

The Importance of Tunneling Pitches

A Machine Learning Baseball Analysis

Danny Thompson

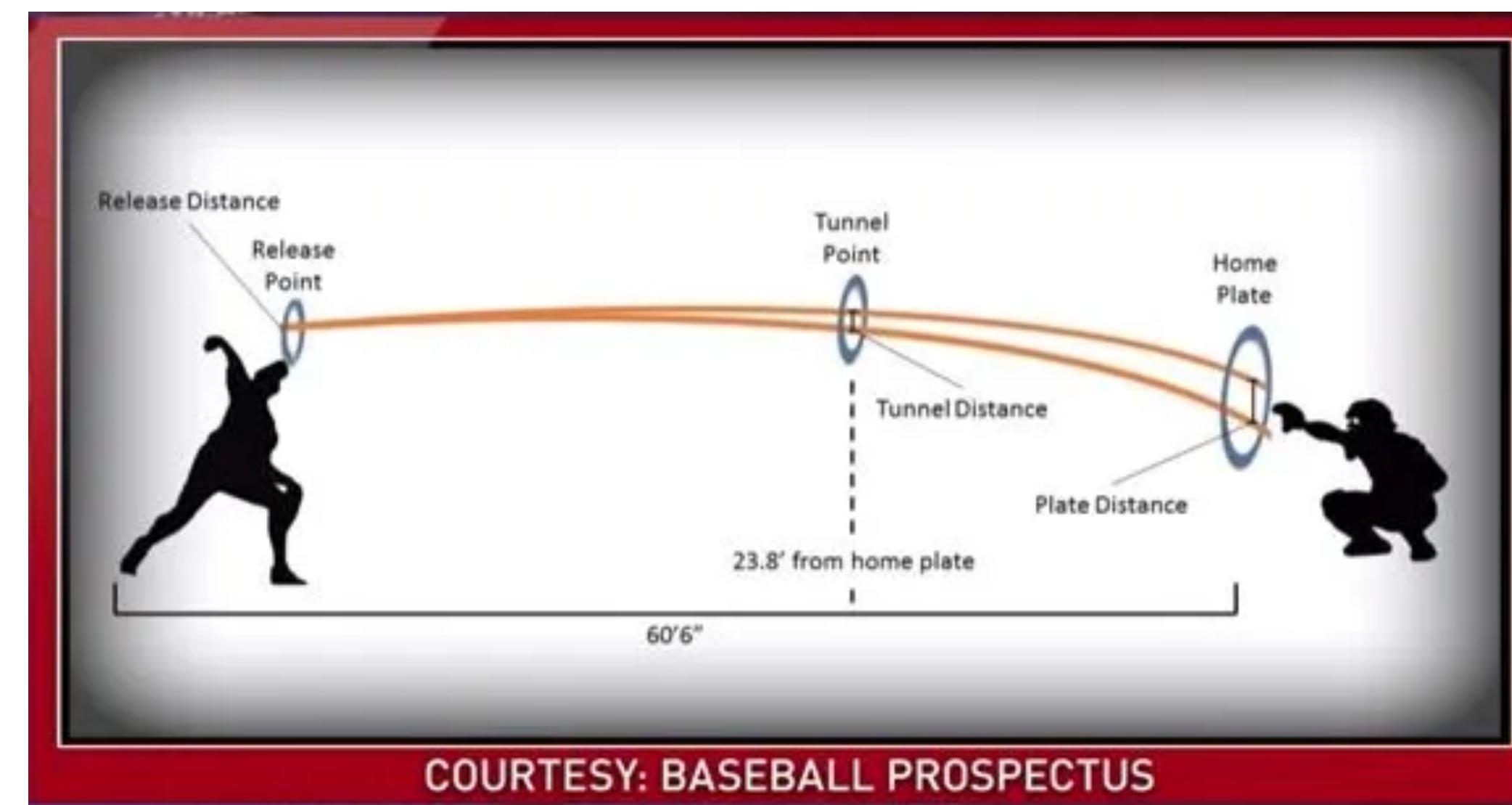


Variable Importance

- The purpose of this project is to take secondary pitches thrown after fastballs and build statistical models that predict one of three pitcher friendly outcomes for those pitches: Whiffs, Chases, and Groundballs.
- The predictive variables used are then ranked in terms of their importance in predicting the outcome, which gives an idea on how important it actually is for a pitcher to focus on.
- Five of the thirteen variables used have to do with comparing the secondary pitch to the fastball just thrown
- The idea then is that a pitcher who wants to fine-tune a secondary pitch or add one to his arsenal to fix his lack of whiffs, chases, or groundballs can wisely prioritize which targets he wants to focus on most during pitch development while keeping his fastball intact.

What is Pitch Tunneling?

- The idea of tunneling pitches is that "two different pitches fly down the same trajectory long enough to look nearly identical through the point when a hitter must decide whether, or not, to swing. If pitches thrown back to back travel down this same 'tunnel' long enough, a hitter won't be able to tell them apart until it's too late" (Blewett)



Greg Maddux

- Maddux understood this concept well. He had stated that his goal was "late quick break, not big impressive break. The bigger the break, the sooner the ball must start to swerve and the more milliseconds the hitter has to react; the later the break, the less reaction time. Deny the batter as much information—speed or type of last-instant deviation—until it is almost too late" (Boswell).
- His main goal was to "make all of my pitches look like a column of milk coming toward home plate. Every pitch should look as close to every other as possible, all part of that 'column of milk'" (Greg Maddux).

The Variables

release_speed

- Pitch velocity at the time of release

release_spin_rate

- The spin rate of the ball in RPM

pfx_x

- Horizontal movement in feet from the catcher's perspective

pfx_z

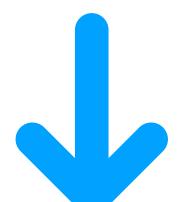
- Vertical movement in feet from the catcher's perspective

plate_x

- Horizontal position of the ball when it crosses home plate from the catcher's perspective

plate_z

- Vertical position of the ball when it crosses home plate from the catcher's perspective



Statcast search CSV documentation. baseballsavant.com.
(n.d.). <https://baseballsavant.mlb.com/csv-docs>

diffattunnel

- How far apart two pitches are at the *Tunnel Point*—the point during their flight when the hitter must make a decision about whether to swing or not (roughly 175 milliseconds before contact)

diffatplate

- How far apart back-to-back pitches end up at home plate

posttunnelbreak

- How much each spin-induced movement is generated on each pitch between the tunnel point and home plate

speeddiff

- The difference, in MPH, between back-to-back pitches

diffatrelease

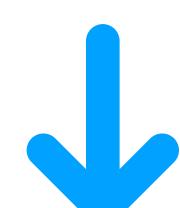
- The average variation between back-to-back pitches at release

breaktotunnelratio

- The ratio of post-tunnel break to the differential of pitches at the *Tunnel Point*

releasetotunnelratio

- The ratio of a pitcher's release differential to their tunnel differential



Sayre, B. (2022, January 19). *Prospectus feature: Introducing pitch tunnels*.
Baseball Prospectus. <https://www.baseballprospectus.com/news/article/31030/prospectus-feature-introducing-pitch-tunnels/>

Model Methodology

- Download all Statcast pitch data from 2015 to 2023 (excluding 2020 shortened season due to unreliability)
- Run all wrangling and model code in R
- Gather all secondary pitches (Curveballs, Sliders, Changeups, Sweepers, Splitters, Knuckle Curves, Slurves) thrown after a fastball (Four-Seamers, Sinkers, Cutters)
- Use physics and trigonometry to calculate the pitch difference variables (HUGE help from <http://baseball.physics.illinois.edu/>)
- Split up data by pitcher handedness, batter handedness, fastball, secondary pitch
- Downsample the majority class of the response variable (Whiff, Chase, Groundball) for a 50/50 split of pitches that were and were not those outcomes.
- Split the downsampled data into a 70/30 training/testing sample split
- Run training data through a **GRADIENT BOOSTING ML ALGORITHM** (with 500 decision trees) to predict the outcome of the pitch
- On testing data, use the model to compare the predicted outcomes to the real outcomes and measure the testing accuracy
- If accuracy is sufficient, run a variable importance graph to measure each variable's impact
- To see the code I wrote to do all this: <https://github.com/djt5>

Abstract

- 163 models were built: 62 dealing with Whiff outcomes, 60 dealing with Chase outcomes, and 41 dealing with Groundball outcomes.
- 77.4% of the Whiff models showed that the tunnel difference is *more important than both* horizontal and vertical break. However, this was only the case for 31.7% of Chase models and just 9.8% of the Groundball models.
- The difference at plate matters a lot for predicting Chases.
- Groundballs were hard to predict and did not yield the high accuracies of the Whiff and Chase models.
- There is no evidence to suggest release differences tip pitches.
- The rest of this PDF contains the results for the 163 models. They are not meant to be read all in one sitting, but rather a reference guide when needed. To search for a specific combination, hit CTRL + F, type in the fastball name, then the secondary pitch name, then the pitcher handedness, batter handedness, and response variable of interest. For example: If I wanted to see changeups thrown after sinkers, from a righty to a lefty, to study whiffs, I'd type **Sinker -> Changeup | RHP -> LHH | Whiff**

The Process of Developing a Pitch

Knowing the importance of each variable is great, but more information is needed. A pitcher needs to see the quantities within those variables he should strive for to improve his outcomes. To help with that process, use the ShinyApp I developed:

https://danielthom18.shinyapps.io/mlb_pitch_development_app/

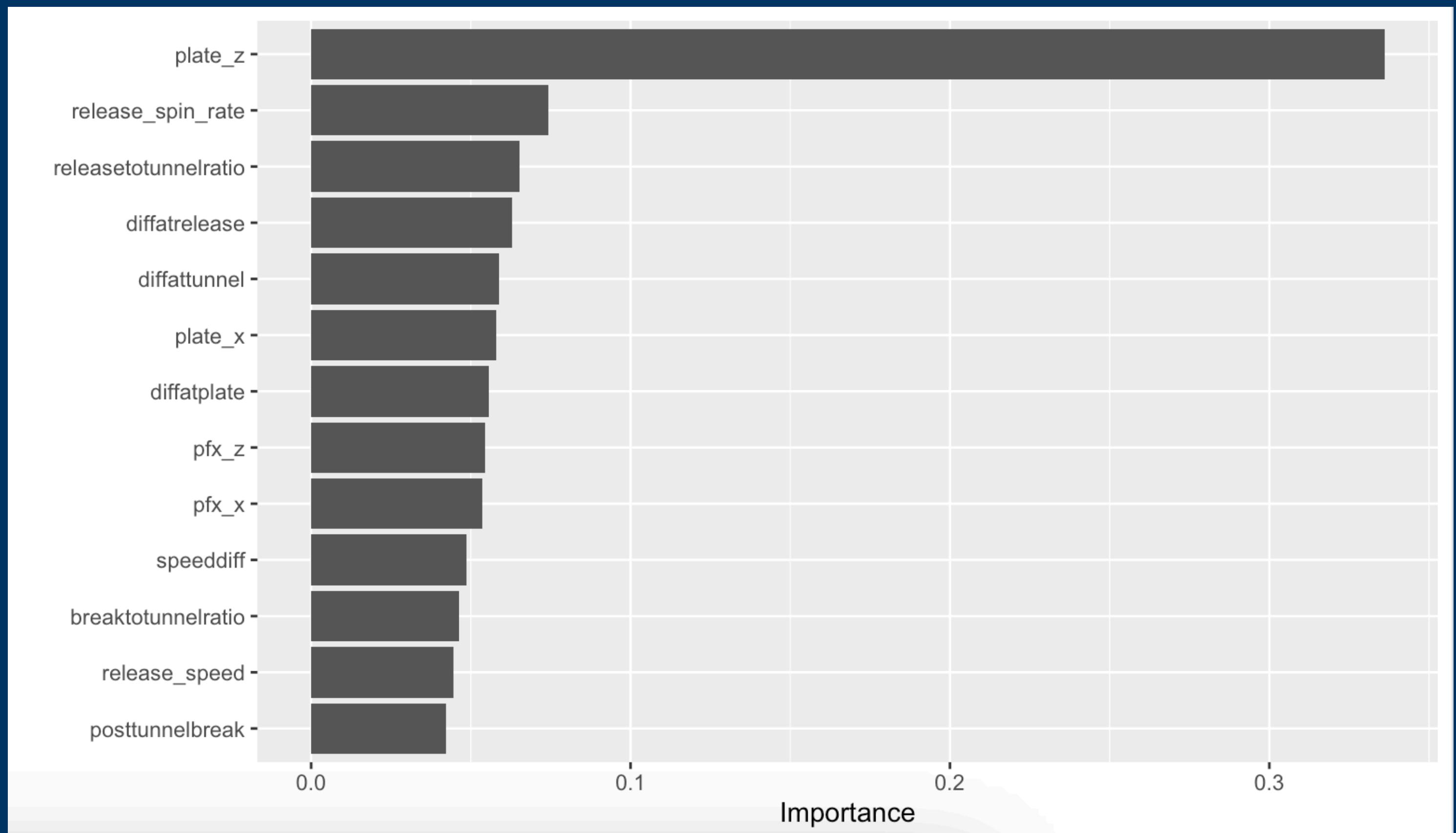
Right Handed Pitchers vs Right Handed Hitters

