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

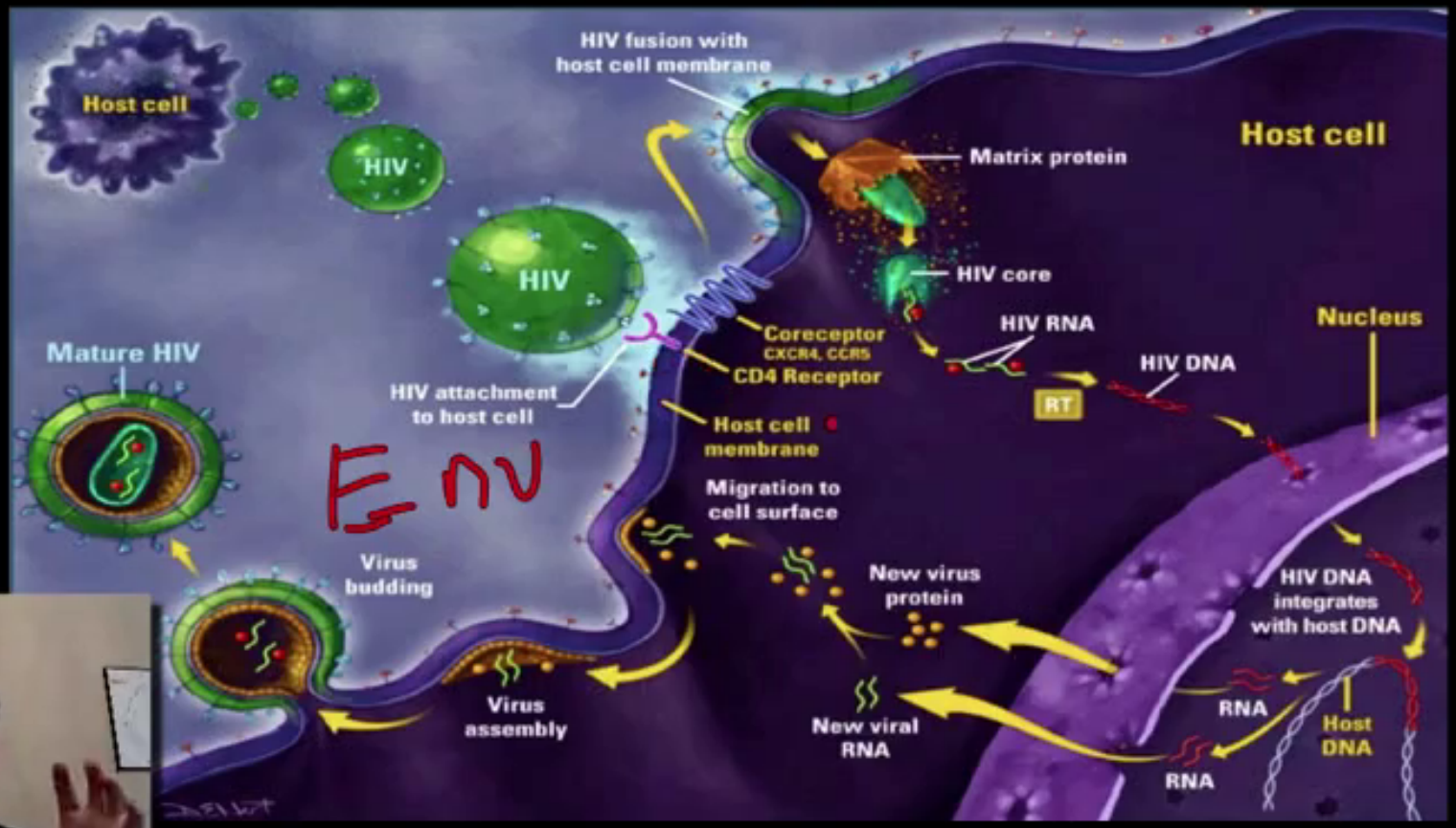
NMR

Electrons

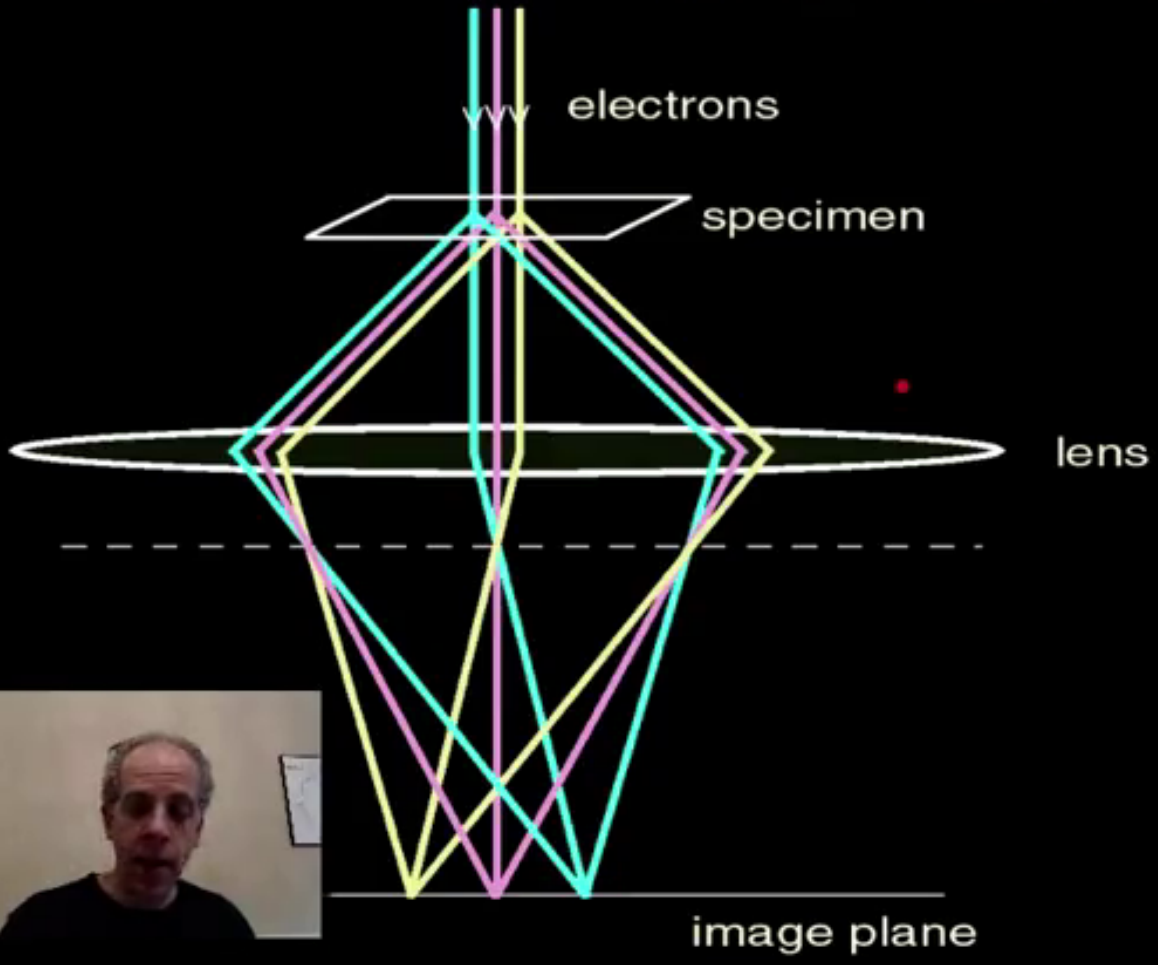
Light

