SModelS

– a Tool for Making Systematic Use of Simplified Models Results

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In collaboration with the SModelS group
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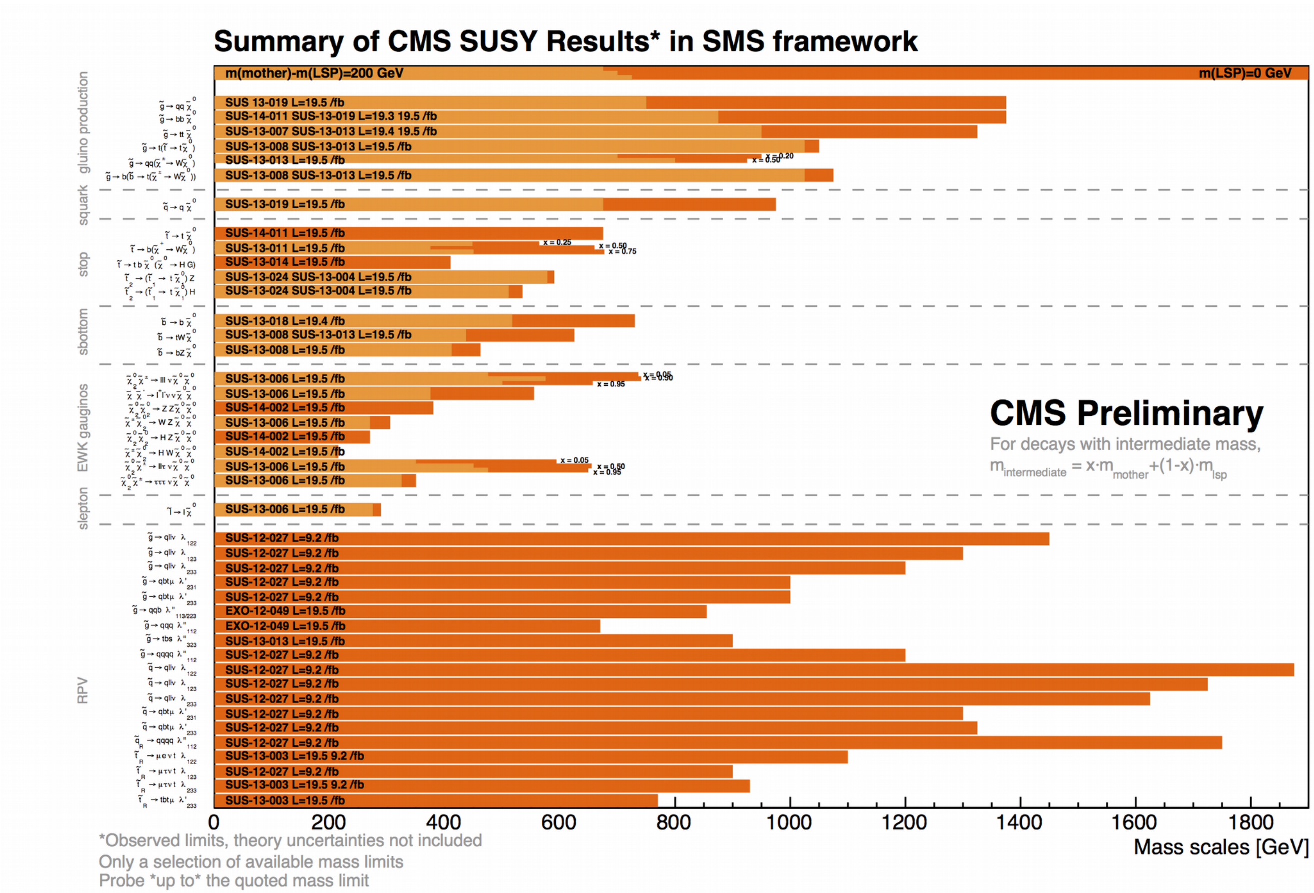
LHCP 2016
Lund, Sweden, 13 – 18 June 2016

Searching for Physics Beyond the Standard Model

A huge number of searches for BSM physics has been performed by CMS and ATLAS:



CMS,
8 TeV results
SUSY,
ICHEP 2014

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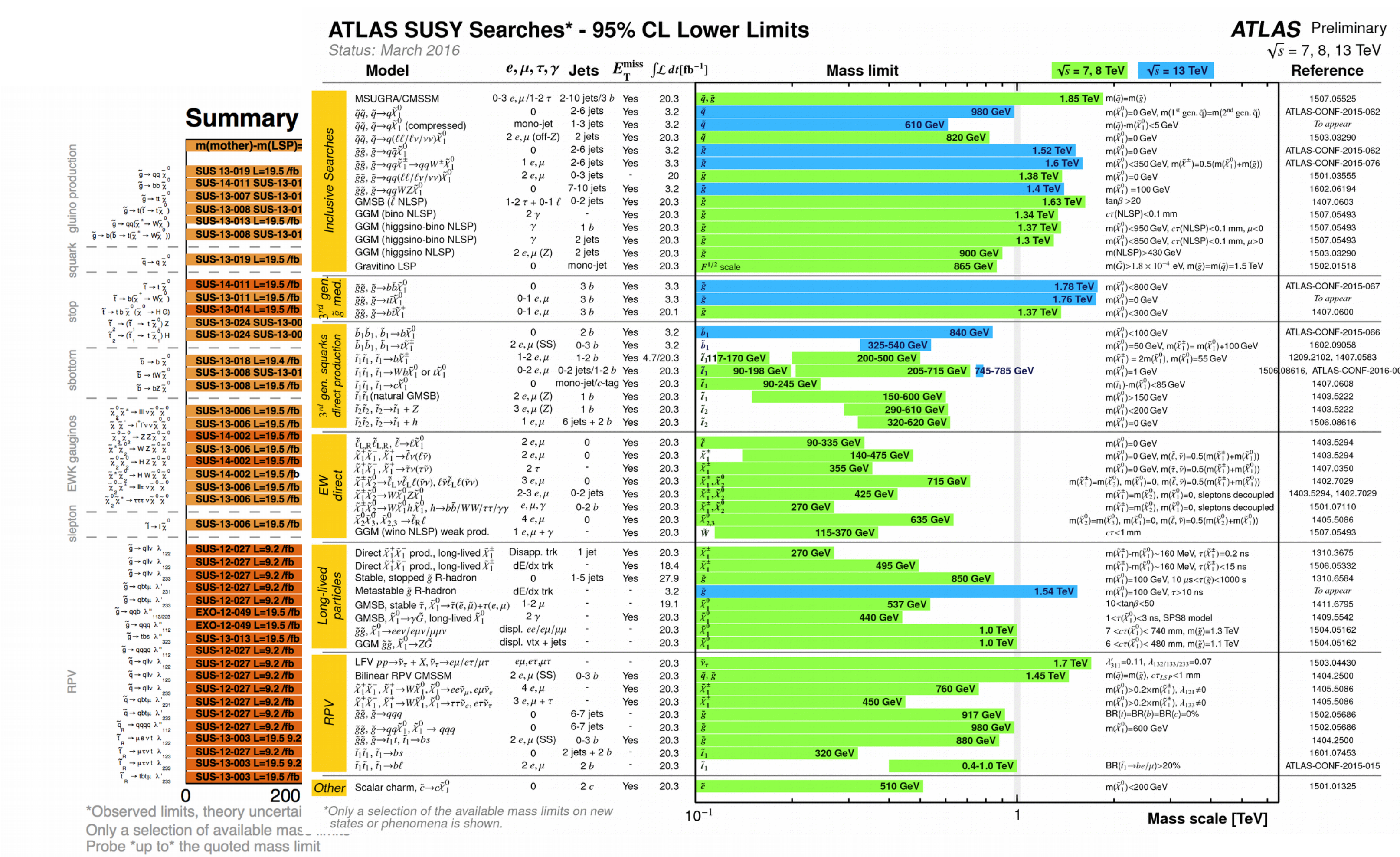

ATLAS
7 + 8 + 13 TeV
SUSY
March 2016
(incomplete!)

