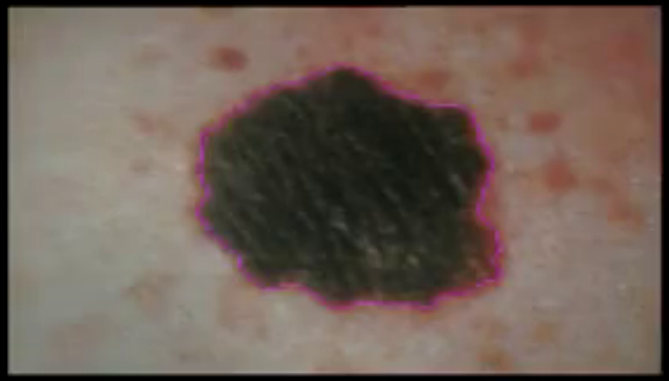
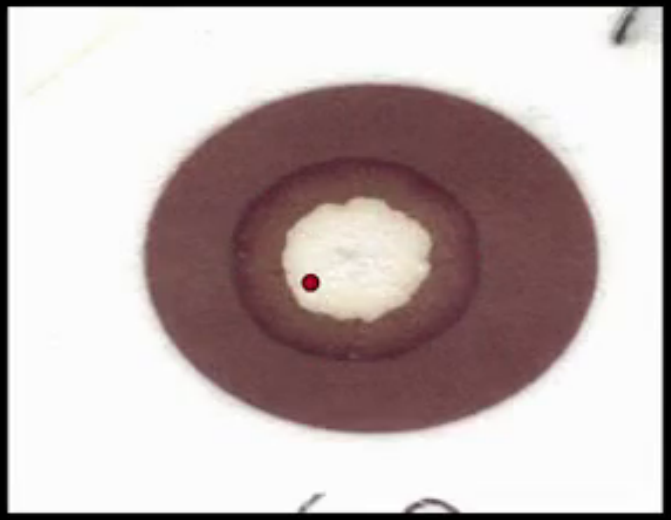
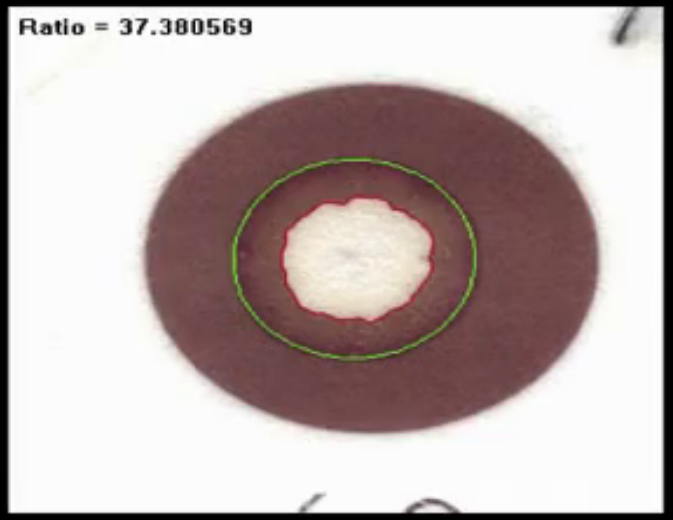
Automatic skin lesion segmentation



A non-invasive test to aid in the diagnosis of cystic fibrosis: Automatic chloride patch/sensor analysis

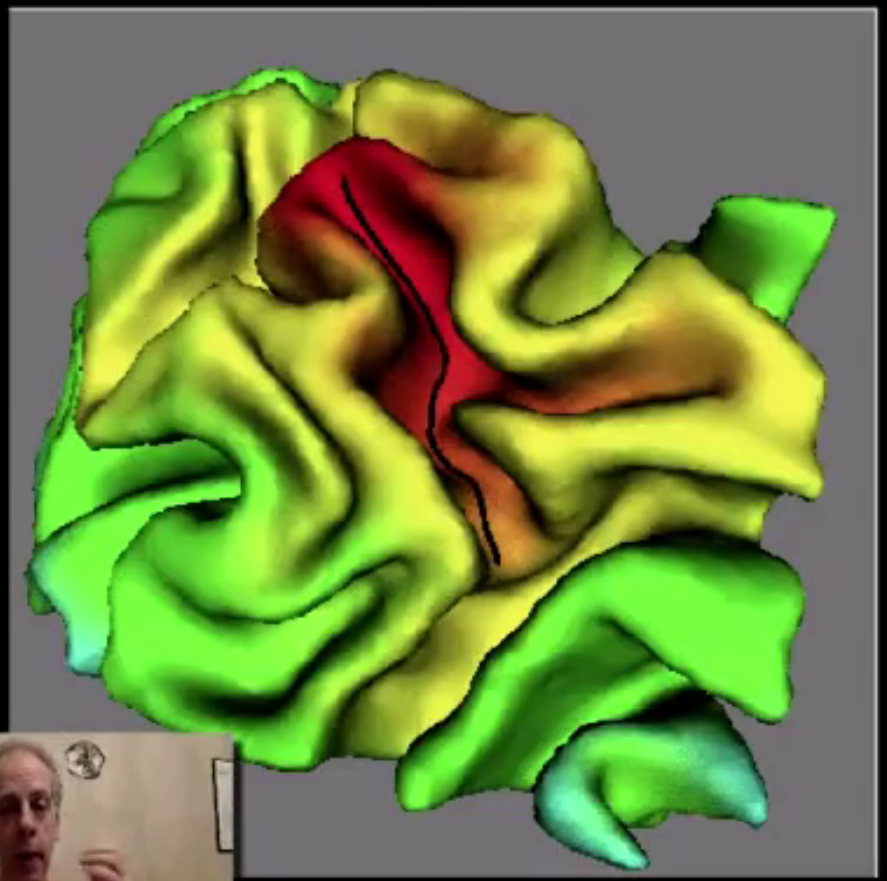


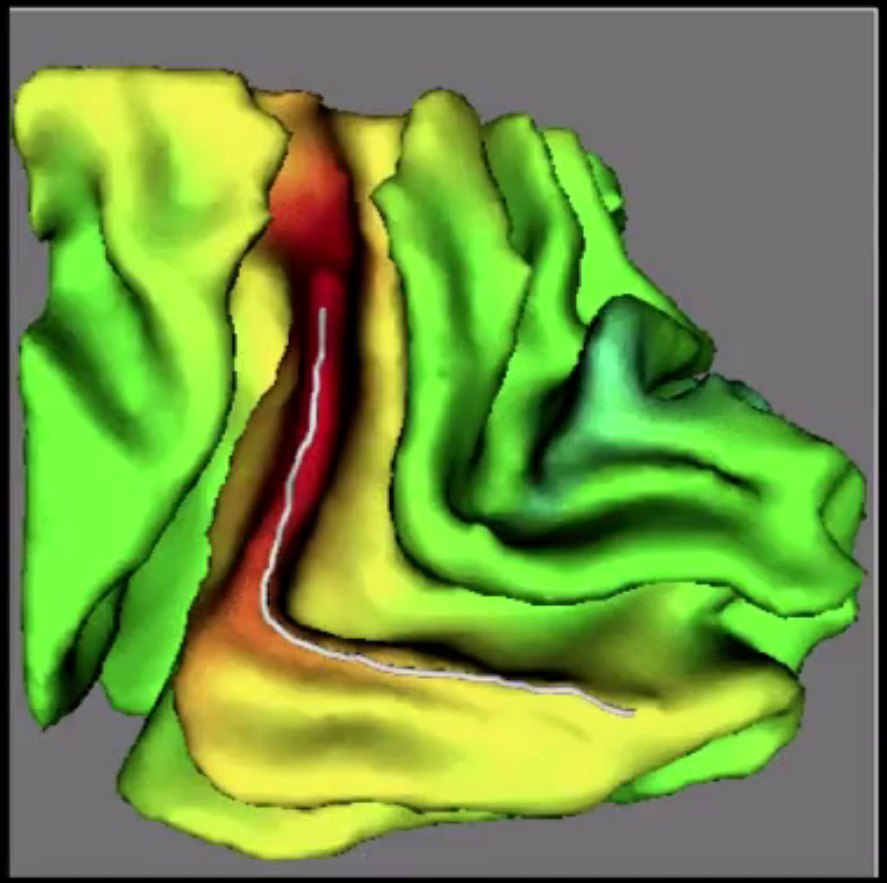
Automatic



- Ratio between red and green areas is in correlation with chloride concentration, aiding in the diagnosis of CF
- Courtesy of PolyChrome and Warren Warwick

