# Bringing Computer Vision to the Court

Adrià Arbués-Sangüesa Universitat Pompeu Fabra Invited talk at CVSports 2021

- PhD Fellow at Universitat Pompeu Fabra (Barcelona), defense in September 2021 (hopefully!).
- Academical contributions: tracking & body-orientation & applications





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  - [1] Single-Camera Basketball Tracker through Pose and Semantic Feature Fusion
  - [2] Multi-Person Tracking by Multi-Scale Detection in Basketball Scenarios
  - [3] Always Look on the Bright Side of the Field: Merging Pose and
  - Contextual Data to Estimate Orientation of Soccer Players
  - [4] Using Player's Body-Orientation to Model Pass Feasibility in Soccer
  - + paper extension under review!
  - [5] Learning Football Body-Orientation as a Matter of Classification

Research team: Adrián Martín (postdoc), Coloma Ballester and Gloria Haro (supervisors)



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- When models are training... I am balling!





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- Academical contributions: tracking & body-orientation & applications
- When models are training... I am balling coaching!





C.B. Cornellà (1st team - 3rd division) @arbues6

F.C. Barcelona (u15)

- PhD Fellow at Universitat Pompeu Fabra (Barcelona), defense in September 2021 (hopefully!).
- Academical contributions: tracking & body-orientation & applications
- When models are training... I am coaching & disseminating!

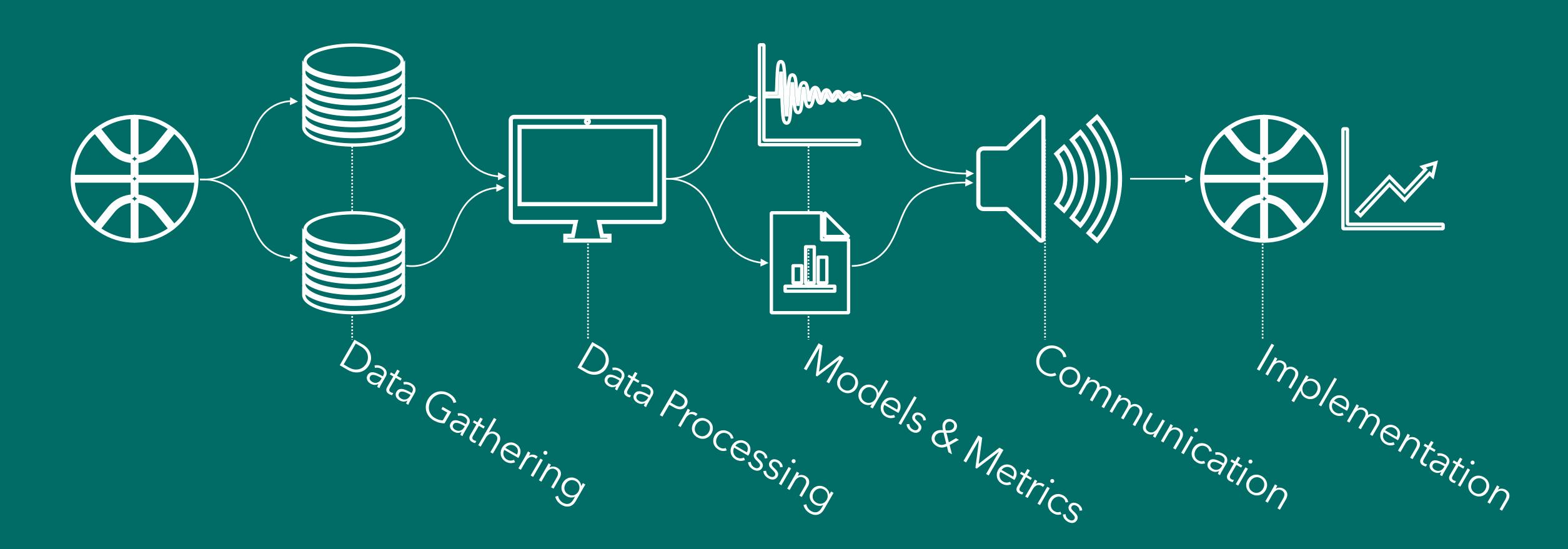




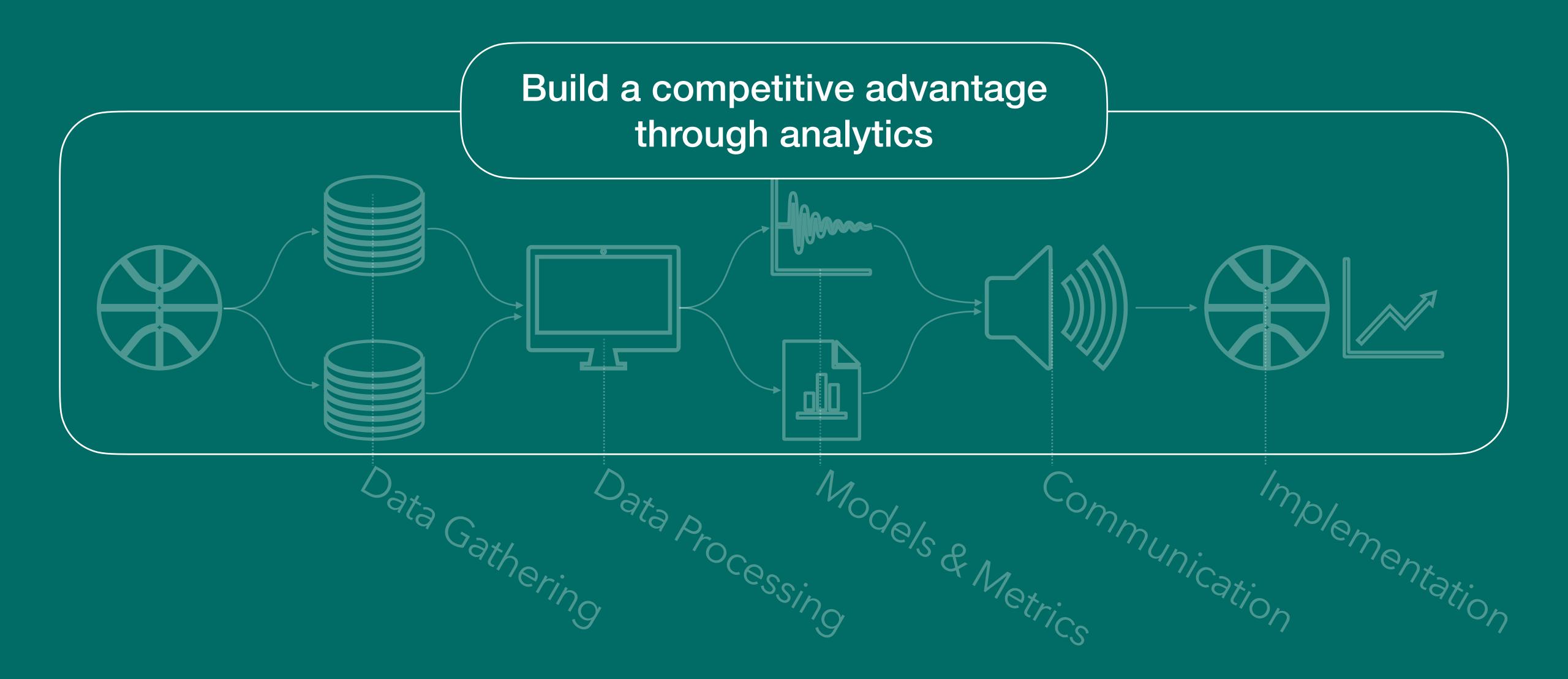


Beyond the 4 Factors

## In this talk...

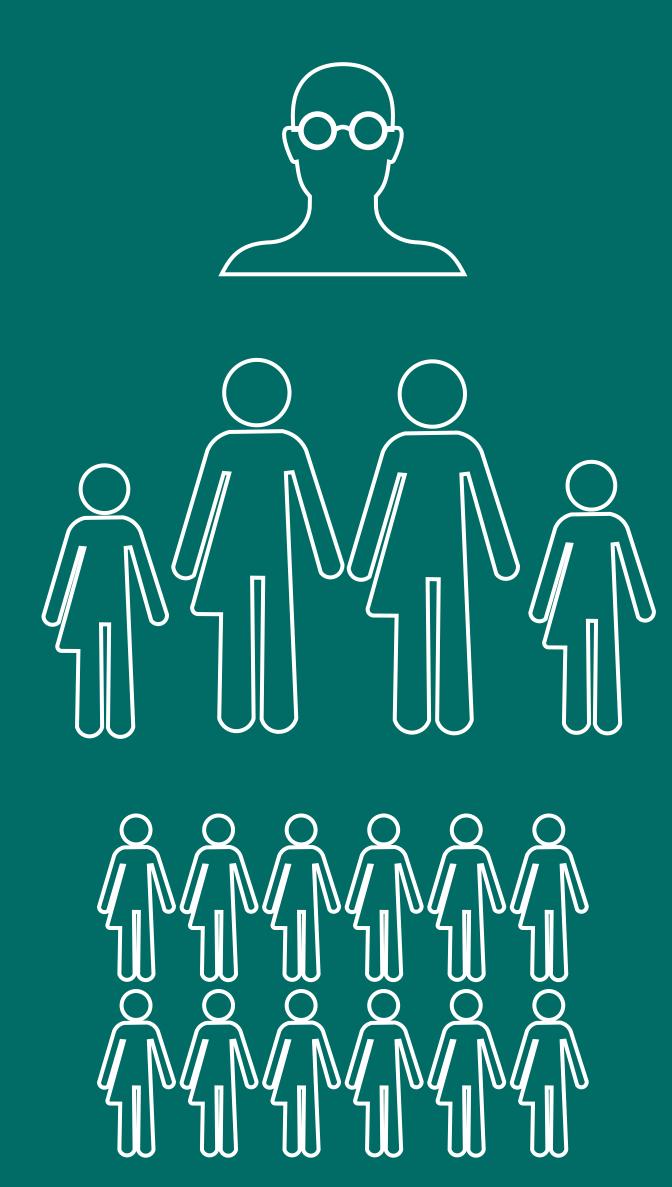


## But first... Why?



## Competitive Advantage

Work hard & listen



GM's / Board of directors Hire the best possible players / coaches Shared Goal: Coaching Staff Winning as many Build team chemistry games as possible Design a playbook Exhaustive scouting Players Stay healthy

## Competitive Advantage



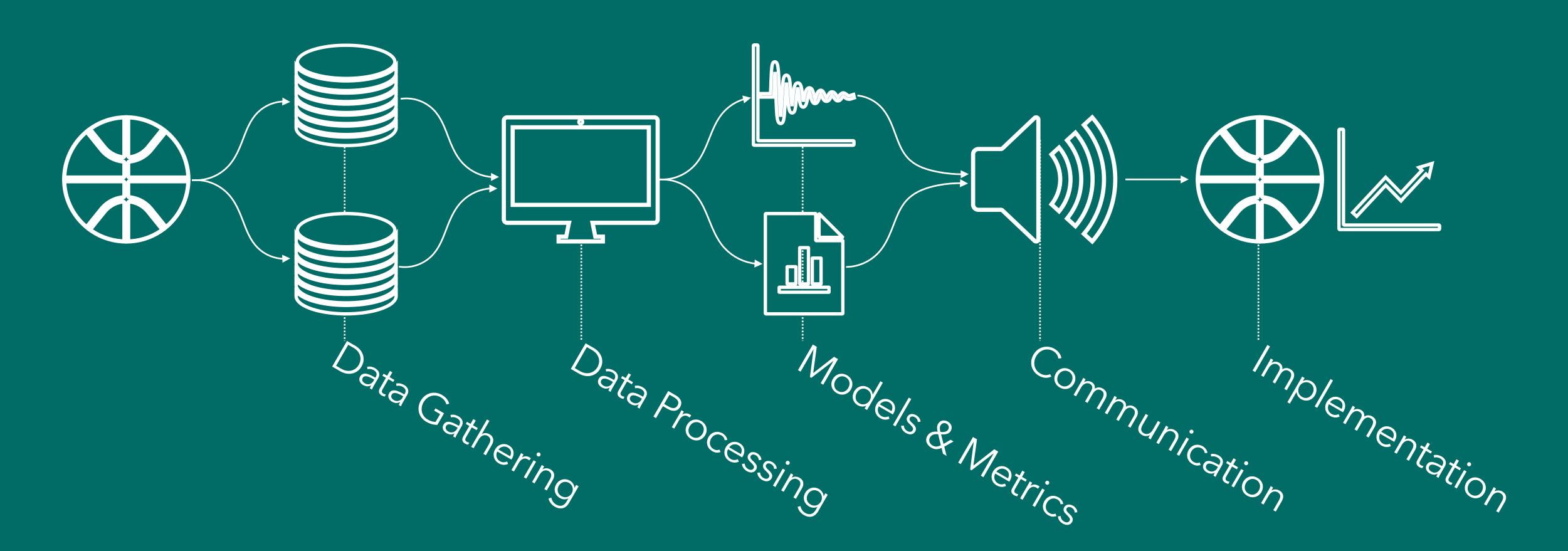
GM's / Board of directors

Hire the best possible players / coaches

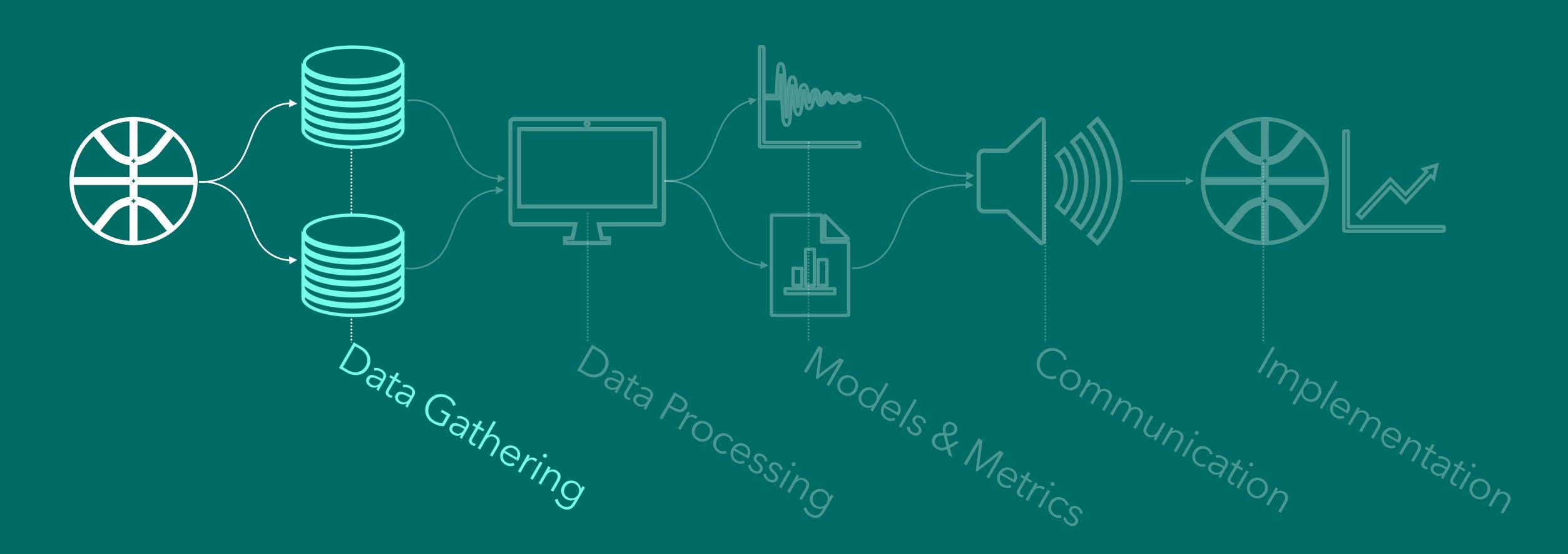
Coaching Staff
Design a playbook
Exhaustive scouting

How? Endless hours of film sessions.
Automated tasks through data-driven processes.

