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

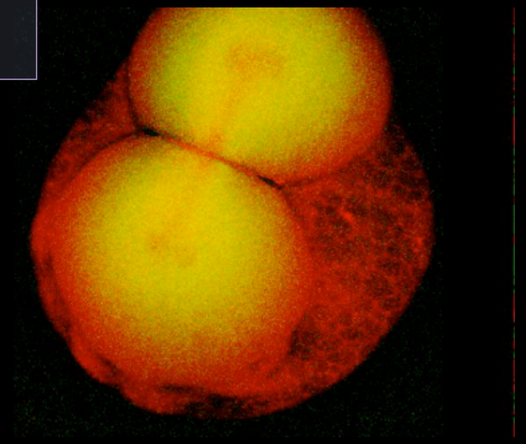
Emmanuel FAURE

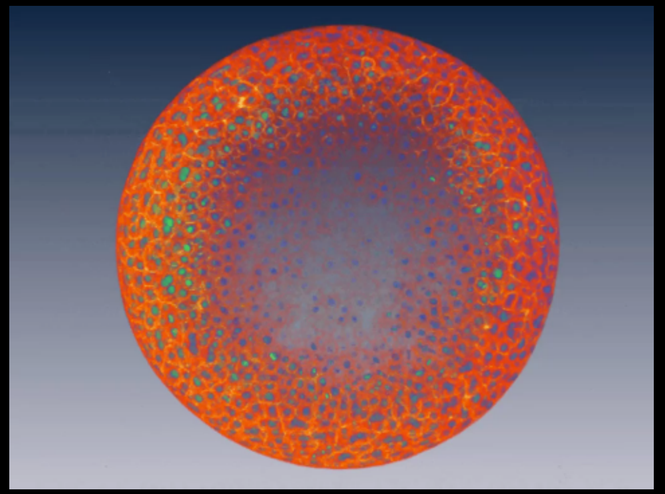
emmanuel.faure@irit.fr

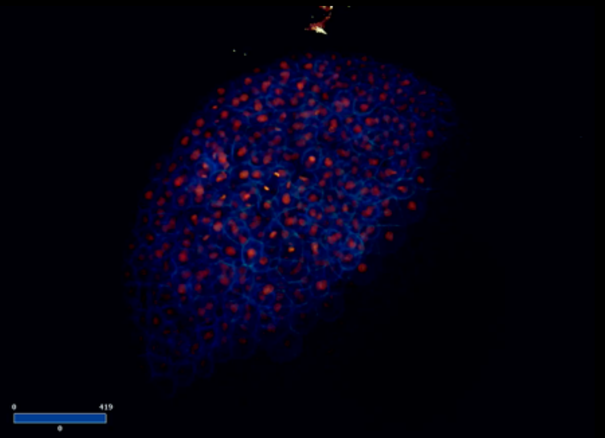
Statistical and biomathematical Models for imaging in cancer
8 Avril 2016 Cancéropole Grand Sud-Ouest

