Irfu - CEA Saclay
Institut de recherche sur les lois fondamentales de l'Univers

Post-Doc Position

The ClearMind project : development of a tens-picoseconds time resolution gamma ray detector for imaging.

DESCRIPTION

Recently, the development of new types of ultra-fast compact photo-detectors has improved the coincidence time resolution (CTR) of scintillation spectrometric chains below 100 ps FWHM. These detectors consist of fast, thin scintillators, typically LSO, LYSO, $LaBr_3$ or $CeBr_3$, optically coupled to SiPM matrices. Thus a very ambitious CTR technological frontier appears at the edge of 10 ps FWHM, which would make it possible to foresee new ultra-fast gamma ray imaging applications. For example, in positron emission tomography (PET), an image could be acquired virtually without tomographic inversion with a 10 ps CTR time-of-flight (TOF)-PET camera.

Time resolution is limited by the shape of the luminescence light pulse, namely its rise and decay times, its statistics and the collection efficiency. As such, the generation of a few dozen Cherenkov photons by photoelectric or Compton electrons is almost instantaneous compared to the production of scintillation light. The collection of both the Cherenkov photons and the scintillation photons is impacted by reflections on the crystal surfaces. In addition, time resolution of the detector is also limited by the uncertainty on depth-of-interaction (DOI) in thick crystals. Spatial resolution in our device depends mainly on detected photo-electron statistics.

We develop a position-sensitive detector consisting of a monolithic scintillating crystal on which a high efficiency photocathode is deposited. This "scintronic" crystal, which combines scintillation and photoelectron generation, optimizes the transmission of scintillation and Cherenkov photons to the photocathode without any optical coupling media (e.g. optical grease). Such a device will avoid internal reflection of optical photons on the crystal/photocathode interface thanks to the high refractive index of the photocathode. The "scintronic" crystal will be encapsulated within a micro-channel plate based multiplier tube (MCP-MT) to amplify the signal and optimize the transit time of the photoelectrons towards the detection anodes, thus minimizing the time resolution of the detection chain. This is the ClearMind project

The ClearMind project is funded by the French National Research Agency. The collaboration keeps developing. It involves today five French laboratories working on particle physics and medical physics, instrumentation and simulation; artificial intelligence (machine learning) and image reconstruction softwares.

Work will focus on the detector hardware optimization and characterization. This will involve lab tests designs and setup, lab measurements, and interactive analysis of data taken. We are using cutting edge fast photo-detection techniques: picosecond laser, fast inorganic scintillators (Cherenkov + scintillation), micro-channel plate photomultipliers (MCP-PMT), fast silicon photomultipliers (SiPM), gigahertz bandwidth amplifiers, SAMPIC waveform recorders. The candidate will be also involved in the detector simulation using the GEANT 4 and GATE software and event reconstruction using machine learning technique.

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QUALIFICATION

- Ph. D. Degree in particle/nuclear physics, nuclear imaging instrumentation or advanced detectors instrumentation.
- Fluent in English, willing to learn French.
- Be comfortable with detector development, commissioning and use of electronics devices.
- Experience with interactive data analysis (Root CERN library) and C++ programming will be an asset.

WORKING ENVIRONMENT

The successful candidate will work in CEA Saclay, IRFU/Departement of Particle Physics, France, in a team of two senior physicists, two post-docs, and two to three PhD students: the CaLIPSO group. Research will happen in close collaboration with IJC-Labs Orsay and CPPM Marseilles.

This is a 24 months fixed-term contract (CDD), starting from July 2021.

CONTACTS

For the application submit your CV and two recommendation letters to :

Dominique Yvon: Dominique.yvon@cea.fr
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REFERENCES:

1. D. Yvon et al., "*Design study of a scintronic crystal targeting tens of picoseconds time resolution for gamma ray imaging: the ClearMind detector*", 2020, JINST 15 P07029, arXiv:2006.14855 [physics.ins-det]
2. C. Canot et al., "*Fast and efficient detection of 511 keV photons using Cherenkov light in PbF2 crystal, coupled to a MCP-PMT and SAMPIC digitization module*", *Journal of Instrumentation* **14** (2019) P12001, arXiv:1909.06107 [physics.ins-det]
3. D. Breton et al., "*Fast electronics for particle time-of-flight measurement, with focus on the SAMPIC ASIC*", Nuovo Cimento C 43 (2020) 7.
4. Dominique Yvon and Viatcheslav Sharvy, « *Détecteur de photons à haute énergie* », Patent N° FR17/59065, 29 Sept. 2017, Déposant(s) : CEA