The Importance of Vertical Approach Angles

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Part of the beauty of baseball is its inherent property of symmetry. It's the only sport in which the defense puts the ball in play, and the offense reacts. It is a complex game of chess, where the batter is constantly trying to think about the location, velocity, and movement of the pitch, and where the pitcher is constantly adjusting to a hitter's tendencies. This property of symmetry doesn't necessarily mean symmetry of shape, but symmetry in approach. Take a heat map for an example:

Cheek, Chase (Left) Mean EV (Catcher's View)

	Far Left	Left	Center	Right	Far Right
Far Top	NA	62.39	73.50	90.45	74.00
Top	NA	76.01	87.98	77.25	82.32
Middle	NA	NA	NA	78.92	64.87
Bottom	74.90	91.71	83.07	81.52	57.67
Far Bottom	NA	102.21	100.17	79.06	NA

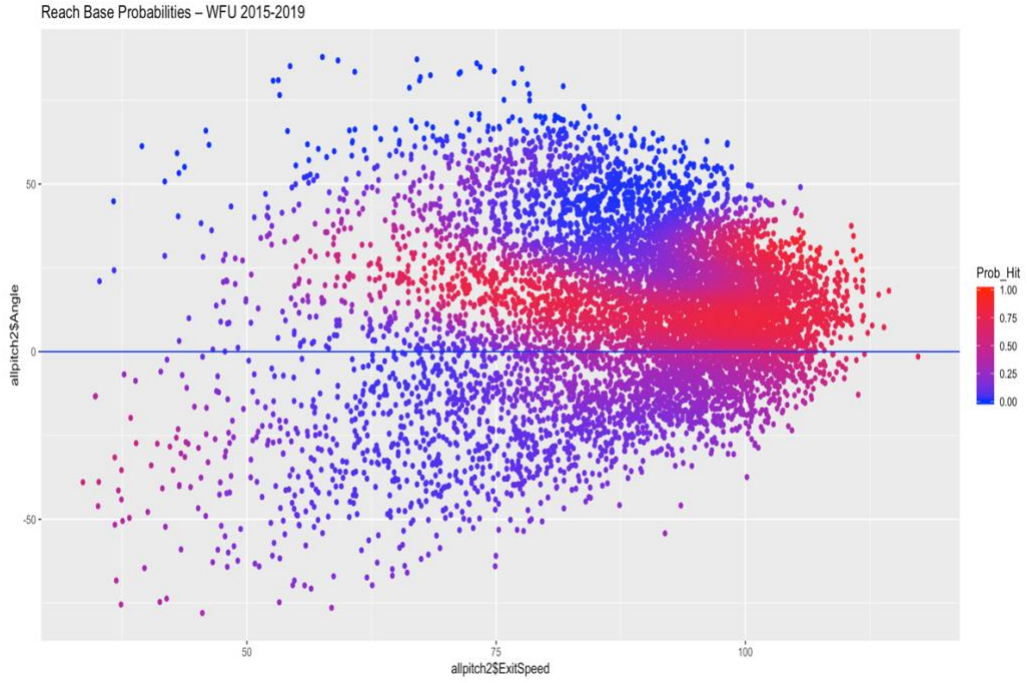
With this information, a pitcher instantly knows to avoid throwing the ball low and away and to pepper the batter with inside pitches, as the exit velocities represented above dictate. The hitter knows his strengths, perhaps crowding the plate, daring the pitcher to throw the ball inside, testing his command. It is this type of inference that reveals the symmetry of baseball.

