Comments On Mimicking ATLAS SUSY Searches Without Prejudice

Ahmed Ismail
SLAC/Stanford
February 13, 2012

J. Hewett, AI, T. Rizzo, M. Rowley, to appear

- Our work: sample 19 (20)-dimensional parameter space of pMSSM, requiring neutralino (gravitino) LSP, to investigate how well searches for new physics constrain a more general version of the MSSM than is typically considered
- We run O(10^6) models that satisfy existing experimental constraints through PGS and homemade analysis code (J. Conley)
- Implemented so far: ATLAS 0/1/2 leptons + jets + MET (1.04/fb), large jet multiplicity (1.34/fb)

The Good

- Differences between spectrum generators can be significant, particularly in corners of parameter space such as the focus point region
- Having SLHA files for benchmark models from experiments is a great way to remove this uncertainty

HepData (CERN-PH-2011-045)

M/MSUGRA	m_1/2 (GeV)																						
m_0 (GeV)	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450	480	510	540	570	600	900	975	1000
40		y	y	y	y	y	y	y	y	y													
60		y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y			
80		y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y			
100		y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y			

The Good

- Tables of results and acceptance * efficiency values for many different benchmark models are helpful
- Can distinguish between discrepancies in cross section calculation vs discrepancies in detector simulation

HepData (CERN-PH-EP-2011-155)

m0		m12		7j55	CLs	nSig	Acc*Eff
m0	180	m12	150	7j55	0.043	173.29	0.0023
m0	180	m12	180	7j55	0.044	61.48	0.002
m0	180	m12	210	7j55	0.046	57.47	0.004
m0	180	m12	240	7j55	0.037	65.99	0.0094
m0	180	m12	270	7j55	0.017	43.52	0.012

The Bad

- Uncertainties on efficiencies would be nice

m_0	$m_{1/2}$		Acceptance per signal region A	B	C	D	E
340	120	ATLAS	0 - 0.02	0 - 0.02	0.08 - 0.1	0 - 0.02	0 - 0.02
		DELPHES	< 0.001	< 0.001	0.06 ± 0.01	< 0.001	< 0.001
	300	ATLAS	0.08 - 0.12	0.12 - 0.14	0.18 - 0.24	0.1 - 0.14	0.08 - 0.1
		DELPHES	0.15 ± 0.01	0.14 ± 0.01	0.16 ± 0.01	0.1 ± 0.01	0.06 ± 0.01
	450	ATLAS	0.26 - 0.28	0.24 - 0.26	0.2 - 0.24	0.16 - 0.2	0.15 - 0.16
		DELPHES	0.33 ± 0.02	0.27 ± 0.02	0.18 ± 0.01	0.17 ± 0.01	0.11 ± 0.01
1140	120	ATLAS	0 - 0.02	0 - 0.02	0.06 - 0.08	0 - 0.02	0 - 0.02
		DELPHES	< 0.001	< 0.001	0.06 ± 0.01	< 0.001	< 0.001
	300	ATLAS	0.04 - 0.06	0.06 - 0.1	0.12 - 0.14	0.06 - 0.1	0.12 - 0.16
		DELPHES	0.05 ± 0.01	0.07 ± 0.01	0.1 ± 0.01	0.07 ± 0.01	0.09 ± 0.01
	450	ATLAS	0.12 - 0.14	0.14 - 0.16	0.16 - 0.18	0.14 - 0.16	0.18 - 0.2
		DELPHES	0.09 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.1 ± 0.01
2500	120	ATLAS	0 - 0.02	0 - 0.02	0.06 - 0.08	0 - 0.02	0 - 0.02
		DELPHES	< 0.001	< 0.001	0.07 ± 0.01	< 0.001	< 0.001
	300	ATLAS	0.02 - 0.04	0.04 - 0.06	0.12 - 0.14	0.06 - 0.08	0.1 - 0.12
		DELPHES	0.02 ± 0.004	0.04 ± 0.01	0.08 ± 0.01	0.04 ± 0.01	0.06 ± 0.01

A. Strübig et al.
ATLAS-Freiburg
Preliminary

0 – 0.02 vs. $1.14 \cdot 10^{-4}$ (HepData, CERN-PH-2011-045)

The Bad

- Various ways to describe object reconstruction
- Can describe reconstructions of electrons, muons, and jets separately, but generally these depend on each other, e.g. as in overlap removal
- Consistent, but confusing, to keep referring back to “preselected” objects, etc. (1109.6606)
- Preferred approach is to describe cuts on object “candidates” in the order that they are applied to yield final objects (1109.6572)
- Listing cuts in logical order makes an analysis more readable and easier to implement

The Bad

- Tables are better for cuts, especially if they're in the main paper
- If there's a table of cuts and a description in the text, they should be consistent and complete
- Cut flows would be very useful

1109.6606

"Tight" 4-jet selection (4JT). A tight selection with at least four jets is defined. The p_T requirement on the non-leading jets is raised to 40 GeV, whereas the leading jet is still required to pass $p_T > 60$ GeV. To define this signal region, three more criteria are imposed: $E_T^{miss} > 200$ GeV, $E_T^{miss}/m_{eff} > 0.15$ and $m_{eff} > 500$ GeV.

