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Electronic VS Pyrotechnic Initiation Timing Comparisons

SB Tavelli



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Electronic VS Pyrotechnic Timing Effects Comparison

- The following presentation is a companion to the DVD providing specific examples of Electronic and Pyrotechnic delay timing.
- The high speed examples reveal the true nature of the effect of timing scatter normally associated with chemical (pyrotechnic) delay trains
- Removal of the timing scatter and millisecond accuracy enables the quarry operator to improve control of:
 - ✓ Vibration – Via the ability to tailor blast timing to obtain phase control over dominant frequencies.
 - ✓ Fragmentation – Given the improved hole to hole interactions, an operator often can expand patterns while improving fragmentation.
 - ✓ Reduced Crushing costs – Improved fragmentation at the bench level leads to reduction in primary crusher expense and improved throughput.

500MS Pyrotechnic Timing

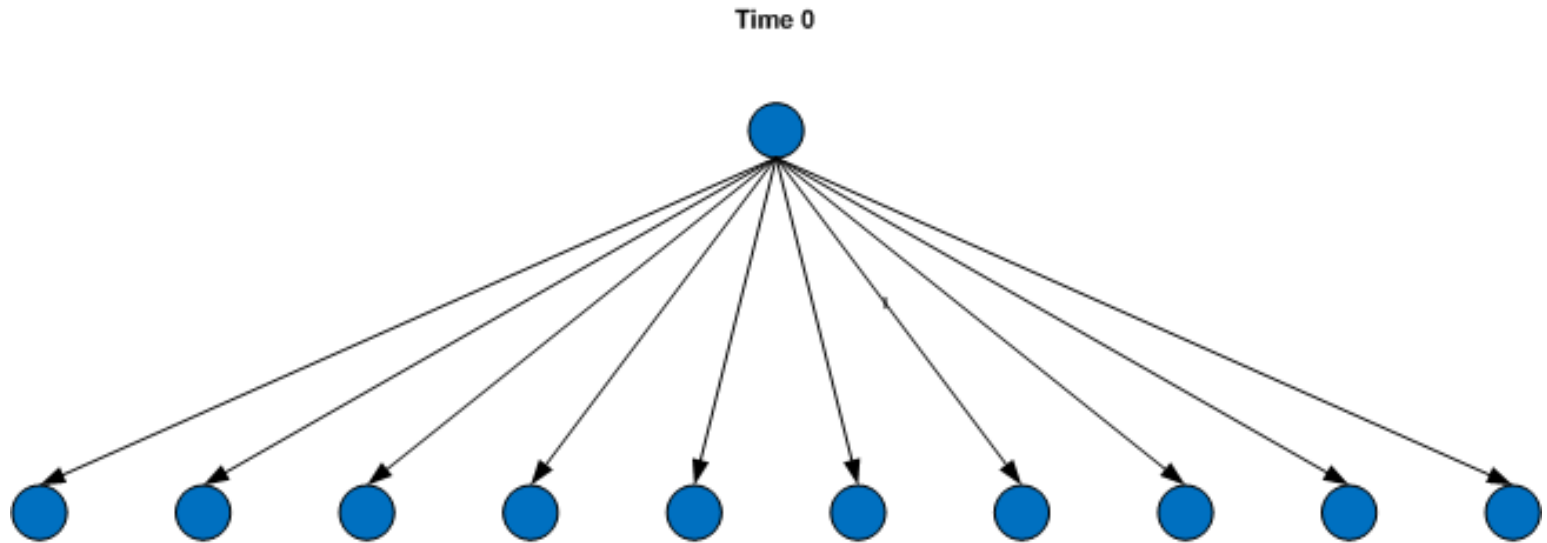


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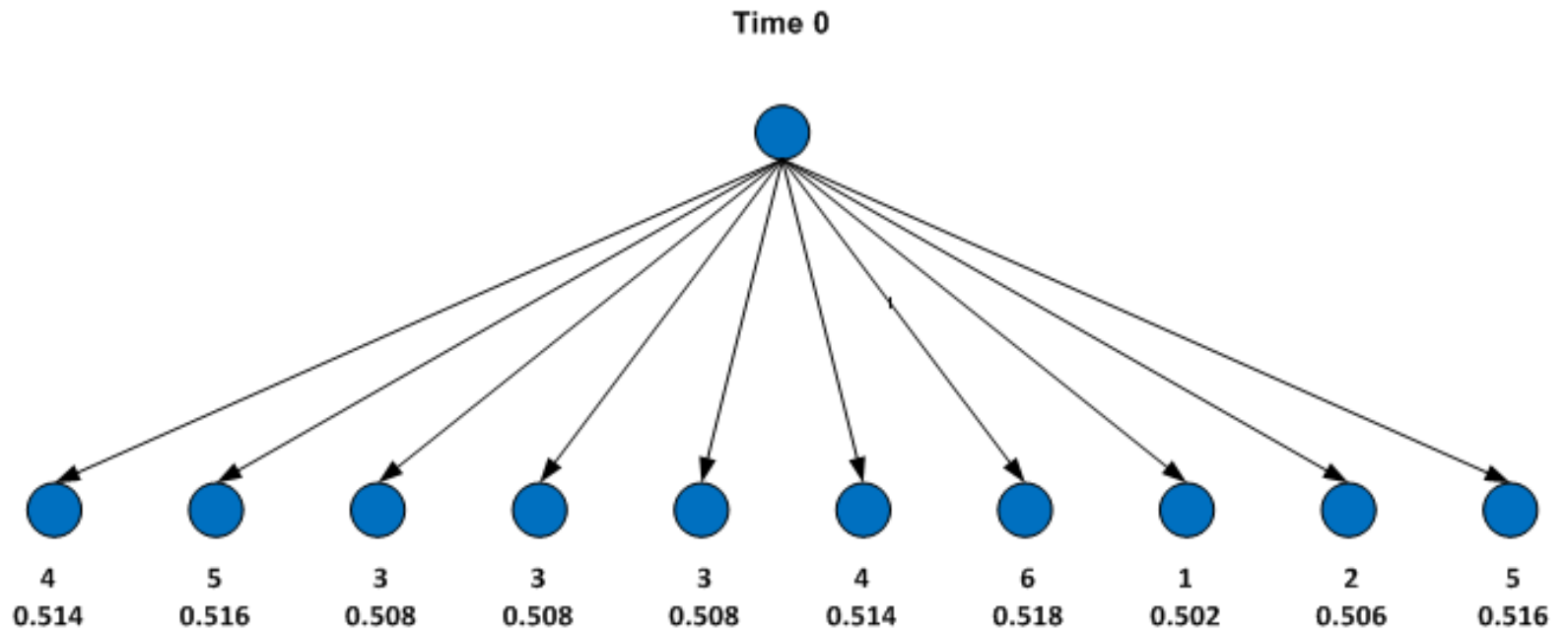
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500MS Pyrotechnic Example



Designed Firing Time 500MS

500MS Pyrotechnic Example



Actual Firing Order / Times

1000MS Pyrotechnic Timing



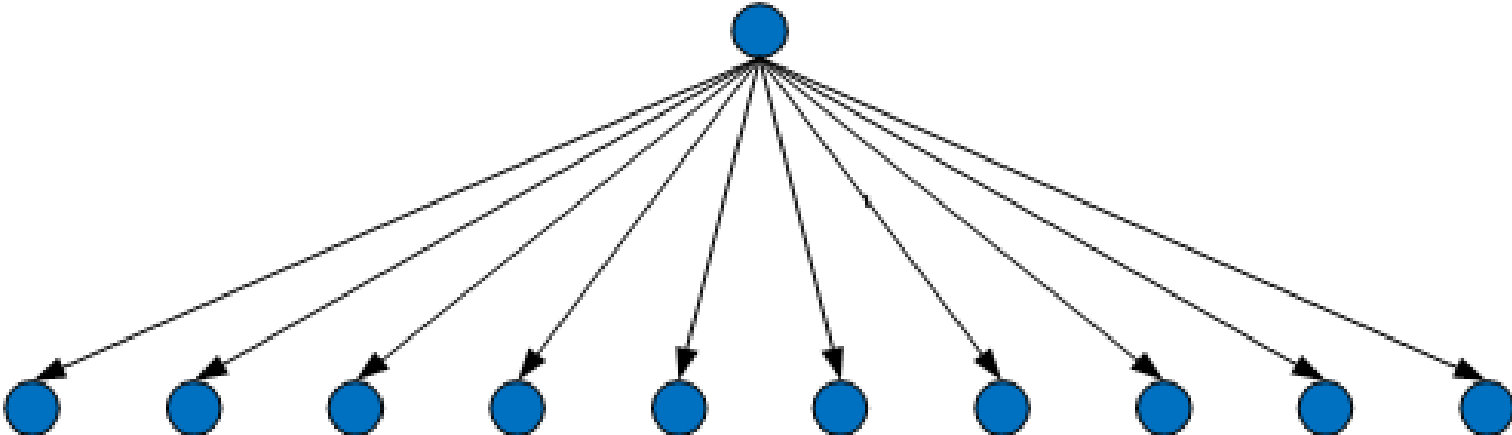
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**1000MS Pyrotechnic
Example**

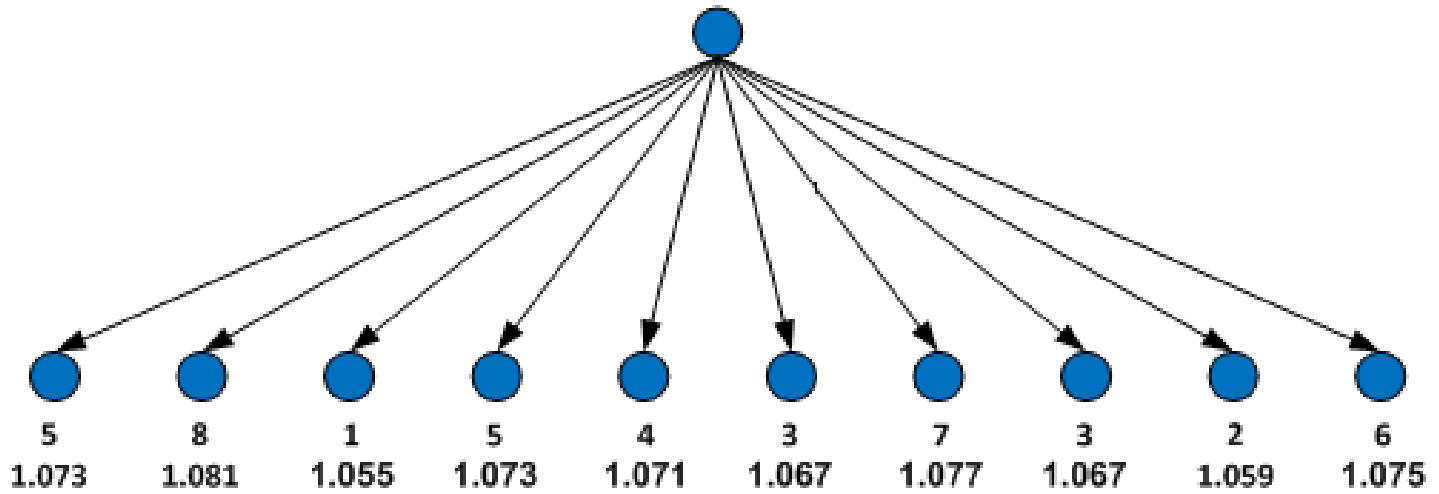
Time 0



Designed Firing Times 1000MS

1000MS Pyrotechnic Example

Time 0



Actual Firing Order / Times

1000MS Electronic Timing



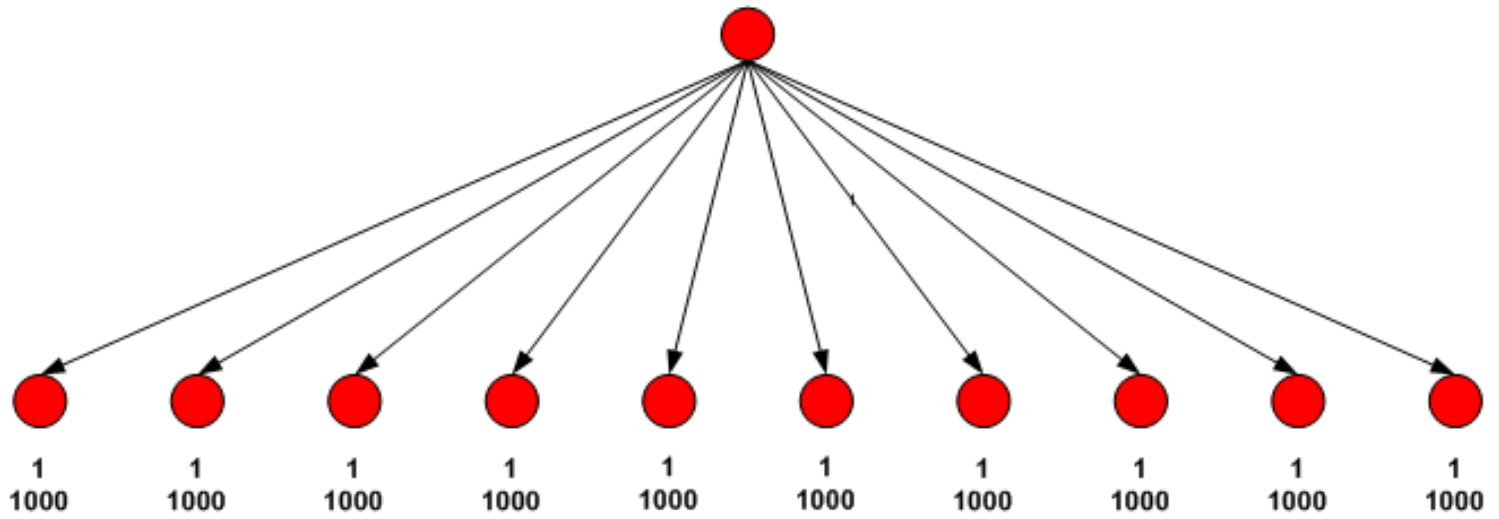
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Electronic Detonators Pgm Time
1000MS

