2ND year Ph.D. report - Beatrice Siri

Ph.D. supervisor: prof. Flavio Gatti.

Detecting B-mode polarization of the Cosmic Microwave Background is one of the main challenges of modern observational Cosmology. It can be proved that polarization B-modes can only be generated when there is a tensor perturbation component present. Inflationary models, proposed along the standard cosmological model, imply the existence of a background of primordial gravitational waves which would generate a curl component (B-modes) in the Cosmic Microwave Background at large angular scales. The amplitude of this signal is expected to be linked to the energy scale of inflation. Thus, a direct measure of large scale B-modes polarization would strongly confirm inflationary theories.
LSPE (Large Scale Polarization Explorer) is an experiment aimed at measuring the polarization of the Cosmic Microwave Background at large angular scales. Its primary target is to improve the limit on the tensor to scalar perturbations amplitude ratio down to r=0.03, at 99.7% confidence. A second target is to produce wide maps of the foreground polarization. The mission is optimised for large angular scales, with coarse angular resolution (around 1.5 degrees FWHM) and wide sky coverage (25% of the sky). The mission is composed of two instruments: SWIPE and STRIP. STRIP is a ground-based telescope that will be installed at El Teide Observatory (Tenerife, Canary Islands). It will use an array of coherent polarimeters with cryogenic HEMT amplifiers to survey the sky at 45 and 90 GHz. SWIPE is a balloon-borne experiment that will fly in a circumpolar long duration balloon mission during the polar night. It will use an array of 326 bolometric polarimeters, with large throughput multi-mode bolometers and rotating Half Wave Plates (HWP), to survey the sky in three bands at 140, 220 and 240 GHz.
My work revolved around fabrication and test of bolometer for the SWIPE instrument. The detectors are TES (Transition Edge Sensor) spider-web bolometers with a micromesh absorber. The bolometer is fabricated using thin film techniques on a silicon nitride membrane over a silicon substrate. The detector is then suspended by removing the silicon layer.
The focus of my second year activity was the production of all the detector needed for the final telescope. Since the number of devices required is quite high (326 bolometers for the telescope plus spare for testing and possible substitutions) we had to improve and adapt our processes to a large scale production. I was responsible for the rework of fabrication procedures to optimise the production rate and for the training of three technicians which helped with the manufacturing process. We managed to process almost 200 detector before the production stopped in March and we are testing them to verify that the requirement for the experiment are met.
Some of the processes I focused on: thin film evaporation automation and quality, multiple chip processing, photolithographic masks designs, membrane etching and suspension. At the moment we are working on finalising detector parameters with minor tweaks based on beam response measurement done in Rome and details of the bolometer integration.
My next goal is a complete electrical characterisation of a finished detector, comparing its performance with the experiment requirements and with simulation results from a simple model I just started working with.

Conferences:

I attended the following conference:

- SuperFOx2020, Conference on Superconductivity and Functional Oxides (http://www.superfox2020.eu/)

At the end of October I will also attend the following conference:

- Applied Superconductivity Conference ASC20 (https://ascinc.org/)

and I participated to the following contribution:

- B. Siri et al. "Impact of Annealing on Titanium Thin Films TC and Crystalline Structure"- poster at SuperFOx2020, presented by me.

Papers:

- M. Biasotti, C. Boragno, L. Ferrari Barusso et al., *The Phonon-Mediated TES Cosmic Ray Detector for Focal Plane of ATHENA X-Ray Telescope*, Journal of Low Temperature Physics 199, 225–230 (2020) DOI: 10.1007/s10909-020-02348-y
- F. Columbro, P.G. Madonia, L. Lamagna et al., *SWIPE Multi-mode Pixel Assembly Design and Beam Pattern Measurements at Cryogenic Temperature*, Journal of Low Temperature Physics 199, 312–319 (2020) DOI: 10.1007/s10909-020-02396-4
- G. Addamo et al. [LSPE collaboration], *The large scale polarization explorer (LSPE) for CMB measurements: performance forecast* (https://arxiv.org/abs/2008.11049, submitted to JCAP)

Attended Courses and Schools:

- Introduction to Quantum Technologies
- EASITrain 3, Superconductivity and its applications (https://indico.cern.ch/event/883251/)