An Engineering Approach to Precision Ammunition Development

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Background

Federal Premium – extensive experience with precision ammunition

- Gold Medal competition: 5.56mm, .308 Win, .300WM, .338LM
- Government contracts: MK316, MK248, Gold Medal .223 Rem, Gold Medal .308 Win

What would happen if you could more accurately predict how well ammunition would perform at long ranges based on data gathered from short range testing?

- Long range testing is time consuming and often impractical
- Accurately characterizing ammunition variables with real data allows manufacturers and customers to predict how long range ammunition performs in all environments and under all situations
- Enhances requirement specifications and customer relations

Overview

Data sets currently being analyzed

- Field testing: Weapon, human and ammunition interactions
- Controlled testing: Ammunition interactions
- Multiple calibers
  - .338LM
  - 300WM

Presenting a subset of .338LM field and controlled testing

- Abundant, readily available data

Photo courtesy of www.army.mil

Assumptions

Assumptions and hypothesis:

1. Increased velocity standard deviation will lead to increased vertical stringing
2. Computer modeling will closely match experimental results
3. Bullets will behave predictably throughout the flight path

Basic testing measurement procedures:

1. Ammunition will be characterized in controlled, lab conditions prior to field or range testing
2. Controlled testing to eliminate human variability
3. Field testing to include human variability
4. Handloaded and machine loaded ammunition will be tested
5. Minimize effects of wind drift variability by measuring vertical dispersion

Ammunition Characterizations

Description:

- Three types of ammunition tested under ‘Field’ conditions (FMK1, FMK2, and FMK3)
- Three types of ammunition testing under ‘Control’ conditions (CMK1, CMK2, CMK3)
- Control MK3 is a ballistic match to Field MK3

Test environment

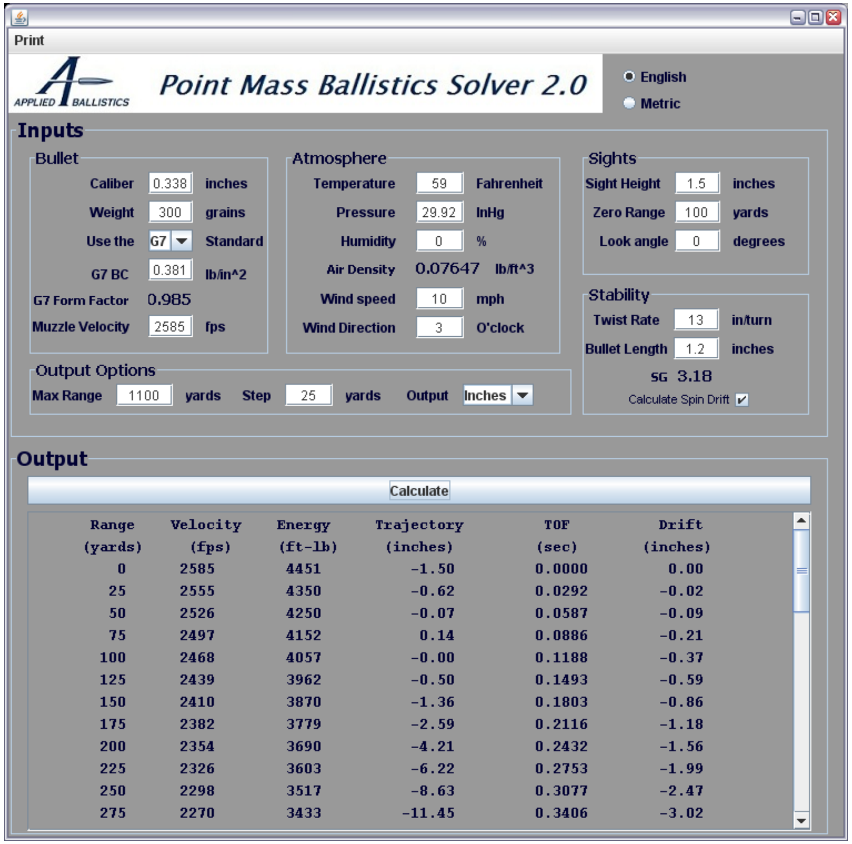
- Controlled environment:
  - Testing performed consecutively to minimize environmental inconsistency
  - 68-72 degree F, low-mid level humidity, known barometric pressure
  - Accuracy measured with Oehler Model 83 acoustic targeting system
  - SAAMI standard P&V testing procedures

Ammunition Type and Group	Average of VELOCITY	StdDev of VELOCITY	Average of VELOCITY MAX	Average of VELOCITY MIN	Average of VELOCITY ES	Average of ES GROUP	StdDev of ES GROUP	Average of %MOA GROUP
FMK1	**2585**	**2**	**2597**	**2573**	**24**	**1.087**	**0.22**	**52%**
Group 1	2582		2596	2574	22	1.240		59%
Group 2	2587		2604	2572	32	1.190		57%
Group 3	2584		2591	2573	18	0.830		40%
FMK2	**2622**	**4**	**2633**	**2614**	**19**	**0.937**	**0.41**	**45%**
Group 1	2624		2635	2617	18	0.980		47%
Group 2	2618		2629	2608	21	1.320		63%
Group 3	2625		2635	2618	17	0.510		24%
Grand Total	**2603**	**21**	**2615**	**2594**	**21**	**1.012**	**0.30**	**48%**