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

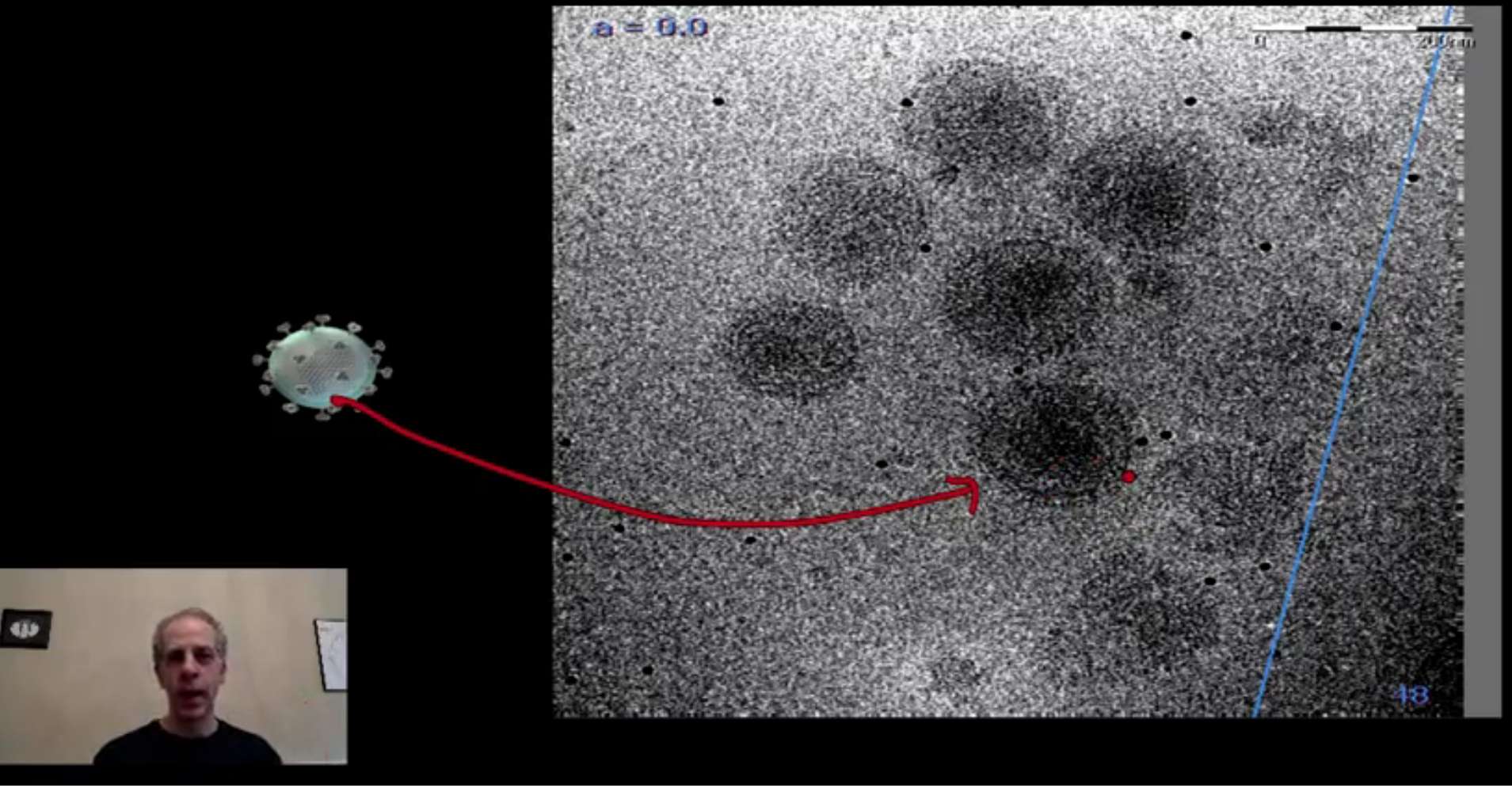
Our Target: Molecular structure of HIV envelope glycoproteins



