*probabilities* of the various possible outcomes of a scattering event. The fundamental connection between probability and frequency (see Sec. 1.5) allows us to compare the theoretical probabilities with the observed relative frequencies in a statistical experiment.

It is useful to divide the statistical experiment into two phases: *preparation* and *measurement*. In the scattering experiment the preparation consists of passing a particle through the acceleration and collimation apparatus and allowing it to interact with the target. The measurement consists of the detection of the particle and the subsequent inference of the angle of scatter. This subdivision of the experiment is useful because the two phases are essentially independent. For the same preparation one could measure the energy instead of the position of the particle, by means of a different kind of detector. Conversely, the same array of detectors shown in Fig. 2.1 could have been used to measure the positions of particles from some other kind of preparation, involving a different target or even an entirely different preparation apparatus.

Having distinguished preparation from measurement, we need to be more precise about just what is being prepared. At first, one might say that it is the particle (more generally, the object of the subsequent measurement) that is prepared. While this is true in an obvious and trivial sense, it fails to characterize the specific result of the preparation. Two identical objects, each subjected to an identical preparation, may behave differently in the subsequent measurements. Conversely, two objects that yield identical results in measurement could have come from entirely different preparations. In the example of Fig. 2.1, the measurement determines only the direction from which the particle leaves the scatterer. One cannot infer from the result of such a measurement what the direction of incidence onto the target may have been (supposing that the preparation apparatus is not visible). If we want to characterize a preparation by its effect, we must identify that effect with something other than the specific object that has experienced the preparation, because the same preparation could lead to various measurement outcomes, and the same measurement outcome could be a result of various preparations.

A specific preparation determines not the outcome of the subsequent measurement, but the *probabilities* of the various possible outcomes. Since a preparation is independent of the specific measurement that may follow it, the preparation must determine probability distributions for all such possible measurements. This leads us to introduce the concept of a *state*, which is identified with the specification of a probability distribution for each observable. (An *observable* is a dynamical variable that can, in principle, be measured.)