Modern radiotherapy procedures like IGRT, SRS, SBRT, gating and dose-escalated prostate therapy require increasingly accurate delivery. The mechanical movements of traditional analogue accelerators typically use potentiometers as transducers for readout and positioning of x-ray jaws, couch, collimator and gantry angles. However, even precision potentiometers have 0.1% tolerances on linearity, i.e., three-digit accuracy that can translate into 0.4 mm inaccuracy in the positioning of jaws for a 40 cm wide field. Voltage signals have to be digitized, and are affected by ageing of electronic components that further degrade the already marginal accuracy. The digital signals from rotary and linear encoders, on the other hand, are immediately amenable to computer processing and are less susceptible to aging until outright failure.

Absolute encoders produce unambiguous digital signals for angles and linear positions, whereas incremental encoders measure distances in relation to a reference point by counting the number of light beam interruptions or pulses from a Hall generator. Stepper motors rotate a fraction of a revolution for each input pulse, directly translating digital signals into angular position. Using high gear ratios, positioning signals can be obtained with any desired number of significant digits, and precisely ground spindles and gears translate these into positions with accuracy typically in the 10 micron range. Because of such high precision, even the positions of flattening filters, light field projectors and other critical collimator components can be digitally adjusted from the keyboard of the accelerator.

Gantry flex can be accounted for by gantry-angle dependent position corrections of kV images. Output calibrations are done by typing the measured dose produced per MU into the computer. Because signals are digital, accelerator performance can be readily monitored remotely. Using the processing power of computers, correction signals in the feedback loops for beam symmetry, beam position, rf driver frequency, etc., can be monitored automatically and applied during energy selection, thereby reducing the initially inaccurate irradiation after each beam interruption.

Medical physicists appreciate the fewer calibrations of jaw, couch, gantry and other motions, and the ease of radiation output calibrations. However, they must be aware of "bugs" and accept the occasional rebooting inherent to computerized systems. Somewhat lengthy initializations of mechanical motions become necessary when incremental transducers lose count due to noise spikes or power interruptions. Shielding sensitive computer components with boron impregnated polyethylene to prevent single-event upsets and other improvements are being implemented. Nevertheless, frequent spot checks as protection against typical computer glitches are recommended.

Educational Objectives:

1. Understand the basic difference between the functioning of analogue and digital accelerators
2. Understand the clinical implications of digital control
3. Enable physicists to tailor quality assurance tests to the new technologies