Recast of LHC searches: MadAnalysis 5 PAD

Daniele Barducci

First meeting of the LHC Dark Matter WG
CERN 11th December 2015

DB, Bein, Belanger, Chalons, Conte, Delaunay, Dumont,
Fuks, Kraml, Kulkarni, Pandey,Sengupta, Sharma, Wymant

Outline

The WG

- brings together theorists and experimentalists to define guidelines and recommendations for the benchmark models, interpretation, and characterisation necessary for broad and systematic searches for dark matter at the LHC.
- develops and promotes well-defined signal models, specifying the assumptions behind them and describing the conditions under which they should be used.
- works to improve the set of tools available to the experiments, such as higher-precision calculations of the backgrounds.
- assists theorists with understanding and making use of LHC results.
- develops and maintains close connections with theorists and other experimental particle DM searches (e.g. Direct and Indirect Detection experiments) in order to help verify and constrain particle physics models of astrophysical excesses, to understand how collider searches and non-collider experiments complement one another, and to help build a comprehensive understanding of viable dark matter models.

- Introduction and motivations for LHC analyses recast
- The MadAnalysis 5 framework and the PAD
- Wrap up and conclusions

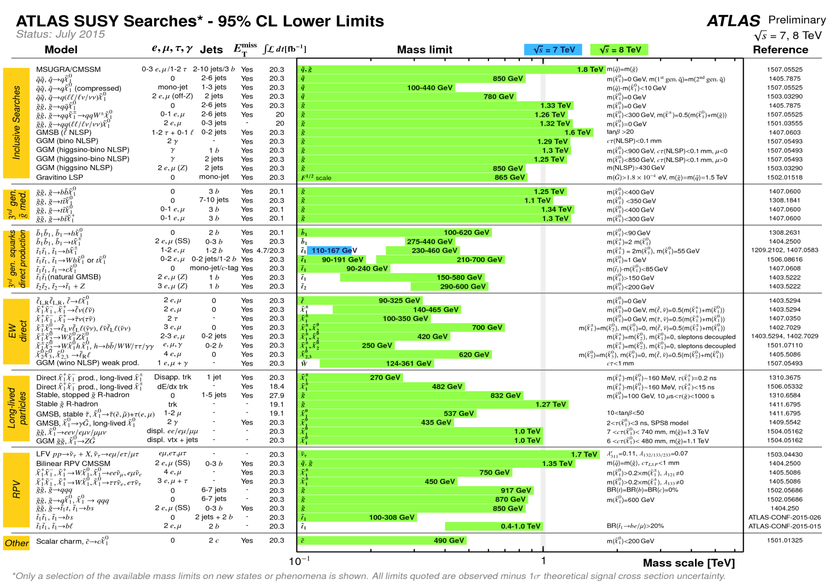
Why recast LHC searches?

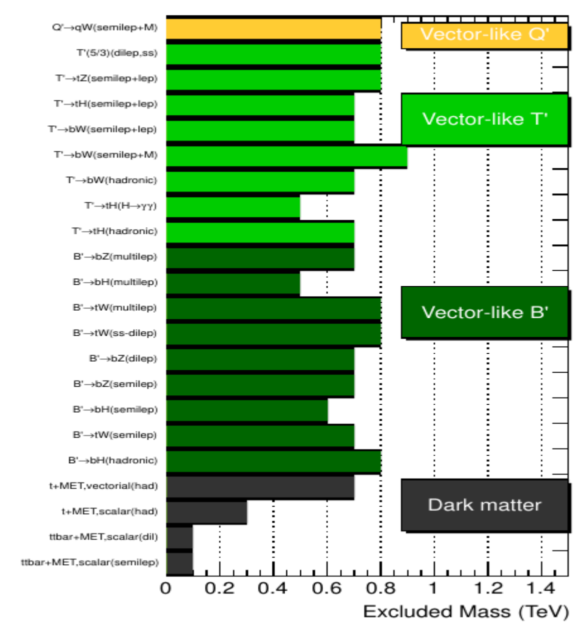
The discovery of a scalar boson has been the major outcome of the 7 and 8 TeV run of the LHC

It has however also been the ”only” new discovery made at the LHC so far

No clear direct signs of new physics have emerged from 7+8 TeV collisions (yet some little excess...)

