

# MadAnalysis5: Recast of LHC searches

## Overview and applications

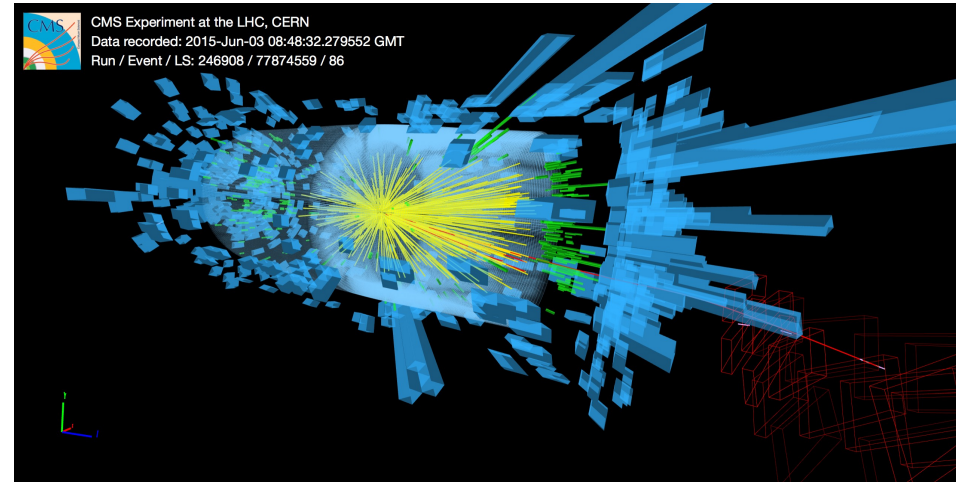
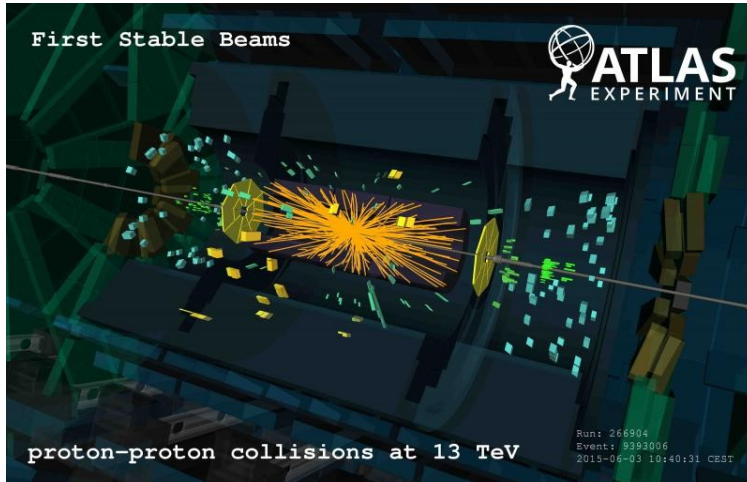
Daniele Barducci  
GDR Terascale: LPSC Grenoble  
25th November 2015

# Outline

- Introduction and motivations to LHC [analyses recast](#)
- The [MadAnalysis 5](#) framework and the PAD
- An example: [wide vector resonances](#) in composite Higgs models
- Conclusions and [prospects](#)

# Why recast LHC searches?

The 13 TeV LHC era just started with the first 13 TeV collisions!!!



Great expectations for the LHC to improve our understanding of the mechanism behind EWSB



# 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...)

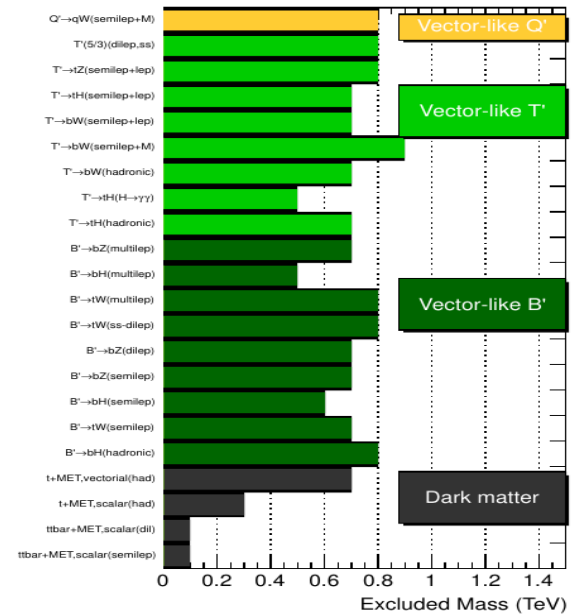
ATLAS and CMS has therefore set limits on common BSM scenarios (SUSY, CHMs, ED...)