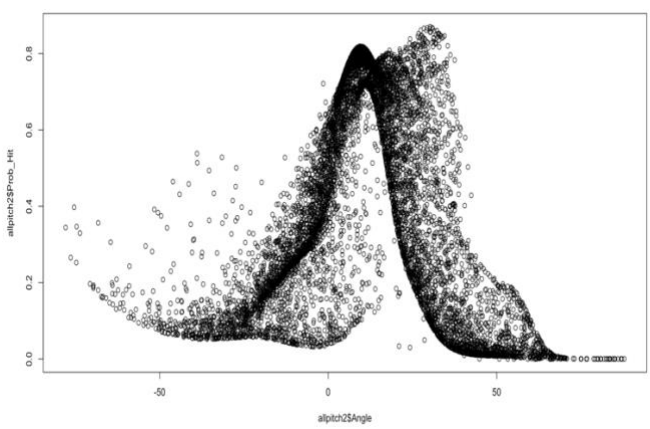
One of the most well-known results of the analytics movement in baseball has been the increase of focus on launch angle. Hitters are attempting to generate loft on the ball. The origins of this movement are likely tied to the increase of defensive shifts in baseball; rather than trying to focus on hitting the ball the other way, or laying down a bunt to keep fielders honest, hitters simply try to elevate the ball.

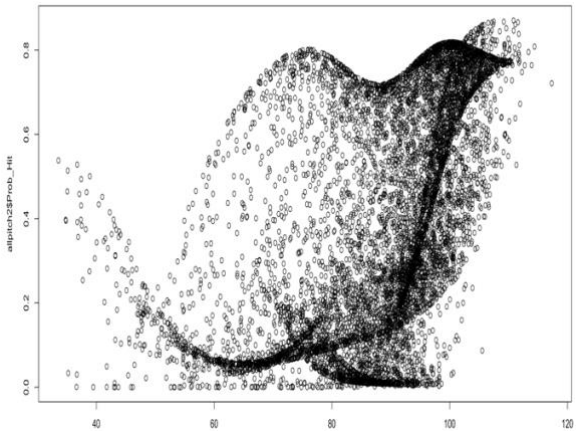
So, what does trying to increase your launch angle mean for the mechanics of a hitter?

To answer this question, think about the path of the baseball from the pitcher's mound to home plate. Due to the height of the mound, the incoming pitch is travelling downwards as it

approaches home plate. A swing with a slightly higher vertical plane matches the flight path of the baseball more than a level swing does, which is how analytically driven minds concur that having a slight upstroke in your swing is beneficial. Because of this adjustment, hitters have a larger impact zone to hit the baseball; they have a wider margin of error in their swing, resulting in more consistent contact with the ball. According to Statcast metrics, approximately 5% of batted balls result in a “barrel”, a certain combination of exit velocity and launch angle that yield elite batting averages and slugging percentages. Because of this low percentage, a great hitter knows how to increase the hit probabilities of their mis-hits. They do this by adjusting their launch angle and swing path to meet the flight path of the ball.





