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## **Deep learning detection of exocytosis events in TIRF microscopy**

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Hugo Lachuer, Emmanuel Moebel, Anne-Sophie Macé, Arthur Masson, Kristine Schauer, et al.. Deep learning detection of exocytosis events in TIRF microscopy. IABM 2025 - Colloque français d'Intelligence Artificielle pour le Bio-Médical, Mar 2025, Nice, France. 2025. <hal-05470418>

**HAL Id: hal-05470418**

**<https://hal.science/hal-05470418v1>**

Submitted on 21 Jan 2026

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# Deep Learning Detection of Exocytosis Events in TIRF microscopy

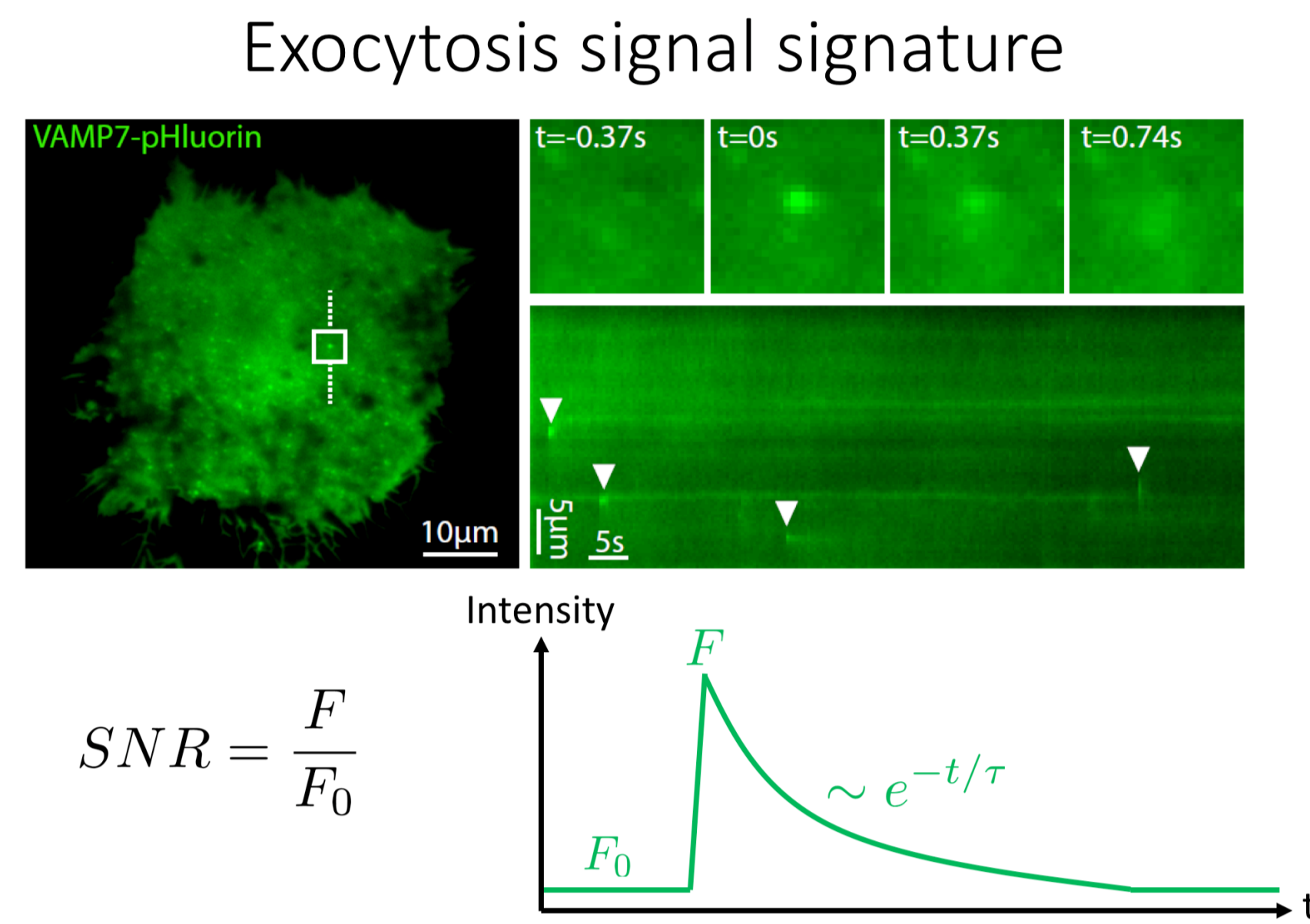
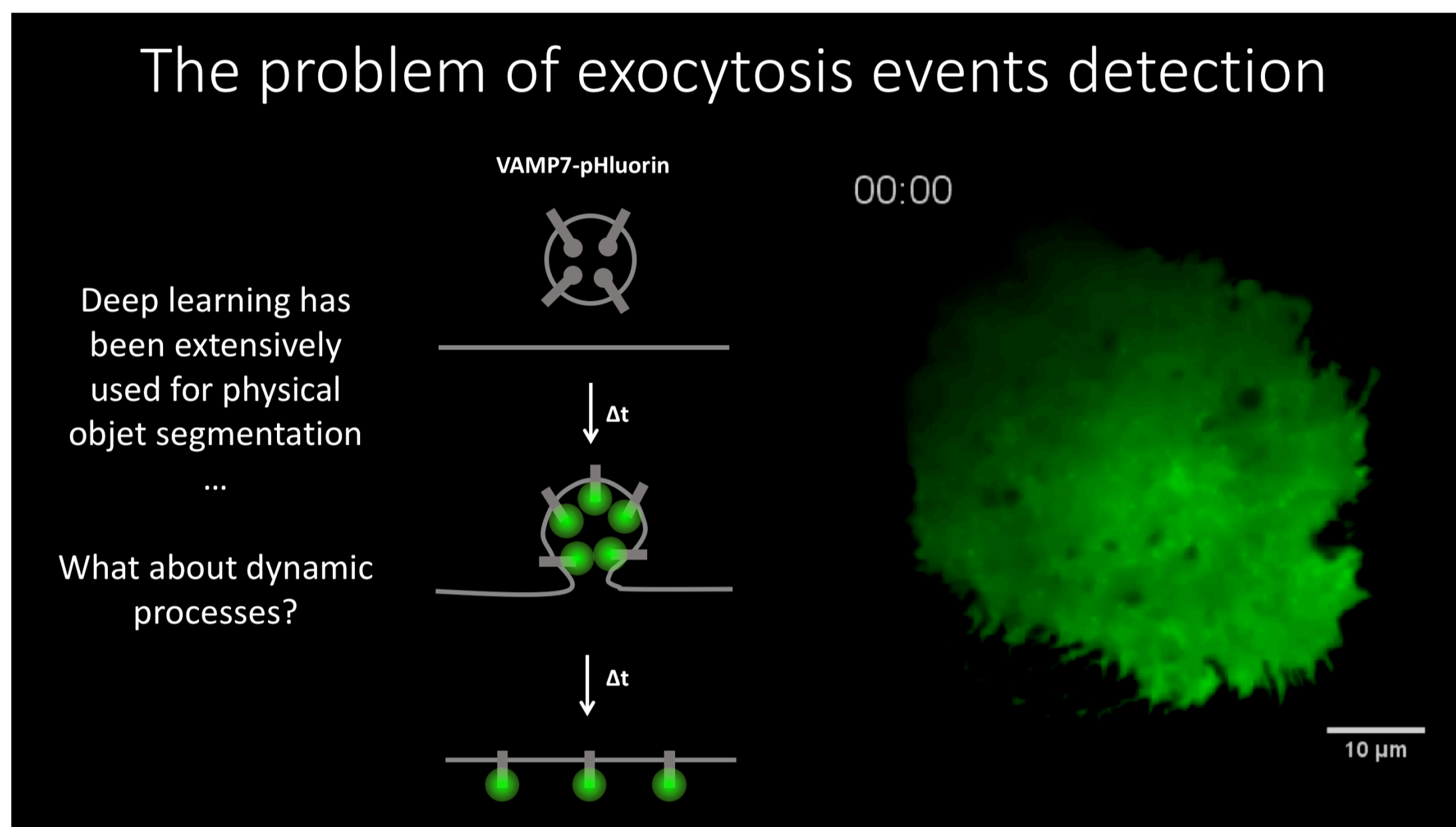
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## 17 years of exocytosis detection!

