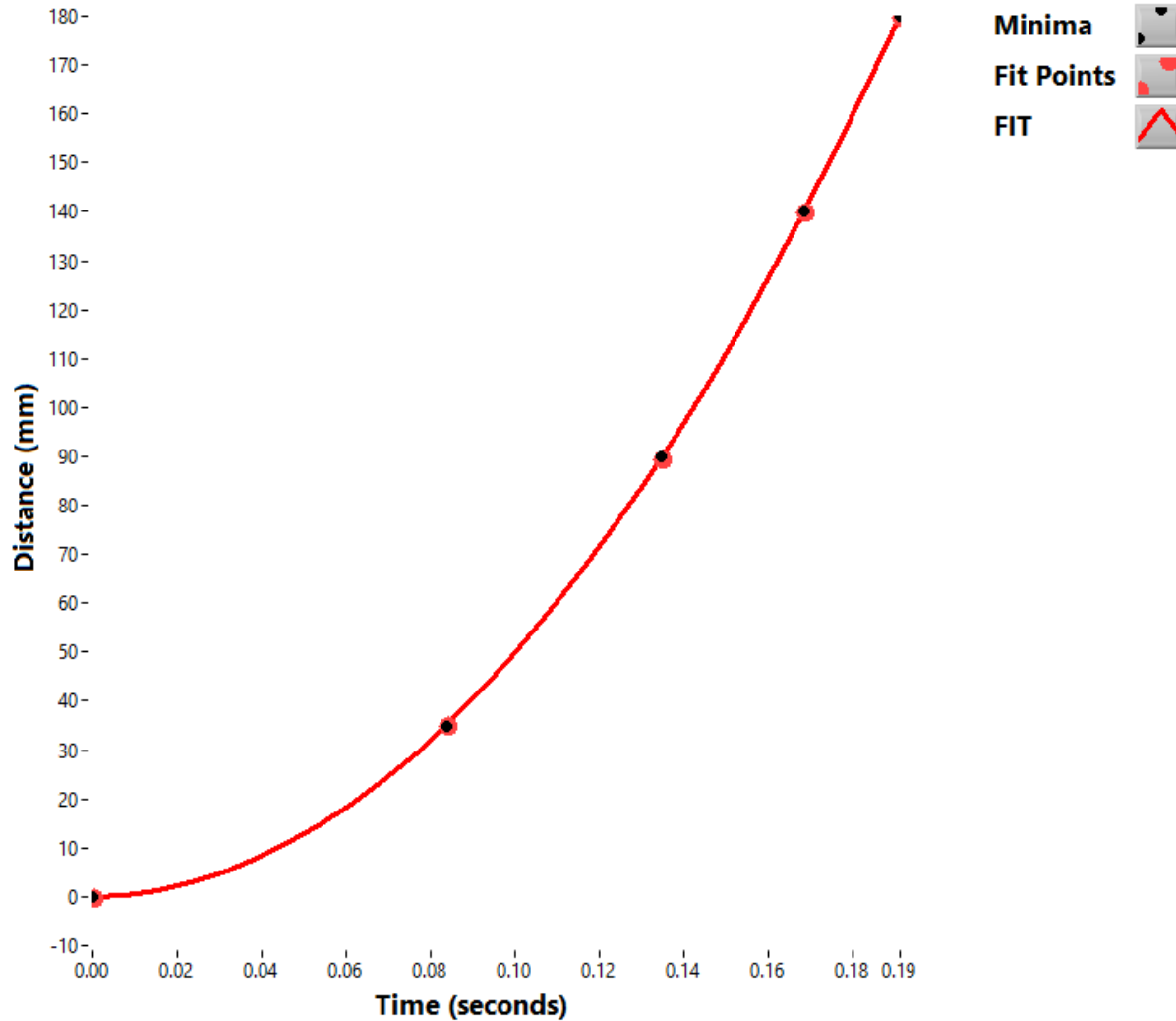


$$g_{calc} = 9.72908 \frac{m}{s^2}$$

Raw Min Calc

Raw Min Calc: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Parabolic Equation Fit To Tower Drop Data

$$X = -0.026mm + \left(12.479 \frac{mm}{s} \right) * t + 0.5 * \left(9729.082 \frac{mm}{s^2} \right) * t^2$$

X calculations from above parabolic fit will be within $\pm 0.173mm$ of the measured X data ~95% of the time using the 2sigma rule of thumb.

The formula for this 2sigma (2σ or 2 Standards of Deviation) calculation is detailed below

$$\sigma = \sqrt{\sum_{i=0}^{n-1} \left(\frac{(x_i - \mu)^2}{n-1} \right)} \quad \text{with mean equation: } \mu = \sum_{i=0}^{n-1} \left(\frac{x_i}{n} \right) \quad \text{where } n = 5$$

This σ equation assumes a normally distributed sample population.

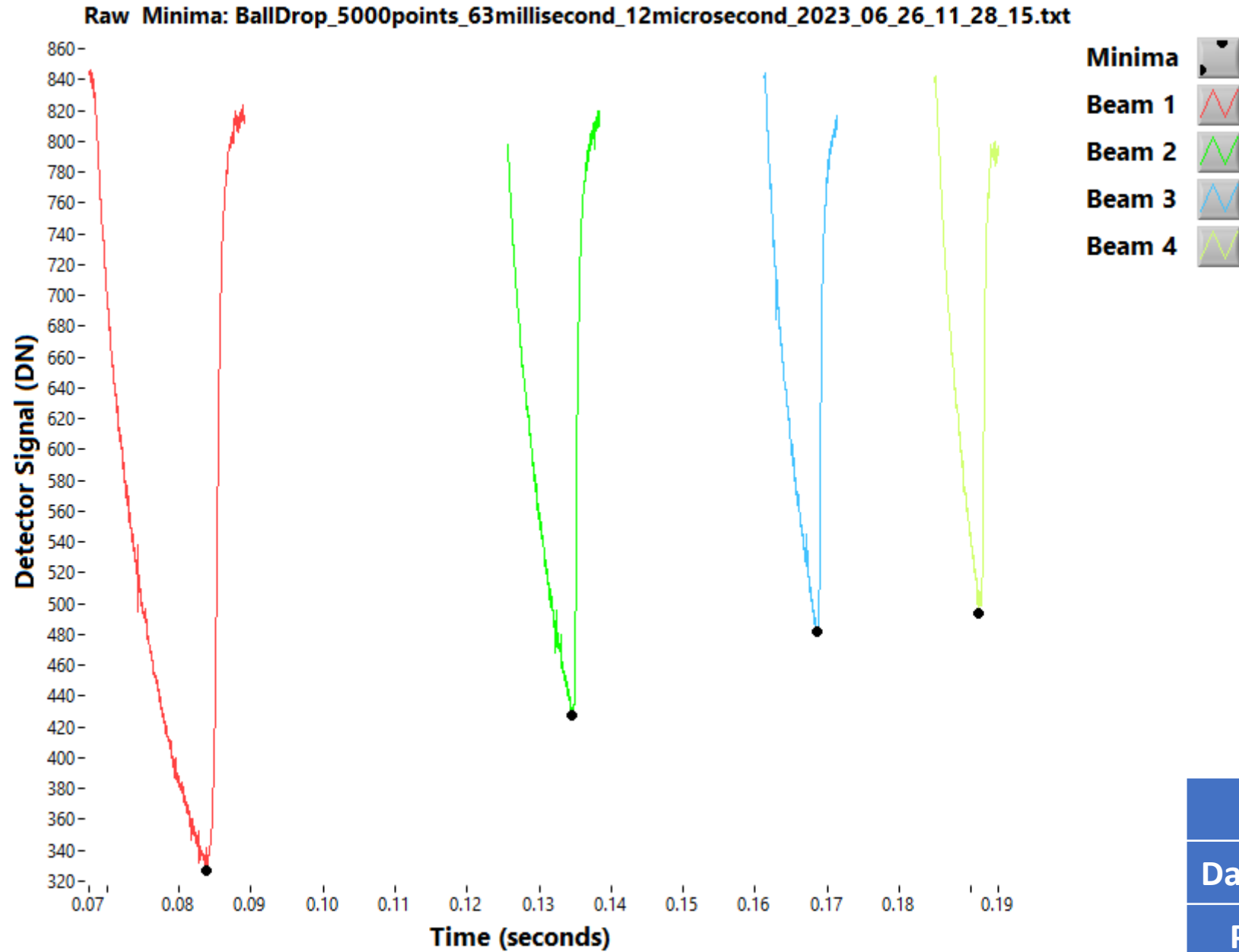
	Start	Beam 1	Beam 2	Beam 3	Beam 4
Minima Time (seconds)	0	0.083759	0.134566	0.168488	0.191078
Ball Top FIT (mm)	-0.026	35.147	89.740	140.172	179.967
Ball Top (mm)	0	35.000	90.000	140.000	180.000
$X_{fit} - X_{ball\ top}$ (mm)	-0.026	0.147	-0.260	0.172	-0.033

$$g_{expected} = 9.79472 \frac{m}{s^2}$$

$$g_{calc} - g_{expected} = -0.06564 \frac{m}{s^2}$$

Therefore: g_{calc} has a **-0.670% difference** from $g_{expected}$

Data Analysis Method (Raw Minima)