Searching for Physics Beyond the Standard Model

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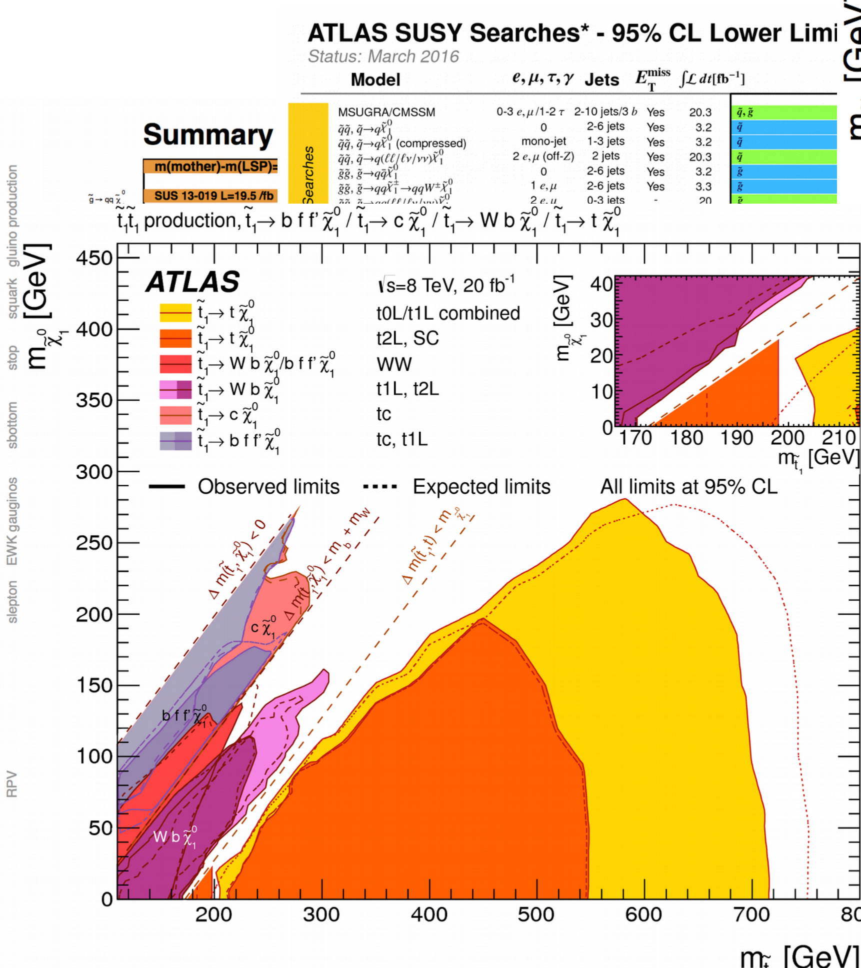
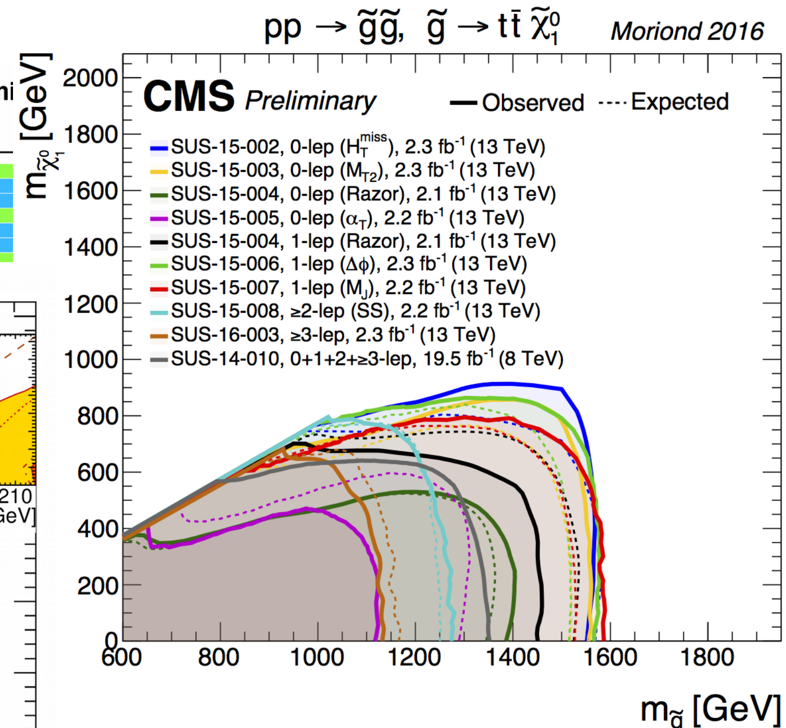
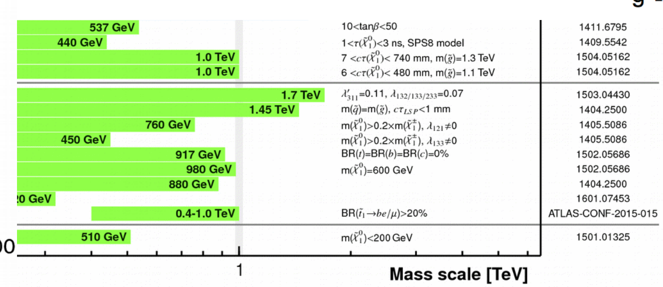


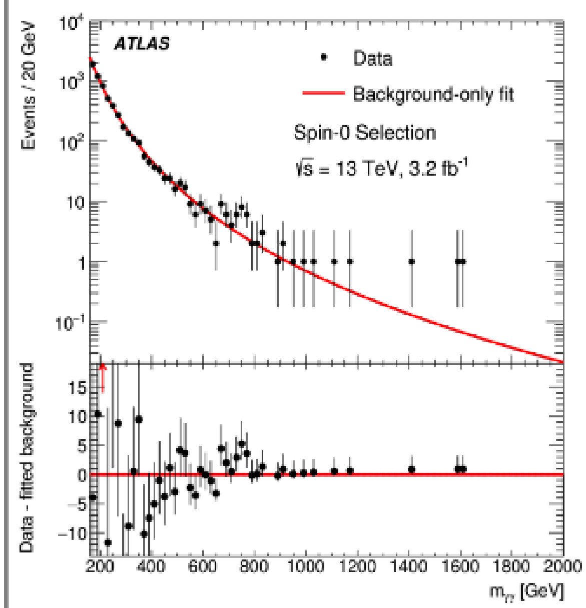
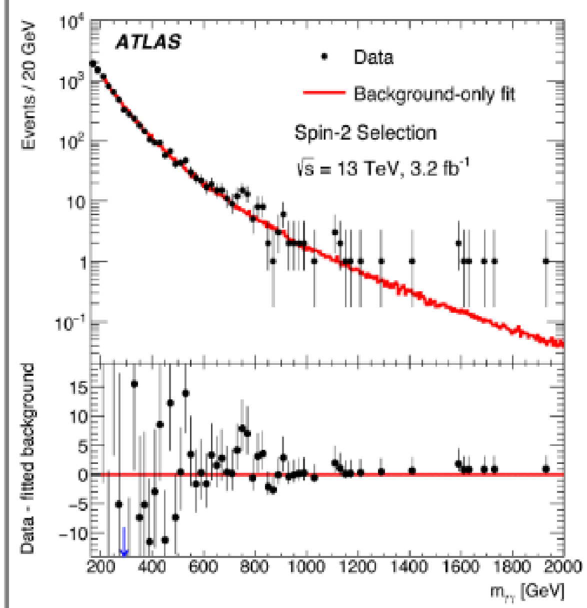




CMS & ATLAS 13 TeV

Searching for Physics Beyond the Standard Model

Yes, in addition to all the null results we see mild excesses e.g. in the 750 GeV di-photons:

Analysis	**Spin-0**	**Spin-2**
Target	Extended Higgs sector	KK-graviton
Selection	2 isolated-γ's: $E_T/m_{\gamma\gamma}$> 0.3, 0.4	2 isolated-γ's: $E_T(\gamma_{1,2})$>55, 55 GeV
$m_{\gamma\gamma}$ spectrum		

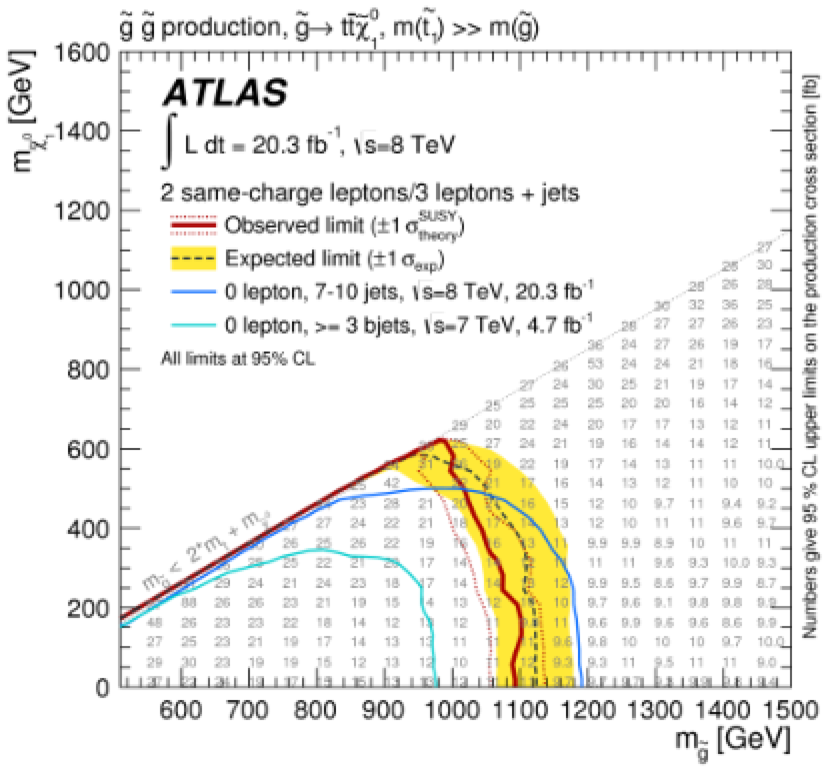
Using 3.2 fb^{-1} of $\sqrt{s}$ = 13 TeV data collected in 2015

