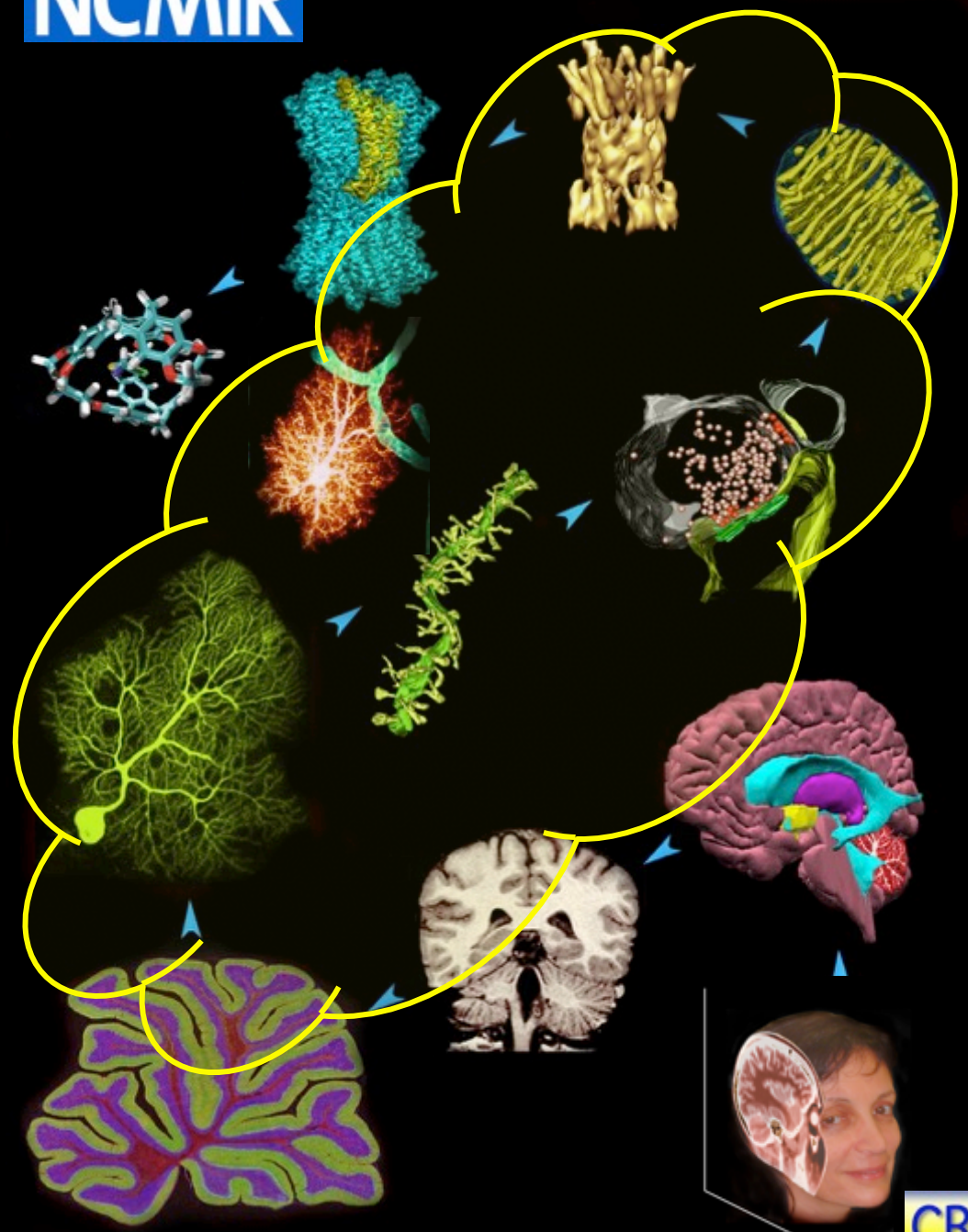
NCMIR

# National Center for Microscopy and Imaging Research

UCSD



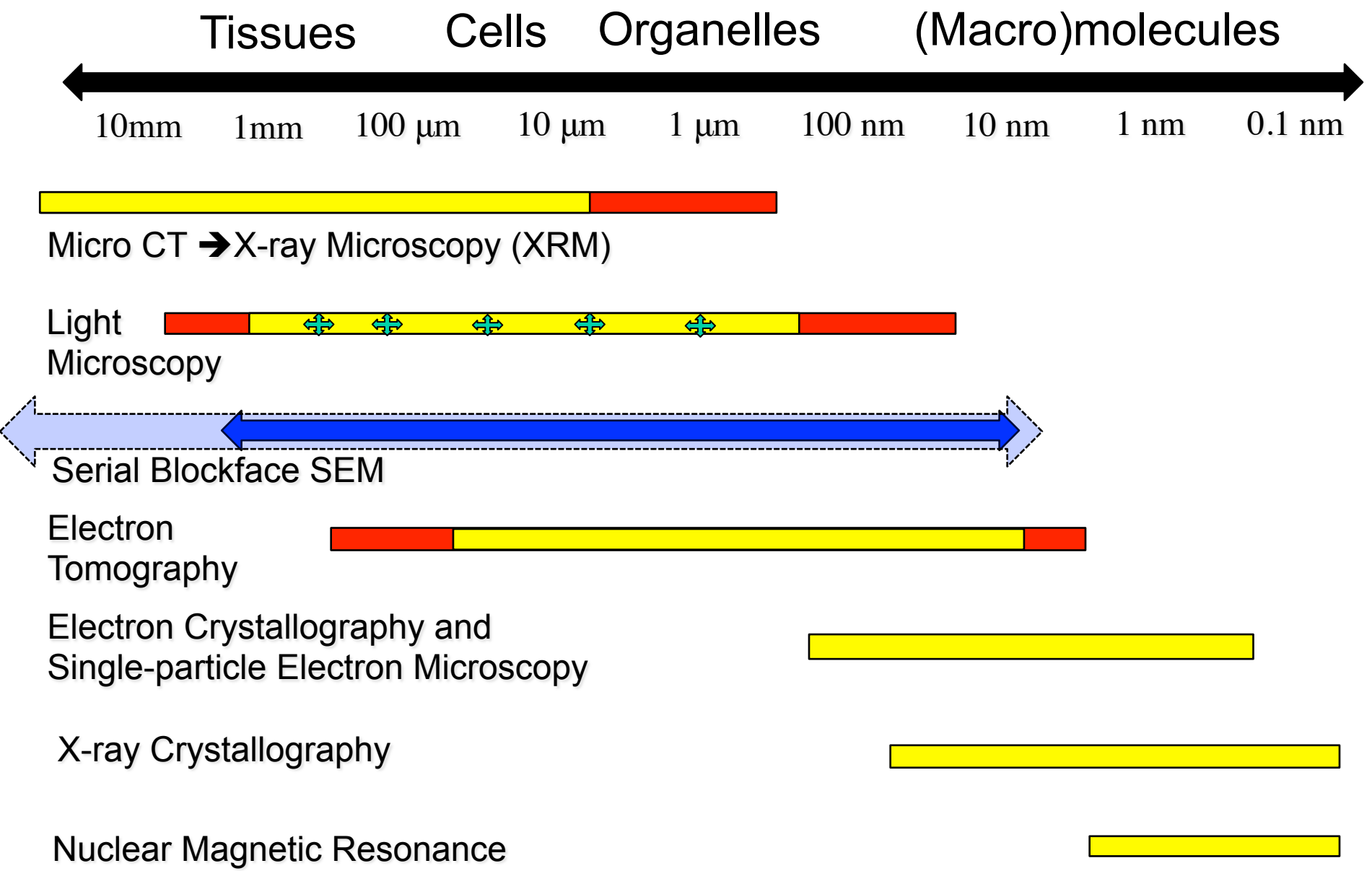

## *Mark H. Ellisman*

*Distinguished Professor of Neurosciences*
*UCSD School of Medicine*
*Center for Research on Biological Systems*


- *New technology development to bridge information gaps in the "mesoscale"*
- *Develop new tools for "correlated microscopy", driven by important biomedical research challenges.*