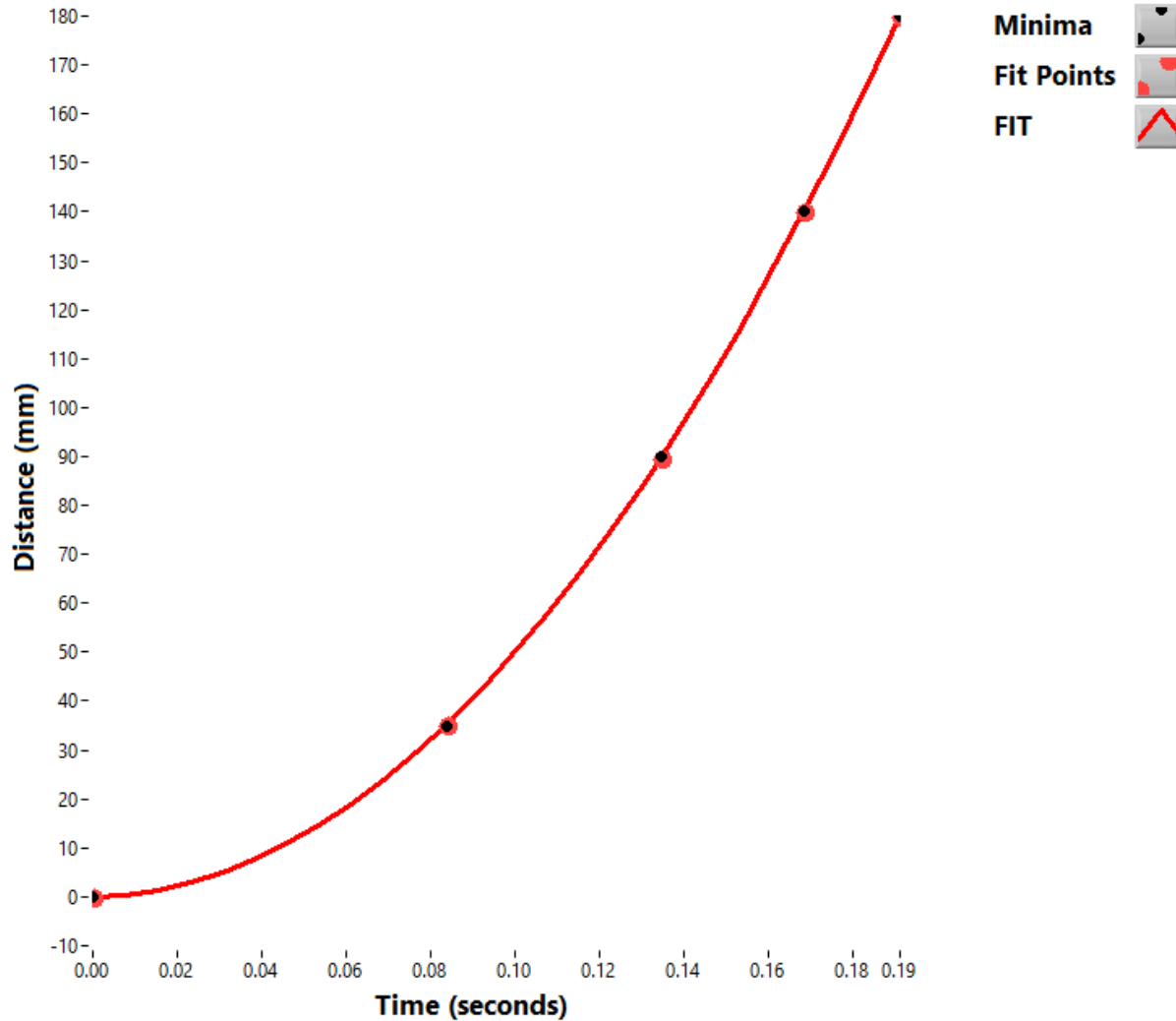


Fit Option	X0 & V0 Vary
Data Manipulation	Raw
Point Selection	Minima

$$g_{calc} = 9.68168 \frac{m}{s^2}$$

Filtered Min Calc

Filtered Min Calc: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Parabolic Equation Fit To Tower Drop Data

$$X = -0.035mm + \left(14.889 \frac{mm}{s} \right) * t + 0.5 * \left(9681.677 \frac{mm}{s^2} \right) * t^2$$

X calculations from above parabolic fit will be within $\pm 0.224mm$ of the measured X data ~95% of the time using the 2sigma rule of thumb.

The formula for this 2sigma (2σ or 2 Standards of Deviation) calculation is detailed below

$$\sigma = \sqrt{\sum_{i=0}^{n-1} \left(\frac{(x_i - \mu)^2}{n-1} \right)} \quad \text{with mean equation: } \mu = \sum_{i=0}^{n-1} \left(\frac{x_i}{n} \right) \text{ where } n = 5$$

This σ equation assumes a normally distributed sample population.

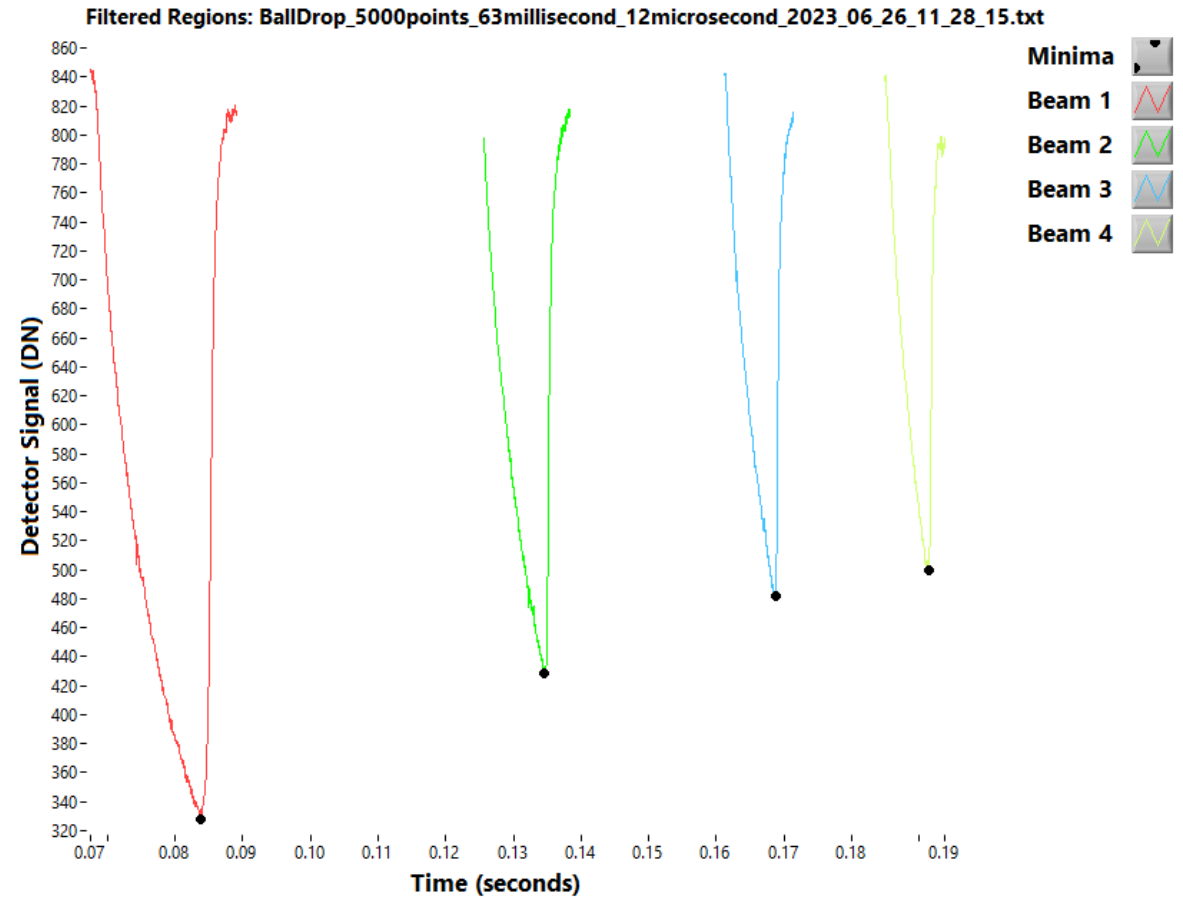
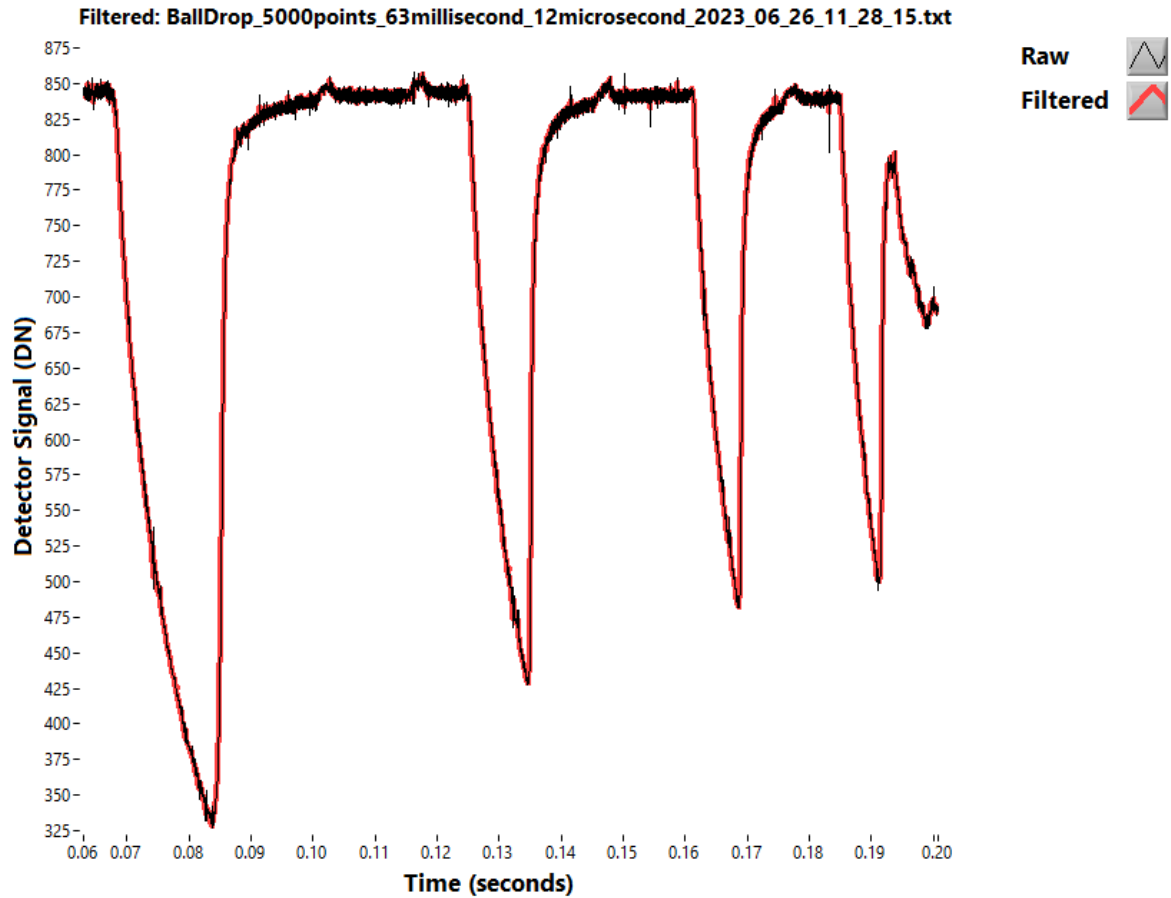
	Start	Beam 1	Beam 2	Beam 3	Beam 4
Minima Time (seconds)	0	0.083786	0.134593	0.168680	0.191298
Ball Top FIT (mm)	-0.035	35.196	89.662	140.213	179.964
Ball Top (mm)	0	35.000	90.000	140.000	180.000
$X_{fit} - X_{ball\ top}$ (mm)	-0.035	0.196	-0.338	0.213	-0.036

