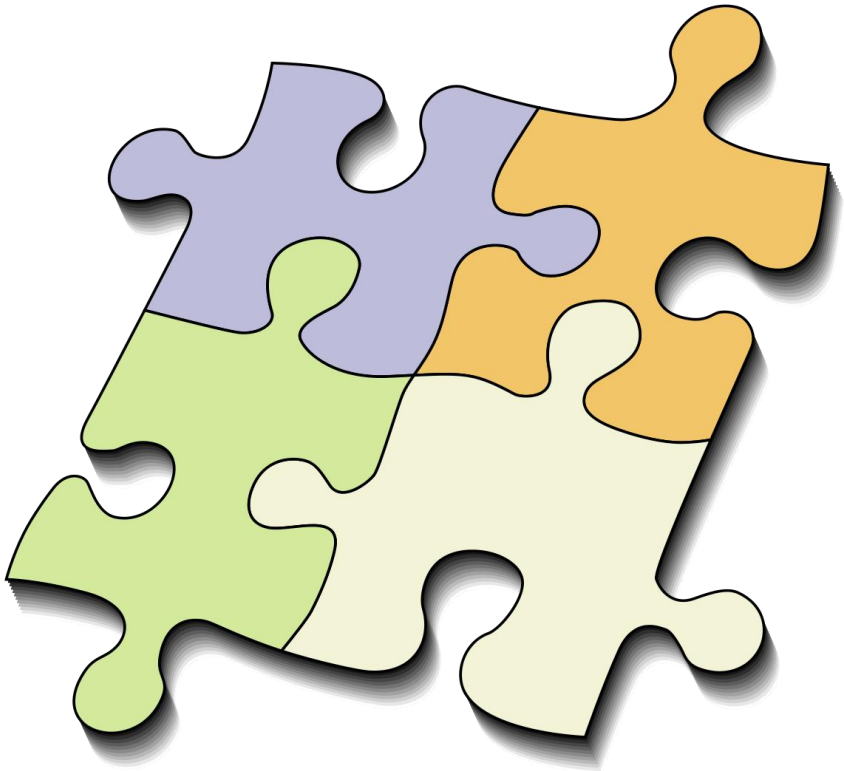
Tutorial category: Expert mode

Implementing signal regions



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Official MadAnalysis 5 website : http://madanalysis.irmp.ucl.ac.be/

Goals of this tutorial

- Defining several signal regions
- Associating a plot or a cut to one or several signal regions
- Extracting the analysis results for each signal region

Requirements

- MadAnalysis 5 is installed on your system and has been launched successfully at least one time. The collection of example samples is installed too.
- A first experience with the expert mode (see the tutorial “First steps in the expert mode”).
- Basic skills in C++ programing.
- Implementing plots or cut in the analysis.
- Analyzing the results of the analysis in the SAF files.

Part 1

Defining and using signal regions

Concept of signal regions

- In order to increase the sensibility of an analysis, it is convenient to split the selected events into different categories called “signal regions”.

- The FOM (Figure Of Merit) such as S/B or $S/\sqrt{S+B}$ is calculated for each signal region and we determine the region which is the most sensible to new physics.

Declaring signal regions

- For declaring a signal region, you need to edit the source file `MyAnalysis.cpp` and to change the content of the function `Initialize()`.

```
MAbool MyAnalysis::Initialize(const MA5::Configuration& cfg,
const std::map<std::string,std::string>& parameters)
{
  ........
}
```

- The signal region is defined with the help of AddRegionSelection. This is an example of definition of 2 signal regions called “ee” and “”mumu”. It can be the case of a Drell-Yan signal ($pp > l^+l^-$) for which the final state are split according to the flavor of the final leptons.

```
Manager()->AddRegionSelection("ee");
Manager()->AddRegionSelection("mumu");
```

Declaring signal regions

- It is important to notice that a signal region must always define before defining a cut or an histogram. That's why it is asked in the previous tutorial to add the following line.

```
Manager()->AddRegionSelection("myregion");
```

Associating a signal region to a cut

- If you would like to assign the signal region “mumu” to a cut called “PT_lepton”, you need to put the signal region name as an argument of the AddCut function.

```
Manager()->AddCut("PT_lepton", "mumu");
```

- It is possible to add several signal regions to a cut. In the following example, we assign two signal regions “mumu” and “ee” to a cut called “PT_lepton”.

```
std::string SRs[] = {"mumu", "ee"};
Manager()->AddCut("PT_lepton", SRs);
```

- If a cut is common to all signal regions, no signal region must be specified as argument of the AddCut function.

```
Manager()->AddCut("PT_lepton");
```

Associating a signal region to an histogram

- Like for the cut, the association between a signal region and an histogram can be performed at the declaration at the histogram via the function AddHisto. In the following example, we add the “mumu” and “ee” signal regions to the plot called “MET”.

```
std::string SRs[] = {"mumu", "ee"};
Manager()->AddHisto("MET", 100, 0., 1000., SRs);
```

How to define a signal region?

- The splitting of the events into signal regions is usually done by a specific selection cut in the Execute function of the MyAnalysis.cpp

- In the following example, the events are sorted according to “ee” and “mumu” signal regions by two cuts.

  - **In the Initialize function**

```
Manager()->AddRegionSelection("ee");
Manager()->AddRegionSelection("mumu");
Manager()->AddCut("only 2e", "ee");
Manager()->AddCut("only 2mu", "mumu");
```

  - **In the Execute function**

```
MAbool 2e  = myEvent.rec()->electrons.size()==2 && myEvent.rec()->muons.size()==0;
MAbool 2mu = myEvent.rec()->electrons.size()==0 && myEvent.rec()->muons.size()==2;
if (!Manager()->ApplyCut(!2e,  "2e" )) return true;
if (!Manager()->ApplyCut(!2mu, "2mu")) return true;
```

Part 2

Getting the results with the SAF files

Implementing signal regions

About this document

- The present document is a part of the tutorial collection of the package MadAnalysis 5 (MA5 in abbreviated form). It has to be conceived to explain in a practical and graphical way the functionalities and the various options available in the last public release of MA5.

- The up-to-date version of this document, also the complete collection of tutorials, can be found on the MadAnalysis 5 website :

  http://madanalysis.irmp.ucl.ac.be/

- Your feedback interests ourselves (bug reports, questions, comments, suggestions). You can contact the MadAnalysis 5 team by the email address : ma5team@iphc.cnrs.fr

Change log

Version	Date	Update
1.0	10/02/2020	Creation and first release (but incomplete)