Laser Ignition Technology

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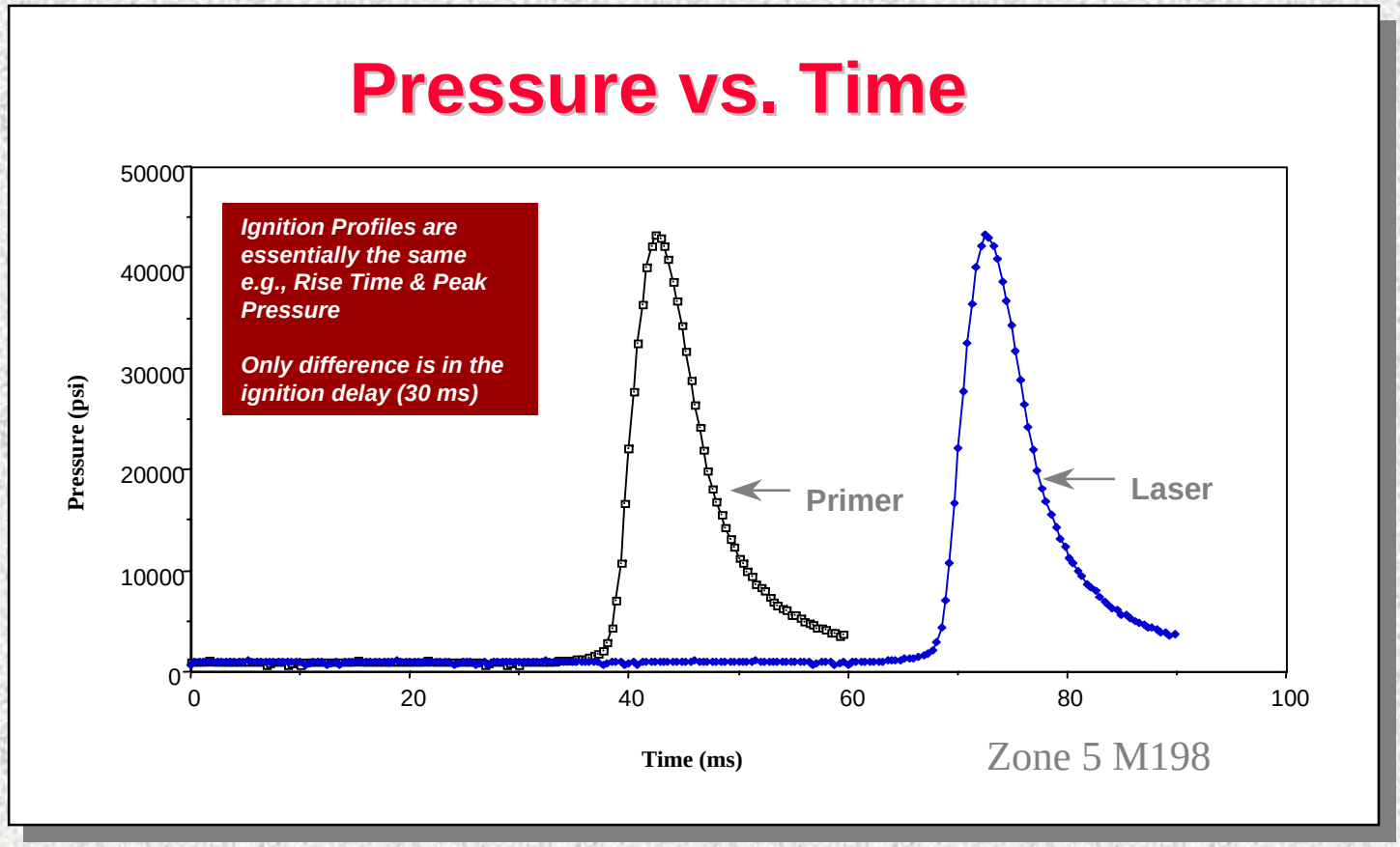
Why Laser Ignition?