## In this talk...



## What kind of stats do we have?



## Basketball analytics: coarse-to-fine approach

Who produce data?



Source: Basketball England

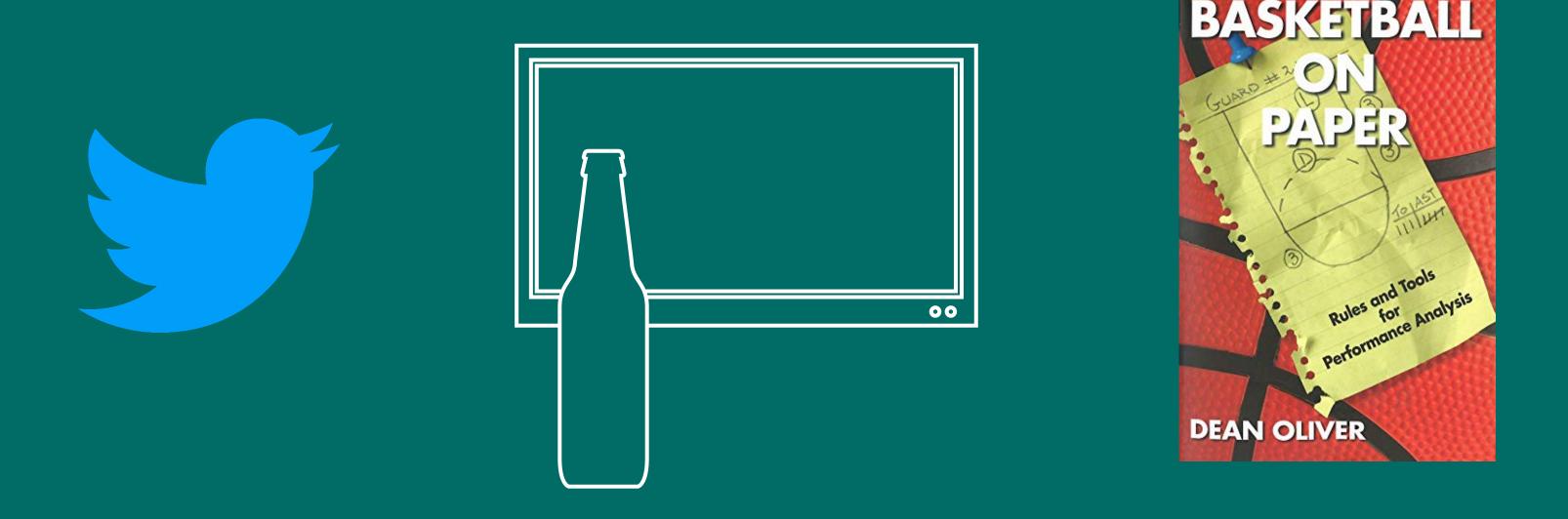
## Basketball analytics: box score

#### March 28th 1990 Chicago Bulls 117 - Cleveland Cavaliers 113

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Michael Jordan	50	69	21	31	2	6	21	23	7	11	6	4	2	5
Scottie Pippen	41	7	3	10	0	0	1	2	2	6	7	5	8	5
Horace Grant	40	16	7	14	0	0	2	4	2	3	4	1	2	4
Bill Cartwright	39	9	3	7	0	0	3	4	1	4	1	0	3	5
John Paxon	23	2	1	4	0	0	0	0	0	0	1	0	2	6
B.J. Armstrong	29	6	2	7	0	0	2	2	0	1	3	2	1	5
Stacey King	17	1	0	4	0	0	1	2	1	0	1	2	0	2
Will Perdue	12	0	0	0	0	0	0	0	0	4	0	0	0	3
Charles Davis	11	5	1	2	1	1	0	0	1	1	1	0	1	2
Clifford Lett	3	2	1	1	0	0	0	0	0	0	0	0	0	2
TEAM	265	117	39	80	3	7	30	37	14	30	24	14	19	39

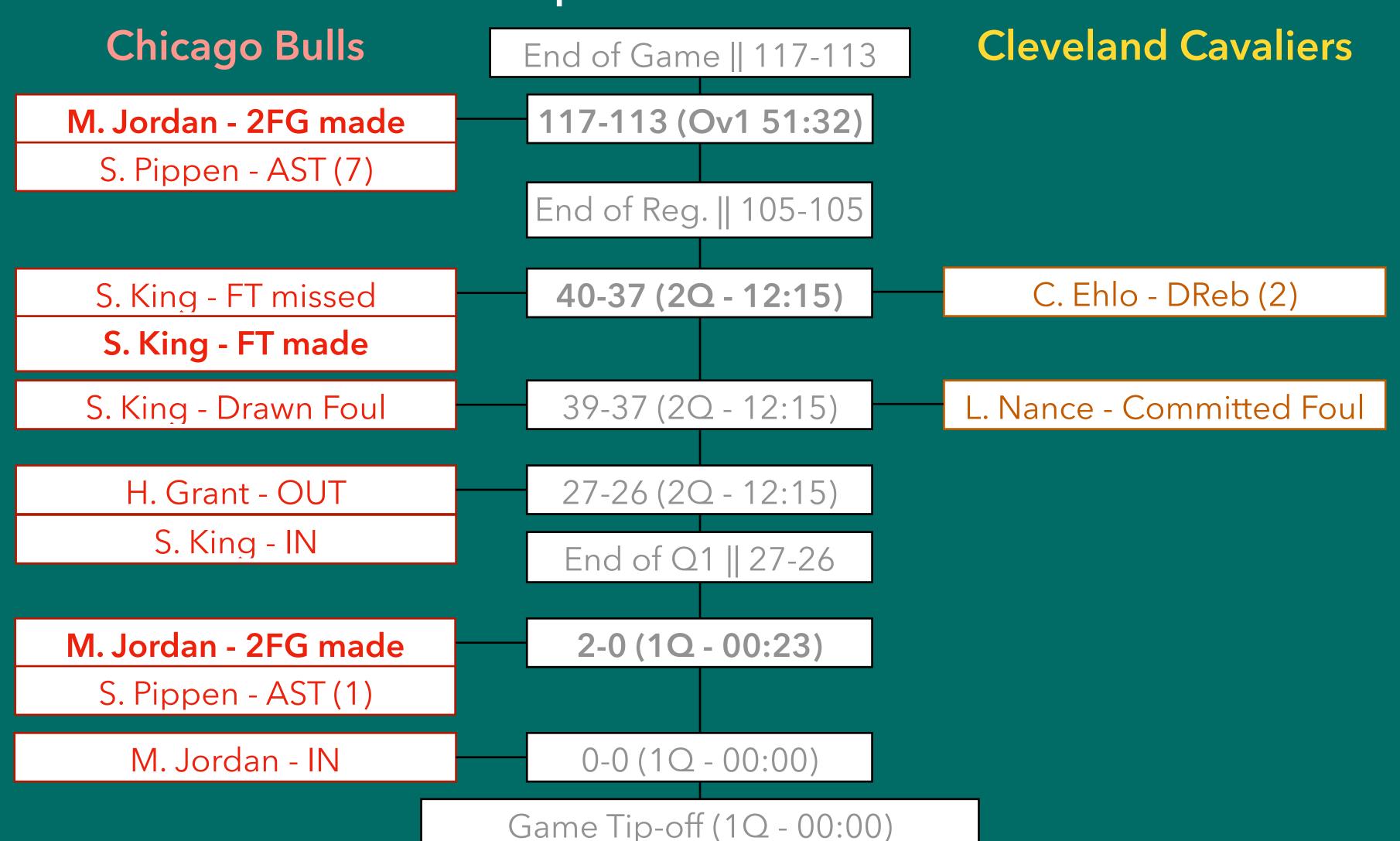
## Basketball analytics: box score

March 28th 1990 Chicago Bulls 117 - Cleveland Cavaliers 113



Other data sources have to be exploited!

## Basketball analytics: play-by-play Temporal domain



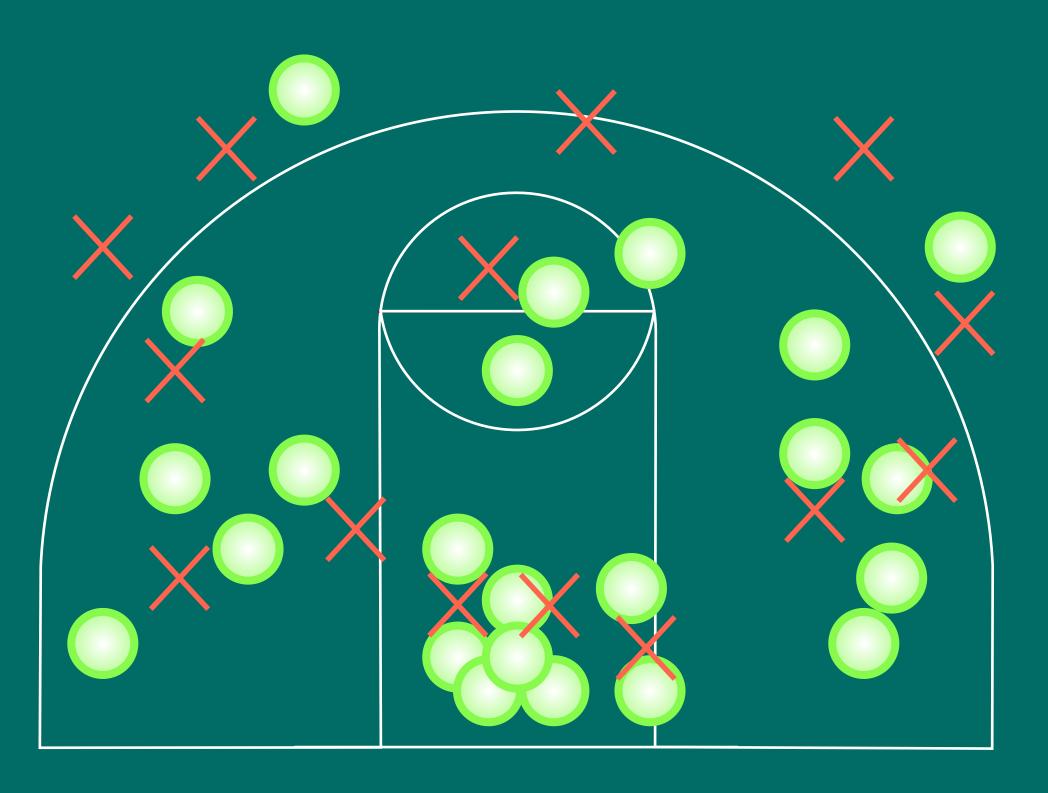
## Basketball analytics: shot charts

## Spatial domain

Single Game 69 points - (21/31 FG2, 2/6 FG3)

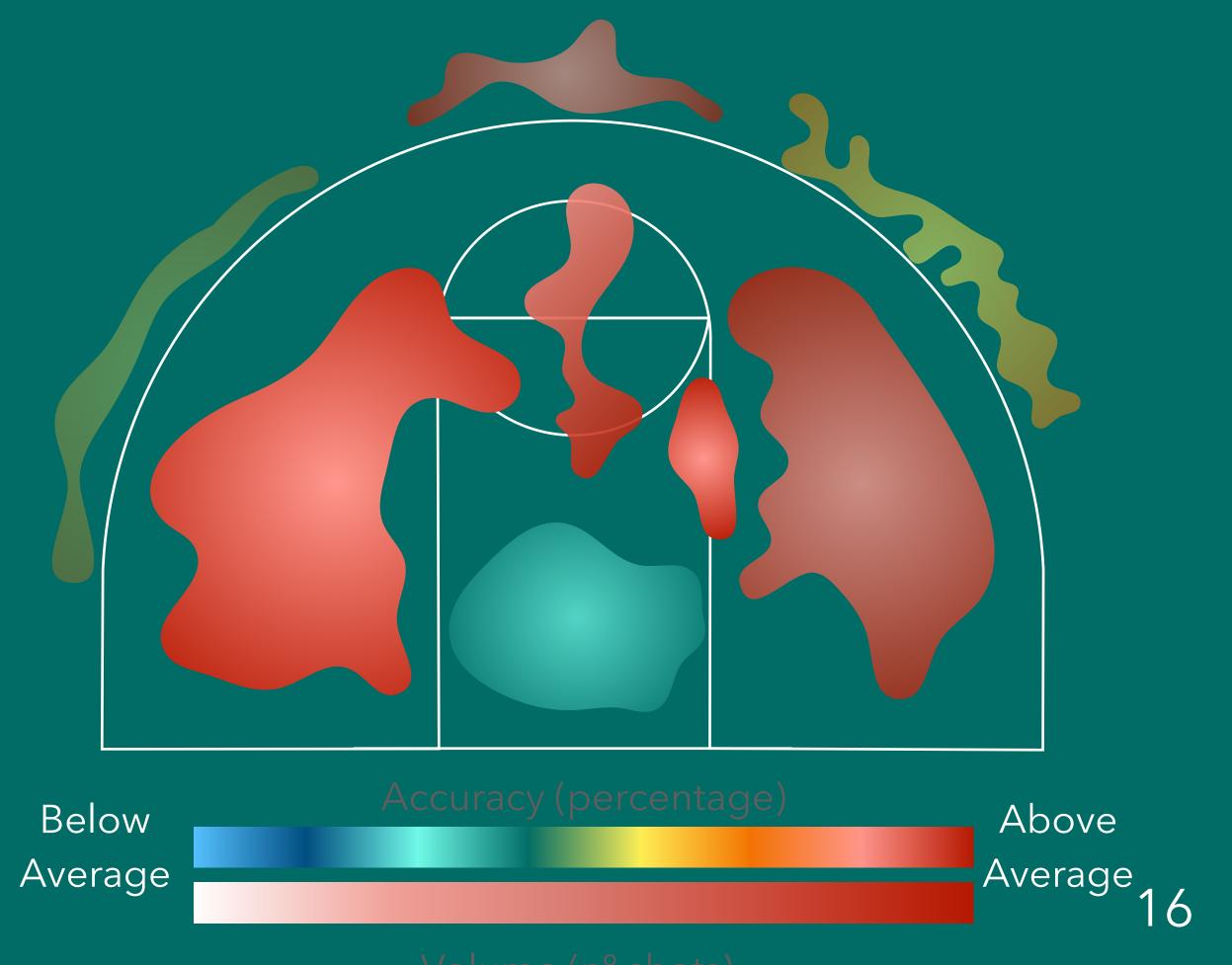
Michael Jordan

Whole Career 30.1 points - (10.9/21.2 FG2, 0.5/1.7 FG3)









## Basketball analytics: coarse-to-fine approach

Box score + play-by-play + shot charts... Is it enough?

