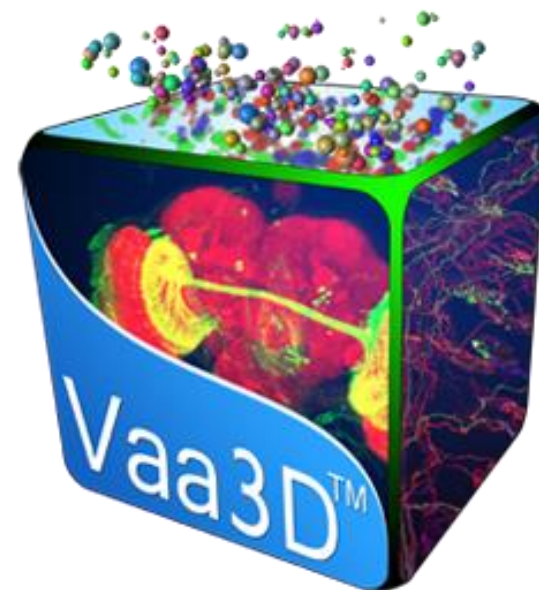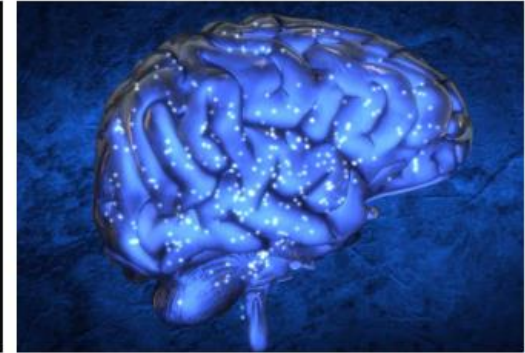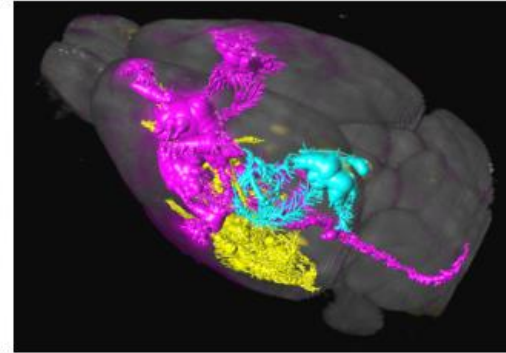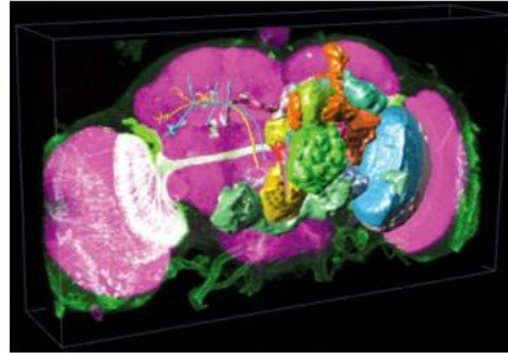# How to visualize various biodata via Vaa3D

Xin Chen

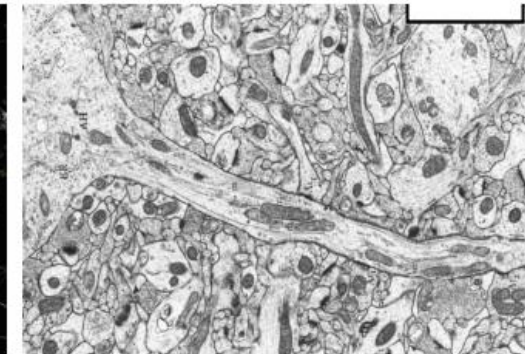Institute for Brain and Intelligence

10/18/2021

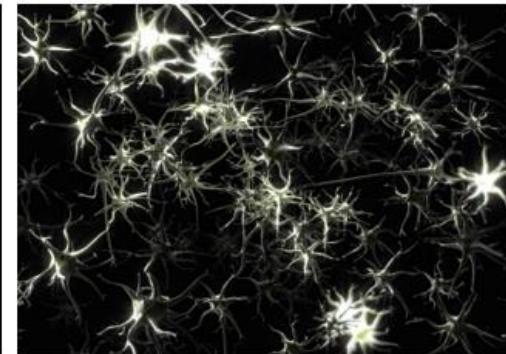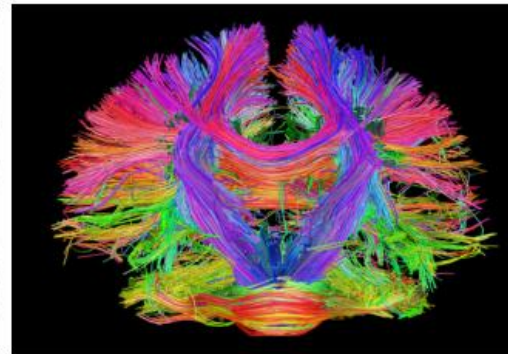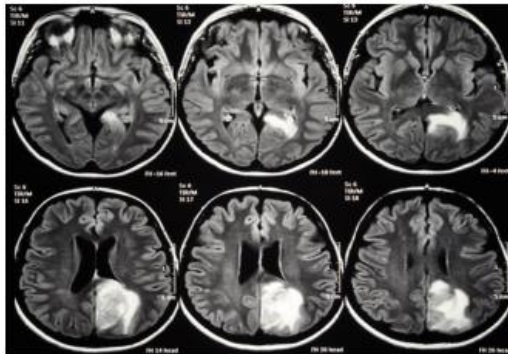# Biodata – various, complicated, containing valuable information

Various species

Various resolution

Various imaging modalities
Various data types, formats, etc.

Vaa3D – 3D Visualization-Assisted Analysis

Visualization

Various-scale (small and large, e.g. terabyte voxel) multidimensional (3D/4D/5D) bioimage

- Tri-view
- 3D viewer – 3D/4D/5D bioimage
- TeraFly – bioimage with unlimited size
- TeraVR – immersive