Time 0



Actual Firing Order / Times

Powder River Basin

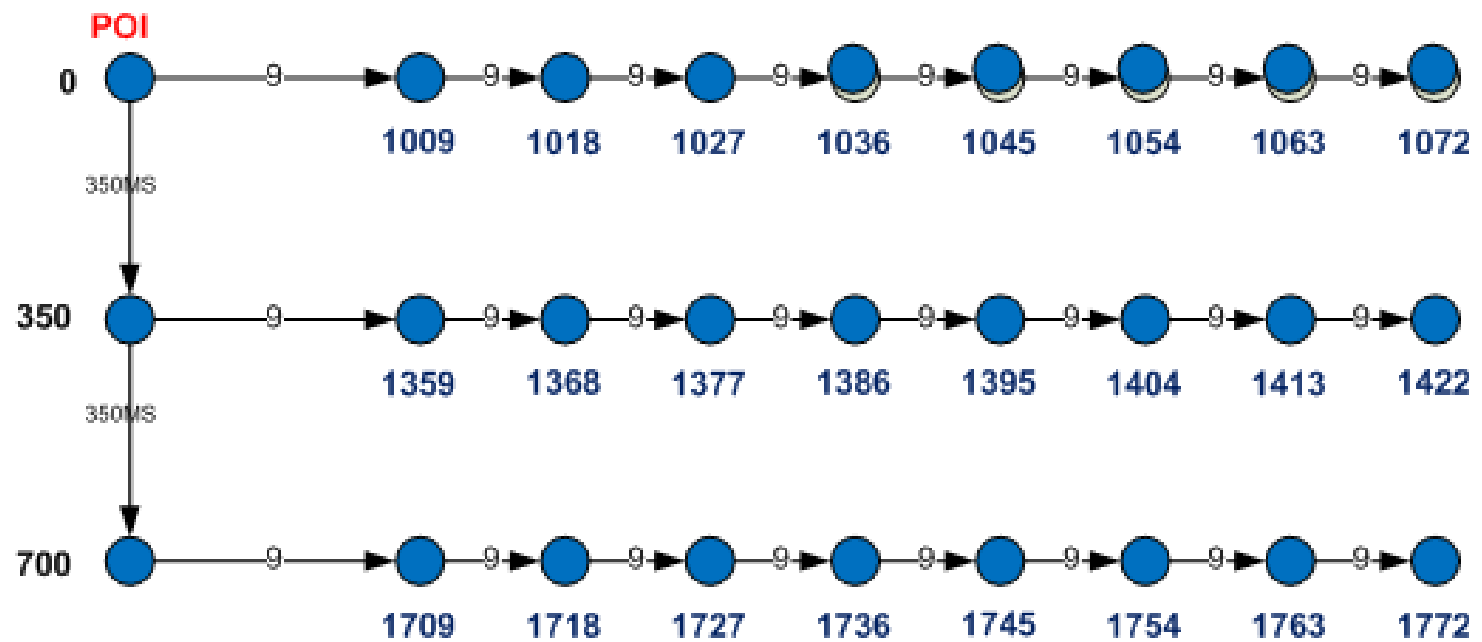


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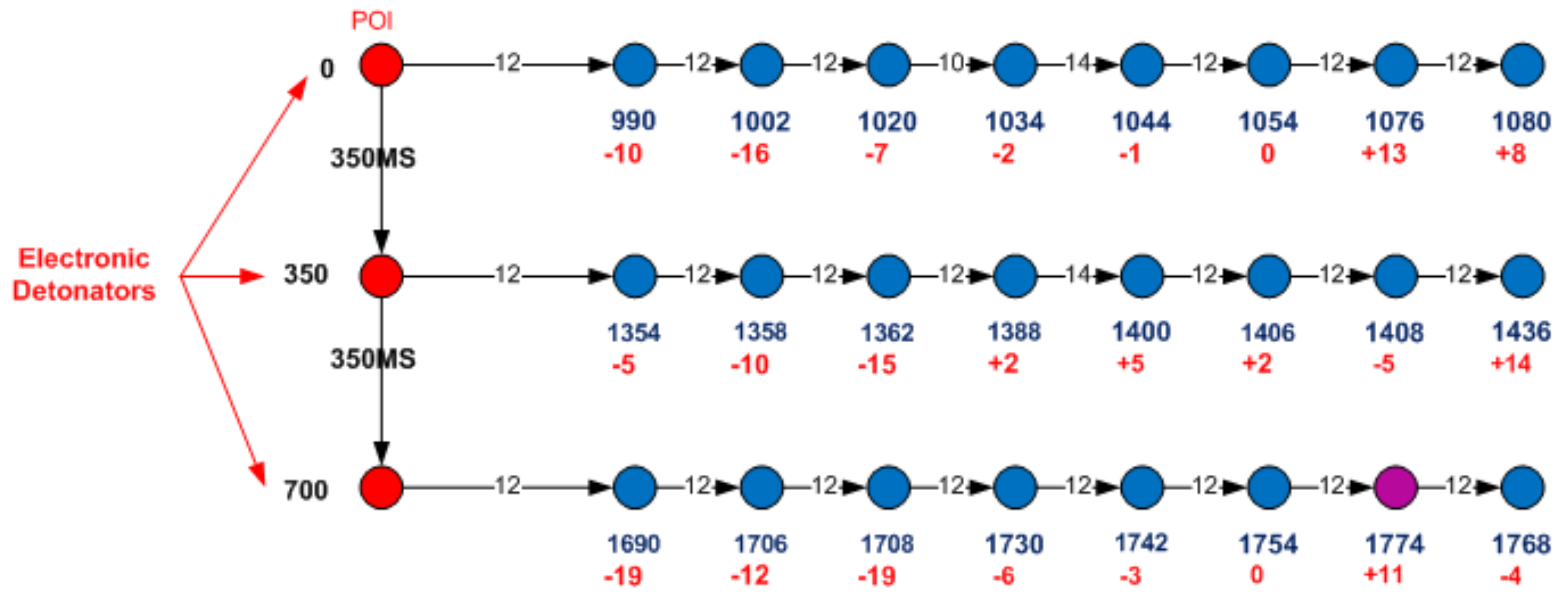
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Pyrotechnic Example Basin Cast Timing Design



Pyrotechnic Example
Basin Cast Timing
Actual Firing Times



1730 = Actual Firing Time

 Hole fired out of sequence

1730 = Deviation From Designed Firing Time

Drifting Perimeter Effect Pyrotechnic VS Electronic Timing

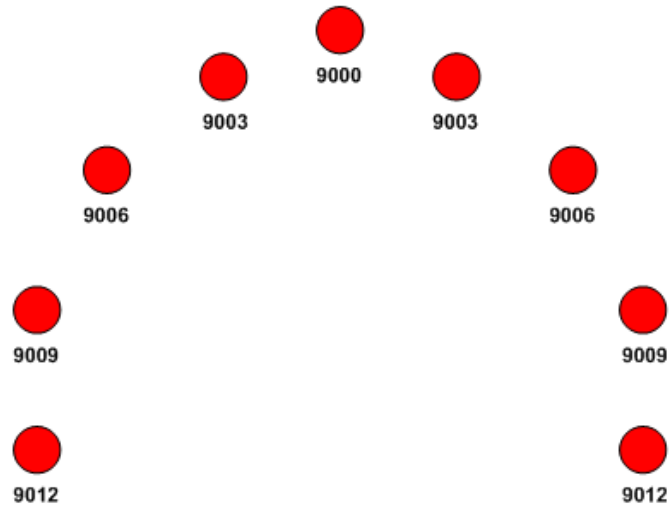
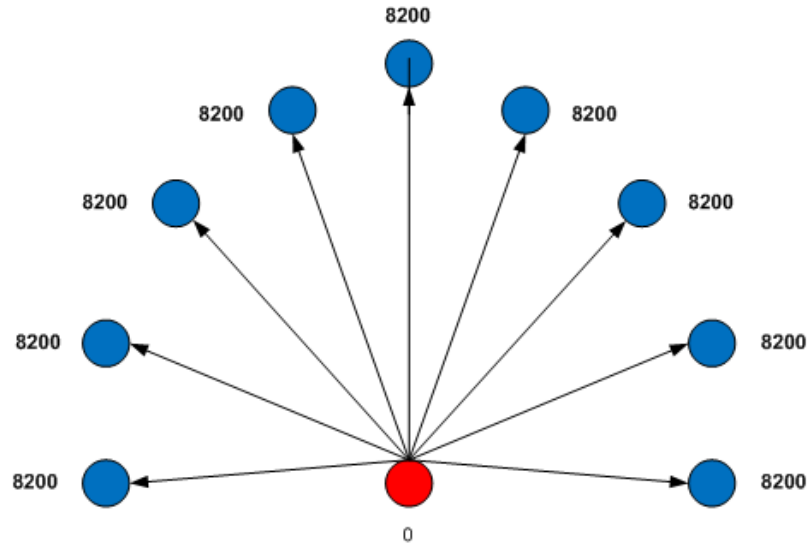


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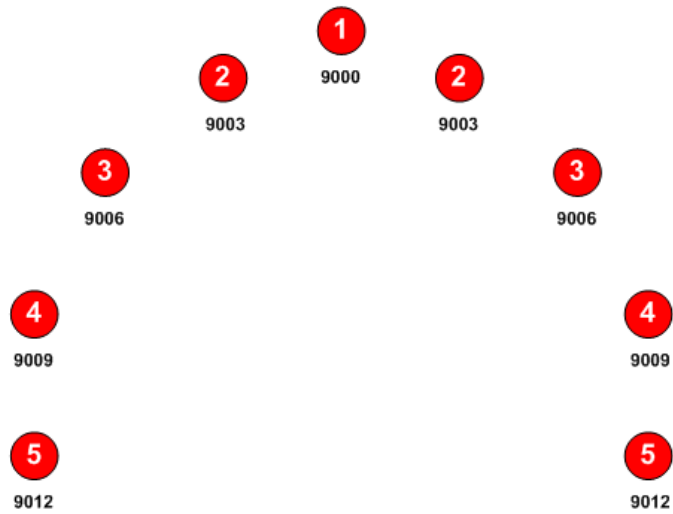
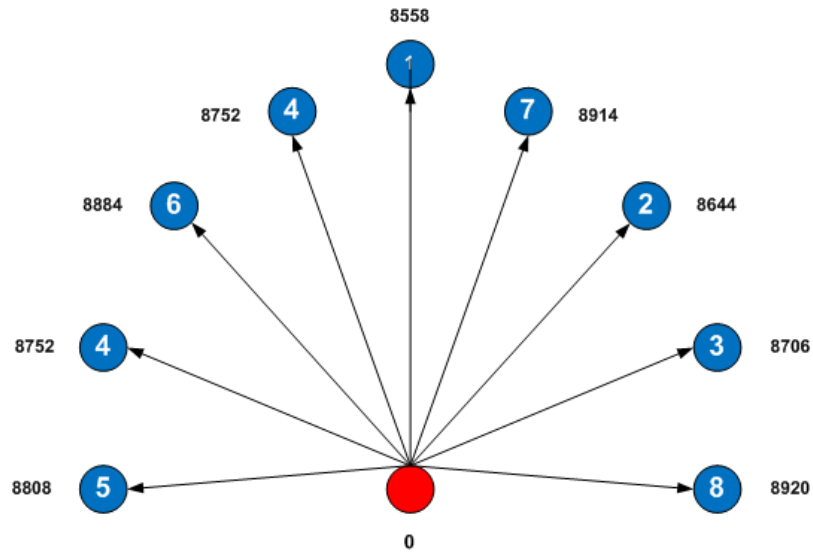
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Pyrotechnic VS Electronic
Drift Perimeter
Design



Electronic Detonators

Pyrotechnic VS Electronic
Drift Perimeter
Actual Firing Times



Electronic Detonators

Electronic Example (4-Row)



