

Description of Additional Supplementary Files

File name: Supplementary Movie 1

Description: Series of reconstructed dodecamer volumes generated in cryoDRGN along the Principal Component 1 (PC1), PC2, and PC3 axis latent embeddings, and recorded as movies in ChimeraX. **(Video Top right)** Latent space representation of particle images of the RUVBL1(Pink)/RUVBL2(Blue) dodecamer as UMAP, after training a cryoDRGN in 8 Dimension latent variable model, respectively. Points denote cluster centers for each assembly state and are connected according to trajectories at evenly spaced z values along PC1, PC2, and PC3 of the latent space. PC1 shows a twist motion of one hexamer relative to the other. PC2 depicts a compaction of the dodecamer, while PC3 shows tilt-like compaction of the dodecamer where one side of the hexamers approach, while the other side diverges (or dispel). These movements are likely to modify the interactions between internal and external D_{II} and reflect the structural dynamics between the two hexamers previously suggested by negative stain analyses³⁵.

File name: Supplementary Movie 2

Description: Series of reconstructed R2S₆₂₂₋₉₂₆P volumes generated in cryoDRGN along the PC1, and PC2 axis latent embeddings, recorded as movies in ChimeraX. **(Video Top right)** Latent space representation of particle images of the R2S₆₂₂₋₉₂₆P complex (RUVBL1 - pink; RUVBL2 - blue; SPAG1_C - green; PIH1D2 - gold) as UMAP, after training a cryoDRGN in 8 Dimension latent variable model, respectively. Points denote cluster centers for each assembly state and are connected according to trajectories at evenly spaced z values along the first, second, and third principal components (PC1 and PC2) of the latent space. Variability along the PC1 axis shows that the RUVBL1/2 ring is decorated mainly with up to 2 SPAG1_C, a very bad resolved third SPAG1_C and PIH1D2. Variability along PC2 axis shows RUVBL1_{D_{II}} lateral movement, while most D_{II} of RUVBL2 volumes that have SPAG1_C bound, are unstructured.