Data Types

- 3D color image stacks
  - Tiff stack (.tif, .tiff)
  - Zeiss LSM (.lsm)
  - MRC (used for electron microscopy images) (.mrc)
  - Vaa3D's raw file (.v3draw, .raw, *.v3dpbd, *.vaa3dpbd) (The PBD files are compressed raw files)
  - Any other image formats (e.g. jpeg, PNP, BMP, ...) supported by LOCI Bioinformats Java library (through a Vaa3D-bioformats plugin, see the plugin pages)
- 5D time series of color image stacks
  - Each time point saved as a separate file (end with suffix like 000.tif, 001.tif, ...)
  - Each time point saved as a single slice of a 3D image stack of whatever formats Vaa3D supports (e.g. tiff, or Vaa3D's raw)
- 3D irregular shaped surfaces
  - Wavefront .OBJ files
  - Vaa3D's surface format (.v3ds)
- 3D neuron structures or any relational data that can be described as a graph
  - SWC file (.swc)
  - Enhanced SWC file (*.eswc)
- 3D point cloud
  - .apo file (a simple CSV format with fixed number of columns)
- 3D landmarks
  - .marker (indeed a simple CSV format)
  - .csv
- Linker files
  - linker files (.ano) that enables opening many data files of different types easily
  - atlas files (.atlas) for managing colocalized/registered image files
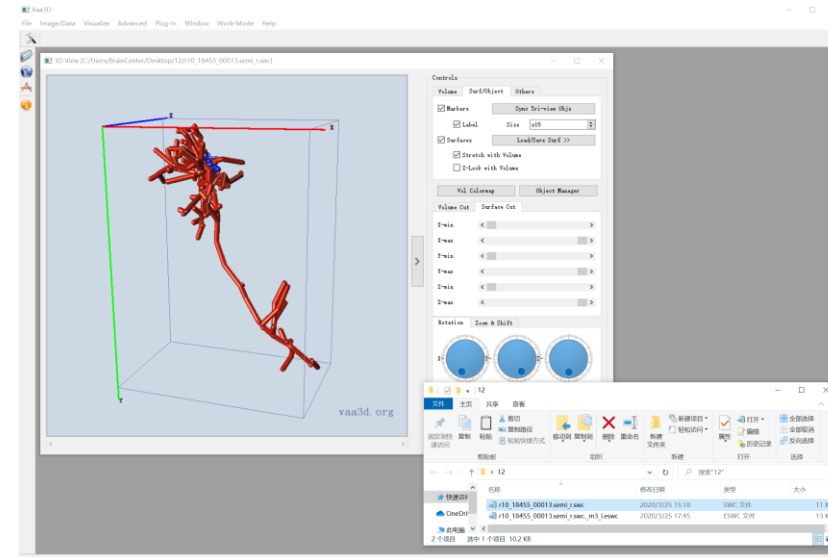
Data Types

Vaa3D: main interface
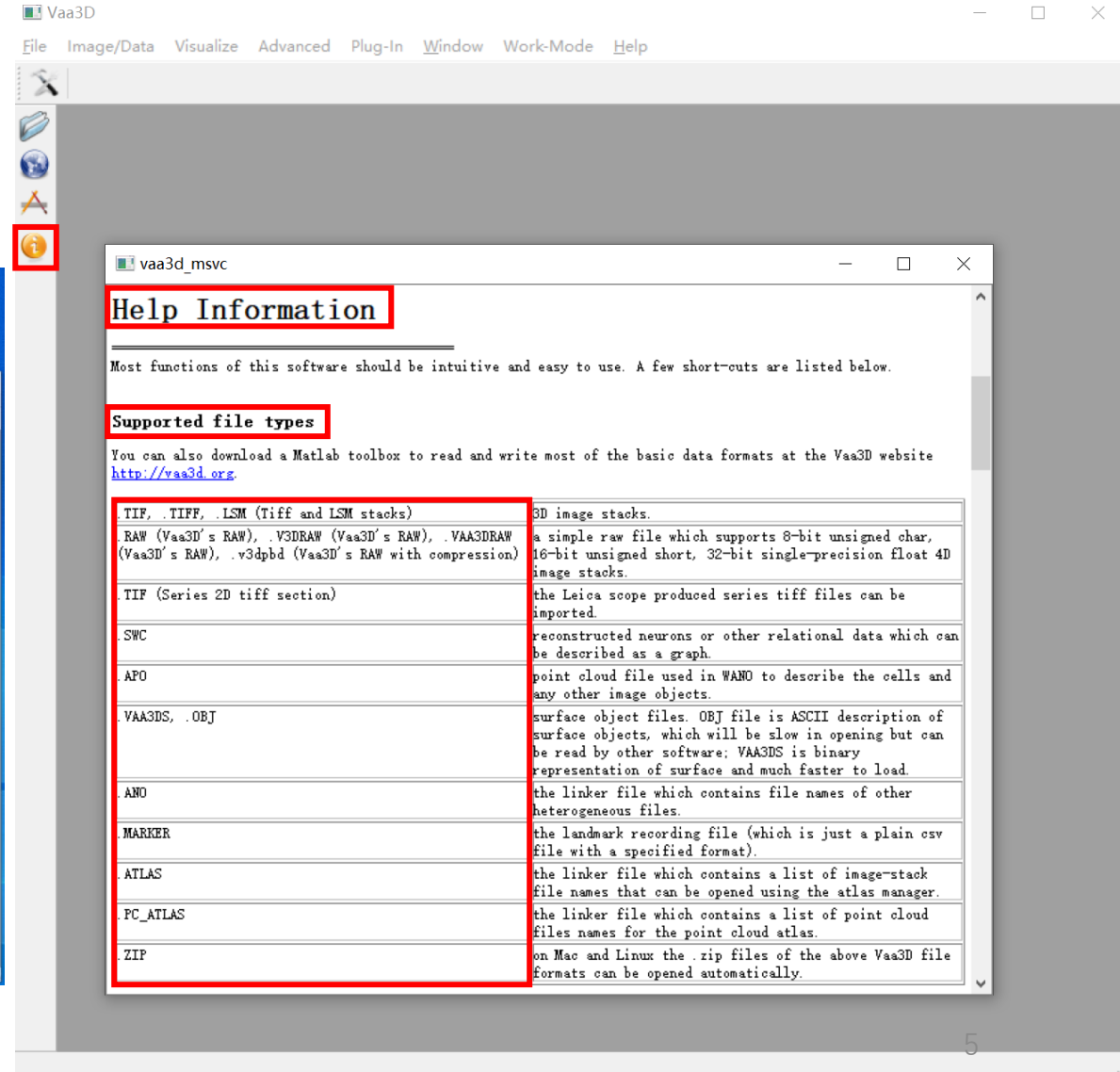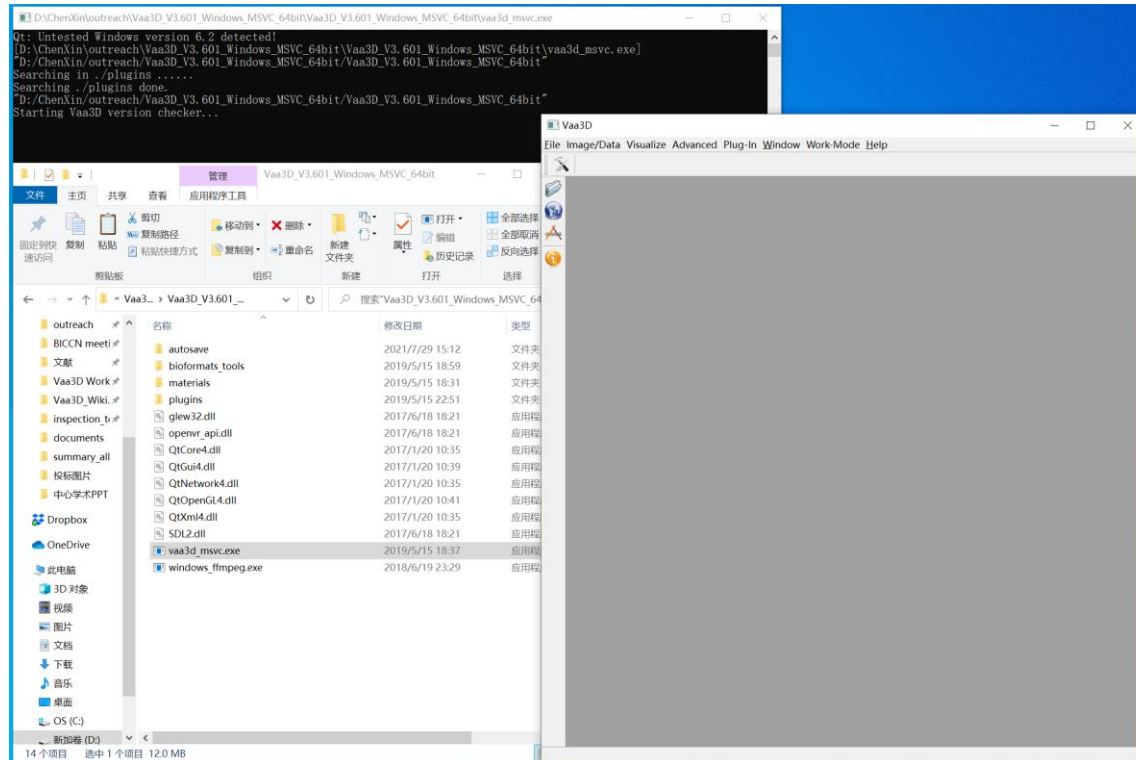
Tiff stack (.tif, .tiff)
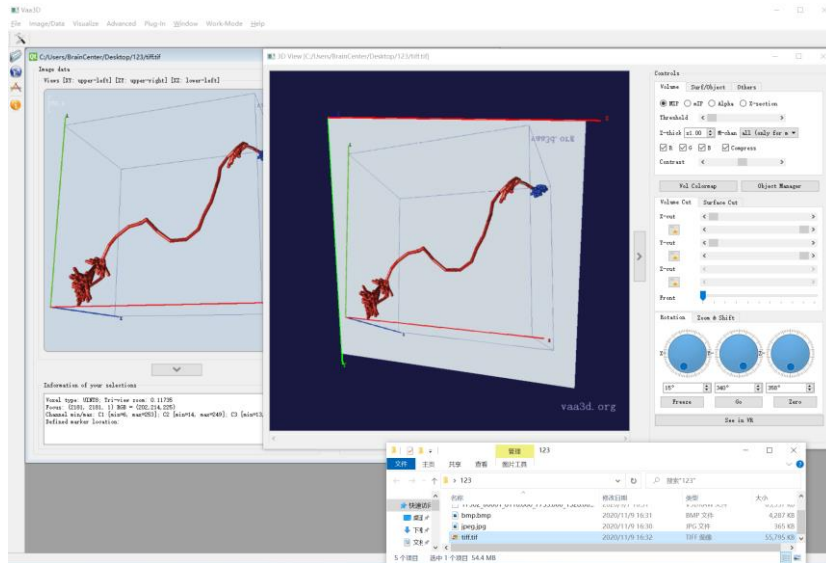
SWC file (.swc)

