Delphes tuning in CheckMATE: The present and the future

http://checkmate.hepforge.org   arXiv:1312.2591

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♔ Contents

♙ Core Delphes changes

♖ Final state tunes

♘ Outstanding issues

♘ Non-detector issues

*I've made the assumption that the audience is familiar with Delphes
and detectors in general
**Please ask lots of questions otherwise this talk is far too short

Delphes
Core
Changes

♚ Delphes Improvements

Added 'flag' functionality

- ♙ Many analyses require multiple 'types' of the same final state object

  - ♖ For example, a single lepton analysis may only require very loose lepton id to veto di-lepton final states efficiently

  - ♘ However, lepton is then required to fulfil much tighter conditions to guard against fakes

  - ♗ Also often seen with b-jets and taus

- ♙ Delphes did not have functionality to implement this consistently

  - ♖ We require that a tighter object is always also a looser object

  - ♘ E.g. → A tight electron will always also be a loose electron

♔ Delphes Improvements

Added 'flag' functionality

- ♟ Big improvement is that we only run Delphes once irrespective of the number of analyses
  - ♜ Single run even with ATLAS and CMS analyses
- ♟ Minimal number of objects stored in Root output

# Isolation

♔ Delphes Improvements
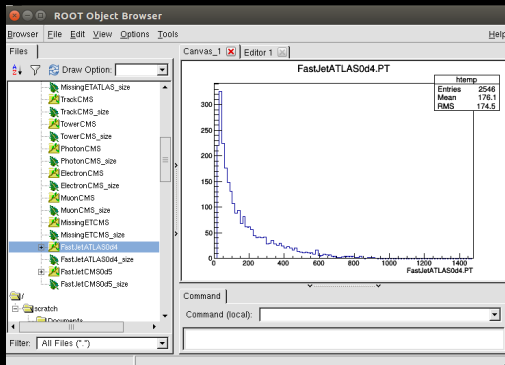
Isolation

- ♙ Flag functionality also allows for more isolation conditions

- ♖ Many analyses have isolations conditions based both on tracks and calorimeter information

- ♘ Also both absolute and relative isolation conditions can be applied

- ♗ Loose electron isolation settings often not stated

  - ♖ Electron id requires an intrinsic isolation

  - ♘ We phenomenologically use a 'loosest' isolation

  - ♗ $\frac{\Sigma(calo(P_T)) - \ell(P_T)}{\ell(P_T)} < 0.2$, within $dR = 0.2$

- ♙ Threshold energy of tracks/calo cells considered for isolation not stated in analyses

♚ Delphes Improvements

Track isolation

- ♟ We use $\Sigma(p_T > 500)$ MeV (private communication)
- ♜ ATLAS-CONF-2014-032 now states $\Sigma(p_T > 400)$ MeV (2nd June)

Calorimeter isolation

- ♟ We use $\Sigma(p_T > 100)$ MeV (private communication)
- ♜ Dominated by calorimeter noise below this

Final State Objects
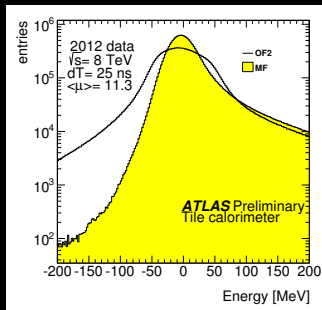
♚ Delphes Improvements

Extensive changes made to Delphes tunes

- ♟ Majority of final state objects have been completely retuned
  - ♜ Electrons
  - ♞ Muons
  - ♝ Taus
  - ♛ B-jets (charm-jets)

- ♟ Default Delphes
  - ♜ Calorimeter → jets and MET
  - ♞ Photons
  - ♝ However, we have seen that these all require improvements

- ♟ All analyses use these common tunes as a basis
  - ♜ If we see a particular analysis fails, we 'fix' within the analysis

