
# CRAFT Analysis - ECAL & HCAL

## - Calibration and Cleaning -

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**U. of Maryland**

**04-August-2009**

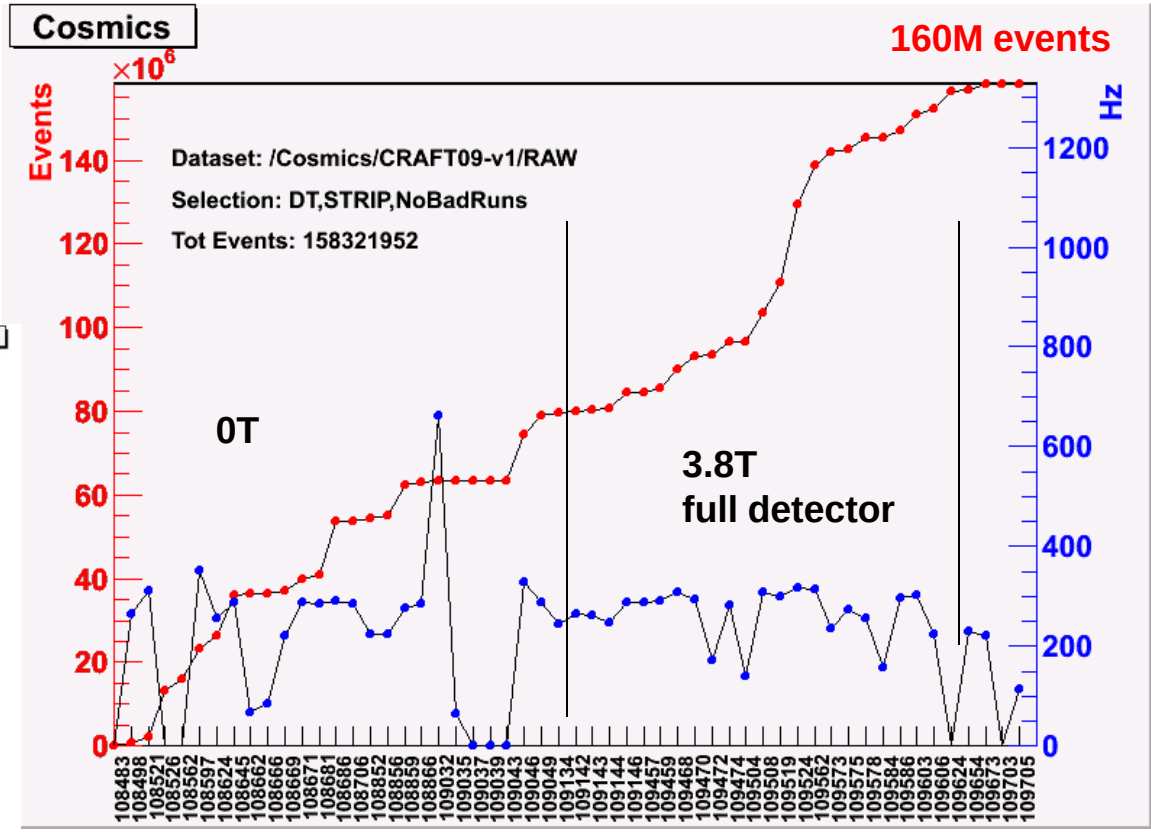
# CRAFT09

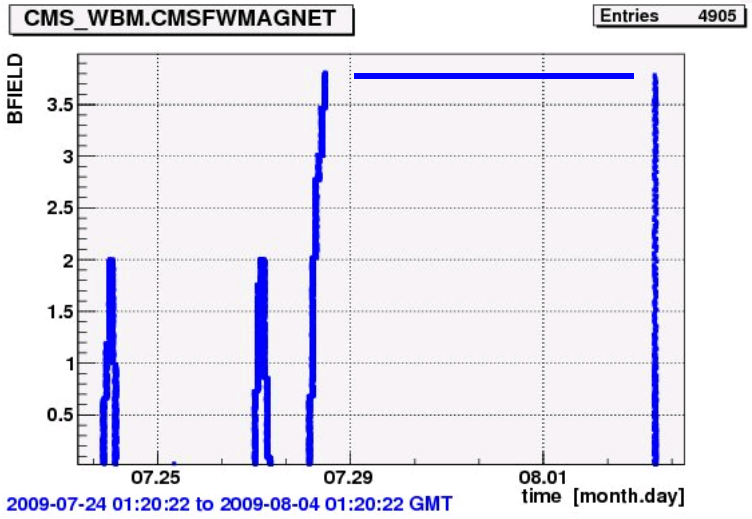
**3.8T 2009.07.28 15:28:09**

**R109011 first run at 3.8 T**
**Hcal Self Tigger**
**R109134 full detector**
**R109524 16 h 40 min**

**R109624 last run before pwr cut**
**Power cut 2009.08.03 14:19:09**

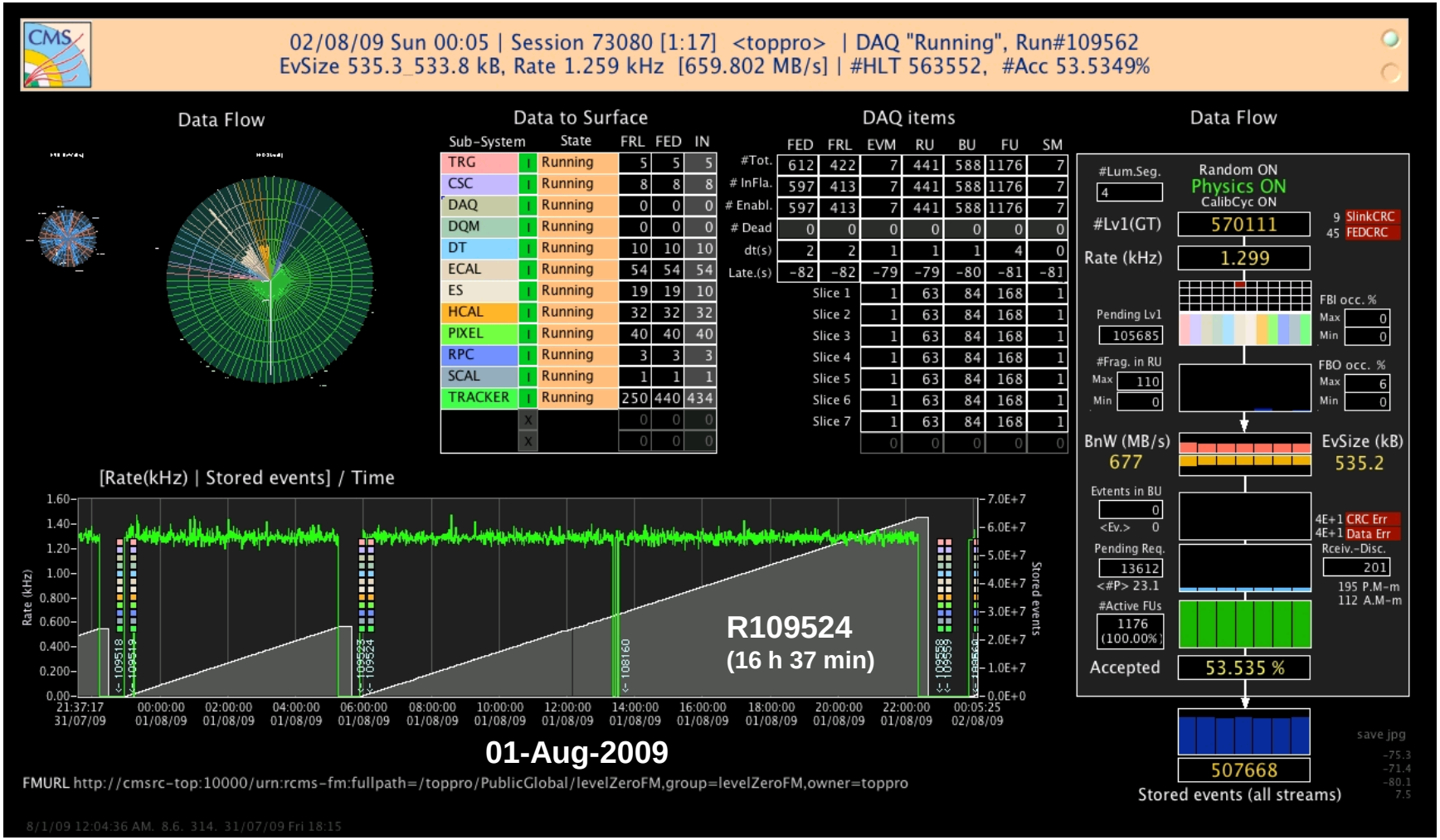