Vaa3D's raw file (.v3draw)
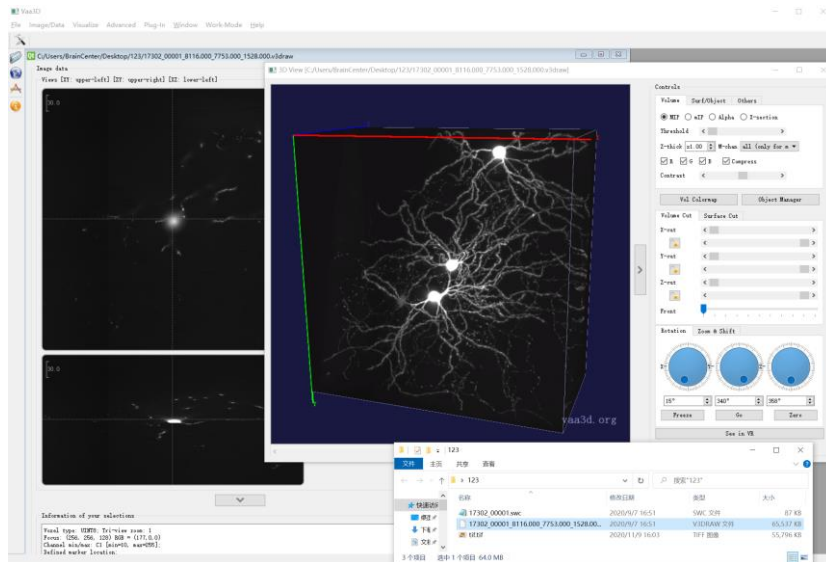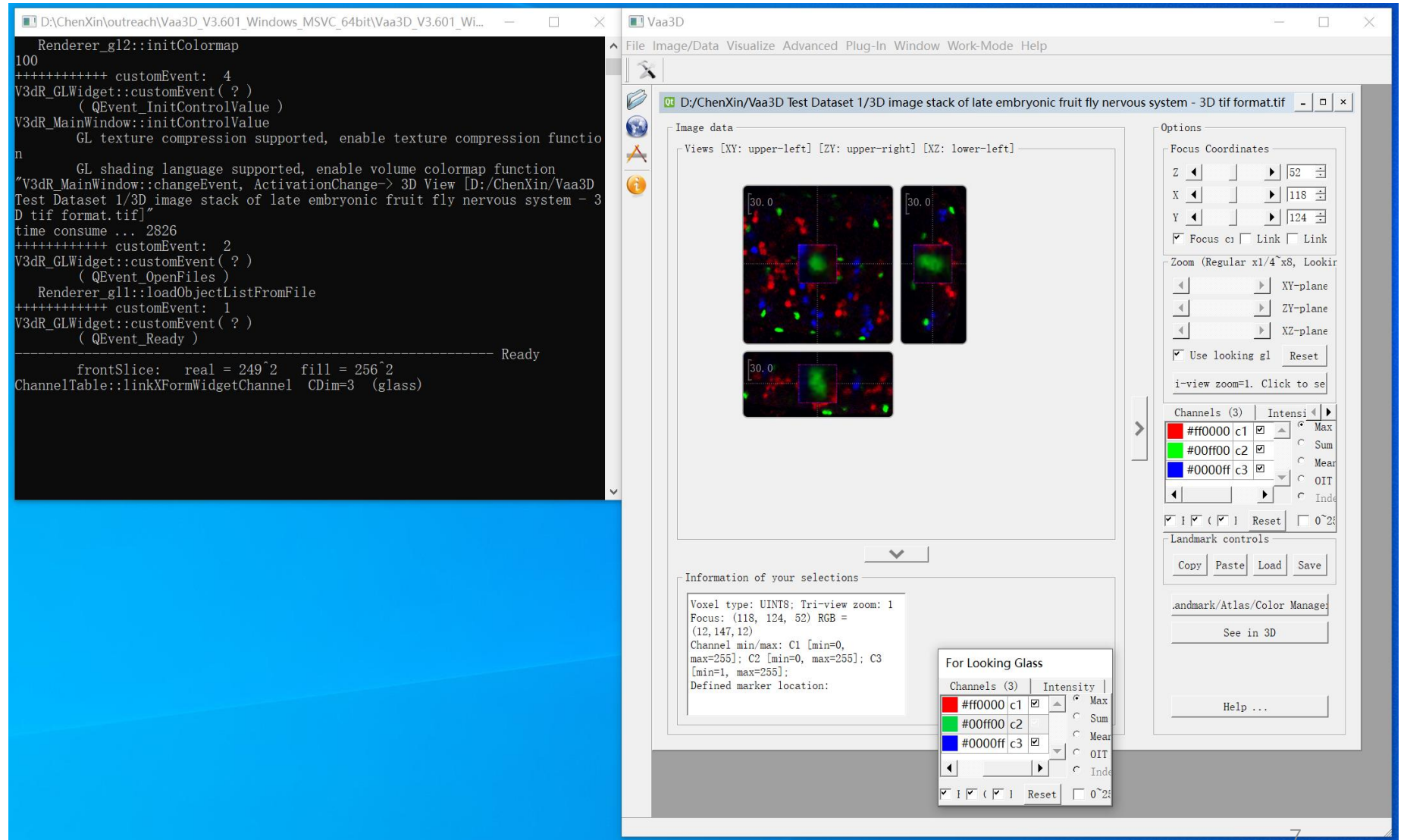