ATLAS and CMS has therefore set limits on common BSM scenarios (SUSY, CHMs, ED...)





Caveat : These limits are strongly dependent upon the underlying (simplified) model assumptions!

Why recast LHC searches? $\frac{N_{theo.models}}{N_{\exp.analyses}} \rightarrow \infty$

Various groups have investigated the problem and developed tools based on two different approaches

SMS approach

Decompose a model signal in terms of simplified models (SMS) topologies

Through efficiency maps or comparing with cross sections upper limits determine if a given model is allowed or excluded

Fastlim [Papucci et al. 1402.0492]
SModelS [Kraml et al. 1312.4175]
XQCAT [DB et al. 1409.3116]

Recast approach

Implement analysis selections in a computer code that allows to test MC events for any given model

For the same models interpreted by ATLAS and CMS, the code should give consistent results: **validation**

ATOM (not public) [Papucci et al]
Checkmate [Drees et al. 1312.2591]
MadAnalysis 5 [Conte et al. 1206.1599]
+ MA5 PAD [Conte et al. 1405.3982, Dumont et al. 1407.3278]

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No need to generate MC events ✓

Simplified model do not cover all possibilities ✗

Fast method, but with limitation

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Need to generate MC events ✗

Can cover **any BSM model** ✓

Analyses can be **shared** ✓✓✓

Maybe slower, but huge potential !!!

MadAnalysis 5 PAD

MA5 is a public framework for phenomenological analyses

Analyse MC events at different particle level: parton, hadronic or detector reconstructed

Analyse MC events in a normal or expert mode

Normal mode: simple commands in a python interface
output of analysis in a human-readable output (HTML and LaTeX)
built in function for basic kinematic variables
ideal for preliminary/simple event analysis

Expert mode: Code an analysis in a C++ format within the SampleAnalyzer framework
Possibility to implement (almost) all the selections adopted in LHC searches
Ideal for high level phenomenological analysis

⇓

This leads to the idea of a Public Analyses Database (PAD)

MadAnalysis 5 PAD

Choose an experimental analysis that, e.g., might have potentiality to cover not yet explored scenarios

→ Understand the selections cuts that the analysis enforces to select signal regions (SRs)

→ Implement the selection cuts in a C++ code with the help of built in functions (for example to compute particle isolations)

→ Test the code with MC samples of the same model points adopted by the experimental collaborations

→ Get the same final number of events as the exp. analysis (easy to say, hard to obtain...)

→ Get the same exclusion CL $CLs(signal, bg, \Delta bg, data)$

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$$CLs\left(signal, bg, \Delta bg, data\right)$$

Share the code with the hep community for other pheno studies

Apply it to your model and obtain your results (easy/hard task... depends...)

Create a public database of analyses MA5 PAD [Dumont et al. 1407.3278]

This might show some blind spots of present analyses to certain models
Possibility to propose different selections more sensitive to a particular scenario

MadAnalysis 5 PAD

The construction of a PAD is well under way `https://madanalysis.irmp.ucl.ac.be/wiki/PublicAnalysisDatabase`

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	Inspire	PDF MadGraph cards	MA5tune
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

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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)	Searches for third-generation squarks in fully hadronic final states (monojet analysis)	S. Sharma, S. Pandey	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

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HEP :: HEPNAMES :: INSTITUTIONS :: CONFERENCES :: JOBS :: EXPERIMENTS :: JOURNALS :: HELP

Information | Citations (0) | Files | Data

MadAnalysis 5 implementation of ATLAS-EXOT-2014-06

Daniele Barducci (LAPTH, Annecy-le-Vieux)

Description: This is the MadAnalysis 5 implementation of the ATLAS mono-photon search with 20.3/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: Barducci, D. (2015) MadAnalysis 5 implementation of ATLAS-EXOT-2014-06. doi: 10.7484/INSPIREHEP.DATA.922E.4BN6

Record added 2015-03-22, last modified 2015-11-13

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ATLAS_EXOT_2014_06

version 1	ATLAS_EXOT_2014_06.cpp	[10.38 KB]	23 Mar 2015, 14:53
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Details of the validation are public and provided in the validation notes!!!

