

Recasting with

MAD **Analysis 5**

Eric Conte, Benjamin Fuks



(Re)interpreting the results of new physics searches at the LHC
June 15-17 2016 @ CERN

- 1. What is MadAnalysis 5?**
- 2. Normal & expert mode**
- 3. MadAnalysis recasting way**
- 4. Using the recast analyses**

- 1. What is MadAnalysis 5?**
2. Normal & expert mode
3. MadAnalysis recasting way
4. Using the recast analyses

What is MadAnalysis 5?

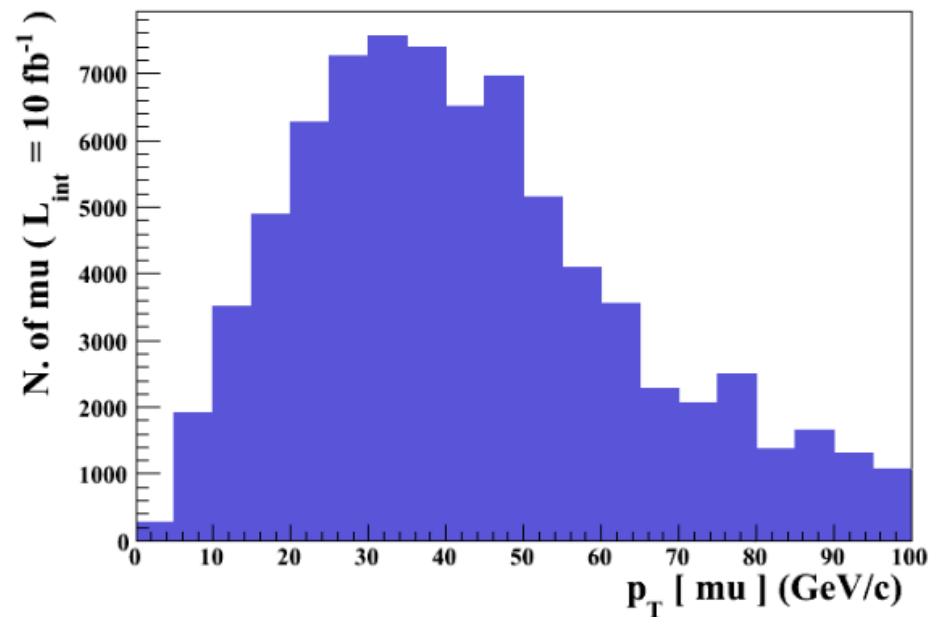
2012: birth of MadAnalysis 5 → basic features:

Comput. Phys.
Commun. 184
(2013) 222-256,
arXiv:1206.1599

- 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.
- Dumping results in a smart report (PDF, DVI or HTML)

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

Statistics table

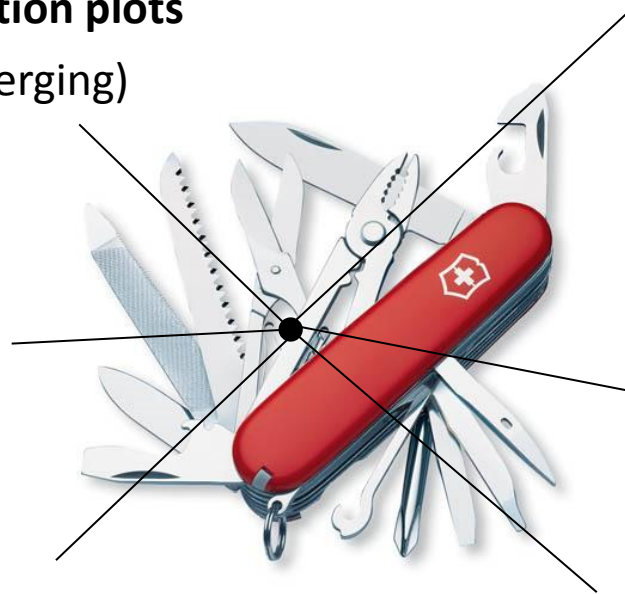


What is MadAnalysis 5?

