Purpose: Patient specific apertures are commonly employed in passive double scattering (DS) proton therapy (PT). This study was aimed at identifying the potential benefits of using such an aperture in pencil beam scanning (PBS).

Methods: An accurate Geant4 Monte Carlo model of the PBS PT treatment head at Massachusetts General Hospital (MGH) was developed based on an existing model of the passive double-scattering (DS) system. The Monte Carlo code specifies the treatment head at MGH with sub-millimeter accuracy and was configured based on the results of experimental measurements performed at MGH. This model was then used to compare out-of-field doses in simulated DS treatments and PBS treatments. The PBS treatments were simulated both with and without the patient-specific aperture used in the DS treatment.

Results: For the conditions explored, a typical prostate field, the lateral penumbra in PBS is wider than in DS, leading to higher absorbed doses and equivalent doses adjacent to the primary field edge. For lateral distances greater than 10cm from the field edge, the doses in PBS appear to be lower than those observed for DS. Including an aperture at nozzle exit reduces the penumbral width by preventing wide-angle scatter from reaching the patient. This can reduce the dose in PBS for lateral distances of less than 10cm from the field edge by over an order of magnitude and allow better dose conformity.

Conclusions: Placing a patient-specific aperture at nozzle exit during PBS treatments can potentially reduce doses lateral to the primary radiation field by over an order of magnitude. This has the potential to further improve the normal tissue sparing capabilities of PBS. The magnitude of this effect depends on the beam spot size of the scanning system and is thus facility dependent.