$$g_{expected} = 9.79472 \frac{m}{s^2}$$

$$g_{calc} - g_{expected} = -0.11304 \frac{m}{s^2}$$

Therefore: g_{calc} has a **-1.154% difference** from $g_{expected}$

Data Analysis Method (Filtered Minima)



Fit Option

X0 & V0 Vary

Box Car Size

3

Data Manipulation

Filtered

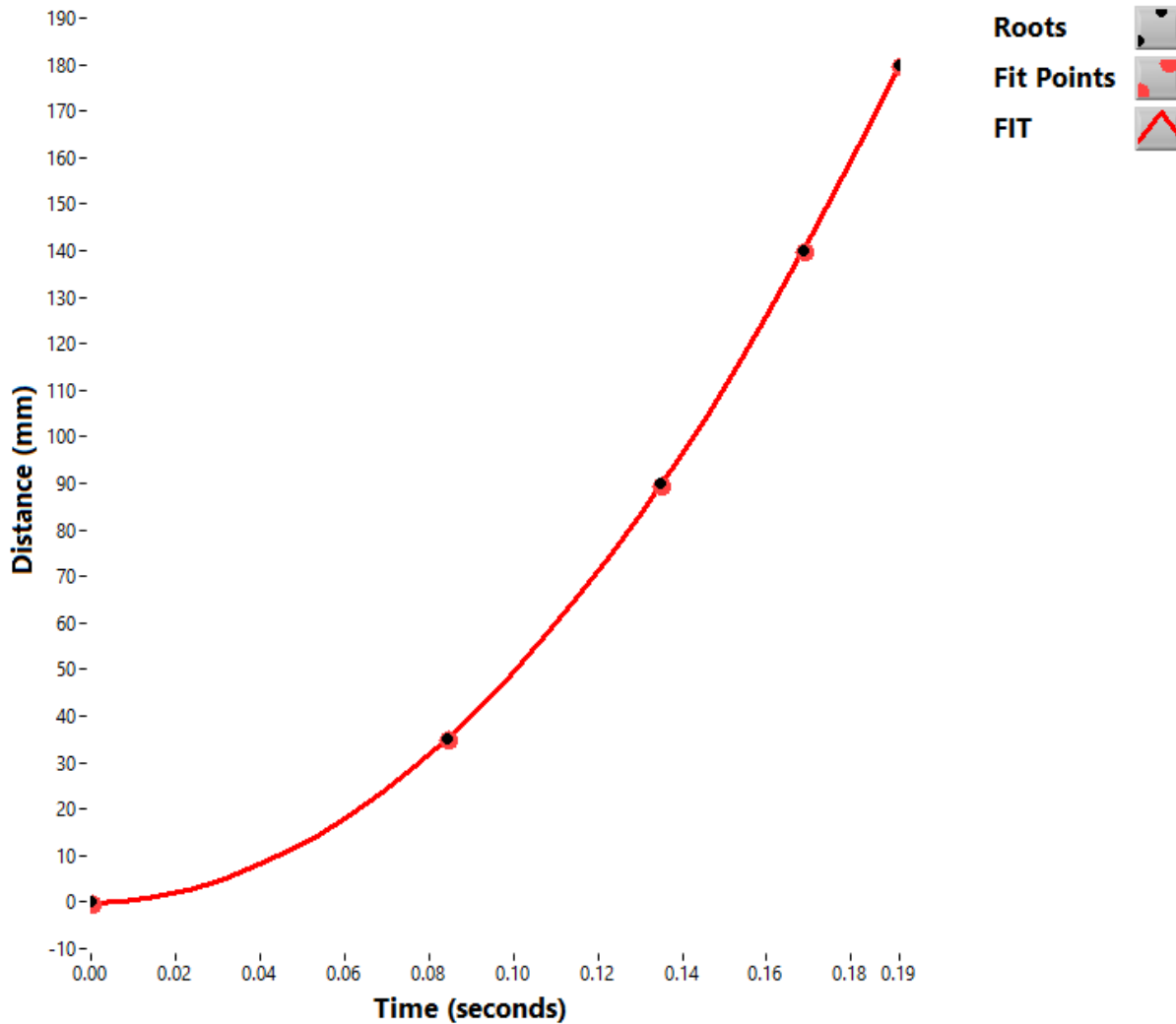
Point Selection

Minima

$$g_{calc} = 9.77286 \frac{m}{s^2}$$

Raw Fit Calc

Raw Fit Calc: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Parabolic Equation Fit To Tower Drop Data

$$X = -0.047mm + \left(5.465 \frac{mm}{s} \right) * t + 0.5 * \left(9772.861 \frac{mm}{s^2} \right) * t^2$$

X calculations from above parabolic fit will be within $\pm 0.234mm$ of the measured X data ~95% of the time using the 2sigma rule of thumb.

The formula for this 2sigma (2σ or 2 Standards of Deviation) calculation is detailed below

$$\sigma = \sqrt{\sum_{i=0}^{n-1} \left(\frac{(x_i - \mu)^2}{n-1} \right)} \quad \text{with mean equation: } \mu = \sum_{i=0}^{n-1} \left(\frac{x_i}{n} \right) \text{ where } n = 5$$

This σ equation assumes a normally distributed sample population.

