Contribution ID: **4** Type: **not specified**

Towards a second generation of metascintillators with nanophotonics and AI

Wednesday, 31 May 2023 15:30 (30 minutes)

Scintillator detectors are the gold standard for radiation detection in industry, security and medical imaging. After decades of steady progress, the performance of ionizing radiation detectors is reaching a limit imposed by physical barriers at the level of the scintillation mechanisms. Present X-ray and γ-ray detector technologies are based on monolithic sensors (scintillating crystals or direct-conversion semi-conductors). They focus on spatial and energy resolution, but have temporal resolution in the range of several hundreds of picoseconds at low energy, limited by the intrinsic intracenter relaxation time in scintillators and the electric carrier mobility in semiconductors. Increasing temporal resolution is of paramount importance for all the application domains, and in particular for increasing the effective sensitivity of PET scanners, allowing significant dose reduction and precise quantitative and dynamic evaluation of metabolic processes..
This presentation will show how this demand for a breakthrough in timing resolution can be realised with the concept of METASCINTILLATORS we have recently introduced. Taking advantage of the potential of rapidly progressing emerging technologies, this novel concept proposes a radical change of vision, addressing directly the scintillation mechanisms and light transport management with nanostructured scintillator heterostructures,. After presentation of the very encouraging results obtained on a first generation of metascintillators, this talk will show how we prepare a second generation, exploiting the ultrafast photon emission produced by nanostructured layers benefiting from the Purcell effect and the 1D, 2D or 3D quantum confinement of excitons in nanocrystals, combined with photonic crystals and photonic fibers for an efficient transport and management of the scintillation photons. Moreover, the combination of metamascintillators and artificial intelligence (AI) will introduce multifunctionality in ionization detectors and open up new corridors of science and technology to be explored.

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