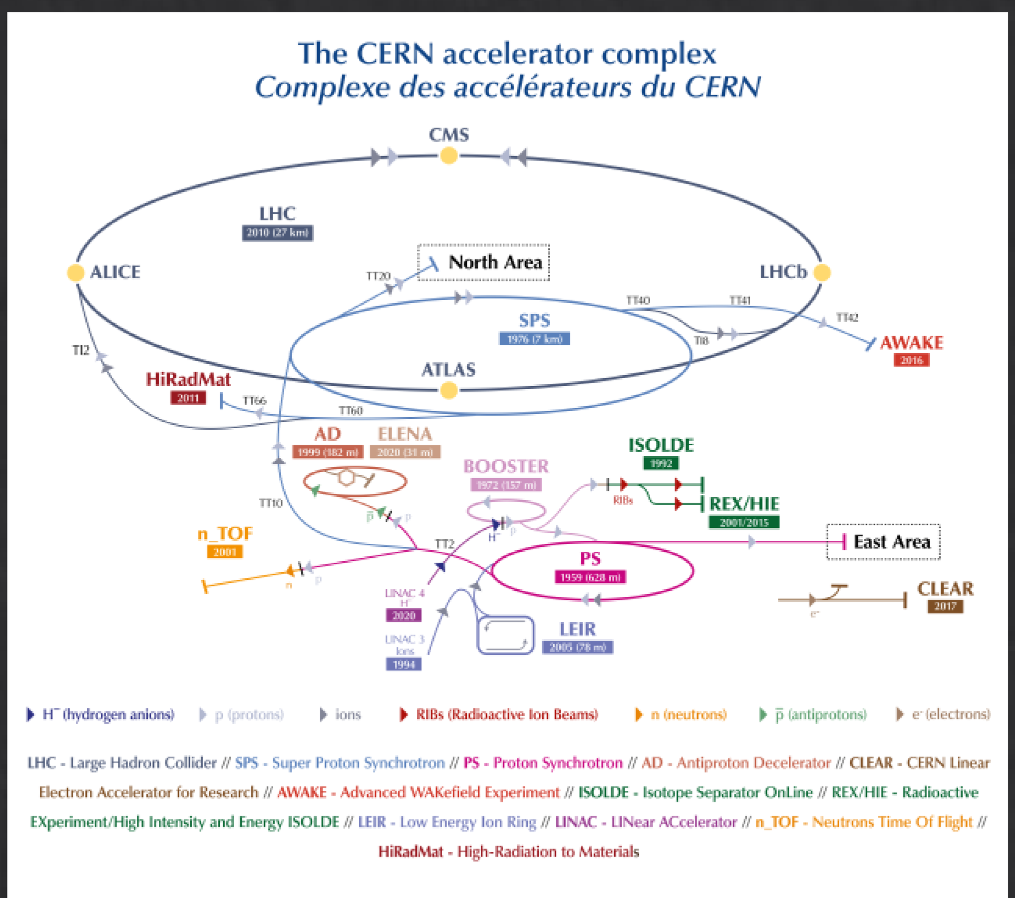
Application of jet density corrections to forward topo towers using the ATLAS detector in the context of $t\bar{t}Z$ ($Z->\nu\bar{\nu}$) measurements

The University Of Sheffield.

PhD student: Michael Postill,
Email: mpostill1@sheffield.ac.uk

ATLAS EXPERIMENT



CERN, The LHC, ATLAS and You

The ATLAS experiment is located on 1 of the 4 intersection points on the ring of the LHC. It consists of its inner strip detector, calorimeter and muon spectrometer. The forward and central regions within the detector are defined using pseudorapidity η:

$$\eta = -\ln\left[\tan\frac{\theta}{2}\right]$$

Where θ is the angle measured from the normal of the proton-proton batch collision. The normal travels through the centre of the detector.

