SUSY Discovery at 10TeV ?

ATLAS-UK SUSY/Exotics Meeting

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Introduction

- 10TeV run coming soon (2-3 months? 100 pb^{-1} possible?)
- Studies show that, if SUSY is relatively light, it could be discovered very early at the LHC (based on 14TeV Monte Carlo)

  – so what about at 10TeV – could we hope to see something?

Introduction

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  – so what about at 10TeV – could we hope to see something?

"Commissioning to 10 TeV should be fast, no quench being anticipated, giving us confidence that the experiments will be recording data at record high energies by the summer.

In 1989, it was only a matter of weeks before LEP produced its first profound result – a measurement of the number of light neutrino families. In this respect at least, history will not be repeating itself. The LHC is a discovery machine, and the discoveries it is chasing will require a little more patience."

Robert Aymar, on the 10TeV run

PDFs – from 14TeV → 10TeV

- Currently no MC… BUT can re-weight existing 14TeV samples
  - hadronic cross section given by:

proton PDFs

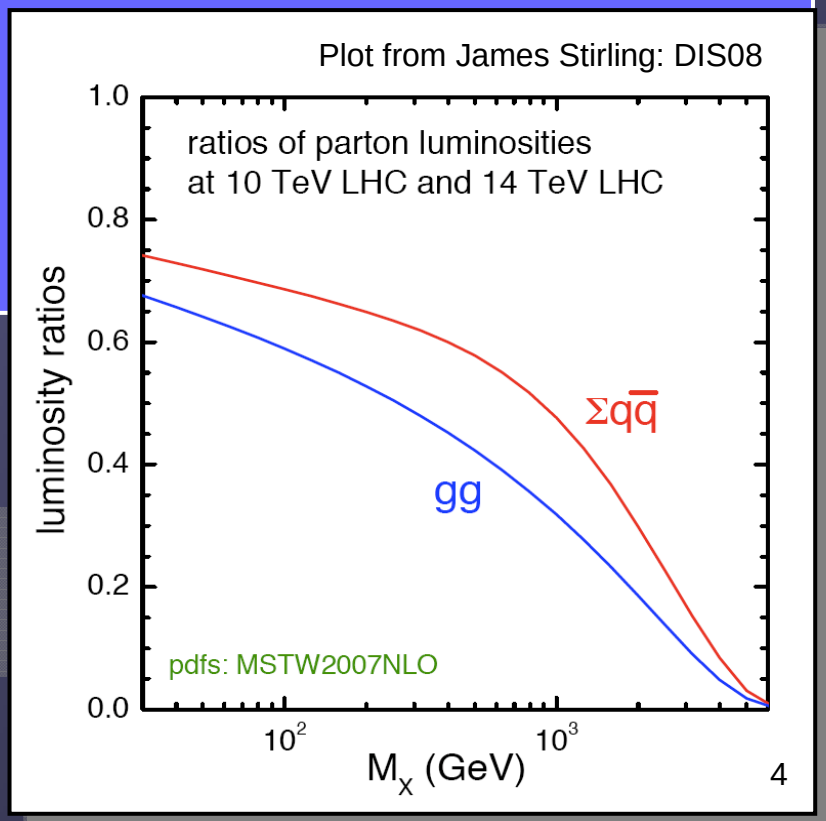
$$\sigma = \sum_{\text{flav}} \int_0^1 dx_1 dx_2 \; PDF(x_1, Q^2, \text{flav}_1) \times PDF(x_2, Q^2, \text{flav}_2) \times \hat{\sigma}$$

For a particular kinematic configuration with $\hat{s}$, $\hat{t}$, $\hat{u}$, should just need to change the probability that incoming partons *had* that configuration i.e. just a PDF re-weight

Re-weight MC to 10TeV using:

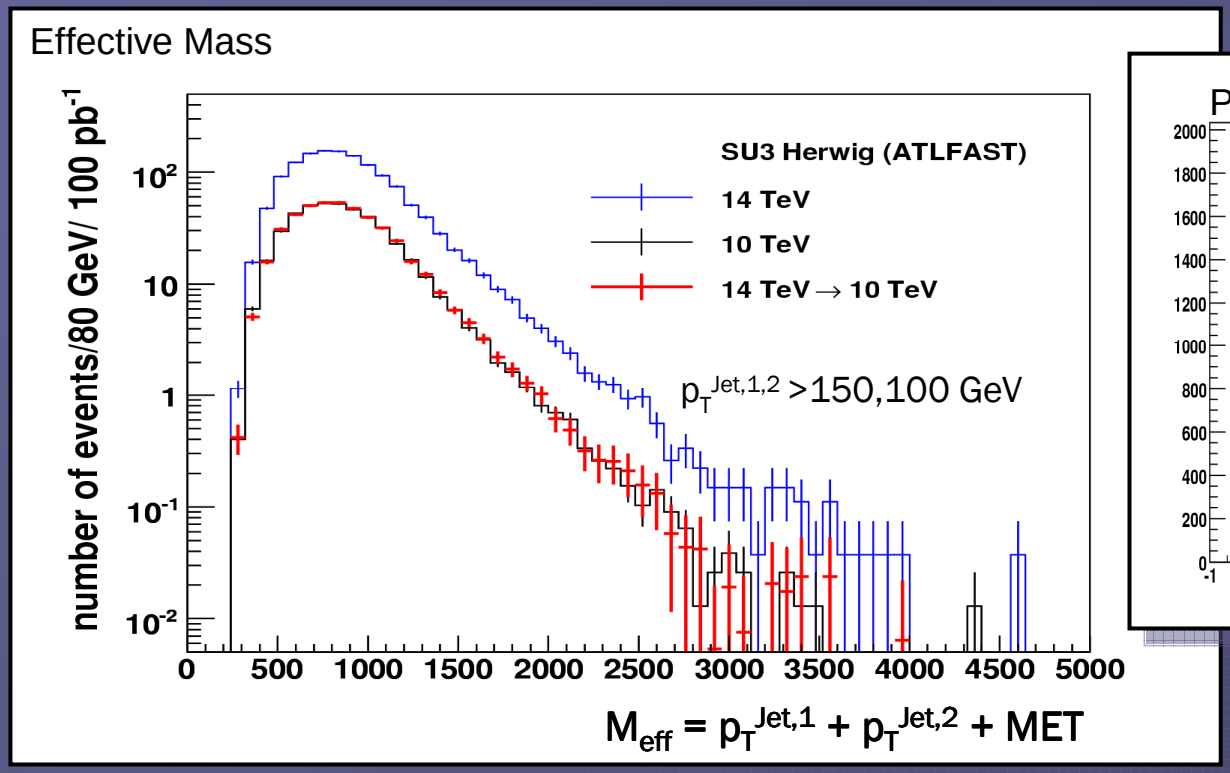
$$\text{Weight} = \frac{PDF\left(x_1', Q^2, \text{flav1}\right) \times PDF\left(x_2', Q^2, \text{flav2}\right)}{PDF\left(x_1, Q^2, \text{flav1}\right) \times PDF\left(x_2, Q^2, \text{flav2}\right)}$$

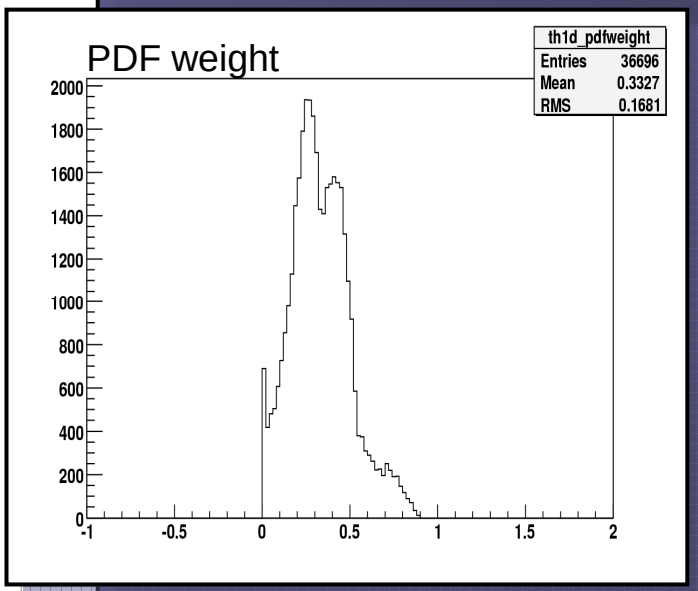
x_i : x of parton i at 14TeV; x_i': x of parton i at 10TeV



