

# MADANALYSIS 5

## From the past to the future

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# Outline

- 1 News from the team
- 2 Overview and basics of MADANALYSIS 5
- 3 Back to the past...
  - The Brazilian version
  - The mid-november LPCC version
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# News from the team



- **More and more users** ⇒ support takes more and more time.
- **Loss of manpower.**
  - \* **Guillaume Serret:** PhD (Oct 2010 - Dec 2012); leaves the field.
  - \* **Manuel Kraft:** intern (Sep - Oct 2012); no budget to renew the contract.
- **This might challenge the respect of the timeline.**
  - \* **Room for help:** pipelining, shower and fastsim interfaces,...

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# The MADANALYSIS 5 scheme

- **Several modules.**
  - \* A **PYTHON command line interface**: **interactive commands**.
  - \* A **C++/ROOT module**, **SAMPLEANALYZER**: **performs the analysis**.
- **Normal mode of running** (user-friendly).
  - \* **Commands typed in the PYTHON interface**.
  - \* Analysis performed **behind the scene** (black box).
  - \* **Human readable output**: HTML,  $\text{\LaTeX}$ .
- **Expert mode** (developer-friendly).
  - \* C++ and ROOT programming skills required.
- **Inputs.**
  - \* Monte Carlo samples (zipped or not)  $\Leftrightarrow$  **datasets**.
  - \* **User commands**.
- **Jobs and results.**
  - \* Translation of the commands by the interface  $\Rightarrow$  **C++ job**.
  - \* **Execution** of the job  $\Rightarrow$  **results**.

# Basic concepts

## ● Command line interface.

- \* **In-line help.**
- \* **Auto-completion.**

```
ma5> help <command>
```

## ● Particles and multiparticles.

- \* Particle are defined by **labels**.
- \* A label points to one or several **PDG-id(s)**.
- \* **MSSM + SM labels**: automatic.
- \* Can be loaded from **UFO files**.
- \* Labels can be **created and deleted**.
  - ▶define and remove.

```
define tau = tau+ tau-  
define mytau+ = -15  
remove mytau+
```

## ● Datasets.

- \* A dataset is a **label**.
- \* **Collects** similar event samples.
- \* Treated **in the same way** by MADANALYSIS 5.
- \* **Formats**: LHE, LHCO, STDHEP, HEPMC.

```
import tt1.hep as ttbar  
import tt2.hep as ttbar  
import Wj1.hep as Wjets  
import Wj2.hep as Wjets
```

# Plots and cuts

## ● The command plot.

- \* Creation of an **histogram**.
- \* **Global observables**  $\Leftrightarrow$  the entire event.
- \* **Properties of the particles** in the event.
- \* **Ordering** of the particles.
- \* **Combining** particles
  - ▶ Sum and differences.
  - ▶ Vectorial or scalar.
- \* Linear or logarithmic scales.

## ● Cuts.

- \* **Selecting/rejecting** events.
- \* **Selecting/rejecting** particles.
  - ▶ not rejecting the event.

## ● Executing of the job.

- \* **Analysis**.
- \* Generation of the **reports**.

```
plot MET
plot N(mu)
plot PT(mu[1])
plot ETA(mu) [logY]
plot M(mu[1] mu[2])
plot dM(mu+ mu-)
```

```
reject MHT < 50
select (mu) PT > 50
```

```
submit
```

# MADANALYSIS 5 - examples (1)

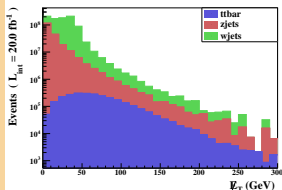
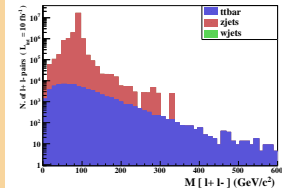
- Kinematical distributions related to particle species.

\* BETA, DELTAR, E, ET, ETA, GAMMA, M, MT, P, PHI, PT, PX, PY, PZ, R, THETA, Y.

- Global event kinematical observables.

