RECASTING LHC ANALYSES WITH MADANALYSIS5

Dipan Sengupta
on behalf of the MA5 team.
S.Bein, B.Fuks, G.Chalons, E.Conte, B.Dumont, S.Kraml,
S.Kulkarni, L. Mitzka and others

Towards a public analysis database

- We think it would be of great value for the whole community to have a database of LHC analyses based on fast simulation.

  → we propose to create such a database using the MadAnalysis 5 framework

Validated analysis codes, easy to check and to use for everybody.

- Can serve for the interpretation of the LHC results in a large variety of models.
- Convenient way of documentation; helps long-term preservation of the analyses performed by ATLAS and CMS.
- Modular approach, easy to extend, everybody who implements and validates an existing ATLAS or CMS analysis can publish it within this framework.
- Provides feedback to the experiments about documentation and use of their results. (The ease with which an experimental analysis can be implemented and validated may actually serve as a useful check for the experimental collaborations for the quality of their documentation.)

What is MadAnalysis 5 ?

E. Conte, B. Fuks, G. Serret, arXiv:1206.1599
E. Conte, B. Fuks, arXiv:1309.7831

- Public framework for analyzing Monte Carlo events
- different levels of sophistication: partonic, hadronic, detector reconstructed
- input formats: StdHep, HepMC, LHE, LHCO, Delphes ROOT files
- user-friendly, flexible and fast
- normal mode: intuitive commands typed in the Python interface
  human-readable output: HTML and LaTeX
- expert mode: C++/ROOT programming within the SampleAnalyzer framework
- powerful tool, well-suited for phenomenological studies for particle colliders

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

Analysis implementation and validation

1. Read and understand the experimental paper

2. Write the C++ analyzer code for MadAnalysis 5

3. The difficult part: get missing information from the experimental collaboration.
   Needed, but not always publicly available, are:

   - efficiencies for trigger, electron, muons, b-tagging, event cleaning, ...
     treatment of ISR, jet energy scale
   - exact configuration of MC tools (versions, run card settings)
     benchmark points: SLHA or LHE files
   - cut flows for the benchmark points
   - expected final number of events in each signal region

4. Digitize the histograms from the experimental paper
   (stupid work; direct numerical form would be highly welcome → HepData, Twiki !)

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EPJ manuscript No.
(will be inserted by the editor)

Towards a public analysis database for LHC new physics searches using MadAnalysis 5

B. Dumont[1], B. Fuks[2,3], S. Kraml[1] (eds.), S. Bein[4], G. Chalons[1], E. Conte[5], S. Kulkarni[1], D. Sengupta[1], and C. Wymant[6a]

[1] Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, 53 Avenue des Martyrs, F-38026 Grenoble Cedex, France
[2] CERN, PH-TH, CH-1211 Geneva 23, Switzerland
[3] Institut Pluridisciplinaire Hubert Curien/Département Recherches Subatomiques, Université de Strasbourg/CNRS-IN2P3, 23 Rue du Loess, F-67037 Strasbourg, France
[4] Department of Physics, Florida State University, Tallahassee, Florida 32306, USA
[5] Groupe de Recherche de Physique des Hautes Energies (GRPHE), Université de Haute-Alsace, IUT Colmar, 34 rue du Grillenbreit BP 50568, 68008 Colmar Cedex, France
[6] LAPTH, 9 Chemin de Bellevue, B.P. 110, Annecy-le-Vieux 74951, France

Received: date / Revised version: date

Abstract. We present the implementation, in the MadAnalysis 5 framework, of several ATLAS and CMS searches for supersymmetry in data recorded during the first run of the LHC. We provide extensive details on the validation of our implementations and propose to create a public analysis database within this framework.

PACS. 12.60.-i Models beyond the standard model – 14.80.-j Other particles (including hypothetical)

1 Introduction

The LHC was designed as a machine of discovery. It was built to explore the TeV energy scale, in order to unravel the mechanism of electroweak symmetry breaking and shed light on new physics beyond the Standard Model (SM). The recent discovery [1,2] of a new particle with mass of 125 GeV and properties consistent with the SM Higgs boson is a first triumph for the LHC physics program and has profound implications for our understanding of the universe. We are, however, still left with many fundamental questions open, and to address them it is imperative that the search for new physics continue at the Simplified Model Spectra (SMS).[1] These searches will be pursued further at higher energies, with first results to be expected soon after the start of Run II in 2015.

There exist, however, many different beyond-the-SM (BSM) theories, and each of them comes with a large variety of concrete realizations. This leads to a multitude of possible scenarios, with complex interrelations between parameters and signatures. It is a challenge for the whole community to work out the implications of the LHC results in the contexts of all these different models, to derive the relevant limits, point out possible loopholes in the current searches, and help design the analyses for the next phase of LHC running at higher energy.

To this end, many groups have been developing private

MadAnalysis 5 physics analysis database

Available Analyses

!! please properly cite all the re-implementation codes you are using (see Inspire citation entry) !!

ATLAS analyses, 8 TeV

Analysis	Short Description	Implemented by	Code	Validation note	Status
ATLAS-SUSY-2013-05 (published)	stop/sbottom search: 0 leptons + 2 b-jets	G. Chalons	Inspire	PDF (figures)	done
ATLAS-SUSY-2013-11 (published)	EWK-inos, 2 leptons + MET	B. Dumont	Inspire	PDF (source)	done

CMS analyses, 8 TeV

Analysis	Short Description	Implemented by	Code	Validation note	Status
CMS-SUS-13-011 (published)	stop search in the single lepton mode	B. Dumont, B. Fuks, C. Wymant	Inspire [1]	PDF (source)	done
CMS-SUS-13-012 (published)	gluino/squark search in jet multiplicity and missing energy	S. Bein, D. Sengupta	Inspire	PDF (source)	done
CMS-SUS-13-016 (PAS)	search for gluinos using OS dileptons and b-jets	D. Sengupta, S. Kulkarni	Inspire	PDF (source)	done

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MadAnalysis 5 implementation of CMS-SUS-13-011: search for stops in the single lepton final state at 8 TeV

Dumont, Beranger (LPSC, Grenoble); Fuks, Benjamin (CERN); Wymant, Chris (Annecy, LAPTH)

Description: This is the MadAnalysis 5 implementation of the CMS search for top-squark pair production in the single lepton final state with 19.5/fb at 8 TeV, to be used for re-interpretation studies. The C++ code contains extensive comments and can thus easily be used as a template for implementing other analyses.

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MadAnalysis 5 implementation of CMS-SUS-13-011: search for stops in the single lepton final state at 8 TeV - Dumont, Beranger *et al.*

cms_sus_13_011

version 1	cms_sus_13_011.cpp	[40.29 KB] 24 Jun 2014, 13:48
	cms_sus_13_011.h	[549 B] 24 Jun 2014, 13:48
	cms_sus_13_011.info	[3.01 KB] 24 Jun 2014, 13:48

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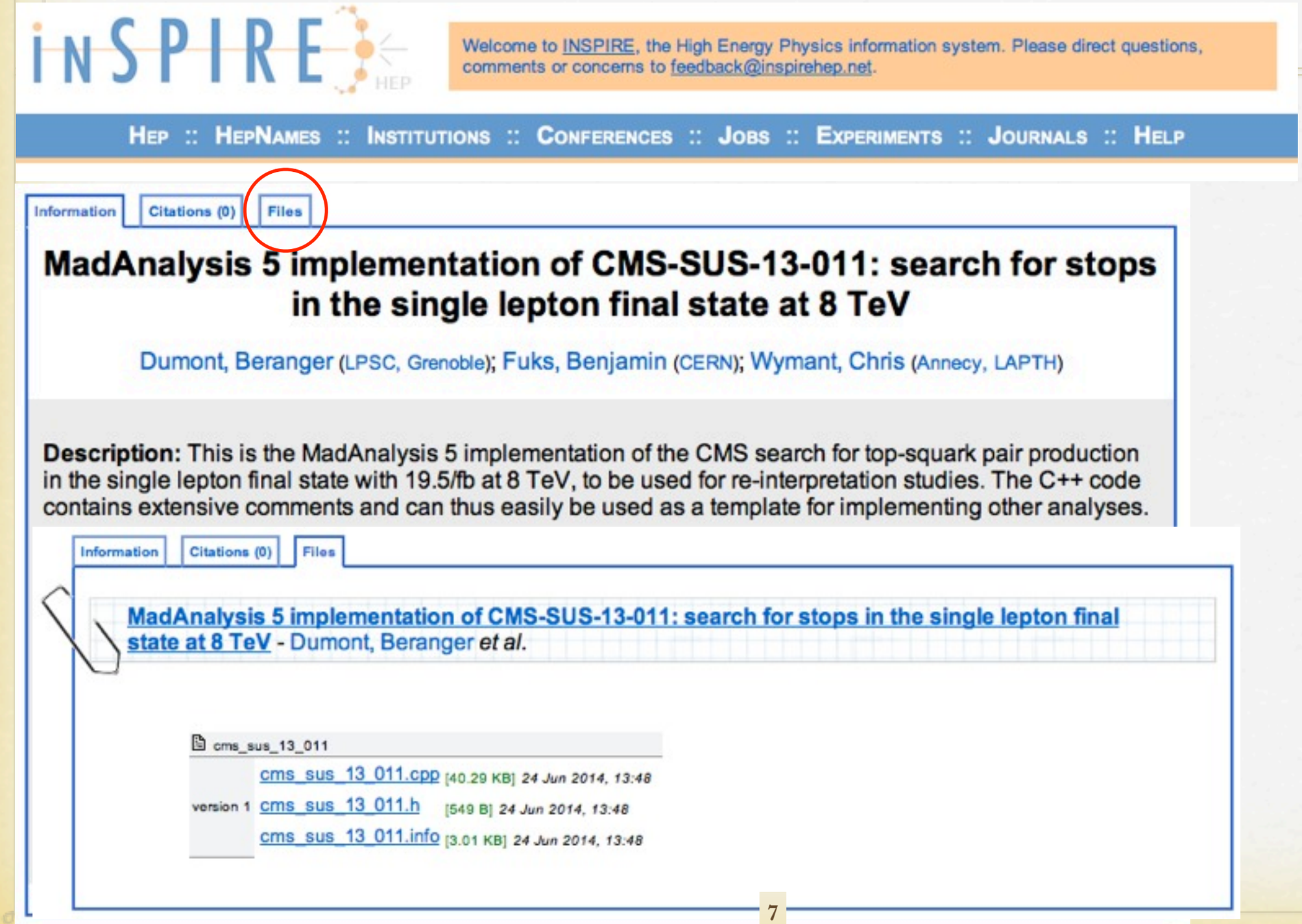

