Reflections on the First ATLAS Blind Data Challenge

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Abstract

We revisit our findings from the first ATLAS Blind Data Challenge, after the sample has been unblinded. We discuss aspects of our study which we analysed well, in particular with respect to the W' and Z', as well as noting other areas - such as the top mass and the leptoquark, in which we ought to have done rather better.

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1 Introduction

The results of the first ATLAS Blind data challenge were announced at the ATLAS overview week in Prague (18th September 2003). A talk was given there [1] by one of the organisers presenting the physics processes which had been simulated, as well as his thoughts on how well the various participants had fared at working them out.

We had previously made a blind study of this data sample, and had submitted to the organisers a short note [2] summarising our findings. We now revisit that analysis with the benefit of hindsight, so that we can evaluate our analysis techniques.

In this paper we summarise what we have learnt from the experience, what we feel we did well, and what could have done better. This should be read in conjunction with the submission we made before the sample was unblinded [2].

2 Physics Studies

The physics in the blind sample was:

- top quark mass of 188 GeV (2 σ from 2002 PDG value).
- Higgs boson with mass of 191 GeV
- Z' mass 1287 GeV, width 41 GeV
- W' mass 1785 GeV
- Leptoquark decaying to $\mu^{\pm}$ + jet, mass 517 GeV.

2.1 Monte Carlo Reference Sample

Our basic analysis strategy seemed sound. We considered the "data" distributions both on their own merits, and in comparison with our own Monte Carlo simulations.

While this was probably the correct way to proceed, we had somewhat overestimated some of the the backgrounds, because we included separately contributions from electroweak gauge boson production both with and without QCD radiation in the matrix element. This resulted in some over-counting of those backgrounds in our reference data, which made it more difficult for us to trust it as much as we might have liked to. We would argue that this demonstrates the need to understand the physics behind the Monte Carlo in some detail if one is to make good experimental predictions.

2.2 W' and Z'

We found the W' and Z' resonances quickly, and made a fine attempt to extract their properties – as far as we could in the time available. Our measurements of the mass and width were good for the Z'. For the W' the mass measurement was good, but we underestimated the uncertainty in our width extraction (the most difficult measurement).

In Prague it was reported by the speaker that our view of the spin of the Z' was that

> *the group concluded that this is spin-0*

This is misrepresentation – it is *not* what we said at all! Our statement in section 3.6 of [2] was that

> *Although bad, this level of consistency is not really good enough to rule out spin-1, but it certainly* disfavours *it with respect to the spin-0 alternative. More statistics will be needed to resolve the issue.*

In fact we were trying to be very cautious in our statement, since we knew that the evidence based on the limited statistics was very thin. In our concluding bullet point we said of the spin that

> *scalar (favoured) or spin-1 (disfavoured but still possible)*

and in the conjectures we sat even more squarely on the fence, saying that while a scalar was favoured by the data, we knew of no physics that could produce this, and

> *if required to plump for a single option, we would feel compelled to conclude that the "least-worst" fit to the neutral resonance data is provided by the assumption that it comes from a [spin-1] Z'-boson.*

Perhaps all we can learn from this is that one risks being mis-reported even when trying to draw even the most careful of conclusions!

2.3 Leptoquark

We narrowly missed out on finding the leptoquark. One of us had investigated the signal from leptoquark pairs decaying into an electron and a jet. This analysis involved selecting events with a pair of opposite sign, same family electrons, and looking for a pair of lepton-jet invariant masses close to each other. If the same approach had been employed on the muon channel, then the signal would have been observed (figure 1).

Another of us had considered both the electron and muon channels. However in that analysis only *single* leptoquark decay was considered, and so the requirement for two such muon-jet combinations to be found with approximately the same invariant mass was not made. This meant that the signal could not be distinguished above the background, and so the leptoquark was not found in that analysis either.

2.4 Top

The worst omission from our note is that we failed to *report* that the top quark mass was more than 10 GeV above the PDG central value, despite having been surprised to *observe* it! We had of course made plots reconstructing the top mass, and some of us had even noticed that the peak value was unusually high. We thought this was particularly odd, since energy losses from jets ought to mean that the reconstructed peak position would be *below* the true mass.

