Muonic X-ray and spherical encoding-based ICF target element imaging [[1]](#footnote-1)\*

Dikai Li1,2,3, Jian Yu1,2,3, Ziming Li1,2,3, Qian Chen1,2,3, Chunhui Zhang4, Zhibing He5, Leifeng Cao1,2,3

（1. College of Engineering Physics, Shenzhen Technology University，Shenzhen, Guangdong, China 518118；2. Center for Intense Laser Application Technology, Shenzhen Technology University，Shenzhen, Guangdong, China 518118；3. Shenzhen Key Laboratory of Ultraintense Laser and Advanced Material Technology, Shenzhen, Guangdong, China 518118；4. School of Nuclear Science and Technology, Lanzhou University, Lanzhou, Gansu, China, 730000; 5. Research Center of laser Fusion, China Academy of Engineering Physics, Mianyang, Sichuan, China, 621900;）

**Abstract**: The elemental distribution in inertial confinement fusion (ICF) targets critically influences their fusion performance. However, existing detection technologies struggle to simultaneously achieve deep penetration, non-destructive analysis, and micron-level resolution. This project proposes a novel method combining muon-induced X-ray emission (MIXE) with spherical coded imaging to overcome the technical limitations in high-precision elemental distribution detection for ICF targets. The method involves irradiating targets with a muon beam to generate characteristic X-rays, which are modulated by a coded spherical aperture to form encoded signals on the detector. Microscale elemental distribution is then reconstructed through deconvolution and CT algorithms. The research encompasses: 1) establishing a physical model for characteristic X-ray emission induced by muons, based on the design parameters of China’s upcoming high-intensity muon source and typical ICF target elemental distributions; 2) optimizing the spherical coded imaging system and reconstruction algorithms; and 3) quantitative calibration of oxygen distribution in targets (targeting spatial resolution ≤5 μm and density measurement uncertainty ≤0.2 at.%). By integrating the advantages of MIXE and spherical coded imaging, this method enables non-destructive, deep-layer detection of multi-element distributions, addressing the limitations of traditional techniques in surface analysis and sample irradiation damage. The project not only serves the demand for high-precision elemental detection in ICF targets but also provides technical support for China’s first high-intensity muon source facility, driving methodological innovation in particle detection technologies under extreme conditions.

Keyword: Muon induced x-ray emission; X-ray coded imaging; ICF target elemental distribution; Muon imaging; Nuclear material detection;

Corresponding author: [lidikai@sztu.edu.cn](mailto:lidikai@sztu.edu.cn) (Dikai Li)

1. [↑](#footnote-ref-1)