Some Physics of Well Hit Balls

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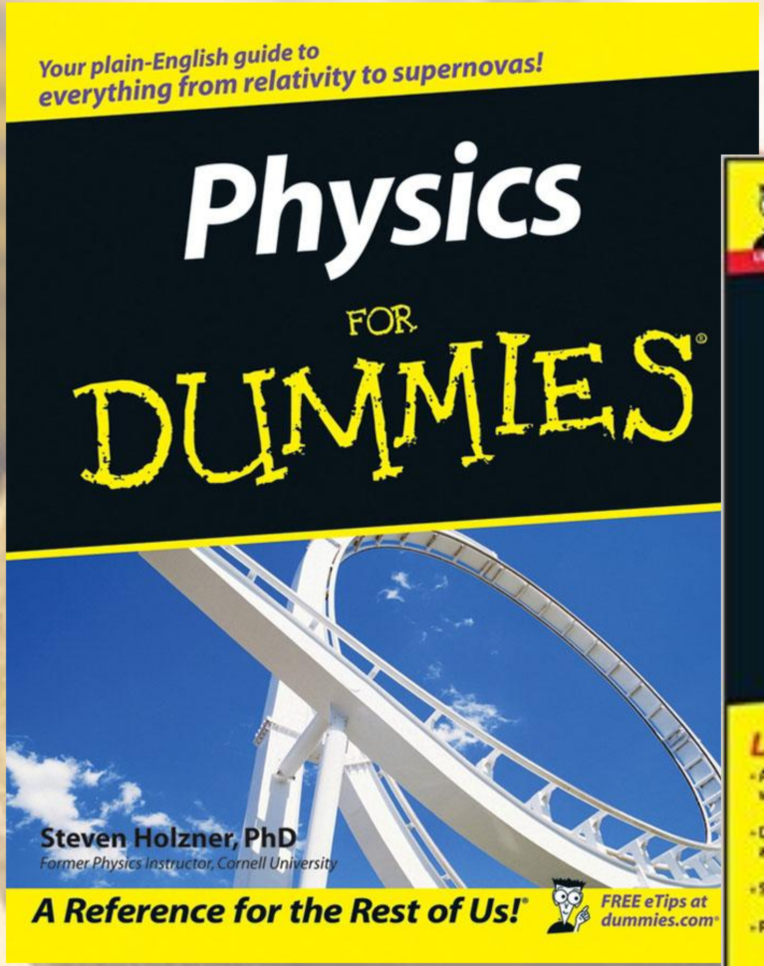
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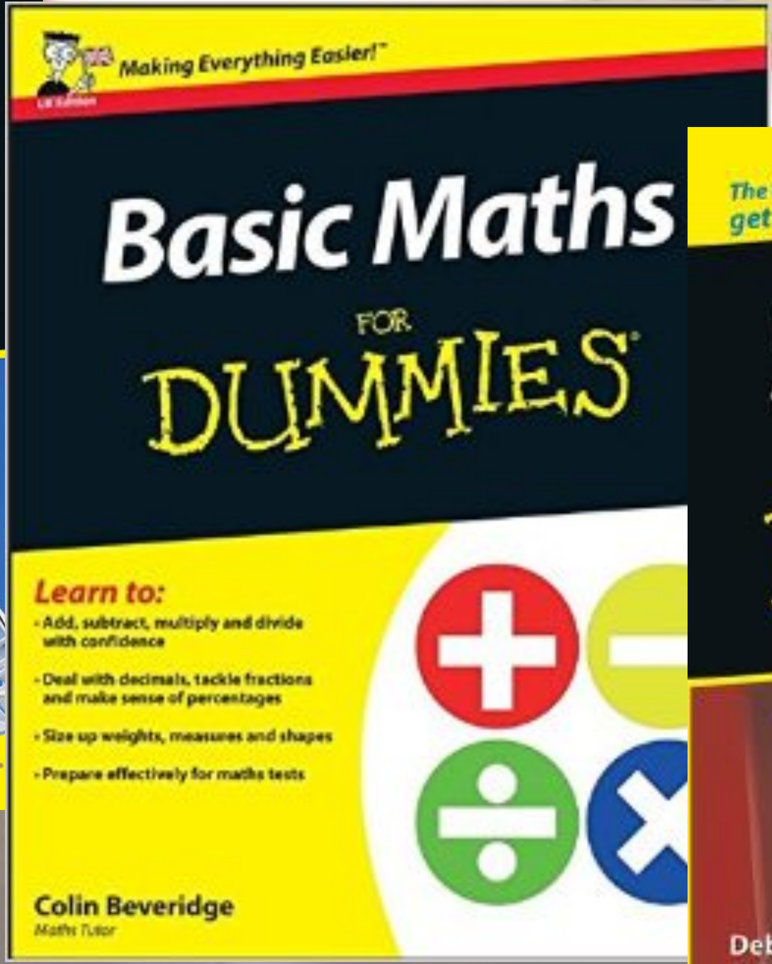
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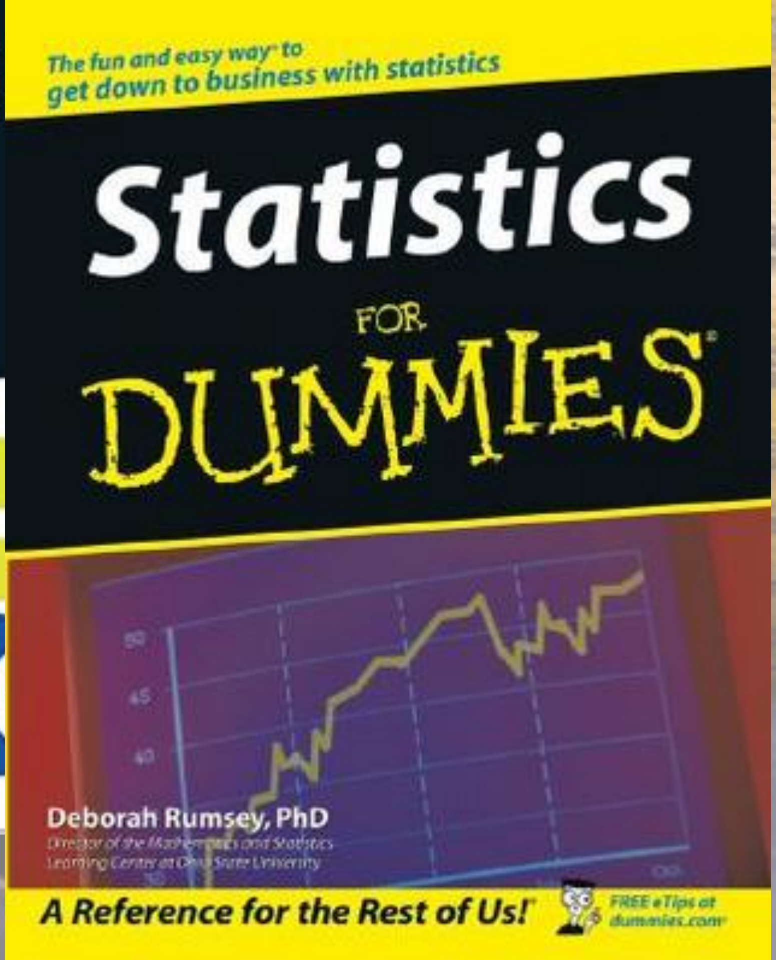
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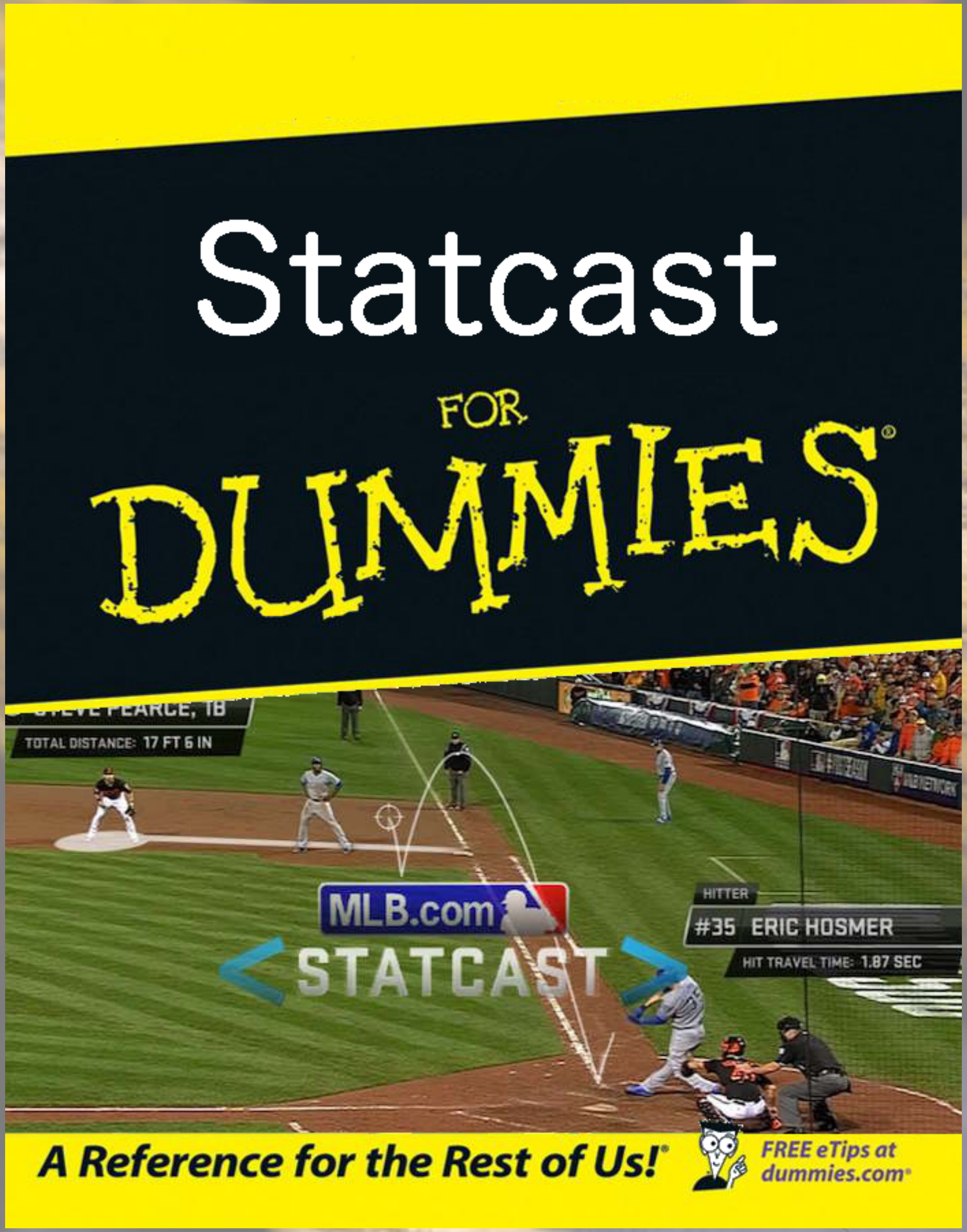

