Off Axis Warhead Detonation

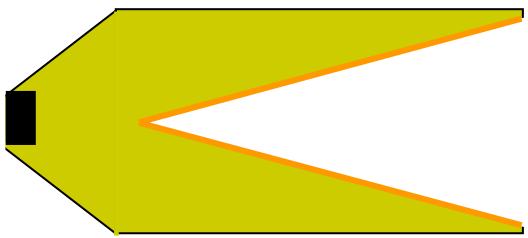
By
CDT Colin Scott, Class of 2006
In association with
Army Research Lab, Weapons Materials Research Directorate, Terminal Effects Division, Lethal Mechanisms Branch, Warhead Technology Team
Project Engineer:
Jim Barb

Agenda

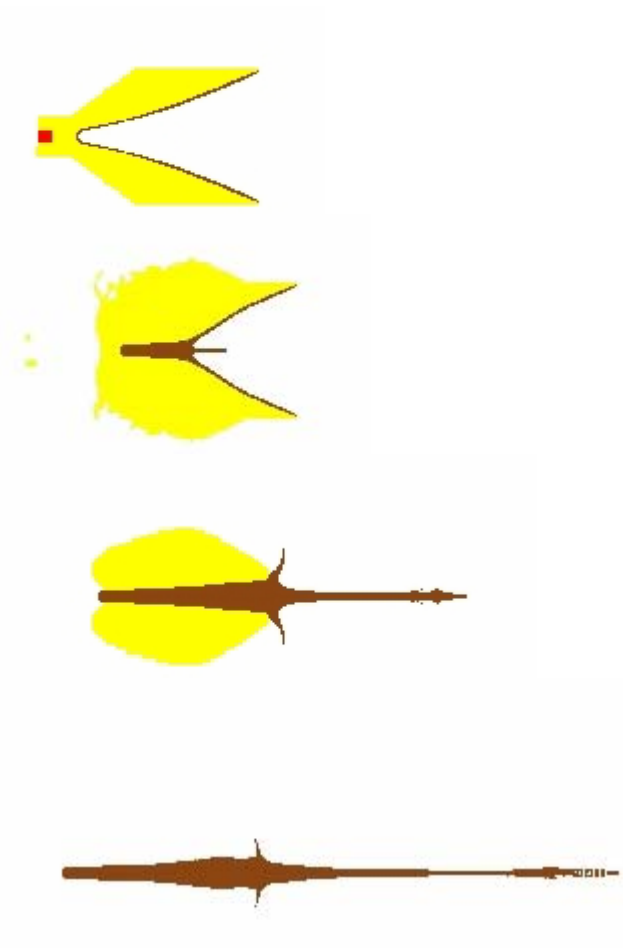
- Shaped Charge Warheads
  - What is a shaped charge
  - Normal shaped charge operation
- Experimental Purpose
- Experimental Setup
- Results
  - Witness plates
  - Data gathering
  - Data reduction
  - Final results
- Conclusions

Shaped Charge Warheads

- High explosive behind a metal, usually copper, liner
  - Explosive collapses the liner forming a jet
- Extremely high velocity of jet causes armor penetration
  - Penetration is a function of velocity, standoff, and density



