3rd year Ph.D. report - Lorenzo Ferrari Barusso

Ph.D. supervisor: prof. Flavio Gatti.

Research activity:

During this year my research work was part of the Athena project. Athena (Advanced Telescope for High Energy Astrophysics) is an ESA project to investigate the universe in the X-ray band. Measurements will examine the baryonic matter evolution in large scale structures, warm-hot intergalactic medium, as well as in energetic compact objects like Black holes, Gamma ray burst. In order to better comprehend our Universe.

Because most of the baryonic component of the Universe is locked up in hot gas at temperatures of around a million degrees, and because of the extreme energetics of the processes close to the event horizon of black holes, understanding the Hot and Energetic Universe requires space-based observations in the X-ray band. Specifically, the theme calls for spatially-resolved X-ray spectroscopy and deep wide-field X-ray spectral imaging with performance greatly exceeding that offered by current observatories like XMM-Newton and Chandra.

ATHENA consists of an X-ray telescope with a fixed 12 m focal length. The telescope focuses X-ray photons onto two instruments, the innovative X-ray Integral Field Unit (X-IFU), based on cryogenic detectors; and the Wide Field Imager (WFI), a Silicon-based DEpleted P-channel Field Effect Transistors (DEPFET) detector. These two instruments combine the high spectral resolution of X-IFU and the high spatial resolution of WFI to provide the scientific goals, with a measurement spectrum from 0.5 to 10 KeV.

X-IFU is based on 50 mK cooled Transition Edge Sensors (TES), films working around the metal-superconductor transition. These can deliver the necessary energy resolution, while providing exceptional efficiency compared to the dispersive spectrometers flown on the current generation of X-ray observatories. The TES technology has already demonstrated the required spectral resolution (2 eV FWHM) but needs to be developed further to provide this over a large field of view (5’ diameter).

My research work is focused on X-IFU, in particular the anticoincidence detector, that is one of the core parts of the instrument. Its scope is the reduction of the signal background of about 2 orders of magnitude. Without it, it shouldn’t be possible to disentangle signals from background on the X-ray main detectors. It will be positioned beside the detector just 1 mm apart.

During this year I’ve performed several studies on the Ir and Ir Au bilayer growth, structure and oxidations for the TES application. This have been done growing several iridium and Iridium Gold bilayer with different thickness and studying their crystalline structure with XRD analysis, critical temperature superficial composition in function of the deposition parameters and conditions. It has been developed an experiment to measure the athermal phonon bulge that dominates our detector fast response and is necessary to build an effective veto system for the telescope. Our setup and the detector are ready, we replicated the Demonstration Model detector with a single TES to be placed inside th cryostat and study its response in function of distance between the TES and the interaction point on the absorber of y rays emitted by a 241Am source. In parallel I’ve continued the fabrication of detectors to check our results and how the procedure changes could affect the complex final result of a cryogenic Transition Edge Sensor based detector.

Courses and exams:

I have attended the following courses:

- Fisica Nucleare Apllicata

I have already taken the exams for the course Criogenia Applicata and I'm in touch with the professors of Elettronica e Acquisizione Dati to take the exam by the end of September.

Papers:

- D'Andrea, M., Ravensberg, K., Argan, A. *et al.* ATHENA X-IFU Demonstration Model: First Joint Operation of the Main TES Array and its Cryogenic AntiCoincidence Detector (CryoAC). *J Low Temp Phys*. https://doi.org/10.1007/s10909-022-02786-w (2022)

- Barret D., et al. The Athena X-ray Integral Field Unit: a consolidated design for the system requirement review of the preliminary definition phase. Preprint submitted to Experimental Astronomy https://doi.org/10.48550/arXiv.2208.14562 (2022)

Conferences:

I participated to the following conferences:

- 15th Pisa Meeting on Advanced Detector La Biodola (Isola d'Elba), May 22 - 28, 2022 https://www.pi.infn.it/pm/

With the following contribution, in the form of poster: L. Ferrari Barusso "**First strctural tests of the CryoAC Detector silicon chip of the Athena X-ray observatory**".

- 15th Workshop On Low Temperature Electronics Matera, June 6 - 9, 2022 https://wolte15.org/

With the following contribution, in the form of talk: L. Ferrari Barusso "**First configurational tests of the CryoAC Detector silicon chip of the Athena X-ray observatory**".

and I will participate by the end of October to:

- Applied Superconductvity Conference 2022 (ASC22) Honolulu (USA) October 23 - 28, 2022 https://www.appliedsuperconductivity.org/asc2022/

With the following contribution, in the form of poster L. Ferrari Barusso "**Ir film structural properties for TES applcation**".