But MadAnalysis 5 can do other things for you:

- Producing special plots such as **ME/PS merging validation plots** (see talk devoted to merging)

- **Writing** the events in another data format.



- Designing a sophisticated analysis in the **expert mode**

- Applying a **jet-clustering algorithm** to your hadronic events

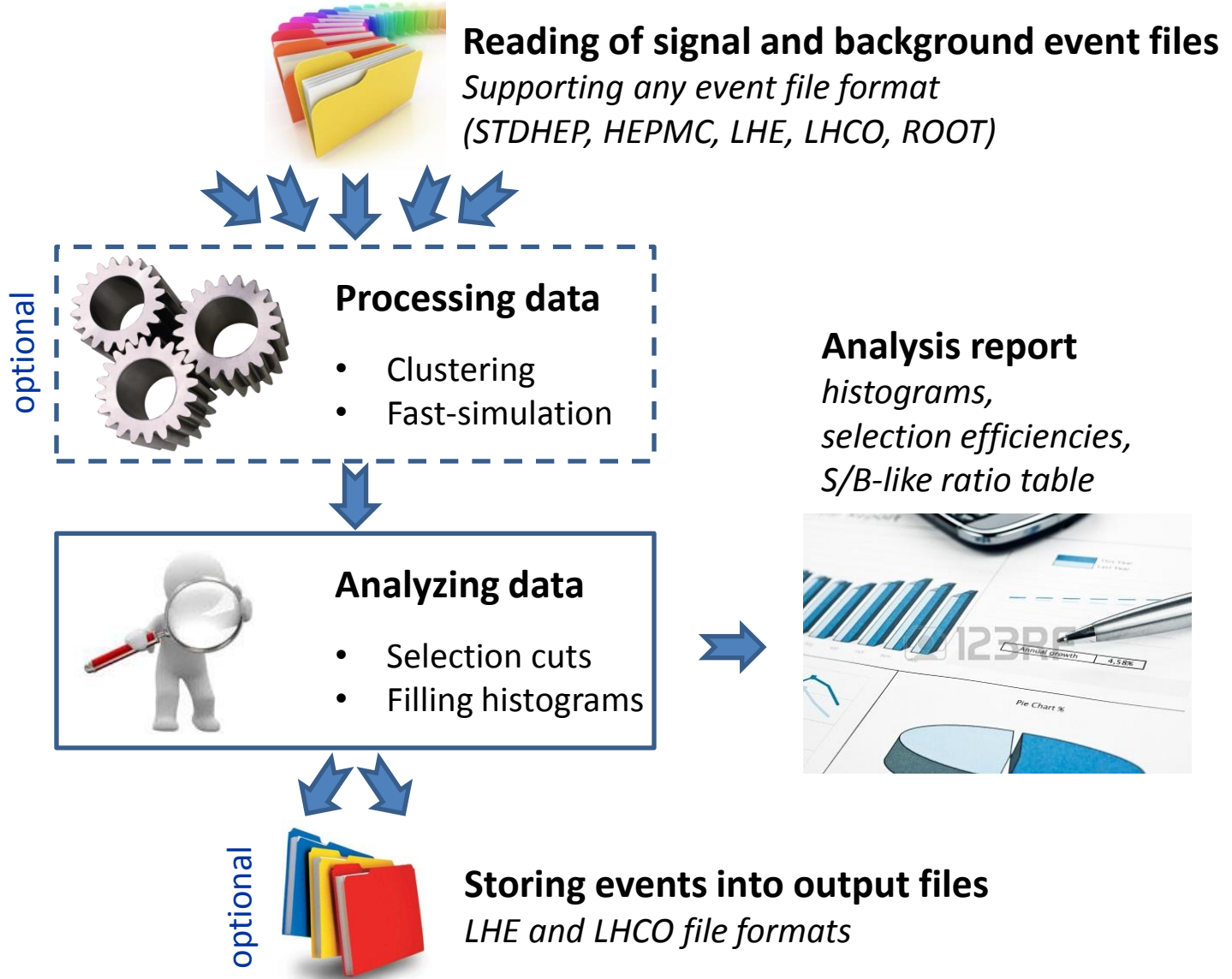
- Applying a **fast-simulation detector (Delphes)** to your hadronic events

- **Recasting an existed analysis** and **computing a limit** to a BSM signal

What is MadAnalysis 5?

