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MAD Analysis 5

A framework dedicated to
phenomenological investigations @ LHC

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Outlines

Overview

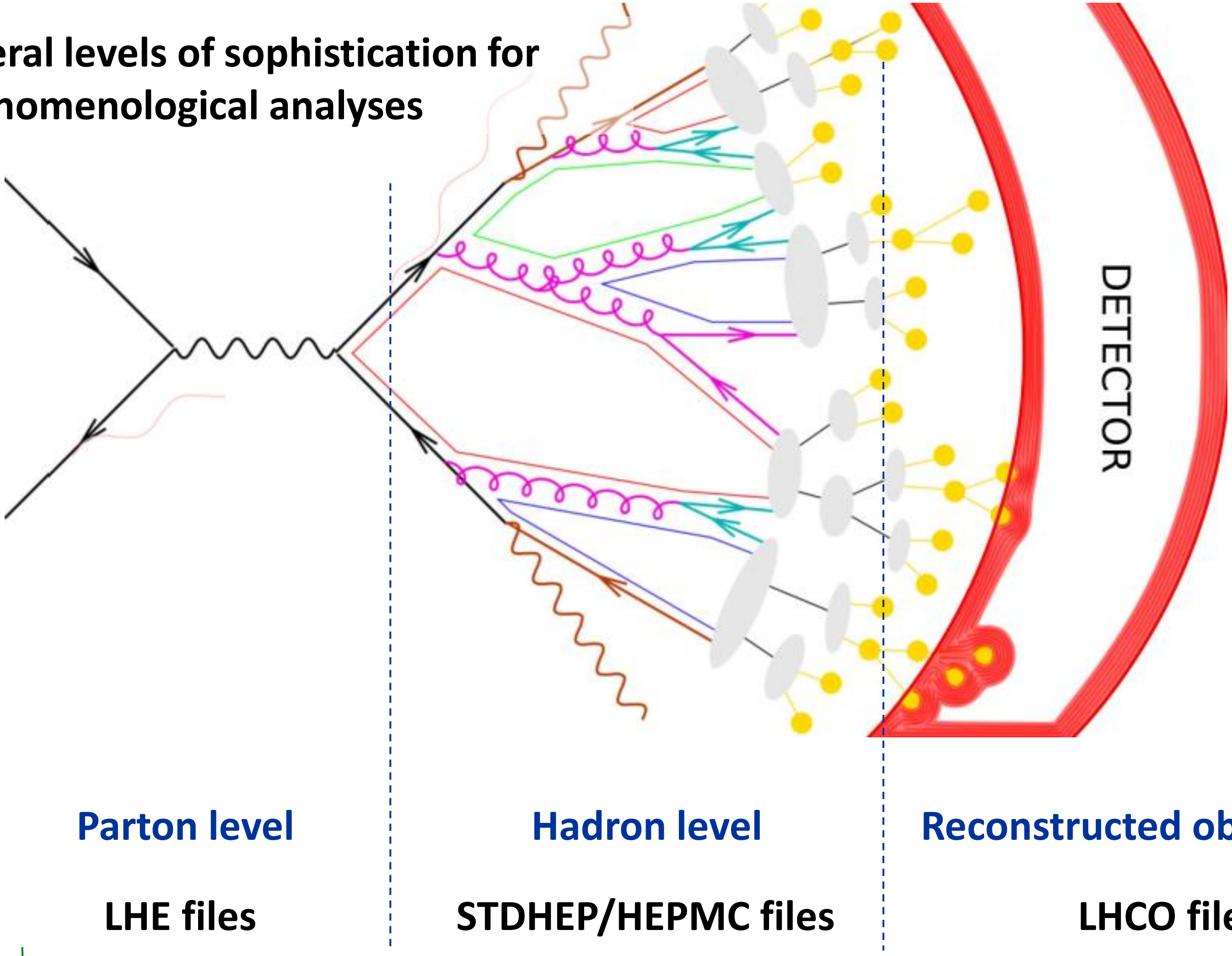
Writing an analysis step-by-step in the normal mode

Interface to the FastJet package

Summary & perspectives

Overview

Several levels of sophistication for phenomenological analyses



Parton level	Hadron level	Reconstructed objects level
LHE files	STDHEP/HEPMC files	LHCO files

A unique framework : MadAnalysis 5

Overview

Scope:

- Reading of signal and background event files
- Production of histograms for different distributions.
- Definition of various selection cuts on the input samples.
- Results of the analysis summed up by a S/B-like ratio table.