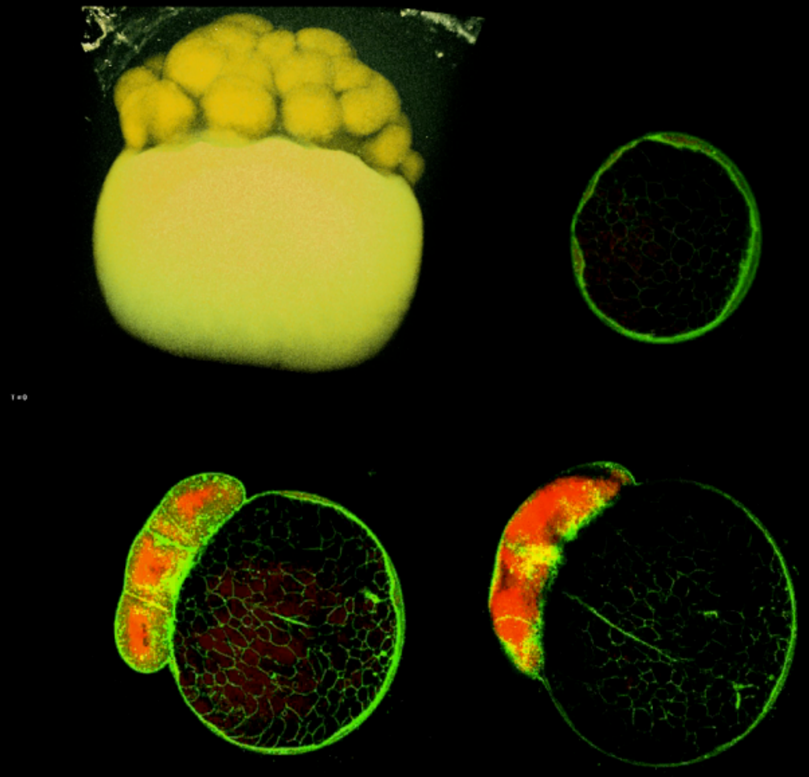
CNRS - INPT - UPS - UT1 - UTM

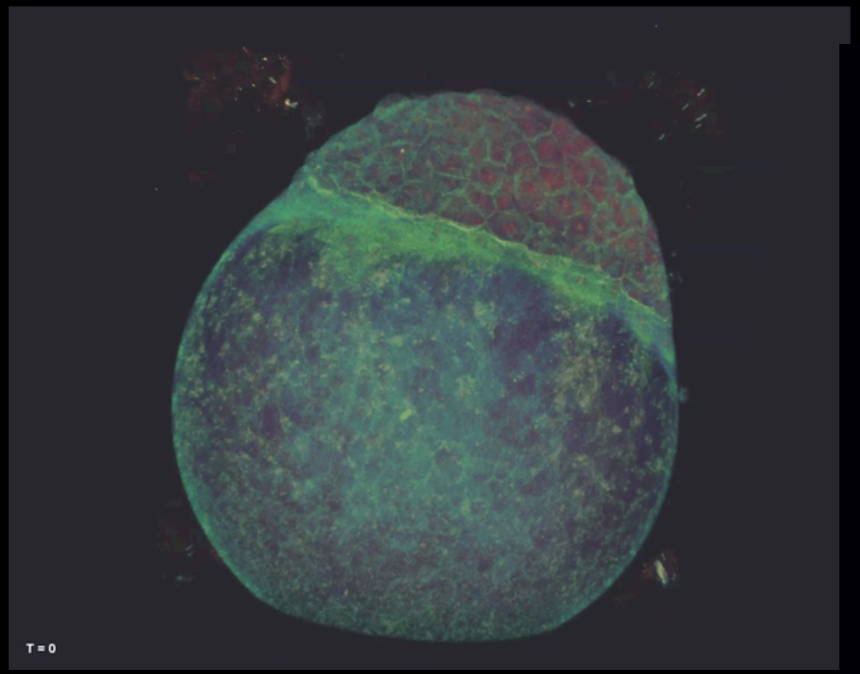
Issues

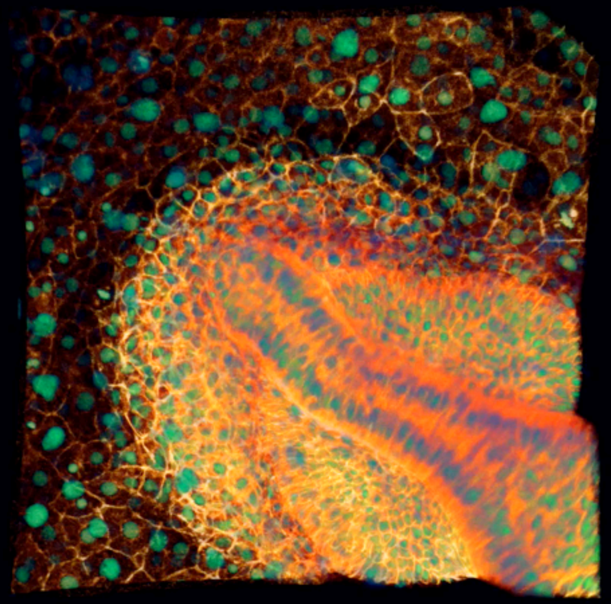




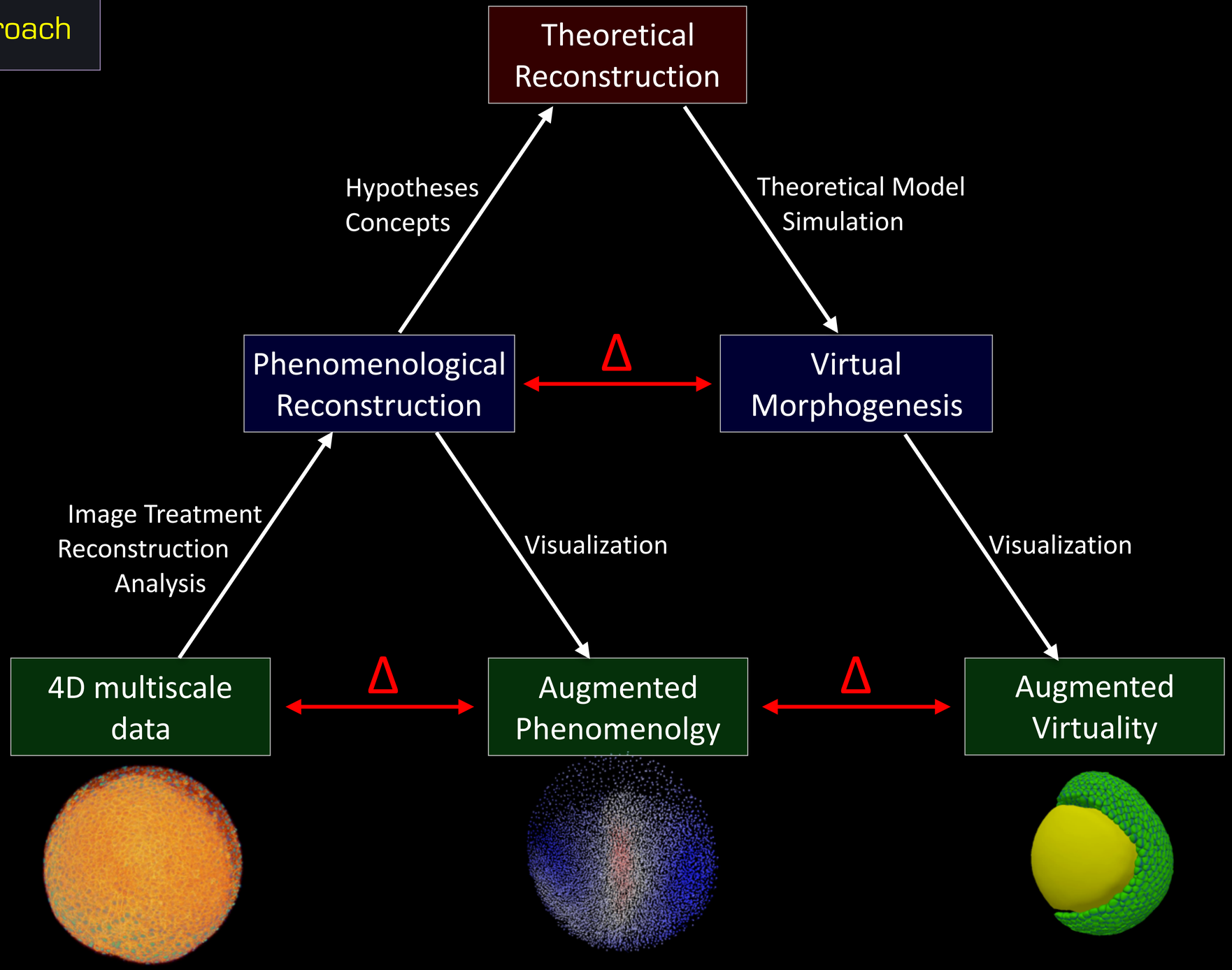




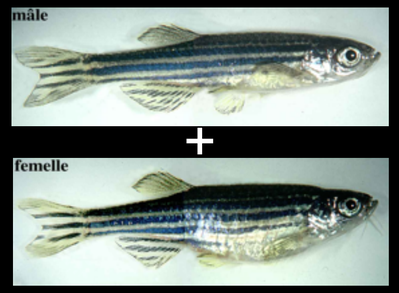




Epistemology Approach



Data Acquisition



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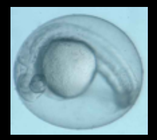
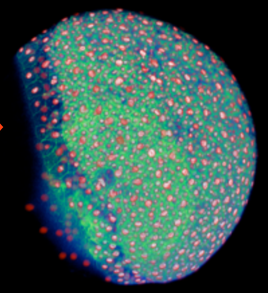


+

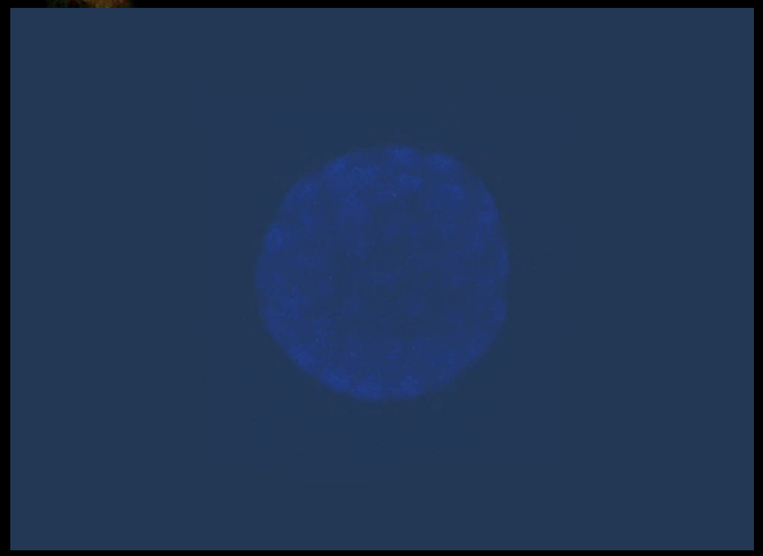
Rawdata

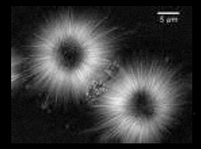
3D + Time



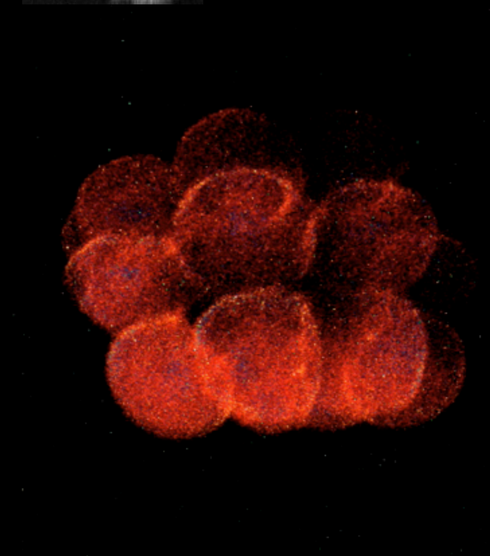
Amphioxus

Phallusia Mamillata

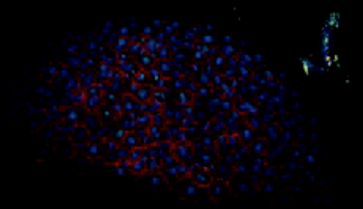




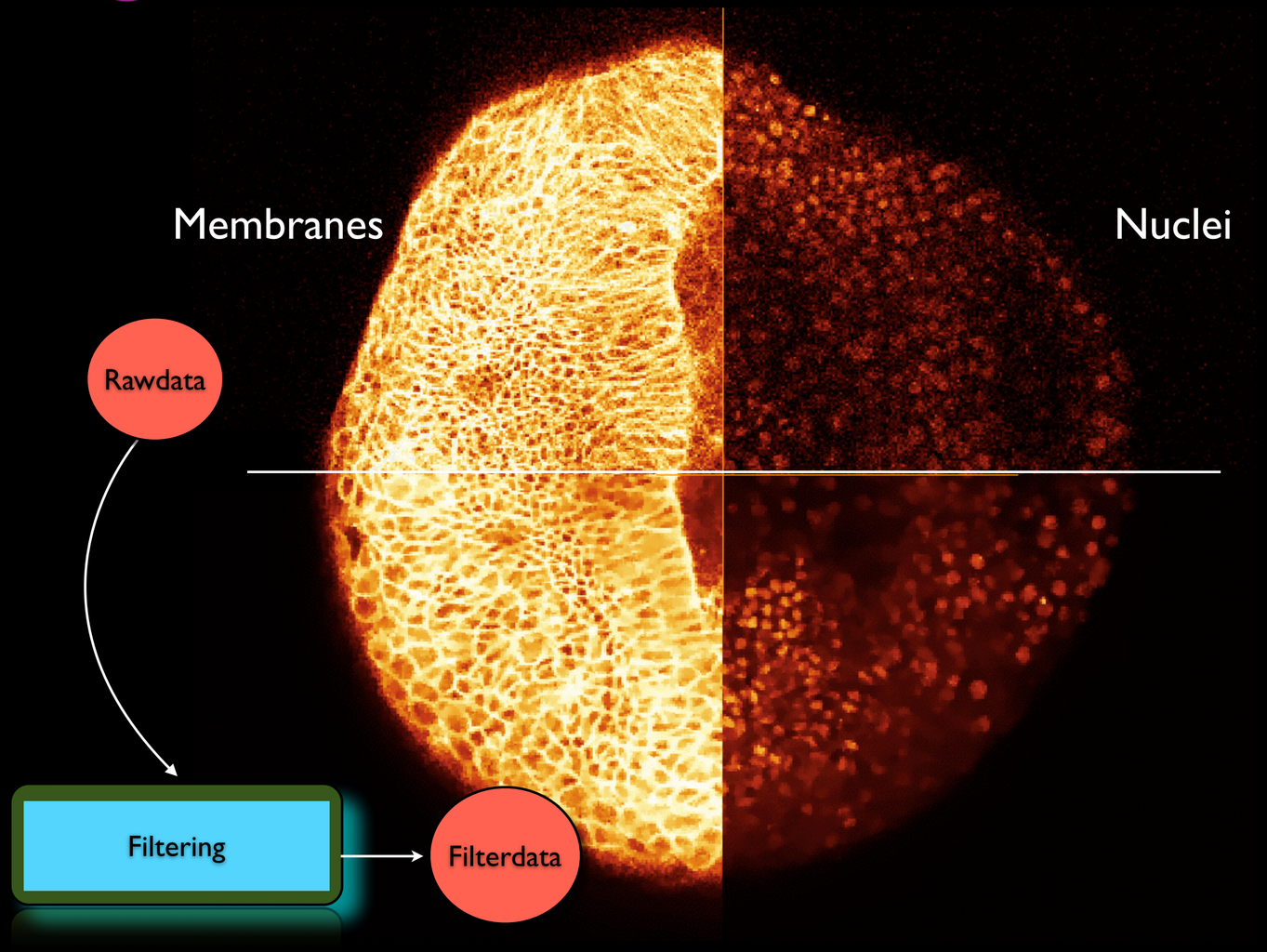
Sea Urchin



Zebrafish



Data Treatment



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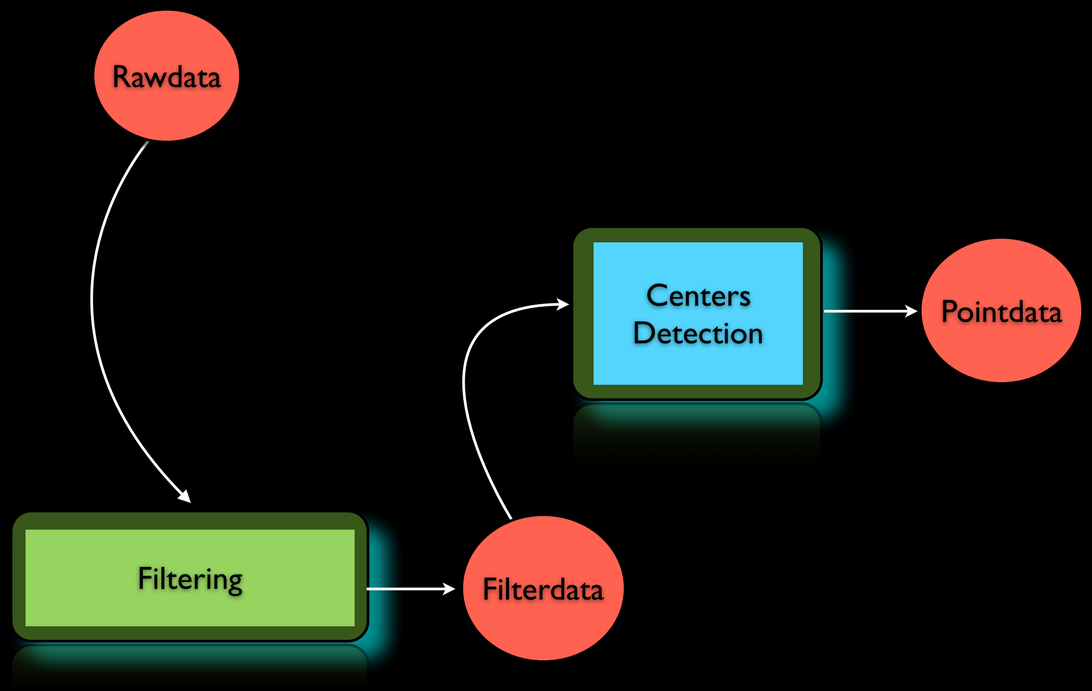