From the MLB.com Statcast Glossary

Statcast collects data using a series of high-resolution optical cameras along with radar equipment. The technology precisely tracks the location and movements of the ball and every player on the field, resulting in an unparalleled amount of information covering everything from the pitcher to the batter to baserunners and defensive players.

Two Pieces of the 2015 Data Set to be Used:

Exit velocity: Velocity of the ball off the bat on batted balls.

Launch angle: The vertical angle at which the ball leaves the bat on a batted ball.

Statcast FOR DUMMIES

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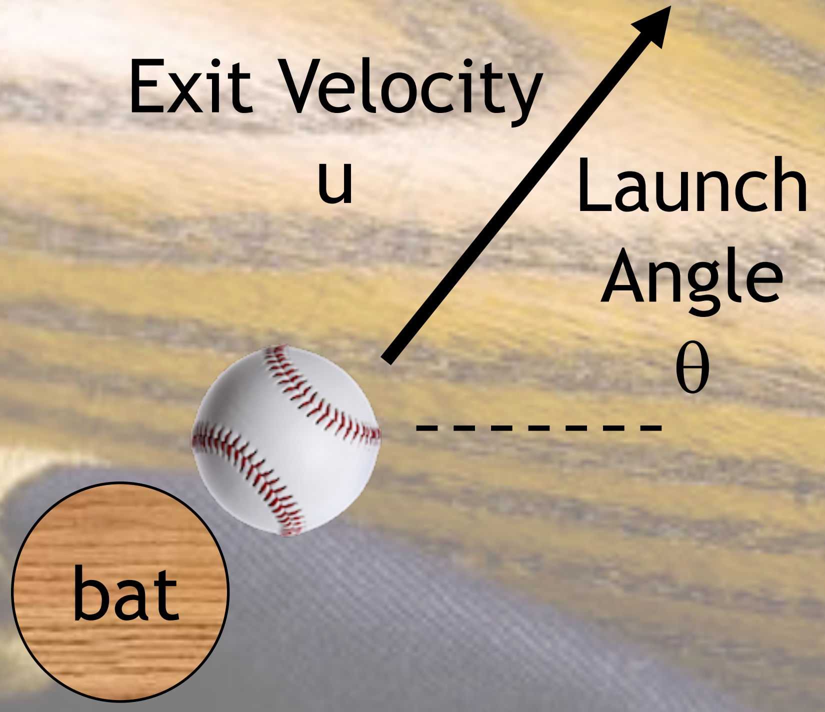
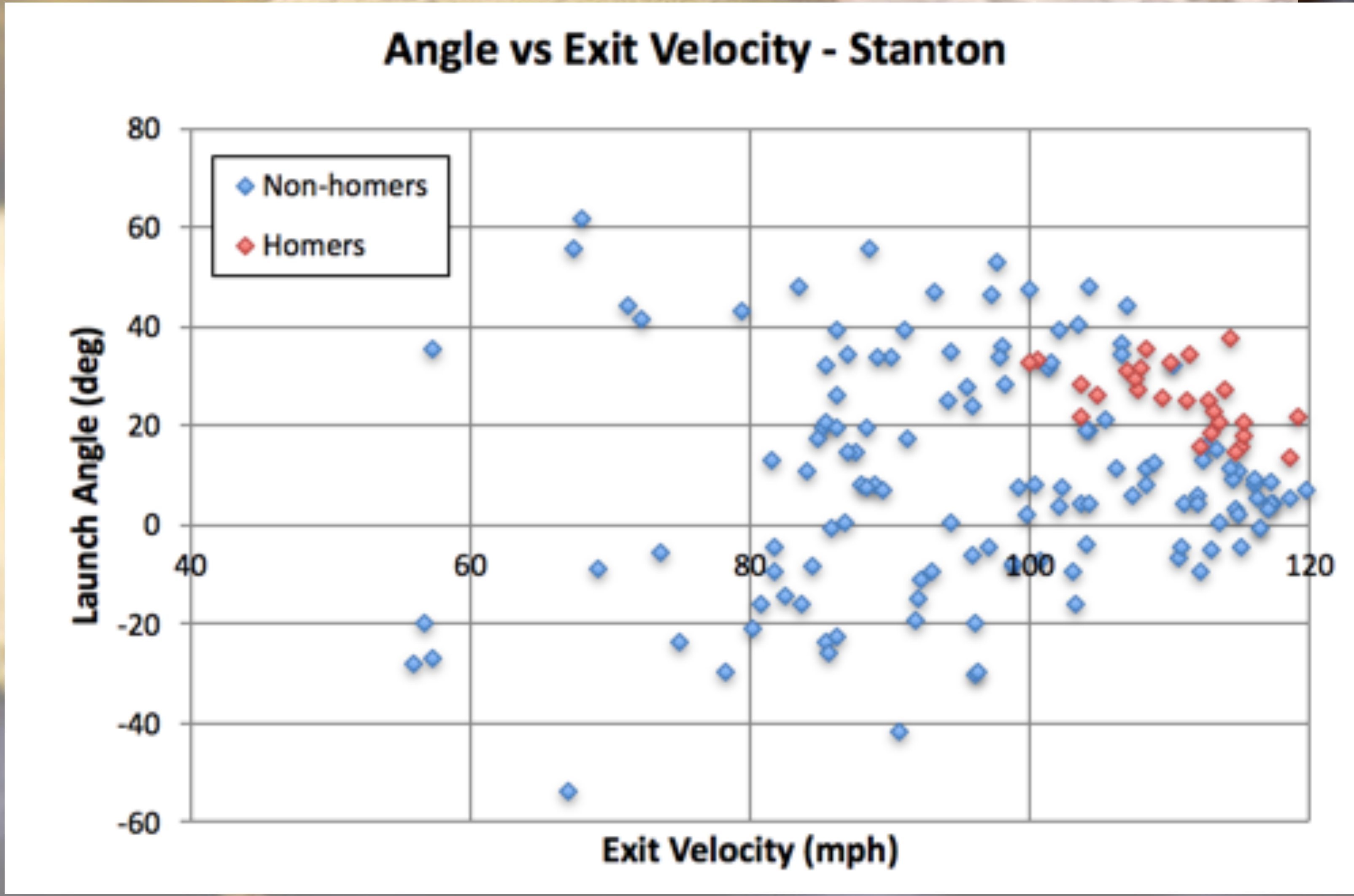
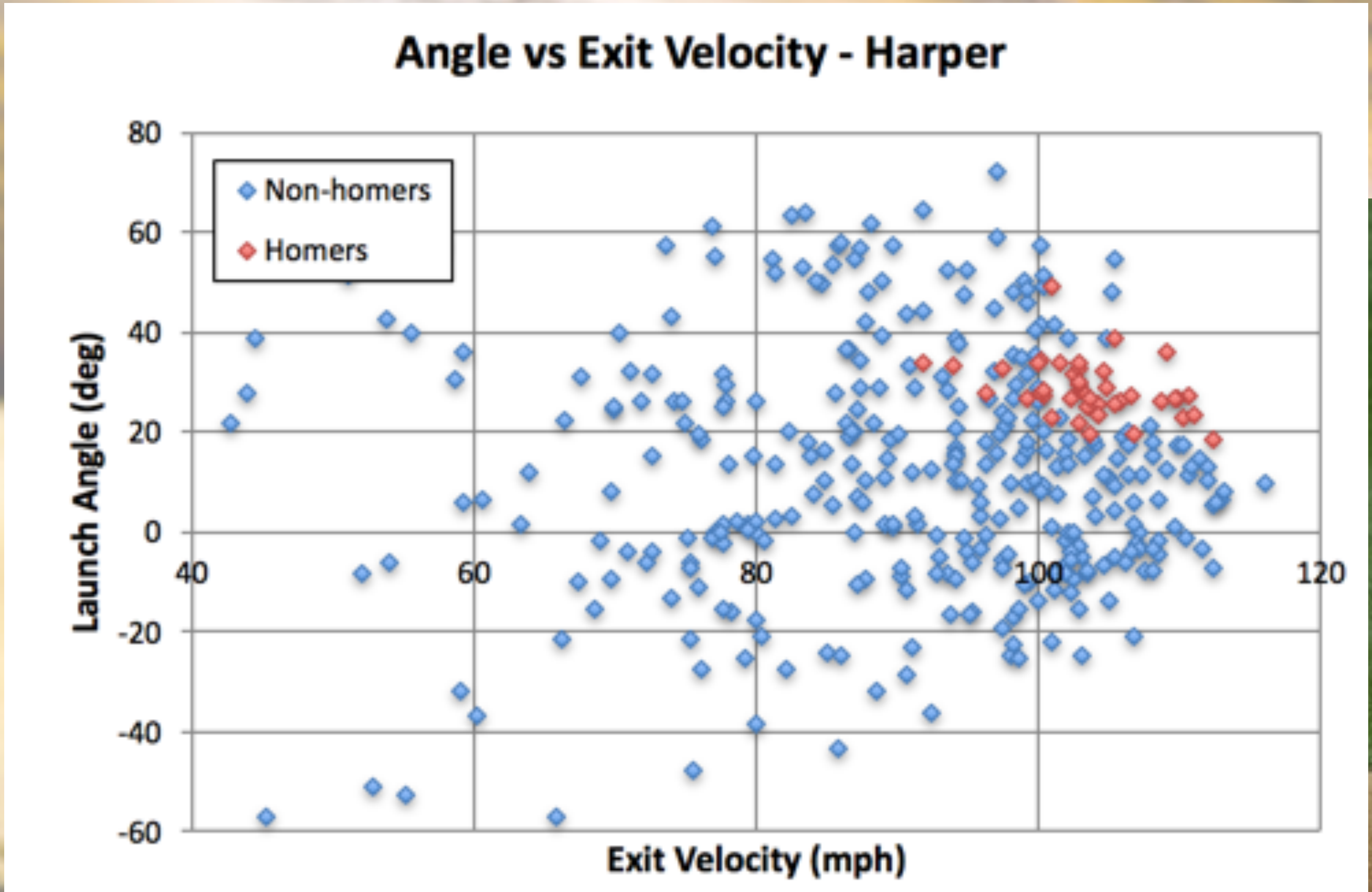
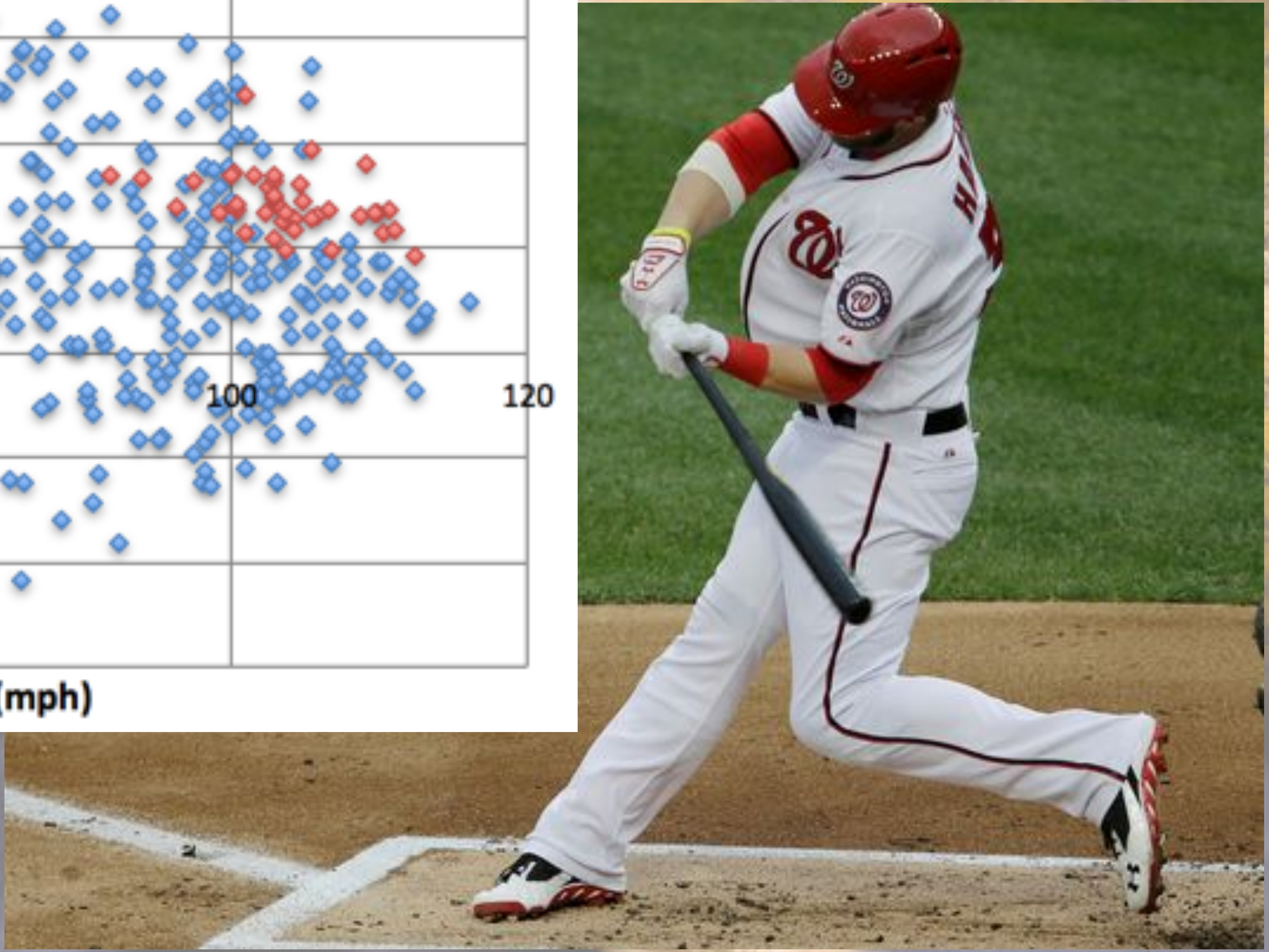
Launch angle: The vertical angle at which the ball leaves the bat on a batted ball.