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MadAnalysis 5 implementation of ATLAS-SUSY-2013-05

Chalons, Guillaume (LPSC, Grenoble)

Description: This is the MadAnalysis 5 implementation of the ATLAS search for third-generation squarks in final states with 0-leptons and two b -jets, with 20.1/fb at 8 TeV, to be used for re-interpretation studies.

Note: Information how to use this code as well as a detailed validation summary are available at http://madanalysis.irmp.ucl.ac.be/wiki/PhysicsAnalysisDatabase

Cite as: Chalons, G. (2014) MadAnalysis 5 implementation of ATLAS-SUSY-2013-05. doi: 10.7484/INSPIREHEP.DATA.Z4ML.3W67

Record created 2014-06-24, last modified 2014-06-24

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each recasted analysis gets a DOI (digital document identifier)
and is individually searchable and citable

Record created 2014-06-24, last modified 2014-06-24

VALIDATED ANALYSES

Search for direct top squark pair production in the single lepton final state at √s = 8 TeV (SUS-13-011)

Contents:

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Search for direct top squark pair production in the single lepton final state at √s = 8 TeV (SUS-13-011)

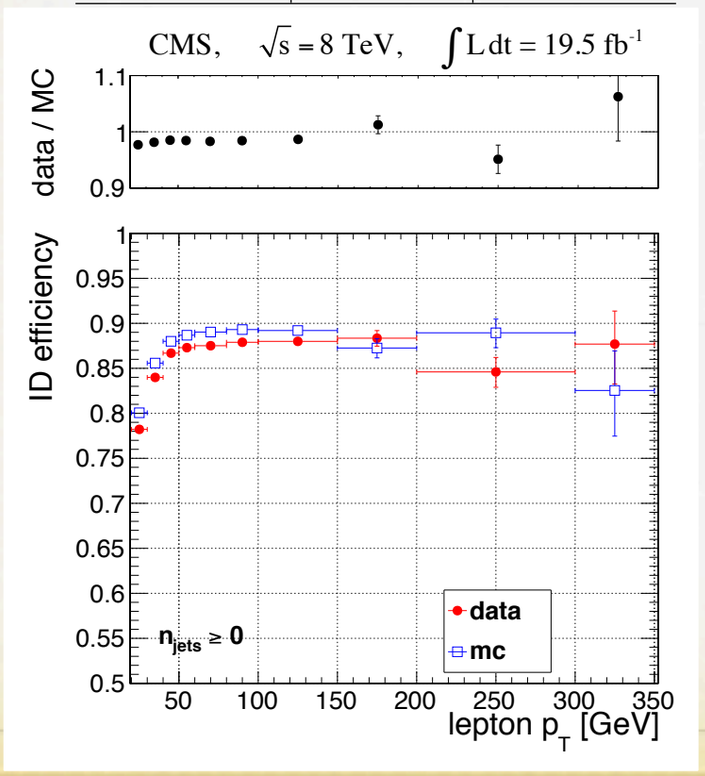
Contents:

- Further information
- Abstract
- Analysis summary
- Approved tables and plots (*click on plot to get larger version*)
  - (pseudo) Feynman diagrams
  - Results: yields vs. background prediction, kinematical distributions of (near-)final event sample
  - Interpretation: SUSY summary plots
  - Interpretation: limits on SUSY parameters
  - Kinematical quantities used in the event selection
  - Signal Region definitions
  - Sample BDT outputs at the preselection stage
  - Control region studies
  - Systematic uncertainties on the background prediction
  - Additional MT and BDT output distributions
  - Monte Carlo modeling of initial state radiation
  - Signal Regions used for limit extraction
  - Acceptance maps, not in paper
  - Additional plots, not in paper
  - Code
  - Electronic material
  - Additional Material to aid the Phenomenology Community with Reinterpretations of these Results

CMS-SUS-13-011: additional material to aid ....

The single electron trigger efficiency. Uncertainties are statistical.

p_T range [GeV]	$\|\eta\| < 1.5$	$1.5 < \|\eta\| < 2.1$
20 - 22	0.00 ± 0.000	0.00 ± 0.000
22 - 24	0.00 ± 0.000	0.00 ± 0.000
24 - 26	0.00 ± 0.000	0.03 ± 0.001
26 - 28	0.07 ± 0.001	0.22 ± 0.002
28 - 30	0.57 ± 0.001	0.52 ± 0.002
30 - 32	0.85 ± 0.001	0.65 ± 0.002
32 - 34	0.88 ± 0.001	0.70 ± 0.002
34 - 36	0.89 ± 0.000	0.72 ± 0.001
36 - 38	0.91 ± 0.000	0.74 ± 0.001
38 - 40	0.92 ± 0.000	0.75 ± 0.001
40 - 50	0.94 ± 0.000	0.77 ± 0.001
50 - 60	0.95 ± 0.000	0.79 ± 0.001
60 - 80	0.96 ± 0.000	0.79 ± 0.002
80 - 100	0.96 ± 0.001	0.80 ± 0.005
100 - 150	0.97 ± 0.001	0.82 ± 0.006
150 - 200	0.97 ± 0.002	0.83 ± 0.014
>200	0.97 ± 0.003	0.85 ± 0.020



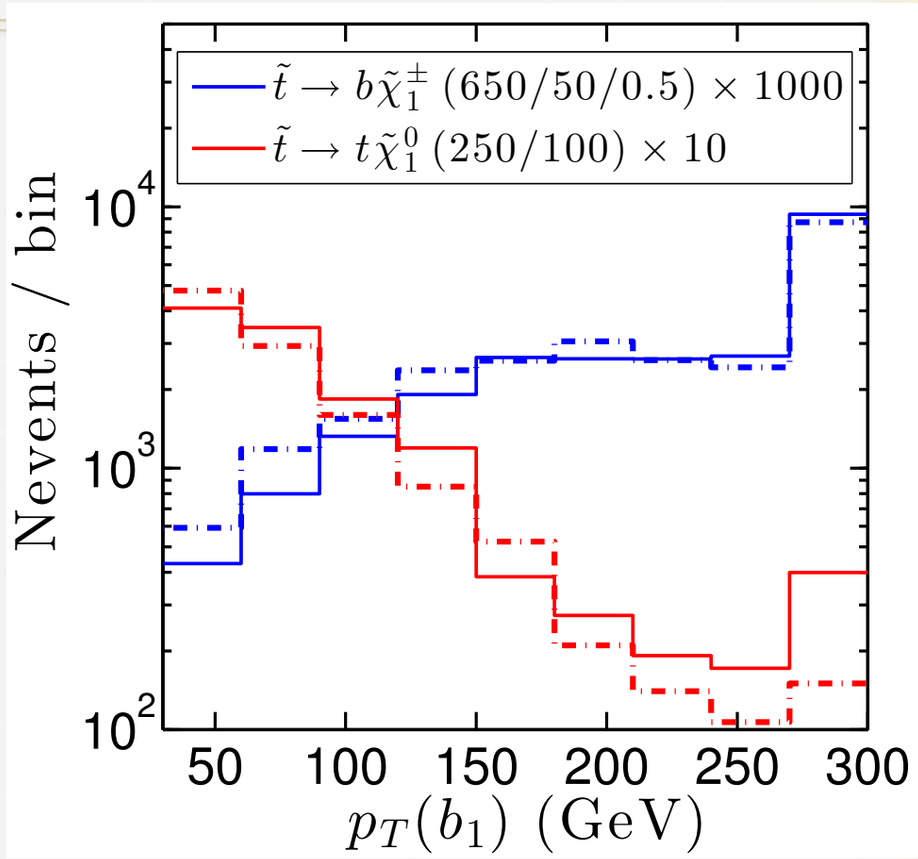
Summary of yields for the $\tilde{t} \to t\tilde{\chi}_1^0$ model with $m_{\tilde{t}} = 650$ GeV and $m_{\tilde{\chi}_1^0} = 50$ GeV. No trigger efficiency or ISR reweighting is applied. In the first block of the table, the first row shows the yield after requiring at least one analysis lepton, at least 4 jets, and MET > 50 GeV. In each subsequent row, the preselection requirements are added one at a time. In the second block of the table the low-mass (LM) signal region yields are indicated. In the third block the high-mass (HM) signal region yields are indicated. The number after LM or HM indicates the MET requirement. The latter results may be compared to the signal yields in Table 4 of http://arxiv.org/pdf/1308.1586.pdf but they are slightly higher ($\sim 10-20\%$) because the trigger and ISR weights are not applied. All uncertainties are statistical only. The bold entry indicates the signal region with the best sensitivity, i.e., the signal region used for limit-setting.