## Muon Data




**CRAFT09 Analysis Info** https://twiki.cern.ch/twiki/bin/view/CMS/CRAFT09AnalysisInfo
**statistics** http://malgeril.web.cern.ch/malgeril/coll_stats_craft09/collcosm.html

# DAQ Status / ~26h history



# CRAFT Data Taking

**LHC Orbit - total 3564 bx's**

**bx 0000 - 3445 Physics**

**2835 bx filled with protons**

**Triggers: jets, MET, HT, egamma, muons**

**611 bx empty, usable for R-hadrons physics**

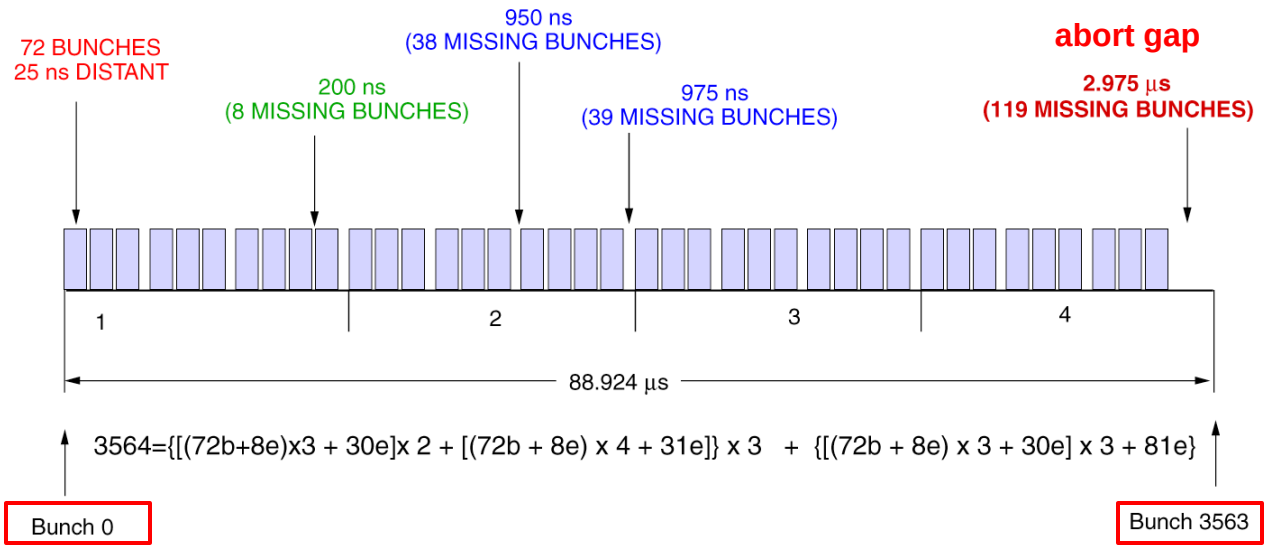
**bx 3446 - 3564 Abort gap (total 119)**

