LOOP TREE DUALITY FOR COLLIDER PREDICTIONS

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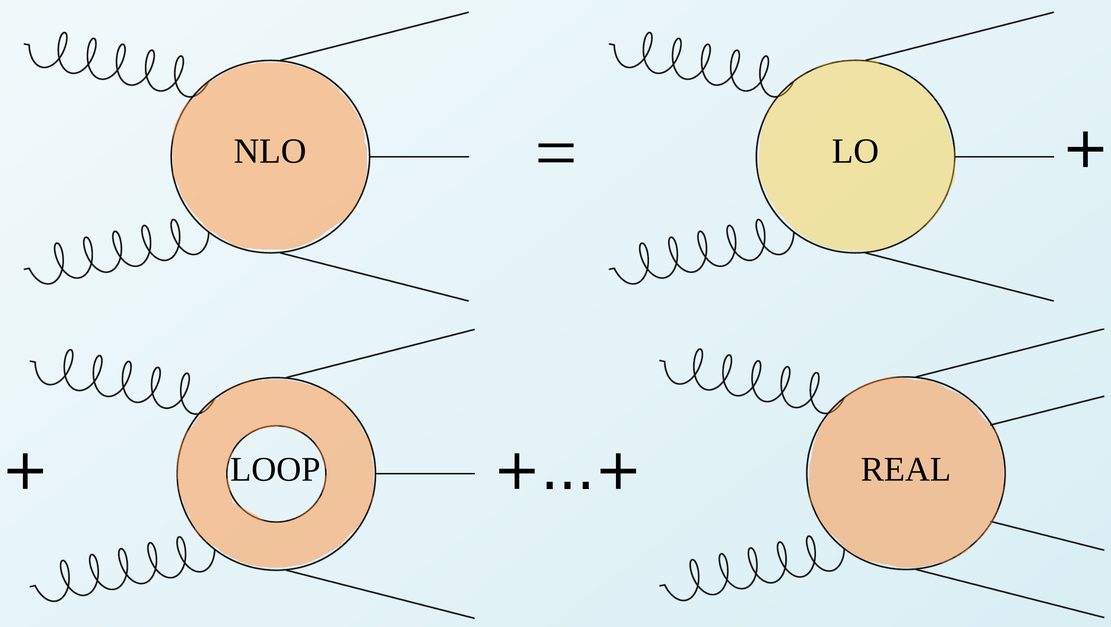
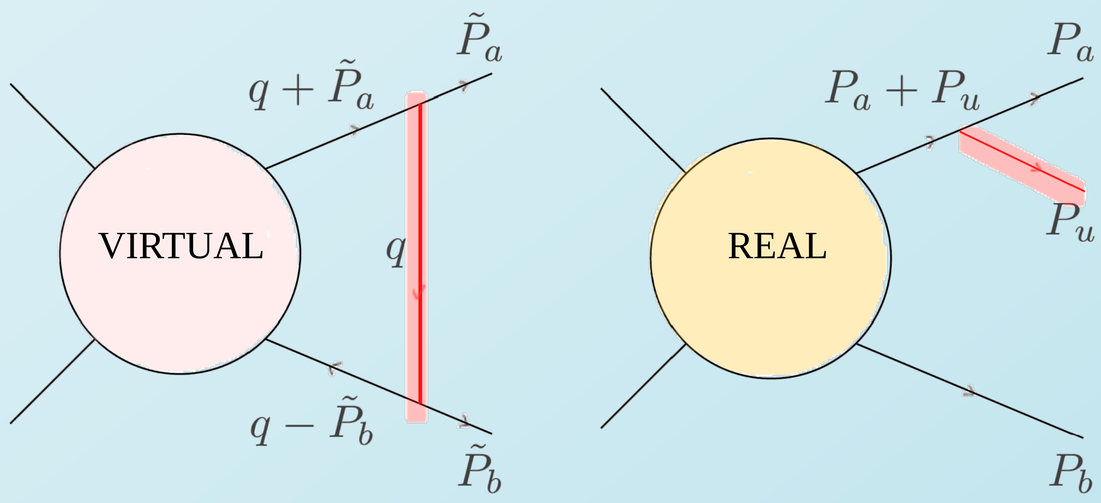
WHY

