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Narrowband Self-Emission Imaging of MagLIF Targets on Z[1]

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The hot, dense stagnation plasma generated by most imploding fusion targets contains a mixture of fuel and pusher materials embedded in complicated temperature and density gradients. Measuring these gradients and the amount of pusher "mix" is important for assessing the quality of the implosion as well as enabling accurate comparisons to simulation tools. Yet these types of measurements are challenging and likely require new diagnostics. Here we present the design of a new x-ray imager based on reflective-crystal optics that were designed to measure the electron-temperature gradients inside the stagnation plasma generated by a magneto-inertial fusion target known as MagLIF, which is presently being developed on Sandia's Z-machine [Gomez, M. R., et al. (2019) IEEE 47]. By using spherically-bent crystals we discovered that we could exploit the narrow bandpass provided by the crystal reflection in order to isolate spectral-line emission and hence a chosen ionic species (e.g., He-like Cobalt). We first developed a two-crystal imaging technique that allowed us to visualize, in two-dimensions, the mixing between different emission sources such as the hydrogen fuel and tracer elements coated onto the pusher. By extending this technique to a three-crystal imaging system, we have now measured spectral-line ratios and hence the variation in electron temperature over the stagnation plasma. These measurements are further supported by high-resolution spectroscopy data, which give additional insight into the plasma conditions and composition. Overall, the development of these imaging and spectroscopic techniques represents an important advancement in diagnostic capabilities for Z, and we hope to further advance these capabilities by implementing time-resolved detectors in the near future.

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