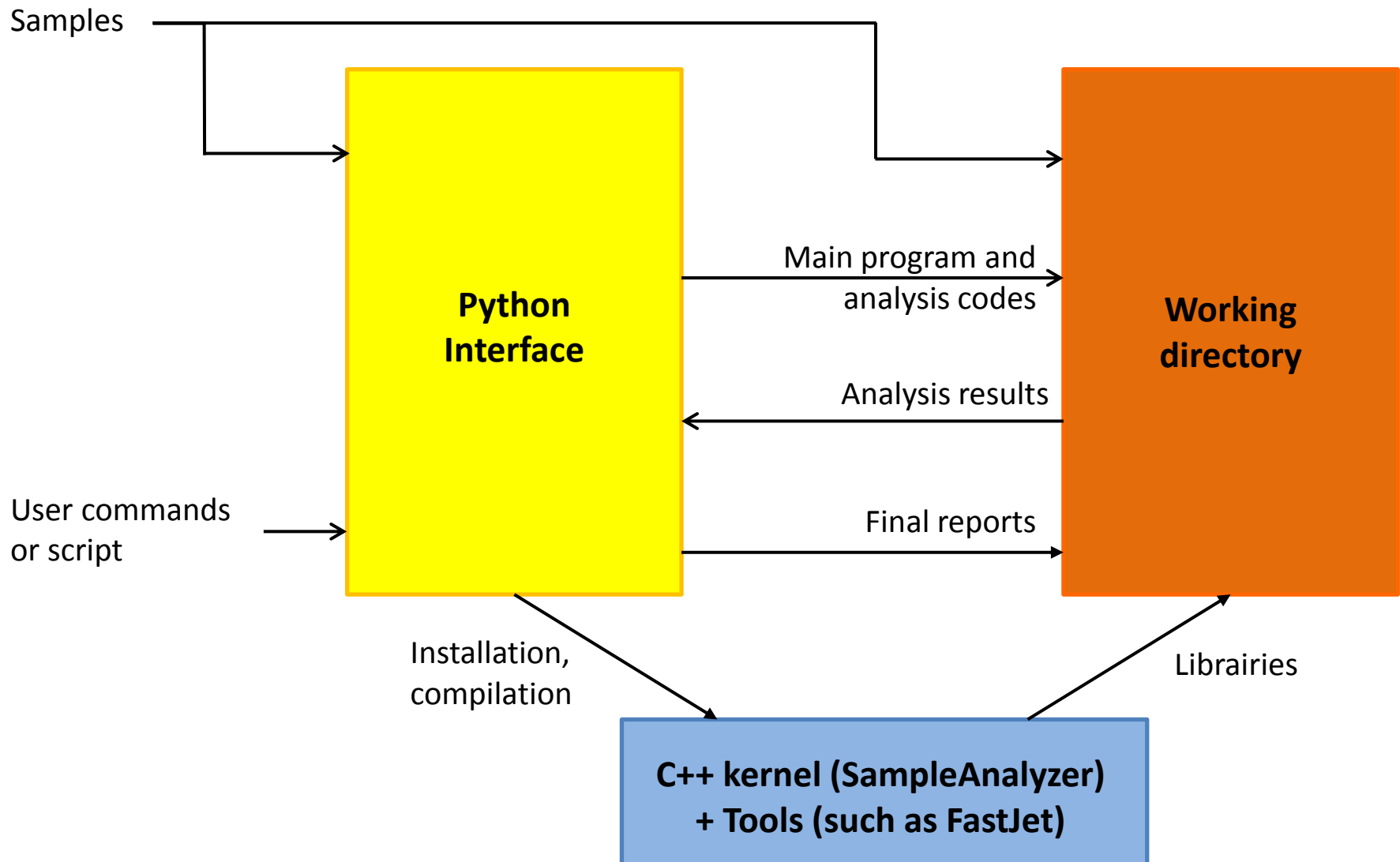
Scope:

Defining an analysis with a dedicated metalanguage



1. What is MadAnalysis 5?
- 2. Normal & expert mode**
3. MadAnalysis recasting way
4. Using the recast analyses

2. Normal & expert mode



2. Normal & expert mode

Normal mode

The MadAnalysis 5 console



```
Platform: Linux 2.6.18-348.12.1.el5 [Linux mode]
Reading user settings ...
Checking mandatory packages:
  - python [OK]
  - python library: numpy [OK]
  - g++ [OK]
  - GNU Make [OK]
  - Root [OK]
  - PyRoot libraries [OK]
Checking optional packages:
  - pdflatex [OK]
  - latex [OK]
  - dvipdf [OK]
  - zlib [OK]
  - FastJet [OK]
  - Delphes [OK]
  - Delphes-MA5tune [DEACTIVATED]
Checking the MadAnalysis library:
=> MadAnalysis libraries found.
=> MadAnalysis test program works.
*****
MadGraph 5 NOT found:
=> Particle labels from input/particles_name_default.txt
=> 87 particles successfully exported.
=> Multiparticle labels from
madanalysis/input/multiparticles_default.txt
=> Creation of the label 'invisible' (-> missing energy).
=> Creation of the label 'hadronic' (-> jet energy).
=> 8 multiparticles successfully exported.

ma5>
```

2. Normal & expert mode

Normal mode

The user can write an analysis with the help of a **meta-language**.
Here we give some simple examples:

- **Plots** : content of the event final state

```
ma5> plot NPID
```

- **Plots** : usual plot

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

- **Plots** : using multiparticle definition

```
ma5> define mu = mu+ mu-  
ma5> plot PT(mu)
```

- **Plots** : using options []

```
ma5> plot PT(j[1]) [logY]  
ma5> plot MET 100 0 1000 [normalize2one]
```

- **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
```

- **And many more possibilities ...**

- Plethora of observables are defined
- Possible to sum, to subtract observables
- Possible to specify the origin of a particle

2. Normal & expert mode

Expert mode

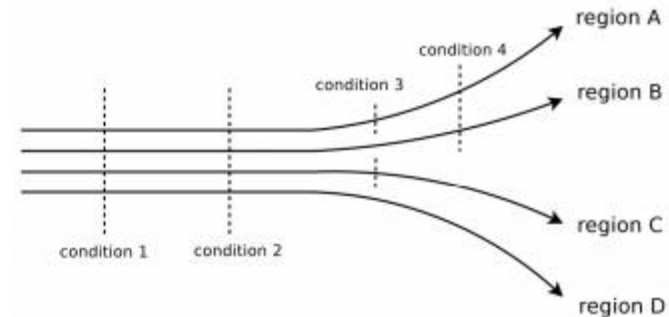
The user can write an analysis directly in C++.

MadAnalysis 5 offers several **developer-friendly** services :

- A common data-format for describing an event
- Interfaces to useful high-energy physics tools
- Ready-to-use observables such as α_T , $MT2$, $MT2_{W'}$...
- Support for multiple sub-analyses (signal and control regions)
- Smart way for handling cuts and histograms

