



# Deep learning with sparse annotations in cell image segmentation

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Research Scientist

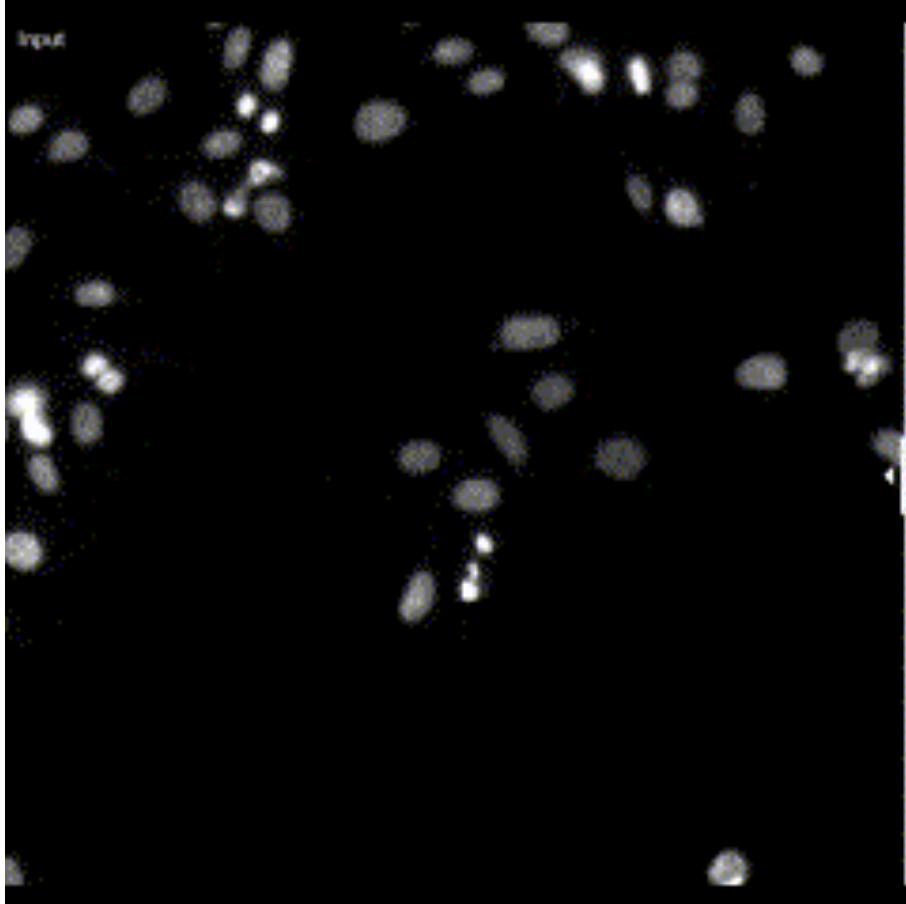
RIKEN BDR, Kobe, Japan

11 May 2023 @NEUBIAS symposium, Porto

Competing interests:  
Ko Sugawara is employed by LPIXEL Inc.



# Instance segmentation in cell image analysis

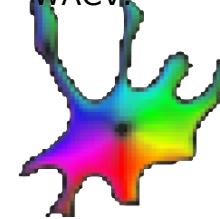


StarDist

<https://github.com/stardist/stardist>

Uwe Schmidt, Martin Weigert, Coleman Broaddus, & Gene Myers. (2018). Cell Detection with Star-convex Polygons, MICCAI.

Martin Weigert, Uwe Schmidt, Robert Haase, Ko Sugawara, & Gene Myers. (2020). Star-convex Polyhedra for 3D Object Detection and Segmentation in Microscopy, WACV.



Cellpose

<https://github.com/stardist/stardist>

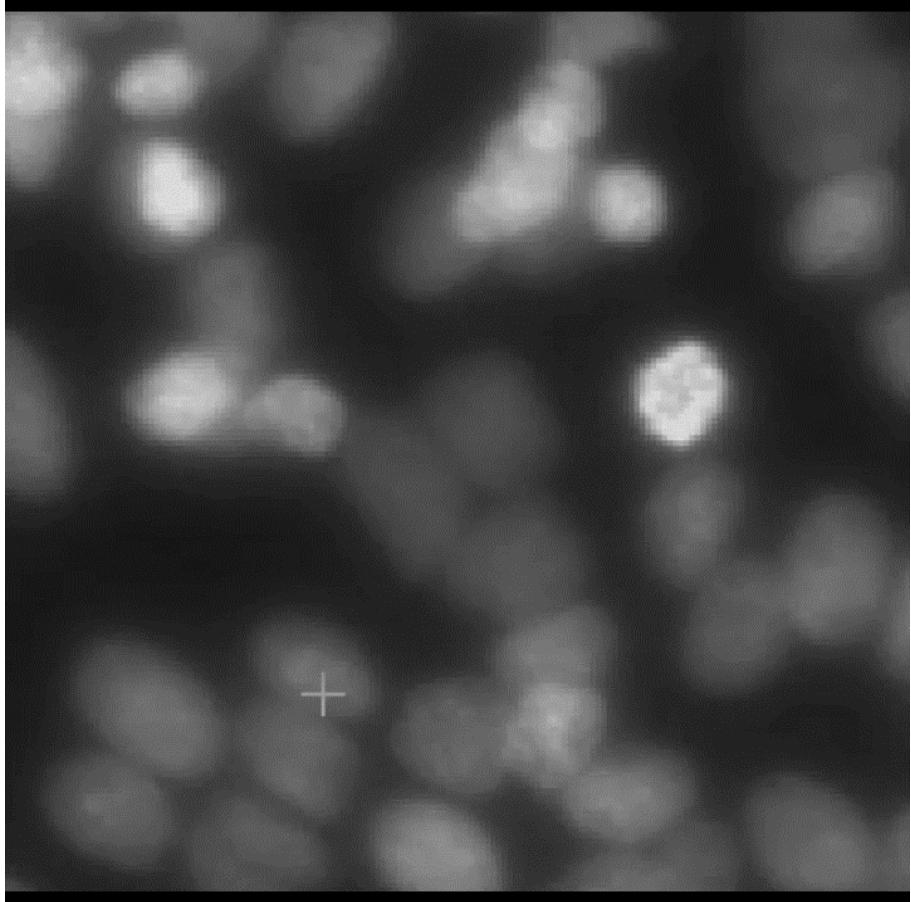
Stringer, C., Wang, T., Michaelos, M., & Pachitariu, M. (2021). Cellpose: a generalist algorithm for cellular segmentation. *Nature methods*, **18(1)**, 100-106.

Pachitariu, M. & Stringer, C. (2022).

Cellpose 2.0: how to train your own model. *Nature methods*, **19**, 1634-1641.

