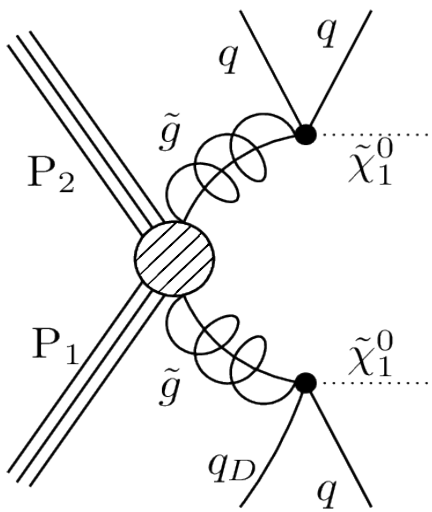
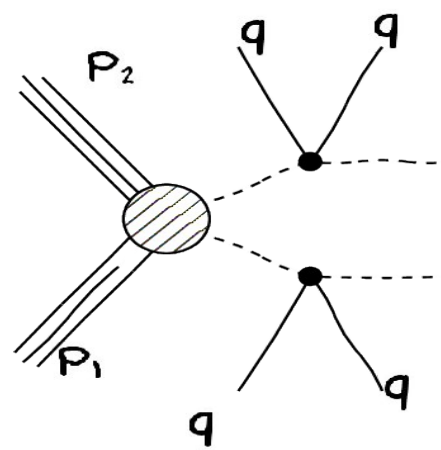
SModelS