Sulcii extraction





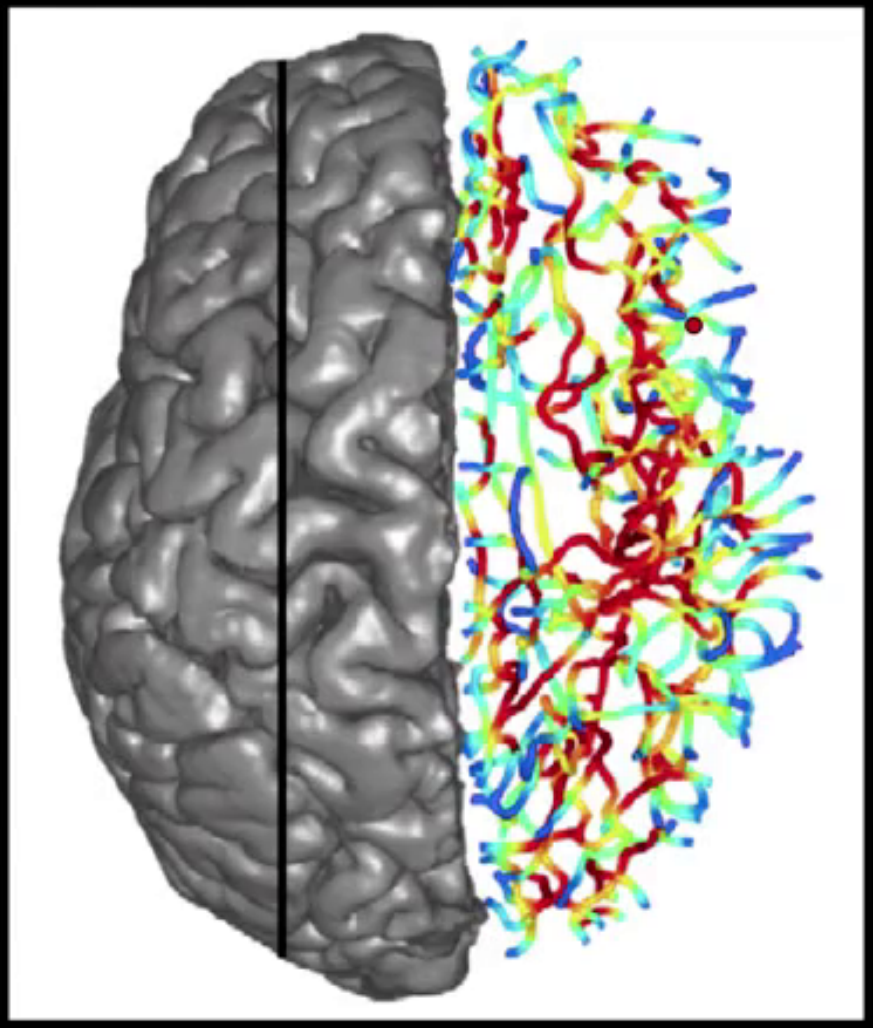


Image Registration, Classification and Averaging in Cryo-Electron Tomography

Thanks to Alberto Bartesaghi and Sriram Subramaniam

Laboratory of Cell Biology

Center for Cancer Research

Imaging technologies for biology

X-ray

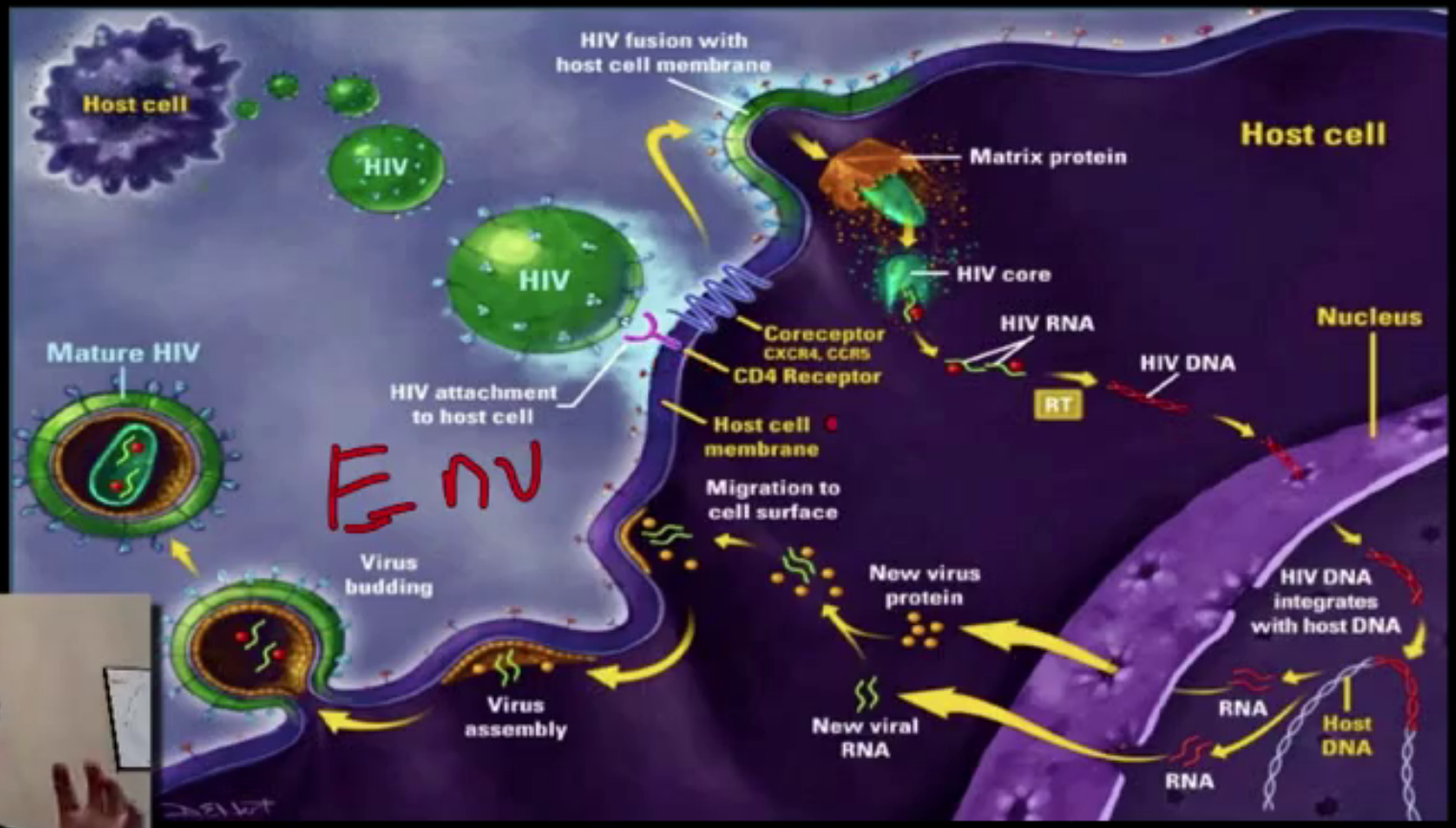
NMR

Electrons

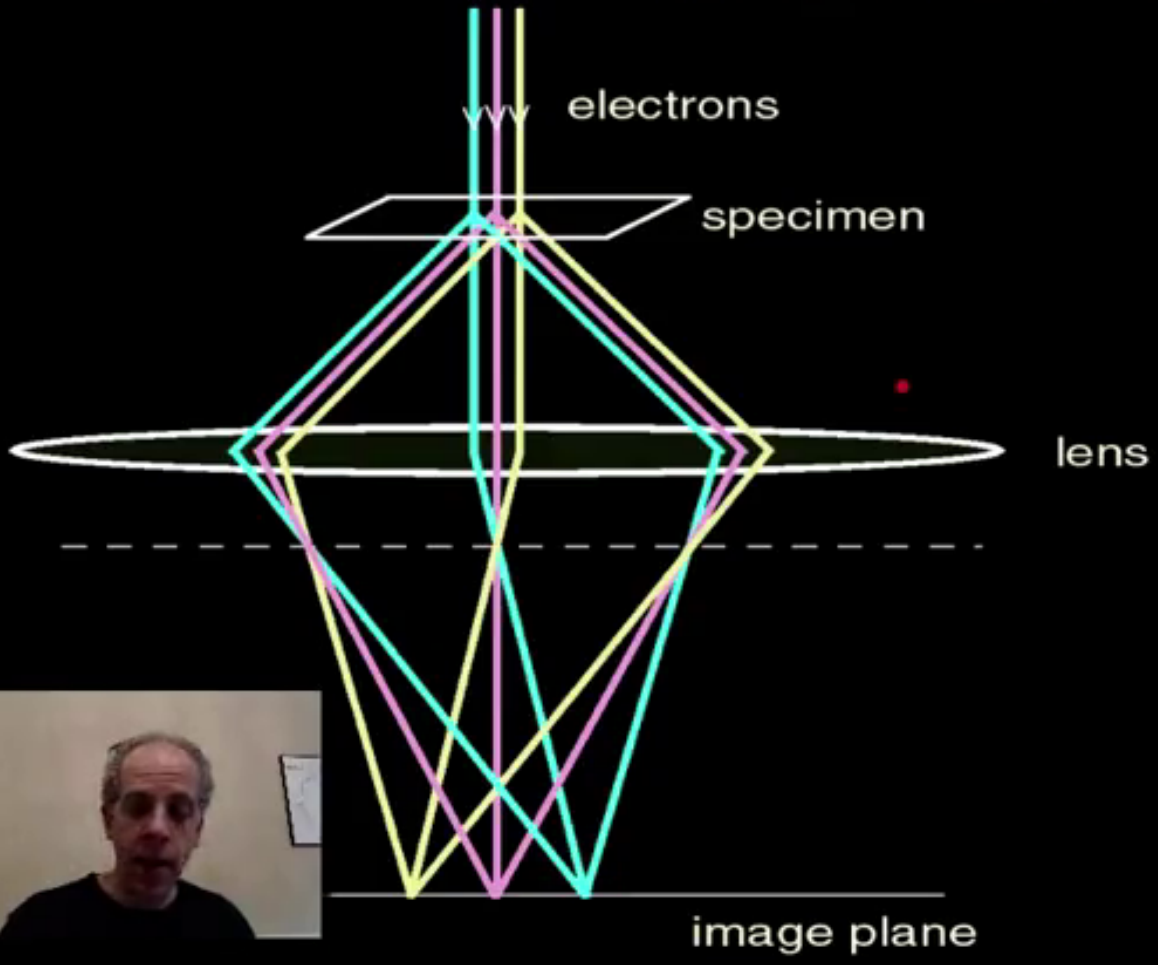
Light

S. Subramaniam, Curr. Opin. Microbiol. (2005)

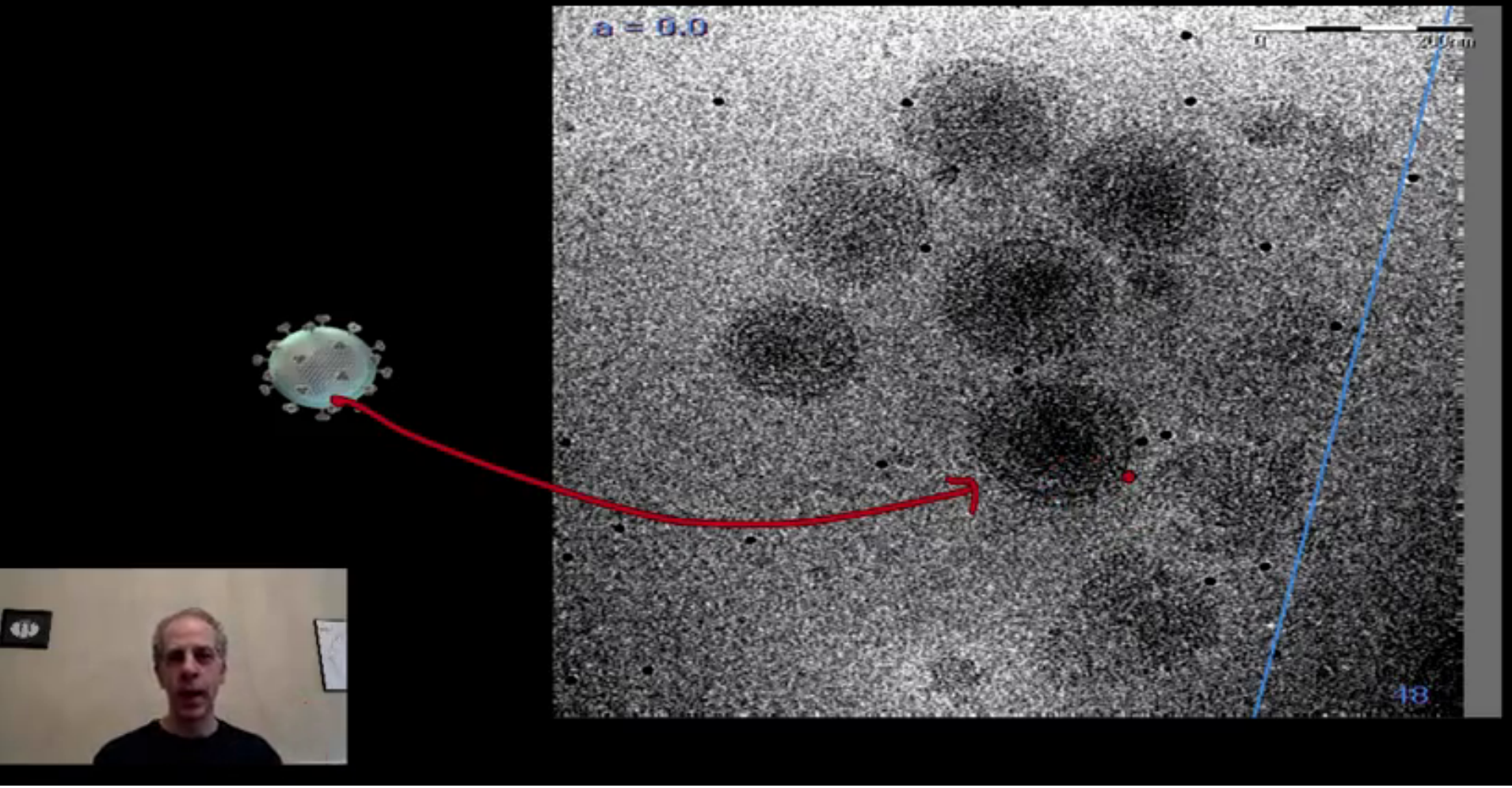
Our Target: Molecular structure of HIV envelope glycoproteins



Transmission Electron Microscopy

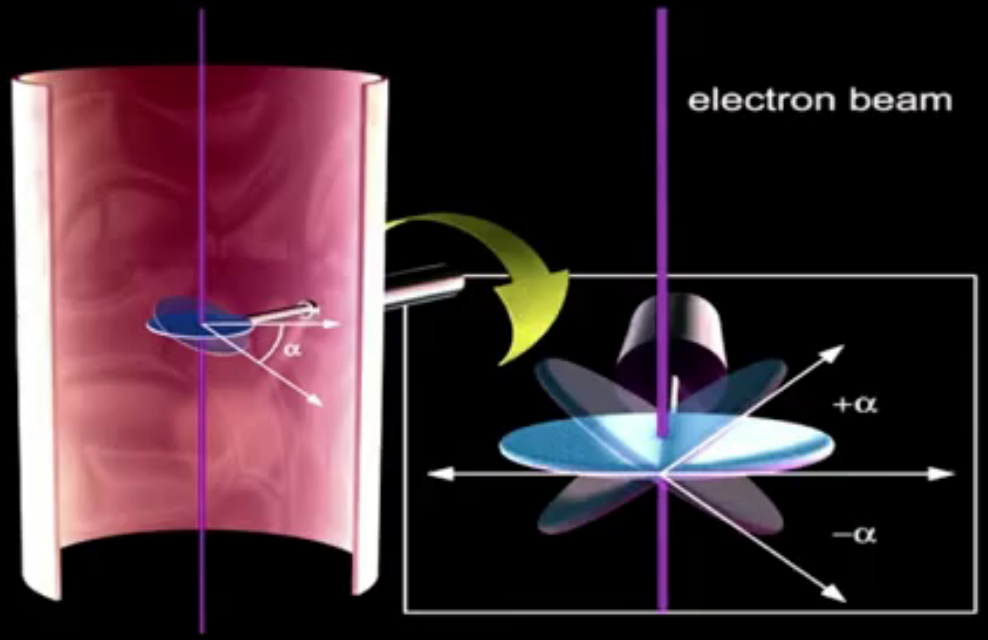


Single Projection Image of HIV

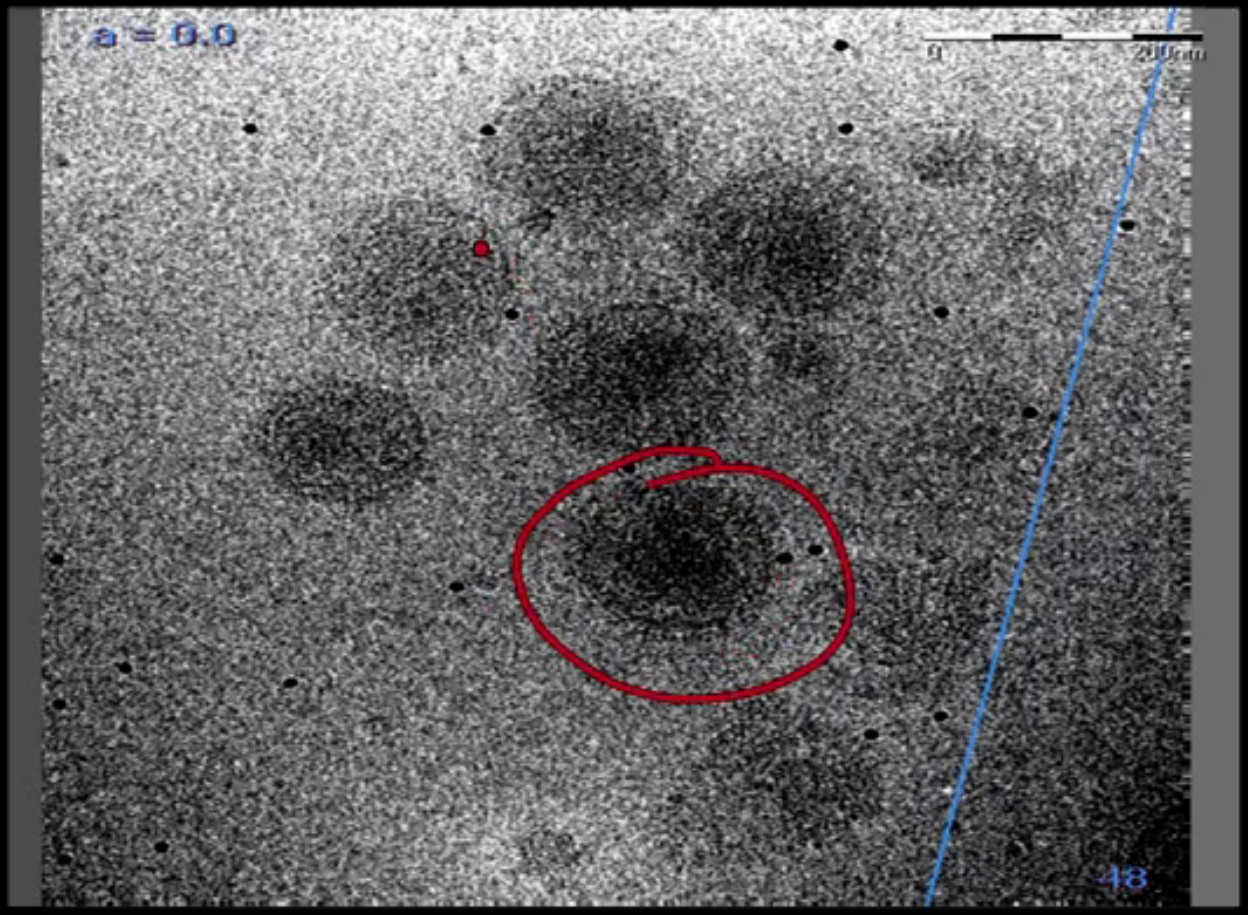


Cryo-Electron Tomography

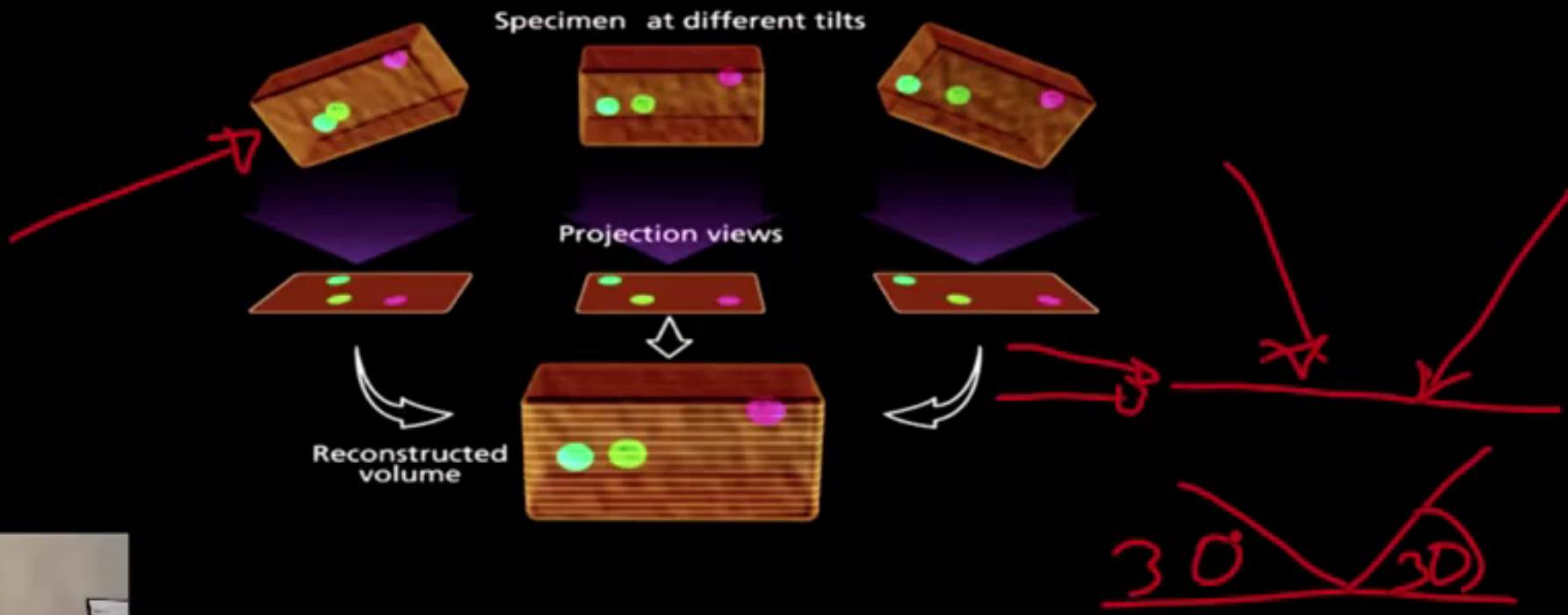
- Reduce radiation damage
- Obtain 3D information



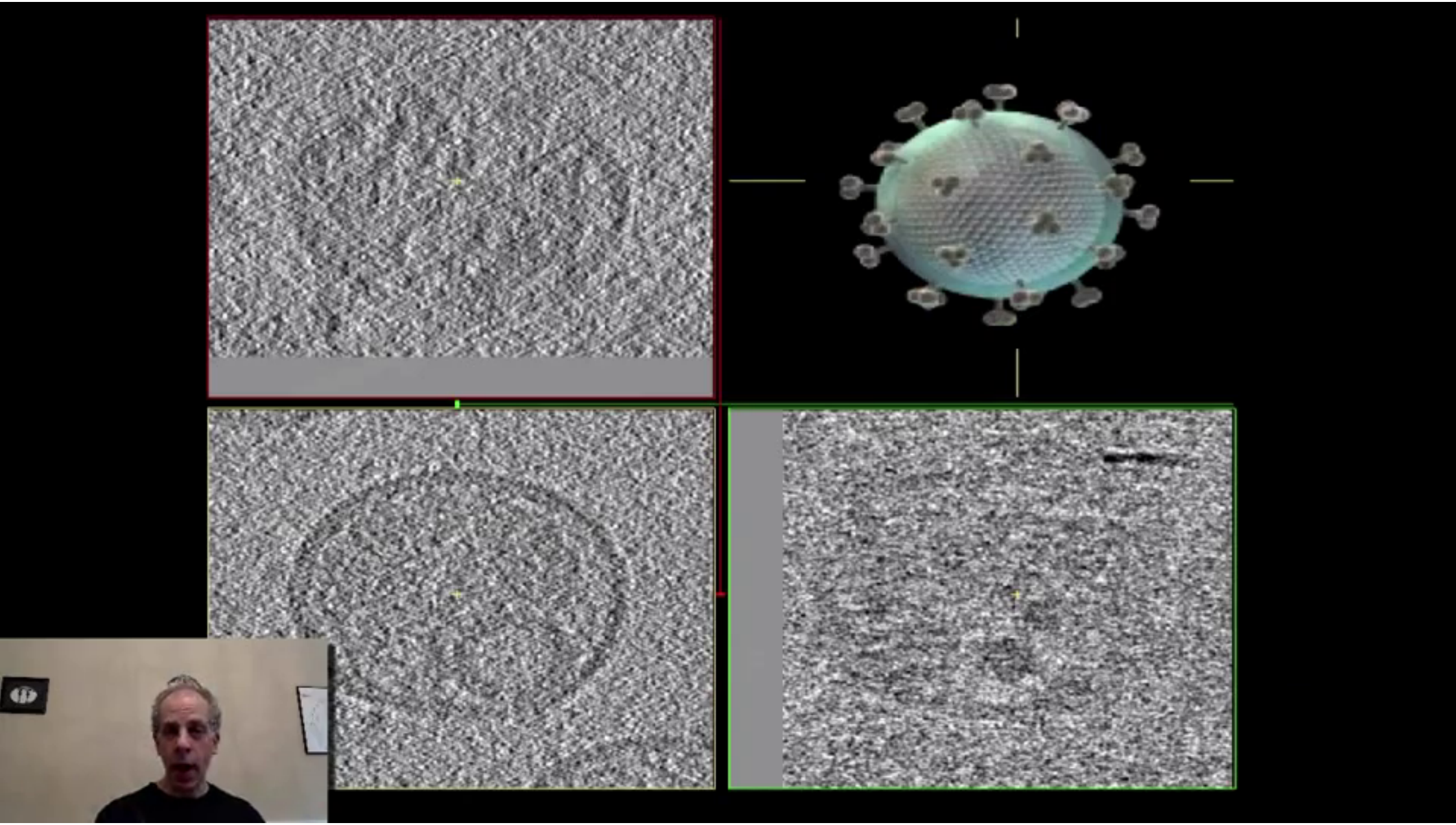
Raw tilt-series of HIV



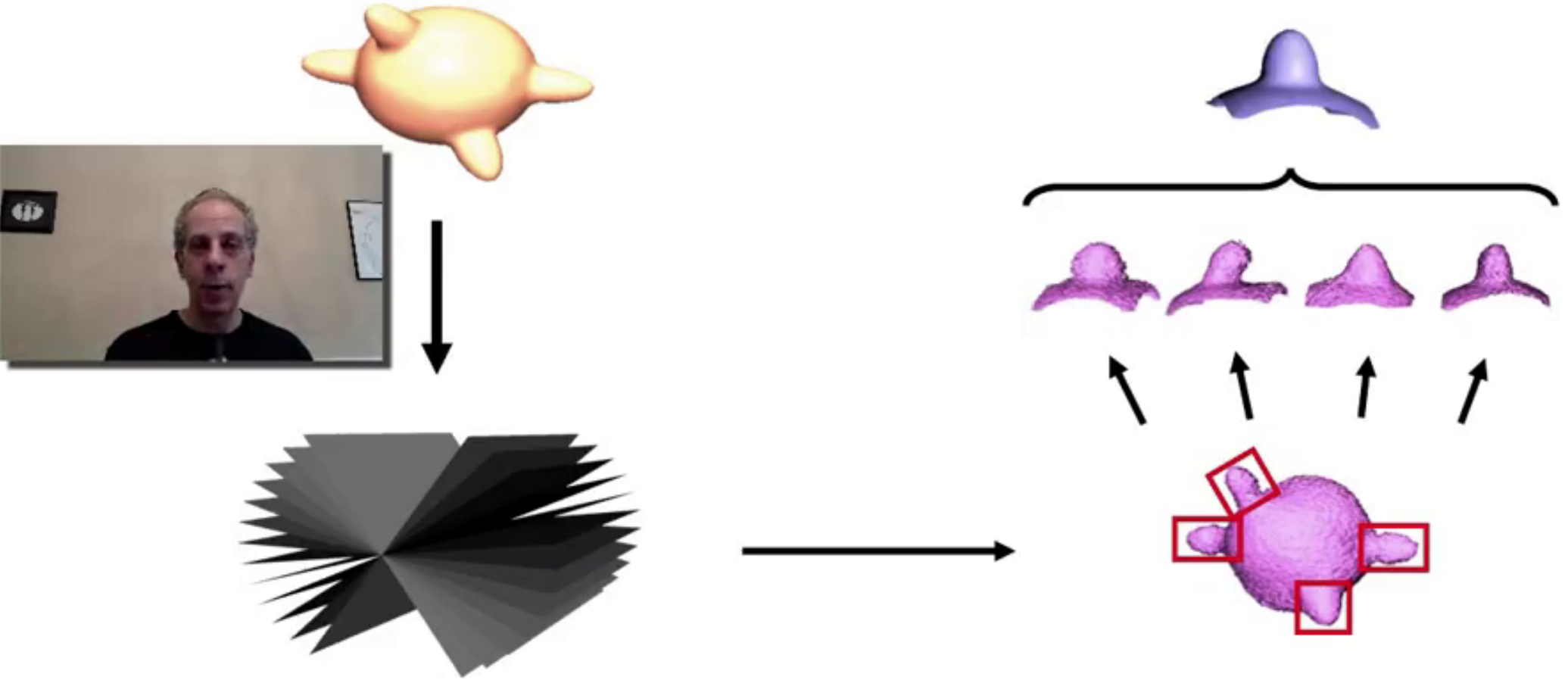
Tomographic Reconstruction



Subramaniam at al., *ASM News* 60, 240-245.

