

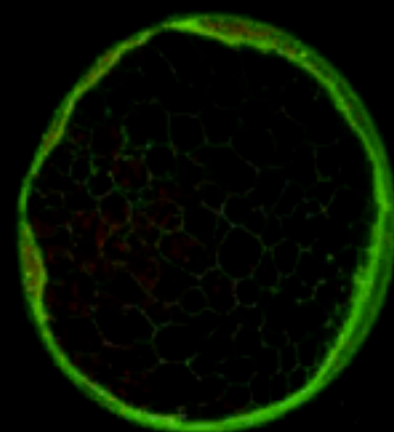
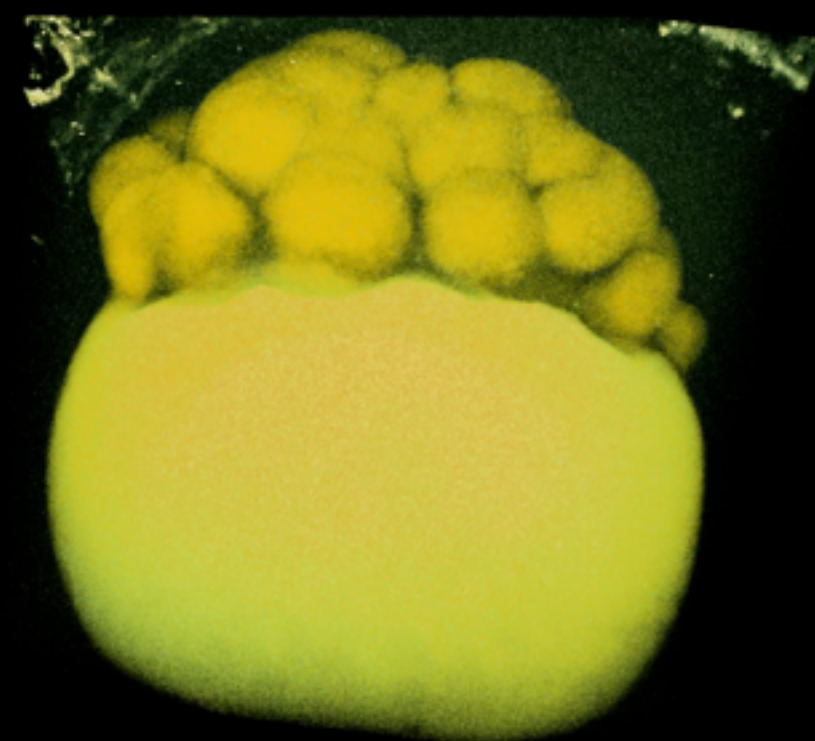
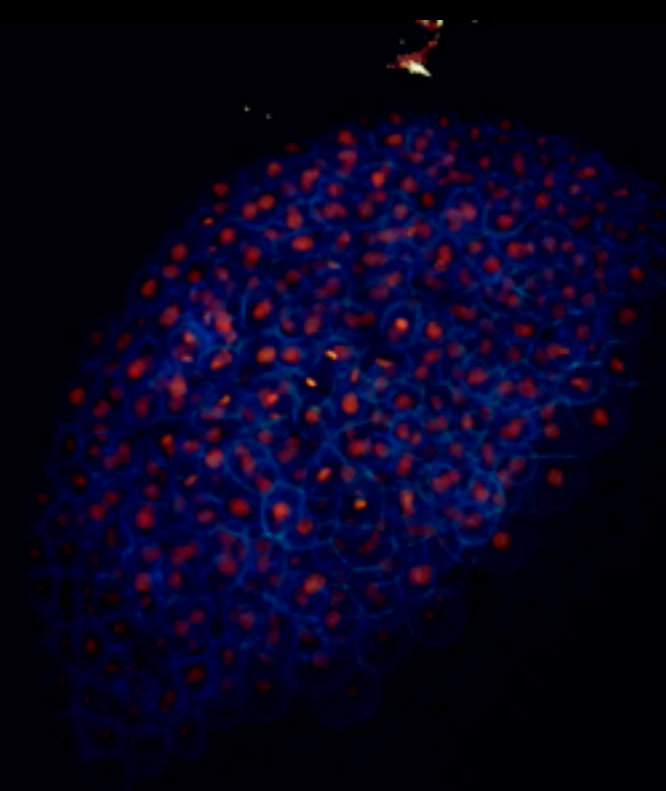
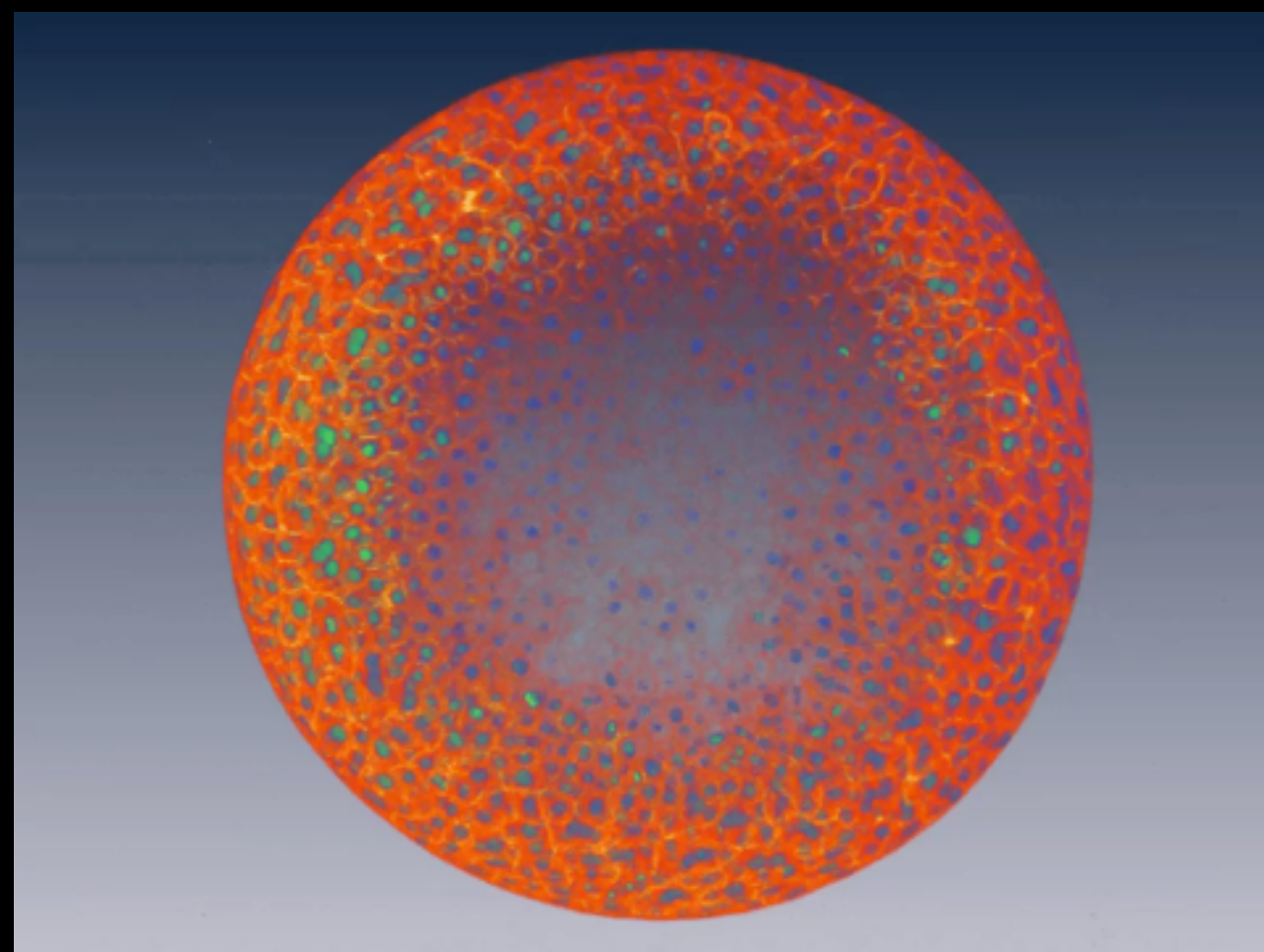
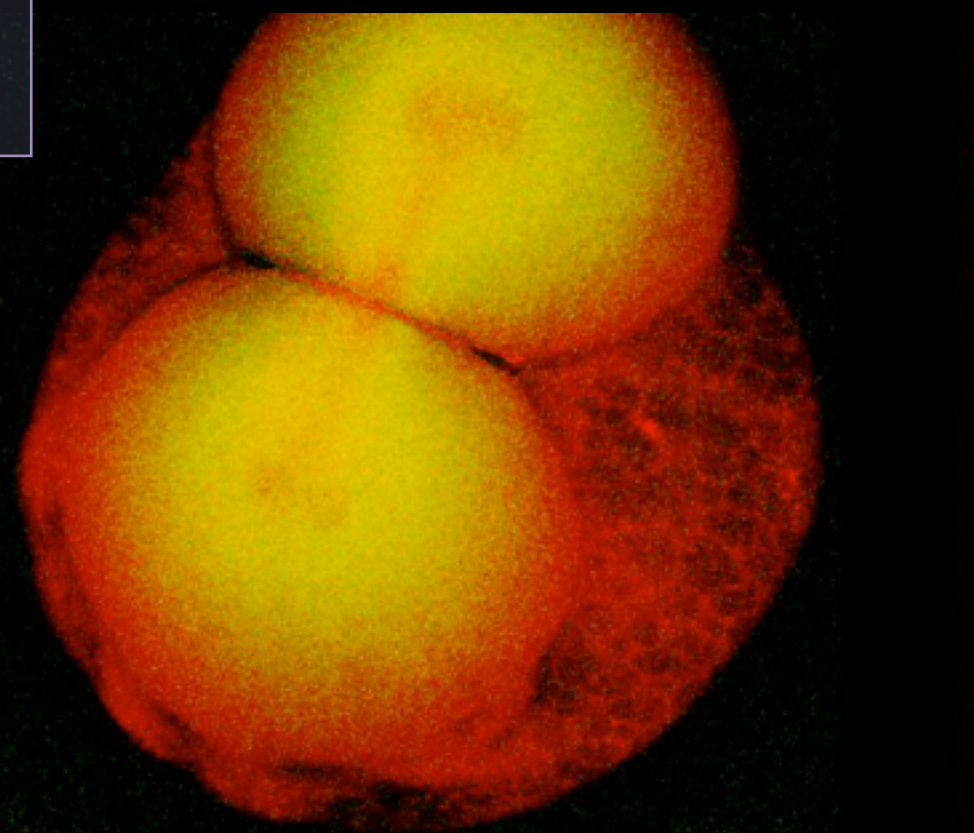
**A workflow to process 3D+time microscopy  
images of developing organisms and  
reconstruct their cell lineage**

Emmanuel FAURE

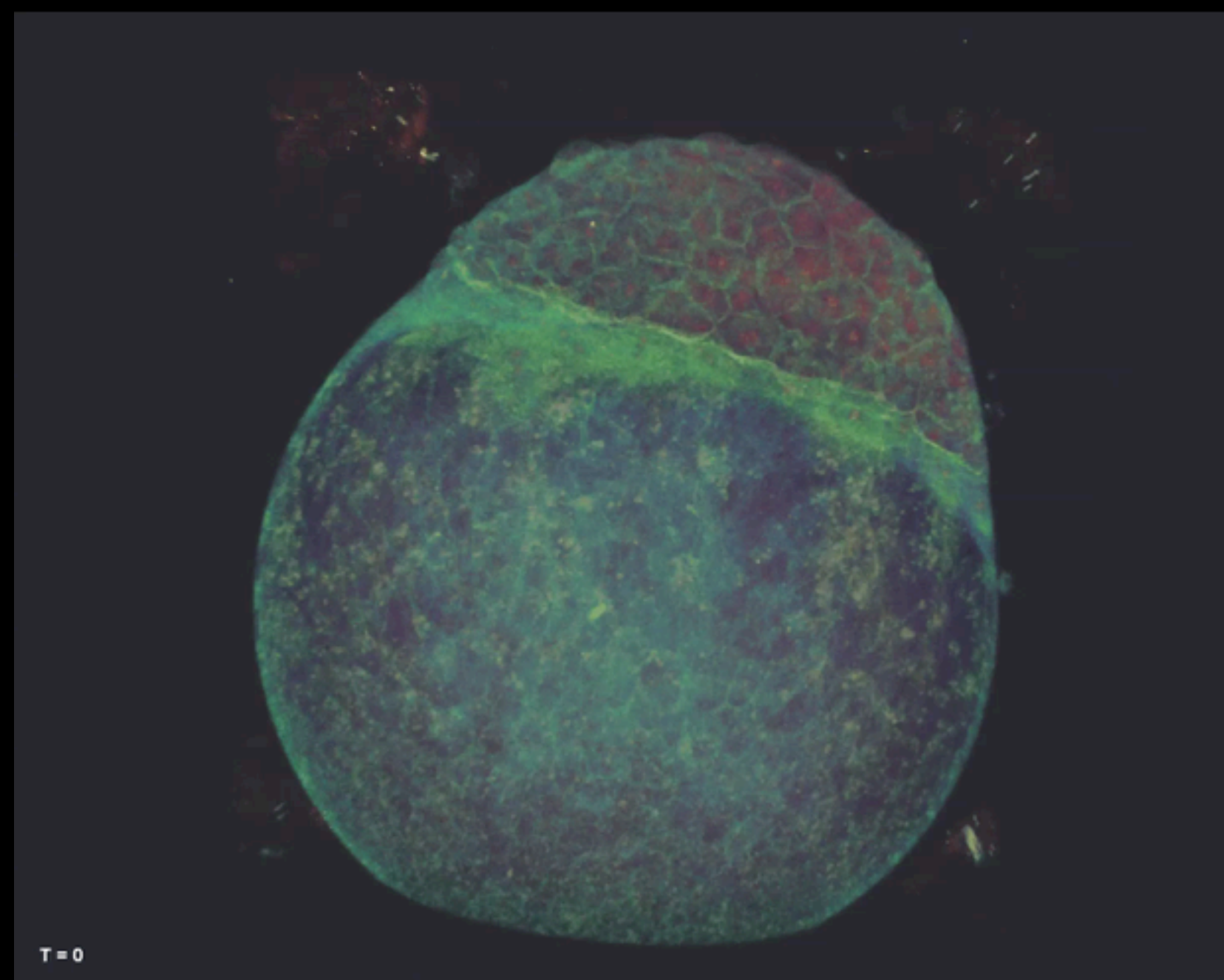
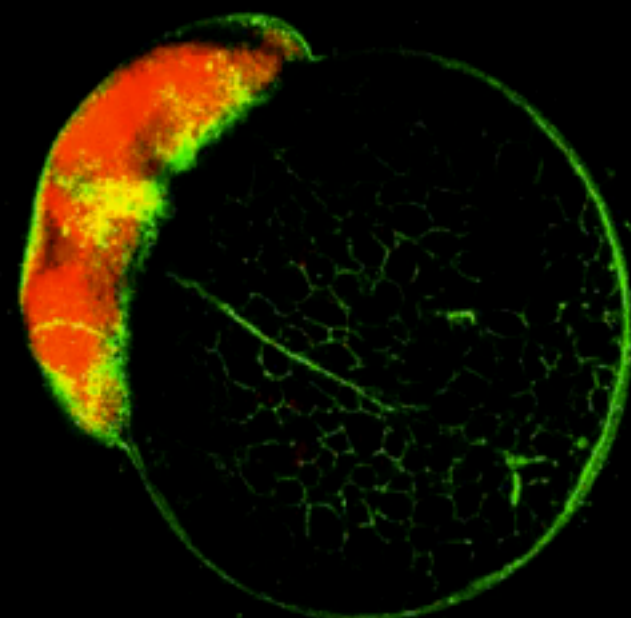
emmanuel.faure@irit.fr

Statistical and biomathematical Models for imaging in cancer  
8 Avril 2016 Cancéropole Grand Sud-Ouest