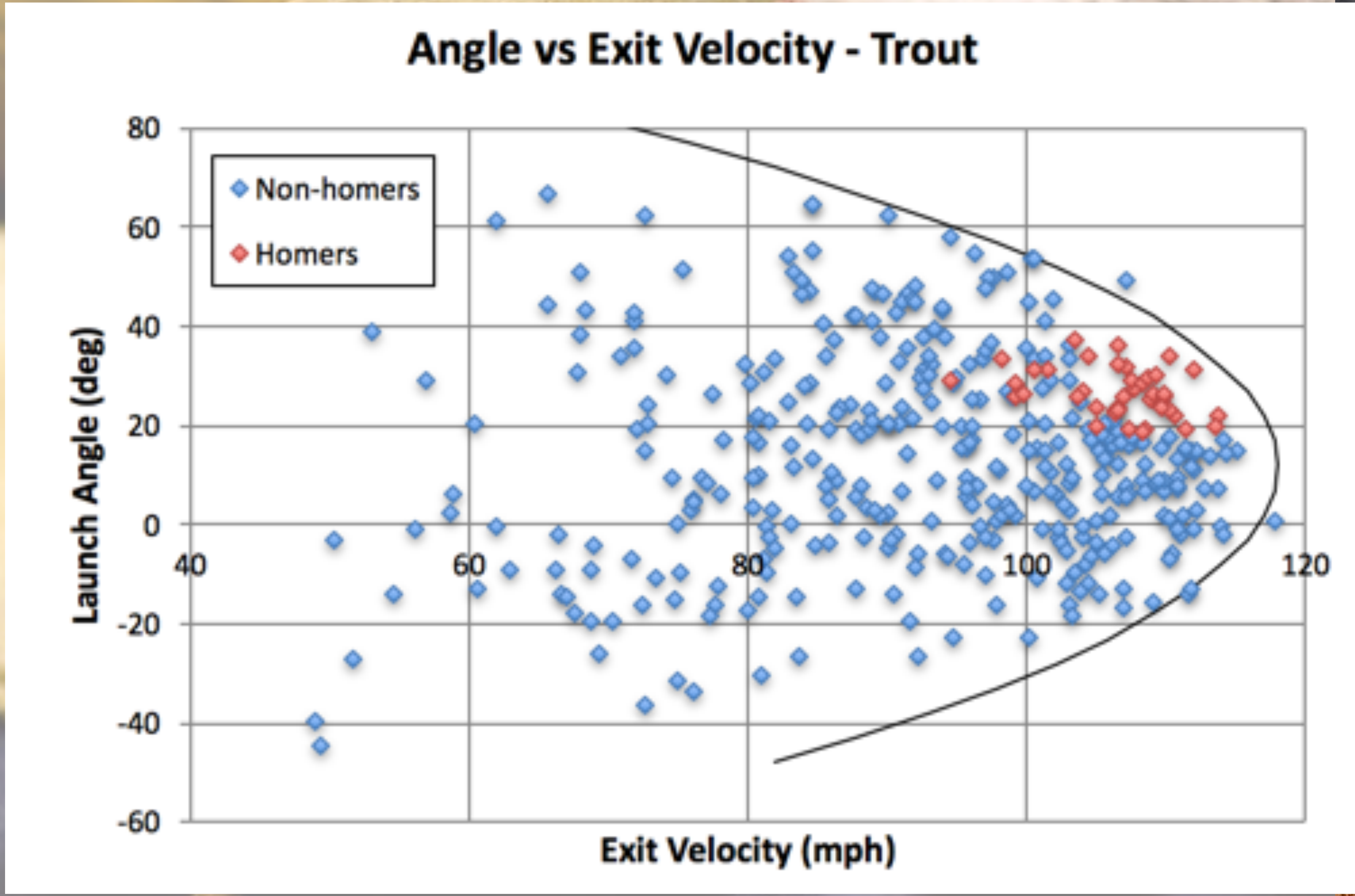


Just after leaving the bat

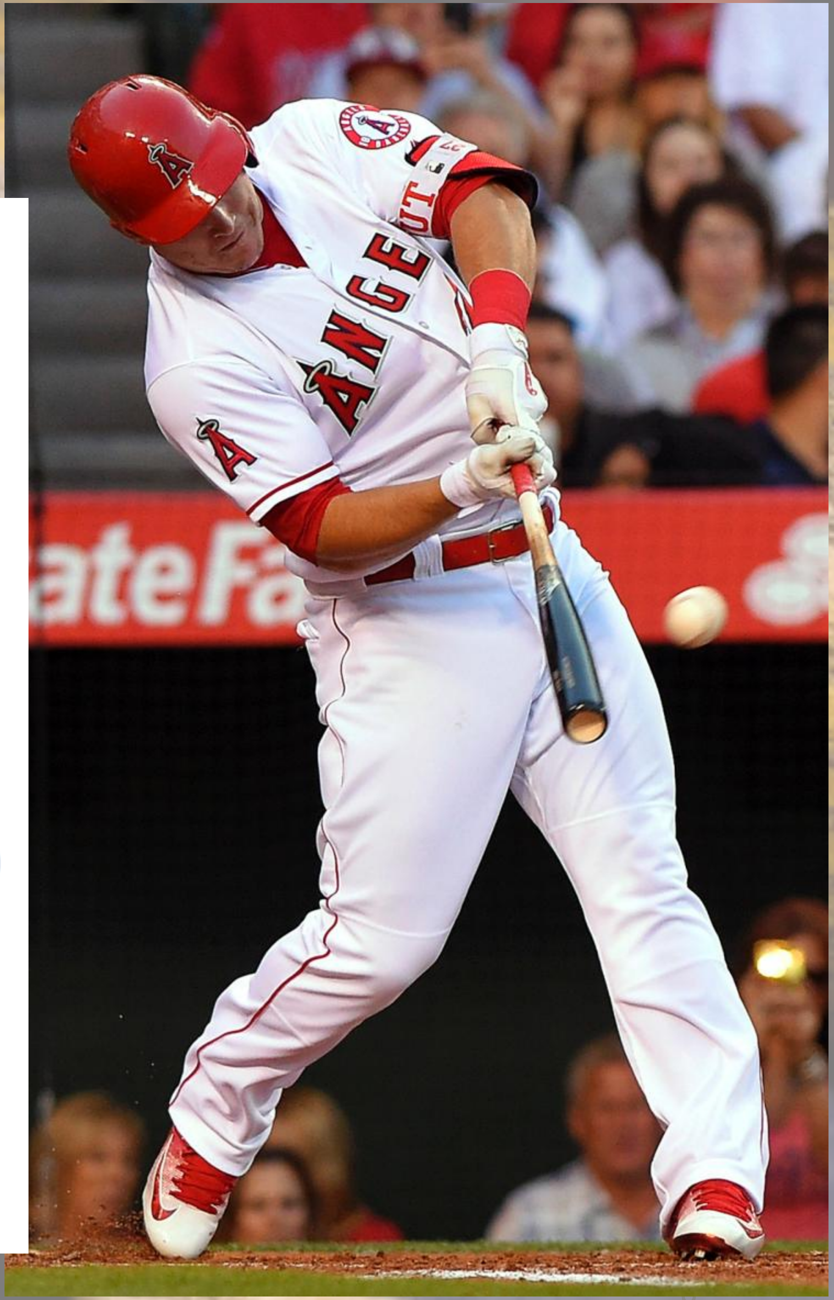

Angle vs Exit Velocity - Stanton
Non-homers
Homers
Launch Angle (deg)
Exit Velocity (mph)
80
60
40
20
0
-20
-40
-60
40
60
80
100
120