**84 bx for physics, e.g. R-hadron physics**

**35 bx for calbration**

**ECAL - pedestal, test pulse, laser data (100Hz)**

**HCAL - pedestal (2Hz), laser (every 10 min.)**

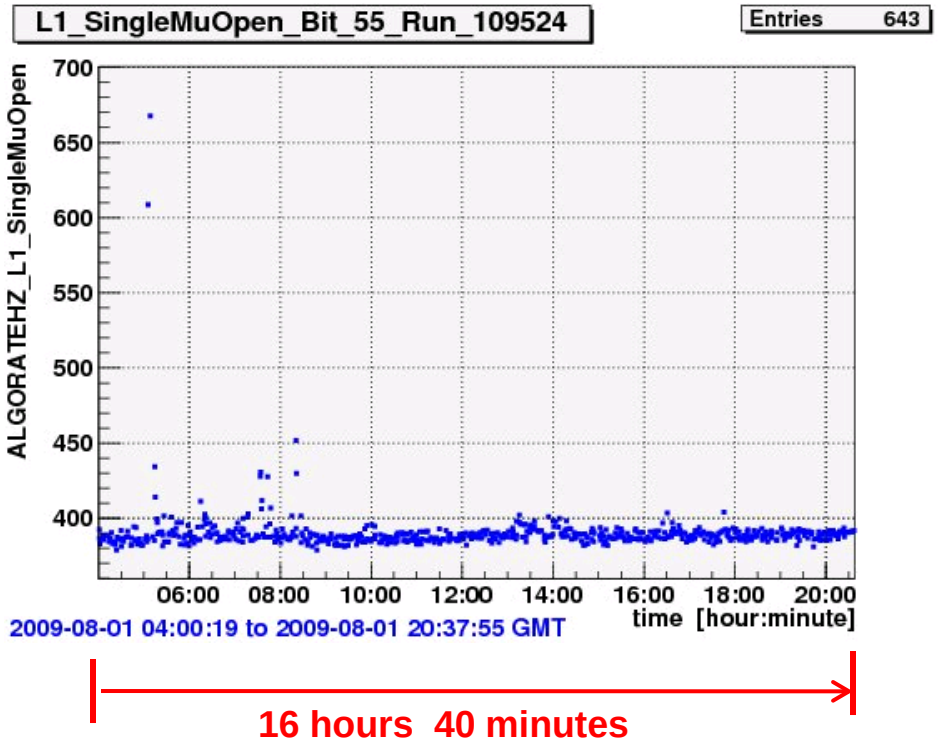



**LHC Startup Plan**

**2 x 2 bx's**
**43 x 43 bx's**
**156 x 156 bx's**

# Triggers in Craft

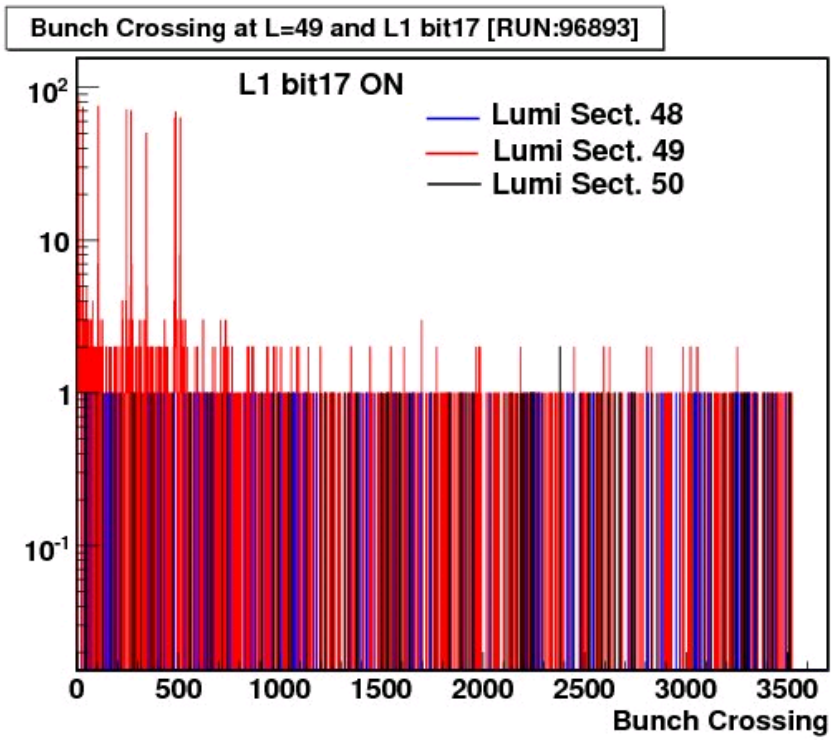
## Muon Trigger Rates (Hz) vs Lumi Segments