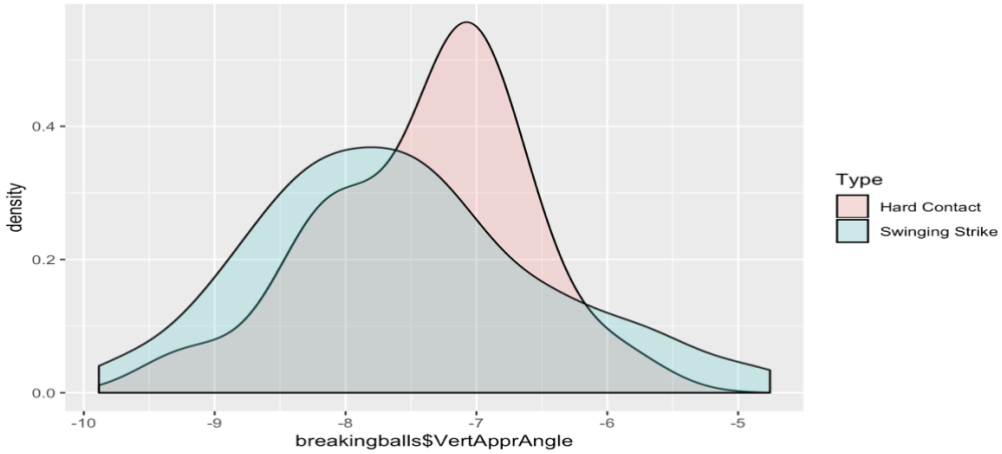


Take a look at the three graphs above. The first, colorful chart measures exit speed on the x axis, launch angle on the y axis, and the color of each dot is smoothed into a hit probability (data is all college baseball games WFU was involved in since 2015). As you can see, there is a lot of red in which the launch angle is between ~ 8 and ~26 and exit speed above ~85. In looking at the hit probabilities plotted on the y axis vs. both launch angle (left) and exit speed (right), however, it is clear there is a stronger relationship with launch angle. This is coachable. By optimizing your launch angle, you can keep your bat path in the zone for a longer period of time, allowing those who do not have elite exit speed to get on base. If you look at the chart depicting hit probability vs. exit speed on the right, you will see a clear relationship after the exit speed hits 95. If you look above it though, in the top quartile of the hit probabilities section, there is a tail that maintains a high hit probability while exit speed is decreasing. This is the result of an optimized launch angle. By looking at the horizontal red band in the first chart, we can confirm this. You can still maintain high hit probabilities at lower exit speeds if you can optimize your launch angle, especially in the college world of metal bats.

We mentioned the symmetry of baseball before and its relation to how players make adjustments. How should pitchers adjust to the launch angle revolution? Well, if a hitter is trying to maximize the time their bat is in the zone, a pitcher's job is to minimize that time. To do this, a pitcher must optimize their approach angles. There are both horizontal and vertical approach angles, however the one I will focus on is the vertical approach angle.

The ideal vertical approach angle differs from pitch to pitch and pitcher to pitcher. For fastballs with a high ratio of induced vertical break to gravitational vertical break, you want a vertical approach angle closer to zero (greater than -5). For fastballs with a low ratio of induced vertical break to gravitational vertical break, you want a vertical approach angle of less than -8 degrees. For fastballs with an approach angle in between -5 and -8 degrees, I would recommend developing a two- seamer or a cutter that generates horizontal movement in order to get the baseball off the barrel. For all breaking pitches, you want vertical approach angles farther away from zero, which resembles sharp movement and the ball appears to break quickly through the zone (sharp approach angles correlate late movement/break).