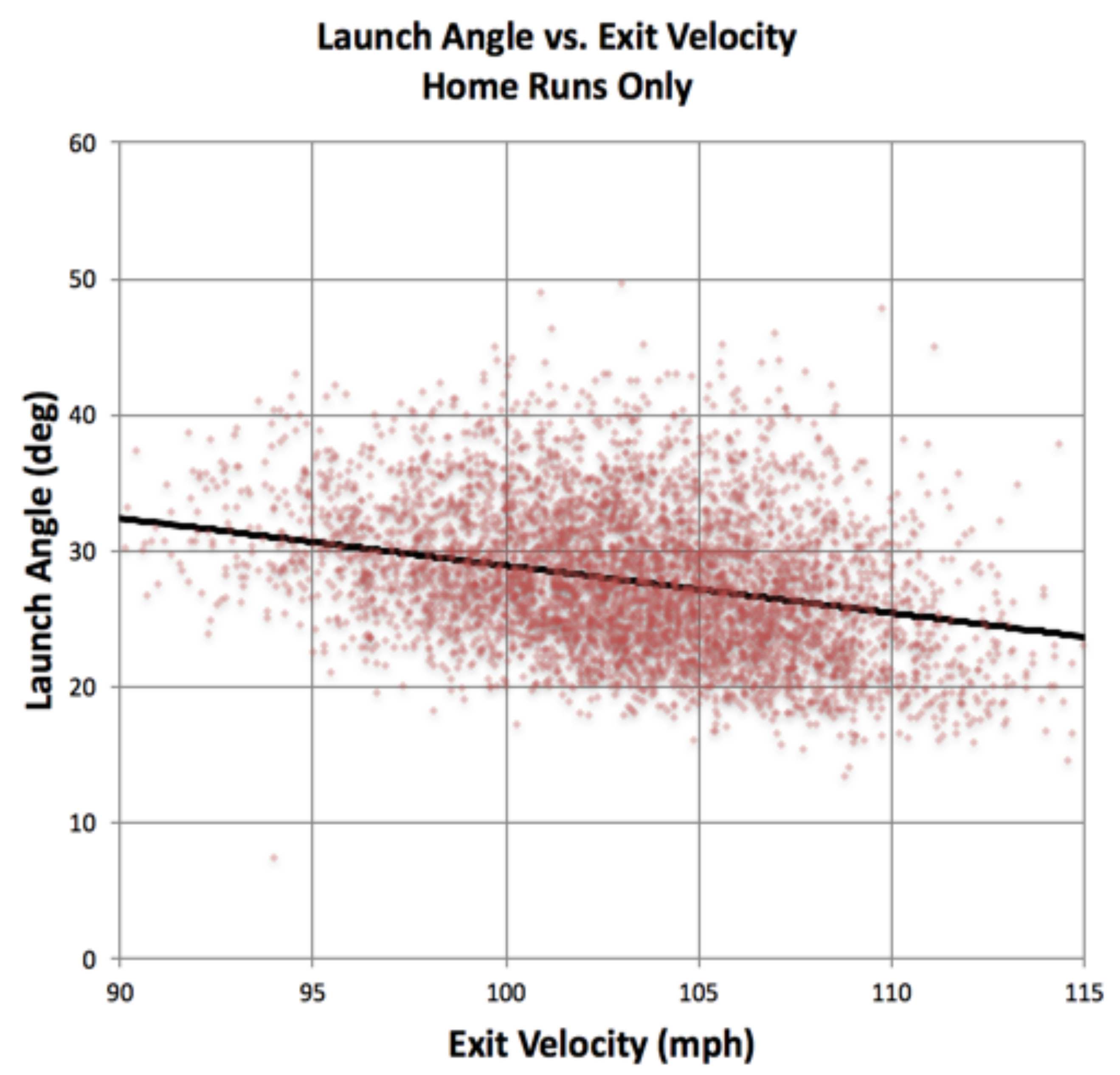

Angle vs Exit Velocity - Harper
Non-homers
Homers
Launch Angle (deg)
Exit Velocity (mph)
80
60
40
20
0
-20
-40
-60
40
60
80
100
120





Angle vs Exit Velocity - Trout
Non-homers
Homers
Launch Angle (deg)
Exit Velocity (mph)
80
60
40
20
0
-20
-40
-60
40
60
80
100
120