Normal Shaped Charge Jet Formation



Time

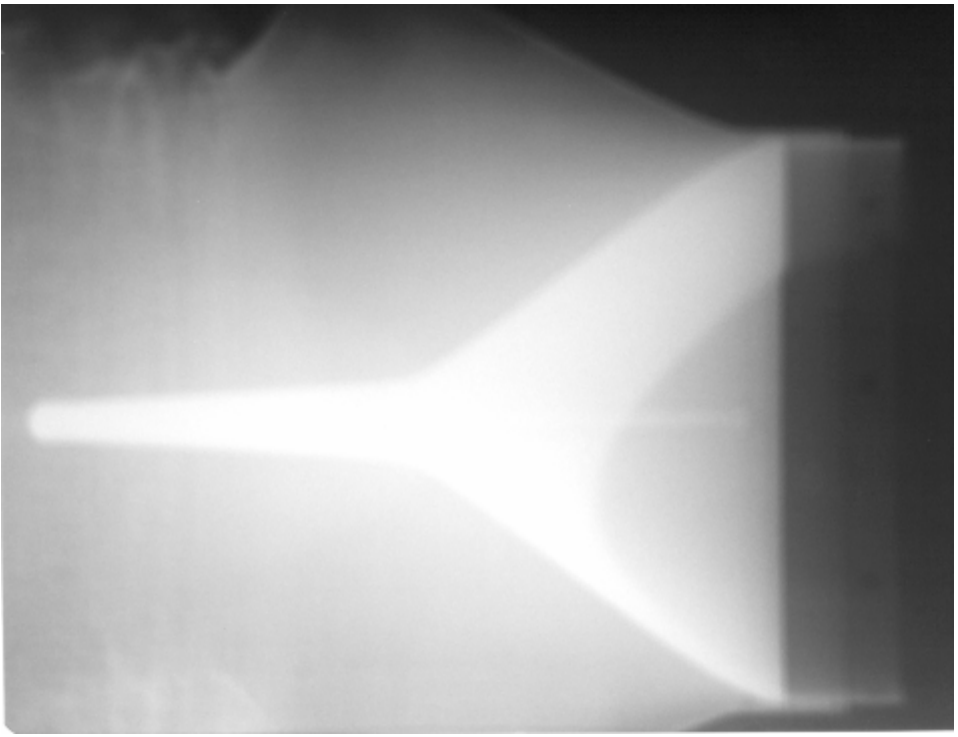
0 μsec

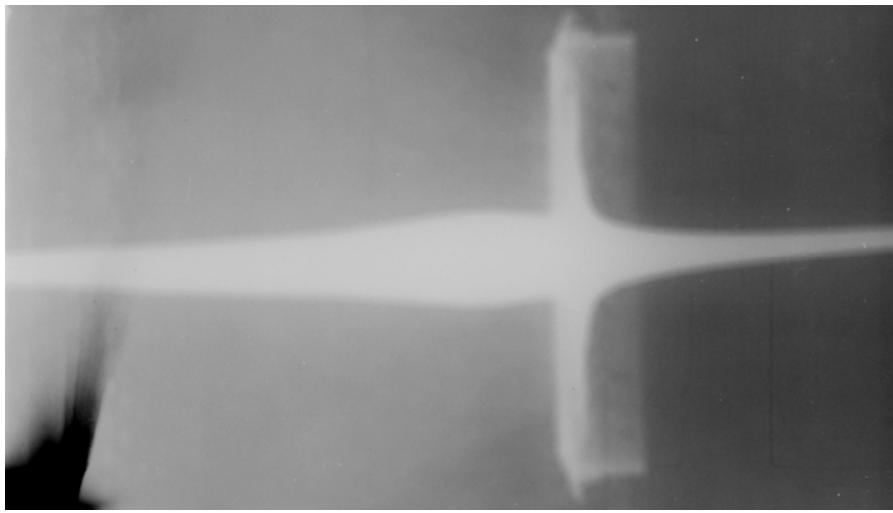
20 μsec

50 μsec

70 μsec

Normal Shaped Charge Operation

