Enabling Model-independent Searches

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Model-independent searches

Increasing trend at the LHC to present model-independent search results, in addition to limits on particular models

Answer a simple question: what is the limit on a final state, rather than a model?

Examples: resonance searches (mass and width), same-sign leptons, multilepton searches, others

On ATLAS/CMS: Exotics/Exotica, SUSY and Higgs groups all publish limits, sometimes on very similar final states. Overwhelming number of papers!

Could we help organize these results better?

For the literature search, how are these papers treated now?

- If there is a relevant limit, goes in that section (*e.g.* Z', SUSY, H++, b'/t', ...)

- If there is not a limit on a particular model, may get lost!

Search for same-sign lepton pairs in ATLAS

- Rare SM process

- Many interpretations: SUSY, H++, b'/t', excited leptons (compositeness)

Results:

Sample	Number of lepton pairs with $m(\ell^\pm\ell^\pm)$				
	> 15 GeV	> 100 GeV	> 200 GeV	> 300 GeV	> 400 GeV
e^+e^+ pairs					
Sum of backgrounds	197 ± 23	108 ± 13	27.0 ± 3.3	8.1 ± 1.2	3.3 ± 0.7
Data	183	93	26	6	1
e^-e^- pairs					
Sum of backgrounds	133 ± 21	60.4 ± 7.9	13.6 ± 2.1	4.4 ± 0.7	$1.5^{+0.3}_{-0.2}$
Data	146	78	12	4	2

(and same for muon pairs)   ATLAS-CONF-2012-069

$$\sigma_{95}^{\text{fid}} = \frac{N_{95}}{\varepsilon_{\text{fid}} \times \int \mathcal{L} dt}$$

N_{95} = 95% confidence level upper limit on the number of events

ε_{fid} = efficiency for detecting events within the fiducial region

$\int \mathcal{L} dt$ = integrated luminosity

This is the result:

Mass range	95% C.L. upper limit [fb]			
	expected $e^{\pm}e^{\pm}$	observed	expected $\mu^{\pm}\mu^{\pm}$	observed
$M > 15$ GeV	$45.0^{+17.3}_{-12.0}$	45.7	$23.4^{+8.6}_{-5.8}$	29.1
$M > 100$ GeV	$24.3^{+9.1}_{-7.0}$	25.6	$11.9^{+4.4}_{-2.9}$	14.6
$M > 200$ GeV	$8.8^{+3.2}_{-2.9}$	8.1	$4.2^{+1.8}_{-1.1}$	6.6
$M > 300$ GeV	$4.5^{+1.6}_{-1.3}$	3.9	$2.3^{+0.8}_{-0.7}$	2.5
$M > 400$ GeV	$2.9^{+1.1}_{-0.9}$	2.3	$1.6^{+0.6}_{-0.5}$	1.7

Many other same-sign papers, optimized for fourth gen quark searches, SUSY, even black holes.

During a discussion about a new theory, optimized searches can be hard to find or interpret.

Events with 3 or 4 leptons sliced and diced into various regions

SUSY limits presented in paper, but interesting for other models as well

Not converted to fiducial cross section limits

arXiv:1204.5341

Table 2: Number of observed events summed over electron and muon flavors compared with expectations from simulated and data-driven backgrounds. The labels in the first column refer to how many Drell–Yan pairs there are (DY#), whether $Z \to \ell^+\ell^-$ is excluded (no-Z), and the S_T binning. S_T ranges in GeV are Low ($S_T < 300\,\text{GeV}$), Mid ($300\,\text{GeV} < S_T < 600\,\text{GeV}$), and High ($S_T > 600\,\text{GeV}$). Labels along the top of the table give the number of τ_h candidates, 0, 1, or 2. All channels are mutually exclusive.

