Searching for Dark Matter with LUX

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The experimental evidence of the existence of a non-barionic dark matter component of the Universe has been strengthened in recent years. Although its nature is still unknown, there is experimental support for the hypothesis that dark matter can be composed by heavy non-relativistic particles commonly referred to as WIMPs (Weakly Interacting Massive Particles). The direct method of detecting such particles is to look for the energy deposited when a WIMP scatters off a nucleus of a target/detector material. In these rare events, the nuclear recoil energies are expected to range from a few keV to a few tens of keV. The main challenge for these experiments is to discriminate between these rare events and the much higher rate background due to natural radioactivity.

LUX (Large Underground Xenon) is a dark matter direct detection experiment using a 350 kg dual-phase Xe TPC, and technologies proposed for ton-scale detectors, such as large water shielding and thermosyphon cryogenics. It aims at a WIMP-nucleon cross-section sensitivity of 7e-46 cm^2 for a 100 GeV WIMP after 300 live-days exposure. It will surpass all existing dark matter limits for WIMP masses above ~10 GeV within weeks of beginning its science run. The detector was operated on the surface at the Sanford Underground Research Facility (SURF) from November 2011 until February 2012, when the detector was fully characterized. It has finished installation in the 4850 feet underground level on January 2013, and the liquid Xe fill phase ended on February 2013. The goal of the current underground run is to assess subsystem performance, Xe purity, and calibrate the detector response to light and charge signals in the low energy range in preparation for the long WIMP Search Run.

This talk will provide an overview of the experiment, focusing on the design elements that make the detector a major competitor in the field of dark matter, and discuss the current status of the underground run.

Developments on Medical Imaging Instrumentation:

Part I: Radiography and CT

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Diagnostic medical imaging is a fundamental part of the practice of modern medicine. The history of medical imaging began in 1895 when Roentgen took the first radiography. Radiography became the oldest and most frequently used form of medical imaging. Nowadays, X-rays are used in several medical imaging techniques, as for instance radiography, fluoroscopy, angiography, and mamography. Computed tomography (CT), introduced in 1972, was a large step forward in medical imaging. CT uses X-rays in conjunction with image reconstruction algorithms to produce cross-sectional images or "slices" of parts of the patient's body.

In spite of being rather well established tecnhiques, radiography and computed tomgraphy has been recently revolutionized due to breakthoughs in the associated instrumentation.

After a brief review of the physical principles of image formation in radiography and CT, we will focus on the requirements regarding instrumentation, namely regarding the detector technology. For each technique, the characteristics and performance of the standard instrumentation is examined, followed by the presentation of some of the current most relevant developments. In each case, the equipment(s) and/or systems, including their design, construction, operation and practical applications are discussed.

Developments on Medical Imaging Instrumentation:

Part II: Nuclear Imaging Techniques

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Nuclear Imaging techniques use very small amounts of radioactive materials (radiopharmaceuticals) to obtain information on biochemical processes in living organisms, being a tool of increasing importance for medical diagnosis. The more commonly used techniques are scintigraphy, SPECT (Single Photon Emission Computed Tomography) and PET (Positron Emission Tomography). The improvement and expanding of these techniques depend on the progress attained in several areas, namely the accelerators and other technologies for the radionuclide production, radiopharmaceuticals, radiation detectors and image processing algorithms. Here we will be concerned only with the detector technology.

In radioisotope imaging techniques, gamma-rays of energy ranging typically from 100 keV to 511 keV have to be detected with the highest possible efficiency and localized with a spatial resolution desirably of the order of a few millimetres or better. In addition, other requirements are posed to the detectors depending on the imaging technique and medical application.

After a brief review of the physical principles of image formation in nuclear medical imaging techniques, we will focus on the requirements of instrumentation, namely regarding the detector technology. For each technique, the characteristics and performance of the standard instrumentation is examined, followed by the presentation of some of the current most relevant developments. The present trend to integrate two or more modalities in a single imaging system in order to obtain complementary information will be presented.