OPTICAL SYSTEM TO CONTROL TERMINATION OF SMALL- AND MEDIUM-CALIBER MUNITIONS

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Needs

- Proximity fuzes (PFs) are widely used in large-caliber (>50 mm) artillery shells, aviation bombs, and missile warheads.
- PF initiates ordnance explosive detonation at a given distance from the target.
- Similar control of termination is needed for small- (12-gauge) and medium-caliber (40-mm) munitions in long-range nonlethal applications and in high-lethality airburst applications.

POC Solution

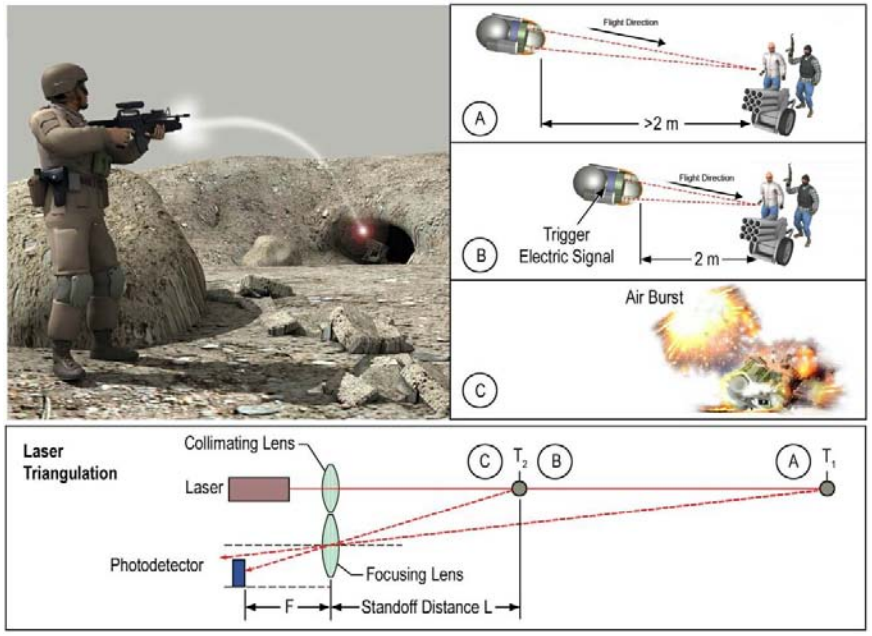
- The best suited fuze is an optical fuze based on a laser triangulation proximity sensor mounted inside a round.
- The laser proximity sensors (LPSs) being developed at POC can respond to a target emerging in front of a flying round at a distance from 0 to 2-3 m with a response time in tens of microseconds.
- Munitions assembled with LPS, does not require weapon modification.
- POC has developed prototypes for 12-gauge (Optical Proximity Sensor - OPS) and 40-mm (Smart Optical Proximity Fuze - SOProF) calibers.

Application Scenarios

Nonlethal

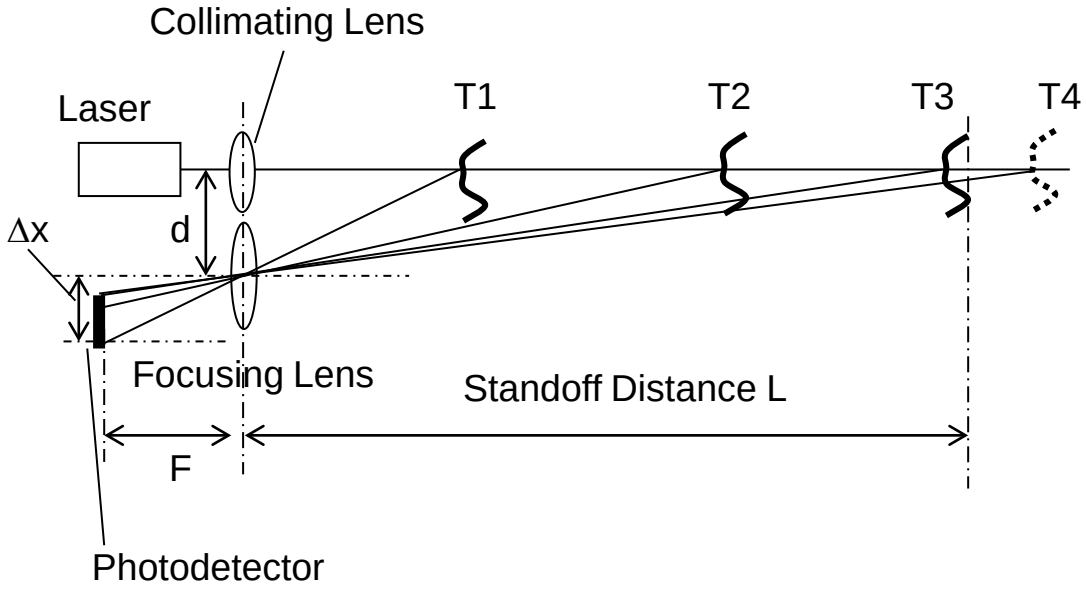
Application of the LPS (OPS) with variable-range kinetic energy munition with inflating bag.

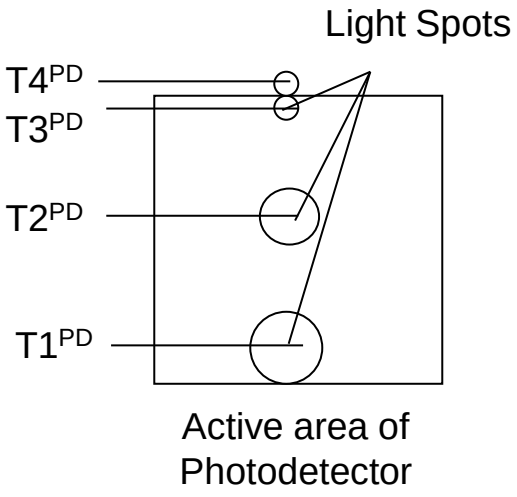
High-Lethality Airburst



LPS (SOProF) installed on a high explosive 40-mm round; detects a target 0 m to 2 m from a projectile and activates electric initiator for airburst.