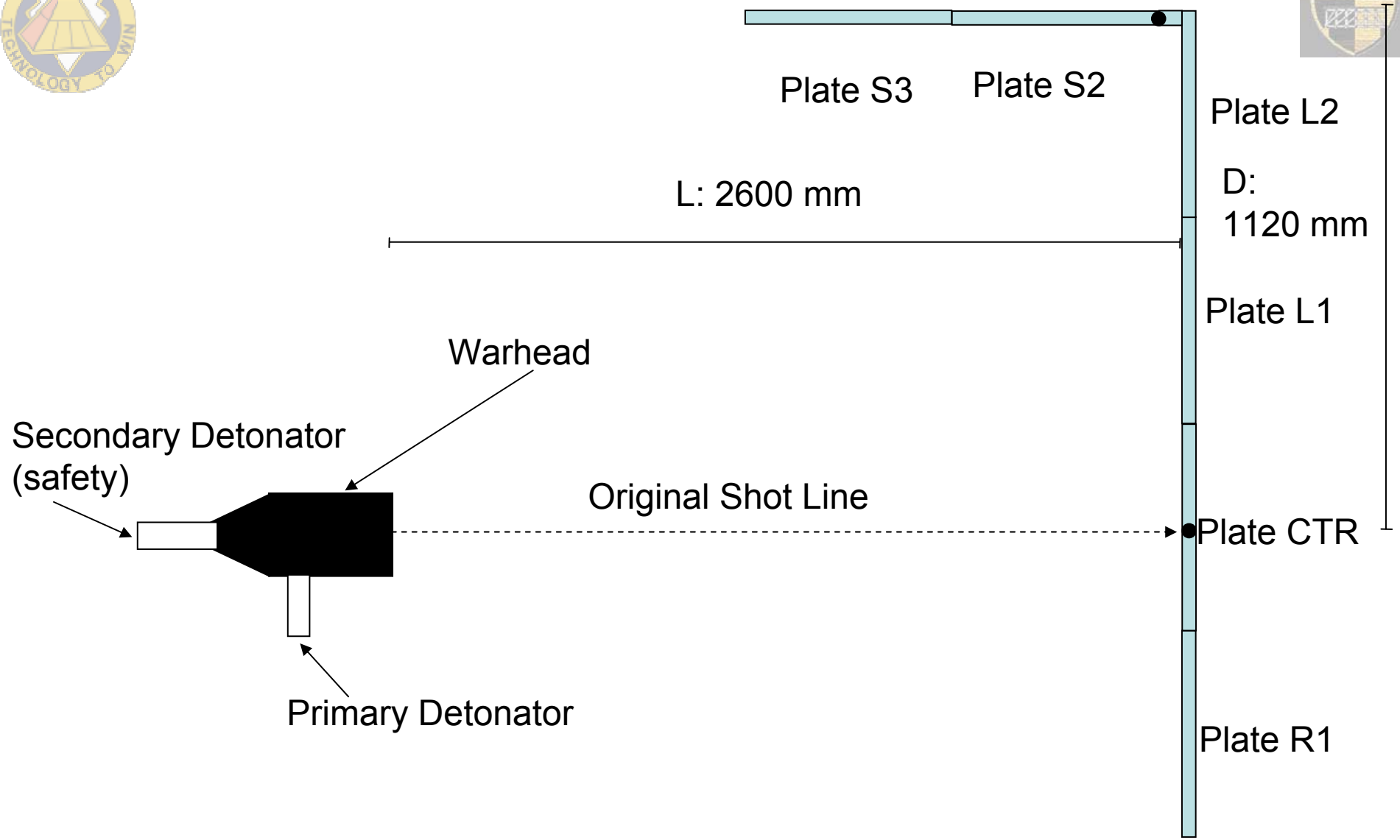




Experimental Purpose

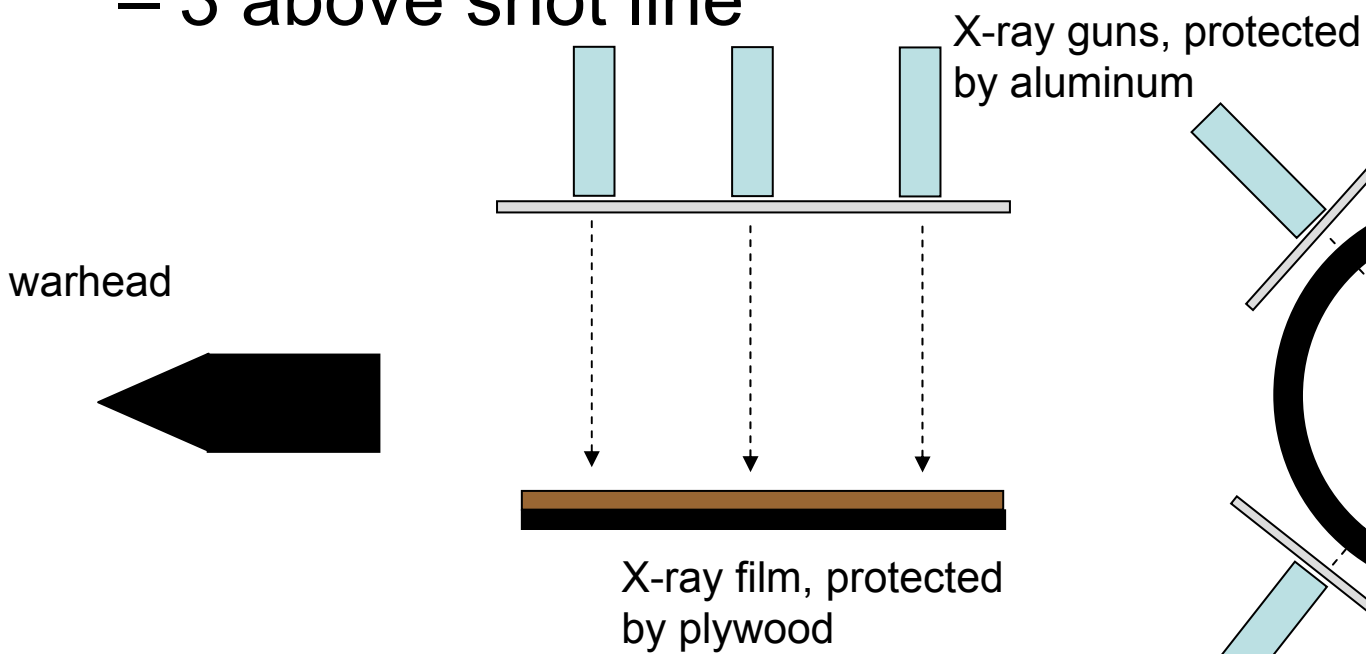
- The purpose of the experiment was to determine the effects of an off axis initiation of the warhead shaped charge.

