Large Scale Cosmic Analysis
The Effect of Masking Bad Channels on Missing Transverse Energy

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Introduction:

This analysis investigates the effect of various bad channel masking configurations using the METCellMaskTool on Missing transverse energy and the large scale behaviour of MET variables in cosmic events. The dataset under consideration includes 81 cosmic runs in the DPD_CALOCOMM stream from the December 2008 reprocessing, amounting to approximately 1.5 million events. Our analysis currently indicates that masking channels labeled as 'affected' tends to have the greatest effect on MET variables. A small scale examination of this effect in one run at the sub-detector level suggests that masking bad channels in the tile calorimeter dominates the shifts in MET variables.

Analysis Methodology:

Secondary aims of this analysis were the demonstration of the capability of extracting results from a large data sample and evaluating the utility of the DPD_CALOCOMM commissioning DPD. The 900 GB commissioning DPD for the 2008 cosmic ray data were transferred to the local Tier 3 computing facility where it was processed several times. The legacy CBNT format was chosen as the tertiary DPD format due to analyst familiarity and the large amount of existing code for creating and filling branches.

The default ntuple in the RecExCommissioning configuration proved to be too large to be an effective D3PD format: the CBNT occupied more disk space than the (ESD-based) commissioning DPD. It was straightforward to reconfigure the CBNT through job options to produce ntuples of a manageable size (in some cases less than 1% of DPD_CALOCOMM size) that were useful for aspects of the analysis. Adding information that was not already created by existing CBNT making classes required the traditional CBNT cut-paste-compile development.

The combination of commissioning DPD and customized CBNT proved adequate for the majority of the analysis described here. The most glaring problem was the selection criteria applied in creating the commissioning DPD: a flat prescale which cut 80% of the interesting, large MET events. Further analysis of the large MET events will require analysis of the full ESD for the run period which is currently being pursued.

The METCellMaskTool:

The METCellMaskTool allows for two possible choices for masking bad channels in MET reconstruction. The first option uses the CaloBadChanTool for both the LAr and the Tile calorimeters and the specification of the type of masking configurations is limited to channels labeled as 'Dead', 'Noisy', 'Affected' or combinations of these. The second option uses the CaloBadChanTool and its aforementioned masking configuration settings for the Tile Calorimeter and the LArBadChannelMasker for the LAr Calorimeter. The LArBadChannelMasker provides a more refined bad channel masking option by providing the user with the flexibility of selecting the types of problems that they wish to mask from a list of 20, some of which are gain dependent. Our analysis has mainly focused on the second choice in the METCellMaskTool, but the results have been confirmed to exist in both scenarios.

As a first step, the following user specified categorizations have been selected for the LArBadChannelMasker:

Dead channels include problem channels labeled as 'deadPhys' and 'deadReadout'.

Noisy channels include problem channels labeled as 'unstableNoiseHG', 'unstableNoiseMG', 'unstableNoiseLG' and 'sporadicBurstNoise'. High noise channels have already been masked in the reprocessed data.

Affected channels include problem channels labeled as 'deadCalib', 'almostDead', 'distorted', 'lowNoiseHG', 'lowNoiseMG', 'lowNoiseLG', 'peculiarCalibrationLine', 'short', 'unstable', 'problematicForUnknownReason', 'missingFEB' and 'shortProblem'.

Large-Scale Behaviour of MET Variables:

Figure 1 shows the magnitude and phi distributions of the Missing Transverse energy for MET_Base and MET_Topo in 1.5 million cosmic events. MET_Base is the vector sum of the transverse energy recorded for all calorimeter cells in which $|E_{cell}|>2\sigma$ and MET_Topo is the vector sum of the recorded transverse energy for all 4-2-0 topoclusters within the calorimeter. In both these scenarios approximately 200 events had an MET value greater than 1TeV. Although masking all bad channels had the effect of shifting the distribution of Missing Transverse energy to a slightly lower value, it did not significantly decrease the number of greater than 1TeV events.

