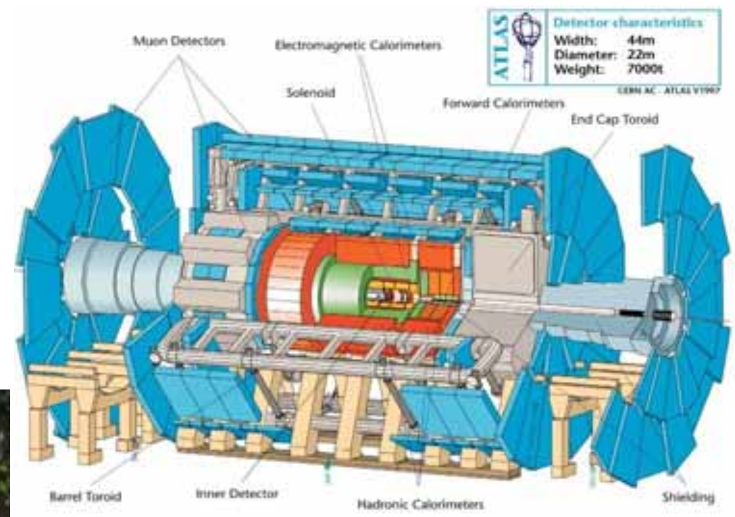
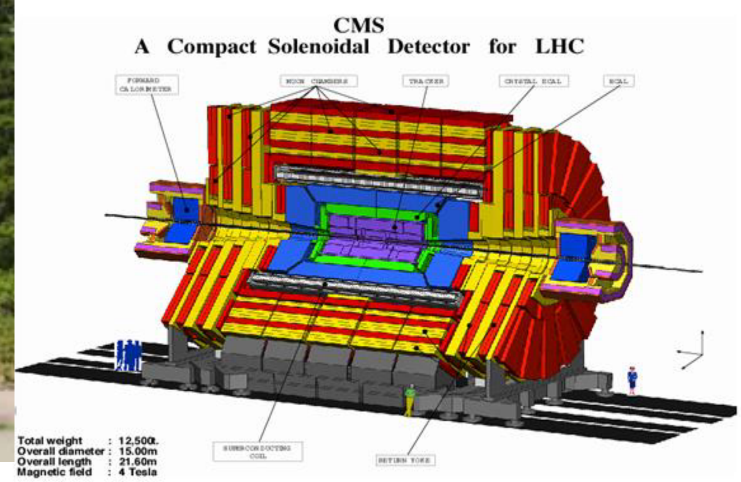
No Prejudice in SUSY Searches @ the 7(&14) TeV LHC

J.A. Conley, J. S. Gainer, J. L. Hewett, M.-P. Le & TGR ; arXiv:1009.2539,1102.xxxx





SLAC NATIONAL ACCELERATOR LABORATORY

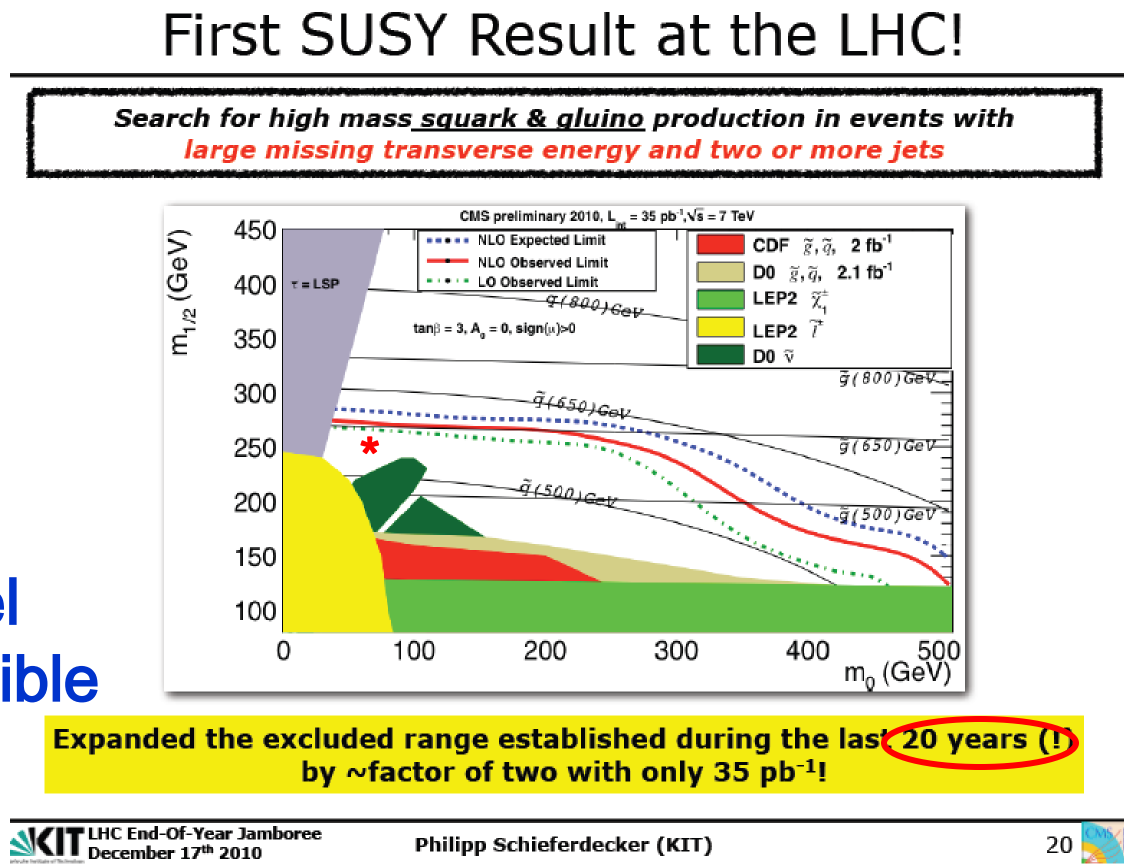
T.G. Rizzo 01/28/11

SUSY searches at the LHC have gotten real !

<u>The Amazing Power of √s !</u>

Even w/ low lumi the LHC probes masses far beyond the reach of the Tevatron…

We'd like to perform LHC SUSY searches in as model independent a way as possible



However, most searches rely on some specific model assumptions, usually mSUGRA….we want to do better & explore SUSY much more generally so nothing is accidentally missed. This is a non-trivial task…

Issues:

- The general MSSM is too difficult to study due to the very large number of soft SUSY breaking parameters (~ 100).
- Analyses are generally limited to specific SUSY breaking scenarios having only a few parameters…can we consider something more general ?

Our Model Generation Assumptions :

- The most general, CP-conserving MSSM with R-parity
- Minimal Flavor Violation at the TeV scale
- The lightest neutralino is the LSP & a thermal relic.
- The first two sfermion generations are degenerate
- The first two generations have negligible Yukawa's.
- No assumptions about SUSY-breaking or unification

This leaves us with the pMSSM:

→ the MSSM with 19 real, TeV/weak-scale parameters…

19 pMSSM Parameters

10 sfermion masses: m_{Q_1}, m_{Q_3}, m_{u_1}, m_{d_1}, m_{u_3}, m_{d_3}, m_{L_1}, m_{L_3}, m_{e_1}, m_{e_3}

3 gaugino masses: M_1, M_2, M_3

3 tri-linear couplings: A_b, A_t, A_τ

3 Higgs/Higgsino: μ, M_A, $\tan\beta$

What are (aren't) the Goals of this Study???

- Prepare a large model sample, ~50k, satisfying 'all' experimental constraints which are ('easily') kinematically accessible at the LHC.
- Examine the properties of the surviving 'models'.

- →→ Do physics analyses with these models.

→ Our goal is NOT to find the 'best-fit' model(s) but to search for possible new physics that is not seen in the more familiar SUSY breaking frameworks

- We will be specifically interested in the capability of the LHC running at 7(&14) TeV to discover some signal for all of these models. Here we focus on the ATLAS SUSY analyses…

How? Perform 2 Random Scans

Flat Priors

emphasizes moderate masses

$100\ \text{GeV} \leq m_{sfermions} \leq 1\ \text{TeV}$

$50\ \text{GeV} \leq |M_1, M_2, \mu| \leq 1\ \text{TeV}$

$100\ \text{GeV} \leq M_3 \leq 1\ \text{TeV}$

$\sim 0.5\ M_Z \leq M_A \leq 1\ \text{TeV}$

$1 \leq \tan\beta \leq 50$

$|A_{t,b,\tau}| \leq 1\ \text{TeV}$

Log Priors

emphasizes lower masses but also extends to higher masses

$100\ \text{GeV} \leq m_{sfermions} \leq 3\ \text{TeV}$

$10\ \text{GeV} \leq |M_1, M_2, \mu| \leq 3\ \text{TeV}$

$100\ \text{GeV} \leq M_3 \leq 3\ \text{TeV}$

$\sim 0.5\ M_Z \leq M_A \leq 3\ \text{TeV}$

$1 \leq \tan\beta \leq 60$

$10\ \text{GeV} \leq |A_{t,b,\tau}| \leq 3\ \text{TeV}$

- Flat Priors : 10^7 models scanned , ~ 68.4 K (0.68%) survive
- Log Priors : 2×10^6 models scanned , ~ 2.9 K (0.14%) survive

→Comparison of these two scans will show the prior sensitivity.

Some Constraints

- W/Z ratio
- $b \rightarrow s\ \gamma$
- $\Delta(g\text{-}2)_\mu$
- $\Gamma(Z \rightarrow \text{invisible})$
- Meson-Antimeson Mixing
- $B_s \rightarrow \mu\mu$
- $B \rightarrow \tau\nu$

- DM density: $\Omega h^2 < 0.121$. We treat this only as an *upper bound* on the neutralino thermal relic contribution

- Direct Detection Searches for DM (CDMS, XENON…)

- LEP and Tevatron Direct Higgs & SUSY searches : there are *many* of these searches & they are quite complicated with many caveats…. These needed to be 'revisited' for the more general case considered here → simulations limit model set size ~1 core-century for set generation

ATLAS SUSY Analyses w/ a Large Model Set

• We passed these models through the ATLAS inclusive MET analysis suites (@ both 7 &14TeV !), designed for mSUGRA , to explore this broader class of SUSY models (~1.5 core-centuries)

• We used the ATLAS SM backgrounds (Thanks!!!), with their associated systematic errors #, their search analyses & also their statistical criterion for SUSY discovery, etc.

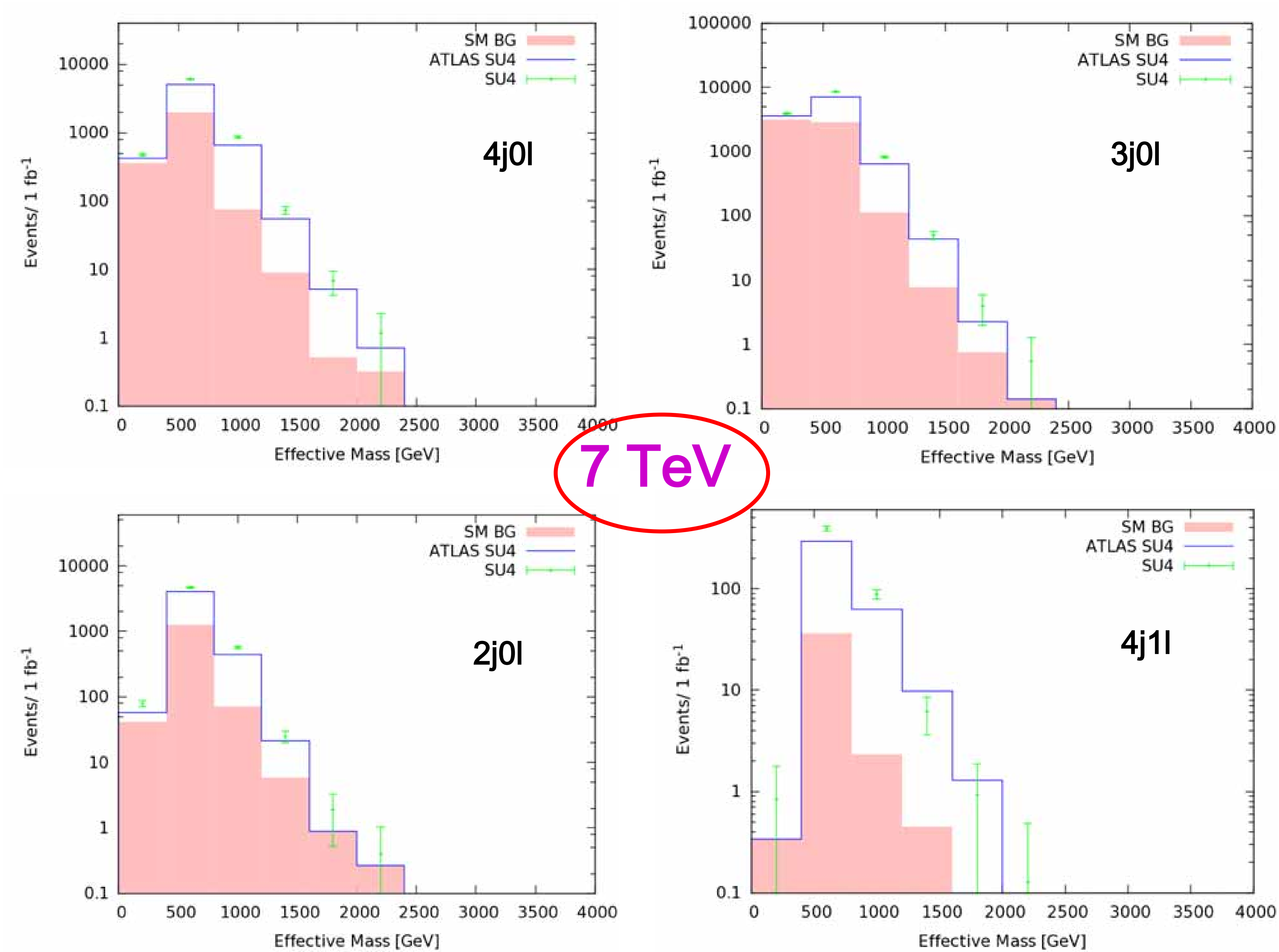
• We first verified that we can approximately reproduce the 7 & 14 TeV ATLAS results for their benchmark mSUGRA models with our analysis techniques for each channel. ..BUT beware of some analysis differences:

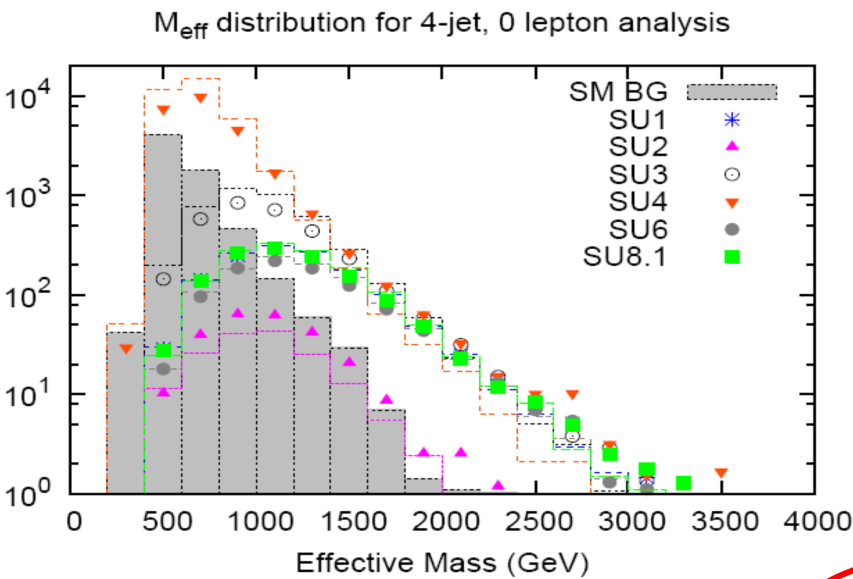
We use the exact expressions for Z_n as given by ATLAS without any approximations ..causing some numerical differences with the ATLAS CSC public results @ 14 TeV