Cutter -> Changeup | RHP -> RHH | Whiff

Training Sample: n = 1182 pitches

Testing Sample: n = 508 pitches

Testing Accuracy: 64.76%

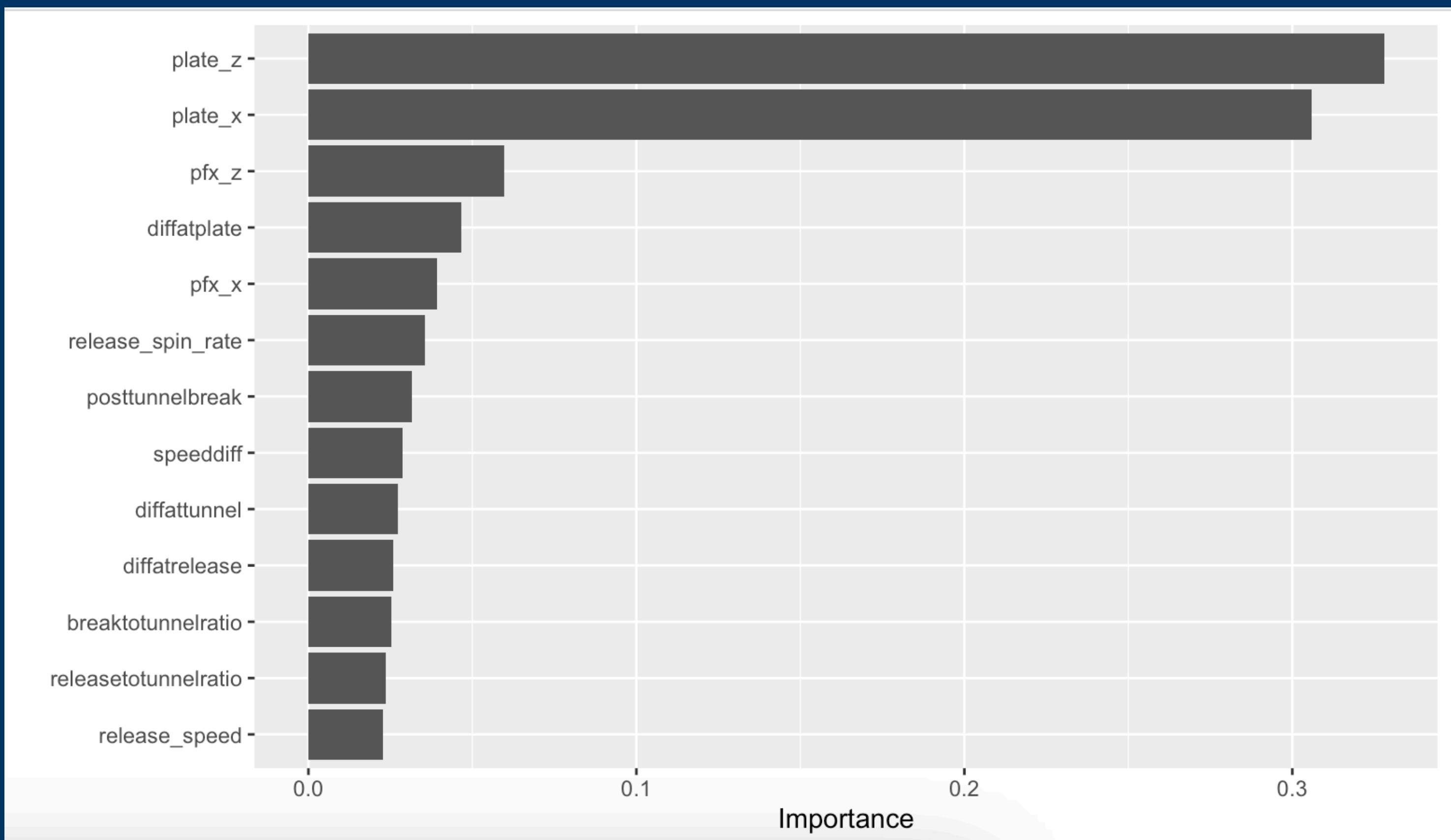


Cutter -> Changeup | RHP -> RHH | Chase

Training Sample: n = 1628 pitches

Testing Sample: n = 698 pitches

Testing Accuracy: 73.64%

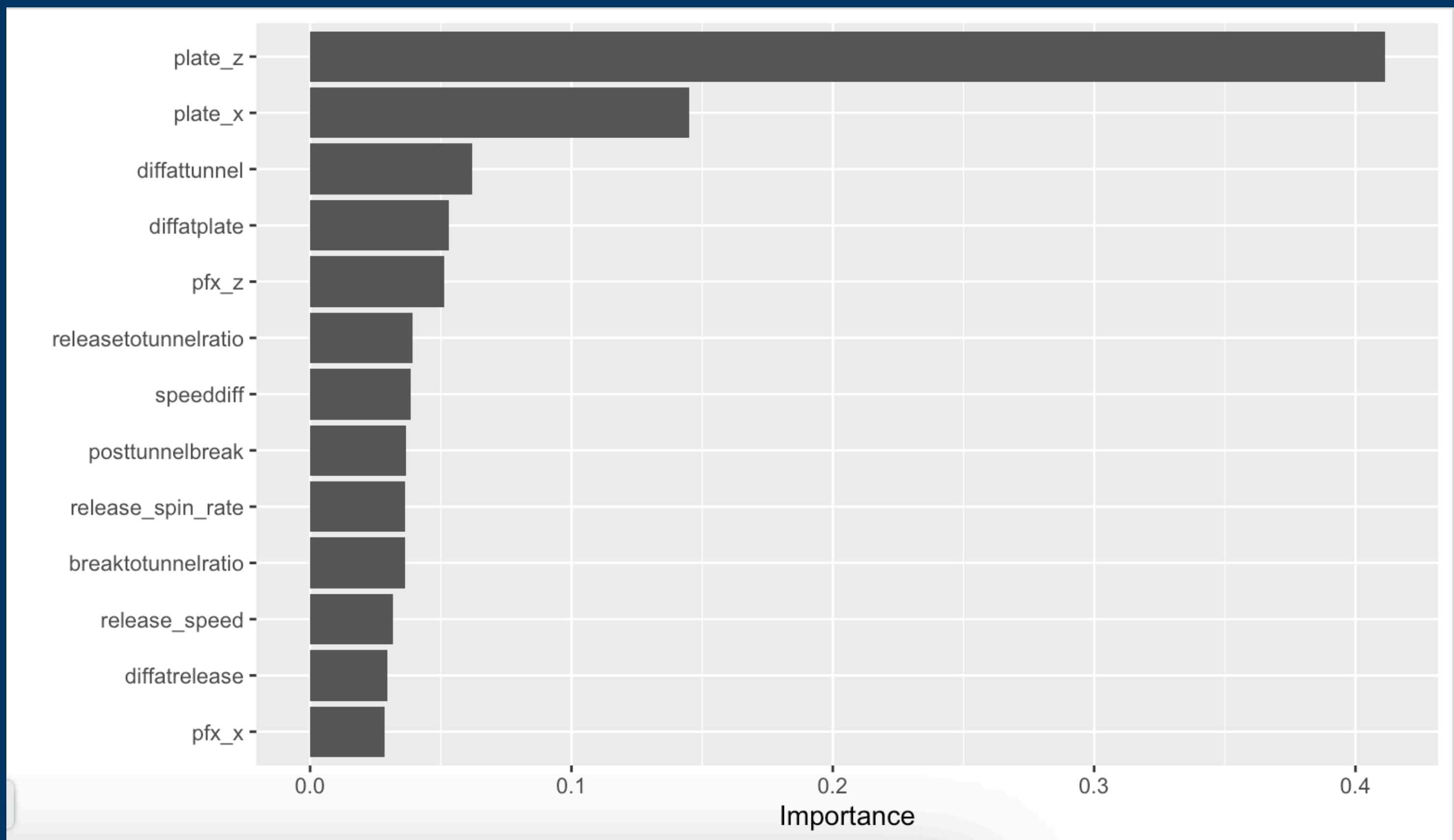


Cutter -> Curveball | RHP -> RHH | Whiff

Training Sample: n = 1702 pitches

Testing Sample: n = 730 pitches

Testing Accuracy: 71.64%

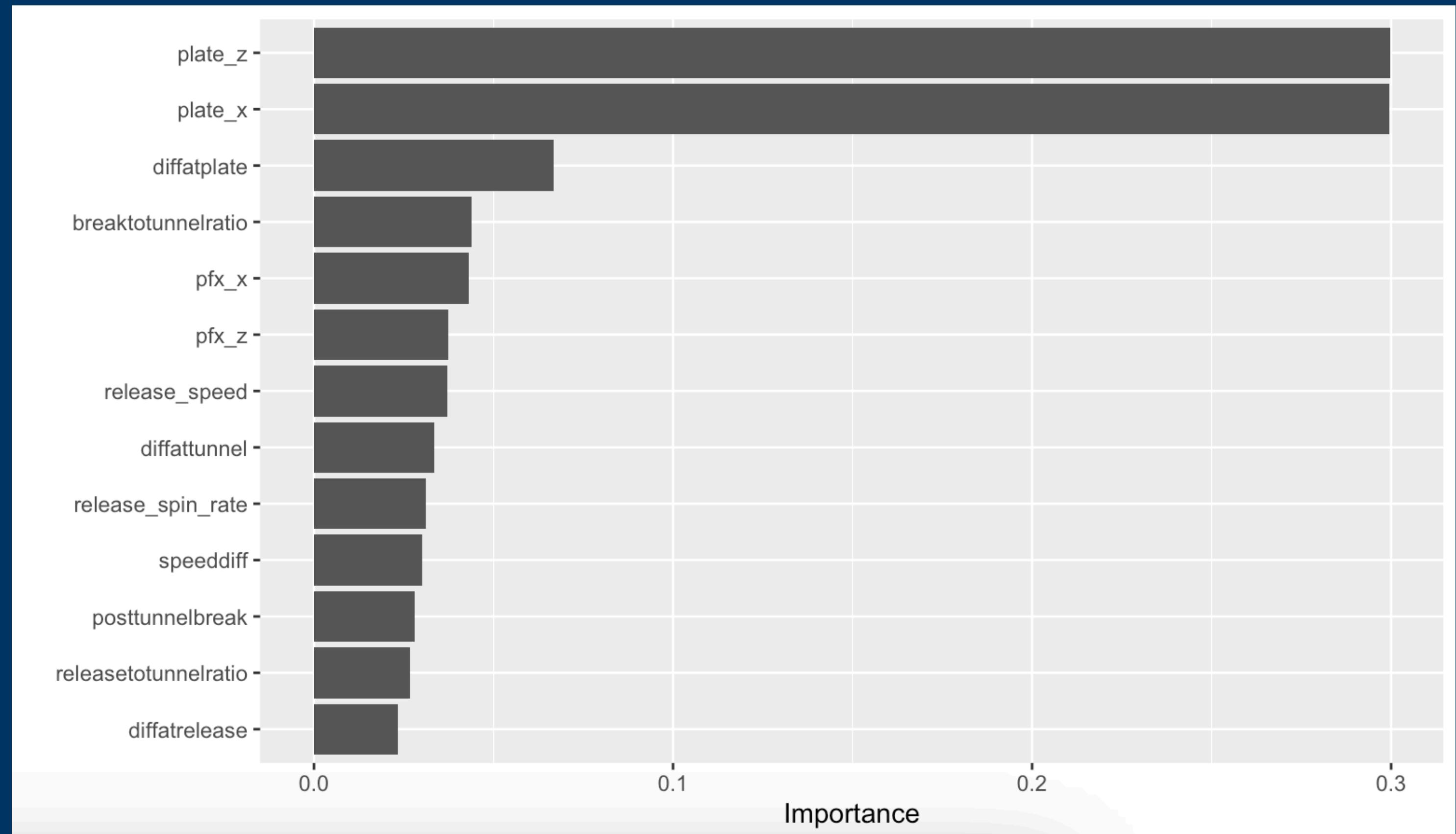


Cutter -> Curveball | RHP -> RHH | Chase

Training Sample: n = 2380 pitches

Testing Sample: n = 1022 pitches

Testing Accuracy: 72.41%

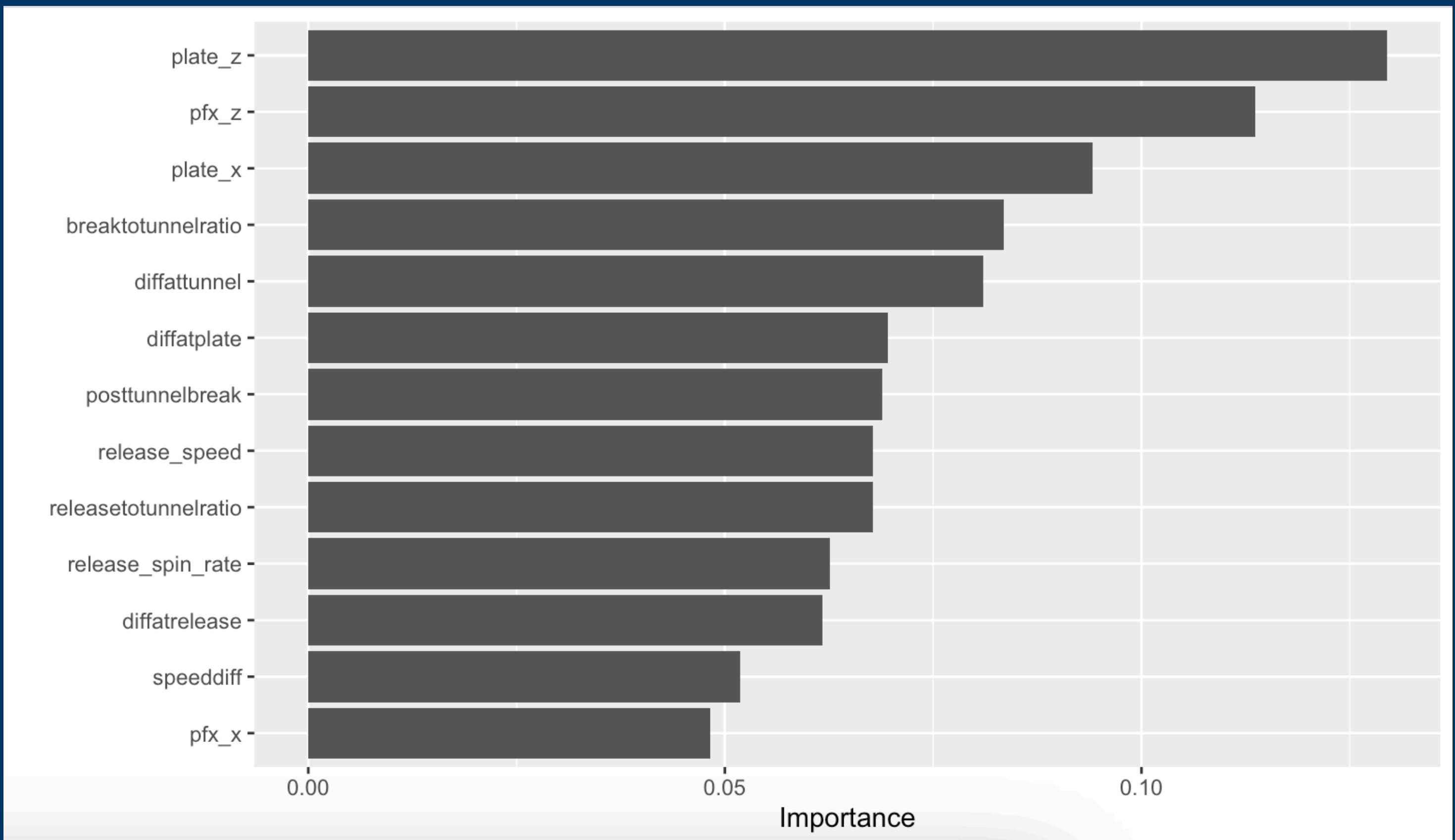


Cutter -> Curveball | RHP -> RHH | Groundball

Training Sample: n = 2380 pitches

Testing Sample: n = 1022 pitches

Testing Accuracy: 62.57%

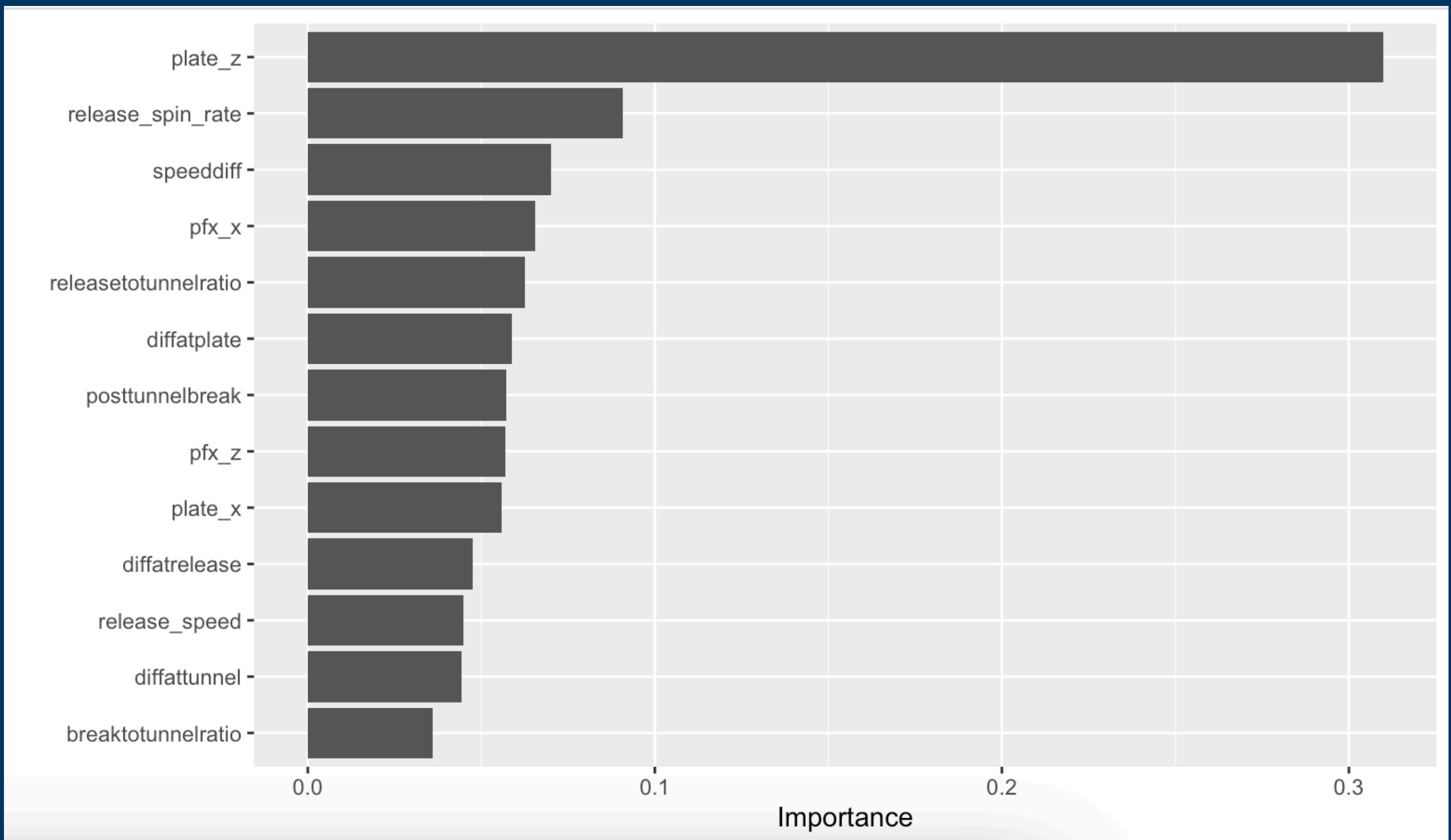


Cutter -> Splitter | RHP -> RHH | Whiff

Training Sample: n = 402 pitches

Testing Sample: n = 174 pitches

Testing Accuracy: 63.22%

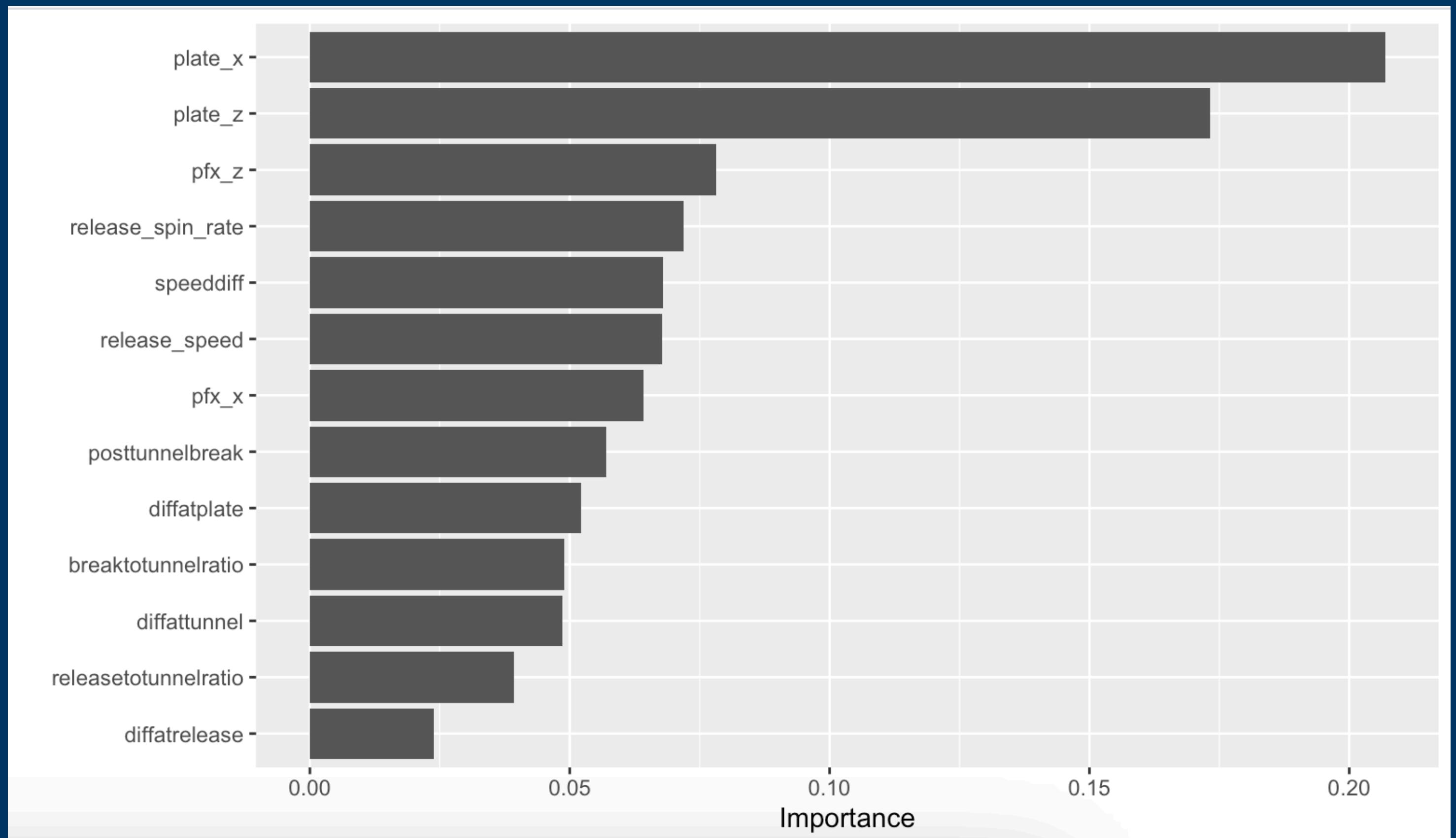


Cutter -> Splitter | RHP -> RHH | Chase

Training Sample: n = 470 pitches

Testing Sample: n = 204 pitches

Testing Accuracy: 66.18%

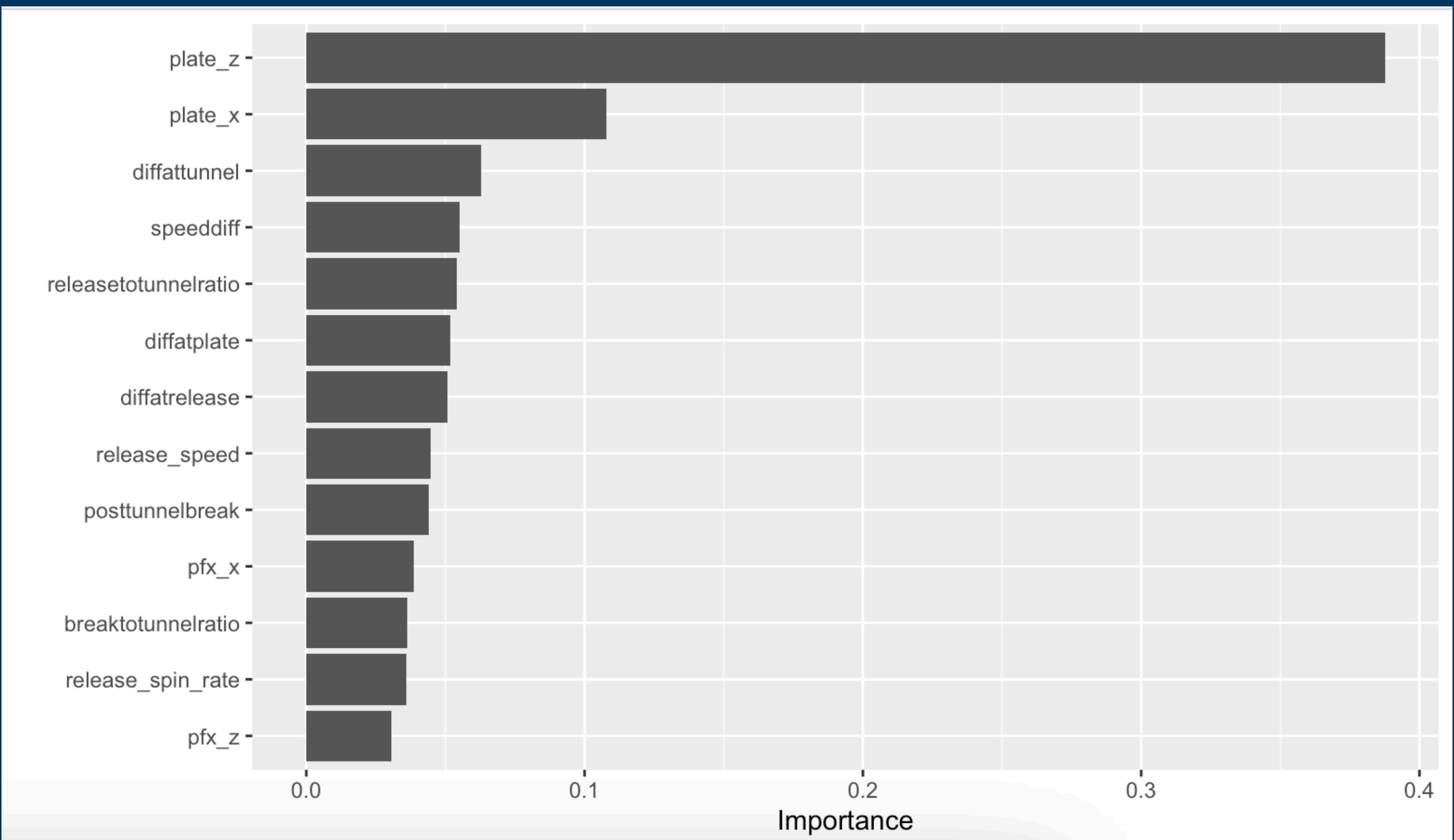


Cutter -> Knuckle Curve | RHP -> RHH | Whiff

Training Sample: n = 640 pitches

Testing Sample: n = 276 pitches

Testing Accuracy: 76.81%

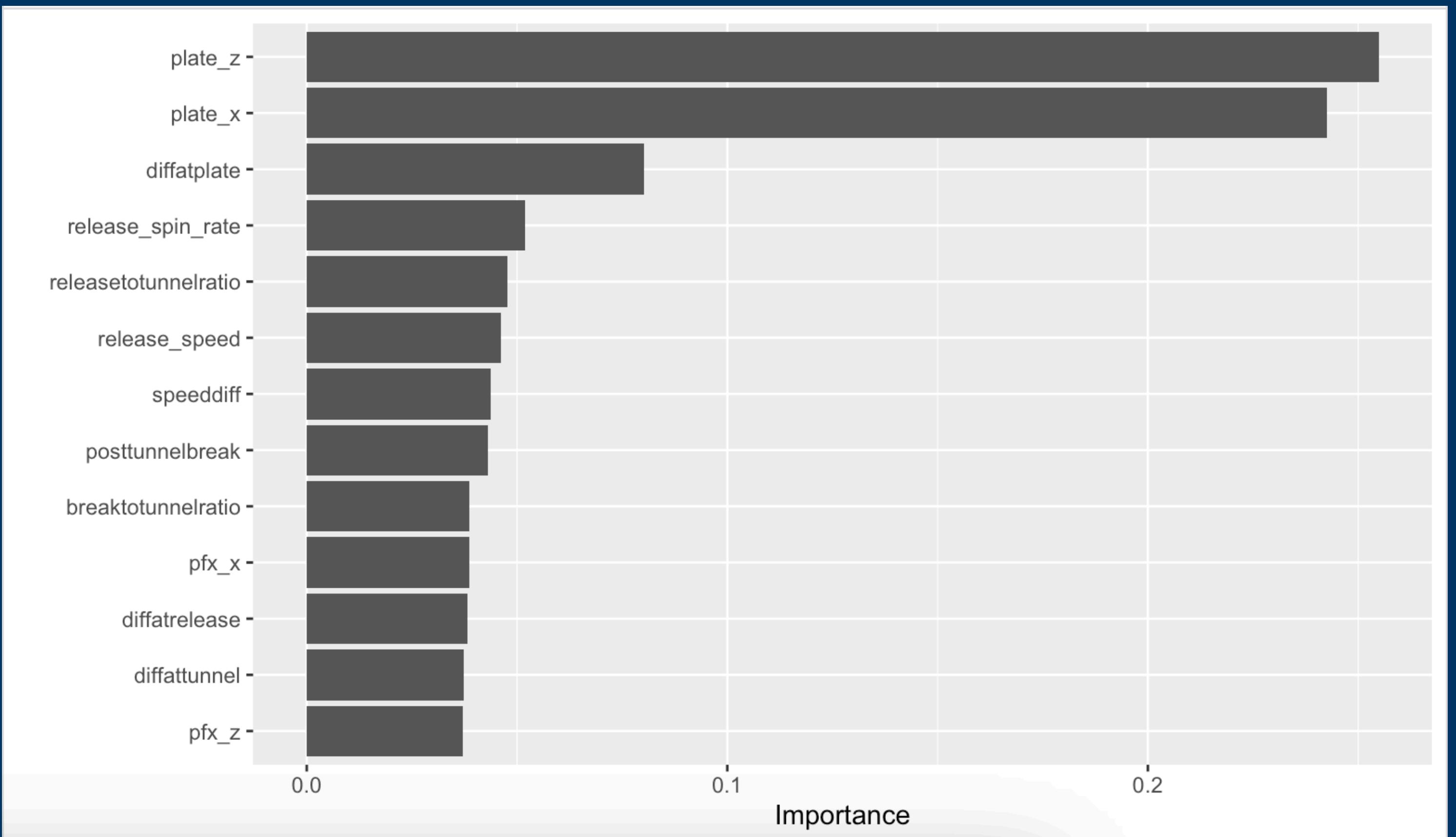


Cutter -> Knuckle Curve | RHP -> RHH | Chase

Training Sample: n = 1004 pitches

Testing Sample: n = 432 pitches

Testing Accuracy: 71.99%

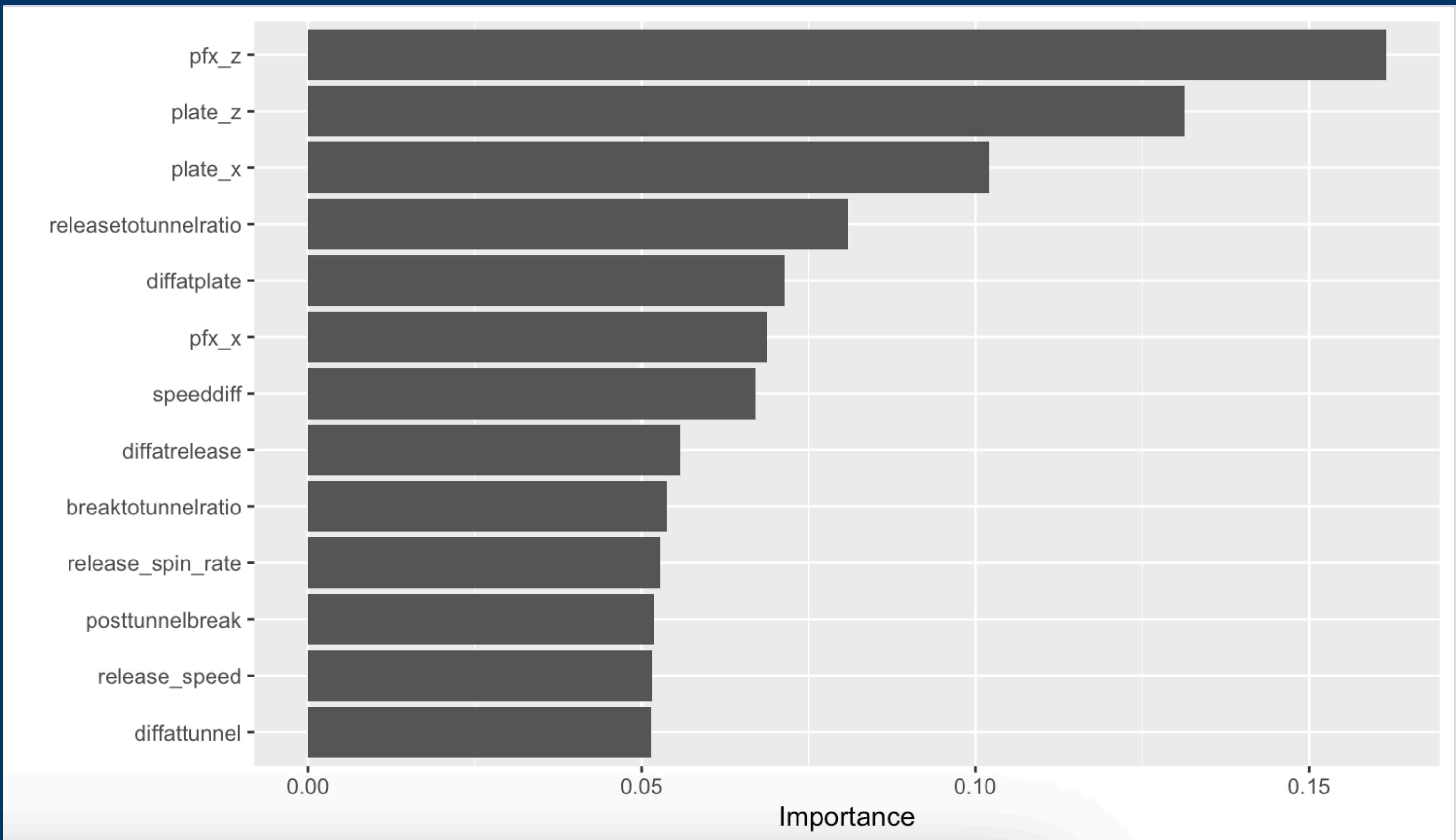


Cutter -> Knuckle Curve | RHP -> RHH | Groundball

Training Sample: n = 344 pitches

Testing Sample: n = 150 pitches

Testing Accuracy: 60%

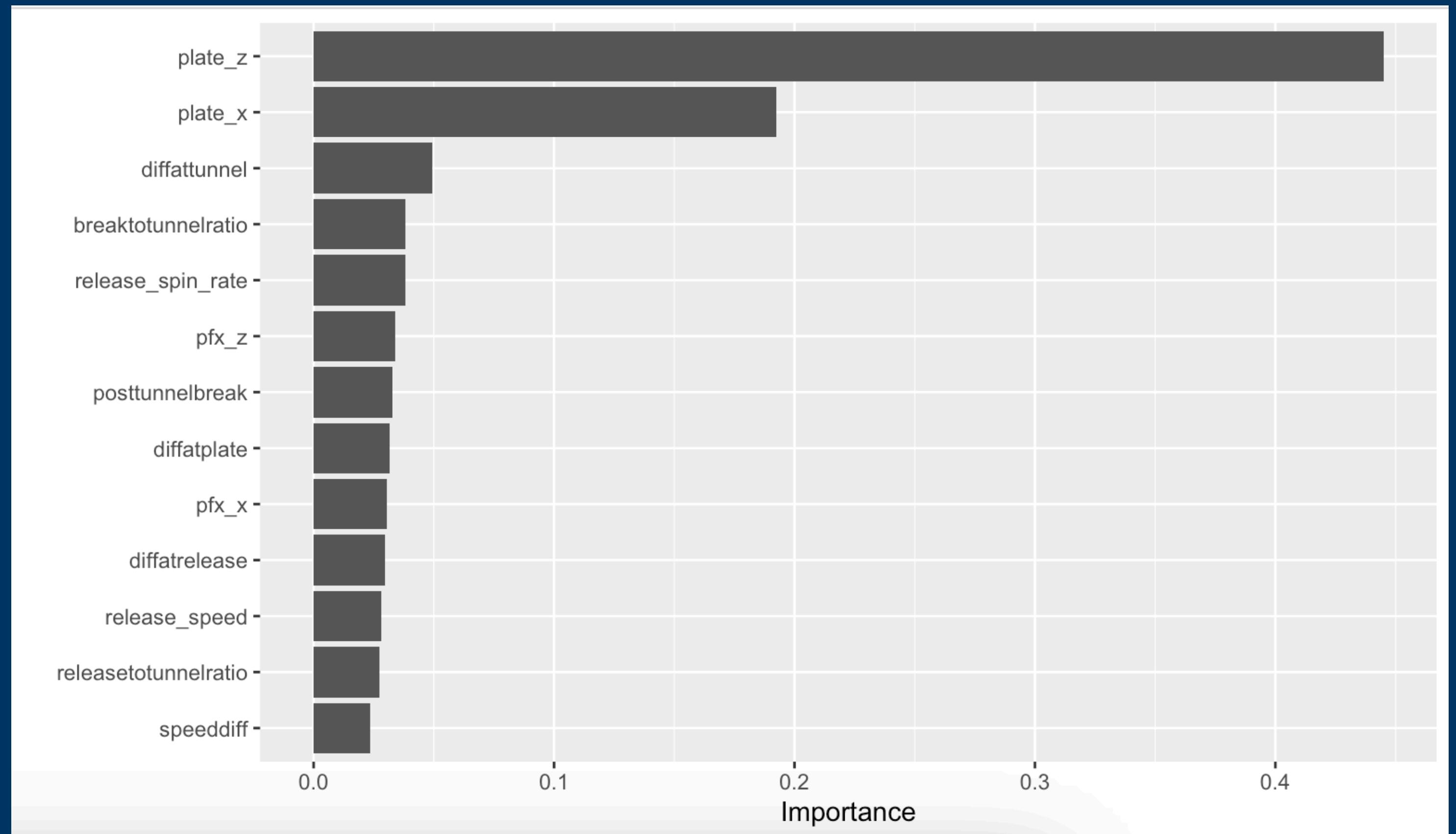


Cutter -> Slider | RHP -> RHH | Whiff

Training Sample: n = 1852 pitches

Testing Sample: n = 794 pitches

Testing Accuracy: 71.66%

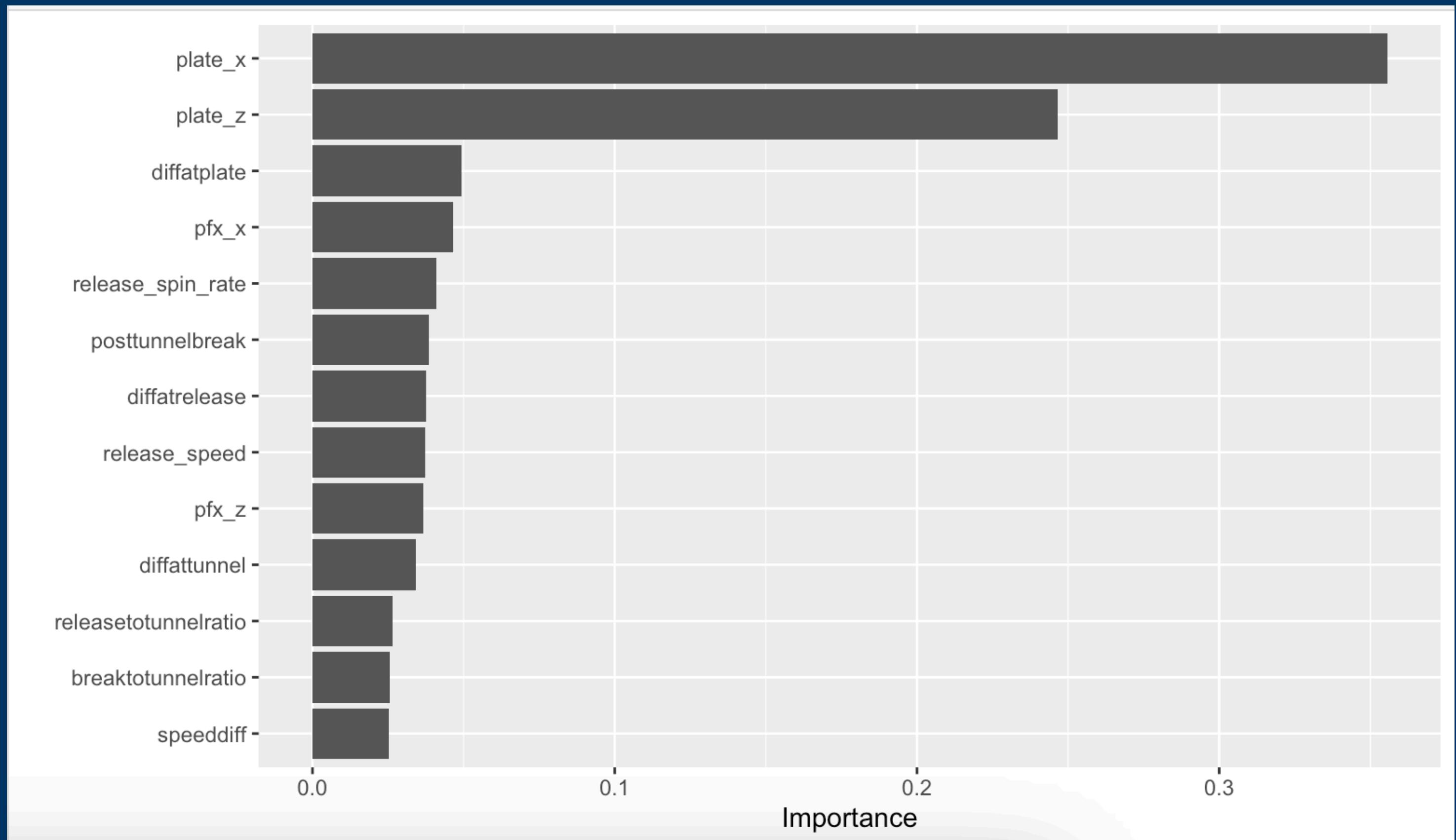


Cutter -> Slider | RHP -> RHH | Chase

Training Sample: n = 2444 pitches

Testing Sample: n = 1048 pitches

Testing Accuracy: 67.08%

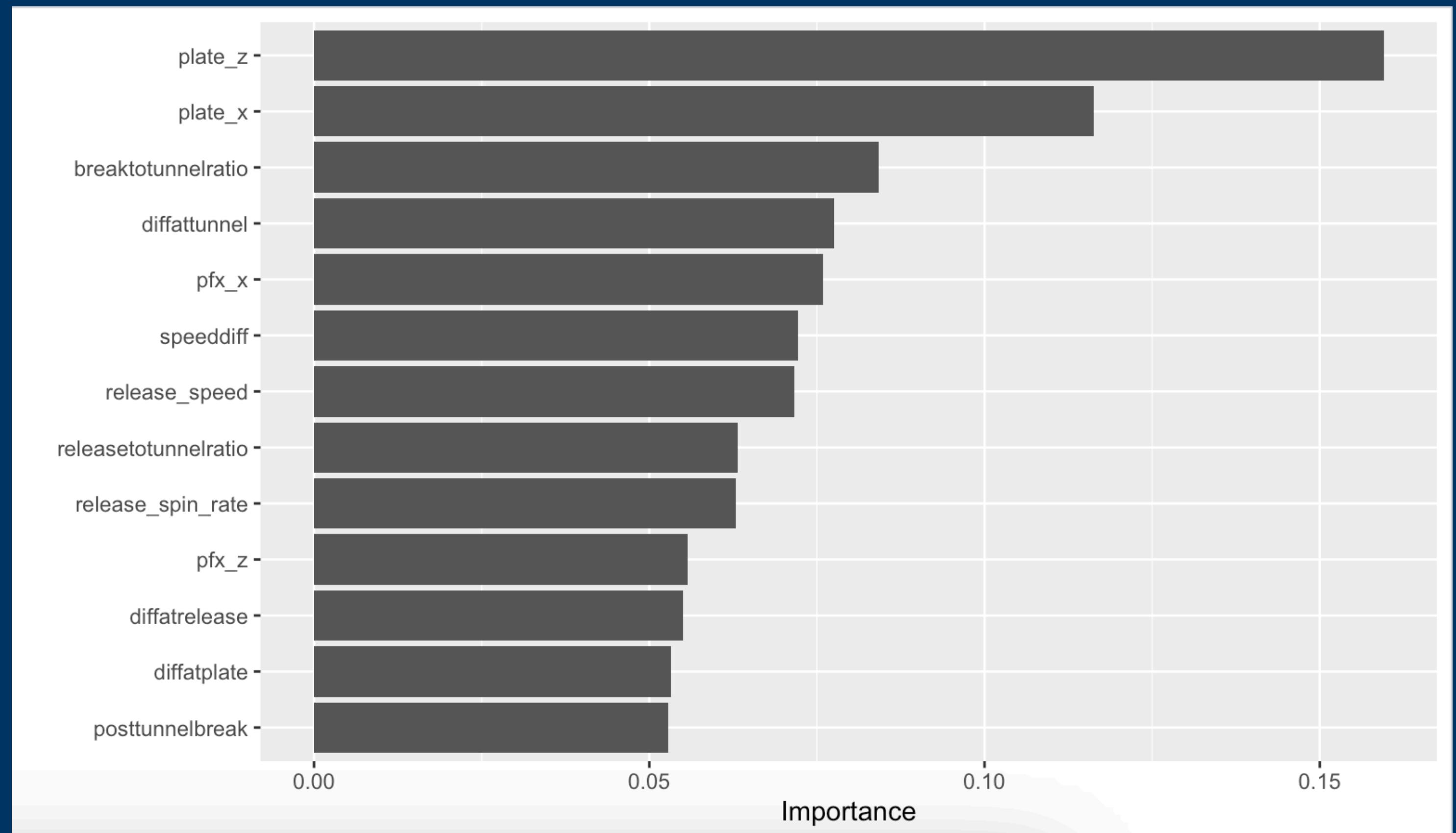


Cutter -> Slider | RHP -> RHH | Groundball

Training Sample: n = 884 pitches

Testing Sample: n = 380 pitches

Testing Accuracy: 56.05%

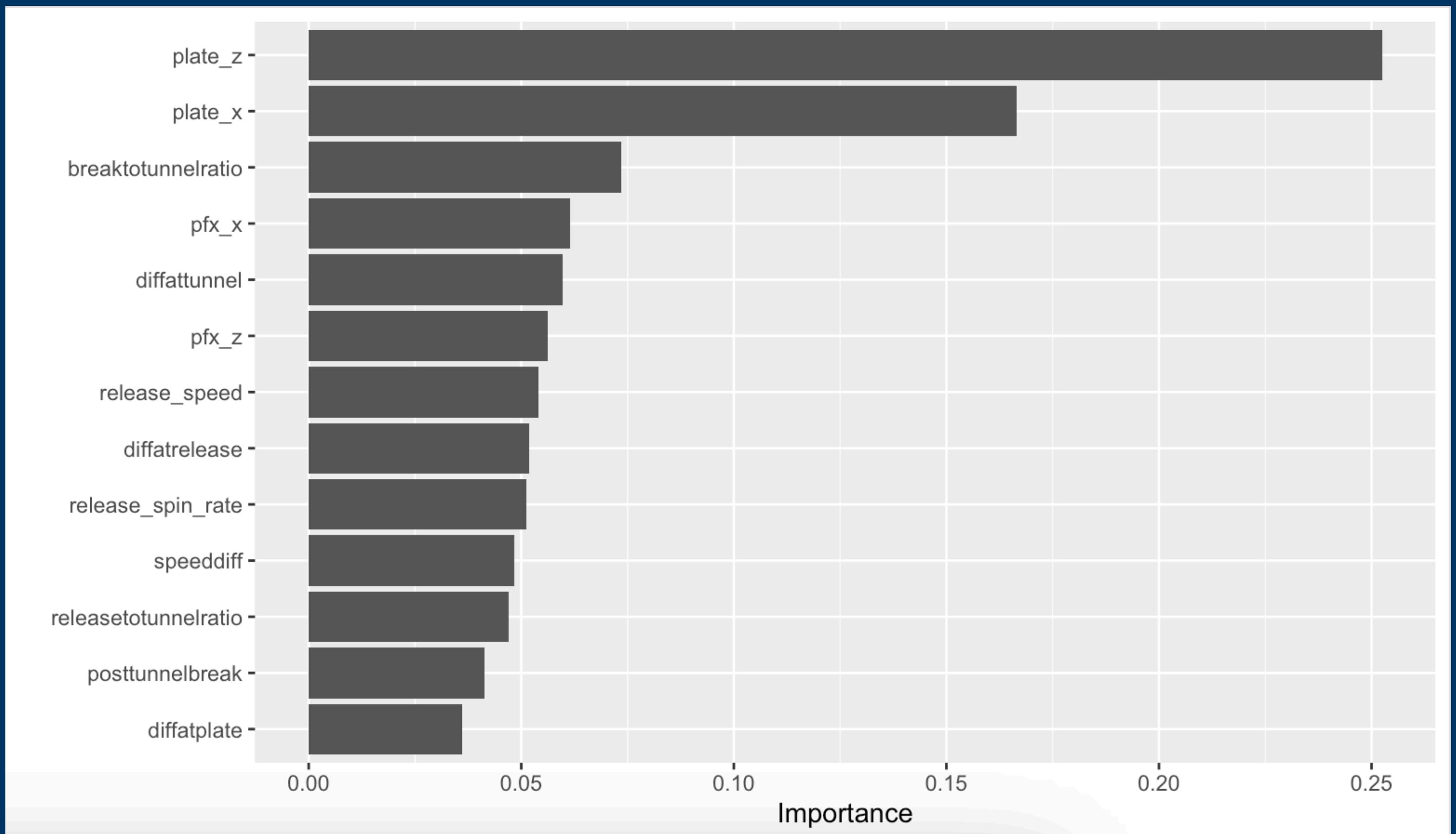


Cutter -> Sweeper | RHP -> RHH | Whiff

Training Sample: n = 554 pitches

Testing Sample: n = 238 pitches

Testing Accuracy: 63.45%

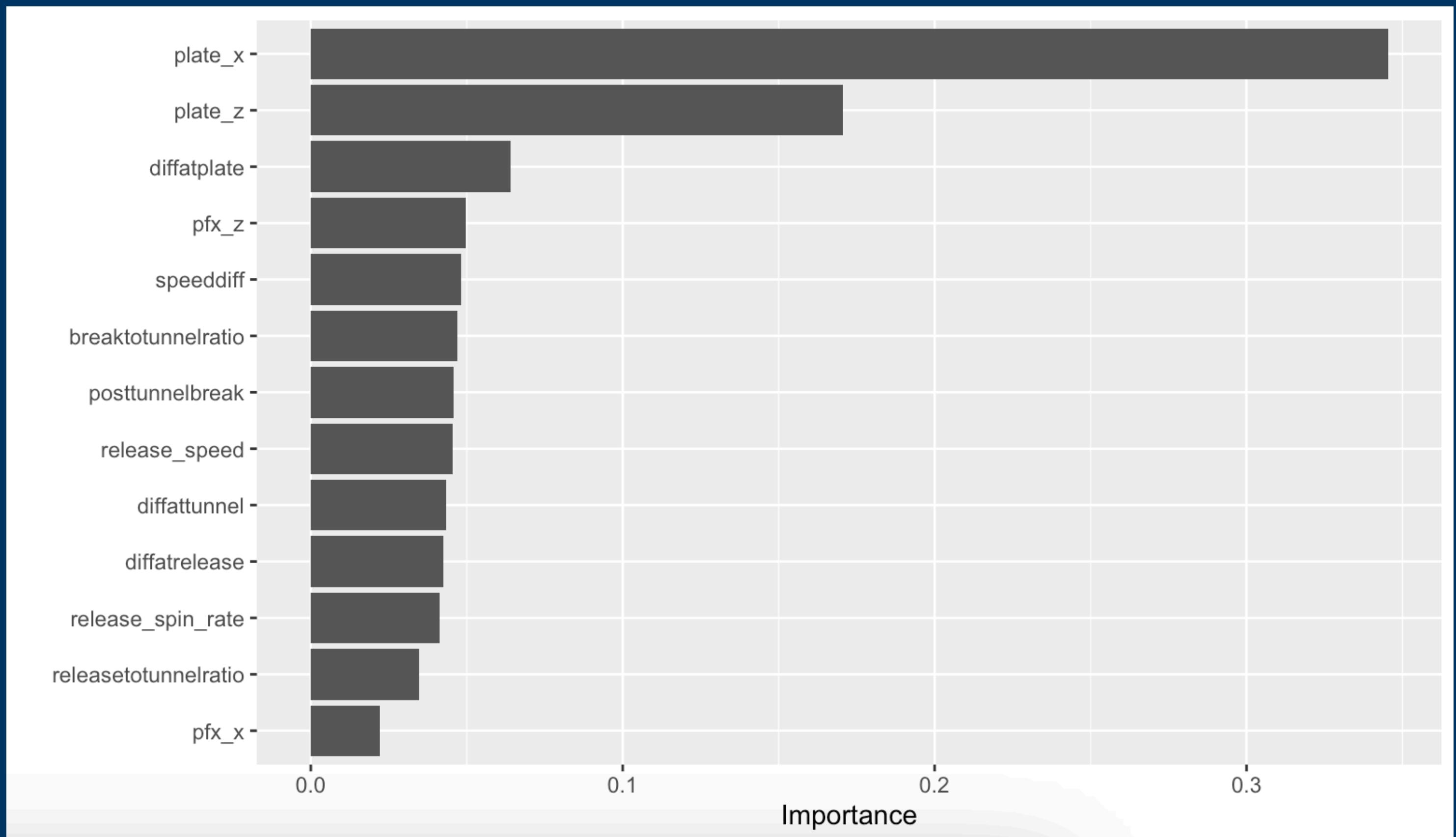


Cutter -> Sweeper | RHP -> RHH | Chase

Training Sample: n = 660 pitches

Testing Sample: n = 284 pitches

Testing Accuracy: 70.42%

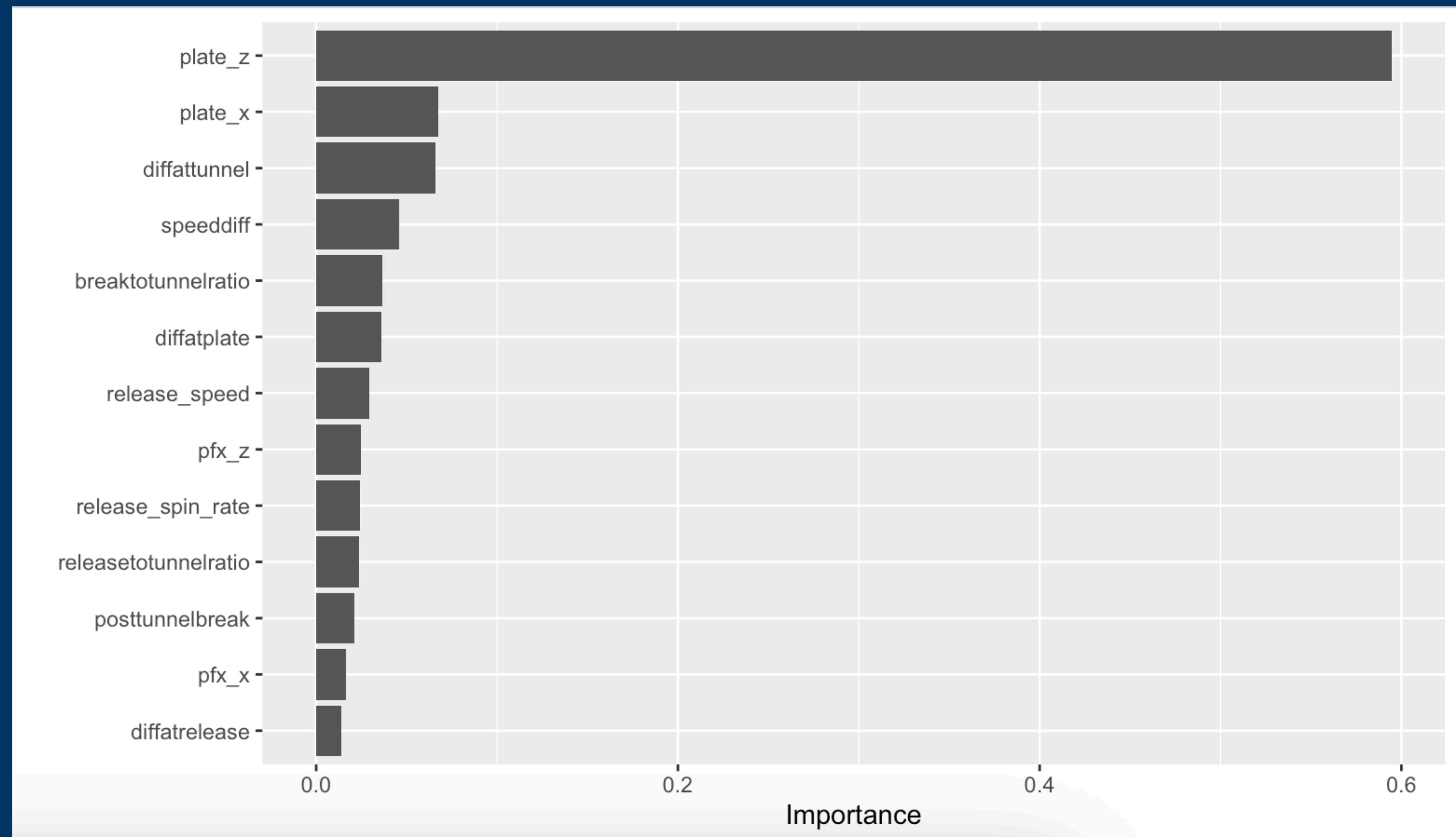


Four-Seam -> Changeup | RHP -> RHH | Whiff

Training Sample: n = 8148 pitches

Testing Sample: n = 3494 pitches

Testing Accuracy: 67.09%

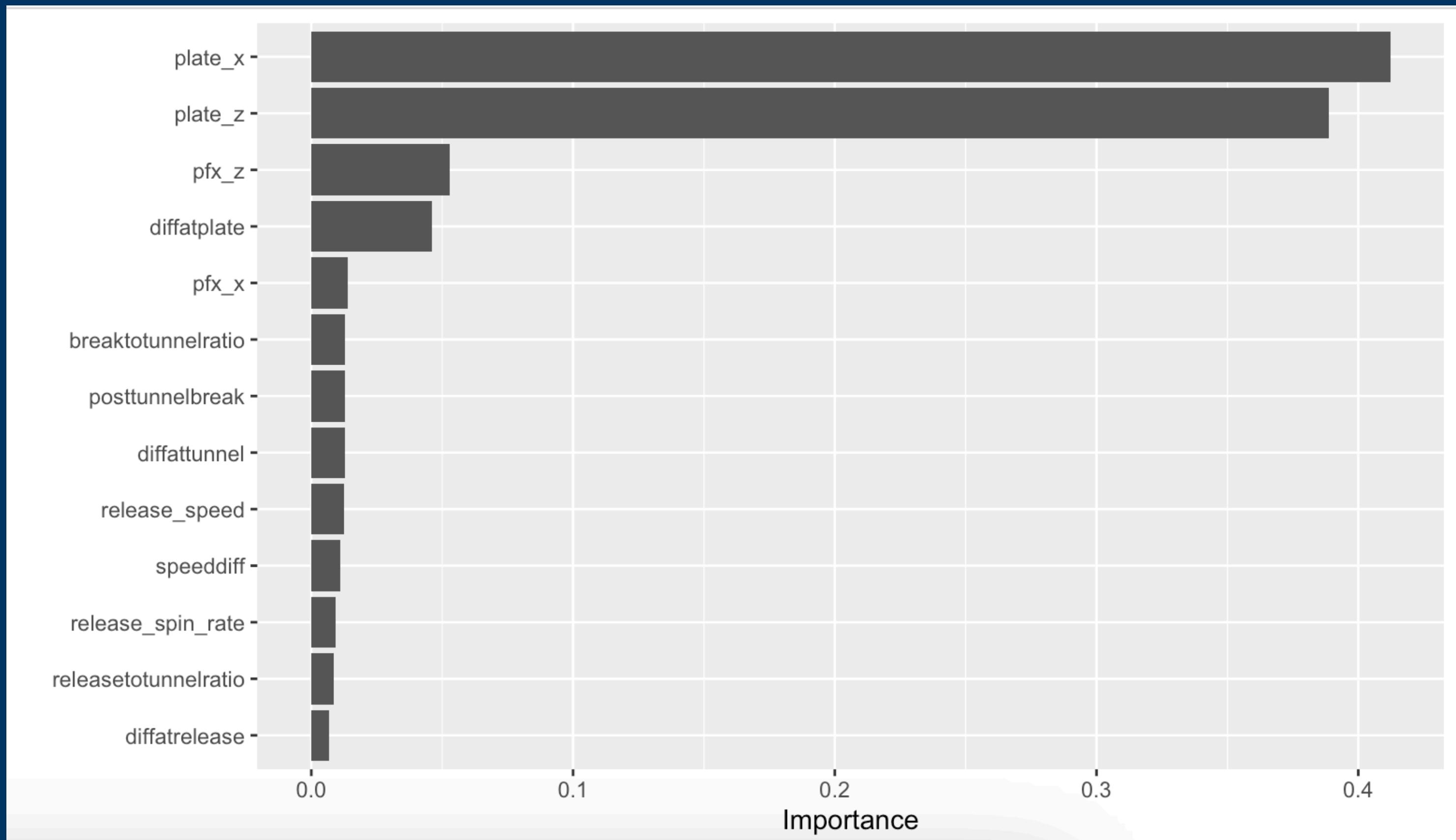


Four-Seam -> Changeup | RHP -> RHH | Chase

Training Sample: n = 11286 pitches

Testing Sample: n = 4838 pitches

Testing Accuracy: 73.11%

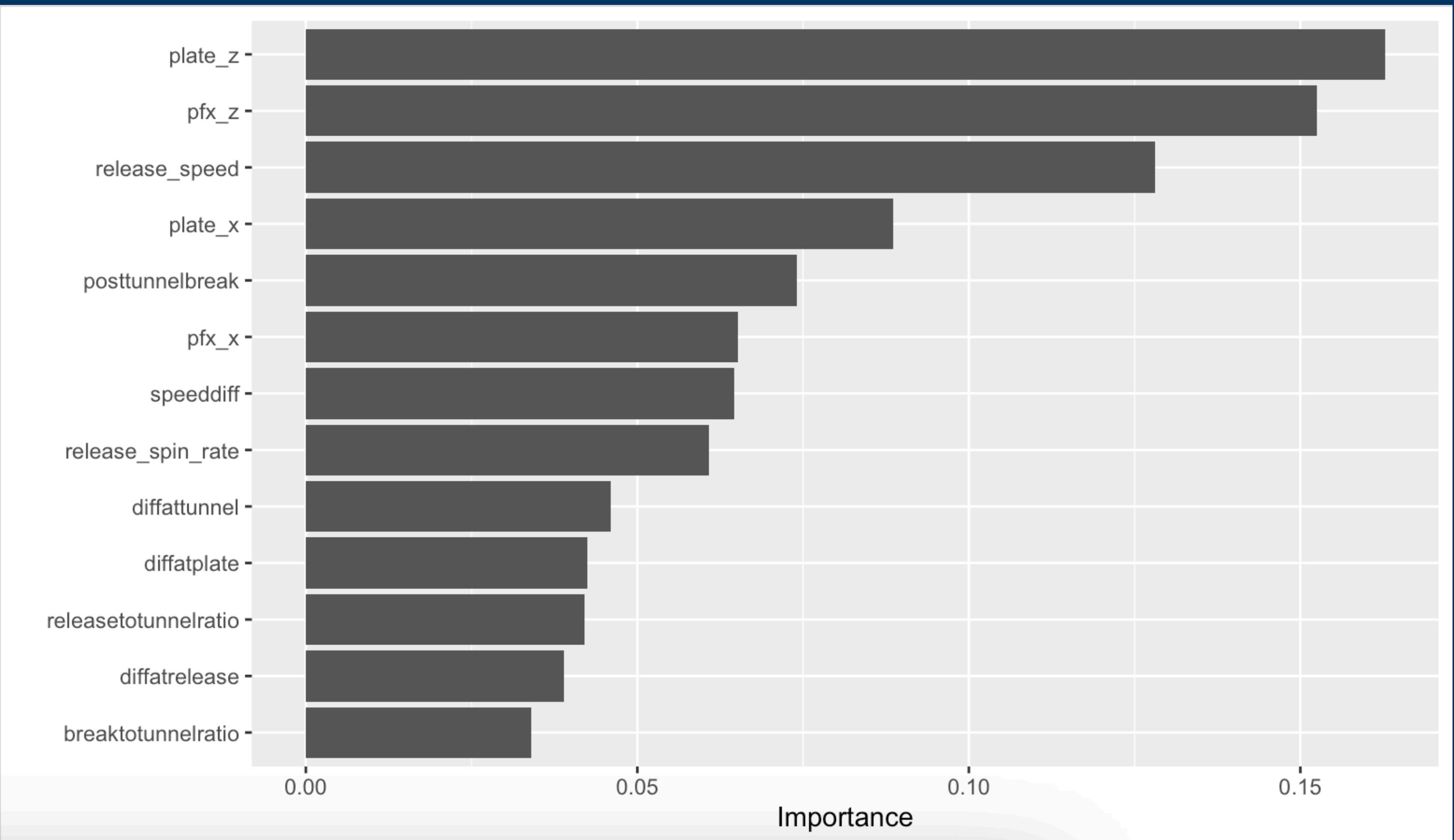


Four-Seam -> Changeup | RHP -> RHH | Groundball

Training Sample: n = 4132 pitches

Testing Sample: n = 1772 pitches

Testing Accuracy: 59.82%

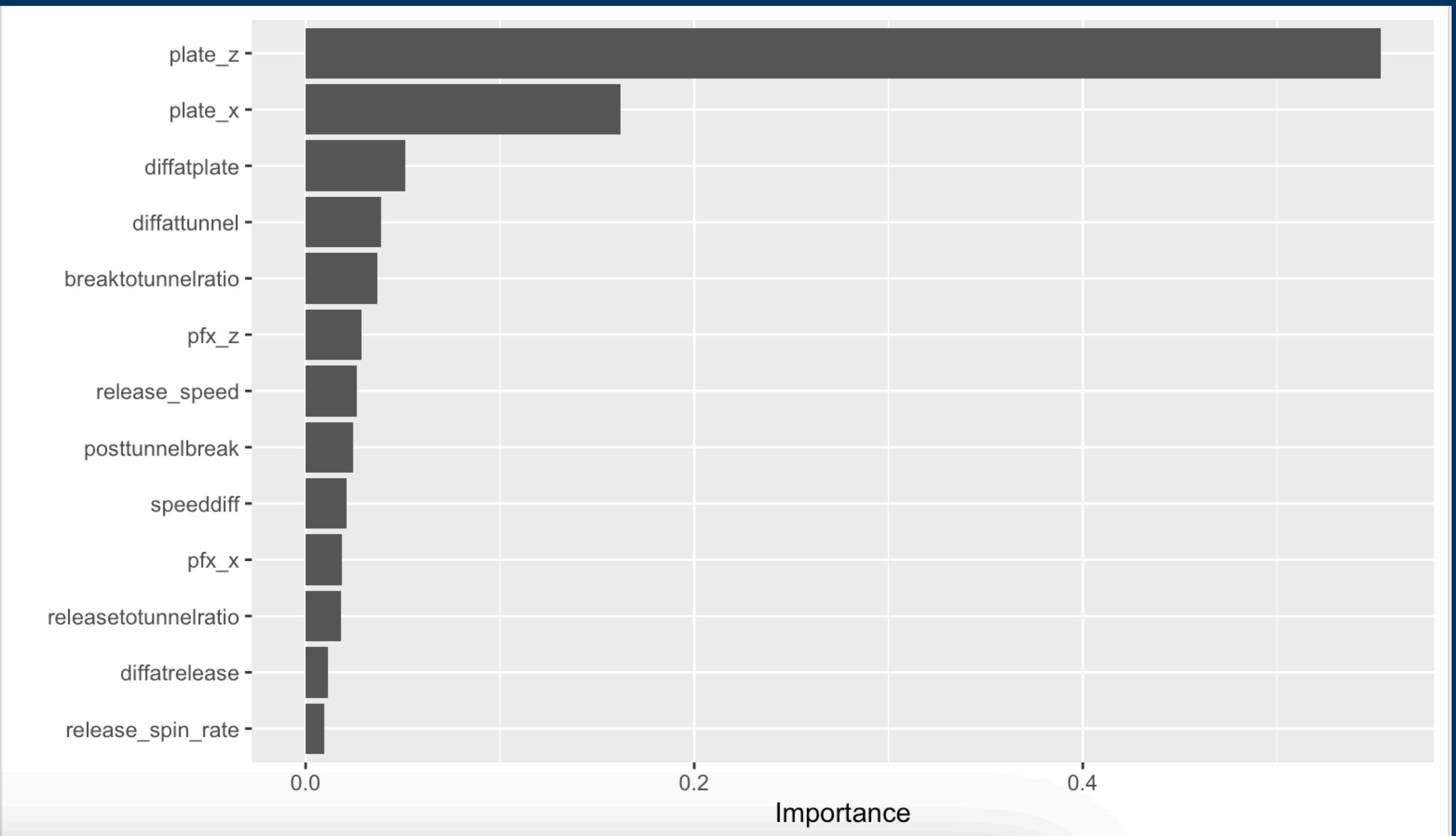


Four-Seam -> Curveball | RHP -> RHH | Whiff

Training Sample: n = 7238 pitches

Testing Sample: n = 3104 pitches

Testing Accuracy: 72.39%

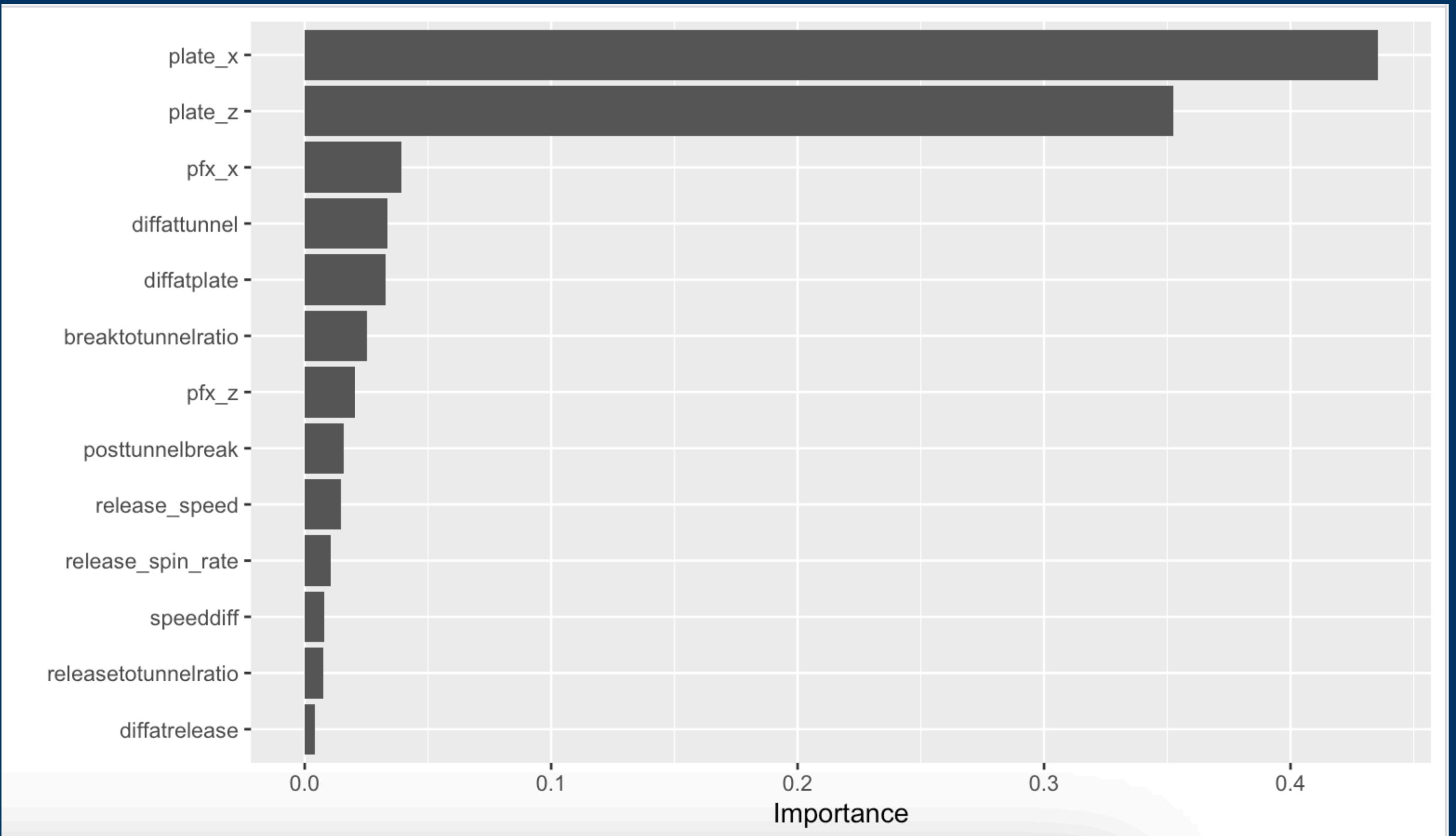


Four-Seam -> Curveball | RHP -> RHH | Chase

Training Sample: n = 10766 pitches

Testing Sample: n = 4616 pitches

Testing Accuracy: 70.99%

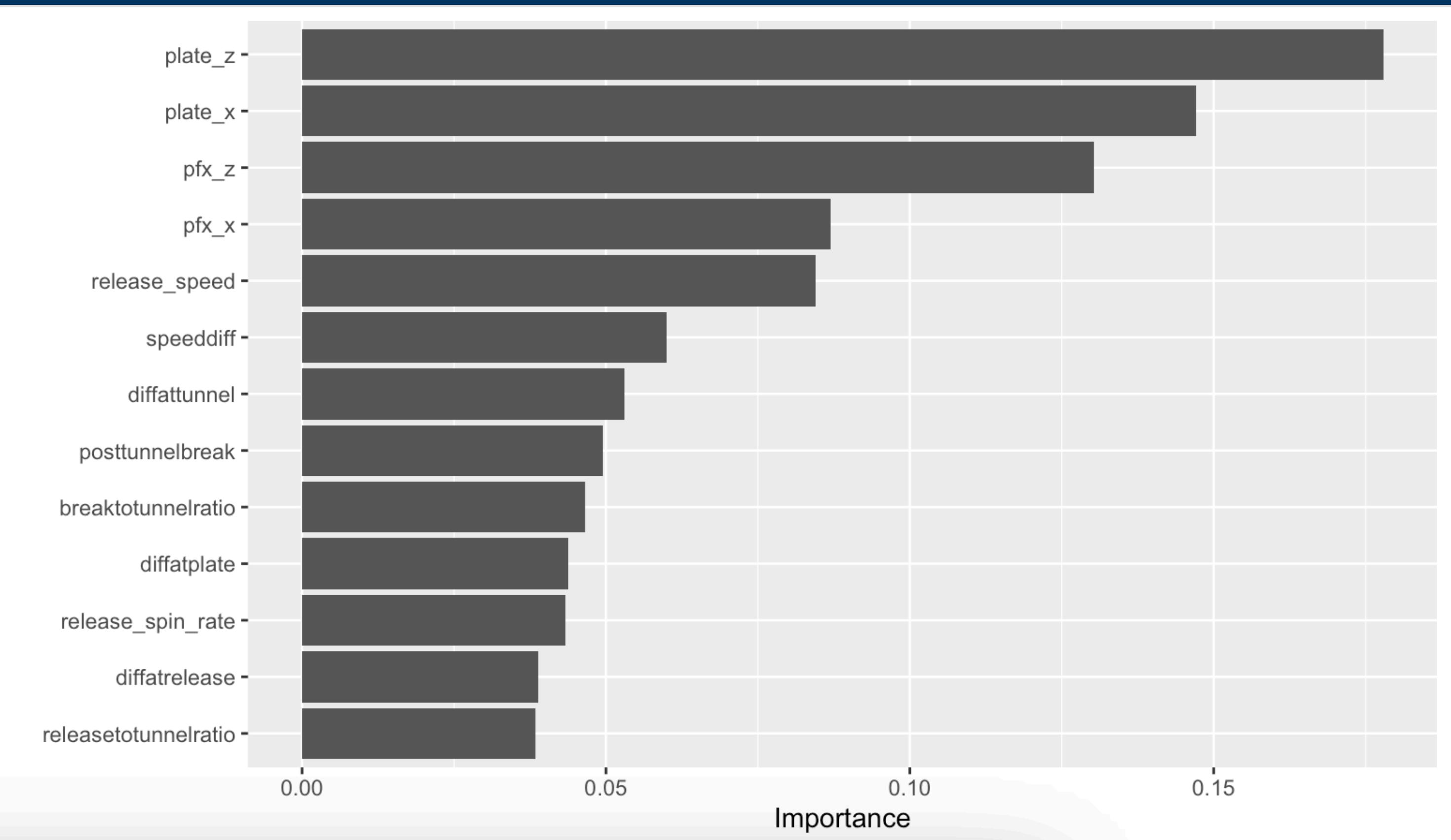


Four-Seam -> Curveball | RHP -> RHH | Groundball

Training Sample: n = 4546 pitches

Testing Sample: n = 1950 pitches

Testing Accuracy: 63.28%

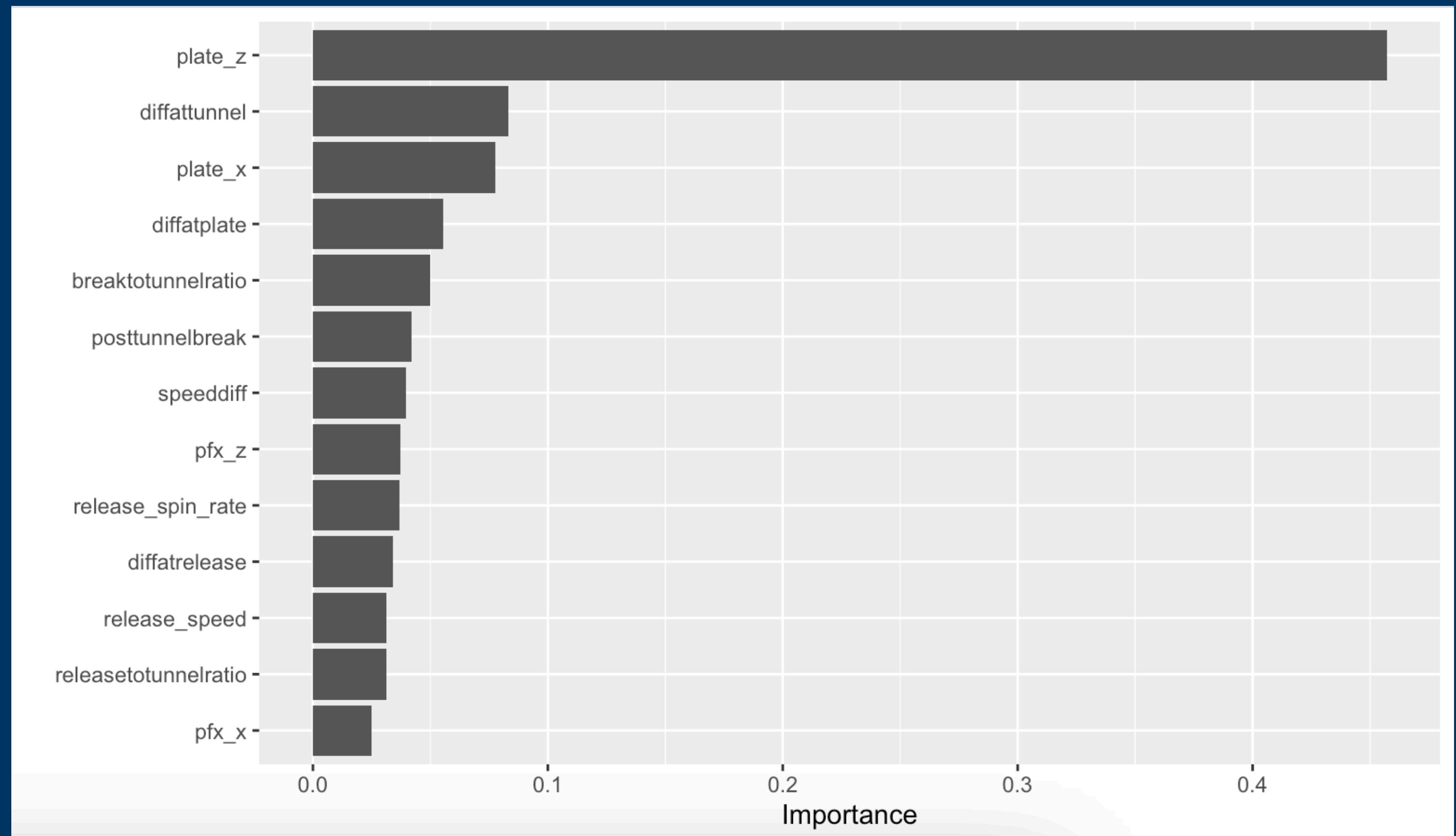


Four-Seam -> Splitter | RHP -> RHH | Whiff

Training Sample: n = 2670 pitches

Testing Sample: n = 1146 pitches

Testing Accuracy: 67.89%

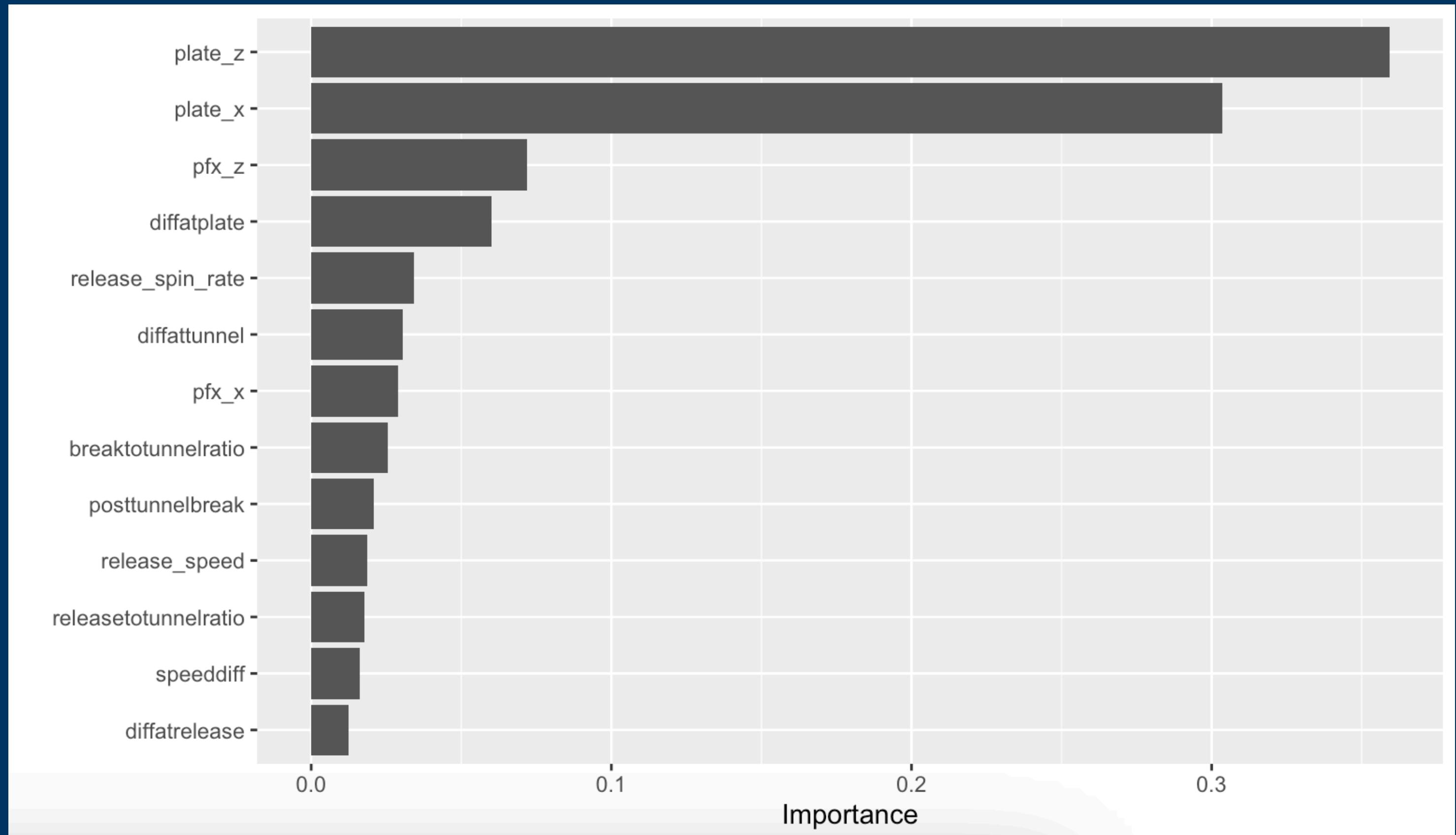


Four-Seam -> Splitter | RHP -> RHH | Chase

Training Sample: n = 3682 pitches

Testing Sample: n = 1580 pitches

Testing Accuracy: 73.35%

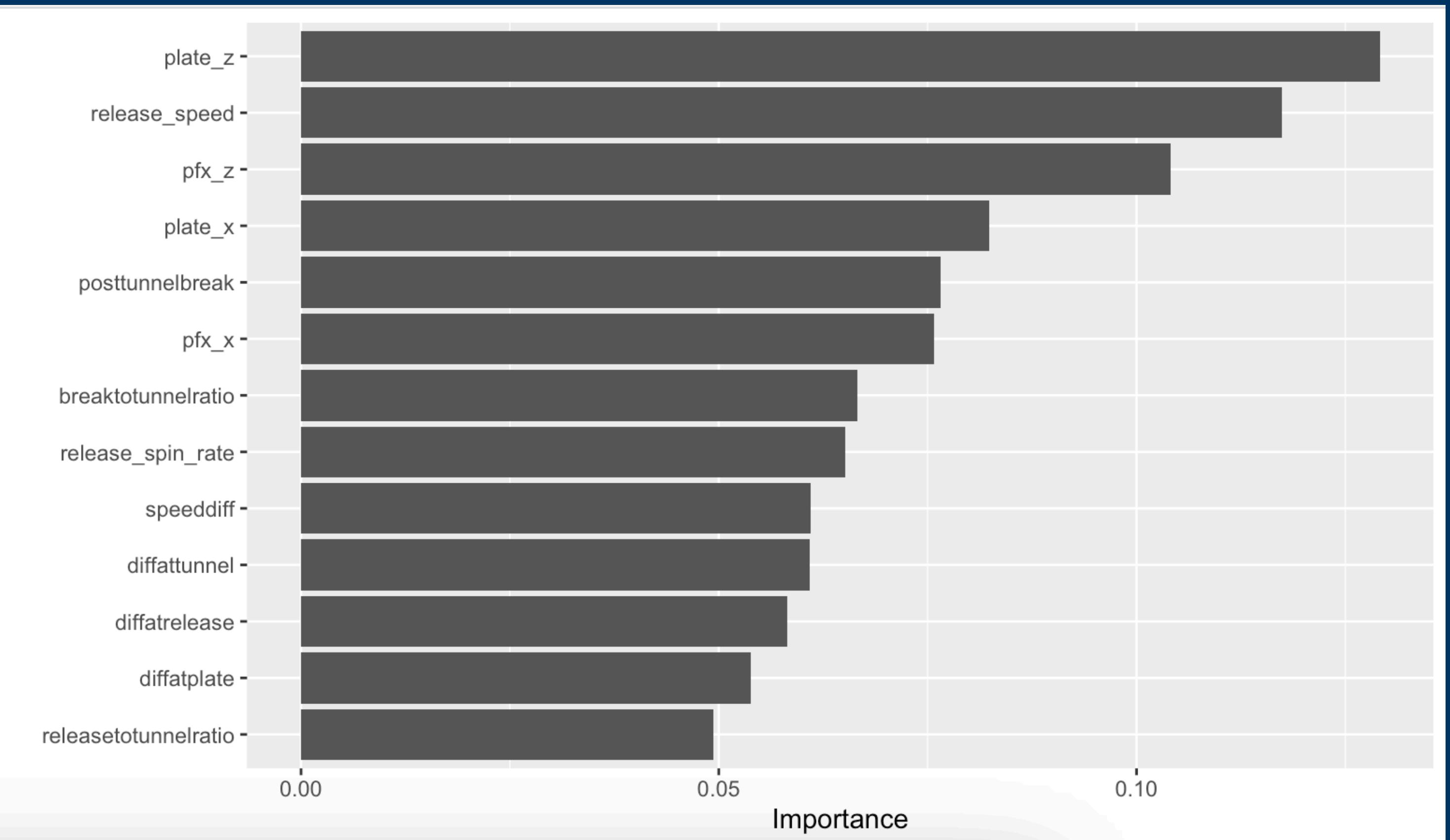


Four-Seam -> Splitter | RHP -> RHH | Groundball

Training Sample: n = 1114 pitches

Testing Sample: n = 480 pitches

Testing Accuracy: 59.17%

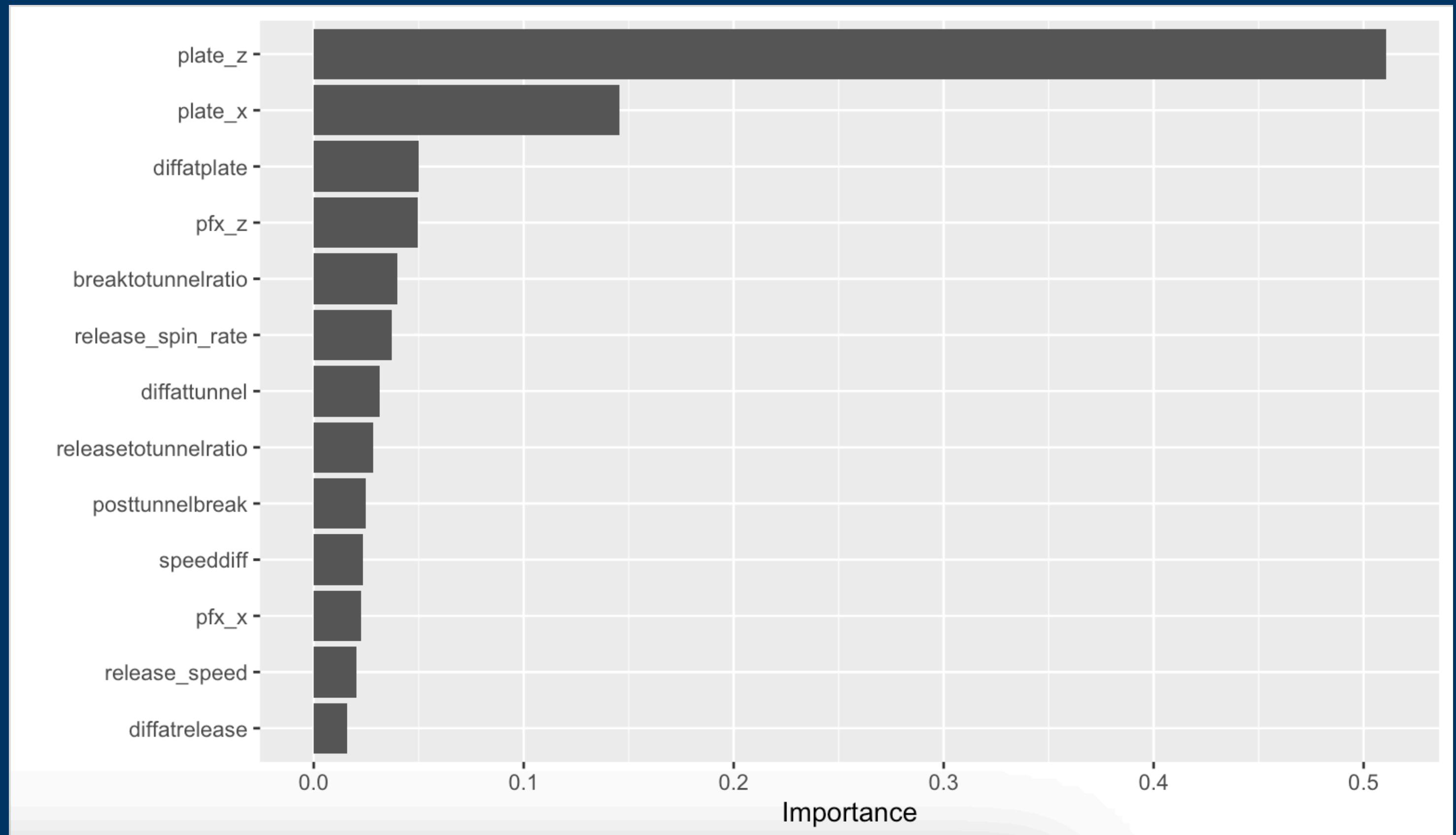


Four-Seam -> Knuckle Curve | RHP -> RHH | Whiff

Training Sample: n = 2880 pitches

Testing Sample: n = 1236 pitches

Testing Accuracy: 74.27%

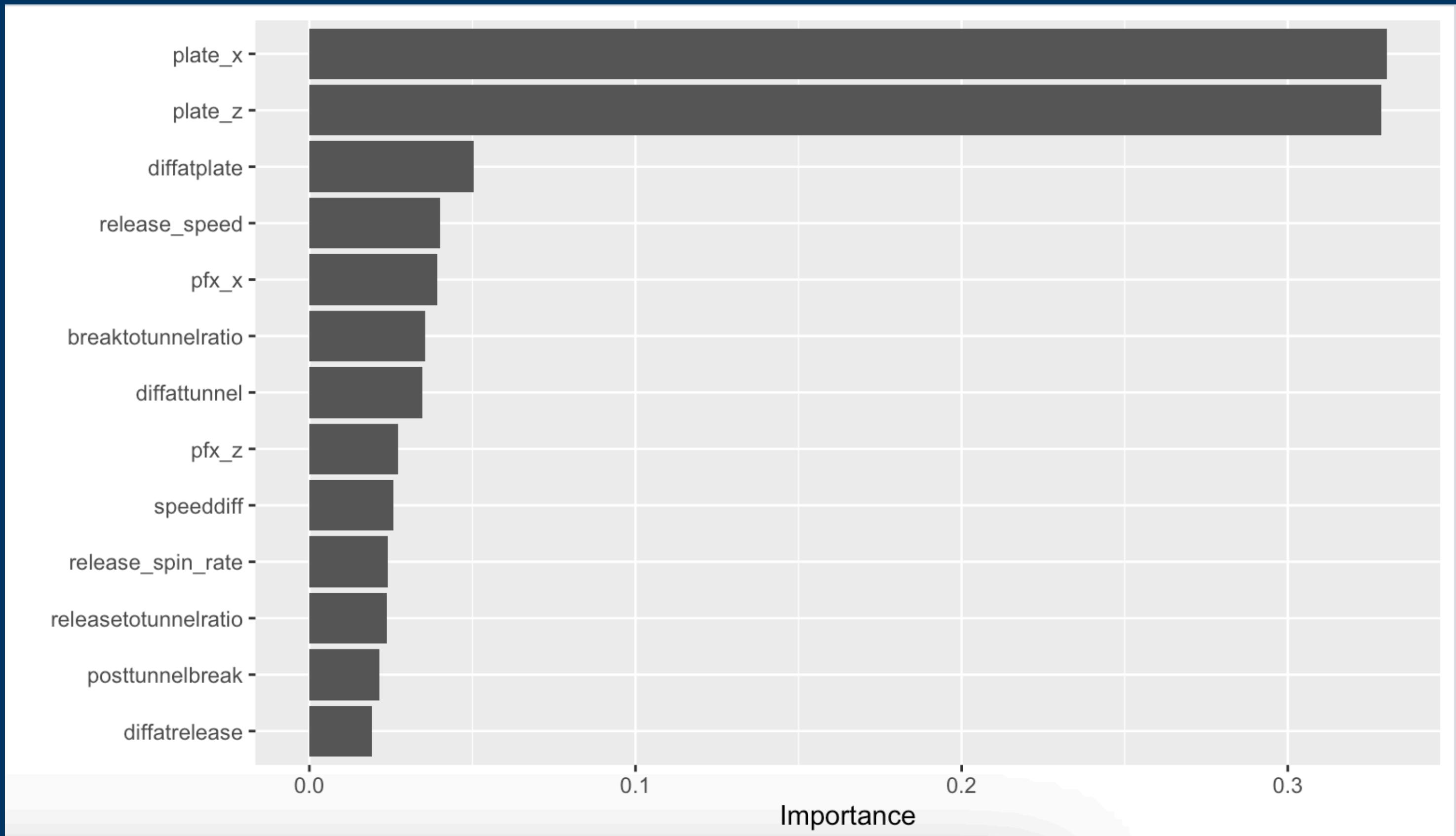


Four-Seam -> Knuckle Curve | RHP -> RHH | Chase

Training Sample: n = 4056 pitches

Testing Sample: n = 1740 pitches

Testing Accuracy: 69.71%

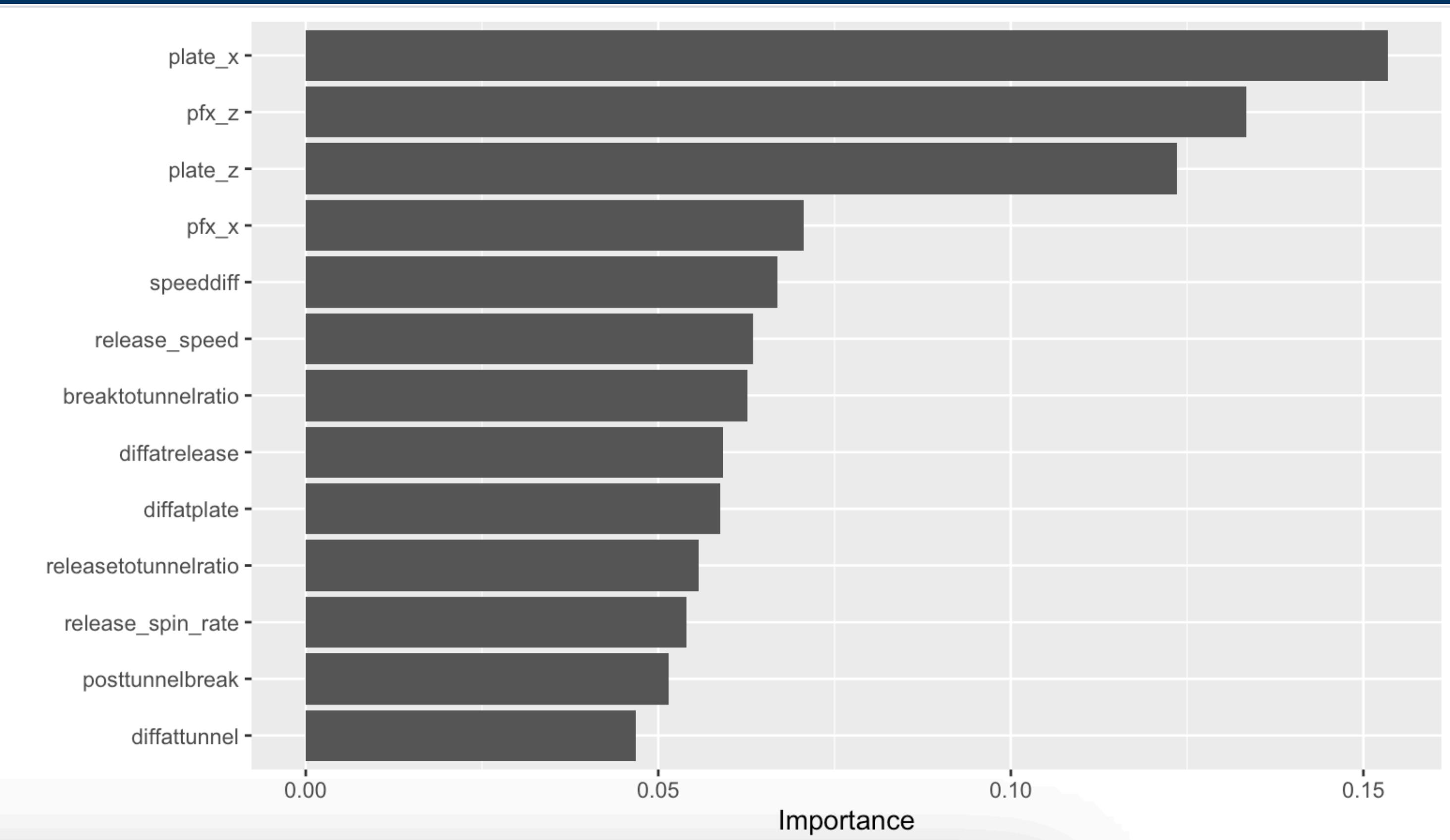


Four-Seam -> Knuckle Curve | RHP -> RHH | Groundball

Training Sample: n = 4056 pitches

Testing Sample: n = 1740 pitches

Testing Accuracy: 69.71%

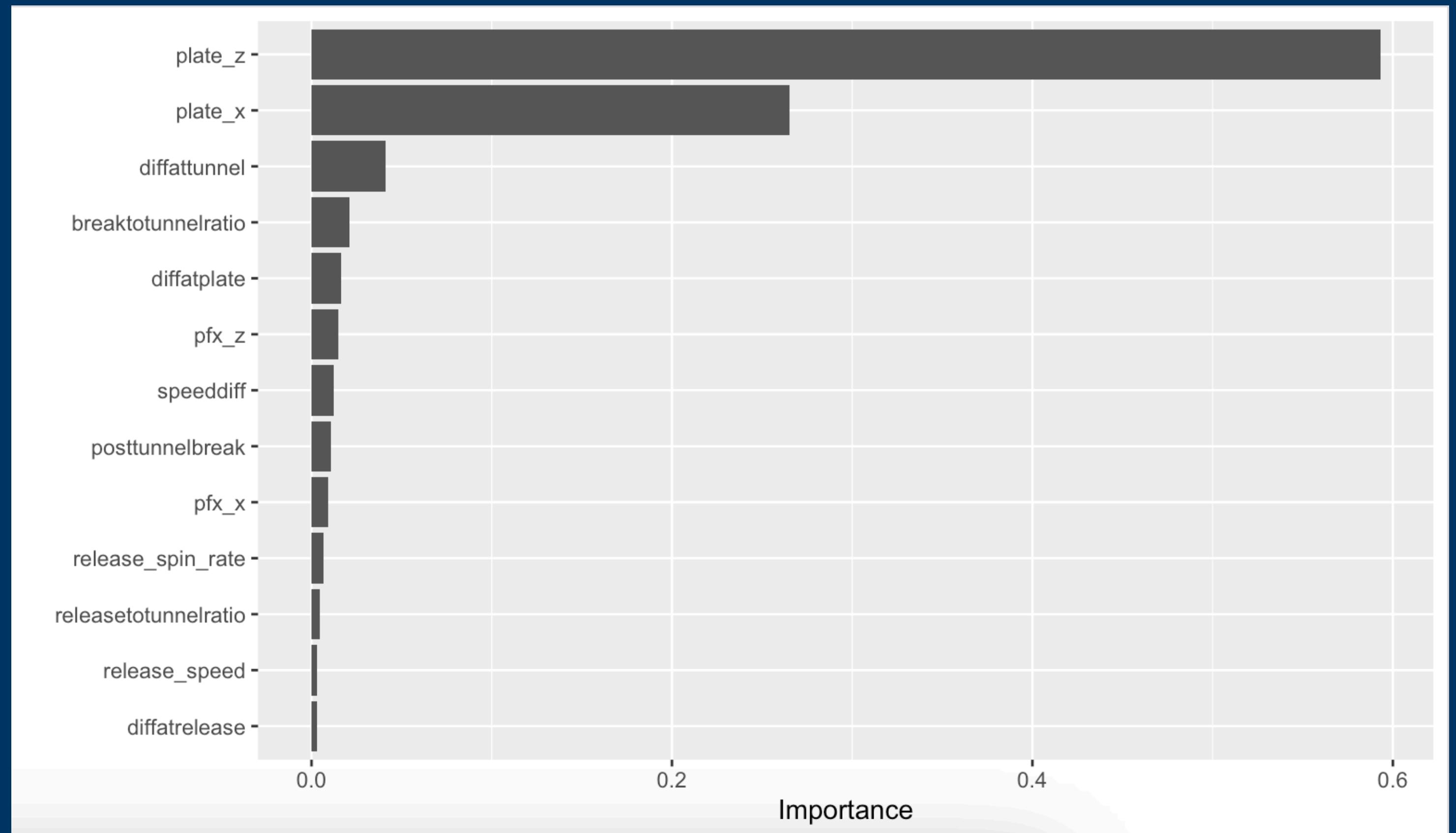


