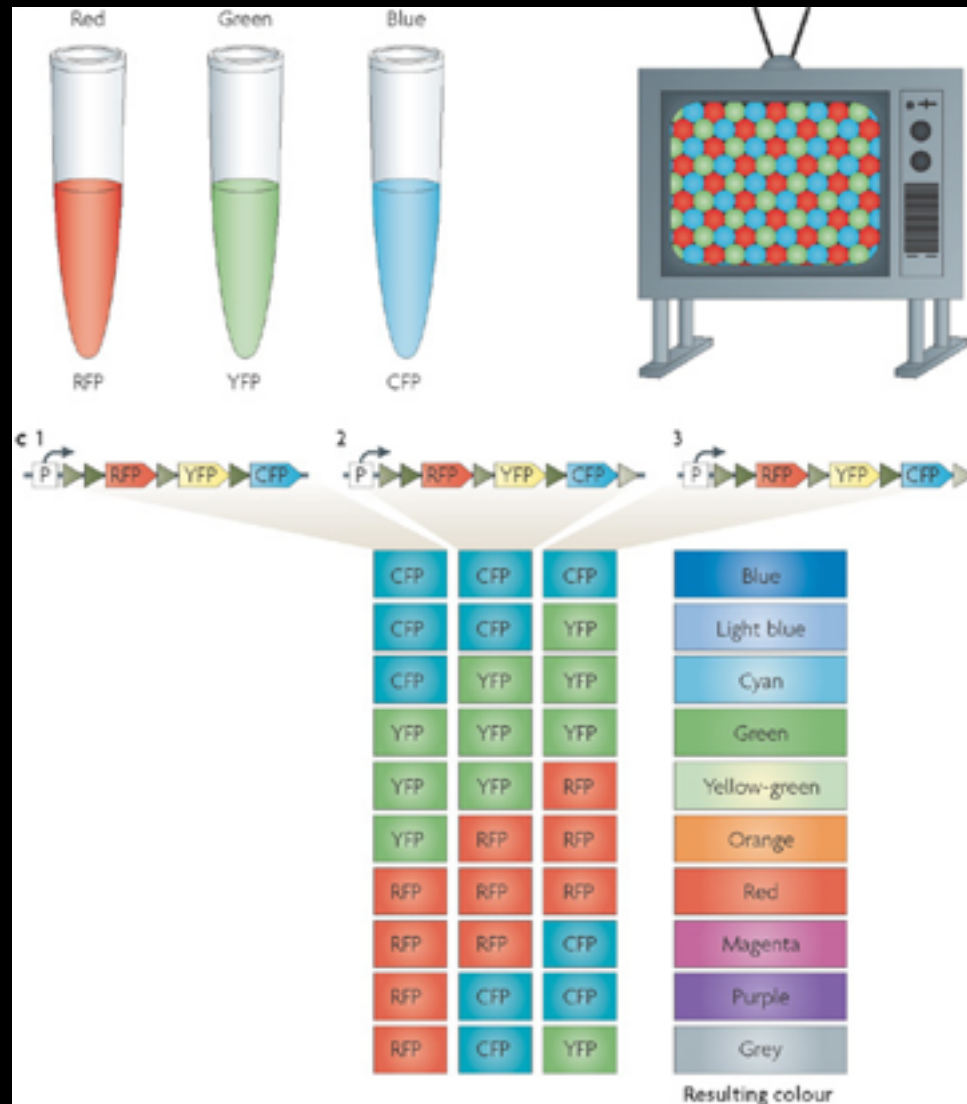


Semi-supervised segmentation of neurons from brainbow images

Uygar Sümbül, Suraj Keshri, Min-hwan Oh,
Dawen Cai, John Cunningham, Liam Paninski