\* **Missing and visible (hadronic) energy** (MET, TET, MHT, THT) + SQRTS.

```
import ttbar_2l.lhe.gz as ttbar
import ttbar_1l.lhe.gz as ttbar
import wjets.lhe.gz as wjets
import zjets.lhe.gz as zjets
plot M(l+ l-) [logy]
submit
open
set ttbar.xsection = 139.6
set wjets.xsection = 35678
set zjets.xsection = 10319
set main.lumi = 20
plot MET 30 0 300 [logy]
resubmit
open
```

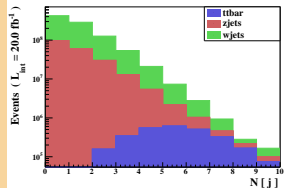
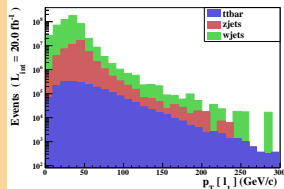




# MADANALYSIS 5 - examples (2)

- **Particle ordering.**
  - \* Can be access with the **squared brackets** [*i*]
  - \* Several possible **ordering variables**. E, ET, ETA, P, PT, PX, PY, PZ.
- **Particle content** of the event npid, napid; **particle multiplicity** N.

```
define l = l+ l-
plot PT(1[1]) 20 0 200 [logy]
set selection[2].rank = Eordering
resubmit
open
define j = j b b~
plot N(j)
resubmit
open
```

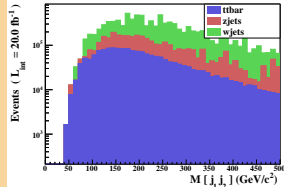


# MADANALYSIS 5 - examples (3)

## ● Cuts.

- ◇ Through the commands `select` and `reject` followed by a condition.
- ◇ **Particle candidates.**
  - \* **Lepton candidates:**  $p_T > 10$  gev.
  - \* **Jet candidates:**  $p_T > 20$  gev.
- ◇ **Events.**
  - \* **Selected events:**  $H_T > 200$  gev.

```
select (l) PT > 10
reject (j) PT < 20
reject THT < 200
plot M(j[1] j[2])
resubmit
open
```



# MADANALYSIS 5 - examples (4)

- **Automated computation of the signal over background ratio.**

- \* Samples can be tagged as **signal** or **background**.
- \* **Formula** for the signal over background ratio can be provided.
- \* **Automatic cut-flow chart** with uncertainties.

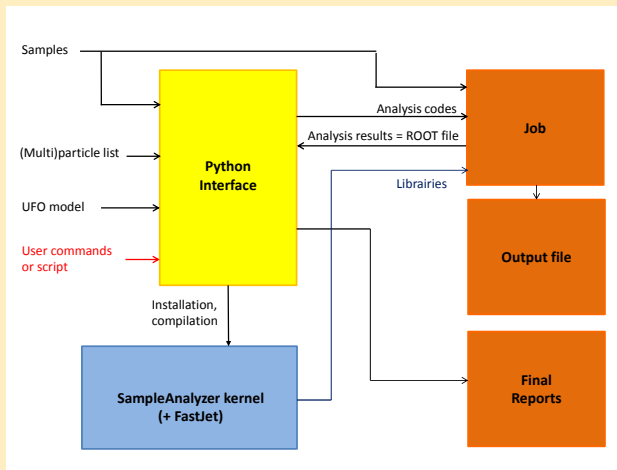
```
set wjets.type = background
set zjets.type = background
set main.sratio = 'S/B'
set main.sberror = '1./(B**2)*sqrt(B**2*ES**2+S**2*EB**2)'
resubmit
open
```

Cuts	Signal (S)	Background (B)	S vs B
initial	2792000	919940000	0.00303
cut 1	2792000	919940000 +/- 0.000173	3.034981e-03 +/- 5.7e-16
cut 2	2792000	919940000 +/- 0.000173	3.034981e-03 +/- 5.7e-16
cut 3	1928561 +/- 772	9583745 +/- 3079	0.201233 +/- 0.000103

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# MADANALYSIS 5 v1.1.2, the Brazilian version