ℓ + ≥ 4 jets + MET>50	31.6 ± 0.3
+ MET>100	29.7 ± 0.3
+ nb ≥ 1	25.2 ± 0.2
+ iso-track veto	21.0 ± 0.2
+ tau-veto	20.6 ± 0.2
+ min-dphi	17.8 ± 0.2
+ chi2	11.9 ± 0.2
+ MT>120	9.6 ± 0.1
LM150	9.1 ± 0.1
LM200	8.2 ± 0.1
LM250	7.1 ± 0.1
LM300	5.7 ± 0.1
HM150	5.5 ± 0.1
HM200	5.4 ± 0.1
HM250	4.9 ± 0.1
HM300	**4.2 ± 0.1**

CMS-SUS-13-011: validation

benchmark point	CMS result	MA 5 result
$\tilde{t} \to b\tilde{\chi}_1^{\pm}$, low ΔM, $E_T^{\rm miss} > 150$ GeV		
(250/50/0.5)	157 ± 9.9	141.2
(250/50/0.75)	399 ± 18	366.8
$\tilde{t} \to b\tilde{\chi}_1^{\pm}$, high ΔM, $E_T^{\rm miss} > 150$ GeV		
(450/50/0.25)	23 ± 2.3	23.4
$\tilde{t} \to b\tilde{\chi}_1^{\pm}$, high ΔM, $E_T^{\rm miss} > 250$ GeV		
(600/100/0.5)	6.1 ± 0.5	5.4
(650/50/0.5)	6.7 ± 0.4	5.8
(650/50/0.75)	6.3 ± 0.4	5.7

cut	$m_{\tilde{t}_1} = 650$ GeV		$m_{\tilde{t}_1} = 250$ GeV	
	CMS result	MA 5 result	CMS result	MA 5 result
$1\ell + \geq 4$jets $+ E_T^{\rm miss} > 50$	31.6 ± 0.3	29.0	8033.0 ± 38.7	7365.0
$+ E_T^{\rm miss} > 100$ GeV	29.7 ± 0.3	27.3	4059.2 ± 27.5	3787.2
$+ n_b \geq 1$	25.2 ± 0.2	23.8	3380.1 ± 25.1	3166.0
+ iso-track veto	21.0 ± 0.2	19.8	2770.0 ± 22.7	2601.4
+ tau veto	20.6 ± 0.2	19.4	2683.1 ± 22.4	2557.2
$+ \Delta\phi_{\rm min} > 0.8$	17.8 ± 0.2	16.7	2019.1 ± 19.4	2021.3
+ hadronic $\chi^2 < 5$	11.9 ± 0.2	9.8	1375.9 ± 16.0	1092.0
$+ M_T > 120$ GeV	9.6 ± 0.1	7.9	355.1 ± 8.1	261.3
high ΔM, $E_T^{\rm miss} > 300$ GeV	4.2 ± 0.1	3.9	—	—
low ΔM, $E_T^{\rm miss} > 150$ GeV	—	—	124.0 ± 4.8	107.9



~10-20% agreement,
quite good for fastsim

ATLAS example: stop/sbottom, 0l2b+MET

JHEP 1310 (2013) 189
arXiv:1308.2631

Description	Signal Regions	
	SRA	SRB
Event cleaning	Common to all SR	
Lepton veto	No e/μ after overlap removal with $p_{\mathrm{T}} > 7(6)$ GeV for $e(\mu)$	
$E_{\mathrm{T}}^{\mathrm{miss}}$	> 150 GeV	> 250 GeV
Leading jet $p_{\mathrm{T}}(j_1)$	> 130 GeV	> 150 GeV
Second jet $p_{\mathrm{T}}(j_2)$	> 50 GeV,	> 30 GeV
Third jet $p_{\mathrm{T}}(j_3)$	veto if > 50 GeV	> 30 GeV
$\Delta\phi(\boldsymbol{p}_{\mathrm{T}}^{\mathrm{miss}}, j_1)$	-	> 2.5
b-tagging	leading 2 jets ($p_{\mathrm{T}} > 50$ GeV, $\lvert\eta\rvert < 2.5$)	2nd- and 3rd-leading jets ($p_{\mathrm{T}} > 30$ GeV, $\lvert\eta\rvert < 2.5$)
	$n_{b\text{-jets}} = 2$	
$\Delta\phi_{\mathrm{min}}$	> 0.4	> 0.4
$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(k)$	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(2) > 0.25$	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(3) > 0.25$
m_{CT}	$> 150, 200, 250, 300, 350$ GeV	-
$H_{\mathrm{T},3}$	-	< 50 GeV
m_{bb}	> 200 GeV	-

- Search for stops and sbottoms in the 0 lepton + 2 b-jets final state with large MET
- Two signal regions optimized for high and low ΔM
- Analysis well documented for physics, but not so well for recasting purposes
- Upon request obtained cut flows as well as SLHA files and some missing details on MC settings.
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m_{CT}	$> 150, 200, 250, 300, 350$ GeV	-
$H_{\mathrm{T},3}$	-	< 50 GeV
m_{bb}	> 200 GeV	-

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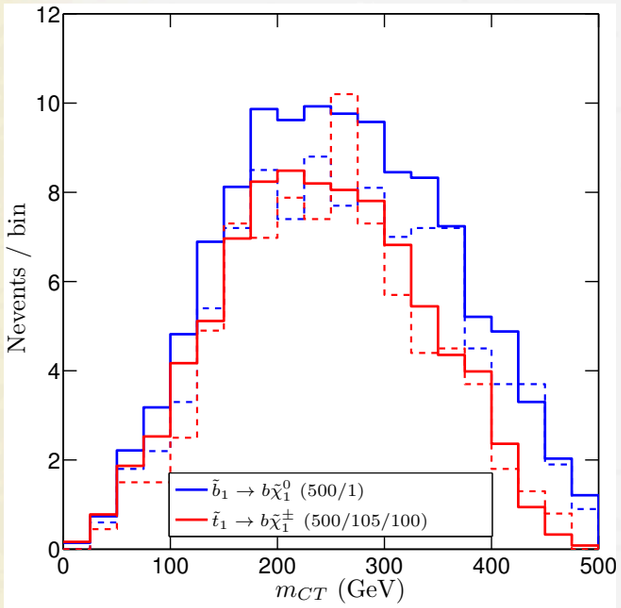
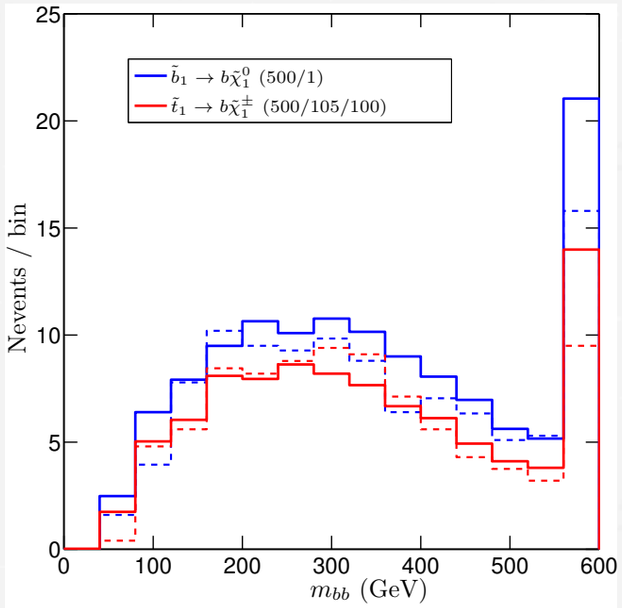
- In general, it is difficult for us to get necessary additional information from ATLAS; less fruitful interaction than with CMS.
→ We would very much like to improve this.