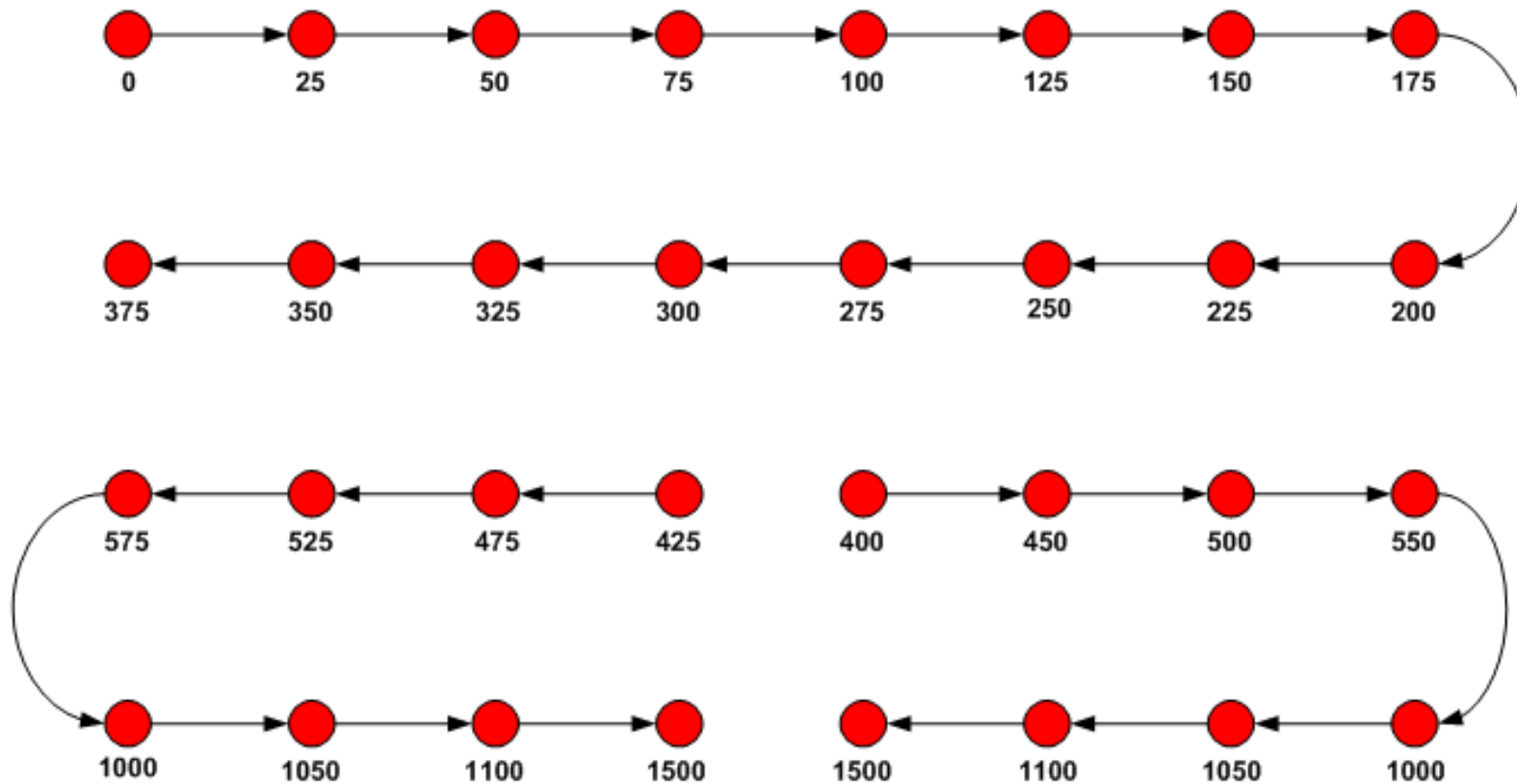
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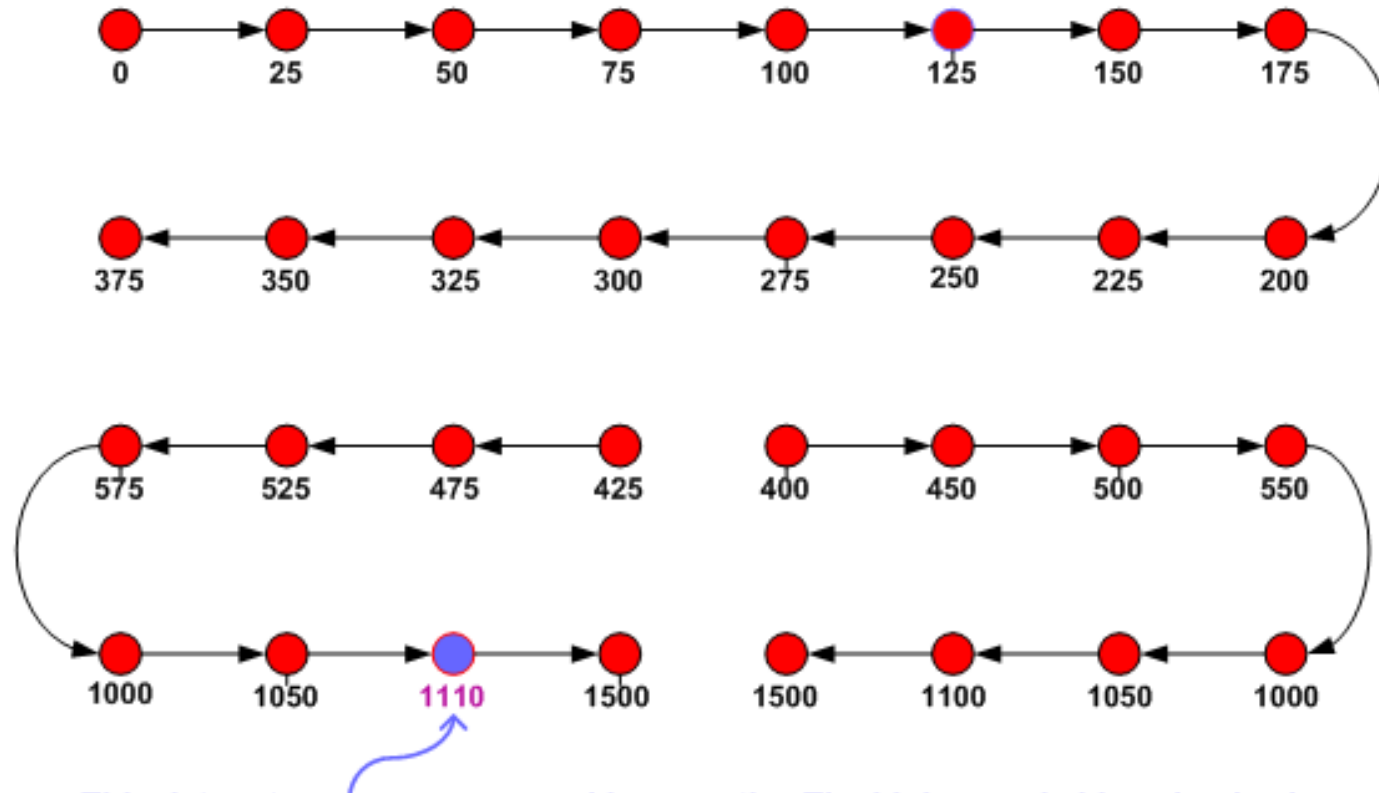
Electronic Timing Flexibility Example

Designed Firing Order



Electronic Timing Flexibility Example

Actual Firing Order



This detonator was programmed incorrectly. The high-speed video clearly shows the hole firing 10MS late. A review of the blast machine timing delivered to the detonators verified the incorrect timing input into the machine.

The purpose of this example is to demonstrate the importance of verifying that the information (delay times) programmed in the blasting equipment matches the plan.

Axial Priming for Faster Column Consumption

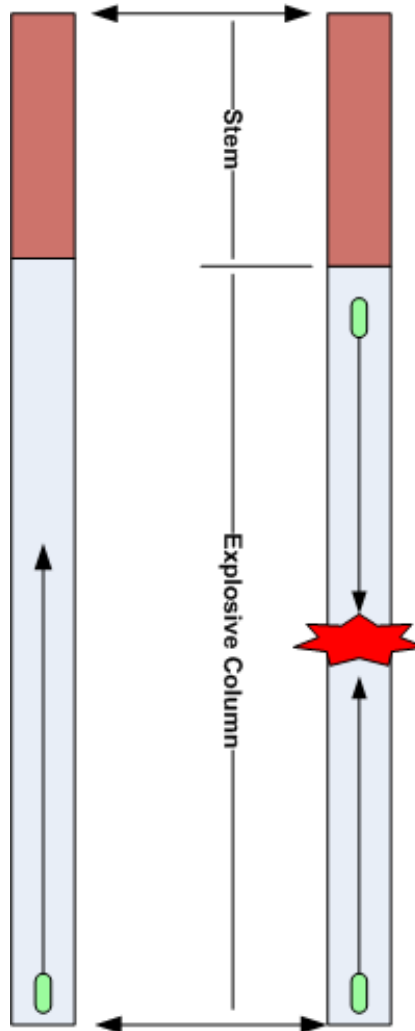


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Effect of Axial Priming on Column Consumption



Electronic VS Pyrotechnic Delays a Practical Study



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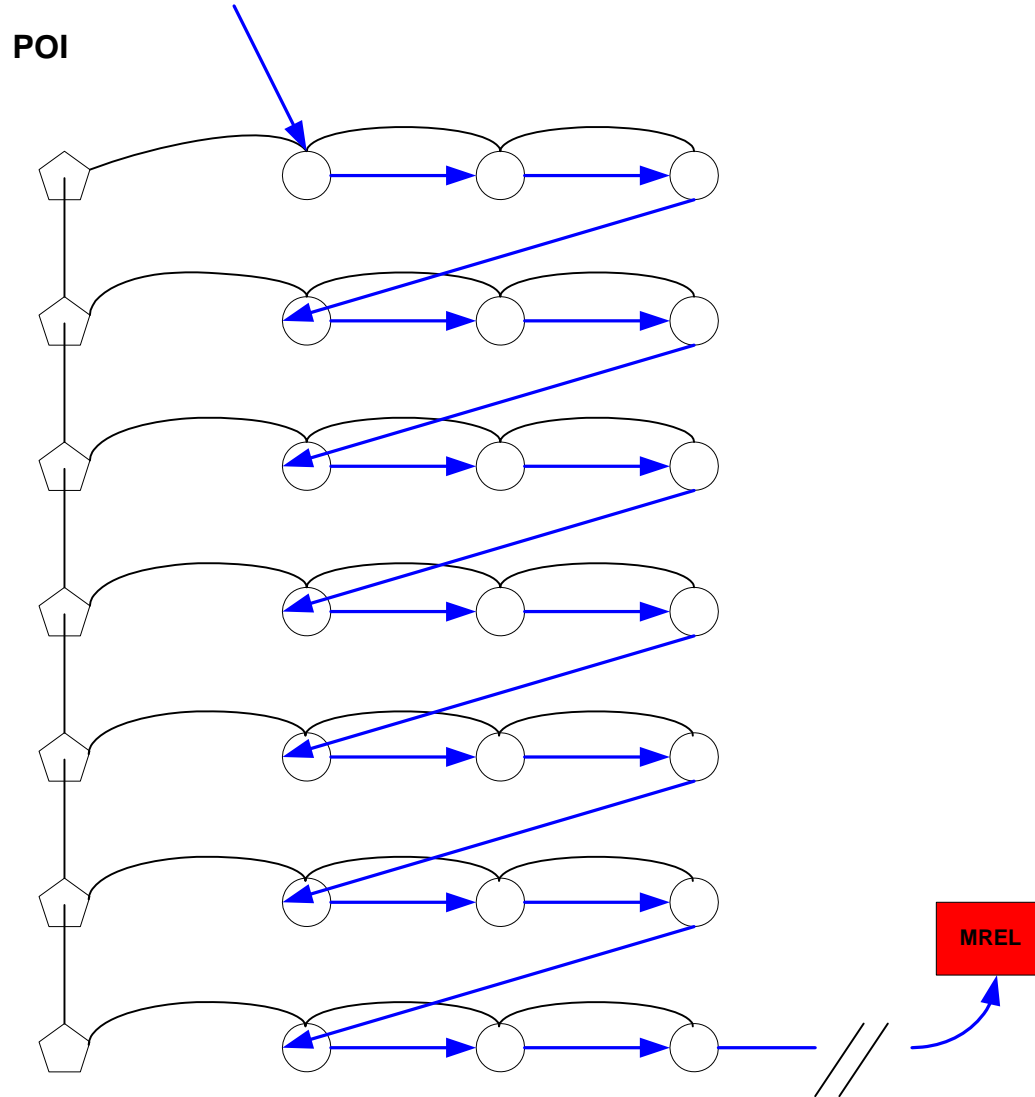
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Test Parameters

- **All tests measured using MREL Micro trap**
 - **1-ohm / ft cable**
 - **2MHz sample rate for maximum data saturation**
- **Inter-row timing determined as timing between the first caps in subsequent rows**
- **Inter-row timing built using 109ms EZTLs**
- **Pyrotechnic timing represents a cumulative deviation from nominal consisting of both the surface (micro-cap) and the in-hole 500ms delay.**