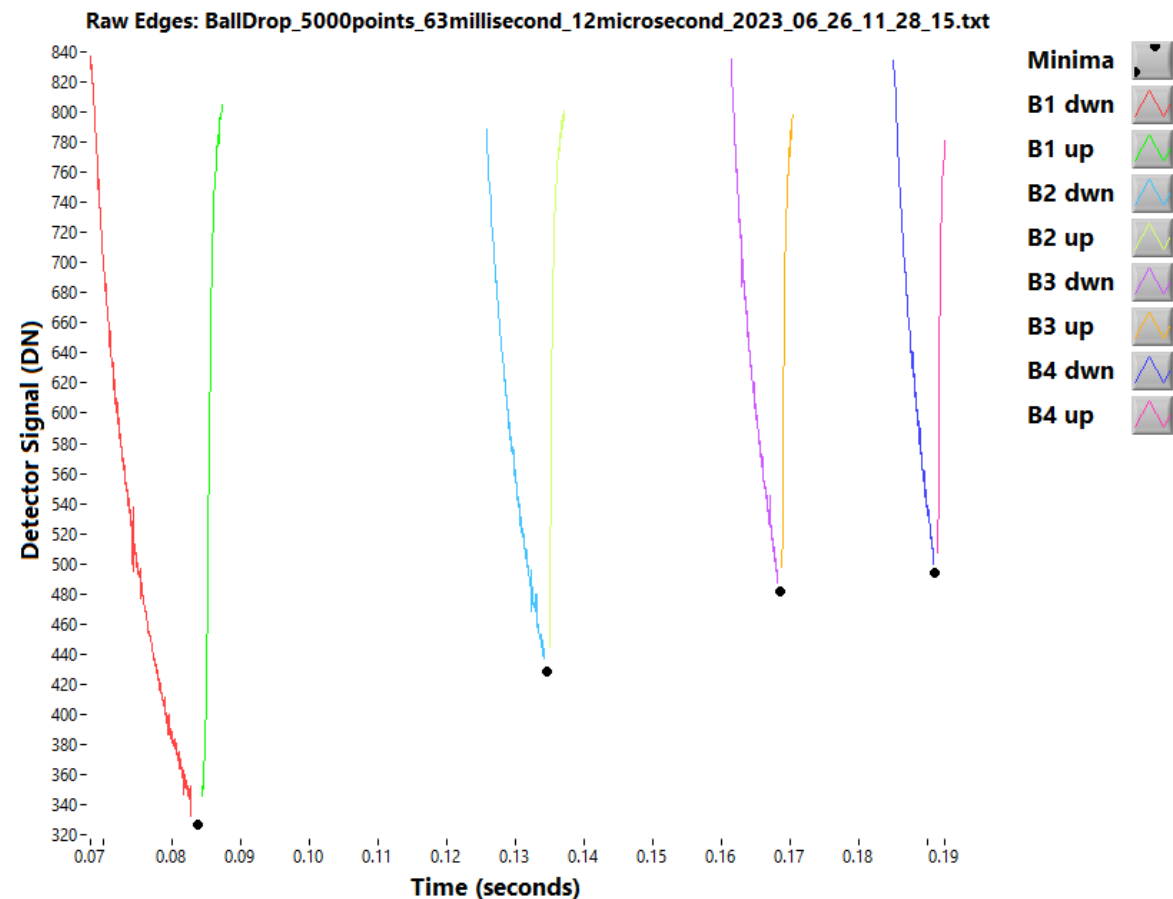
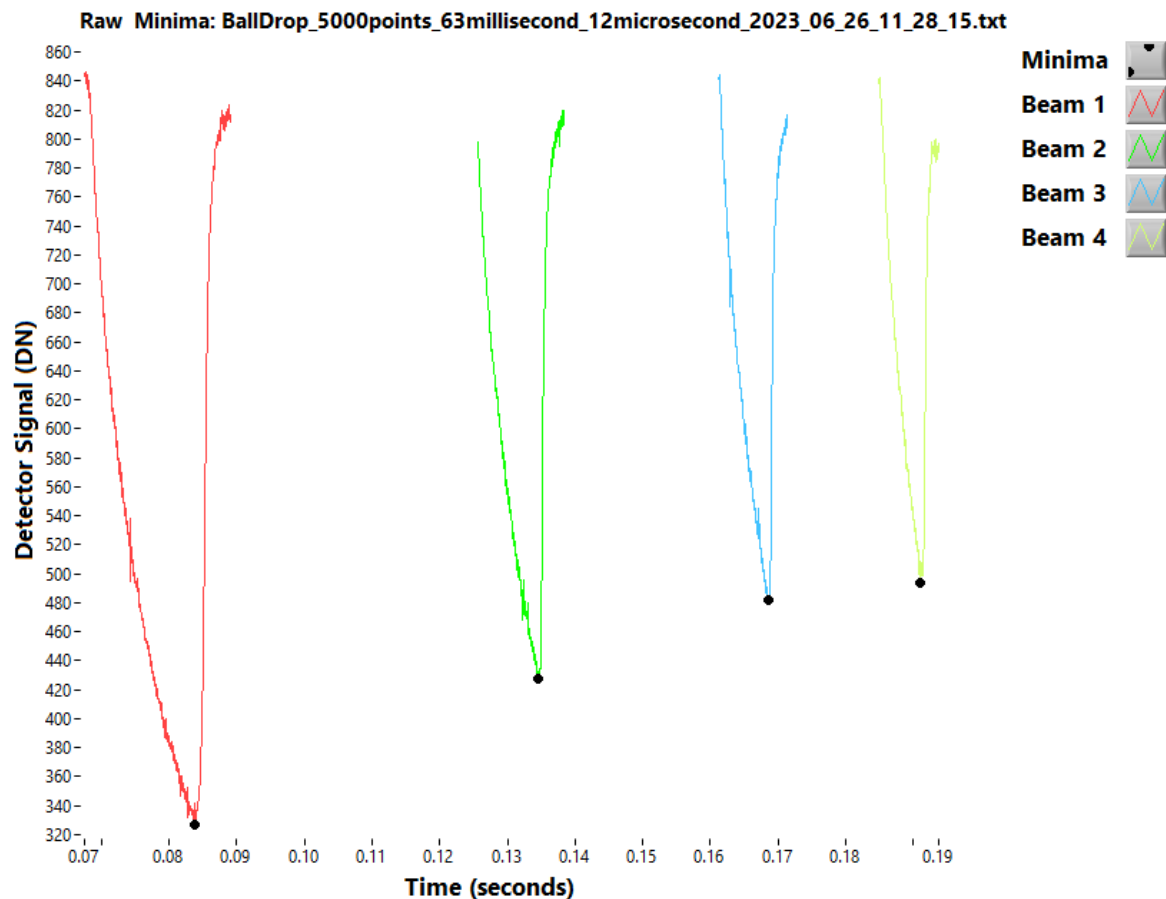
	Start	Beam 1	Beam 2	Beam 3	Beam 4
Roots Time (seconds)	0	0.084428	0.134915	0.168826	0.191405
Ball Top FIT (mm)	-0.047	35.245	89.634	140.150	180.017
Ball Top (mm)	0	35.000	90.000	140.000	180.000
$X_{fit} - X_{ball\ top}$ (mm)	-0.047	0.245	-0.366	0.150	0.017

$$g_{expected} = 9.79472 \frac{m}{s^2}$$

$$g_{calc} - g_{expected} = -0.02186 \frac{m}{s^2}$$

Therefore: g_{calc} has a **-0.223% difference** from $g_{expected}$

Data Analysis Method (Raw Poly Fit)

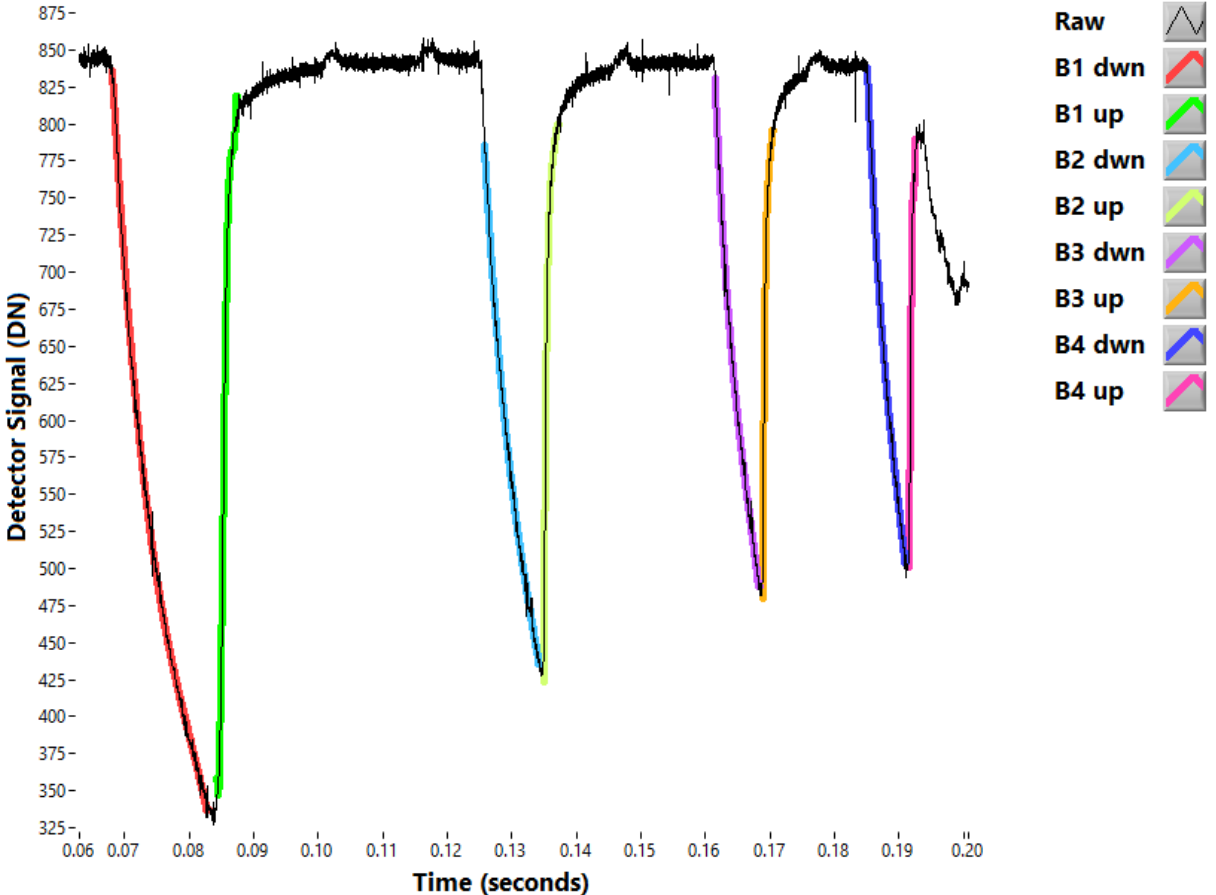


Fit Option	X0 & V0 Vary
Data Manipulation	Raw
Point Selection	Polynomial intersection

