

Space, Time, and Skill: Understanding High Performance Sport

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w/ Dan Cervone, Alex D'Amour, Alexander Franks,
Andrew Miller, and Kirk Goldsberry

The State of Defensive Analytics

Totals

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Rk	Player	Pos	Age	Tm	G	GS	MP	FG	FGA	FG%	3P	3PA	3P	2P	2PA	2P	eFG%	FT	FTA	FT%	ORB	DRB	TRB	AST	STL	BLK	TOV	PF	PTS
1	Kevin Durant	SF	25	OKC	81	81	3122	849	1688	.503	192	491	.391	657	1197	.549	.560	703	805	.873	58	540	598	445	103	59	285	174	2593
2	Carmelo Anthony	PF	29	NYK	77	77	2982	743	1643	.452	167	415	.402	576	1228	.469	.503	459	541	.848	145	477	622	242	95	51	198	224	2112
3	LeBron James	PF	29	MIA	77	77	2902	767	1353	.567	116	306	.379	651	1047	.622	.610	439	585	.750	81	452	533	488	121	26	270	126	2089
4	Kevin Love	PF	25	MIN	77	77	2797	650	1421	.457	190	505	.376	460	916	.502	.524	520	633	.821	224	739	963	341	59	35	196	136	2010
5	Blake Griffin	PF	24	LAC	80	80	2863	718	1359	.528	12	44	.273	706	1315	.537	.533	482	674	.715	192	565	757	309	92	51	224	265	1930
6	Stephen Curry	PG	25	GSW	78	78	2846	652	1383	.471	261	615	.424	391	768	.509	.566	308	348	.885	46	288	334	666	128	14	294	194	1873
7	James Harden	SG	24	HOU	73	73	2777	549	1205	.456	177	483	.366	372	722	.515	.529	576	665	.866	61	283	344	446	115	29	265	177	1851
8	DeMar DeRozan	SG	24	TOR	79	79	3017	604	1407	.429	64	210	.305	540	1197	.451	.452	519	630	.824	51	292	343	313	86	28	176	197	1791
9	Paul George	SF	23	IND	80	80	2898	577	1362	.424	182	500	.364	395	862	.458	.490	401	464	.864	64	478	542	283	151	22	224	198	1737
10	Dirk Nowitzki	PF	35	DAL	80	80	2628	633	1273	.497	131	329	.398	502	944	.532	.549	338	376	.899	40	458	498	216	73	45	117	165	1735
11	Damian Lillard	PG	23	POR	82	82	2937	553	1304	.424	218	554	.394	335	750	.447	.508	371	426	.871	35	253	288	457	64	22	193	197	1695
12	DeMarcus Cousins	C	23	SAC	71	71	2298	591	1191	.496	0	7	.000	591	1184	.499	.496	432	595	.726	218	613	831	207	109	91	251	270	1614
13	LaMarcus Aldridge	PF	28	POR	69	69	2498	652	1423	.458	3	15	.200	649	1408	.461	.459	296	360	.822	166	599	765	178	63	68	123	147	1603
14	Al Jefferson	C	29	CHA	73	73	2553	700	1376	.509	3	15	.200	697	1361	.512	.510	191	277	.690	156	636	792	155	67	79	124	176	1594
15	John Wall	PG	23	WAS	82	82	2980	579	1337	.433	108	308	.351	471	1029	.458	.473	317	394	.805	38	295	333	721	149	40	295	219	1583
16	Monta Ellis	PG	28	DAL	82	82	3023	576	1278	.451	69	209	.330	507	1069	.474	.478	339	430	.788	38	257	295	471	141	23	264	197	1560
17	Goran Dragic	SG	27	PHO	76	75	2668	552	1093	.505	122	299	.408	430	794	.542	.561	316	416	.760	69	176	245	447	104	22	213	206	1542
18	Klay Thompson	SG	23	GSW	81	81	2868	559	1259	.444	223	535	.417	336	724	.464	.533	147	185	.795	38	211	249	181	74	37	135	234	1488
19	Kyrie Irving	PG	21	CLE	71	71	2496	532	1237	.430	123	344	.358	409	893	.458	.480	291	338	.861	52	207	259	433	108	23	190	163	1478
20	Isaiah Thomas	PG	24	SAC	72	54	2497	496	1096	.453	127	364	.349	369	732	.504	.510	346	407	.850	47	163	210	454	93	8	213	185	1465
21	Rudy Gay	SF	27	TOT	73	73	2531	537	1179	.455	65	197	.330	472	982	.481	.483	318	387	.822	113	324	437	209	95	56	224	171	1457
22	Kyle Lowry	PG	27	TOR	79	79	2862	457	1080	.423	190	500	.380	267	580	.460	.511	313	385	.813	88	281	369	586	121	15	194	267	1417
23	Thaddeus Young	PF	25	PHI	79	78	2718	582	1283	.454	90	292	.308	492	991	.496	.489	163	229	.712	166	310	476	182	167	36	165	213	1417
24	Anthony Davis	C	20	NOP	67	66	2358	522	1005	.519	2	9	.222	520	996	.522	.520	348	440	.791	207	466	673	105	89	189	109	200	1394
25	Jeff Green	SF	27	BOS	82	82	2805	482	1171	.412	135	396	.341	347	775	.448	.469	283	356	.795	54	326	380	138	57	47	165	180	1382
26	Zach Randolph	PF	32	MEM	79	79	2705	560	1198	.467	2	20	.100	558	1178	.474	.468	250	337	.742	265	530	795	200	54	23	183	210	1372
27	Wesley Matthews	SG	27	POR	82	82	2780	445	1009	.441	201	511	.393	244	498	.490	.541	252	301	.837	51	238	289	197	76	14	110	176	1343
28	Arron Afflalo	SG	28	ORL	73	73	2552	464	1011	.459	128	300	.427	336	711	.473	.522	274	336	.815	32	230	262	248	35	3	146	136	1330
29	Paul Millsap	PF	28	ATL	74	73	2482	483	1047	.461	76	212	.358	407	835	.487	.498	286	391	.731	154	473	627	232	129	78	185	210	1328
30	Jeff Teague	PG	25	ATL	79	79	2542	456	1040	.438	74	225	.329	382	815	.469	.474	318	376	.846	34	174	208	528	89	17	232	158	1304





GOAL: Correct the imbalance of defensive metrics in the NBA.