**ATLAS SUSY Searches\* - 95% CL Lower Limits**  
Status: July 2015

**ATLAS Preliminary**  
 $\sqrt{s} = 7, 8 \text{ TeV}$

Model	$\epsilon \cdot \mu \cdot \tau \cdot \gamma$	Jets	$E_{miss}$	$L_{int} [fb^{-1}]$	Mass limit	$\sqrt{s} = 7 \text{ TeV}$	$\sqrt{s} = 8 \text{ TeV}$	Reference
<b>Inclusive Searches</b>								
MSUGRA/CMSSM	$0 < \mu < 1/2$	$2 < 10$ jets $\geq 0$	Yes	20.3	1.8 TeV	850 GeV	1.8 TeV	1507.0525
$\tilde{g} \rightarrow q\bar{q}$	0	2-6 jets	Yes	20.3	100-440 GeV	760 GeV	1465.7875	1507.0525
$\tilde{g} \rightarrow q\bar{q}$ (compressed)	monojet	1-2 jets	Yes	20.3			1503.0590	1503.0590
$\tilde{g} \rightarrow q\bar{q}$ (compressed)	$2 < \mu < 2$	2 jets	Yes	20.3			1465.7875	1507.0525
$\tilde{g} \rightarrow q\bar{q}$	0	2-6 jets	Yes	20.3		1.33 TeV	1465.7875	1507.0525
$\tilde{g} \rightarrow q\bar{q}$	0	2-6 jets	Yes	20.3		1.28 TeV	1501.0555	1507.0525
$\tilde{g} \rightarrow q\bar{q}$	$0 < \mu < 2$	2 jets	Yes	20.3		1.32 TeV	1501.0555	1507.0525
$\tilde{g} \rightarrow q\bar{q}$	$1 < \mu < 1$	0-2 jets	Yes	20.3		1.6 TeV	1467.0030	1507.0525
GMSB (bino NLSP)	2 $\mu$	0	Yes	20.3		1.28 TeV	1507.05493	1507.05493
GGM (higgsino bino NLSP)	2 $\mu$	0	Yes	20.3		1.3 TeV	1507.05493	1507.05493
GGM (higgsino bino NLSP)	2 $\mu$	2 jets	Yes	20.3		1.25 TeV	1503.0590	1503.0590
GGM (higgsino NLSP)	2 $\mu$	2 jets	Yes	20.3		850 GeV	1503.0590	1503.0590
GraVino LSP	0	monojet	Yes	20.3	95% scalars		1502.0118	1502.0118
<b>3<math>\gamma</math> dim. prod.</b>								
$\tilde{g} \rightarrow q\bar{q}$	0	3 $\gamma$	Yes	20.1		1.29 TeV	1467.0060	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	0	7-10 jets	Yes	20.3		1.1 TeV	1308.1841	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	0	1 $\mu$ , 3 $\gamma$	Yes	20.1		1.34 TeV	1467.0060	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	0	1 $\mu$ , 3 $\gamma$	Yes	20.1		1.3 TeV	1467.0060	1467.0060
<b>3<math>\gamma</math> dim. prod. (non-resonant)</b>								
$\tilde{g} \rightarrow q\bar{q}$	0	2 $\gamma$	Yes	20.1		100-820 GeV	1308.2031	1464.2500
$\tilde{g} \rightarrow q\bar{q}$	2 $\mu$	SS	Yes	20.3		275-440 GeV	1209.2102, 1467.0563	1308.2031
$\tilde{g} \rightarrow q\bar{q}$	1.2 $\mu$	1-2 $\gamma$	Yes	4.720.3		110-191 GeV	1308.2031	1308.2031
$\tilde{g} \rightarrow q\bar{q}$	0.2 $\mu$ , 0.2 jets $\geq 2$	0	Yes	20.3		200-460 GeV	1467.0060	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	0	monojet+tag	Yes	20.3		90-240 GeV	1467.0060	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	0	monojet+tag	Yes	20.3		150-580 GeV	1467.0060	1467.0060
$\tilde{g} \rightarrow q\bar{q}$	3 $\mu$	2 jets	Yes	20.3		200-400 GeV	1467.0060	1467.0060
<b>EW direct</b>								
$\tilde{g} \rightarrow q\bar{q}$	2 $\mu$	0	Yes	20.3		90-325 GeV	1463.0294	1463.0294
$\tilde{g} \rightarrow q\bar{q}$	2 $\mu$	0	Yes	20.3		180-385 GeV	1463.0294	1463.0294
$\tilde{g} \rightarrow q\bar{q}$	2 $\mu$	0	Yes	20.3		100-390 GeV	1467.2380	1467.2380
$\tilde{g} \rightarrow q\bar{q}$	2 $\mu$	0	Yes	20.3		700 GeV	1467.2380	1467.2380
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		420 GeV	1403.0294, 1462.7029	1403.0294, 1462.7029
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		250 GeV	1501.0710	1501.0710
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		620 GeV	1465.0098	1465.0098
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		124-361 GeV	1507.05493	1507.05493
<b>EW indirect</b>								
Direct $\tilde{g} \rightarrow q\bar{q}$ prod. long-lived $\tilde{g}$	Discard. th.	1 jet	Yes	20.3		270 GeV	1310.3075	1310.3075
Direct $\tilde{g} \rightarrow q\bar{q}$ prod. long-lived $\tilde{g}$	disc. th.	0	Yes	20.3		482 GeV	1310.3075	1310.3075
Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9		832 GeV	1316.6584	1316.6584
Stable $\tilde{g}$ R-hadron	th.	0	Yes	18.1		537 GeV	1411.6795	1411.6795
GMSB, stable $\tilde{g}$ R-hadron	1-2 $\mu$	0	Yes	19.1		435 GeV	1409.5642	1409.5642
GMSB, $\tilde{g}$ R-hadron	2 $\mu$	0	Yes	20.3		1.0 TeV	1504.0162	1504.0162
GGM $\tilde{g} \rightarrow q\bar{q}$	disc. th.	0	Yes	20.3		1.0 TeV	1504.0162	1504.0162
<b>RPV</b>								
LFV $\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		1.7 TeV	1503.0430	1503.0430
Bilinear RPV CMSSM	2 $\mu$ (SS)	0-3 $\gamma$	Yes	20.3		1.35 TeV	1464.2500	1464.2500
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		450 GeV	1465.5088	1465.5088
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		917 GeV	1502.0588	1502.0588
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		870 GeV	1502.0588	1502.0588
$\tilde{g} \rightarrow q\bar{q}$	0	0-2 jets	Yes	20.3		890 GeV	1464.250	1464.250
$\tilde{g} \rightarrow q\bar{q}$	0	2 jets + 2 $\gamma$	Yes	20.3		100-308 GeV	ATLAS CONF-2015-026	ATLAS CONF-2015-026
$\tilde{g} \rightarrow q\bar{q}$	0	2 $\gamma$	Yes	20.3		490 GeV	1501.0125	1501.0125

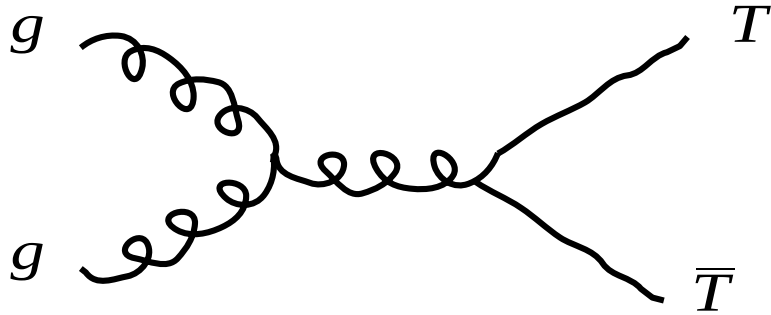
\*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 $\sigma$  theoretical signal cross section uncertainty.



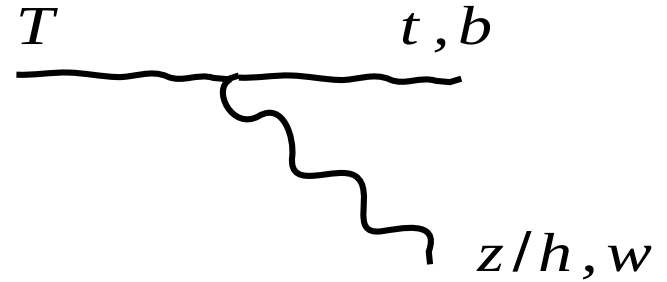
**Caveat** : These limits are **strongly dependent** upon the underlying (simplified) model assumptions!