**each point : One lumi segments**

**one lumi segments = 2^20 LHC orbits**
**= 25 nsec x 3564 bx's x 2^20 orbits**
**= 93.4 seconds**

## Jet 20 Trigger vs Bunch crossing number

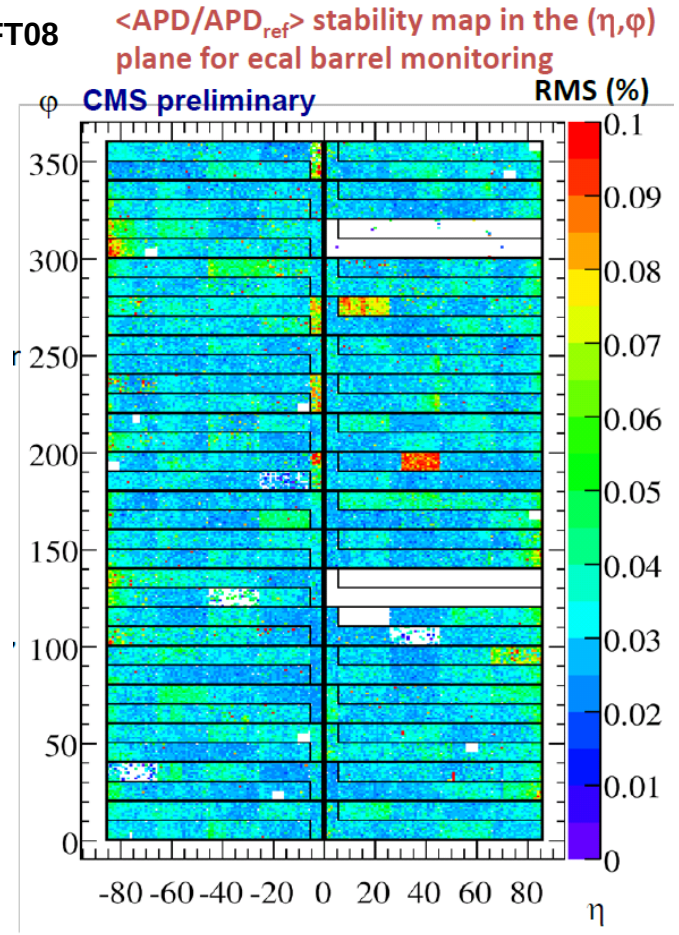



**Several spikes seen in jet trigger rates at early bx's in this MWGR, R96893.**

# Abort Gap Data

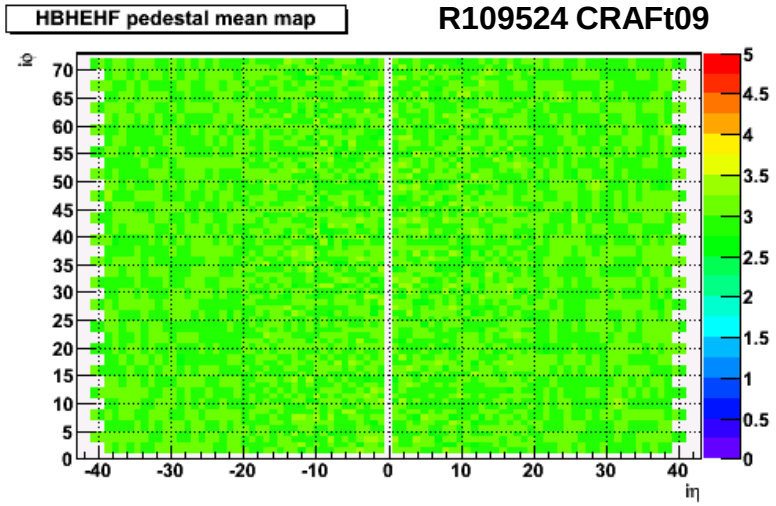
## ECAL Laser Monitoring

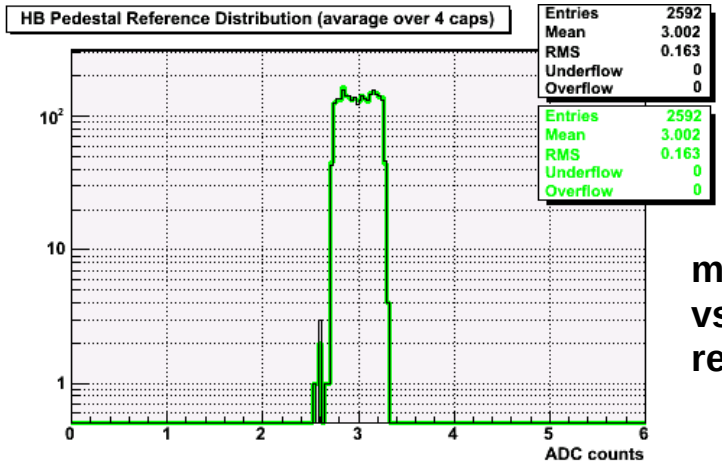
CRAFT08




- Stability better than 1% for most of channel.
- Use diodes (PN) for reference in CRAFT09.

