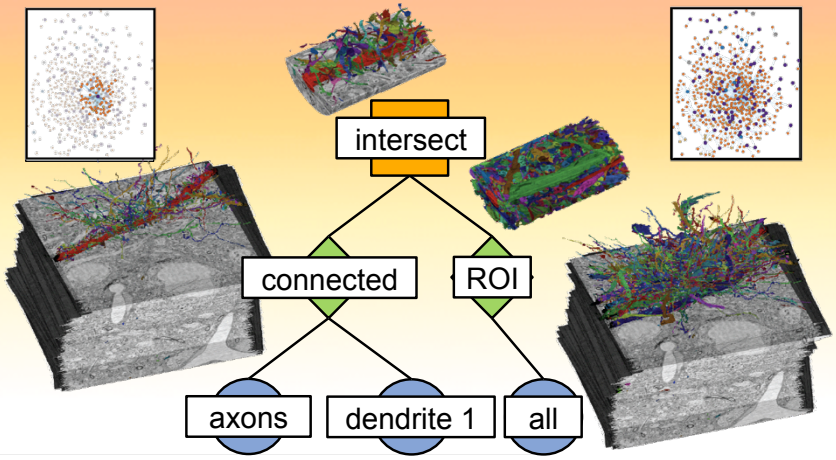
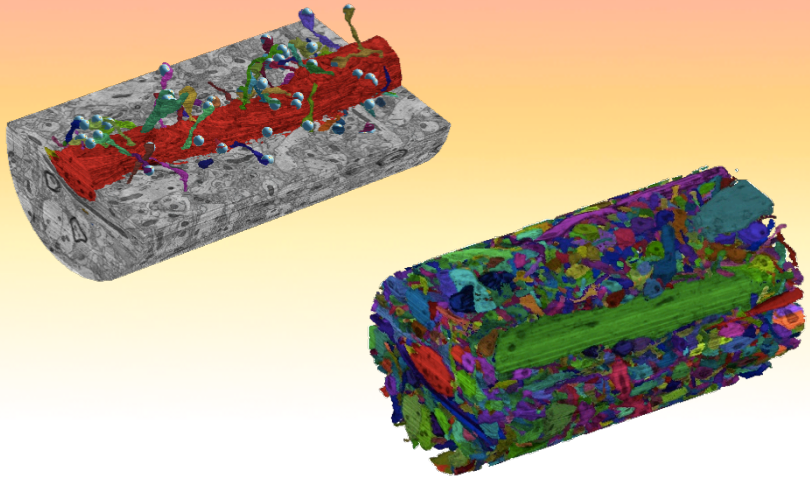