Transmission Electron Microscopy

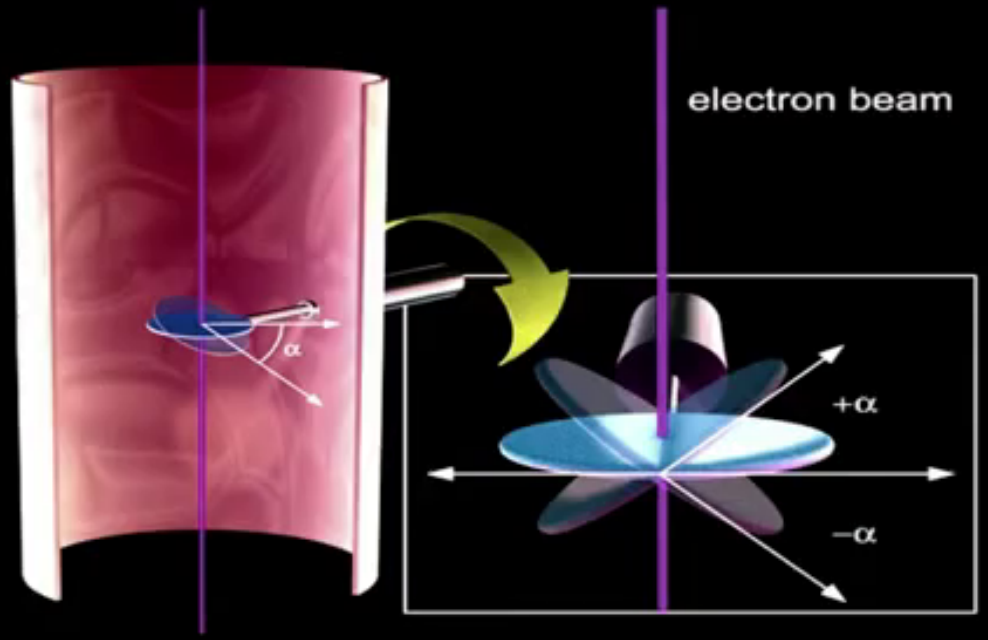


Single Projection Image of HIV

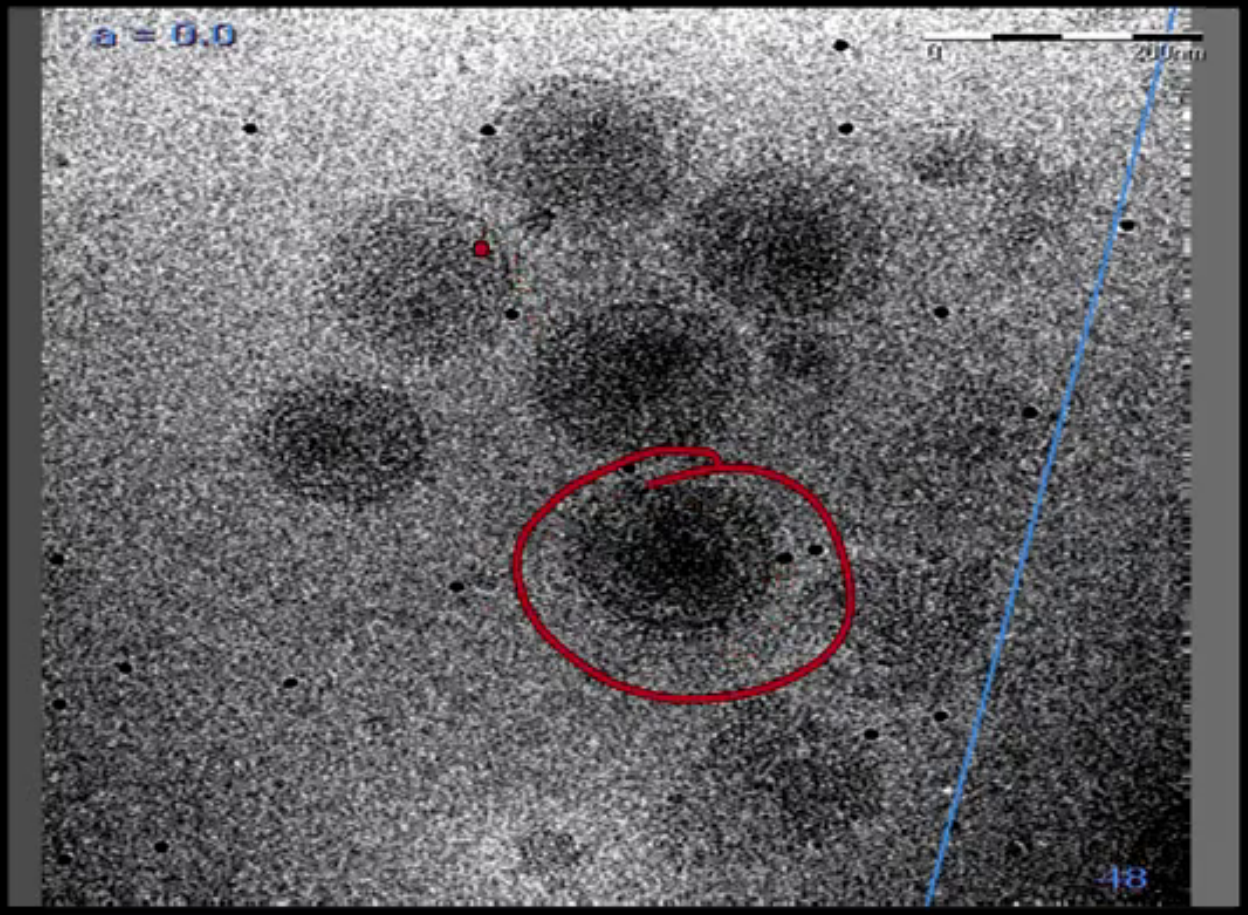


Cryo-Electron Tomography

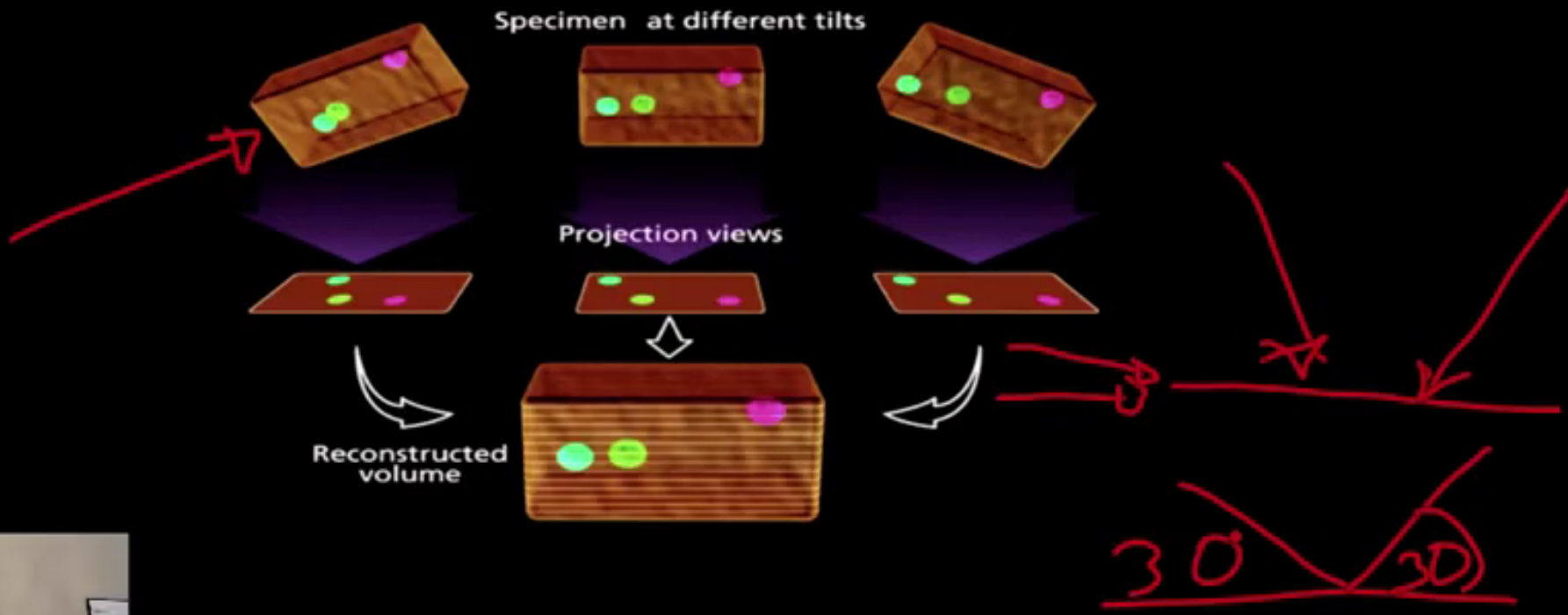
- Reduce radiation damage
- Obtain 3D information



