

# A workflow for cloud-based AI development of multiplex IF image analysis using the OMERO Plus platform

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## Summary

The use of AI in digital pathology is crucial for analyzing tissue specimens, which contain millions of cells. Digital pathology workflows benefit from AI, especially when using bright-field images. However, AI becomes even more vital for multiplex immunofluorescence (mIF) whole-slide images due to the increased number of fluorescent channels and the greater bit-depth per pixel. The complex and information-rich nature of mIF images necessitates enhanced systems for data management and efficient visualization of both the mIF image and the AI-based analysis results. In this context, we introduce STARVUE™, a highly automated, cloud-based platform. It integrates OMERO Plus, AWS SageMaker, and AI models developed by Ultivue, facilitating complex mIF visualization and image analysis at scale.

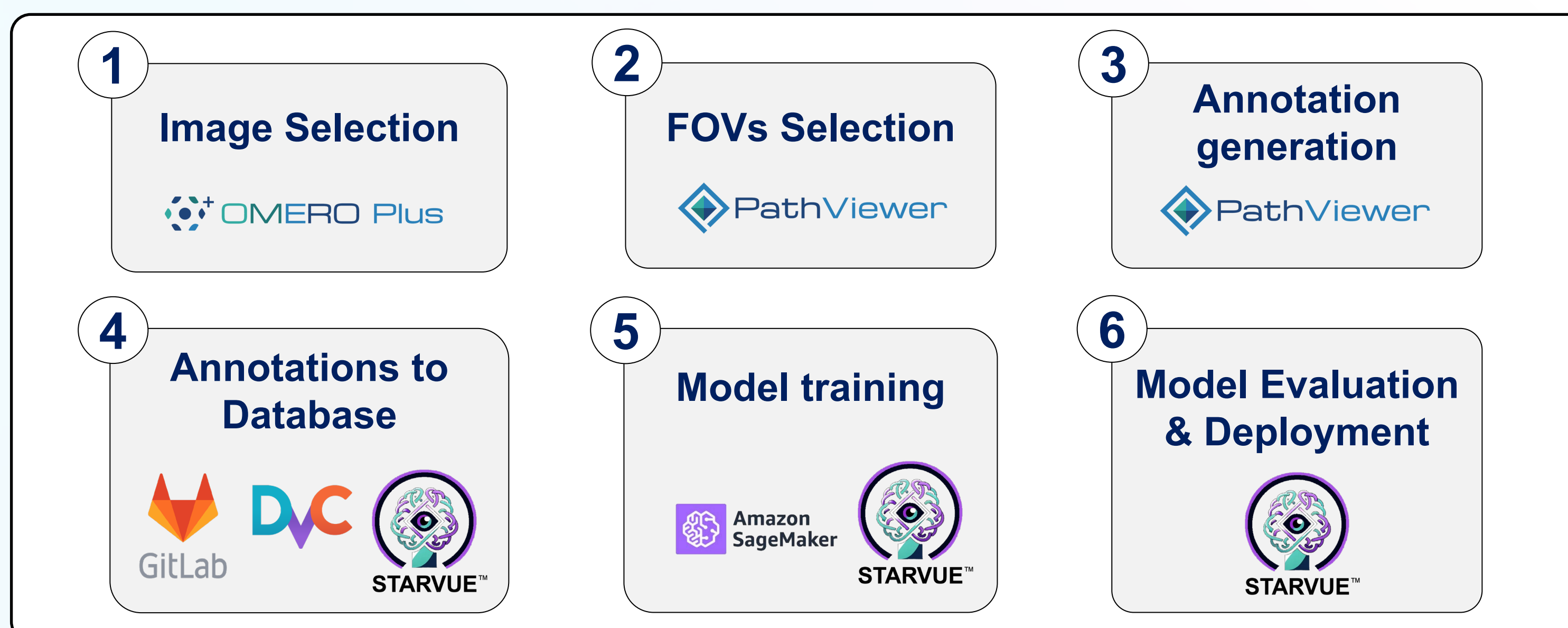


Figure 1. Overview of workflow steps followed to develop AI models in the STARVUE™ infrastructure.

## Workflow For Model Development

**1 Images Selection** Slides used for training or validation are imported into OMERO and organized in a training data project

