

Summary of HCAL Noise Filters

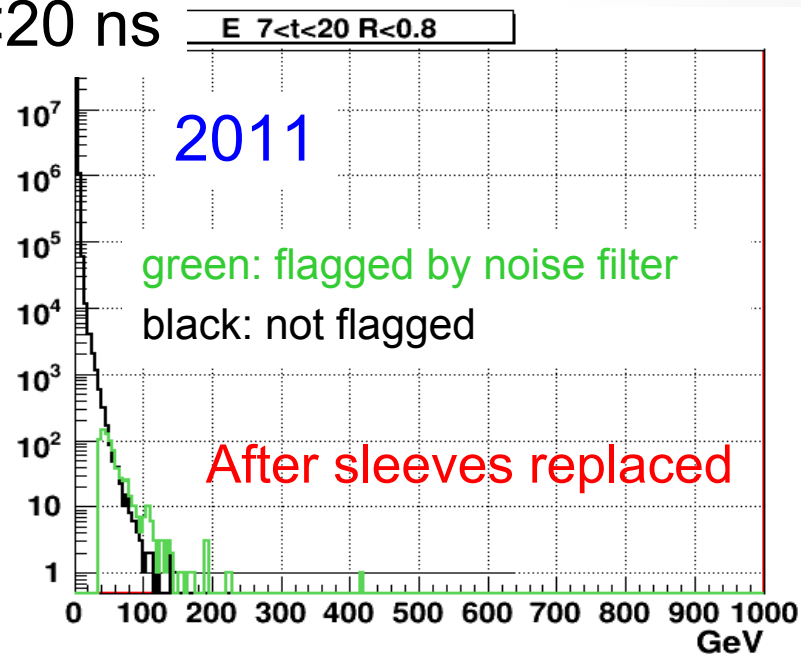
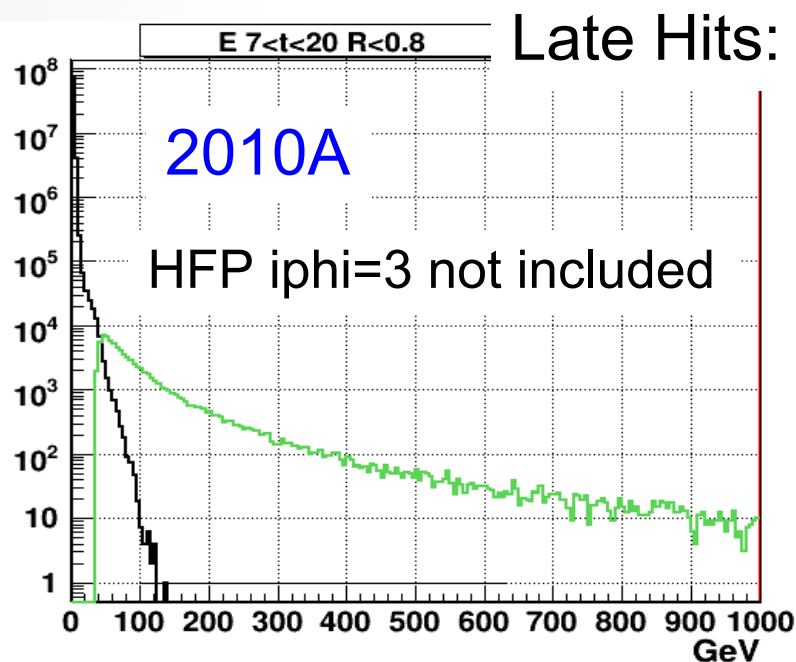
Yi Chen (*Caltech*)
**Representing work of
HCAL noise WG and DPG**

Outline

- Several sources of HCAL noise present:
 - **Noise in HF**: three main sources: 1) scintillation light produced in the light guide sleeves, 2) Cherenkov light in PMTs, 3) and punch-through particles hitting the PMTs.
 - **Noise in HBHE**: from one channel up to HPD (*18 channels*) or RBX (*72 channels*)
- Will summarize various noise identification and rejection algos developed by HCAL noise WG and DPG
 - Also, some software and hardware modifications to reduce noise in HF
- Noise filters applied at various stages
 - **HLT** – HF **rechit cleaning**, and HBHE **event rejection**: some of the HLT paths suffer from noise rates
 - **RECO-level** – HF rechit cleaning: CaloTowers made using cleaned rechits
 - **User analysis-level** – HBHE **event filter**: user can reject noise events with HPD/RBX-type noise
- **Available soon**: HBHE rechit cleaning at RECO-level using fit-based discriminants
 - Parameters updated in 4.3 and will backported in 4.2, are not turned on in default RECO

HF Noise in 2011

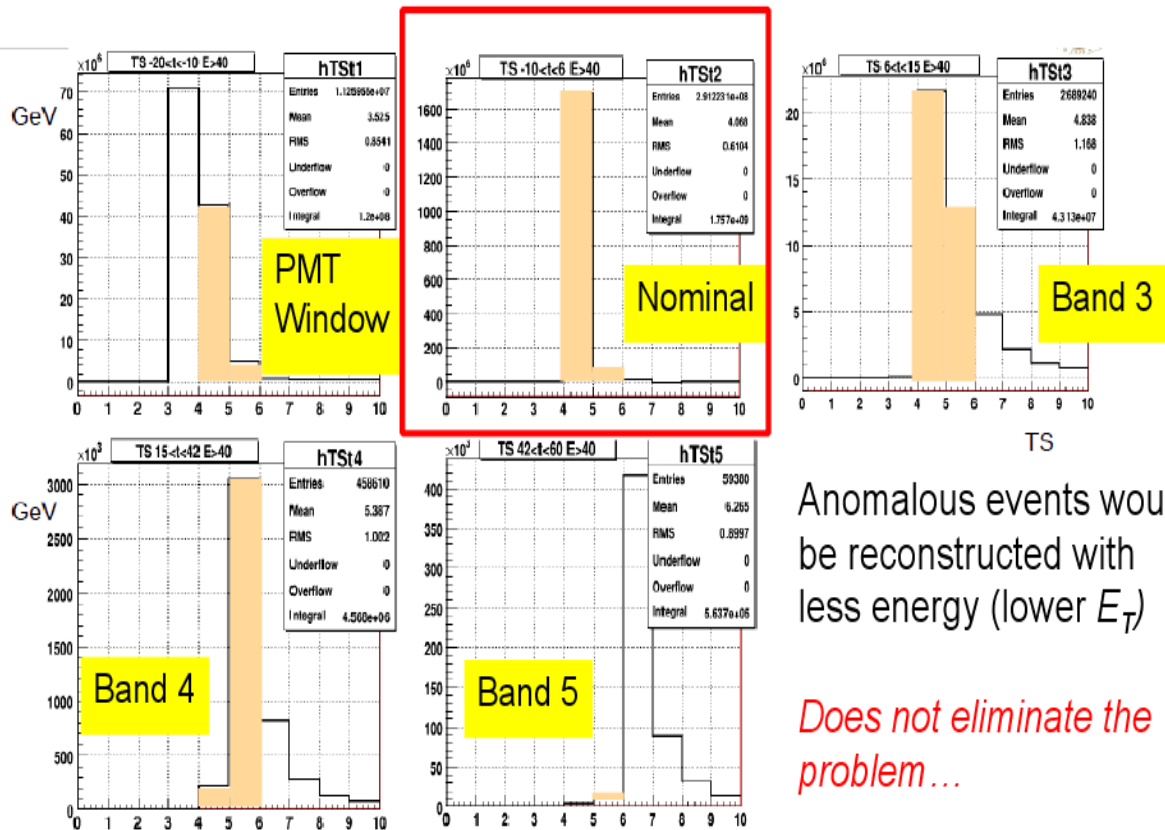
- The noise environment in 2011 is different than in 2010
 - Replaced the light guide sleeves: **reduce late noise from scintillation light**
 - Using 2TS for the energy reconstruction in HF: **reduce late and early PMT noise**
 - 50ns bunch spacing: use 2TS for HF rechit energy reco-> **reduce effect from OOT PU**
 - BX-1 veto being used: early HF noise can cause pre-triggers
- Noise identification algos have been updated with the above in mind