```
count the event in region D
if (condition 3)
{
    count the event in region C
    if (condition 4)
    {
        count the event in region A
    }
}
if (condition 4)
{
    count the event in region B
}
```

naïve implementation



MadAnalysis implementation

(each condition is evaluated only one time)

1. What is MadAnalysis 5?
2. Normal & expert mode
- 3. MadAnalysis recasting way**
4. Using the recast analyses

3. MadAnalysis recasting way

Signal events
(STDHEP or HEPMC format)

Available on the CERN CDS information server CMS PAS SUS-12-019

CMS Physics Analysis Summary

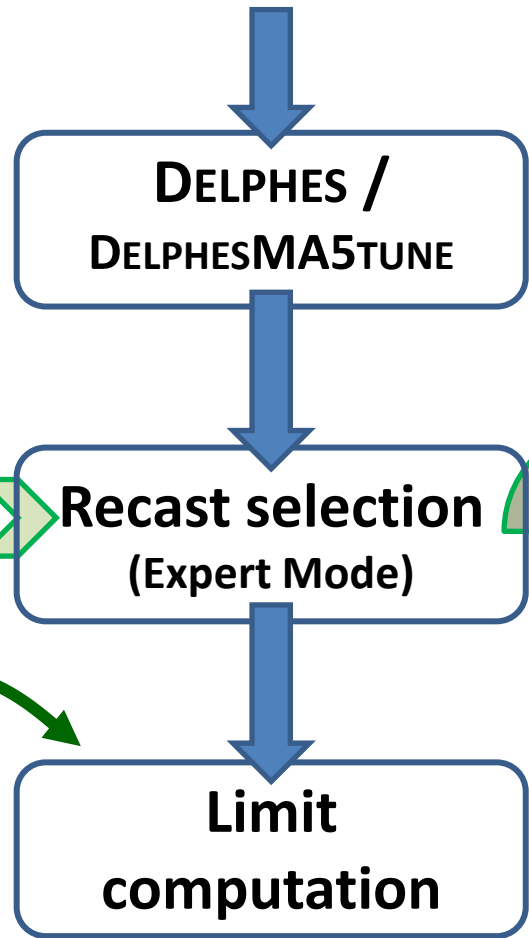
Contact: cms-pag-conveners-susy@cern.ch 2014/08/24

Search for physics beyond the standard model in events with two leptons, jets, and missing transverse energy in pp collisions at $\sqrt{s} = 8$ TeV

The CMS Collaboration

Abstract

This note presents a search for physics beyond the standard model in final states with two opposite-sign same-flavor leptons, jets, and missing transverse energy, in a sample of 8 TeV pp collisions collected with the CMS detector at the CERN LHC. The experimental analysis focuses on searches for a kinematic edge in the invariant mass distribution of the opposite-sign same-flavor lepton pair. The size of the data sample corresponds to an integrated luminosity of 19.4 fb^{-1} . We do not observe evidence for a statistically significant signal.



Numbers of data and background events



Physics Analysis Database

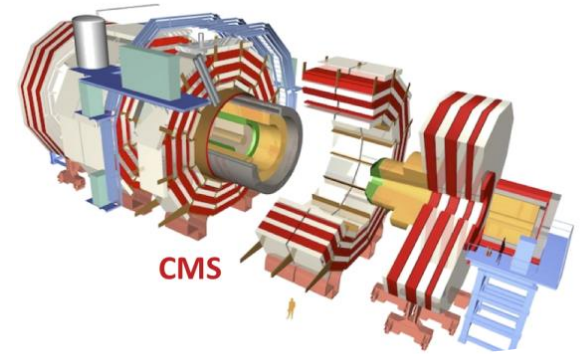


Eur.Phys.J. C74 (2014) 3103

3. MadAnalysis recasting way



**Detector
very-fast-simulation**



**old
way**

Delphes MA5-Tune

Special tuning of the Delphes 3.0 package provided by MadAnalysis 5

**new
way**

Delphes + MA5 card

Official Delphes release using special CMS/ATLAS detector cards provided by MadAnalysis 5

from
MA5
v1.2

- Reducing the ROOT size.
- Lepton & photon isolation done @ analysis level.
- More realistic parametrization of the b-tagging(mis-)efficiency @ analysis level.
- More info on generated particles.

- Most of the features implemented in the official Delphes release.
- Other features are encapsulated into external Delphes modules.
- Lepton & photon isolation always done @ analysis level + **improvement.**

3. MadAnalysis recasting way