Shot Suppression



Shot Disruption

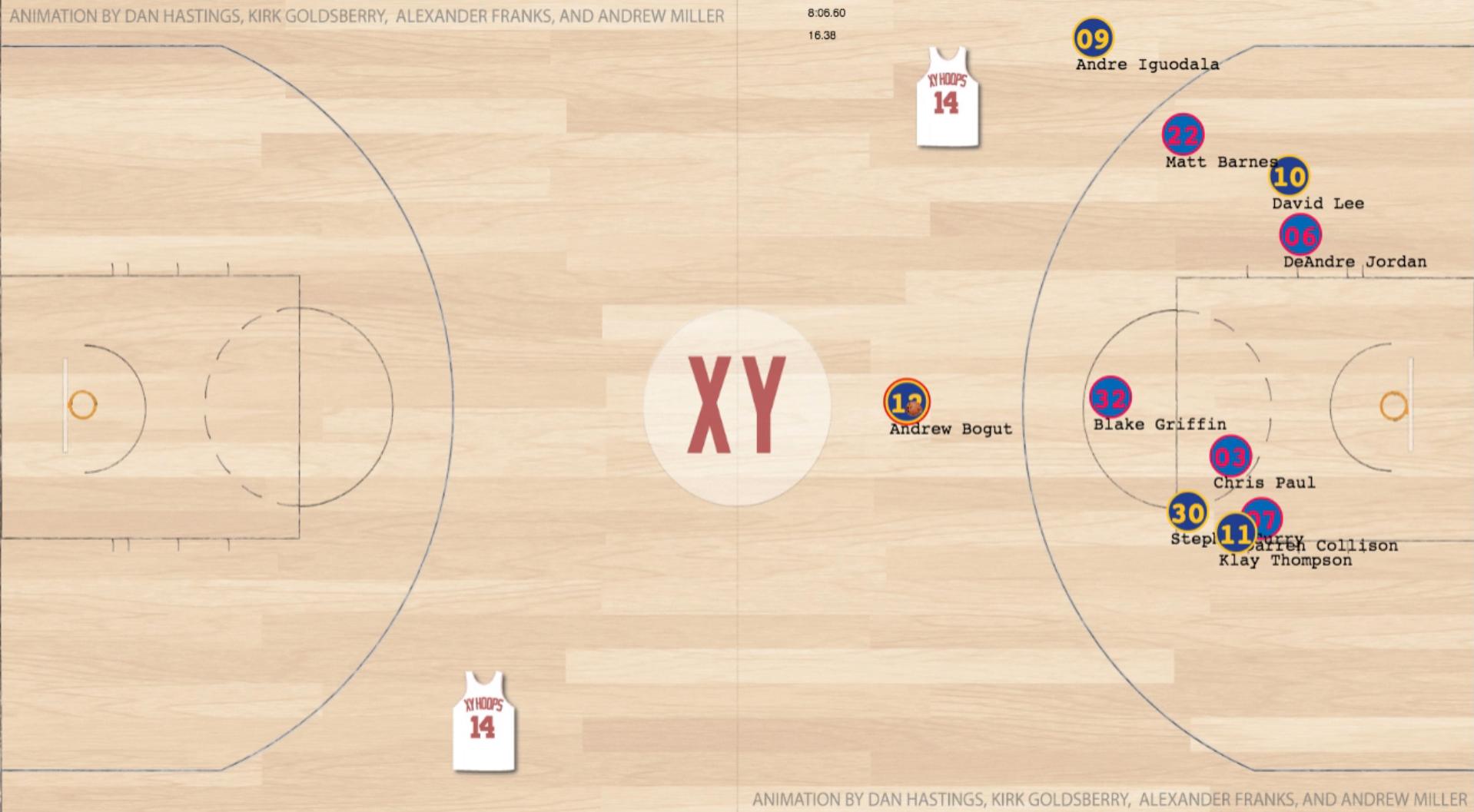


Contemporary Analytics

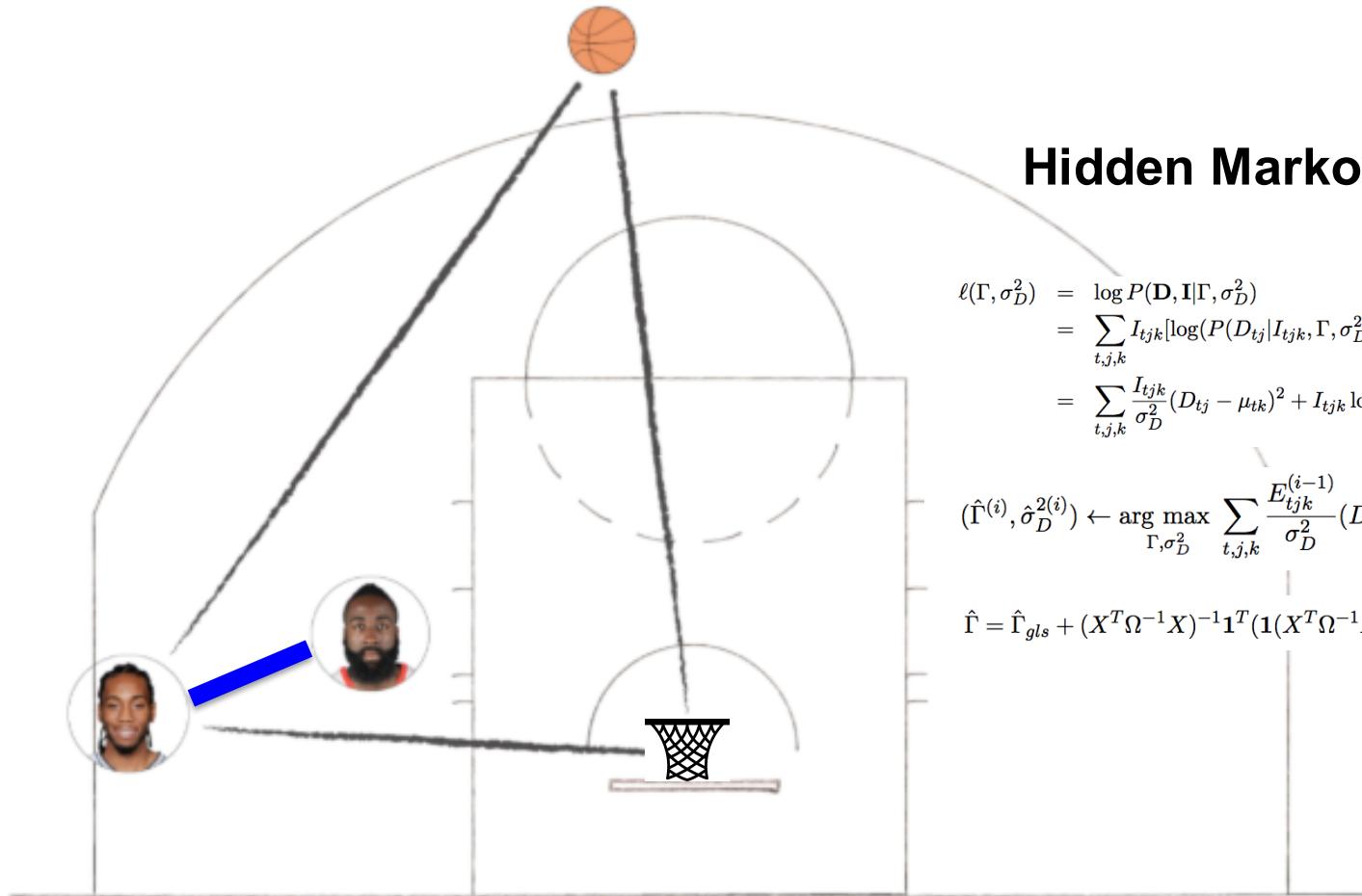


Assessing Defensive Intent

ANIMATION BY DAN HASTINGS, KIRK GOLDSBERRY, ALEXANDER FRANKS, AND ANDREW MILLER



Who's Guarding Whom?