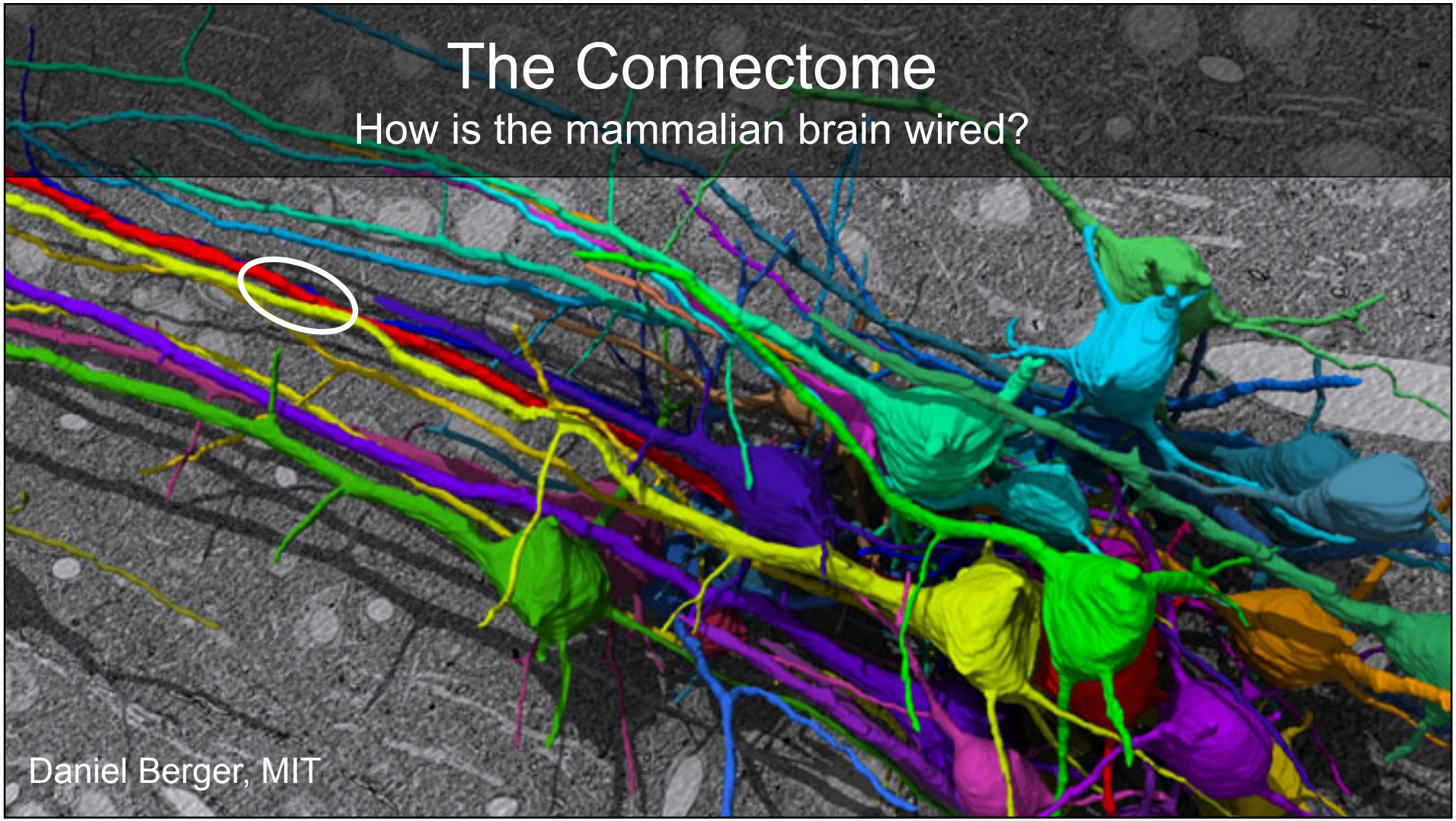
ConnectomeExplorer

Query-Guided Visual Analysis of Large Volumetric Neuroscience Data

KAUST

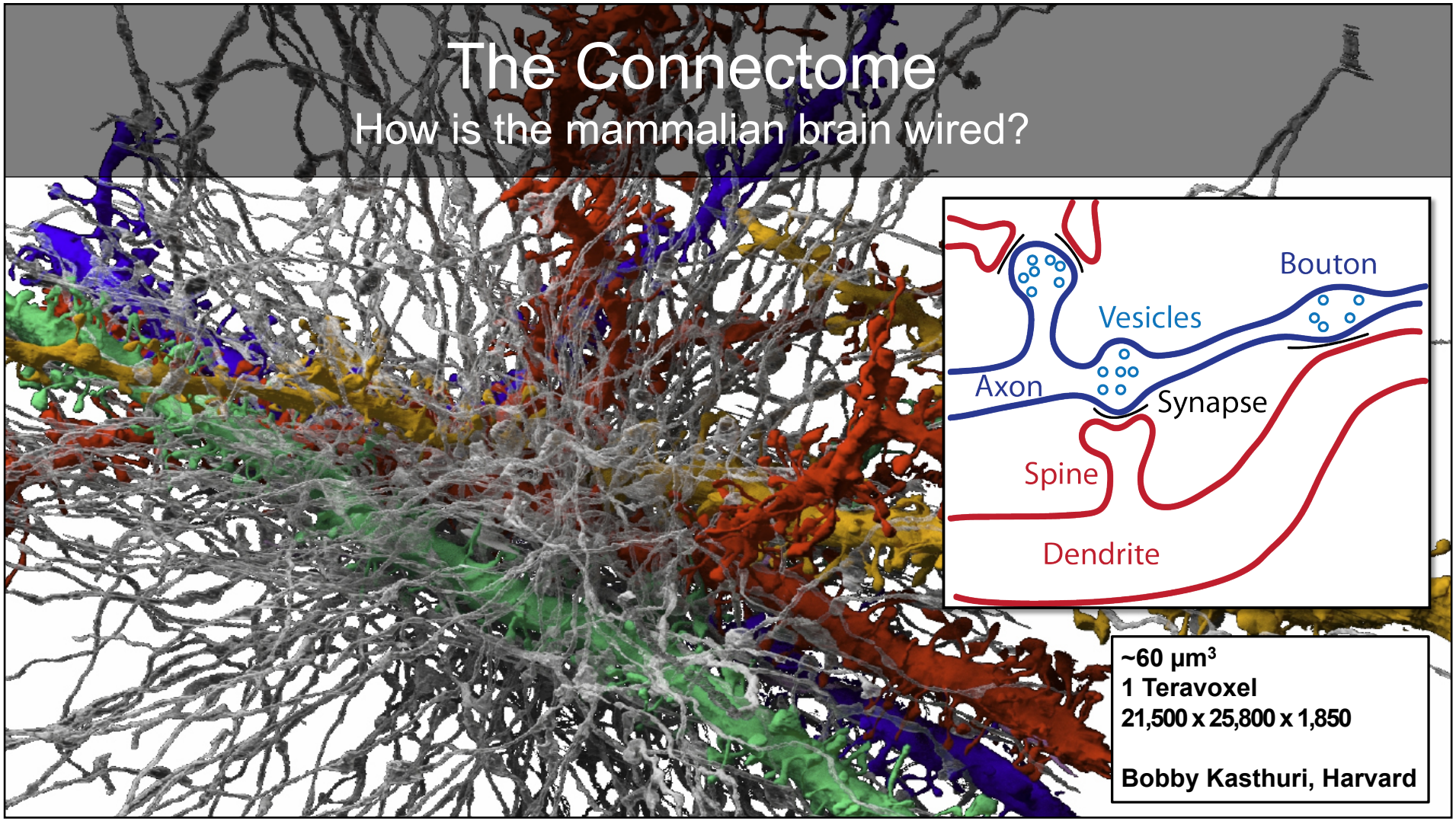
HARVARD
School of Engineering
and Applied Sciences

Johanna Beyer, Ali Al-Awami, Bobby Kasthuri,
Jeff W. Lichtman, Hanspeter Pfister, Markus Hadwiger


The Connectome
How is the mammalian brain wired?
Daniel Berger, MIT

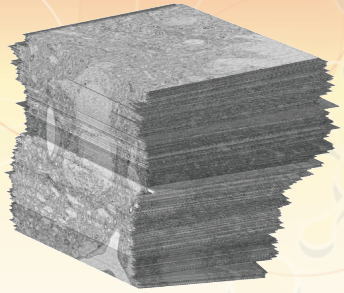
The Connectome

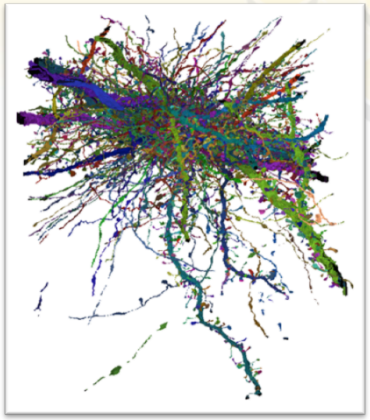
How is the mammalian brain wired?