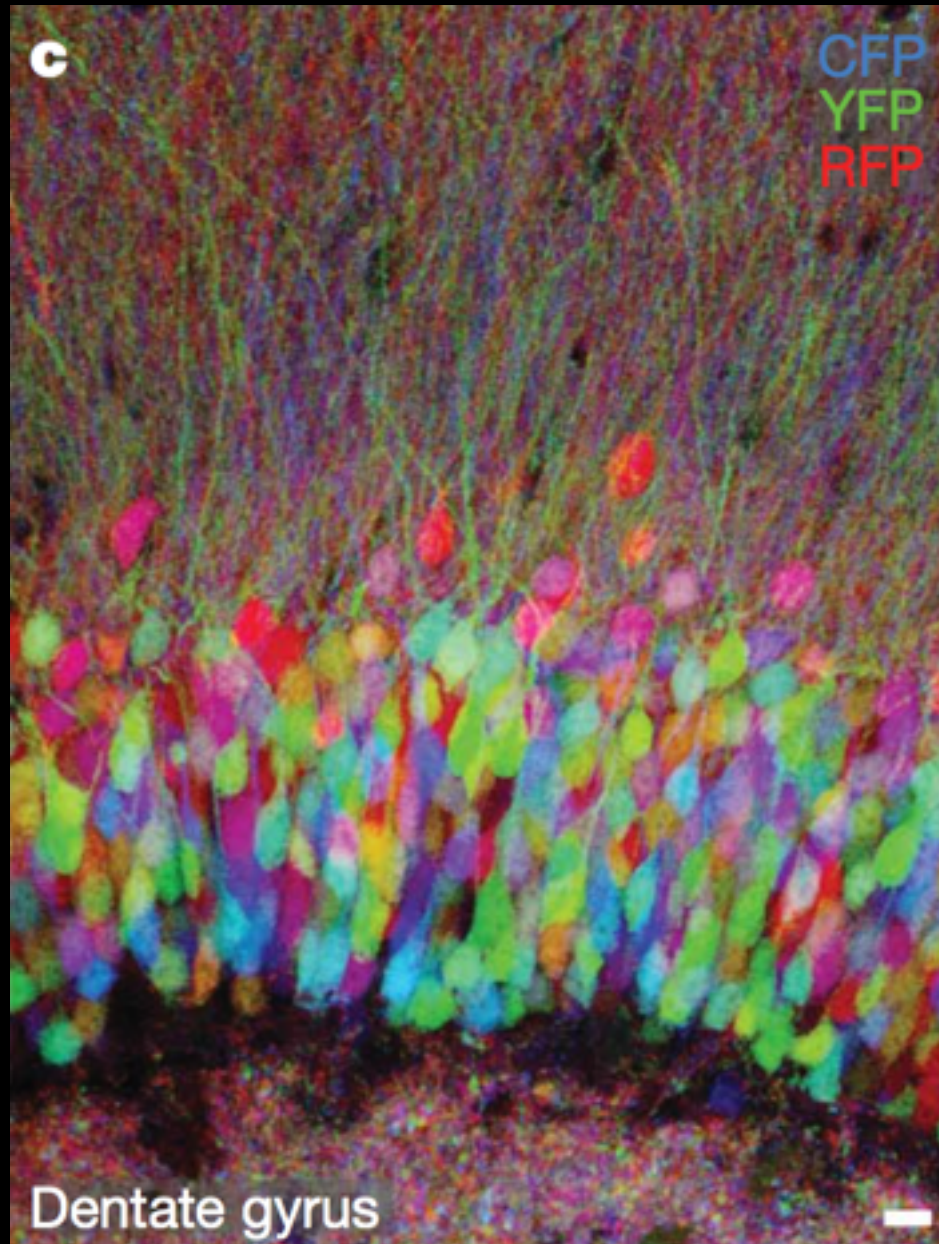
The Brainbow construct



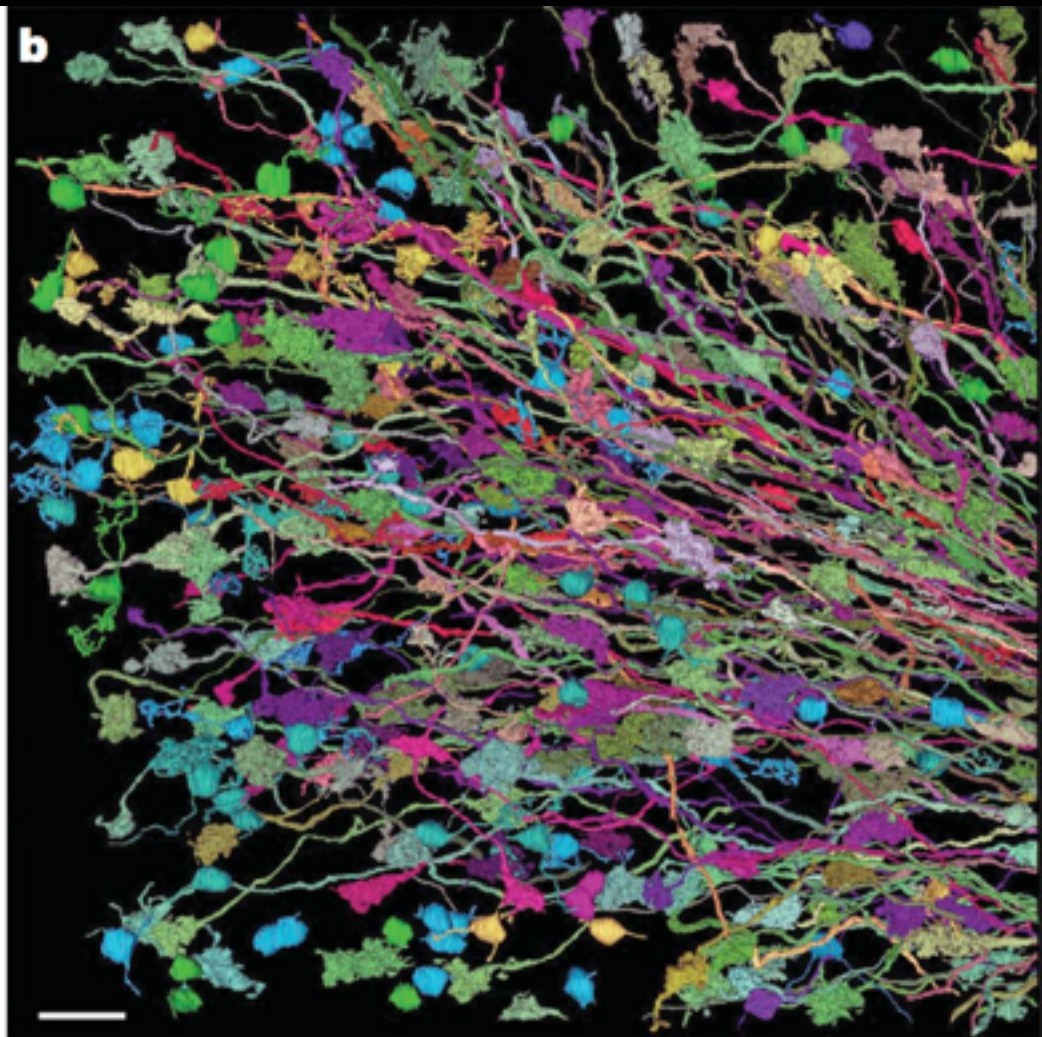
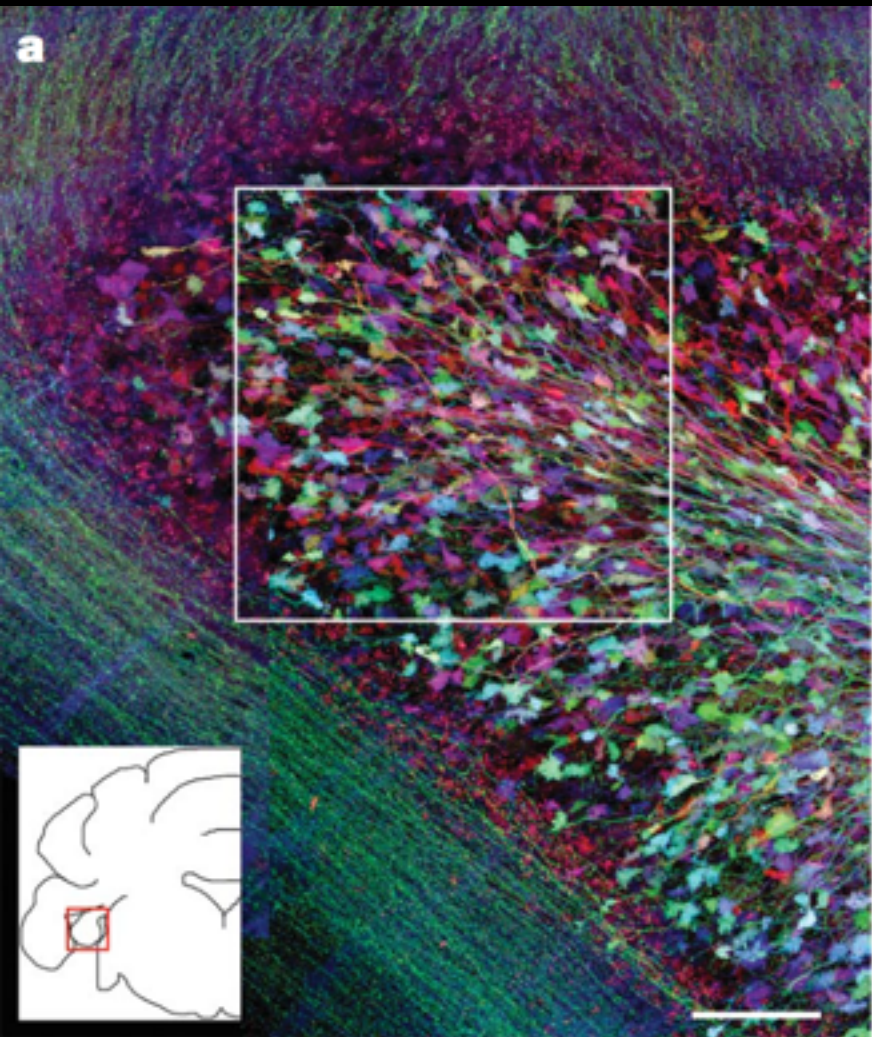
Lichtman et al.