A database with MadAnalysis 5 implementations of LHC analyses
<http://madanalysis.irmp.ucl.ac.be/wiki/PhysicsAnalysisDataBase>

B. Dumont et al, Eur.
Phys. J. C75 (2015) 56

ATLAS analyses, 8 TeV

Analysis	Short Description	Implemented by	Code	Validation note	Version
⇒ ATLAS-SUSY-2013-05 (published)	stop/sbottom search: 0 leptons + 2 b-jets	G. Chalons	⇒ Inspire	⇒ PDF ⇒ (figures)	MA5tune
⇒ ATLAS-SUSY-2013-11 (published)	EWK-inos, 2 leptons + MET	B. Dumont	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ ATLAS-HIGG-2013-03 (published)	ZH->ll+invisible	B. Dumont	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ ATLAS-EXOT-2014-06 (published)	mono-photons + MET	D. Barducci	⇒ MA5tune ⇒ v1.2/Delphes3	⇒ PDF ⇒ MadGraph cards	MA5tune + v1.2/Delphes3
⇒ ATLAS-SUSY-2014-10 (published)	2 leptons + jets + MET	B. Dumont	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ ATLAS-SUSY-2013-21 (published)	0 leptons + mono-jet/c-jets + MET	G. Chalons, D. Sengupta	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ ATLAS-SUSY-2013-02 (published)	0 leptons + 2-6 jets + MET	G. Chalons, D. Sengupta	⇒ Inspire	⇒ PDF	MA5tune
⇒ ATLAS-SUSY-2013-04 (published)	0 leptons + >6 jets + MET	B. Fuks, M. Blanke, I. Galon	⇒ Inspire	⇒ PDF	MA5tune

[⇒ Delphes card](#) for ATLAS-SUSY-2013-05, ATLAS-SUSY-2013-21 and ATLAS-EXOT-2014-06

[⇒ Delphes card](#) for ATLAS-SUSY-2013-11, ATLAS-SUSY-2013-02 and ATLAS-HIGG-2013-03

[⇒ Delphes card](#) for ATLAS-SUSY-2013-04

[⇒ Delphes card](#) for ATLAS-SUSY-2014-10

Big work achieved by the PAD collaboration

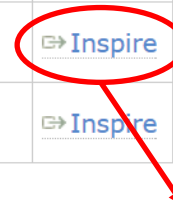
3. MadAnalysis recasting way

A database with MadAnalysis 5 implementations of LHC analyses
<http://madanalysis.irmp.ucl.ac.be/wiki/PhysicsAnalysisDataBase>

B. Dumont et al, Eur.
 Phys. J. C75 (2015) 56

CMS analyses, 8 TeV

Analysis	Short Description	Implemented by	Code	Validation note	Version
⇒ CMS-SUS-13-011 (published)	stop search in the single lepton mode	B. Dumont, B. Fuks, C. Wymant	⇒ Inspire [1]	⇒ PDF ⇒ (source)	MA5tune
⇒ CMS-SUS-13-012 (published)	gluino/squark search in jet multiplicity and missing energy	S. Bein, D. Sengupta	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ CMS-SUS-13-016 (PAS)	search for gluinos using OS dileptons and b-jets	D. Sengupta, S. Kulkarni	⇒ Inspire	⇒ PDF ⇒ (source)	MA5tune
