Purpose:
To validate the Massachusetts General Hospital's (MGH's) proton pencil beam algorithm (PBA) dose calculations in lung cancer patients against GEANT4 Monte Carlo simulations.

Methods:
Three lung cancer patients with variations in tumor size and location, were considered in this study. Treatment planning was first performed for each patient following specific protocol guidelines and dose distributions were calculated with MGH PBA. The same plans were subsequently simulated with the GEANT4 Monte Carlo toolkit using a complete implementation of the MGH's proton delivery system with demonstrated accuracy in other tumor sites such as head and neck, prostate, etc. 20 million particles were simulated for each beam to ensure sufficient statistical accuracy. The dose distributions for each plan, as well as for each individual beams, were then compared 1) visually using an in-house analysis tool Dose Comparison Application (DCA), and 2) systematically using a 2mm/2% and 3mm/3% 3D gamma index analysis.

Results:
GEANT4 simulations and PBA calculations show excellent visual agreement in lung cancer patients. Every plan successfully passes a full 3D gamma index test (95% γ values ≤ 1). No significant discrepancy were seen for any of each individual beams, hence showing agreement between the two fully independent models. These results highlight the accuracy of MGH's proton dosimetry in lung, and the ability to safely plan treatments for lung tumor patients at MGH.

Conclusions:
MGH's PBA dose calculations in lung were successfully compared with simulated Monte Carlo dose distributions. Monte Carlo is considered the gold standard for proton dose calculations, and these results therefore stress the high quality of the pencil beam algorithm calculations at MGH. This work further emphasizes the excellence of radiotherapeutic treatments at MGH's Francis H. Burr Proton Center.