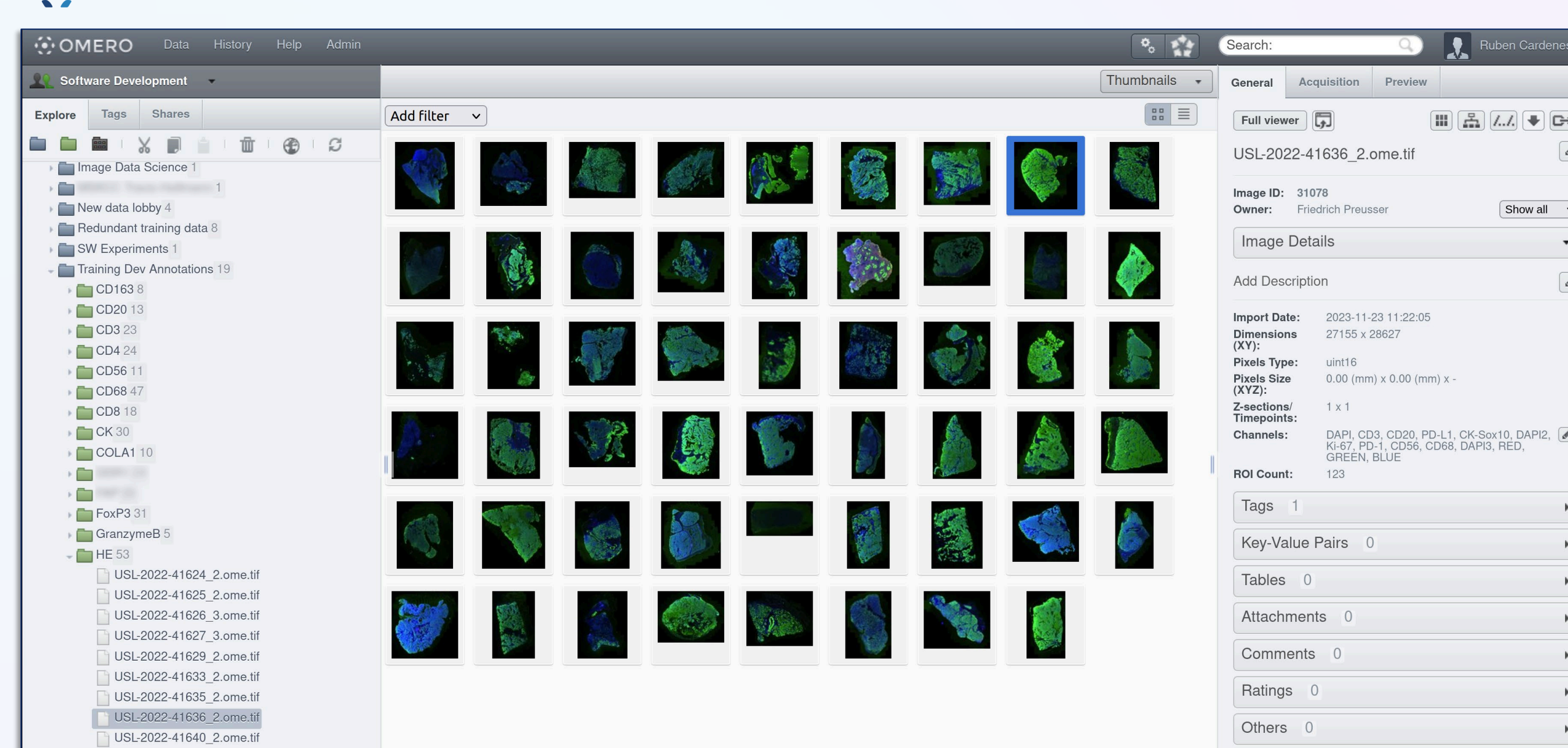


Figure 2. OMERO Plus overview.

**2 FOVs Selection** Field of Views (FOVs) of interest are selected in PathViewer for each slide, to restrict annotations to desired places.

