

**DEUTSCHES ELEKTRONEN-SYNCHROTRON**  
Ein Forschungszentrum der Helmholtz-Gemeinschaft



DESY-THESIS-2024-007  
May 2024

**First Simultaneous Measurement of Single and  
Pair Production of Top Quarks in Association  
with a Z Boson at the LHC**

by

F. C. Colombina

ISSN 1435-8085

**NOTKESTRASSE 85 – 22607 HAMBURG**