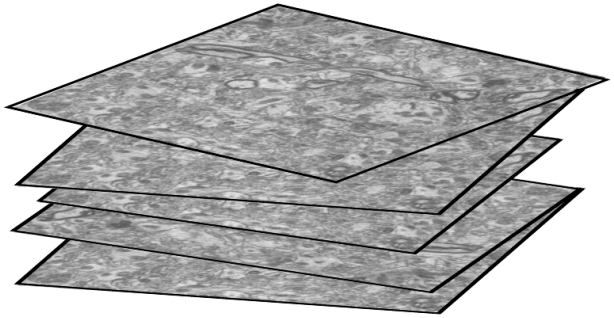


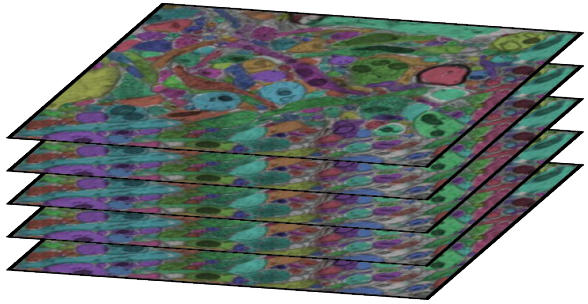
Motivation

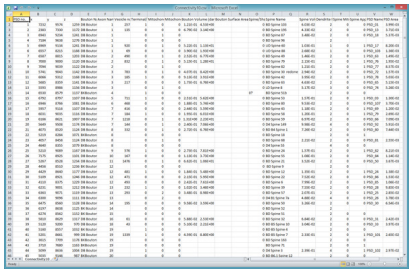
- Huge amount of data scanned
- Took years to align and segment
- How to analyze it?