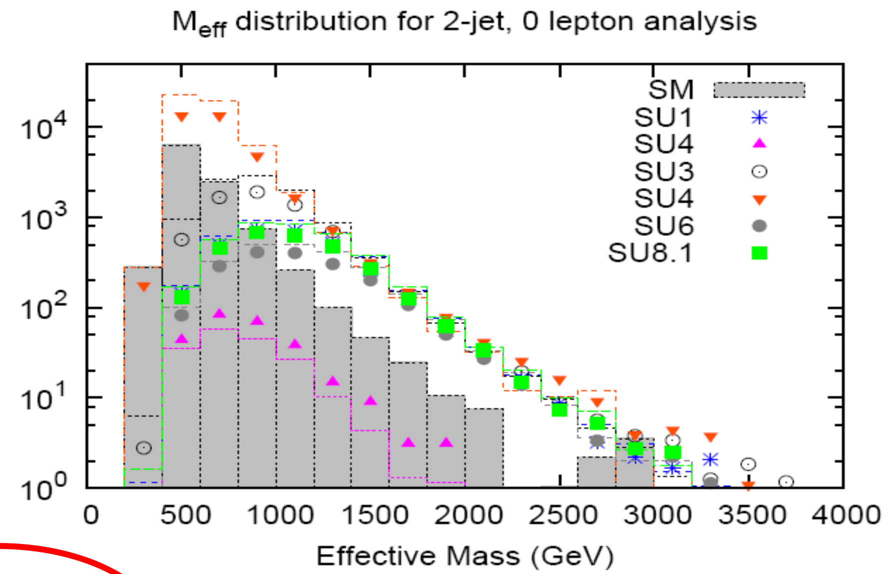
ATLAS	US
ISASUGRA generates spectrum & sparticle decays	SuSpect generates spectra with SUSY-HIT# for decays
Partial NLO cross sections using PROSPINO & CTEQ6M	NLO cross section for all 85 processes using PROSPINO** & CTEQ6.6M
Herwig for fragmentation & hadronization	PYTHIA for fragmentation & hadronization
GEANT4 for full detector sim	PGS4-ATLAS for fast detector simulation

** version w/ negative K-factor errors corrected

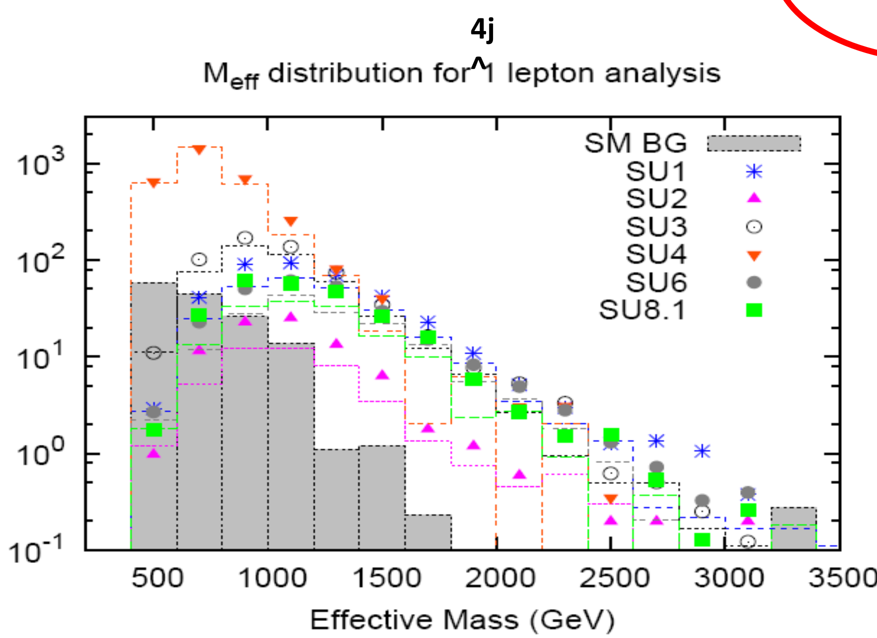
version w/o negative QCD corrections, with 1st & 2nd generation fermion masses & other very numerous PS fixes included. e.g., explicit small Δm chargino decays, etc.

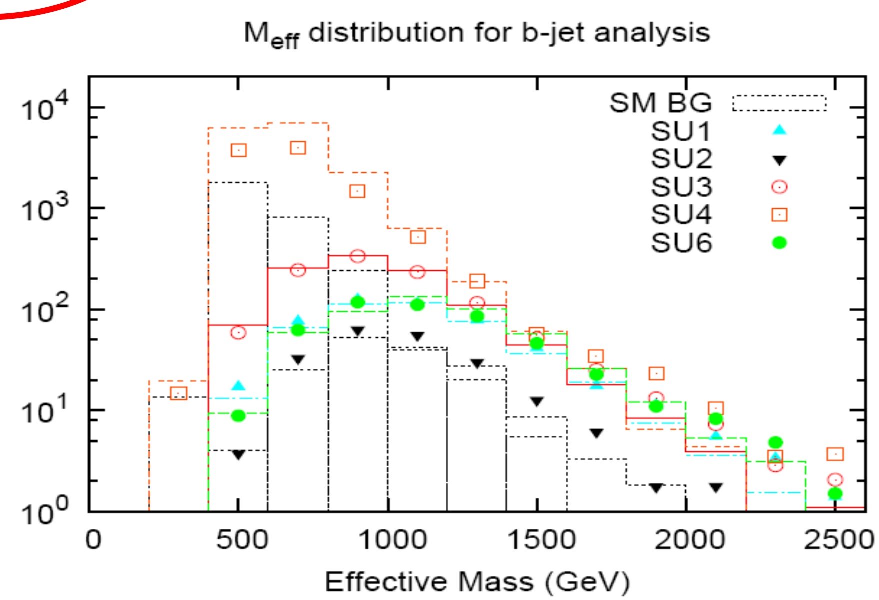

7 TeV
4j0l
3j0l
2j0l
4j1l
SM BG
ATLAS SU4
SU4
Events/ 1 fb-1
Effective Mass [GeV]
0
500
1000
1500
2000
2500
3000
3500
4000
0.1
1
10
100
1000
10000
100000


M_eff distribution for 4-jet, 0 lepton analysis
SM BG
SU1
SU2
SU3
SU4
SU6
SU8.1
Effective Mass (GeV)


M_eff distribution for 2-jet, 0 lepton analysis
SM
SU1
SU4
SU3
SU4
SU6
SU8.1
Effective Mass (GeV)

14 TeV


4j
M_eff distribution for ^1 lepton analysis
SM BG
SU1
SU2
SU3
SU4
SU6
SU8.1
Effective Mass (GeV)


M_eff distribution for b-jet analysis
SM BG
SU1
SU2
SU3
SU4
SU6
Effective Mass (GeV)

→ We do quite well reproducing ATLAS benchmarks with some small differences due to, e.g., (modified) public code usages

- The first question to ask is 'how well do the ATLAS analyses cover these pMSSM model sets?' More precisely, 'what fraction of these models can be discovered (or not!) by any of the various ATLAS analyses & which ones do best?'

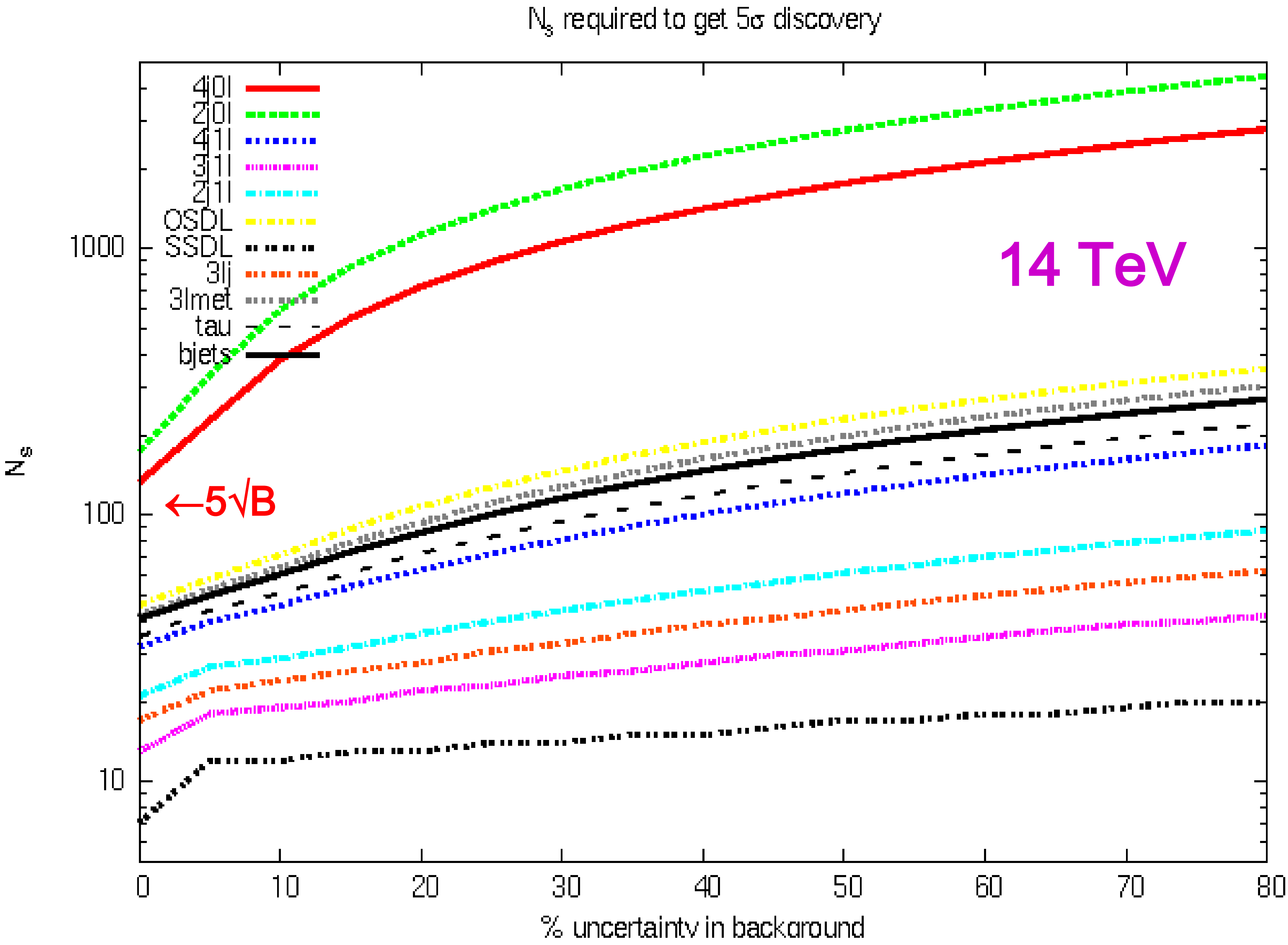
  →→ CLEARLY this will depend on the integrated luminosity as well as the assumed systematic uncertainty on the SM backgrounds..understanding these is critical !

- Next, we'll need to understand WHY some models are missed by these analyses even when high luminosities are available

ATLAS 14TeV/ 1fb $^{-1}$ Backgrounds & 'Target' Signal Counts

ANALYSIS	BACKGROUND	S=5, δB=50%	δB=20%
4j0l	709	1759	721
2j0l	1206	2778	1129
4j1l	41.6	121	62
3j1l	7.2	44	28
2j1l	18.2	61	36
OSDL	84.7	230	108
SSDL	2.3	17	13
3l1j	12	44	28
3lm	72.5	198	94
τ	51	144	72
b	69	178	86

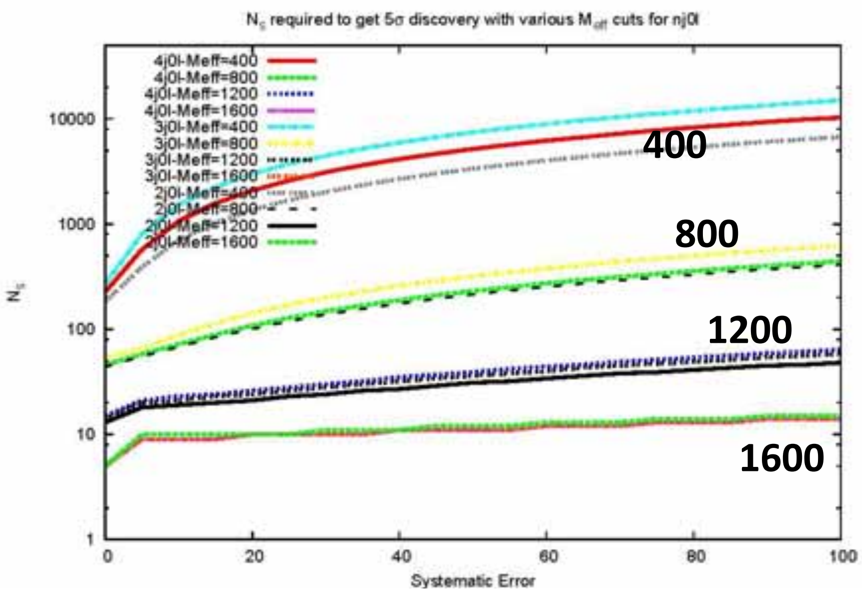
Pure 'QCD' processes, which have the largest reach, ALSO have the bar set high for S=5 due to the large SM backgrounds & their uncertainties