Computer Modeling Overview

Commercially available ballistics software

- Point Mass Ballistics Solver 2.0
  - Inputs include:
    - Caliber
    - Weight
    - Ballistics Coefficient
    - Muzzle Velocity
- Standard ICAO atmospheric conditions
- Similar results to PRODAS



Computer Modeling – Typical Field MK1

Ballistics:

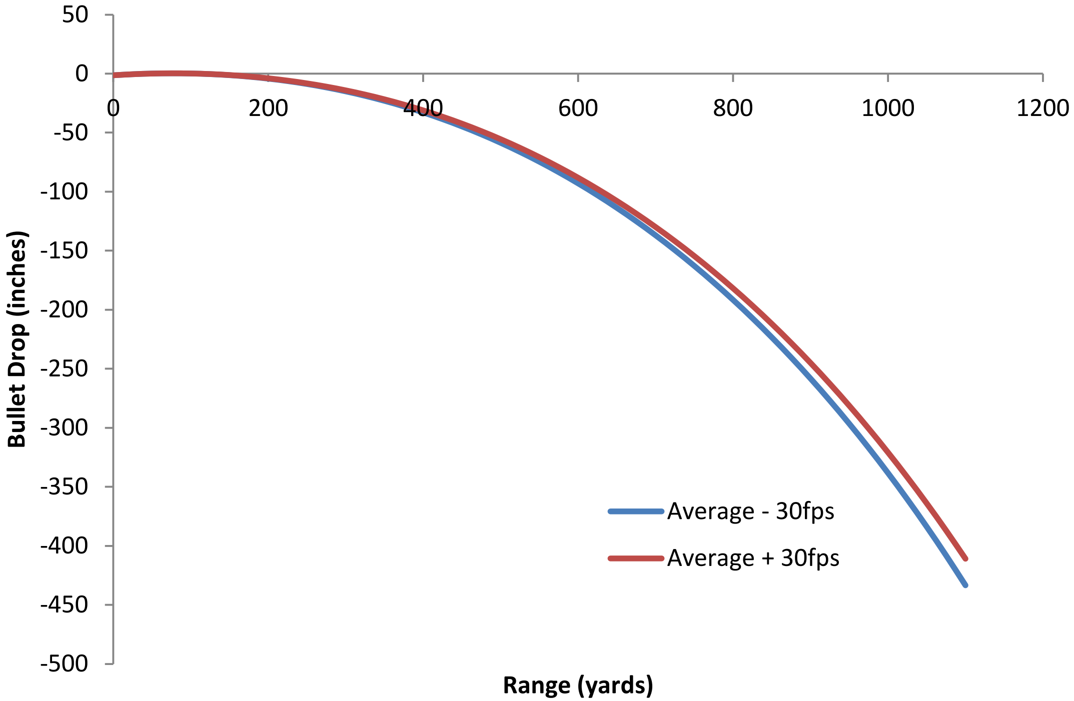
- G7 BC: 0.381; average velocity: 2585 fps
- Muzzle Velocity 1: 2555 fps (-30fps)
- Muzzle Velocity 2: 2615 fps (+30fps)

Atmospherics:

- Temperature: 59 degree F
- Pressure: 29.92 inHg
- Density: 0.07647 lb/ft^3

Predicted bullet drop (1,000yds):

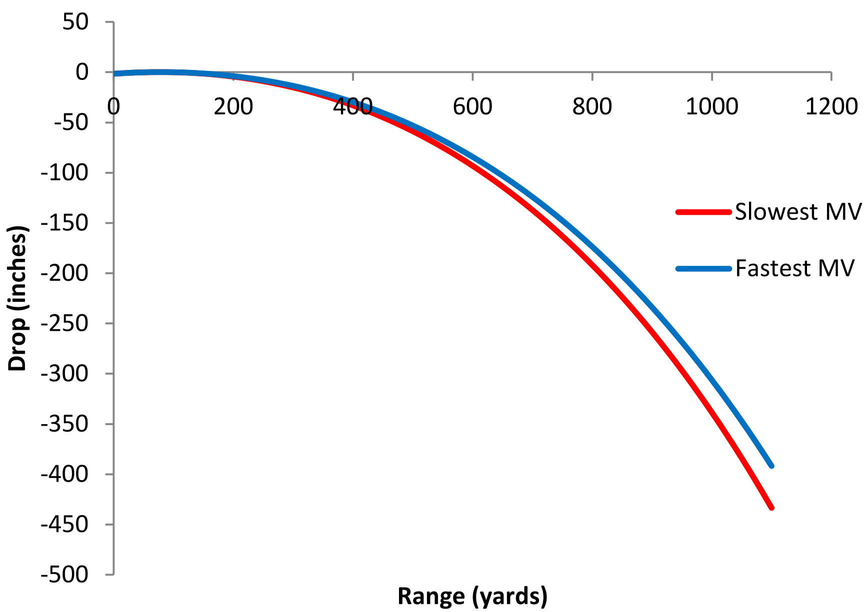
- Velocity 1: -339.92 in
- Velocity 2: -322.31 in
- Delta: 17.49 in