- ♟ So far we have only implemented ATLAS tunings.
  - ♜ CMS is on the todo list

♚ Delphes Improvements

Electrons

- ♙ We implement lookup tables based on P_T and η
- ♖ Taken from arXiv:1110.3174 and ATL-COM-PHYS-2013-1287 (7 TeV)
- ♘ Implemented for loose, medium and tight electrons
- ♝ For each P_T point we multiply by η distribution normalised to 1

♚ Delphes Improvements
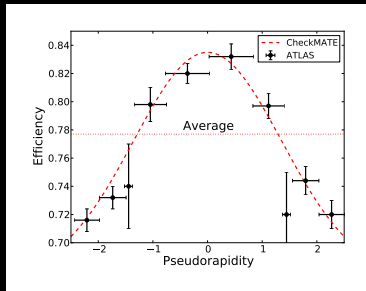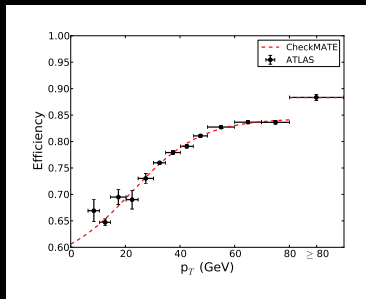
Electrons

- ♟ Now been updated with full 2-d binning @ 8 TeV ATLAS-CONF-2014-032 (2nd June)
- ♜ Numbers are actually very similar
- ♞ As this is a conf note all numbers need to be read in by hand... (any volunteers???)

♚ Delphes Improvements
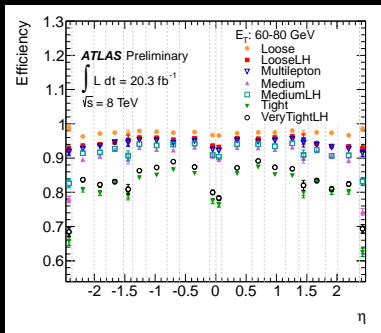
Muons

- ♙ Same idea for muons (both segment tagged and combined)
- ♜ $\sim P_T$ independent above 6 GeV
- ♞ Taken from ATLAS-CONF-2011-063 (7 TeV)
- ♝ ATLAS have now updated to 8 TeV but results are basically the same
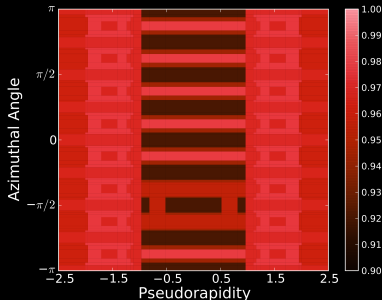
$Z \to \ell\ell$

♟ Performance checks tell us, if our functions are correct (slightly unfair on Delphes default.....)

Invariant Muon Mass in $Z \to \mu^+\mu^-$

- Standalone Delphes
- Delphes+CheckMATE
- ATLAS Result

$m_{\mu\mu}$ (GeV)

Pseudorapidity in $Z \to e^+e^-$

- Standalone Delphes
- Delphes+CheckMATE
- ATLAS Result

η_{ee} (GeV)
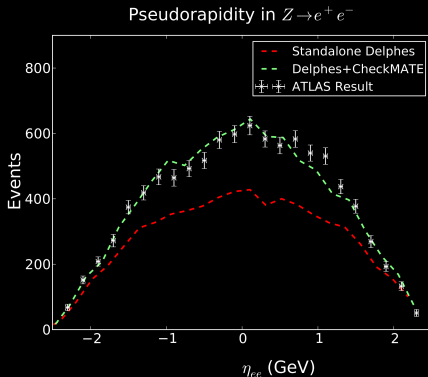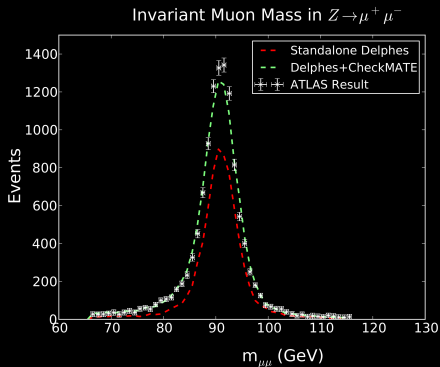
Taus

♟ Signal and background efficiencies for both 1 and 3-prong taus

♜ Taken from ATLAS-CONF-2013-064 (8 TeV)

♔ Delphes Improvements
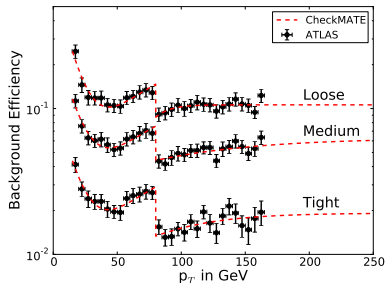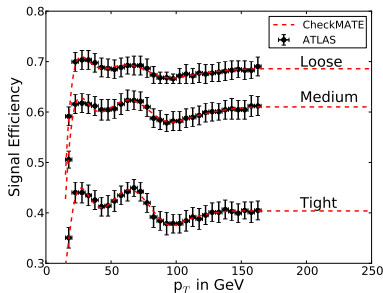
B-tagging

- ♙ B-tagging implemented in ATLAS with an MVA
- ♖ For b-jets, c-jets and light-jets
- ♘ ATLAS-CONF-2012-040, ATLAS-CONF-2012-09, ATLAS-CONF-2012-043 (all 7 TeV)

♛ Delphes Improvements
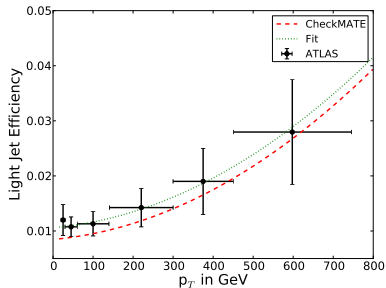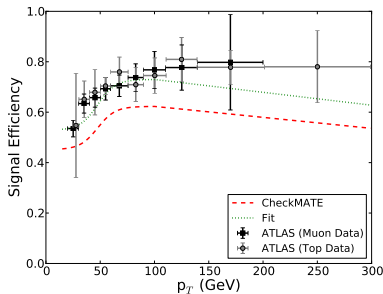
B-tagging

- ♟ We also parameterise the whole ROC curve
- ♜ Allows user to select any b-tagging efficiency and fake-rate is automatically adjusted

♘ Delphes Improvements
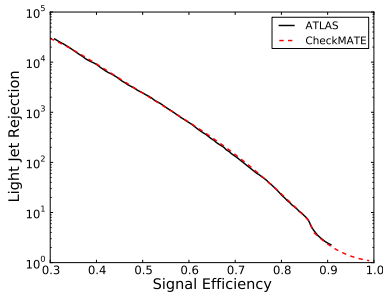
B-tagging

- ♙ New results at 8 TeV need implementing
- ♜ ATLAS-CONF-2014-046, ATLAS-CONF-2014-004 (3rd July)
- ♞ Numbers have not changed much
- ♝ We correctly guessed deterioration at high P_T
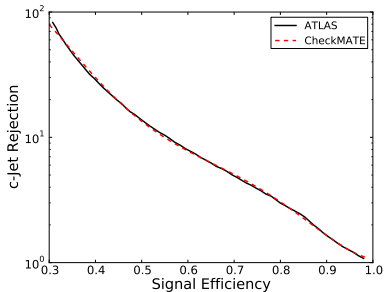- ♛ Once again conf-notes....

♚ Delphes Improvements
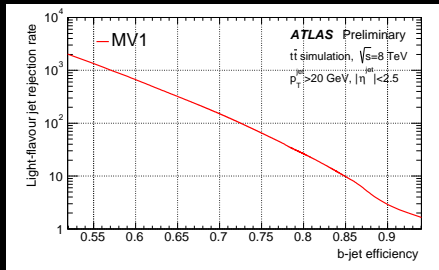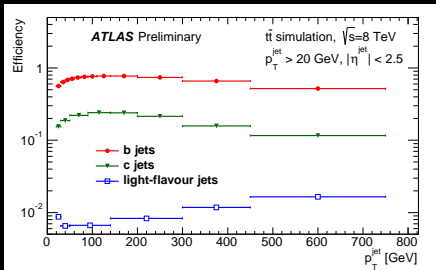
B-tagging

- ♟ More important is the effect of other jets
- ♜ ATLAS-CONF-2014-014 (19th August)
- ♞ B-tagging gets worse if another jet lies close
- ♝ We need to experiment to see what works best
- ♛ Once again conf-notes....

♚ Delphes Improvements
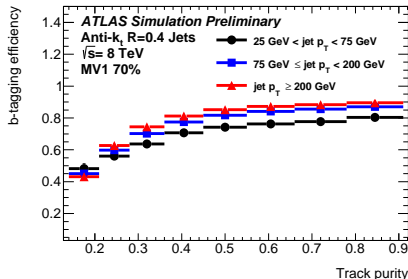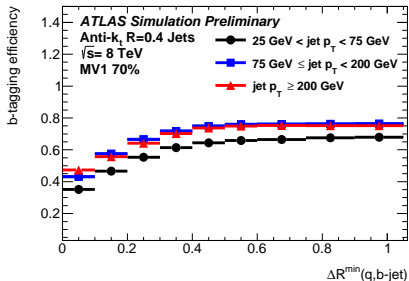
B-tagging

♙ $\Delta R(jet_q, jet_b)$ is difficult to be generator agnostic

♜ Implementing track impurities will also require work

♞ Centrality of b-quark should be easy
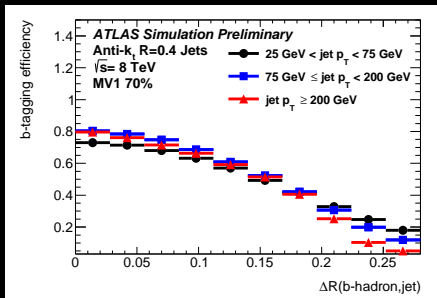
Outstanding Issues

Calorimeter Smearing

- ♟ Delphes appears to undersmear jets (and thus MET) compared to ATLAS
- ♜ Example in WW production

♔ Outstanding Issues

Calorimeter Smearing

- ♟ Can also be seen in hadronic top reconstruction
    - ♜ e.g stop search with one isolated lepton (arXiv:1407.0583)
    - ♞ $\tilde{t}_1 \to t\tilde{\chi}_1^0$ search targets one hadronic top (tN_med)
    - ♝ ATLAS → $130 < m_{jjj} < 195$ GeV
    - ♛ CheckMATE → $140 < m_{jjj} < 185$ GeV
- ♟ Does not effect 'normal' jets + met searches so much
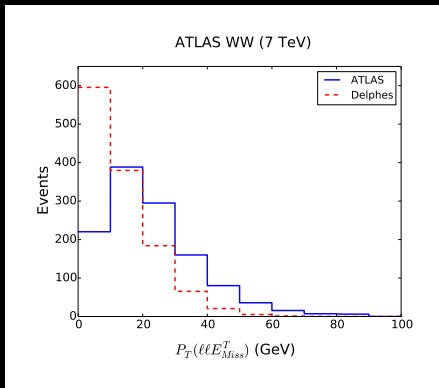   - ♜ Increased smearing on falling distribution has small effect on acceptance
- ♟ Potentially serious for exclusive jet binning
    - ♜ However... experiments should really be discouraged from performing these cuts anyway
    - ♞ Essetially a jet veto
    - ♝ Not theoretically under control in electroweak production.
    - ♛ $t\bar{t}$ is far worse...

