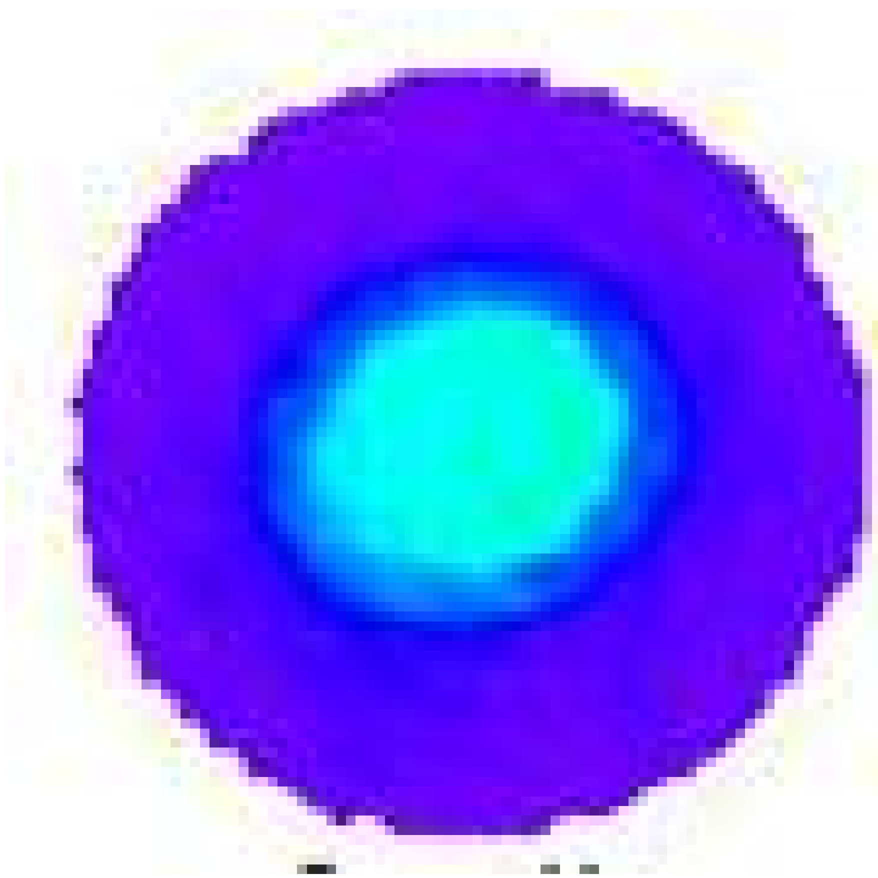
THREE DIMENSIONAL DOSIMETRY

Verification of cancer treatment planning is very important for modern conformal radiotherapy techniques, such as IMRT (Intensity Modulated Radiation Therapy), stereotactic radiosurgery and radiotherapy, and HDR (High Dose Rate) brachytherapy. These techniques require knowledge of 3D (three dimensional) dose distribution. The most frequently used system for 3D dose distribution is an automatic positioning water phantom connected with a "point" detector (ion chamber, semiconductor detector or diamond detector). Unfortunately, this system does not allow to map complex dose distributions formed by superposition of different radiation beams. It does not allow to record integral dose distribution. Another frequently used system is a tissue-equivalent phantom containing materials, such as TLD or x-ray/radiochromic film. This system has many practical problems. For example, the phantoms cannot be easily extended to any required anatomical shape or geometries including different tissue types.

The recent techniques for 3D dosimetry include (1) so called Fricke-infused gel dosimeter, which combines the basic gel dosimeter principle with well established Fricke dosimeter and (2) that based on (a) polymerization of acrylic monomers and (b) development of color by change in pH in a gel medium. The system based on polymerization of acrylic monomers has many drawbacks, such as (1) sensitivity to visible blue and UV lights, (2) high sensitivity to temperature of irradiation, (3) short shelf life, e.g., a few weeks at room temperature, (4) very high sensitivity to oxygen, (5) short archival life, e.g., readings should be taken within a week, (6) toxic vinyl monomers which require special handling and disposal, (7) not being self-supporting, e.g., require a glass container, (8) image is opaque and not in colors, and (9) during the measurement the light is scattered and hence one has to map with NMR technique. The dye system requires a very high dose. The dyes can diffuse as the temperature of the gel is increased or melted. Many of the dyes undergo reversible color change or can be tampered with other chemicals or processes. For example, an image created by a pH sensitive dye, can be altered by changing the pH. Gel dosimetry has one basic and fundamental flaw: that the image can be destroyed by melting the gel above a predetermined temperature, for example: heating the irradiated gelatin gel above ~45^{o}C. Hence, there is a need (1) for a system where the image cannot be easily tampered with and if tampered it should be evidenced (2) for an indicating material, which once exposed to radiation an image is produced, it cannot be reversed, and the matrix or binder cannot be easily melted. Our system has none of the above drawbacks. We use a solid, transparent, plastic block and diacetylenes which polymerize to a colored polymer at very low dose.

A top photograph of a plastic block in a vial irradiated with a narrow beam of 100 KeV X-ray

A side photograph of a plastic block in a vial irradiated with a narrow beam of 100 KeV X-ray



A scanned cross section of the block for dose distribution