MET: A High-Sensitivity Multiple Emission Tomography Scanner Based On Inorganic Scintillators

M. Pizzichemi[1,2], G. Terragni[2], F. Pennazio[3], L. Cassano[1], L. Arnone[1], M. N. Colombo[1], E. Fiorina[3], F. Cossio[3], M. Fadavi Mazinani[3], E. Auffray[2], L. Presotto[1]

[1]*University of Milano-Bicocca, Milano, Italy*
[2]*CERN, Geneva, Switzerland*
[3]*INFN Turin, Torino, Italy*
Corresponding Author: marco.pizzichemi@cern.ch

Inorganic scintillators play a central role in modern nuclear medicine imaging, forming the basis of detectors used in Positron Emission Tomography (PET), such as LSO/LYSO and BGO, as well as in Single Photon Emission Computed Tomography (SPECT), where NaI remains the standard choice. The growing importance of theranostics and research with long-lived isotopes demands imaging systems far more sensitive than standard PET or SPECT. Many emerging isotopes lie outside current detector capabilities, resulting in low sensitivity, high background, and poor quantification, as seen with 90Y verification and 124I or 89Sr imaging.

The Multiple Emission Tomography (MET) project introduces a novel imaging device based on inorganic scintillators, capable of operating in dual modes: PET-style coincidence detection of 511 keV photon pairs and single-photon Compton-scattering detection in a single-layer configuration.

The technical configuration of the MET prototype utilizes a DOI-capable light-sharing scheme. Each module consists of a 16 × 16 matrix of depolished LYSO crystals coupled to an 8 × 8 array of Hamamatsu Silicon Photomultipliers (SiPMs). This design, supported by a custom algorithm to solve Compton kinematics, allows for the precise measurement of the photon's depth of interaction (DOI) and the identification of the first crystal of interaction in scattering events.

Latest results from the characterization of the first MET prototype modules show promising performance. The detector has achieved an average energy resolution of 11.6 ± 0.1% FWHM at 511 keV and an average DOI resolution of 3.5 ± 0.1 mm FWHM. While current results use the TOFPET2 ASIC, the project is transitioning to the ALCOR ASIC, which will offer higher bandwidth (up to 2 Mevents/s per channel) and 25 ps time binning to support high-rate Compton reconstruction. This technology is expected to significantly impact theranostics, collimator-less SPECT, and in-vivo range verification for Charged Particle Therapy.

Acknowledgments: This work is supported by the European Union-Next Generation EU, Mission 4 Component 1 CUP H53D23007430001 "Multiple Emission Tomography", and carried out at CERN in association with the Crystal Clear Collaboration.