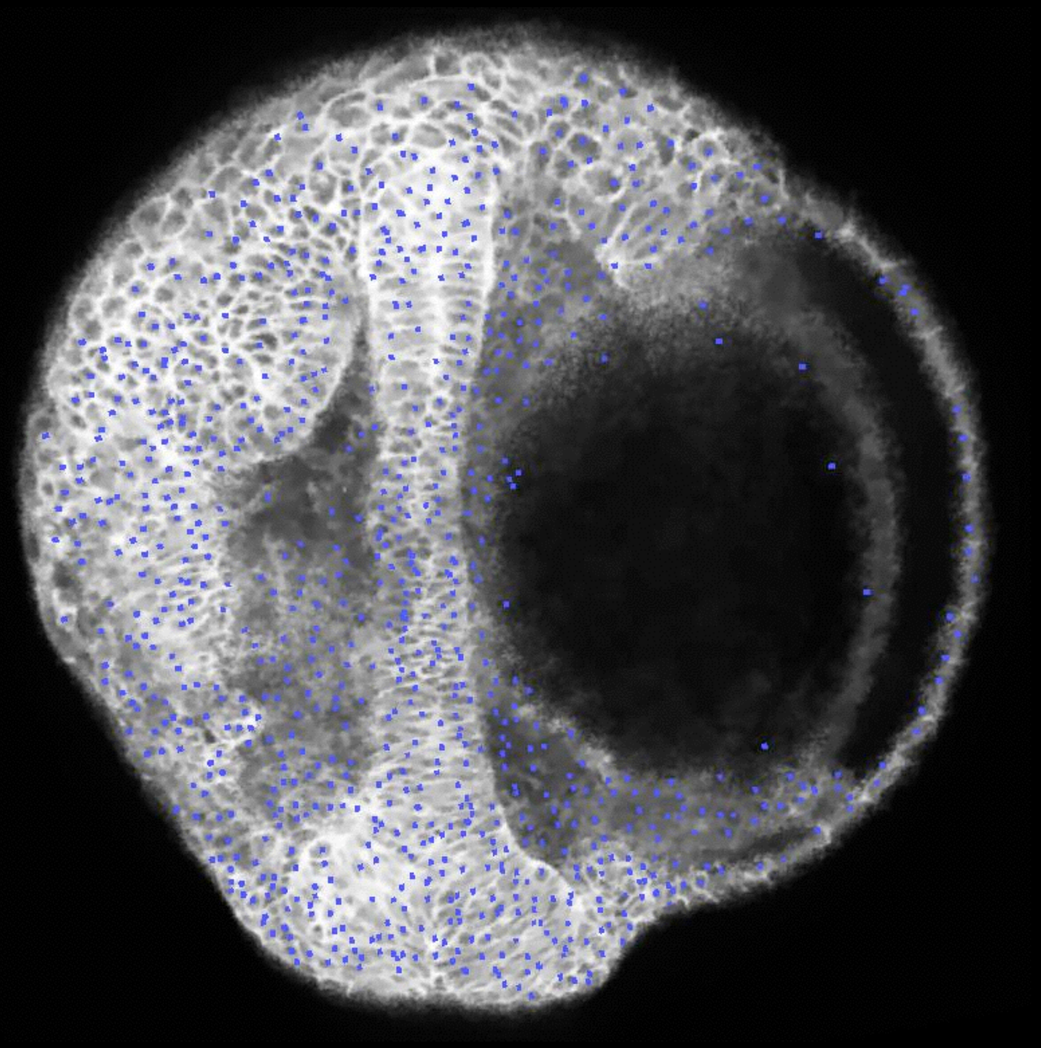

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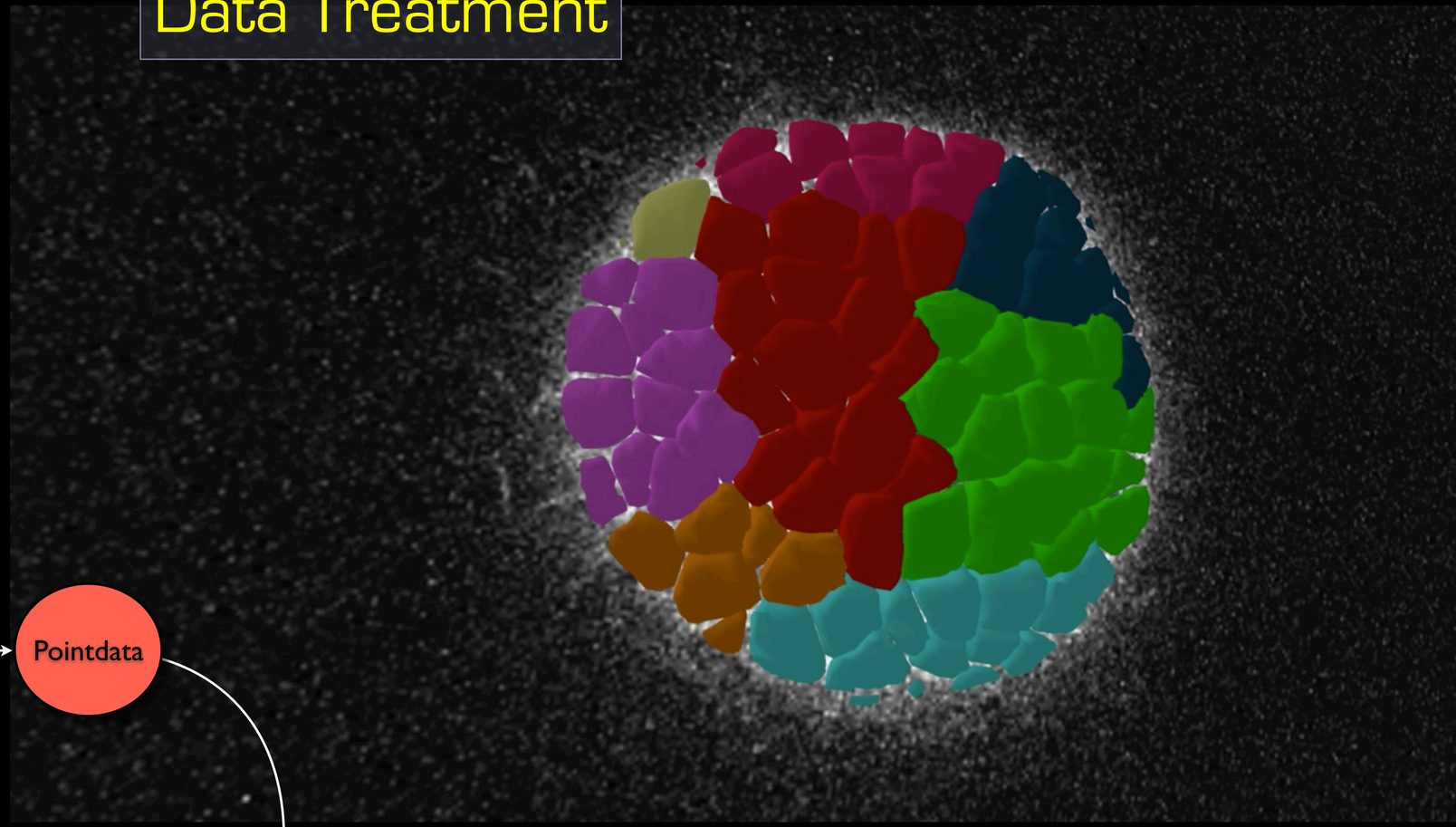