HF Noise in 2011

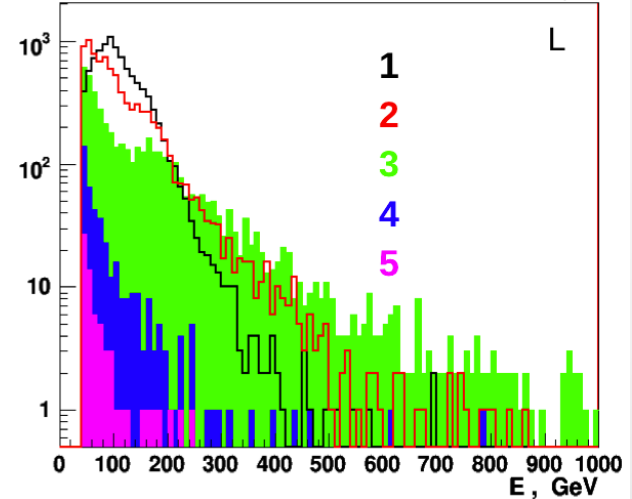
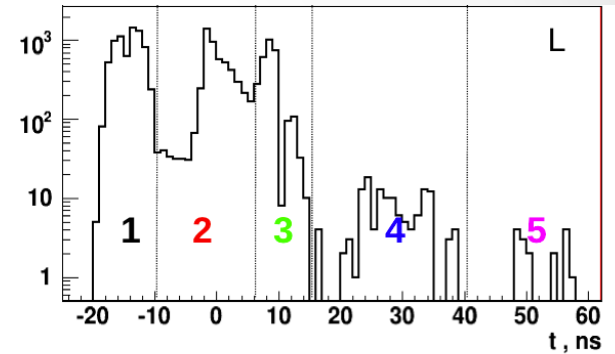
Since Jan 2011 we are using 2TS instead of 4TS for HF energy reconstruction

Less sensitive to anomalous signals and out of time pileup



Anomalous events would be reconstructed with less energy (lower E_T)

Does not eliminate the problem...



Time distribution in HF and the energy spectrum of various bands

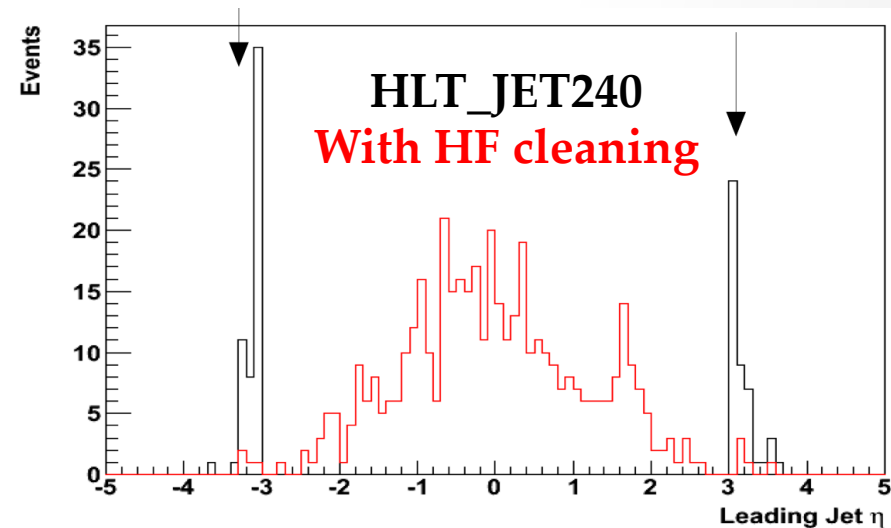
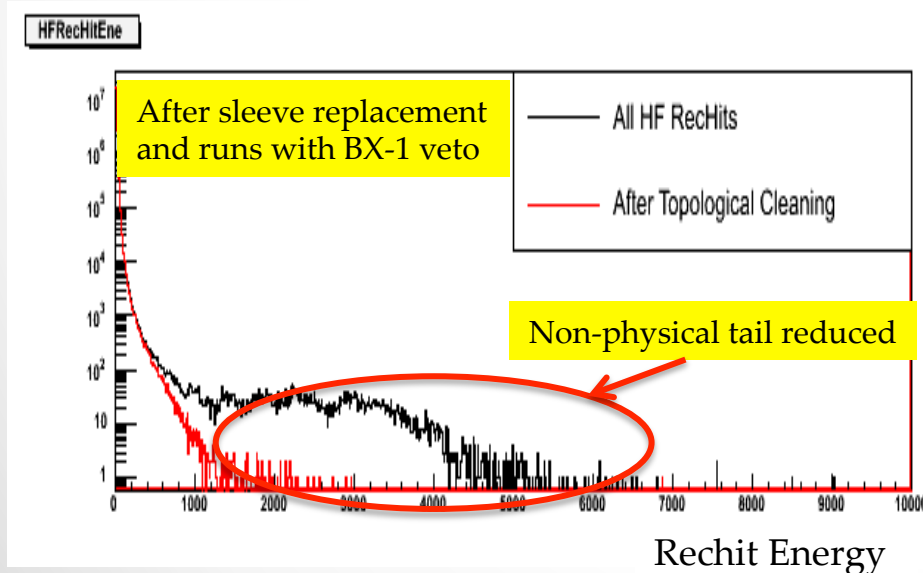
Part 1

