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Laser Technology Update: Pulsed Impulsive Kill Laser (PIKL)

Presented to NDIA 2000 Joint Services Small Arms Symposium
29 August 2000

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Presentation Topics

- Introduction
- PIKL program
  - Overview
  - LANL prototype development
  - Armstrong labs bio-effects analysis
- Solid state lasers
  - Overview
  - Technology advancements
- PIKL Technology
  - Operational benefits
- Summary

Introduction

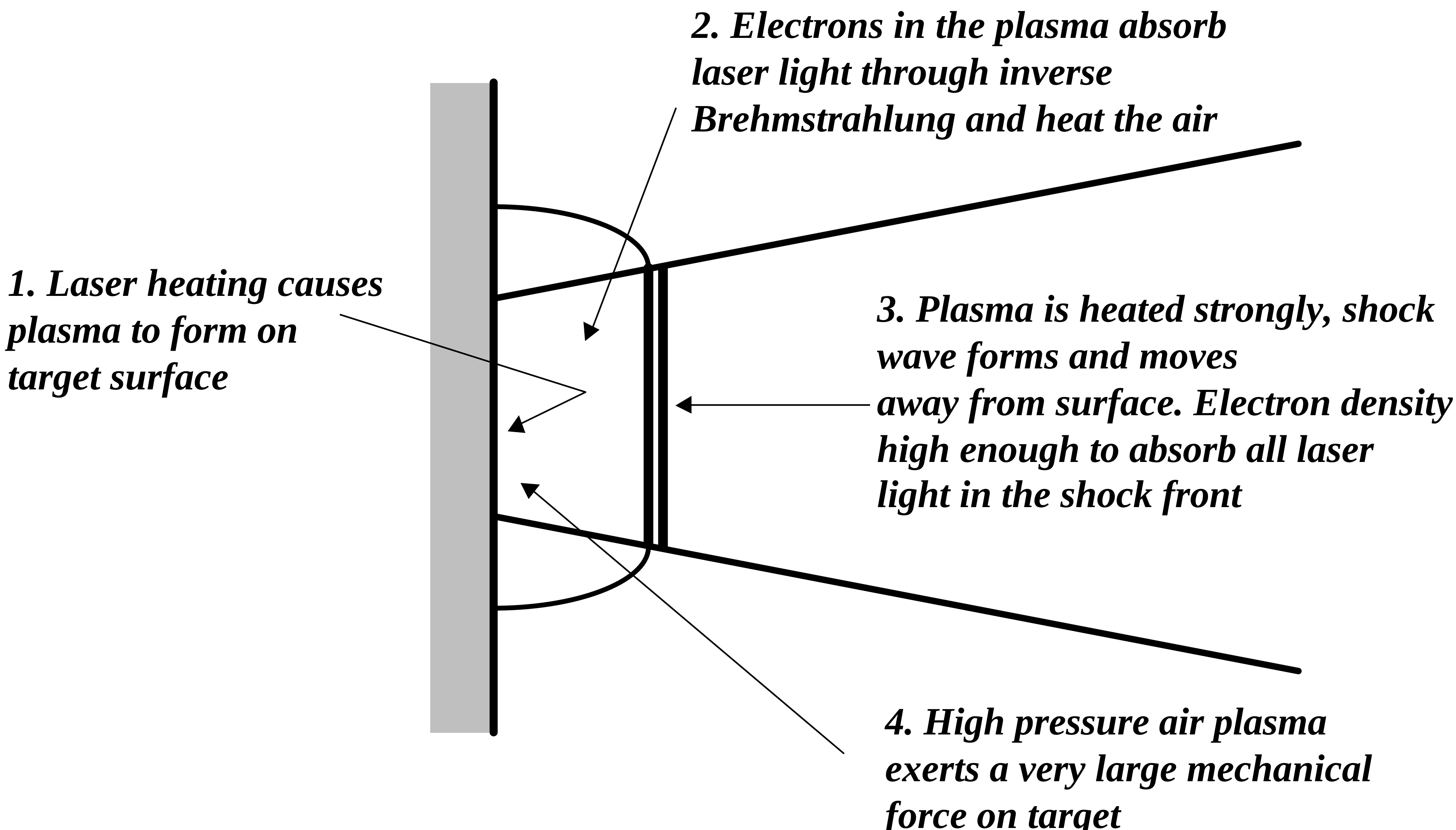
- Strong interest in ability to vary target effects
  - Lethal to less than lethal
  - Military, DOJ, other law enforcement agencies
  - Area denial, MOUT, MOOT, MOBA, facility protection
- Laser technology pursued over last 15 years
  - PIKL technology sponsored
  - Subject target to mechanical loading and ablation
  - Chemical lasers present problems
- Solid state laser technology promising
  - Size, weight, performance advantages
  - Peak and average powers
  - Performance parameters can be achieved