Data from 2018 Data Science Bowl, BBBC038v1,  
Caicedo et al., Nature Methods, 2019  
Visualized with streamlit-image-comparison

# Problems and questions in annotation

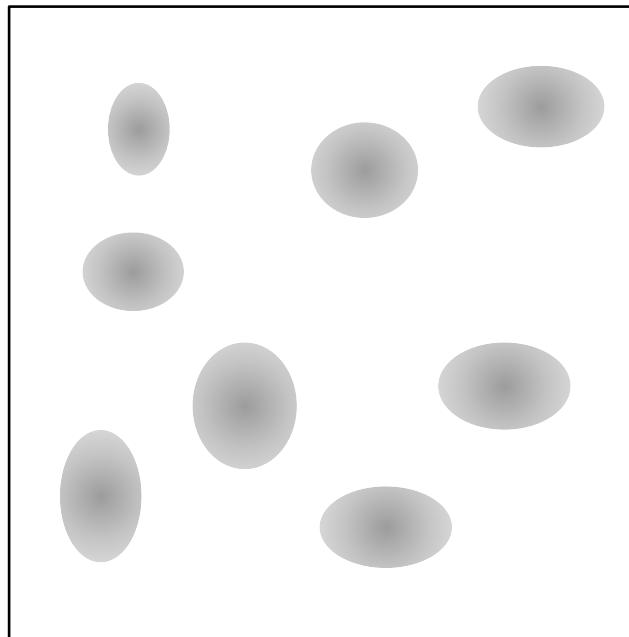


- Annotation is time-consuming
- How many annotations are required?
- Is the selection of annotations important?

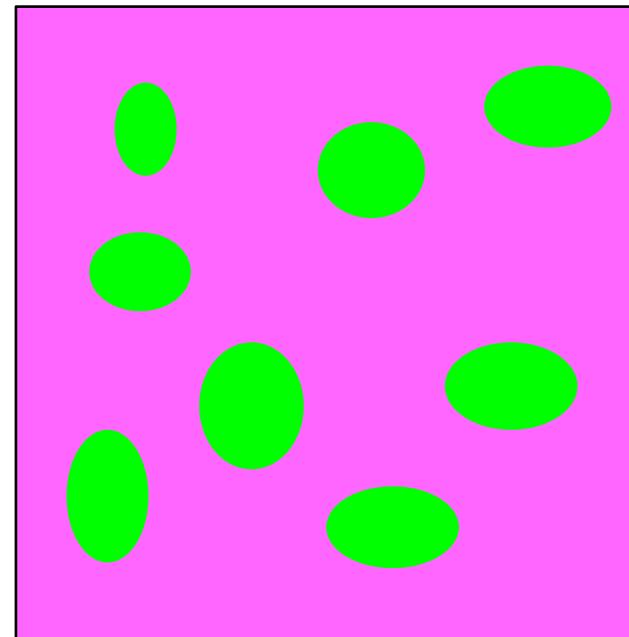
Data from 2018 Data Science Bowl, BBBC038v1,  
Caicedo et al., Nature Methods, 2019  
Visualized and annotated in Fiji

# Sparse annotation

Input image

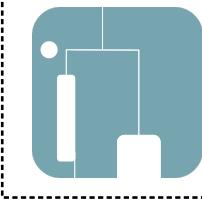
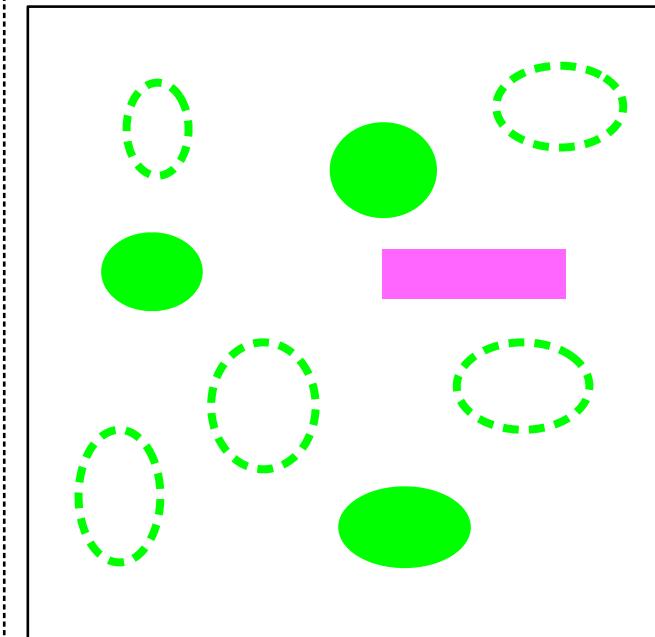


Dense annotation  
(common approach)



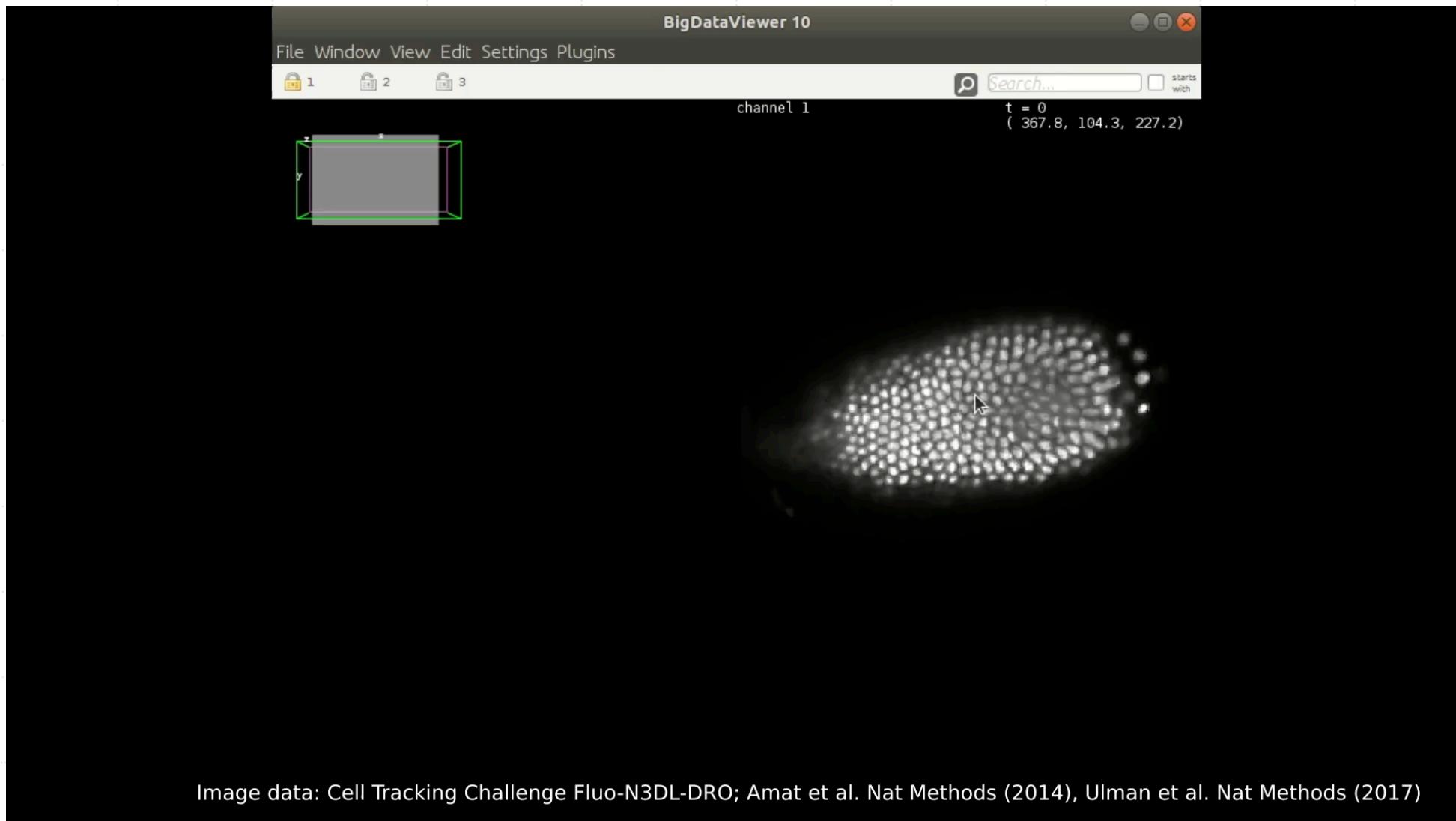
Green: foreground  
Magenta: background

Sparse annotation  
(our approach)



