SIGNAL AND BACKGROUND

The processes that particle physicists are interested in are often very rare, which makes them difficult to observe. Researchers must sift through large amounts of data to find only a few possible occurrences of the process of interest, making it similar to looking for a needle in a haystack. Fortunately, ATLAS physicists have developed strategies to help with this task.

WHAT IS SIGNAL?

The word "signal" is used to designate the process of interest in a given analysis. There are two main types of analyses: searches and measurements. For searches, the signal is a sign of some new physics phenomenon, for example a new particle not predicted by the Standard Model (SM). For a measurement, the signal is a SM process that we wish to understand better.

WHAT IS BACKGROUND?

The word "background" is used to describe anything that mimics a signal, leaving a similar signature in the detector. It could come from a known Standard Model process, or other sources. Note that what is considered a signal for one analysis could be a background for another.

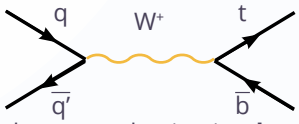
Z′ production is the **signal**...

Search for new Z′ boson

... and SM $t\bar{t}$ production is a **background.**

SM $t\bar{t}$ production is the **signal**...

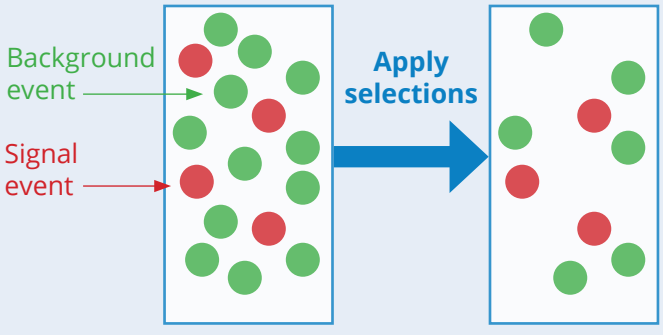
Measurement of Standard Model $t\bar{t}$ production



... and SM single top production is a **background.**

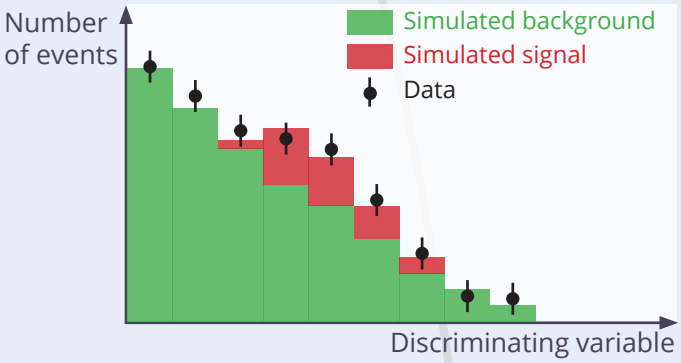
EVENT SELECTION

One of the main goals of a search or measurement is to increase the signal-to-background ratio. This is done by applying selection criteria to the particle-collision events that favour the signal. For example, one could require a minimum momentum threshold for certain objects, or a specific number of leptons or photons. This filters out events that are most likely to be background and therefore makes the signal easier to spot.



DISCRIMINATING VARIABLES

After applying the selection criteria, physicists identify one or more quantities that are expected to be very different between signal and background, called discriminating variables. These quantities are visualised in histograms (as shown below). If the collision data agree with the combined signal-plus-background prediction, this could be an indication that the signal of interest is indeed present.



MACHINE LEARNING TECHNIQUES

Many analyses today use machine learning techniques to better separate signal and background. Instead of selecting only a few discriminating variables, machine learning algorithms can use information from many different variables to make a decision about whether a given event looks more like signal or background. This can lead to large improvements in precision.