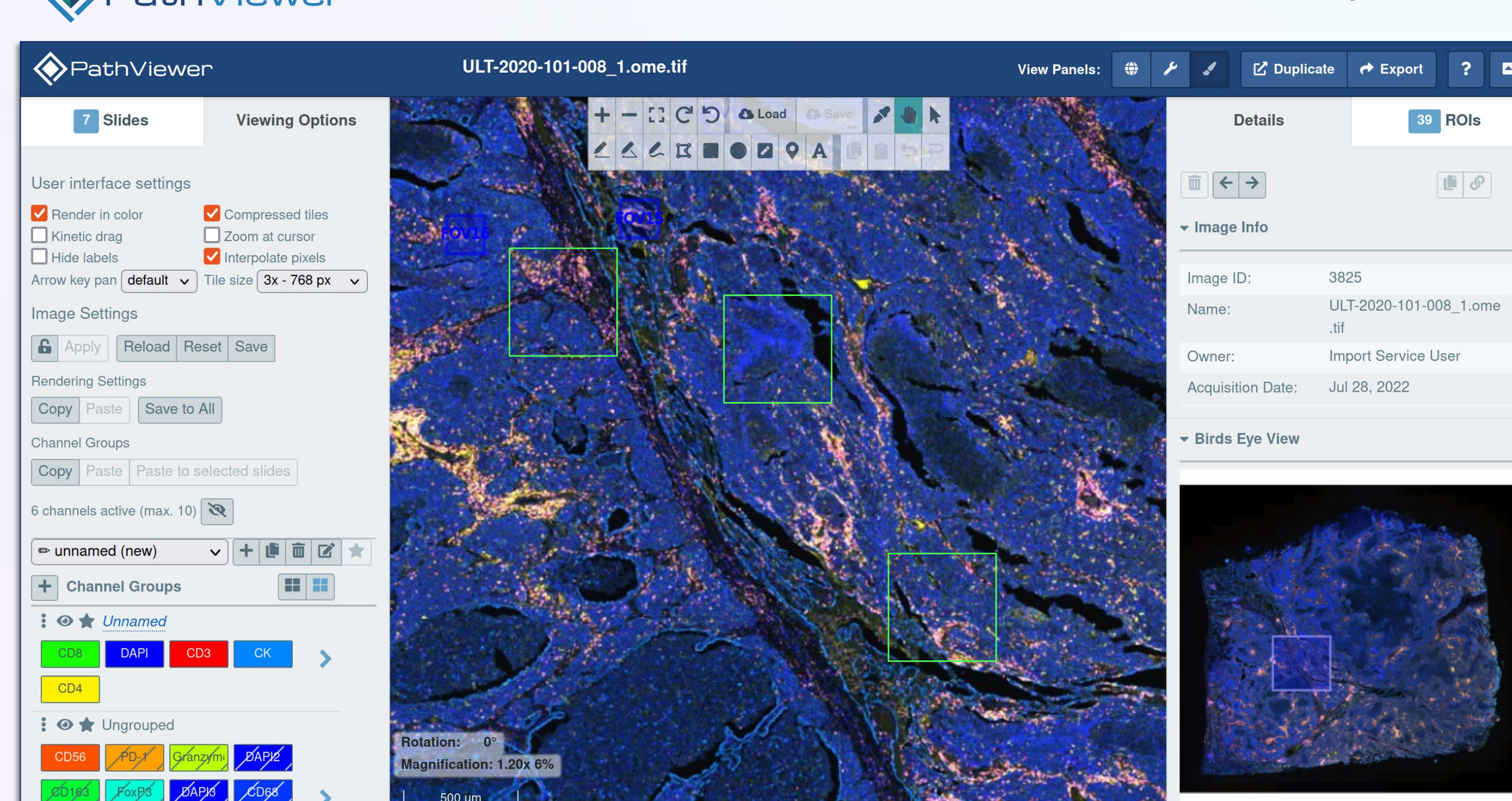


Figure 3. PathViewer user interface showing a mIF image produced with ISP technology and rectangular field of views overlaid in green.

## 3 Annotation generation PathViewer

Annotations are done either manually or semi-automatically. Three types of annotations are considered:

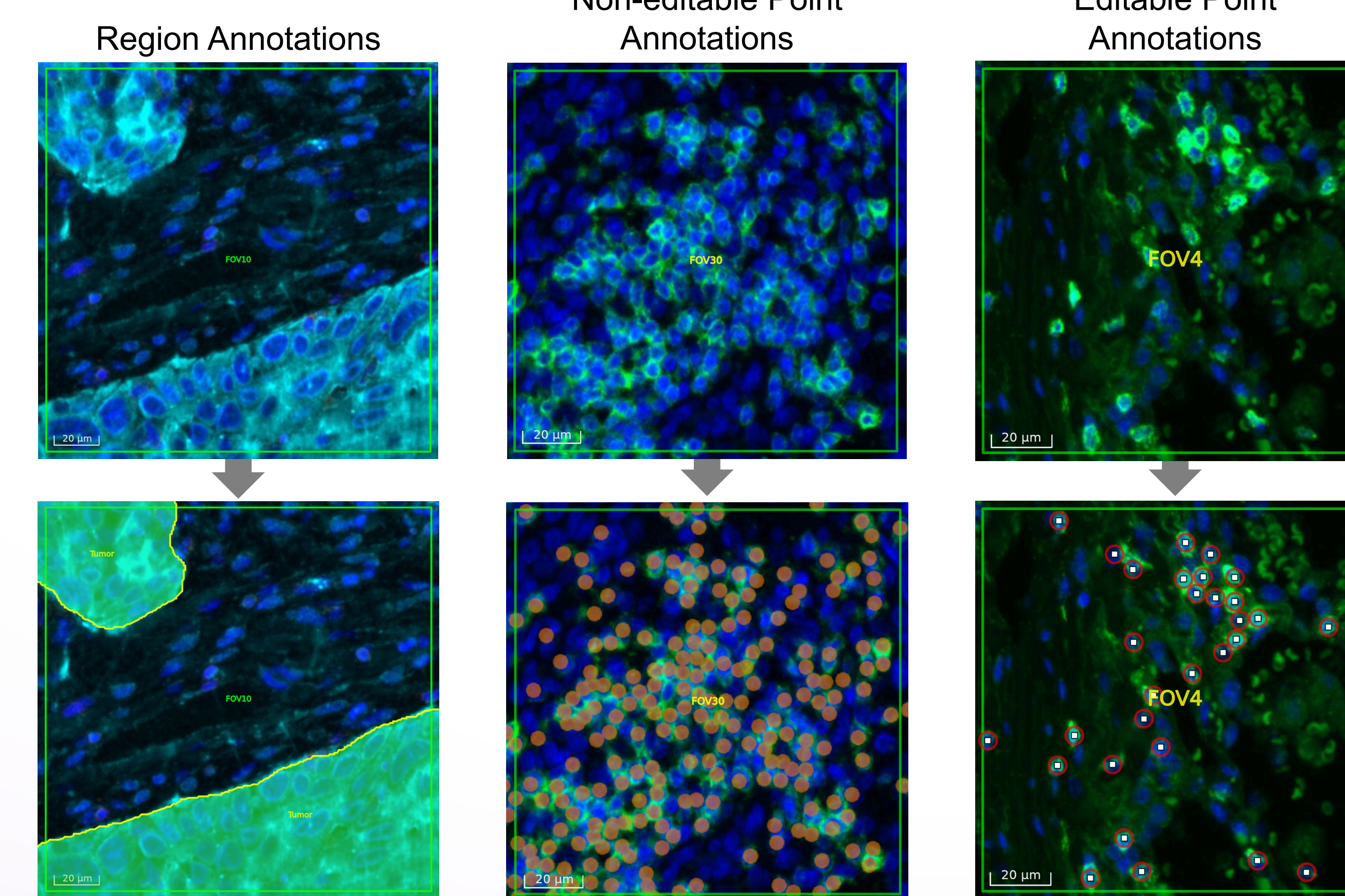
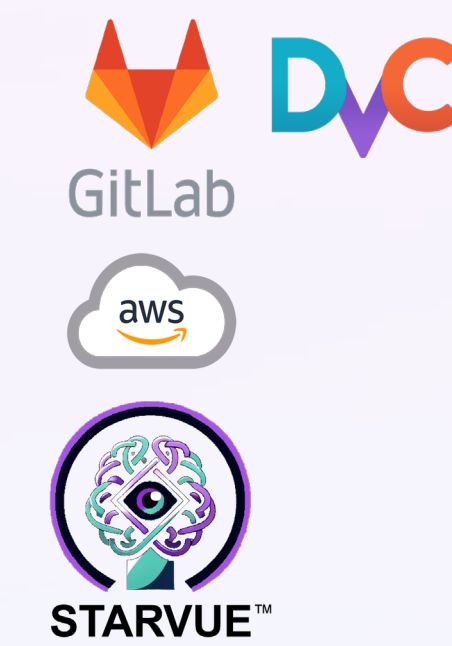


Figure 4. Types of annotations used in PathViewer for model training

## 4 Annotations to Database

Annotations and FOVs are downloaded, checked for consistency, and transferred to a database

- Data is versioned using Git and DVC, (we can go back to any specific data version if needed, as well as with all our software)
- Data is stored in the cloud using AWS
- Data transfer, checks and module integrations are powered by STARVUE™ technology



## 5 Model training

Models are trained in the cloud using the following technologies

- SageMaker is used as cloud computing resource
- Models are trained with pytorch libraries
- Models training pipeline is implemented using STARVUE™ technology



## 6 Model Evaluation & Deployment

Trained models are evaluated and when meeting criteria, selected for deployment. Models are deployed in AWS Cloud in ONNX or TensorRT format using STARVUE™ technology.

- Models deployed in AWS S3
- Models exported to ONNX format
- Evaluation and deployment are powered by STARVUE™ technology



## Results Visualization

AI segmentation results of cells and regions are visualized using PathViewer as overlays on the original images by converting them to the OME-NGFF label image format that uses Zarr multidimensional arrays. This advanced visualization supports millions of cell overlays, on the fly phenotyping, and customizable channel visualization settings