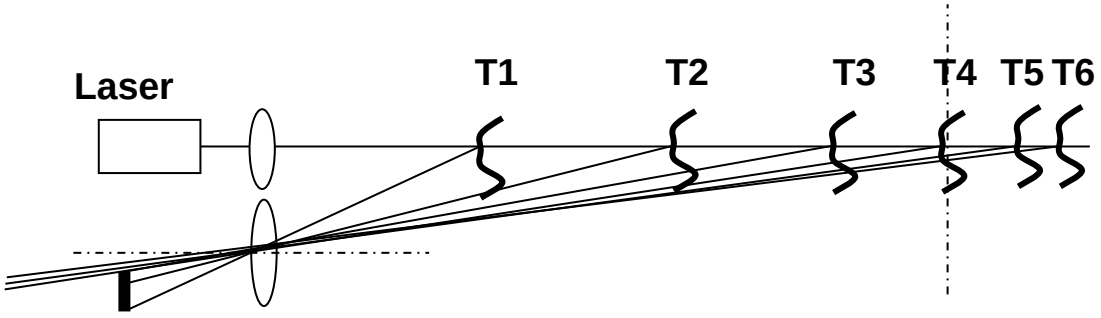
Laser Triangulation Principle



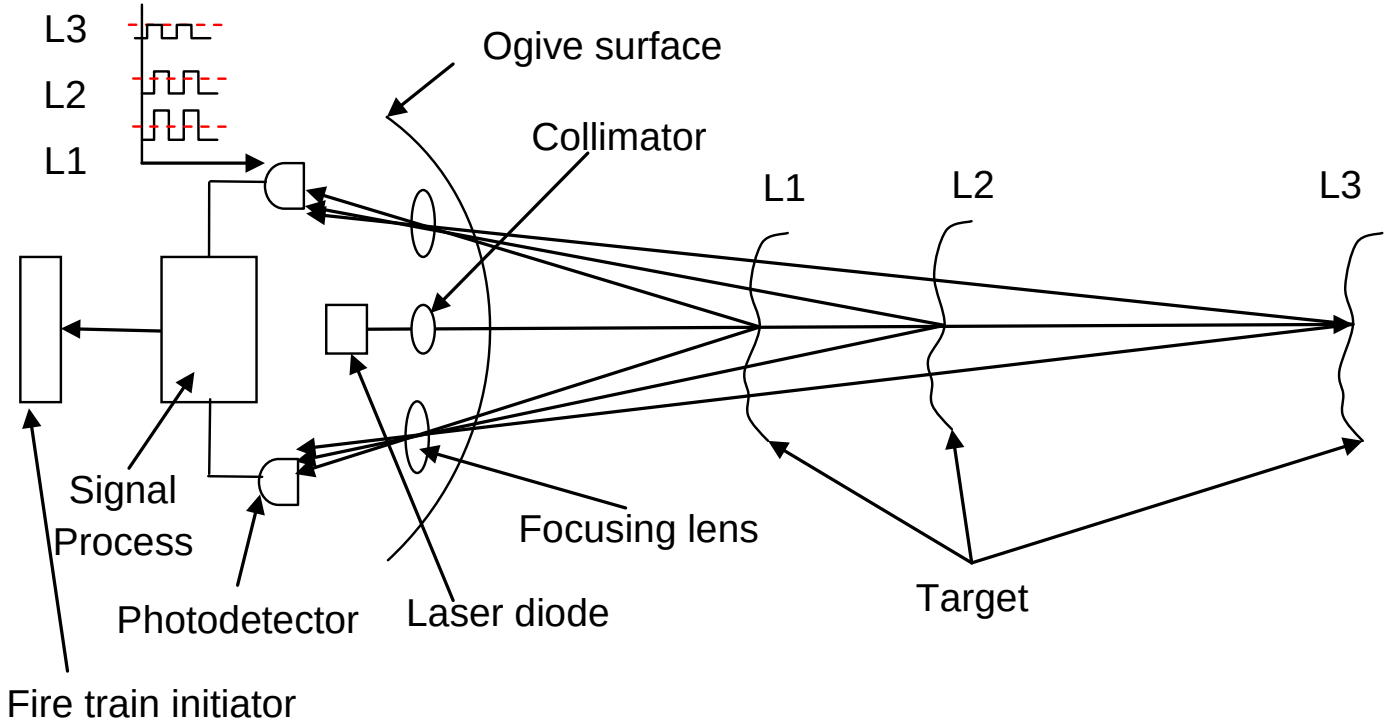


The transmitted laser beam reflecting from a target located at distances from T1 to T4 causes displacement of the beam image across the active area of the photodetector from position T1PD to T4PD. The beam image reflected from a target in position T4 does not reach the active area of the photodetector.

Laser Triangulation Principle (Cont.)