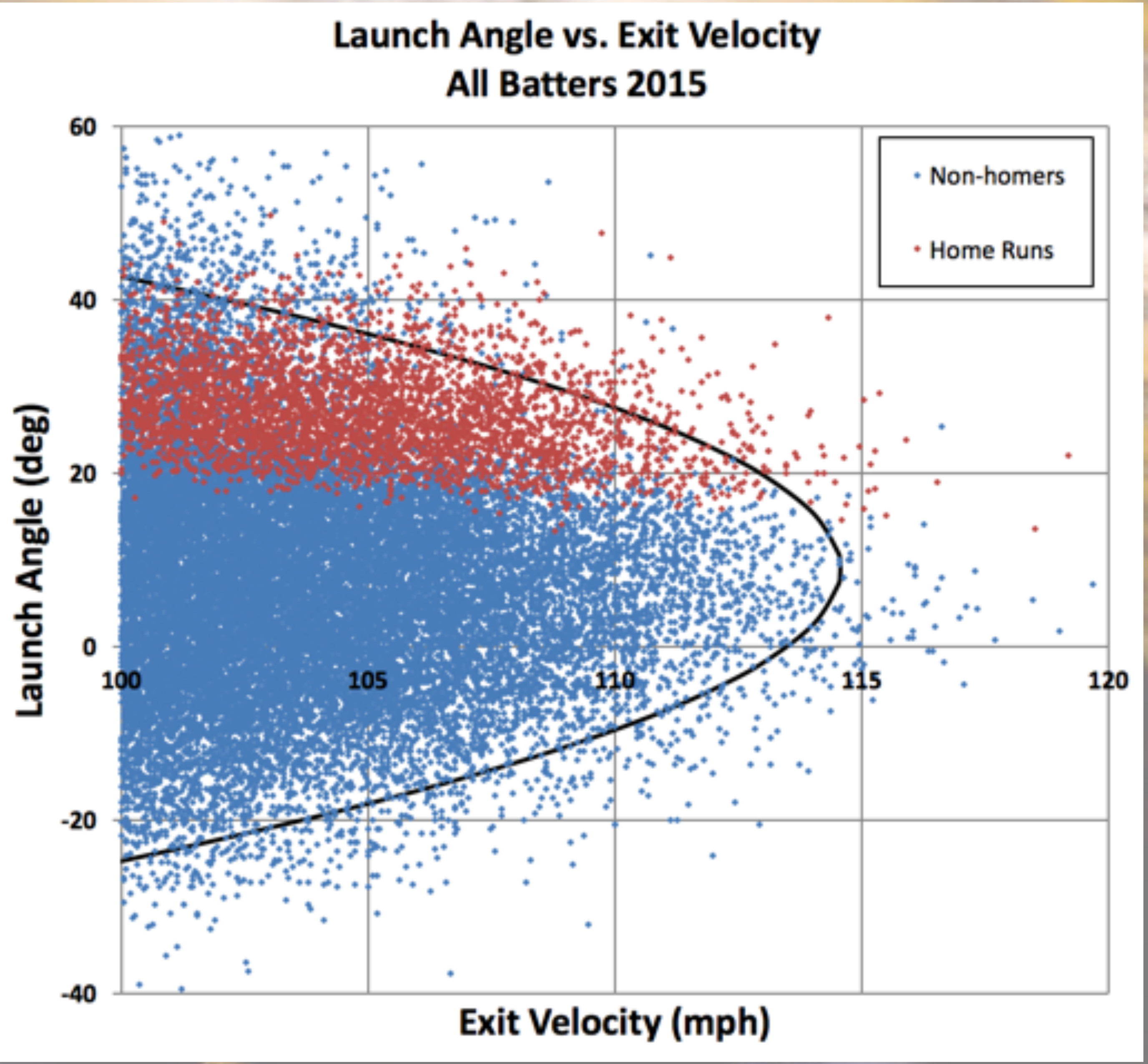
All Homers in 2015

They form a cluster.

- Launch angles 15 to 45 degrees.
- Exit Velocity 90 to 115 mph.

Lower velocity requires higher launch angle - high fly ball.

Higher velocity for lower launch angles - line drive homer.



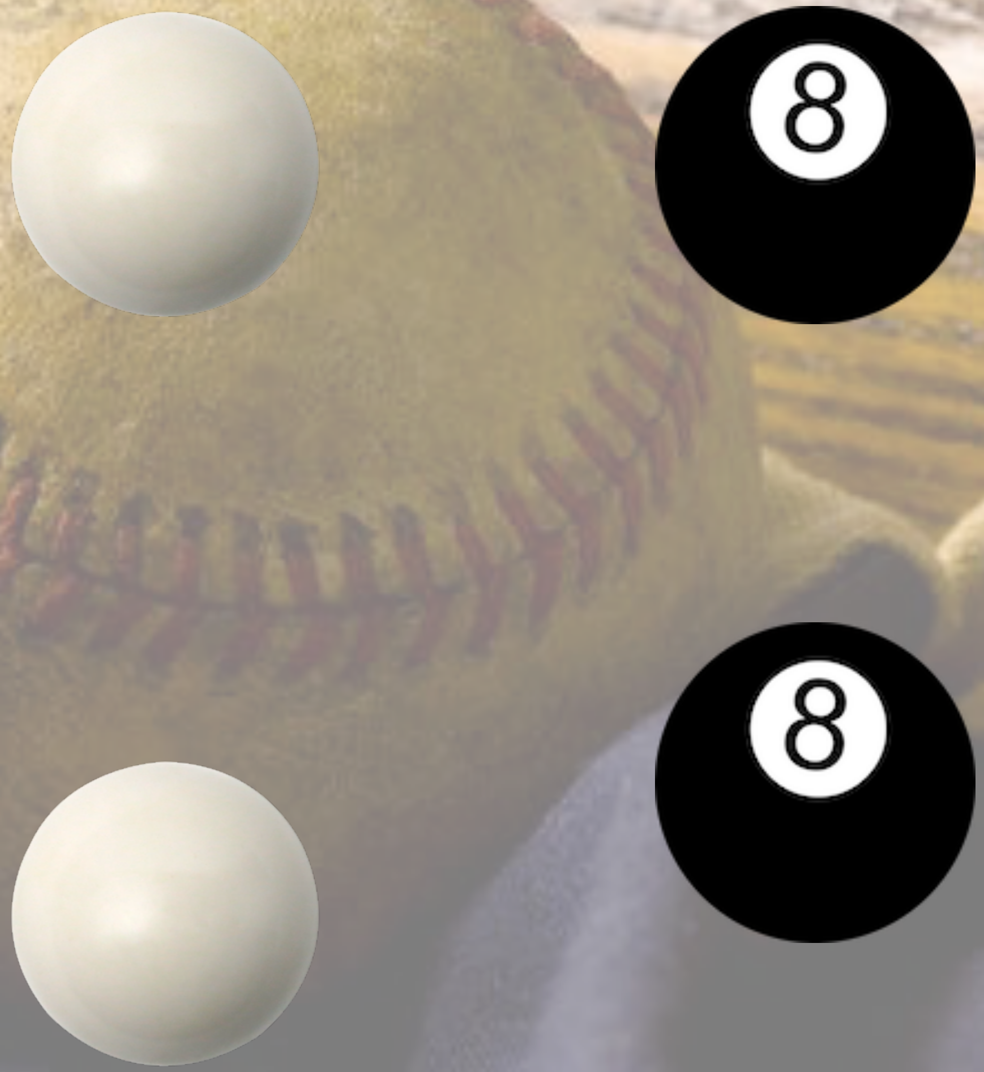
Back to the Launch Angle vs. Exit Velocity

The arrow shape is real, not an illusion for the best batters.

Before we go into any physics, let's use some "common sense" from a game of eight ball.

The Physics of Pool

Direct Hit



Indirect Hit

The Physics of Baseball

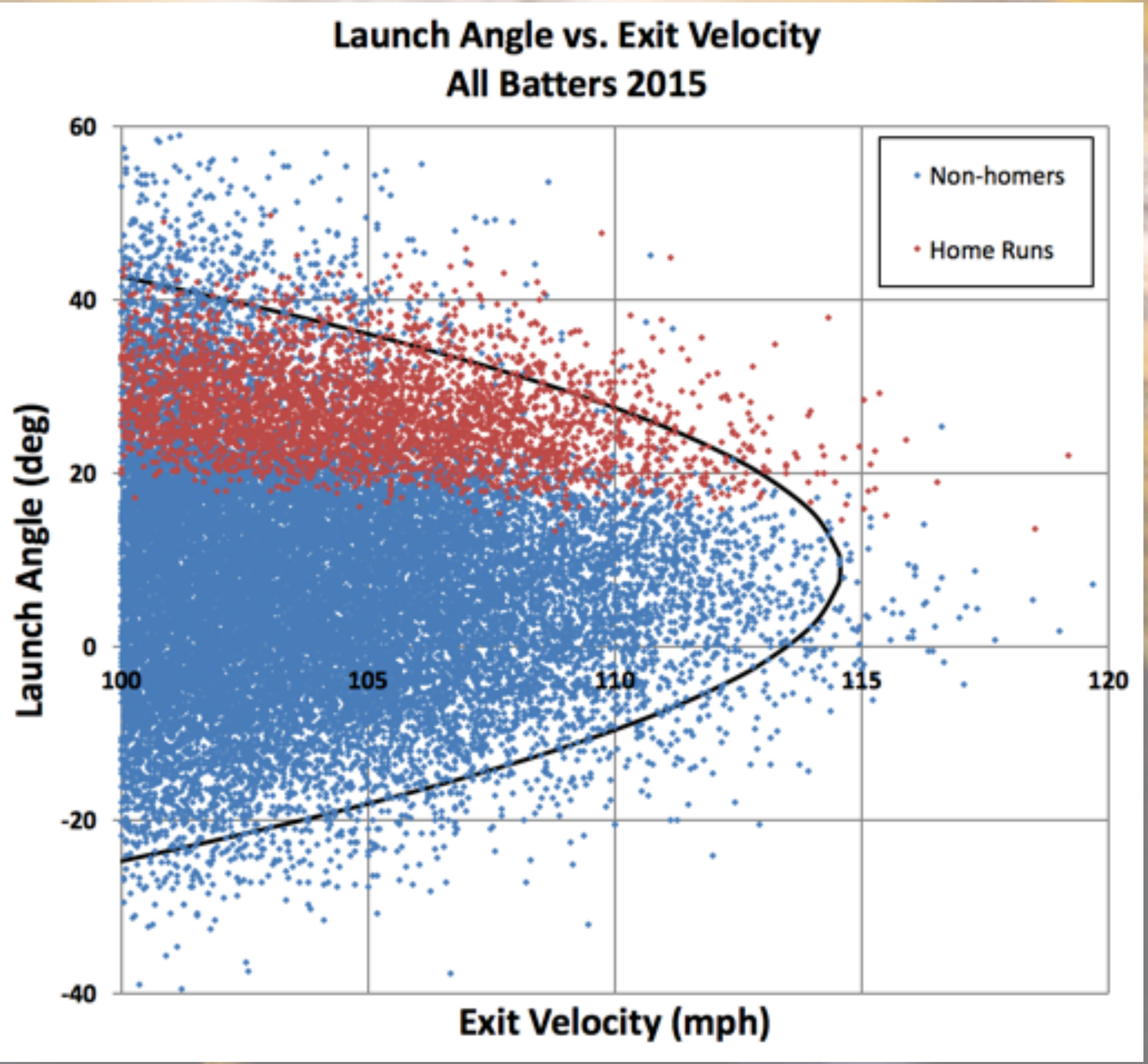
Direct

Hit

“on the screws”

