Characterization of the Electron Beam from the THz Driven Gun for AXSIS.


Abstract

The AXSIS (Attosecond X-ray Science: Imaging and Spectroscopy) project aims for coherent, THz-driven, attosecond development of a compact, fully tested as a source of the ultra-short electron bunches required for the X-ray source. A compact THz driven gun was developed, produced and commissioned at a test-stand chamber in CFEL (DESY). Results of the first experiments on the production and characterization of the electron beam are presented.

Introduction

The AXSIS project (Attosecond X-ray Science: Imaging and Spectroscopy) is foreseen to provide a fully coherent attosecond X-ray radiation. This radiation will be used for 3D imaging and spectroscopy for the structural biology problems. The fully coherent attosecond X-ray will be provided by inverse Compton scattering of a laser beam on an electron bunch accelerated in the AXSIS linac. The experiment will use a dielectric loaded waveguide to accelerate e-bunches up to 15 MeV. In the frame of the project it is planned to use a THz-driven electron gun. For the first experiments a THz-driven gun capable of delivering 25 keV electron energies was developed and tested at DESY CFEL. In order to characterize the electron beam from this gun, diagnostics capable of detecting low energy, low charge electron beam are required.

Horn gun design and simulation

Parameters of the THz pulse

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design</th>
<th>Measured</th>
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<tbody>
<tr>
<td>Frequency, GHz</td>
<td>300</td>
<td>450</td>
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<tr>
<td>Beam size at waist, mm</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Rise time, ps</td>
<td>2.5</td>
<td>2.5</td>
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<tr>
<td>Laser energy, µJ</td>
<td>5</td>
<td>17</td>
</tr>
</tbody>
</table>

Measure and simulated THz pulse profile

Optimization of the UV injection time

Simulation of the experimental parameters

Diagnostic devices and experimental results

Microchannel plate detector with a phosphor screen and camera: Used to measure the beam transverse profile. The MCP has a moderate gain of 2.10^6 at 1 kV and a pore size of 5 µm. A P43 phosphor screen attached to the MCP allows further signal amplification and imaging is done with the help of the CMOS camera and telescope lens.

Continuous channel electron multiplier: Used to measure the electron charge. The electron multiplier has a multiplication of 1.3.10^7 at the working point of 2 kV DC voltage applied to its anode. As the positive DC voltage is applied to the anode which serves as an electron collector, the readout scheme to separate it from the electron signal was developed and realized.

Electron beam focused at the MCP with a help of air coil:

Electron beam focused at the MCP with a help of air coil and deflected by dipole:

Parallel plates:

Electrostatic parallel plates are designed to allow horizontal control of the beam direction and manufactured at the DESY workshop. By design these plates allow a deflection of a 25 keV electron beam by 10°.

General layout, from left to right: gun and plates in the vacuum chamber, air coil, dipole, MCP with camera

Summary

A first THz gun potentially capable of delivering electron beams of tens of fC and tens of keV was successfully put into operation. First experiments allow measurement of the energy, which is lower than could be potentially achieved with this gun, as the experimental conditions were worse than the design case. In such a way an improvement of the experimental parameters is required to match the design case. Nevertheless, preliminary results showed an electron energy of a few keV. More experiments will be done in the nearest future and detailed analysis of the electron energy will be done.

Acknowledgement

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