UCSD IDI Workshop
May 6TH, 2015

# 3D Imaging and Analysis of Cells and Tissues



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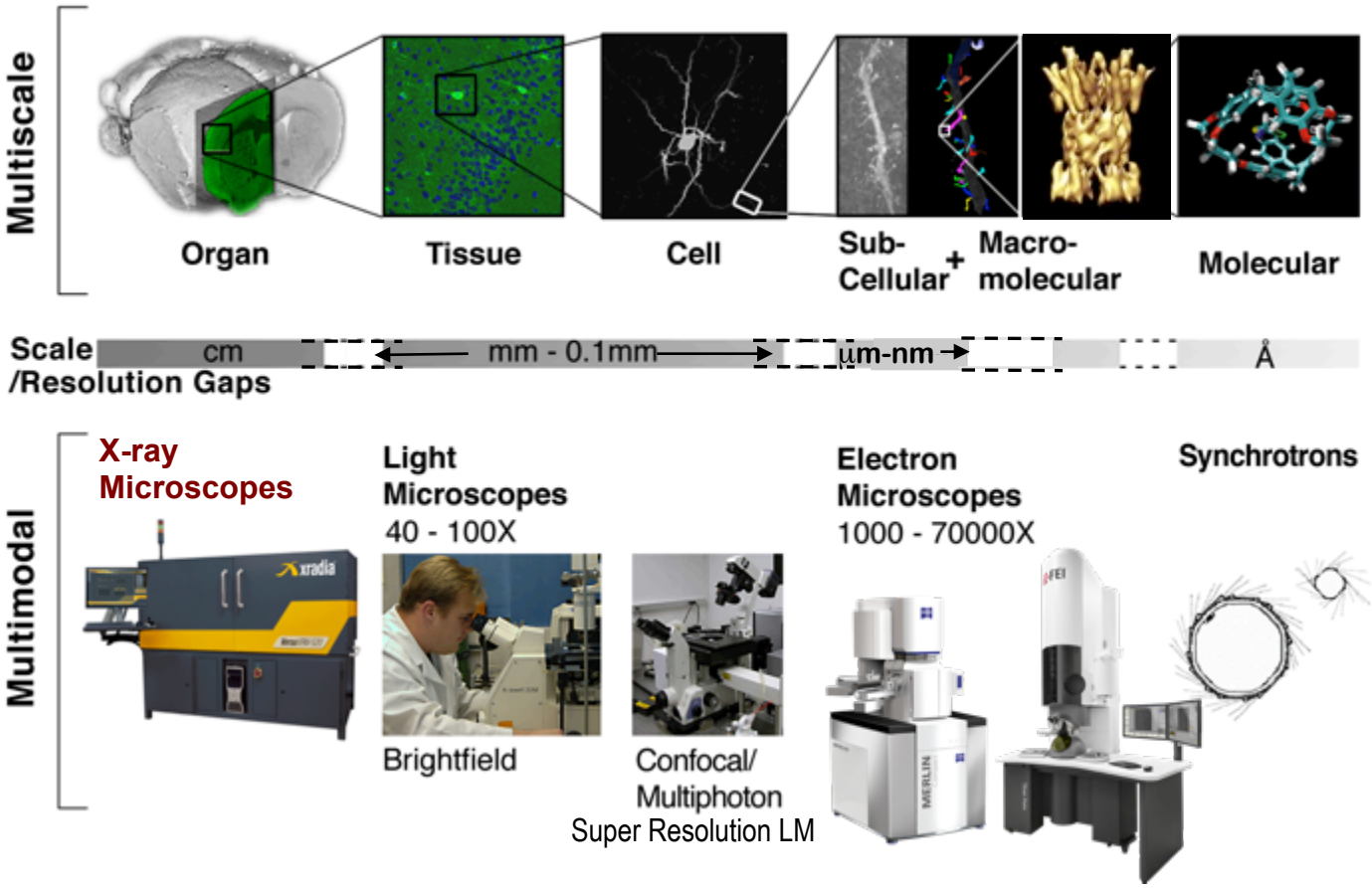
# Identify specific length scales where quantitative imaging remains challenging and develop methods to go there.

*Identify research projects to use as technology drivers requiring smooth traversal of gaps in scale and/or the integration of measurements from multiple methods.*




**Accelerate the processes required to fill in information about biological systems of complete cells for the "mesoscale" – from ~ 4 nm continuously to ~ 100 $\mu$m and beyond – and to provide tools to assemble, explore and analyze these large multiscale data sets.**

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# A RESOURCE of RESOURCES

## Distributed Telemicroscopy Resources

Osaka Univ. PNNL Oxford Univ.

## Community Resources

CCDB/Cell Image Library

Neuroscience Information Framework

PREMIER NETWORK

Pooled Resources for Electron Microscopy, Informatics, Education and Research

## Calit2

HPC Cluster

NBCR

GPGPU Cluster

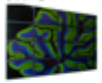
HPC Cluster

CRBS

Petabyte Storage Facility

## Advanced Visualization

StarCAVE



OptIPortal Tiled Display

Development Systems

40 Gbps "PRISM@UCSD"

NCMIR

40 Gbps "PRISM@UCSD"

## SDSC

Production Systems

Data Storage

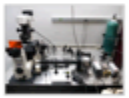
## Petascale Compute Resources

SDSC XSEDE TACC

## Scientific Instruments

Ultra-wide Field Intra-vital LM Instruments

Super-resolution PALM/dSTORM



Multi-color EM, EFTEM

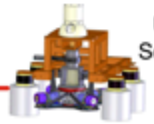
X-ray Microscope

1 Gbps

10 Gbps

Serial Block EMs

Wide-field STEM/TEM EFTEM

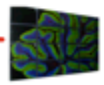


Ultra-wide field Serial Section EM Tomography Instruments

10 Gbps

Graphics Workstations

Large Memory Nodes



OptIPortal Tiled Display

END User FIONA Workstation

10 Gbps

NCMIR Data Storage Servers

High Performance Data Servers NetApp

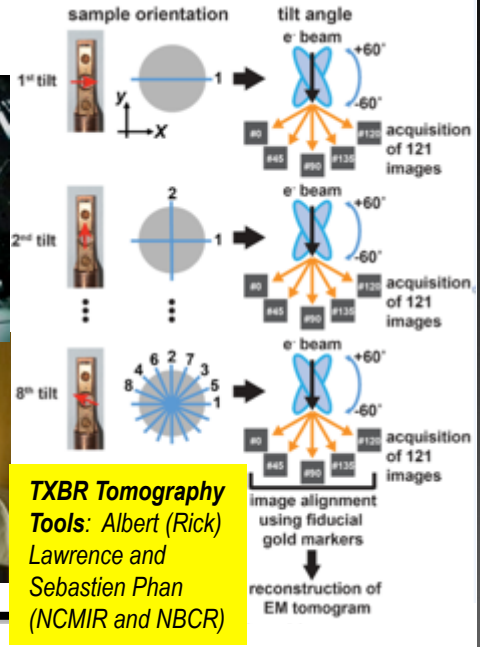
VM Server Farm (Services, Web, DB)

