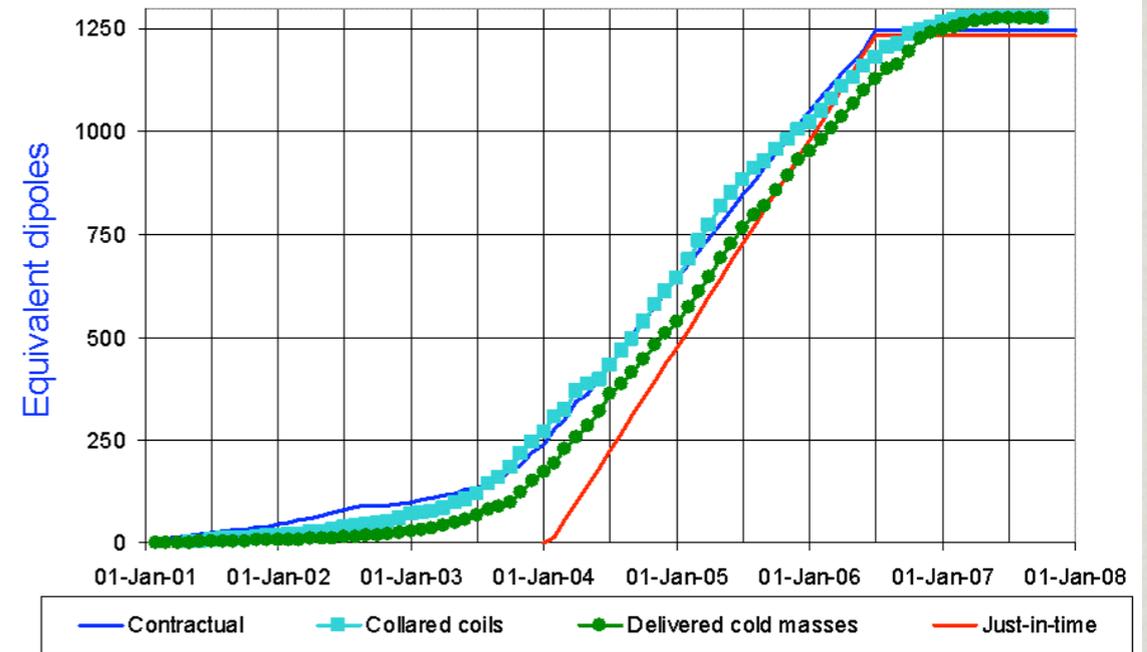


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Dipole cold masses



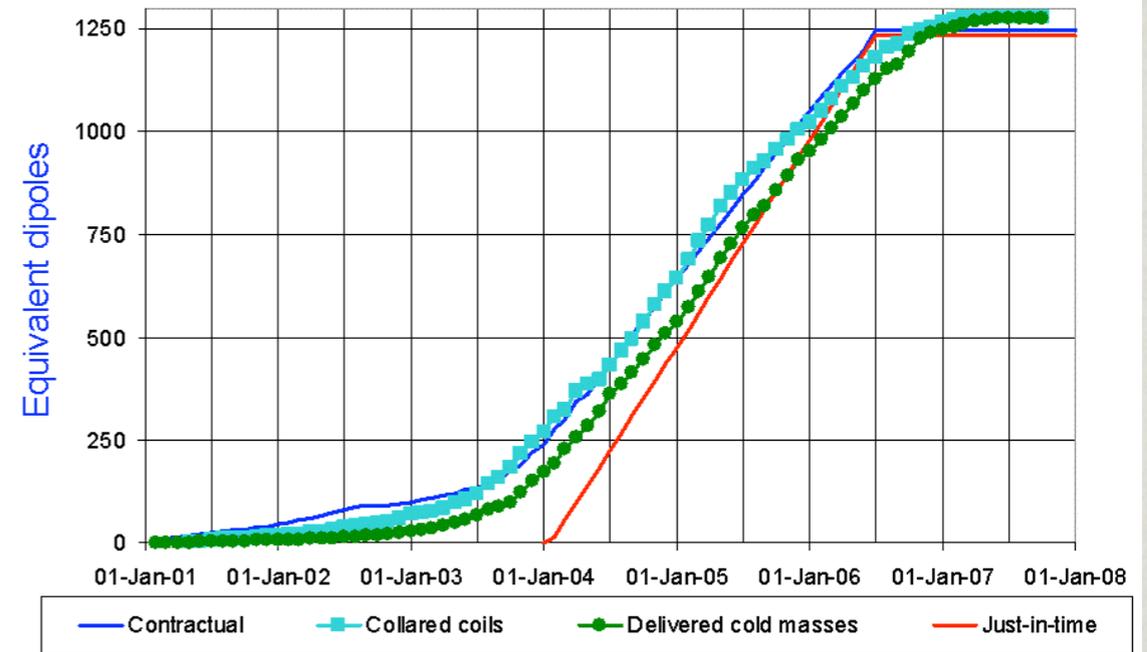
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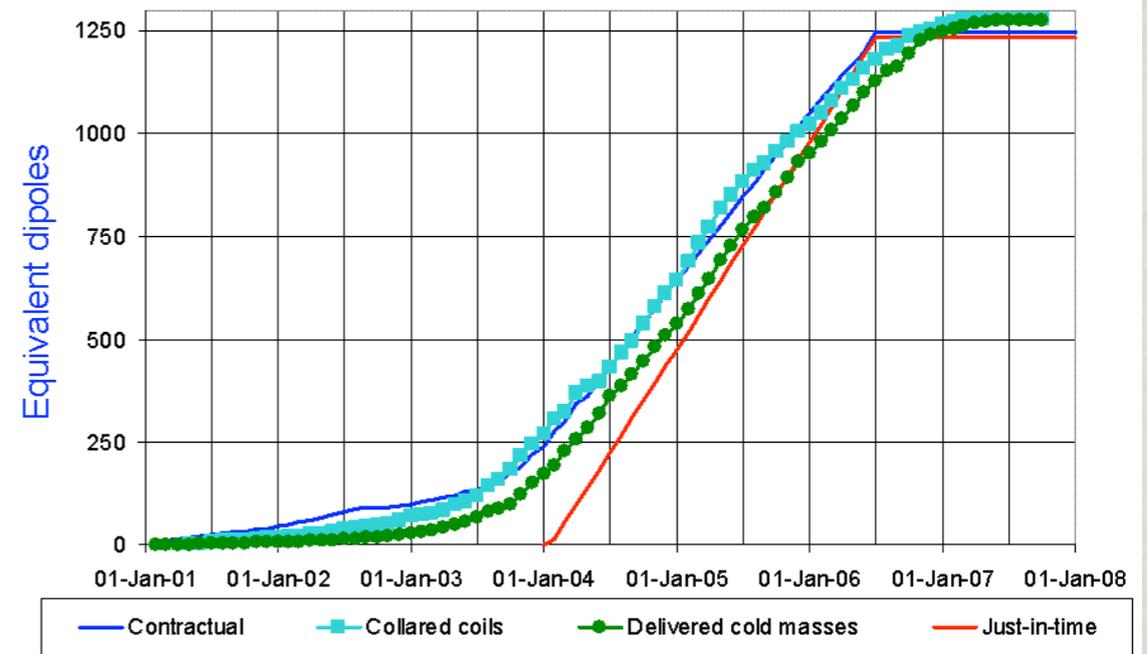
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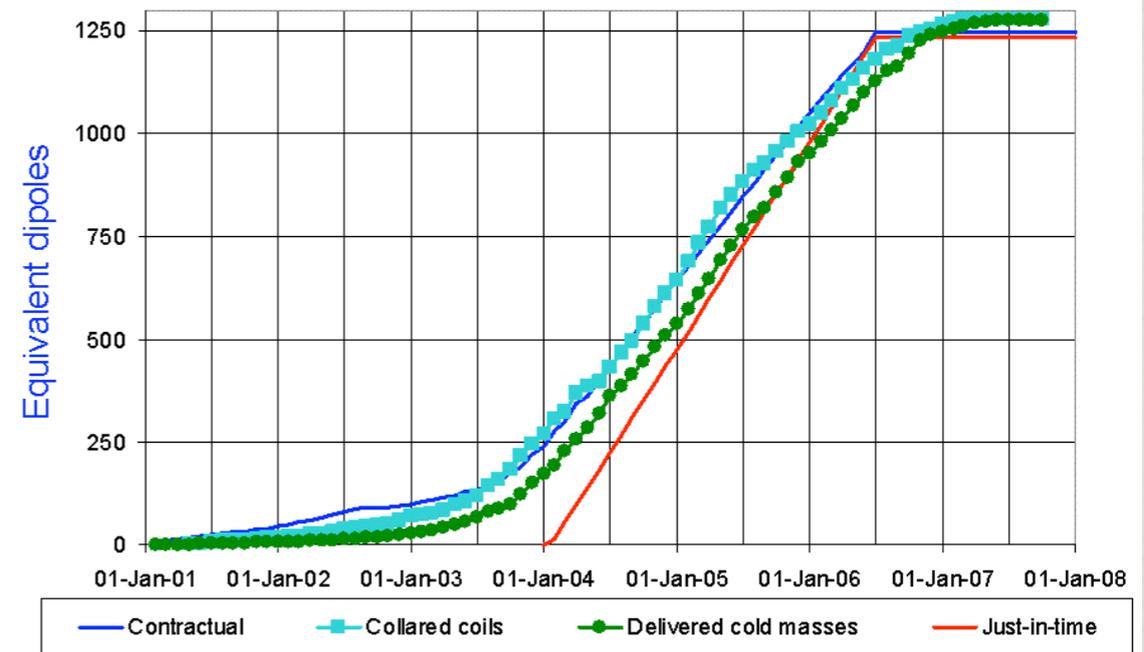