Making systematic use of the experimental simplified models results



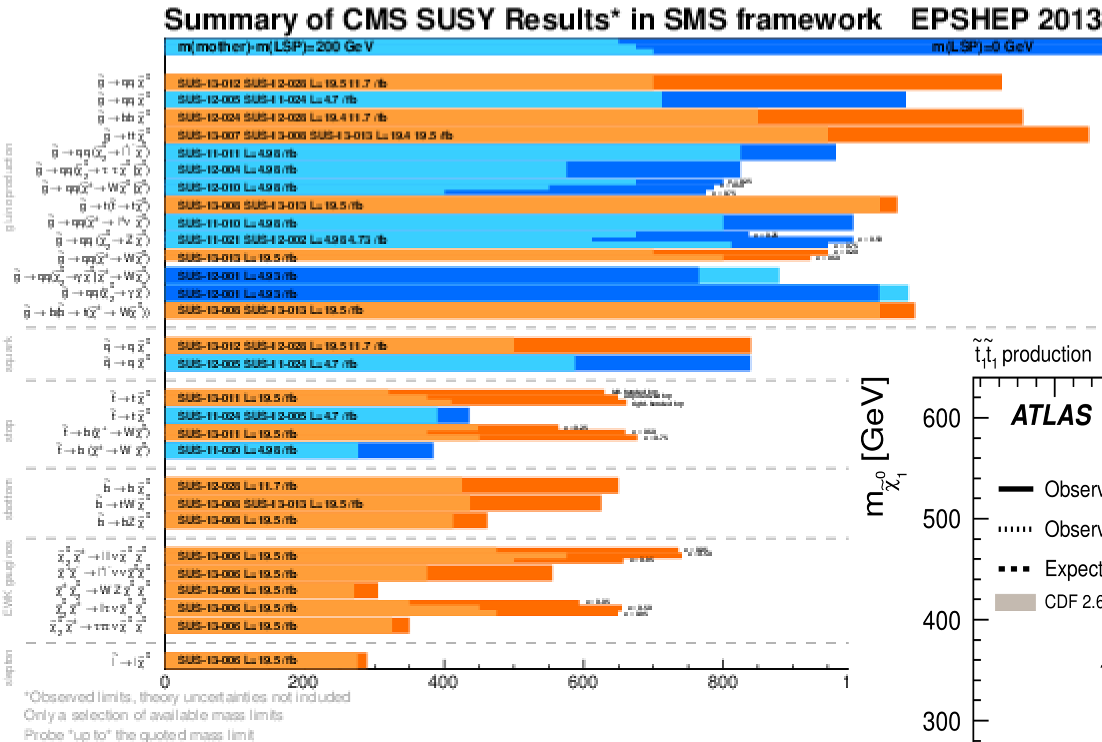


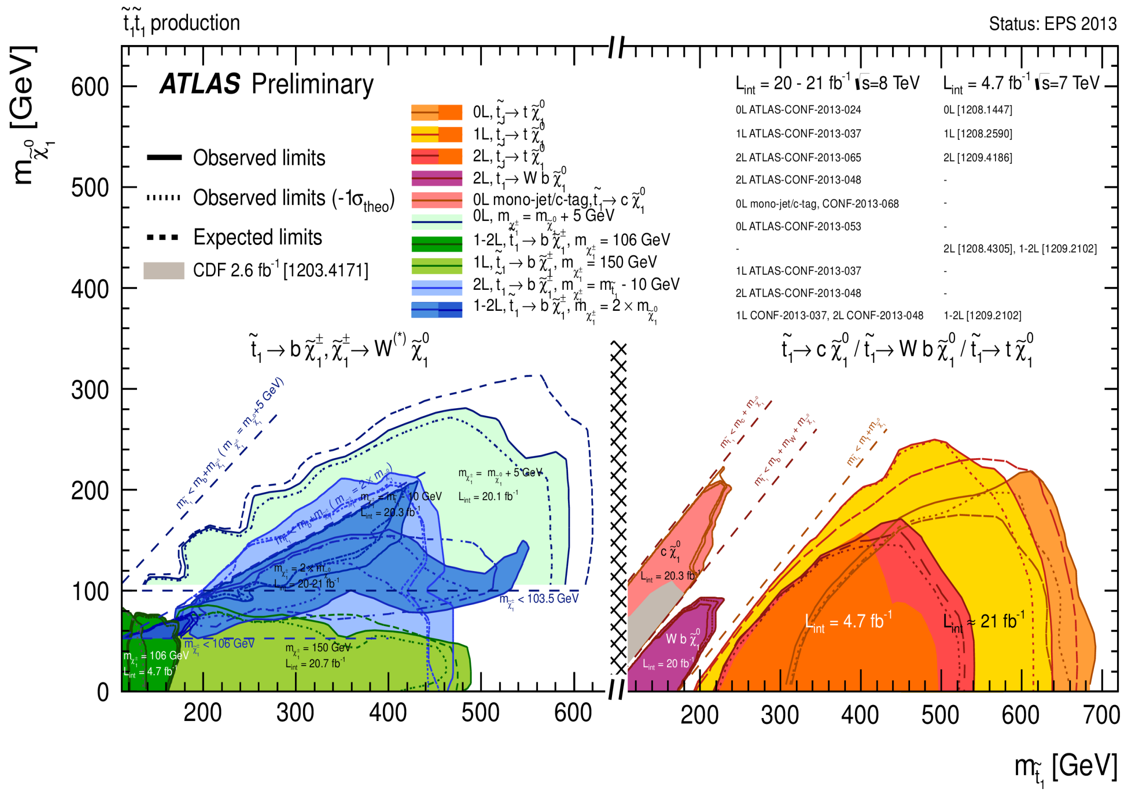
Sabine Kraml (LPSC Grenoble), Suchita Kulkarni (LPSC Grenoble), Ursula Laa (HEPHY), Andre Lessa (USP São Paulo), Doris Proschofsky (HEPHY), Wolfgang Waltenberger (HEPHY)

SUSY13 conference, Trieste, Italy, August 2013

The motivation

Motivation





Aim:

To make maximum use of experimental SMS results in the interpretation of BSM models

The idea

The idea

– Build up a database of experimental SMS results.

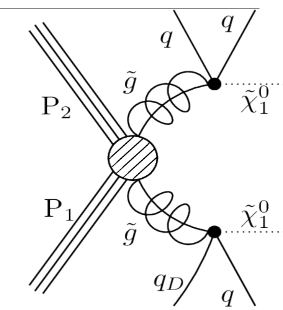
– Devise a generic SMS decomposition scheme that can decompose arbitrary fundamental models

– Apply the experimental SMS results to the fundamental models

The database

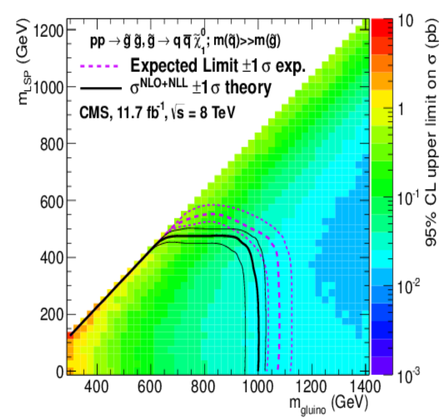
Our database of SMS results

A single entry in our database essentially looks like this:

Analysis name	Reference	sqrt(s)	Tx name of result
α_T	CMS-SUS-12-028	8 TeV	T1: ~g ~g, ~g → q q LSP 

(we actually collect some more info like the integrated lumi, the efficiency maps, journal reference, etc)

upper limit on production xsec



All this info comes directly from the experiment!

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS12028

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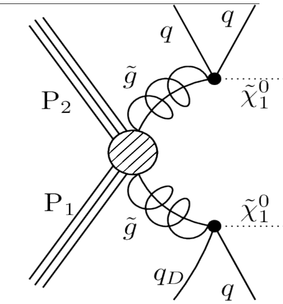
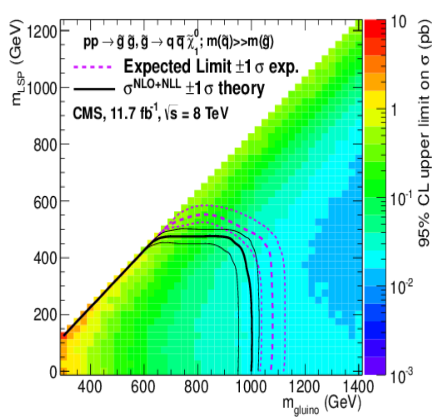
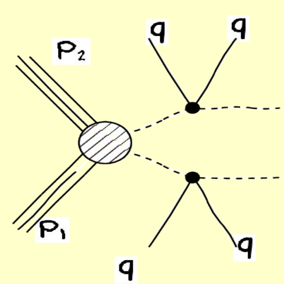
α_T	CMS-SUS-12-028	8 TeV	T1: ~g ~g, ~g → q q LSP 

upper limit on production xsec	constraint	condition
	[[jet,jet]],[[jet,jet]] 	none

We read the publications and produce this description of the SMS results (in this "SmodelS" formalism that I will describe in the next slides)