**Spatio-Temporal Analysis of Constitutive Exocytosis in Epithelial Cells**  
Ralfast Sebastiani, Marie-Elena Diaz, Guillermo Sapiro, Alexander S. Krieger, Jose Morchoy-Bogani, and Daniel S. Greer

**Dissecting Multiple Steps of Glucose-Induced Exocytosis in Endocrine Cells**  
Li Bai, Yan Wang, Junjie Fan, Yu Chen, Wei Jia, and Tao Ai

**Automatic Identification of Fusion Events in TIRF Microscopy**  
Katarina Mela, Agathe Comte, James M. M. Murray, David E. James, William E. Skene

**Automated Detection and Analysis of Exocytosis**  
Felix Ullrich, Stephan L. Oesper

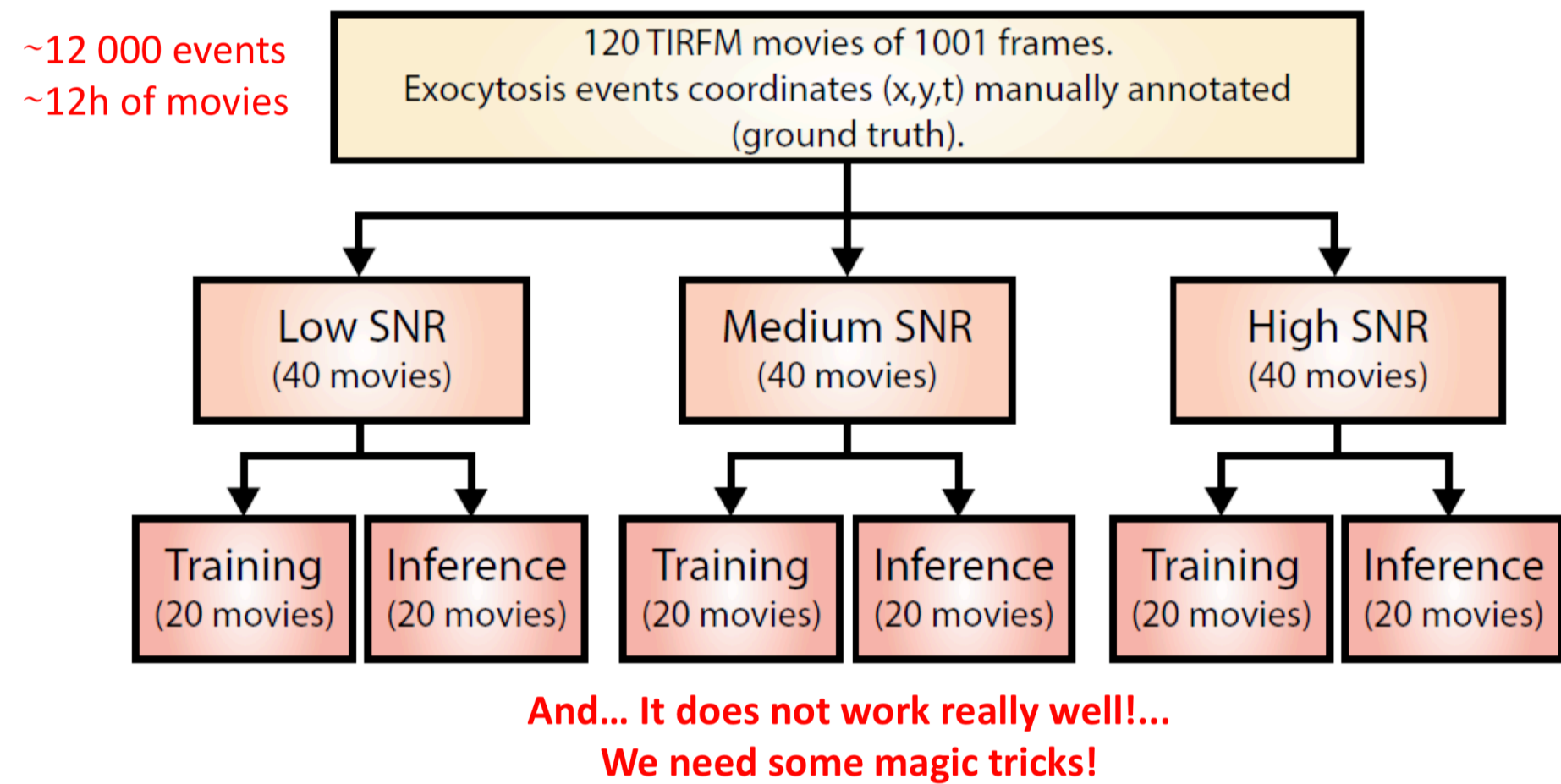
**Insulin Stimulates Membrane Fusion and GLUT4 Accumulation in Clathrin Coats on Adipocyte Plasma Membranes**  
Shaoxiang Huang, Larry M. Liskovitz, Christine Jones, Karl D. Blich, Chris Standley, Sergio Frenkel, Silvia Correas, Kevin E. Quigley, and Michael P. Czech