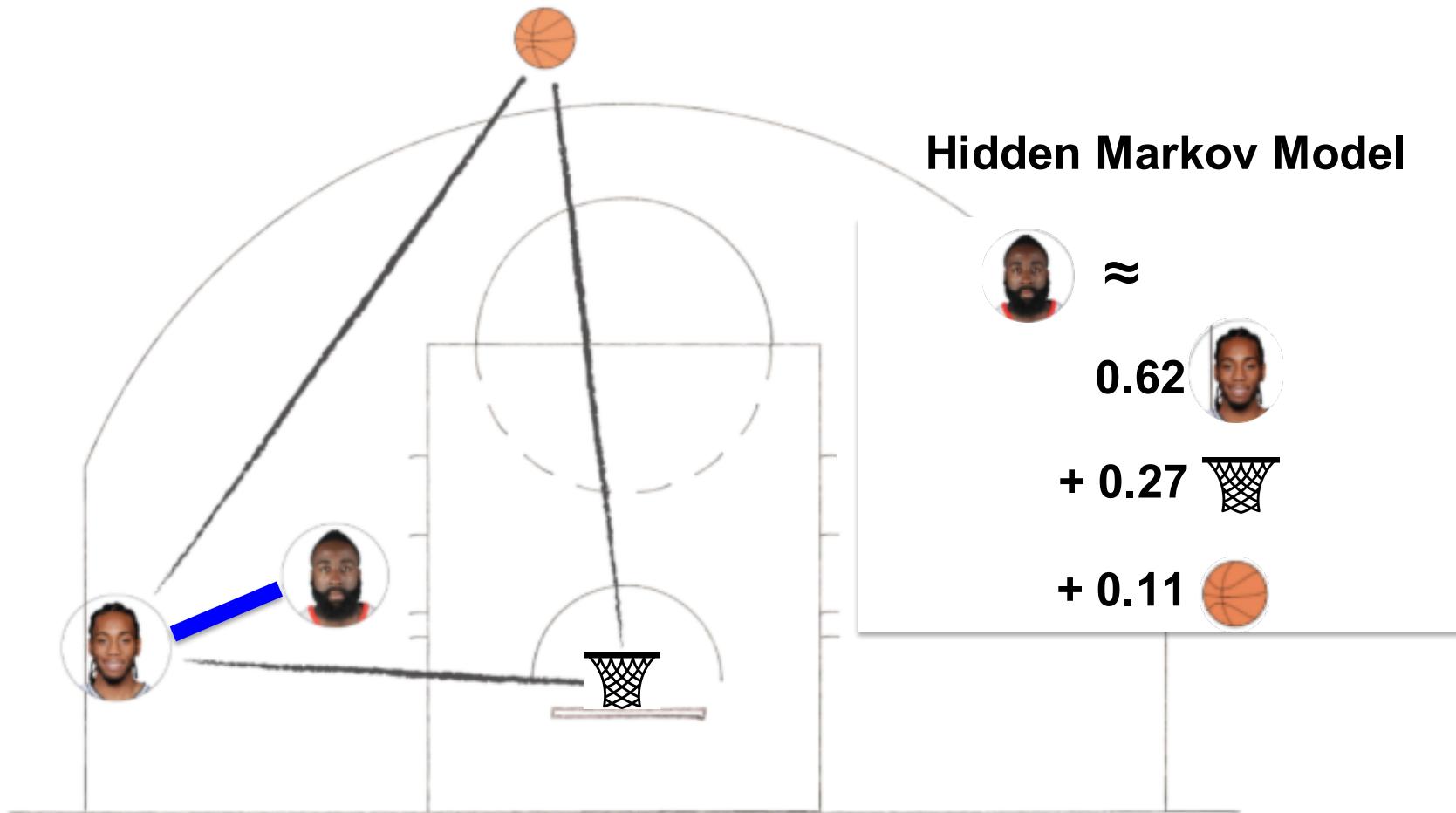
Hidden Markov Model

$$\begin{aligned}\ell(\Gamma, \sigma_D^2) &= \log P(\mathbf{D}, \mathbf{I}|\Gamma, \sigma_D^2) \\ &= \sum_{t,j,k} I_{tjk} [\log(P(D_{tj}|I_{tjk}, \Gamma, \sigma_D^2)) + \log(P(I_{tjk}|I_{(t-1)j}))] \\ &= \sum_{t,j,k} \frac{I_{tjk}}{\sigma_D^2} (D_{tj} - \mu_{tk})^2 + I_{tjk} \log P(I_{tjk}|I_{(t-1)j})\end{aligned}$$

$$(\hat{\Gamma}^{(i)}, \hat{\sigma}_D^{2(i)}) \leftarrow \arg \max_{\Gamma, \sigma_D^2} \sum_{t,j,k} \frac{E_{tjk}^{(i-1)}}{\sigma_D^2} (D_{tj} - \Gamma X_{tk})^2, \quad \Gamma \mathbf{1} = 1$$

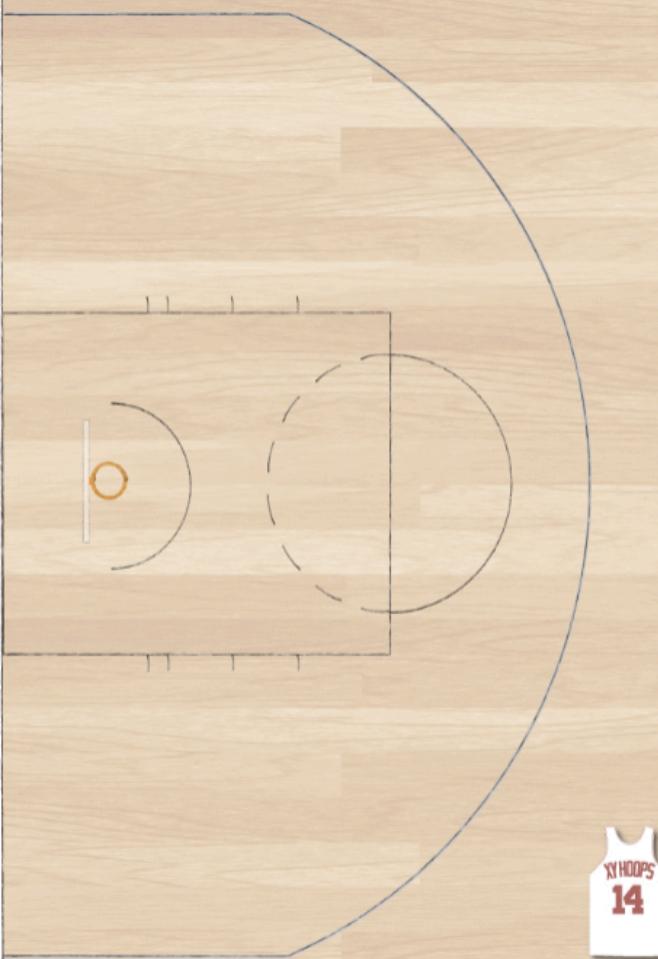
$$\hat{\Gamma} = \hat{\Gamma}_{gls} + (X^T \Omega^{-1} X)^{-1} \mathbf{1}^T (\mathbf{1} (X^T \Omega^{-1} X)^{-1} \mathbf{1}^T)^{-1} (1 - \hat{\Gamma}_{gls} \mathbf{1}),$$

Who's Guarding Whom?



Who's Guarding Whom?