PIKL Program
Overview

- Program began in 1992 under auspices of JSSAP
  - ARDEC program lead
  - Effort split into 2 concurrent research projects:
    - Los Alamos National Lab (LANL): development of operational prototype of a surface discharge initiated DF laser
    - Armstrong Laboratory/Optical Radiation Division: analysis of biological effects of exposure to moderate energy (<1 kJ) infrared laser pulses

PIKL Program

Overview



PIKL Program

Overview

- Pulsed impulsive kill laser (PIKL)
  - Target interaction: ablation and mechanical impulse
  - Pulse ‘trains’ can literally chew through target material
    - No burning
  - Effect is independent of:
    - Laser type
    - Target type

PIKL Program

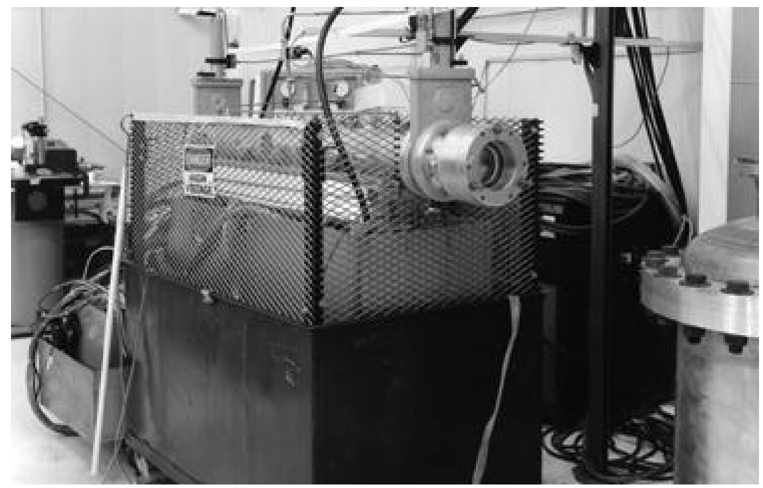
LANL Prototype Development

- Chemical laser chosen to meet energy per pulse and system portability goals
- DF laser chosen for excellent transmissivity especially over longer distances desired (1-2km)
- UV initiation chosen to improve efficiency and reliability

PIKL Program

LANL Prototype Development

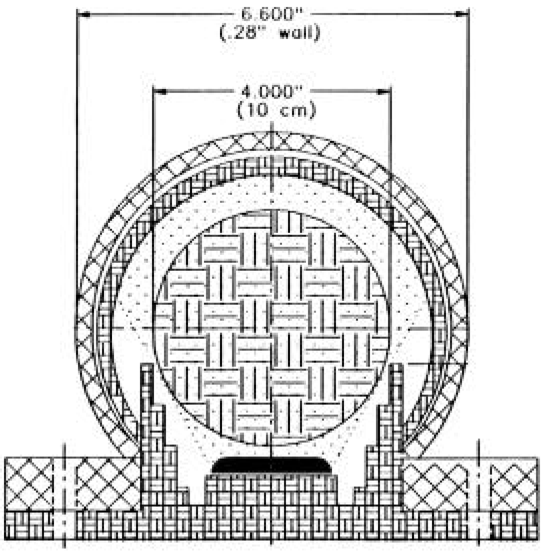
- 1992: pre-prototype proof-of-principle laser built using parts from LANL’s meteor chemical laser program
  - Surface discharged DF laser
  - Produced over 100 joules in a 10 microsecond wide pulse
  - Suffered from flaws such as gas leakage



