IFEL driver for IGS

Alex Murokh
RadiaBeam Technologies, LLC.

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IFEL (RUBICON) Collaboration:
S. Boucher, A. Tremaine (RadiaBeam Technologies);
M. Polyanskiy, I. Pogorelsky, V. Yakimenko (BNL);
P. Musumeci (UCLA), W. Brown (MIT)
• Motivation for IFEL IGS driver
• RUBICON experiment
## State-of-the-art Linac for 700 MeV IGS

<table>
<thead>
<tr>
<th>Technology</th>
<th>Gradient</th>
<th>Length</th>
<th>Risk</th>
<th>Recurrent Cost Est.</th>
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<tr>
<td>Off-the-shelf SLAC-type linac</td>
<td>20 MV/m</td>
<td>35 m</td>
<td>Low</td>
<td>~ $5 mm</td>
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- Proven technology
- Not practical for mobile platform applications
- Not cheap
## Novel linac designs

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- Higher gradient are possible in S-band
- A prototype is under development
Moving to higher frequency (X-band)

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<td>90 MV/m</td>
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- Very promising technology
- Based on years of research and optimization for NLC
- A major risk and cost driver is a poor industrial participation in X-band klystron development
### IFEL alternative to RF accelerators

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<td><strong>Inverse Free Electron Laser (IFEL)</strong></td>
<td>700 MV/m</td>
<td>1 m</td>
<td>High</td>
<td>~ $ 1 mm</td>
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• Motivation for IFEL IGS driver
• RUBICON experiment
RUBICON is a pilot experiment

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<th>Input beam energy</th>
<th>Future IFEL/ICS</th>
<th>RUBICON</th>
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<tr>
<td>Input electron beam energy</td>
<td>75 MeV</td>
<td>50 MeV</td>
</tr>
<tr>
<td>Final electron beam energy</td>
<td>700 MeV</td>
<td>150 MeV</td>
</tr>
<tr>
<td>Laser wavelength</td>
<td>0.8 µm</td>
<td>10.6 µm</td>
</tr>
<tr>
<td>Average accelerating gradient</td>
<td>&gt; 600 MV/m</td>
<td>~ 200 MeV/m</td>
</tr>
<tr>
<td>Laser seed power</td>
<td>5 TW</td>
<td>0.5 TW</td>
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RUBICON goals

- An IFEL pilot project for IFEL-ICS concept
- Achieving record high gradient and good beam capture with the CO2 driven IFEL:
  - > 200 MV/m;
  - > 50 % capture.
- Demonstrating recirculation and re-amplification of the laser beam to achieve high average power IFEL,
  - up to 100 CO2 pulses, 12 ns apart per each RF pulse.
- Experimental investigation of IFEL physics in re-circulation regime
  - Stability, transverse mode structure, acceleration/capture fluctuations, etc.
ATF-BNL CO2 Laser

 Pikosecond pulse generation

CO2 oscillator

Pockels cell

10-ns 10-ns

3-atm preamplifier

Kerr cell

3-atm preamplifier

Ge switch

14-ps YAG

14-ps YAG

10-atm amplifier

Ge switch

5-ps

5-ps

200-ps

200-ps

9-atm final amplifier

5-ps SH-YAG

5-ps YAG

6 ps

1 TW

1 TW

1 TW

Laser oscillator

Pockels cell

3 atm. pre-amplifier

Ge switch

Kerr cell

10 atm. amplifier

9 atm. final amplifier

5 J

5 ps

30 mJ

5 ps

30 mJ

5 ps

50 mJ

200 ps

5 mJ

10 ns

5 mJ

10 ns

100 mJ

200 ns

Picosecond pulse generation

Amplification
A 22-m reamplification loop will carry 6 pulses (12 ns apart), to achieve RUBICON goal of pulse train IFEL acceleration.
C02 Laser Re-Circulation (Approach #2)

- A 22-m reamplification loop will carry 6 pulses (12 ns apart), to achieve RUBICON goal of pulse train IFEL acceleration.
CO2 Laser Re-Circulation

- Simulations demonstrate good beam quality preservation for a re-amplified laser pulse over the duration of the macro-bunch.
Conclusions

• IFEL is a promising technology to fundamentally reduce cost and footprint of the ICS gamma sources.
• RUBICON is a pilot project initiated specifically in the context of ICS application.
• RUBICON is a 5 years program:
  • 2010-2011 to demonstrate record high gain (lead by UCLA);
  • 2011-2012 to demonstrate and characterized multi-bunch IFEL acceleration (pending Phase II SBIR grant);
  • 2013-2014 to combine IFEL with the ICS;
• A success of this project would enable development of a practical stand-alone high average power IFEL-ICS system in a 5 year horizon.
• This work was supported by DTRA (DOD) Phase I SBIR Contract # HDTRA1-10-P-0021