# Re-interpreting SUSY analyses: A (lazy) phenomenologists' wishlist

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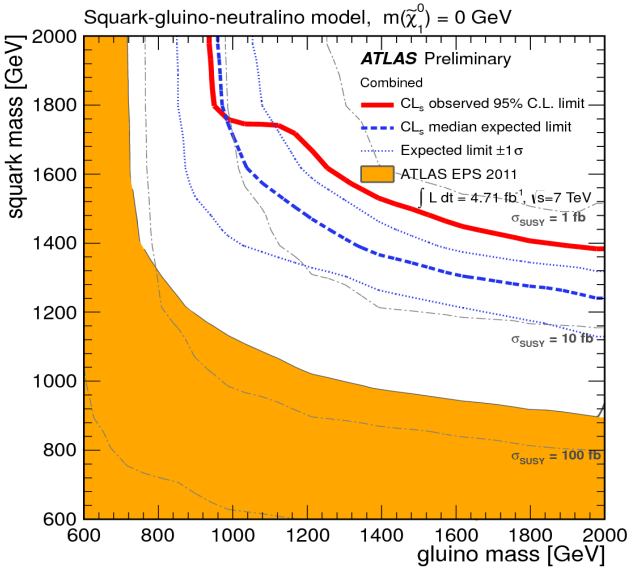
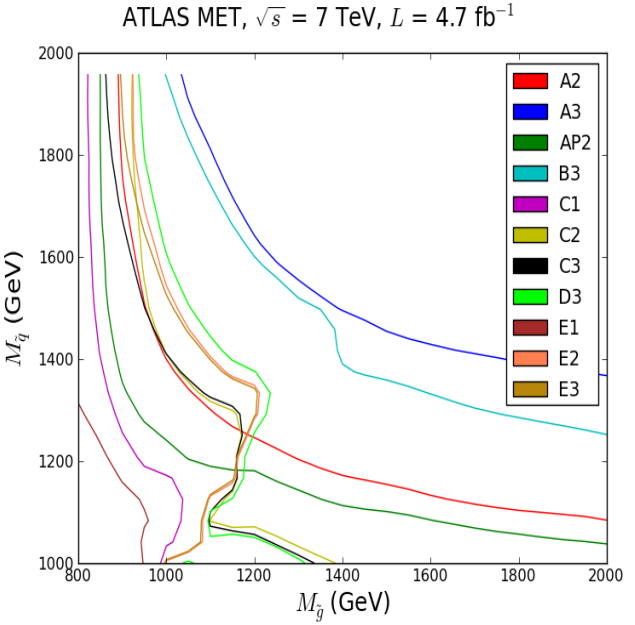
# Motivation

- I now have experience of coding a number of experimental analyses
  - Some better than others
  - None perfect.....
- How can experimentalists make things easier for a (stupid and lazy) phenomenologist?
- Also means conveners get less bothered by annoying emails
- New analyses are getting much better!



# Recommendations

## Searches for New Physics: Les Houches Recommendations for the Presentation of LHC Results

S. Kraml, B. C. Allanach, M. Mangano, H. B. Prosper, S. Sekmen (editors), C. Balazs, A. Barr, P. Bechtle, G. Belanger, A. Belyaev, K. Benslama, M. Campanelli, K. Cranmer, A. De Roeck, M. J. Dolan, T. Eifert, J. R. Ellis, M. Felcini, B. Fuks, D. Guadagnoli, J. F. Gunion, S. Heinemeyer, J. Hewett, A. Ismail, M. Kadastik, M. Kramer, J. Lykken, F. Mahmoudi, S. P. Martin, T. Rizzo, T. Robens, M. Tytgat, A. Weiler

Eur. Phys. J. C 72 (2012) 1976
arXiv:1203.2489

Abstract:
We present a set of recommendations for the presentation of LHC results on searches for new physics, which are aimed at providing a more efficient flow of scientific information between the experimental collaborations and the rest of the high energy physics community, and at facilitating the interpretation of the results in a wide class of models. Implementing these recommendations would aid the full exploitation of the physics potential of the LHC.