[Utah] Cross-screen between Hornacek and Malone

[Chicago] No defensive switch

[Utah] Low-post play for Malone

[Chicago] Double team from weak side (baseline)

Jordan steals the ball – Malone loses it

[Chicago] Jordan calls an isolation play

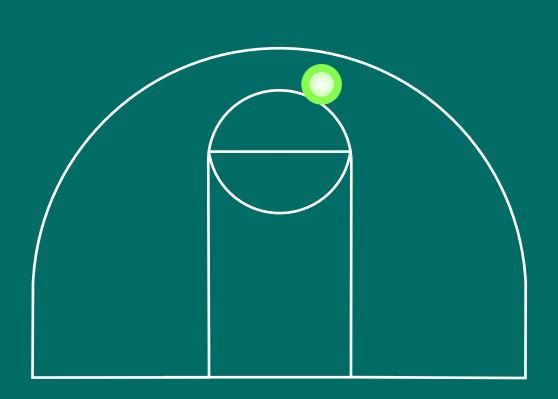
[Chicago] Jordan dribbles to his right, crosses over, and scores

a 2-point-open shot pull-up step-back with 5 seconds left.

[Utah] Byron Russell was the assigned defender, and could not

handle Jordan's crossover.

Malone - turnover Jordan - steal Jordan - 2 FG made



## Basketball analytics: coarse-to-fine approach

Box score + play-by-play + shot charts... Is it enough, Zeljko?

#### We are missing:

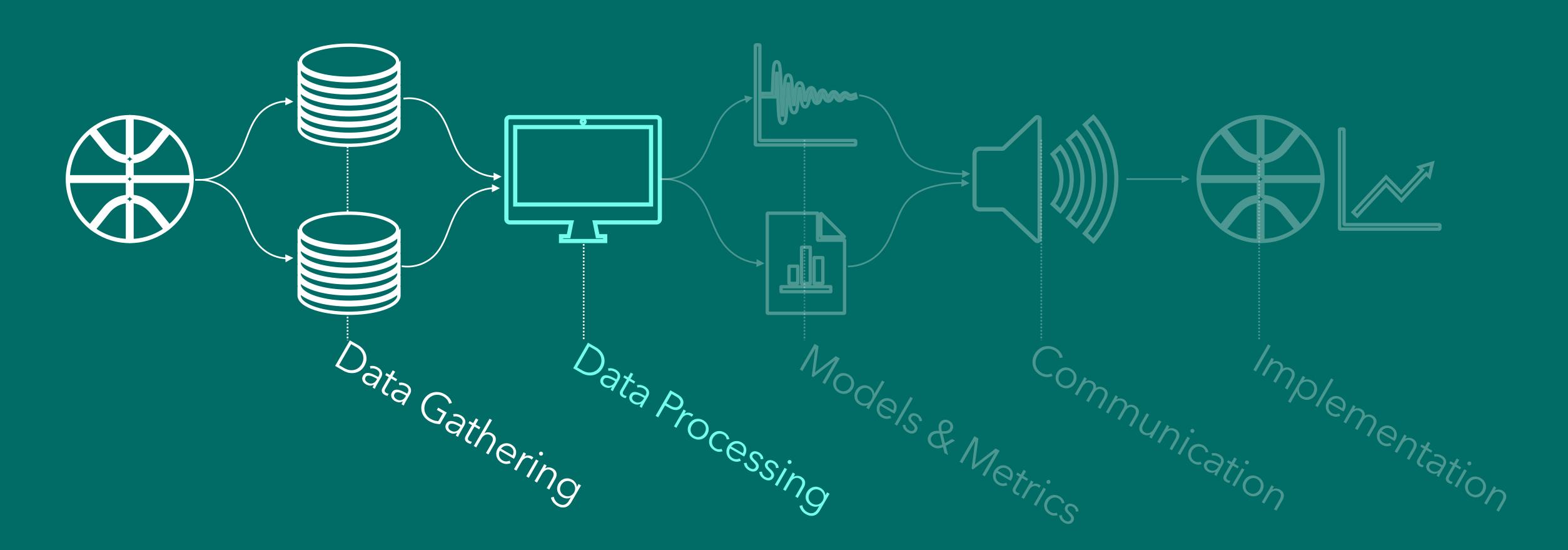
- Types of shots (playtype)
- Types of shots (difficulty)
- Team strategy
- Defensive metrics
- Defensive assignments

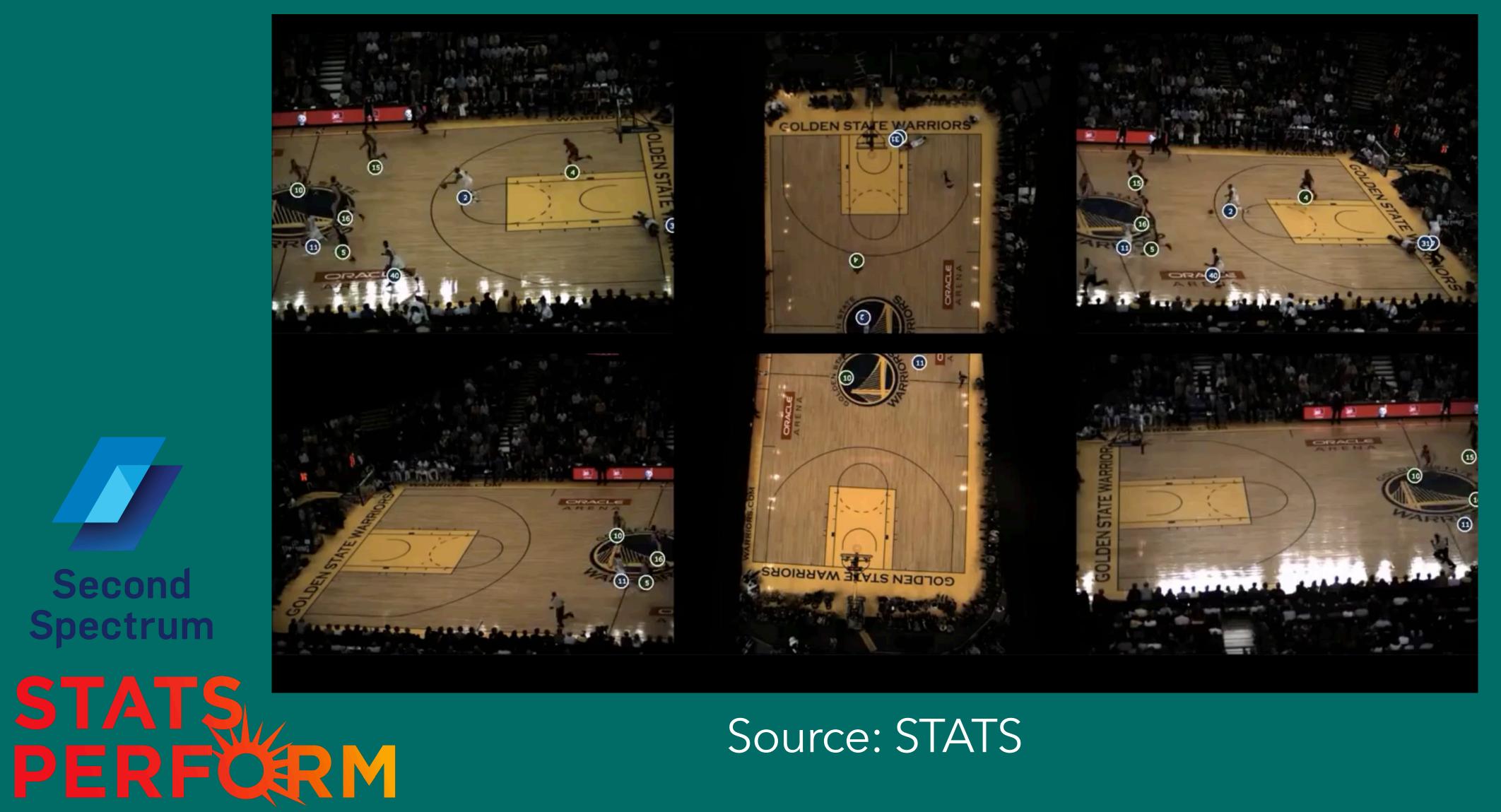


Source: Gettylmages

Solution? Time-consuming video-analysis shifts, or... Tracking!

