Ravera Simone

simone.ravera@cern.ch simone.ravera@ge.infn.it

Dottoranto in Fisica e Nanoscienze - Ciclo XXXVIII - First Year Report

Tutors

Claudia Gemme: Researcher at *Istituto Nazionale Fisica Nucleare* division of Genova
Fabrizio Parodi: Professor at *University of Genova* - Physics Department

Research activity

My research activity fits in the context of the ATLAS experiment Phase-II upgrades. With the beginning of the High-Luminosity program of the Large Hadron Collider (LHC), the instantaneous luminosity of the machine will increase by a factor of seven with respect to the current performance of the LHC. To cope with these harsher conditions in terms of radiation hardness and electronic performance the ATLAS experiment will be equipped with a completely new all-silicon tracker, the so-called Inner Tracker (ITk). My research is focused on constructing and qualifying the parts for the new tracker. I carry out these activities within the group ATLAS ITk of the INFN of Genova.
The ITk will be instrumented with 5 layers of hybrid pixel modules. They consist of a pixel sensor for signal detection, Front-End electronics (FE) for readout and discrimination and an electrical flex to flex to distribute power and collect data. Each pixel of the sensor is connected to a readout channel of the FE through a process called bump-bonding. This process consists in depositing solder (SnAg, SnPb) or Indium bumps and then connecting the layers through a thermal compression cycle (flip-chip). A flex module is then glued to the back of the sensor. Two technologies are used for the ITk Pixel detector sensors: 3D sensors in the innermost layer in triplet modules, consisting of three single FE-sensor assemblies on a triplet flex, and planar sensors in quad modules in all other layers, consisting of four FE chips on a sensor tile on a quad flex.
During my first year within the group, my activities' main goal was to qualification the first pre-production sensors that will instrument the innermost layer. These novel 3D silicon pixel sensors are produced with an innovative technique that involves directly drilling the charge collection electrodes into the silicon substrate. This technique reduces the distance between the electrodes [o(50 μm)], significantly increasing their radiation hardness. Sensors will be produced in different layouts to accommodate different regions of the detector: a 50x50 pixel pitch layout in the side regions of the detector and a 25x100 pixel pitch design in the central region. Since sensor performance needed to be validated after irradiation, I personally joined the installation of several modules at the IRRAD facility at CERN, where the sensors have been irradiated up to a fluence of $1.7 \cdot 10^{16}$ n_{eq}/cm^2. After the irradiation, I joined the beam test activities at the CERN Super Proton Synchrotron beamlines, participating in the installation of modules and in the data taking. At the end of the campaigns I took care of the data analysis, the main goal was to study the efficiency of the sensor as a function of the bias voltage. Thanks to the analysis result I proved that these 3D sensors meet the ITk requirements. Also thanks to these results, the 50x50 layout sensors passed the Production Readiness Review (PRR) and got the green light for the production. The PRR for the 25x100 layout is foreseen in November 2023, and I'm currently working on the test beam data analysis to validate the performance of this layout.
The ITk project is now in the pre-production phase, concerning the modules pre-production all the samples are expected to be ready at the beginning of 2024. In addition, all ITk institutes have to show that they can assemble and test the modules before moving on to the production phase. This validation process of the pre-production results is called, within the ITk community, Site Qualification. Regarding this project, I have personally taken care of developing the modules testing setup in the laboratory of Genoa, bringing the laboratory to be qualified. Thanks to this work, the Genoa laboratory was one of the first sites to be able to test a pre-production module in July 2022.

fabrizio.parodi@gmail.compt

ATTENDED COURSES

Machine Learning for Particle Physics: *A. Coccaro, F.A. Di Bello*
QCD and Collider Physics: *S. Marzani* - To be attended in September 2023
Theoretical physics: *G. Ridolfi*
The double trouble of the missing matter in the Universe: *E. Branchini*

EXAMS TAKEN

Machine Learning for Particle Physics: *A. Coccaro, F.A. Di Bello*

PUBBLICATIONS

Giovanni Calderini et al. **Qualification of the first pre-production 3D FBK sensors with ITkPixV1 readout chip"**. In: PoS Pixel2022 (2023), p. 025. doi: 10.22323/1.420.0025.

CONFERENCES

TREDI23: 18th Trento Workshop on Advanced Silicon Radiation Detectors, Trento, 28 February - 2 March 2023. Talk: *Pixel cell local efficiency of FBK 3D pre-production pixel sensors after irradiation up to* $1.9 \cdot 10^{16}$ n_{eq}/cm^2
IFAE 2023: Incontri di Fisica delle Alte Energie, Catania, 12-14 April 2023. Poster: *Risultati sul primo sistema di test multi-modulo per l'Endcap del rivelatore ATLAS ITk Pixel*