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UNIVERSITÀ DEGLI STUDI DI PADOVA

PhD course of National Interest in Technologies for Fundamental Research in Physics and Astrophysics

Annual report

Name and surname: Michele Verdoglia
Cycle and a.a.: XXXIX / 2023-2024
Supervisor: Alessandro Cardini and Adriano Lai

- **Research activity carried out during the year** (*Describe the aim of the project (very briefly), discuss the research activity carried out during the year mentioning the difficulties encountered until now and the actions taken to face them. 1 page max intotal.*)

The PhD project consists in carrying out R&D activities in the context of the *Upgrade II* of the LHCb experiment (at CERN) planned for 2032, in particular of the Vertex Locator (VeLo) detector. The objective is to characterize and optimize the 3D silicon pixel sensors and the front-end electronics for VeLo detector, this technology aims to provide 10 µm of spatial resolution and 50 ps time resolution. Furthermore, these performances must be maintained at high irradiance levels up to $5 \cdot 10^{16}$ 1 MeV n_{eq} cm^{-2}.

The research activities carried out during this first year can be summarized as follows:

Study and characterization in the laboratory of highly irradiated (up to $\Phi = 10^{17}$ 1 MeV n_{eq} cm^{-2}) TimeSPOT (3D trench silicon pixel sensors) test structures, with particular attention to the study of time resolution, at low temperature (-20°C). I used a Sr-90 radioactive source to study the overall performance of the test structures and a microfocused laser to study the performance inpixels. These studies show good performance in terms of time, around 20 ps. Other measures concern the reconstruction of the IV curves as a function of temperature, the study of the efficiency by performing counting rate measurements as a function of the threshold and of the reverse voltage applied to the pixels.
Study and characterization of the front-end behavior as a function of temperature. To perform these measurements I used a climatic chamber, a vector network analyzer and a fast rise-time pulser. The results are that the temperature variation in the range of -40 and -20 is of the order of 6%-8%, this is very important to perform a correct conversion of the signal amplitude from mV to electron units, when the pixels are used at low temperature.

Study of highly irradiated test structures at H8 SPS (CERN) using ionizing minimal particles in the temperature range -40°/-20°C. This activity required a lot of preparation, the design of the setup was of considerable importance, testing different components and tools to be able to use them remotely. Finally, managing the data acquisition and control during data taking. Perform test beam data analysis; this task mainly requires coding via C++/Root and statistical applications to assign appropriate errors to the results. The test beam campign demonstrates excellent performance of high irradiated test structures: time resolution of the order of 11 ps, efficiency of 97% and charge collection efficiency fully recoverable by acting on the reverse bias. The results will be published in October in Frontiers.

- **List of attended courses and passed exams**

  1) Advanced Scientific programming in MATLAB (**passed**)

  2) Simulation of optical photon propagation for generic scintillator-based detectors (**attended**)

- **List of attended conferences, workshops and schools, with mention of the presented talks**

1) TREDI 2024: Characterisation and preliminary results on 3D trench pixel sensors irradiated up to 10^{17} 1 MeV n_{eq} cm^{-2} (https://agenda.infn.it/event/39042/contributions/221958/);

2) SIF 2024 (9-13 September 2024): Caratterizzazione e risultati preliminari su sensori 3D a trincea altamente irraggiati a fluenze fino a 10^{17} 1 MeV n_{eq} cm^{-2} (https://2024.congresso.sif.it/talk/232).

- **List of published papers/proceedings**

  1) LHCb Upgrade II Scoping Document (https://cds.cern.ch/record/2903094?ln=en);

  2) Observation of muonic Dalitz decays of X_b mesons and precise spectroscopy of hidden-beauty states (https://www.researchgate.net/publication/383037128_Observation_of_muonic_Dalitz_decays_of_chi_b_mesons_and_precise_spectroscopy_of_hidden-beauty_states);

  3) Measurement of CP violation in $B^0 \rightarrow D^+ D^-$ and $B^0_s \rightarrow D^+_s D^-_s$ decays (https://www.researchgate.net/publication/383791869_Measurement_of_CP_violation_in_B0rightarrowDD-_and_B0_srightarrowD_sD-_s_decays);

  4) Characterization of 3D trench silicon pixel sensors irradiated at $1 \cdot 10^{17}$ 1 MeV n_{eq} cm^{-2} (to be published on Frontiers, October 2024).

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- **Thesis title (even temporary)**

  High spatial and temporal resolution pixelated radiation sensors characterization for next generation experiments in fundamental physics

Date, 09/09/2024 **Signature** Verdoglia Michele

Seen, the supervisors