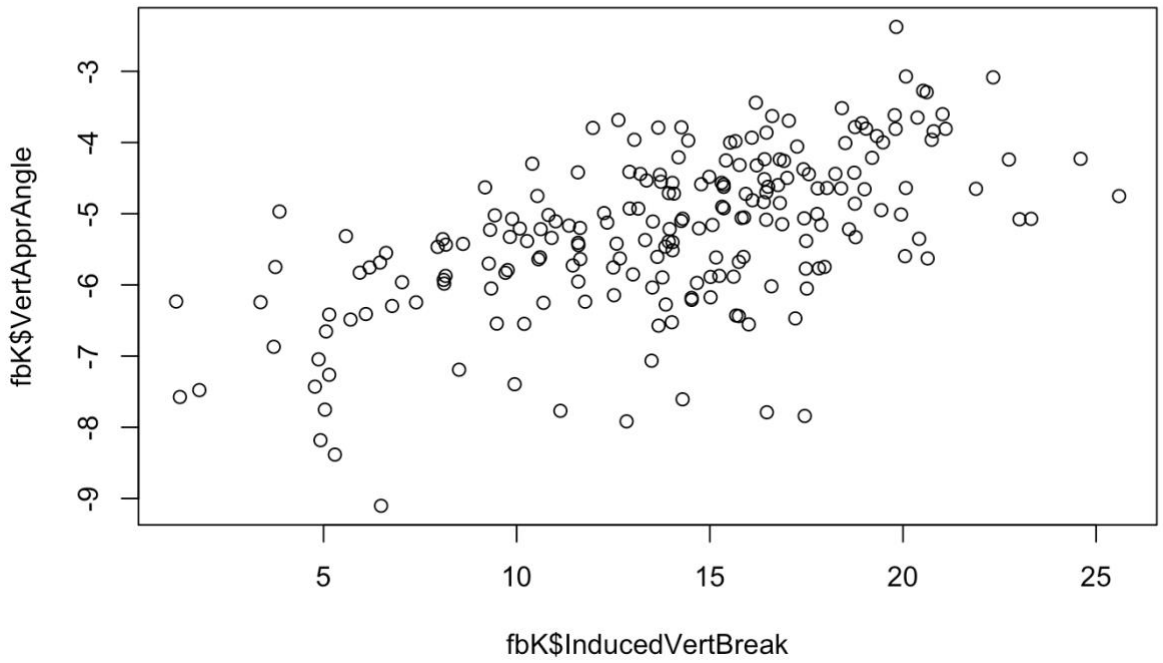
A “shallow” vertical approach angle for hopping four seamers does not mean the pitch can be considered ‘flat’. Because of the added height from the mound, the ball will appear to rise as it enters the strike zone. This rising action is called the Magnus Force – the result of complimentary airflows on the bottom of the baseball pushing up on the ball. The ball doesn’t actually rise, but essentially, the batter expects the ball to drop, and swings under the pitch – perception is reality when it comes to hitting. For breaking pitches like sliders and curveballs, you want sharper vertical approach angles. A breaking ball with a steep vertical approach angle means it has a high spin rate and gyro degree (Rapsodo); the ball is locked into its flight path, and the ball is cutting hard through the strike zone. A baseball cutting hard through the pentagonal cube that is the strike zone decreases the same impact zone the launch angle revolution was designed to increase, both in terms of distance and time, as well as a hitter’s margin of error.



I took a sample of 5000 pitches thrown in games played by Wake Forest over the 2019 season. I grouped together all of the right-handed pitchers, and isolated swinging strikes and hard contact results (defined as an exit velocity of 93 mph or higher and a launch angle between 8 and 30 degrees). The top histogram overlays fastballs resulting in hard contact (shaded red) and fastballs resulting in swinging strikes (shaded blue). As you can see, fastballs with vertical approach angles closer to zero yielded more swinging strikes. The hard contact fastballs have a mean vertical approach angle of -5.85 degrees; when accounting for the plane of the pitch, a fastball with this vertical approach angle would be considered flat (the danger zone will generally be between -5.5 and -7.5 degrees). The bottom histogram overlays breaking balls resulting in hard contact (shaded red) and breaking balls resulting in swinging strikes (shaded blue). As predicted, the steeper the vertical approach angle (further in the negative direction), the better result for our pitchers.

A pitcher's vertical approach angle reveals a lot about a pitch. A shallow vertical approach angle that approaches 0 (on fastballs) correlates to a high spin efficiency, and an unbalanced ratio of induced vertical break to vertical break (aiding in deception), all highly valued characteristics in an analytical world. Unfortunately, TrackMan does not have a metric detailing spin efficiency, but take a look at the plot below, with vertical approach angle on the

y-axis, and induced vertical break on the x-axis- the data here is for fastballs only:



From the subset I used, the correlation between vertical approach angle and induced vertical break was .56; the closer our vertical approach angle is to zero, the higher our induced vertical break. With a higher induced vertical break, the better the "rise" on the pitch, the better the result for our pitchers. This is merely the tip of the iceberg when it comes to using analytics to improve pitch characteristics, but the symmetry of baseball remains. In order to combat the launch angle revolution, throw some fastballs that hop, and off of the fastball throw steep breaking balls; they will both have the desired vertical approach angles to result in pitching success. Pitches with characteristics like this will make it harder for the batter to get on plane, disrupt their timing, and increase margin for error for a pitcher.