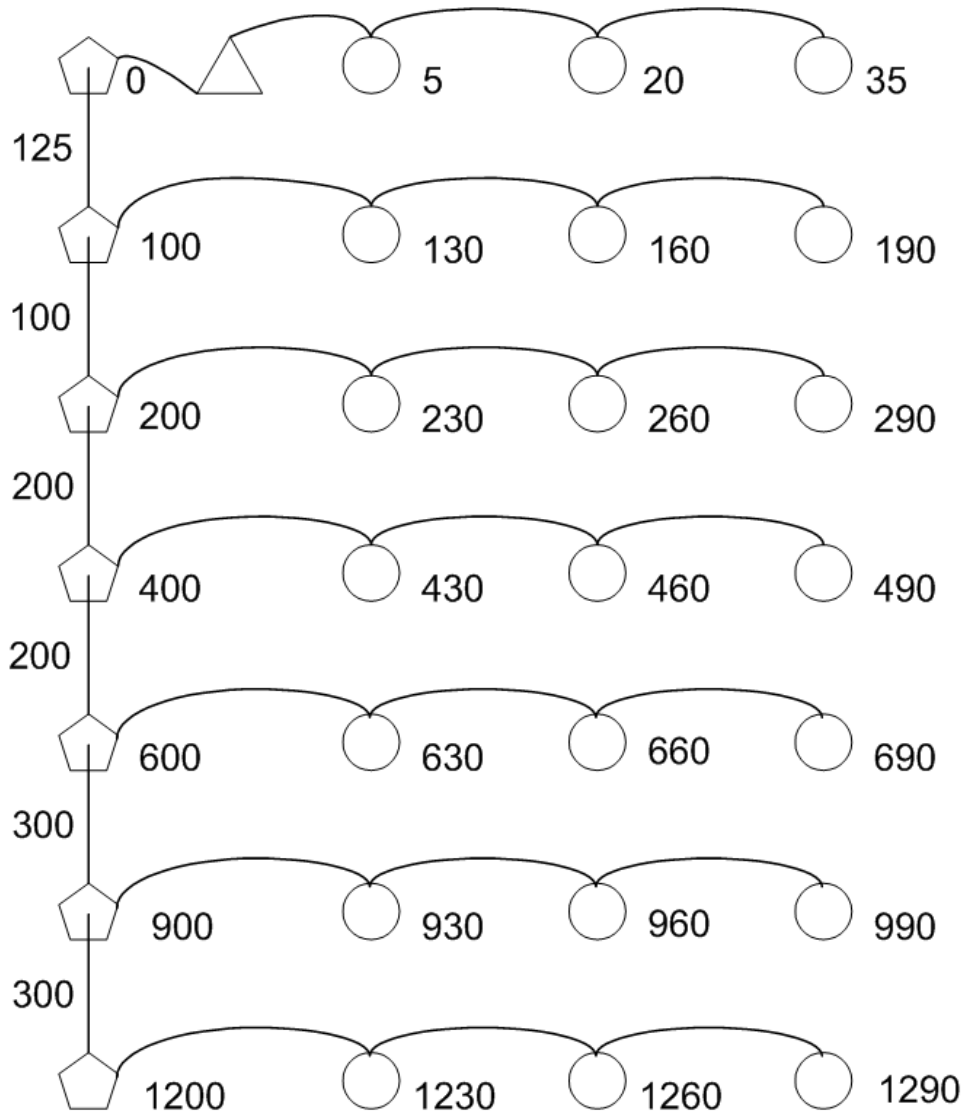
Timing Schematic



Summary VOD data

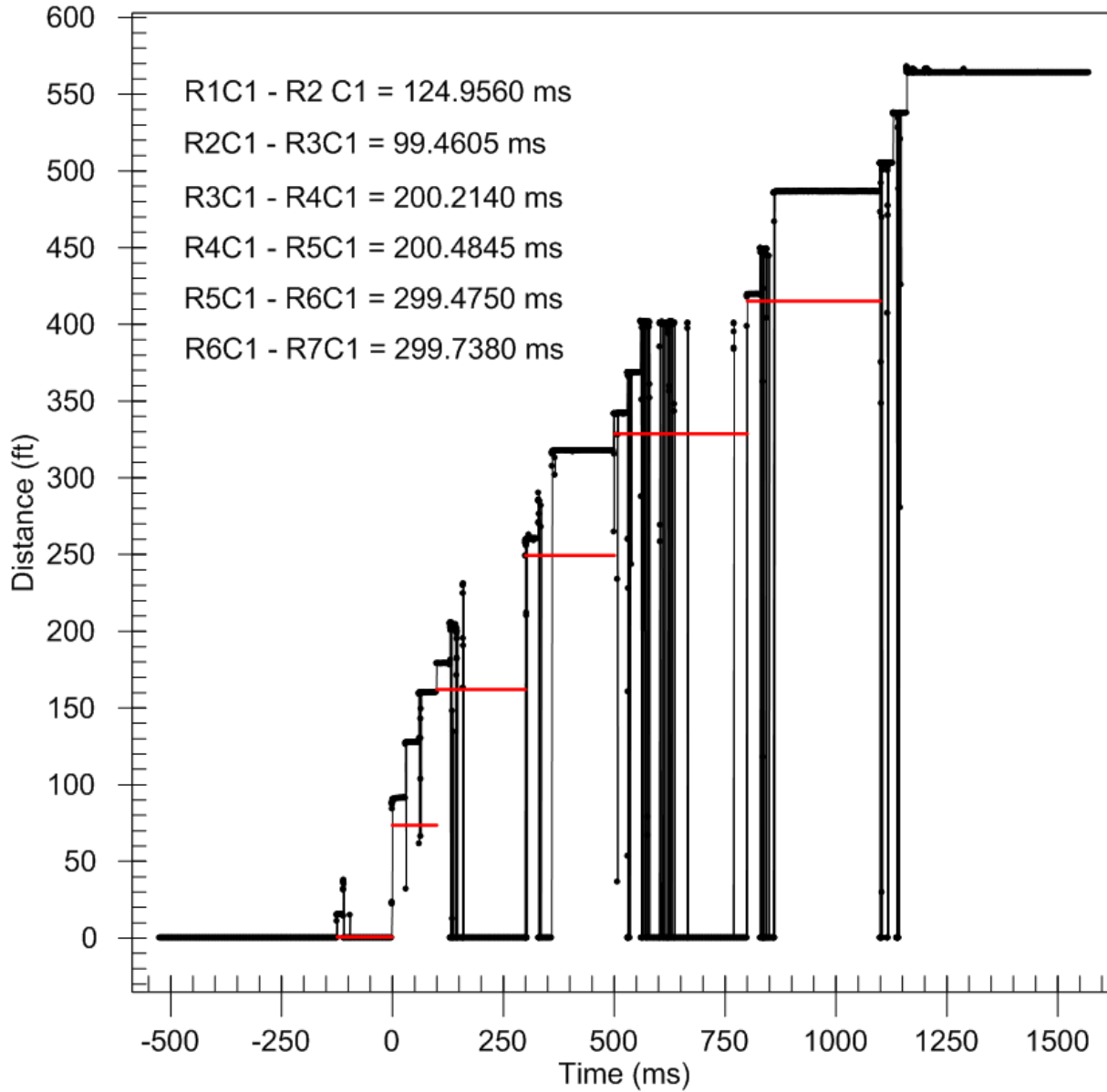
Timing Comparison conducted @ Municipal							
	HotShot				Pyrotechnic		
	Pgm.	Act.	Dev.		Nom.	Act.	Dev.
<i>R1</i>	0				0		
<i>R1 to R2</i>	125	124.96	-0.04		109	96.86	-12.14
<i>R2 to R3</i>	100	99.46	-0.54		109	113.21	4.21
<i>R3 to R4</i>	200	200.21	0.21		218	218.21	0.21
<i>R4 to R5</i>	200	200.48	0.48		218	209.34	-8.66
<i>R5 to R6</i>	300	299.48	-0.52		327	326.91	-0.09
<i>R6 to R7</i>	300	299.74	-0.26		327	320.11	-6.89
<i>R1C1 to C2</i>	15	14.98	-0.02		17	28.93	11.93
<i>R1C2 to C3</i>	15	14.98	-0.02		17	2.99	-14.01
<i>R2C1 to C2</i>	30	29.07	-0.93		25	21	-4
<i>R2C2 to C3</i>	30	30.53	0.53		25	19.78	-5.22
<i>R3C1 to C2</i>	30	30.3	0.3		25	15.83	-9.17
<i>R3C2 to C3</i>	30	29.71	-0.29		25	35.72	10.72
<i>R4C1 to C2</i>	30	29.79	-0.21		25	25.28	0.28
<i>R4C2 to C3</i>	30	30.38	0.38		25	21.08	-3.92
<i>R5C1 to C2</i>	30	30.87	0.87		25	27.9	2.9
<i>R5C2 to C3</i>	30	29.11	-0.89		25	21.43	-3.57
<i>R6C1 to C2</i>	30	29.72	-0.28		25	10.74	-14.26
<i>R6C2 to C3</i>	30	30.24	0.24		25	19.77	-5.23
<i>R7C1 to C2</i>	30	30.06	0.06		25	12.61	-12.39
<i>R7C2 to C3</i>	30	30.16	0.16		25	24.02	-0.98
Maximum Deviation			0.87				11.93
Minimum Deviation			-0.93				-14.26
Range			1.8				26.19

