Particle Physics Summer Student Programme

Event Selection

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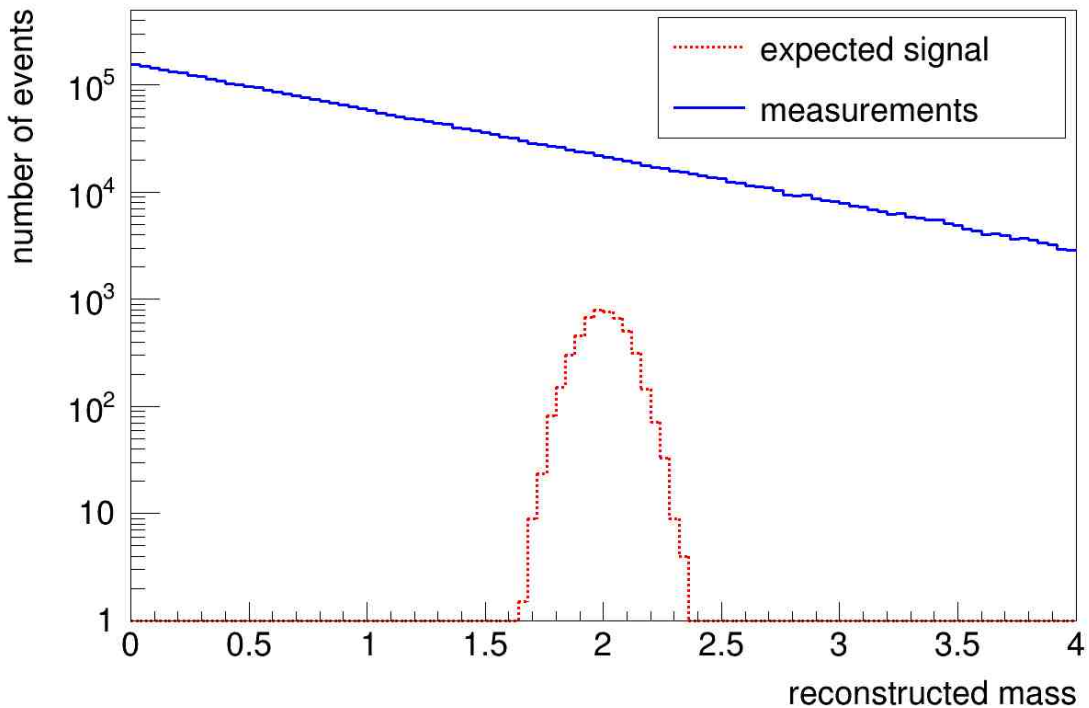
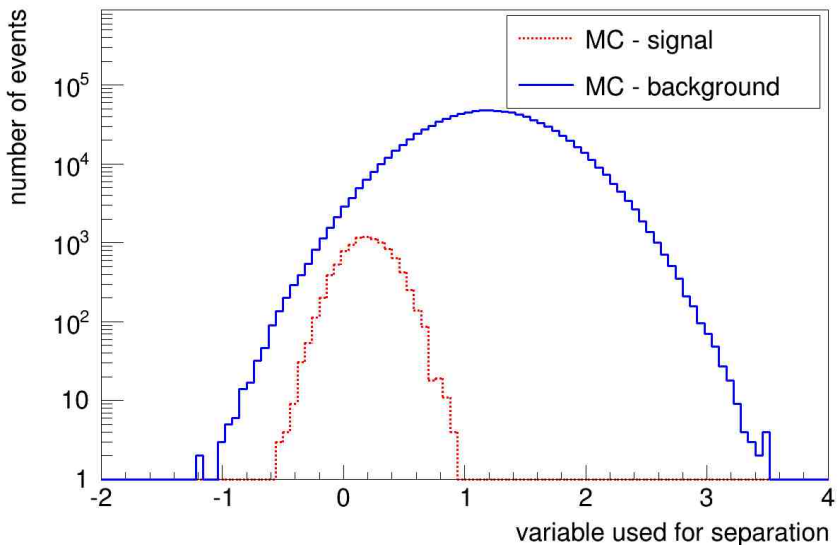
Motivation

- Particles produced in the collisions usually have very short lifetime. For example, the Higgs boson will decay after about 10^{-22} s.
- In detectors only decay products (stable particles) may be observed. E.g. one of Higgs decay modes is two proton production: $H \rightarrow \gamma\gamma$.
- However, considering all registered di-photon events will lead to much more 'signal' than expected from the $H \rightarrow \gamma\gamma$ cross-section.
- Lets look at the plot below:
  - expected signal is much smaller than background,
  - signal is not visible in data – statistical fluctuations ($\sqrt{events}$) dominate.

