Purpose:
The purpose of this work is to further develop a power approximation of energy-range relationship for therapeutic proton beams based on range-energy tables from Janni's Data, ICRU Data, and Monte Carlo simulated Data.

Methods:
The energy deposition in water was simulated with MCNPX. The energy tally in MCNPX physics cards included the total energy. The proton source was defined as a pencil beam with uniformly distributed in area. The proton energy in simulation ranged from 40 MeV to 250 MeV with increments of 5 MeV. A three dimensional dose matrix was simulated with voxel dimension of 1x1x1 mm^3. A central-axis-slice for each individual simulation was used for range analysis.

Results:
The range difference between Janni's and ICRU data increased from sub-millimeter to ~4 mm as energy changed from 40 MeV to 250 MeV with average difference as 1.08%. The Monte Carlo simulation data lies between Janni's Data and ICRU data with average 0.57% below Janni's Data, and average 0.50% above ICRU Data. The range-energy table from Janni's, ICRU and Monte Carlo Simulation are all in very good agreement with each other, with coefficients of correlation between 0.9999 to 1.000.
The relationship between proton range and energy can be fitted by a power approximation. Generally the power relation can be expressed by R = a*E^p. With unit of R in mm and E in MeV, the factor a and the exponent p in proton energy-range power approximation were determined to be 0.023, 1.763 from Janni's Data, 0.022, 1.770 from ICRU Data, and 0.0225, 1.766 from MC simulation.

Conclusions:
Monte Carlo simulation provided very close agreement to the two widely used proton range-energy tables. The approximation of range-energy power relationship based on Monte Carlo data provide slightly different factor a and exponent p from those based on Janni's and ICRU Data.