- A tool to identify individual neurons by color

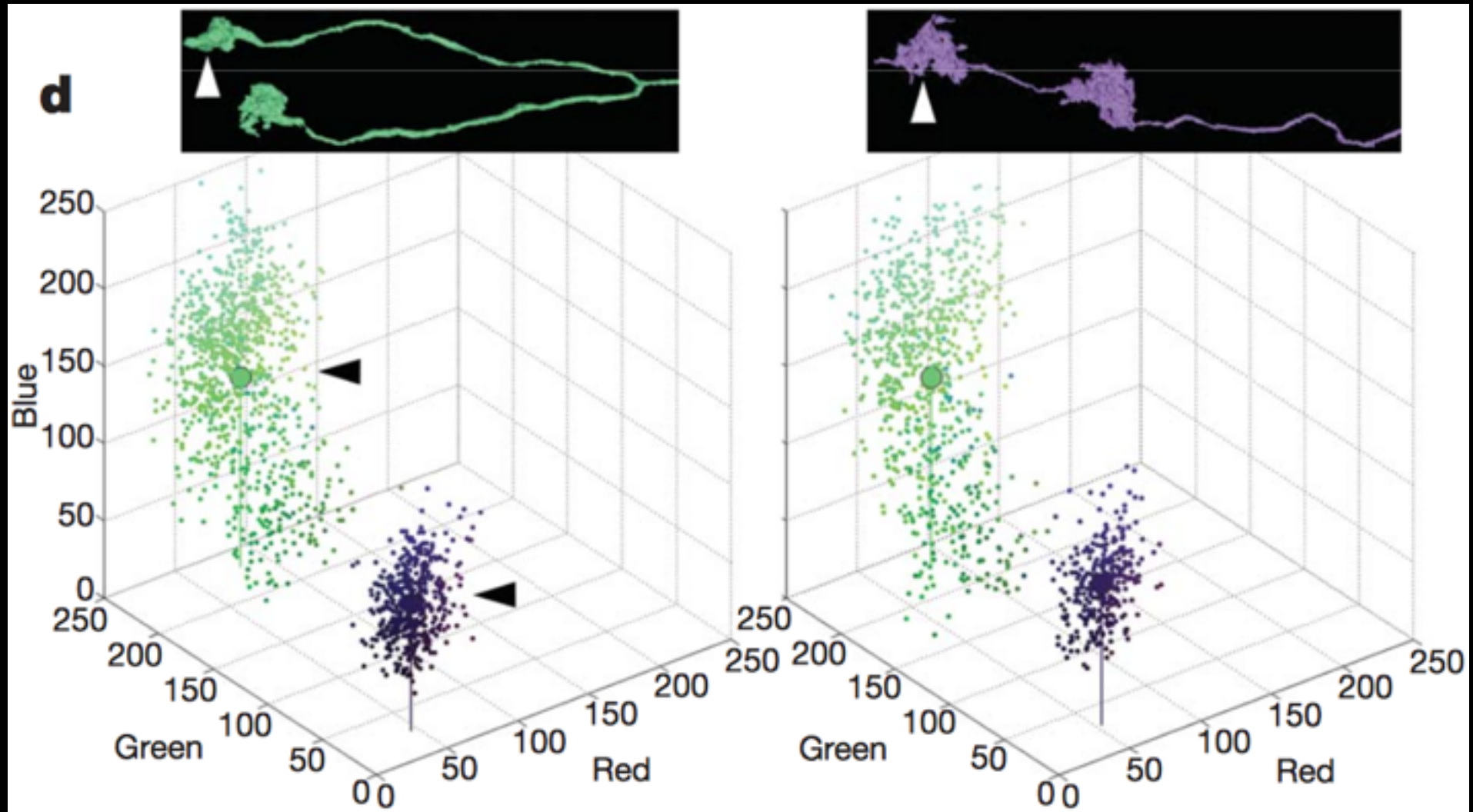
The structural substrate beneath



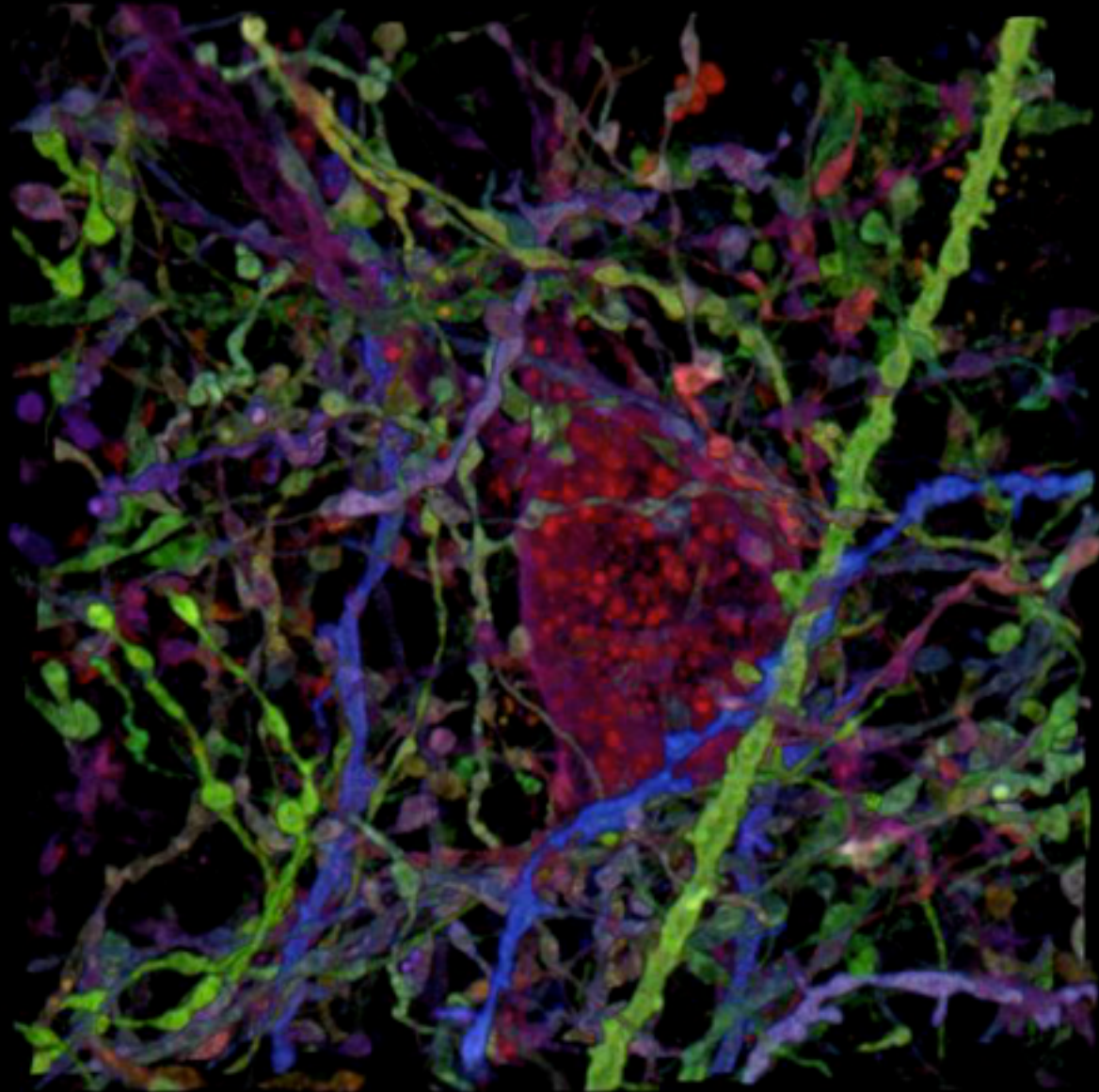
The structural substrate beneath



Noise sources

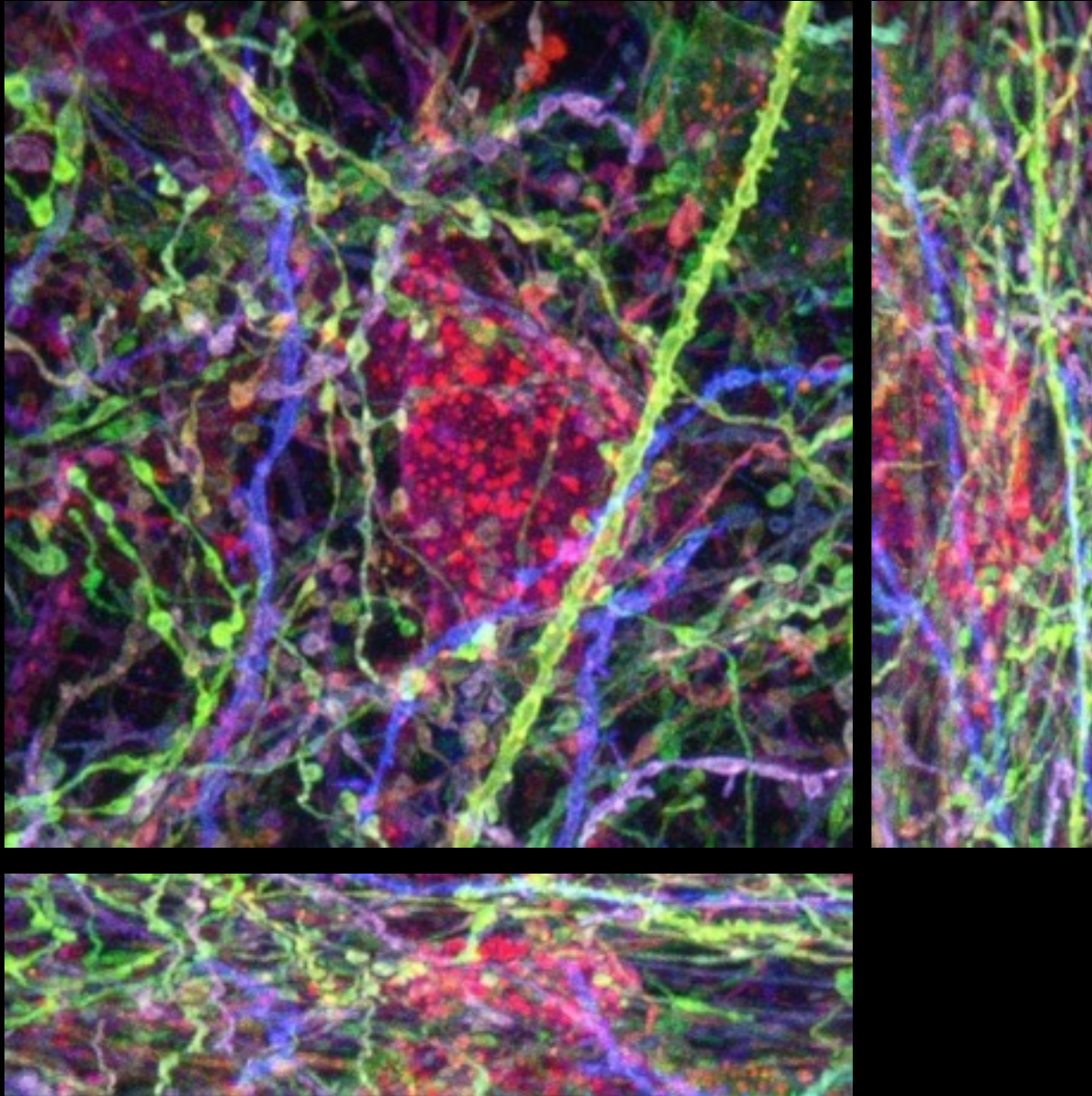


3D image stacks of neuronal tissues

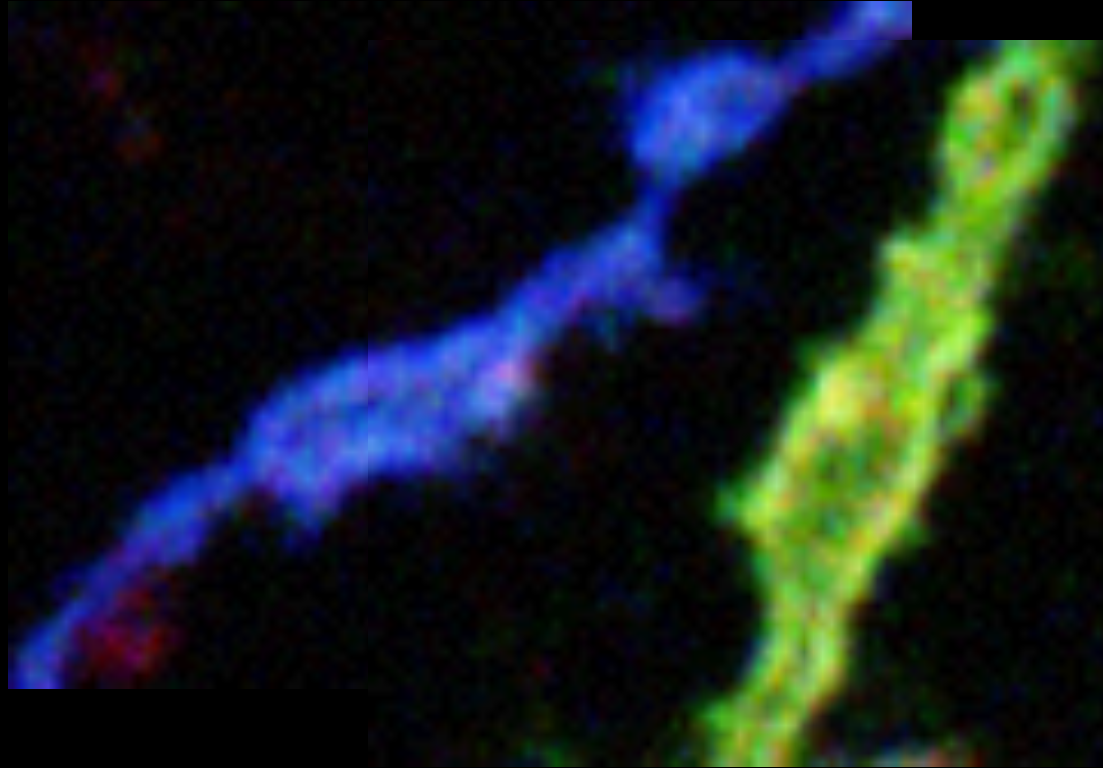


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UMich

