

Top quark mass effects in W^+W^- production through gluon fusion

Young Scientists Meeting 2026, Aachen

Mateusz Czaja

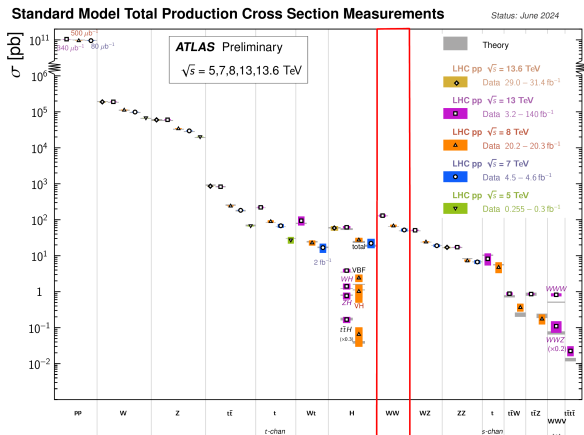
in colaboration with Matthias Steinhauser, Daniel Stremmer, and Ben Rott

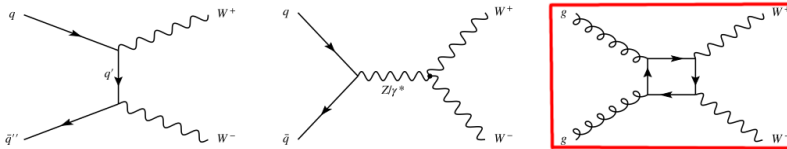
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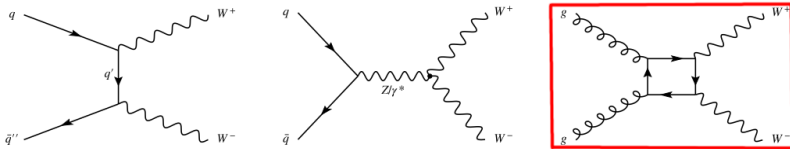
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- This project contributes to the $ggXY$ package [D. Stremmer, 2026].
- W^+W^- production measured with the highest precision among all di-boson channels.
 $\sigma_{pp \rightarrow WW} = (127 \pm 4) \text{ pb}$ [ATLAS Collaboration, 2025].
- Expected experimental precision below 1% during the HL-LHC phase.

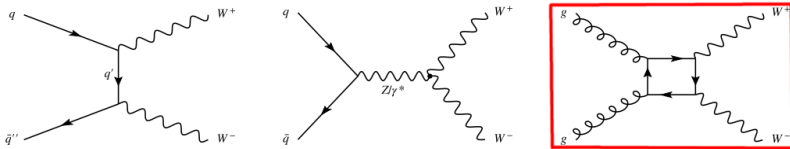




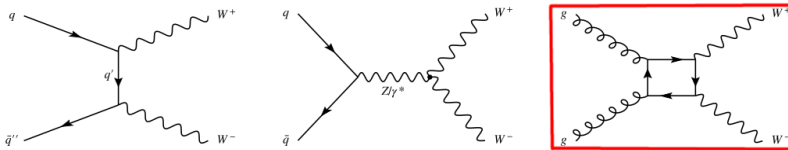
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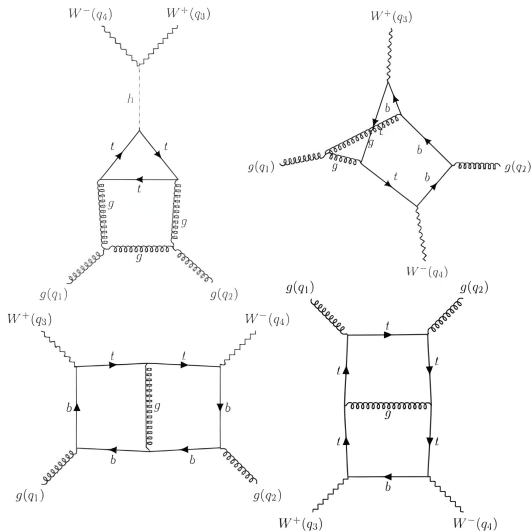
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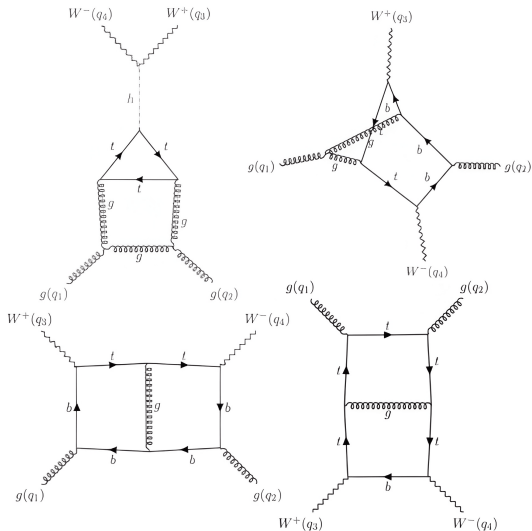
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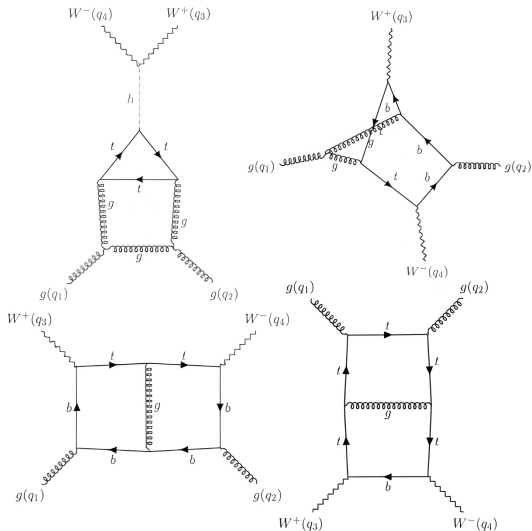
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- The $q\bar{q}$ background reduced in the region of collinear leptons produced in the decays of the W bosons. The gluon fusion contribution grows from 5% to 30%.