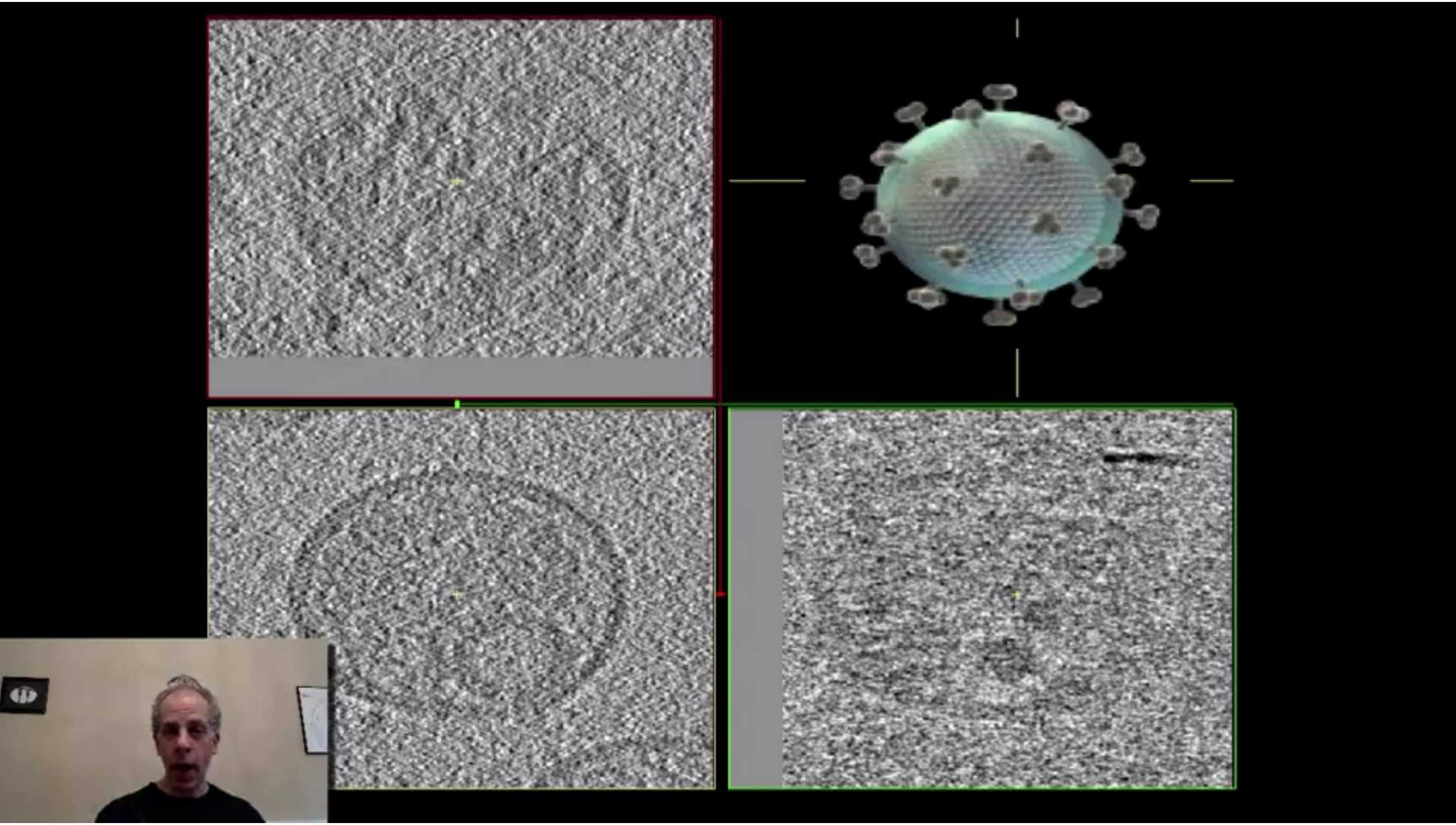
Raw tilt-series of HIV



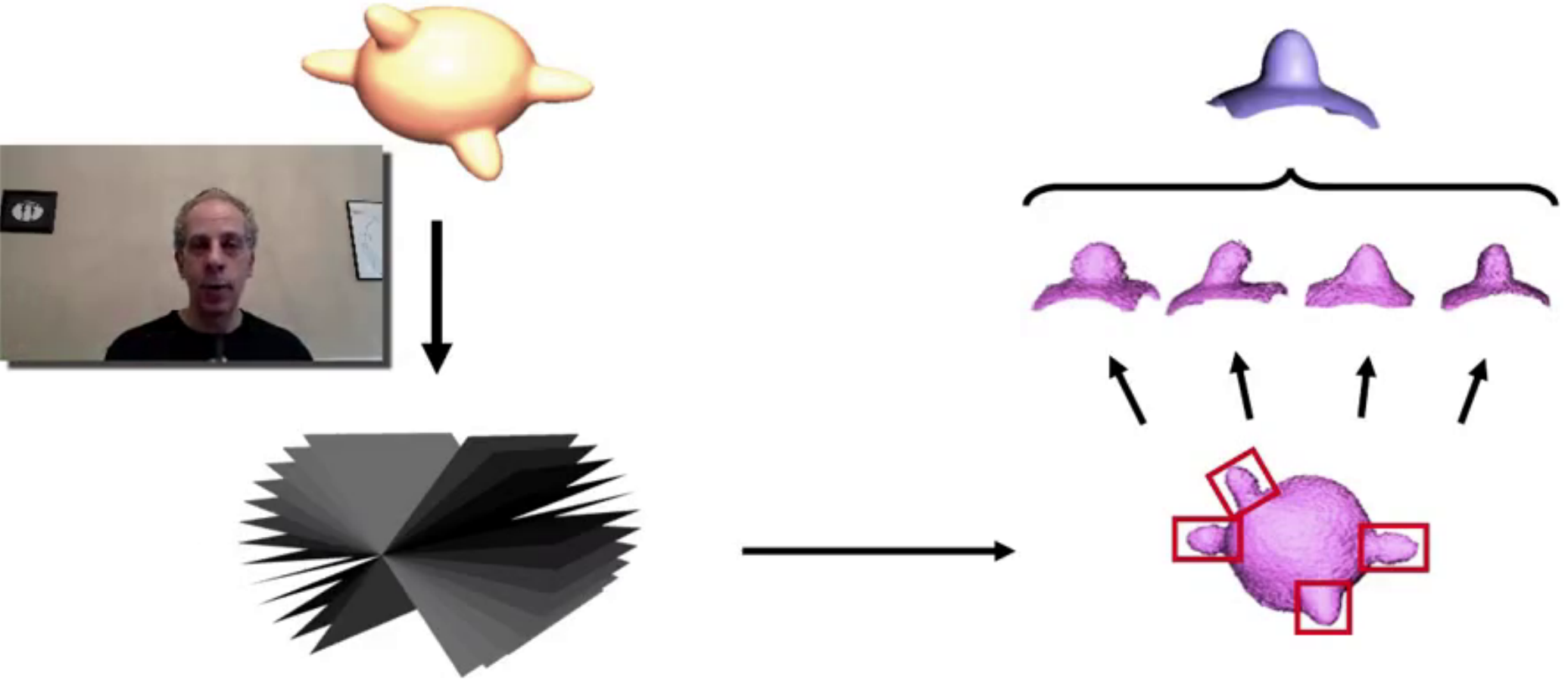
Tomographic Reconstruction



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