Experimental Setup

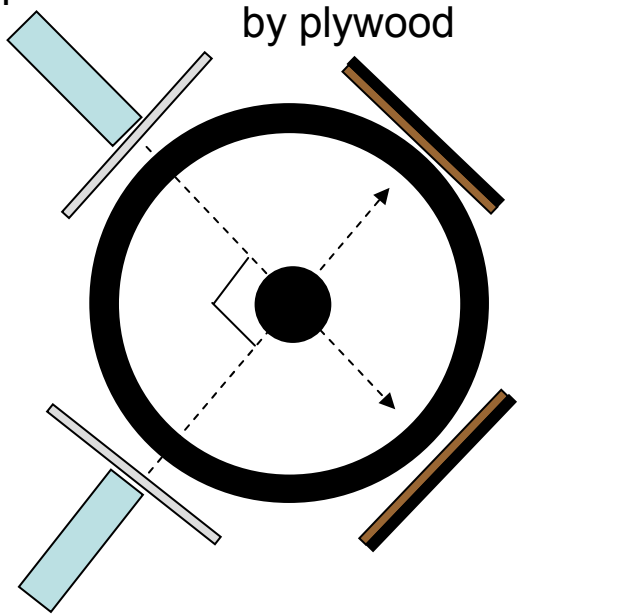


Experimental Setup, Instrumentation

- 5 X-ray tubes
  - Two in barbette
  - 3 above shot line

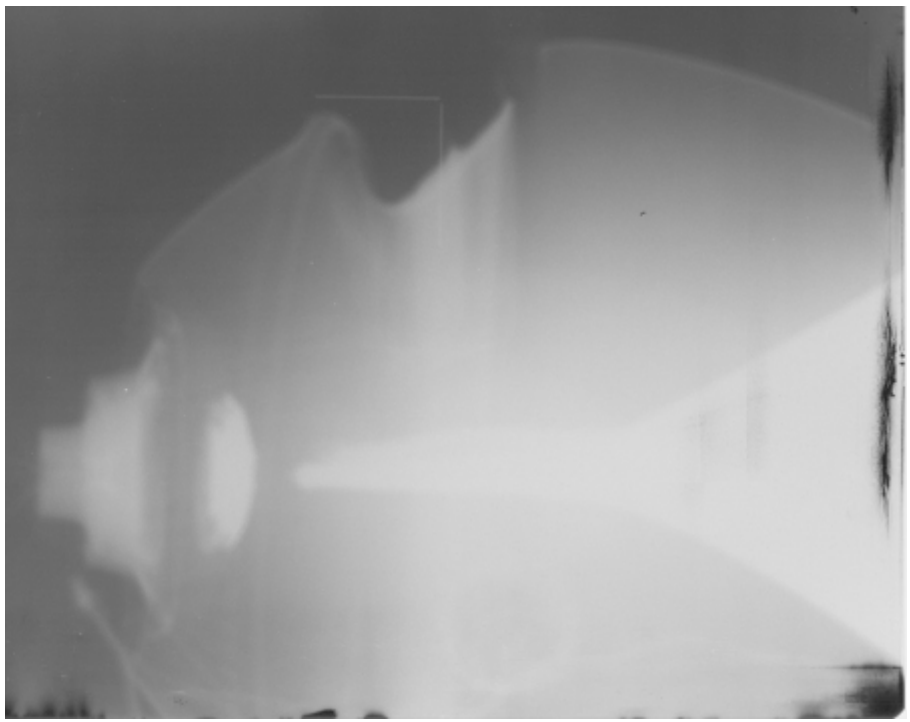


Side view without barbette

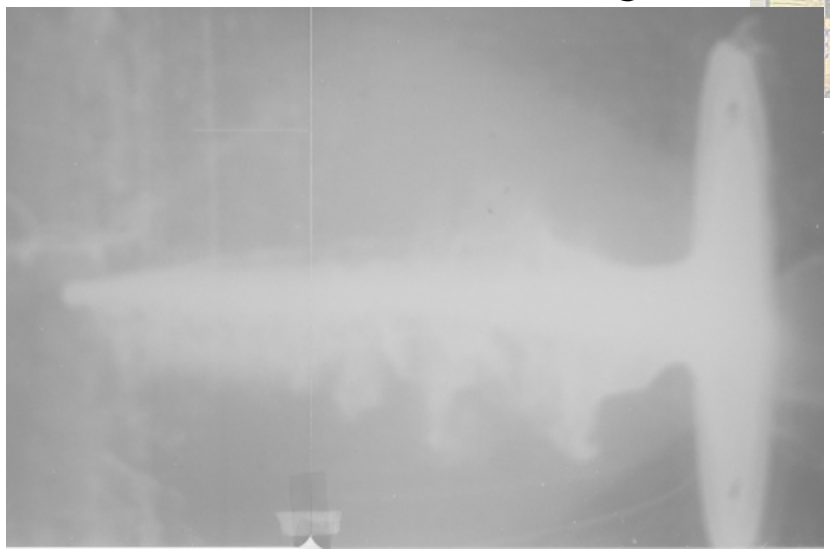


Front view of barbette

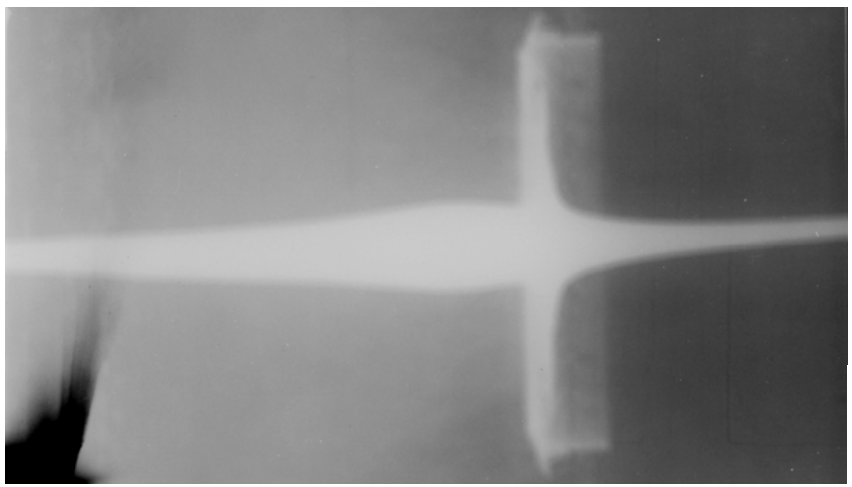