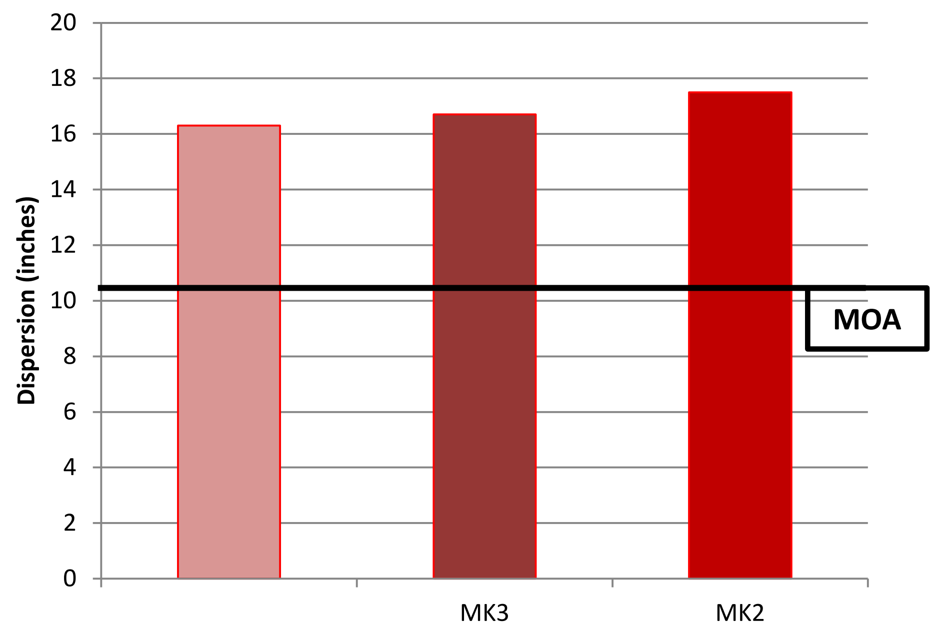


Computer Modeling – Field Ammunition

Significant difference between low velocity rounds and high velocity rounds

- Modeling indicates well over 1 MOA difference is possible just from velocity variation
  - Field MK1: 17.5 inches = 167% MOA
  - Field MK2: 16.7 inches = 160% MOA
  - Field MK3: 16.3 inches = 156% MOA



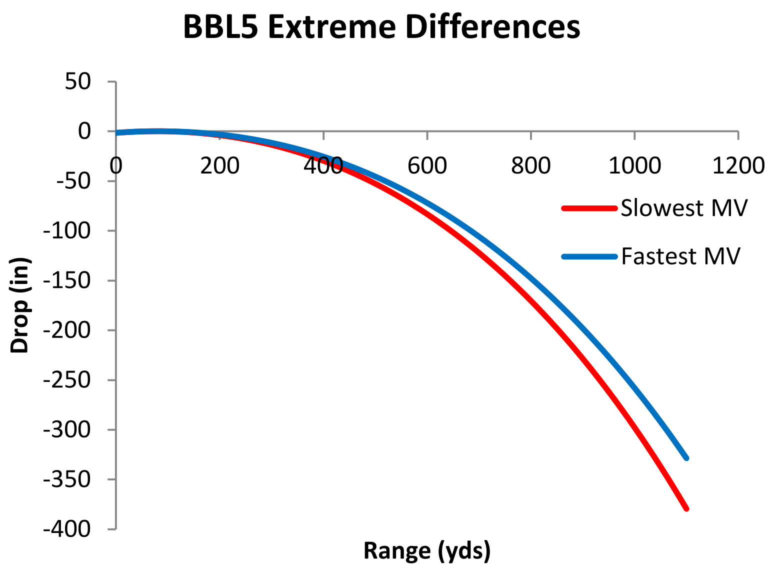


Computer Modeling – Control Ammunition

Computer modeling repeated with control ammunition - significant difference between low velocity rounds and high velocity rounds remains

– Well over 1 MOA difference is possible just from velocity variation

- 27" Barrel (BBL5)
  - » Control MK1: 12.92 inches = 123% MOA
  - » Control MK2: 16.7 inches = 160% MOA
  - » Control MK3: 16.3 inches = 156% MOA



- 24" Barrel (BBL6)
  - » Control MK1: 15.37 inches = 147% MOA
  - » Control MK2: 15.86 inches = 152% MOA
  - » Control MK3: 16.09 inches = 154% MOA

Field and Control Testing Predictions

Most obvious expected interaction:

– ‘Y’ impact vs. velocity

  - Direct correlation between vertical (‘Y’) impact and velocity
  - Velocity increase leads to high vertical (‘Y’) impact

Other interactions explored but not presented:

– ‘Y’ impact vs. shooter

– ‘Y’ impact vs. time of day

– Group size vs. barrel length

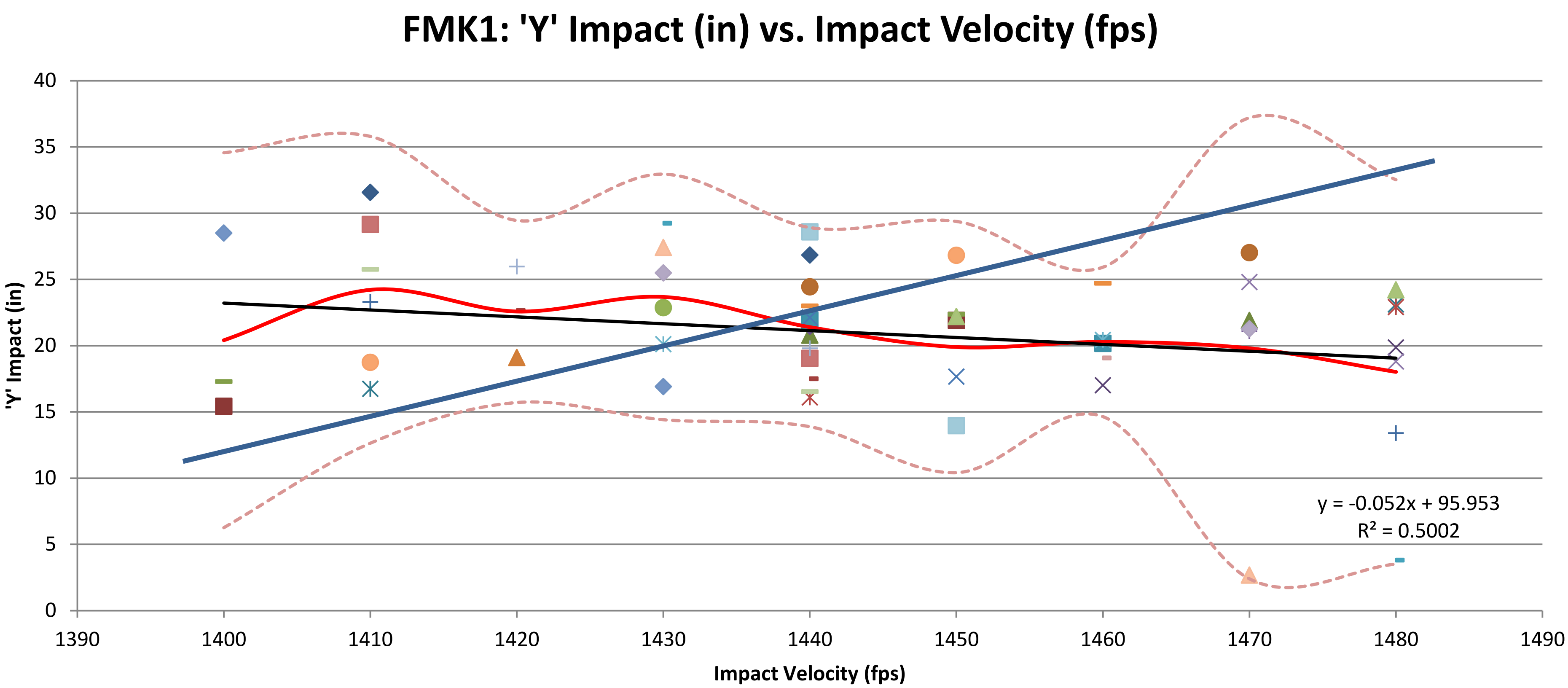
– Group size vs. time of day

– Etc.

Field Testing Overview

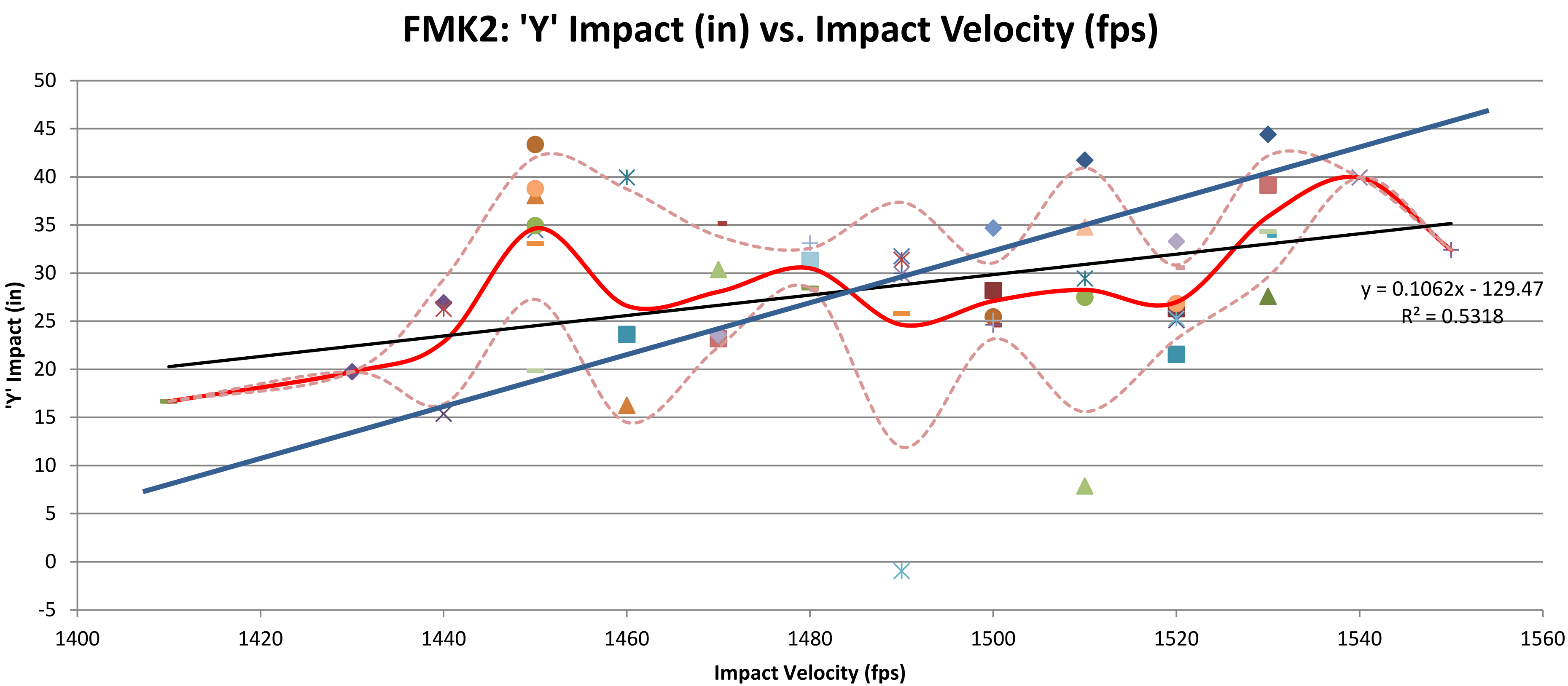
- Includes human error
  - Multiple experienced shooters
- Different variants of ammunition – ammunition optimized for rifle system; same ammunition used for computer modeling
  - Gathered target velocity
- Multiple rifles
  - Various manufacturers
  - Same make and model, nearly consecutive serial numbers
- 1,000 yard testing
  - Exact environmental data unavailable
    - » Field MK1 and MK2 – Overcast, light snow, constant 3-5 mph wind, 29-31 degree F
    - » Field MK3 – Clear, 4-10 mph wind, 34-35 degree F