NCMIR

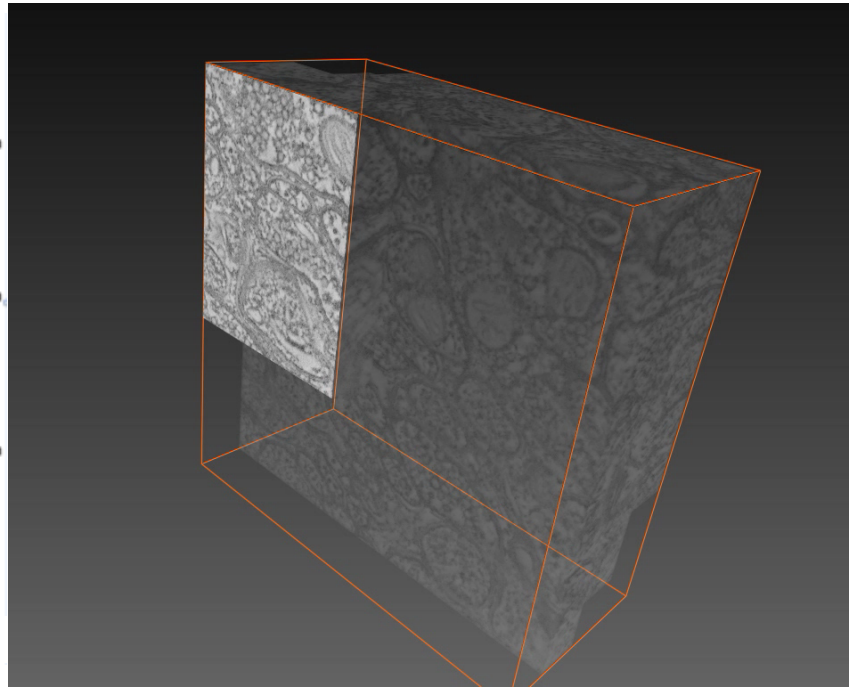
**Local SOM Infrastructure**

# Advances in 3D EM Methods to Image Macromolecules, Cells and Tissues

## *Electron Tomography*

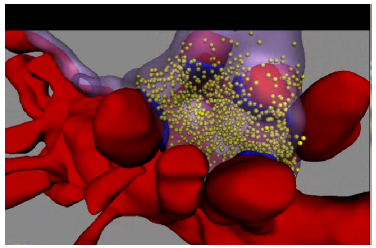


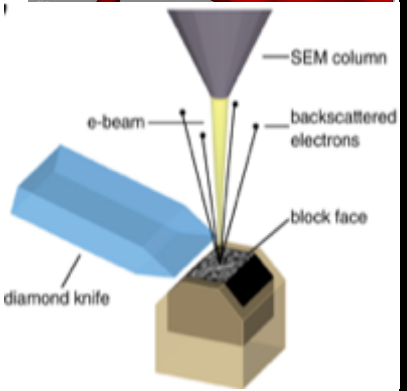

***TXBR Tomography Tools***: *Albert (Rick) Lawrence and Sebastien Phan (NCMIR and NBCR)*

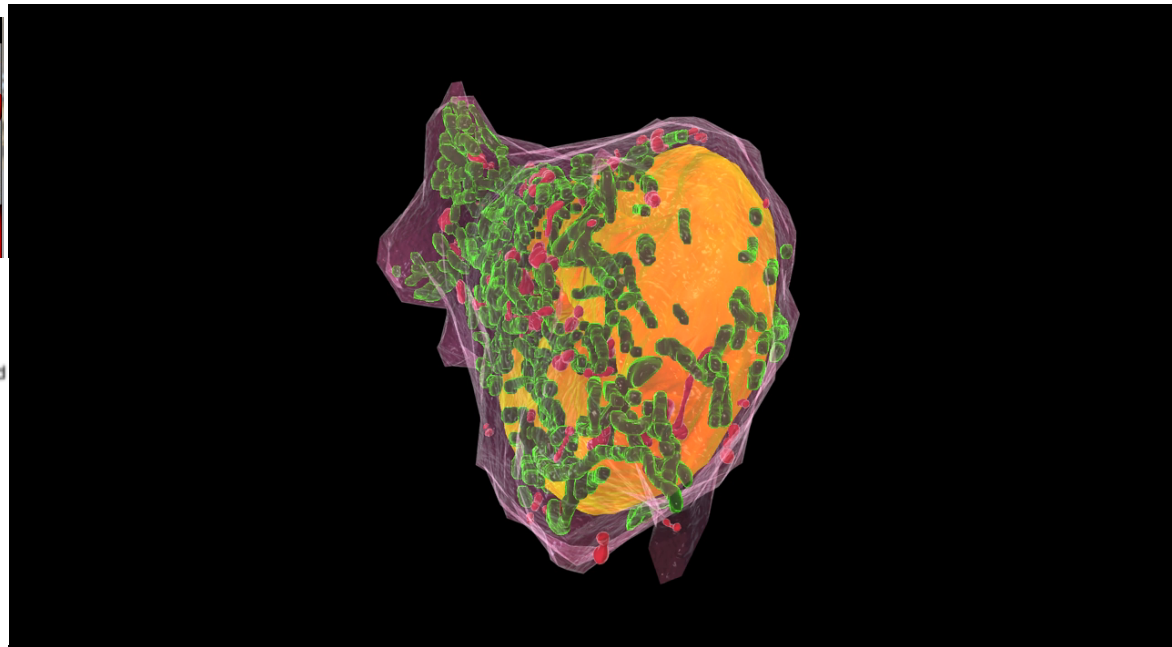


## *Serial Block EM*


## *Ultramicrotome*

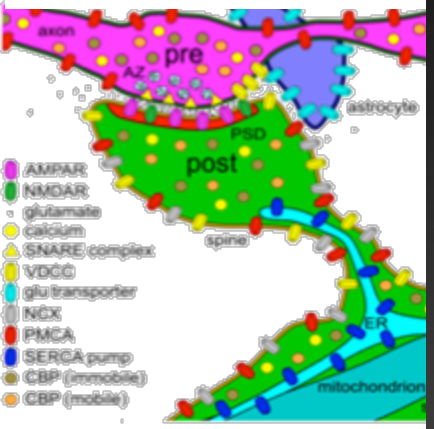




# Multiscale Modeling of Electrodynamics in the Dendritic Spine Head & Neck

*Drawing From Tom Bartol and Terry Sejnowski, Salk Institute*



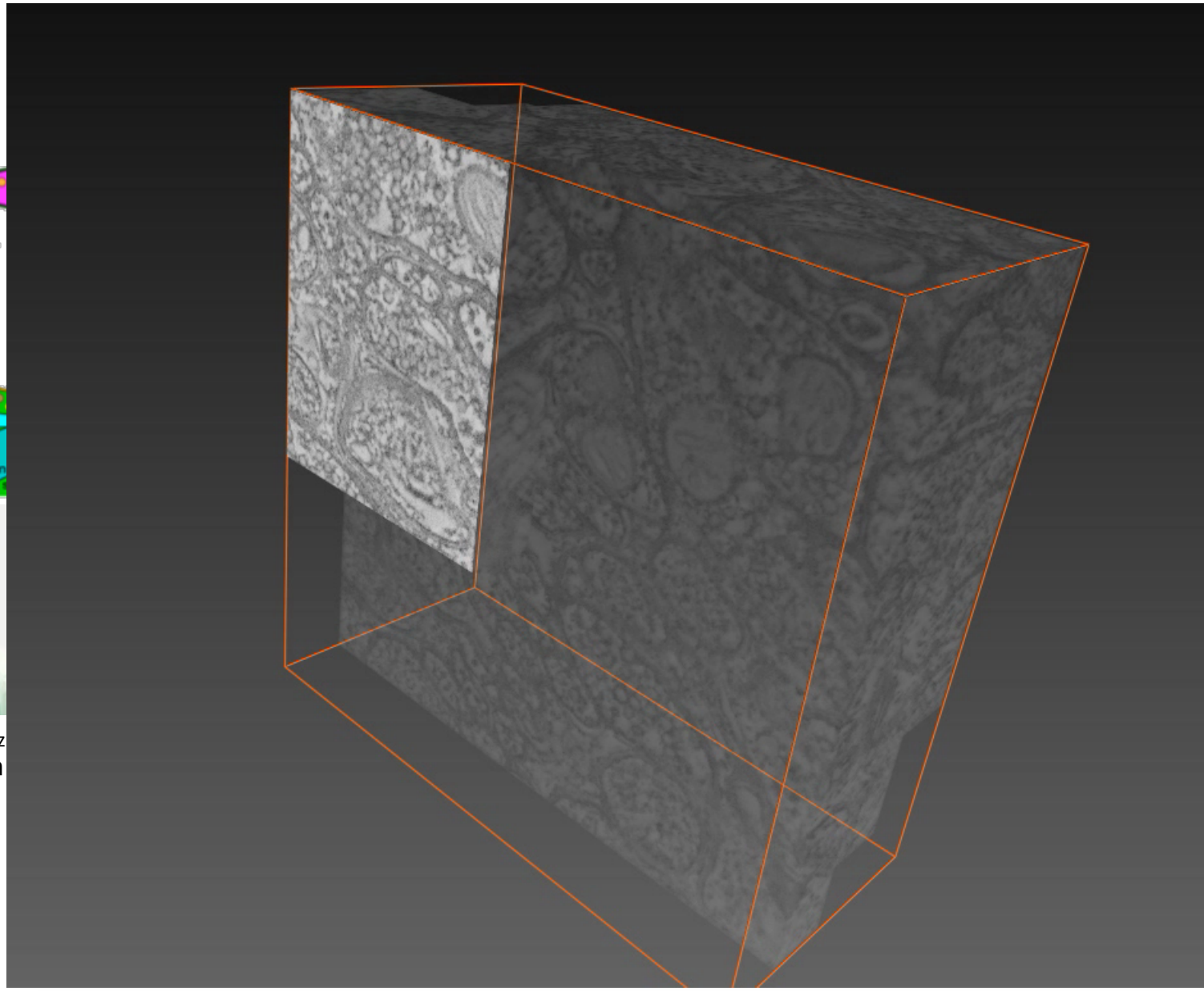

Dinu Patirniche

Prof.Andreas Herz

**Ludwig-Maximilians-Univ.Munich**

Eric Bushong
NCMIR

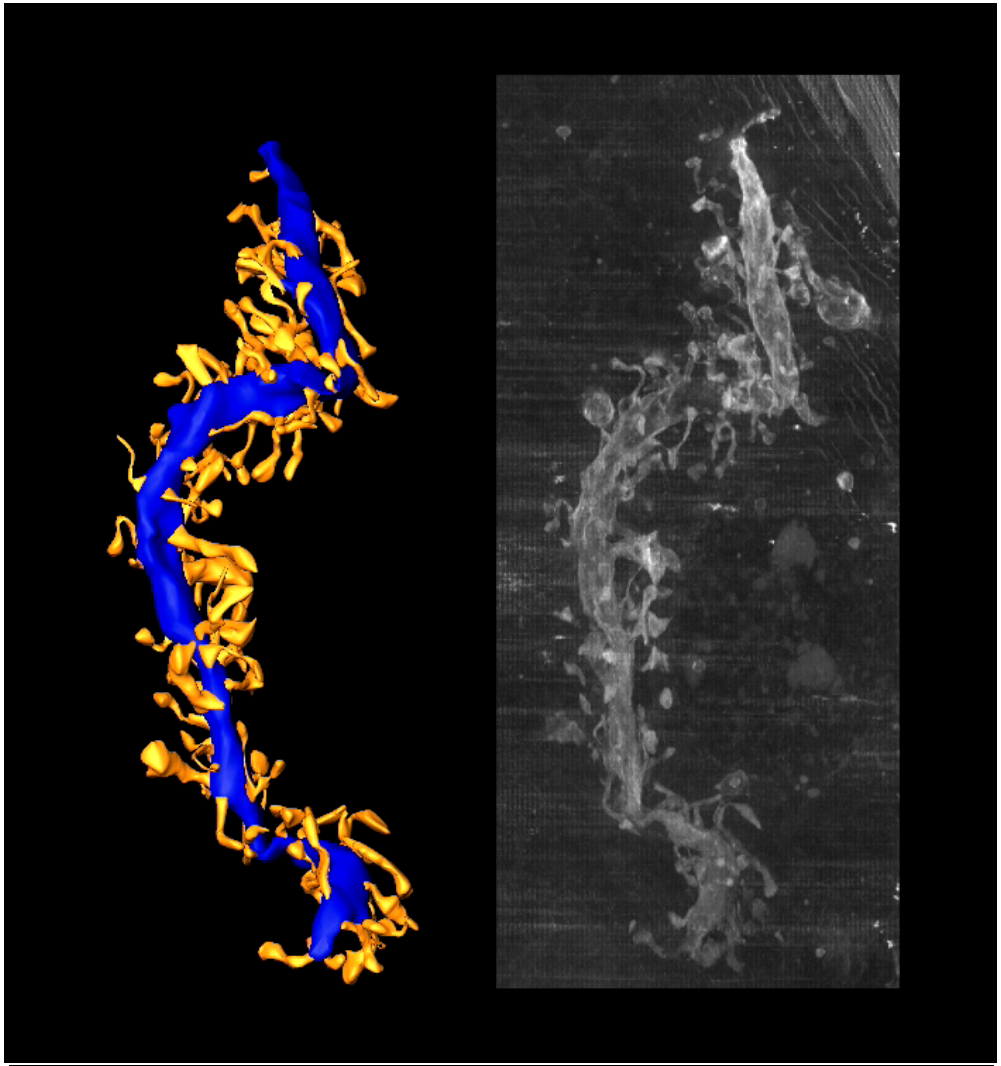
Sebastien Phan
NCMIR - NBCR



New DBP: Andreas Herz – Ellisman _NIDA & German Govt. “CRCNS”