⇒ CMS-SUS-14-001 (published)	Third-generation squarks in fully hadronic final states (monojet analysis)	S. Sharma, S. Pandey	⇒ Inspire	⇒ PDF	MA5tune
⇒ CMS-SUS-14-001 (published)	Third-generation squarks in fully hadronic final states (top-tag analysis)	S. Bein, P. Atmasiddha, S. Sharma	⇒ Inspire	⇒ PDF	MA5tune
⇒ CMS-B2G-12-012 (published)	T5/3 top partners in same-sign dilepton channel	D. Barducci, C. Delaunay	⇒ Inspire	⇒ PDF ⇒ (source) , ⇒ cards	v1.2/Delphes3
⇒ CMS-B2G-12-022 (published)	Monotops	J. Guo, E. Conte, B. Fuks	To appear	To appear	v1.2/Delphes3
⇒ CMS-B2G-14-004 (published)	Dark matter with top quark pairs (single lepton)	B. Fuks and A. Martini	⇒ Inspire	⇒ PDF ⇒ MadGraph cards	v1.2/Delphes3
⇒ CMS-EXO-12-047 (published)	Monophoton	J. Guo, E. Conte, B. Fuks	⇒ Inspire	⇒ PDF ⇒ Pythia script	v1.2/Delphes3
⇒ CMS-EXO-12-048 (published)	Monojet	J. Guo, E. Conte, B. Fuks	⇒ Inspire	⇒ PDF ⇒ MadGraph cards	v1.2/Delphes3



next slide

Big work achieved by the PAD collaboration

3. MadAnalysis recasting way



Files are versioned, can be downloaded

Informations

Citations (1)

Fichiers

MadAnalysis5 implementation of the CMS monojet search (EXO-12-048)

Guo, Jun; Conte, Eric; Fuks, Benjamin

Description: This is the MadAnalysis5 implementation of the CMS search for monojet systems. This search targets events featuring a single hard jet produced in association with missing energy.

Note: Information on how to use this code as well as a detailed validation summary are available at <http://madanalysis.irmp.ucl.ac.be/wiki/PublicAnalysisDatabase>. The CMS analysis is documented at <https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO12048>.

Cite as: Guo, J., Conte, E., Fuks, B. (2016). MadAnalysis5 implementation of the CMS monojet search (EXO-12-048). doi: [10.7484/INSPIREHEP.DATA.JAN2.UNDA](https://doi.org/10.7484/INSPIREHEP.DATA.JAN2.UNDA)

1. What is MadAnalysis 5?
2. Normal & expert mode
3. MadAnalysis recasting way
- 4. Using the recast analyses**

4. Using the recast analyses

- **Installing the required framework within MadAnalysis 5.**

→ All available analyses are automatically downloaded from the PAD.

→ 3 options: only Delphes-based analyses, only DelphesMA5tune-based analyses, or both.