Laser Triangulation in an Axially Symmetric Configuration

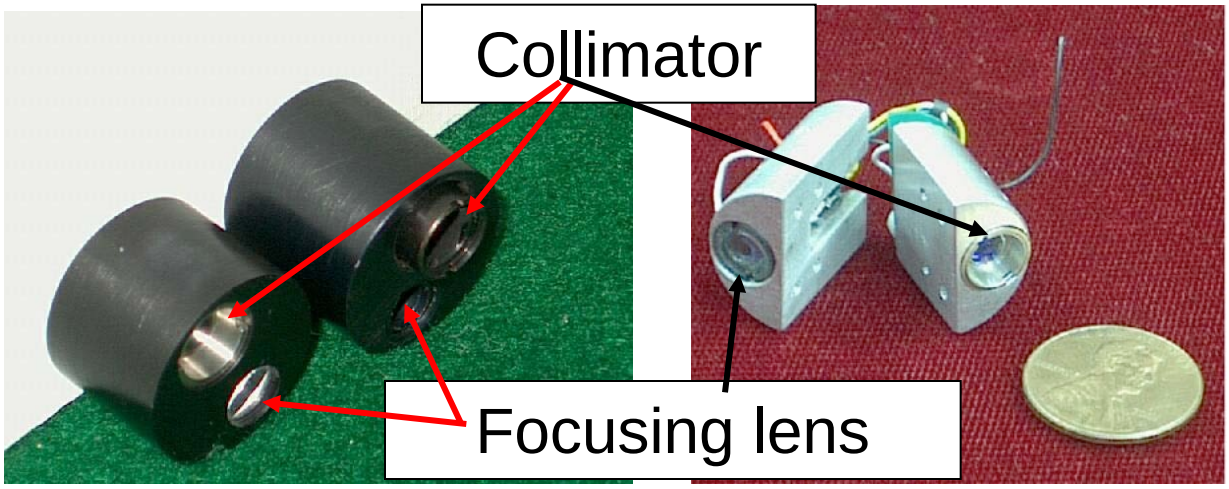


Advantages of axial symmetric arrangement of multiple apertures and photodetectors:

- Better ballistics due to center of gravity being located on the longitudinal axis of a round.
- Higher SNR due to averaging of multiple output signals

POC's LPS Prototypes

Three generations of OPS prototypes for 12-gauge caliber



Outside diameter, mm	17.8
Length including PC board, mm	19.0
Weight (without battery), g	10.2
Distance range, m	3-5
Light source: Laser diode @ 808 nm	200 mW

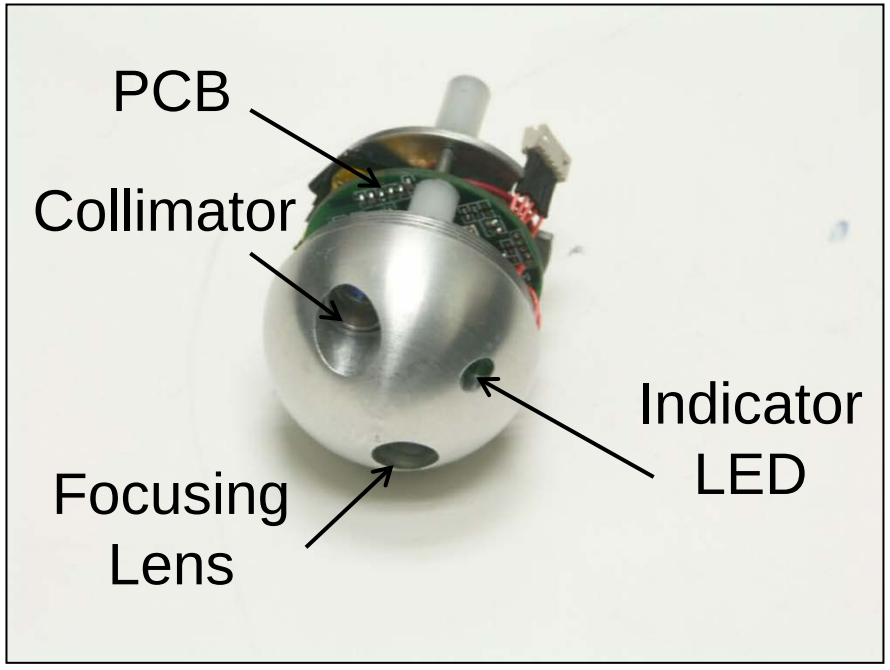
Splitting OPS for nonlethal applications.

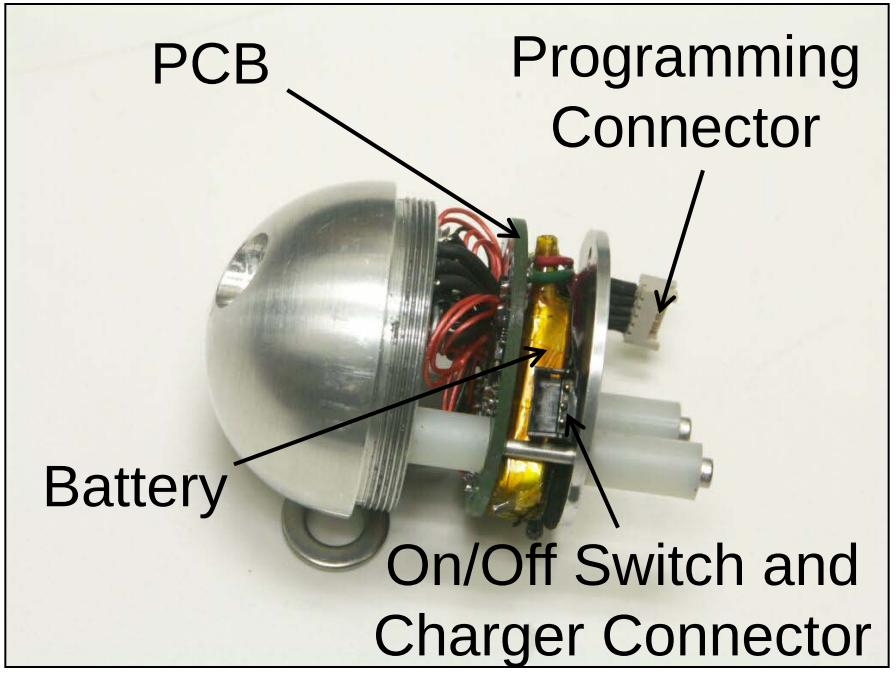
Power: 6 V Li/MnO_2 battery

LPS Prototypes (Cont.)

