

# Plastic Deformation of Steel Plates Under High Velocity Impact

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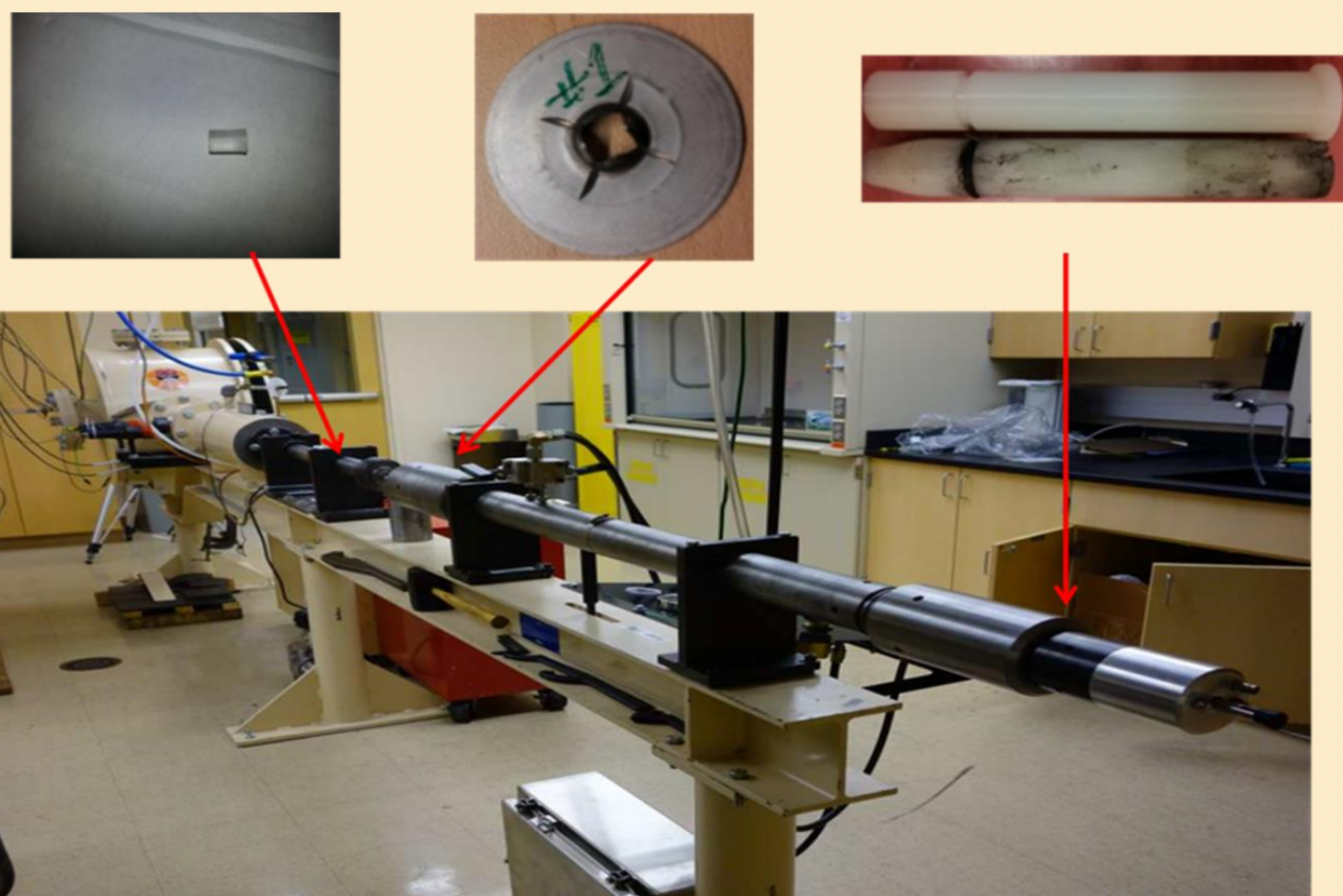
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## Objective

- ❖ Measure material deformation under high velocity impact.
- ❖ Explore the capabilities of the newly developed Multiplexed Photonic Doppler Velocimetry (MPDV) system.
- ❖ Study factors that affect the accuracy of computational techniques to simulate high velocity impact.

