Constraints on BSM models

IPMU-YITP workshop
Kyoto, 9 September 2011

David Grellscheid
IPPP, Durham University

ThePEG

L. Lönnblad

Toolkit for high energy physics event generation

ThePEG

L. Lönnblad

Toolkit for high energy physics event generation

Herwig++

Box of physics implementations

ThePEG

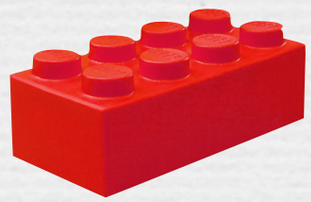
L. Lönnblad

Toolkit for high energy physics event generation

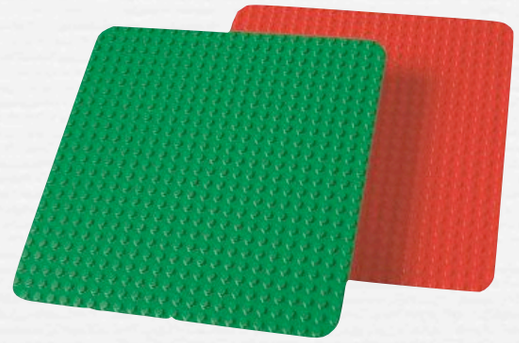
Herwig++

Box of physics implementations

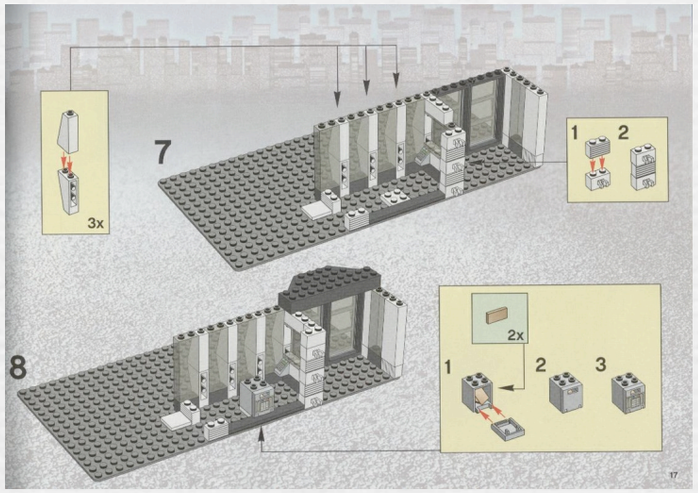
Each building block is a compiled C++ class