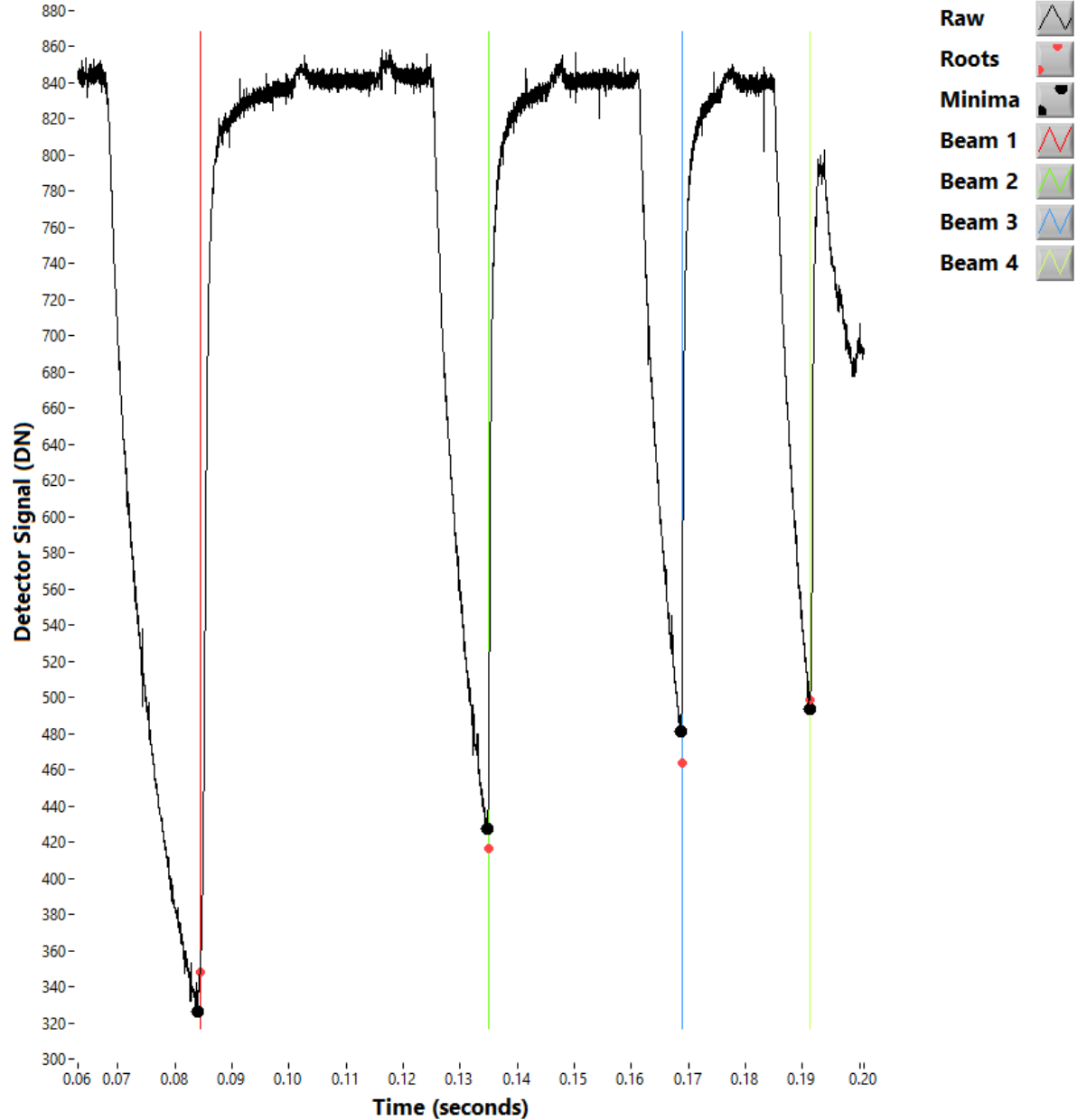
Polynomial Order Down	3 Orders
Region Down Start	10 Digital Number
Region Down End	10 Digital Number
Polynomial Order Up	4 Orders
Region Up Start	20 Digital Number
Region Up End	20 Digital Number

Data Fit Roots and Residuals

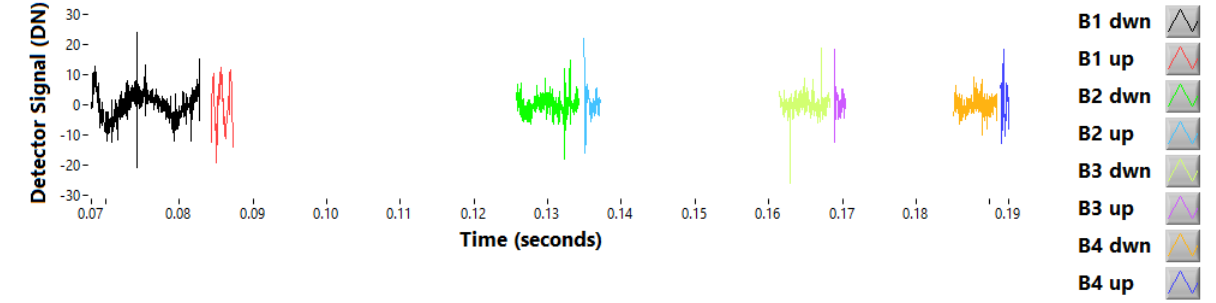
Raw Fit: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Raw Roots: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Raw Residual: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Polynomial Fit Equations

Beam 1 Down

$$Y = 73238.962 DN + \left(-2694954.947 \frac{DN}{s}\right) * t + \left(33444416.332 \frac{DN}{s^2}\right) * t^2 - \left(139256559.277 \frac{DN}{s^3}\right) * t^3$$

Beam 1 Up

$$Y = 2821369655.092 DN + \left(-131306065843.793 \frac{DN}{s}\right) * t + \left(2291434273437.613 \frac{DN}{s^2}\right) * t^2 - \left(17771108950875.441 \frac{DN}{s^3}\right) * t^3 + \left(51679765298998.391 \frac{DN}{s^4}\right) * t^4$$

Beam 2 Down

$$Y = 659155.903 DN + \left(-14741933.041 \frac{DN}{s}\right) * t + \left(110165551.779 \frac{DN}{s^2}\right) * t^2 - \left(274896185.526 \frac{DN}{s^3}\right) * t^3$$

Beam 2 Up

$$Y = -12998209053.397 DN + \left(+380608802429.585 \frac{DN}{s}\right) * t - \left(4179321007211.404 \frac{DN}{s^2}\right) * t^2 + \left(20396254591977.691 \frac{DN}{s^3}\right) * t^3 - \left(37327306950566.102 \frac{DN}{s^4}\right) * t^4$$

Beam 3 Down

$$Y = 3338957.657 DN + \left(-59951101.873 \frac{DN}{s}\right) * t + \left(359064516.508 \frac{DN}{s^2}\right) * t^2 - \left(717245410.474 \frac{DN}{s^3}\right) * t^3$$

Beam 3 Up

$$Y = -80352173814.908 DN + \left(+1889406342604.371 \frac{DN}{s}\right) * t - \left(16660357427374.064 \frac{DN}{s^2}\right) * t^2 + \left(65292105574492.984 \frac{DN}{s^3}\right) * t^3 - \left(95955135459086.797 \frac{DN}{s^4}\right) * t^4$$

Beam 4 Down

$$Y = 6295120.800 DN + \left(-99328479.788 \frac{DN}{s}\right) * t + \left(522671320.000 \frac{DN}{s^2}\right) * t^2 - \left(917131516.728 \frac{DN}{s^3}\right) * t^3$$