Experimental Barbette X-Rays



30.7 μsec

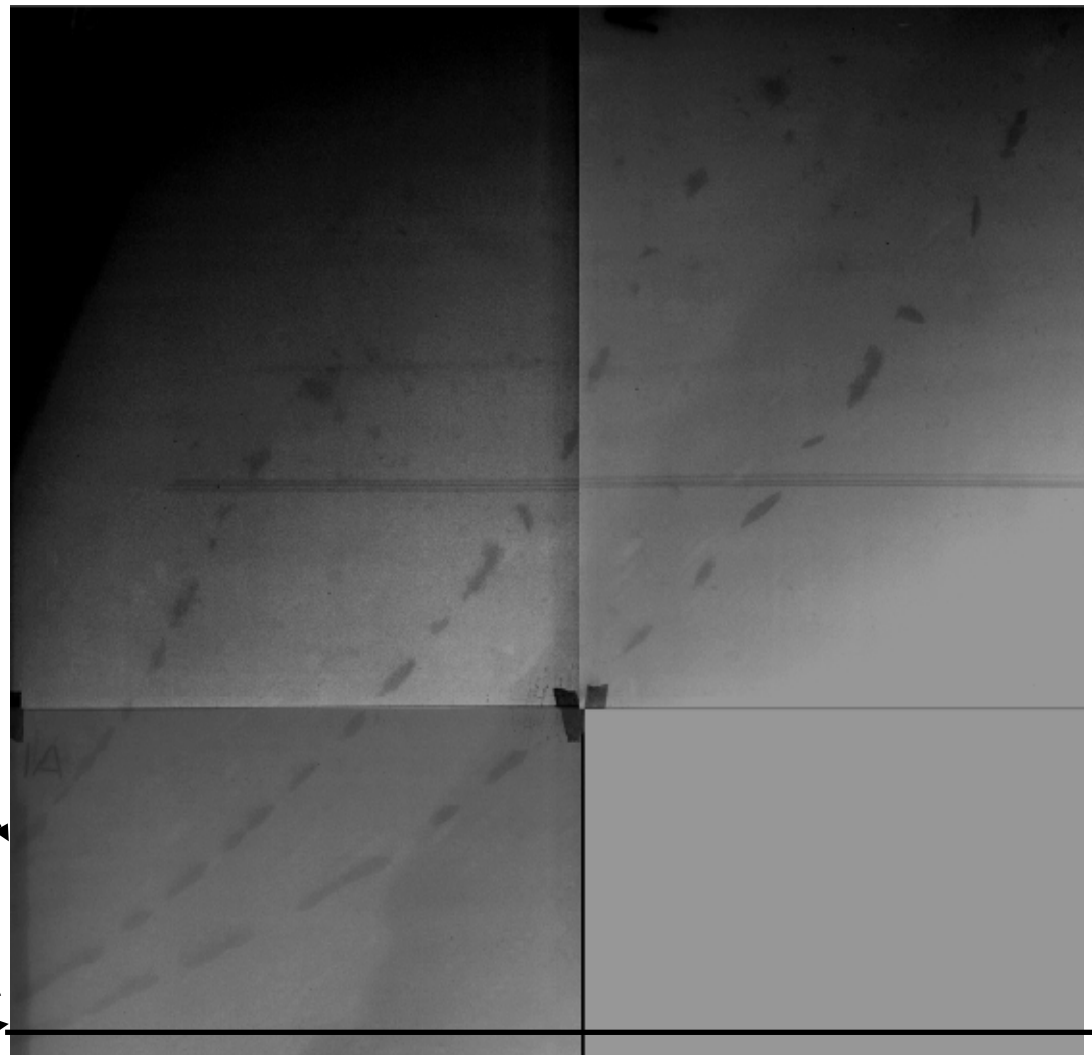


Experimental shot 55.5 μsec



Comparison shot

Experimental Jet X-Rays



275.8 μsec

350.8 μsec

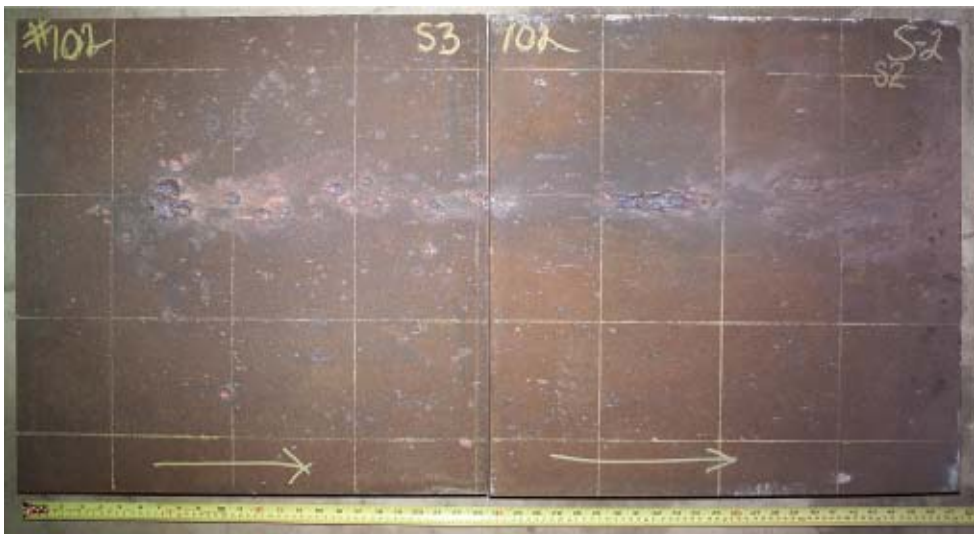
425.9 μsec

Original shot line

Witness Plates

Front Plates

Side Plates