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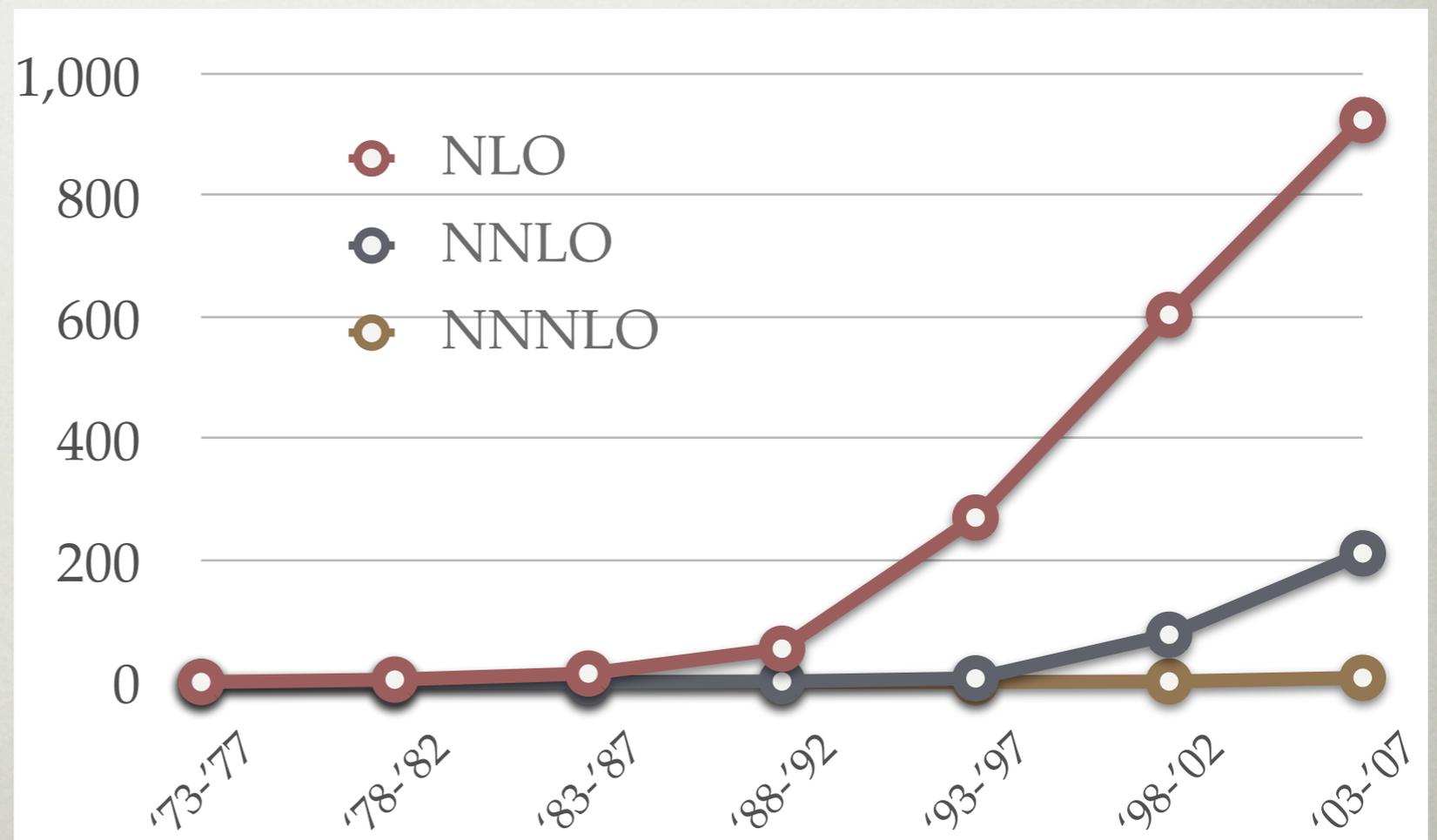
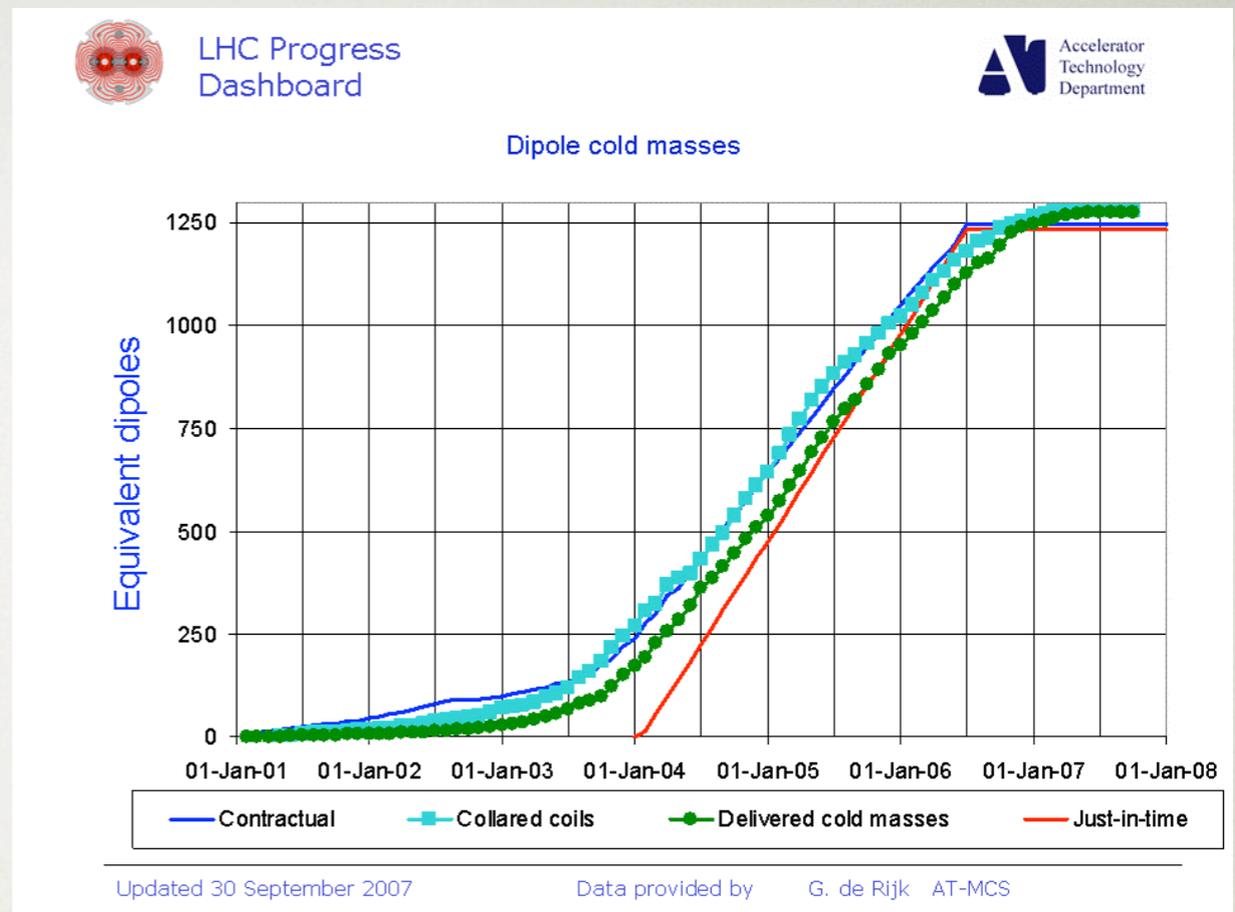
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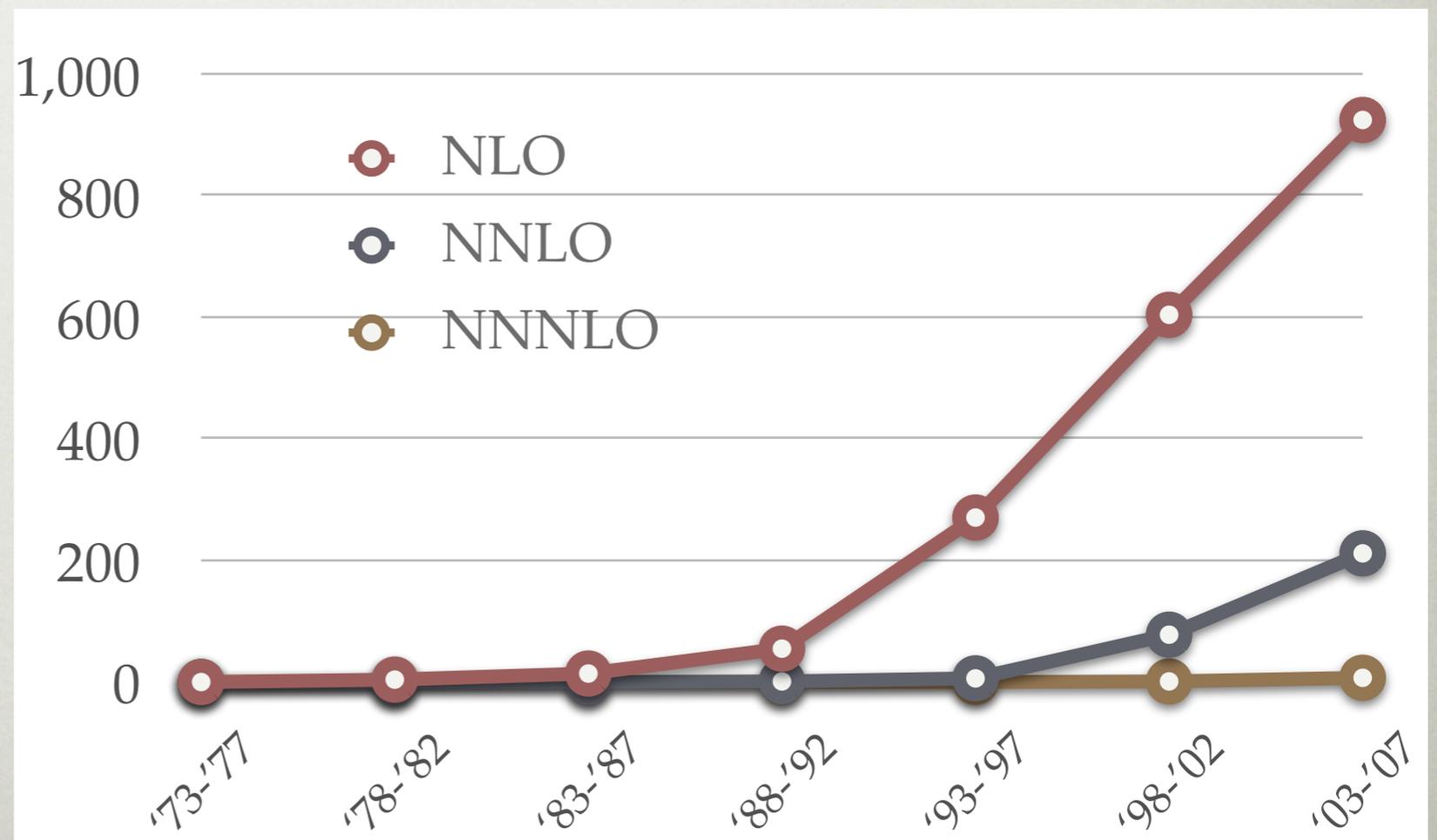
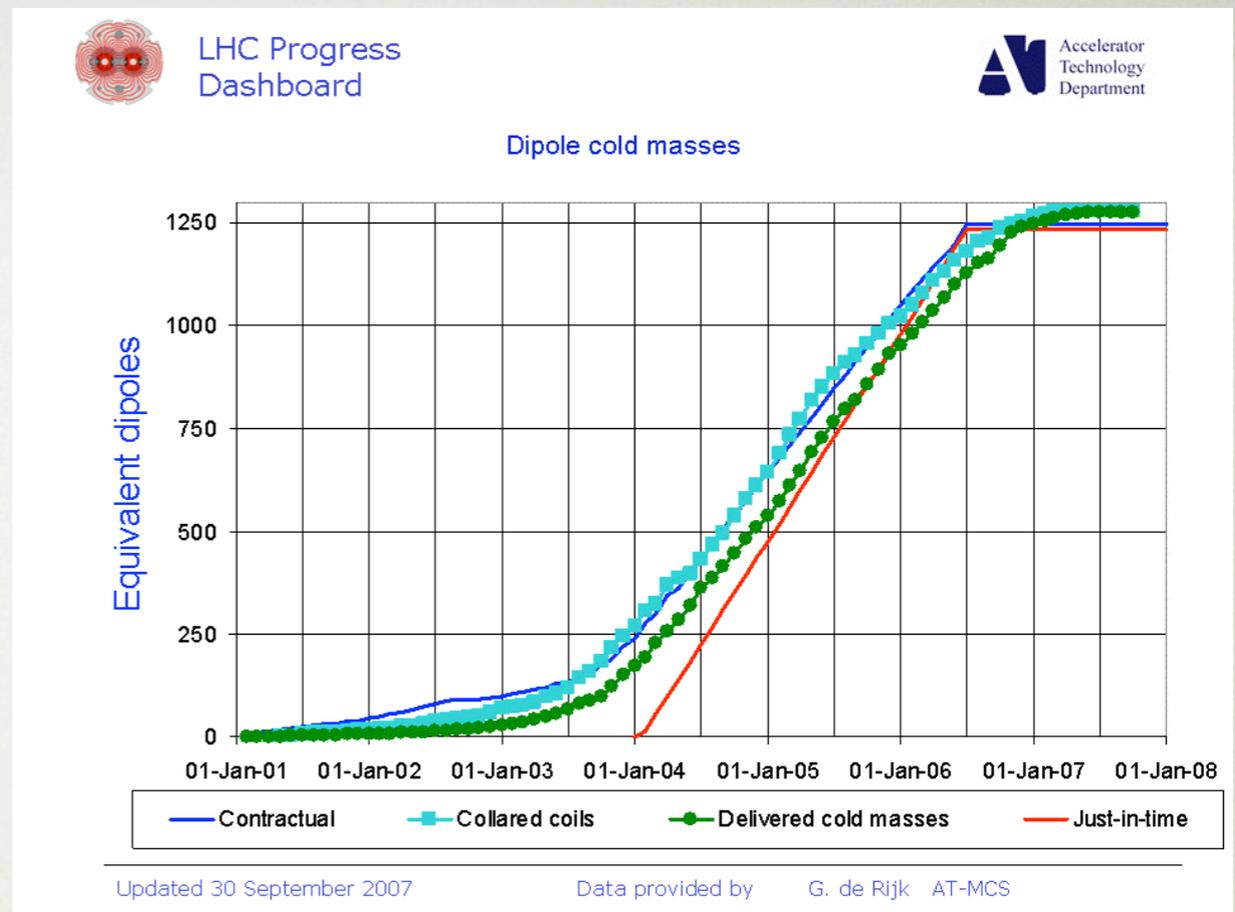
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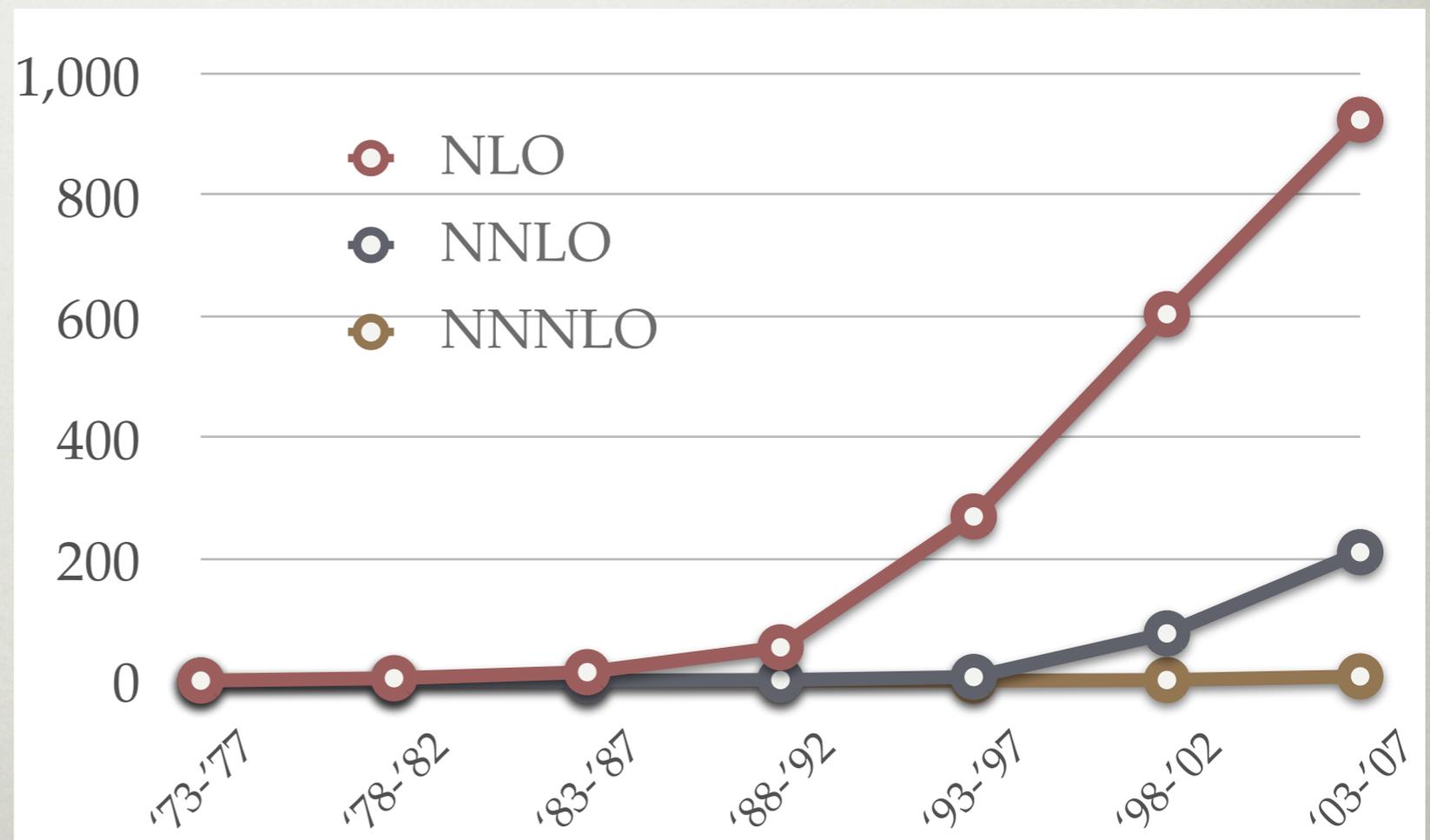
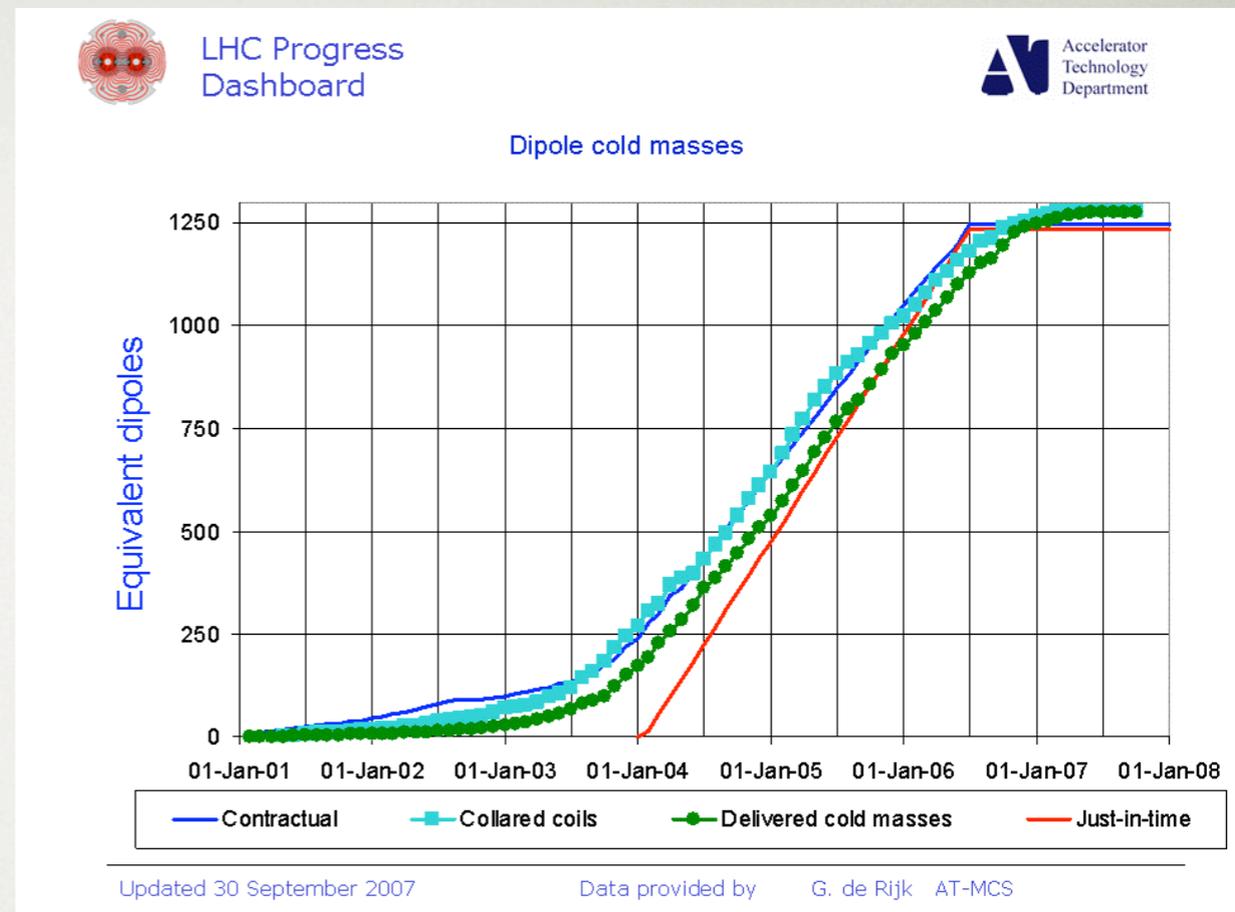