# Why recast LHC searches?

Example: The case of **Vector-Like Quarks** in Composite Higgs models

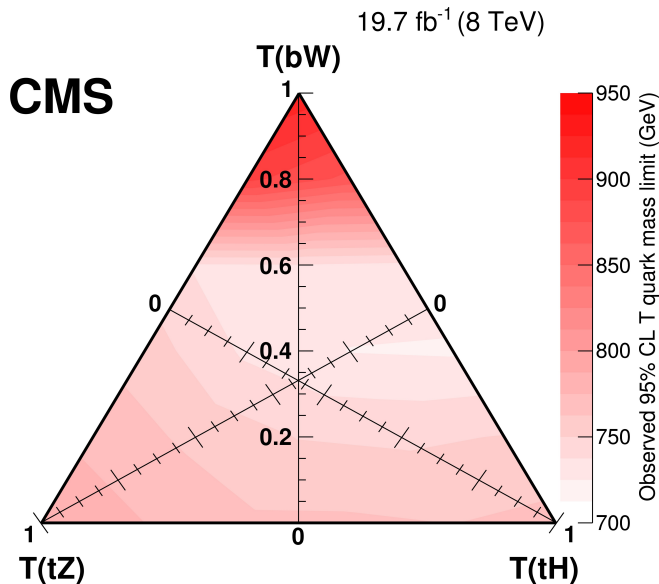


One VLQ pair produced via QCD



The VLQ decays into 3rd generation SM quarks

Bounds on the T mass in function of the various branching ratios into given final state



These limits do not apply if

- More than one VLQ (also of different charge) is present
- The VLQ can decay in other channels (light gen, DM...)
- Other production mode are relevant (EW production)
- Different models can give the same final state signal

$$\frac{N_{theo. models}}{N_{exp. analyses}} \rightarrow \infty$$

How can one apply LHC results to a given BSM scenario?

# Why recast LHC searches?

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**

**Checkmate** [Drees et al. 1312.2591]  
**MadAnalysis 5** [Conte et al. 1206.1599]

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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

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

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**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)

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

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

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

Get the same exclusion CL  
*CLs (sign, back,  $\Delta$  back, data)*

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**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
<a href="#">ATLAS-SUSY-2013-05</a> (published)	stop/sbottom search: 0 leptons + 2 b-jets	G. Chalons	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">figures</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-11</a> (published)	EWK-inos, 2 leptons + MET	B. Dumont	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-HIGG-2013-03</a> (published)	ZH->ll+invisible	B. Dumont	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-EXOT-2014-06</a> (published)	mono-photons + MET	D. Barducci	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">MadGraph cards</a>	MA5tune
<a href="#">ATLAS-SUSY-2014-10</a> (published)	2 leptons + jets + MET	B. Dumont	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-21</a> (published)	0 leptons + mono-jet/c-jets + MET	G. Chalons, D. Sengupta	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-02</a> (published)	0 leptons + 2-6 jets + MET	G. Chalons, D. Sengupta	<a href="#">Inspire</a>	<a href="#">PDF</a>	MA5tune

Analysis	Short Description	Implemented by	Code	Validation note	Version
<a href="#">CMS-SUS-13-011</a> (published)	stop search in the single lepton mode	B. Dumont, B. Fuks, C. Wymant	<a href="#">Inspire</a> [1]	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-13-012</a> (published)	gluino/squark search in jet multiplicity and missing energy	S. Bein, D. Sengupta	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-13-016</a> (PAS)	search for gluinos using OS dileptons and b-jets	D. Sengupta, S. Kulkarni	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-14-001</a> (published)	Searches for third-generation squarks in fully hadronic final states (monojet analysis)	S. Sharma, S. Pandey	<a href="#">Inspire</a>	<a href="#">PDF</a>	MA5tune
<a href="#">CMS-B2G-12-012</a> (published)	T5/3 top partners in same-sign dilepton channel	D. Barducci, C. Delaunay	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a> , <a href="#">cards</a>	v1.2/Delphes3

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<a href="#">ATLAS-HIGG-2013-03</a> (published)	ZH->ll+invisible	B. Dumont	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">(source)</a>	MA5tune
<a href="#">ATLAS-EXOT-2014-06</a> (published)	mono-photons + MET	D. Barducci	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">MadGraph cards</a>	MA5tune
<a href="#">ATLAS-SUSY-2014-10</a> (published)	2 leptons + jets + MET	B. Dumont	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">(source)</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-21</a> (published)	0 leptons + mono-jet/c-jets + MET	G. Chalons, D. Sengupta	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">(source)</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-02</a> (published)	0 leptons + 2-6 jets + MET	G. Chalons, D. Sengupta	<a href="#">Inspire</a>	<a href="#">PDF</a>	MA5tune

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Code are **uploaded** to inSPIRE and have a DOI assigned. **Possibility to cite them**

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

Information Citations (1) **Data**

### MadAnalysis 5 implementation of CMS-B2G-12-012

Barducci, Daniele; Delaunay, Cédric

**Description:** This is the MadAnalysis 5 implementation of the CMS same-sign dilepton search with 19.5/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., Delaunay, C. (2015). MadAnalysis 5 implementation of CMS-B2G-12-012. doi: [10.7484/INSPIREHEP.DATA.GRGZ.FST3](https://doi.org/10.7484/INSPIREHEP.DATA.GRGZ.FST3)

This dataset complements the following publication:  
[Validation note for the CMS same-sign dilepton analysis: CMS B2G 12 012](#)

Record added 2015-11-02, last modified 2015-11-12

Information Citations (1) Files **Data**

### MadAnalysis 5 implementation of CMS-B2G-12-012 - Barducci, Daniele et al.

**CMS\_B2G\_12\_012**

[CMS\\_B2G\\_12\\_012.cdd](#) [17.1 KB] 02 Nov 2015, 13:24

version 1 [CMS\\_B2G\\_12\\_012.h](#) [548 B] 02 Nov 2015, 13:24

[CMS\\_B2G\\_12\\_012.info](#) [171 B] 02 Nov 2015, 13:24

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<a href="#">⇒ATLAS-SUSY-2013-05</a> (published)	stop/sbottom search: 0 leptons + 2 b-jets	G. Chalons	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(figures)</a>	MA5tune
<a href="#">⇒ATLAS-SUSY-2013-11</a> (published)	EWK-inos, 2 leptons + MET	B. Dumont	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒ATLAS-HIGG-2013-03</a> (published)	ZH->ll+invisible	B. Dumont	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒ATLAS-EXOT-2014-06</a> (published)	mono-photons + MET	D. Barducci	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒MadGraph cards</a>	MA5tune
<a href="#">⇒ATLAS-SUSY-2014-10</a> (published)	2 leptons + jets + MET	B. Dumont	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒ATLAS-SUSY-2013-21</a> (published)	0 leptons + mono-jet/c-jets + MET	G. Chalons, D. Sengupta	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒ATLAS-SUSY-2013-02</a> (published)	0 leptons + 2-6 jets + MET	G. Chalons, D. Sengupta	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a>	MA5tune

Analysis	Short Description	Implemented by	Code	Validation note	Version
<a href="#">⇒CMS-SUS-13-011</a> (published)	stop search in the single lepton mode	B. Dumont, B. Fuks, C. Wymant	<a href="#">⇒Inspire</a> [1]	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒CMS-SUS-13-012</a> (published)	gluino/squark search in jet multiplicity and missing energy	S. Bein, D. Sengupta	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒CMS-SUS-13-016</a> (PAS)	search for gluinos using OS dileptons and b-jets	D. Sengupta, S. Kulkarni	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a>	MA5tune
<a href="#">⇒CMS-SUS-14-001</a> (published)	Searches for third-generation squarks in fully hadronic final states (monojet analysis)	S. Sharma, S. Pandey	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a>	MA5tune
<a href="#">⇒CMS-B2G-12-012</a> (published)	T5/3 top partners in same-sign dilepton channel	D. Barducci, C. Delaunay	<a href="#">⇒Inspire</a>	<a href="#">⇒PDF</a> <a href="#">⇒(source)</a> , <a href="#">⇒cards</a>	v1.2/Delphes3