```
ma5>install DelphesMA5tune  
ma5>install PADForMA5tune
```

and/or

```
ma5>install Delphes  
ma5>install PAD
```

**Normal mode with
the PYTHON console**



- **Importing your signal samples**
- **Activating the recasting mode**

```
ma5>set main.recast = on
```

- **Launching the processing**

```
ma5>submit  
MA5: Would you like to edit the recasting Card ? (Y/N)
```

4. Using the recast analyses



Recasting card: only 'ON' / 'OFF' to be changed

# AnalysisName	PADType	Switch	DelphesCard	
atlas_susy_2013_04	v1.1	off	delphes_card_atlas_sus_2013_04.tcl	# ATLAS - multijet + met
atlas_sus_13_05	v1.1	on	delphes_card_atlas_sus_2013_05.tcl	# ATLAS - stop/sbottom - 0 lepton + 2 bjets + met
atlas_susy_2013_11	v1.1	off	delphes_card_atlas_sus_2013_11.tcl	# ATLAS - ewkinos - 2 leptons + met
atlas_susy_2013_21	v1.1	off	delphes_card_atlas_sus_2013_05.tcl	# ATLAS - monojet
atlas_susy_2014_10	v1.1	off	delphes_card_atlas_sus_2014_10.tcl	# ATLAS - squark-gluino - 2 leptons + jets + met
atlas_1405_7875	v1.1	off	delphes_card_atlas_sus_2013_11.tcl	# ATLAS - squark-gluino - 0 leptons + 2-6 jets + met
atlas_higg_2013_03	v1.1	off	delphes_card_atlas_sus_2013_11.tcl	# ATLAS - ZH to invisible + 2 leptons
cms_sus_13_012	v1.1	off	delphes_card_cms_standard.tcl	# CMS - squark-gluino - MET/MHT
cms_sus_13_016	v1.1	off	delphes_card_cms_standard.tcl	# CMS - gluinos - 2 leptons + bjets + met
cms_sus_14_001_TopTag	v1.1	on	delphes_card_cms_sus14004.tcl	# CMS - stop - the top tagging channel
cms_sus_14_001_monojet	v1.1	off	delphes_card_cms_standard.tcl	# CMS - stop - the monojet channel
cms_sus_13_011	v1.1	on	delphes_card_cms_standard.tcl	# CMS - stop - 1 lepton + bjets + met
ATLAS_EXOT_2014_06	v1.2	off	delphes_card_atlas_sus_2013_05_pad.tcl	# ATLAS - monophoton
cms_exo_12_047	v1.2	off	delphes_card_cms_b2g_12_012.tcl	# CMS - monophoton
cms_exo_12_048	v1.2	off	delphes_card_cms_b2g_12_012.tcl	# CMS - monojet
cms_b2g_14_004	v1.2	off	delphes_card_cms_b2g_14_004.tcl	# CMS - Dark matter production with a t \bar{t} pair
cms_b2g_12_022	v1.2	off	delphes_card_cms_b2g_14_004.tcl	# CMS - Monotop search
CMS_B2G_12_012	v1.2	off	delphes_card_cms_b2g_12_012.tcl	# CMS - T5/3 partners in the SSDL channel

Illustrative output (beware of low statistics for the example)

# analysis name	signal region	sig95(exp)	sig95(obs)		efficiency	stat. unc.
cms_sus_13_011	Stop->T+neutralino, LowDeltaM, MET>200	0.3301365	0.2651069		0.0070623	0.0083740
cms_sus_13_011	Stop->T+neutralino, LowDeltaM, MET>250	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->T+neutralino, LowDeltaM, MET>300	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->T+neutralino, HighDeltaM, MET>150	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->T+neutralino, HighDeltaM, MET>200	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->T+neutralino, HighDeltaM, MET>250	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->T+neutralino, HighDeltaM, MET>300	-1	-1		0.0000000	0.0000000
cms_sus_13_011	Stop->b+chargino, LowDeltaM, MET>100	2.9531986	2.7750373		0.0070623	0.0083740
cms_sus_13_011	Stop->b+chargino, LowDeltaM, MET>150	1.1270604	0.8966912		0.0070623	0.0083740
cms_sus_13_011	Stop->b+chargino, LowDeltaM, MET>200	0.4476290	0.3246151		0.0070623	0.0083740
cms_sus_13_011	Stop->b+chargino, LowDeltaM, MET>250	-1	-1		0.0000000	0.0000000

MAD Analysis 5 in few words:

- A **multi-purpose** tool for phenomenologists:
 - **Normal mode:** user-friendly, based on a homemade meta-language
 - **Expert mode:** developer-friendly
- Interfaced to Delphes, MadAnalysis can be used for **recasting** existed analyses and **reinterpreting** LHC results.
- All recast analyses are stored on the **PAD (Physics Analysis Database)**
 - ~ 20 recast LHC8 analyses ; first LHC13 analyses soon
 - **see talks on Friday for examples**
- All the recast analyses can be applied on a given signal in order to determine if this signal is excluded or not.

Next development:

- Interfacing totally MadAnalysis 5 to MadGraph 5 (very soon)
- New graphical driver (soon)
- Parallel jobs