ELEPHAN  
T

# Training a detection model from scratch in ELEPHANT

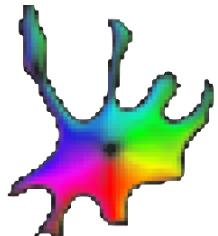


# Make StarDist and Cellpose compatible with sparse annotation



StarDist

[https://github.com/stardist/  
stardist](https://github.com/stardist/stardist)



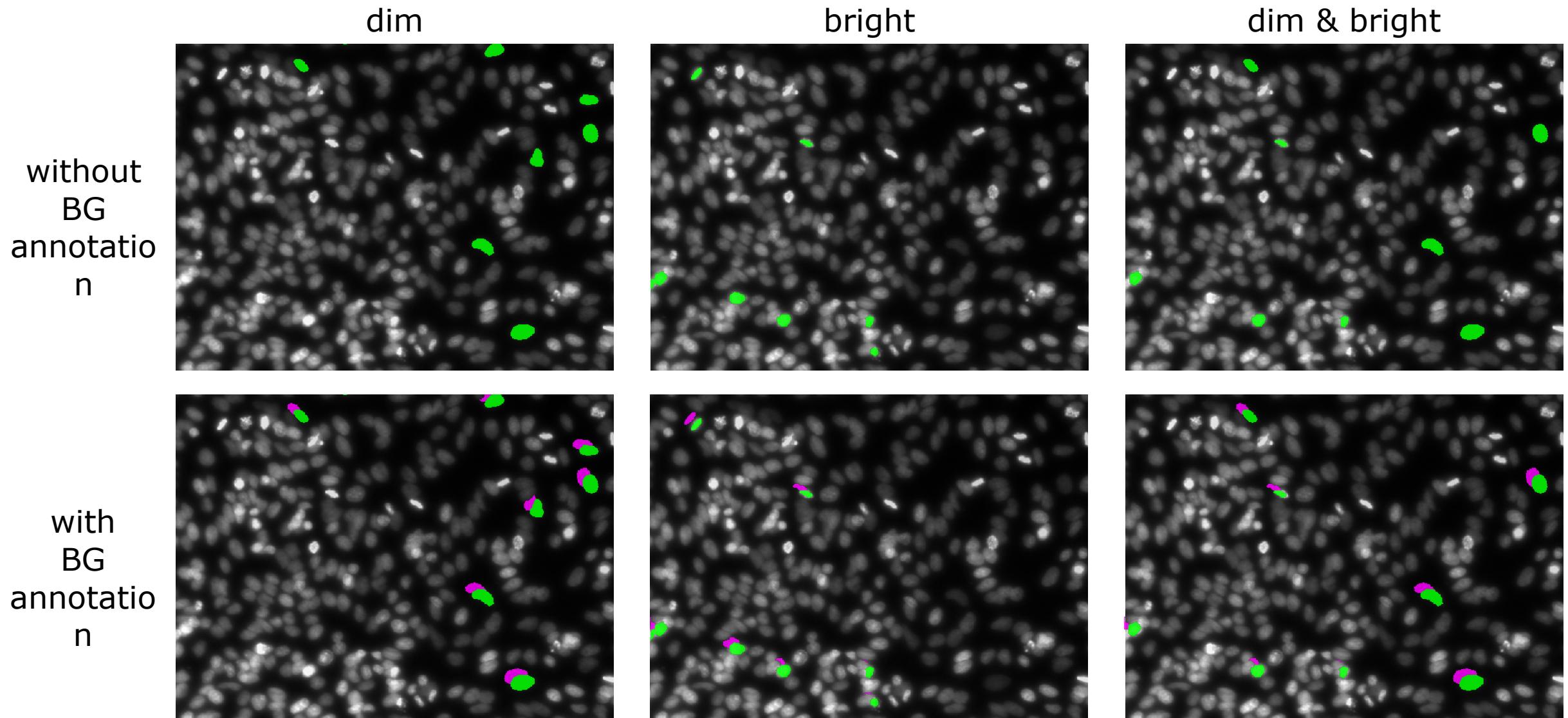
Cellpose

[https://github.com/stardist/  
stardist](https://github.com/stardist/stardist)

