Calculation of Charged-Particle Transport for NIF Mix Diagnostics

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The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory is designed to demonstrate thermonuclear ignition of DT gas, with a net gain in energy, using the technology of indirect-drive inertial confinement fusion (ICF). Hydrodynamical instabilities result in mixing of the DT fuel with the outer shell material during the implosion of the capsule. We have been working on a new technique to diagnose the nature of mix occurring in ignited and partially failed NIF capsules.

Our mix diagnostic for NIF relies on the fact that energetic (knock-on) tritium nuclei from the fuel will interact with nuclei from the shell material, and these reactions are very sensitive to the amount and type of mix taking place. For example, triton reaction rates on the shell material can be increased by two orders of magnitude by mixing between the shell and the DT gas compared to a fiducial no-mixing case. These reactions produce high-energy β−emitters, and we presently have a Laboratory Directed Research and Development (LDRD) project to develop β-spectroscopy as a diagnostic for mix at NIF.

An ongoing experimental program at the Omega facility at Los Alamos National Laboratory has been fielded as a proof of principle for this idea. The present experiments use ^{13}C as the capsule shell, although at NIF ^{9}Be and/or plastic shells will be used. For these experiments the key reaction of interest is the $^{13}C(t,\alpha)^{12}B(\beta-)$ reaction. We ran a series of calculations for ^{13}C ICF capsules using the LASNEX code. The yields of these capsules are about 10^{13}. We have developed the computational tools to determine accurately the production of knock-on tritons, their transport in the burning capsule, and subsequent yields for triton-induced diagnostic reactions (see Fig. 1). We coupled the output of LASNEX with our new charged-particle transport post-processor.

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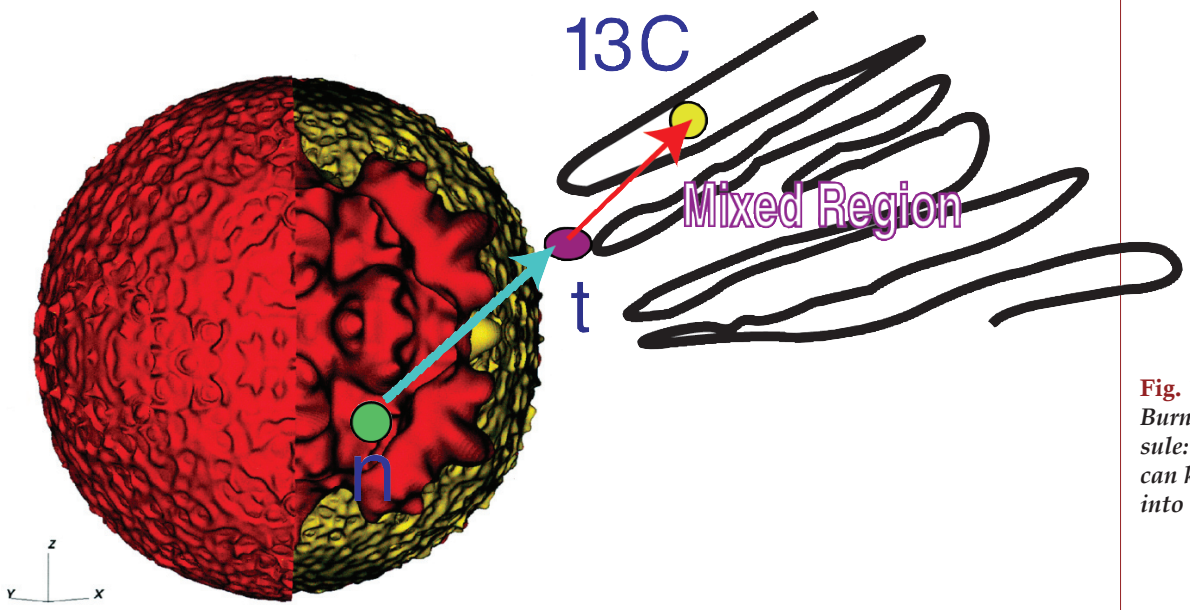

Fig. 1.
Burning DT NIF capsule: 14 MeV neutrons can knock the tritons into the ^{13}C mix region.