Innovative Single-Shot Diagnostics for Electrons From Laser WakeField Acceleration at FLAME

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On behalf of SPARC_LAB collaboration
SPARC_LAB is a multi-disciplinary TEST Facility composed by a high brightness LINAC and the high power laser FLAME: this characteristic makes it unique.

Sources for Plasma Accelerators and Radiation Compton with Lasers and Beams

FLAME laser

Final amplification stage from ~600 mJ to 6J

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>6 J</td>
</tr>
<tr>
<td>Duration</td>
<td>23 fs</td>
</tr>
<tr>
<td>Wavelength</td>
<td>800 nm</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>60/80 nm</td>
</tr>
<tr>
<td>Spot @ focus</td>
<td>10 μm</td>
</tr>
<tr>
<td>Peak Power</td>
<td>300 TW</td>
</tr>
<tr>
<td>Contrast Ratio</td>
<td>$10^{10}$</td>
</tr>
</tbody>
</table>
Importance of single shot diagnostics

- Plasma accelerators allow to achieve extremely high accelerating gradient (>100GV/m).
- Electron beams from plasma are still characterized by:
  - Relatively large energy spread (~5%);
  - Shot-to-shot instabilities.
- Single shot diagnostics are very helpful to properly characterize plasma beams.
- Emittance measurement: development of a scheme based on incoherent Optical Transition Radiation (OTR).
Single shot emittance measurements based on incoherent OTR

The angular distribution of incoherent TR is sensitive to beam divergence: the central minimum is not zero.

**Emittance:**

\[ \varepsilon = \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle xx' \rangle^2} \]

From spot size

From angular distribution
Single shot emittance measurements based on incoherent OTR

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**Emittance:**

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From spot size

From angular distribution

**IDEA: Microlens array!**
Experimental setup

9x9mm array, 300um pitch, 18.5mm focal length

ZEMAX Simulations

Custom code written in Zemax Programming Language to simulate the OTR from the whole beam
Results

Comparison between simulation and measurements

Angular distribution from the central microlens

1) Laser interacts with pre-formed plasma.
2) Electron acceleration and positive charge left on target.
3) Only more energetic electrons (*fast electrons*) escape and their electric field causes ion acceleration.

Experimental Setup

LASER PARAMETERS:
- Energy 4J
- 35fs FWHM
- $w_0=30\mu m$

Experimental results

Temporal window: 10 ps.

Experimental results


Temporal window: 10 ps.
Influence of target shape

Planar target

Wedged target

Tip target

Influence of target shape

Planar target

Wedged target

Tip target

Charge/Energy increase

Conclusions

- A novel scheme for single shot emittance measurements based on incoherent OTR has been reported.
  - First tests on RF LINAC have represented a proof of principle of this system.
  - A new experimental run is foreseen in the next future.
- We presented the first time-resolved measurements probing the emitted fast electrons from TNSA based on EOS technique.
  - We studied the influence of target shape: a field enhancement has been measured.
  - A new experimental run has started in the last two weeks.
Thanks for your attention!

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