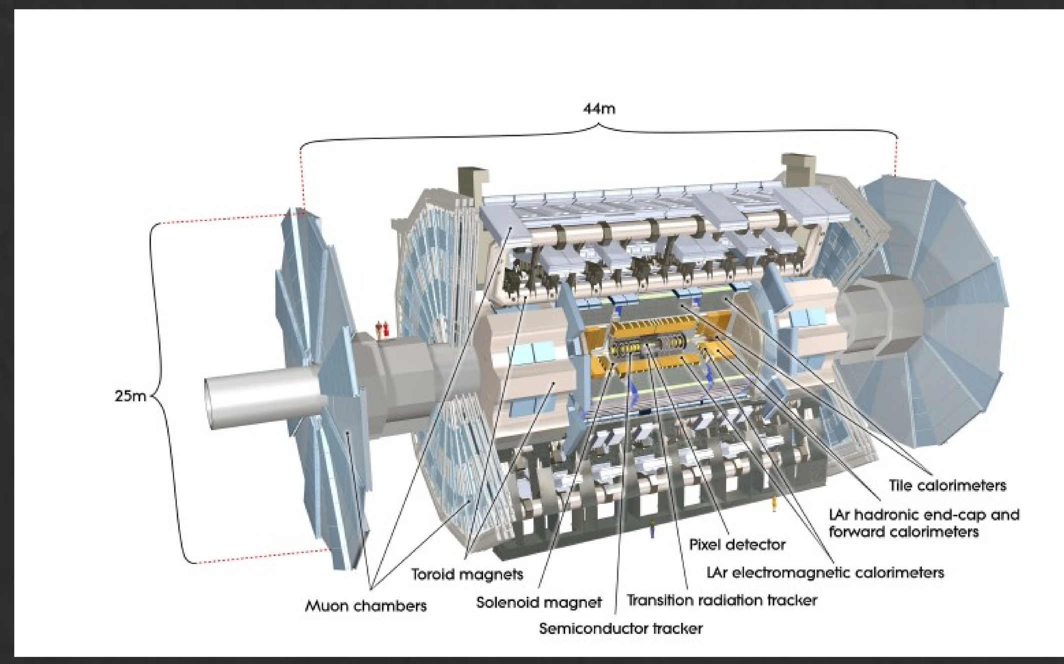
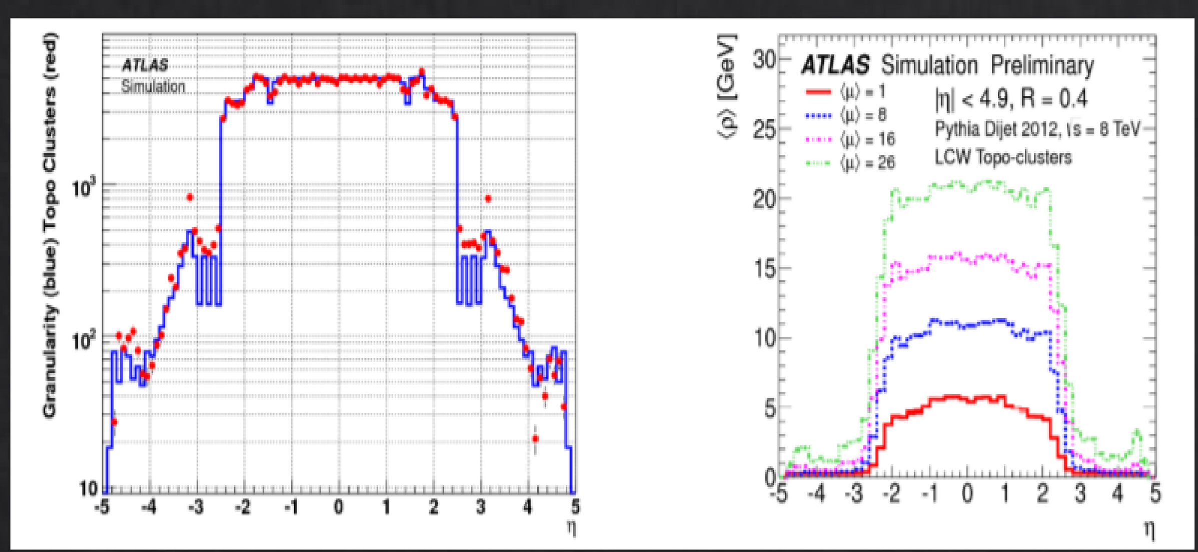


Figure 1.1: Cut-away view of the ATLAS detector [2].