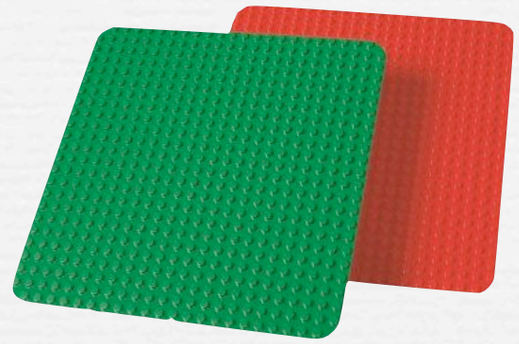
ThePEG Repository



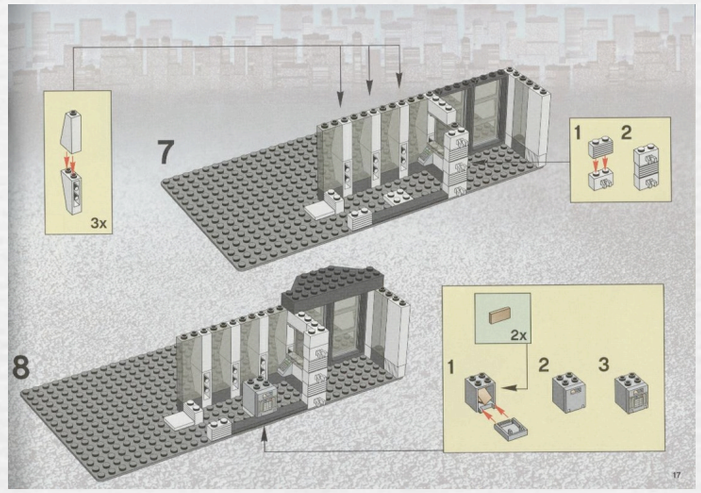
plaintext
setup files



ThePEG Repository

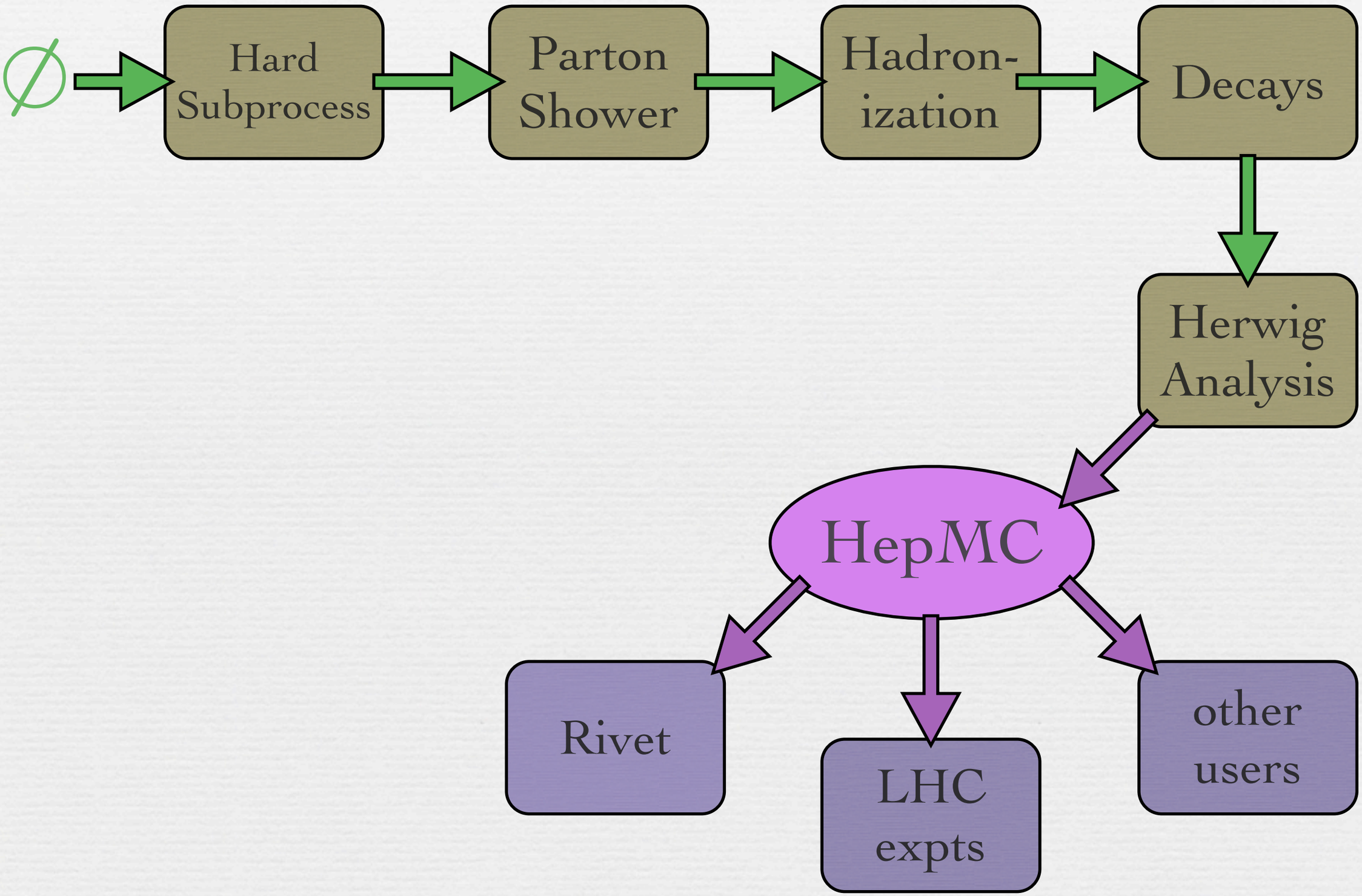


plaintext
setup files

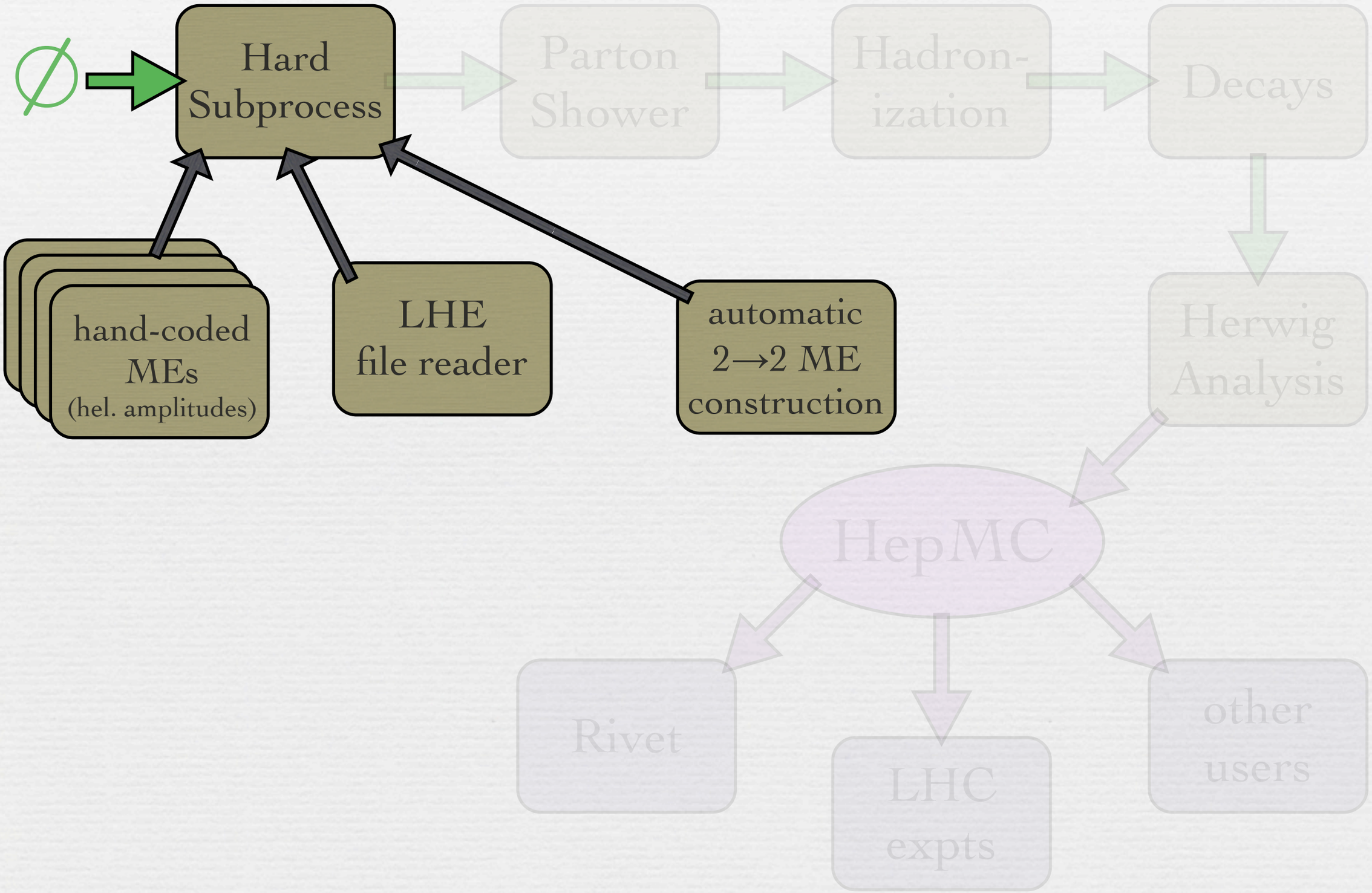


no more compilation needed here

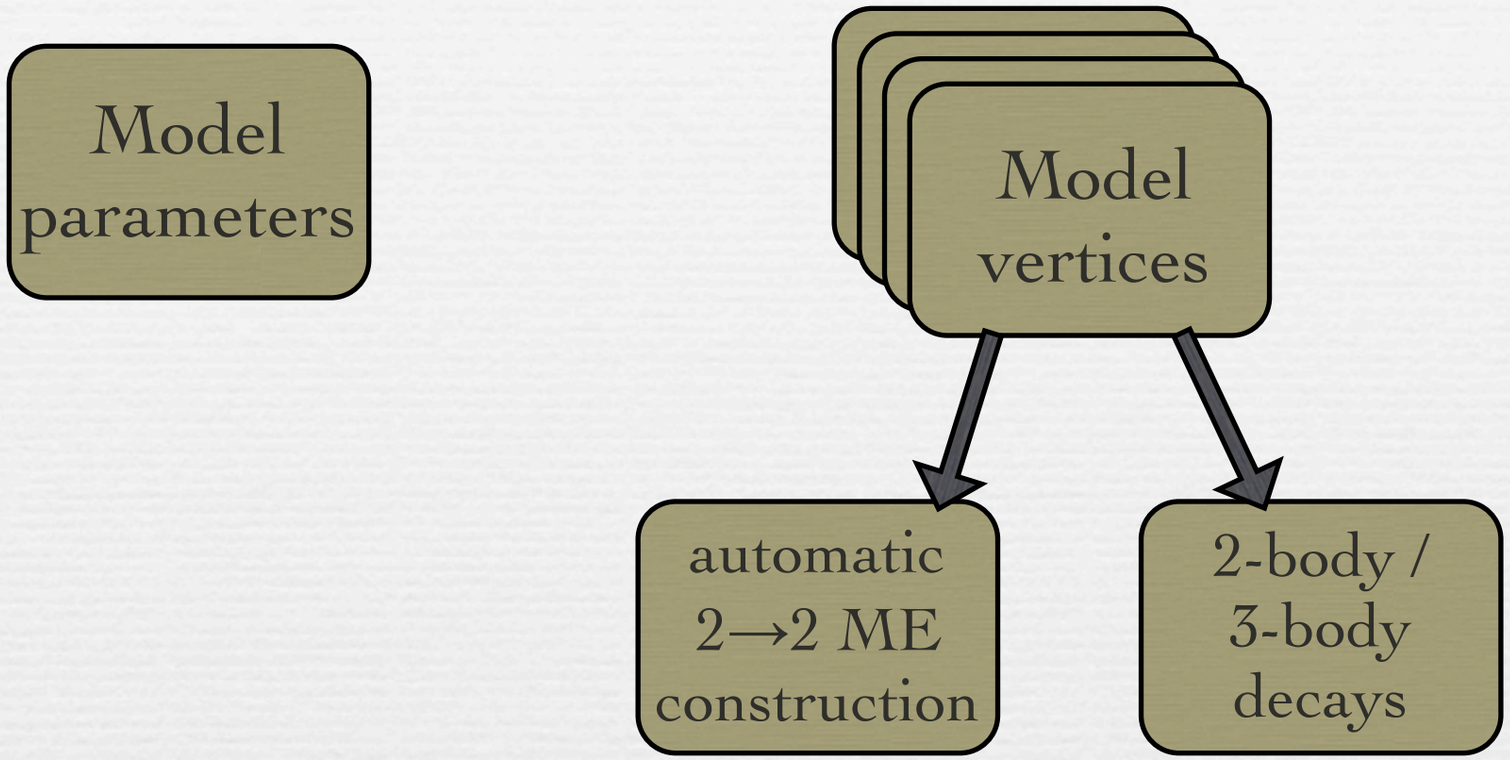
Event record flow



Event record flow



BSM model



Available models:

MSSM (includes SLHA reader)

Universal extra dimensions

Randall-Sundrum gravitons; Z'; anomalous hVV

BSM setup

```
read   MSSM.model
set    HPConstructor:IncludeEW No

insert HPConstructor:Incoming 0 g
insert HPConstructor:Incoming 1 u
insert HPConstructor:Incoming 2 ubar
insert HPConstructor:Incoming 3 d
insert HPConstructor:Incoming 4 dbar

insert HPConstructor:Outgoing 0 ~u_L
insert HPConstructor:Outgoing 1 ~u_Lbar
insert HPConstructor:Outgoing 2 ~d_L
insert HPConstructor:Outgoing 3 ~d_Lbar

setup  MSSM/Model SPhenoSPS1a.spc
set    TwoBodyDC:CreateDecayModes No
set    ThreeBodyDC:CreateDecayModes No

#insert DecayConstructor:DisableModes 0 ~u_L->~chi_20,u;
#insert DecayConstructor:DisableModes 1 ~chi_20->~e_R-,e+;
```

CERN-PH-EP-2011-022, Submitted to Phys. Lett. B

Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in $\sqrt{s} = 7$ TeV proton-proton collisions

The ATLAS Collaboration

Abstract

A search for squarks and gluinos in final states containing jets, missing transverse momentum and no electrons or muons is presented. The data were recorded by the ATLAS experiment in $\sqrt{s} = 7$ TeV proton-proton collisions at the Large Hadron Collider. No excess above the Standard Model background expectation was observed in 35 pb^{-1} of analysed data. Gluino masses below 500 GeV are excluded at the 95% confidence level in simplified models containing only squarks of the first two generations, a gluino octet and a massless neutralino. The exclusion increases to 870 GeV for equal mass squarks and gluinos. In MSUGRA/CMSSM models with $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$, squarks and gluinos of equal mass are excluded below 775 GeV. These are the most stringent limits to date.

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_{T} [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_{T} [GeV]	> 40	> 40	> 40	> 40
	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\mathrm{jet}, \vec{P}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$	> 0.4	> 0.4	> 0.4	> 0.4
	$E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

Table 1: Criteria for admission to each of the four overlapping signal regions A to D. All variables are defined in §4.

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_{T} [GeV]	> 120	> 120	> 120	> 120
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	m_{T2} [GeV]	–	> 300	–	–

Table 1: Criteria for admission to each of the four overlapping signal regions A to D. All variables are defined in §4.

	Signal region A	Signal region B	Signal region C	Signal region D
QCD	$7\ ^{+8}_{-7}$[u+j]	$0.6\ ^{+0.7}_{-0.6}$[u+j]	$9\ ^{+10}_{-9}$[u+j]	$0.2\ ^{+0.4}_{-0.2}$[u+j]
W+jets	50 ± 11[u] $^{+14}_{-10}$[j] $\pm$ 5[$\mathcal{L}$]	4.4 ± 3.2[u] $^{+1.5}_{-0.8}$[j] ± 0.5[$\mathcal{L}$]	35 ± 9[u] $^{+10}_{-8}$[j] ± 4[$\mathcal{L}$]	1.1 ± 0.7[u] $^{+0.2}_{-0.3}$[j] ± 0.1[$\mathcal{L}$]
Z+jets	52 ± 21[u] $^{+15}_{-11}$[j] $\pm$ 6[$\mathcal{L}$]	4.1 ± 2.9[u] $^{+2.1}_{-0.8}$[j] ± 0.5[$\mathcal{L}$]	27 ± 12[u] $^{+10}_{-6}$[j] ± 3[$\mathcal{L}$]	0.8 ± 0.7[u] $^{+0.6}_{-0.0}$[j] ± 0.1[$\mathcal{L}$]
$t\bar{t}$ and t	10 ± 0[u] $^{+3}_{-2}$[j] $\pm$ 1[$\mathcal{L}$]	0.9 ± 0.1[u] $^{+0.4}_{-0.3}$[j] ± 0.1[$\mathcal{L}$]	17 ± 1[u] $^{+6}_{-4}$[j] ± 2[$\mathcal{L}$]	0.3 ± 0.1[u] $^{+0.2}_{-0.1}$[j] ± 0.0[$\mathcal{L}$]
Total SM	118 ± 25[u] $^{+32}_{-23}$[j] ± 12[$\mathcal{L}$]	10.0 ± 4.3[u] $^{+4.0}_{-1.9}$[j] ± 1.0[$\mathcal{L}$]	88 ± 18[u] $^{+26}_{-18}$[j] ± 9[$\mathcal{L}$]	2.5 ± 1.0[u] $^{+1.0}_{-0.4}$[j] ± 0.2[$\mathcal{L}$]
Data	87	11	66	2

Table 2: Expected and observed numbers of events in the four signal regions. Uncertainties shown are due to "MC statistics, statistics in control regions, other sources of uncorrelated systematic uncertainty, and also the jet energy resolution and lepton efficiencies" [u], the jet energy scale [j], and the luminosity [$\mathcal{L}$].

8. Summary

This letter reports a search for new physics in final states containing high-p_{T} jets, missing transverse momentum and no electrons or muons. Good agreement is seen between the numbers of events observed in the four signal regions and the numbers of events expected from SM sources. Signal regions A, B, C and D exclude non-SM cross sections within acceptance of 1.3, 0.35, 1.1 and 0.11 pb respectively at 95% confidence.

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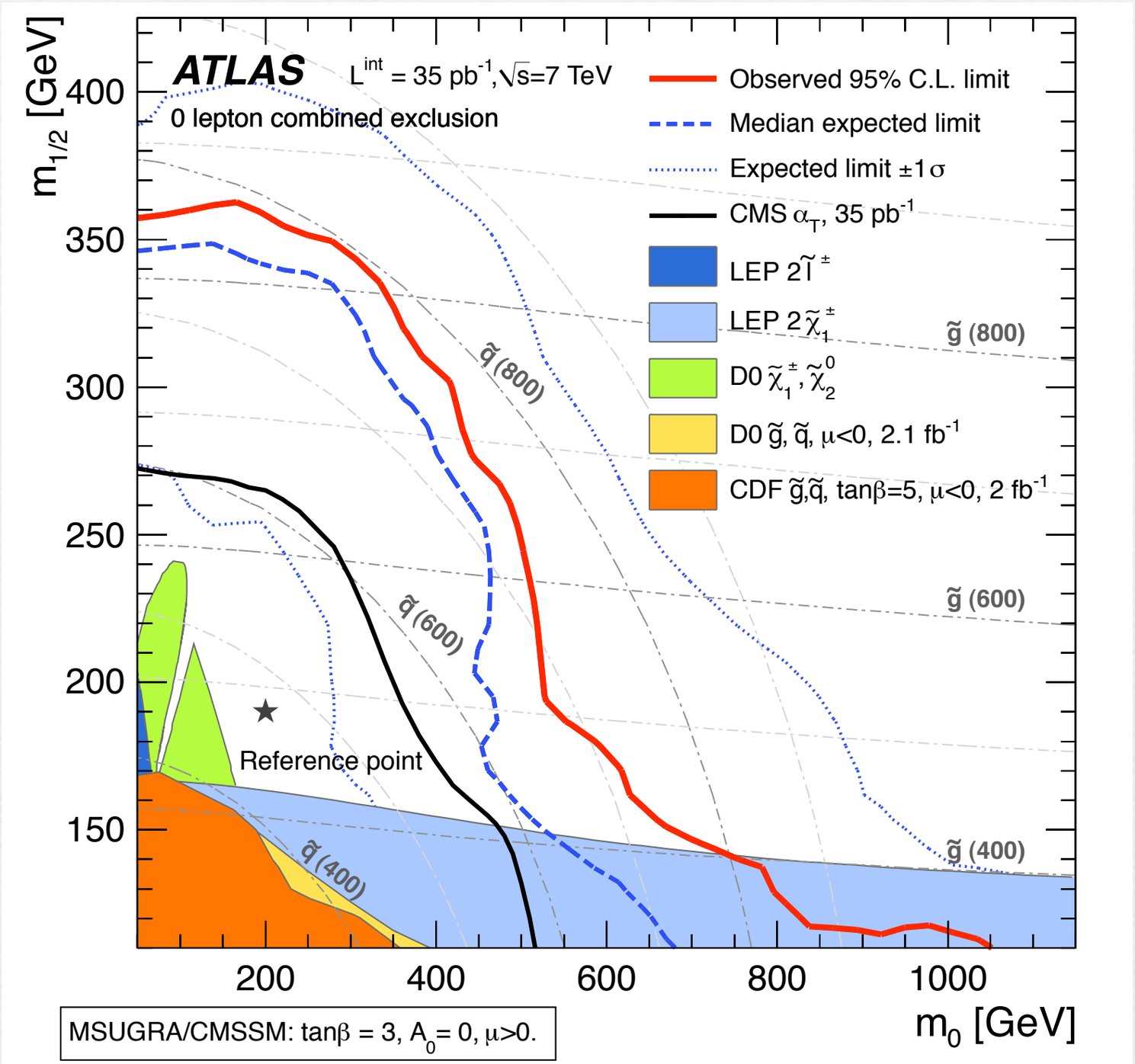
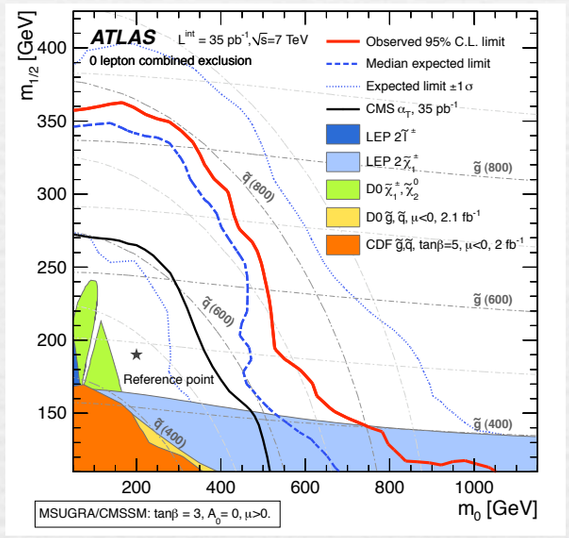


Figure 3: 95% C.L. exclusion limits in the $\tan\beta = 3$, $A_0 = 0$ and $\mu > 0$ slice of MSUGRA/CMSSM, together with existing limits [3, 4] with the different model assumptions given in the legend.