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8:05.20

15.03



09

Andre Iguodala

22

Matt Barnes

10

Davis Lee
DeAndre Jordan

11

Klay Thompson

07

Darren Collison

12

Andrew Bogut

03

Chris Paul

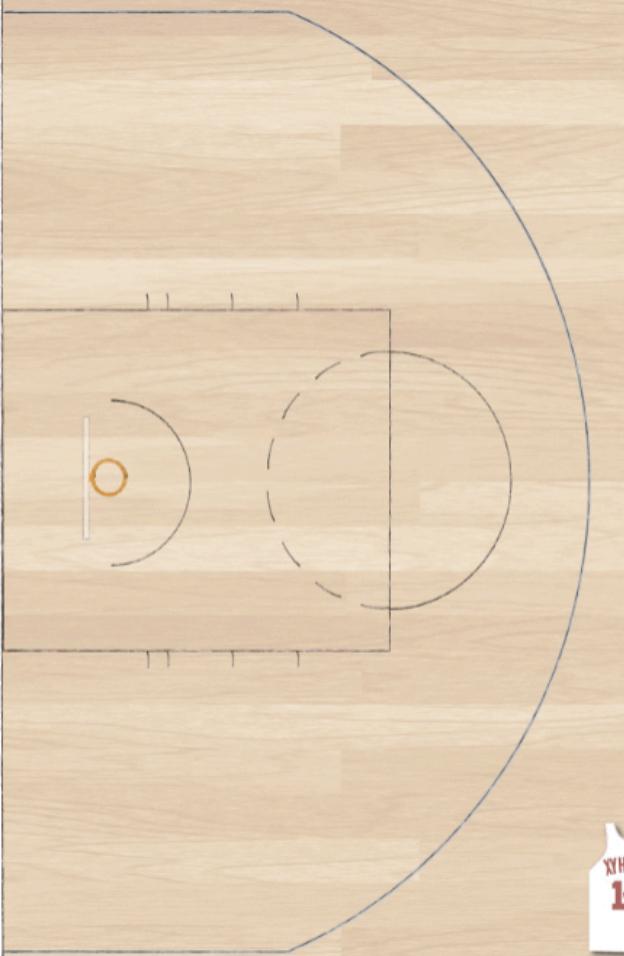
30

Stephen Curry

ANIMATION BY DAN HASTINGS, KIRK GOLDSBERRY, ALEXANDER FRANKS, AND ANDREW MILLER

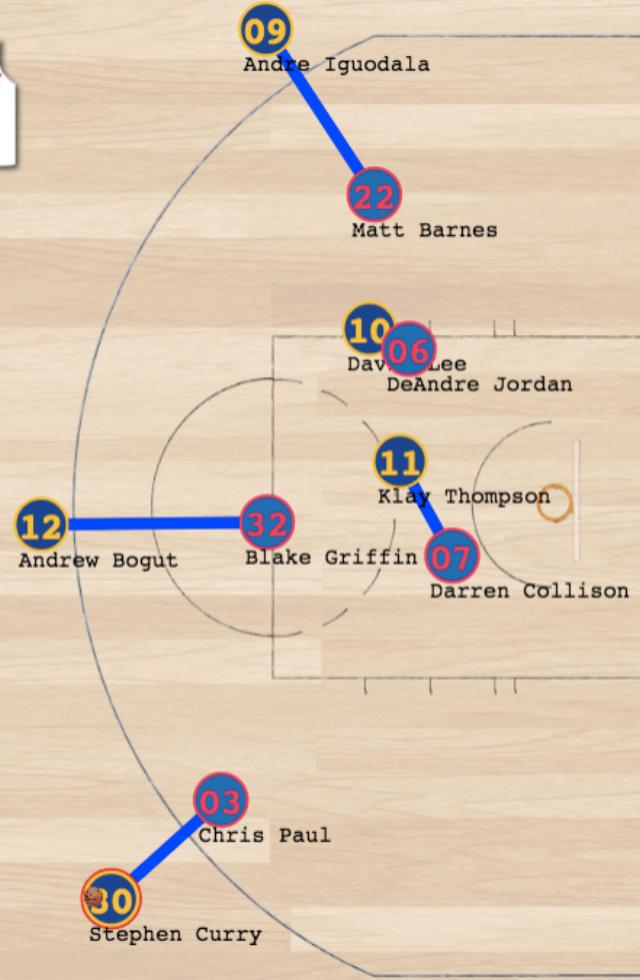
Who's Guarding Whom?

ANIMATION BY DAN HASTINGS, KIRK GOLDSBERRY, ALEXANDER FRANKS, AND ANDREW MILLER



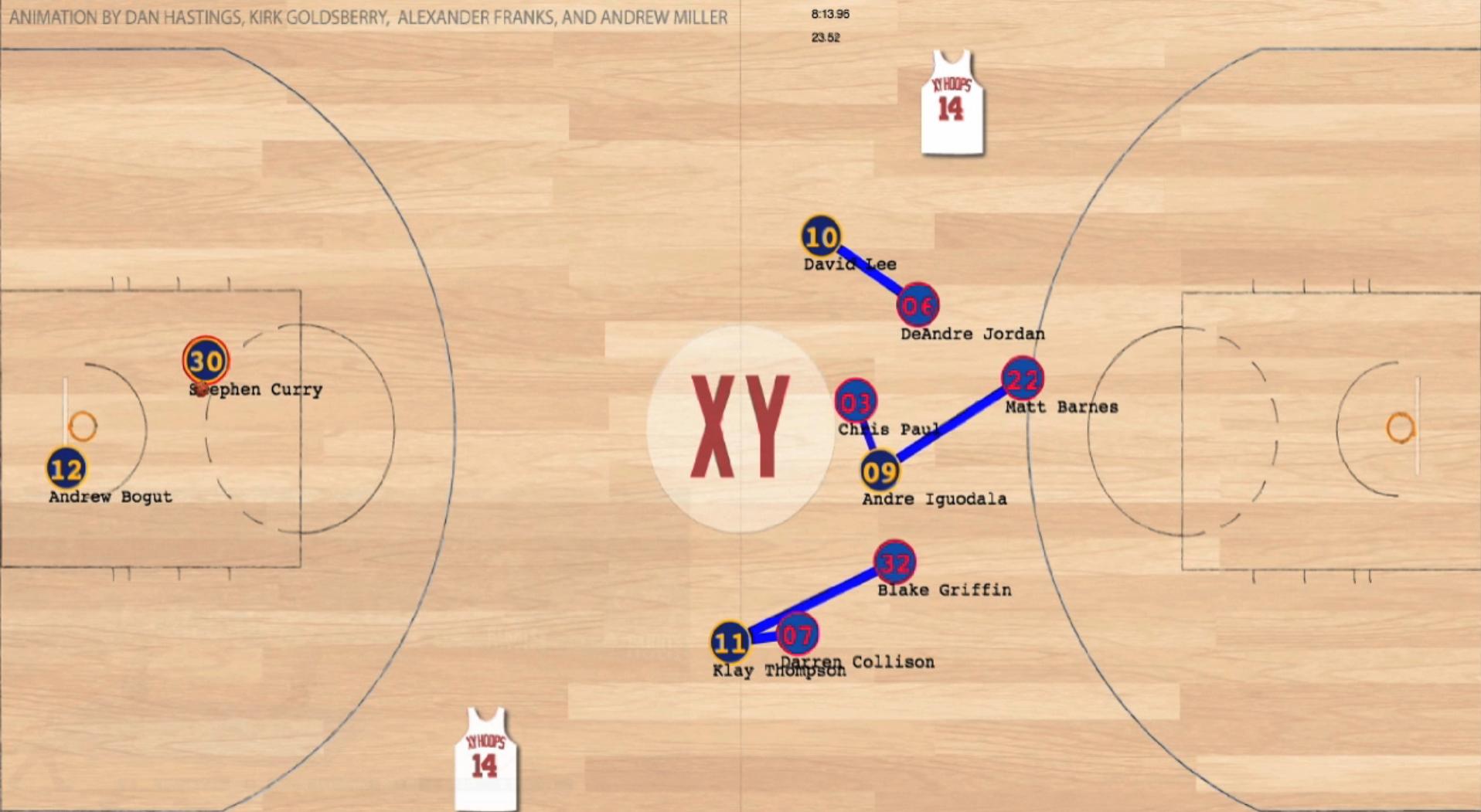
8:05.20

15.03



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An Ensemble of New Metrics



Counterpoints

How do we define “points against”?

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- **“Counterpoints”:** An estimate of the points scored against a particular defender (disruption)

Counterpoints

How do we define “points against”?

- **“Counterpoints”**: An estimate of the points scored against a particular defender (disruption)
- **“Shots Against”**: An estimate of the shots attempted against a particular defender (suppression)

Possession Breakdown

- Late possession

Rank	Name	Contest Percentage
1	Roy Hibbert	41.9
2	Robin Lopez	40.1
3	Ian Mahinmi Joakim	39.3
4	Noah	37.3
5	T. Mozgov	37.2