Electronic Delay Layout



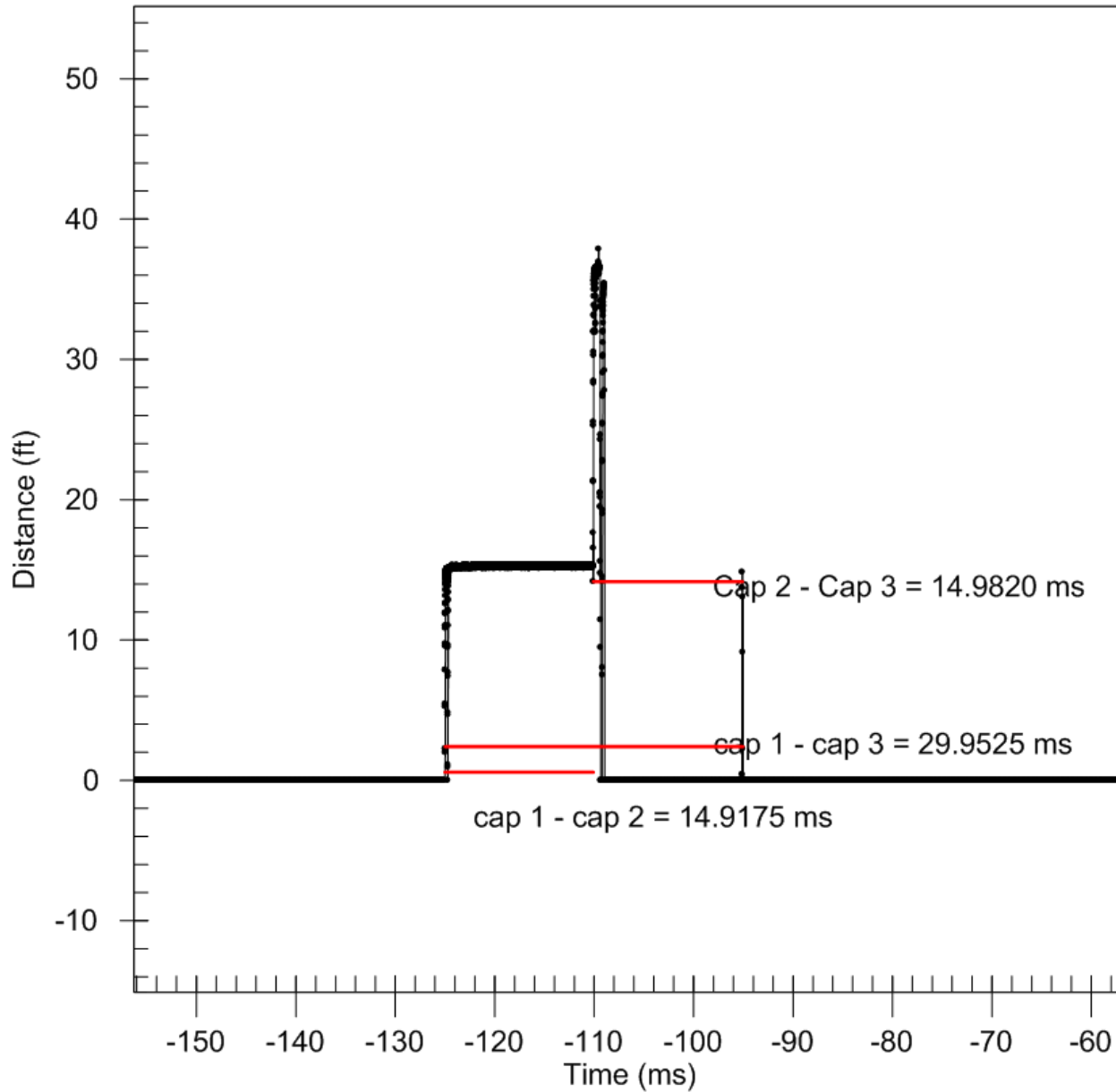
Electronic Timing

Row to Row Accuracy



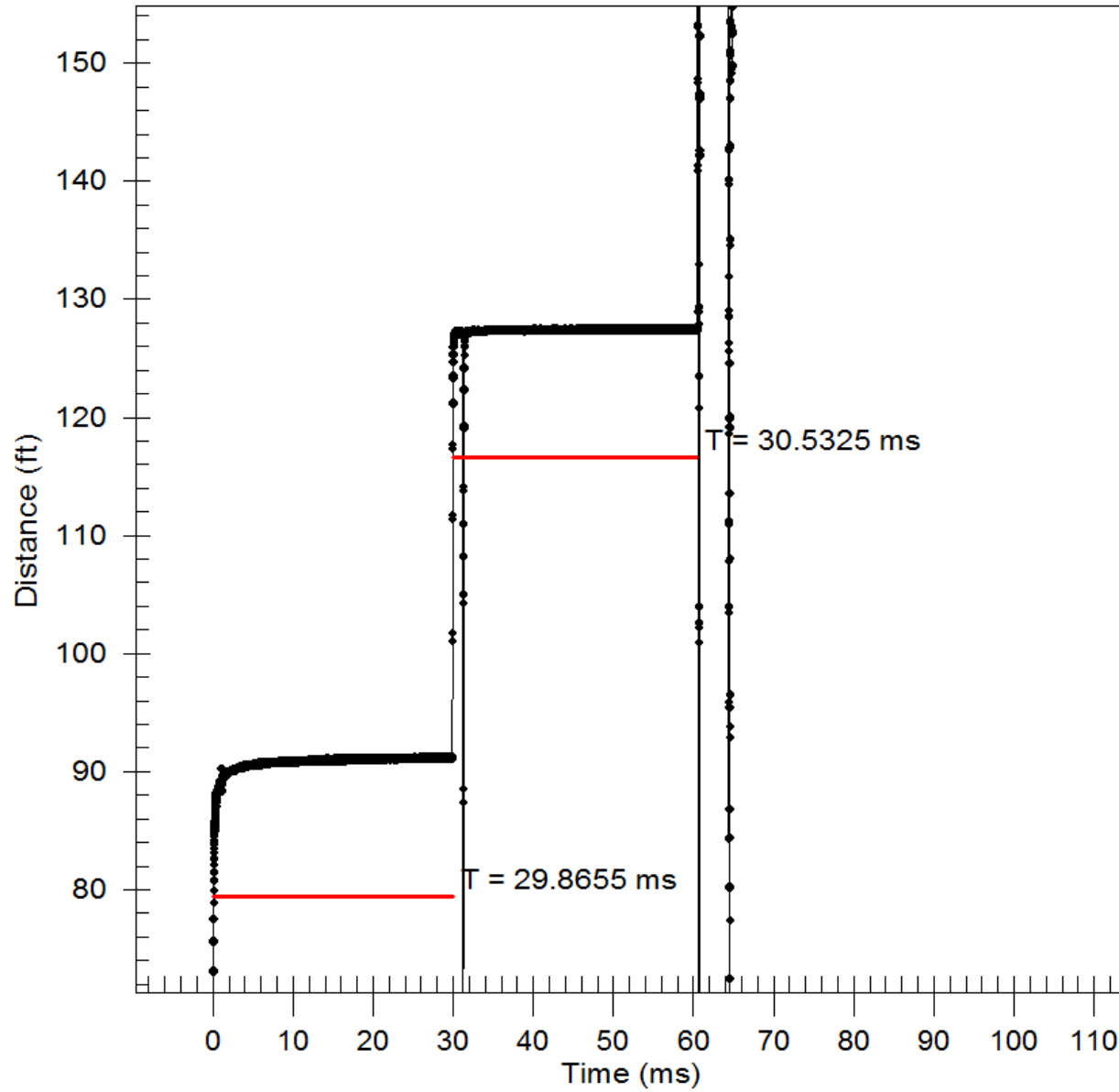
Electronic Timing

Row 1 Timing



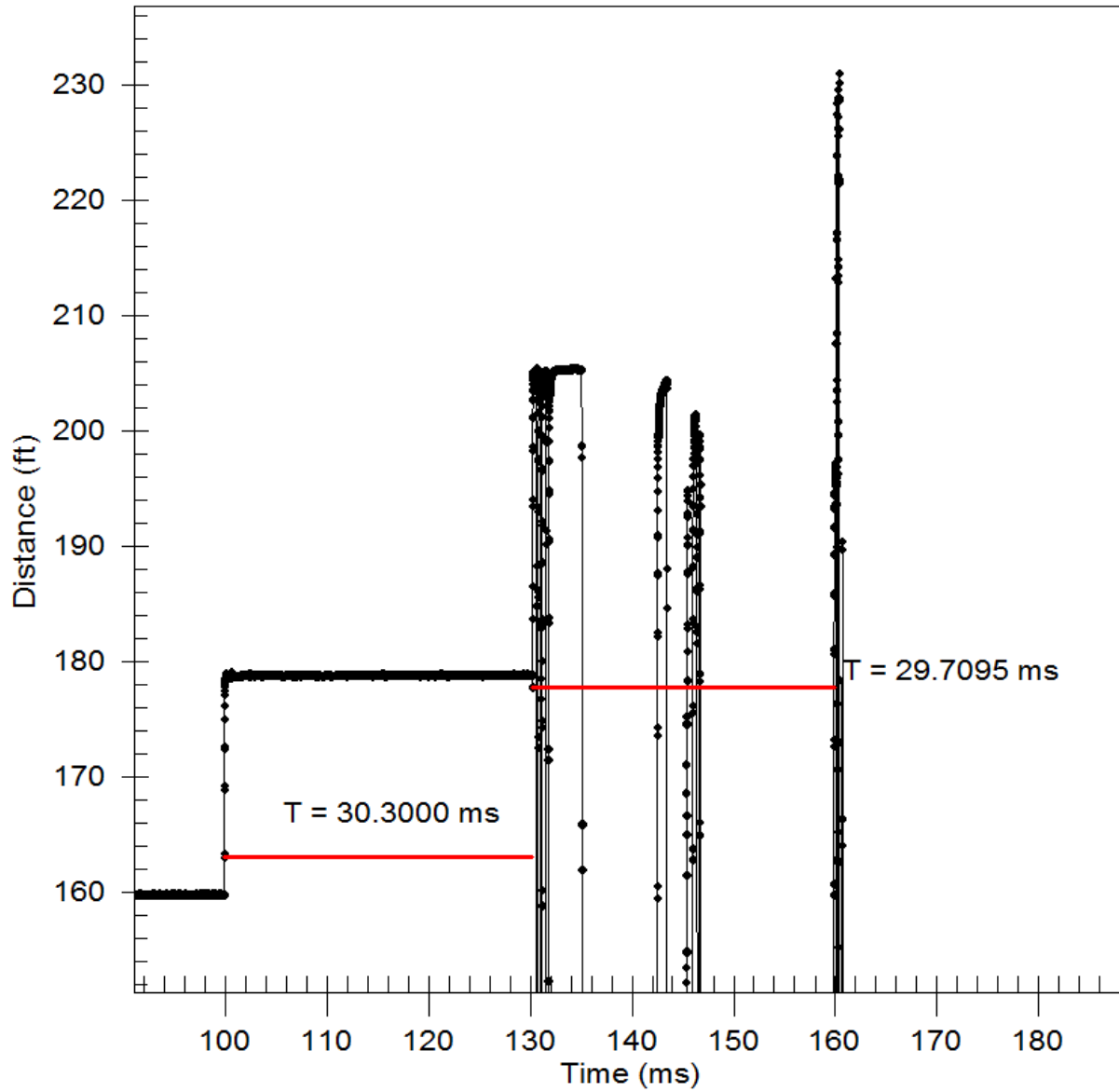
Electronic Timing

Row 2



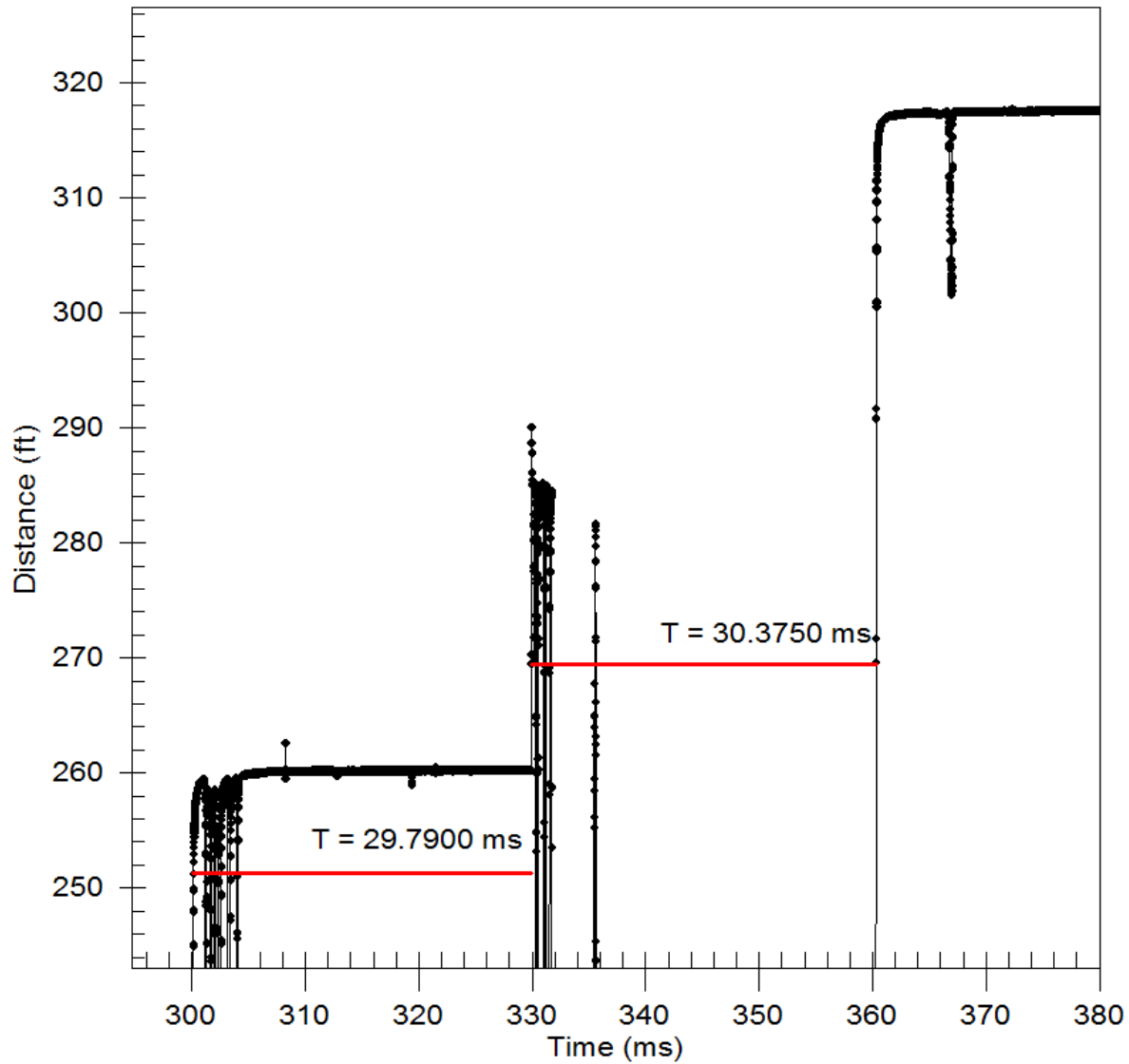
Electronic Timing

