Spectral X-ray micro-CT (μCT) extends conventional tomography by adding energy-resolved information to the three-dimensional reconstruction, allowing materials identification based on their attenuation properties. Among the different approaches developed to access spectral information, photon-counting detectors (PCDs) have made spectral μCT increasingly attractive, combining energy discrimination with count-rate capabilities suitable for a broad range of imaging applications. However, the spectral information provided by conventional PCDs is generally limited to a few energy bins with resolutions of a few keV [1], which may reduce the sensitivity to materials with similar attenuation properties. Hyperspectral detection addresses this limitation using a different approach, based on high-frame-rate charge-integrating detectors and single-photon event reconstruction, providing sub-keV energy resolution over a large number of flexible energy channels.

This talk will introduce the main concepts and technologies used for spectral X-ray imaging, with particular focus on hyperspectral detection. The novel CITIUS detector, developed by RIKEN and Sony Semiconductor Solutions Corp., will be presented as an example of a new generation of hyperspectral detectors. CITIUS is based on a 650 μm-thick silicon sensor and provides single-photon event reconstruction with energy resolutions below 800 eV (FWHM), enabled by low noise and a high frame rate of 26.1 kfps [2]. Its active area and pixel size make it particularly suitable for laboratory radiographic and tomographic imaging.

The first laboratory radiographic and μCT results obtained at the OptImaTo facility (Trieste, Italy) will be presented, showing the potential of hyperspectral detection for material discrimination and quantitative spectral imaging. By resolving fine spectral features in the transmitted spectrum, hyperspectral μCT may approach XRF-like chemical sensitivity while retaining the much higher efficiency of transmission measurements and compatibility with laboratory X-ray sources.

References

[1] M. Campbell et al., JINST (2016)

[2] V. Di Trapani et al., Sci. Rep. (2026)