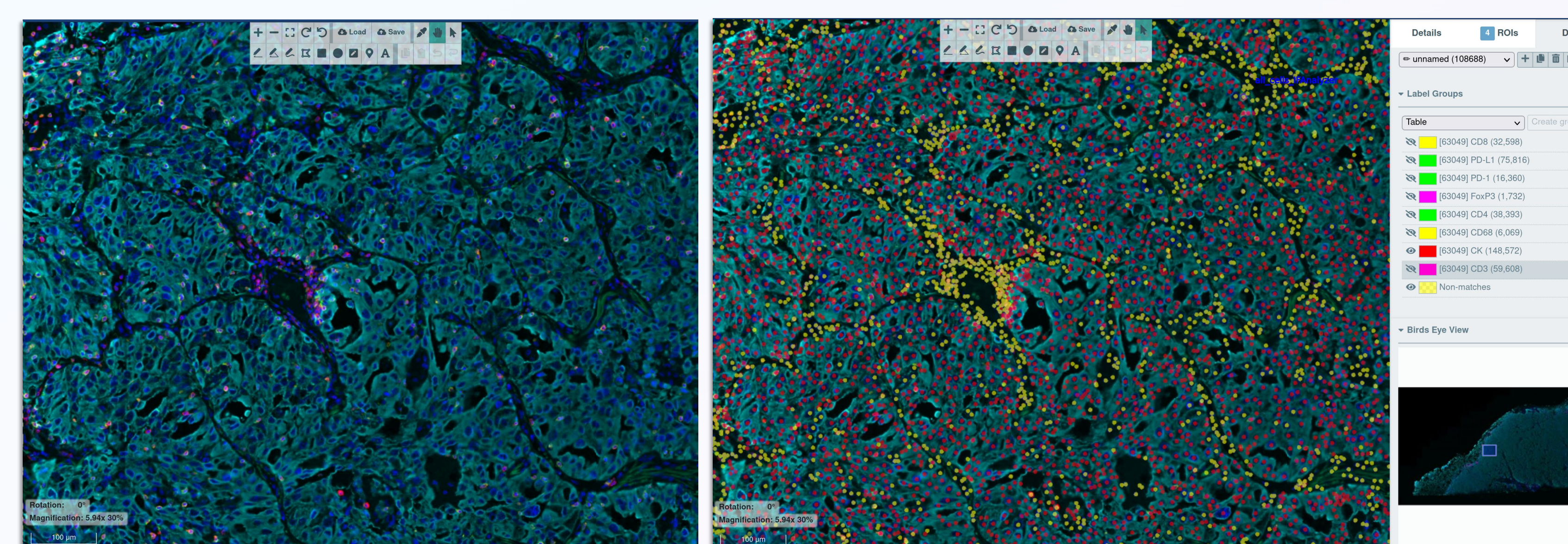
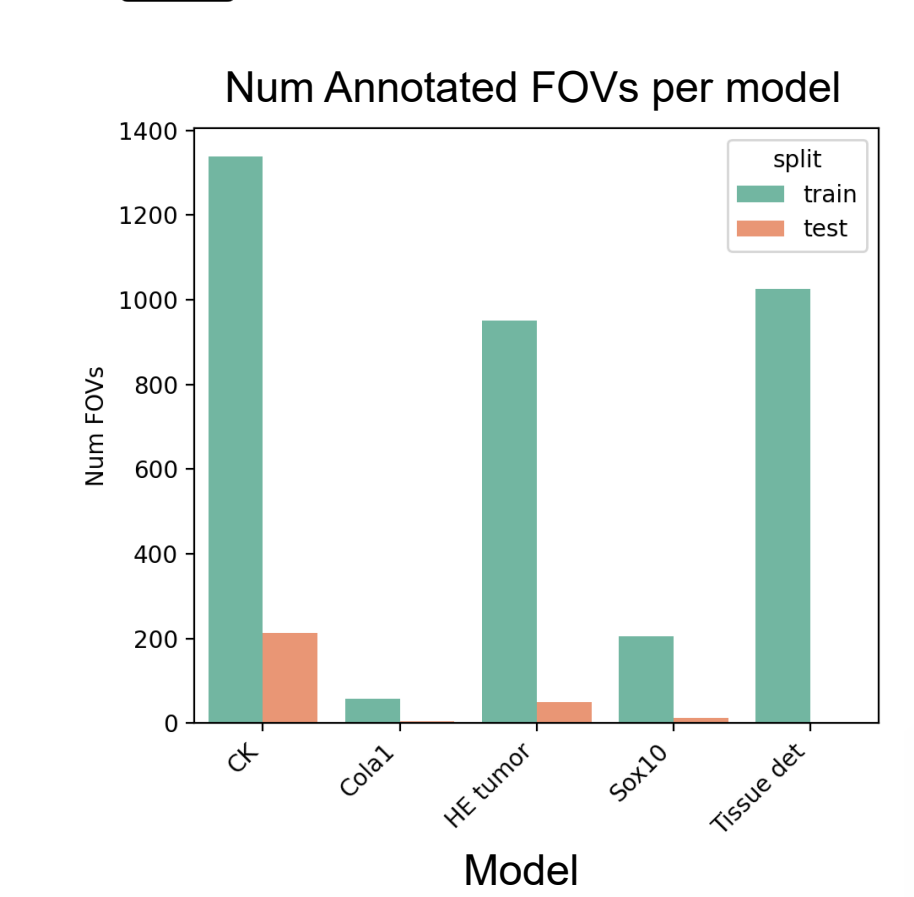


Figure 5. PathViewer visualization of OME-NGFF tables as overlays. Left: no overlays. Right: overlaid detected cells as dots, red for CK positive, yellow for the rest