16

Taken from Thorsten Wengler (monday plenary)

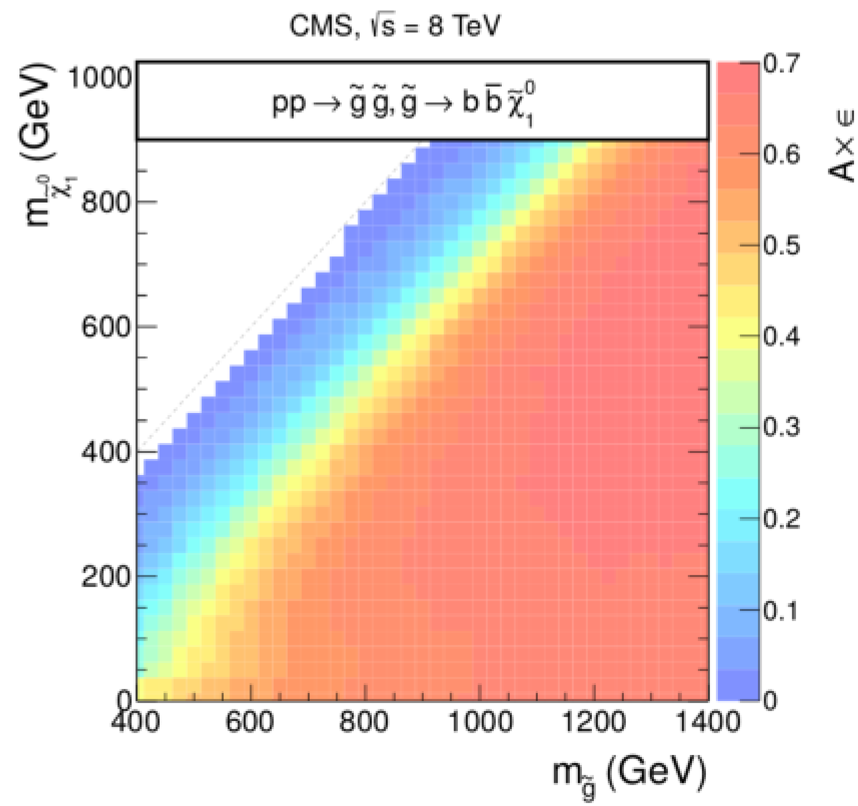
Null results for BSM searches are typically presented as:

Upper Limit (UL) maps:



(ATLAS SUSY-2013-09)

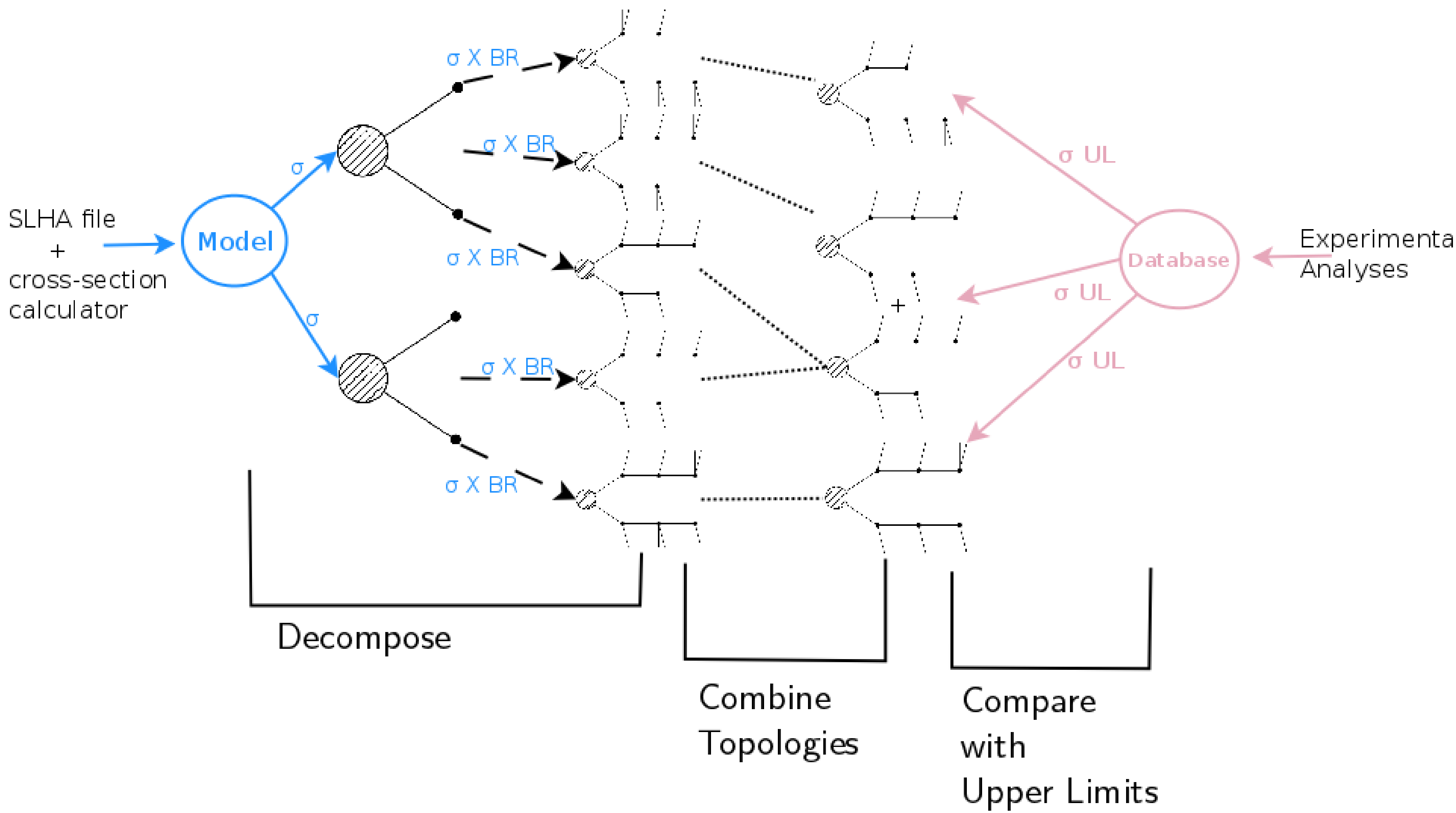
Efficiency maps:



(CMS SUS-12-024)

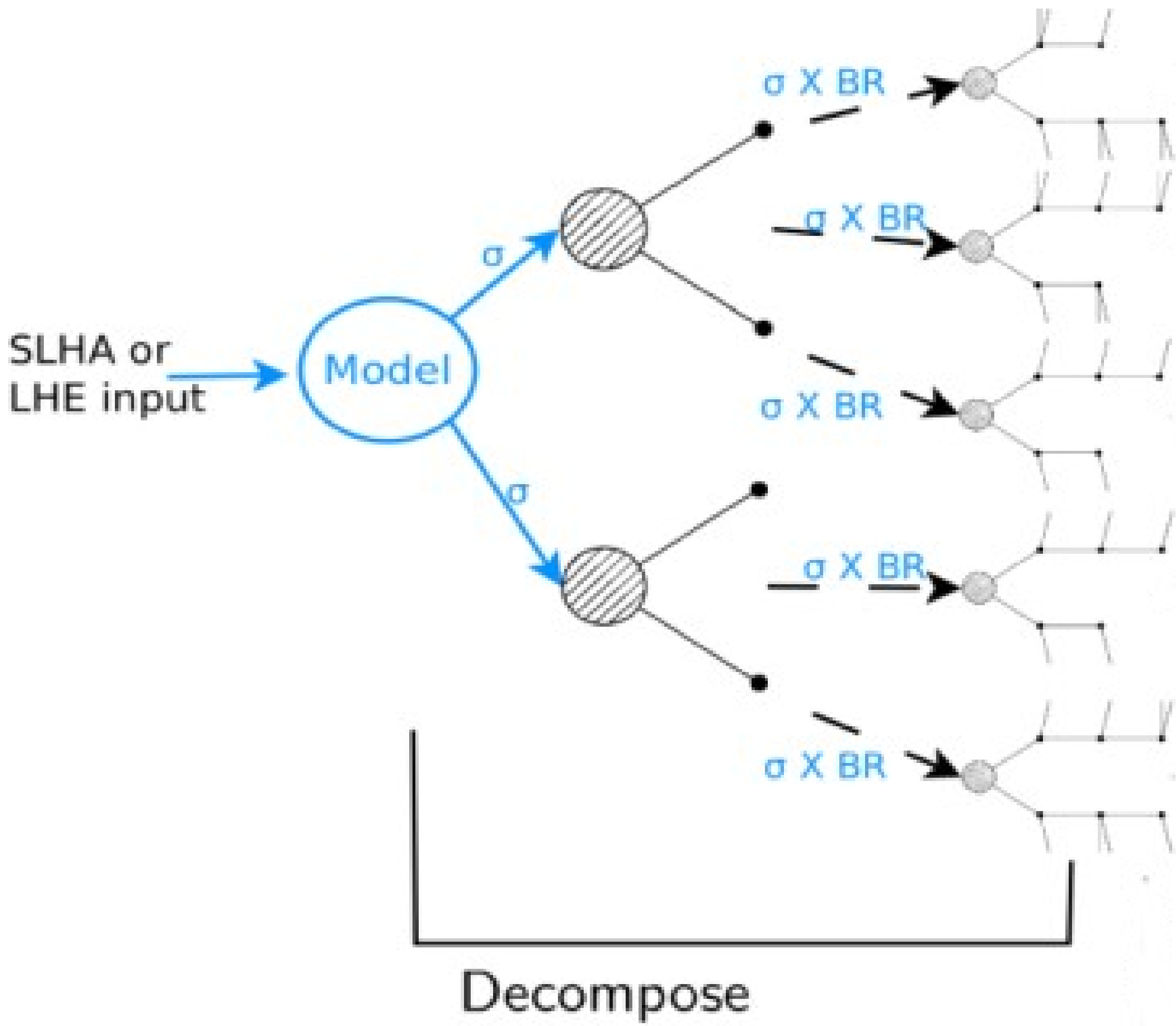
SModelS

– a tool for making systematic use of simplified models null results



How SModelS works:

1) Decomposition of a fundamental model



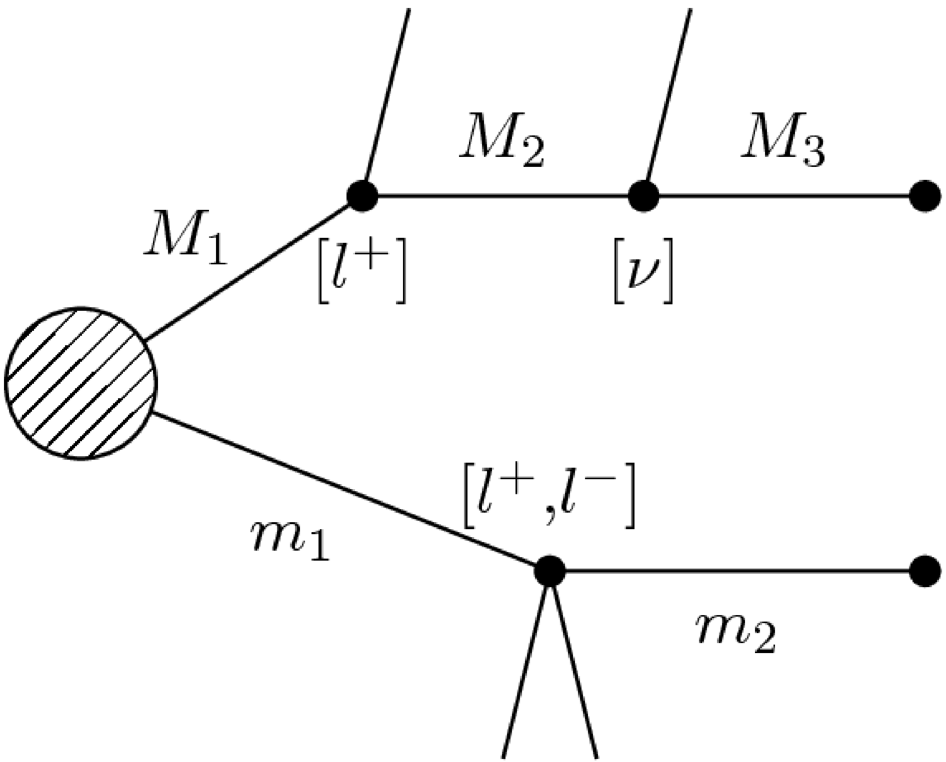
Input: SLHA file (mass spectrum, BRs) or LHE file (parton level)

Currently the model must have a $\mathbf{Z}_2$ symmetry

The decomposition produces a set of simplified model topologies (dubbed “elements”)

How SModelS works:

Simplified Model Topology:



$= [[l^+],[\nu]]$

$= [[l^+,l^-]]$

$= [\ [[l^+],[\nu]]\ ,\ [[l^+,l^-]]\ ]$
$([[M_1,M_2,M_3],[m_1,m_2]])$

Each topology is described by:

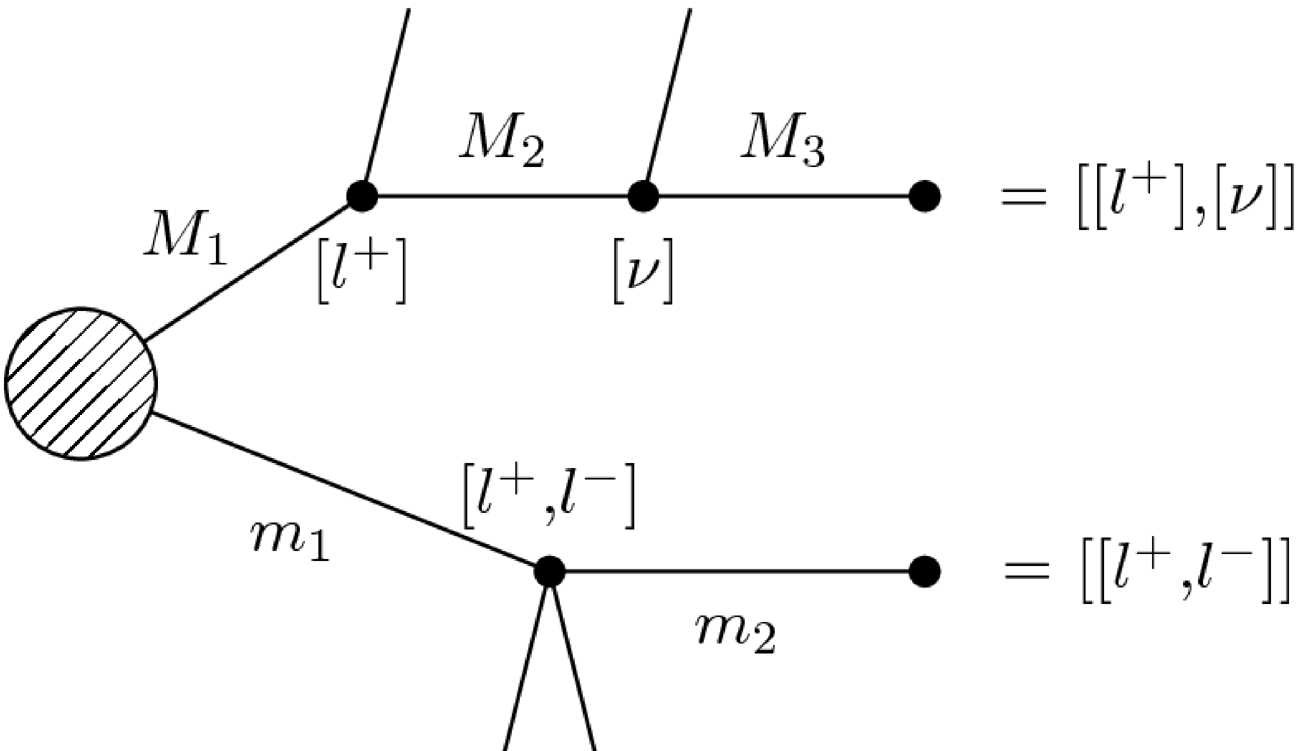
- Topology shape + final states
- BSM masses
- σ x BR

We (currently) ignore spin, color, etc of the BSM particles

It is model independent, there is no reference to the original model

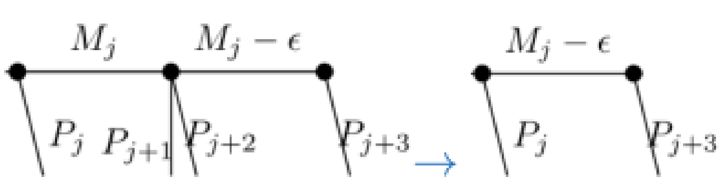
How SModelS works:

Simplified Model Topology:

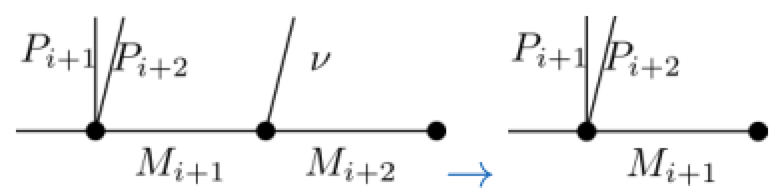


$$= [\ [[l^+],[\nu]]\ ,\ [[l^+,l^-]]\ ]$$
$$([[M_1,M_2,M_3],[m_1,m_2]])$$

Soft particles are ommitted:



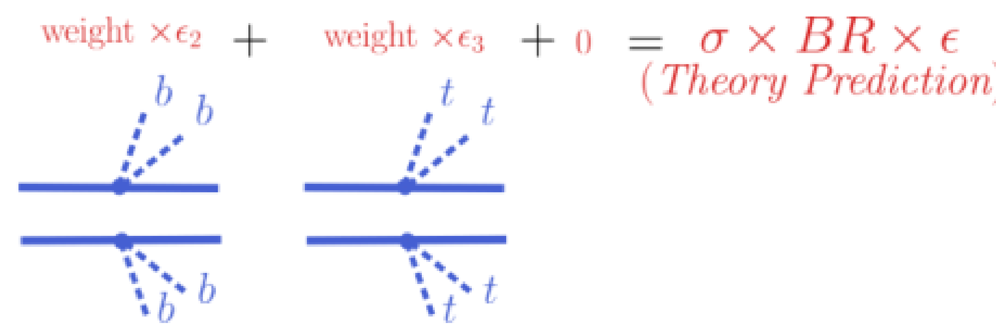
Invisible final states are grouped into effective LSPs:

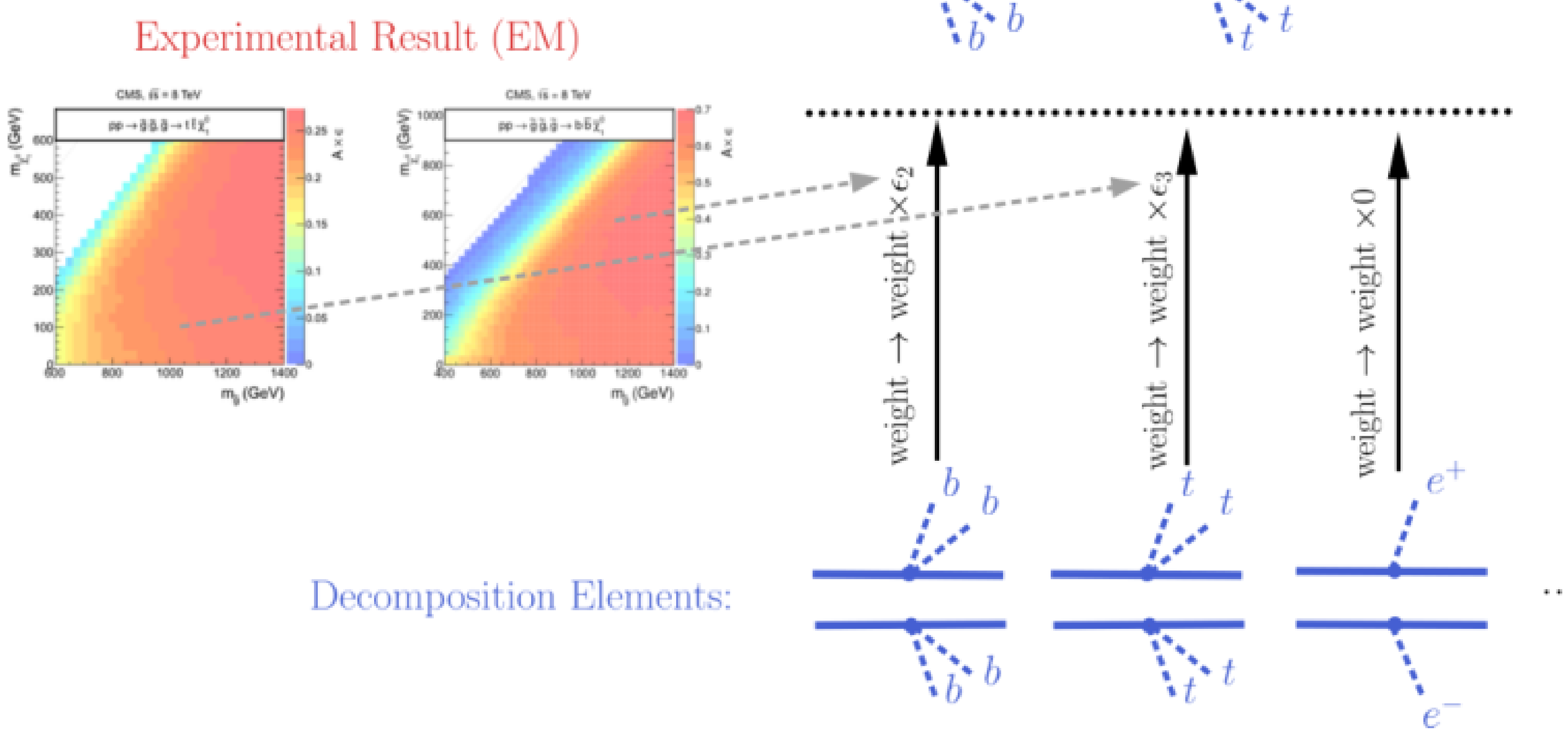


How SModelS works:

2) Computation of predicted signal strength:

For **efficiency map results** we have signal efficiencies for various “elements”, and we can add them together:

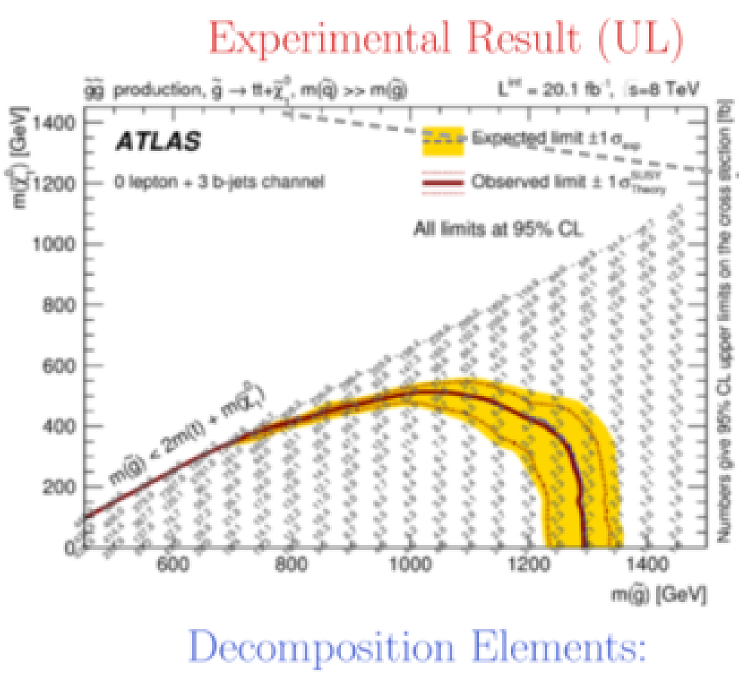


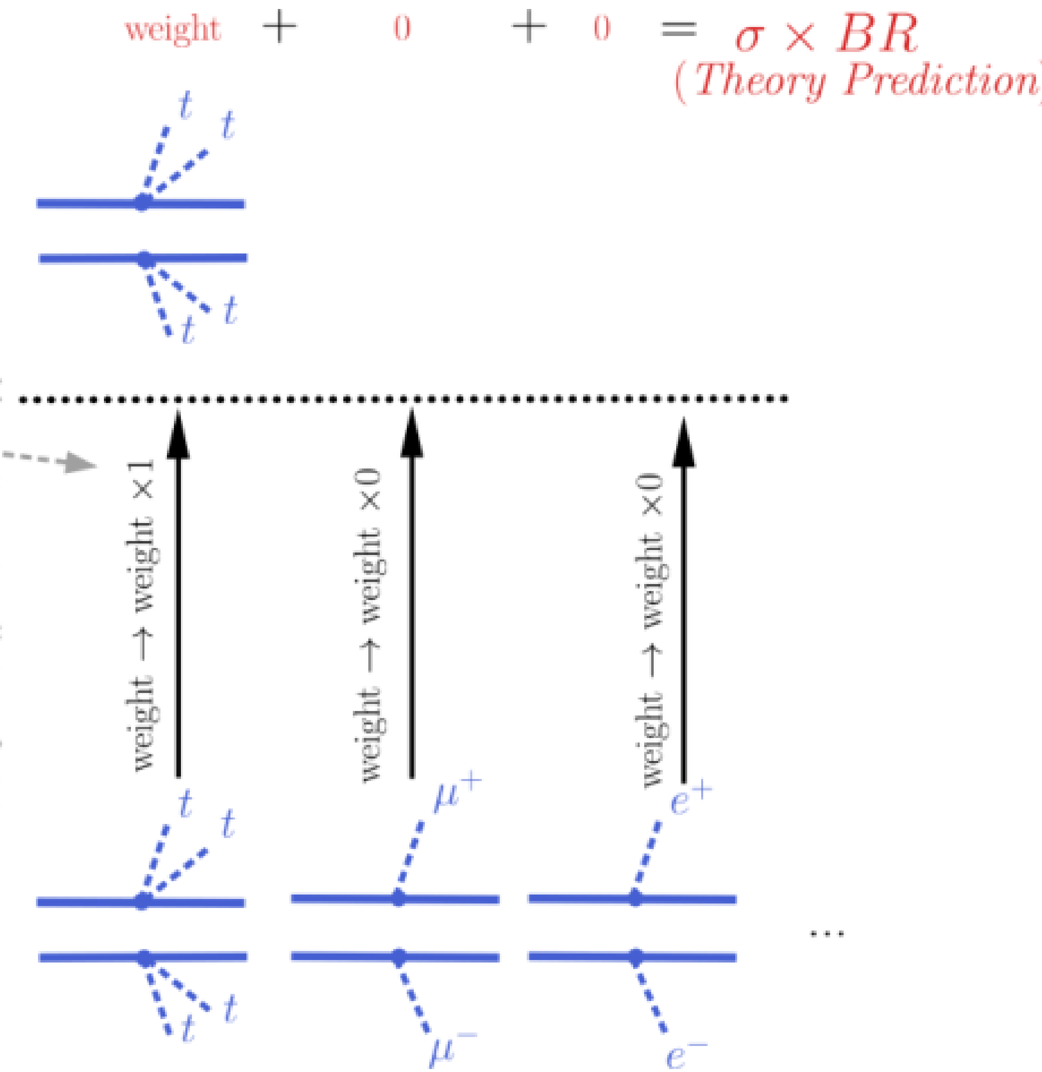


How SModelS works:

2) Computation of predicted signal strength:

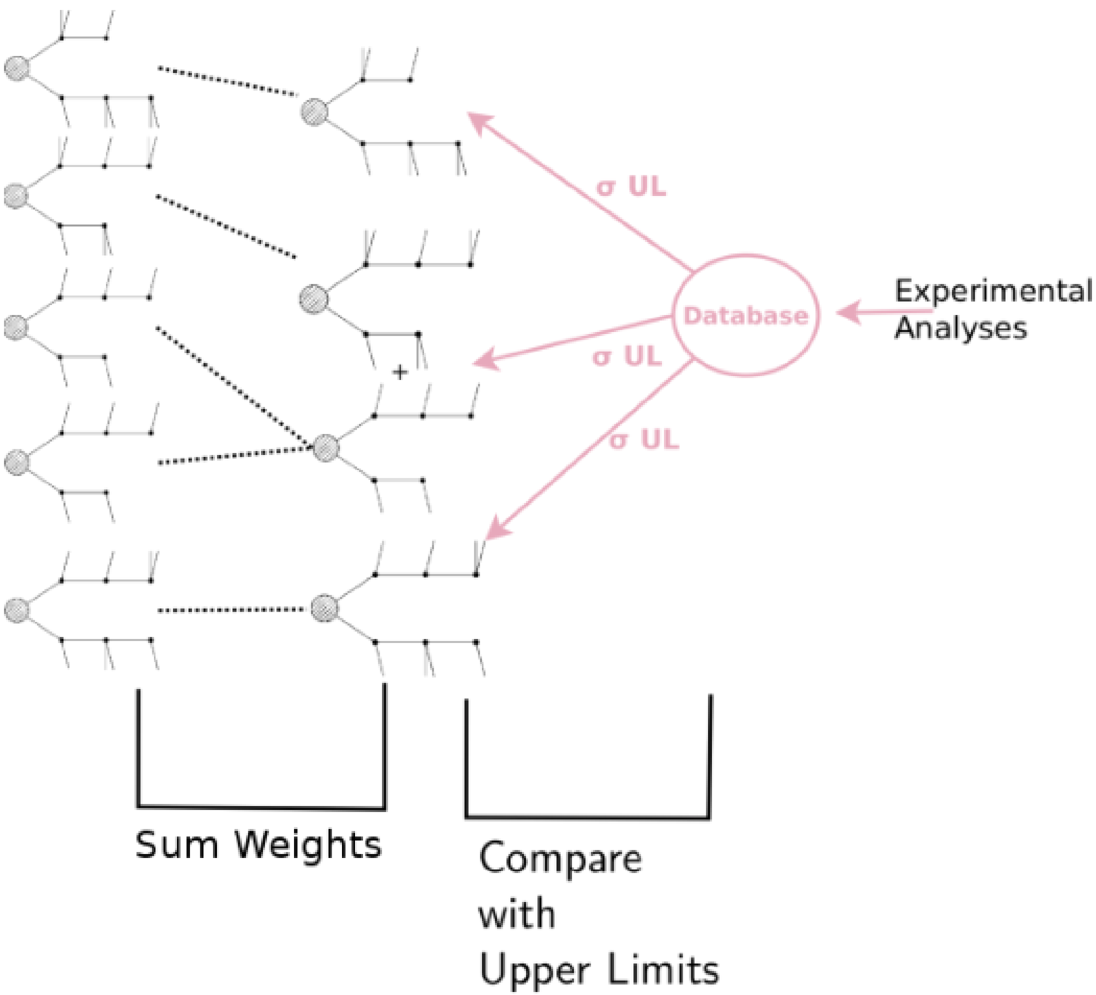
Upper limit results we cannot add up:





How SModelS works:

3) Comparison of predicted signal strengths with experimental result:



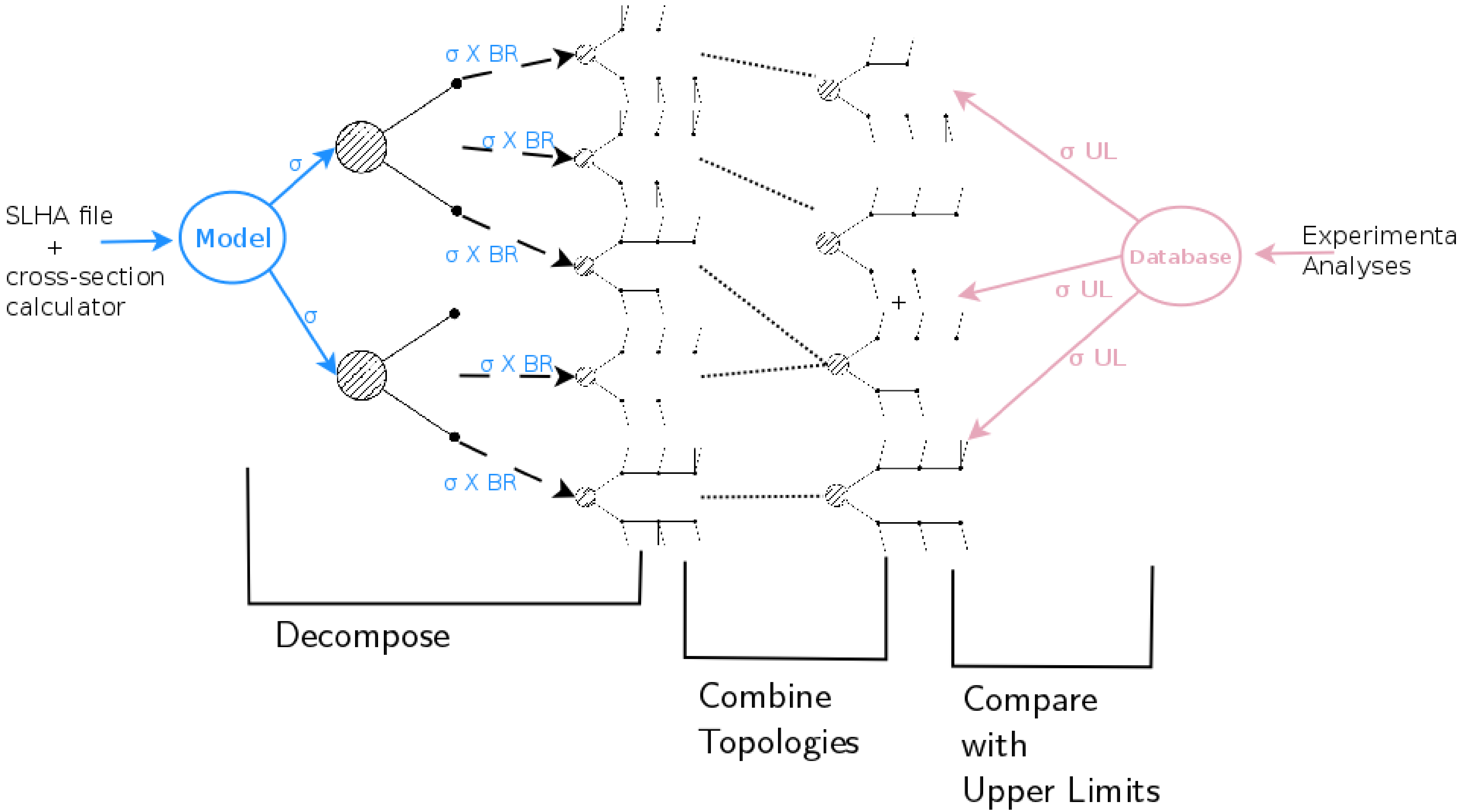
- **Upper Limit Results:**
  Predicted signal strength = σ x BR
  Experimental result: σ_{UL}

- **Efficiency Map Results:**
  Predicted signal strength = ∑ σ x BR x ε
  Experimental result: σ_{UL}=N_{UL}/ L from $N_{observed}$, expected(BG), error(BG)

- r = predicted / σ_{UL}

- Model is excluded if most constraining analysis has r > 1

How SModelS works:



What's in the database?