## Modifications:

1. Distinguish unlabeled pixels from annotated pixels
2. Ignore unlabeled pixels in loss calculation

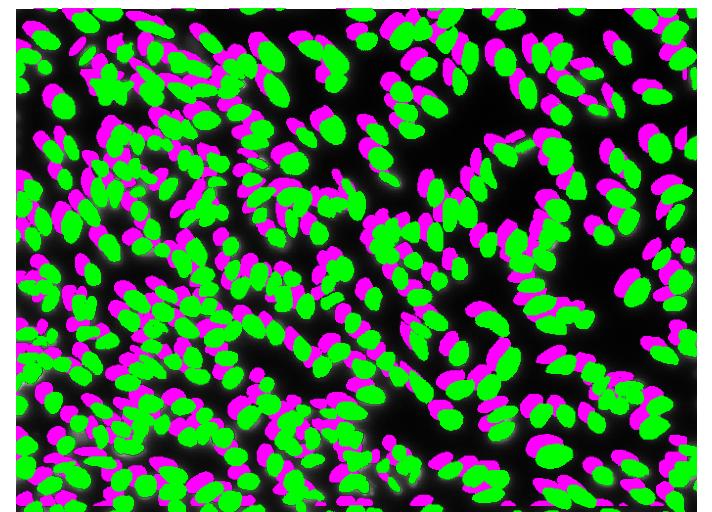
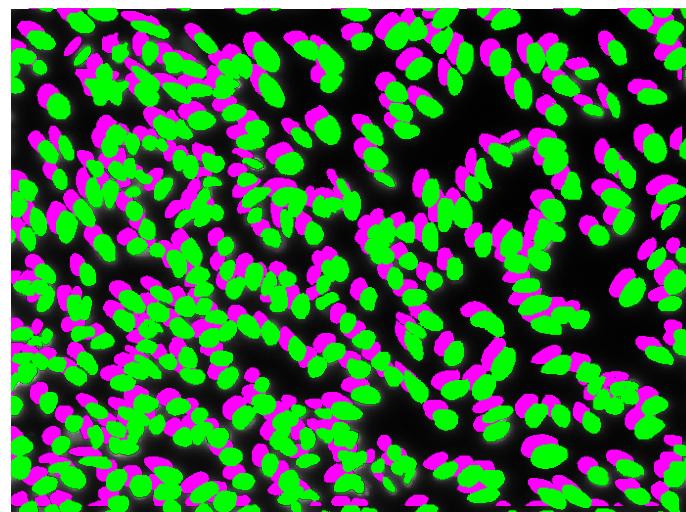
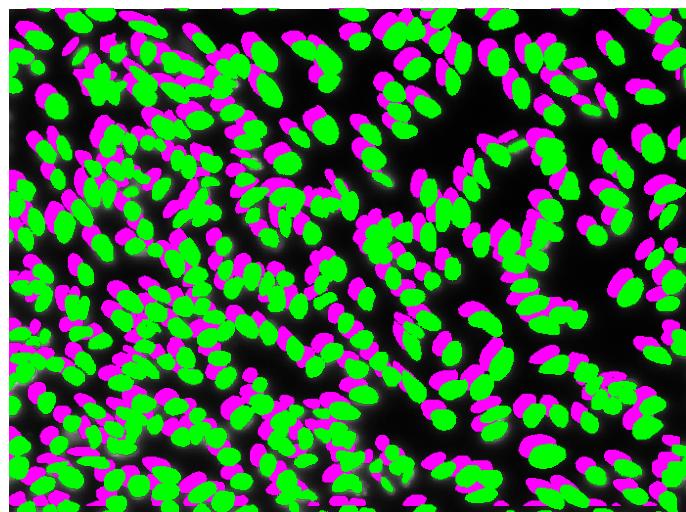
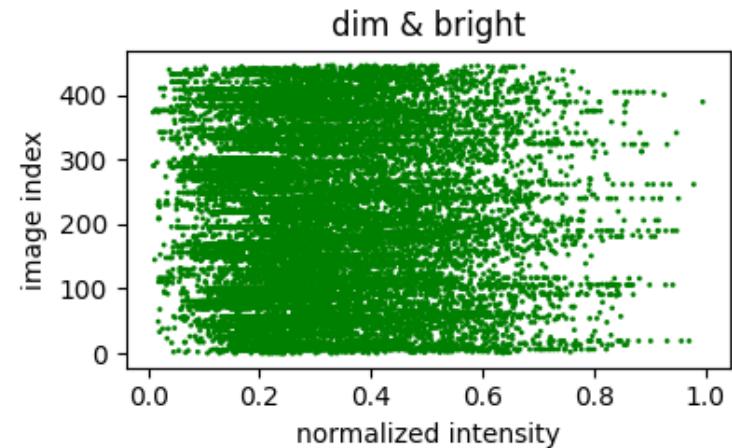
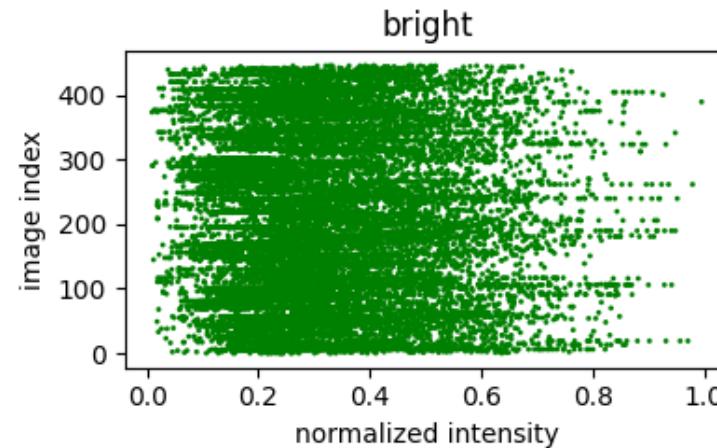
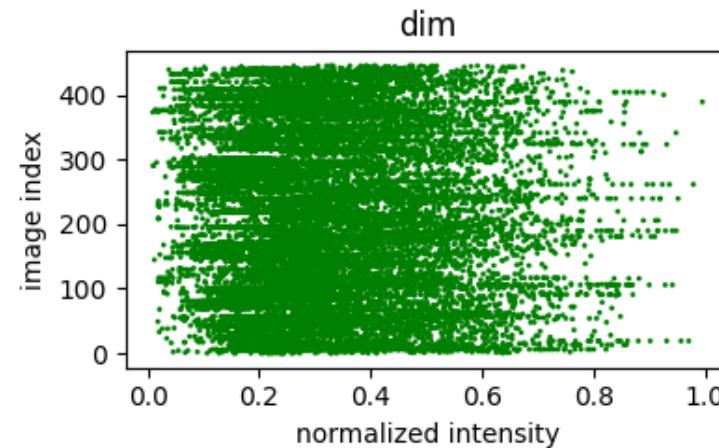
# Comparison of sparse annotation strategies



Data from 2018 Data Science Bowl, BBBC038v1, Caicedo et al., Nature Methods, 2019

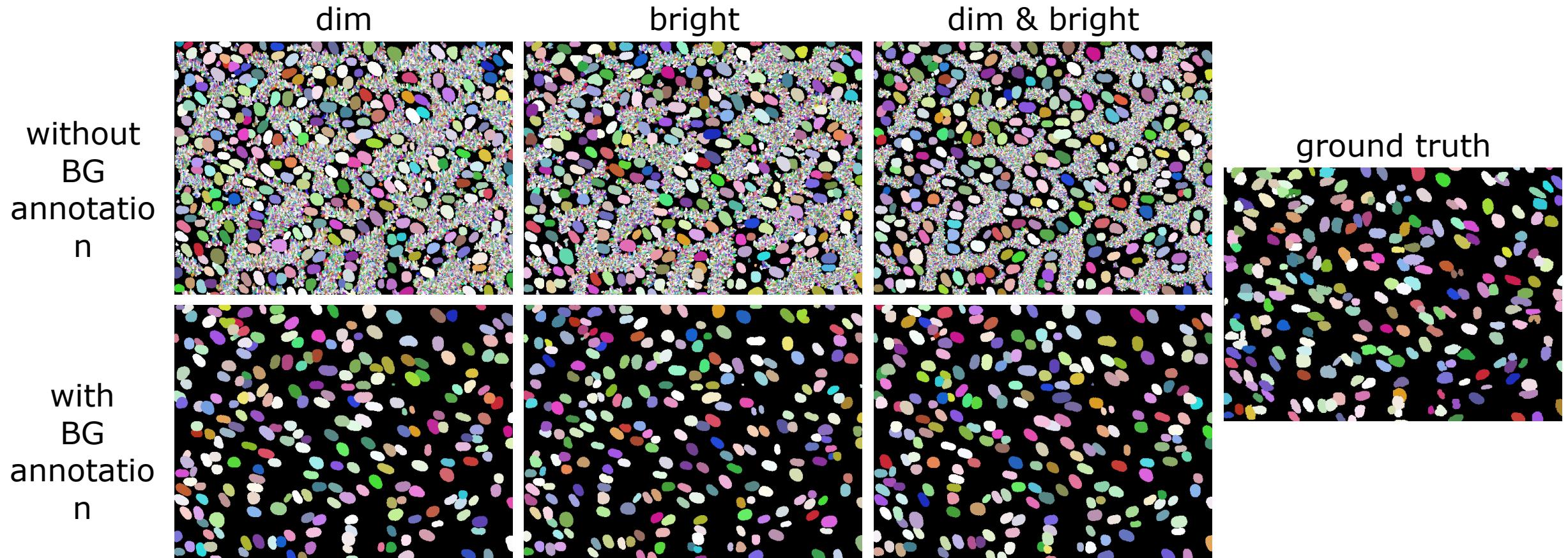
# Comparison of sparse annotation strategies