## Two-Stage Light Gas Gun

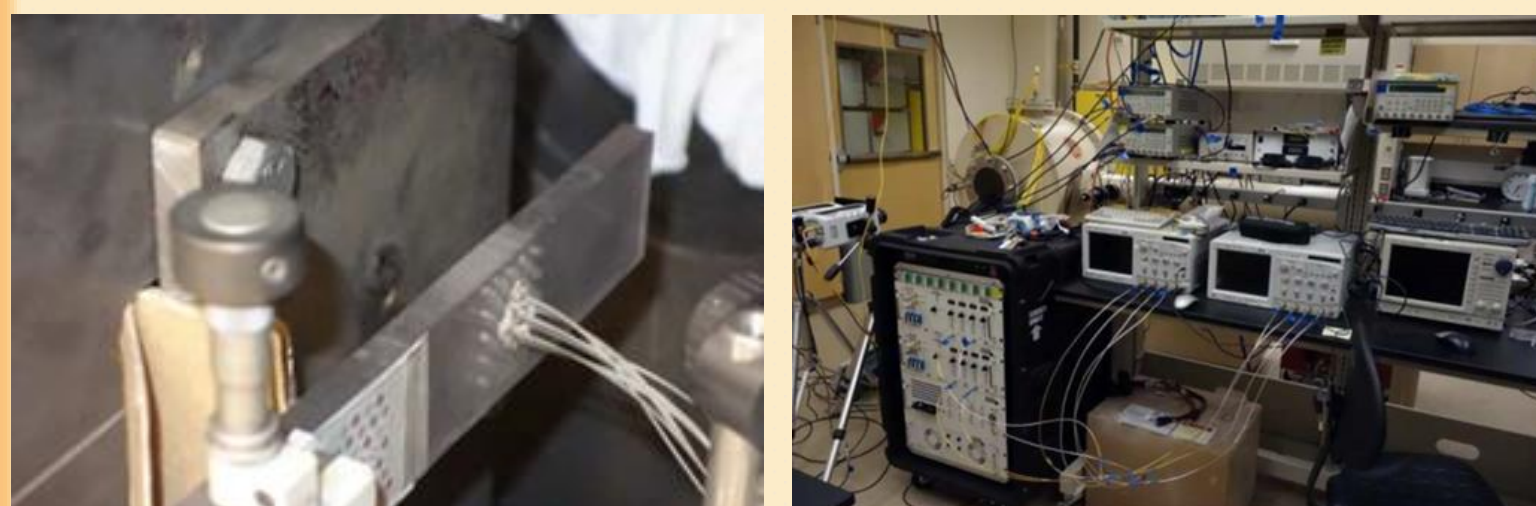
- ❖ A two-stage light gas gun is used to launch cylindrical projectiles into target plates at velocities ranging between 4.5-6 km/s.
- ❖ The gun uses either Hydrogen or Helium.
- ❖ Projectile: **Lexan (5.6 mm diameter)**
- ❖ Target: **A36 steel (12.7 mm thickness)**
- ❖ The target is bolted on a mounting plate.



