Purpose:
Linear energy transfer (LET) is a measure of local energy deposition along the particle track. There is a positive correlation between relative biological effectiveness (RBE) and LET. As a result, LET painting has become a recent focus in particle therapy planning. The goal of this research is to develop a planning algorithm that can simultaneously optimize dose and LET distributions for particle therapy.

Methods:
It is well known that the high-LET region of a charged particle beam is located at the distal edge of the Bragg peak. Therefore if a beam stops at the center of the target, its high LET region is also likely inside the target. This makes lower energy beams more preferable than high energy beams. Intuitively, this means each target voxel should be treated using its “closet” beam, or lowest possible energy beam. This observation makes Voronoi partition a natural choice for simultaneously optimizing dose and LET distributions, which given a set of objects partitions a metric space into cells, where each cell corresponds to a region closest to an object.

A planning algorithm based on Voronoi partition has been implemented in C. Given a set of particle beams, the algorithm first partitions the target into a set of Voronoi cell, each corresponding to the region of the tumor closest to a beam. Then a constrained least square solver is used to determine the optimal plan with minimized beam energies, which simultaneously optimizes the LET distributions.

Results:
The planning algorithm has been tested on a skull base tumor using protons. A desired LET is observed inside the target, and dose and LET distributions are simultaneously optimized.

Conclusions:
Voronoi partition can guide the optimization to simultaneously optimize dose and LET distributions.

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