∼ 30 ATLAS CONF-Notes/publications

Experimental Result	$\sqrt{s}$	lumi	data type
ATLAS-CONF-2012-105	8	5.8	upperLimit
ATLAS-CONF-2012-166	8	13.0	upperLimit
ATLAS-CONF-2013-001	8	12.8	upperLimit
ATLAS-CONF-2013-007	8	20.7	upperLimit
...	...	...	...
ATLAS-SUSY-2013-14	8	20.3	upperLimit
ATLAS-SUSY-2013-15	8	20.3	efficiencyMap
ATLAS-SUSY-2013-15	8	20.3	upperLimit
ATLAS-SUSY-2013-16	8	20.1	efficiencyMap
ATLAS-SUSY-2013-16	8	20.1	upperLimit
ATLAS-SUSY-2013-18	8	20.1	efficiencyMap
ATLAS-SUSY-2013-18	8	20.1	upperLimit
ATLAS-SUSY-2013-19	8	20.3	upperLimit
ATLAS-SUSY-2013-23	8	20.3	upperLimit
ATLAS-SUSY-2014-03	8	20.3	efficiencyMap
ATLAS-SUSY-2015-09	13	3.2	upperLimit

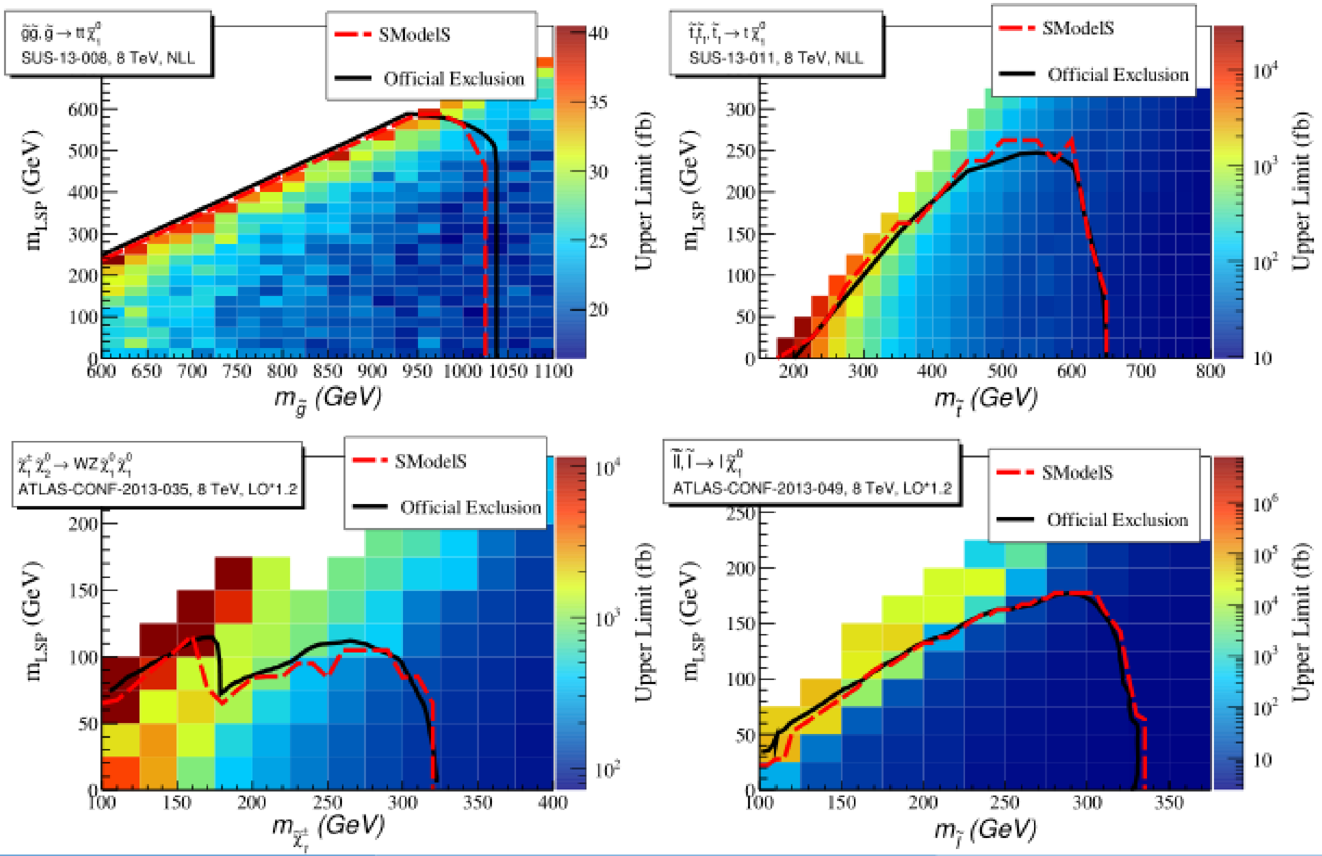
∼ 20 CMS CONF-Notes/publications

Experimental Result	$\sqrt{s}$	lumi	data type
CMS-SUS-12-024	8	19.4	efficiencyMap
CMS-SUS-12-024	8	19.4	upperLimit
CMS-SUS-12-028	8	11.7	upperLimit
CMS-SUS-13-002	8	19.5	upperLimit
CMS-SUS-13-004	8	19.3	upperLimit
CMS-SUS-13-006	8	19.5	upperLimit
CMS-SUS-13-007	8	19.3	efficiencyMap
CMS-SUS-13-007	8	19.3	upperLimit
CMS-SUS-13-011	8	19.5	efficiencyMap
CMS-SUS-13-011	8	19.5	upperLimit
CMS-SUS-13-012	8	19.5	efficiencyMap
CMS-SUS-13-012	8	19.5	upperLimit
CMS-SUS-13-015	8	19.4	efficiencyMap
CMS-SUS-13-015	8	19.4	upperLimit
CMS-SUS-13-019	8	19.5	upperLimit
...	...	...	...
CMS-SUS-PAS-13-016	8	19.7	upperLimit
CMS-SUS-PAS-13-018	8	19.4	upperLimit
CMS-SUS-PAS-15-002	13	2.2	upperLimit

We can and will (and do) extend our database by using efficiency maps produced outside the experimental collaborations (using recasting tools like MadAnalysis5)

Validation

For validating our database, we define:
full model := simplified model
And check if we can reproduce the official exclusion curves.
When we have efficiencies, we can also check σ_{UL} for every point in the “mass planes”:



Physics Applications

SModelS has so far been used to:

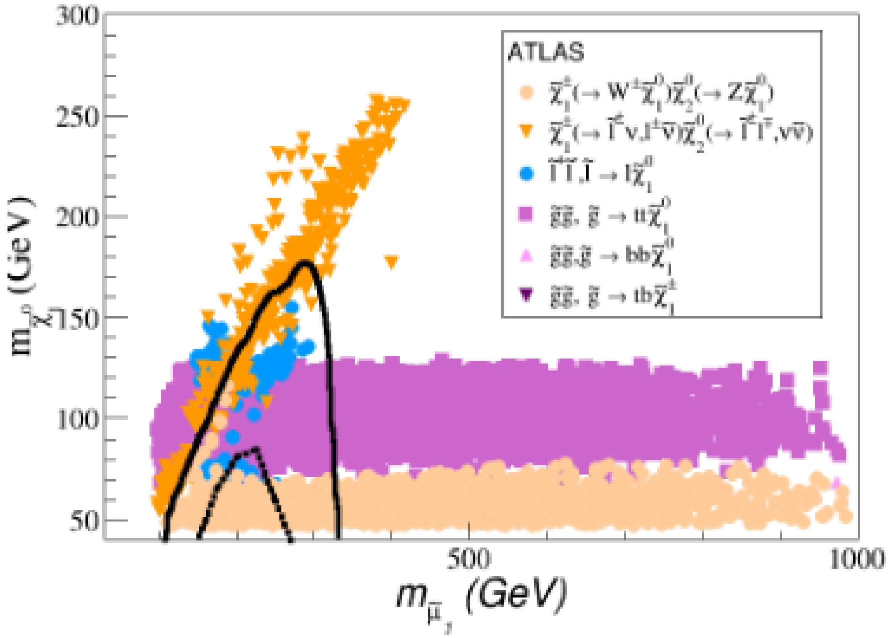
-) quickly identify regions of model parameter space that can easily be excluded by analyses, before employing more “heavy weight” strategies for exploring model parameter spaces.