Vaa3D's raw file (*.v3dpbd)
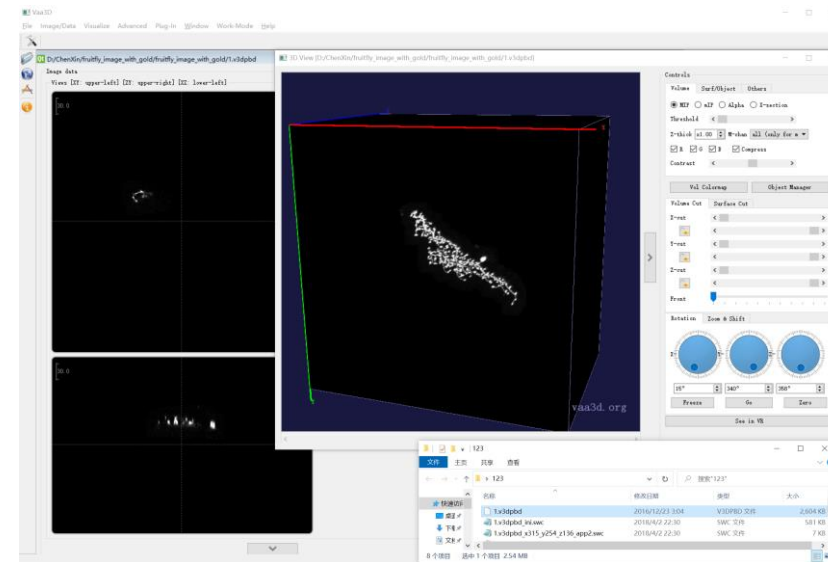
Tri-view

3 orthogonal views
Focus coordinates
Zoom
Looking Glass
Intensity
Landmarks
Atlas
Color channels
……

3D Viewer

MIP (Maximal intensity projection)
mIP (minimal intensity projection)
Alpha blending
Cross-sectional view
Threshold
Z-thick
Contrast
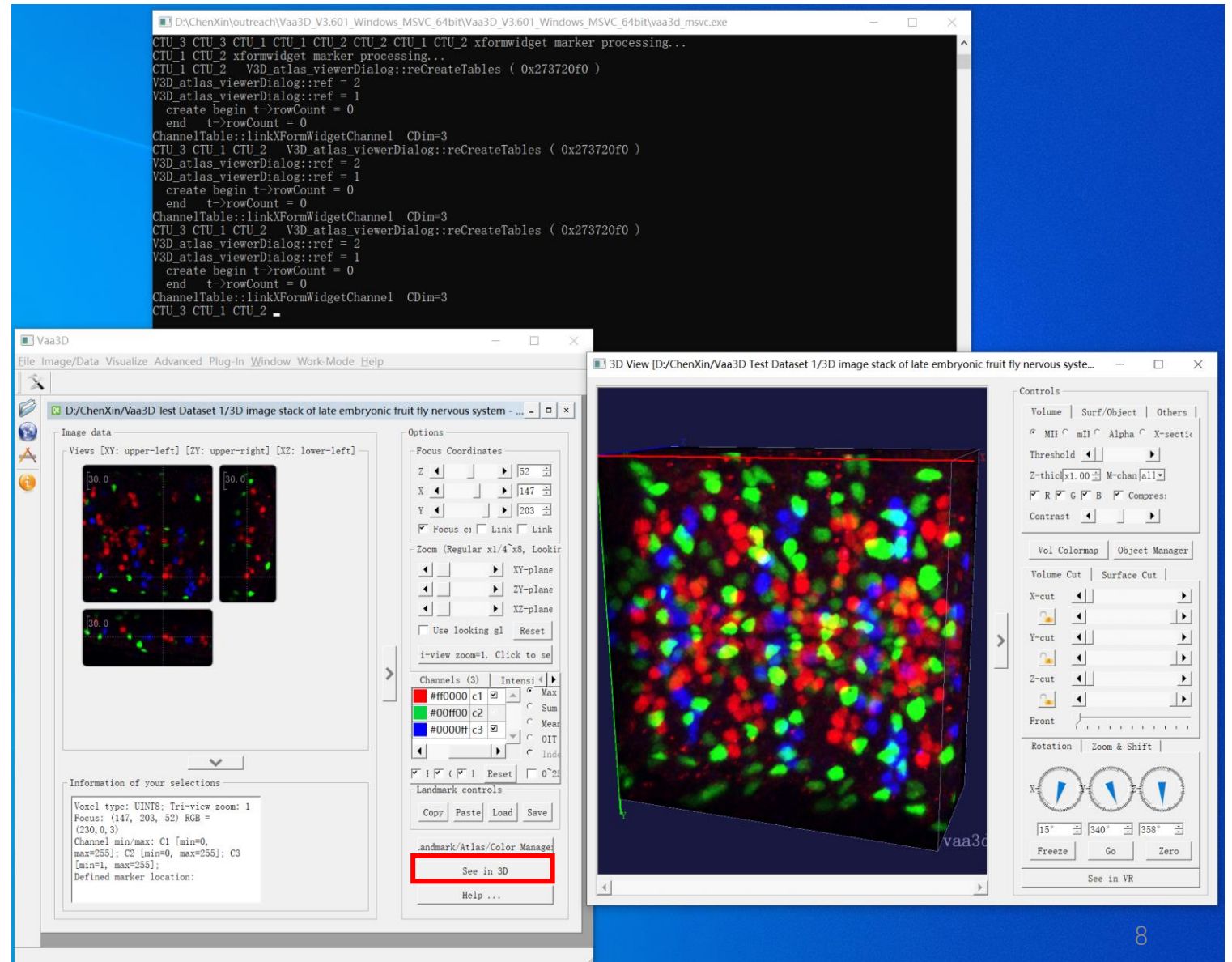Channel
Surf/Object
Volume Colormap
Object Manager
Volume Cut
Surface Cut
Rotation, Zoom, Shift
……

