Developing Time-resolved X-ray Diffraction Diagnostics at NIF

N. E. Palmer[1], L. R. Benedetti[1], C. E. Vennari[1], P. R. Nyholm[1], R. B. Petre[1], J. C. Delora-Ellefson[1], N. Bhandarkar[1], A. C. Carpenter[1], S. R. Nagel[1], J. E. Eggert[1], D. K. Bradley[1], A.J. Mackinnon[1], Y. Ping[1]

[1]*Lawrence Livermore National Laboratory, Livermore, CA 94550, USA*

Corresponding Author Email: palmer36@llnl.gov

As part of a program to measure phase transition timescales in materials under dynamic compression, we have designed new x-ray imaging diagnostics to make multiple x-ray diffraction measurements during a single laser-driven experiment. Our experimental design involves placing several ns-gated hCMOS sensors within a few cm of a laser-driven target. The sensors must be protected from an extremely harsh environment that includes debris, EMP, and unconverted laser light, while also ensuring laser-facility machine safety. Measuring x-ray diffraction with these hCMOS sensors involves additional challenges because the full aperture of the sensor must be open to diffraction signal, and x-ray backlighting can generate enormous x-ray background.

We have implemented a staged approach to this platform development. First we developed a demonstration diagnostic with two sensors to confirm that we could adequately protect the hCMOS sensors from the harsh environment and also acquire acceptable diffraction data. This allowed the technical team to address the most significant challenges first and to assess the risks quickly. Moreover, it allowed for the collection of scientifically useful data during development.

Based on the success of the demonstration diagnostic, we have recently developed an improved instrument that can field up to eight hCMOS sensors in a flexible geometry that can participate in several successive NIF shots. The design also allows for future iterations to include faster hCMOS sensors and an embedded x-ray streak camera.

While the lessons learned from the demonstration diagnostic did not eliminate all surprises during the fielding of the new instrument, the staged approach expedited the learning process and allowed us to respond quickly to challenges. The issues encountered with the new instrument, such as EMP upsets, remind us that perceived-small changes can have significant impacts.

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