The outlet can have at least two output branches, the first of the two output branches for separating the particles to be sorted, and the second of the two output branches for outputting the remainder of the particles that have not been segregated. The system can also include a sorting system operatively connected to the channel for selectively diverting particles to the first output branch.

[0011] In a final aspect, a method is provided for separating target particles from a population of particles and can include providing a population of particles, including target particles, in a fluid suspension and flowing the fluid suspension through at least one channel under conditions that cause at least some of the particles to form a localized flux of particles in the channel. The method can further include dividing an output from the channel into first and second output branches in which the output branches are configured so that the second output branch receives a flow that is enriched in target particles while the first output branch receives a flow reduced in target particles.

[0012] Specific embodiments of any of these aspects can include moving the fluid suspension can focus the particles into four localized streams, two localized streams, and/or a single localized stream. The channel can have a hydraulic diameter and a ratio of a size of the particles focused to the hydraulic diameter that is greater than or equal to about 0.07. The ratio of particle size to hydraulic diameter can be less than or equal to about 0.5. In some embodiments, a Reynolds Number of the fluid flow during focusing can be greater than or equal to about 1 and less than or equal to about 250. In some embodiments, a particle Reynolds number for the fluid suspension moving through the channel is greater than or equal to about 0.2. The one or more focused stream lines can have a width that is less than or equal to about five times, four times, three times, two times, and/or 1.05 times a size of the focused particles. Embodiments of the system can increase the concentration of particles in solution.

[0013] In the enumerated aspects or in any of their embodiments, at least first and second outlet branches can be formed at an outlet portion of the channel and at least one of the first and second outlet branches can be located on the substrate so as to receive the particles from a focused stream line and/or from the single localized stream. In some embodiments, the channel can have a rectangular cross-section. In other embodiments, the rectangular channel can have a width of less than or equal to about 1000 micrometers, 650 micrometers, 100 micrometers, 80 micrometers, 65 micrometers, 50 micrometers, 20 micrometers, and/or 10 micrometers.

[0014] In any of the aspects, embodiments can include those in which particles are cells, including mammalian cells, blood cells, tumor cells, and/or bacteria cells. In addition, the aspect ratio of the rectangular cross-section can result in the focusing of particles into two streams. Focusing of particles into one or more localized stream lines can space the particles approximately evenly longitudinally. In some embodiments, the aspect ratio of a first rectangle dimension to a second rectangle dimension can be between approximately 0.3 and 0.8. In other embodiments, the aspect ratio can be approximately 1 to 2.

[0015] In the enumerated aspects or in any of their embodiments, the system can include at least one channel that curves and is symmetric and sigmoidal. In other embodiments, the channel can be asymmetric and sigmoidal. The location of the focused stream within the channel can depend upon inertial forces and Dean drag forces acting on the particles. The location can further depend upon centrifugal forces acting on the particles. A Dean number for flow through the channel can be less than or equal to about 20. In some embodiments of the system, the radius of curvature can vary and/or can change after each inflection of the curve. A cross sectional dimension of the channel can vary and can change after each inflection of the curve. In one embodiment, the channel can form a spiral.

[0016] In other embodiments, a plurality of channels can be provided on the substrate and at least some of the channels can be configured to allow serial flow. A plurality of channels can be provided on the substrate and a first channel can have first and second output branches leading to second and third channels respectively. At least two of the channels can be configured to focus particles of different predetermined diameters. The system can include a detector for detecting and enumerating particles in the one or more focused stream lines and for detecting and enumerating particles in the single localized stream. The system can further include a tagging system for tagging selected particles with a tag that can be detected by the detector, the detector thereby detecting and enumerating the selected particles. In any and all aspects, embodiments can include systems in which the focusing can result exclusively from the inertial forces. Other embodiments can include systems in which the focusing can result from inertial and other forces.

[0017] In any of the aspects, further embodiments can include methods for focusing particles in which the fluid flow through the channel is laminar and wherein the Reynolds Number of the fluid flow is between about 1 and 250. Focusing can produce a localized flux of particles enriched in a first particle based on particle size. A first particle diameter divided by a hydraulic diameter of the channel can be greater than or equal to about 0.07 and the first particle diameter divided by the hydraulic diameter of the channel can be less than or equal to about 0.5. In some embodiments, the channel has a rectangular cross-section, a height, a width, and a hydraulic diameter equal to 2*height*width/(width+height) and the rectangular cross-section has an aspect ratio of between approximately 0.3 and 0.8 and/or approximately 1 to 2.

[0018] In the enumerated aspects or in any of their embodiments, methods for focusing particles can include applying an asymmetric force to the particles to produce one to three localized fluxes of particles. The asymmetric force can include, but is not limited to, centrifugal, hydrodynamic drag, electrical, magnetic, thermal, sonic, optical, or dielectrophoretic forces. In some embodiments, the asymmetric force can include a Dean drag force that is equal to or greater than about 0.5 nN. Particles can include, but are not limited to, cells, beads, viruses, organelles, nanoparticles, and molecular complexes. Cells can include, but are not limited to, bacterial cells, blood cells, cancer cells, tumor cells, mammalian cells, protists, plant cells, and fungal cells.

[0019] In any of the aspects, embodiments can also include methods for focusing particles in which the channel is curved and wherein a Dean number of the moving fluid is less than or equal to about 20. The curved channel can be sigmoidal and/or spiral. In other embodiments, the curved channel can be sigmoidal and asymmetric and the radius of curvature can vary from one inflection point in the sigmoidal curve to a next inflection point in the sigmoidal curve. In some embodiments, a first radius curve can be followed by a larger radius curve. The first radius curve can apply a Dean drag that is about eight times greater than a Dean drag applied in the