The phi distributions of MET_Base and MET_Topo in Figure 1 exhibit dips at $\varphi \sim \pm\pi/2$. This trend is assumed to originate from the fact that most of the cosmic muons going through the Atlas detector are minimum ionizing particles, therefore, a muon that passes near the interaction vertex is likely to leave an equal amount of ionizing energy in the upper and lower half of the detector which may cancel out in an MET calculation. The asymmetry seen between the upper half (negative φ in MET) and lower half (positive φ in MET) of the detector is currently under investigation. A 50 GeV cut on Missing transverse energy tends to smooth out this effect significantly. Our hypothesis for this asymmetry include the possibility of coherent calorimeter effects such as pedestal shifts or the general top-to-bottom topology of cosmic events. In order to investigate the latter hypothesis we have been looking at Monte Carlo simulated cosmics, which currently do not have any trigger cuts applied to them, and observe a slight asymmetry between positive and negative φ for low energy muons ($10<E<300$GeV at the surface of the earth). This slight asymmetry, however, is not enough to fully explain the effects seen.

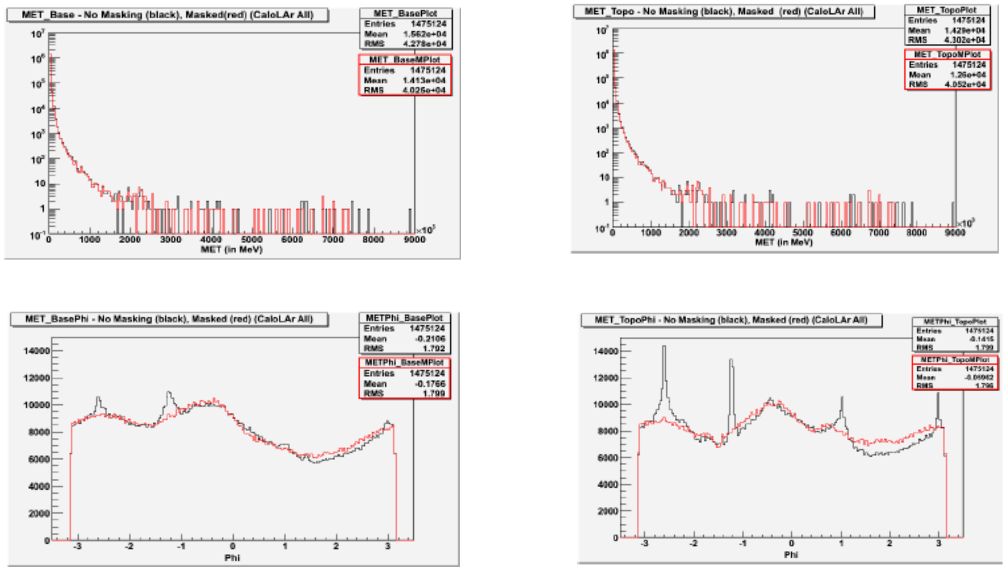

Figure 1. MET_Base distribution (upper left). MET_Topo distribution (upper right). Phi distribution of MET_Base (lower left). Phi distribution of MET_Topo (lower right). Black lines reflect the distributions prior to masking and the red lines are after masking all bad channels in the calorimeter.

Masking all bad channel categories has the effect of smoothing out the sharp peaks seen in Figure 1 of the phi distributions of MET. It is believed that these sharp peaks are more pronounced in MET_Topo because there are fewer cells involved in the case of topocluster MET reconstruction than MET_Base, which may enhance some bad channel effects. We have briefly looked at some of the runs that possess many events with an MET phi value lying in the regions of interest and have some possible candidates for the types of bad channels in the LAr calorimeter that are contributing to these sharp peaks. The peak at $\varphi \sim -2.6$ is believed to arise from a known sporadicBurstNoise channel, the peak at $\varphi \sim 1$ may be due to any one of the following bad channel candidates; ie. Unstable, lowNoiseHG, sporadicBurstNoise. The peak at $\varphi \sim 1.4$ is specific to a particular run. Other peaks that don't appear to have a possible LAr bad channel candidate are likely to have arisen from effects in the tile.

General Trends for Different Masking Configurations:

Figure 2 shows the shift in MET_Base after applying the bad channel masking tool versus the value of MET_Base after masking. It can be seen that masking bad channels tends to have the greatest effect on low (< 20 GeV) MET values. However, there is also a significant number of events with large MET values that experience TeV range shifts after masking. Approximately 0.4% of cosmic events have an MET value greater than 20 GeV and experience a shift of at least 10 GeV after masking all bad channels. The most significant effect appears to arise from bad channels labeled as 'affected' followed by those labeled as 'noisy'. Masking bad channels labeled as 'dead' seems to not make a significant difference in the calculated MET values. The number of bad channels belonging to each masking configuration, the specific problems contributing to large shifts in MET and the nature of the events involved are currently under investigation.