Sub-Volume Averaging in Electron Tomography



Reconstitution From Noisy and Incomplete Images

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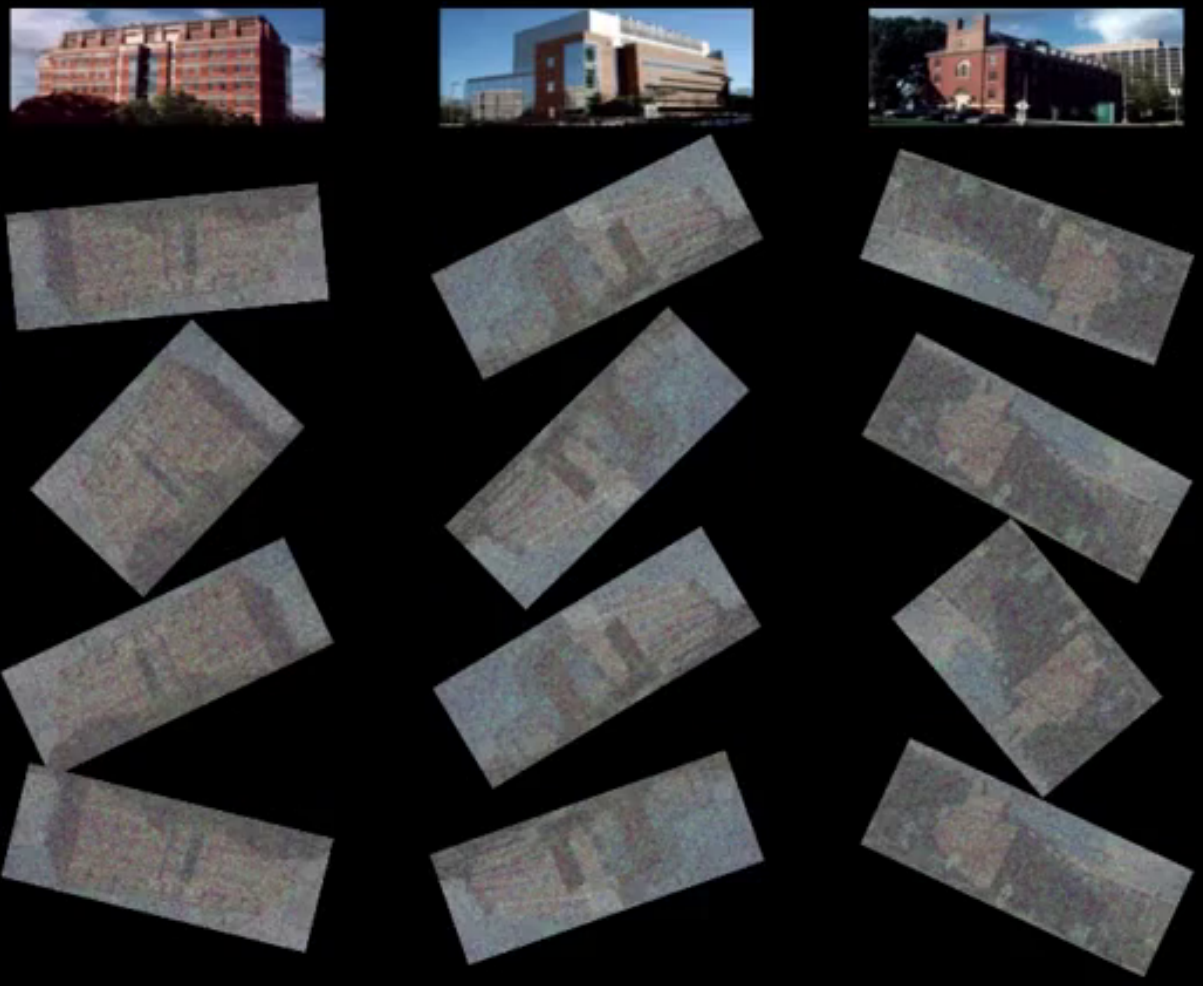