Our database of SMS results

analysis	$\sqrt{s}$	lumi	topologies	constraints
ATLAS-CONF-2012-105	8	5.8	T1tttt	[[[t+,t-]],[[t+,t-]]]
ATLAS-CONF-2012-166	8	13.0	T2tt	[[[t]],[[t]]]
			T6bbWW	[[[b],[W]],[[b],[W]]]
ATLAS-CONF-2013-001	8	12.8	T2bb	[[[b]],[[b]]]
ATLAS-CONF-2013-007	8	20.7	T1tttt	[[[t+,t-]],[[t+,t-]]]
			T1tbtb	[[[t,b]],[[t,b]]]
			T5WW	[[[jet,jet],[W]],[[jet,jet],[W]]]
ATLAS-CONF-2013-024	8	20.5	T2tt	[[[t]],[[t]]]
ATLAS-CONF-2013-025	8	20.7	T6ttZZ	[[[Z],[t]],[[Z],[t]]]
ATLAS-CONF-2013-028	8	20.7	TChiChipmStauL	2.*([[[nu],[ta]],[[ta+],[ta-]]] + [[[...
			TChipChimStauSnu	[[[ta-],[nu]],[[nu],[ta+]]] + [[[ta+]...
ATLAS-CONF-2013-035	8	20.7	TChiWZ	[[[W]],[[Z]]]
			TChiChipmSlepL	2.*([[[L],[L]],[[L],[nu]]] + [[[L],[L...
ATLAS-CONF-2013-036	8	20.7	TChiChiSlepSlep	[[[l+],[l-]],[[l+],[l-]]]+[[[l-],[l+]...
ATLAS-CONF-2013-037	8	20.7	T2tt	[[[t]],[[t]]]
			T6bbWW	[[[b],[W]],[[b],[W]]]
ATLAS-CONF-2013-049	8	20.3	TSlepSlep	[[[e+]],[[e-]]]+[[[mu+]],[[mu-]]]
ATLAS-CONF-2013-053	8	20.1	T2bb	[[[b]],[[b]]]
ATLAS-CONF-2013-061	8	20.1	T1tbtb	[[[t,b]],[[t,b]]]
			T1bbbb	[[[b,b]],[[b,b]]]
			T1tttt	[[[t,t]],[[t,t]]]
ATLAS-CONF-2013-062	8	20.0	T2bb	[[[b]],[[b]]]

analysis	$\sqrt{s}$	lumi	topologies	constraints
SUS-13-011	8	19.5	T2tt	[[[t]],[[t]]]
			T6bbWW	[[[b],[W]],[[b],[W]]]
SUS-12-006	7	4.98	TChiWZ	[[[W]],[[Z]]]
SUS-11-013	7	4.98	TChiWZ	[[[W]],[[Z]]]
SUS-12-026	8	9.2	T1tttt	[[[t+,t-]],[[t+,t-]]]
SUS-12-011	7	4.98	T2	[[[jet]],[[jet]]]
SUS-13-012	8	19.5	T2	[[[jet]],[[jet]]]
			T1	[[[jet,jet]],[[jet,jet]]]
SUS-12-024	8	19.4	T1bbbb	[[[b,b]],[[b,b]]]
			T1tttt	[[[t,t]],[[t,t]]]
SUS-13-007	8	19.4	T1tttt	[[[t,t]],[[t,t]]]
SUS-12-005 SUS-11-024	7	4.7	T2	[[[jet]],[[jet]]]
SUS-13-006	8	19.5	TChiWZ	[[[W]],[[Z]]]
			TChiChipmStauStau	[[[ta],[ta]],[[nu],[ta]]]
			TSlepSlep	[[[l+]],[[l-]]]
			TChiChipmSlepStau	[[[L],[L]],[[nu],[ta]]]
			TChiChipmSlepL	2.*([[[L],[L]],[[L],[nu]]] + [[[L],[L...
			TChipChimSlepSnu	[[[L-],[nu]],[[nu],[L+]]] + [[[L+],[n...
SUS-13-008	8	19.5	T6ttWW	[[[t],[W]],[[t],[W]]]
			T1tttt	[[[t,t]],[[t,t]]]
			T6bbZZ	[[[b],[Z]],[[b],[Z]]]
			T7btbtWW	[[[b],[t],[W]],[[b],[t],[W]]]
			T5tttt	[[[t],[t]],[[t],[t]]]
SUS-13-013	8	19.5	T5WW	[[[jet,jet],[W]],[[jet,jet],[W]]]
			T6ttWW	[[[t+],[W-]],[[t+],[W-]]]+[[[t-],[W+]...
			T1tttt	[[[t+,t-]],[[t+,t-]]]
			T1tsttst	[[[t+],[t-]],[[t+],[t-]]]+[[[t-],[t+]...
SUS-12-022	8	9.2	TChiWZ	[[[W]],[[Z]]]
			TChiChipmStauStau	[[[ta],[ta]],[[nu],[ta]]]
			TSlepSlep	[[[l+]],[[l-]]]
			TChiChipmSlepStau	[[[L],[L]],[[nu],[ta]]]
			TChiChipmSlepL	2.*([[[L],[L]],[[L],[nu]]] + [[[L],[L...
			TChipChimSlepSnu	[[[L-],[nu]],[[nu],[L+]]] + [[[L+],[n...
SUS-11-022	7	4.98	T1bbbb	[[[b,b]],[[b,b]]]
			T2tt	[[[t]],[[t]]]
			T1tttt	[[[t,t]],[[t,t]]]
			T2	[[[jet]],[[jet]]]
			T1	[[[jet,jet]],[[jet,jet]]]
			T2bb	[[[b]],[[b]]]
SUS-12-028	8	11.7	T1bbbb	[[[b,b]],[[b,b]]]
			T2tt	[[[t]],[[t]]]
			T1tttt	[[[t,t]],[[t,t]]]
			T2	[[[jet]],[[jet]]]
			T1	[[[jet,jet]],[[jet,jet]]]
			T2bb	[[[b]],[[b]]]

Currently we are at
about 30 analyses, total.
We aim to be comprehensive:

if we find the results available in
digitized format, we take them.

The SMS decomposition scheme

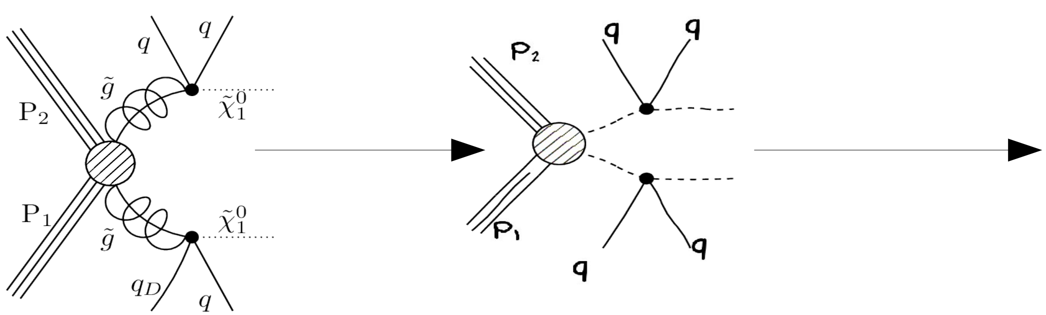
(a.k.a. the SModelS formalism)

Constraints and conditions

We introduce a formalism to describe what part of a fundamental theory a certain experimental result can be applied to.
We need two concepts to describe this: constraints, and conditions.

A **constraint** defines what part of a fundamental theory an experimental result will be applied to (i.e. what part of theory does the result “constrain”)

Example: CMS, α_T (SUS-12-028) the “T1” result:



[[jet,jet]],[[jet,jet]]

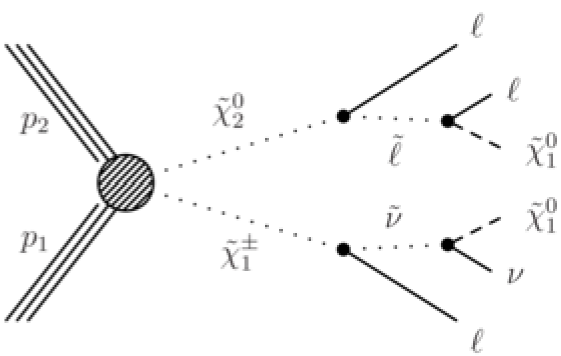
Meaning that this result will be applied to all those parts of a theory that produce two decay branches with two vertices with two jets from each vertex (and missing ET).
Flavors and signs are taken into account (e.g. we can express statements like “opposite sign dileptons” or “all three flavors”)

Constraints and conditions

We introduce a formalism to describe what part of a fundamental theory a certain experimental result can be applied to.
We need two concepts to describe this: constraints, and conditions.

A **condition** describes additional requirements that need to be fulfilled in order for the experimental result to be applicable.

Example: CMS “weakino analysis”, SUS-12-022, “tau-enriched” scenario:



Assuming ~lR, they let the chargino decay only into tau leptons, the neutralino is flavor democratic.

The constraint in this case reads: [[[L],[L]],[[nu],[tau]]]

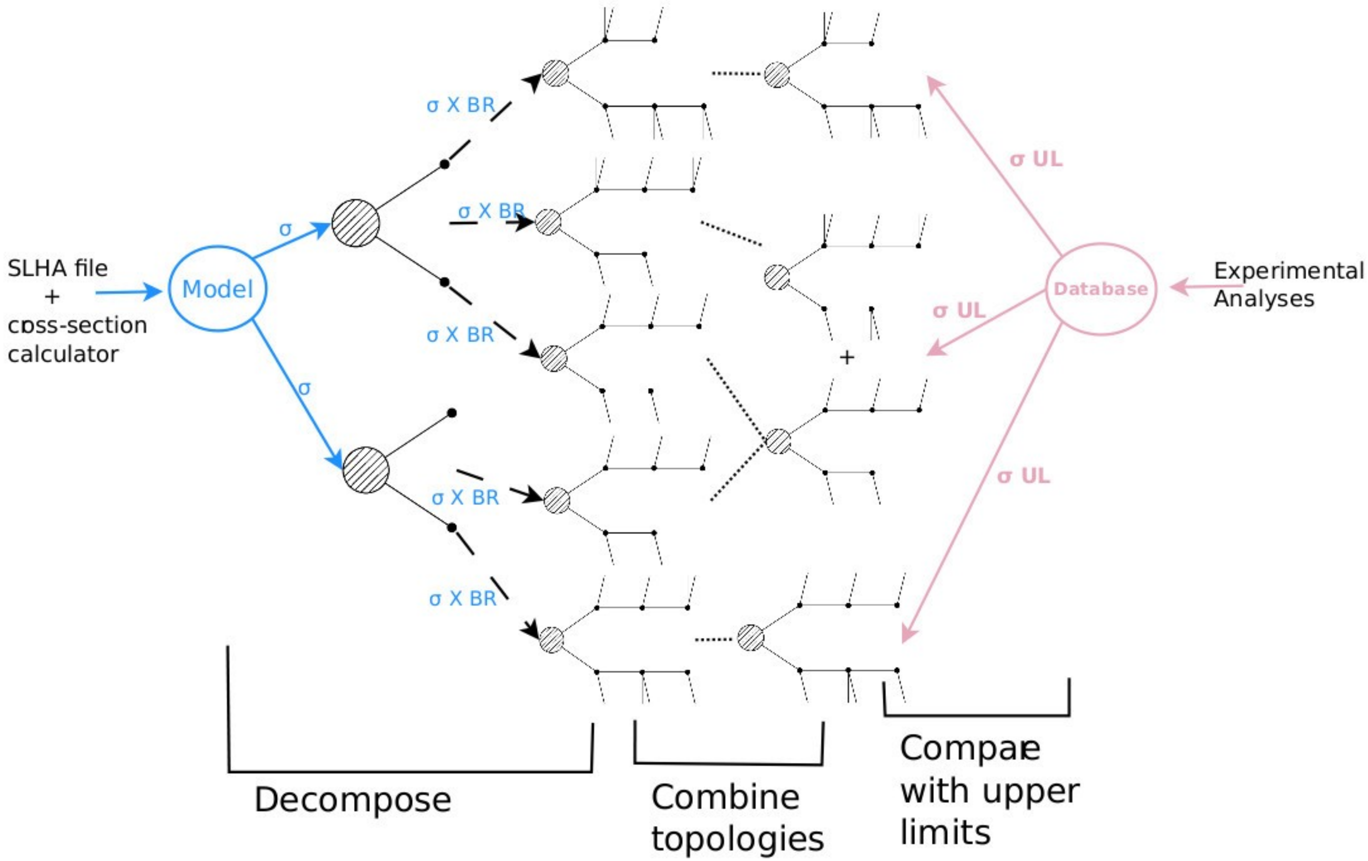
(L stands for e, mu, or tau)

In addition, flavor-democracy needs to also be required:
[[[L],[L]],[[nu],[tau]]] > 3*[[[tau],[tau]],[[nu],[tau]]]

(it's an inequality because we allow for conservatism)

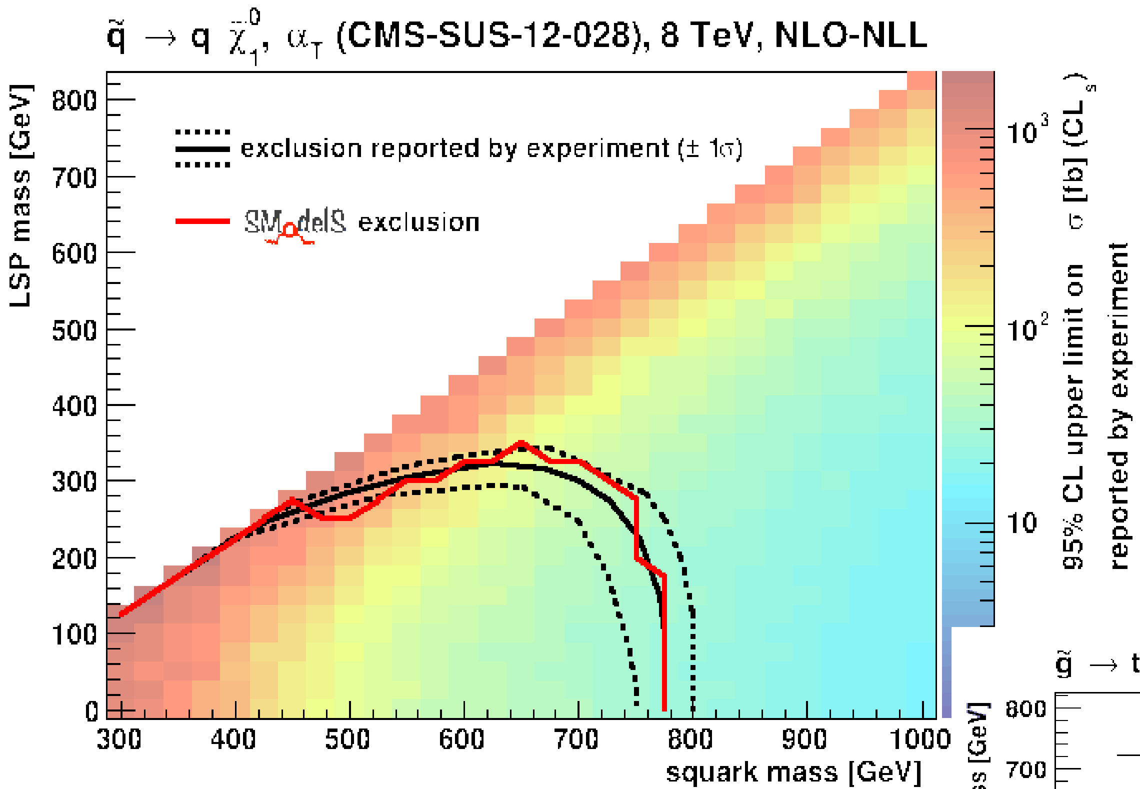
How it works

SLHA input file (model description) → SMS Decomposition (get sigma*BR for each topology) → Obtain Experimental Constraints from database