Code are **uploaded** to inSPIRE and have a DOI assigned. **Possibility to cite them**

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

Information Citations (1) **Data**

### MadAnalysis 5 implementation of CMS-B2G-12-012

Barducci, Daniele; Delaunay, Cédric

**Description:** This is the MadAnalysis 5 implementation of the CMS same-sign dilepton search with 19.5/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., Delaunay, C. (2015). MadAnalysis 5 implementation of CMS-B2G-12-012. doi: [10.7484/INSPIREHEP.DATA.GRGZ.FST3](https://doi.org/10.7484/INSPIREHEP.DATA.GRGZ.FST3)

This dataset complements the following publication:  
[Validation note for the CMS same-sign dilepton analysis: CMS B2G 12 012](#)

Record added 2015-11-02, last modified 2015-11-12

Details of the validation are **public** and provided in the **validation notes!!!**

Information Citations (1) Files **Data**

### MadAnalysis 5 implementation of CMS-B2G-12-012 - Barducci, Daniele et al.

CMS\_B2G\_12\_012

- [CMS\\_B2G\\_12\\_012.cdd](#) [17.1 KB] 02 Nov 2015, 13:24
- version 1 [CMS\\_B2G\\_12\\_012.h](#) [548 B] 02 Nov 2015, 13:24
- [CMS\\_B2G\\_12\\_012.info](#) [171 B] 02 Nov 2015, 13:24



# MadAnalysis 5 PAD

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

Analysis	Short Description	Code	Validation note	Version
<a href="#">ATLAS-SUSY-2013-05</a> (published)	stop/sbottom search: 0 leptons + 2 jets		<a href="#">PDF</a> <a href="#">figures</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-11</a> (published)	EWK-inos, 2 leptons + MET		<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-HIGG-2013-03</a> (published)	ZH->ll+invisible		<a href="#">MadGraph cards</a>	MA5tune
<a href="#">ATLAS-EXOT-2014-06</a> (published)	mono-photons + MET		<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-SUSY-2014-10</a> (published)	2 leptons + jets		<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-21</a> (published)	0 leptons + mono-jet		<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">ATLAS-SUSY-2013-02</a> (published)	0 leptons + 2-6 jets + MET		<a href="#">PDF</a>	MA5tune

Analysis	Short Description	Code	Validation note	Version
<a href="#">CMS-SUS-13-011</a> (published)	stop search in the single lepton channel	<a href="#">Inspire [1]</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-13-012</a> (published)	gluino/squark search in jet multiplicity and b-jet		<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-13-016</a> (PAS)	search for gluinos using OS dileptons and b-jet	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a>	MA5tune
<a href="#">CMS-SUS-14-001</a> (published)	Searches for third-generation squarks and gluinos	<a href="#">Inspire</a>	<a href="#">PDF</a>	MA5tune
<a href="#">CMS-B2G-12-012</a> (published)	T5/3 top partners in same-sign dilepton channel	<a href="#">Inspire</a>	<a href="#">PDF</a> <a href="#">source</a> , <a href="#">cards</a>	v1.2/Delphes3

**Soon on the PAD**  
**CMS: eejj (excess)**  
**mono-j mono-gamma**  
**ATLAS: multi-jet**

Code are **uploaded** to inSPIRE and have a DOI assigned. Possibility to cite them

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Information Citations (1) Files **Data**

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CMS\_B2G\_12\_012

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# Validation of a search

Reproducing (with some degree of accuracy) the experimental 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.

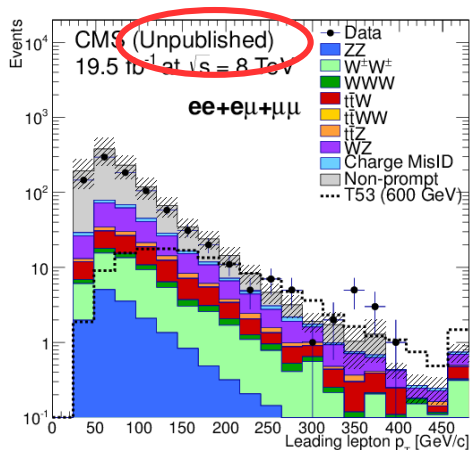
This is an intrinsic difference between a theory/pheno and an experimental study  
We accept this and we aim to reproduce exp. results within a certain accuracy

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

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

- Exact **configuration of MC tools** used for signal generation (cards settings)
- **Benchmark points** used for signal generation (SLHA or, better, LHE)
- **Cutflows and Histograms** for the given benchmark points

This can be easily provided (HEPdata, Twiki...) and is sometimes done



[Phys. Rev. D 91, 012008 \(2015\)](#)

[Erratum](#)

3 November 2014

e-print [arXiv:1411.1559](#)

[Inspire record](#)

[Data points](#)

[Figures, Tables and Auxiliary Material](#)

Nominal	9989
<b>Pre-selected:</b>	
1. Trigger	8582
2. Good vertex	8574
3. Cleaning cuts	8213
<b>SR Cuts:</b>	
1. $E_T^{\text{miss}} > 150$ GeV	4131
2. At least one loose photon with $p_T > 125$ GeV ( $ \eta  < 2.37$ )	2645
3. The leading photon is tight with $ \eta  < 1.37$	2068
4. The leading photon is isolated	1898
5. $\Delta\phi(\gamma_{\text{leading}}, \mathbf{E}_T^{\text{miss}}) > 0.4$	1887
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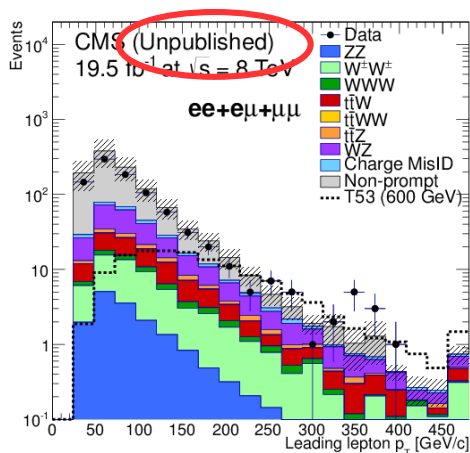
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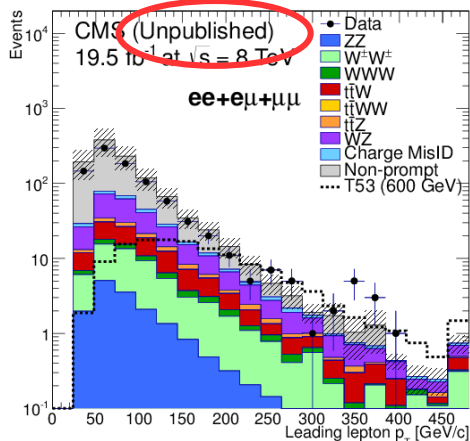
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always!!!