**Most of the codes are not available, and poor evaluations (few cells and few experimental conditions, no quantification of missed events).**

**All these methods are based on a similar principle: exocytosis events are identified according to intensity profile (peak + exponential decay).**

**→ Still no consensual method (reinventing the wheel...).**

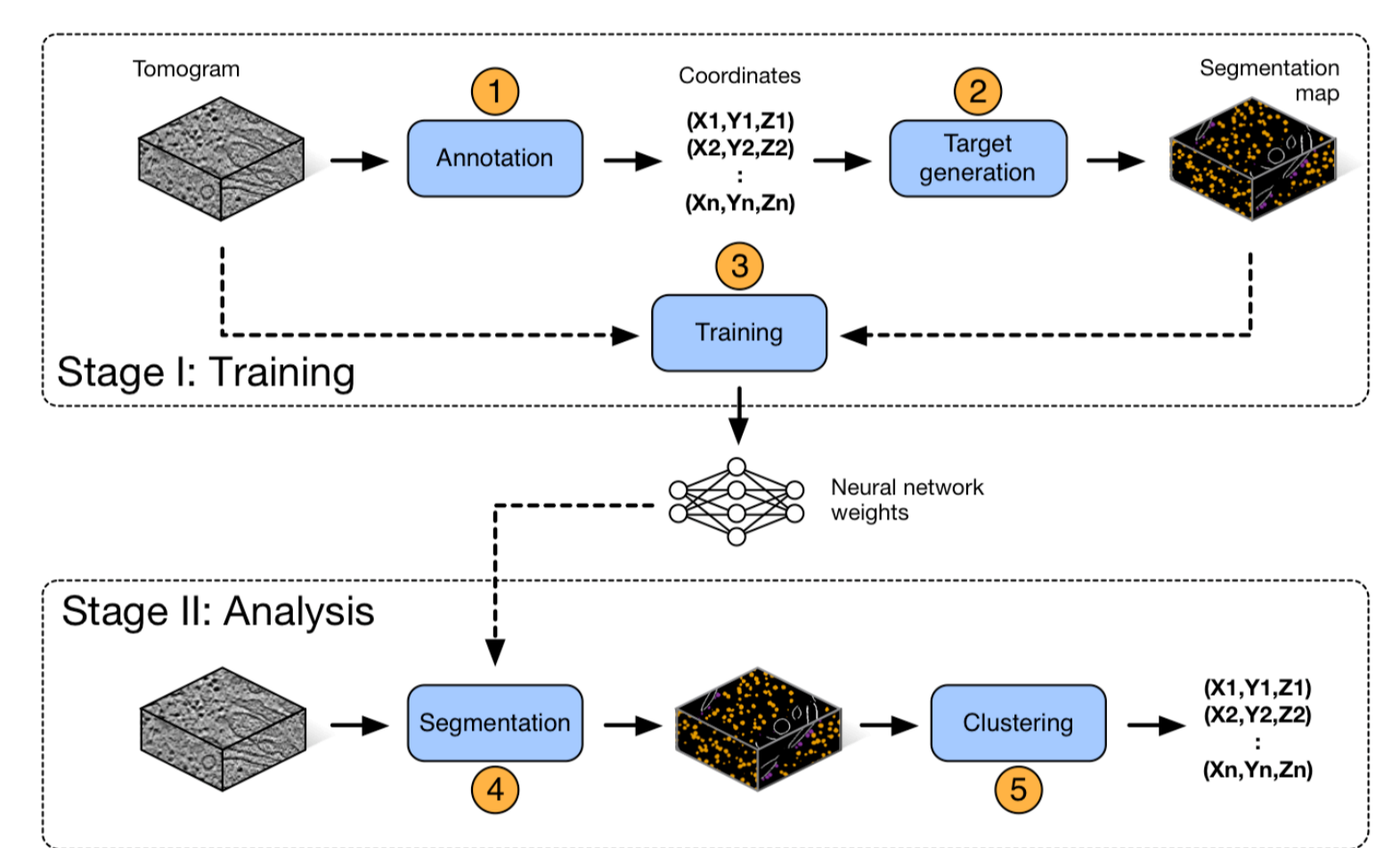
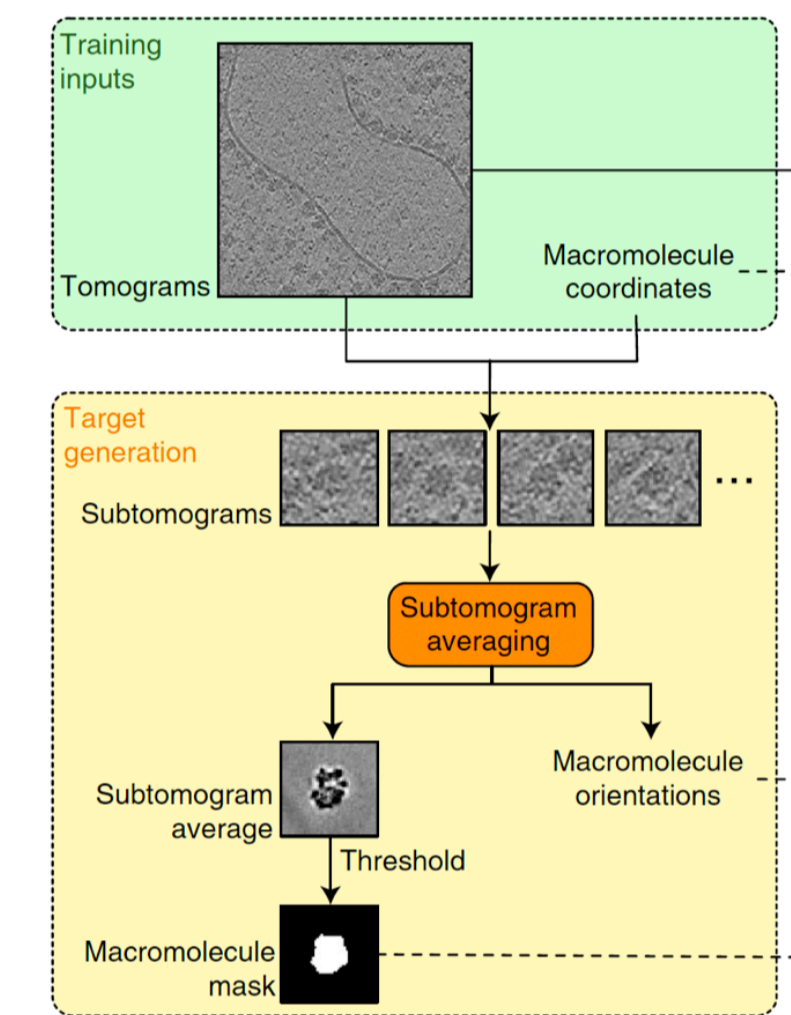
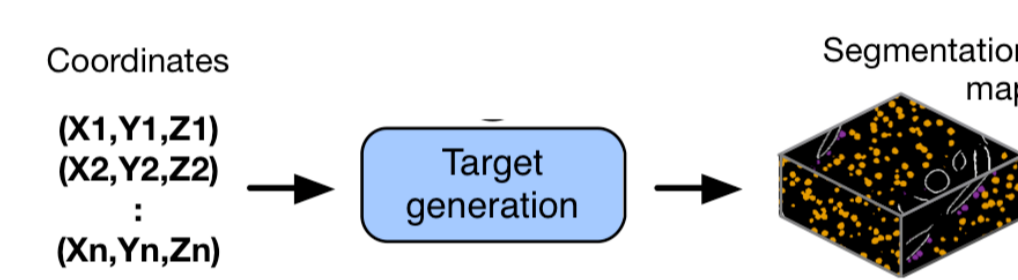
## Database