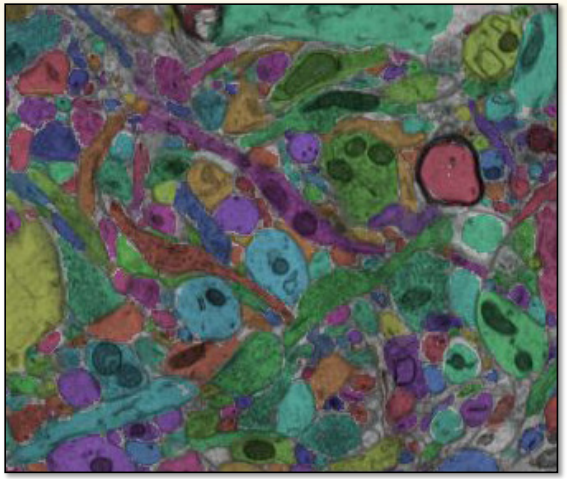


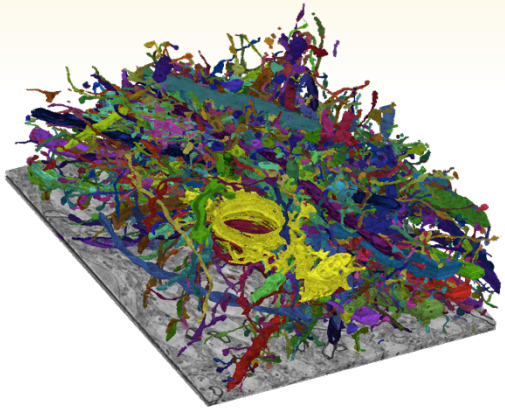


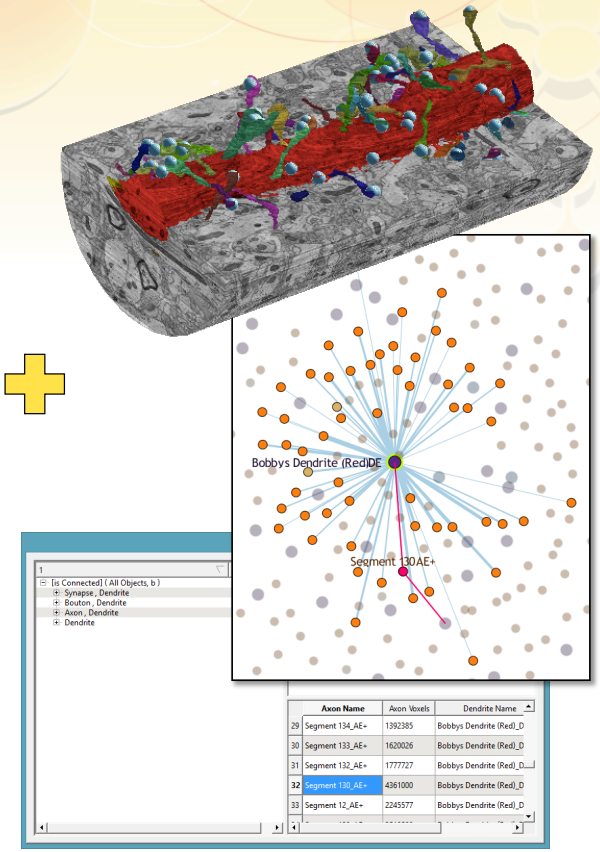




Towards Visual Connectomics

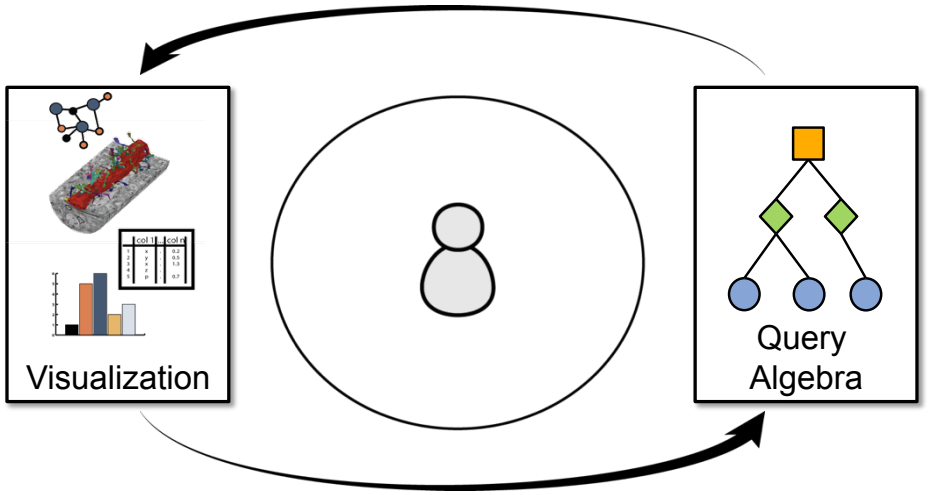


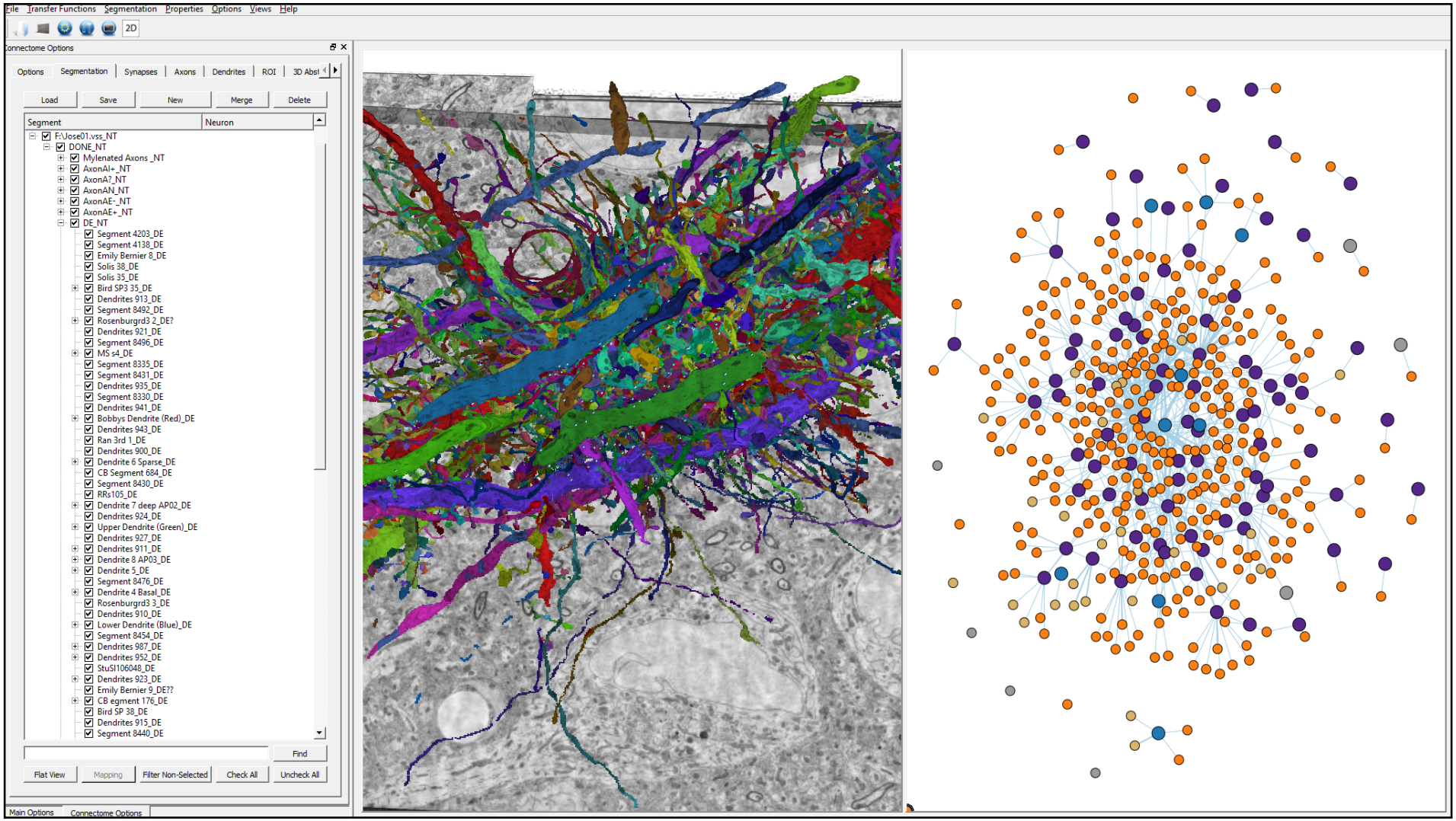




Contributions

- Fully dynamic, domain-specific queries
- Simple set-based query algebra
- Iterative, interactive query specification
- Query-driven petascale visualization pipeline (extends [SciVis 2012])




