Purpose: To develop an effective and efficient method for optimizing the beam current modulation (BCM) pattern in commissioning proton beams using passive scattering and range modulation wheels. This modulation pattern is essential in producing beams with properly weighted spread-out Bragg peaks for the desired depth-dose distribution.

Method and Materials: The proton beam nozzle houses the spinning modulation wheel (600 rpm) and the various scattering components and translates the modulated beam current to a depth-dose distribution. This translation can be described, for a specific configuration of the nozzle, i.e., with a specific wheel position at a specific time, by a function C(x, t), defined as the dose produced at depth x and time t for a unit beam current at the time t. While the function C(x, t) is difficult to calculate theoretically due to the complex scattering paths in the nozzle and the phantom, it can be easily obtained by measuring the dose as a function of time and by a proper deconvolution taking into account the delays from the measuring circuit. With C(x, t) determined, one can calculate the depth dose distributions for any given BCM. Then the optimal BCM can be found, not by repeated measurements, as was often done before, but by numerical calculations. A window-based software has been developed to measure the time-dose functions and to perform numerical BCM optimizations.

Results: The method was applied to optimize the BCM for a number of proton beams. The differences between the calculated and measured depth dose distributions are less than 1%, well within the clinical requirement.

Conclusions: We have developed an effective and efficient method for optimizing the beam current modulation for proton therapy beams using passive scattering.