Implementation of a 3D halo neutral model in the TRANSP code and application to projected NSTX-U plasmas

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A 3D halo neutral code developed at the Princeton Plasma Physics Laboratory and implemented for analysis using the TRANSP code is applied to projections of plasma performance for the National Spherical Torus experiment-Upgrade (NSTX-U). The 3D halo neutral code uses a "beam-in-a-box" model that encompasses both injected beam neutrals and resulting halo neutrals. Upon deposition by charge exchange, a subset of the full, one-half and one-third beam energy components produce first generation halo neutrals that are tracked through successive generations until an ionization event occurs or the descendant halos exit the box. The 3D halo neutral model and Neutral Particle Analyzer (NPA) simulator in the TRANSP code have been benchmarked with the Fast-Ion D-Alpha simulation (FIDAsim) code, that provides Monte-Carlo simulations of beam neutral injection, attenuation, halo generation and halo spatial diffusion. When using the same atomic physics database, FIDAsim and TRANSP simulations get excellent agreement on the spatial profile and magnitude of beam and halo neutral densities as well as the NPA energy spectrum. The simulations show that halo neutrals remain in the vicinity of the neutral beam footprint as expected and that halo neutral density can be comparable with beam neutral density. The halo neutrals can double the NPA flux, but have minor effects on the shape of the NPA energy spectrum.