# SYNAPSE: Cell → Subcellular Structure → Macromolecule

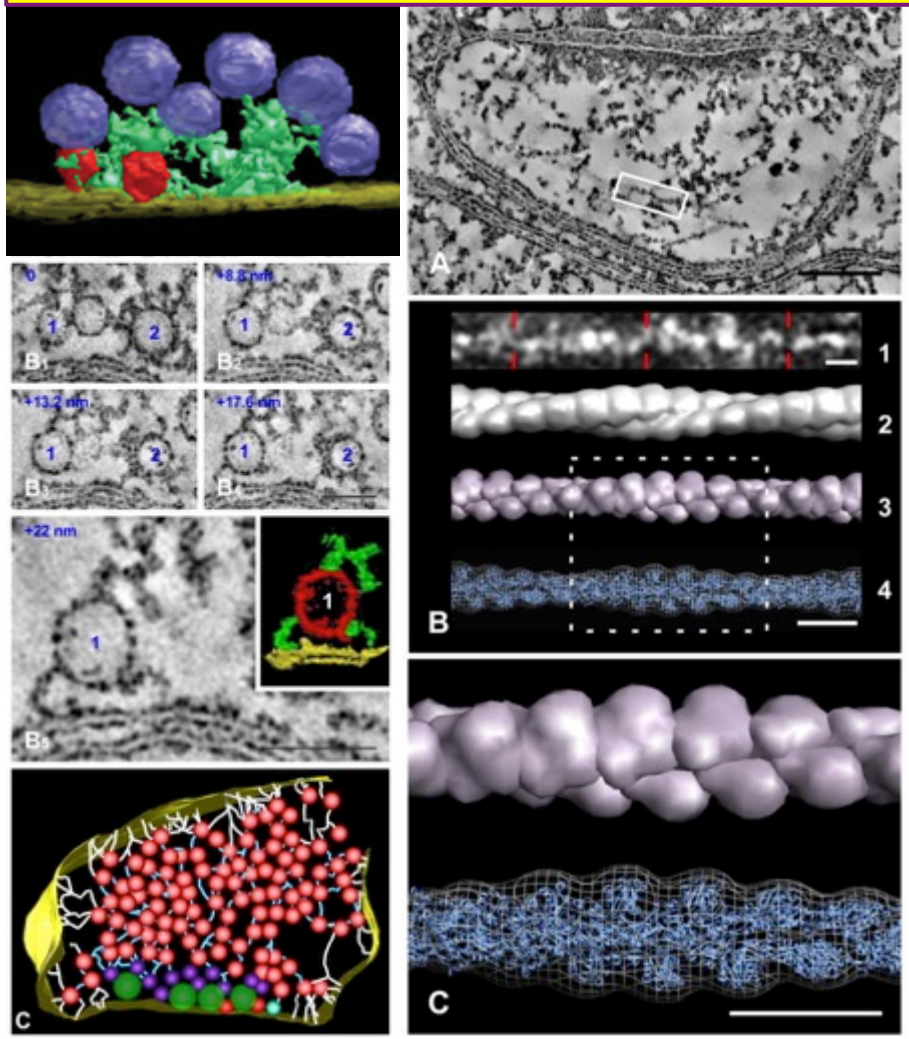
## Electron Tomographic Analysis of Synaptic Ultrastructure



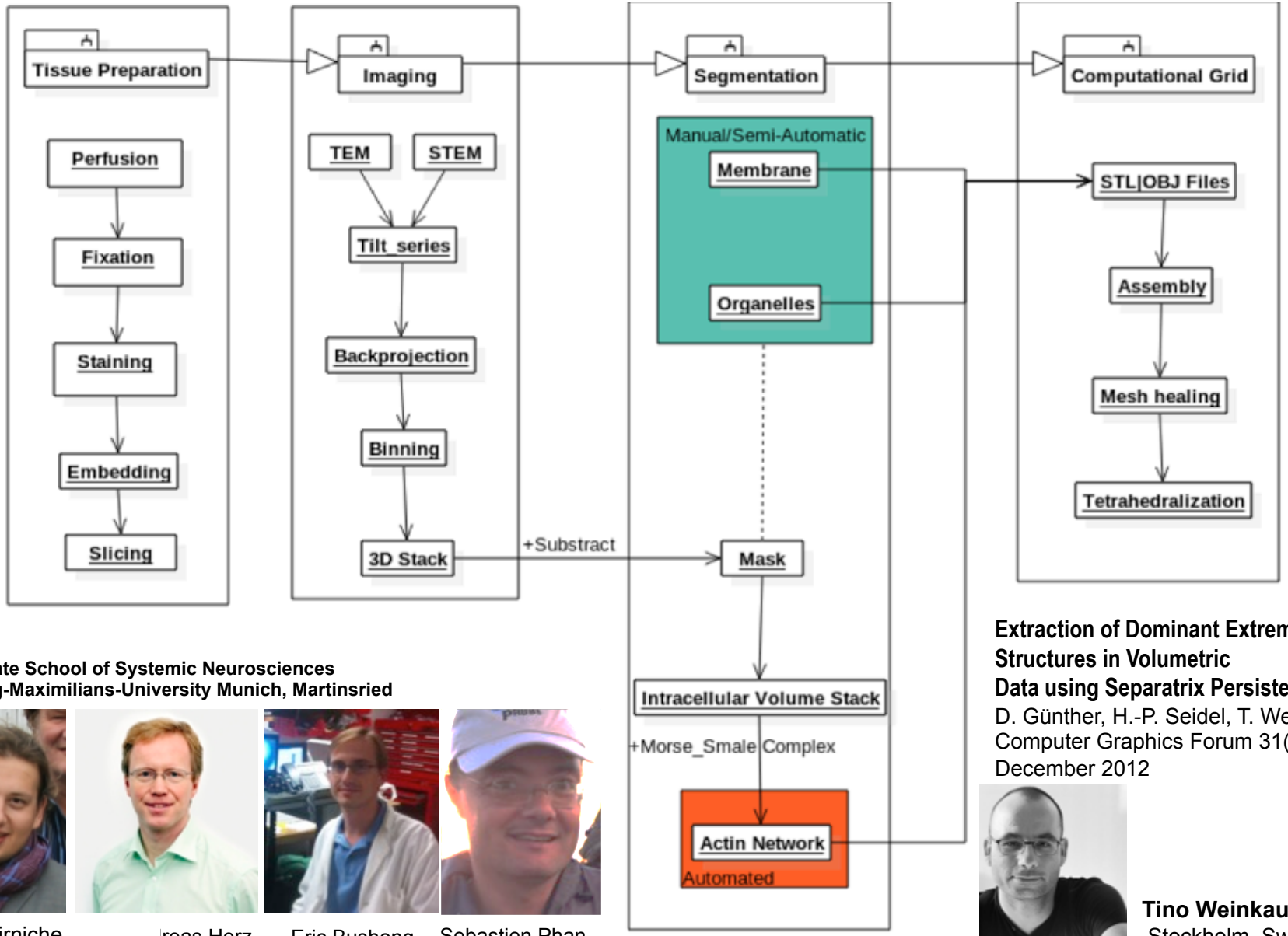
Tomography of 5 $\mu$m thick section of spiny dendrite imaged on the 3MeV with Ultra High Voltage EM at Osaka University

***Alain Burette, T. Lesperance, J. Crum, M. Martone, N. Volkmann, M. Ellisman, & R. Weinberg***

**J Comp Neurol. 2012**; 520(12):



# Building an *"in silico"* Model of the 3D Ultrastructure of the Head, Neck and Shaft of the Dendritic Spine: Reconstructing Multi-scale Structure to Simulate Electrodynamics