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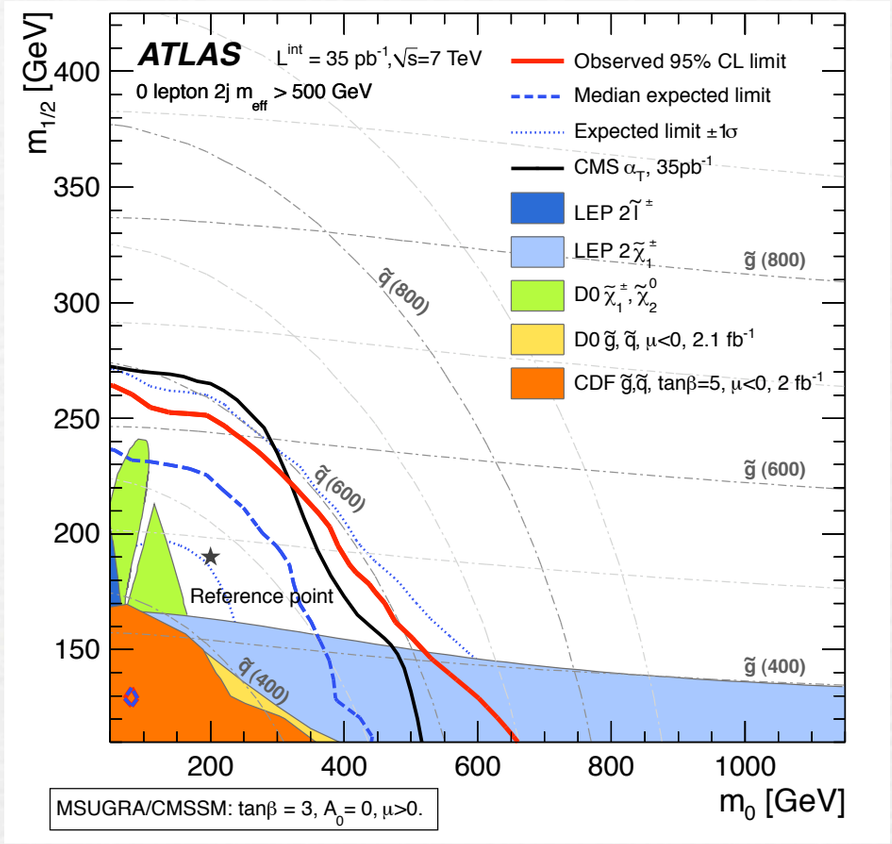
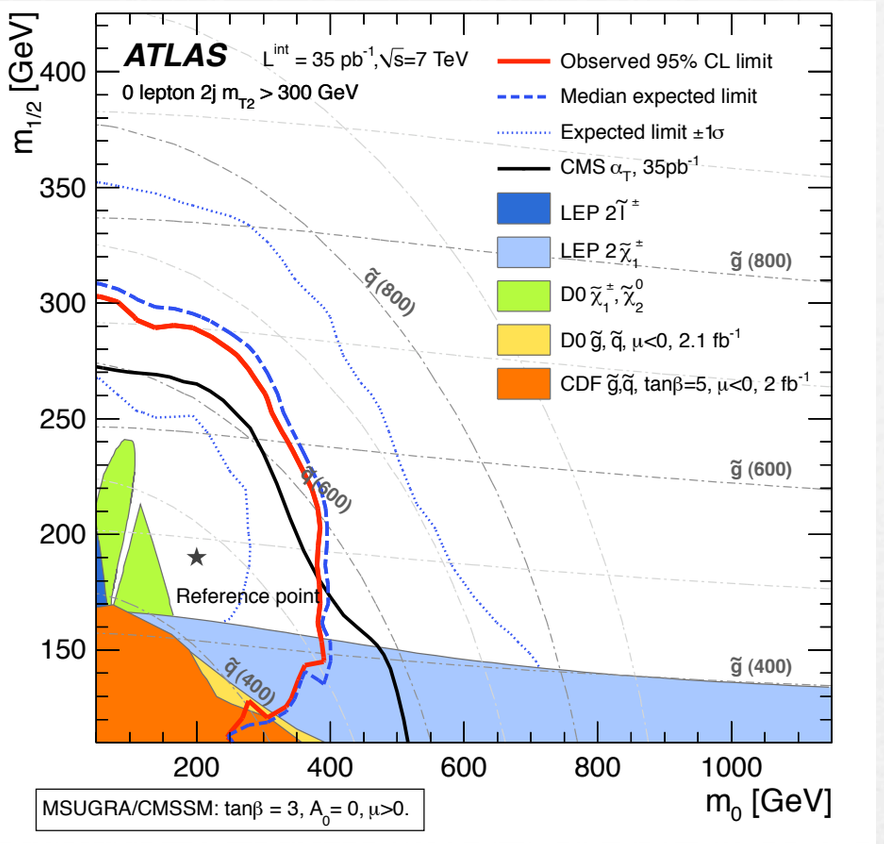
A

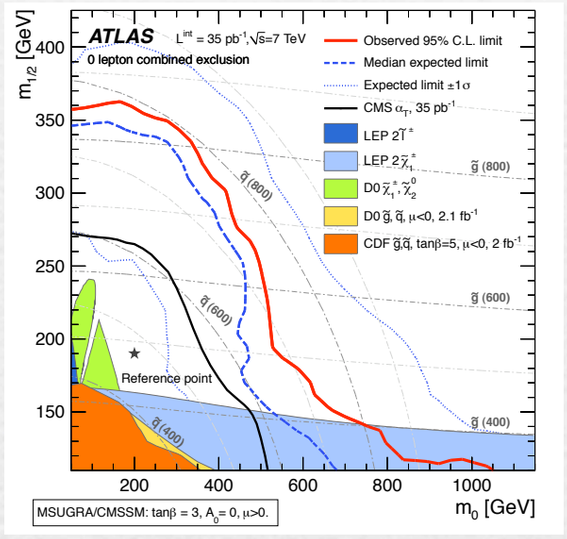
1.3 pb



B

0.35 pb





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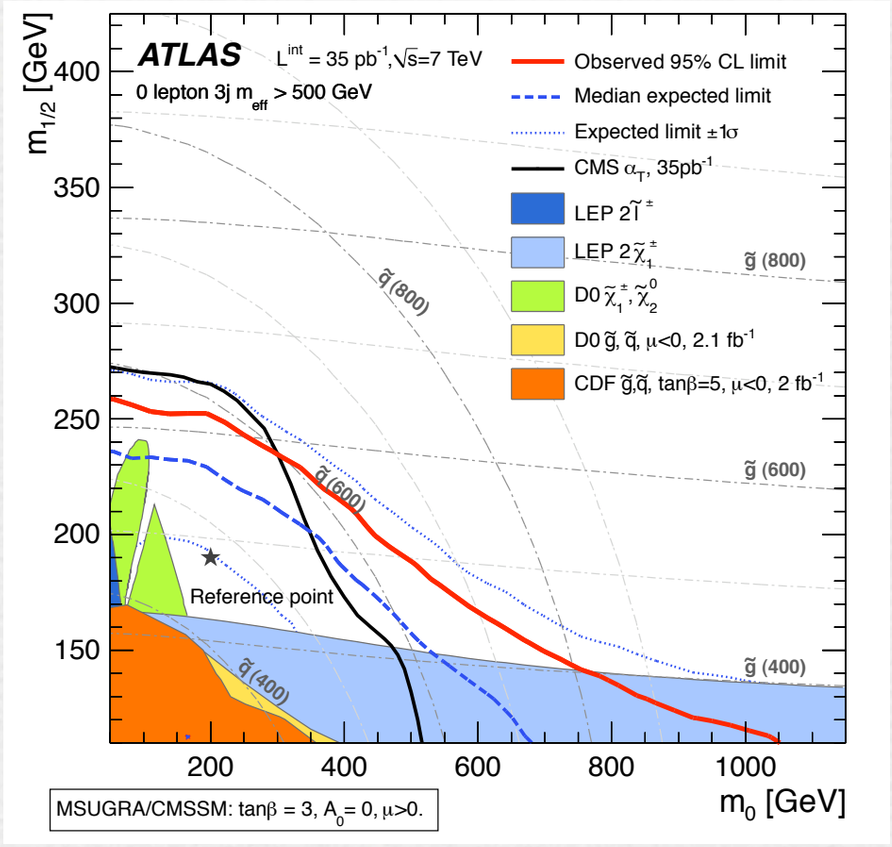
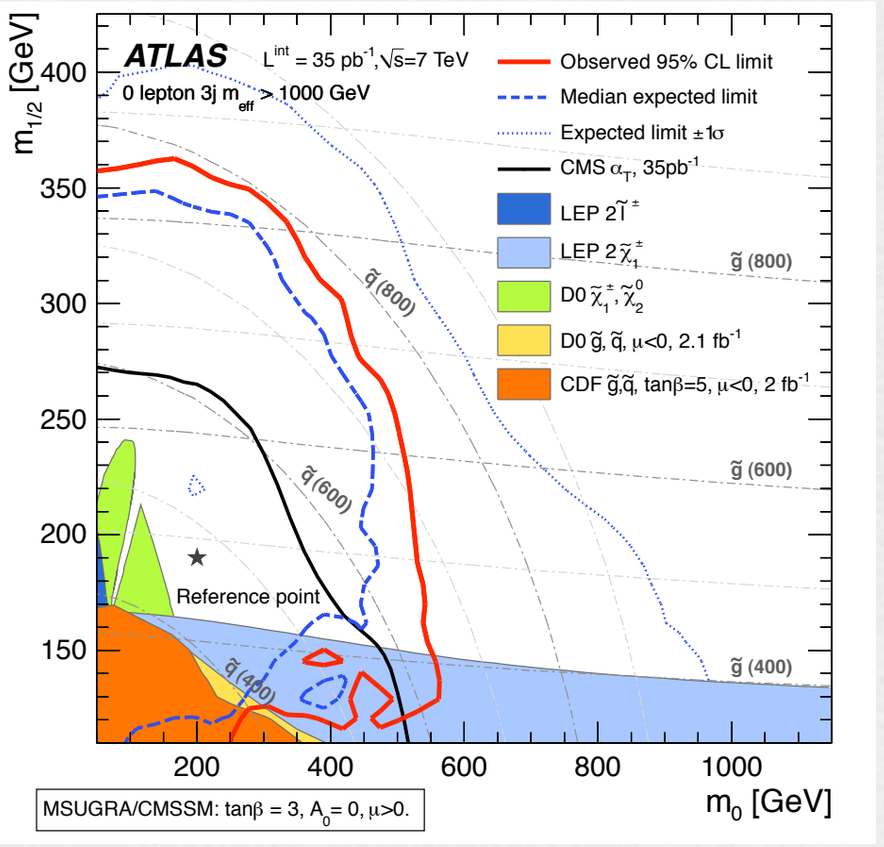
C