# My Personal wishlist

- All variables defined (Etmiss, Ht, meff....)
- Cuts in tabular form
- Cut flows for benchmark points
- Limits for each signal region
- Please keep analyses binned (or offer a tool that gives likelihoods)
- More detailed error breakdowns (theory, background, luminosity.....)
- Physical data from plots (also for conf notes....)
- Exact MC information
- Efficiency maps for final state objects (leptons, b quarks, photons....)
- Momentum resolution maps for final state objects
- All possible helpful information provided online
- Analysis 'PhD tested'

# Pheno “Fussball”


- Which LHC experiment currently implements these recommendations best?
- All current 8 TeV studies from ATLAS and CMS considered
- I have no link with either experiment!!!

# Defining all variables

- In the past, most analyses I have coded required me to email the authors to clarify details
  - This wastes everyone's time!
- Be aware that many observables have slightly different definitions (HT, MET, MT2.....)
  - Even within collaborations
  - Including code for more complicated observables is very helpful
- Sending the reader on a reference trail is annoying
- Lepton isolation criteria are often the worse offenders

# Defining all variables

## ATLAS

| | |
|---|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
| *3 lep + Etmiss [EW production]* | |
| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
| *0 lep + >=2-6 jets + Etmiss* | |
| *0 lep + >=6-9 jets + Etmiss* | |

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

# Defining all variables

## ATLAS

| | |
|---|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
| *3 lep + Etmiss [EW production]* | |
| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
| *0 lep + >=2-6 jets + Etmiss* | |
| *0 lep + >=6-9 jets + Etmiss* | |

**= 87%**

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

**= 50%**

**ATLAS 1 : 0 CMS**

# Cuts in tabular form

| Requirement | Channel | | | | |
|---|---|---|---|---|---|
| | A<br>2-jets | B<br>3-jets | C<br>4-jets | D<br>5-jets | E<br>6-jets |
| $E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] > | 160 | | | | |
| $p_{\mathrm{T}}(j_1)$ [GeV] > | 130 | | | | |
| $p_{\mathrm{T}}(j_2)$ [GeV] > | 60 | | | | |
| $p_{\mathrm{T}}(j_3)$ [GeV] > | – | 60 | 60 | 60 | 60 |
| $p_{\mathrm{T}}(j_4)$ [GeV] > | – | – | 60 | 60 | 60 |
| $p_{\mathrm{T}}(j_5)$ [GeV] > | – | – | – | 60 | 60 |
| $p_{\mathrm{T}}(j_6)$ [GeV] > | – | – | – | – | 60 |
| $\Delta\phi(\mathrm{jet}, \mathbf{E}_{\mathrm{T}}^{\mathrm{miss}})_{\mathrm{min}}$ [rad] > | 0.4 ($i = \{1, 2, (3)\}$) | | 0.4 ($i = \{1, 2, 3\}$), 0.2 ($p_{\mathrm{T}} > 40$ GeV jets) | | |
| $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(Nj)$ > | 0.3/0.4/0.4 (2j) | 0.25/0.3/– (3j) | 0.25/0.3/0.3 (4j) | 0.15 (5j) | 0.15/0.25/0.3 (6j) |
| $m_{\mathrm{eff}}$(incl.) [GeV] > | 1900/1300/1000 | 1900/1300/– | 1900/1300/1000 | 1700/–/– | 1400/1300/1000 |

Table 1: Cuts used to define each of the channels in the analysis. The $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}$ cut in any $N$ jet channel uses a value of $m_{\mathrm{eff}}$ constructed from only the leading $N$ jets (indicated in parentheses). However, the final $m_{\mathrm{eff}}$(incl.) selection, which is used to define the signal regions, includes all jets with $p_{\mathrm{T}} > 40$ GeV. The three $E_{\mathrm{T}}^{\mathrm{miss}}/m_{\mathrm{eff}}(Nj)$ and $m_{\mathrm{eff}}$(incl.) selections listed in the final two rows denote the 'tight', 'medium' and 'loose' selections respectively. Not all channels include all three SRs.