3D image stacks of neuronal tissues

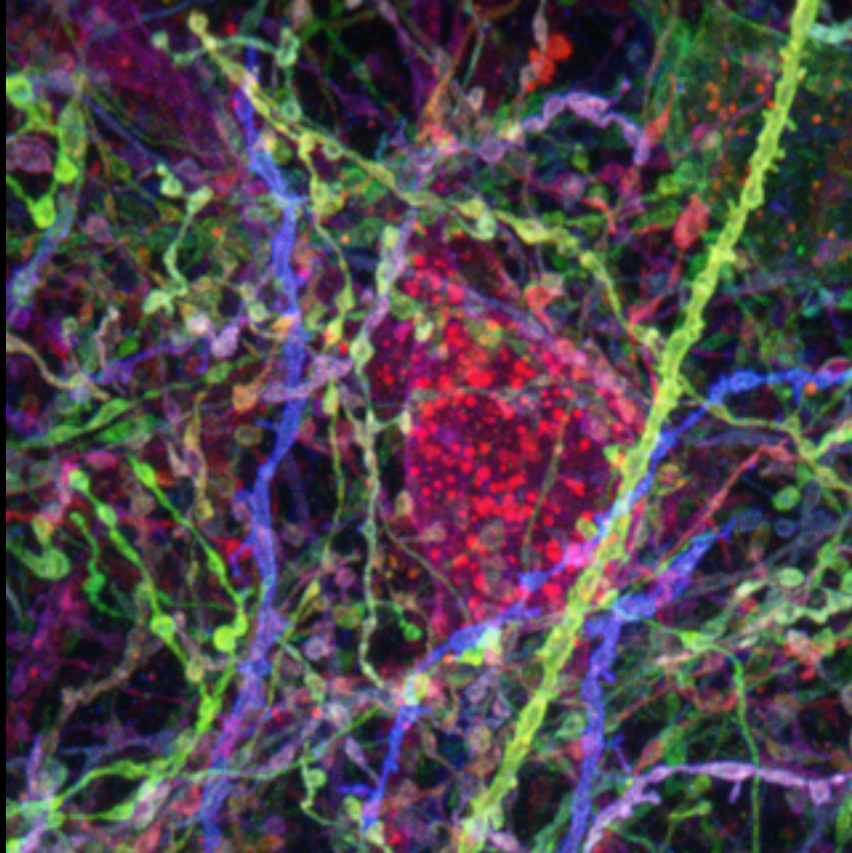


Noise in the Improved Brainbow



The task: segment individual neurons

- Partition $S = \{ [x_v \ y_v \ z_v \ r_v \ g_v \ b_v] \}_v$

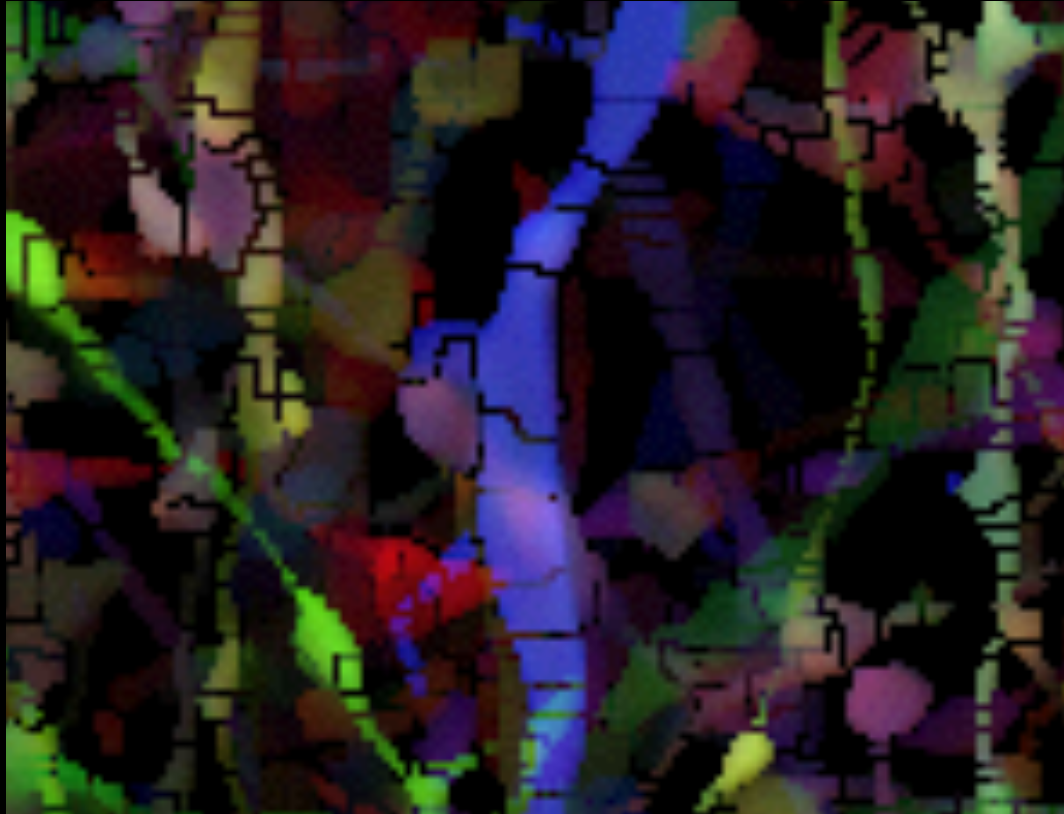


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- Very high apparent size

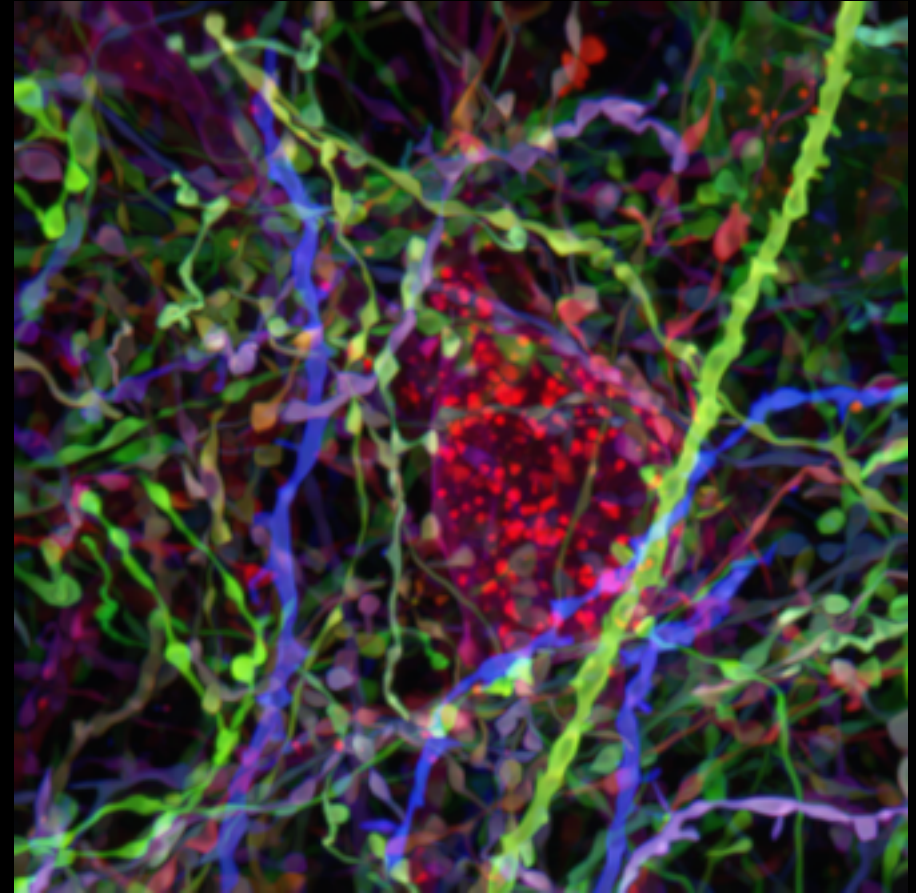
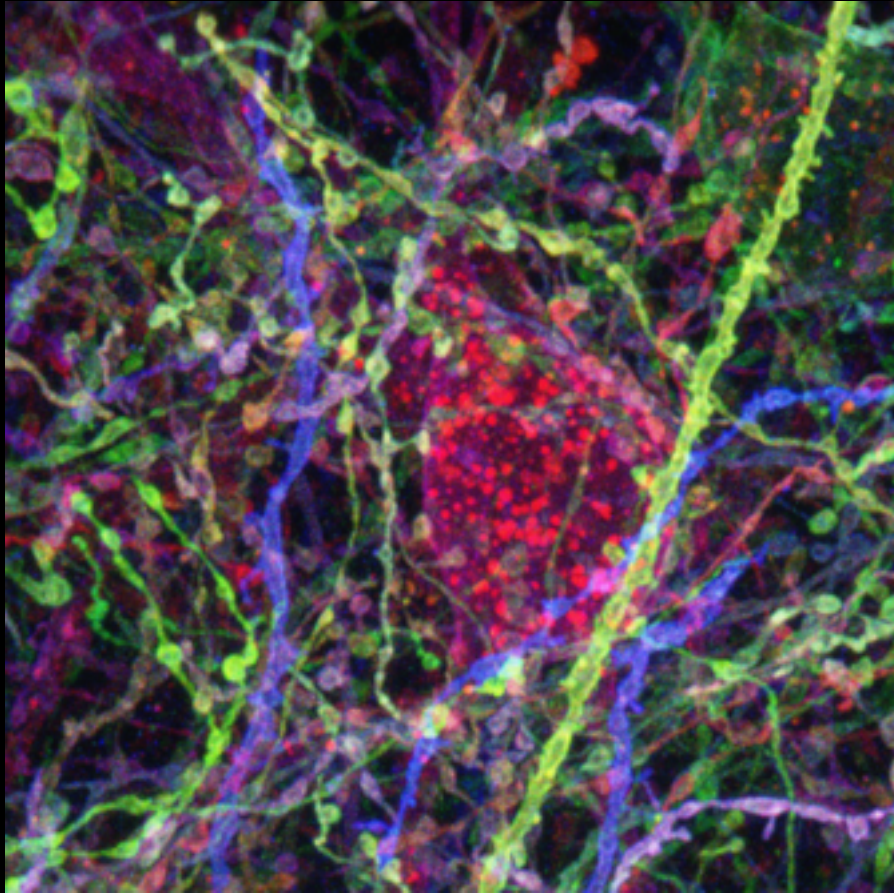
Supervoxels