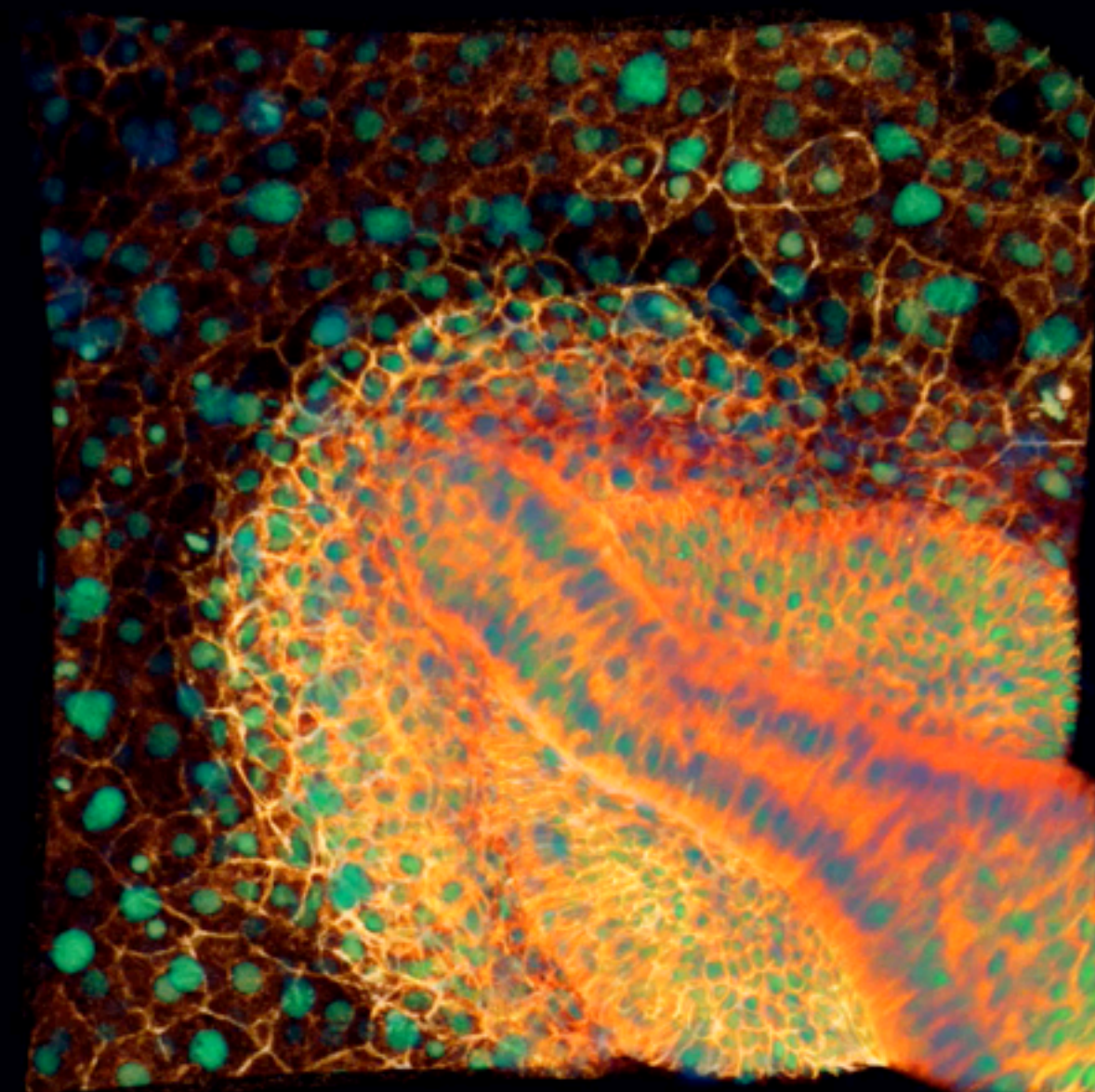
# Issues



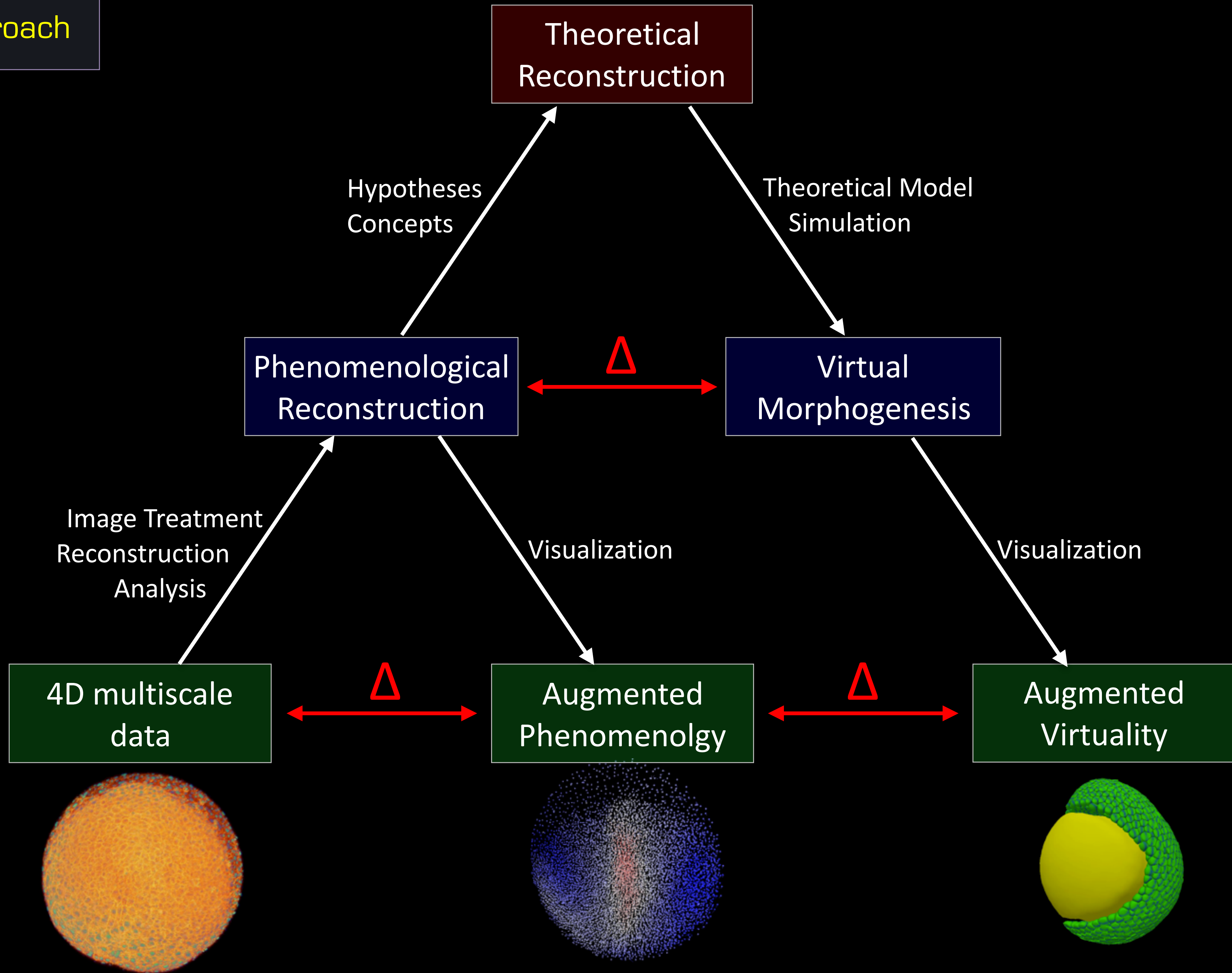
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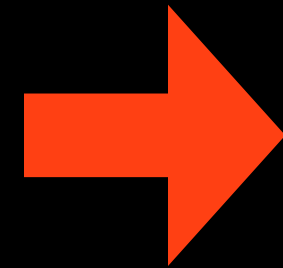
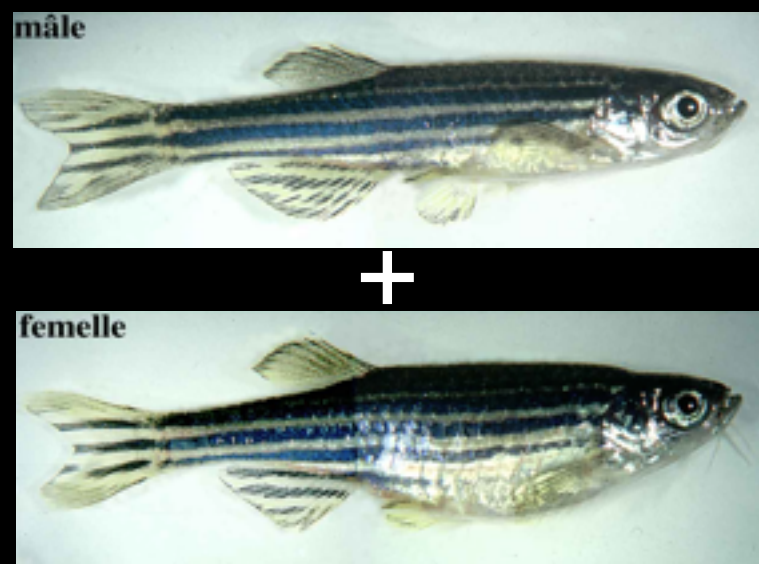
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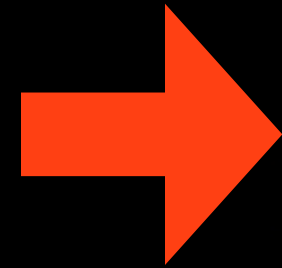
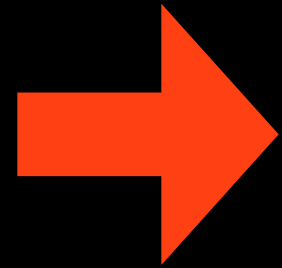
Epistemology Approach



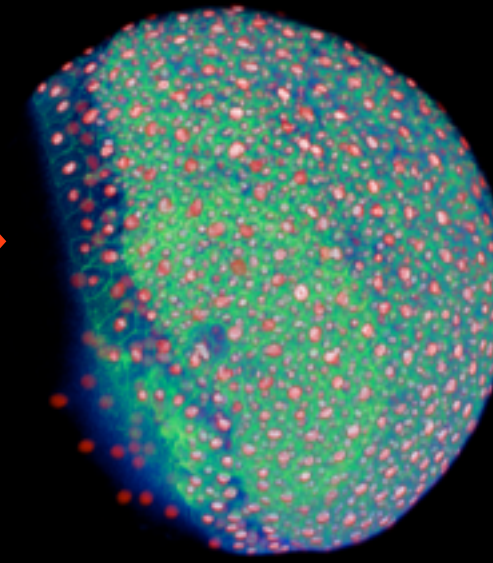
Data Acquisition



+



3D + Time



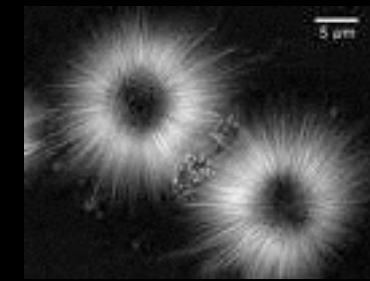
Rawdata



Amphioxus



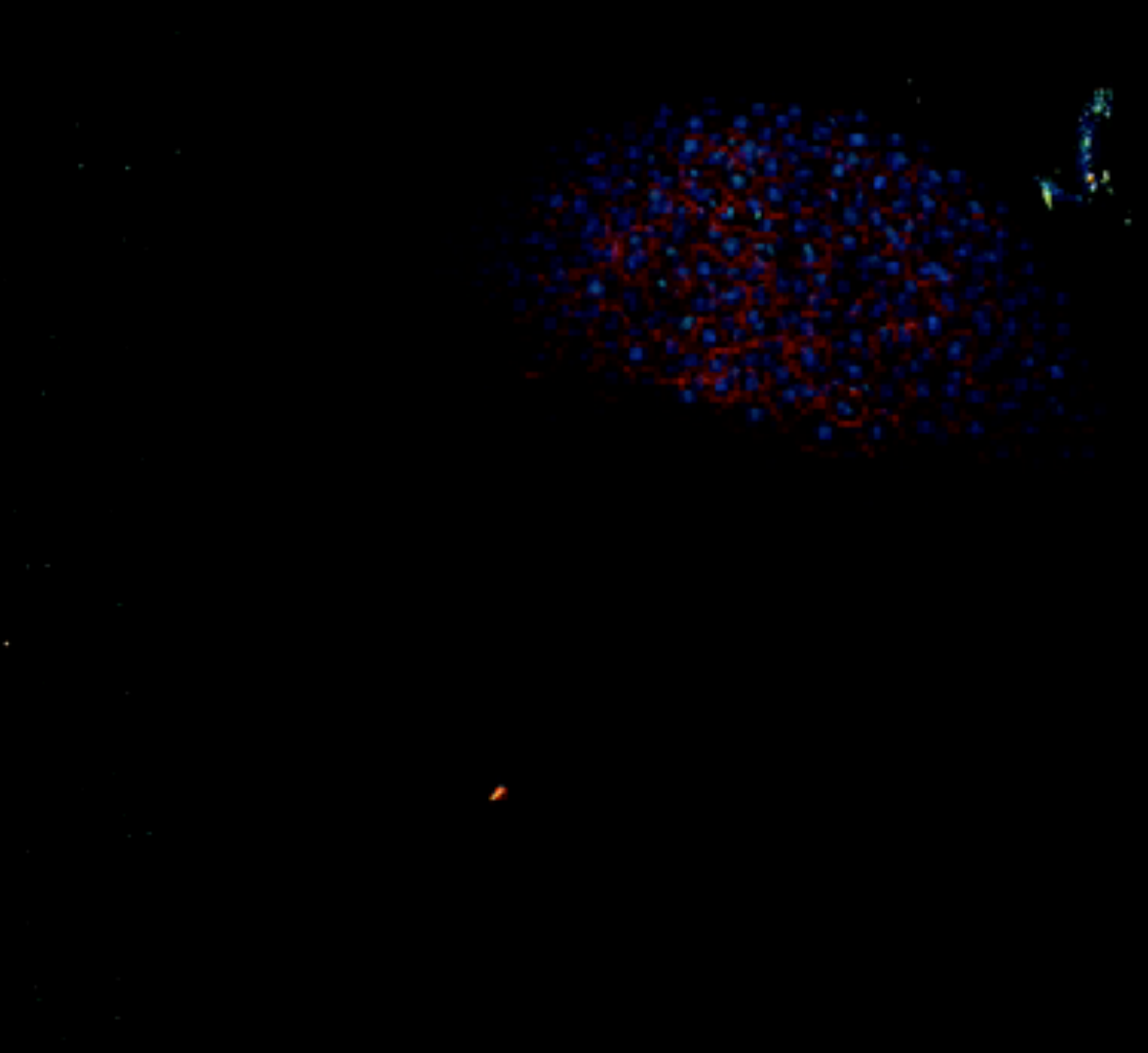
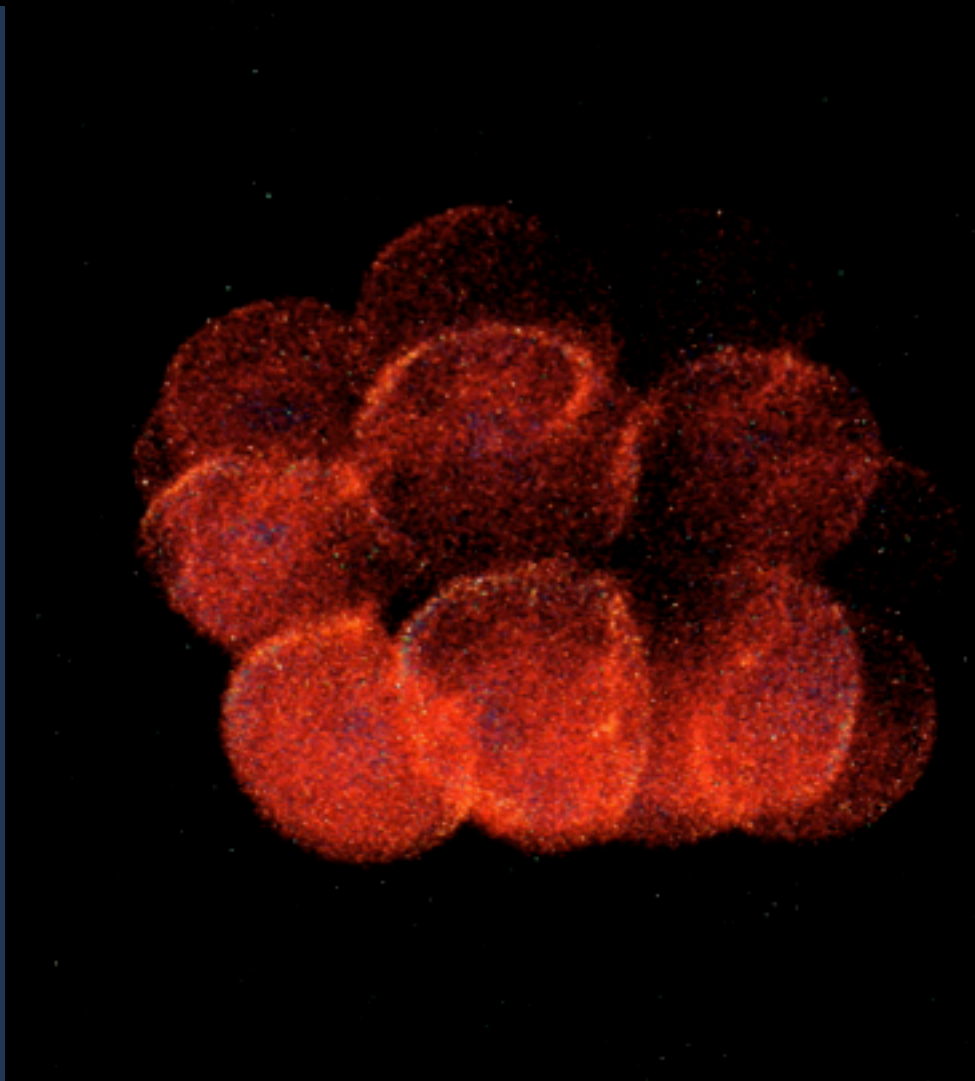
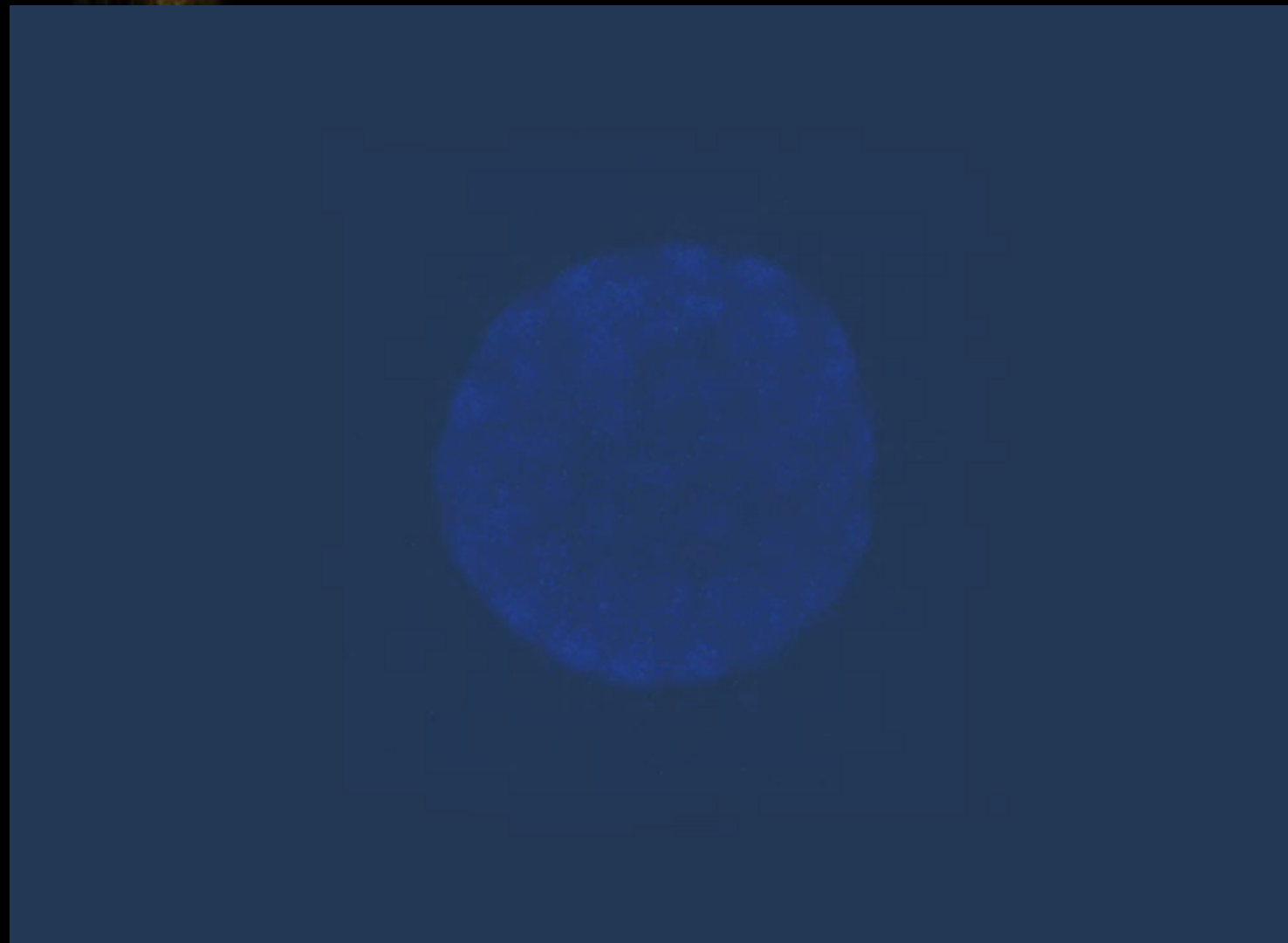
Phallusia Mamillata