Four-Seam -> Slider | RHP -> RHH | Whiff

Training Sample: n = 26856 pitches

Testing Sample: n = 11512 pitches

Testing Accuracy: 71.78%

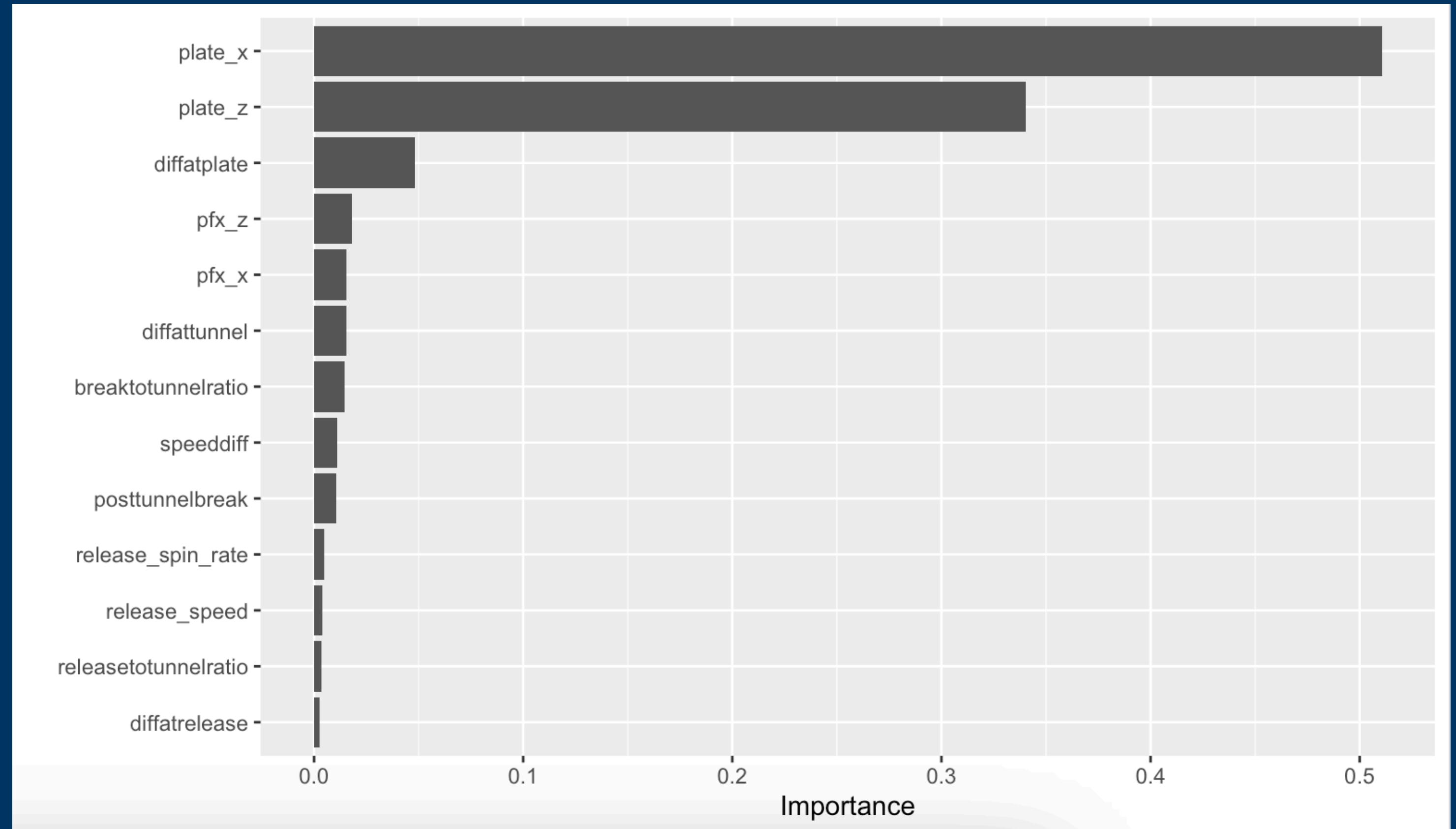


Four-Seam -> Slider | RHP -> RHH | Chase

Training Sample: n = 34156 pitches

Testing Sample: n = 14640 pitches

Testing Accuracy: 68.82%

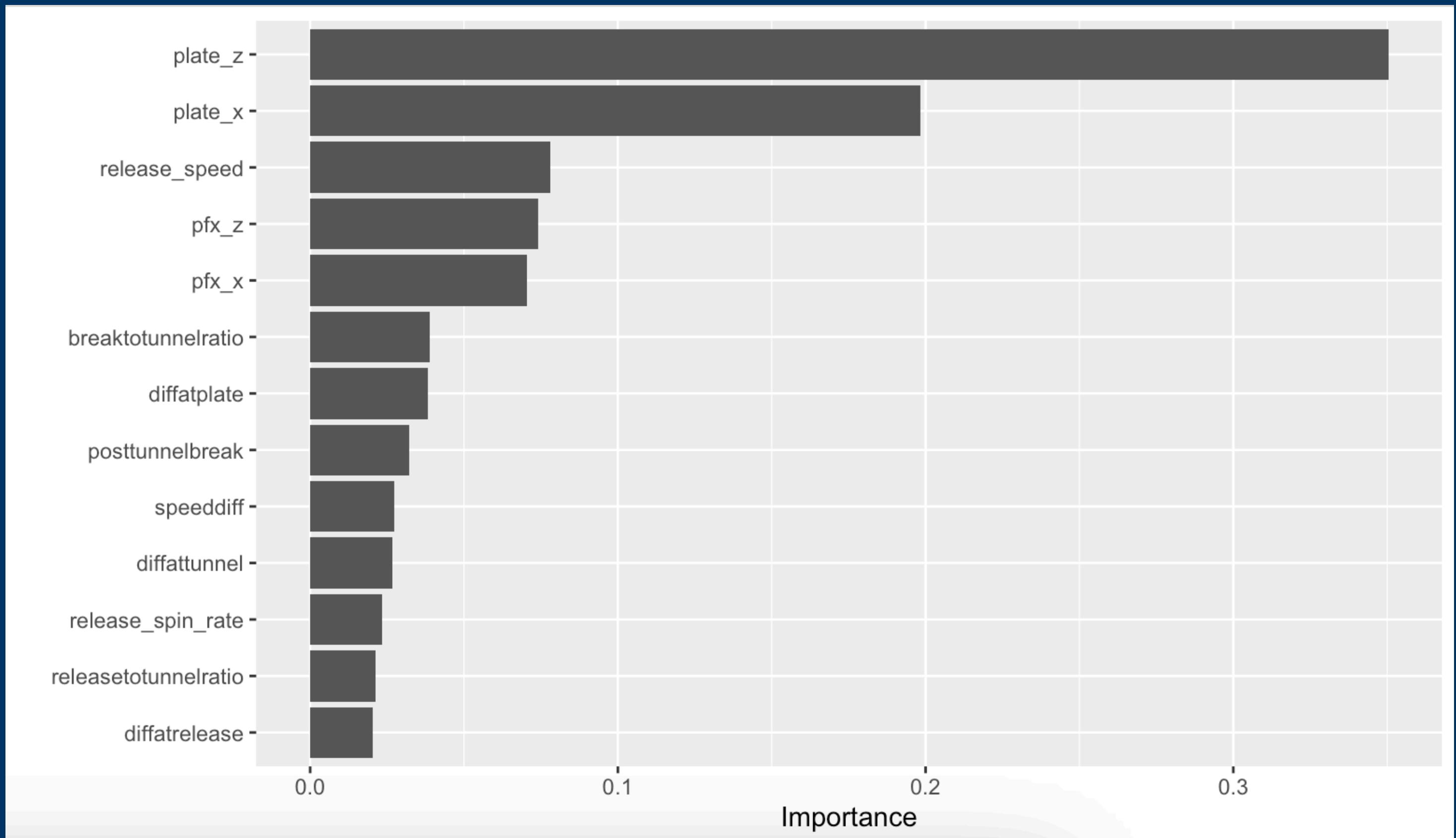


Four-Seam -> Slider | RHP -> RHH | Groundball

Training Sample: n = 13472 pitches

Testing Sample: n = 5774 pitches

Testing Accuracy: 62.18%

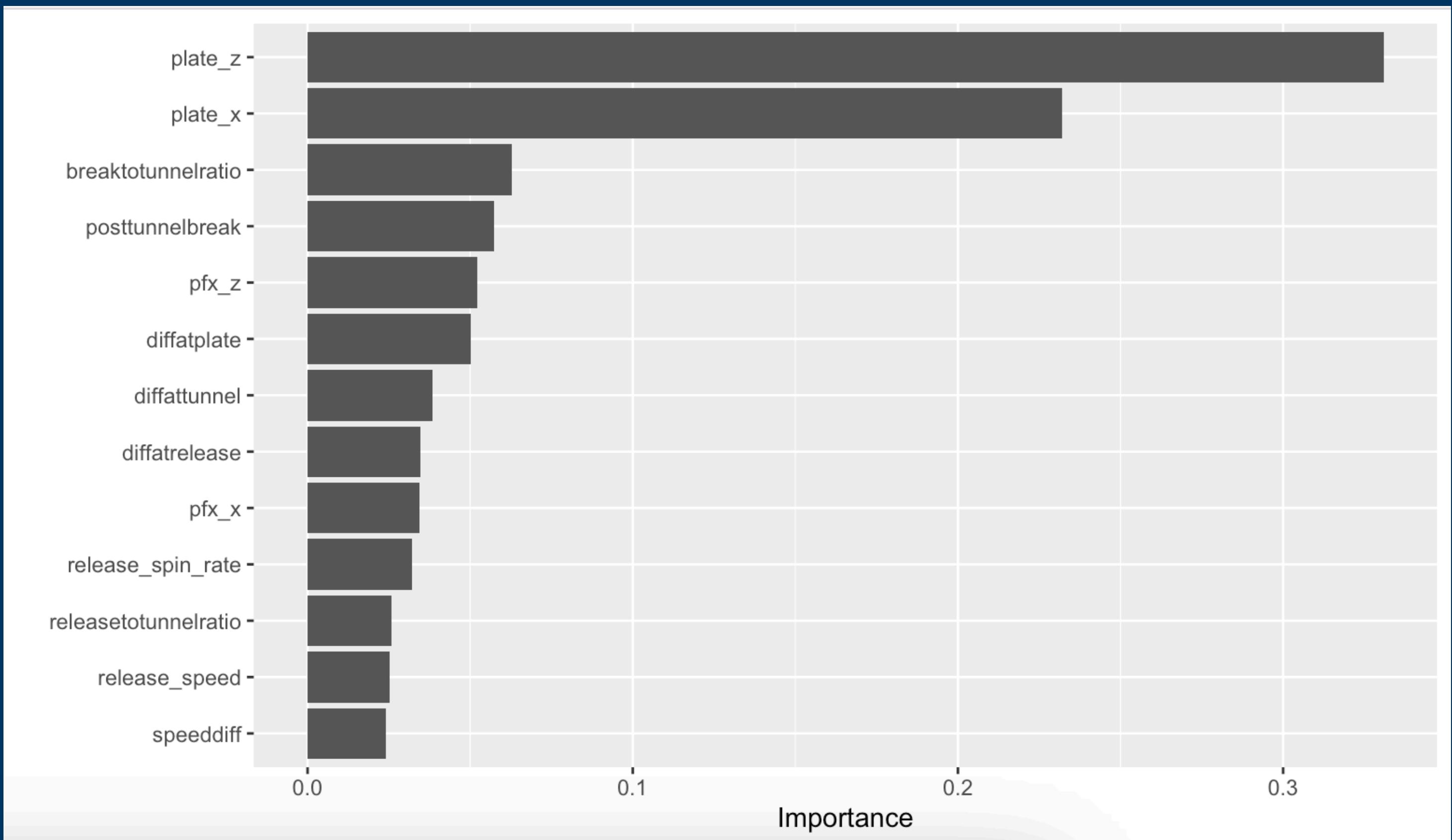


Four-Seam -> Sweeper | RHP -> RHH | Whiff

Training Sample: n = 1930 pitches

Testing Sample: n = 830 pitches

Testing Accuracy: 71.08%

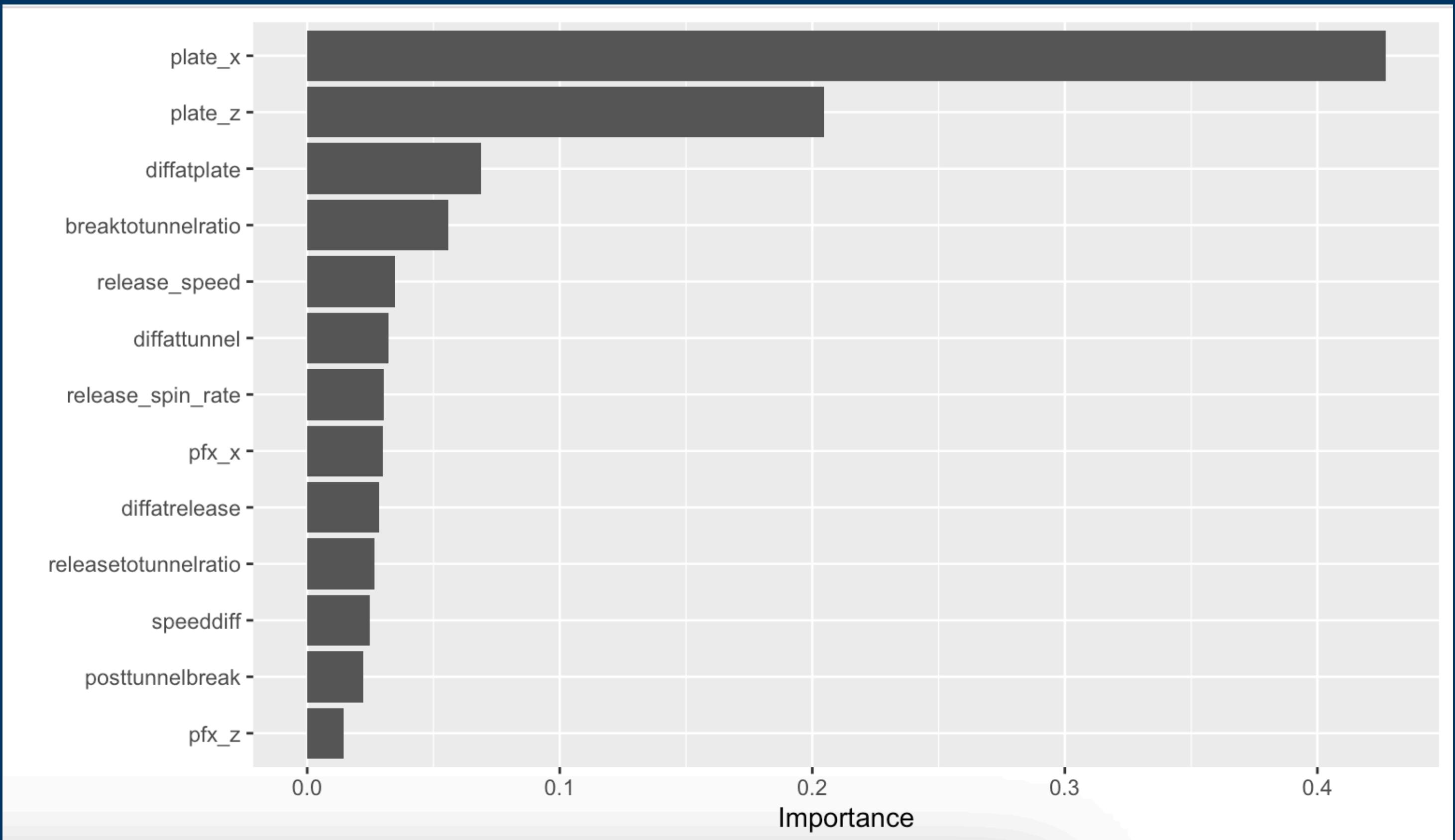


Four-Seam -> Sweeper | RHP -> RHH | Chase

Training Sample: n = 2684 pitches

Testing Sample: n = 1152 pitches

Testing Accuracy: 70.4%

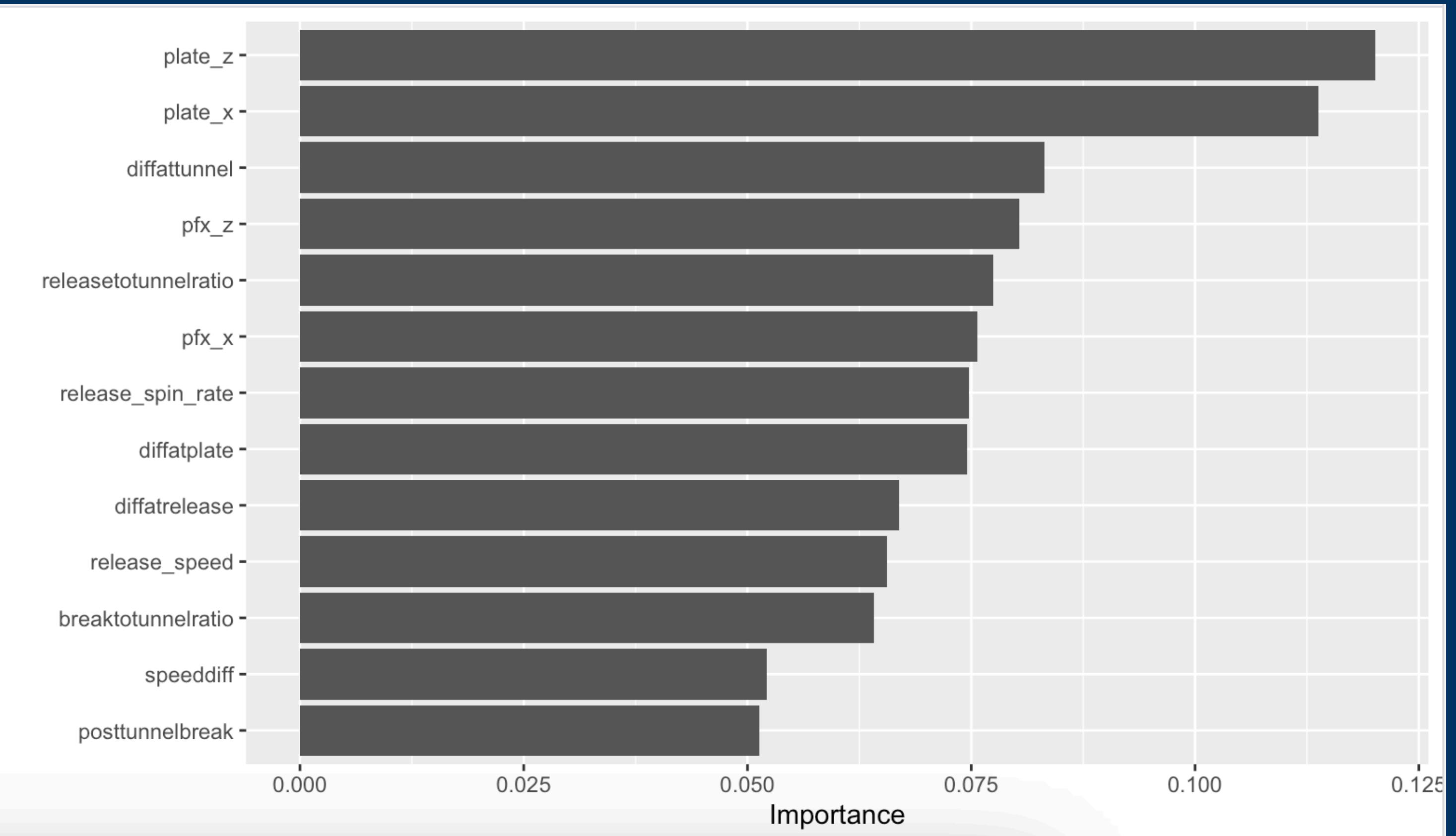


Four-Seam -> Sweeper | RHP -> RHH | Groundball

Training Sample: n = 708 pitches

Testing Sample: n = 304 pitches

Testing Accuracy: 58.55%

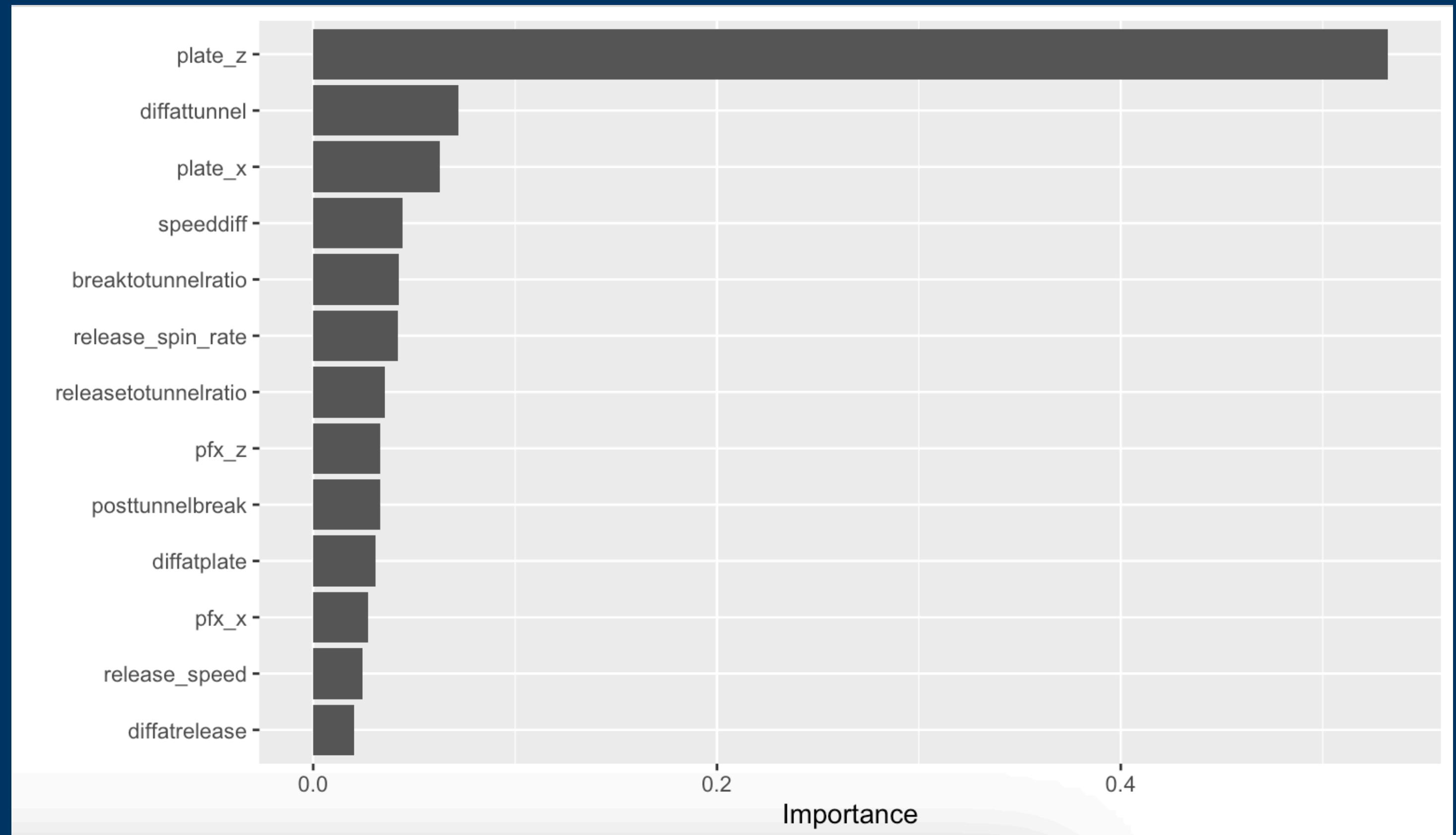


Sinker -> Changeup | RHP -> RHH | Whiff

Training Sample: n = 5098 pitches

Testing Sample: n = 2186 pitches

Testing Accuracy: 66.01%

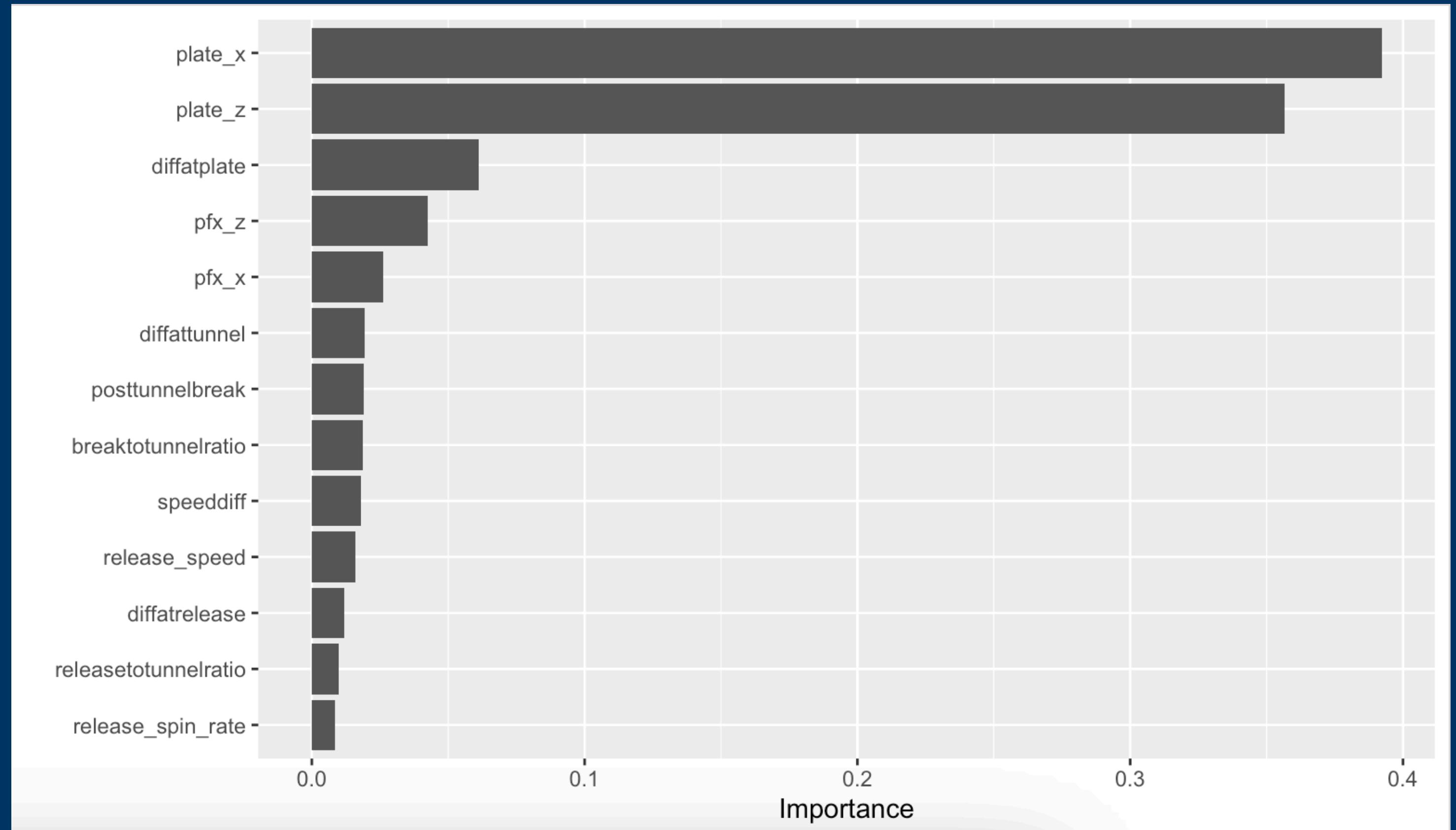


Sinker -> Changeup | RHP -> RHH | Chase

Training Sample: n = 7092 pitches

Testing Sample: n = 3042 pitches

Testing Accuracy: 73.34%

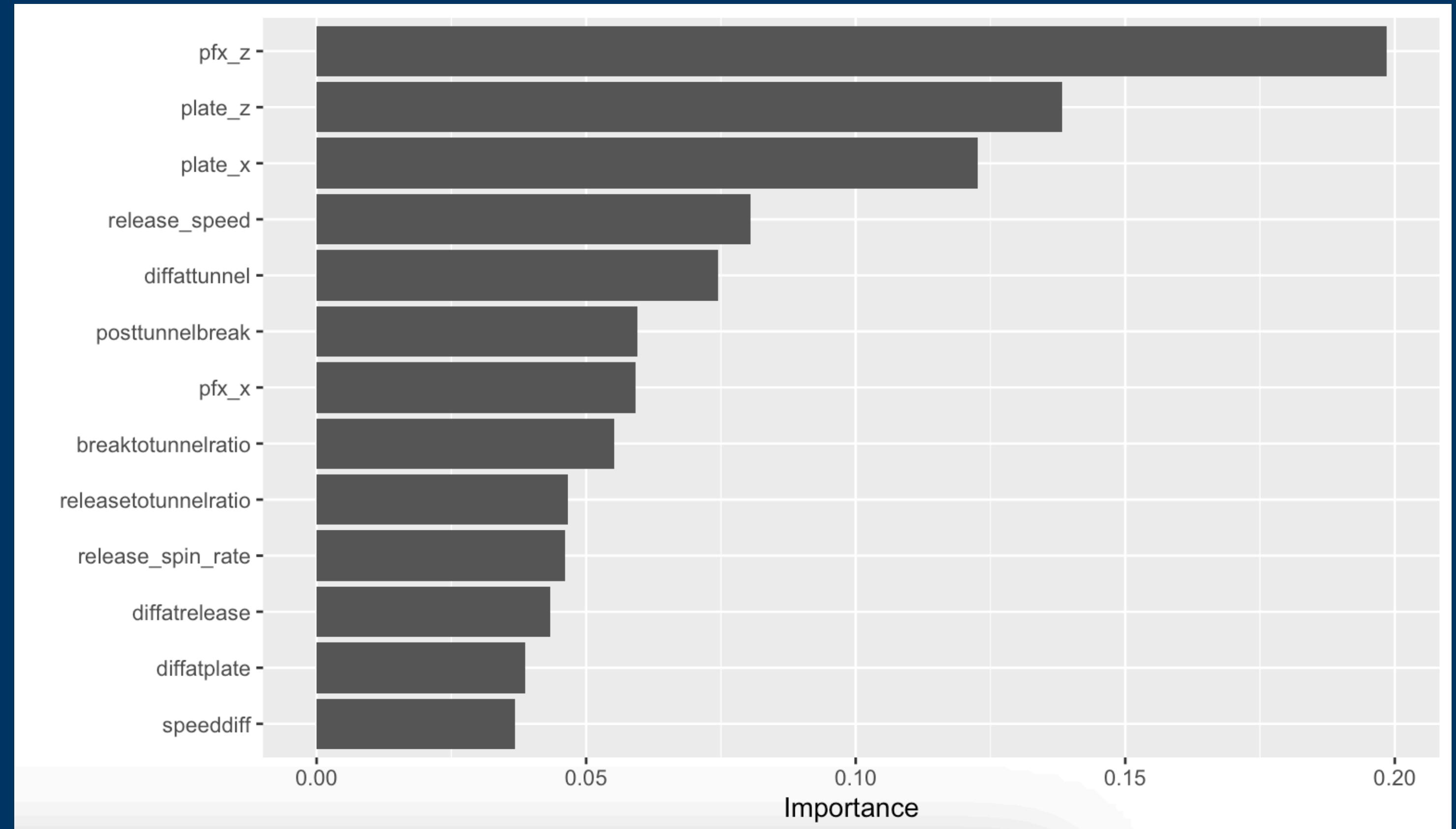


Sinker -> Changeup | RHP -> RHH | Groundball

Training Sample: n = 2440 pitches

Testing Sample: n = 1048 pitches

Testing Accuracy: 59.83%

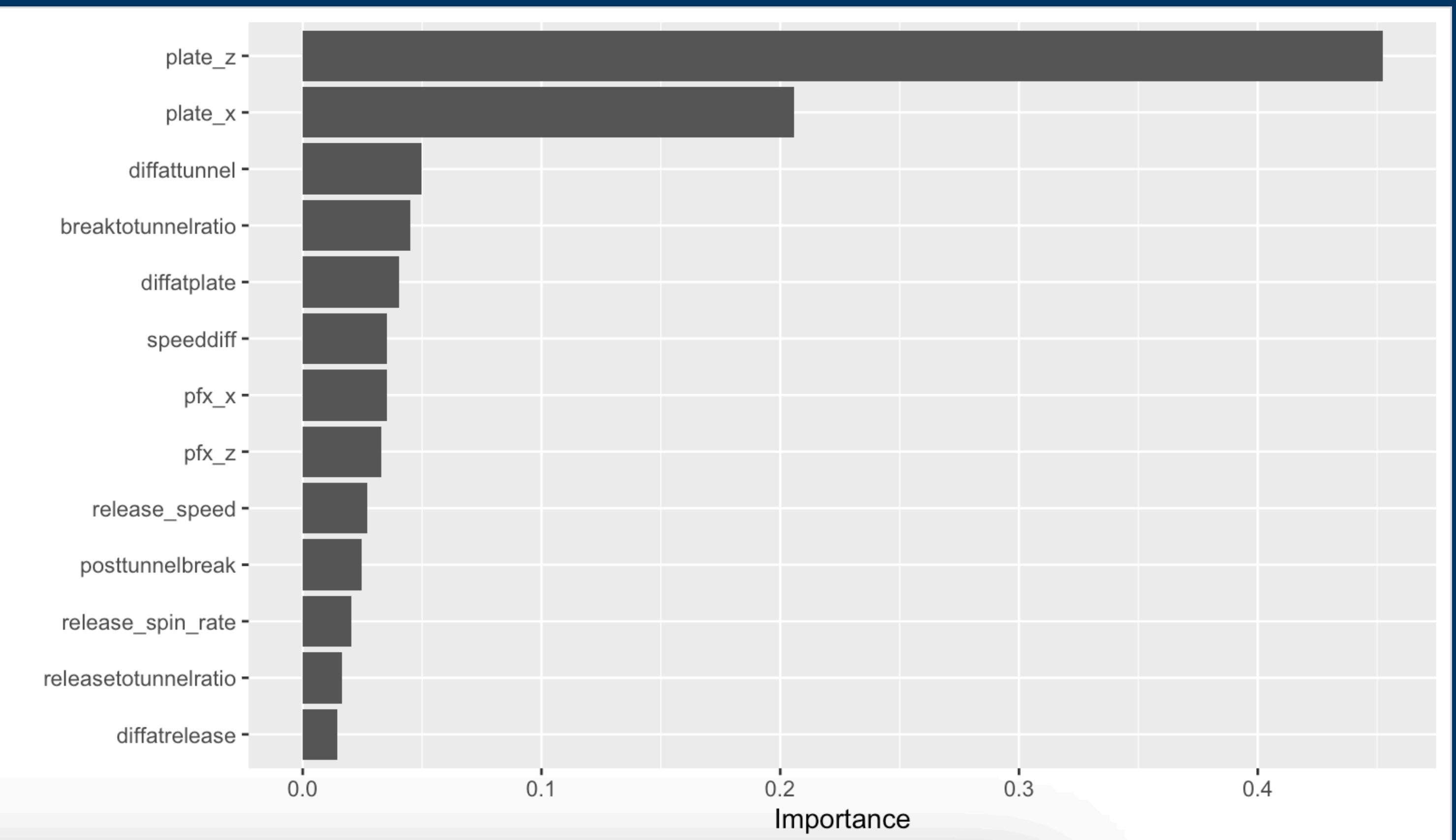


Sinker -> Curveball | RHP -> RHH | Whiff

Training Sample: n = 4214 pitches

Testing Sample: n = 1820 pitches

Testing Accuracy: 71.43%

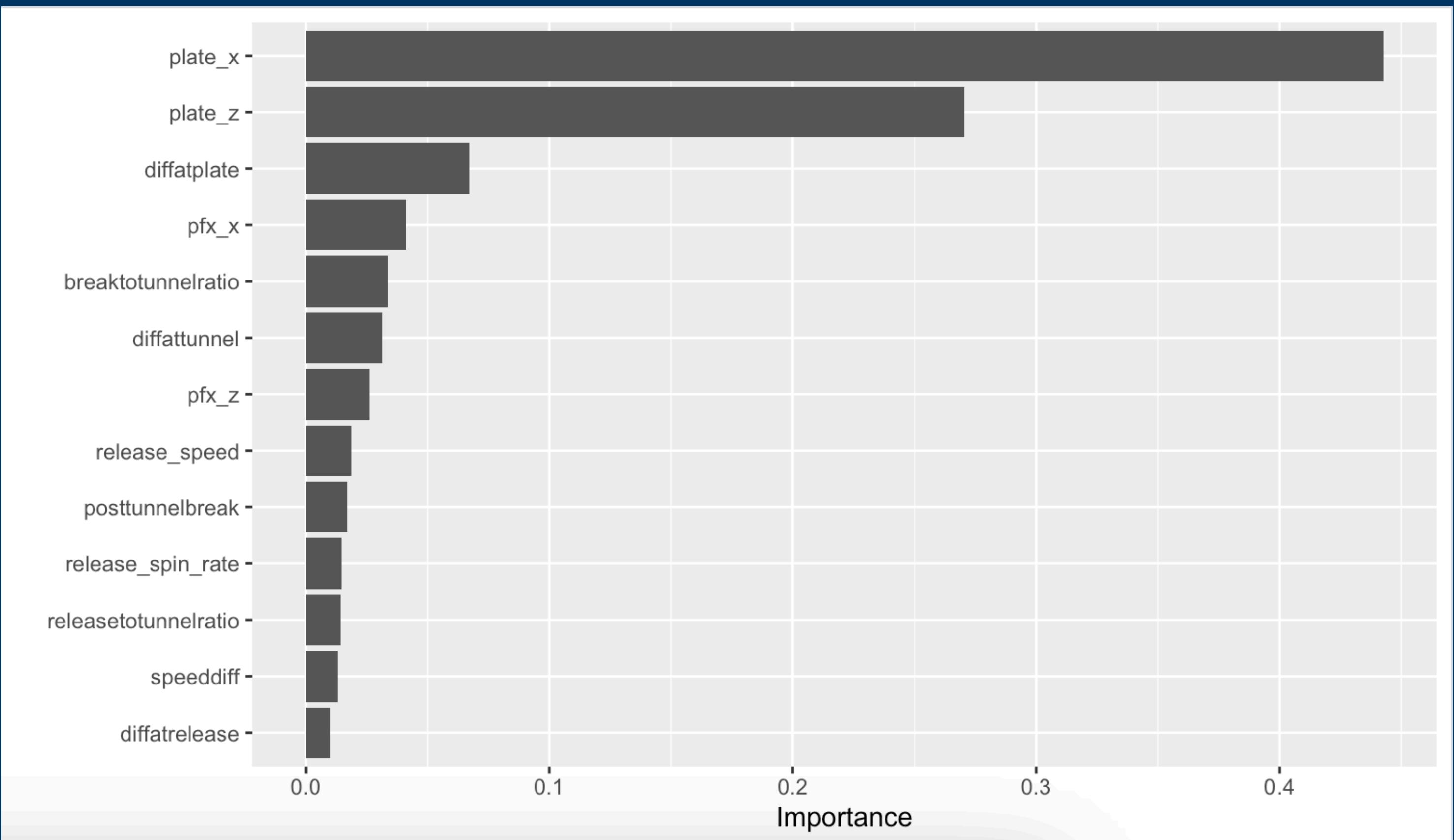


Sinker -> Curveball | RHP -> RHH | Chase

Training Sample: n = 5814 pitches

Testing Sample: n = 2492 pitches

Testing Accuracy: 71.35%

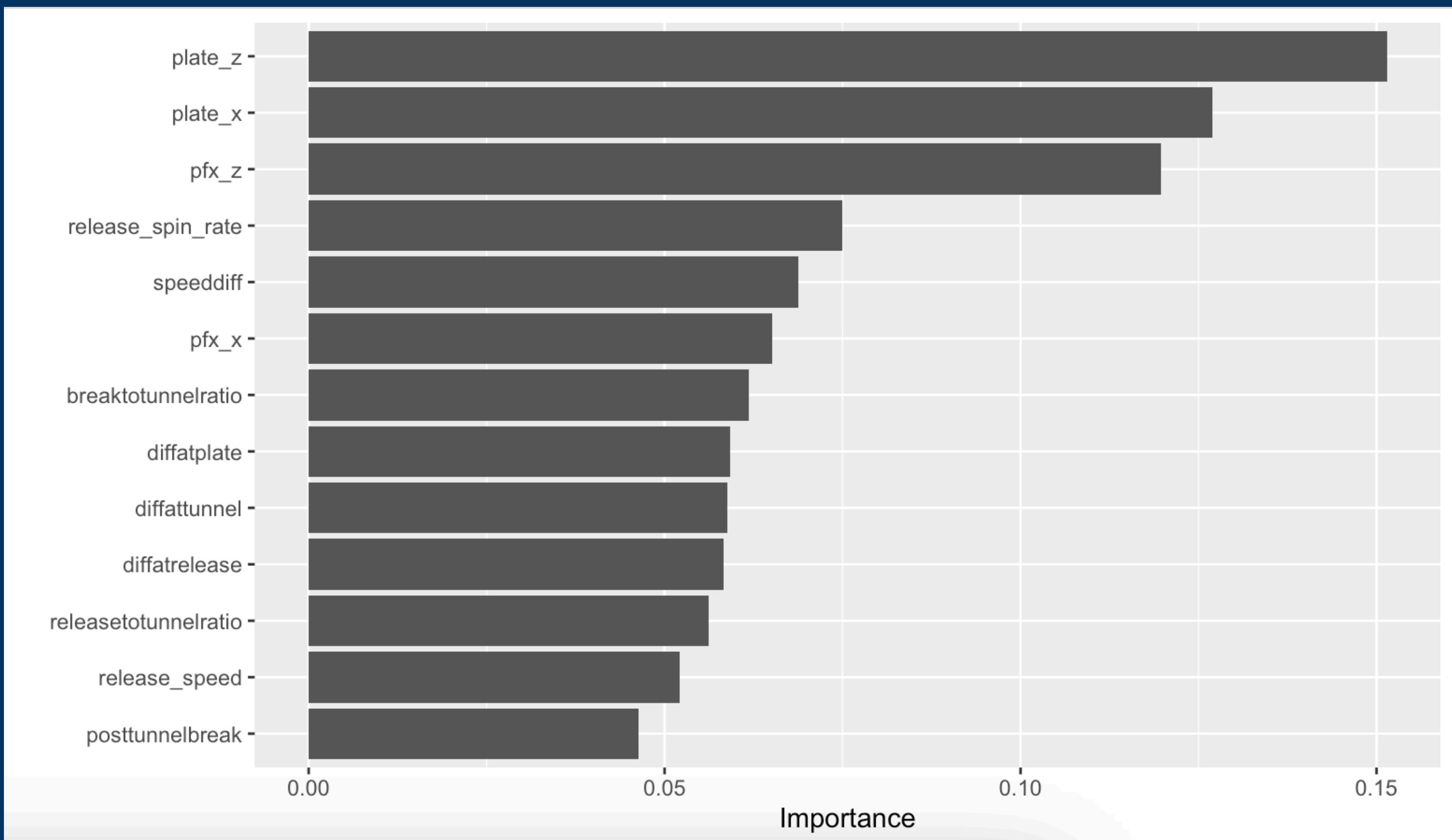


Sinker -> Curveball | RHP -> RHH | Groundball

Training Sample: n = 2398 pitches

Testing Sample: n = 1028 pitches

Testing Accuracy: 62.55%

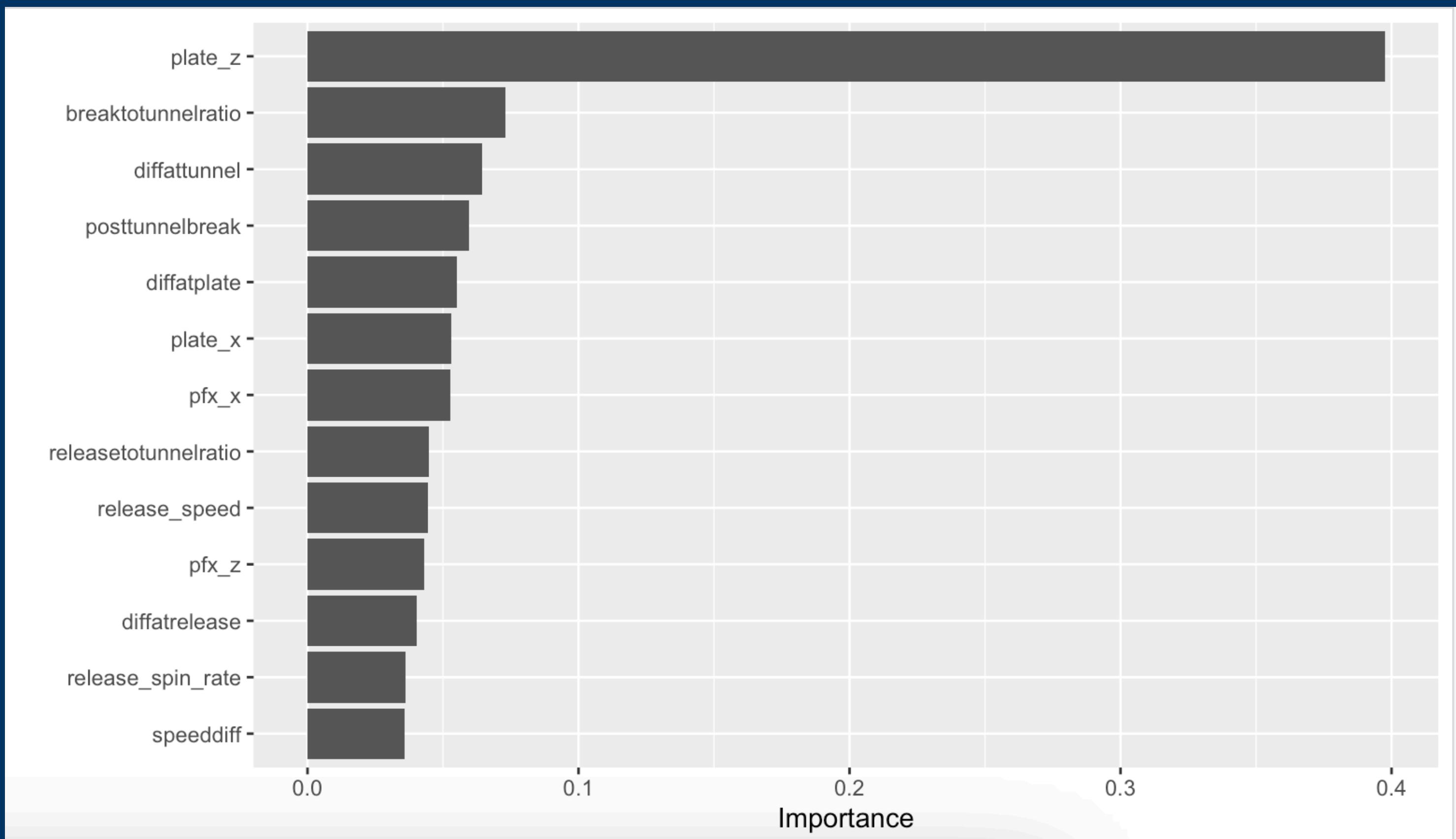


Sinker -> Splitter | RHP -> RHH | Whiff

Training Sample: n = 964 pitches

Testing Sample: n = 416 pitches

Testing Accuracy: 65.14%

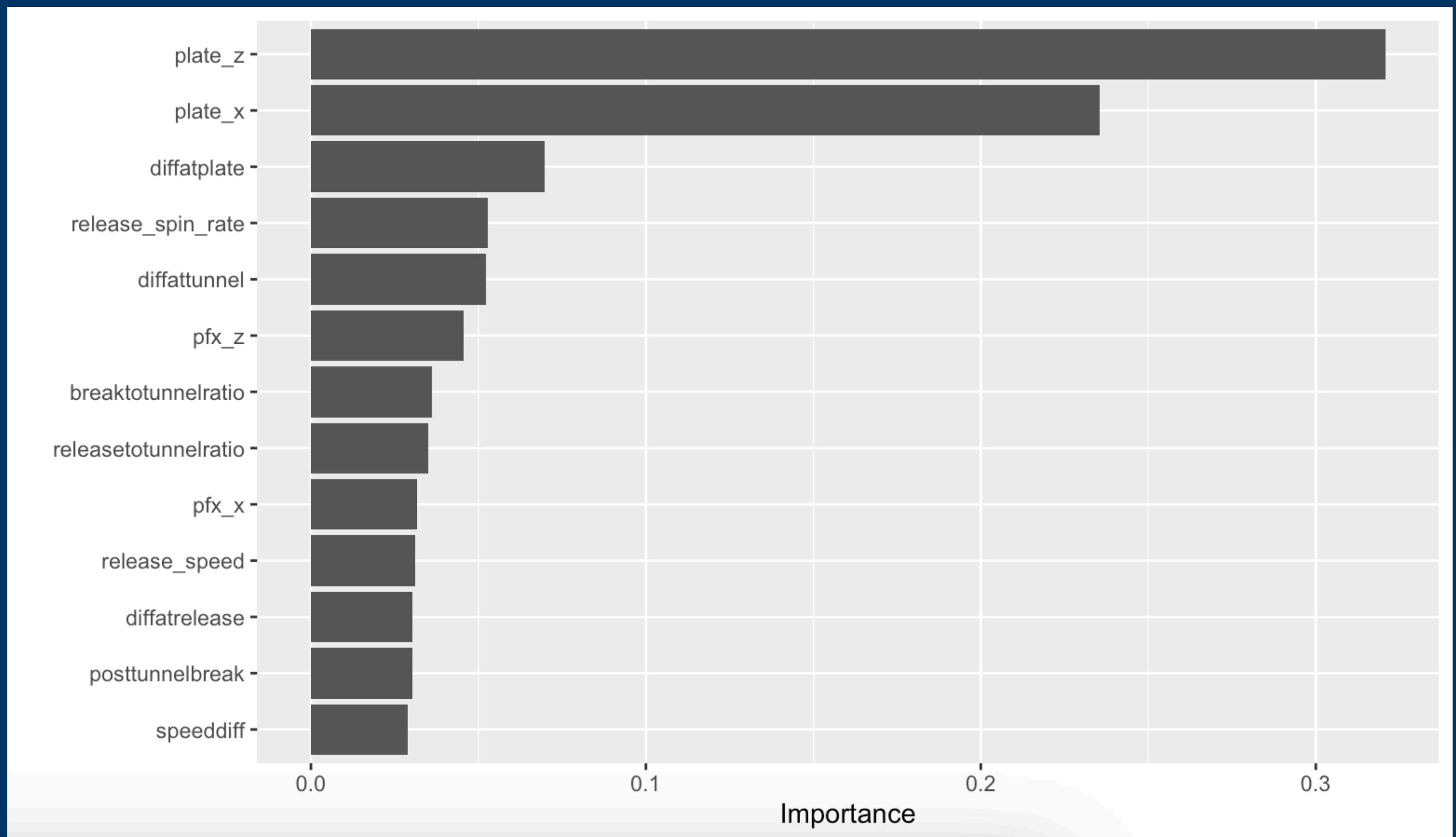


Sinker -> Splitter | RHP -> RHH | Chase

Training Sample: n = 1488 pitches

Testing Sample: n = 640 pitches

Testing Accuracy: 72.03%

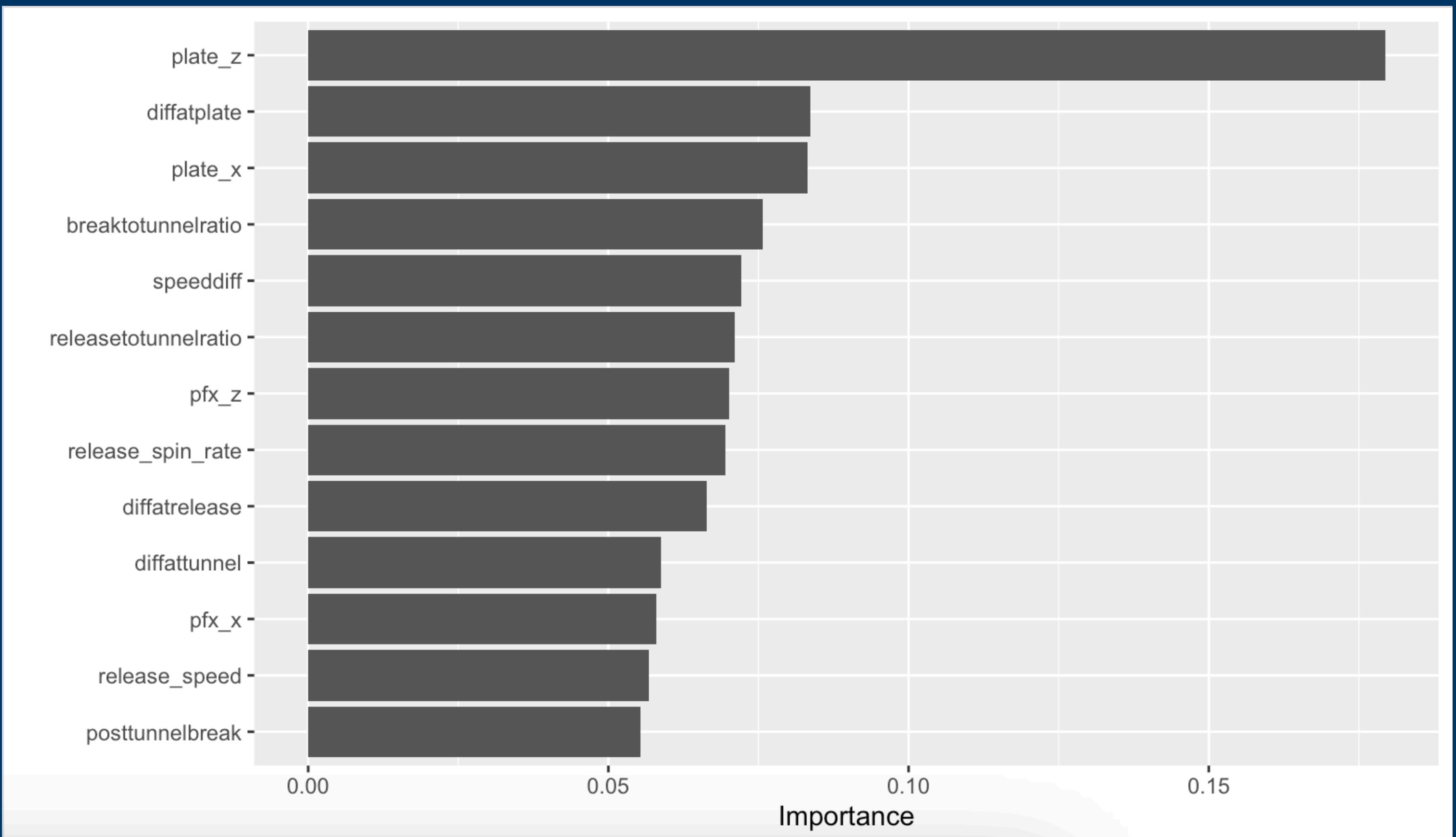


Sinker -> Splitter | RHP -> RHH | Groundball

Training Sample: n = 464 pitches

Testing Sample: n = 200 pitches

Testing Accuracy: 57.5%

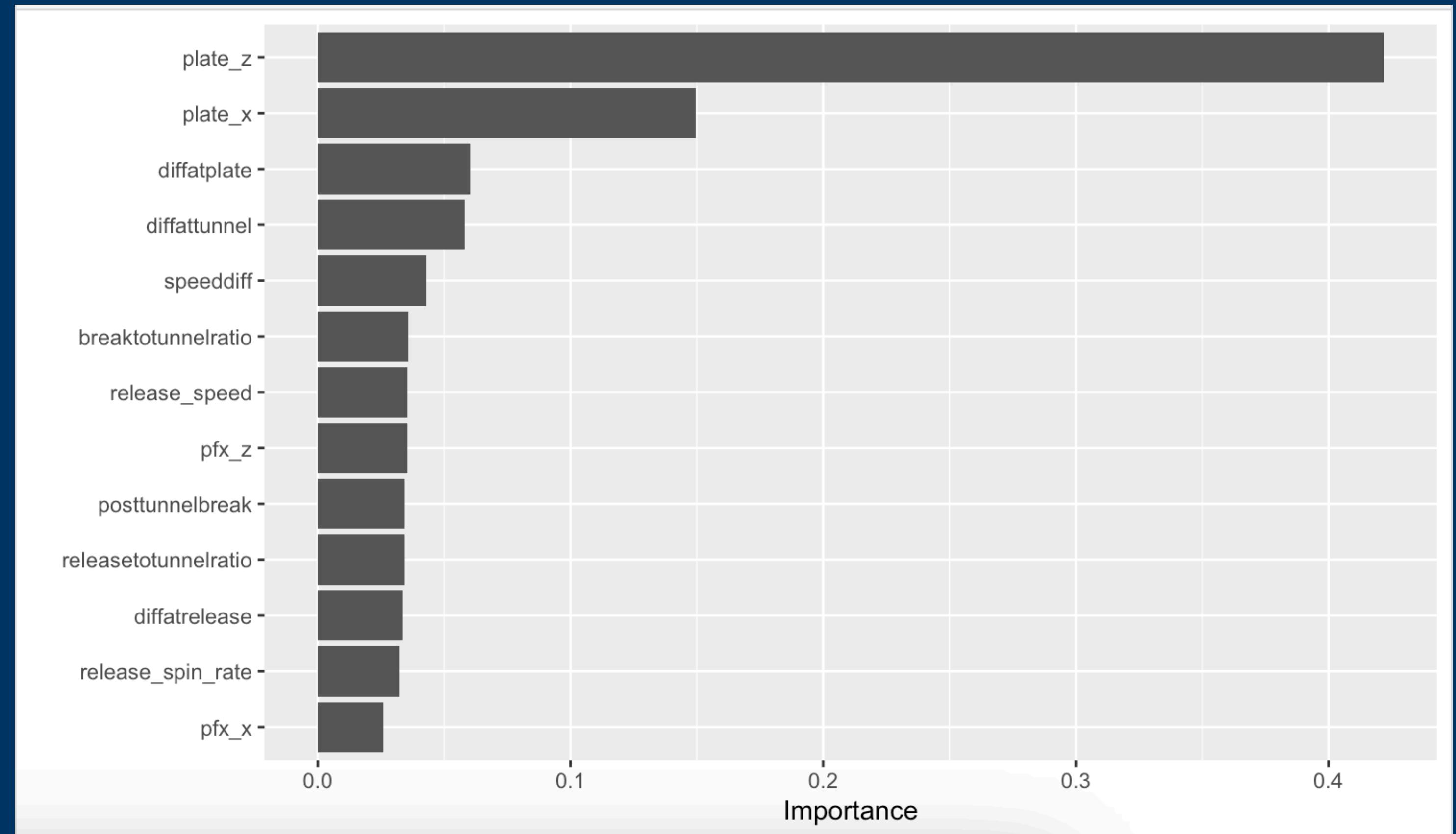


Sinker -> Knuckle Curve | RHP -> RHH | Whiff

Training Sample: n = 1004 pitches

Testing Sample: n = 432 pitches

Testing Accuracy: 70.83%

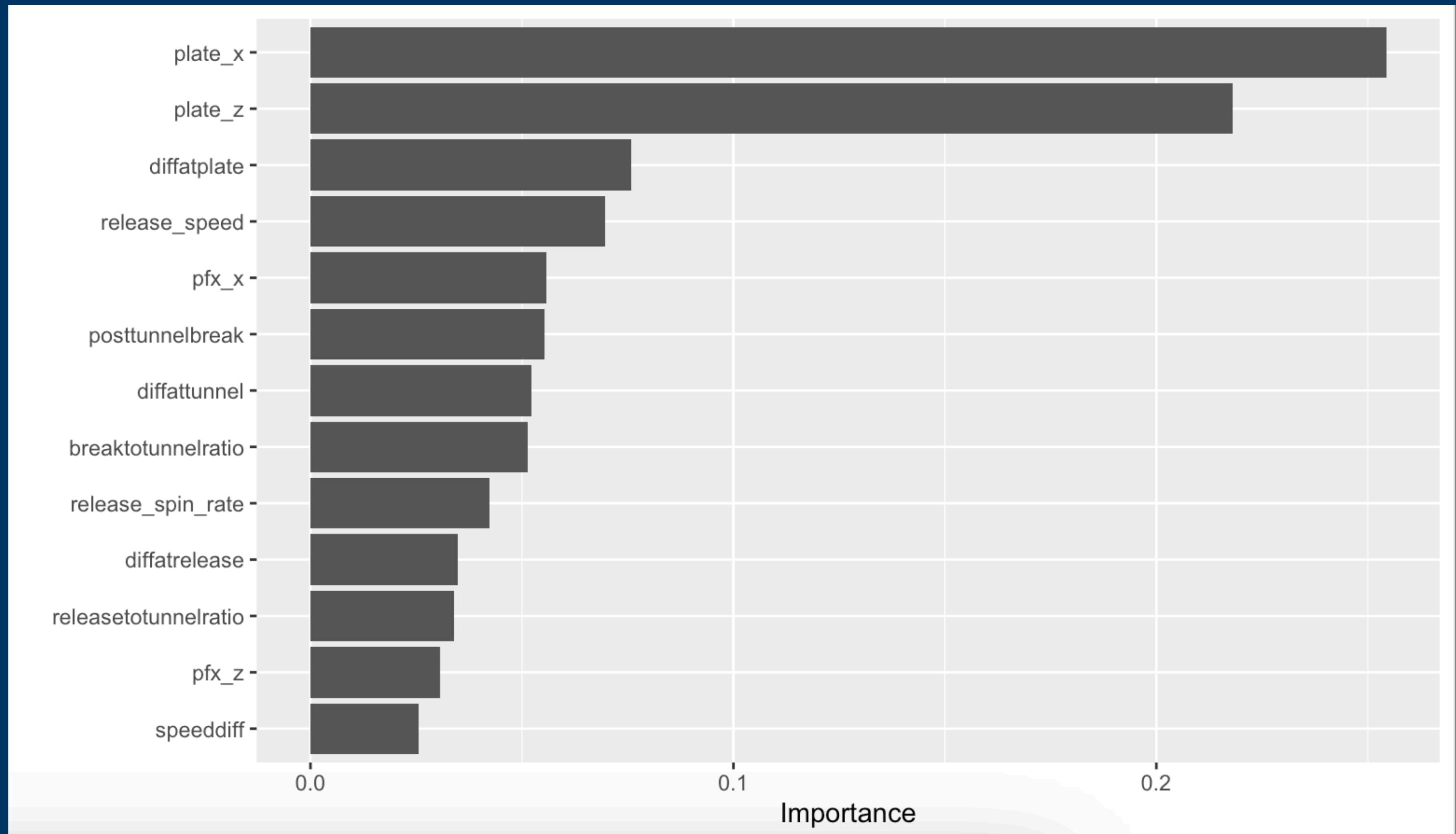


Sinker -> Knuckle Curve | RHP -> RHH | Chase

Training Sample: n = 1500 pitches

Testing Sample: n = 644 pitches

Testing Accuracy: 68.48%

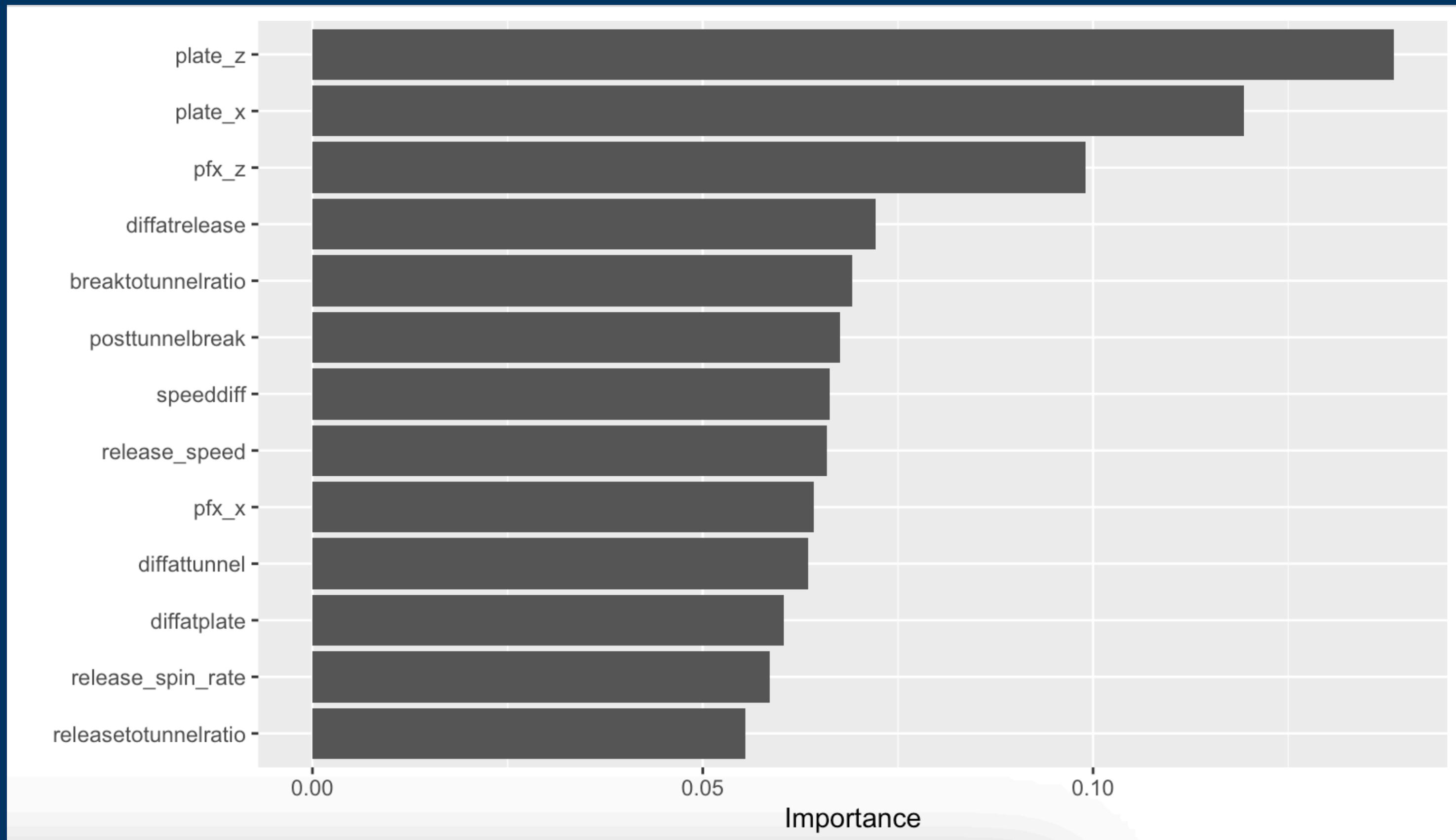


Sinker -> Knuckle Curve | RHP -> RHH | Groundball

Training Sample: n = 592 pitches

Testing Sample: n = 254 pitches

Testing Accuracy: 58.66%

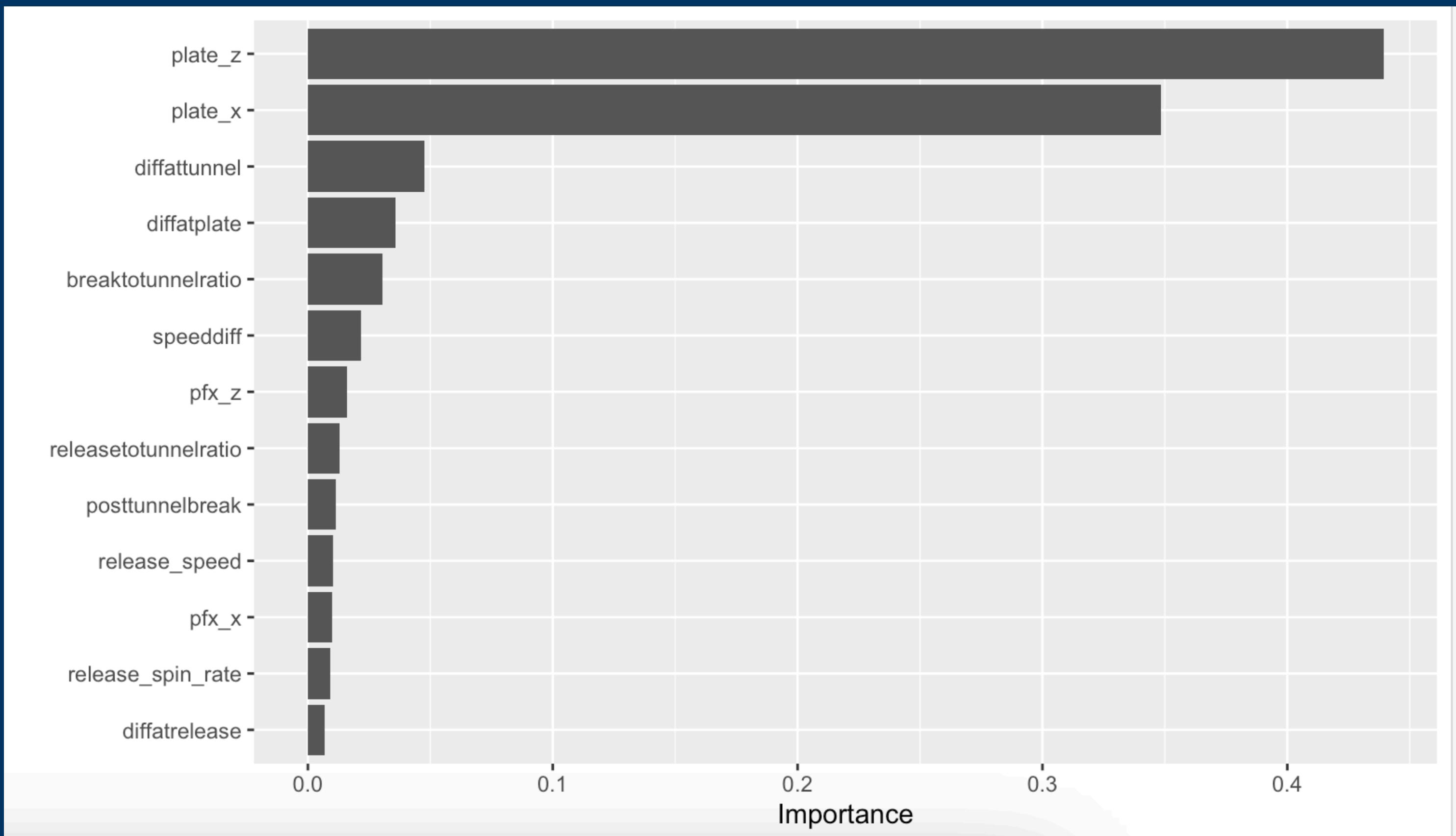


Sinker -> Slider | RHP -> RHH | Whiff

Training Sample: n = 13024 pitches

Testing Sample: n = 5582 pitches

Testing Accuracy: 70.98%

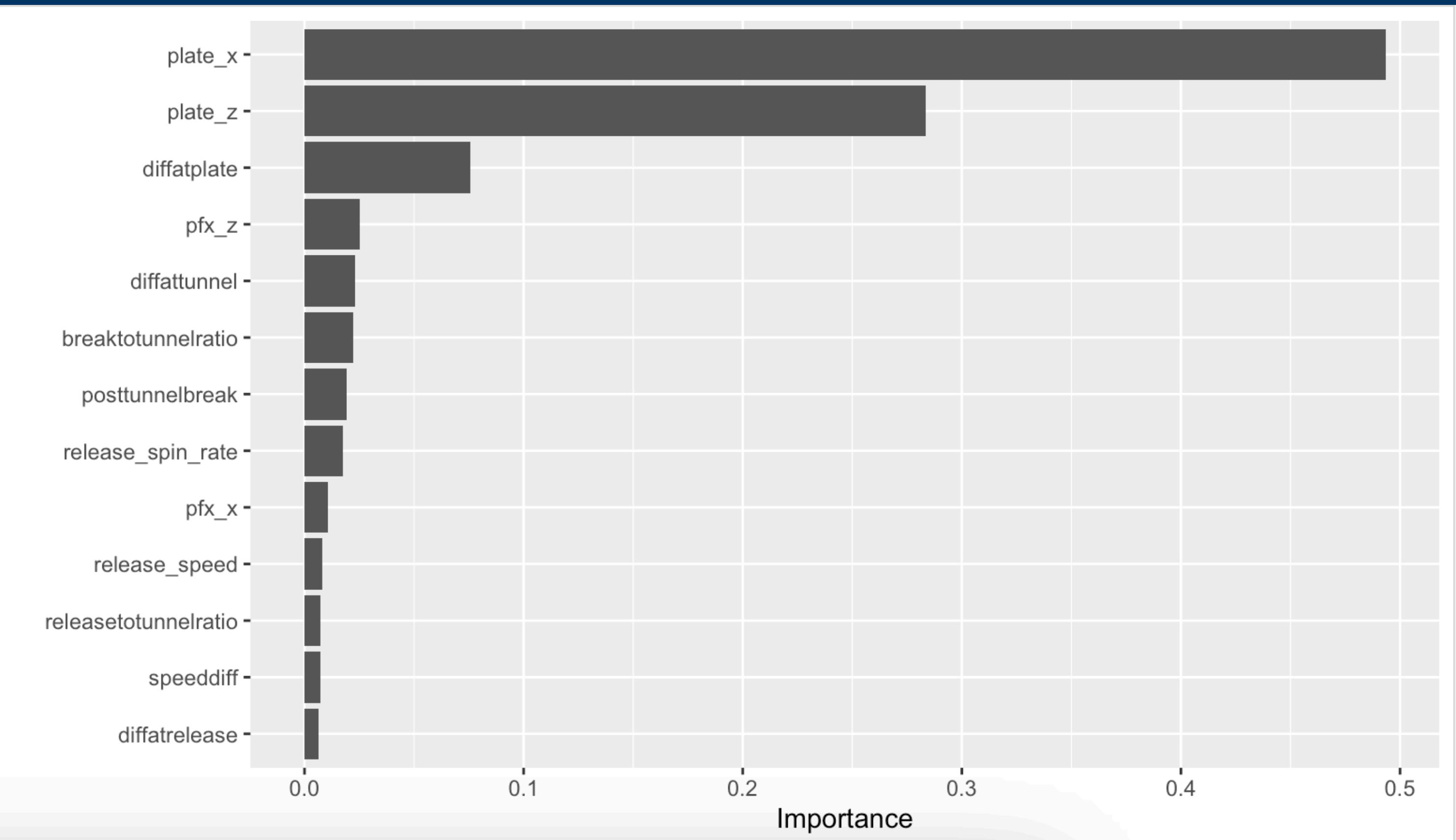


Sinker -> Slider | RHP -> RHH | Chase

Training Sample: n = 16314 pitches

Testing Sample: n = 6992 pitches

Testing Accuracy: 68.61%

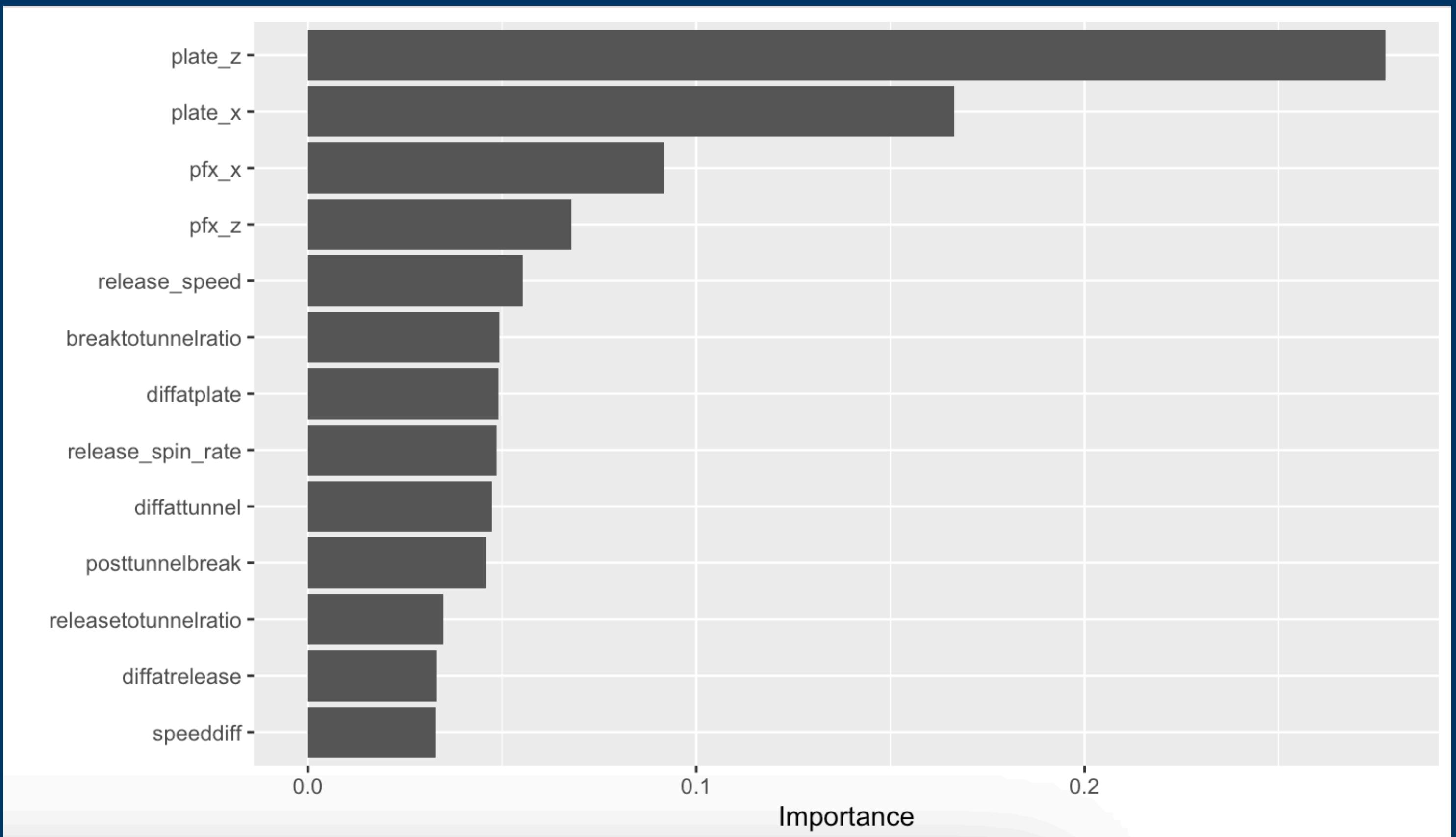


Sinker -> Slider | RHP -> RHH | Groundball

Training Sample: n = 6336 pitches

Testing Sample: n = 2718 pitches

Testing Accuracy: 60.85%

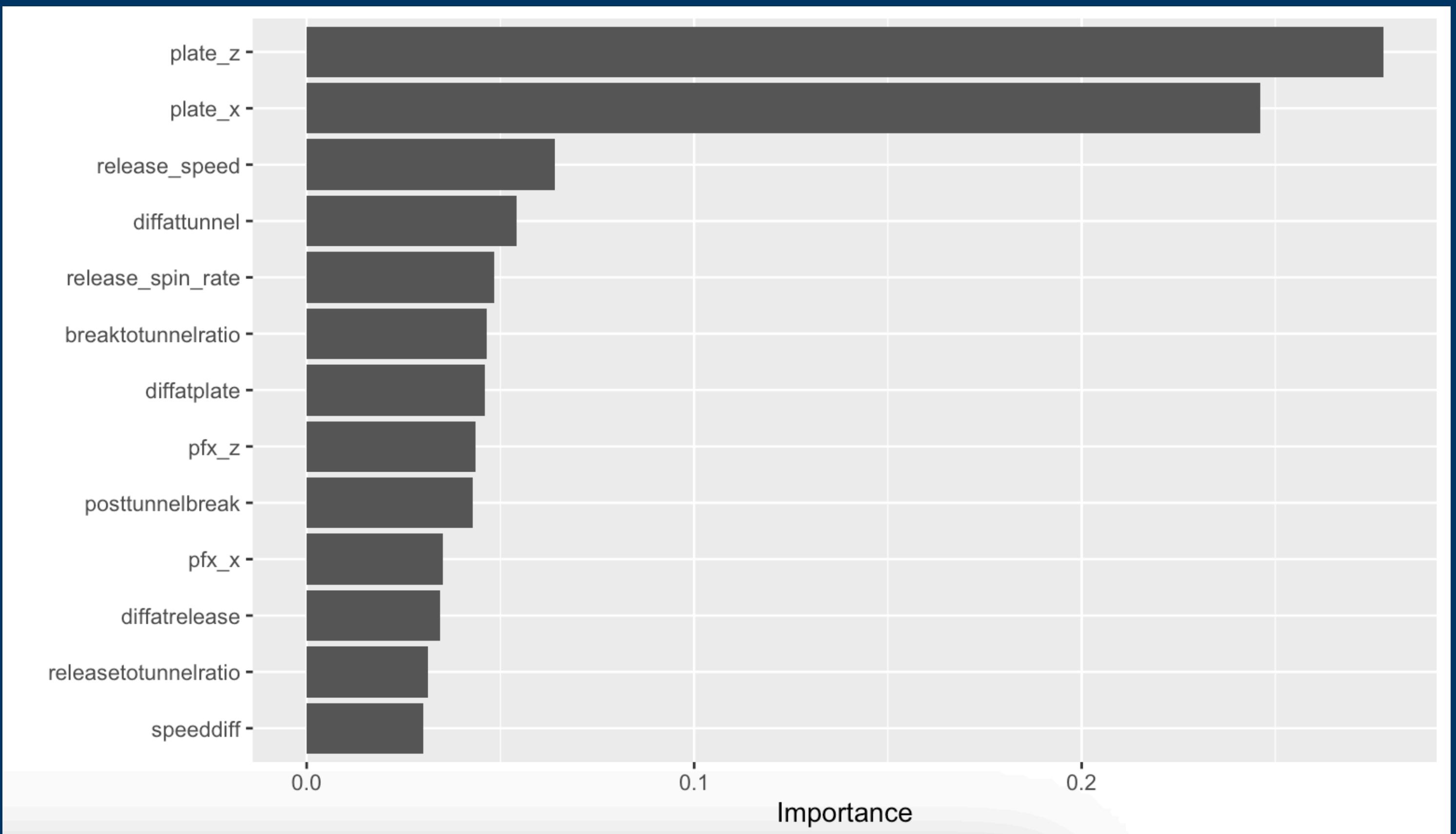


Sinker -> Sweeper | RHP -> RHH | Whiff

Training Sample: n = 1522 pitches

Testing Sample: n = 654 pitches

Testing Accuracy: 70.8%

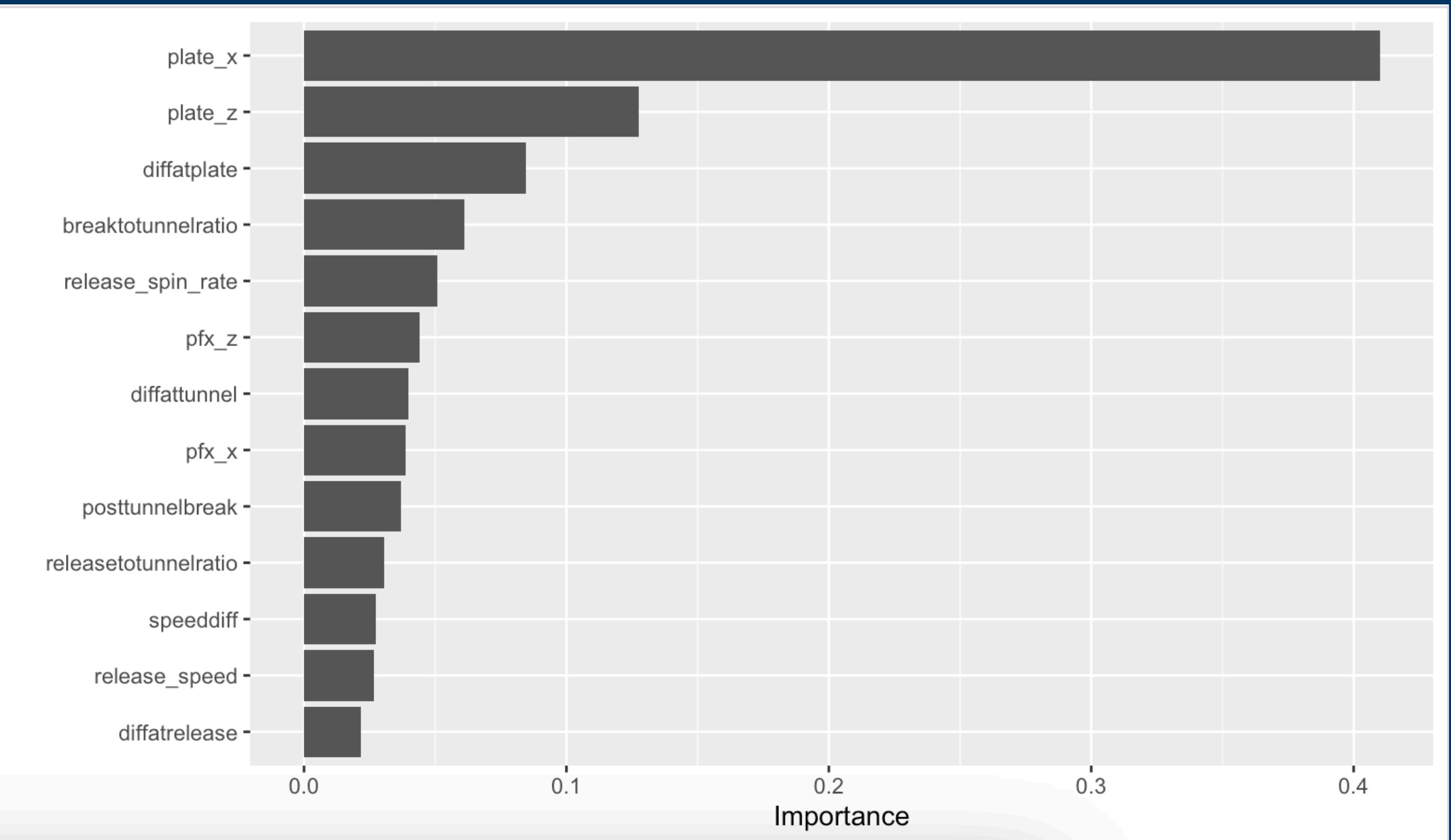


Sinker -> Sweeper | RHP -> RHH | Chase

Training Sample: n = 1860 pitches

Testing Sample: n = 798 pitches

Testing Accuracy: 69.17%

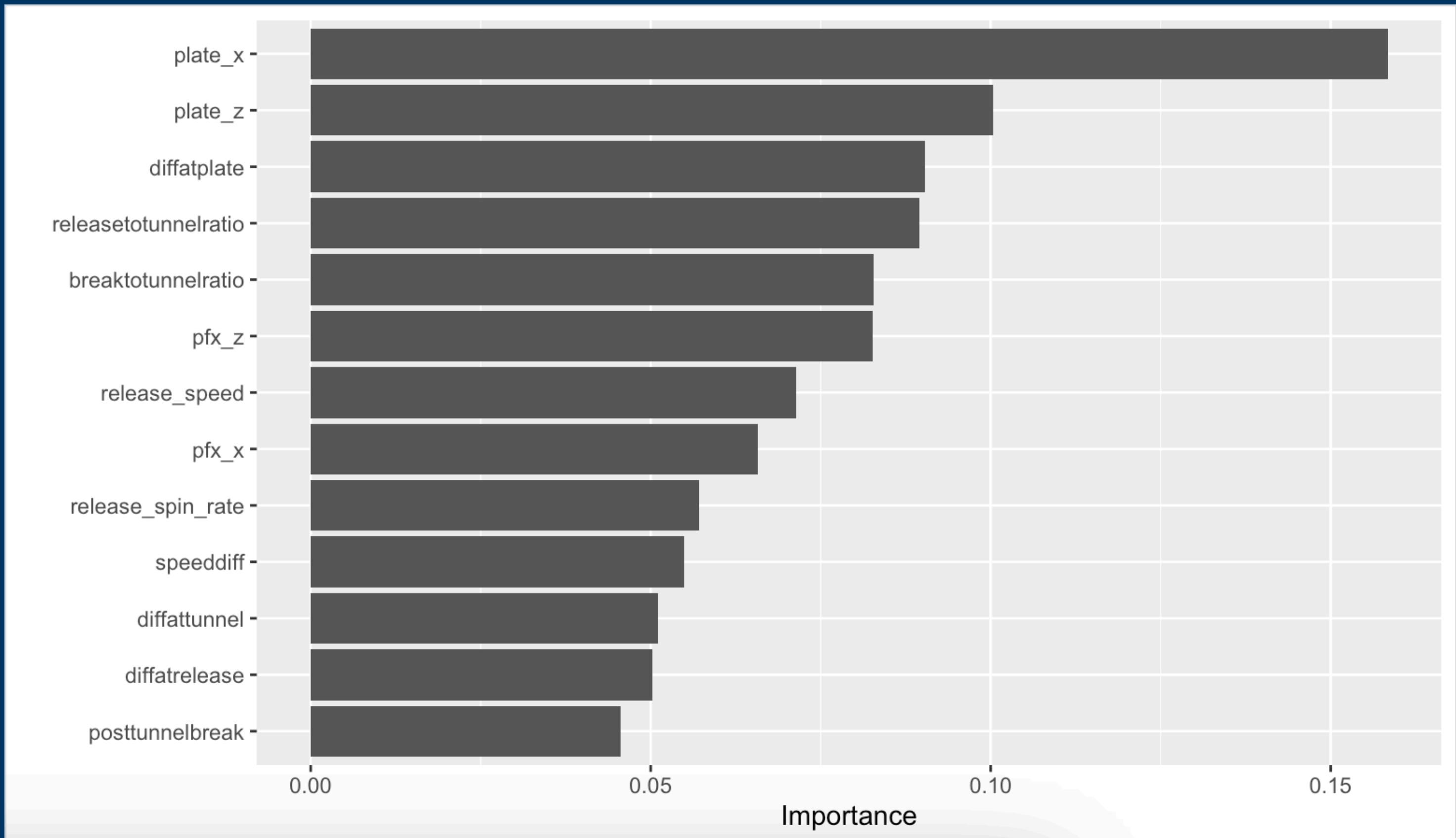


Sinker -> Sweeper | RHP -> RHH | Groundball

Training Sample: n = 556 pitches

Testing Sample: n = 240 pitches

Testing Accuracy: 66.25%

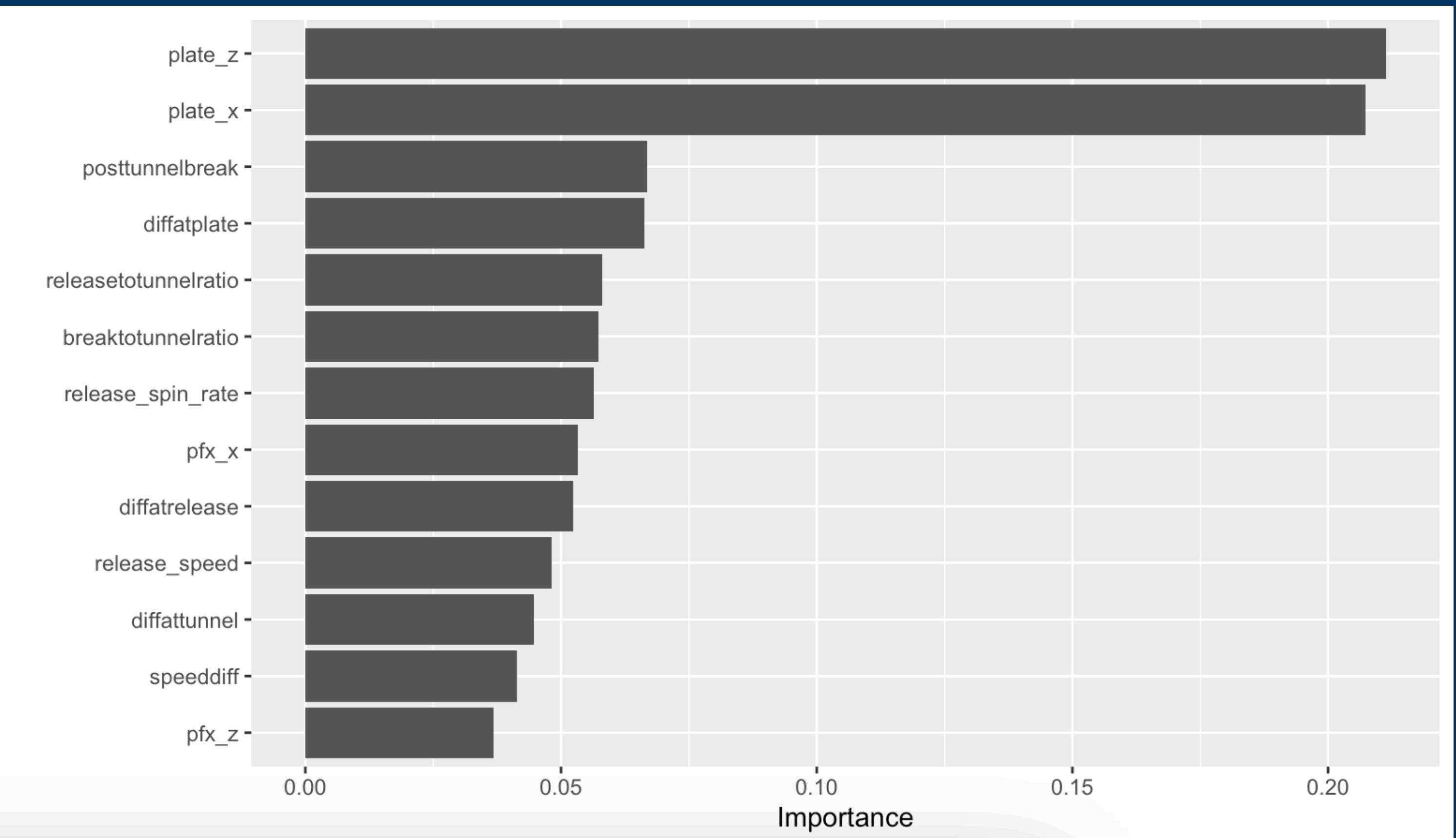


Sinker -> Slurve | RHP -> RHH | Whiff

Training Sample: n = 396 pitches

Testing Sample: n = 172 pitches

Testing Accuracy: 75.58%

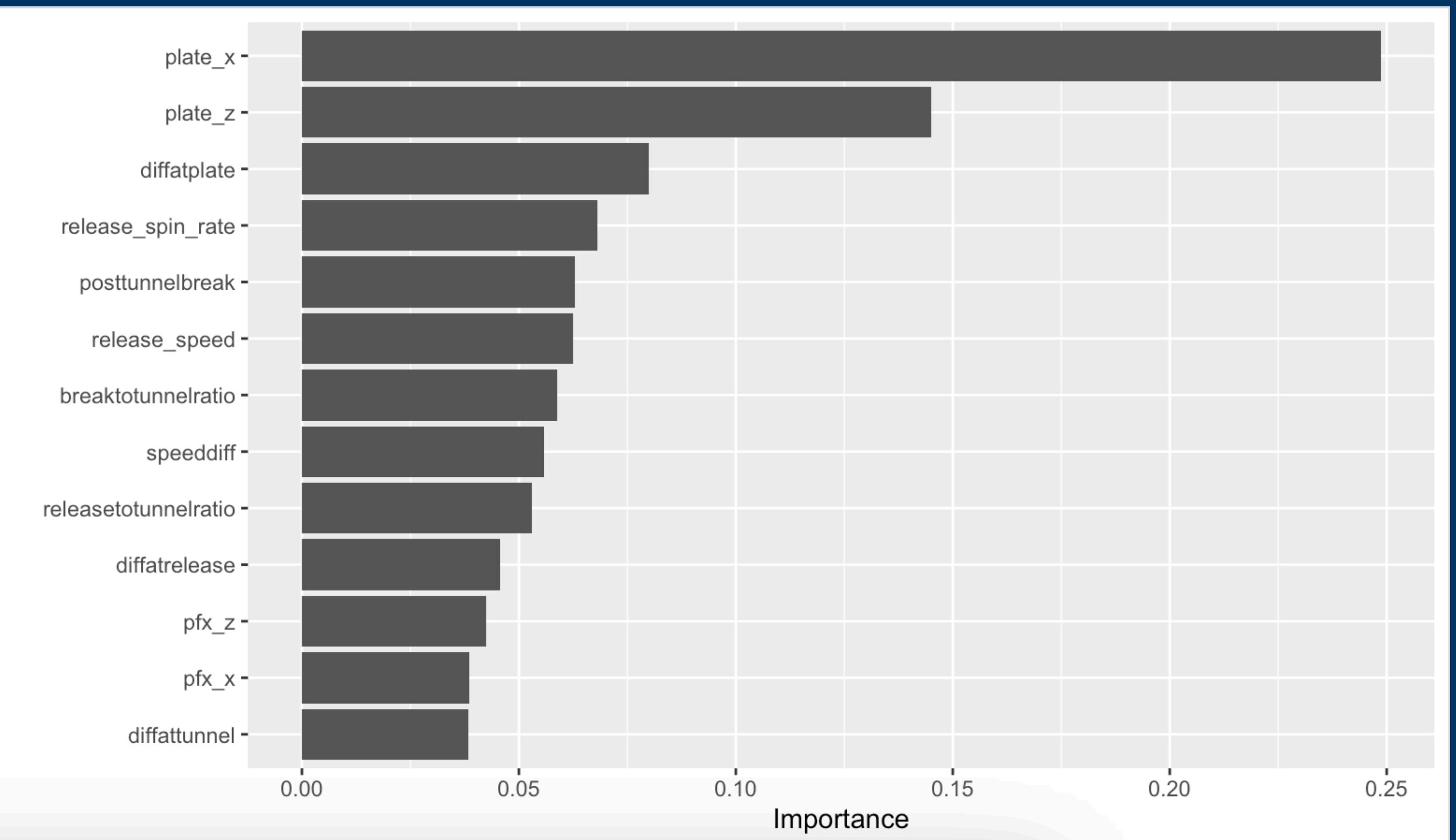


Sinker -> Slurve | RHP -> RHH | Chase

Training Sample: n = 608 pitches

Testing Sample: n = 262 pitches

Testing Accuracy: 66.03%

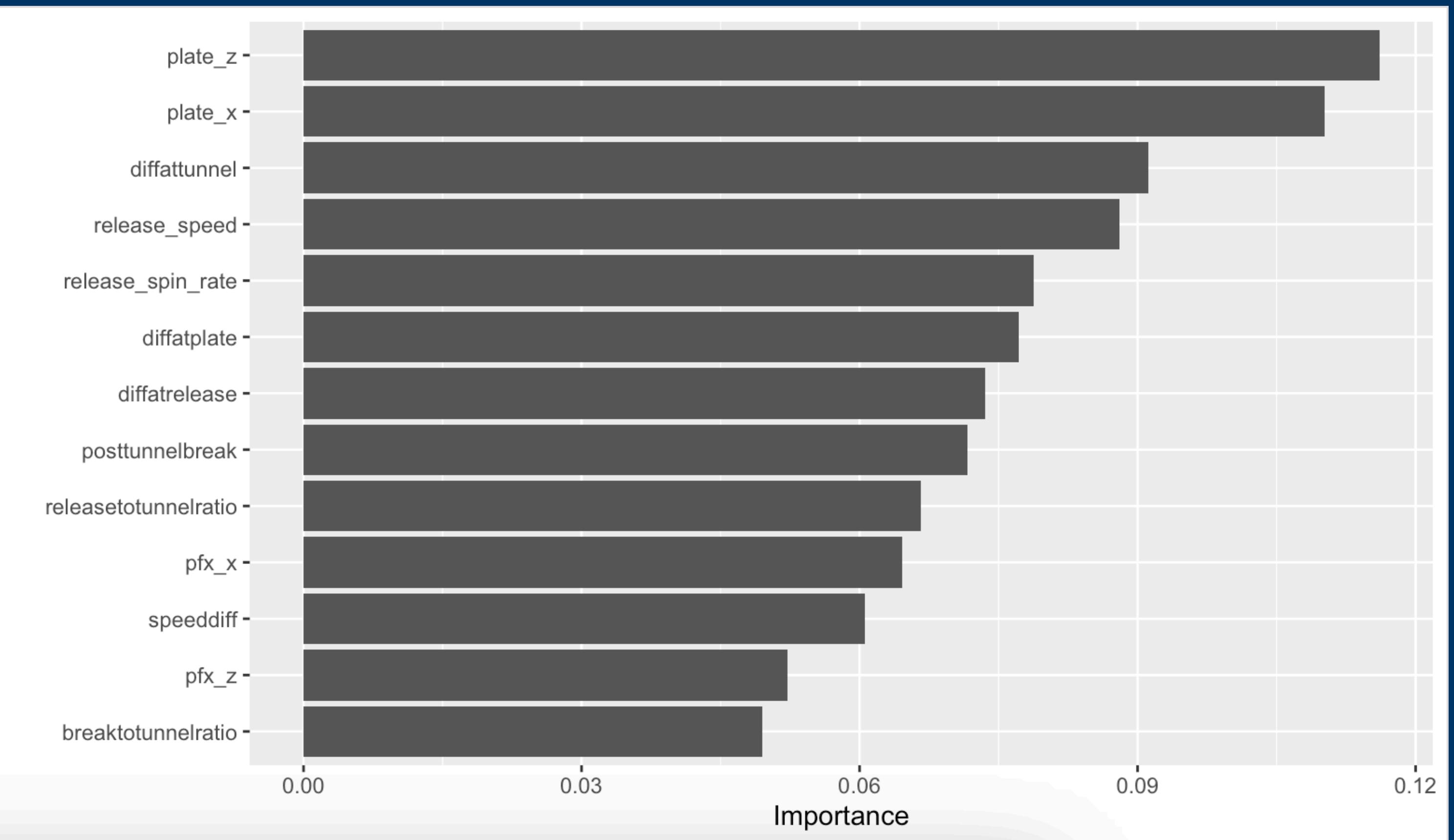


Sinker -> Slurve | RHP -> RHH | Groundball

Training Sample: n = 212 pitches

Testing Sample: n = 92 pitches

Testing Accuracy: 60.87%



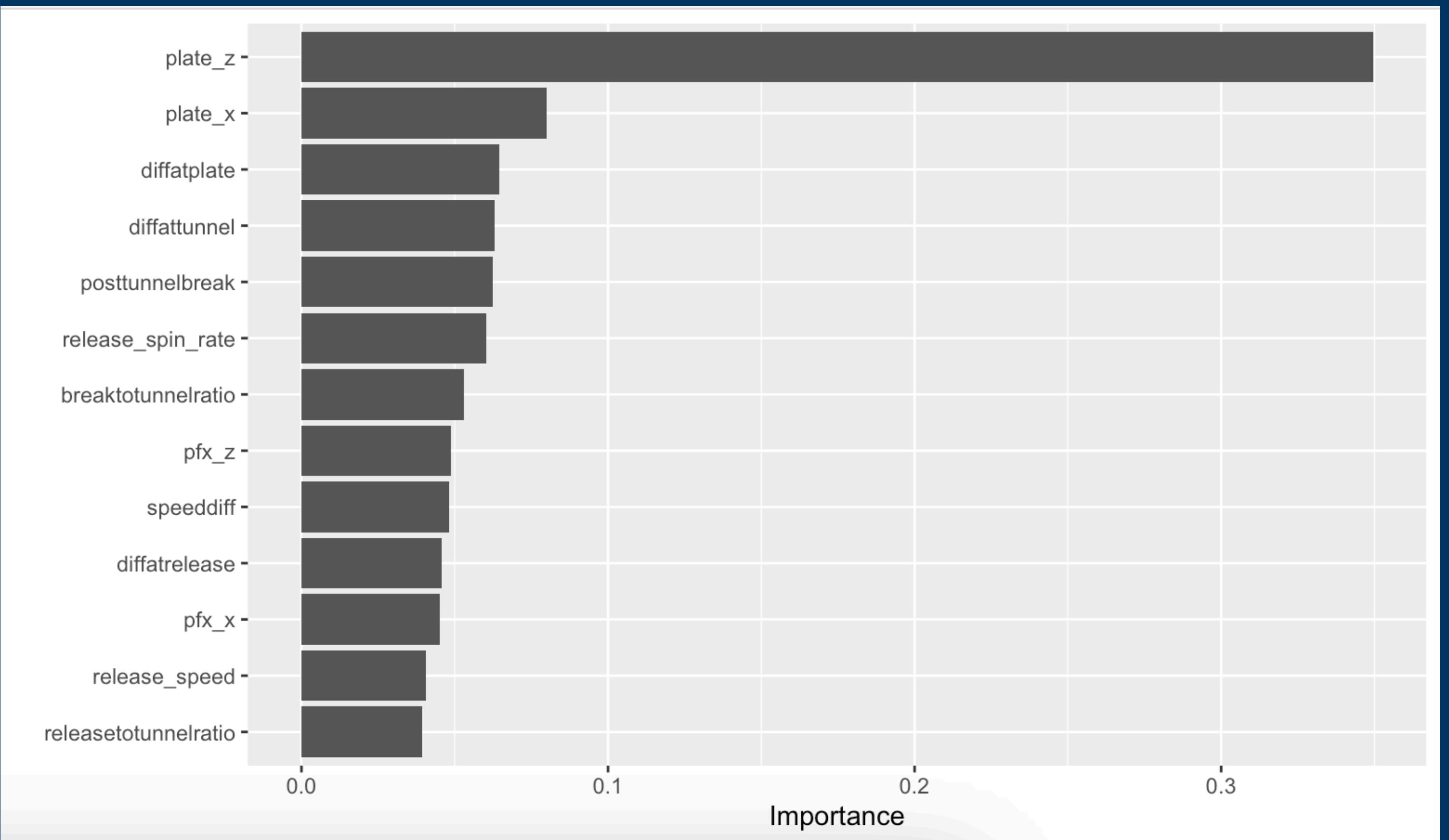
Right Handed Pitchers vs Left Handed Hitters