PIKL Program

LANL Prototype Development

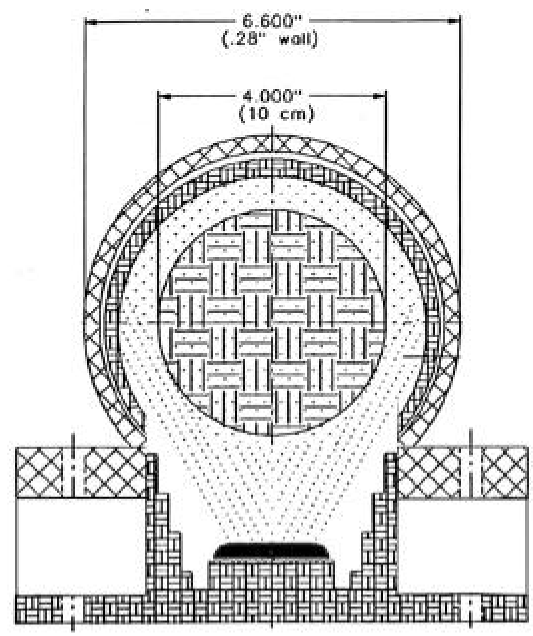
- May 1993: compact prototype DF laser put into service
  - Redesign of pre-prototype laser
  - Improvement in UV illumination reduced pulse width to 3-5 ms
  - Produced energies up to 126 joules
  - Arcing problems necessitated redesign



PIKL Program

LANL Prototype Development

- December 1993: high-energy DF prototype laser built
  - Incorporated best aspects of pre-prototype and compact prototype
  - Arcing problem eliminated
  - Energies over 300 joules per shot
  - Pulse widths of 3-5 microseconds
  - Design provided proof of pulsed DF laser concept with high pulse energies and good reliability



PIKL Program

LANL Prototype Development

- High energy prototype used to study laser pulse effects
  - Photographic paper, wet chamois (skin simulant), BDU material, Kevlar vest material
  - Quantifying target effect required measuring impulse delivered to target
  - Impulse transducer system designed to measure effects

PIKL Program

LANL Prototype Development

- Impulse tests performed using both high-energy prototype DF laser and WSMR CO_2 laser
  - DF laser tested at pulse energies up to 200 joules
  - CO_2 laser tested at pulse energies up to 900 joules
  - Measured impulses were 7-10 dyne-seconds per joule for chamois, Kevlar and BDU targets

PIKL Program

Armstrong Labs Bio-effects Analysis

- Goal: assess technical viability of the PIKL concept
  - Estimate the injury/lethality potential of PIKL
  - Use a combination of theoretical modeling, experiments on biosimulant targets, and previously published data on impulse injuries
- Experiments: high energy microsecond length infrared pulses on targets
  - Ballistic pendulum-mounted planar targets: total impulse coupling and coupling efficiency
  - Gel-block targets: embedded with pressure sensors to measure surface and internal pressures generated
  - Target materials included chamois, BDU cloth, and Kevlar
  - Data obtained both with LANL prototype laser and PLVTS device at HELSTF/WSMR

PIKL Program

Armstrong Labs Bio-effects Analysis

- PLVTS details
  - Pulsed CO_2 laser
  - Wavelength: 10.6 microns
  - Pulse duration: 32 – 34 microseconds
  - Single pulse or multi-pulse mode (10 Hz)
  - Pulse energies: 100 – 1200 j/pulse
  - Spot size used for testing: 2 x 3 cm

PIKL Program

Armstrong Labs Bio-effects Analysis

- Test results
  - Detonative coupling occurred at pulse energies of ~ 400 J
  - Breakdown threshold: ~ 2×10^6 w/cm^2
  - Average coupling coefficients
    - Chamois: 8 dyne-sec/j
    - BDU over chamois: 9 dyne-sec/j
  - Maximum impulse and pressure: 10,000 dyne-sec and 25 atmospheres

