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Evaluation of the Ignition and DDT Characteristics of CL-20 using a Laser Hotplate Configuration

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Eric J. Welle, Edward S. Virostko, and Alexander S. Tappan
Sandia National Laboratories
Explosive Components Facility,
Albuquerque, NM, USA

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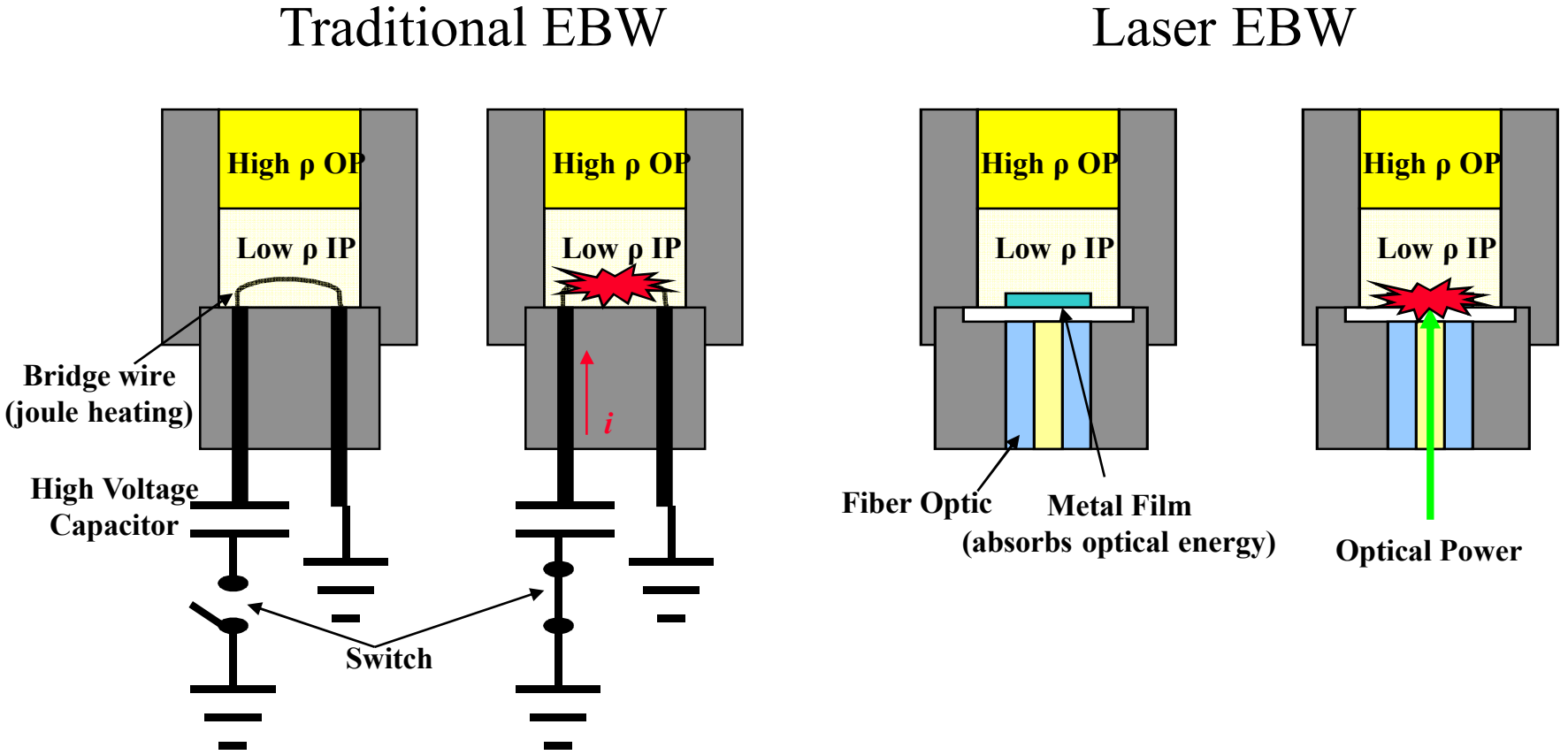
Outline

- Introduction:
  - Problem statement and proposed solution
  - How a Laser EBW works and similarities to traditional EBWs
- Experimental Configuration
  - Laser hotplate optical layout
- Results
  - Streak camera measurements
- Conclusions

Introduction

- The significant phenomena in transient explosive behavior occur at interfaces and are strongly affected by explosive properties
  - Interfaces: Explosive-bridgewire, explosive-confinement, explosive-explosive
  - Explosive Properties: Chemical and mechanical nature of materials
- Traditional EBW devices do not allow for easy interrogation of transient initiation behavior
- Laser EBW platform is more easily modified to enable interrogation of initiation phenomena

How does a Laser EBW work?