**Graduate School of Systemic Neurosciences**
**Ludwig-Maximilians-University Munich, Martinsried**



Dinu Patirniche


reas Herz

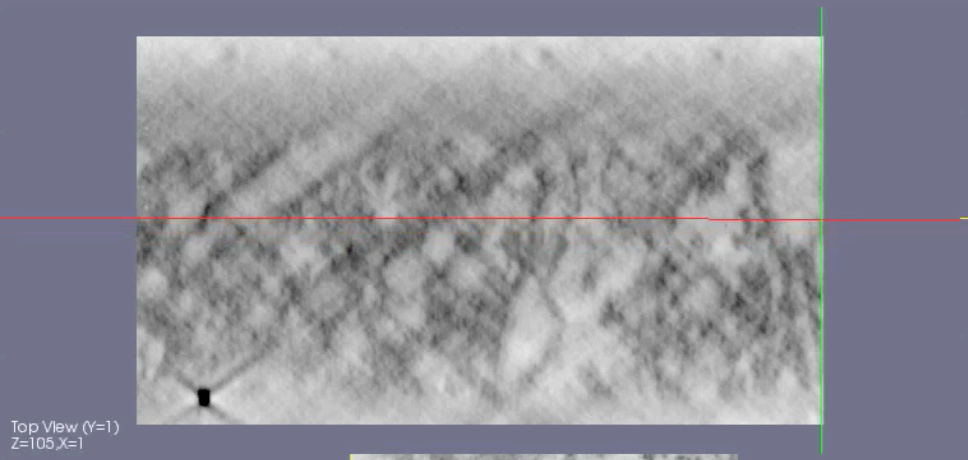

Eric Bushong

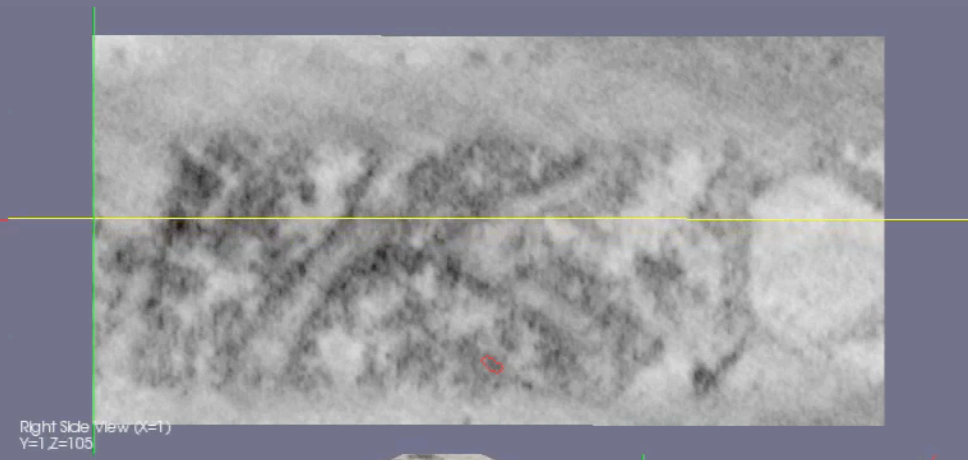

Sebastien Phan

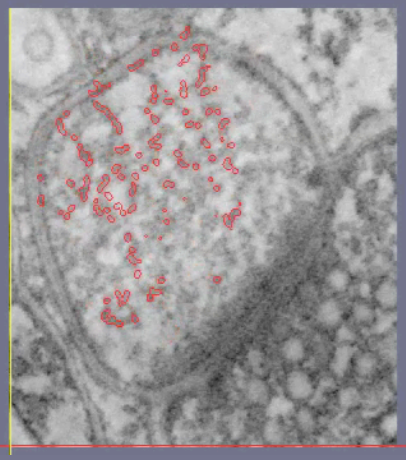
**Extraction of Dominant Extremal Structures in Volumetric Data using Separatrix Persistence**
D. Günther, H.-P. Seidel, T. Weinkauf
Computer Graphics Forum 31(8), December 2012