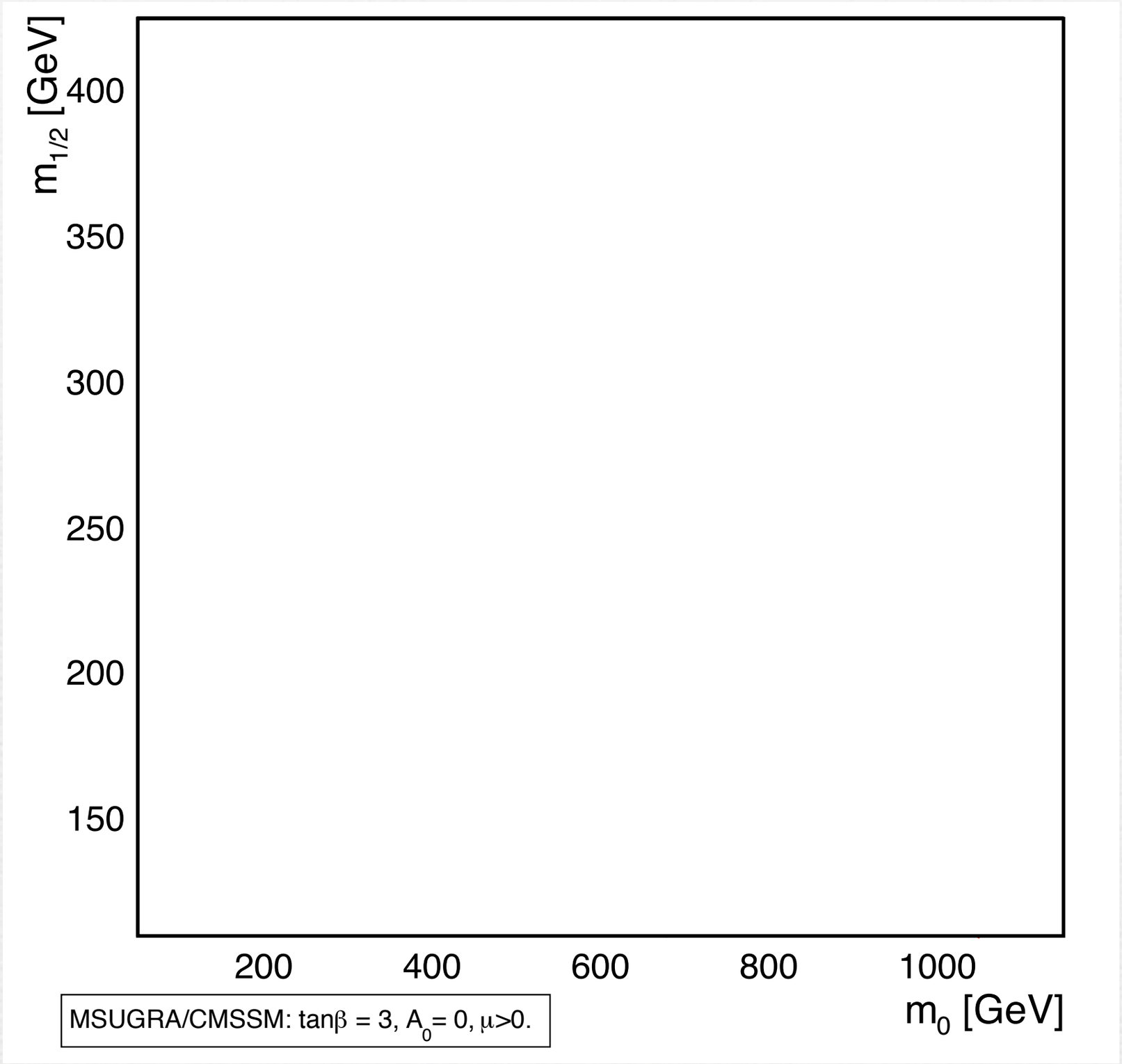
1.1 pb

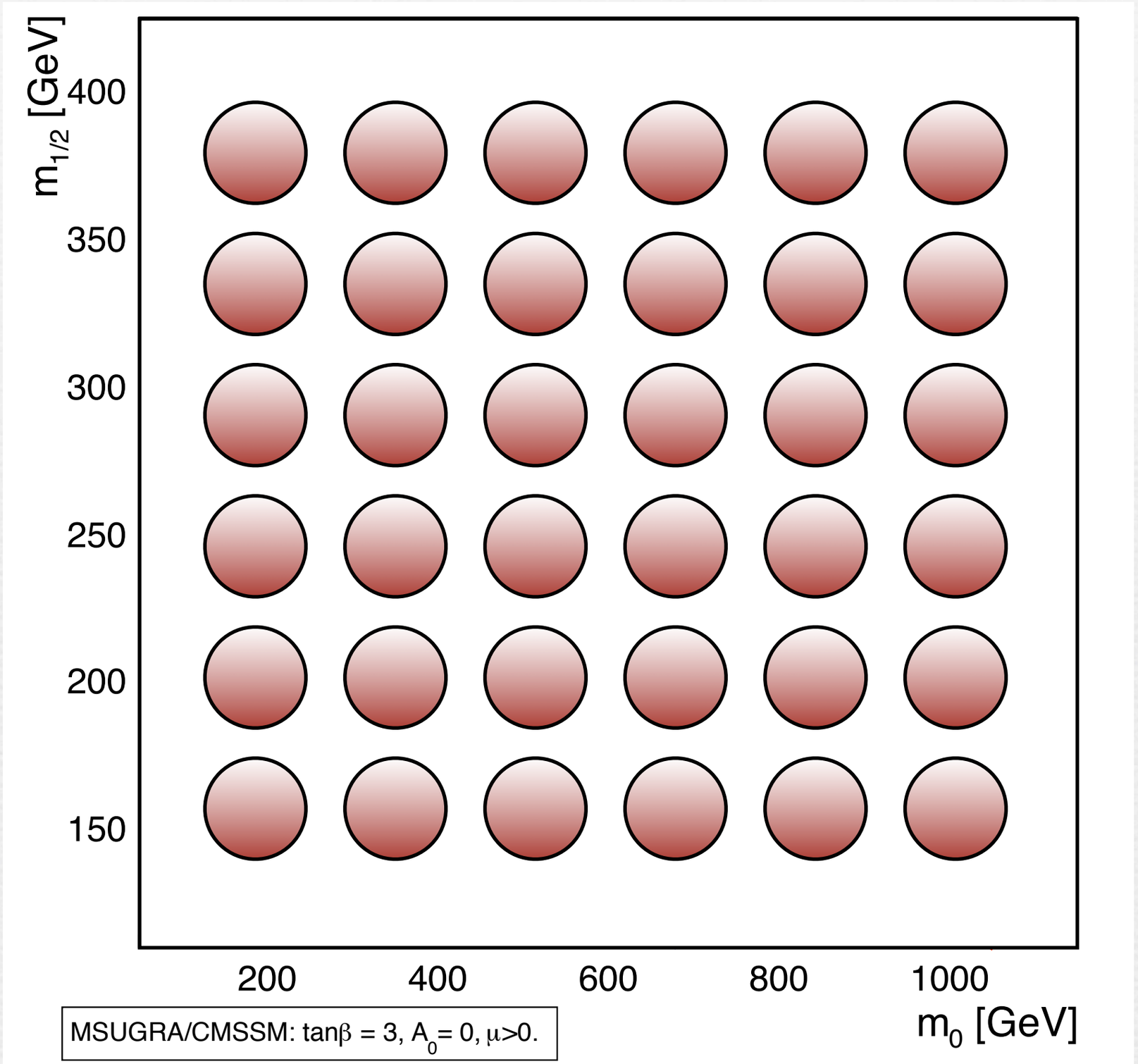


D

0.11 pb




$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.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400
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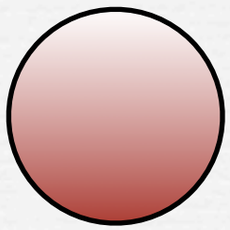
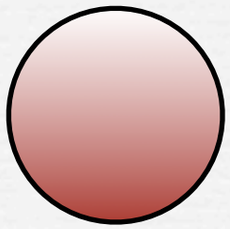


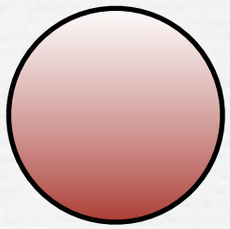
$$m_0,\, m_{1/2},\, A_0 = 0,\, \tan\beta = 3,\, \mu > 0$$



$$m_0,\, m_{1/2},\, A_0 = 0,\, \tan\beta = 3,\, \mu > 0$$

$$\downarrow$$

Softsusy
B.C. Allanach

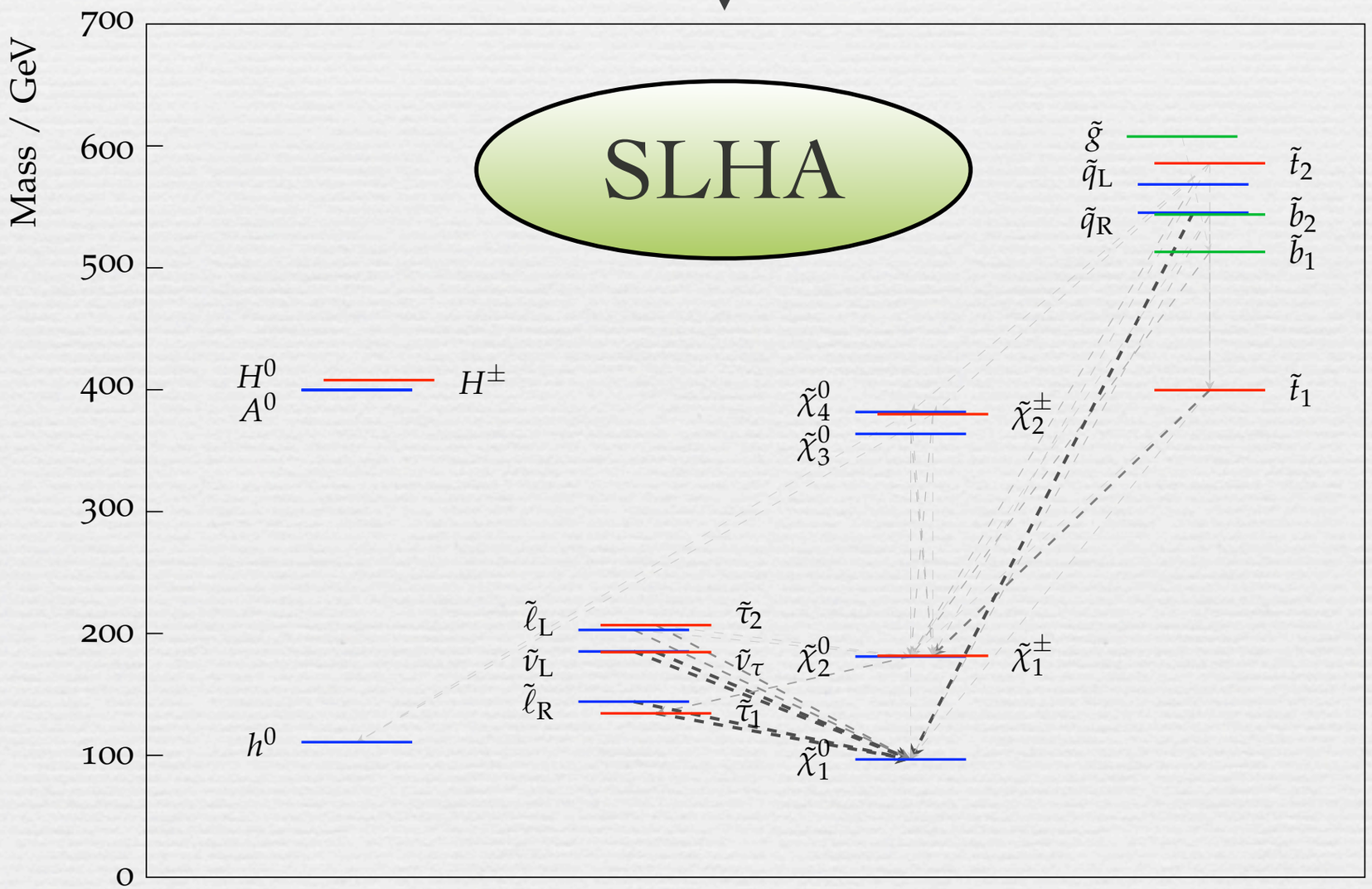


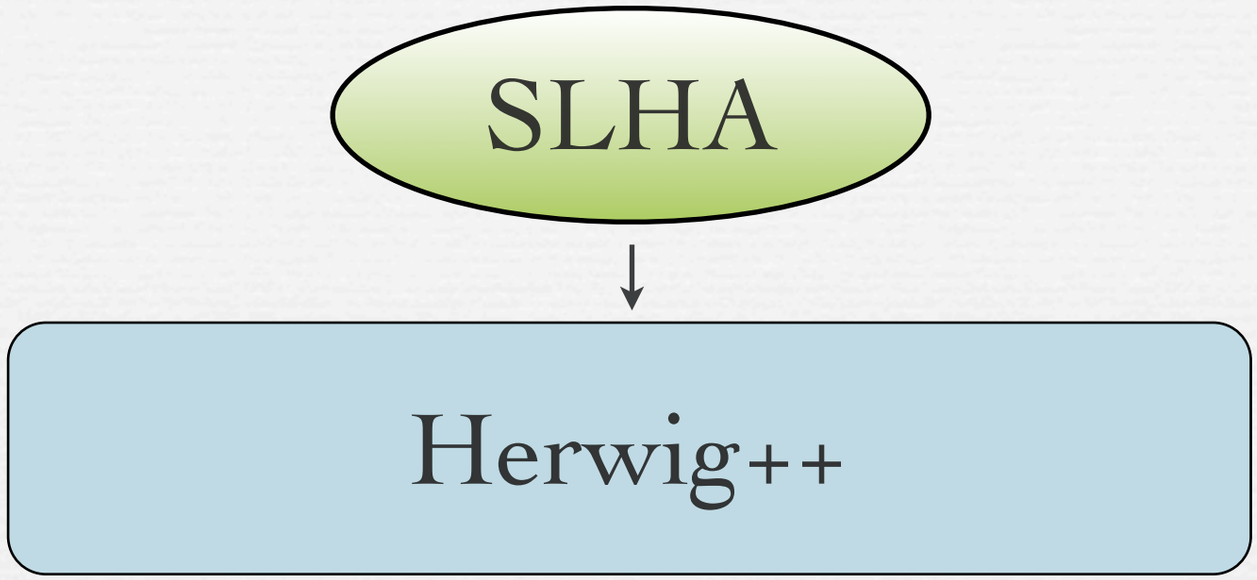
$$m_0,\ m_{1/2},\ A_0 = 0,\ \tan\beta = 3,\ \mu > 0$$

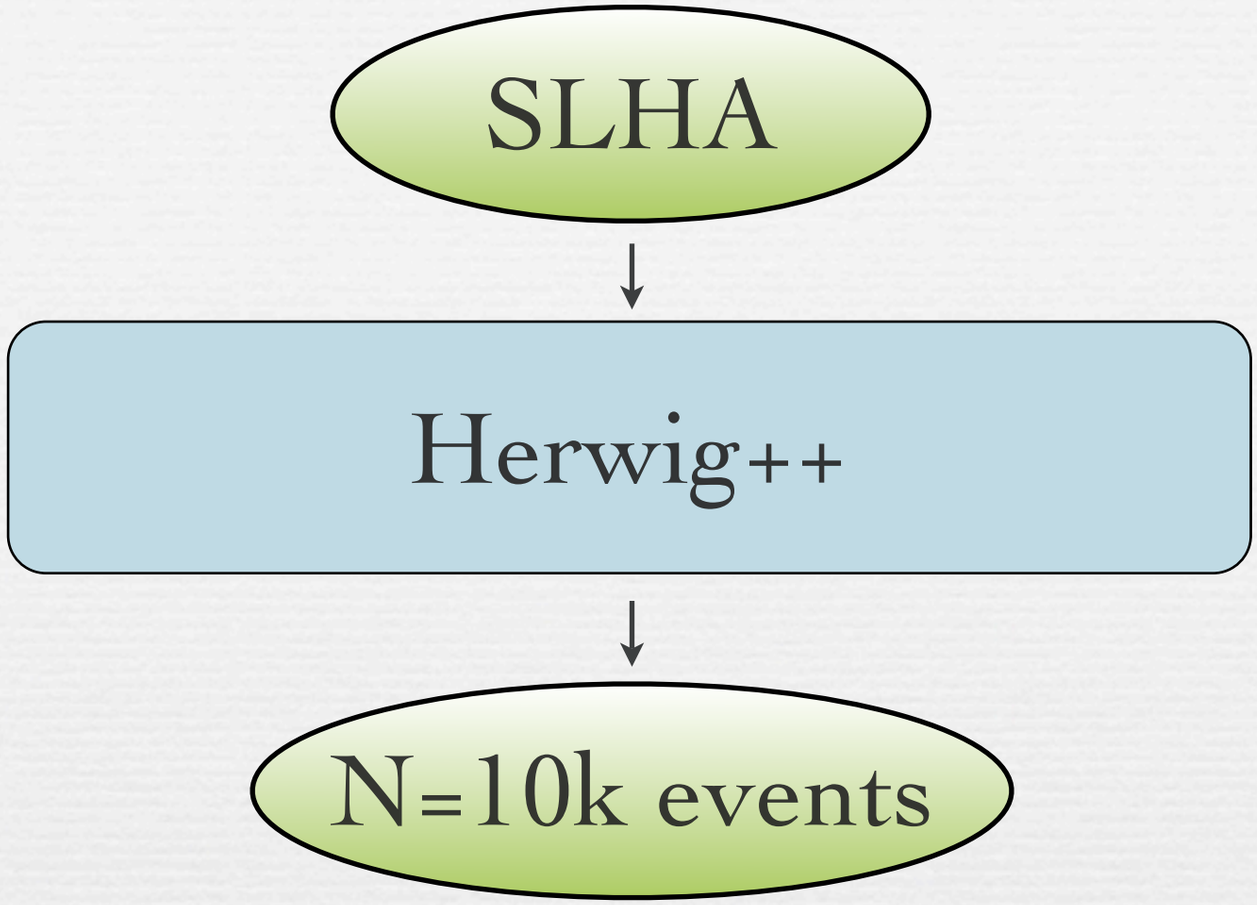
↓

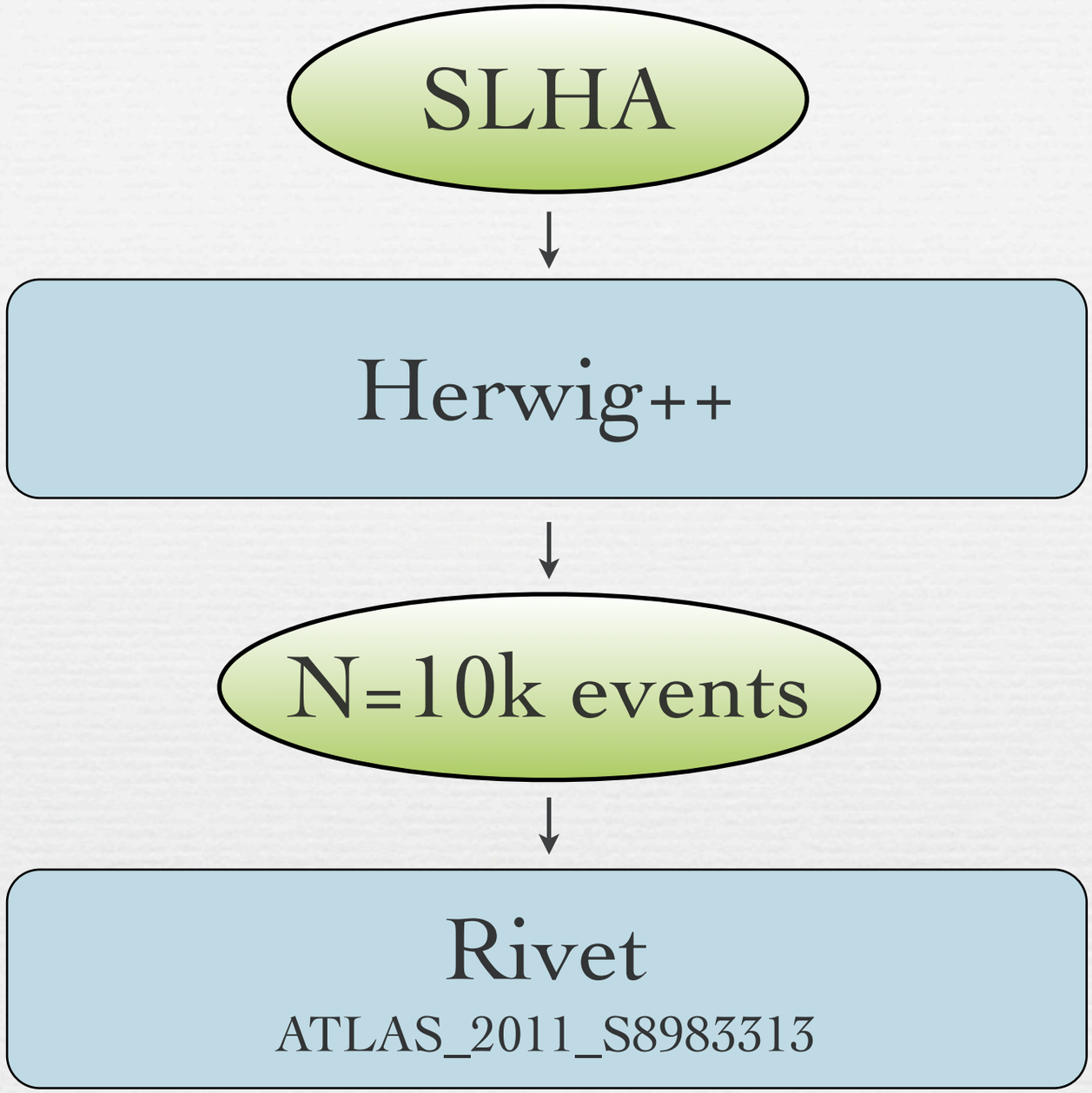
Softsusy
B.C. Allanach

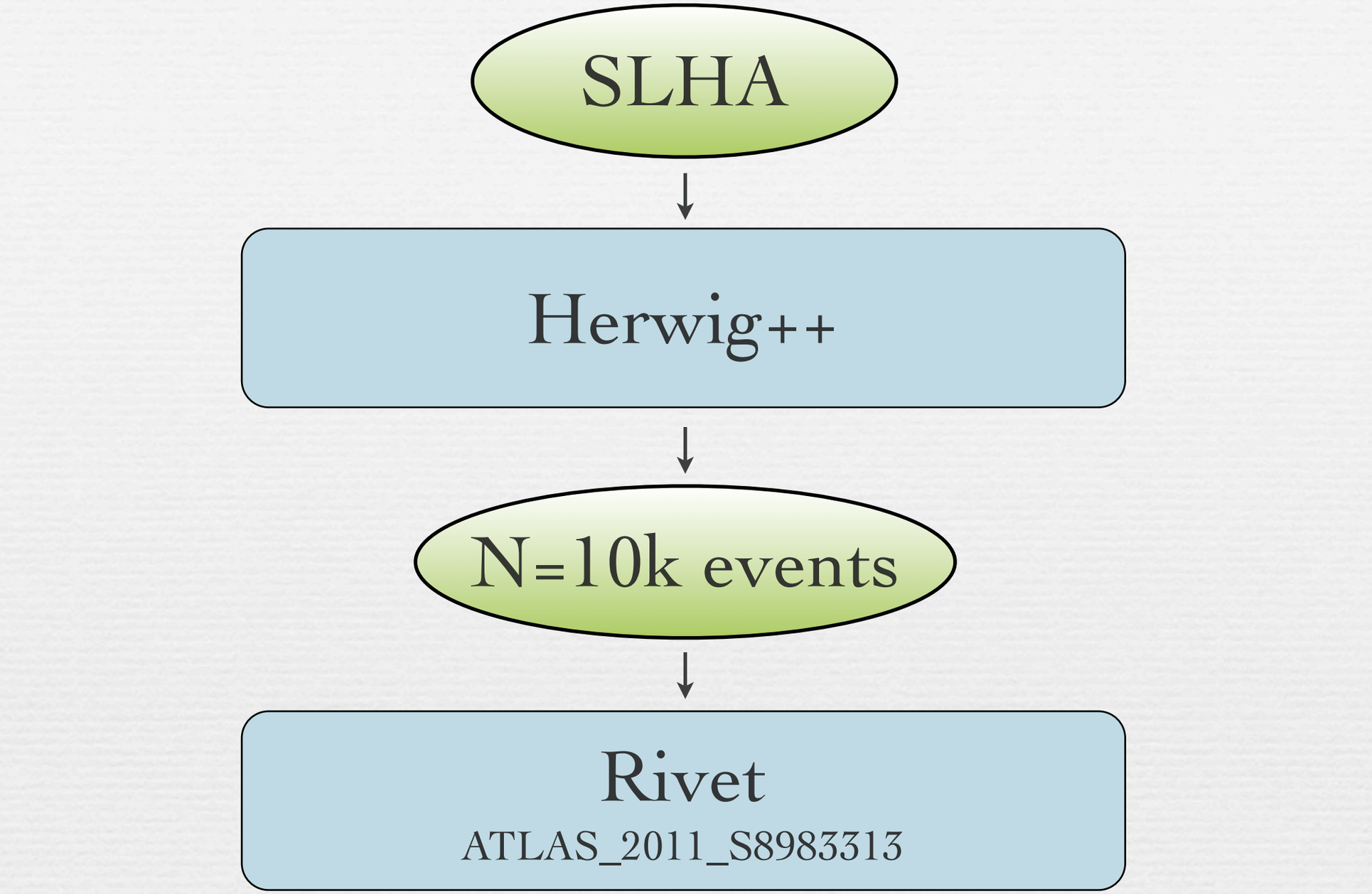
↓




SLHA
Herwig++


SLHA
Herwig++
N=10k events


SLHA
Herwig++
N=10k events
Rivet
ATLAS_2011_S8983313



one SUSY point gives 4 counts

8. Summary

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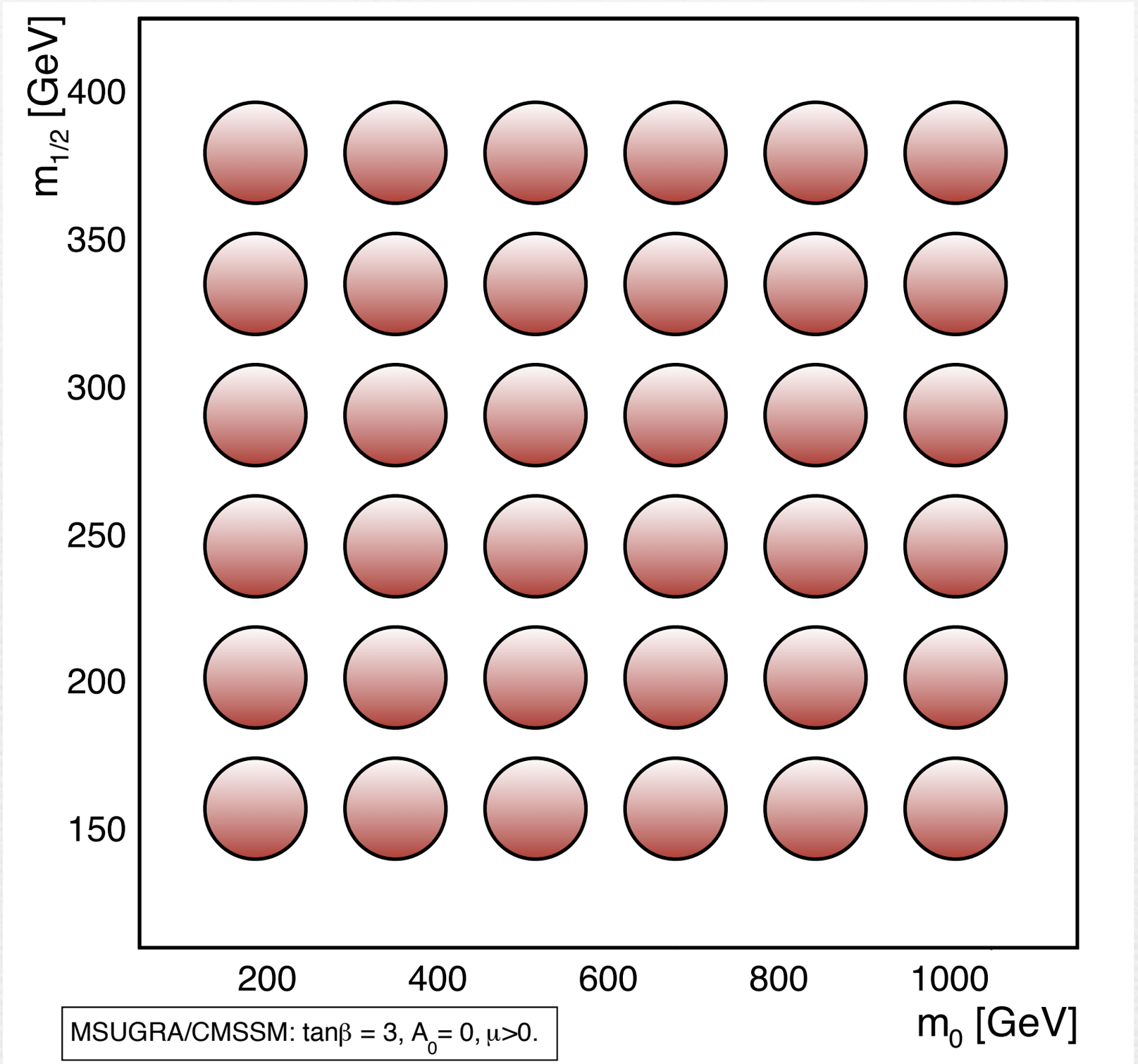
A B C D

$$\sigma_{\mathrm{A}} = \frac{A}{N}\,\sigma$$

$\sigma_A < 1.3\,\mathrm{pb}$?