- The NLO QCD contribution to $\sigma_{gg \rightarrow WW}$ computed for massless quarks in [F. Caola, et al., 2016] The correction increased $\sigma_{pp \rightarrow WW}^{(total)}$ by $O(2\%)$ and $\sigma_{gg \rightarrow WW}$ by $O(50\%)$.

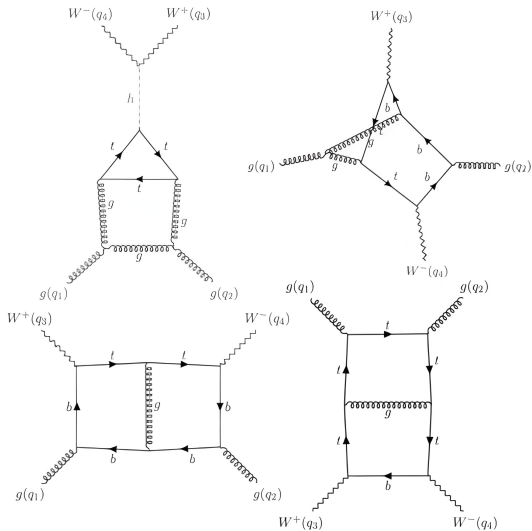


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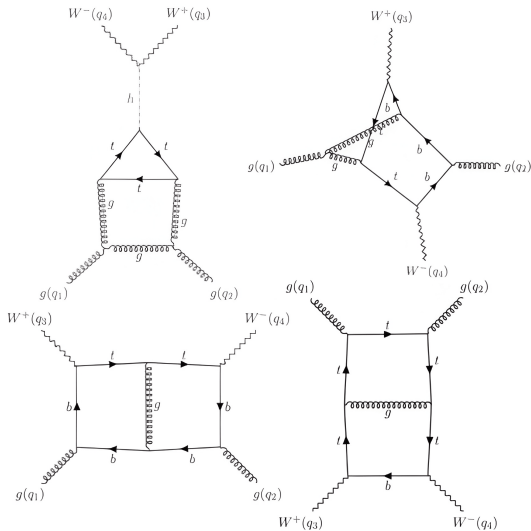


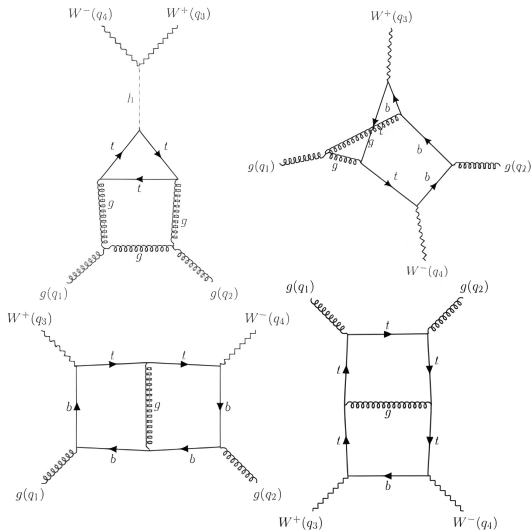
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- **The goal of the project: compute two-loop QCD contribution of the third quark generation to $\sigma_{gg \rightarrow WW}$ for arbitrary parameters.**

- Diagrams generated with QGraf. Two classes:
 - Triangles with an intermediate h or Z .
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 - Boxes with $W^\pm$ attached to the quarks directly.
- 99 diagrams contributing to the boxes at the 2-loop level.
- The amplitude is constructed automatically:
 - The Feynman rules are inserted with TAP IR.
 - The Dirac and Lorentz algebra done with the in-house CALC setup.
 - Each term mapped onto a scalar integral depending on s , t , W virtualities $q_{3,4}^2$, and m_t .

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Breaks down for large p_T .