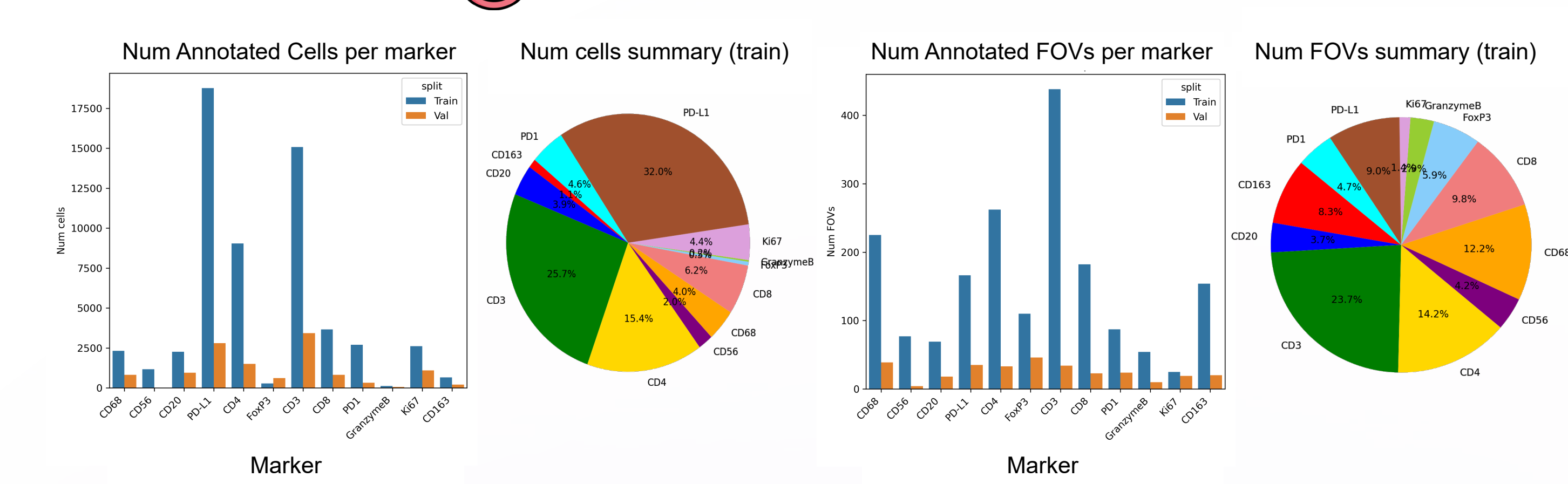
## Data Summary

### Region data



Model	Num FOVs	Bit depth
CK	1553	16 bit
Collagen	62	16 bit
Sox10	219	16 bit
Tissue	1026	8 bit
Total	2860	

