

The research group
High Energy Physics

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

Nordin Breugelmans

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

**Studying Higgs boson production in association with
a charm quark with the CMS experiment in the SM and beyond**

Supervisor:

Prof. dr. Michael Tytgat (VUB)

Co-supervisor:

Prof. dr. Gerrit Van Onsem (VUB)

The defense will take place on

Monday, November 2, 2026 at 4 p.m.

VUB Etterbeek campus, Pleinlaan 2, Elsene,
Auditorium LIC.0.04

The defense can be followed through a live stream:
Contact nordin.breugelmans@vub.be for more
information.

Members of the jury

Prof. dr. Stijn Buitink (VUB, chair)

Prof. dr. Steven Lowette (VUB)

Prof. dr. Alberto Mariotti (VUB)

Prof. dr. Barbara Clerbaux (ULB)

Prof. dr. Agni Bethani (UCLouvain)

Prof. dr. Alexander Schmidt (RWTH Aachen
University, DE)

Curriculum vitae

Nordin Breugelmans completed his Master of Science degree at VUB, Belgium. In 2021, he joined the Inter-University Institute for High Energies (IIHE) at the VUB as a PhD researcher under the supervision of Prof. Dr. Jorgen D'Hondt and, subsequently, Prof. Dr. Michael Tytgat and Prof. Dr. Gerrit Van Onsem. During his doctoral research, he performed on-site shift work and offline calibration for the CMS experiment at CERN. Alongside his research, he served as a teaching assistant for two bachelor's courses and co-supervised six bachelor theses. He has presented his ongoing research a.o. at MIT (Boston) and published his work in JHEP.

Abstract of the PhD research

In 2012, the CMS and ATLAS experiments at the CERN Large Hadron Collider (LHC) announced the discovery of the Higgs boson, a particle whose existence was predicted nearly 50 years earlier in order to explain how fermions and heavy bosons acquire their masses. Its discovery, often described as the final piece of the Standard Model (SM) puzzle, marked the beginning of a new era of testing the scalar sector of the SM at the LHC.

Although the Higgs boson has been the focus of meticulous research, many of its predicted properties and interactions remain to be verified through experiment. Such efforts are important, as several open questions of the SM suggest the existence of a scalar sector that is more complex than currently theorized. Effects of physics beyond the SM could, for example, enter the interactions of the Higgs boson with the first and second generation fermions. As such, the measurement of the charm-Higgs interaction strength has become a logical next milestone for the LHC. Experimental upper limits on the value of this coupling have been observed by probing the decay of a Higgs boson into charm quarks. An alternative approach to constrain the charm-Higgs coupling is by considering the associated production with a charm quark in the final state, which forms the process of interest in this work.

In the first part this work, a simulation study of the process is performed at next-to-leading order in QCD, and the main theoretical uncertainties are identified. In the second part, the analysis aspects of the Higgs-charm final state in the $H \rightarrow ZZ^* \rightarrow 4\mu$ decay channel are discussed, as well as a comparison to proton-proton collision data collected by the CMS experiment in 2018. Finally, for the first time, the sensitivity of the Higgs-charm process to effects originating from new physics is explored using dimension-six operators in Effective Field Theory.