## Where does Computer Vision fall in this context?



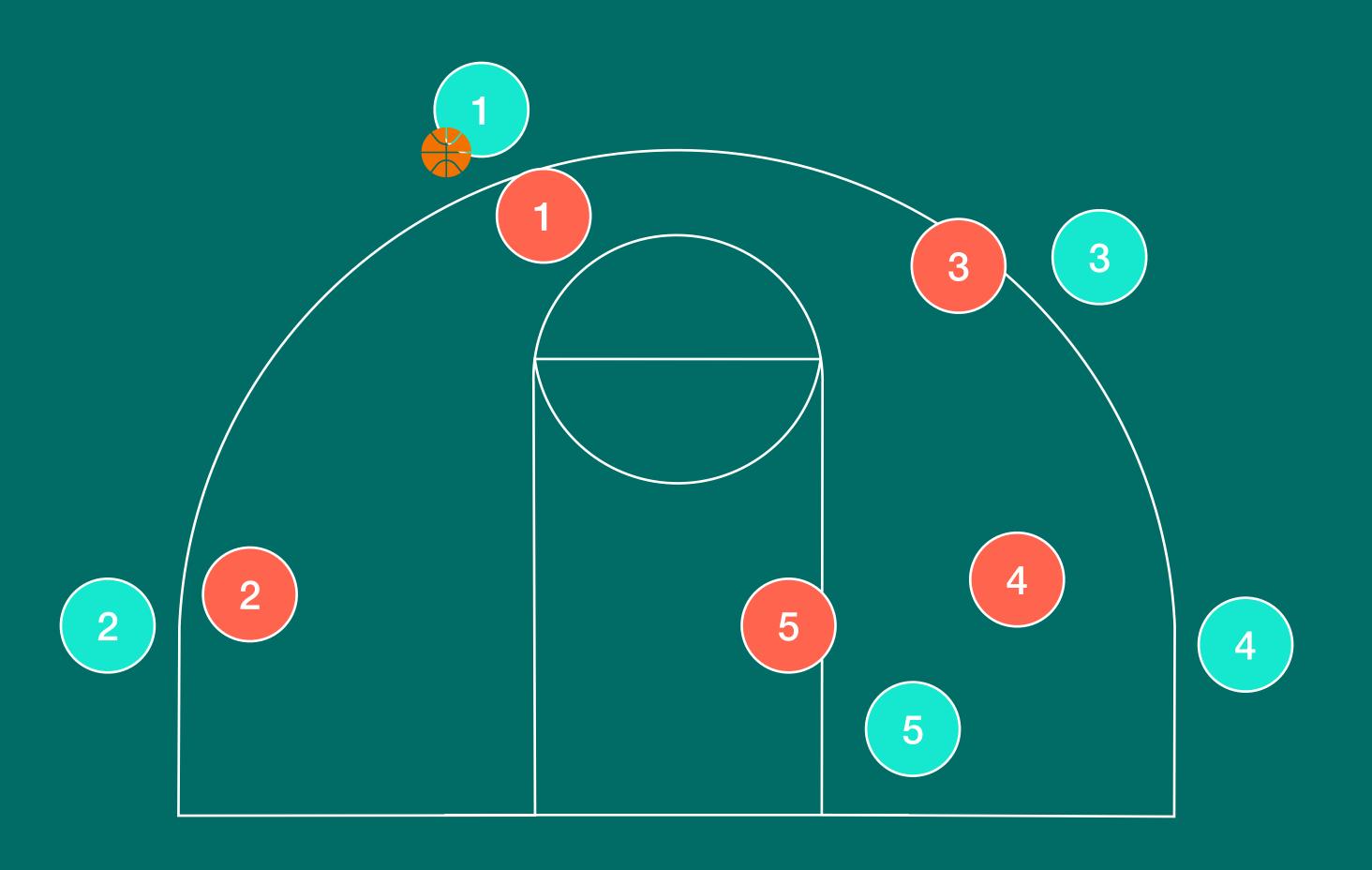




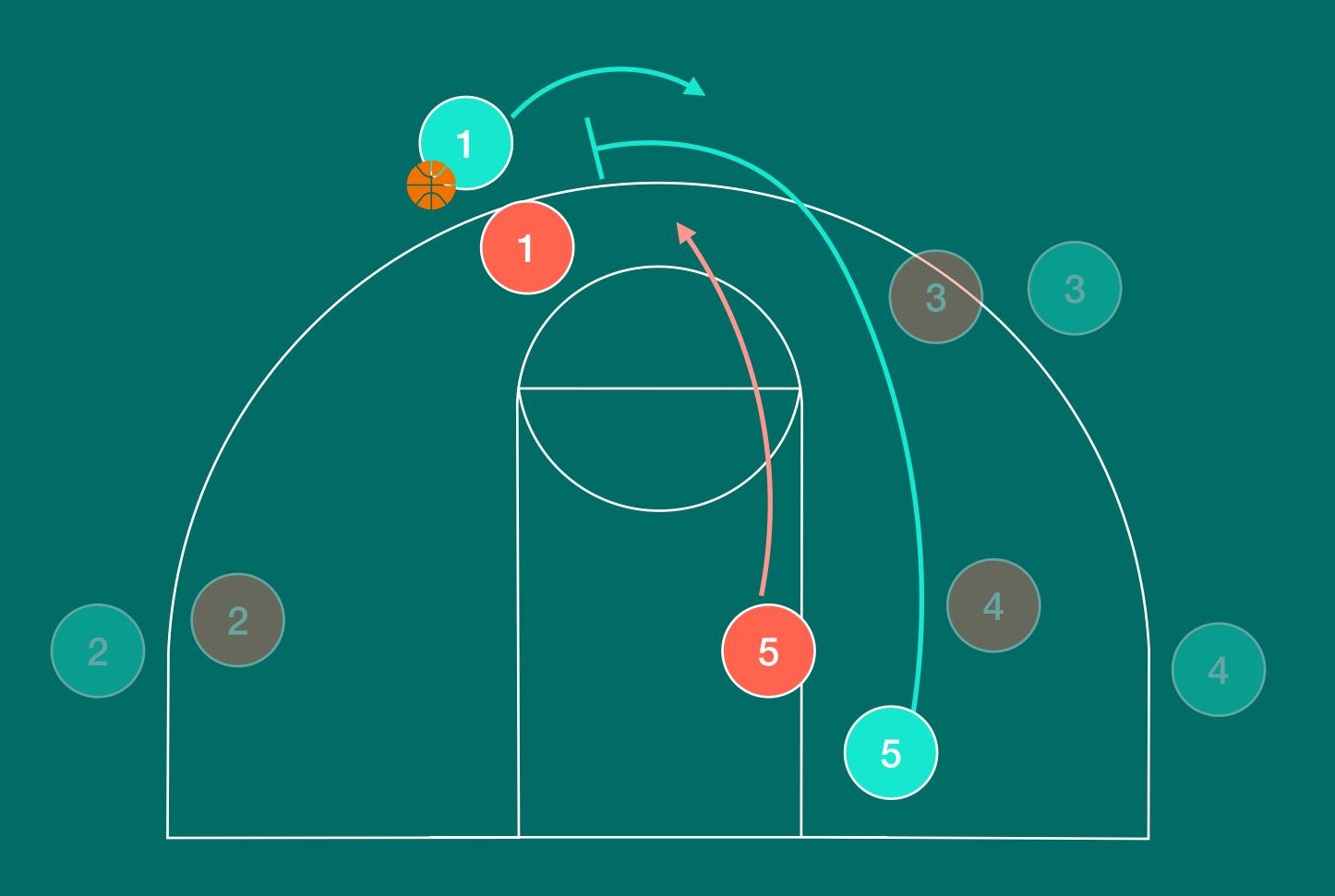
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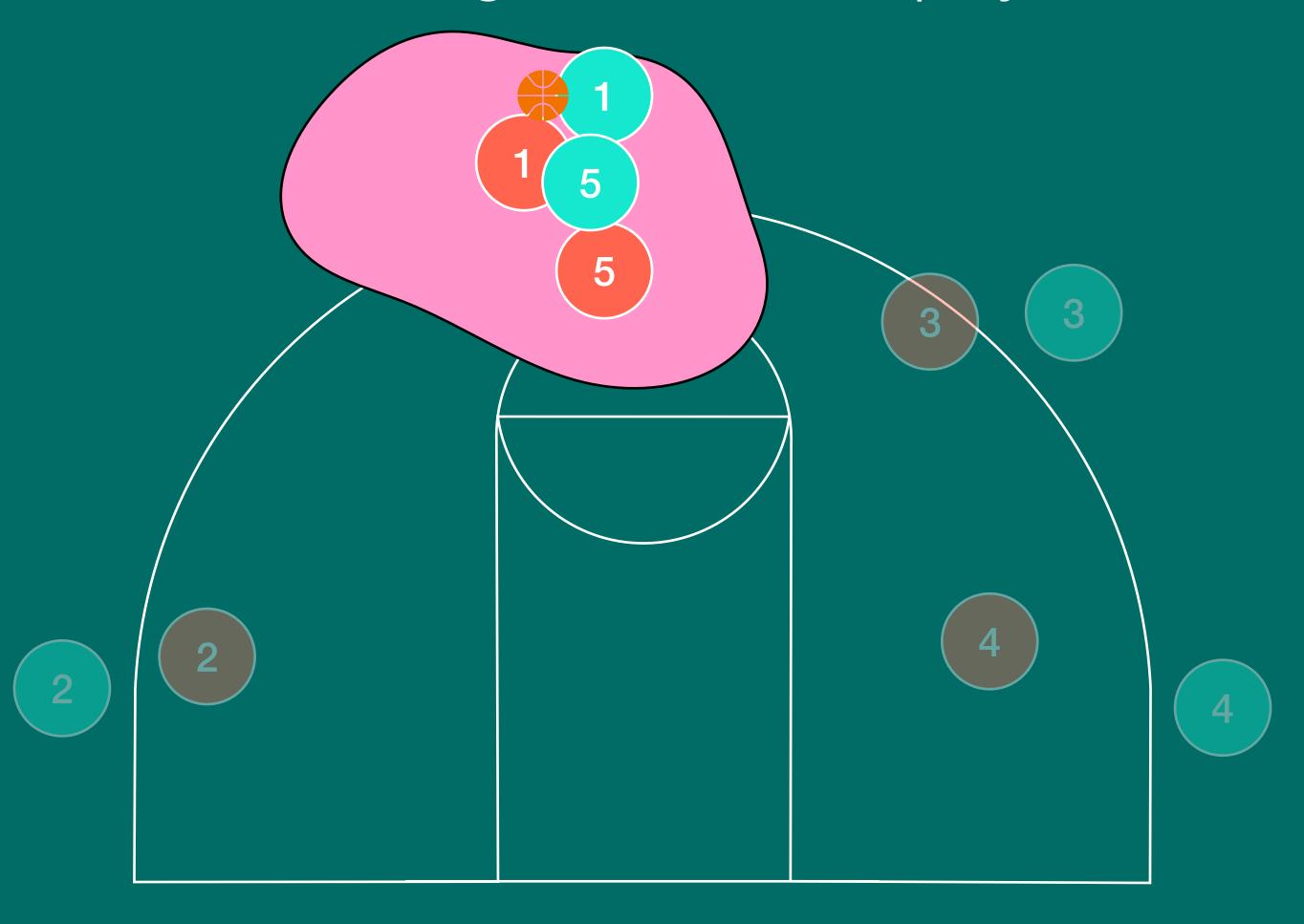
Challenge - ball-screen play