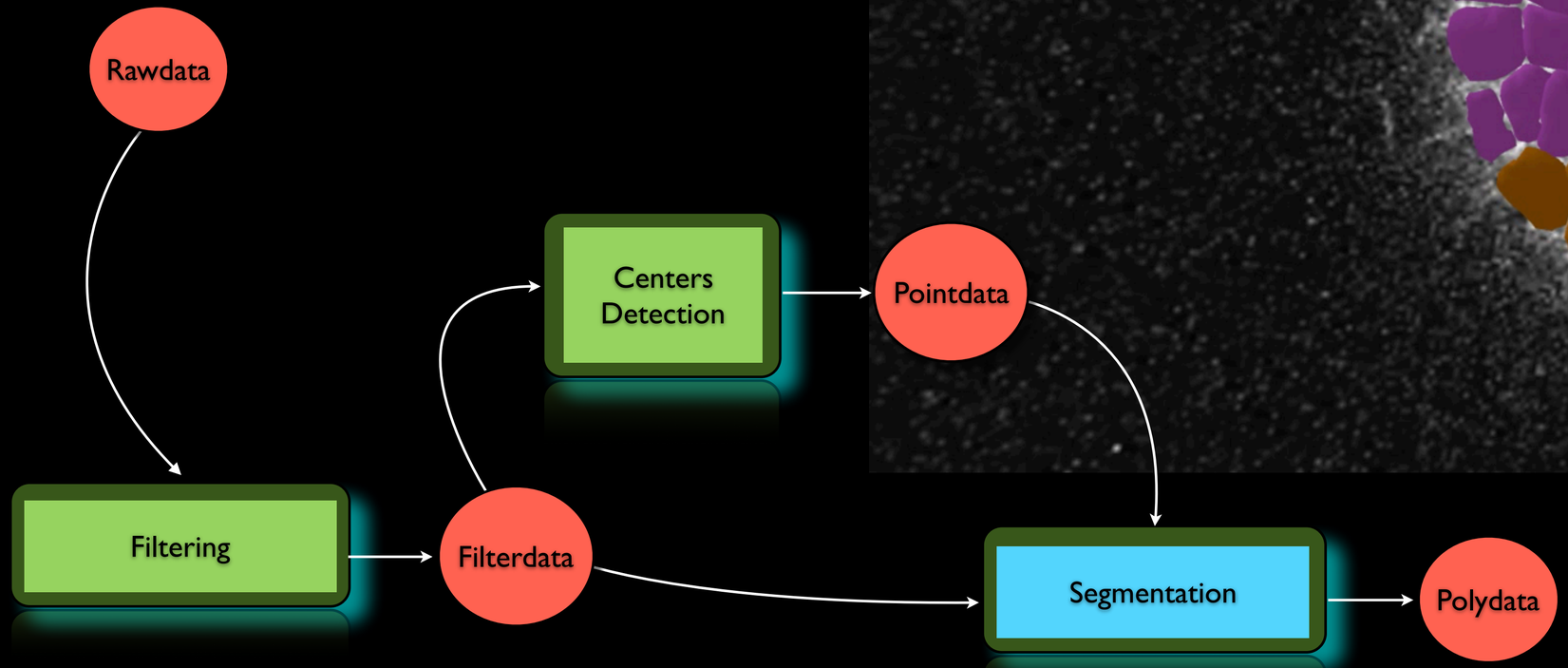

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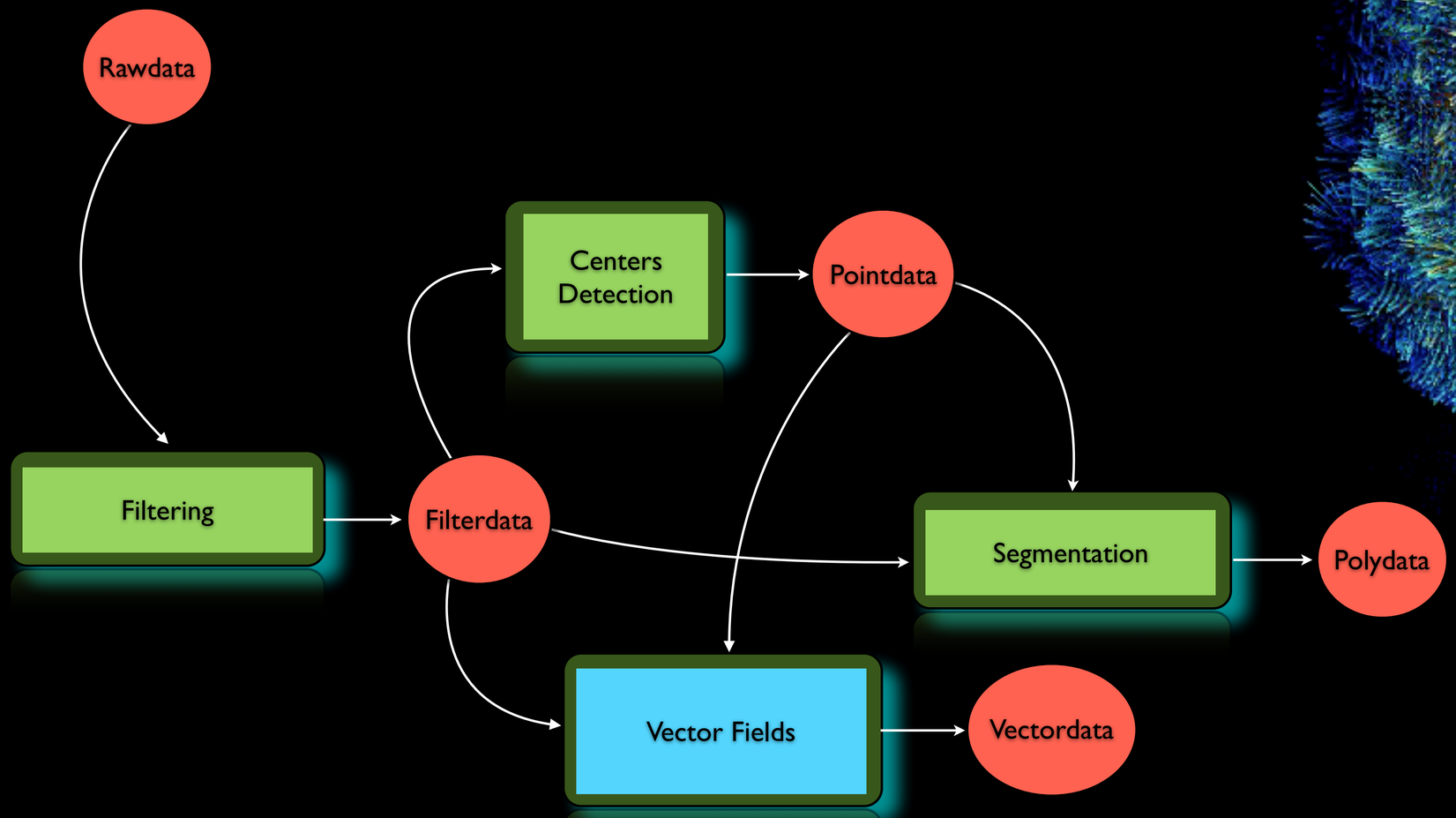

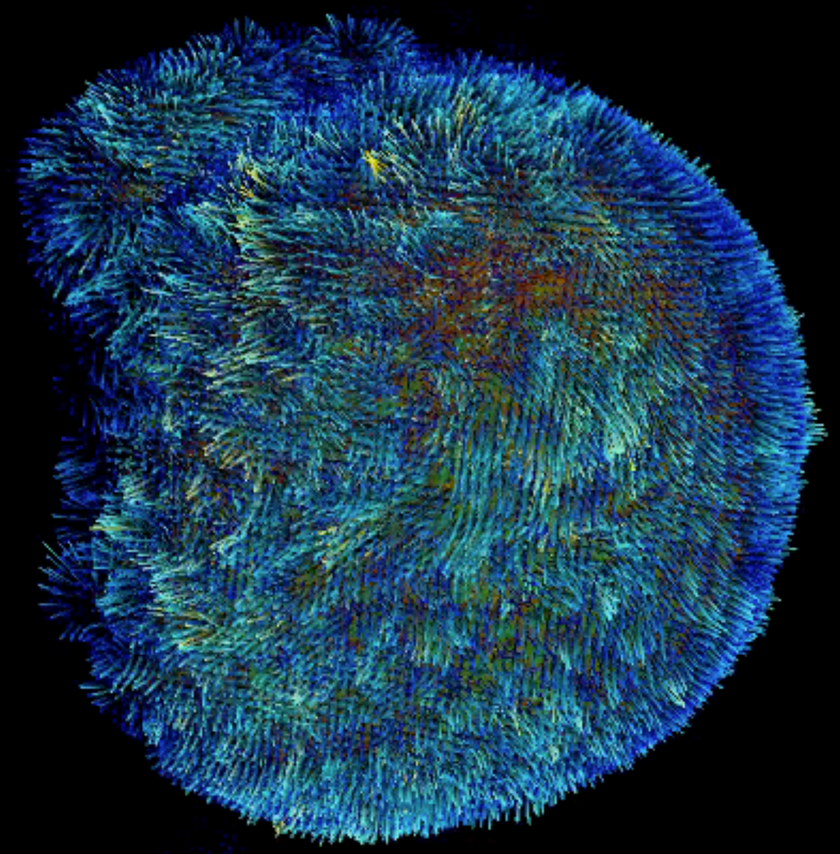

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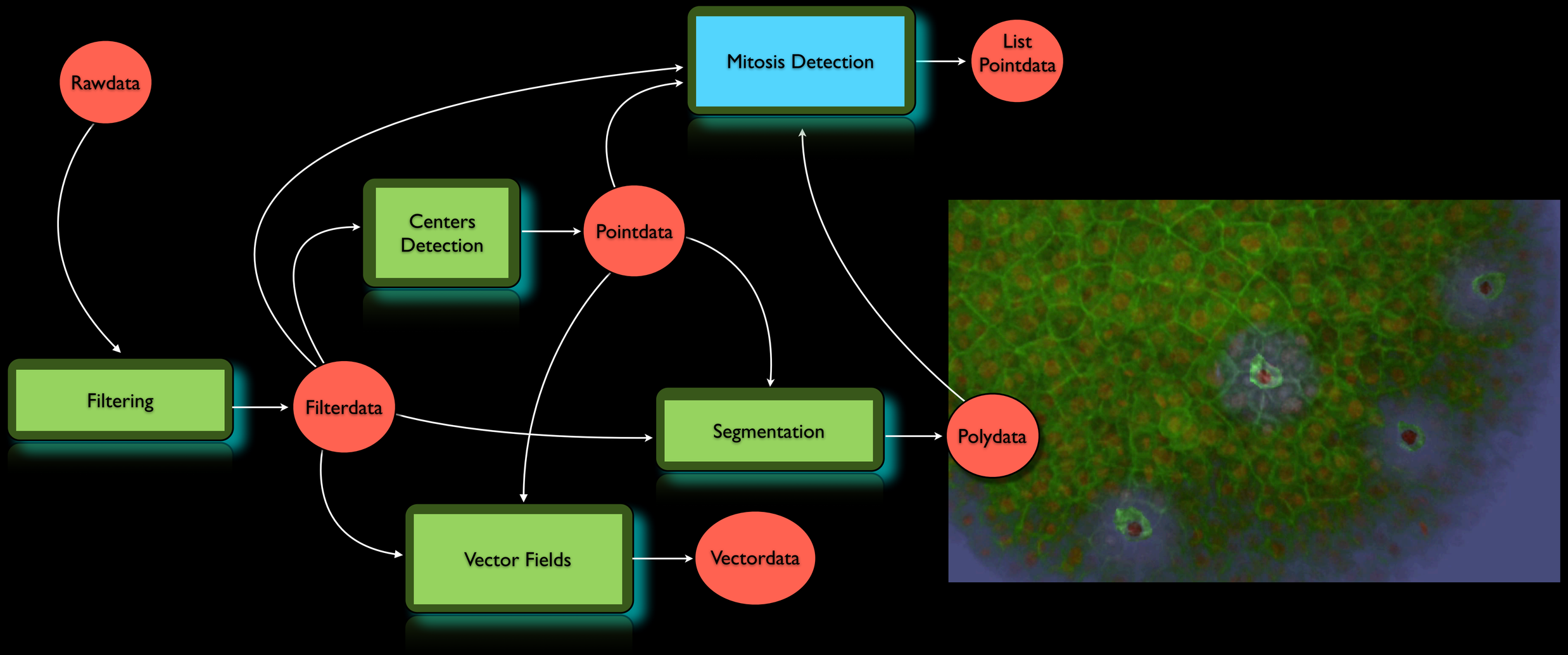