Condition 5 (100.0% annotated)



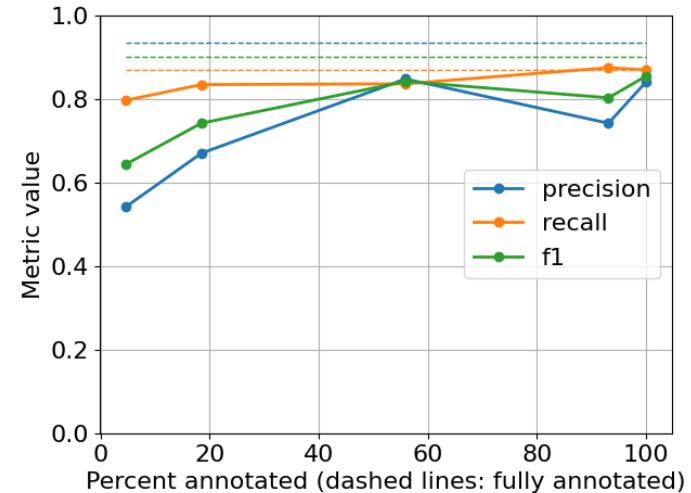
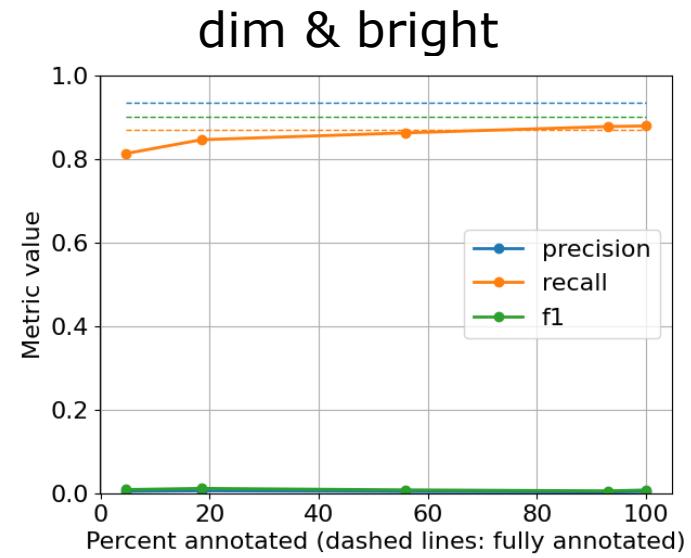
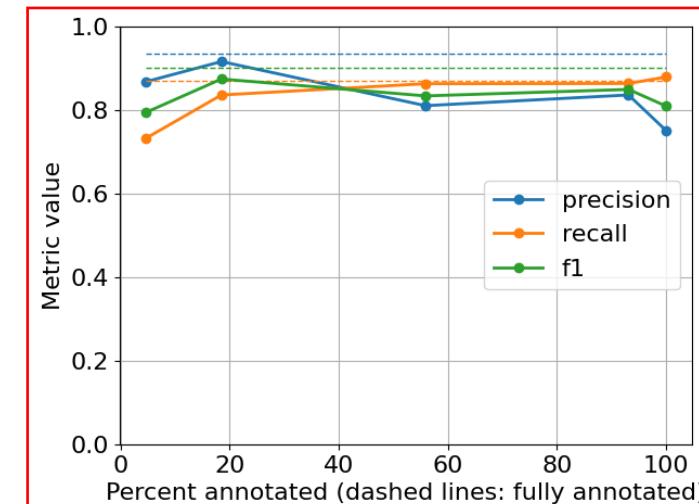
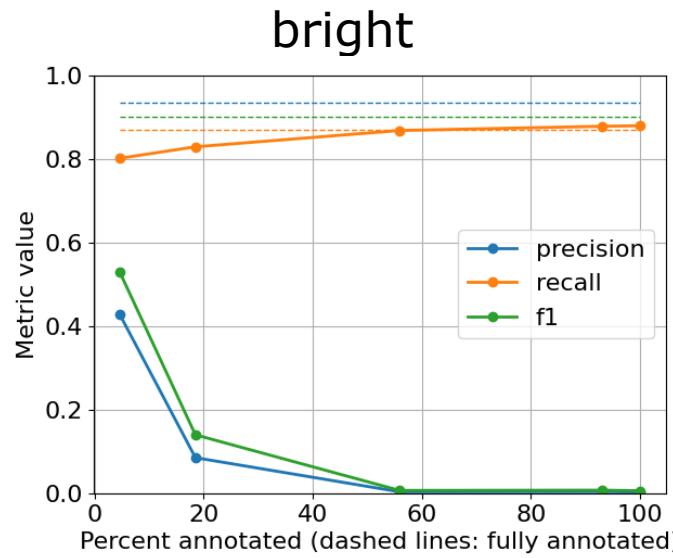
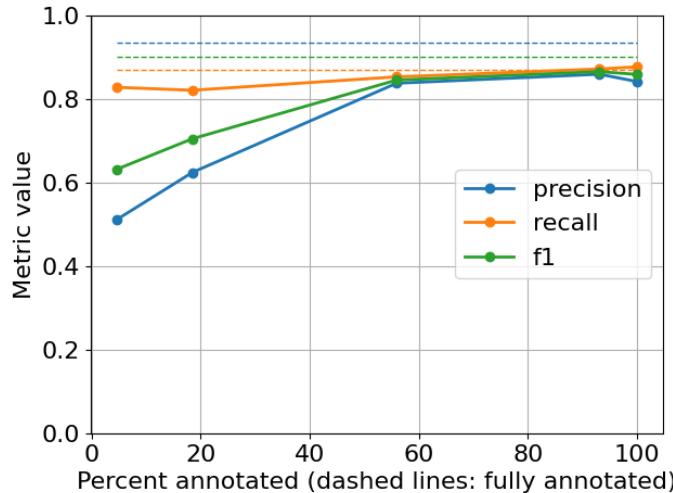
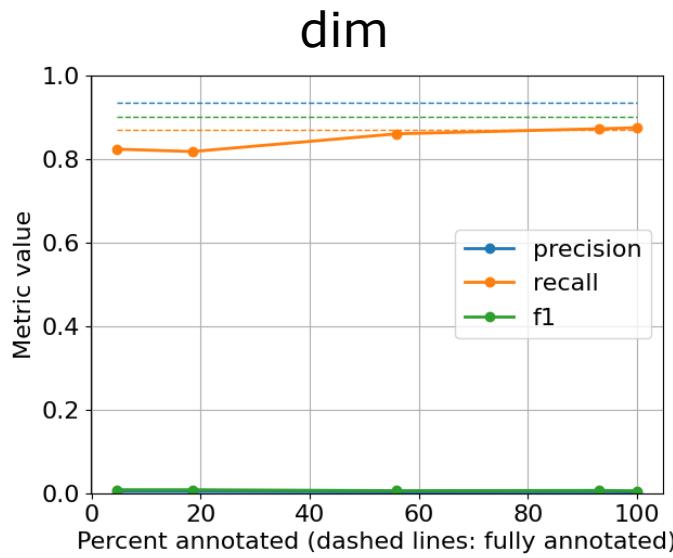
# Results: StarDist

Condition 5 (100% annotated)



