

The Research Group

Elementary Particle Physics

has the honor to invite you to the public defense of the PhD thesis of

Seth MOORTGAT

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

First measurement of the cross section of top quark pair production with additional charm jets with the CMS experiment

Promotor:

Prof. Jorgen D'Hondt

The defence will take place on

Monday 20 May 2019 at 10:00h

in Auditorium D.2.01 at the Campus Humanities, Sciences and Engineering of the Vrije Universiteit Brussel, Pleinlaan 2 - 1050 Elsene, and will be followed by a reception.

Members of the jury:

Prof. Alex Sevrin (chairperson)
Prof. Petra Van Mulders (secretary)
Prof. Alberto Mariotti (co-promotor)
Prof. Steven Lowette
Prof. Philippe Claeys
Prof. Fabio Maltoni (UCL)
Prof. Florencia Canelli (Zurich Univ.)
Prof. Nuno Castro (LIP, Lisbon)

Curriculum vitae

Seth Moortgat obtained his Masters degree in Physics in 2015 at the Vrije Universiteit Brussel. He is a member of the CMS Collaboration at the Large Hadron Collider at CERN, where he is responsible for the development of techniques to identify heavy flavor jets. He has developed for the first time an algorithm to identify jets from charm quarks, as well as new techniques that make use of Machine Learning algorithms to increase the sensitivity to new physics processes.

Abstract of the PhD research

The Standard Model (SM) of Particle Physics describes the elementary building blocks of the universe and the forces that are responsible for the interactions amongst them. The discovery of the Brout-Englert-Higgs boson at the Large Hadron Collider in 2012 marked the final milestone in completing this model as we know it today. Nevertheless, the Standard Model is not a complete theory, as it cannot explain phenomena such as dark matter, neutrino masses, and it does not include gravity.

Motivated by the need for precise background estimates in the top-Higgs sector, the CMS and ATLAS Collaborations at the LHC have developed an ambitious program in measuring precisely the production of a top quark pair with additional bottom jets (ttbb). It is however of equal importance to measure also the production of a top quark pair with additional charm jets (ttcc). Recently, the development of dedicated algorithms for charm jet identification have opened up the possibility to disentangle and measure also the ttcc cross section for the first time.

This thesis presents the first measurement of the ttcc process with the CMS detector at the LHC using proton-proton collision data collected in 2017. The ttcc cross section ($\sigma_{t\bar{t}c\bar{c}}$) is measured with a precision of around 20%, resulting in $\sigma_{t\bar{t}c\bar{c}} = 5.86 \pm 1.14$ pb in the full phase space. The presented analysis strategy allows for a simultaneous extraction of the ttcc, ttbb and tt + light jet cross sections from the information that resides in the charm-jet identification discriminants.

Finally, the Standard Model Effective Field Theory framework (SMEFT) provides a model-independent way to interpret these measurements in terms of new physics interactions. A novel methodology is presented in which Machine Learning methods are used to provide more stringent constraints on the coefficients that parametrize the new physics interactions in the SMEFT. These methods are demonstrated using the results obtained from the CMS measurement of the ttcc and ttbb processes.