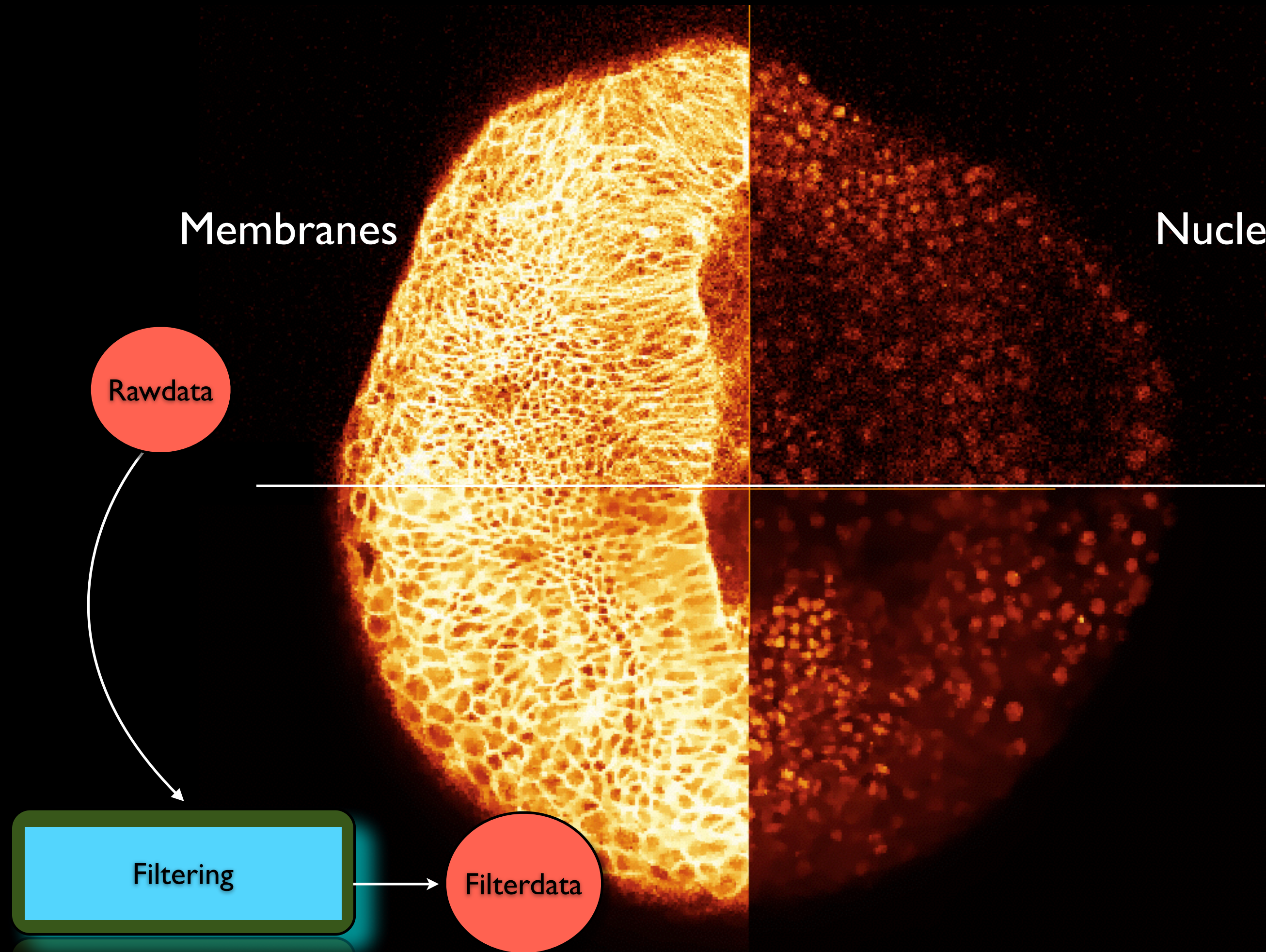


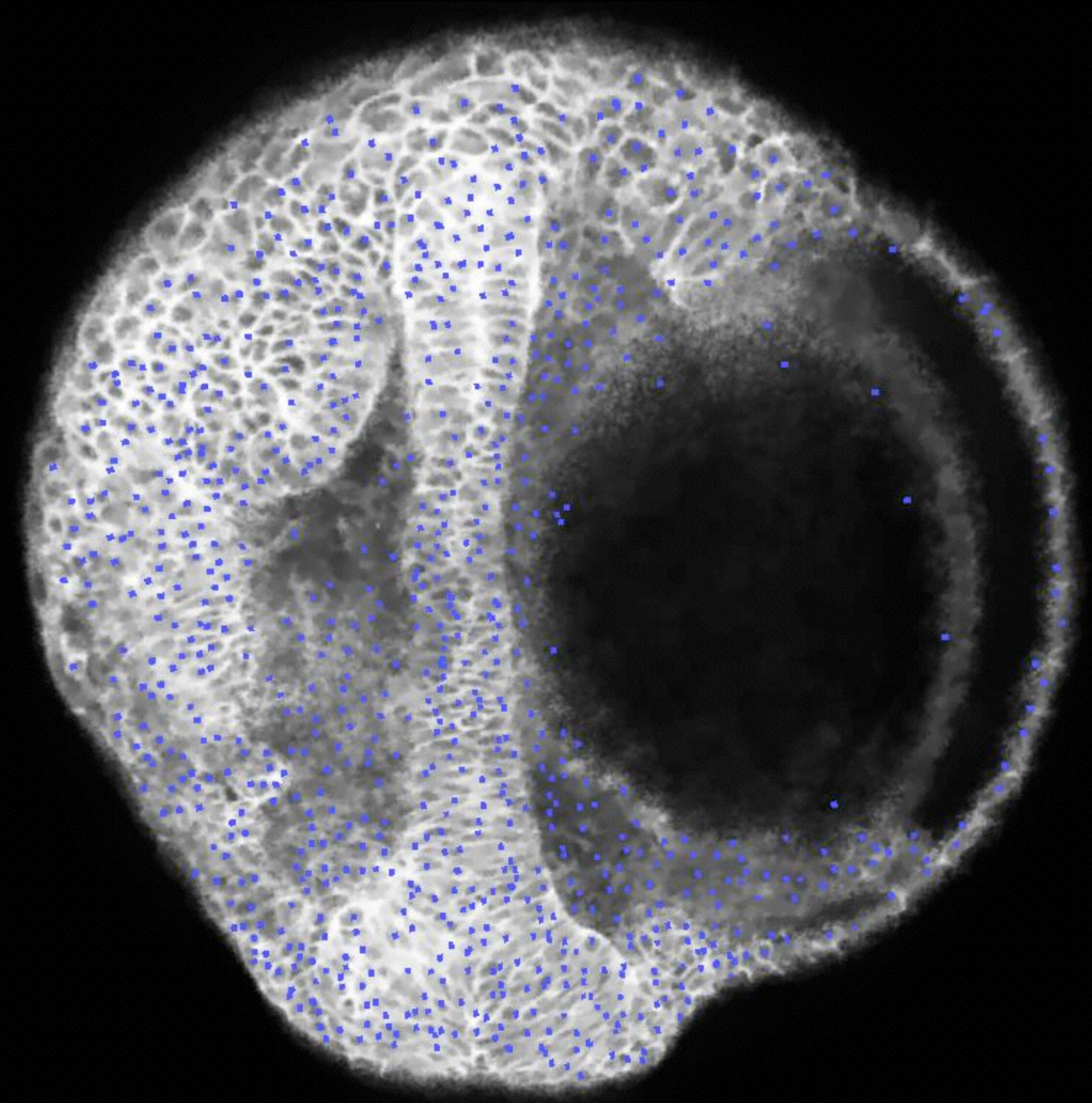
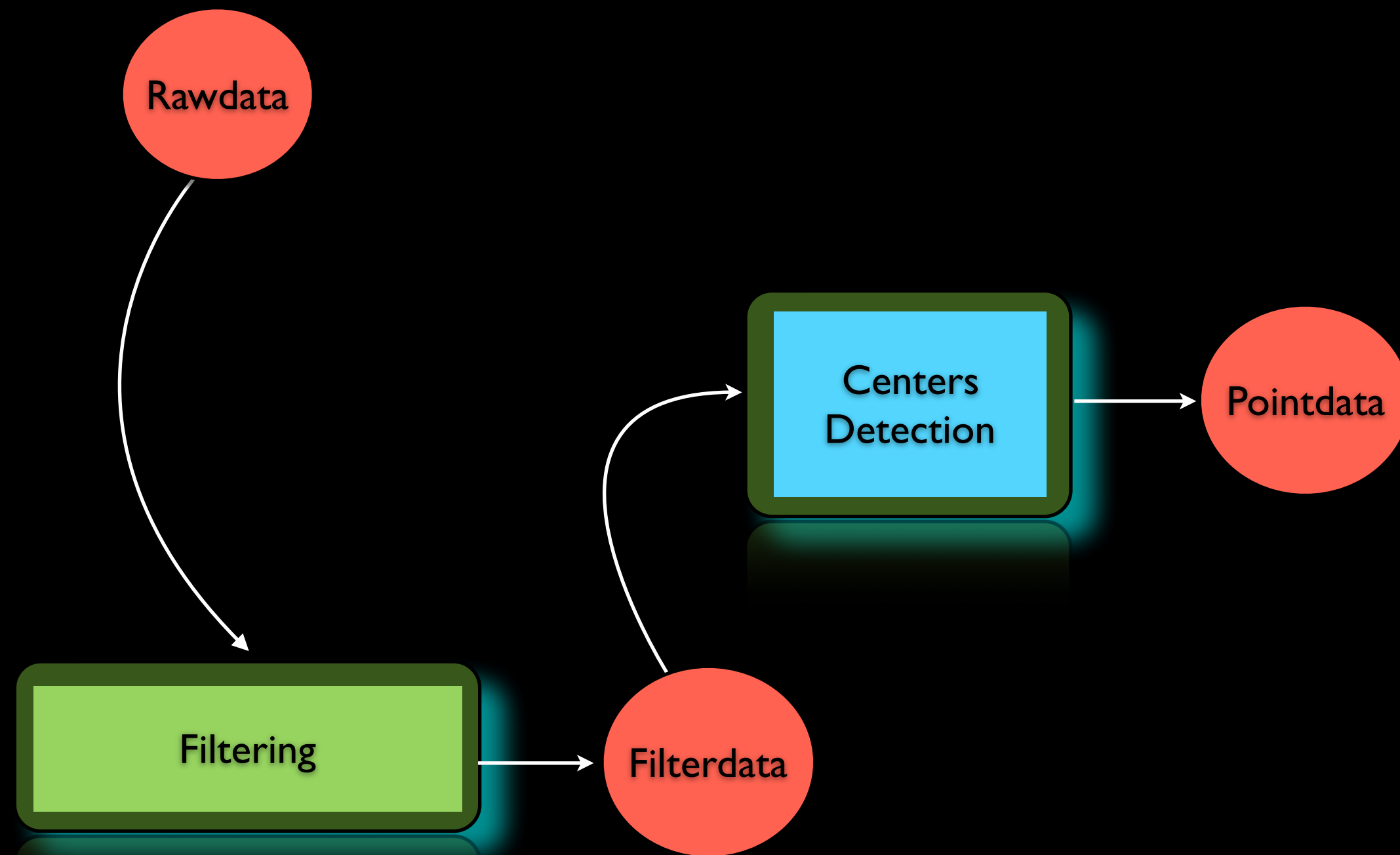
Sea Urchin