ATLAS 0 lepton + 2b: validation for SRA





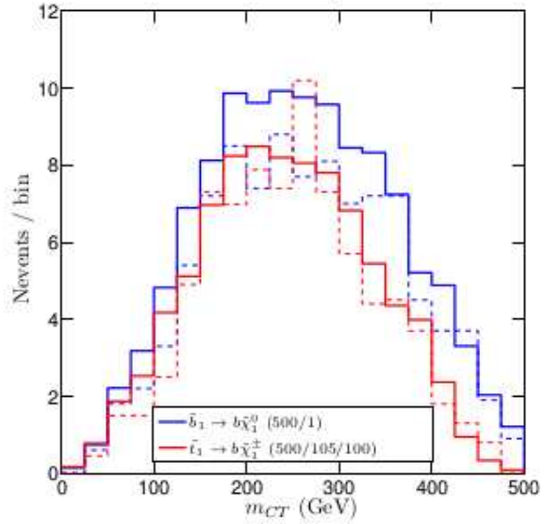
solid: MA5 result
dashed: ATLAS result

cut	$m_{\tilde{b}_1} = 500$ GeV ATLAS result	$m_{\tilde{b}_1} = 500$ GeV MA 5 result	$m_{\tilde{t}_1} = 500$ GeV ATLAS result	$m_{\tilde{t}_1} = 500$ GeV MA 5 result
$E_T^{\text{miss}} > 80$ GeV filter	1606.0	1628.2	1632.0	1585.2
+ Lepton veto	1505.0	1223.5	1061.0	863.2
+ $E_T^{\text{miss}} > 150$ GeV	1323.0	1052.2	859.0	696.3
+ Jet Selection	119.0	142.3	39.0	47.6
+ $M_{bb} > 200$ GeV	96.0	116.5	32.0	38.8
+ $M_{CT} > 150$ GeV	82.0	97.5	26.8	31.7
+ $M_{CT} > 200$ GeV	67.0	80.7	20.2	24.5
+ $M_{CT} > 250$ GeV	51.0	60.8	13.2	16.6
+ $M_{CT} > 300$ GeV	35.0	42.3	7.7	9.2

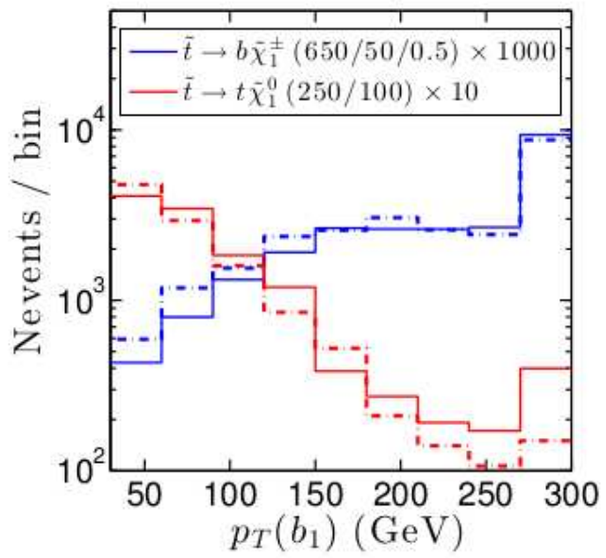
good agreement (~20%)

THE STATE OF AFFAIRS TILL NOW

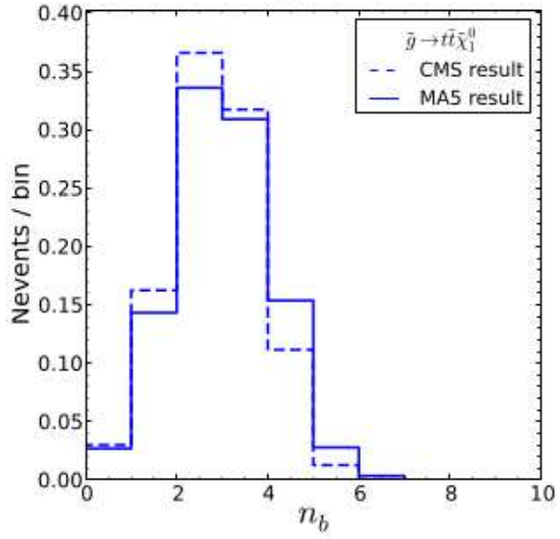
ATLAS 0 lepton 2b



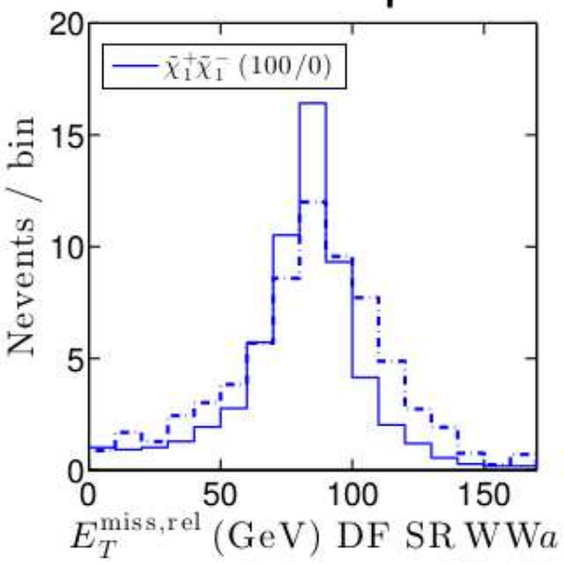
CMS 1 lepton



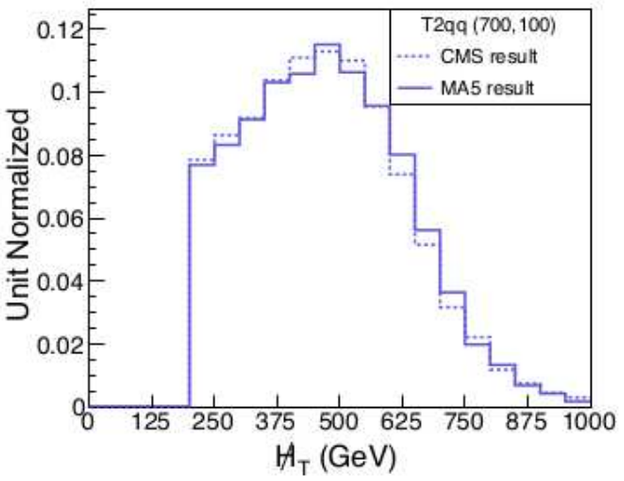
CMS dileptons + b's

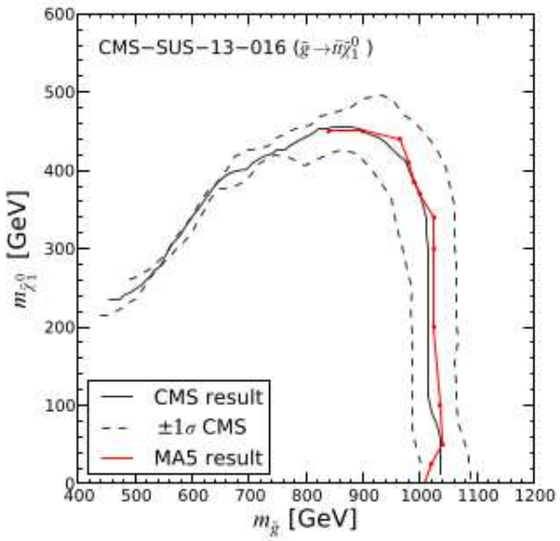


ATLAS dilepton



CMS multi-jet





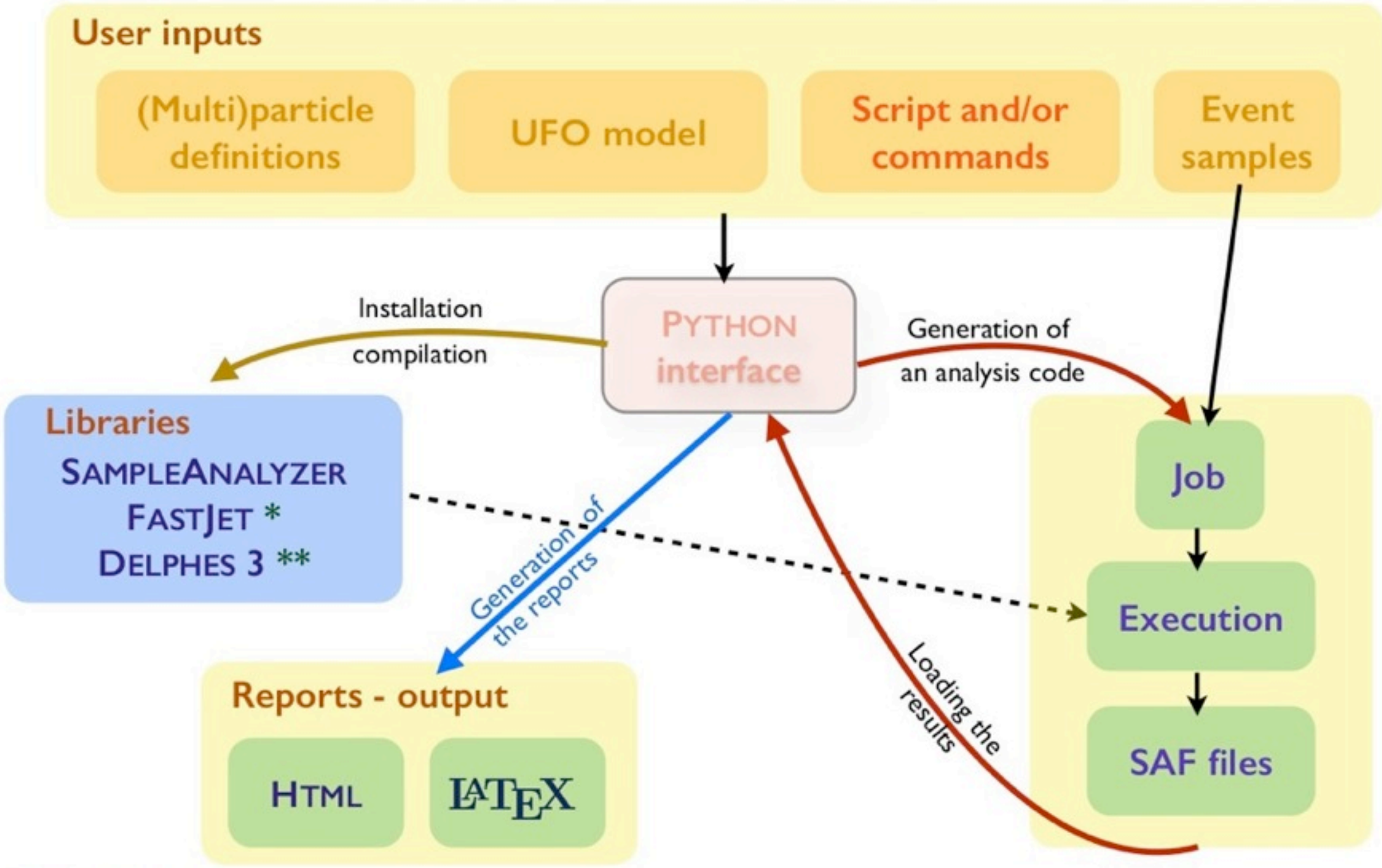
IMPLEMENTATION AND VALIDATION OF ONGOING ANALYSES