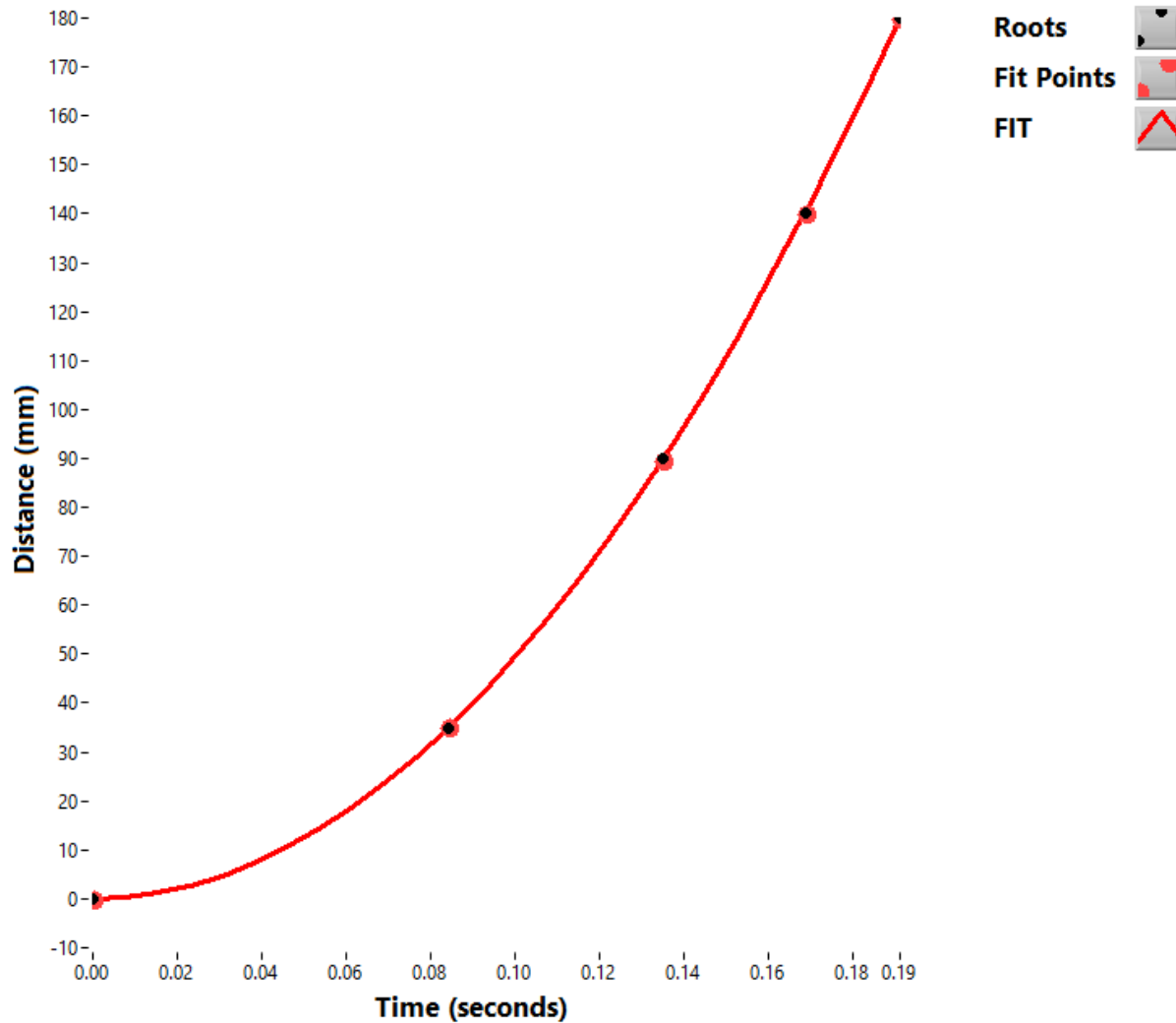
Beam 4 Up

$$Y = 1782579321355.564 DN + \left(-37136655710629.695 \frac{DN}{s}\right) * t + \left(290126228834841.312 \frac{DN}{s^2}\right) * t^2 - \left(1007366921479368.370 \frac{DN}{s^3}\right) * t^3 + \left(1311652101984458.000 \frac{DN}{s^4}\right) * t^4$$

$$g_{calc} = 9.80645 \frac{m}{s^2}$$

Filtered Fit Calc

Filtered Fit Calc: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Parabolic Equation Fit To Tower Drop Data

$$X = -0.034mm + \left(3.152 \frac{mm}{s} \right) * t + 0.5 * \left(9806.447 \frac{mm}{s^2} \right) * t^2$$

X calculations from above parabolic fit will be within $\pm 0.243mm$ of the measured X data ~95% of the time using the 2sigma rule of thumb.

The formula for this 2sigma (2σ or 2 Standards of Deviation) calculation is detailed below

$$\sigma = \sqrt{\sum_{i=0}^{n-1} \left(\frac{(x_i - \mu)^2}{n-1} \right)} \quad \text{with mean equation: } \mu = \sum_{i=0}^{n-1} \left(\frac{x_i}{n} \right) \text{ where } n = 5$$

This σ equation assumes a normally distributed sample population.

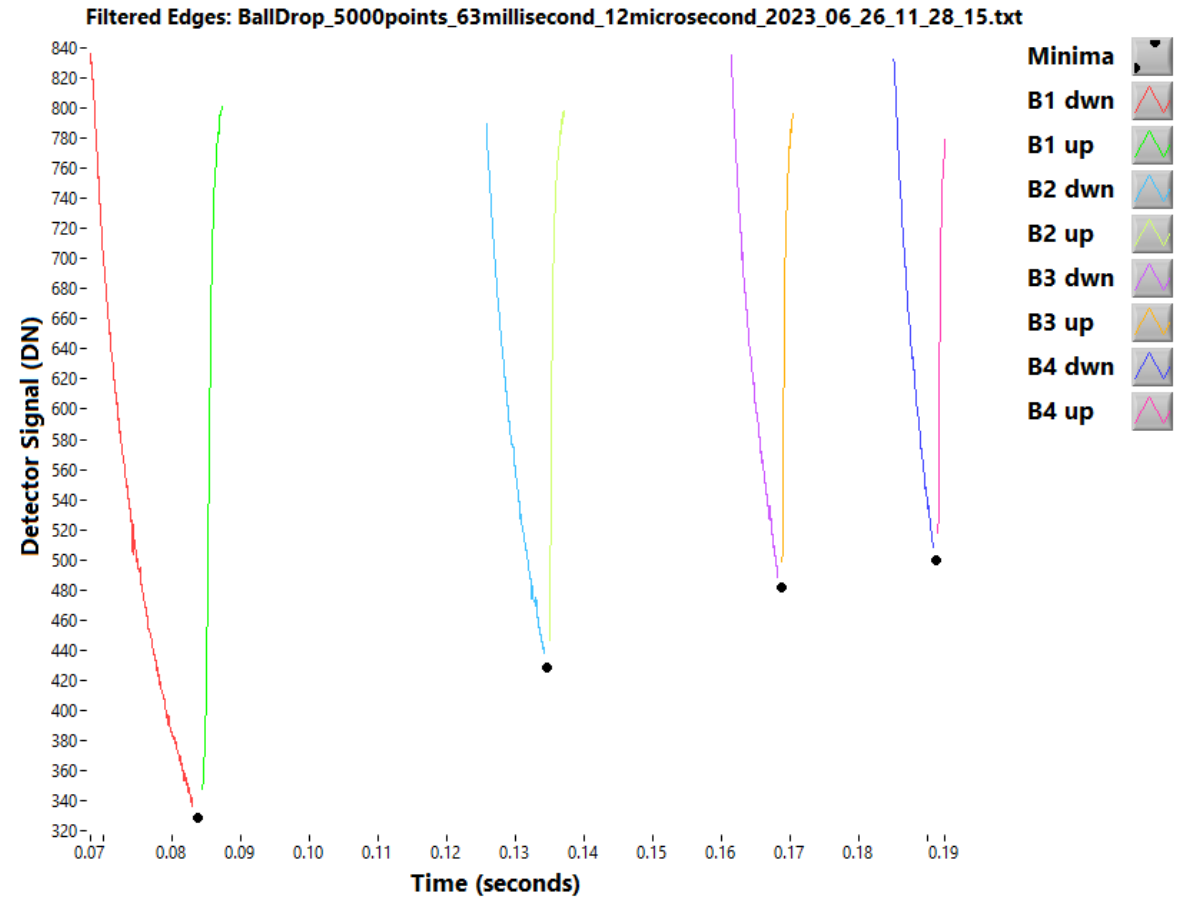
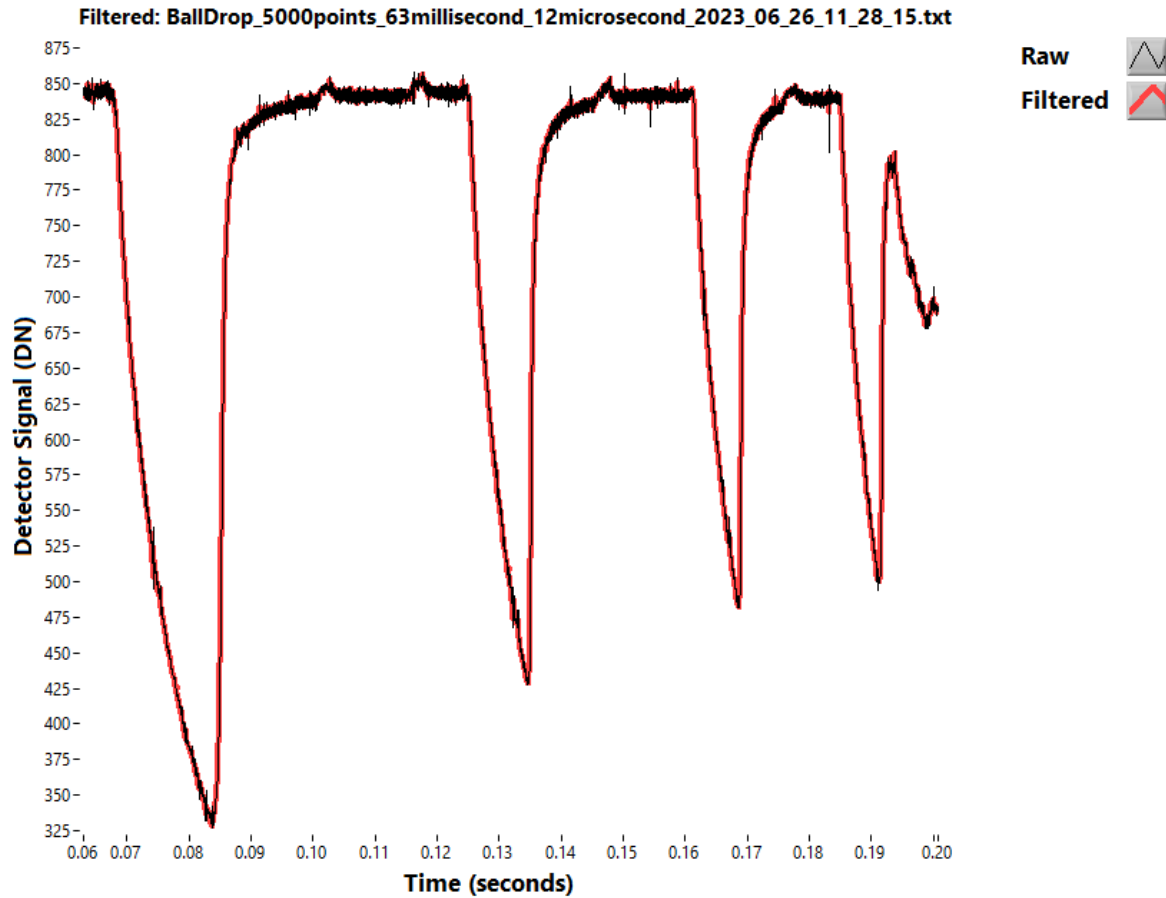
	Start	Beam 1	Beam 2	Beam 3	Beam 4
Roots Time (seconds)	0	0.084448	0.134915	0.168826	0.191268
Ball Top FIT (mm)	-0.034	35.199	89.639	140.250	179.946
Ball Top (mm)	0	35.000	90.000	140.000	180.000
$X_{fit} - X_{ball\ top}$ (mm)	-0.034	0.199	-0.361	0.250	-0.054