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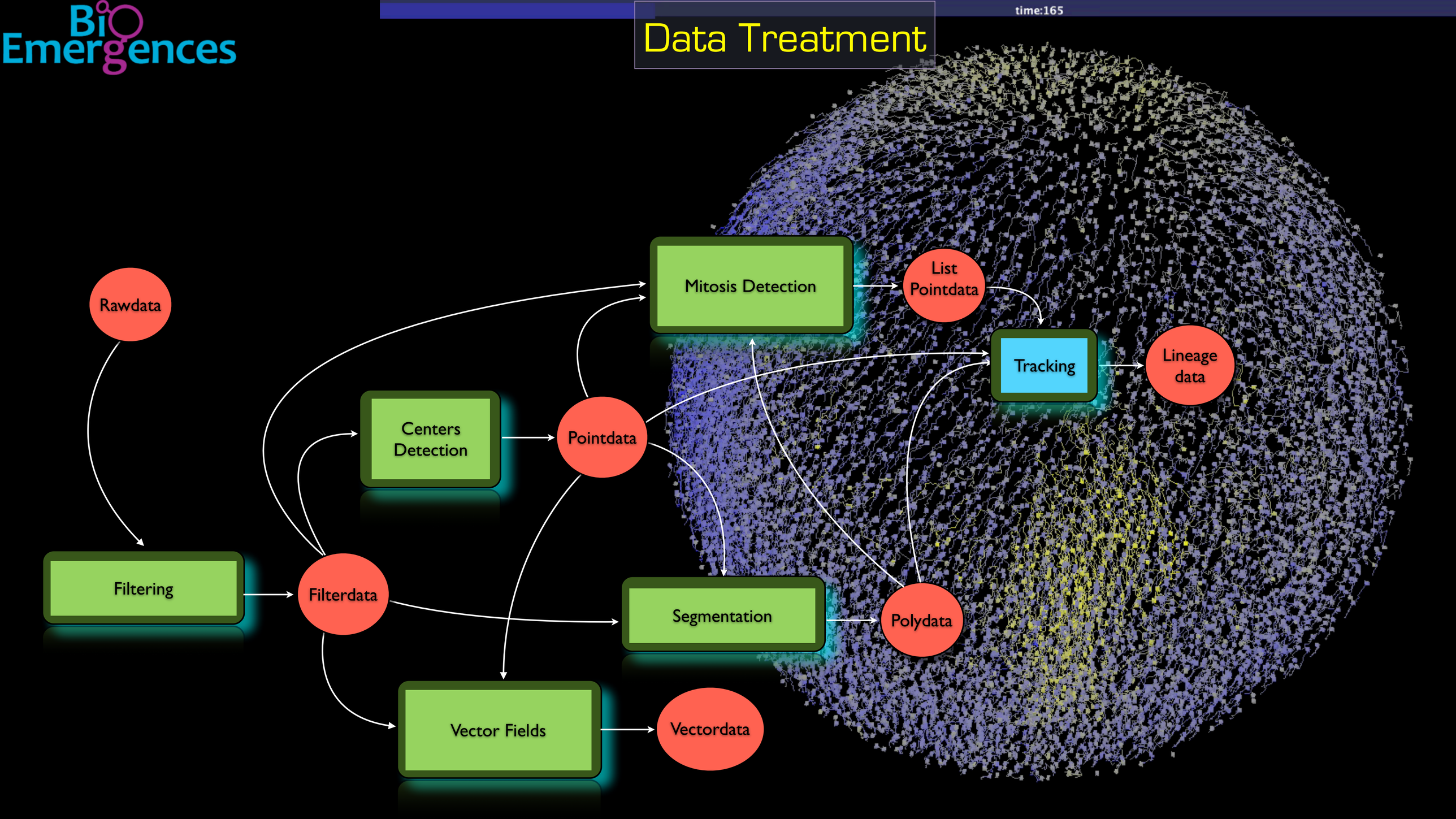
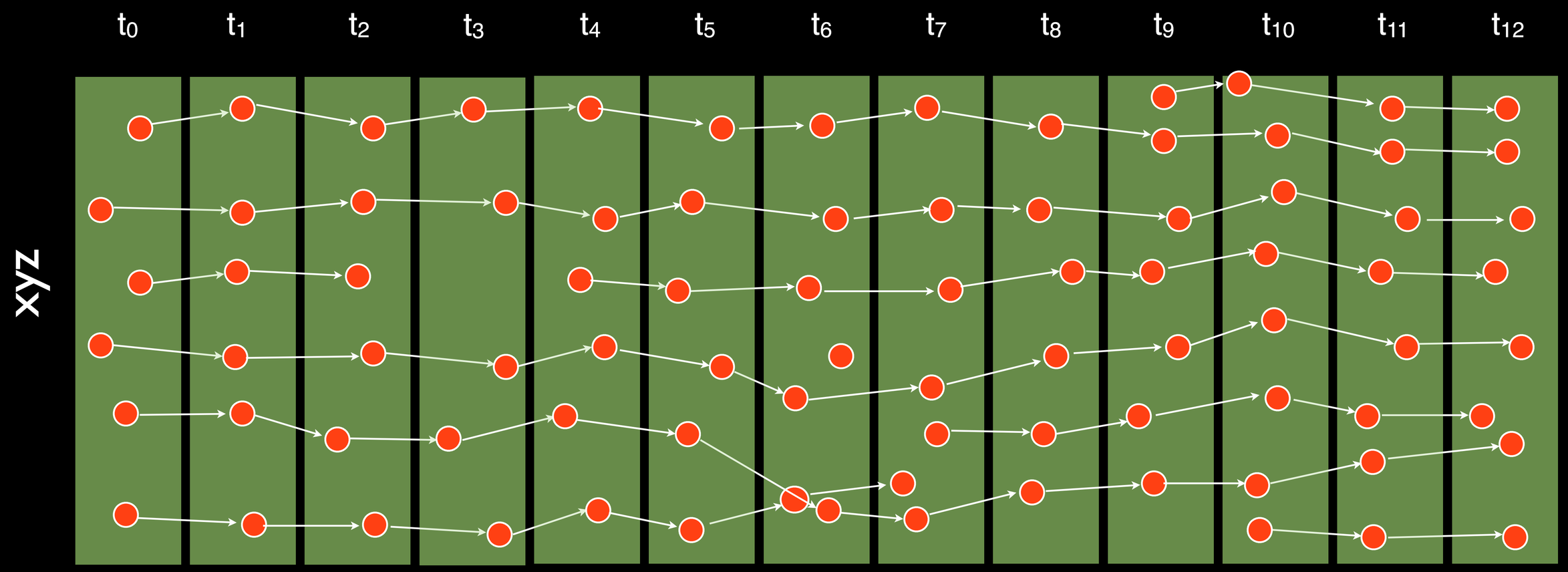