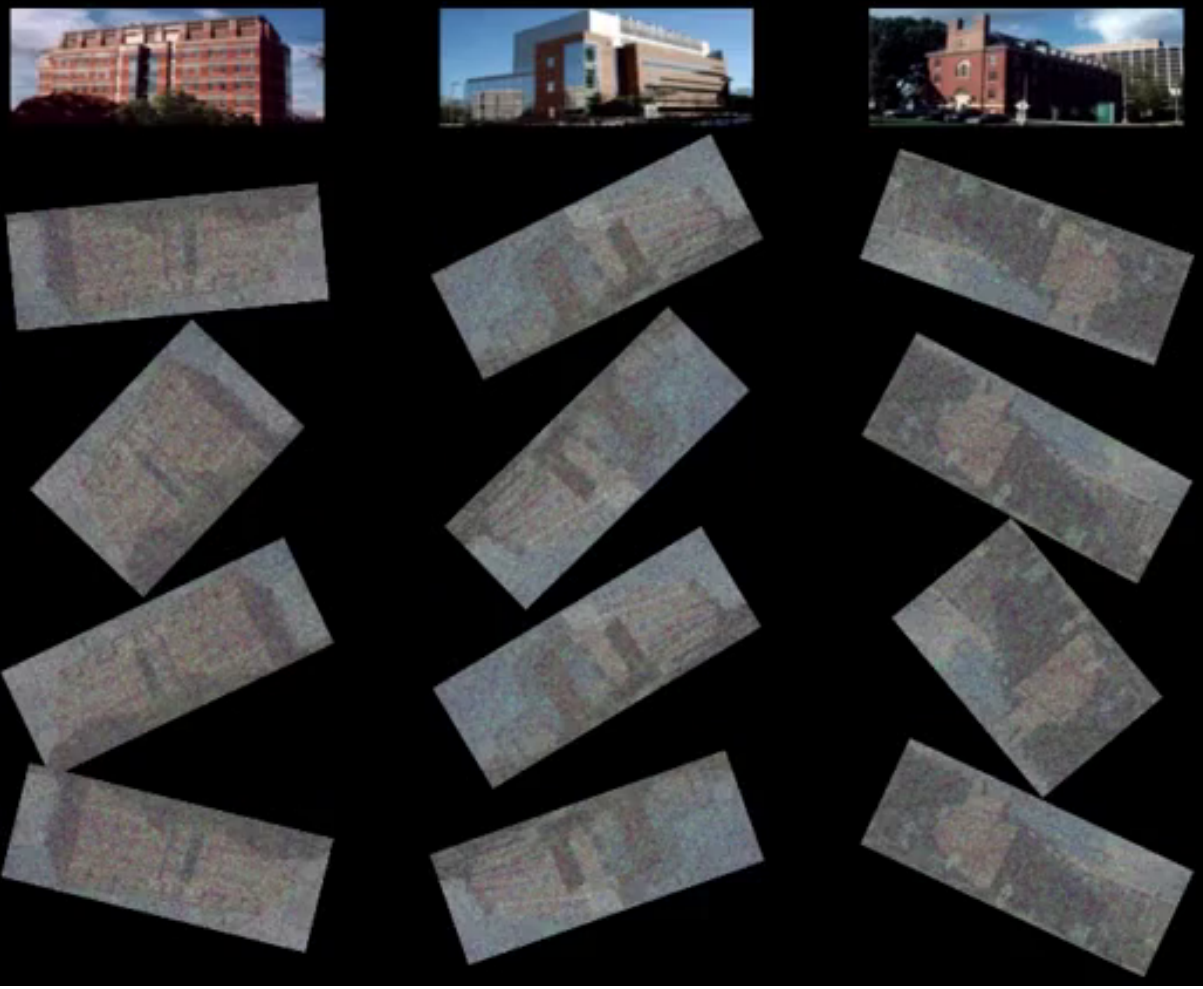


Sub-Volume Averaging in Electron Tomography

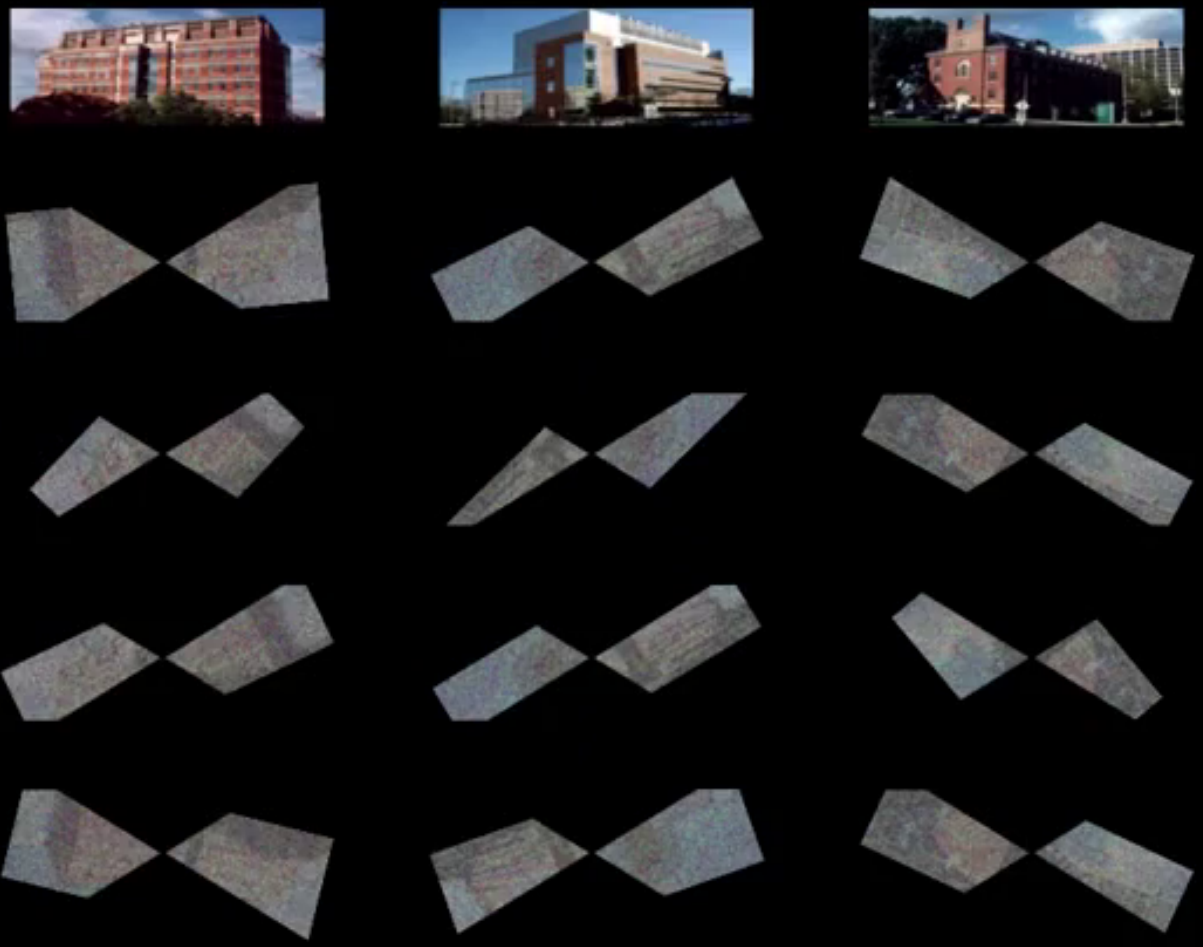


Reconstitution From Noisy and Incomplete Images

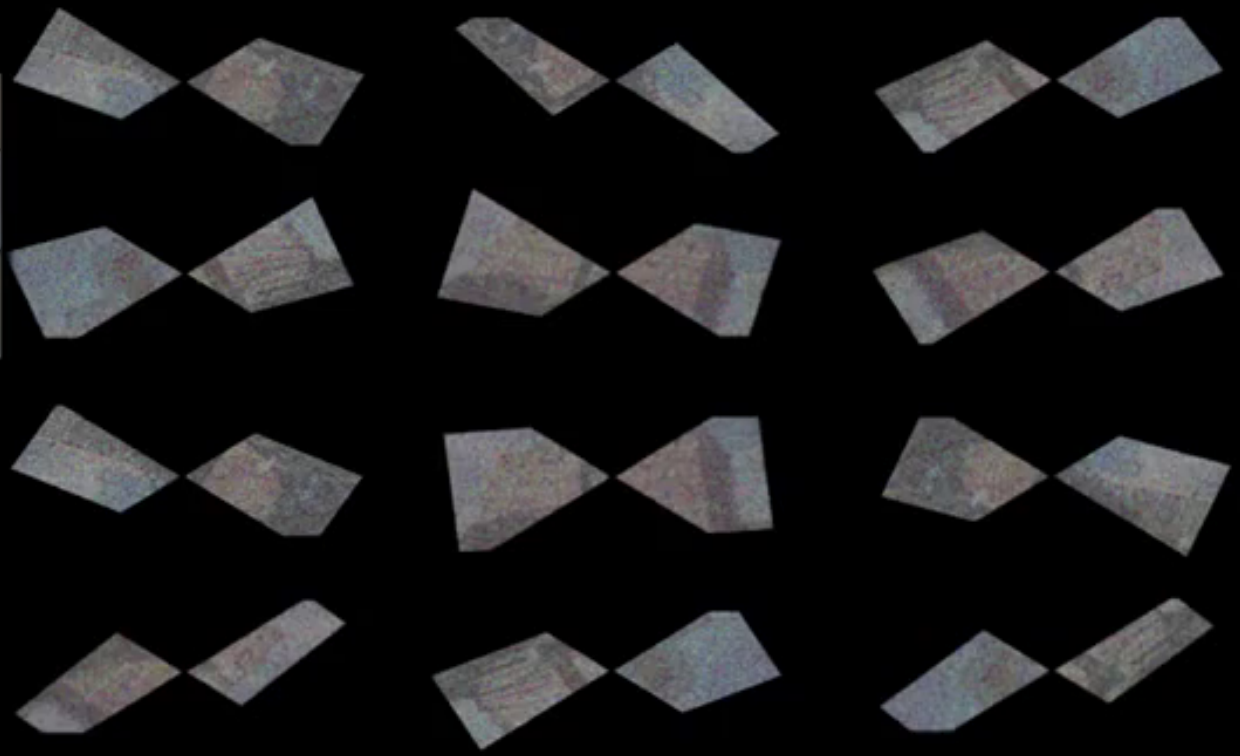
Reconstitution From Noisy and Incomplete Images



Reconstitution From Noisy and Incomplete Images



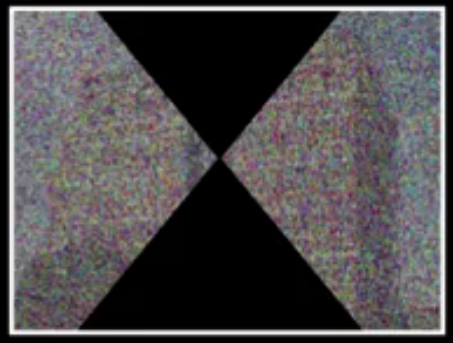
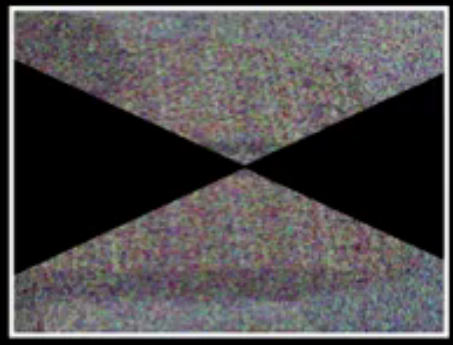
Reconstitution From Noisy and Incomplete Images



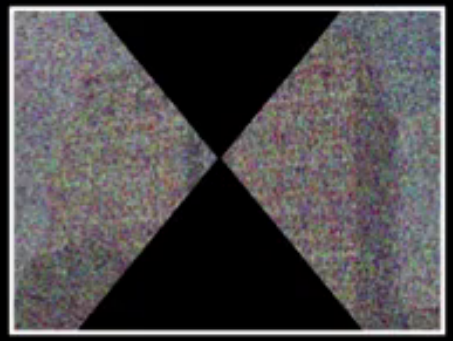
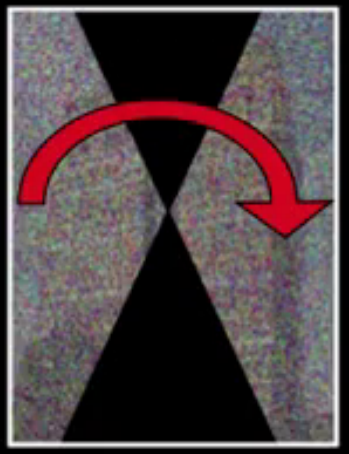
Imaging Challenges of Sub-Volume Averaging in ET

- Low SNR makes alignment difficult
- Alignment ambiguities due to missing data
- 3D datasets require extensive computation