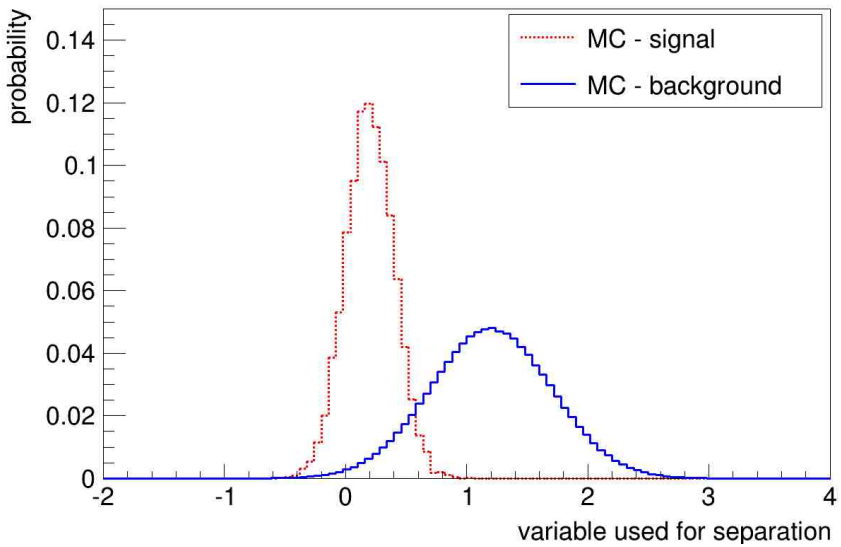


Event Selection and Normalization

- Fortunately, besides the reconstructed mass, we have much more info about measured vent.
- In addition, we can use Monte Carlo generators to make samples simulation background and (hypothetical) signal properties.
- Note that amount of data in generated (and collected) samples may differ. In fact, background sample contains usually much more events than signal sample. Therefore, it is useful to normalize distributions to probability.



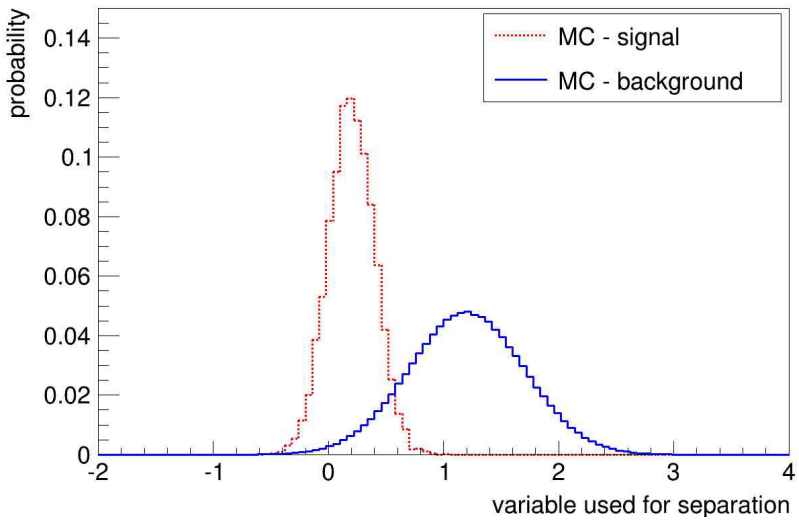
Distribution of signal and background normalized to the number of generated events.



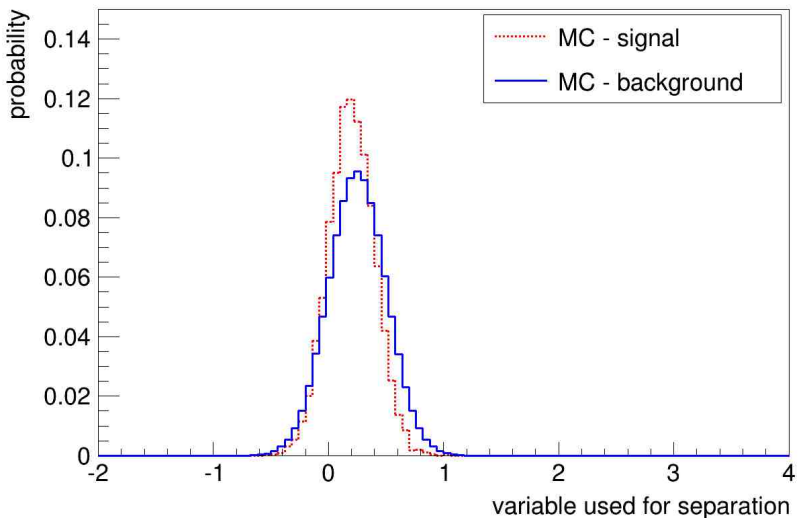
Distribution of signal and background normalized to probability (integral of all bins is equal to 1).

Choice of Selection Variable

- There are many selection (and optimization) methods – full discussion is much beyond the scope of this simple exercise.
- We will use one of the simplest methods:
  - normalize signal and background to probability,
  - check where signal is starting to be dominant,
  - set selection criteria:
    - cut will remove much more background than signal AND
    - after the selection there will be at least 50% of signal left[1].