Tracking

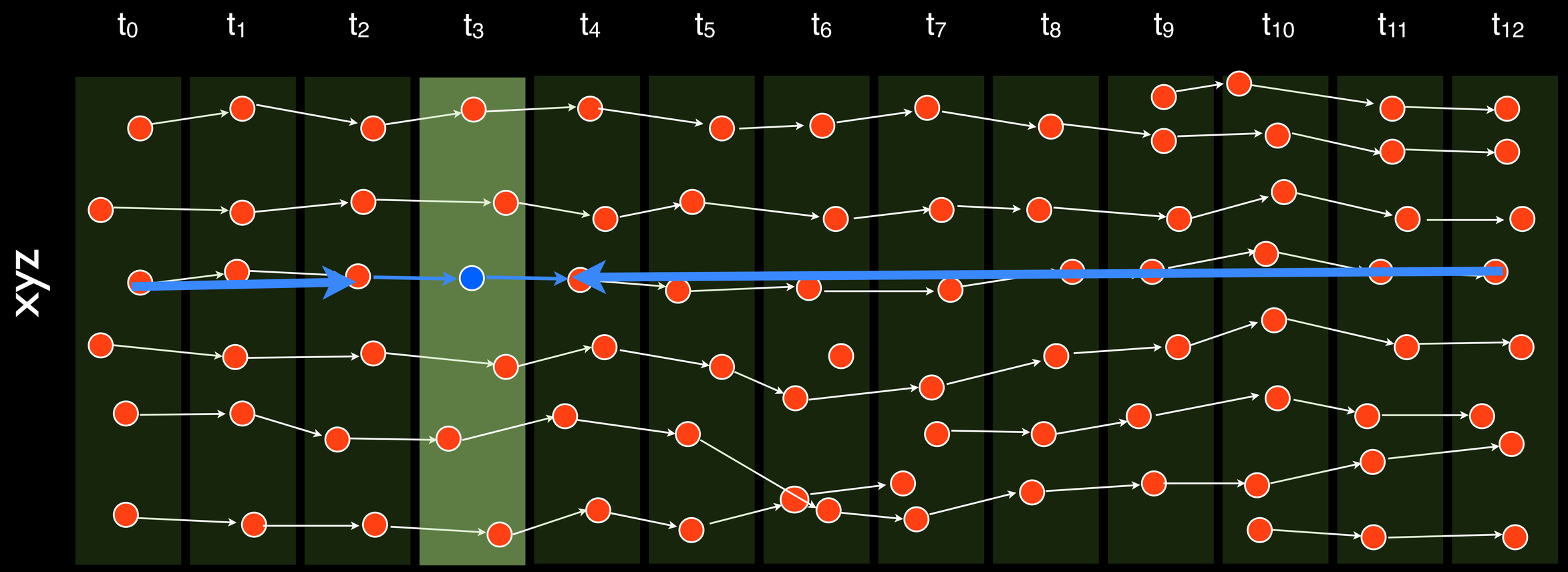
Tracking by nearest neighbors



~ 90% of good links

Tracking

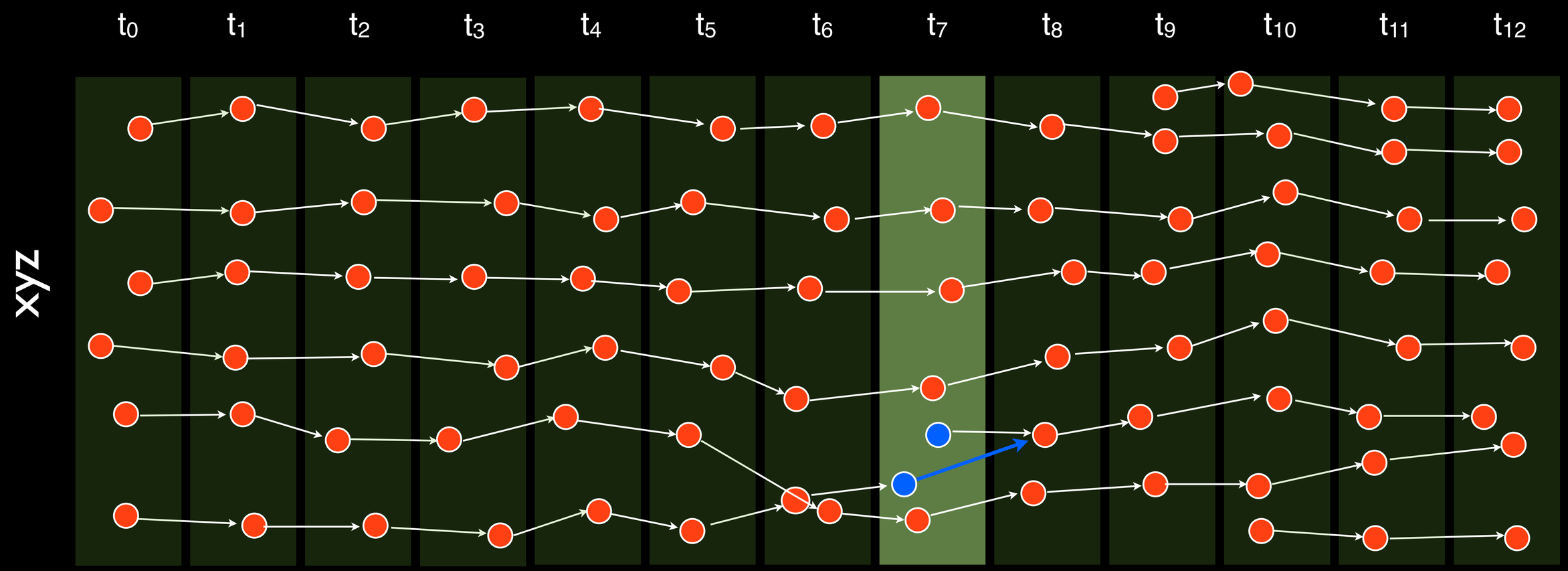
Data treatment artefacts



False Negative

Tracking

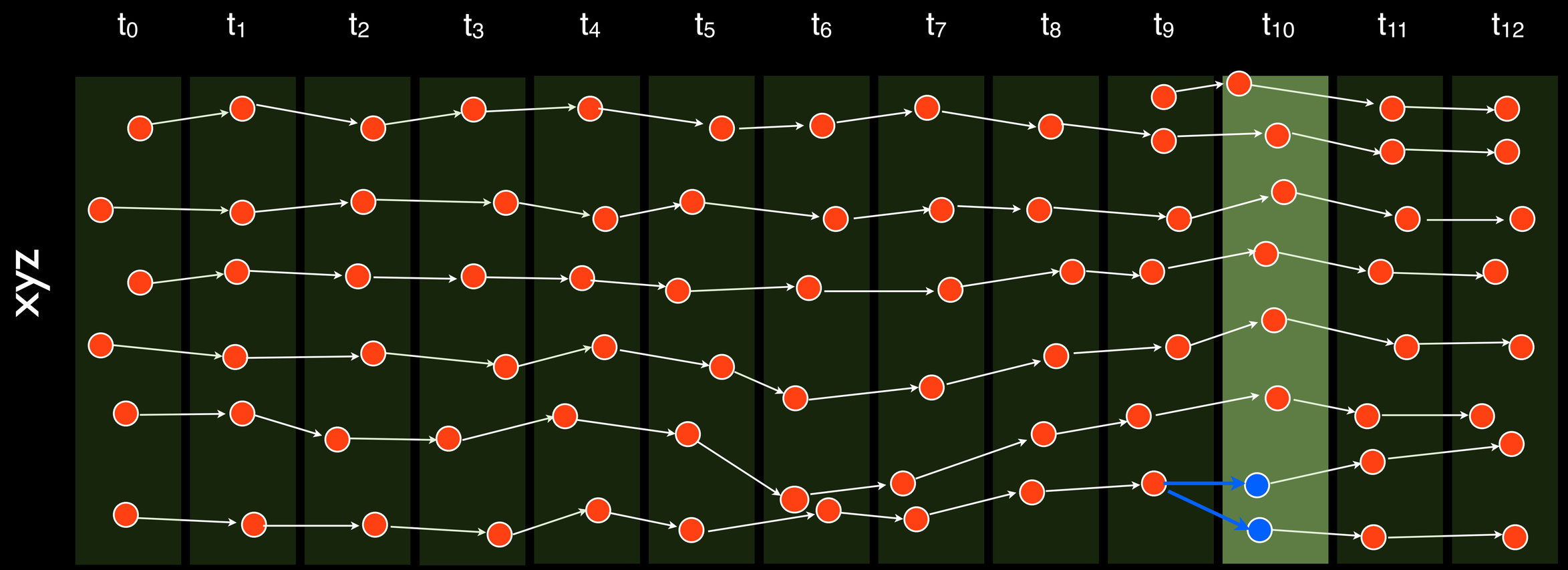
Data treatment artefacts



False Positive

Tracking

Coherence arguments



Cell division

Tracking

Acquisition artefacts

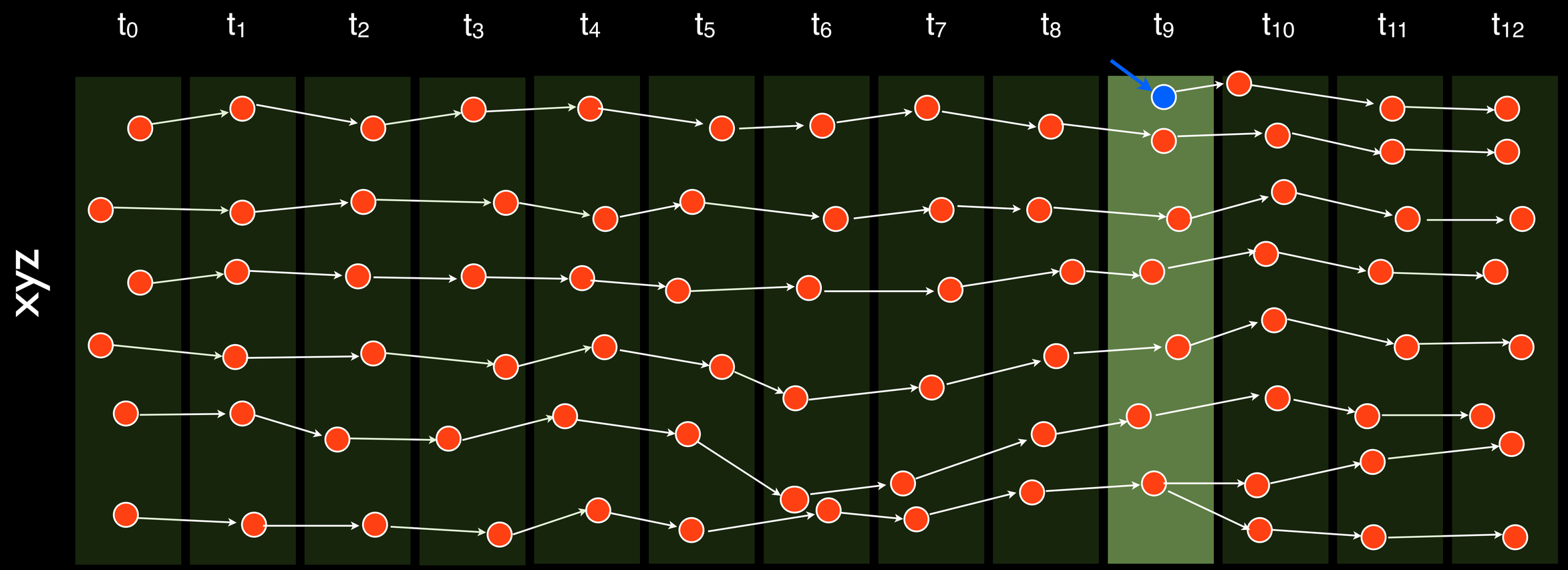
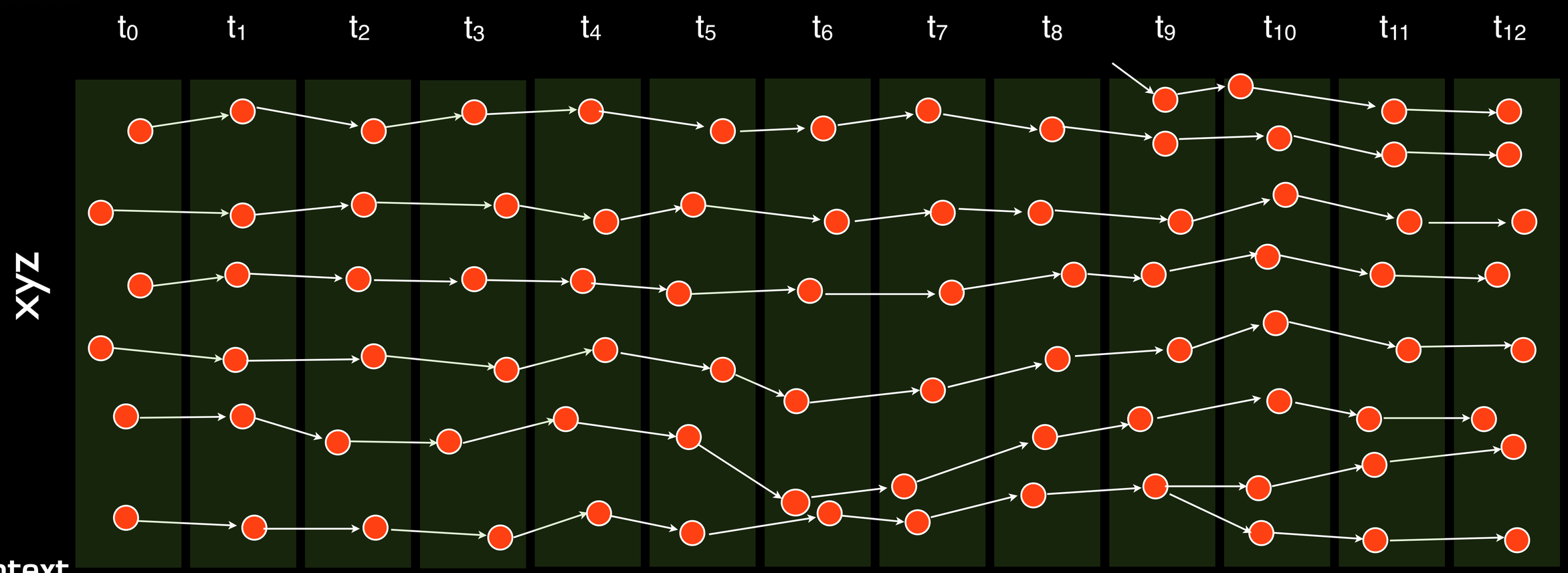


Image borders

Tracking

Results



Context

Data:

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

Evaluation : % valid temporal links

Results : ~ 2% of errors

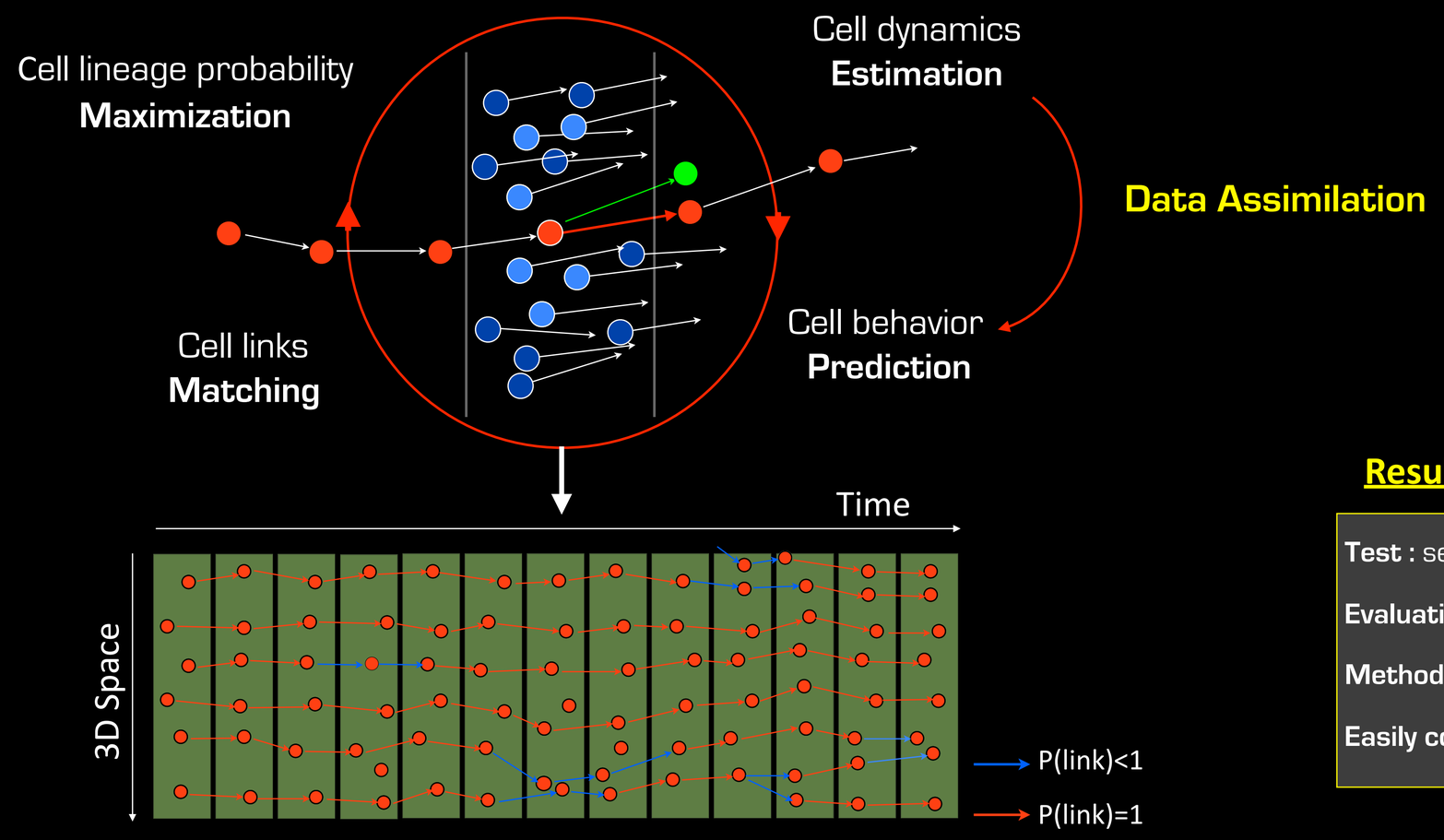
100% good links ?