Gas gun experimental setup

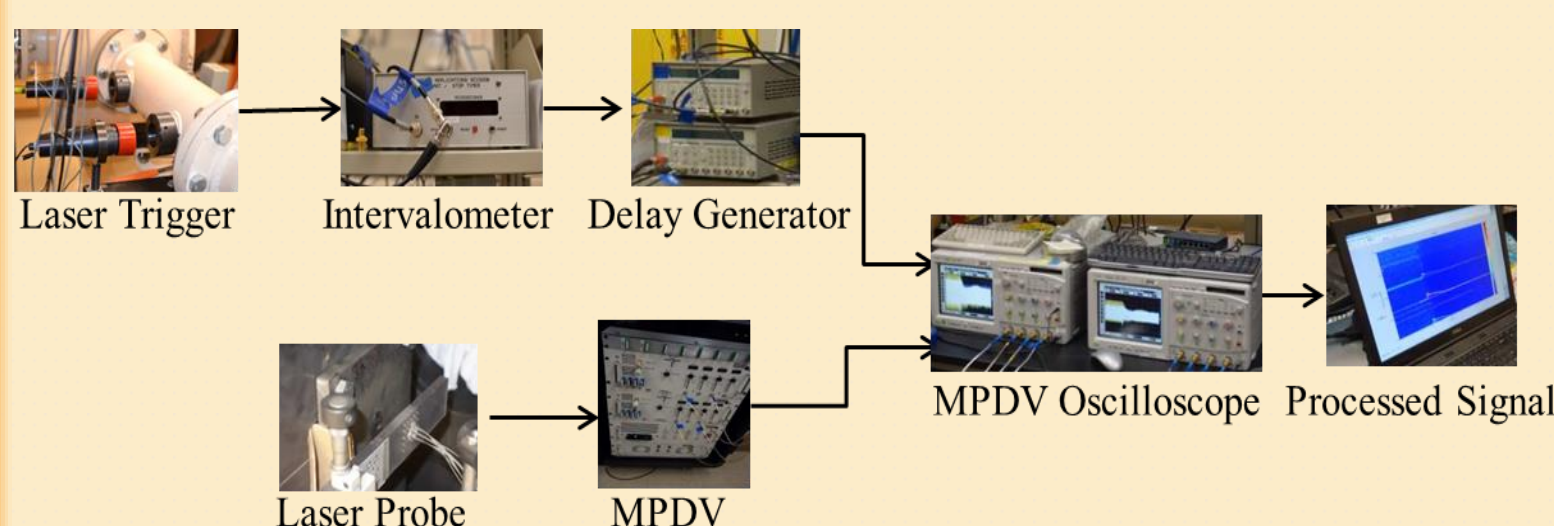
## Data Acquisition Setup

- ❖ Laser intervalometer system is used to measure projectile velocity.
- ❖ A 9-probe MPDV system is used to measure velocity at the back surface of the target plate.



9-probe MPDV holder

MPDV hardware



Data acquisition overview

## Experimental Results

- ❖ High velocity impact typically creates a small crater in the front of plate and a bulge on the back surface.