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Noise treatment at HLT

HF rechit cleaning

- Was reported at TSG that the jet triggers were picking up HF noise, and threatening physics.
 - E.g. <https://indico.cern.ch/getFile.py/access?contribId=6&sessionId=0&resId=1&materialId=slides&confId=120350>
- We have implemented the HF noise cleaning at the HLT
 - Use only topological rechit cleaning at the moment
 - Details of the algorithm used are at [1].
- Same setting as last year – safe from effects of OOT pileup
- Remove rechits from CaloTowers
 - Any trigger that uses HF will be affected
 - Deployed after the switch to CMSSW 4.2, no problems so far



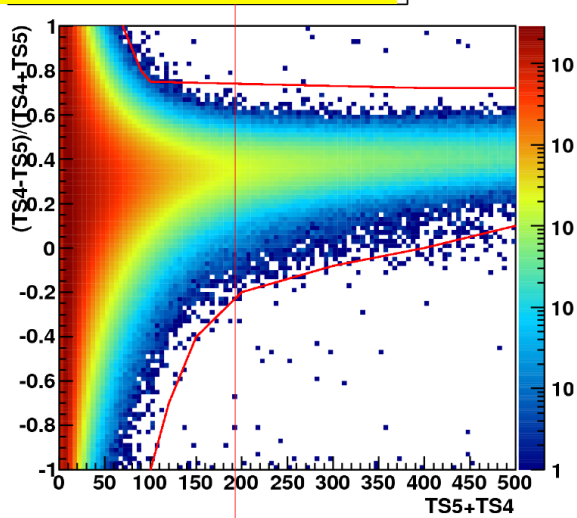
HBHE event filtering

- Purity in MET triggers is low, causing physics triggers to be pre-scaled
 - See e.g.:
<https://indico.cern.ch/getFile.py/access?resId=1&materialId=slides&contribId=10&sessionId=0&subContId=0&confId=132231>
- The existing noise event filter from last year ("*ICHEP filter*") is sensitive to OOT PU in 50ns data (because uses E2/E10)
 - We designed a new variable based on only in-time energy deposits
 - This algorithm is similar to the filter used in offline analysis, i.e. **rejects events**
- Currently implemented as "*commissioning*" triggers together with original MET triggers
 - No harm could be done, no extra bandwidth consumed
 - Once people are confident, drop the original MET triggers
 - Paths: HLT_METXXX_HBHENoiseFiltered_v1 (100, 120, 200)
- Additional "activity-gating" to protect collision events
 - If there are more than two RBX having energy greater than 10 GeV, keep the event regardless of the filter

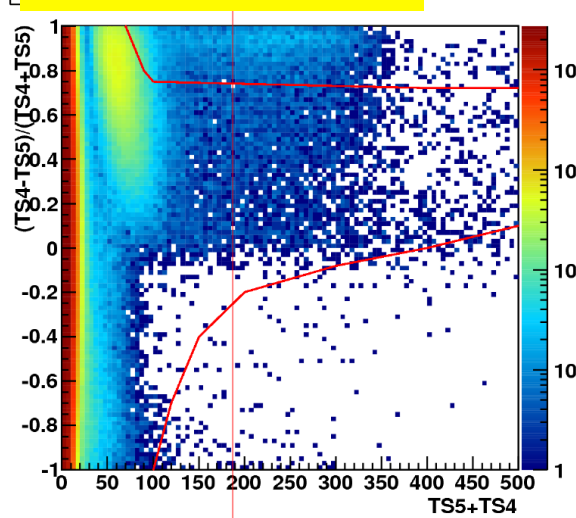
HBHE event filtering

- The filter cuts on:
 - R45**, formed by the in-time energy only, if energy of readout box at least 50 GeV
 - Number of hits in an HPD
 - Number of hits in an HPD if there is no other activity in the readout box
 - Number of ADC0 counts in readout boxes that have non-negligible energy
- Efficiency is ~50% for rejecting noise events