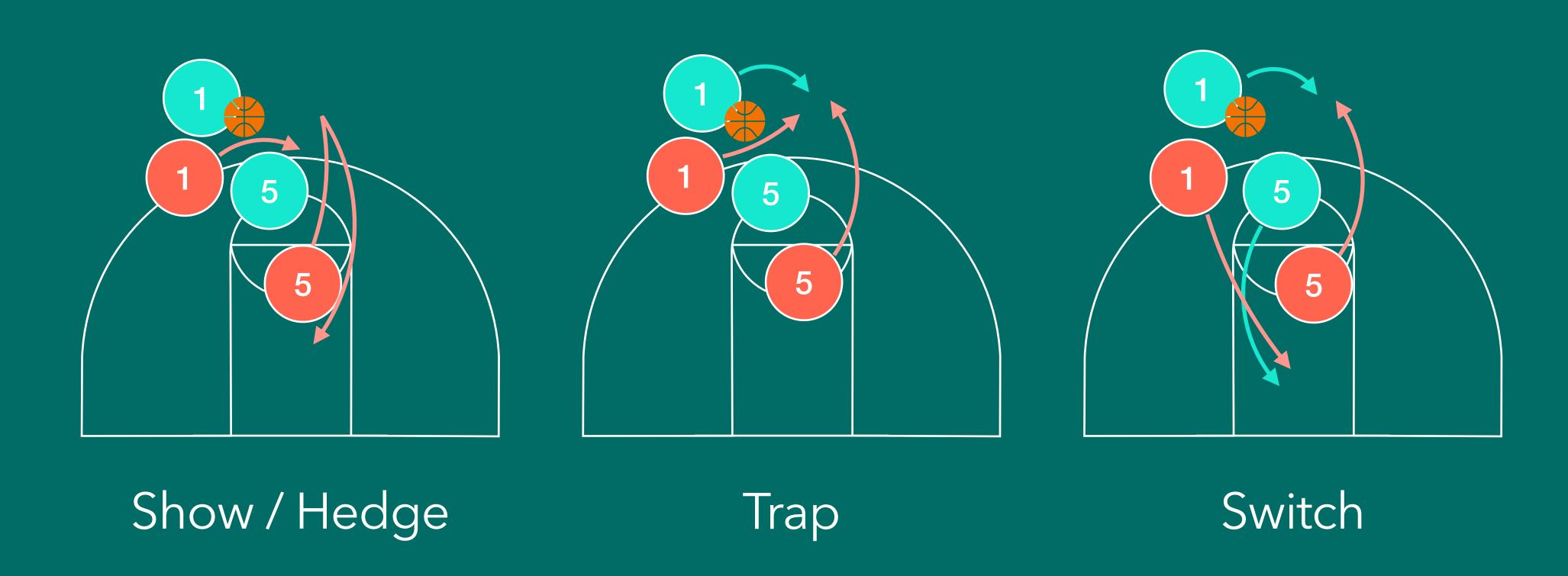
Challenge - ball-screen play



Challenge - ball-screen play

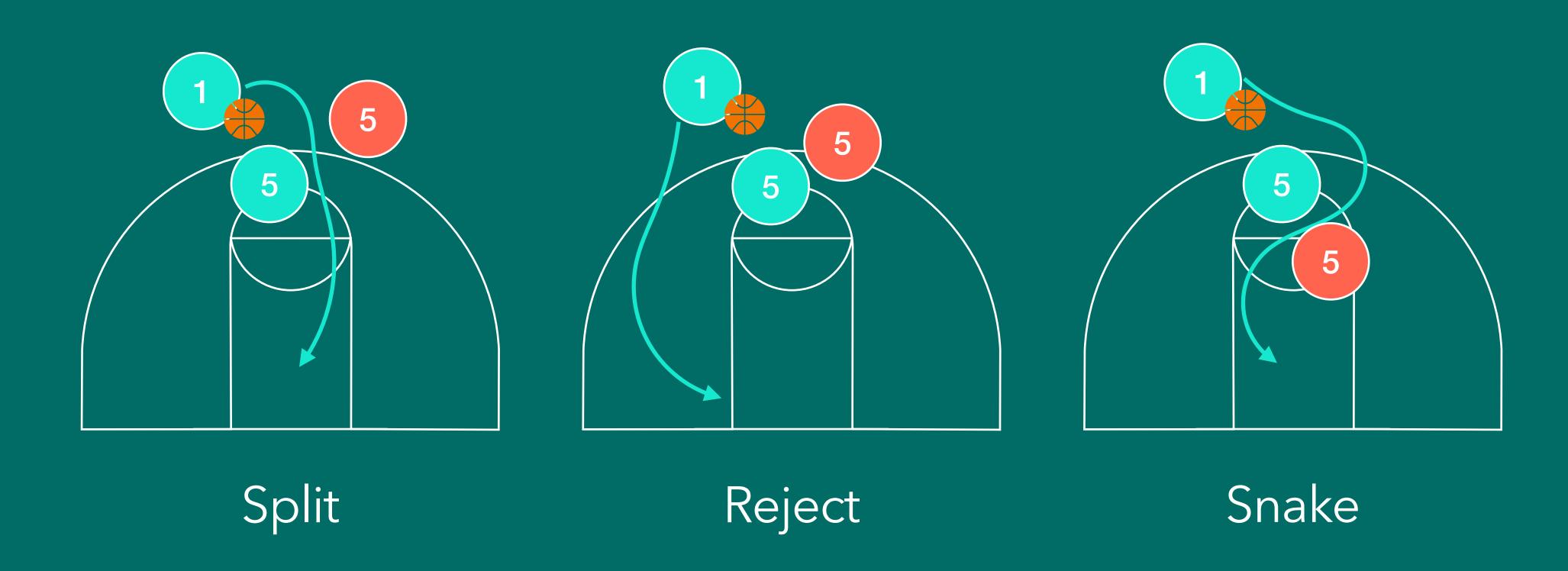


Challenge - ball-screen play



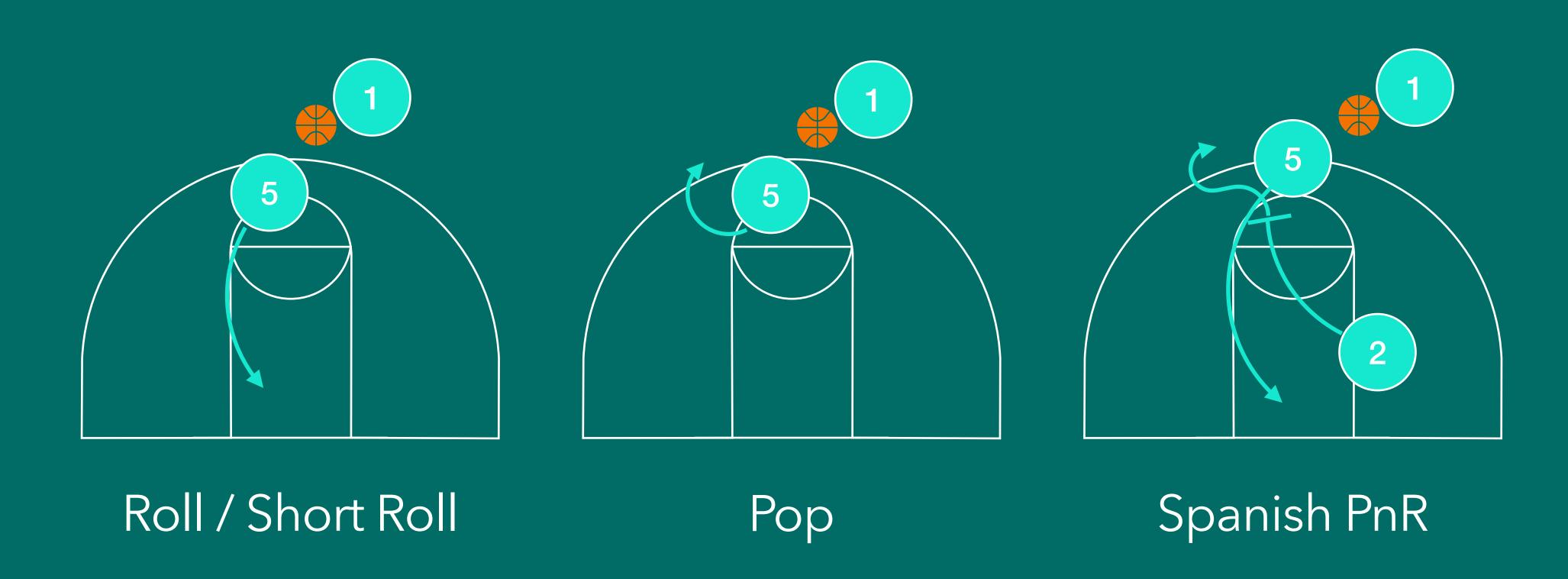
Decision-making process: defense

Challenge - ball-screen play

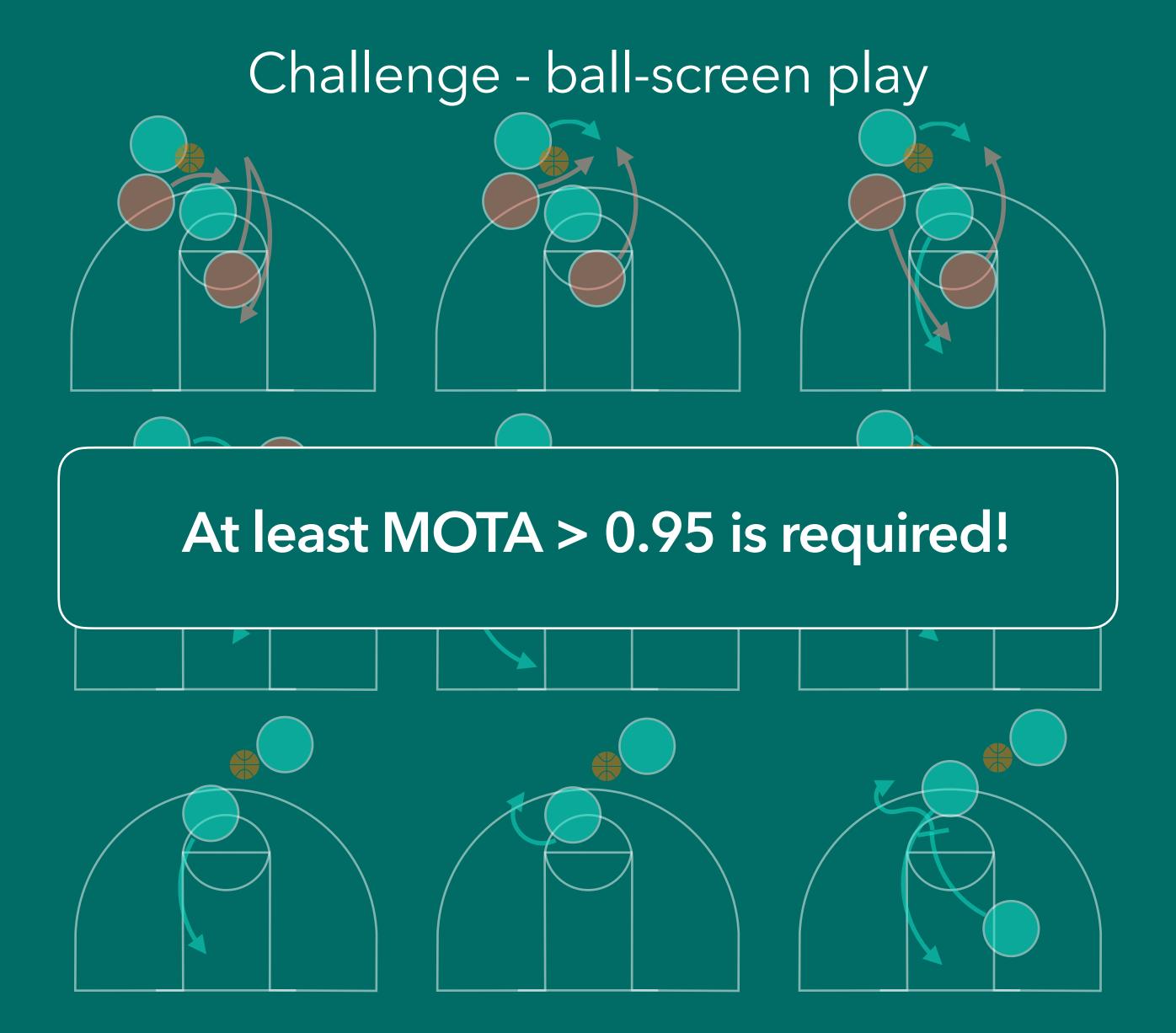


Decision-making process: ball handler

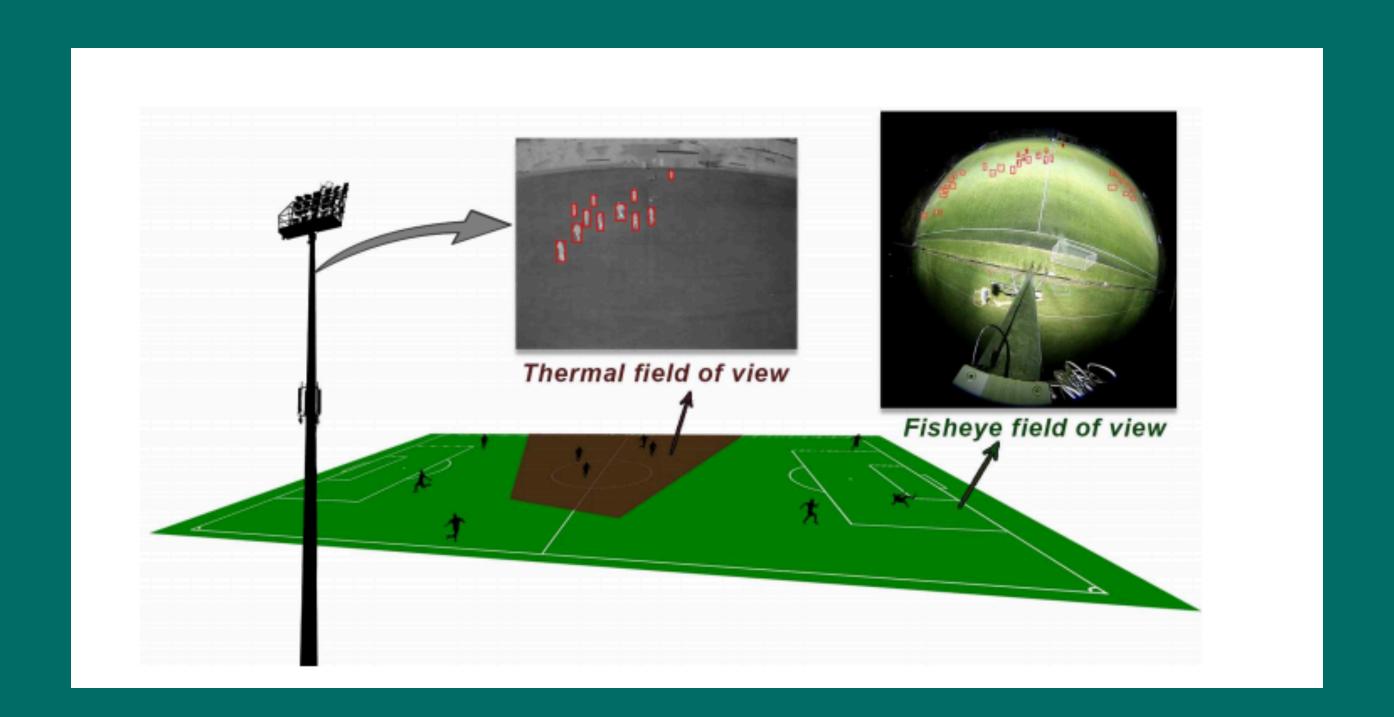
Challenge - ball-screen play



Decision-making process: screener



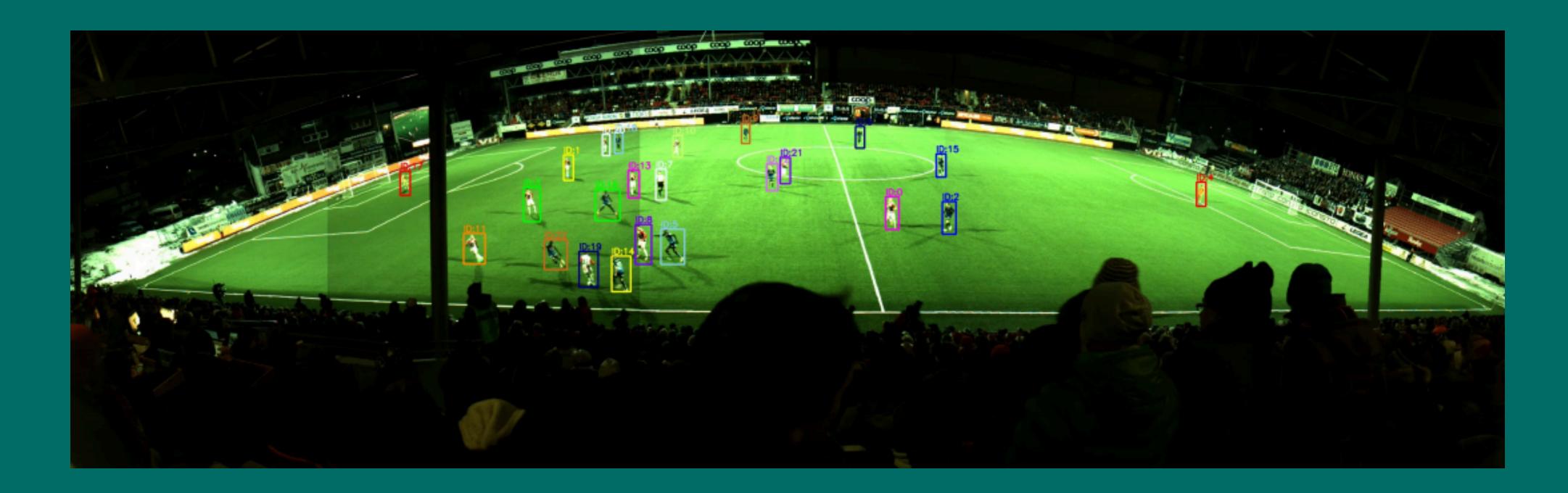
• Complex set-ups, or... Provide automatic CV-based tracking data through creative low-cost solutions!



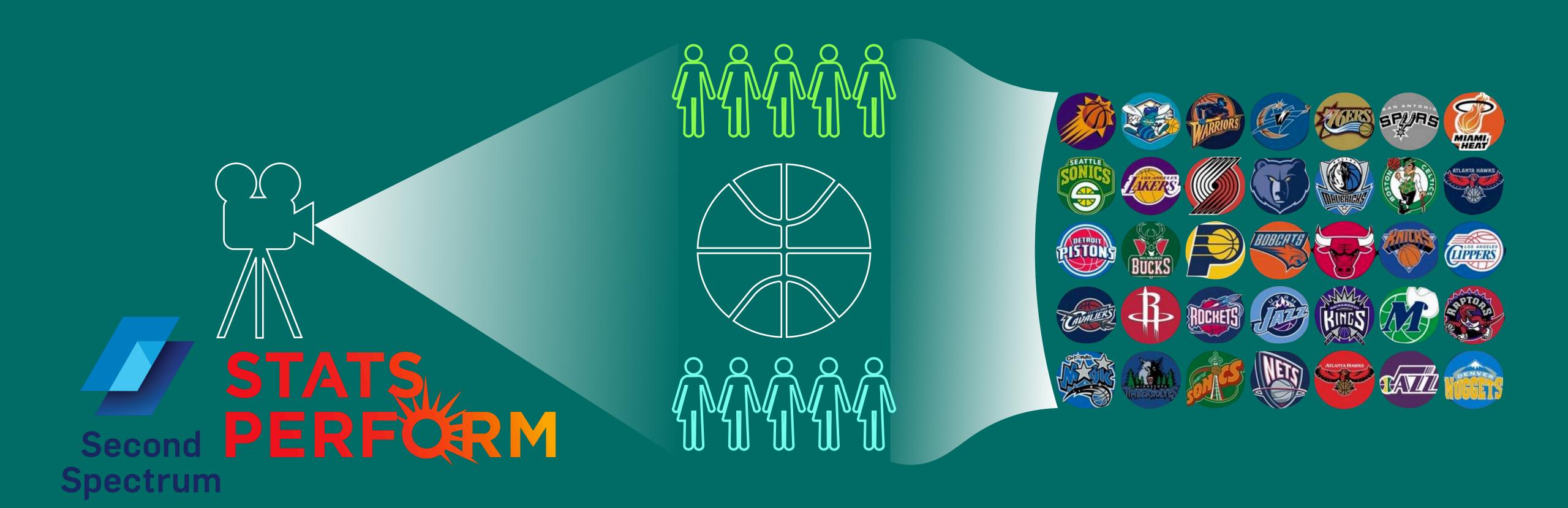
Multimodal and multiview distillation for real-time player detection on a football field [Cioppa, Deliège, et al.]

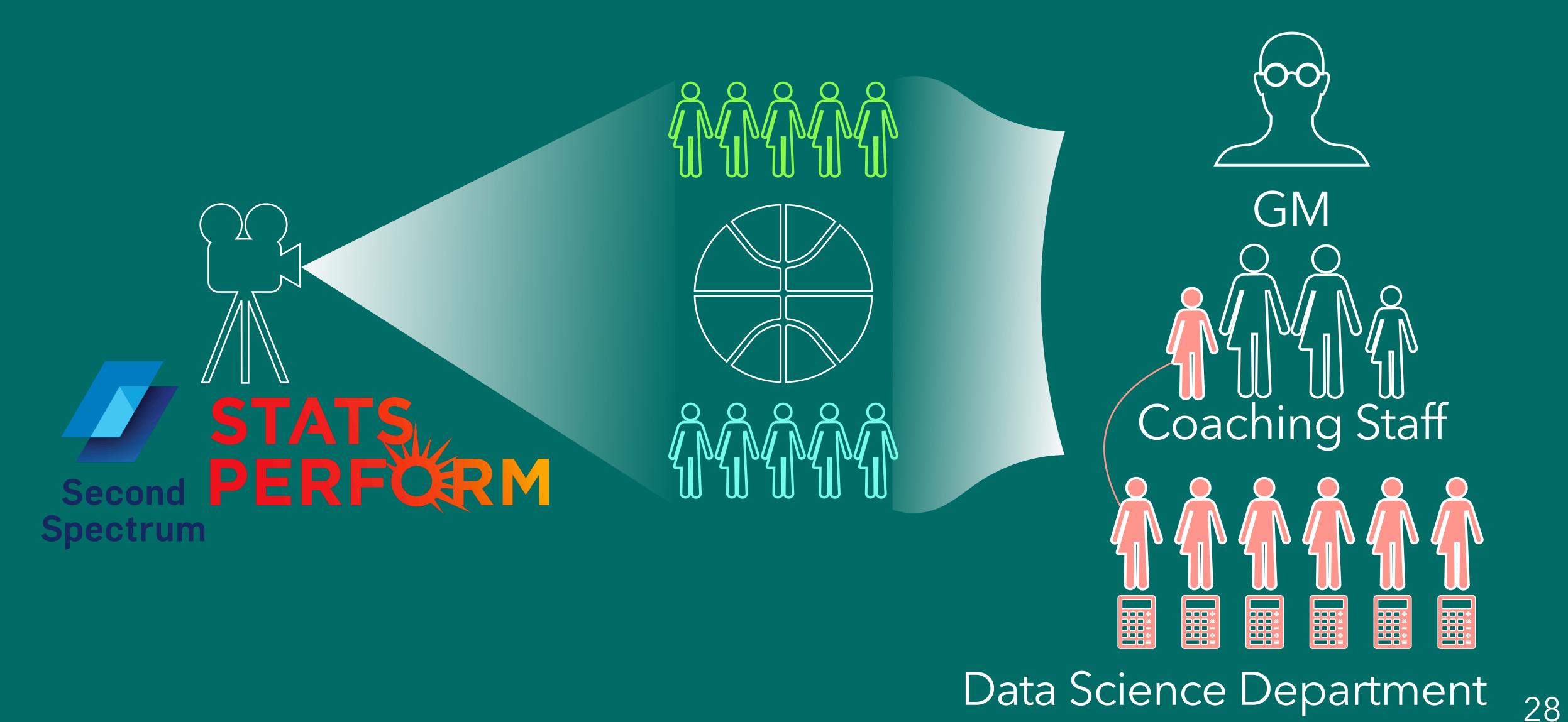
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• Complex set-ups, or... Provide automatic CV-based tracking data through creative low-cost solutions!



Self-Supervised Small Soccer Player Detection and Tracking [Hurault et al.]