File Transfer Functions Segmentation Properties Options Views Help
2D
Connectome Options
Options Segmentation Synapses Axons Dendrites ROI 3D Abst
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AxonA?_NT
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Bird SP3 35_DE
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Dendrites 943_DE
Ran 3rd 1_DE
Dendrites 900_DE
Dendrite 6 Sparse_DE
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Segment 8430_DE
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Dendrite 7 deep AP02_DE
Dendrites 924_DE
Upper Dendrite (Green)_DE
Dendrites 927_DE
Dendrites 911_DE
Dendrite 8 AP03_DE
Dendrite 5_DE
Segment 8476_DE
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Rosenburgrd3 3_DE
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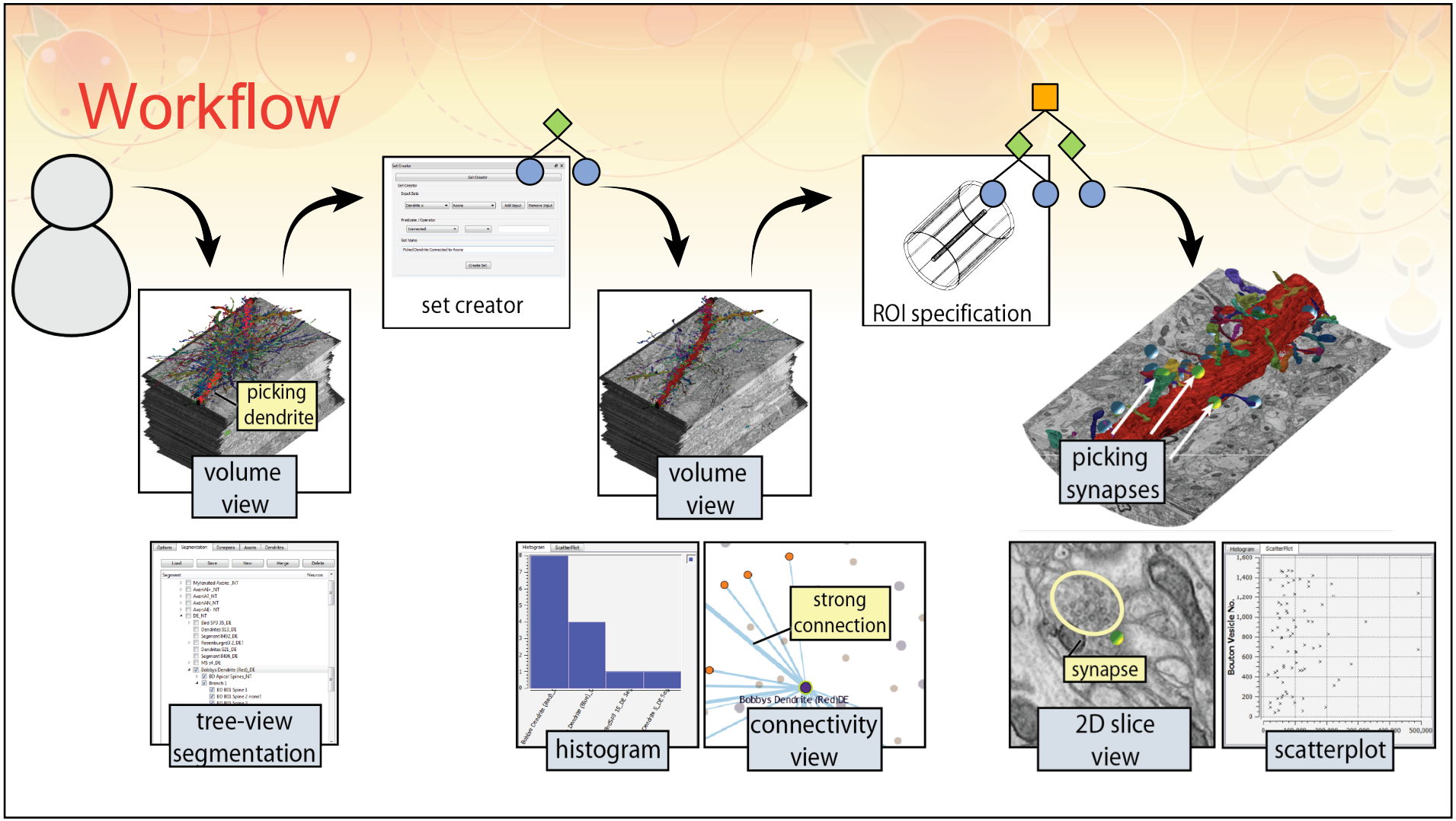
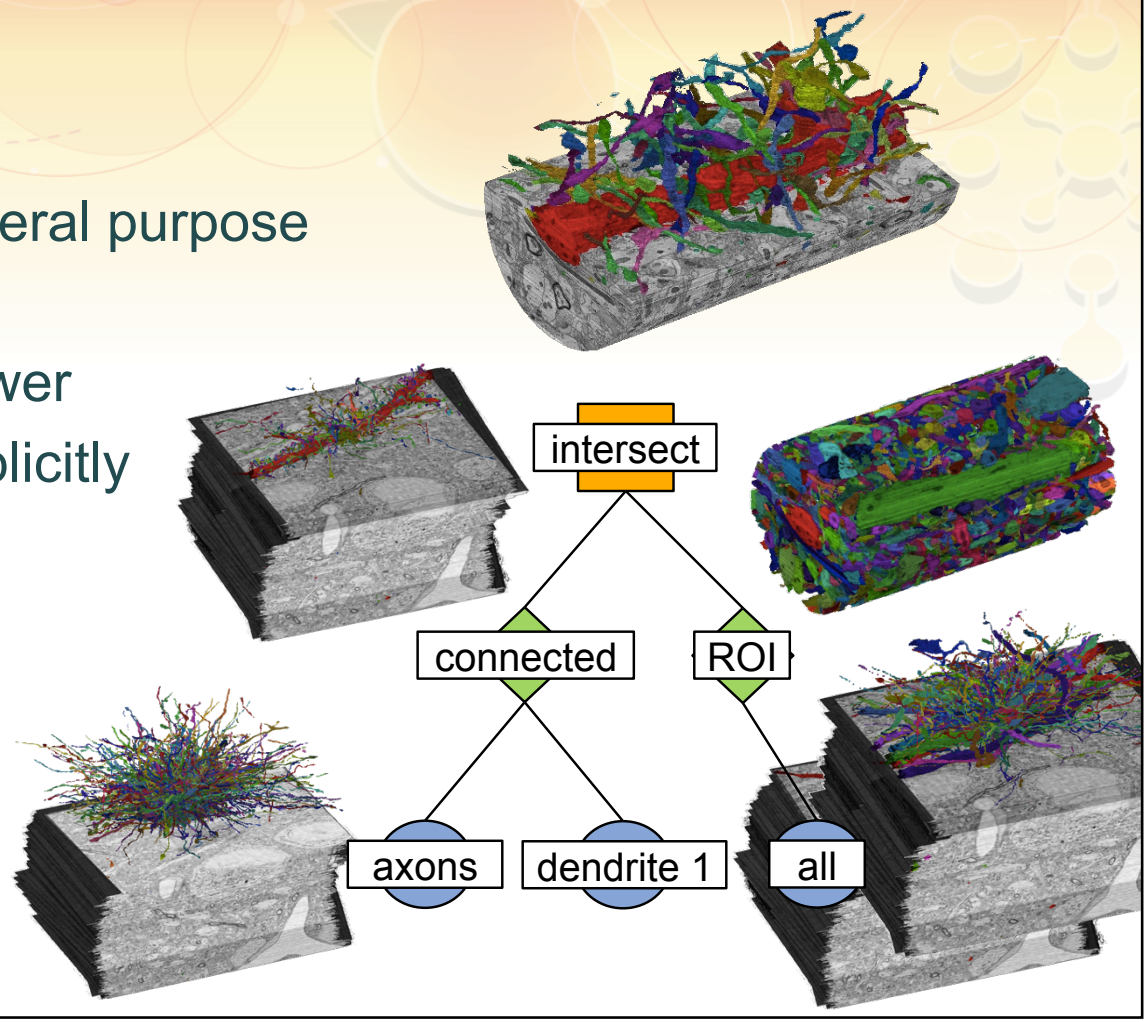