‘Y’ Impact vs. Velocity: FMK1



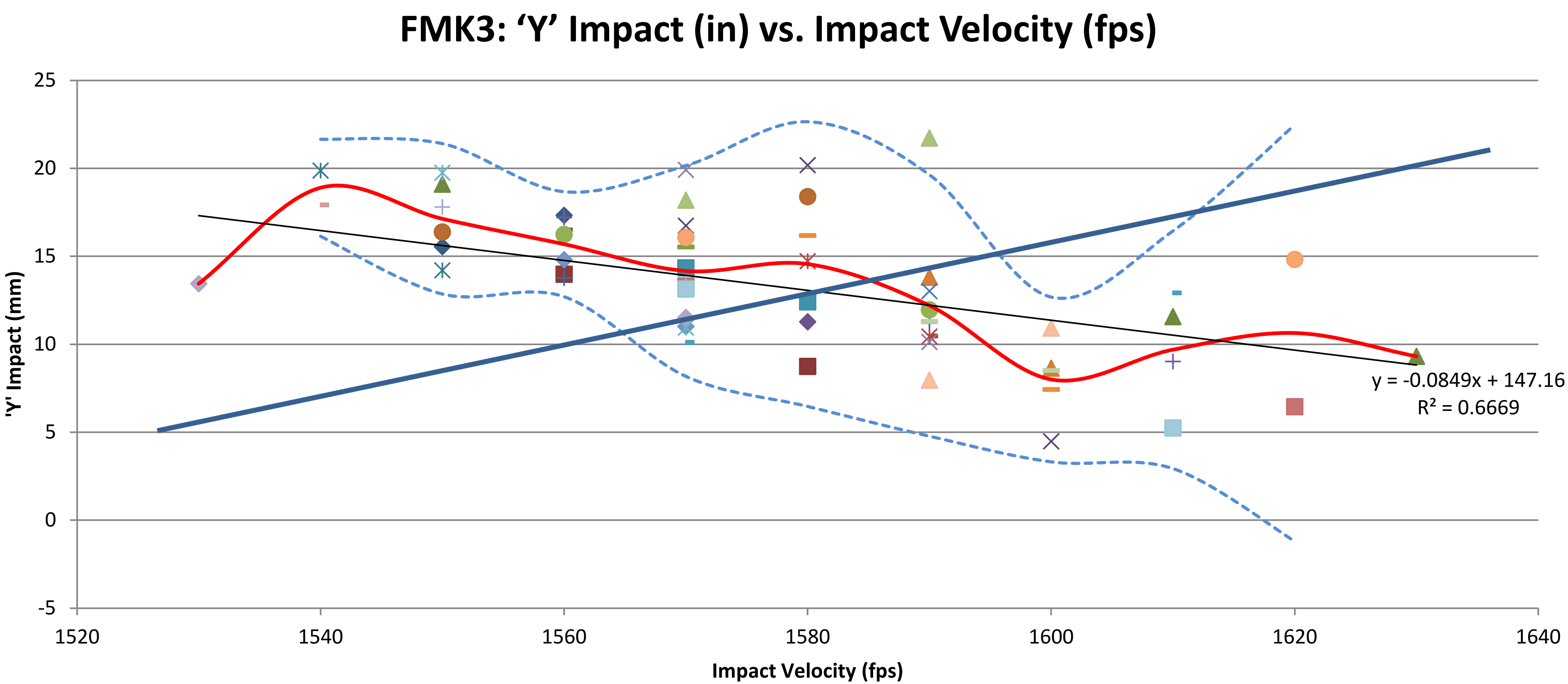
*Barrels plotted separately do not exhibit significantly different results