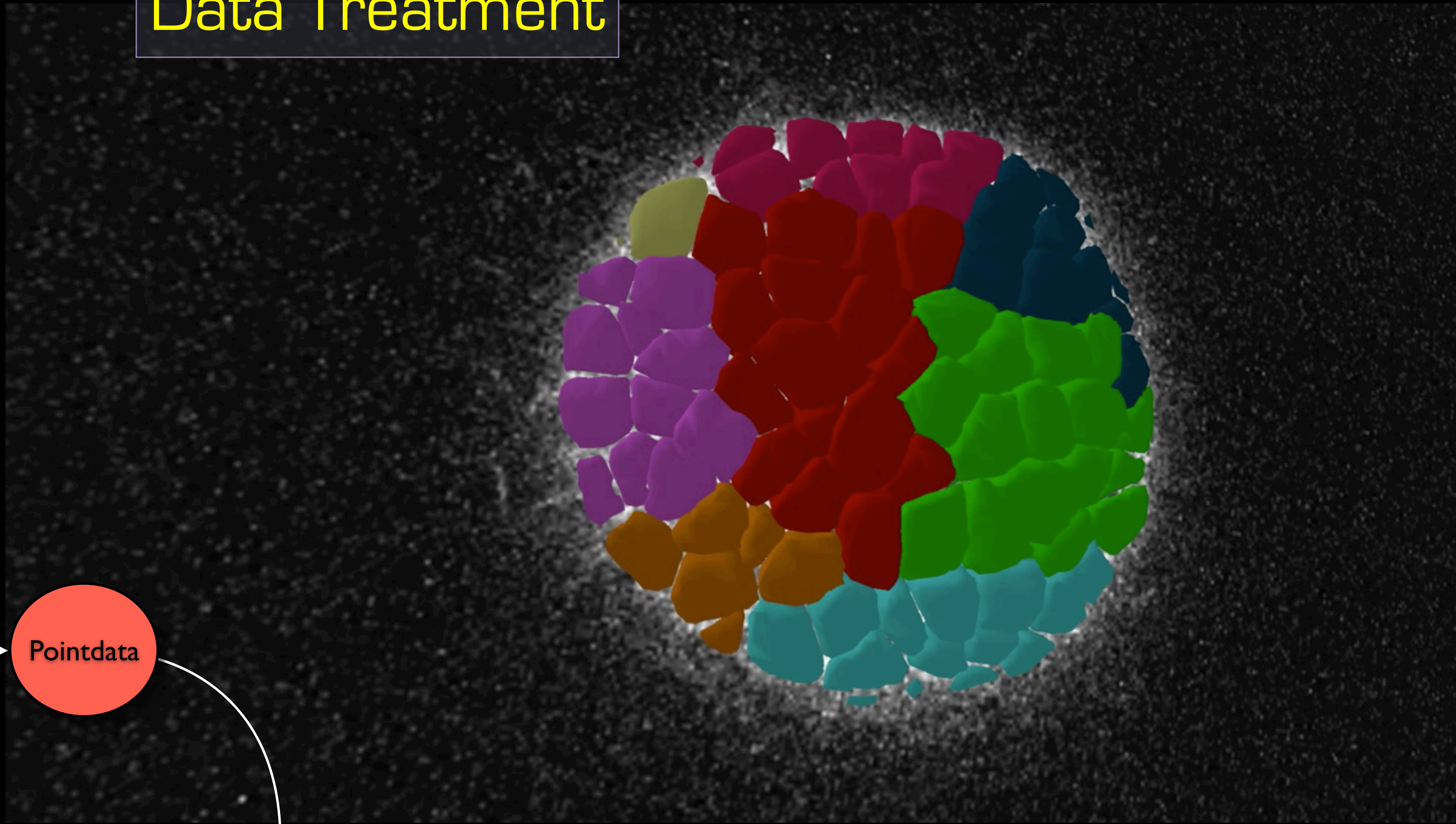
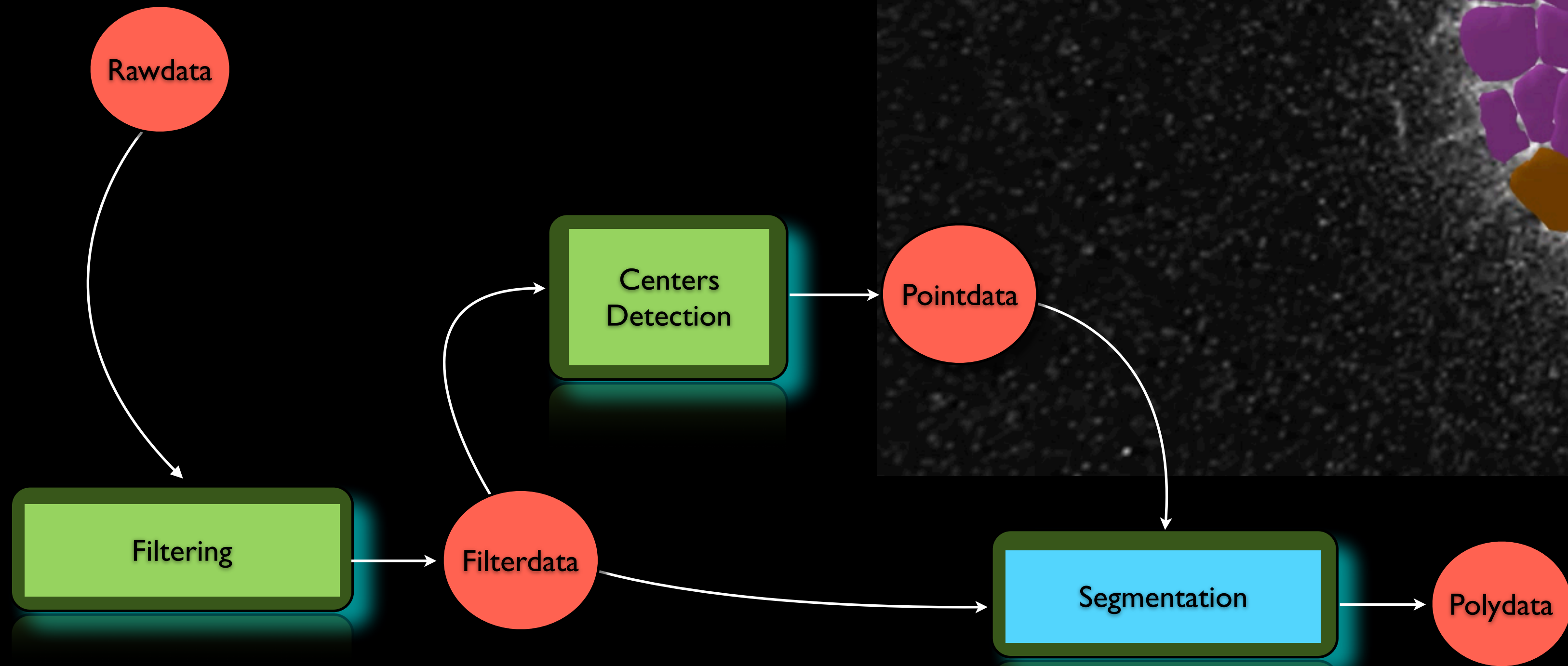
Zebrafish

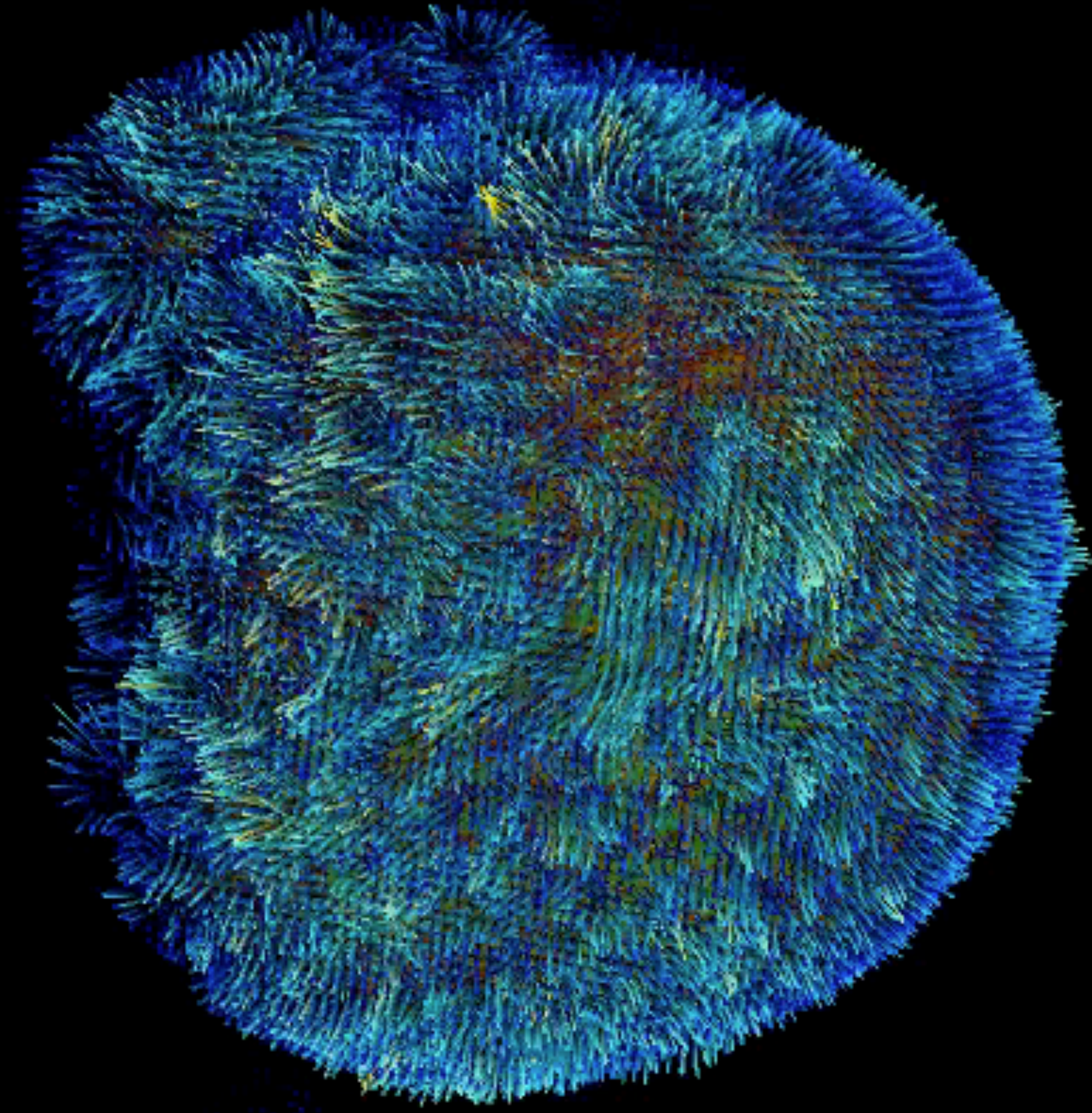
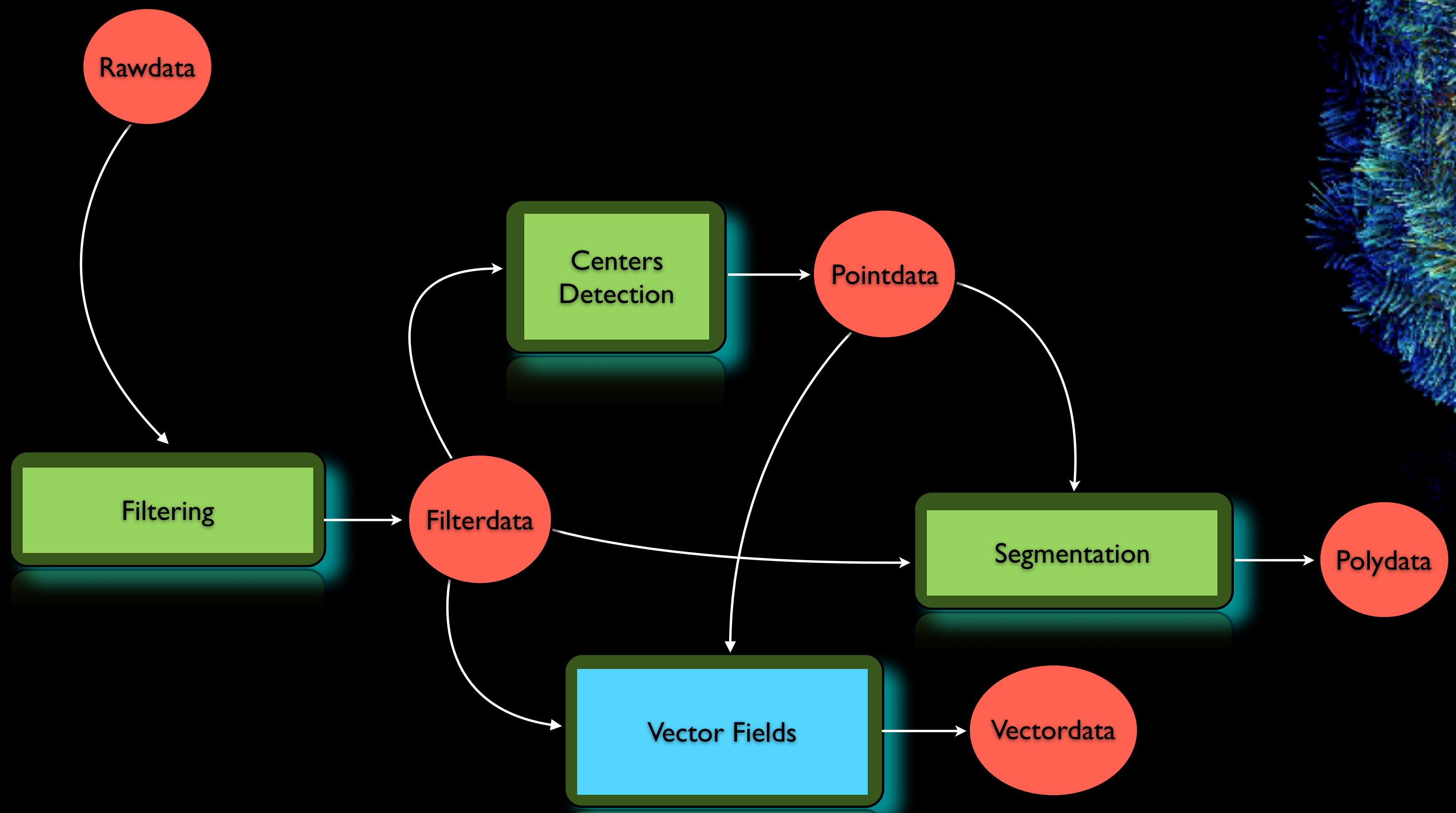