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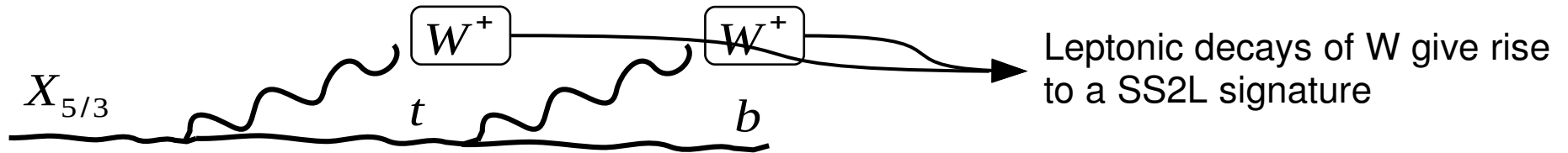
# Validation of a search

Example: CMS search for top partners of charge 5/3 in a same-sign dilepton (SS2L) final state  
CMS-B2G-12-012



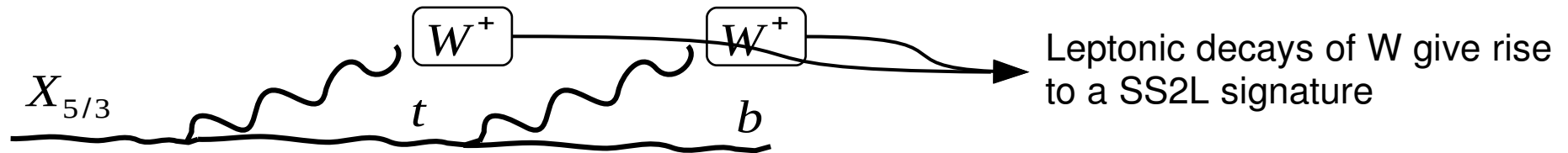
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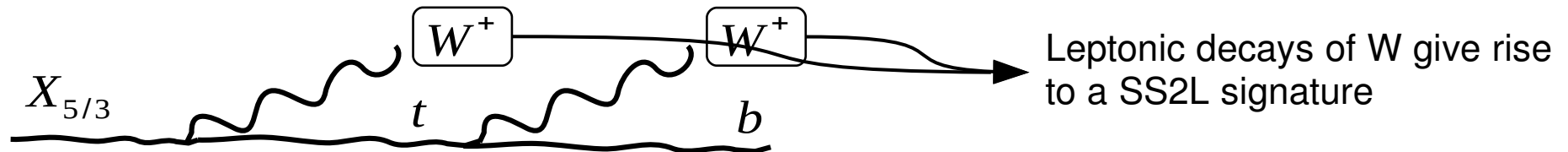
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- Isolation for leptons  $\sum_{n_i \in \Delta R < 0.3} p_T^{n_i} / p_T^e < 0.15$   $\sum_{n_i \in \Delta R < 0.4} p_T^{n_i} / p_T^u < 0.2$
- At least 2 isolated same sign lepton
- Veto on Z boson mass window
- $H_T = E_T^{miss.} + \sum p_T^j + \sum p_T^l > 900 GeV$