Vaa3D-TeraFly: Overview

TeraFly extends the Vaa3D software to cope with (potentially) **unlimited** sized bioimage even on laptops with a limited amount of system memory (≤ 4 GB) and video card memory (≤ 1 GB)

- fast rendering/visualization of **3/4/5D terabyte**-scale microscopy images
- **instant** zoom-in/out with mouse-scroll
- visualization-assisted **annotation** of 3D objects at different scales
- image format conversion tool (**TeraConverter**) included

- the underlying idea is to mimic the behavior of Google Earth
  - what you see is what you need (WYSIWYN)
  - multiresolution representation

Google Earth

Bria, A. et al. Nature Methods, 2016.
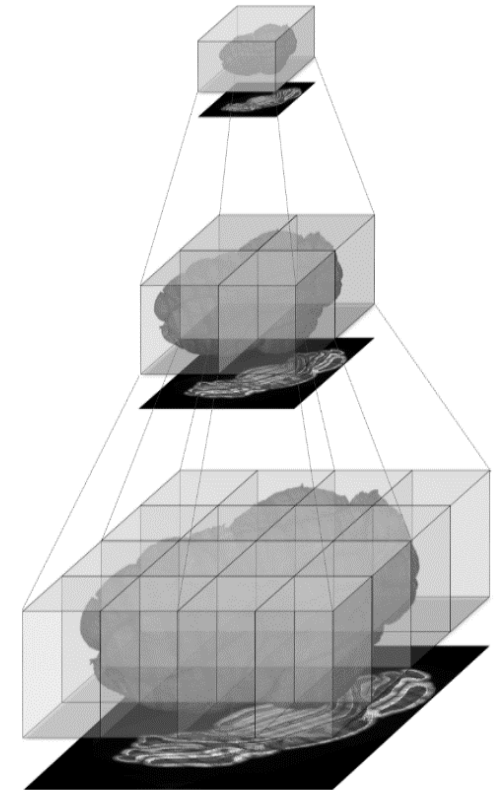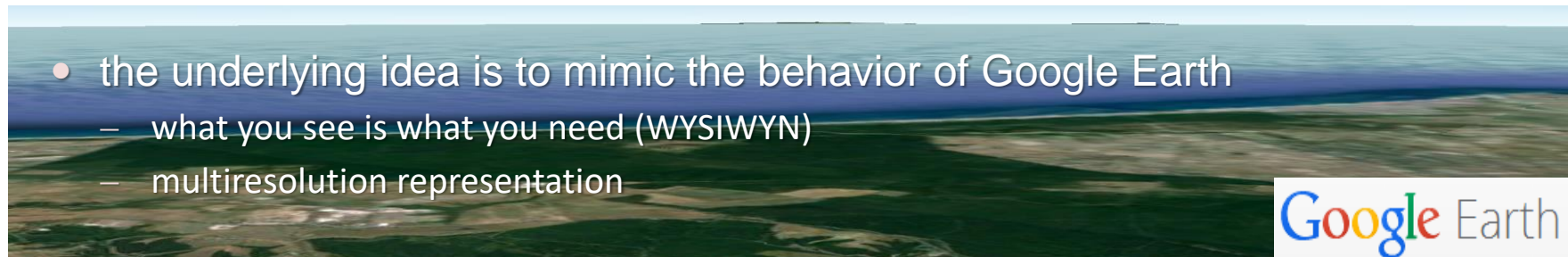
Vaa3D-TeraFly: Architecture
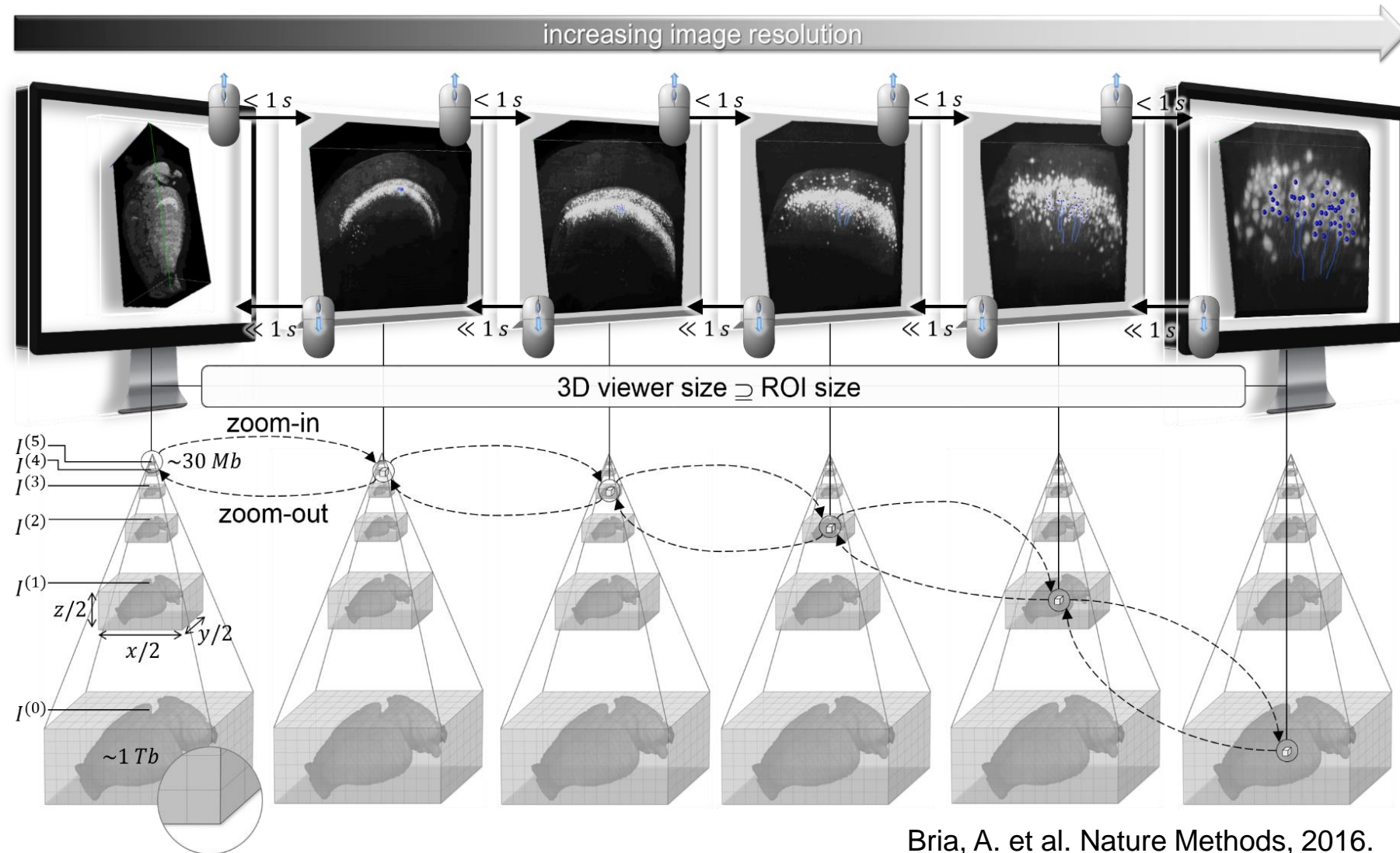
Bria, A. et al. Nature Methods, 2016.