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MadAnalysis 5 PAD

Dark Matter searches in the PAD

Monojet searches

- ATLAS-SUSY-2013-021: compressed SUSY
- CMS-SUS-14-001: compressed SUSY
- CMS-EXO-12-048: non SUSY (soon)

Monophoton searches

- ATLAS-EXOT-2014-006: non SUSY
- CMS-EXO-12-047: non SUSY (soon)

Validation: Reproducing (with some degree of accuracy) the exp. results is not always a trivial task

Problem 1. Fast detector simulation tools (e.g. Delphes) can not reproduce the degree of accuracy of full experimental simulations.

This is an intrinsic difference between a theory/pheno and an experimental study

We accept this and we aim to reproduce exp. results within a certain accuracy

Problem 2. Sometimes not enough details of exp. analyses are provided

This is a problem that can be overcome by working close with exp. colleagues

Validation of a search

Example: ATLAS-EXOT-2014-06 Monophoton search

Phys. Rev. D 91, 012008 (2015)

Erratum

3 November 2014

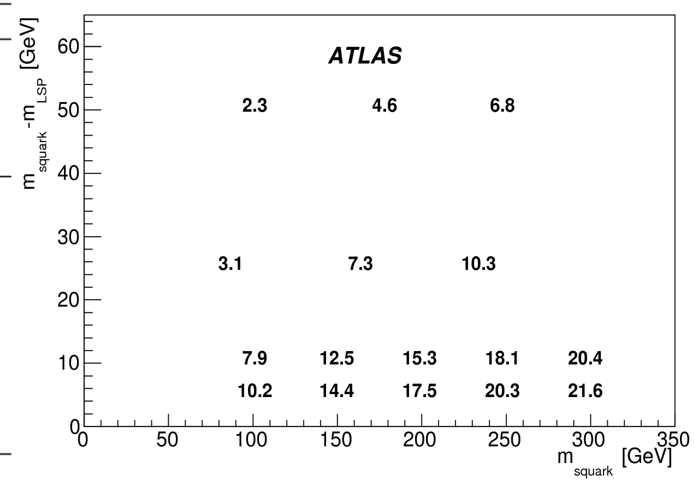
e-print arXiv:1411.1559

Inspire record

Data points

Figures, Tables and Auxilliary Material

Nominal	9989
Pre-selected:	
1. Trigger	8582
2. Good vertex	8574
3. Cleaning cuts	8213
SR Cuts:	
1. $E_T^{miss} > 150$ GeV	4131
2. At least one loose photon with $p_T > 125$ GeV($\lvert\eta\rvert < 2.37$)	2645
3. The leading photon is tight with $\lvert\eta\rvert < 1.37$	2068
4. The leading photon is isolated	1898
5. $\Delta\phi(\gamma^{\text{leading}}, \boldsymbol{E}_T^{miss}) > 0.4$	1887
6. Jet veto: $N_{jet} \leq 1$ and $\Delta\phi(\text{jet}, \boldsymbol{E}_T^{miss}) > 0.4$	1219
7. Lepton veto	1188



<u>Extremely well documented search:</u>

- SLHA cards for signal points on HEPdata ✓
- HelpPlots of A x Eff. all the signal points ✓
- No histograms for signal distributions ✗
- Cutflow for a signal point on the Twiki ✓
- ATLAS provided us with MG cards ✓✓

Easy comparison of our simulation with the available information: efficiencies and exclusion plots...