- **Supports continuous, remote, fully automated firing and high rates of fire**
- **Improved system safety - Safety interlocks will not allow the LIS to fire unless the gun is layed on target**
- **Eliminates the burdens of conventional primers:**
  - Fewer items to resupply (logistics benefit)
  - Eliminates the need for a primer autofeed mechanism
  - Potential for significant life cycle cost savings versus primer ignition
  - Green System - No need to dispose of old primers

Laser Ignition System Performance



Pressure curve identical to primer with 30msec offset

Laser Ignition Vs. Primer

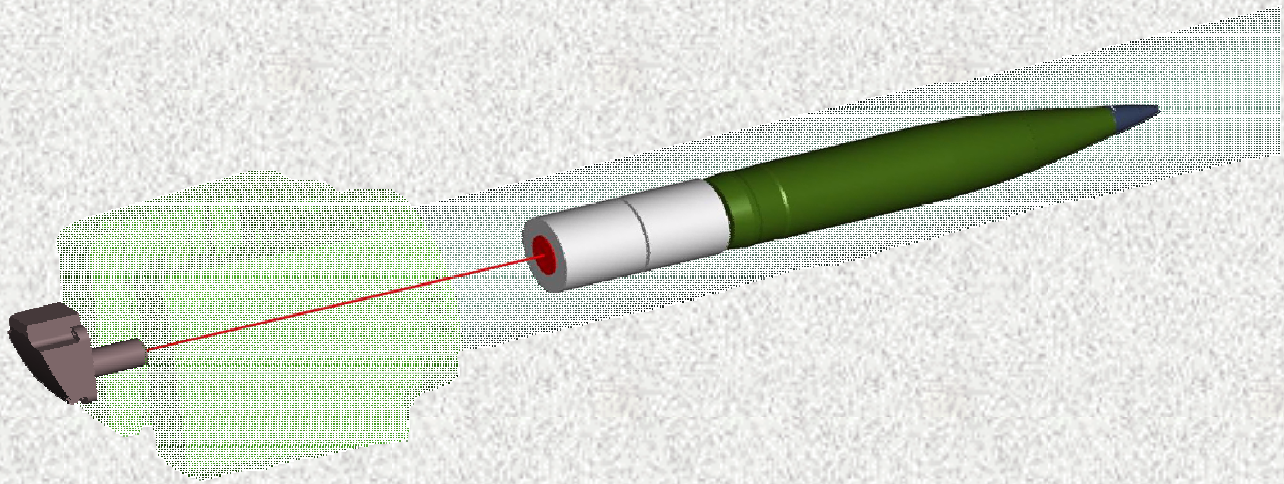
Laser	Primer
Supports Continuous, Remote, Automated High-Rate Fires – No moving parts; no firing timeline impact – > 12 Rounds per minute	**Diminished Rates of fire** – Difficult to automate, must eject spent primer – Moving parts, Prone to jamming – Rearm impacts Time Line – Limited number of primers before resupply
Significant Life Cycle Cost Savings: – Reduced Logistics – No primer logistics supply tail to the battlefield – Improved Reliability – > 99% – Green Technology – Eliminates manufacture, storage, disposal of energetic materials – Decreased costs of logistics tail, storage and disposal associated with Primers	**Additional Life Cycle Costs** – Logistics Burden: Resupply – Lower reliability- Primer Jams and Misfires – Environmentally Unfriendly: Lead based therefore manufacture, storage and disposal concerns – Costs associated with Transport and storage of energetic material
Improves Safety – Electronic Interlocks will not allow the weapon to fire unless the gun is layed on target – Provide Capability for remote “Check Fire” – No Hang fires	**Safety Issues** – Transport and storage of energetic material – Disposal of duds – Potential Hang Fires
Misfire – Automated Misfire Procedure • Automatically triggered to fire higher energy pulse in the event of a misfire for multiple pulses	**Misfire** – Complicated Misfire Procedure • Manually fire primer multiple times • Swap primer

Paladin Laser Accomplishments

•February 1995 - Demonstrated a Paladin mounted LRS-200 Laser Ignition System to the U.S. Army Field Artillery School (15 rounds fired)