Row 3



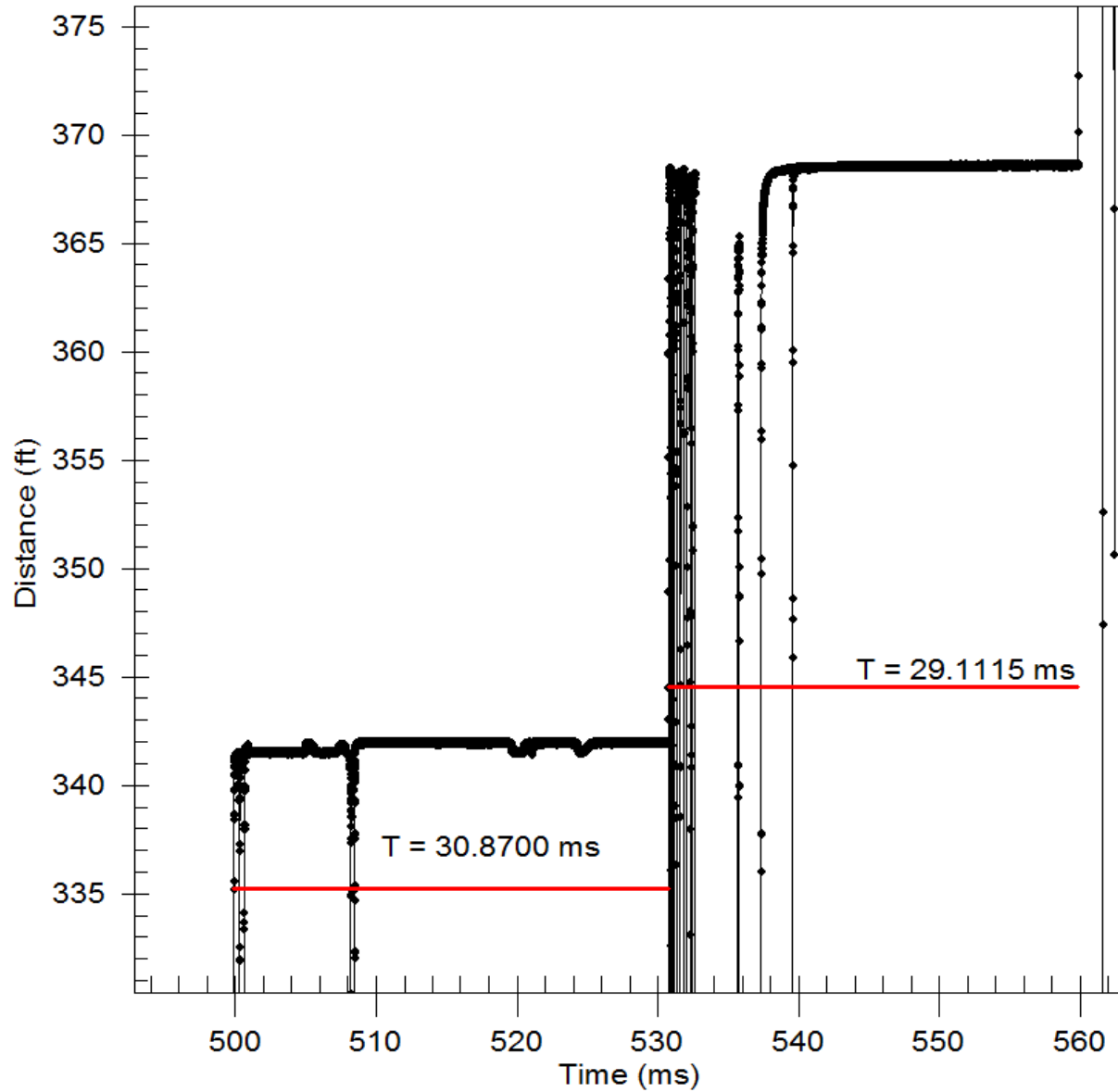
Electronic Timing

Row 4



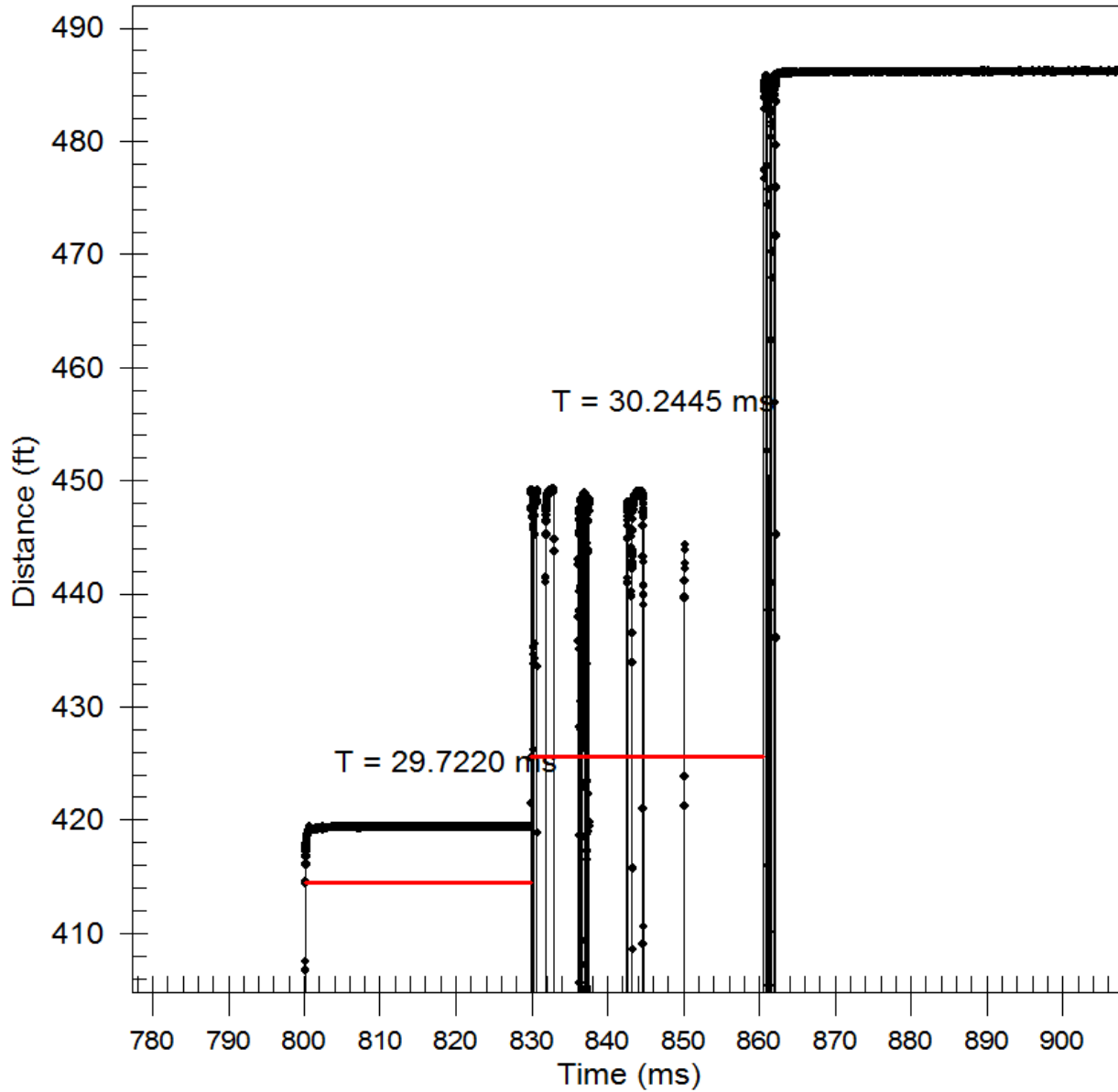
Electronic Timing

Row 5



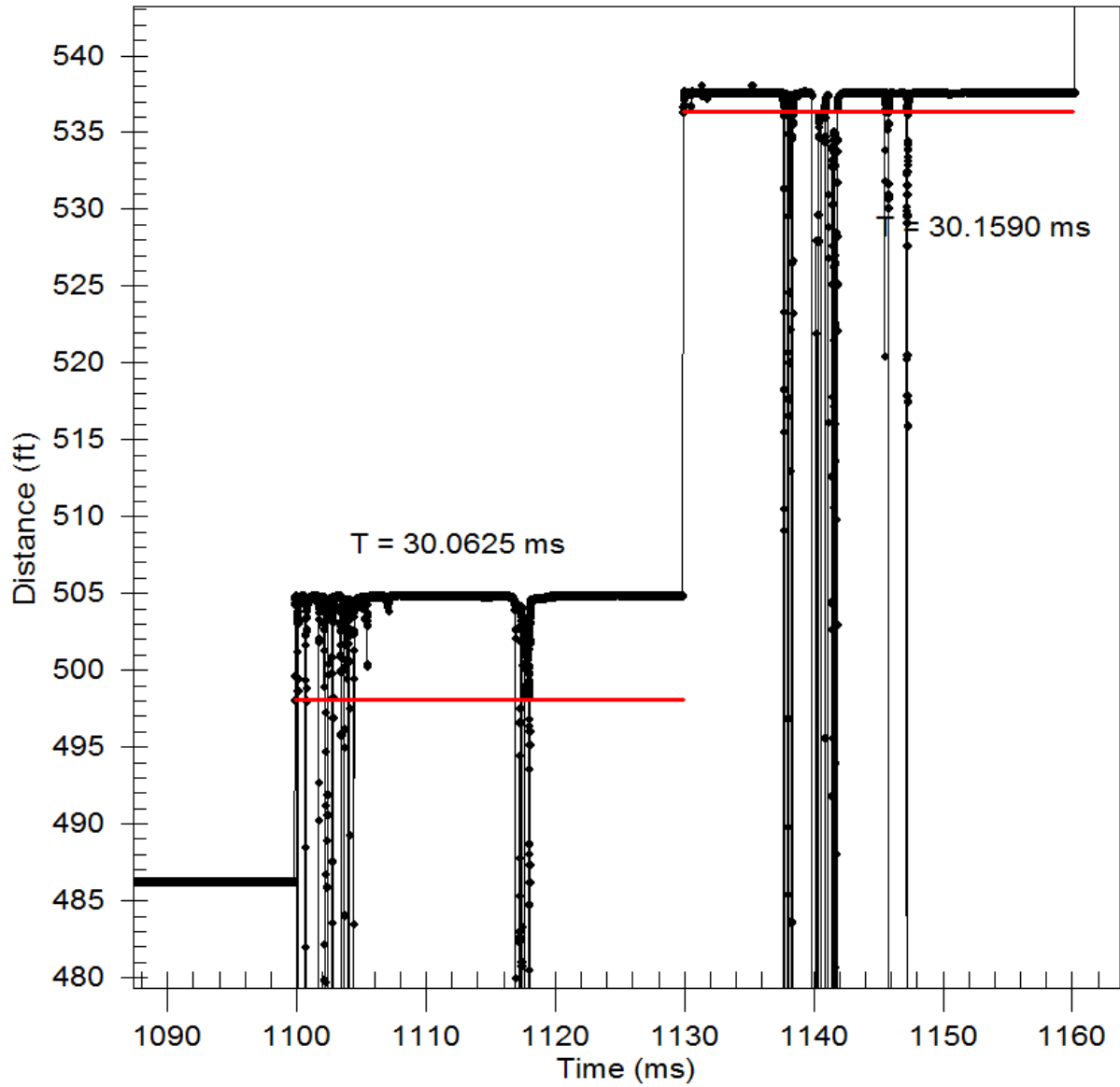
Electronic Timing

Row 6

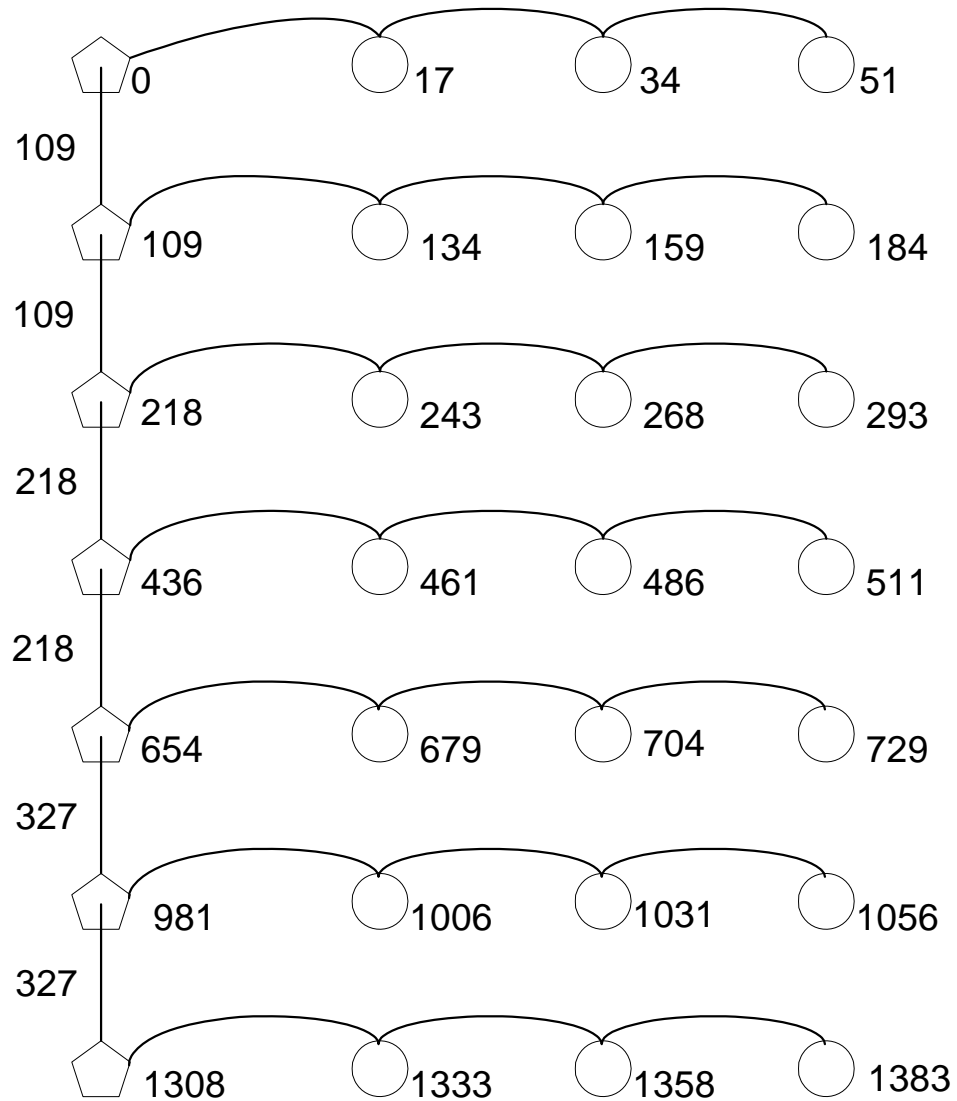


Electronic Timing

Row 7