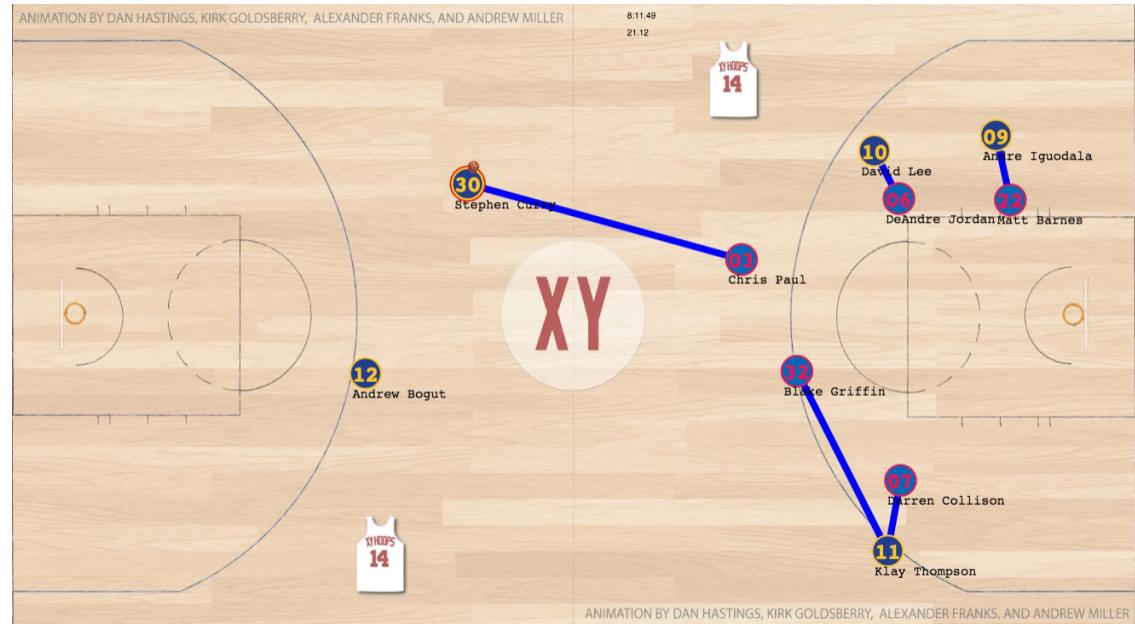
Possession Breakdown

- Late possession
- Early possession

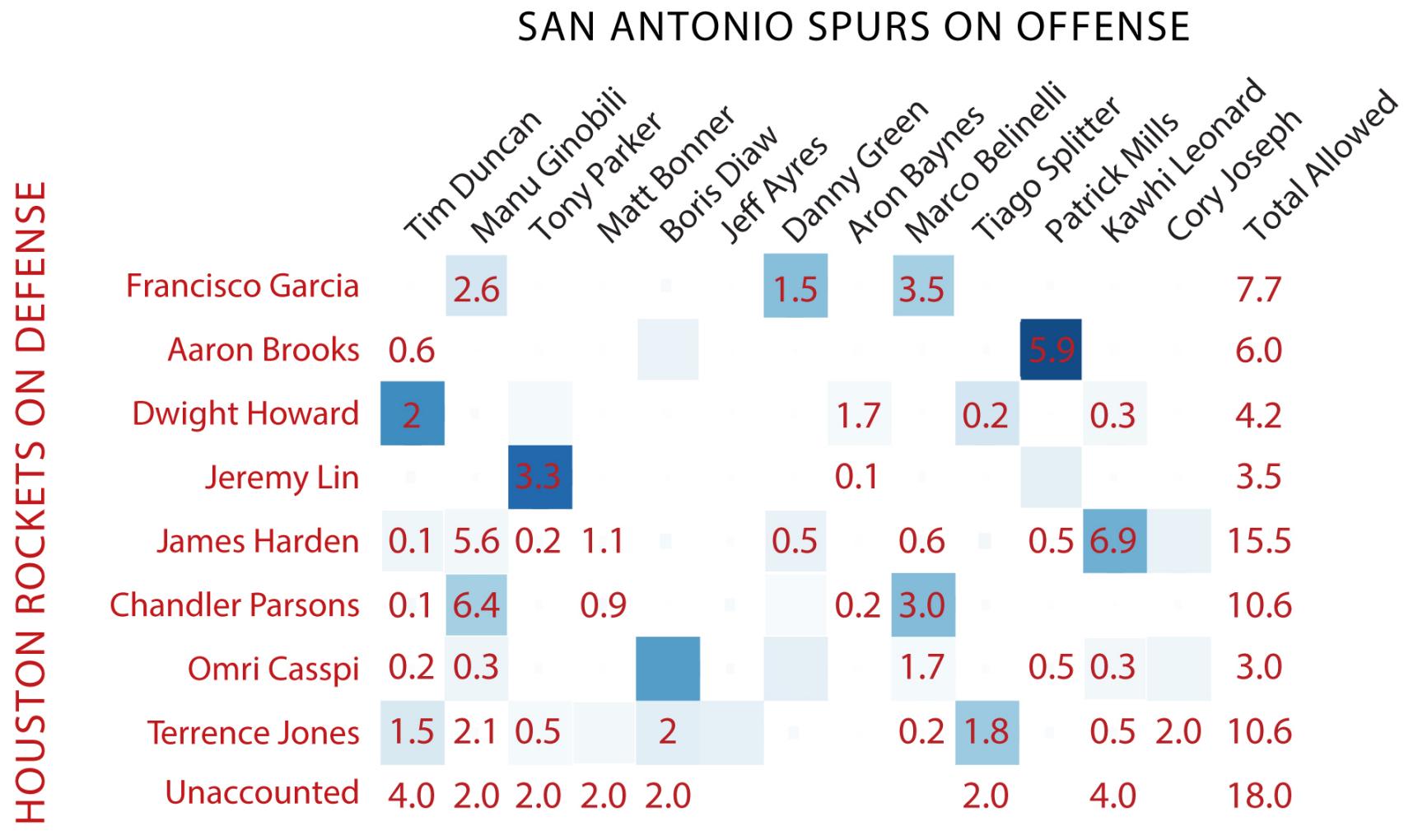


Possession Breakdown

- Late possession
- Early possession
- Full possession



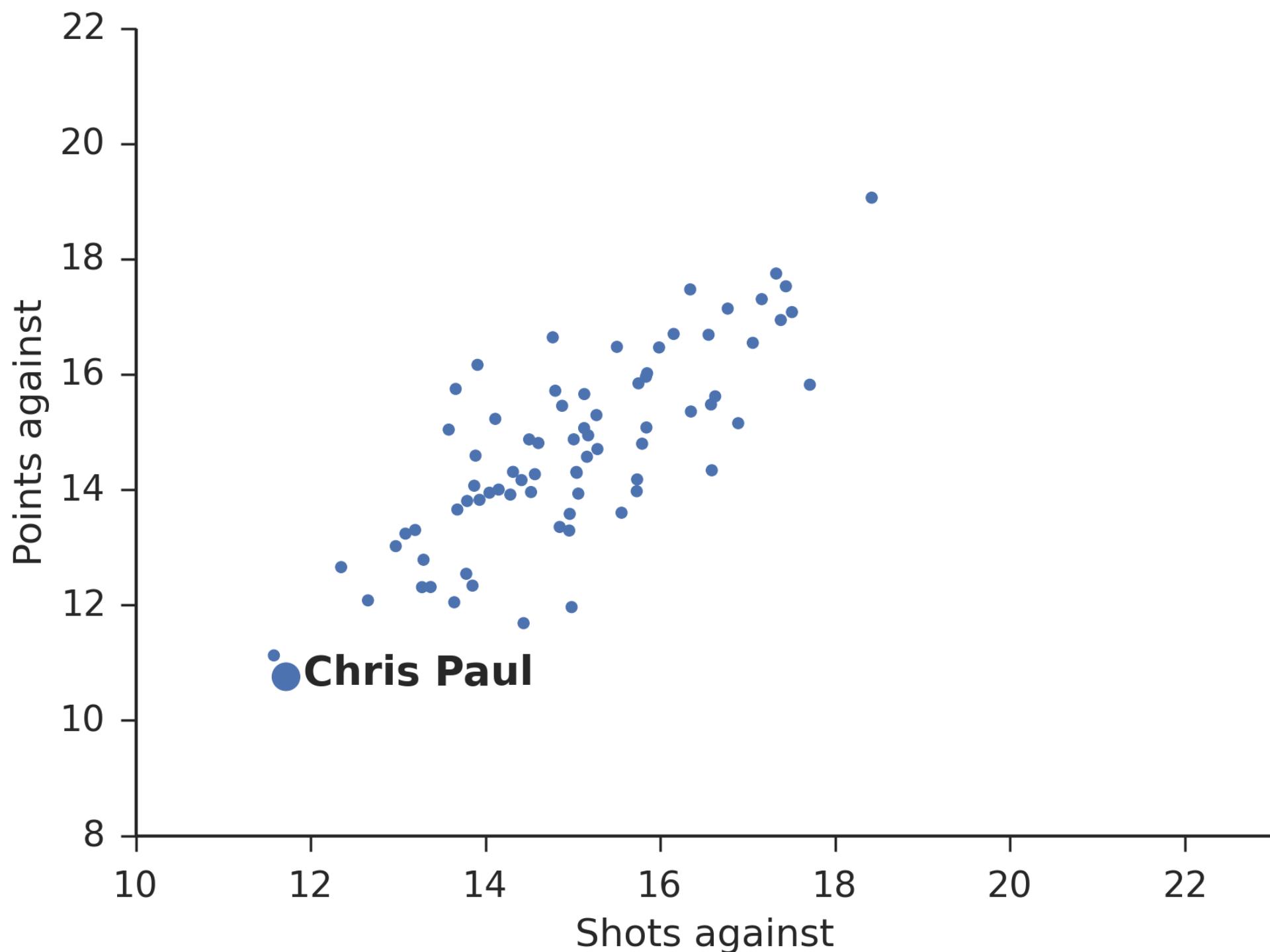
WHO IS GUARDING WHOM? AND HOW MANY POINTS DID THEY GIVE UP?