Indirect

Hit



"Common Sense" tells us:

- For a given launch angle, there is a maximum speed.
- For lower launch angles this speed is larger.

The arrow is explained!

But as my wife often reminds me,

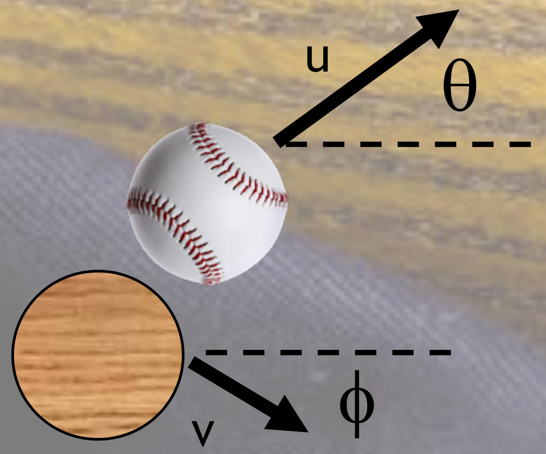
“Common sense is neither!”

Some Physics of the Ball-Bat Collision

Our Goal

Explain the plots of the launch angle θ versus the exit velocity u.

Just before collision

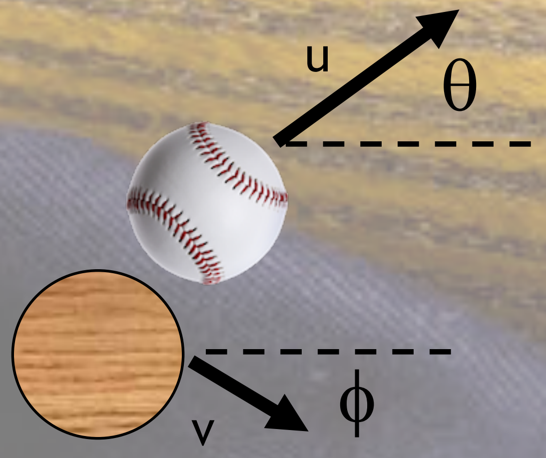


Just after collision

Some Physics of the Ball-Bat Collision

Physics Principles:

Just before collision



Just after collision

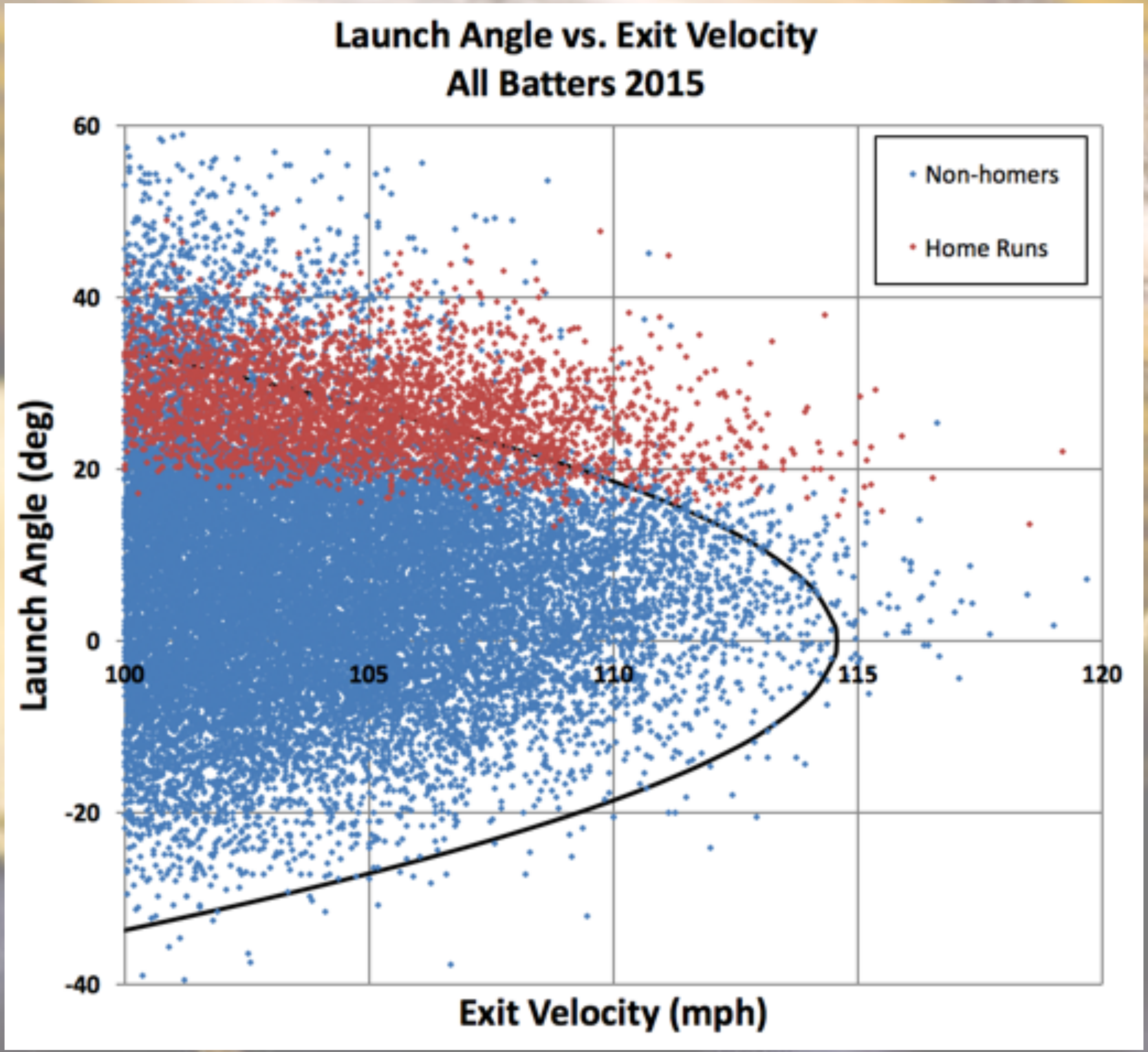
Linear Momentum is conserved:

$$0 = M\,u\,sin\theta - m\,v\,sin\phi$$

$$M\,v_o - m\,u_o = M\,v\,cos\phi + m\,u\,cos\theta$$

Some mechanical energy is lost during the collision:

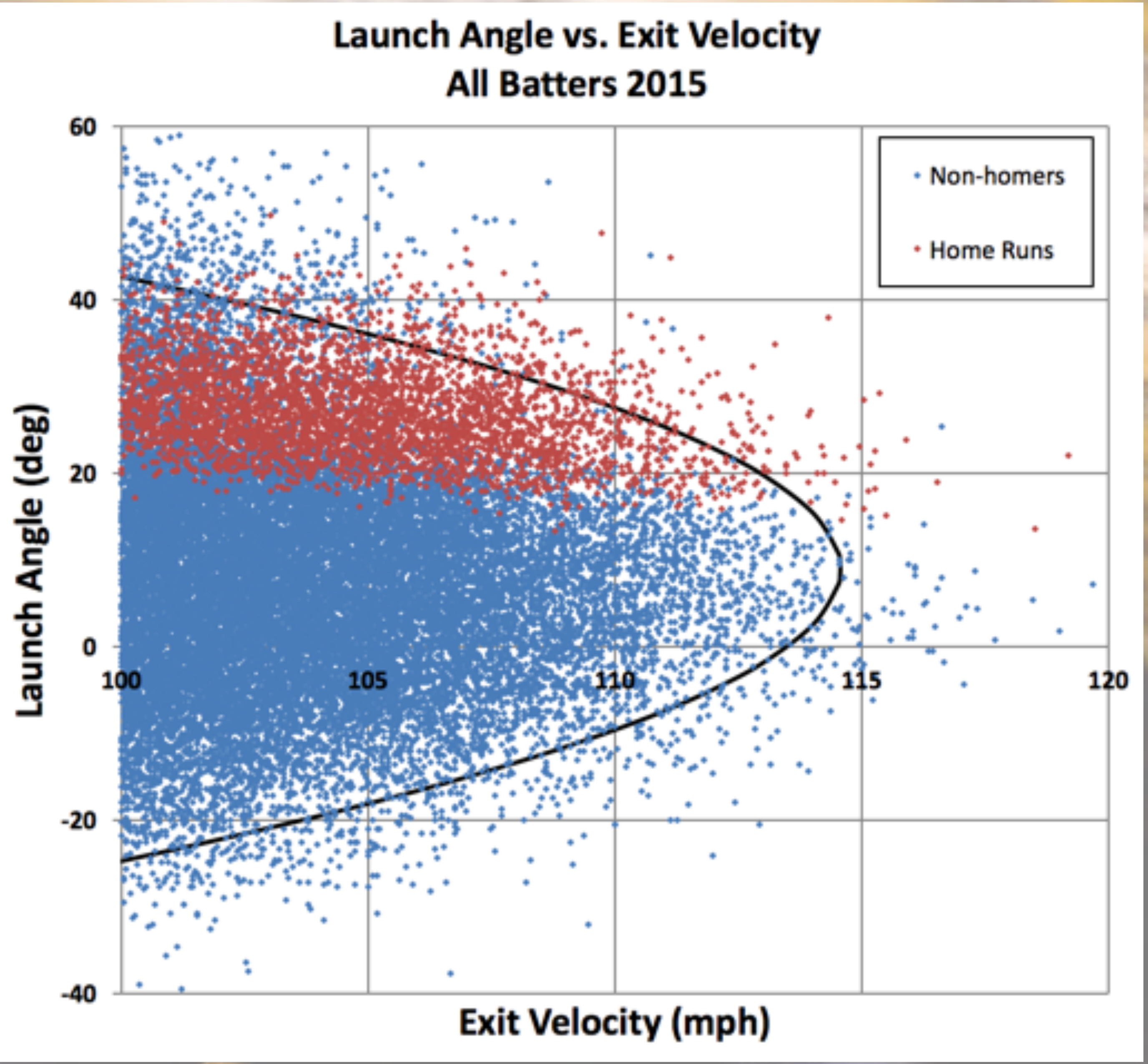
$$\frac{1}{2}m\,u^2 + \frac{1}{2}M\,v^2 = e\left(\frac{1}{2}m\,u_o^2 + \frac{1}{2}M\,v_o^2\right)$$



Here's the best I could do:

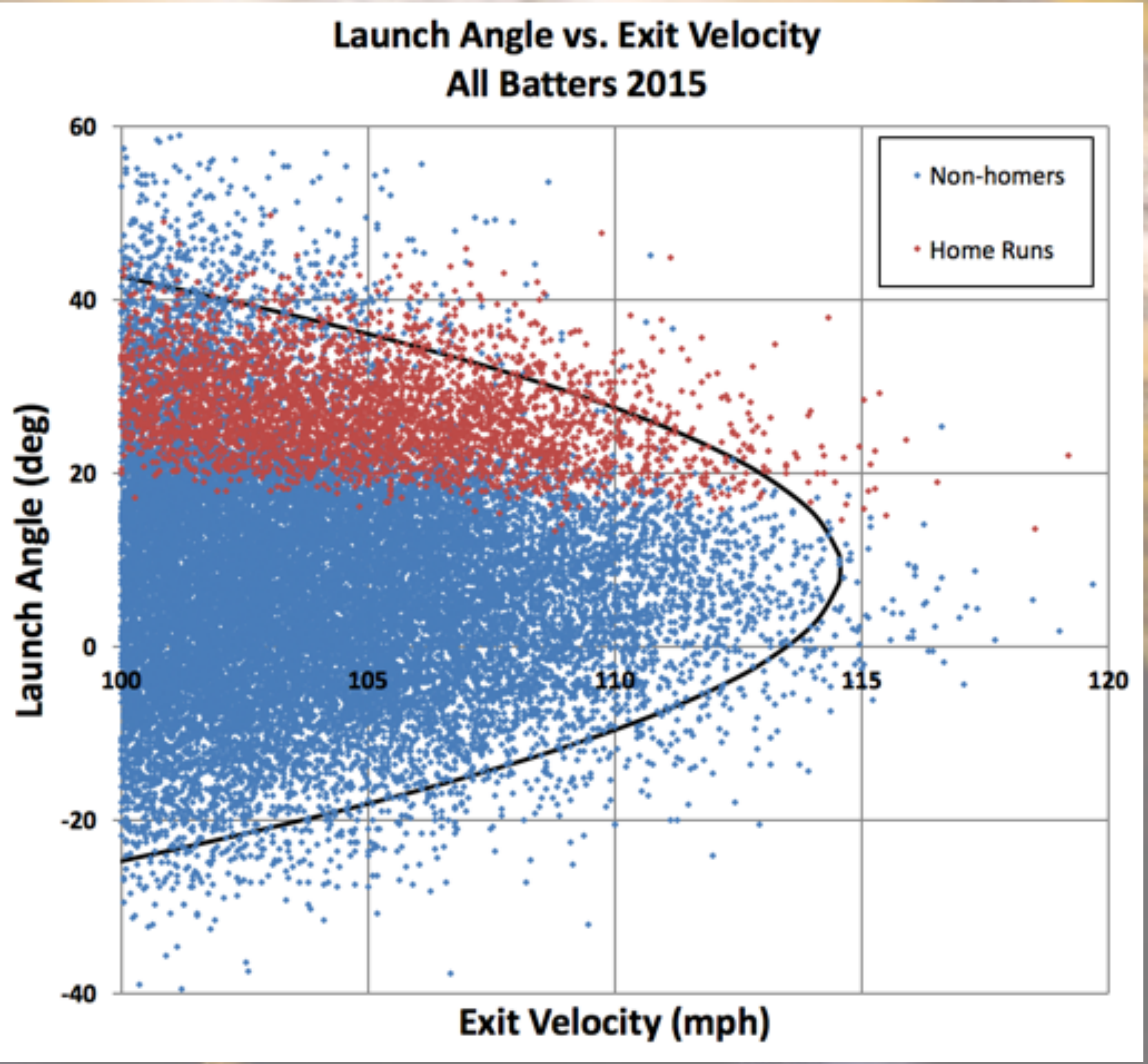
- v_o = 70 mph
- u_o = 90 mph
- e = 58%

There is something wrong.



Lifting the curve 9° gives this beautiful fit!

What gives?



Batters typically have an upper cut that biases the launch angle upward!


Ichiro
Suzuki's
3000th Hit

What have we learned?

Plots of Launch Angle vs. Exit Speed form an arrow because:

- For a given launch angle, there is a maximum speed.
- For lower launch angles this speed is larger.

Homers form a cluster.

- Launch angles 15 to 45 degrees.
- Exit Velocity 90 to 115 mph.

Is it Physics
Or
“Common Sense?”

For more physics and baseball visit:

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