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Radio frequency photo multiplier tube: Possible applications in bio-medical devices

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The detection of visible light underpins a wide range of scientific, engineering and applied techniques. At present, the detection of optical signals, down to the single-photon level, is carried out with Avalanche photodiodes (APD), vacuum photomultiplier tubes (PMT), or hybrid photon detectors (HPD). APD, PMT and HPD enable one to obtain precise time information about the detected photons, which is necessary in many diverse fields such as particle detection in high energy and nuclear physics, astrophysical imaging and medical imaging. The time resolution limit of current APD, PMT or HPD for single photo-electron detection is about 100 ps FWHM. It is well known that timing systems based on radio frequency (RF) fields can provide precision of the order 1 ps or better . Streak cameras, based on such principles, are used routinely for measurements in the ps time scale. Nevertheless, such RF timing techniques have so far not found wide application in fields such as elementary particle physics, nuclear physics and bio-medical imaging. This is mainly related to the inability of commercially available devices to provide fast, instantaneous readout. Recently a new photon detector the radio frequency photo multiplier tube (RFPMT) was developed at Yerevan Physics Institute. Such a photomultiplier tube combines the advantages of a regular PMT or APD and the streak camera. It would be capable of detecting optical photons and providing fast (~ns) output signals, similar to a fast PMT. Event by event processing of single photons, with about 1 ps temporal resolution would be possible. The time resolution and minimal time bin for single photons detected by RFPMT is about a picosecond. The RFPMT can be operated at MHz rates and with a dedicated spiral scanning system operational rates can achieve THz over a short interval of about 100 ns, while the longer term averaged rate would be at the GHz level. The RFPMT has the potential to become a breakthrough in the single photon based timing technology. Potentially it has a number of applications in time-domain biomedical imaging devices, for example in fluorescence lifetime imaging (FLIM) microscopy, stimulated emission depletion (STED) nanoscope, diffuse optical tomography (DOT) and time-of-flight positron emission tomography (TOF-PET).

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Translational application of laser speckle contrast imaging: From bench to bedside

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Laser Speckle Contrast Imaging (LSCI) utilizes non-visible laser light to quantify the velocity of blood flow within tissue microcirculation. Such technology may be helpful in assessing the viability of healing wounds and understanding conditions where capillary blood flow is pathologically changed. Murine models of myocutaneous revascularization, such as the surgical creation of a dorsal skin flap, inform advances in the treatment of healing wounds in health and disease. In the laboratory setting, we have used LSCI extensively to evaluate surgical flap engraftment in a variety of transgenic mice. The device has proven useful in differentiating the healing characteristics of wild-type flaps from those of obese, hyperglycemic animals. A total of 53 mice were analyzed after the creation of identical 200 mm2 surgical flaps. A variety of strains were utilized including C57BL/6 (wild-type), leptin and leptin receptor-deficient (ob-/ob- and db-/db- respectively), analogous heterozygous strains (ob+/ob- and db+/db-) and mice rendered obese as a result of a high-fat diet. Data derived from LSCI imaging was found to be instrumental in discovering previously-unreported characteristics of angiogenesis in certain genetically obese mouse strains. In translating LSCI technology to a human clinical setting, our team has investigated cutaneous revascularization and engraftment of split-thickness skin grafts applied to visceral granulation tissue following severe abdominal trauma. Coupled with advanced histological and molecular techniques, LSCI has improved our understanding of skin graft healing. Future clinical applications of LSCI imaging may include the assessment of chronic wound perfusion and the adequacy of surgical wound debridement.

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