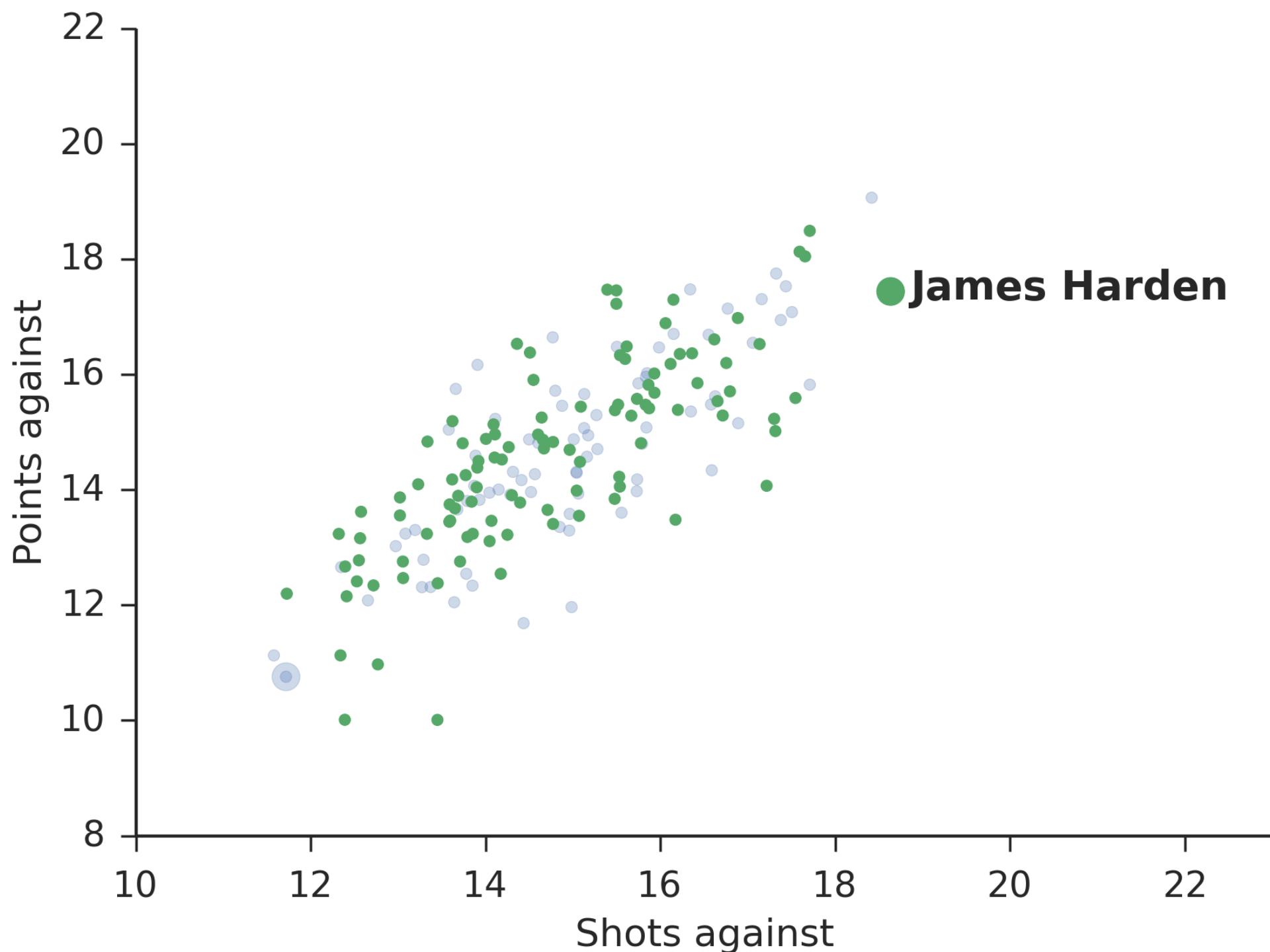


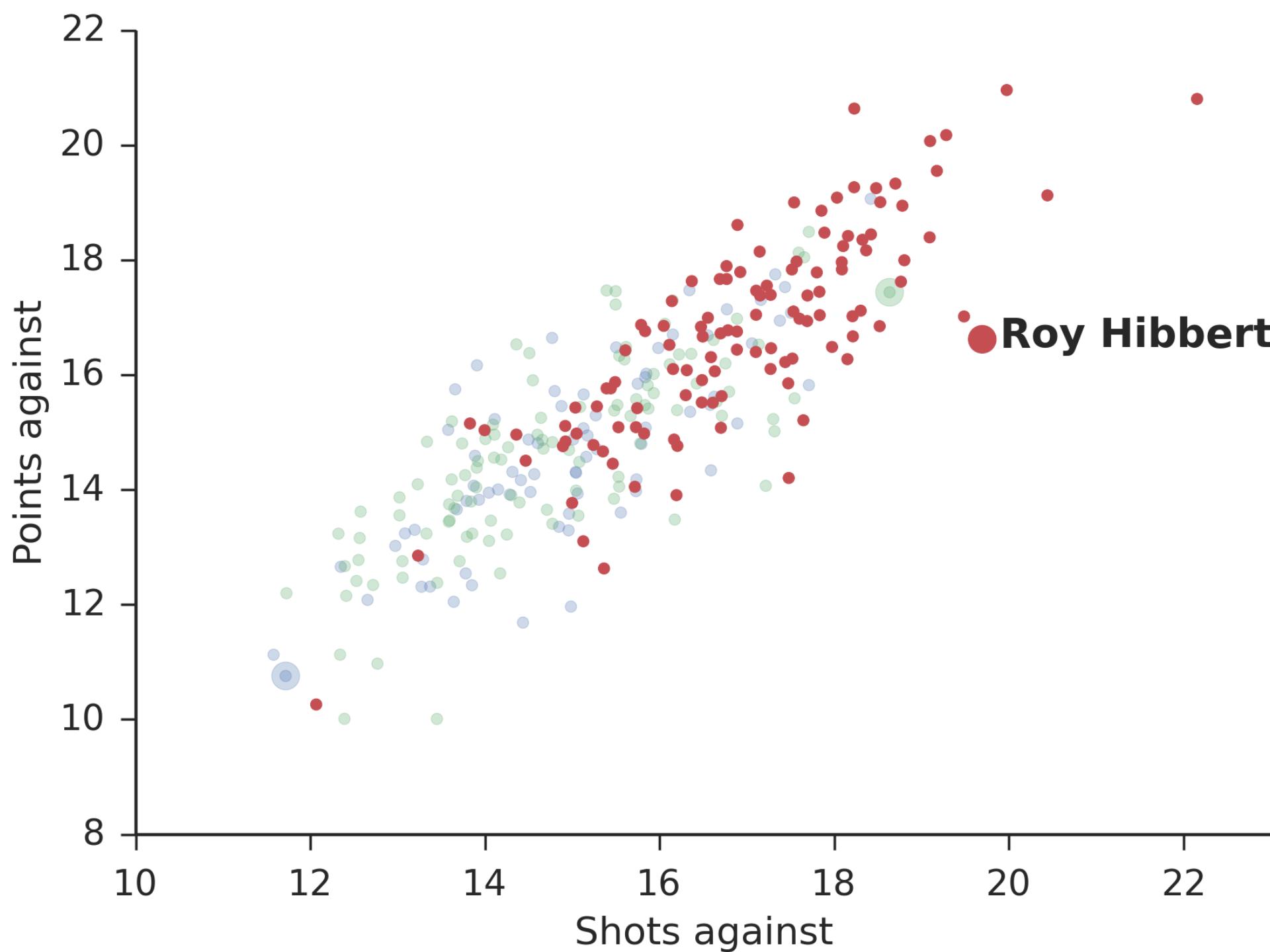
Percentage of time defending



Houston at San Antonio
Dec. 25, 2013









“Rondo-Curry Conundrum”



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Defensive metrics need to account for offensive usage and skill.

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Defensive metrics need to account for offensive usage and skill.

