Purpose: To explore the ability of a new dosimetry system to identify imposed PDR and HDR brachytherapy errors (needle swaps and displacements) in a phantom.

Methods: The new dosimeter is based on the radioluminescence of a fiber-coupled carbon doped aluminum oxide crystal. Treatment plans previously used for cervix PDR and prostate HDR brachytherapy in the hospital were replicated by mounting interstitial titanium needles on a perineal template. One needle carried the 1 mm diameter dosimeter probe, positioned in the reconstructed tumor region. The remaining needles were connected to PDR and HDR Varian GammaMed Plus afterloaders, carrying 192-Ir sources. Irradiations were conducted with all needles submerged in water. Relative crystal and source dwell positions, used for reference TG43 dose calculations, were acquired from CT images of the HDR setup. Several errors were imposed by swapped needle pairs and 2, 5, 10, 20 or 30 mm displacements.

Results: Dose measurements that deviated from the null case by more than three standard deviations were defined as potential treatment errors. The standard uncertainty, calculated as the quadrature sum of the repeatability and the position uncertainty, was smaller than 5.7% and 4.4% for all channels and the integrated dose for the PDR and HDR measurements, respectively. Comparisons on a channel-to-channel basis correctly revealed imposed treatment errors in 25 PDR cases out of 32. Only five errors were revealed based on the integrated dose comparisons for the complete pulse. The HDR measurements correctly identified 61 out of 72 possible guide tube connection errors. The 11 unidentified errors involved channels with similar dwell times and relative needle-to-dosimeter distances.

Conclusions: The study demonstrated that time resolved dosimetry can detect errors in brachytherapy that are unseen by integrated dose measurements. The new system correctly identified over 8 out of 10 tested and clinically relevant PDR and HDR brachytherapy errors.