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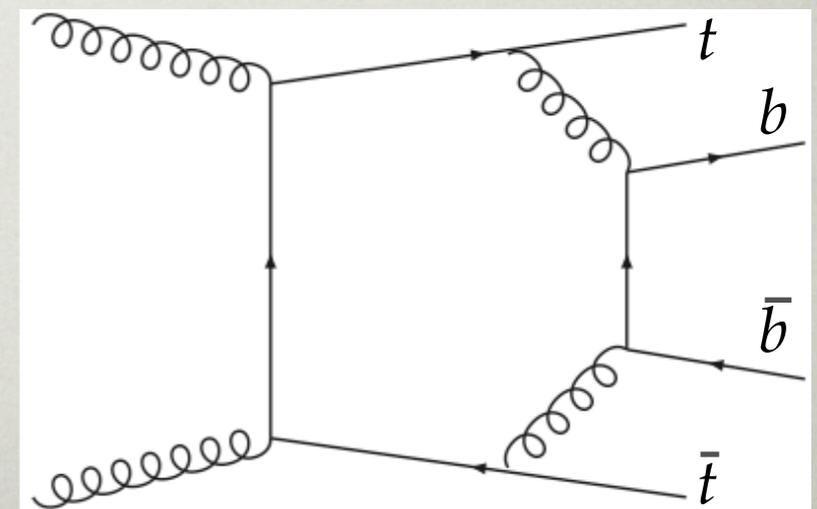
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- Even complete calculations are not yet suitable for a wide audience
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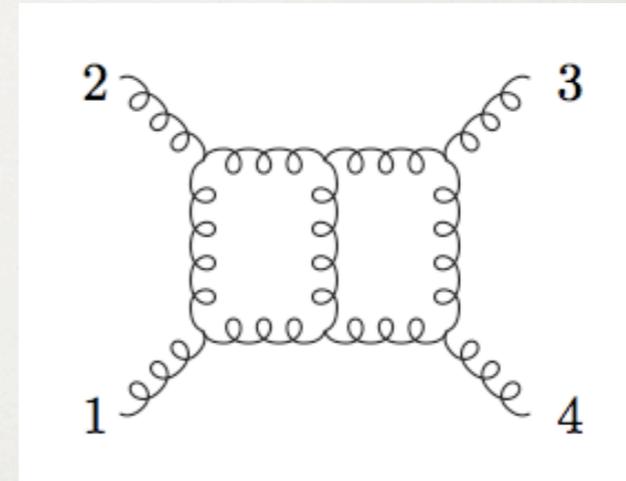
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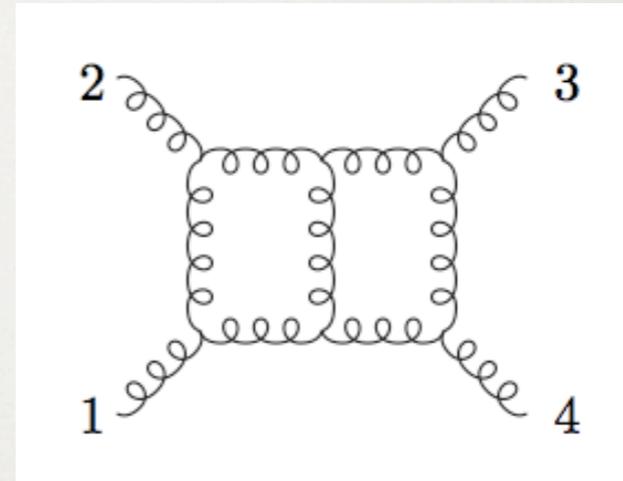