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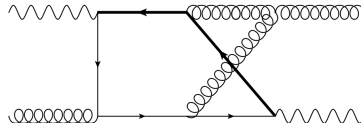
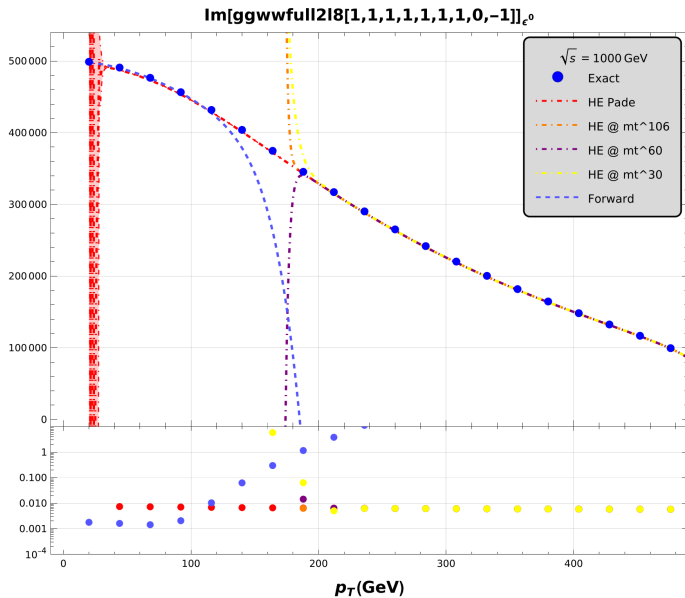
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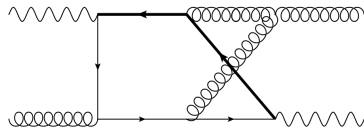
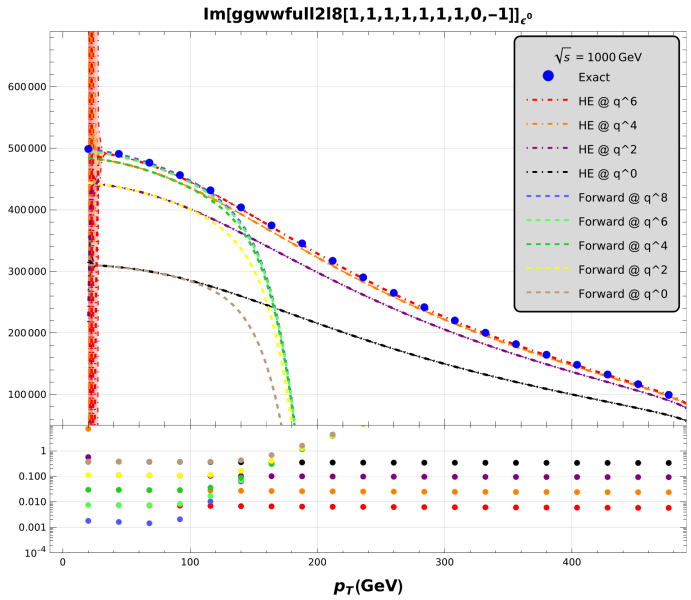
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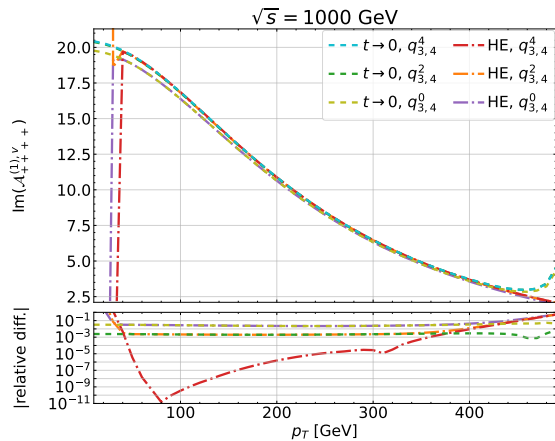
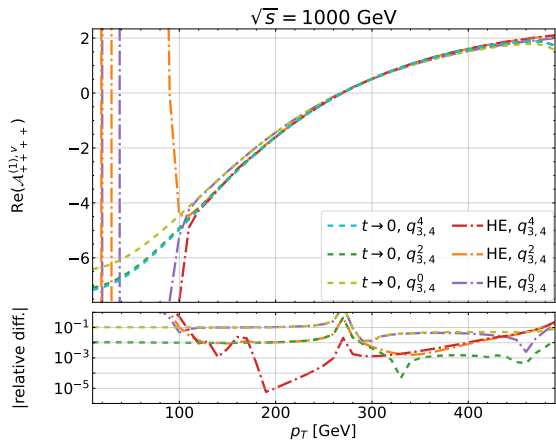
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- Boundary conditions expressed using Mellin-Barnes integrals. Computed using various inverse Mellin transform techniques. For the most complicated masters, we also utilized the DE in t/s .







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- Around 300 new master integrals computed with a heavy use of DEs and Mellin-Barnes techniques.
- The analytic results allow for an efficient computation of the amplitude.