Cutter -> Changeup | RHP -> LHH | Whiff

Training Sample: n = 2158 pitches

Testing Sample: n = 926 pitches

Testing Accuracy: 63.93%

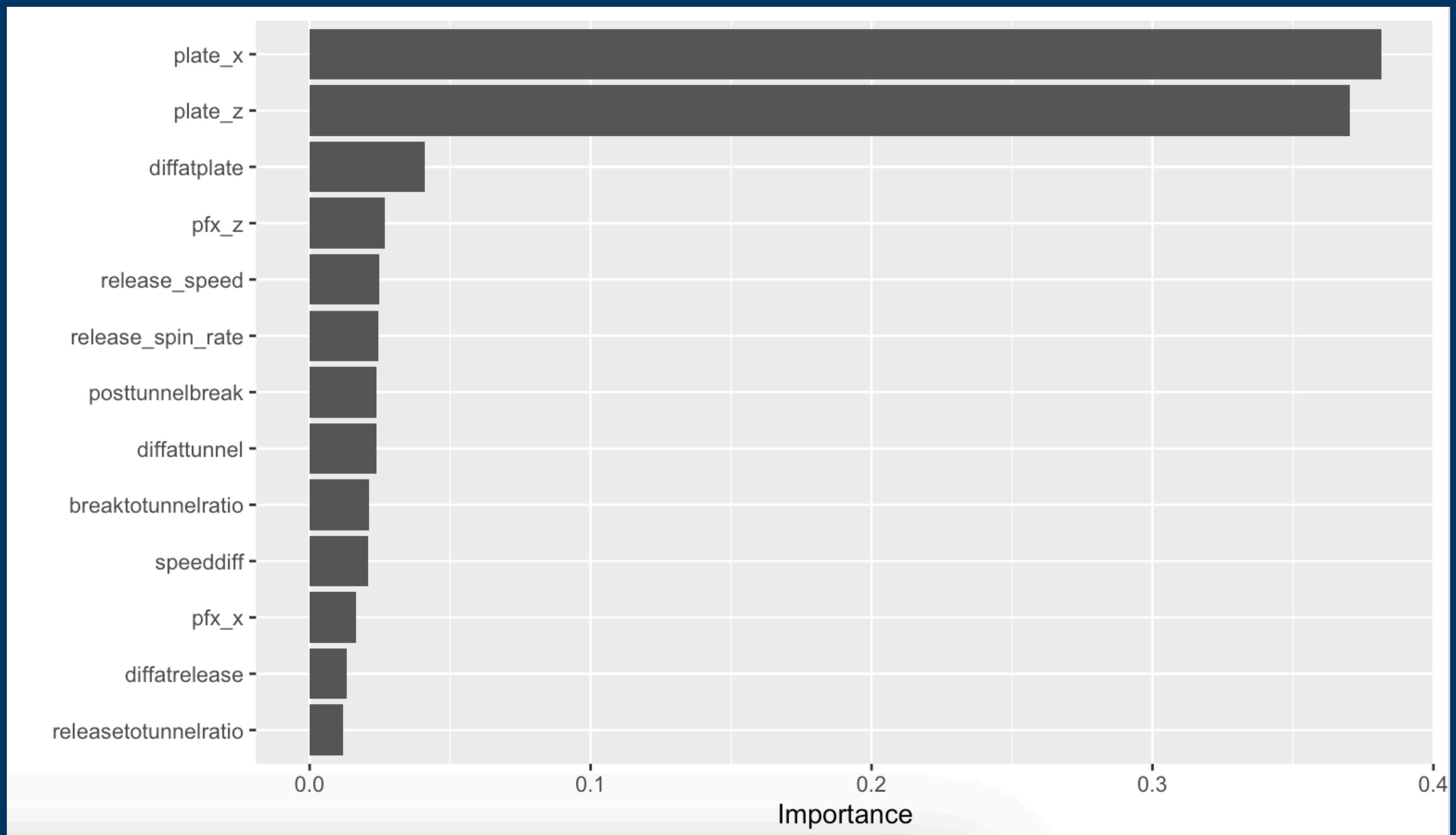


Cutter -> Changeup | RHP -> LHH | Chase

Training Sample: n = 2158 pitches

Testing Sample: n = 926 pitches

Testing Accuracy: 73.04%

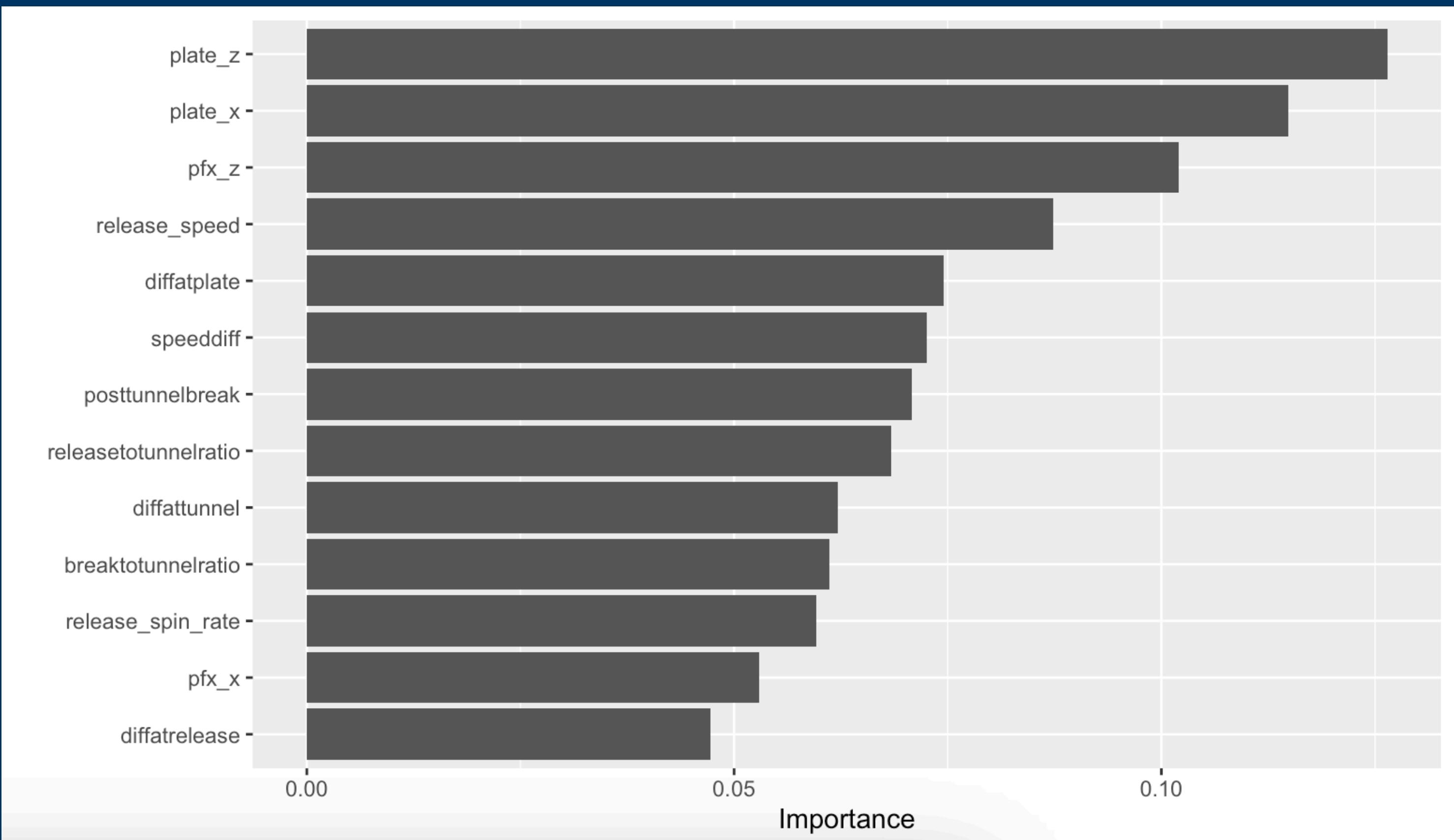


Cutter -> Changeup | RHP -> LHH | Groundball

Training Sample: n = 2158 pitches

Testing Sample: n = 926 pitches

Testing Accuracy: 59.52%

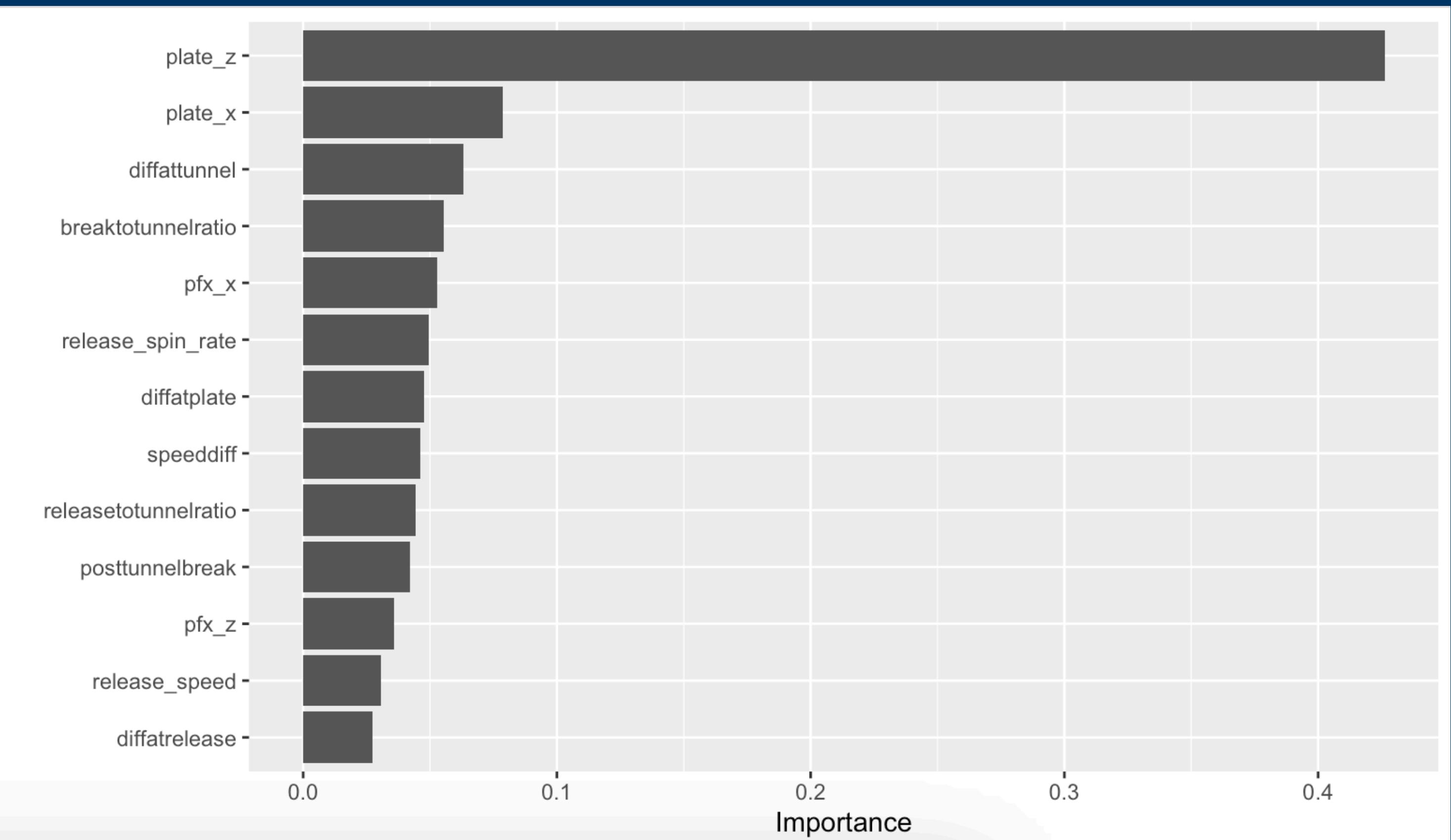


Cutter -> Curveball | RHP -> LHH | Whiff

Training Sample: n = 1594 pitches

Testing Sample: n = 684 pitches

Testing Accuracy: 72.37%

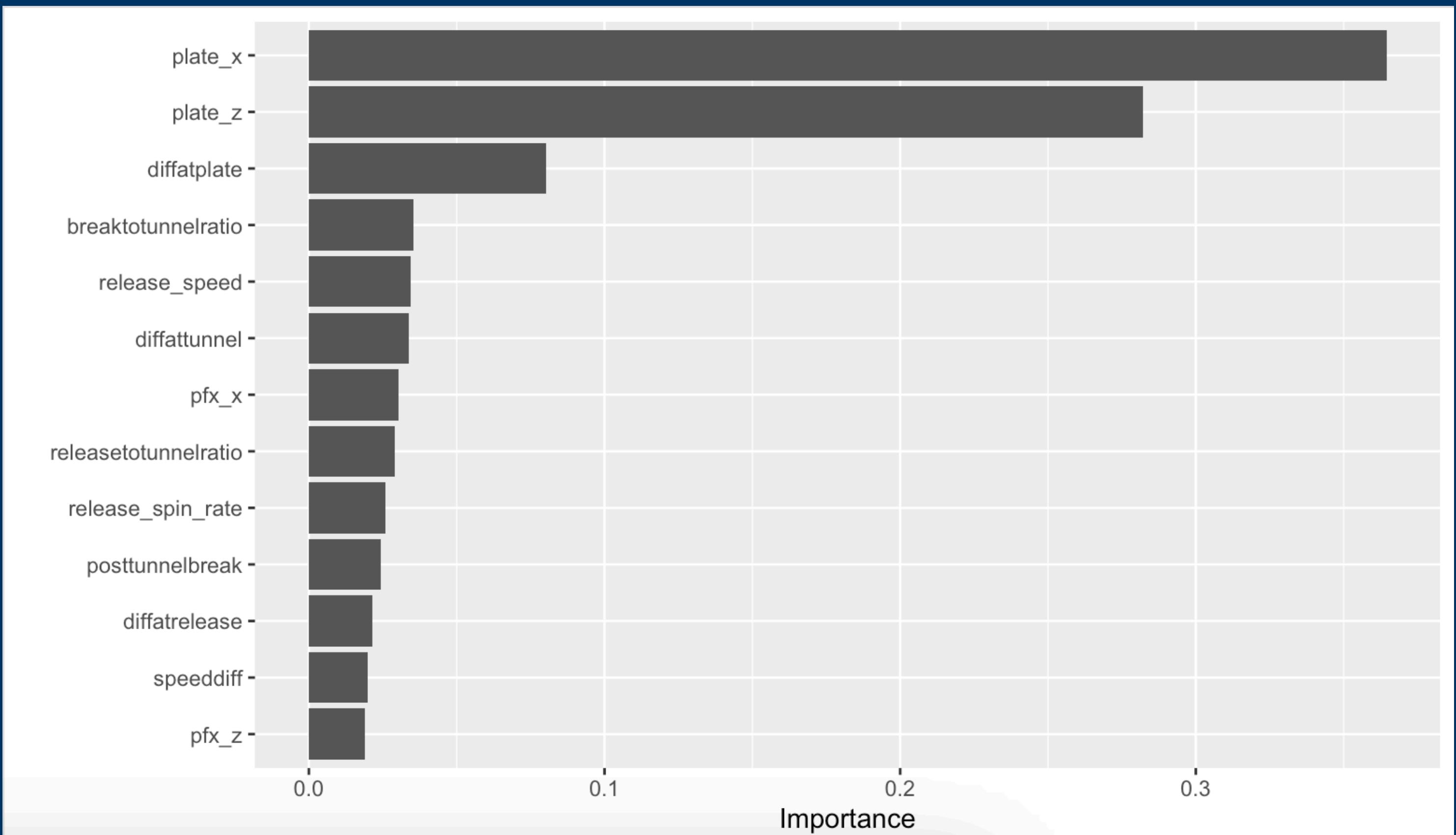


Cutter -> Curveball | RHP -> LHH | Chase

Training Sample: n = 2350 pitches

Testing Sample: n = 1008 pitches

Testing Accuracy: 72.92%

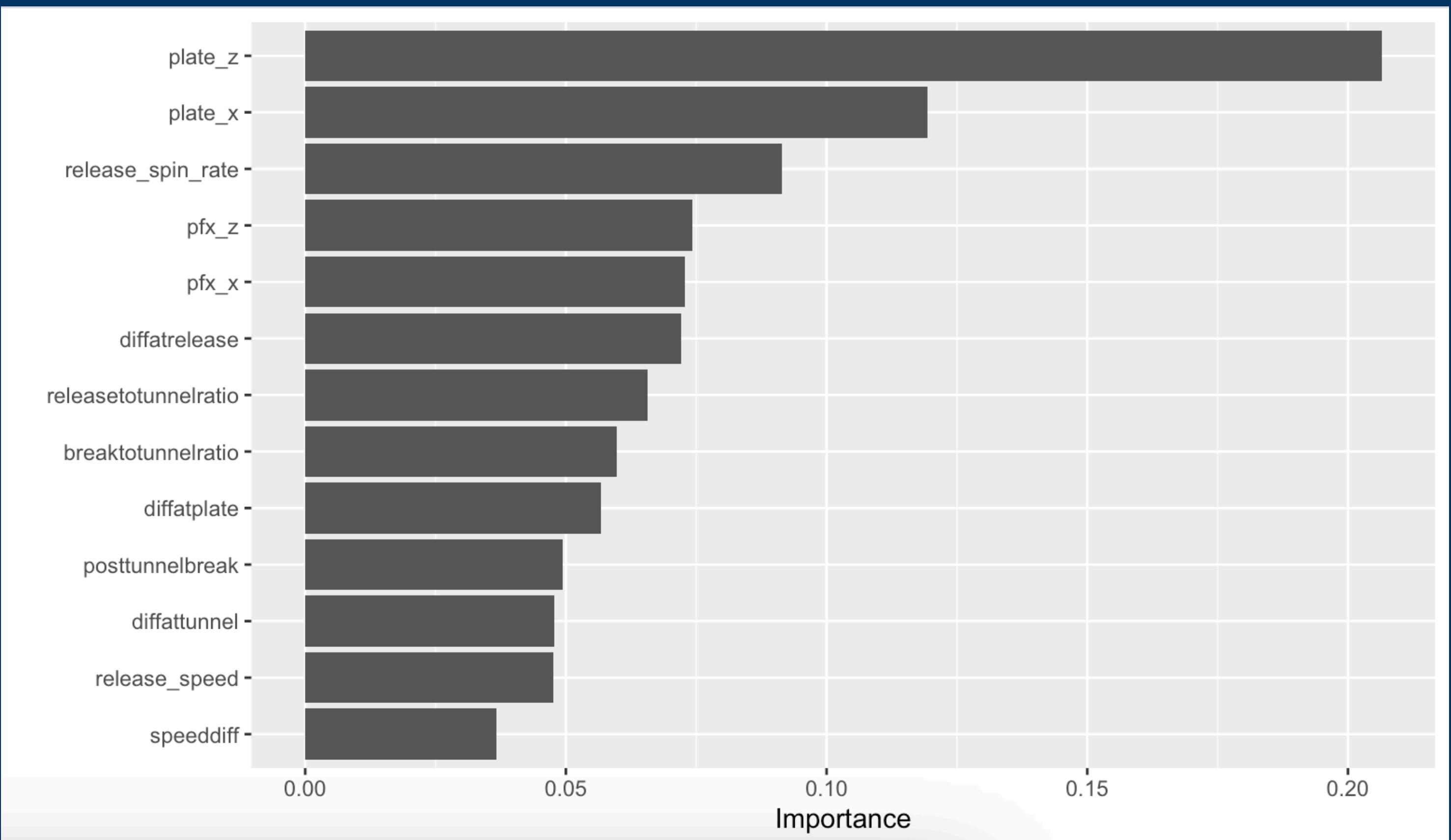


Cutter -> Splitter | RHP -> LHH | Whiff

Training Sample: n = 418 pitches

Testing Sample: n = 180 pitches

Testing Accuracy: 64.44%

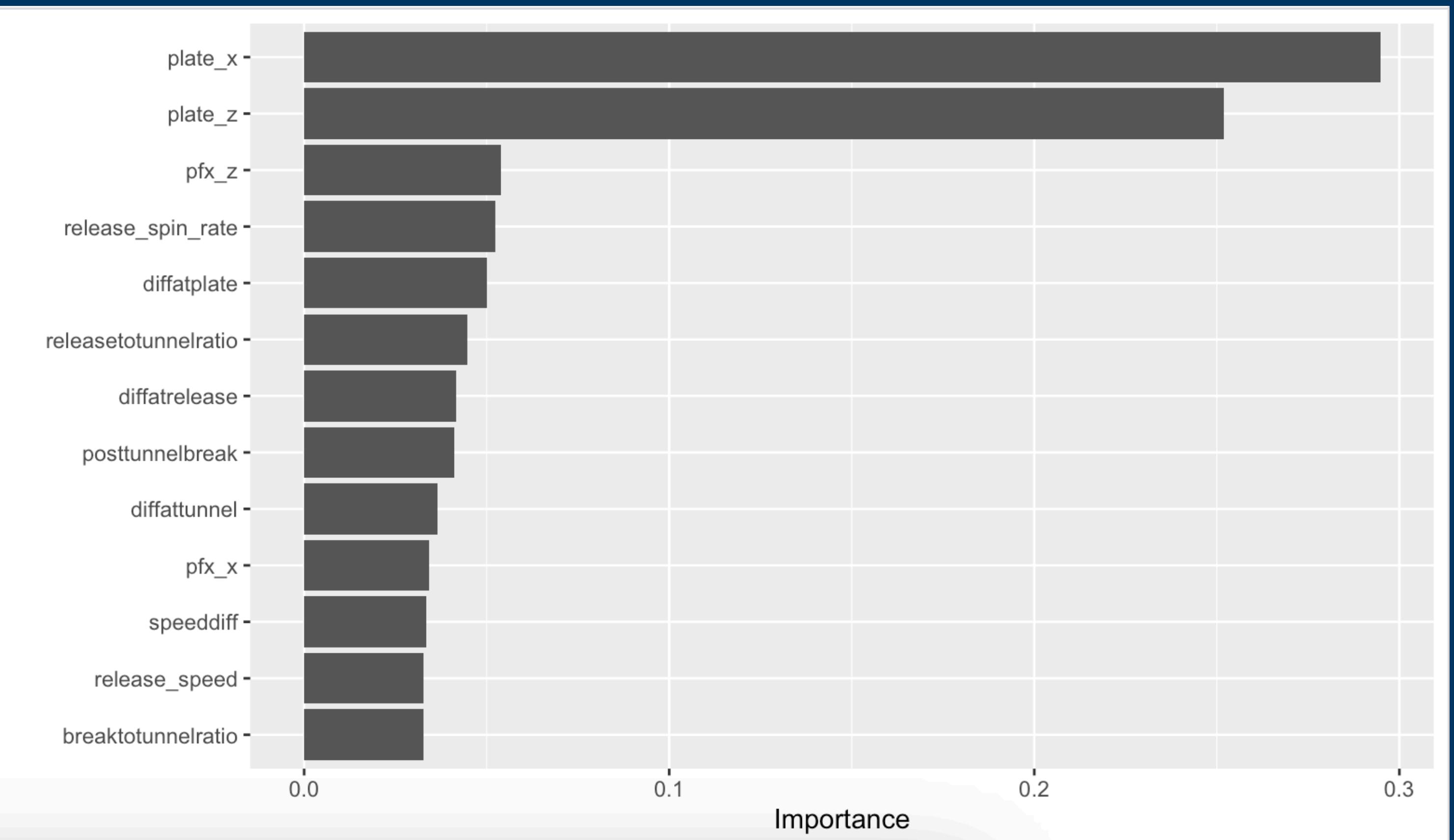


Cutter -> Splitter | RHP -> LHH | Chase

Training Sample: n = 704 pitches

Testing Sample: n = 302 pitches

Testing Accuracy: 74.17%

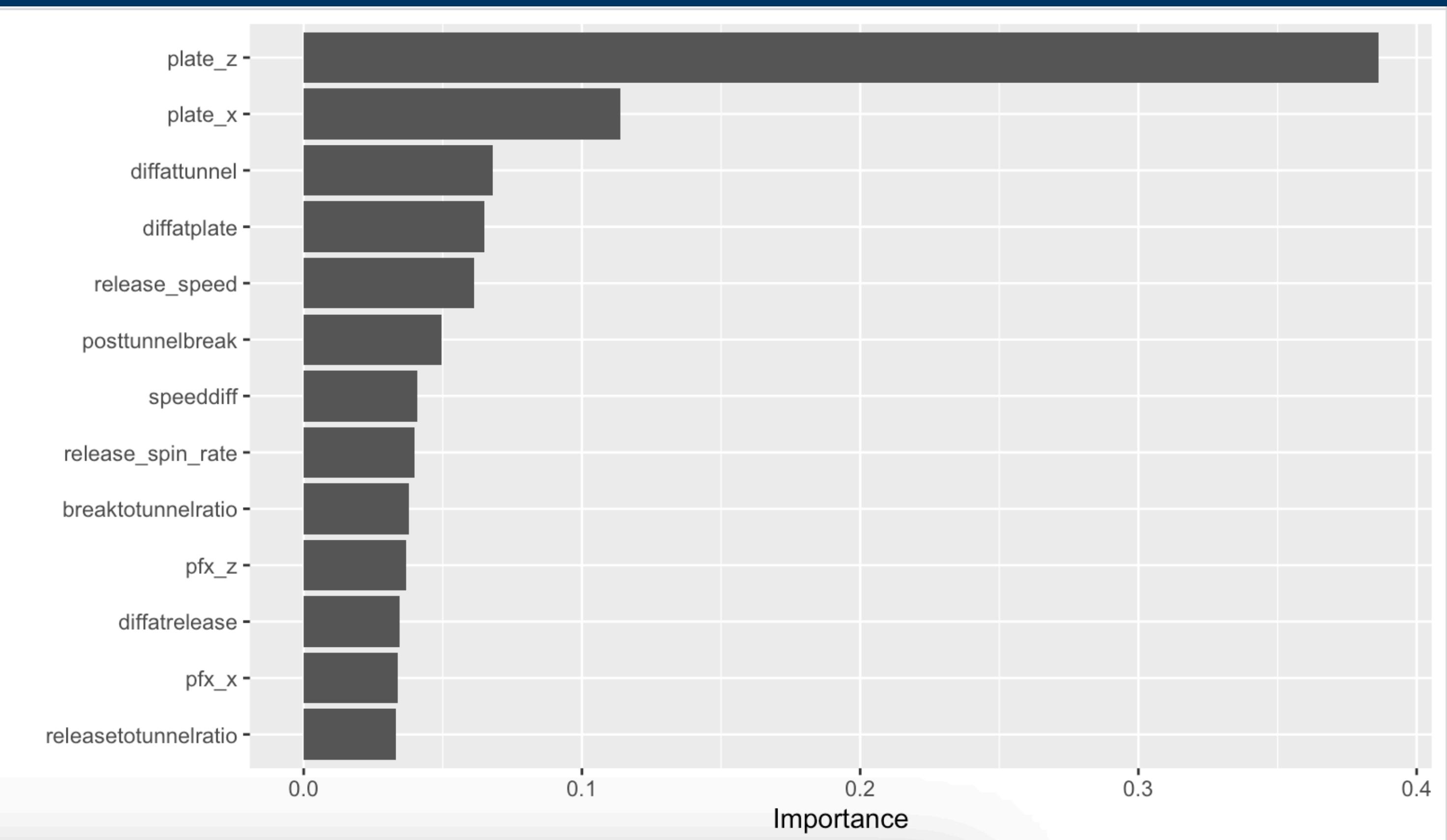


Cutter -> Knuckle Curve | RHP -> LHH | Whiff

Training Sample: n = 732 pitches

Testing Sample: n = 316 pitches

Testing Accuracy: 73.73%

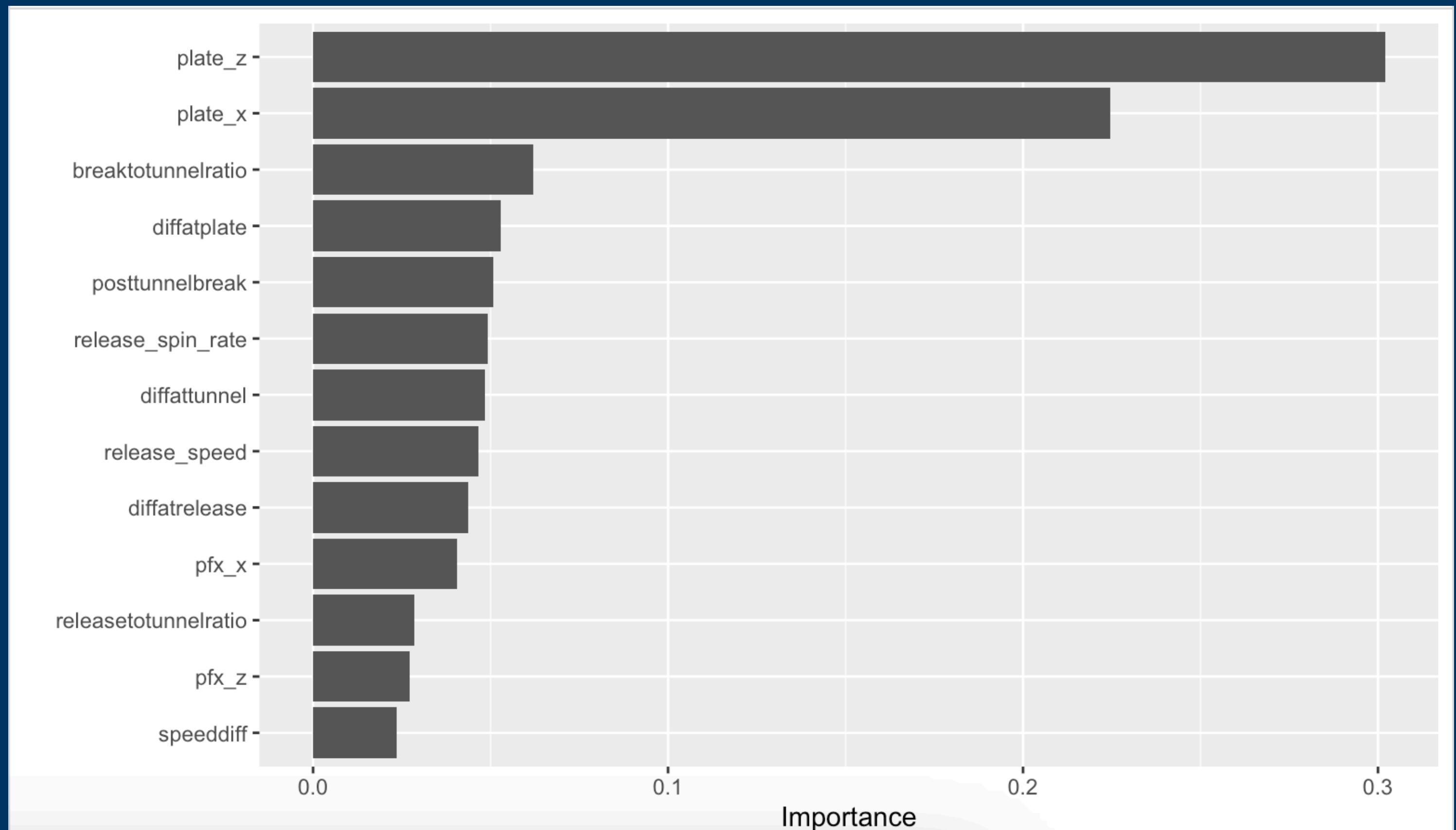


Cutter -> Knuckle Curve | RHP -> LHH | Chase

Training Sample: n = 1012 pitches

Testing Sample: n = 436 pitches

Testing Accuracy: 72.25%

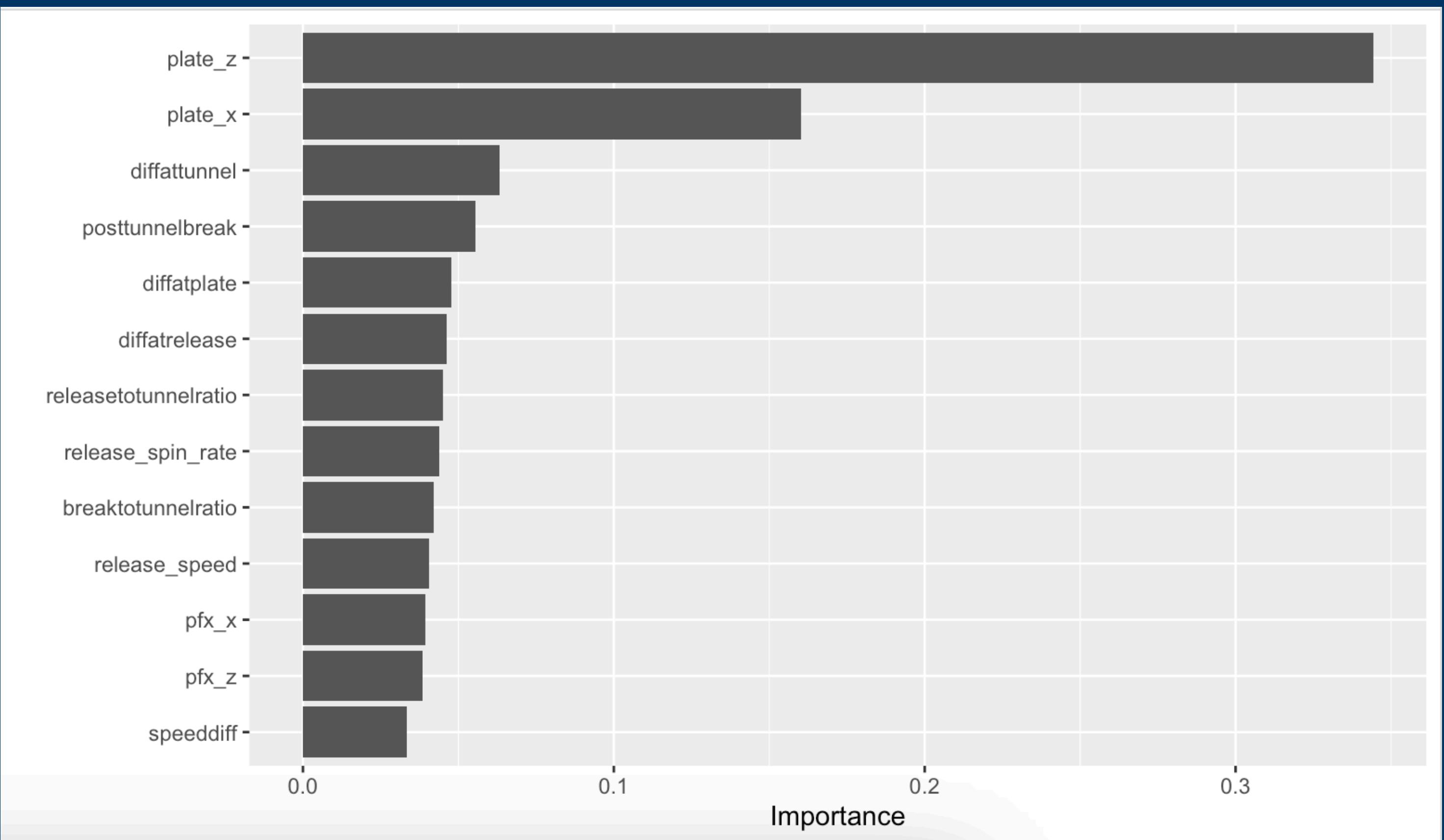


Cutter -> Slider | RHP -> LHH | Whiff

Training Sample: n = 982 pitches

Testing Sample: n = 422 pitches

Testing Accuracy: 72.27%

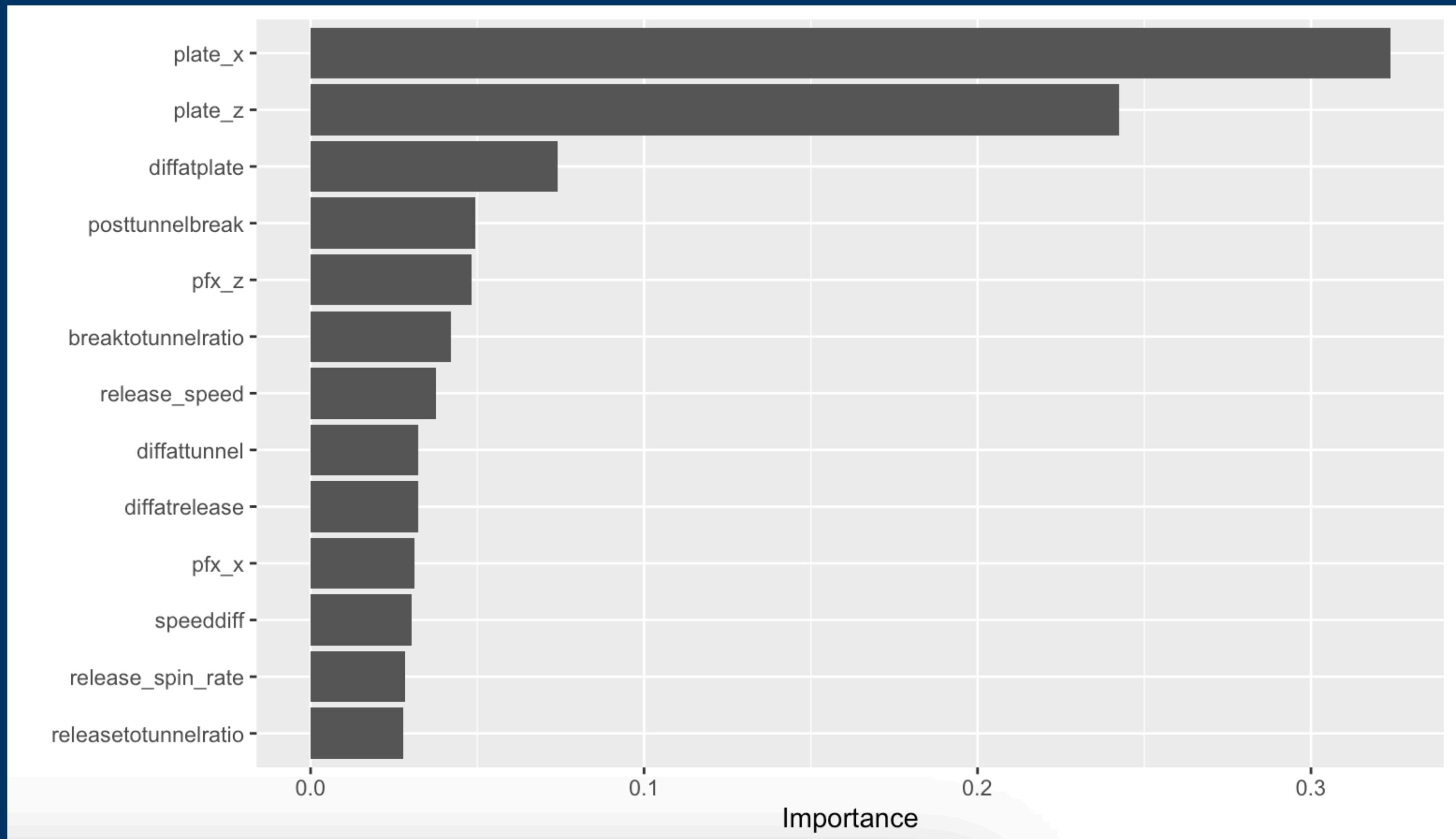


Cutter -> Slider | RHP -> LHH | Chase

Training Sample: n = 1436 pitches

Testing Sample: n = 616 pitches

Testing Accuracy: 68.18%

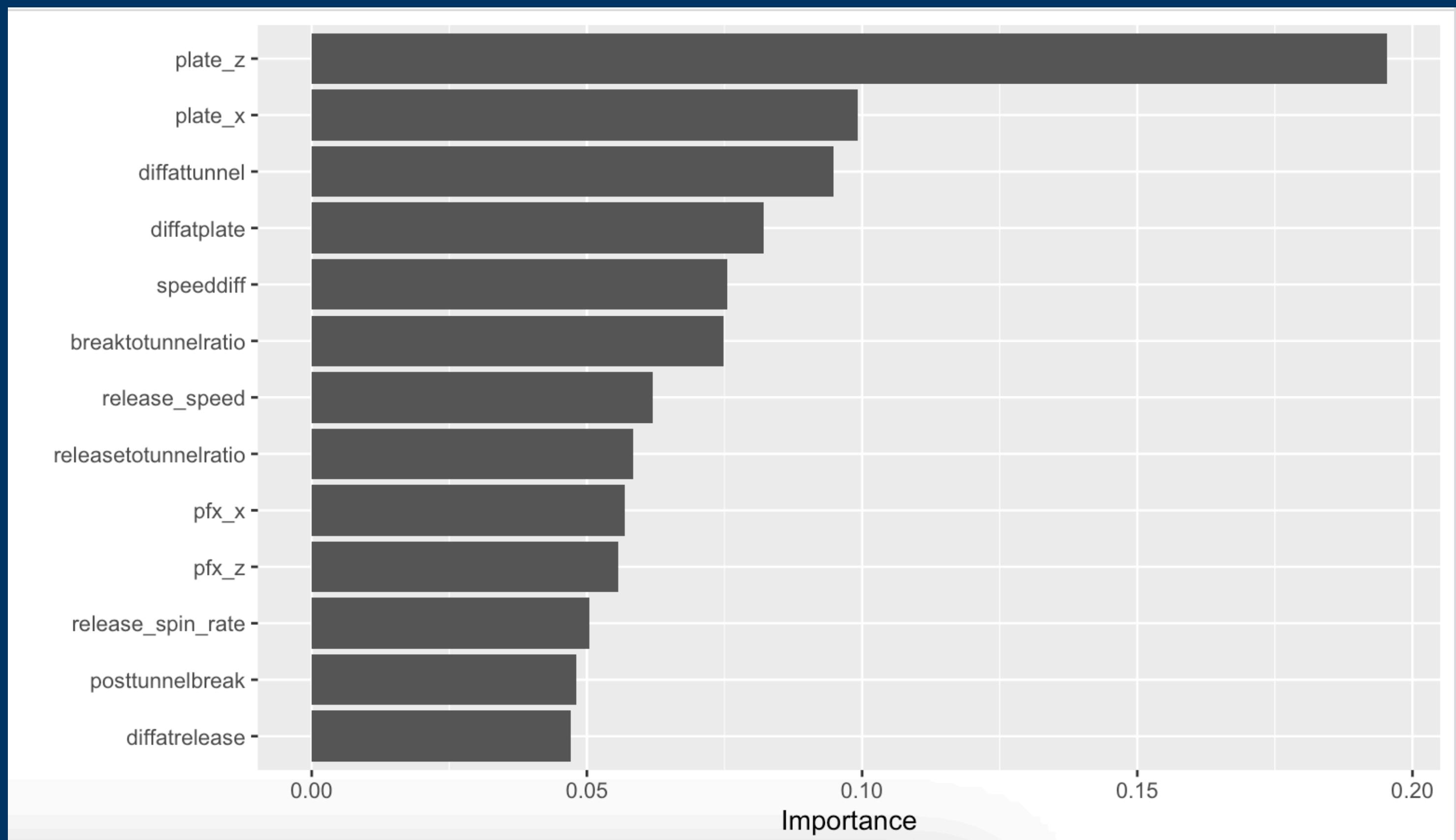


Cutter -> Sweeper | RHP -> LHH | Whiff

Training Sample: n = 248 pitches

Testing Sample: n = 108 pitches

Testing Accuracy: 65.74%

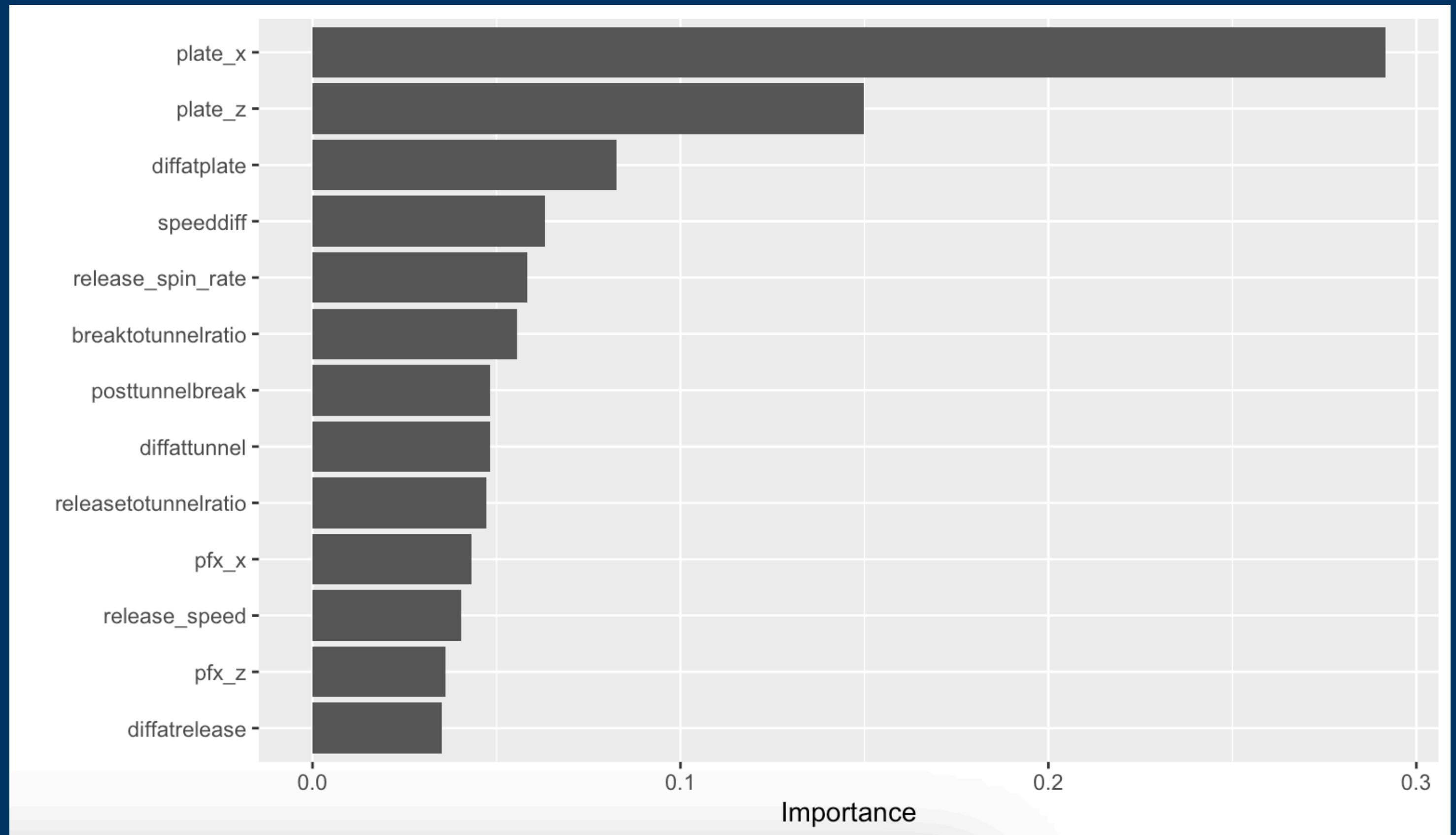


Cutter -> Sweeper | RHP -> LHH | Chase

Training Sample: n = 358 pitches

Testing Sample: n = 156 pitches

Testing Accuracy: 71.15%

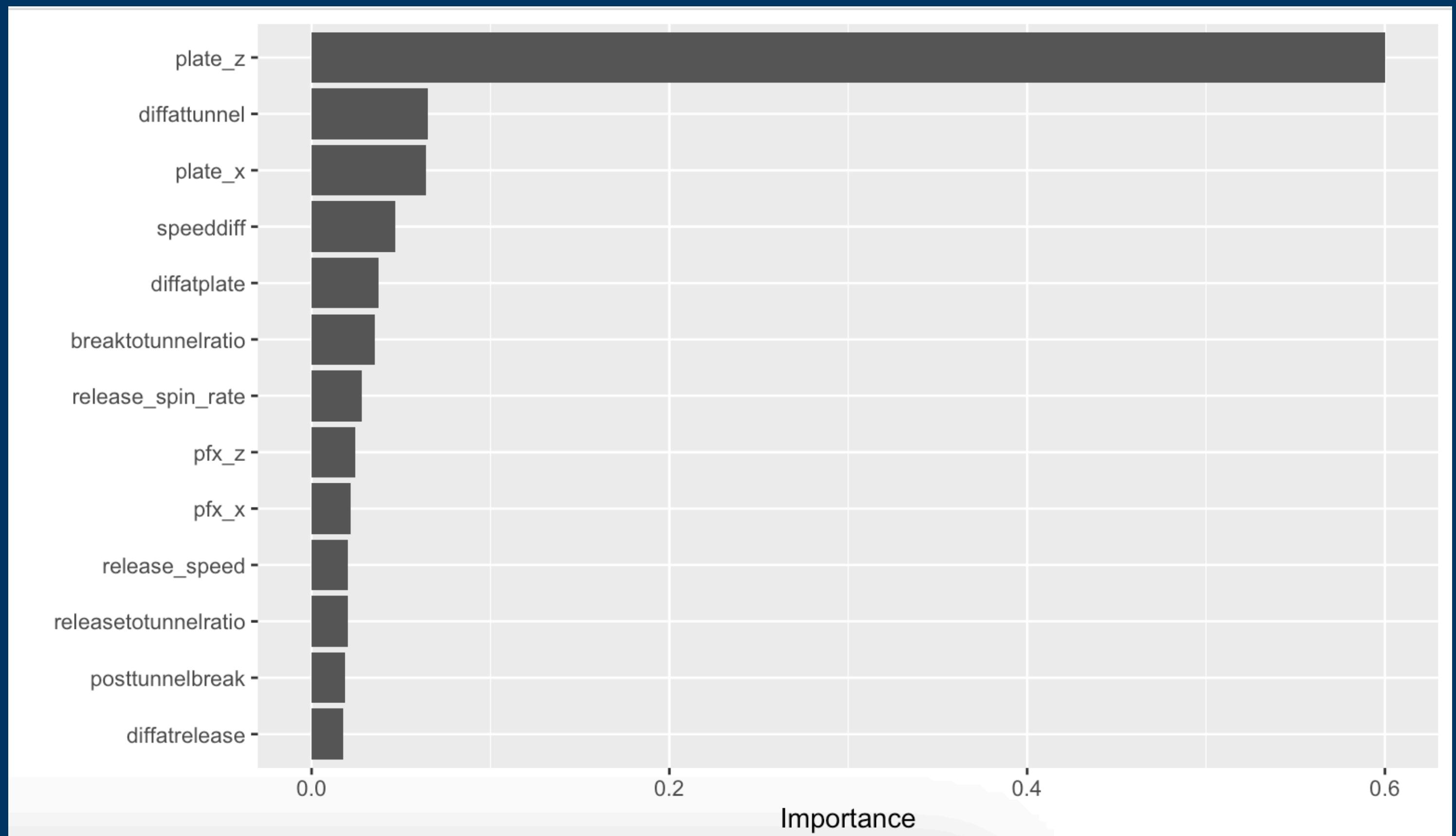


Four-Seam -> Changeup | RHP -> LHH | Whiff

Training Sample: n = 15196 pitches

Testing Sample: n = 6514 pitches

Testing Accuracy: 64.05%

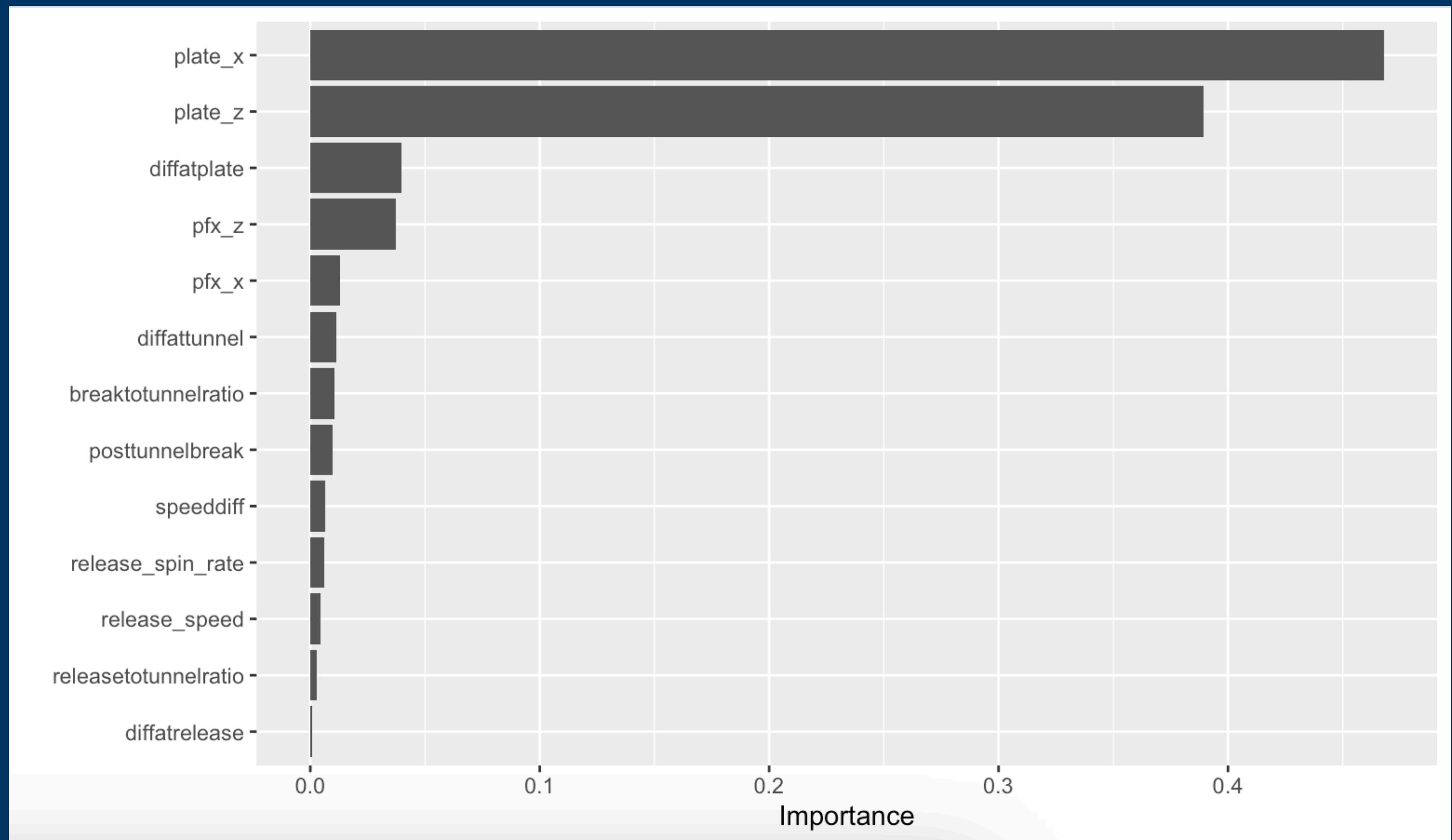


Four-Seam -> Changeup | RHP -> LHH | Chase

Training Sample: n = 26362 pitches

Testing Sample: n = 11300 pitches

Testing Accuracy: 73.66%

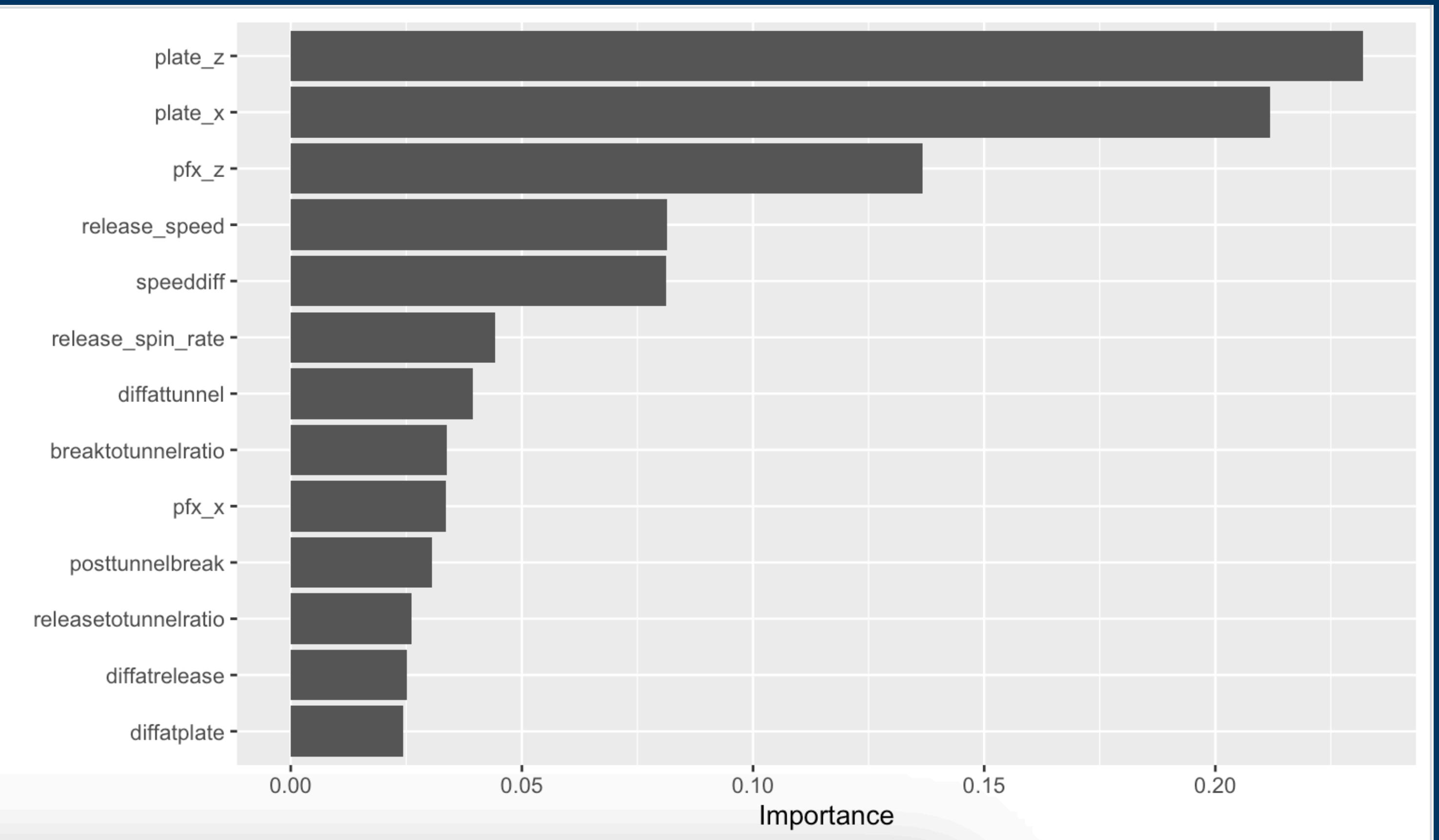


Four-Seam -> Changeup | RHP -> LHH | Groundball

Training Sample: n = 11634 pitches

Testing Sample: n = 4988 pitches

Testing Accuracy: 61.67%

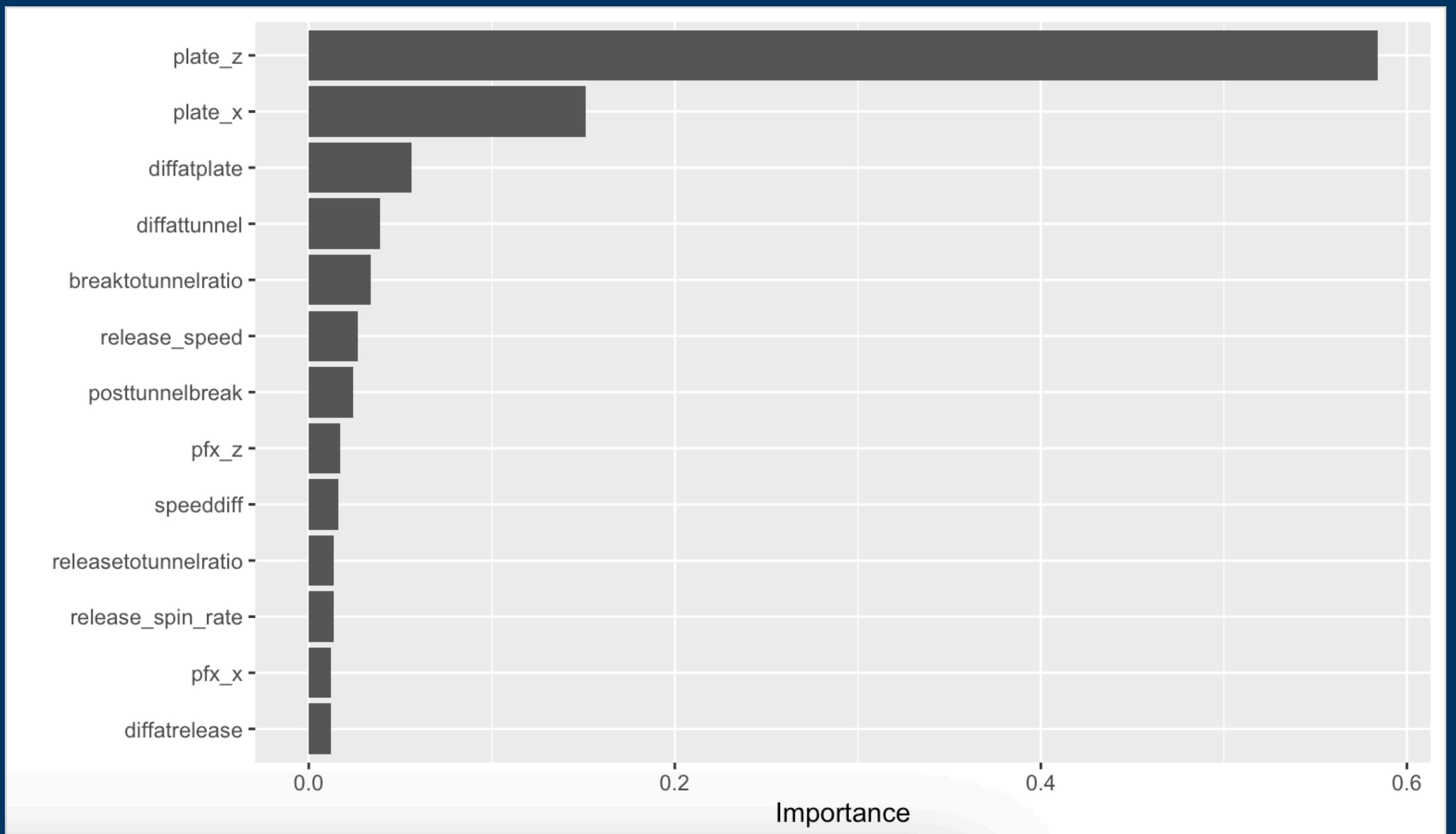


Four-Seam -> Curveball | RHP -> LHH | Whiff

Training Sample: n = 7706 pitches

Testing Sample: n = 3304 pitches

Testing Accuracy: 72.15%

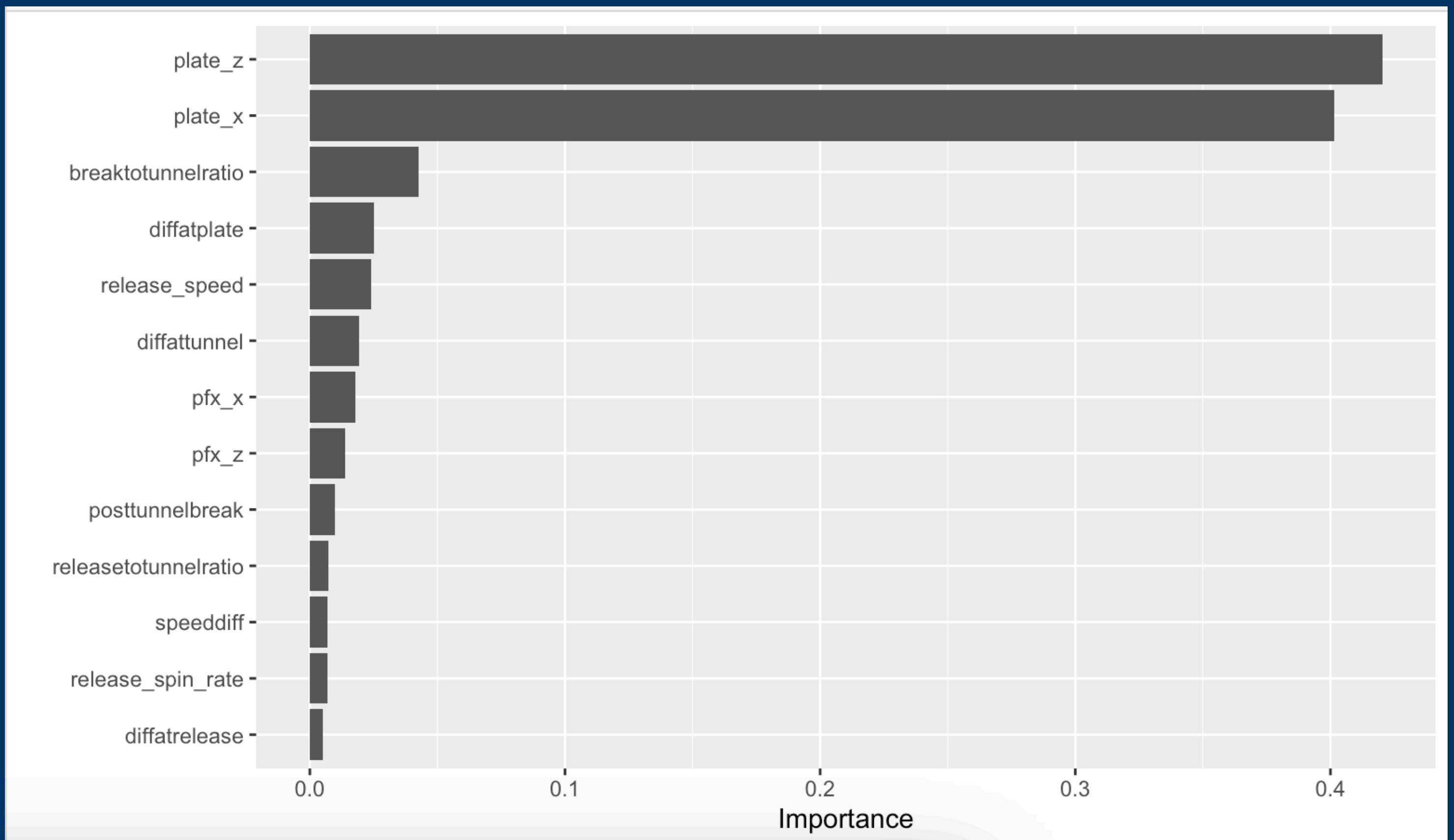


Four-Seam -> Curveball | RHP -> LHH | Chase

Training Sample: n = 12150 pitches

Testing Sample: n = 5208 pitches

Testing Accuracy: 72.85%

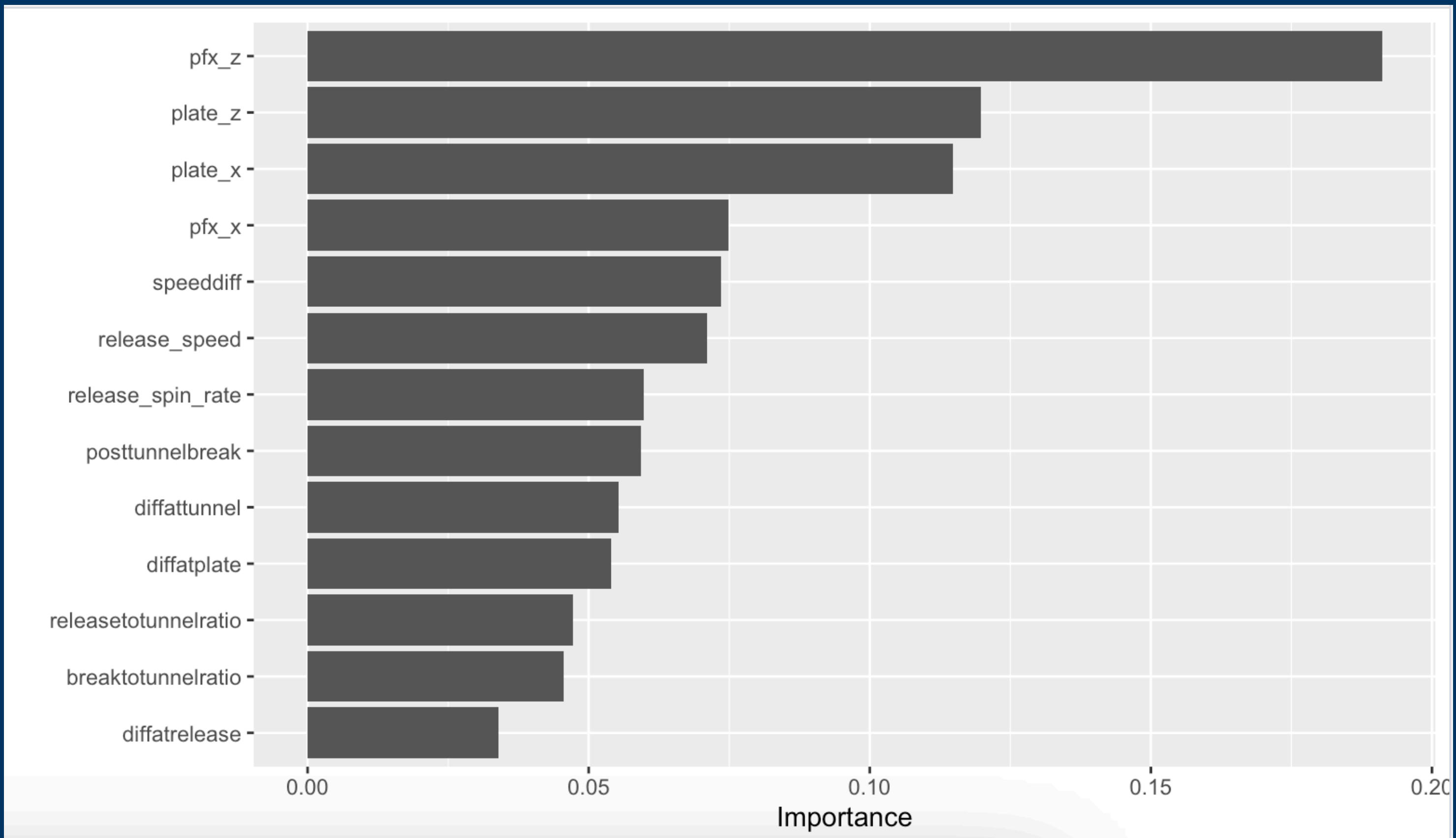


Four-Seam -> Curveball | RHP -> LHH | Groundball

Training Sample: n = 4768 pitches

Testing Sample: n = 2046 pitches

Testing Accuracy: 60.56%

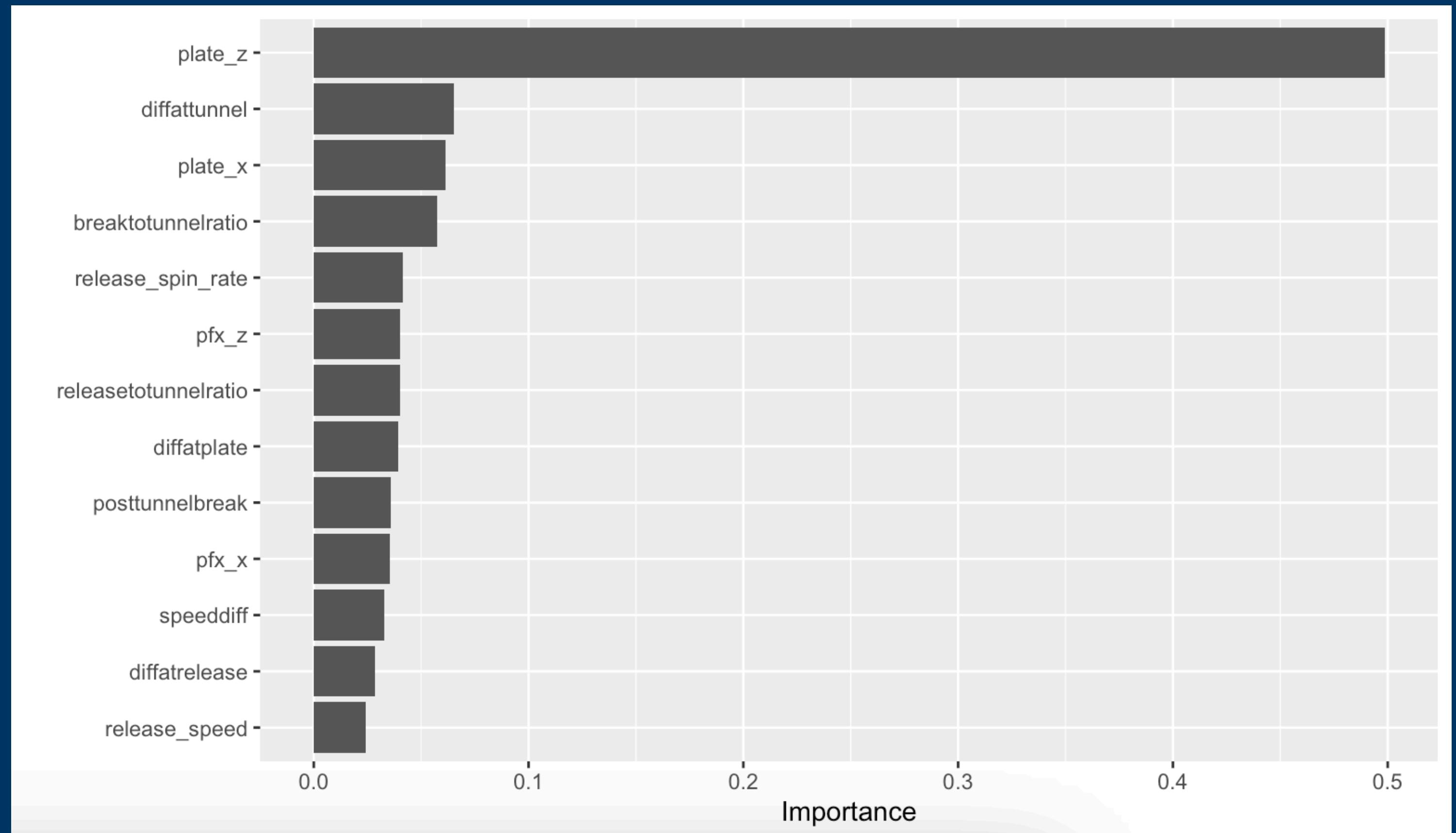


Four-Seam -> Splitter | RHP -> LHH | Whiff

Training Sample: n = 3606 pitches

Testing Sample: n = 1546 pitches

Testing Accuracy: 68.63%

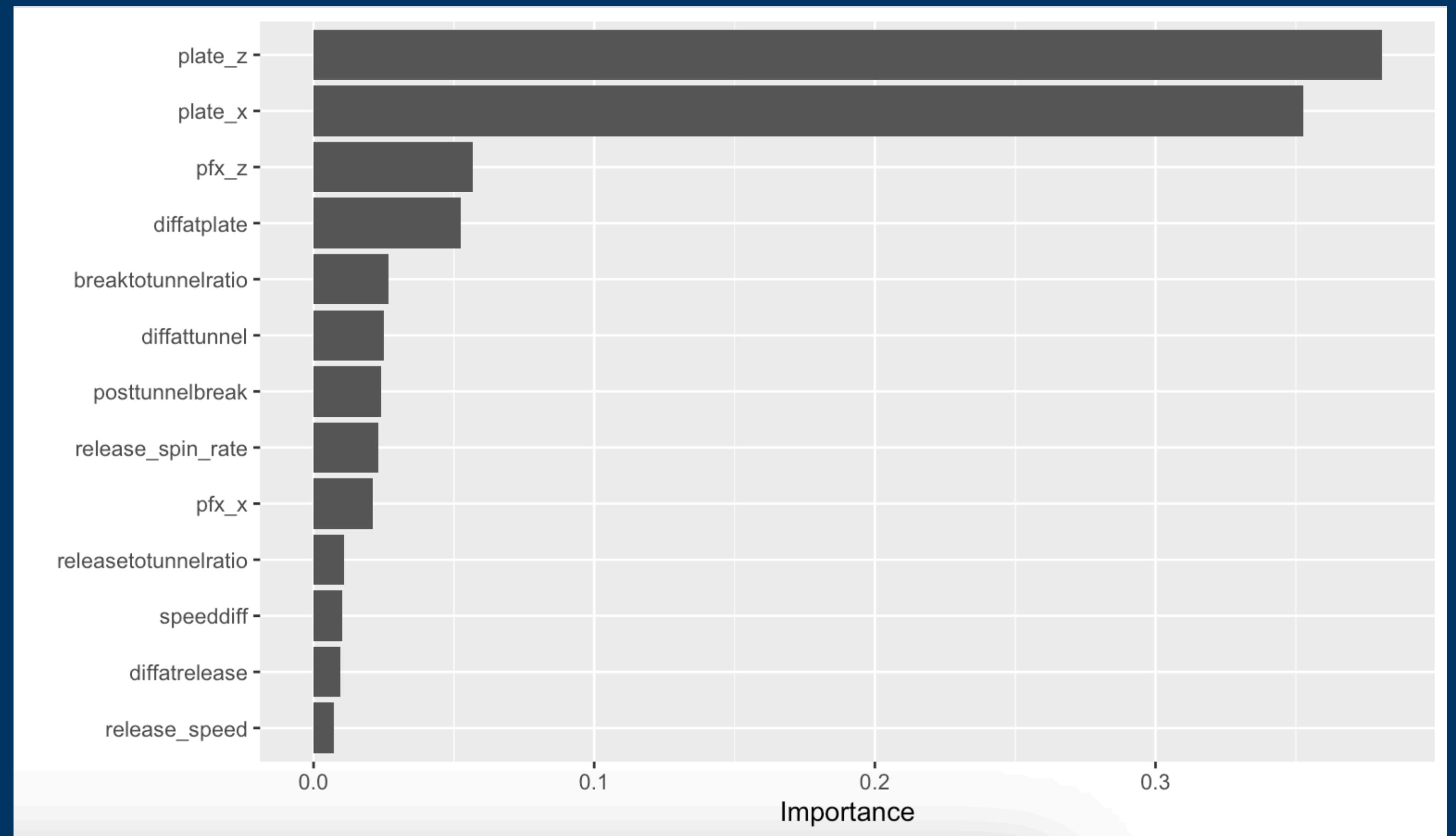


Four-Seam -> Splitter | RHP -> LHH | Chase

Training Sample: n = 5970 pitches

Testing Sample: n = 2560 pitches

Testing Accuracy: 72.07%

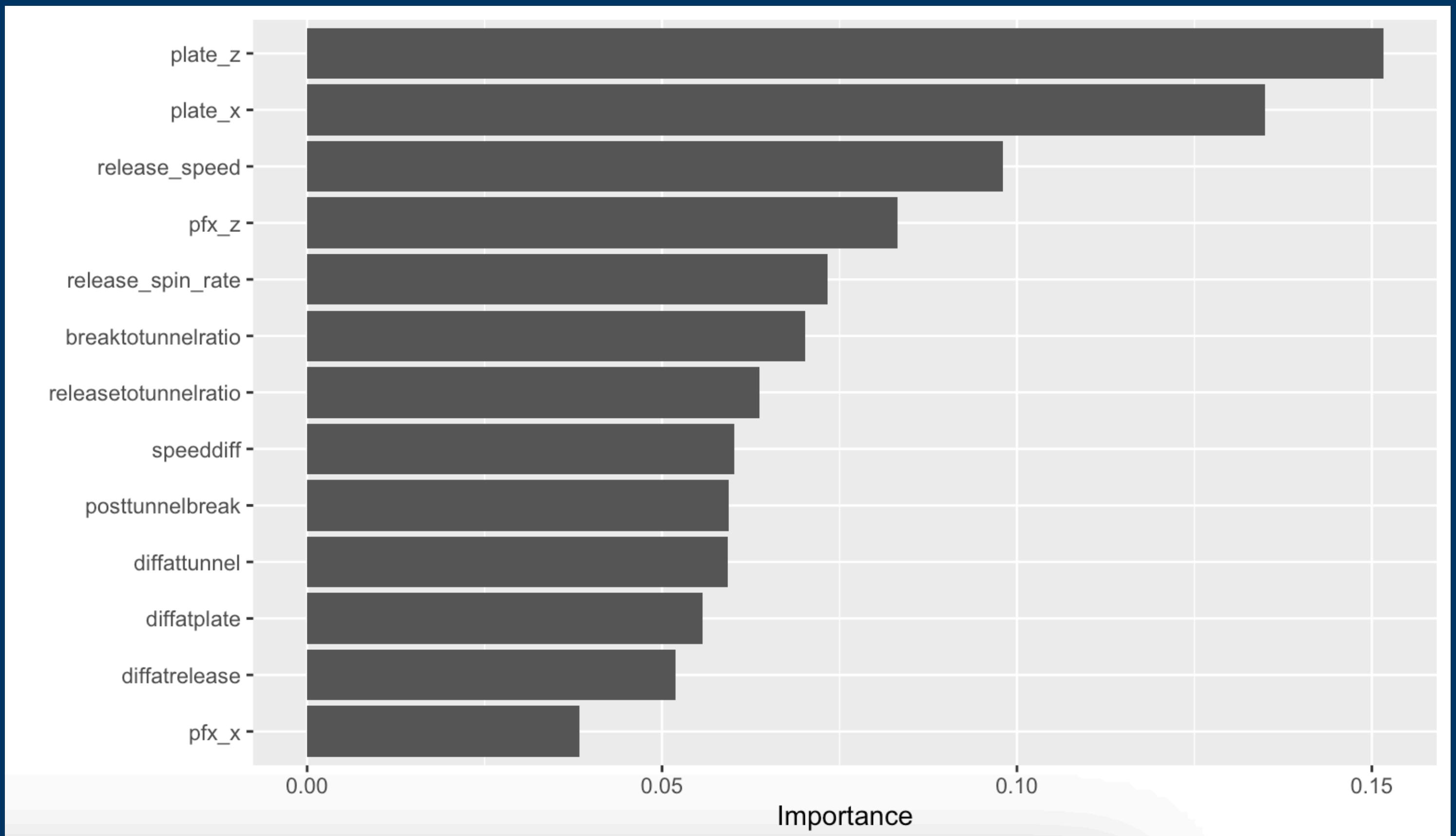


Four-Seam -> Splitter | RHP -> LHH | Groundball

Training Sample: n = 2032 pitches

Testing Sample: n = 872 pitches

Testing Accuracy: 63.07%

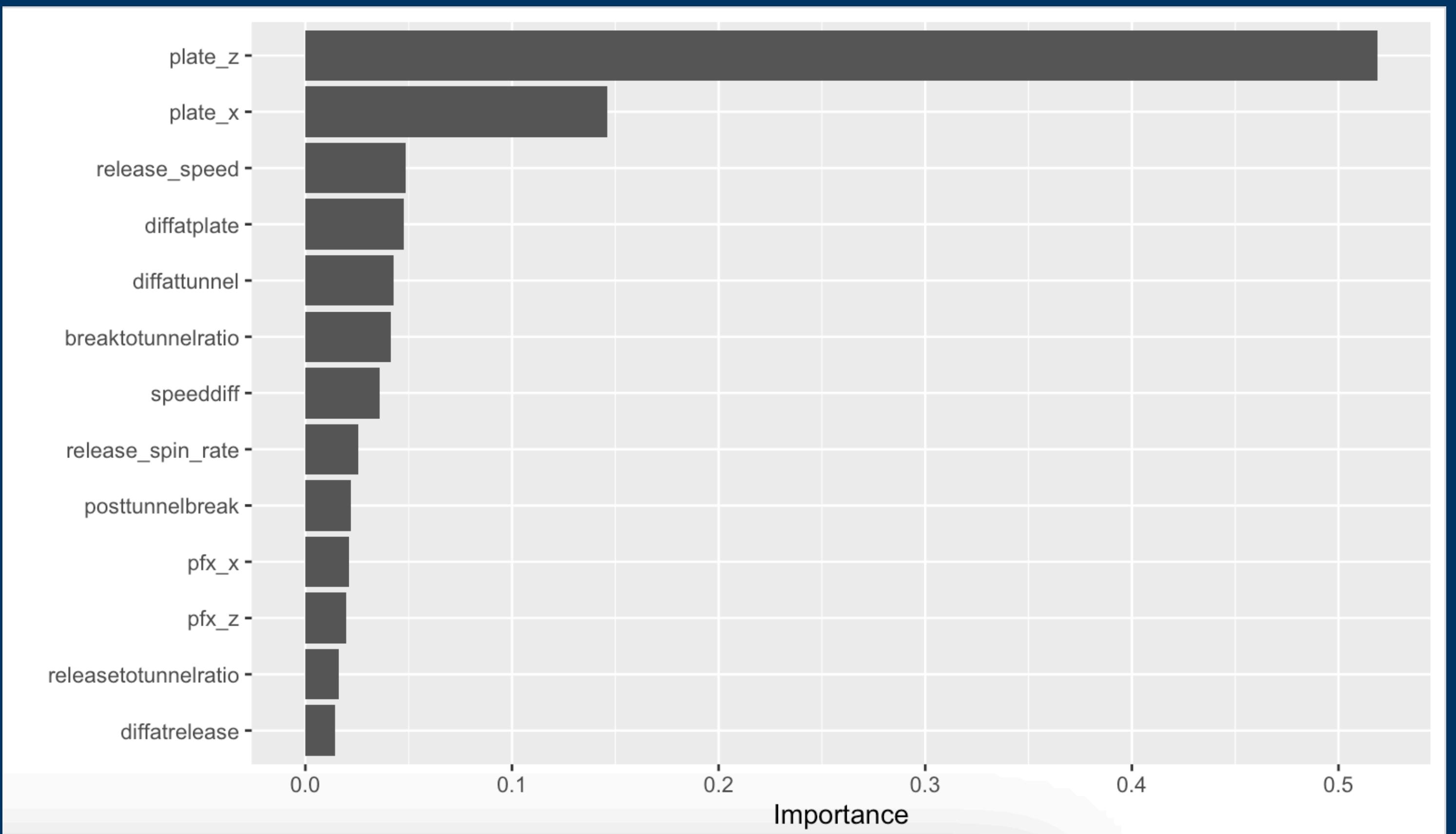


Four-Seam -> Knuckle Curve | RHP -> LHH | Whiff

Training Sample: n = 2970 pitches

Testing Sample: n = 1274 pitches

Testing Accuracy: 73.08%

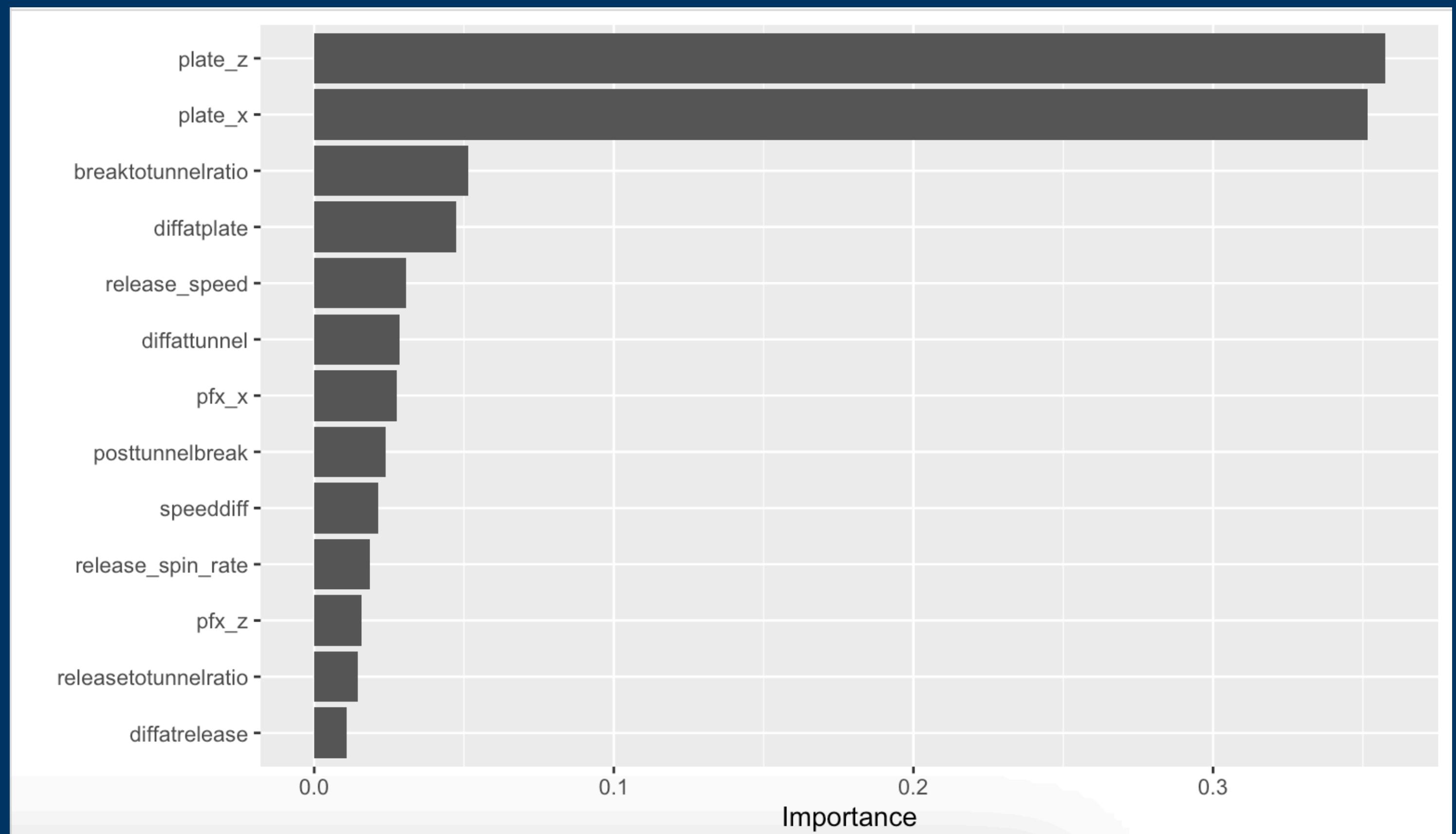