Cross-section:
use LO Herwig++ result
or NLO value from Prospino


$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
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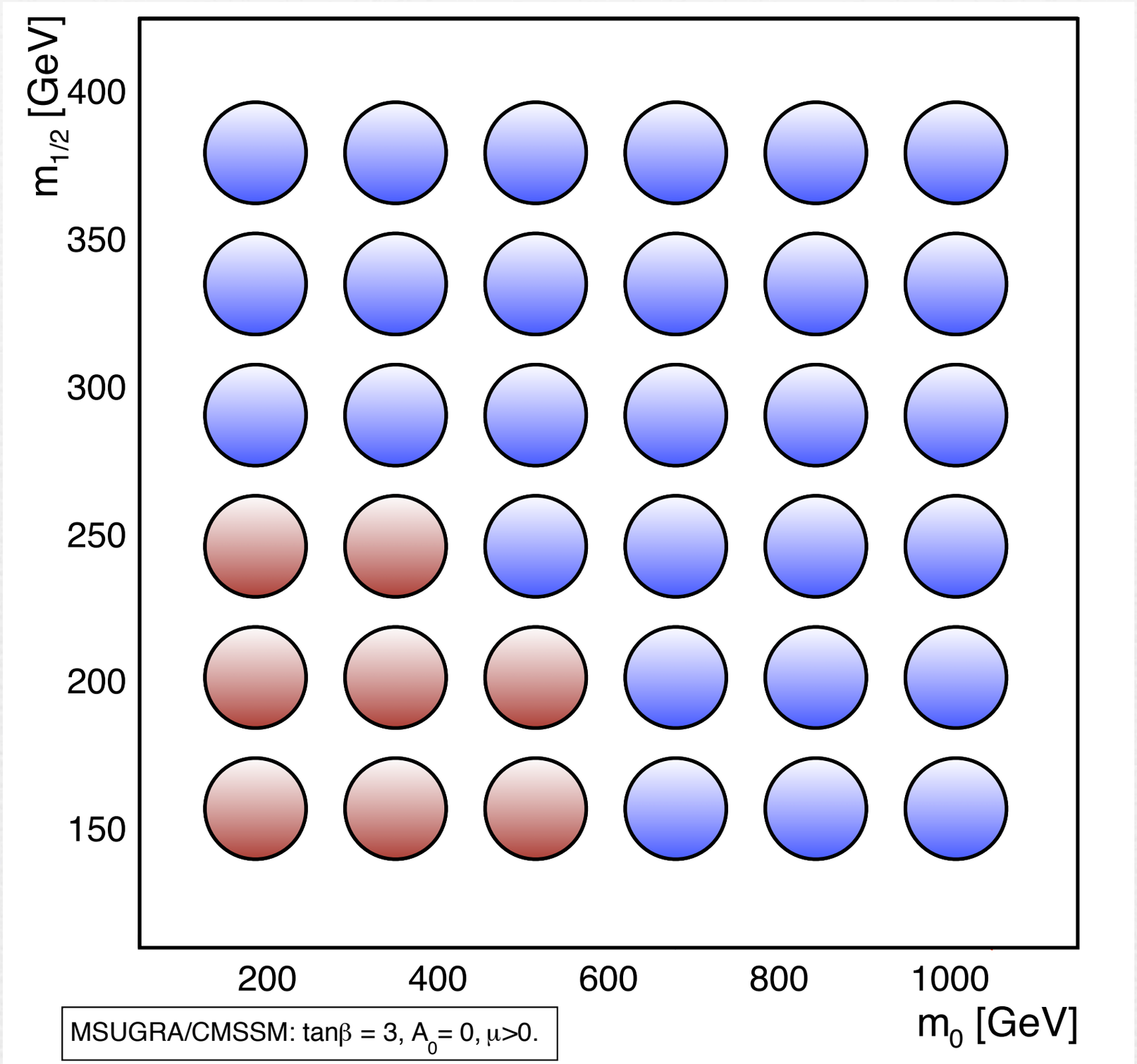
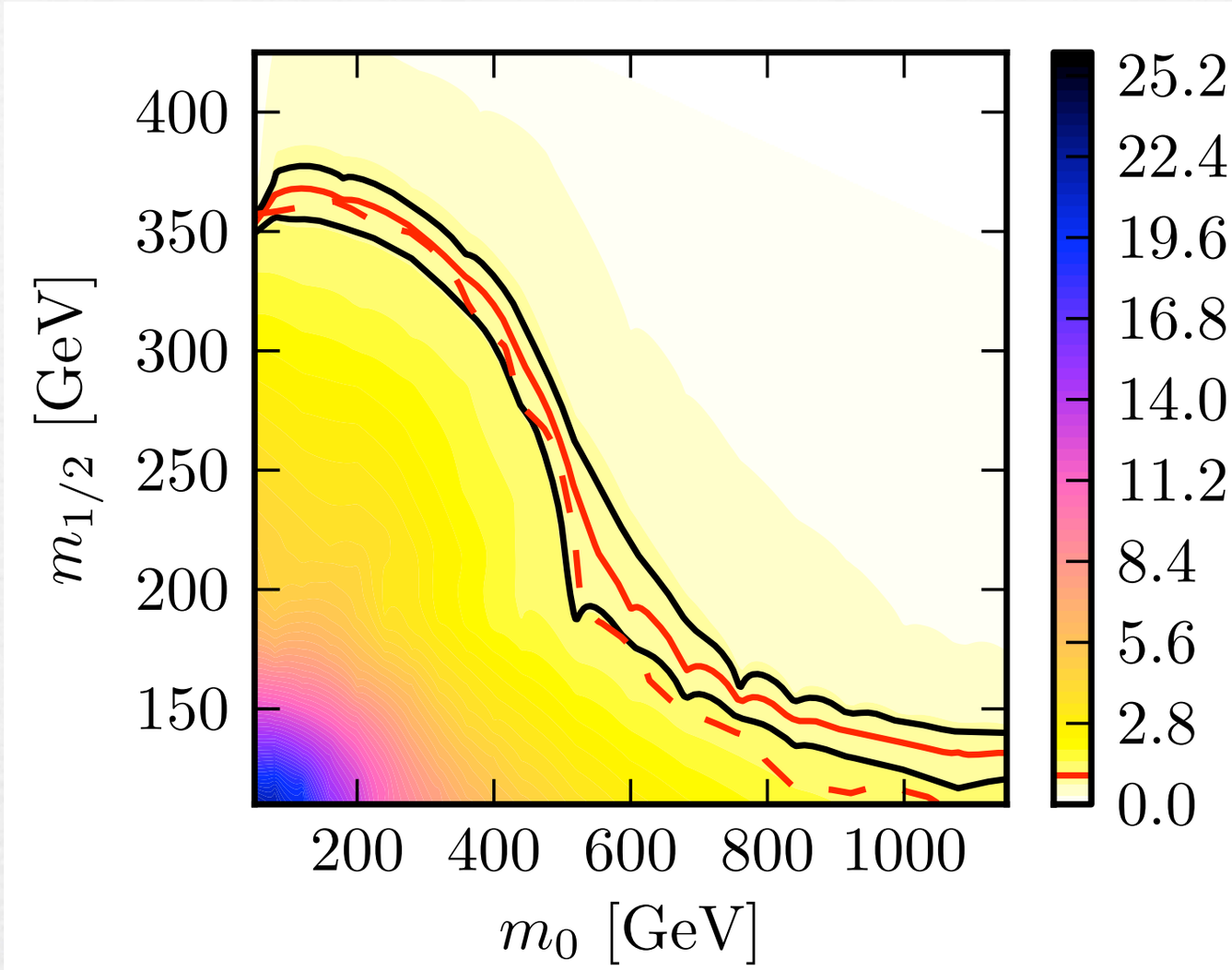
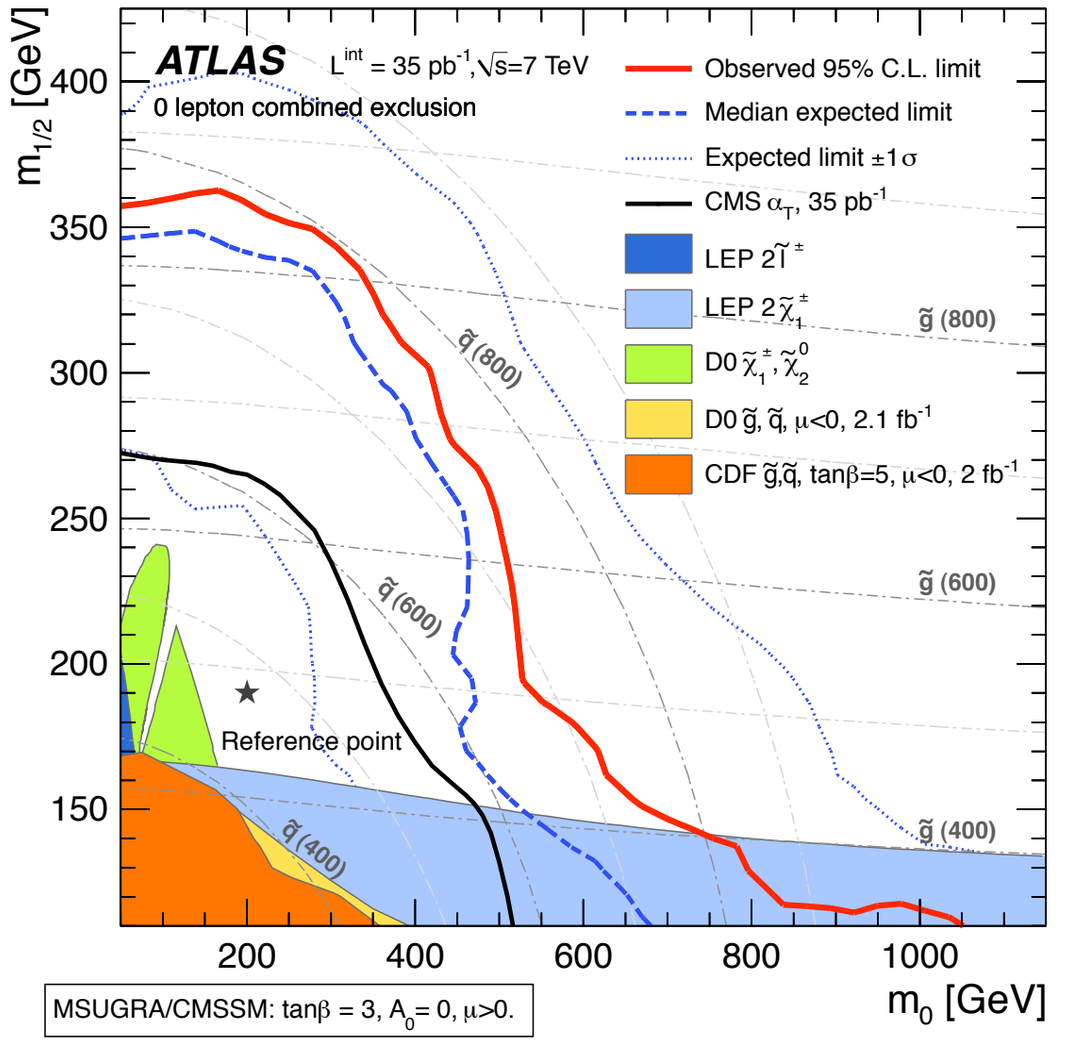
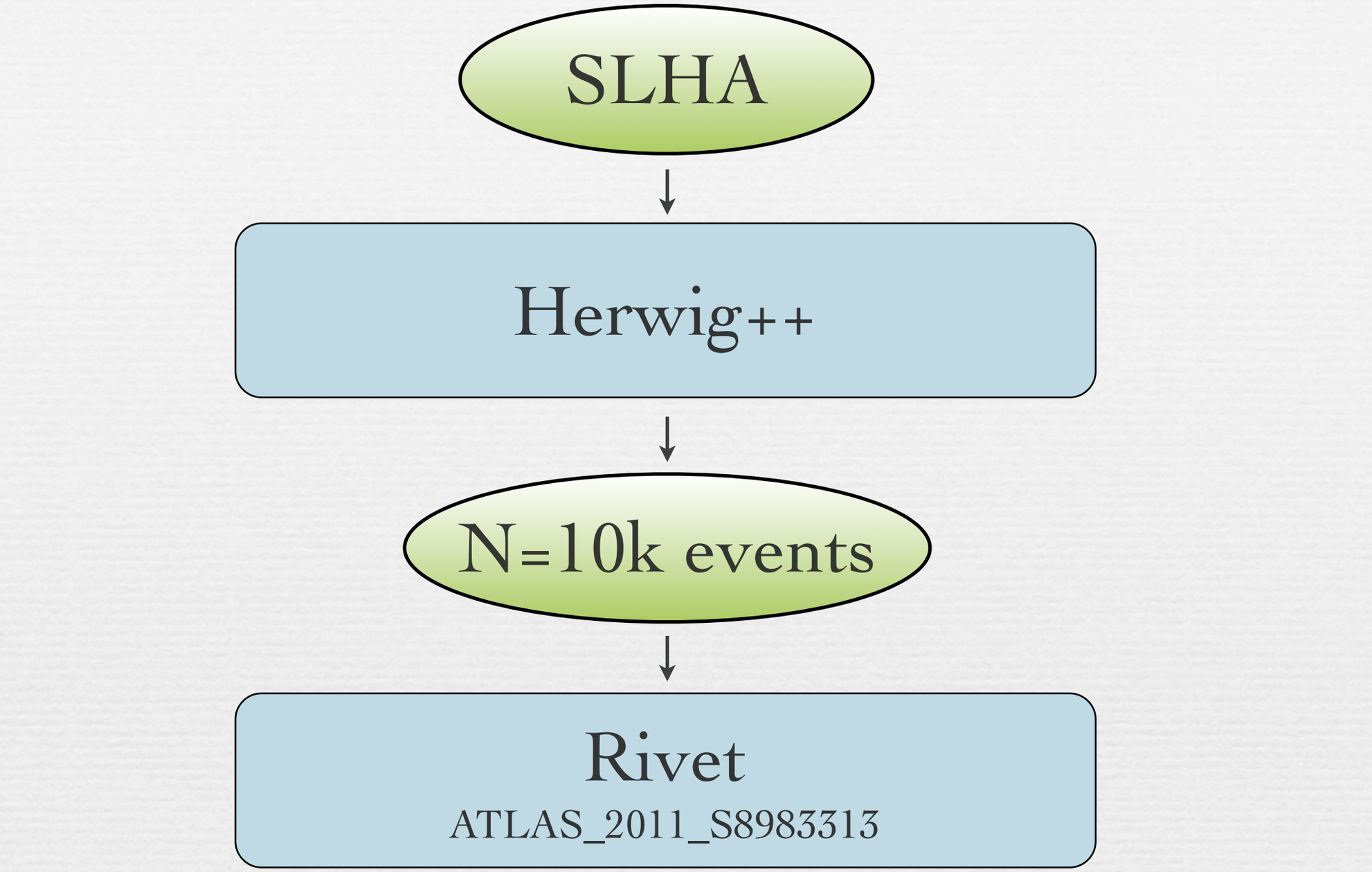
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0 = 0, μ>0.


$m_{1/2}$ [GeV]
400
350
300
250
200
150
200
400
600
800
1000
m_0 [GeV]
MSUGRA/CMSSM: tanβ = 3, A_0 = 0, μ>0.


400
350
300
250
200
150
$m_{1/2}$ [GeV]
200 400 600 800 1000
m_0 [GeV]
25.2
22.4
19.6
16.8
14.0
11.2
8.4
5.6
2.8
0.0


ATLAS
L^{int} = 35 pb^{-1}, $\sqrt{s}$=7 TeV
0 lepton combined exclusion
Observed 95% C.L. limit
Median expected limit
Expected limit ±1σ
CMS α_T, 35 pb^{-1}
LEP 2$\tilde{l}^{\pm}$
LEP 2$\tilde{\chi}_1^{\pm}$
D0 $\tilde{\chi}_1^{\pm}$, $\tilde{\chi}_2^0$
D0 $\tilde{g}$, $\tilde{q}$, μ<0, 2.1 fb^{-1}
CDF $\tilde{g}$,$\tilde{q}$, tanβ=5, μ<0, 2 fb^{-1}
$\tilde{g}$ (800)
$\tilde{g}$ (600)
$\tilde{g}$ (400)
$\tilde{q}$ (800)
$\tilde{q}$ (600)
$\tilde{q}$ (400)
Reference point
MSUGRA/CMSSM: tanβ = 3, A_0= 0, μ>0.
$m_{1/2}$ [GeV]
m_0 [GeV]
400
350
300
250
200
150
200
400
600
800
1000


SLHA
Herwig++
N=10k events
Rivet
ATLAS_2011_S8983313
A
B
C
D
1.3 pb
0.35 pb
1.1 pb
0.11 pb

Pure general gauge mediation
SUSY benchmark points

New Constraints on Gauge Mediation and Beyond from LHC SUSY Searches at 7 TeV

Matthew J. Dolan, David Grellscheid, Joerg Jaeckel,
Valentin V. Khoze and Peter Richardson