Relevant features of MadAnalysis 5 design:

- Study at any sophistication level (parton, hadron, reconstructed)
- Supporting any event file format (STDHEP, HEPMC, LHE, LHCO …)
- **User-friendly** → professional analyses in a simple way
- **Flexible**: no limit on the analysis complexity
- **Easy** to maintain and to validate

Overview

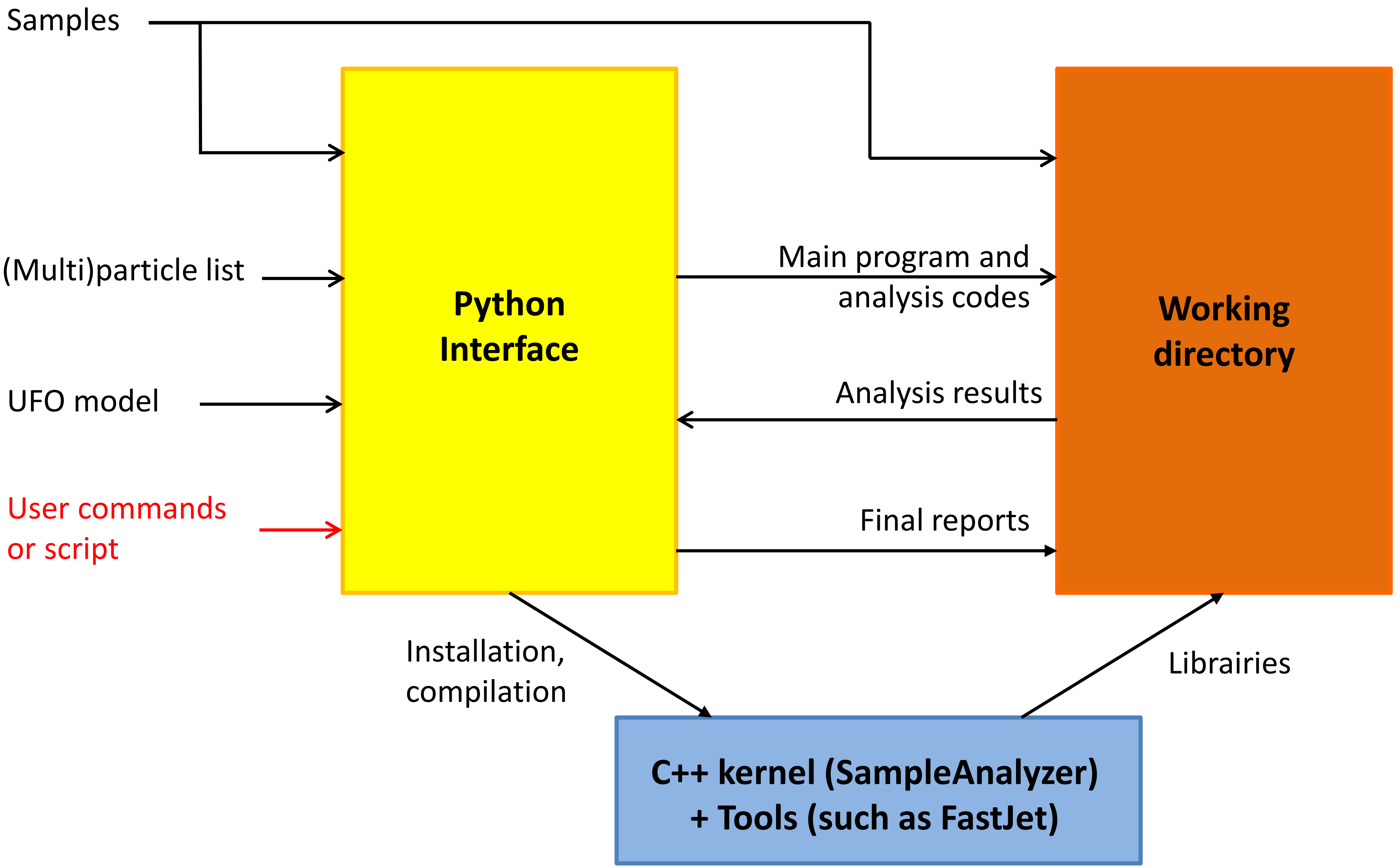
Requirements:

Mandatory	Optional
Python 2.6 or a more recent version (but not the 3.X series) **GNU GCC** compiler **ROOT** 5.27 or a more recent version	**zlib** **Latex** / PDFLatex **FastJet** 3.0 or a more recent version

Where MadAnalysis can be downloaded ?

- From the official website https://launchpad.net/madanalysis5 **(new address)**
- From MadGraph 5 interface **(available soon)**

Overview



Samples

(Multi)particle list

UFO model

User commands
or script

Python Interface

Main program and
analysis codes

Analysis results

Final reports

Working directory

Installation,
compilation

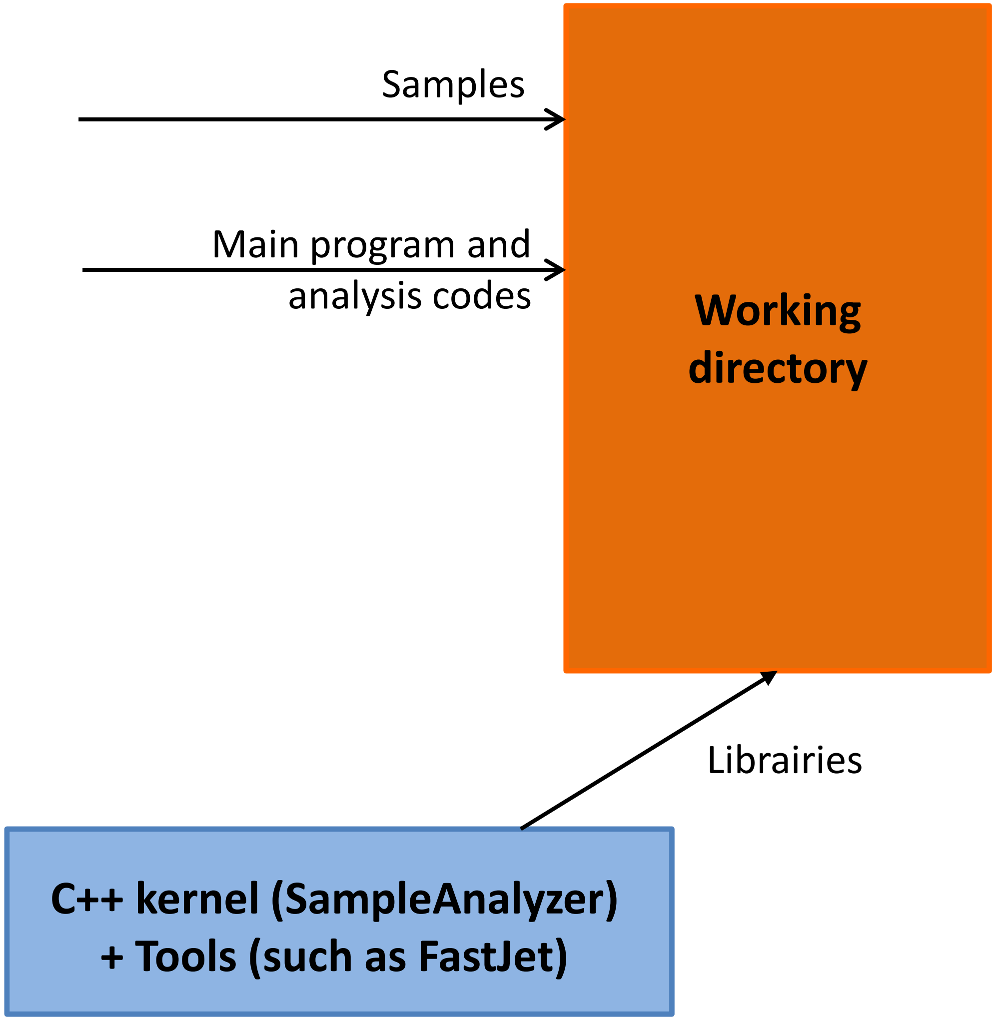
Librairies

C++ kernel (SampleAnalyzer)
+ Tools (such as FastJet)

Overview

MadAnalysis has an **expert mode** (developer-friendly) :

- C++ programming within the SampleAnalyzer framework.
- The Python interface creates a blank analysis as a starting point.


Samples

Main program and analysis codes

Working directory

Librairies

C++ kernel (SampleAnalyzer) + Tools (such as FastJet)

Writing an analysis step-by-step

First start of MadAnalysis 5:

- **Execution**

Parton level	Hadron level	Reconstructed objects level
bin/ma5 or bin/ma5 –P	bin/ma5 –H	bin/ma5 -R

- **Initial sequence:**
  - **Step 1: Testing all dependencies.**
  - **Step 2: Compiling (if necessary) the C++ library.**
  - **Step 3: Importing the list of particles and multiparticles (from MadGraph if this program is found on your system).**

Writing an analysis step-by-step

Defining new particles and multiparticles

- Particles are defined by **labels**, which could point to one or several **PDG-id**.
- SM and MSSM labels are automatically loaded at the starting of MadAnalysis.
- The user can define his own labels :

```
ma5> define mu = mu+ mu-
```

- All labels defined in a UFO model can be loaded too.

Importing datasets

- For MadAnalysis, a **dataset** is a collection of samples which will be merged.
- All sample files are stored in a dataset.

```
ma5> import tt*.lhe
```

```
ma5> import tt*.lhe as ttbar
ma5> import Wj*.lhe as Wjets
```

- Possibility to tag datasets as **signal** or **background**.

Writing an analysis step-by-step

Defining an analysis: plots and/or cuts

- **Histograms**
  - Observable can be related to the event or the properties of a particle
  - Plethora of observables: N, E, ET, M, MT, P, PT, PX, PY, PZ, THETA, ETA, …, ALPHAT
  - Combining particles

```
ma5> plot MET
ma5> plot PT(mu)
```

```
ma5> plot M(mu+ mu-)
```

- **Cuts : selecting / rejecting events**

```
ma5> reject MHT < 50
ma5> select N(mu) >= 2
```

- **Cuts : selecting / rejecting a particle or a combination**

```
ma5> select (mu) PT > 50
ma5> select 80 < M (mu+ mu-) < 100
```

Writing an analysis step-by-step

Defining an analysis: plots and/or cuts

Several options or syntaxes allow to extend the potential of MadAnalysis.
Some examples:

- By default, a combination is interpreted as the vector sum of momenta.
  This interpretation can be changed by adding a prefix to the observable label.
  For instance : vPT, sPT, dsPT, dvPT, rPT
- List of observables specific to the reconstructed object level : ISOL, HE_EE, NTRACKS, …
- Selecting a particle according to its rank in energy (or to other observables)

```
ma5> plot PT(mu+[1])
```

- Selecting a particle according to its history (requirements on mother, grand-mother …)

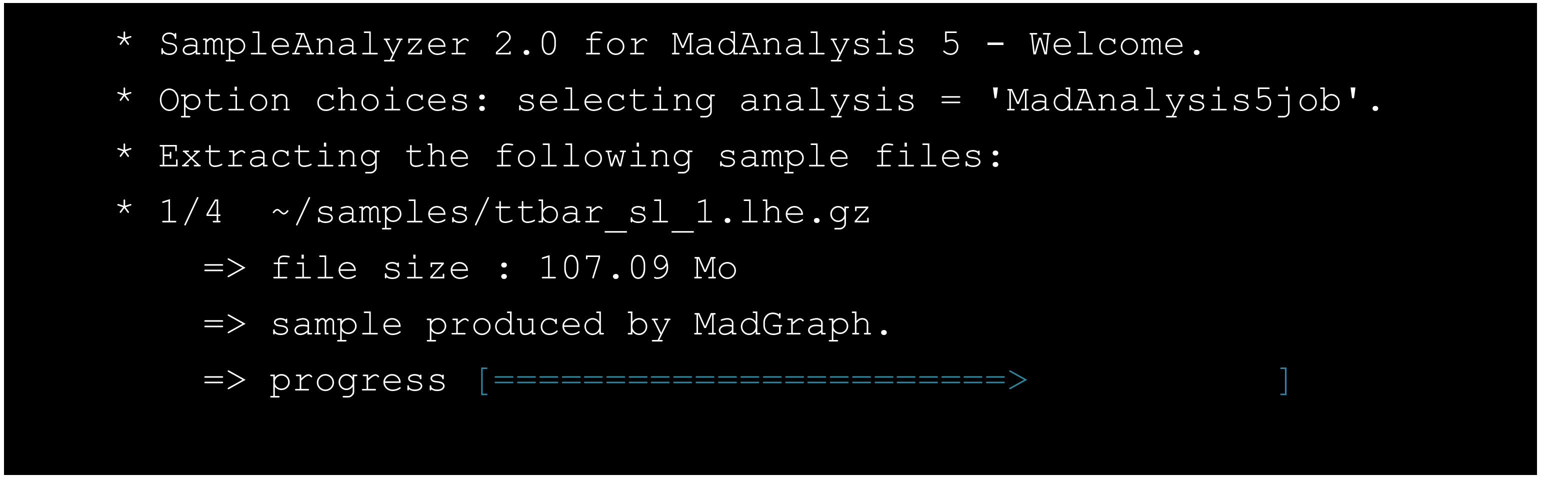
```
ma5> plot PT(mu+ < w+ < t~)
```

Writing an analysis step-by-step

Launching the analysis:

This can be done by the command **`submit`**

- Creating a working directory (with a default name if no name is specified)
- Compiling the C++ job
- Launching the analysis over the different samples contained in the datasets



```
* SampleAnalyzer 2.0 for MadAnalysis 5 - Welcome.
* Option choices: selecting analysis = 'MadAnalysis5job'.
* Extracting the following sample files:
* 1/4  ~/samples/ttbar_sl_1.lhe.gz
    => file size : 107.09 Mo
    => sample produced by MadGraph.
    => progress [=======================>           ]
```

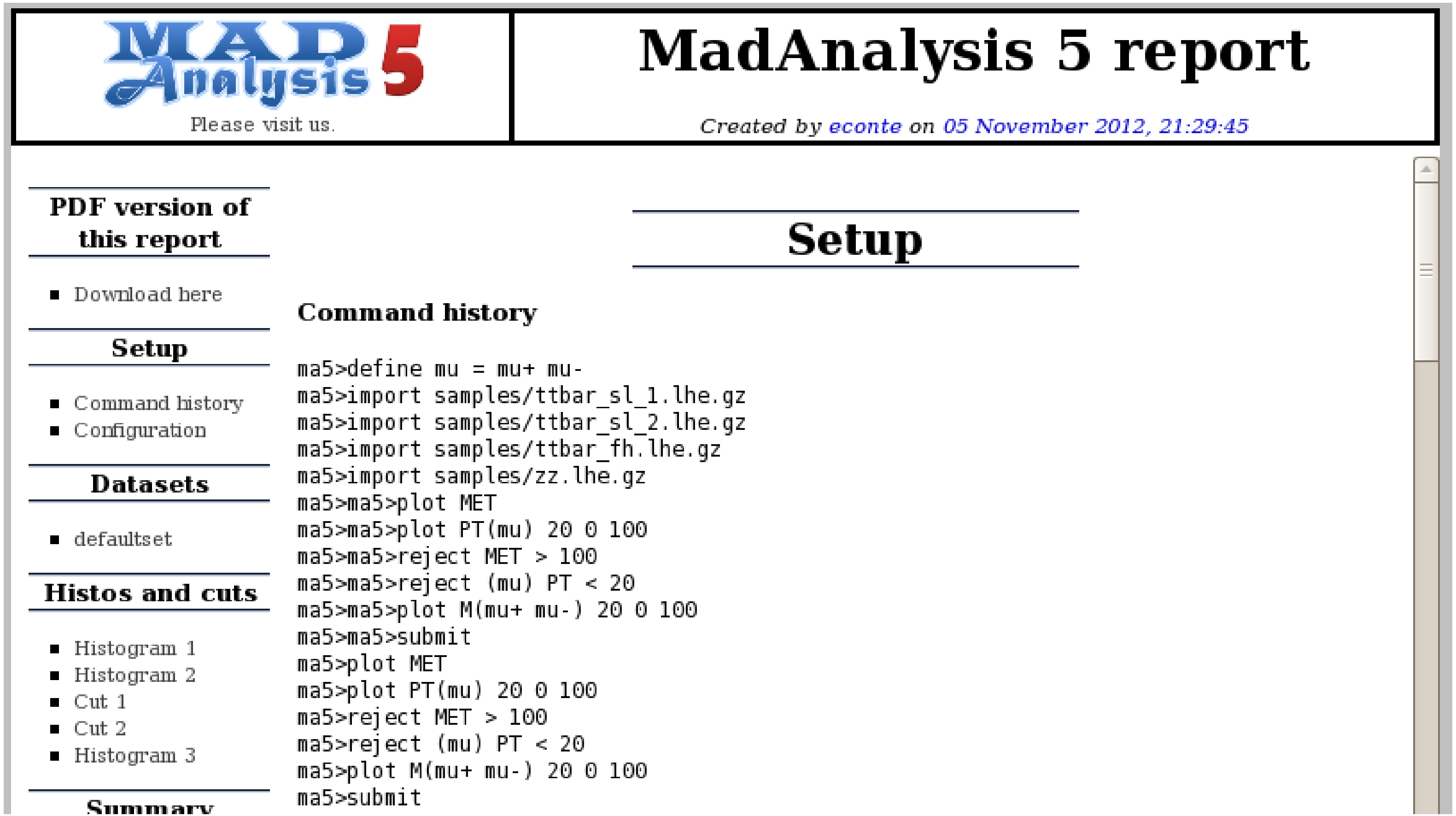
If you modify, after the submission, the analysis or the layout of the plots , the results can be updated in an optimized way by the command **`resubmit`**.

Writing an analysis step-by-step

Opening a generated report:

The command **open** displays the HTML report of the last job created.

Reports in PDF and DVI format are also available.



MadAnalysis 5

Please visit us.

MadAnalysis 5 report

Created by econte on 05 November 2012, 21:29:45

PDF version of this report

- Download here

Setup

- Command history
- Configuration

Datasets

- defaultset

Histos and cuts

- Histogram 1
- Histogram 2
- Cut 1
- Cut 2
- Histogram 3

Summary

Setup

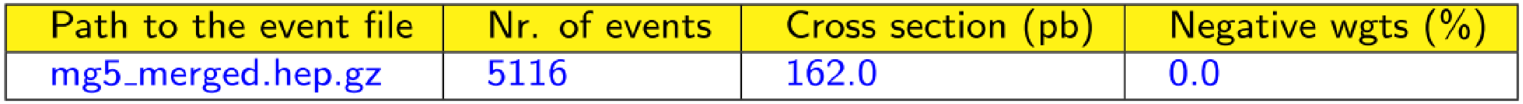
Command history

```
ma5>define mu = mu+ mu-
ma5>import samples/ttbar_sl_1.lhe.gz
ma5>import samples/ttbar_sl_2.lhe.gz
ma5>import samples/ttbar_fh.lhe.gz
ma5>import samples/zz.lhe.gz
ma5>ma5>plot MET
ma5>ma5>plot PT(mu) 20 0 100
ma5>ma5>reject MET > 100
ma5>ma5>reject (mu) PT < 20
ma5>ma5>plot M(mu+ mu-) 20 0 100
ma5>ma5>submit
ma5>plot MET
ma5>plot PT(mu) 20 0 100
ma5>reject MET > 100
ma5>reject (mu) PT < 20
ma5>plot M(mu+ mu-) 20 0 100
ma5>submit
```

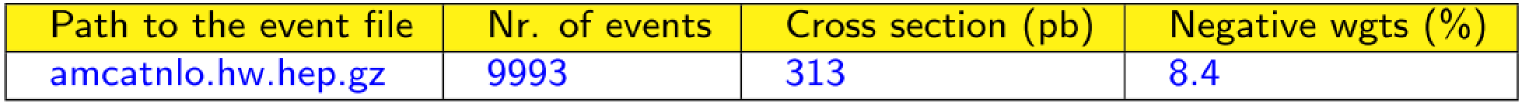
Writing an analysis step-by-step

Opening a generated report:

Details on sample information



Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
mg5_merged.hep.gz	5116	162.0	0.0



Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
amcatnlo.hw.hep.gz	9993	313	8.4

- By default, MadAnalysis5 takes into account the **event-weights** contained in the samples. If no event-weights are available, there are set to one.
- MadAnalysis5 handles **negative event-weights** produced by NLO generators and propagates them properly into the uncertainties calculation (whatever the ROOT version).

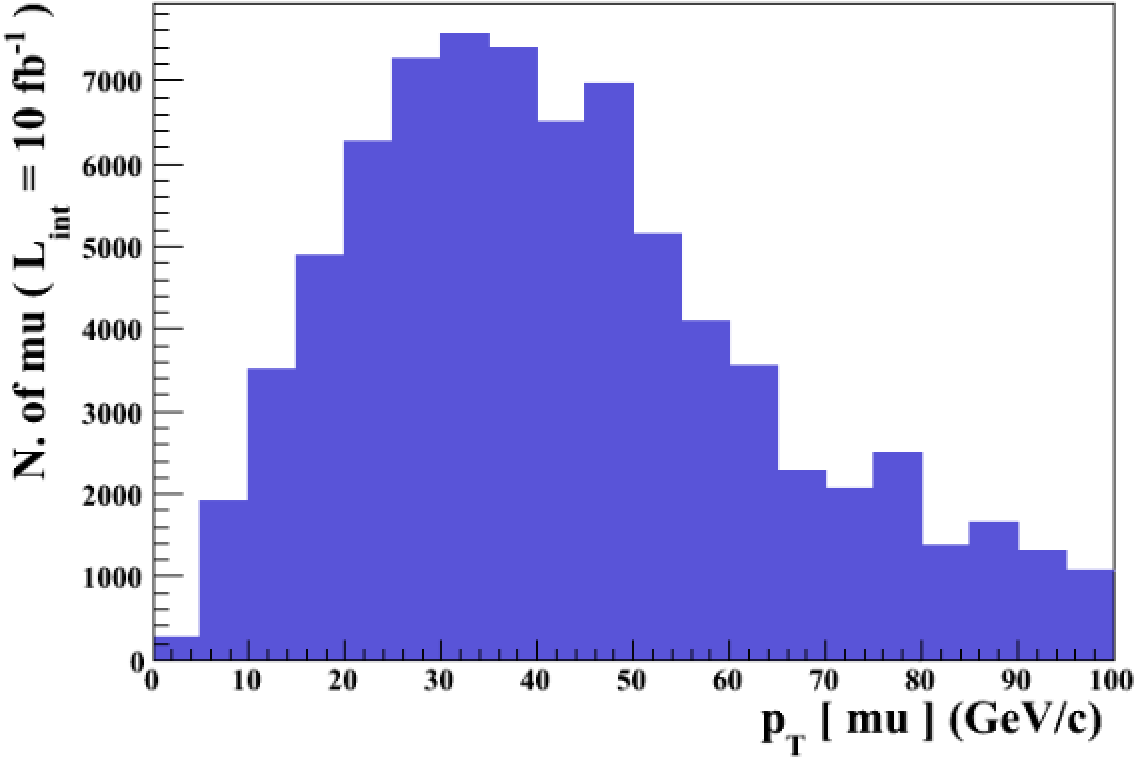
Writing an analysis step-by-step

Opening a generated report:

Details on histogramming

Dataset	Integral	Entries / events	Mean	RMS	Underflow	Overflow
defaultset	82747	0.752	42.8177	21.36	0.0	1.296

Statistics table



- the cross section of the sample is automatically extracted from the sample
- Integrated luminosity is by default 10 fb^{-1}. This value can be set by the user:

```
ma5> set main.lumi =
```

Interface to the FastJet package

Jet clustering algorithms:

Thanks to A. Alloul for validation

- Need to install **FastJet** and interface it to MadAnalysis
  → just one command line:

```
ma5>  install fastjet
```

- Large selection of jet algorithms

```
ma5>  set  main.clustering.algorithm  =

antikt          cdfjetclu       genkt   kt      siscone
cambridge       cdfmidpoint     gridjet none
```

- Adopting a jet algorithm → new options (**algorithm** & **object-identification** parameters)

```
ma5>  set  main.clustering.algorithm  =  antikt
ma5>  set  main.clustering.ptmin   =  5
ma5>  set  main.clustering.radius  =  1
ma5>  set  main.clustering.bjet.efficiency  =  0.5
```

- Possibility to save the clustered events in to a “simplified” LHE (and LHCO format soon)

```
ma5>  set  main.outputfile = “mysample.lhe.gz”
```

Interface to the FastJet package

Jet-merging validation plots:

Matrix elements

hard partons

2 complementary approaches

Need to merge them
but avoid double counting.