→ **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

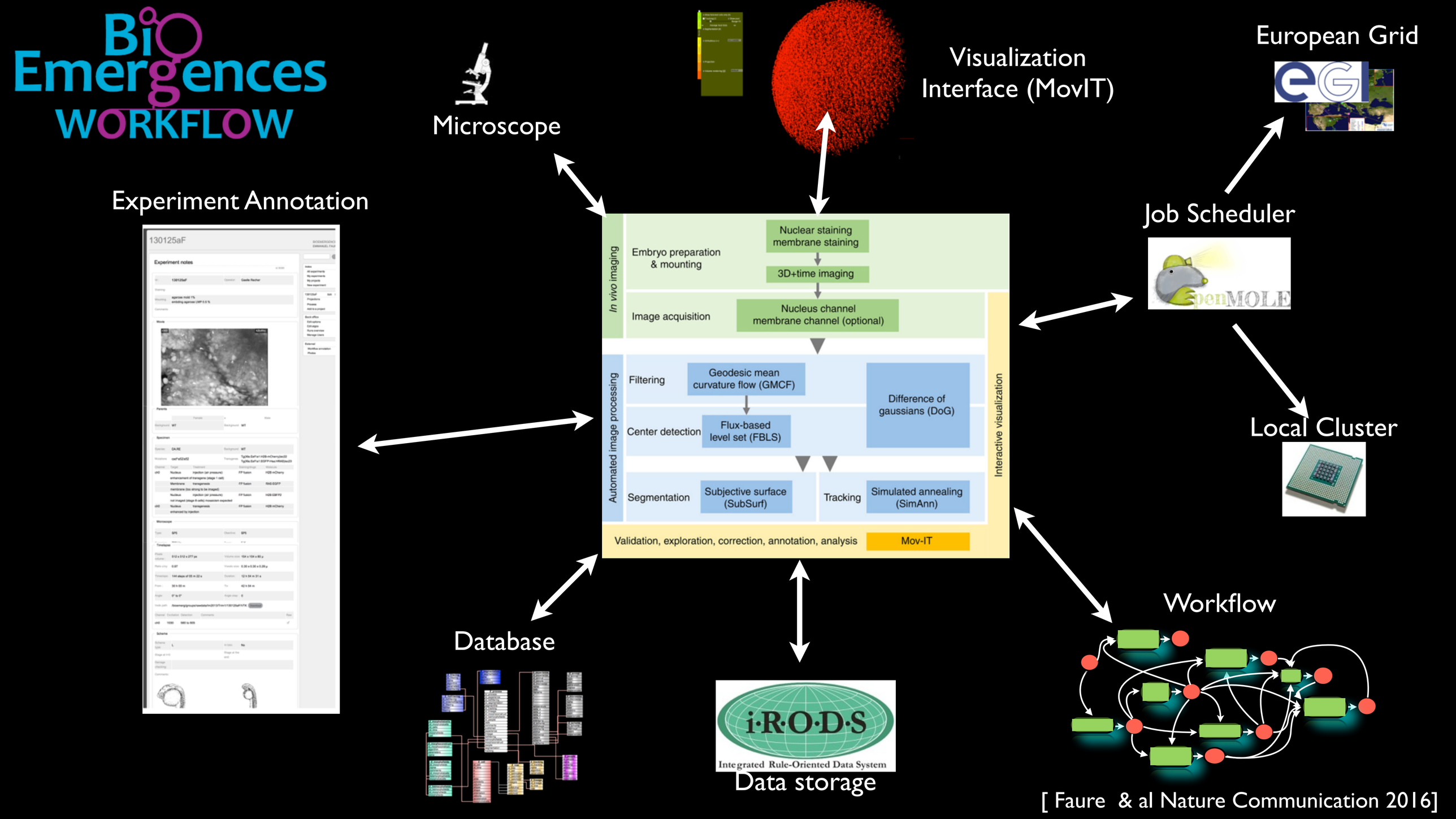
Results:

Test : several organisms

Evaluation : % erros ≦ other methods

Method without parameters

Easily correctable cell lineage



[Faure & al Nature Communication 2016]

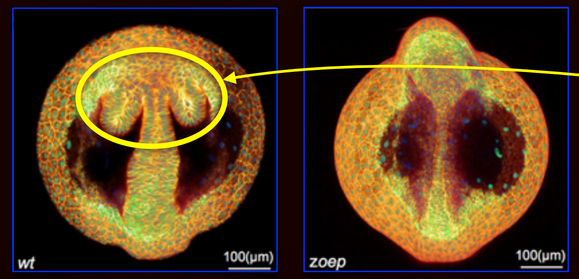
Reconstruction of multiscale dynamics of animal morphogenesis

Results:

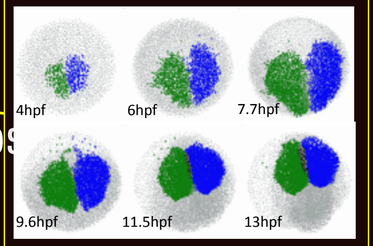
Issue: Understanding cellular dynamics

Wildtype embryo

Mutant embryo



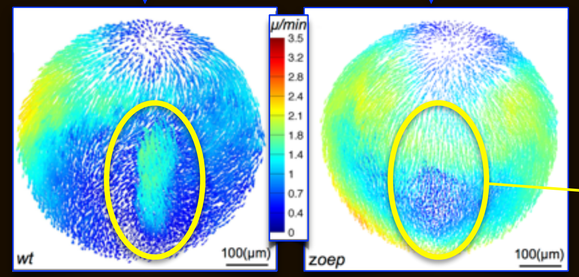
Obs



Eye separation

Objective : Comparison of digital embryos

Method : Automated Reconstruction using a web-service

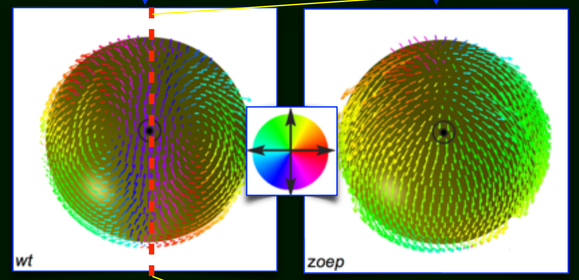


Digitizing

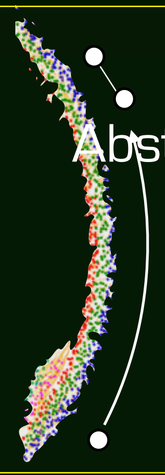
zoep lacks a part of the hypoblast

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

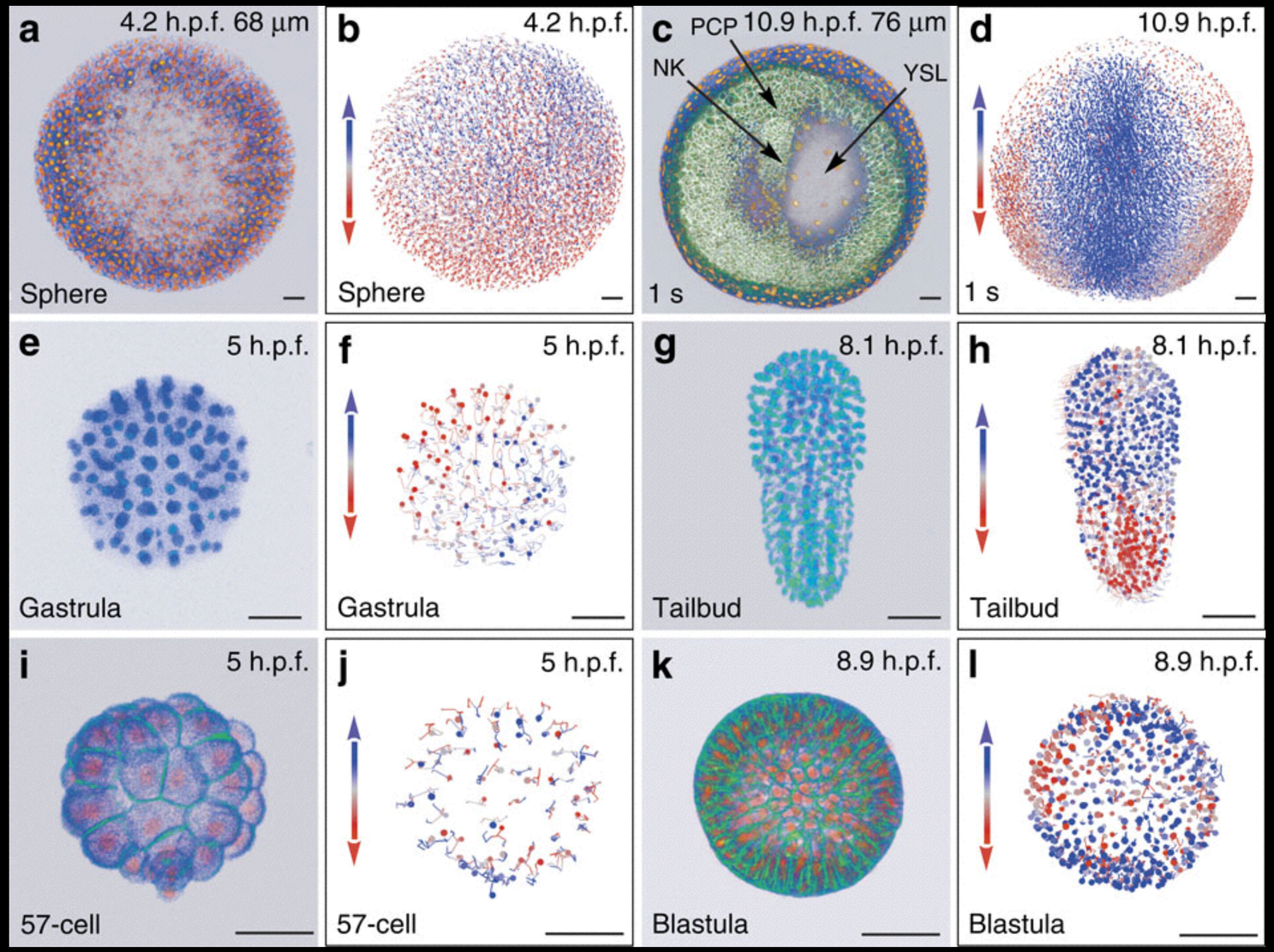
Organisms Reconstruction

[Faure & al Nature Communication 2016]