Workflow
picking dendrite
volume view
set creator
volume view
ROI specification
picking synapses
tree-view segmentation
histogram
strong connection
Bobbys Dendrite (Red)DE
connectivity view
synapse
2D slice view
scatterplot

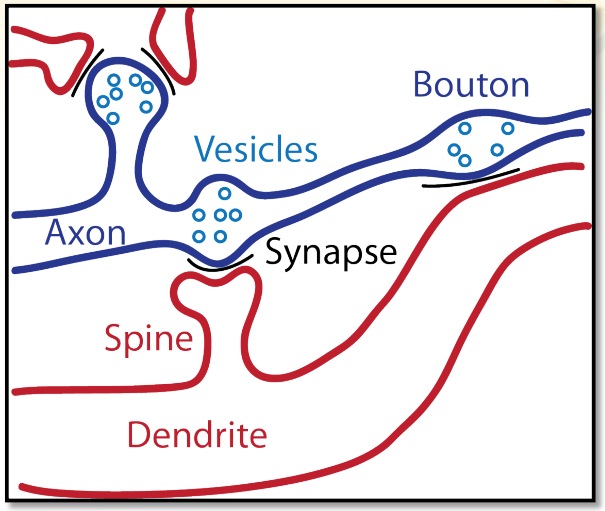
Dynamic Queries

- Knowledge-based vs. general purpose
  - Simple to use
  - Enough expressive power
  - Exploit connectivity implicitly
- Components
  - Query algebra
  - Visual Set Creator



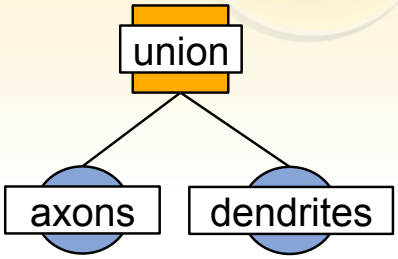
Set Algebra

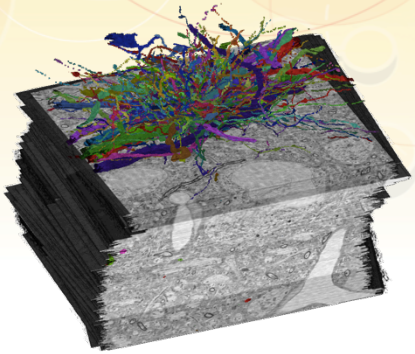
- Result of every query is a set
- Set can contain:
  - Objects axons {axon x, synapse y}
  - Ordered tuples of objects <axons, dendrites>
  - Sets {{synapses axon 1}, {synapses axon 2}}
- Object attributes
  - name, size, excitatory, vesicle number, etc.

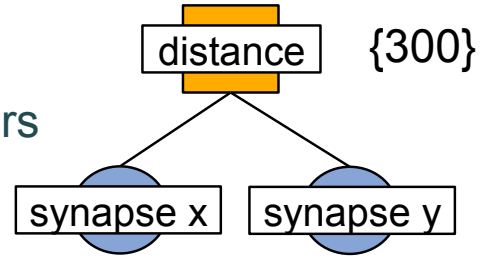


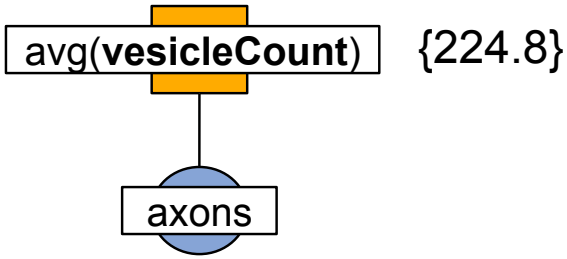
Operators

- Set operators
  - `union, intersect, etc.`
  - `project`
  - `group`
- Spatial operators
  - `distance`
- Statistical operators
  - `avg, count, dev, etc.`