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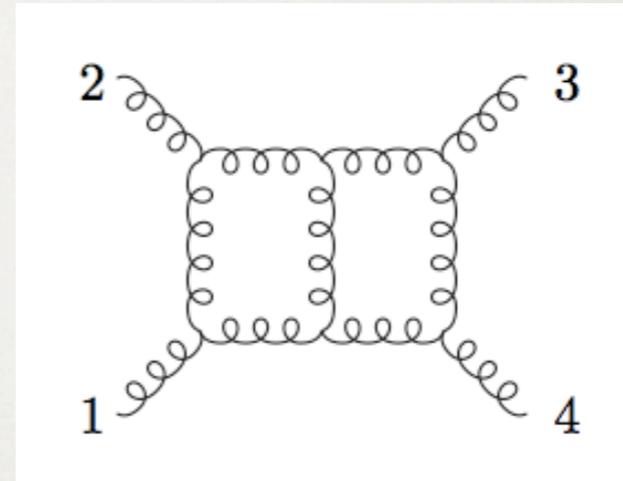
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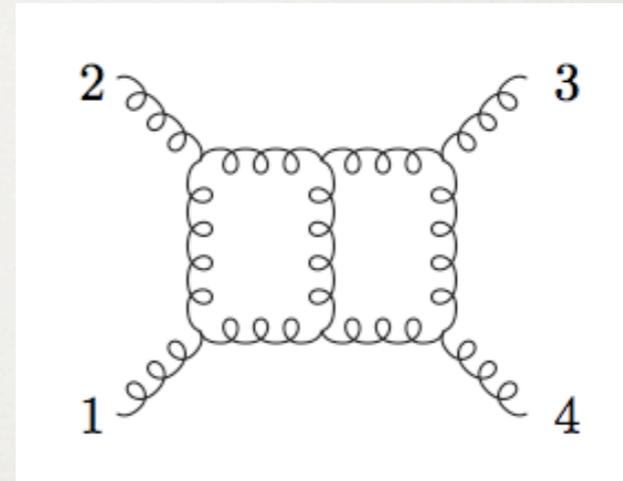
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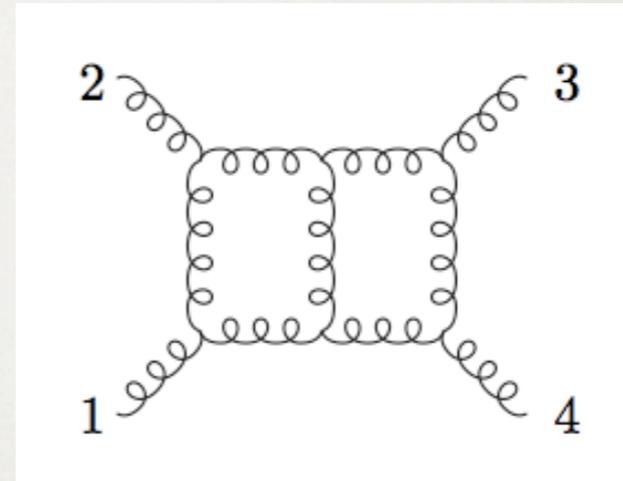
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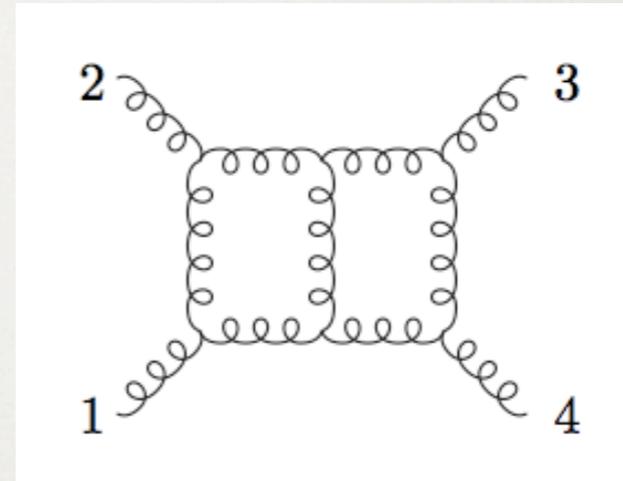


