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:

- **ITk Half Ring Local Support Tests Analysis**
  During this second year, I am primarily working on Outer Endcap (OEC) Local Support QA/QC tests. The OEC Local Supports are carbon supports half-ring shaped.
  We are moving towards the production phase of the ITk Local Supports.
  I'm mainly involved on OEC Local Support thermal deformation measurements. These measurements are performed to measure the CTE (Coefficient of Thermal Expansion) and, in general, to validate the Finite Element Analysis (FEA) of the Half Ring.
  I'm also involved on the OEC Local Support thermal performances. With the help of a thermo-camera, injecting hot liquid inside of the Half Ring pipe, we can measure the heat transfer to the Local Support surface. In this way we can check that there are no important anomalies or non-uniformities in the heat propagation.

- **Offline Software (Athena) Misalignment Algorithm**
  I am the main developer for offline software upgrade alignment analysis, with the target to study the impact of the initial detectors position resolution and the possible structural movements on future software alignment techniques. The current alignment software is inherited and based on the current ATLAS tracker, but the new tracker for HL-LHC has completely different mechanical supports, with other degrees of freedom. Therefore, an optimization of the alignment algorithms is required. Moreover, this task should give feedback to the construction team on the requested knowledge of the detector parts positioning during the integration.

- **ITk Triplets Module assembly**
  Triples Modules are composed by three chip+sensor glued on a flex that houses the electronics. A mechanical arm with suckers and a camera are used to look at the chips, raise, roto-translate and place the chips on the flex.
  For this module assembly, during this second year I've helped developing a Graphical User Interface (GUI) aiming to automate the gluing process.
  I am also working on a Convolutional Neural Network (CNN) that is able to recognize which part of the chip the camera is framing. In this way mechanical arm can automatically move the chip to the flex.

- **3D Pixel Modules RD53A analysis**
  Last November I went to DESY (Hamburg, Germany) facility to test 3D pixel module with electron beam. The efficiency of the 3D pixel modules was studied. To analyze data collected in the testbeam a reconstruction software written by the ATLAS testbeam community has been used. All the modules under test were found to have an efficiency higher then 97% (ATLAS baseline for module end of the life).

- **Winner of CERN Doctoral Student position**
  I have won a CERN Doctoral Student position with the following research project:
  A hardware task focused on the development of large-scale system tests, with particular emphasis on readout and calibration procedures. On the offline software side, I will work on

the upgrade tracking software developed to study the impact of the initial detector's position resolution and the possible structural movements on future software alignment techniques. I am based at CERN from last July until July 2021.

Publications and Proceedings

- **Novel 3D Pixel Sensors for the Upgrade of the ATLAS Inner Tracker**, S. Terzo et al. Frontiers in Physicis, 21 April 2021, DOI: 10.3389/fphy.2021.624668.
- **3D pixel modules characterization with RD53A readout for ATLAS ITk Upgrade,** L. Vannoli Il Nuovo Cimento C – Vol. 44, N. 2-3, 2021, DOI: 10.1393/ncc/i2021-21082-9.

PhD Exams

2020:

- **Introduction to the Foundations of Quantum Mechanics and Applications:**
  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:**
  To pass the exam, I have written a report on "Higgs Detection Using Machine Learning Methods in ATLAS Experiment".
- **Electronics & Data Acquisition:**
  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.

2021:

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

Conference Talks:

- **SIF 2021:**
  09 - 2021 – "Costruzione e qualifica dei supporti locali dell'endcap esterna del rivelatore a pixel di ATLAS per HL-LHC"
- **ITk Week:**
  02 - 2021 – "First misalignment studies with ITk layouts"
  02 - 2021 – "Endcap Local supports database"
- **Co-speaker of TREDI Workshop**:
  16° Trento Workshop on Advanced Silicon Radiation Detectors – "Performance of irradiated FBK 3D sensors for the ATLAS ITk pixel detector"
  15° Trento Workshop on Advanced Silicon Radiation Detectors – "Characterization of FBK 3D pixel sensor modules based on RD53A readout chip for the ATLAS ITk"

Grants:

- **SIF:** Scientific committee has selected my talk "**Caratterizzazione di moduli con sensori 3D e readout RD53A per ATLAS ITk Pixel**" as best communication. My talk has been published on the physics journal "Il Nuovo Cimento - Colloquia and Communications in Physics"
- **Simil Fellow:** I won a Doctoral Student position at CERN from July 2020 to July 2021.