Four-Seam -> Knuckle Curve | RHP -> LHH | Chase

Training Sample: n = 2970 pitches

Testing Sample: n = 1274 pitches

Testing Accuracy: 70.05%

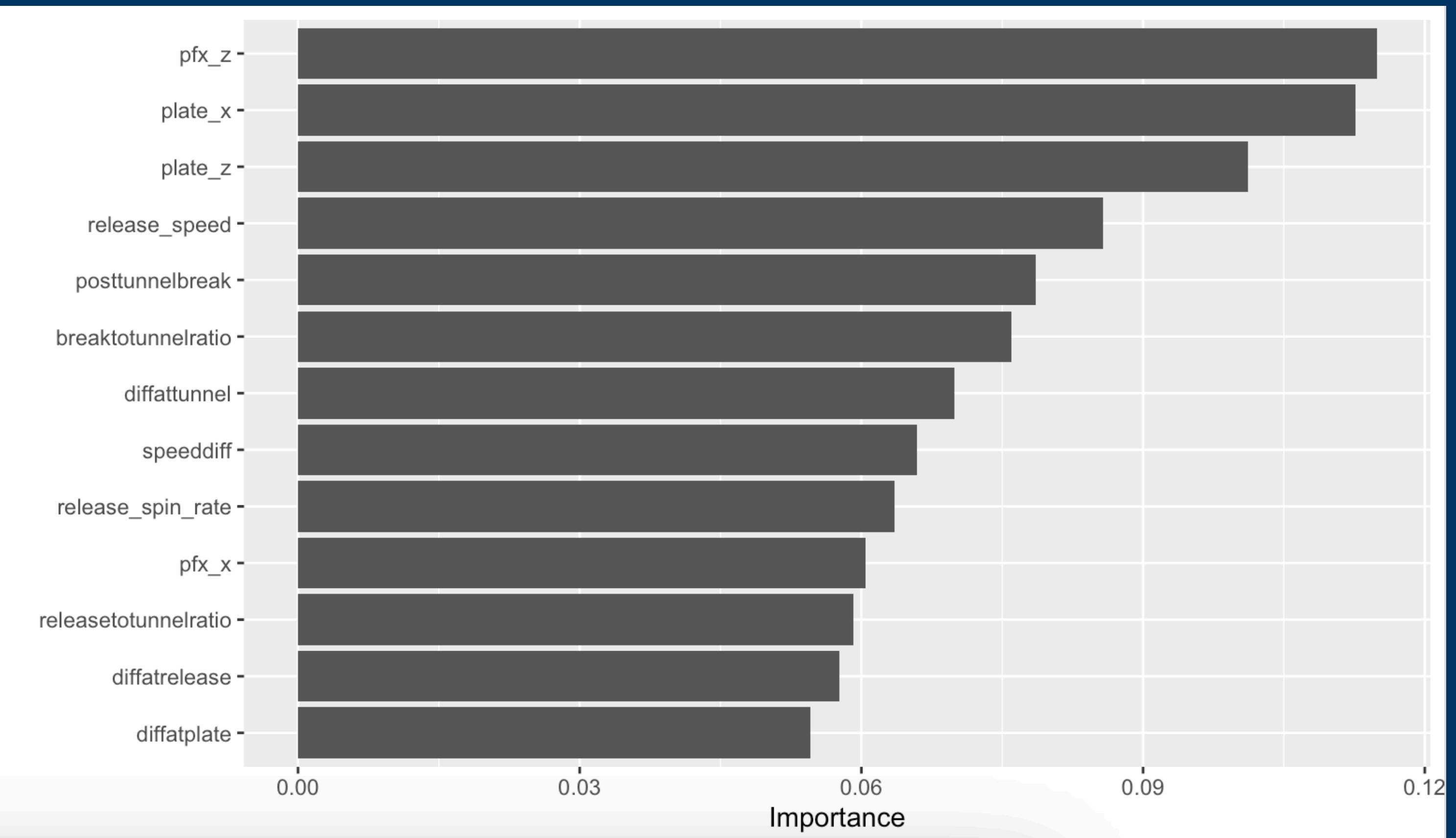


Four-Seam -> Knuckle Curve | RHP -> LHH | Groundball

Training Sample: n = 1520 pitches

Testing Sample: n = 652 pitches

Testing Accuracy: 57.98%

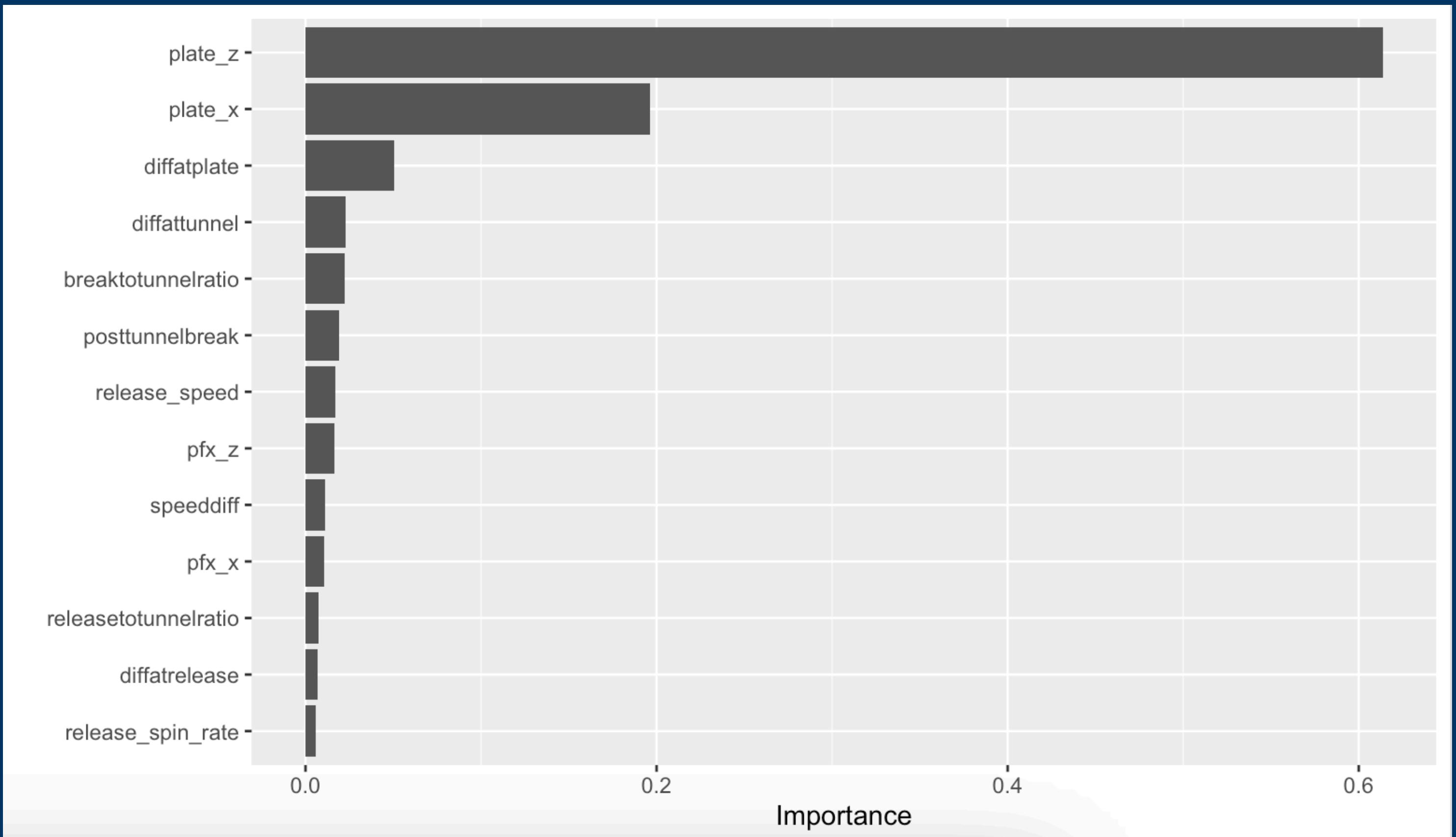


Four-Seam -> Slider | RHP -> LHH | Whiff

Training Sample: n = 12860 pitches

Testing Sample: n = 5514 pitches

Testing Accuracy: 72.51%

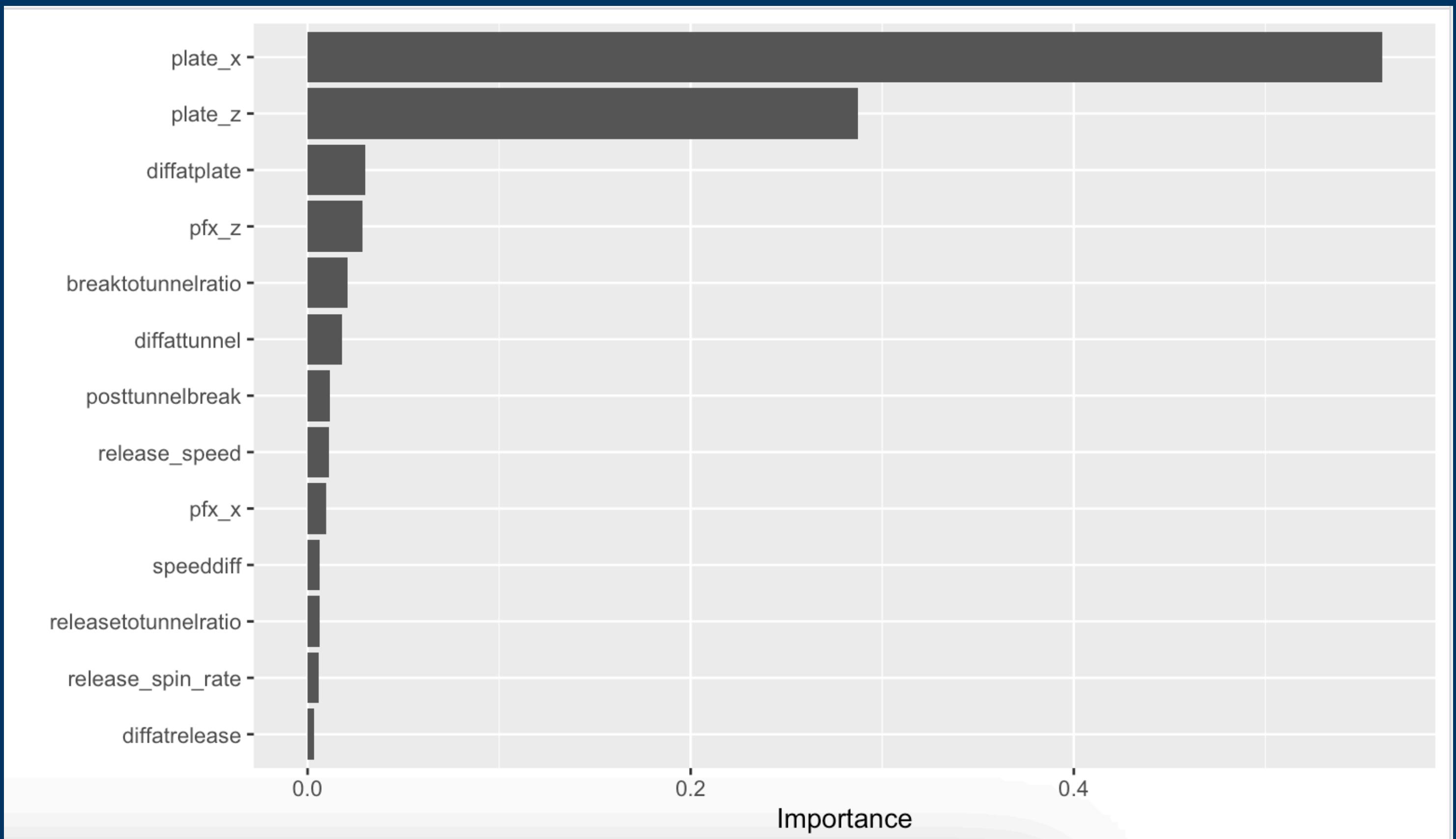


Four-Seam -> Slider | RHP -> LHH | Chase

Training Sample: n = 17508 pitches

Testing Sample: n = 7506 pitches

Testing Accuracy: 71.02%

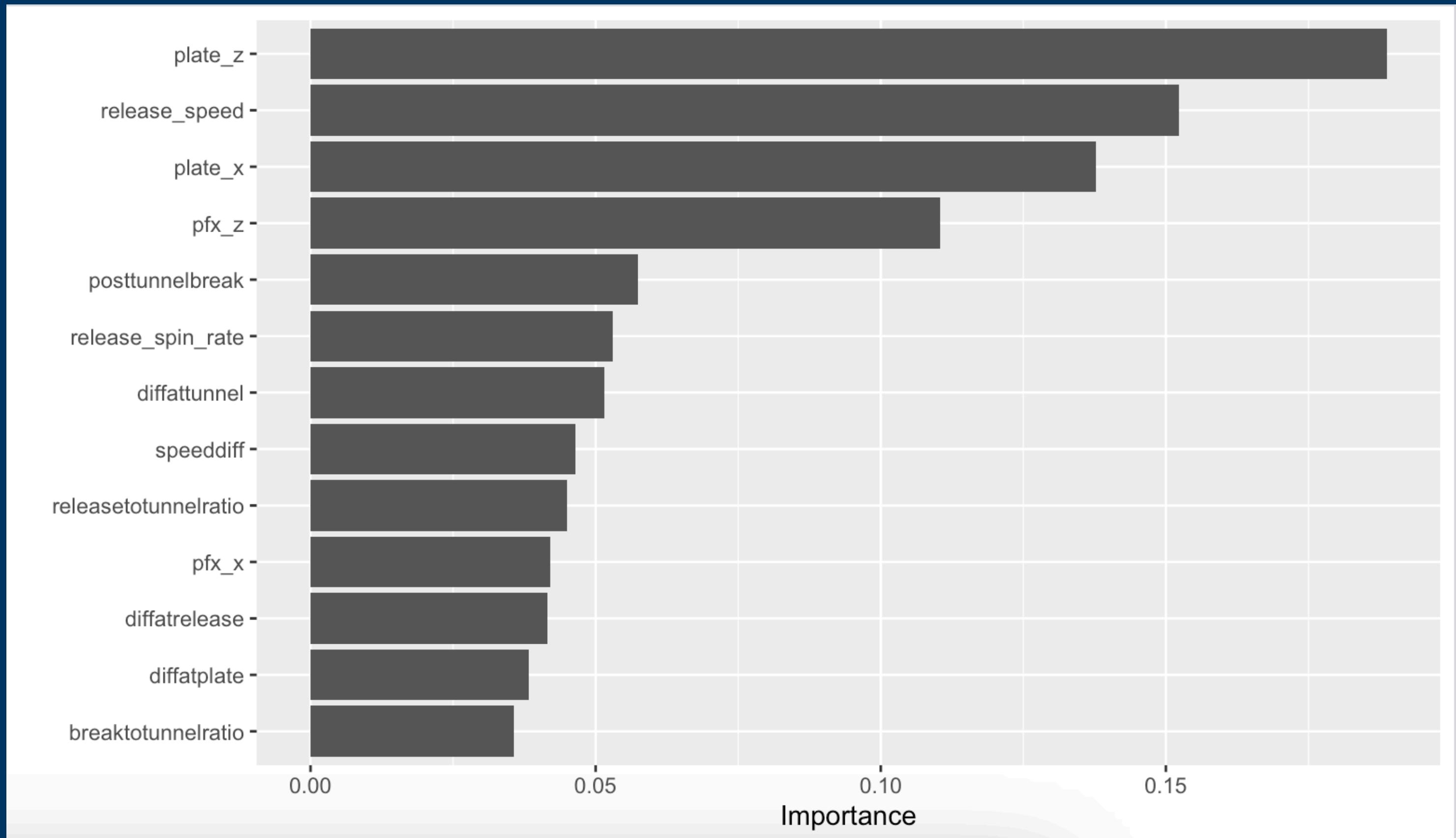


Four-Seam -> Slider | RHP -> LHH | Groundball

Training Sample: n = 5400 pitches

Testing Sample: n = 2316 pitches

Testing Accuracy: 59.84%

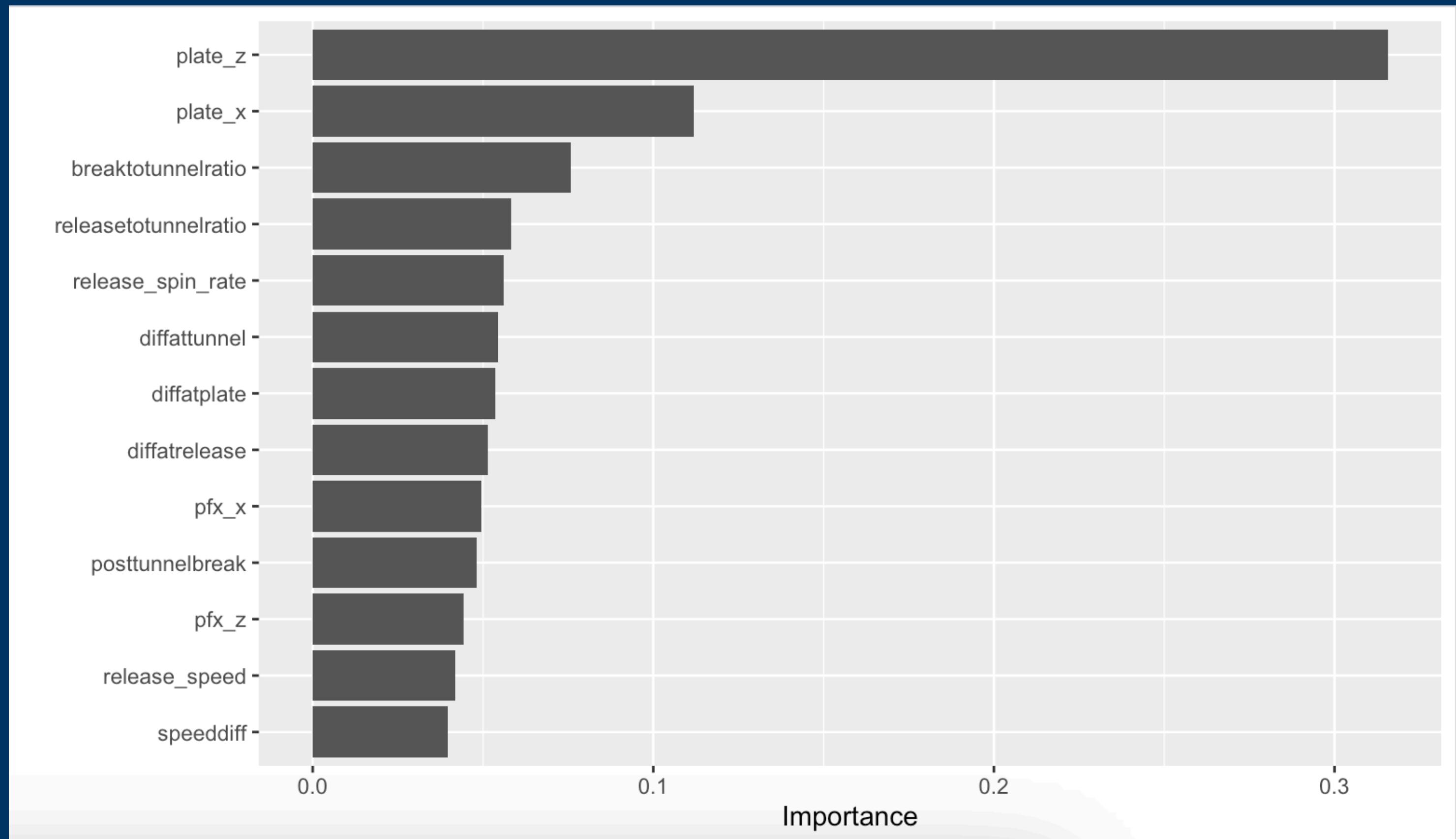


Four-Seam -> Sweeper | RHP -> LHH | Whiff

Training Sample: n = 694 pitches

Testing Sample: n = 298 pitches

Testing Accuracy: 68.46%

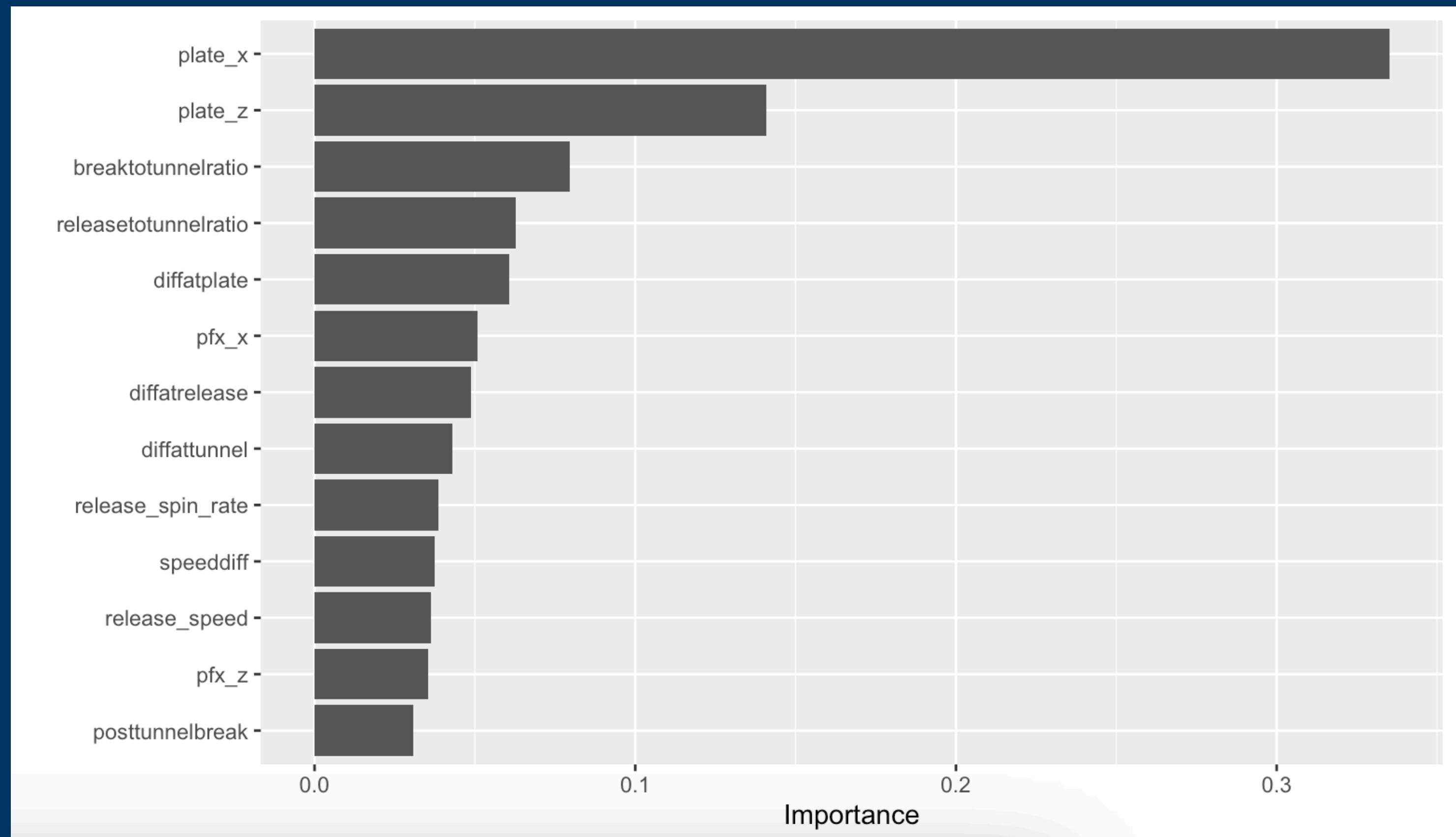


Four-Seam -> Sweeper | RHP -> LHH | Chase

Training Sample: n = 960 pitches

Testing Sample: n = 414 pitches

Testing Accuracy: 71.26%

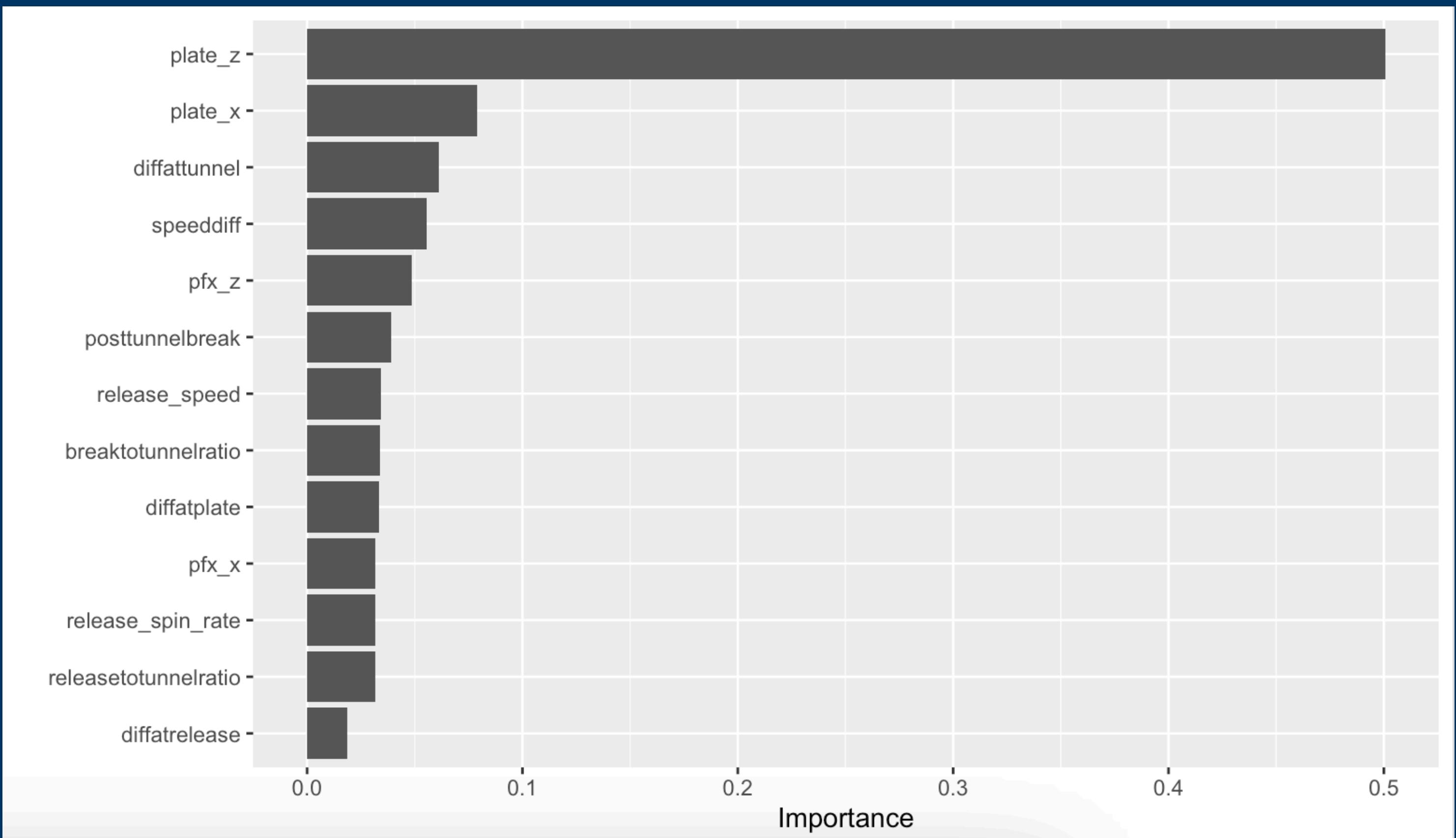


Sinker -> Changeup | RHP -> LHH | Whiff

Training Sample: n = 6516 pitches

Testing Sample: n = 2794 pitches

Testing Accuracy: 63.64%

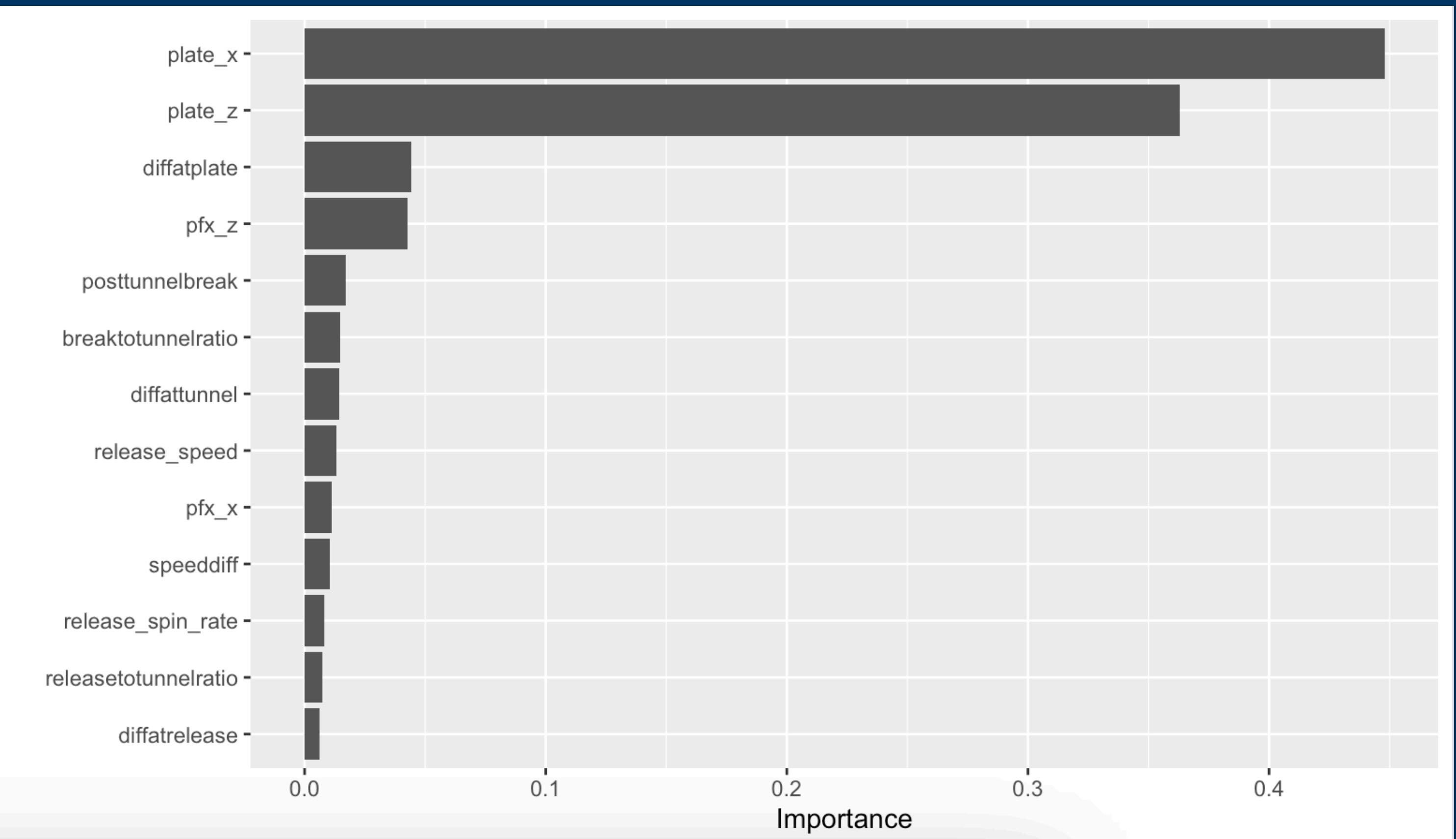


Sinker -> Changeup | RHP -> LHH | Chase

Training Sample: n = 11600 pitches

Testing Sample: n = 4998 pitches

Testing Accuracy: 73.31%

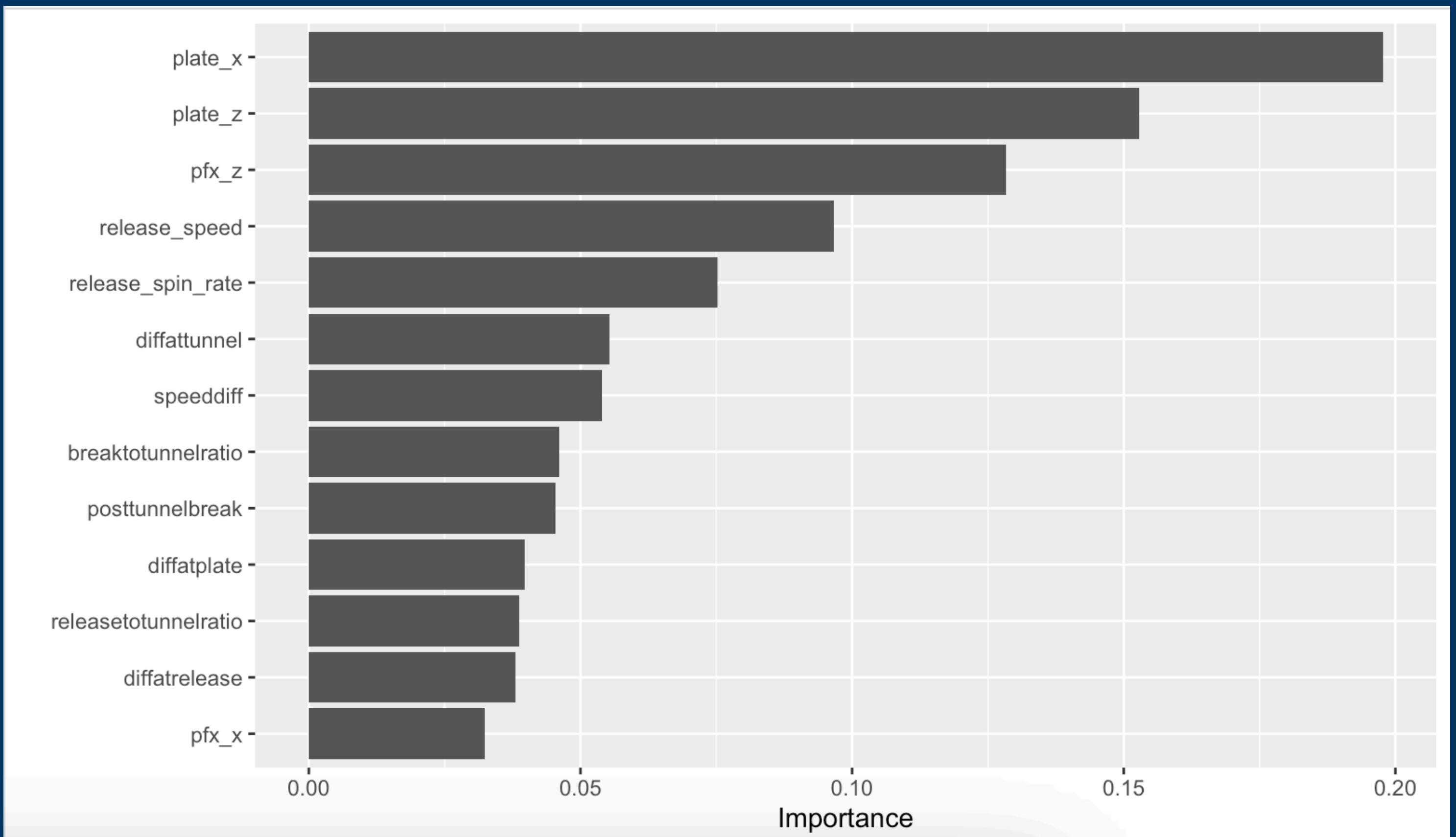


Sinker -> Changeup | RHP -> LHH | Groundball

Training Sample: n = 5196 pitches

Testing Sample: n = 2228 pitches

Testing Accuracy: 60.55%

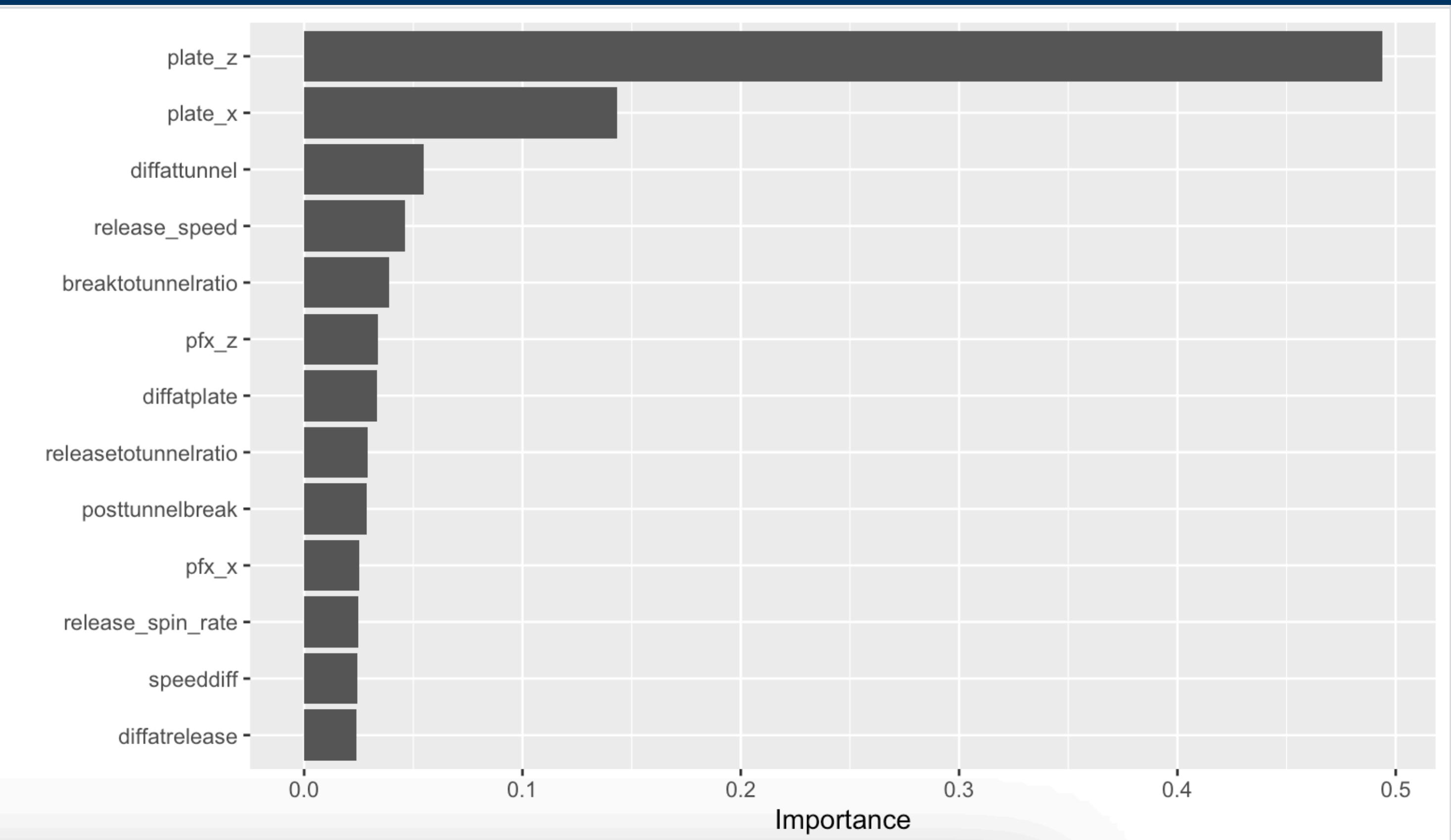


Sinker -> Curveball | RHP -> LHH | Whiff

Training Sample: n = 2860 pitches

Testing Sample: n = 1226 pitches

Testing Accuracy: 73%

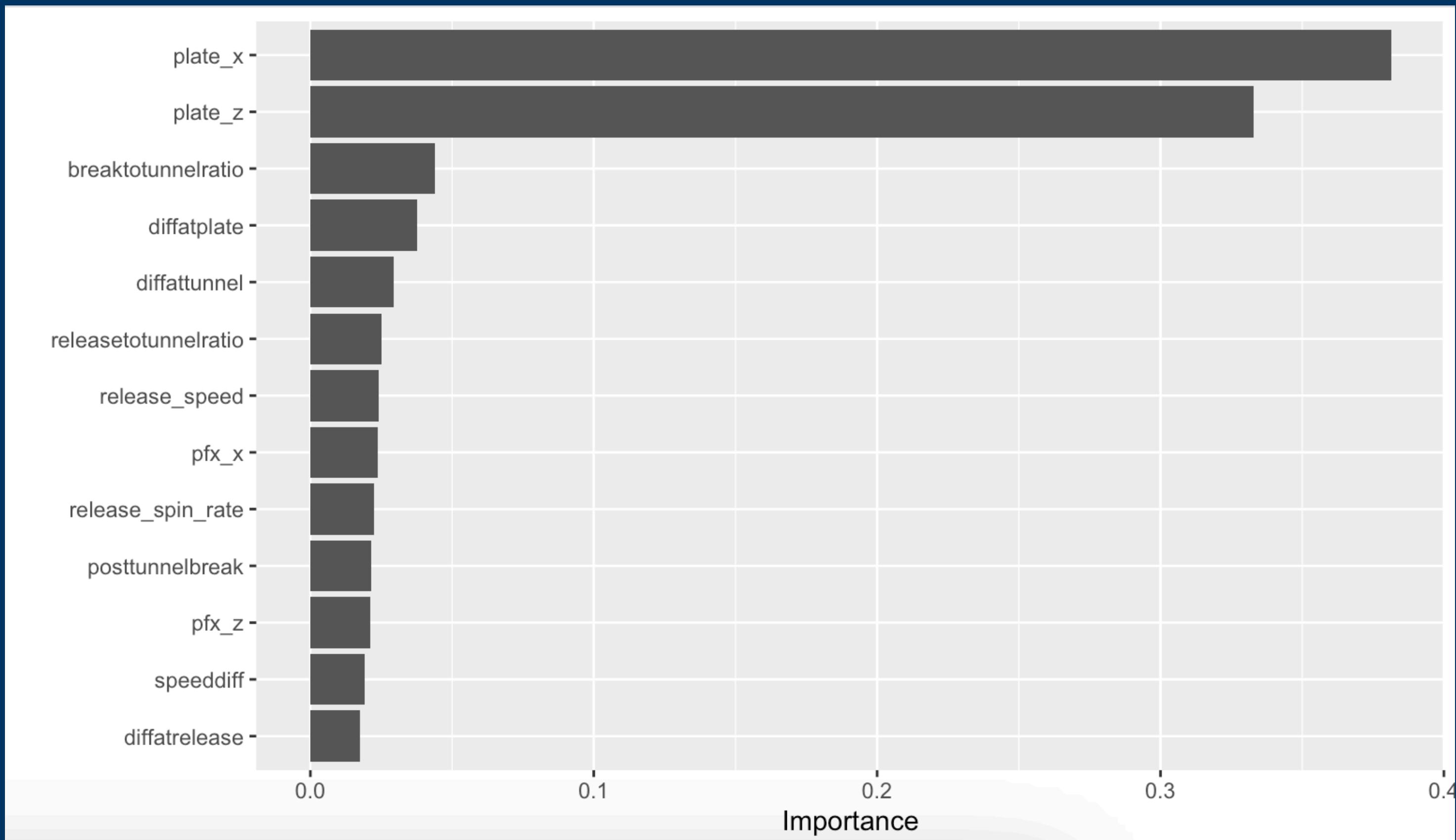


Sinker -> Curveball | RHP -> LHH | Chase

Training Sample: n = 4338 pitches

Testing Sample: n = 1860 pitches

Testing Accuracy: 72.74%

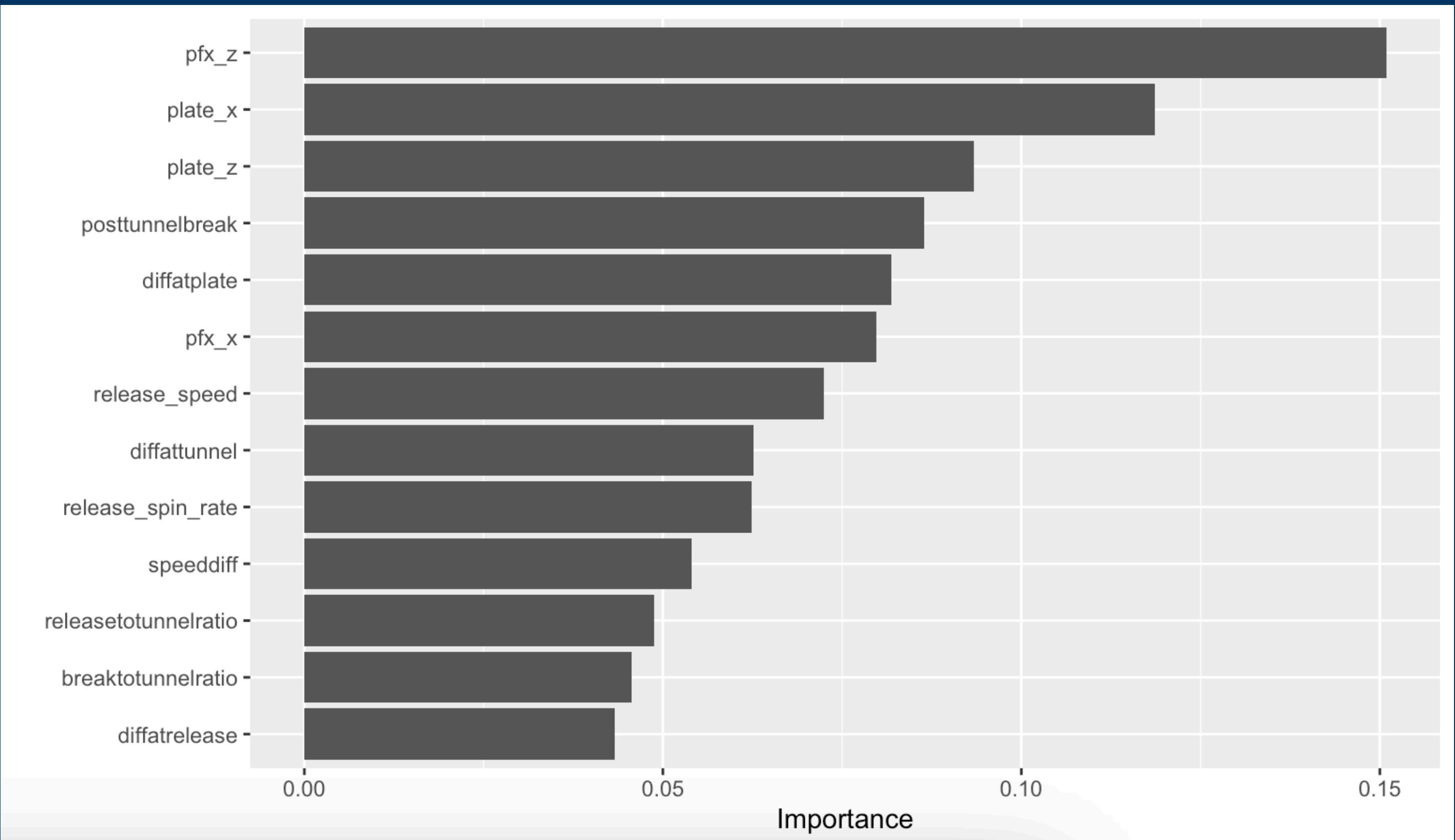


Sinker -> Curveball | RHP -> LHH | Groundball

Training Sample: n = 1728 pitches

Testing Sample: n = 742 pitches

Testing Accuracy: 54.99%

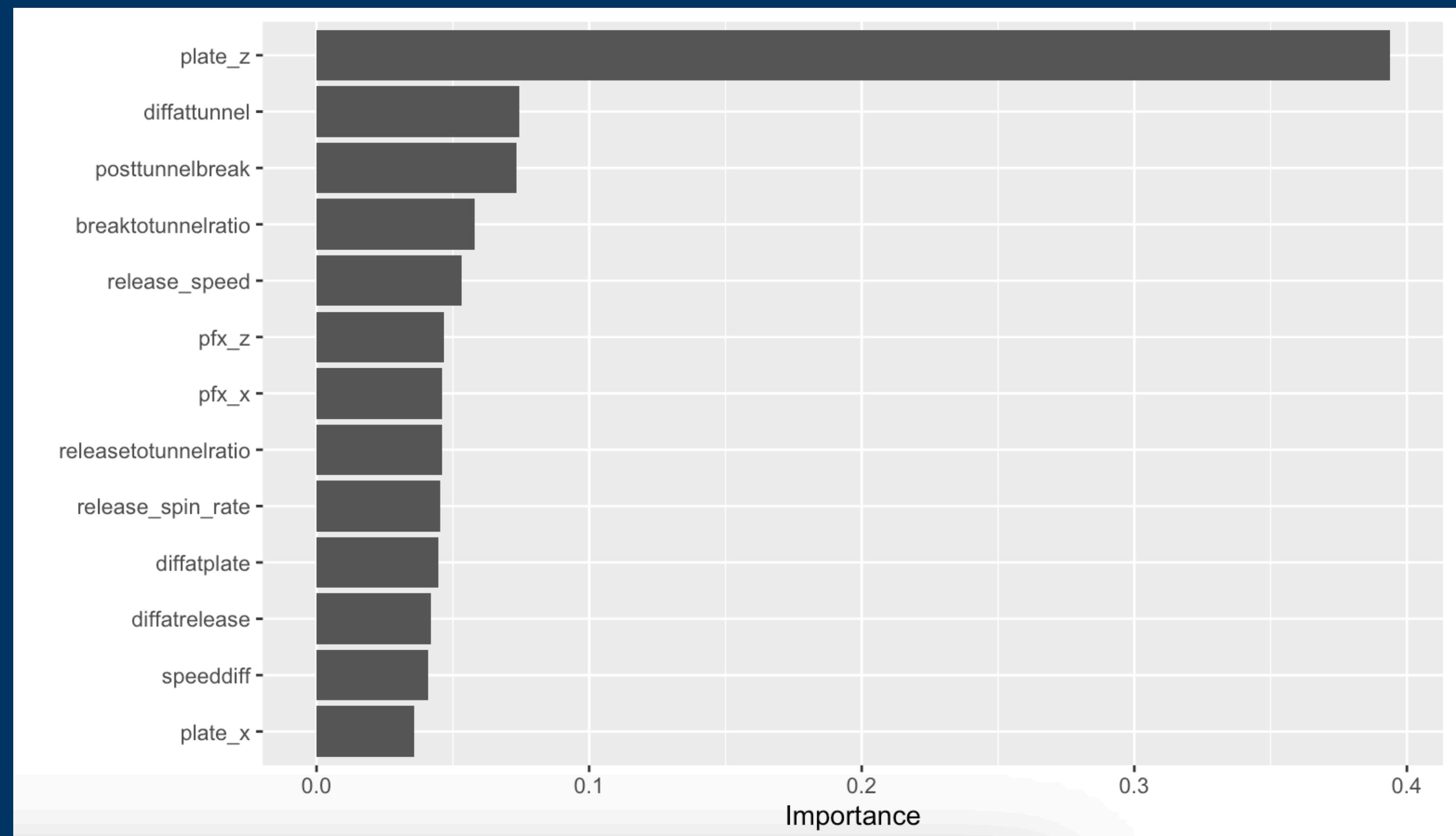


Sinker -> Splitter | RHP -> LHH | Whiff

Training Sample: n = 1182 pitches

Testing Sample: n = 508 pitches

Testing Accuracy: 69.29%

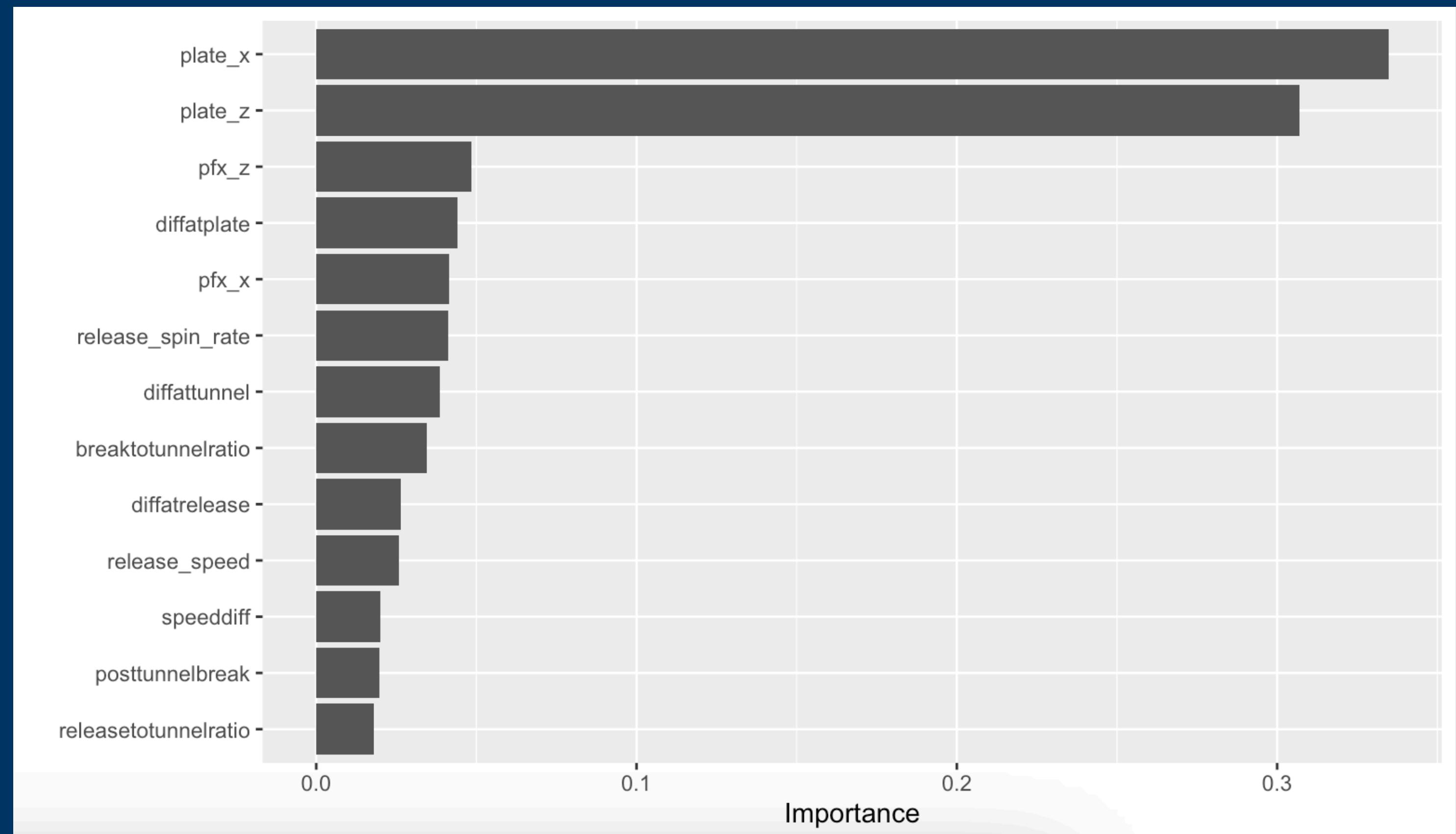


Sinker -> Splitter | RHP -> LHH | Chase

Training Sample: n = 2020 pitches

Testing Sample: n = 868 pitches

Testing Accuracy: 73.85%

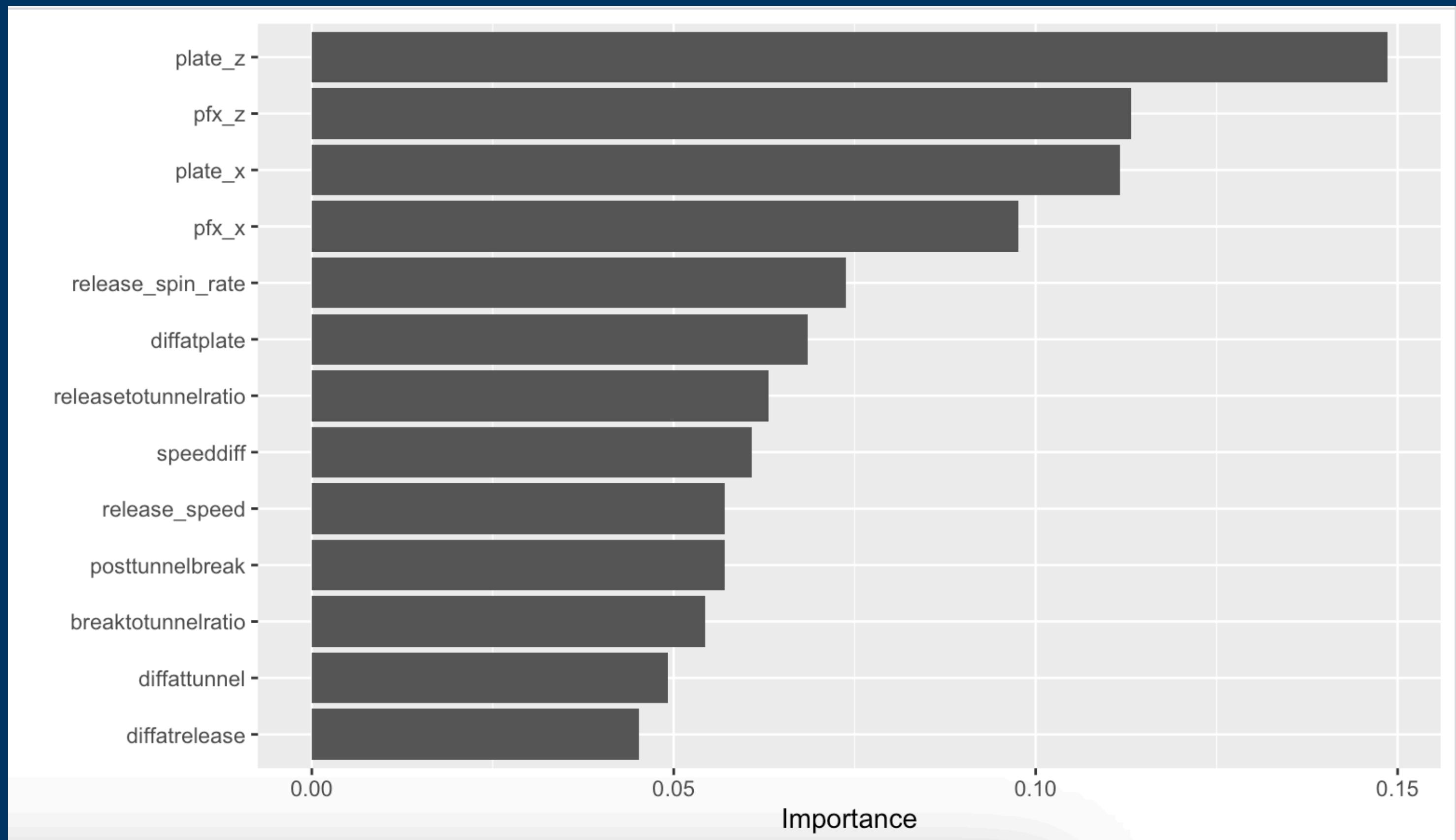


Sinker -> Splitter | RHP -> LHH | Groundball

Training Sample: n = 770 pitches

Testing Sample: n = 330 pitches

Testing Accuracy: 56.67%

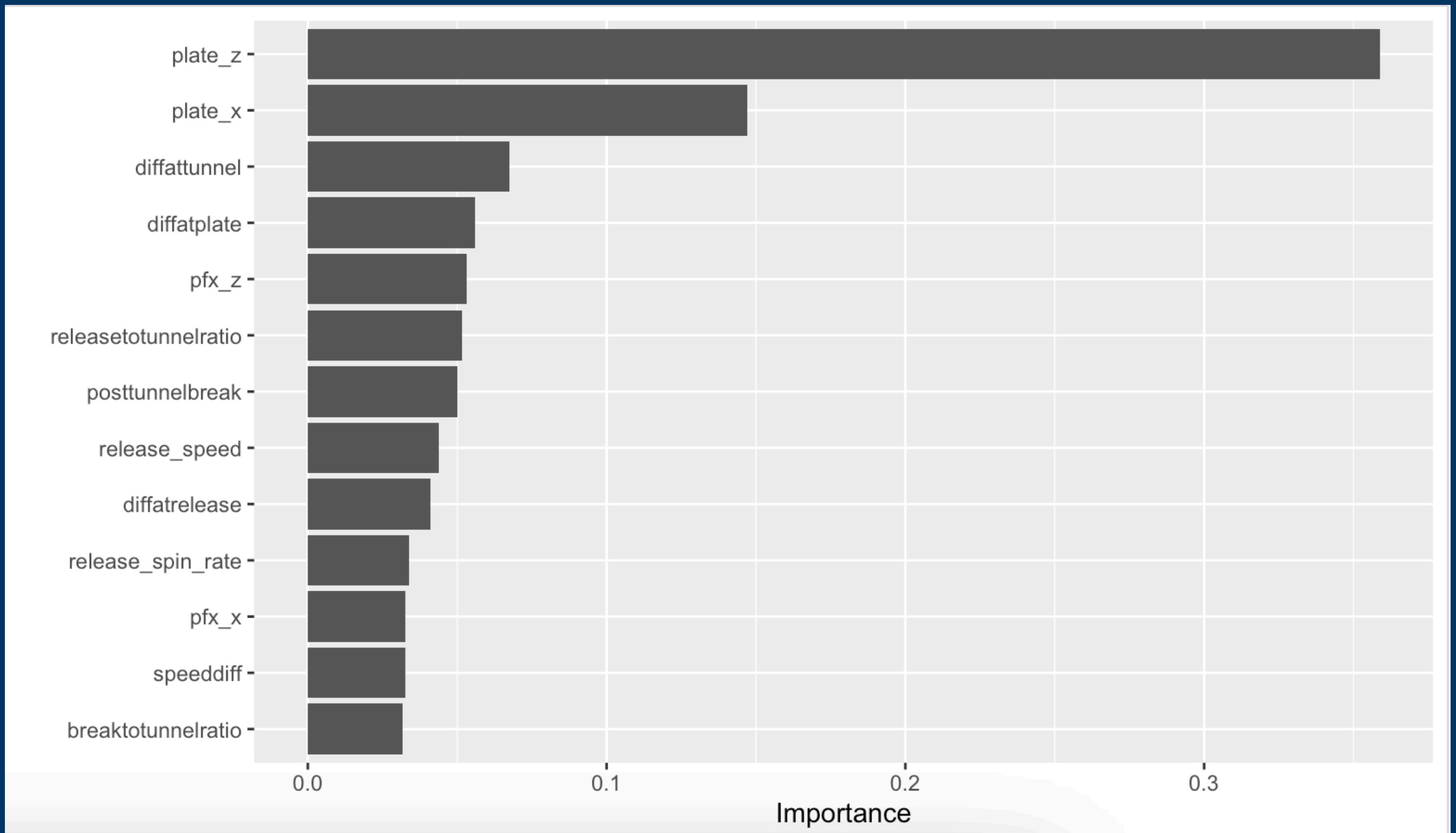


Sinker -> Knuckle Curve | RHP -> LHH | Whiff

Training Sample: n = 970 pitches

Testing Sample: n = 416 pitches

Testing Accuracy: 70.43%

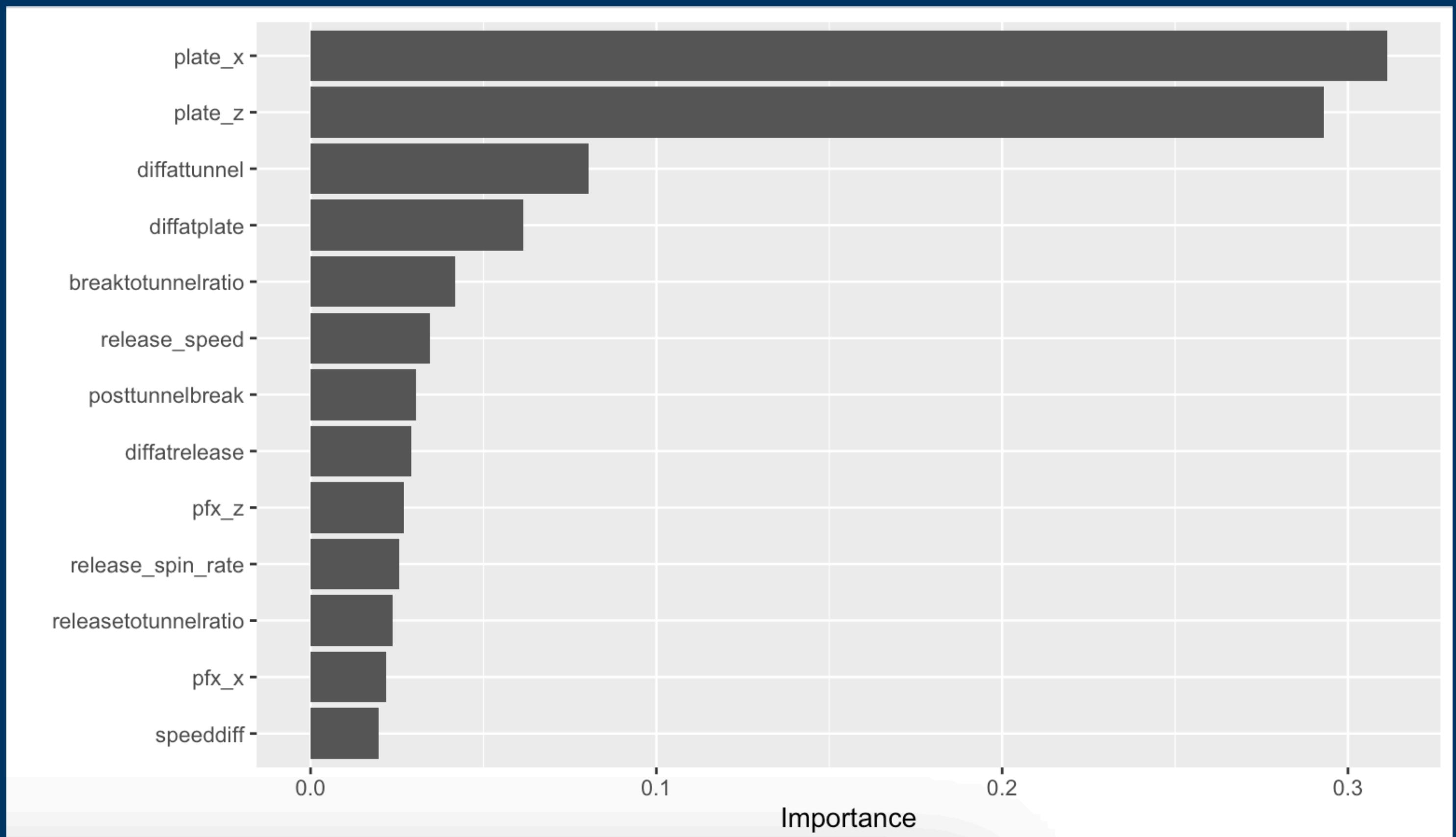


Sinker -> Knuckle Curve | RHP -> LHH | Chase

Training Sample: n = 1410 pitches

Testing Sample: n = 606 pitches

Testing Accuracy: 71.78%

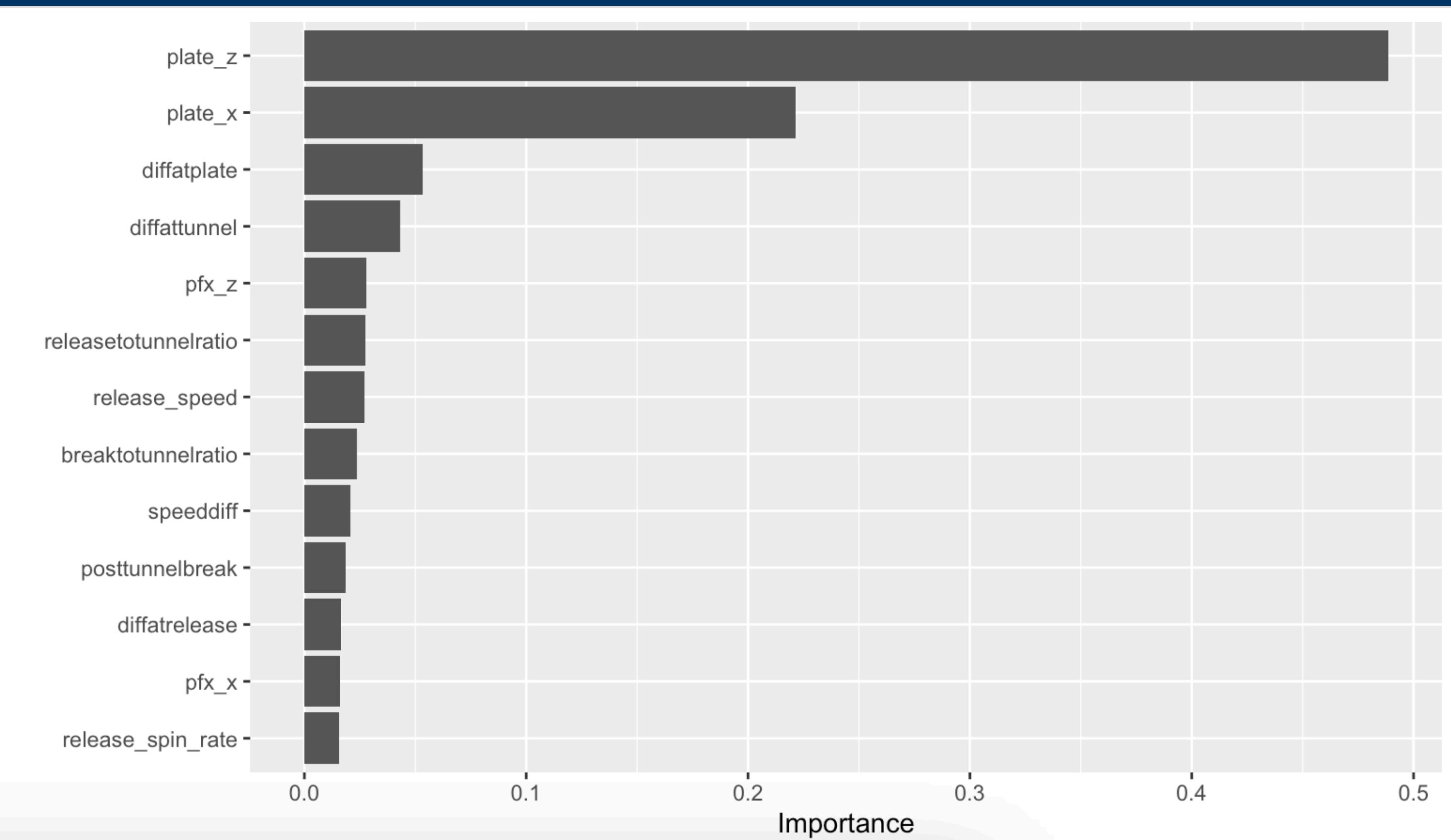


Sinker -> Slider | RHP -> LHH | Whiff

Training Sample: n = 5138 pitches

Testing Sample: n = 2202 pitches

Testing Accuracy: 71.03%

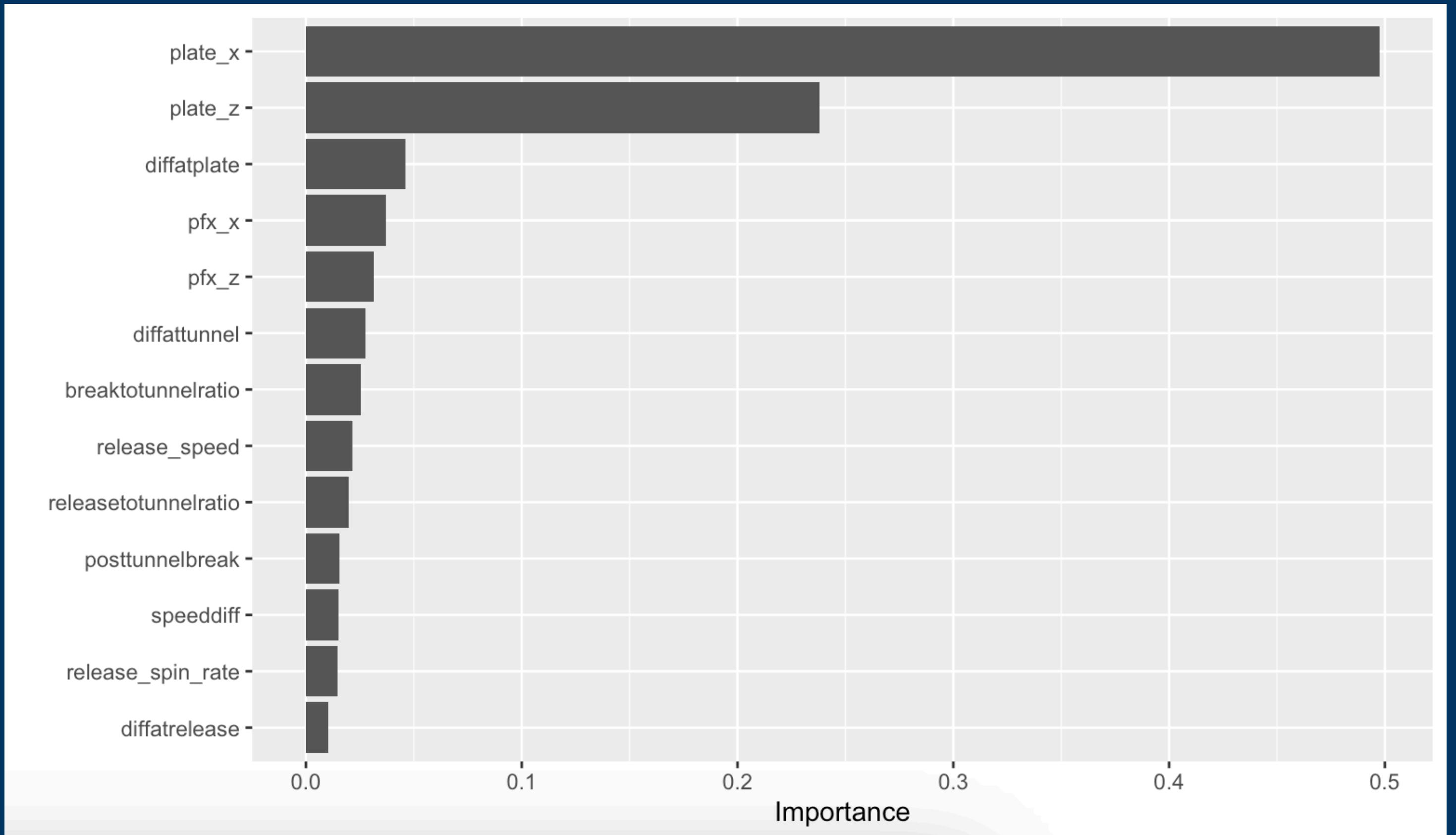


Sinker -> Slider | RHP -> LHH | Chase

Training Sample: n = 6892 pitches

Testing Sample: n = 2954 pitches

Testing Accuracy: 70.75%

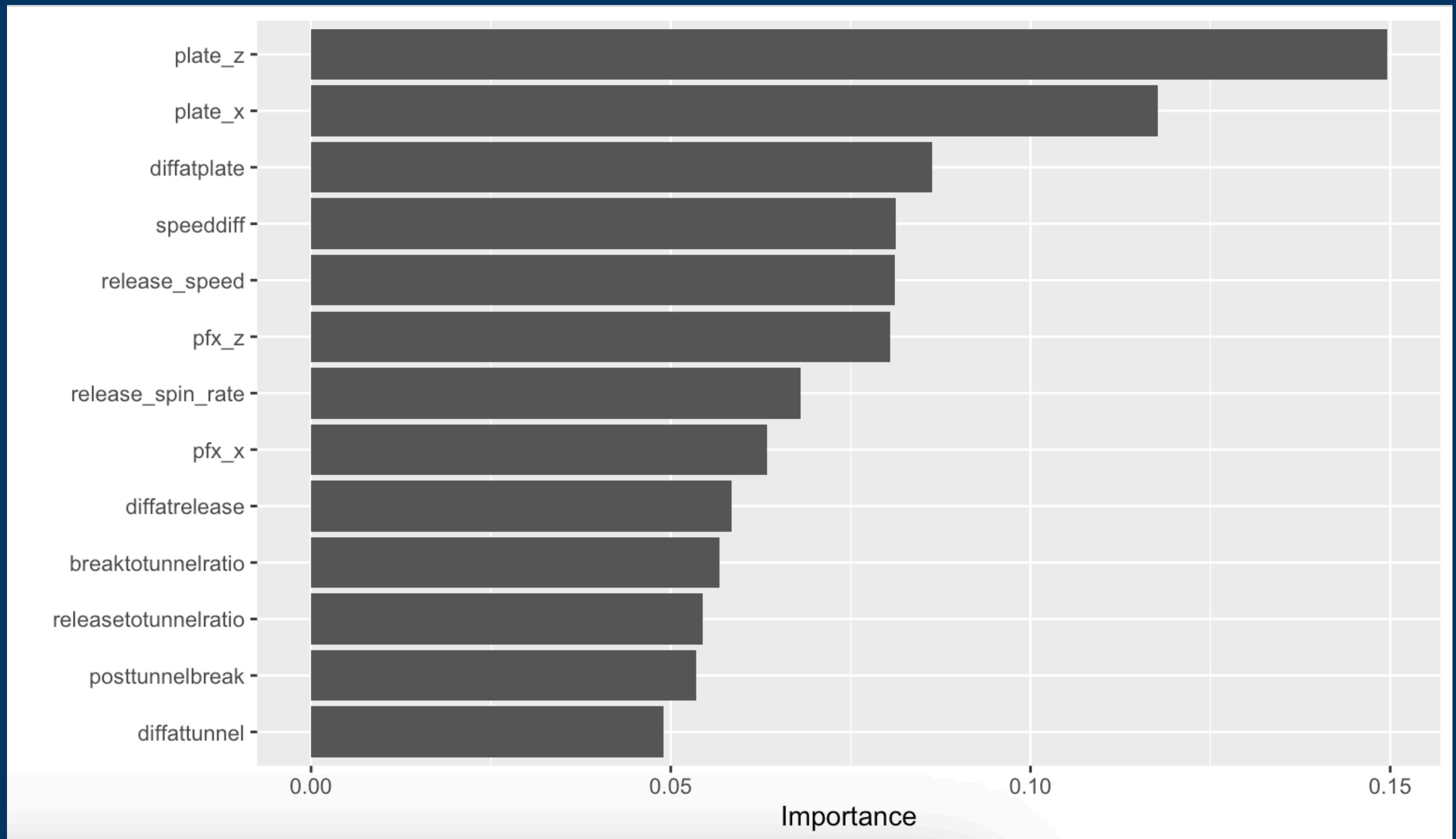


Sinker -> Slider | RHP -> LHH | Groundball

Training Sample: n = 2172 pitches

Testing Sample: n = 932 pitches

Testing Accuracy: 59.23%

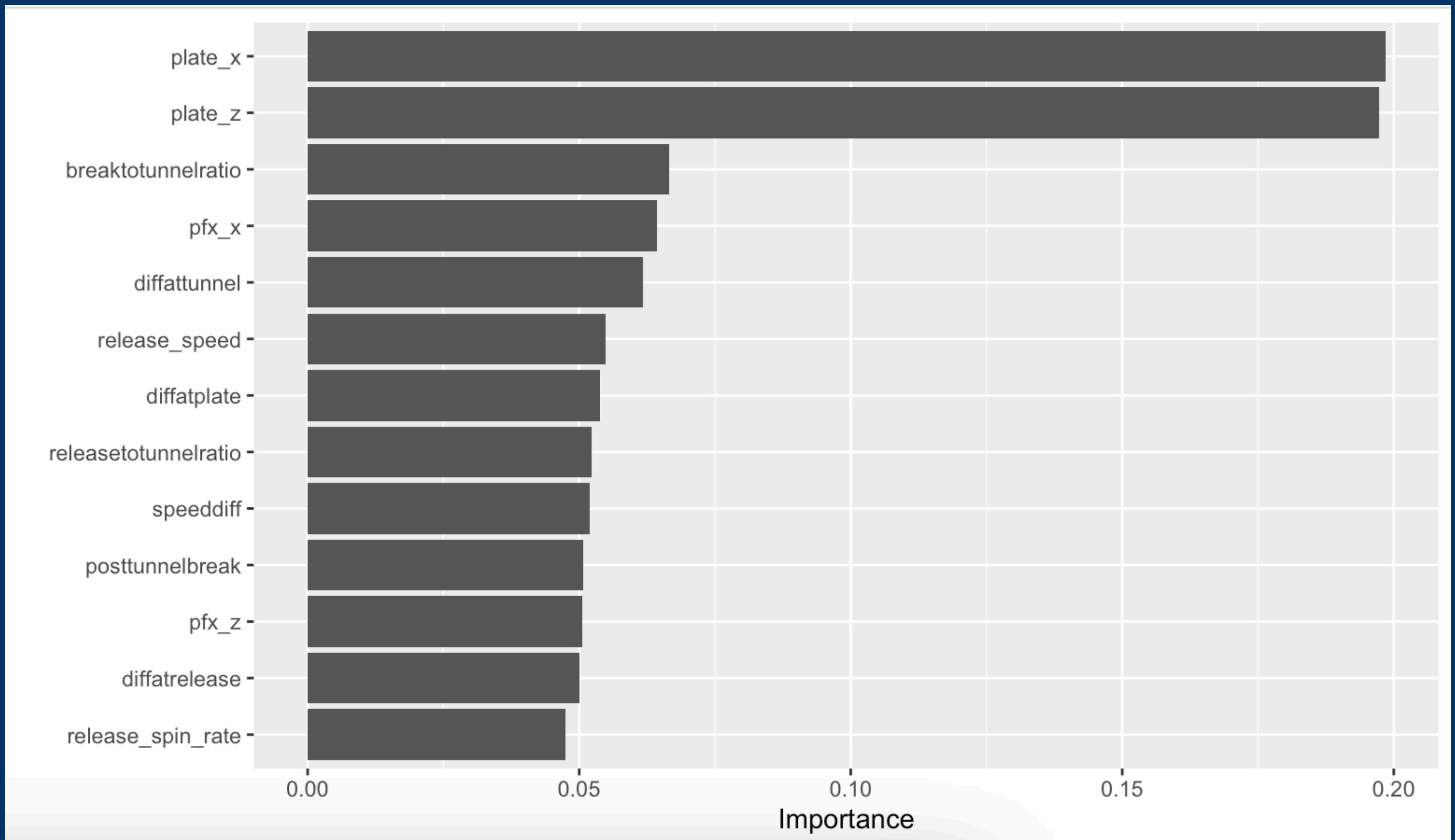


Sinker -> Sweeper | RHP -> LHH | Whiff

Training Sample: n = 284 pitches

Testing Sample: n = 122 pitches

Testing Accuracy: 67.21%

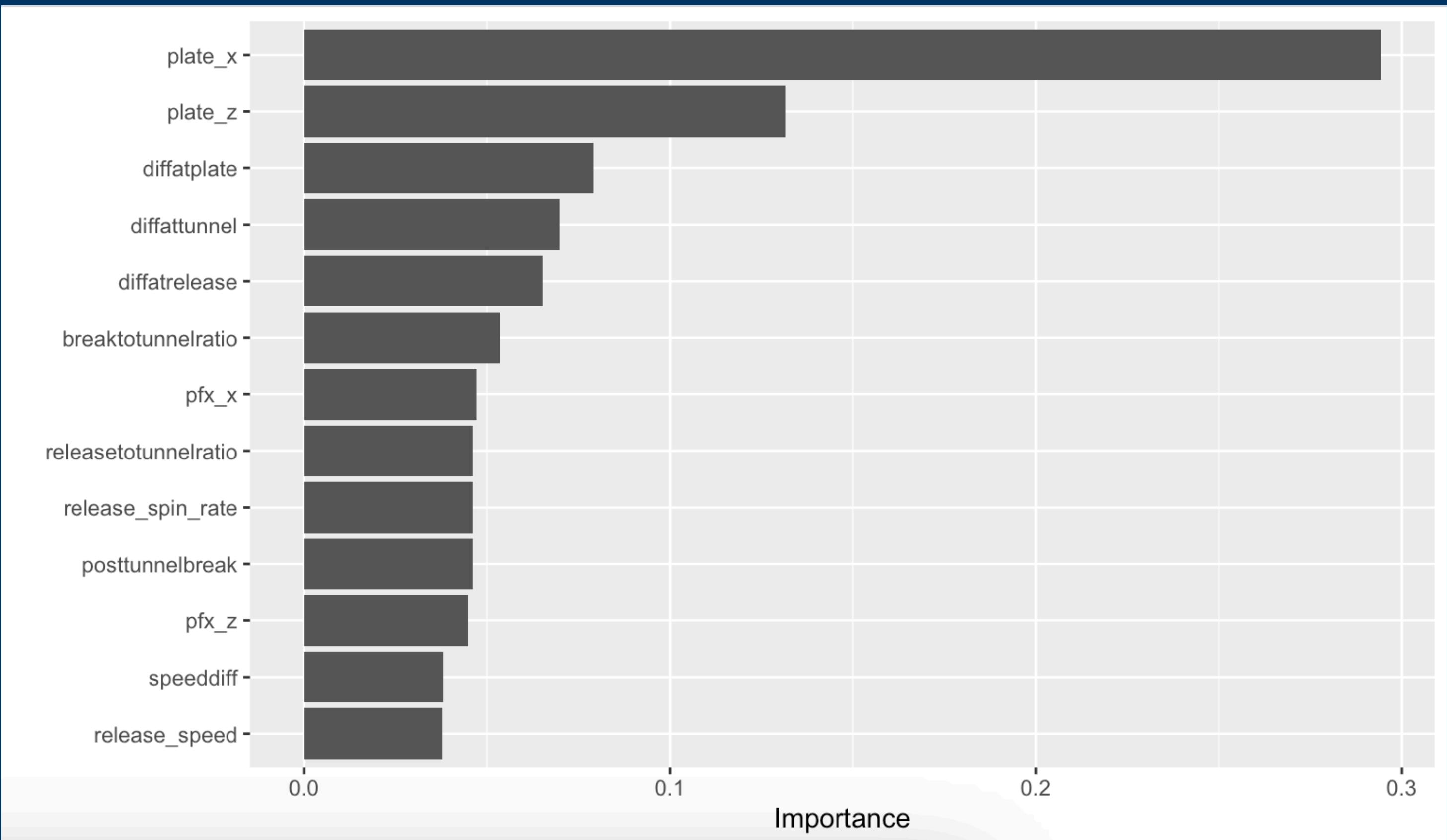


Sinker -> Sweeper | RHP -> LHH | Chase

Training Sample: n = 364 pitches

Testing Sample: n = 158 pitches

Testing Accuracy: 69.62%



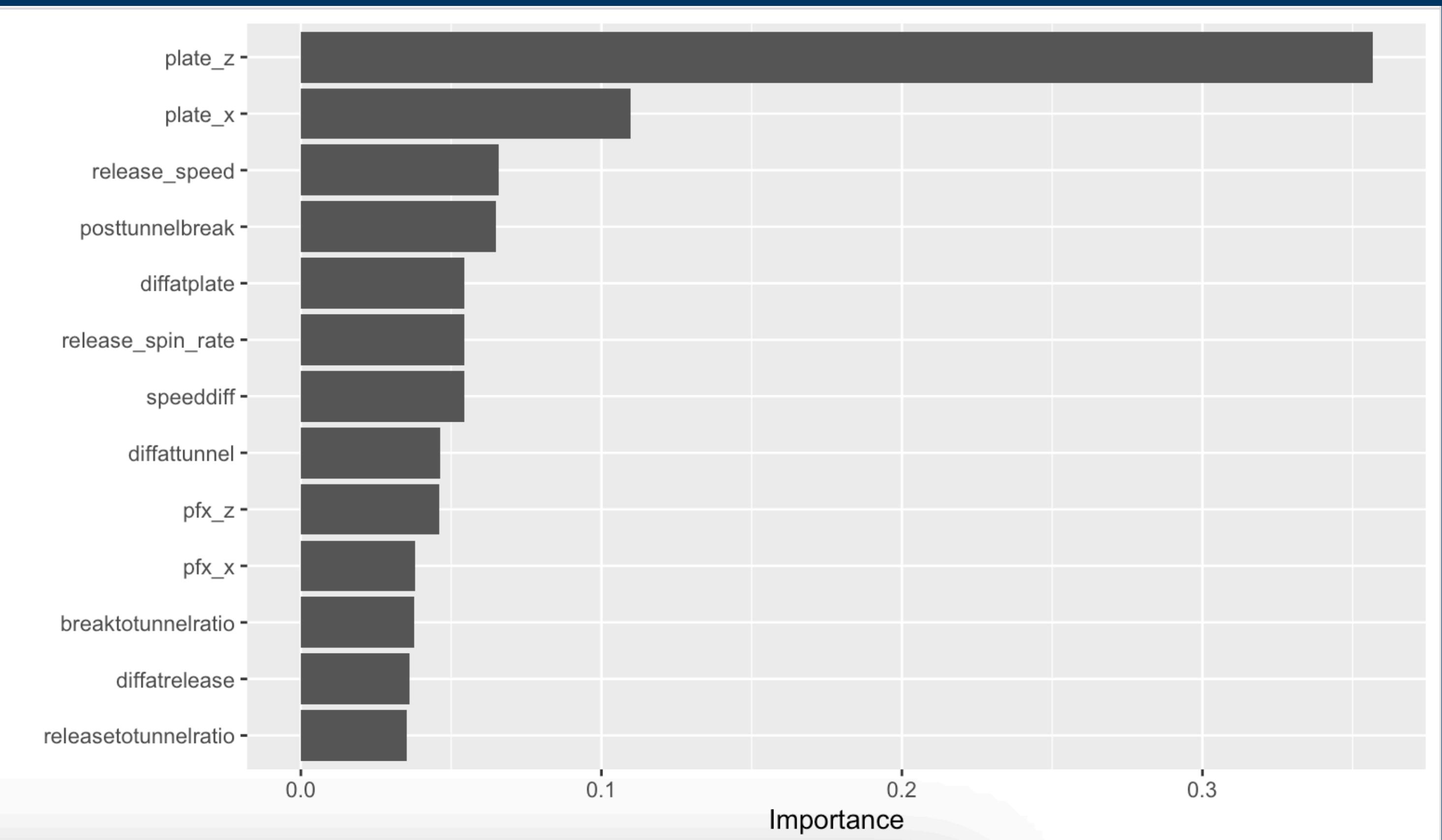
Left Handed Pitchers vs Right Handed Hitters