Check of Reweight Method

EG: SU3 SUSY events generated in ATLFAST





example weights (all < 1)

- Good agreement between reweighted and 10TeV samples (bkgs also checked)

SUSY analysis

- EG: CSC5-style, inclusive 2- and 3-Jet analyses (full details in note)
  - results shown in main part of talk are for the 2-Jet case (3-Jet results in backups)

Cut No.	2-Jet Analysis Cuts
0	J70_XE70 trigger
1	$p_T^{Jet,1} > 150$ GeV
2	$p_T^{Jet,2} > 100$ GeV
3	MET > max(100,0.3*M_{eff})
4	|phi(Jet1,2)-phi(MET)| > 0.2
5	no isolated lepton

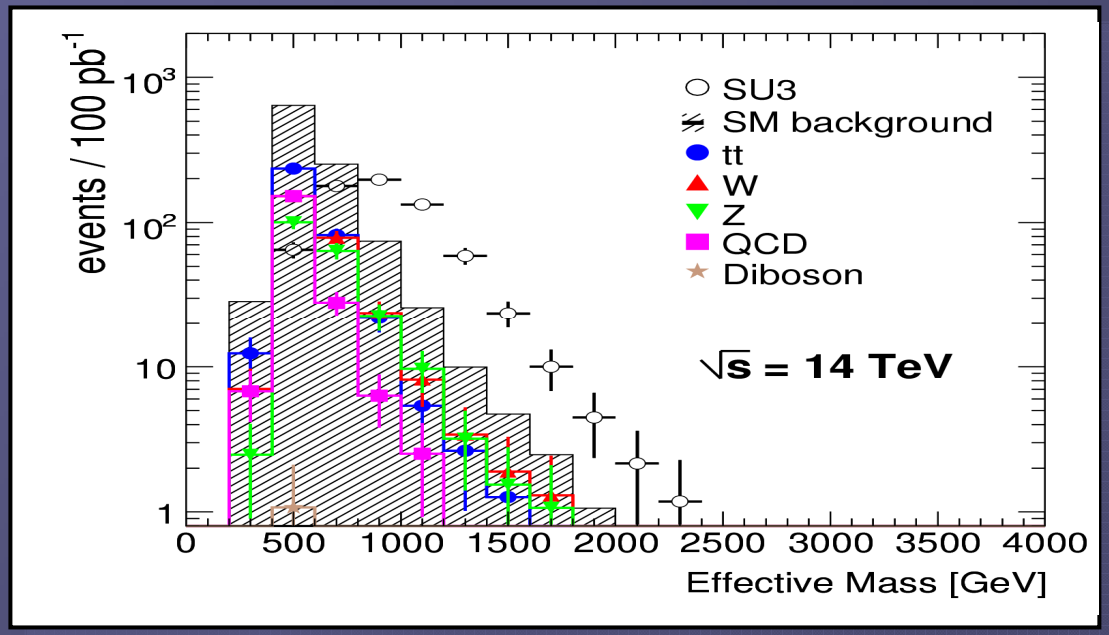
"Generic search for R-parity conserving SUSY in 2-Jet + MET +0-lepton channel"

Effective Mass: $M_{eff} = \sum p_T^{Jet,i} + MET$ [sum runs over two highest-p_T jets]