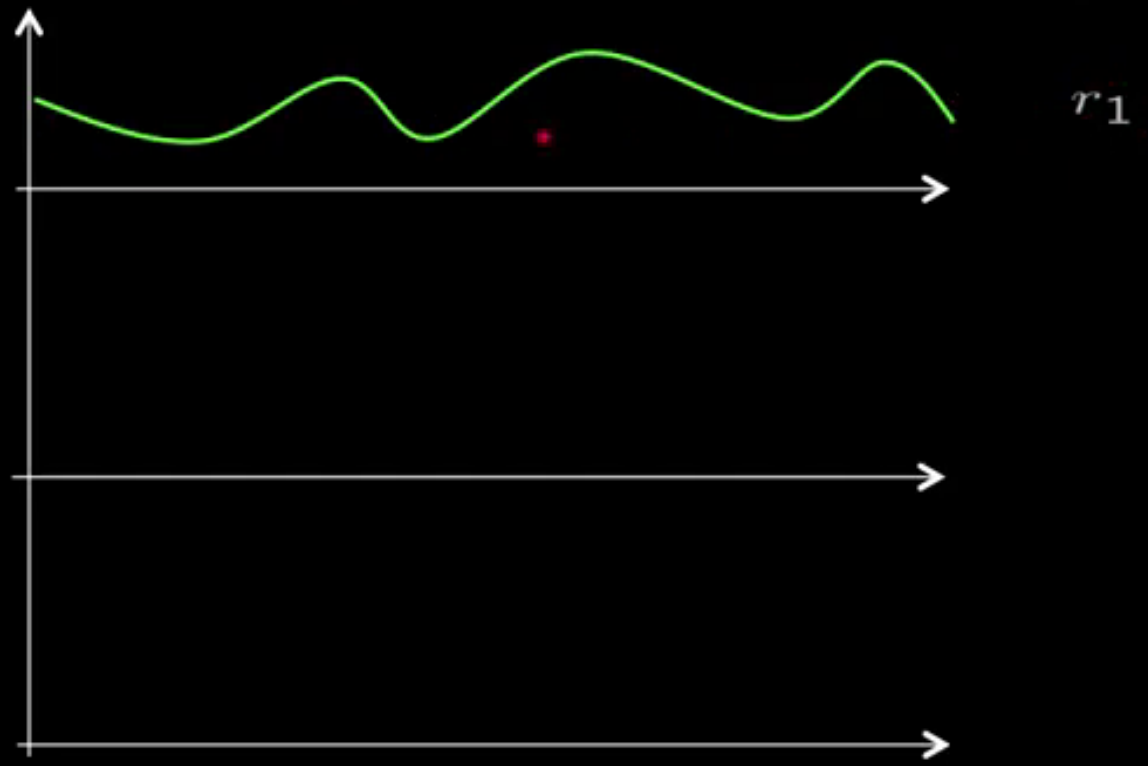
Effects of Missing Data on Alignment

$d($  ,  $)$

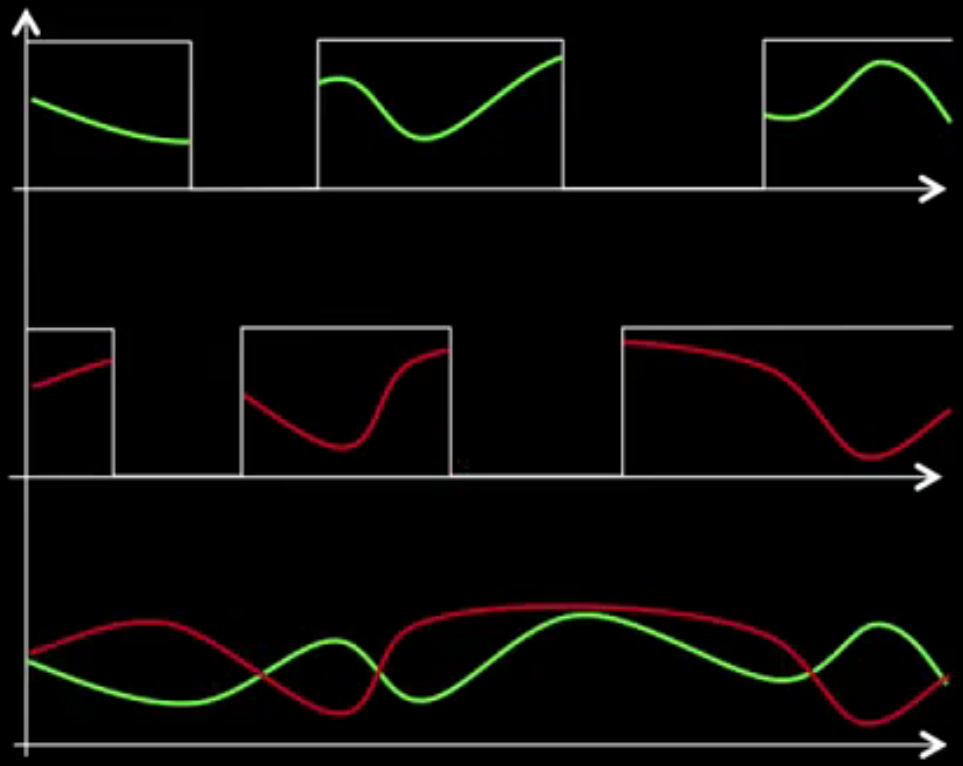
Effects of Missing Data on Alignment

$d($  ,  $)$

Similarity with Missing Information



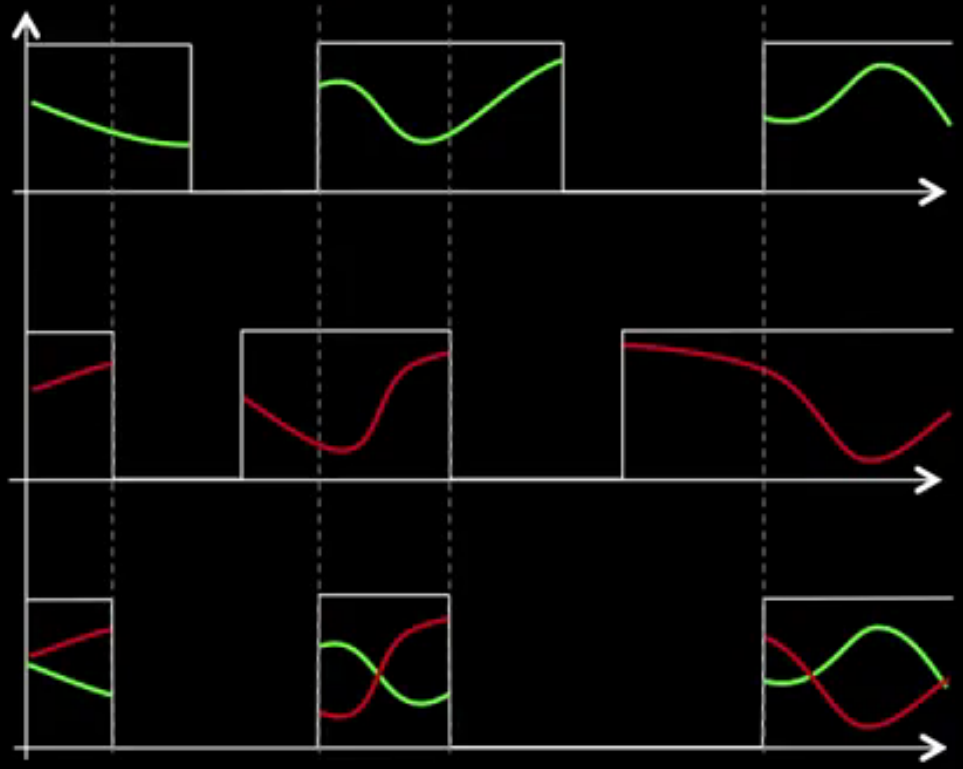
Similarity with Missing Information



$r_1 \cdot w_1$

$r_2 \cdot w_2$

Similarity with Missing Information



$r_1 \cdot w_1$

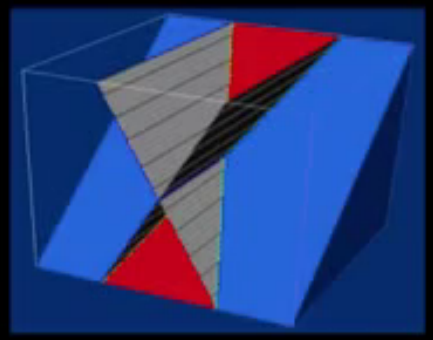
$r_2 \cdot w_2$

$||r_1 - r_2|| \cdot w_1 \cdot w_2$

$$d = \frac{\sum ||r_1 - r_2|| \cdot w_1 \cdot w_2}{\sum w_1 \cdot w_2}$$

Similarity of partially occluded volumes in Fourier space

$$\hat{\mathcal{F}}_1 = \mathcal{F}_1 \mathcal{W}_1, \quad \hat{\mathcal{F}}_2 = \mathcal{F}_2 \mathcal{W}_2, \quad \mathcal{W}_i \rightarrow [0, 1]$$



Missing Wedge
Measured Data

$$d = \frac{\int_{\mathcal{B}} ||\hat{\mathcal{F}}_1 - \hat{\mathcal{F}}_2|| \, \mathcal{W}_1 \, \mathcal{W}_2}{\int_{\mathcal{B}} \mathcal{W}_1 \, \mathcal{W}_2}$$

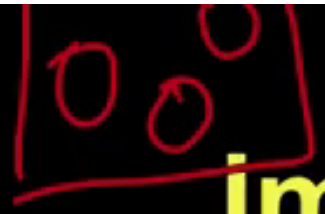
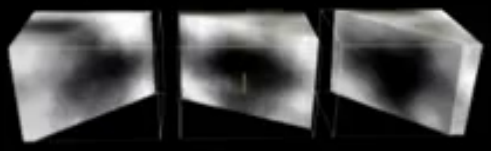
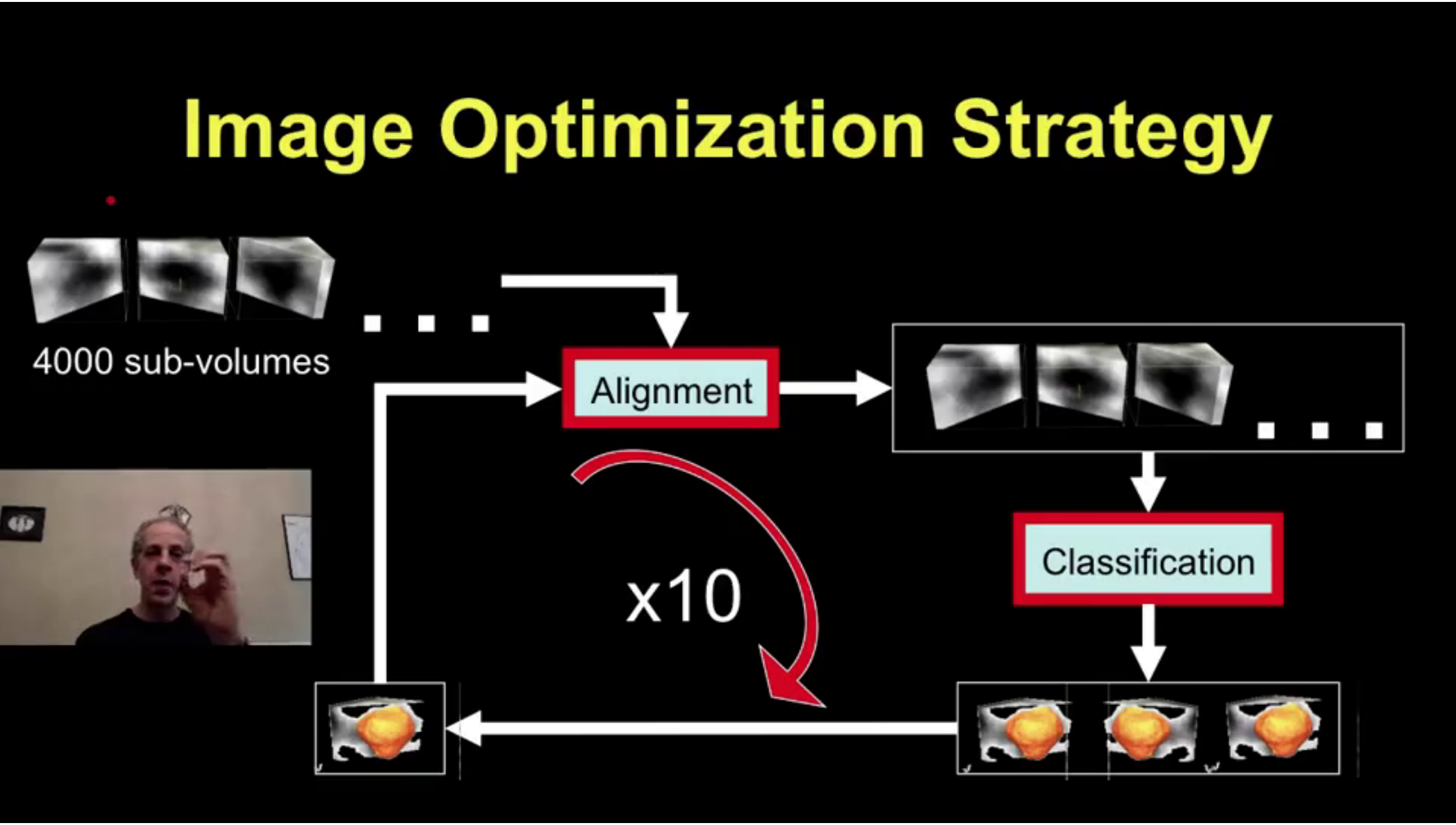


Image Optimization Strategy

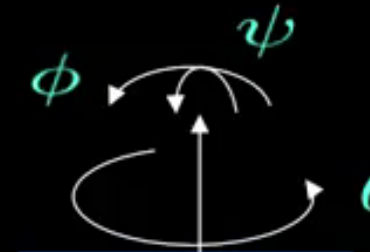


4000 sub-volumes

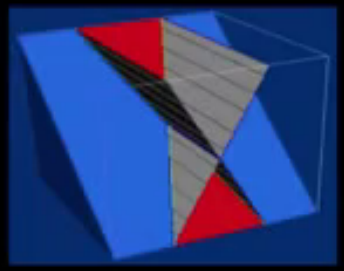
Image Optimization Strategy

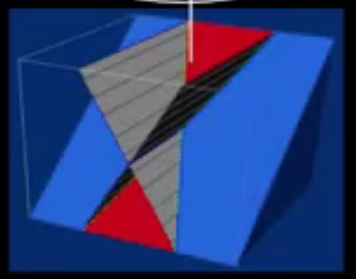


3D Image Alignment

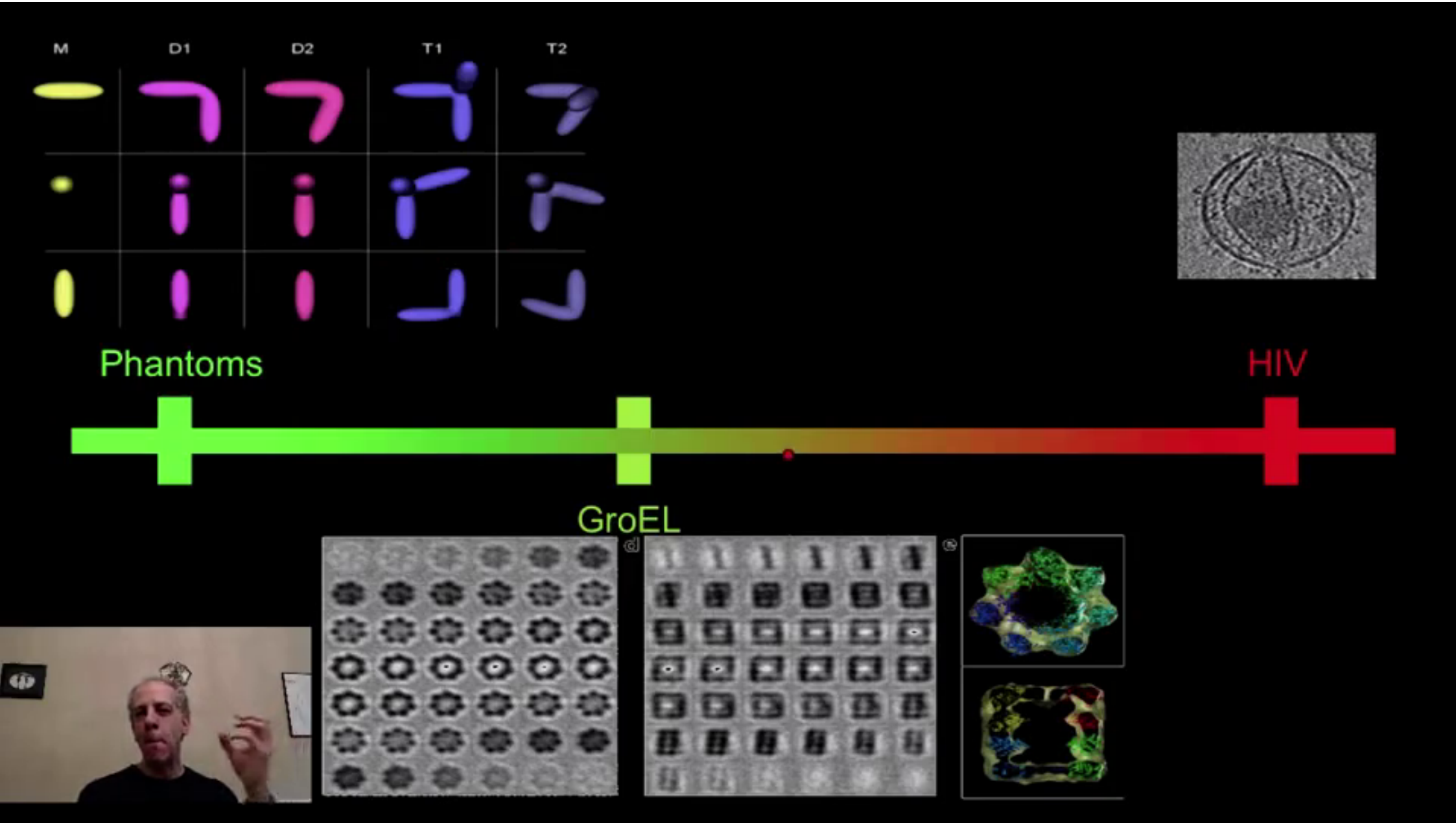


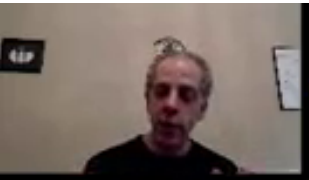
$$\min_{\theta,\phi,\psi,\vec{t}} d(\quad,\quad)$$





- 6 DOF problem: Speed-up in Fourier domain


M
D1
D2
T1
T2
Phantoms
HIV
GroEL

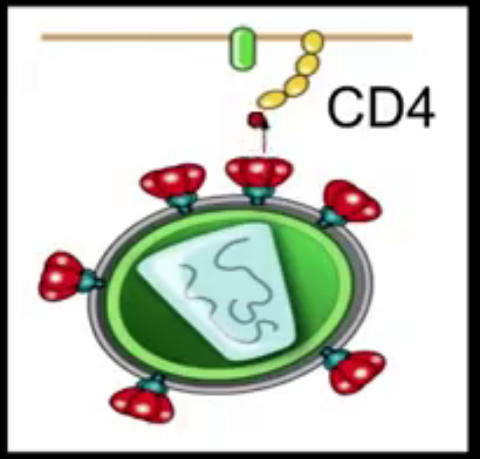


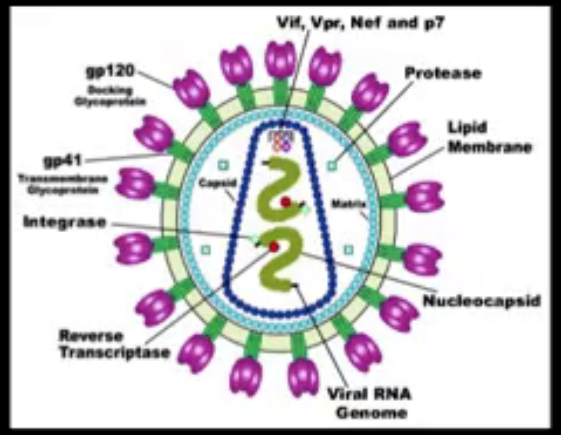
HIV envelope glycoproteins

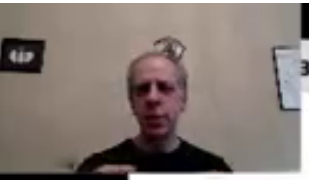
- Mediate virus binding to the cell surface receptor CD4 on target cells to initiate infection
- Functional unit is a trimer

  of **gp120** (surface glycoprotein)

  and **gp41** (transmembrane unit).
- Structure of components available.
- Structure of the trimer remains elusive.







38/nature07159 nature

LETTERS

Molecular architecture of native HIV-1 gp120 trimers

Jun Liu[1]*, Alberto Bartesaghi[1]*, Mario J. Borgnia[1]*, Guillermo Sapiro[2] & Sriram Subramaniam[1]

[1]Laboratory of Cell Biology, Center for Cancer Research, National Cancer Institute, NIH, Bethesda, Maryland 20892, USA. [2]Department of Electrical and Computer Engineering, University of Minnesota, Minneapolis, Minnesota 55455, USA.
*These authors contributed equally to this work.