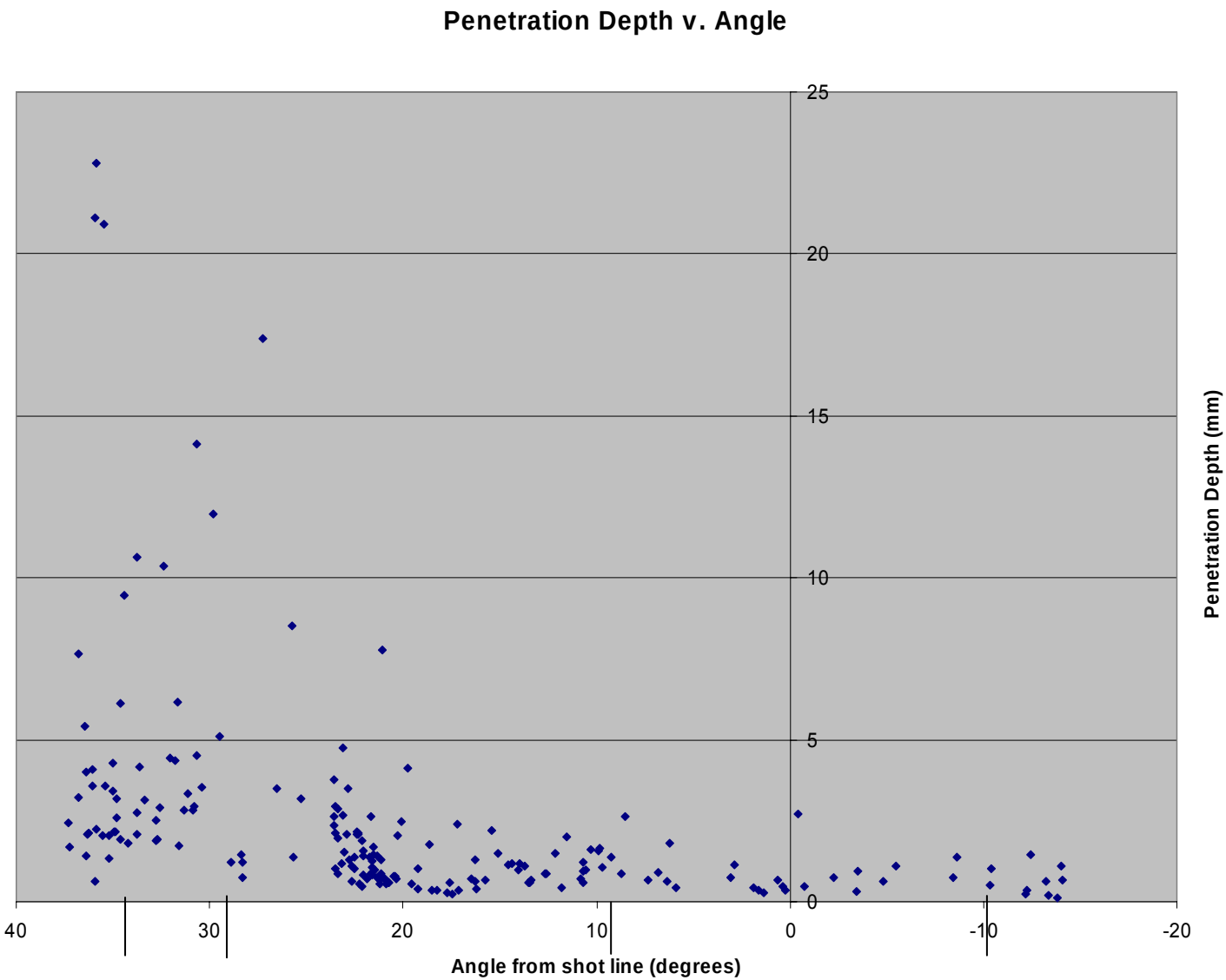
Data Gathering

- Depth of penetration measured for each impact
  - Measured individually using calipers
- Image scanned into computer
  - Using Image-Pro Plus each impact site becomes a shape
  - Area, X-coordinate, Y-coordinate, box length, and box height outputted to Excel

