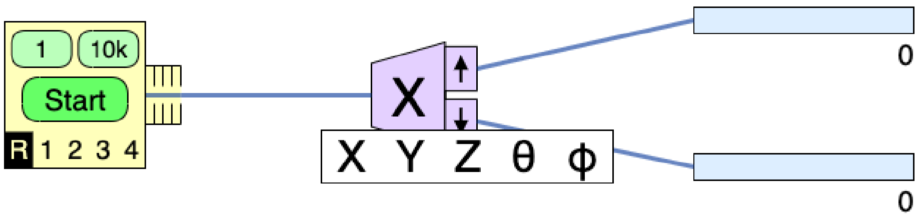
Getting Acquainted with the Stern Gerlach Experiment Simulation

1. Measure a single particle's z-component of spin S_z

   a) The default experiment is to measure S_x so we need to change the orientation of the analyzer. Change the orientation of the analyzer by clicking on "X" label and selecting "Z".



   b) To send 1 particle through the experiment, click on the box labeled "1" on the oven (the green box on the left). Each measurement result will either be $S_z = \frac{+\hbar}{2}$ or $S_z = \frac{-\hbar}{2}$. Do this several times.

      Do you notice any patterns?

   c) Try sending 10,000 atoms through the experiment.

   d) Try sending atoms continuously by pressing the "Start" button.

      What are you noticing about these experiments?

      Solution Students should notice that the pattern is randomness. About half of the particle go into each counter.

2. Do some experimenting and determine the probability that a particle leaving the oven will end up in the top counter. How confident are you in your estimate?

   Solution If I do a bunch of sets of experiments, the average fraction of particles that end up in the top counter is my best estimate of the probability.

$$\mathcal{P}\backslash = \frac{x_n}{M}$$

$$\bar{\mathcal{P}} = \frac{1}{N}\sum_{n=1}^{N}\mathcal{P}_n$$

   Where x_n is the number of particles in the top counter after 1 set of M experiments (particles). N is the total number of sets.

   My intution is that the more experiments I do, the more confident I am in my average as an estimate. My confidence in my answer can be quantified by the standard error (or standard deviation of the mean).

$$
\begin{aligned}
StErr_{\mathcal{P}} &= \frac{SD_{\mathcal{P}}}{\sqrt{N}} \\
&= \frac{1}{\sqrt{N}} \sqrt{\sum_{n=1}^{N} (\bar{\mathcal{P}} - \mathcal{P}_n)^2} \\
&= \frac{1}{\sqrt{MN}} \sqrt{\sum_{n=1}^{N} (\bar{x} - x_n)^2}
\end{aligned}
$$

See this discussion of the statistics of Stern-Gerlach experiments for more.