Purpose:

Currently, no commercial proton treatment planning systems have been FDA-approved for Monitor Unit (MU) prediction. Patient and field specific MU numbers and output factors are therefore determined by either measurements or in-house modeling. The purpose of this project is to assess the modeling accuracy and determine in which cases measurements are necessary.

Methods:

We developed an in-house analytical model to predict output factors for patient specific proton fields, taking into account the effect of proton range, modulation width, and field size on the dose output. A refined model, which incorporated more commissioning data and accounted for the effects of scanning area and field size, was developed later and retrospectively applied to the fields. Model-predicted and measured output factors were compared for 1074 proton fields. Causes for the differences were analyzed for differences of 2.5% or more, which would be used for future improvement and determine in which cases where measurements are needed.

Results:

For the 1074 patient fields we analyzed, the refined model predicted output factors within 2% for 91.6% of fields, 2.5% for 96.9% for fields, and 3% for 99.7% of fields, compared to 85.2%, 93.6 and 98.2% respectively for the old model. Large differences between modeling and measurements (>2.5%) typically occurred for shallow range, large modulation, and/or irregular shaped proton fields. Causes for differences were analyzed, which mainly include dose rate dependence, off axis fields, data interpolation, and snout position effects.

Conclusion:

The study demonstrated that the analytical model can predict output factors accurately for most patient specific proton fields. For over 90% of proton fields, measurements may not be necessary, thus improving work flow and saving valuable proton beam time. It is possible to further improve modeling accuracy by incorporating more commissioning data, dose rate effects and other factors into the output factor model.