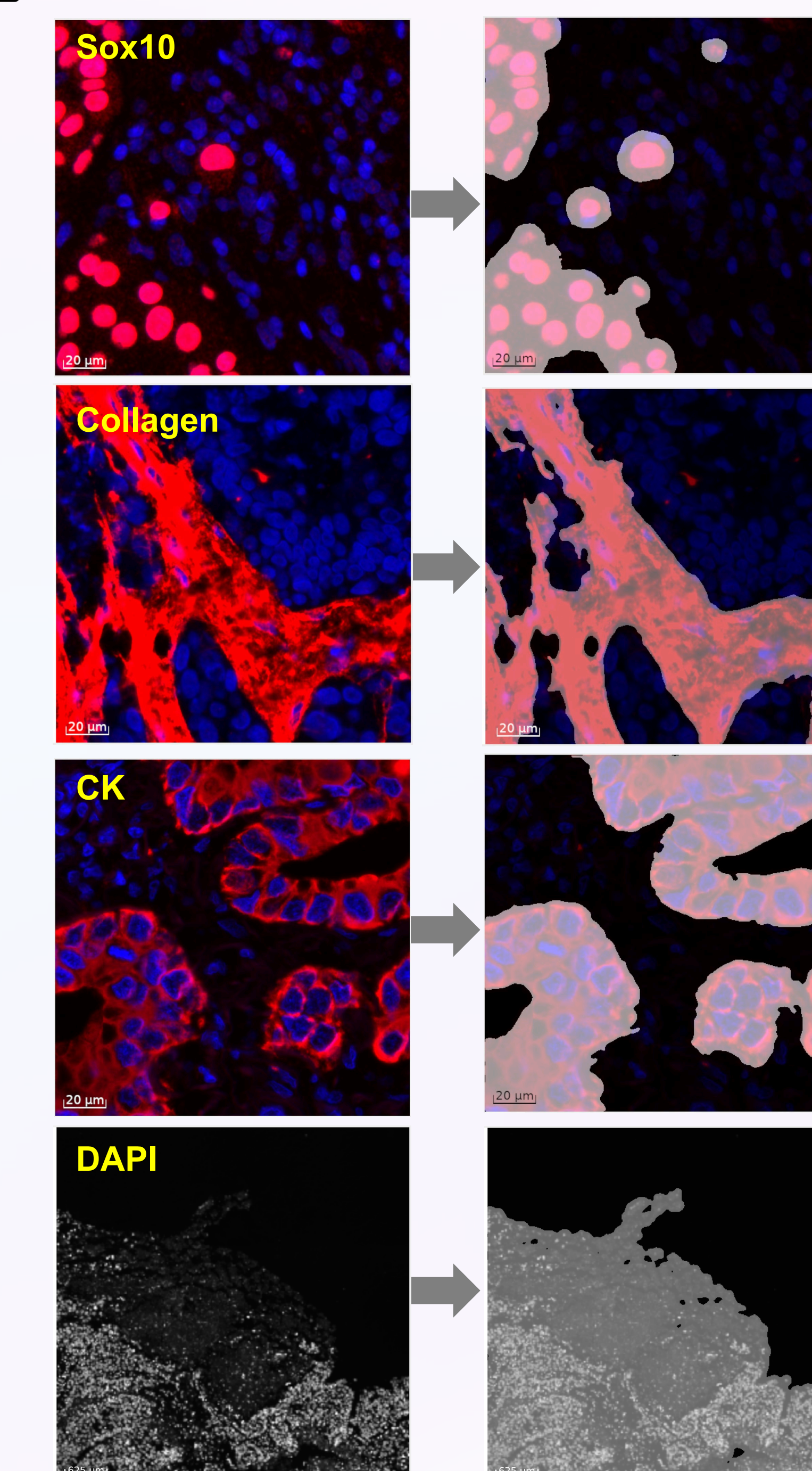
### Cell detection data



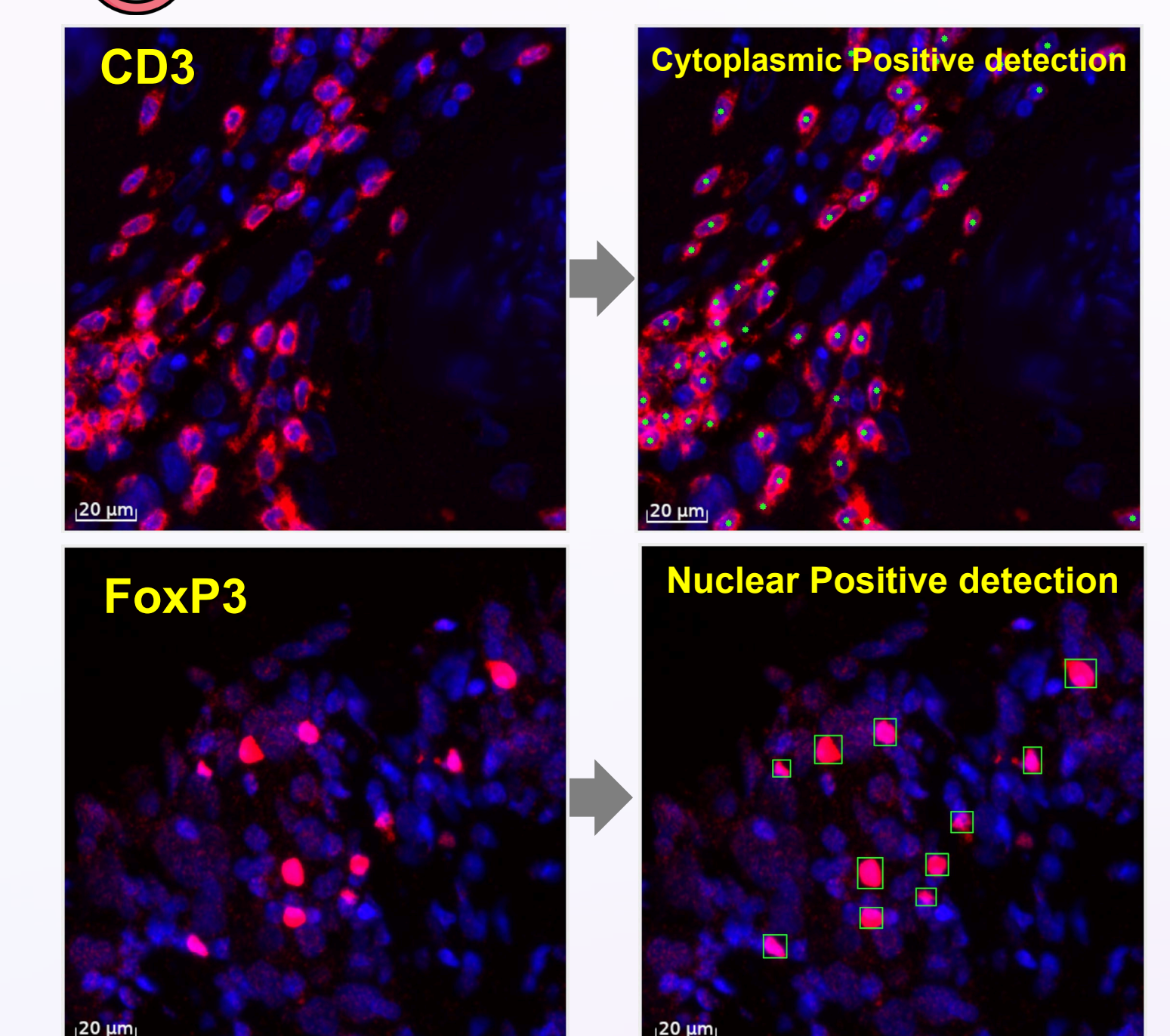
Model	Num FOVs	Num cells	Num markers	Bit depth
Cytoplasmic	2101	73562	16	16 bit
Nuclear	233	8446	3	16 bit
Total	2334	82008	19	

