TOP PAIR PRODUCTION AT THE LHC

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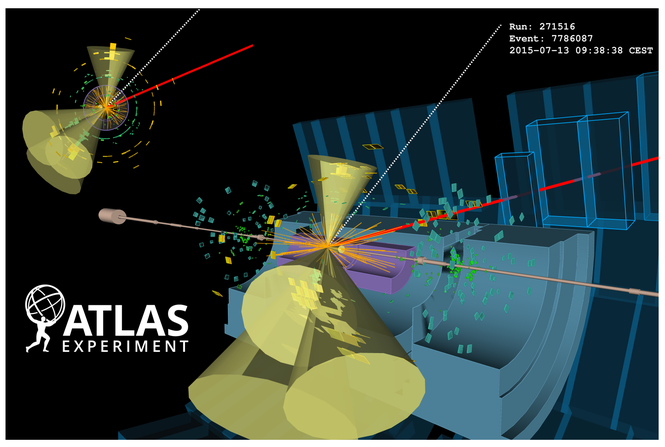
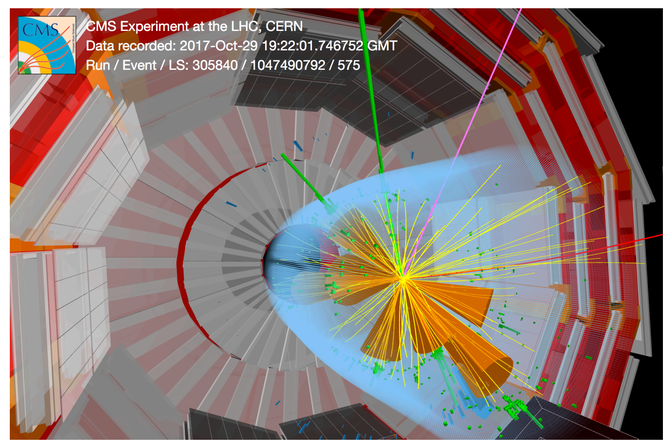
THE TOP QUARK AT LHC



Display of a candidate boosted top quark pair production event recorded by ATLAS

- The top quark is the **heaviest** particle in the Standard Model;
- Important for **Standard Model** studies:
  - strong coupling with the Higgs Boson;
  - top mass is a fundamental parameter;
- Important for **Beyond the Standard Model** studies:
  - possible window on new physics;
  - background to new physics searches;
- Impressive experimental precision must be matched by accurate theoretical predictions!

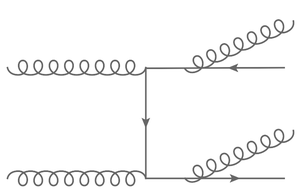
We computed NNLO QCD corrections.



Display of a candidate top quark pair production event in association with a Higgs boson recorded by CMS

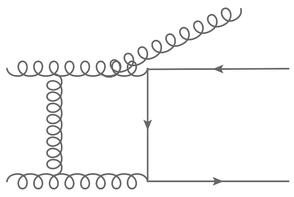
THE INGREDIENTS

Double real



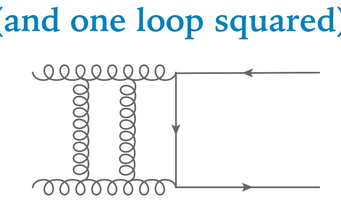
IR divergent

Real -virtual



IR divergent

Two loop virtual (and one loop squared)

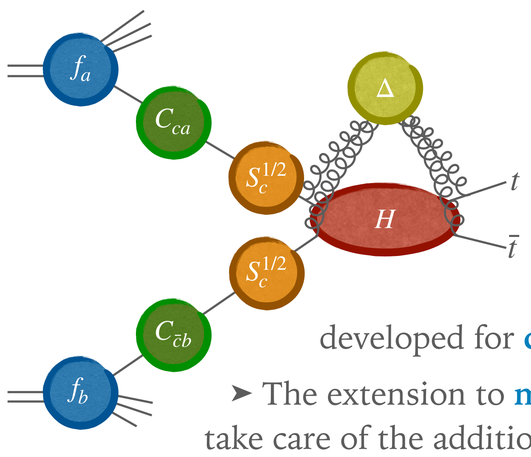


IR divergent

- All the amplitudes are available but they are separately divergent in the Infrared (IR) region (soft and collinear singularities).
- IR divergences cancel once all contributions are combined but they do not allow a straightforward implementation of **numerical techniques**.
- We need a method to handle and cancel **IR singularities**.

THE METHOD – q_T SUBTRACTION

- The **q_T subtraction** formalism is a method to handle IR singularities in NNLO computations. It is implemented in the **public code MATRIX**.