$$g_{expected} = 9.79472 \frac{m}{s^2}$$

$$g_{calc} - g_{expected} = 0.01173 \frac{m}{s^2}$$

Therefore: g_{calc} has a **0.120% difference** from $g_{expected}$

Data Analysis Method (Filtered Poly Fit)

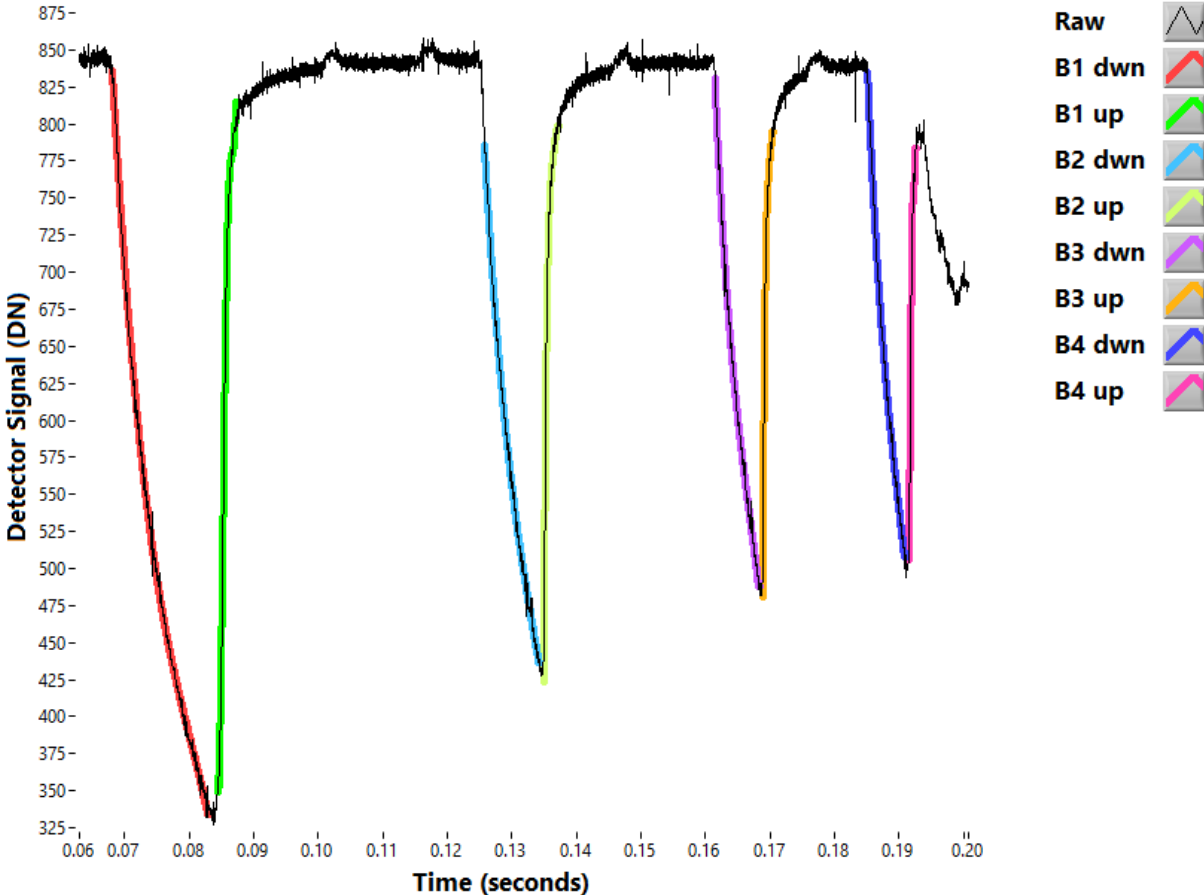


Fit Option	X0 & V0 Vary
Data Manipulation	Filtered
Box Car Size	3
Point Selection	Polynomial intersection

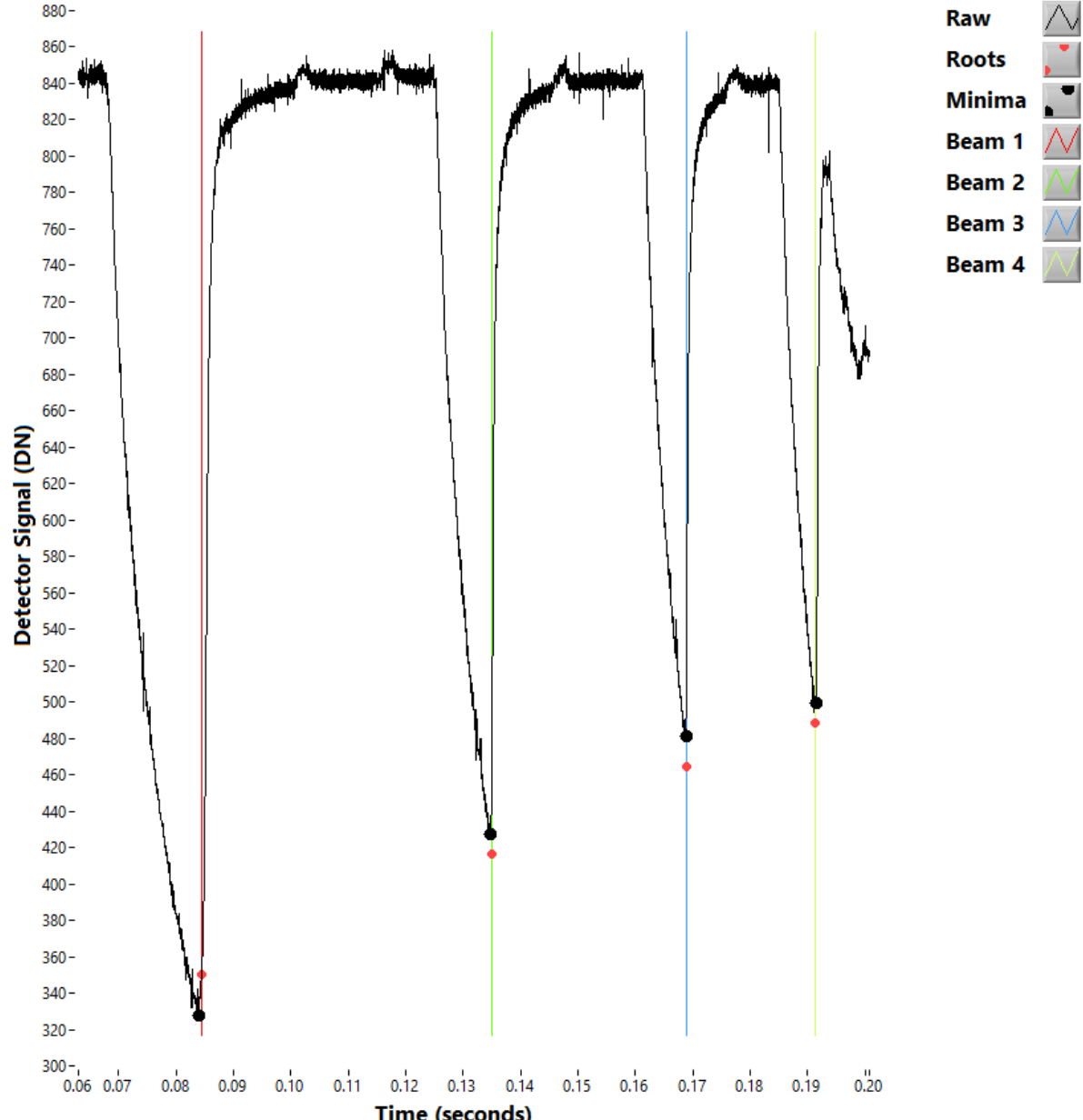
Polynomial Order Down	3 Orders
Region Down Start	10 Digital Number
Region Down End	10 Digital Number
Polynomial Order Up	4 Orders
Region Up Start	20 Digital Number
Region Up End	20 Digital Number