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```
// Select electrons with pT>7, |eta|<2.4
for(unsigned int ie=0; ie<event.rec()->electrons().size(); ie++){
  const RecLeptonFormat * CurrentElectron = &(event.rec()->electrons()[ie]);
  if(CurrentElectron->pt()>30.0 && fabs(CurrentElectron->eta())<2.4){
    SignalElectrons.push_back(CurrentElectron);
  }
}
// We apply a tight isolation criteria to electrons
SignalElectrons = PHYSICS->Isol->tracker->getRelIsolated(SignalElectrons,event.rec(),0.15,0.3,0.5);
```

PHYSICS contains special functions

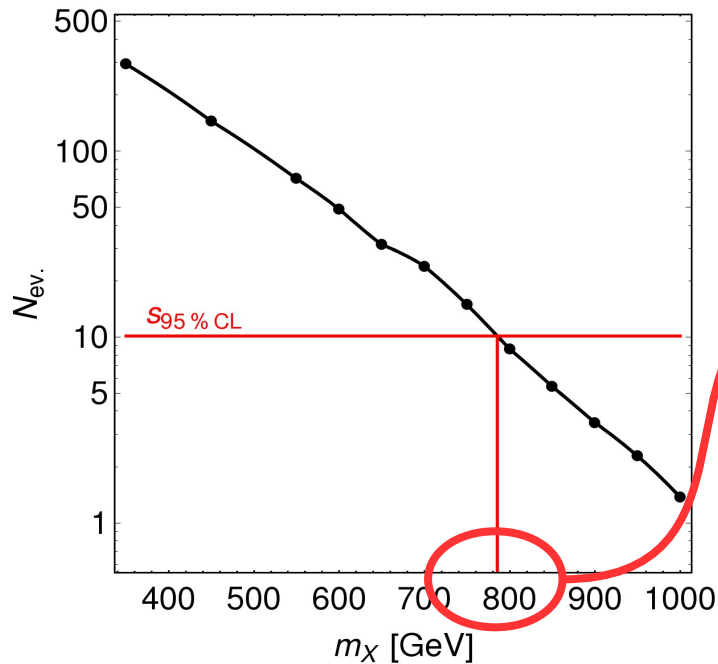
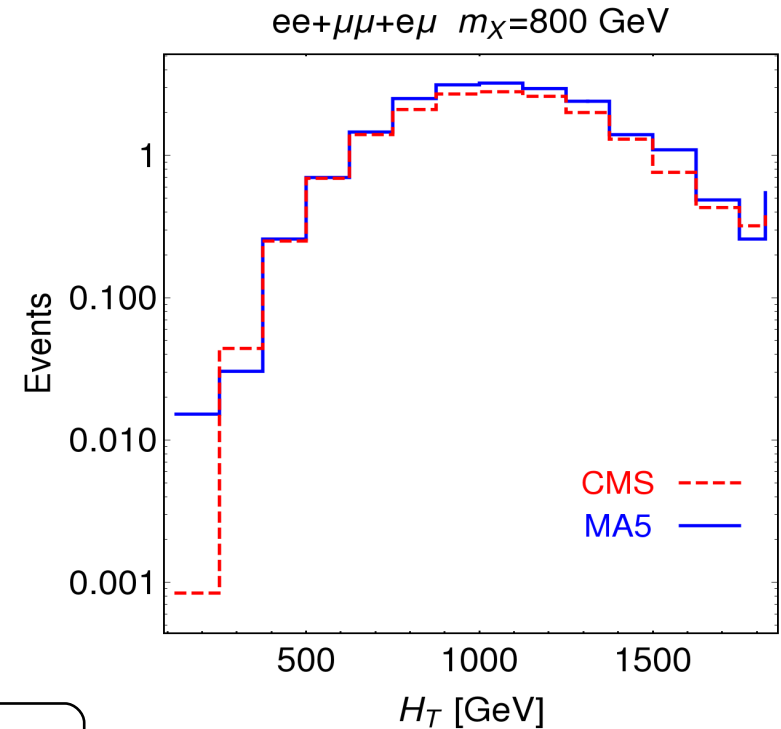
- $\alpha_T$
- $M_{T2}$
- Isolations
- ...



# Validation of a search

Compare simulations with the available information: efficiency, histograms, exclusion plots...

Signal Region	CMS official results	MA5 results
$ee$	2.1	2.3
$\mu\mu$	2.8	2.1
$e\mu$	4.7	4.2



$m_{X_{5/3}} > 790$  GeV

CMS results is 800 GeV

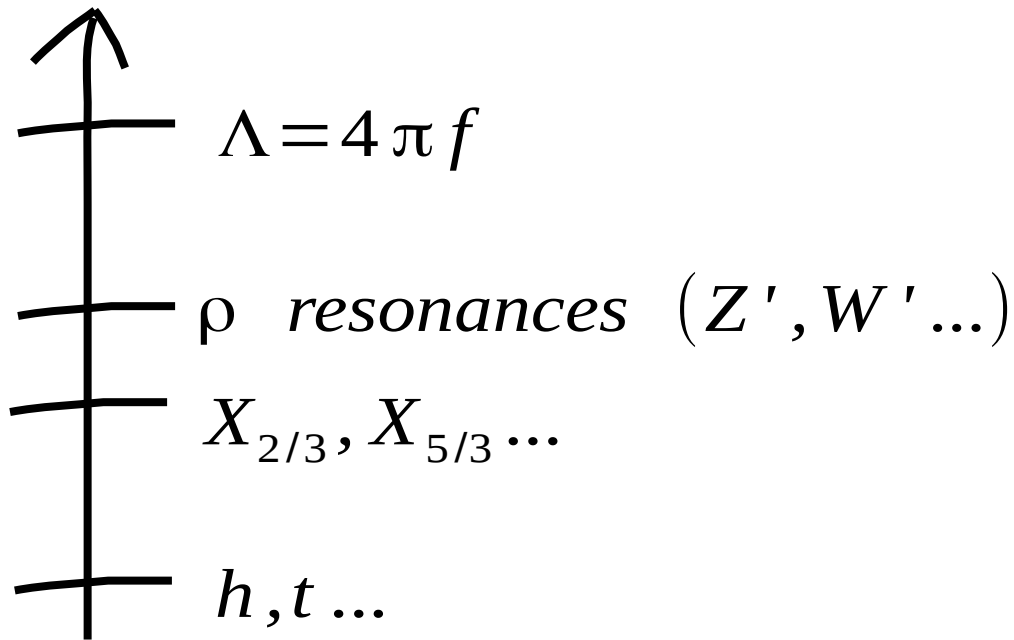
Validated!!!

# Reinterpretation of a search

Wide electroweak vector resonances in Composite Higgs Models