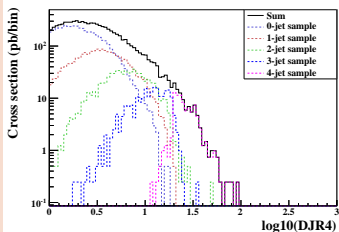
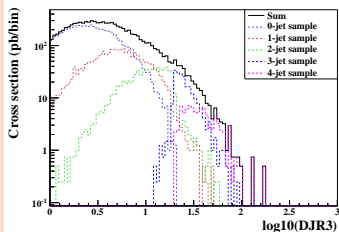
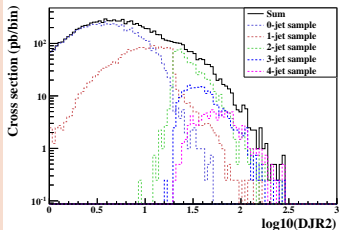
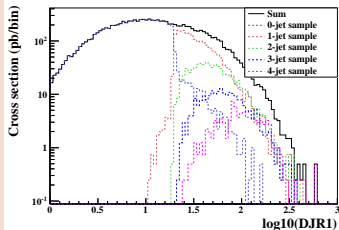
# MADANALYSIS 5 v1.1.2, checking the merging (1).

- **Merging matrix-elements with 0,1,2,3,... extra jets.**
  - ◇ Study of the smoothness of the **differential jet rate distributions**.
  - ◇ This **validates** the choices for the merging parameters.
- **Running MADANALYSIS 5 in hadron-level mode:** `bin/ma5 -H`

```
import zjets.hep.gz as zjets
set zjets.xsection=10319
set main.lumi = 20
set main.merging.check = true
set main.merging.njets = 4
submit
open
```

- ◇ We can choose  $n_{\max}$  → the number of desired histograms.

## MADANALYSIS 5 v1.1.2, checking the merging (2).



# MADANALYSIS 5 v1.1.2, jet reconstruction (1).

- **The (STDHEP or HEPMC) event files contain lots of hadrons.**  
⇒ **Jet clustering** is required.

The reco mode: `bin/ma5 -R`

- **MADANALYSIS 5 is interfaced to 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 (the algorithm parameters).**

```
set main.clustering.algorithm = antikt  
set main.clustering.ptmin = 5  
set main.clustering.radius = 1
```

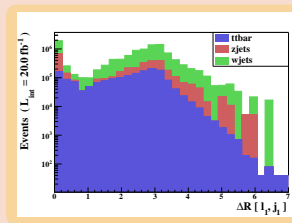


# MADANALYSIS 5 v1.1.2, jet reconstruction (2).

## ● A small example.

```

set main.clustering.algorithm=antikt
set main.clustering.ptmin = 5
set main.clustering.radius = 1
import ttbar_2l.hep.gz as ttbar
import ttbar_1l.hep.gz as ttbar
import wjets.hep.gz as wjets
import zjets.hep.gz as zjets
set ttbar.xsection=139.6
set wjets.xsection=35678
set zjets.xsection=10319
set main.lumi = 20
set main.normalize = lumi
select (l) PT > 20
reject (j) PT < 50
reject THT < 200
plot DELTAR(l[1],j[1]) 30 0 7 [logy]
submit
open
  
```



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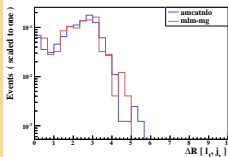
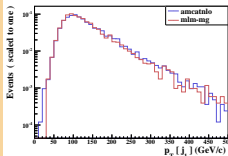
# MADANALYSIS 5 v1.1.5, the LPCC version

- **Compatibility with aMc@NLO.**
  - \* Support for **weighted events**.
  - \* Improvement of the `STDHEP` reader.
- **New layout for the reports.**
- **Simplification of the syntax.**
  - \* **Suppression of the `generate_xxx` commands.**
  - \* **Automatic generation of the reports.**
  - \* **Improvement of the `submit` command.**
- **Invention of the `SAF` format.**
  - \* **Text-based format** for histograms, cuts.
  - \* First link leading to the **suppression of `PYROOT`**.
  - \* Inspired by the **XML language** but much **simpler**.

