Purpose: Beam orientation optimization (BOO) tries to find a solution which contains nonzero fluence map at only a small number of beam angles to achieve a dosimetric objective. This is equivalent to require that the solution fluence map is sparse at the beam angle level. As such, we develop a BOO algorithm via adaptive L1 minimization, an optimization scheme known to result in a sparse solution.

Methods: In addition to the energy function for the dosimetric objective, we introduce a sparsity energy into the total energy function. The sparsity energy is obtained by first taking L2 norm of beamlet intensities within each angle and then taking weighted L1 norm over angles. Such an energy term favors solutions with nonvanishing fluence map at only a few beam angles. During optimization, the weighting factors in the L1 norm are adaptively adjusted. Starting with all candidate angles, the optimization process identifies unimportant orientations gradually and removes them without largely sacrificing the dosimetric objective. The whole process terminates when a target number of beams is achieved. Fluence map optimization (FMO) is then performed based on the optimized configuration and on unoptimized (equiangular) beams. The final FMO energy function values are compared to evaluate plan qualities.

Results: In one typical prostate case, the plan quality is compared with that from unoptimized beam angles. We have further systematically validated our algorithm in the contexts of 5-9 coplanar beams for 5 prostate patients and 1 head-and-neck patient. It is found that our BOO algorithm can lead to lower FMO objective values in 28 out of 30 combinations of patients and target number of beams.

Conclusions: The developed BOO algorithm utilizing adaptive L1 minimization is found to be effective for identifying important beam angles, which leads to better plan qualities than unoptimized beam configurations.