Results: SU3 vs. SM bkg

EG: CSC5 2–Jet + MET + 0–lepton SUSY analysis:

- Integrated L = 100 pb^{-1}
- **BEFORE** reweighting ➔



Results: SU3 vs. SM bkg

EG: CSC5 2–Jet + MET + 0–lepton SUSY analysis:

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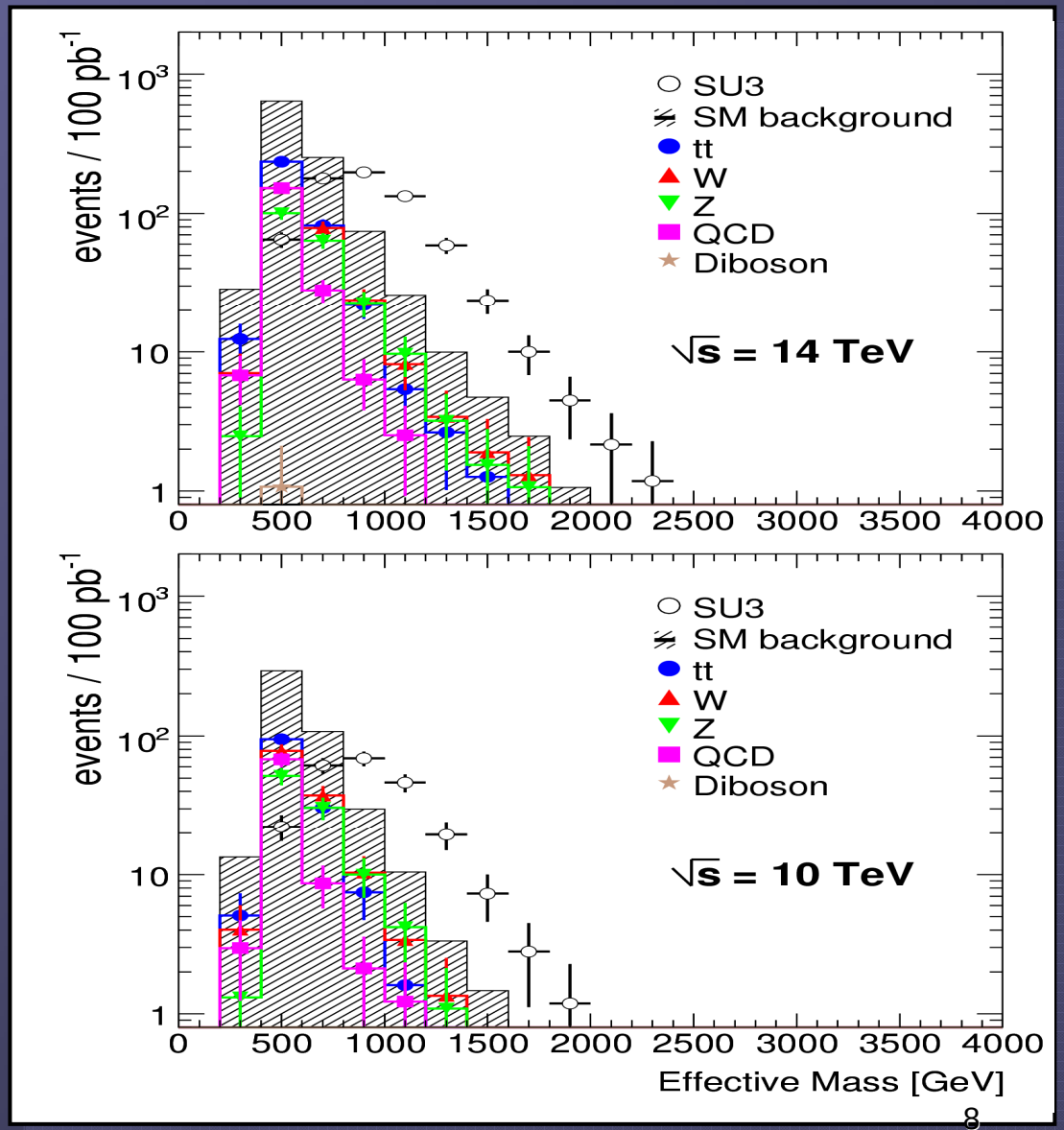
- **AFTER** reweighting ➘

