An inverse Compton scattering X-ray source as a stepping-stone on the path to a synchrotron facility

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1. Introduction

Synchrotron radiation facilities are integral to the worldwide scientific and research infrastructure. The brilliant X-ray beams they produce provide insight into the structure and behavior of the materials that make up the world around us. This insight drives progress in many disciplines from materials, life, biomedical and geo sciences to drug discovery, microelectronics, additive manufacturing and even cancer treatment. While most large or developed countries operate one or more synchrotron light sources, smaller or developing countries aspire to build a synchrotron to support and grow their local research communities. For countries without experience in such large research projects, this can be a daunting challenge in terms of technical expertise, planning and funding. An inverse Compton light source, like the Lyncean CLS 300, can be a stepping-stone towards this goal by offering an operational machine with synchrotron-like performance that comes on-line quickly at a substantially lower cost.

2. Lyncean CLS 300

An Inverse Compton Scattering (ICS) [1,2] source works by colliding a high-power laser beam with a relativistic electron beam, resulting in the energy of the backscattered photons in the X-ray regime. So far, the only ICS in regular user operation is the Munich Compact Light Source (MuCLS) [3], a combination of Lyncean Technologies' first generation Compact Light Source (CLS) [4] and a beamline with two end-stations built by researchers at the Technical University of Munich [5].

Here we present a concept for the CLS 300 [6], an ICS X-ray source that is about two orders of magnitude brighter than the MuCLS. Depending on its configuration, it covers an X-ray energy range of about 30-90 keV, or 60-180 keV, well suited for many material science applications. It will provide X-ray flux of up to 4 x 10^{12} photons/s within a beam divergence of 4 mrad and a bandwidth of around 10%. This is well-suited for high resolution, micro-CT imaging of millimeter-sized samples at micron resolution, with a flux density similar to some high-energy synchrotron beamlines. The beam properties of the new design are also compatible with focused beam applications such as high-energy diffraction, since using a lower divergence part of the beam with lower bandwidth allows the use of several types of X-ray optics commonly used at synchrotron beamlines.

In this presentation, we will discuss the novel concepts applied to the design of this X-ray source as well as the resulting beam properties. We will discuss several imaging and diffraction application examples where this system can approach or meet the performance of synchrotron beamlines. We will show how a CLS facility provides the means for slowing the migration of valuable research talent by forming the cornerstone of a local X-ray user community, while users gain expertise in the operation of an accelerator and development of beamlines, thereby setting the stage for the development of a large synchrotron facility.

3. References

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