

Analysis Reinterpretation Discussion: what information is needed, what is provided and what is missing?

June 16, 2016

Introduction

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“Be happy, but never satisfied”

~ Bruce Lee

Cutflows

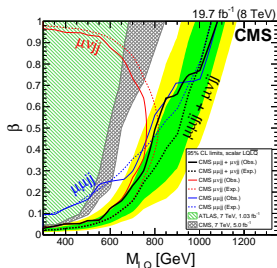
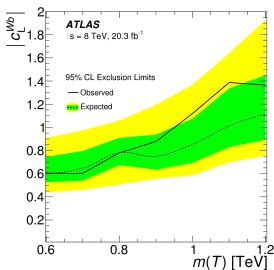
- Is this now the default method for reinterpretation validation?
- Is there a better way to perform validation?
- Can a two-way information flow help the experiments as well?
 - For example spotting typos in analysis papers

SR	Cut	$\tilde{q} - \bar{\tilde{q}}, \tilde{q} \rightarrow q + \tilde{\chi}_1^0$		$\tilde{b} - \bar{\tilde{b}}, \tilde{b} \rightarrow b + \tilde{\chi}_1^0$		$\tilde{t} - \bar{\tilde{t}}, \tilde{t} \rightarrow c + \tilde{\chi}_1^0$	
Pre-Selection	Total EvtS	1917	100%	4245	100%	3930	100%
	Trigger	1604	84%	3450	81%	3162	80%
	Event Cleaning	1592	83%	3421	81%	3140	80%
	Lepton veto	1591	83%	3418	81%	3138	80%
	$N_{\text{jets}} \leq 4$	1492	78%	3180	75%	2926	74%
	$\Delta\phi(\text{jet}, \vec{p}_T^{\text{miss}}) > 0.4$	1409	73%	3015	71%	2776	71%
	Leading jet quality requirements	1343	70%	2842	67%	2618	67%
	Leading jet with $p_T > 250$ GeV and $|\eta| < 2.4$	435	23%	761	18%	698	18%
$E_T^{\text{miss}} > 250$ GeV	404	21%	693	16%	636	16%	
EM1	$250 \text{ GeV} < E_T^{\text{miss}} < 300 \text{ GeV}$	58	3%	134	3%	124	3%
EM2	$300 \text{ GeV} < E_T^{\text{miss}} < 350 \text{ GeV}$	65	3%	139	3%	130	3%
EM3	$350 \text{ GeV} < E_T^{\text{miss}} < 400 \text{ GeV}$	59	3%	111	3%	104	3%
EM4	$400 \text{ GeV} < E_T^{\text{miss}} < 500 \text{ GeV}$	85	4%	145	3%	129	3%
EM5	$500 \text{ GeV} < E_T^{\text{miss}} < 600 \text{ GeV}$	53	3%	78	2%	74	2%
EM6	$600 \text{ GeV} < E_T^{\text{miss}} < 700 \text{ GeV}$	34	2%	41	1%	35	1%
EM7	$E_T^{\text{miss}} > 700 \text{ GeV}$	49	3%	46	1%	40	1%

13TeV ATLAS monojet (arXiv:1604.07773, Submitted to PRD)

Cutflows → Possible Improvements

- So far patchy coverage in exotics (mono-X is exception)
 - Is this a problem?
 - ATLAS example → VLQ search could be useful for many models beyond those studied (arXiv:1602.05606, Submitted to EPJC)
 - CMS example → Lepto-quark search could also be widely useful (arXiv:1509.03744, PRD 93 (2016) 032004)
- Would cutflows for every signal region be useful?
- What about cutflows for SM backgrounds?



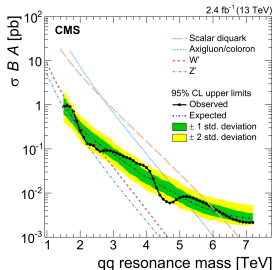
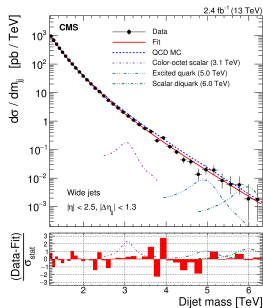
Cutflows continued...