In both cases, a high temperature and pressure plasma is formed at electro- or opto- Explosive interfaces that leads to a compaction wave affected DDT event.

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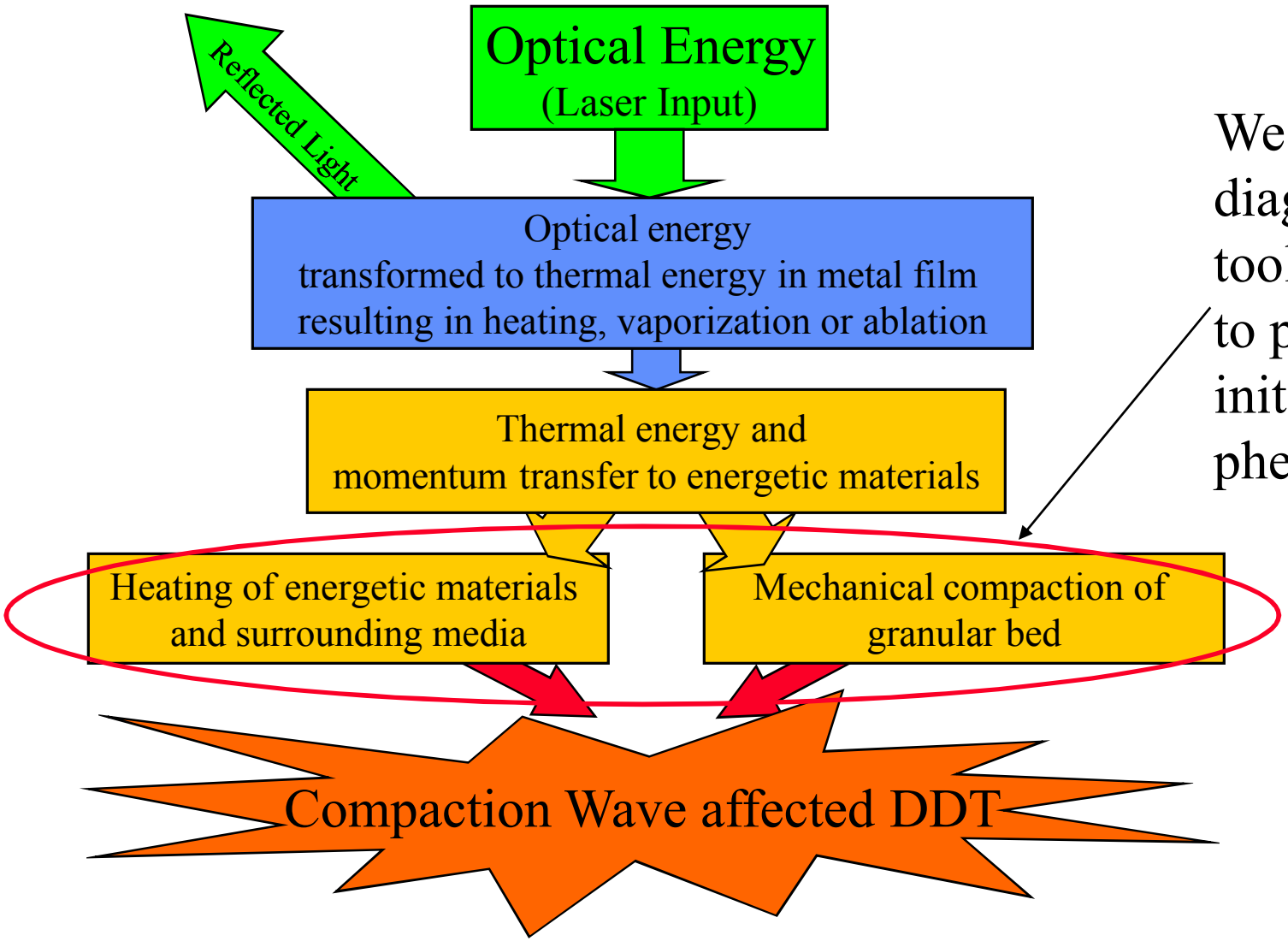
Understanding Initiation in a Laser EBW



We need diagnostic tools/platforms to probe initiation phenomena!