‘Y’ Impact vs. Velocity: FMK2



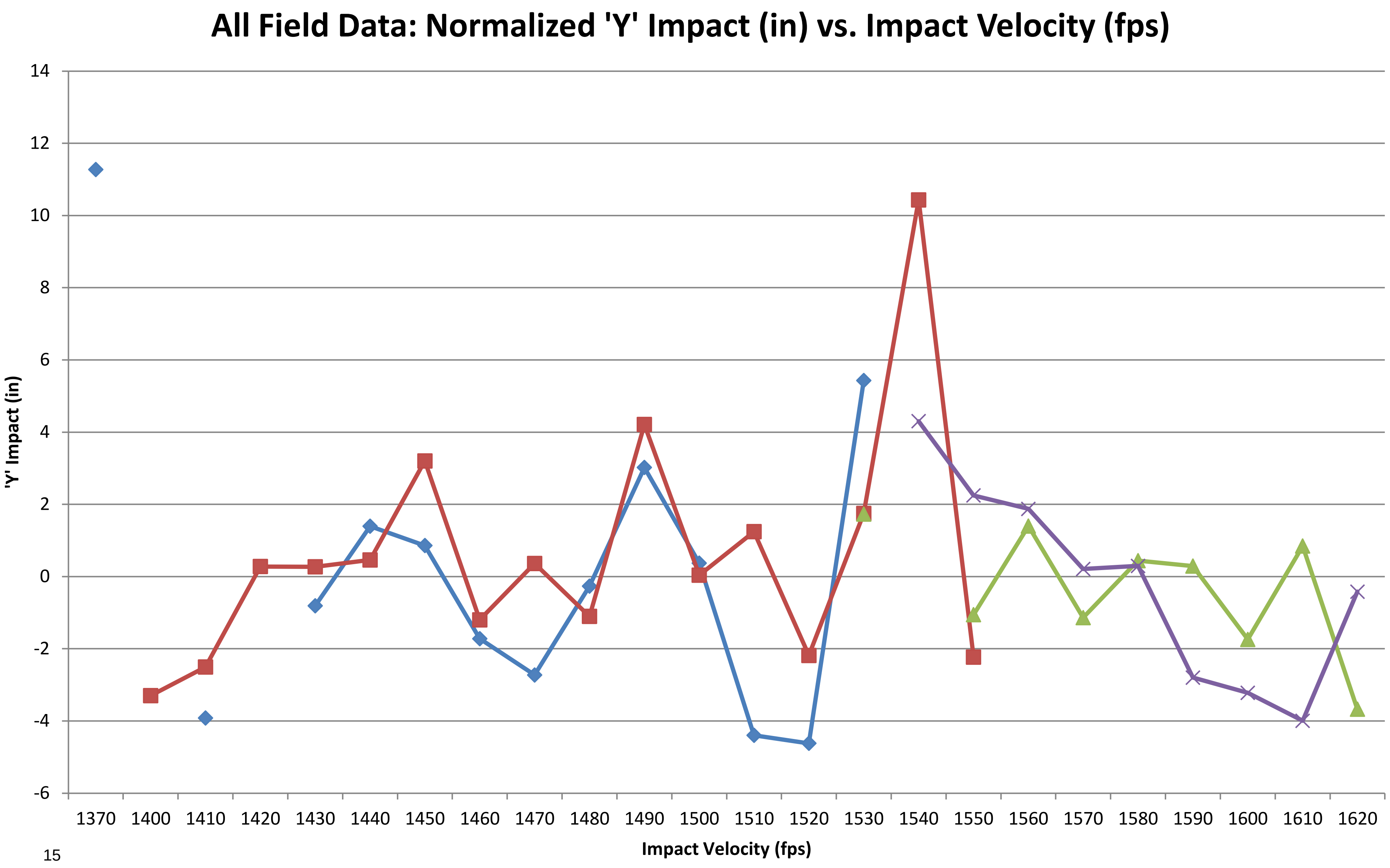
*Barrels plotted separately do not exhibit significantly different results

‘Y’ Impact vs. Velocity: FMK3



*Barrels plotted separately do not exhibit significantly different results

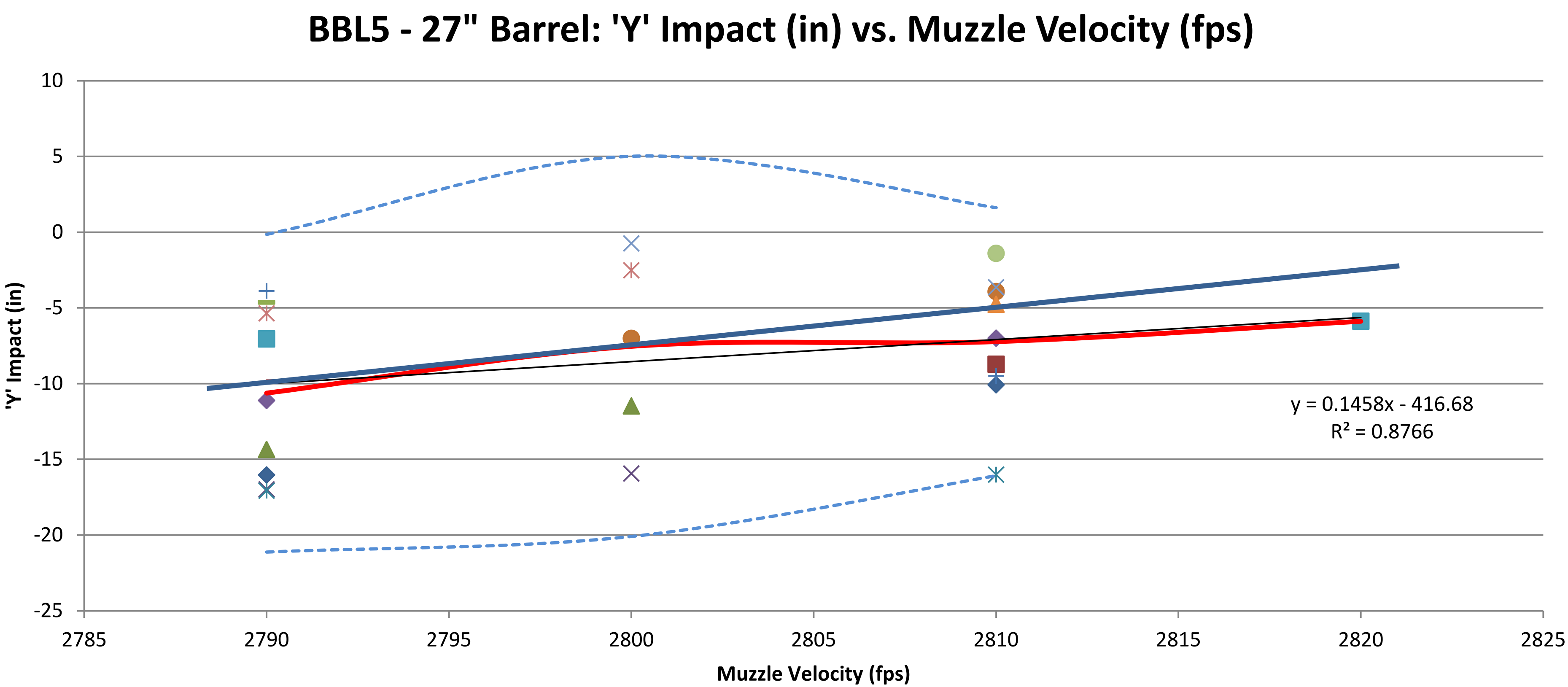
‘Y’ Impact vs. Velocity: Combined Field Data



