Ph.D. Annual Report

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Research Activity

The research activity can be subdivided into three main arguments:

- **ITk Half Ring Local Support Metrology Analysis**
  The ATLAS experiment plans the replacement of the ATLAS Inner Detector with a new full silicon Inner Tracker (ITk) detector composed by two subdetectors, one with strips and one with pixels.
  The ITk innermost system will be made of silicon pixels both in the central barrel region and in the endcap region. The Italian collaboration is responsible to deliver at CERN one of the two endcap for final integration and installation in the detector. In the endcap region, the pixel modules will be directly glued on Half Rings local supports, ~ 60 per each endcap, arranged in such a way to cover the foreword region up to $\eta = 3.6$. The Half Rings are made in carbon fiber and they are produced in Genova Laboratory.
  In 2020, we have finalized the testing procedure for the quality checks to be performed during the production of the Half Rings. In particular, to test the mechanical and thermal properties of the Half Rings we have used a CMM (Coordinate Measuring Machine) with a STIL optical sensor installed above. The STIL optical sensor, composed by a controller with an optical pen, returns the vertical coordinate of the object under test, while the CMM returns the coordinates on the horizontal plan. Using an environmental box, we have climatized the Half Ring under test. Several data taken campaigns have been performed to have different runs in different temperature conditions of the Half Ring. My work has consisted in the data analysis of these different runs to extrapolate two different information from data:
    - Global deformation of the Half Ring, in order to find defects on the Half Ring surface. To carry out this task I have fitted the data with a planar fit function and then I've studied the residual between data and the points on the planar fit.
    - Half Ring thermal deformation: I wrote several data analysis programs (both in python and C++ programming language) to compare specific locations of the Half Ring at different temperatures. To simplify the analysis, two holes were made on the Half Ring in order to find the coordinates of the hole centers. These coordinates were compared, and the temperature deformations were studied. The measured Coefficient of thermal expansion has then compared to FEA simulation.

  My work has been recently presented in the Endcap construction meetings.

- **3D Pixel Modules RD53A analysis**
  The ITk 3D pixel modules are composed of a 3D pixel sensor bump bounded to a FrontEnd chip which is in turn wire bonded to the electrical interface (the RD53A board) that provides power and allows routing of data to the acquisition system. The 3D pixels differ from planar ones in greater resistance to radiation due to the shorter drift length of the charge, less chance of entrapment and high electric field with lower voltages.

In Genova Lab, I have tested the RD53A modules to study their analogue performance. Then, using a radioactive source of Americium-241, I've studied noisy or inefficient pixels. Last October at DESY (Hamburg, Germany) testbeam facility, I have tested the devices studied in Genova with an electron beam. I have then analyzed the collected data and measured the efficiency of the 3D pixel modules. To analyze data collected in the testbeam a reconstruction software written by the ATLAS testbeam community has been used.

- **Outer Endcap Local Support ITk Production Database**
  To become an ATLAS author, the policy foresees to devote a reasonable amount of time to a "service task", so called a Qualification Task. My ATLAS Qualification Task concerns the development of the Outer Endcap Local Support in the ITk Production Database, where all the data produced during the tests of the parts in the detector construction will be stored. Following the Outer Endcap Local Support ABS developed by the ATLAS community and using the Production Database API, I have instantiated every single component of the Local Support. Moreover, the production stages and the QC tests have been added inside the database to keep a record of the status of the components under test and to track the development of the assembled components.
  The next step will be the development of a Graphic User Interface (GUI) of the Production Database to simplify its use and limit its use to these functions:
  - Add new components
  - Looking for components already added by the institute
  - Link different components between each other to create new components
  - Add new tests and test results

- I am regularly reporting my progress both in the database group meetings and in the endocarp meetings my progress on this task.

Attended courses and exams given

- **Introduction to the Foundations of Quantum Mechanics and Applications:** In order to pass the exam, I have 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:** In order to pass the exam, I have written a report on "Higgs Detection Using Machine Learning Methods in ATLAS Experiment".
- **Electronics & Data Acquisition:** In order to pass the exam, in collaboration with a Ph.D. colleague, I have developed a Verilog firmware runnable on an FPGA board. The firmware is a VGA controller that displays multiple colored columns on the screen.
- **Gravitational Waves:** Exam not given yet.
- **Superconductor magnets design:** Exam not given yet.

Conferences

SIF: "Caratterizzazione di moduli con sensori 3D e readout RD53A per ATLAS ITk Pixel".
ITk Week: "Local supports database status".