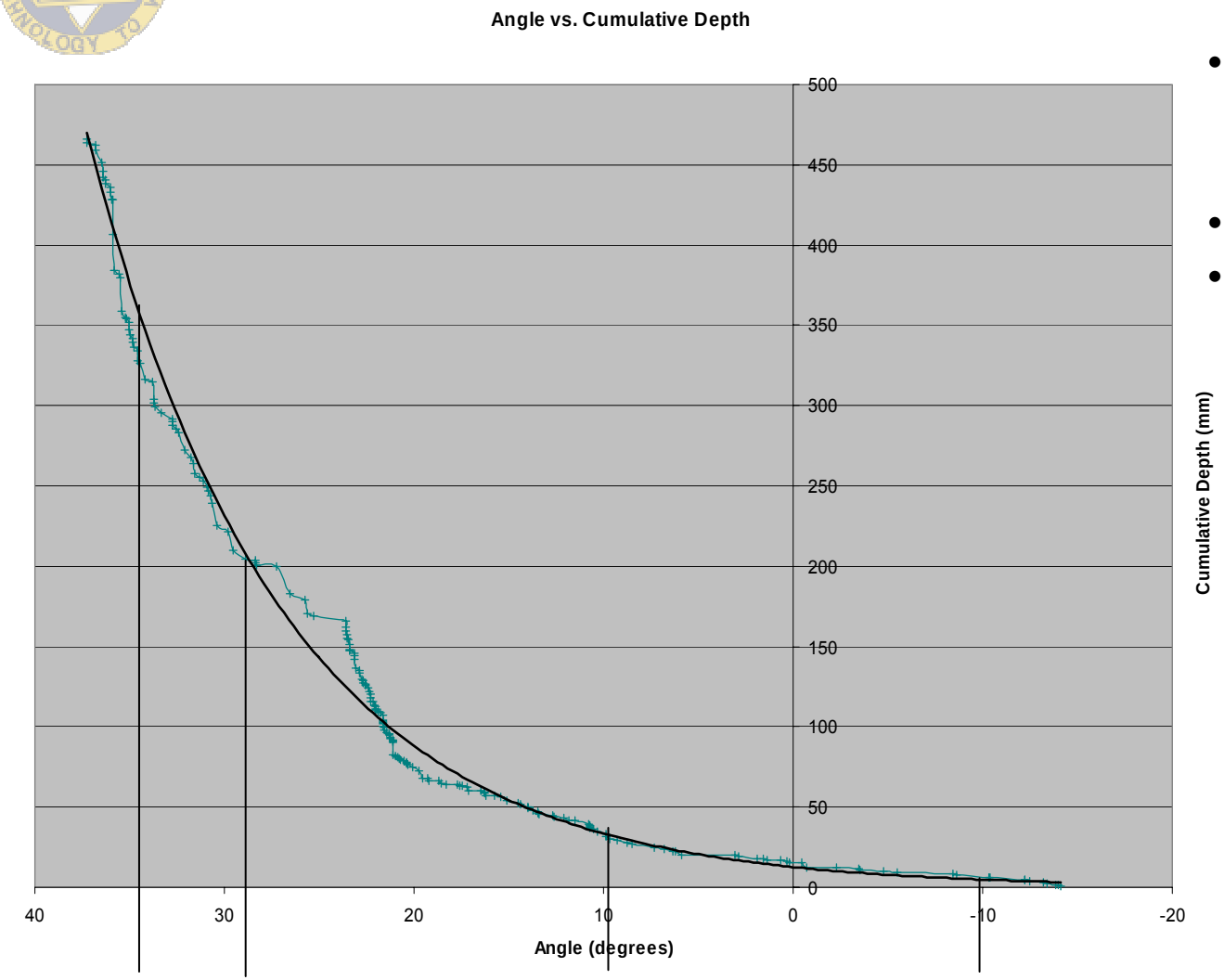
Data Reduction

- Angle conversion
  - For front plates: $\theta = \tan^{-1} \frac{X - coordinate}{L}$
  - For side plates: $\theta = \frac{\pi}{2} - \tan^{-1} \frac{L - (X - coordinate)}{D}$
- Depth correction for normal depth
  - For front plates: $D = \frac{d}{\cos\theta}$
  - For side plates: $D = \frac{d}{\sin\theta}$
- Cumulative depth
  - Use cumulative depth to get a better picture of the pattern
  - Cumulative function is similar to an integral

Data Plot


Penetration Depth v. Angle
25
20
15
10
5
0
40
30
20
10
0
-10
-20
Angle from shot line (degrees)
Penetration Depth (mm)

Preliminary Results



- Cumulative function:
  - $D=12.703e^{0.0968(\theta)}$
  - R^2 value: .9803
- Standard function:
- $D=1.22956e^{0.0968(\theta)}$

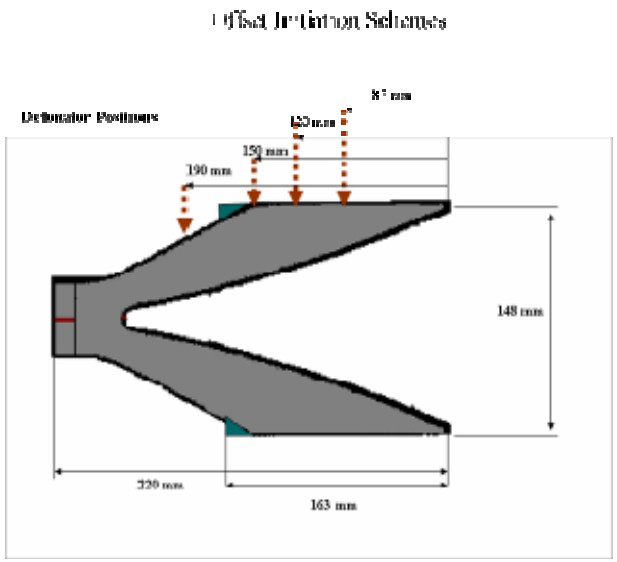
Conclusions

- The warhead did not strike along its intended shot line with any significant impacts