Control Testing Overview

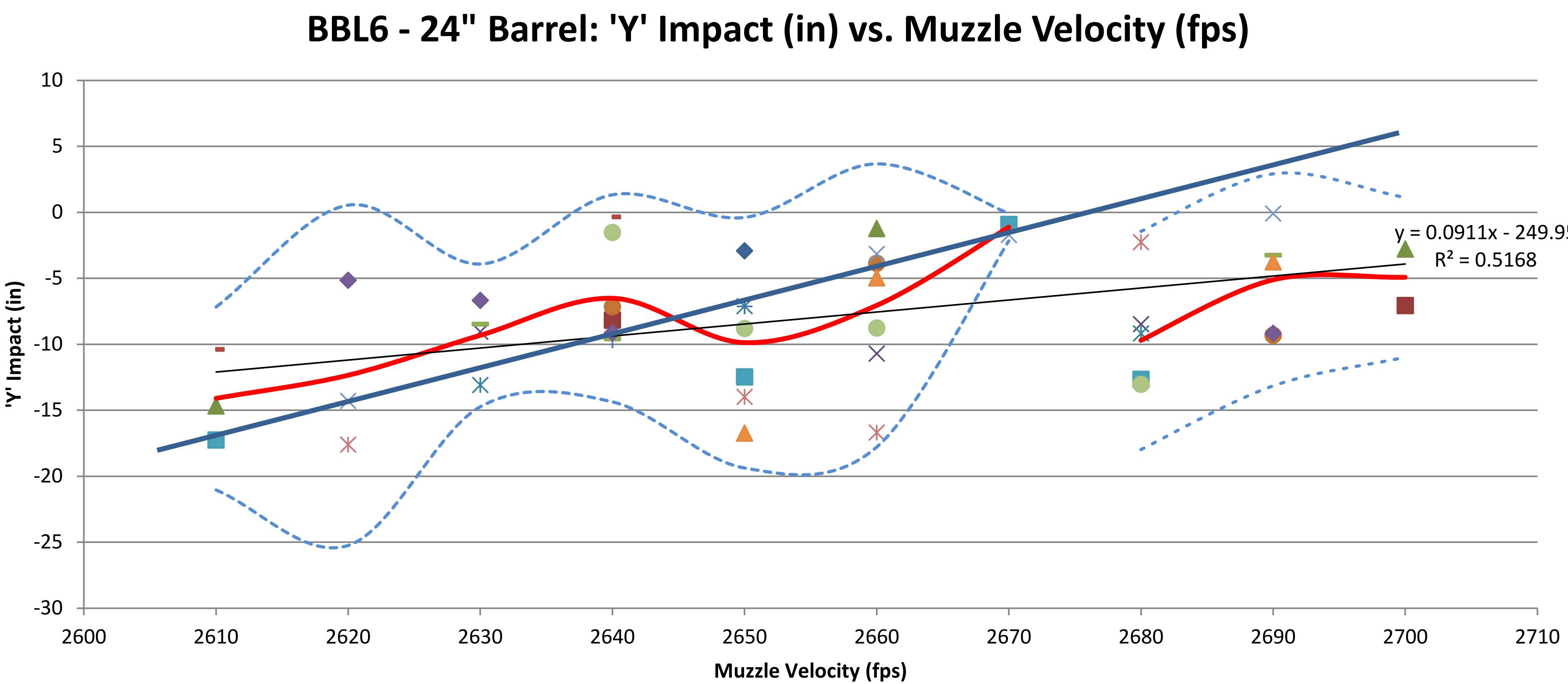
- Eliminates human error
  - Machine style rest
  - Fixed barrel: Two clamping points
- Three types of ammunition
  - Control MK1, 2, 3 (CMK1, CMK2, CMK3)
  - Muzzle velocity at 10 feet
- Multiple barrels
  - New accuracy barrels
  - Same make, consecutive serial numbers
- 1,000 meter testing
  - Exact environmental data collected
    - » BBL 5 (27" Barrel) – 89.06 degree F, 39.52% RH, 28.96 BP, 0-3 mph wind
    - » BBL 6 (24" Barrel) – 82.76 degree F, 57.3% RH, 28.85 BP, 0-3 mph wind