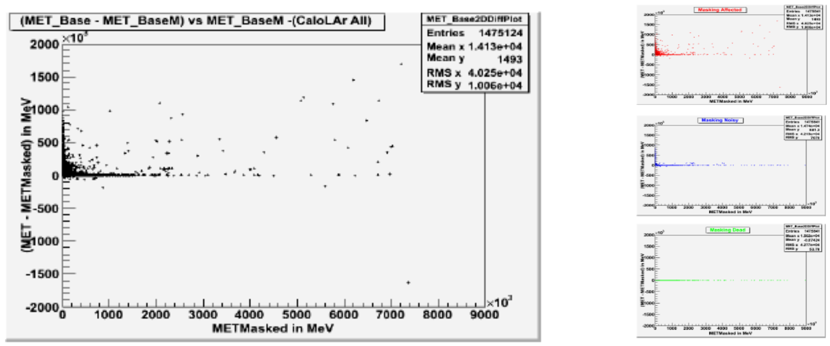

Figure 2. Shift in MET_Base after masking vs. masked MET_Base. Masking all bad channels (left). Masking all bad channels labeled as 'affected' (upper right). Masking all bad channels labeled as 'noisy' (middle right). Masking all bad channels labeled as 'dead' (lower right).

The Effect of Masking at the Sub-detector level:

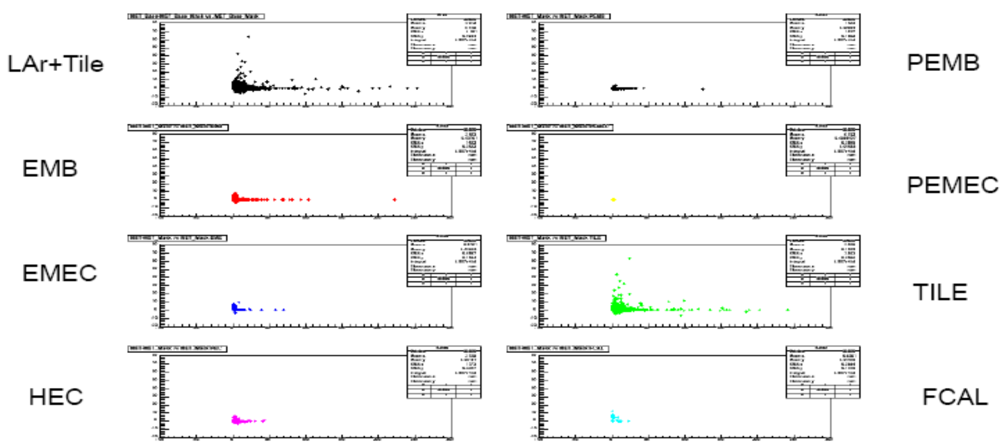

Figure 3. Shift in MET_Base after masking vs. masked MET_Base for the various sub-detectors within the calorimeter in run 90525)

An initial examination into the effect of the various bad channel masking configurations at the sub-detector level has been performed on run 90525. The extension of this investigation to the full cosmic dataset is currently underway. Our preliminary results, seen in Figure 3, suggest that large shifts in MET values tend to primarily arise from masking affected channels in the tile calorimeter. It should, however, be noted that bad channels in the tile calorimeter are either masked or given an 'isAffected' status. There are no channels labeled as noisy or dead in the tile calorimeter. The 'isAffected' status in the tile calorimeter implies that one of the two readout channels for a given tile cell has been assigned an 'isBad' status, in wich case the readout from the unaffected channel is used twice. If both readout channels are in an 'isBad' state, the response of that cell is set to zero. Channels get an 'isBad' status if they have any of the following flags: 'AdcDead', 'DataCorruption', 'VeryLargeHfNoise', 'NoData', 'WrongDspConfig', 'NoPmt', 'NoHV', 'WrongHV'.

Future Plans:

We are currently begining the extension of our analysis to the full March 2009 reprocessed cosmic dataset. This extension should enable us to further examine the effect of the various masking configurations at the sub-detector level in order to see if the tile calorimeter is indeed responsible for the large MET shifts that have been observed. Furthermore, we will be able to separate out the effect of masking in the LAr calorimeter which may currently be drowned out by the more dramatic effects from the tile calorimeter. Ultimately, we hope to be able to understand the best use of the METCellMaskTool for future MET studies.

Our large scale analysis will allow us to study general calorimeter based pathologies and further investigate events with TeV range MET values in greater detail.