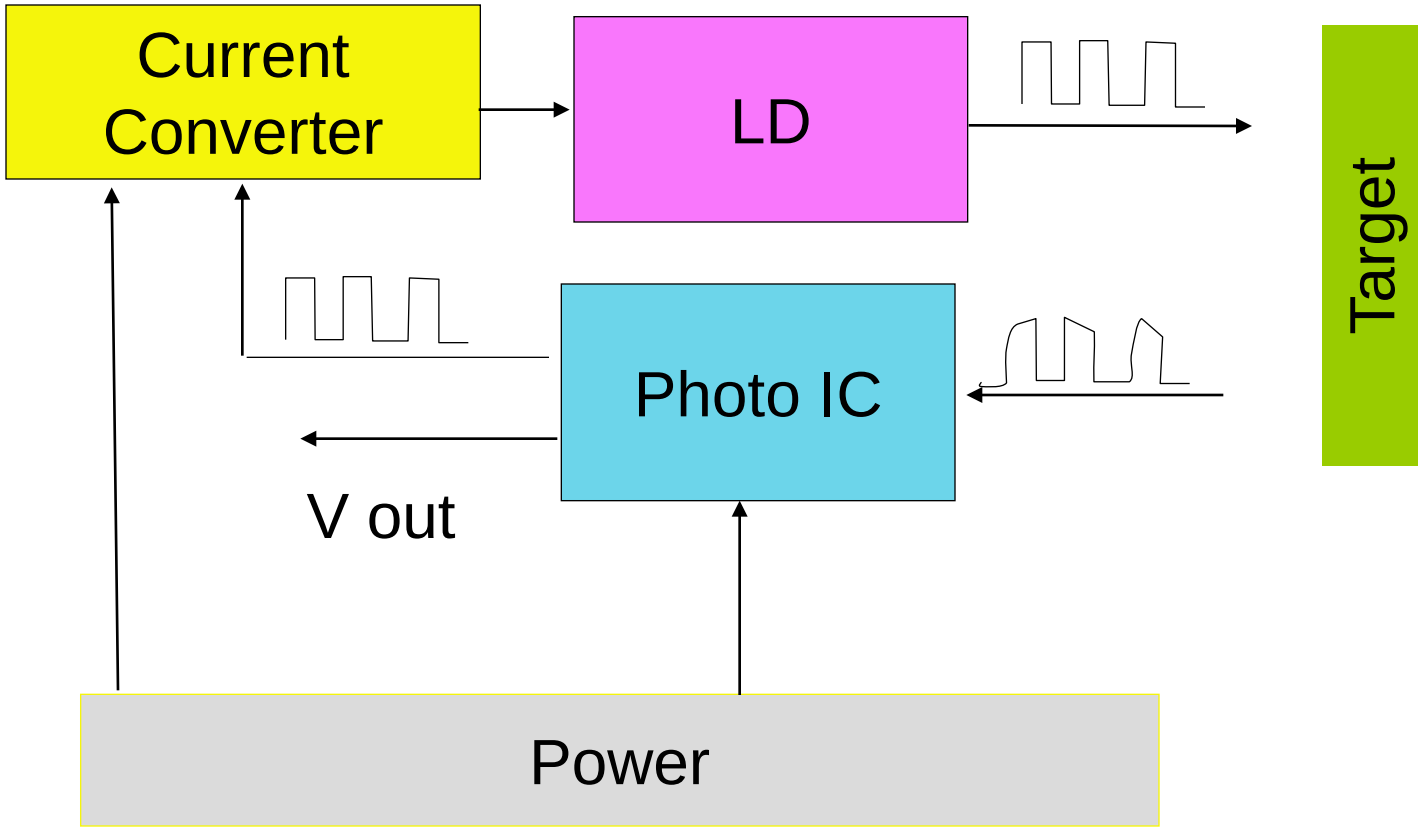
LPS (SOProF) assembled in M433 40-mm round model.