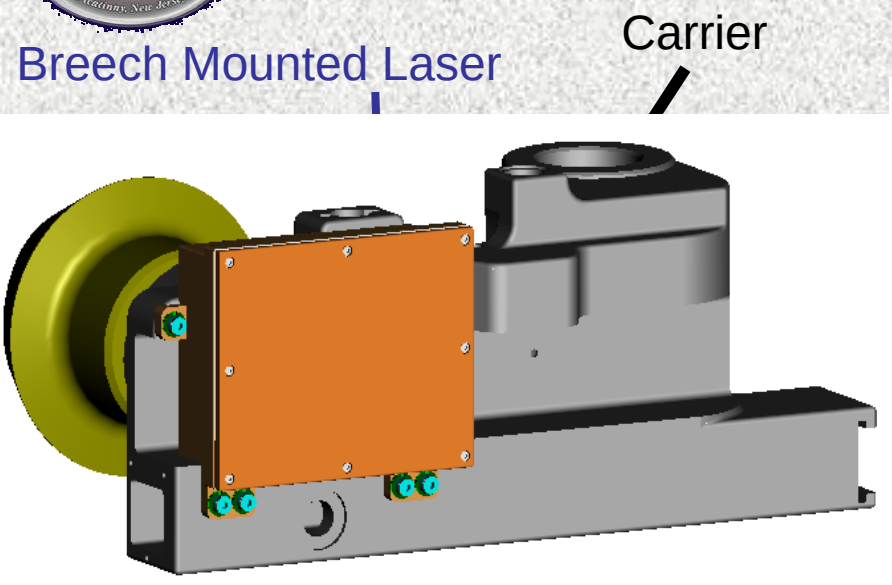
•July 1996 - Demonstrated a Paladin mounted LRS-200 Laser Ignition System in Kuwait (43 rounds fired)

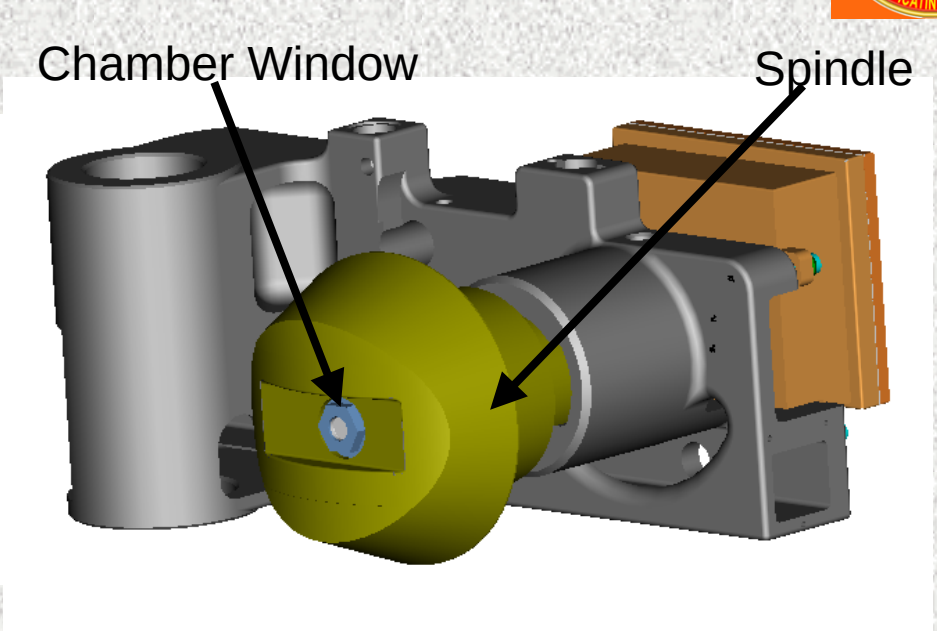
Crusader Laser Accomplishments



- Maximum Rate of Fire of 10 – 12 rounds per minute
- Electrical make-break breech connector
- Multiple Round Simultaneous Impact (MRSI) Capability
- Durable Chamber Window – over 1000 Effective Full Charge Firings
- Durable Laser Igniter Design – over 3000 Rounds on One Igniter
- Over 14,000 rounds fired