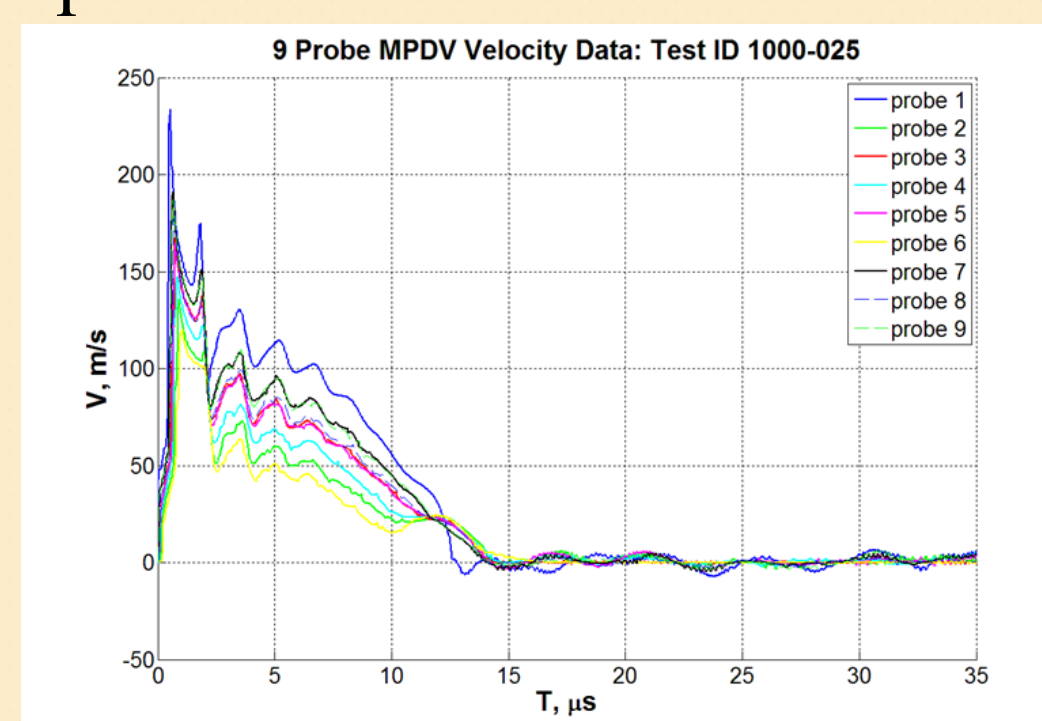
Typical target plate after experiment

- ❖ Spalling is observed in the target plate.



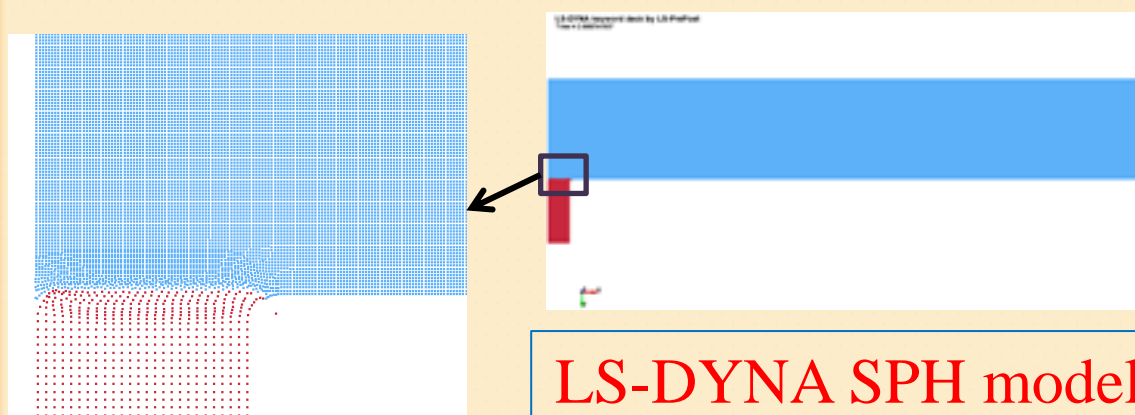
Spalling of target plate (sectioned)

- ❖ The 9-probe MPDV collects free surface velocity at a set of points.



## Numerical Simulation

- ❖ Two different simulation methods are used:
  - Smooth Particle Hydrodynamics (SPH) in LS-DYNA
  - Hydrocode in CTH
- ❖ 2D axisymmetric model
- ❖ Johnson-Cook material model
- ❖ Grüneisen equation of state (EOS)
- ❖ Spall is defined by a pressure cut-off ( $P_{min}$ ) value.
- ❖ SPH particles have equal mass.