- Identify the foreground
- Obtain an oversegmentation

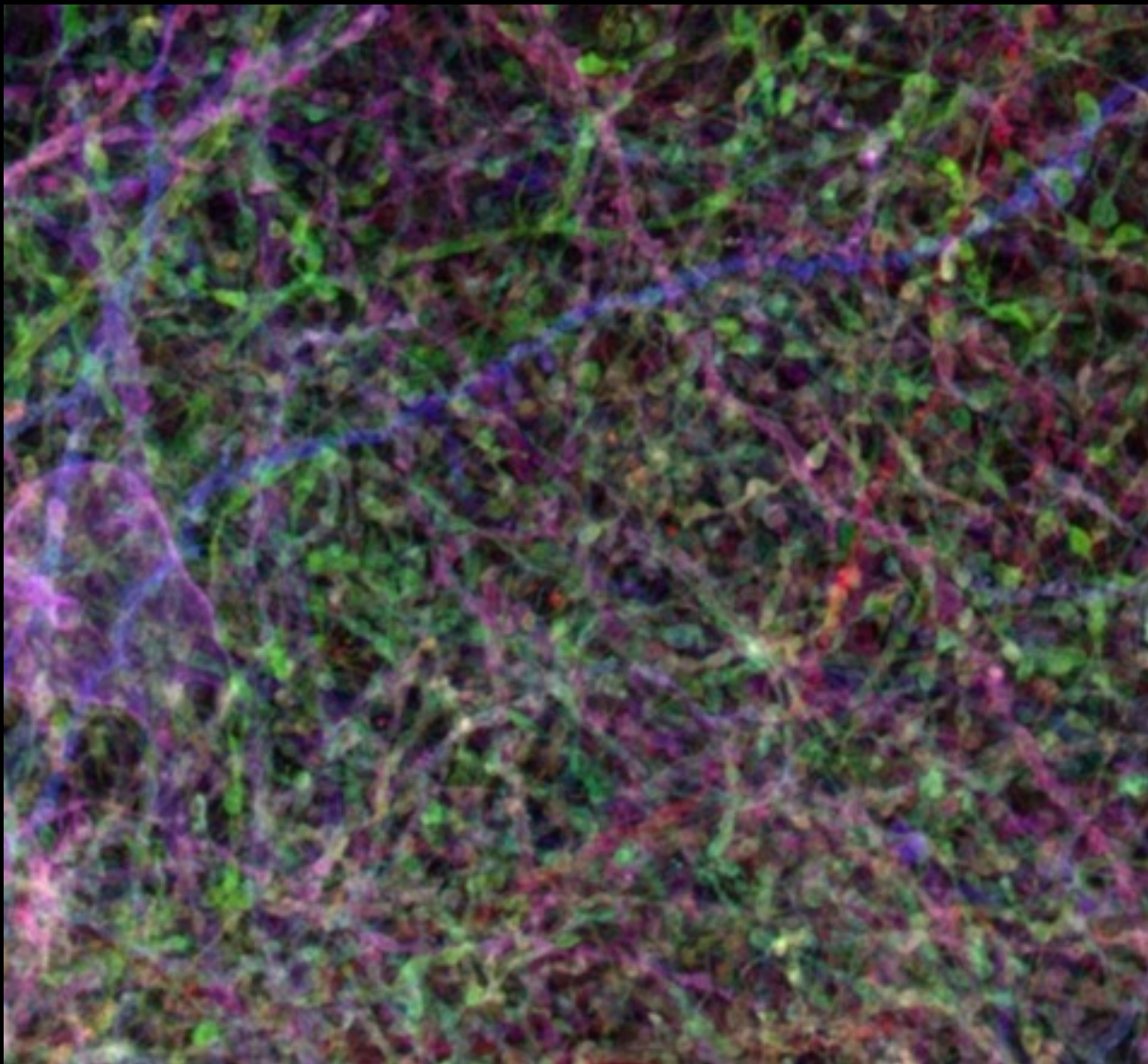


- Summarize each supervoxel's color with the mean:
- # voxels / # supervoxels ~ 100

Collaborative filtering and watershed transformation



BM4D

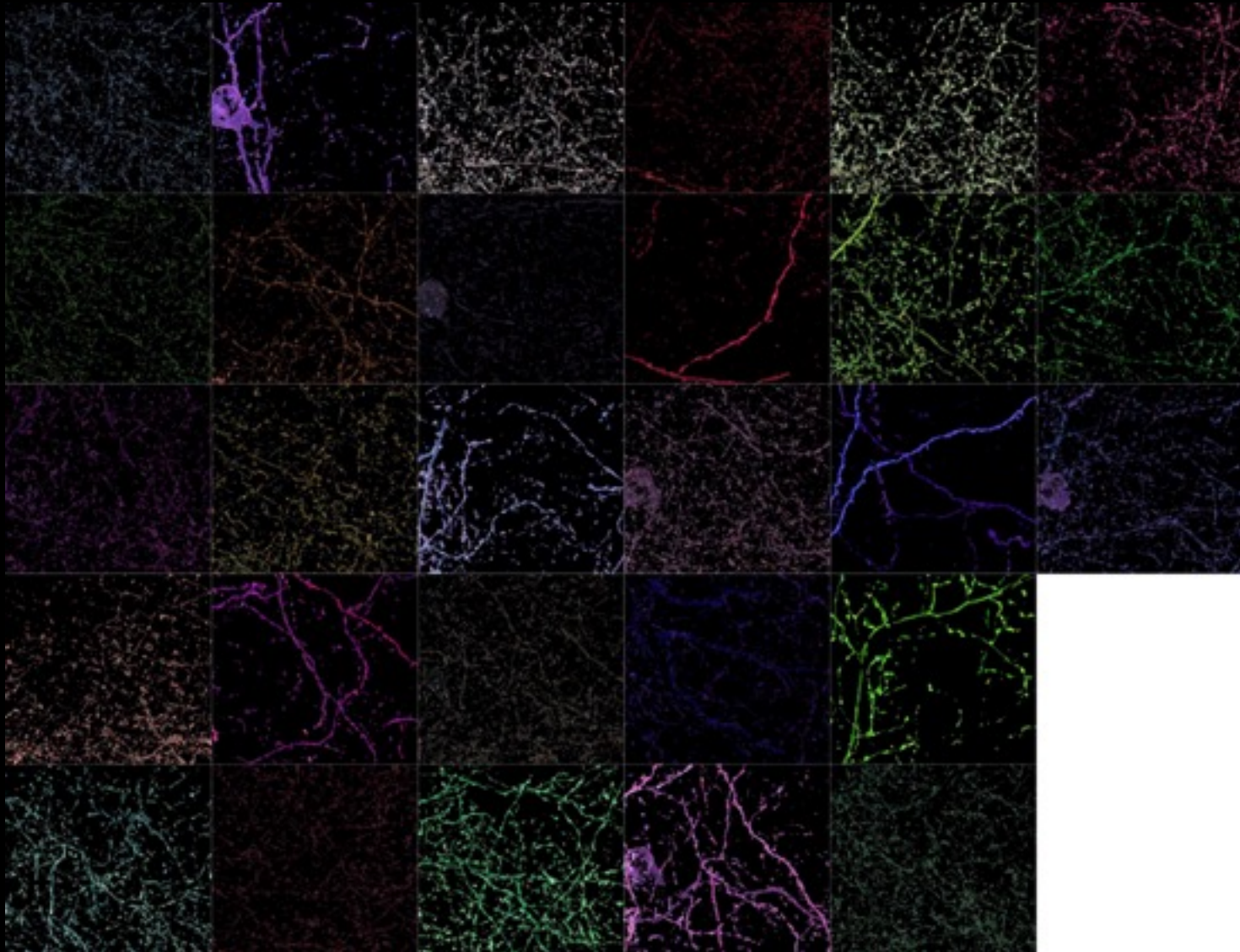


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- 764 x 704 x 223 voxels $\sim$ 76 μ x 70 μ x 67 μ
- 125K supervoxels