## HCAL Pedestal



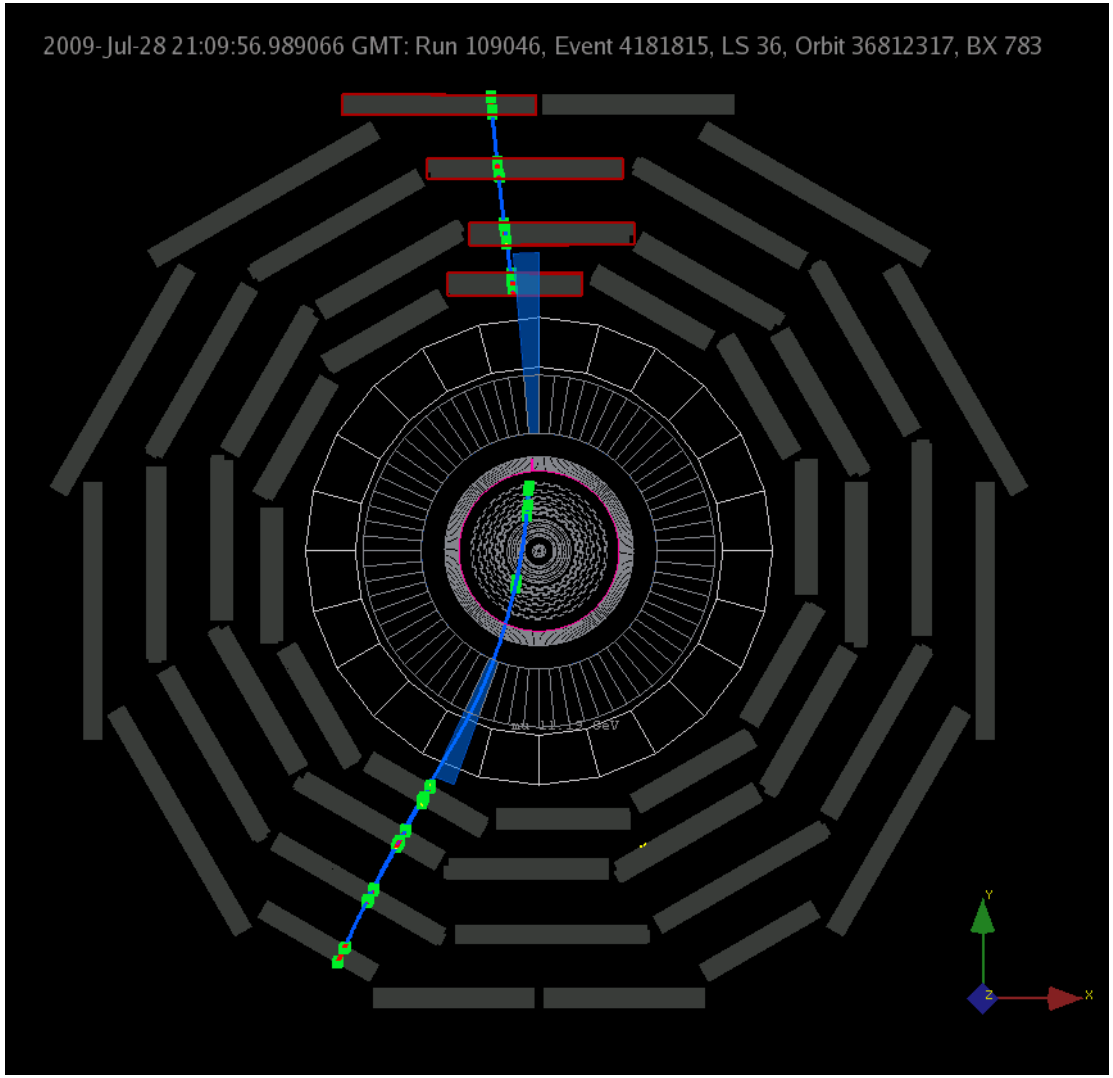




Dataset (TestEnables) - HCAL gap data

# Triggers and Datasets

| L1 bits and name (bold: enabled) | | HLT | Dataset | Analysis |
|---|---|---|---|---|
| **(55) L1_SingleMuOpen** | **390.2 Hz** | **HLT_L1MuOpen** | **Cosmics** | **Alignment Energy scale** |
| **(62) L1_SingleMu10** | **214.9** | **HLT_L1MU20** | | |
| **(45) L1_SingleEG1** | **89.1 Hz** | | **Calo** | |
| (46) L1_SignleEG2 | 3.6 | | | |
| (47) L1_SingleEG5 | 0.3 | | | |
| **(15) L1_SingleJet6U (ps 1/100)** | **9.1 Hz** | **HLT_L1Jet6U** | **Calo** | |
| **(16) L1_SingleJet10U** | **78.0** | **HLT_Jet** | **Calo** | **HCAL Noise Fake MET** |
| (17) L1_SingleJet20U | 9.5 | HLT_Jet30U | | |
| (20) L1_SingleJet50U | 2.3 | | | |
| **(63) L1_ETT60** | **2.3 Hz** | | | |
| **(65) L1_ETM20** | **11.2 Hz** | **HLT_L1MET20** | **Calo** | |
| (69) L1_ETM80 | 1.2 | HLT_MET100 | | |
| **(70) L1_HTT100** | **1 Hz** | **HLT_HT100U** | **Calo** | |

**Trigger Tables:** https://twiki.cern.ch/twiki/bin/view/CMS/TriggerTables **(8E29 V5, Commission)**
**HLT Config Browser:** http://cms-project-confdb-hltdev.web.cern.ch/cms-project-confdb-hltdev/browser/
**(ORCOF/cdaq/cosmic/commissioning/CRAFT/… – find HLT key in Run Summary )**




## Analysis of Cosmic Dataset

- Calo trigger efficiency
- Calo timing mesuremnt
- Calo energy scale

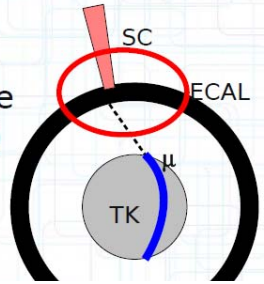
**Need a good matching of muon track and enrgy cluster in the calorimeter.**

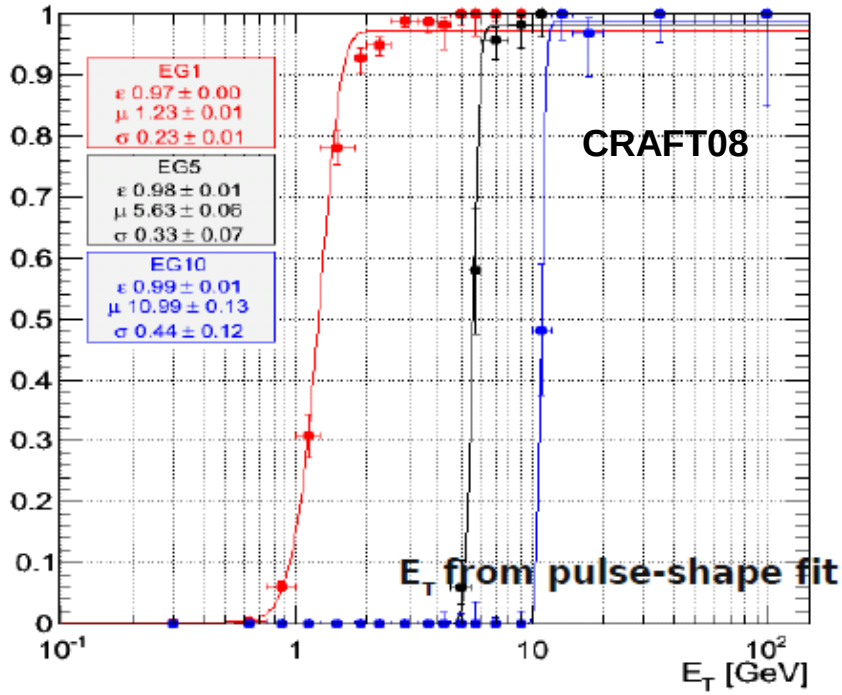
# L1 Trigger Efficiency and Trun-on Curve