Vaa3D-TeraFly: Schema of 3D-5D Formats

Bria, A. et al. Nature Methods, 2016.
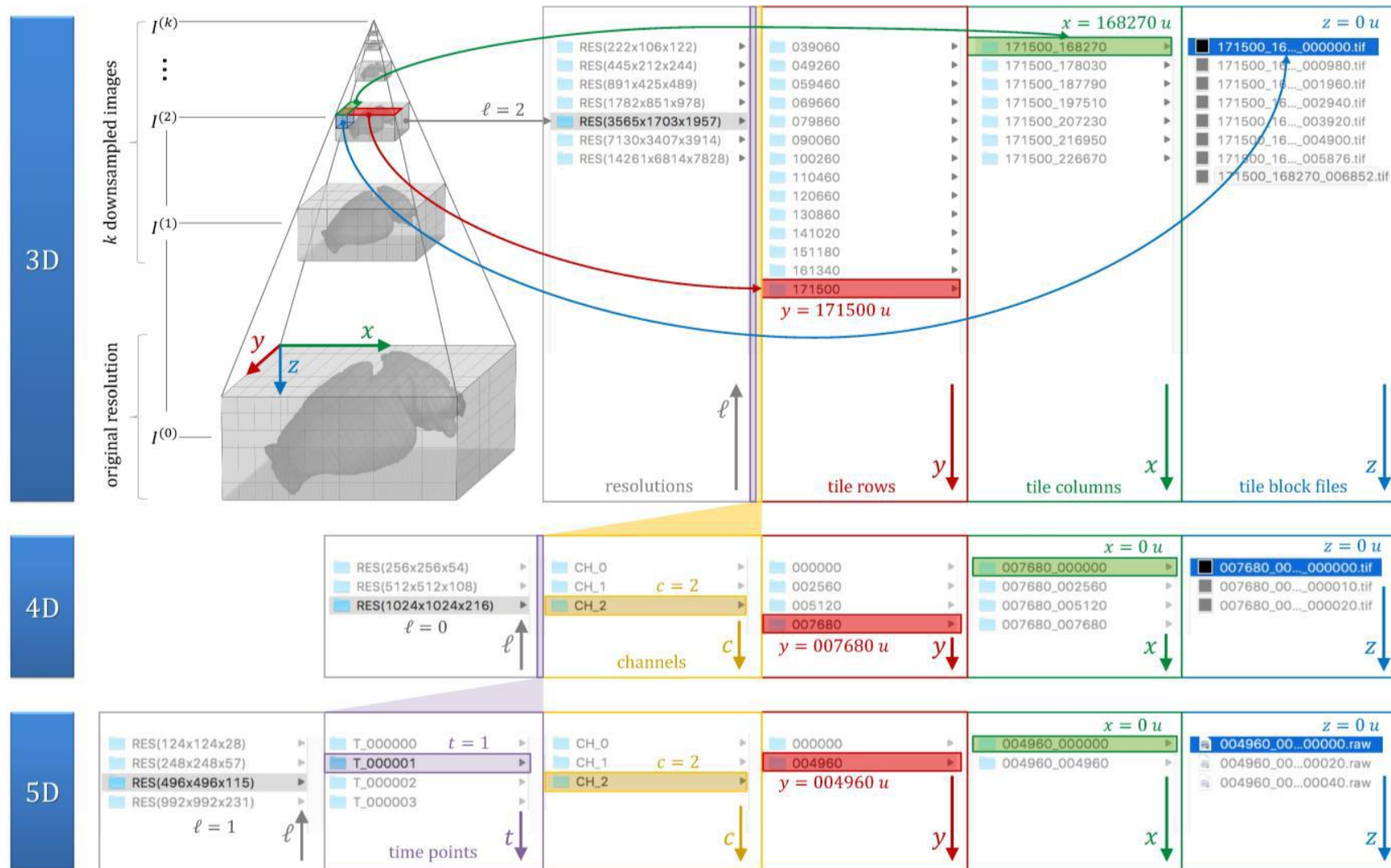
Vaa3D-TeraFly: User Interface
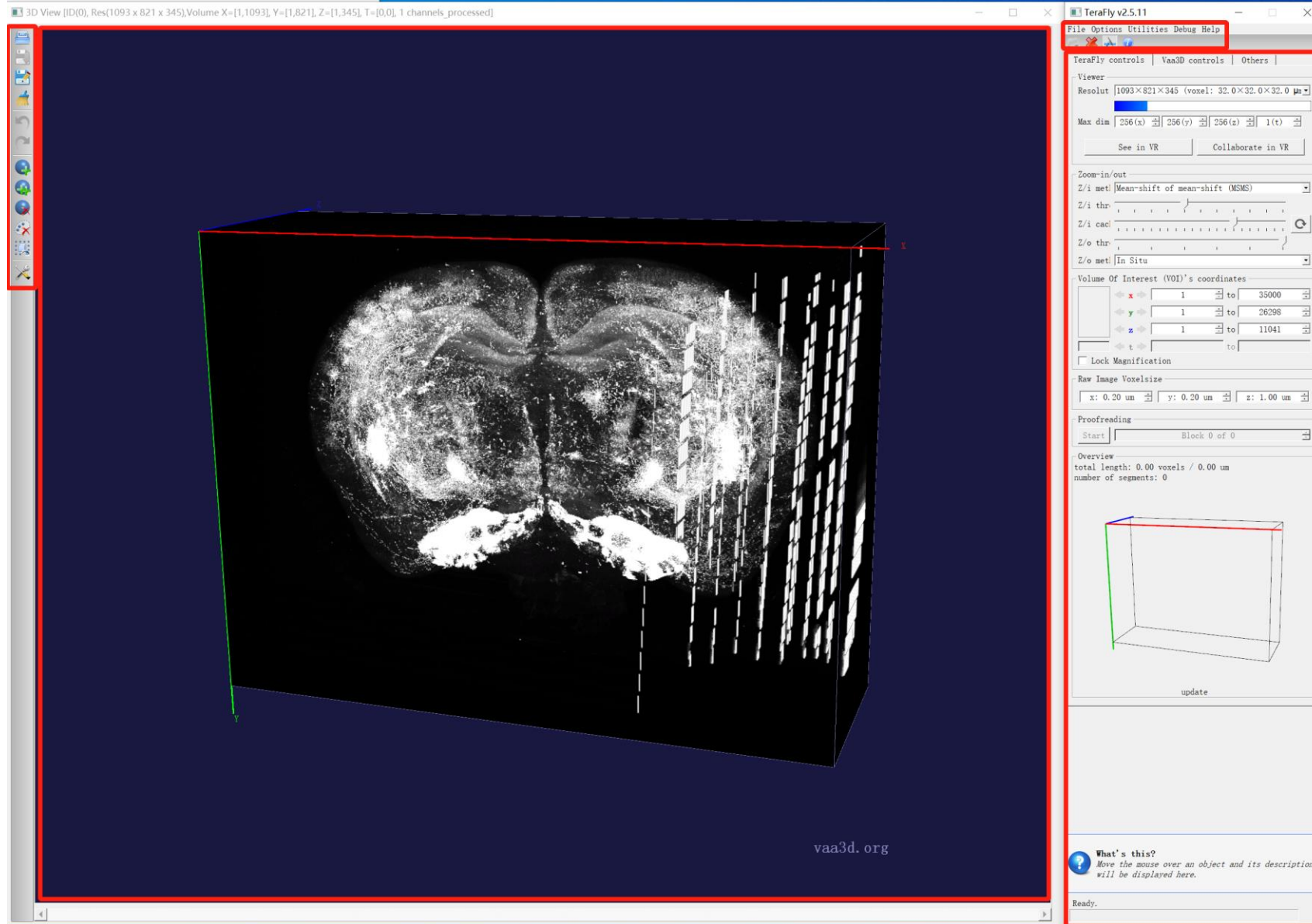
TeraConverter and TeraFly