## Models Overview

### Tissue segmentation models



### Cell detection models



### Generative models

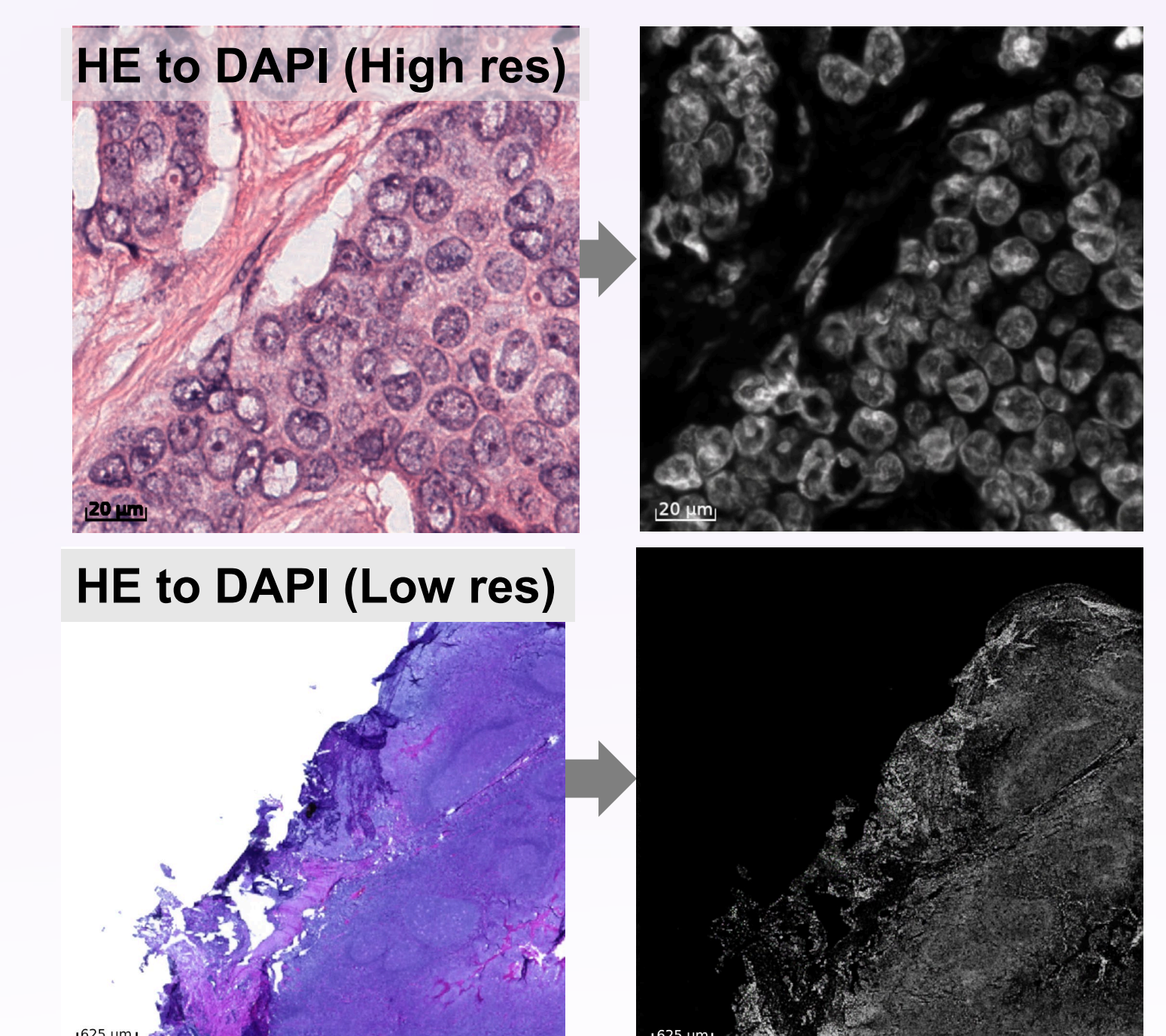


Figure 6. Example results for some of the different AI models developed for analysis and multimodal image co-registration

## Conclusion

The combination of OMERO Plus, PathViewer, AWS SageMaker, and STARVUE™ technology, successfully addresses mIF Big Data management complexities in a cloud environment for digital pathology. The architecture is highly scalable, cost effective, and reliable enabling a very efficient AI model development and deployment workflow. The cloud-based workflow enables easy management of massive multi-TB datasets, allowing for seamless scalability. Furthermore, the browser-based OMERO Plus and PathViewer interface facilitates effortless global collaboration.