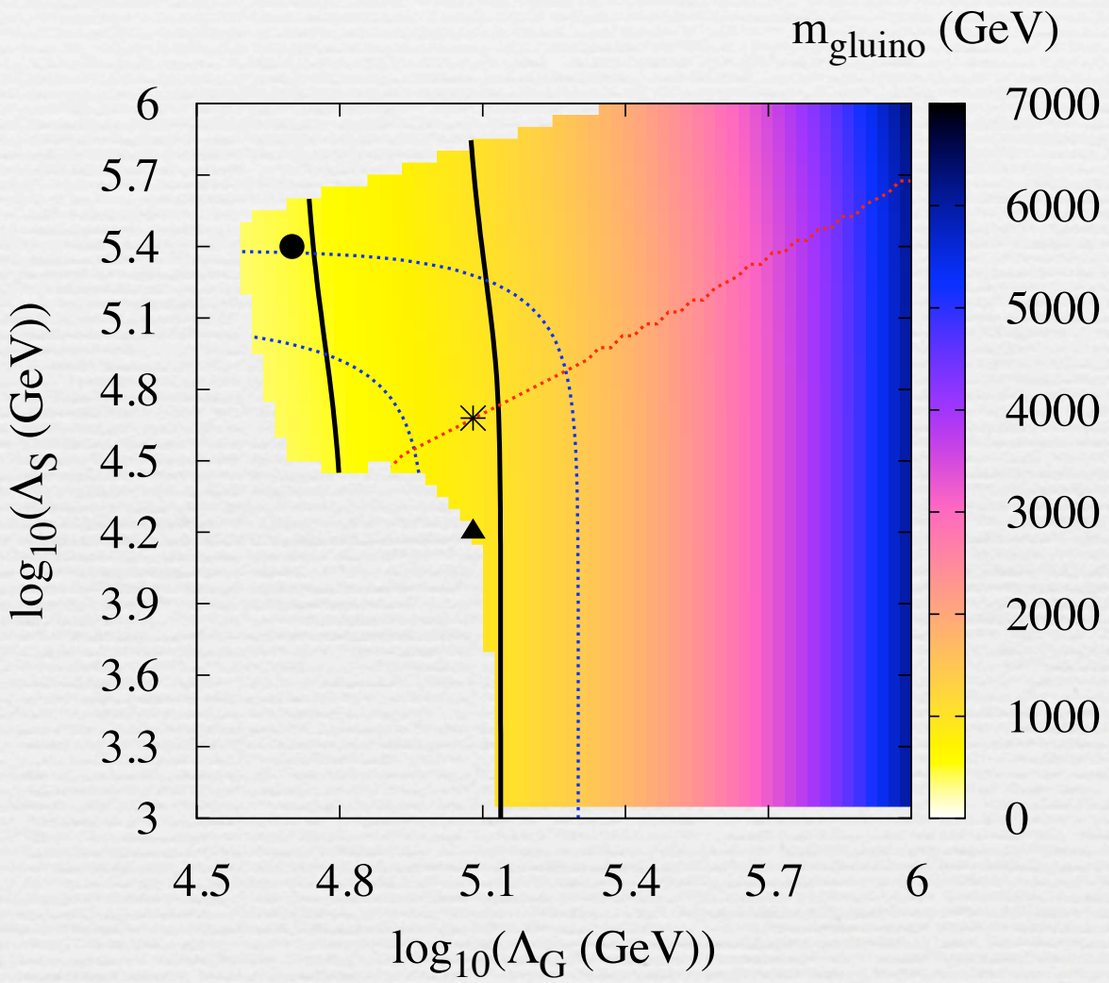
Institute for Particle Physics Phenomenology, Department of Physics, Durham University, Durham DH1 3LE, United Kingdom

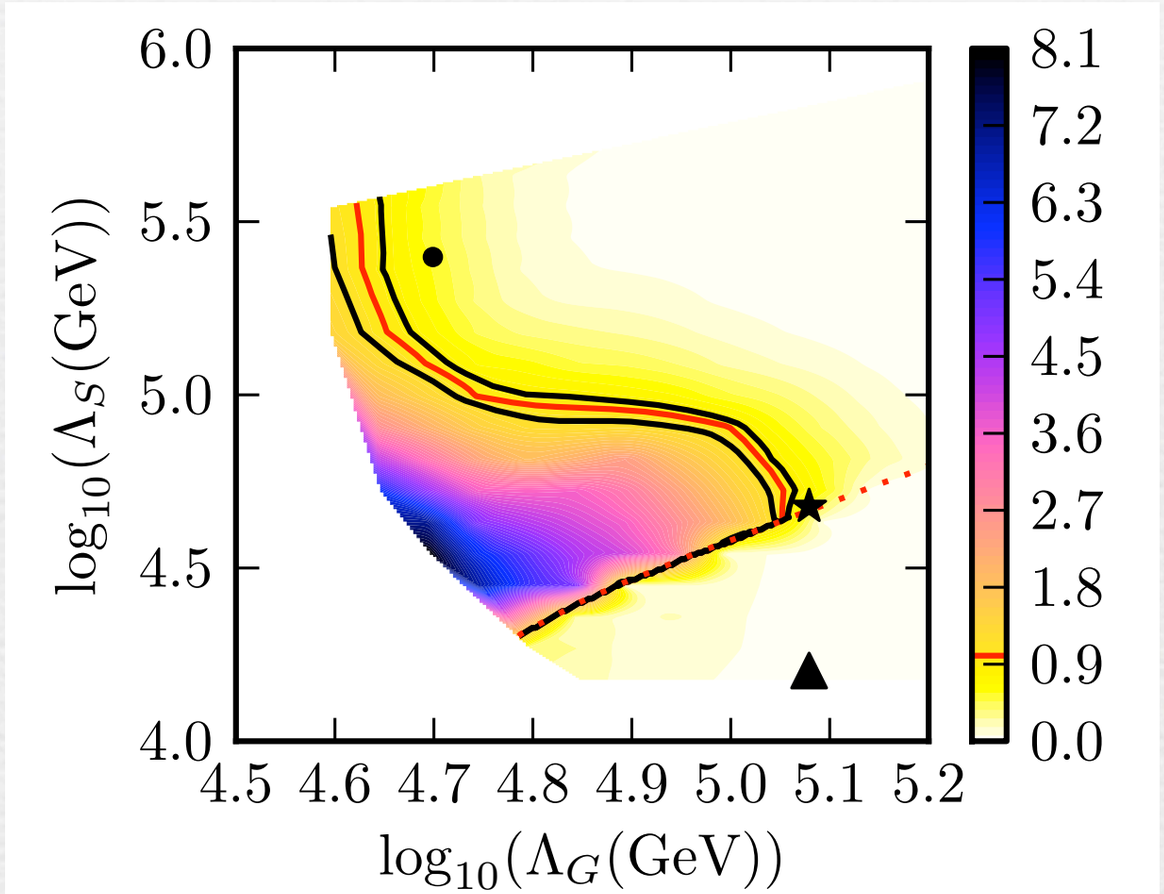
arXiv:1104.0585

Pure general gauge mediation

Λ_G Gaugino mass scale

Λ_S Scalar mass scale



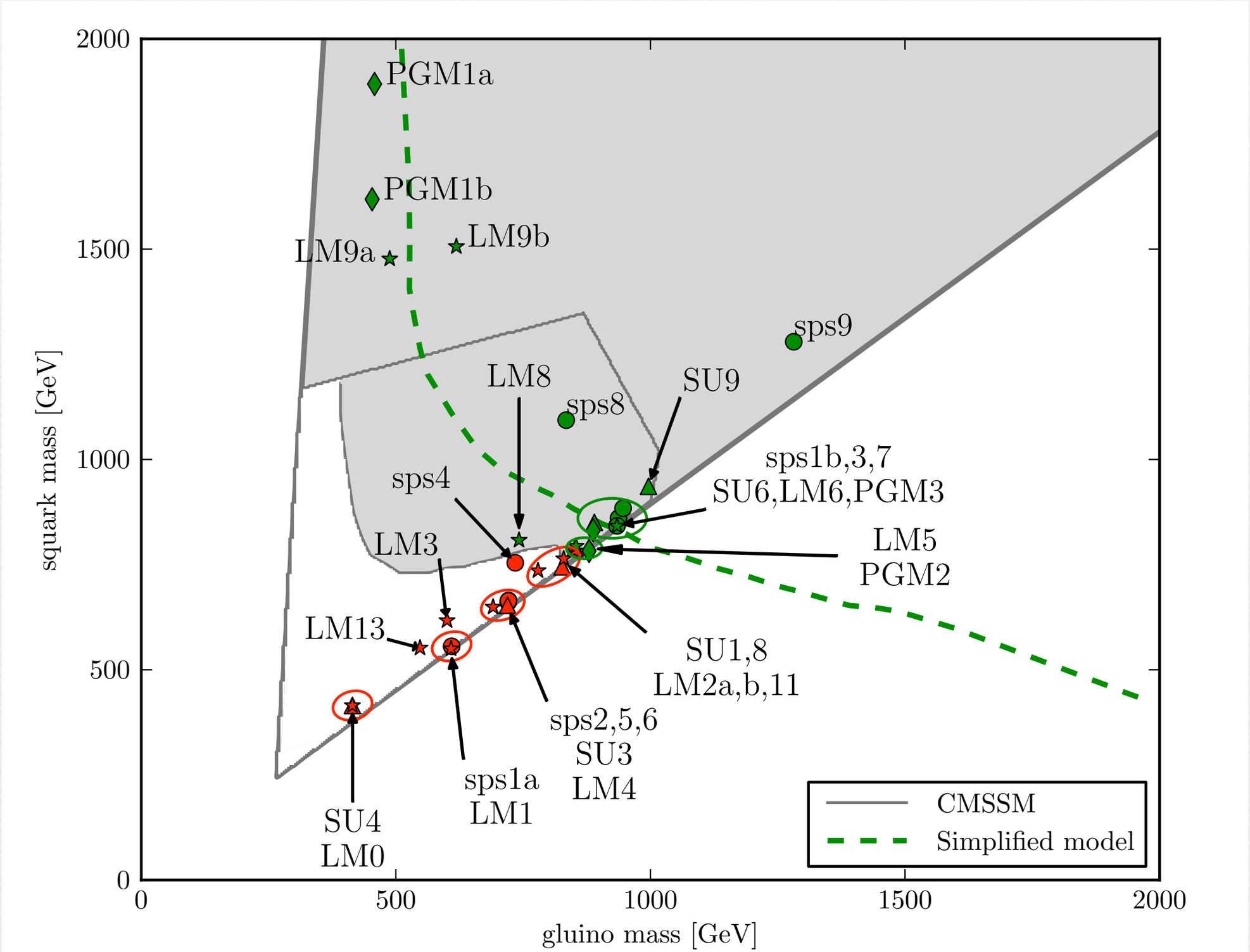


$$M_{\rm mess} = 10^{14}\,{\rm GeV}$$

SUSY benchmark points

Benchmark point	mediation scenario	σ/pb				status
		A	B	C	D	ATLAS 35pb^{-1}
ATLAS Limits		1.3	0.35	1.1	0.11	
sps1a [13]	CMSSM	2.031	0.933	1.731	0.418	A,B,C,D
sps1b [13]	CMSSM	0.120	0.089	0.098	0.067	allowed
sps2 [13]	CMSSM	0.674	0.388	0.584	0.243	B,D
sps3 [13]	CMSSM	0.123	0.093	0.097	0.067	allowed
sps4 [13]	CMSSM	0.334	0.199	0.309	0.144	D
sps5 [13]	CMSSM	0.606	0.328	0.541	0.190	D
sps6 [13]	CMSSM (non-universal $m_{\frac{1}{2}}$)	0.721	0.416	0.584	0.226	B,D
sps7 [13]	GMSB ($\tilde{\tau}_1$ NLSP)	0.022	0.016	0.023	0.015	allowed
sps8 [13]	GMSB ($\tilde{\chi}_1^0$ NLSP)	0.021	0.011	0.022	0.009	allowed
sps9 [13]	AMSB	0.019*	0.004*	0.006*	0.002*	A,B,C,D
SU1 [14]	CMSSM	0.311	0.212	0.246	0.143	D
SU2 [14]	CMSSM	0.009	0.002	0.010	0.001	allowed
SU3 [14]	CMSSM	0.787	0.440	0.637	0.258	B,D
SU4 [14]	CMSSM	6.723	1.174	7.064	0.406	A,B,C,D
SU6 [14]	CMSSM	0.140	0.101	0.115	0.074	allowed
SU8a [14]	CMSSM	0.251	0.174	0.197	0.120	D
SU9 [14]	CMSSM	0.060	0.046	0.053	0.040	allowed

SUSY benchmark points



Future directions

Your favourite BSM models

scans / individual points

Future directions

Your favourite BSM models

scans / individual points

SLHA

Future directions

Your favourite BSM models
scans / individual points

SLHA

Rivet
ATLAS_2011_S8983313

A

B

C

D

Future directions

Your favourite BSM models
scans / individual points

SLHA

Rivet	Rivet	Rivet
ATLAS_2011_S8983313	ATLAS_2011_S.....	ATLAS_2011_S.....
A, B, C, D	2j, 3j, 4j	?, ?, ?