#### **NBA ANALYTICS STAFF BY TEAM**

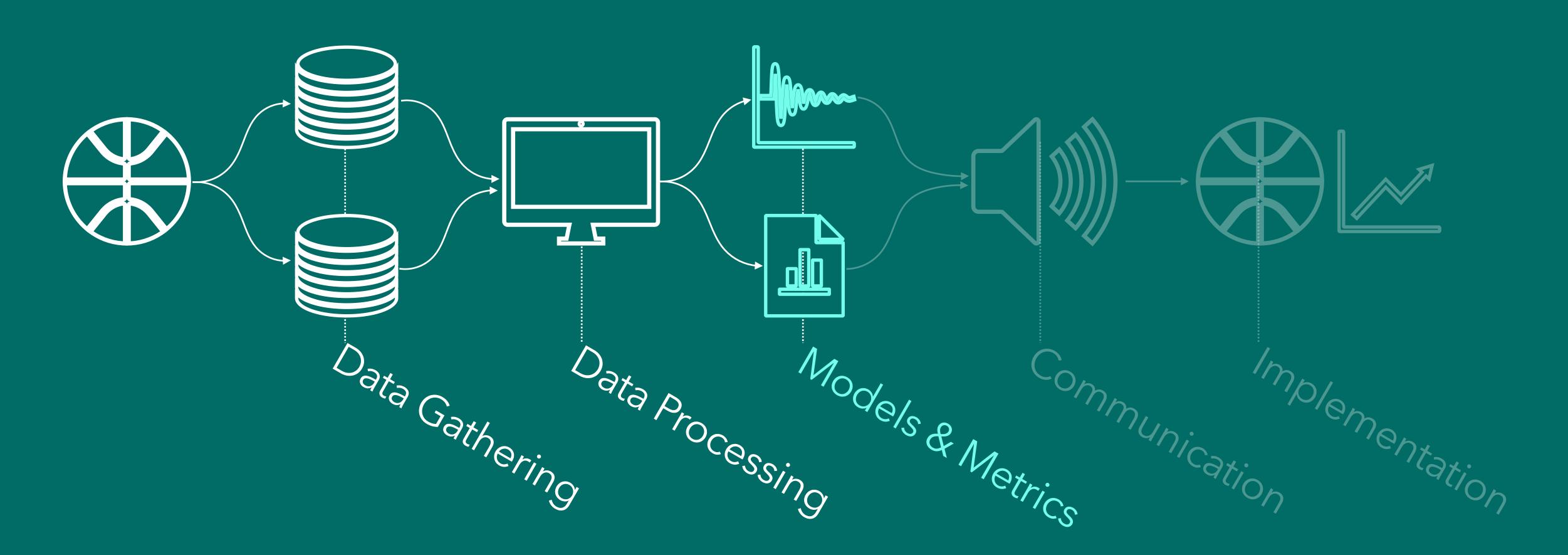
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Source: Seth Partnow

#### **NBA ANALYTICS STAFF BY TEAM**

Team	Staffer	Title	Team	Staffer	Title	Team	Staffer	Title
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	Max Horowitz	Sr. Data Scientist, Basketball Strategy & Analytics		Ryan Renteria	Basketball Analytics Advisor		Sergi Oliva	VP, Strategy
William S	Mike Zarren	Assistant GM and Team Counsel		Nick Fleder	Basketball Data Analyst	P.B.	John Boyles	Director, R&D
	David Sparks	Director of Basketball Analytics		Jud Winton	VP of Research and Analytics		Grant Fiddyment	Manager, Basketball Research
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	Drew Cannon	Basketball Ops Analyst	$\Theta \blacksquare \Theta$	Marshall Smith	Basketball Data Analyst	Work of the second	Ivana Seric	Sr. Data Scientist
	Luigi Sorbara	Basketball Ops Statistician and Programmer	V <u>™</u> V	Ben Starks	Basketball Data Analyst	•	Tegan Bunsu Ashby	Developer
- 1	David Lewin	Director of Player Personnel	9	Matt Elijah	Manager of Strategic Planning		DJ MacLeay	Video Coordinator
	Glenn DuPaul	Director of Analytics		Chethan Reddy	Full Stack Developer	4	Thomas Bridges	Assistant Video Coordinator
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	Kevin Roark	Basketball Systems Developer		Harry Heffernan	Basketball Analyst and Developer	SUNS	Hiroki Witt	Basketball Operations Analyst
	Rohan Jaitley	Basketball Video and Analytics Assistant		Rich Cho	VP of Basketball Strategy		Zach Williams	Director of Basketball Analytics
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	Alexande							Analyst
Ψ,	Michael	JBA scientific		artma	nto are not	`\/\_	2000	Ind Analytics
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(6)	Brad H							ıst
	Jeremy	Gooder Cr	Cate	novo	I CV metrics	2 0	CIOri	and Development
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	Zach Chu	Basketball Analytics Liason	and the same	Kelsey Roberts	Database/Basketball Analyst		Keith Boyarsky	VP, Basketball Strategy and Research
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	Pabail Sidhu	Director of Basketball Analytics & Innovation		James Kopanidis	Strategic Planning Analyst	SHING	Dean Oliver	Assistant Coach
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				Dylan Murphy	Basketball Operations Analyst			@SethPartnow
				Anna Zhao	Data Scientis∜Developer			

## What metrics are we supposed to extract?



## Metrics: Guidelines (not only CV)

[Credits - Justin Jacobs]

Model implicit features that cannot be estimated with the physics of the game. Learn from the output - valuable insights.

Prediction

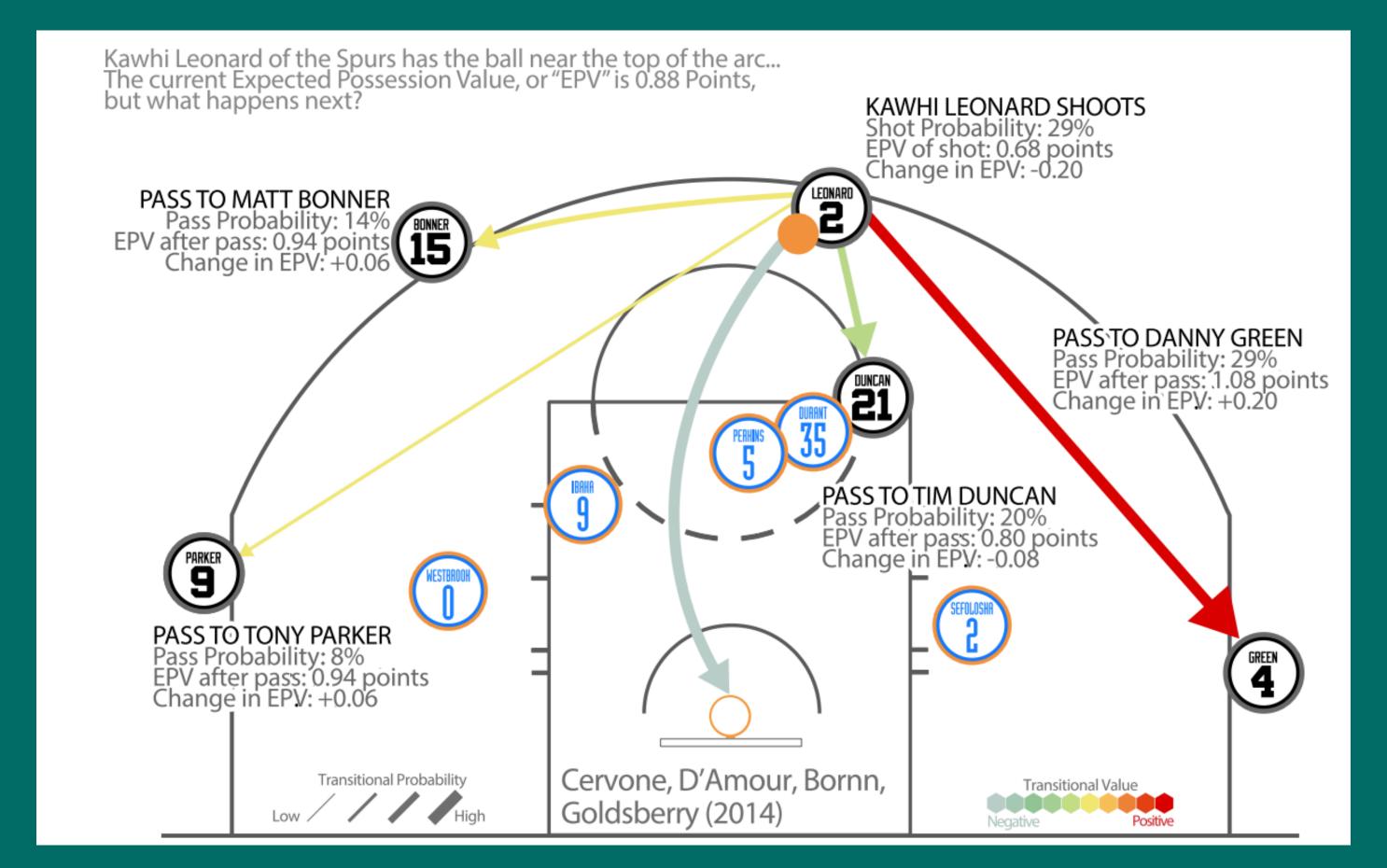
Interpretability

Actionable Intelligence

Sacrifice accuracy for interpretability.

## Metrics: on top of CV - Predict

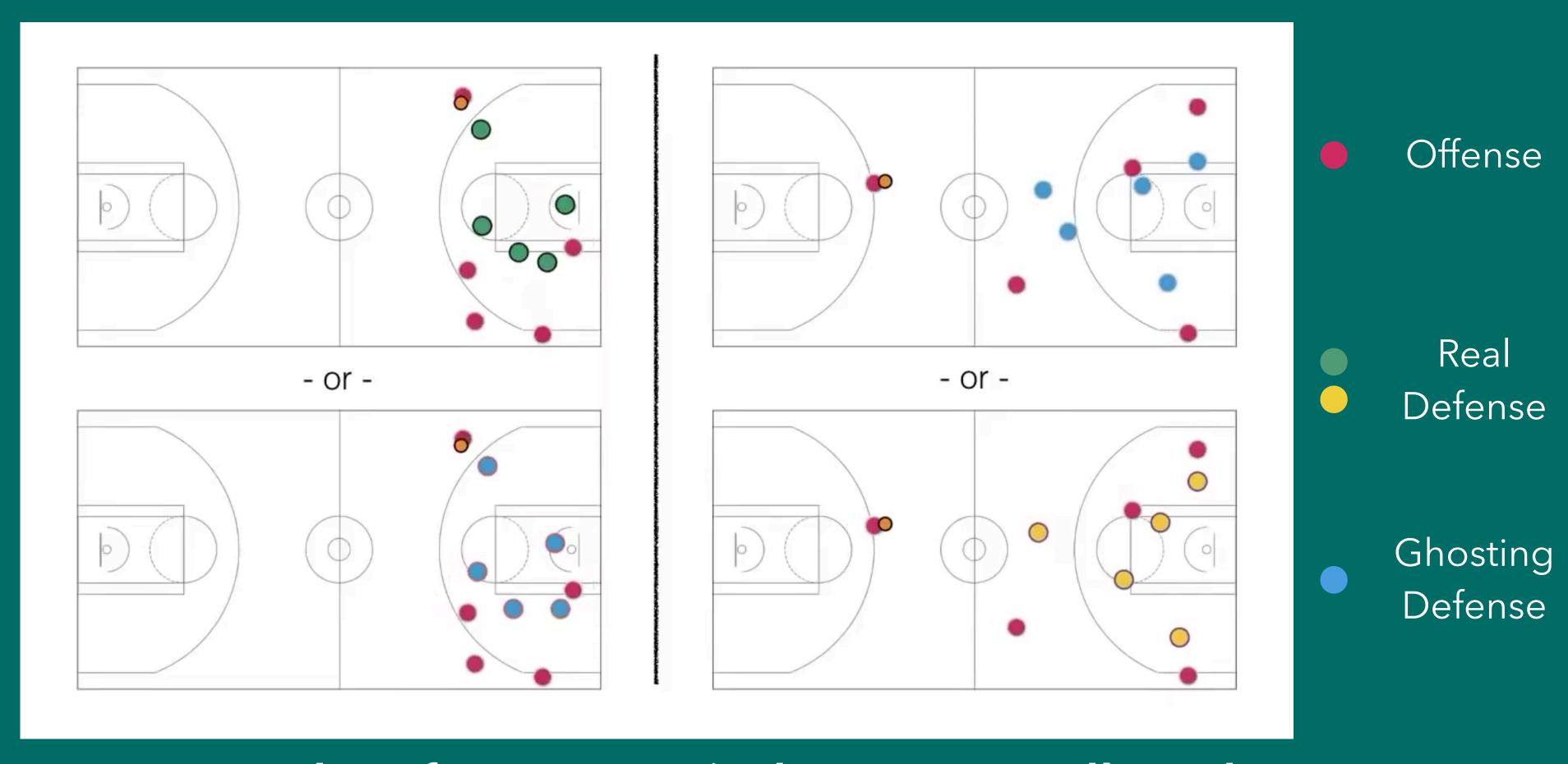
Train models from tracking data to obtain meaningful insights



EPV Models [Cervone et al. 2014 - basketball, Fernández et al. - soccer 2019]

## Metrics: on top of CV - Predict

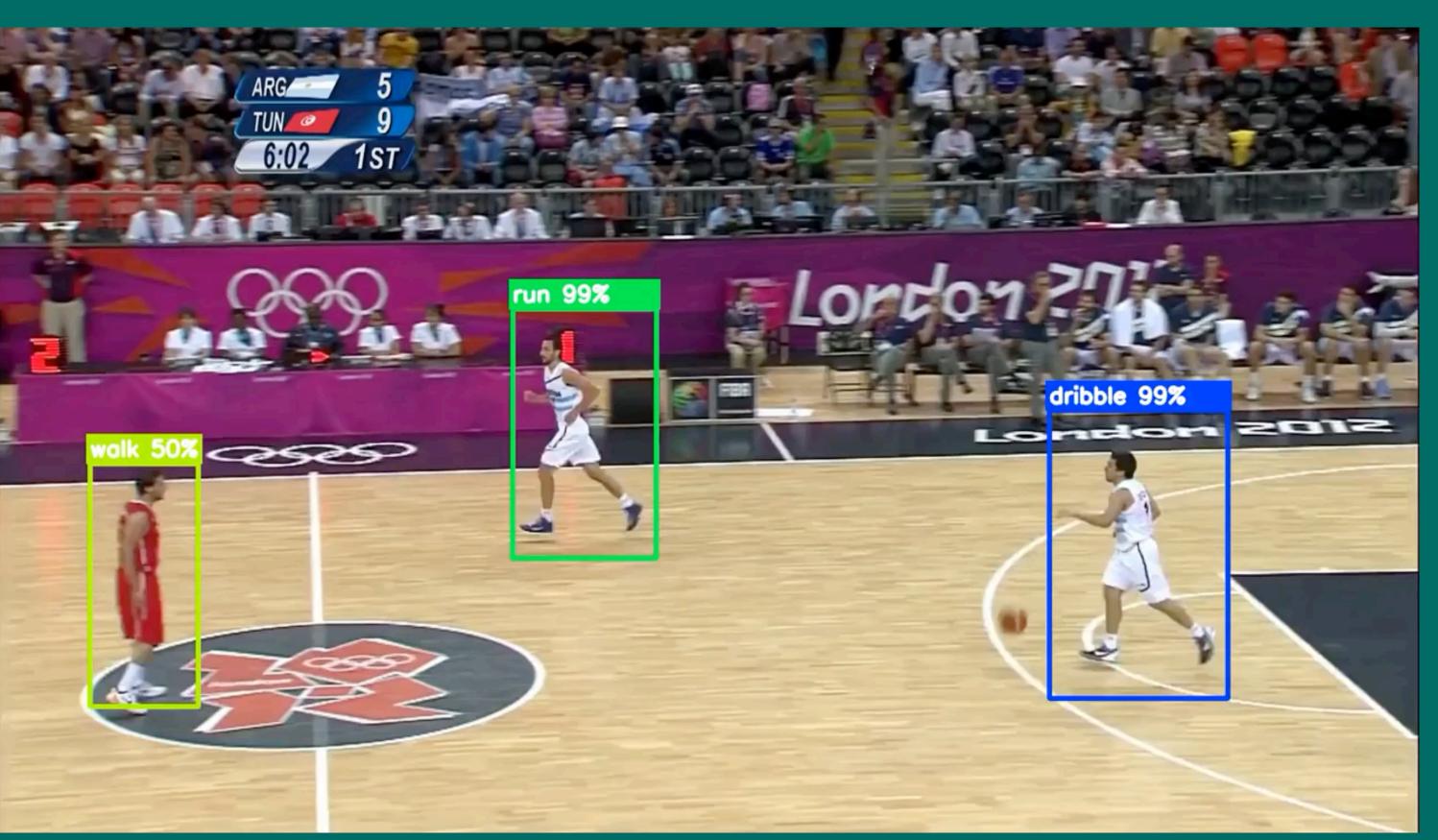
Train models from tracking data to obtain meaningful insights



Bhostgusters - What if scenarios / Ghosting [Seidl et al., 2018]

- Add more layers the 2D information to re-define metrics:
  - A player is at (X, Y) and he/she is...