Validation of a search

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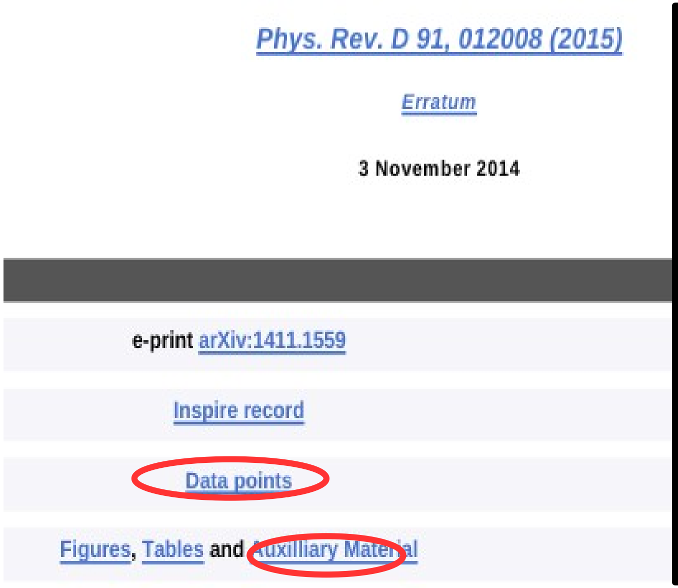
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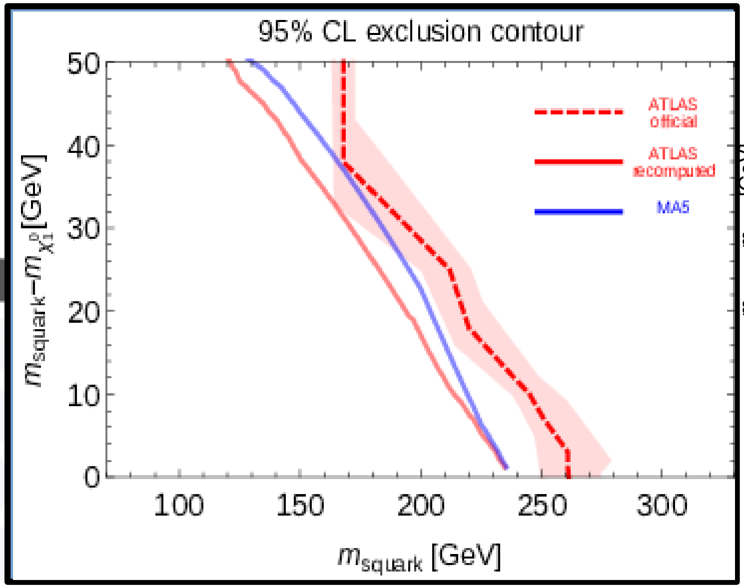