Selection	$N(\tau_h)=0$ obs	$N(\tau_h)=0$ expected	$N(\tau_h)=1$ obs	$N(\tau_h)=1$ expected	$N(\tau_h)=2$ obs	$N(\tau_h)=2$ expected
4 Lepton results						
4ℓ (DY0) S_T(High)	0	0.0010 ± 0.0009	0	0.01 ± 0.09	0	0.18 ± 0.07
4ℓ (DY0) S_T(Mid)	0	0.004 ± 0.002	0	0.28 ± 0.10	2	2.5 ± 1.2
4ℓ (DY0) S_T(Low)	0	0.04 ± 0.02	0	2.98 ± 0.48	4	3.5 ± 1.1
4ℓ (DY1, no Z) S_T(High)	1	0.009 ± 0.004	0	0.10 ± 0.07	0	0.12 ± 0.05
4ℓ (DY1, Z) S_T(High)	1	0.09 ± 0.01	0	0.51 ± 0.15	0	0.43 ± 0.15
4ℓ (DY1, no Z) S_T(Mid)	0	0.07 ± 0.02	1	0.88 ± 0.26	1	0.94 ± 0.29
4ℓ (DY1, Z) S_T(Mid)	0	0.45 ± 0.11	5	4.1 ± 1.2	3	3.4 ± 0.9
4ℓ (DY1, no Z) S_T(Low)	0	0.09 ± 0.04	7	5.5 ± 2.2	19	13.7 ± 6.4
4ℓ (DY1, Z) S_T(Low)	2	0.80 ± 0.34	19	17.7 ± 4.9	95	60 ± 31
4ℓ (DY2, no Z) S_T(High)	0	0.02 ± 0.01	–	–	–	–
4ℓ (DY2, Z) S_T(High)	0	0.89 ± 0.34	–	–	–	–
4ℓ (DY2, no Z) S_T(Mid)	0	0.20 ± 0.09	–	–	–	–
4ℓ (DY2, Z) S_T(Mid)	3	7.9 ± 3.2	–	–	–	–
4ℓ (DY2, no Z) S_T(Low)	1	2.4 ± 1.1	–	–	–	–
4ℓ (DY2, Z) S_T(Low)	29	29 ± 12	–	–	–	–
3 Lepton results						
3ℓ (DY0) S_T(High)	2	1.14 ± 0.43	17	11.2 ± 3.2	20	22.5 ± 6.1
3ℓ (DY0) S_T(Mid)	5	7.4 ± 3.0	113	97 ± 31	157	181 ± 24
3ℓ (DY0) S_T(Low)	17	13.5 ± 4.1	522	419 ± 63	1631	2018 ± 253
3ℓ (DY1, no Z) S_T(High)	6	3.5 ± 0.9	10	13.1 ± 2.3	–	–
3ℓ (DY1, Z) S_T(High)	17	18.7 ± 6.0	35	39.2 ± 4.8	–	–
3ℓ (DY1, no Z) S_T(Mid)	32	25.5 ± 6.6	159	141 ± 27	–	–
3ℓ (DY1, Z) S_T(Mid)	89	102 ± 31	441	463 ± 41	–	–
3ℓ (DY1, no Z) S_T(Low)	126	150 ± 36	3721	2983 ± 418	–	–
3ℓ (DY1, Z) S_T(Low)	727	815 ± 192	17631	15758 ± 2452	–	–
Total 4ℓ	37	42 ± 13	32.0	32.1 ± 5.5	124	85 ± 32
Total 3ℓ	1021	1137 ± 198	22649	19925 ± 2489	1808	2222 ± 255
Total	1058	1179 ± 198	22681	19957 ± 2489	1932	2307 ± 257

Authors don't attempt to provide every interpretation in their paper

- Additional interpretation papers would be included in PDG in the proper section

Would need to give lepton efficiencies, etc., as a footnote, link to HepData/Rivet

Proposal going forward:

- Allocate a new code for these searches, or a set of codes?

- Add a new section? If so, overseer(s) should work closely with search groups at the LHC (Exotics, SUSY, Higgs) to ensure all relevant papers are included.

- Start with a webpage? Could help to iterate within the community on what should appear.

  - Link to HepData, other services, as this can help make data easier to find, show what's missing

- May be difficult at first (could miss papers, need to define benchmarks) but could become a great resource!