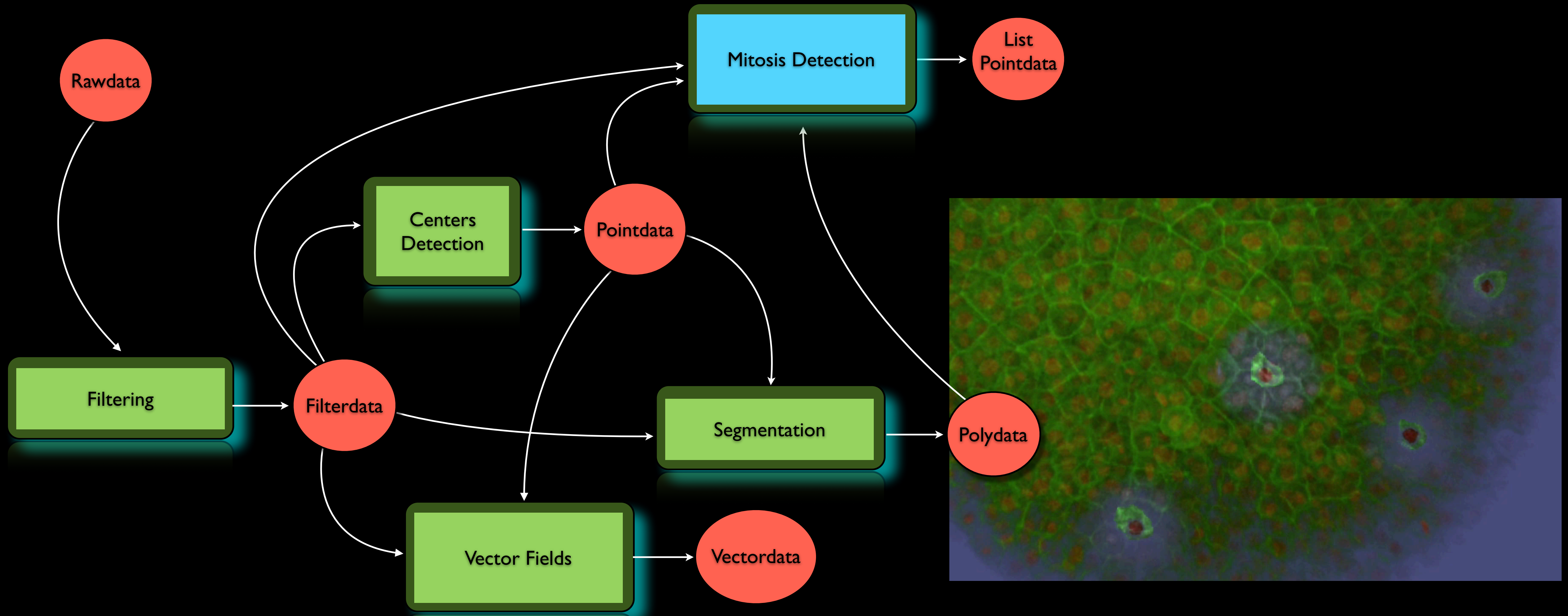


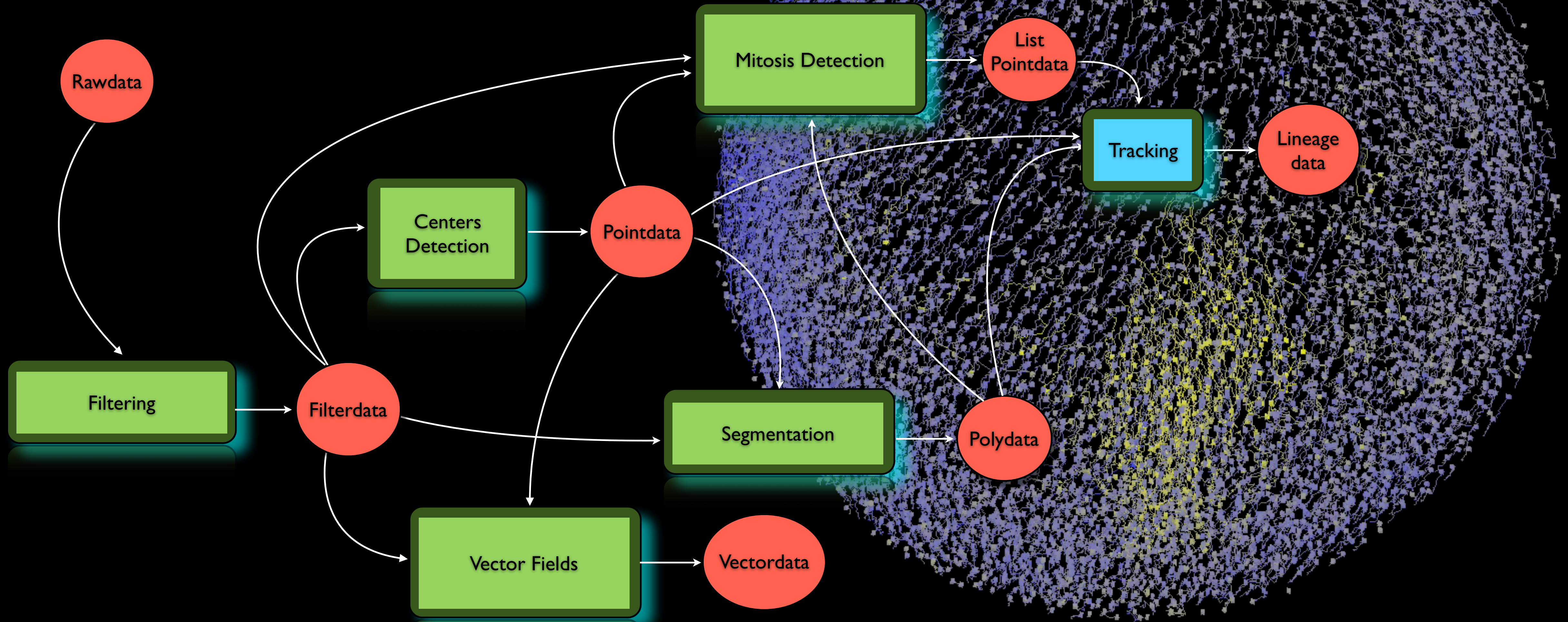
Data Treatment



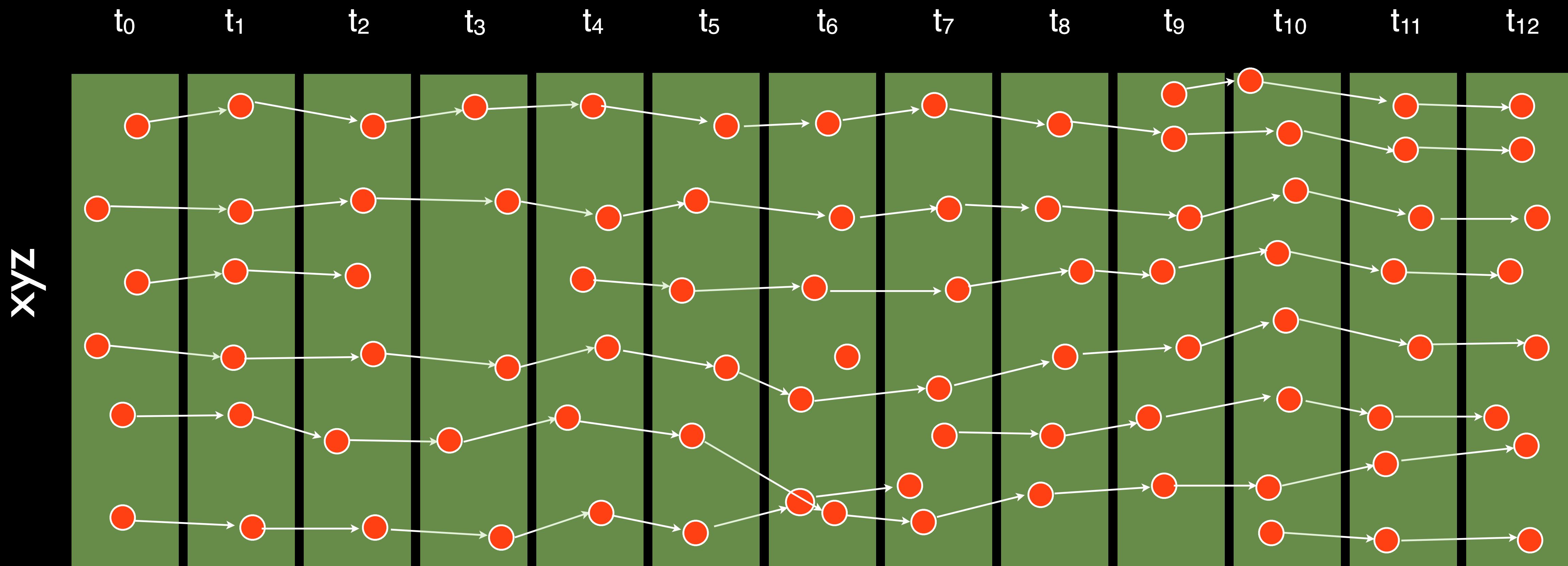






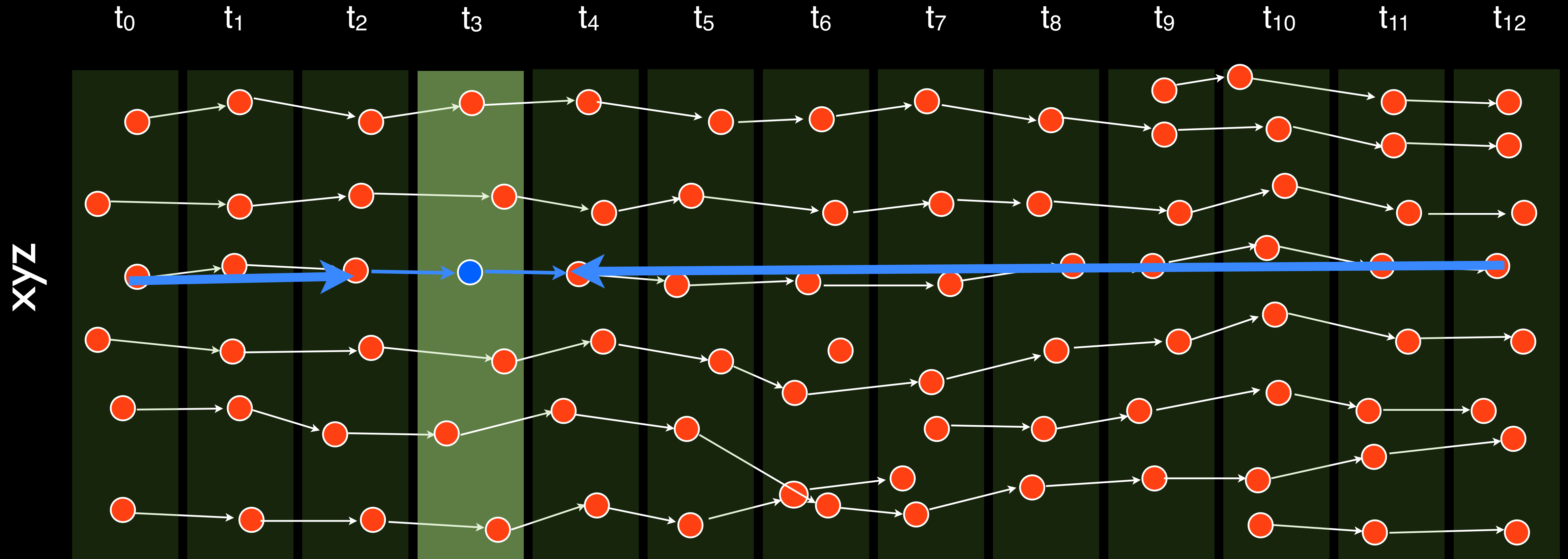


## Tracking by nearest neighbors



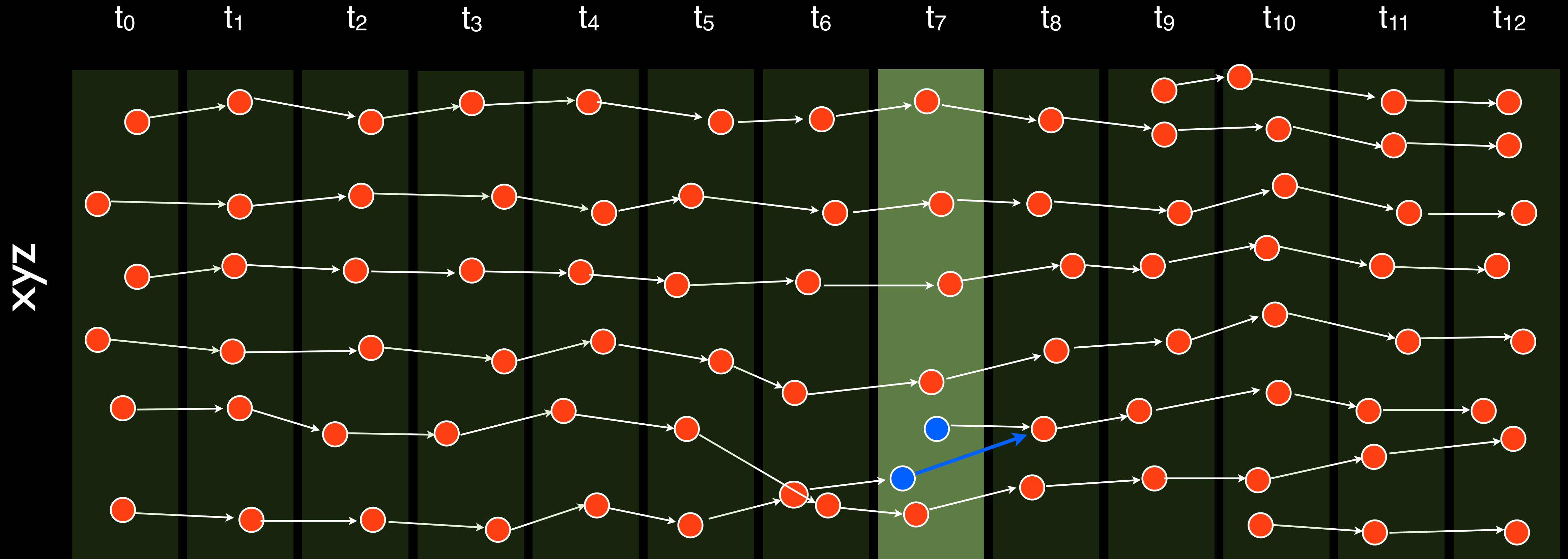
Tracking

# Data treatment artefacts



False Negative

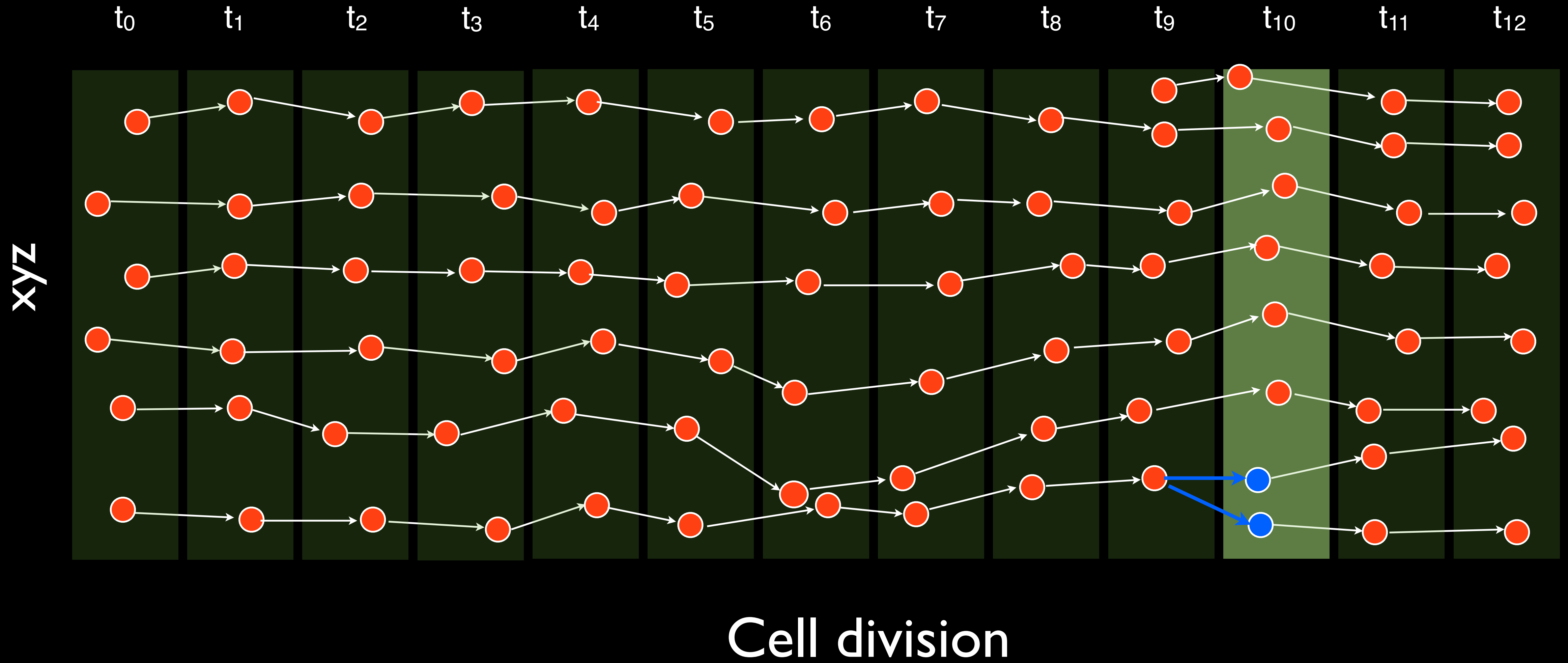
# Data treatment artefacts



False Positive

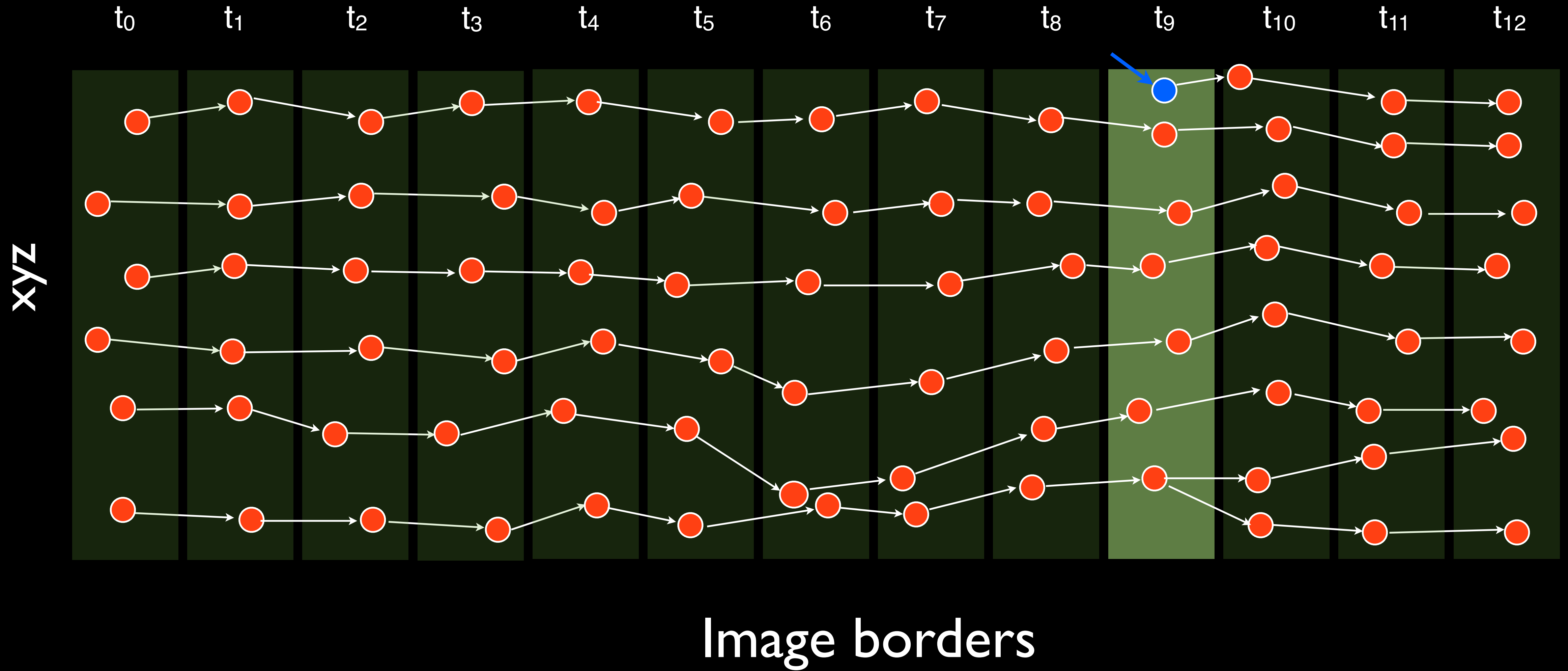
Tracking

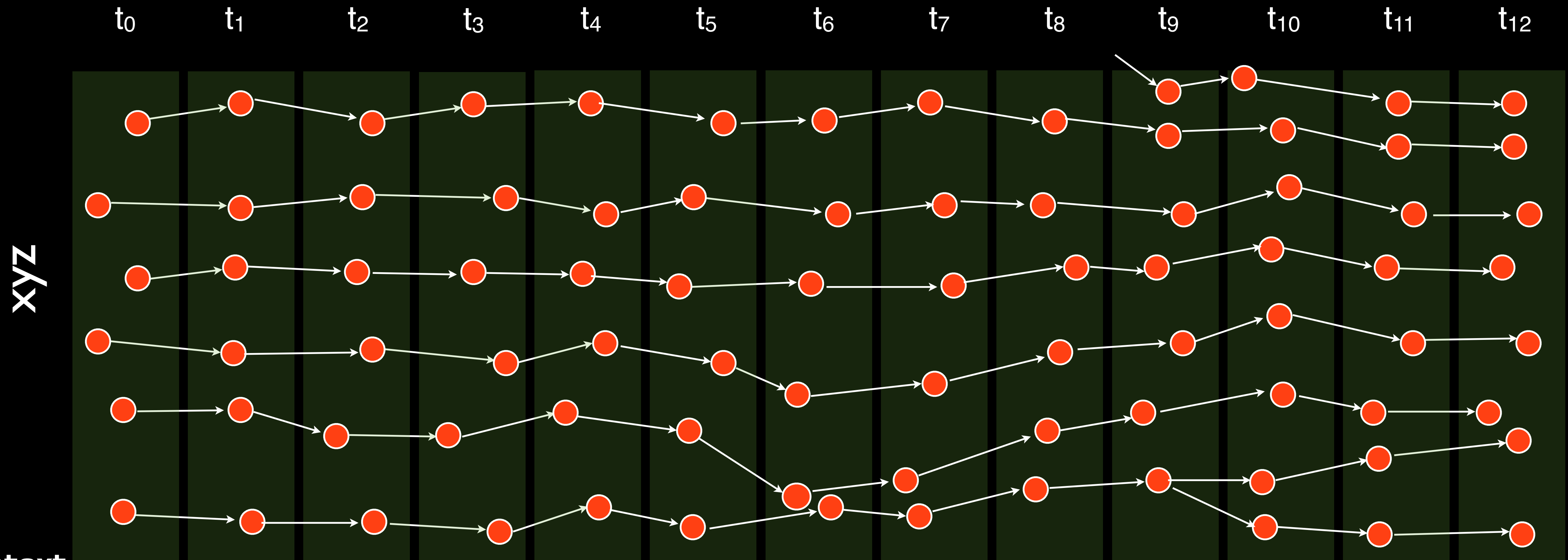
# Coherence arguments




Tracking

# Acquisition artefacts



Context

## Data:

- ~ 3 millions of centers 
- ~ 12 hours of acquisition
- ~ 500 time steps

Evaluation : % valid temporal links

Results : ~ 2% of errors

100% good links ?

