Bean Counter Sample Problem

Design a digital circuit to count beans flowing through a tube, as illustrated to the right. All beans are the same size; the tube's diameter is only slightly larger than a bean. (Don't worry, they won't get stuck.) The speed of the beans varies slowly.

The beans are to be counted using two photodetectors and light sources. Each photodetector is connected to a conditioning circuit (not illustrated) which has a single digital output. The photodetectors are spaced one bean length apart; their outputs are labeled d_1 and d_2.

An output is logic `1` when a bean is in front of the respective photodetector, logic `0` otherwise. The `0`-to-`1` transition occurs when the leading edge of a bean is precisely at the center of a photodetector's field of view. The beans sometimes clump together; when such a clump of beans passes a photodetector it will produce a continuous logic `1`, **not** a series `1`, `0`, `1`, ... (which would make this problem trivial).

The design can use basic logic gates, flip-flops, registers, loadable up/down counters, and clocks of any frequency.

If the beans are all the same size and if the speed of a clump does not change while it is passing the photodetector then the count must be exact.

(Note: In the version of the question used in the doctoral qualifying, master's comprehensive exam the bean count could be off by one. Yes, they were grad students but they only had about 30 minutes and no simulator to check their work.)