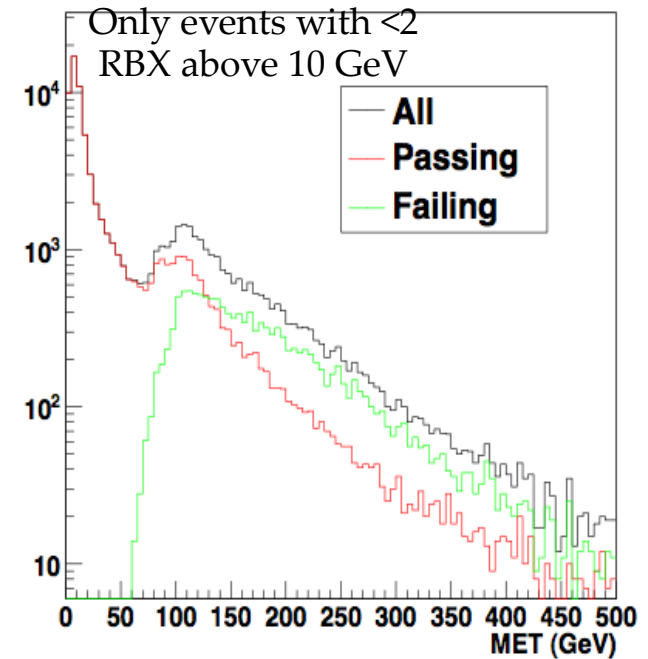
R45 in MinBias sample



R45 in Noise dataset



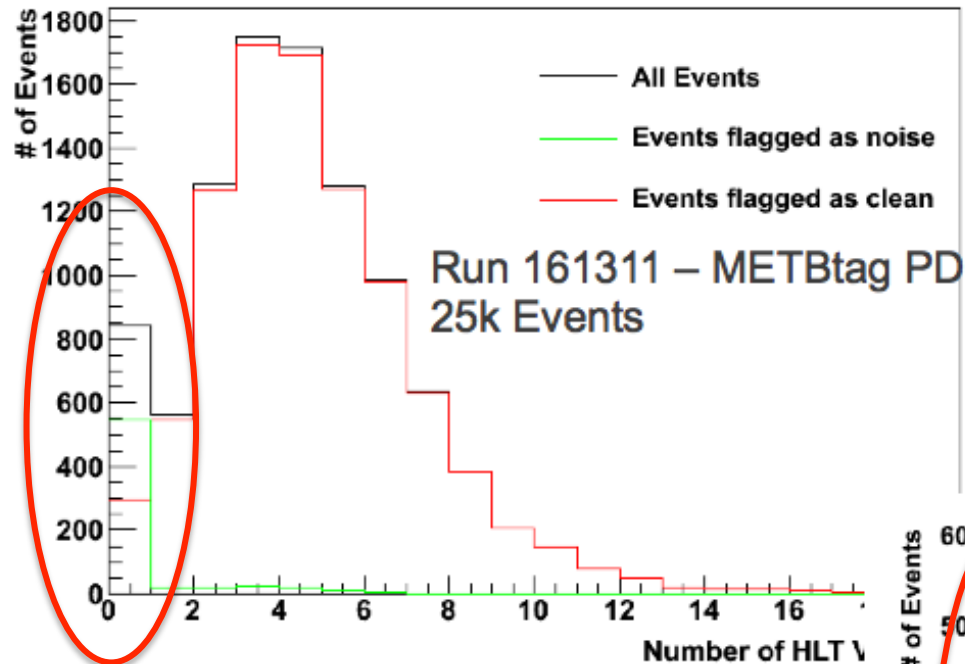
MET constructed from HBHE rechits



- Distribution of R45 variable used in the filter
 - Events outside the cut envelope are rejected

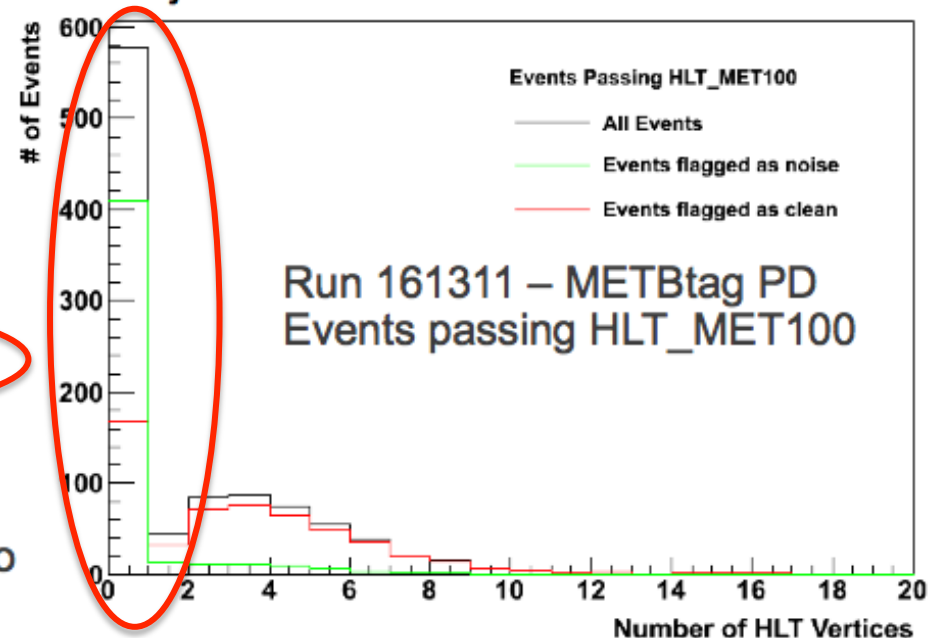


Online Filter Performance



- Events where the HLT was not able to reconstruct a vertex are mostly triggered on noise (from many sources)
 - Filter rejects 70% of events in this bin
- Filters with a reconstructed vertex are generally noise coincident with a real interaction
 - For safety, the online filter is designed to keep most of these events

- Events are checked with the following criteria:
 - Any RBX failing R45 with > 50 GeV
 - Any RBX with > 10 ADC zero and > 10 GeV
 - Any HPD with > 16 hits above 1.5 GeV
 - Any HPD with > 9 hits above 1.5 GeV and no hits in other HPD in RBX
- If any of these fail **and** there are at most 2 RBXs with > 10 GeV, then the event is rejected



Part 2

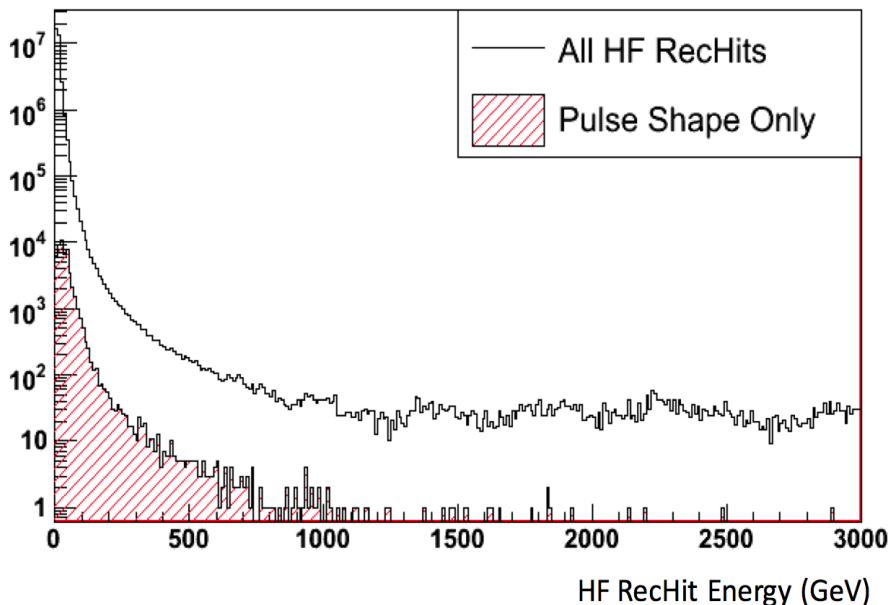
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Noise treatment at RECO-level

HF rechit cleaning

- Clean rechits in RECO: CaloTowers built from cleaned collection
- Enable the pulse-shape based cleaning
 - Topological cleaning is applied at HLT, and also in reco
 - Pulse-shape cleaning uses an updated variable: $TS4/(TS3+TS4+TS5)$:
 - sensitive to early and late hits
- Removes some residual anomalous signals
 - Due to replacing sleeves and 2TS reconstruction in HF reduces noise
 - Efficiency of pulse-shape based algos is reduced due to above changes

HFRecHitEne



Changes in HF (sleeve replacement, 2TS E reco) reduce the rate of noise that was previously removed by the pulse shape filter