14 TeV ➔ 10 TeV:

- SU3 signal reduced by ~ 2.9
- SM bkg reduced by ~ 2.3

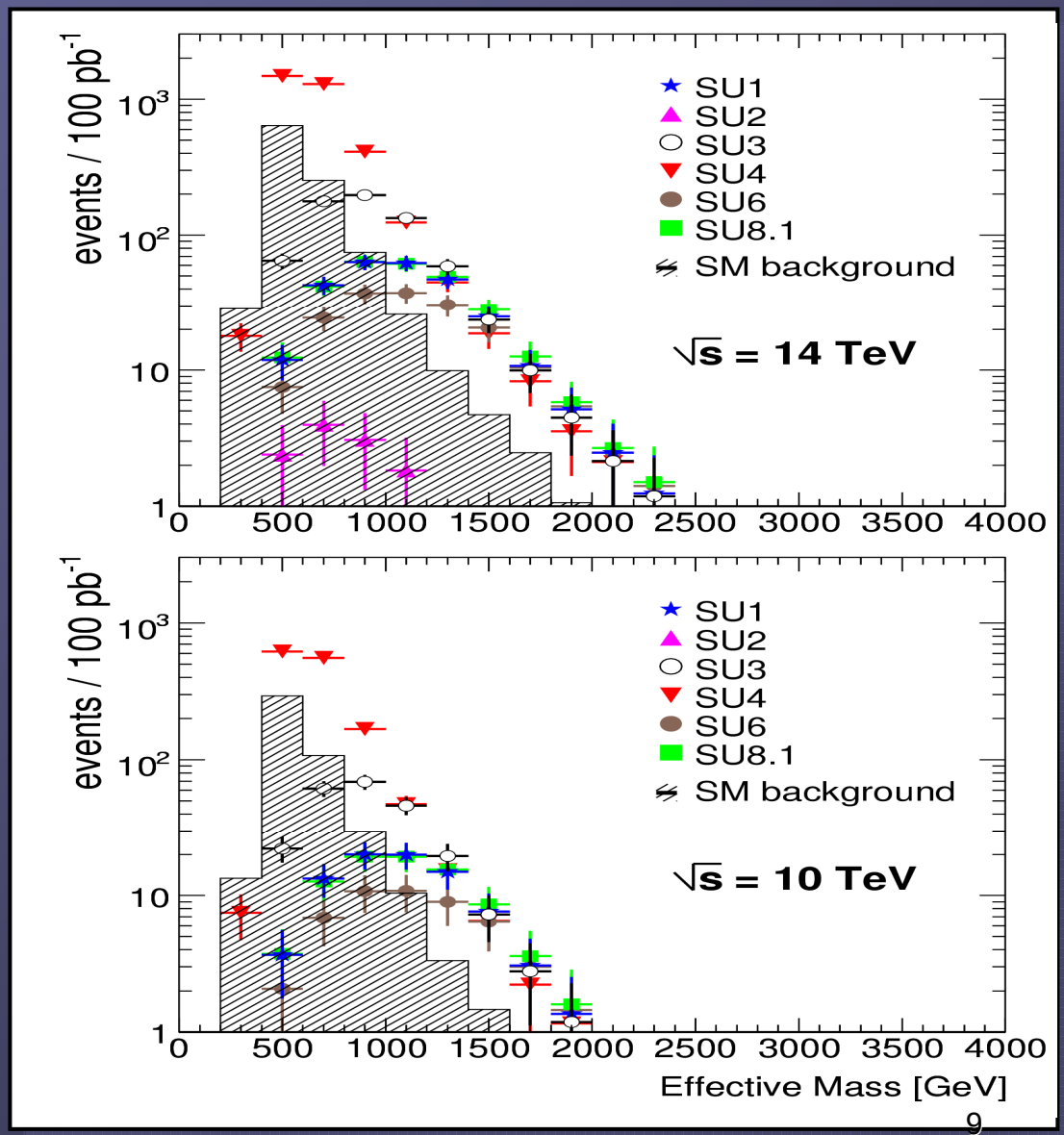


Results: other mSUGRA points

EG: CSC5 2–Jet + MET + 0–lepton SUSY analysis:

- Integrated L = 100 pb^{-1}
- Comparison of some other SUSY benchmark points (SUX)
  - all are mSUGRA, but cover quite a wide range of phenomenologies

SU1	coannihilation region
SU2	focus point region
SU3	bulk region
SU4	low mass point
SU6	funnel region
SU8.1	coannihilation region



Statistical Significances

100 pb^{-1}

Statistical Significance ($S/\sqrt{B}$)		
	14TeV	10TeV
SU1	23	12
SU2	< 1	< 1
SU3	39	22
SU4	106	67
SU6	16	8
SU8	24	12

- Numbers are maximum significances (taken above some M_{eff} threshold)
  (don't take too much notice of the actual values – it's just to get a rough feeling)

Discovery Significances

100 pb^{-1}

Discovery Significance (Z_n) *		
	14TeV	10TeV
SU1	9.1	5.9
SU2	<1	<1
SU3	11.2	8.3
SU4	12.5	12.5
SU6	7.5	4.8
SU8	9.7	6.2

- Numbers are maximum significances (taken above some M_{eff} threshold)
  (don't take too much notice of the actual values – it's just to get a rough feeling)

* Z_n is a measure of the significance (as used in CSC5) which tries to take into account systematic uncertainties on the bkg measurements. The numbers in the table above are calculated assuming 50% uncertainty on QCD and 20% on all other bkgs – these are not necessarily the "right" numbers – dedicated bkg studies needed for those!

Summary

- Is there potential for discovery with small amounts of 10 TeV data?
  - ➢ **YES – there does seem to be potential!**

- A 5x increase in centre-of-mass energy compared to previous experiments is still a lot!!! – and the discovery of light SUSY may not need much data (it doesn't take much to give large $S/\sqrt{B}$ values for the models considered here)
  - **BUT that data still needs to be understood**

- This was really just a quick look for fun – to see if anything is even potentially feasible! It looks like it could be, but the limiting factor will of course be how well we can **determine and understand** the backgrounds with the small amount of data we expect.

BackUps

Results: other mSUGRA points

EG: CSC5 3–Jet + MET + 0–lepton SUSY analysis:

- Integrated L = 100 pb^{-1}

Cut	3-Jet Analysis Cuts
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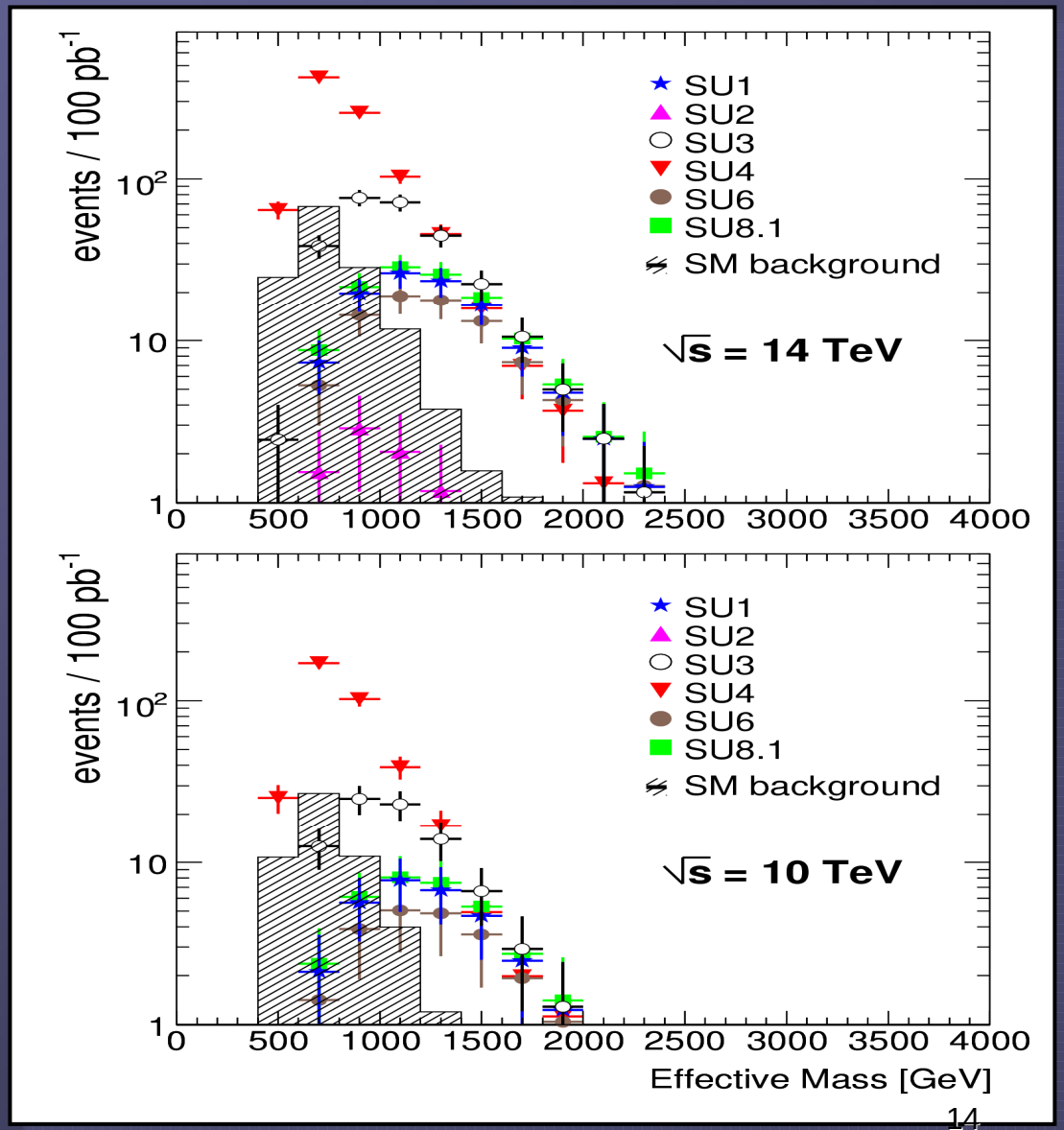

mSUGRA Points

- More details on the mSUGRA points considered

	m0	m1/2	A0	tanβ	μ	Region
SU1	70	350	0	10	> 0	Coannihilation
SU2	3550	300	0	10	> 0	Focus point
SU3	100	300	-300	6	> 0	Bulk
SU4	200	160	-400	10	> 0	Low mass
SU6	320	375	0	50	> 0	Funnel
SU8.1	210	360	0	40	> 0	Coannihilation

MC Bkg Samples

Sample	CSC ID	σ (pb)	N
T1	005200	450	600 K
TTbar	005204	383	100 K
J4MET	008090	916.40	70K
J5MET	008091	655.	85K
J6MET	008092	67.42	35K
J7MET	008093	5.3	4K
J8MET	008094	2.21×10^{-2}	4K
WW	005985	24.5	50K
WZ	005986	2.1	50K
ZZ	005987	7.8	50K
Zee	008194	46.2	5K
Zmumu	008195	9.60	5K
Ztautau	008191	4.50	5K
Znunu	008190	41.33	35K
Wenu	008270	49.05	50K
Wmunu	008271	28.64	50K
Wtaunu	008272	55.91	50K