Fundamentals of nuclear instrumentation

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Instrumentation occupies a special position in nuclear physics. Between art and science, it is the mean, for the physicist, to understand the phenomena he studies and to prove his theories. If the creative part of the experimenter can and must develop during the conception of a measurement device, it obeys basic laws that are essential to master at the highest level to make the best use of the equipment. It is precisely the study of these laws that will guide us in this course.

We will approach the subject by making a quick tour of the different types of detectors. We will see that despite their diversity, unified modeling technics allow to easily and precisely define the signal and the information it carries (deposited energy, interaction time of a particle, identity thereof, interaction point,...).

This information, which result from physical interactions, is disturbed by various noise sources (primary quantum fluctuations, electronics-EMC-microphonic noise,...). We will study the major methods of signal processing that define the ultimate limits it is possible to attain knowing the information sought and the noise that affects it.

Finally, we will apply this knowledge to understand the optimization techniques in various fields of nuclear instrumentation (spectroscopy, time measurement, pulse shape discrimination ...).

The presentation will be illustrated with virtual but realistic experiments operating on the statistical computing platform 'R' (http://www.r-project.org/).