- A table of cuts is much easier to understand
- This can be given as supplementary information
- Example from ATLAS-CONF-2012-109

# Cuts in tabular form

## ATLAS

| | |
|---|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
| *3 lep + Etmiss [EW production]* | |
| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
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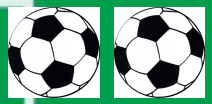
| *0 lep + >=6-9 jets + Etmiss* | |

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

# Cuts in tabular form

## ATLAS



| | |
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| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
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| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
| *0 lep + >=2-6 jets + Etmiss* | |
| *0 lep + >=6-9 jets + Etmiss* | |

**= 93%**

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

**= 30%**

**ATLAS 2 : 0 CMS**

# Cut Flows

- Cut Flows make verifying an analysis much easier
- Reconstruction efficiencies can checked
- Bugs in analysis code quickly found
- Especially important for more complicated variables and final state objects
- High statistics for benchmark points
- Example from ATLAS-CONF-2013-037

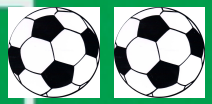
| **Preselection** | **e-channel** | | **μ-channel** | |
|---|---|---|---|---|
| | $N_{\text{weighted}}$ | $\varepsilon$ | $N_{\text{weighted}}$ | $\varepsilon$ |
| No cuts | 99989.9 | | 99989.9 | |
| Trigger | 85621.8 | 85.63% | 85954.1 | 85.96% |
| Fake $E_{\text{T}}^{\text{miss}}$ veto | 85496.1 | 85.50% | 85823.4 | 85.83% |
| Cosmic muon veto | 85185.3 | 85.19% | 85500.4 | 85.51% |
| Bad muon veto | 85184.7 | 85.19% | 85499.8 | 85.51% |
| Primary vertex | 85162.0 | 85.17% | 85474.0 | 85.48% |
| Jet/$E_{\text{T}}^{\text{miss}}$ Cleaning | 84678.3 | 84.69% | 84985.8 | 84.99% |
| Lepton (=1 baseline) | 17819.8 | 17.82% | 13502.3 | 13.50% |
| Lepton (=1 signal) | 11784.9 | 11.79% | 11025.8 | 11.03% |
| 4 jets (80, 60, 40, 25) | 6271.4 | 6.27% | 6062.9 | 6.06% |
| ≥1 b-tag in 4 leading jets | 5388.8 | 5.39% | 5144.1 | 5.14% |
| **further selection** | | | | |
| $E_{\text{T}}^{\text{miss}} > 100$ GeV [all SRs] | 4392.5 | 4.39% | 4252.2 | 4.25% |
| $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} > 5$ [all SRs] | 4285.9 | 4.29% | 4161.5 | 4.16% |
| $\Delta\varphi(\text{jet}_2, \vec{p}_{\text{T}}^{\text{miss}}) > 0.8$ [all SRs] | 3816.5 | 3.82% | 3696.8 | 3.70% |
| $\Delta\varphi(\text{jet}_1, \vec{p}_{\text{T}}^{\text{miss}}) > 0.8$ [not SRtN2] | 3722.8 | 3.72% | 3610.9 | 3.61% |
| **cuts for SRtN2** | | | | |
| $E_{\text{T}}^{\text{miss}} > 200$ GeV | 2185.9 | 2.19% | 2123.0 | 2.12% |
| $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} > 13$ | 1172.0 | 1.17% | 1158.7 | 1.16% |
| $m_{\text{T}} > 140$ GeV | 973.9 | 0.97% | 937.6 | 0.94% |
| **cuts for SRtN3** | | | | |
| $E_{\text{T}}^{\text{miss}} > 275$ GeV | 965.0 | 0.97% | 903.9 | 0.90% |
| $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} > 11$ | 937.4 | 0.94% | 883.1 | 0.88% |
| $m_{\text{T}} > 200$ GeV | 565.6 | 0.57% | 487.6 | 0.49% |
| **cuts for SRbC1–SRbC3** | | | | |
| $E_{\text{T}}^{\text{miss}} > 150$ GeV | 3080.1 | 3.08% | 2950.1 | 2.95% |
| $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} > 7$ | 3017.2 | 3.02% | 2898.3 | 2.90% |
| $m_{\text{T}} > 120$ GeV | 2347.1 | 2.35% | 2230.9 | 2.23% |
| $E_{\text{T}}^{\text{miss}} > 160$ GeV [SRbC2, SRbC3] | 2256.6 | 2.26% | 2133.8 | 2.13% |
| $E_{\text{T}}^{\text{miss}} / \sqrt{H_{\text{T}}} > 8$ [SRbC2, SRbC3] | 2174.8 | 2.18% | 2085.3 | 2.09% |
| $m_{\text{eff}} > 550$ GeV [SRbC2] | 2042.0 | 2.04% | 1972.2 | 1.97% |
| $m_{\text{eff}} > 700$ GeV [SRbC3] | 1397.8 | 1.40% | 1263.8 | 1.26% |

