**Movie S1.** Rad50 core cavity rearrangements. Rad50 structures in the absence (start position) and presence (end position) of AMPPNP were superimposed and movies made by transitioning between these two states. Rad50 sheets are shown as cartoon and helices as cylinder representations, and coloring is as in the text (N-lobe blue, signature coupling helices cyan, C-lobe orange and extended signature motif magenta, with the core cavity shown as in a green surface representation). While nucleotide (sticks) and magnesium (spheres) are present in the structures only in the end state, nucleotide is shown throughout as a reference. The movie shows the N-lobe subdomain rotation that occurs upon nucleotide binding with the concomitant remodeling of the Rad50 core cavity.

**Movie S2.** Close-up view of the Rad50 core cavity rearrangement. Movie was made as for Movie S1, except helices are shown as cartoons. The start position (with the larger cavity) in the absence of nucleotide, transitioning to the bound state by the end of the movie. Key signature helix residues are shown, from left to right R797, L802, R805, L806.