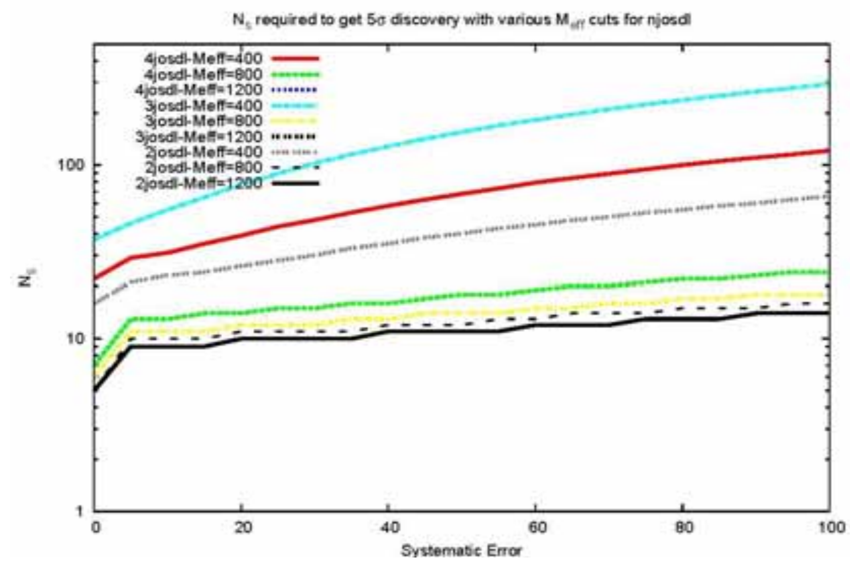


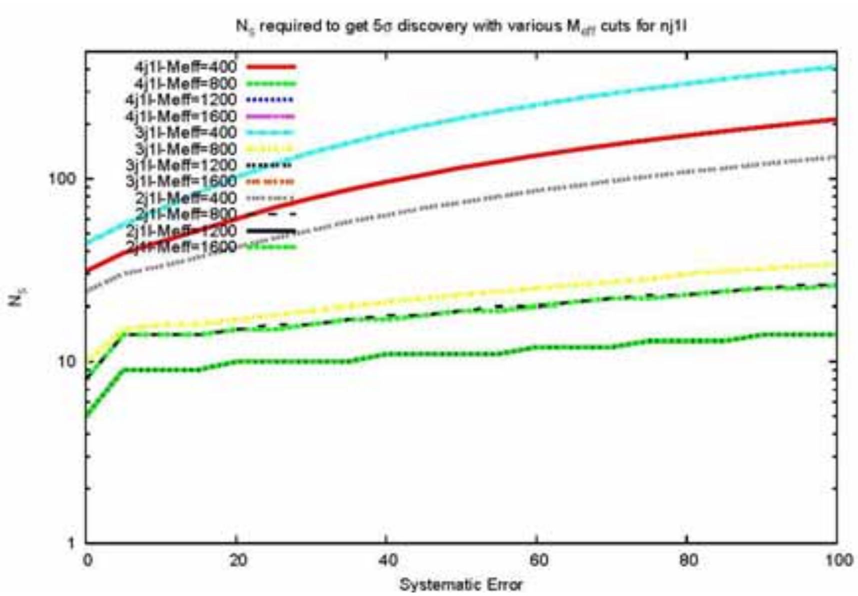
N_s required to get 5σ discovery
4l0l
2l0l
4l1l
3l1l
2l1l
OSDL
SSDL
3lj
3lmet
tau
bjets
14 TeV
←5√B
N_s
% uncertainty in background
1000
100
10
0
10
20
30
40
50
60
70
80

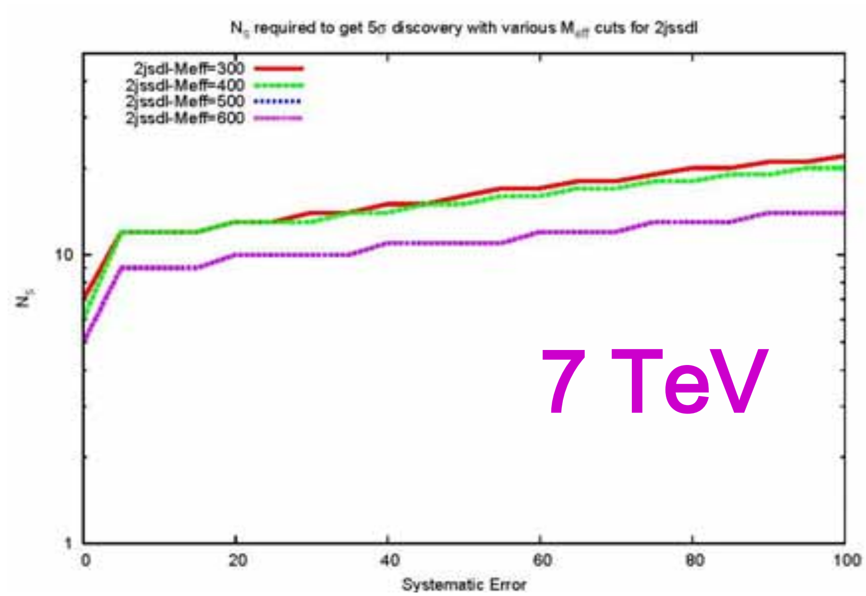
- How many signal events do we need to reach S=5?

Depends on the M_{eff} cut which is now 'optimized' @ 7 TeV









Time For Only A Few Results….

Overall 7 TeV Results for the Flat Prior Set

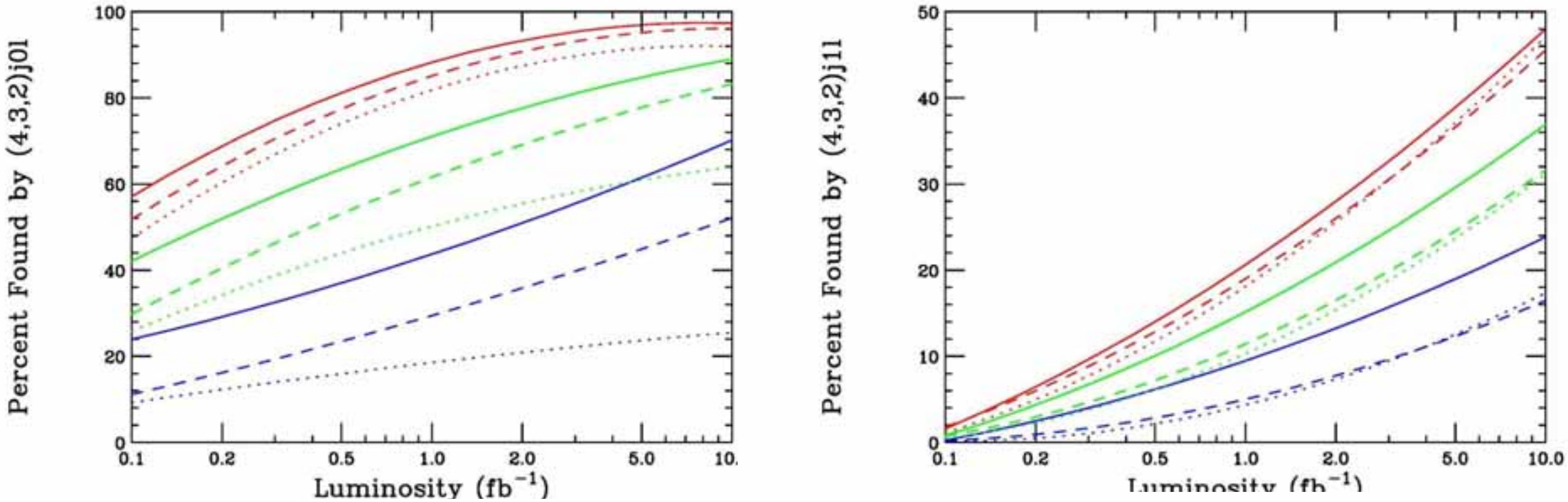
These are the fractions of the model set that are discovered at the S=5 level by each of the 7 TeV ATLAS analyses

Analysis	20 $\mathcal{L}_{0.1}$	20 $\mathcal{L}_{1}$	20 $\mathcal{L}_{10}$	50 $\mathcal{L}_{0.1}$	50 $\mathcal{L}_{1}$	50 $\mathcal{L}_{10}$	100 $\mathcal{L}_{0.1}$	100 $\mathcal{L}_{1}$	100 $\mathcal{L}_{10}$
4j0l	57.073	88.241	97.356	42.061	71.018	88.967	23.906	43.661	70.148
3j0l	51.792	85.087	96.172	29.822	61.56	83.203	11.135	29.427	52.12
2j0l	47.423	81.842	92.004	25.771	50.162	63.931	9.2019	18.507	25.502
4j1l	1.5773	20.611	47.976	0.79985	15.132	36.902	0.23832	9.4566	23.839
3j1l	1.771	18.988	45.544	0.71941	11.406	31.611	0.17874	4.878	16.473
2j1l	1.0888	18.096	47.116	0.46769	10.265	31.096	0.16086	4.3254	17.358
4jOSDL	0.51536	4.8646	17.018	0.39471	3.0728	8.5827	0.25619	2.0108	3.8683
3jOSDL	0.61068	6.4449	23.797	0.39173	4.9718	15.061	0.20108	3.4928	7.7218
2jOSDL	0.69409	5.8685	22.915	0.60919	4.6129	13.474	0.4096	3.0892	7.1319
2jSSDL	0.10575	3.8443	22.327	0.098305	3.2307	17.003	0.067026	2.1374	12.25

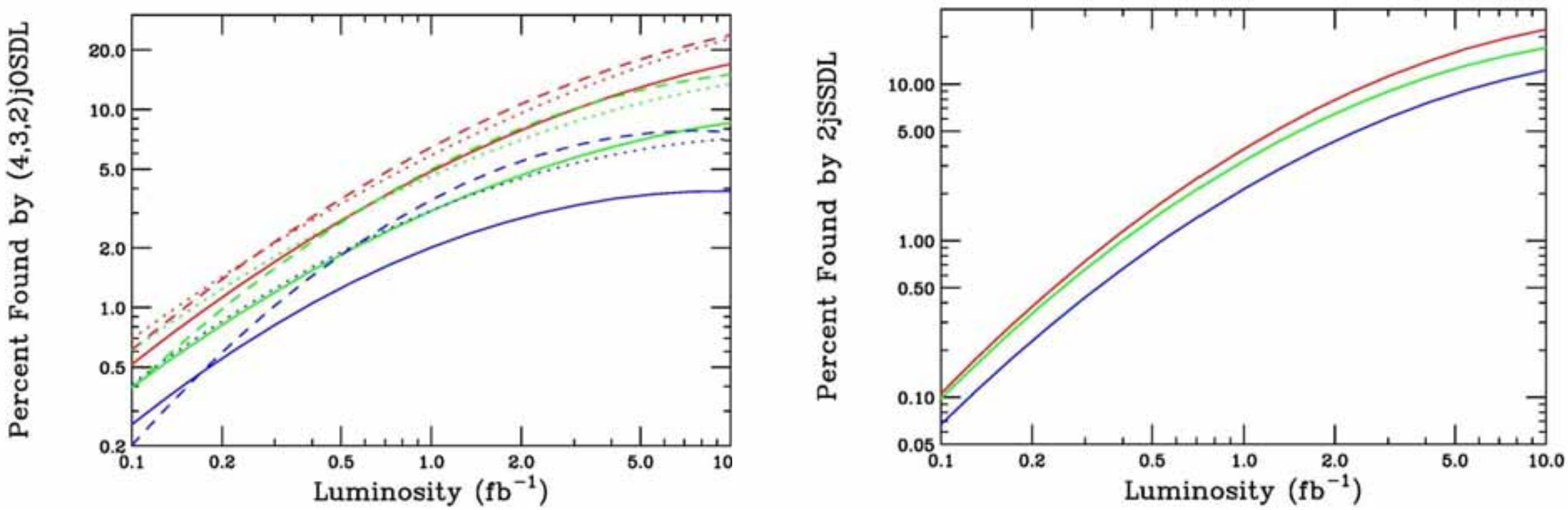
…however, plots are much easier to look at…