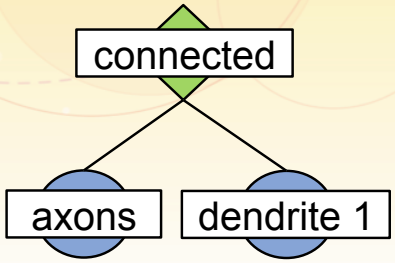


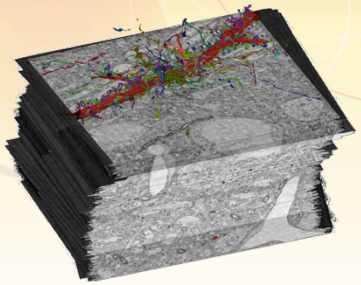




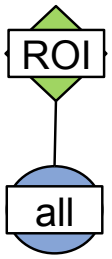
Predicates

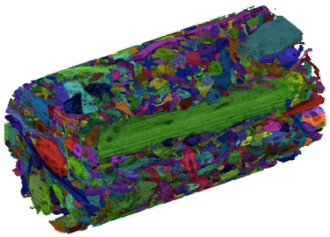
- Topological predicates
  - `connected, part of`



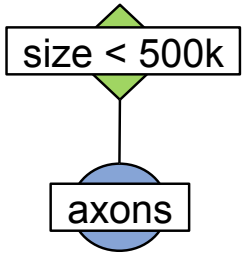


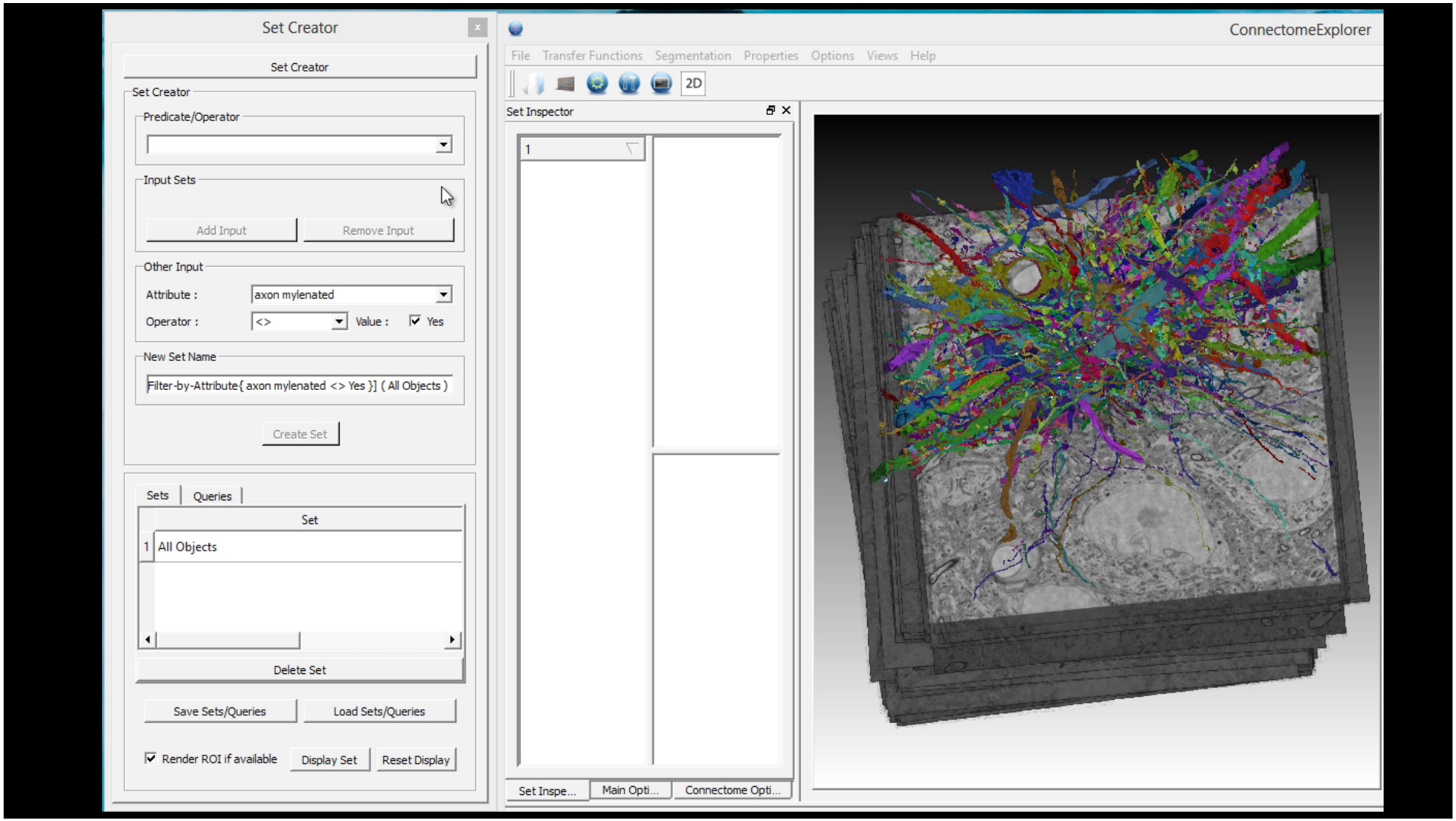
- Spatial predicates
  - `ROI, distance`