## ECAL

Method:

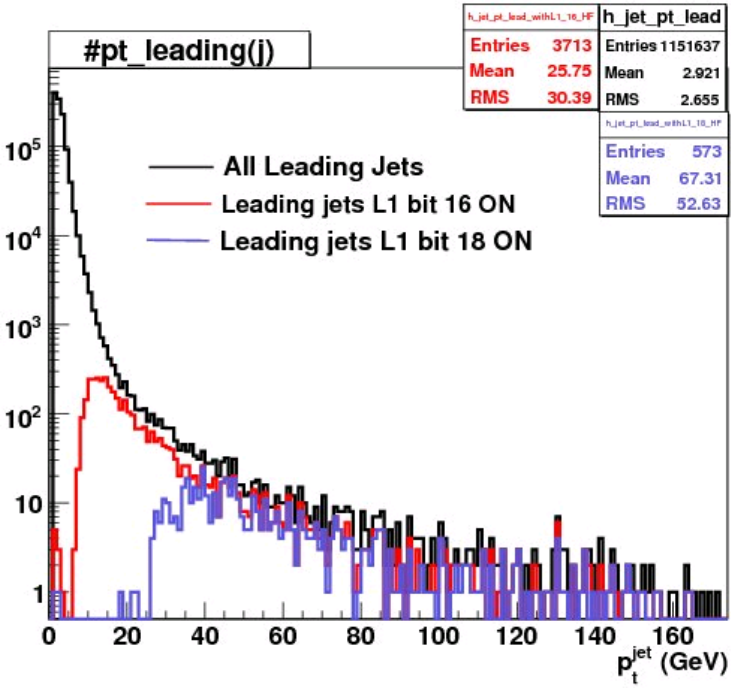
- Look at muon-triggered events
- Look for SuperClusters around the μ tracks extrapolation (denom.)
- Match L1 EG candidates to SuperClusters (numerator)




## HCAL

**Leading jets in muon trigger events vs L1bit**
**CRAFT08 R68021**




**ECAL:** - efficiency plateau at >98%
- shift in turn-on due to different energy scale in L1 and offline.

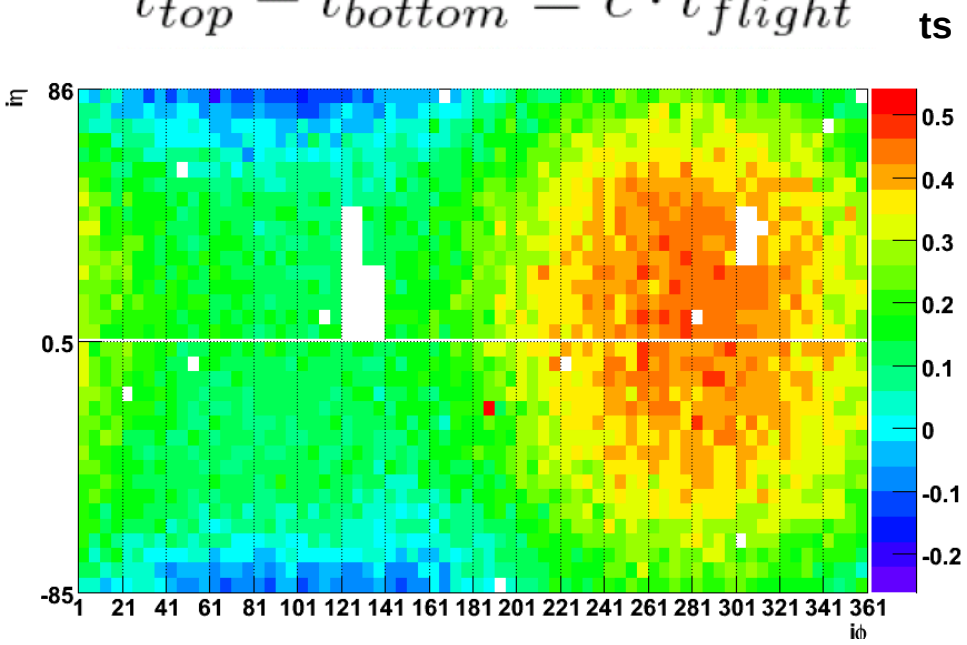
**HCAL:** - low efficiency due to synchronization issue with cosmic muons.