Topo Towers: the good, the bad and the drop-off in the forward region

In reconstruction we search for the interesting events among the large number of soft events which have lower pt. The pileup density attempts to measure how much of the lower P_T events overlays the detector in an area relevant for reconstructing the jet (of the event being studied) with the pileup contribution subtracted.

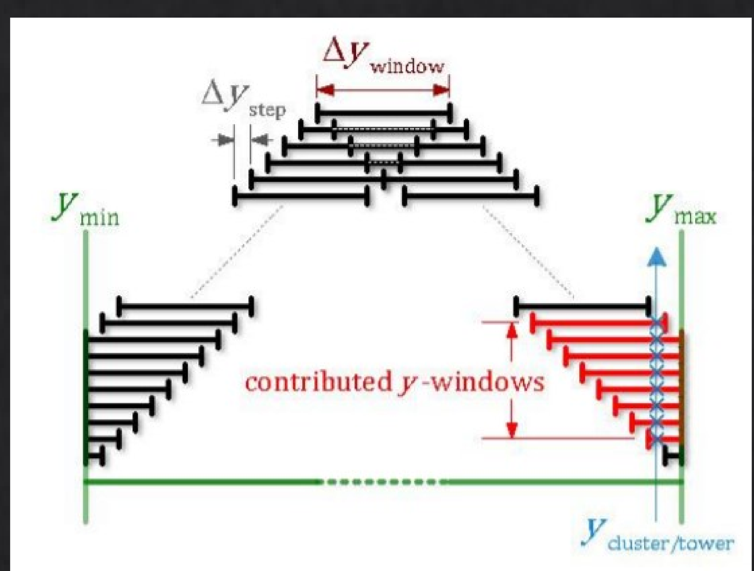
In the ATLAS calorimeter the individual cells are broken up in two ways. CaloClusters or Topo towers. Topo Towers are rigid well defined locations that take in all signal data from a set area η x ϕ while clusters have a much less well defined catchment area with signal being clustered together topologically but with an irregular shape based off signal to noise optimisation. This makes calculations of the pileup energy density (ρ) difficult in the forward region. The forward region itself is comprised of the region of |η|>2.5.



As can be seen here the drop off in granularity in the forwarded region causes a steep fall in ρ

Figure 2.0 on the left: Calorimeter readout granularity and number of topo-clusters as a function of the nominal η. Figure 2.1 on the right: The median Transverse momentum density (ρ) as a function of η. For both figures η can be approximated as rapidity. [4]

A solution to the drop off in ρ in the forwarded region is to use a sliding window approach on topo towers within the forwarded region. This involves calculating the average ρ over a small η window. Then sliding that window in small steps across the tower.