| **SR selection** | **e-channel** | **μ-channel** |
|---|---|---|
| SRtN1 (Σ) | 2064.66 | 1995.34 |
| SRtN2 | 408.46 | 431.46 |
| SRtN3 | 191.84 | 190.26 |
| SRbC1 | 1566.12 | 1543.63 |
| SRbC2 | 297.30 | 298.78 |
| SRbC3 | 84.32 | 75.32 |

Table 10: Preselection cutflow and signal region selection for the stop→top+LSP benchmark point with $m_{\tilde{t}} = 500$ GeV and $m_{\text{LSP}} = 200$ GeV. 100000 events were generated. Event weights are applied to correct simulated events to data, account for identification, reconstruction and trigger efficiencies.

# Cut Flows

## ATLAS



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| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
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## CMS

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|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

# Cut Flows

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
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| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

**= 40%**

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

**= 0%**

**ATLAS 3 : 0 CMS**

# Limit Numbers

Table 5: Signal model independent upper limits on the number of beyond-SM events ($N_{\text{non-SM}}$) and the visible signal cross section ($\sigma_{\text{vis}} = \sigma_{\text{prod}} \times A \times \epsilon$) in the five signal regions. The numbers (in brackets) give the observed (expected) 95% CL upper limits. Calculations are performed with pseudo-experiments.

| Obs. (exp.) upper limits | SR2L1A | SR2L1B | SR2L2 | SR3L1 | SR3L2 |
|---|---|---|---|---|---|
| $N_{\text{non-SM}}$ | 7.5 (9.0) | 3.5 (4.1) | 4.2 (5.2) | 5.5 (6.4) | 4.9 (3.9) |
| $\sigma_{\text{vis}}$ [fb] | 0.36 (0.43) | 0.17 (0.20) | 0.20 (0.25) | 0.27 (0.31) | 0.24 (0.19) |

- To compare with experimental analyses, the actual limit number is very useful
- Many different limit setting methods on the market
  - To validate an analysis, it's good to know the exact number used.
- Example taken from ATLAS-CONF-2013-025

# Limit Numbers

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
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| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

# Limit Numbers

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
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| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

**= 100%**

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

**= 10%**

**ATLAS 4 : 0 CMS**

# Binned Analyses

- Binned analyses are by far the easiest to implement
- Not giving the actual binning used in analysis is not very useful.....
- If likelihood functions across many bins are used, a tool should be provided to repeat this
- For analyses with many signal regions, data files are extremely useful

# Binned Analyses

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
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| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

# Binned Analyses

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

**= 100%**

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

**= 45%**

**ATLAS 5 : 0 CMS**

# Detailed Errors

- Without a detailed breakdown of errors, replicating an experimental analysis is impossible
- Crucial to the limit setting procedure is the systematic error on the number of signal events of the new physics model considered
  - This information is often not included
- A separation of statistical sources to systematic errors
  - Very useful when trying to extrapolate expected experimental performance
- Error on the luminosity should also be given separately