♚ Outstanding Issues

Trigger

- ♙ Ideally we would like to implement trigger independently of analyses
    - ♜ Lack of global trigger information makes this impossible
- ♙ We implement triggers individually for each analysis
    - ♜ Unfortunately many analyses give no information about the trigger
- ♙ E.g. → atlas-conf-2013-035 (trilepton + MET) has no trigger information
    - ♜ Use single lepton trigger from atlas-conf-2012-104
    - ♞ Use di-lepton trigger from atlas-conf-2012-049

♘ Outstanding Issues

Trigger

- ♙ No trigger turn-on curves given
- ♖ We believe this is the single biggest source of errors for lepton analyses → especially for soft leptons
- ♞ Ideally, all triggers used should be documented centrally

Events are triggered using two-lepton triggers. There are two dielectron triggers with the leading and sub-leading lepton p_T thresholds of $(14, 14)$ GeV and $(25, 8)$ GeV, and two dimuon triggers with the p_T thresholds of $(14, 14)$ GeV and $(18, 8)$ GeV. Additionally, two electron-muon triggers with $(p_T^e, p_T^\mu) >$ $(14, 8)$ GeV and $(8, 18)$ GeV are used. The dielectron triggers have efficiencies ranging between 85% and 98%, where the lowest efficiency comes from the asymmetric dielectron trigger in the end-cap region. The dimuon triggers have efficiencies ranging between 52% (77%) and 80% (98%) in the barrel (end-caps), where the lowest efficiency trigger comes from the symmetric dimuon trigger. The asymmetric electron-muon triggers have efficiencies ranging between 65% and 82%. All quoted efficiencies have been measured in data with respect to reconstructed leptons with p_T in excess of the nominal thresholds.

Non-detector Simulation Issues

♘ Non-detector Simulation Issues

Cutflows

- ♙ ATLAS now implements cutflows for all SUSY analyses
    - ♖ A massive help when coding analyses
- ♖ We would like this to be extended to ALL analyses (including SM)
- ♘ CMS is severely lacking on this point......
- ♗ Only useful if reasonable statistics used

This can also benefit the experiments

- ♙ With the help of cutlows, CheckMATE alone has found...
    - ♖ Wrongly documented P_T cuts
    - ♘ Wrongly weighted b-tag efficiencies
    - ♗ Missing kinematical cuts

♕ Non-detector Simulation Issues

Fully documented Monte-Carlo settings

- ♙ Different Monte-Carlos can produce suprisingly different results
  - ♙ Especially treatment of ISR
- ♖ Dumping all settings onto a wiki would be amazing
  - ♙ SLHA files
  - ♖ Monte-Carlo generator files
- ♙ Often generator level cuts are applied
  - ♙ Is this at matrix element or full event level?
  - ♖ Often non-standard and not transparent
- ♙ Easy to waste a lot of time trying to validate with a completely different setup...

Fully documented errors

- ♟ We would like to combine signal regions and analyses to calculate stronger limits

- ♜ Fully documented errors are a pre-requisite for this task
    - ♟ Allows us to calculate error correlations
    - ♜ Assuming uncorrelated errors only improves bounds marginally
    - ♞ Assuming fully correlated errors significantly overestimates bounds

- ♟ Each background must have every source detailed along with the value

♚ Non-detector Simulation Issues

Stand-alone limit setting codes

- ♟ Even better would be stand-alone codes
- ♜ Produced by the experiment for each analysis
    - ♞ Python code for CMS Rivet analysis developed but never released
- ♟ User is only required to enter expected events in each signal region
- ♜ Code returns p-value
- ♞ Probably more chance of world peace tomorrow than this happening for conf-notes in my lifetime...

A
Final
Plea

♔ A Final Plea

Conf note data

- ♙ This will almost certainly be ignored...
- ♖ But reading data from plots...
    - ♘ Takes a huge amount of time
    - ♗ Is extremely boring
    - ♕ Induces errors
    - ♔ And is completely crazy
- ♙ We live in a digital age
- ♖ Can we please have plots in a digital format...

♘ please......

♗ please......

♕ please......