- Large differences can occur between Monte-Carlo setups/tunes
 - Would SLHA files (+FeynRules if uncommon model) help?
 - Can Monte-Carlo setup cards be provided?
 - How about actual event files?
- ATLAS has stopped providing cutflows for SUSY conf-notes
 - Is this a policy decision or was time simply short?
 - Some new exotic conf-notes (monophoton and dijet) have cutflows???
- CMS does not always provide cutflows automatically (but are generally very helpful when prodded)
 - Is this a problem?
- Are cutflows always performed in a logical way?
 - E.g Variables that require b-tag used before b-tag required.

Binned Results

- If only the limit is given but no binned result, is this a problem?
 - Does this make the analysis impossible to reinterpret in arbitrary models?
 - Are binned fitted backgrounds required too?
 - Common for 'exotics' analyses
- For example this could be useful for very wide resonances
- Can resonant searches can be used for non-resonant models?

CMS dijet (Phys. Rev. Lett. 116 (2016) 071801, arXiv:1512.01224)

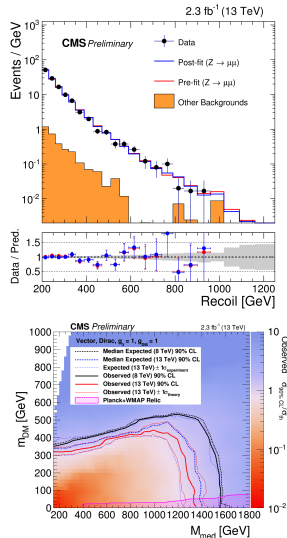


Binned Results

So far ok for SUSY searches

- Will a move towards complicated likelihood based analyses change this?
- Will the stronger limits that are promised mean that this is pushed?
- Is it better to provide 'strongest possible' limit for one particular model of one particular theory?
- Or to provide a result that can be reinterpreted for any model in any theory?

CMS monojet (CMS-PAS-EXO-16-013)



Possible solutions

Can we find a solution that also works for reinterpretation?

Possible solutions

- Provide bin by bin numbers as well?
 - How will exclusion power be harmed?
 - Is this better than no exclusion at all?
- **Is providing a likelihood code possible?**
 - Code that takes binned (or unbinned) data
→ returns likelihood
- Is providing the full correlation matrix an option?

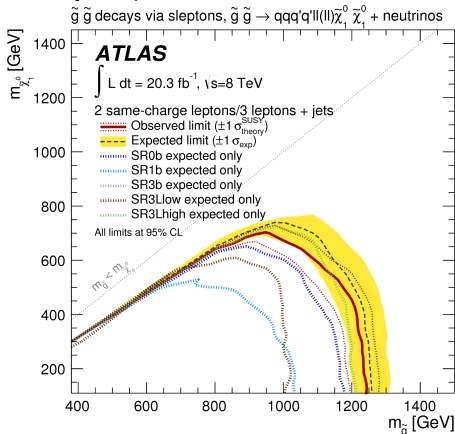
Correlation matrix

- Would allow combinations of signal regions within and beyond single analyses (assuming orthogonal signal regions)
- How detailed a breakdown of systematic uncertainties is required?
 - Would a standardised form across analyses help?
- Could statistical correlations for overlapping signal regions be provided?
 - Would this be possible over different analyses?
 - **Are statistical correlations or orthogonal signal regions preferred?**

