Decay lab

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1 Objective of the experiment:

To examine the exponential decay associated with a short-lived radioactive source, and determine its half-life. To observe the Gaussian (bell-shaped) curve from the counting statistics of a long-lived radioactive source.

2 Materials:

Radioactive sources (long and short-lived)

Geiger counter and tray holder

Timer/Counter (only used to power Geiger counter, not for counting or timing)

Computer

3 Method:

Gaussian distribution A long-lived source (137 Cs, 60 Co) will decay negligibly during a few hours. Nevertheless, the counts observed during equal sampling intervals can lactate substantially due to the statistical (random) nature of decay processes

Lifetime measurement: The decay of 137 Ba* follows an exponential law, similar to what you may have seen in the Capacitance lab (229 students). In this case however, you will be interested in number (or change in number) with respect to time, rather than Voltage with respect to time. In the following equation, we can see that the decay rate R drops off exponentially from the initial value R0 . Note that we do not actually measure the number of decays, but rather the rate of change of number of decays (since rate of change of number is merely the time derivative of number.

4 Results:

The reactor-produced 137 Cs has a half-life of 30 years. It can decay (by beta – emission) either to the stable ground (lowest energy) state of daughter 137

Ba or (more often, also with lower energy b - emission) to a short-lived (a few minutes) excited state (denoted 137 Ba *). This excited state decays to the 137 Ba ground state with emission of an (uncharged) gamma ray.

5 Discussion of the experiment:

The detector will be the same for all – a gas-filled Geiger counter, where collisional passage of a charged particle releases ionization (free atomic electrons and positive gas ions) for collection by an electric field, producing an electrical current pulse. In the statistical counting of 137 Cs, the charged decay beta will be detected, so the counter efficiency will be essentially 100 percent (if the b is headed in the right direction). In the lifetime study, the primary decay photons (gammas) are uncharged; only if the gamma interacts with a gas atom to release an atomic electron, with subsequent charge-release cascade, is the g detected. The detector efficiency will therefore be ¡ 100 percent.