FLAT

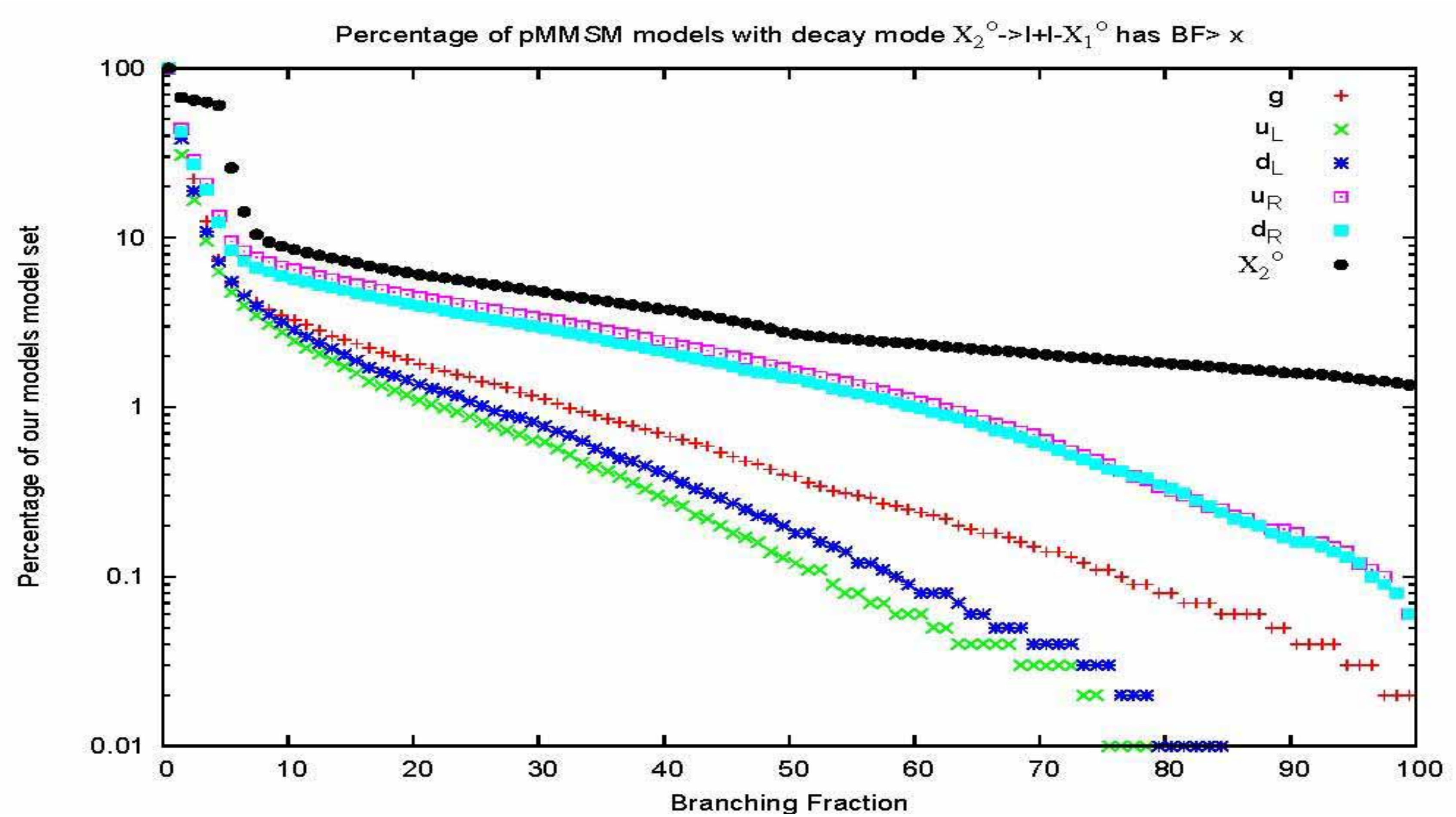
Solid=4j, dash=3j, dot=2j final states

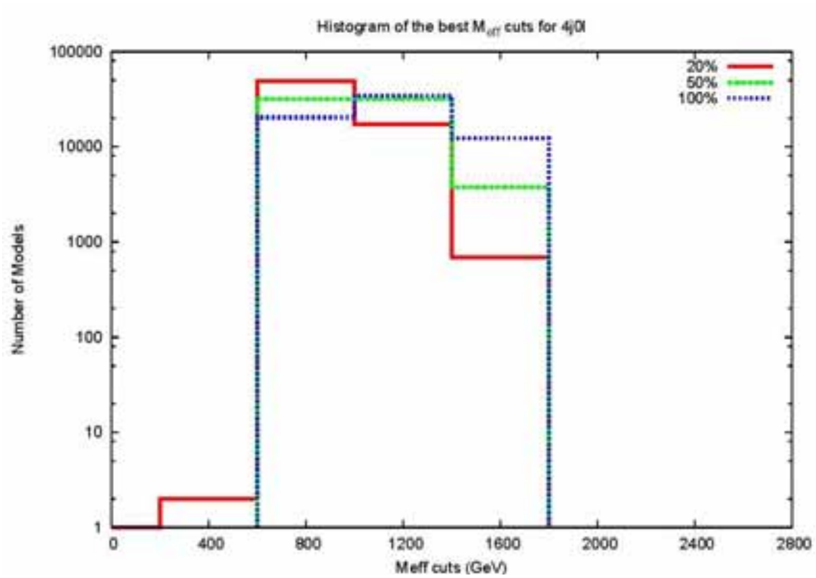


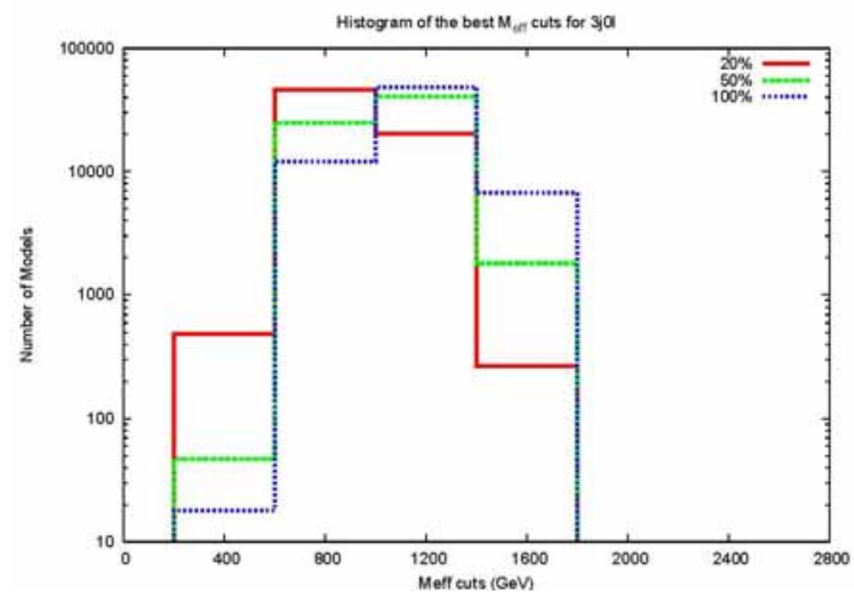
Red=20%, green=50%, blue=100% background systematic errors



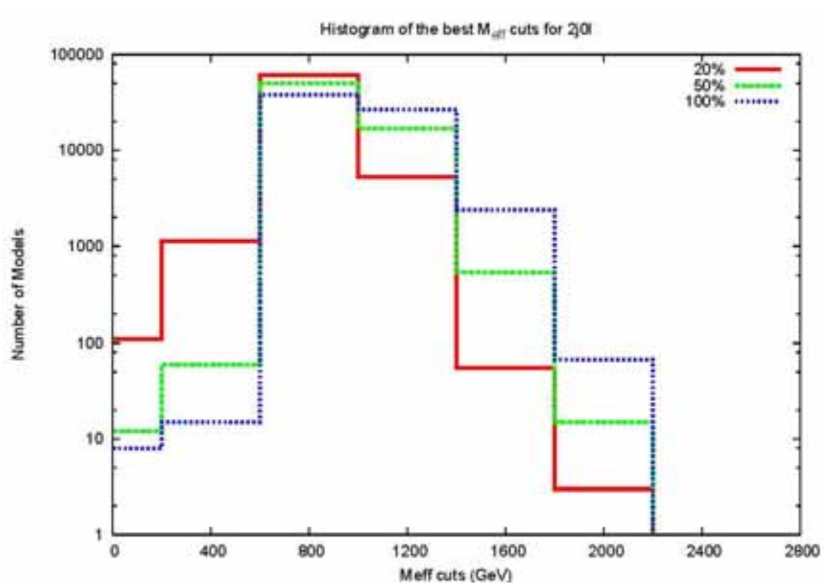
- Note that as the number of required leptons increases the corresponding model 'coverage' decreases significantly unless the integrated lumi is large. Why? The BF to leptons pairs is relatively small in our model set...e.g. :







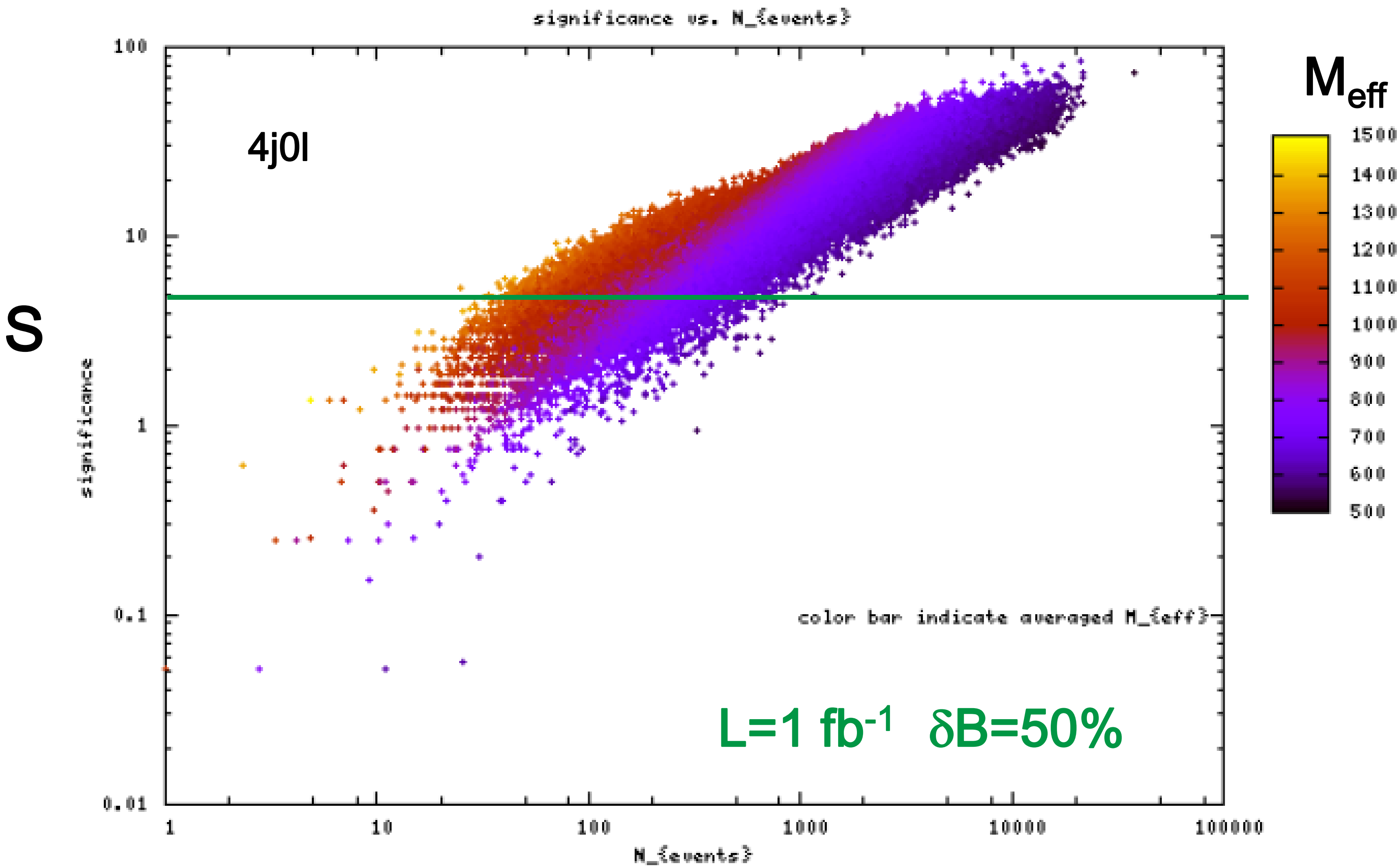
‘Best’ M_{eff} cut



As the background uncertainty grows, harder M_{eff} cuts are needed to achieve maximum model significance in all of the various channels.

Note that the M_{eff} cut is less important for final states with fewer jets. This persists even in analyses with leptons.

Also note that for models with smaller numbers of signal events harder M_{eff} cuts are necessary to obtain S=5



Overall 7 TeV Results for the Log Prior Set

Remember that these models have masses extending out to 3 TeV so the numbers are lower than in the FLAT case..

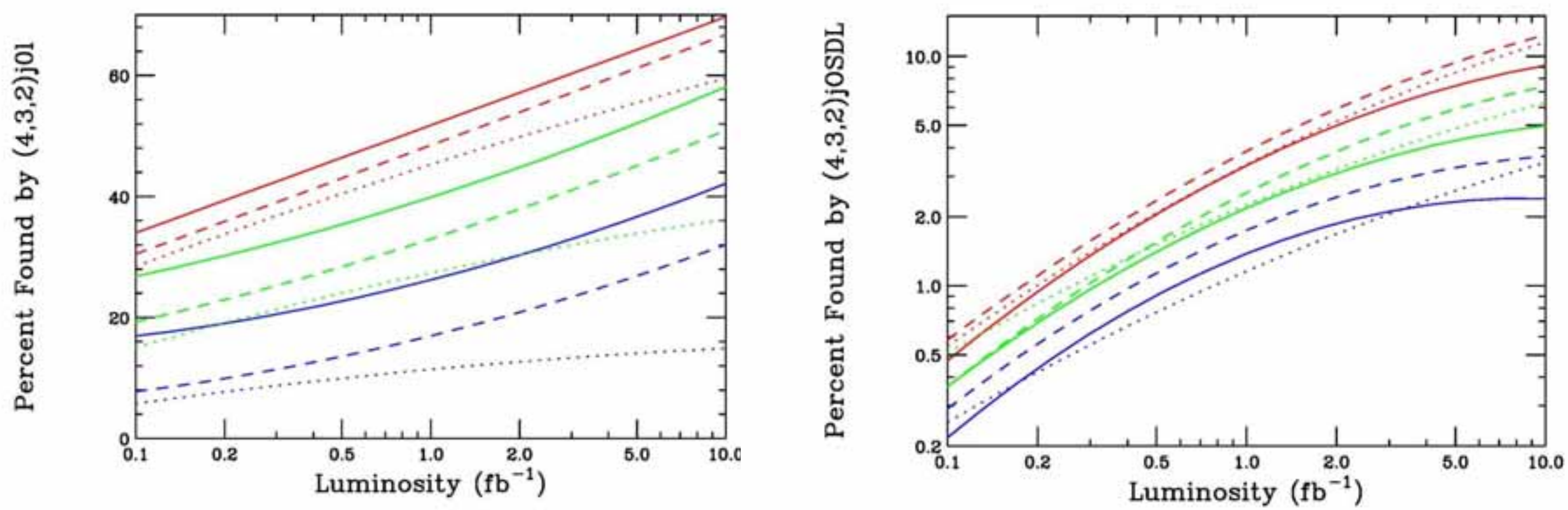
Analysis	20 $\mathcal{L}_{0.1}$	20 $\mathcal{L}_1$	20 $\mathcal{L}_{10}$	50 $\mathcal{L}_{0.1}$	50 $\mathcal{L}_1$	50 $\mathcal{L}_{10}$	100 $\mathcal{L}_{0.1}$	100 $\mathcal{L}_1$	100 $\mathcal{L}_{10}$
4j0l	33.999	51.762	69.669	26.807	39.847	58.118	16.927	26.19	42.136
3j0l	30.476	48.456	66.727	19.252	32.946	50.926	7.7733	16.927	32.038
2j0l	28.442	45.26	59.535	15.946	27.352	36.179	5.7755	11.406	14.893
4j1l	1.0897	10.243	25.863	0.47221	7.0832	18.017	0.18162	4.1773	11.115
3j1l	1.3803	8.5361	22.412	0.54486	4.5405	13.331	0.18162	1.4893	5.8482
2j1l	0.69016	7.1195	22.993	0.21794	3.3418	12.459	0.10897	1.344	5.8118
4jOSDL	0.47221	3.3418	9.1173	0.36324	2.1794	4.9764	0.21794	1.3803	2.3974
3jOSDL	0.58118	3.8503	12.423	0.36324	2.5427	7.4101	0.29059	1.7436	3.6687
2jOSDL	0.54486	3.3781	11.551	0.50854	2.2521	6.2841	0.25427	1.5619	3.4508
2jSSDL	0.21794	2.47	12.822	0.1453	1.9615	9.5169	0.10897	1.453	6.2841

…again, plots are much easier to look at…

LOG

In the LOG prior case, a very similar pattern is observed except that the reaches are reduced in all channels by roughly ~30-50% since the spectrum extends out to larger sparticle masses, i.e., up to ~3 TeV.

Solid=4j, dash=3j, dot=2j final states

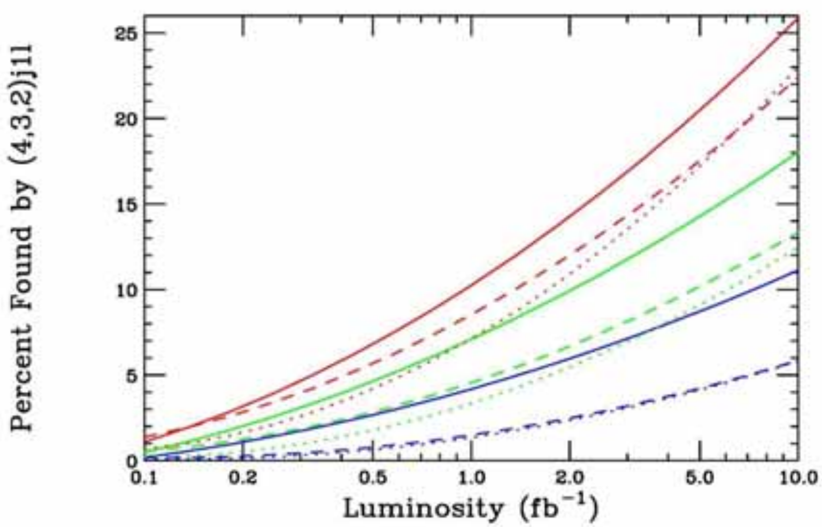


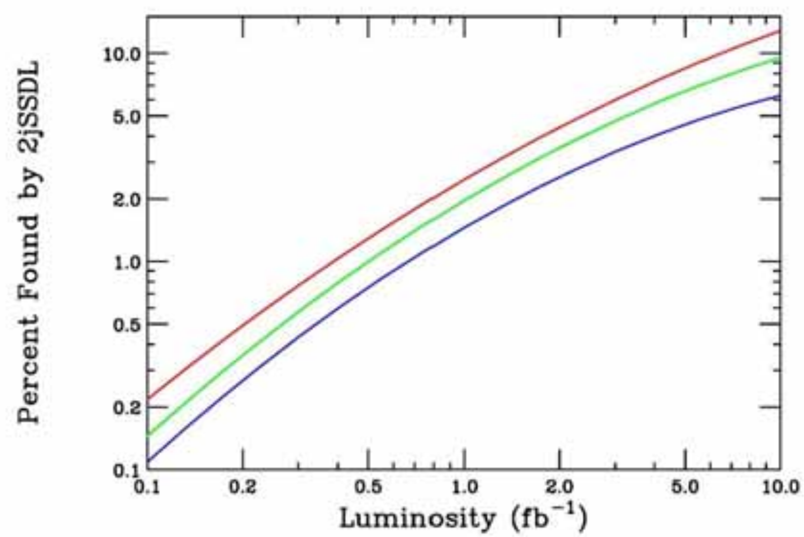
Red=20%, green=50%, blue=100% background systematic errors

LOG (cont.)

