

Supplementary Video 1. Bead manipulation: loading, release, mixing, circulation, and re-trapping for the antibody coating step. **(a)** This movie shows the process of loading the protein G-conjugated polystyrene beads (6.7 μm , 2.5% weight/volume) into the two upper columns (80 nL) behind the closed sieve valves. **(b)** Once the antibody containing solution was loaded into the adjacent circulation chamber (370 nL), the beads were released into the circulation chamber by opening the sieve valves. This initiates the antibody coating incubation step of the assay. The beads were circulated both clockwise and counter-clockwise in the circulation chamber by switching the pumping direction every 80 sec. Reversal of the flow direction helps promote homogenous mixing and prevents bead clumping. **(c)** After the coating step, the beads were re-trapped back in the columns by closing the sieve valves. The movie runs at 8 (a) or 16 (b,c) times true speed.