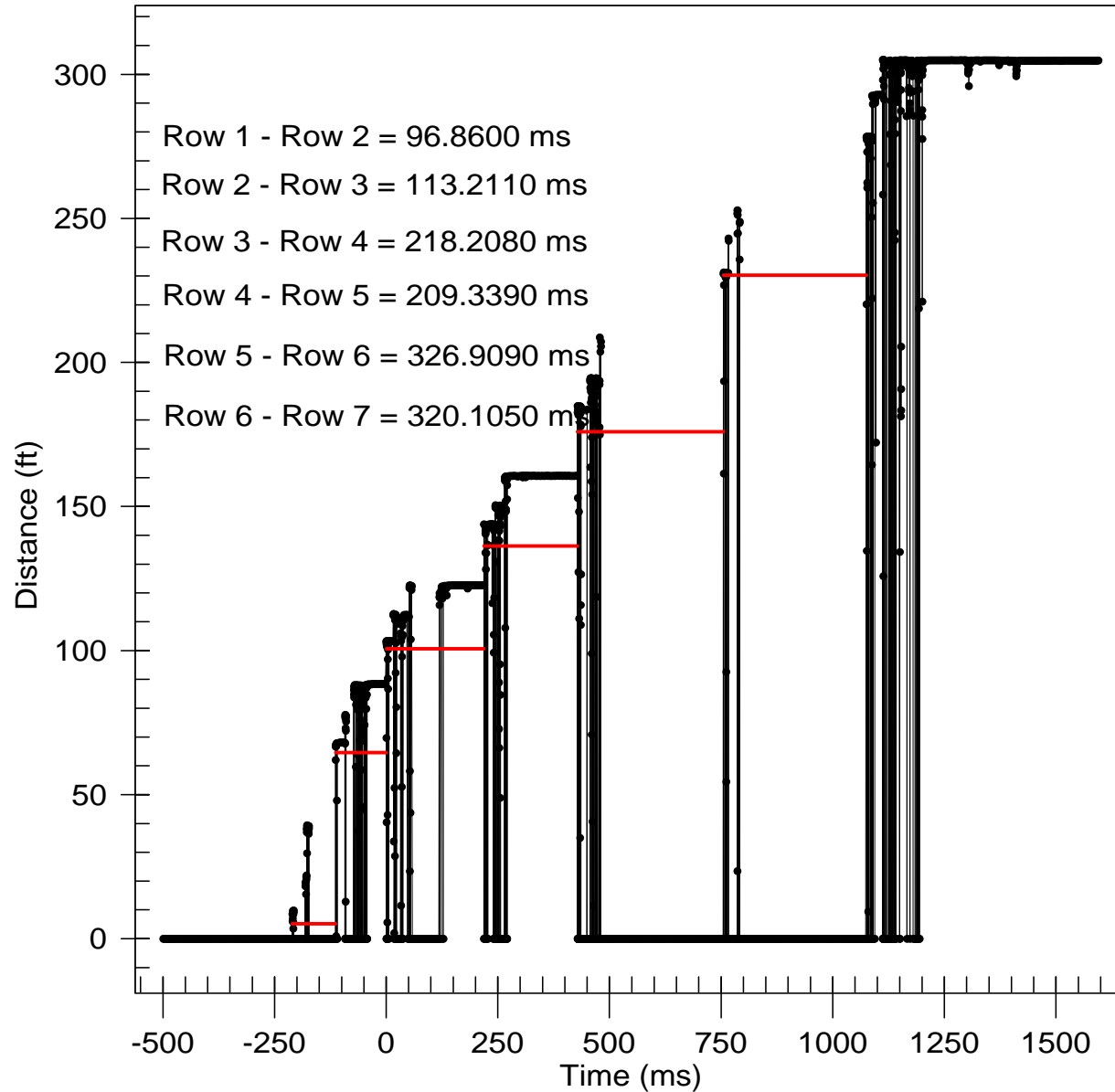


Pyrotechnic Test Layout



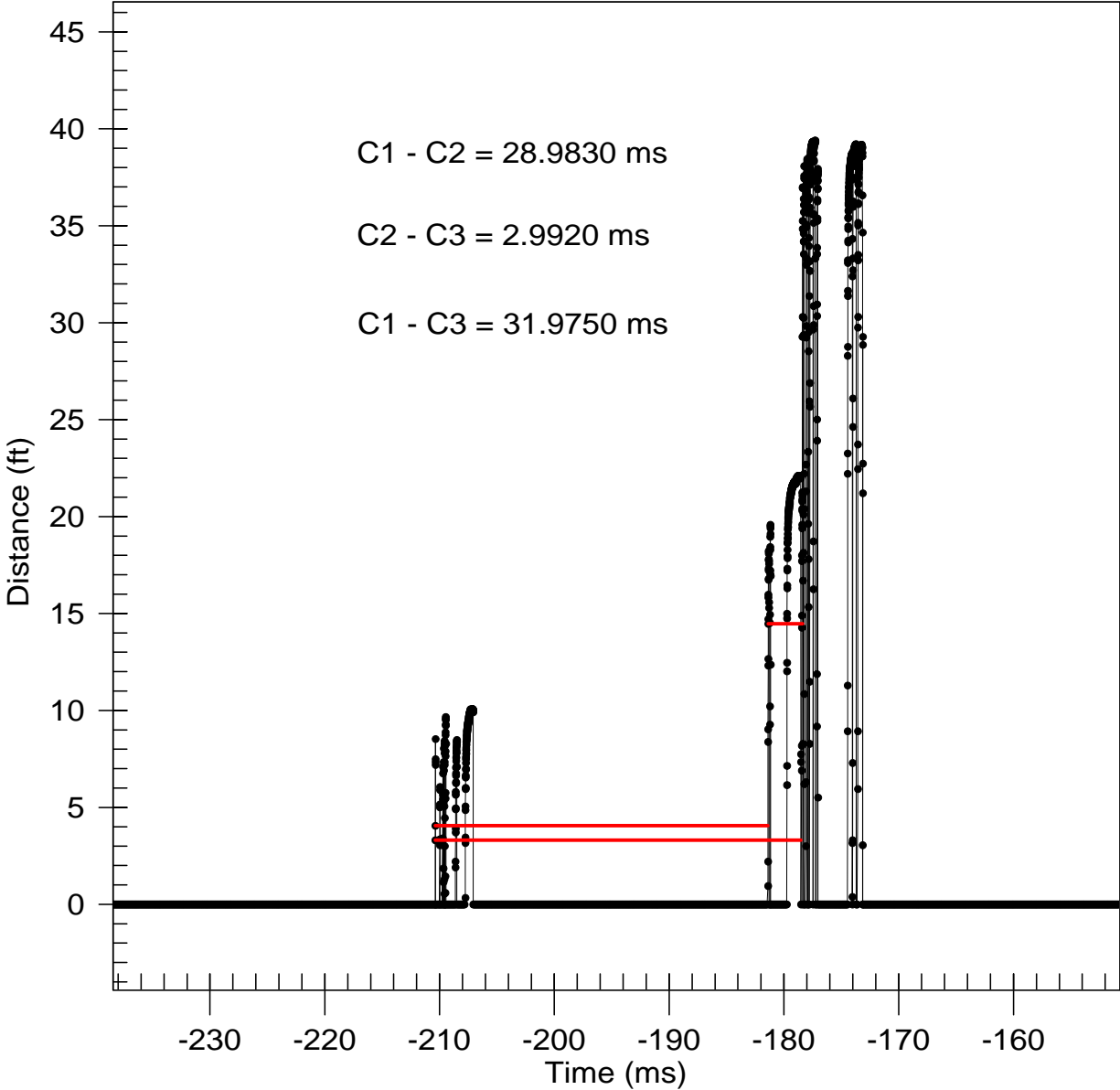
Pyrotechnic Timing Accuracy

Row to Row Timing



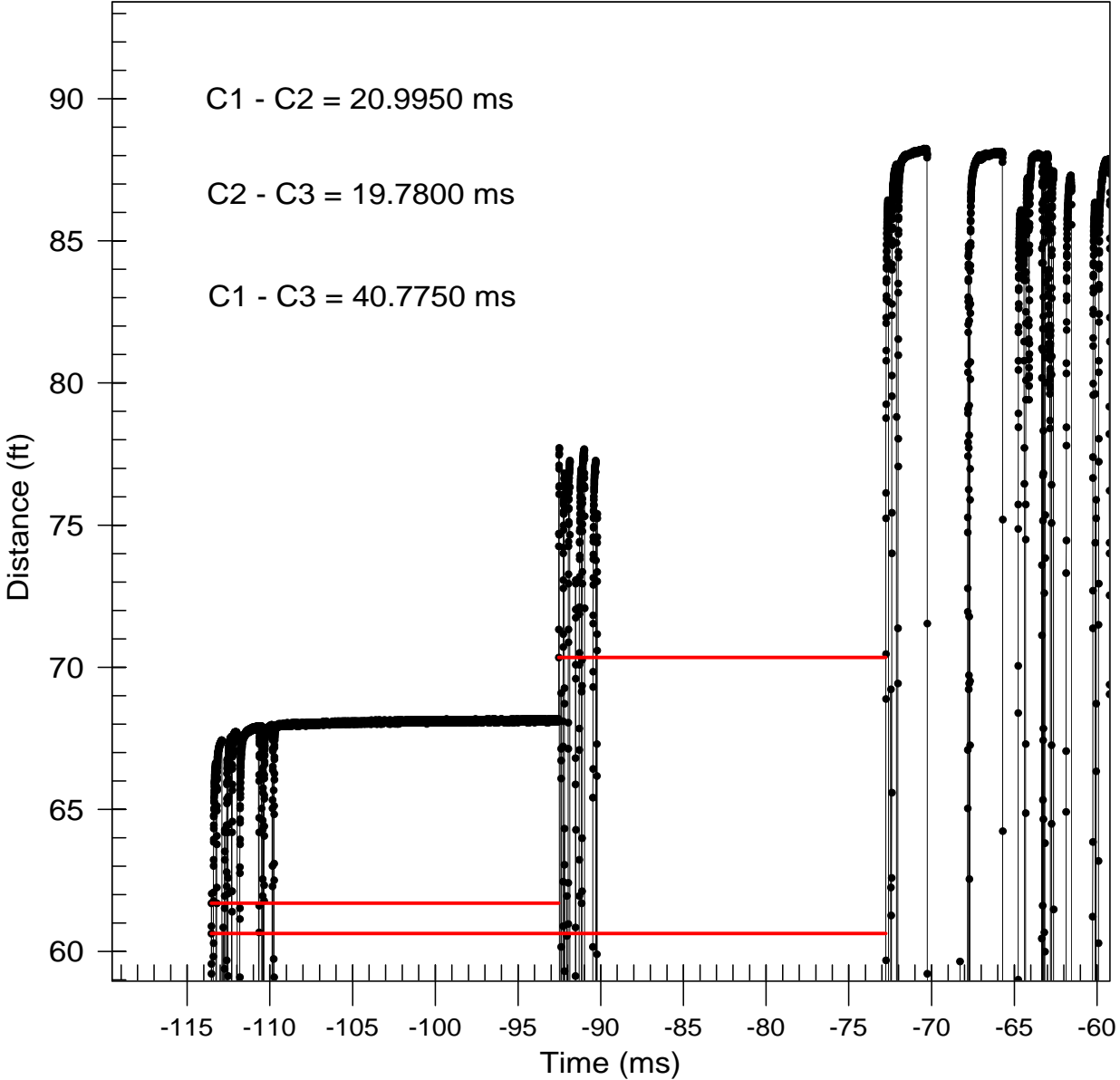
Pyrotechnic Timing

Row 1 (17ms Nominal)



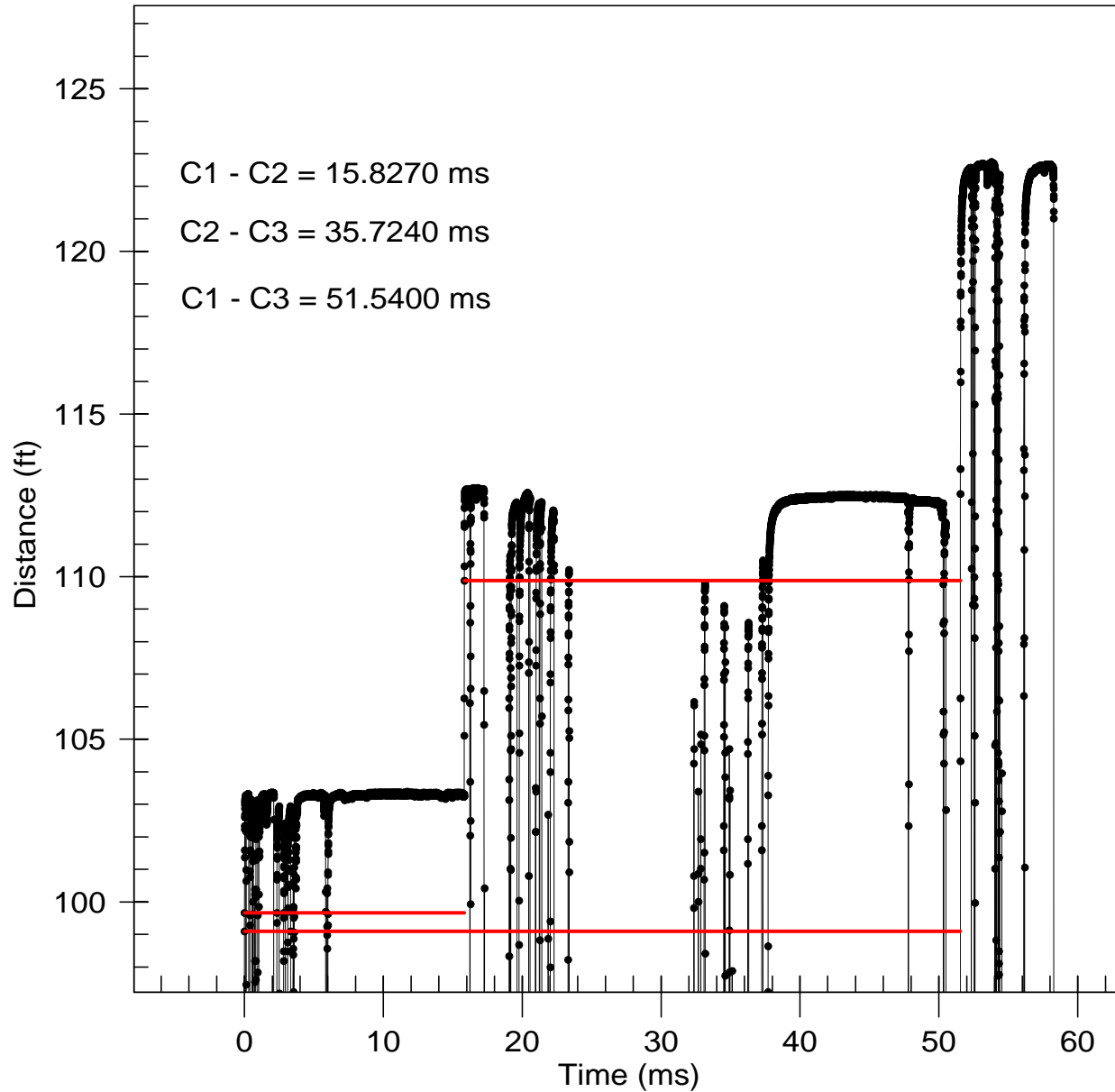
Pyrotechnic Timing

Row 2 (25ms Nominal)