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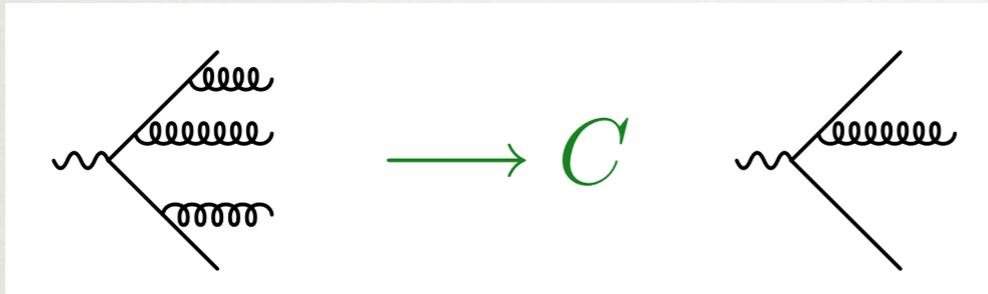


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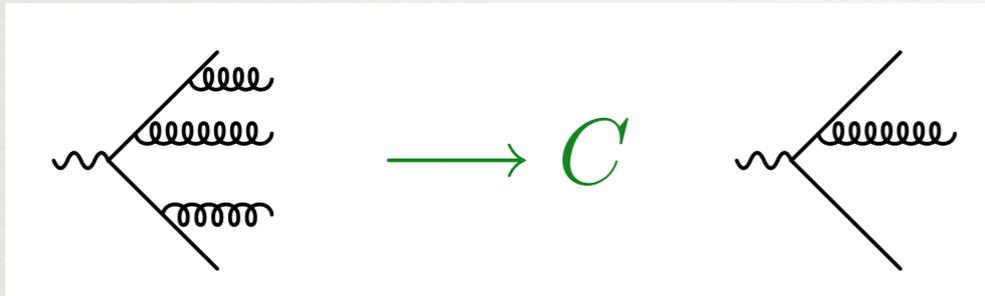
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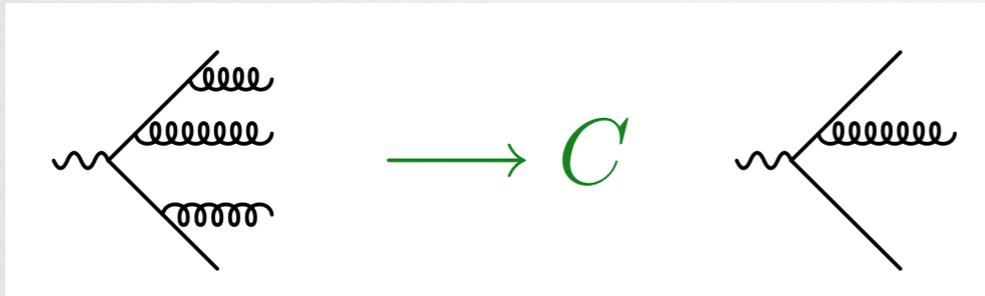