- Maximum penetrations observed were significantly less than the warhead capability
- Therefore the warhead failed to be effective

Planned Testing

Offset Initiation Test Summary

Measurements				Times				
Shot Number	Offset Location	Standoff to Front Witness	Distance from Shot line to Side Witness	Barbette X-ray Tubes		Out side X-rayTubes		
				Tube 1	Tube 2	Tube 3	Tube 4	Tube 5
	(mm)	(mm)	(mm)	(µsec)	(µsec)	(µsec)	(µsec)	(µsec)
98	87	2480	1136	75.6	30.7	125.7	150.6	175.7
99	87	2500	1155	55.6	25.8	220.8	250.7	300.7
101	87	2600	1119	57.2	25.7	220.8	270.6	320.6
102	120	2600	1120	55.5	30.7	221.2	270.7	320.8
103	120	2600	1112	55.8	30.7	175.7	225.7	300.7
104	120	2600	1140	55.6	30.7	100.6	140.6	400.7
105	190	2600	1131	55.4	30.7	250.6	350.6	400.7
106	190	2600	1131	55.5	30.6	250.7	350.8	400.7
107	190	2600	1131	55.5	25.8	250.7	350.7	400.8
108	150	2600	1130	55.6	30.6	250.8	350.6	425.7
109	150	2600	1121	55.5	30.7	275.8	350.8	425.9
110	150	2600	1132	55.5	30.7	275.7	350.7	425.7



Questions?