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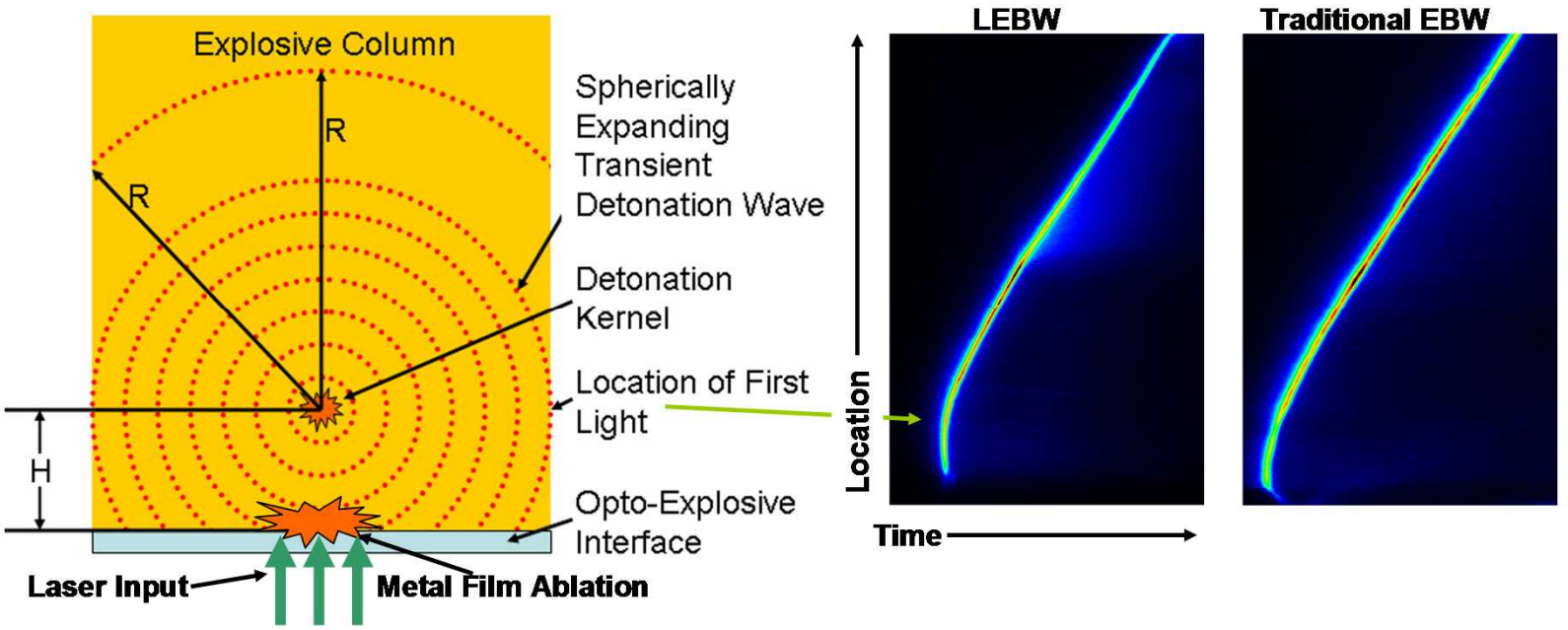
Traditional EBW and Laser EBW Similarities



- Critical similarities are present at the ignition boundary for traditional and laser EBW devices
  - Similar knee-like structures observed during streak camera testing
  - Similar function times and reaction wave spreading
- Historical experimental configuration fails to ***directly*** probe initiation location
  - Huygens' reconstruction used to model reaction wave progress from detonation kernel