$M_{T2}^{\ell\ell}$	Systematic uncertainties (%)										
	Stat.	ℓ ES	JES	Uncl.	JER	b tag	ℓ eff.	ISR	ML	σ	Total
≥ 80 GeV	± 1	$+4$ -5	$+2$ -1	$+3$ -1	$+3$ -3	$+1$ -0	$+1$ -1	$+1$ -1	$+1$ -1	$+1$ -1	$+7$ -6
≥ 90 GeV	± 2	$+6$ -6	$+5$ -2	$+7$ -1	$+7$ -4	$+2$ -0	$+1$ -1	$+0$ -0	$+2$ -2	$+1$ -1	$+14$ -9
≥ 100 GeV	± 4	$+6$ -5	$+9$ -2	$+10$ -1	$+12$ -2	$+1$ -1	$+1$ -1	$+2$ -1	$+3$ -3	$+2$ -2	$+20$ -9
≥ 110 GeV	± 7	$+9$ -5	$+9$ -1	$+4$ -0	$+5$ -0	$+1$ -2	$+0$ -0	$+3$ -2	$+7$ -7	$+5$ -5	$+18$ -13
≥ 120 GeV	± 10	$+4$ -5	$+12$ -3	$+2$ -0	$+5$ -0	$+3$ -1	$+0$ -0	$+6$ -4	$+12$ -12	$+5$ -5	$+22$ -18

Combination: ATLAS example

- ATLAS provided nice example of individual signal regions and combination
- How much work is this?
- Is this the best way to present such results?



Correlation matrix: Tight Binning

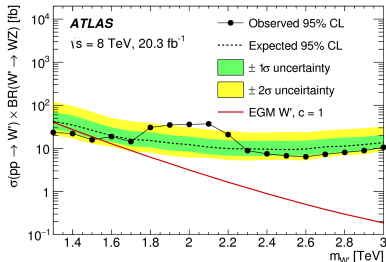
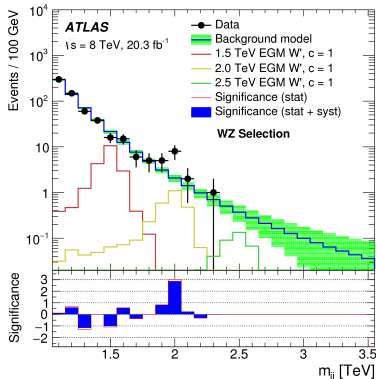
Is the lack of a correlation matrix already an issue for some analyses?