- ATLAS-SUS-2013-04 (arXiv :1308.1841) : Multijet +MET. [Blanke+ BF + Galon] (Starting)
- ATLAS-SUS-2013-12 (arXIV:1402.7029) : Trilepton +MET [De Causmaecker, BF, Mawatari] (Problems with validation).
- ATLAS-SUS-2013-13 (arXiv:1405.5086) :At least four leptons + MET. [Mawatari] (Starting).
- ATLAS-SUS-2013-14 (arXiv:1407.0350) : Two hadronic taus + MET [De Causmaecker, BF](Problems with validation)
- ATLAS-SUS-2013-18 (arXiv:1403.4853) :At least 3 b-jets + MET [Mitzka,BF] (Starting)
- ATLAS-SUS-2013-19 (arXiv:1407.0600) : Two leptons + b-jets +MET [Chalons](Problems with validation).
- CMS-SUS-PAS-13-007 : single lepton + b-jets +MET [Laa, DS] (Problems with validation)

Using MadAnalysis5 in Normal and Expert Mode

MADANALYSIS 5: normal running mode

[Conte, BenjFuks, Serret (CPC '13); Conte, BenjFuks (arXiv:1309.7831); Conte, Dumont, BenjFuks, Wymant (1405.3982)]

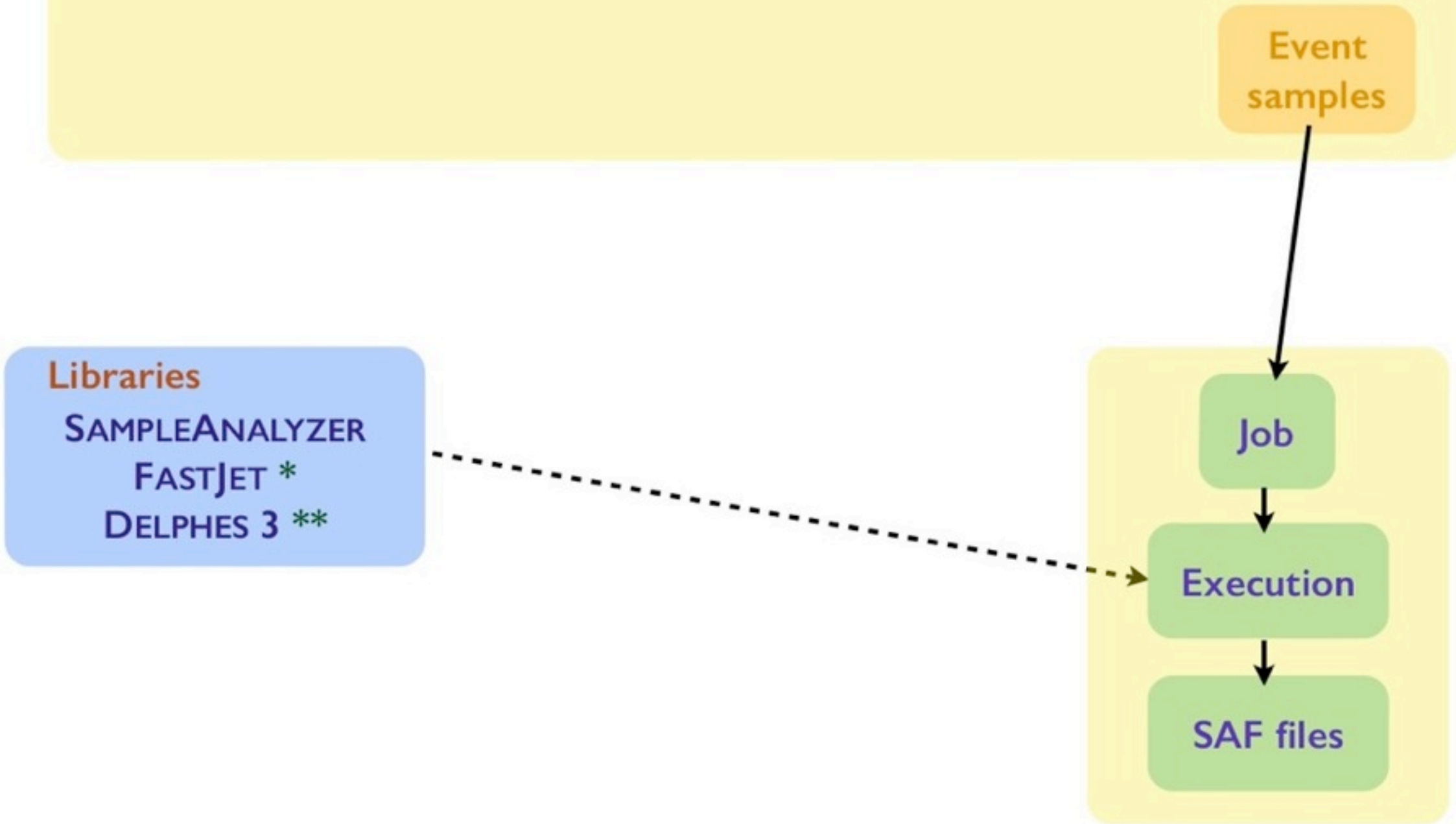


* [Cacciari, Salam (PLB '06)]

** [de Favareau, Delaere, Demin, Giammanco, Lemaitre, Mertens, Selvaggi (JHEP'14)]

MADANALYSIS 5: expert running mode

[Conte, BenjFuks, Serret (CPC '13); Conte, BenjFuks (arXiv:1309.7831); Conte, Dumont, BenjFuks, Wymant (1405.3982)



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Motivation for the expert mode of MADANALYSIS 5

[Conte, Dumont, BenjFuks, Wymant (1405.3982)]

✦ MADANALYSIS 5 is used without any interface (as an external package)

- ✤ More freedom in the observables (only some of them can be called from the PYTHON console)
- ✤ Complicated cuts can be implemented
- ✤ More suitable for large numbers of events (using several cores)

✦ The expert mode is developer-friendly

The analysis is a C++ class

The SAMPLEANALYZER internal data format

- ★ Readers for Lhe, StdHep, HepMC, Lhco and DELPHES/DELFES
- ★ Many classes and methods for particle and object properties
- ★ Specific methods for histograms and cuts
- ★ *etc.* (see 1405.3982)

Services

- ★ Physics observables (transverse variables, object identification, isolation)
- ★ Streamers
- ★ Exceptions
- ★ *etc.*

Interfaces

- ★ FASTJET
- ★ DELPHES 3
- ★ DELFES 3

[LH 2013 proceedings]

DELFES has been developed together with related SAMPLEANALYZER modules:

- ★ isolation
- ★ tracks
- ★ output files

Scripts

- ★ Compilation
- ★ Linking
- ★ Analysis skeleton generator

FEATURES OF THE EXPERT MODE

- Specifically designed to enable the recast of CMS and ATLAS analysis.

- Multiple sub-analysis are handled efficiently.

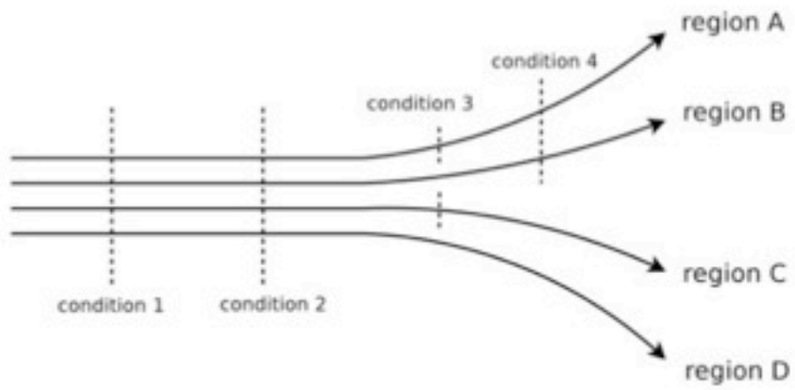
- Observables like M_{T2} and M_{T2W} are included.

- Efficient handling of histograms and cuts.

✦ Handling cuts and histograms

✤ Naive approach not efficient (see cut #4 for instance)

```
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
}
```



✤ A more efficient algorithm has been implemented

★ Each cut condition is only evaluated once

★ It is applied to all surviving regions simultaneously

✤ Similar treatment for histograms

- Downloading, setting up and implementing analyses in the expert mode of MA5

DOWNLOADING MADANALYSIS5

MadAnalysis 5 - A package for event file analysis

Log in / Register

Overview | Code | Bugs | Blueprints | Translations | Answers

MadAnalysis 5 v1.1.11

MadAnalysis 5 » **v1.1.11**

This milestone contains **Public** information

Everyone can see this information.