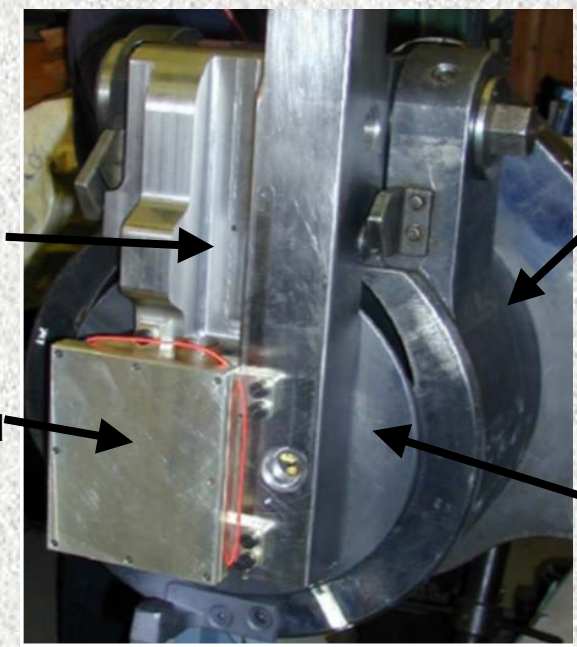
NLOS-C Laser Accomplishments





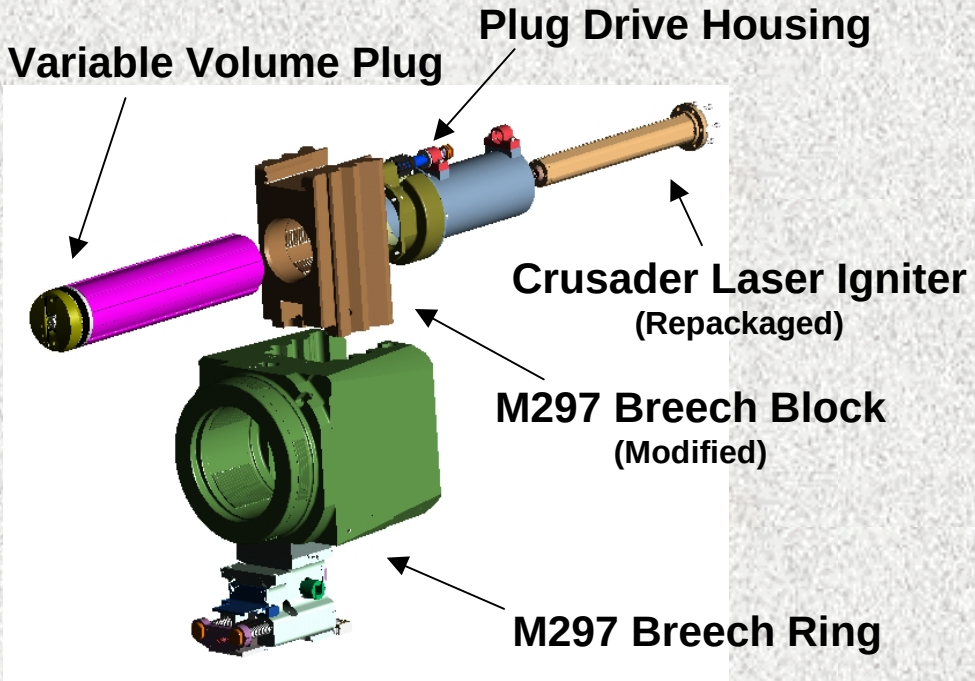
- Successfully Adapted Crusader Laser Ignition Technology to NLOS-Cannon in less than 10 months
- Performed M&S, and finite element analysis of system components to increase robustness
- Successfully fired over 240 rounds

NLOS- C Breech Mounted Laser



Variable Volume Chamber Cannon (V^2C^2) Laser Accomplishments

P.O.P. Cannon Design



- Quick response laser implementation
- Uses laser compatible 155mm MACS w/ 105mm cannon
- Successfully fired over 140 rounds

Future Objectives

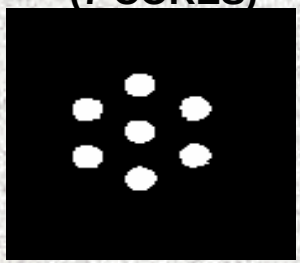
- Evaluate and develop emerging laser technologies for use in weapon systems.
- Develop lower power robust lasers for implementation in towed artillery systems.
- Work With leading edge technology specialist to develop more versatile systems.
- Two Small Business Innovative Research (SBIR) Programs in progress
  - **PC Photonics**
    - Multi-Core Fiber laser
  - **Coherent Technologies**
    - Wave Guide Laser

PC Photonics - Multi Core Fiber Lasers

- The output is a high brightness
- Output is highly stable and extremely robust
- Power can be scaled up to thousands of watts good beam characteristics
- Array size – output power increases with the array size or the core number, while maintaining a good beam quality.
- Fiber length –uniform gain is established over any fiber length through multiple launching ports. The output power scales linearly with the length of the fiber.