Weighted k-means

- LUV color space
- Color SNR $\propto \sqrt{\text{voxel count}}$



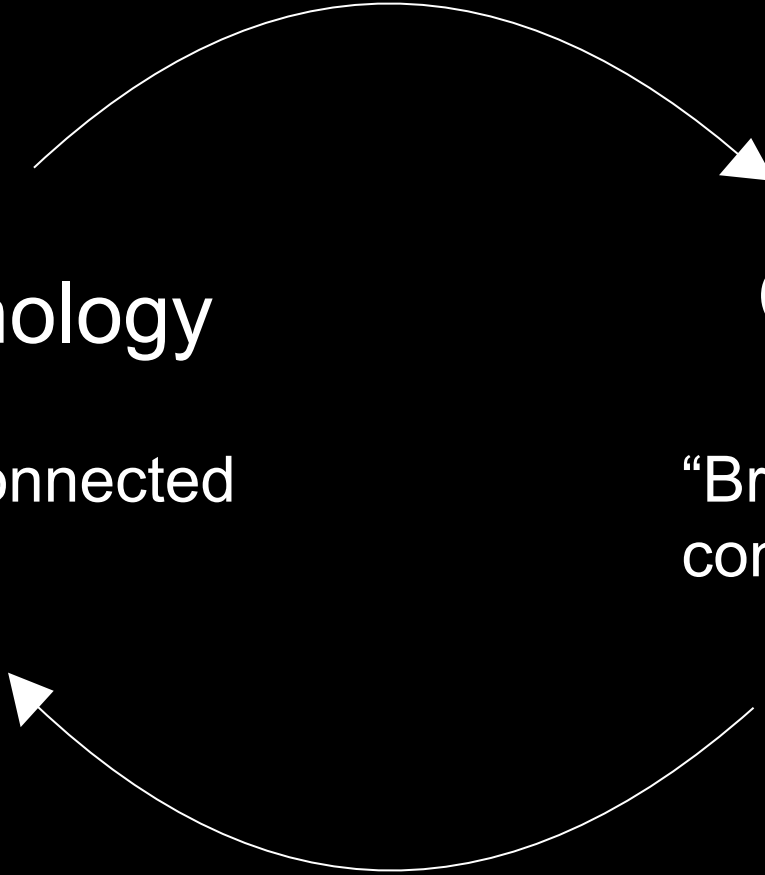
Utilize both space and color

Morphology

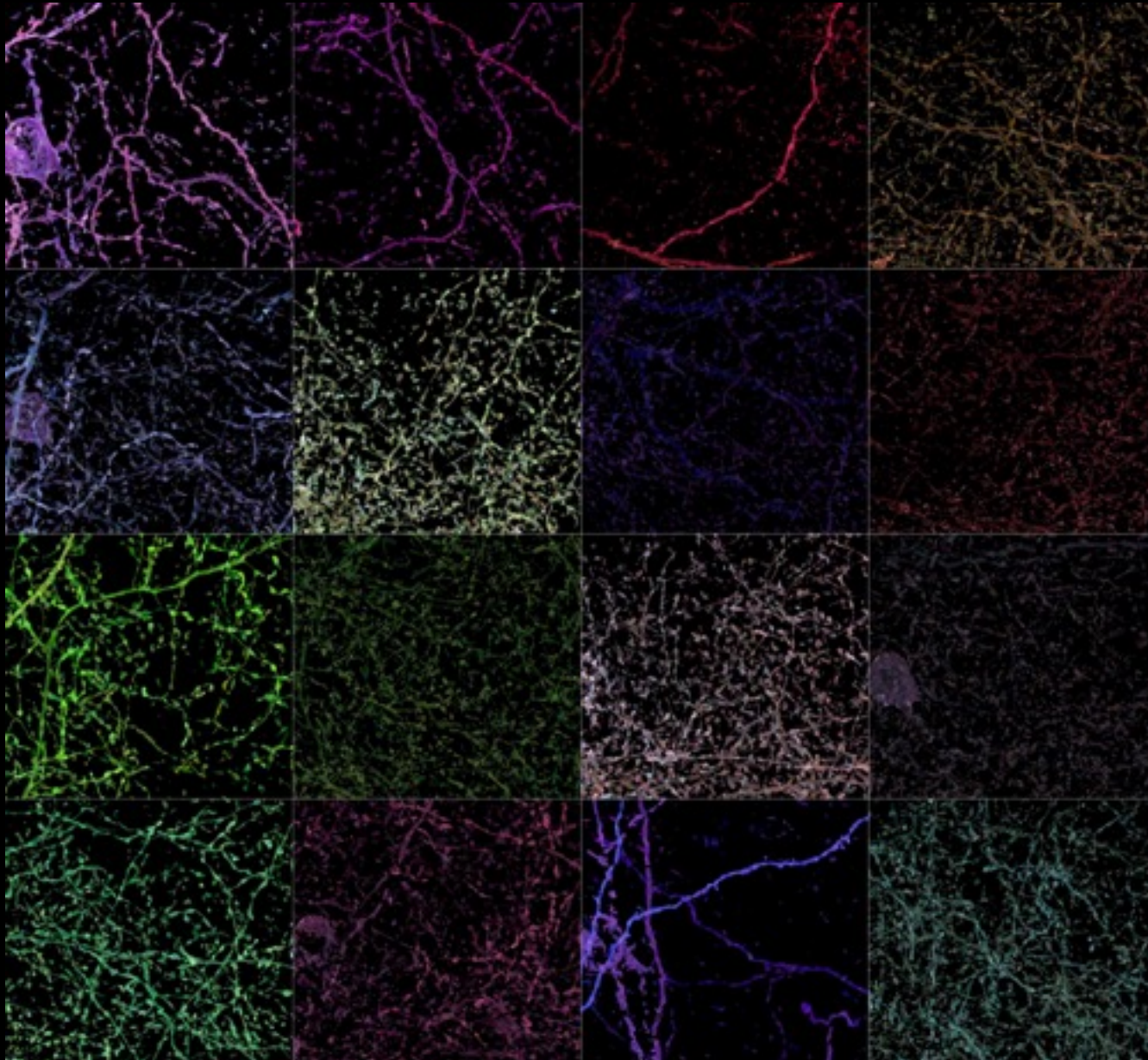
“Neurons are connected components.”

Color

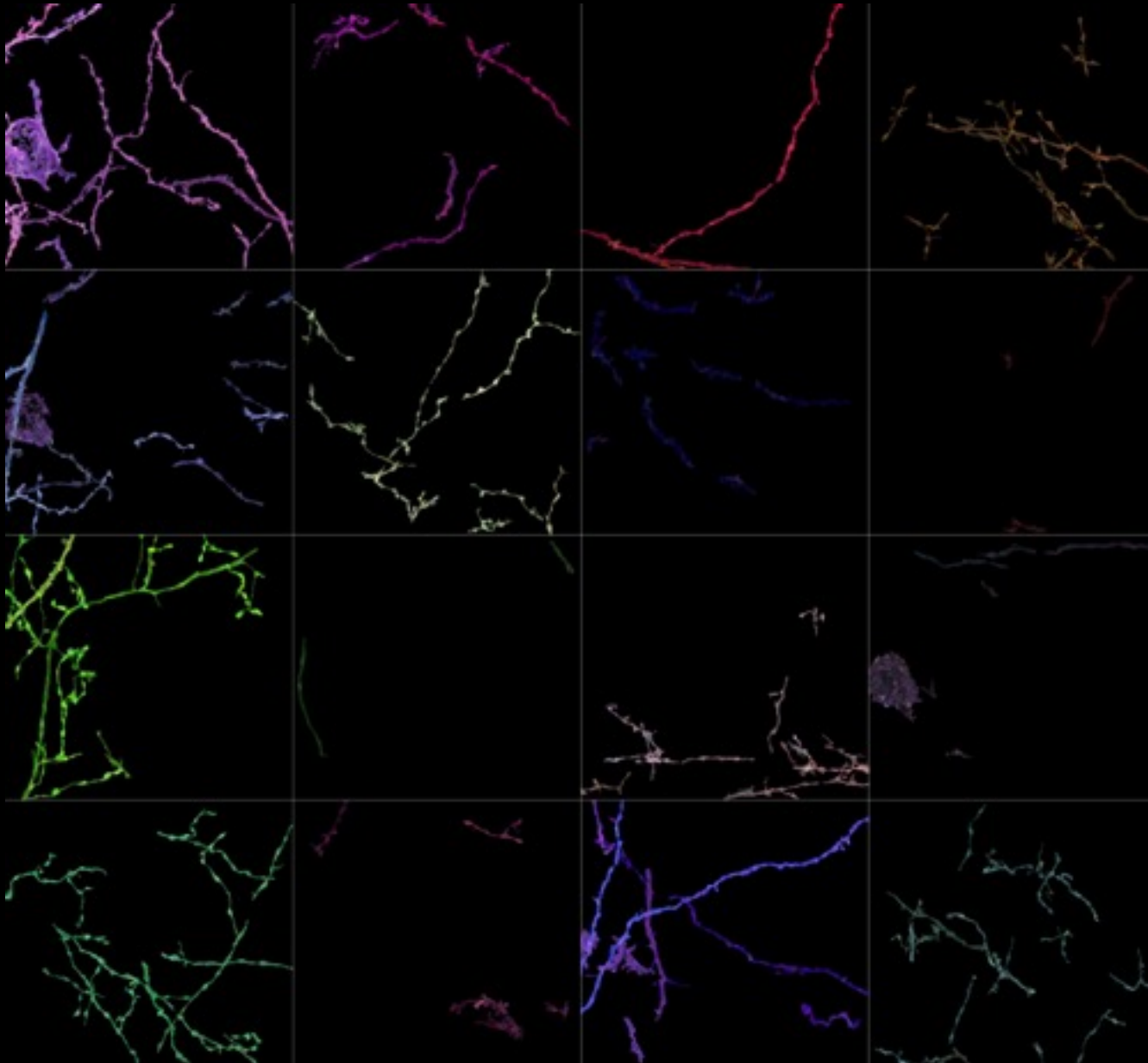
“Brainbow promises consistent colors.”



