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A proposal for a TOF PET and SPECT MRI probe for diagnosis and follow up of prostate cancer

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Prostate cancer (PCa) is the sixth most common cancer in the world, the third most common cancer in men, and the most common cancer in men in Europe, North America, and some parts of Africa. The incidence is increasing steadily in almost all countries, yet we know little about its causes. PCa is a biologically heterogeneous disease for which a variety of treatment options are available but a precise disease characterization is needed: evaluation of cancer location, size, and extent and an indication of tumor aggressiveness. Pre-treatment knowledge of these prognostic variables is essential for achieving minimally invasive, patient-specific therapy. The current standard for diagnosing PCa is transrectal ultrasound (TRUS) guided sextant biopsy with or without additional biopsies. PCa is the only malignancy where the diagnosis is made from tissue obtained on a blind biopsy, and that is inadequate in assessing the grade of the disease. A novel multidisciplinary approach is required. Imaging may play a key role provided dedicated prostate imagers and procedures are available. In fact considerable improvements have been implemented in diagnosis with the Magnetic Resonance Imaging (MRI) technique, and with nuclear medicine techniques (PET and SPECT). However, those modalities do not adequately address the problem of distinguishing lethal from non-lethal disease, a prediction of disease prognosis or of treatment response. Due to sub-optimal prostate imaging geometries with these generic large instruments and their associated poor spatial resolutions preventing separation of the signal from surrounding organs, the sensitivity, spatial resolution and lesion contrast attained are inferior to what can be potentially achievable with optimized dedicated prostate imagers and procedures. Traditional morphologically based prostate imaging needs to be complemented by functional and molecular imaging techniques. Recently a new research project was initiated by a large INFN collaboration with the goal of designing, building and testing in phantom tests an endorectal PET-TOF probe compatible with MRI. The concept has been developed based on different concepts discussed during the Prostate Workshop (Rome 2005) from Moses, Levin and Clinthorne, further developed by Majewski and Clinthorne and from a proposal presented to EU FP7 on PET-TOF-MRI chaired by INFN and ISS Rome. We think that multimodality and TOF capability, while challenging, are a necessity to achieve proper operation. This probe would allow diagnosis, biopsy guidance and follow-up of prostate cancer. Fully exploiting the TOF capability would allow not only to increase the SNR/NECR but also to get rid of the huge background coming from the bladder. A timing resolution of ˜300 ps would allow this, but we believe that even better timing resolution seems to be potentially possible. Extensive simulation of the entire system is needed for selecting the scintillator (LSO (doped with Ca) or LaBr(Ce)), its degree of segmentation and the light collection geometry. Silicon Photo Multipliers (SiPMs) are mandatory as photodetectors. Fast readout based on the advanced compact ASIC already under study in the framework of the INFN research in the field as well as on the expertise present in the collaboration from developing ASIC for HE physics experiment. Using SiPM will allow not only the advantages of fusing morphological and functional techniques, but also the MR spectroscopy adding fundamental complementary information. The research team is establishing several collaborations, with the Marek Moszynski's group on electronics development, with Johns Hopkins (Martin Pomper) on development of new prostate biomarkers, with the Michael Hofmann group on selection and possibly testing different prostate radiotracers, as well as with ISS Oncology Department on mouse models, and with other clinical departments (Rome, Torino, Naples). The SPECT-MRI option will be also evaluated.

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