Power: 3.7 V Li-ion rechargeable battery



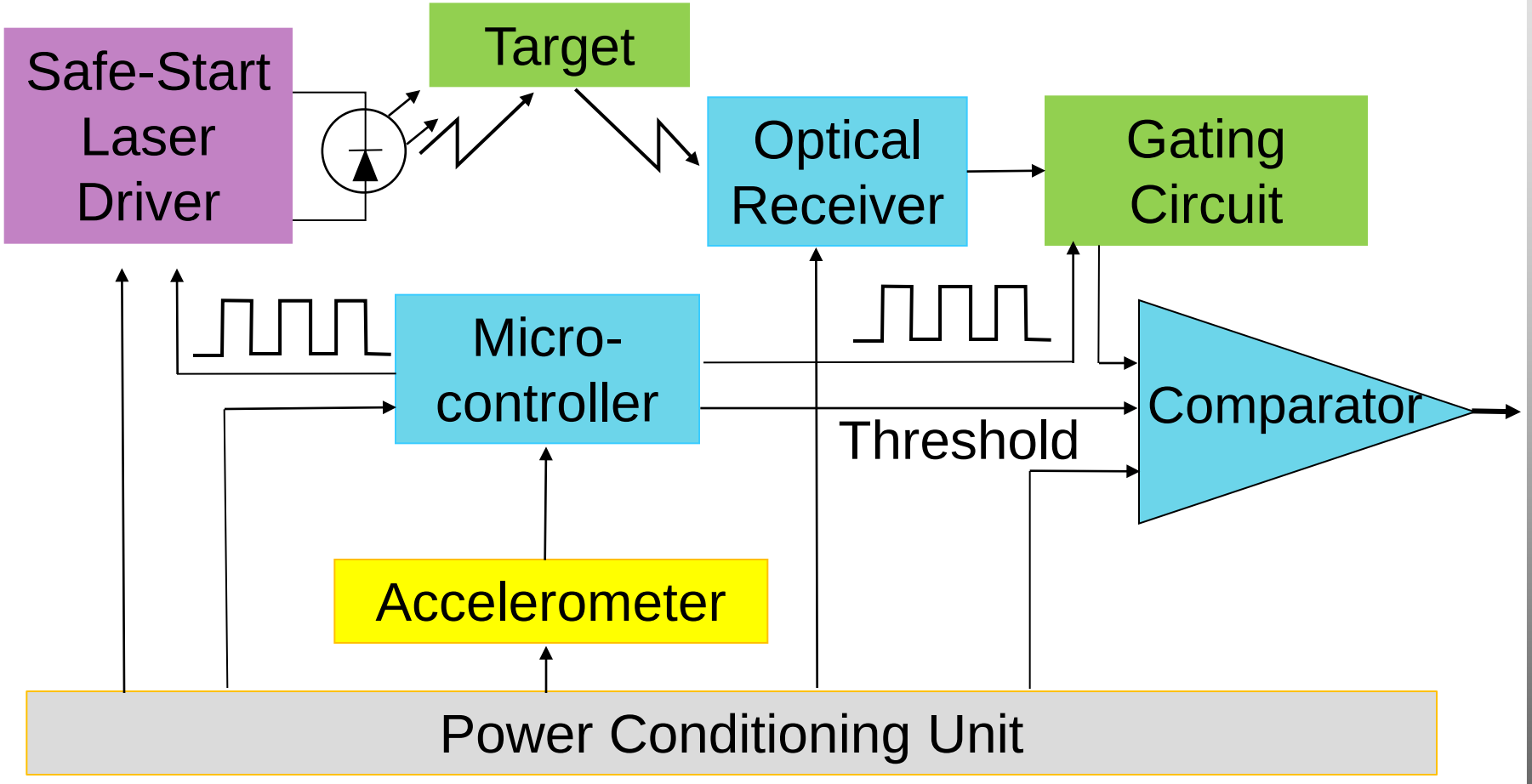


LPS Electronics



Block diagram of LPS prototype electronic circuitry for 12-gauge round. Light-modulating photo IC provides synchronous light detection, improving SNR and miniaturizing LPS package.

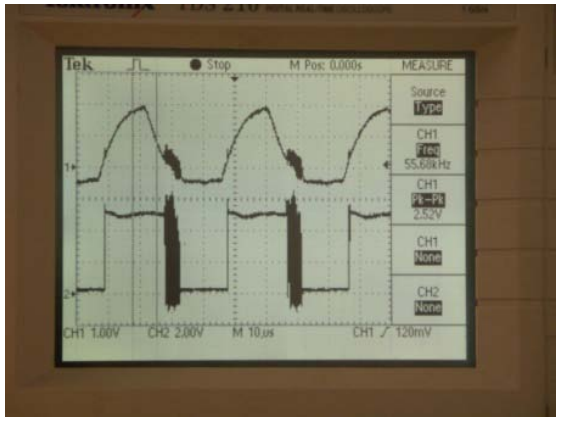
LPS Electronics (Cont.)



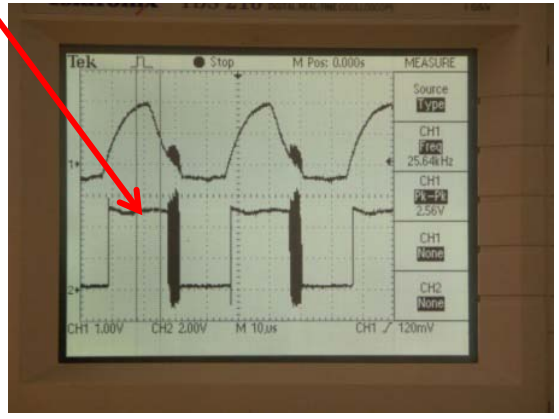
Block diagram of LPS prototype electronic circuitry for 40-mm round. Accelerometer functions as a power switch. Light modulation minimizes power consumption.

LPS Performance

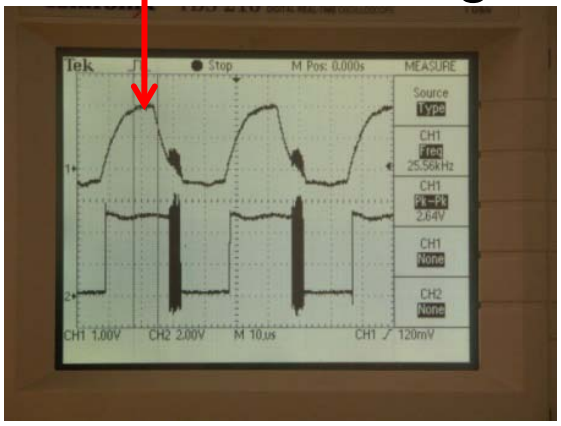
Output signals from the photodetector (top curve) and comparator (bottom curve) for different distances to the target.



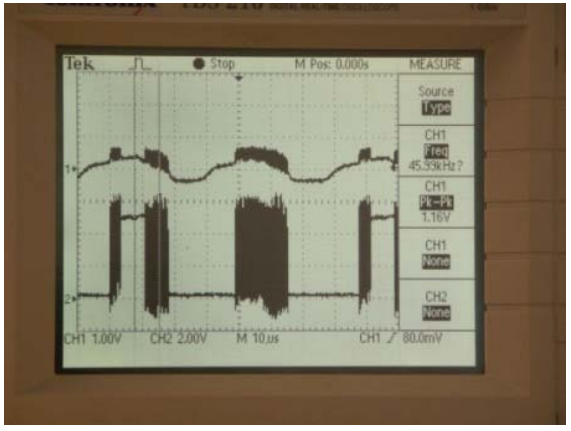
3 in.



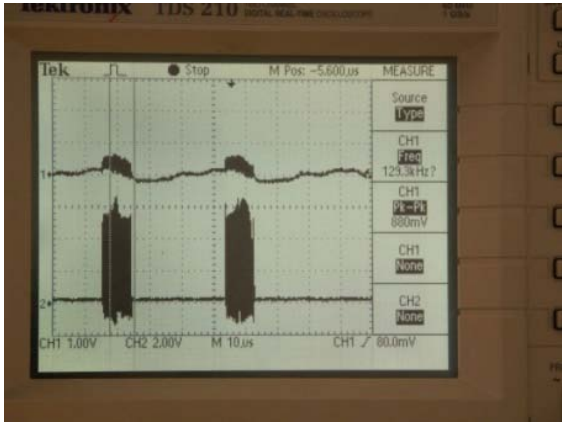
10 in.