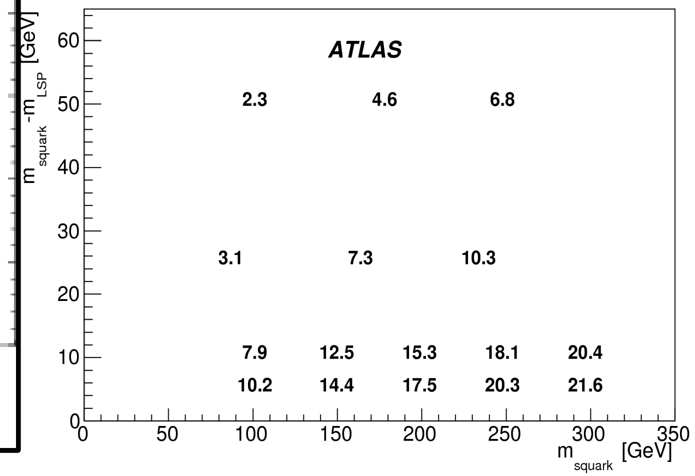

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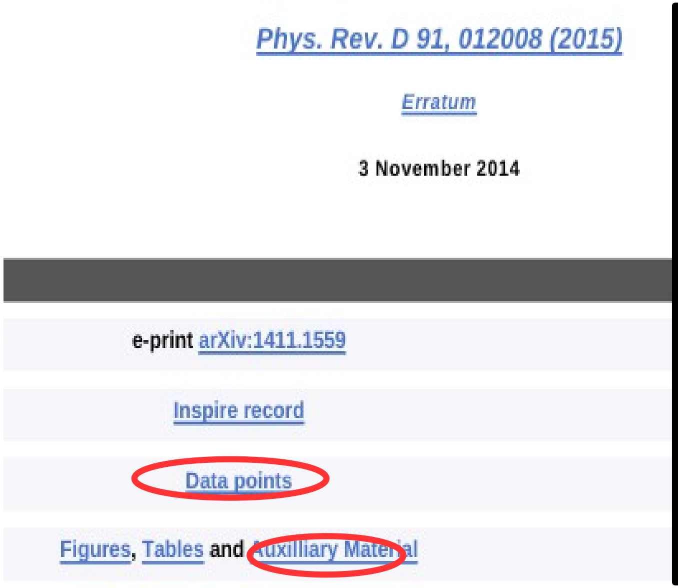

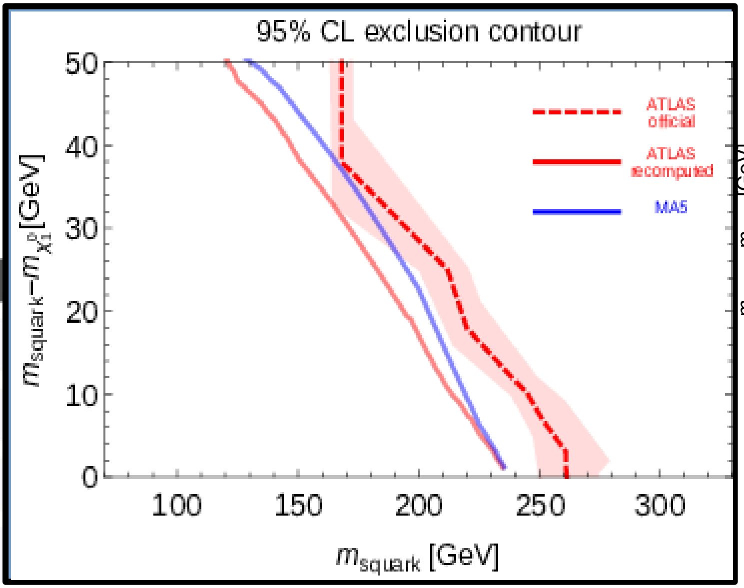

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Recaster wishlist

Implementation

- Clear description of all the cuts, including their sequence
- Efficiencies for reconstructing physics objects: electrons, muons, taus, b/c tagging…
- Efficiencies for triggers, event cleaning, i.e anything that can not be reproduced within a fast detector simulation

Validation

- Exact configuration of MonteCarlo tools (MadGraph, CalcHEP, PYTHIA)
  - version, input card and settings…
- Clear description of the generated process
  - Number of extra partons generated, cross section order…
- Clear definition of bechmark points for all SRs (masses, couplings, widhts…)
  - SLHA or other input cards, LHE parton level events…
- Detailed cutflows for (at least) one benchmark point
  - Including (pre)selection requirements…
- Plots of kinematic distributions for (at least) one benchmark points
  - After different cut selection…
- Acceptance and efficiencies for simulated signal points

Conclusions

- Reinterpreting the LHC analyses is crucial to fully exploit the data that the LHC has delivered
- Two complementary approach are possible: simplified models and analyses recast
- Through the recast approach we can aim at the creation of a database of recast analyses
- These analyses are available for all the hep community for pheno studies

- The MadAnalysis 5 framework is an active project
- MadAnalysis 5 PAD is a project that requires manpower to expand: we encourage colleagues to validate their search and share the results on the PAD database

- ATLAS and CMS analyses are generally very well documented
- Always need a complete set of basic information to allow recast the analyses
- HEPdata, twiki… are powerful platform to share these information
- Also goes in the direction of preserving analyses in time

Looking forward for first 13 TeV analyses

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