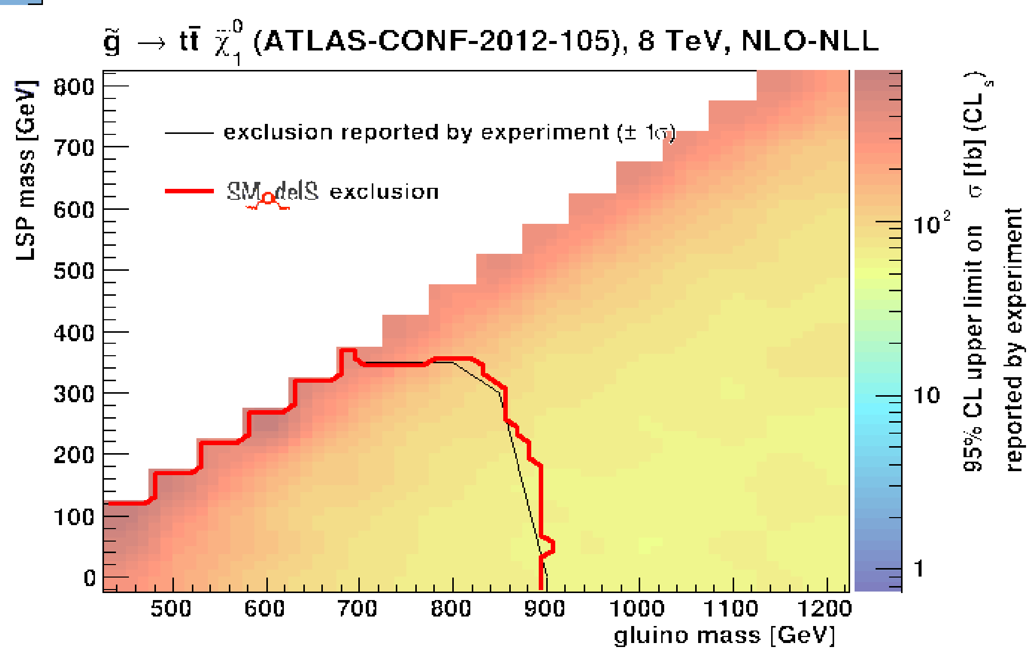
Making sure it all works

Validation of the method



One out of several tests we have made to be sure we
– decompose correctly
– properly understand the experimental results

If we pretend that the simplified model **is** the full model, can we reproduce the exclusion lines reported by the experiments?



Application to a simple MSSM model

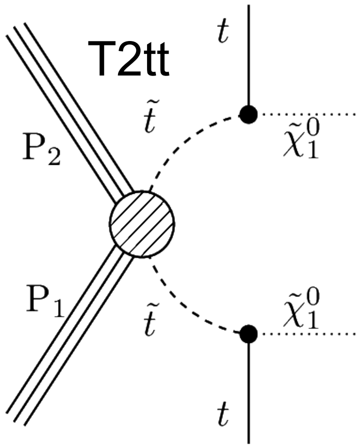
The model

Our test model is a simplified version of the pMSSM, assuming GUT relationship between the gaugino parameters.

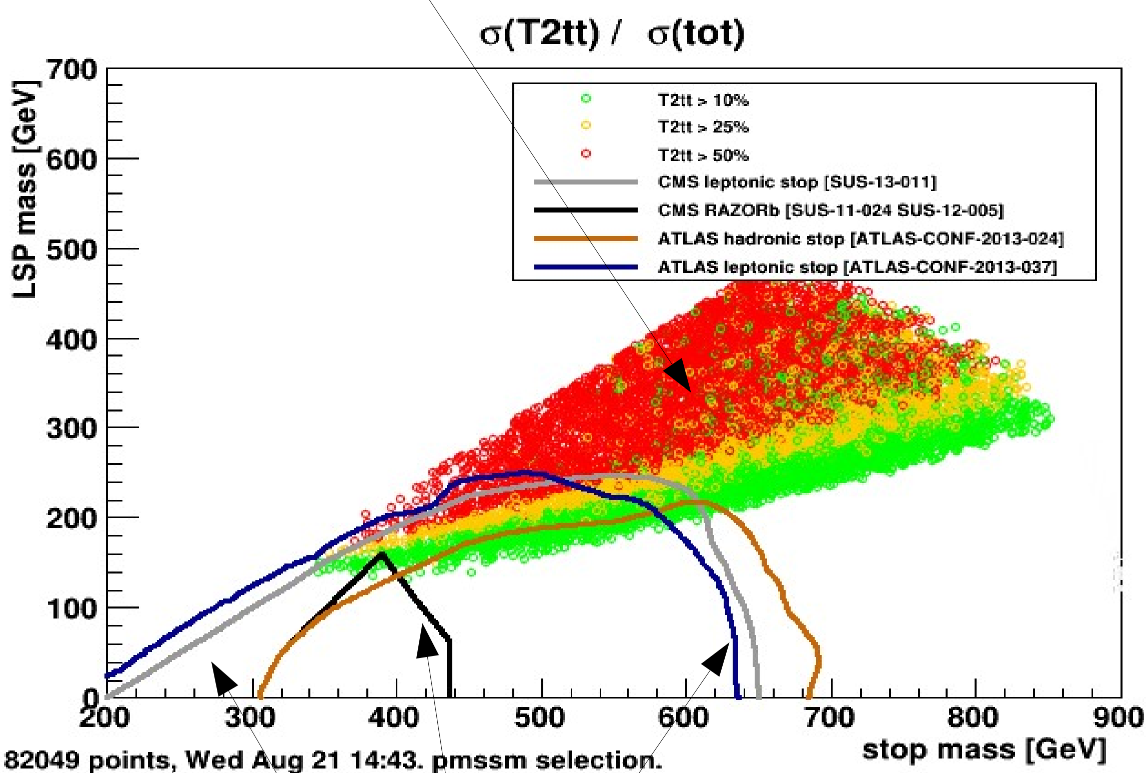
Parameter	Range	Description
M1	100 – 1000 GeV	Gaugino mass
M01	0 – 3000 GeV	1^{st} / 2^{nd} generation sfermion
M03	0 – 1000 GeV	3^{rd} generation sfermion
MA	100 – 2000 GeV	Pseudoscalar Higgs
μ	100 – 1000 GeV	
tan β	2 - 50	
Ab	-1000 – 1000 GeV	Trilinear coupling, sbottom
Atau	-1000 – 1000 GeV	Trilinear coupling, stau
At	-3 – 3 * M03	Trilinear coupling, stop