Cutter -> Changeup | LHP -> RHH | Whiff

Training Sample: n = 2402 pitches

Testing Sample: n = 1030 pitches

Testing Accuracy: 63.98%

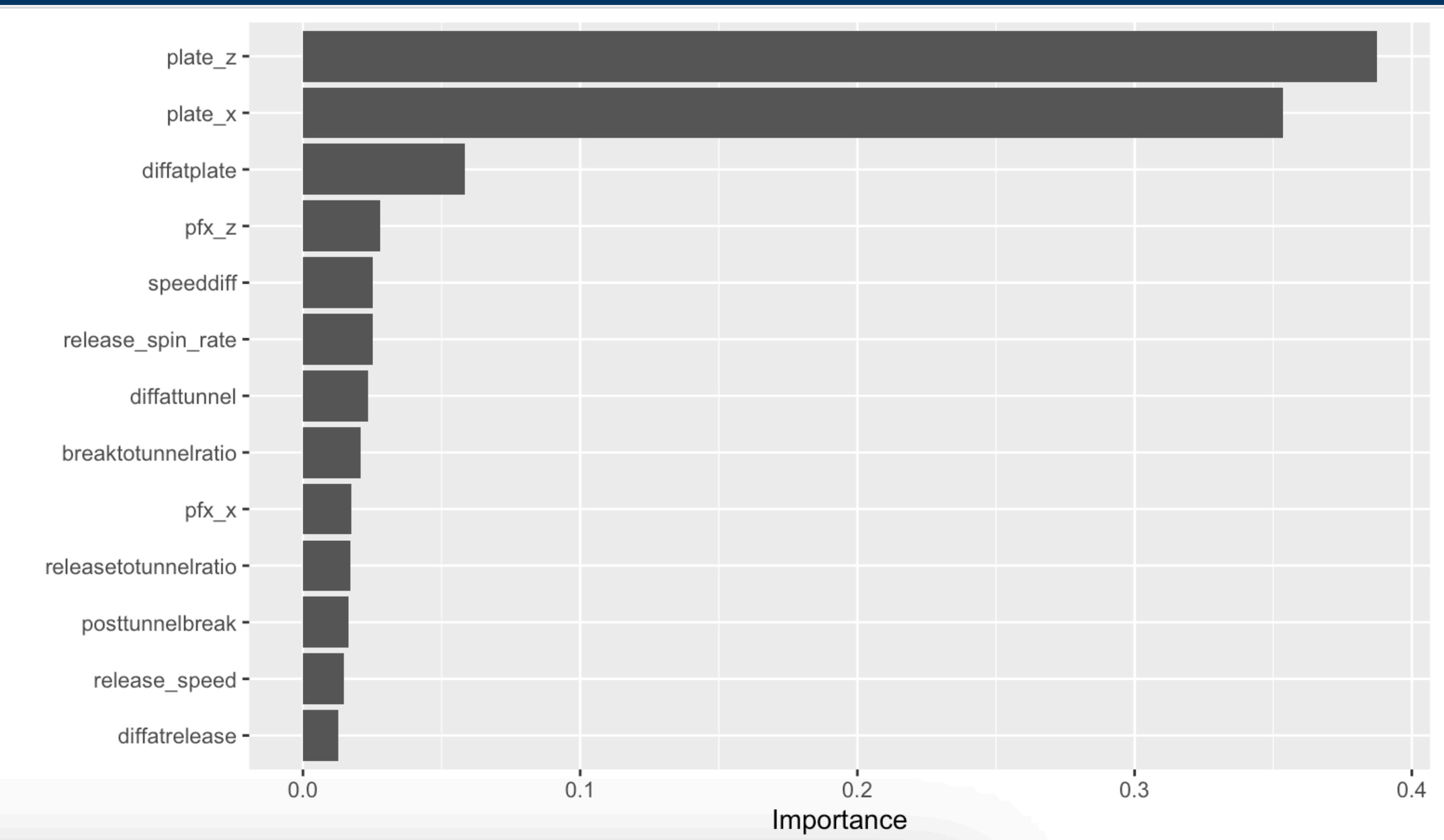


Cutter -> Changeup | LHP -> RHH | Chase

Training Sample: n = 4520 pitches

Testing Sample: n = 1938 pitches

Testing Accuracy: 71.52%

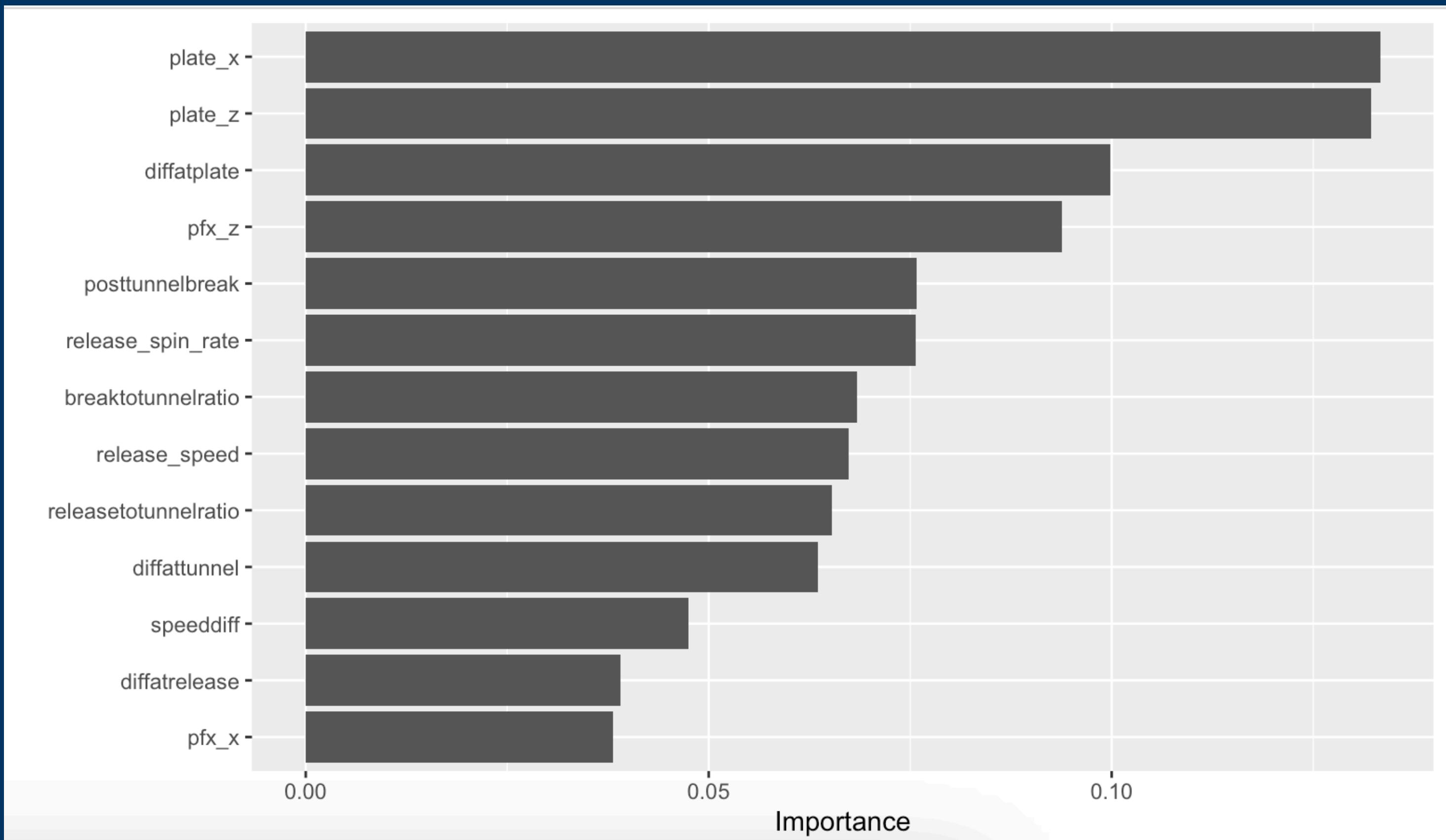


Cutter -> Changeup | LHP -> RHH | Groundball

Training Sample: n = 1734 pitches

Testing Sample: n = 744 pitches

Testing Accuracy: 61.96%

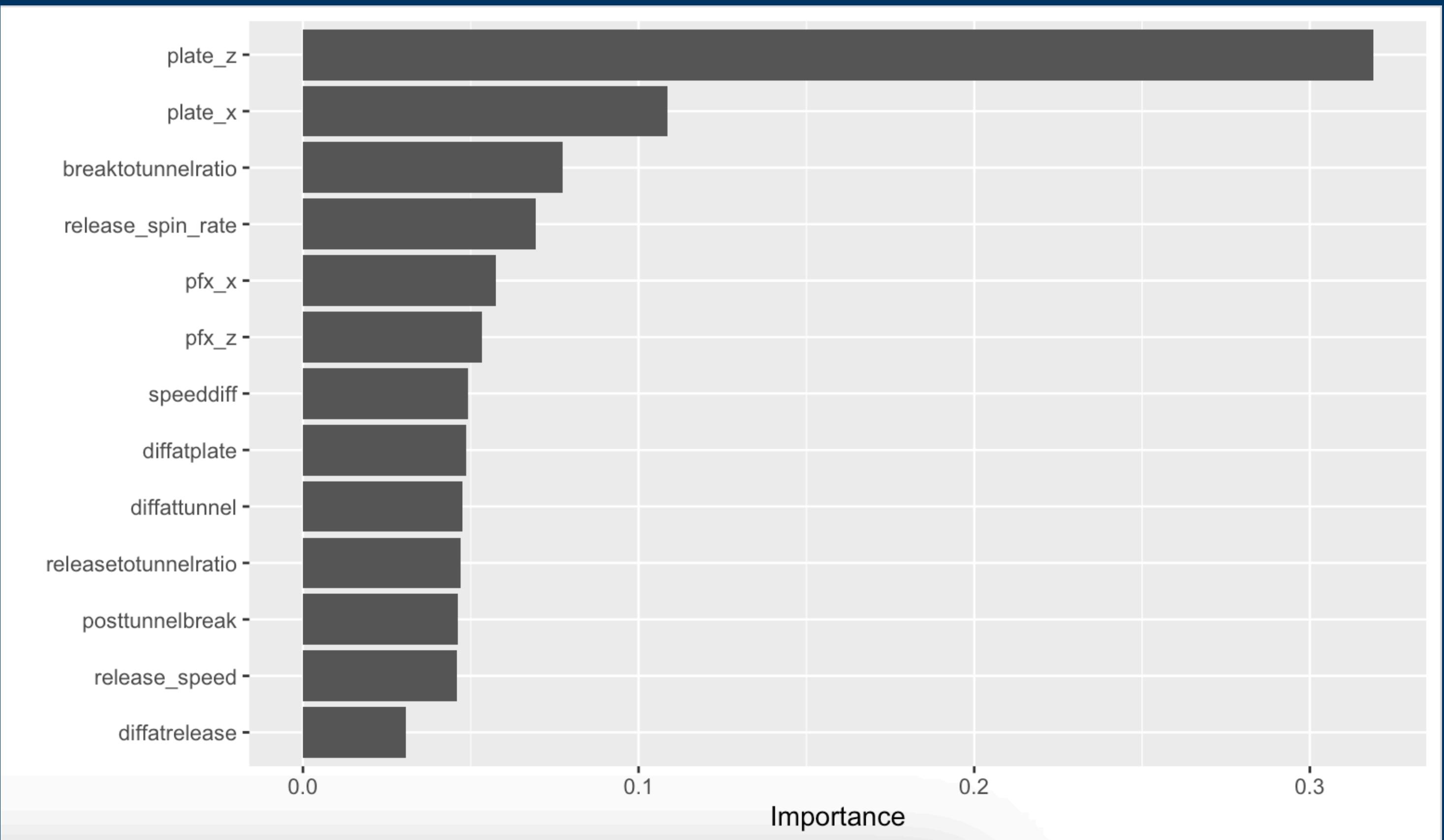


Cutter -> Curveball | LHP -> RHH | Whiff

Training Sample: n = 924 pitches

Testing Sample: n = 398 pitches

Testing Accuracy: 74.12%

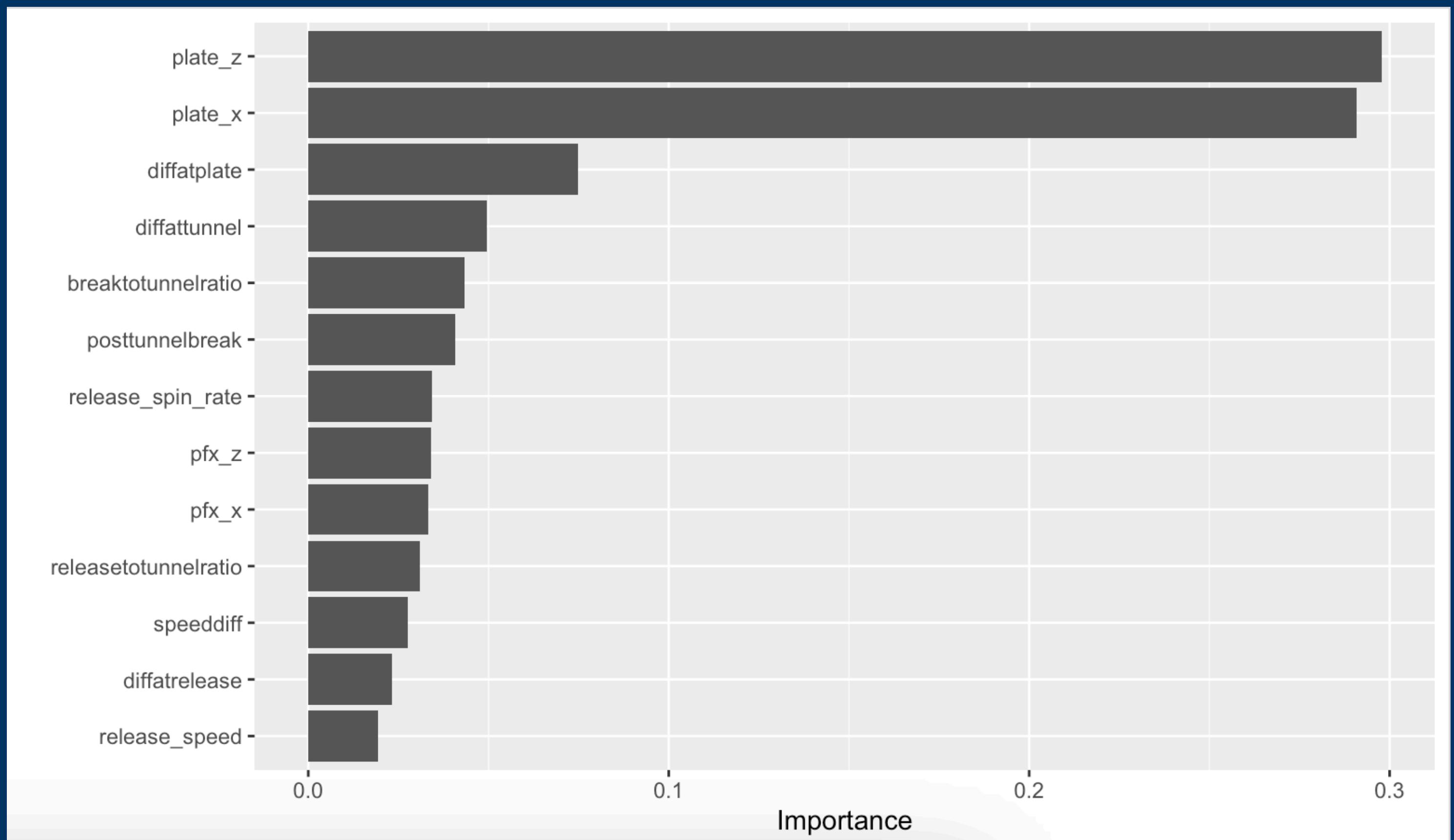


Cutter -> Curveball | LHP -> RHH | Chase

Training Sample: n = 1486 pitches

Testing Sample: n = 638 pitches

Testing Accuracy: 73.2%

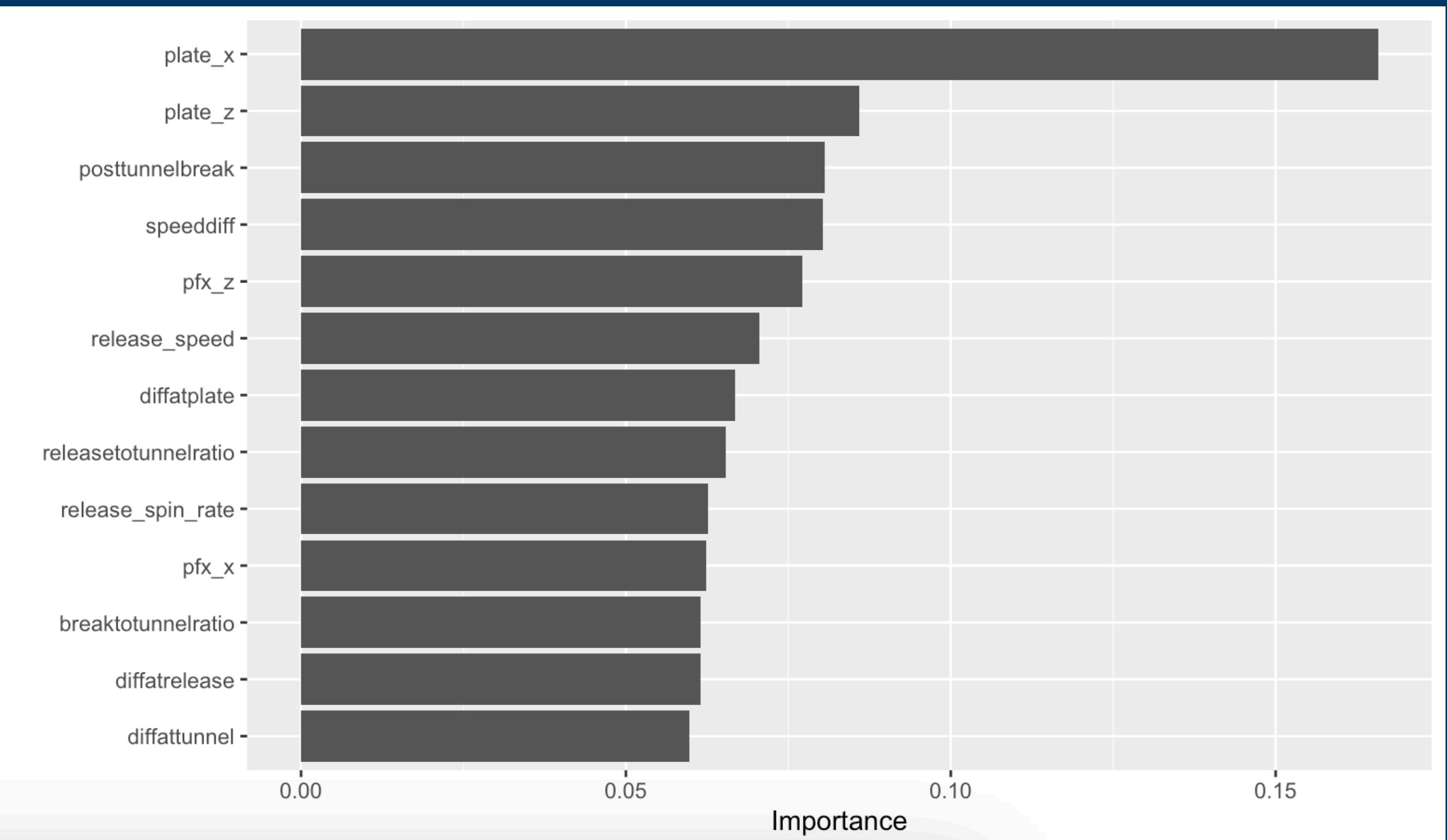


Cutter -> Curveball | LHP -> RHH | Groundball

Training Sample: n = 504 pitches

Testing Sample: n = 218 pitches

Testing Accuracy: 61.93%

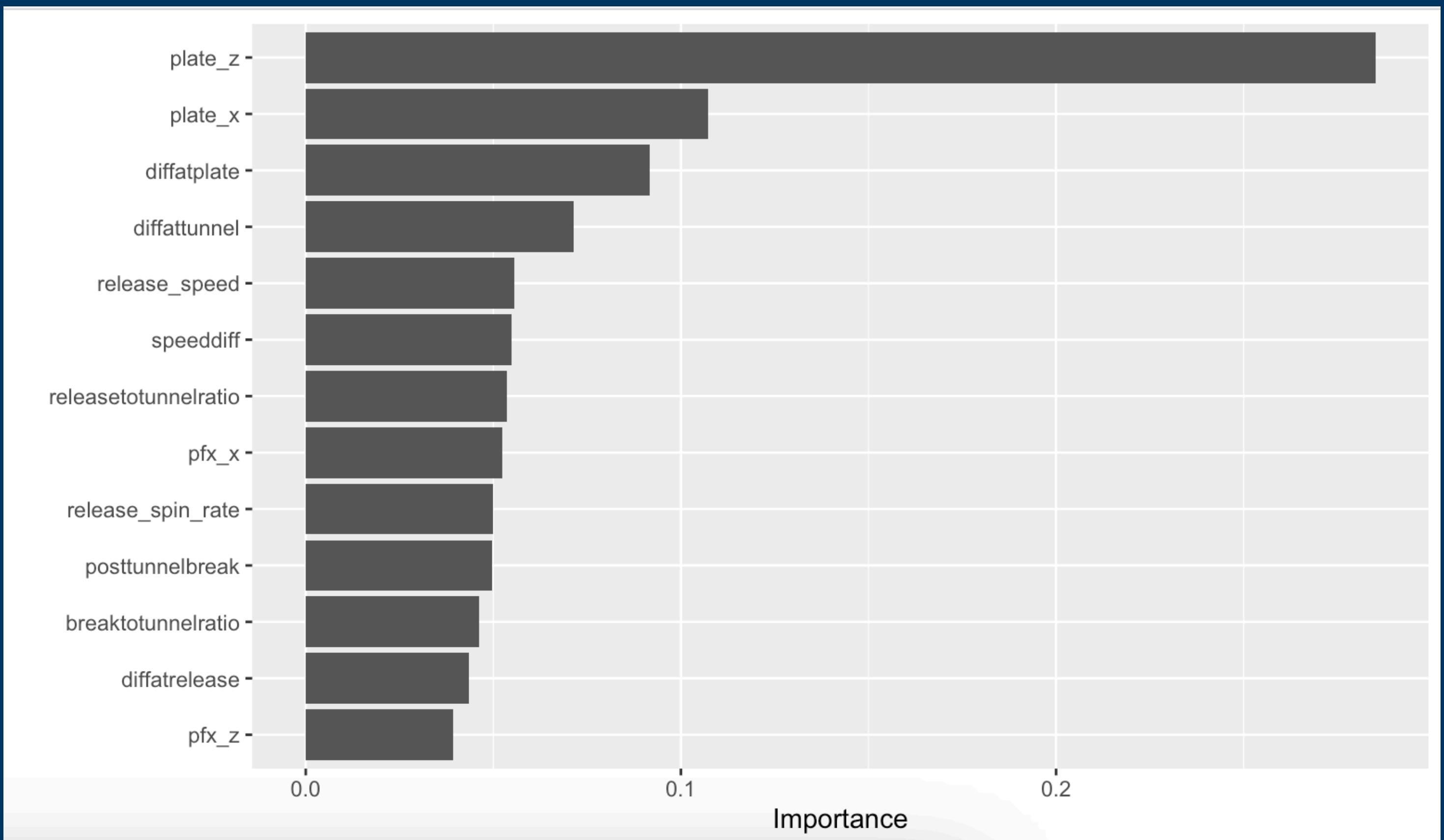


Cutter -> Slider | LHP -> RHH | Whiff

Training Sample: n = 322 pitches

Testing Sample: n = 140 pitches

Testing Accuracy: 70%

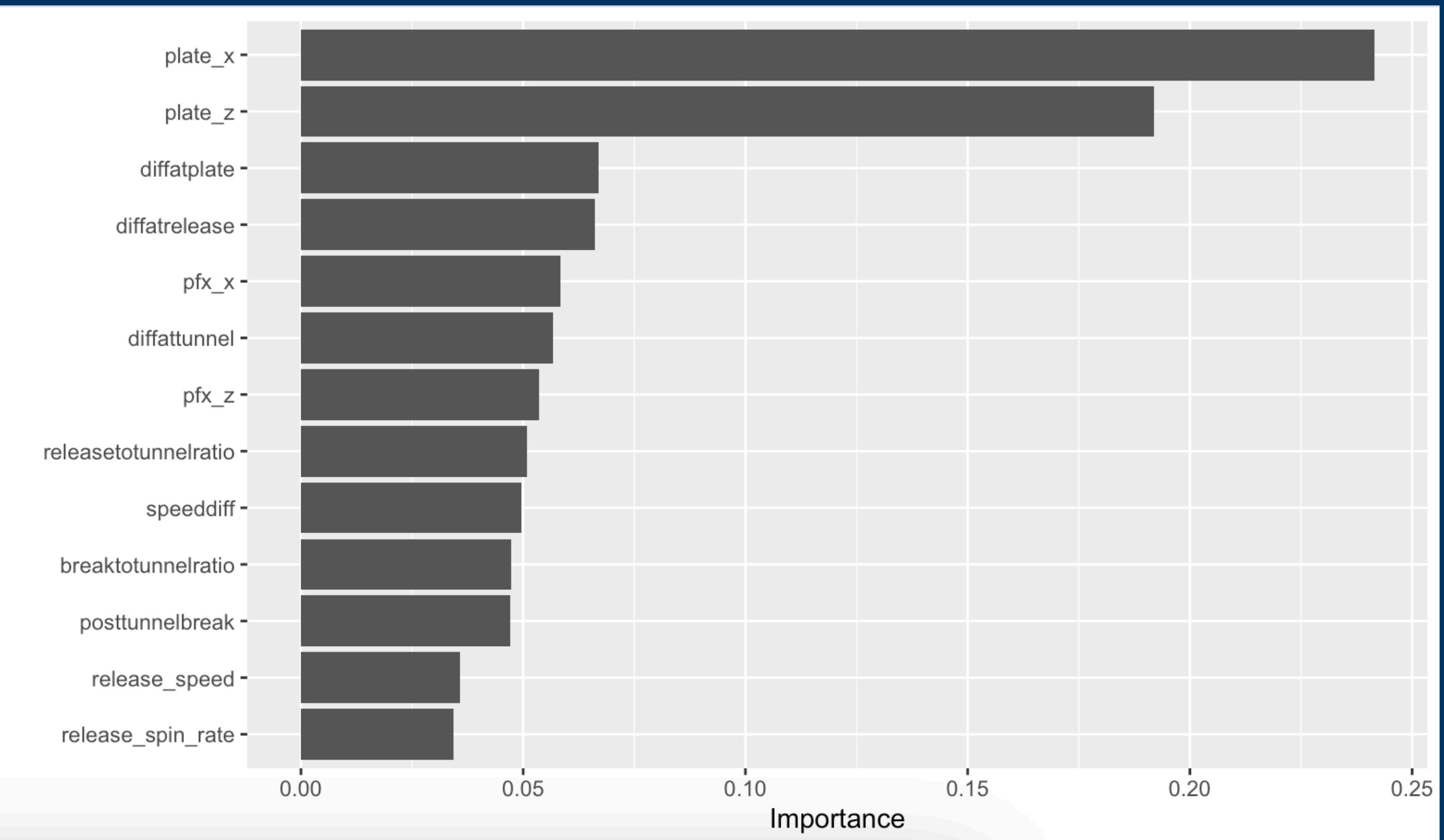


Cutter -> Slider | LHP -> RHH | Chase

Training Sample: n = 522 pitches

Testing Sample: n = 226 pitches

Testing Accuracy: 71.24%

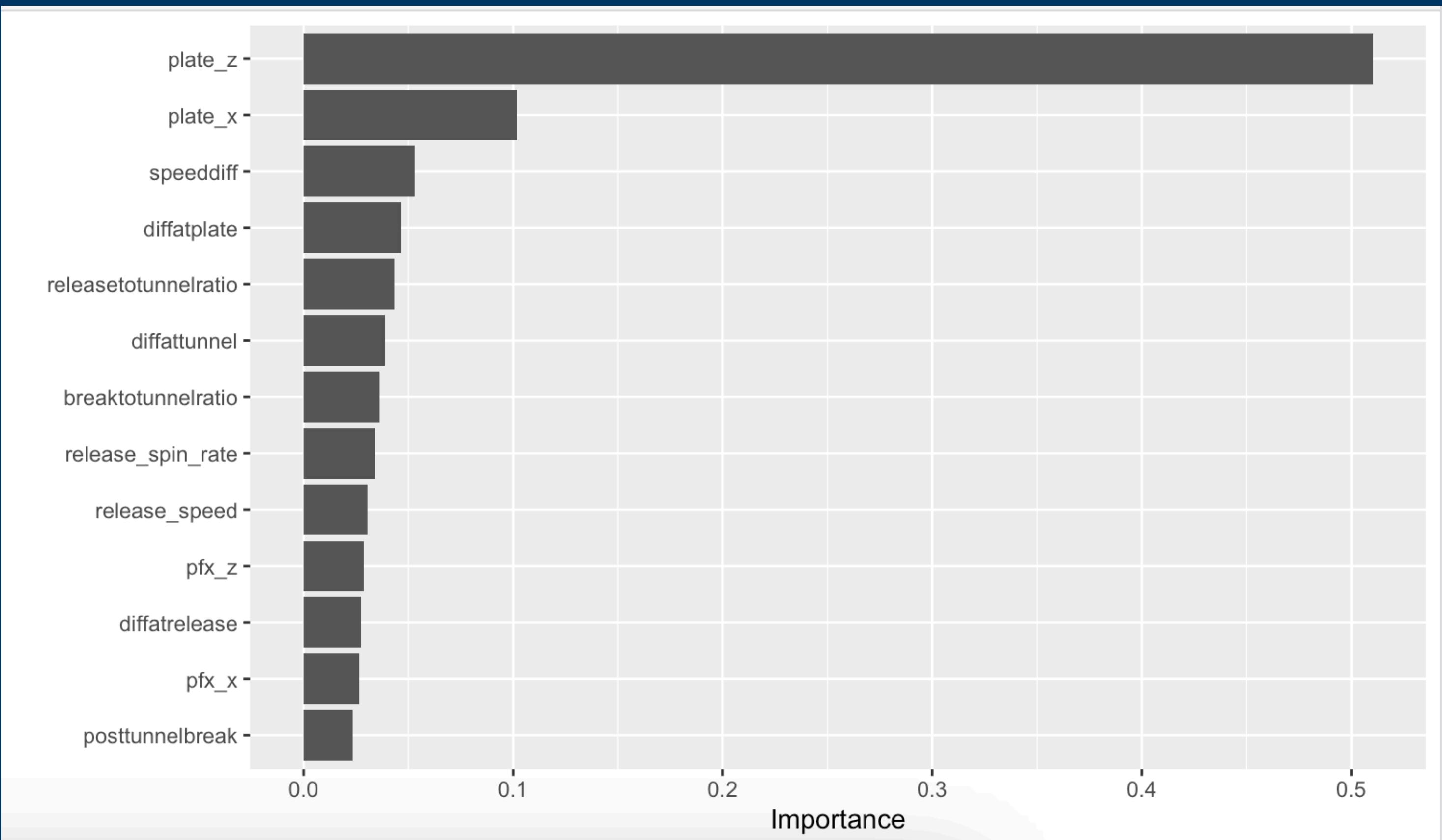


Four-Seam -> Changeup | LHP -> RHH | Whiff

Training Sample: n = 9500 pitches

Testing Sample: n = 4072 pitches

Testing Accuracy: 63.95%

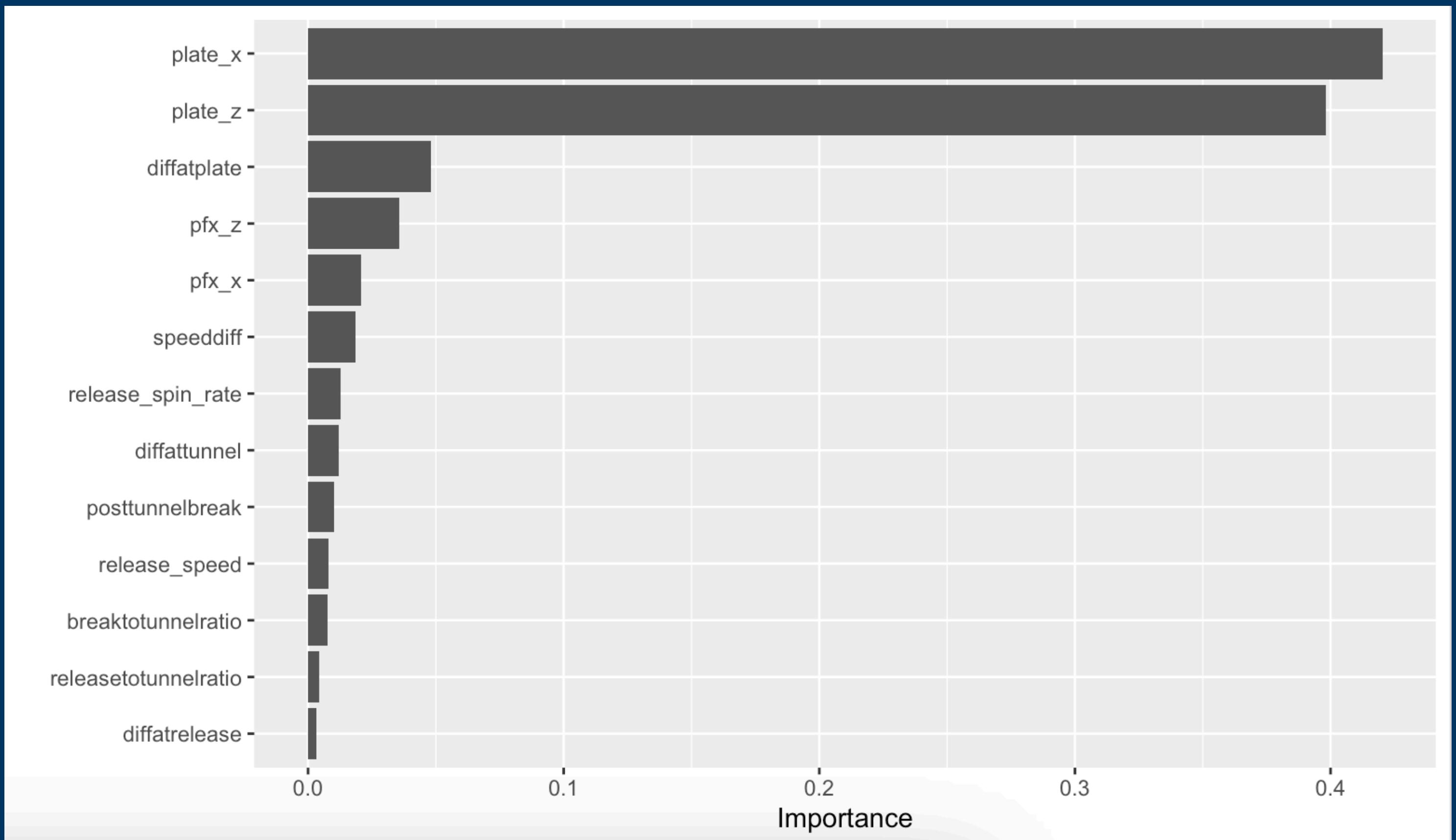


Four-Seam -> Changeup | LHP -> RHH | Chase

Training Sample: n = 15628 pitches

Testing Sample: n = 6544 pitches

Testing Accuracy: 72.62%

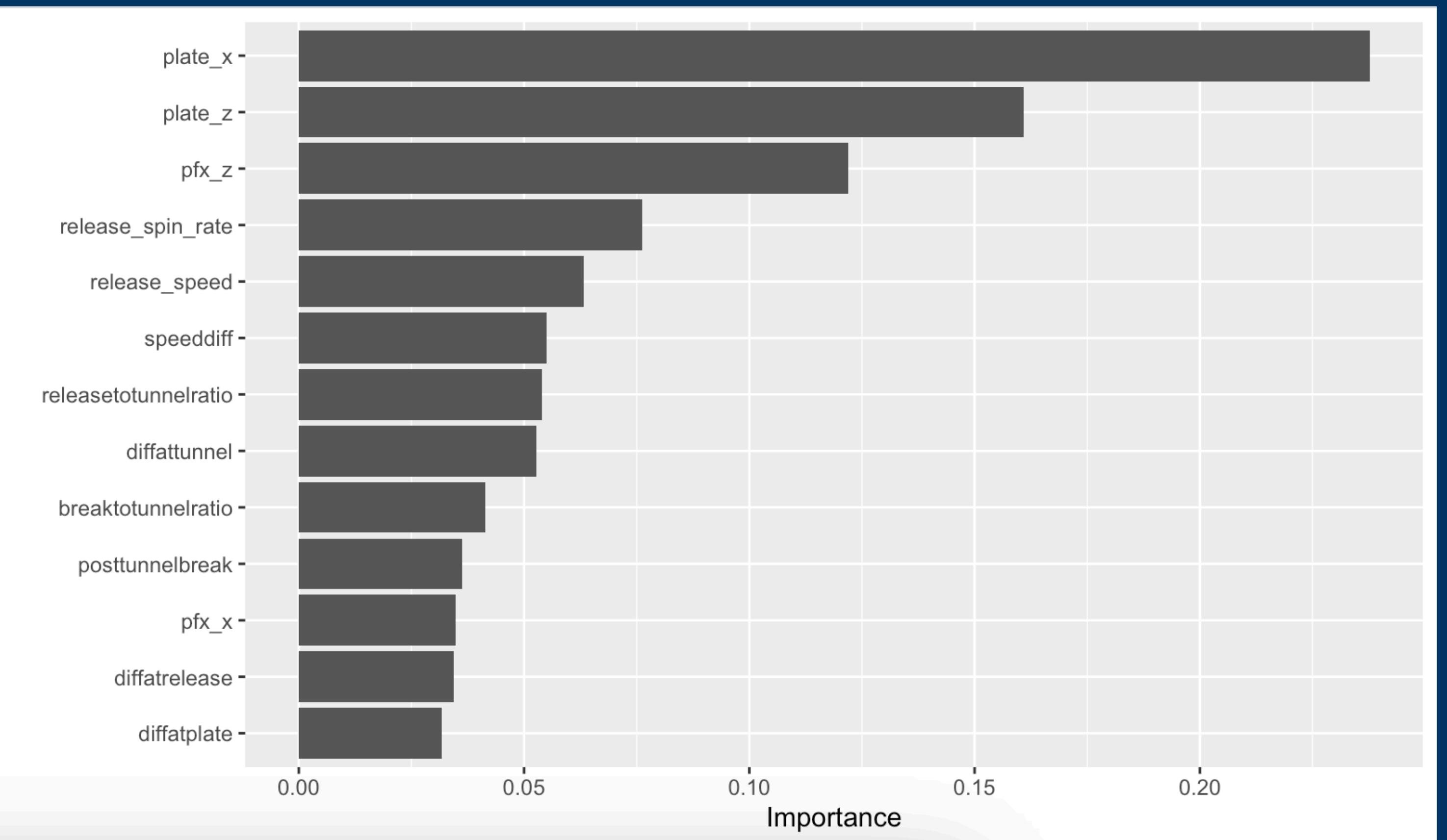


Four-Seam -> Changeup | LHP -> RHH | Groundball

Training Sample: n = 6768 pitches

Testing Sample: n = 2902 pitches

Testing Accuracy: 60.68%

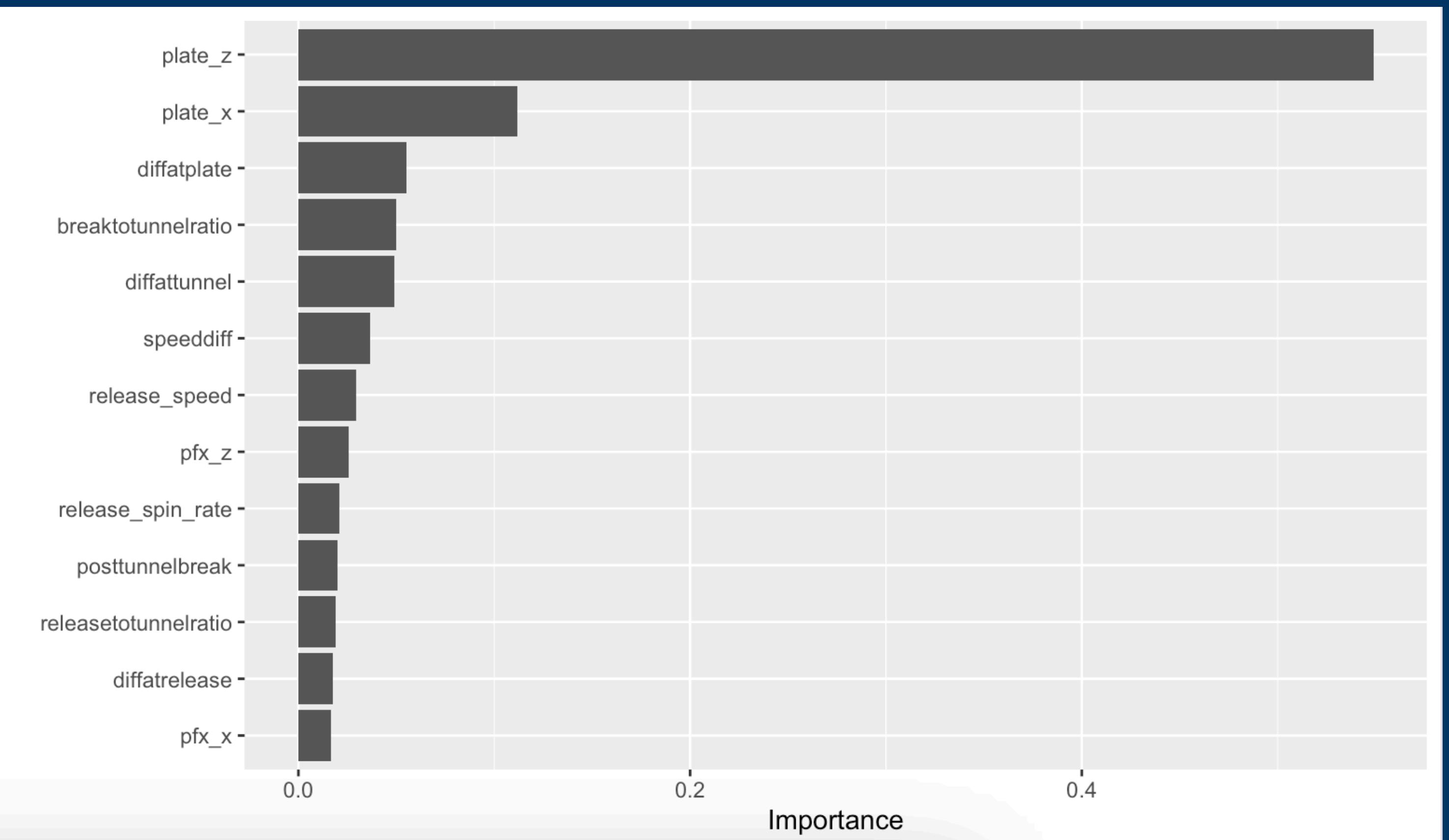


Four-Seam -> Curveball | LHP -> RHH | Whiff

Training Sample: n = 4680 pitches

Testing Sample: n = 2006 pitches

Testing Accuracy: 71.04%

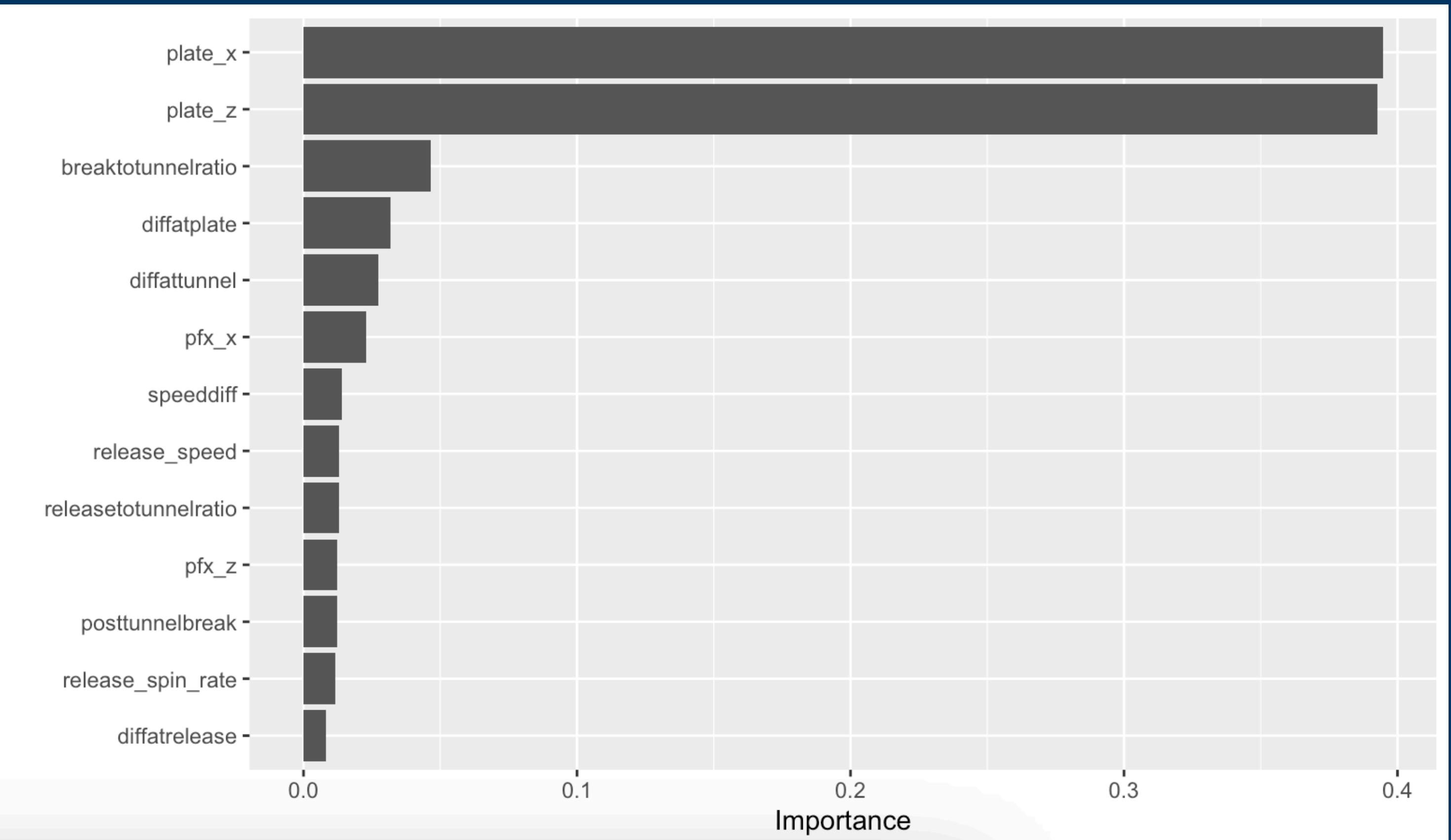


Four-Seam -> Curveball | LHP -> RHH | Chase

Training Sample: n = 7320 pitches

Testing Sample: n = 3138 pitches

Testing Accuracy: 71.77%

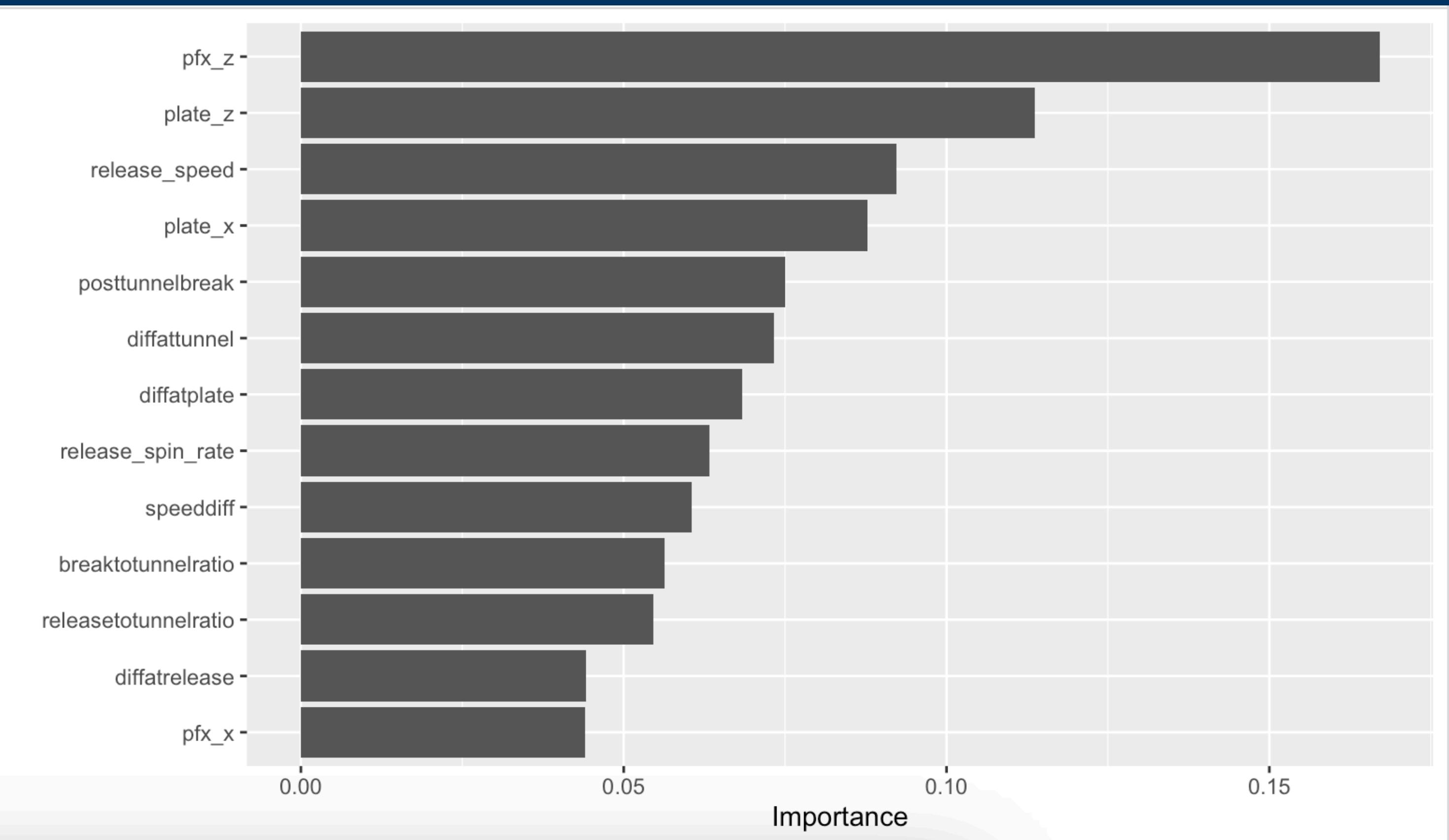


Four-Seam -> Curveball | LHP -> RHH | Groundball

Training Sample: n = 2962 pitches

Testing Sample: n = 1270 pitches

Testing Accuracy: 58.9%

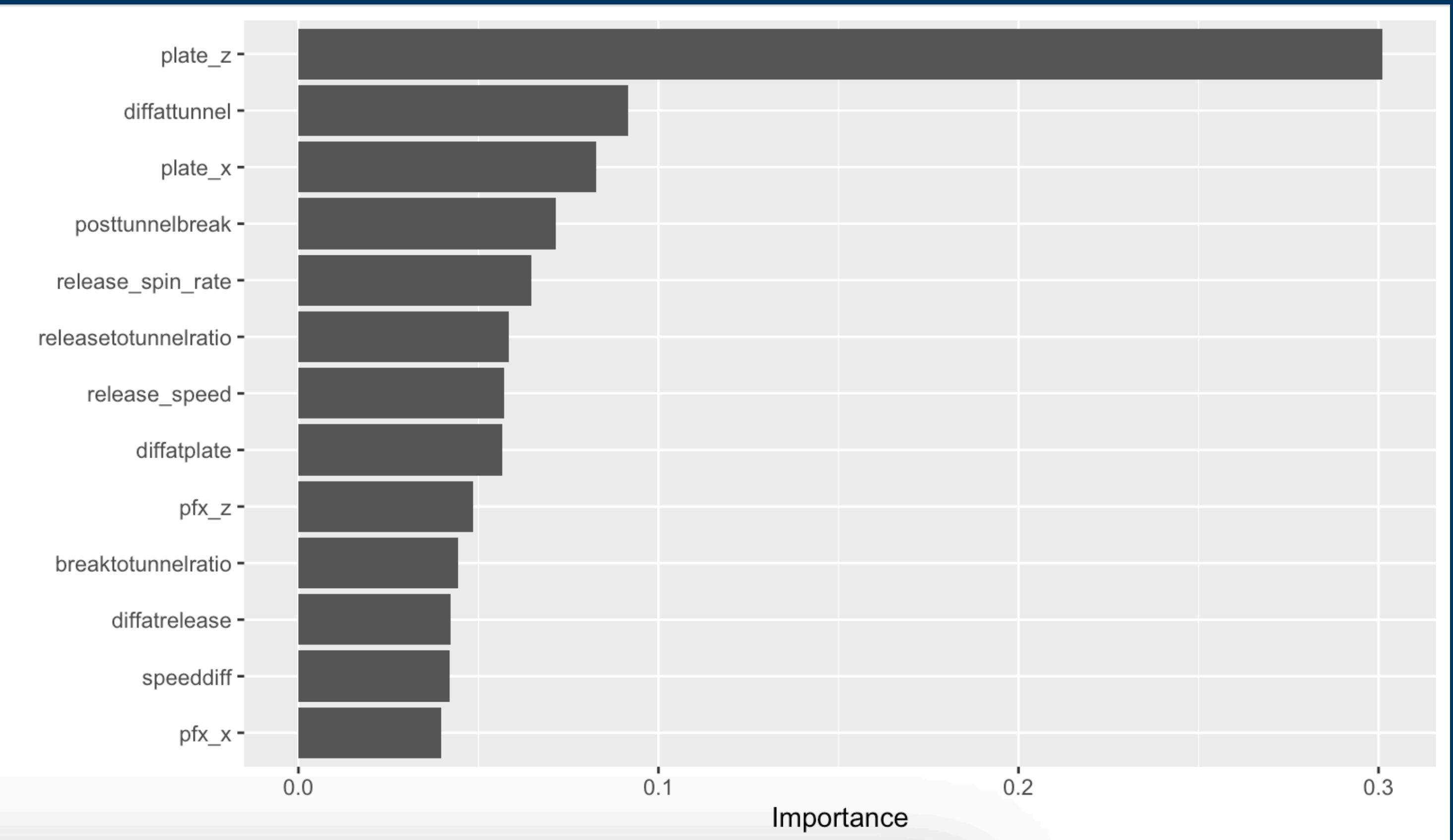


Four-Seam -> Splitter | LHP -> RHH | Whiff

Training Sample: n = 428 pitches

Testing Sample: n = 184 pitches

Testing Accuracy: 62.5%

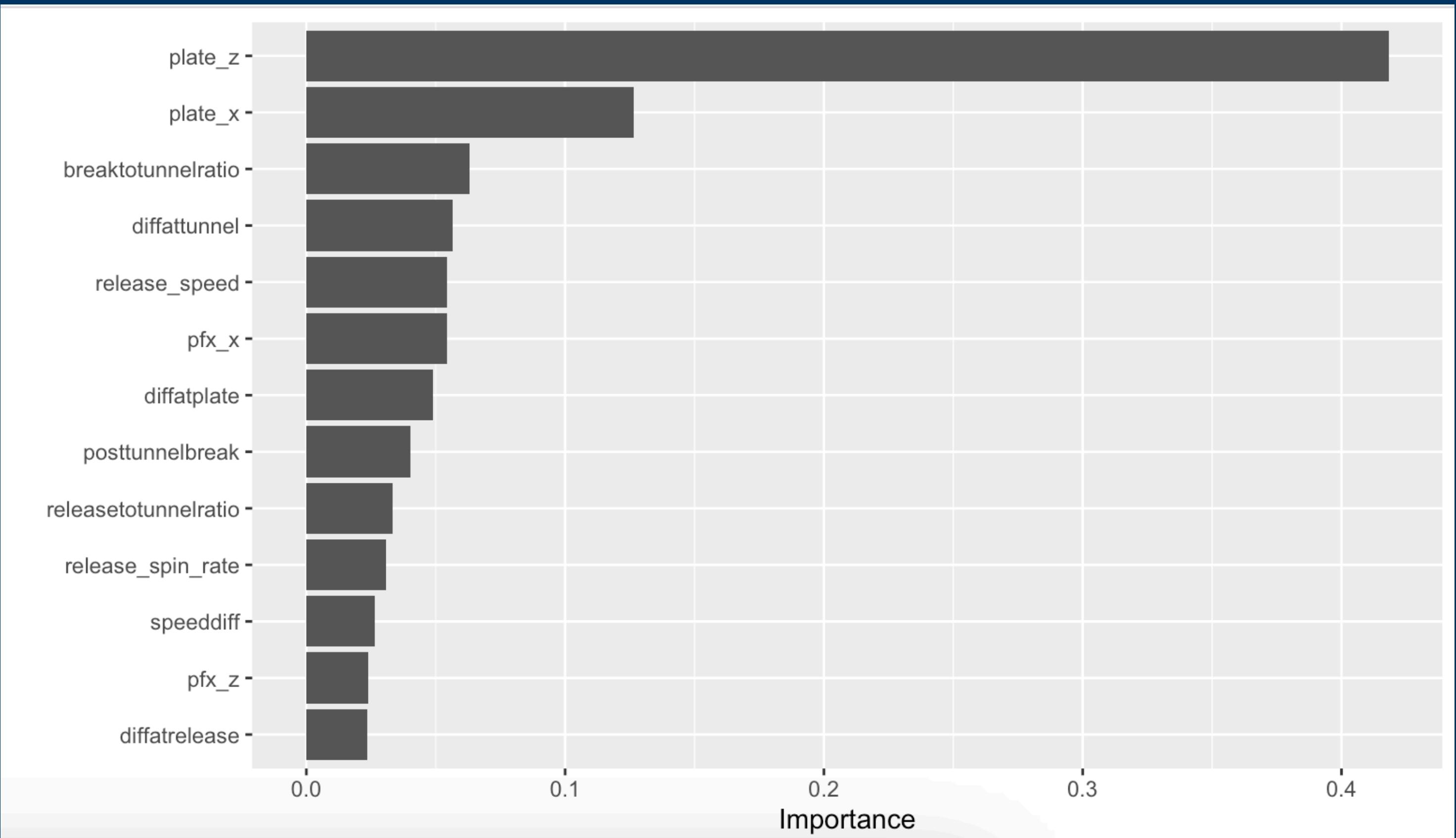


Four-Seam -> Knuckle Curve | LHP -> RHH | Whiff

Training Sample: n = 1058 pitches

Testing Sample: n = 456 pitches

Testing Accuracy: 71.93%

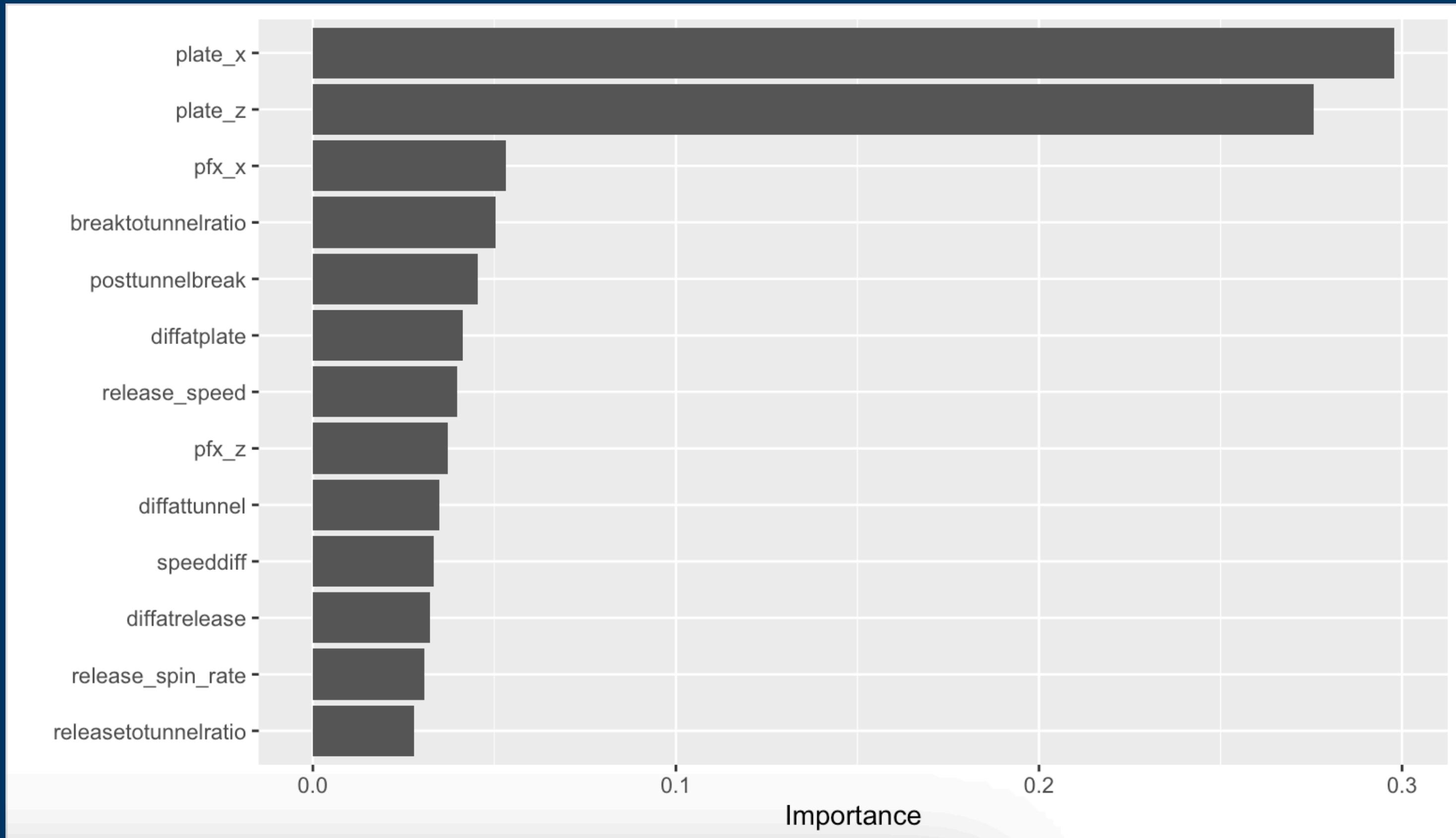


Four-Seam -> Knuckle Curve | LHP -> RHH | Chase

Training Sample: n = 1468 pitches

Testing Sample: n = 630 pitches

Testing Accuracy: 70.95%

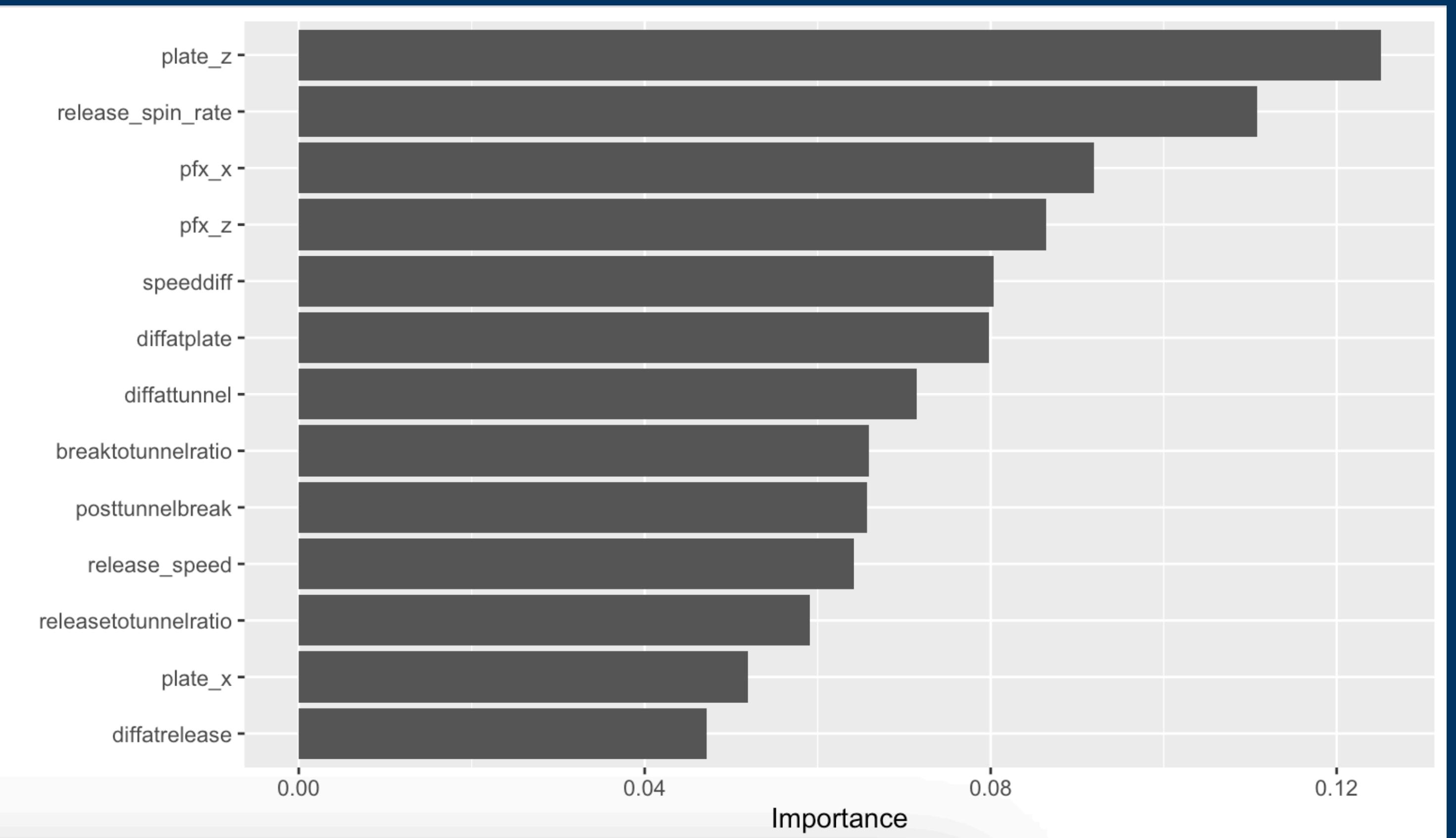


Four-Seam -> Knuckle Curve | LHP -> RHH | Groundball

Training Sample: n = 546 pitches

Testing Sample: n = 236 pitches

Testing Accuracy: 61.02%

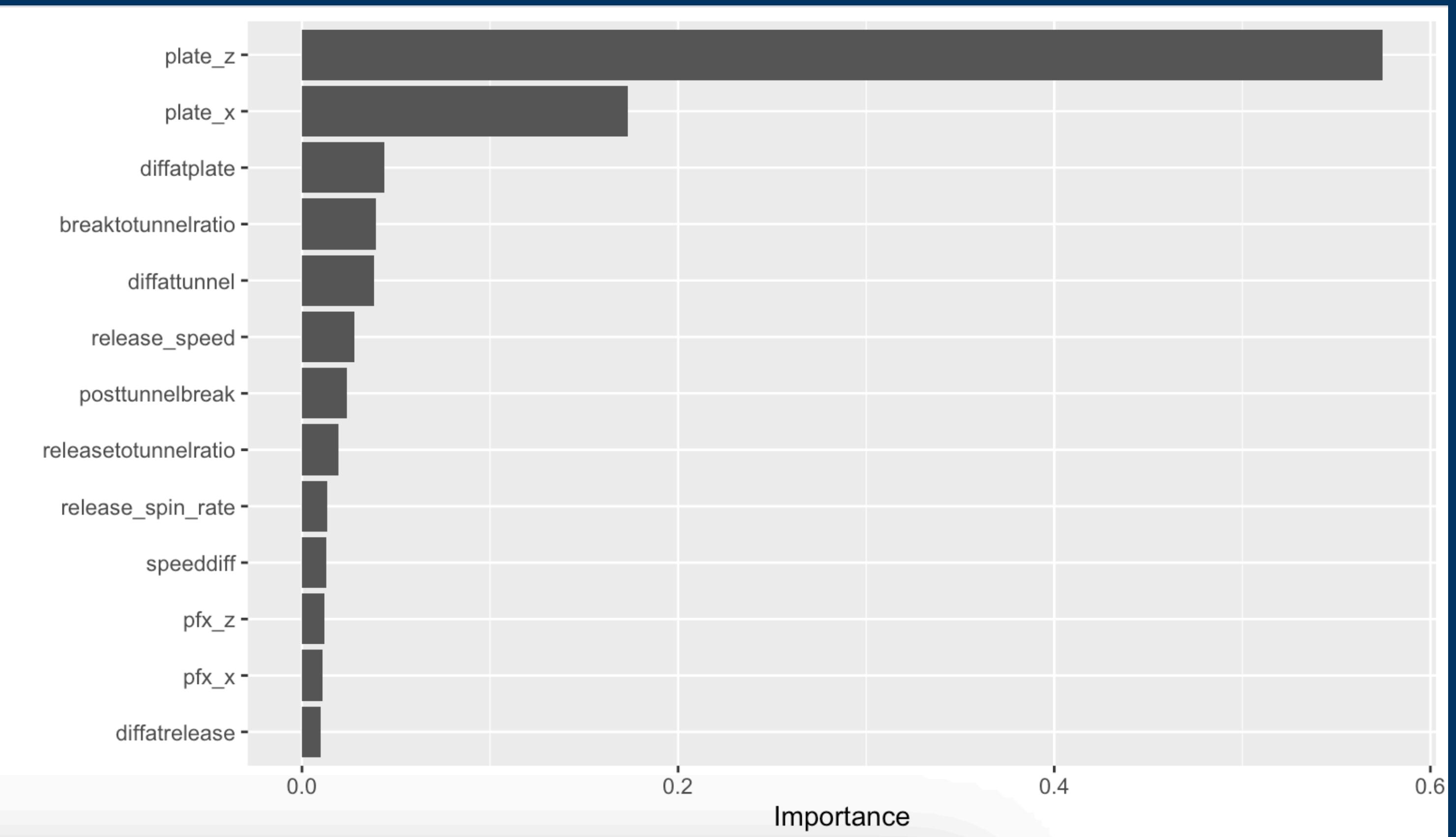


Four-Seam -> Slider | LHP -> RHH | Whiff

Training Sample: n = 8492 pitches

Testing Sample: n = 3640 pitches