And... It does not work really well!... We need some magic tricks!

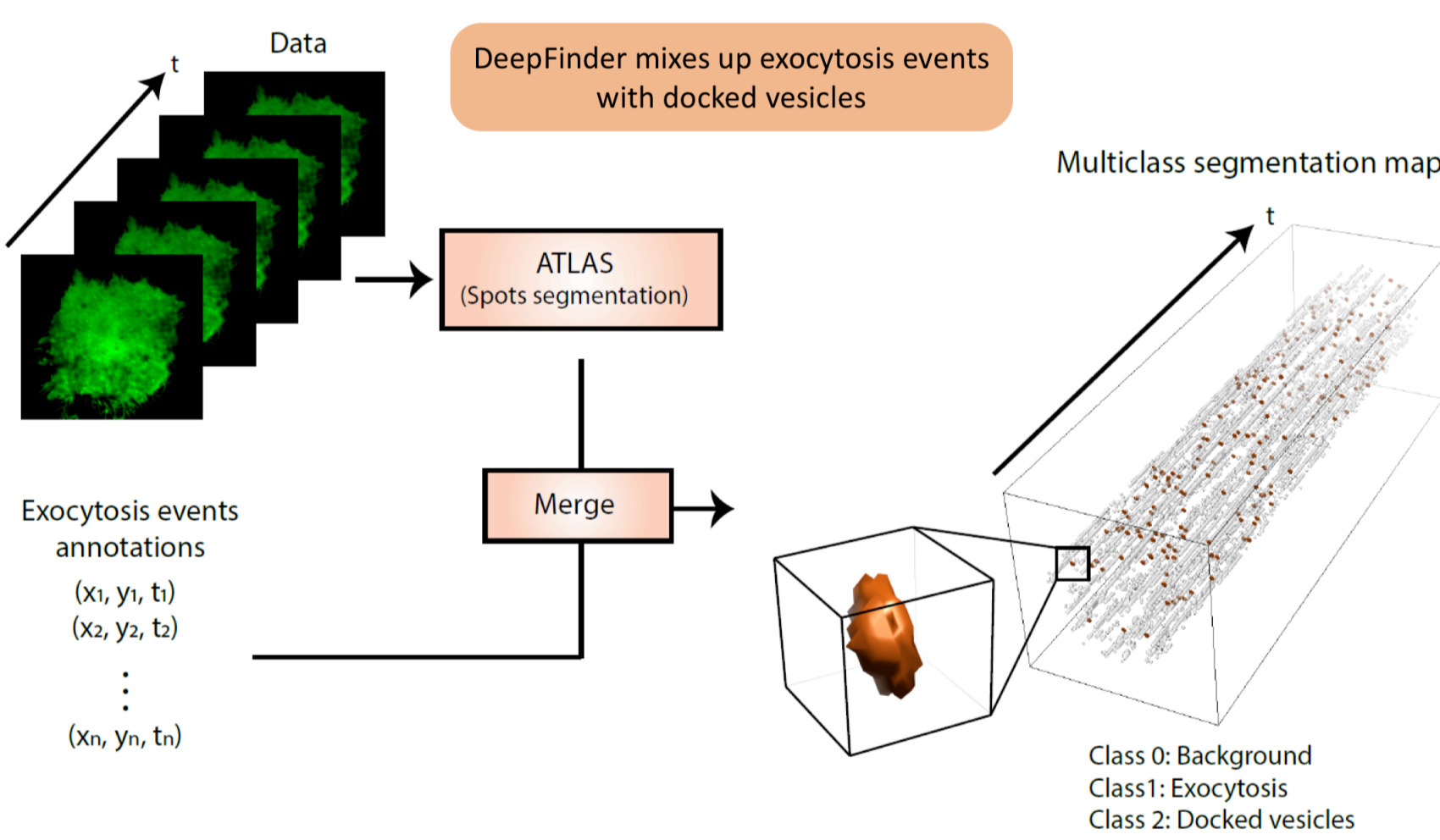
## DeepFinder for macromolecule detection in cryo-ET