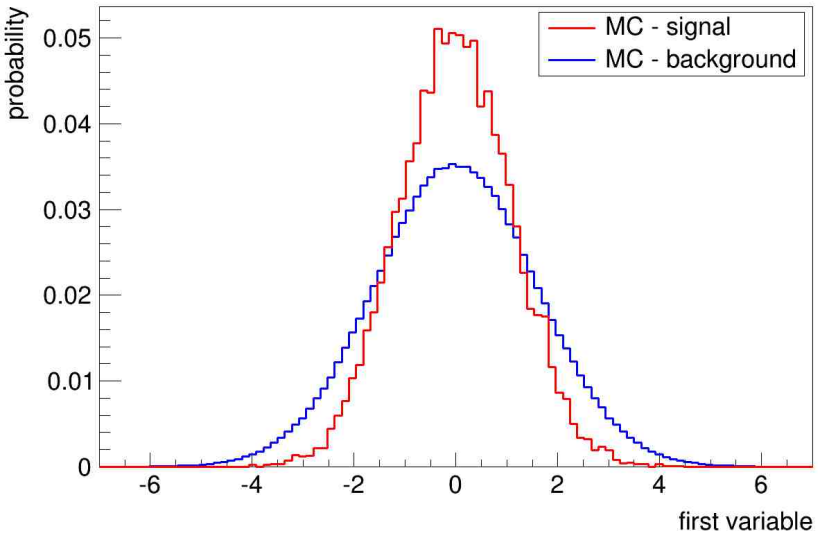
Good separation variable – requiring events with values greater than 0.6 will reject background a lot and will leave significant amount of signal.

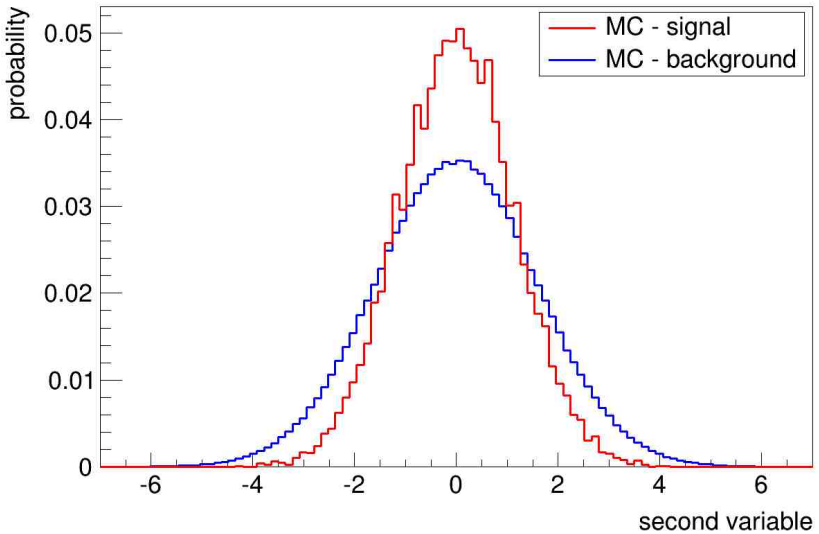


Bad separation variable.

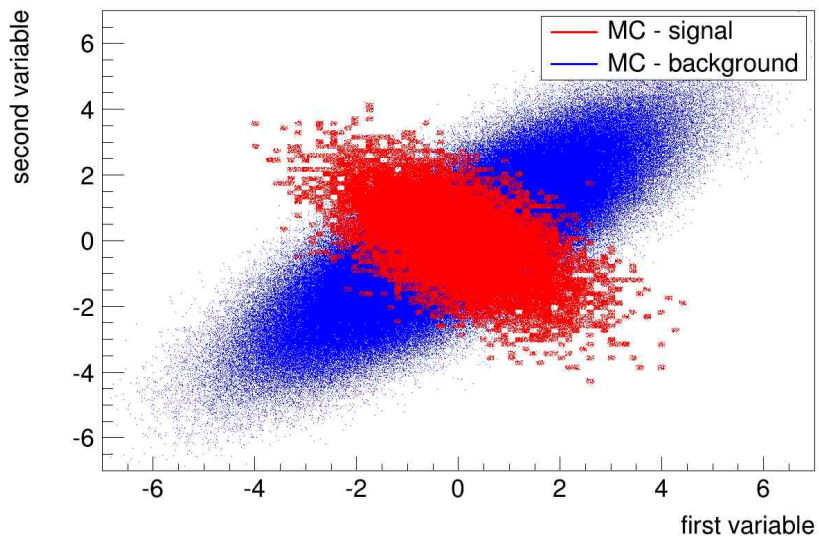
[1] During the next ROOT classes, you should select the probability that not-muon is classified as mu_like in 95-98% of cases and muon is classified as mu_like in more than 90% of cases (exact values are up to you).

- Sometimes a single value is not good for separation:





- BUT their correlation can lead to an effective cut:



Expected Results

After the selection, signal should be clearly visible in data: