MadAnalysis 5

A new framework for collider phenomenology

Guillaume Serret (Université de Strasbourg / IPHC Strasbourg)

in collaboration with Eric Conte & Benjamin Fuks

GDR Terascale @ Clermont-Ferrand

April 25, 2012.

Outline

Collider Phenomenology

- New **framework** to build complete **analyses** of **Monte Carlo** event files.
- **Three levels** of **analysis** :

partonic
hadronic
reconstructed } **unique** framework

Collider Phenomenology

History

MadGraph4 MadAnalysis 4		MadGraph5 MadAnalysis 5
• written in FORTRAN	⇒	• written in PYTHON & C++
• not very user-friendly		• very user-friendly
• check samples		• uses ROOT
• low flexibility		• allows to built sophisticated analysis

MadAnalysis 5 is going beyond the scheme of the Mad software.

MadAnalysis 5 is also a **standalone** package.

Collider Phenomenology

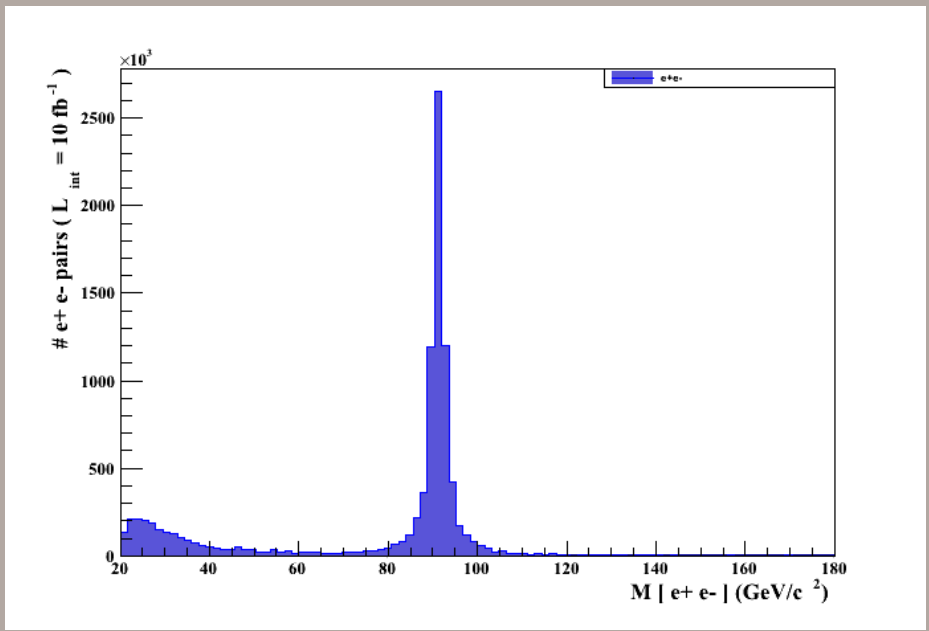
History

What can we do ?

- Kinematical variables **distributions** (MadAnalysis 4)

Example :

- Generated : `p p > e+ e-`
- **Invariant mass** of lepton pair

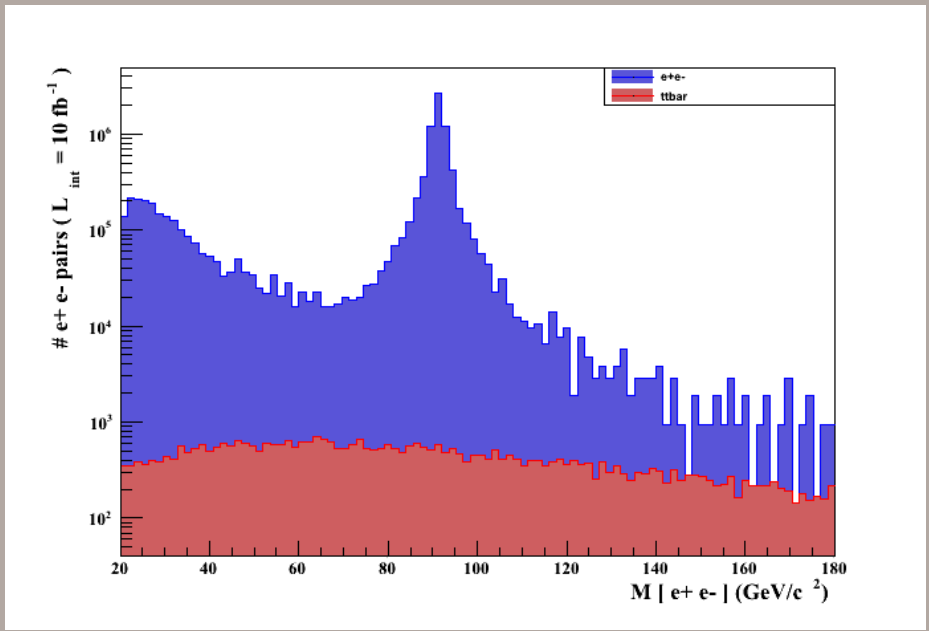


Collider Phenomenology

History

What can we do ?

- Kinematical variables **distributions** (MadAnalysis 4)
- **Superposing and stacking**
  - two different datasets

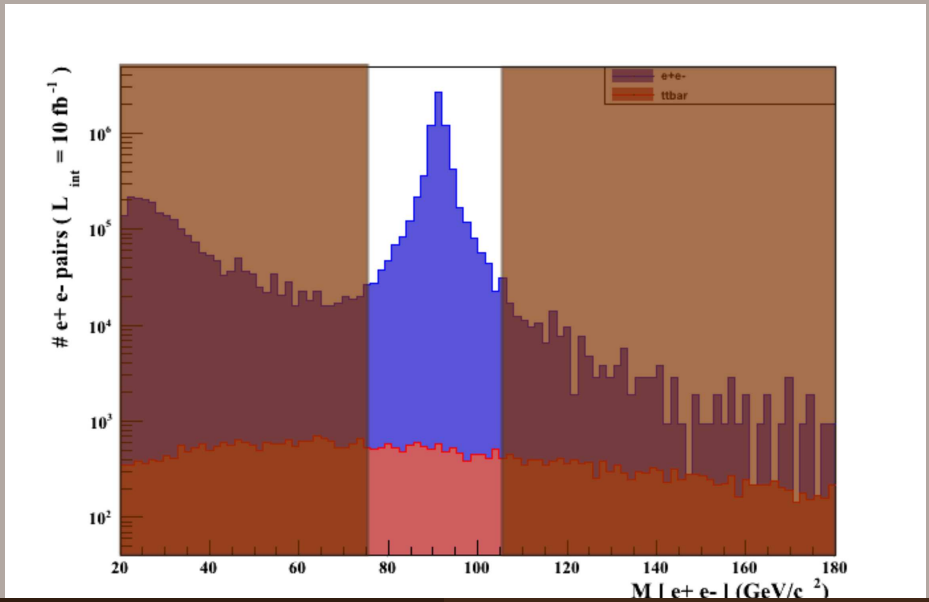


Collider Phenomenology

History

What can we do ?

- Kinematical variables **distributions** (MadAnalysis 4)
- **Superposing and stacking**
- Applying **cuts**
  - Favored kinematical region



Collider Phenomenology

History

What can we do ?

- Kinematical variables **distributions** (MadAnalysis 4)
- **Superposing and stacking**
- Applying **cuts**
- Automated calculation of **Signal/Background** ratio.

Collider Phenomenology

History

What can we do ?

- Kinematical variables **distributions** (MadAnalysis 4)
- **Superposing and stacking**
- Applying **cuts**
- Automated calculation of **Signal/Background** ratio.

What can we get ?

- **Results** presented in an **automatically generated** and **human readable report**.

File Edit View History Bookmarks Tools Help

MadAnalysis 5 HTML report

file:///home/gserret/WorkingZone/madanalysis/trunk/madanalysis-developmer

Google

Personnel Tools MadAnalysis5 RPV Pheno FeynRules Webmail

MadAnalysis 5

Please visit us.

MadAnalysis 5 report

Created by gserret.

Wednesday, 25 April 2012 at 08:04:56.

Table of contents.

Command history.

```
ma5>import /home/gserret/WorkingZone/madgraph5/PPEE/Events/run_01/unweighted_events.lhe.gz as e+e-
ma5>import /home/gserret/WorkingZone/madgraph5/ttbar_dilep/Events/run_01/unweighted_events.lhe.gz as ttbar
ma5>plot M(e+ e-) 100 20 180
ma5>set selection[1].logY = true
ma5>submit Demo
ma5>generate_html Demo/HTML
```

Configuration.

File Edit View History Bookmarks Tools Help

MadAnalysis 5 HTML report

file:///home/gserret/WorkingZone/madanalysis/trunk/madanalysis-developmer

Google

Personnel Tools MadAnalysis5 RPV Pheno FeynRules Webmail

Configuration.

MadAnalysis version 0.5.117 (2012/04/24).
Histograms correspond to an integrated luminosity of 10 fb^{-1}.

Datasets used..

ttbar (signal).

Event files	Number of events	Cross section (pb)
/home/gserret/WorkingZone/madgraph5/ttbar_dilep/Events/run_01 /unweighted_events.lhe.gz	10000	4.8803 +/- 0.0193
FINAL	10000	4.8803 +/- 0.0193

e+e- (signal).

Event files	Number of events	Cross section (pb)
/home/gserret/WorkingZone/madgraph5/PPEE/Events/run_01 /unweighted_events.lhe.gz	10000	946.62 +/- 2.25
FINAL	10000	946.62 +/- 2.25

Histograms / Cuts.

File Edit View History Bookmarks Tools Help

MadAnalysis 5 HTML report

file:///home/gserret/WorkingZone/madanalysis/trunk/madanalysis-developmer

Google

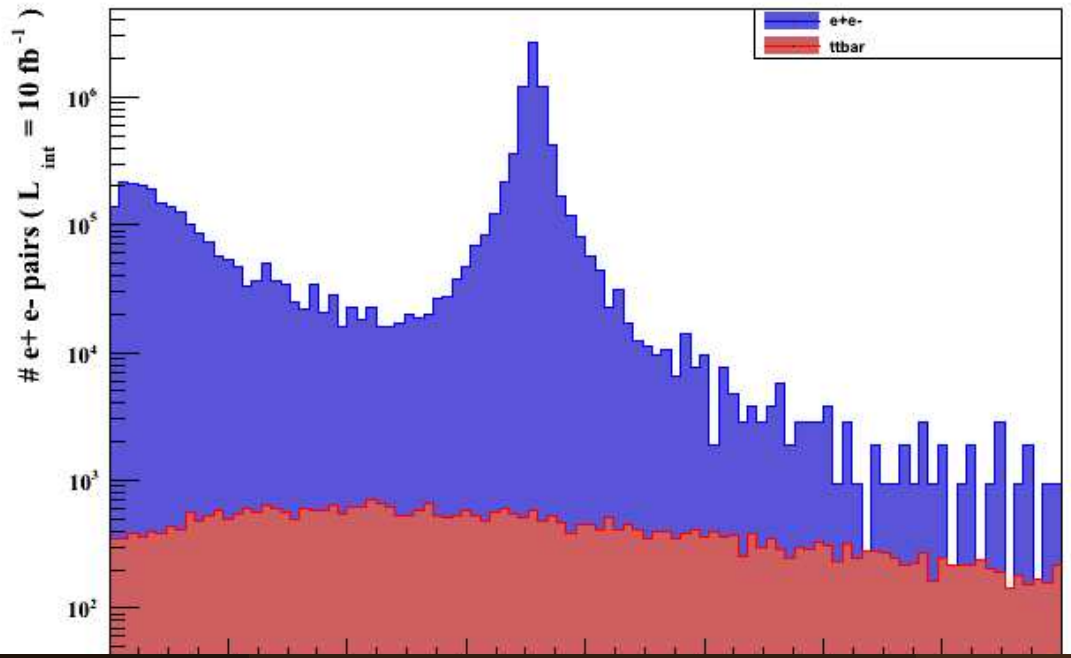
Personnel Tools MadAnalysis5 RPV Pheno FeynRules Webmail

Histograms / Cuts.

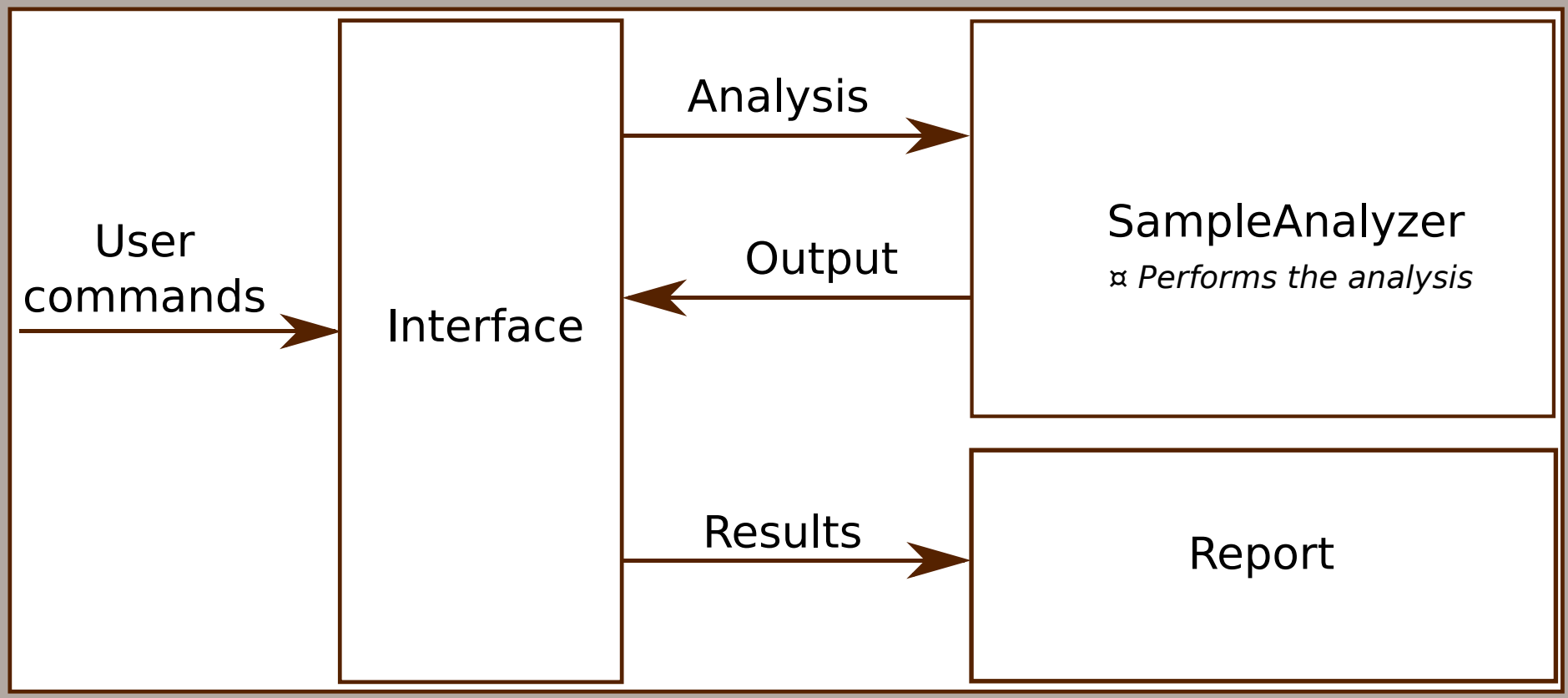
Histogram number 1.

Dataset	# events	Mean	RMS	% Underflow	% Overflow
e+e-	9466199	78.0228	26.11	0.0	0.22
ttbar	48803	87.0171	41.04	2.33	13.12

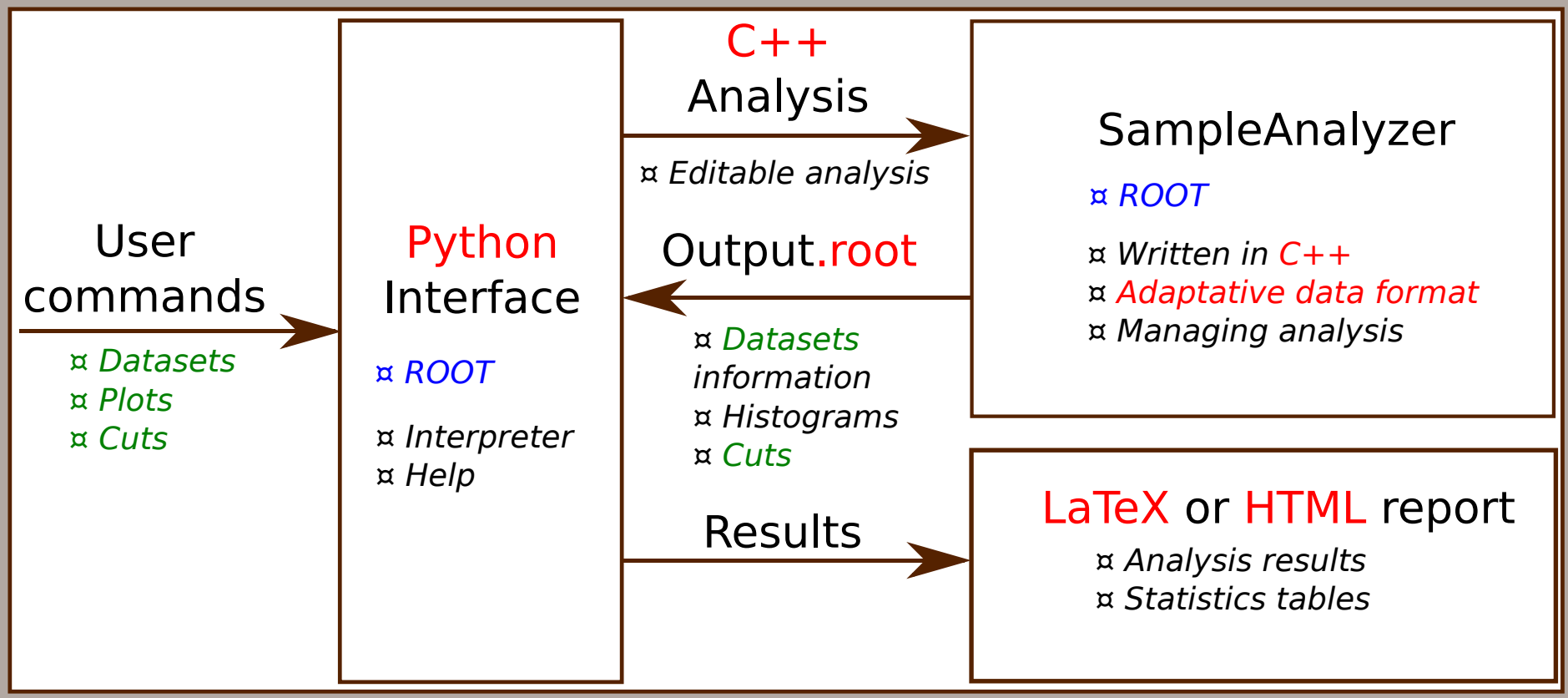
Histogram number 1 - Statistics



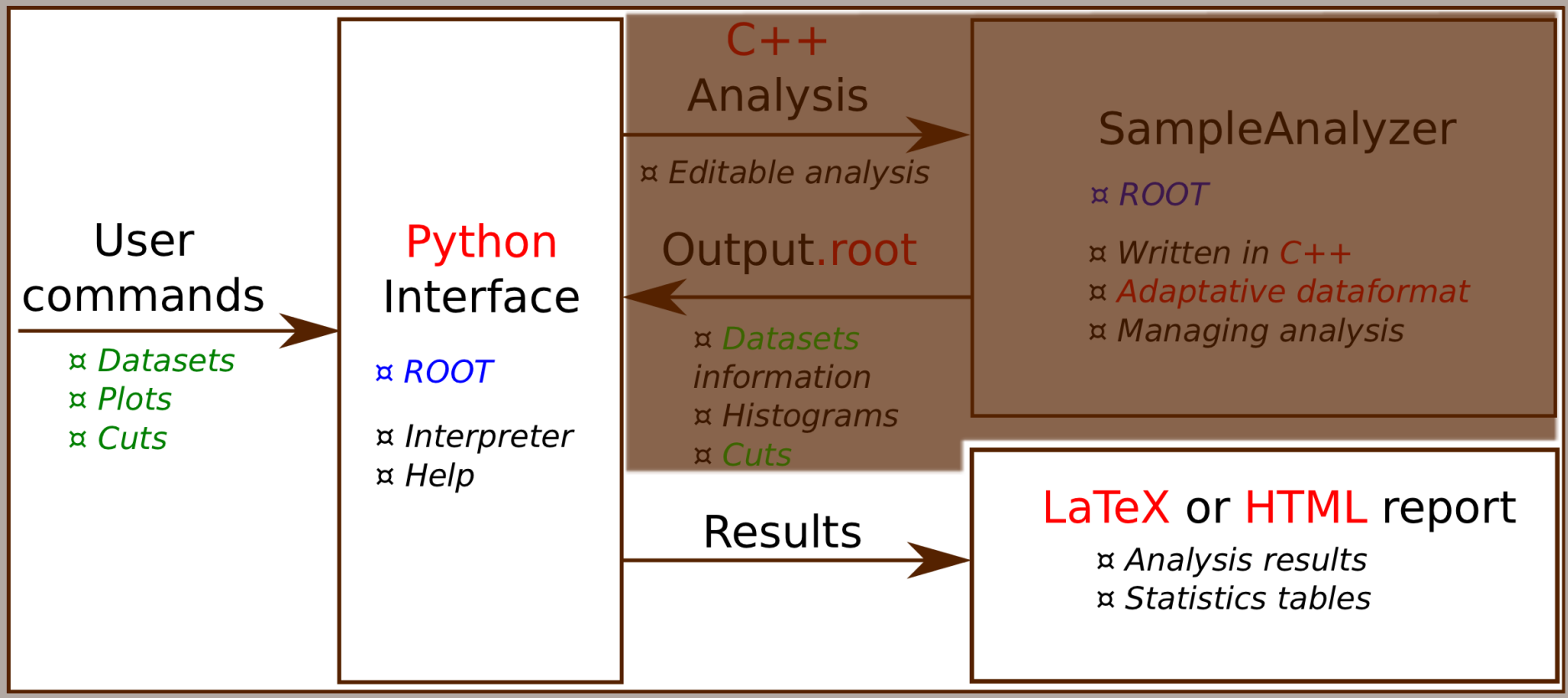
MadAnalysis 5



MadAnalysis 5

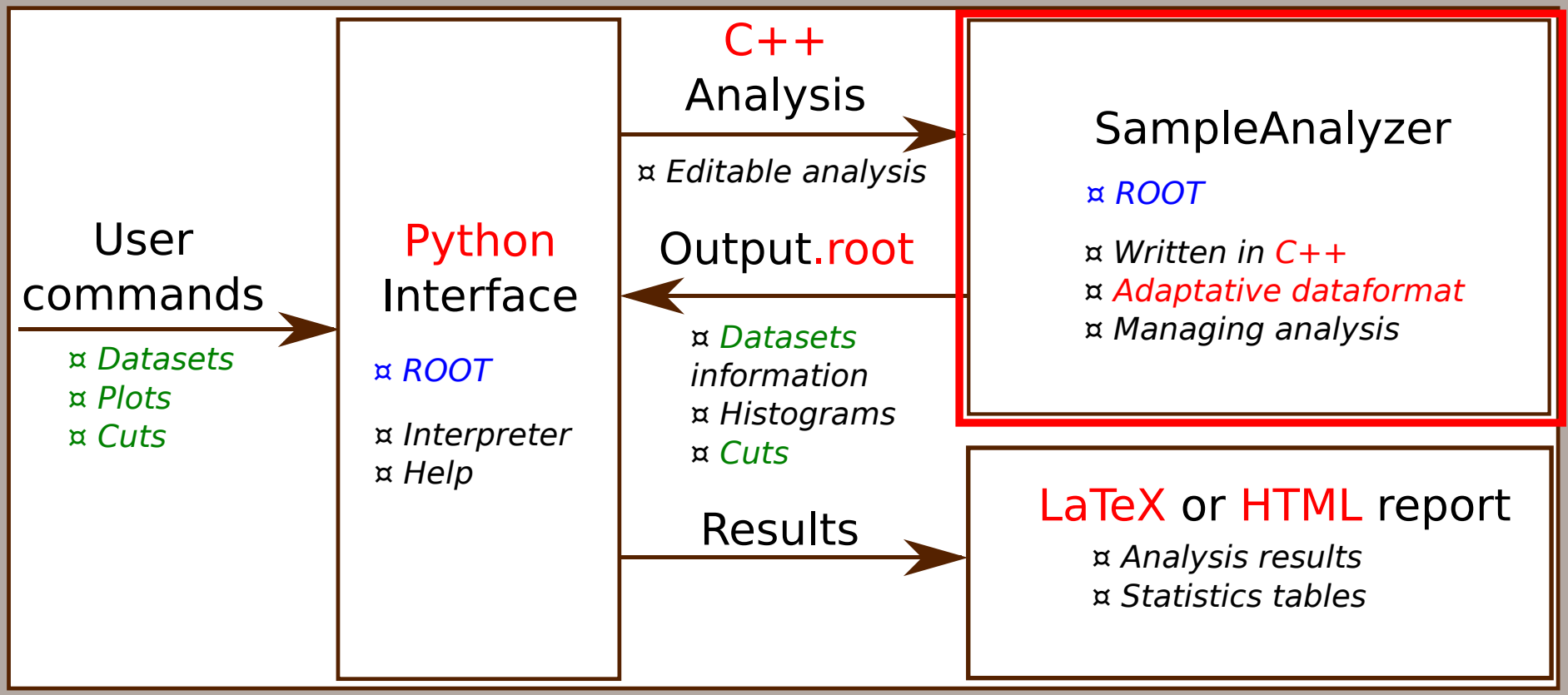


MadAnalysis 5



- *Traditional* use : everything but the interface is transparent.

MadAnalysis 5



- *Traditional* use : everything but the interface is transparent.
- *Advanced* use : the user is implementing his analysis in the `SampleAnalyzer` framework.

Interface

- PYTHON **command line interface** : `ma5>`

Interface

- PYTHON **command line interface** : `ma5>`

```
[gserret@sbgat508 madanalysis-development]$ ./bin/ma5
Checking ROOT libraries ...
Loading ROOT libraries ...
Checking g++ libraries ...
Checking zlib libraries ...
Checking MadAnalysis library ...
System configuration has changed since the last use. Need to rebuild the library
   Creating (or overwriting) folder 'lib'...
   Copying 'SampleAnalyzer' source files...
   Creating a 'Makefile'...
   Compiling the MadAnalysis library...
   Linking the MadAnalysis library...
   Checking the MadAnalysis library presence...
```

Check-out

Behind the scene compilation

```
************************************************************
*                                                          *
*       W E L C O M E  to  M A D A N A L Y S I S  5        *
*                                                          *
*                 /'\_/`\/\  __ \/\  ___\                  *
*                /\      \ \ \_\ \ \ \__/                  *
*                \ \ \__\ \ \  __ \ \___``\                *
*                 \ \ \_/\ \ \ \/\ \/\ \_\ \               *
*                  \ \_\\ \_\ \_\ \_\ \____/               *
*                   \/_/ \/_/\/_/\/_/\/___/                *
*                                                          *
*   MA5 release : 0.5.114                    2012/04/17    *
*                                                          *
*   The MadAnalysis Development Team - Please visit us at  *
*   https://server06.fynu.ucl.ac.be/projects/madanalysis   *
*                                                          *
*              Type 'help' for in-line help.               *
*                                                          *
************************************************************
```

- **Auto-completion** + Interactive **help** : `ma5>help <command>`

MadAnalysis 5 lies on simple **concepts** :

Datasets

MadAnalysis 5 lies on simple **concepts** :

Datasets

Regroup **sample files** that can be **treated in the same way** during the analysis, as a unique object refered with a **label**.

Suppose you have three sample files :

- **Sample 1** : **ttbar** - 10 000 events
- **Sample 2** : **ttbar** - 20 000 events
- **Sample 3** : **Z'** - 10 000 events

You can

- gather **Sample 1 & 2** in the **ttbar dataset**
- put **Sample 3** in the **zprime dataset**
- `ma5>import Sample1.lhe as ttbar`
- `ma5>import Sample2.lhe as ttbar`
- `ma5>import Sample3.lhe as zprime`

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Particles are identified with a **PDG-Id** : **not very user-friendly**.
In MadAnalysis 5 :

- **particle** object :
  - denoted with a **label**,
  - refers to **PDG-Id**. Example :
    - `ma5>define mu+ = -13`
- **multiparticle** object :
  - denoted with a **label**,
  - refers to several particles

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

SUSY + SM particles **automatically loaded** with **standard names** in MadAnalysis 5

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots** : displaying information about

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots** : displaying information about
  - **global** observables with respect to the **event**
    - missing transverse energy
    - particle content & multiplicity
    - ...
- `ma5>plot MET`

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots** : displaying information about
  - **non-global** observables with respect to the **particles** :
    - kinematical information (p_T,θ, ϕ, ...)
  -

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

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots** : displaying information about
  - **non-global** observables with respect to the **particles** :
    - kinematical information (p_T,θ, ϕ, ...)
    - multiplicity
  - `ma5>plot N(mu)`

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots** : displaying information about
  - **non-global** observables with respect to the **particles** :
    - kinematical information (p_T,θ, ϕ, ...)
    - multiplicity
    - combining particles
  -

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

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

- **plots**
- **cuts** : **reject events/candidates** not fulfiling a certain **condition**
  - reject event with MET $<$ 50 GeV
  - reject mu candidate with PT $>$ 50 GeV

- ```
  ma5>reject MET < 50
  ```
- ```
  ma5>select (mu) PT < 50
  ```

MadAnalysis 5 lies on simple **concepts** :

Datasets

Particles/Multiparticles

Selection : plots & cuts

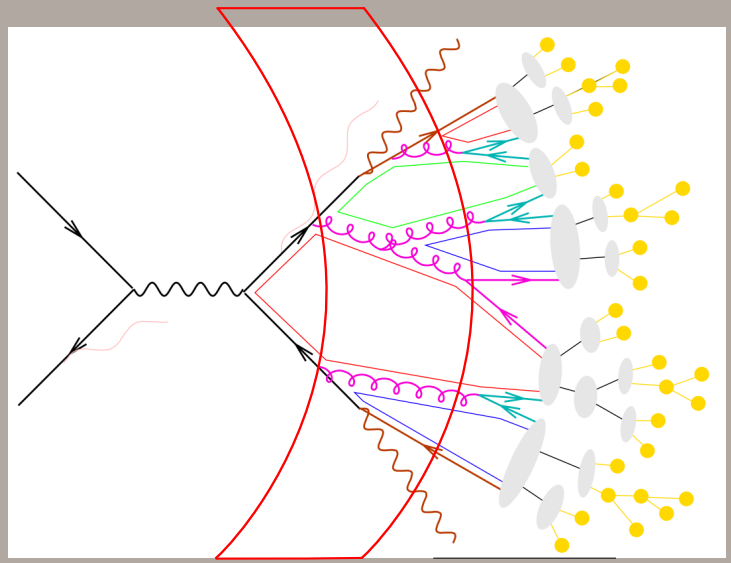
Report

Displaying **results** in a complete **report** written in LaTeX or HTML

Different working levels

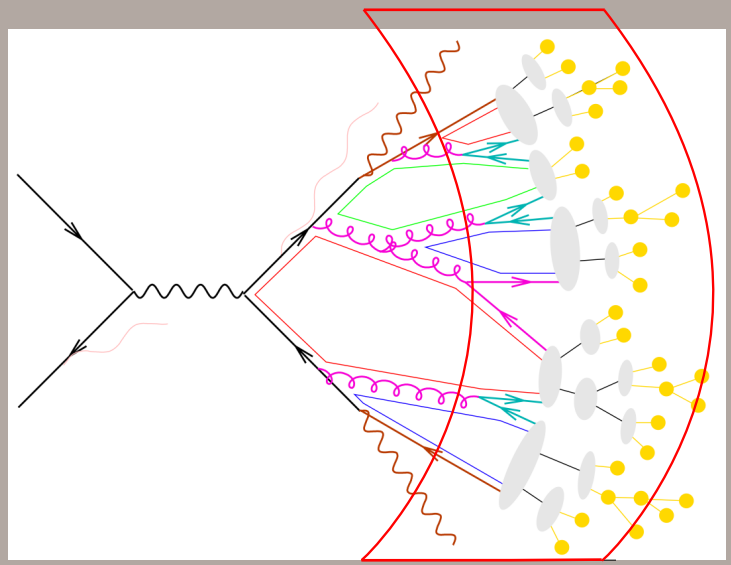
Different working levels

- **Partonic**



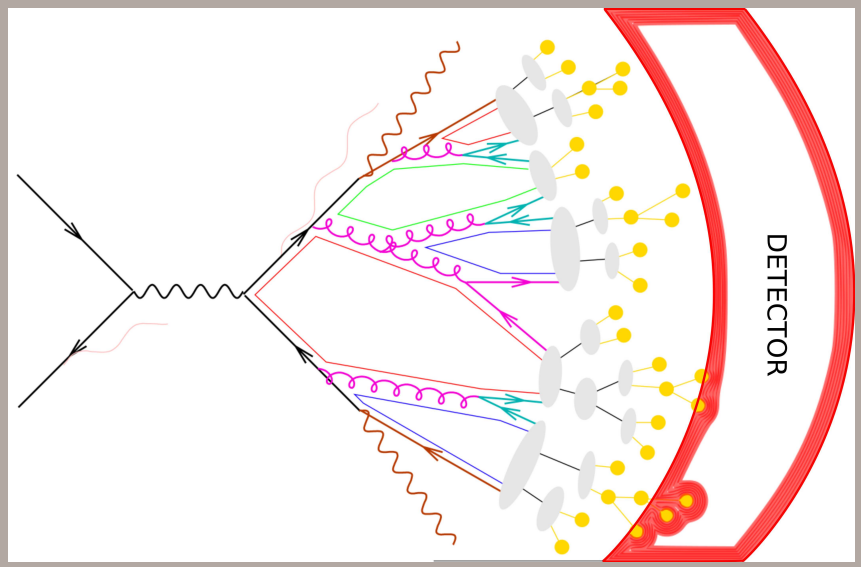
Different working levels

- **Partonic**
- **Hadronic**



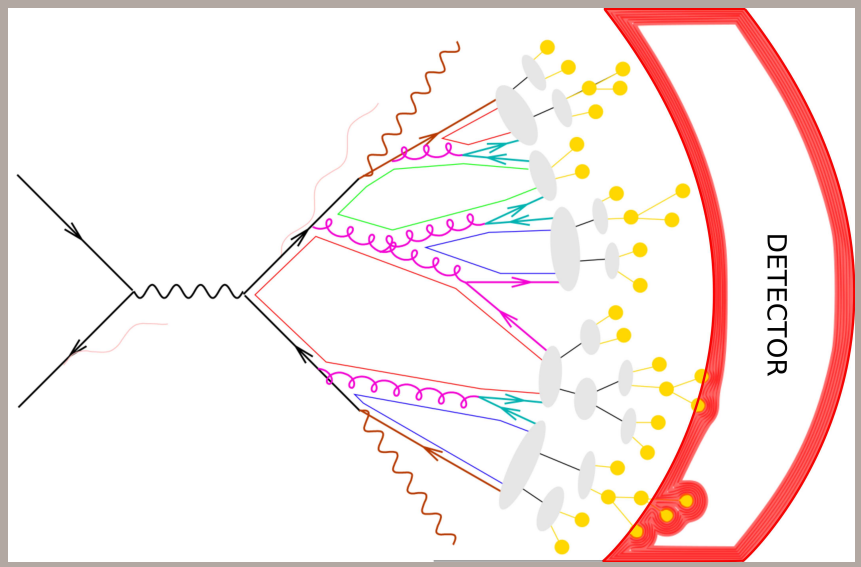
Different working levels

- **Partonic**
- **Hadronic**
- **Reconstructed**



Different working levels

- **Partonic**
- **Hadronic**
- **Reconstructed**
- Supported files :
  `.lhe`, `.hepmc`, `.stdhep`, `.lhco`.



Different working levels

Importing UFO model

Can directly import **particles information** from the model generated by FEYNRULES (through Universal Feynrules Output).

- **automatic** generation of labels

What the user want

which concept(s) are involved

How to do it with MA5

What the user want
which concept(s) are involved

How to do it with MA5

An analysis step by step

Importing files
defining datasets

```
ma5>import myfile.lhe.gz
```

Importing model
loading particles

```
ma5>import UFO_modelpath/
```

Defining new objects
defining (multi-)particles

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

Defining selections
defining cuts & plots

```
ma5>reject MET > 150
```

Launching SampleAnalyzer
defining job

```
ma5>submit jobpath/
```

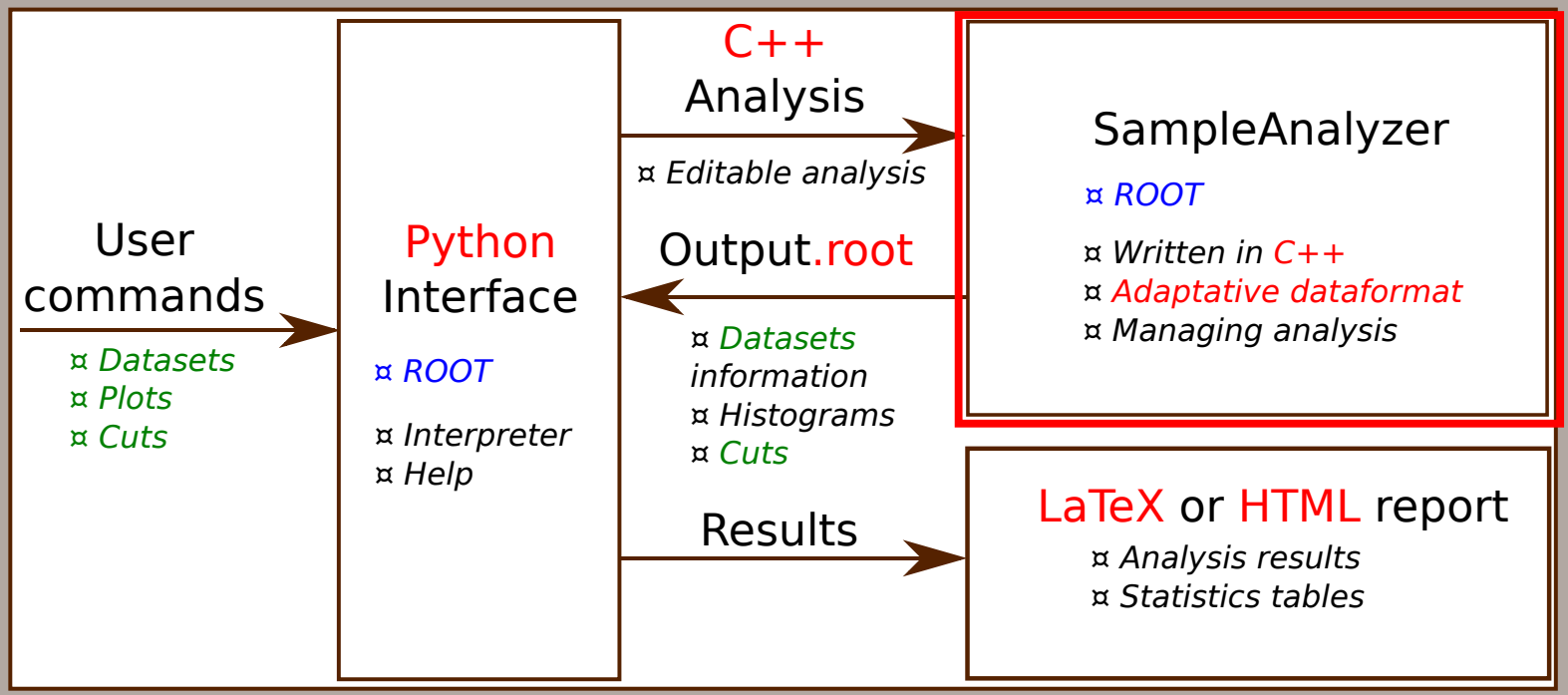
Displaying results
defining report

```
ma5>generate_html RepPath/
```

Advanced analysis

- more **sophisticated plots** (2D, 3D, ...)
- **new observables** (asymmetry,...)

Even the expert mode is **developer-friendly** !
Just needed to have **good skills** in programing.



Conclusion

- New **framework** based on :
  - C++ kernel,
  - **User-friendly** PYTHON **interface**.
- **Efficient** way of performing an analysis :
  - reading event files,
  - defining analysis,
  - displaying results.
- **Expert mode** available :
  - open the door to the **imagination** of the users.
- **Many more** sophisticated functionalities are implemented [1]
  - particle ordering,
  - event history,
  - displaying options,
  - ...

1. **120 pages manual**

Thanks for your attention

- **Public** version available soon.
- Webpage
  - **https ://server06.fynu.ucl.ac.be/projects/madanalysis/wiki/**
- β-version distributed yesterday
- New β-testers are **welcome**, please ask !
- Remarks, suggestions, requests, anything :

ma5team@iphc.cnrs.fr