Converting instance-wise annotations (i.e., coordinates) into voxel-wise annotations (i.e., segmentation maps)

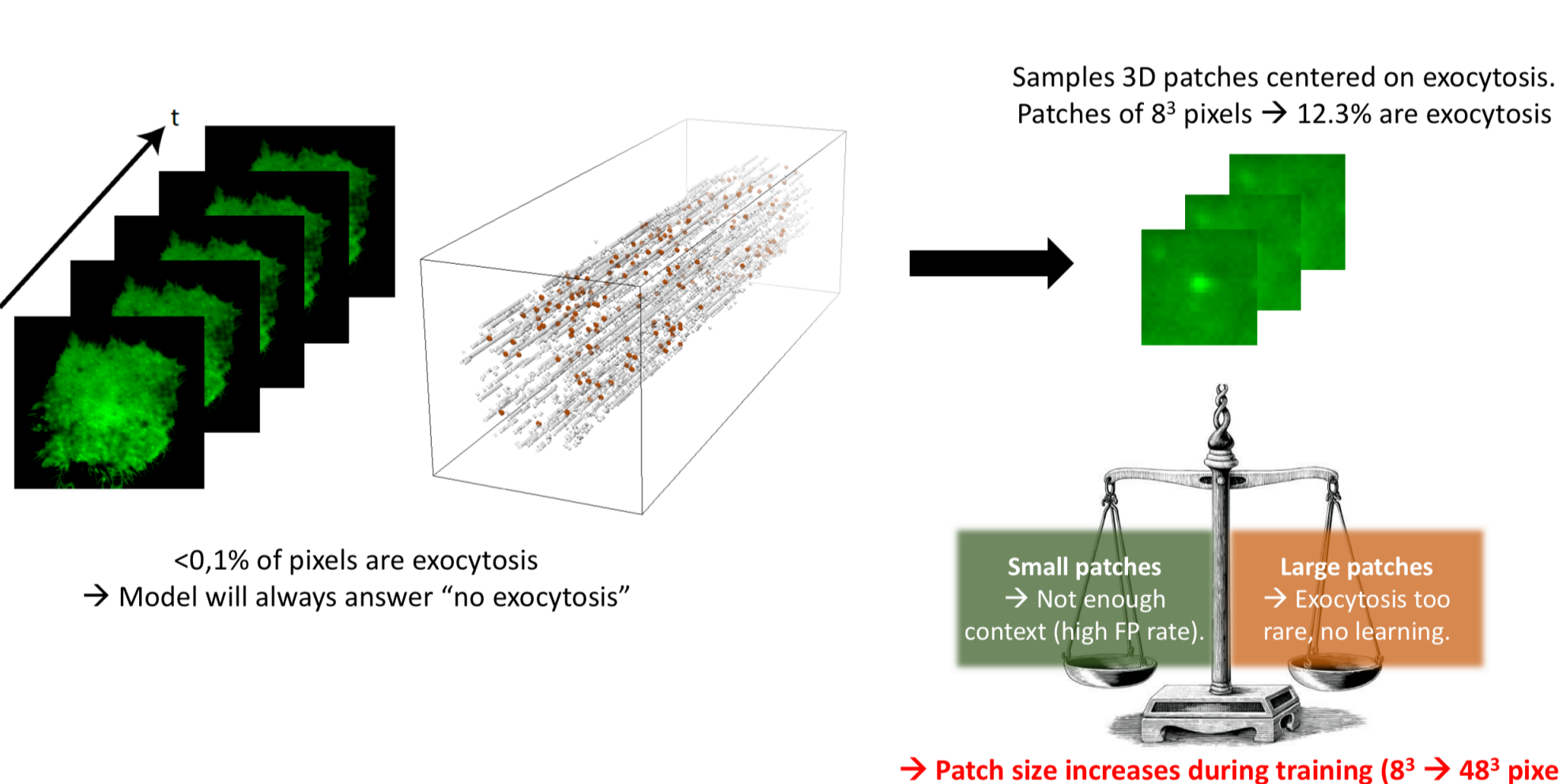


## ExoDeepFinder for exocytosis event detection in TIRFM

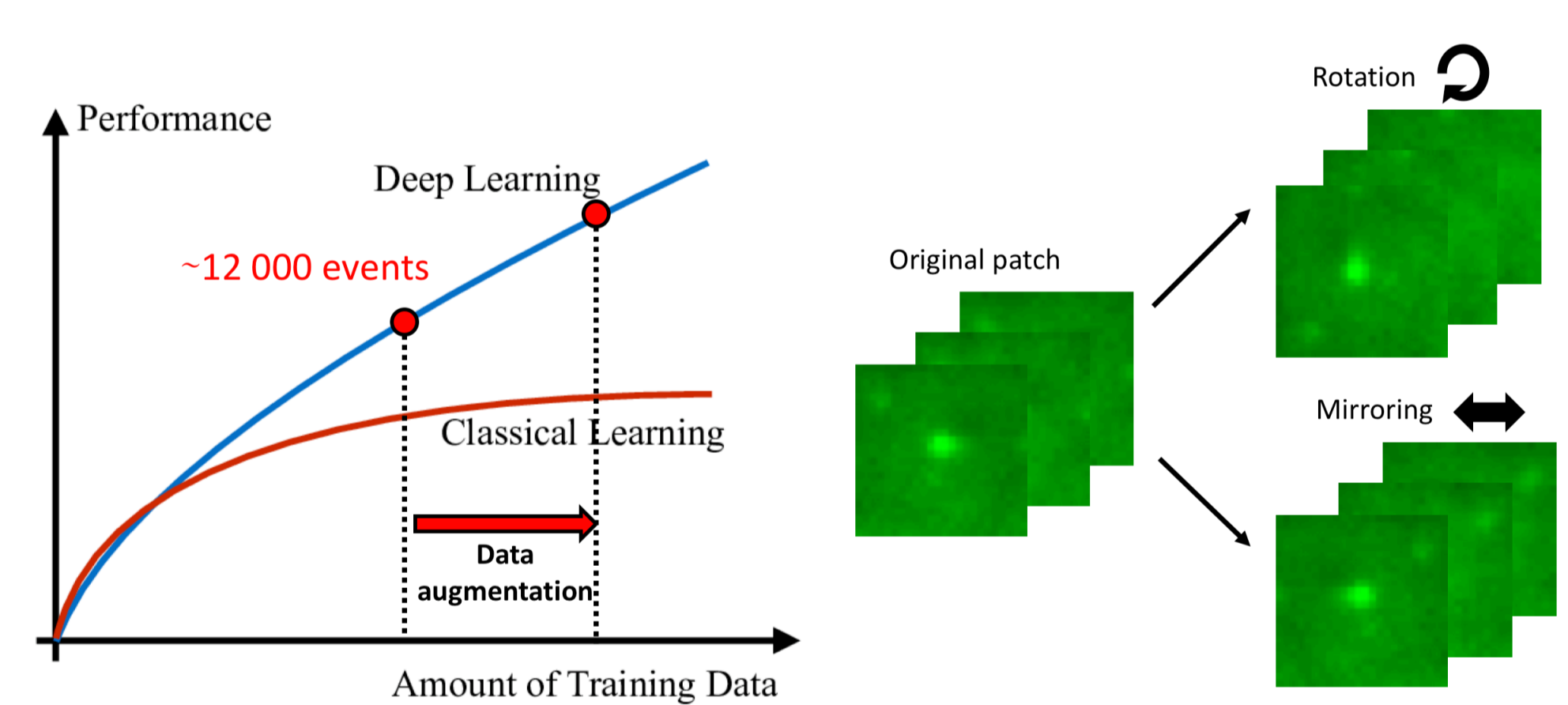
### Trick 1: Multi-class segmentation strategy