LS-DYNA SPH model

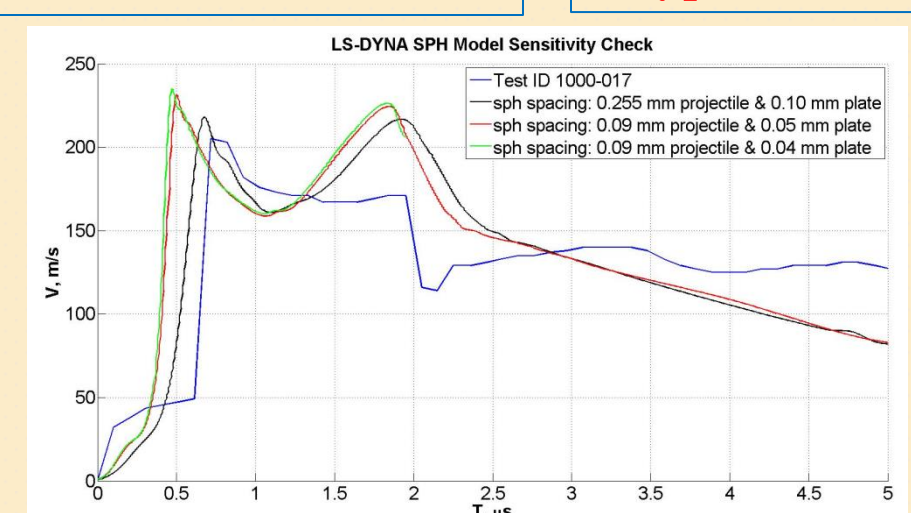
CTH model

## Simulation Comparison



Typical LS-DYNA simulation

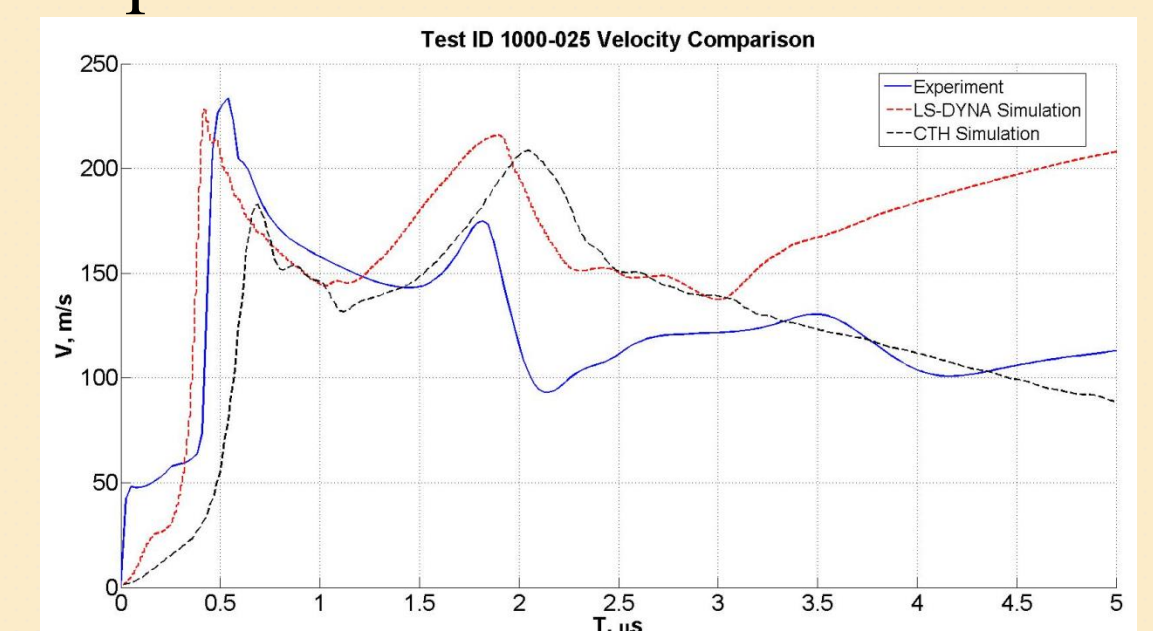
Typical CTH simulation



- ❖ From above study, SPH particle spacing 0.05 mm is selected for plate for better HEL representation.

- ❖ CTH zone size is 0.30 mm x 0.30 mm

- ❖ Comparison



Average percentage difference in experiments (7) and LS-DYNA simulations (7)

Crater Diameter	3.48
Penetration	9.27
Bulge	15.81

## Conclusion

- ❖ Two-stage light gas gun has been used successfully in high velocity plastic deformation experiment.
- ❖ Free surface velocity have been measured using 9-probe MPDV system.
- ❖ Both LS-Dyna and CTH can capture the impact phenomenon reasonably.
- ❖ Further refinement of simulation models are still in progress.
- ❖ High-speed imaging can contribute to understanding the impact phenomena more precisely.

## Acknowledgement

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