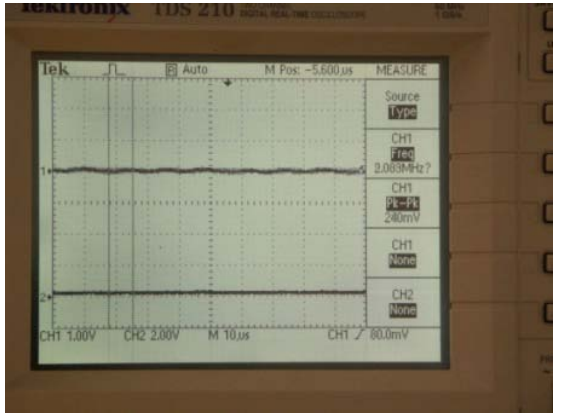
12 in.



36 in.



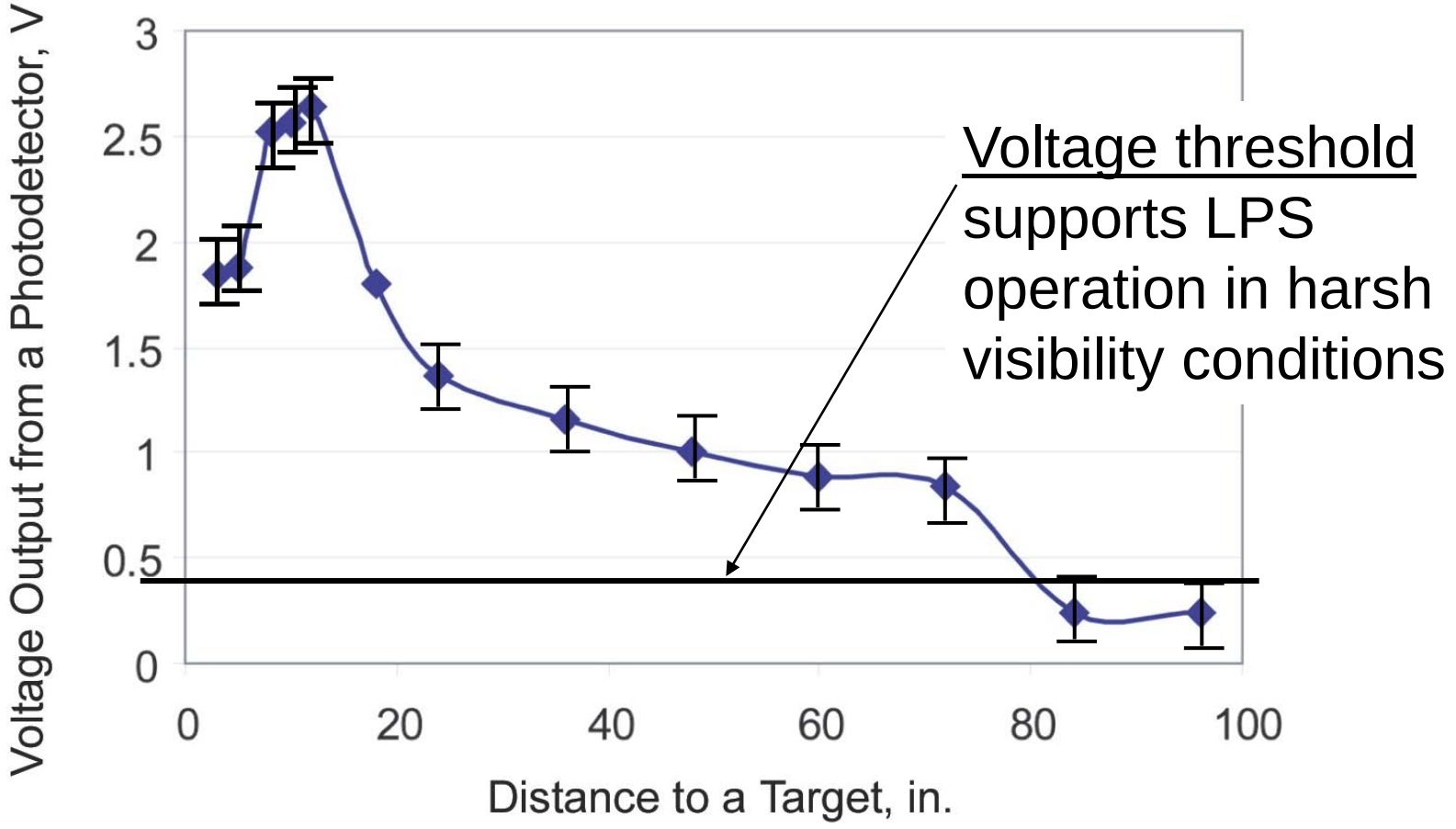
72 in.



No response 96 in.

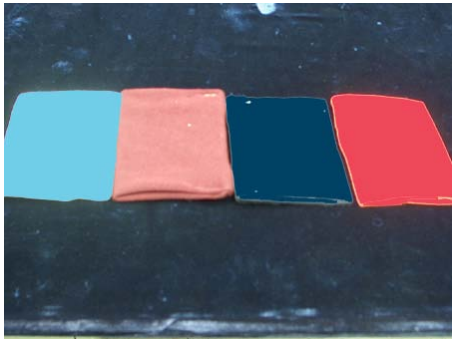
LPS Performance (Cont.)