**Composite Higgs Models** in a nutshell

- The Higgs is assumed to be a **bound state** of a new strongly interacting sector at a scale  $f \sim \text{TeV}$
- The Higgs is light with respect to the scale  $f$  since it is assumed to be a **(pseudo) GB**
- Similar pattern for which **pions** can be described as pNGB of chiral symmetry breaking
- Many interesting phenomenological consequences, **actively searched** for at the LHC

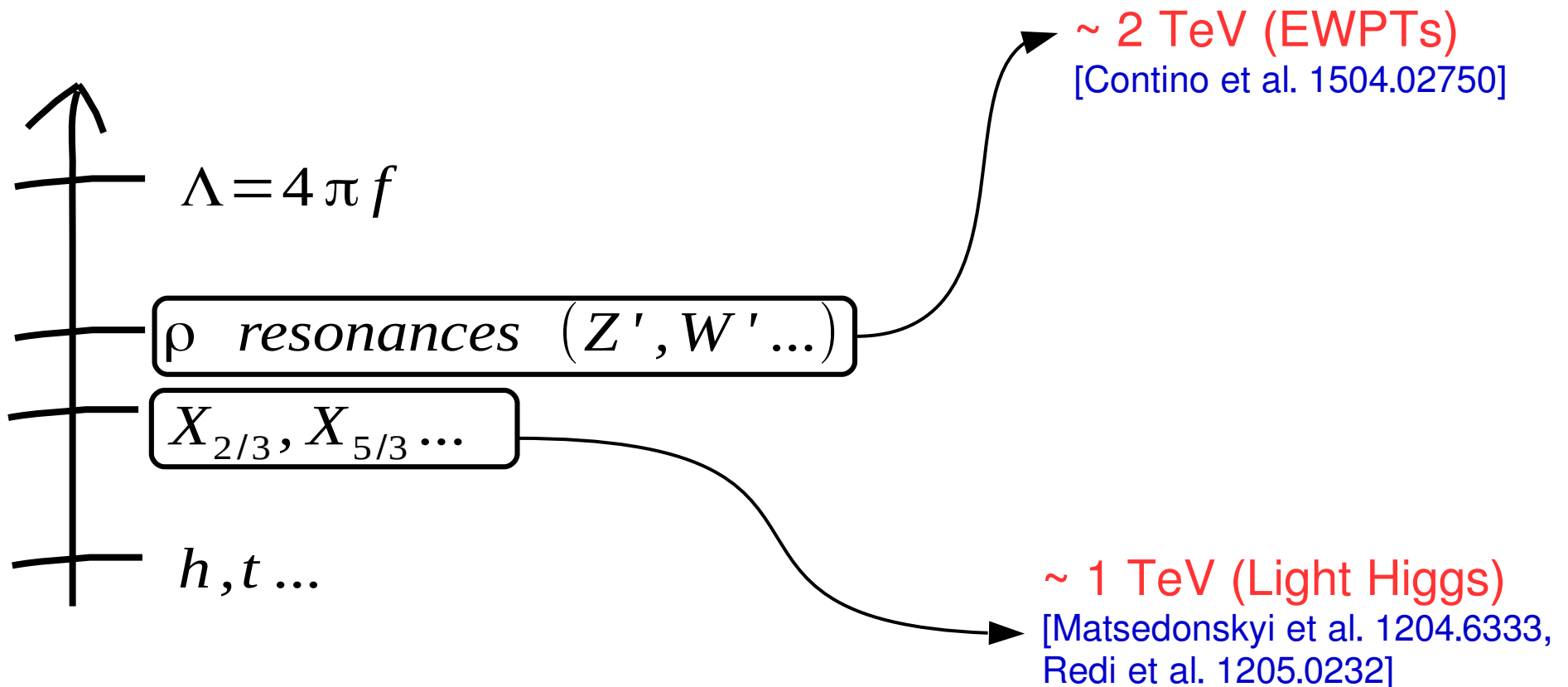


# Reinterpretation of a search

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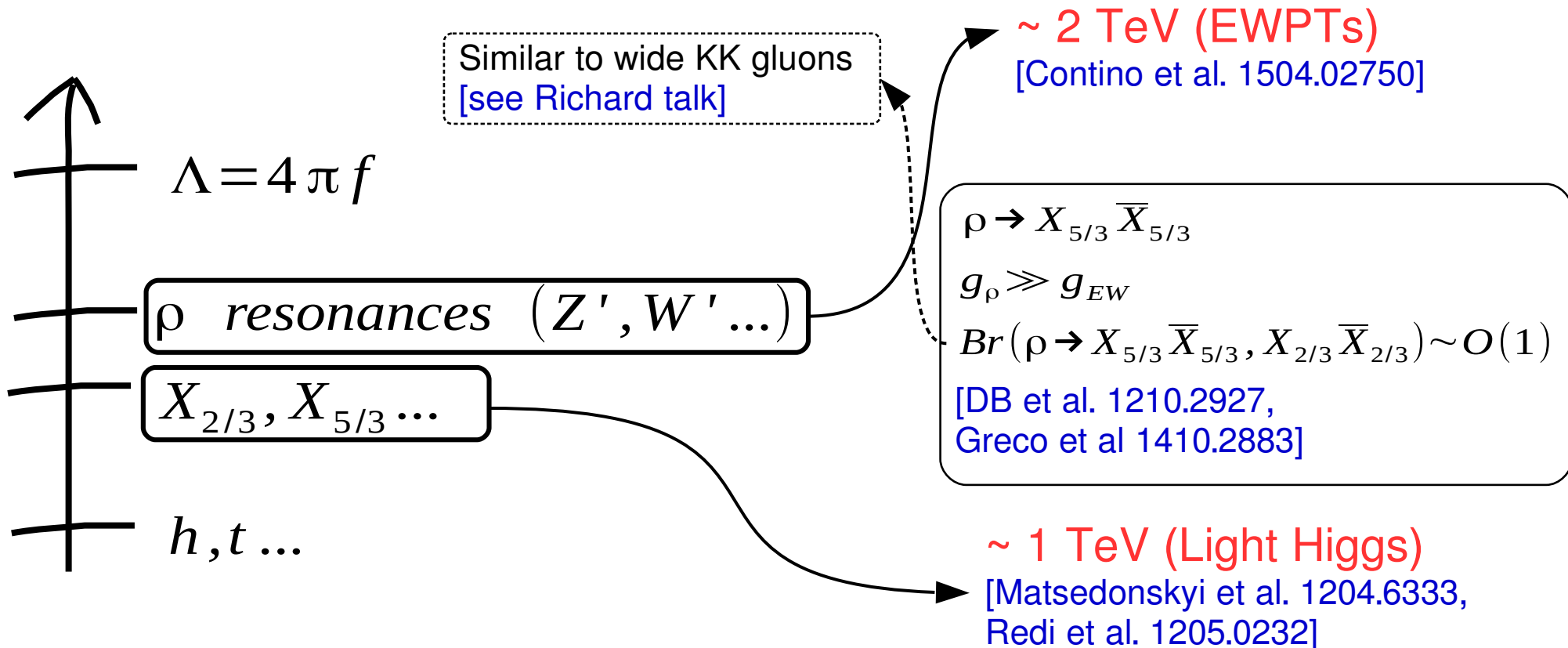


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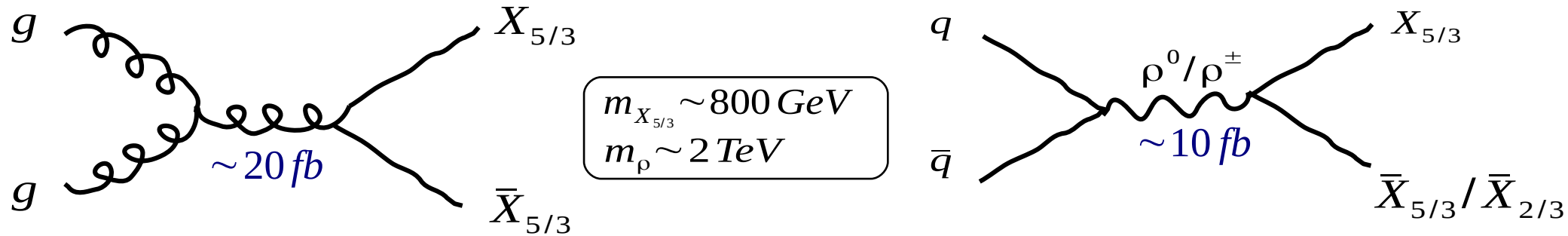


# Reinterpretation of a search

At the LHC vector resonances are searched for in [dilepton](#) and [diboson](#) channels  
Increased BRs into top partners make these search [lose sensitivity](#)  
The [stronger bound](#) is generally onset by the [S-parameter](#) [Greco et al 1410.2883]

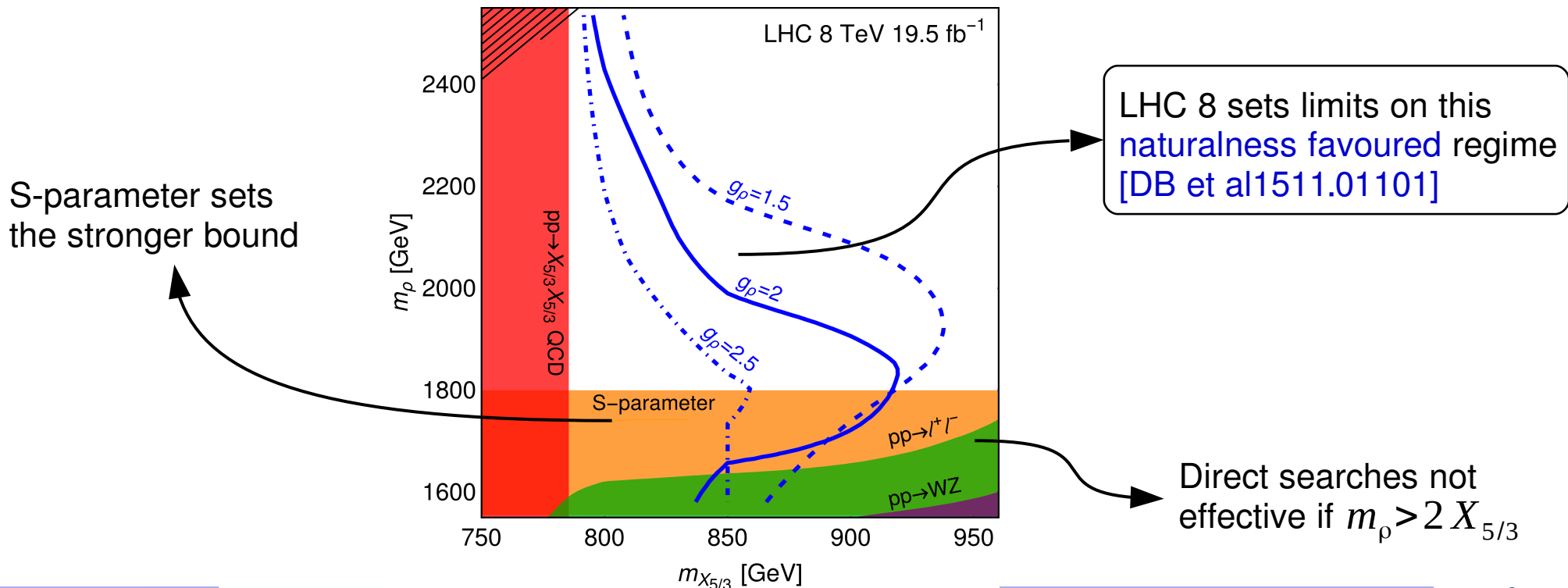
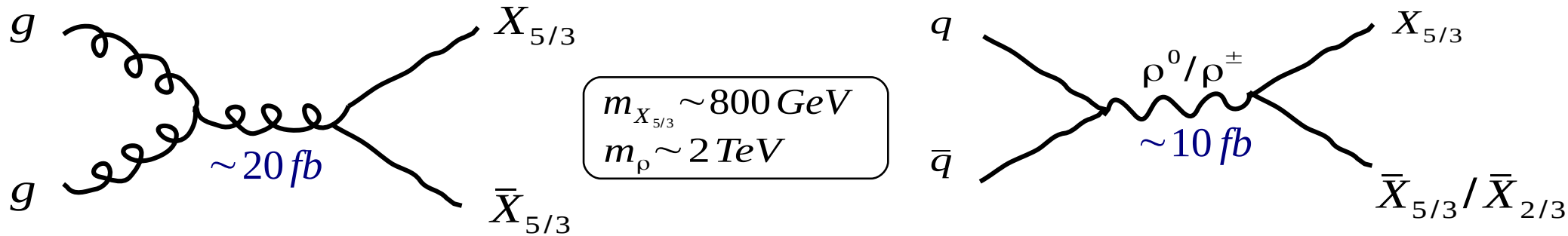