- Add more layers the 2D information to re-define metrics:
  - A player is at (X, Y) and he/she is jumping / passing / screening...



Proper definition of open / contested shots

Body-language / Effort

Automatic playtype

Summarization

Action Recognition [Francia et al., 2018]

- Add more layers the 2D information to re-define metrics:
  - A player is at (X, Y) and he/she's facing towards  $x^{\circ}$  (+ pose data)



Field-of-view estimation

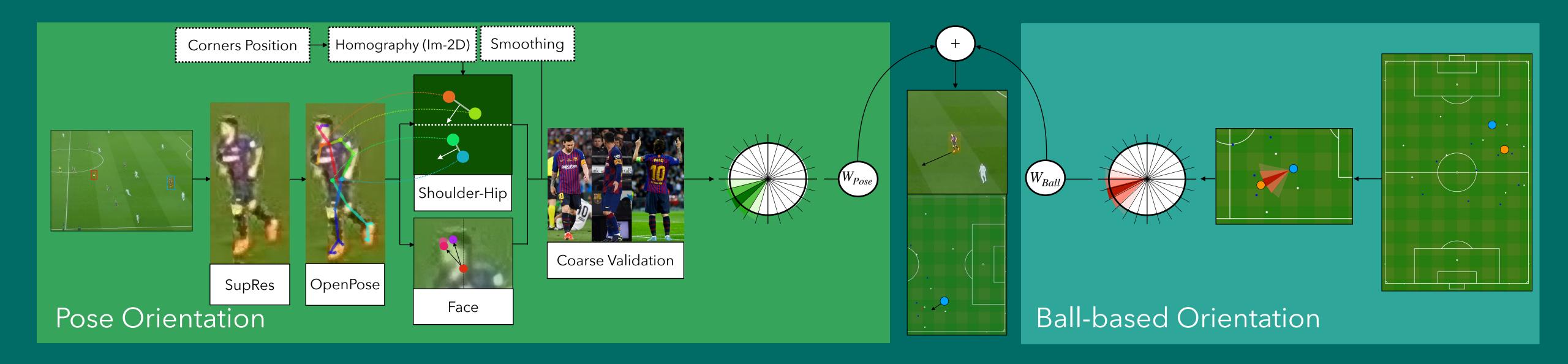
Specific angle stats:

- Passing / screening

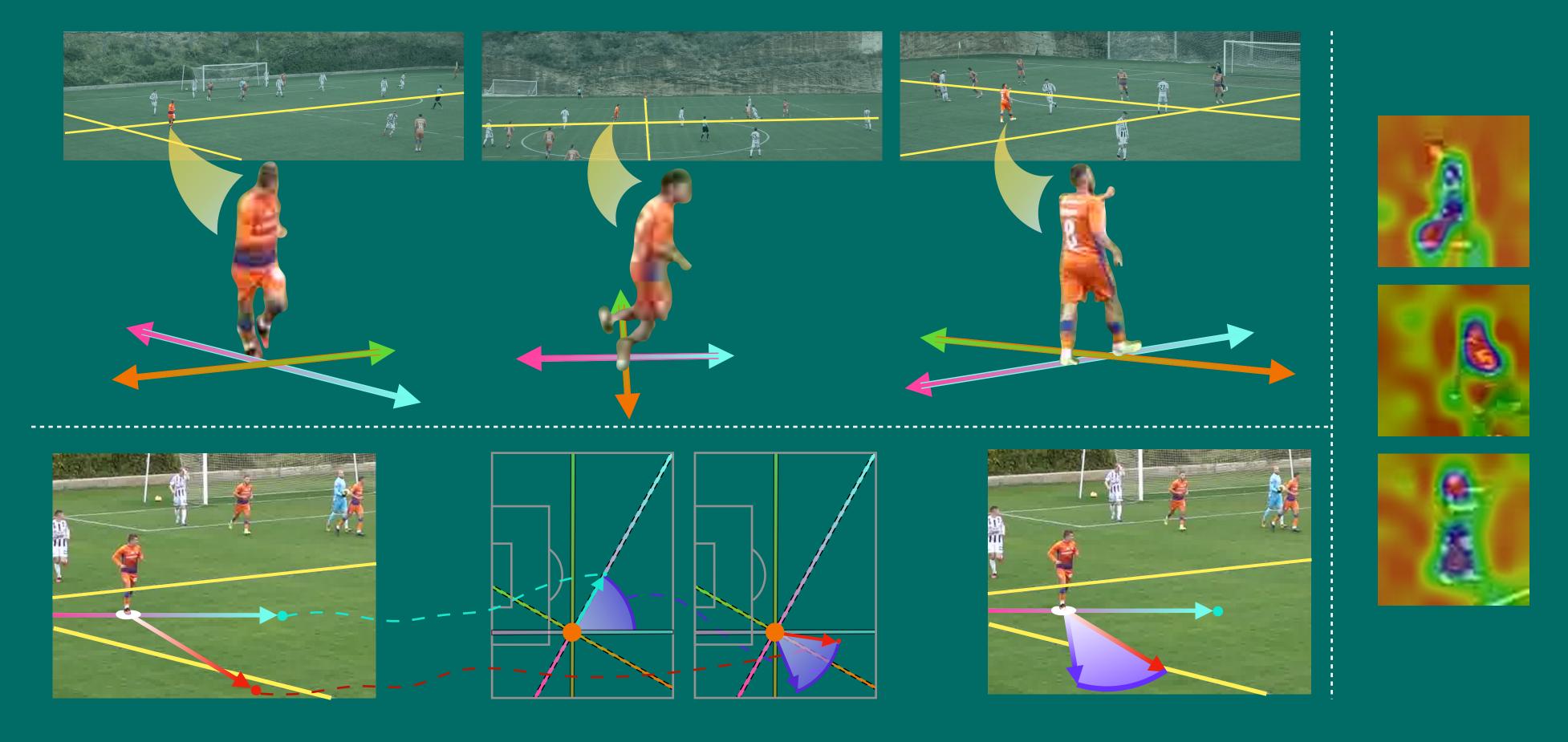
Left / right deviations

Model refinement a posteriori

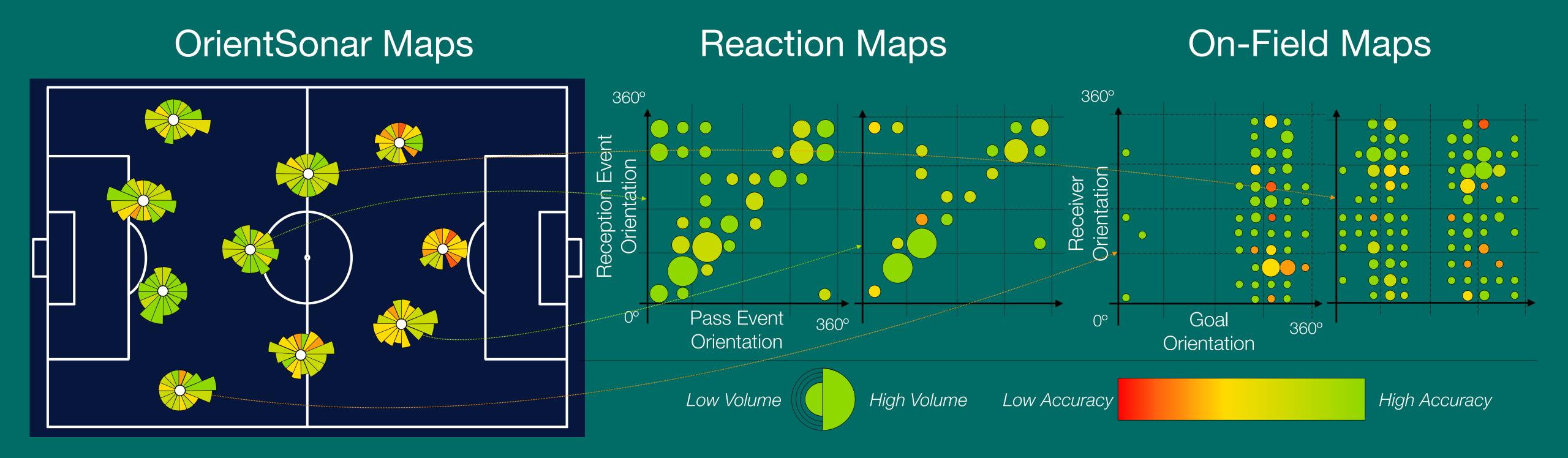
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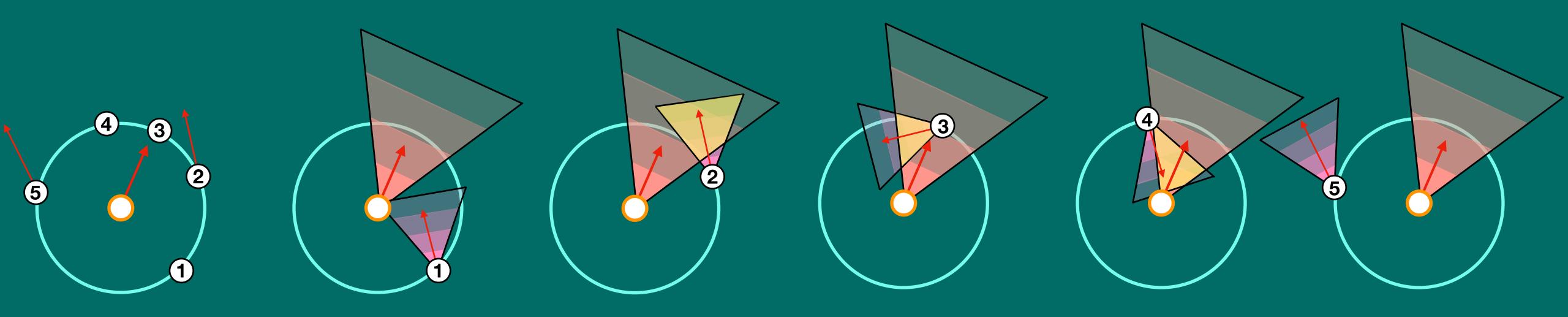
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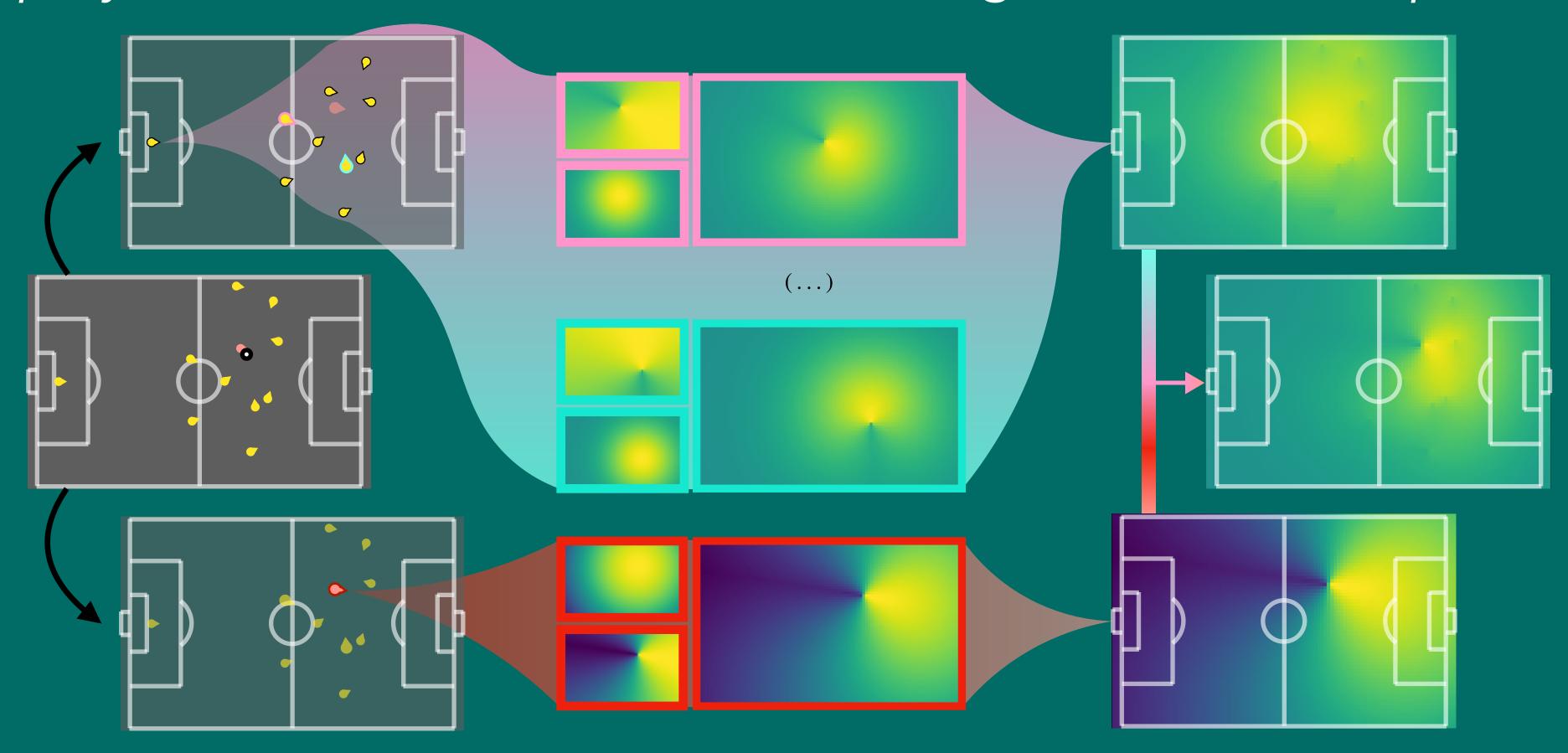
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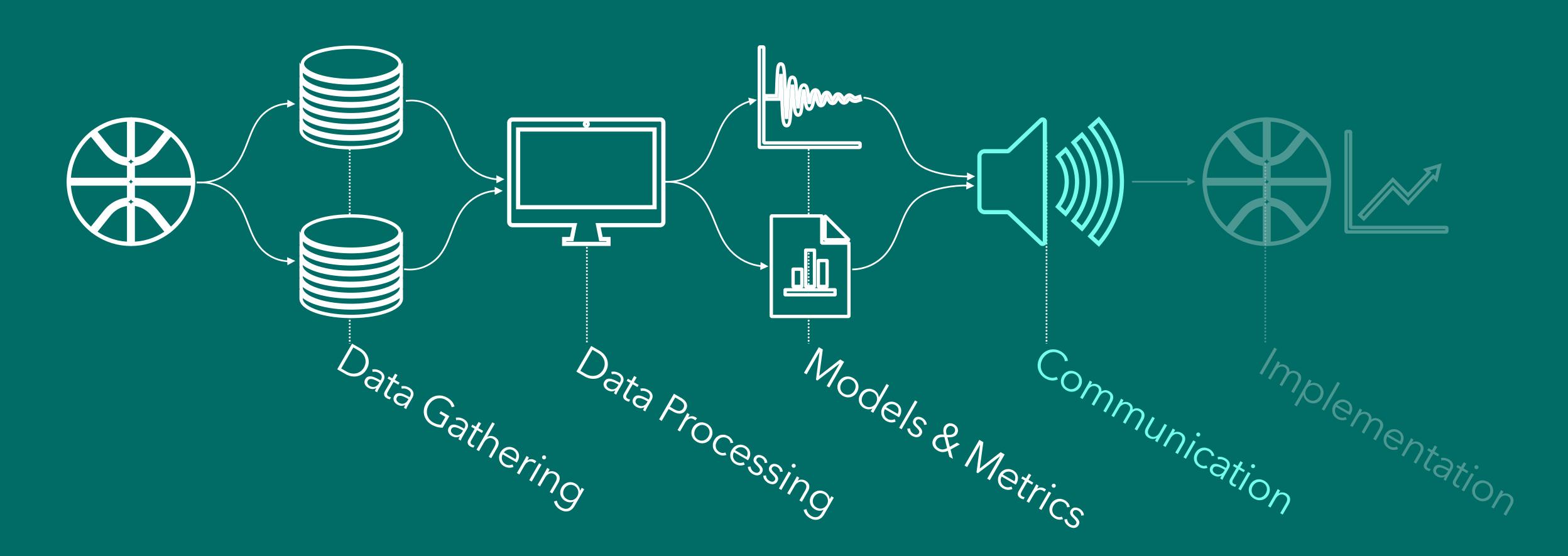
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Stay tuned!

