# A Three-Dimensional Electronic Detector Array for Dose Verification in Radiotherapy: Proof of Product

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**Purpose:** Proof of product (POP) of a three-dimensional (3D) electronic detector array that can provide volumetric prescription dose quality assurance (QA) of an IMRT/VMAT plan within minutes after irradiation.

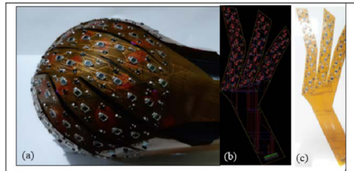
**Methods:** A 3D electronic detector array has been constructed. It consists of three concentric PMMA semi-spherical layers, 210 photodiodes in a semi-isotropic distribution and a farmer chamber in its central volume. The innermost layer has a 2 cm radius, five active matrices (AMs) and 15 AM pixels per matrix. Each AM pixel comprises a BPW34S photodiode, a 1 μF storage capacitor and a NX7002AK MOSFET. The central and outermost layers have radiuses of 4 cm and 6 cm, five active matrices (AMs) each and 60 and 135 AM pixels per matrix, respectively. A dose calibration that matched the TPS calculated dose to the voltage measured by each photodiode in a 20 x 20 $cm^2$ 6 MV parallel-opposed SAD beams to a specific dose at isocenter, was applied to a QA measurement. Furthermore, the detector array design was converted to DICOM and exported to a TPS to be used for plan verification of a 3D conformal intracranial target treatment.

**Results:** Spherical coordinates were used to map the dose distribution from the calculated (TPS) and measured sources. A direct dose analysis for each diode was performed and a percent dose difference of ≤ 4% was observed. Gamma value analysis is in progress and results are pending.

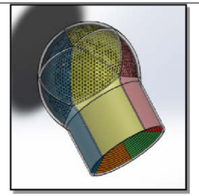
**Conclusions:** These preliminary results demonstrate the feasibility and mark the beginning of the development of 3D electronic detector array for IMRT/VMAT QA. The need for such a device is compelling due to advances in linac technology that have made high precision treatments routine.

**Innovation/Impact:** To our knowledge, this is the first proof of product (POP) of a 3D electronic detector array for IMRT/VMAT QA. A more advanced design will consist of a 20 cm diameter semi-spherical detector array with 31,560 photodiodes of submillimetric dimensions and distributed isotropically within the semi-spherical volume. Direct experimental data on volumetric dose verification, CI, GI, DVH and gamma-values can be provided by this 3D electronic detector array.

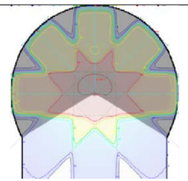
**System Description and Results:**



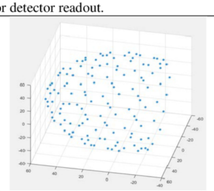

Photograph of the semi-spherical detector array outer layer (a). Active matrix design performed in Autodesk EAGLE software (Autodesk Inc, San Rafael, CA) (b). Active matrix made out PCB Flex (c).



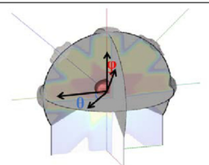
Schematic of the proposed high resolution 3D spherical detector. It would consist of 16 semi-spherical concentric layers, 31,560 isotropically distributed photodiodes and five active matrices per layer for detector readout.



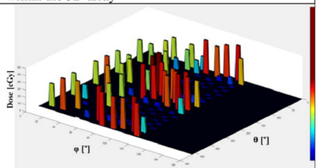
3D irradiation depicted in the TPS



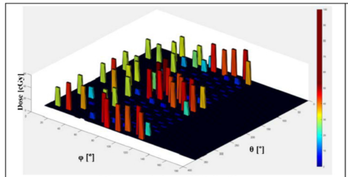
MathCAD view of the isotropic detector distribution within the 3D array



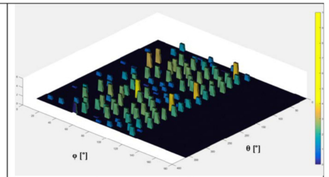

Spherical coordinates used for mapping the dose distribution




TPS Calculated dose distribution




Measured dose distribution




Percent dose difference