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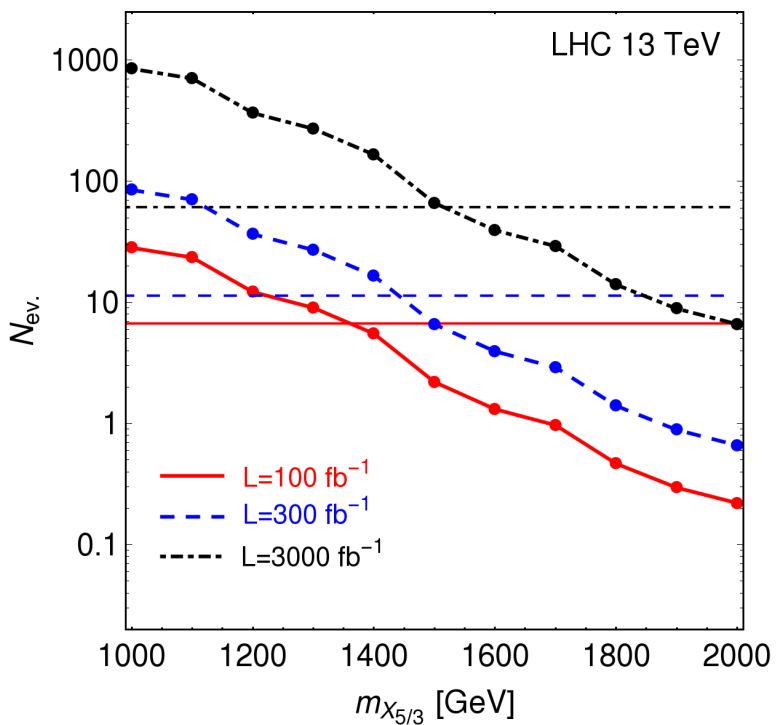


# Projections for a search

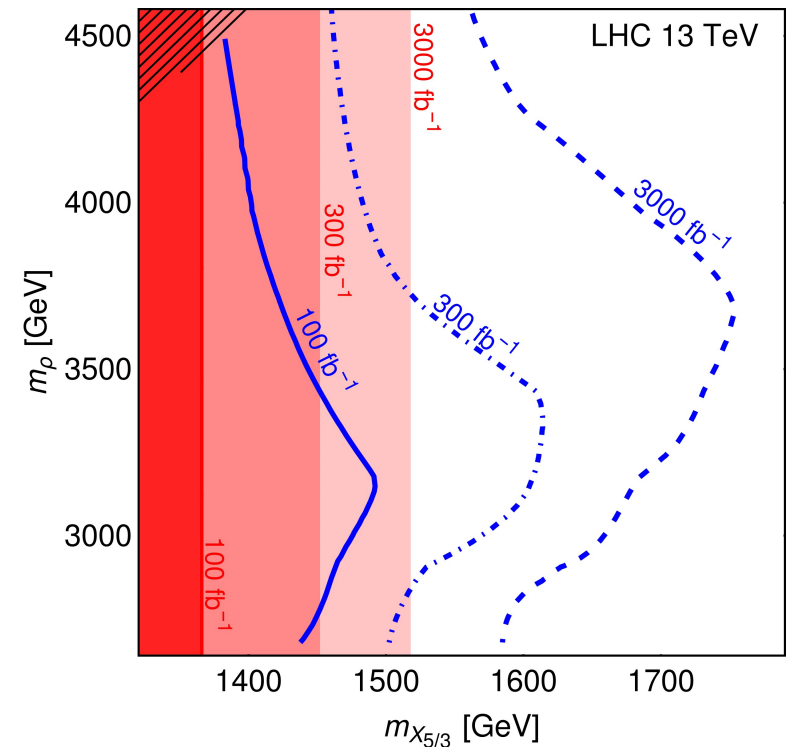
Projections for the 13 TeV LHC, increased cut threshold [DB et al1511.01101]

- $H_T > 1500 \text{ GeV}$
- $H_T + E_T^{\text{miss}} > 2000 \text{ GeV}$
- Main backgrounds  $ttZ, ttW, WW, WZ, WWW$

Only QCD pair production



QCD + EW production





# Conclusions

- Reinterpreting the LHC analyses is crucial to fully exploit the data that the LHC has delivered
- Two complementary approaches are possible: [simplified models](#) and data [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
- Reinterpretation of dedicated searches useful to constrain otherwise [elusive](#) particles

- The MadAnalysis 5 framework is an [active project](#)
- Soon new features within the package, that will allow an [easier](#) and [more automatic](#) recast of the searches present in the PAD
- 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
- The shared analyses can be [cited](#) by other studies

# Thank you!!!