HepData (CERN-PH-EP-2011-153)

Selection	Signal Regions 3JL	3JT	4JL	4JT	Control Regions 3J	4J
Number of Leptons	= 1					
Lepton p_T (GeV)	> 25(20) for electrons (muons)					
Veto lepton p_T (GeV)	> 20(10) for electrons (muons)					
Number of jets	≥ 3		≥ 4		≥ 3	≥ 4
Leading jet p_T (GeV)	60	80	60	60	60	60
Subsequent jets p_T (GeV)	25	25	25	40	25	25
$\Delta\phi(\vec{jet}_i, \vec{E}_T^{miss})$	[> 0.2 (mod π)] for all 3 (4) jets					
m_T (GeV)	> 100				$40 < m_T < 80$	
E_T^{miss} (GeV)	> 125	> 240	> 140	> 200	$30 < E_T^{miss} < 80$	
E_T^{miss}/m_{eff}	> 0.25	> 0.15	> 0.30	> 0.15	–	–
m_{eff} (GeV)	> 500	> 600	> 300	> 500	> 500	> 300

$m_T > 100$ GeV

The Ugly

- Kinematic variable definitions aren't always straightforward
- e.g. “high mass” region in jets + MET
- 1109.6572: “all jets with p_T > 40 GeV are used to compute m_{eff}”
- ATLAS-CONF-2011-155: “all jets with p_T > 40 GeV are used to compute m_{eff} (however, the MET / m_{eff} cut still uses only the leading four jets)”
- Please define variables once, but only once

The Ugly

- It can be hard to reproduce certain cuts

are subsequently retained. For 84% of the data used, a temporary electronics failure in the LAr barrel calorimeter created a dead region in the second and third longitudinal layers, approximately 1.4×0.2 in $\Delta\eta \times \Delta\phi$, in which on average 30% of the incident jet energy is lost. The impact on the reconstruction efficiency for $p_{\mathrm{T}} > 20$ GeV jets is found to be negligible. If any of the four leading jets fall into this region the event is rejected, causing a loss of signal acceptance which is smaller than 15% for the models considered here.

1109.6572
position of dead region?

the data-taking period, a localized electronics failure in the LAr barrel calorimeter created an electronically dead region in the second and third calorimeter layers, approximately 1.4×0.2 in $\Delta\eta \times \Delta\phi$, in which on average 30% of incident jet energy is lost. The impact on reconstruction efficiency for $p_{\mathrm{T}} > 20$ GeV jets is found to be negligible. Since the energy response for jets in the problematic region is underestimated due to this extra dead area, a correction factor is applied to the jet transverse momenta. Events are rejected if the correction applied to any jet candidate provides a contribution to $E_{\mathrm{T}}^{\mathrm{miss}}$ that is greater than both 10 GeV and $0.1\,E_{\mathrm{T}}^{\mathrm{miss}}$. When identification of jets contain-

1110.2299
efficiency?

ing to approximately 1.4×0.2 in $\Delta\eta \times \Delta\phi$. Events with an electron in this region are vetoed, leading to loss of signal efficiency of about 1%. The energy measurement for jets in the data in the problematic region is underestimated. A correction to the jet energy is made using the energy depositions in the cells neighbouring the dead region, and this is also propagated to $E_{\mathrm{T}}^{\mathrm{miss}}$. The correction to the jet energy amounts to a few percent for jets just touching the dead region and reaches 40 percent for jets in the center of the dead region. The contribution of jets in the dead region to $E_{\mathrm{T}}^{\mathrm{miss}}$ can be estimated and is denoted as $E_{\mathrm{T}}^{\mathrm{miss}}(\mathrm{hole})$. Projecting this quantity on the direction of $E_{\mathrm{T}}^{\mathrm{miss}}$ gives the quantity $\Delta E_{\mathrm{T}}^{\mathrm{miss}}(\mathrm{hole}) = E_{\mathrm{T}}^{\mathrm{miss}}(\mathrm{hole}) \cdot \cos\Delta\phi(\mathrm{jet}, \vec{E}_{\mathrm{T}}^{\mathrm{miss}})$. Events with $\Delta E_{\mathrm{T}}^{\mathrm{miss}}(\mathrm{hole}) > 10$ GeV and $\Delta E_{\mathrm{T}}^{\mathrm{miss}}(\mathrm{hole})/E_{\mathrm{T}}^{\mathrm{miss}} > 0.1$ are rejected. This requirement rejects less than 0.5% of the events in the signal regions, and up to 2% of the events in the control regions.

1109.6606
better, though it would still be nice to know where the dead region is

least five associated tracks. Due to readout problems in the LAr calorimeter for a subset of the data, events in data and MC containing a jet with $p_{\mathrm{T}} > 20$ GeV or an identified electron with $-0.1 < \eta < 1.5$ and $-0.9 < \phi < -0.5$ are rejected. Each selected event must contain exactly two

1110.6189
perfect!

Summary

- Overall experience with 1/fb searches has been positive
- Benchmark SLHA files, with results and efficiencies, have proven particularly useful
- Different searches provide varying levels of clarity in descriptions of object reconstruction, kinematic variables and cuts; tables are better!
- Wishlist: consistent cut descriptions, cut flows, and efficiency uncertainties