### Trick 2: rare class issue



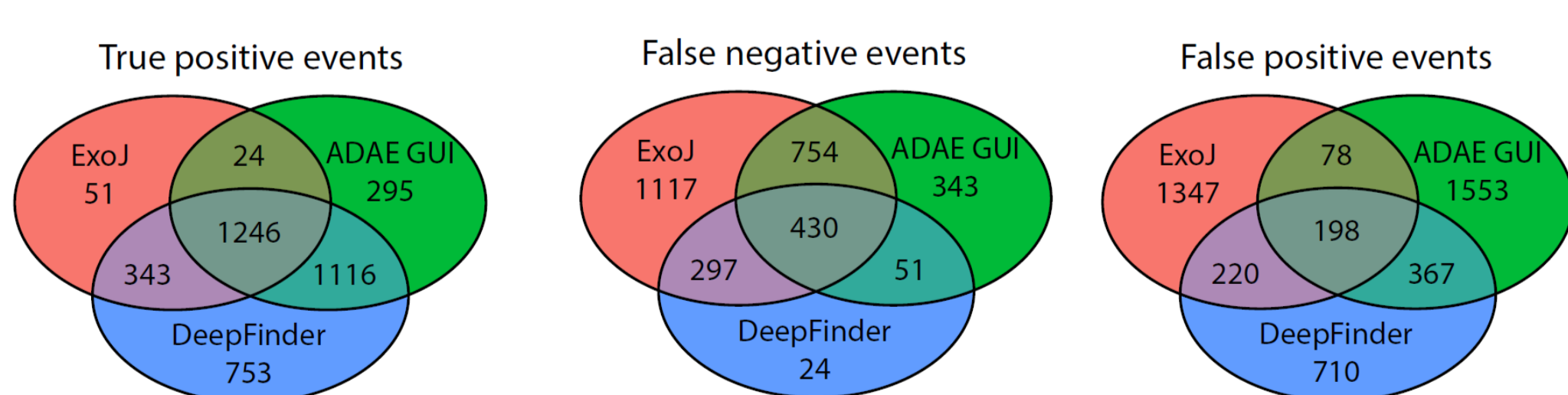
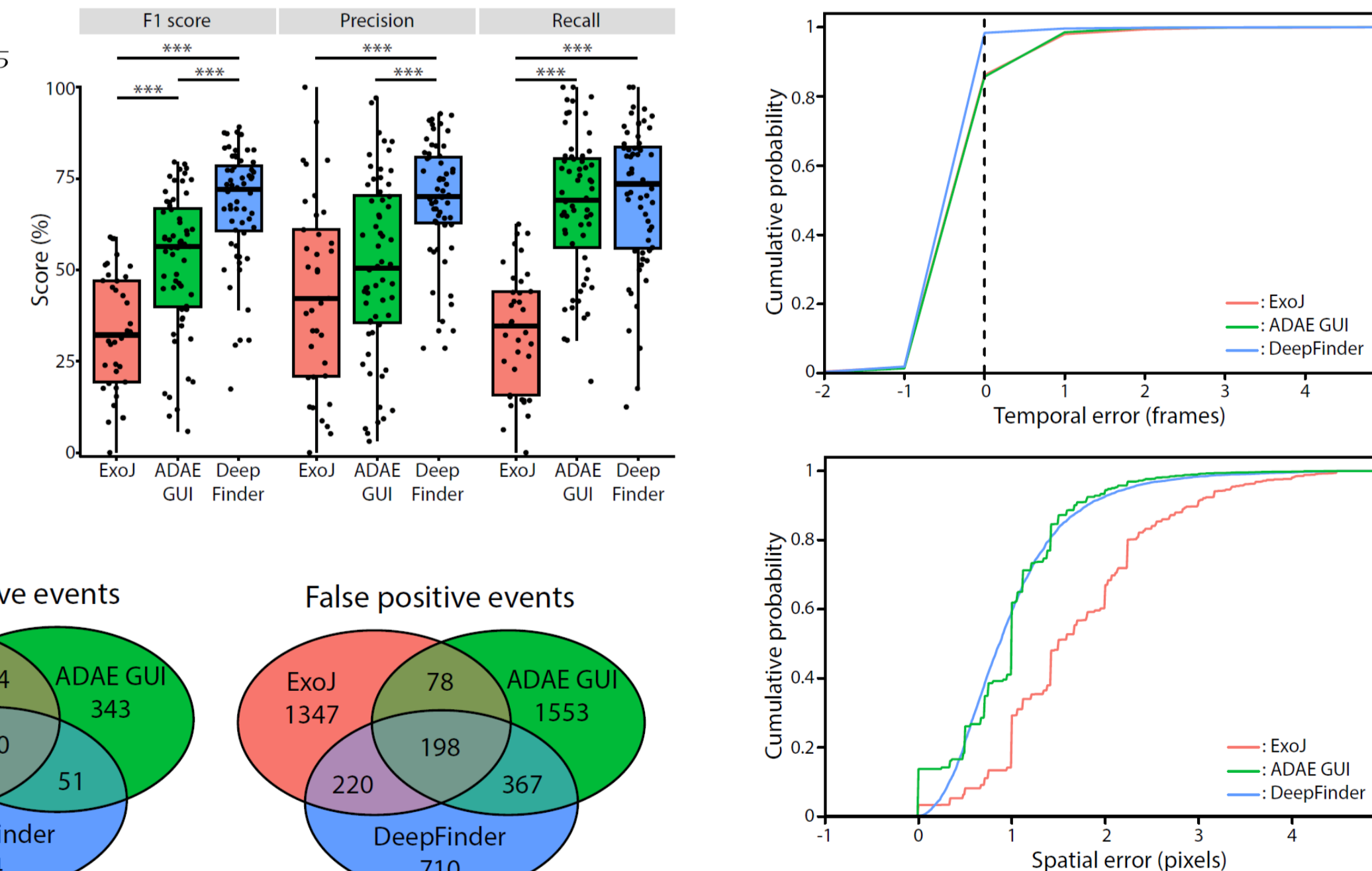
### Trick 3: Data augmentation



