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

Annual report

Name and surname: Gabriel Botogoske

Cycle and a.a.: 39th

Supervisor: Francesco di Capua

- 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 in total.

The goal of my project is to build a small prototype of the proposed Far Detector 3 (FD3) for the Deep Underground Neutrino Experiment (DUNE). DUNE is an international neutrino oscillation experiment aimed at probing CP violation in the neutrino sector, identifying the neutrino mass hierarchy, and searching for proton decay, as well as solar and supernova neutrinos, among other objectives. To detect neutrinos, DUNE will use Liquid Argon Time Projection Chamber (LArTPC) technology and will consist of four Far Detectors. The main aspects of the first two detectors have already been established, while the specifics of the last two modules still need to be decided. My goal is to test one of the proposals for Far Detector 3, which will be a LArTPC. In this design, the field cage will be covered with large foils of PEN, and wide area photosensors based on cryogenic SiPMs, similar to those used in the DARKSIDE-20k experiment, will be used to detect the scintillation light.

In the first year of my PhD, I participated in activities related to two experiments. For what concern DUNE, initially, I analyzed two data campaigns to determine the efficiency of the MEGACELL X-ARAPUCA (a photodetector that will be used in DUNE FD2) at cryogenic temperatures (immersed in Liquid Argon at 87K). During the first campaign, the setup experienced significant noise due to poor grounding, making it challenging to obtain reliable results. However, by applying the total variation filter found in the literature, we managed to extract some useful data. In the second campaign, the start focus was on addressing the noise issues. After two weeks of modifications and testing, the noise was completely eliminated. Ultimately, it was discovered that when the MEGACELL when held in a horizontal position, it can bend the light guide, decreasing its efficiency.

I also assisted with the photon efficiency analysis of another MEGACELL module, the dual-faced one, which will be installed at the cathode of FD2. This work was part of a mission at CIEMAT in Madrid. For these analyses, I also learned to use GEANT4 to estimate the



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geometrical acceptance of the VUV photons impacting on the MEGACELL X-ARAPUCA. Additionally, I went to CERN for about one month to work on proto-DUNE HD (a prototype of DUNE FD1) data. My work involved the commissioning of the Photon Detection System and, in particular, the analysis of the light yield of cosmic rays as a function of the electric field and investigating the variation of the slow component of scintillation as a function of the applied voltage. In this period, I also did shifts for the protoDUNE HD detector, which is important to make sure everything is doing fine and smooth during the data taking.

DARKSIDE experiment, which is a LArTPC aiming to detect direct interactions of WIMPs (dark matter candidates), I contributed to the setup aimed at characterizing the Photon Detection Units (PDUs) that will detect scintillation photons in the detector. Additionally, I developed an online and real-time camera interface to assist the Proto0 experiment, which is an R&D project designed to better understand the characteristics of the liquid-gas argon interface and the PDUs.

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

- **Rare event search with Time Projection Chamber** - need to scheduled the exam
- **Cryogenics sensors for astroparticle physics** - approved
- **Cabling and Shielding for low noise applications** - approved
- **Machine learning for physics** - need to scheduled the exam
- **Vacuum Technologies** - approved

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

- DarkSide Young Academy: 02/21/24 to 02/24/24 in Naples
- 15th International Neutrino Summer School 2024: 06/03 to 06/14 in Bologna
- LIDINE 2024: Light Detection In Noble Liquids: 08/26 to 08/28 in São Paulo/BRAZIL. I present a talk named: DUNE Photon Detection System

- **List of published papers/proceedings**

- **Thesis title (even temporary): Study of the light detection properties of PoWER: A proposed Far Detector for DUNE**

Date, 10/09/2024

Signature

Seen, the supervisor