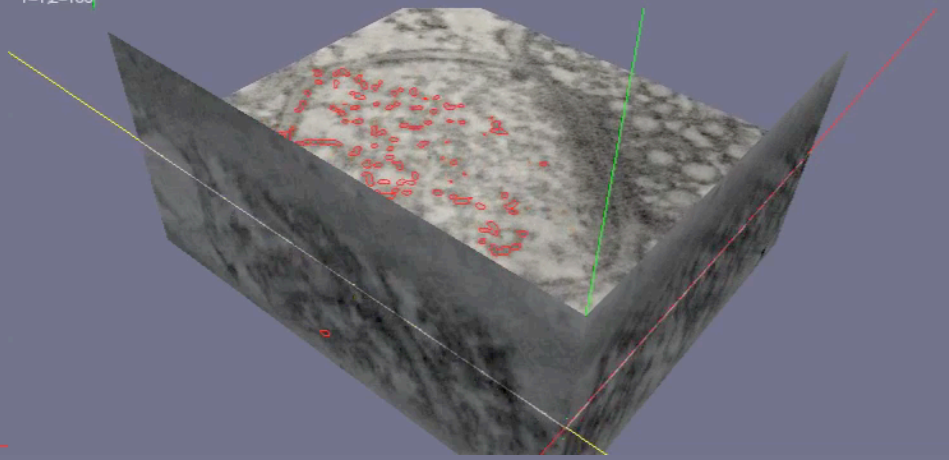



**Tino Weinkauf** KTH
Stockholm, Sweden

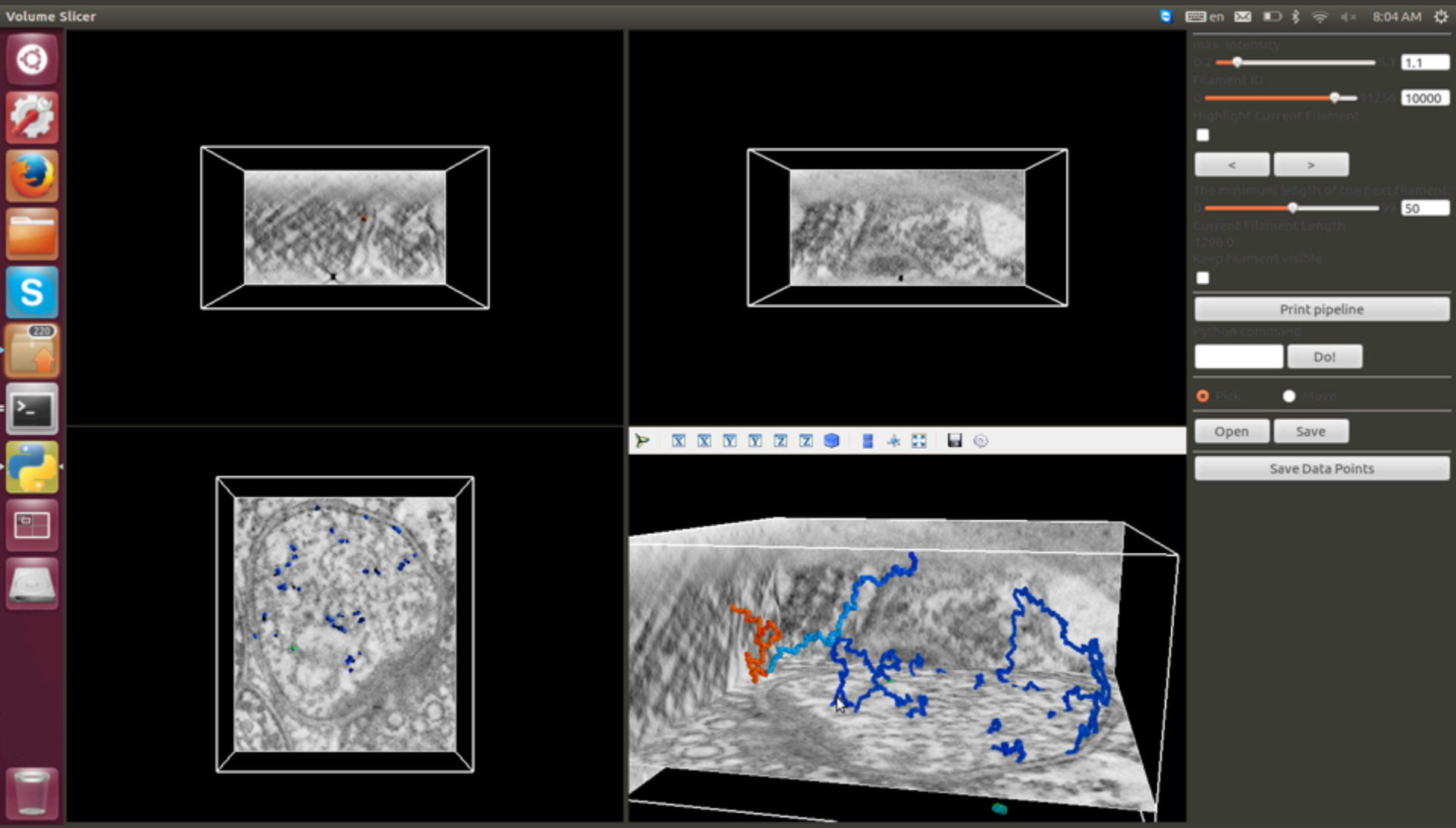

Top View (Y=1)
Z=105,X=1

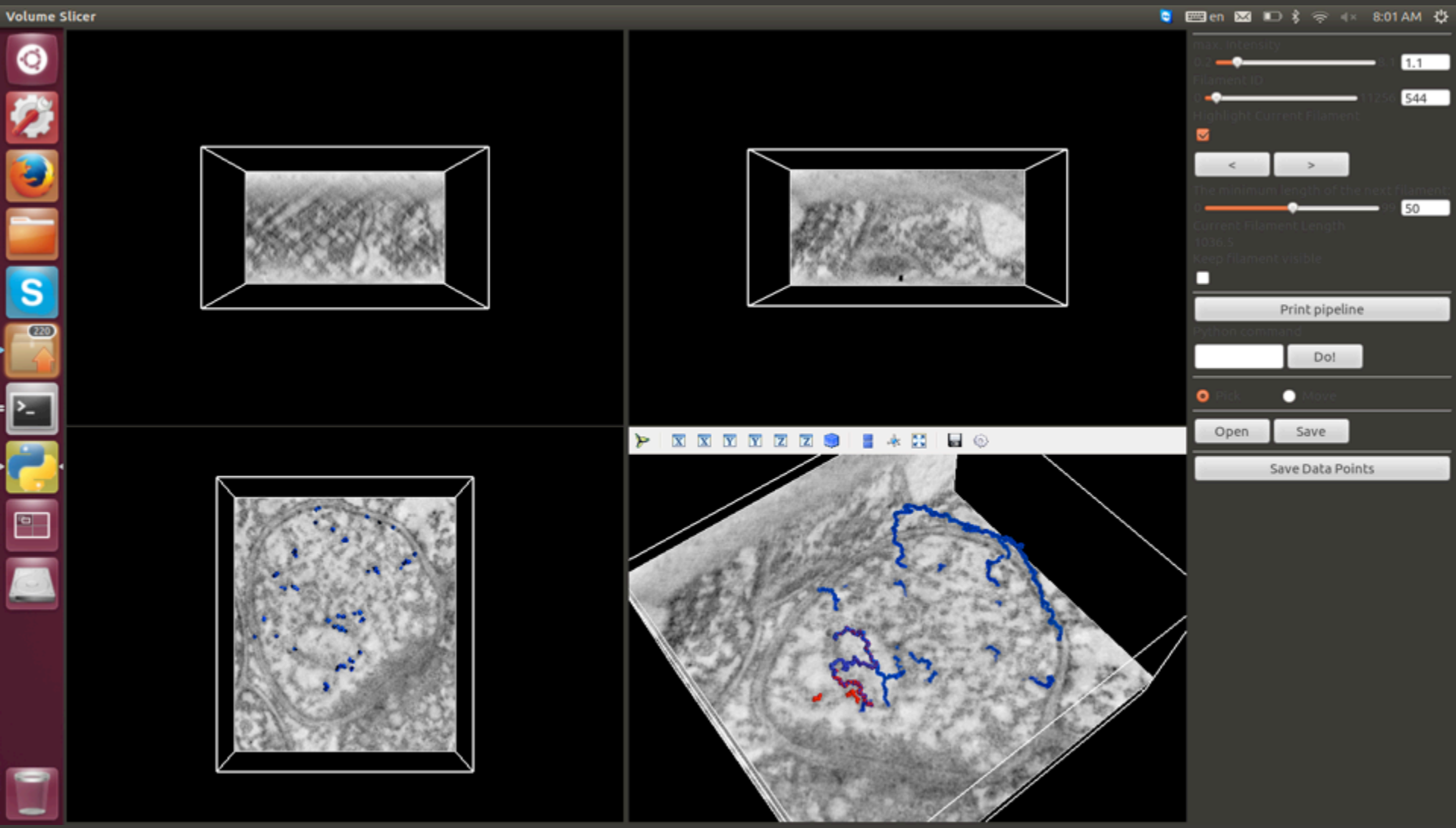

Right Side View (X=1)
Y=1,Z=105

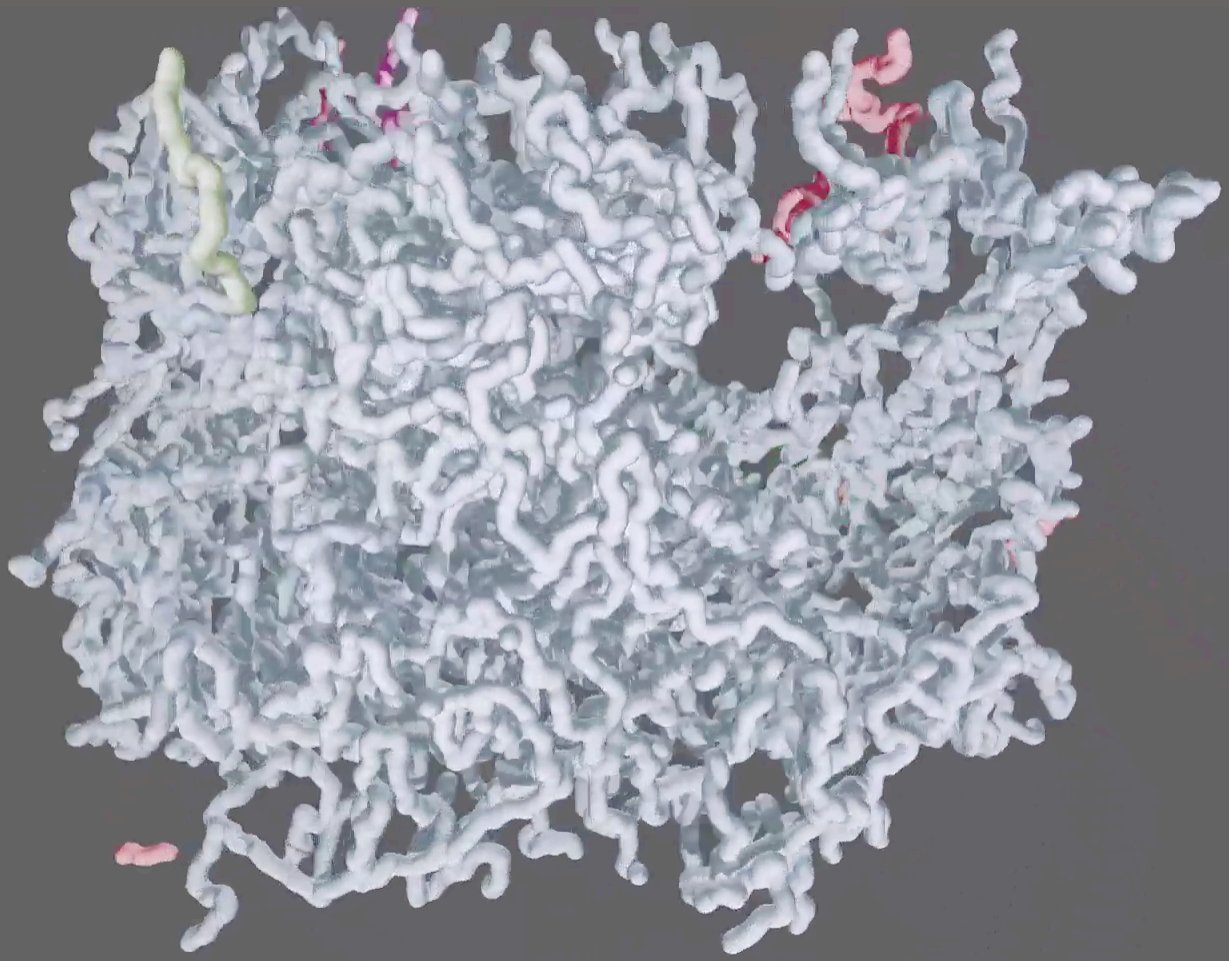

Front View (Z=105)
X=1,Y=1




Z
Y
X


Volume Slicer
en
8:04 AM
max. intensity
1.1
Filament ID
10000
Highlight Current Filament
<
>
The minimum length of the next filament
50
Current Filament Length
1296.0
Keep Filament visible
Print pipeline
Python command
Do!
Pick
Move
Open
Save
Save Data Points


Volume Slicer
en
8:01 AM
max. intensity
1.1
Filament ID
544
Highlight Current Filament
<
>
The minimum length of the next filament
50
Current Filament Length
1036.5
Keep Filament visible
Print pipeline
Python command
Do!
Pick
Move
Open
Save
Save Data Points



D. Günther, H.-P. Seidel, T. Weinkauf
Extraction of Dominant Extremal Structures in Volumetric Data using Separatrix Persistence
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**Tino Weinkauf**
Professor of Visualization.
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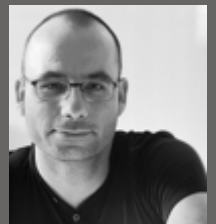
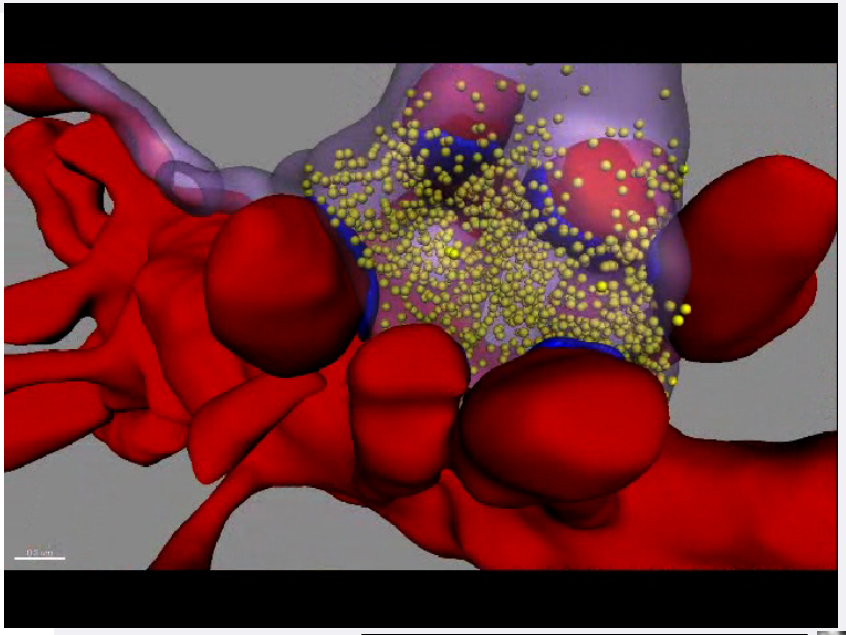
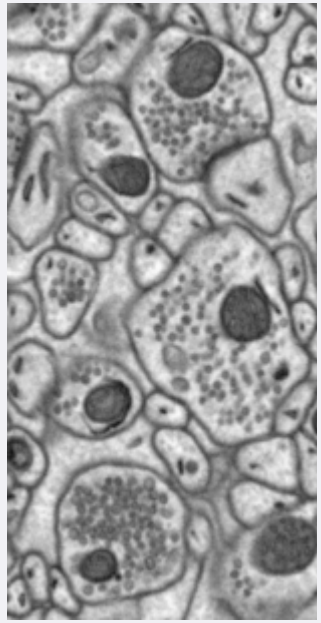