- Use cryo-electron tomography combined with 3D image averaging and classification
- Report 3D “snapshots” of trimeric spike:
  - Unliganded state
  - Complex with broadly neutralizing b12
  - Ternary complex with CD4 and 17b

Imaging the spike at different states

- 80 tilt series, 400 virus, 4K spikes
  1. Unliganded state
  2. Complex with b12
  3. Ternary complex with CD4 and 17b

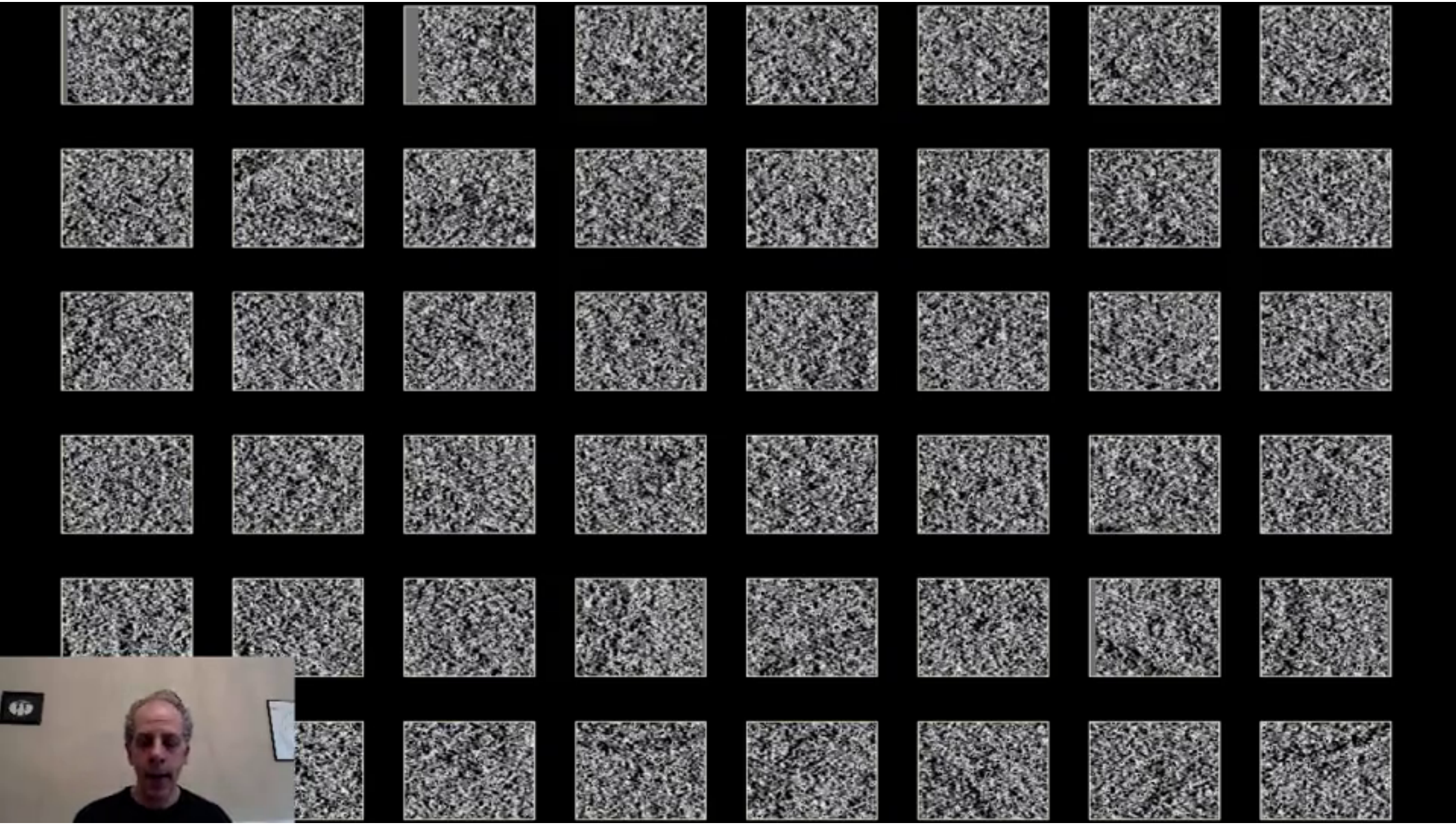


Image Refinement Loop

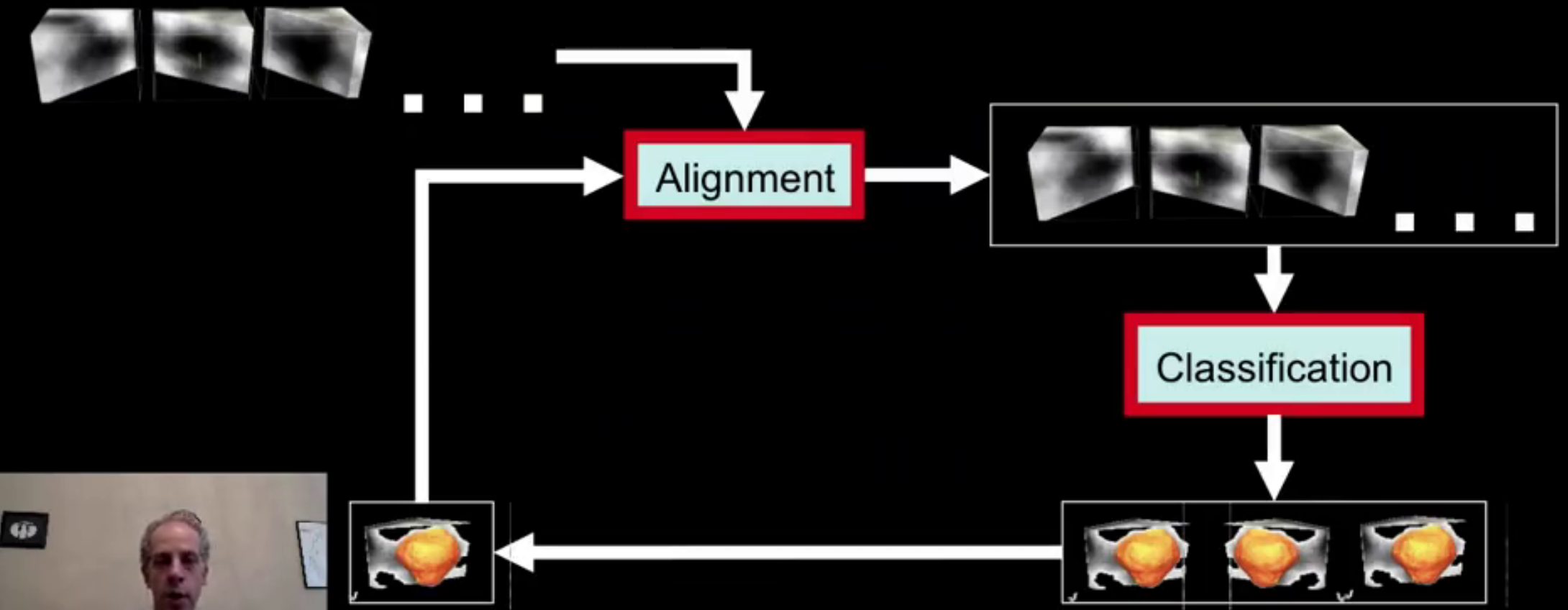
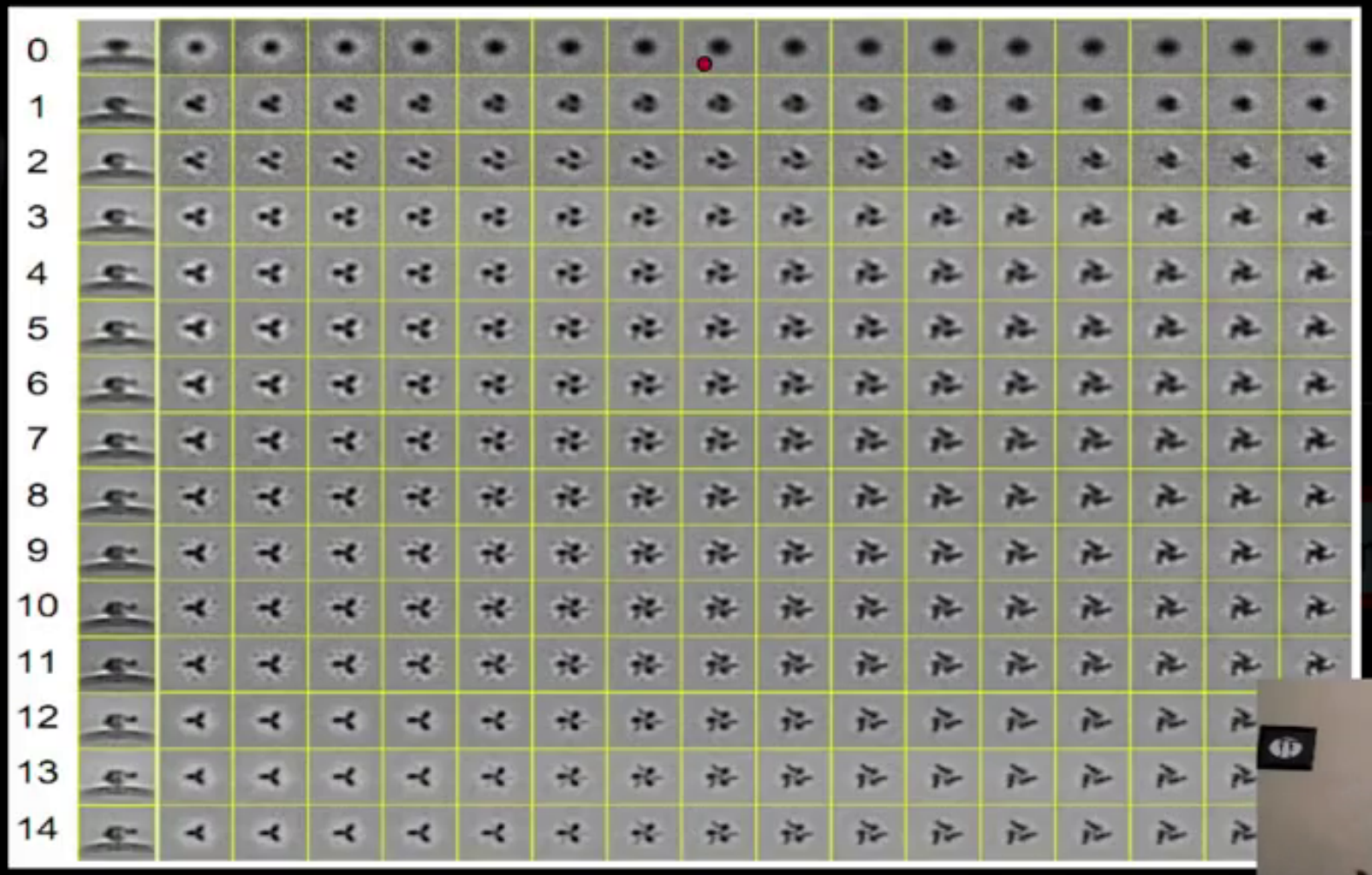
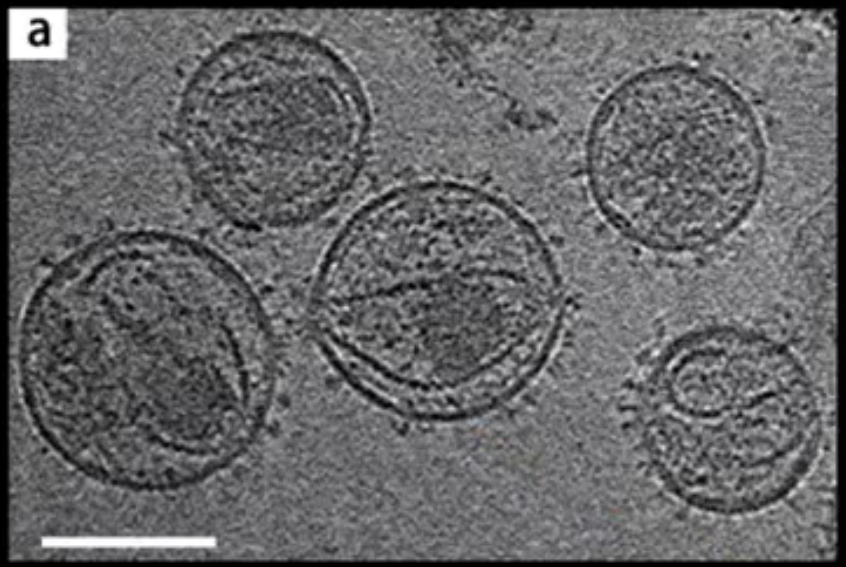
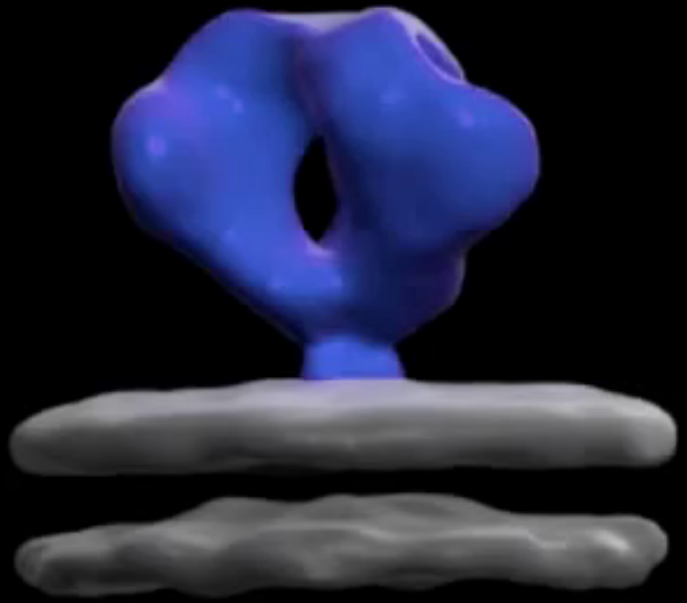
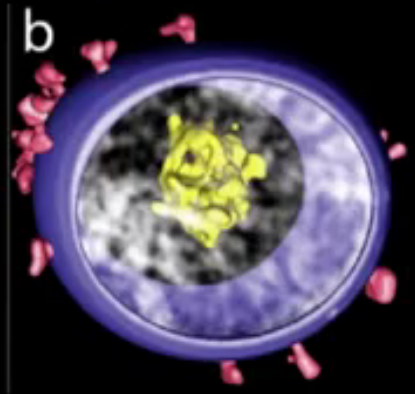