Parton showers

soft partons

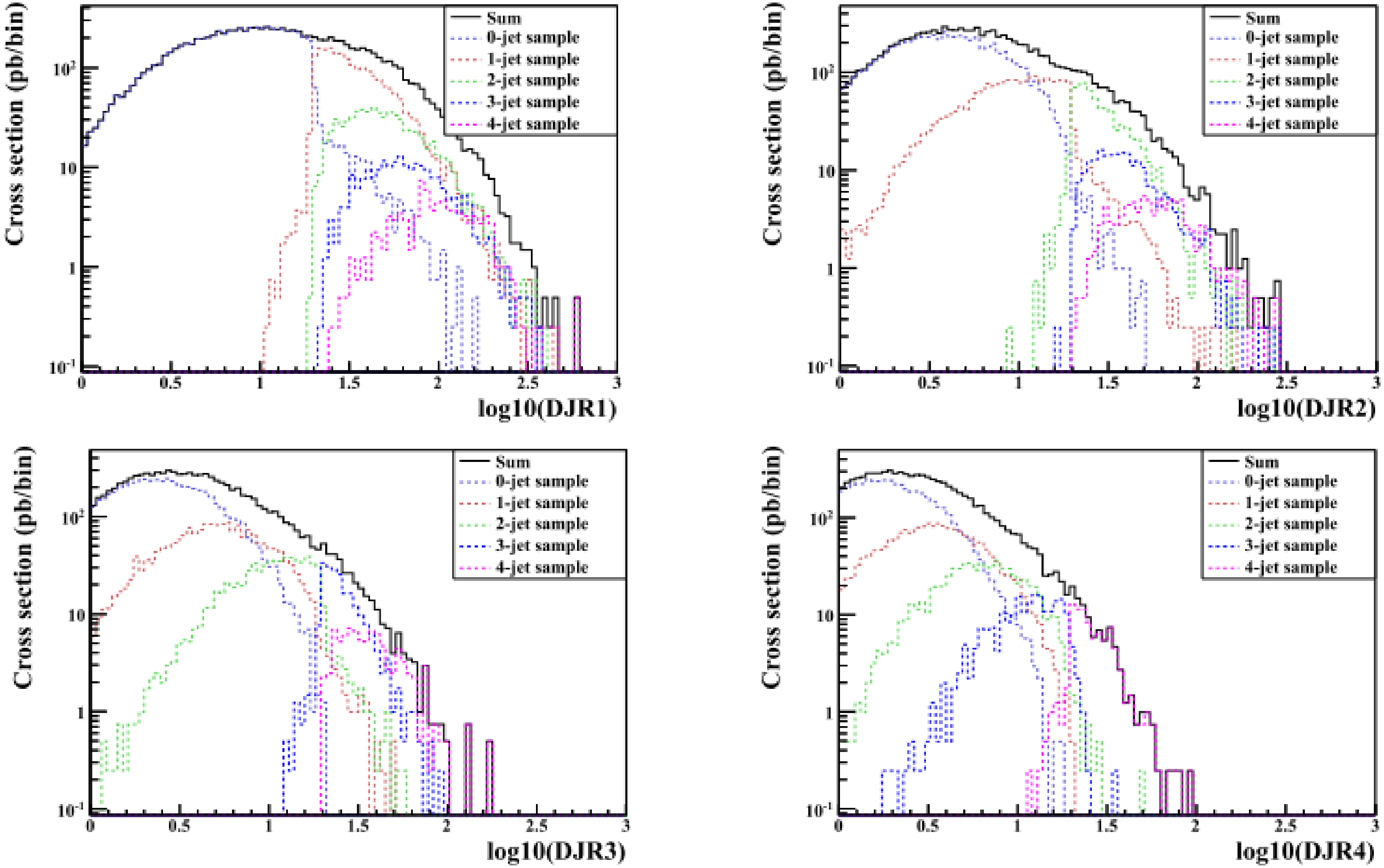
- **Merging matrix-elements with 0, 1, 2, 3, …. extra jets**
  - Study of the smoothness of the differential jet rate (DJR) distributions.
    - The scale for which an event goes from a N → N+1 jet configuration.
    - Extremely sensible to the merging procedure.
  - This validates the choices for the merging parameters.
- **Running MadAnalysis 5 in hadron-level mode: bin/ma5 -H**

```
ma5> set  main.merging.check  =  true
ma5> set  main.merging.njets  =  4
```

Interface to the FastJet package

Jet-merging validation plots:

Example of Z production with 0, 1, 2, 3, 4 extra jets



Summary and perspectives

- **MadAnalysis 5 = a unique framework with two ways to use it :**
  - **Normal mode:** python interface with intuitive commands.
  - **Expert mode:** requiring programming skills (C++, ROOT).

- **Interfaced to FastJet**, MadAnalysis 5 can:
  - launch a specified **jet clustering** sequence to hadronic events.
  - save samples to «simplified» LHE format (LHCO format very soon).
  - achieve and display the **plots validating the jet merging procedure**.

- **Some leads for further developments:**
  - More and more user-friendly (**tutorials)**.
  - Integration into MadGraph 5 / aMC@NLO
  - Interfaces to physics-relevant packages : **fast-simulation** (Delphes), **showering**

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https://launchpad.net/madanalysis5
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