SModelS

An unexpected journey

2013—2024 and beyond

Sabine
PhD 1999 at HEPHY
2001-2007 at CERN
since 2008 in Grenoble

Andre
PhD 2011 in Oklahoma
Postdoc in Sao Paulo
since 2015 UFABC

Wolfgang
PhD 2004 at HEPHY (CMS)
stayed in Vienna ….

Gaël Alguero, Federico Ambrogi, Jan Heisig, Charanjit K. Khosa, Juhi Dutta, Suchita Kulkarni, Ursula Laa, Veronika Magerl, Wolfgang Magerl, Philipp Neuhuber, Doris Proschofsky, Jory Sonneveld, Michael Traub, Matthias Wolf, Alicia Wongel; Mohammad Mahdi Altakach, Sahana Narasimha, Timothée Pascal, Camila Ramos, Humberto Reyes-González, Théo Reymermier, Yoxara Villamizar; Leo Constantin, Lucas Ramos, …

2013

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since 2015 UFABC

Wolfgang
PhD 2004 at HEPHY (CMS)
stayed in Vienna ….

Suchita Kulkarni
postdoc in Grenoble
(later in Vienna)

Ursula Laa
MSc in Vienna
PhD in Grenoble

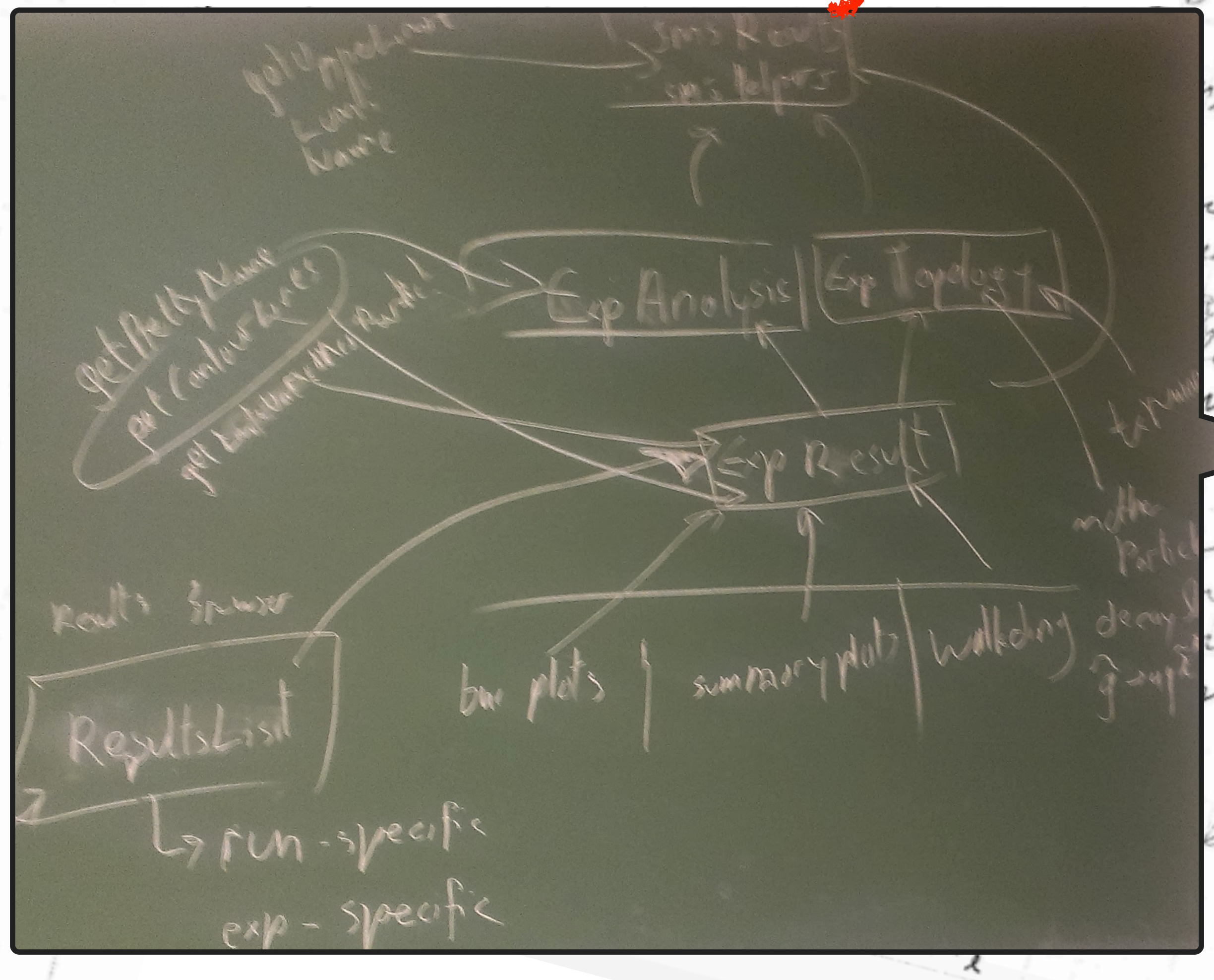
Doris Proschofsky
MSc student

Wolfgang Magerl
MSc student

“I was visiting Grenoble and Suchita was trying to use a code Wolfgang had for using simplified model results, but it was not working out”

research visit to Grenoble, Jan-Apr 2013

Vienna, early 2013



LPSC14001
HEPHY-PUB 932/13

SModelS: a tool for interpreting simplified-model results from the LHC and its application to supersymmetry

Sabine Kraml[1*], Suchita Kulkarni[1†], Ursula Laa[2‡], Andre Lessa[3§], Wolfgang Magerl[2¶], Doris Proschofsky-Spindler[2‖], Wolfgang Waltenberger[2**]

[1] *Laboratoire de Physique Subatomique et de Cosmologie, UJF Grenoble 1, CNRS/IN2P3, INPG, 53 Avenue des Martyrs, F-38026 Grenoble, France*

[2] *Institut für Hochenergiephysik, Österreichische Akademie der Wissenschaften, Nikolsdorfer Gasse 18, 1050 Wien, Austria*

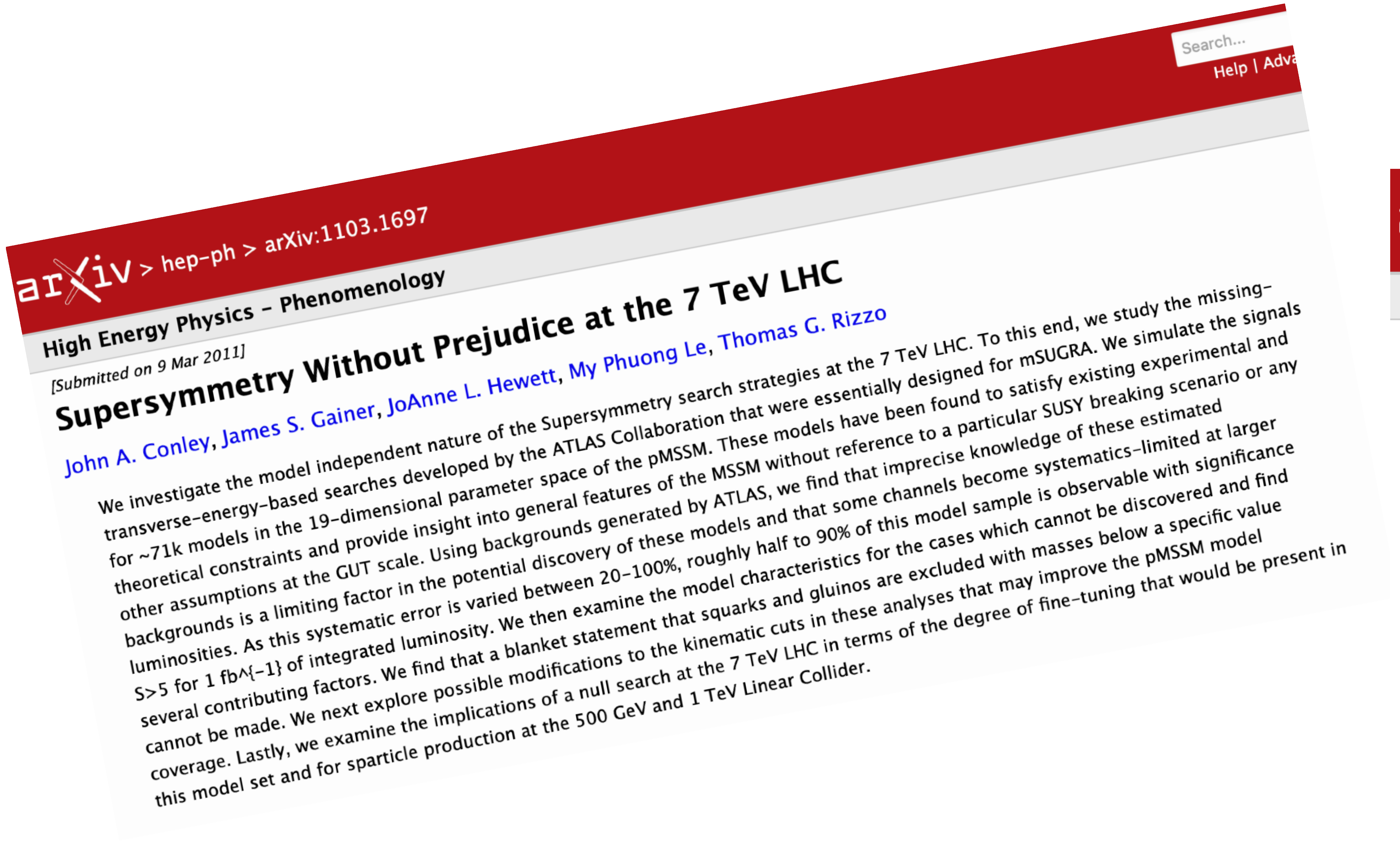
[3] *Instituto de Física, Universidade de São Paulo, São Paulo - SP, Brazil*

Abstract

We present a general procedure to decompose Beyond the Standard Model (BSM) collider signatures presenting a $\mathbb{Z}_2$ symmetry into Simplified Model Spectrum (SMS) topologies. Our method provides a way to cast BSM predictions for the LHC in a model independent framework, which can be directly confronted with the relevant experimental constraints. Our concrete implementation currently focusses on supersymmetry searches with missing energy, for which a large variety of SMS results from ATLAS and CMS are available. As show-case examples we apply our procedure to two scans of the minimal supersymmetric standard model. We discuss how the SMS limits constrain various particle masses and which regions of parameter space remain unchallenged by the current SMS interpretations of the LHC results.

This was the time of LHC Run 1 (2010-2013)

- Higgs discovery !!!
- An uprising of phenomenologists (+ some exp) who wanted to do more with the experimental results


arXiv > hep-ph > arXiv:1103.1697

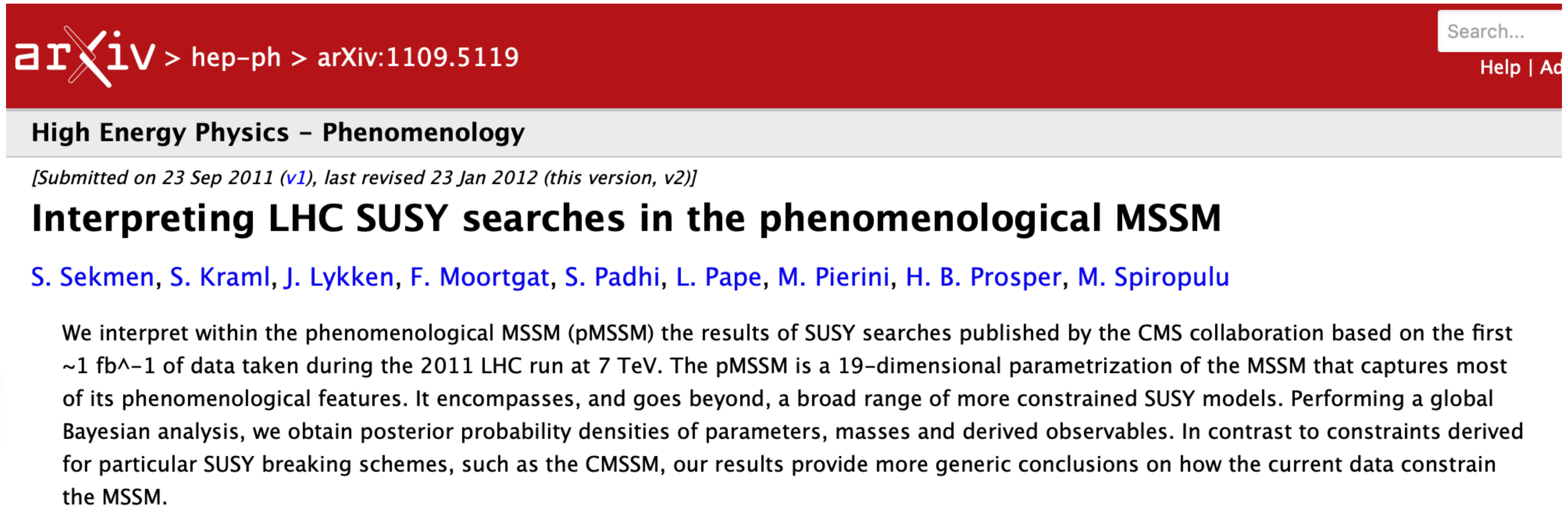
High Energy Physics – Phenomenology

[Submitted on 9 Mar 2011]

Supersymmetry Without Prejudice at the 7 TeV LHC

John A. Conley, James S. Gainer, JoAnne L. Hewett, My Phuong Le, Thomas G. Rizzo

We investigate the model independent nature of the Supersymmetry search strategies at the 7 TeV LHC. To this end, we study the missing-transverse-energy-based searches developed by the ATLAS Collaboration that were essentially designed for mSUGRA. We simulate the signals for ~71k models in the 19-dimensional parameter space of the pMSSM. These models have been found to satisfy existing experimental and theoretical constraints and provide insight into general features of the MSSM without reference to a particular SUSY breaking scenario or any other assumptions at the GUT scale. Using backgrounds generated by ATLAS, we find that imprecise knowledge of these estimated backgrounds is a limiting factor in the potential discovery of these models and that some channels become systematics-limited at larger luminosities. As this systematic error is varied between 20-100%, roughly half to 90% of this model sample is observable with significance S>5 for 1 fb^{-1} of integrated luminosity. We then examine the model characteristics for the cases which cannot be discovered and find several contributing factors. We find that a blanket statement that squarks and gluinos are excluded with masses below a specific value cannot be made. We next explore possible modifications to the kinematic cuts in these analyses that may improve the pMSSM model coverage. Lastly, we examine the implications of a null search at the 7 TeV LHC in terms of the degree of fine-tuning that would be present in this model set and for sparticle production at the 500 GeV and 1 TeV Linear Collider.


arXiv > hep-ph > arXiv:1109.5119

High Energy Physics – Phenomenology

[Submitted on 23 Sep 2011 (v1), last revised 23 Jan 2012 (this version, v2)]

Interpreting LHC SUSY searches in the phenomenological MSSM

S. Sekmen, S. Kraml, J. Lykken, F. Moortgat, S. Padhi, L. Pape, M. Pierini, H. B. Prosper, M. Spiropulu

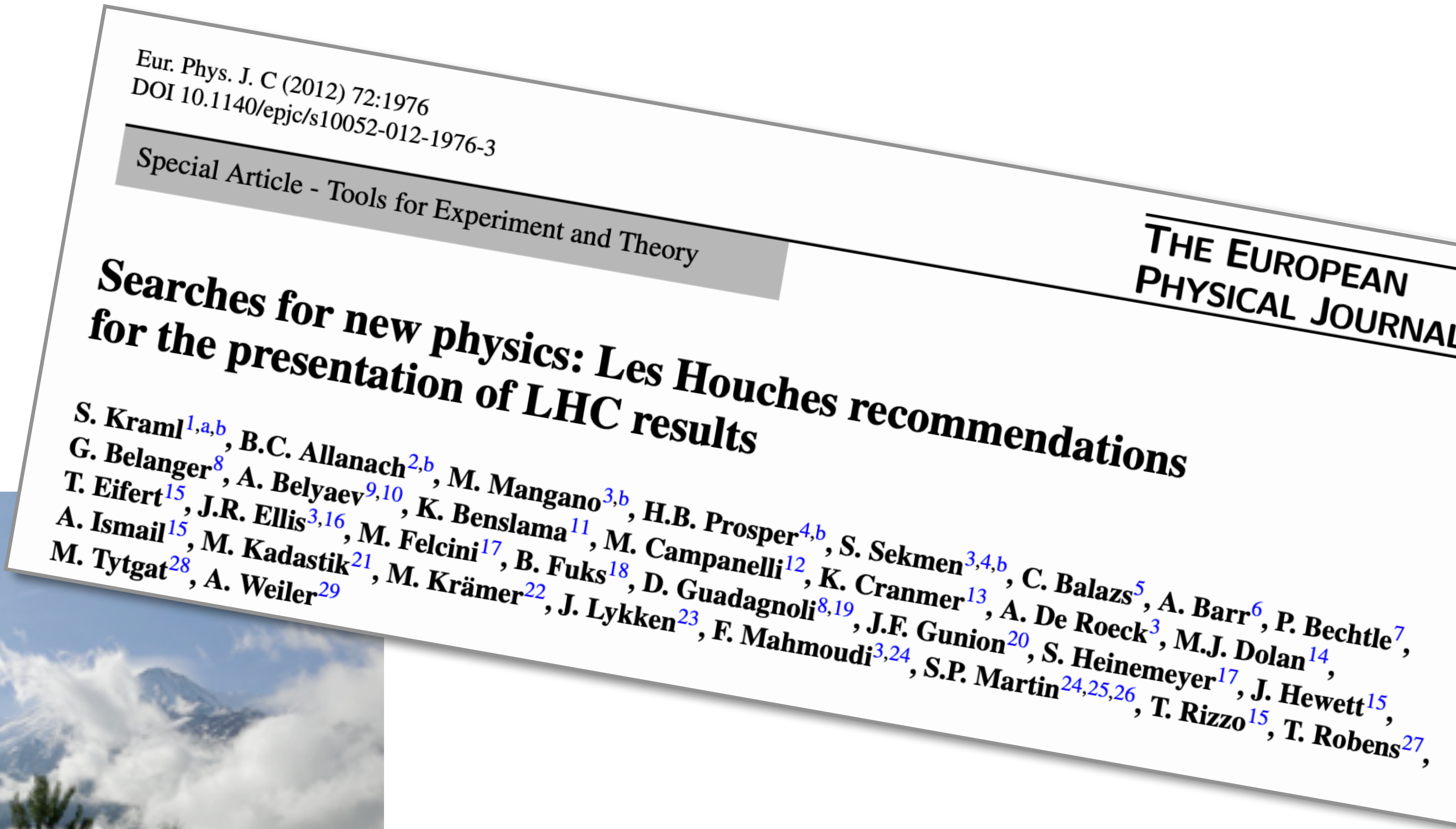
We interpret within the phenomenological MSSM (pMSSM) the results of SUSY searches published by the CMS collaboration based on the first ~1 fb^-1 of data taken during the 2011 LHC run at 7 TeV. The pMSSM is a 19-dimensional parametrization of the MSSM that captures most of its phenomenological features. It encompasses, and goes beyond, a broad range of more constrained SUSY models. Performing a global Bayesian analysis, we obtain posterior probability densities of parameters, masses and derived observables. In contrast to constraints derived for particular SUSY breaking schemes, such as the CMSSM, our results provide more generic conclusions on how the current data constrain the MSSM.

Les Houches Recommendations

"Physics at TeV Colliders" workshop series in Les Houches, next to Mont Blanc

- At the PhysTev2011 workshop, we started to discuss a set of recommendations for presenting the LHC results in a form that would be most useful to the community at large, and that would help to maximize the scientific return of the LHC.
- Initial recommendations were thoroughly discussed and refined with input from ATLAS and CMS collaborations in a dedicated LPCC miniworkshop 13 Feb 2012

→ final document arXiv:1203:2489 (33 authors)


Eur. Phys. J. C (2012) 72:1976
DOI 10.1140/epjc/s10052-012-1976-3

Special Article - Tools for Experiment and Theory

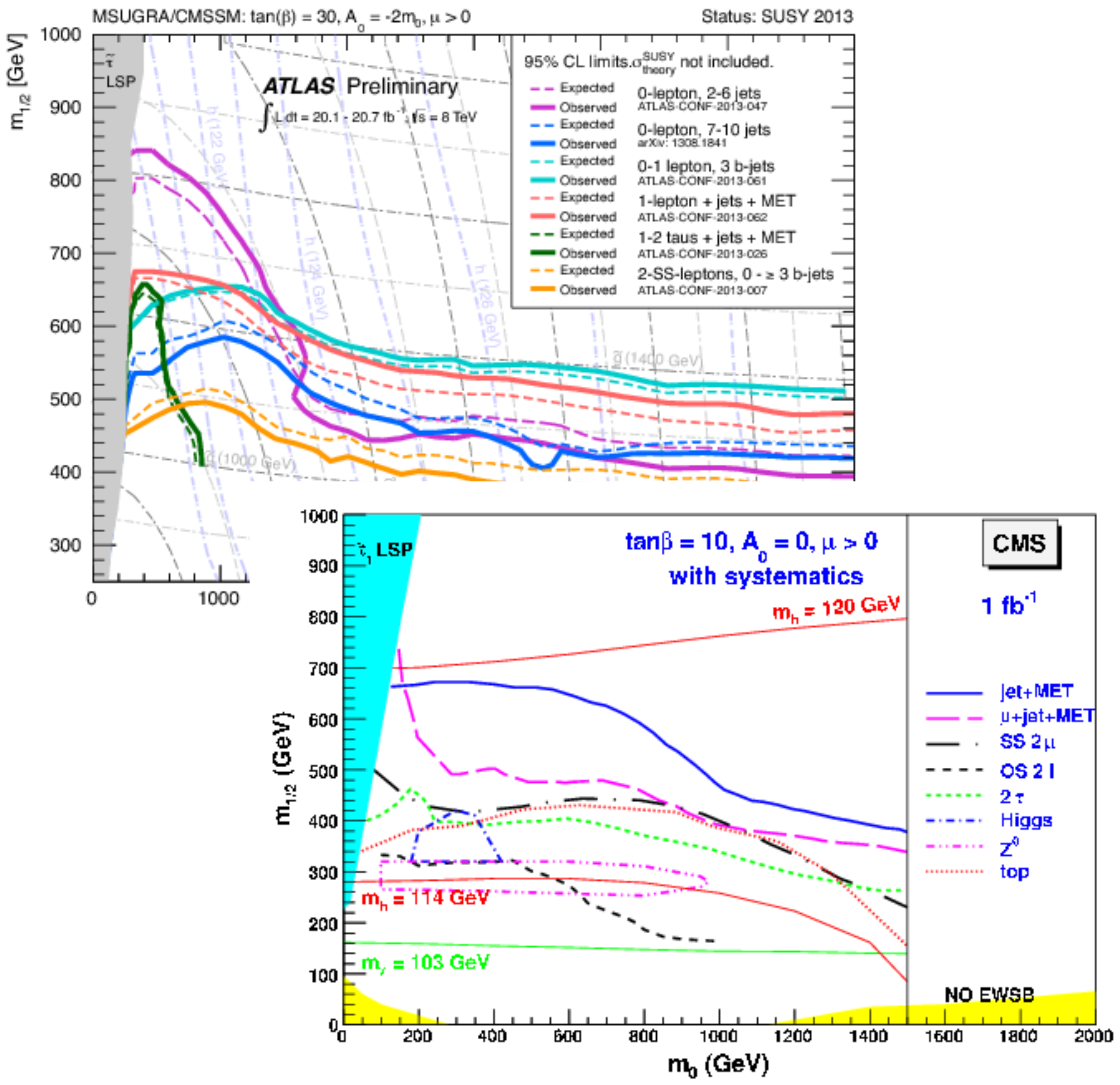
THE EUROPEAN PHYSICAL JOURNAL

Searches for new physics: Les Houches recommendations for the presentation of LHC results

S. Kraml[1,a,b], B.C. Allanach[2,b], M. Mangano[3,b], H.B. Prosper[4,b], S. Sekmen[3,4,b], C. Balazs[5], A. Barr[6], P. Bechtle[7], G. Belanger[8], A. Belyaev[9,10], K. Benslama[11], M. Campanelli[12], K. Cranmer[13], A. De Roeck[3], M.J. Dolan[14], T. Eifert[15], J.R. Ellis[3,16], M. Felcini[17], B. Fuks[18], D. Guadagnoli[8,19], J.F. Gunion[20], S. Heinemeyer[17], J. Hewett[15], A. Ismail[15], M. Kadastik[21], M. Krämer[22], J. Lykken[23], F. Mahmoudi[3,24], S.P. Martin[24,25,26], T. Rizzo[15], T. Robens[27], M. Tytgat[28], A. Weiler[29]

S. Kraml   GDR Terascale, Clermont-Ferrand, 23-25 Apr 2012   3

ATLAS/CMS started to move from mSUGRA to simplified models



Proceedings of the DPF-2011 Conference, Providence, RI, August 8-13, 2011

Interpretations of SUSY Searches in ATLAS with Simplified Models

Hideki Okawa, on behalf of the ATLAS Collaboration
Department of Physics and Astronomy, University of California at Irvine, Irvine, CA, USA

We present the status of interpretations of Supersymmetry (SUSY) searches in ATLAS at the Large Hadron Collider (LHC) using simplified models. Such models allow a systematic scan through the phase space in the sparticle mass plane, and in the corresponding final state kinematics. Models at various levels of simplification have been studied in ATLAS. The results can be extrapolated to more general new physics models which lead to the same event topology with similar mass hierarchies. Searches in the no-lepton channel with 1.04 fb^{-1} of data from 2011 and the same-sign dilepton channel with 35 pb^{-1} of data from 2010 are presented. No excess above t…

CMS

CERN-PH-EP/2012-351
2013/12/03

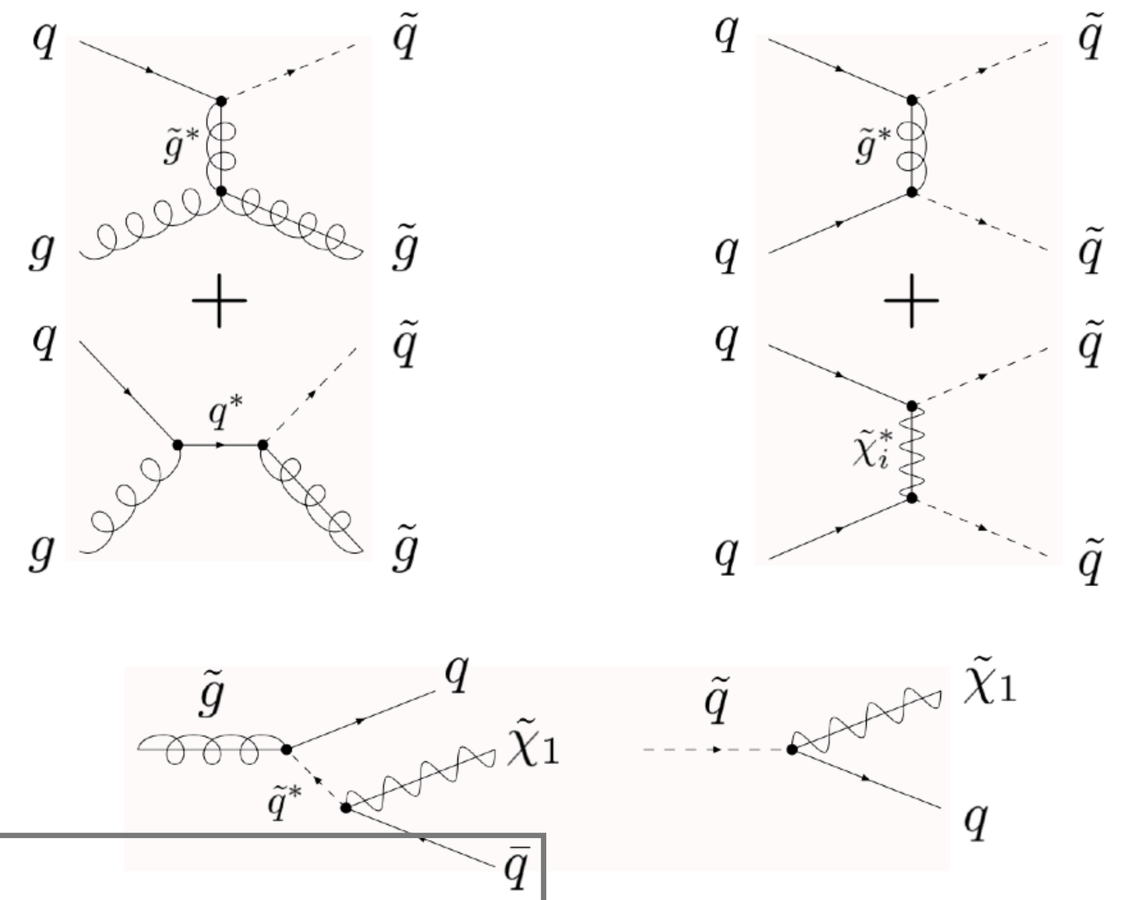
CMS-SUS-11-016

Interpretation of searches for supersymmetry with simplified models

The CMS Collaboration*

Wolfgang!

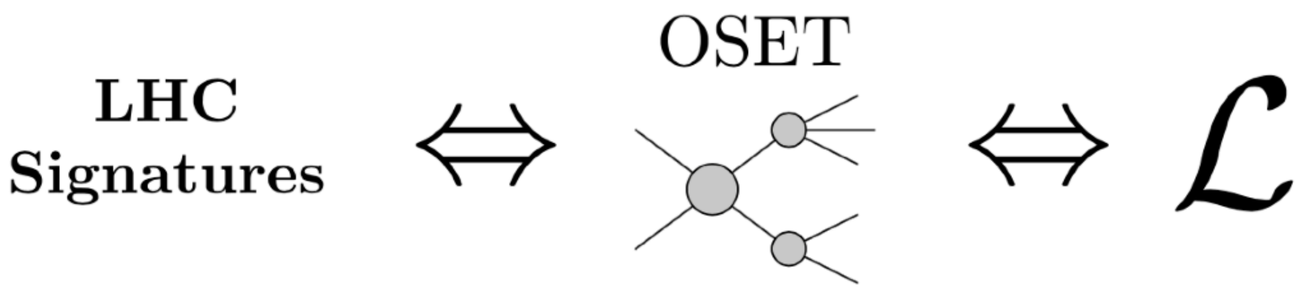
Idea already 2006/7, before the start of the LHC



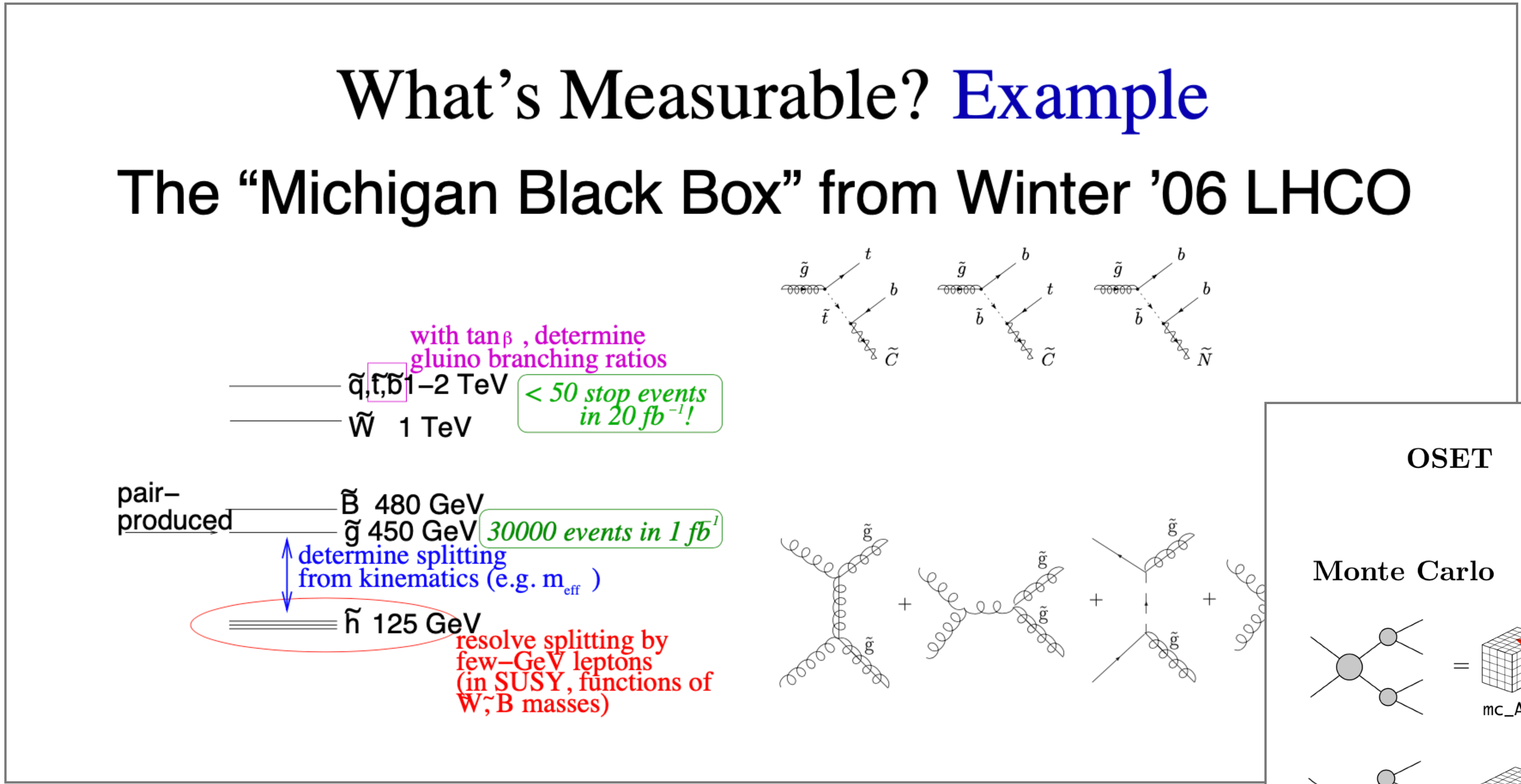
MARMOSET: The Path from LHC Data to the New Standard Model via On-Shell Effective Theories

Nima Arkani-Hamed, Philip Schuster, Natalia Toro, Jesse Thaler, Lian-Tao Wang, Bruce Knuteson, Stephen Mrenna

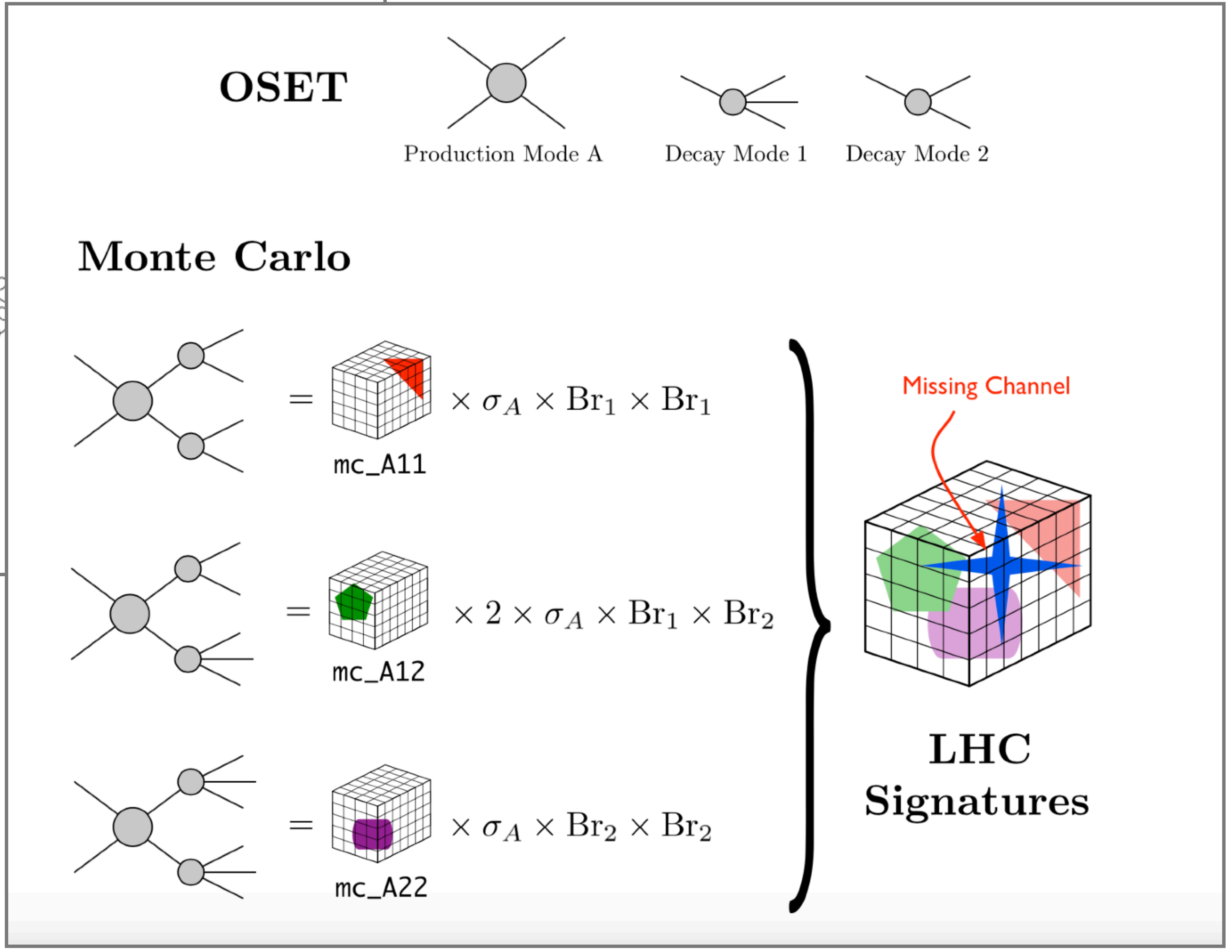
> "[…] We show that On-Shell Effective Theories (OSETs) effectively characterize hadron collider data in terms of masses, production cross sections, and decay modes of candidate new particles. An OSET description of the data strongly constrains the underlying new physics, and sharply motivates the construction of its Lagrangian. Simulating OSETs allows efficient analysis of new-physics signals, especially when they arise from complicated production and decay topologies. To this end, we present MARMOSET, a Monte Carlo tool for simulating the OSET version of essentially any new-physics model. […]"



e-Print: hep-ph/0703088



Philip Schuster, ATLAS Forum Talk, 2006



hep-ph/0703088

The LHC Olympics 2006

Coinciding with the kickoff of the winter Olympics in Torino, more than 70 physicists gathered at CERN from across the globe for an Olympics of their own on 9-10 February. Their challenge, however, involved brains rather than brawn.

When turned on in 2008, the LHC will be the world's biggest and most powerful particle accelerator. […] When the beams are smashed together, showers of new particles and a possible glimpse at what the universe looked like in its first few moments will be created for physicists to study.

However, interpreting the data produced from the LHC won't be an easy task. […] To prepare for the challenge, physicists want to test and improve their ability to decipher the information correctly and efficiently. The LHC Olympics is a coordinated effort to do just that, minus the gold, silver and bronze of the athletic competition.

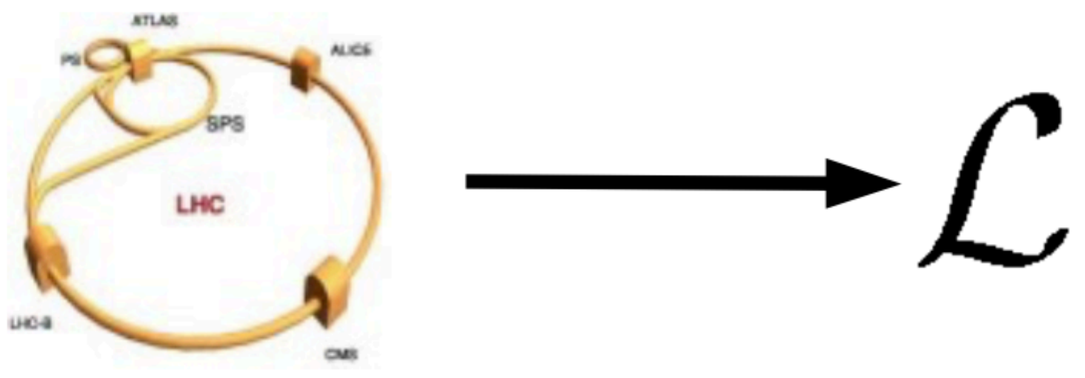
As part of the LHC Olympic series, teams of theorists from the University of Michigan, Harvard University and the University of Washington set up three mock data sets that could be generated once the accelerator is turned on. The data sets, known as black boxes, were posted online and LHC Olympians were asked to interpret the data, looking for particles and evidence of theories that haven't yet been witnessed or confirmed.

> *"The main idea is if you can't do it for the simulated case, it's even less likely you can do it for the real case,"* Kane said. "*It makes people learn to think differently and approach the problem the way it will have to be approached."*

Gordy Kane

https://public-archive.web.cern.ch/en/Spotlight/SpotlightOlympics-en.html

Until a short time ago, we (naively, maybe) thought we could try to reconstruct a fundamental Lagrangian directly from LHC data.
Some of us would e.g. try to find which mSUGRA point is most compliant with LHC data.
Others would e.g. go for extra dimensions (which can look very much like SUSY models in the LHC)

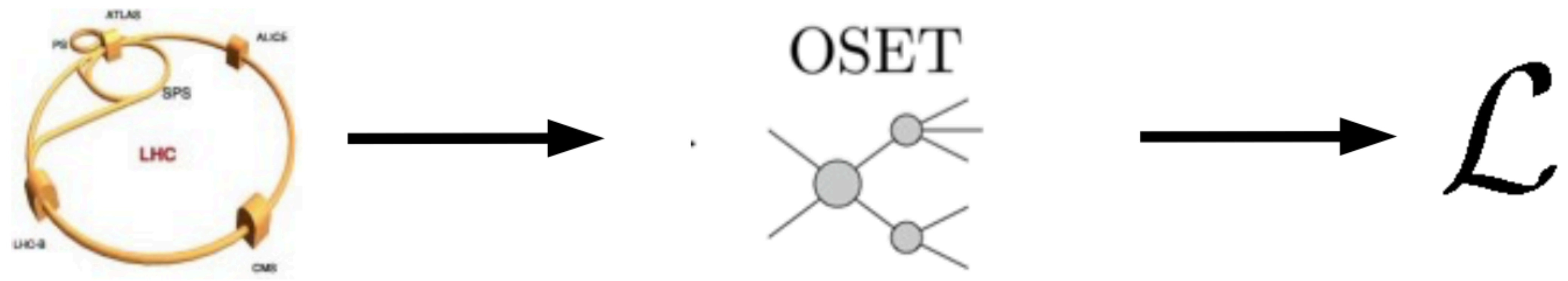


Physics in Progress Seminar, Hephy, December 2009

Wolfgang Waltenberger

Wolfgang @ CMS, 2009

Only very recently our vision has changed a bit, thanks to the idea of "On-Shell Effective Theories".
Instead of directly going for the full TeV-scale Lagrangian, we try to construct and fit OSETs, with on-shell particles only which describe the data.
LHC and Non-LHC people alike can then try to match fundamental theories with the OSET.



Physics in Progress Seminar, Hephy, December 2009

Wolfgang Waltenberger

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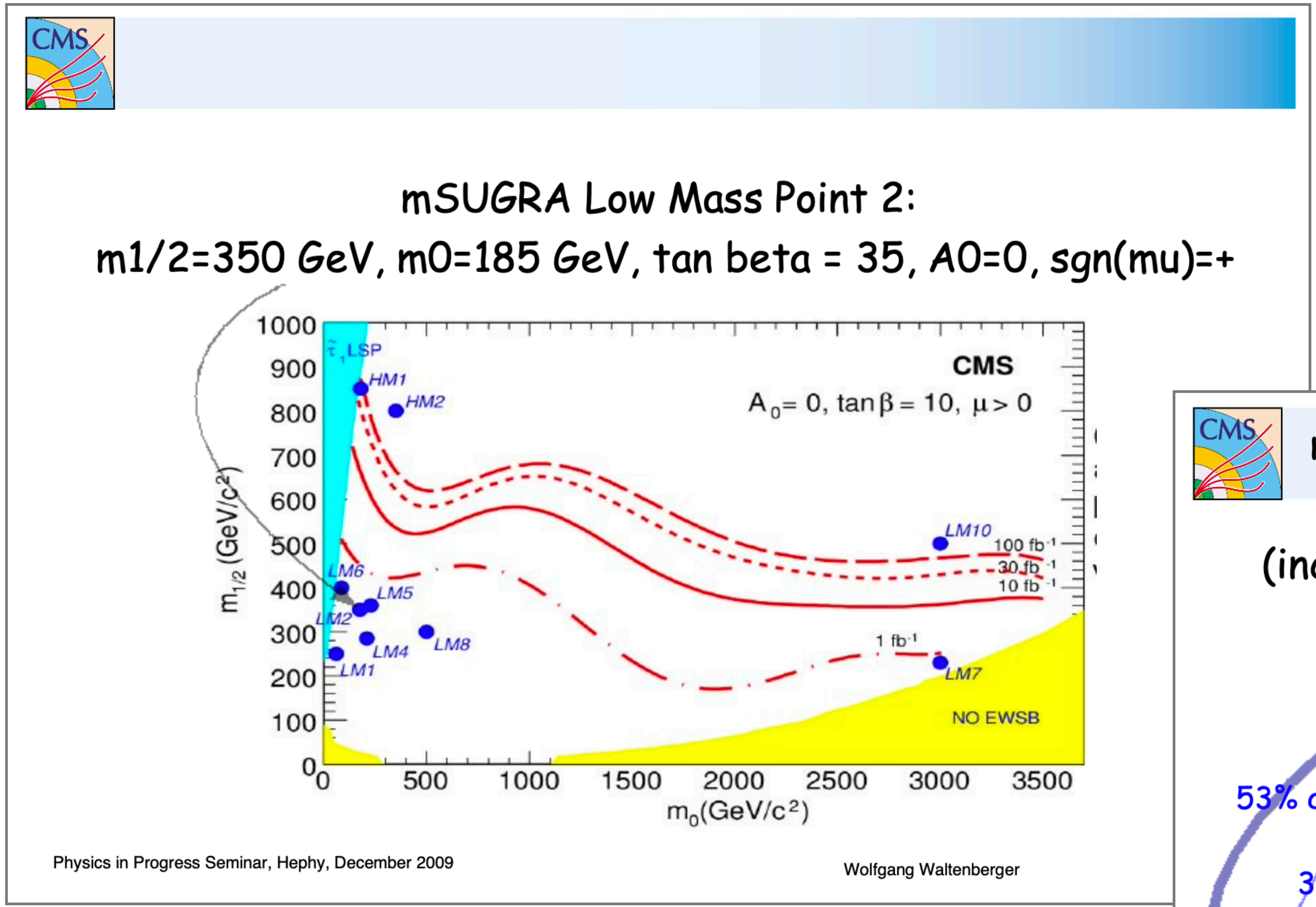
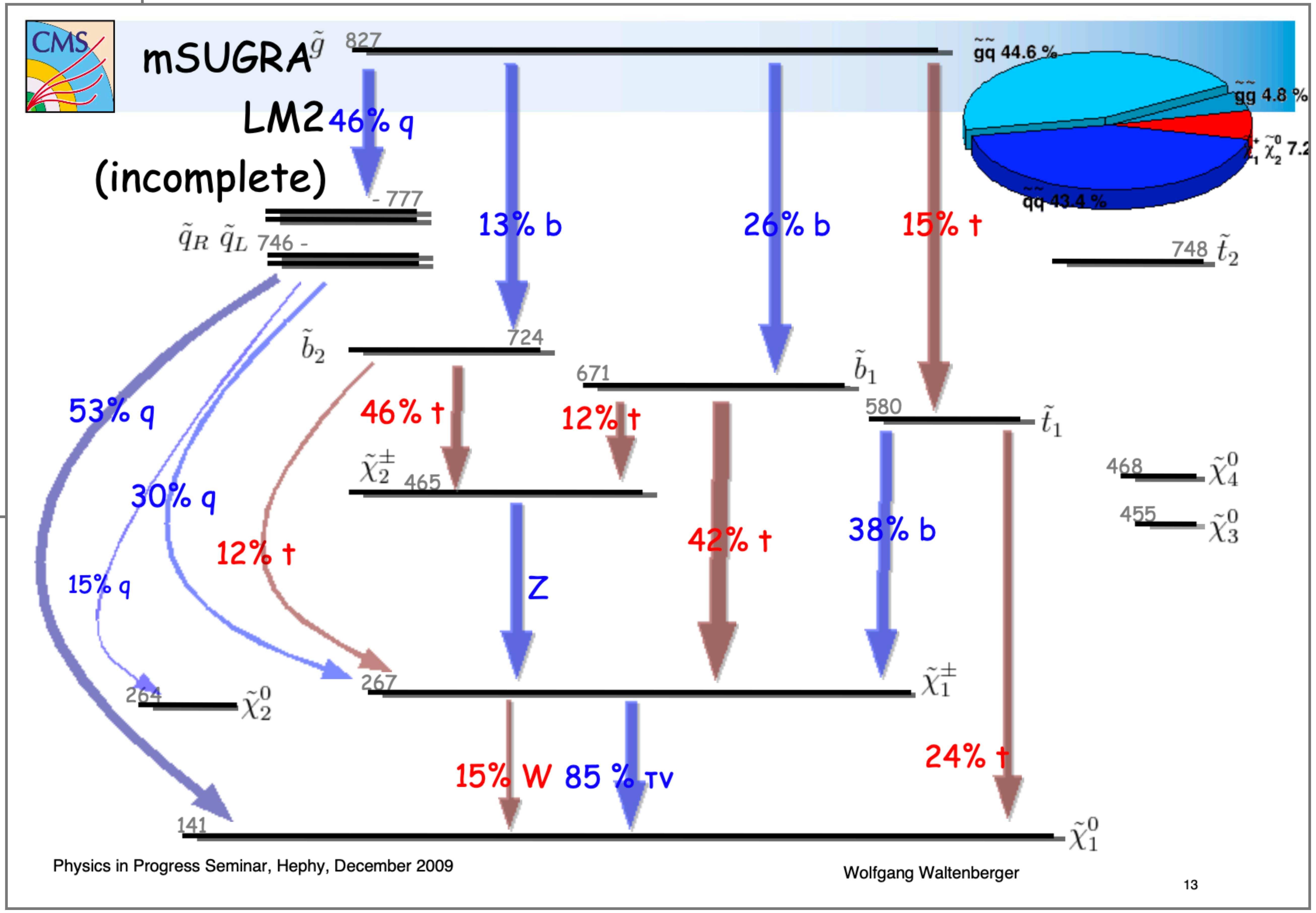
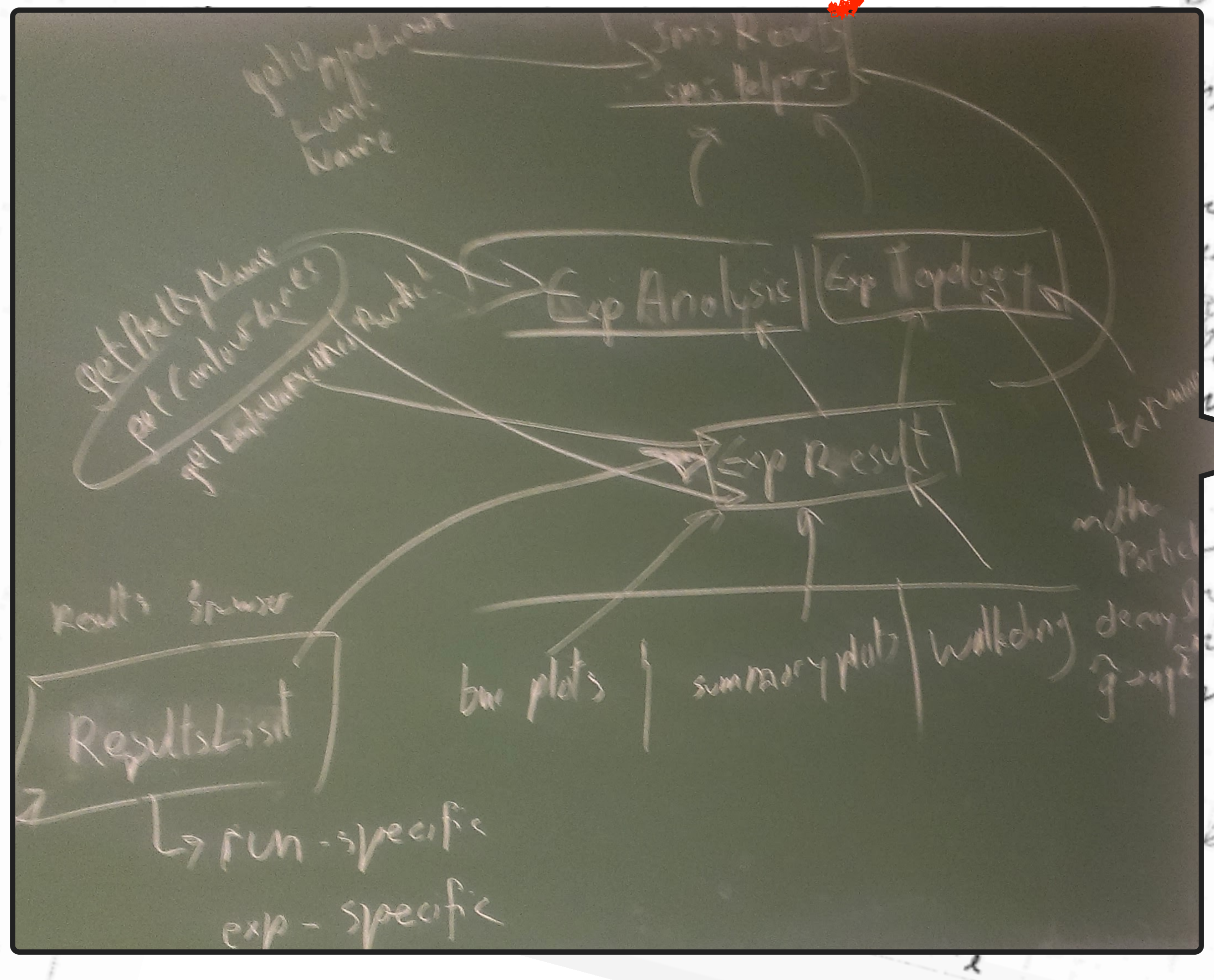

mSUGRA Low Mass Point 2:
m1/2=350 GeV, m0=185 GeV, tan beta = 35, A0=0, sgn(mu)=+
CMS
A0= 0, tan β = 10, μ > 0
τ̃1 LSP
HM1
HM2
LM1
LM2
LM4
LM5
LM6
LM7
LM8
LM10
100 fb-1
30 fb-1
10 fb-1
1 fb-1
NO EWSB
m1/2 (GeV/c²)
m0(GeV/c²)
Physics in Progress Seminar, Hephy, December 2009
Wolfgang Waltenberger


mSUGRA
LM2
(incomplete)
827
777
746
724
671
580
748
468
455
465
267
264
141
46% q
13% b
26% b
15% t
53% q
30% q
15% q
46% t
12% t
12% t
42% t
38% b
Z
15% W
85 % τν
24% t
g̃q̃ 44.6 %
g̃g̃ 4.8 %
q̃q̃ 43.4 %
Physics in Progress Seminar, Hephy, December 2009
Wolfgang Waltenberger
13

"I was visiting Grenoble and Suchita was trying to use a code Wolfgang had for using simplified model results, but it was not working out"

research visit to Grenoble, Jan-Apr 2013

Vienna, early 2013



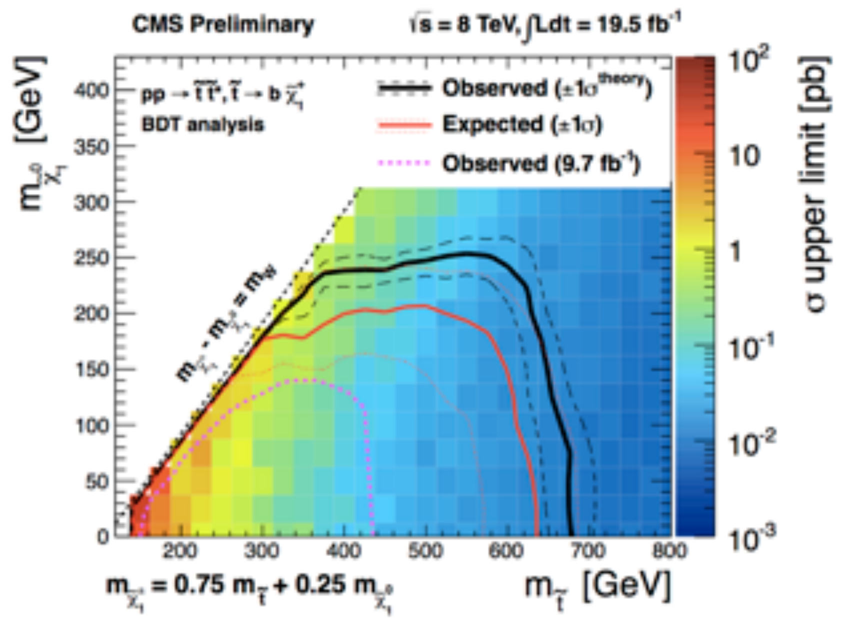
Les Houches workshop June 2013

Wishlist for the presentation of SMS results

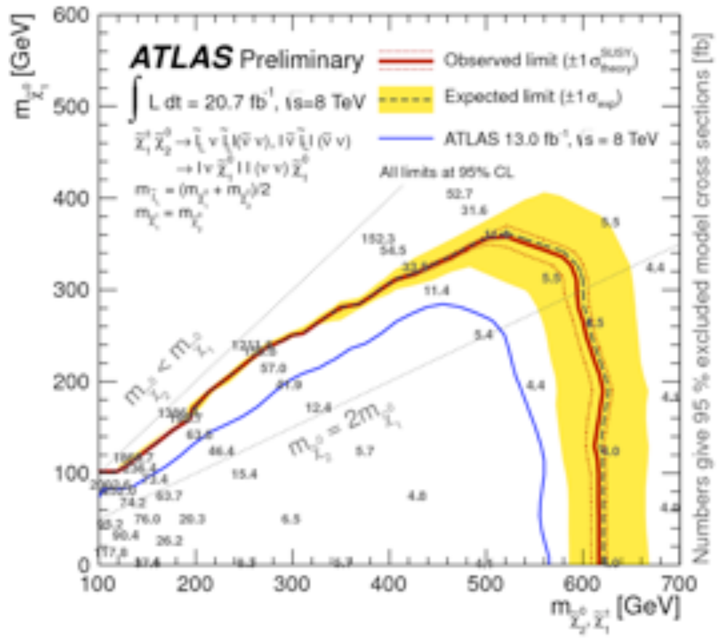
1. Digitize, digitize, digitize, ...
2. For topologies involving cascade decays, provide results for more than one (at least 3) intermediate mass values.
3. Provide good coverage of the parameter space considered.
4. Avoid too restrictive assumptions (and obviously don't make unphysical ones).
5. For topologies involving different decays on each leg, parametrize results in terms of branching fractions.
6. Give expected upper limits on σ x BR in addition to the observed ones.
7. ..... *(in progress)*

Everything is on the wiki. Interested people here in LH: Wolfgang, Suchita, Sabine, Aoife, Sofio, Tobias

the good



the bad



and we don't show the ugly ....

LPSC14001
HEPHY-PUB 932/13

SModelS: a tool for interpreting simplified-model results from the LHC and its application to supersymmetry

arXiv:1312.4175v1 [hep-ph] 15 Dec 2013

Sabine Kraml[1*], Suchita Kulkarni[1†], Ursula Laa[2‡], Andre Lessa[3§], Wolfgang Magerl[2¶], Doris Proschofsky-Spindler[2‖], Wolfgang Waltenberger[2**]

[1] *Laboratoire de Physique Subatomique et de Cosmologie, UJF Grenoble 1, CNRS/IN2P3, INPG, 53 Avenue des Martyrs, F-38026 Grenoble, France*

[2] *Institut für Hochenergiephysik, Österreichische Akademie der Wissenschaften, Nikolsdorfer Gasse 18, 1050 Wien, Austria*

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first stable release

LPSC14295
HEPHY-PUB 945/14

SModelS v1.0: a short user guide

arXiv:1412.1745v1 [hep-ph] 4 Dec 2014

Sabine Kraml[1], Suchita Kulkarni[1,2], Ursula Laa[1,2], Andre Lessa[3], Veronika Magerl[2], Wolfgang Magerl[2], Doris Proschofsky-Spindler[2*], Michael Traub[2], Wolfgang Waltenberger[2]

[1] *Laboratoire de Physique Subatomique et de Cosmologie, Université Grenoble-Alpes, CNRS/IN2P3, 53 Avenue des Martyrs, F-38026 Grenoble, France*

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[3] *Instituto de Física, Universidade de São Paulo, São Paulo - SP, Brazil*

Email: smodels-users@lists.oeaw.ac.at

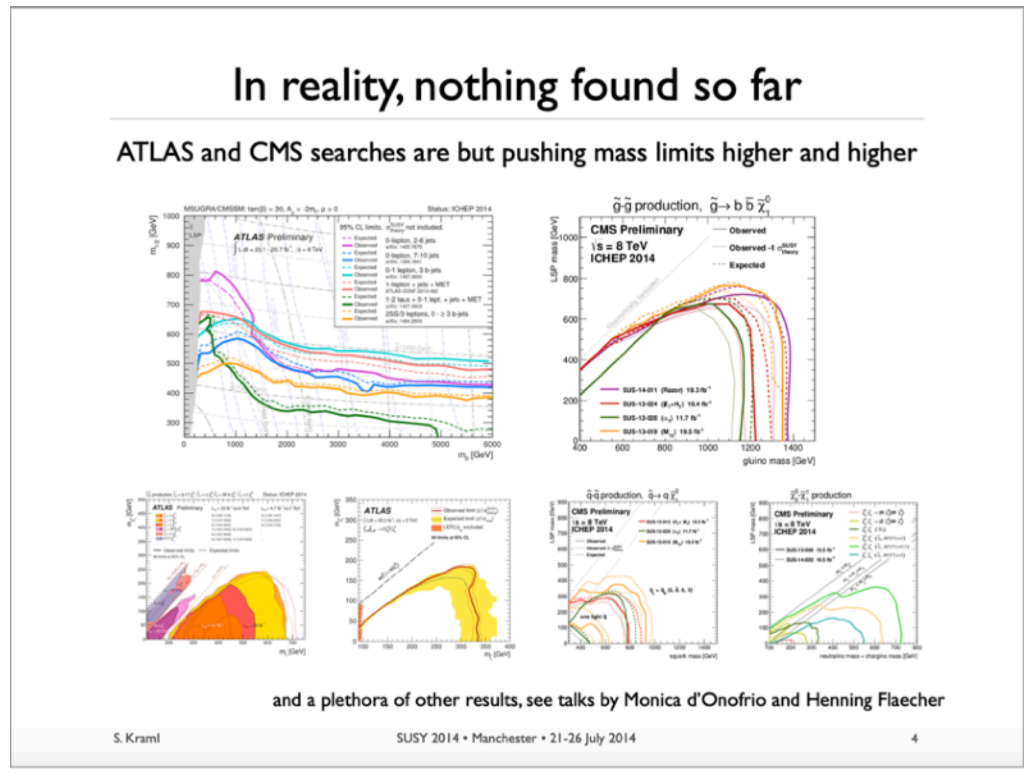
Abstract

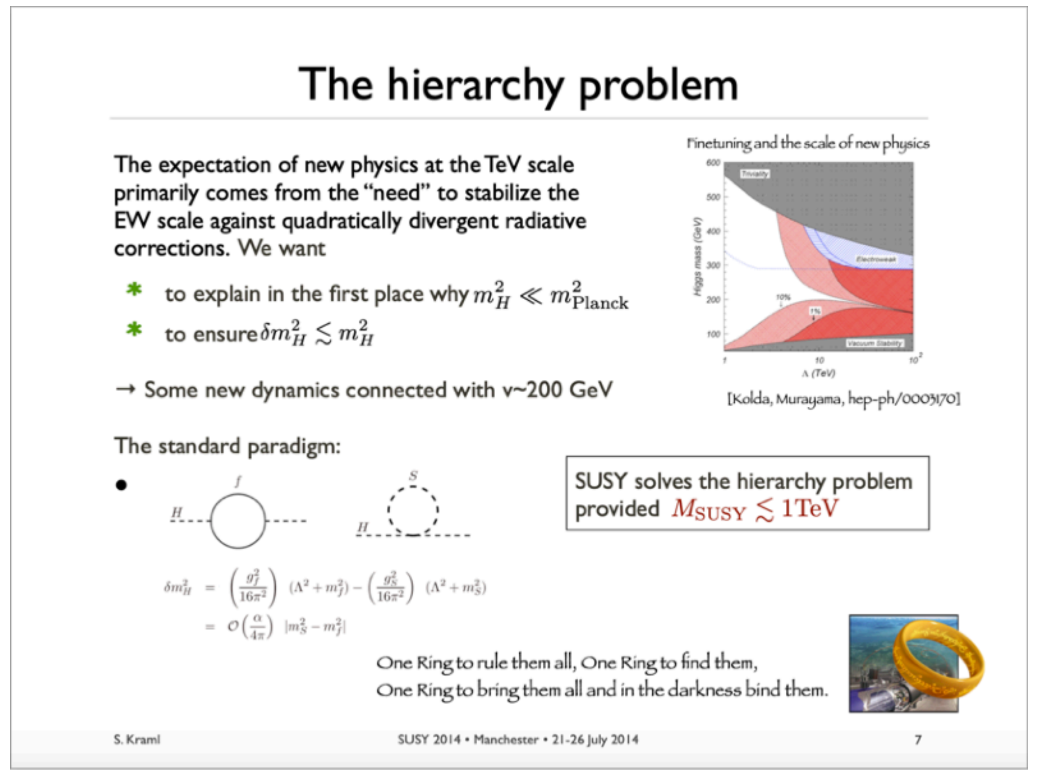
SModelS is a tool for the automatic interpretation of simplified-model results from the LHC. Version 1.0 of the code is now publicly available. This document provides a quick user guide for installing and running SModelS v1.0.

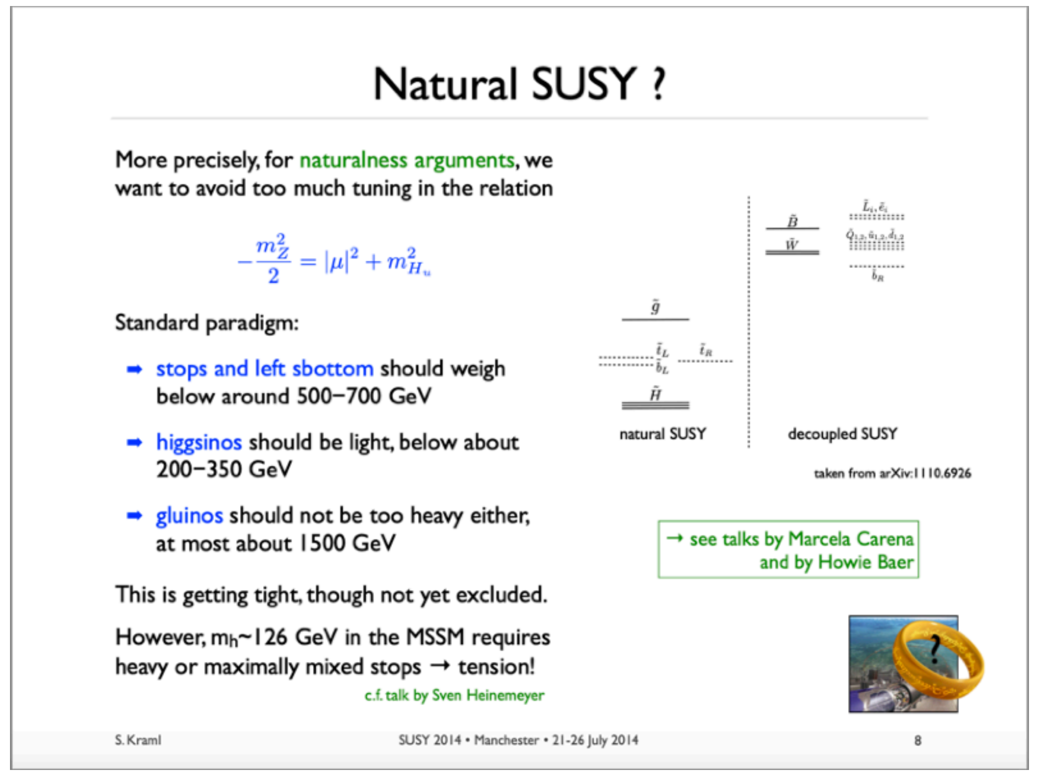
Database with 13 ATLAS + 13 CMS analyses

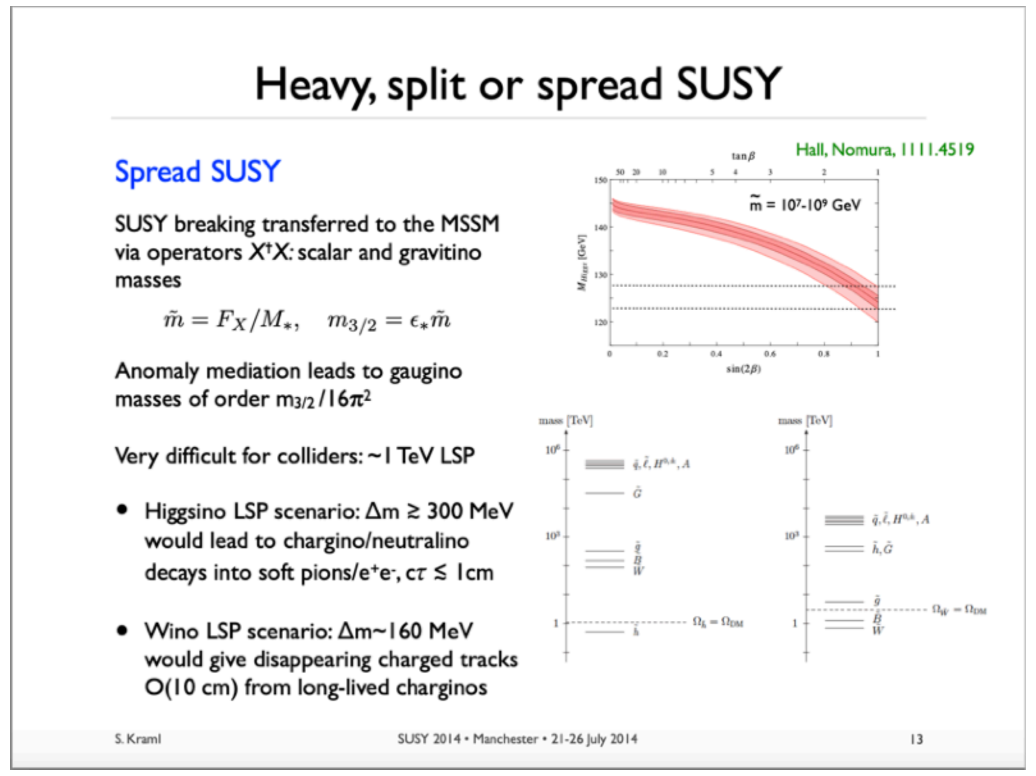
“Our method provides a way to cast BSM predictions for the LHC in a model independent framework, which can be directly confronted with the relevant experimental constraints.”

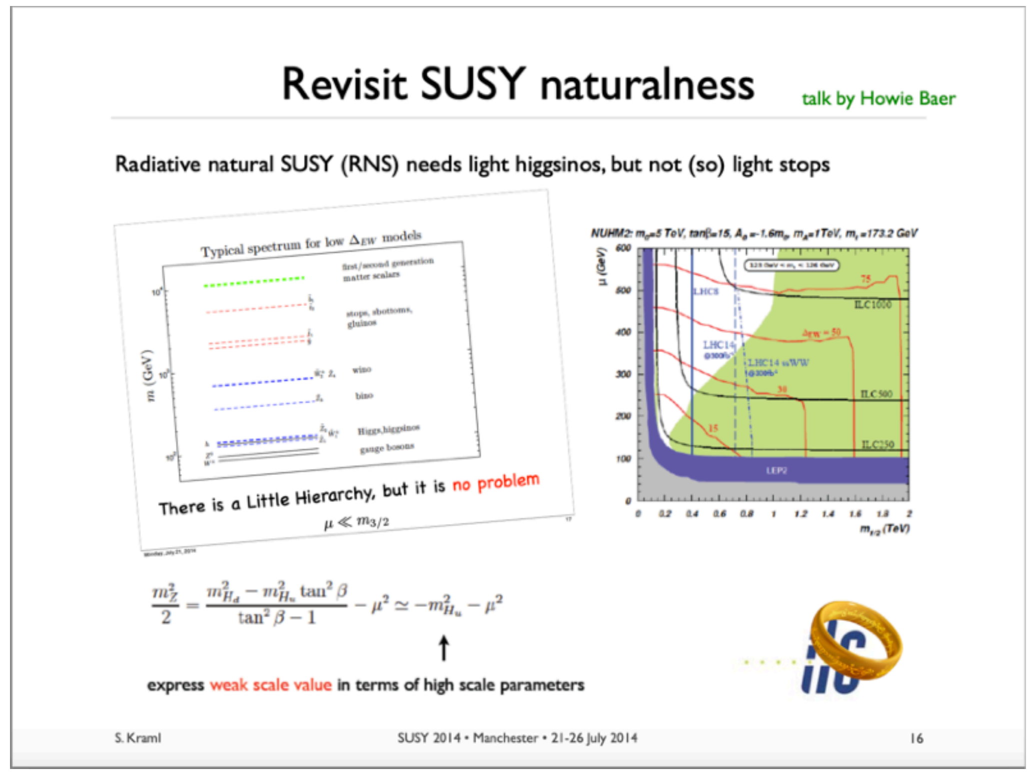
“As show-case examples we apply our procedure to two scans of the MSSM. We discuss how the SMS limits constrain various particle masses and which regions of parameter space remain unchallenged by the current SMS interpretations of the LHC results.”

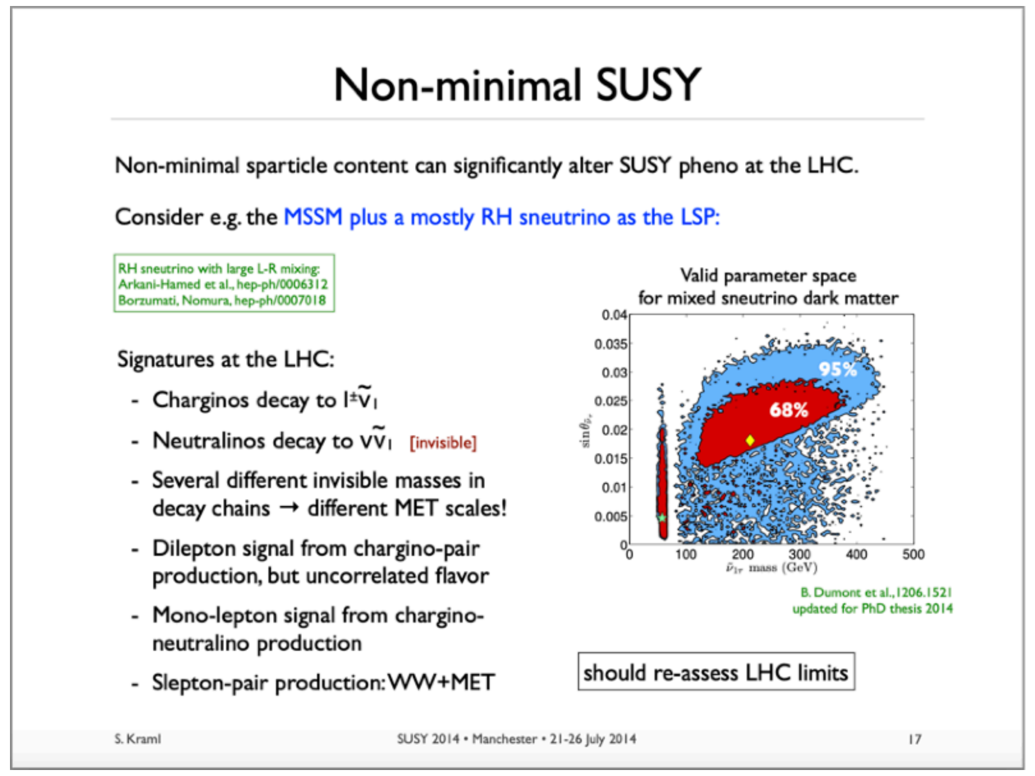




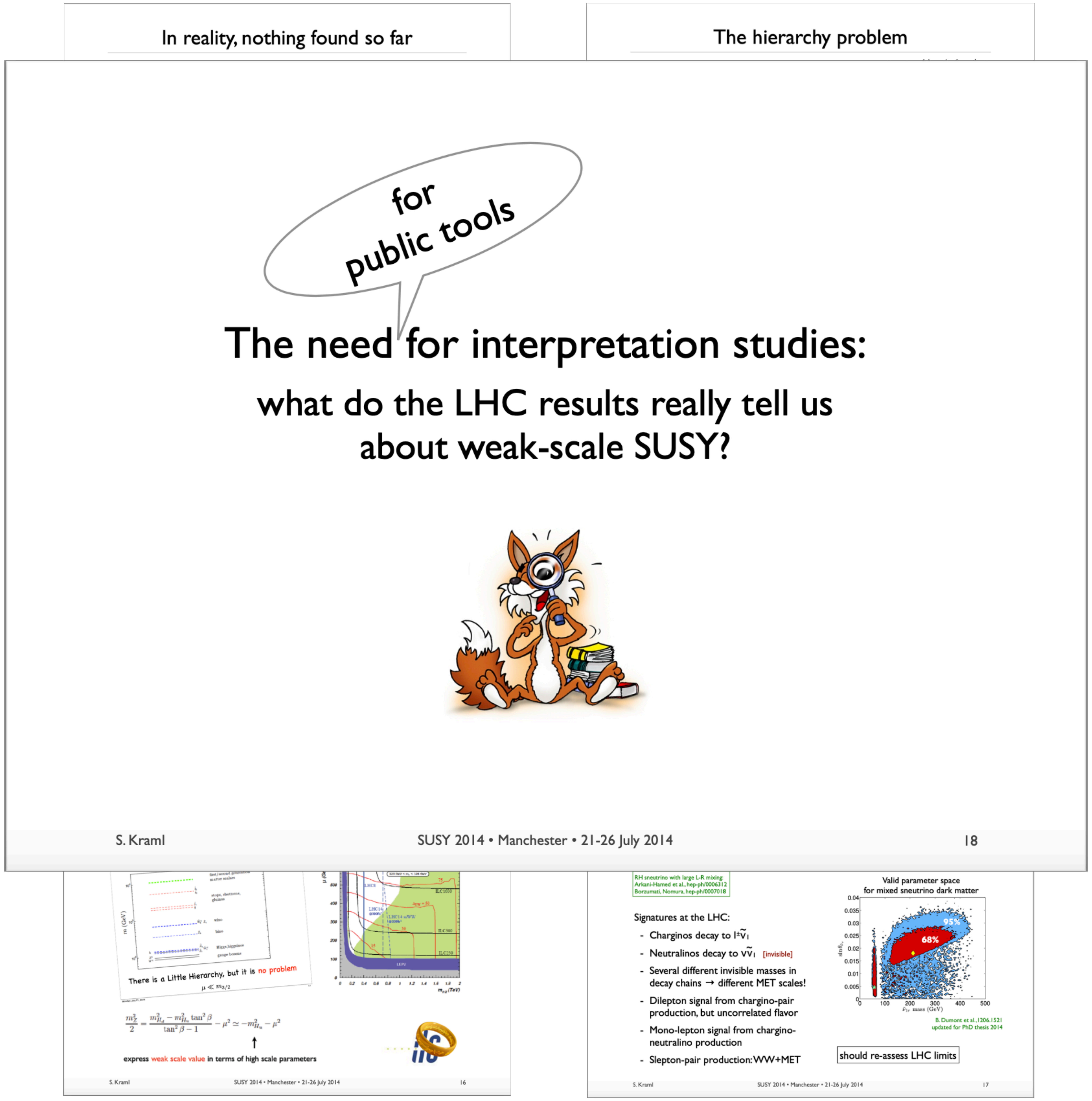








review talk at SUSY 2014 conf



review talk at SUSY 2014 conf

review talk at SUSY 2014

Interpretation tools

- Several groups have been developing private codes for recasting BSM searches
- A number of public tools have become available recently

Simplified Models (SMS)

- SModelS: generic decomposition into SMS topologies, cross section upper limits from more than 50 ATLAS and CMS SMS results
  [SK, Kulkarni, et al., 1312.4175]
  this talk
- Fastlim: reconstructs visible cross sections for SMS topologies from pre-calculated efficiency and cross section tables; currently 11 ATLAS analyses implemented.
  [Papucci et al., 1402.0492]
  see talk by K. Sakurai

Event simulation

- CheckMATE : checks 95% CL limits for simulated events of any model; currently has 8 ATLAS and 1 CMS SUSY analyses implemented
  [Drees et al., 1312.2591]
- MA5 PAD: public analysis database within the MadAnalysis5 framework; currently 2 ATLAS + 3 CMS analyses, more in progress
  [Dumont et al., 1407.3278]
  this talk

- Public tools are useful to and get tested by a large number of people. Helps remove bugs, and we do not constantly need to re-invent the wheel!

review talk at SUSY 2014

Interpretation tools

- Several groups have been developing private codes for recasting BSM searches
- A number of public tools have become available recently

Simplified

- SModelS: gene
SMS topologi
limits from m
CMS SMS res
- Fastlim: recon
sections for S
pre-calculated
section tables
analyses imple

- Public tools are
Helps remove

S. Kraml

To take home

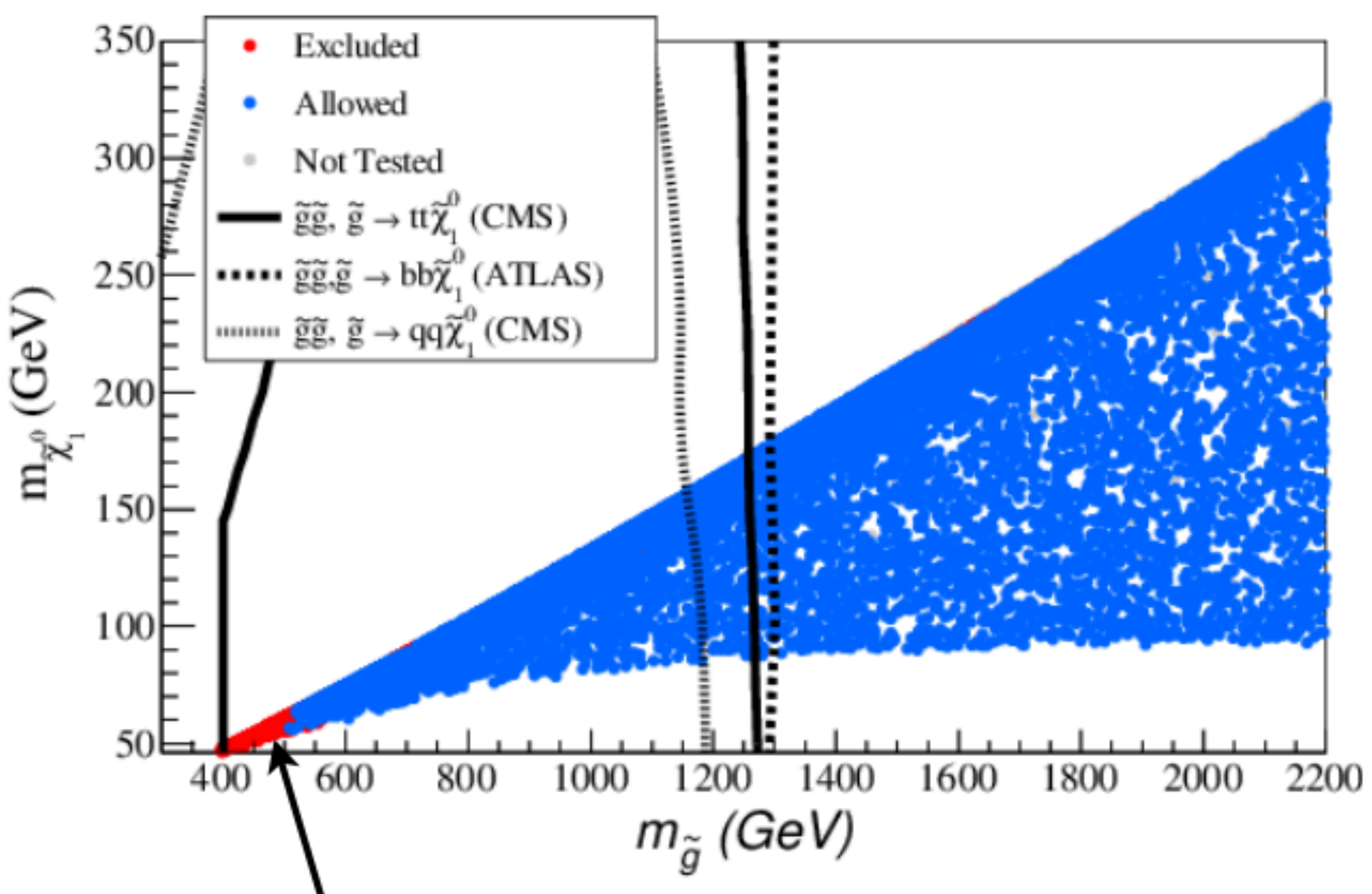
- In the multiverse picture, the scale of SUSY breaking may have nothing to do with stabilizing the weak scale. In this case the Higgs may be the only discovery at the LHC (and other colliders provided there will be any).
- Nonetheless weak-scale SUSY is by no means excluded, and naturalness remains a very well-motivated guideline.
- There's a multitude of possible SUSY 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.
- Much more experiment-theory interaction is needed to make the most out of the LHC results. We need to develop theoretical tools but we also need more information on the experimental analyses.

search for SUSY with an open (access) mind

S. Kraml SUSY 2014 • Manchester • 21-26 July 2014 37

SModelS results: 7-parameter (p)MSSM

- Allowed points on top of excluded ones

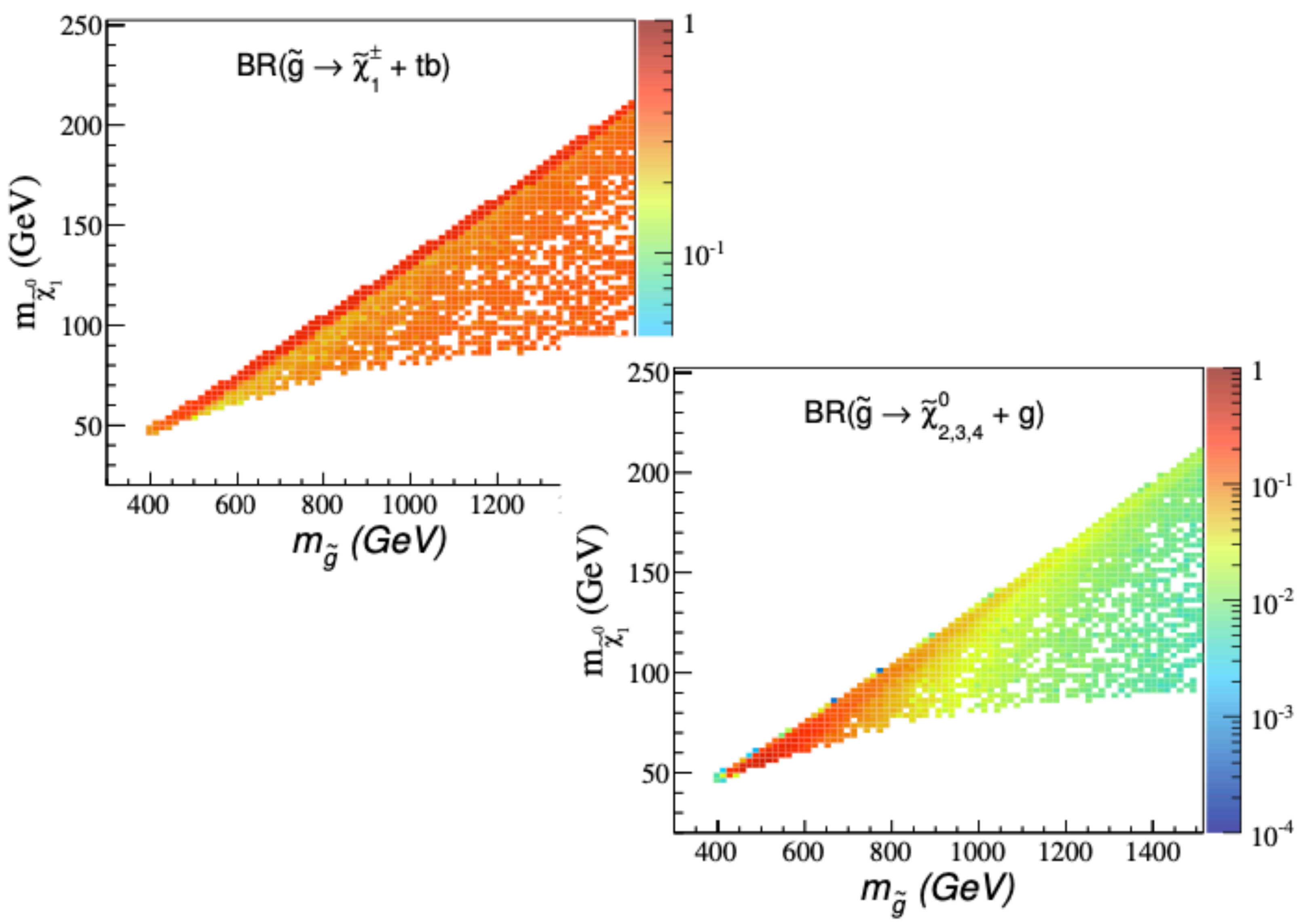


only small region strictly excluded by SMS results

Scan over:
$M_3 = 3M_2 = 6M_1$
slepton mass parameters
$\tan\beta$, μ
(squarks decoupled)

mh = 123-128 GeV, B-physics constraints, ...

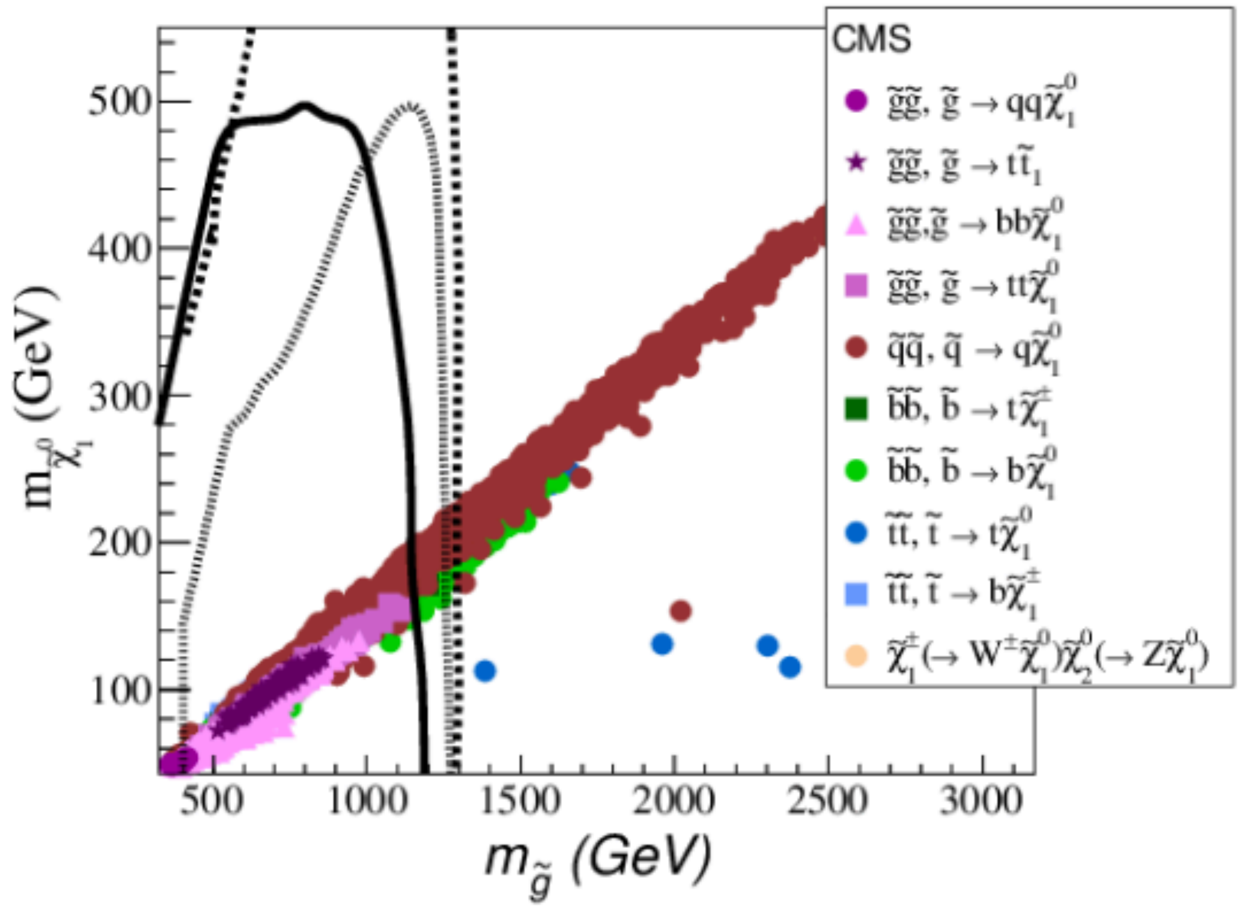
NB: large BR's but no SMS results available

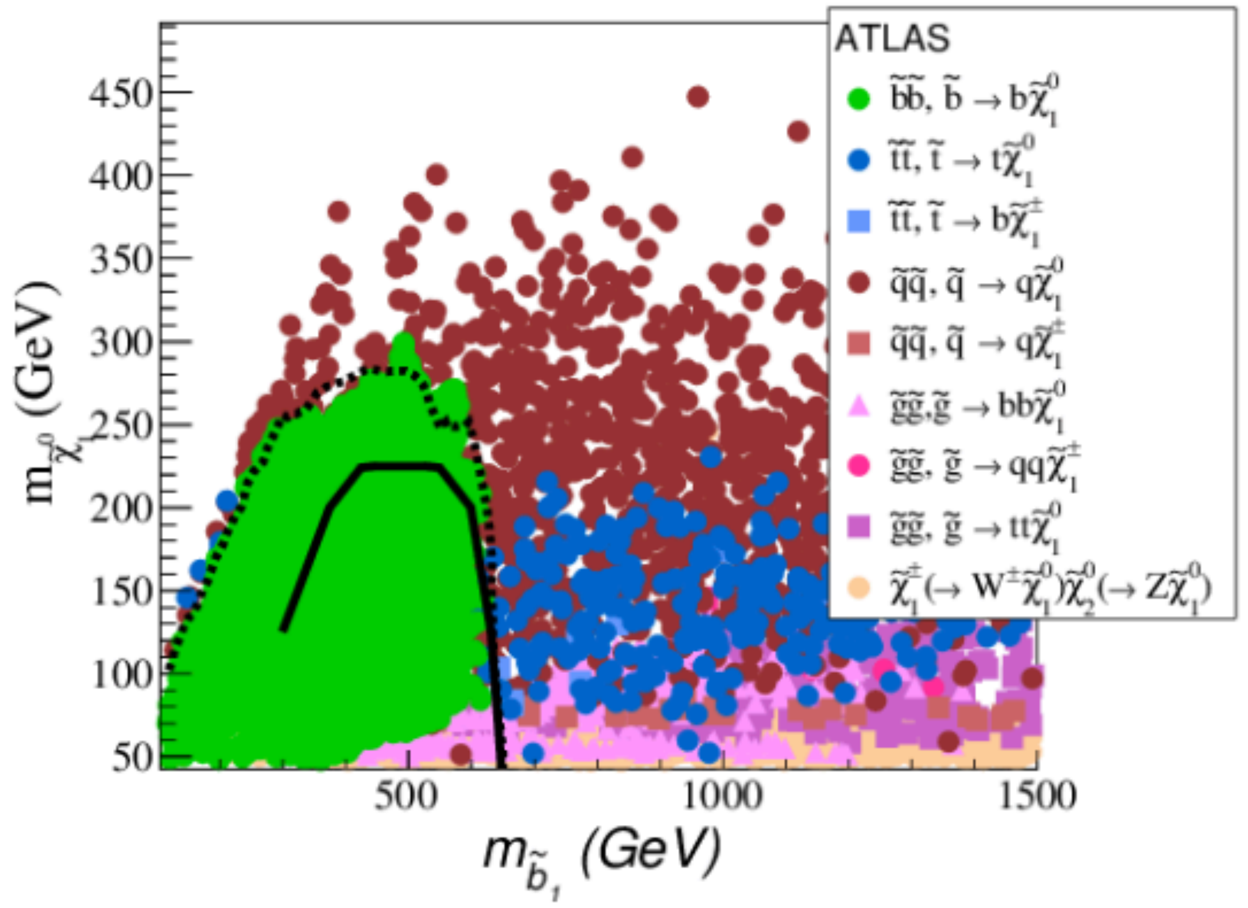


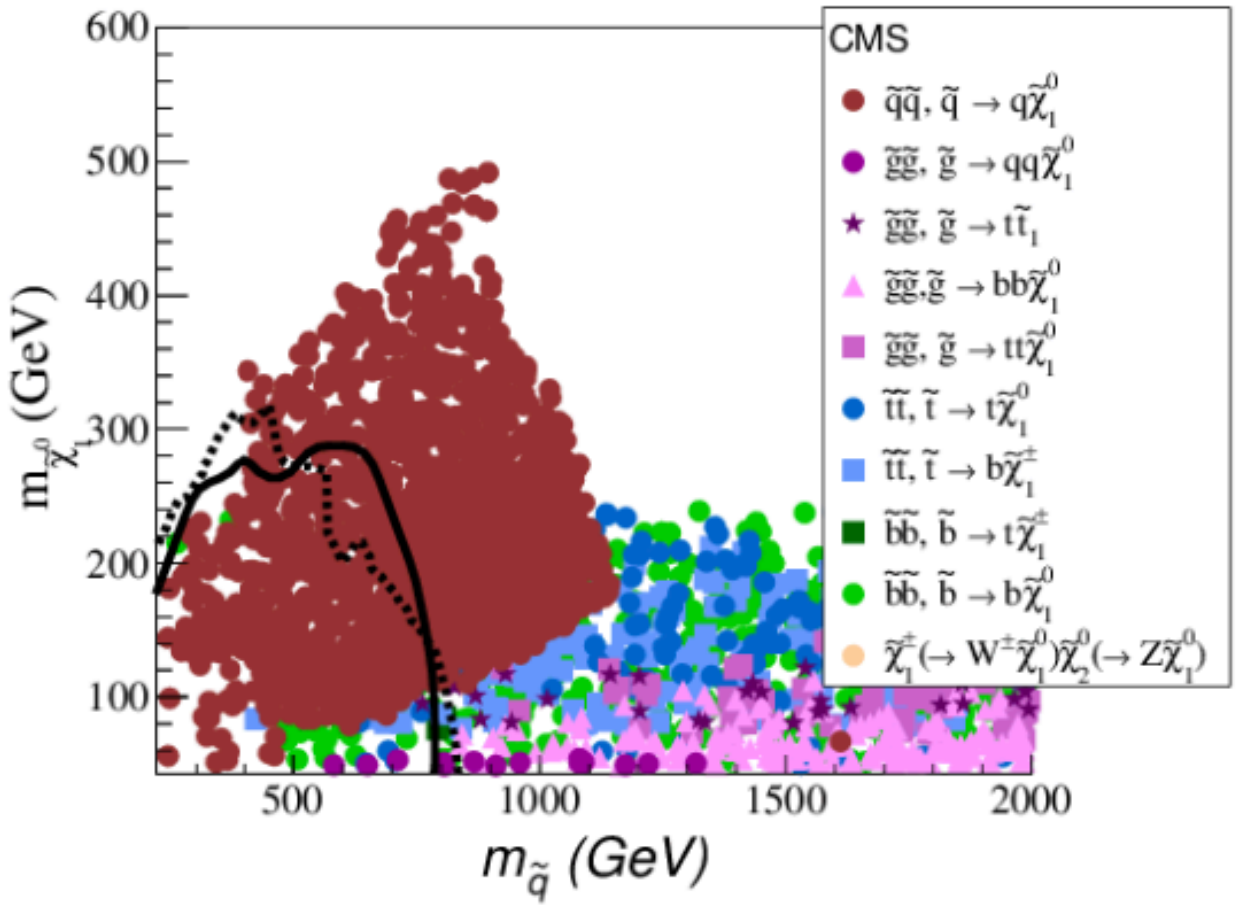
SModelS results: 9-parameter (p)MSSM

Scan over:
$M_3 = 3M_2 = 6M_1$
stop and sbottom masses
light-flavor squark mass
$\tan\beta$, μ
(sleptons decoupled)

mh = 123-128 GeV, B-physics constraints, ...



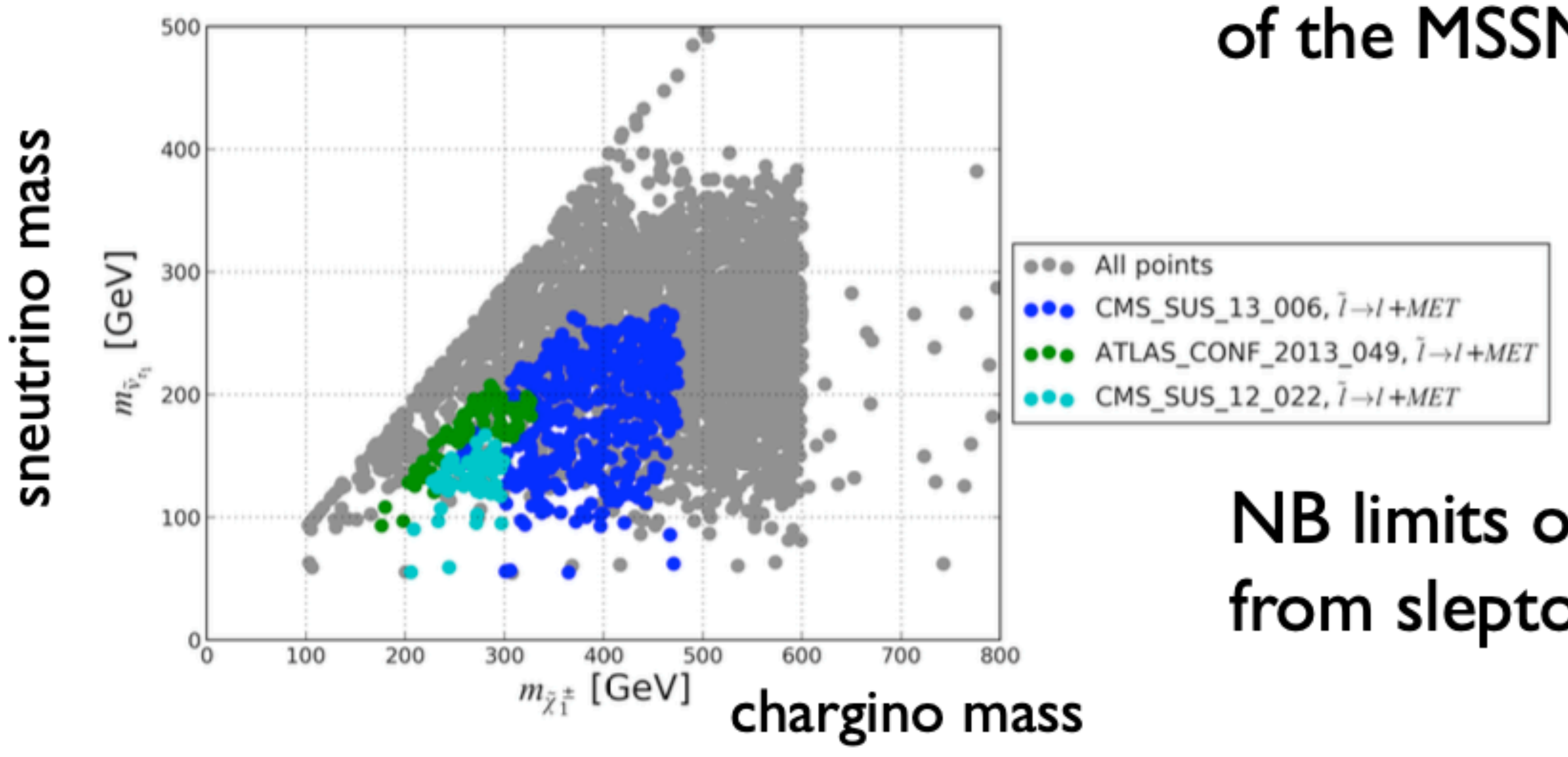




excluded points, labelled by most constraining topology; analogous results for ATLAS ↔ CMS

Mixed sneutrino dark matter model

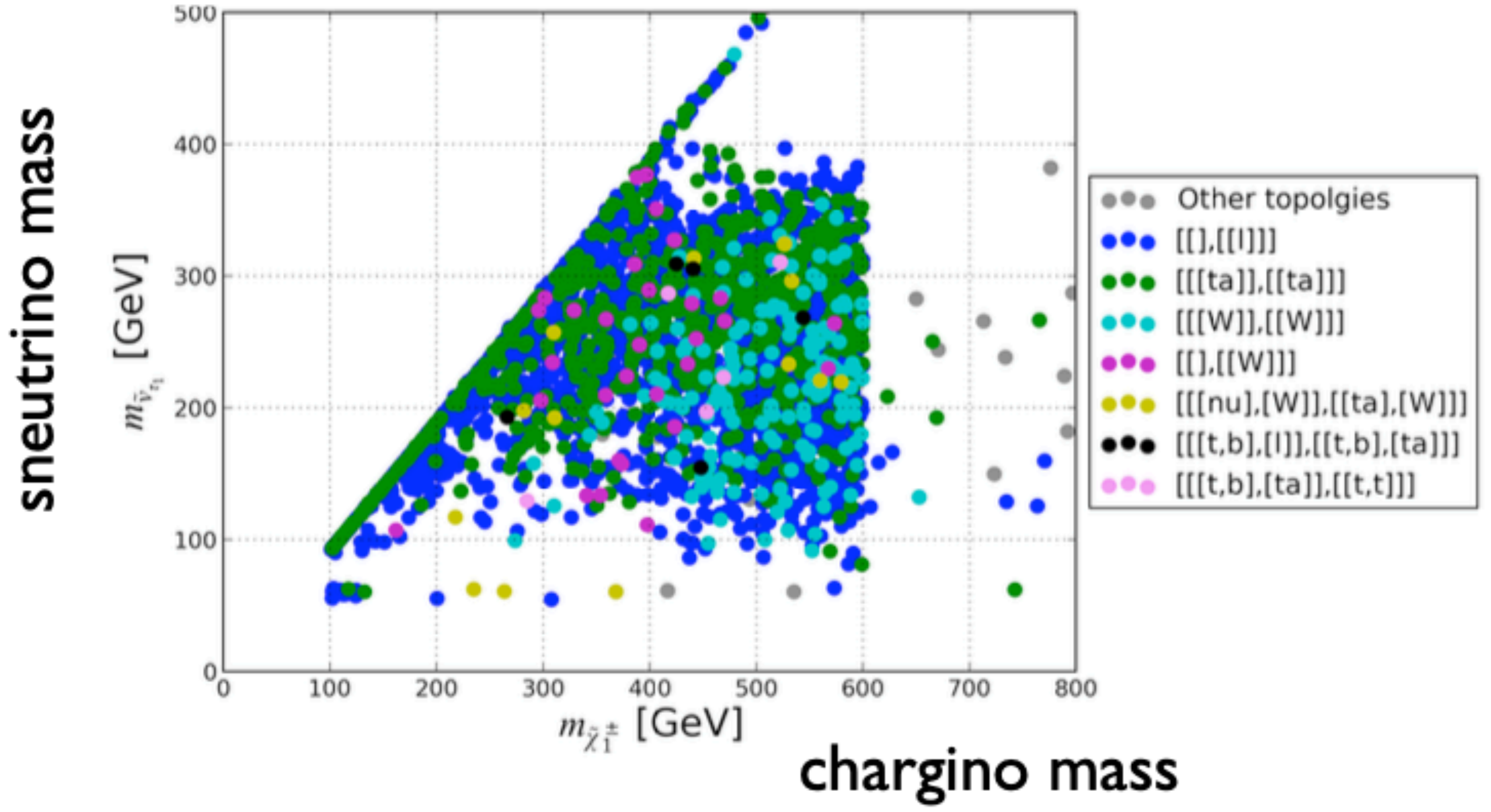
excluded points grouped by analysis



SModelS works "out of the box" for extensions of the MSSM, like the MSSM + RH sneutrino LSP

NB limits on charginos here actually come from slepton searches (dilepton channel)

not-excluded points grouped by final state



Most important "missing topology", i.e. for which no SMS results exists, is single lepton+MET

Work in progress with C. Arina, S. Kulkarni and U. Laa

SMS Caveats

- A realistic SUSY spectrum does not necessarily fully decompose into SMS's. For instance, long decay chains have no SMS-equivalent by definition.
- Effects of off-shell particles in production and/or decay modes may influence the kinematic distributions.
- In SModelS, we decompose a spectrum according to the masses of the R-odd particles in each decay chain, and the number and nature of the R-even (SM) particles produced in each vertex. However, we do not use information on the nature of the R-odd particles → spin/helicity effects are not taken care of (in other words, don't use it blindly)

To circumvent these caveats: simulate events, emulate detector response, apply analysis cuts, ... → fastsim

arXiv:1312.4175

Summer 2014

SModelS: a tool for interpreting simplified-model results from the LHC and its application to supersymmetry #16

Sabine Kraml (LPSC, Grenoble), Suchita Kulkarni (LPSC, Grenoble), Ursula Laa (Vienna, OAW), Andre Lessa (Sao Paulo U.), Wolfgang Magerl (Vienna, OAW) et al. (Dec 15, 2013)

Published in: *Eur.Phys.J.C* 74 (2014) 2868 • e-Print: 1312.4175 [hep-ph]

SModelS v1.0: a short user guide #15

Sabine Kraml (LPSC, Grenoble), Suchita Kulkarni (LPSC, Grenoble and Vienna, OAW), Ursula Laa (LPSC, Grenoble and Vienna, OAW), Andre Lessa (Sao Paulo U.), Veronika Magerl (Vienna, OAW) et al. (Dec 4, 2014)

e-Print: 1412.1745 [hep-ph]

First "SModelS Fest" in Vienna 2014

Interpreting LHC searches for new physics with SModelS #14

Ursula Laa (Annecy, LAPTH and LPSC, Grenoble) (Oct 7, 2015)

Published in: *PoS* EPS-HEP2015 (2015) 105 • Contribution to: EPS-HEP 2015, 105 • e-Print: 1510.01999 [hep-ph]

2015: Wolfgang visits Andre for 4-5 months

SModelS: A Tool for Making Systematic Use of Simplified Models Results #13

SModelS Collaboration • Wolfgang Waltenberger (Vienna, OAW) for the collaboration. (Nov 21, 2016)

Published in: *J.Phys.Conf.Ser.* 762 (2016) 1, 012076 • Contribution to: ACAT 2016

Yearly SModelS Fest alternating btw Grenoble and Vienna

2017

Efficiency maps

SModelS v1.1 user manual: Improving simplified model constraints with efficiency maps

Federico Ambrogi (Vienna, OAW), Sabine Kraml (LPSC, Grenoble), Suchita Kulkarni (Vienna, OAW), Ursula Laa (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Veronika Magerl (Freiburg U.), Jory Sonneveld (Hamburg U.), Michael Traub (Vienna, OAW), Wolfgang Waltenberger (Vienna, OAW)

Published in: *Comput.Phys.Commun.* 227 (2018) 72-98 • e-Print: 1701.06586 [hep-ph]

extensive manual, basis of what's now the online manual

Federico
PhD in Vienna

On the coverage of the pMSSM by simplified model results

Federico Ambrogi (Vienna, OAW), Sabine Kraml (LPSC, Grenoble), Suchita Kulkarni (Vienna, OAW), Ursula Laa (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Wolfgang Waltenberger (Vienna, OAW)

Published in: *Eur.Phys.J.C* 78 (2018) 3, 215 • e-Print: 1707.09036 [hep-ph]

comprehensive physics study showing to what extent SMS results cover the general MSSM

Uschi
PhD in Grenoble

May 2017

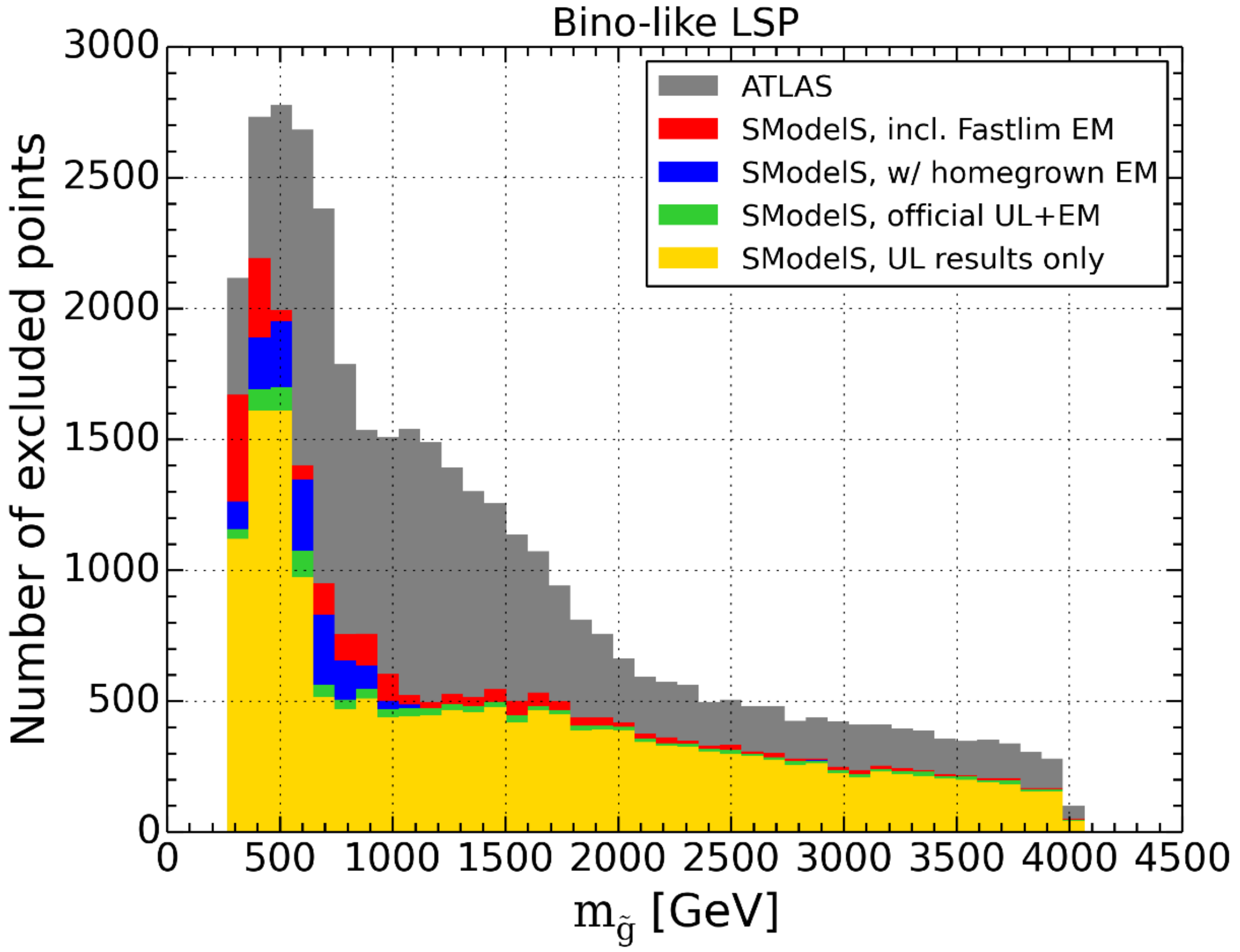
2 weeks SModelS Fest
in Grenoble

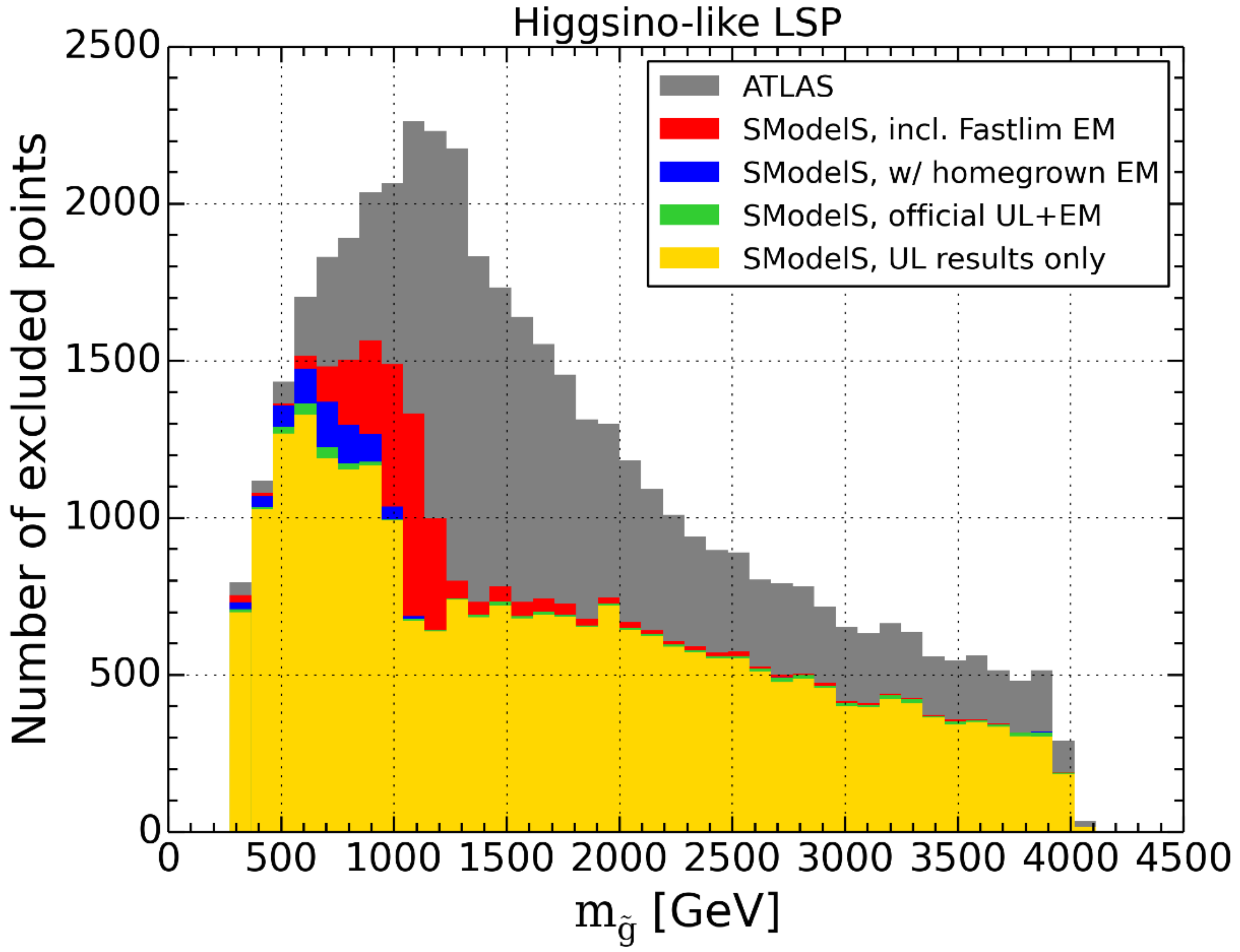
Coverage of the pMSSM by simplified model results

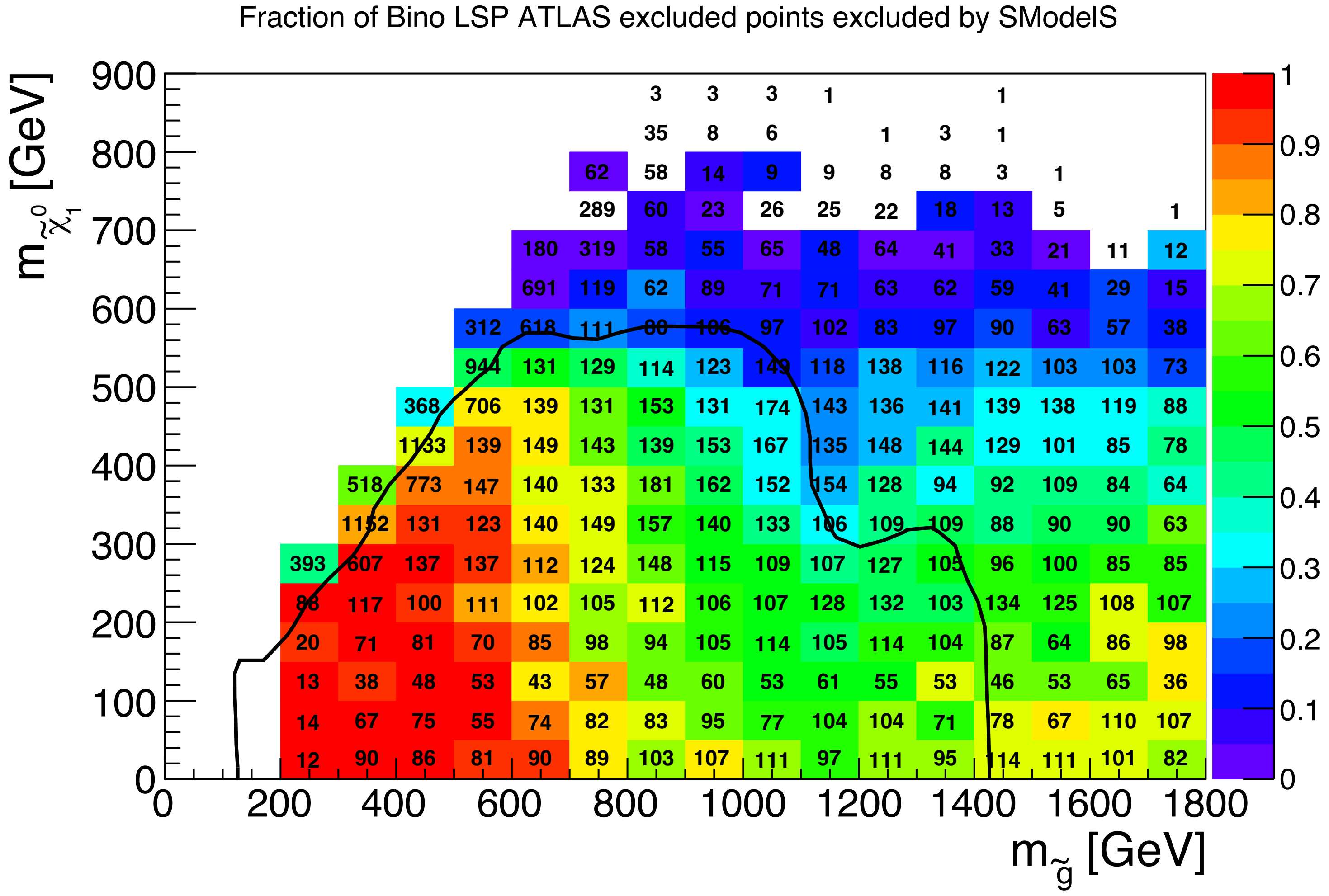
1707.09036

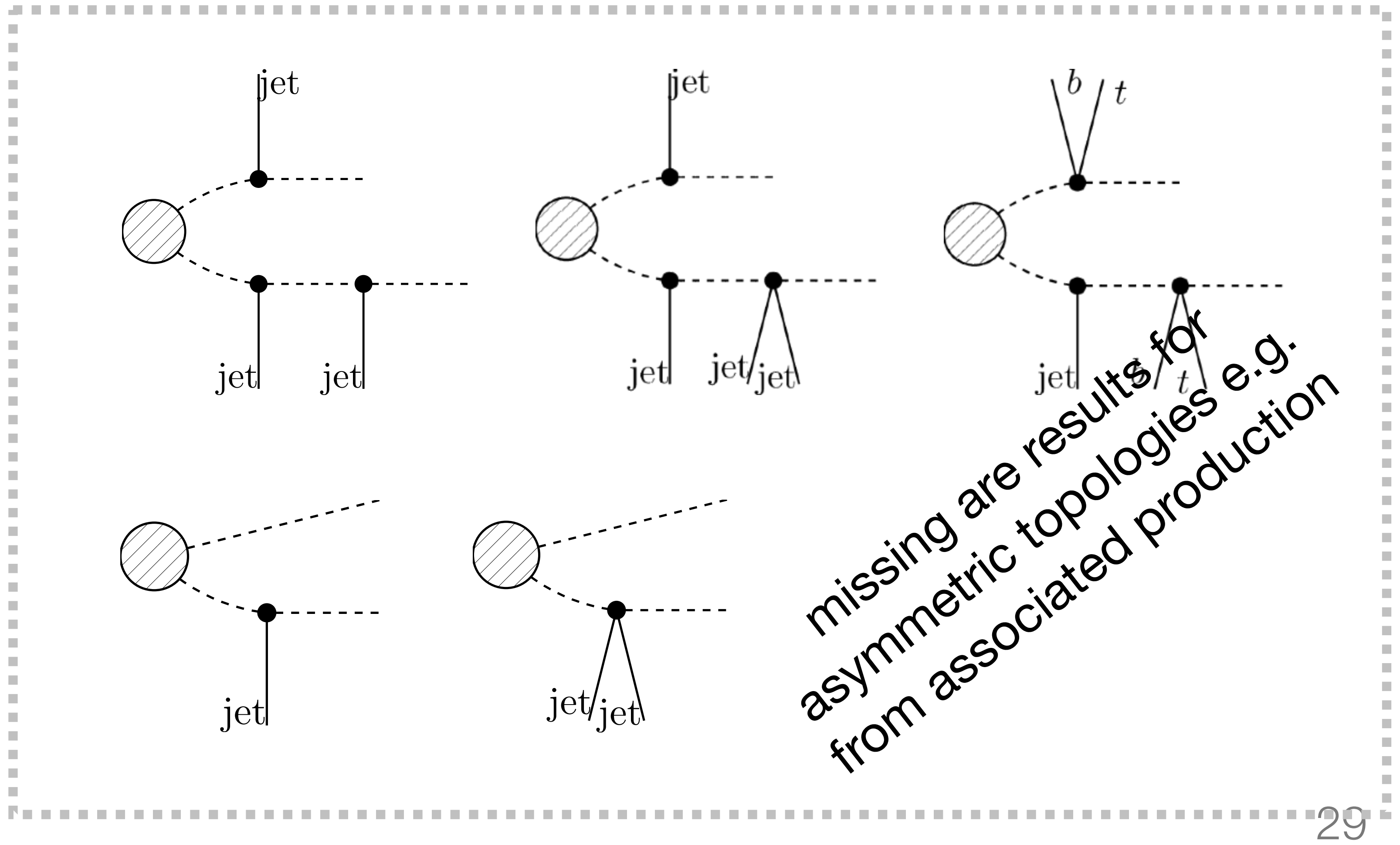
>300k scan points from 2015 “Summary of the ATLAS experiment’s sensitivity to supersymmetry after LHC Run 1 interpreted in the phenomenological MSSM,”
JHEP 10 (2015) 134, 1508.06608.

	Bino-like LSP	Higgsino-like LSP
Total number of points	38575	45594
Number of points excluded – UL results only	16957	25024
Number of points excuded – full database	21151	28669
	~55%	**~63%**









Coverage of the pMSSM by simplified model results

ATLAS results

	Analysis	Ref.	ID	SModelS database
Inclusive	0-lepton + 2–6 jets + E_T^{miss}	[35]	SUSY-2013-02*	6 UL, 2 EM
	0-lepton + 7–10 jets + E_T^{miss}	[36]	SUSY-2013-04*	1 UL, 10 EM
	1-lepton + jets + E_T^{miss}	[37]	SUSY-2013-20*	1 UL from CONF-2013-089 [38]
	$\tau(\tau/\ell)$ + jets + E_T^{miss}	[39]	SUSY-2013-10	n.i.
	SS/3-leptons + jets + E_T^{miss}	[40]	SUSY-2013-09	1 UL (+5 UL, CONF-2013-007 [41])
	0/1-lepton + 3b-jets + E_T^{miss}	[42]	SUSY-2013-18*	2 UL, 2 EM
	Monojet	[43]	—	— (but monojet stop, see below)
Third generation	0-lepton stop	[44]	SUSY-2013-16*	1 UL, 1 EM
	1-lepton stop	[45]	SUSY-2013-15*	1 UL, 1 EM
	2-leptons stop	[46]	SUSY-2013-19*	2 UL
	Monojet stop	[47]	SUSY-2013-21	4 EM
	Stop with Z boson	[48]	SUSY-2013-08	1 UL
	2b-jets + E_T^{miss}	[49]	SUSY-2013-05*	3 UL, 1 EM
	tb+E_T^{miss}, stop	[50]	SUSY-2014-07	—
Electroweak	ℓh	[51]	SUSY-2013-23*	1 UL
	2-leptons	[52]	SUSY-2013-11	4 UL, 4 EM
	2-τ	[53]	SUSY-2013-14	—
	3-leptons	[54]	SUSY-2013-12	5 UL
	4-leptons	[55]	SUSY-2013-13	—
	Disappearing Track	[56]	SUSY-2013-01	n.a.
Other	Long-lived particle	[57, 58]	—	n.a.
	$H/A \to \tau^+\tau^-$	[59]	—	n.a.

Fastlim EMs

	Analysis	Ref.	ID
Incl.	0-lepton + 2–6 jets + E_T^{miss}	[60]	ATLAS-CONF-2013-047
	0-lepton + 7–10 jets + E_T^{miss}	[61]	ATLAS-CONF-2013-054
	1-lepton + jets + E_T^{miss}	[62]	ATLAS-CONF-2013-062
	0/1-lepton + 3b-jets + E_T^{miss}	[63]	ATLAS-CONF-2013-061
Third gen.	0-lepton stop	[64]	ATLAS-CONF-2013-024
	1-lepton stop	[65]	ATLAS-CONF-2013-037
	2-leptons stop	[66]	ATLAS-CONF-2013-048
	2b-jets + E_T^{miss}	[67]	ATLAS-CONF-2013-053
EW	ℓh	[68]	ATLAS-CONF-2013-093

CMS results

	Analysis	Ref.	ID	SModelS database
Gluino, Squark	jets + E_T^{miss}, α_T	[69]	SUS-12-028	4 UL
	3(1b-)jets + E_T^{miss}	[70]	SUS-12-024	2 UL, 3 EM
	jet multiplicity + H_T^{miss}	[71]	SUS-13-012	4 UL, 20 EM
	$\geq$ 2 jets + E_T^{miss}, M_{T2}	[72]	SUS-13-019	8 UL
	$\geq$ 1b + E_T^{miss}, Razor	[73]	SUS-13-004	5 UL
	1 lepton + $\geq$ 2b-jets + E_T^{miss}	[74]	SUS-13-007	3 UL, 2 EM
	2 OS lept. + $\geq$4(2b-)jets + E_T^{miss}	[75]	PAS-SUS-13-016	2 UL
	2 SS leptons + b-jets + E_T^{miss}	[76]	SUS-13-013	4 UL, 2 EM
	b-jets + 4 Ws + E_T^{miss}	[77]	SUS-14-010	2 UL
Third gen.	0 lepton + $\geq$ 5(1b-)jets + E_T^{miss}	[78]	PAS-SUS-13-015	2 EM
	0 lepton + $\geq$ 6(1b-)jets + E_T^{miss}	[79]	PAS-SUS-13-023	4 UL
	1 lepton + $\geq$ 4(1b-)jets + E_T^{miss}	[80]	SUS-13-011	4 UL, 2 EM
	b-jets + E_T^{miss}	[81]	PAS-SUS-13-018	1 UL
	soft leptons, few jets + E_T^{miss}	[82]	SUS-14-021	2 UL
EW	multi-leptons + E_T^{miss}	[83]	SUS-13-006	6 UL

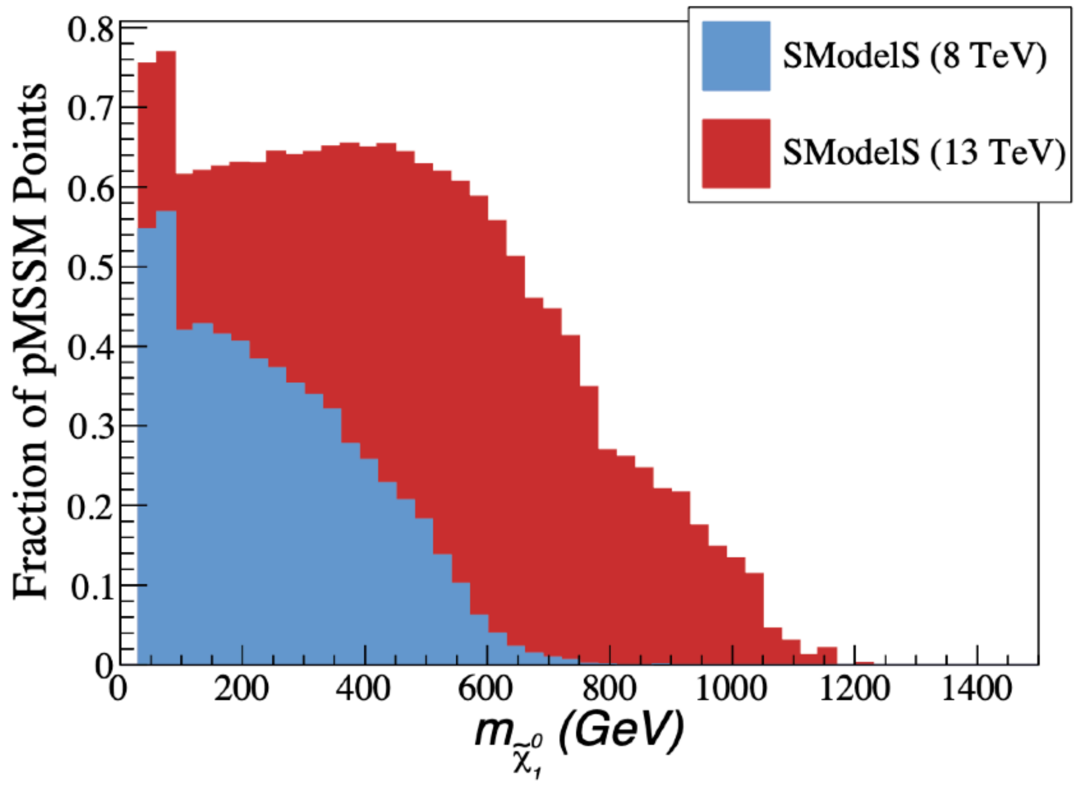
Juhi Dutta
PhD Allahabad

SModelS extension with the CMS supersymmetry search results from Run 2

Juhi Dutta (Harish-Chandra Res. Inst.), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Wolfgang Waltenberger (Vienna, OAW)

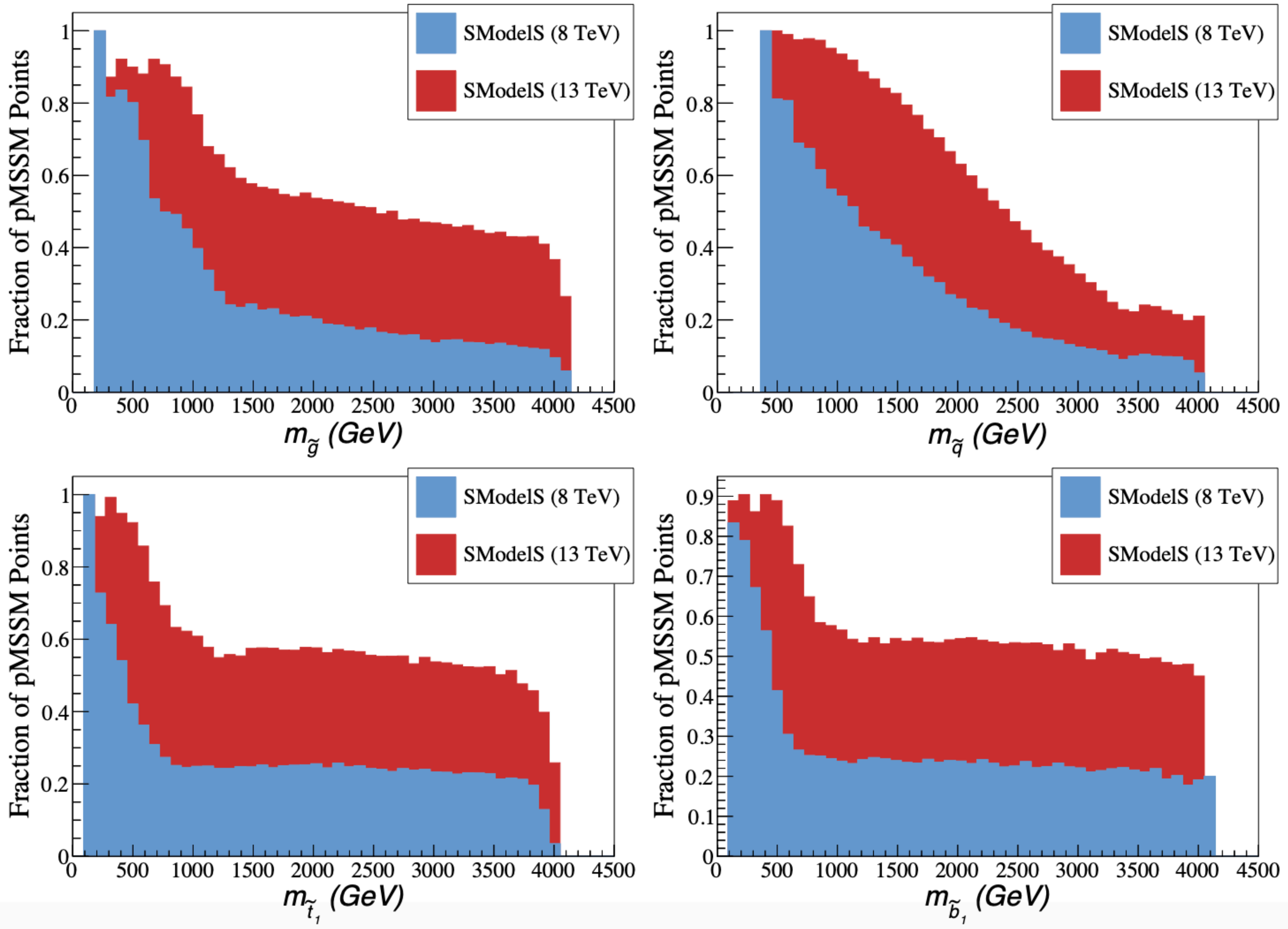
results from 19 CMS SUSY analyses from Run 2 with 36 fb^{-1} of data

CEFIPRA-funded research visit of Juhi during SModelS Fest in Grenoble, May 2017



	Bino-like LSP	Higgsino-like LSP	Wino-like LSP
Total number of points	99,492	123,498	8,772
# points excluded – 8 TeV results only	23,253	32,219	1,389
# points excuded – full database	62,159	65,768	3,212

Points from ATLAS pMSSM scan, w/o long-lived charged particles



Published in: *LHEP* 1 (2018) 1, 5-12 • e-Print: 1803.02204 [hep-ph]

2018

Long-lived particles

Jan Heisig
Aachen/Louvain

Constraining new physics with searches for long-lived particles: Implementation into SModelS

Jan Heisig (RWTH Aachen), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.)

Published in: *Phys.Lett.B* 788 (2019) 87-95 • e-Print: 1808.05229 [hep-ph]

SModelS Fest in Vienna
June 2018

$$\tilde{\sigma} = \sigma_{\text{prod}} \left(\prod_i \text{BR}_i \times \mathcal{F}^i_{\text{prompt}} \right) \mathcal{F}^X_{\text{long}} \mathcal{F}^Y_{\text{long}} \,,$$

$$\mathcal{F}_{\text{prompt}} = 1 - \exp\left(-\frac{1}{c\tau} \left\langle \frac{\ell_{\text{inner}}}{\gamma\beta} \right\rangle_{\text{eff}} \right)$$

$$\mathcal{F}_{\text{long}} = \exp\left(-\frac{1}{c\tau} \left\langle \frac{\ell_{\text{outer}}}{\gamma\beta} \right\rangle_{\text{eff}} \right)$$

SModelS v1.2: : long-lived particles, combination of signal regions, and other novelties

Federico Ambrogi (Vienna, OAW), Juhi Dutta (Harish-Chandra Res. Inst.), Jan Heisig (Louvain U., CP3), Sabine Kraml (LPSC, Grenoble), Suchita Kulkarni (Vienna, OAW), Ursula Laa (Monash U.), Andre Lessa (ABC Federal U.), Philipp Neuhuber (Vienna, OAW), Humberto Reyes-González (LPSC, Grenoble), Wolfgang Waltenberger (Vienna, OAW), Matthias Wolf (Vienna, OAW)

Published in: *Comput.Phys.Commun.* 251 (2020) 106848 • e-Print: 1811.10624 [hep-ph]

Humberto
PhD Grenoble

2019

- LLP White Paper with chapter on reinterpretation (Andre, Sabine)
- Dirac Gaugino studies with Humberto
- Les Houches workshop (Humberto goes TACO and ML)
- Lilith-2 (Sabine w/ Vietnamese coll.)
- Brazilian Community Report on Dark Matter (Andre)
- a lot of work towards the Reinterpretation Forum report

… and Wolfgang plays with protomodelling …

2020

Despite the pandemic

Charanjit Kosa
PD Sussex

SModelS Database Update v1.2.3

Charanjit K. Khosa (Sussex U.), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Philipp Neuhuber (Vienna, OAW), Wolfgang Waltenberger (Vienna, OAW)

Published in: *LHEP* 2020 (2020) 158 • e-Print: 2005.00555 [hep-ph]

Dawn of the EMCreator

13 ATLAS and 10 CMS searches, 6 for full Run 2 lumi; 21 EM results recasted with MA5

Gaël
PhD in Grenoble

A SModelS interface for pyhf likelihoods

Gaël Alguero (LPSC, Grenoble), Sabine Kraml (LPSC, Grenoble), Wolfgang Waltenberger (Vienna, OAW)

Published in: *LHEP* 2020 (2020) 158 • e-Print: 2005.00555 [hep-ph]

pyhf ∂ifferentiable $\mathscr{L}$ikelihoods

First ones to use ATLAS full LLHDs

Kyle Cranmer

in his PhyStat seminar on
“Likelihood publishing, RECAST, and simulation-based inference”
14 Oct 2020

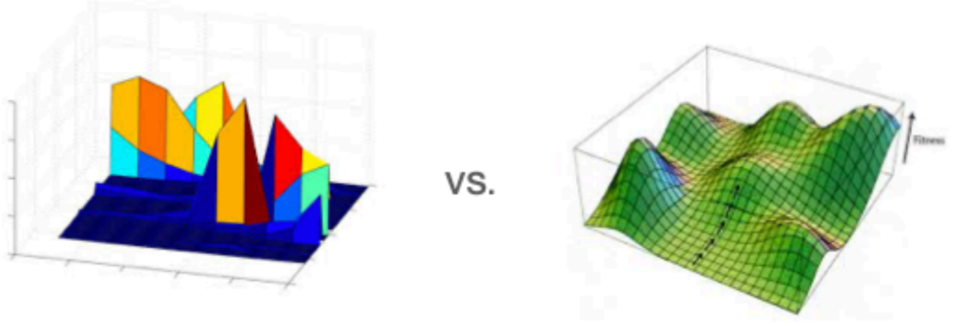
https://indico.cern.ch/event/962997/

THEORISTS REJOICE

Going further

Besides allowing us to better reproduce the official limits of each analysis, the full likelihoods

- will greatly improve global fits



- offer interesting possibilities to explore cross-analysis correlations
  - Systematic naming of nuisances?

- Both is also very useful for projects like the Protomodel Builder
  (cf talk by W. Waltenberger on June 4)
- Differentiability will allow for gradient-based methods in the future
- Lots to do on the pheno side, we are not yet using the full potential of full likelihoods.

S. Kraml - Feedback on use of public likelihoods - 24 Sep 2020 25

https://indico.cern.ch/event/957797/contributions/4026032/ 57

2020

Despite the pandemic

Humberto defends his thesis and moves to Genova

2020

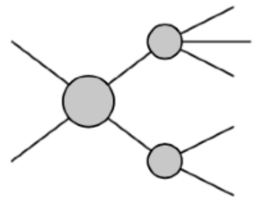
Despite the pandemic

Artificial Proto-Modelling: Building Precursors of a Next Standard Model from Simplified Model Results

Wolfgang Waltenberger (Vienna, OAW), André Lessa (ABC Federal U.), Sabine Kraml (LPSC, Grenoble)

“We present a novel algorithm to identify potential dispersed signals of new physics in the slew of published LHC results. It employs a random walk algorithm to introduce sets of new particles, dubbed “proto-models”, which are tested against simplified-model results from ATLAS and CMS (exploiting the SModelS software framework). … “

Published in: *JHEP* 03 (2021) 207 • e-Print: 2012.12246 [hep-ph]

LHC Signatures $\Leftrightarrow$ OSET  $\Leftrightarrow$ $\mathcal{L}$

recall the LHCO’06 and hep-ph/0703088 …

Builder Combiner Critic

PROTOMODEL BUILDER

2021

Constraining new physics with SModelS version 2

Gaël Alguero (Grenoble), Jan Heisig (Aachen & Louvain), Charanjit K. Khosa (Genoa & Bristol), Sabine Kraml (Grenoble), Suchita Kulkarni (Graz U.), Andre Lessa (ABC Federal U.), Humberto Reyes-González (Genoa), Wolfgang Waltenberger (Vienna), Alicia Wongel (DESY)

> *“…**extended topology description** with a flexible number of particle attributes, such as spin, charge, decay width, etc. This enables, in particular, the treatment of a wide range of signatures with long-lived particles. […].*
>
> *The current database includes results from searches for heavy stable charged particles, disappearing tracks, displaced jets and displaced leptons, in addition to a large number of prompt searches. The capabilities of the program are demonstrated by **two physics applications**: constraints on long-lived charged scalars in the scotogenic model, and constraints on the electroweak-ino sector in the Minimal Supersymmetric Standard Model.“*

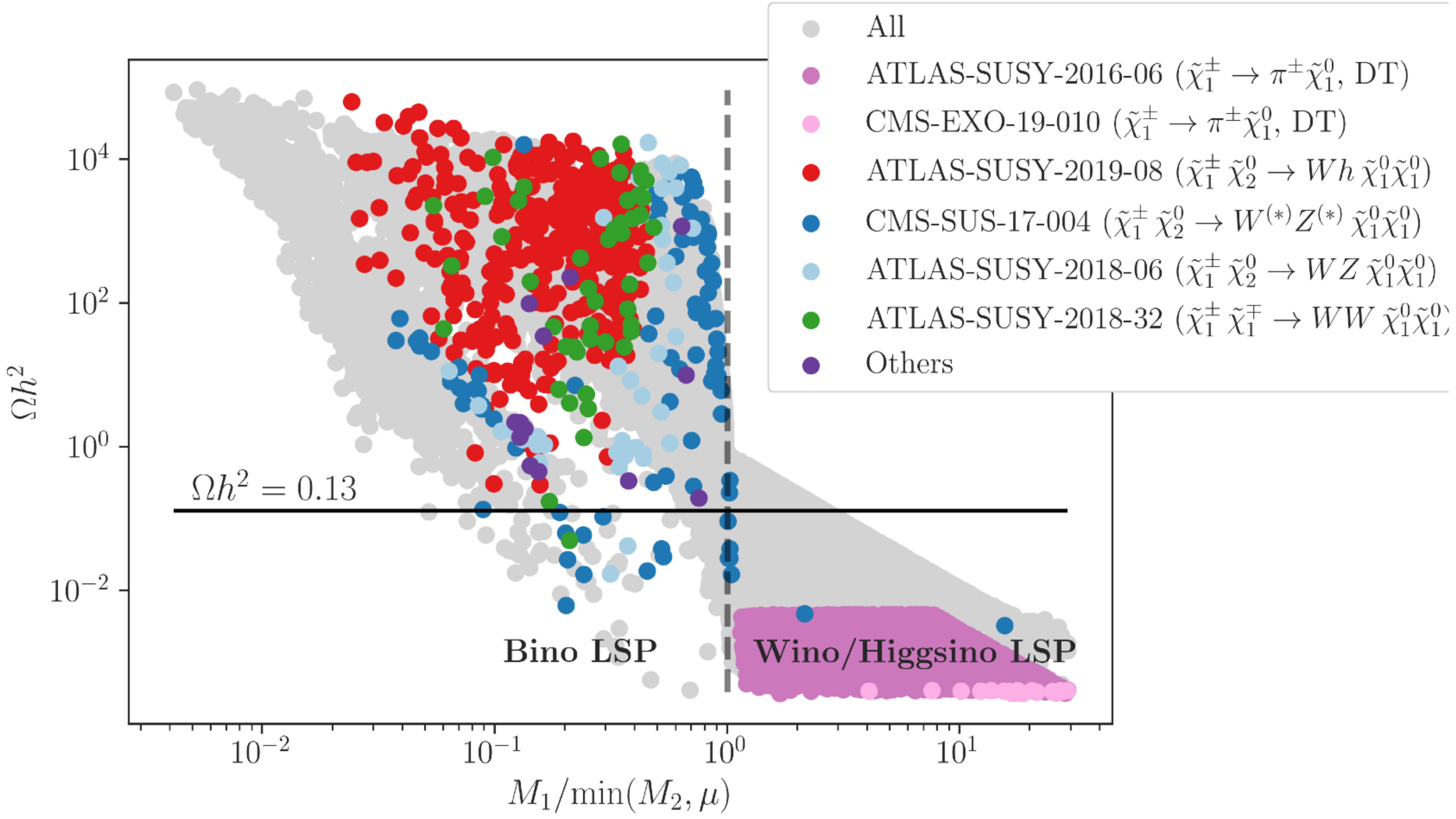
Alicia
MSc Vienna

Gaël, Humberto, Jan

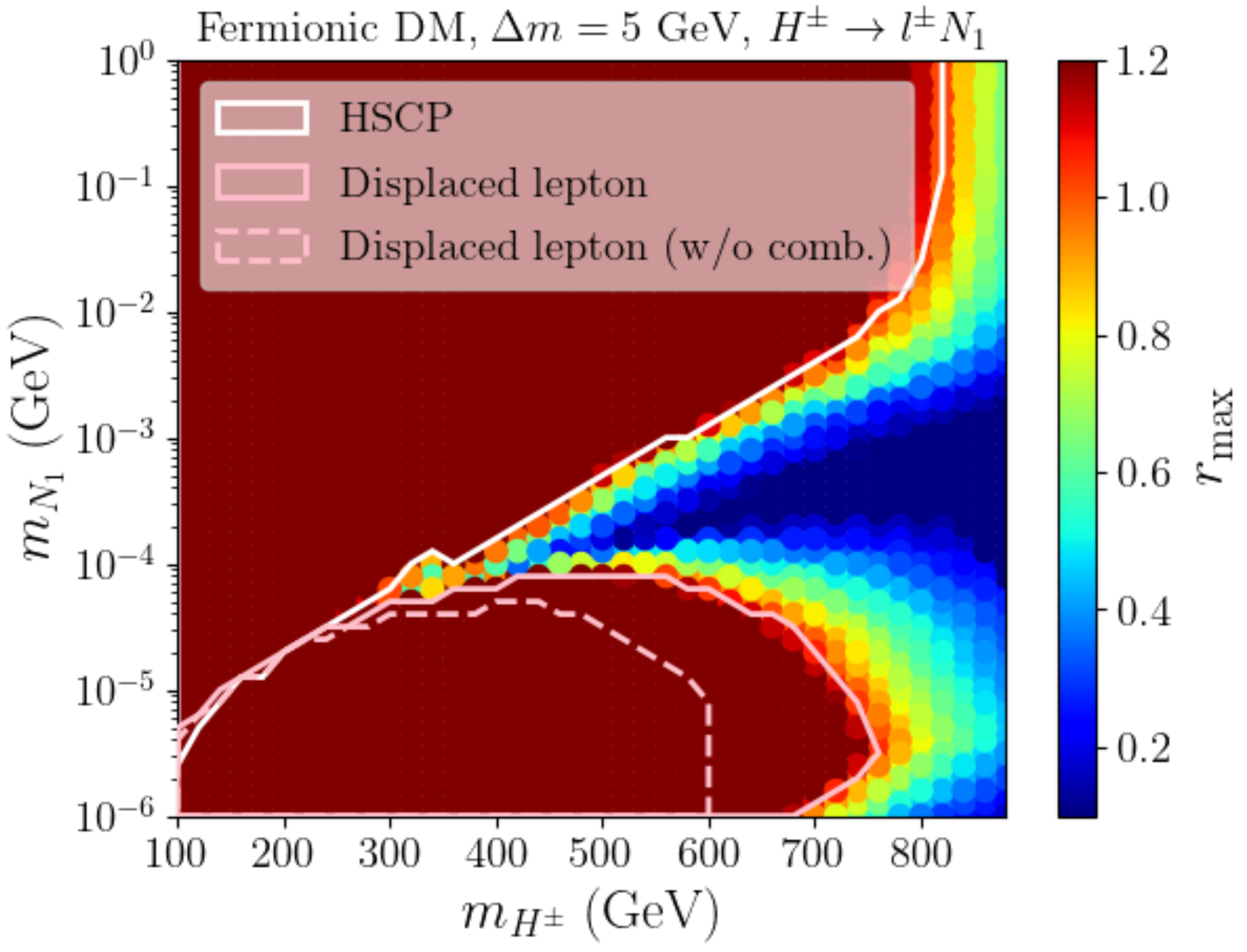
Published in: *JHEP* 08 (2022) 068 • e-Print: 2112.00769 [hep-ph]

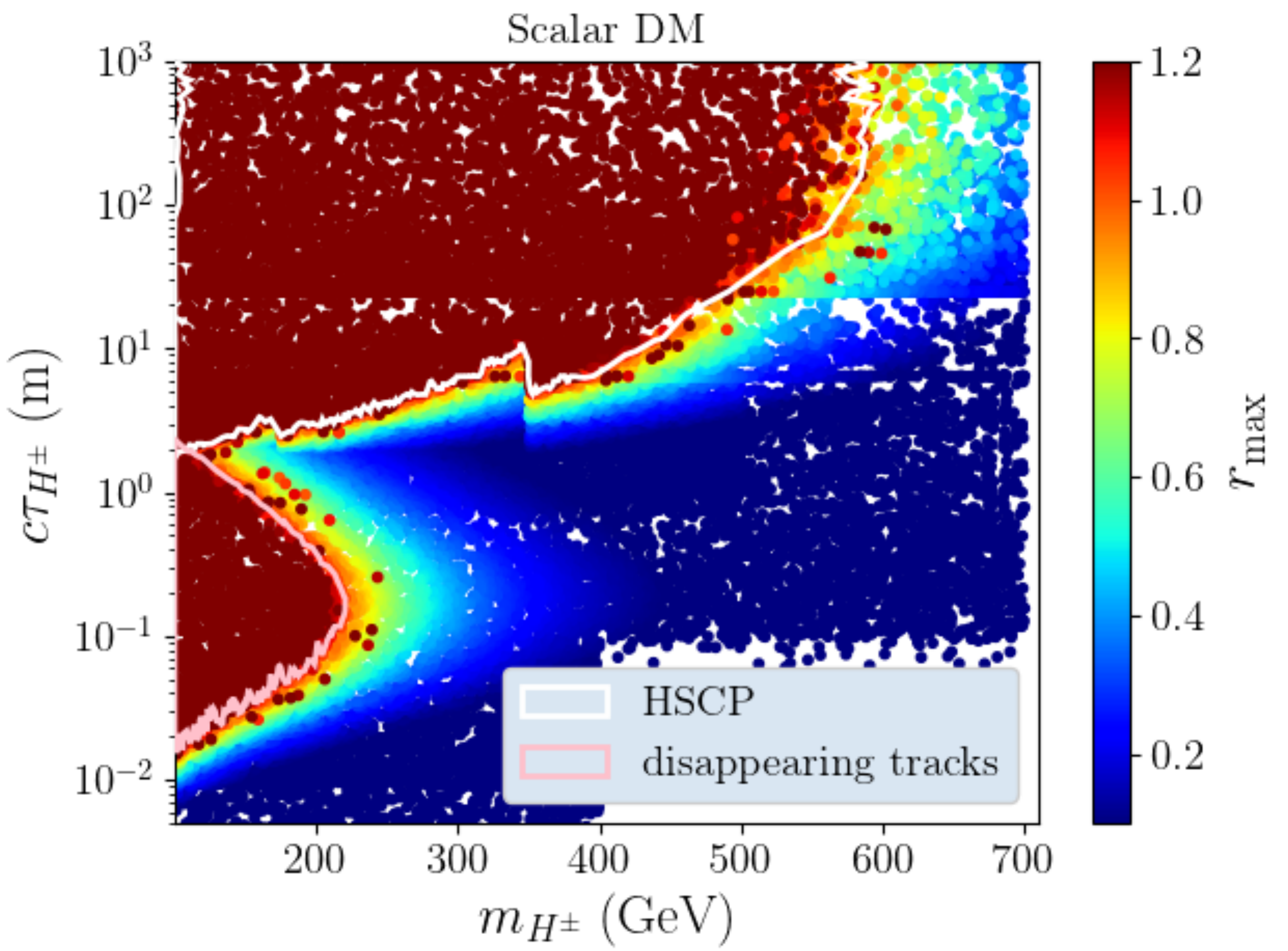
SModelS v2
2112.00769

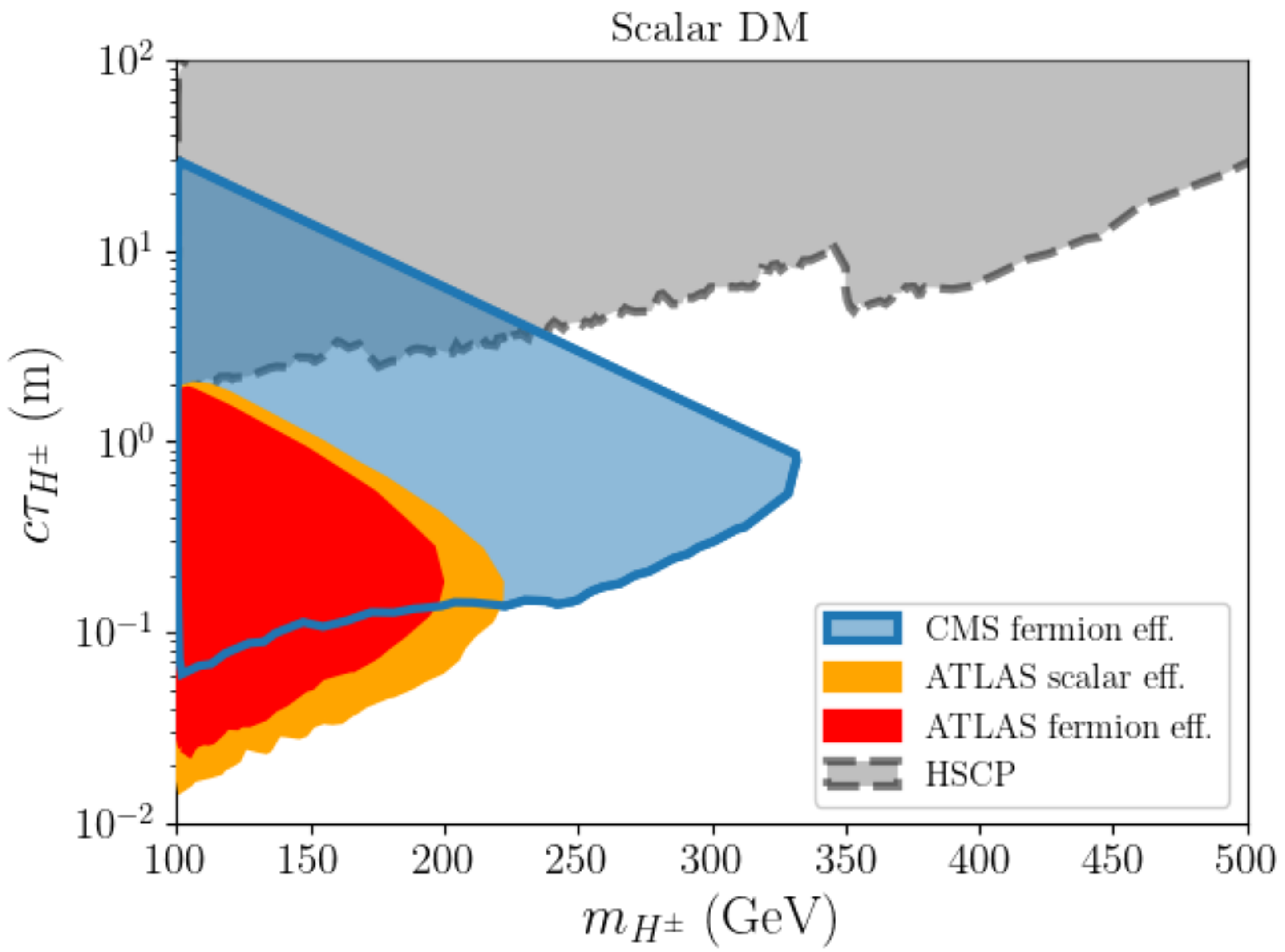
MSSM
EW-ino scan



Scotogenic Model
(Scalar DM case = IDM)







2021

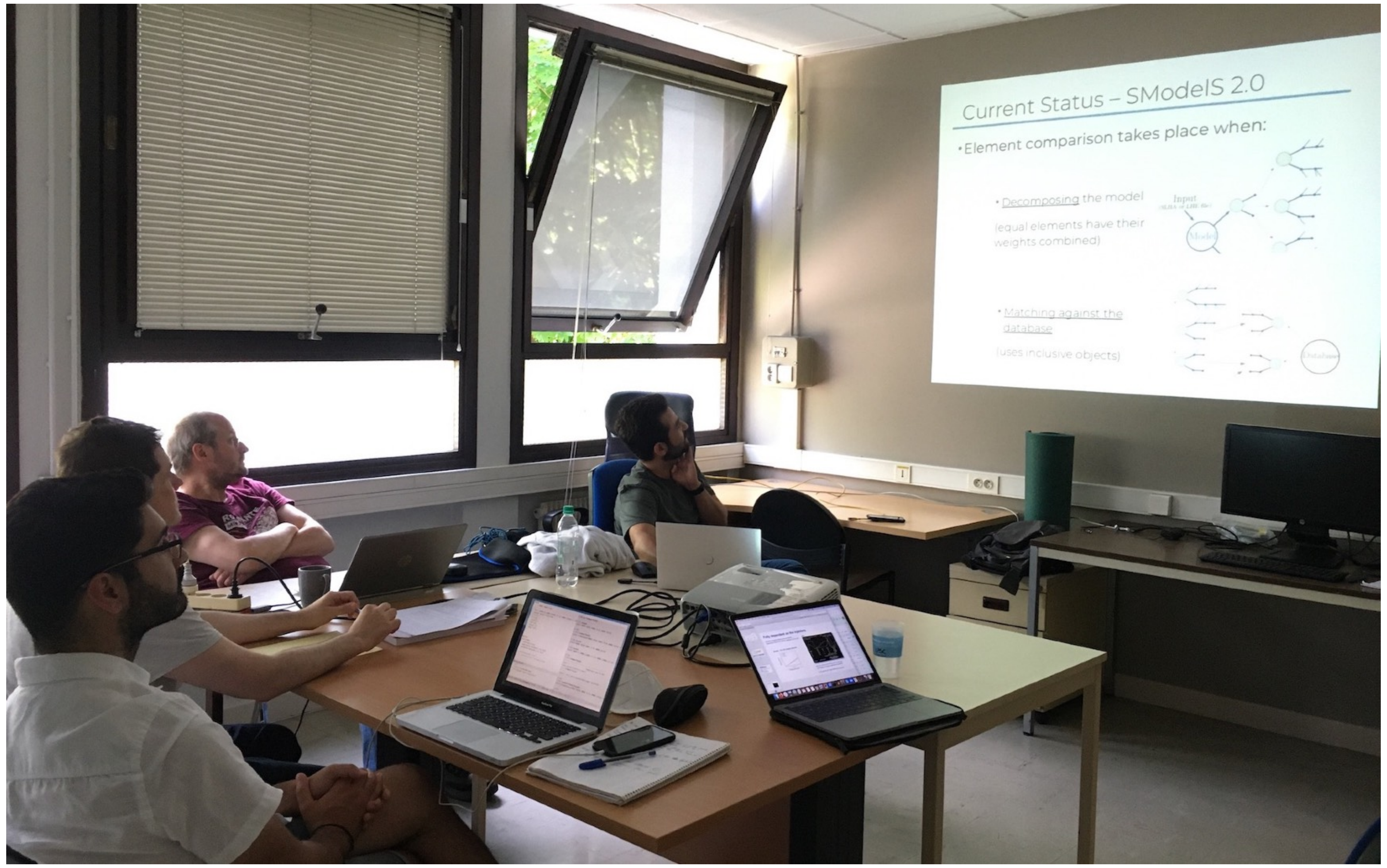
New guy: Timothée

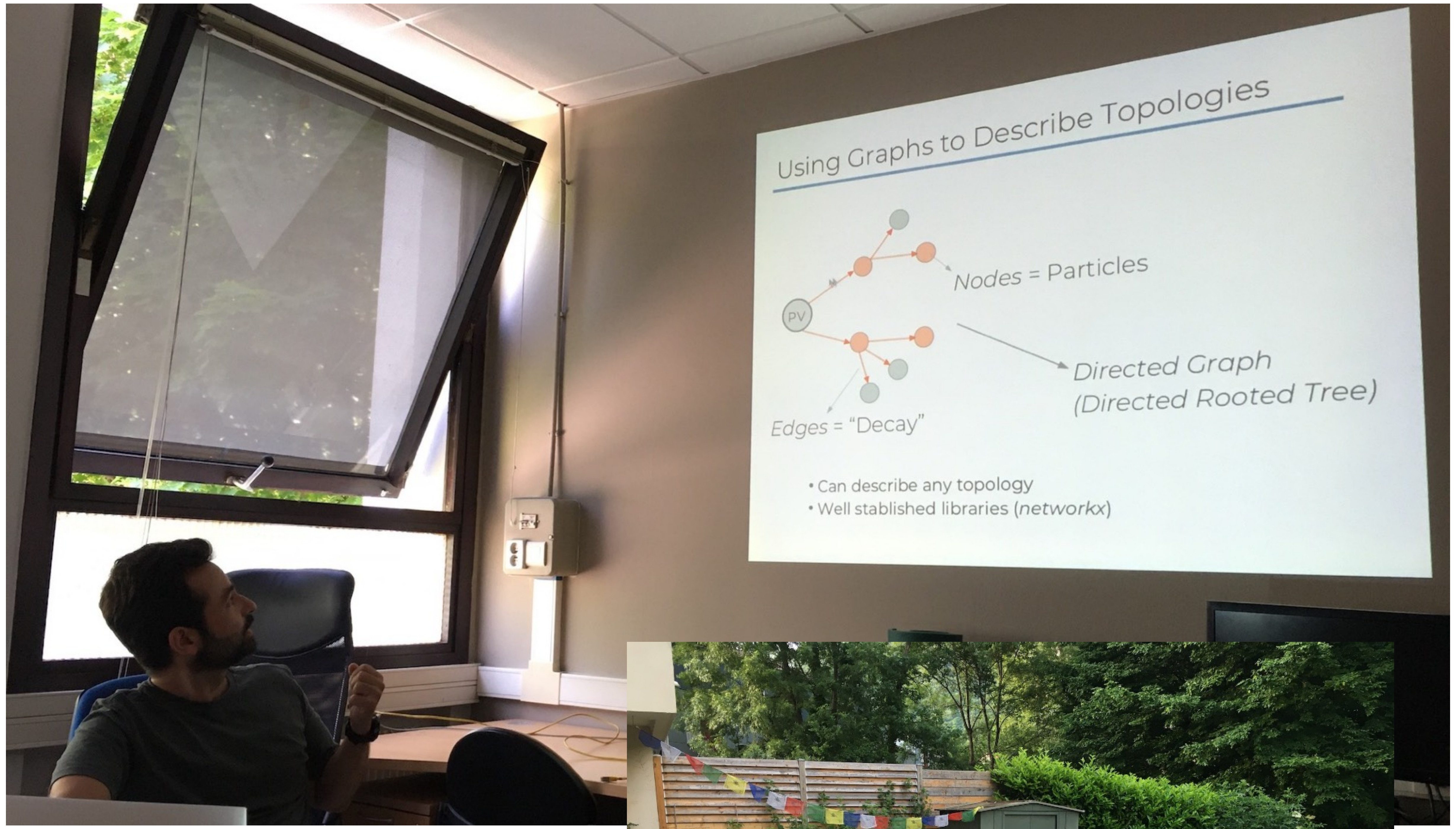
Oct. 7th

Oct. 12th

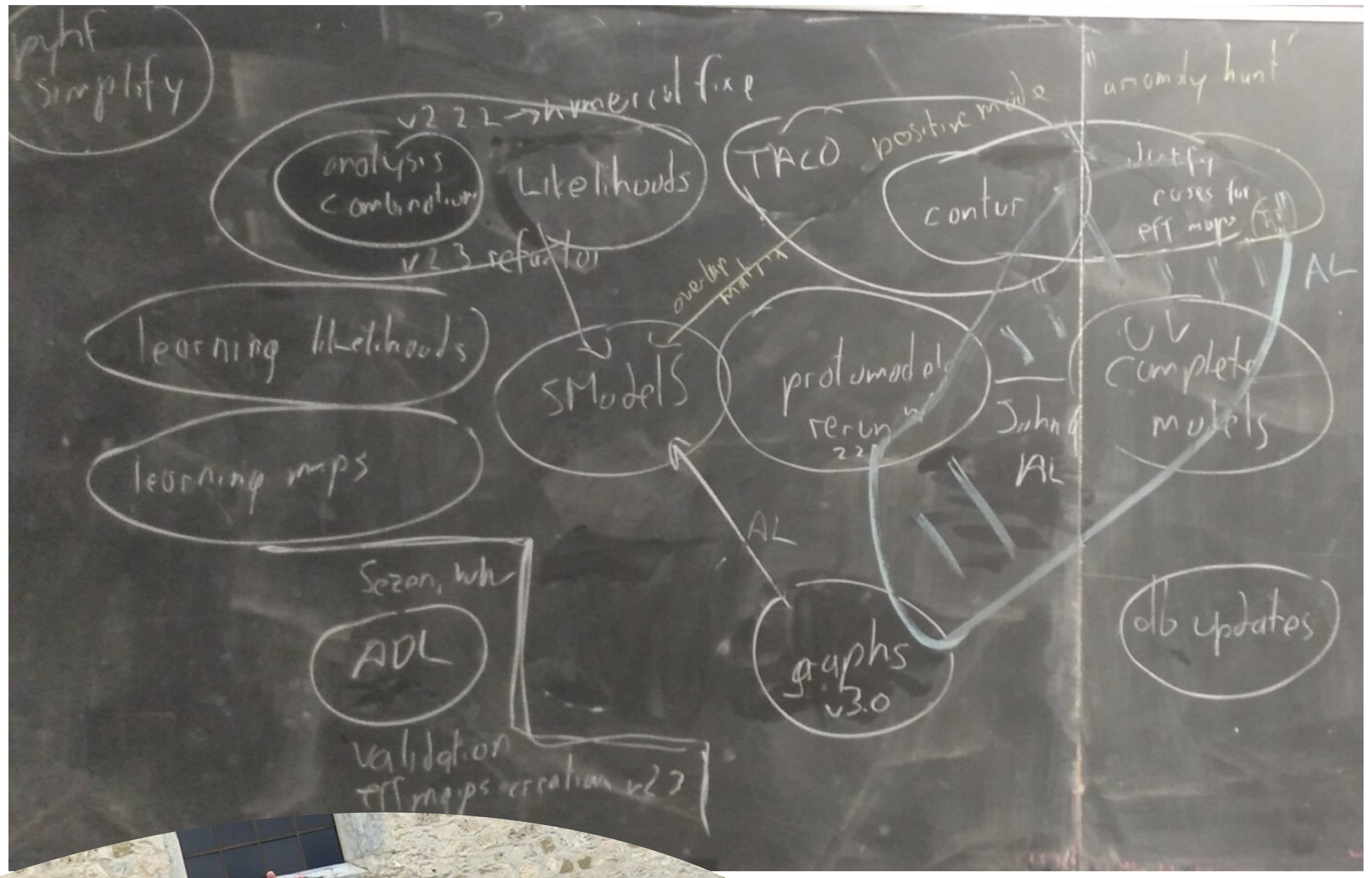
2022

Towards SModelS v3: Graphs



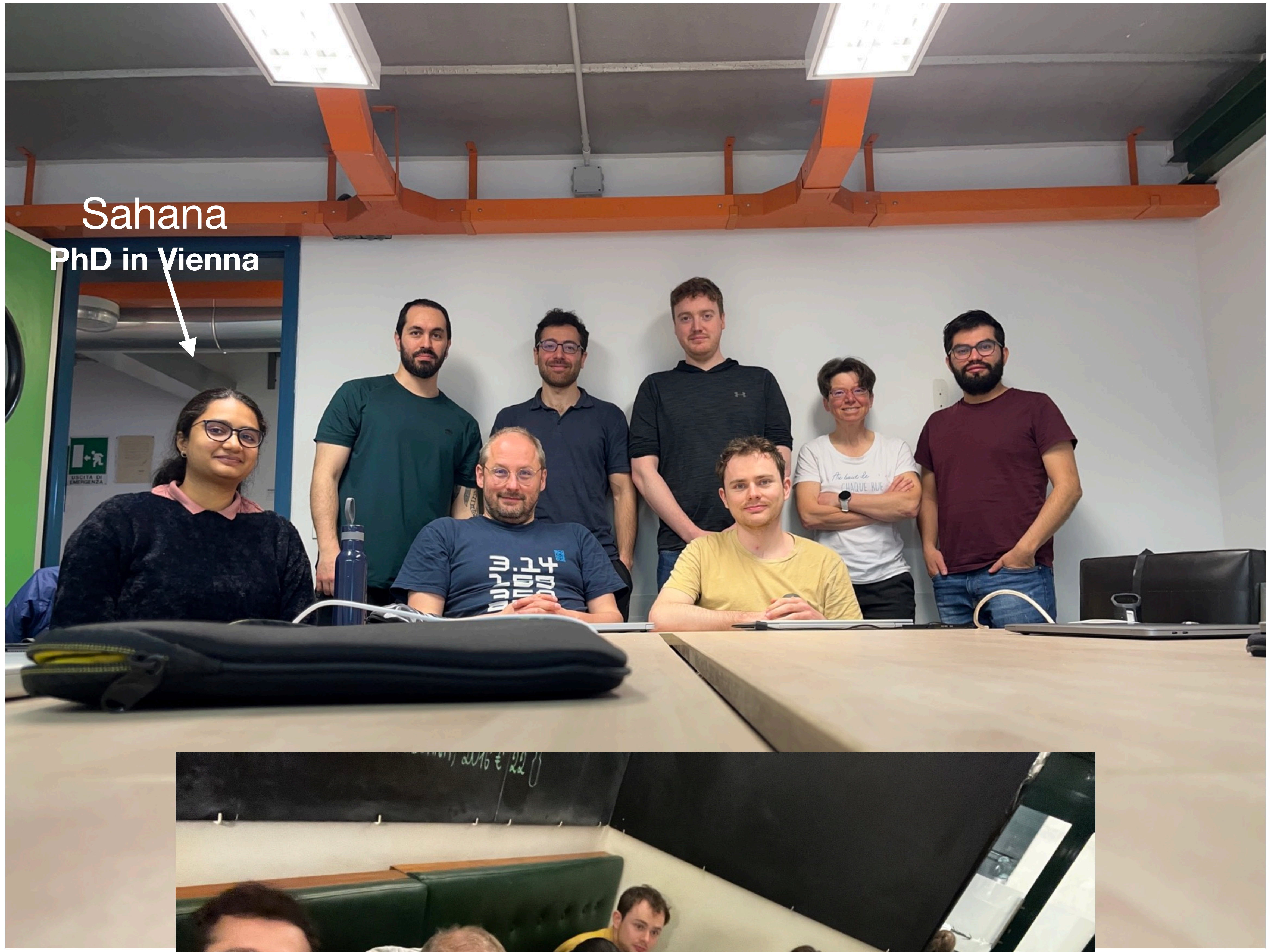


2022 … analysis combinations and protomodels v2



2023

... continued ....



SModelS + TACO in Genova

(March)

2023

SModelS v2.3: Enabling global likelihood analyses

Mohammad Mahdi Altakach (LPSC, Grenoble), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Sahana Narasimha (Vienna, OAW), Timothée Pascal (LPSC, Grenoble), Wolfgang Waltenberger (Vienna, OAW and Vienna U.)

Published in: *SciPost Phys.* 15 (2023) 185 • e-Print: 2306.17676 [hep-ph] June

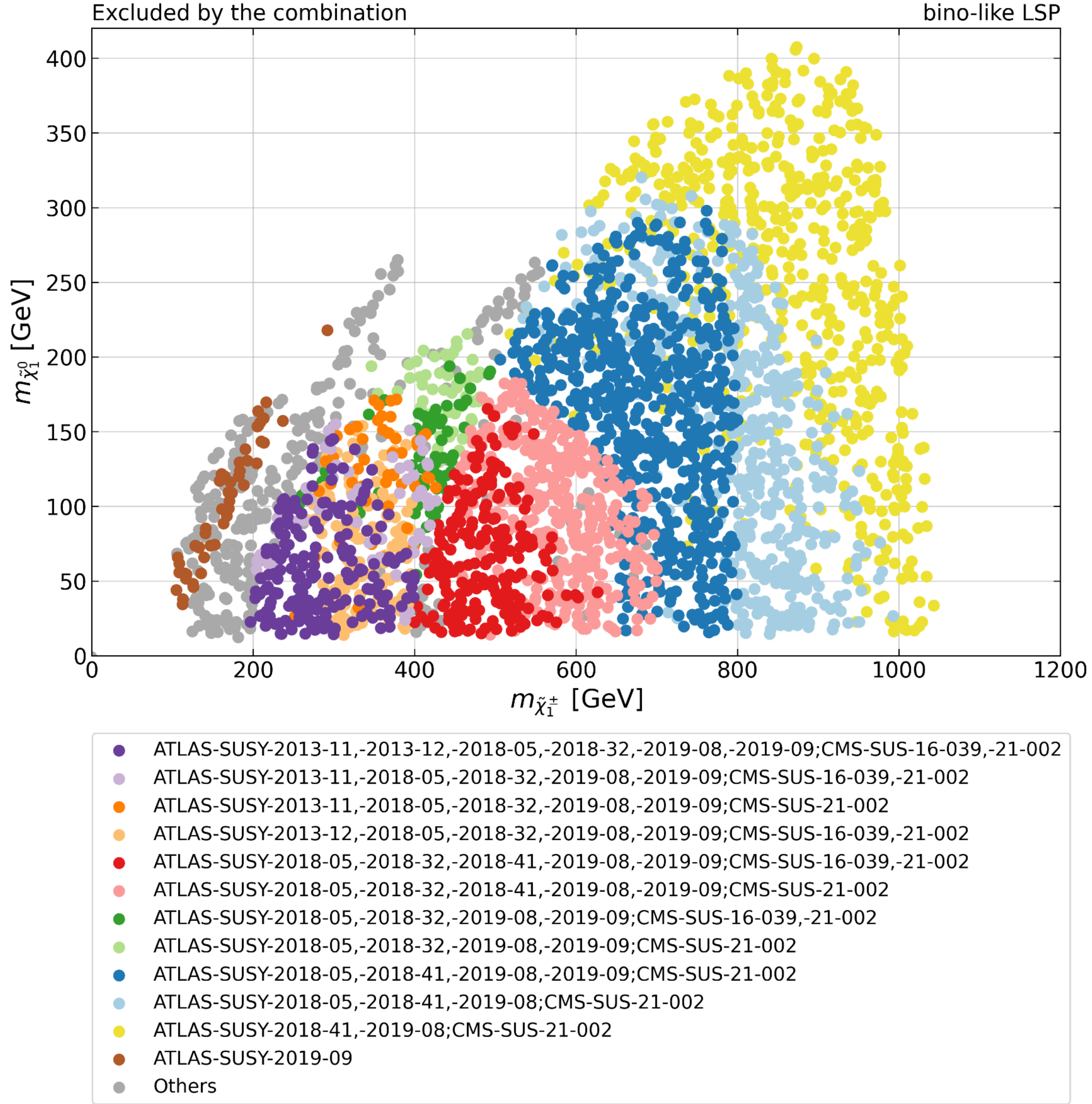
Global LHC constraints on electroweak-inos with SModelS v2.3

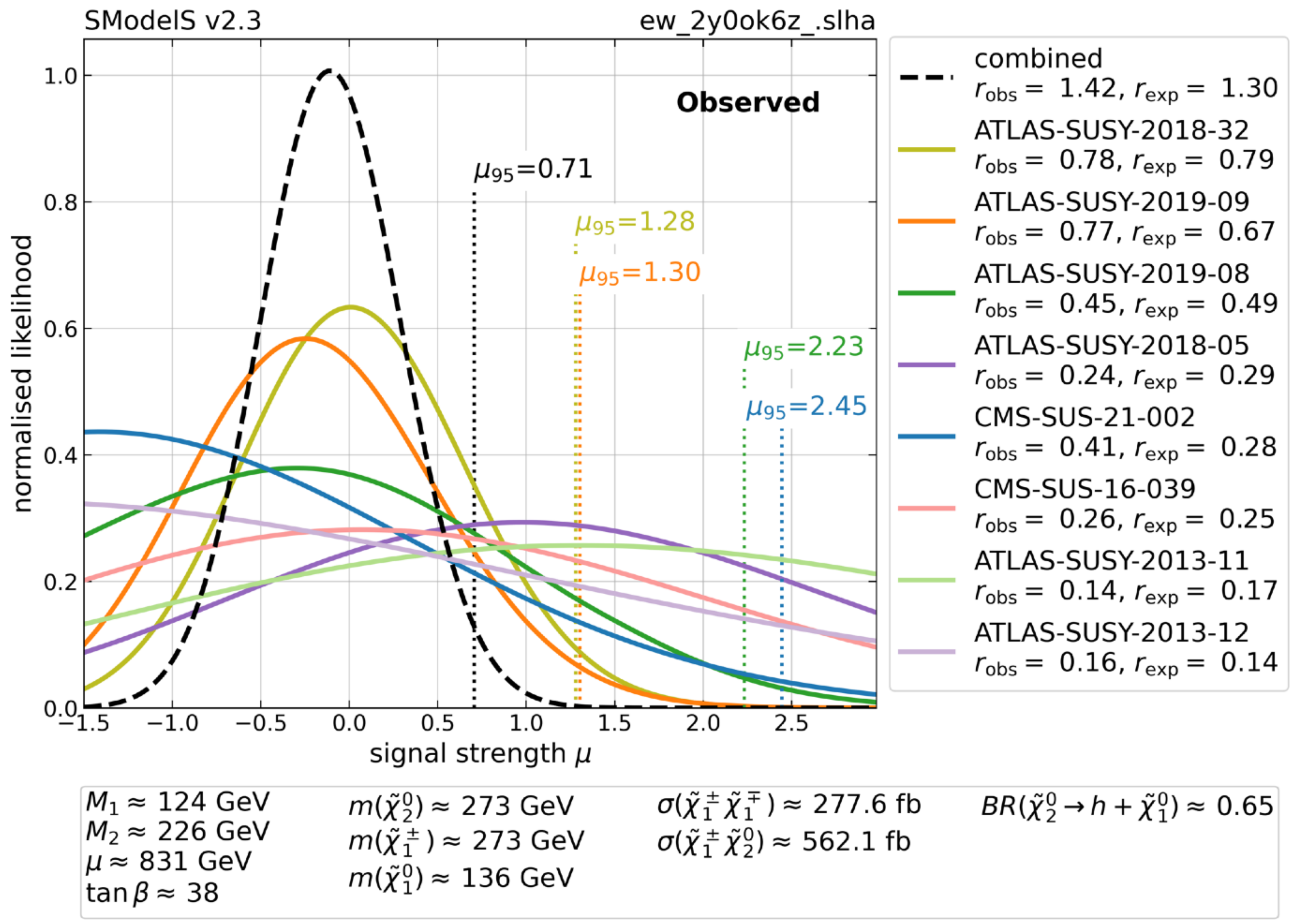
Mohammad Mahdi Altakach (LPSC, Grenoble), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Sahana Narasimha (Vienna, OAW), Timothée Pascal (LPSC, Grenoble), Théo Reymermier (IP2I, Lyon), Wolfgang Waltenberger (Vienna, OAW and Vienna U.)

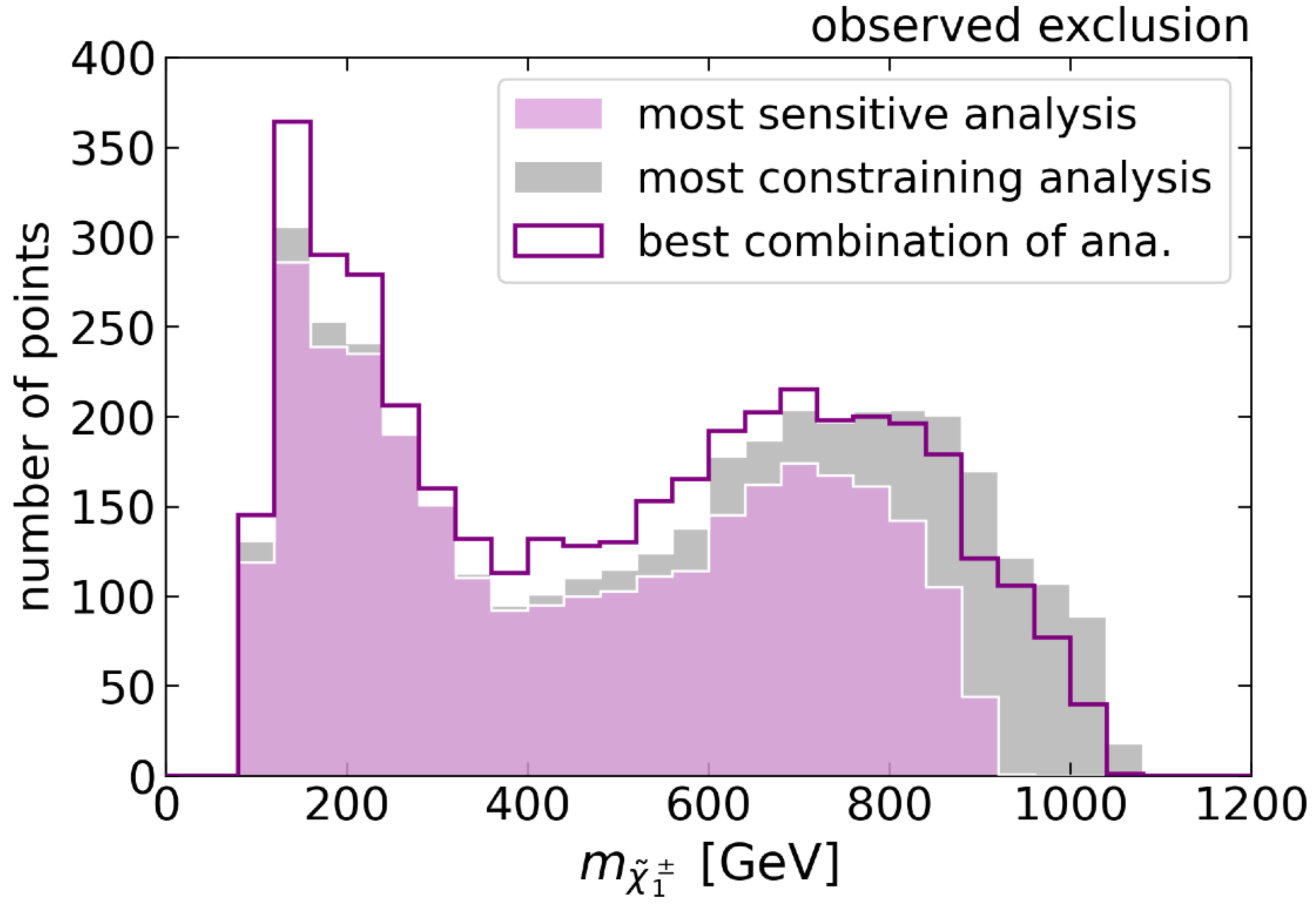
Published in: *SciPost Phys.* 16 (2024) 101 • e-Print: 2312.16635 [hep-ph] Dec.

Timothée

14 Sahana and Jamie visiting in June


Excluded by the combination
bino-like LSP
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_1^\pm}$ [GeV]
ATLAS-SUSY-2013-11,-2013-12,-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-16-039,-21-002
ATLAS-SUSY-2013-11,-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-16-039,-21-002
ATLAS-SUSY-2013-11,-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-21-002
ATLAS-SUSY-2013-12,-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-16-039,-21-002
ATLAS-SUSY-2018-05,-2018-32,-2018-41,-2019-08,-2019-09;CMS-SUS-16-039,-21-002
ATLAS-SUSY-2018-05,-2018-32,-2018-41,-2019-08,-2019-09;CMS-SUS-21-002
ATLAS-SUSY-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-16-039,-21-002
ATLAS-SUSY-2018-05,-2018-32,-2019-08,-2019-09;CMS-SUS-21-002
ATLAS-SUSY-2018-05,-2018-41,-2019-08,-2019-09;CMS-SUS-21-002
ATLAS-SUSY-2018-05,-2018-41,-2019-08;CMS-SUS-21-002
ATLAS-SUSY-2018-41,-2019-08;CMS-SUS-21-002
ATLAS-SUSY-2019-09
Others


SModelS v2.3
ew_2y0ok6z_.slha
Observed
normalised likelihood
signal strength μ
μ_{95}=0.71
μ_{95}=1.28
μ_{95}=1.30
μ_{95}=2.23
μ_{95}=2.45
combined r_{obs} = 1.42, r_{exp} = 1.30
ATLAS-SUSY-2018-32 r_{obs} = 0.78, r_{exp} = 0.79
ATLAS-SUSY-2019-09 r_{obs} = 0.77, r_{exp} = 0.67
ATLAS-SUSY-2019-08 r_{obs} = 0.45, r_{exp} = 0.49
ATLAS-SUSY-2018-05 r_{obs} = 0.24, r_{exp} = 0.29
CMS-SUS-21-002 r_{obs} = 0.41, r_{exp} = 0.28
CMS-SUS-16-039 r_{obs} = 0.26, r_{exp} = 0.25
ATLAS-SUSY-2013-11 r_{obs} = 0.14, r_{exp} = 0.17
ATLAS-SUSY-2013-12 r_{obs} = 0.16, r_{exp} = 0.14
$M_1 \approx$ 124 GeV
$M_2 \approx$ 226 GeV
$\mu \approx$ 831 GeV
$\tan\beta \approx$ 38
$m(\tilde{\chi}_2^0) \approx$ 273 GeV
$m(\tilde{\chi}_1^\pm) \approx$ 273 GeV
$m(\tilde{\chi}_1^0) \approx$ 136 GeV
$\sigma(\tilde{\chi}_1^\pm \tilde{\chi}_1^\mp) \approx$ 277.6 fb
$\sigma(\tilde{\chi}_1^\pm \tilde{\chi}_2^0) \approx$ 562.1 fb
$BR(\tilde{\chi}_2^0 \to h + \tilde{\chi}_1^0) \approx$ 0.65


observed exclusion
most sensitive analysis
most constraining analysis
best combination of ana.
number of points
$m_{\tilde{\chi}_1^\pm}$ [GeV]

2024

SModelS v3: going beyond Z_2 topologies

"While previous versions were limited to models with a-type symmetry, such as R-parity conserving supersymmetry, version 3 can now handle arbitrary signal topologies. To this end, the tool was fully restructured and now relies on a graph-based description of simplified model topologies. [...] we discuss the interplay of resonance and missing energy searches, and the model's coverage by the currently available simplified model results."

Mohammad Mahdi Altakach (LPSC, Grenoble), Sabine Kraml (LPSC, Grenoble), Andre Lessa (ABC Federal U.), Sahana Narasimha (Vienna, OAW), Timothée Pascal (LPSC, Grenoble), Camila Ramos (ABC Federal U.), Yoxara Villamizar (ABC Federal U.), Wolfgang Waltenberger (Vienna, OAW)

Camila
PhD Sao Paulo

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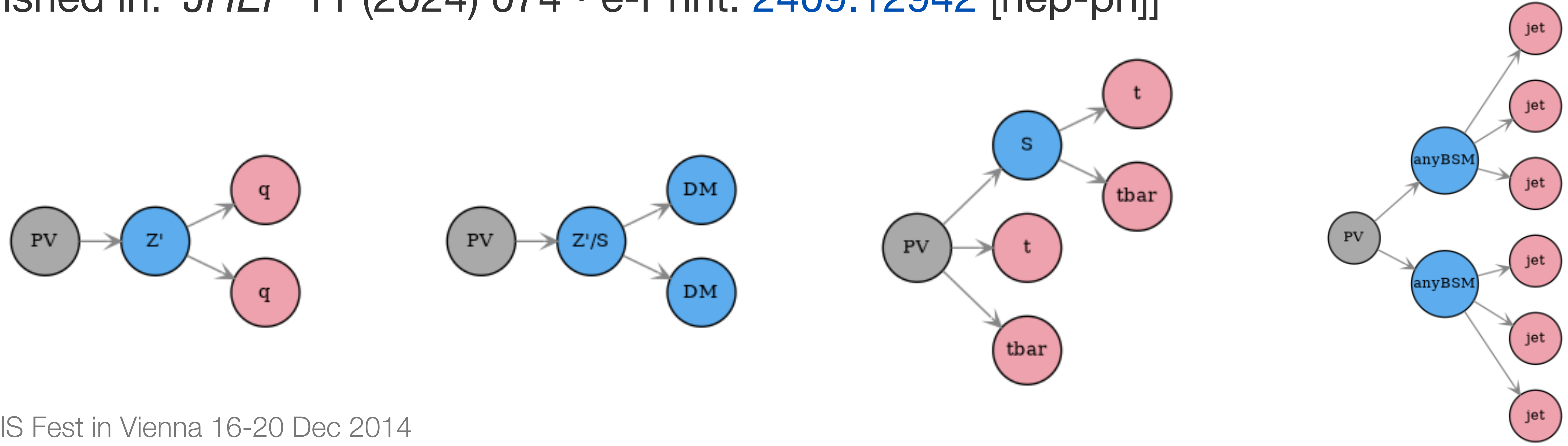

Yoxara
PD Sao Paulo

2024

Thimotée defends his thesis (28/11)

Suchita
PD Grenoble+Vienna

Uschi
PhD Grenoble

Federico
PhD Vienna

Philipp
MSc Vienna

Alicia
MSc Vienna

Humberto
PhD Grenoble

Gaël
PhD Grenoble

Timothée
PhD Grenoble

Mohammad
PD Grenoble

Sahana
PhD Grenoble

Yoxara
PD Sao Paulo

Camila
PhD Sao Paulo

Théo
PhD Lyon (w/Gren.)

Léo
PhD Grenoble

Lucas
PhD Sao Paulo

.....

Jory Sonnefeld
PD Hamburg

Juhi Dutta
PhD Allahabad

Jan Heisig
PD Aachen/Louvain

Charanjit Kosa
PD Sussex

Jack Araz
PD Durham/Jefferson

Jamie Yellen
PhD Glasgow

Rafal Maselek
PD Grenoble

THE ADVENTURE CONTINUES …

(happy SModelS Fest !)

Next steps

- Protomodels v2 and v3
- Learned likelihoods
- Database updates (LLPs, lept. resonances, `strong’ SUSY, …)
- Kinematic dependences / resolve the primary vertex
- EMcreator refurbishing
- Interfaces with Spey and CMS Combine; SLv3; …

- Comparison w/ ATLAS EWino study
- Model-specific global fits
- Combination of searches and measurements (Rivet/CONTUR)
- Non-SUSY physics studies (VLQs, non-simplified / non-WIMP DM, …)
- ADL validation
- Visualisation tools
- …