Production of quasi-ellipsoidal laser pulses for next generation high brightness photoinjectors

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Abstract

Free Electron Lasers (FELs) require high brightness electron beams. One of the most promising methods to generate such beams is the use of RF guns and a proper shaping of the corresponding photo cathode laser pulses. It was already demonstrated that temporal and transverse flat-top laser pulses can produce very low emittance beams. Nevertheless, according to beam dynamics simulations further improvements can be achieved using quasi-ellipsoidal laser pulses, e.g. 30\% reduction in transverse projected emittance at 1 nC bunch charge.

In a collaboration between DESY, the Institute of Applied Physics (IAP) in Nizhny Novgorod and the Joint Institute of Nuclear Research (JINR) in Dubna such a laser system capable of producing trains of micropulses, where each micropulse has a quasi-ellipsoidal pulse shape, has been developed. The prototype of the system was recently installed at the Photo Injector Test facility at DESY in Zeuthen (PITZ) and is now in the commissioning phase.

Motivation – Beam Dynamics Simulations with Astra

Space charge impact on transverse emittance minimization:

- Laser pulses with cylindrical transverse shape and temporal Gauss / flat top profile
- 3D ellipsoidal laser pulse (spatially and transversely shaped)

- Non-linear space charge forces and non-linear phase spaces
- linear space charge forces and linear phase spaces

Slice emittance for 1 nC bunch charge

- 30 - 50 \% lower average slice emittance
- better longitudinal compression
- reduced beam halo

Laser system and 3D pulse shaper setup

<table>
<thead>
<tr>
<th>Laser pulse characterization (scanning cross correlator)</th>
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<tbody>
<tr>
<td>Main pulse</td>
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<tr>
<td>200 fs</td>
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<tr>
<td>3 μs</td>
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<td>50 μs (max. delay time)</td>
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</tbody>
</table>

- Top: Scanning cross correlator: working principle
- Bottom: simulated (ideal) 3D laser pulse shape, bottom: measured temporal laser pulse shape after shaping (IR)

Experimental results (1st electrons generated in April 2015)

- Top: Scanning cross correlator: working principle
- Bottom: Measured temporal laser pulse shape after shaping (IR)

References


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