TomoTherapy patient QA using exit detector measurement of pre-treatment in-air delivery

We are exploring ways to fully implement STAT-RAD, a totally new palliative radiation oncology workflow that provides a procedure that is rapid, convenient, effective, less toxic and less expensive than current multi-week treatment courses. To reduce the time required to perform pre-treatment patient specific QA, we want to develop a method to eliminate phantom setup and film processing by using the measured exit detector signal during pre-treatment in-air delivery.

In order to reconstruct detector signal from the planned sinogram, we modeled the individual leaf profile and tongue and groove (T&G) profile. We created calibration procedures that recorded the individual leaf profile as well as the adjacent leave-pair open profile. The T&G profile was obtained by subtraction as shown in Fig.1. The accuracy of the detector signal reconstruction is verified with several calibration procedures. The all leaves open procedure is illustrated in Fig.2. The reconstructed detector signal (magenta) agrees with the actual signal (blue) within 1%.

![Fig.1 calculate T&G profile](image1.png) ![Fig. 2 reconstruct leave all open profile with less than 1% error](image2.png)

The algorithm was applied to patient plans. Fig.3 shows the comparison between reconstructed detector data and the actual measured data over several projections. Fig.4 shows the comparison of one projection. Any difference observed was determined as the deviation occurred during the delivery.

![Fig. 3 planned (reconstructed) detector signal vs measured signal](image3.png) ![Fig. 4 comparison of one projection](image4.png)

To determine whether the deviation during the delivery was big enough to cause a failed QA, we estimated the point dose from the detector signal difference. A simple algorithm was developed to give an estimate. For a point of interest, we first found the detector that records the primary fluence that go through this POI for each projection. These detectors form a sinusoid curve in the detector sinogram and the projections it impacted was within a jaw width. The percentage dose error can be estimated by the jaw-profile weighted difference over the sinusoid curve in the detector sinogram. For a more accurate estimate, ray tracing can be performed to take attenuation into account.

We intentionally introduced delivery errors by modifying the delivery sinogram. The same error introduced sinogram was delivered both in-air (as pretreatment QA) and with a cheese phantom containing an ion chamber. The point dose estimation at the location of the ion chamber agreed to within 3% with the actual measurement.