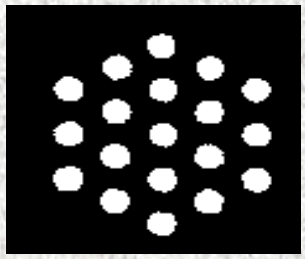
One Ring

(7 CORES)



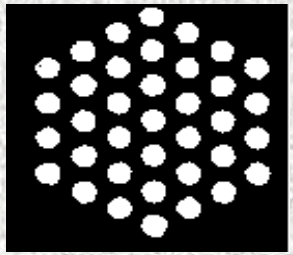
Two Rings

(19 CORES)



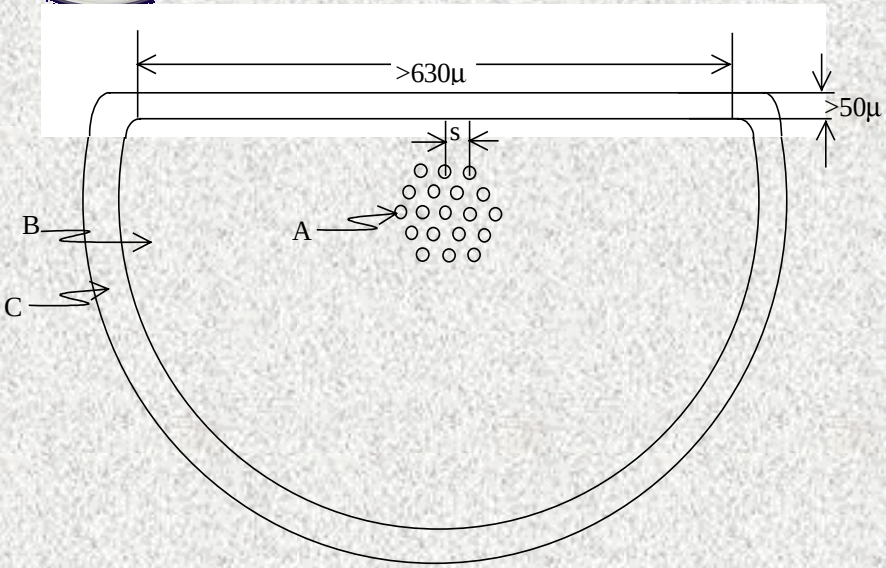
Three Rings

(37 CORES)