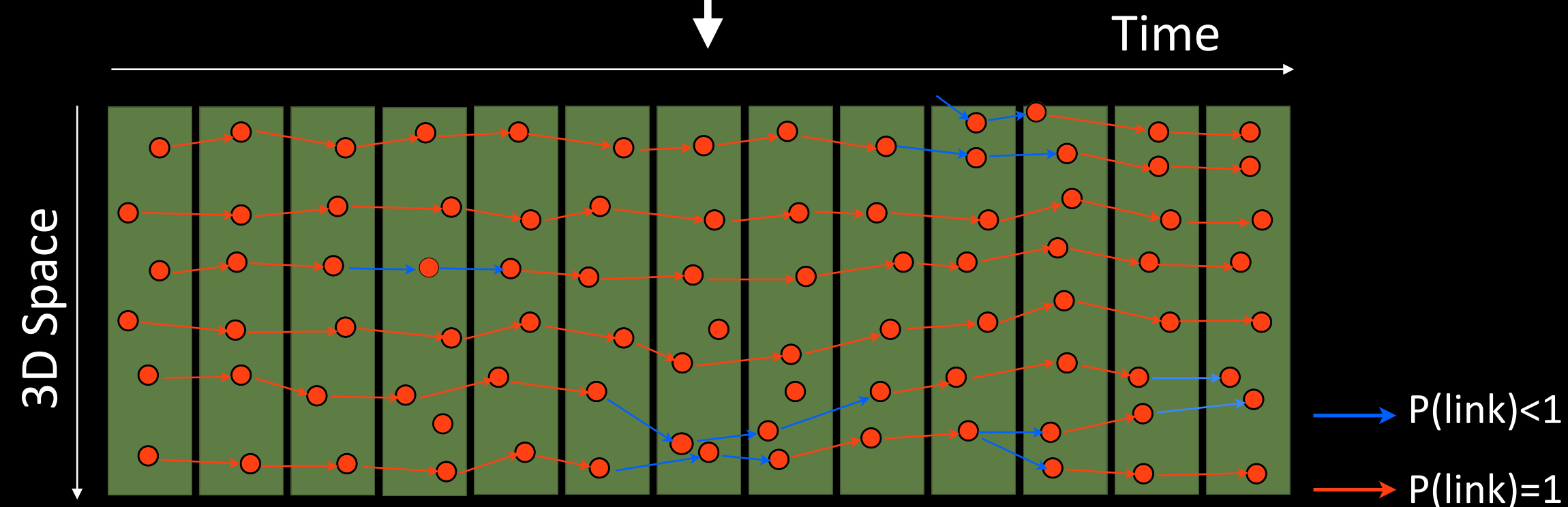
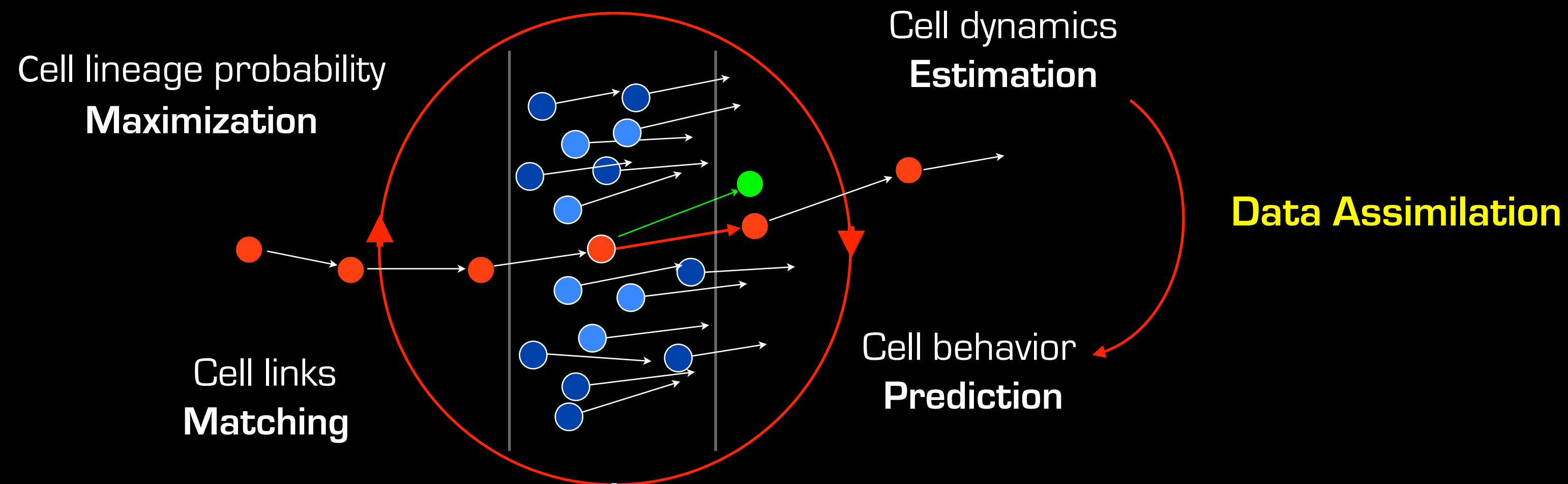
→ No cell history fully reconstruct



# Probabilistic Reconstruction

**MorphoTrack** : a probabilistic cell tracking algorithm without any parameters by data assimilation

**Spread certainties by iteration (EM Algorithm)**



Digital embryo with a probability associated to each link

## Results:

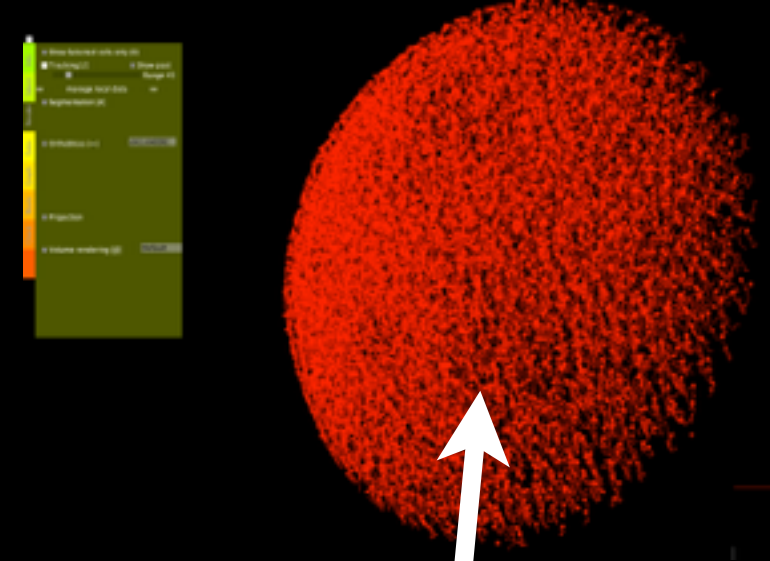
Test : several organisms

Evaluation : % erros  $\leq$  other methods

Method without parameters

Easily correctable cell lineage

# BiEmergences WORKFLOW

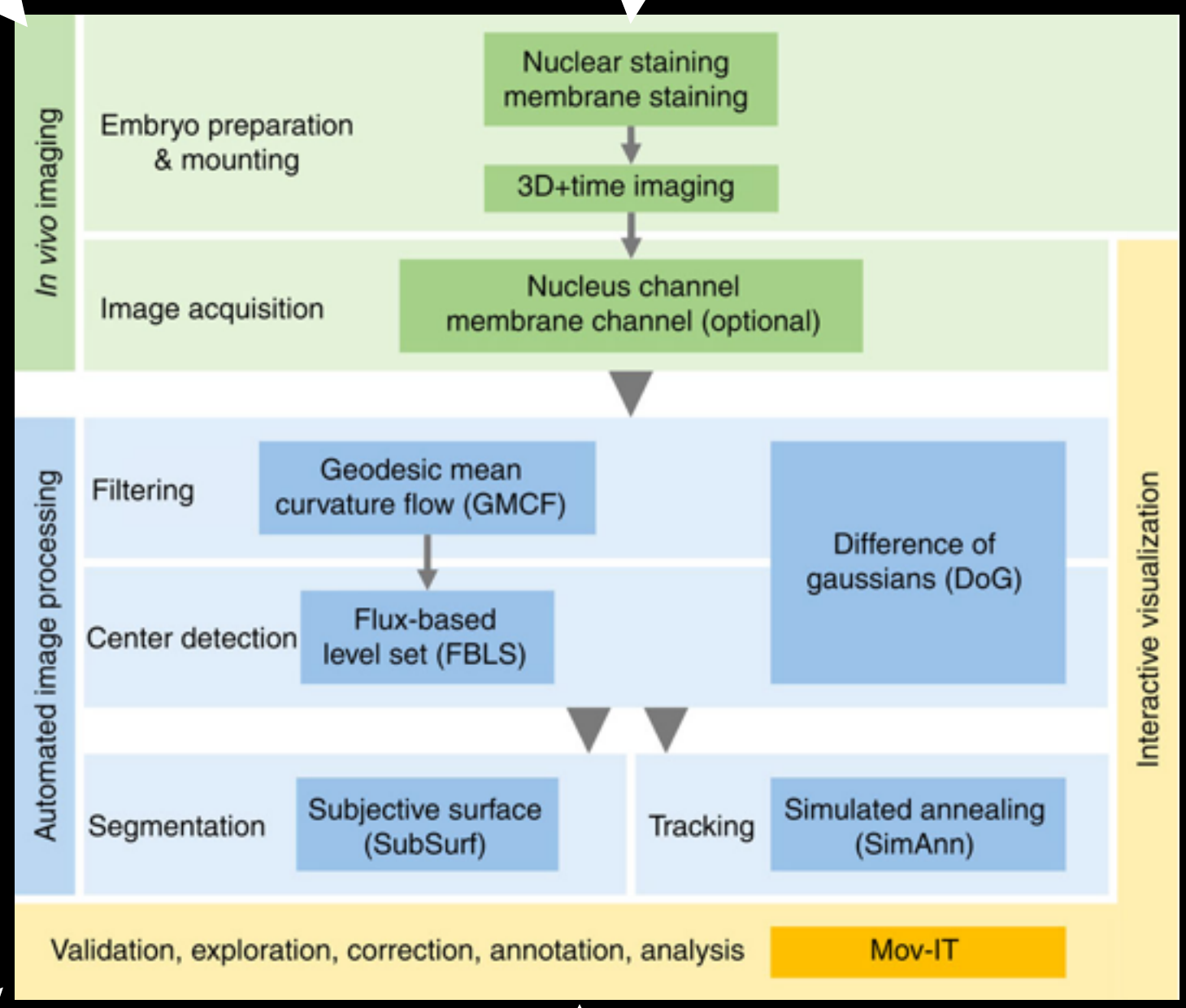
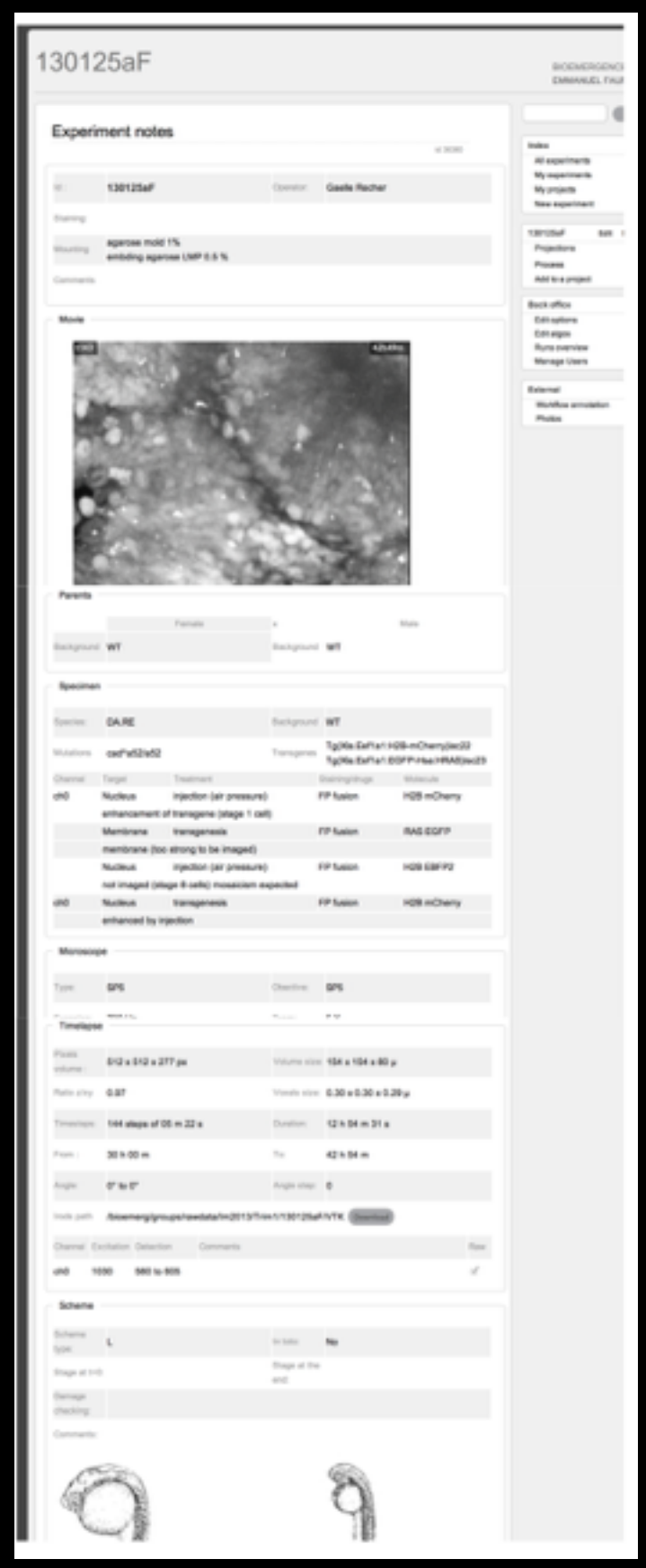


Visualization Interface (MovIT)