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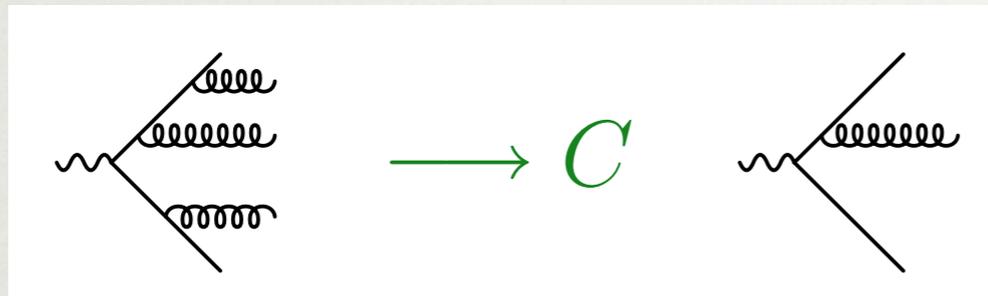
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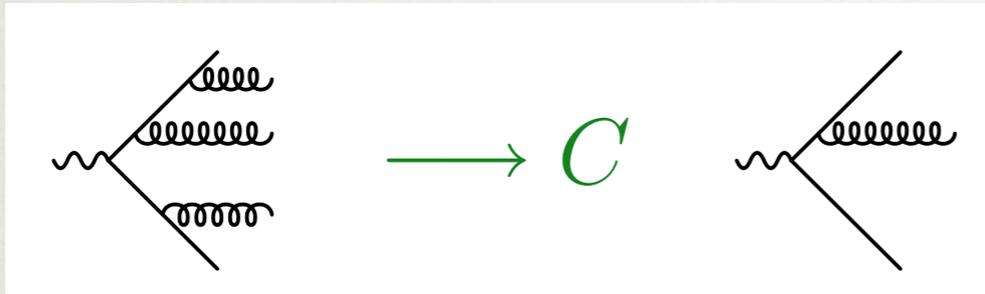
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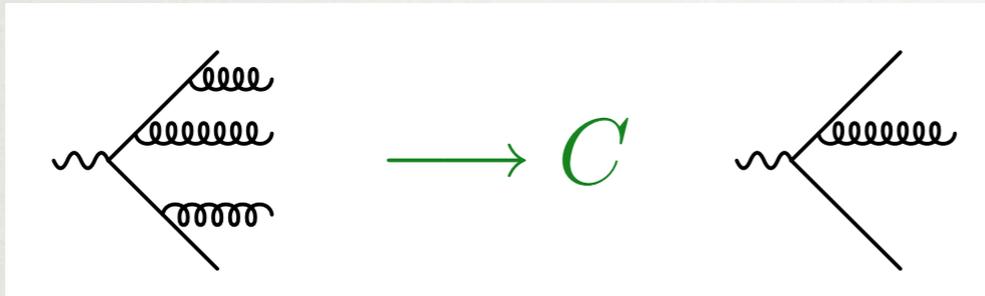
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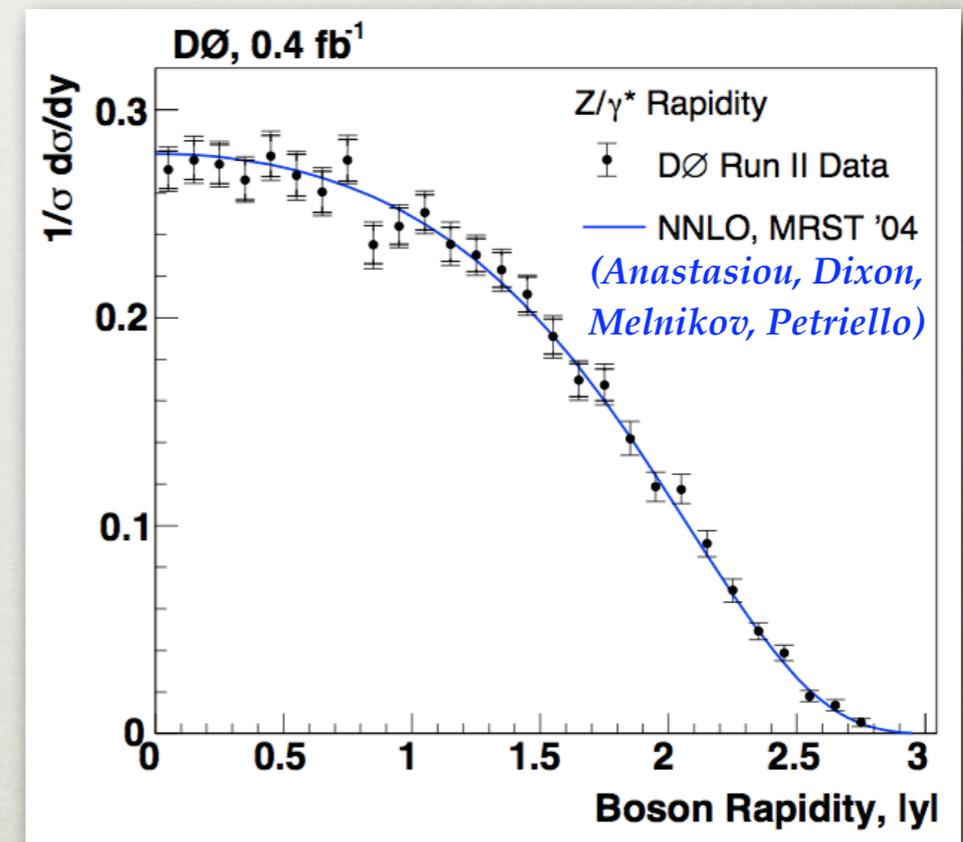
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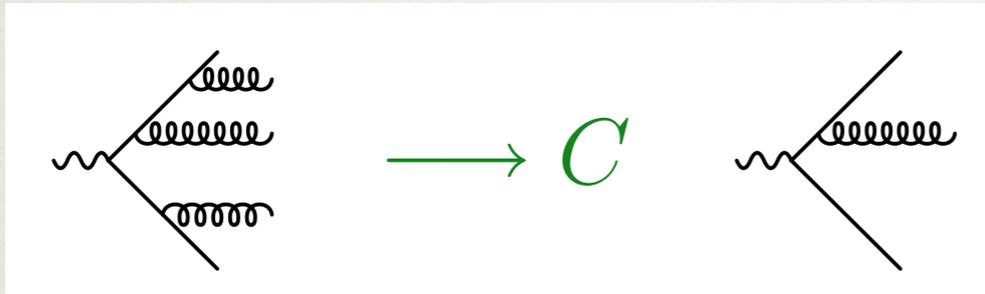


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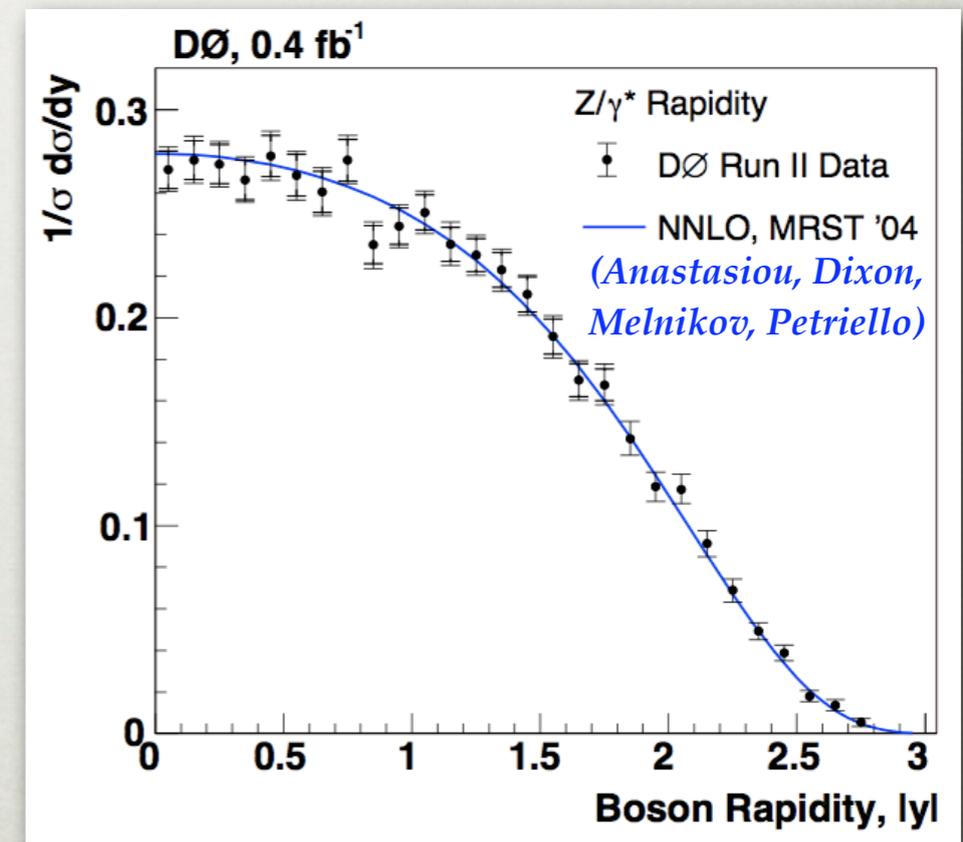