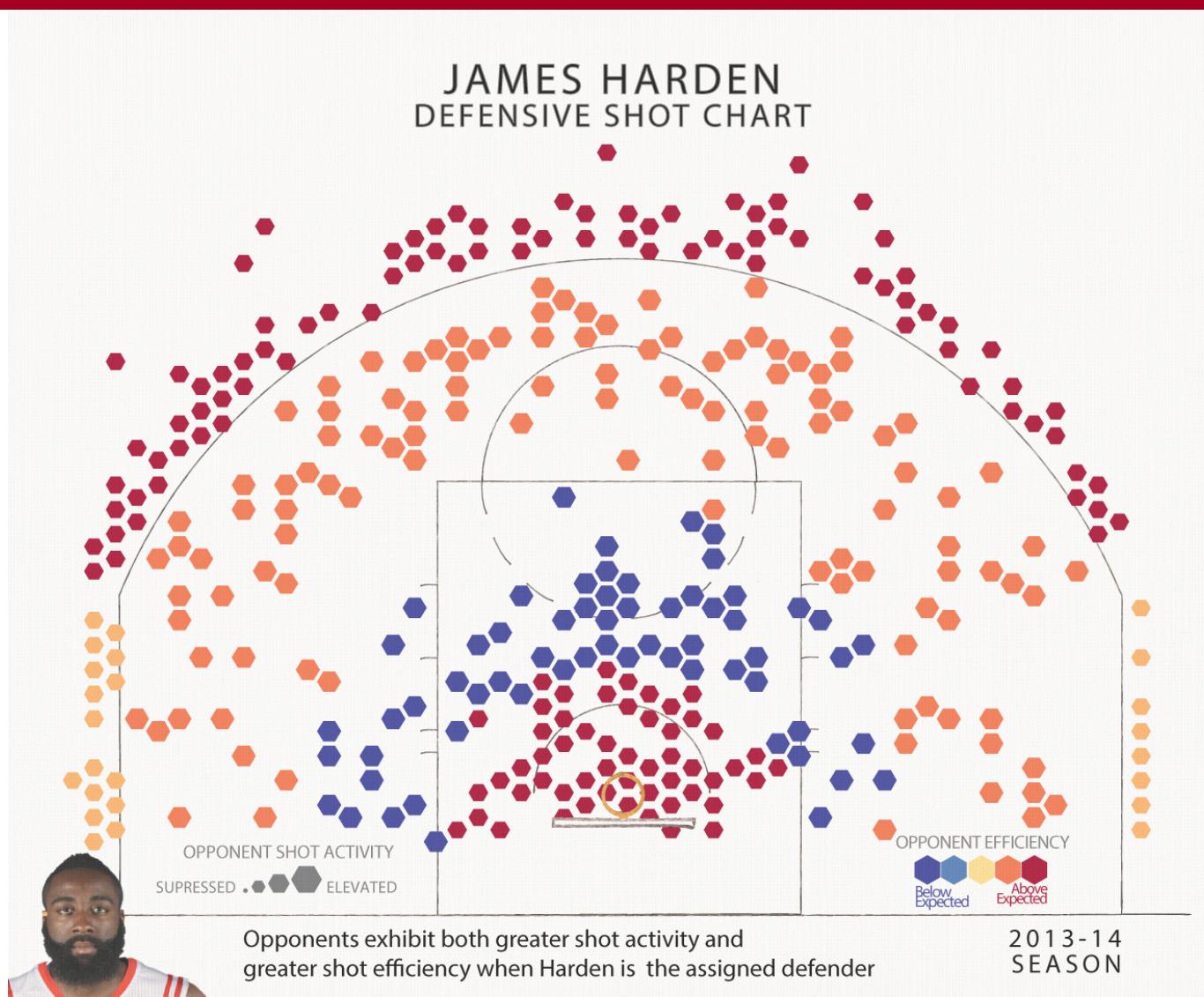
- Model offensive and defensive skill (by location)

“Rondo-Curry Conundrum”

Defensive metrics need to account for offensive usage and skill.

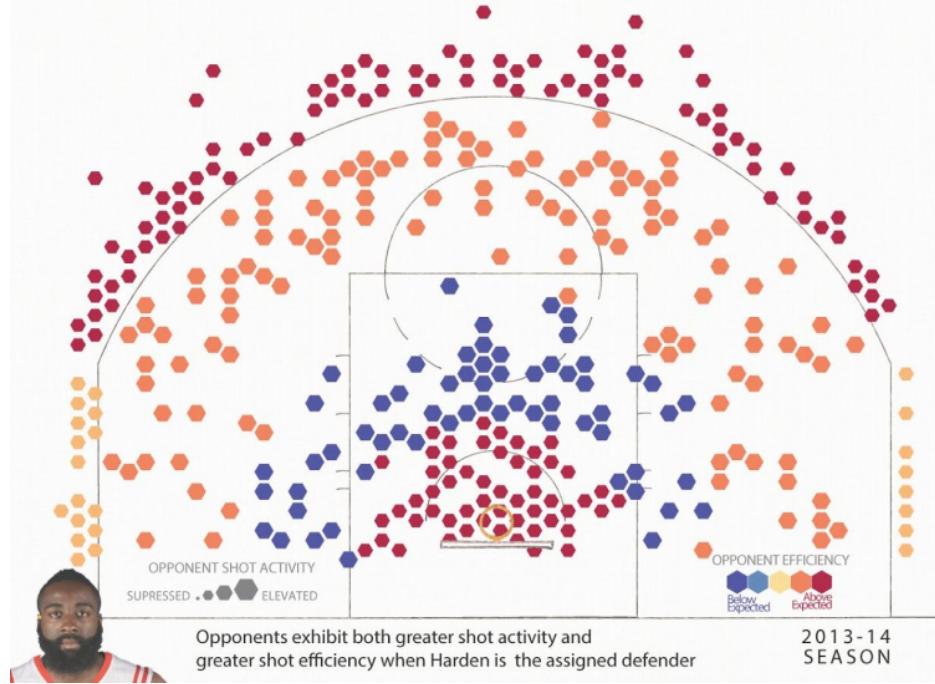
- Model offensive skill (by location)
- Model defensive effect on offense (by location)
 - Effect on shooting frequency
 - Effect on shooting efficiency