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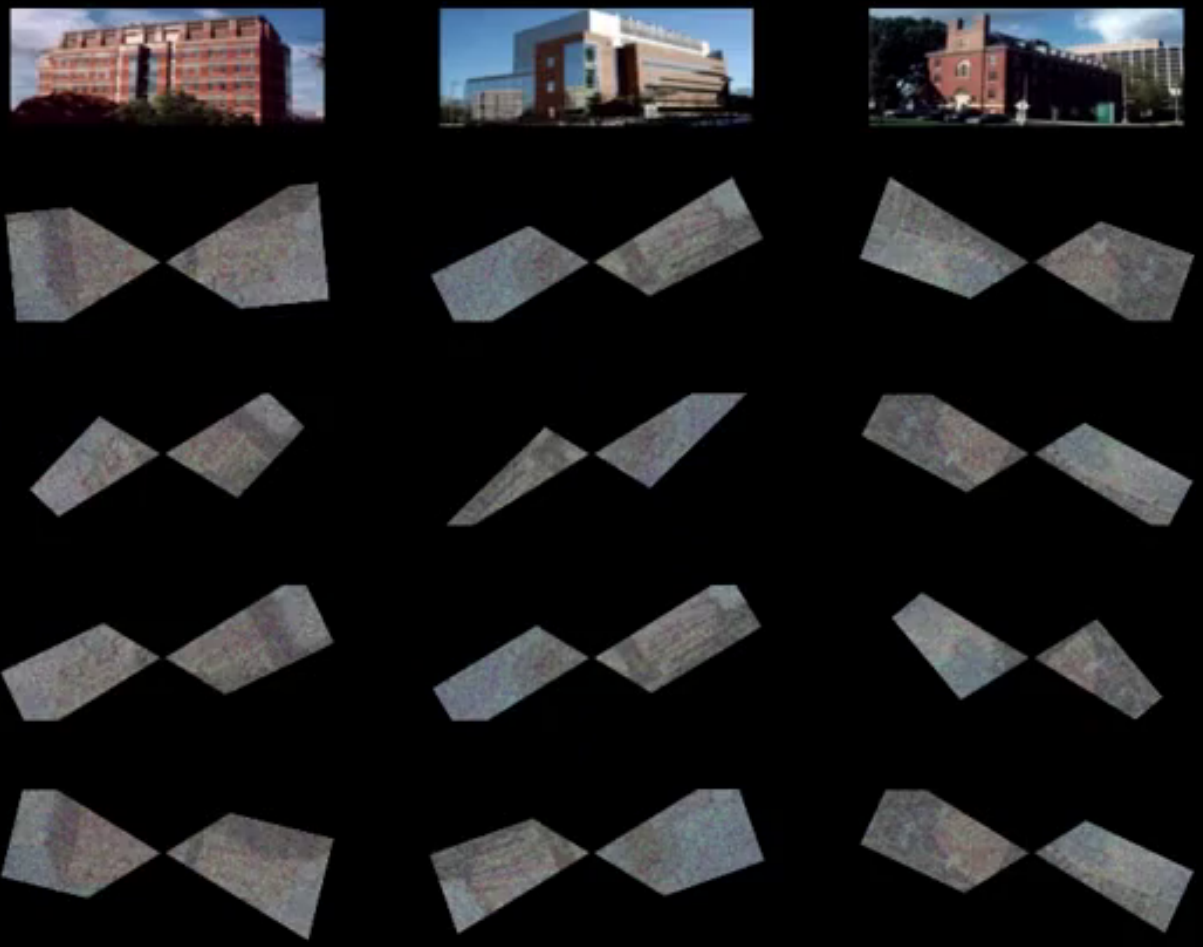
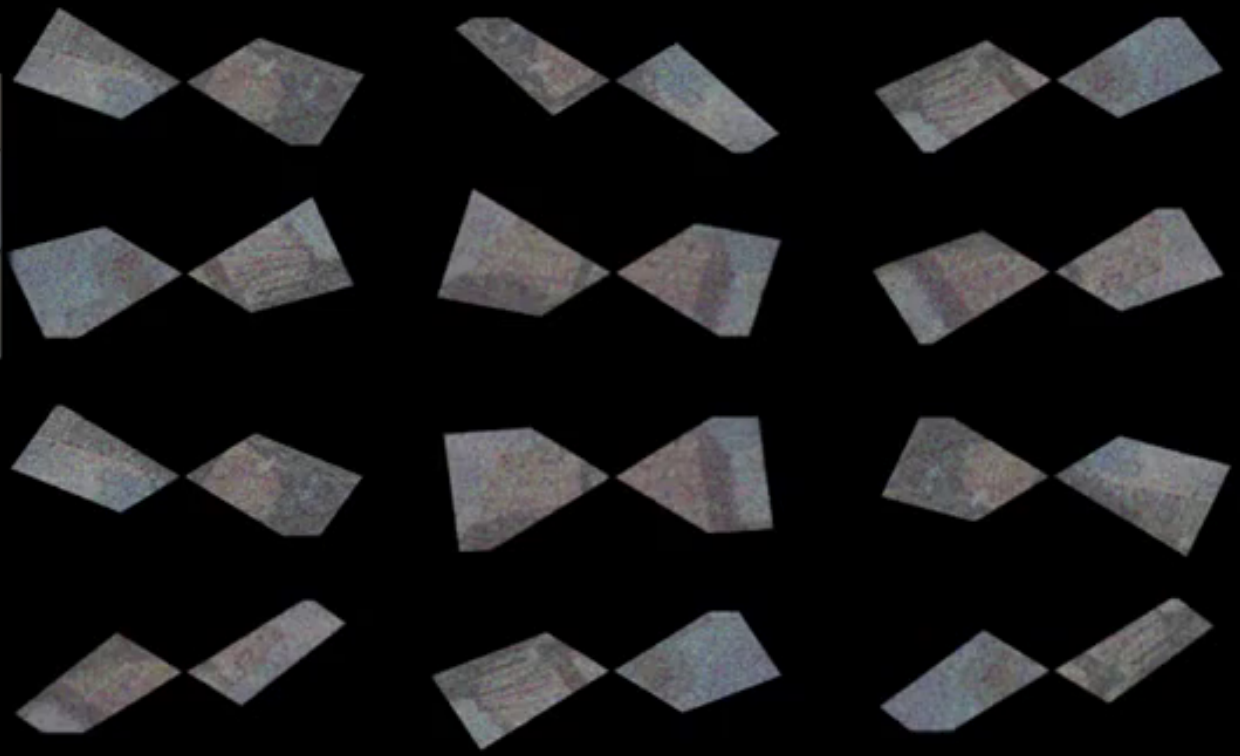