R^2	M_R (GeV)	t \bar{t}	Multijet	$W(\rightarrow \ell\nu)$	Other	Total	Observed
[0.08, 0.12[	[800, 1000]	47.1 \pm 8.6	21.1 \pm 32.0	6.1 \pm 1.9	6.0 \pm 2.3	80.2 \pm 33.4	75
	[1000, 1200]	15.2 \pm 4.1	4.7 \pm 9.9	1.9 \pm 0.9	2.2 \pm 0.9	24.0 \pm 10.6	24
	[1200, 1600]	7.3 \pm 4.8	1.4 \pm 0.9	1.3 \pm 1.0	1.4 \pm 0.7	11.4 \pm 5.1	10
	[1600, 2000]	0.8 \pm 1.2	0.2 \pm 0.2	0.4 \pm 0.5	0.1 \pm 0.0	1.5 \pm 1.3	0
	[2000, 4000]	0.8 \pm 1.1	0.0 \pm 0.1	0.4 \pm 0.6	0.1 \pm 0.1	1.4 \pm 1.3	0
[0.12, 0.16[	[800, 1000]	15.5 \pm 4.2	2.5 \pm 1.2	1.1 \pm 0.8	2.8 \pm 1.2	21.9 \pm 4.8	34
	[1000, 1200]	3.4 \pm 1.8	0.5 \pm 0.3	1.3 \pm 0.6	1.2 \pm 0.7	6.4 \pm 2.0	8
	[1200, 1600]	2.8 \pm 2.3	0.2 \pm 0.1	0.6 \pm 0.5	0.6 \pm 0.4	4.1 \pm 2.3	3
	[1600, 2000]	0.8 \pm 1.2	0.0 \pm 0.1	0.2 \pm 0.3	0.1 \pm 0.0	1.1 \pm 1.2	0
	[2000, 4000]	0.8 \pm 1.1	0.0 \pm 0.0	0.2 \pm 0.4	0.0 \pm 0.0	1.0 \pm 1.1	0
[0.16, 0.24[	[800, 1000]	9.1 \pm 5.8	0.7 \pm 0.4	1.8 \pm 1.4	2.4 \pm 1.1	14.0 \pm 6.0	16
	[1000, 1200]	2.5 \pm 2.4	0.2 \pm 0.1	0.5 \pm 0.5	1.5 \pm 0.8	4.7 \pm 2.5	4
	[1200, 1600]	0.9 \pm 1.0	0.1 \pm 0.1	1.3 \pm 0.9	0.2 \pm 0.2	2.5 \pm 1.4	2
	[1600, 2000]	0.9 \pm 1.6	0.0 \pm 0.0	0.2 \pm 0.3	0.0 \pm 0.0	1.1 \pm 1.7	1
	[2000, 4000]	0.9 \pm 1.3	0.0 \pm 0.0	0.2 \pm 0.3	0.0 \pm 0.0	1.1 \pm 1.3	0
[0.24, 0.5[	[800, 1000]	7.4 \pm 7.0	0.1 \pm 0.1	0.9 \pm 1.2	2.1 \pm 1.0	10.4 \pm 7.2	8
	[1000, 1200]	1.3 \pm 1.4	0.0 \pm 0.0	0.9 \pm 1.0	0.6 \pm 0.3	2.7 \pm 1.6	0
	[1200, 1600]	0.8 \pm 1.4	0.0 \pm 0.0	0.4 \pm 0.6	0.2 \pm 0.2	1.5 \pm 1.5	1
	[1600, 2000]	0.8 \pm 1.1	0.0 \pm 0.0	0.2 \pm 0.2	0.1 \pm 0.0	1.0 \pm 1.1	0
	[2000, 4000]	0.8 \pm 1.2	0.0 \pm 0.0	0.2 \pm 0.3	0.0 \pm 0.0	1.1 \pm 1.2	0
[0.5, 1]	[800, 1000]	2.0 \pm 1.9	0.0 \pm 0.0	0.4 \pm 0.6	0.5 \pm 0.3	2.9 \pm 2.0	0
	[1000, 1200]	0.9 \pm 1.3	0.0 \pm 0.0	0.2 \pm 0.4	0.1 \pm 0.1	1.2 \pm 1.4	1
	[1200, 1600]	0.9 \pm 1.2	0.0 \pm 0.0	0.2 \pm 0.3	0.1 \pm 0.1	1.2 \pm 1.3	0
	[1600, 2000]	0.8 \pm 1.1	0.0 \pm 0.0	0.2 \pm 0.5	0.0 \pm 0.0	1.0 \pm 1.2	0
	[2000, 4000]	0.8 \pm 1.0	0.0 \pm 0.0	0.2 \pm 0.3	0.0 \pm 0.0	1.0 \pm 1.0	0

CMS razor (arXiv:1602.02917, accepted for PRD)

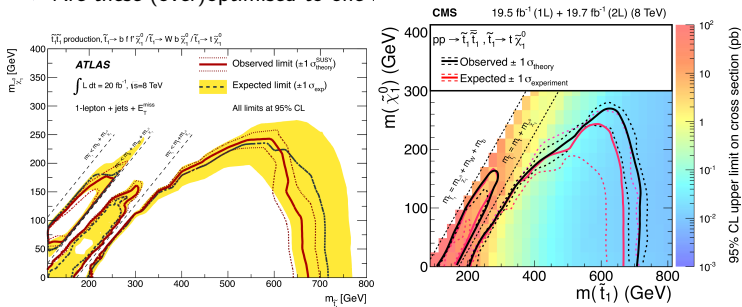
Correlation matrix: Bump hunts

- How accurate are bump hunt reinterpretations without the correlation matrix?
- Does applying an overall systematic to each bin (very) significantly reduce the limit?
- Can residual shape systematic be completely ignored?



MVA for signal regions

- How easily can MVA analyses be reinterpreted?
 - Can the MVA code be published?
 - Can cut and count be simultaneously provided?
- How much do experimental analyses actually gain?
 - Is this worth stopping any possible reinterpretation?
 - Compare ATLAS (non-BDT) with CMS (BDT)
- MVA's vs cut and count as we perturb model
 - Are these (over)optimised to one model?