Also, at larger lumi's, the discovery curves do not flatten as much as in the FLAT case since the systematic errors are less important for the LOG priors. This is because the search limitations can be statistics dominated due to the heavier mass spectrum.

Solid=4j, dash=3j, dot=2j final states





Red=20%, green=50%, blue=100% background systematic errors

Next Question(s):

If models are found, are they found in only one of these analyses or many? What fraction of our models are missed completely by ATLAS ?

- If models are found only in one analysis we may worry about that the validity of that particular analysis…

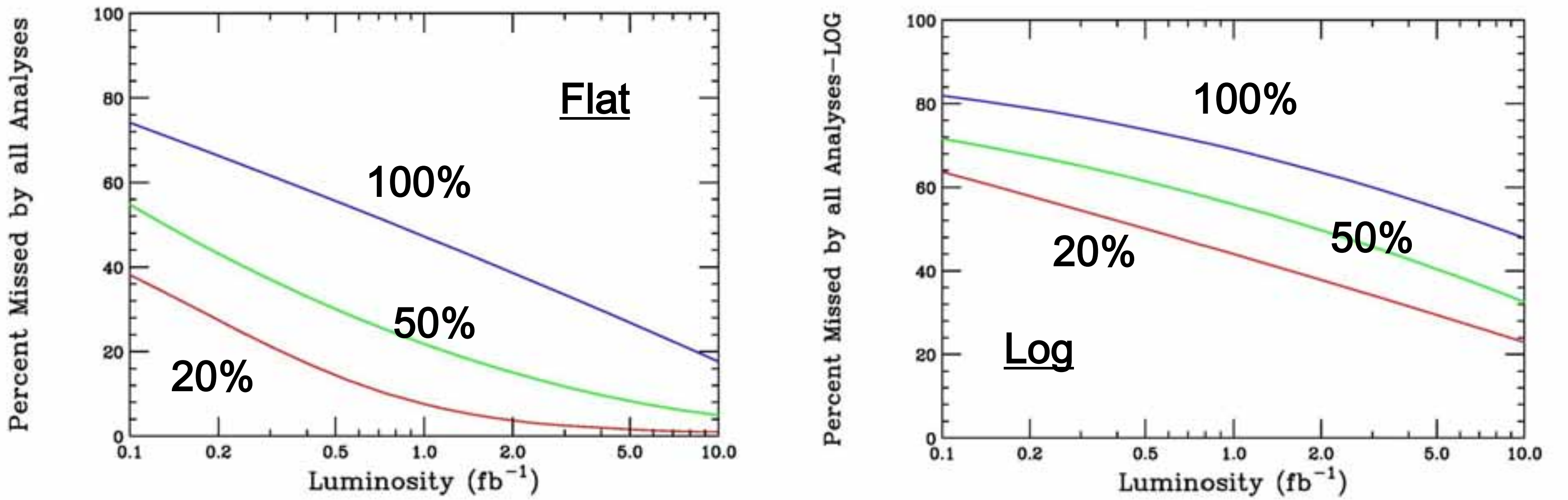
What fraction of models are found by **n** analyses @7 TeV assuming, e.g., δB=20% ?

# anl.	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_1$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_1$	Log $\mathcal{L}_{10}$
0	38.172	7.5501	0.9965	63.64	43.988	22.92
1	9.2928	4.1988	0.90862	5.376	4.8674	5.8482
2	8.7432	4.6665	1.6102	3.6687	5.6665	6.0298
3	41.836	59.878	39.573	26.008	34.907	35.38
4	0.65686	4.9257	7.9422	0.25427	2.2158	6.4657
5	0.53472	4.2629	6.7163	0.47221	2.0341	4.8311
6	0.54366	8.5391	13.494	0.32692	3.0875	6.5383
7	0.067026	2.5217	8.9044	0.21794	1.453	4.1773
8	0.062558	1.2288	5.6364	0.036324	0.72648	2.2884
9	0.077452	1.2958	6.548	0	0.58118	2.9422
10	0.013405	0.93241	7.6711	0	0.47221	2.579

The n=0 case is the most interesting one..

The results are highly sensitive to the SM background uncertainty

How does the pMSSM coverage evolve w/ lumi ??



The coverage is quite good..BUT REMEMBER these models were designed (hopefully) for relatively early LHC discovery !

The models that FAIL to be found are perhaps more interesting…

Estimated ATLAS pMSSM Model Coverage RIGHT NOW for 45 pb^{-1} @ 7 TeV

δB :	100%	50%	20%
FLAT:	15%	32%	48%
LOG :	14%	24%	30%

Wow! This is actually quite impressive as these LHC SUSY searches are just beginning !!!

These figures emphasize the importance of <u>decreasing</u> the background systematic error to obtain good pMSSM model coverage. For FLAT priors we see that, e.g.,

$L=5(10)\ fb^{-1}$ and $\delta B=100\%$ is 'equivalent' to

$L=0.65(1.4)\ fb^{-1}$ and $\delta B=50\%$ (<u>x7</u>) OR to

$L=0.20(0.39)\ fb^{-1}$ and $\delta B=20\%$ (<u>x25</u>) !!

This effect is less dramatic for the LOG case due to the potentially heavier mass spectrum

What about searches @ 14 TeV ?

FLAT

Analysis	50% error 1 fb^{-1}	50% error 10 fb^{-1}	20% error 1 fb^{-1}	20% error 10 fb^{-1}
4j0l	88.331	88.578	98.912	99.014
2j0l	87.616	87.774	98.75	98.802
1l4j	41.731	44.885	56.849	63.045
1l3j	64.058	70.907	69.725	81.111
1l2j	62.942	68.419	70.646	80.641
OSDL	6.0958	6.6796	15.262	18.659
SSDL	14.774	25.518	18.501	32.887
3lj	13.549	17.361	19.293	28.97
3lm	2.7406	2.9135	4.8844	5.8284
tau	83.51	86.505	96.928	98.695
b	73.983	76.939	91.672	94.867

!!

The fraction of models 'found' by n different analyses @14 TeV for δB=50% :

Number of analyses	Flat, 1 fb^{-1}	Flat, 10 fb^{-1}	Log, 1 fb^{-1}	Log, 10 fb^{-1}
0	0.56754	0.36796	31.823	27.024
1	1.3458	0.98841	6.2704	6.5374
2	3.396	2.5141	8.9525	10.072
3	13.175	10.635	11.816	11.098
4	22.014	18.455	16.491	16.344
5	9.5512	10.3	5.6905	6.6135
6	15.227	16.929	6.0529	7.1456
7	20.081	17.697	6.7416	6.1954
8	7.6394	11.75	3.0083	4.371
9	3.9205	6.3569	1.5223	2.6226
10	2.0825	2.7943	1.0511	1.1783
11	1.0013	1.2116	0.57992	0.79818

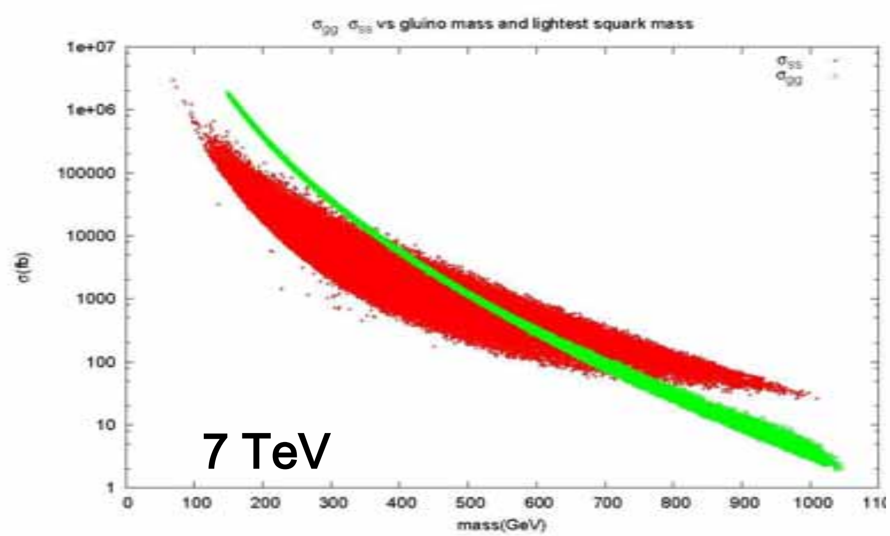
The Undiscovered SUSY

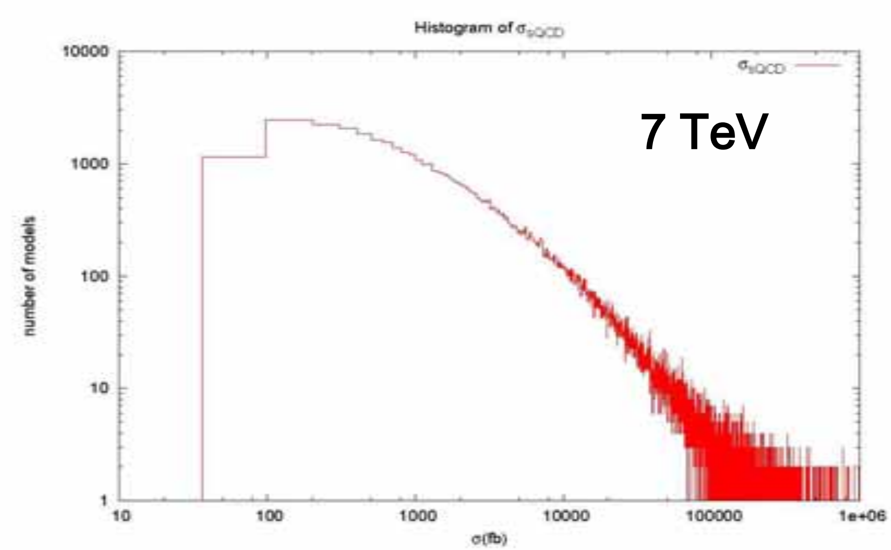
Why Do Models Get Missed by ATLAS?

The most obvious things to look at first are :

- small signal rates due to suppressed σ's
- which can be correlated with large sparticle masses
- & can be associated w/ large SM background systematics

σ's : Squark & gluino production cross sections @ 7 TeV cover a very wide range & are well correlated with the search significance. But, some models with large production rates lead to a low significance assuming L=1 fb^{-1} & $\delta B=50\%$. There are models with $\sigma > 30$ pb that are missed by all ATLAS analyses !

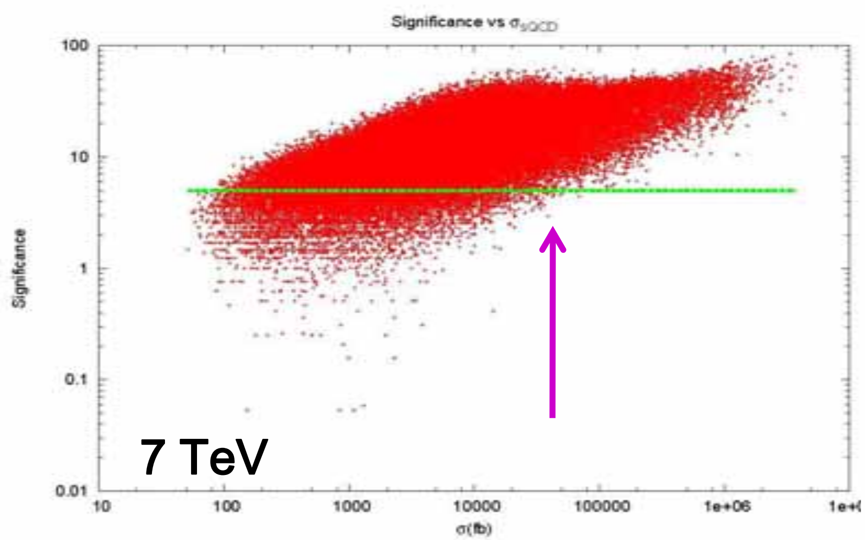


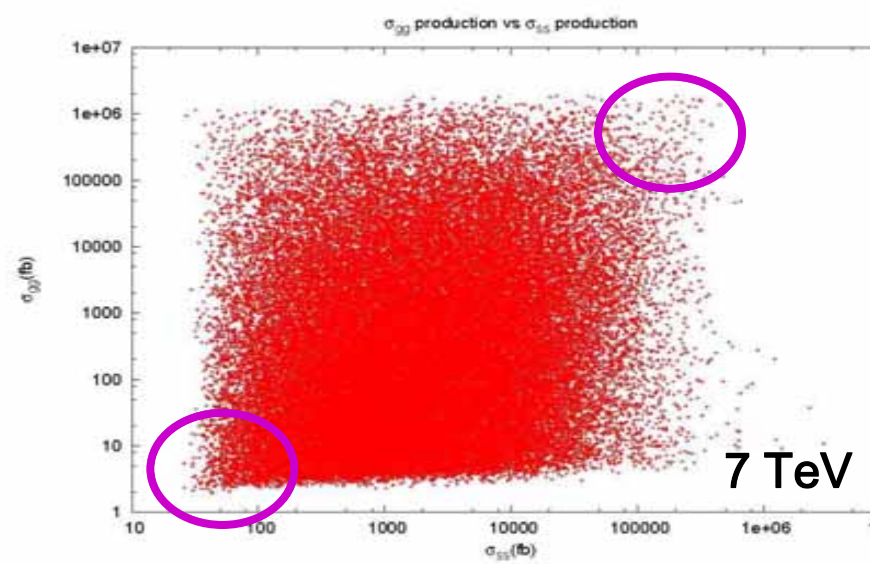


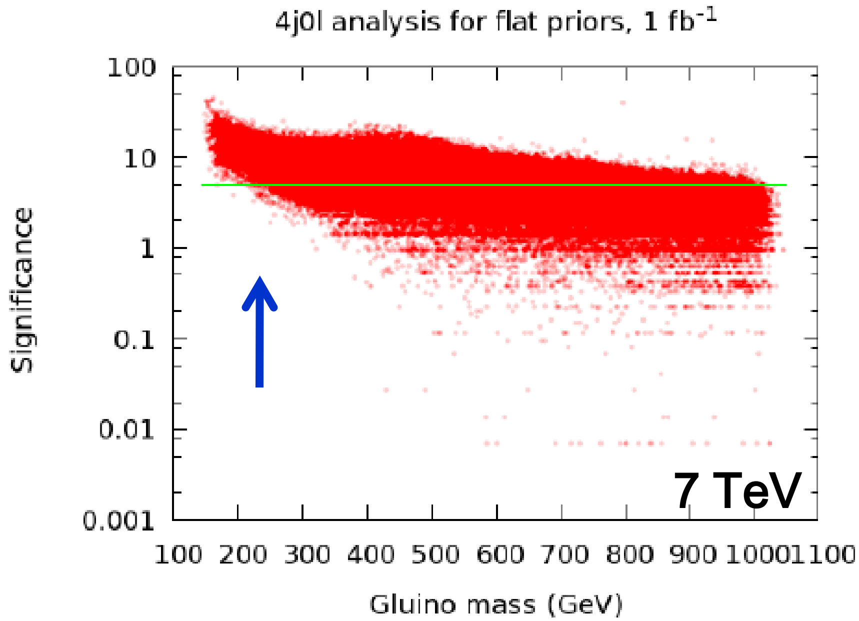
Note that for a given value of the cross section, the search significance can vary over a very wide range.

