Side Pumped Nd:YAG Laser
The Beginning
Side pumped laser spark plug
End Pumped Nd:YAG Laser
The Next Step
End pumped, Nd:YAG laser
End Pumped Laser Spark Plug

- Pump Optical Fiber
- Collimating Lens
- Focusing Lens
- Q-switched Nd:YAG Laser
- Beam Steering Optics
Input Energy vs Output Energy (Nd:1.1%)

- OC 50%
- OC 60%
- OC 70%

Output Energy (Joules) vs Input Energy (Joules) graph.
End Pumped Laser CW Output Analysis

- **Nd 1.1%**
  - 50% Output Coupler: 47.98%
  - 60% Output Coupler: 56.66%
  - 70% Output Coupler: 65.42%

- **Nd 0.9%**
  - 50% Output Coupler: 67.97%
  - 60% Output Coupler: 55.29%
  - 70% Output Coupler: 46.21%
Pump beam scanning configuration
Beam Shape
40 mm collimating lens, 75 mm focusing lens
Fixed Asphere - Beam Diameter w/ 50mm

<table>
<thead>
<tr>
<th>Beam Scanner Distance (cm)</th>
<th>Beam Diameter (microns)</th>
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<tbody>
<tr>
<td></td>
<td>21.29mm</td>
</tr>
<tr>
<td></td>
<td>29.41mm</td>
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<tr>
<td></td>
<td>30.66mm</td>
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<td></td>
<td>20.27mm</td>
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<td></td>
<td>19.38mm</td>
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<td></td>
<td>18.54mm</td>
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<td></td>
<td>17.14mm</td>
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Optical Focus Position Inside Laser Crystal

Laser Crystal Length (cm)

Beam Diameter (micros)

-1000 -800 -600 -400 -200 0 200 400 600 800 1000

50mm at 19.33mm
75mm at 47.18mm
100mm at 75.83mm

Woodruff, Sept 18, 2007
Thermal management parameters

<table>
<thead>
<tr>
<th>Material</th>
<th>$\rho$ – density $g \cdot cm^{-3}$</th>
<th>$K$ - thermal conductivity $W \cdot cm^{-1} \cdot K^{-1}$</th>
<th>$C$ specific heat $J \cdot g^{-1} \cdot K^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd:YAG</td>
<td>4.56</td>
<td>0.14</td>
<td>0.59</td>
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<tr>
<td>Aluminum</td>
<td>2.70</td>
<td>2.37</td>
<td>0.89</td>
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<tr>
<td>Copper</td>
<td>8.96</td>
<td>4.01</td>
<td>0.38</td>
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<tr>
<td>Silver</td>
<td>10.5</td>
<td>4.29</td>
<td>0.23</td>
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</tbody>
</table>
2-D view of temperature distribution

Bare Rod
3-D view of the temperature distribution

- Bare rod
- Al ring
- Cu ring
- Ag ring
Optical Distributor
Distributor Signals

- Hall
- Photodiode
- Timing
- Light beam
Current Status

- Pulse energies of >8 millijoule
- Pulse width of 5-6 nanosecond
- $M^2$ to be determined
- Sapphire and fused silica lens assemblies under construction
- Costs are dropping...
To Do List

- Test laser components
  - Test higher concentrations of Cr:YAG
  - Test lower reflectivity output couplers
  - Cool the YAG rod
- Test 200 watt, 400 micrometer fiber laser
- Test plug lens assemblies
- Engine test
Laser Sparkplug Costs

- **Single Unit, OTS costs**
  - Laser pump source - ~$12k
  - Pump power supply - ~$7k
  - Optical fiber - <$30/m
  - Distributor - ~$300 + a motor driver
  - Laser plugs ~$800 + mounts

- **Source + Distributor <$20k + plug costs**
- **Should drop with mass production**
Thanks to MLEF Students

- Ricardo Velez – Univ. of Mass.
- Adrian Comacho-Berrios – Univ. of Mayaguez
- Candace Cobb – Norfolk Univ.