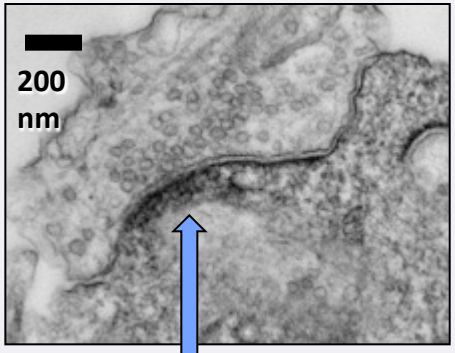
# NCMIR's Merlin HV Serial Block Face SEM SYSTEM

- *Compared to FEI➔ a 20x speedup in throughput & 3x higher lateral resolution (in "X and Y").*
- *Each Scan ~ 32k x 32k so 1 billion pixel Images – Volumes are becoming 10's of Terabytes*
- *➔➔ This will speed up ~3X by Mid 2015 With Improvements in BSE Detector with GATAN*
- *➔➔ Implementing Multiple labels in EM using genetically introduced probes*

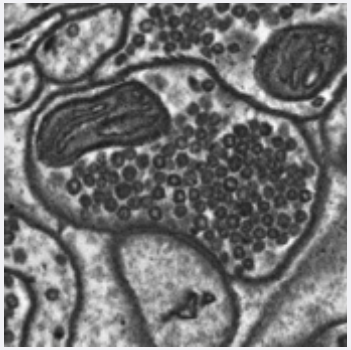

**32k x 32k scans and 3 x 3 mosaics are obtainable: So, 10 billion pixel images!**





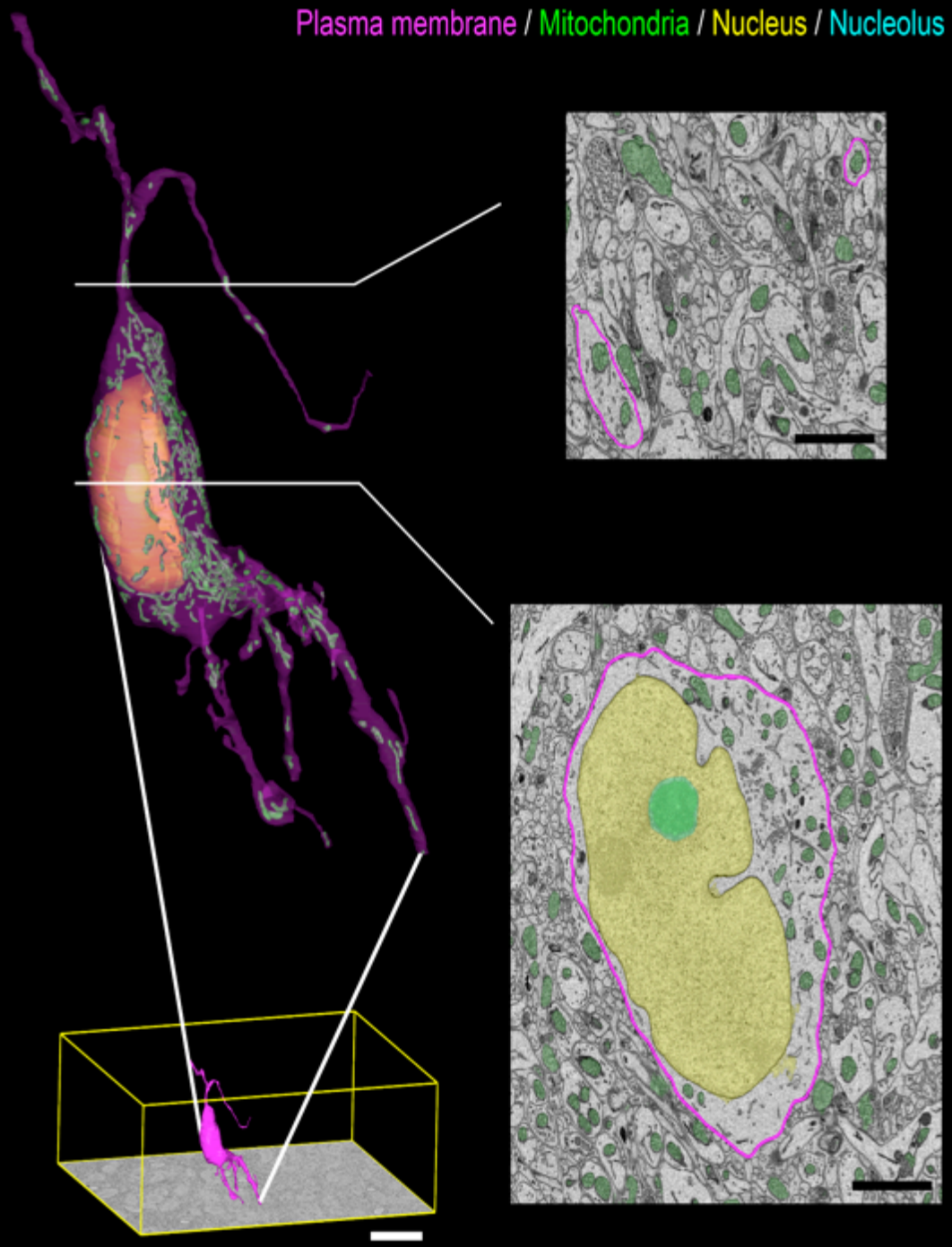



miniSOG on PSD95 Margaret Butko
….Butko et al., Nature NS 2012



Lowering Landing Energy, Boosting Detector Efficiency & Resolution

Alex Perez
(NCMIR)



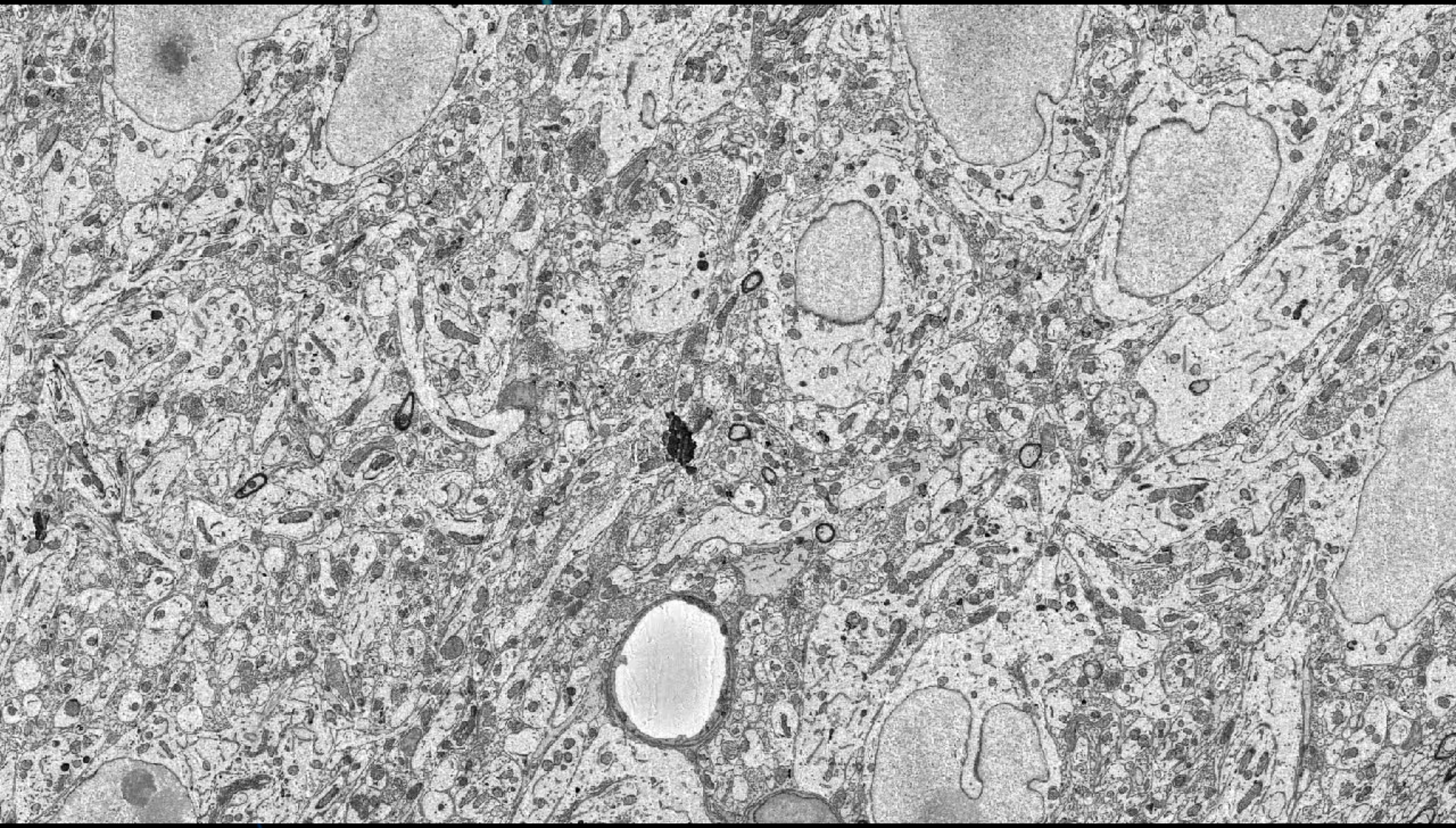

# **S**calable system for **L**arge data **A**nalysis and **S**egmentation utilizing **H**igh Performance Computing **(SLASH)**