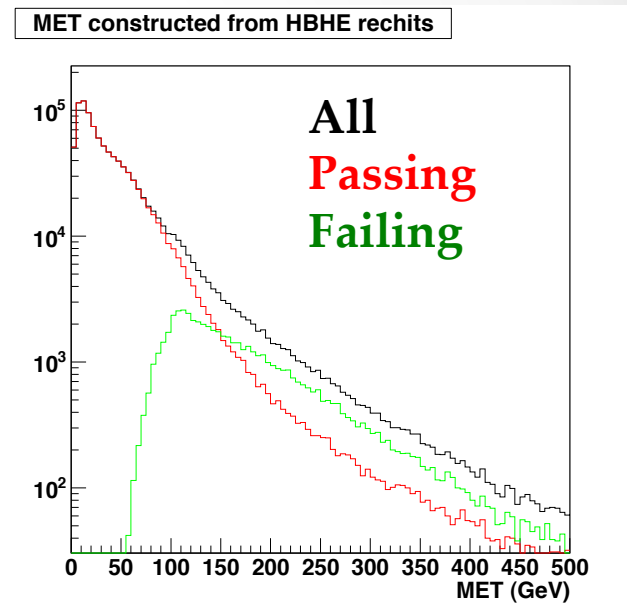
Part 3

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Analysis-level event filter

HBHE user event filter

- Identical to the HLT filter, except with no activity-gating
- Algorithm will flag events as noisy
 - Running the filter on MC ttbar events does not reject any events (out of 10K RelVal sample)
 - Pulse shape in MC is not well modeled, so the check in data is the most relevant one (p.8)
- The flag is stored in the HcalNoiseSummary object
 - HcalNoiseSummary object is available in RECO and AOD
 - Code infrastructure is ready since CMSSW422
 - Instructions to use the filter are at:
<https://twiki.cern.ch/twiki/bin/view/CMS/HBHEAnomalousSignals2011>
- Analyzers are recommended to reject events flagged by this algorithm from their analysis
 - Same as was done last year using the “ICHEP filter”
 - “2011 HBHE event filter”



MET distribution in
METBtag dataset

Summary on available cleaning

- Everything presented so far is available now, CMSSW4.2.2
- **HLT**
 1. HF **HLT** topological noise rechit **cleaning**
 2. HBHE **HLT** event filter – three MET triggers
- **RECO**
 1. HF **reco-level** noise rechit **cleaning** (*topological+pulse-shape*)
- **User level**
 1. HBHE **user level** noise event filter
 2. <https://twiki.cern.ch/twiki/bin/view/CMS/HBHEAnomalousSignals2011>

Part 4

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Pulse-shape based rechit cleaning

Fit-based algos for HBHE

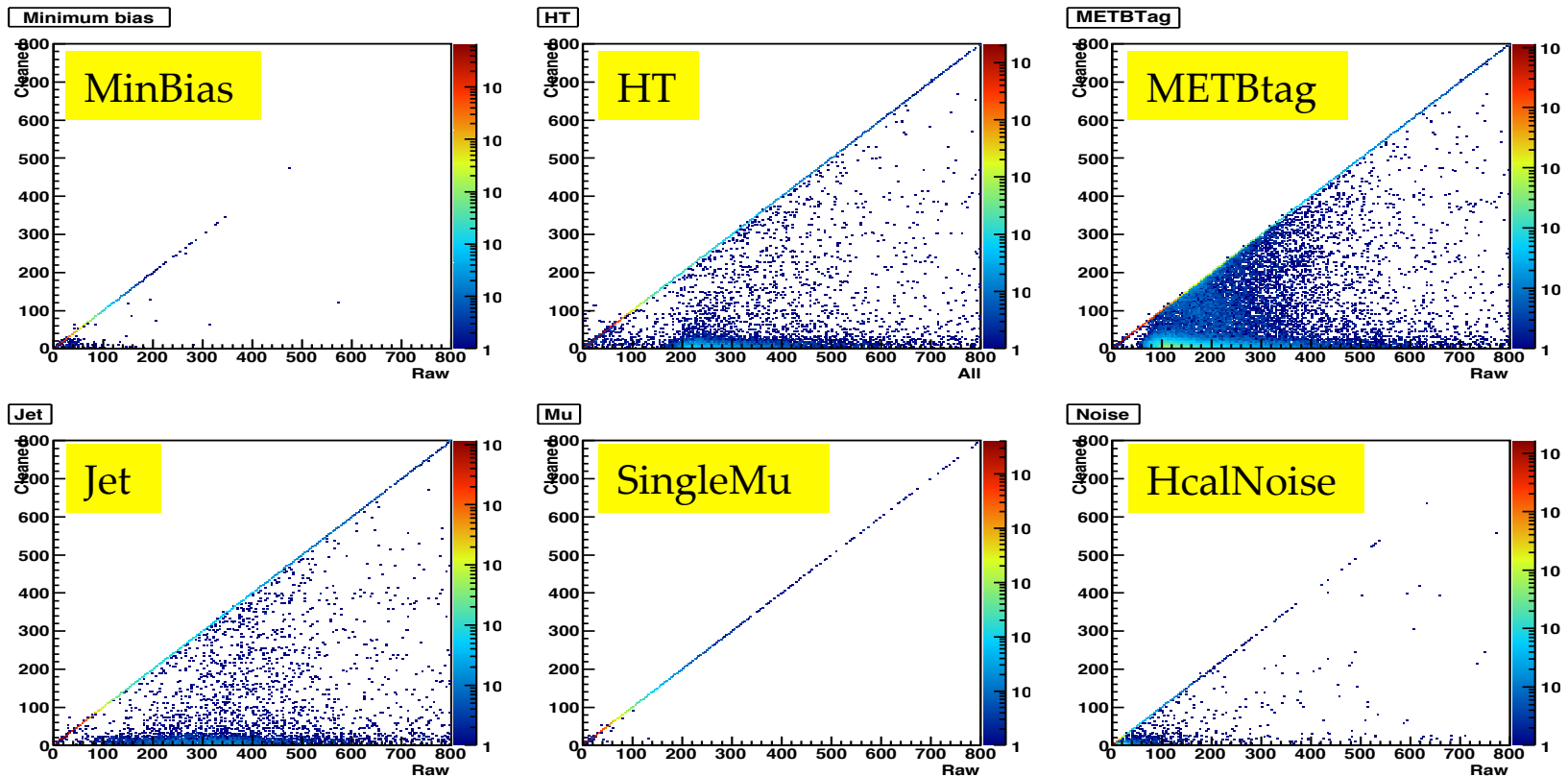
- “2011 HBHE event filter” is ~50% efficient
 - There is still residual noise left
- Use pulse shape information to clean the residual noise
 - **Fit to the pulses** and see if the result is compatible with signal
 - Compare pulses with good pulse shape and to noise hypotheses. If too close to noise hypotheses, **reject the rechit**
- The algorithms will pick out pulses that are very different wrt to good pulse
 - Designed to pick out noise that **can not be caught otherwise**
 - **Complementary** to topology-based and JetID filters for HBHE
- The algorithms will clean rechits (a la ECAL or HF noise)
 - CaloTowers will be built on top of cleaned rechit collections
- Tuned using 2011 data with 50ns.
 - Same settings also work for 75ns and 150ns data

