New Radiation Detection Technology for accurate QA in Heavy Ion Therapy.

Anatoly B.Rosenfeld

Centre for Medical Radiation Physics, School of Physics, University of Wollongong

On behalf of CMRP and Australian Hadron Therapy Collaboration

With cancer incidence rates increasing to approximately 1% of the population per annum, one third of Australians are expected to develop cancer in their [1]. Up to 40% of cancer patients are currently treated with radiation therapy [2]. Conventional X-ray radiotherapy is suitable for many tumour types but has limitations when tumours are located in proximity to critical organs or in paediatric treatments. Heavy Ion (HIT) and Proton Therapies (PT) are very promising technologies for cancer treatment that overcomes these limitations and must be utilised to compliment X-ray therapy.

Delivery of HIT and PT is much more complicated than X-ray therapy and require quality assurance (QA) of the range (energy) of heavy ions and protons, parameters and spatial positioning of the pencil scanning beam (PCB), physical dose delivery and radiobiological efficiency of the beam applicable for routine practice and some of them in real time *in vivo*.

Suite of new semiconductor radiation detectors and technologies to address needs of QA in HIT and PT are under development at CMRP. Prompt in a phantom ion range and SOBP position verification utilizing *Dose Magnifying Glass* (DMG) based on edge on silicon strip detectors has been proposed, justified by Monte Carlo simulations and recently tested on $^{12}C^{+6}$ ion beam at HIMAC, Japan and PT at LLMC, USA. Transmission detector system *Magic Plate* to be placed between nozzle and patient has been proposed and developed for in vivo real time measurements of energy and position of PSB simultaneously which is based on 2D array of discrete small size RadHard epitaxial Si detectors embedded in a thin 0.4 mm thick KAPTON. *Magic Plate* with 0.2-2 mm spatial resolution based on bulk silicon pixel detectors has been developed for QA of beam tracking system adapting radiation field to image guided movable target and successfully tested on X-ray LINAC.

New SOI microdosimeters utilizing 3D detector technology [3] for fabrication of array of 3D cylindrical micron size (10 μm^3) detectors mimicking ionizing energy deposited in biological cells has been developed and fabricated in framework of 3D MiMiC collaboration [4]. They will allow fast RBE verification with high spatial resolution. All these detector system have been pioneered at CMRP are innovative and addressing current ANSTO initiative on building of Australian National Heavy Ion Therapy research and Treatment Facility.

Overview of PET and prompt gamma imaging techniques for in vivo real time dose distribution verification in HIT and PT and state-of-the-art detector system for them will be presented and discussed.

[1] http://www.statistics.cancerinstitute.org.au
[2] Baskar, R, et al 2012, 'Cancer and Radiation Therapy: Current Advances and Future Directions', Int. J. Med. Sci., 9(3), 193-199.
[3] Parker, S. et al 2006,'3DX: An X-Ray Pixel Array Detector With Active Edges', IEEE Trans on Nucl. Sci., 53, 1676-1688
[4] http://www.sintef.no/home/Information-and-Communication-Technology-ICT-old/Microsystems-and-Nanotechnology/Competence-and-services-/Silicon-radiation-sensors/3DMiMic/