The main goal of the Large Hadron Collider (LHC) is to test the **Standard Model of Particle Physics** and to search for new physics up to the TeV energy scale.
To this end, the LHC experiments are collecting data for a vast range of scattering processes, where different combinations of particles are produced.
To test the Standard Model, such data needs to be compared against **precise theoretical predictions** based on the Standard Model Lagrangian.



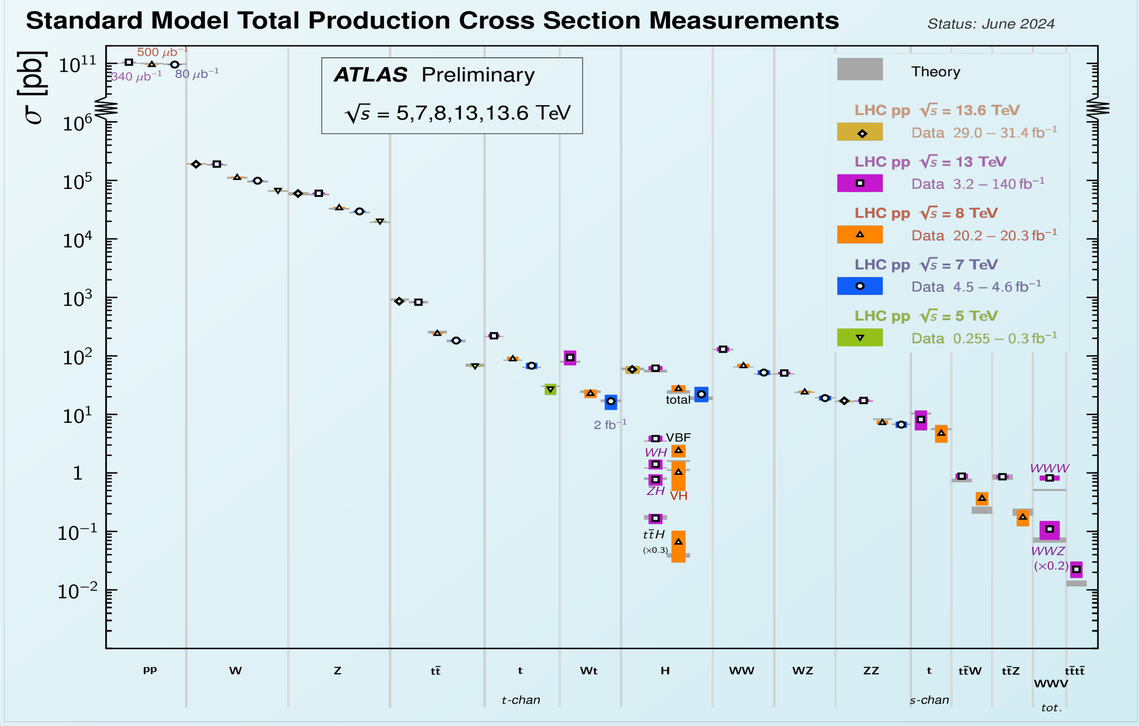
LTD

In order to extend the automation of precision calculations to Next-to-Next-to-Leading Order (**NNLO**), which involves diagrams up to two loops, we are currently developing a new method that combines the OpenLoops algorithm with the so-called **Loop-Tree Duality** (LTD) technique.
In this approach, loop diagrams are calculated via numerical integration over the loop momenta, and one of the attractive features of the LTD technique lies in its applicability to loop integrals that can not be solved with analytic techniques.