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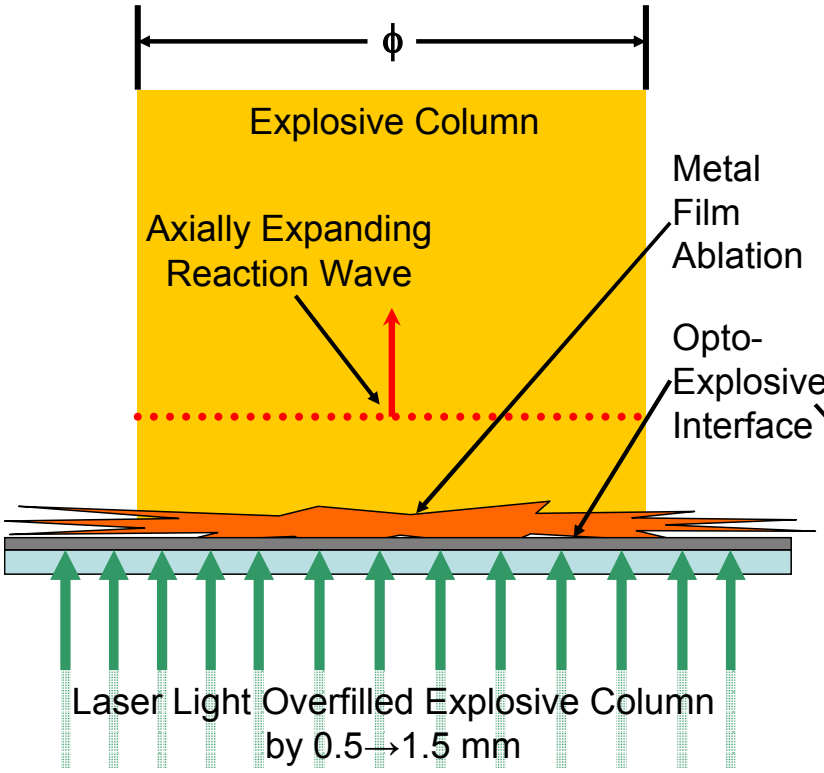
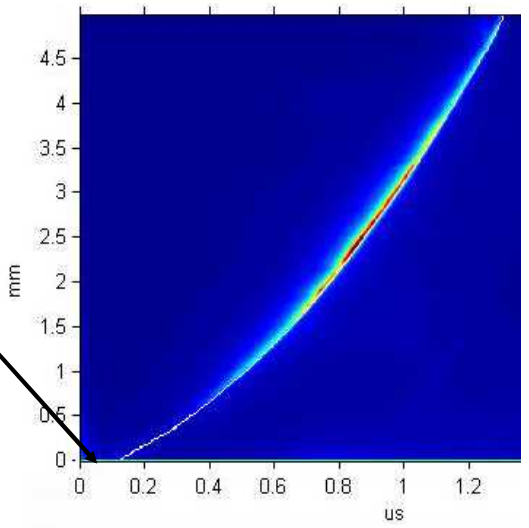
Laser Hotplate Concept

- **Benefits of this geometry are that early time phenomena are more directly measurable and it is more ideally two dimensional**
  - **Laser source provides a more uniform ablation boundary condition**