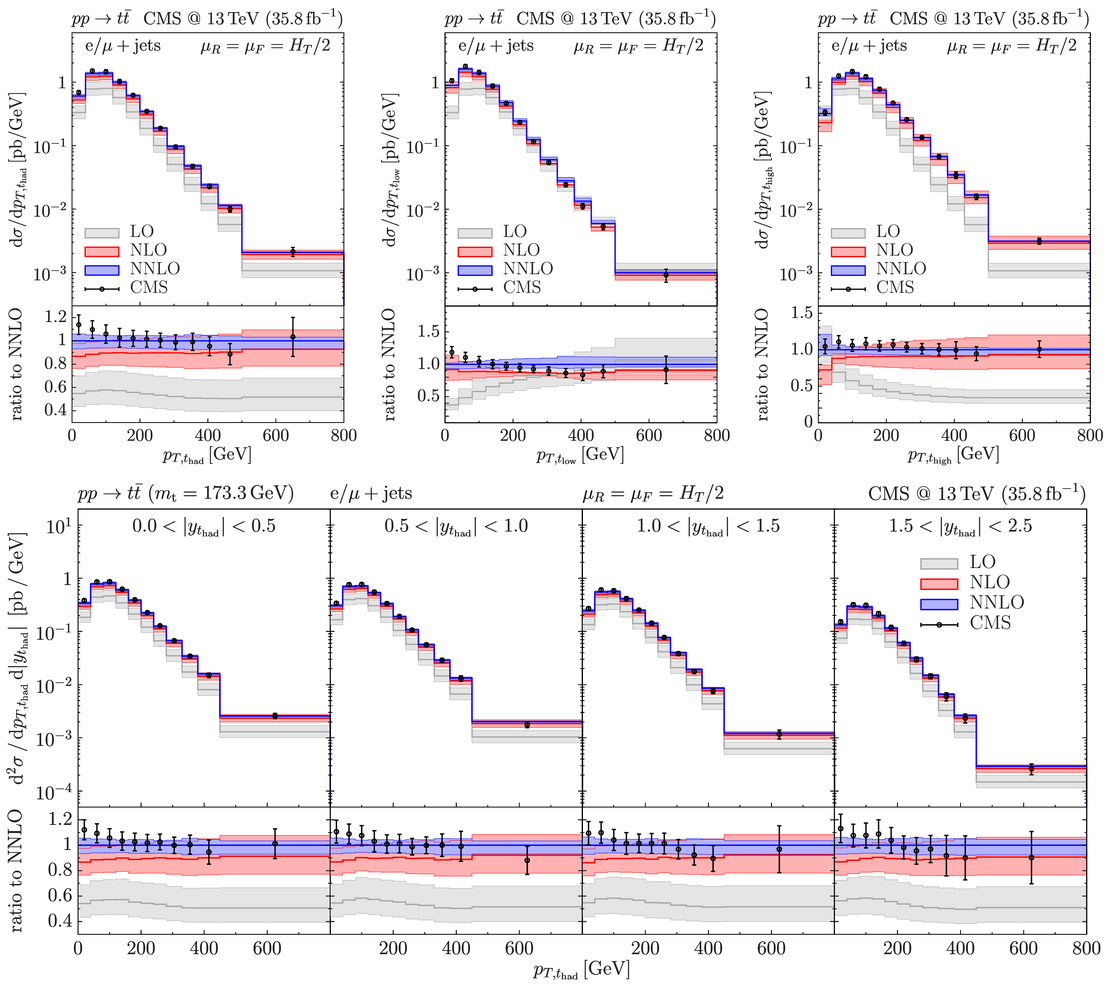
$$d\sigma^F_{NNLO} = d\sigma^F_{NNLO}\Big|_{q_T=0} + d\sigma^F_{NNLO}\Big|_{q_T\neq 0}$$

$$d\sigma^{F+jets}_{(N)LO}$$

$$d\sigma^F_{NNLO} = \mathscr{H}^F_{NNLO} \otimes d\sigma^F_{LO} + \left[d\sigma^{F+jets}_{NLO} - d\sigma^{CT}_{NLO}\right]$$

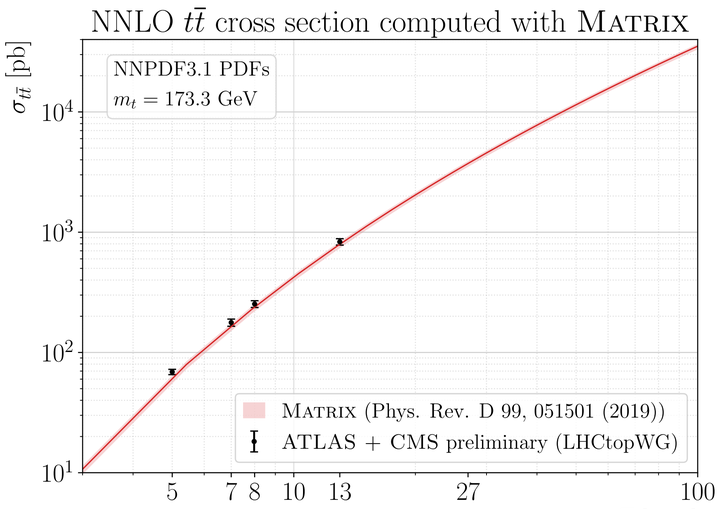
- q_T subtraction was originally developed for **colourless** final states.
- The extension to **massive coloured** final state requires to take care of the additional **final-state soft singularities.**

RESULTS – COMPARISON WITH DATA



- **Single** and **double differential distributions** are compared with recent LHC data from the **CMS** collaboration.
- Results for NNLO single and multi-differential distributions in **1000-2000 CPU days**.
- Reduction of the theoretical uncertainties. NLO and NNLO bands overlap, suggesting **convergence** of the perturbative expansion.
- Data and theory are **consistent** within uncertainties.

RESULTS – TOTAL CROSS SECTION



- **Inclusive cross section** in excellent agreement with the literature.
- Per-mille accuracy in **~1000 CPU days**.

$\sqrt{s}$	σ_{NNLO} [pb]
8 TeV	$238.5(2)^{+3.9\%}_{-6.3\%}$
13 TeV	$794.0(8)^{+3.5\%}_{-5.7\%}$
100 TeV	$35215(74)^{+2.8\%}_{-4.7\%}$

SUMMARY

- The **top quark** is of great importance both for Standard Model and Beyond the Standard Model studies.
- Accurate theoretical predictions require **higher orders corrections**!
- We computed **NNLO QCD** corrections with the **q_T subtraction** formalism.
- **Outlook**:
  - Combine with EW corrections;
  - Extension to different processes: top quark decays, $t\bar{t}H$…
- **Bachelor and Master projects available!**