The unfortunate fact is that we didn't go on to study this unexpected feature in our data. We had at that time already discovered the W' and Z', and since we were busy with the 'new physics', the highish mass top quark did not seem so interesting and wasn't studied any further. In some ways this reflects the bias of the experimentalists, since our group primarily studies signatures for new physics.

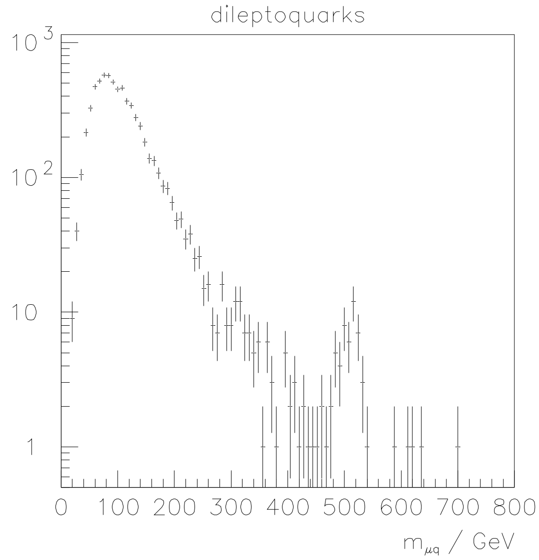

Figure 1: Muon-jet invariant mass distribution for events with two opposite sign muons, and two leptoquark candidates with similar mass. Note the resonance near 500 GeV. As explained in the text, this plot was not made in the muon channel during our analysis.

2.5 Spin of the Standard Model Z

The lack of spin correlations in standard model Z boson in the blind sample surprised us. In section 3.6 of [2] we said that we found this very unusual, but bearing in mind that we knew it has come from Monte Carlo rather than real data we don't claim to have discovered that the SM Z is really a scalar! No mention of the effect was made at Prague, so we have no further insight into why Z spin correlations should have been absent. However given this omission in *known physics* it is in no way impossible that the spin correlations were also missing in the Z' of the blind sample. This could perhaps be why the angular distributions tended to favour a scalar resonance.

2.6 Isolated Photons

We reported in section 2.4 of [2] finding a large excess in number of isolated photons compared to our own reference sample. This was attributed in Prague to a difference in the AtlFast definition of isolation for photons. This difference demonstrated the need for a common understanding of what constitutes a physics object and was reported to the AtlFast authors.

2.7 General Strategy

One would like to think that one could re-measure well understood quantities before going on to look for exotics. For example at the start of LHC running, ATLAS plans to start it's analysis with measurments of the standard model W, Z and top to convince ourselves we can trust our data. In our blind challenge, we probably ought to have followed more closely such a bottom-up style of analysis.

It perhaps isn't sensible to push this point too far, given that we were doing an exercise, and that it was supposed to be fun. However if we had starting by grounding ourselves in standard model physics, we may have reported the top mass discrepancy, and tried harder to reconstruct the Higgs which we believed we had insufficient statistics to make a serious attempt on.

3 Concluding remarks

Our analysis was awarded with one of three small prizes for a detailed study the properties of the W' and Z' bosons. While the competitive aspect of the challenge was fun, the real benefit of the exercise came from the analysis postmortem and evaluation, which we have tried to convey here.

It's worth noting that as a group of PhD students and young post-docs working on ATLAS, most of us had no experience with analysing real physics data. The exercise was therefore a very useful insight into approaching data analysis.

We would like to conclude by thanking the organisers of the blind challenge for their hard work designing the competition and producing the data samples. We found the blind challenge to be great fun, and hope that something similar can be repeated in the future.

References

[1] The transparencies can be found at `http://agenda.cern.ch/askArchive.php?categ=a03190&id=a03190s30t4/transparencies`

[2] *Observations concerning the first ATLAS Blind Data Challenge* A.J. Barr and others, ATLAS physics note.