Zebrafish

Ascidian

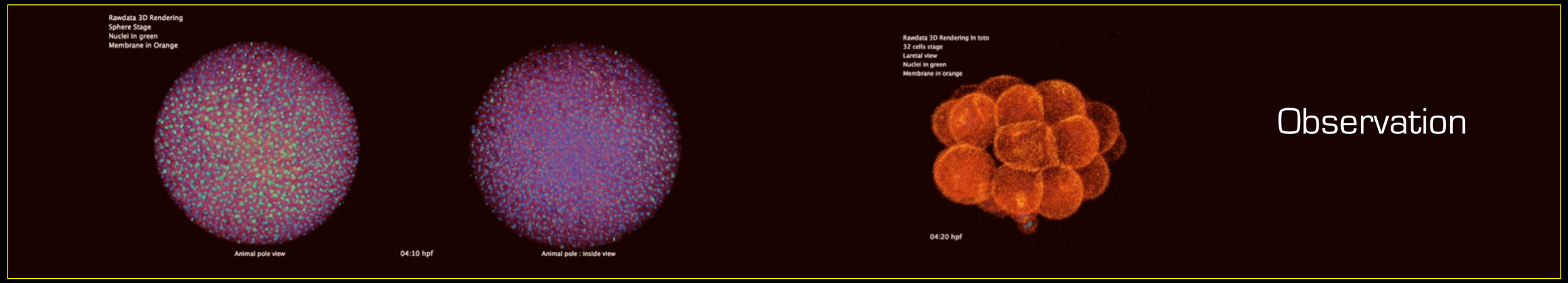
Sea Urchin



MovIT : Interactive Visualisation Interface

[Faure & al Nature Communication 2016]

Zebrafish | Sea Urchin

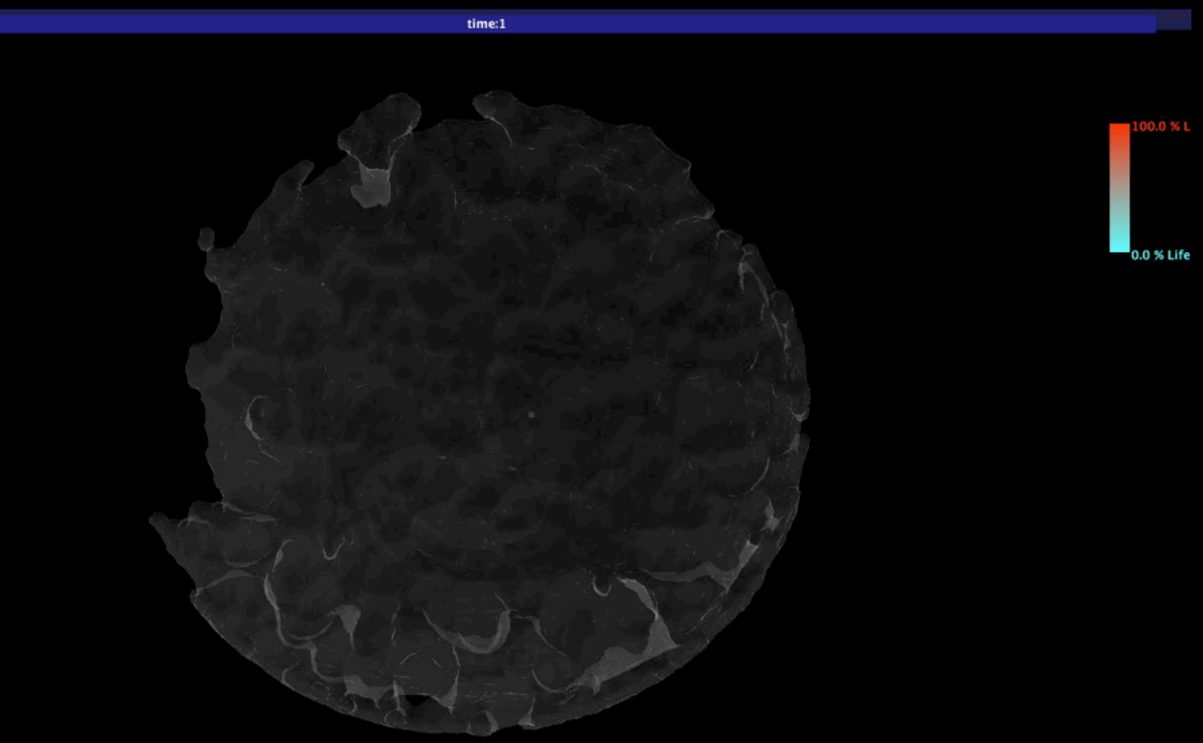


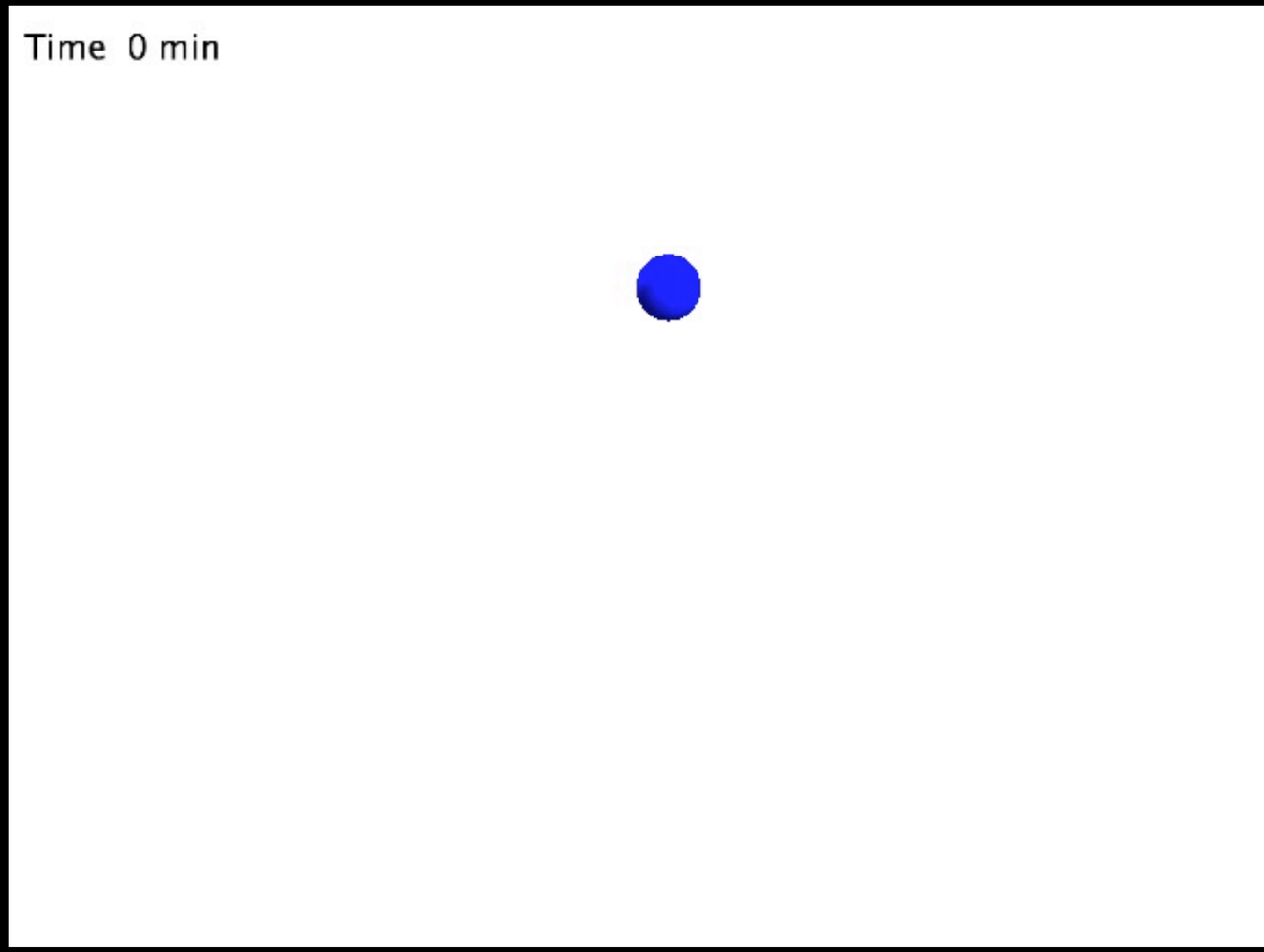
Observation

Digitizing

Abstraction

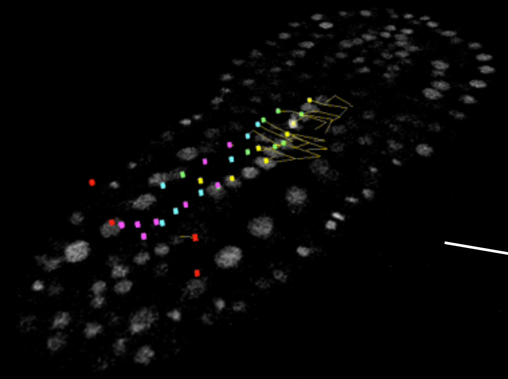
Division Prototype for zebrafish early embryo cell lineage

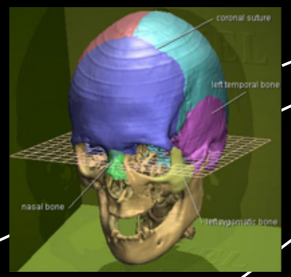


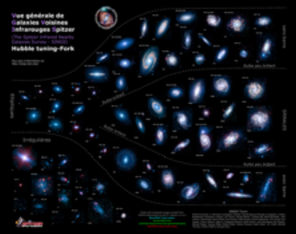


[Olivier & al Science 2010]

Ground truth : create annotated databases







→ data analysis
→ improve reconstruction algorithms
→ evaluate methods

Images Annotation Plateform

→ detection
→ classification
→ segmentation
→ tracking

Serious Game

Citizen Science

Varieties of world

Education

Levels

Diffusion

Thanks !