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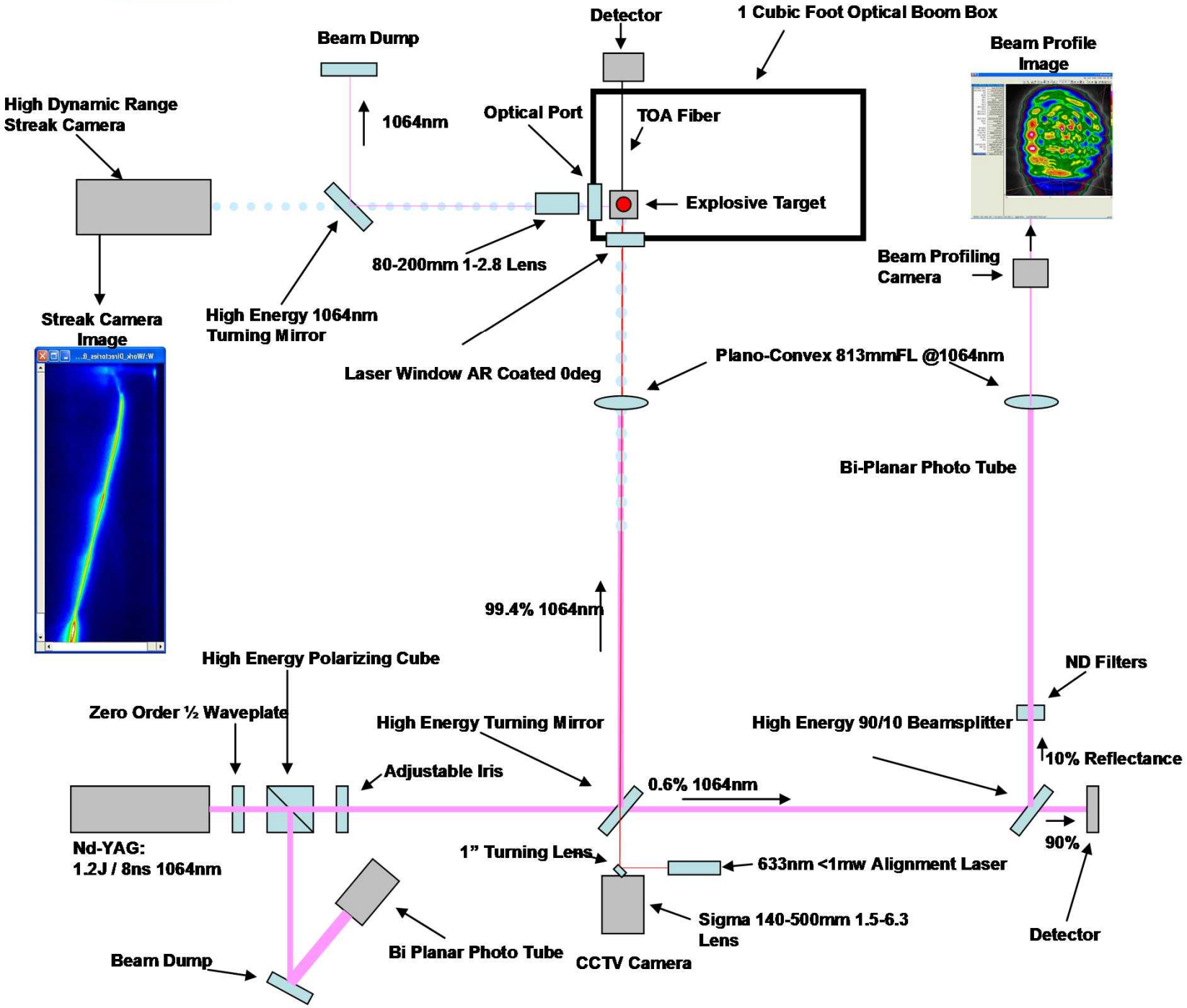
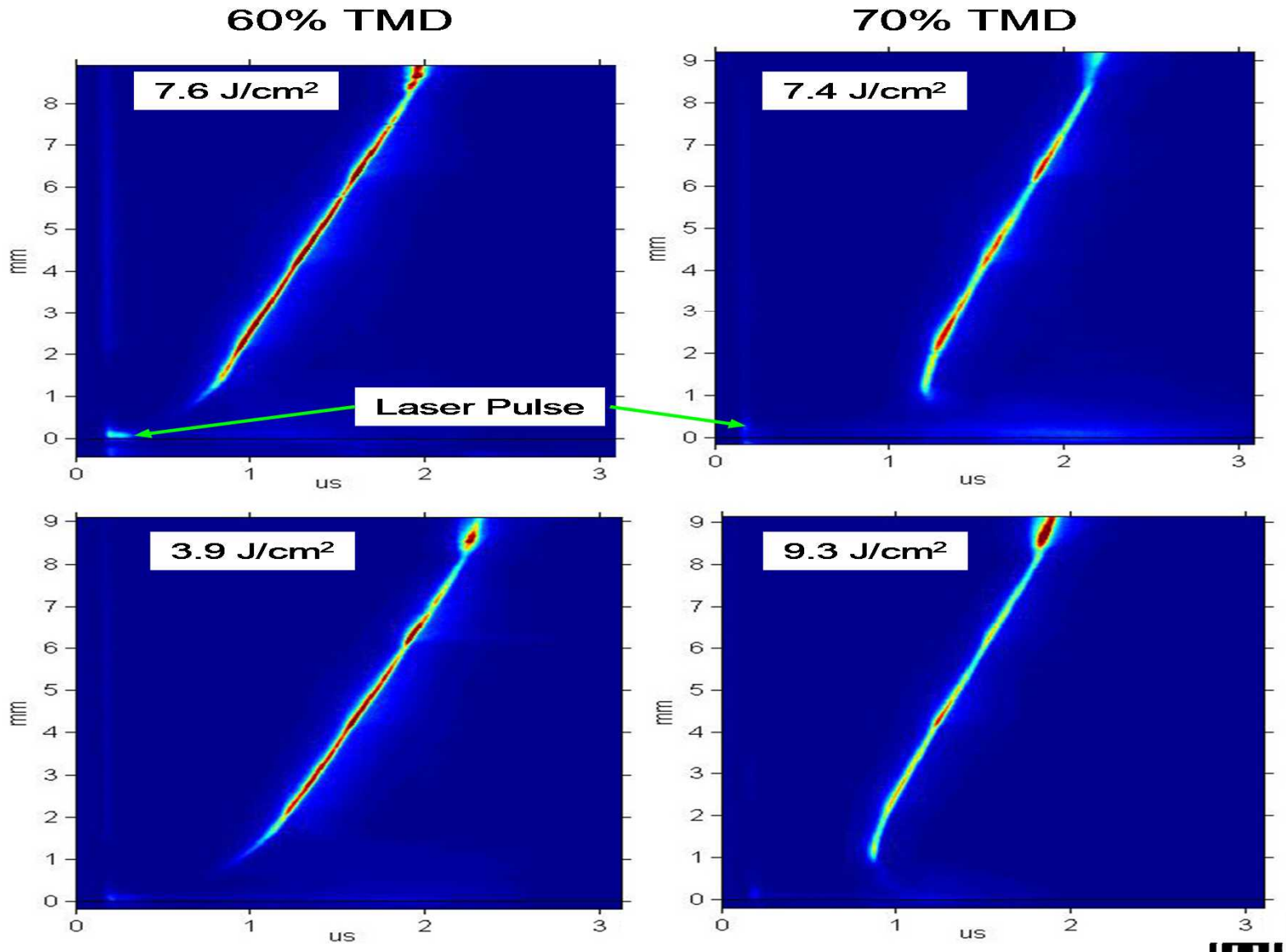