# cosmic muon timing

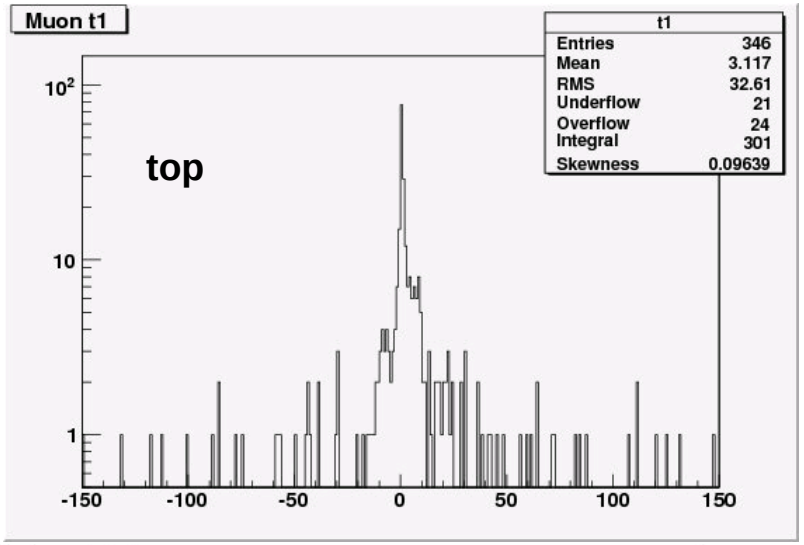
## ECAL Timing

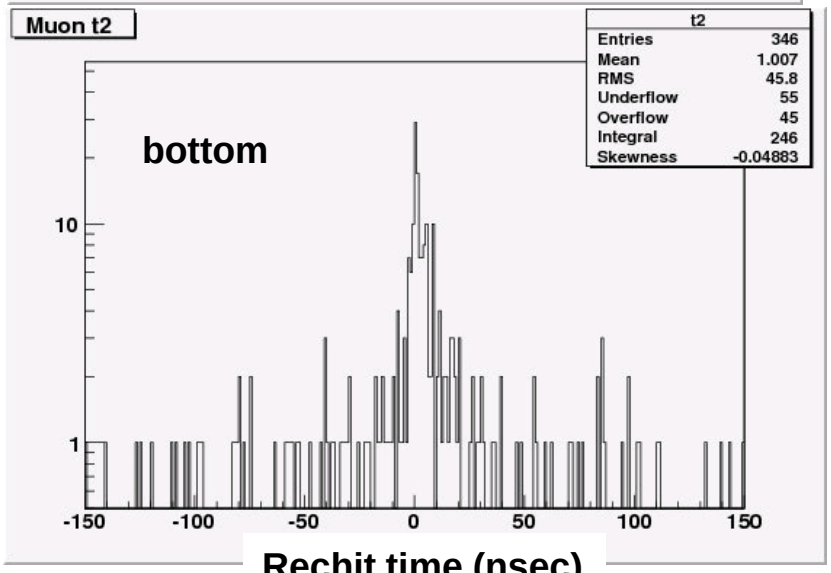
- Average timing of cosmic signal
- Top-bottom difference (t.o.f.)

$$t_{top} - t_{bottom} = c \cdot t_{flight}$$




## HCAL Timing



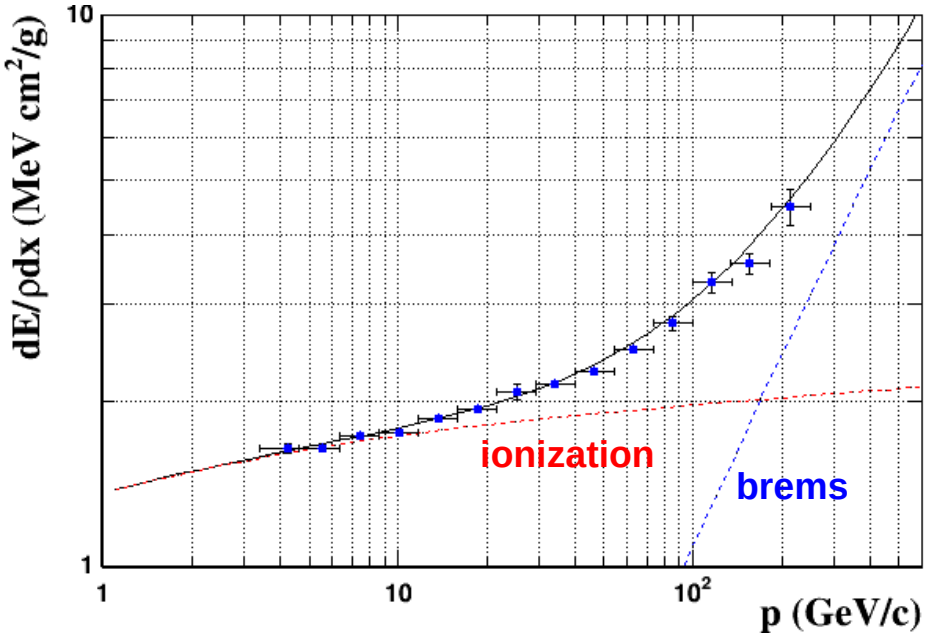




**ECAL timing was set for pp collision.**
**HCAL timing was adjusted for cosmic muons.**

# Validation of Energy Scale

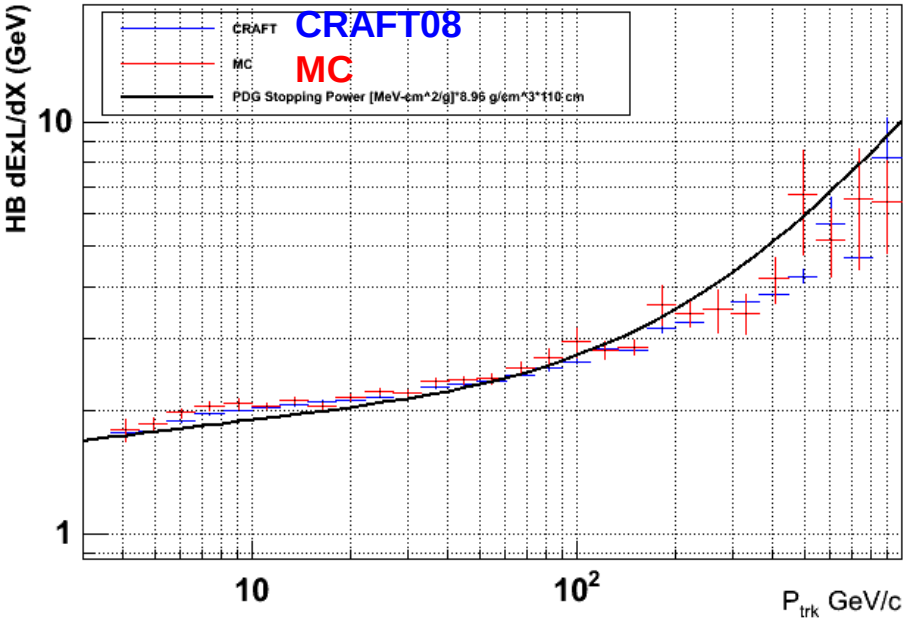
**Reconstructed energy for cosmic muons agree with expected value (MC, Testbeam), i.e. the energy scale in CMSSW Reco is “correct”.**