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#### I have stats... Now what?



#### Communication

Each communication channel is unique



#### Communication

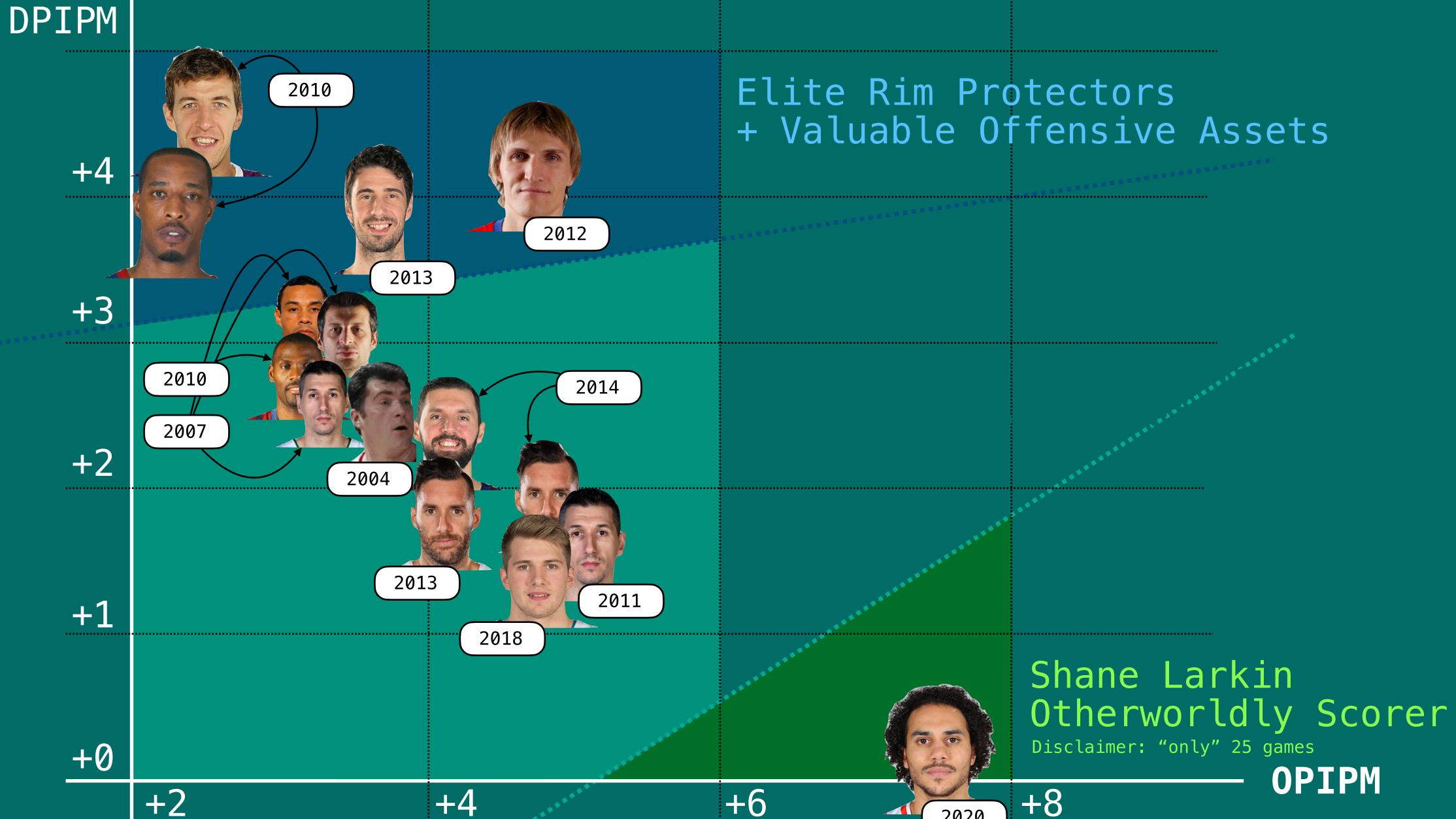


Be a valuable resource, not a coaching thread

Learn how to ask the appropriate questions

Acquire the coaching staff's lingo

# Communication: visualization Elite Rim Protectors 2010



#### Communication

#### [Credits - Seth Partnow]

- Being better is not being right at everything, it is being less wrong.
- Put data in the language of sport hybrid profiles.
- Properties of language:



Arbitrariness



Almost all statistics are arbitrary (not the scoreboard)
We use representative abstractions of game concepts (e.g. rebound)

#### Communication

#### [Credits - Seth Partnow]

- Being better is not being right at everything, it is being less wrong.
- Put data in the language of sport hybrid profiles.
- Properties of language:

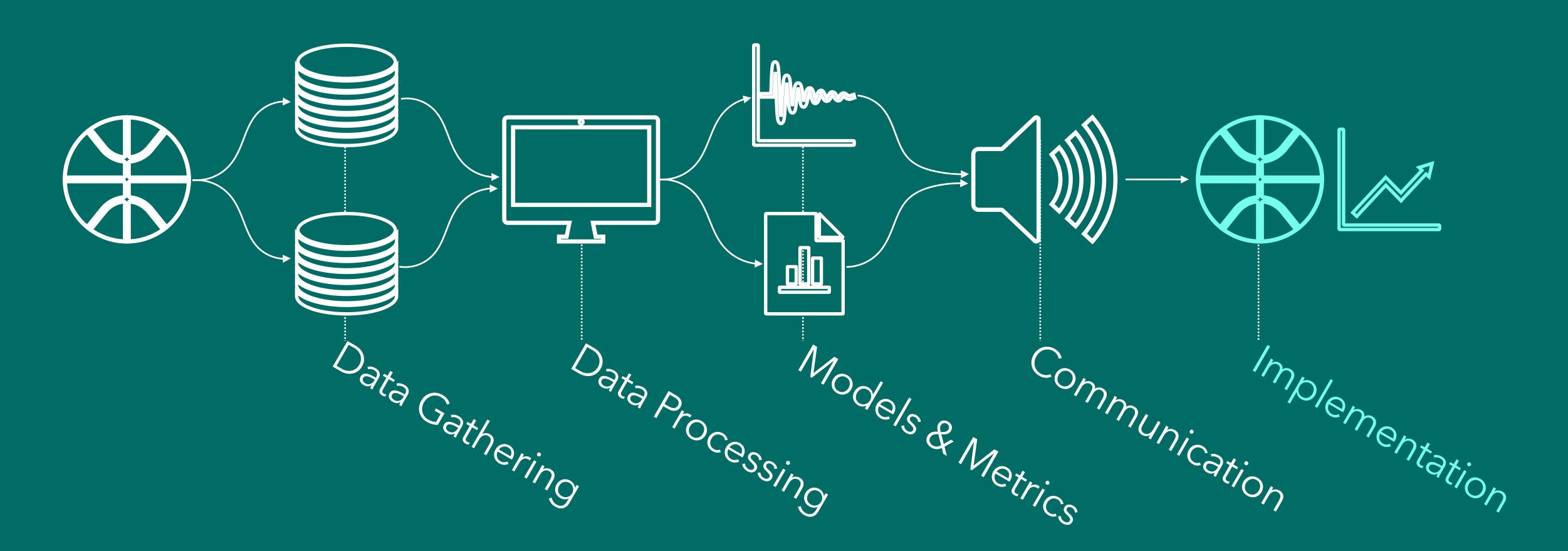


Cultural
Transmission

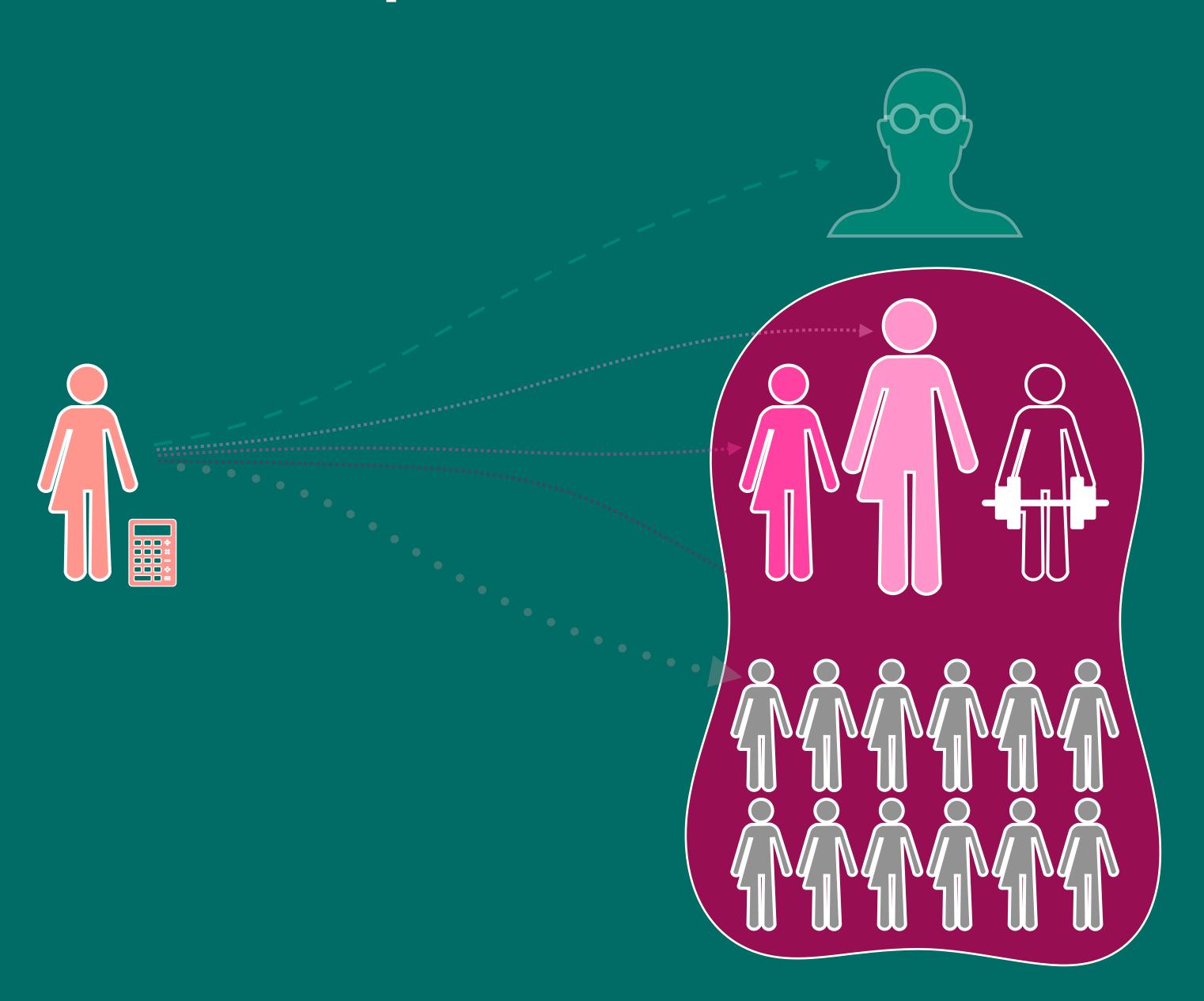


Naming stats: objective & basic, clear calculation / concepts. Avoid: unnecessary jargon / opaque terms, snake oil.

### In this talk...



# Implementation



## Acknowledgements

Gloria Haro Coloma Ballester Adrián Martín Martí Casals Seth Partnow Todd Whitehead Justin Jacobs Andrew Patton Mike Beuoy Nathan Walker Xavi Pardina Juan Llaneza Diego Ocampo Javier Fernández Raúl Peláez

## Thanks for the attention

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Free agent from fall 2021!