- Object attribute predicates




Set Creator
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Transfer Functions
Segmentation
Properties
Options
Views
Help
2D
Set Inspector
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Set Inspe...
Main Opti...
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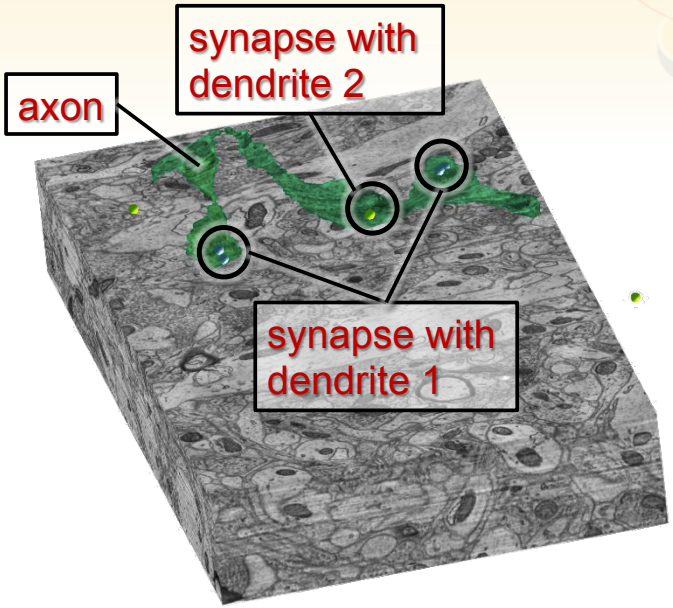
Use Case – Multiple Hit Axon

Goal:

- Analyze connectivity and morphology
  - Location of synapses
  - Sequential vs.
    non-sequential arrangement
  - Spatial distribution



User Feedback

- Two main user classes
  - Neuroscientist (hypotheses testing, exploration)
  - Data analyst (proofreading)

Feedback:

- ✓ Dynamic exploration & queries
- ✓ 3D visualization
- ✓ Connectivity graph view
- ✓ Linked views
- ✓ Quantitative analysis

Conclusions

- ✓ Powerful, yet simple query algebra

  intuitive interactive exploration & analysis of large neuroscience data

- ✓ Built-in domain knowledge

  makes queries simpler & more powerful

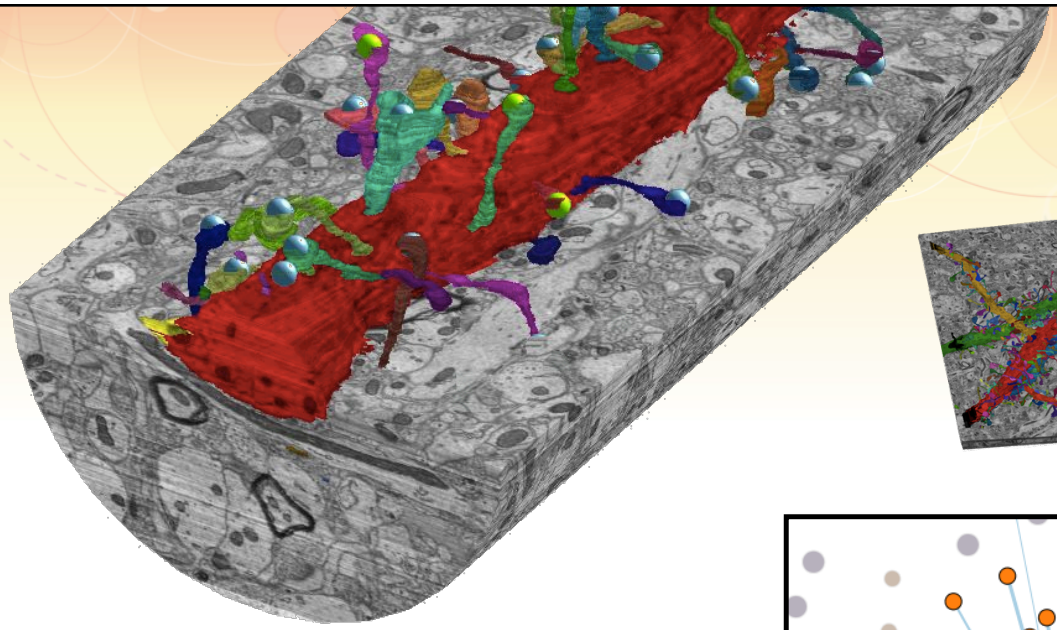
- ✓ Query-driven approach

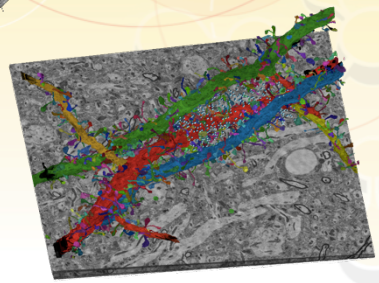
  on-the-fly query evaluation with petascale memory management

- ✓ Iterative query refinement

  allows to quickly extend, combine, shuffle existing queries

Thanks





Acknowledgements:

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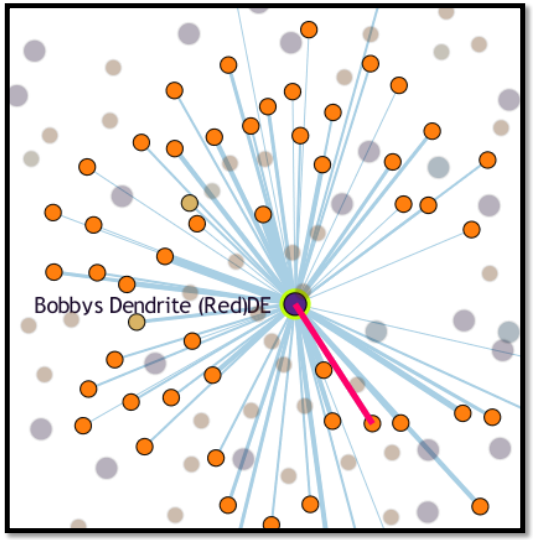
http://seas.harvard.edu/~jbeyer/connectome_explorer.html



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