# MADANALYSIS 5 v1.1.5, examples (1)

- Comparison of  $t\bar{t}$  samples (MG5 + merging vs. aMC@NLO).
- Illustration of the simplified syntax.

```
set main.clustering.algorithm = antikt
import amcatnlo.hw.hep.gz as amcatnlo
import mg5_merged.hep.gz as m1m-mg
set main.stacking_method = normalize2one
plot PT(j[1]) 50 0 500 [logy]
select N(1)==1
select MET > 50
plot DELTAR(1[1],j[1]) 30 0 10 [logy]
submit
open
```



# MADANALYSIS 5 v1.1.5, examples (2)

## ● The aMC@NLO sample information (handling of the weights).

- \* Sample consisting of: **signal** events.
- \* Generated events: **9993** events.
- \* Normalization to the luminosity: **3138081+/- 0** events.
- \* **Ratio (event weight): 314 - warning: please generate more events (weight larger than 1)!**

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
<a href="#">amcatnlo.hw.hep.gz</a>	9993	313	8.4

## ● The mlm-merged sample information (no weights).

- \* Sample consisting of: **signal** events.
- \* Generated events: **5116** events.
- \* Normalization to the luminosity: **1620000+/- 0** events.
- \* **Ratio (event weight): 316 - warning: please generate more events (weight larger than 1)!**

Path to the event file	Nr. of events	Cross section (pb)	Negative wgts (%)
<a href="#">mg5_merged.hep.gz</a>	5116	162.0	0.0

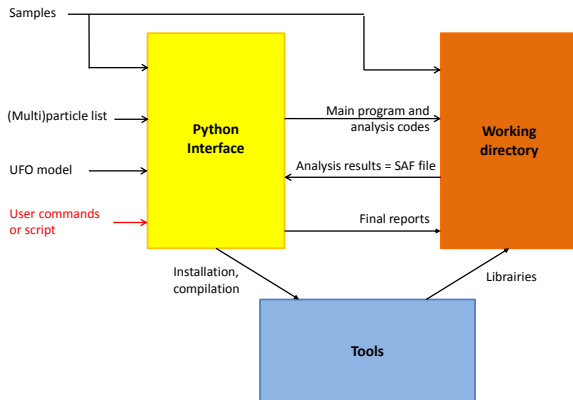
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# On the road to MADANALYSIS 5 v1.2.0 (1)

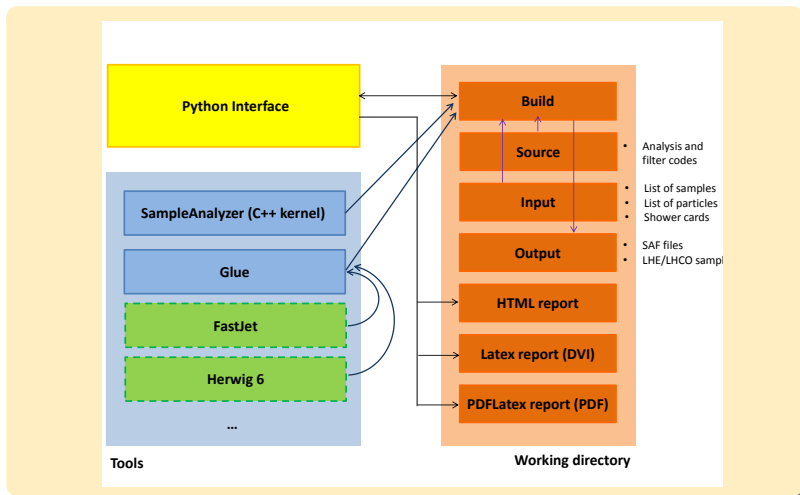
- **Total reorganization of the working directory.**
  - \* Analysis **source files**.
  - \* Executable in a **build** directory.
  - \* **Linking** to SAMPLEANALYZER and to glues.
  - \* **Input** directory with cards generated by MADANALYSIS 5.
  - \* **Output** directory (event samples) + **report** directories.
- **A collection of static libraries.**
  - \* **Interfaced tools**: SAMPLEANALYZER, FASTJET, **HERWIG 6**, **etc.**
  - \* **Installation** from the PYTHON interpreter.
  - \* MADANALYSIS 5 comes with **glues** → wrappers.
  - \* **Showering**: MADANALYSIS 5 will play the role of MC@NLO-UTILITIES.
- **Invention of the SAF format.**
  - \* **Text-based format** for histograms, cuts.
  - \* First link leading to the **suppression of PYROOT**.
  - \* Inspired by the **XML language** but much **simpler**.