- *Tolga Tasdizen*
- *Elizabeth Jurrus*

*Univ of Utah - SCi*

- *Tom Deerinck*
- *Eric Bushong*
- *Alex Perez*

*UCSD - NCMIR*



# Specialized Instruments Fielded for Correlated, Multiscale, Multimodal Data Acquisition

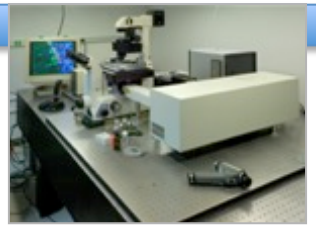
1Å 1nm 10nm 100nm 1μm 10μm 100μm 1mm 10mm 100mm

Live

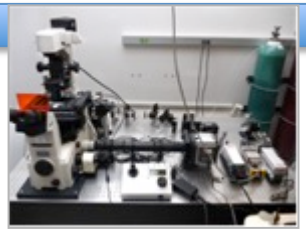
Fixed

Embedded

3D/4D Fluorescence/Intra-vital LM



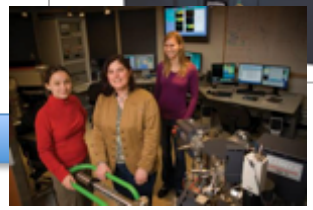
PALM/STORM

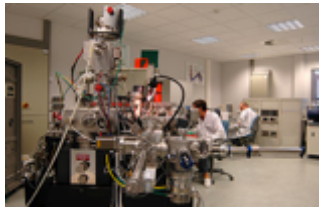


XRM


NanoSIMS

SEM





**National Resource for Imaging Mass Spectrometry**
Harvard Medical School/Brigham and Women's Hospital
(C. Lechene)

IVEM/ Serial Section EM/EELS

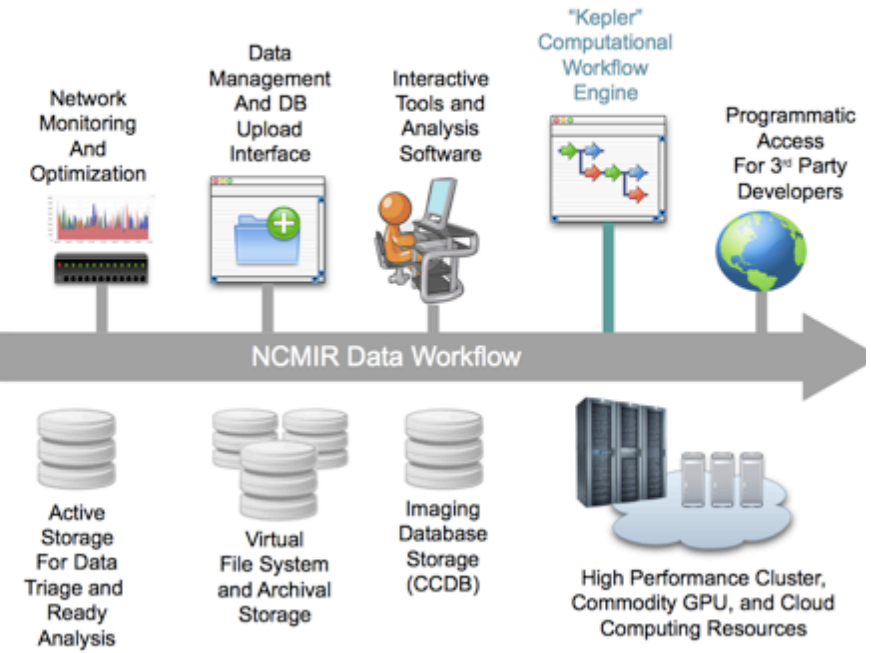
**Caltech Microanalysis Center**
(V. Orphan)

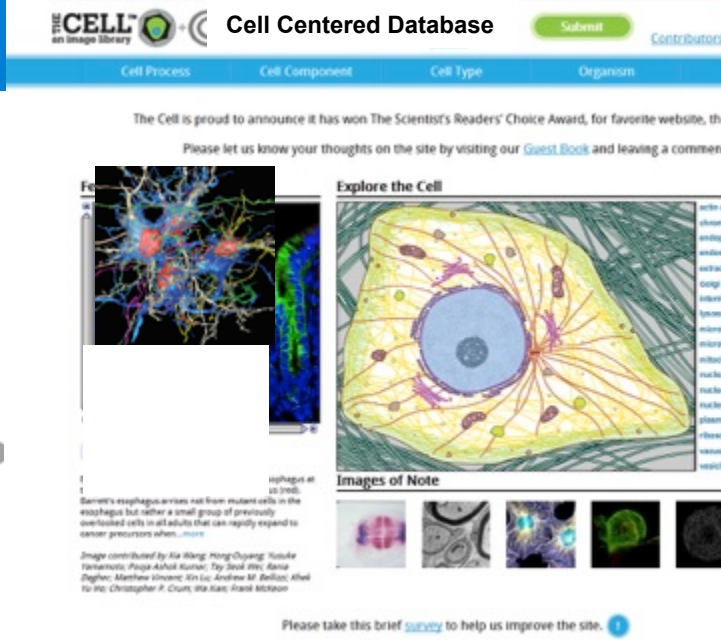
**Scientific Instrumentation Unit**
**Centre de Recherche Public Gabriel Lippman**
**Belvaux, Luxembourg**
(S. Moorthy)

Embedded

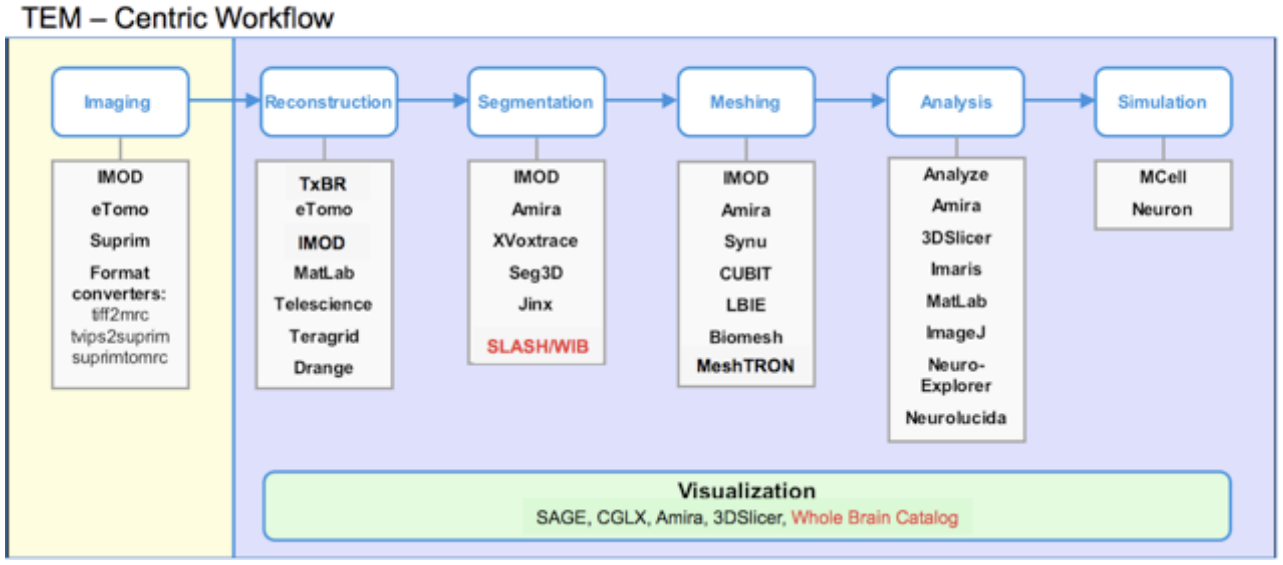
# NCMIR

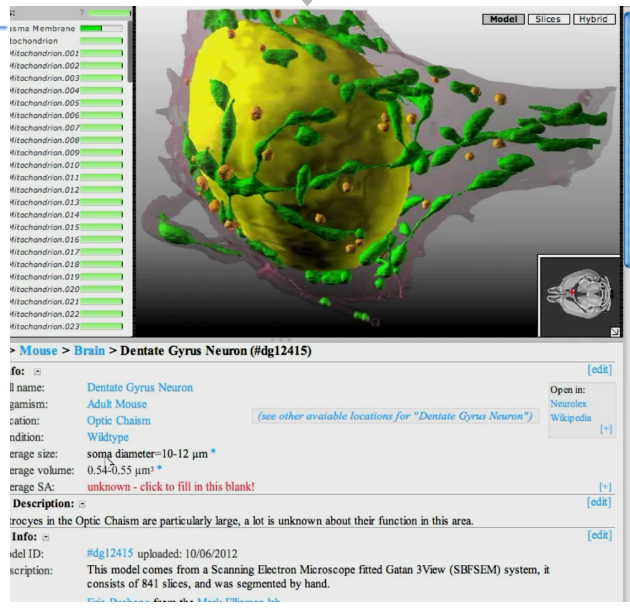
## OPEN ACCESS SHARED RESEARCH RESOURCES




## Integrated Workflows of Imaging and Analysis Tools



*The End*