'Y' Impact vs. Velocity: Barrel 5



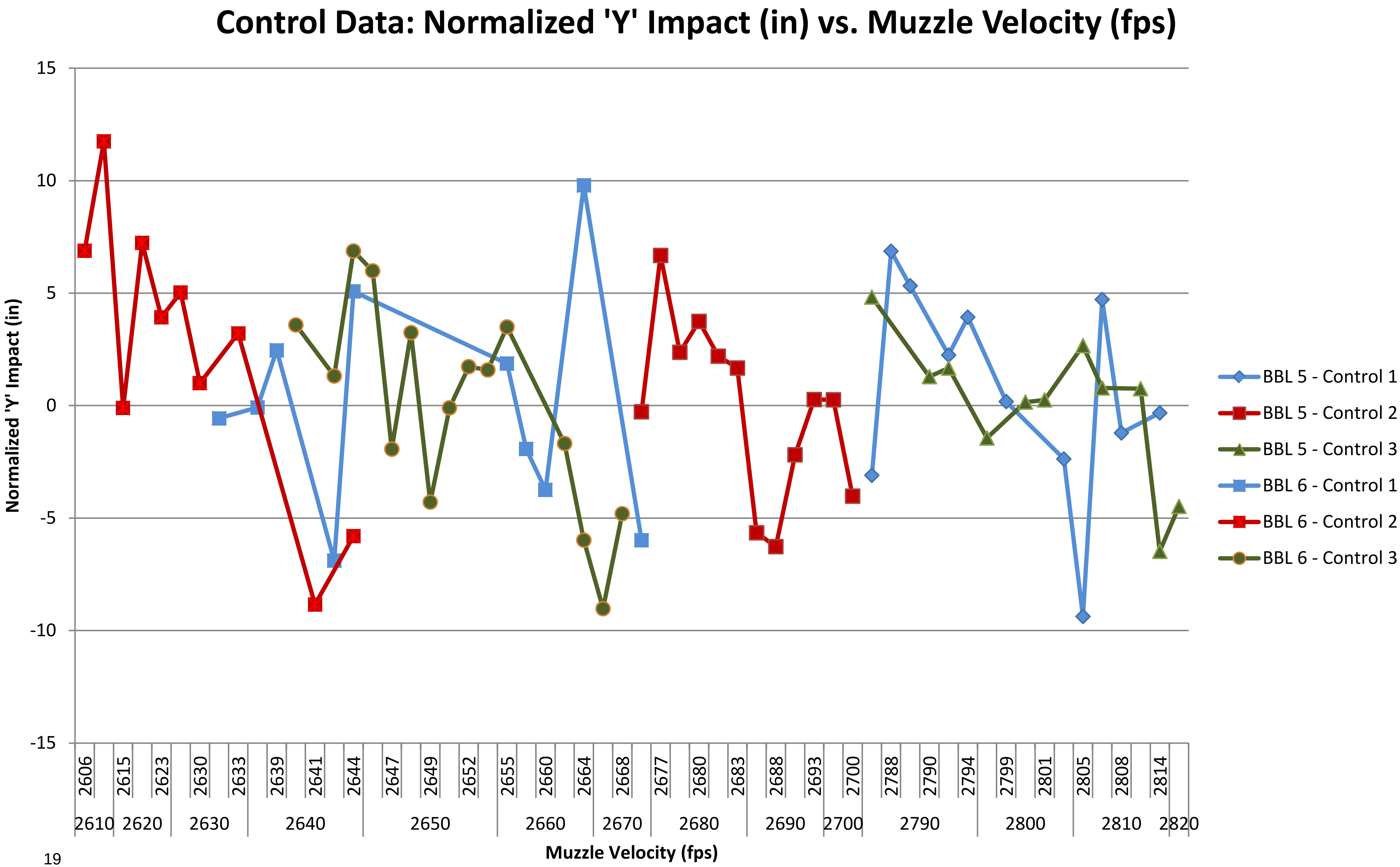
*Muzzle velocity taken at 10 feet from muzzle

‘Y’ Impact vs. Velocity: Barrel 6



*Muzzle velocity taken at 10 feet from muzzle

‘Y’ Impact vs. Velocity: Combined Control Data



Results, Conclusions, and Future Testing

Results:

1. No appreciable change in ‘Y’ axis impact at velocity extremes for field ammunition
2. Controlled data more closely matches predicted data with some unexplained anomalies
3. No appreciable difference in shooter interactions

Preliminary conclusions:

1. Velocity variation may be less important than weapons interactions in real world situations
2. Computer modeling may not accurately predict real world usage
3. Total systems approach to ammunition and weapons system design will enhance warfighter capabilities

Future testing:

1. Continue to incorporate data throughout testing cycles to confirm or invalidate conclusions
2. Characterize launch dynamics
   - System jump analysis, including muzzle pointing vector in relation to muzzle velocity

What are your questions?