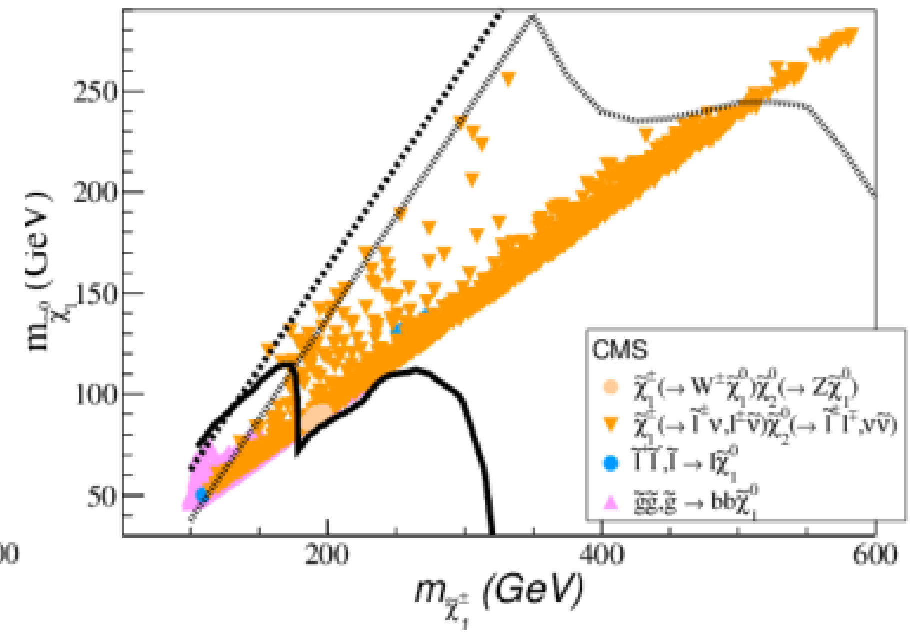
-) identify the most constraining analyses for a model

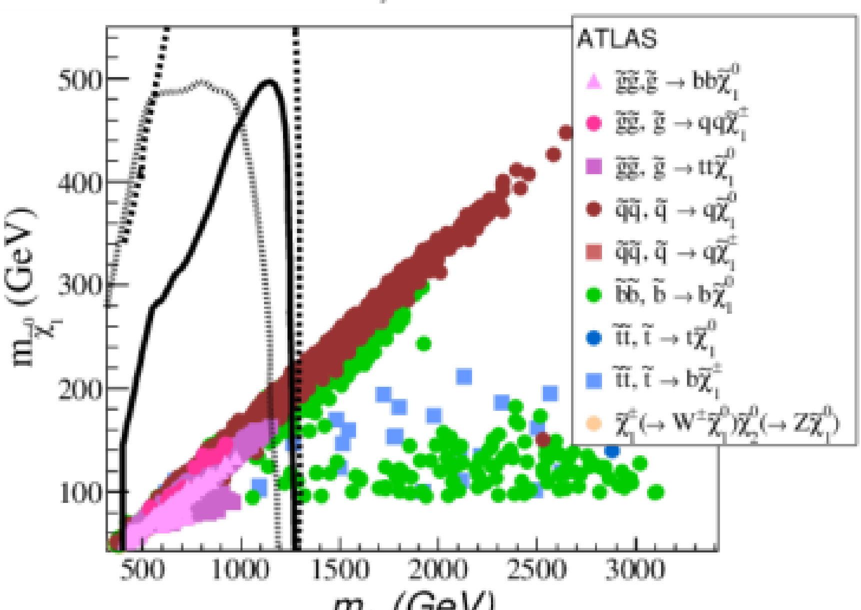
-) identify topologies and regions of parameter space that CMS and ATLAS are blind to.

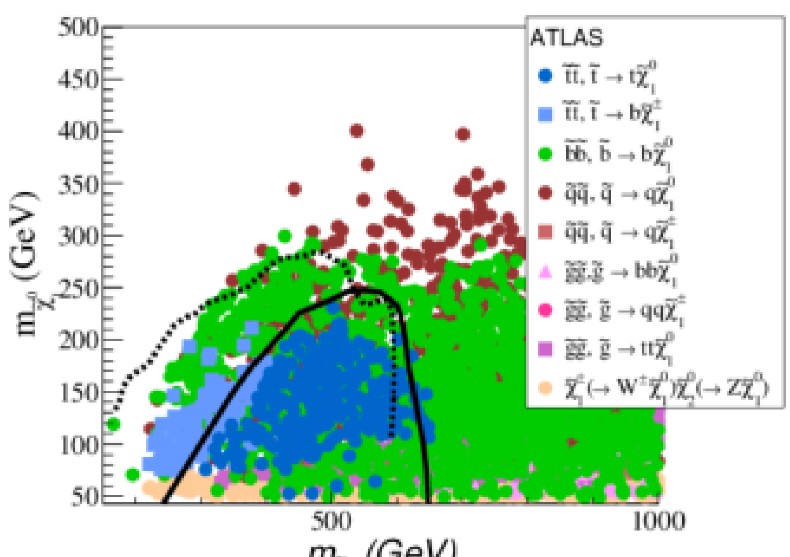
-) Very quickly recast results to different models

Physics Applications

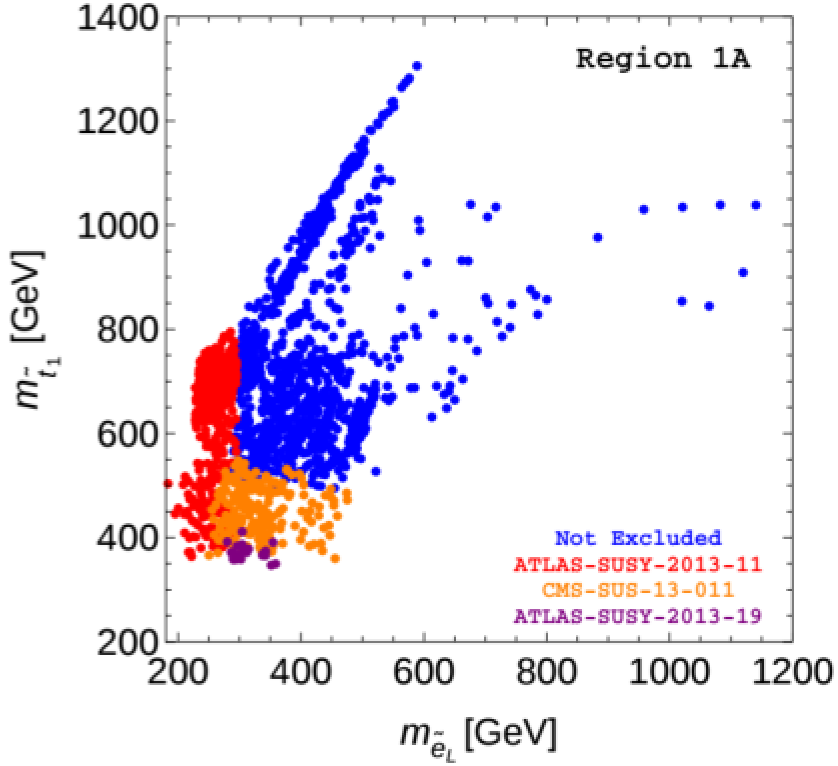




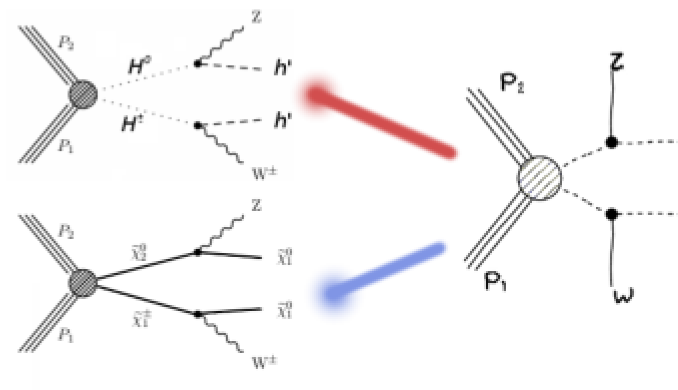


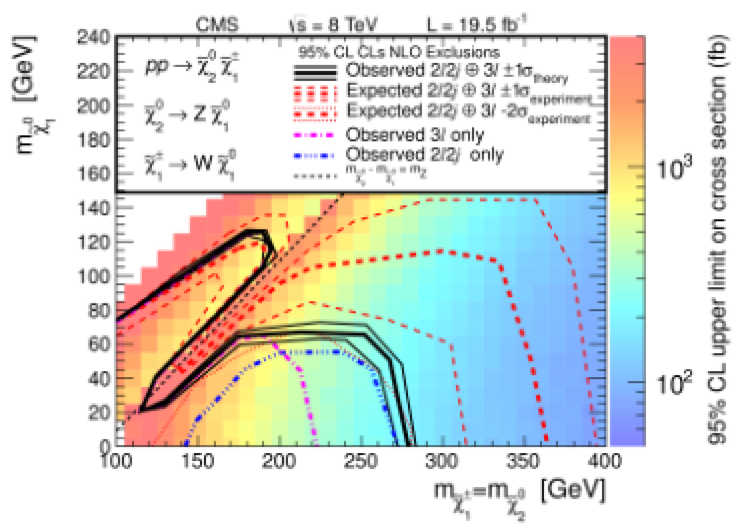


Physics Applications



D. Barducci, G. Bélanger, C. Hugonie and A. Pukhov, JHEP 1601 (2016) 050





⇒ LHC constraints on 2HDM

Availability

SModelS is written entirely in python and is available here:

http://smodels.hephy.at

It uses pythia and nllfast for the computation of the cross sections.

Future

We intend to extend the functionality of SModelS in several ways:

- Extend to non-Z_2 / non-MET topologies
- Extend to long-lived particles (HCSP scenarios)
- Make use of likelihoods
- Make use of positive results (“excesses”)

Summary

SModelS can be used to quickly:

- Identify the most constraining topologies and analyses for a given model
- Identify the topologies missed by CMS and ATLAS
- Recast results to different scenarios
- Since it does not have to run simulations, it is very fast

Limitations:

- It is tied to the simplified models results, for upper limit maps it is overly conservative
- No simplified models results available for long decay chains
- It is only as good as its database of results

Thanks!