European Grid



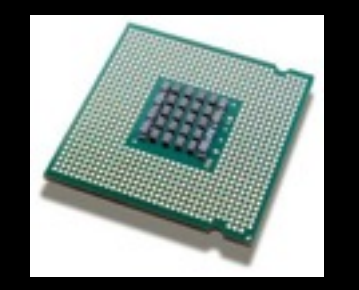
Experiment Annotation



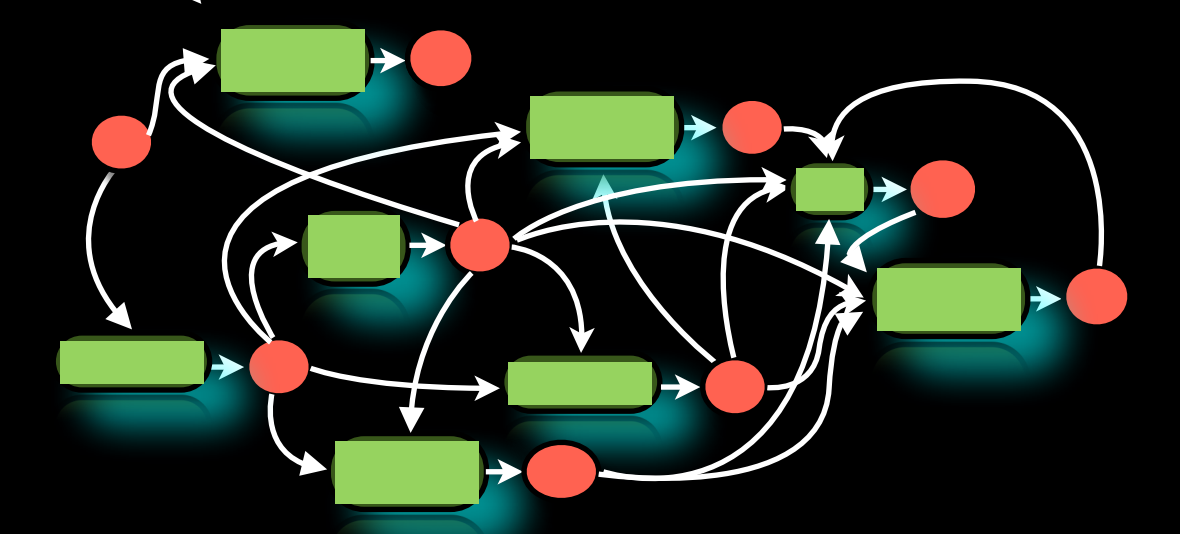
Job Scheduler



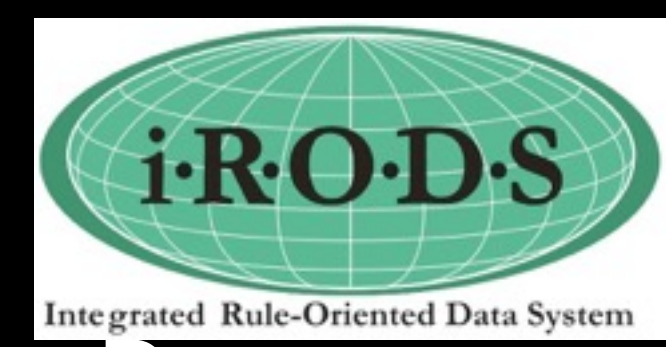
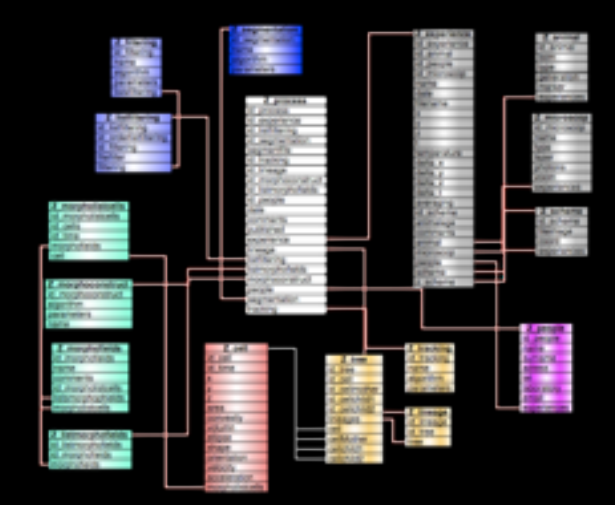
Local Cluster



Workflow



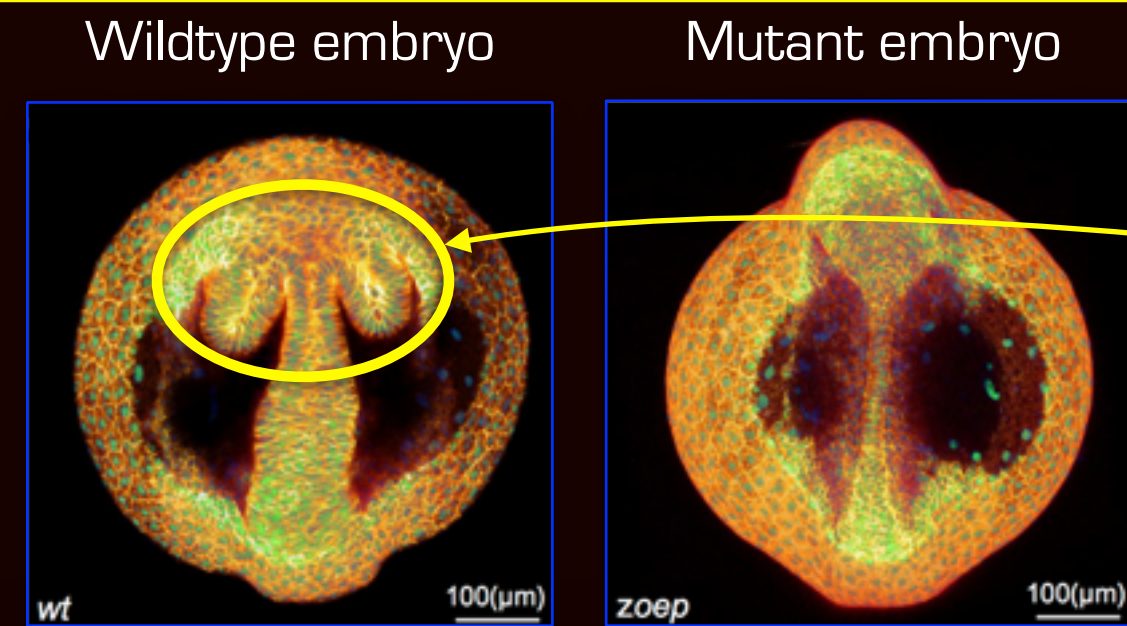
Database



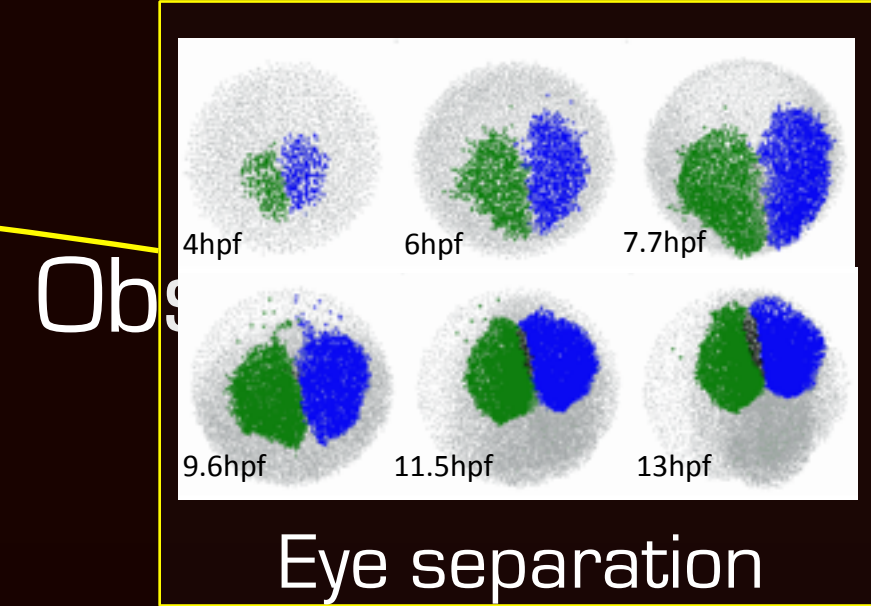
Data storage

# Reconstruction of multiscale dynamics of animal morphogenesis

**Issue:** Understanding cellular dynamics

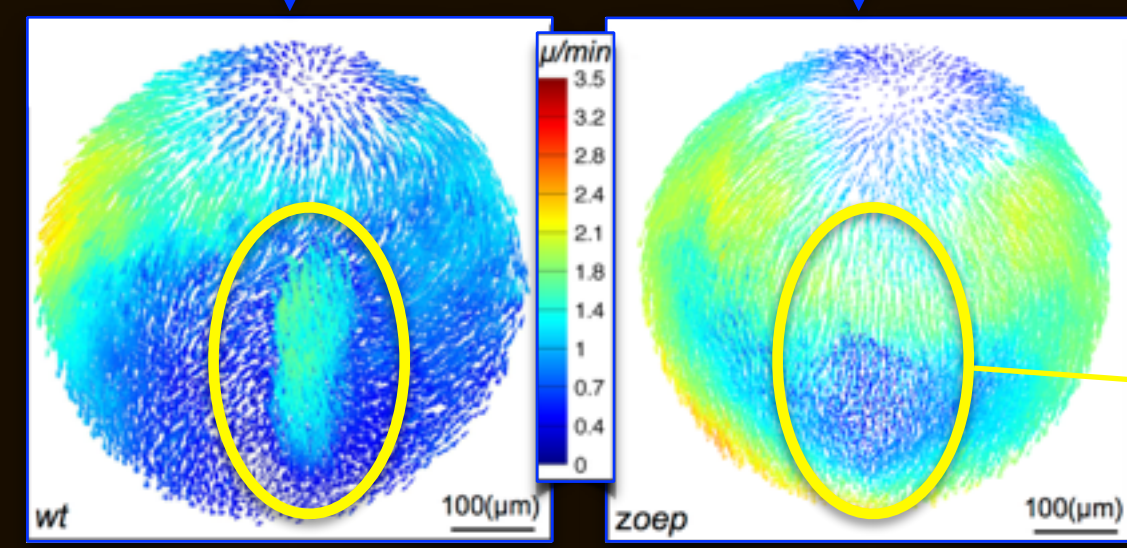


## Results:



**Objective:** Comparison of digital embryos

**Method:** Automated Reconstruction using a web-service

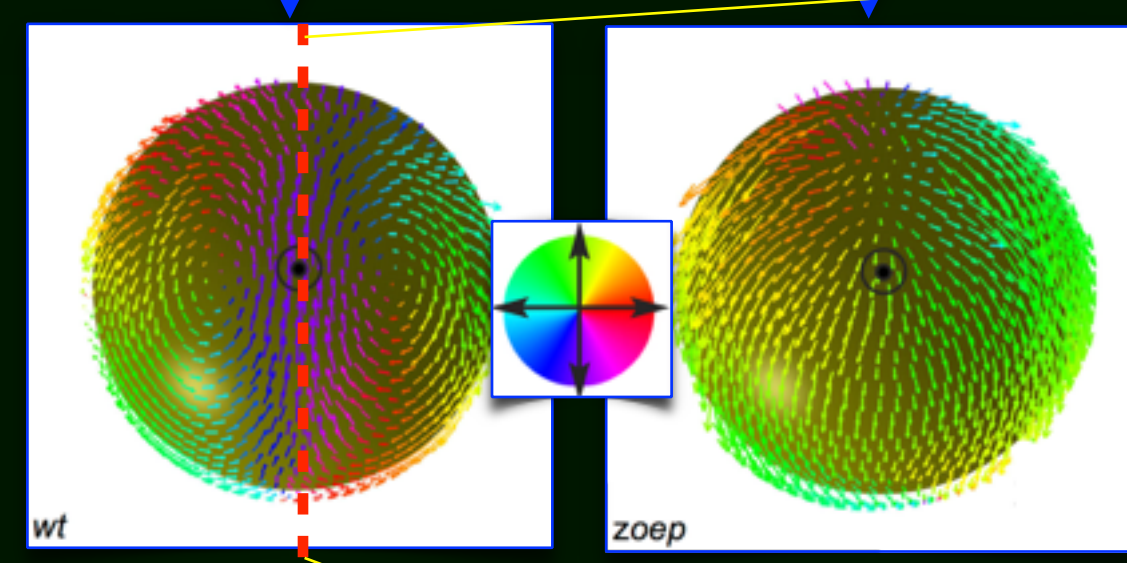


## Digitizing

zoep lacks a part of the hypoblast

**Objective:** Construction of prototypes

- Methods:**
- 3D Registration ( images and objects)
  - Temporal rescale (Dynamics )
  - Local averaging



Prototypes

**Abstraction**

Correlation between cell movement and orientation of the division

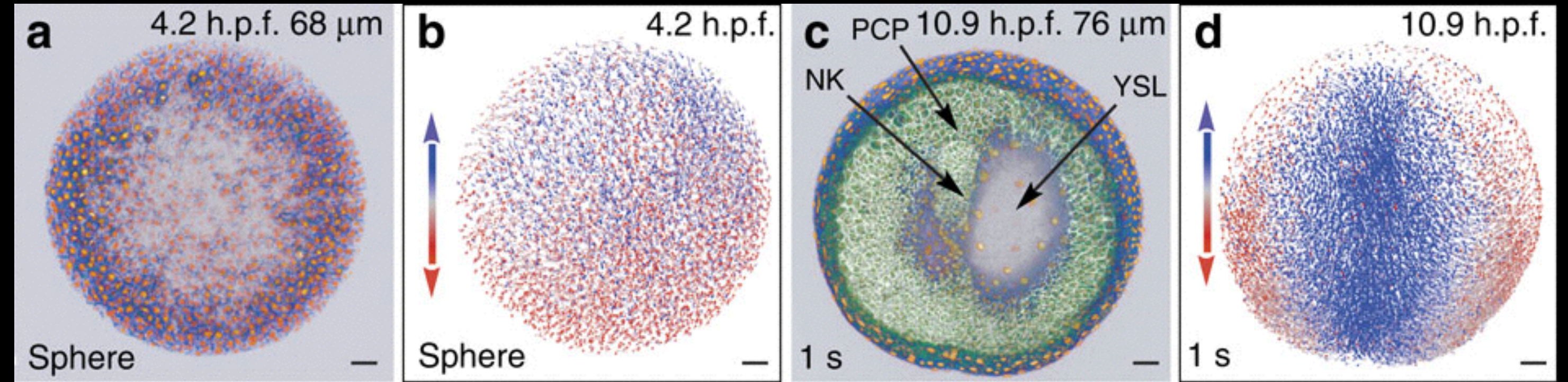
**Orthoslice view**

Cells confined to their layer during gastrulation

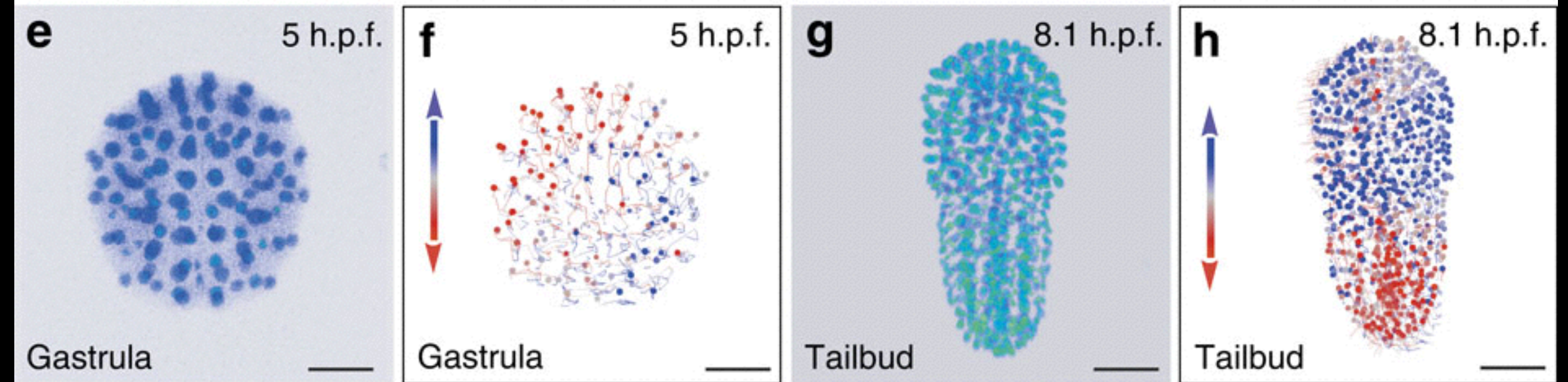
# Organisms Reconstruction

[ Faure & al Nature Communication 2016]