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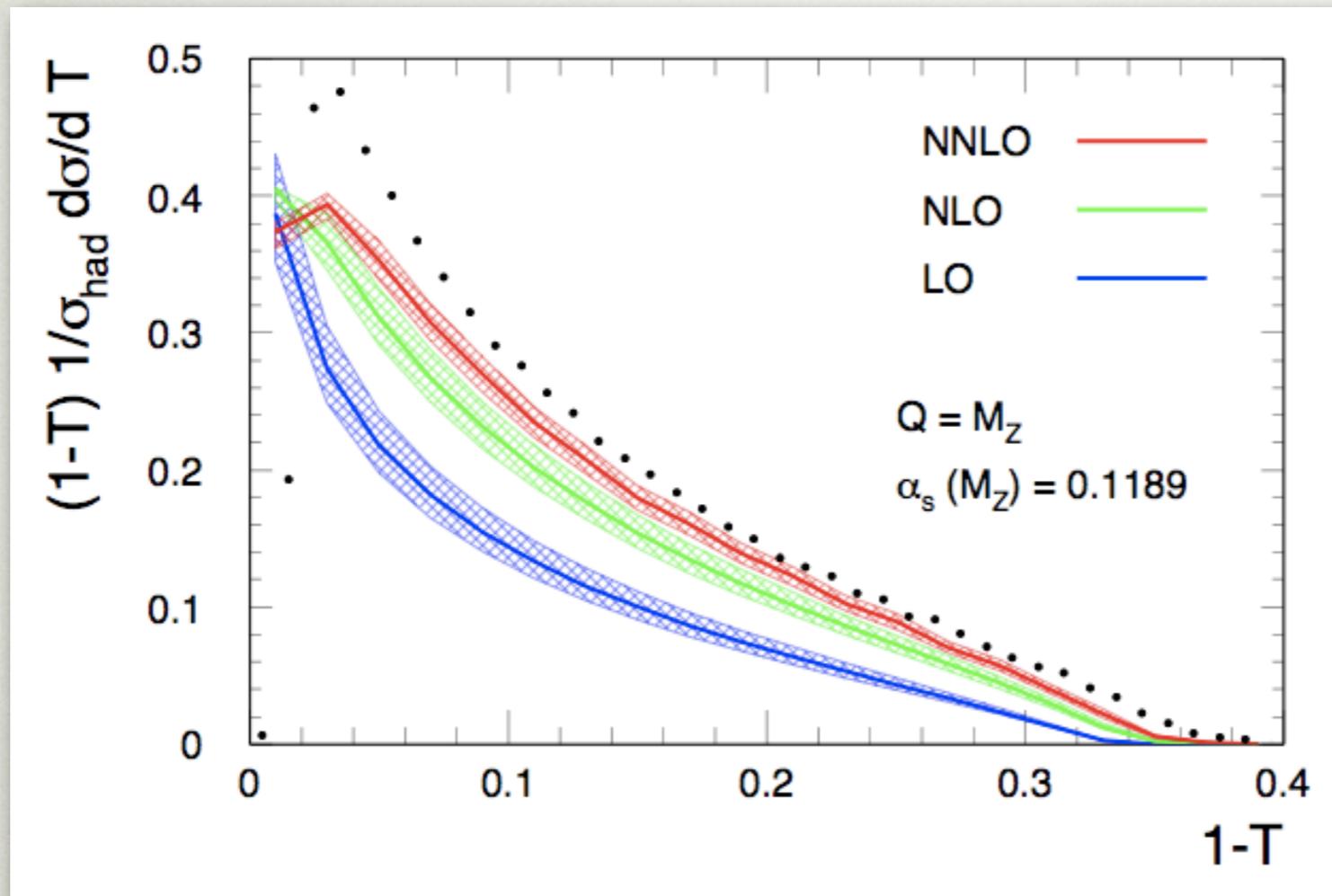


- A solution, the antenna-subtraction method, has been successfully applied to the NNLO calculation of 3-jet production in e^+e^- collisions.

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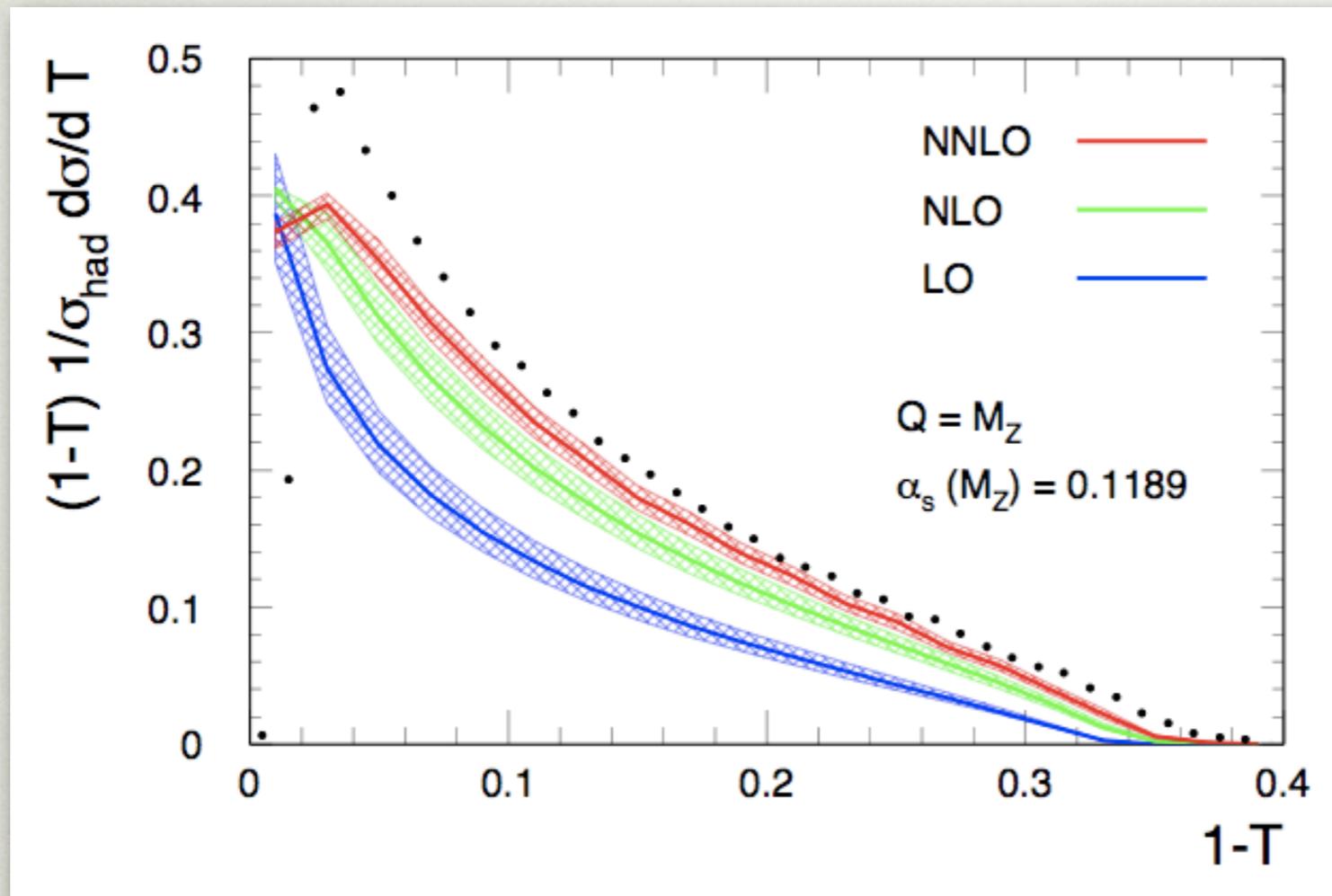


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Modest increase in prediction and reduction in scale uncertainty when going from NLO to NNLO

Improvement in shape when compared with ALEPH data (dots), requiring smaller hadronization corrections

