Instrumentation Design and Data Analysis Methodology for Applied and Fundamental Research

The Department of Science and High Technology at Università dell'Insubria in Como hosts the activities of the team lead by Massimo Caccia, professor, and Romualdo Santoro, associate professor. The team develops instruments and methods based on the use of Silicon detectors of ionizing particles and light, together with related Data Analysis techniques.

The core activities are based on the use of Silicon Photomultipliers (SiPM) and custom, pixel detectors. SiPM are state-of-the-art single photon sensitive devices with photon number resolving capability, low bias supply, robustness, low cost, magnetic field immunity, extreme time resolution and, last but not least, design flexibility. Pixel detectors are designed to guarantee the reconstruction of the impact point of a sub-atomic particle with a few micron precision.

The team is currently involved in international curiosity driven and applied research projects:

- Experimental particle physics is looking beyond the Large Hadron Collider at CERN, with long term projects aimed at the construction of a ring of about 100 km circumference, initially accelerating electrons and positrons at a centre of mass energy corresponding to the Higgs particle mass. Within this community, the team addresses the development of a calorimeter, optimized for hadron energy reconstruction, and a pixel detector for short living beauty and charmed particles;
- Biophotonics is a running up science & technology. The team co-developed a technique for the detection of single photon trains by cells, in response to Ca++ intake, for diagnostics and environmental Science;
- Medical Physics activities in the team are essentially connected to ORIGIN (https://origin2020.eu), a project focused on real-time dosimetry in oncological brachytherapy, namely radiation therapy based on the use of radioactive sources inserted in the patient's body;
- Random Power (www.randompower.eu) is a project turned into a start-up company, leading an EU project funded within the ATTRACT program (https://attract-eu.com). The core of Random Power is the development of a platform for generating random bit streams, based on the quantum properties of semiconductors and targeted to crypto-security and privacy preservation.

Selected reference papers are reported below and more informations can be obtained by

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Selected papers:

- R. Santoro et. Al., SiPMs for Dual-Readout Calorimetry. Instruments 2022, 6, 59. https://doi.org/10.3390/instruments6040059

- I. Vivarelli et. Al., Exposing a fibre-based dual-readout calorimeter to a positron beam. 2023 https://doi.org/10.48550/arXiv.2305.09649

- M. Antonello et. Al., Present status and perspective of dual-readout calorimetry for future accelerators, Int. J. Mod. Phys. A, 35, (2020), doi: 10.1142/S0217751X20410122

- L. Pancheri et al., "Fully Depleted MAPS in 110-nm CMOS Process With 100–300-μm Active Substrate," in IEEE Transactions on Electron Devices, vol. 67, no. 6, pp. 2393-2399, June 2020, doi: 10.1109/TED.2020.2985639.

- M. Caccia et Al., Silicon Photomultipliers and SPAD imagers in biophotonics: Advances and prospectives, NIMA, Vol. 926, 101 - 117 (2019) https://doi.org/10.1016/j.nima.2018.10.204

- S. Lomazzi et. Al., Assessment of the potential of SiPM-based systems for bioluminescence detection, NIMA, Vol 979, 164493 (2020), https://doi.org/10.1016/j.nima.2020.164493

- S. Cometti, et. Al., Characterization of scintillating materials in use for brachytherapy fiber based dosimeters, NIMA, Vol 1042, 167083 (2022),https://doi.org/10.1016/j.nima.2022.167083

- Homeland security

- R. Santoro et Al., Qualification of a compact neutron detector based on SiPM, JINST 15 C05053 (2020), DOI 10.1088/1748-0221/15/05/C05053

- M. Caccia et al., In-silico generation or Random bit streams, Nuclear Instruments and Methods, A980 (2020) 164480