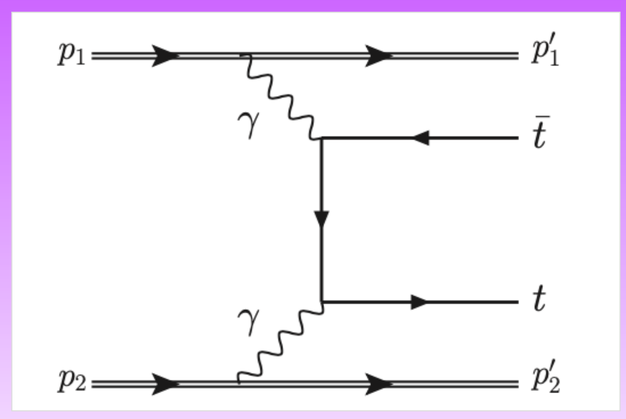
Central exclusive production of $t\bar{t}$ pairs at the LHC

MATTEO PISANO (matteo.pisano@cern.ch)

on behalf of the CMS and TOTEM Collaborations

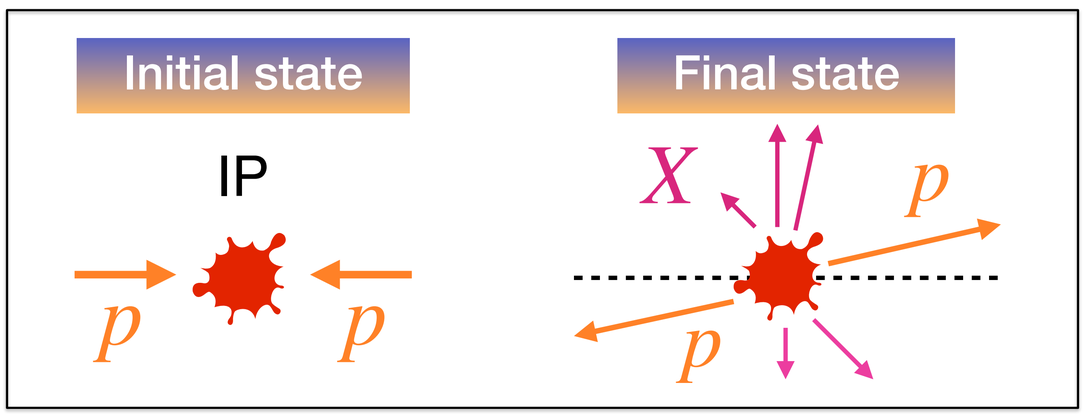
Supervisors: Michele Gallinaro & Jonathan J. Hollar



What is a central exclusive production (CEP) process?

A CEP process is characterised by the presence of two undissociated, i.e. intact, protons in the final state: $p + p \rightarrow p + X + p$.

- Protons intact from the primary interaction are deflected;
- Protons lose energy during the interaction;
- An extra system X is created.



CEP PROCESS: a graphical representation.

The CMS experiment and CEP processes

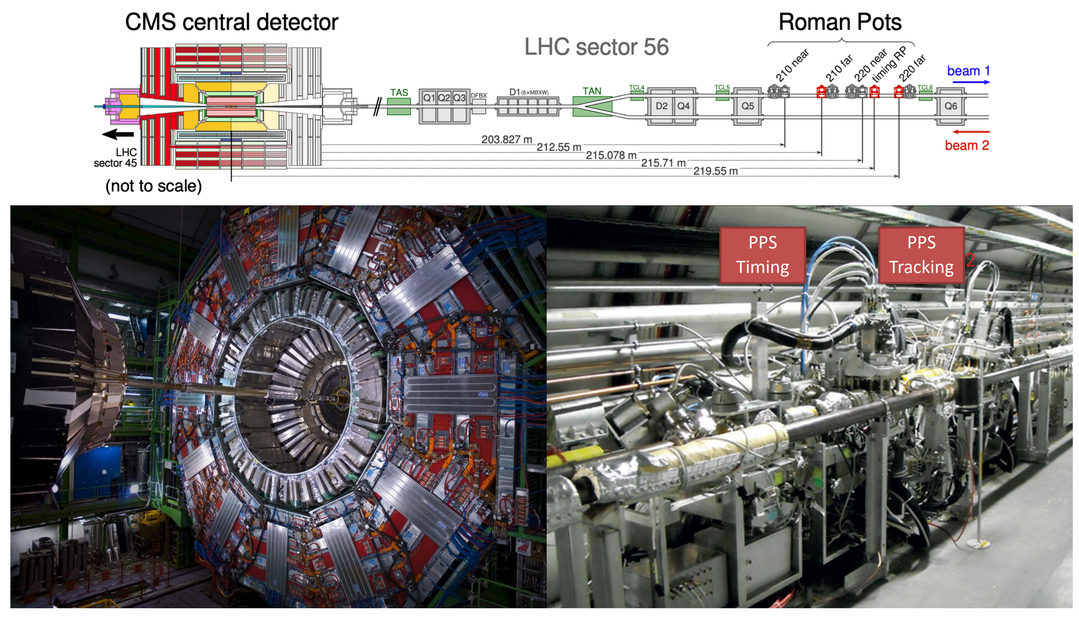
This analysis is performed using data recorded in 2017 by CMS. The ingredients to study CEP processes are:

- The central detector: allows reconstructing of the X system.
- The forward detector (PPS): allows tagging the outgoing protons.

PPS is a symmetrical detector at a distance of ± 200 m from the interaction point, composed by a set of detectors located in different stations (Roman Pots - RP):

- Tracking stations (two per arm): they can reconstruct the fraction of momentum lost by the protons during the interaction (ξ).
- Timing stations (one per arm): their objective is relating the protons tagged by PPS to the primary event triggered in the central system. They were not used in this analysis.