# Detailed Errors

## ATLAS

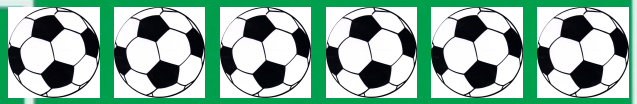
| | |
|---|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
| *3 lep + Etmiss [EW production]* | |
| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
| *0 lep + >=2-6 jets + Etmiss* | |
| *0 lep + >=6-9 jets + Etmiss* | |

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

# Detailed Errors

## ATLAS



| | |
|---|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* | |
| *3 lep + Etmiss [EW production]* | |
| *4 lep + Etmiss [EW production, RPV]* | |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* | |
| *Z + b-jet + jets + Etmiss [GMSB stop]* | |
| *1-2 taus + jets + Etmiss [GMSB]* | |
| *2 taus + Etmiss [EW production]* | |
| *2 ss lep + 0-3 b-jets + Etmiss* | |
| *2 lep + Etmiss [Medium stop]* | |
| *2 bjets + Etmiss [Direct sbottom]* | |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* | |
| *Monojet + Etmiss [WIMP, gravitino prod.]* | |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* | |
| *0 lep + >=2-6 jets + Etmiss* | |
| *0 lep + >=6-9 jets + Etmiss* | |

**= 70%**

## CMS

| | |
|---|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* | |
| *2 same-sign leptons + b-jets* | |
| *3 lep + b-jets + Etmiss [RPV]* | |
| *1 lep + 6(2 b-)jets + Etmiss* | |
| *HT + MET + >= 1 b-jet [Shape]* | |
| *3 lep + Etmiss* | |
| *3 lep [RPV]* | |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* | |
| *lep final states [EW production]* | |
| *Photons + jets + Etmiss* | |

**= 55%**

**ATLAS 6 : 0 CMS**

# Plot Data

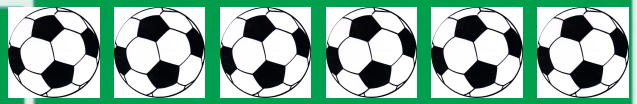
- All plots should have the original data placed online
- Conf notes are becoming more and more important
- Reading bin by bin is soul destroying!
- Example from ATLAS (Phys Rev D 87 052002)

Path: /HepData/8360/d3-x1-y1
The fiducial efficiency for muons in different p_T ranges.
Location: T 7
. : Prompt MU : TAU->MU : TAU->MU
ABS(ETARAP) : > 0.1 : < 0.1 : < 0.1
RE : .GE.3LEPTON+- MM X
SQRT(S) : 7000.0 GeV
x: PT IN GEV
y : Fiducial Efficiency

| x | xlow | xhigh | y | dy+ | dy- | y | dy+ | dy- | y | dy+ | dy- | y | dy+ | dy- |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.5 | 10.0 | 15.0 | 0.852 | +0.002 | -0.002 | 0.47 | +0.02 | -0.02 | 0.66 | +0.004 | -0.004 | 0.36 | +0.02 | -0.02 |
| 17.5 | 15.0 | 20.0 | 0.896 | +0.002 | -0.002 | 0.51 | +0.01 | -0.01 | 0.71 | +0.005 | -0.005 | 0.38 | +0.02 | -0.02 |
| 22.5 | 20.0 | 25.0 | 0.912 | +0.001 | -0.001 | 0.52 | +0.01 | -0.01 | 0.734 | +0.005 | -0.005 | 0.43 | +0.03 | -0.03 |
| 27.5 | 25.0 | 30.0 | 0.921 | +0.001 | -0.001 | 0.5 | +0.01 | -0.01 | 0.75 | +0.006 | -0.006 | 0.39 | +0.03 | -0.03 |
| 35.0 | 30.0 | 40.0 | 0.927 | +0.001 | -0.001 | 0.507 | +0.007 | -0.007 | 0.779 | +0.005 | -0.005 | 0.46 | +0.03 | -0.03 |
| 45.0 | 40.0 | 50.0 | 0.928 | +0.001 | -0.001 | 0.513 | +0.008 | -0.008 | 0.784 | +0.007 | -0.007 | 0.45 | +0.04 | -0.04 |
| 55.0 | 50.0 | 60.0 | 0.932 | +0.001 | -0.001 | 0.532 | +0.009 | -0.009 | 0.79 | +0.01 | -0.01 | 0.37 | +0.05 | -0.05 |
| 70.0 | 60.0 | 80.0 | 0.932 | +0.001 | -0.001 | 0.524 | +0.009 | -0.009 | 0.81 | +0.01 | -0.01 | 0.43 | +0.06 | -0.06 |
| 90.0 | 80.0 | 100.0 | 0.932 | +0.002 | -0.002 | 0.51 | +0.01 | -0.01 | 0.77 | +0.02 | -0.02 | 0.53 | +0.09 | -0.09 |
| 150.0 | 100.0 | 200.0 | 0.93 | +0.002 | -0.002 | 0.5 | +0.01 | -0.01 | 0.83 | +0.02 | -0.02 | 0.47 | +0.12 | -0.12 |
| 300.0 | 200.0 | 400.0 | 0.919 | +0.007 | -0.007 | 0.45 | +0.05 | -0.05 | 0.59 | +0.11 | -0.11 | - | | |

# Plot Data

## ATLAS



| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

# Plot Data

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

**= 0%**

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

**= 5%**

**ATLAS 6 : 1 CMS**

# Plot Data

However.....

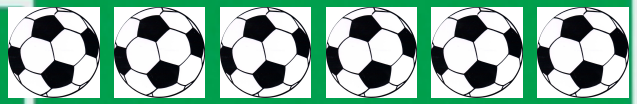
- ATLAS places the histogram data for virtually every published analysis on HEPDATA
- Only 1 (out of 24) CMS published analysis has been uploaded to HEPDATA
- Some CMS data is available via wiki

# Exact MC Information

- Monte-Carlo programs are continually changing and evolving
- To match experimental results, the exact Monte-Carlo used should be stated
- If any no default settings are used, these should also be carefully stated
- Can have a surprisingly large effect.....

# Exact MC Information

## ATLAS



| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

## CMS

| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

# Exact MC Information

## ATLAS

| |
|---|
| *1 lep + 4(1 b-)jets + Etmiss [Med/heavy stop]* |
| *3 lep + Etmiss [EW production]* |
| *4 lep + Etmiss [EW production, RPV]* |
| *0 lep + 6 (2 b-)jets + Etmiss [Heavy stop]* |
| *Z + b-jet + jets + Etmiss [GMSB stop]* |
| *1-2 taus + jets + Etmiss [GMSB]* |
| *2 taus + Etmiss [EW production]* |
| *2 ss lep + 0-3 b-jets + Etmiss* |
| *2 lep + Etmiss [Medium stop]* |
| *2 bjets + Etmiss [Direct sbottom]* |
| *0 lep + >=3 b-jets + Etmiss [3g squarks]* |
| *Monojet + Etmiss [WIMP, gravitino prod.]* |
| *Z + jets + Etmiss [GGM, higgsino NLSP]* |
| *0 lep + >=2-6 jets + Etmiss* |
| *0 lep + >=6-9 jets + Etmiss* |

**= 20%**

## CMS

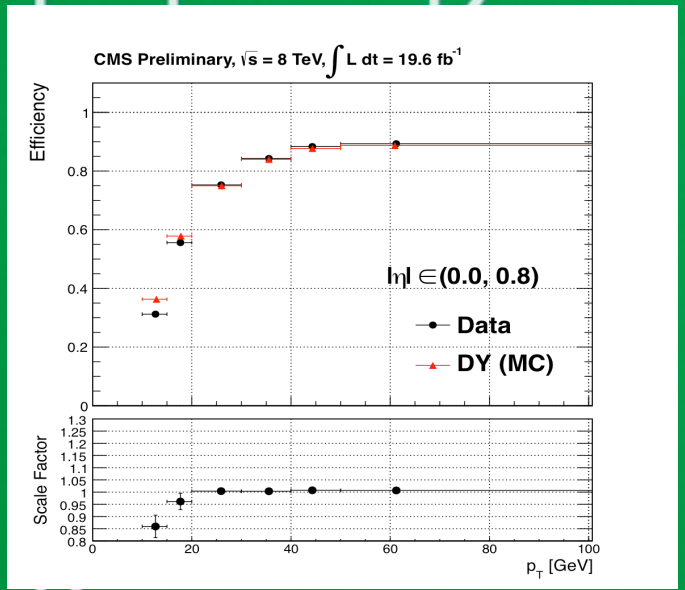
| |
|---|
| *0, 1, 2, 3, or ≥ 4 b jets + Etmiss* |
| *2 same-sign leptons + b-jets* |
| *3 lep + b-jets + Etmiss [RPV]* |
| *1 lep + 6(2 b-)jets + Etmiss* |
| *HT + MET + >= 1 b-jet [Shape]* |
| *3 lep + Etmiss* |
| *3 lep [RPV]* |
| *1 lep + 4(1 b-)jets + Etmiss [Direct stop]* |
| *lep final states [EW production]* |
| *Photons + jets + Etmiss* |

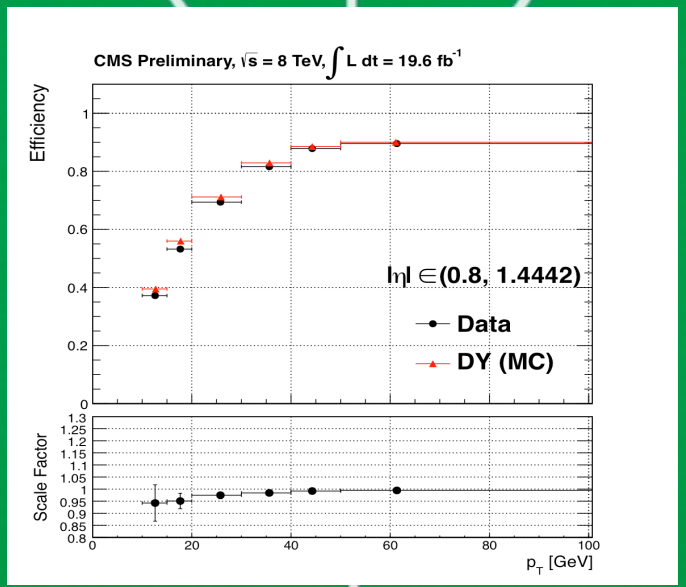
**= 30%**

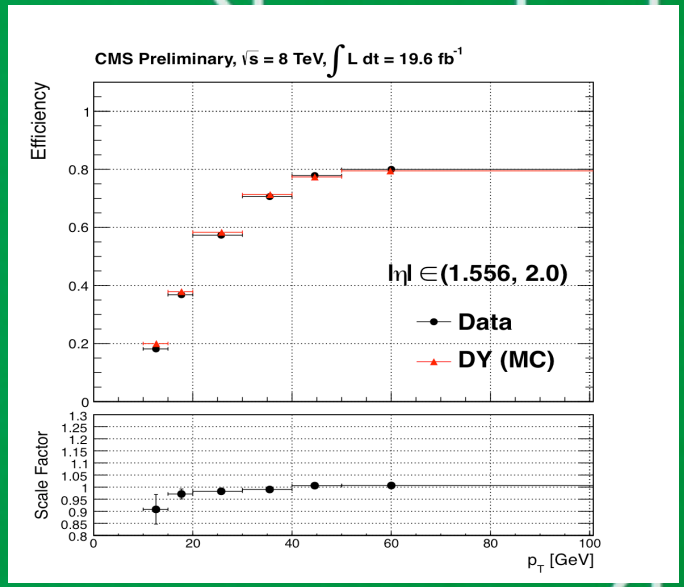
**ATLAS 6 : 2 CMS**

# Efficiency/Reconstruction Maps

- Provides an easy way to code an analysis
- Verification of fast detector simulations
- Maps in pT/eta space
- This information would be amazing in data files...
- Example from CMS DP -2013/003