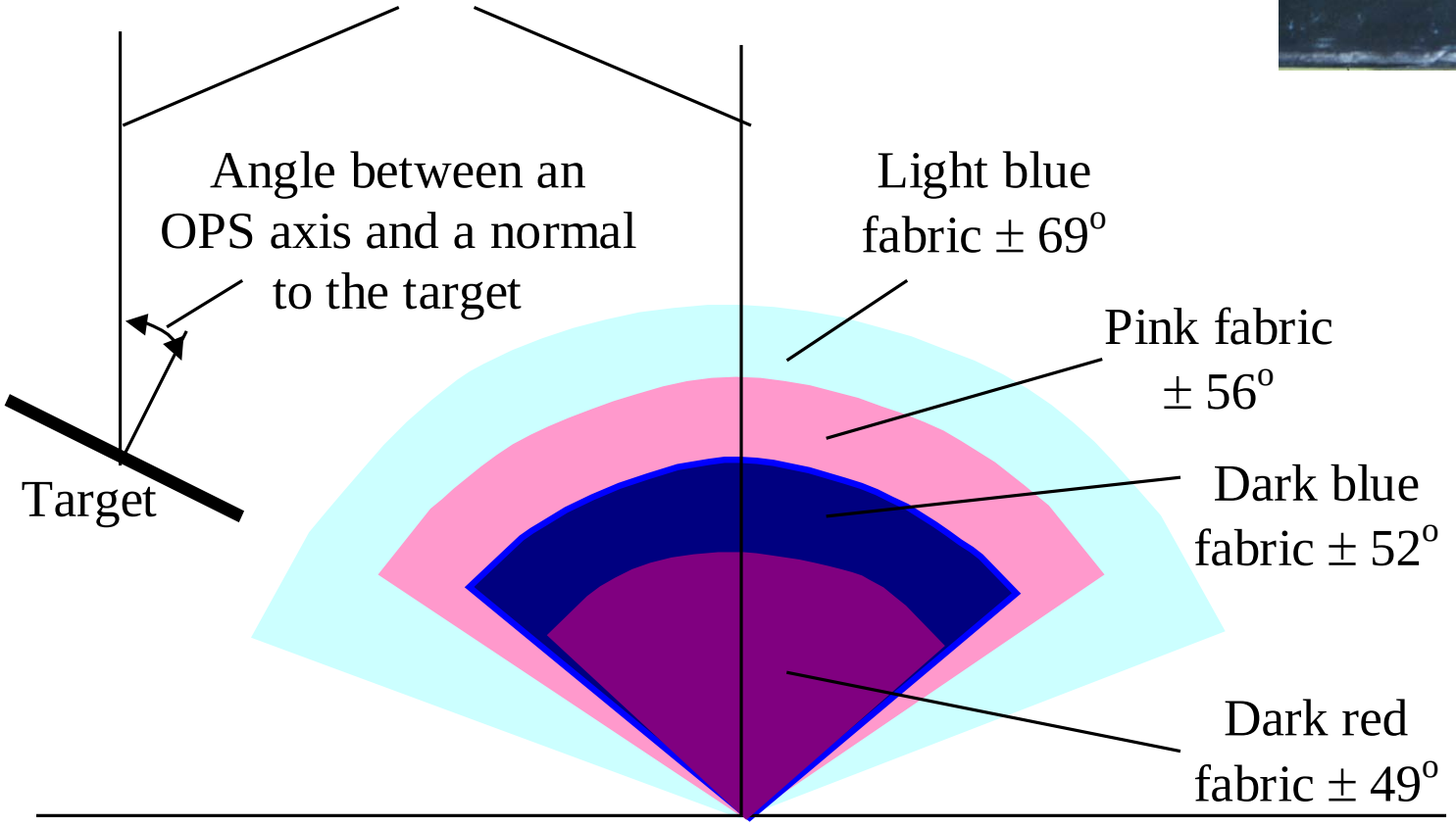
Output signals from the photodetector (top curve) and comparator (bottom curve) for different distances to the target.



LPS Performance

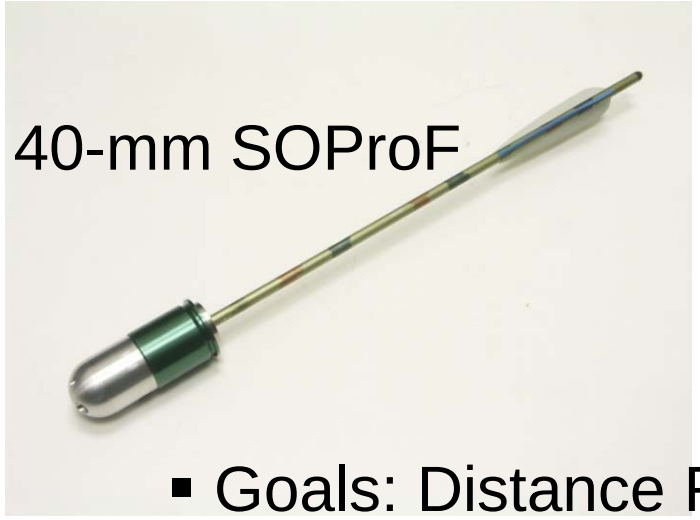
Angular diagrams of target detection at a distance of 3 m for four fabrics differing in color and texture, covering the target surface.