Detector
1 Cubic Foot Optical Boom Box
Beam Dump
Beam Profile Image
High Dynamic Range Streak Camera
1064nm
Optical Port
TOA Fiber
Explosive Target
80-200mm 1-2.8 Lens
Beam Profiling Camera
Streak Camera Image
High Energy 1064nm Turning Mirror
Laser Window AR Coated 0deg
Plano-Convex 813mmFL @1064nm
Bi-Planar Photo Tube
99.4% 1064nm
High Energy Polarizing Cube
ND Filters
Zero Order ½ Waveplate
High Energy Turning Mirror
High Energy 90/10 Beamsplitter
10% Reflectance
Adjustable Iris
0.6% 1064nm
Nd-YAG:
1.2J / 8ns 1064nm
1" Turning Lens
633nm <1mw Alignment Laser
90%
Sigma 140-500mm 1.5-6.3 Lens
Detector
Beam Dump
Bi Planar Photo Tube
CCTV Camera

Streak Camera Images of CL-20 DDT Events



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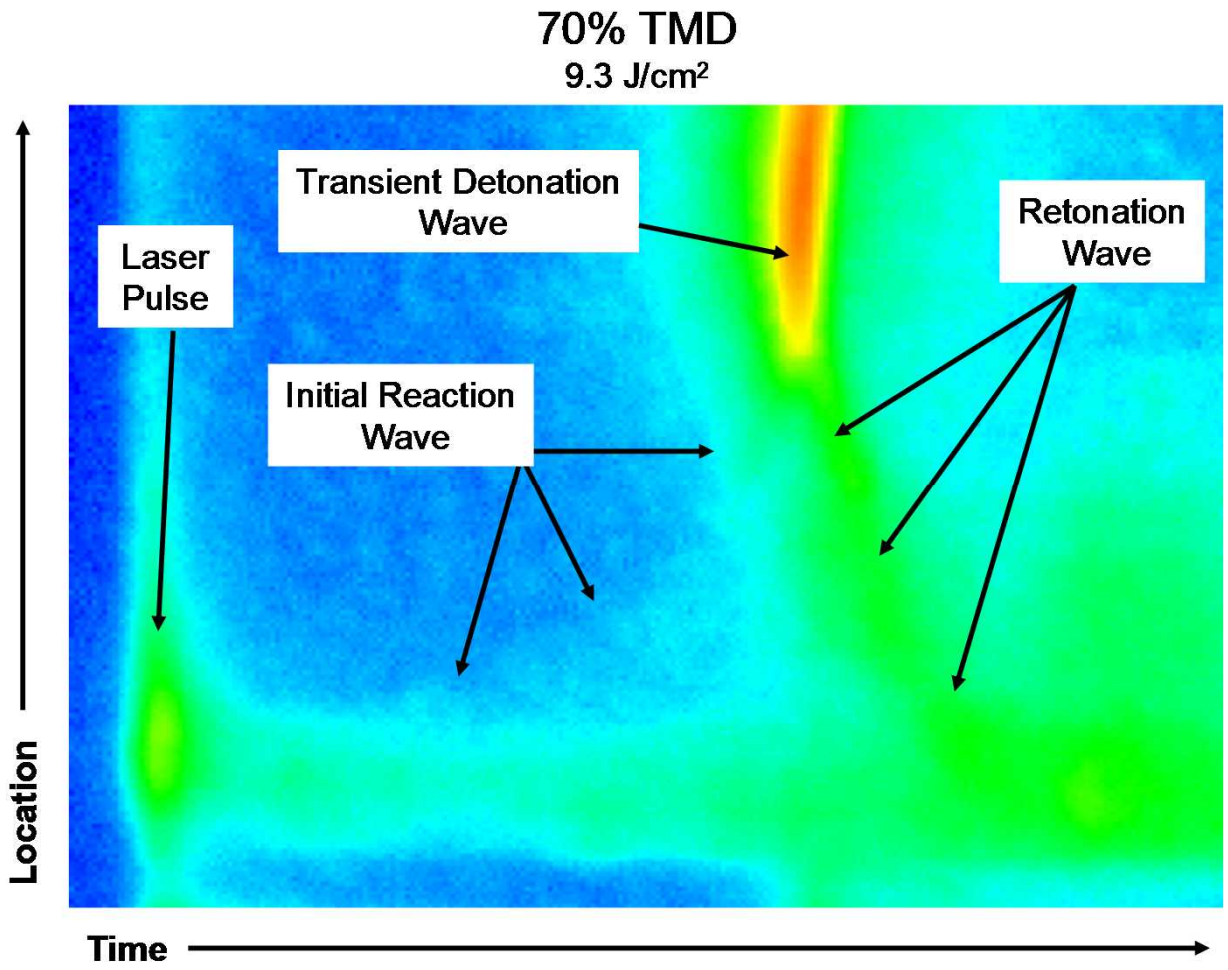
Zoomed View of Ignition Region

- Rearward traveling retonation wave velocity is ~5.5 mm/μs
- Steady state velocity at 70% TMD is ~7 mm/μs based upon the streak camera results



Conclusions

- A new experimental approach intended to enable probing of the early stages of ignition and DDT processes has been developed and demonstrated
- The initial testing included evaluating the DDT characteristics of CL-20 at 60% and 70% TMD
- It was found that the higher density tends to retard the onset of the transient detonation waves
- The measurable reaction waves for the 60% TMD cases appeared to progress in a continuous fashion where the 70% TMD cases exhibited discontinuities and retonation waves for one test case
- Future testing will target the region in close proximity to the metal film where the early stages of bed compaction and combustion are occurring