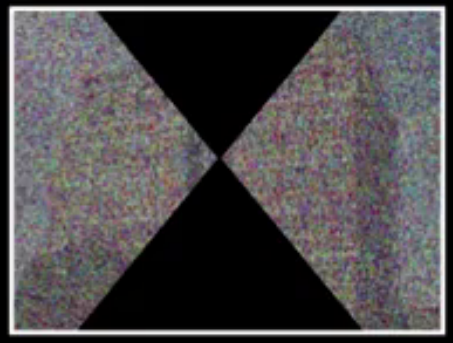
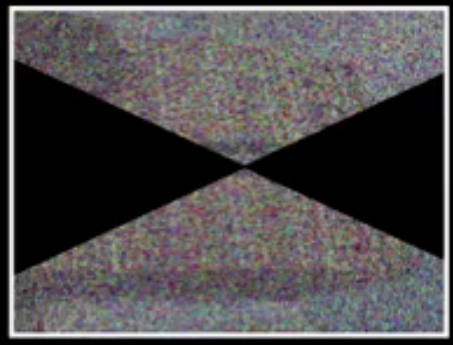
Reconstitution From Noisy and Incomplete Images



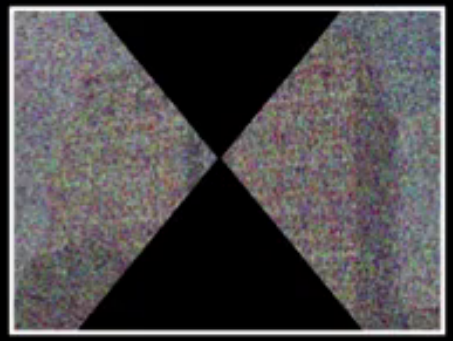
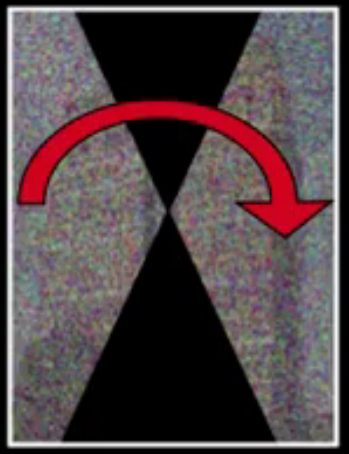
Imaging Challenges of Sub-Volume Averaging in ET