- new structure for the detection of the user system
- new structure for installing the external packages
- the user can choose which package to use via the user_isntall.dat file
- first steps for the externalization of extra modules such as root, numpy, etc...
- first steps for a dedicated interface to root, gnuplot and matplotlib
- official release of the MASTune for Delphes
- interface to the recasting package
- many bug fixes
- improved portability with mac OS

https://launchpad.net/madanalysis5/+milestone/v1.1.11

Milestone information

Project: MadAnalysis 5

Series: trunk

Version: v1.1.11

Released: 2014-07-17

Registrant: Benjamin Fuks

Release registered: 2014-07-17

Active:

No. Drivers cannot target bugs and blueprints to this milestone.

Download RDF metadata

Activities

Assigned to you:

No blueprints or bugs assigned to you.

Assignees:

No users assigned to blueprints and bugs.

Blueprints:

No blueprints are targeted to this milestone.

Bugs:

No bugs are targeted to this milestone.

Download files for this release

After you've downloaded a file, you can verify its authenticity using its MD5 sum or signature.
(How do I verify a download?)

File	Description	Downloads
MadAnalysis5_v1.1.11_patch1.tar.gz (md5)	release of version v 22 l (a few bug fixes)	78

DOWNLOADING MADANALYSIS5

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SETTING UP

- Check if the requisite packages are installed.

- Python 2.6 or above. (Not the 3.X series however)

- The GNU GCC compiler.

- ROOT v5.27 or above with PYROOT libraries installed.

```
lpsc-32-1.in2p3.fr:> ./bin/ma5

************************************************************
*                                                          *
*        W E L C O M E  to  M A D A N A L Y S I S  5       *
*                                                          *
                    _______  _______
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                     [DISABLED]
```

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*                        _______  _______                  *
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INSTALLING PACKAGES

- Install packages like Fastjet, Delphes or the delphesMA5-tune (Later today).

```
ma5>install delphesMA5tune

   ************************************************************
                    Installing delphesMA5tune
   ************************************************************
```

```
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   ************************************************************
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   ************************************************************
   Detecting a previous installation ...
   => not found. OK
   ************************************************************
```

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CONVERTING STDHEP FILES TO ROOT FILES

- Use the delphesMA5tune to convert stdhep files to detector simulated root files.(More on this in Benjamin's talk later today.)

- Important modifications: Isolation of leptons and photons moved to the analysis section.
- Reduction of file size by removal of calorimeter towers and PF objects.
- Only hard scattering process, final state leptons and b quarks are stored.
- Results in reduction of root file size by a factor of 10.

```
ma5>set main.fastsim.package = delphesMA5tune
ma5>set main.fastsi
main.fastsim.detector  main.fastsim.output    main.fastsim.package   main.fastsim.pileup
ma5>set main.fastsim.detector =
atlas  cms
ma5>set main.fastsim.detector = cms
ma5>import /h
/home  /hyb1  /hyb2  /hyb3  /hyb4  /hyb5  /hyb6
ma5>import "/theo/dipan/tag_1_pythia_events.hep"
 ** ERROR: The dataset '"/theo/dipan/tag_1_pythia_events.hep"' has not been found or has a unsuppor
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```

A HANDS ON EXAMPLE: CMS-SUS-13-011

- CMS search for stops in single lepton + high multiplicity jets + b-jets + missing transverse energy.
- Targets stop → t + LSP , stop → b + light chargino. Characterized by low Δm and high Δm and divided into 16 SRs.
- LHE files, detailed trigger efficiencies provided by the CMS collaboration.
- Supplementary material including cut flows, additional histograms are now available on the CMS twiki page.

SETTING UP THE EXPERT MODE

- Start with ./bin/ma5 -R -e (reconstructed and expert mode)

```
Welcome to the expert mode of MadAnalysis
Please enter a folder name for creating an empty SampleAnalyzer job
Answer: newanalysis
   Creating folder '/theo/dipan/madanalysis5/newanalysis_'...
   Copying required 'SampleAnalyzer' source files...
Please enter a name for your analysis
Answer: user
   Writing an empty analysis...
A new class called 'user' will be created.
Done !
```

```
Guidelines for writing an analysis in expert mode

1. Entering the directory '/theo/dipan/madanalysis5/newanalysis_/Build'

2. Setting the environment variables by loading setup.sh or setup.csh according to your SHELL

3. Entering the directory '/theo/dipan/madanalysis5/newanalysis_/Build/SampleAnalyzer/User/Analyzer'

4. Editing Analysis 'user.h' and 'user.cpp' files

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```

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```

STRUCTURE OF THE ANALYZER

- The header file.

cms_sus_13_011.h

```
#ifndef analysis_cms_sus_13_011_h
#define analysis_cms_sus_13_011_h

#include "SampleAnalyzer/Process/Analyzer/AnalyzerBase.h"

namespace MA5
{
class cms_sus_13_011 : public AnalyzerBase
{
  INIT_ANALYSIS(cms_sus_13_011,"cms_sus_13_011")

 public:
  virtual bool Initialize(const MA5::Configuration& cfg, const std::map<std::string,std::string>& parameters);
  virtual void Finalize(const SampleFormat& summary, const std::vector<SampleFormat>& files);
  virtual bool Execute(SampleFormat& sample, const EventFormat& event);

 private:
};
}

#endif
```

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STRUCTURE OF THE ANALYZER

- The analyzer code in MA5 expert mode consists of the basic functions :
- Initialize : Initialization of signal regions, declaration of cuts, histograms and user defined functions.
- Execute : Containing the analysis cuts and weights applied to each event.
- Finalize : Production of the results, histograms and cut flows.

DECLARING SRS, CUTS AND HISTOGRAMS IN INITIALIZE

DECLARING SRS, CUTS AND HISTOGRAMS IN INITIALIZE

```
// VERY IMPORTANT FOR DOCUMENTATION, TRACEABILITY, BUG REPORTS
INFO << "        <><><><><><><><><><><><><><><><><><><><><><><><>" << endmsg;
INFO << "        <>  Analysis: CMS-SUS-13-011, arXiv:1308.1586 <>" << endmsg;
INFO << "        <>            (stop search, single lepton)    <>" << endmsg;
INFO << "        <>  Recasted by: B.Dumont, B.Fuks & C.Wymant  <>" << endmsg;
INFO << "        <>  Contact: dumont@lpsc.in2p3.fr             <>" << endmsg;
INFO << "        <>           fuks@cern.ch                     <>" << endmsg;
INFO << "        <>           wymant@lapth.cnrs.fr             <>" << endmsg;
INFO << "        <>  Based on MadAnalysis 5 v1.1.11            <>" << endmsg;
INFO << "        <>  For more information, see                 <>" << endmsg;
INFO << "        <>  http://madanalysis.irmp.ucl.ac.be/wiki/PhysicsAnalysisDatabase" << endmsg;
INFO << "        <><><><><><><><><><><><><><><><><><><><><><><><>" << endmsg;
```

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```
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INFO << "         <><><><><><><><><><><><><><><><><><><><><><><><>" << endmsg;
```

```
// Declare all the different signal regions in the analysis, simply giving
// them a name and telling RSManager they exist:
Manager()->AddRegionSelection("Stop->T+neutralino, LowDeltaM, MET>150");
Manager()->AddRegionSelection("Stop->T+neutralino, LowDeltaM, MET>200");
Manager()->AddRegionSelection("Stop->T+neutralino, LowDeltaM, MET>250");
Manager()->AddRegionSelection("Stop->T+neutralino, LowDeltaM, MET>300");
Manager()->AddRegionSelection("Stop->T+neutralino, HighDeltaM, MET>150");
Manager()->AddRegionSelection("Stop->T+neutralino, HighDeltaM, MET>200");
Manager()->AddRegionSelection("Stop->T+neutralino, HighDeltaM, MET>250");
Manager()->AddRegionSelection("Stop->T+neutralino, HighDeltaM, MET>300");
Manager()->AddRegionSelection("Stop->b+chargino, LowDeltaM, MET>100");
Manager()->AddRegionSelection("Stop->b+chargino, LowDeltaM, MET>150");
Manager()->AddRegionSelection("Stop->b+chargino, LowDeltaM, MET>200");
Manager()->AddRegionSelection("Stop->b+chargino, LowDeltaM, MET>250");
Manager()->AddRegionSelection("Stop->b+chargino, HighDeltaM, MET>100");
Manager()->AddRegionSelection("Stop->b+chargino, HighDeltaM, MET>150");
Manager()->AddRegionSelection("Stop->b+chargino, HighDeltaM, MET>200");
Manager()->AddRegionSelection("Stop->b+chargino, HighDeltaM, MET>250");
```

DECLARING SRS, CUTS, AND HISTOGRAMS

DECLARING SRS, CUTS, AND HISTOGRAMS