Image Refinement Loop




a

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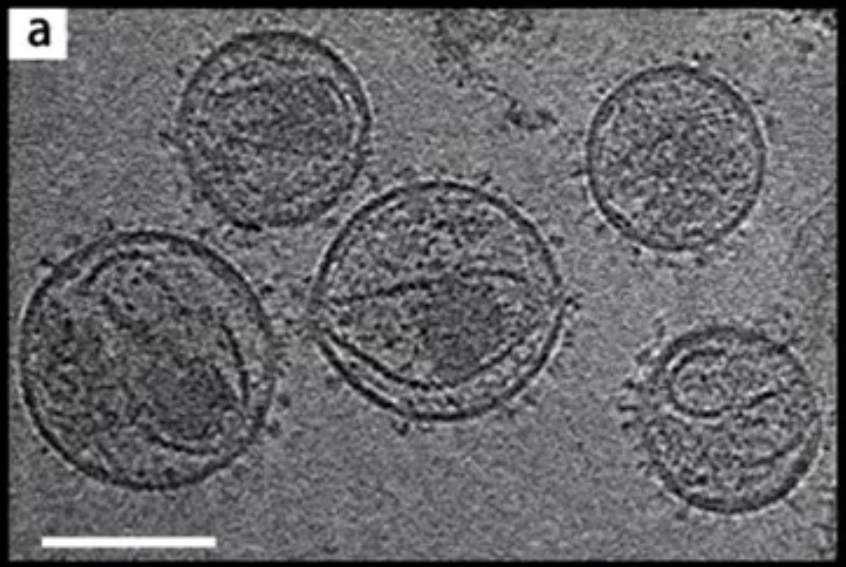
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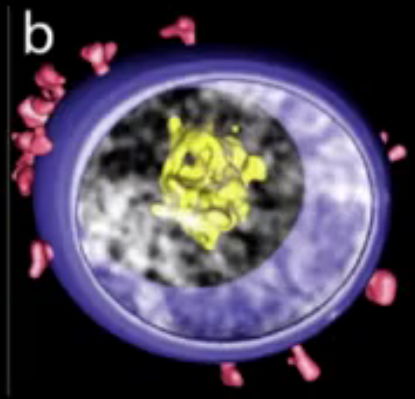
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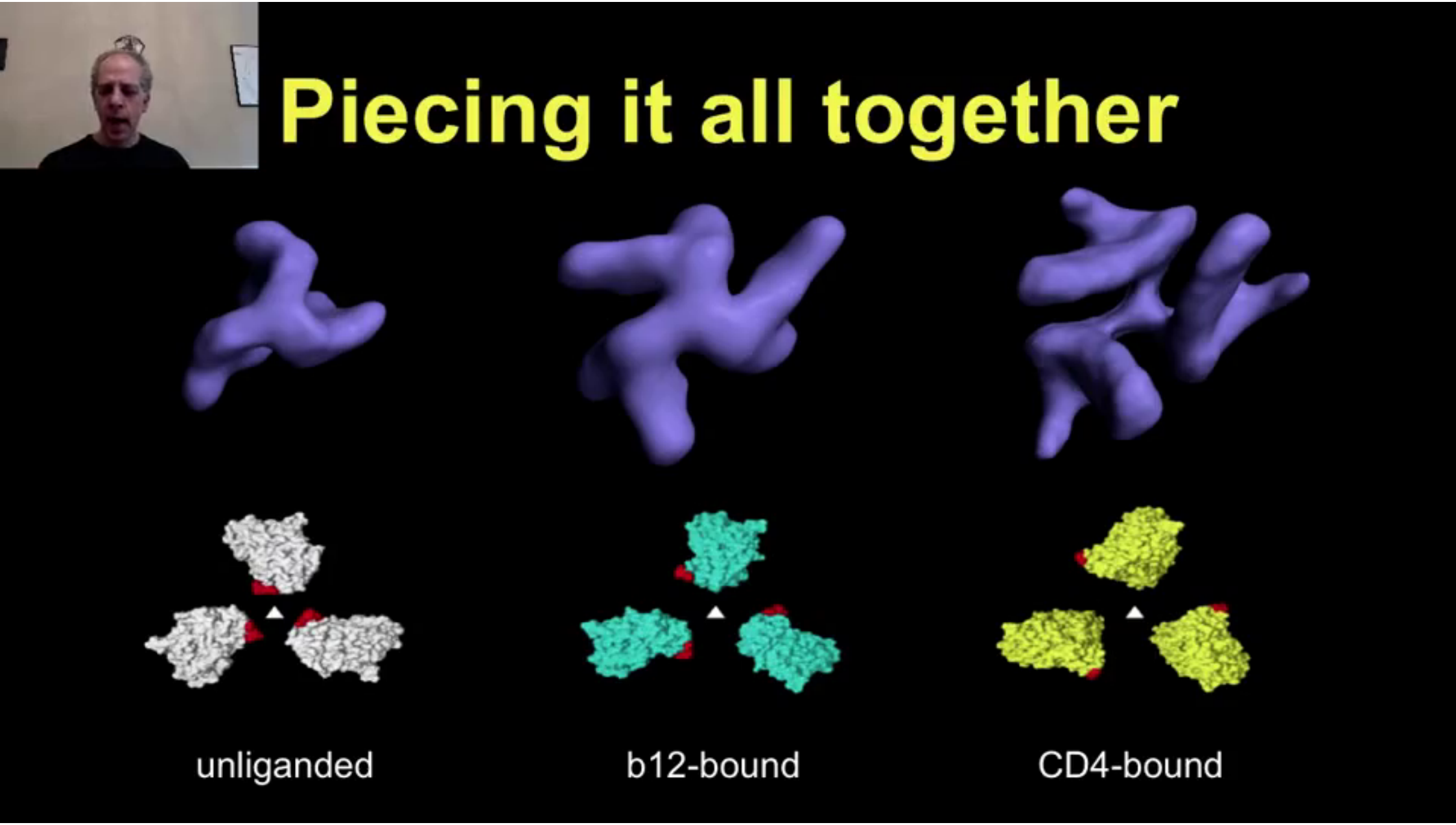
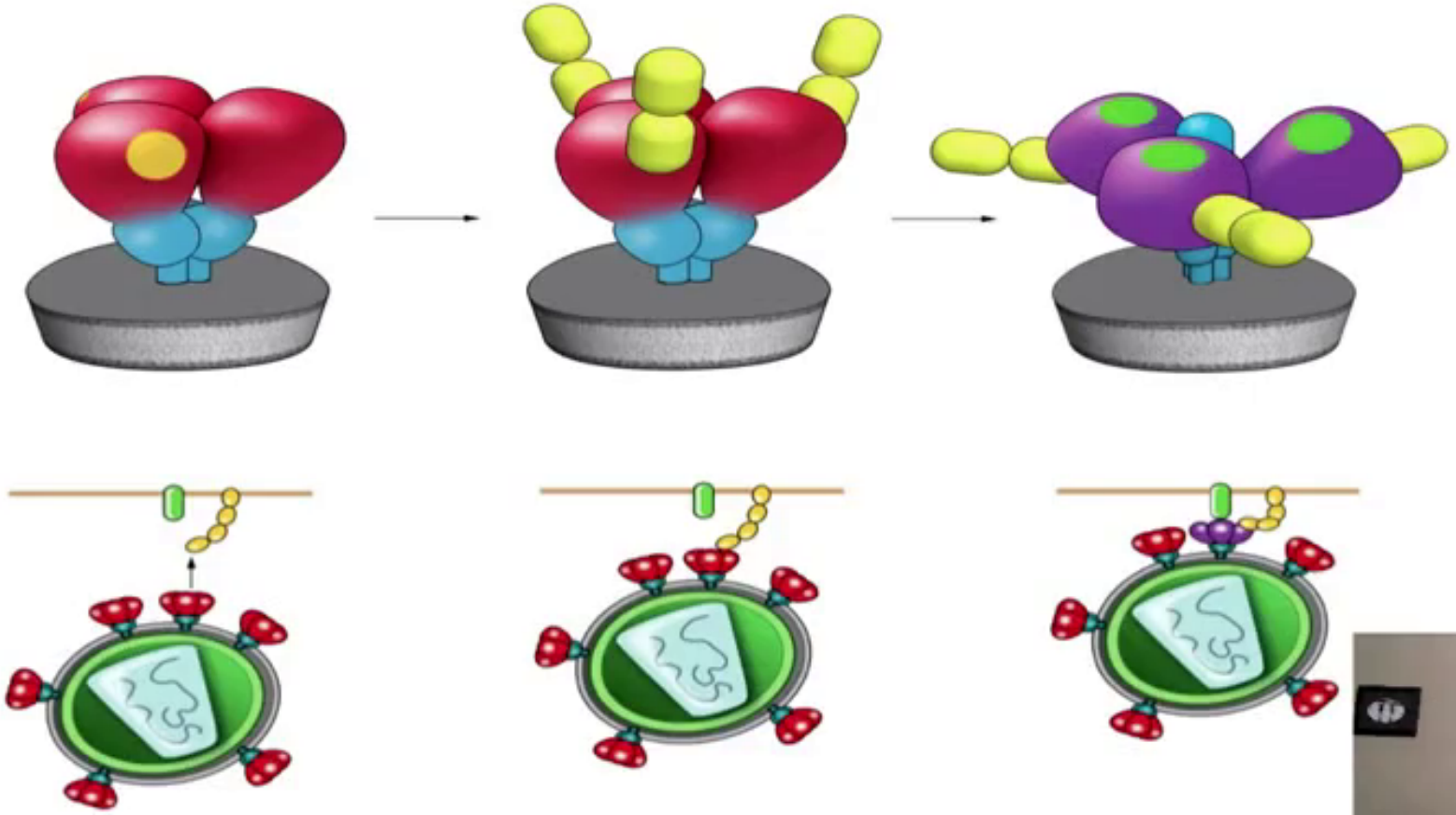

Piecing it all together
unliganded
b12-bound
CD4-bound

Conformational changes of the trimeric spike that occur upon CD4 binding



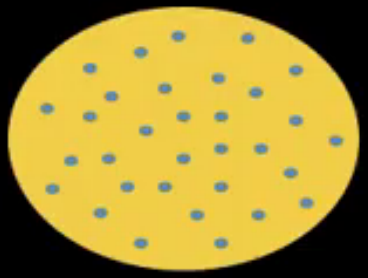
Diffusion-Weighted MRI

Provides architecture of biological tissues

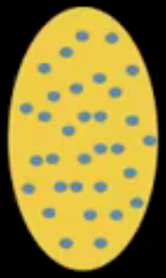
Used to study:

- **Neurological disorders**
- **Brain development**
- **Structure of brain fiber bundles**