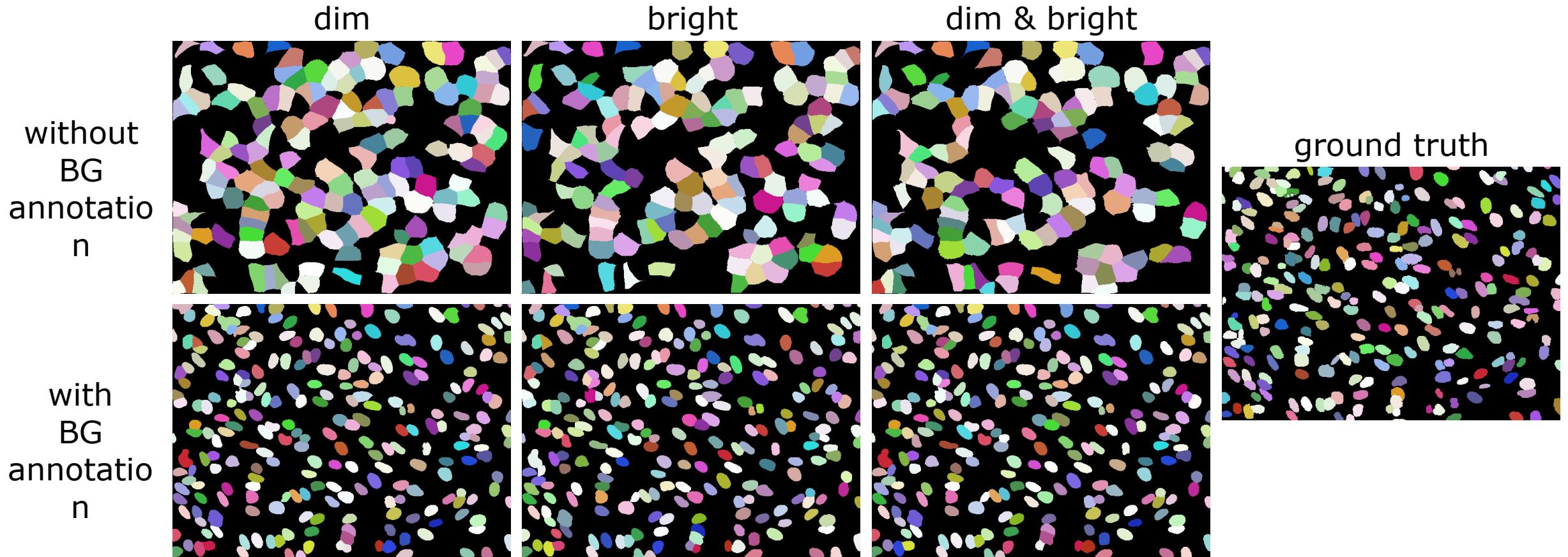
# Results: StarDist

without  
BG  
annotation



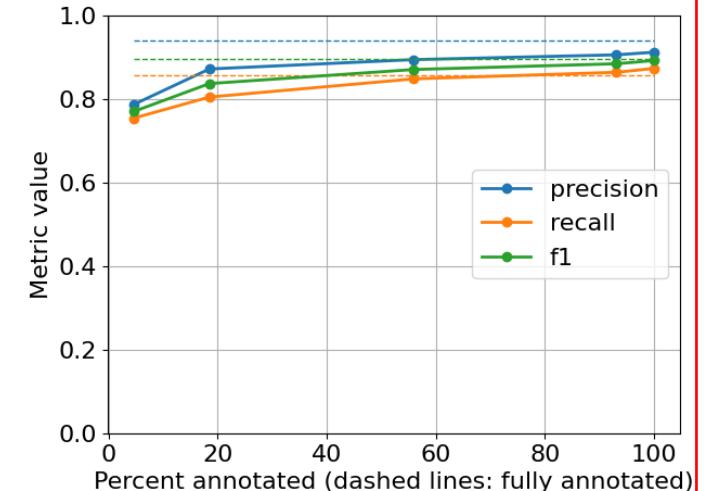
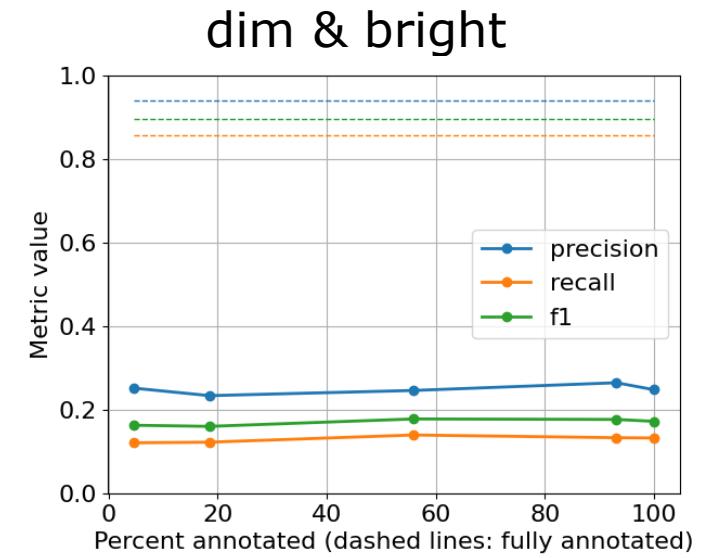
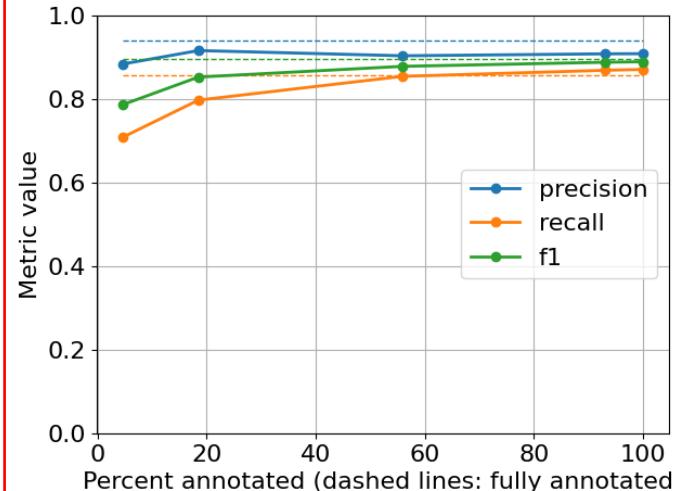
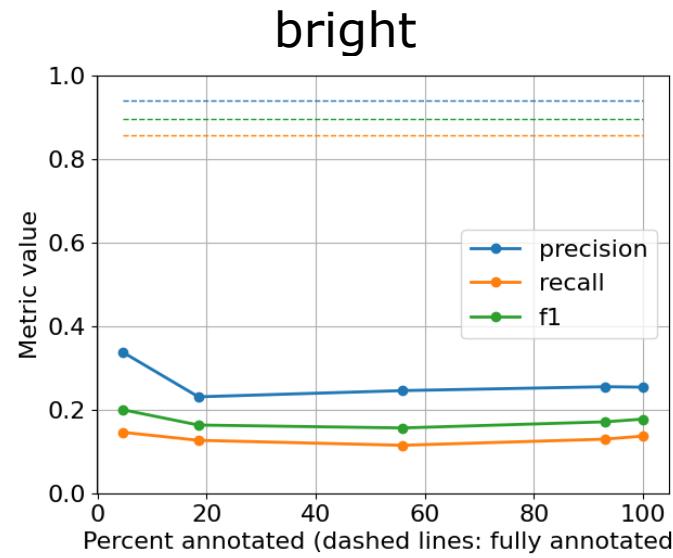
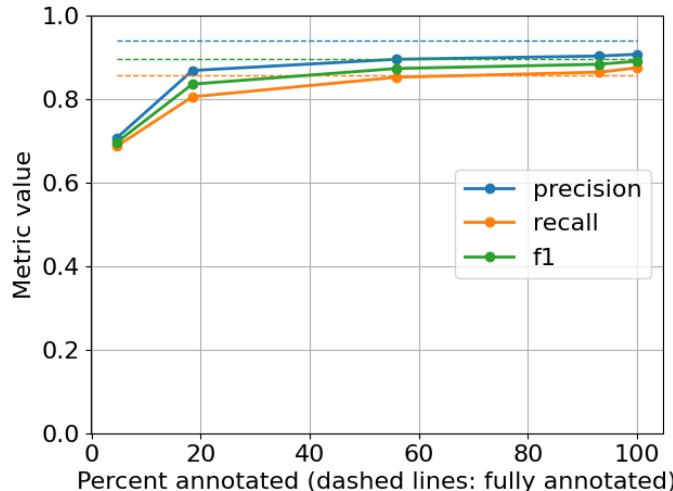
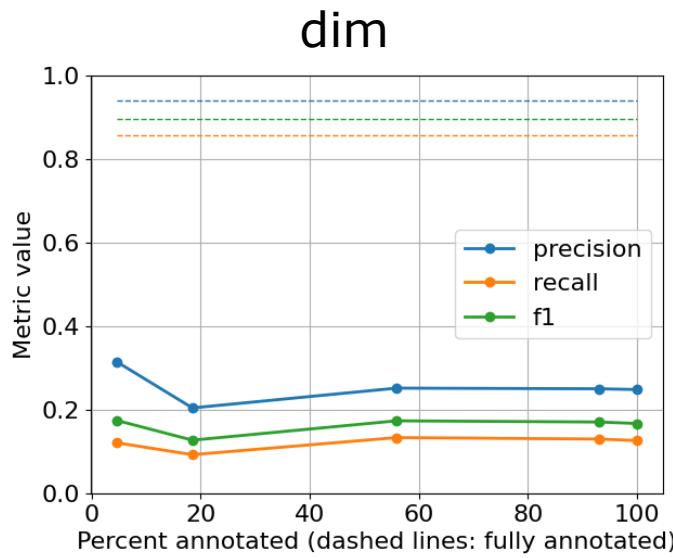
# Results: Cellpose