Certainly some models will be missed at 7(or 14) TeV due to their associated small production cross sections but this is the least interesting situation…

What about the sparticle masses themselves?

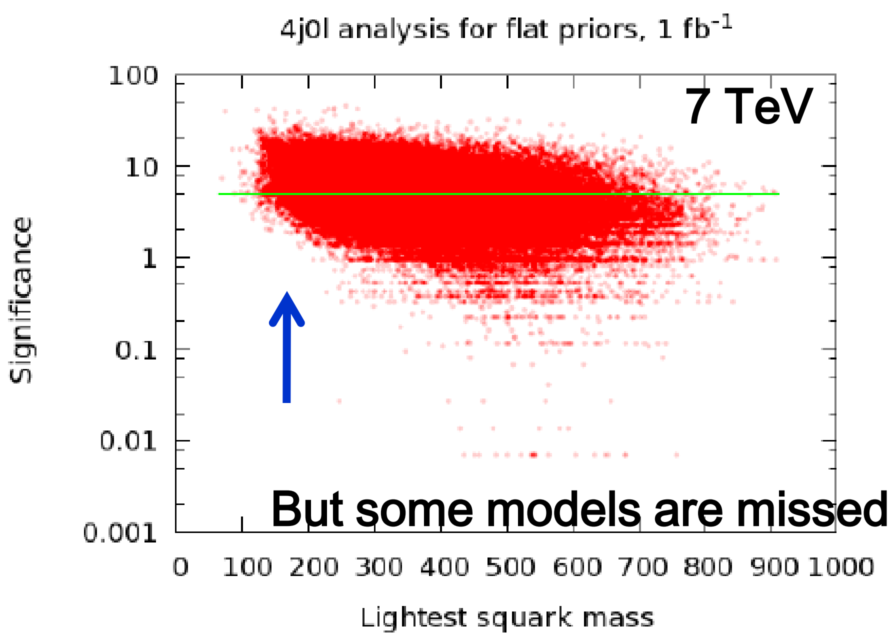


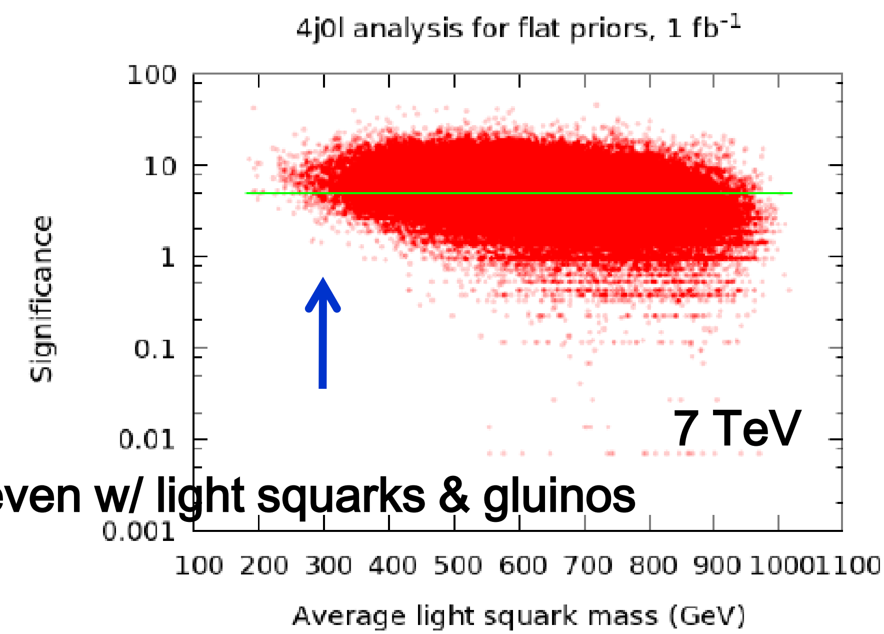




Masses: We clearly observe that some models will be missed when either squarks & or gluinos are very heavy…no surprise!

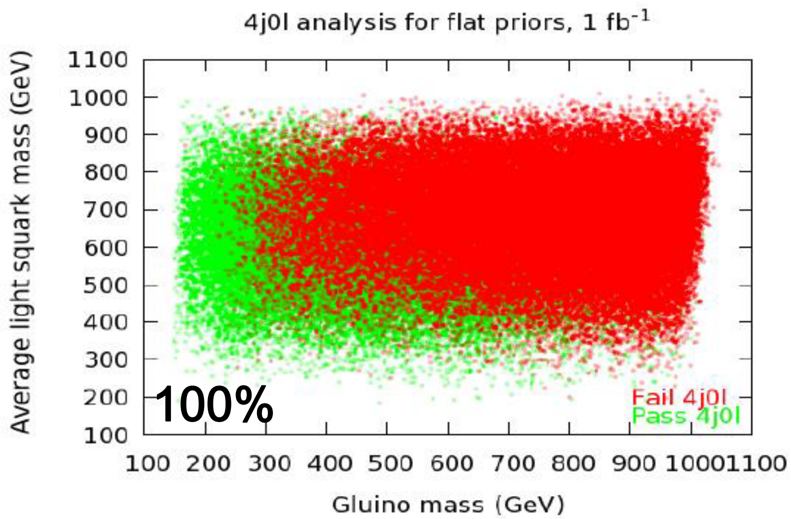
However we see here that for a given squark or gluino mass the search significance spans a wide range due to other aspects of the model parameter space.





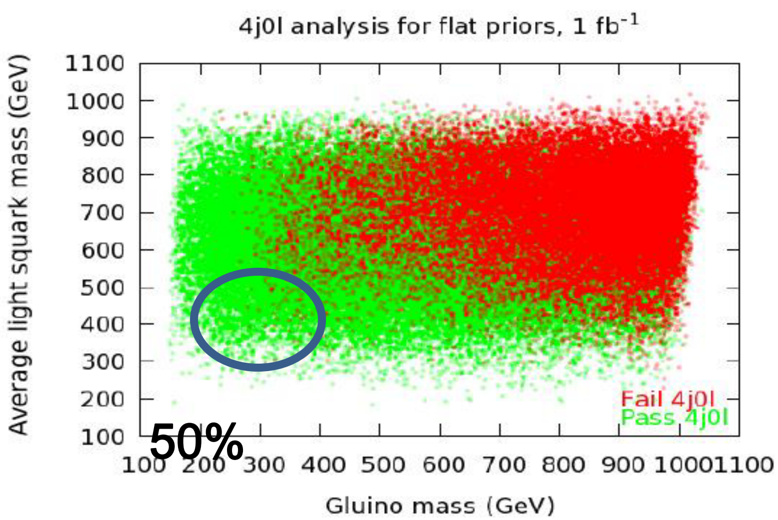
But some models are missed even w/ light squarks & gluinos

SYSTEMATICS: The 4j0l analysis has the best coverage but is quite sensitive to the systematic error. 2j0l is even more so.

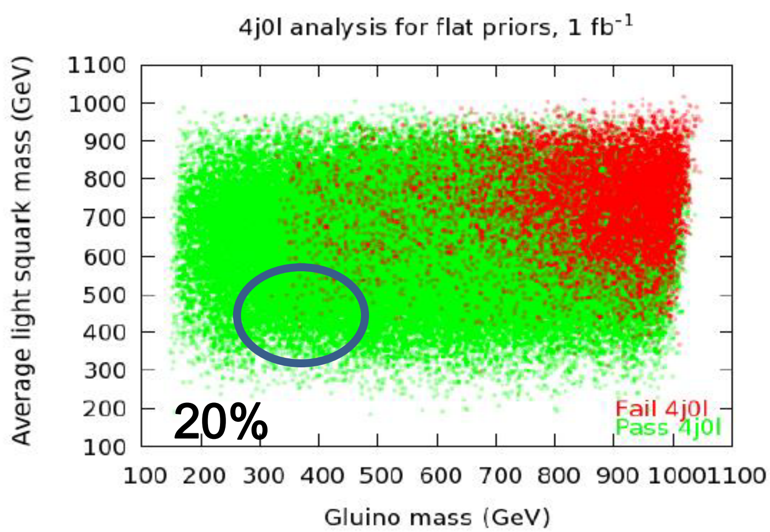


The number of missed models is also quite sensitive to the size of background uncertainty.

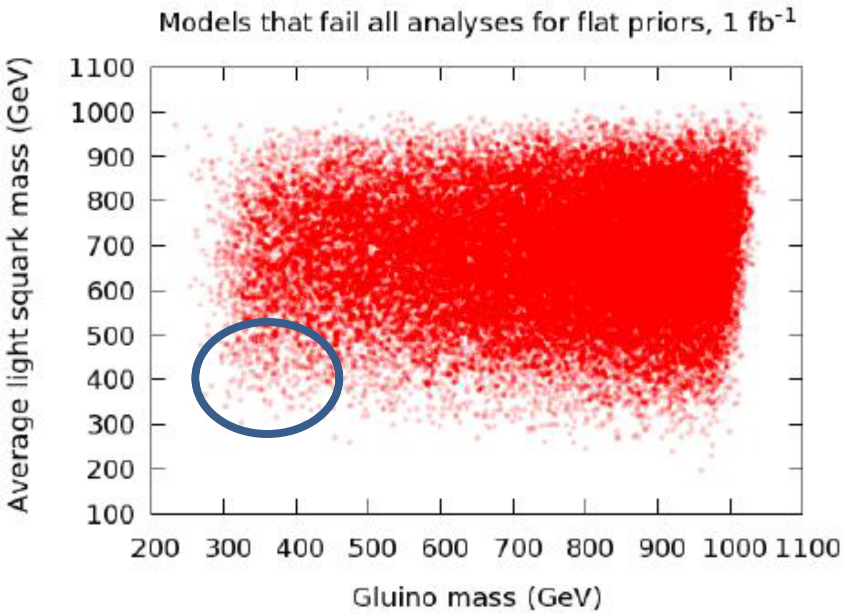
But there are models w/ light squarks &/or gluinos that are always missed…



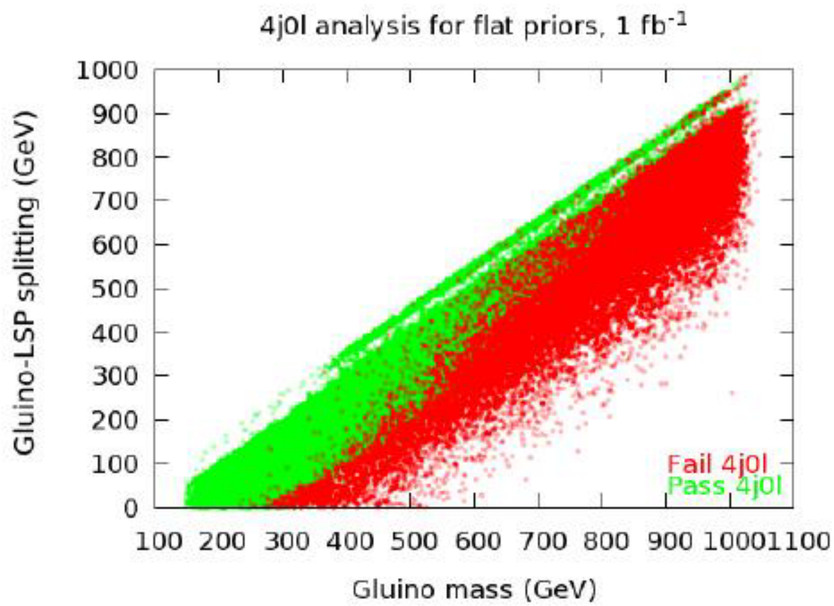
7 TeV



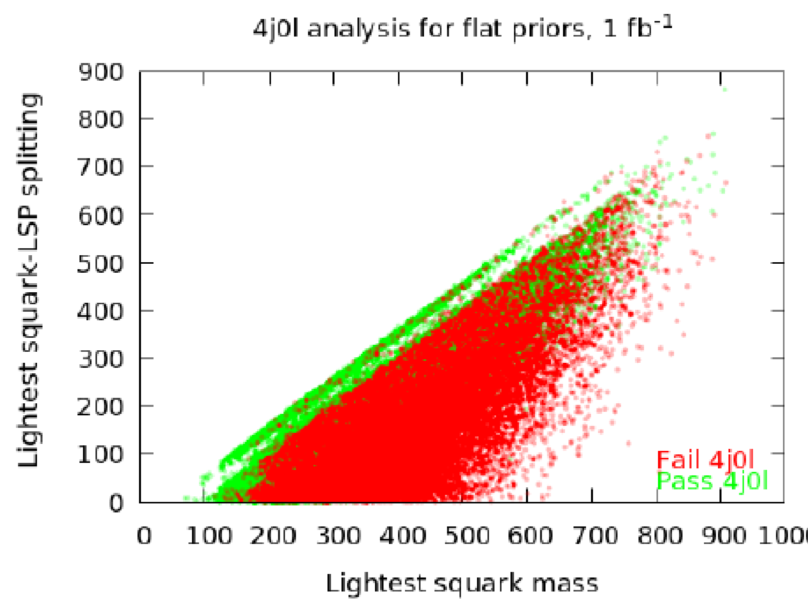
Cause I: Soft jets & leptons



Both 7 & 14 TeV models can be missed due to small mass splittings between squarks and/or gluinos and the LSP → softer jets or leptons not passing cuts. ISR helps in some cases…