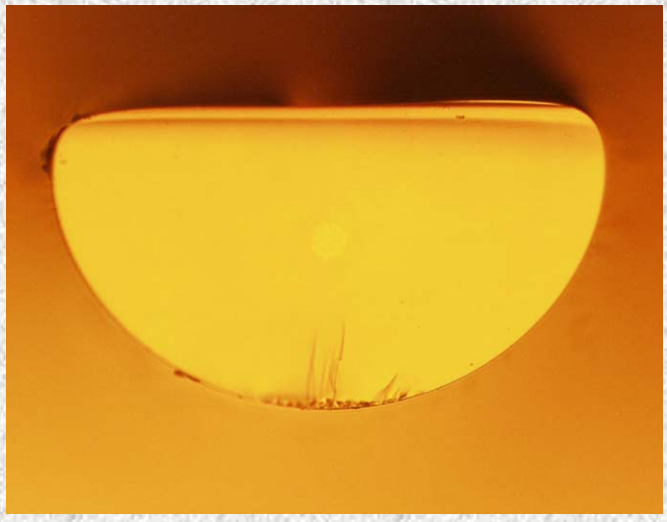


MULTICORE FIBER LASER ARRAYS

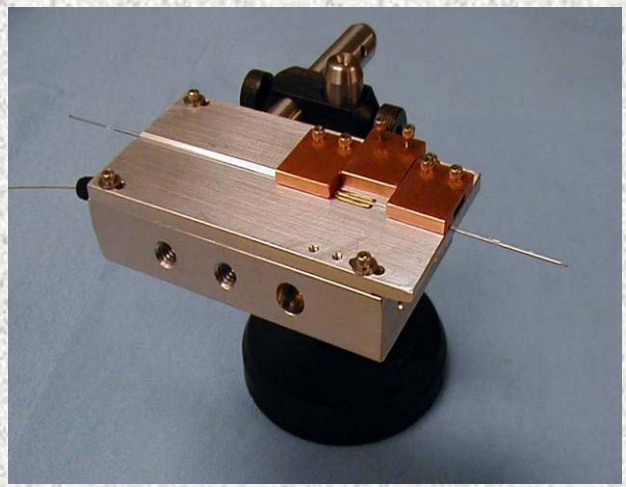
19 Core Fiber and Side Pump Device



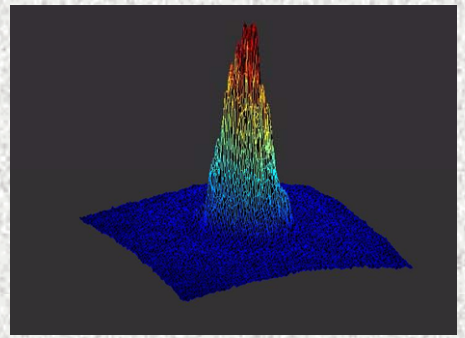
DESIGN OF A 19-CORE FIBER



CROSS-SECTION OF A 19-CORE D-SHAPED FIBER



SIDE-PUMPING OF MULTICORE FIBER LASER



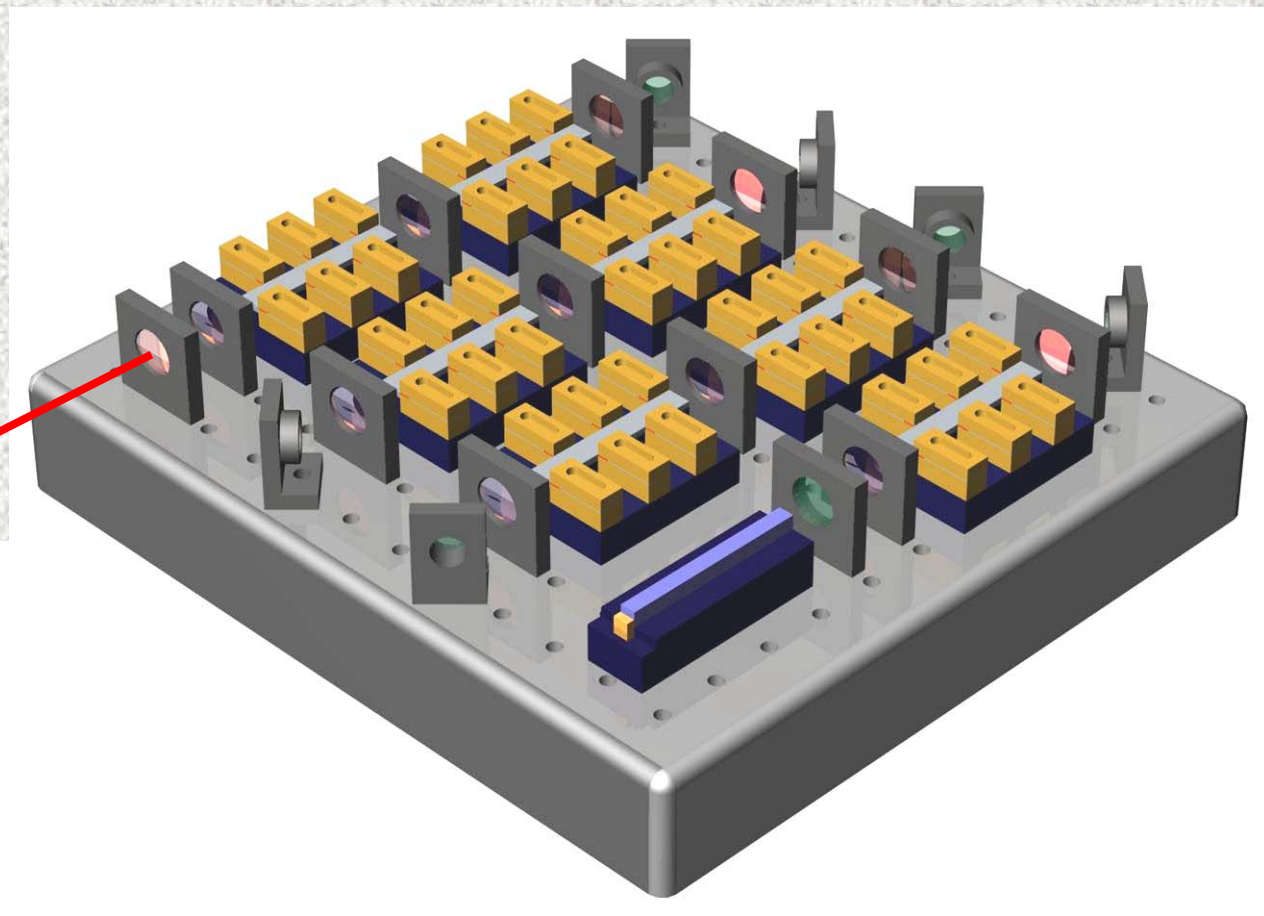
OUTPUT IN A HIGH-BRIGHTNESS BEAM

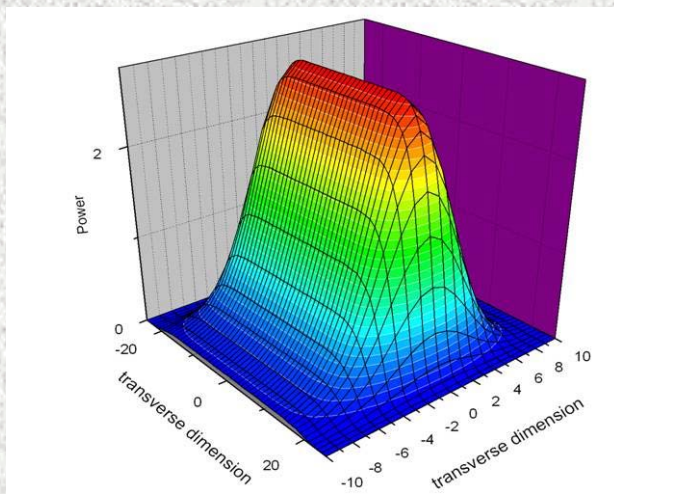
Coherent Technologies Approach

Innovative beam-combining architecture, capable of dramatically enhancing the combined brightness (>300x) of multiple diode bars to generate near diffraction-limited output at multi-kW levels.

- **The beam-combiner uses the diode bars to drive an active laser MOPA implementing CTI's proprietary wave guide technology that offers:**
  - **Enhanced brightness by dramatic beam quality improvement over diode lasers, with minimal reduction in electrical-optical efficiency**
  - **The high efficiency and beam quality of a fiber laser, but at much higher peak/ average powers**
  - **Simple and efficient (>90%) diode-coupling**
  - **Modular architecture scalable to kW levels**
  - **Excellent thermal handling**
  - **Compact ruggedizable architecture with a clear path to a fieldable prototype**
  - **Leverage off other in-house programs**

Phase II breadboard deliverable, and output beam profile





ARDEC Research Programs

Ultimate goal to establish cross platform ignition system

- 2000 Tech base program
  - Teamed with leading scientists, Industry and Academia
  - Results technical report entitled “Estimation of Laser Ignition Parameters for MACS”
  - Thorough evaluation of available laser technologies and application to laser ignition
- In-house Laboratory Independent Research (ILIR) Laser Program
  - 2003 program designed to fully evaluate the emerging laser technologies and evaluate nano-materials compatibility with laser ignition
  - Results:
    - Emerging technologies excellent laser characteristics for ignition.
    - Patent application for a Pre-igniter to enhance laser ignition and reduce laser requirements

Summary

•Laser Ignition has the potential to greatly improve existing and future artillery systems

- Safer
- Environmentally Friendly
- Cheaper
- Reliable
- Automated Operation
- Technology Driven System Improvements
- Versatile and Flexible