Generate TeraFly data format:
"Advanced", "Big-Image_Data",
"TeraConverter", "Step 1: Import
volume from:", "Step 2: Convert
volume to:", "Start"

**Visualize the TeraFly data
format generated:** "Advanced",
"Big-Image_Data", "TeraFly",
"File", "Open TeraFly Image (3-
5D)", "RES(......)", "OK", zoom
in/out, rotate
Adjust the control panel such as
shift, resolution, Z-thick, contrast,
Volume Cut, Surface Cut
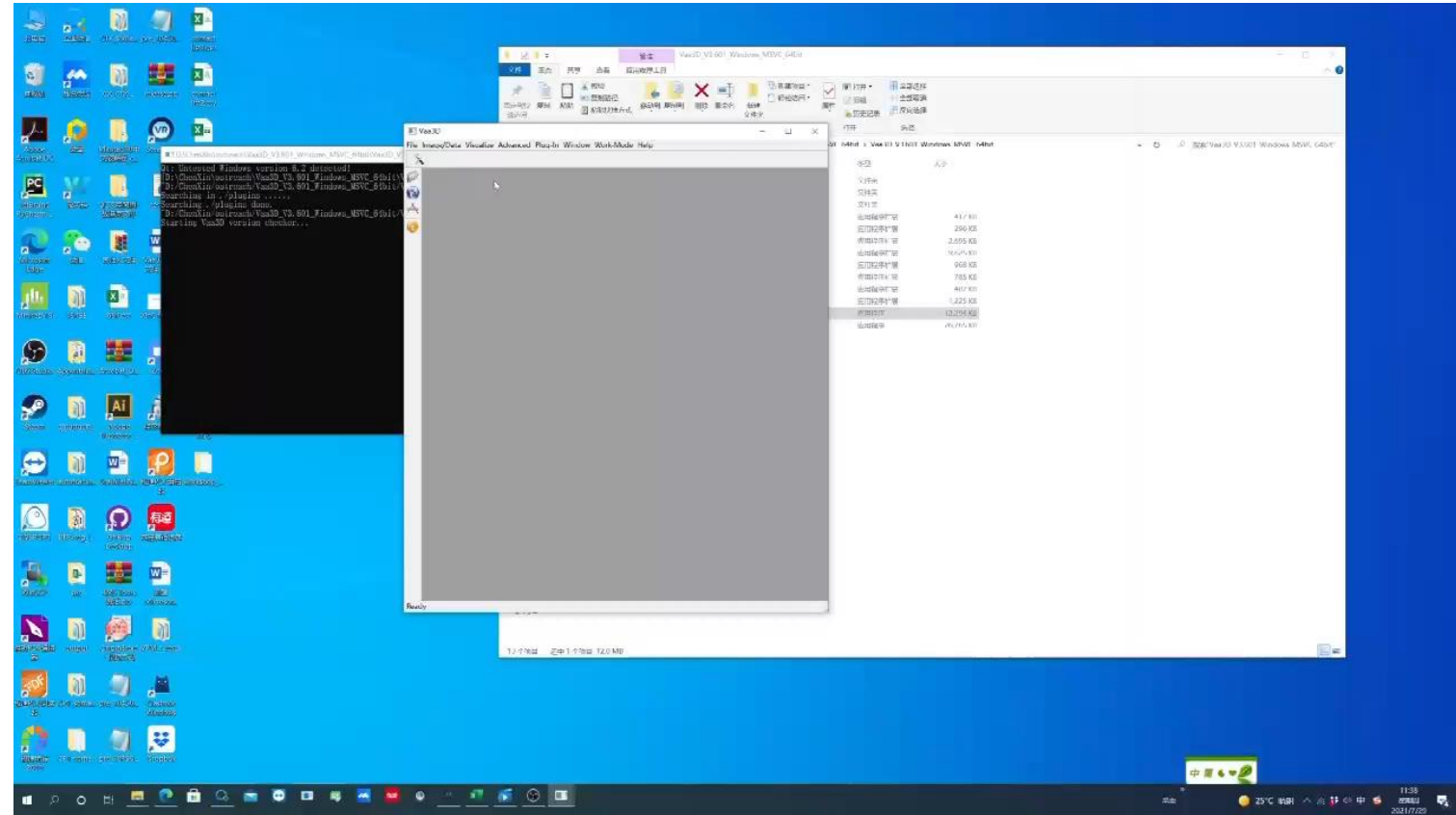
TeraVR

