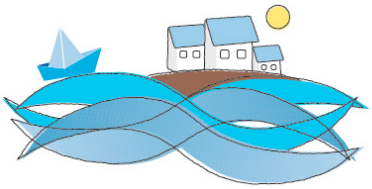

Mediterranean Thematic Workshops in Advanced Molecular Imaging

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Scintillators: a new way to fast emission

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Scintillating crystals performance in terms of light output and timing are key parameters in order to achieve ultimate time resolution in radiation detector systems, particularly in the low energy regime of medical imaging. State-of-the-art Time of Flight measurements present Coincidence Time Resolution (CTR) values on the order of 140 picoseconds for 20 mm long LYSO:Ca crystals using 511 keV, which translate into a background rejection area on the order of few centimeters. Reaching the milimeter level on vertex identification means lowering CTR values down to 10 ps. From the scintillator point of view and in strong correlation with the photodetector time performance, lowering CTR values implies increasing photostatistics, shortening scintillating signal rise and decay times or introducing a prompt signal. Measurements of the intrinsic light yield for LYSO crystals done using electron excitation conclude on 40 000 Ph/MeV $\pm$ 10\% (syst) $\pm$ 3\% (stat). This values sets a limit on the improvement that photostatistics could bring to the CTR measurements and new ways to fast prompt emission are being explored looking at new materials: nanocrystal.

Nanocrystals are semiconductors grown at different levels of confinement, which define its optoelectronic properties and band gap structure in the visible range. They usually present high quantum efficiency (QE) and fast recombination times on the order of few hundreds of picoseconds under laser excitation, in comparison with bulk scintillators (τd_LYSO ˜ 40 ns). Under ionising radiation of few tents of keV, Auger recombination is responsible for weakly emissive multiexciton population, which among other effects, degenerate the high QE. A new generation of Auger suppressed materials have been tested using a Hamamatsu streak camera and a picosecond pulsed X-ray tube up to 40 keV. The materials are CdSe nanoplatelets and CdSe/CdS giant shell quantum dots. Measurements under single photon counting mode and instrumental response function of 70 ps, show near zero rise time, resolution limited first decay component and a second component between 200-400 ps for both materials. The small time differences between laser and x-ray irradiation for CdSe nanoplatelets point towards a high suppression of the non-radiative channels. First deposition of nanocrystals on conventional scintillators has been also characterized showing a long third decay coming from absorption and remission of scintillating light by the nano-materials. However, spectrally resolved information show comparable light yield between nano-materials and scintillators when integrating over the firsts nanoseconds.

Primary author: R. MARTINEZ TURTOS, UNIVERSITA MILANO-BICOCCA & INFN, (IT) (Universita & INFN, Milano-Bicocca (IT))

Co-author: Mr GRIM, Joel (Research Naval Laboratory)

Presenter: R. MARTINEZ TURTOS, UNIVERSITA MILANO-BICOCCA & INFN, (IT) (Universita & INFN, Milano-Bicocca (IT))

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