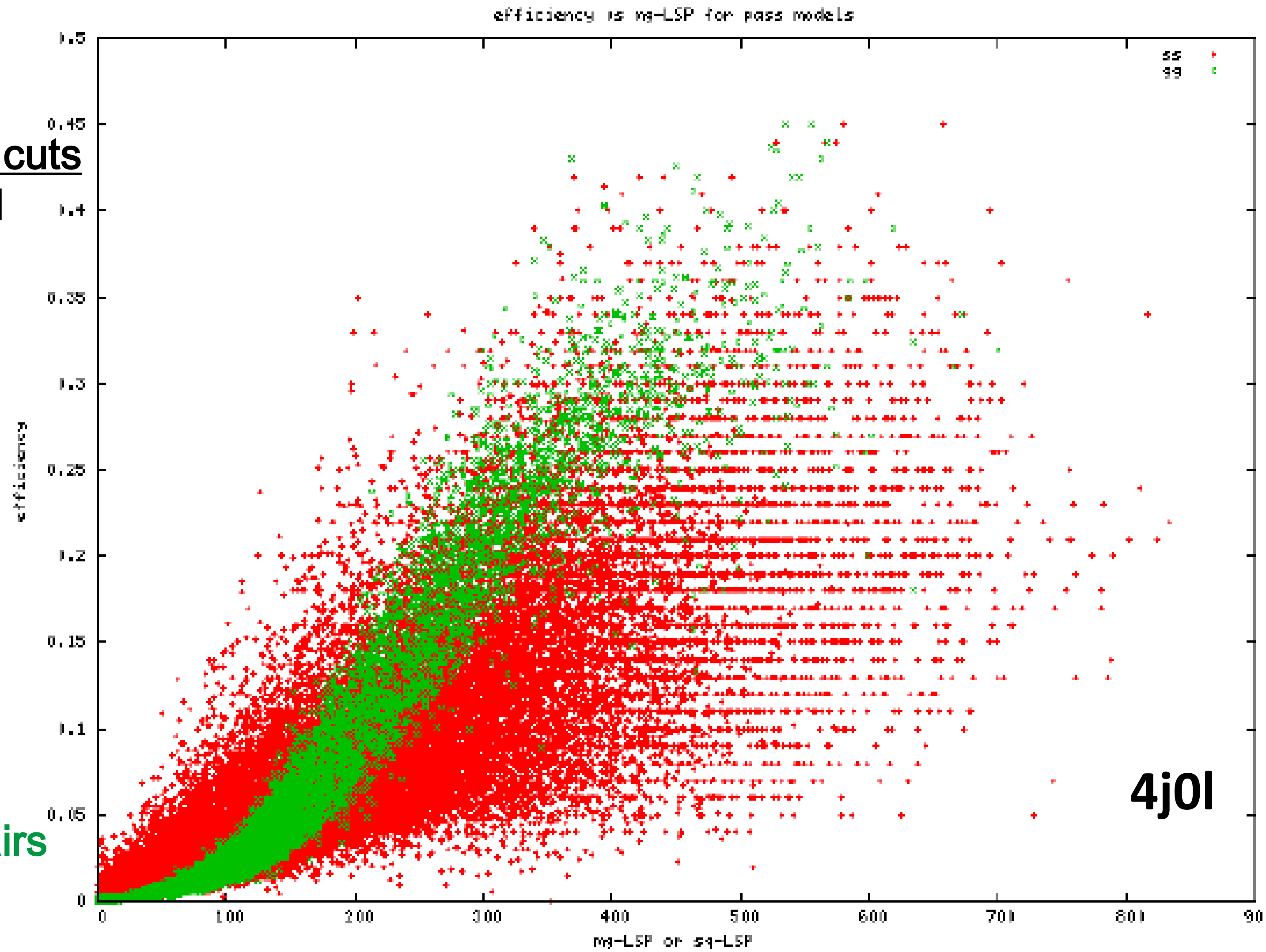


7 TeV



For small mass splittings w/ the LSP a smaller fraction of events will pass analysis cuts

<u># of evts passing cuts</u>
total generated



Mass Splitting with the LSP

Red=gluino pairs
Green=squark pairs

- This generalizes to the case where the overall sparticle spectrum is 'compressed' (especially in the LOG case)

Cause II: Low MET final states

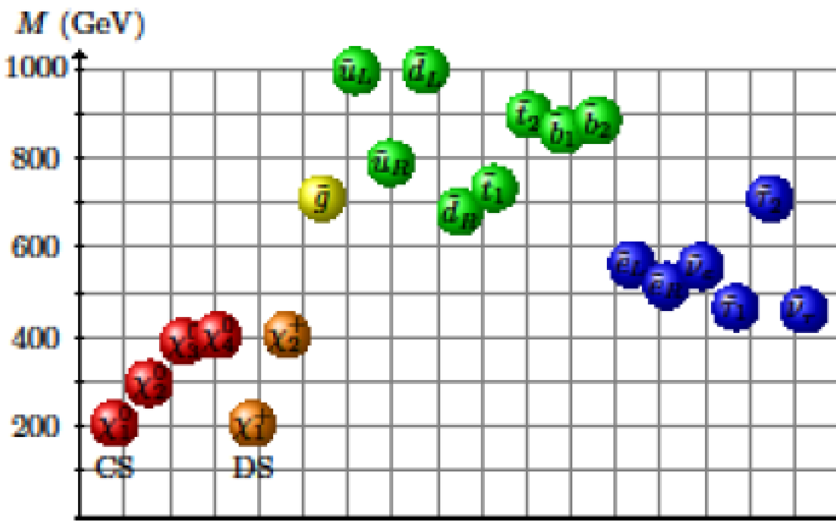
→ There are pMSSM model cascades that dominantly end in long-lived charginos that are detector-stable so the amount of MET is too small for any of these analyses.

→ Small changes in the sparticle spectrum can lead to significant changes in the model visibility

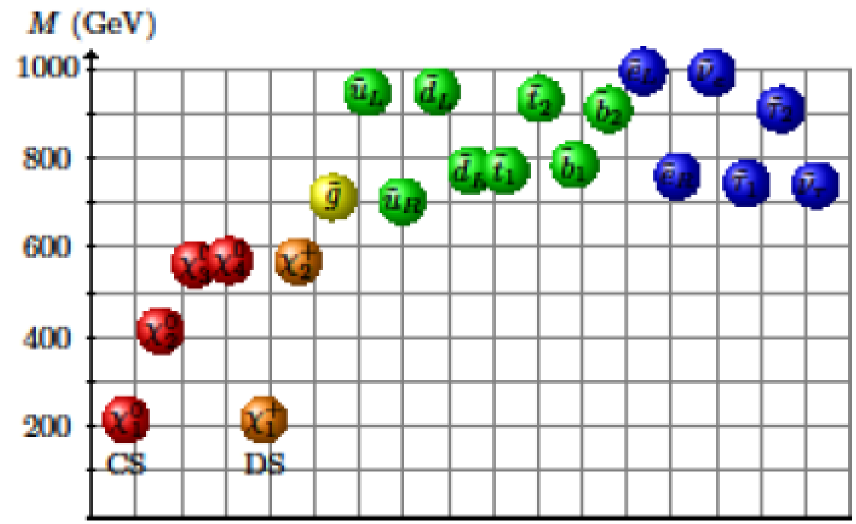
→ Here is one out of MANY examples…

Example:

43704



63170



Failed model 43704(process-partonicXS-fullXS-frac.diff)				Sister model 63170			
62	591.6537	552.6714	0.0705342	62	554.1683	598.2279	-0.0736501
63	919.5316	1007.283	-0.0871171	63	1136.412	1115.883	0.0183972
68	1689.407	2207.448	-0.234679	68	1574.955	2111.774	-0.254203
69	4117.824	4558.5	-0.0966714	69	4469.741	4868.156	-0.0818411

#Cut	lepton-pt	num-leps	MET	hardest jet	Meff-4	Meff-3	Meff-2	Sum-4jet-pt	Sum-3jet-pt	Sum-2jet-pt
43704	46.50313	0.3305726	114.8049	424.9652	1070.408	996.6819	859.0967	893.2752	819.5494	681.9642
63170	74.5432	0.3209754	200.8012	368.0755	1090.669	1005.495	867.3606	819.9918	734.8182	596.6838

What went wrong ??

In 43704: gluinos$\rightarrow$ d_R $\rightarrow \chi_2^0$ $\rightarrow$W + 'stable' chargino (~100%)
(Calahan, FL) as the χ_2^0 –LSP mass splitting is ~91 GeV

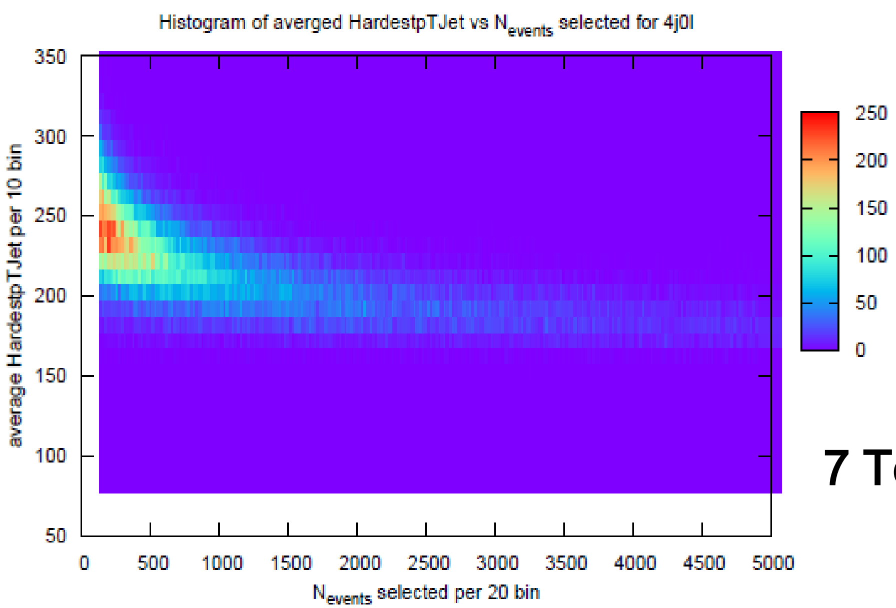
In 63170: gluinos$\rightarrow$ u_R $\rightarrow \chi_2^0$ $\rightarrow$ Z/h + LSP (~30%) as the
(St. Louis, MO) χ_2^0 –LSP mass splitting is larger ~198 GeV

- Again: a small spectrum change can have a large effect on the signal observability!
- $\rightarrow$ Searches for stable charged particles may fill in some gaps

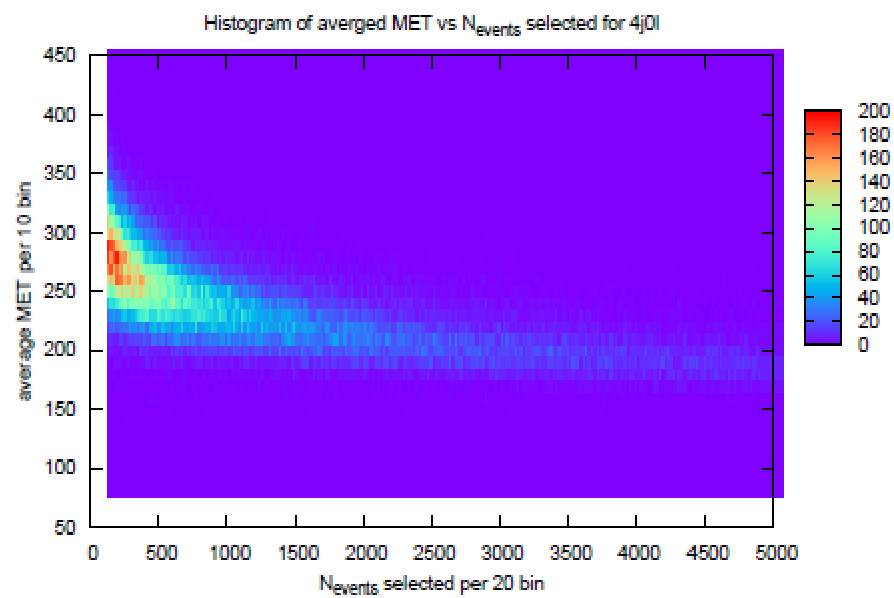
- In many cases analysis cuts may be increased significantly w/o any substantial loss of signal rates for most models. One finds, e.g., that we could raise the p_T requirement on

  i) the leading jet to ~150 GeV (from 100 GeV) in 4j0l
  ii) the lepton to ~25 GeV (from 20 GeV) in 4j1l
  iii) the MET to ~175 GeV (from 80 GeV) in 4j0l

without any significant impact on model coverage



7 TeV

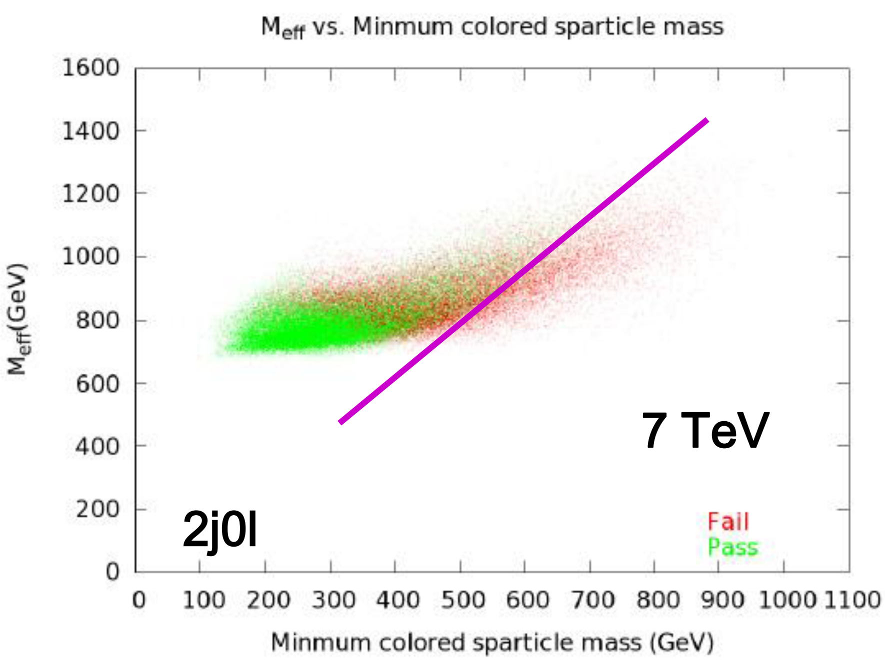


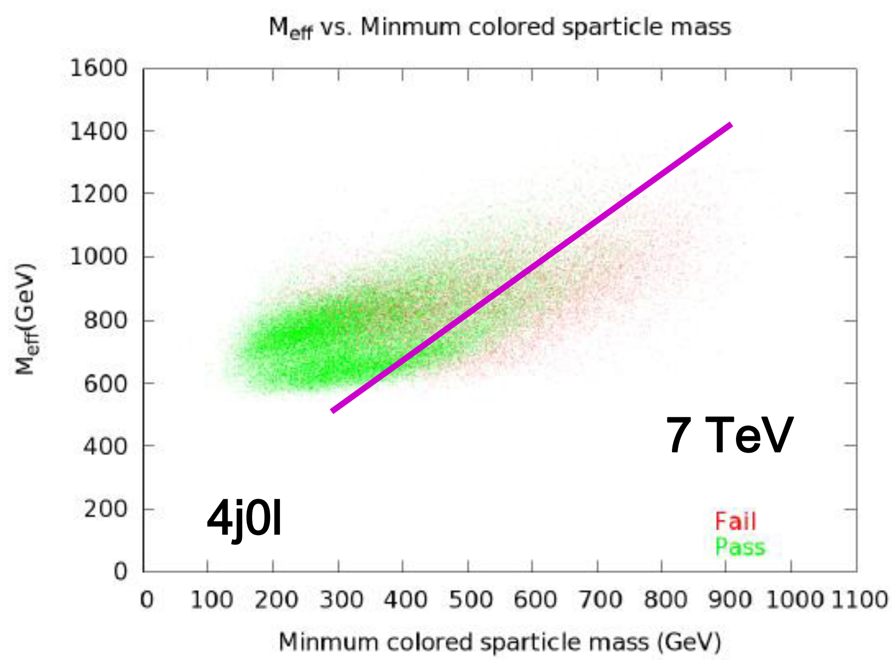
The SUSY ‘mass scale’

• In mSUGRA, one finds M_{eff} ~1.5 M (lightest colored particle)

• @ 7 TeV for pMSSM models this is not generally true except when the sparticle masses are > ~600 GeV