Integrate immersive and collaborative
3-D visualization, interaction, and
hierarchical streaming of teravoxel –
scale images.

Wang, Y. et al. Nature Communications, 2019.

TeraVR

TeraVR (single user): see in VR
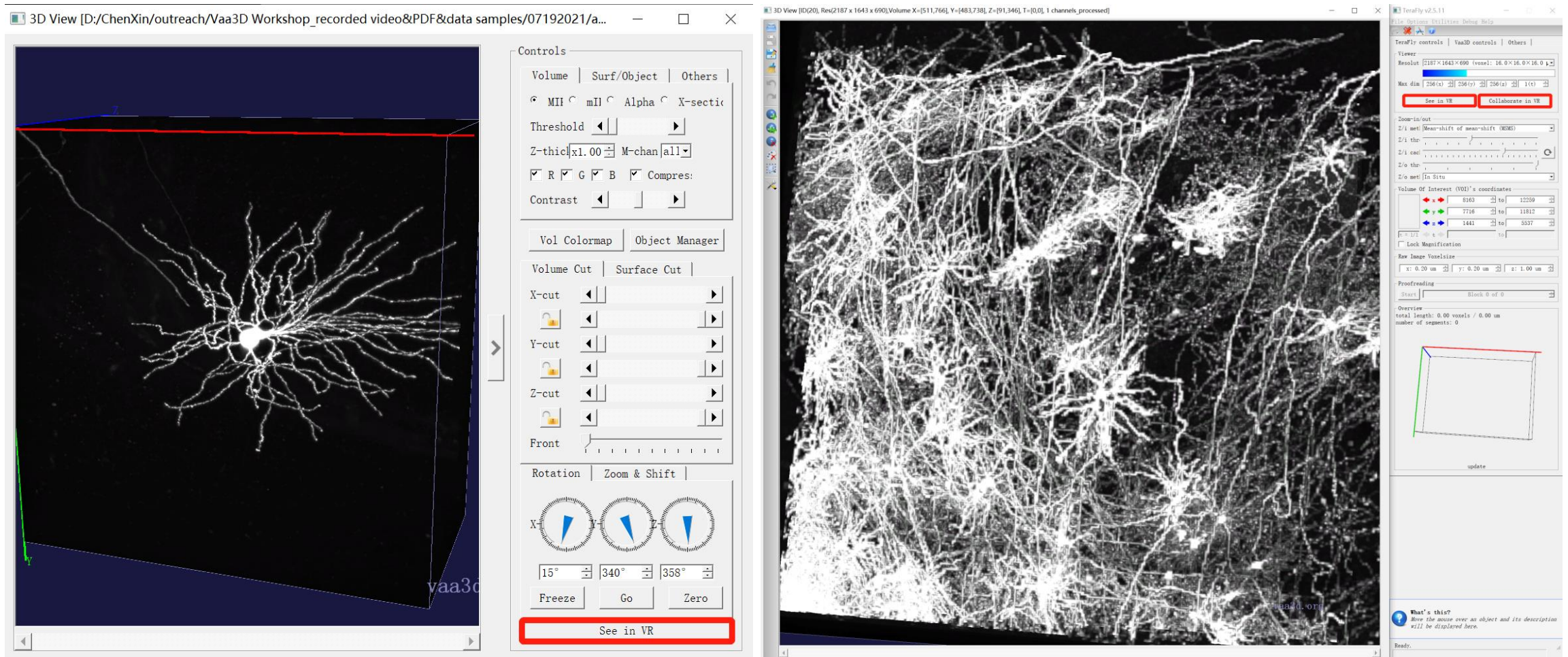**VR-Farm (multiple users):** collaborate in VR
MR-Farm (multiple users)

TeraVR

Summary

Vaa3D – 3D Visualization-Assisted Analysis

Visualize various multidimensional (3D/4D/5D) biodata

- Tri-view
- 3D viewer – 3D/4D/5D bioimage
- TeraFly – bioimage with unlimited size
- TeraVR – immersive

Extended readings

More details can be found in the below papers:

- Peng, H., Ruan, Z., Long, F., Simpson, J.H. & Myers, E.W. V3D enables real-time 3D visualization and quantitative analysis of large-scale biological image data sets. Nat. Biotechnol. 28, 348-353 (2010). DOI:10.1038/nbt.1612

- Peng, H., Bria, A., Zhou Z., Iannello, G. & Long, F. Extensible visualization and analysis for multidimensional images using Vaa3D. Nat. Protoc. 9, 193-208 (2014). DOI:10.1038/nprot.2014.011

- Peng, H., Tang, J., Xiao, H., Bria, A., et al. Virtual finger boosts three-dimensional imaging and microsurgery as well as terabyte volume image visualization and analysis. Nat. Commun. 5, 4342 (2014). DOI:10.1038/ncomms5342

- Bria, A., Iannello, G., Onofri, L. & Peng, H. TeraFly: real-time three-dimensional visualization and annotation of terabytes of multidimensional volumetric images. Nat. Methods 13, 192-194 (2016). DOI:10.1038/nmeth.3767

- Wang, Y. et al. TeraVR empowers precise reconstruction of complete 3-D neuronal morphology in the whole brain. Nat. Commun. 10, 3474 (2019). DOI:10.1038/s41467-019-11443-y

Thank you!