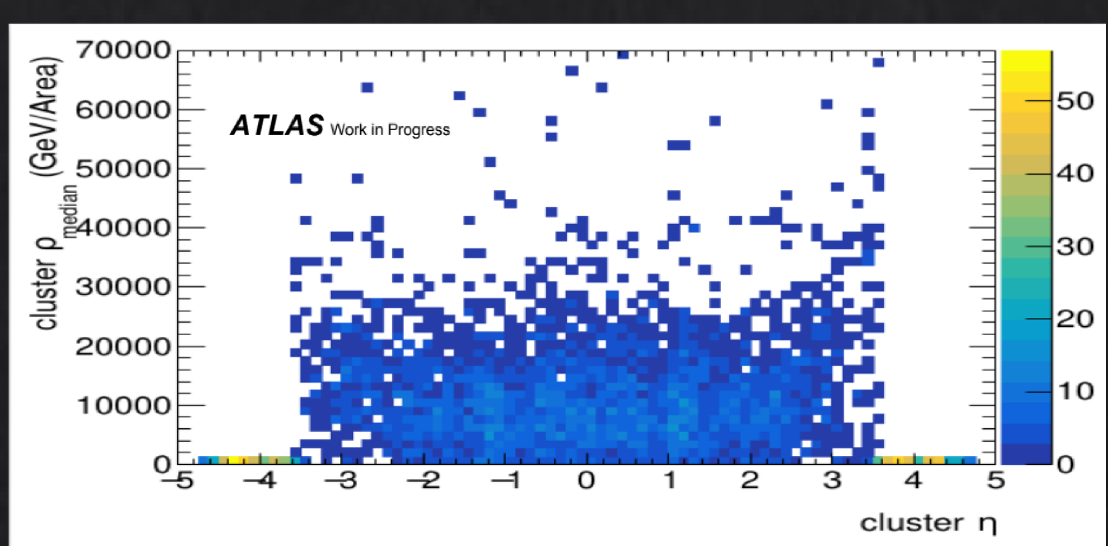


Figure 2.3: The median pileup density in the central region using the sliding window approach.

ttZ: The man with the golden cross section

$t\bar{t}Z$ consists of the production of a top anti-top pair in association with a Z boson.

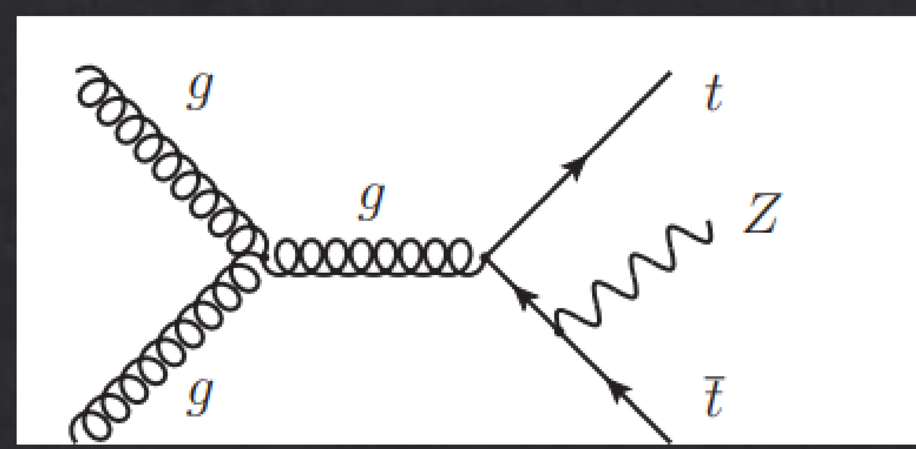
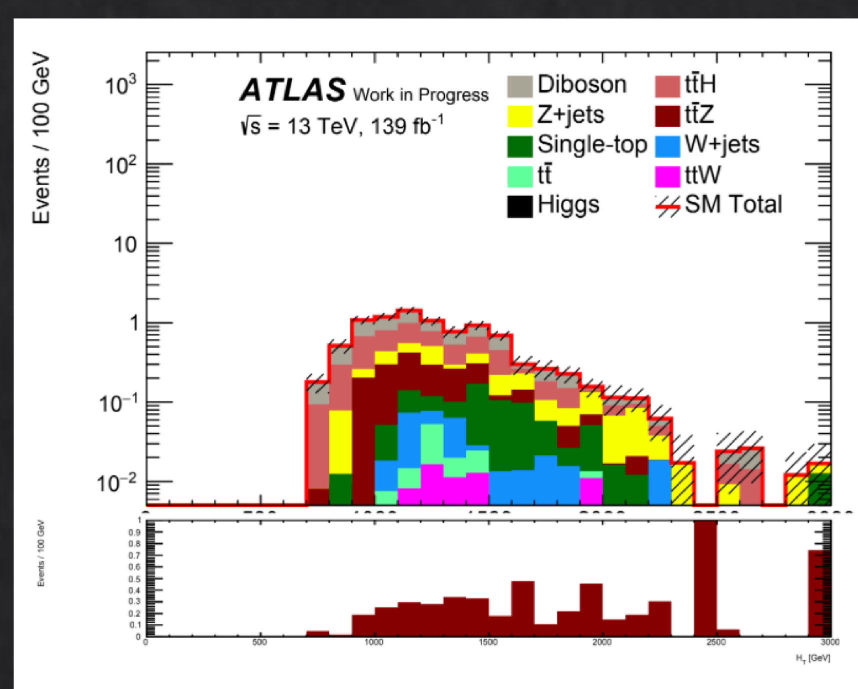
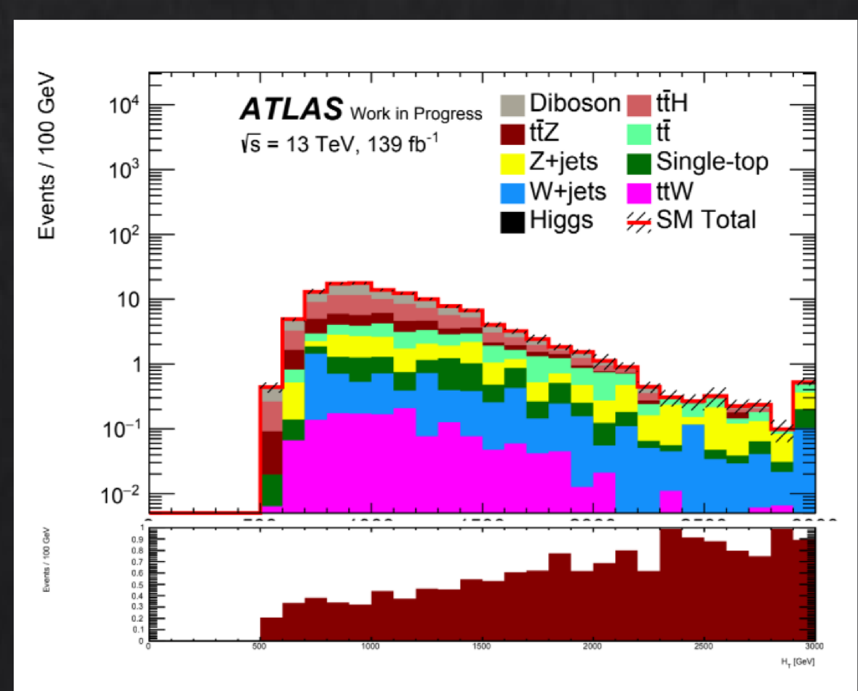