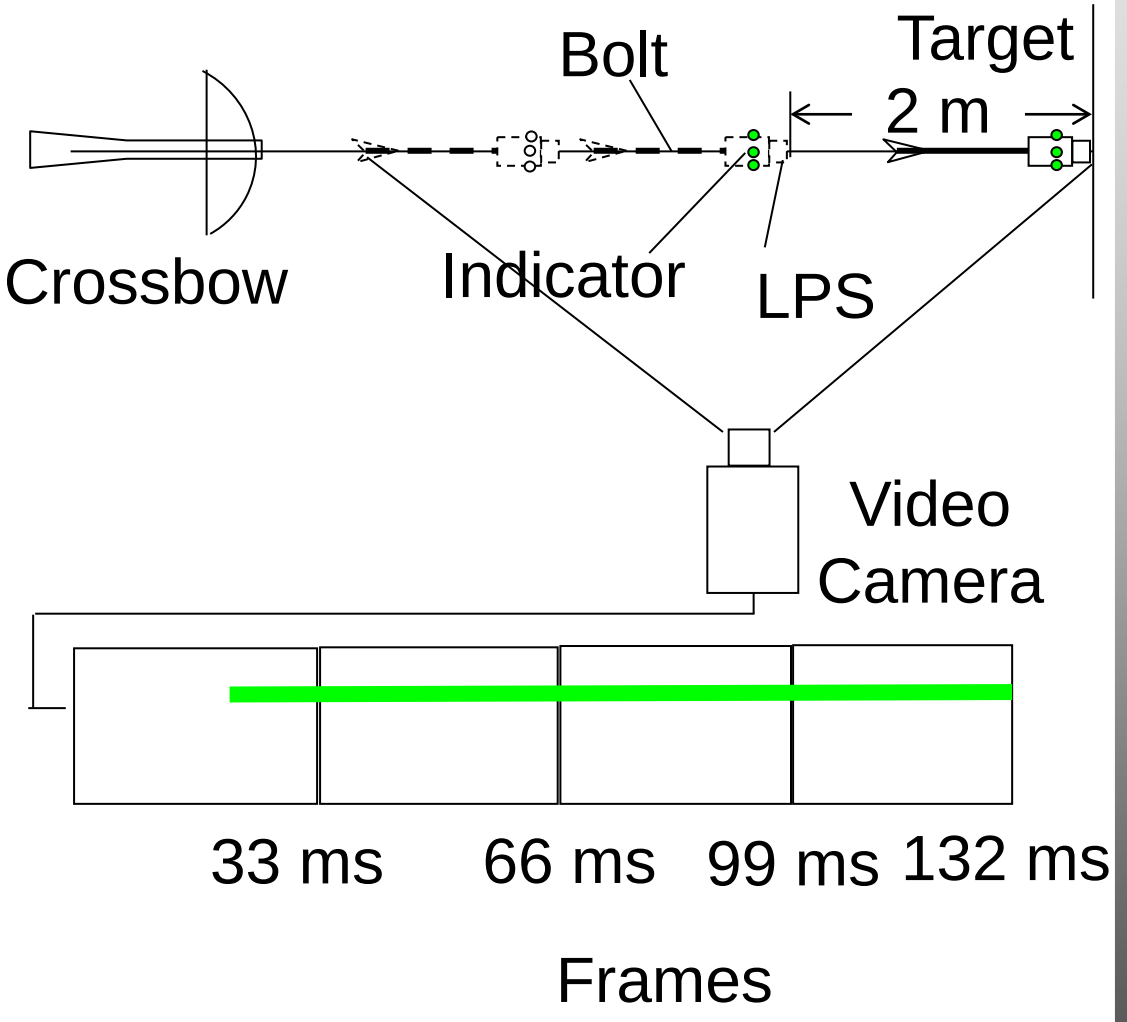




LPS Performance Demonstration

12-Gauge OPS



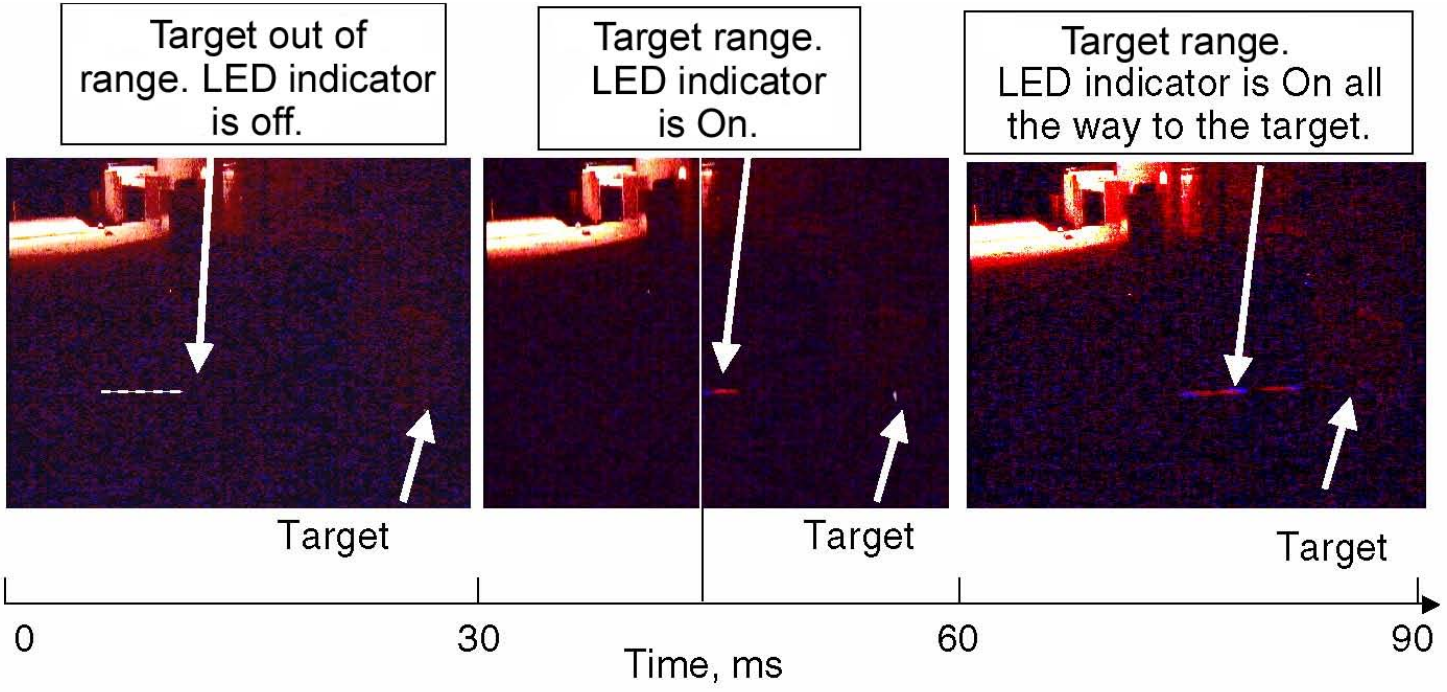


- Goals: Distance Range Verification; Shock Survivability

LPS Performance Demonstration (Cont.)

12-gauge OPS

40-mm SOPrOF



Summary of LPS Performance Demonstration

Parameter	Value
Bolt path during 1 frame	125 cm
Bolt speed with OPS assembly (estimated from light track)	47 m/s
Bolt deceleration while hitting the target (5 cm penetration to full stop)	≈2300 g

Parameter	Value
Bolt speed with M433/SOProF assembly (estimated)	45 m/s
Bolt deceleration while hitting the target (5 cm penetration to full stop)	≈2025 g

Potential LPS Applications