Testing Accuracy: 72.06%

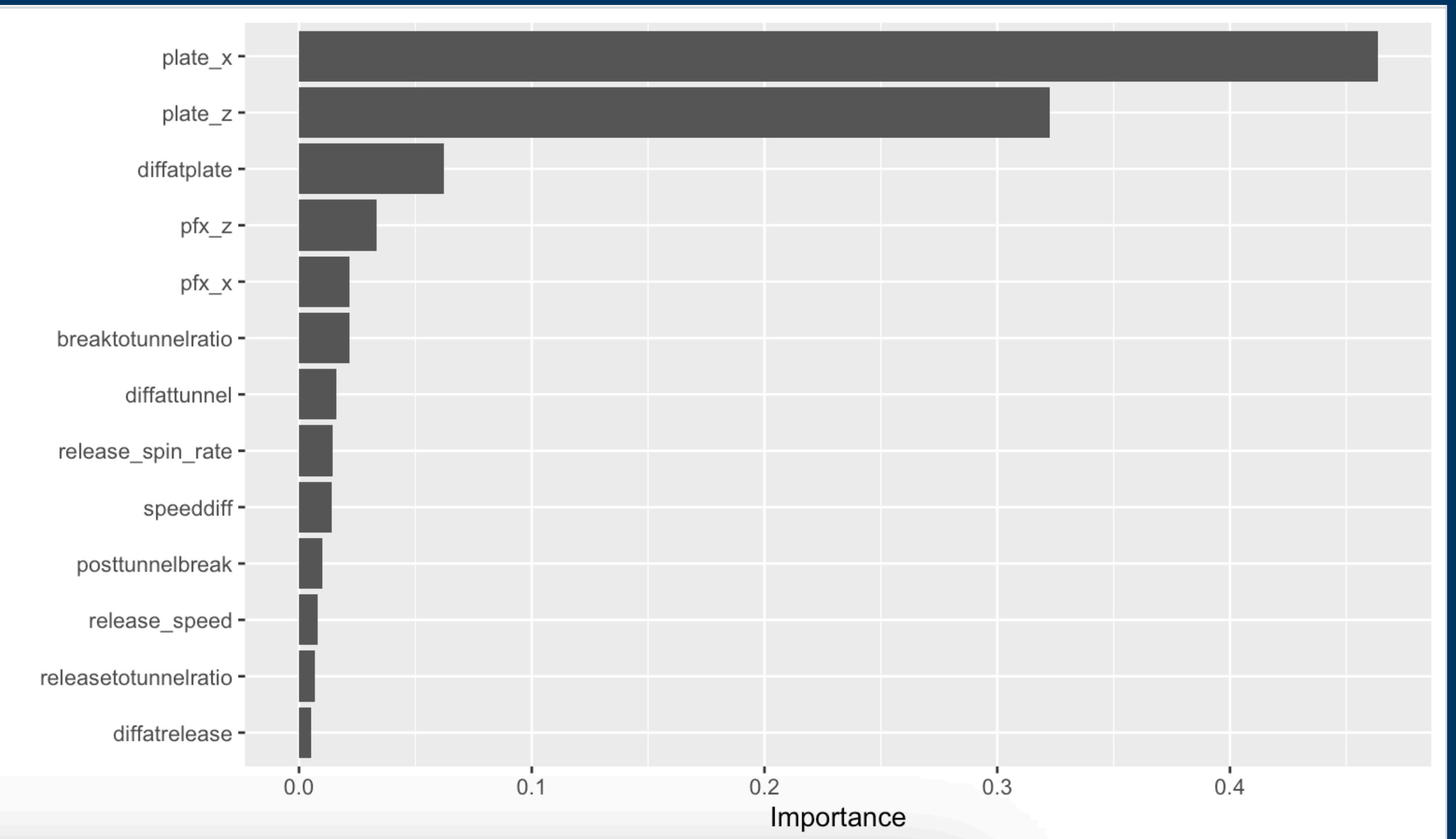


Four-Seam -> Slider | LHP -> RHH | Chase

Training Sample: n = 11476 pitches

Testing Sample: n = 5036 pitches

Testing Accuracy: 71.35%

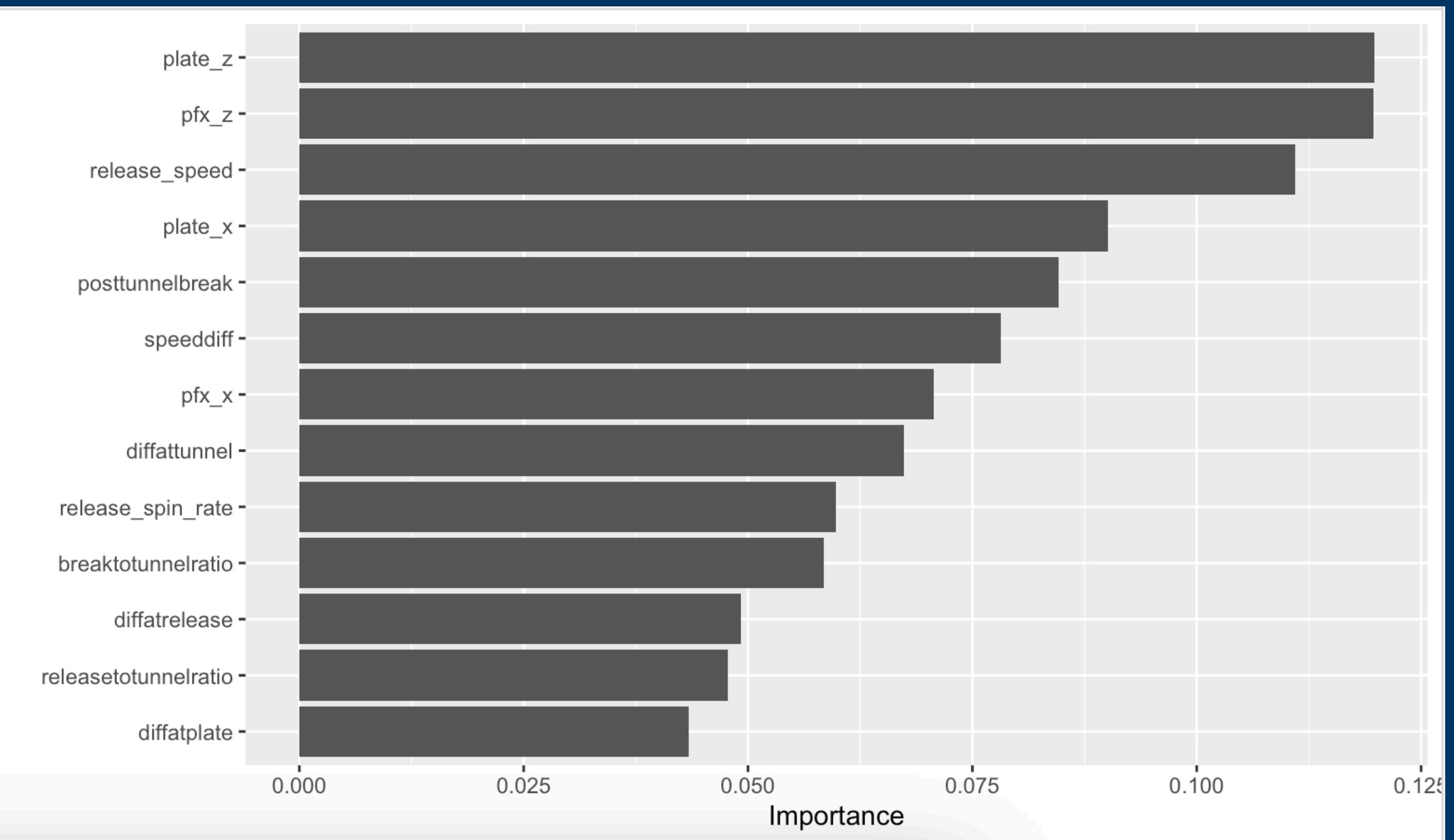


Four-Seam -> Slider | LHP -> RHH | Groundball

Training Sample: n = 11476 pitches

Testing Sample: n = 5036 pitches

Testing Accuracy: 57.77%

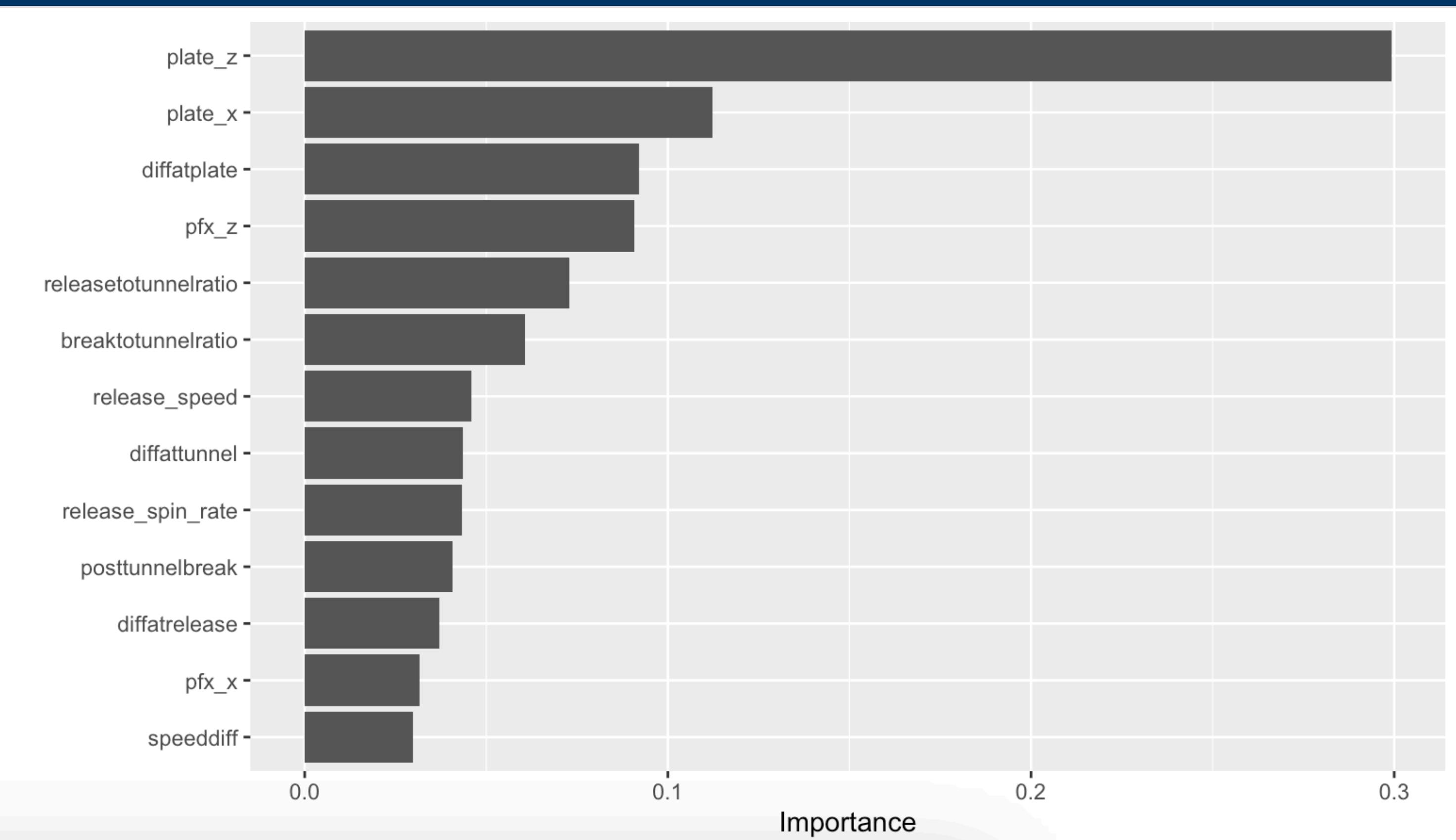


Four-Seam -> Sweeper | LHP -> RHH | Whiff

Training Sample: n = 402 pitches

Testing Sample: n = 174 pitches

Testing Accuracy: 67.24%

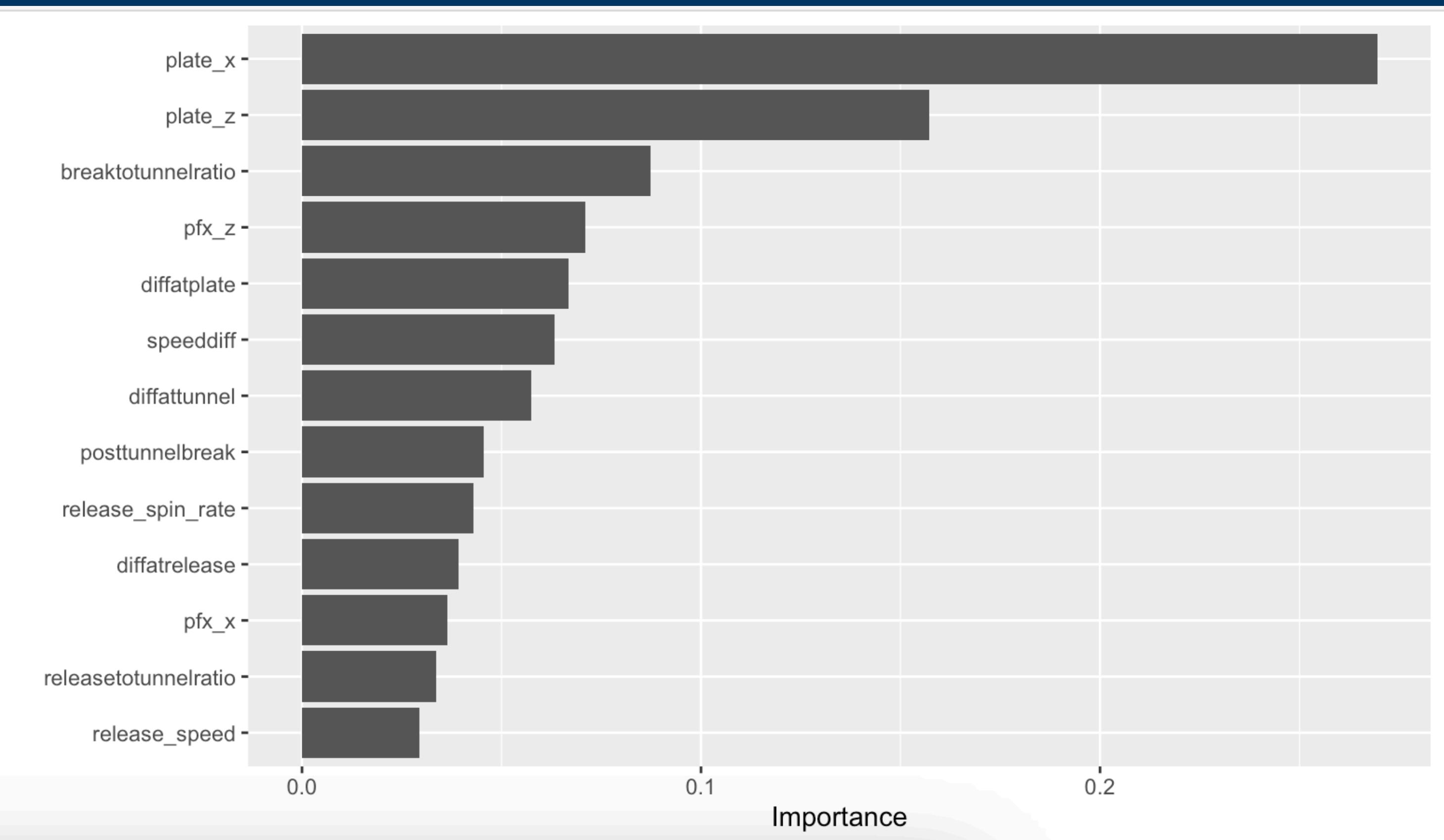


Four-Seam -> Sweeper | LHP -> RHH | Chase

Training Sample: n = 644 pitches

Testing Sample: n = 276 pitches

Testing Accuracy: 75.36%

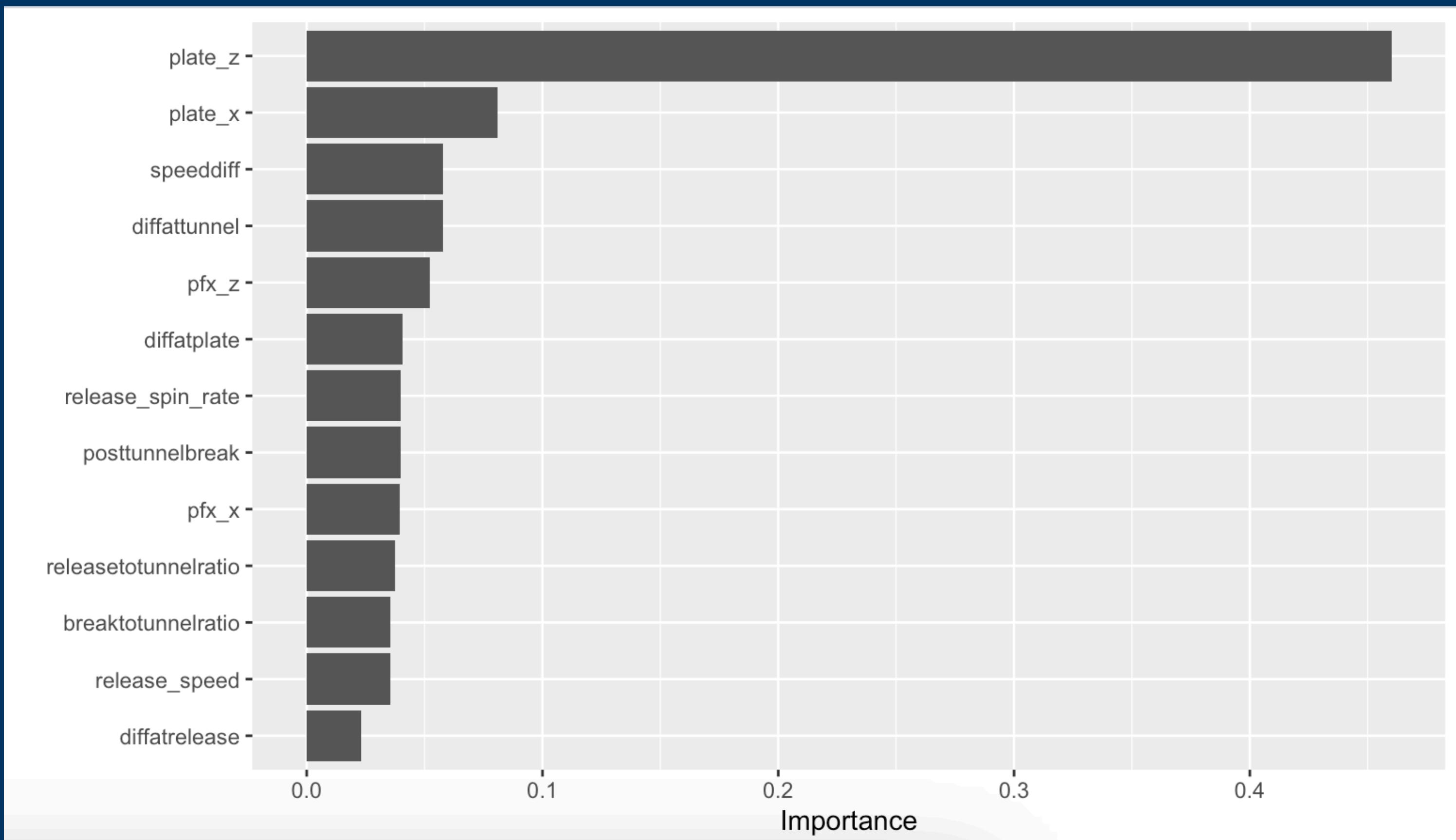


Sinker -> Changeup | LHP -> RHH | Whiff

Training Sample: n = 6070 pitches

Testing Sample: n = 2064 pitches

Testing Accuracy: 64.13%

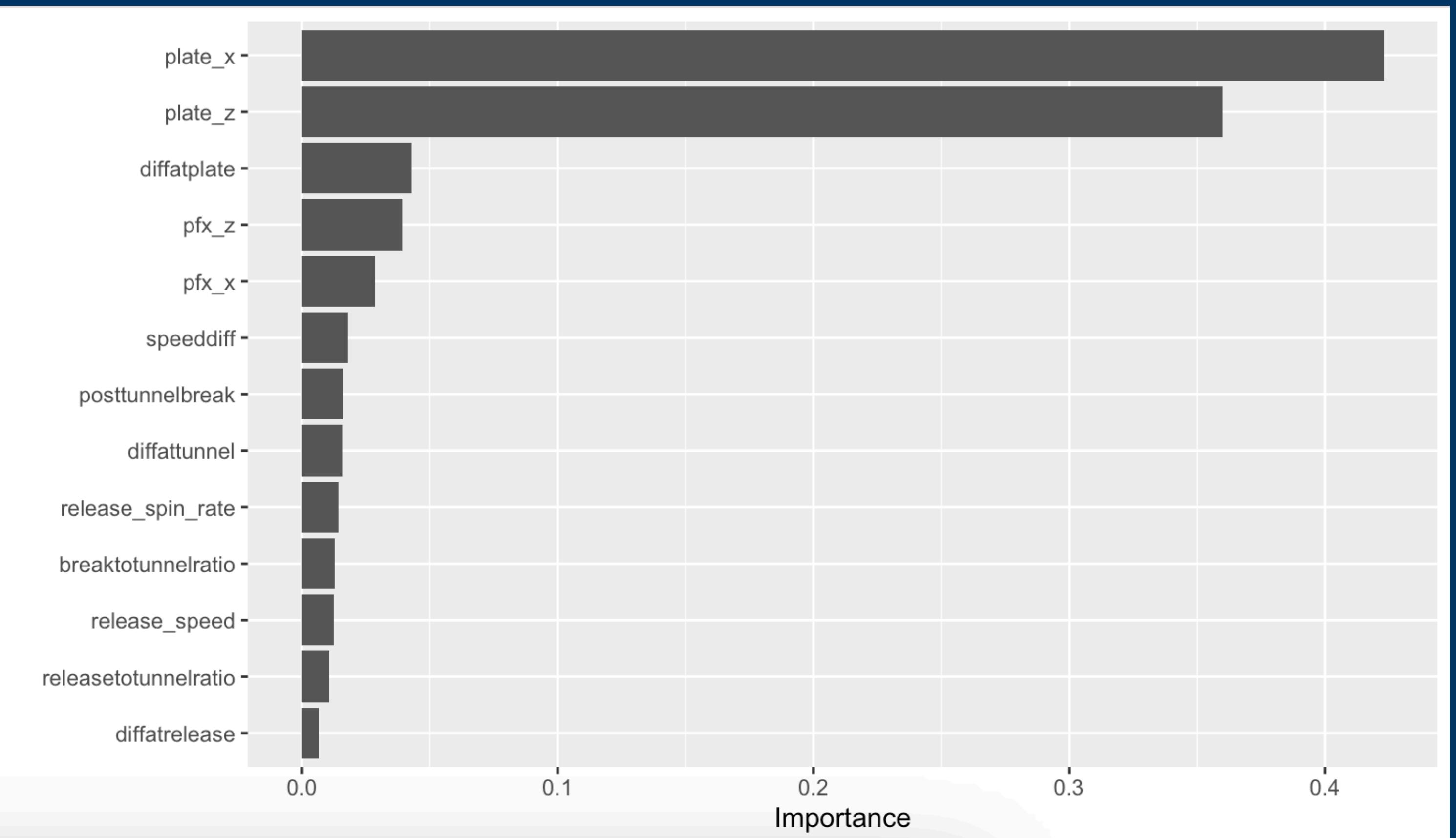


Sinker -> Changeup | LHP -> RHH | Chase

Training Sample: n = 10014 pitches

Testing Sample: n = 4294 pitches

Testing Accuracy: 70.28%

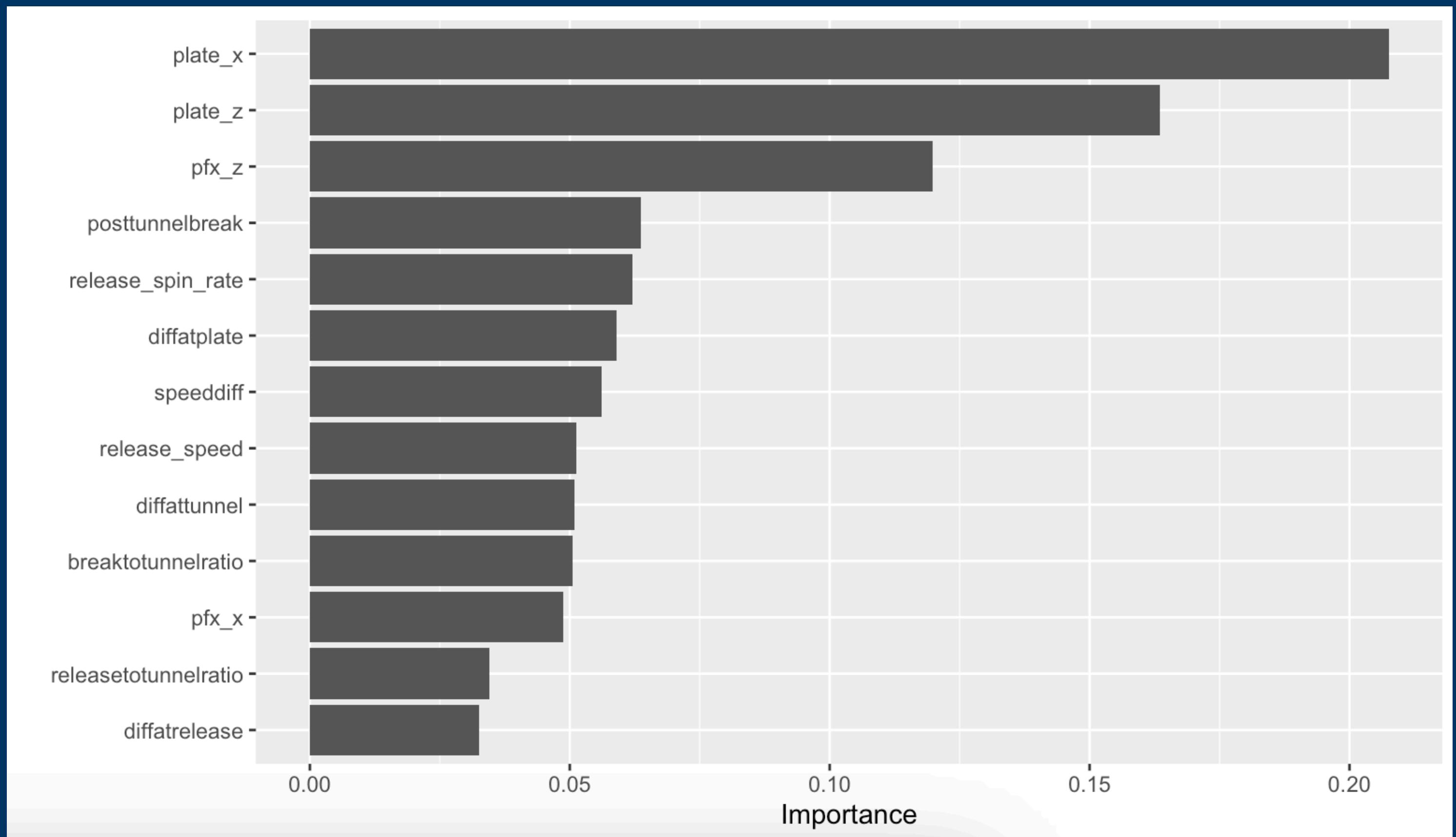


Sinker -> Changeup | LHP -> RHH | Groundball

Training Sample: n = 4512 pitches

Testing Sample: n = 1934 pitches

Testing Accuracy: 60.34%

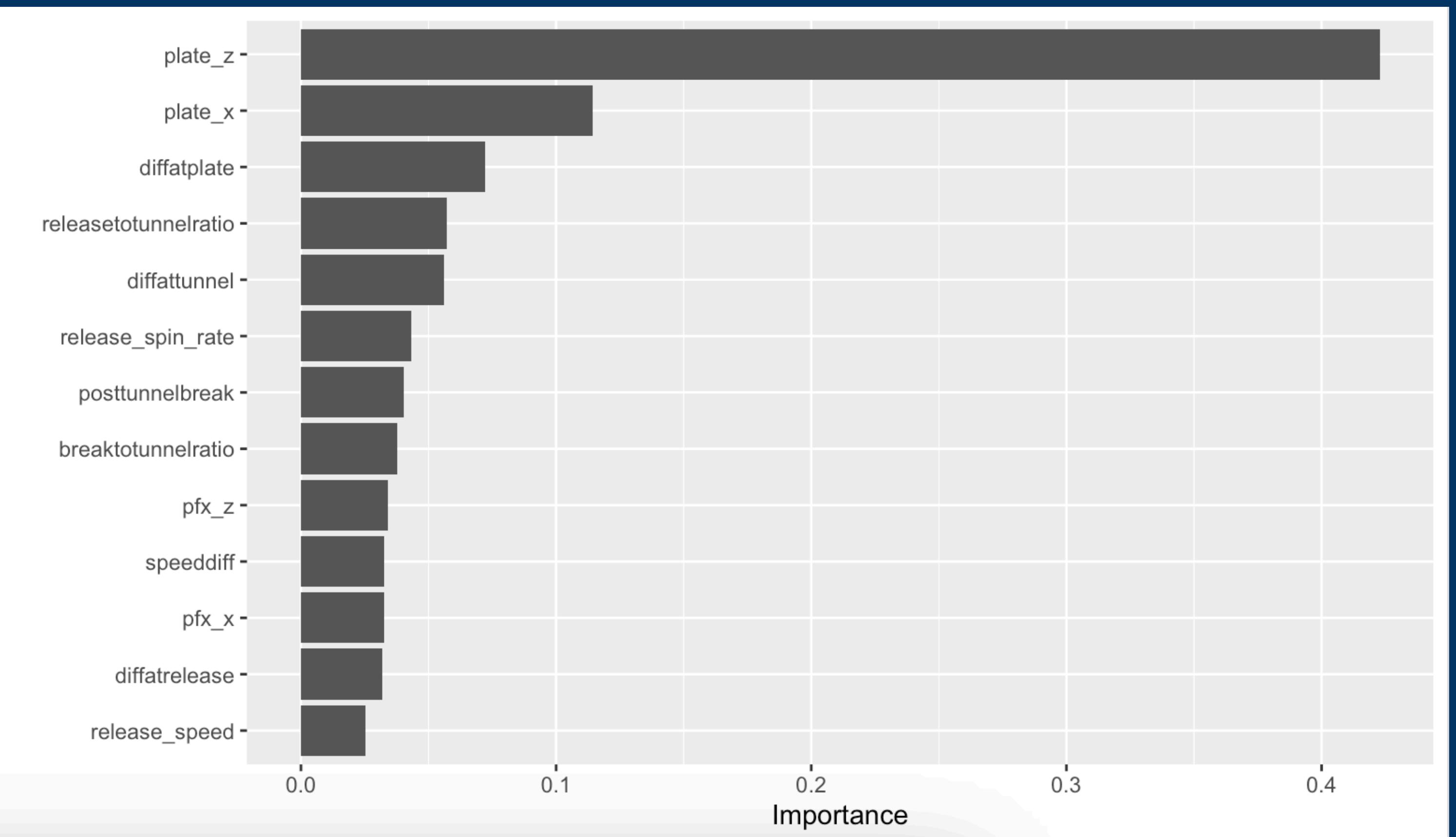


Sinker -> Curveball | LHP -> RHH | Whiff

Training Sample: n = 1926 pitches

Testing Sample: n = 828 pitches

Testing Accuracy: 71.74%

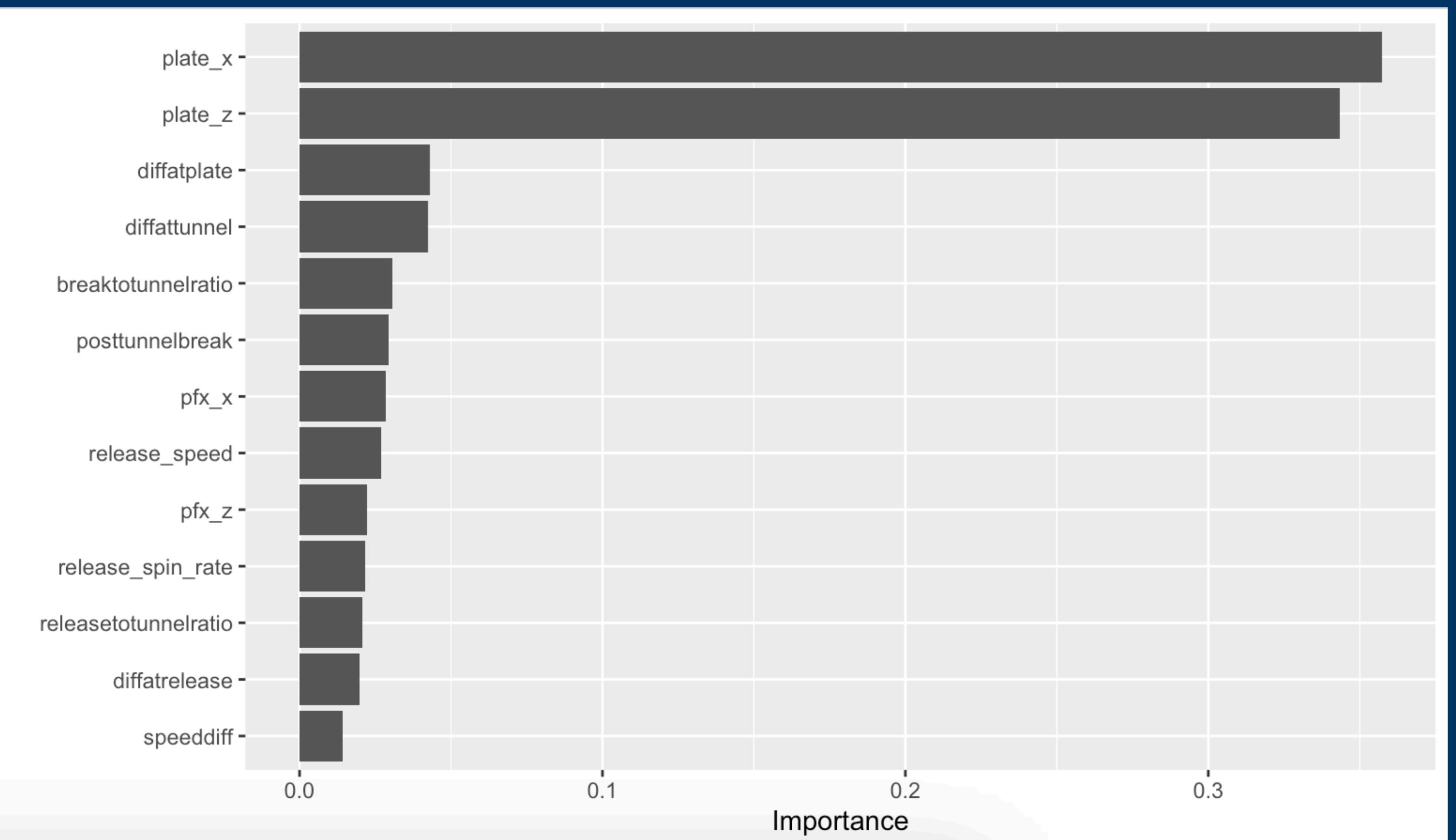


Sinker -> Curveball | LHP -> RHH | Chase

Training Sample: n = 2756 pitches

Testing Sample: n = 1182 pitches

Testing Accuracy: 69.63%

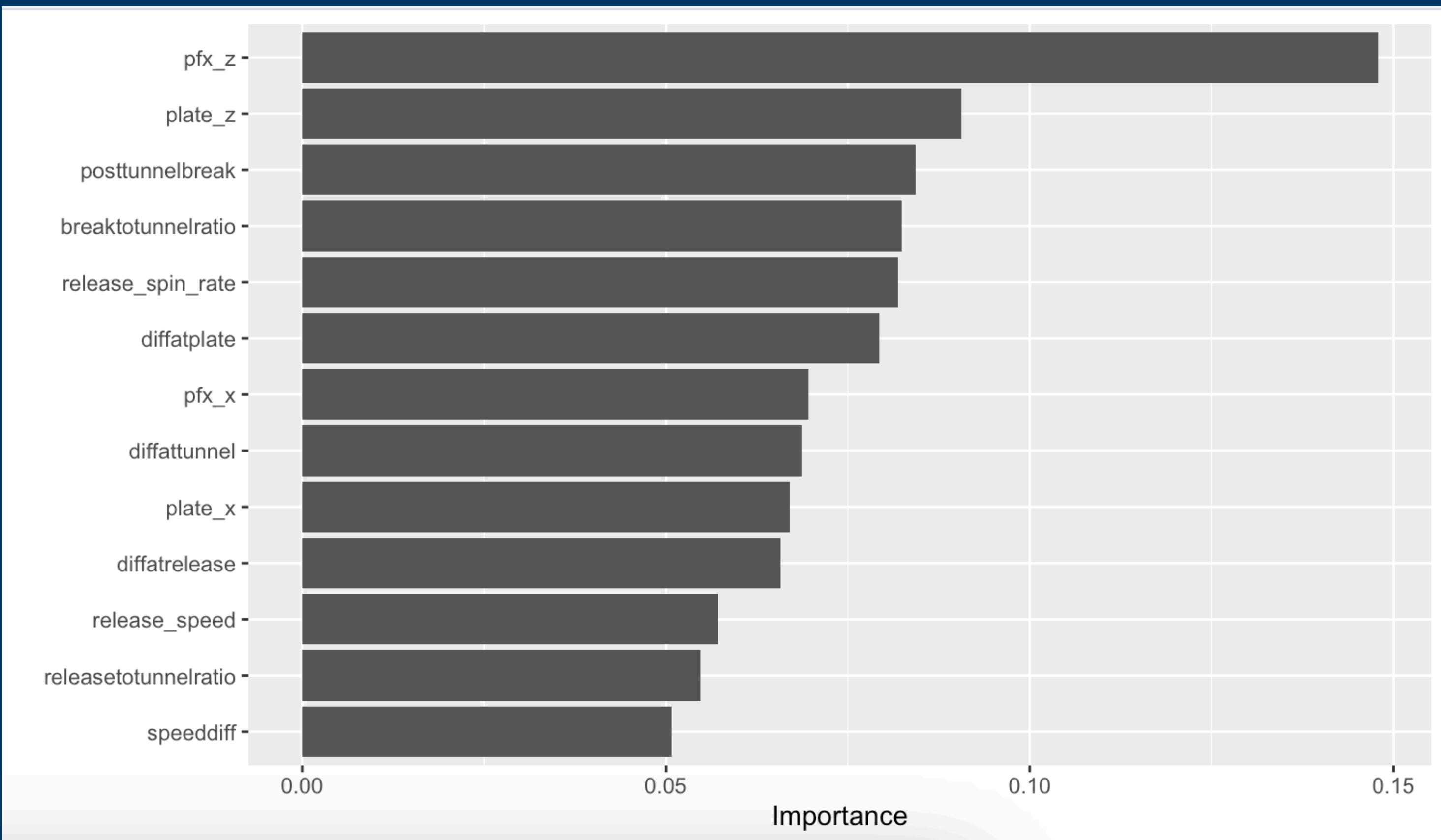


Sinker -> Curveball | LHP -> RHH | Groundball

Training Sample: n = 1036 pitches

Testing Sample: n = 444 pitches

Testing Accuracy: 59.68%

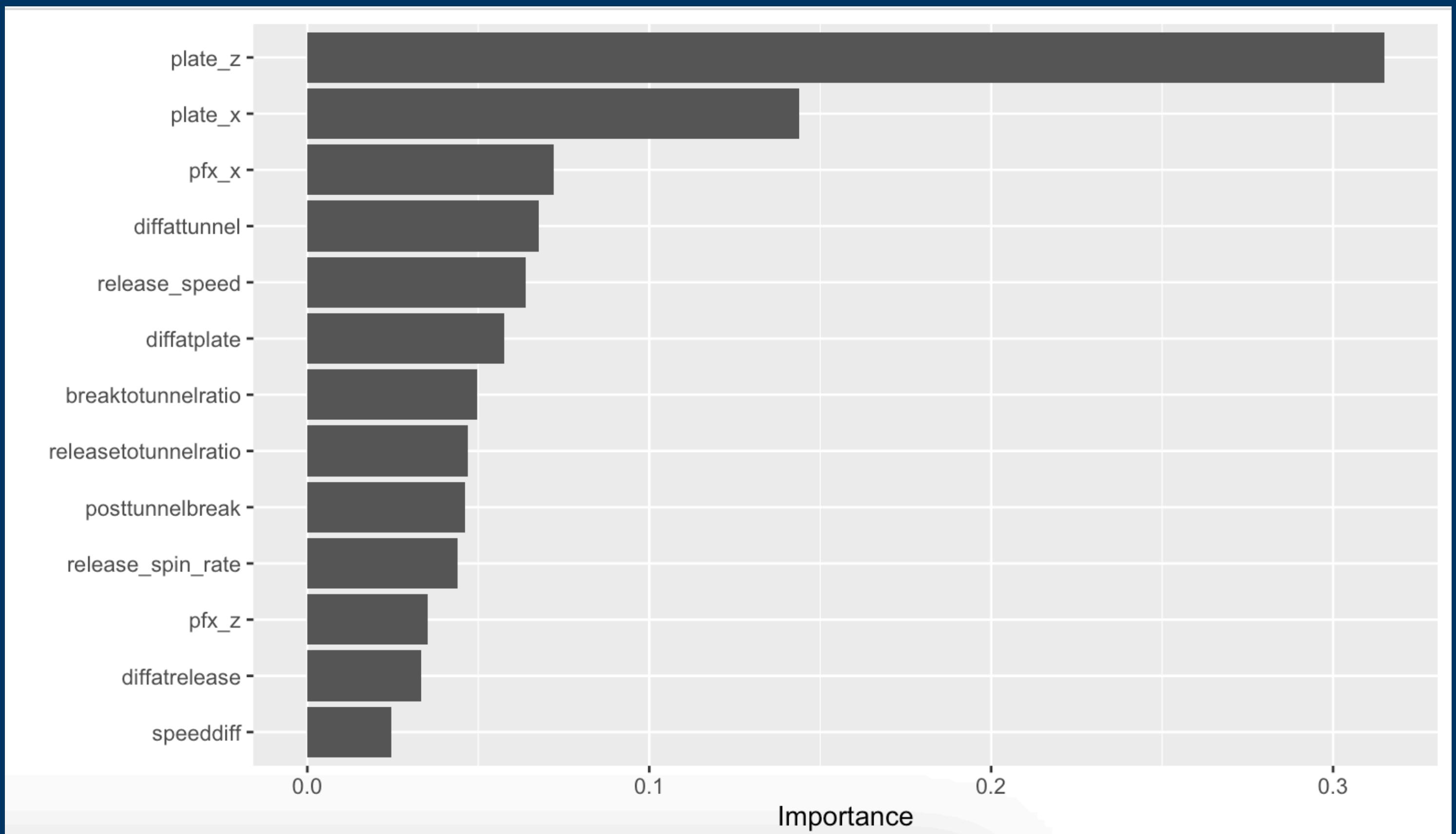


Sinker -> Knuckle Curve | LHP -> RHH | Whiff

Training Sample: n = 700 pitches

Testing Sample: n = 302 pitches

Testing Accuracy: 70.53%

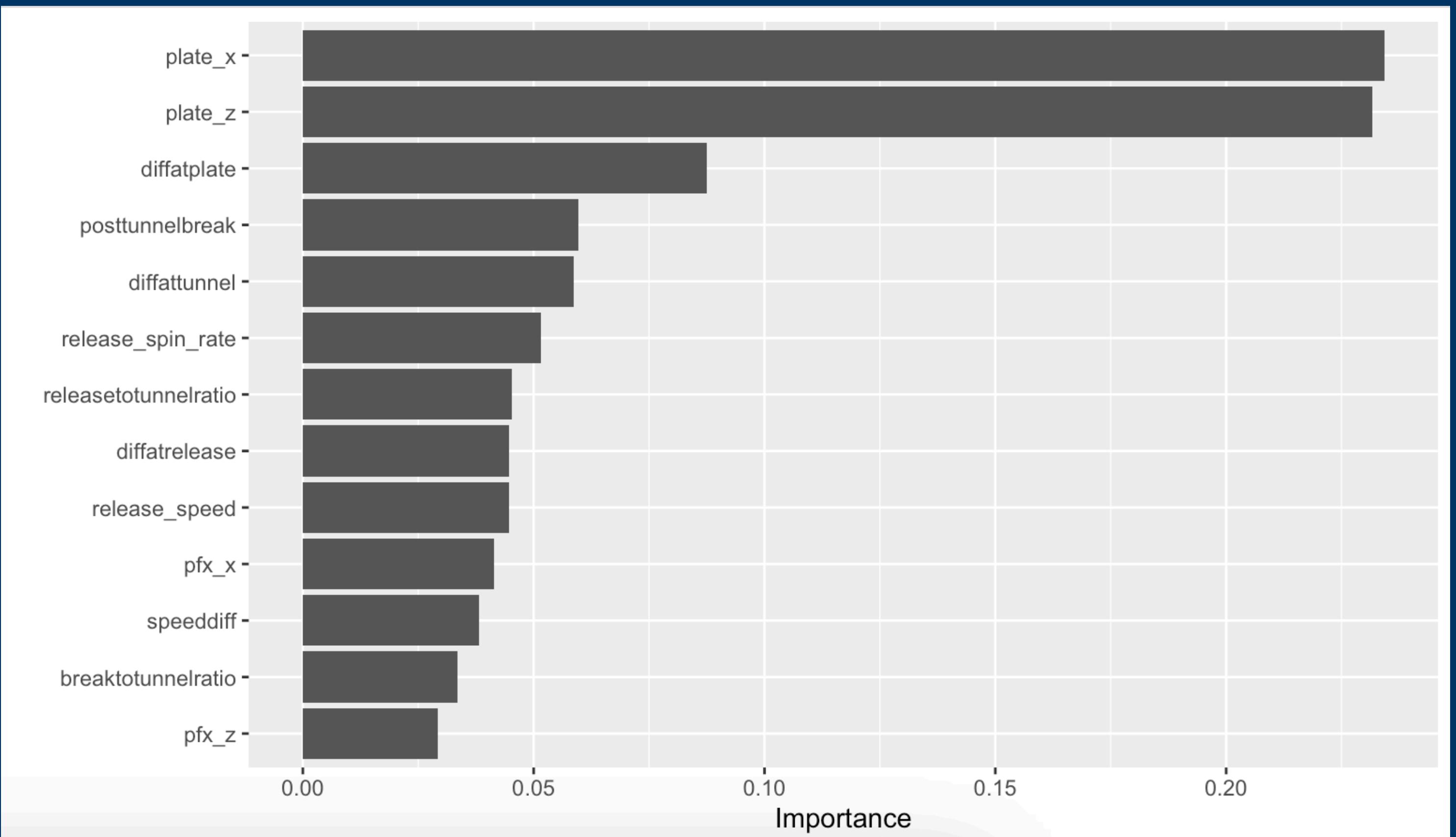


Sinker -> Knuckle Curve | LHP -> RHH | Chase

Training Sample: n = 424 pitches

Testing Sample: n = 182 pitches

Testing Accuracy: 65.38%

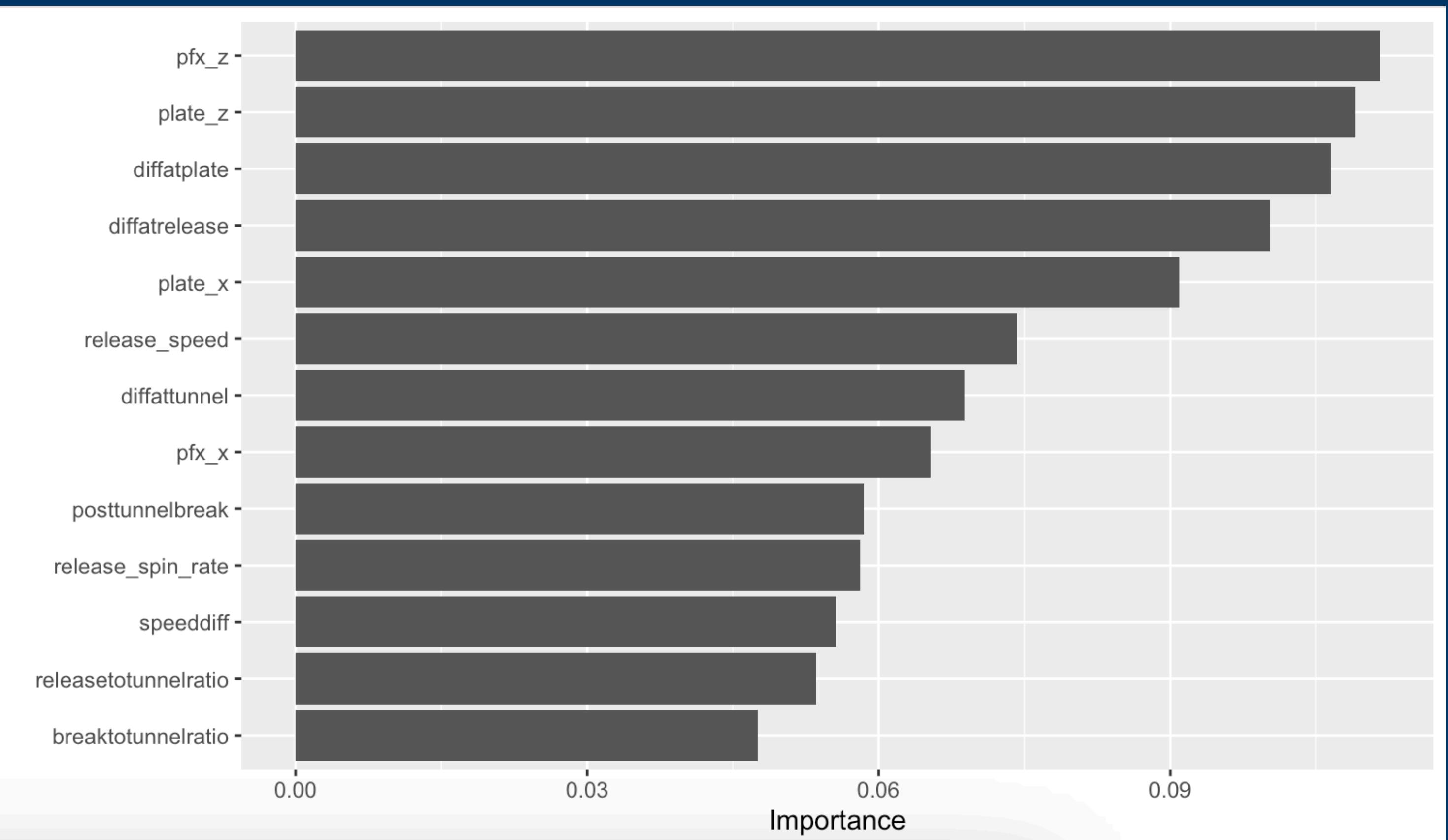


Sinker -> Knuckle Curve | LHP -> RHH | Groundball

Training Sample: n = 424 pitches

Testing Sample: n = 182 pitches

Testing Accuracy: 65.38%

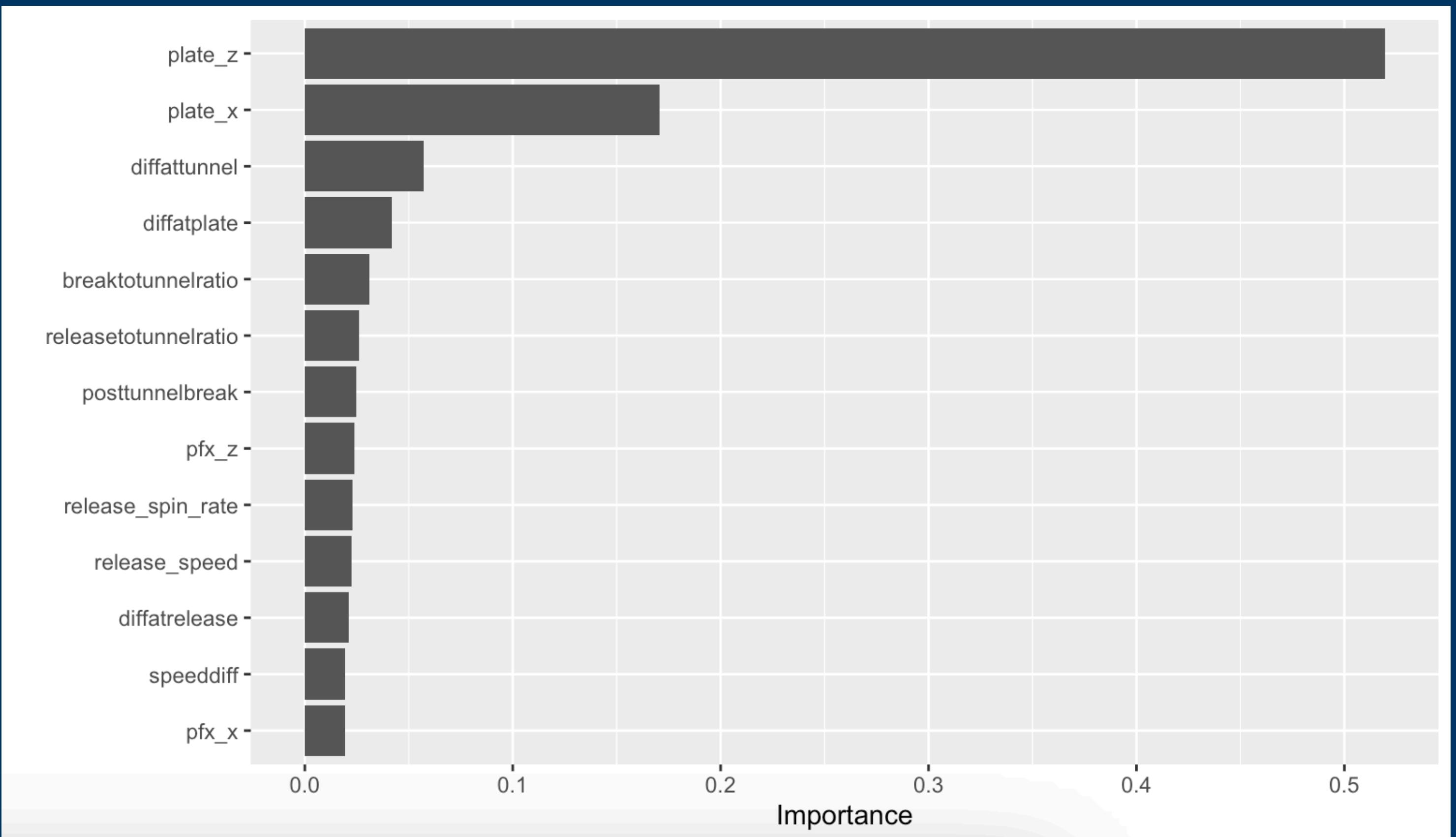


Sinker -> Slider | LHP -> RHH | Whiff

Training Sample: n = 3780 pitches

Testing Sample: n = 1622 pitches

Testing Accuracy: 72.44%

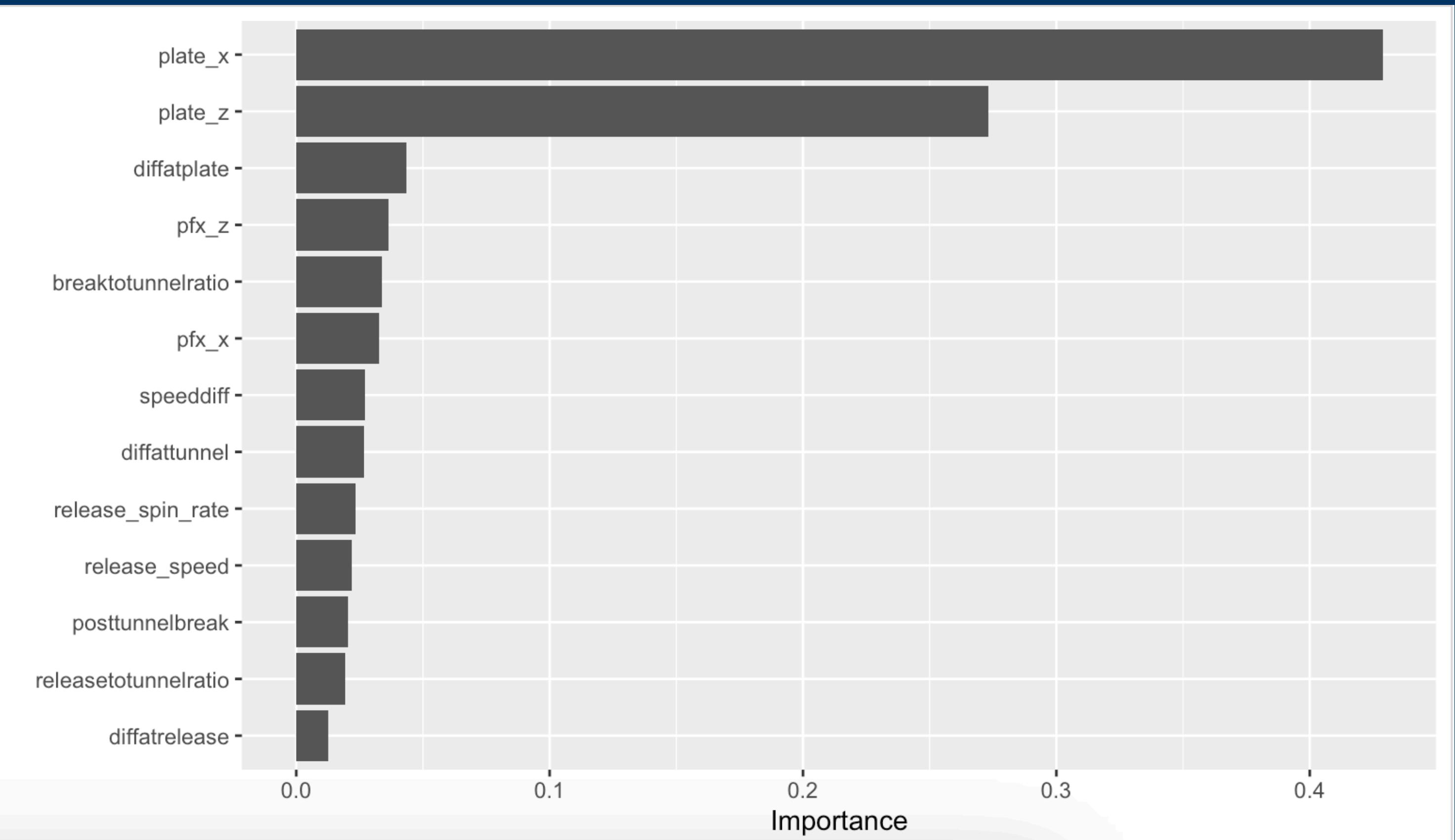


Sinker -> Slider | LHP -> RHH | Chase

Training Sample: n = 5286 pitches

Testing Sample: n = 2266 pitches

Testing Accuracy: 71.71%

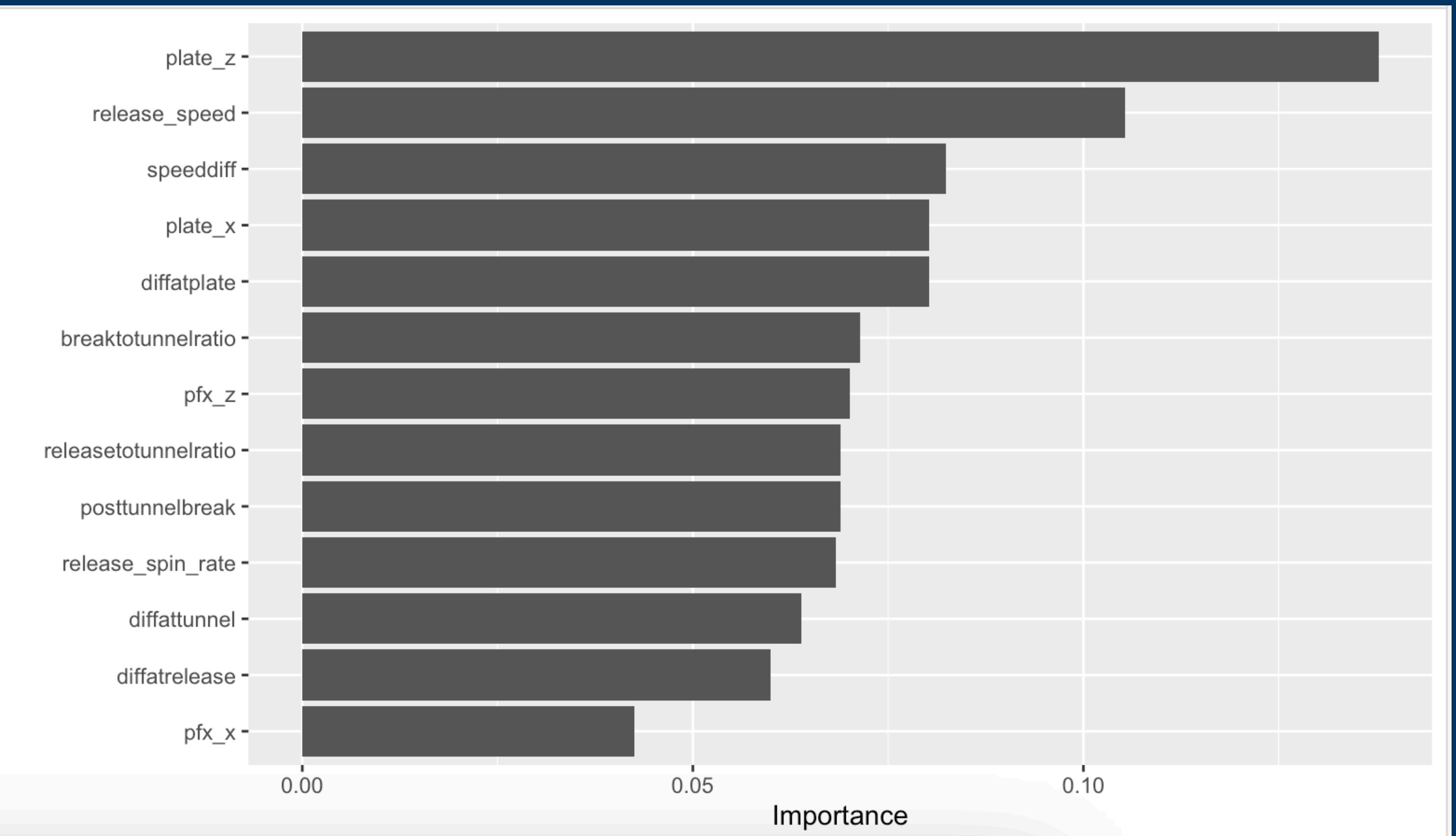


Sinker -> Slider | LHP -> RHH | Groundball

Training Sample: n = 1446 pitches

Testing Sample: n = 622 pitches

Testing Accuracy: 56.59%

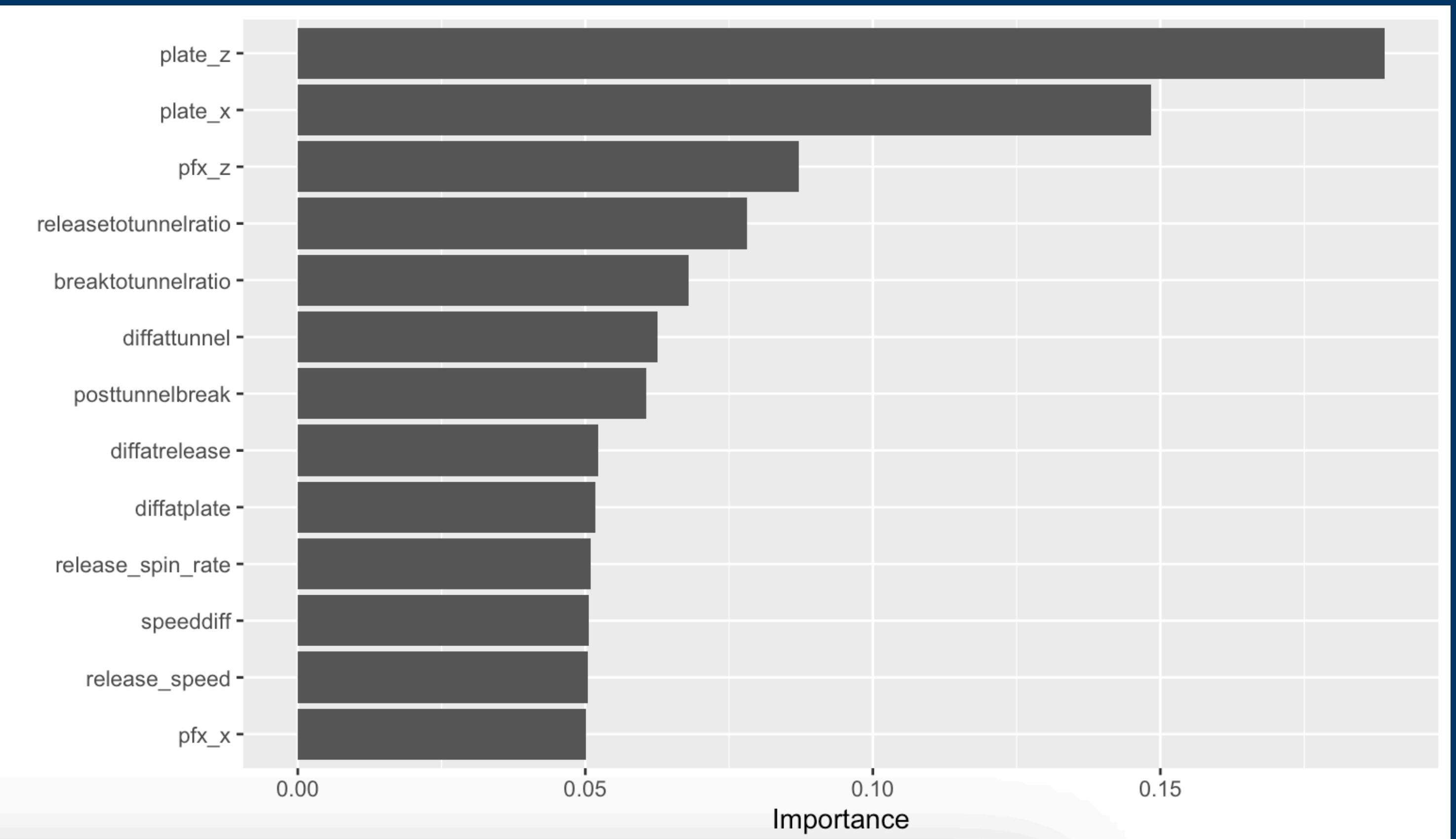


Sinker -> Sweeper | LHP -> RHH | Whiff

Training Sample: n = 244 pitches

Testing Sample: n = 106 pitches

Testing Accuracy: 69.81%

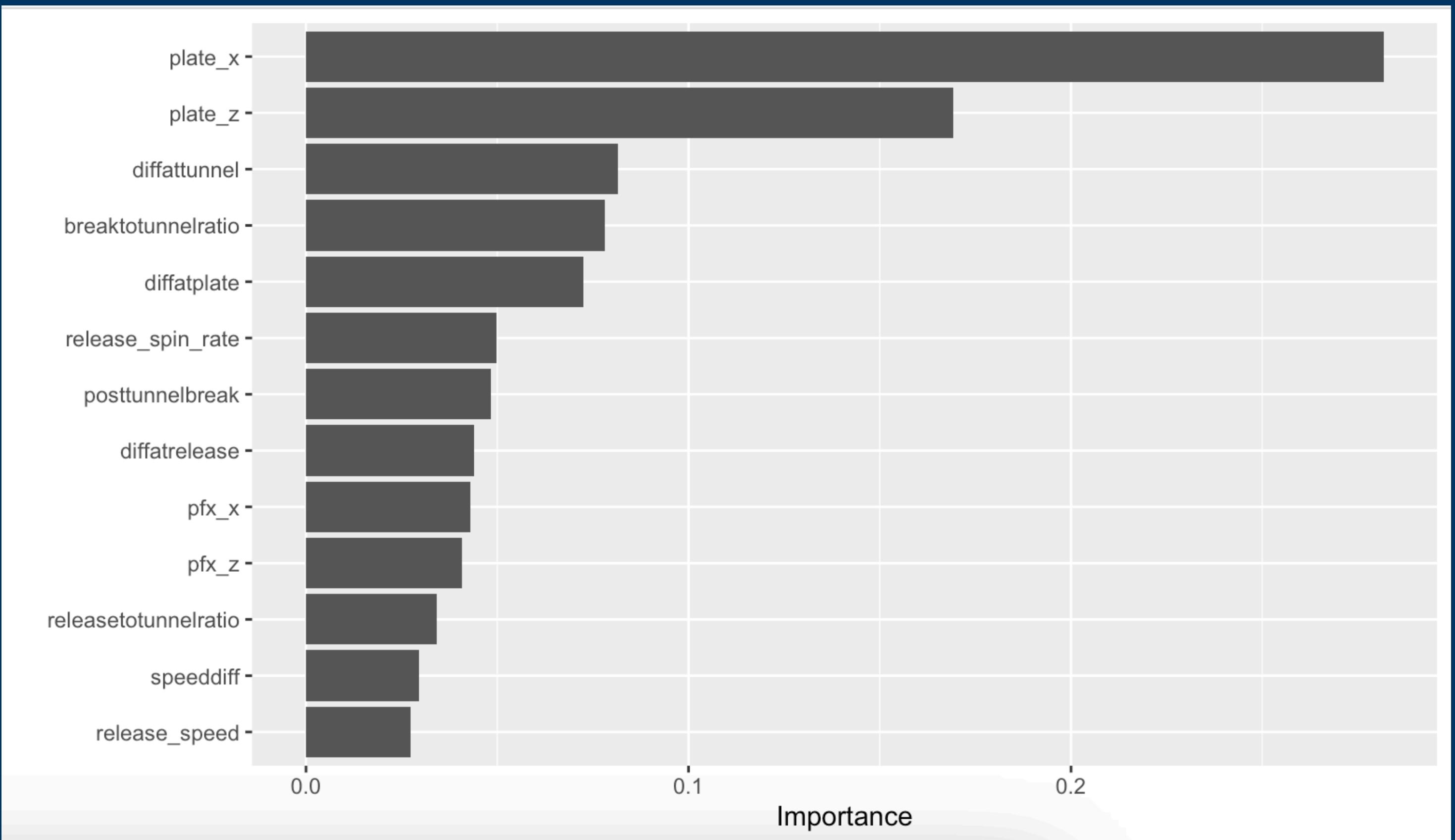


Sinker -> Sweeper | LHP -> RHH | Chase

Training Sample: n = 400 pitches

Testing Sample: n = 172 pitches

Testing Accuracy: 68.02%



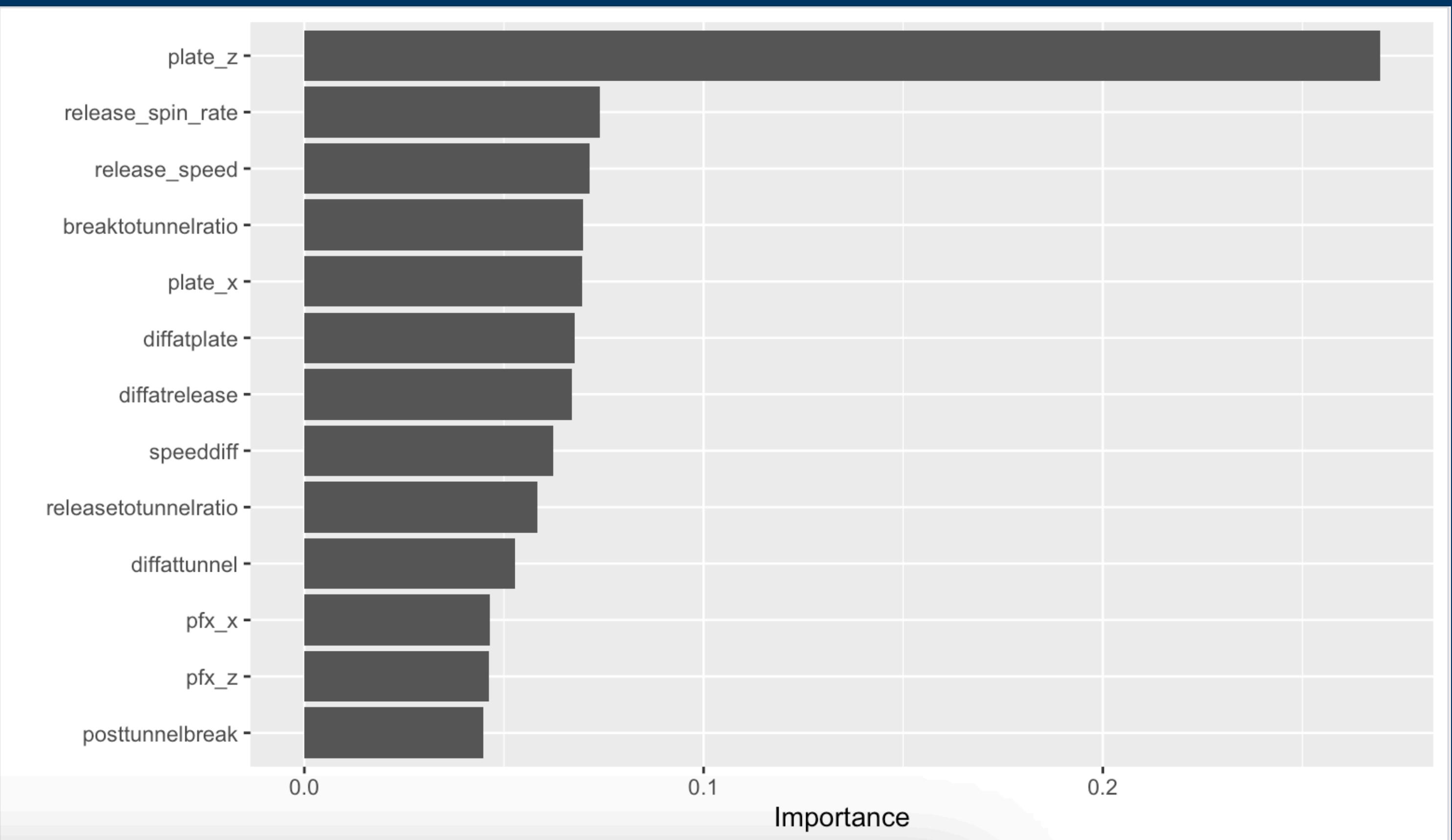
Left Handed Pitchers vs Left Handed Hitters