```
// Declare all the cuts used in the analysis.
// Note that the order in which you declare cuts defines the order in which
// they appear in the cut flow table. What you want this order to be is the
// order in which the cuts are applied. It's therefore on you to declare cuts
// in the order that they are applied, so as to have a sensible cut flow at
// the end.
// Cuts are declared with RSManager's AddCut method. A cut needs a (string)
// name, and a set of signal regions which it applies to; if the latter is not
// specified, i.e. AddCut is called with only a name as its argument, the cut
// is taken to apply to *all* signal regions, i.e. it's a common cut, not a
// region-specific cut. We do this here:
Manager()->AddCut("ISR boost factor");
Manager()->AddCut("trigger");
Manager()->AddCut("1+ candidate lepton");
Manager()->AddCut("4+ central jets");
Manager()->AddCut("MET > 50 GeV");
Manager()->AddCut("MET > 100 GeV");
Manager()->AddCut("1+ b-tagged jet");
Manager()->AddCut("veto isol lepton and track");
Manager()->AddCut("No hadronic tau");
Manager()->AddCut("dphi(MET, j1 or j2) > 0.8");
```

DECLARING SRS, CUTS, AND HISTOGRAMS

DECLARING SRS, CUTS, AND HISTOGRAMS

```
// Some cuts, on the other hand, apply only to some of the regions and not all
// of them. To declare such cuts, call the method AddCut with a second
// argument - an array of strings - with each string corresponding to the name
// of a signal region. This is what we do next.
// (Note that we have declared all common cuts first, then all region-specific
// cuts afterwards; we clarify that it doesn't need to be done like this -
// that's just the order of the cuts in the experimental analysis we're
// implementing here.)
string SRForMet150Cut[] = {"Stop->b+chargino, LowDeltaM, MET>150",
  "Stop->b+chargino, HighDeltaM, MET>150",
  "Stop->T+neutralino, LowDeltaM, MET>150",
  "Stop->T+neutralino, HighDeltaM, MET>150"};
```

DECLARING SRS, CUTS, AND HISTOGRAMS

DECLARING SRS, CUTS, AND HISTOGRAMS

```
Manager()->AddHisto("MT",10,0,300); // Fig. 2a
Manager()->AddHisto("MET",10,100,350); // Fig. 2b
Manager()->AddHisto("MT2W",17,75,500); // Fig. 2c
Manager()->AddHisto("chi2",20,0,20); // Fig. 2d
Manager()->AddHisto("HTratio",25,0,1); // Fig. 2e
Manager()->AddHisto("pT(leading b-jet)",9,30,300); // Fig. 2g
Manager()->AddHisto("pT(l)",8,20,100); // Fig. 2i
Manager()->AddHisto("JetMETMindeltaPhi",15,0,PI); // Fig. 2f
Manager()->AddHisto("deltaR(l, leading b-jet)",15,0,5); // Fig. 2h
Manager()->AddHisto("MT2W after MT>120",17,75,500); // Fig. add 12
Manager()->AddHisto("chi2 after MT>120",20,0,20); // Fig. add 14
Manager()->AddHisto("HTratio after MT>120",25,0,1); // Fig. add 16
Manager()->AddHisto("JetMETMindeltaPhi after MT>120",25,0,PI); // Fig. add 17
Manager()->AddHisto("pT(leading b-jet) after MT>120",20,0,500); // Fig. add 13
Manager()->AddHisto("deltaR(l, leading b-jet) after MT>120",20,0,5); // Fig.
                                                                    // add 15
```

DEALING WITH RECO OBJECTS, ISOLATION OBSERVABLES

DEALING WITH RECO OBJECTS, ISOLATION OBSERVABLES

```
// first declare the empty containers:
vector<const RecLeptonFormat*> OtherLeptons;
vector<const RecLeptonFormat*> SignalElectrons, SignalMuons;
vector<const RecJetFormat*> myJets;
vector<const RecTauFormat*> myTaus;
vector<const RecTrackFormat*> myTracks;

// fill the tracks container:
for(unsigned int ii=0; ii<event.rec()->tracks().size(); ii++)
{
  const RecTrackFormat *CurrentTrack = &(event.rec()->tracks()[ii]);
  double pt = CurrentTrack->pt();
  double abseta = fabs(CurrentTrack->eta());
  // |eta| < 2.1 not mentioned in the paper, but confirmed by Alessandro Gaz
  if(pt>10. && abseta<2.1)
    myTracks.push_back(CurrentTrack);
}
```

DEALING WITH RECO OBJECTS, ISOLATION OBSERVABLES

DEALING WITH RECO OBJECTS, ISOLATION OBSERVABLES

```
// lepton isolation: pTsum in a cone of Delta R = 0.3, excluding the lepton
// itself, should be < min(5 GeV, 0.15*pT_lepton)
// We remove from SignalElectrons and SignalMuons those leptons that are
// not isolated, and put them in OtherLeptons, since their presence in the
// event may yet cause a veto.

// Note that we start at the end of the container and iterate backwards
// through it because we may *remove* elements from it as we go.
// Note also that we use a signed int, as subtracting 1 from an unsigned
// int that's currently equal to zero returns a huge number, not -1, which
// fails to terminate the loop.
for(int ii=SignalElectrons.size()-1; ii>=0; ii--)
{
  for(unsigned int jj=0; jj<SignalElectrons[ii]->isolCones().size(); jj++)
  {
    if(fabs(SignalElectrons[ii]->isolCones()[jj].deltaR() - 0.3) < 0.001)
    {
      if(SignalElectrons[ii]->isolCones()[jj].sumPT()
         > min(5.,.15*SignalElectrons[ii]->pt()))
      {
        OtherLeptons.push_back(SignalElectrons[ii]);
        SignalElectrons.erase(SignalElectrons.begin()+ii);
        break;
      }
    }
  }
}
```

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```

isolcones method of the RecLeptonFormat class

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isolcones method of the RecLeptonFormat class

Σ p_T of all tracks lying in the cone

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}
```

isolcones method of the RecLeptonFormat class

Σ p_T of all tracks lying in the cone

OBSERVABLES AND CUTS

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```
// MT: the transverse mass of the signal lepton and the missing pT
double MT = SignalLepton->mt_met(pTmiss);
double mt2w = PHYSICS->Transverse->MT2W(myJets,
                                        SignalLepton,event.rec()->MET());

// chi^2: we use the CMS (public) snippet of code
double chi2 = calculateChi2(myJets);

double MinDeltaPhiJetMET = min(myJets[0]->dphi_0_pi(pTmiss),
                               myJets[1]->dphi_0_pi(pTmiss));
```

OBSERVABLES AND CUTS

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                               myJets[1]->dphi_0_pi(pTmiss));
```

```
  // <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
  // Signal region definitions
  // <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
  // Now we're into the signal-region-specific cuts.
  // If no signal region is left passing cuts, we stop analysing this event.

  if(!Manager()->ApplyCut((MET > 150.),"MET > 150 GeV"))
    return true;
  if(!Manager()->ApplyCut((MET > 200.),"MET > 200 GeV"))
    return true;
  if(!Manager()->ApplyCut((MET > 250.),"MET > 250 GeV"))
    return true;
  if(!Manager()->ApplyCut((MET > 300.),"MET > 300 GeV"))
    return true;
  if(!Manager()->ApplyCut((mt2w > 200.),"MT2W > 200 GeV"))
    return true;
  if(!Manager()->ApplyCut((LeadingBjetpT > 100.),
                          "Leading b-jet pT > 100 GeV"))
    return true;
}
```

FILLING UP HISTOGRAMS

```
// Some histos which are defined only after the previous cut:
Manager()->FillHisto("MT2W after MT>120", mt2w);
Manager()->FillHisto("chi2 after MT>120", chi2);
Manager()->FillHisto("HTratio after MT>120", HTratio);
Manager()->FillHisto("JetMETMindeltaPhi after MT>120", MinDeltaPhiJetMET);
Manager()->FillHisto("pT(leading b-jet) after MT>120",LeadingBjetpT);
Manager()->FillHisto("deltaR(l, leading b-jet) after MT>120",deltaRb1l);
```

LOOKING AT THE OUTPUT

- The output contains :
  - A SAF file cms_sus_13_011.saf listing the names of all implemented SRs.
  - A Subdirectory Histograms with a SAF files histos.saf.
  - A Subdirectory Cutflows with SAF files named according to the SRs definitions.