Figure 3.0: The dominant leading-order Feyman diagrams for $t\bar{t}Z$ production in pp collisions [3].

$t\bar{t}Z$ in beyond SM processes such as the SUSY all-hadronic stop search (stop0L) is an irreducible source of background as when ($t\bar{t}Z \rightarrow \nu\bar{\nu}$) with Z decaying by $Z \rightarrow \nu\bar{\nu}$ in association with tt decaying purely hadronically, it produces a $t\bar{t}$+MET state which is identical to the one produced in the stop signal. Therefore we have decided to use regions previously used in stop0L to make a measurement of the ttZ cross section



The repurposed regions of the stop0L are loosened in order to increase the purity of ttZ in the sample.



As can be seen the purity is much higher when MET is loosened however there is a balancing act between statistics and purity.

Figure 3.1: The top image represents the SUSY signal region A region which has been tightened(SRATT). The bottom image represents the SUSY region with loosened parameters: MET, MT2Chi and METSig

The big picture

In $t\bar{t}Z$ or SUSY analysis most of the processes take place within the central region. Therefore most analysis wouldn't care about the pileup density fall off if it wasn't for the missing transverse momentum (MET). MET needs total coverage of the entire calorimeter in order to reconstruct the data accurately. Therefore increasing the effectiveness of topo towers in the forward region helps with both the accuracy and percussion of measurements such as $t\bar{t}Z$.

References

[1]-E. Mobs, The CERN accelerator complex - 2019. Complexe des accélérateurs du CERN - 2019, Jul 2019. General Photo.

[2]-The ATLAS Collaboration et al 2008 JINST 3 S08003

[3]-Khachatryan, V. et al. (2014) 'Measurement of top quark-antiquark pair production in association with a W or Z boson in pp collisions at $\sqrt{s}$ = 8 TeV', The European physical journal. C, Particles and Fields, 74(9), p. 3060. doi:10.1140/epjc/s10052-014-3060-7.

[4]- M. Cacciari and G. P. Salam, "Pileup subtraction using jet areas," Phys. Lett. B, vol. 659, pp. 119-126, 2008.