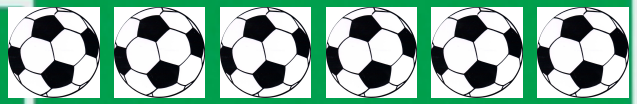


# Efficiency/Reconstruction Maps

## ATLAS



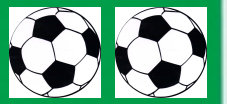
| Efficiency Maps | |
|---|---|
| *Electron* | |
| *Muon* | |
| *Photon* | |
| *B-quarks* | |
| *Taus* | |

**= 50%**

| Resolution Maps | |
|---|---|
| *Electron* | |
| *Muon* | |
| *Photon* | |
| *Taus* | |
| *Jets* | |
| Missing Energy | |

**= 50%**

## CMS



| Efficiency Maps | |
|---|---|
| *Electron* | |
| *Muon* | |
| *Photon* | |
| *B-quarks* | |
| *Taus* | |

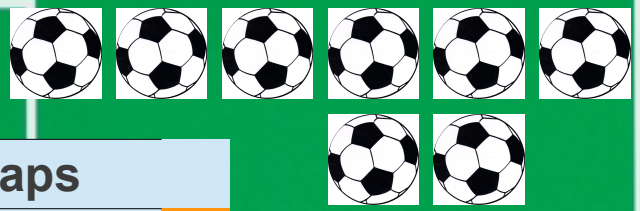
**= 50%**

| Resolution Maps | |
|---|---|
| *Electron* | |
| *Muon* | |
| *Photon* | |
| *Taus* | |
| *Jets* | |
| Missing Energy | |

**= 42%**

# Efficiency/Reconstruction Maps

## ATLAS



| Efficiency Maps |
|---|
| *Electron* |
| *Muon* |
| *Photon* |
| *B-quarks* |
| *Taus* |

= 50%

| Resolution Maps |
|---|
| *Electron* |
| *Muon* |
| *Photon* |
| *Taus* |
| *Jets* |
| Missing Energy |

= 50%

## CMS

| Efficiency Maps |
|---|
| *Electron* |
| *Muon* |
| *Photon* |
| *B-quarks* |
| *Taus* |

= 50%

| Resolution Maps |
|---|
| *Electron* |
| *Muon* |
| *Photon* |
| *Taus* |
| *Jets* |
| Missing Energy |

= 42%

**ATLAS 8 : 3 CMS**

# Congratulations to ATLAS!!!

# PhD Tested Analysis

- Perhaps all analyses could be given to a PhD student in the collaboration but outside the particular analysis group
- They should be able to reproduce the analysis within a day without asking questions
- Many analyses lack information, contain crucial typos, ambiguous wording
- I won't name and shame here.....

# PhD Tested Analysis

- All analyses should be given to a PhD student in the collaboration but outside the group
- They should be able to reproduce the analysis within a day without asking questions
- Many analyses lack information, contain crucial typos, ambiguous wording
- I won't name and shame here.....

# Extra Wishlist

- When writing SUSY analyses please keep in mind the phenomenologists that want to use the analysis
- The more data dumped on the web, the better!
    - It's fine to give disclaimers
- Example analysis code is very useful
- Supplying a likelihood calculator with each analysis would be amazing
- Things are definitely improving!

# EXPERIMENTALISTS


# WE NEED YOU!

# Backup

# Dark Matter at Fermi-LAT

- Christoph Weniger (ex DESY) has found hints of dark matter with Fermi-LAT telescope. (JCAP 1208 (2012) 007, arXiv1204.2797)
- Not a member of the collaboration – used publicly available data
- Shows the potential of giving public access to data
- I'm not advocating that all data from ATLAS and CMS should be public but.....
- More than we get now would be nice!