

Simon Ghizzo

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PHD IN PHYSICS AND NANOSCIENCES - XXXIX CYCLE - FIRST YEAR REPORT

Tutors

Antonino Sergi: Professor at University of Genova - Physics Department Roberta Cardinale: Professor at University of Genova - Physics Department

RESEARCH ACTIVITY

My research activity focuses onto two main topics, conducted within the framework of the Large Hadron Collider beauty (LHCb) experiment at CERN: the development and characterisation of new single-photon photodetectors for the future upgrade of the Ring Imaging Cherenkov (RICH) subdetectors of the LHCb experiment and the analysis of data of the LHCb experiment with the objective of making initial observations of new decay channels and searching for exotic multiquark states in b-hadrons decays.

The High-Luminosity program of the Large Hadron Collider (LHC) will result in a significant increase in the instantaneous luminosity. In order to ensure the excellent functionality of the LHCb detector in these harsher conditions in terms of radiation hardness and occupancy in the detector, the RICH subdetectors of the LHCb experiment have to be upgraded. The Upgrade II, scheduled during LHC's Long Shutdown 4 (LS4), will require to improve the reconstructed Cherenkov angle resolution, to increase the spatial granularity and to introduce the timing information, as well as an excellent radiation hardness, high detection efficiency and good readout capability. In order to achieve this, improvements are planned in the optical mirror system and the photodetector planes. Regarding this last point, it is crucial to maintain the RICH occupancy below 30% and to be able to measure the time of arrival of photons with a resolution better than 100ps, which significantly reduces the possible photosensor candidates capable of replacing the Multi-Anode PMTs currently used in RICH. My research is focused on the study of one of the most promising photodetector candidates, the Silicon PhotoMultiplier (SiPM). Indeed, while SiPMs are capable of single photon detection, high detection efficiency, good time resolution, high granularity and cost-effective coverage of large areas, they also exhibit undesired properties, such as high noise rate (due to dark counts and correlated noise) which increases with radiation exposure. Therefore the developement of radiation hard SiPMs, in collaboration with industrial partners, is a key factor for the Upgrade II of the LHCb RICH detector.

I built a measurement setup in Genova to characterise SiPMs under different operating conditions and, after having studied the Dark Count Rate and the Photon Detection Efficiency of the sensor, I'm currently focusing on obtaining a setup capable of characterising the time resolution of the sensor with sub-nanosecond precision.

I also took part in tests on beam that took place between April and May 2024 at the SPS Testbeam Facility at CERN, where different photodetectors were tested on the beamline. I'm currently in charge of the analysis of the SiPMs data, performing corrections and comparative studies, with a view to a future publication.

Furthermore, I joined the ECFA DRD4 International Collaboration, a recently established collaboration, aimed to bundle and boost R&D activities in photodetector technology and particle identification techniques for future high-energy physics experiments and facilities.

On the analysis side of my PhD work, I'm currently analysing the data from LHCb Run 2 (and plan to add also Run 3 dataset as soon as it becomes available) for the first observation of the $B_s^0 \to J/\psi (\to \mu^+\mu^-) \Lambda (\to p\pi^-) \overline{\Lambda} (\to \overline{p}\pi^+)$ decay. Although the analysis is still ongoing and not yet ready for publication, much progress has been made and the preliminary results are promising. In fact, I have already implemented and trained a multivariate Boosted Decision Tree algorithm for signal-background discrimination of the decay of interest using real data from LHCb and Monte Carlo simulation of the expected process, and I am currently optimising the selection process.

ATTENDED COURSES:

Machine Learning for Particle Physics (6 CFU): F.A. Di Bello, A. Coccaro, R. Torre - Attended Gravitational waves (3 CFU): G. Gemme, A. Chincarini, F. Sorrentino - Attended QCD and Collider Physics (3 CFU): S. Marzani - To be attended in September 2024

SCHOOLS AND CONFERENCES

LHCb Italia 2024 Bologna (IT), 31 January 2024 to 2 February 2024
LHCb Starterkit 2024 CERN (CH), 12 February 2024 to 16 February 2024
DRD4 collaboration meeting CERN (CH), 17 June 2024 to 20 June 2024
Fermilab-CERN HCP Summer School 2024 Fermilab (US), 22 July 2024 to 2 August 2024

OTHER ACTIVITIES

Teaching tutor (C_SMFN_11): Mathematics tuition for students participating in the national selection phase of the International Mathematical Olympiad (IMO)