



Contribution ID: 166

Type: **not specified**

Target metrology of Inertial Confinement Fusion fuel capsules using a Laser Wakefield Acceleration based Betatron X-ray source

Thursday, 25 July 2024 17:20 (20 minutes)

We are utilizing a sub-ps, sub-10 micron X-ray source for X-ray phase contrast imaging (XPCI) tomography of Inertial Confinement Fusion (ICF) fuel capsules. We will present results from an experiment in April 2024 at the Advanced Laser Light Source in Montreal, Canada. Radiography data was captured with Laser Wakefield Acceleration blowout regime betatron X-rays with a critical energy of 15-25 KeV. Experimental goals met include imaging 360 degrees of an ICF fuel capsule, and benchmarking optimal resolution parameters of the system. Imaging the full rotation of the object will allow us to do a tomographic reconstruction of these fuel capsules with a resolution of ~4 μm . The optimal resolution benchmarked is ~1 μm , which is comparable to current methods. We use X-ray phase contrast imaging to differentiate between thin low Z layers in the ICF fuel capsule. The Fresnel-Kirchoff integral formula can be used to determine source characteristics from XPCI fringes seen in radiographs¹, we will also employ HADES (an X-ray ray tracing simulation code). The results of this experiment provide a comparison of current industrial methods such as X-ray tubes to LWFA based X-ray sources. Ultimately, our aim is to develop a diagnostic for not just target metrology of ICF fuel capsules, but employable to observe ICF implosions with unprecedented spatio-temporal resolution.

This work was performed under the auspices of the Lawrence Livermore National Security, LLC, (LLNS) under Contract No. DE-AC52-07NA27344.

References

[1]Vargas, X-ray phase contrast imaging of additive manufactured structures using a laser wakefield accelerator. PPCF, 61 (2019) 054009.

Working group

WG6 : Radiation generation, medical and industrial applications

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Session Classification: WG6