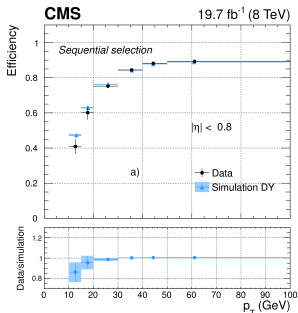
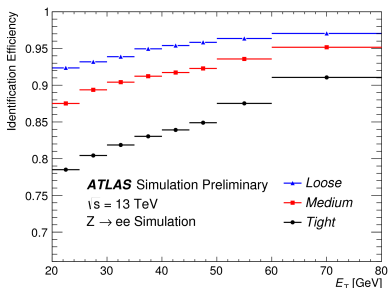


ATLAS Stop (JHEP 11 (2014) 118, arXiv:1407.0583)

CMS Stop (arXiv:1602.03169, submitted to JHEP)

Detector performance data

- Do we need more detailed detector performance data?
- Are efficiencies and smearing as a function of η and p_T enough?
- **Would digitisation (huge number of plots) make life easier?**
 - Very few performance plots on HEPDATA (or anywhere)
- Are analysis by analysis or global functions a better idea?

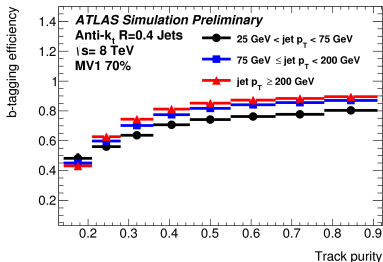
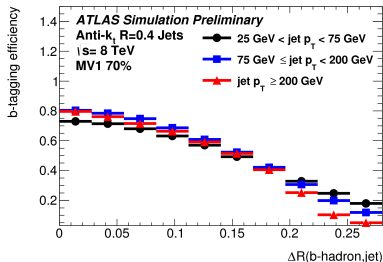


ATLAS (ATLAS-CONF-2016-024)

CMS (arXiv:1502.02701, JINST 10 (2015) P06005)

Extra flavour tagging info

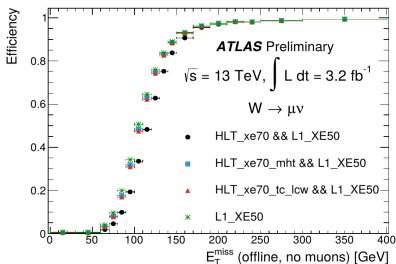
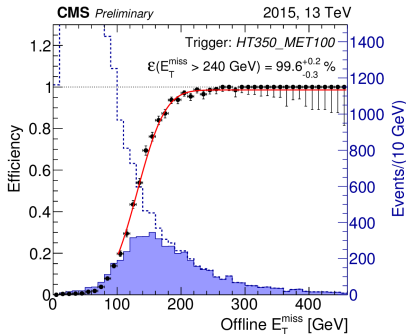
- How sensitive is flavour tagging to event multiplicity?
- Can we develop better fastsim taggers?
- Is this info available for all tagged final states?



ATLAS (ATL-PHYS-PUB-2014-014)

Trigger efficiencies

- How important are trigger efficiencies to analyses?
- Is this information documented properly and available?
- Can this be digitised?
 - Very few performance plots (if any) on HEPDATA



CMS (CMSPublic/L1TriggerDPGResults)

ATLAS (ATL-DAQ-PUB-2016-001)

Reinterpretation as a core motivation

- Are all final state objects and kinematical variables clearly defined?
 - Do citations always match the actual variable used?
- Are isolation conditions always clearly given?
- Is it possible for experimental papers to be written more with a thought to reinterpretation?

Possible Idea?

Give analysis to a random PhD student who was not involved

- Can they reproduce a cutflow within a day?

Extra questions!

- For analyses containing displaced vertices, is there a strategy to improve reinterpretation?
- Are LHCb searches recastable and are people interested in this possibility?
- Is a digitisation policy (HEPDATA) for all plots possible?



“If you always put limit on everything you do, physical or anything else. It will spread into your work and into your life. There are no limits. There are only plateaus, and you must not stay there, you must go beyond them.”

~ Bruce Lee