A CO$_2$ Laser-driven LINAC

Status Report

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Outline

1. Choosing the Structure Material
2. Design of the Laser-driven LINAC
3. Mode-Excitation
4. Phase Diagnostics
5. Experiment Schedule for This Year
# 1. Choosing the Structure Material

CO₂ laser damage threshold experiments conducted at ATF (Jan. 2001)

<table>
<thead>
<tr>
<th>Material</th>
<th>200-psec pulse length</th>
<th>100-nsec pulse length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fluence (J/cm²)</td>
<td>Intensity (GW/cm²)</td>
</tr>
<tr>
<td>Ge</td>
<td>0.19</td>
<td>0.95</td>
</tr>
<tr>
<td>ZnSe</td>
<td>0.45</td>
<td>2.3</td>
</tr>
<tr>
<td>CVD Diamond</td>
<td>1.20</td>
<td>6.0</td>
</tr>
</tbody>
</table>

**Difficulties with CVD Diamond**

1. Hard to get $f < 5$ cm diamond lens
   → considering a larger structure
2. Hard to machine a $\sim 50 \, \mu m$ hole through Diamond
   → getting a 266-nm pulsed laser at 100 kW, 10 kHz.

**Temporary Solution: Will use ZnSe for the first experiment**

acceleration gain $\sim 60\%$ of diamond

![Image showing a comparison between a 50 µm hole and a 125 µm line](image.png)
2. Design of the Laser-driven LINAC

A Staggered lens-array Structure with TEM$_{01}$ or TEM$_{11}$ Acceleration Mode

Each lens’ temperature is varied independently by a TE cooler/heater
Dimensions of the Accelerating Stages

\[ f = \frac{5z_R}{3} = 3.81 \text{cm} \]

\[ 2/3 \times z_R = 24 \text{ cm} = 1.5 \times 16 \]

1.52 cm

65 um

1.5 cm
$E_z$ Along the Axis with 65-μm Holes

Blue: laser field without slippage
Red: field seen by the electron (with velocity slip)
Total Energy Gain

24-cm ZnSe Lens Array, $\text{TEM}_{01} \Rightarrow 250 \text{ keV}$
**Phase I: ZnSe Laser LINAC Design Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam waist</td>
<td>280 µm</td>
</tr>
<tr>
<td>Damage threshold intensity</td>
<td>2.25 GW/cm²</td>
</tr>
<tr>
<td>Laser wavelength</td>
<td>10.6 µm</td>
</tr>
<tr>
<td>Optical field mode</td>
<td>TEM(0_1)</td>
</tr>
<tr>
<td>Phase tuning (by varying lens temperature)</td>
<td>180 ° / 93 Deg. C for ZnSe</td>
</tr>
<tr>
<td>Total Gain</td>
<td>250 keV over 24-cm linac</td>
</tr>
</tbody>
</table>
3. TEM\textsubscript{01} or TEM\textsubscript{11} Mode-excitation

\begin{itemize}
  \item \( W_0 = 1 \text{ cm} \)
  \item \( \phi = 6 \text{ mm} \)
  \item \( \phi = 10 \text{ mm}, \text{Phase tuned by temperature} \)
  \item \( f = 25.4 \text{ cm} \)
  \item \( f = 5.08 \text{ cm} \)
  \item \( f = 3.81 \text{ cm}, \text{with 5 cm separation} \)
  \item \( W_0 = 280 \text{ um} \)
\end{itemize}
Beam Profile at the End of the Mode Converter
4. Phase Diagnostics

For ZnSe at $\lambda = 10.6 \, \mu m$, the adjustment is $2^{-}/$Deg. C.

TE cooler/heater in every lens
5. Experiment Schedule for this year

Jan. ~ Feb.: ATF visit
vacuum test, optical test, finalizing design, operator training…..

Feb. ~ Apr..: NTHU, Taiwan
laser machining, mode conversion, phase control experiment…..

May: ATF visit for the first experiment

August: further experiment for improvement