# On the road to MADANALYSIS 5 v1.2.0 - the structure (1)

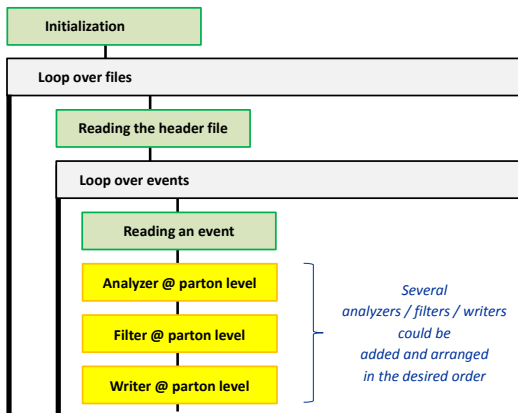




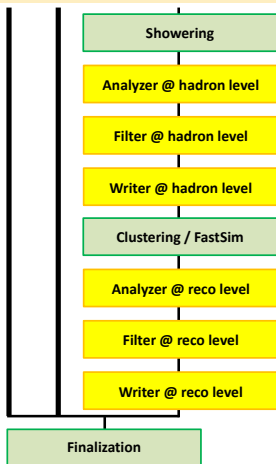
# On the road to MADANALYSIS 5 v1.2.0 - the structure (2)



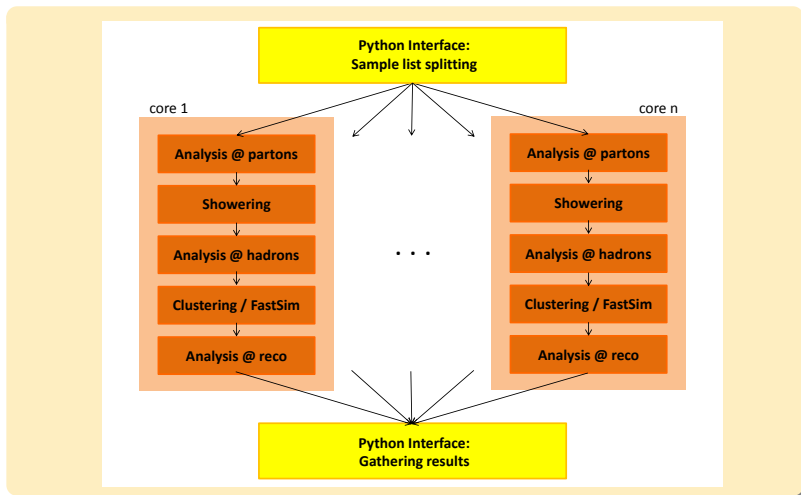
# On the road to MADANALYSIS 5 v1.2.0 - working dir (1)



# On the road to MADANALYSIS 5 v1.2.0 - working dir (2)



# In a not that far away future: pipe-line and parallelization



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# Summary.

- **MADANALYSIS 5 is a new framework for collider phenomenology.**
  - \* **Unique** → partonic, hadronic or reconstructed events.
  - \* **User-friendly** → PYTHON command line interface.
  - \* **Flexible** → a C++ kernel.
- **A special mode for expert users also exists.**
  - \* **Developer-friendly** → C++ and ROOT skills required.
  - \* **No limitations.**
- **Getting more and more interfaced to aMC@NLO.**
  - \* **Weighted events** are supported.
  - \* **Pipe-lining** of the showering on-going (a new structure is there).
  - \* **Pipe-lining** of the fastsim is the next step.

Try the code (and love it).

```
http://madananalysis.irmp.ucl.ac.be  
ma5team@iphc.cnrs.fr
```