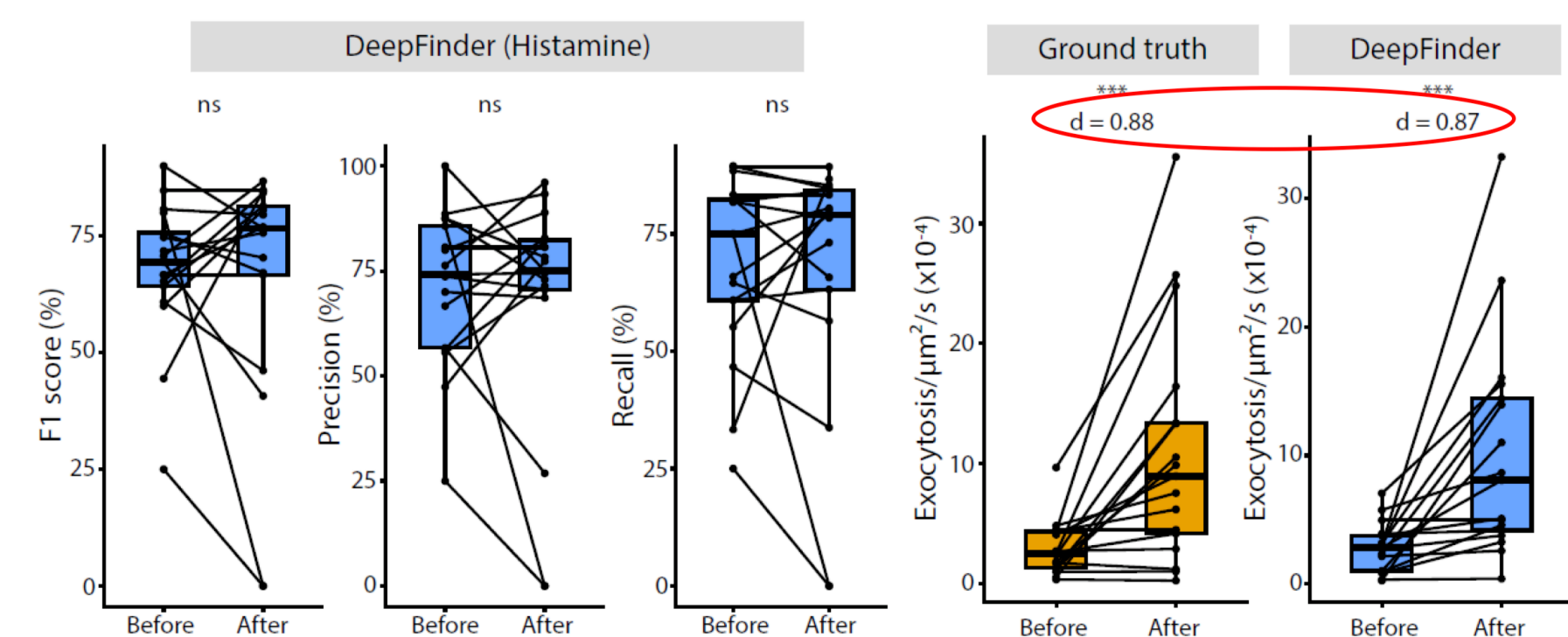
## ExoDeepFinder performances

	$F1 = \frac{2TP}{2TP + FP + FN}$	$Recall = \frac{TP}{TP + FN}$	$Precision = \frac{TP}{TP + FP}$
All	67.64 ± 15.91	70.07 ± 19.81	68.75 ± 16.57
Subset A	54.77 ± 20.50	52.30 ± 23.02	64.65 ± 22.13
Subset B	61.68 ± 20.06	62.75 ± 23.65	65.94 ± 20.35
Subset C	63.62 ± 19.82	63.95 ± 23.68	69.60 ± 20.30
Subset D	62.67 ± 19.39	62.51 ± 23.58	69.67 ± 20.23
Subset E	64.51 ± 19.93	62.95 ± 22.96	70.96 ± 19.51
Low SNR	62.19 ± 18.83	69.91 ± 21.23	61.54 ± 22.20
Medium SNR	58.26 ± 20.22	70.05 ± 23.07	58.31 ± 24.74
High SNR	60.37 ± 21.18	58.26 ± 23.16	68.67 ± 22.70

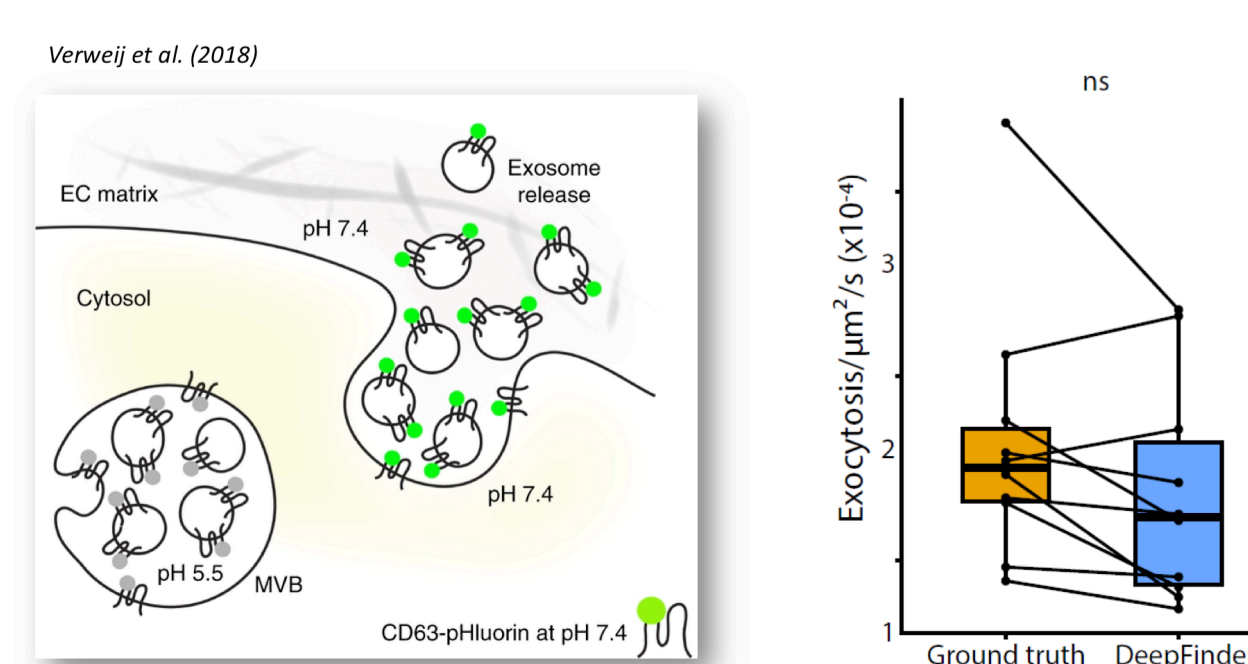
## Comparison with state-of-the-art methods



## Is ExoDeepFinder robust to new experimental conditions?



## Can ExoDeepFinder extrapolate to another cargo?



## TAKE-AWAY MESSAGES

Deep learning architectures can be transposed from one problem (cryo-EM) to another (TIRF)  
→ **Transferability**

ExoDeepFinder outcompetes well-established methods  
→ **Performance**

ExoDeepFinder needs a small training dataset  
→ **Frugality and adaptability**

ExoDeepFinder is robust to experimental conditions and can even extrapolate to another cell type/cargo  
→ **Plasticity**

ExoDeepFinder is open-source and released under user-friendly software (also as Python code).  
→ <https://pypi.org/project/exodeepfinder/>

ExoDeepFinder can be extended to other tasks in the future (endocytosis, blinking in super-resolution, etc.)  
→ **Generality**