Defensive Shot Charts

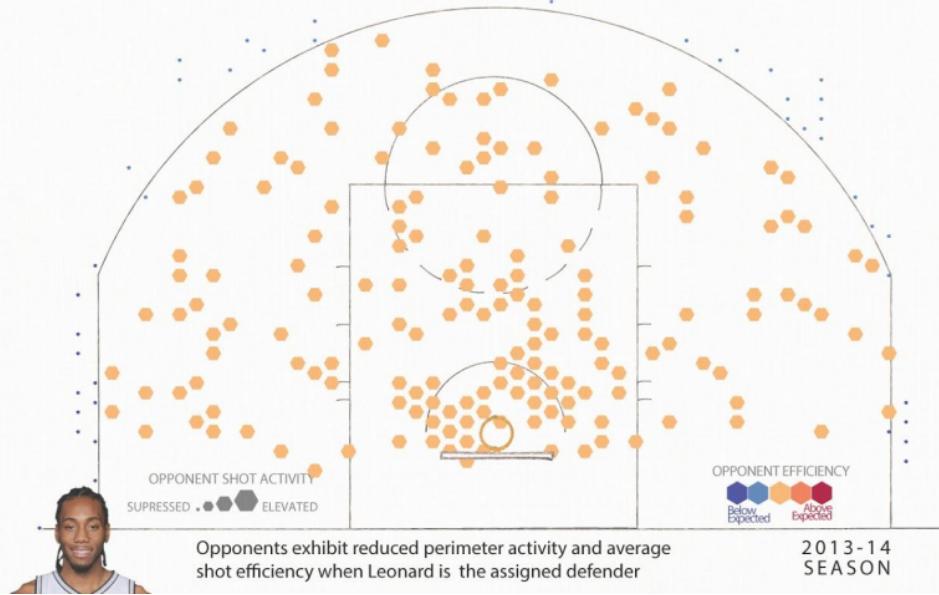


Defensive Shot Charts

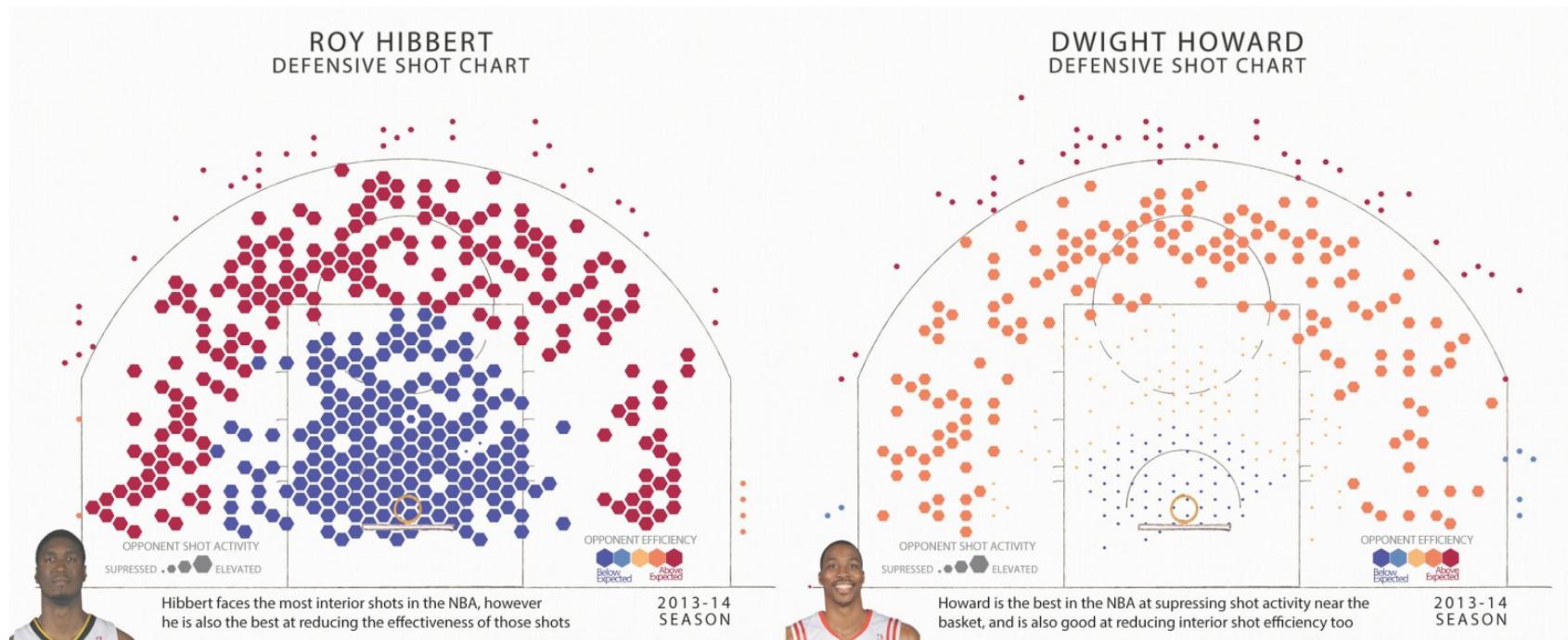
JAMES HARDEN
DEFENSIVE SHOT CHART



KAWHI LEONARD
DEFENSIVE SHOT CHART

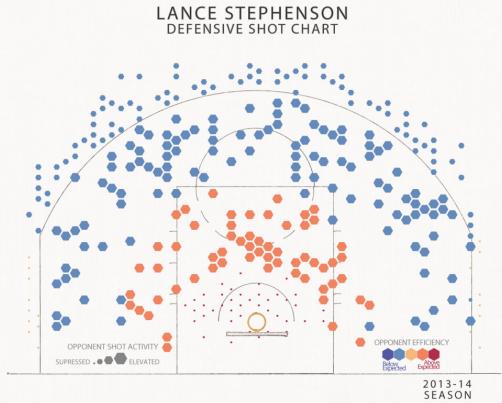
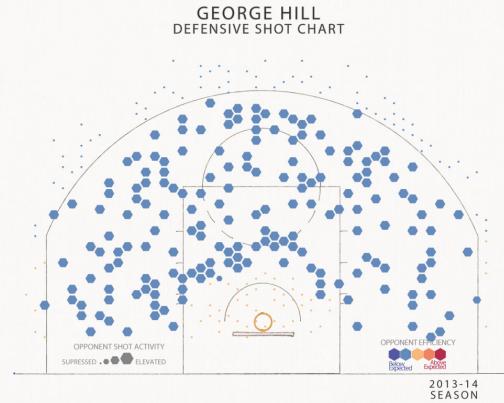


The Big Men

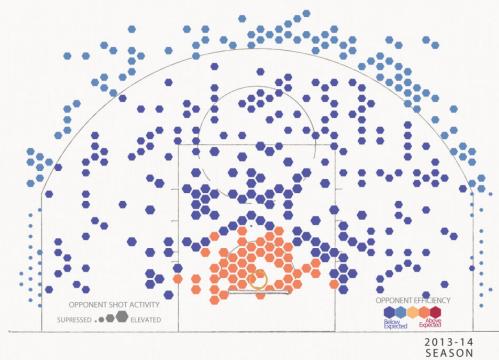


See “The Dwight Effect” (Goldsberry et al, 2013)

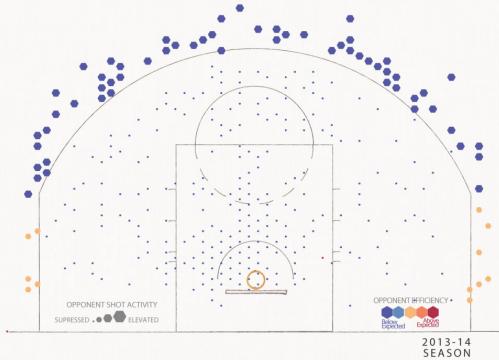
The Importance of Context



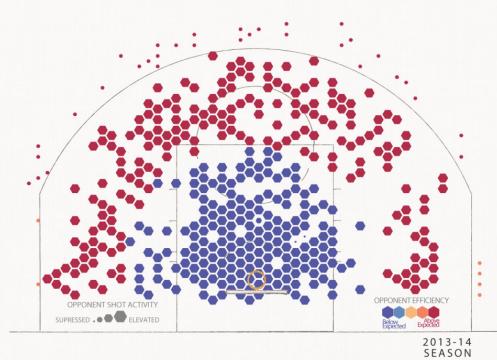
PAUL GEORGE
DEFENSIVE SHOT CHART



DAVID WEST
DEFENSIVE SHOT CHART



ROY HIBBERT
DEFENSIVE SHOT CHART



Thanks!

- [1] Cervone, Dan, et al. "POINTWISE: Predicting Points and Valuing Decisions in Real Time with NBA Optical Tracking Data." MIT Sloan Sports Analytics Conference 2014 (2014)
- [2] Franks, Alexander, et al. "Characterizing the Spatial Structure of Defensive Skill in Professional Basketball." *To Appear in the Annals of Applied Statistics* (2014)
- [3] Goldsberry, Kirk, and Eric Weiss. "The Dwight effect: A new ensemble of interior defense analytics for the NBA." MIT Sloan Sports Analytics Conference, 2013.
- [4] Kubatko, Justin, et al. "A starting point for analyzing basketball statistics." *Journal of Quantitative Analysis in Sports* 3.3 (2007).
- [5] Miller, Andrew, et al. "Factorized Point Process Intensities: A Spatial Analysis of Professional Basketball." *Proceedings of The 31st International Conference on Machine Learning*. 2014.
- [6] Omidiran, Dapo. "A new look at adjusted plus/minus for basketball analysis." MIT Sloan Sports Analytics Conference 2011 (2011)
- [7] Sampaio, Jaime, et al. "Discriminant analysis of game-related statistics between basketball guards, forwards and centres in three professional leagues." *European Journal of Sport Science* 6.3 (2006): 173-178.
- [8] Sampaio, Jaime, Eric J. Drinkwater, and Nuno M. Leite. "Effects of season period, team quality, and playing time on basketball players' game-related statistics." *European Journal of Sport Science* 10.2 (2010): 141-149.