Fit-based algos for HBHE

- Flags have been in default reco since 4.2.0,
 - Severity level currently not high enough for rechits to be excluded from Calotowers/PF rechits
- We are now collecting wide feedback from JetMET POG
 - Algorithm were validated by HCAL noise WG and DPG
 - MET scanners team could be enormous help in commissioning this cleaning
 - Would like to enable the cleaning, once POG and PAGs endorse it as well
- Enable cleaning in 430pre6 release to validate performance with standard relvals on data and MC
 - Once checked, we can backport to 42X patch release
- Summary values (number of cleaned rechits and their total energy) are stored in the HcalNoiseSummary object.
 - Available in RECO/AOD

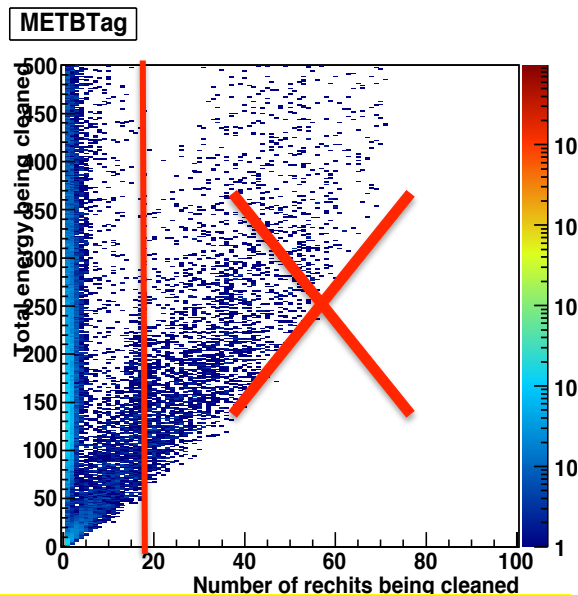
Performance of fit-based algos

- Performance of the cleaning checked in several datasets
 - MinBias, HT, METBtag, Jet, SingleMuon, Noise
- Plots below compare MET with all rechits (x-axis) VS MET using only good rechits (y-axis)
 - MET reduced dramatically in noise events
 - Very small rate of over-cleaning (events above diagonal): $< 0.01\%$

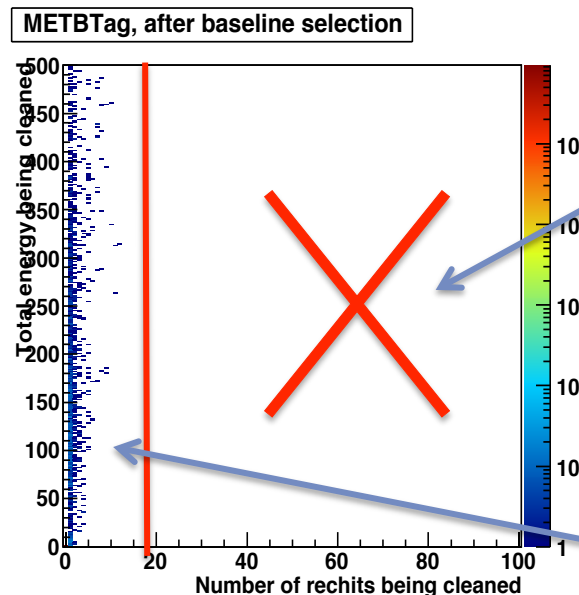


Fit-based algos for HBHE

- As indicated by failure scenario studies by the JetMET group, effect of 18-channel failure is small, while 72-channel failure is non-negligible.
 - <https://indico.cern.ch/getFile.py/access?contribId=33&resId=1&materialId=slides&confId=134144>
- People can choose to drop event if there are too many rechits being cleaned.
 - We propose to set the limit at **18** channels (1 HPD) (as shown in the plots below).
 - This limit is configurable at analysis-level



Total cleaned energy vs # of removed rechits (before applying HBHE event filter)



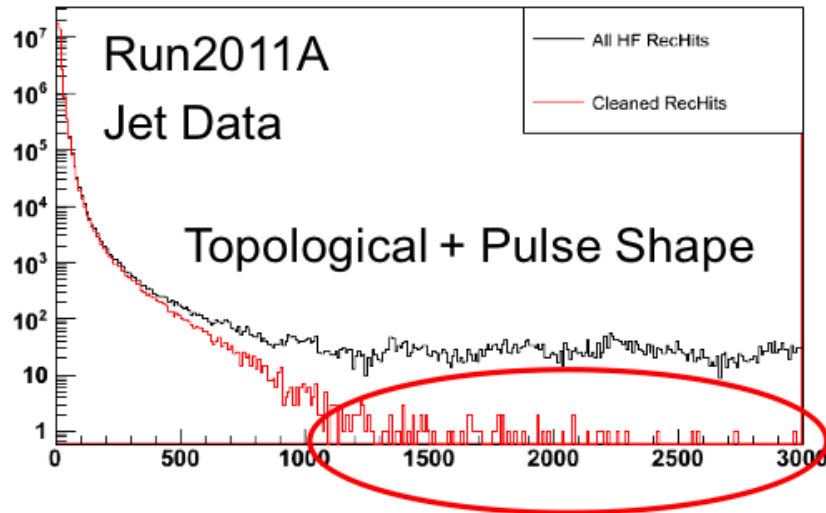
Total cleaned energy vs # of removed rechits (**after** applying HBHE event filter)

After “2011 HBHE event filter”, it’s very rare for an event to have high- multiplicity noise