Since the kinematic of the central system is related to the proton momentum loss, the knowledge of ξ is crucial to reduce the background contribution.



CMS AND PPS: Schematic drawing of the beam line with CMS and PPS detectors (top). CMS detector (bottom left), one arm of PPS (bottom right).

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CMS-TOP-21-007

MORE INFO

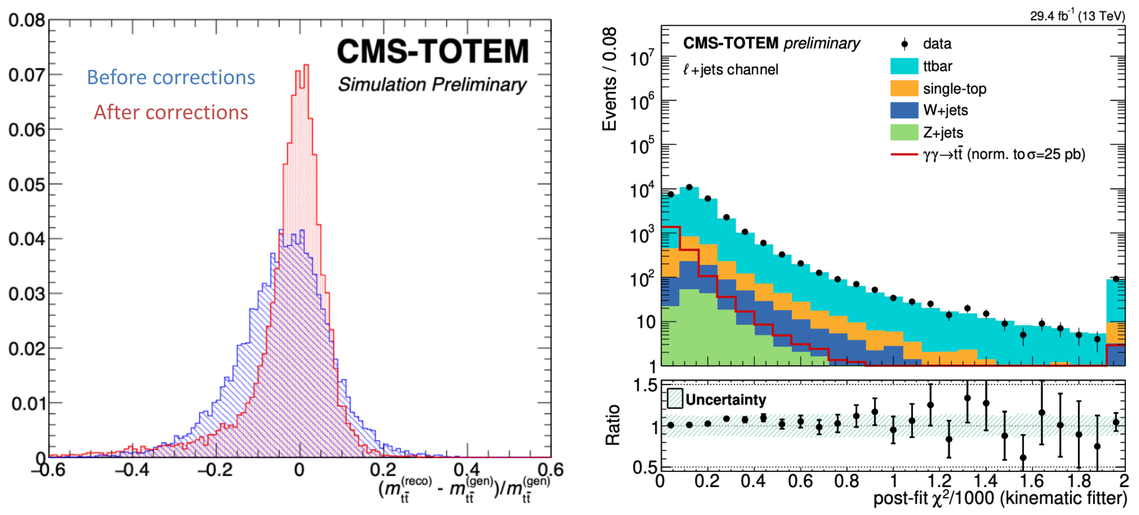
Why the $t\bar{t}$ CEP is such an interesting process?

- It was never studied before;
- Probe of the *photon-top quark* (γt) coupling;

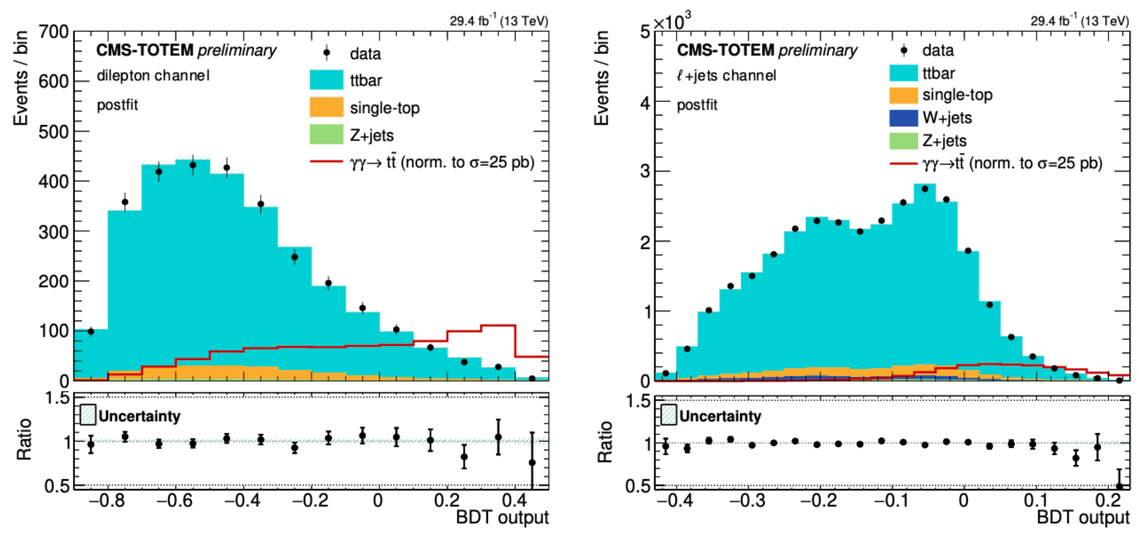
Two different decay modes studied: dileptonic (two leptons in the final state) and single-lepton decay mode (one lepton + jets in the final state).

One of the key points of the analysis is the usage of a kinematic fitter to reduce the uncertainties on the objects in the final state.

To best separate signal from background, a multivariate analysis (MVA) tool based on boosted decision trees (BDT) was developed. As to the MVA tool, an input variable of capital importance was the χ^2 of the kinematic fitter, which quantifies the agreement between the kinematic quantities measured by CMS central system and ξ.



Kinematic fitter: resolution of the central system invariant mass before (blue) and after (red) applying the kinematic fitter (left); χ^2 distribution for signal and backgrounds (right).



MVA classifier output for dilepton channel (left) and single lepton channel (right). These distributions were used to set the limit.

The extracted limit on the signal cross section is **0.59 pb** (SM expectation is about 0.1 fb) obtained using proton-proton collision data with a center-of-mass energy of 13 TeV collected by CMS detector in 2017, corresponding to an integrated luminosity of 29.4 fb^{-1}.

The analysis is presented in *"CMS and TOTEM Collaborations, CMS-PAS-TOP-21-007, (2022)*.

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