The primary advantage of 3D conformal radiation therapy (3D CRT) is the dose escalation within the target volume that theoretically should increase the therapeutic ratio. The clinical success of this strategy depends however on the precision with which the planned dose distributions are delivered to the patient in three dimensional space. This requires adequate quality assurance methods, including 3D dosimetry using phantoms. The measurement of dynamically delivered dose distributions having very high dose gradients calls for a cumulative 3D dosimetry with millimeter resolution. 1D or 2D dosimeters such as ion chambers, diodes or TLD's, film, or plastic scintillators do not fulfill these requirements.

In gel dosimetry, a tissue-equivalent, rigid gel phantom undergoes some measurable chemical change when irradiated, usually as a result of progressive radiolysis of its components. For three dimensional interrogation of dose information stored in the gels, MRI or optical transmission CT scanning have been used. Gel dosimeters are used as phantoms for which a 3D treatment plan can be written based on initial CT and/or MRI imaging. The irradiated gels are then imaged optically or by MRI, and the resultant dose maps are compared with the plan, using image correlation and fusion techniques. Various dose mapping programs have been developed for analyzing the data derived from the gels, and more are under development.

Many different types of gel dosimeters have been developed over the past fifty years. Recently, gel dosimeters of a new type, so-called BANG® polymer gels, have been introduced. In these gels, radiation-induced free-radical chain polymerization of various acrylic or vinyl monomers that are dissolved in the gel produces sub-micron sized polymer particles whose concentration increases in proportion to the absorbed dose. Because the particles remain entrapped in the gel matrix and because they scatter light, a permanent 3D image of the dose distribution is formed that can be seen as an immobilized white cloud of dose-dependent density in the transparent gel. Both the optical transmission CT scanning and the MRI provide quantitative measurement of dose distributions in the gel, with accuracy of 3% or better.

BANG gels are muscle tissue equivalent in both the density and atomic composition. The sensitivity of the gel can be chemically modified for specific applications, so that the maximum dose can be as low as 1 Gy or as high as 50 Gy.

BANG gel dosimeters have been applied to stereotactic radiosurgery, brachytherapy and IMRT. It is anticipated that with the advent of dynamic 3D CRT and with further development of software for gel-derived data analysis the use of BANG polymer gel dosimeters for quality assurance will become more widespread.

Educational objectives:

1. Describe the need for 3D, high-resolution dosimetry in 3D CRT.
2. Explain the physics and chemistry of gel dosimeters in general, and BANG polymer gels in particular.
3. List the radiological properties of polymer gel dosimeters.
4. Explain how to use gel dosimeters.
5. Review the clinical applications (3D CRT; SRS; IMRT; Brachytherapy -interstitial, intracavitary, intravascular).