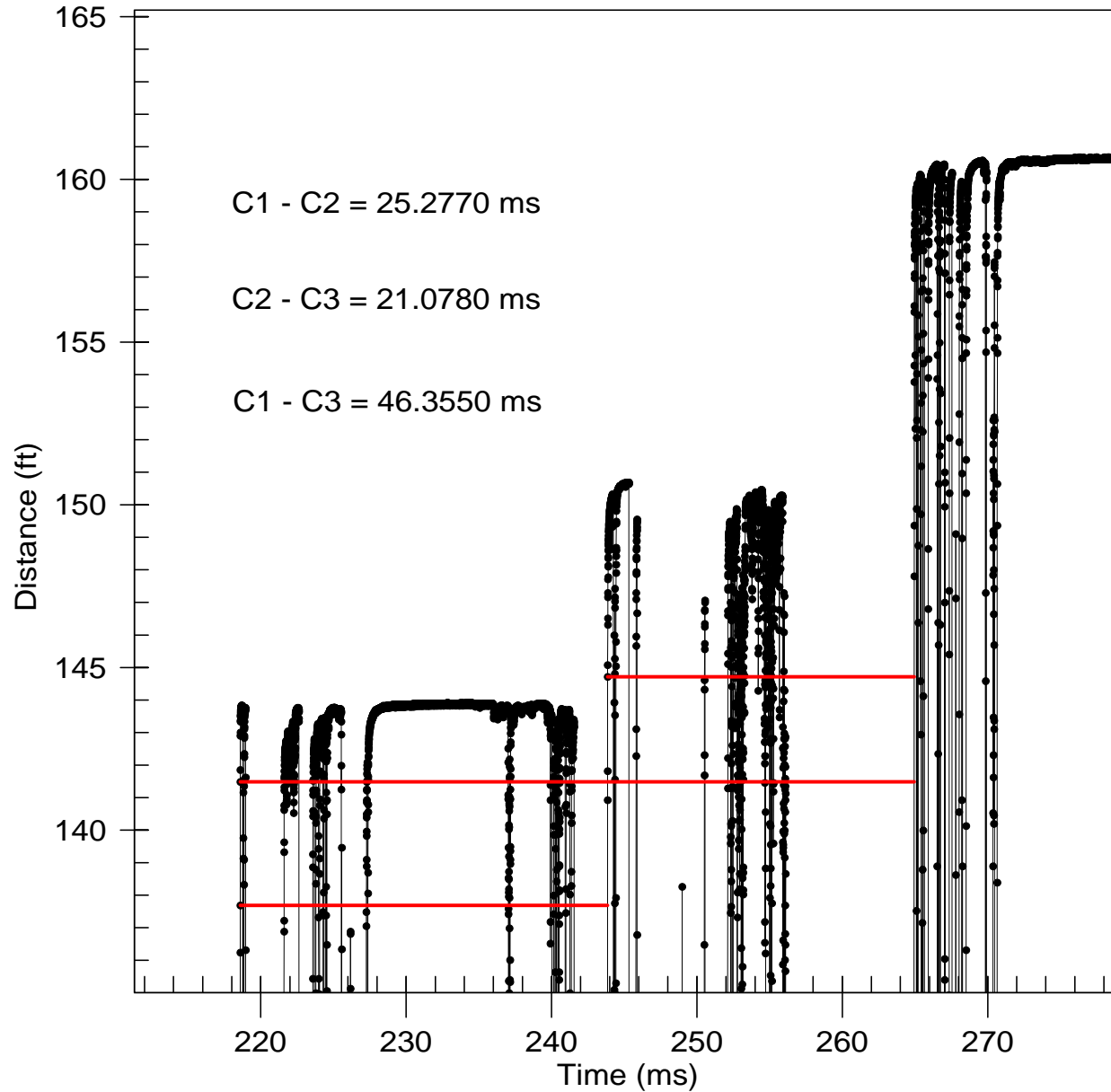
Pyrotechnic Timing

Row 3 (25ms Nominal)



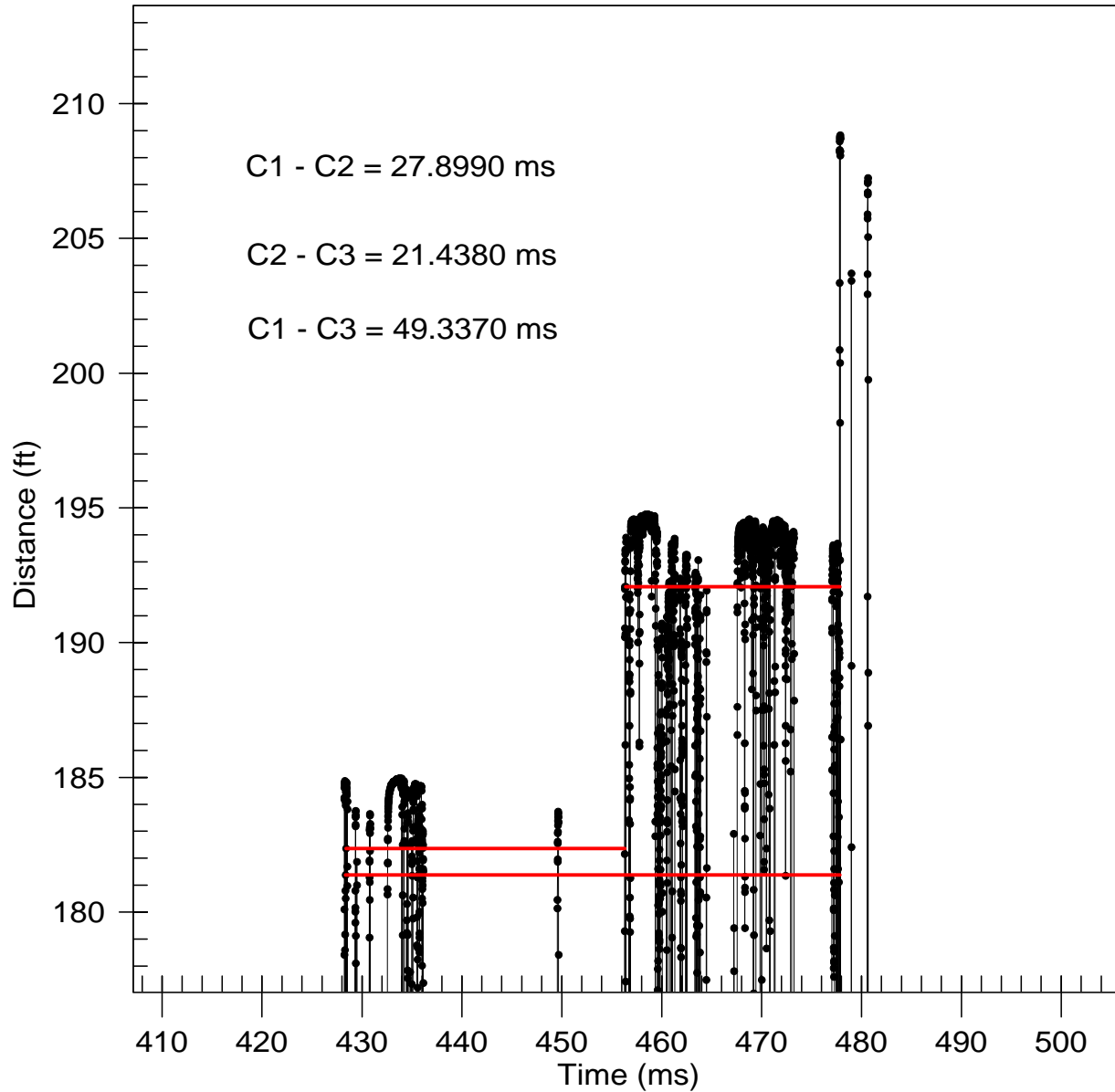
Pyrotechnic Timing

Row 4 (25ms Nominal)



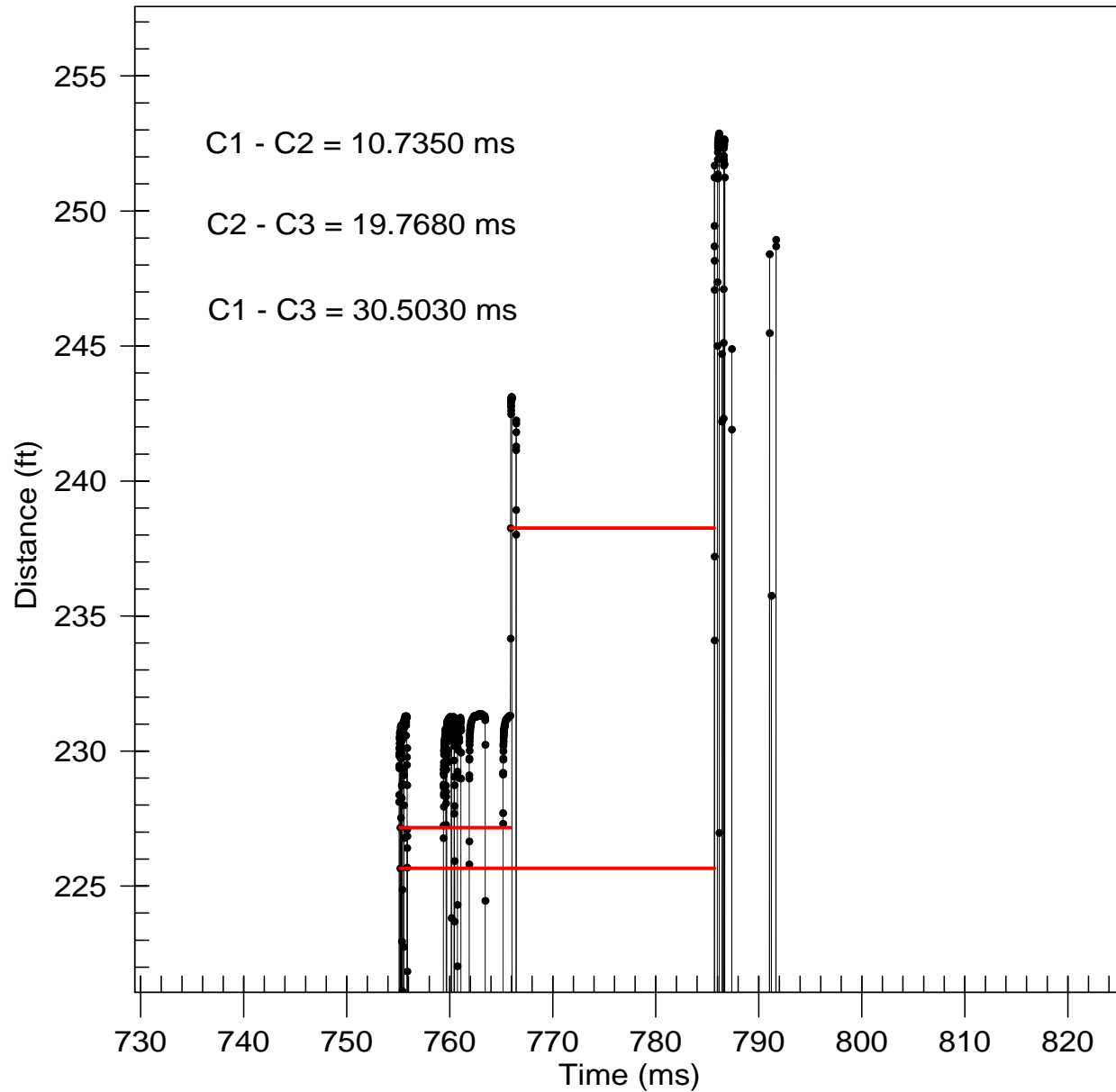
Pyrotechnic Timing

Row 5 (25ms Nominal)



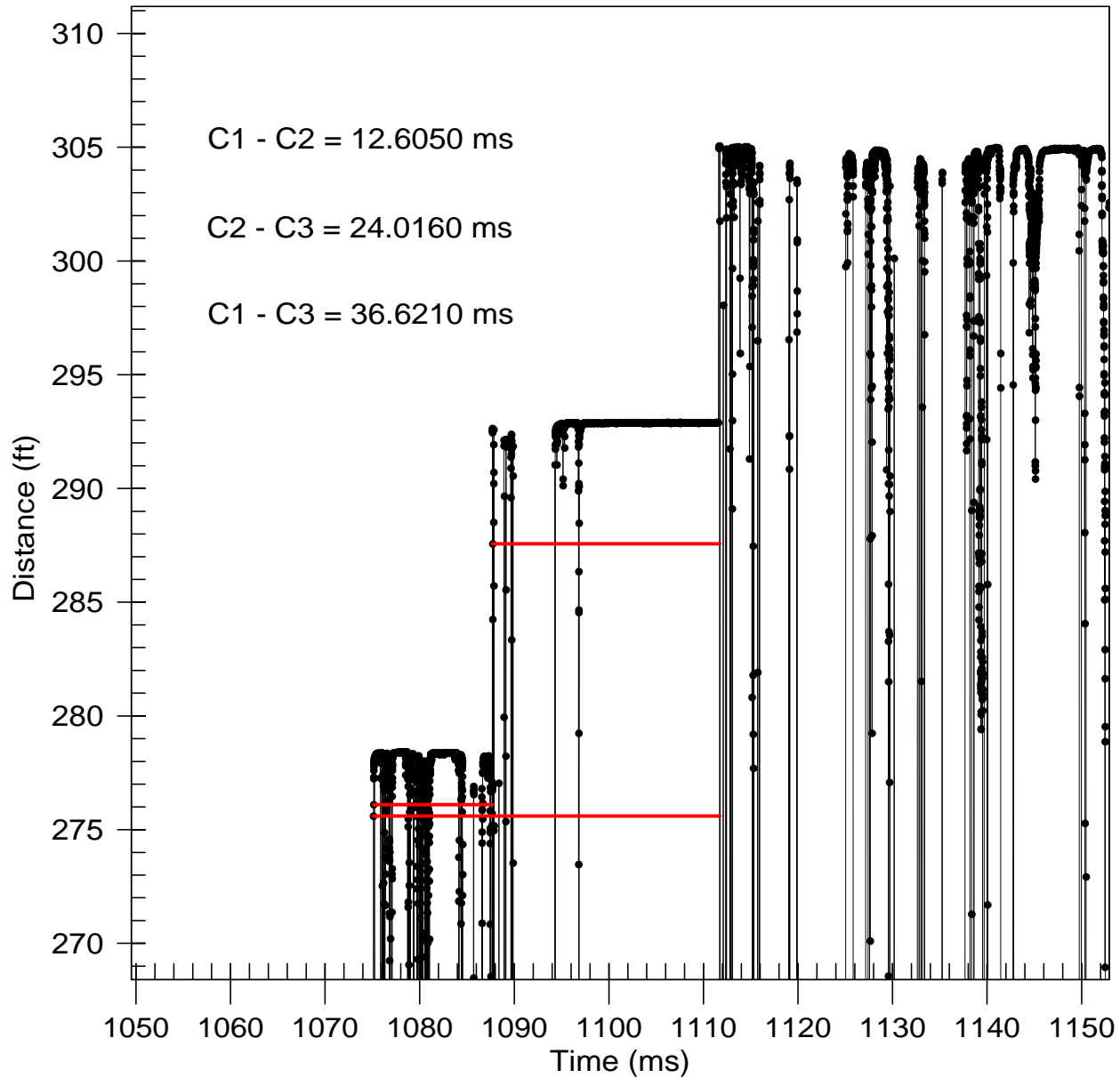
Pyrotechnic Timing

Row 6 (25ms Nominal)



Pyrotechnic Timing

Row 7 (25ms Nominal)



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