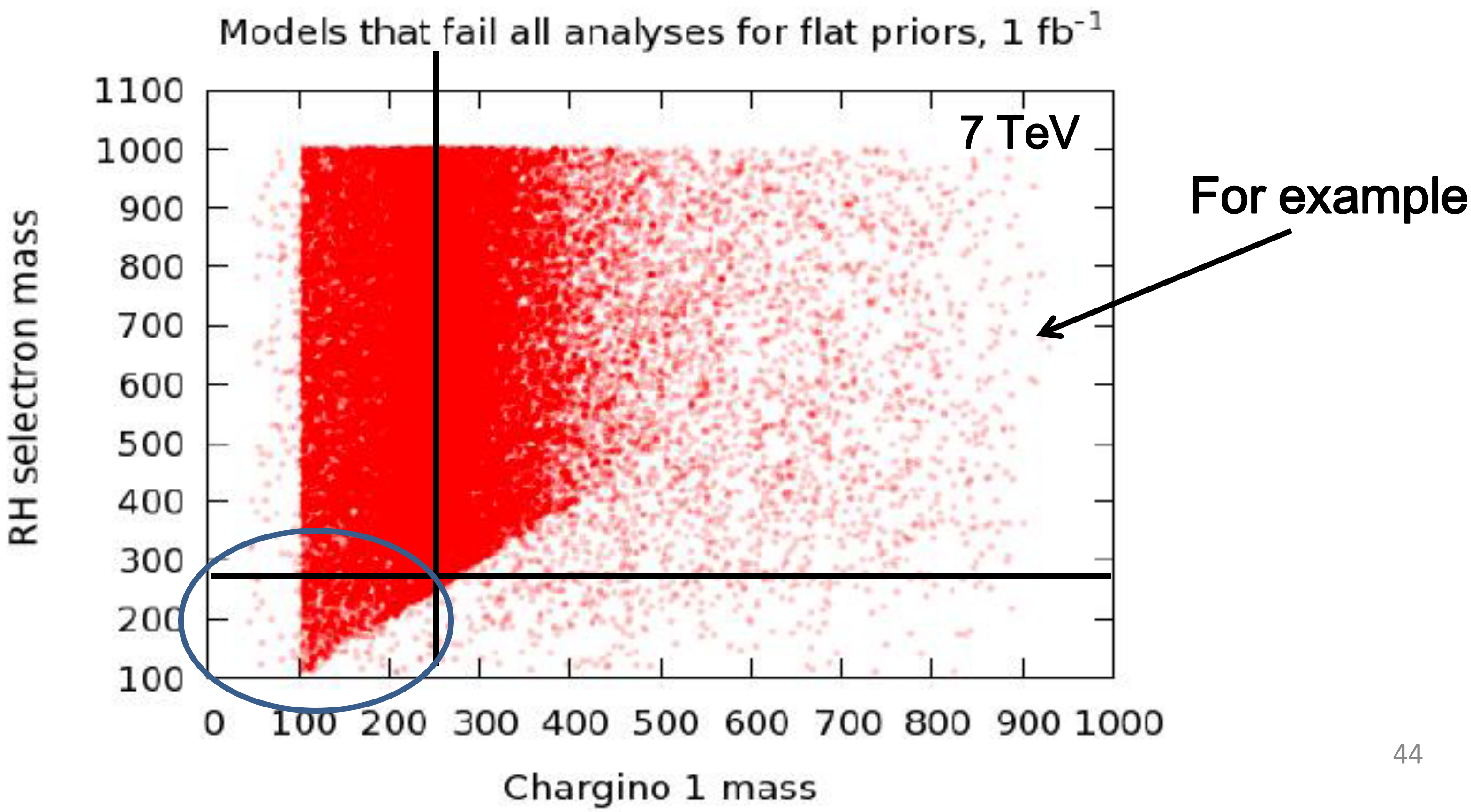
• This is also true @ 14 TeV…





LC Implications

It is often said that if the LHC 'doesn't find anything in 2011-2' then a 500 GeV LC is 'useless'. BUT what if we look at our failing set of models? Are there SUSY particles kinematically accessible @ 500 GeV in them? YES!



→ In fact, in the set of 14623(1546) FLAT(LOG) models NOT found at 7 TeV w/ 1 fb^{-1} and δB=50% there are…

eL	107(101)	dL	35(11)
eR	260(209)	dR	220(96)
τ1	730(381)	uL	52(16)
τ2	30(36)	uR	124(64)
νe	151(117)	b1	289(75)
$\nu\tau$	386(236)	b2	1(0)
N1	5487(1312)	t1	93(9)
N2	2738(1035)	t2	0(0)
N3	429(352)	C1	4856(1208)
N4	10(18)	C2	94(54)
g	0(0)		

That's a LOT of SUSY partners!

Summary & Conclusions

- ATLAS searches at both 7 &14 TeV (& any value in between) with modest lumi will do quite well at 'discovering' the FLAT pMSSM models & not at all badly with the LOG prior set

- With 45 pb^{-1} , a reasonable fraction of this model space has already been 'covered' !

- Reducing SM background uncertainties is crucial to enhancing model coverage..much more so than lumi increases alone

- Models 'missed' primarily due to either compressed spectra *or* because of low MET cascades ending in 'stable' charginos *or*…

- The search for TeV scale SUSY has finally begun !

Location: La Guardia Airport, New York, USA Credit: Stephanie Braunstein

Would today's X-ray security equipment be able to detect Canada?

BACKUP SLIDES

Search 'effectiveness': If a model is found by only 1 analysis which one is it??

Analysis	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_{1}$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_{1}$	Log $\mathcal{L}_{10}$
4j0l	71.037	63.533	59.18	75.676	63.433	41.615
3j0l	1.154	11.493	18.689	1.3514	11.94	21.118
2j0l	26.206	13.799	4.4262	20.27	15.672	12.422
4j1l	0.30454	4.6116	6.5574	0	5.9701	7.4534
3j1l	0.096169	0.81589	0.98361	0	0	0.62112
2j1l	0.080141	1.8801	4.0984	0	0	6.2112
4jOSDL	0.048085	0	0	0	0.74627	0
3jOSDL	0.032056	1.6318	0.32787	0	0	0.62112
2jOSDL	0.99375	1.6673	0.4918	1.3514	1.4925	1.8634
2jSSDL	0.048085	0.56758	5.2459	1.3514	0.74627	8.0745

δB=20%

Search 'effectiveness': If a model is found by only 1 analysis which one is it??

Analysis	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_1$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_1$	Log $\mathcal{L}_{10}$
4j0l	90.094	75.633	73.564	92.989	78.859	61.856
3j0l	0.053602	6.6891	8.1851	0	4.0268	15.722
2j0l	8.2226	1.9023	0.81944	6.2731	2.0134	1.2887
4j1l	0.35377	11.626	8.7438	0.369	12.416	9.7938
3j1l	0.032161	0.08848	0.88463	0	0	0.7732
2j1l	0.096484	1.3184	3.343	0	0	1.5464
4jOSDL	0.11792	0.017696	0.0093119	0	0.67114	0
3jOSDL	0	1.221	0.29798	0.369	0.33557	0
2jOSDL	1.0077	1.0441	0.88463	0	1.0067	1.2887
2jSSDL	0.021441	0.4601	3.2685	0	0.67114	7.732

$\delta B = 100\%$

Search 'effectiveness': If a model is found by only 1 analysis which one is it??

Analysis	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_{1}$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_{1}$	Log $\mathcal{L}_{10}$
4j0l	84.381	72.165	61.678	87.556	70.149	61.397
3j0l	0.084255	11.496	18.777	0.44444	6.4677	12.868
2j0l	14.018	3.7424	1.6595	8.8889	5.4726	4.7794
4j1l	0.2633	7.1883	8.3589	0.88889	14.428	8.8235
3j1l	0.052659	0.43779	1.0449	0	0	0.73529
2j1l	0.094787	1.9065	3.4112	0	0	1.1029
4jOSDL	0.073723	0.014122	0	0	0	0
3jOSDL	0.010532	0.93207	0.4917	0	0.49751	1.1029
2jOSDL	0.97946	1.6099	0.95267	1.7778	0.99502	0.36765
2jSSDL	0.042127	0.5084	3.6263	0.44444	1.99	8.8235

δB=50%

4j0l & 2j0l are the most powerful analyses…

What fraction of models are found by n analyses @ 7 TeV assuming δB=100% ?

# anl.	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_1$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_1$	Log $\mathcal{L}_{10}$
→ 0	74.112	47.23	17.635	81.911	69.016	47.875
1	13.894	16.834	15.996	9.8438	10.825	14.094
2	4.4759	13.331	21.917	3.1602	7.7007	15.91
3	7.3282	18.166	26.186	4.9401	10.607	15.365
4	0.10575	1.8827	6.478	0.036324	0.79913	2.6153
5	0.037237	1.0322	4.7174	0.036324	0.32692	1.7436
6	0.023832	0.7075	3.3008	0	0.32692	1.0171
7	0.019363	0.57345	2.1703	0.072648	0.36324	0.87178
8	0.0029789	0.16831	1.0025	0	0.036324	0.36324
9	0.0014895	0.064047	0.46474	0	0	0.10897
10	0	0.011916	0.13257	0	0	0.036324

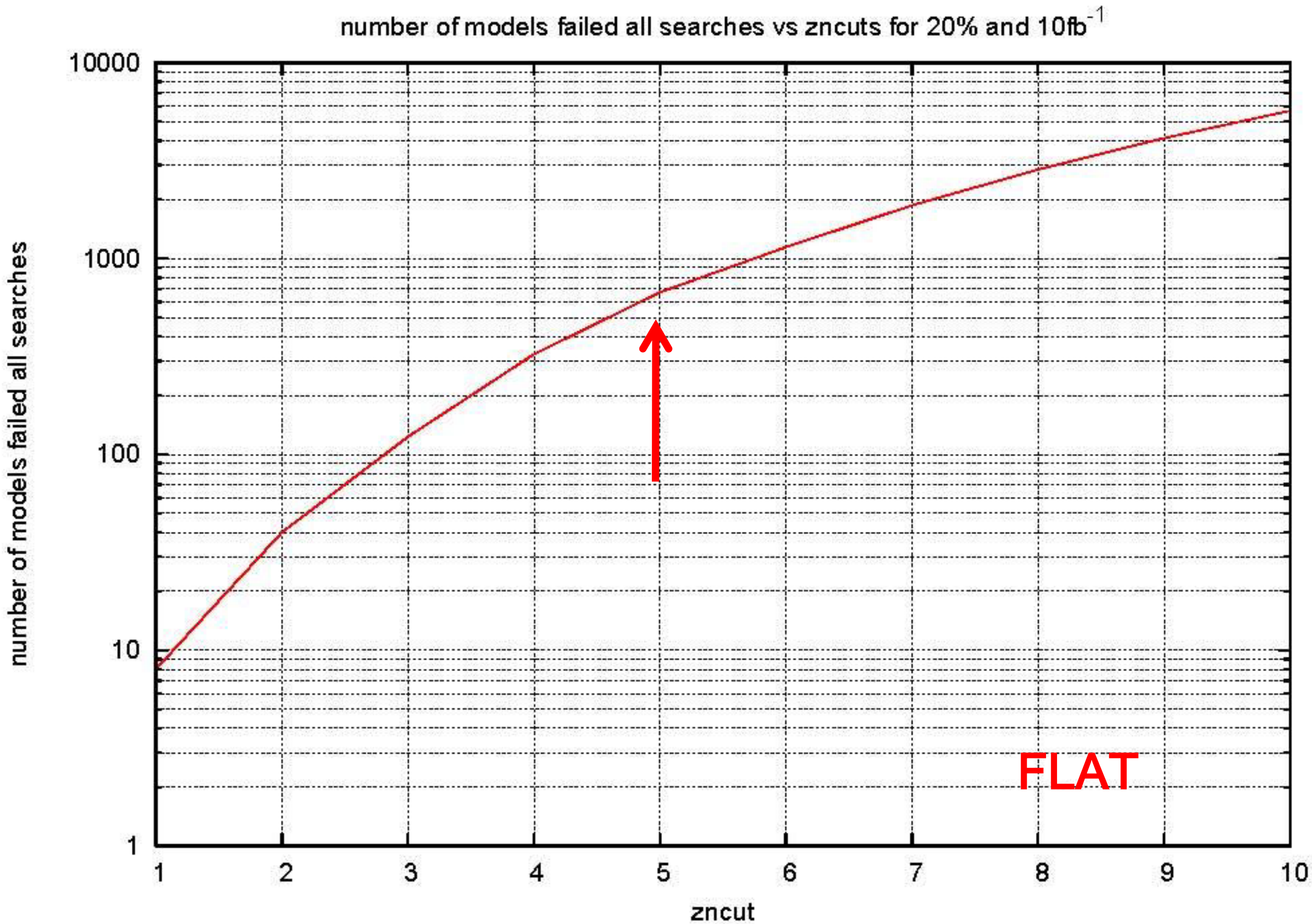
Plots of these results are more informative, e.g., for n=0

What fraction of models are found by (only) n analyses @ 7 TeV assuming δB=50%

# anl.	Flat $\mathcal{L}_{0.1}$	Flat $\mathcal{L}_1$	Flat $\mathcal{L}_{10}$	Log $\mathcal{L}_{0.1}$	Log $\mathcal{L}_1$	Log $\mathcal{L}_{10}$
0	54.756	21.772	4.8782	71.558	55.903	32.546
1	14.143	10.547	4.847	8.1729	7.3011	9.8801
2	7.8435	11.453	9.959	5.0854	7.1195	12.532
3	22.552	42.949	40.705	14.857	24.228	28.478
4	0.29938	4.1407	8.3533	0.18162	1.7436	4.5768
5	0.15788	3.1562	7.619	0	1.3803	3.4871
6	0.1415	3.3036	9.1487	0.072648	1.0534	3.4871
7	0.061068	1.4075	6.049	0.036324	0.79913	1.9615
8	0.031279	0.58536	3.6166	0.036324	0.32692	1.4166
9	0.013405	0.43493	2.9716	0	0.036324	1.235
10	0.0014895	0.25172	1.853	0	0.10897	0.39956

Clearly the case n=0, where NO models are found, is the most interesting !

Curious Aside: How many models remain missing in the ‘best’ case as the minimum requirements of S=5 for all searches is weakened?



The fraction of models ‘found’ by **n** different analyses @ 14 TeV for δB=20% : Reducing systematic is the way to go !

Number of analyses	Flat, 1 fb^{-1}	Flat, 10 fb^{-1}	Log, 1 fb^{-1}	Log, 10 fb^{-1}
0	0.016411	0.0059733	18.688	12.629
1	0.077577	0.041813	5.3597	4.1728
2	0.57139	0.22848	7.299	8.1241
3	4.9157	2.5939	9.4147	8.161
4	22.083	13.719	21.791	17.393
5	5.9003	6.0883	6.1707	8.7518
6	11.173	14.751	7.2285	10.377
7	30.085	24.238	11.742	10.487
8	9.4376	13.201	4.5839	8.1241
9	6.051	10.57	2.9619	4.8006
10	6.5538	10.175	2.9267	4.2836
11	3.1359	4.3874	1.8336	2.6957

Aside:

- Powerful analyses , e.g., (2,3,4)j0l , can fail completely in 'exceptional' cases. This could happen in these cases if the model spectrum almost always leads to high p_T leptons. But then these models could be captured in many cases by the analogous (2,3,4)j1l analyses. E.g. :