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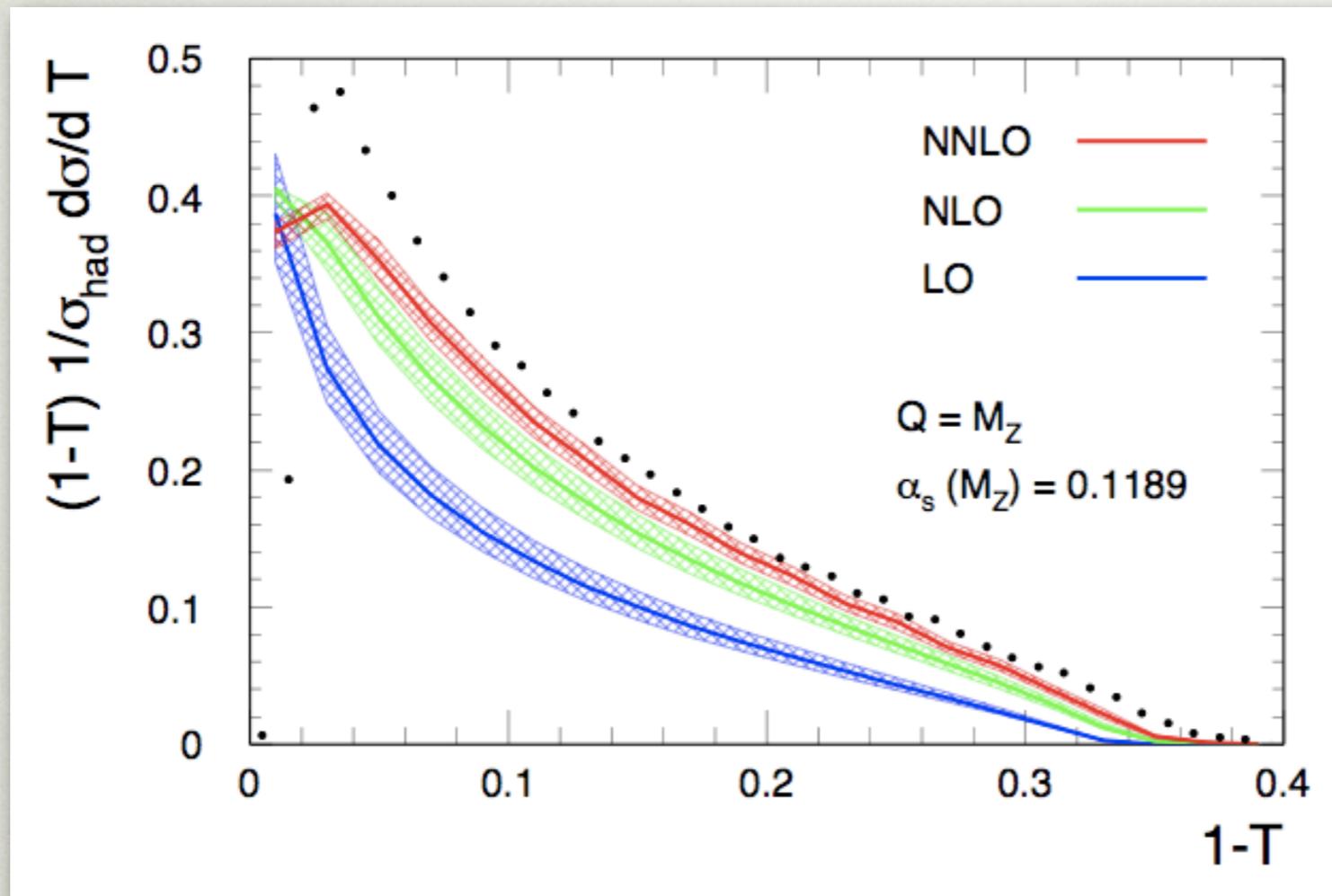
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- Technical challenge: singularities are now present also in the initial state and constraints on kinematics change. The same but different.

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Les Houches
workshop, 2005

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- Something simple missing? Theorists always happy for motivation!

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“The ideal would be the creation of a master program which for any desired process would generate the graphs, assign the momenta in the loops, evaluate the gamma matrix traces and colour algebra, and perform the integrals.”

CLNS 81/504
July 1981

QCD CORRECTIONS TO THE GLUONIC WIDTH OF THE T MESON

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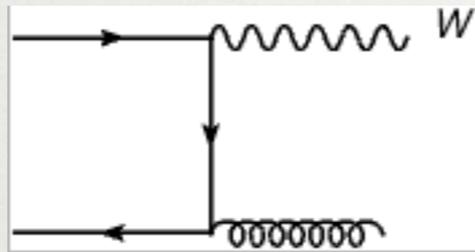
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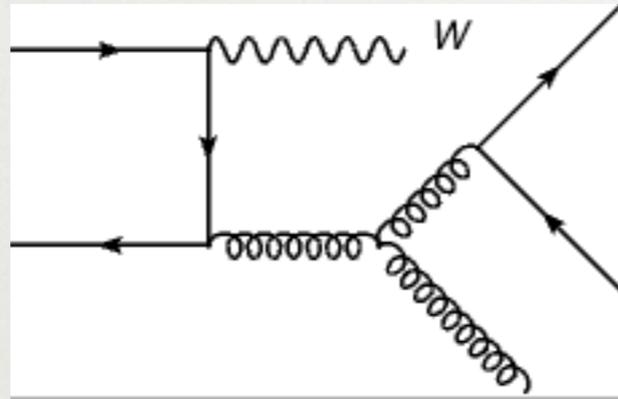
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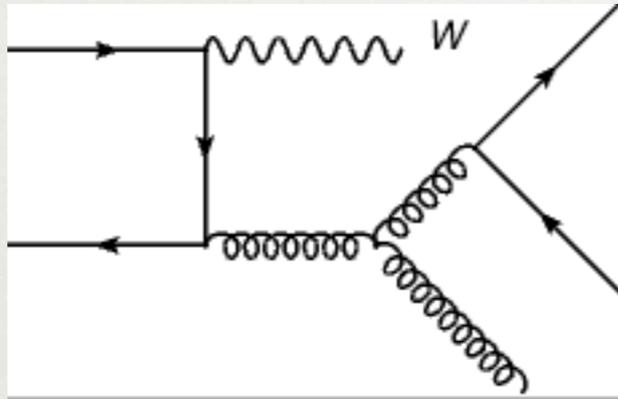
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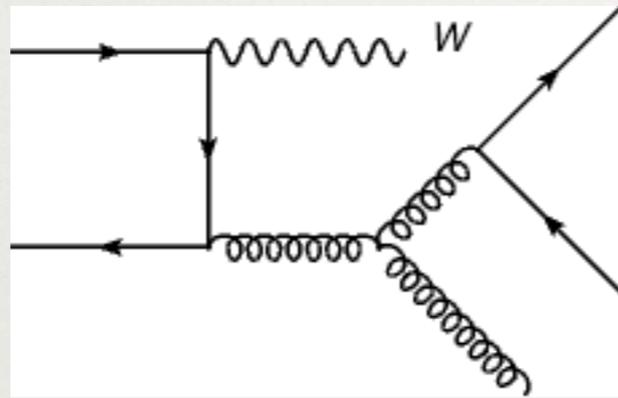
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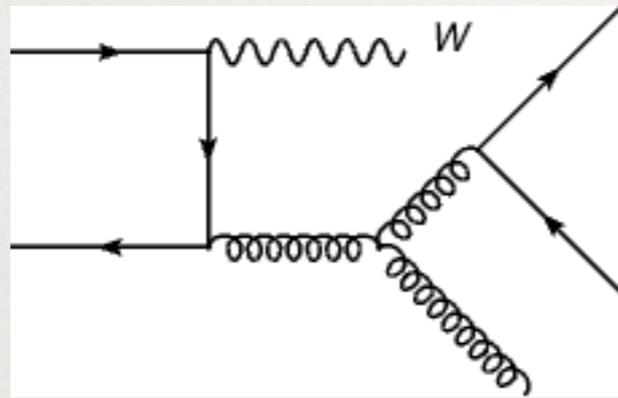


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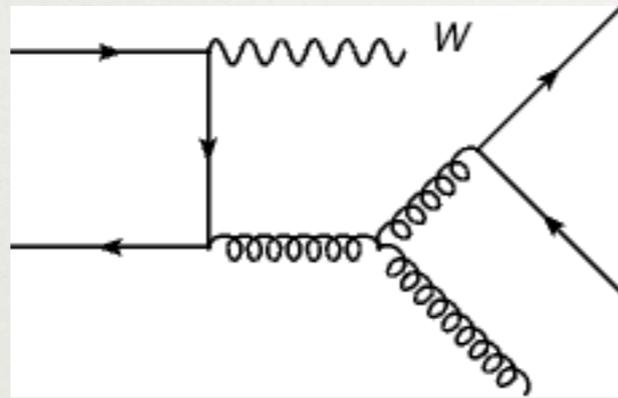


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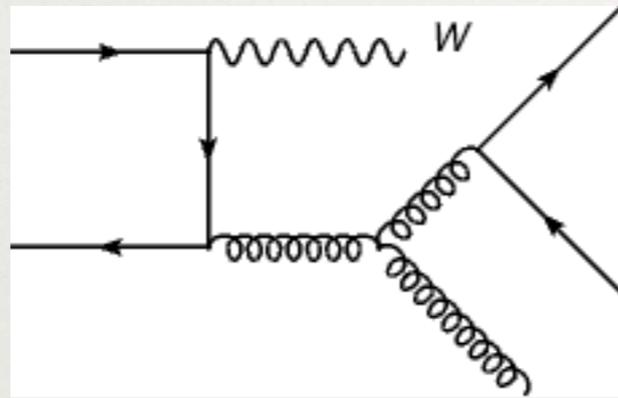


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- Largely complementary to fixed order, where predictions are parton-level only and are generally not valid at low p_T . Horses for courses!

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