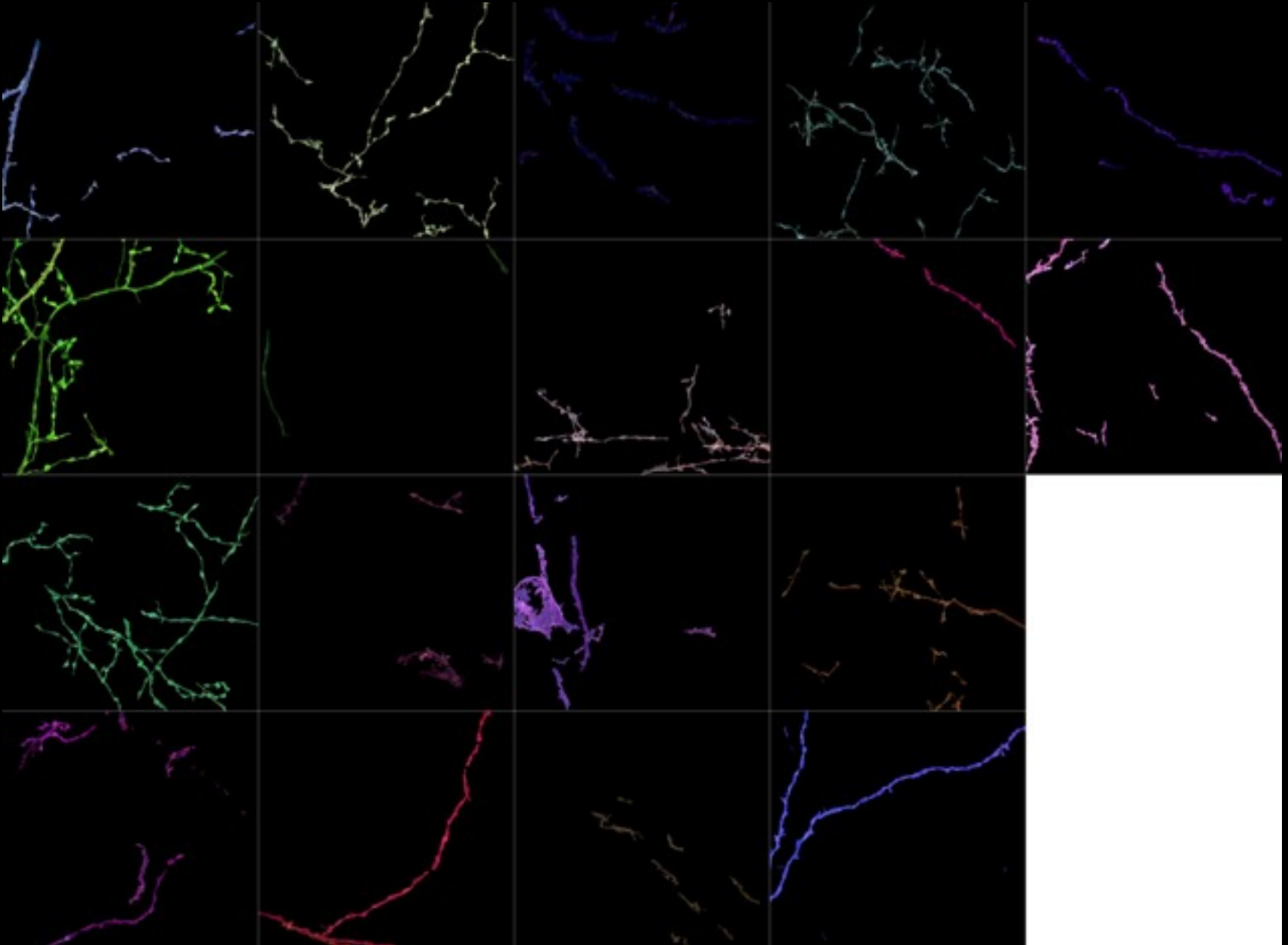
1. Undersegment



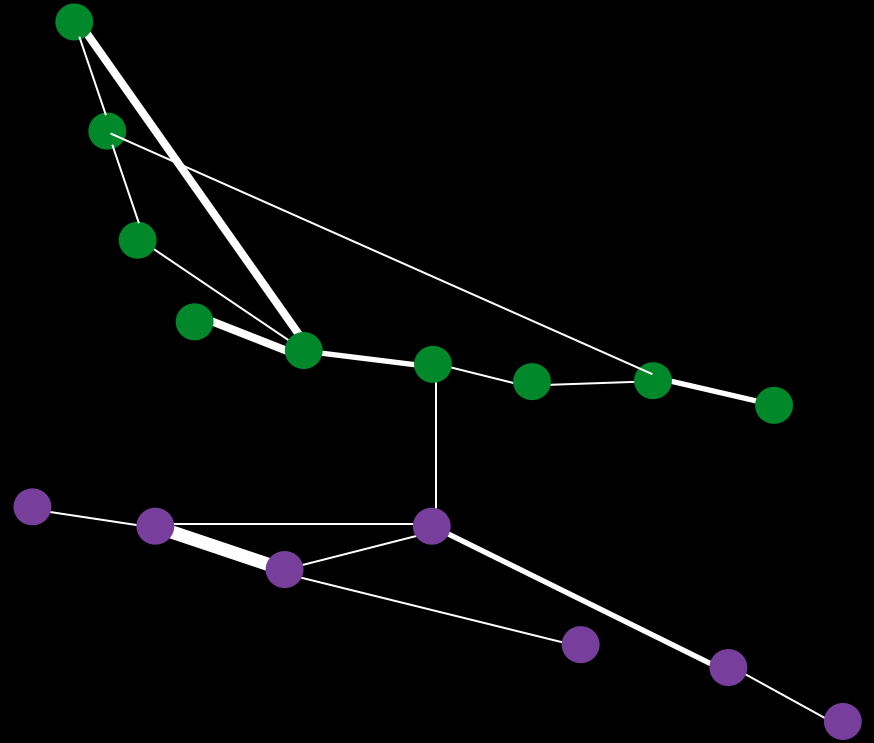
2. Retain big connected components



3. Cluster-level user manipulation

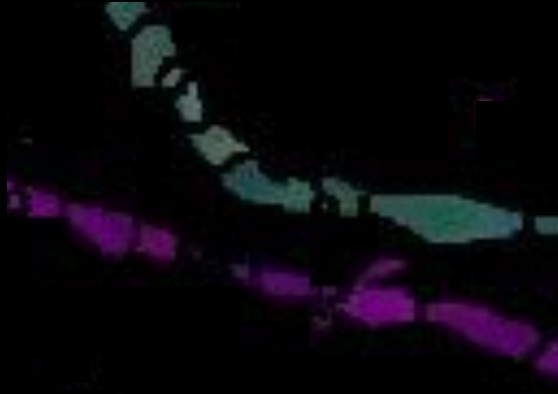


Supervoxels are the nodes of a graph



- Edge weights based on color (and space)
- Small supervoxels can have local edges only
- Need sparse connectivity due to size
- The task: cluster the nodes of the graph

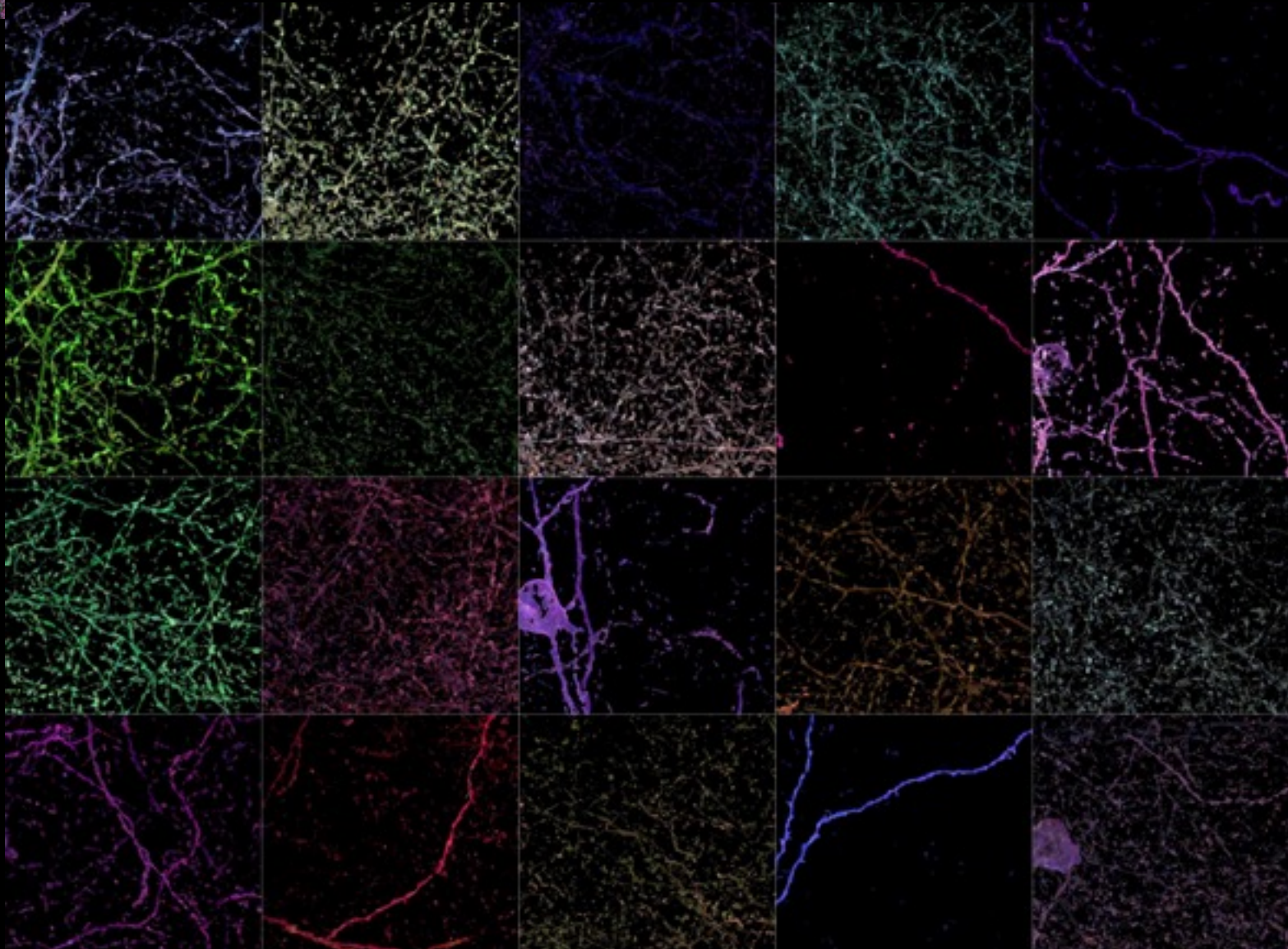
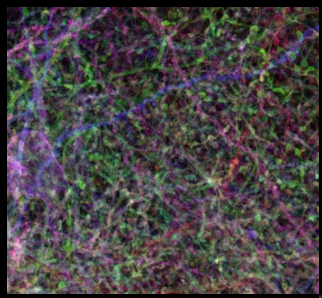
Semi-supervised spectral clustering