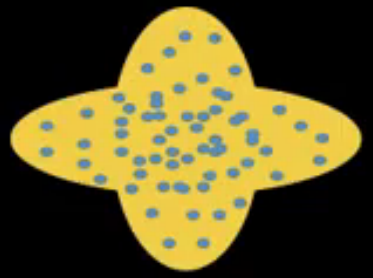
Diffusion of Water Molecules



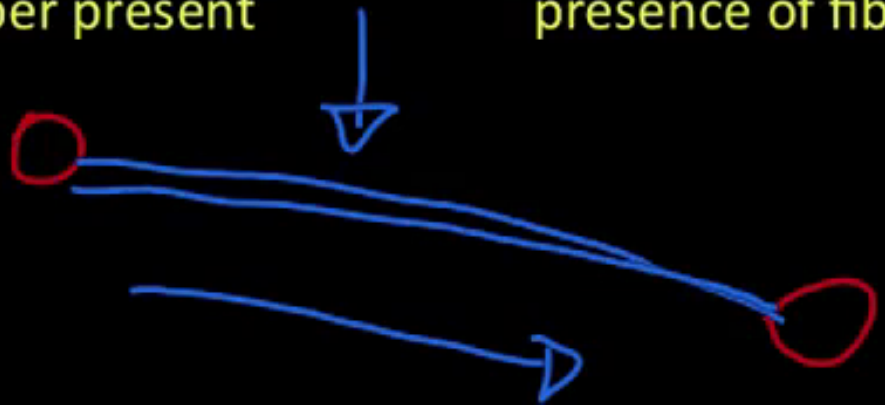
Isotropic Diffusion
no fiber present



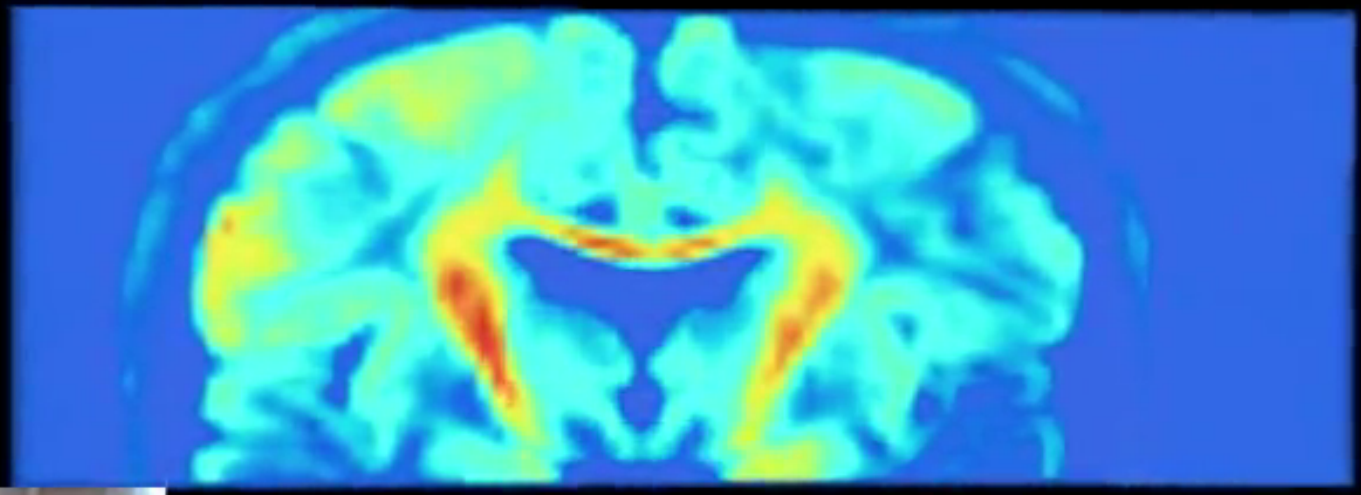
Anisotropic Diffusion
presence of fiber



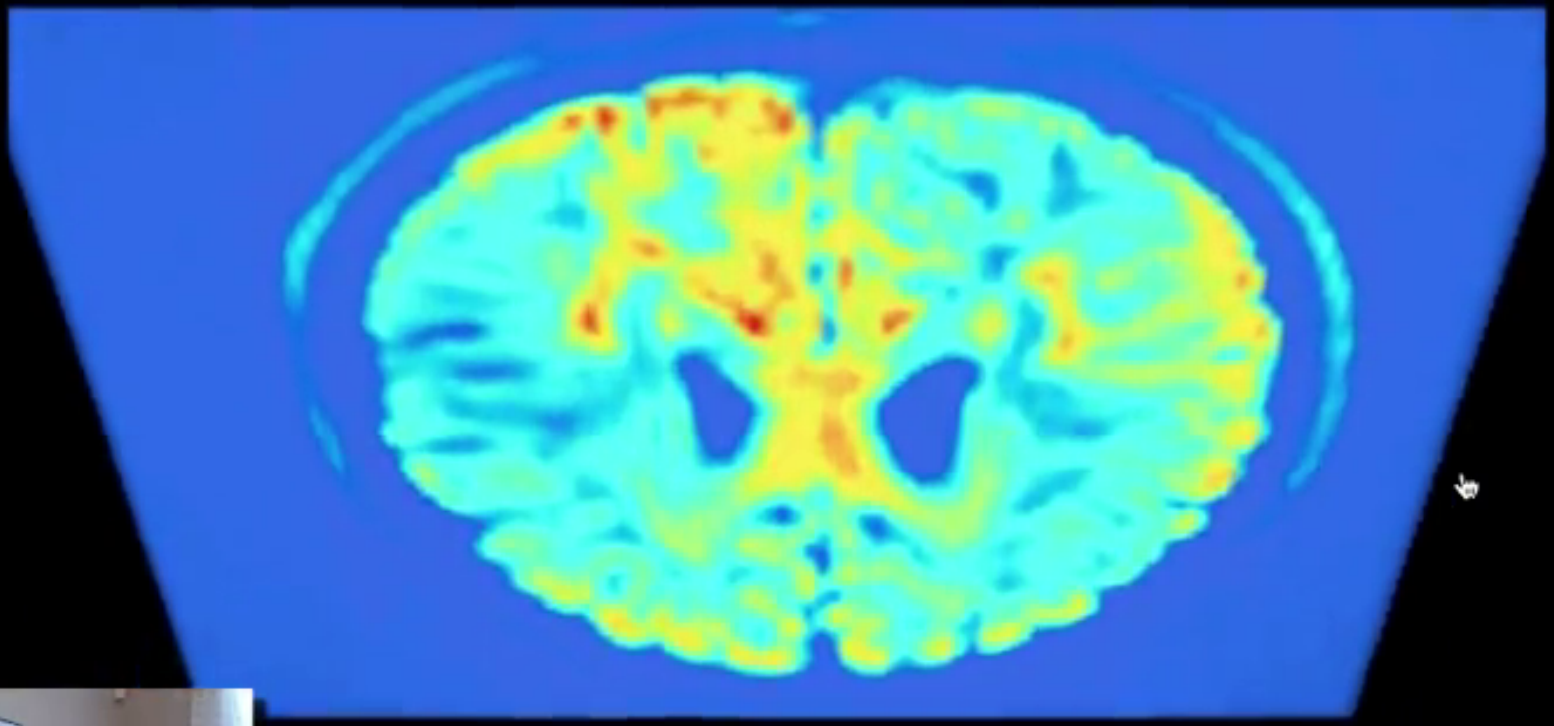
Orthogonal Diffusion
fiber crossing

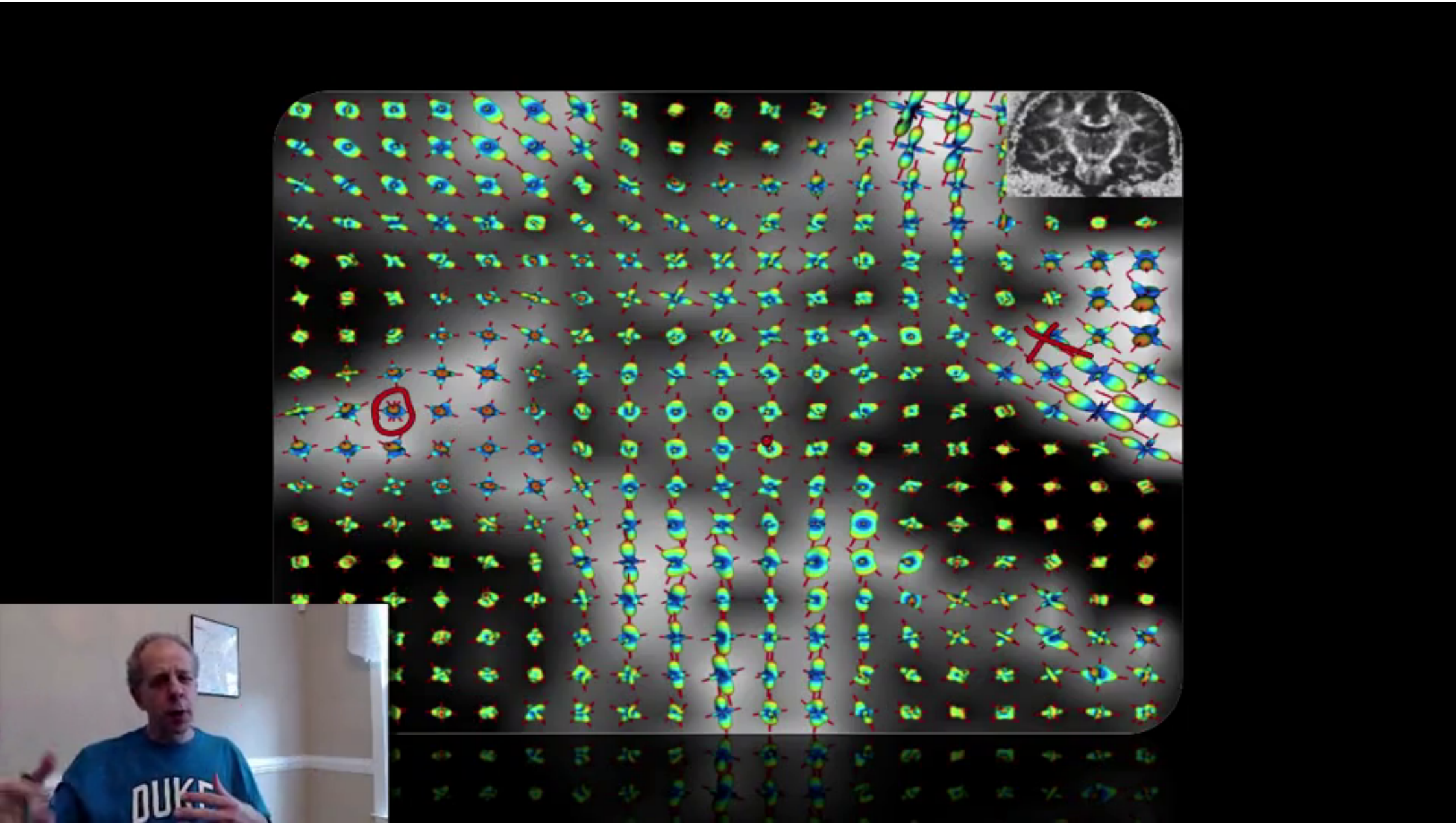


Diffusion-Weighted MR Image

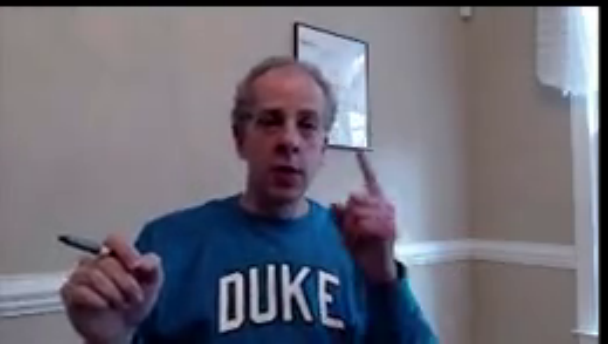


Diffusion-Weighted MR Image

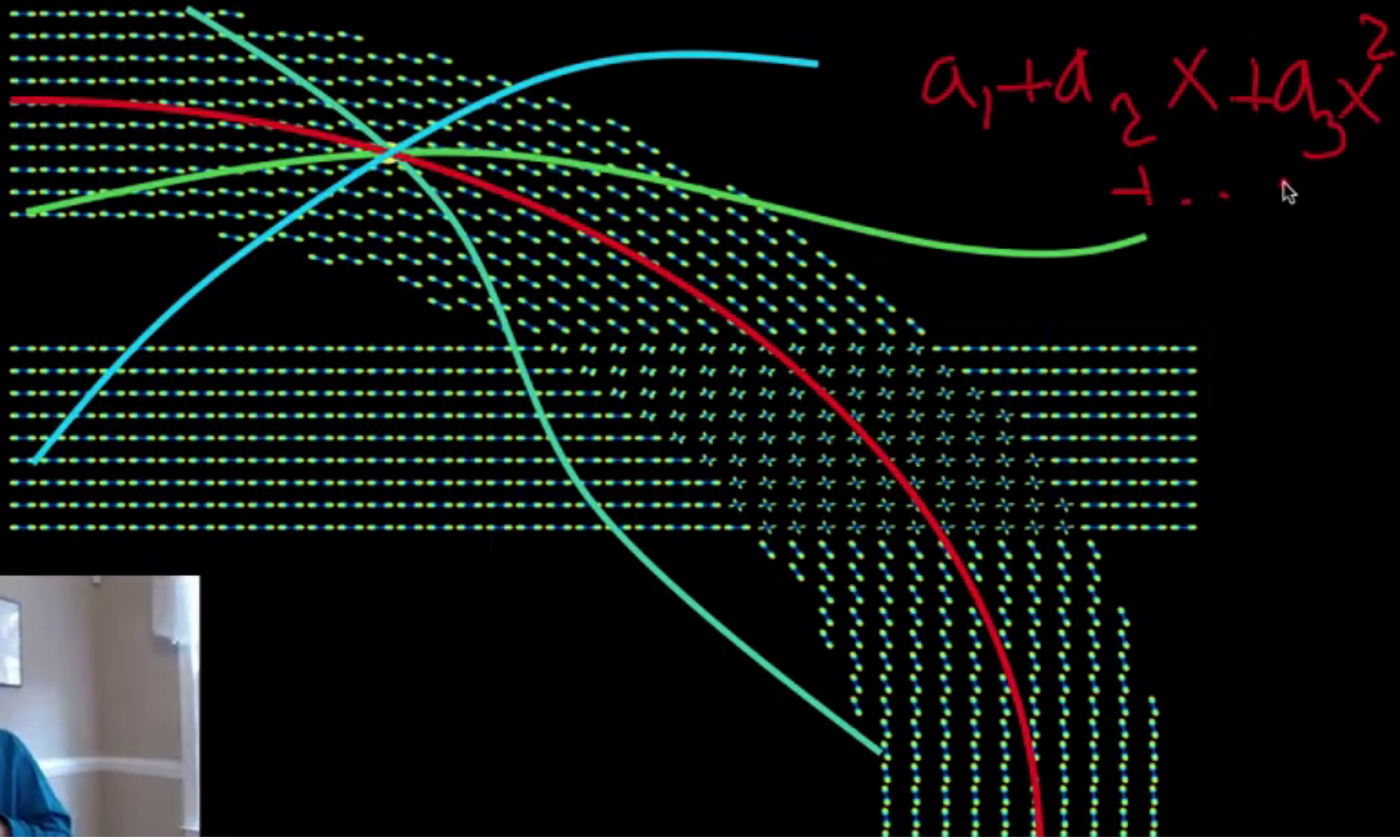




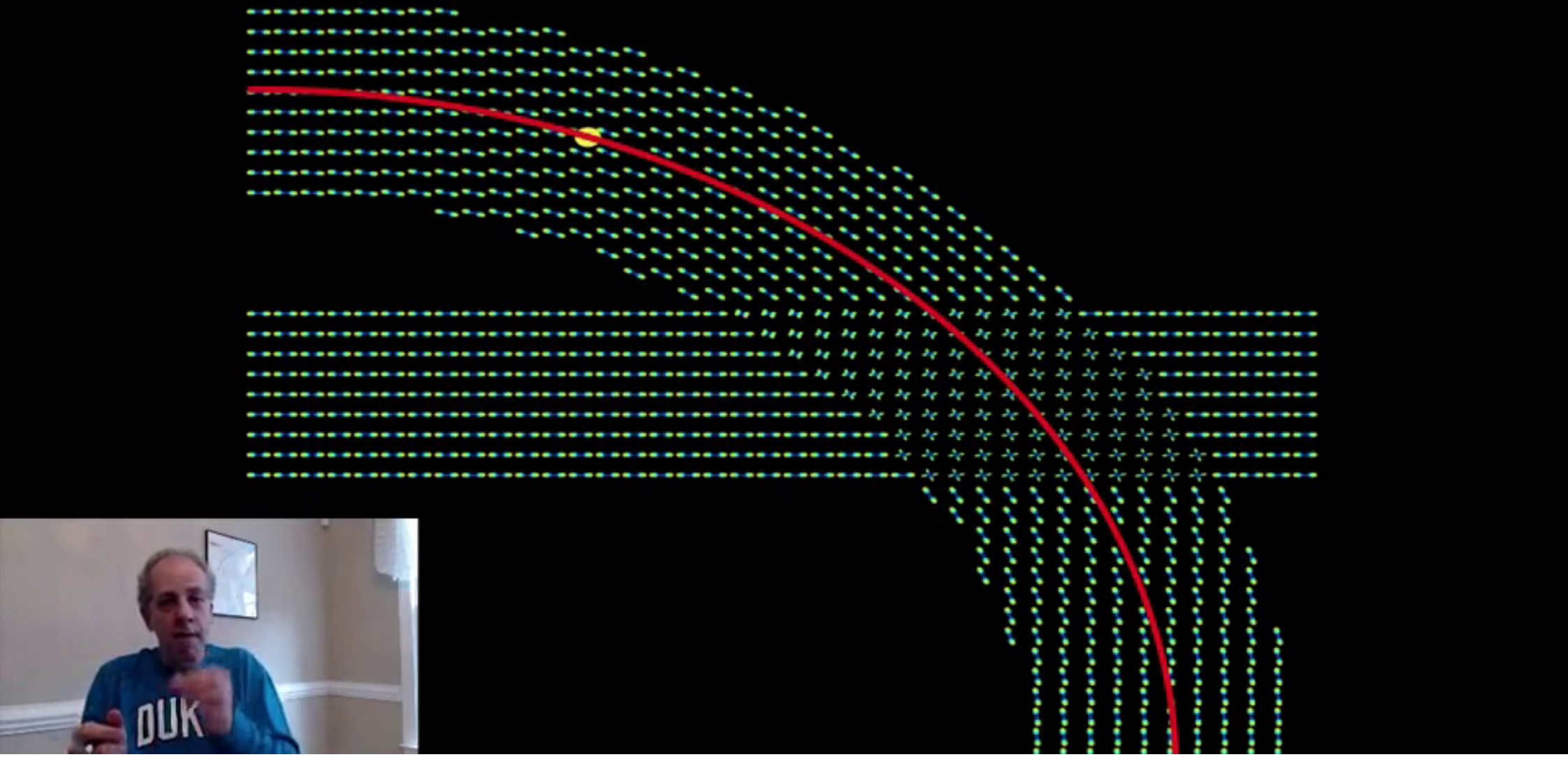
Hough Transform !!!



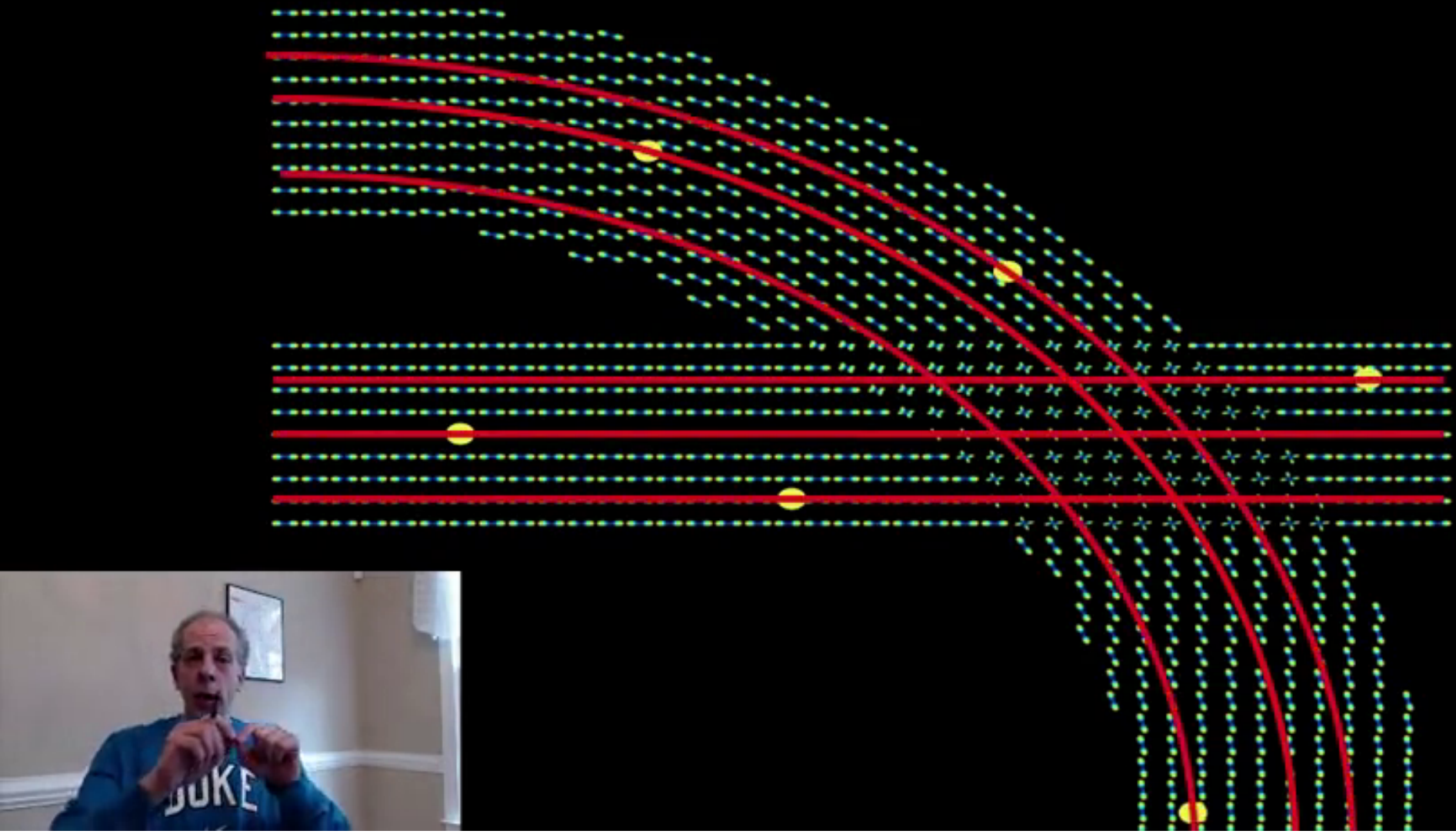
Hough Transform !!!



Hough Transform !!!



Hough Transform !!!



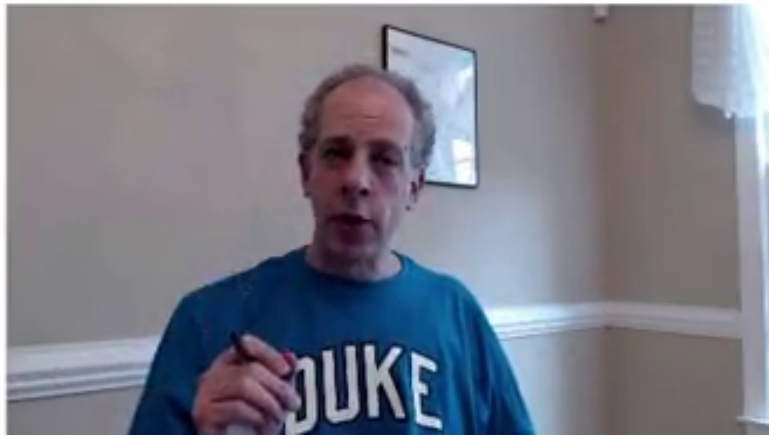

DUKE

Brain Imaging: Deep Brain Stimulation

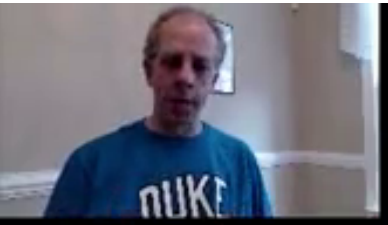
Image and Video Processing: From Mars to Hollywood with a Stop at the Hospital

Guillermo Sapiro

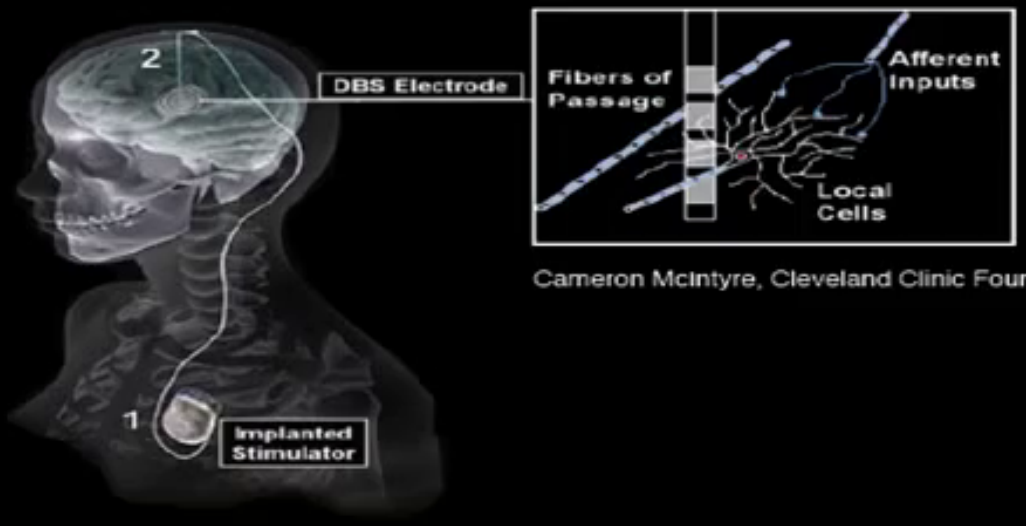
Duke
UNIVERSITY



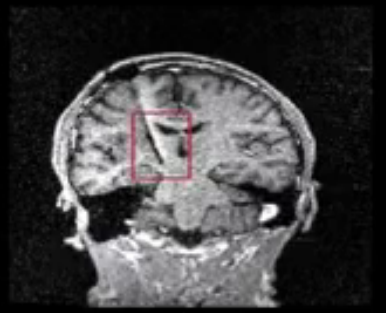
Thanks to Lenglet, Aganj, Harel, Duchin, SIS

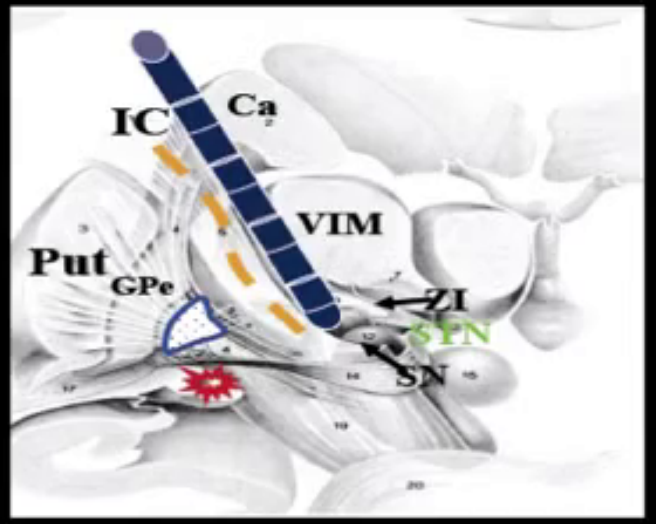


Deep Brain Stimulation (DBS)



Cameron McIntyre, Cleveland Clinic Foundation



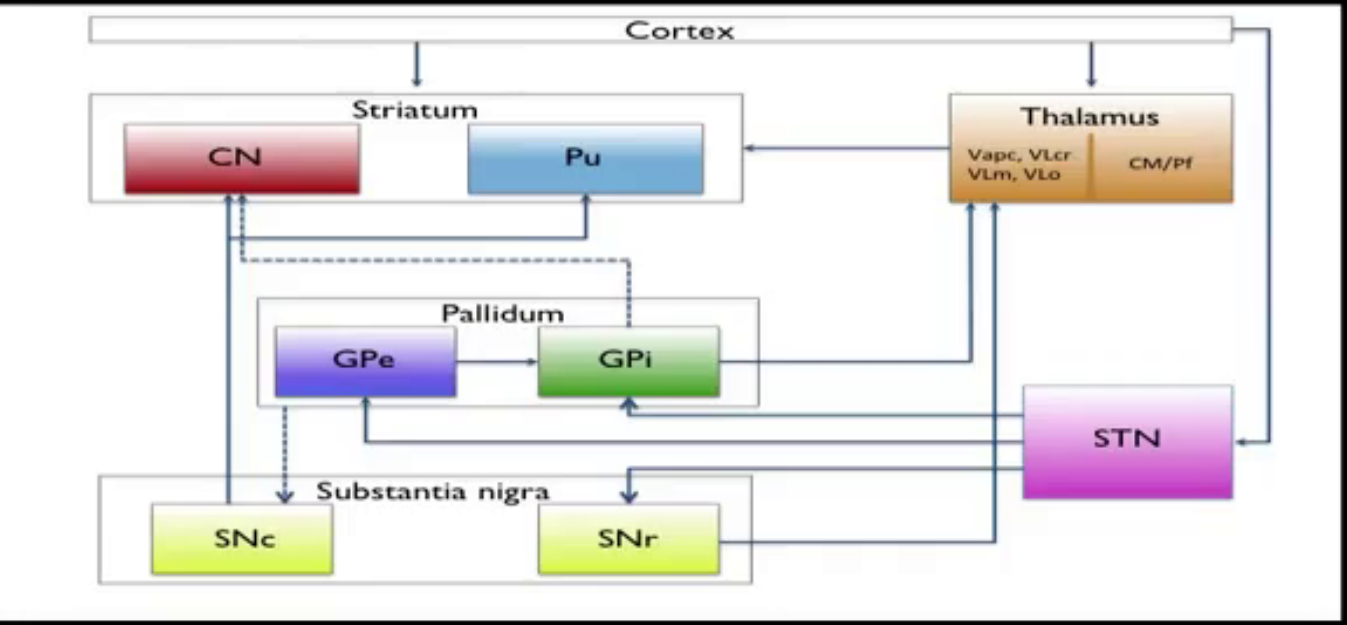


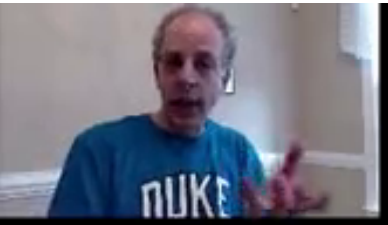
Successful DBS surgery is critically dependent on precise placement of DBS electrodes into target structures

Students: A good place to take a break if needed.

