Supplemental Video Descriptions

Supplementary Video S1. The 4Pi PSF numerically phase-shifted over 360 degrees. The four channels s_1 (yellow), p_1 (blue), s_2 (green), p_2 (purple) of the 4Pi PSF were extracted from the scan of a fluorescent bead and rendered as a 3D volume. The phase of the PSF was numerically shifted through several cycles of 360 degrees.

Supplementary Video S2. Neuronal Cytoskeleton: Detail of Immunolabeled Beta-II Spectrin in a Primary Neuron. Animation of a relatively linear section of an axon, taken from the dataset shown in Fig. 5. Localizations have been colored according to their *z*-coordinate.

Supplementary Video S3. Neuronal Cytoskeleton: Immunolabeled Beta-II Spectrin in a Primary Neuron. Animation of the complete dataset shown in Fig. 5, including a fly-through through the axonal process. Localizations have been colored according to their *z*-coordinate.

Supplementary Video S4. Neuronal Cytoskeleton: Visualization of the creation of an unwrapped view. Sequential visualization of perpendicular (*x*-*z*) sections through the 4Pi-STORM image, sliding along the centerline of an axon in which beta-II Spectrin was immunolabeled (as depicted in Supplementary Fig. S24, region 1, first 10 µm). To obtain an unwrapped view, an elliptical band was fit to the Beta-II Spectrin distribution and integrated along the radial direction.

Supplementary Video S5. Crista Junctions in Mitochondria: Immunolabeled Mic60 in a U-2 OS Cell. Animation of the dataset shown in Supplementary Fig. S27. Localizations have been colored according to their *z*-coordinate.

Supplementary Video S6. Crista Junctions in Mitochondria: Immunolabeled Mic60 in a COS-7 Cell. Animation of the dataset shown in Supplementary Fig. S30. Localizations have been colored according to their *z*-coordinate.

Supplementary Video S7. Crista Junctions and DNA Nucleoids in Mitochondria: Immunolabeled Mic60 (blue) and dsDNA (yellow) in a COS-7 Cell. Animation of the multicolor dataset shown in Fig. 6g-j, containing a sequential visualization of thin-slice sections through a single mitochondrion from the 3D dataset.