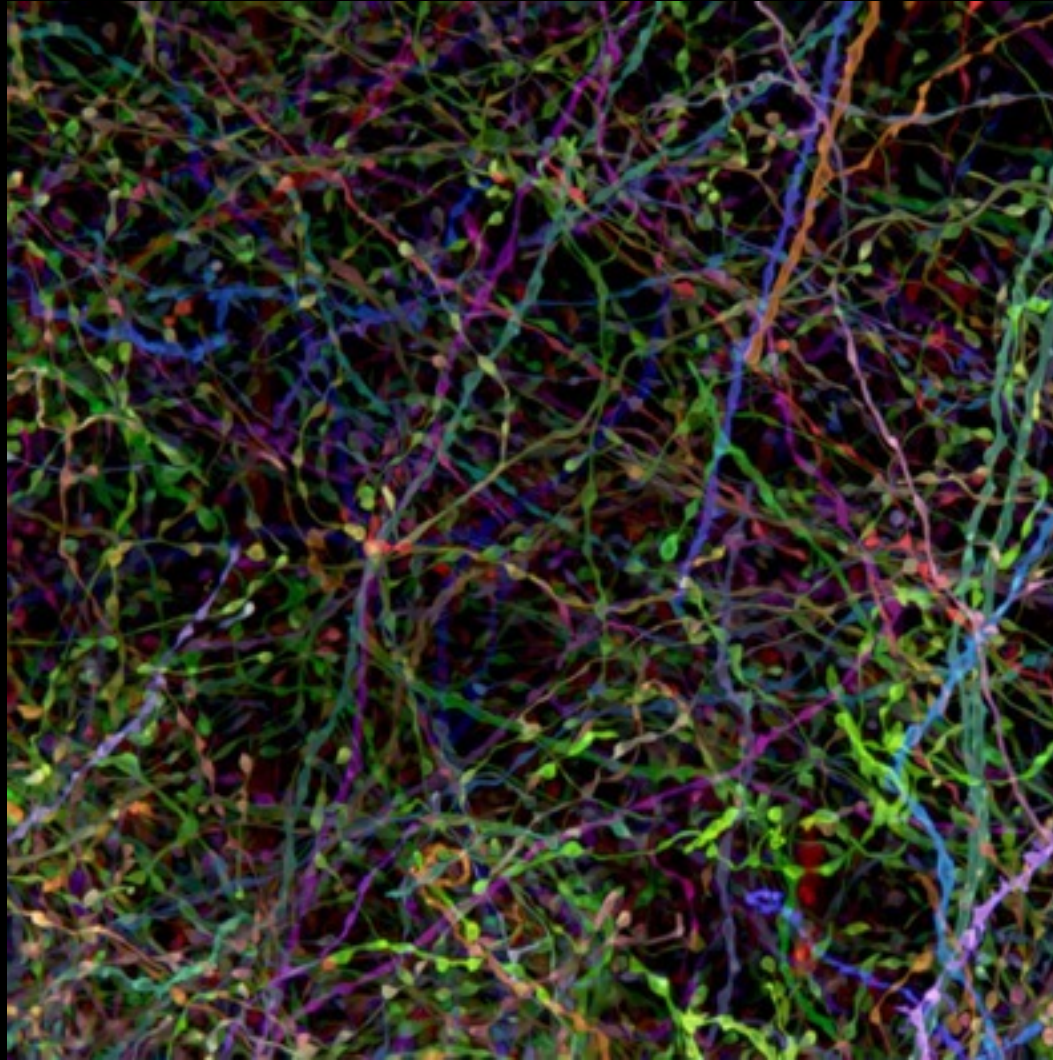
Kamvar et al, 2003
Kulis et al, 2005

- Calculate affinity matrix ($\sim 2\%$ dense)
 - Impose edge weights from user input
 - Calculate normalized eigenvectors of Laplacian
-
- Weighted k-means on the feature vectors
 - Impose cluster memberships from user input

4. Spectral clustering



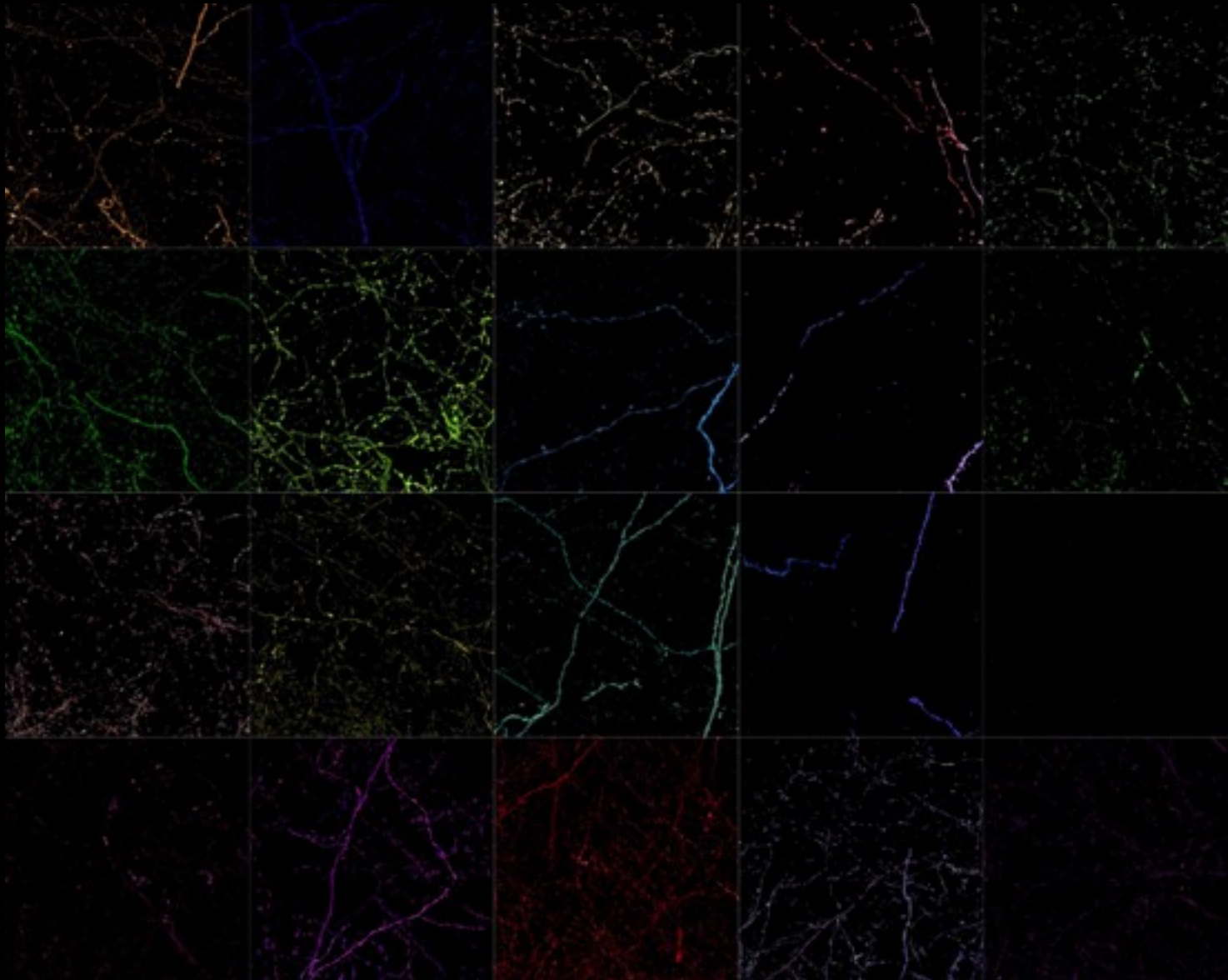
Another image stack



Dawen Cai
UMich

- 1020 x 1020 x 225 voxels $\sim 102\mu \times 102\mu \times 67\mu$
- 86K supervoxels

4. Spectral clustering



Challenges

- Number of neurons
- Edge weights (spatio-color)
- Warmer starts for more user interaction

Thank you