We consider only points that
- satisfy the LEP constraints
- produce a Higgs within mass window of [123,128]
- comply with the low energy observables Bsg, Bsmumu

Result: direct stop decay

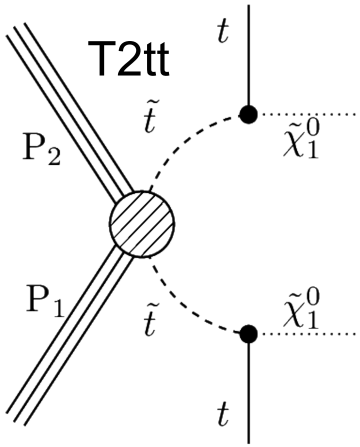


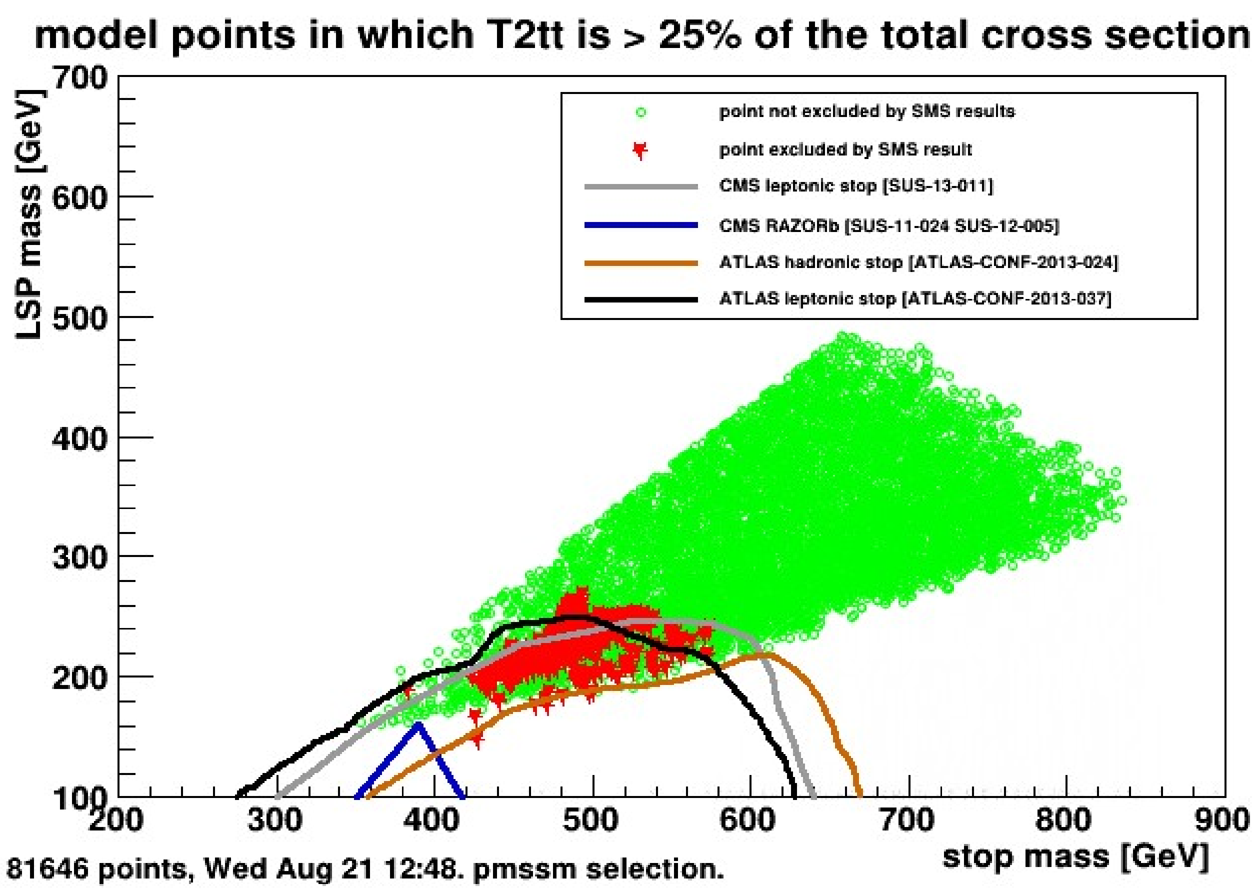
Prevalence of direct stop decays

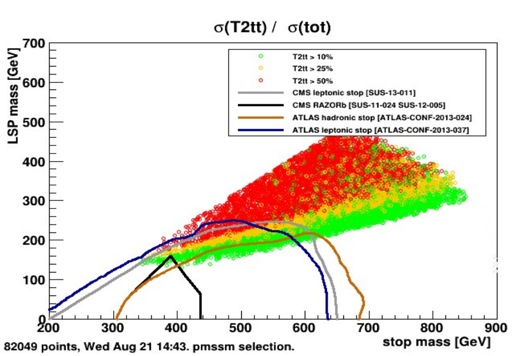


Exclusion lines reported by the experiments

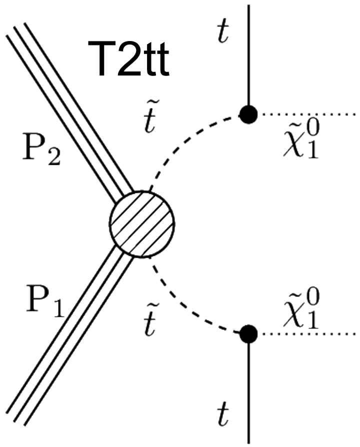
Result: direct stop decay

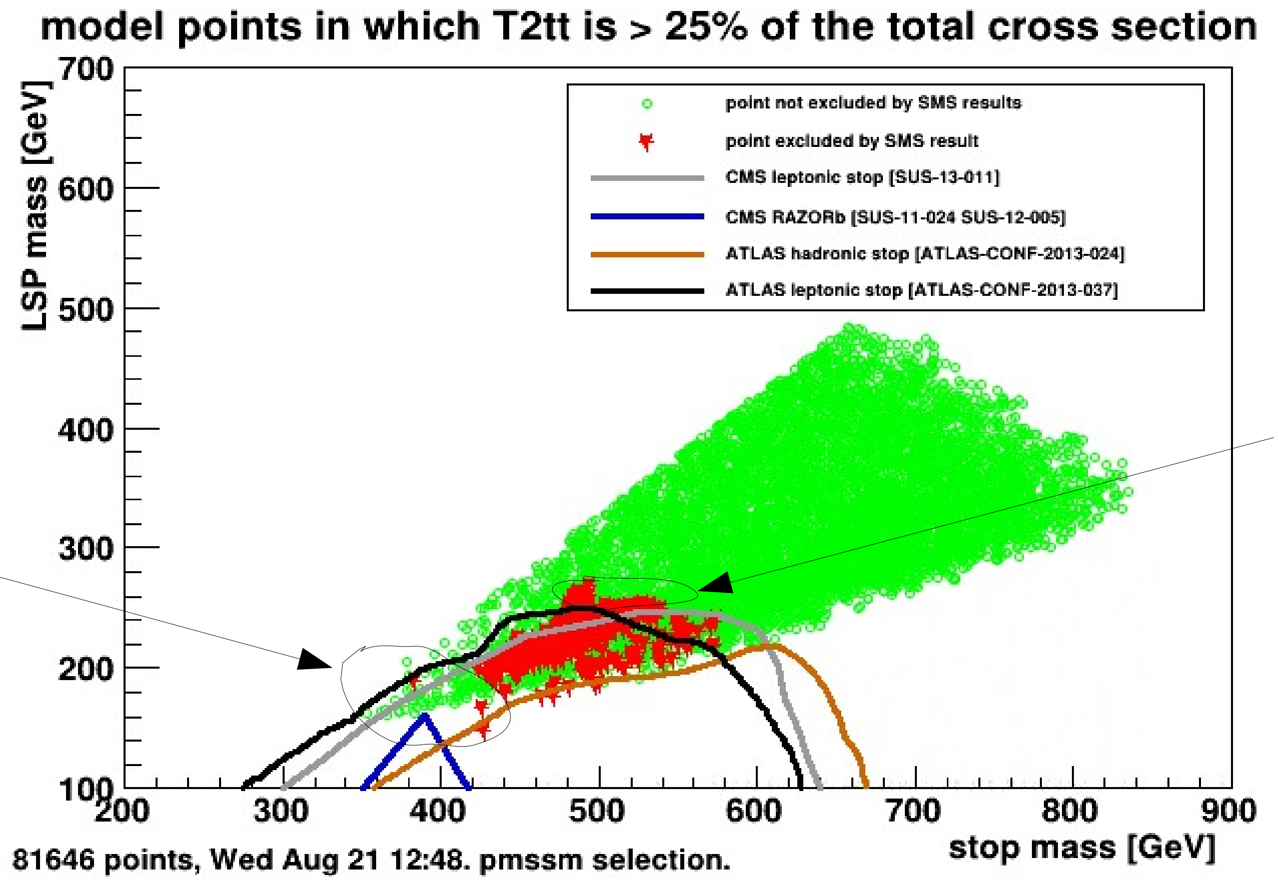






Result: direct stop decay





BR(T2tt) becomes low

gluino at 1500 GeV slightly increases cross section relative to decoupled limit

Future developments

For the future

– produce more SMS results for more complicated cases outside the experimental collaborations, redoing the analyses with e.g. delphes (in collaboration with other pheno groups)

– produce approximate likelihoods for SMS results

– possibly combine likelihoods where it's easy

– maybe also the experiments start publishing likelihoods? We would pick them up.

– apply to different SUSY models, e.g natural susy model

– think about applying results from opposite-spin scenarios (SUSY) to same-spin scenarios (UEDs, composite Higgs, …):
Is the application justified or do the kinematics vary too much when going from SUSY to e.g. UED matrix elements?

– we also want to collaborate with the fittino group, first use SmodelS decomposition as a “diagnostic tool”, then evolve from there

Beyond the SModelS group

Les Houches wishlist

A wishlist has been compiled at the Les Houches workshop this june, from the SMS phenomenologists, regarding the SMS results made public by the experiments.
I will mention only the main issues that have been raised:

1. **Digitize, digitize, digitize ….** (meaning: please provide all histograms in an electronic format. CMS is already doing this. ATLAS says they want to do this only for the final published results.)

2. **For topologies involving cascade decays, provide results for more than one (at least 3) intermediate mass values.**
We will interpolate. If we cant interpolate, we wont use the result.

3. **Provide good coverage of the parameter space considered.**
We wont interpolate over too large gaps in efficiencies / upper limits.

… and some more wishes, see:

http://phystev.in2p3.fr/wiki/2013:groups:np:susysms

LPCC simplified models coordination workshop

Oct 29th / 30th 2013 @ CERN

There are at least 4 – 5 pheno groups working with simplified models results.
In this LPCC workshop we want to start to loosely coordinate the effort between the different pheno groups. One common vision is to provide interoperability between SMS interpretation building blocks.