We will be able to clean residual low-multiplicity noise

Residual Noise

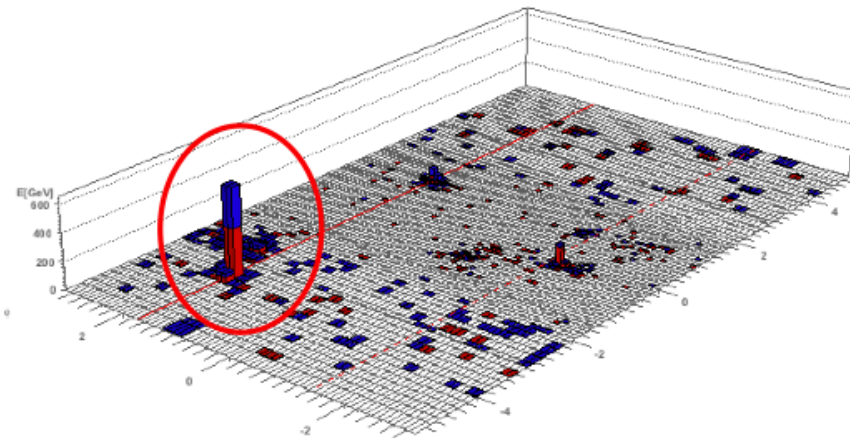
HFRecHitEne



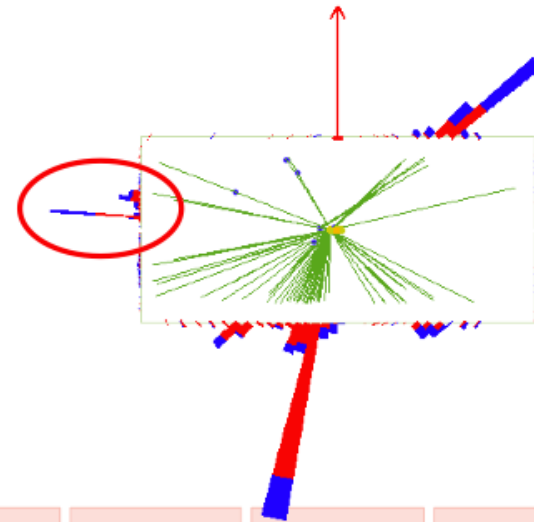
Residual noise after applying the HF filters will be tricky to remove

Scanned events with RecHit $E > 1000$ GeV

High energy multi-hit events can be mixed in with collision data



Develop more aggressive filtering



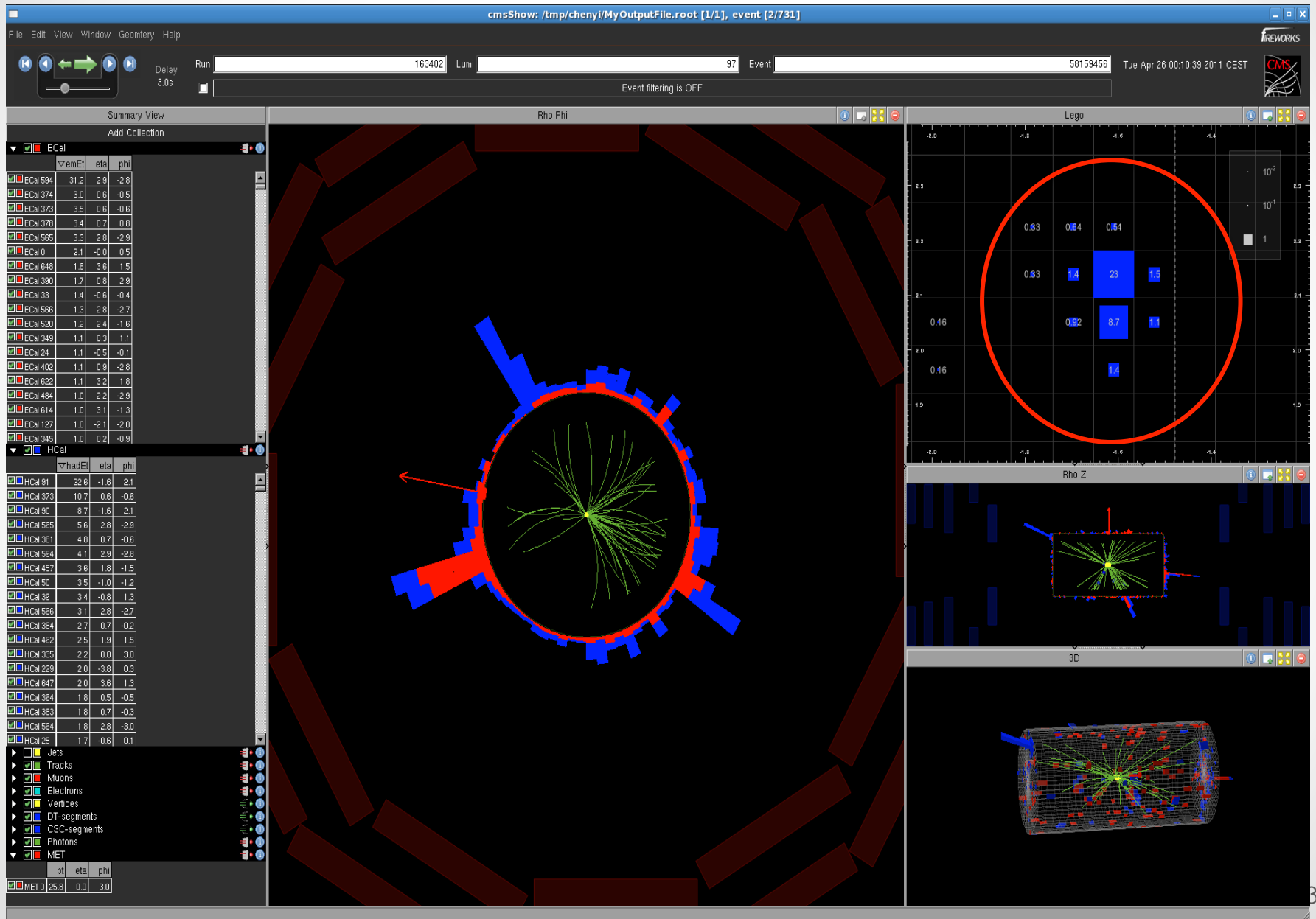
Summary

- A set of suggestions is presented for
 - **HF HLT cleaning** (topological) –deployed now
 - **HBHE HLT filter** – deployed now in a few backup triggers
 - **HF reconstruction-level cleaning** (topological+pulse-shape)– is turned on now
 - **HBHE user level noise filter** – already included in the reconstruction – available for people to use
 - **HBHE fit-based residual noise cleaning** – started to be checked by groups interested in using the filter: earliest to get in default reco is 4.3/4.4
- **Provided** JetMET/PF POGs/PAGs are ready to enable the filter, we could provide instructions so that users can re-reco on the fly with cleaning using fit-based flags
 - 4.2 rereco with fit-based cleaning enabled is not going to happen
 - Earliest re-reco with this cleaning enabled is 4.3 or 4.4
- A note summarizing the fit-based filters is being finalized
 - A summary note of all HCAL noise algorithms will be provided
- For more information, please refer to the Hcal Noise WG twiki
 - <https://twiki.cern.ch/twiki/bin/view/CMS/HCALNoiseWG2010>