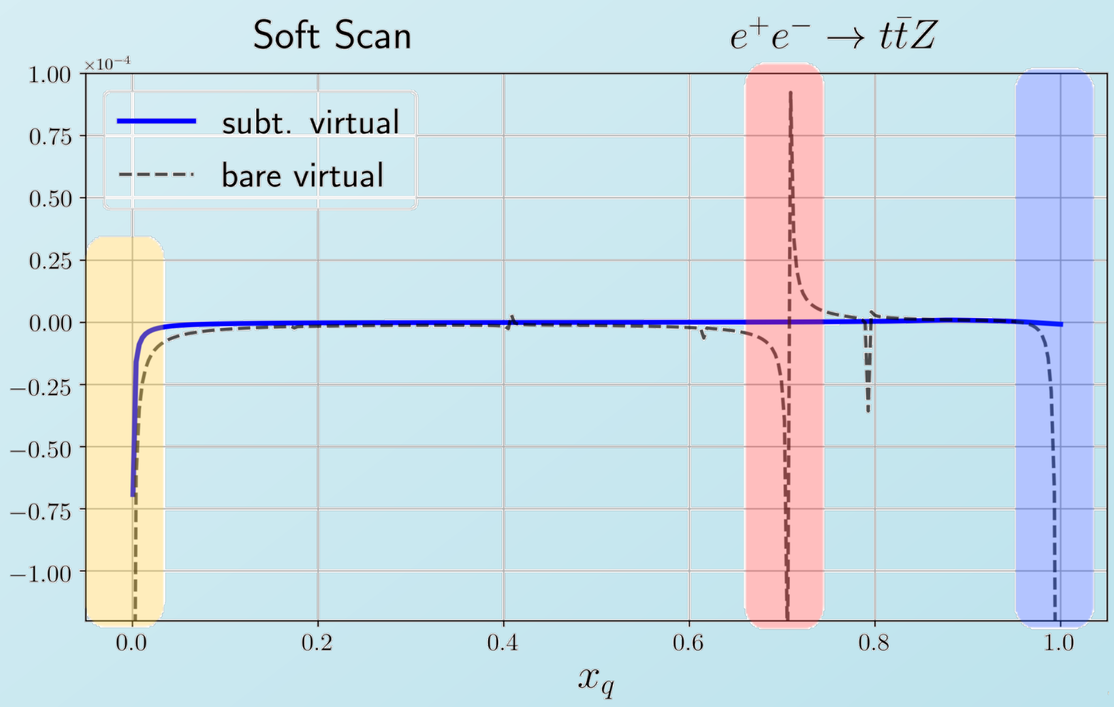
NEXT

The understanding of the singularity structure of one-loop integrands and a fully general algorithm for their local cancellation are the key ingredients of our fully automated LTD algorithm, which is going to generate NLO predictions for **any scattering process** in the SM.
Combining this NLO algorithm with existing OpenLoops technology for one and two-loop calculations, we then plan to **extend the automation** of perturbative calculations to NNLO.



QFT

In perturbative Quantum Field Theory, theoretical predictions for scattering processes are typically calculated in terms of **Feynman diagrams**.
At leading order (LO) only tree diagrams contribute, while Next-to-Leading Order (**NLO**) calculations also require one-loop diagrams, which involve nontrivial integrations over the loop momentum. The number of one-loop diagrams and their complexity grows extremely fast with the number of scattering particles, and our group developed an automated algorithm, called **OpenLoops**, which supports NLO calculations for arbitrary SM processes involving up to millions of one-loop diagrams.



NOW

At the moment we are developing the first **fully automated LTD** algorithm at NLO. One of the main challenges lies in the fact that numerical one-loop integrands involve ultraviolet (UV), threshold and infrared (IR) singularities, which need to be cancelled before numerical integration.
The first two types of singularities are removed through a numerical implementation of UV renormalisation in combination with threshold subtraction terms, while the remaining IR singularities can be directly canceled through an appropriate combination of loop diagrams and real-emission tree diagrams.