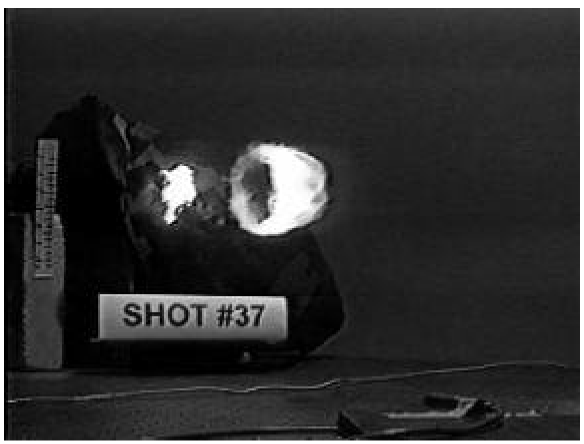
PIKL Program

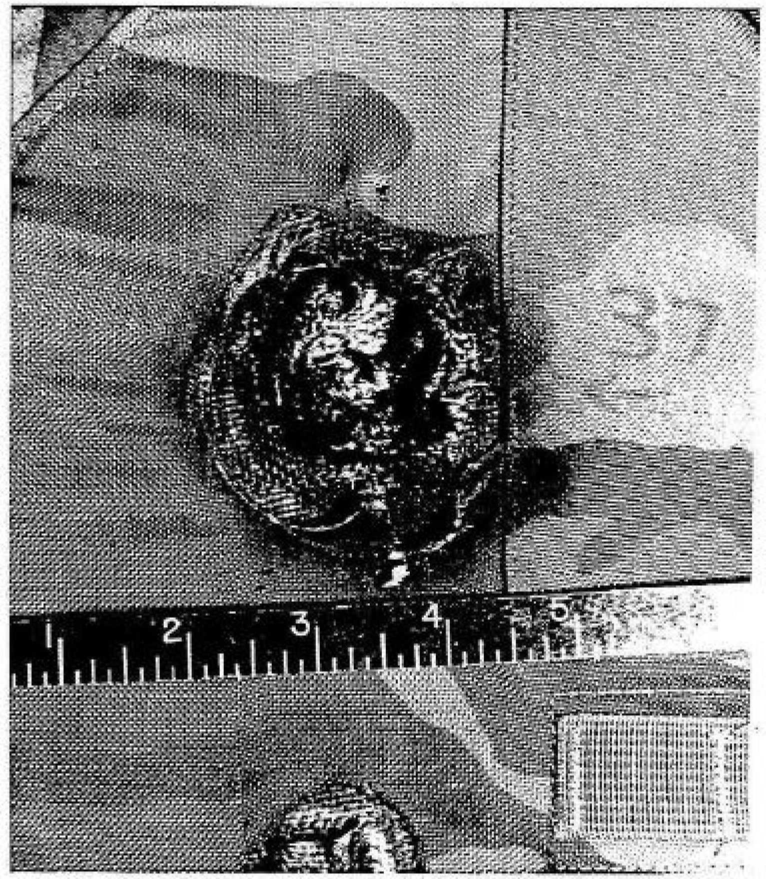
Armstrong Labs Bio-effects Analysis

- Conclusions
  - Impulses and pressures developed were two orders of magnitude below those needed to produce serious injuries with single pulses
  - Detonative coupling does not appear to produce greater probability of damage than ablative coupling
  - Surface damage can be significant with ablative coupling
    - Multiple pulse trains produced moderate to severe damage

PIKL Program

Armstrong Labs Bio-effects Analysis





Solid State Lasers
Overview

- Solid state (SS) laser technology is advancing rapidly
- SS lasers offer many advantages to future weaponization concepts:
  - Smaller size
  - Lower weight
  - Ease of use/handling (no hazardous chemicals)
  - Frequency agility through dye doping

Solid State Lasers
Technology Advancements

- Diode-pumping
  - Higher electrical efficiency than flash pumping
  - Higher reliability and lifetimes
  - Smaller weight/volume
  - More rugged
  - Less waste heat

Solid State Lasers
Technology Advancements

- Slab lasers
  - High optical performance
  - Minimal performance degradation due to thermal effects
    - Reduced optical distortions
    - Easier removal of waste heat

Solid State Lasers
Technology Advancements

- Dye-doped solid state laser rods
  - Frequency agility without dangerous liquid solvents
  - Ease of use with solid state host
  - Operation in three pump modes: CW, mode-locked, and pulsed
    - Outputs can be varied

PIKL Technology
Operational Benefits

- PIKL is a “feeder” technology into the Agile Target Effects (ATE) STO and Future Combat System (FCS)
  - ATE STO addresses AAN short list for Future Fighting Ground Vehicle
  - Developing brassboard weapons capable of lethal tunable target effects
  - Demonstrate utility of Directed Energy Weapons (DEW) against personnel and materiel targets
- Leveraging with SMDC and LLNL and their SS laser technology

PIKL Technology
Operational Benefits

- Applying PIKL technology for FCS:
  - Anti-materiel effects:
    - Disrobing explosive armor
    - "Blunt Trauma"
    - Anti-UAV
  - Anti-personnel effects:
    - "Blunt Trauma"
    - Suppression
- Rapidly project Tunable Target Effects to ranges of 2 km

PIKL Technology
Operational Benefits

- Application of PIKL technology
  - Area Denial
  - Crowd Control
  - Facility Protection
  - Suppression
  - Military Operation Other than War
  - Military Operation on Urban Terrain
  - Law Enforcement

Summary

- Technologies such as PIKL that can provide varying target effects (lethal and less than lethal) have a broad area of interest
- PIKL technology has made significant progress over the past 15 years
- Solid state lasers have also made significant strides
- Combining SS laser technology and the PIKL concept can produce systems with the necessary parameters required for military utility