LOOKING AT THE OUTPUT

THE OUTPUT SUBDIRECTORY IS PRESENT IN THE BUILD DIRECTORY

LOOKING AT THE OUTPUT

THE OUTPUT SUBDIRECTORY IS PRESENT IN THE BUILD DIRECTORY

```
<SAFheader>
</SAFheader>

<InitialCounter>
"Initial number of events"      #
19114           0               # nentries
1.911400e+04    0.000000e+00    # sum of weights
1.911400e+04    0.000000e+00    # sum of weights^2
</InitialCounter>

<Counter>
"at least 2 leptons"            # 1st cut
1671            0               # nentries
1.671000e+03    0.000000e+00    # sum of weights
1.671000e+03    0.000000e+00    # sum of weights^2
</Counter>

<Counter>
"at least 2 OS leptons"         # 2st cut
157             0               # nentries
1.570000e+02    0.000000e+00    # sum of weights
1.570000e+02    0.000000e+00    # sum of weights^2
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```

```
<SAFheader>
</SAFheader>

<Histo>
<Description>
"njet"
# nbins         xmin            xmax
15              0               15
# associated RegionSelections
 Gluino->TT+neutralino                          # Region nr. 1
</Description>
<Statistics>
13 0 # nevents
13 0 # sum of event-weights over events
13 0 # nentries
13 0 # sum of event-weights over entries
13 0 # sum weights^2
86 0 # sum value*weight
614 0 # sum value^2*weight
</Statistics>
<Data>
0 0 # underflow
0 0 # bin 1 / 15
0 0 # bin 2 / 15
0 0
0 0
0 0
3 0
6 0
2 0
0 0
1 0
0 0
0 0
1 0
```

AN EXCLUSION CODE

- Limit setting by install RecastingTools. (generates exclusion.py)
- Takes acceptance*efficiency from the SAF files as input.

- run as ./exclusion_CLs.py analysis_name mypoint.txt [run number] [cross section].
- For multiple SRs it picks out the most sensitive SR.
- Create the .info file from the experimental paper.

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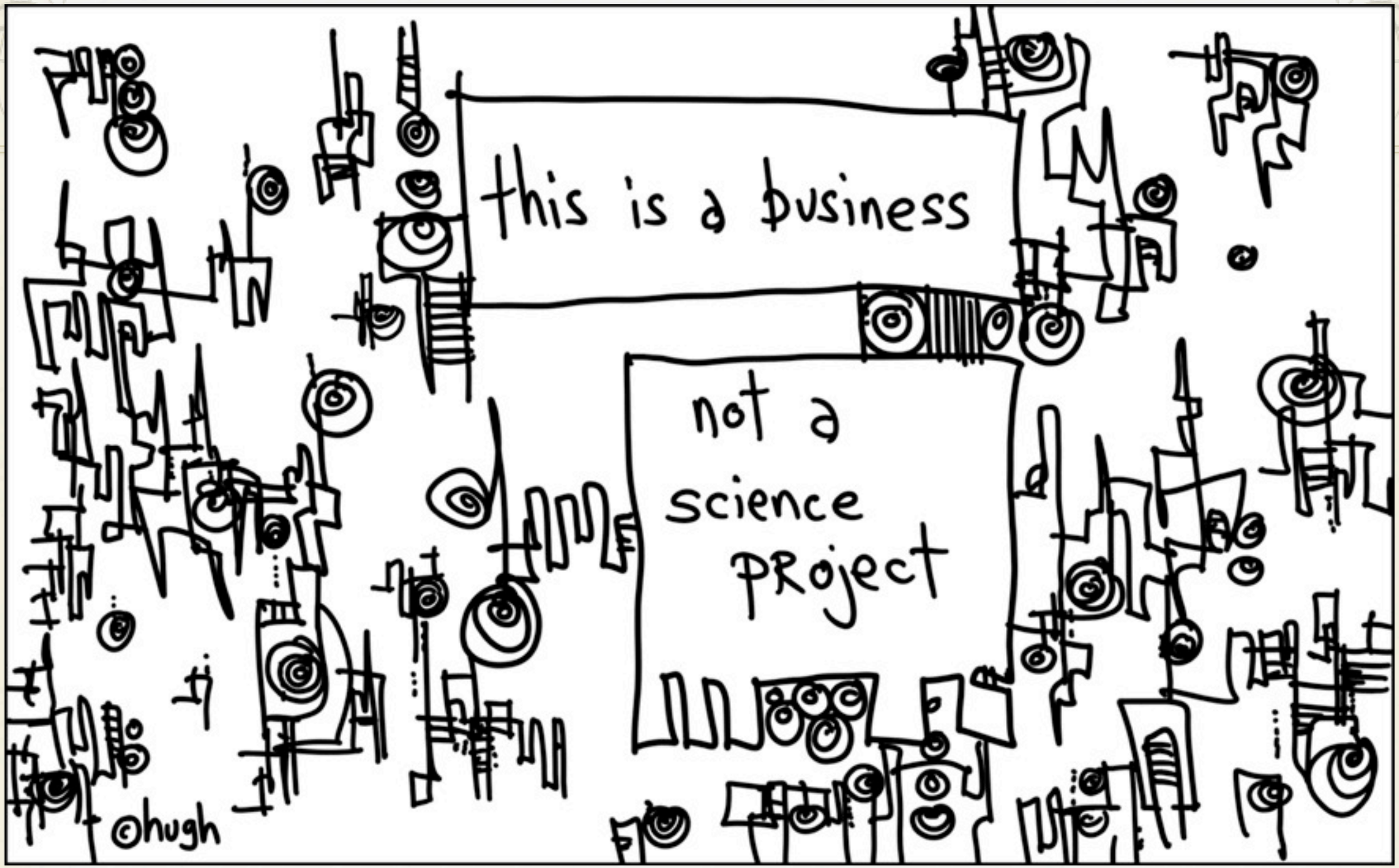
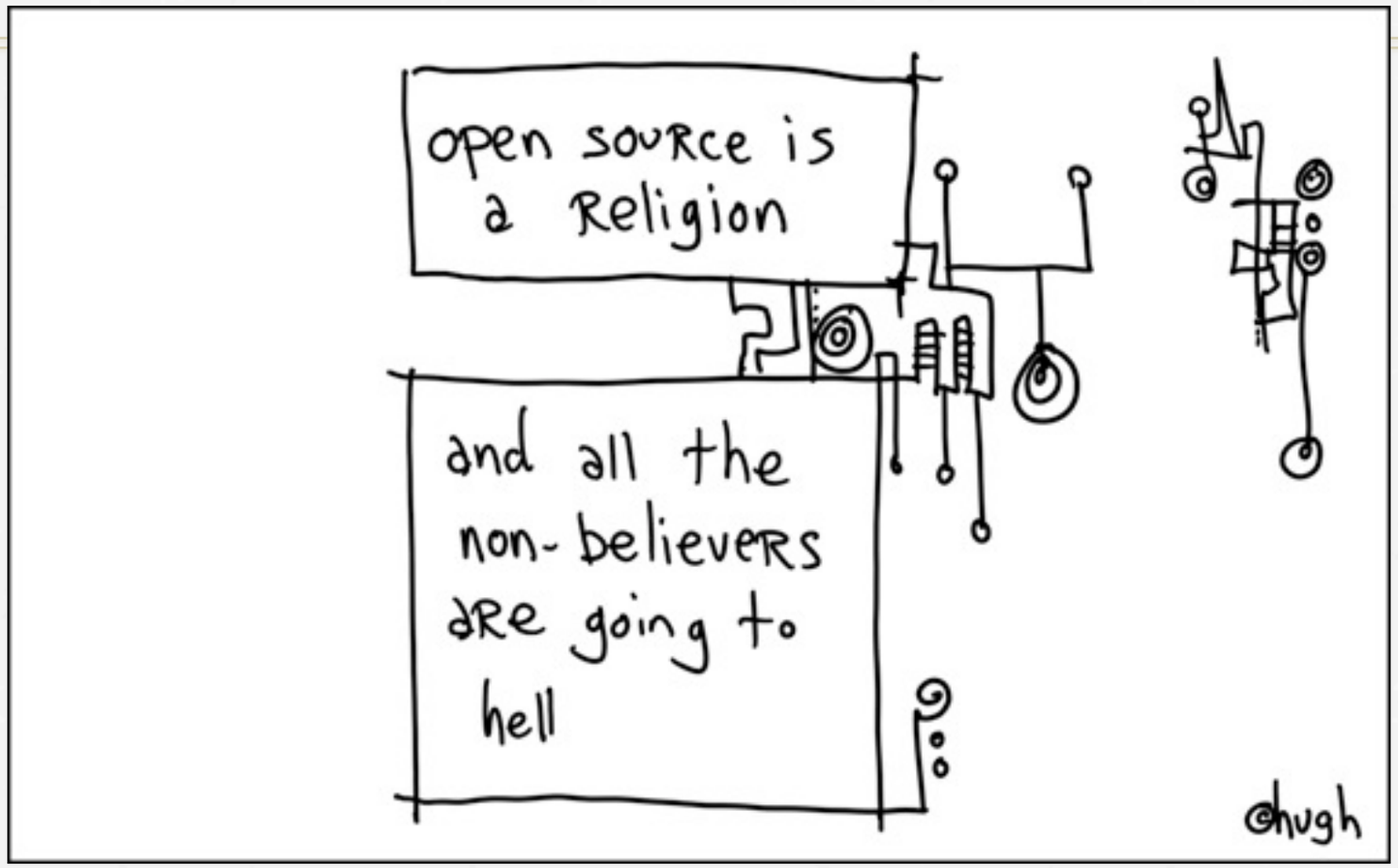
```
<!--
this XML file serves for the statistical interpretation of the MA5 simulation.
it lists the number of observed events <nobs>, number of expected backgrounds <nb>
and number of background uncertainty <deltanb> in each of the regions
-->

<!--
to be put in the same directory as the analysis code,
i.e. Build/SampleAnalyzer/Analyzer/
-->

<analysis id="cms_sus_13_011">
  <lumi>19.5</lumi> <!-- in fb^-1 -->

  <!-- first, the signal regions targeting stop -> t neutralino -->

  <!--
     region definition: the attribute "id" has to match the name of the region
     as defined in the analysis code;
     the attribute "type" can be "signal" or "control" and is optional (default=signal)
  -->
  <region type="signal" id="Stop->T+neutralino, LowDeltaM, MET>150">
    <nobs>227</nobs>
    <nb>251</nb>
    <deltanb>50</deltanb>
  </region>
```


this is a business
not a
science
project
©hugh


open source is a Religion
and all the non-believers are going to hell
©hugh