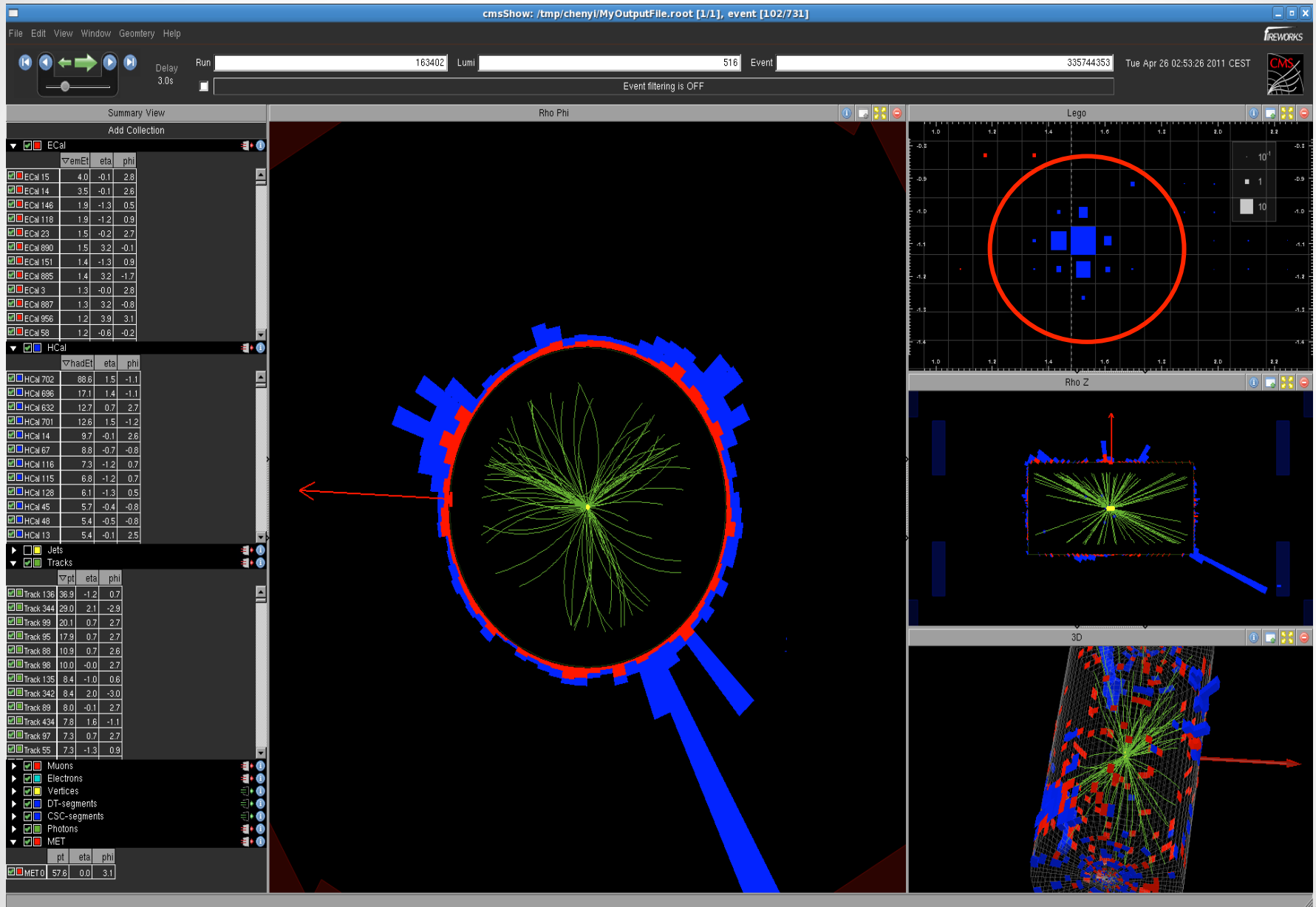
Isolation based filter

- An isolation based filter was developed last year to reject HBHE noise events
 - May be overagressive in rejecting events
 - Uses E2/E10 as one of the variables (E10 integrates 10TS, 250ns)
 - Isolation may be sensitive to OOT PU in HBHE, where we use 4TS to reco energy
- We replaced the E2/E10 with R45 variable from the new filter
 - Check if with this setting the filter is safe
 - The updated filter would be the “2011 HBHE baseline filter” + isolation
 - Isolation means there are
 - >10 isolated rechits **OR** the energy of removed rechits is >50GeV (or ET>25)
- A few event displays of rejected events on the next slides
 - There are some events that are not obvious noise events, algorithm may need to be retuned

Event 1



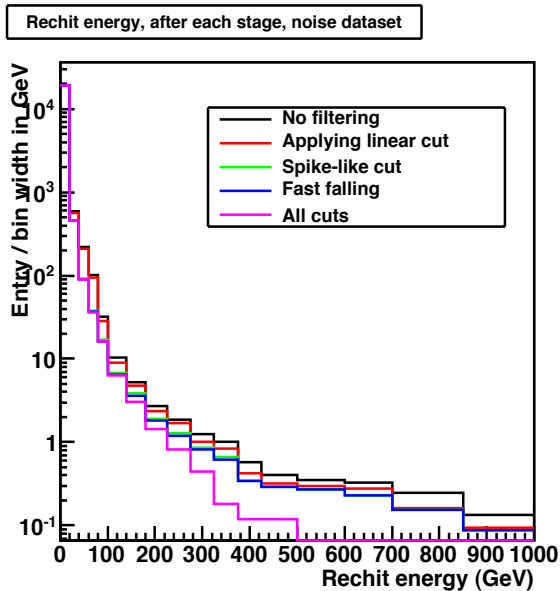
Event 2



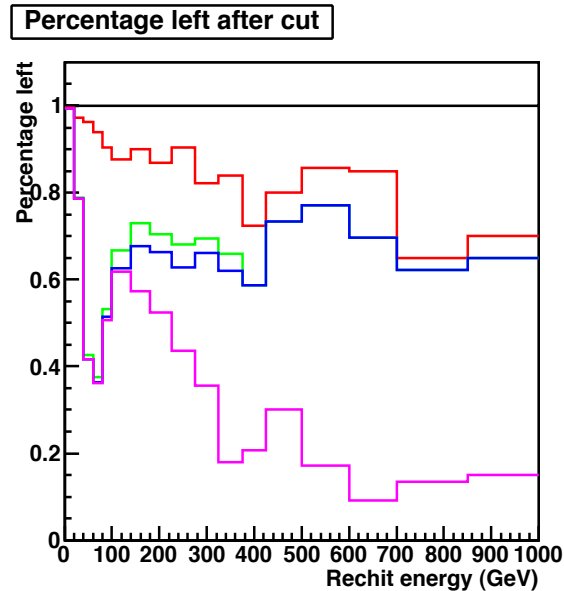
Backup

Performance of fit-based algos

Noise dataset



Noise dataset



METBtag