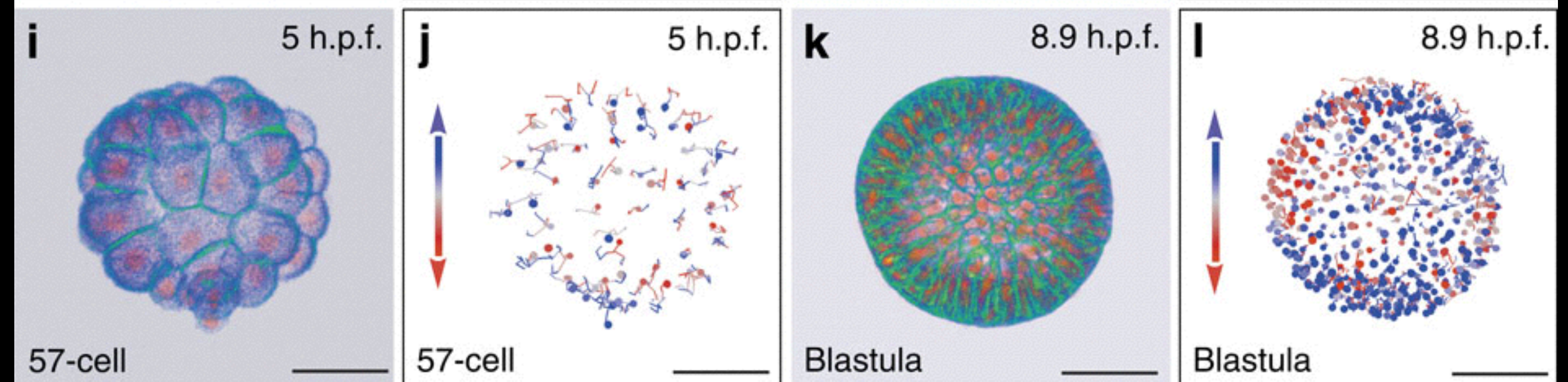
Zebrafish



Ascidian



Sea Urchin

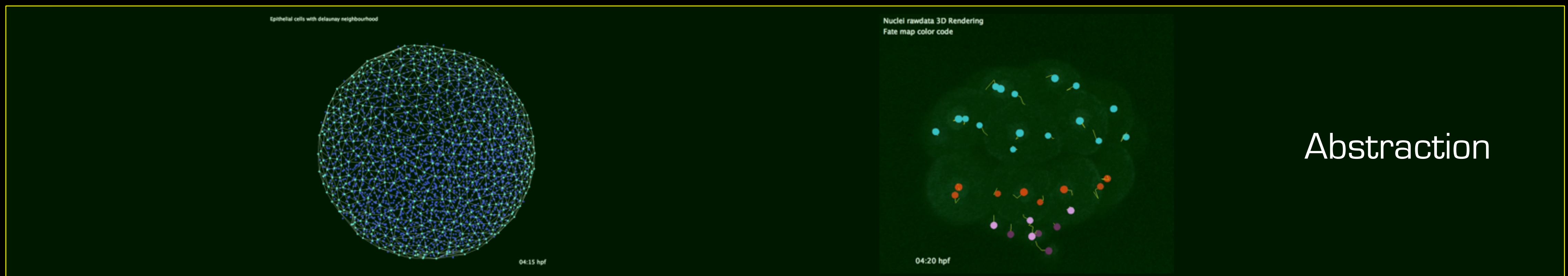
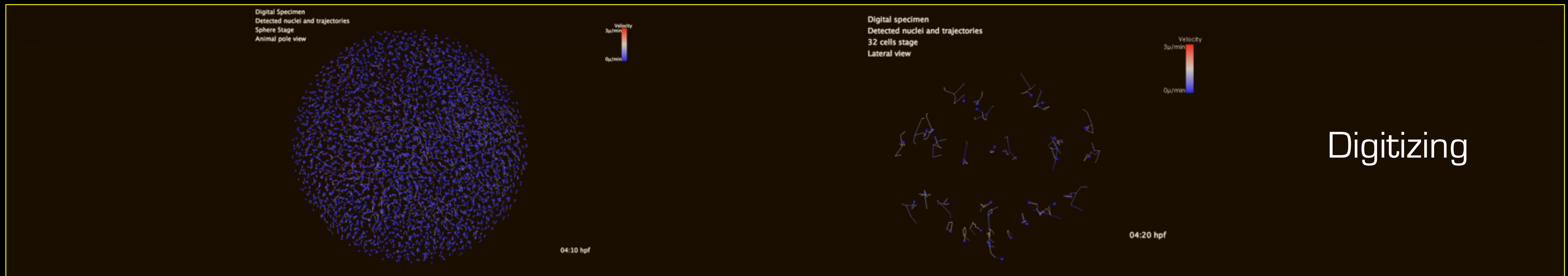
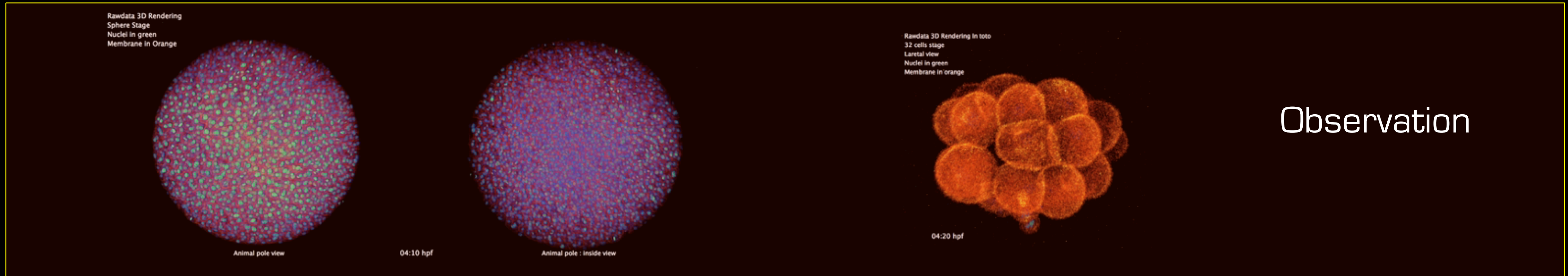


# MovIT : Interactive Visualisation Interface

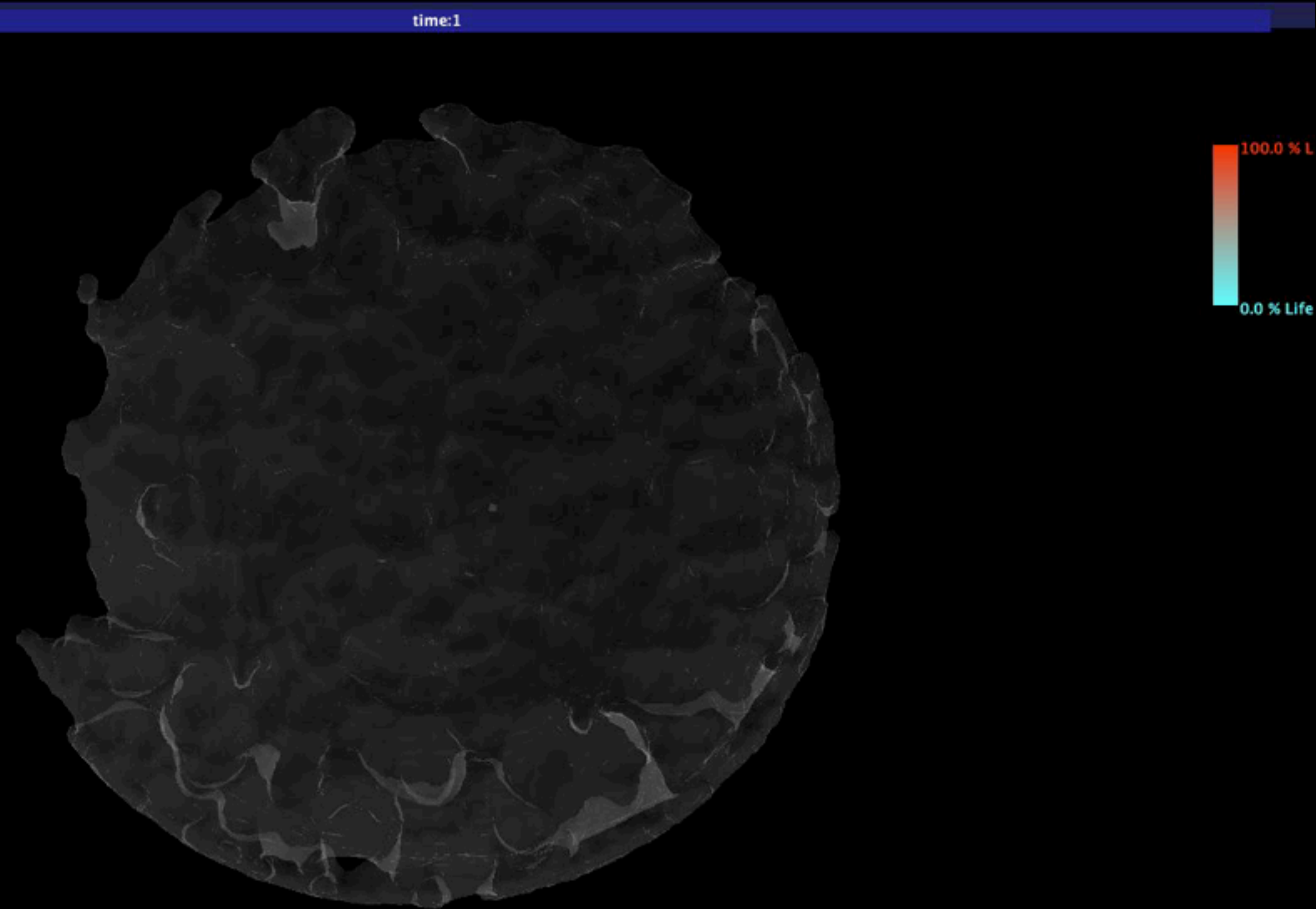
[ Faure & al Nature Communication 2016]

## Zebrafish

## Sea Urchin



# Division Prototype for zebrafish early embryo cell lineage



Time 0 min

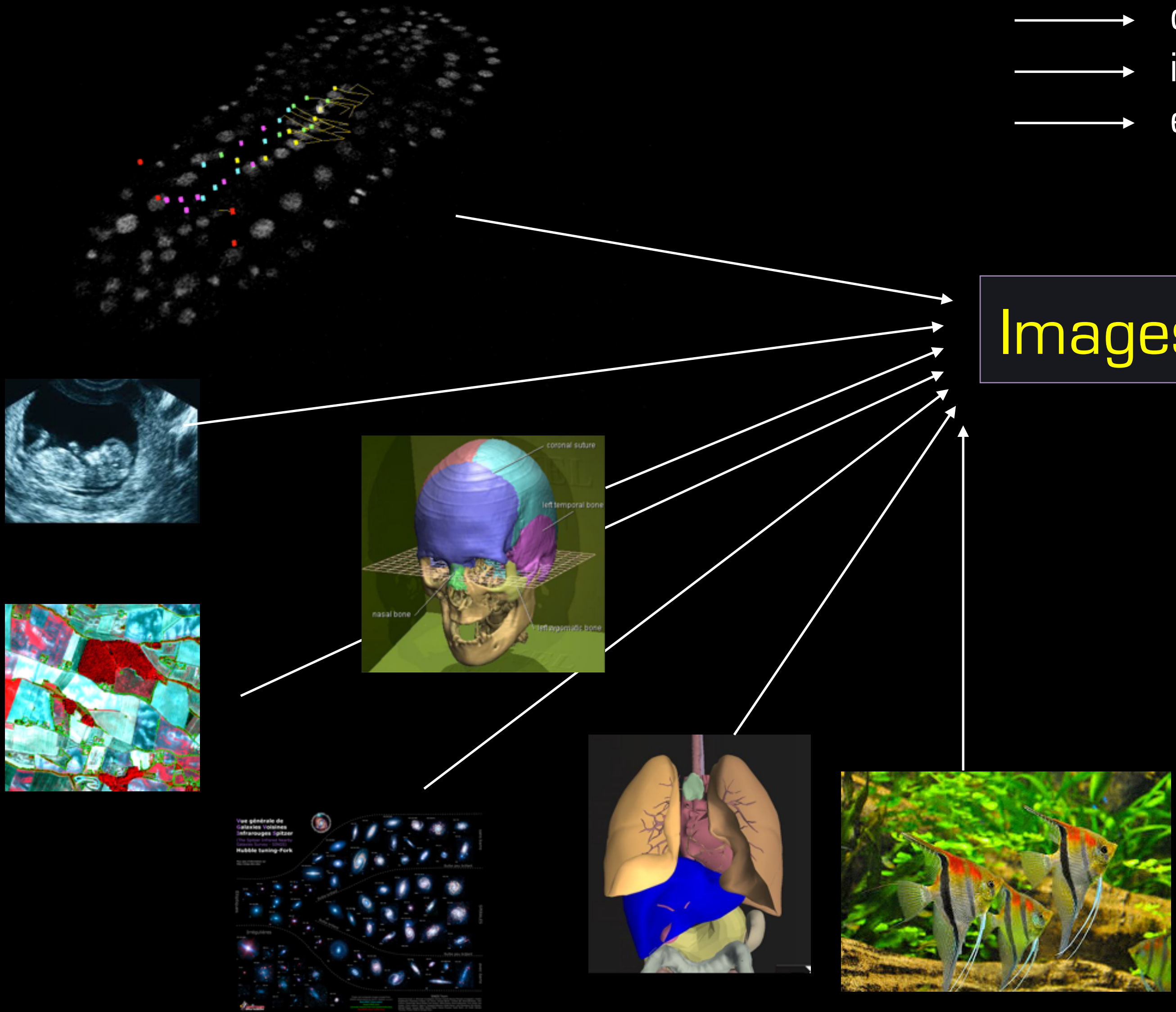


# Ground truth : create annotated databases

- data analysis
- improve reconstruction algorithms
- evaluate methods

## Images Annotation Platform

- detection
- classification
- segmentation
- tracking



# Serious Game



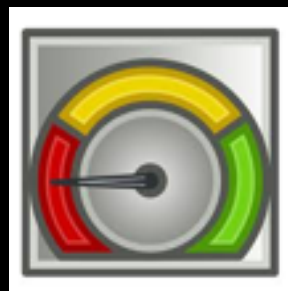
Citizen Science



Varieties of world



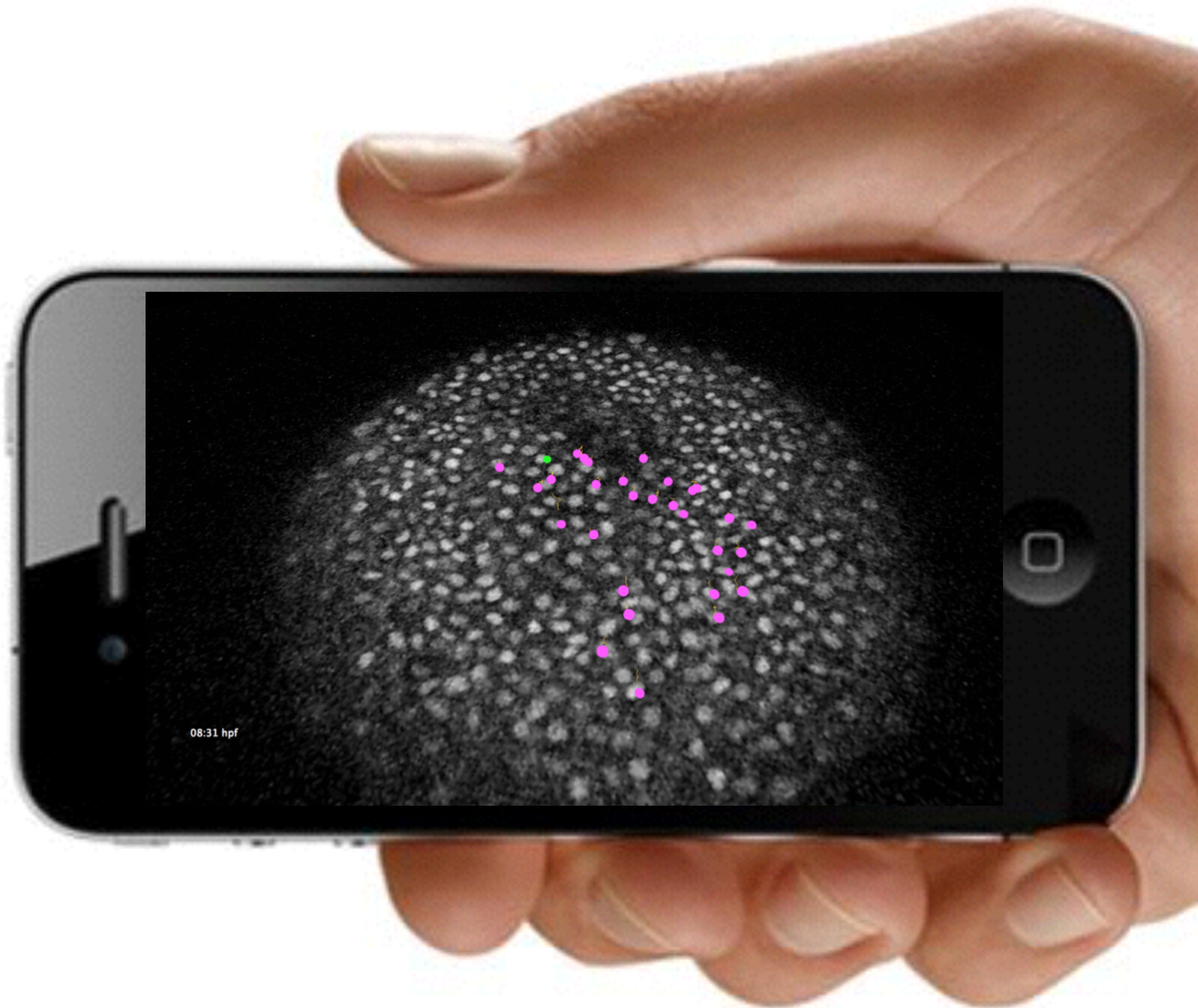
Education



Levels



Diffusion





Thanks !