Data Fit Roots and Residuals

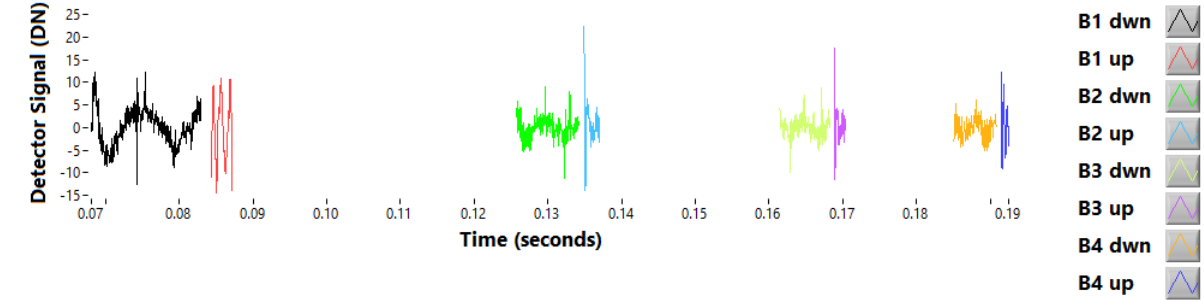
Filtered Fit: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Filtered Roots: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Filtered Residual: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Polynomial Fit Equations

Beam 1 Down

$$Y = 72499.253 DN + \left(-2665076.461 \frac{DN}{s}\right) * t + \left(33042723.235 \frac{DN}{s^2}\right) * t^2 - \left(137459109.601 \frac{DN}{s^3}\right) * t^3$$

Beam 1 Up

$$Y = 3099515517.970 DN + \left(-144288440273.888 \frac{DN}{s}\right) * t + \left(2518657520765.446 \frac{DN}{s^2}\right) * t^2 - \left(19538589732512.617 \frac{DN}{s^3}\right) * t^3 + \left(56835300041587.625 \frac{DN}{s^4}\right) * t^4$$

Beam 2 Down

$$Y = 663502.842 DN + \left(-14841324.830 \frac{DN}{s}\right) * t + \left(110922853.061 \frac{DN}{s^2}\right) * t^2 - \left(276819006.061 \frac{DN}{s^3}\right) * t^3$$

Beam 2 Up

$$Y = -12748162372.790 DN + \left(+373269763909.349 \frac{DN}{s}\right) * t - \left(4098544952592.409 \frac{DN}{s^2}\right) * t^2 + \left(20001126673769.273 \frac{DN}{s^3}\right) * t^3 - \left(36602506940588.836 \frac{DN}{s^4}\right) * t^4$$

Beam 3 Down

$$Y = 3318228.232 DN + \left(-59572402.066 \frac{DN}{s}\right) * t + \left(356758636.633 \frac{DN}{s^2}\right) * t^2 - \left(712565776.668 \frac{DN}{s^3}\right) * t^3$$

Beam 3 Up

$$Y = -80570178139.223 DN + \left(+1894640563942.718 \frac{DN}{s}\right) * t - \left(16707469119649.684 \frac{DN}{s^2}\right) * t^2 + \left(65480507823423.484 \frac{DN}{s^3}\right) * t^3 - \left(96237586154468.719 \frac{DN}{s^4}\right) * t^4$$

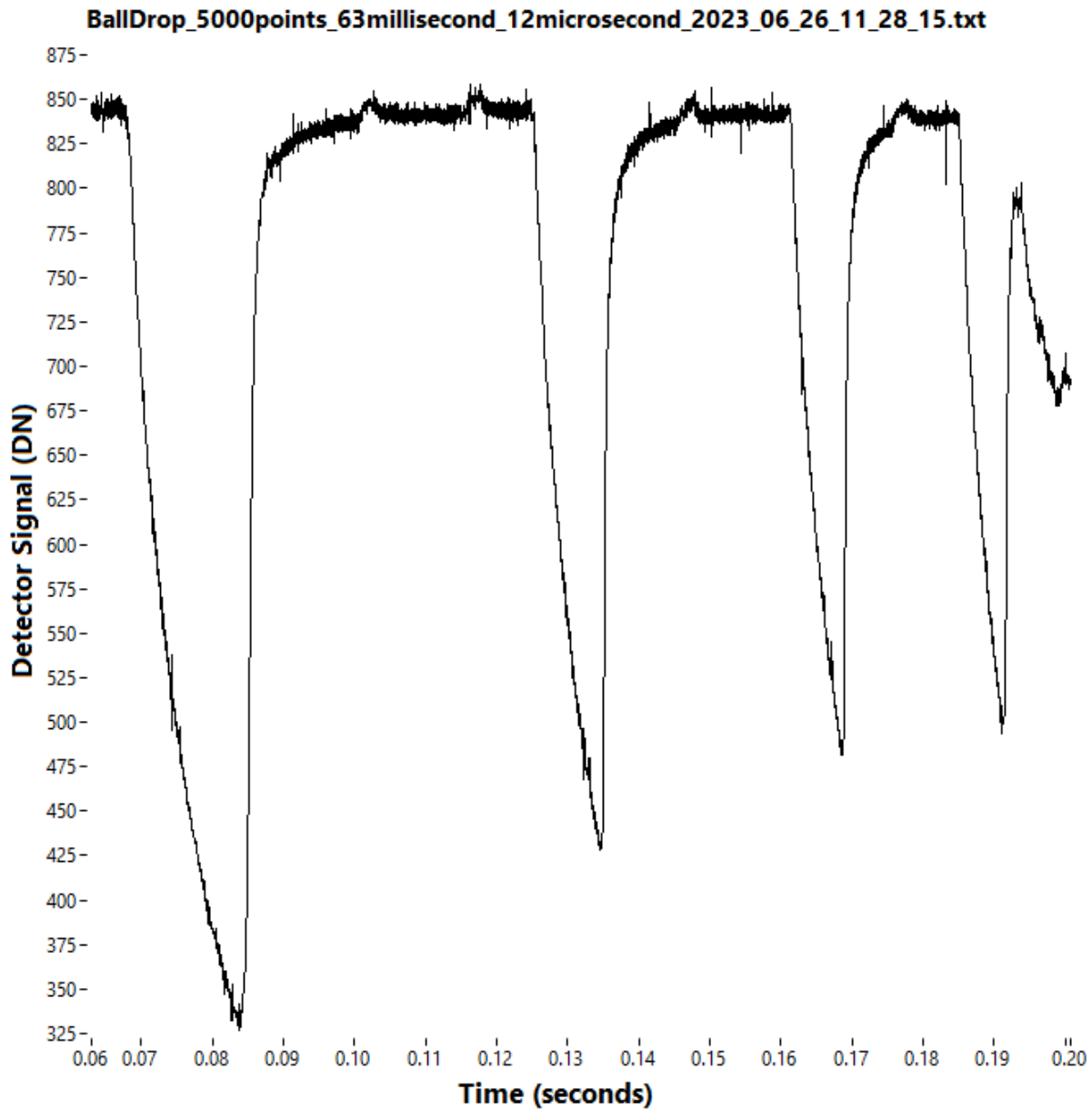
Beam 4 Down

$$Y = 6353839.155 DN + \left(-100260878.386 \frac{DN}{s}\right) * t + \left(527606274.503 \frac{DN}{s^2}\right) * t^2 - \left(925837510.676 \frac{DN}{s^3}\right) * t^3$$

Beam 4 Up

$$Y = 1509853826143.980 DN + \left(-31458527003198.949 \frac{DN}{s}\right) * t + \left(245794421568468.531 \frac{DN}{s^2}\right) * t^2 - \left(853536381392982.250 \frac{DN}{s^3}\right) * t^3 + \left(1111481450163357.620 \frac{DN}{s^4}\right) * t^4$$

Tower Drop File: BallDrop_5000points_63millisecond_12microsecond_2023_06_26_11_28_15.txt



Name	
Description	
Date	06/26/2023
Time	11:28:15
Mean Point Spacing	27.555μsec
DN min	327
DN max	327
point count	5000
Point to Point STDEV	0.544μsec
Latitude	39.921°
Altitude	5856ft
G Expected	$9.794719 \frac{m}{s^2}$
Mag Delay(msec)	63msec
Programmed Point Delay	63μsec
Ball Top Position	-25.000mm
Ball Diameter	12.690mm
Beam Diameter	3.800mm
Beam 1.000	10.000mm
Beam 2.000	65.000mm
Beam 3.000	115.000mm
Beam 4.000	155.000mm