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

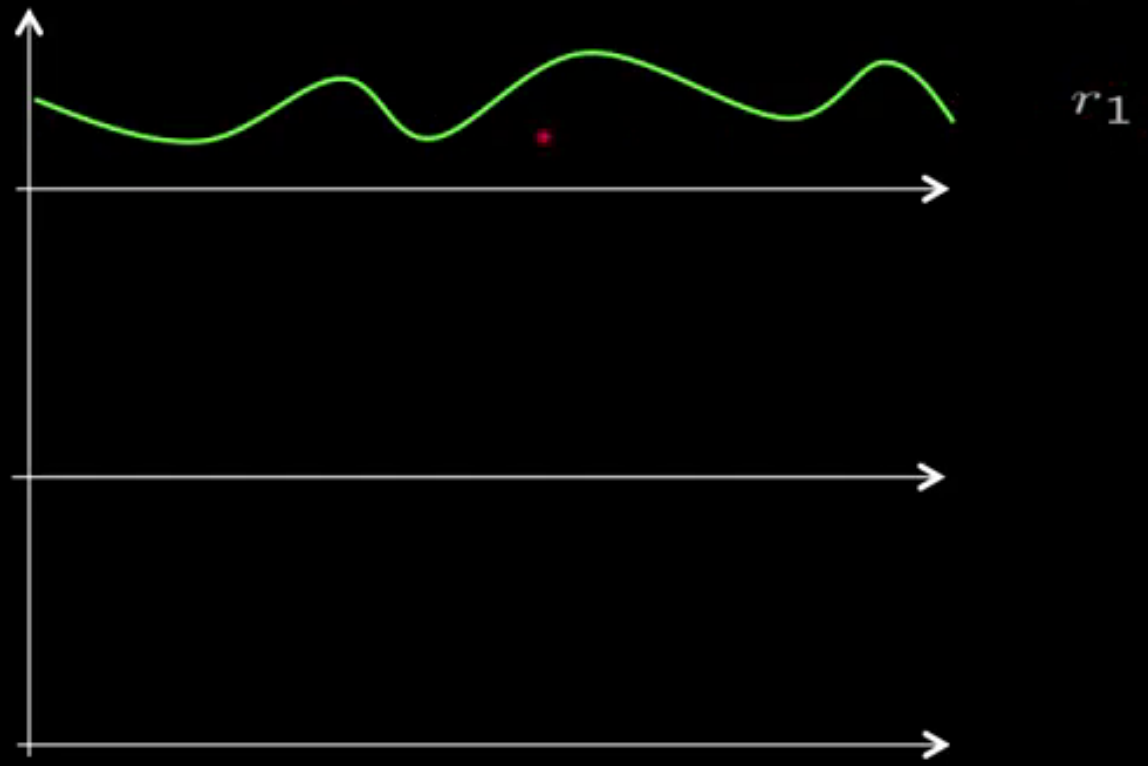
Effects of Missing Data on Alignment

$d($  ,  $)$

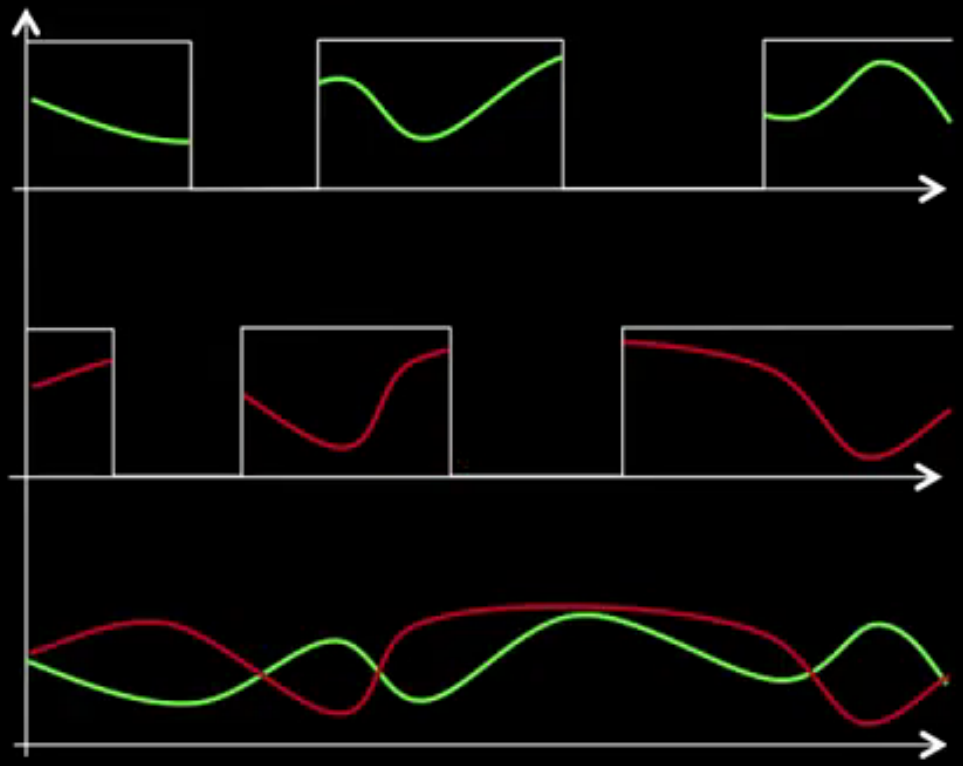
Effects of Missing Data on Alignment

$d($  ,  $)$

Similarity with Missing Information



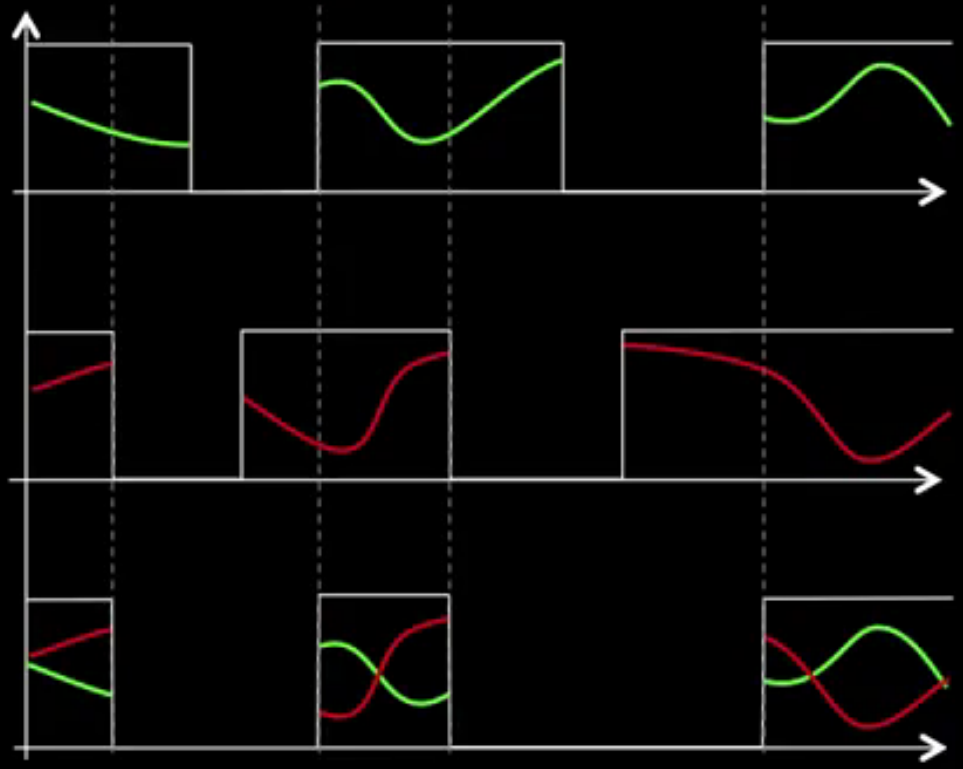
Similarity with Missing Information



$r_1 \cdot w_1$

$r_2 \cdot w_2$

Similarity with Missing Information



$r_1 \cdot w_1$

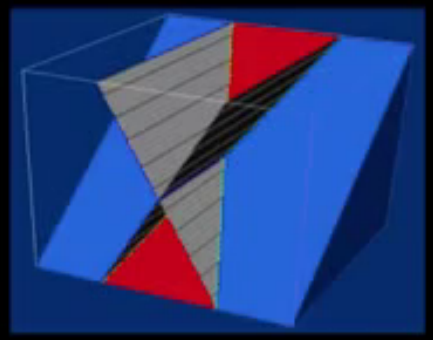
$r_2 \cdot w_2$

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

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

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

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