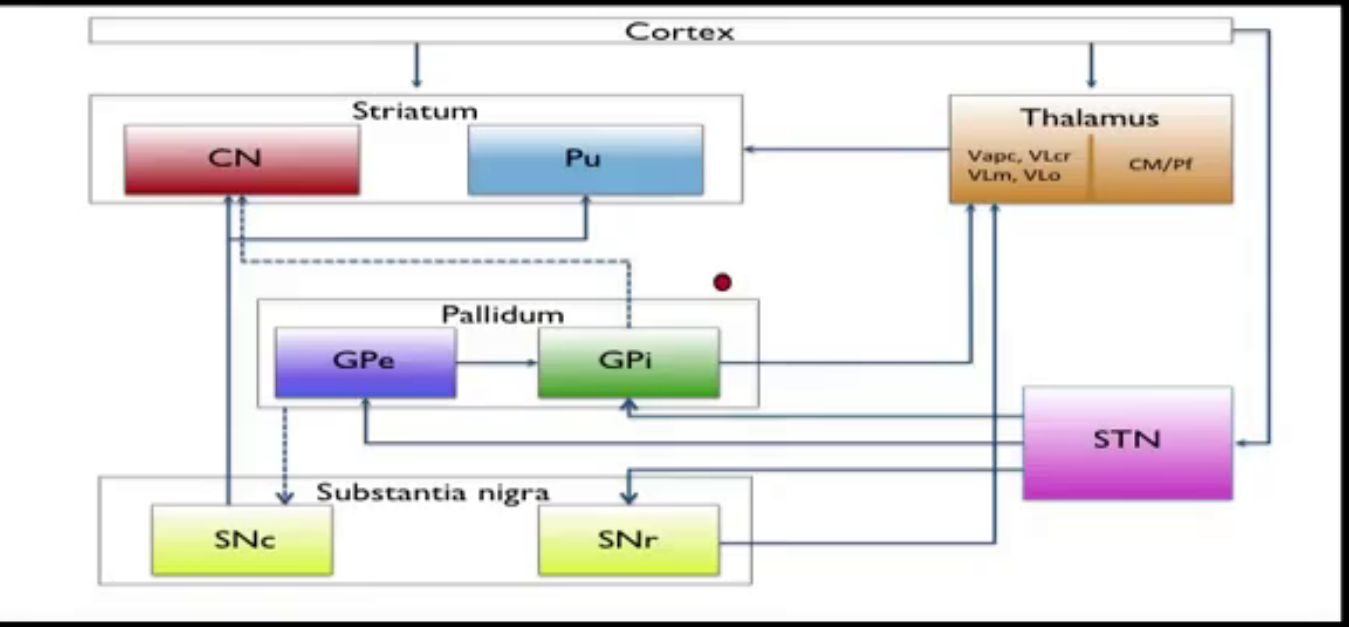
Duke UNIVERSITY

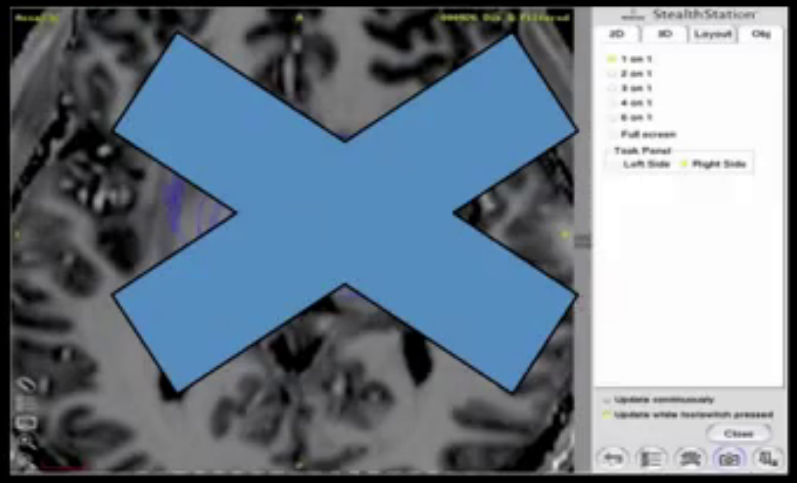
Brain Imaging and DBS

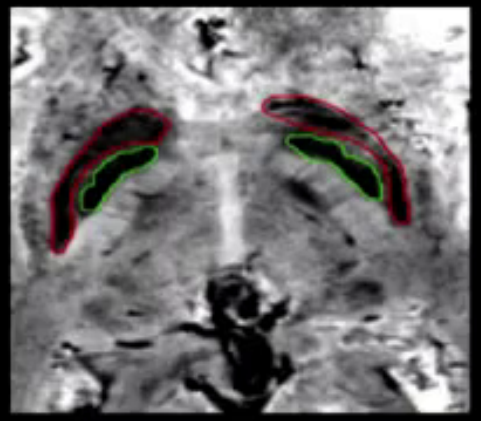


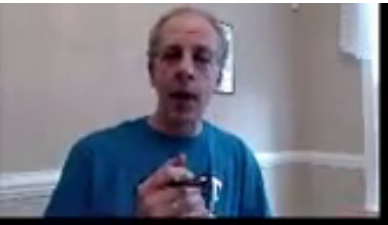


Brain Imaging and DBS

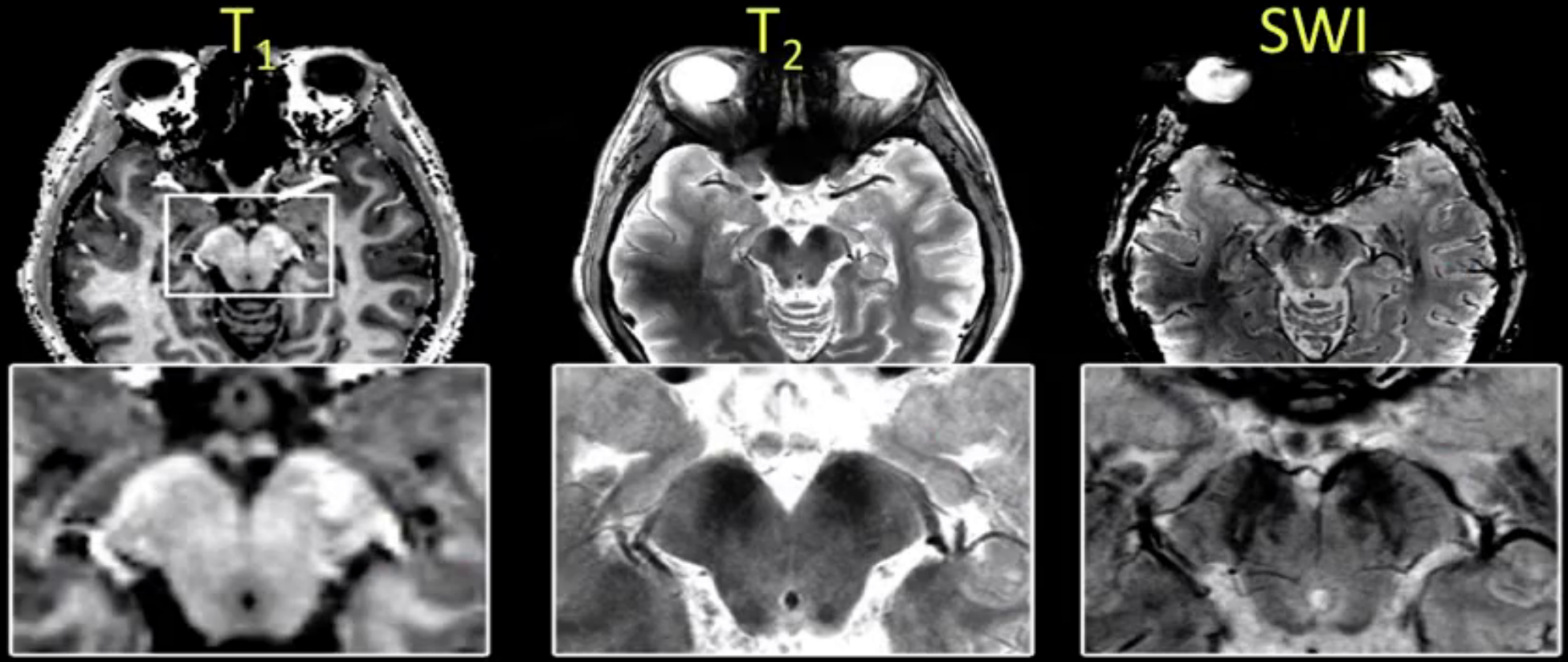


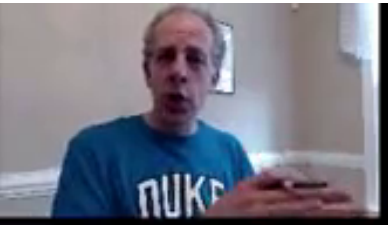




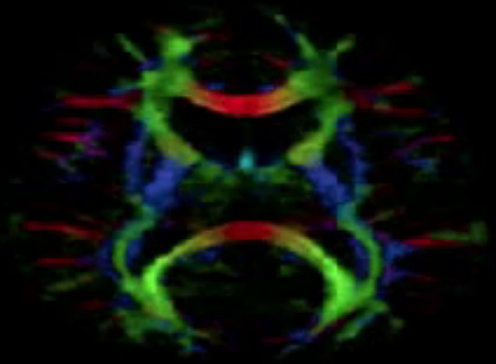


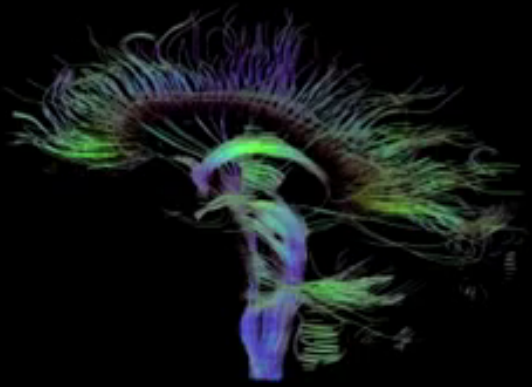
Brain Imaging and DBS

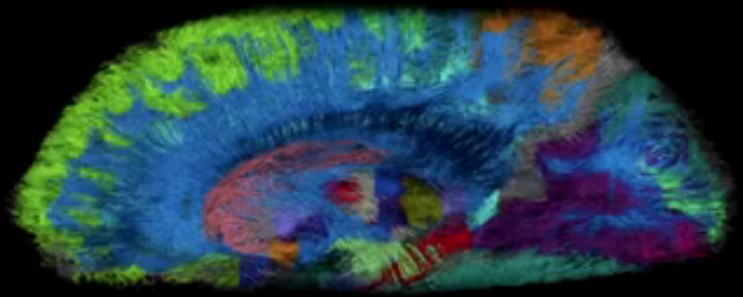


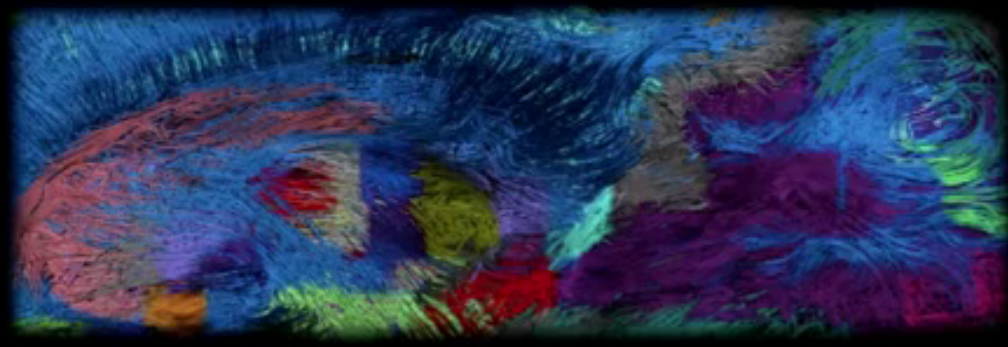


Brain Imaging and DBS

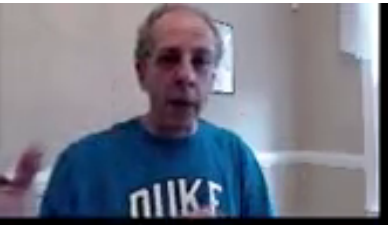




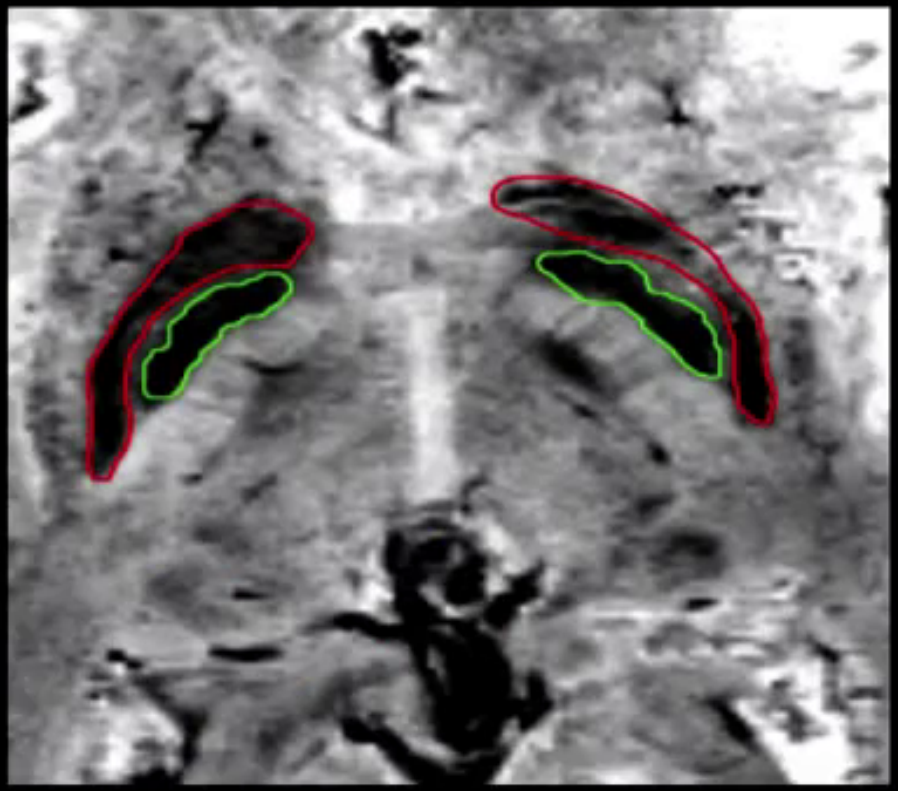




Human, 7T, 1.5 x 1.5 x 1.5 mm^3
Tractography – Paul Thompson, UCLA



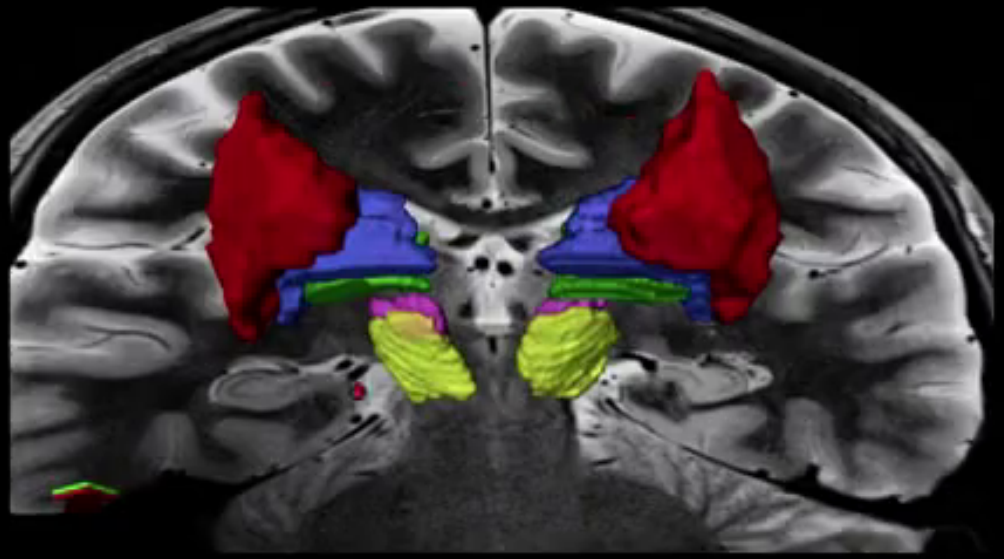
Brain Imaging and DBS

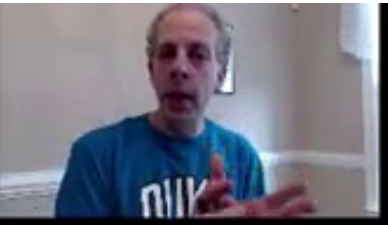


GP = Globus pallidus

GPi = DBS Target for Dystonia

Brain Imaging and DBS: ROI





Brain Imaging and DBS: DWI