Cutter -> Changeup | LHP -> LHH | Whiff

Training Sample: n = 244 pitches

Testing Sample: n = 106 pitches

Testing Accuracy: 71.7%

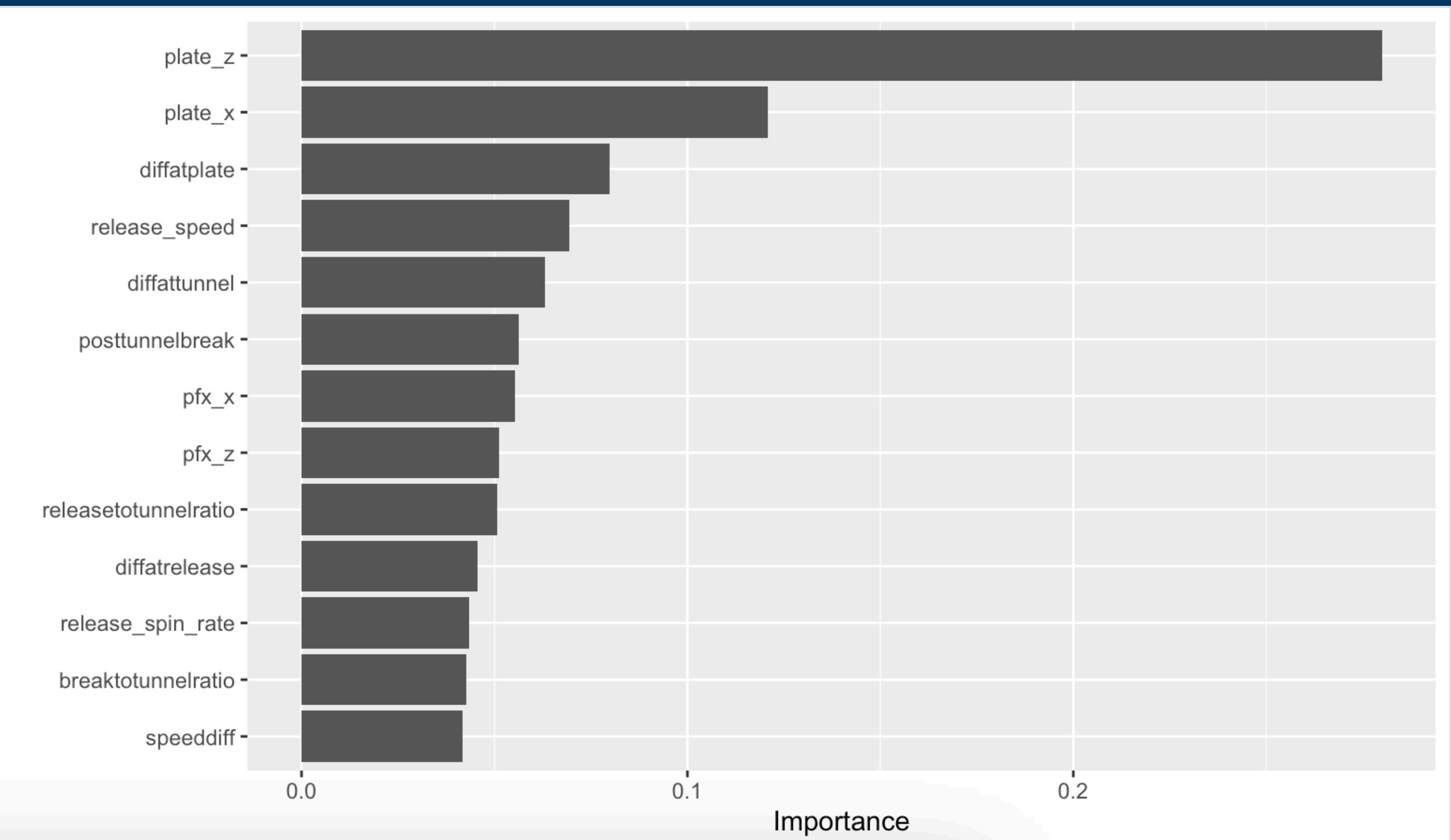


Cutter -> Curveball | LHP -> LHH | Whiff

Training Sample: n = 384 pitches

Testing Sample: n = 166 pitches

Testing Accuracy: 69.28%

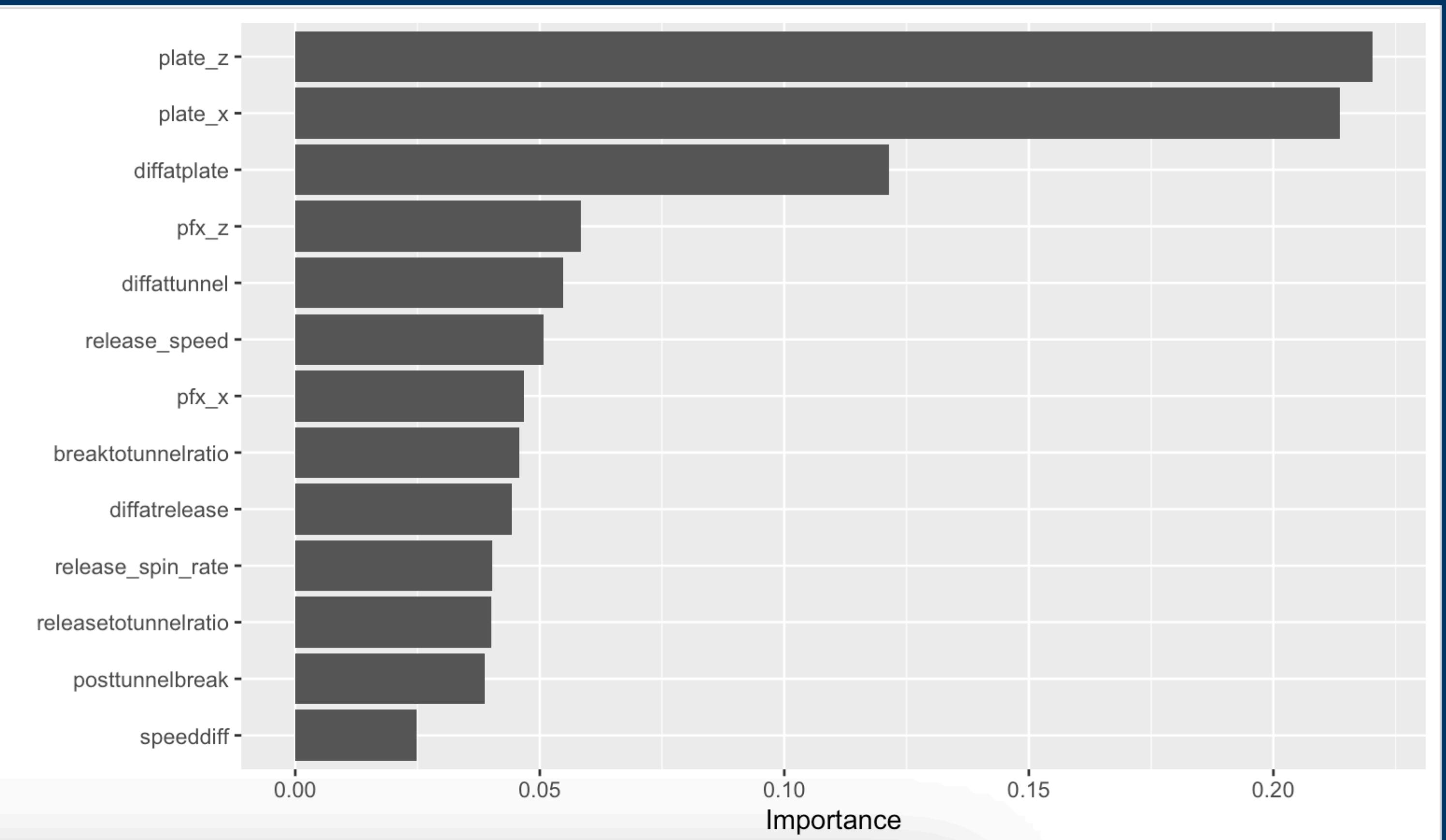


Cutter -> Curveball | LHP -> LHH | Chase

Training Sample: n = 508 pitches

Testing Sample: n = 218 pitches

Testing Accuracy: 70.64%

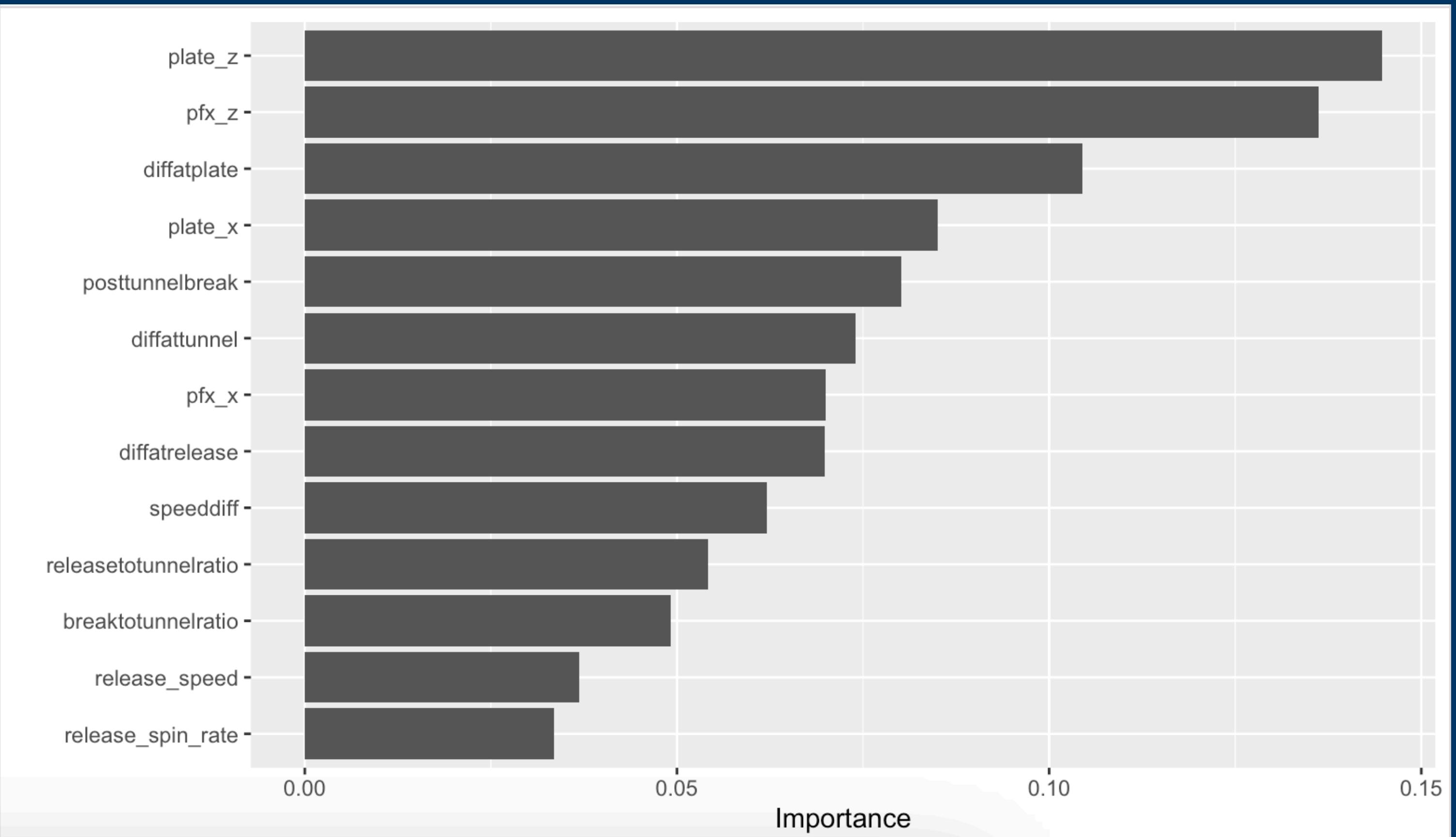


Cutter -> Curveball | LHP -> LHH | Groundball

Training Sample: n = 192 pitches

Testing Sample: n = 84 pitches

Testing Accuracy: 69.05%

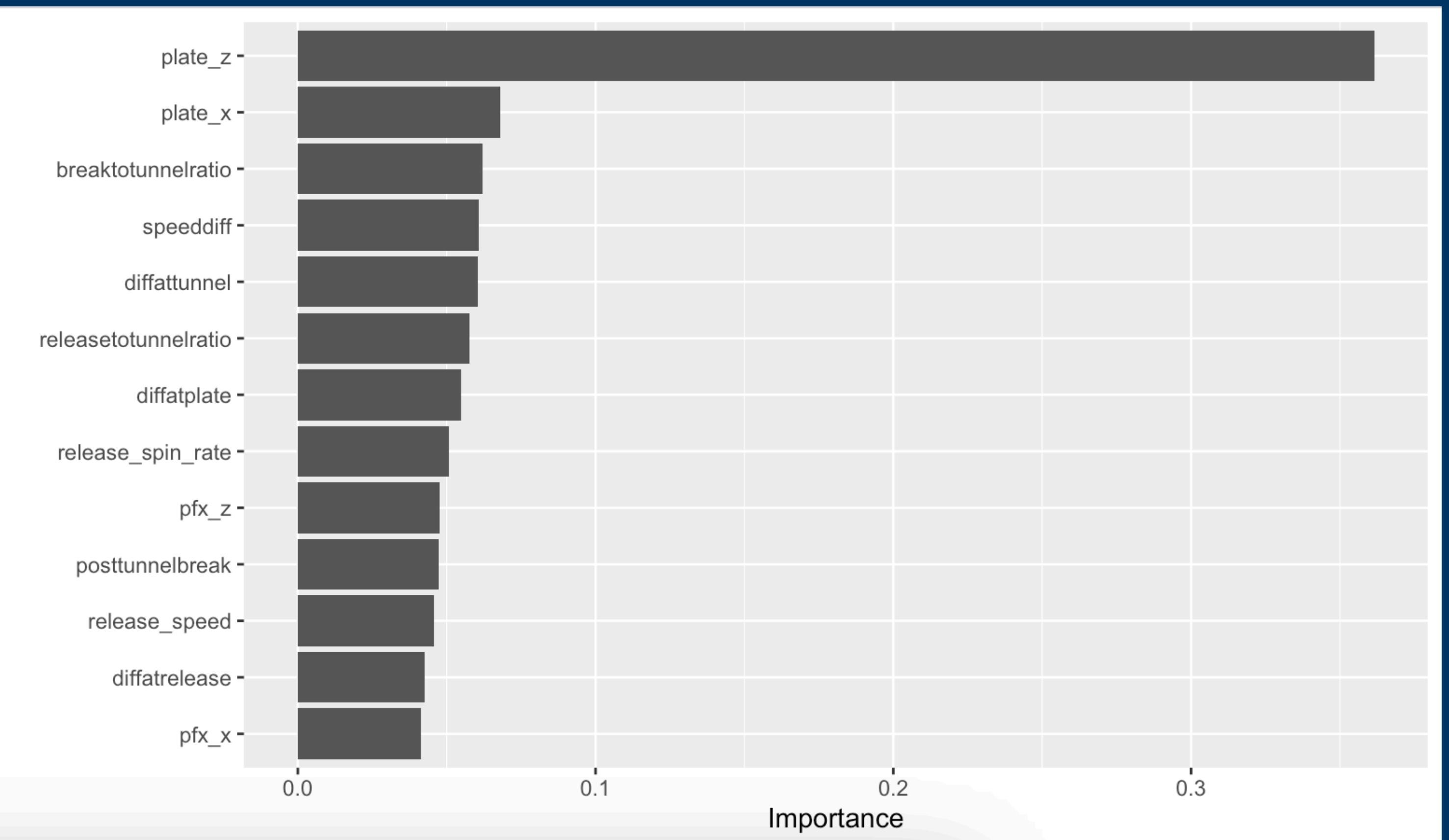


Four-Seam -> Changeup | LHP -> LHH | Whiff

Training Sample: n = 1054 pitches

Testing Sample: n = 452 pitches

Testing Accuracy: 70.13%

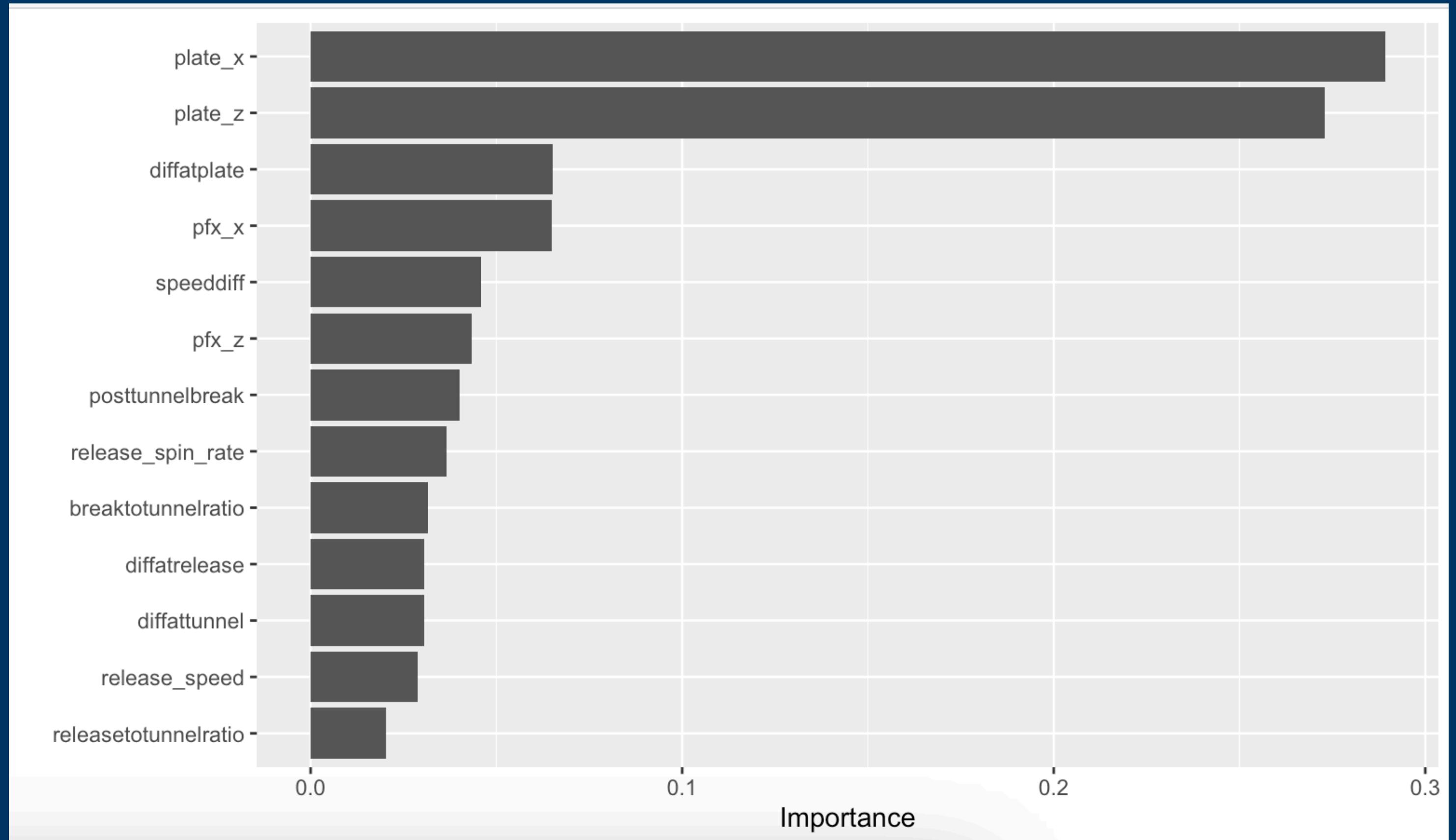


Four-Seam -> Changeup | LHP -> LHH | Chase

Training Sample: n = 1348 pitches

Testing Sample: n = 580 pitches

Testing Accuracy: 70.86%

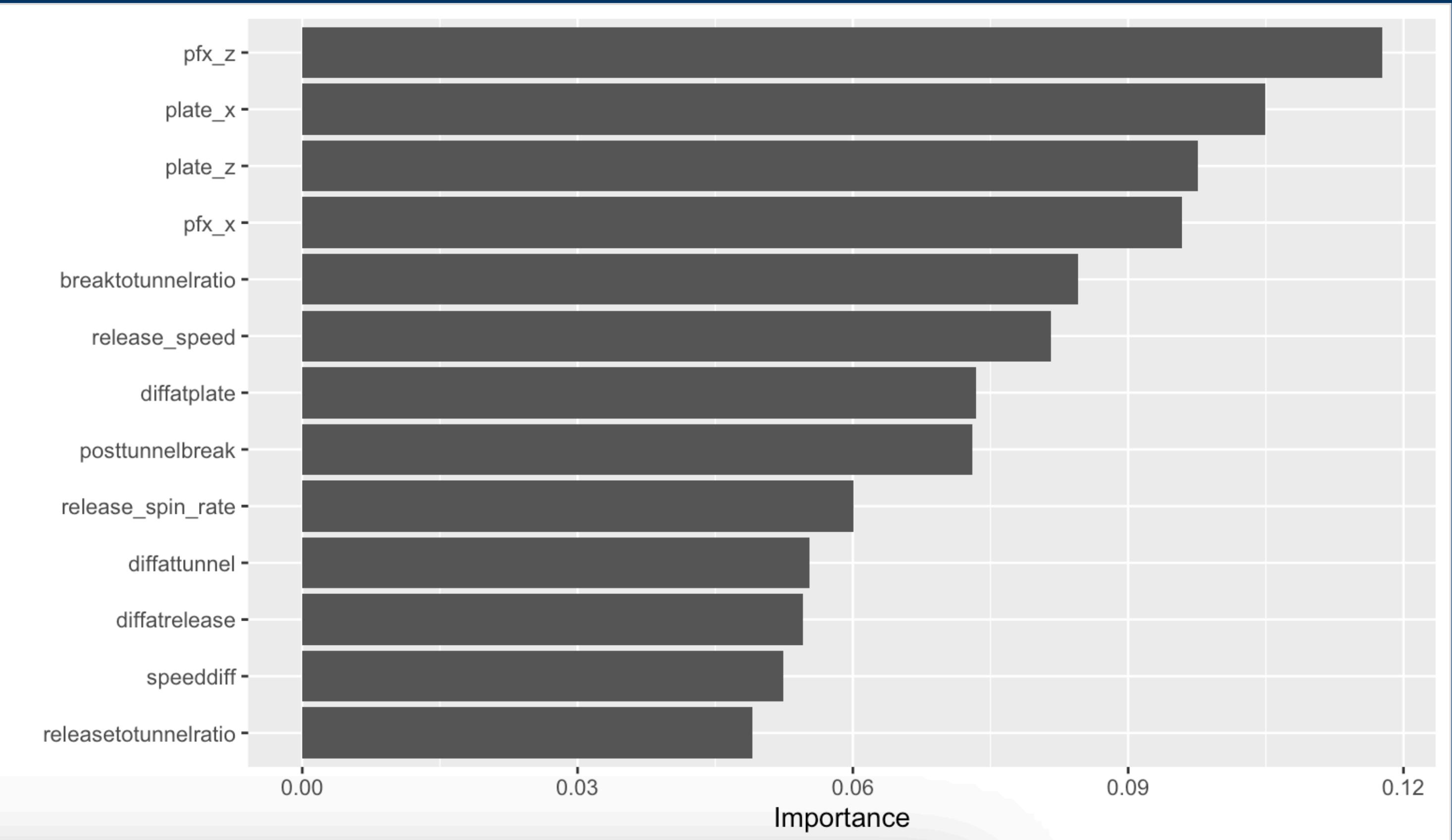


Four-Seam -> Changeup | LHP -> LHH | Groundball

Training Sample: n = 496 pitches

Testing Sample: n = 214 pitches

Testing Accuracy: 63.08%

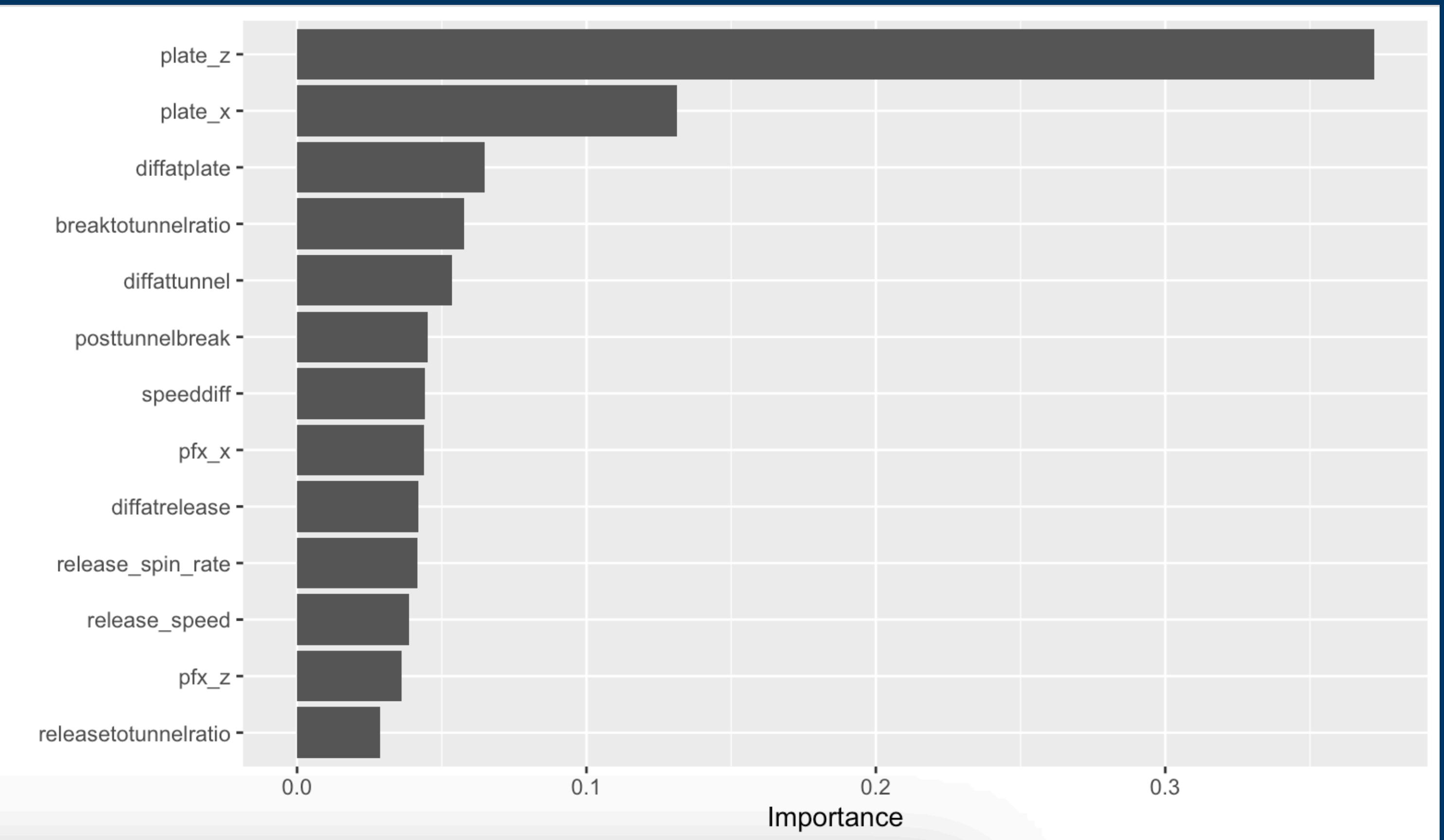


Four-Seam -> Curveball | LHP -> LHH | Whiff

Training Sample: n = 1728 pitches

Testing Sample: n = 742 pitches

Testing Accuracy: 71.7%

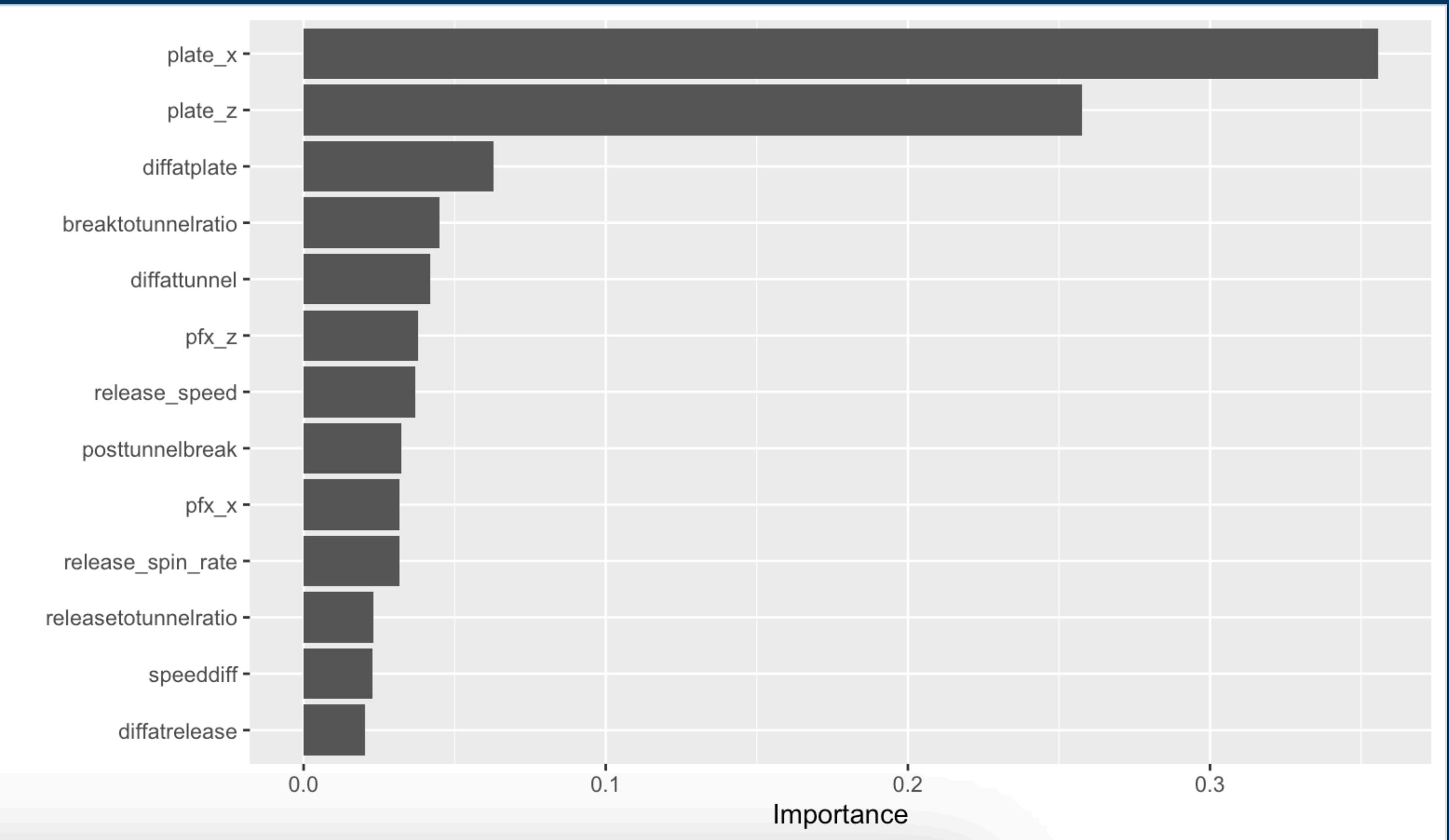


Four-Seam -> Curveball | LHP -> LHH | Chase

Training Sample: n = 2534 pitches

Testing Sample: n = 1086 pitches

Testing Accuracy: 71.09%

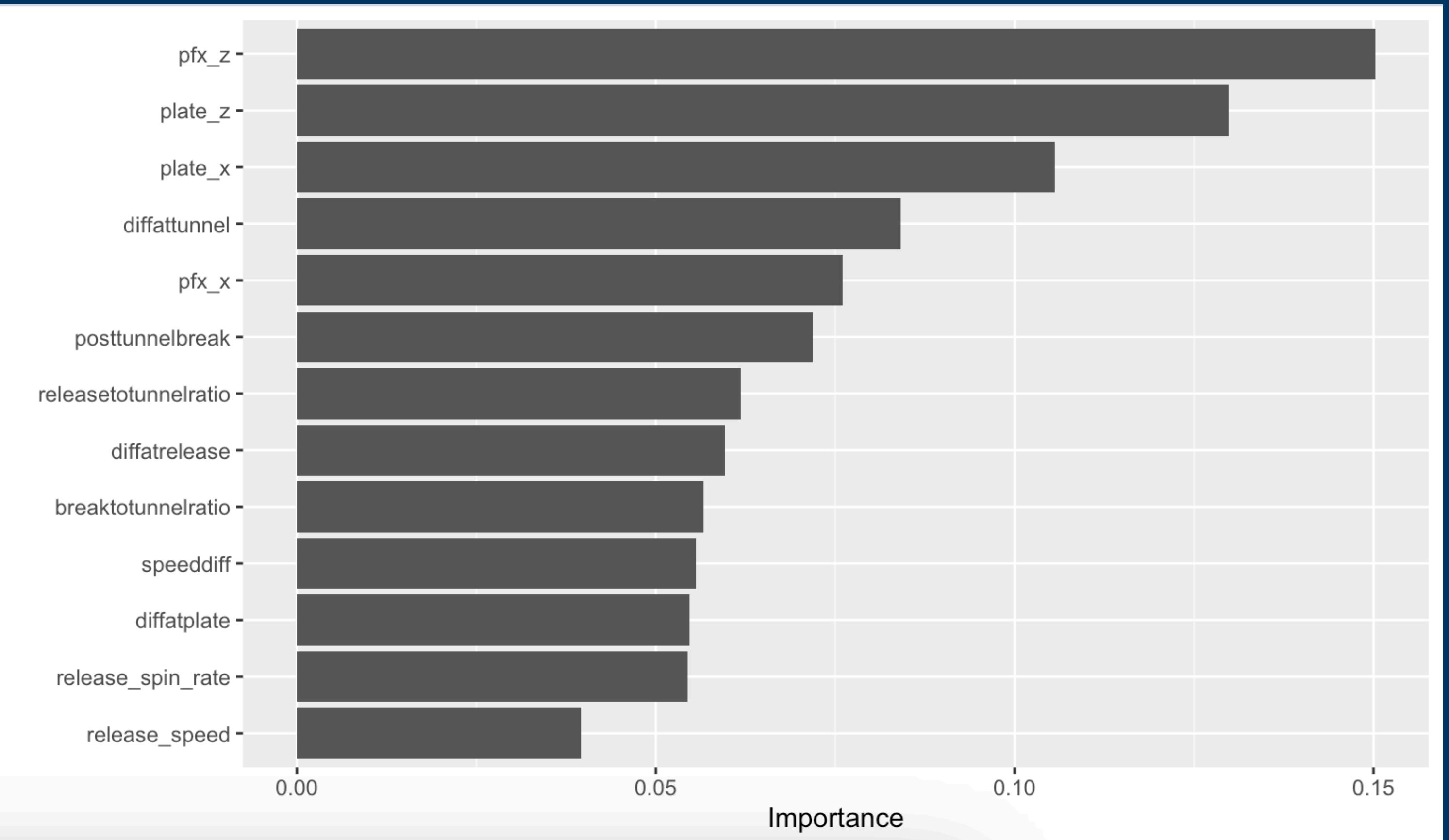


Four-Seam -> Curveball | LHP -> LHH | Groundball

Training Sample: n = 1206 pitches

Testing Sample: n = 518 pitches

Testing Accuracy: 60.23%

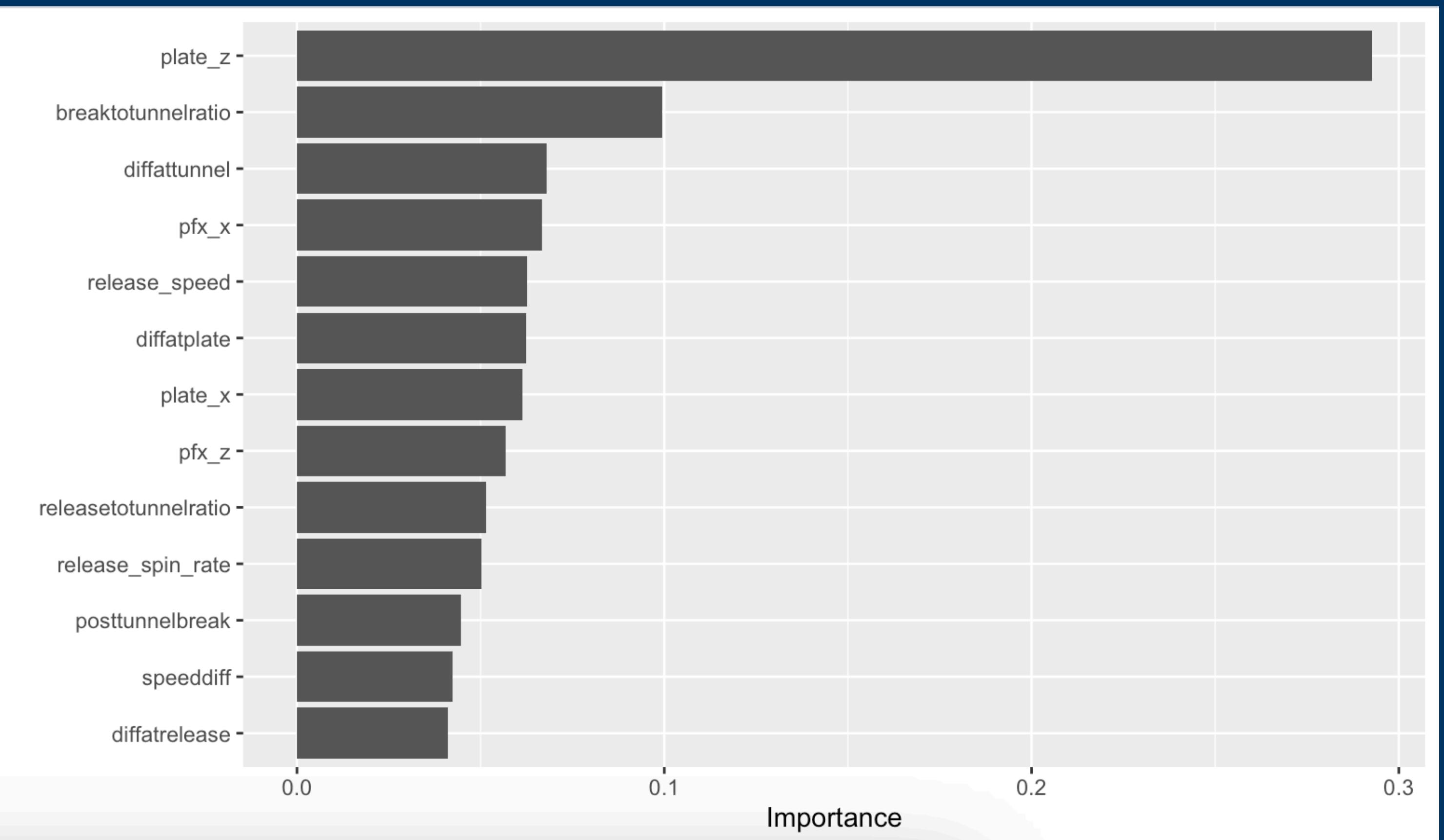


Four-Seam -> Knuckle Curve | LHP -> LHH | Whiff

Training Sample: n = 274 pitches

Testing Sample: n = 118 pitches

Testing Accuracy: 69.49%

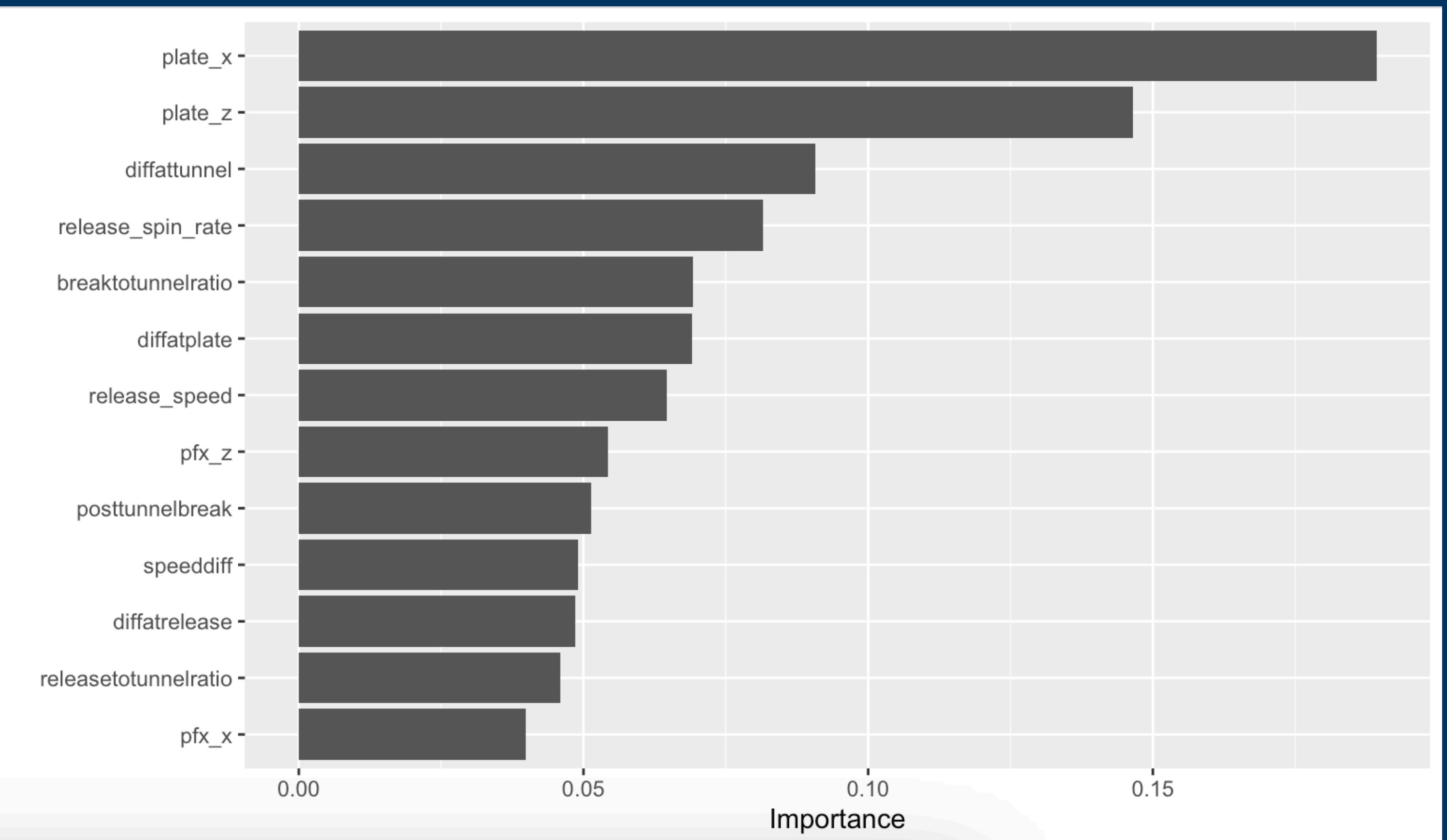


Four-Seam -> Knuckle Curve | LHP -> LHH | Chase

Training Sample: n = 432 pitches

Testing Sample: n = 186 pitches

Testing Accuracy: 67.74%

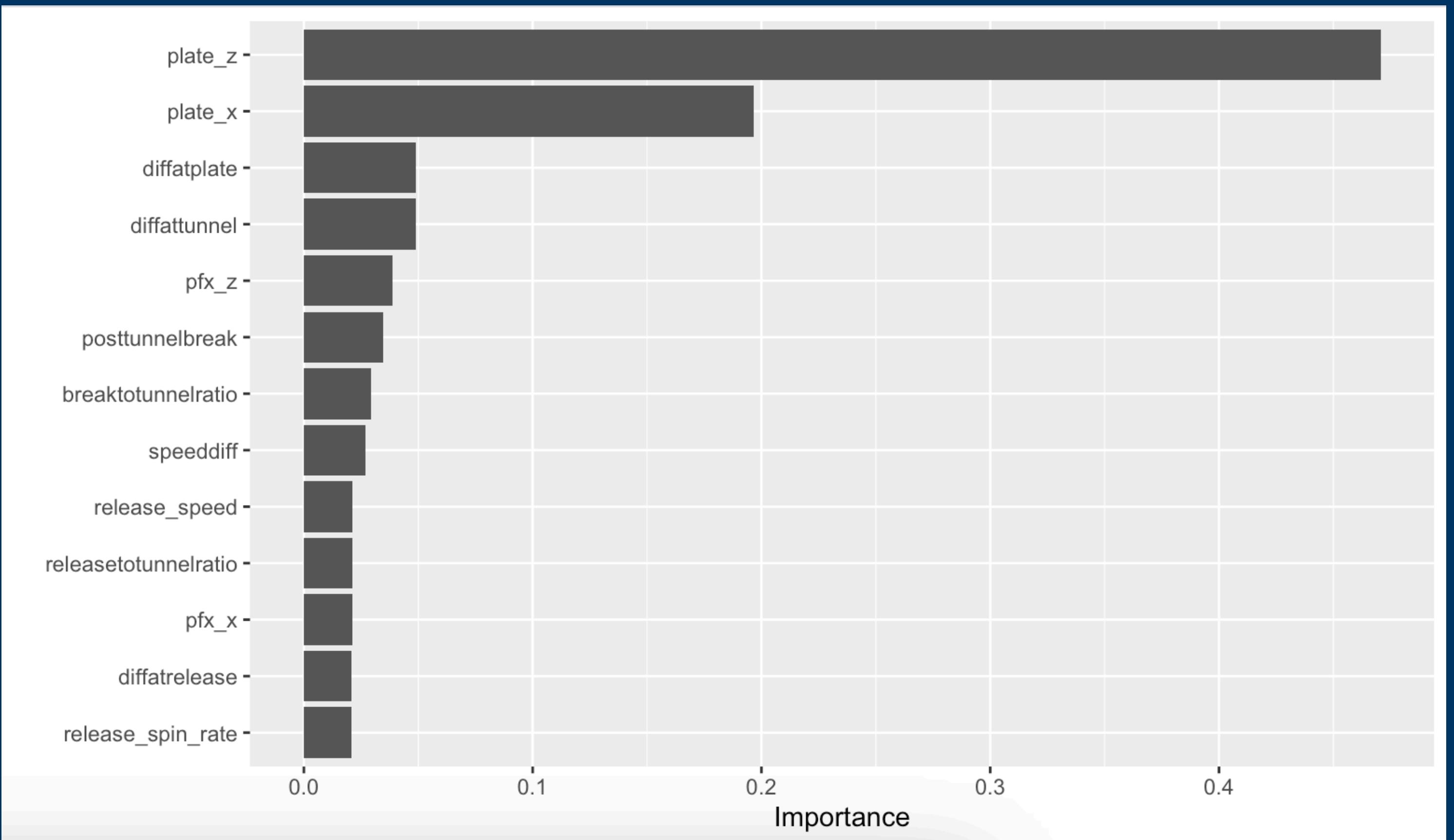


Four-Seam -> Slider | LHP -> LHH | Whiff

Training Sample: n = 5220 pitches

Testing Sample: n = 2238 pitches

Testing Accuracy: 69.57%

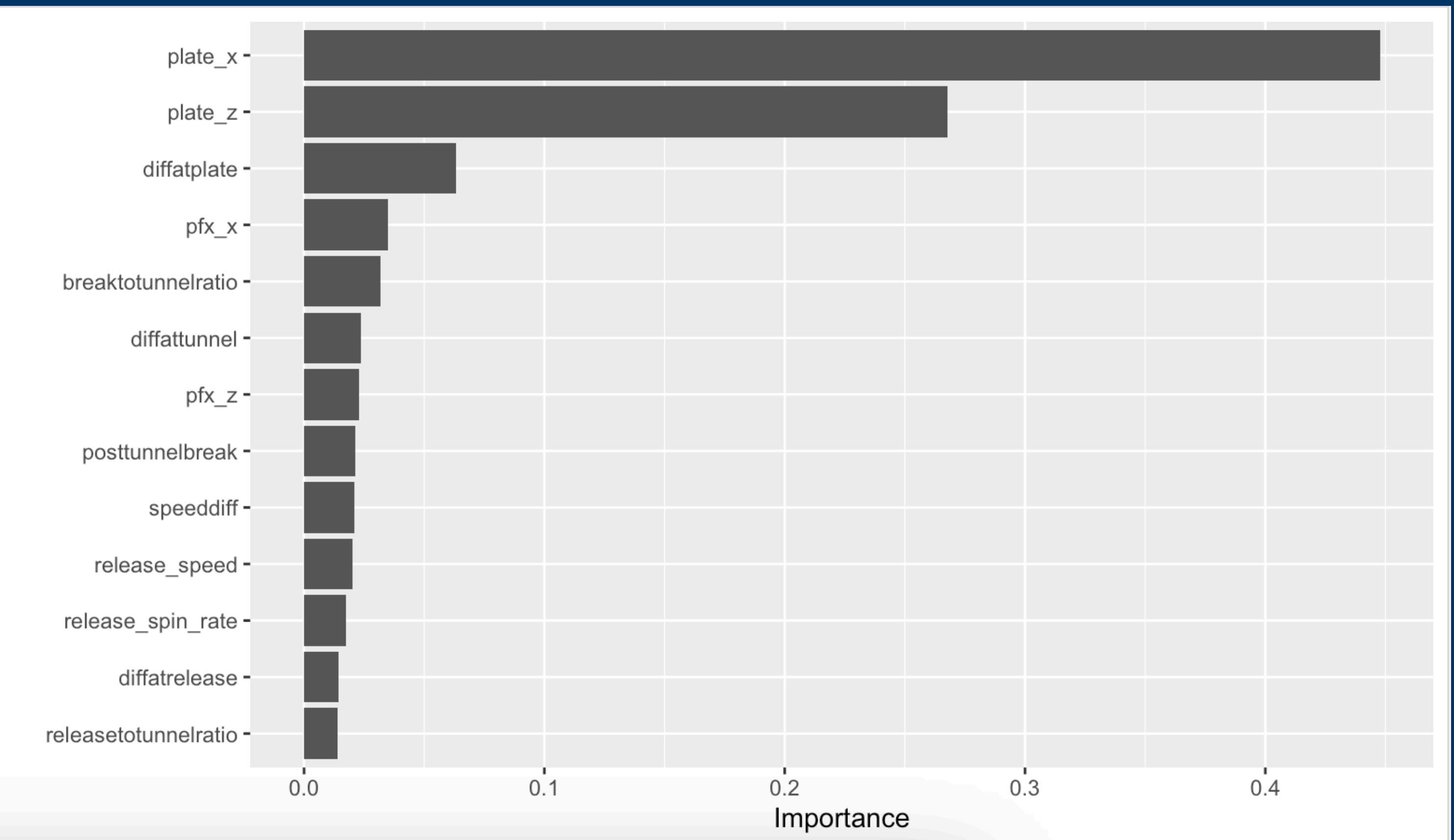


Four-Seam -> Slider | LHP -> LHH | Chase

Training Sample: n = 6570 pitches

Testing Sample: n = 2816 pitches

Testing Accuracy: 68.36%

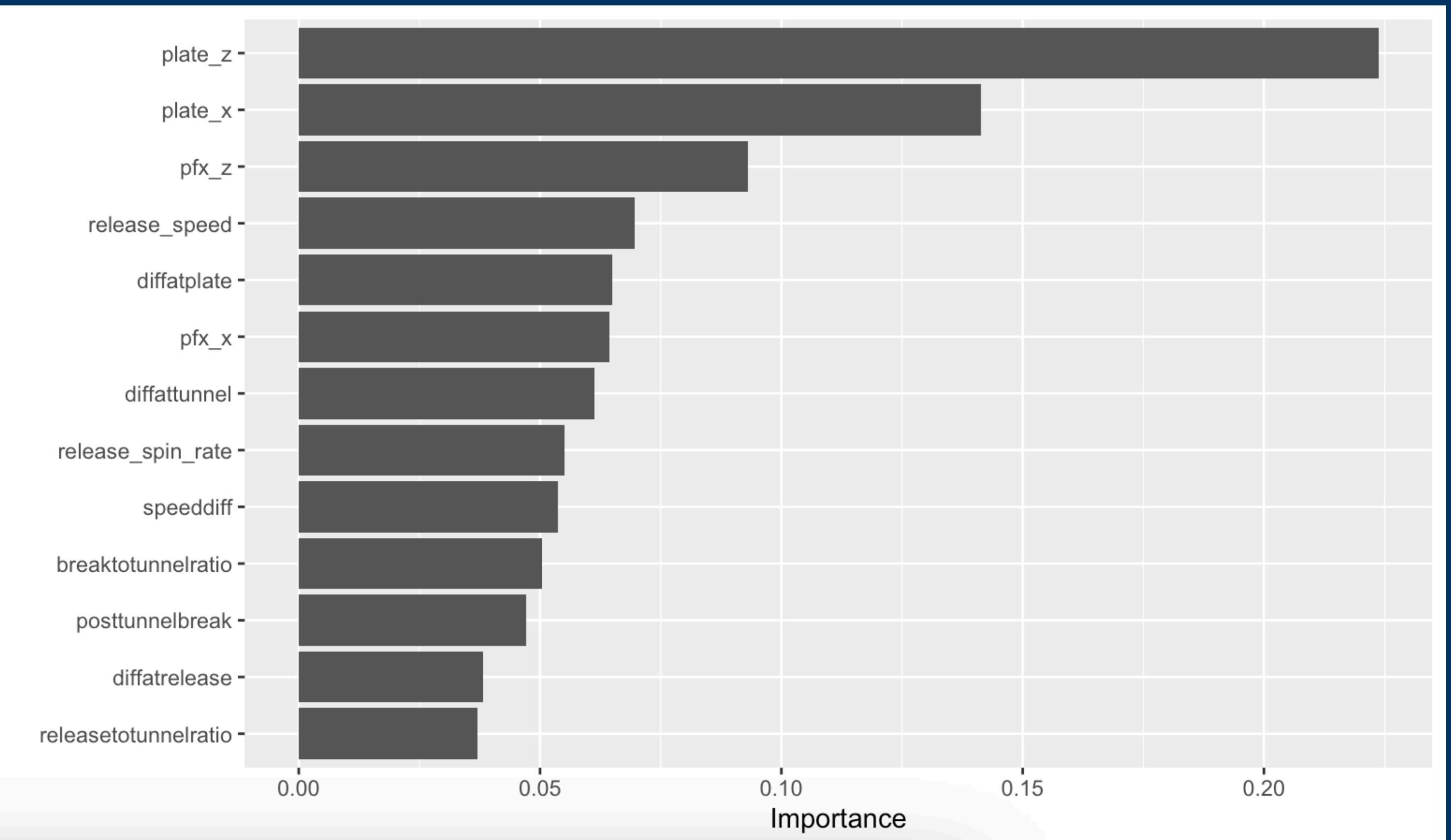


Four-Seam -> Slider | LHP -> LHH | Groundball

Training Sample: n = 2738 pitches

Testing Sample: n = 1174 pitches

Testing Accuracy: 62.18%

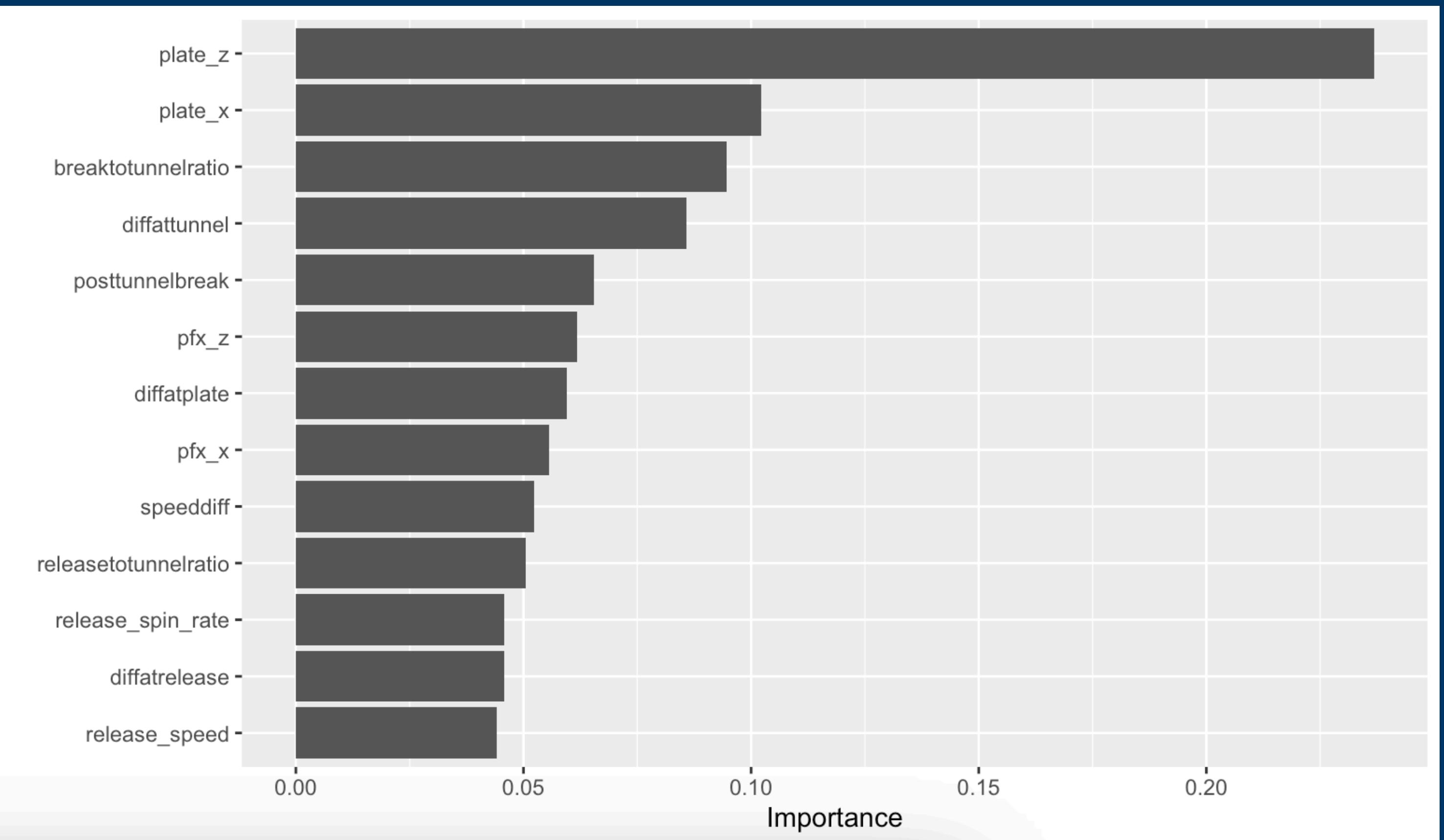


Four-Seam -> Sweeper | LHP -> LHH | Whiff

Training Sample: n = 360 pitches

Testing Sample: n = 156 pitches

Testing Accuracy: 67.95%

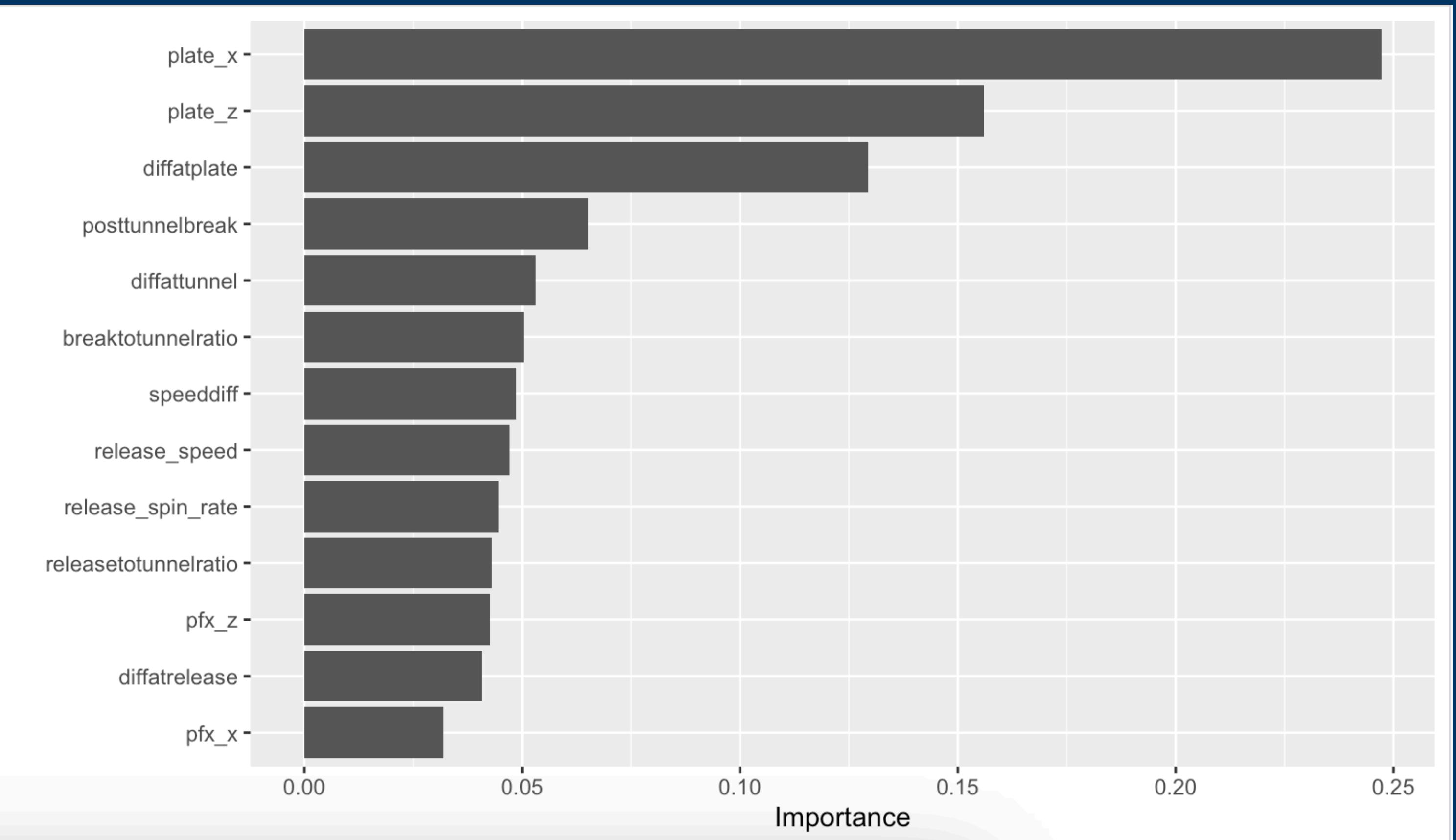


Four-Seam -> Sweeper | LHP -> LHH | Chase

Training Sample: n = 452 pitches

Testing Sample: n = 196 pitches

Testing Accuracy: 71.94%

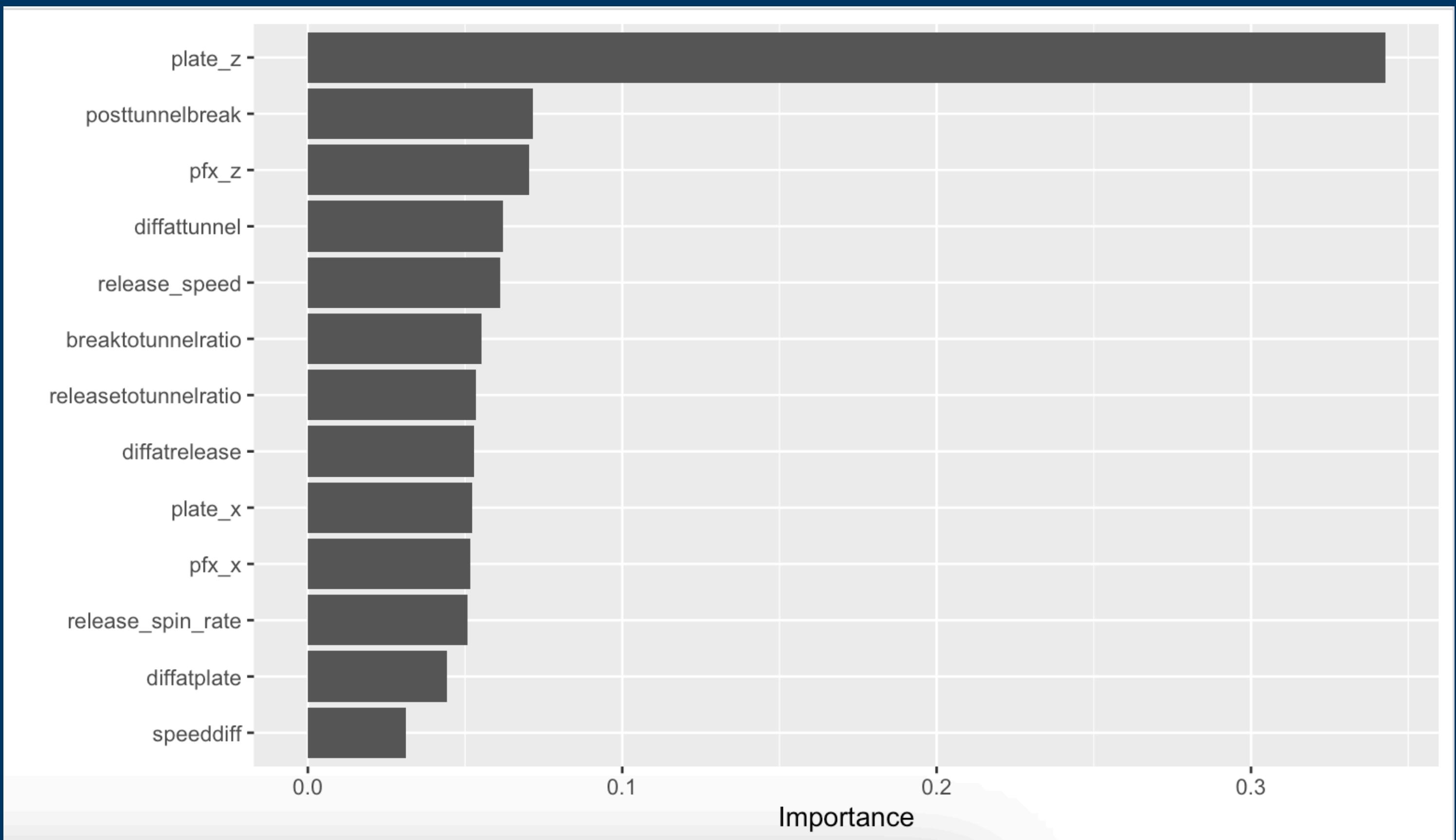


Sinker -> Changeup | LHP -> LHH | Whiff

Training Sample: n = 1006 pitches

Testing Sample: n = 434 pitches

Testing Accuracy: 63.13%

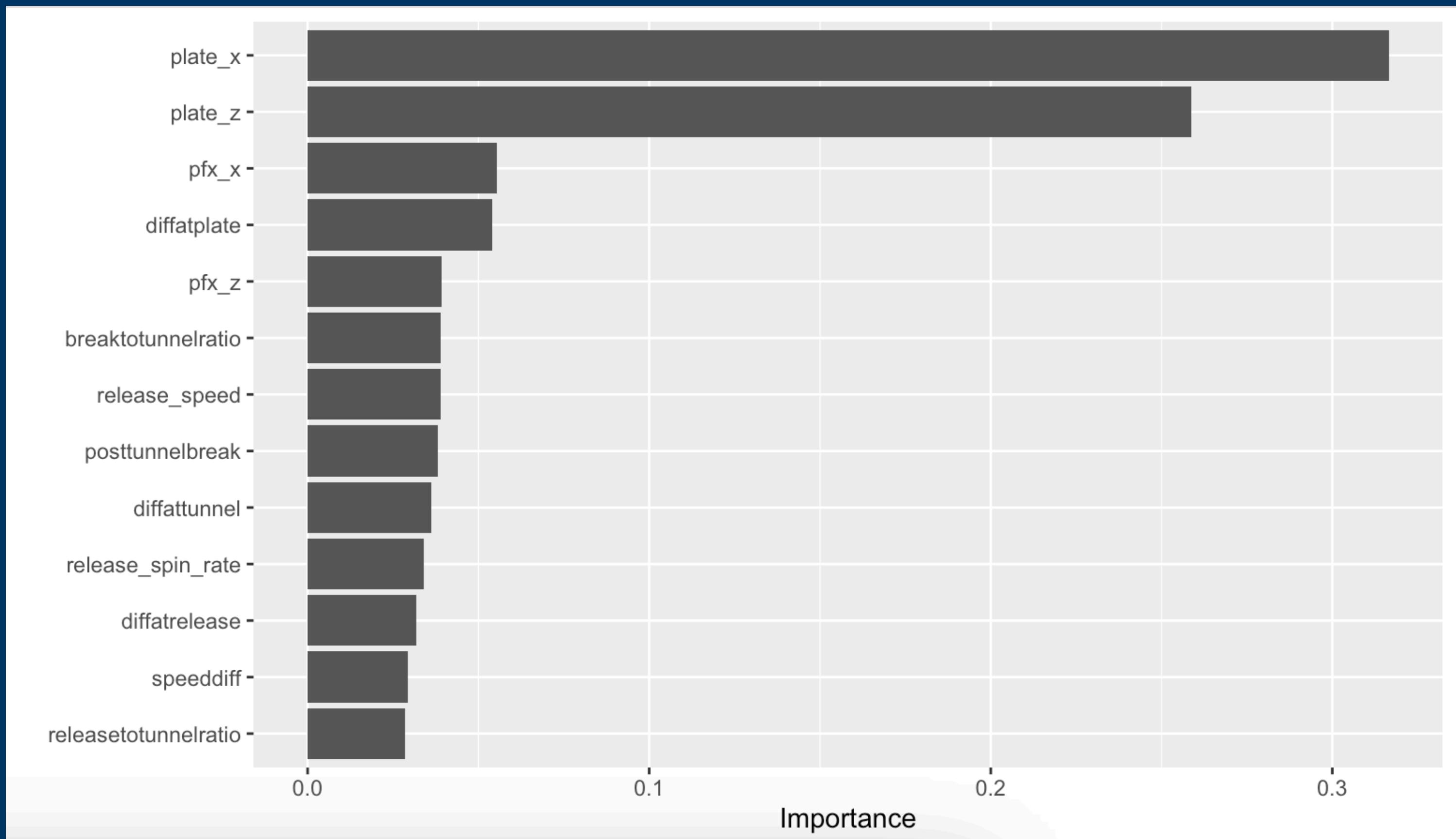


Sinker -> Changeup | LHP -> LHH | Chase

Training Sample: n = 1362 pitches

Testing Sample: n = 586 pitches

Testing Accuracy: 69.62%

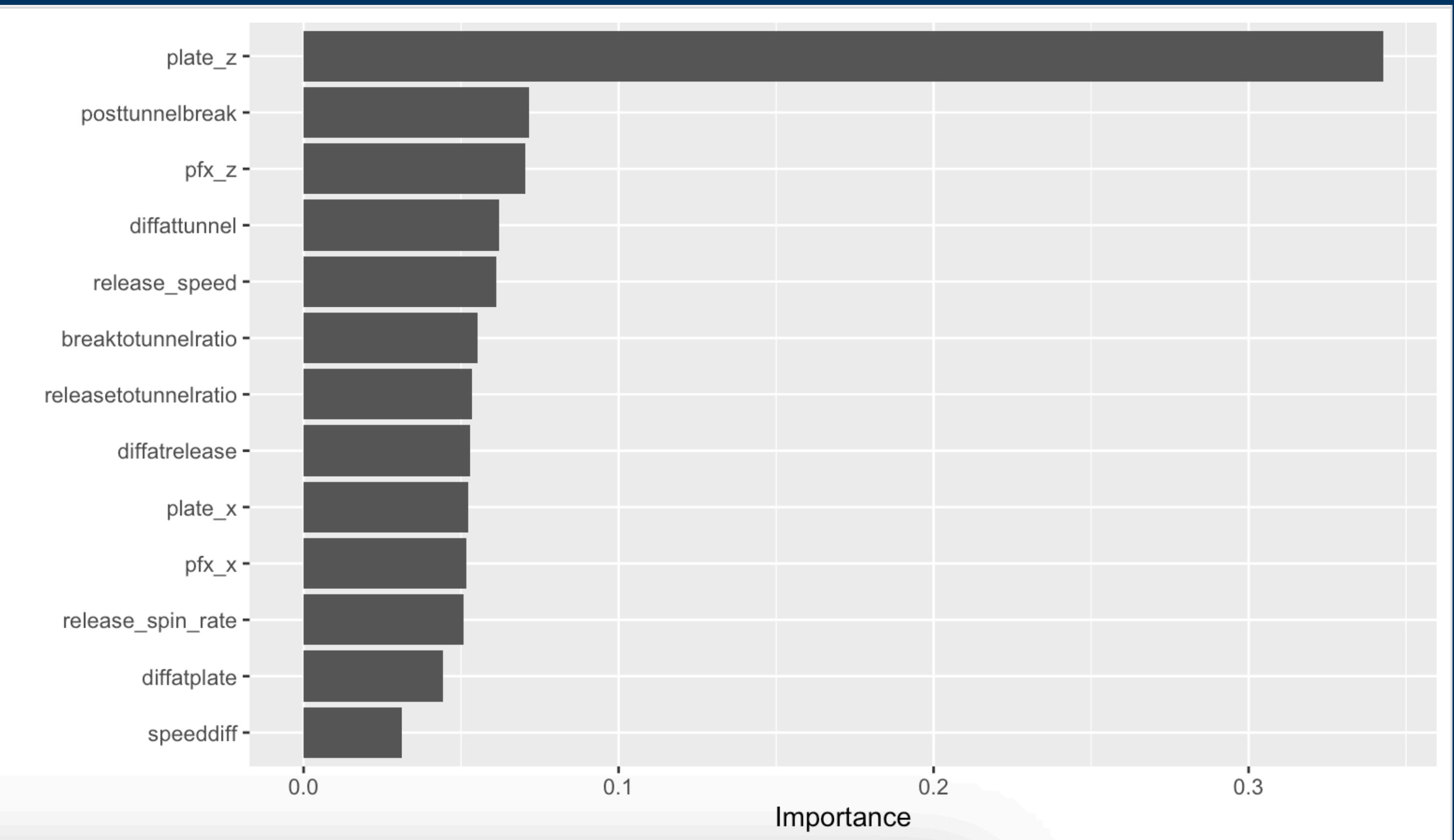


Sinker -> Curveball | LHP -> LHH | Whiff

Training Sample: n = 1006 pitches

Testing Sample: n = 434 pitches

Testing Accuracy: 63.13%

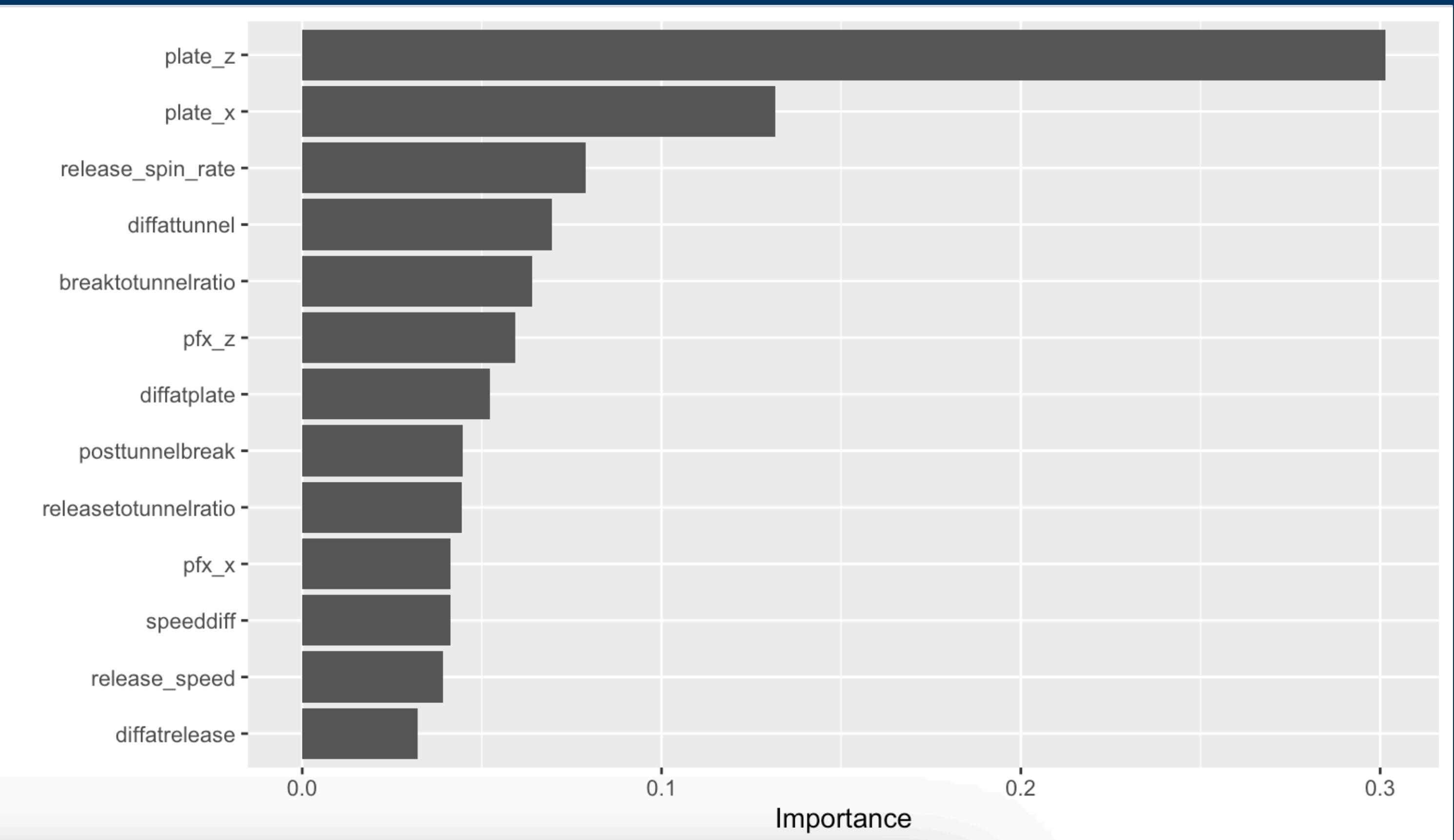


Sinker -> Curveball | LHP -> LHH | Chase

Training Sample: n = 1432 pitches

Testing Sample: n = 614 pitches

Testing Accuracy: 70.85%

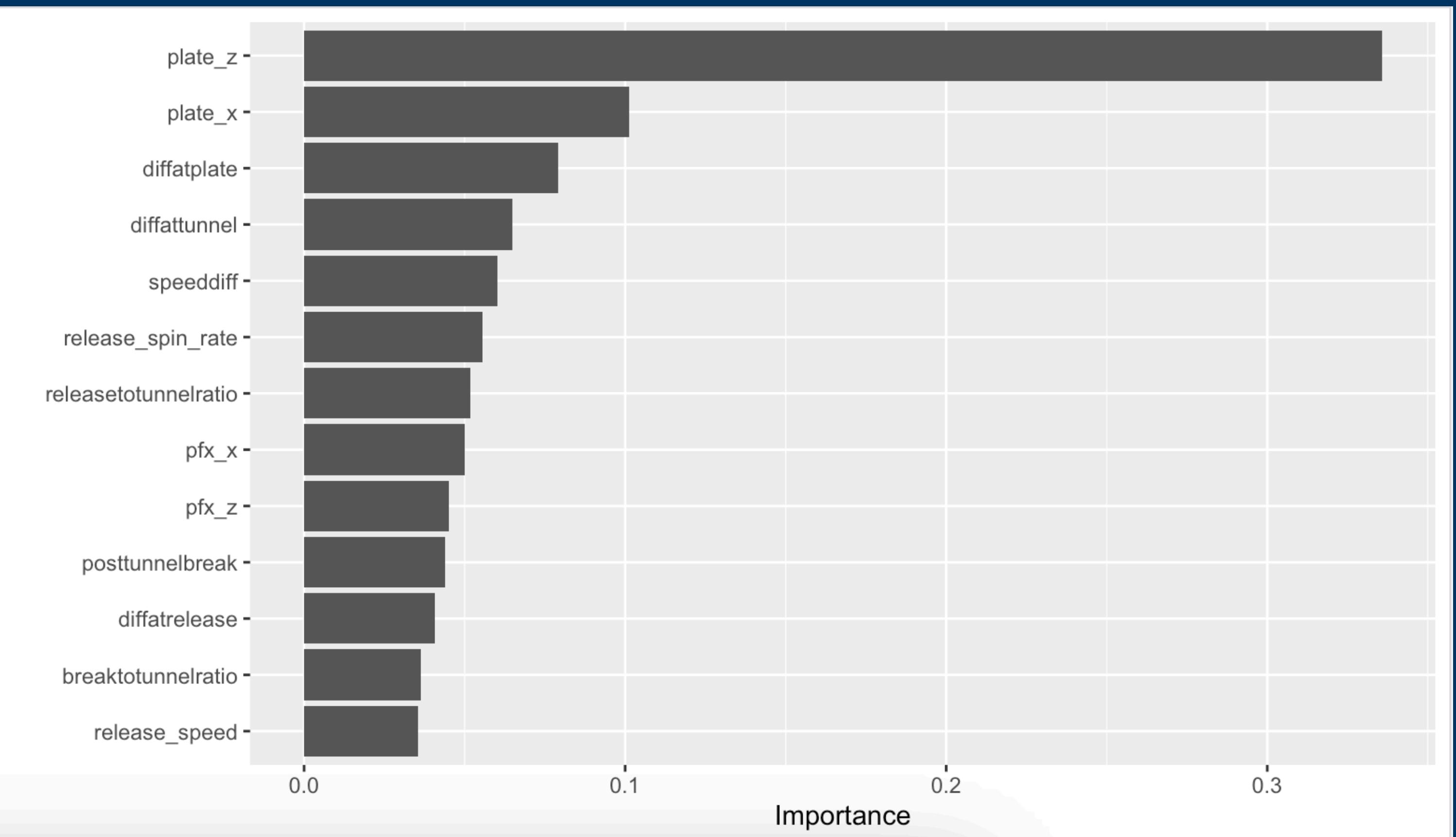


Sinker -> Knuckle Curve | LHP -> LHH | Whiff

Training Sample: n = 280 pitches

Testing Sample: n = 122 pitches

Testing Accuracy: 77.05%

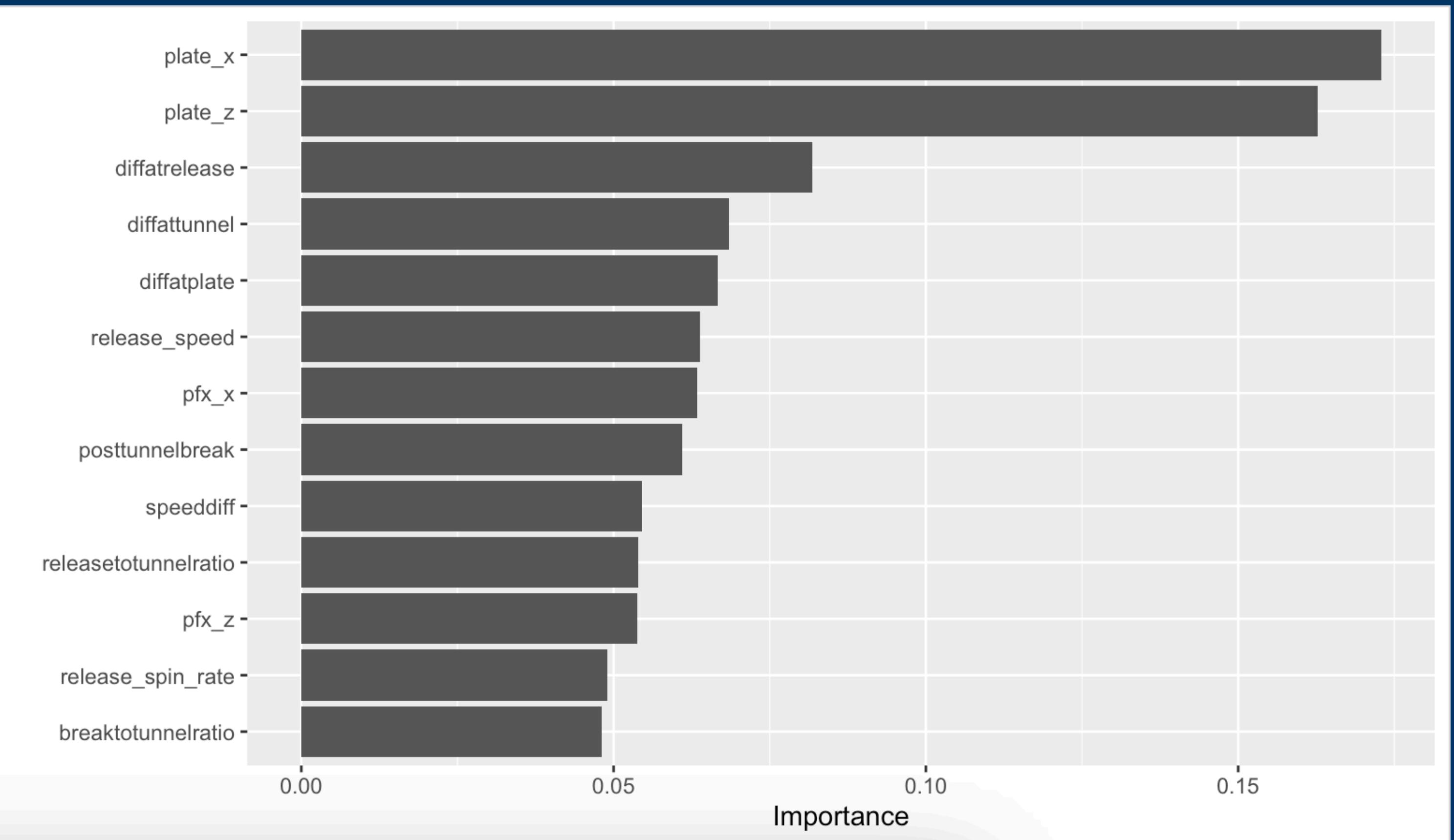


Sinker -> Knuckle Curve | LHP -> LHH | Chase

Training Sample: n = 436 pitches

Testing Sample: n = 188 pitches

Testing Accuracy: 64.36%

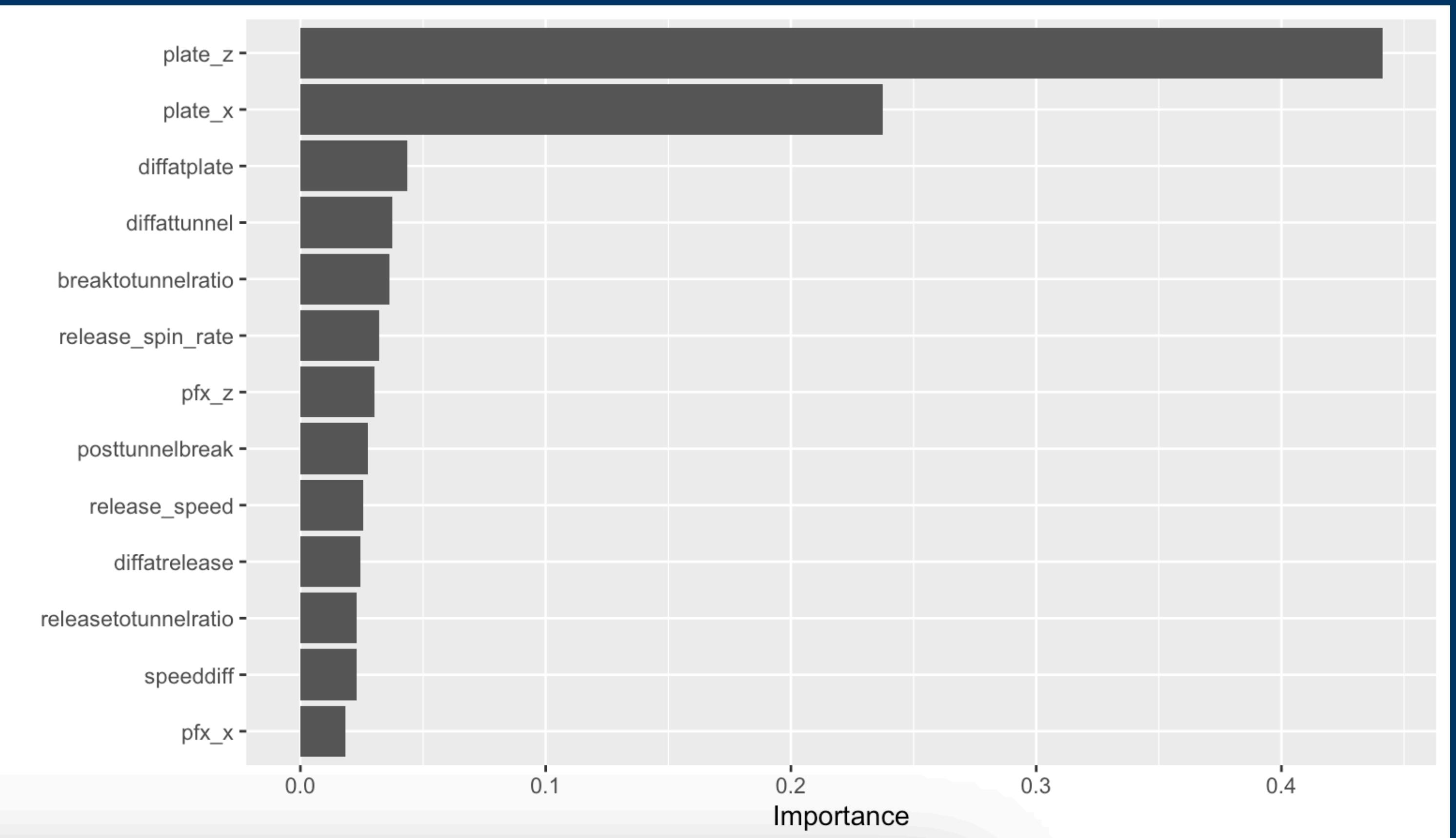


Sinker -> Slider | LHP -> LHH | Whiff

Training Sample: n = 3022 pitches

Testing Sample: n = 1296 pitches

Testing Accuracy: 70.29%

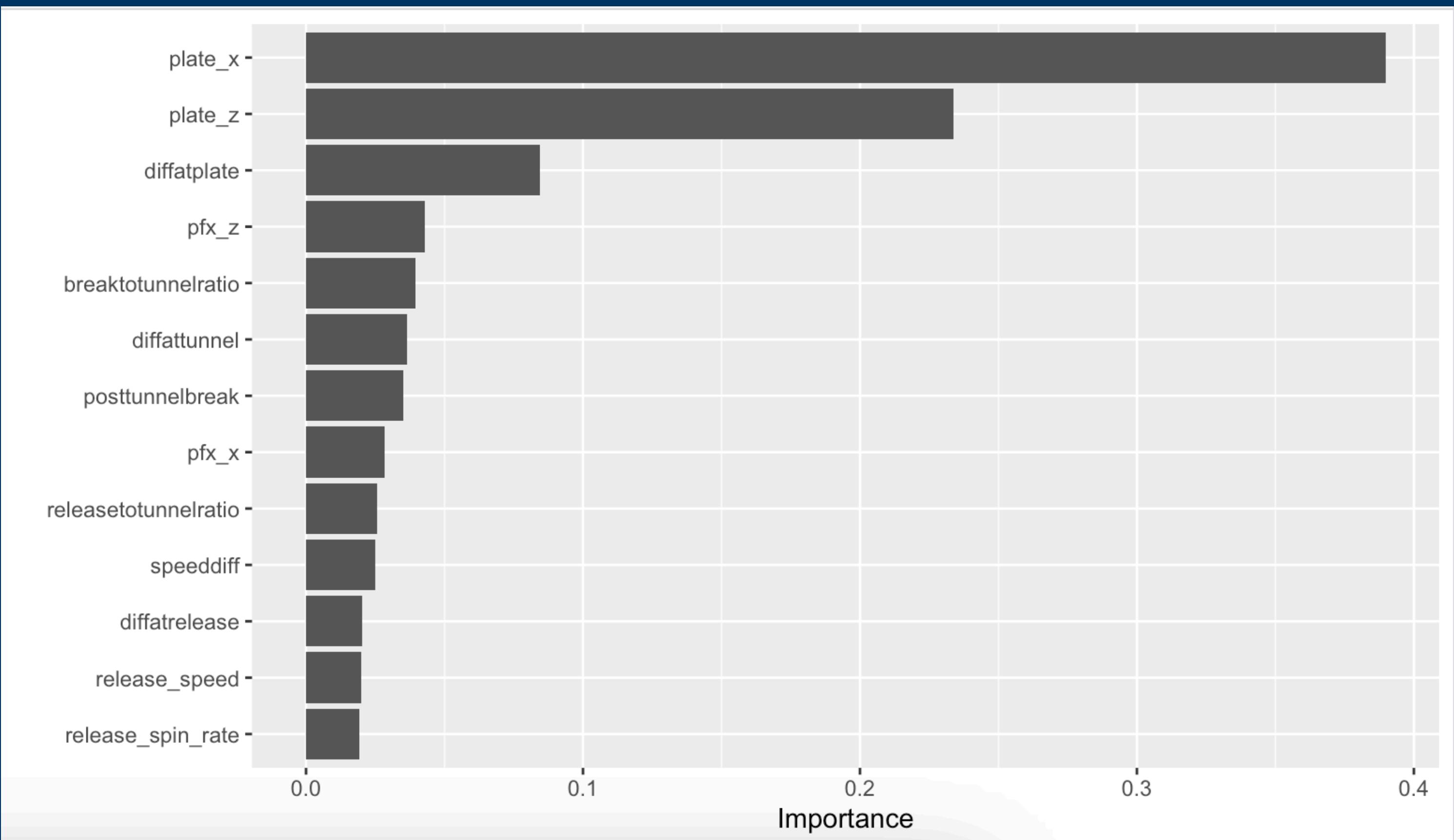


Sinker -> Slider | LHP -> LHH | Chase

Training Sample: n = 3714 pitches

Testing Sample: n = 1592 pitches

Testing Accuracy: 67.09%



Sinker -> Slider | LHP -> LHH | Groundball

Training Sample: n = 1386 pitches

Testing Sample: n = 596 pitches

Testing Accuracy: 60.57%

