Ph.D. Annual Report

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Research Activity

My Ph.D. research is focused on ITk, the new ATLAS Inner Tracker. The main arguments are:

- **Beam Test on ITk 3D pixel Modules:**
  From April to last August several beam test campaigns take place at Proton-Synchrotron (PS) and Super Proton-Synchrotron (SPS) at CERN.
  In total, 4 modules were tested: two of them were not irradiated, while the other two were previously irradiated at Bonn to the fluency of $10^{16} n_{eq}/cm^2$, to simulate the natural aging of the modules when exposed to the intense radiation present in the area of the ATLAS detector closest to the LHC interaction point. From these beam tests we have obtained encouraging results: the unirradiated modules showed a hit efficiency constantly higher than 98% at any Bias Voltage (we tested these modules with a bias voltage on the sensor from 0 up to 10 V). The modules with irradiated sensors showed a hit efficiency higher than 97% from 40 V of bias voltage. Some other studies were performed from the data taken during the beam tests, like the leakage current on the sensors vs the bias voltage, to evaluate the power dissipation of the modules at any bias voltage and the number of noisy pixels removed from the data taking vs the bias voltage. This analysis shows how the increase of the bias voltage is due to the increase of noisy pixels, which however turned out to be not tuned properly. Further studies on how a retuning procedure carried out at each new bias voltage could mitigate the increase of noisy pixels and therefore avoid having to mask them during data taking.
- **ITk pixel Demonstrator at SR1 (CERN):**
  In SR1 at CERN, an RD53A modules demonstrator is under development. It will be composed of 1 barrel longeron, 2 inclined Half-Ring, and a maximal capacity of 40 RD53A modules. The readout system consists of 8 optoboards for the conversion of an electrical signal into an optical signal. The optoboards are grouped within an optobox.
  Multi-module readout using phase-1 FELIX system, with FLX712. During my permanence at CERN, I worked on this setup with the aim of being able to do the first ITk pixel modules data taking. The current setup, which is not the final one, is composed of a FELIX readout system connected by optical fiber to an optobox. The current optobox contains 7 optoboard. The optoboards are connected to a patch panel (PP0) upon which the modules are powered in series. Between the modules and the PP0, a pigtail cable is used to transmit data and power. This system can take data with the ITk modules and some scans have been taken.

ATLAS Pixel Desk Shifts:

During my stay at CERN, I took part in a series of ATLAS control room shifts, especially during the LHC's power-up period. During this phase, I had my shifts during the first beam injection tests inside the accelerator and took part in the first SPLASH events data

taking. “Splash” events are used by the experiments to test their numerous subdetectors and to synchronize them with the LHC clock. These events are recorded when the path of particles traveling in the LHC vacuum pipe is intentionally obstructed using collimators – one-metre-long graphite or tungsten jaws that are also used to catch particles that wander too far from the beam centre and to protect the accelerator against unavoidable regular and irregular beam losses. The particles sprayed from the collision between the beam and the collimators are mostly muons.

Publications and Proceedings

- Construction and test of the SM1 type Micromegas chambers for the upgrade of the ATLAS forward muon spectrometer - J. Agarwala, M.G. Alviggi, M. Antonelli, L. Vannoli, et al., Oct 1, 2022
- Characterization of FBK 3D pixel sensor modules based on RD53A readout chip for the ATLAS ITk - Md.A.A. Samy, A. Lapertosa, L. Vannoli, C. Gemme, G.F. Dalla Betta, Dec 22, 2021

Ph.D. Exams

2020:

- **Introduction to the Foundations of Quantum Mechanics and Applications:**
  I developed a Qiskit code runnable on IBM quantum computer. This code simulates the Aspect experiment which proves the CHSH inequality violation. Moreover, I have reported on GRW theory.
- **Deep Learning: A Hands-On Introduction:**
  I wrote a report on “Higgs Detection Using Machine Learning Methods in ATLAS Experiment”.
- **Electronics & Data Acquisition:**
  In collaboration with a Ph.D. colleague, we developed a Verilog firmware runnable on an FPGA board. The firmware is a VGA controller that displays multiple-colored columns on the screen.

2021:

- **Experimental Particle Physics:**
  I gave a talk on CMS experiment muon detector upgrade with GEM (Gas Electron Multiplier) detector.

2022:

- **Progettazione di Magneti Superconduttori:**
  I gave a talk on the ATLAS experiment toroid magnet system.
- **INFN School of Statistics at Paestum:**
  I have to give a talk on the topics covered during the lessons attended at the school. I plan to have this talk by the end of September 2022

Conference and Schools:

- **INFN School of Statistic at Paestum**
- **CERN ISOTDAQ School at Catania**

Grants:

- **Simil Fellow:** I won a Doctoral Student position at CERN from July 2021 to July 2022.

- **Post-doc Grant**: I applied and took the oral interview for the scholarship competition for one year of research activity at the University of Genoa, starting from 1 November 2022.