Condition 5 (100% annotated)



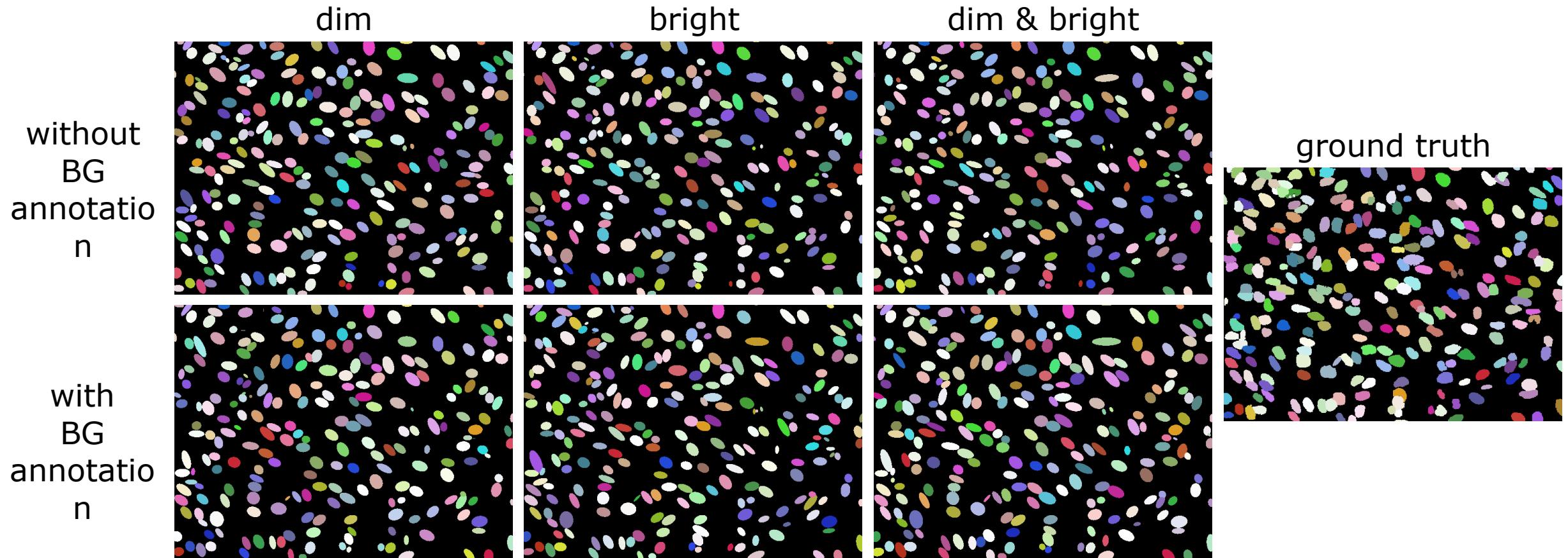
# Results: Cellpose

without  
BG  
annotation



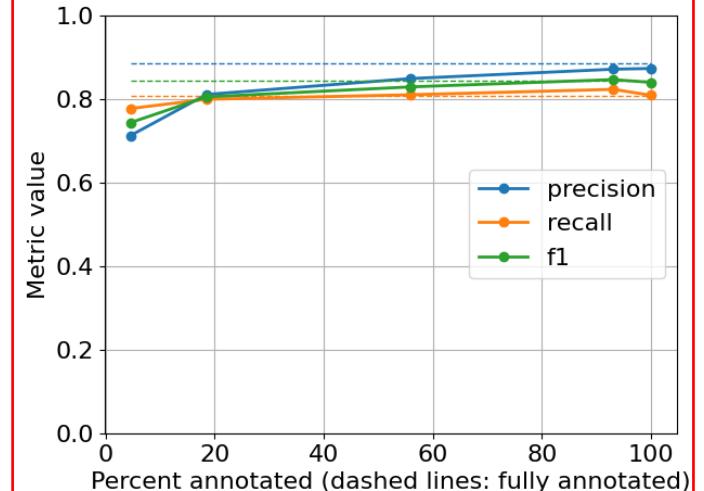
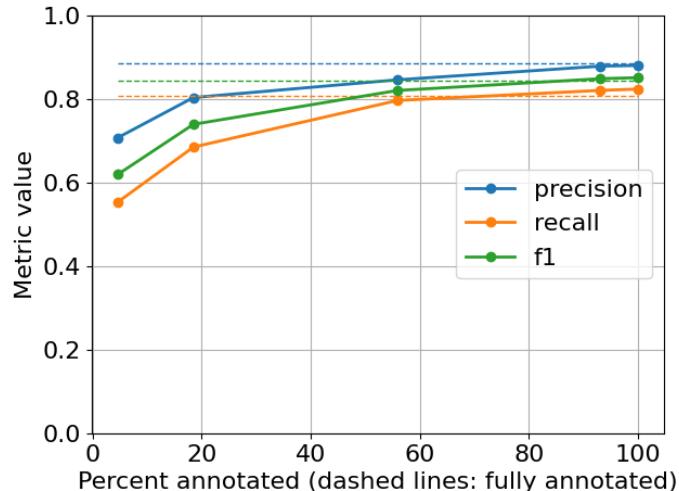
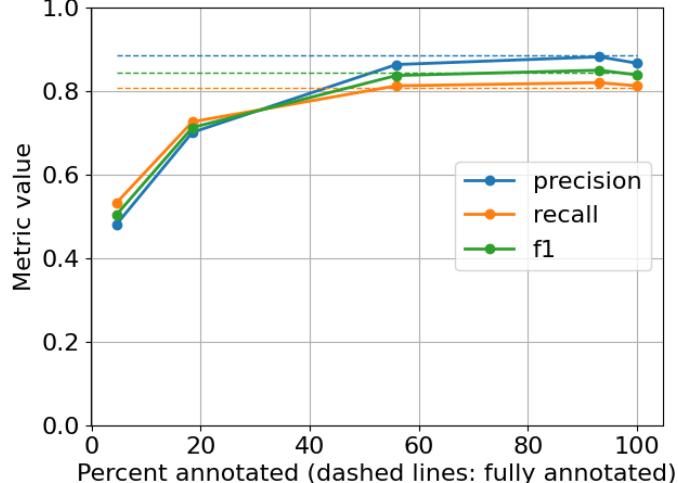
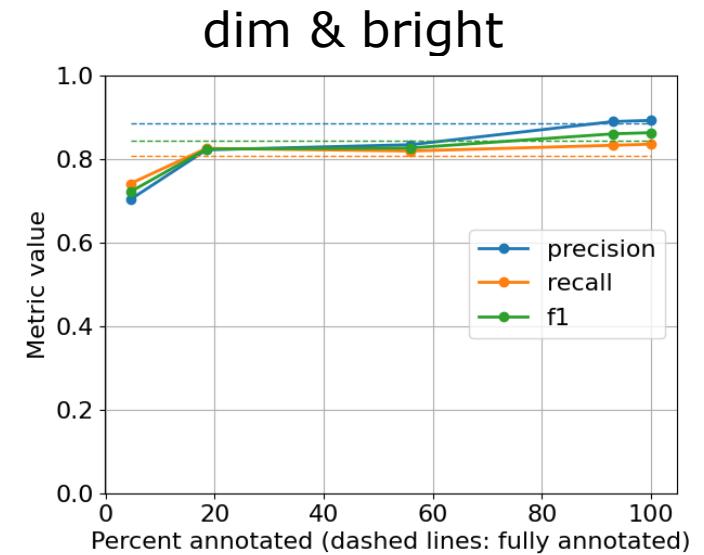
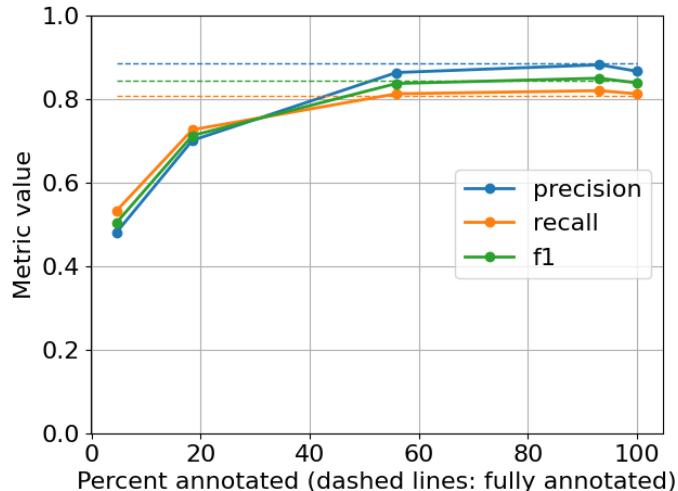
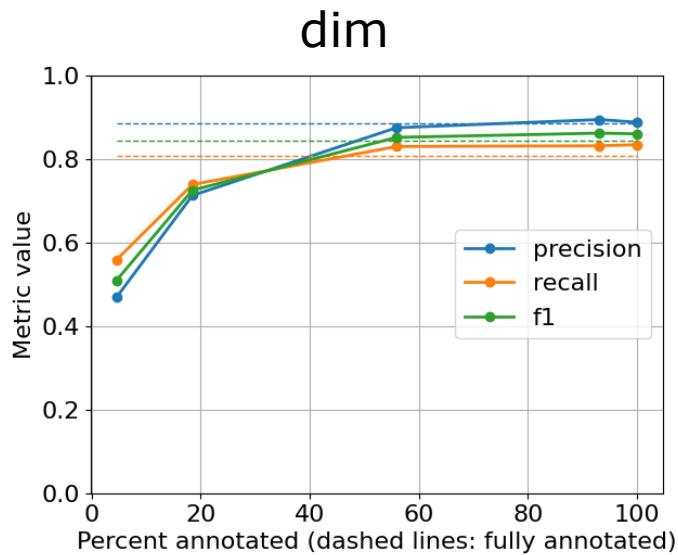
# Results: ELEPHANT

Condition 5 (100% annotated)



# Results: ELEPHANT

without  
BG  
annotation



# Summary

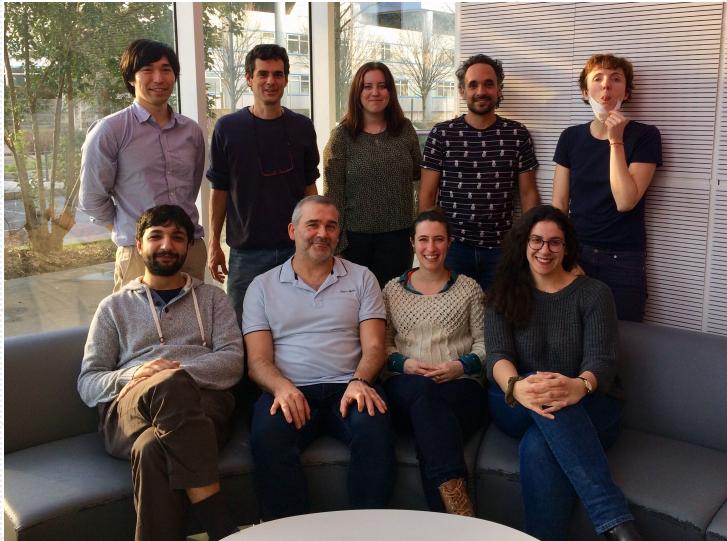
- We have made Cellpose and StarDist compatible with sparsely annotated data.
- Background annotation is essential to train Cellpose and StarDist models.
- ~5% of the whole annotation gives already good results.
- The selection of annotation matters.

# Future perspectives

- Implement user-interactive interfaces for Cellpose and StarDist working with sparse annotations. (combine with SegmentAnything)

# Acknowledgements

## Averof lab



**Michalis Averof** and lab  
members



## Onami lab



**Shuichi Onami** and lab  
members

## Open source community

**StarDist** and **Cellpose**  
teams

Source code:  
[https://github.com/ksugar/  
cellsparse](https://github.com/ksugar/cellsparse)