**ECAL**




**Momentum of muon track**

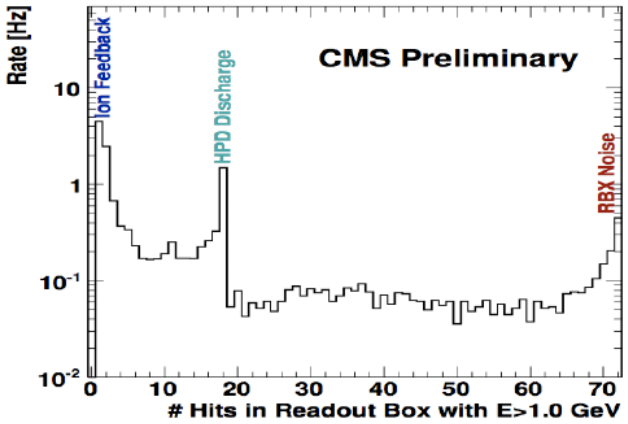
**HCAL**




**Momentum of muon track**

# Analysis of Calo Dataset

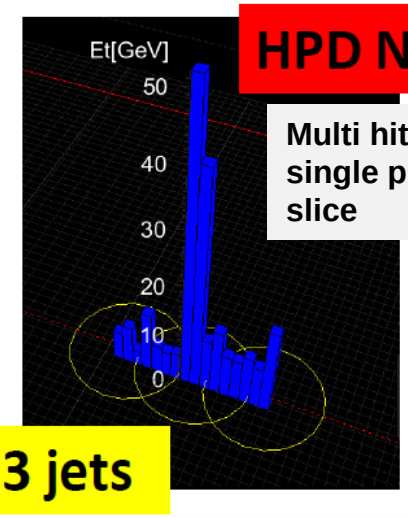
## Calorimeter Noise

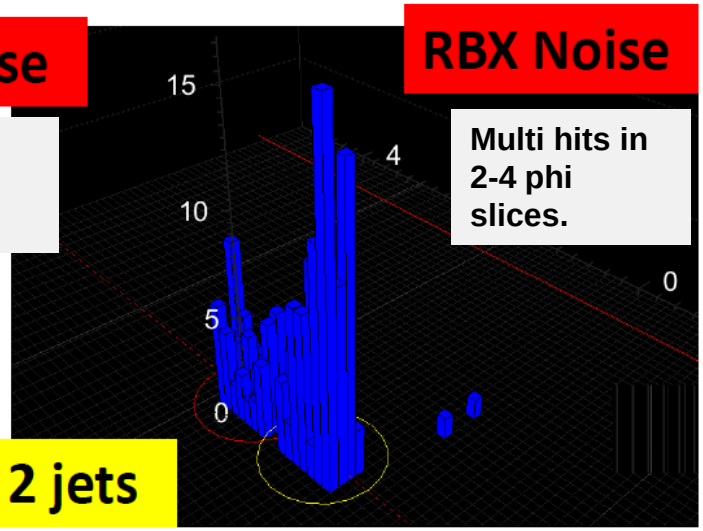



**Observe hardware related noise with distinct patterns**

***Replaced noisy HPDs***
***Reduced operating voltage***

***Jet algorithm reconstructs noise as Jets***




JTERM IV | Frank Chlebana, Fermilab | 21

**Calo noise is a source of large fake MET.**

**Real background to SUSY sample.**

**Cosmic muon induced large MET events are also included in Calo dataset.**

**How to identify and reject those background events?**

# Large MET Events in CRAFT

| L1 MET rates | CRAFT09(*) | QCD (8E29) |
|---|---|---|
| MET 20 GeV | 11 Hz | 14 Hz |
| MET 30 GeV | 6 | 1 |
| MET 80 GeV | 1 | ~0 |

(*) from rate plots in Run Summary

**Source of fake MET (and jets):**

1) Cosmic muon bremsstrahlung in calorimeter
2) HCAL HPD noise and RBX noise
3) ECAL noise

**Those events can be removed with**

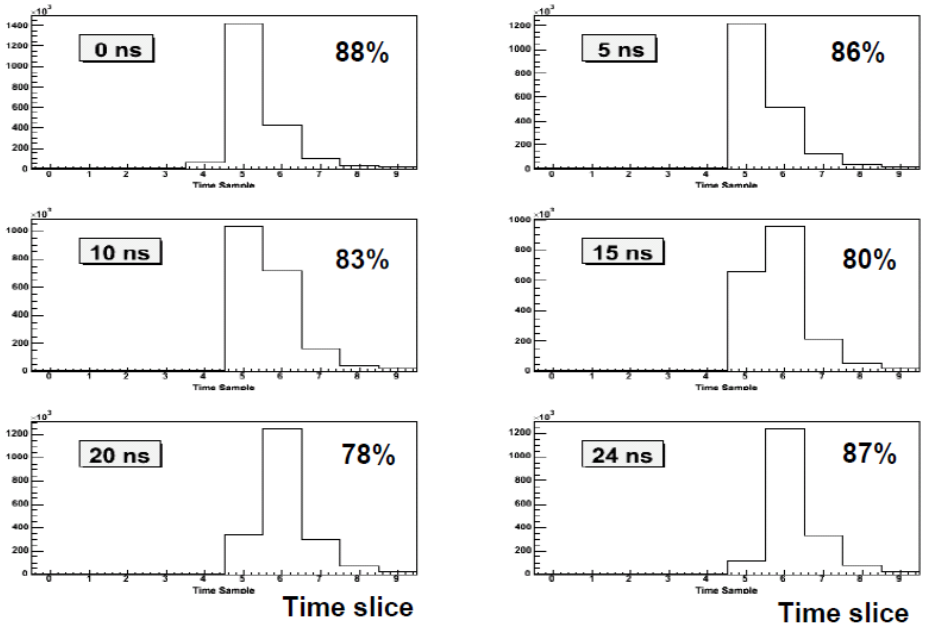
a) pulse shape of signal
b) timing of signal
c) correlation with other detectors
- charged track in Tracker (CHF: charge fraction)
- energy in ECAL vs HCAL (EMF: em fraction)

d) WE DO NOT use the hit pattern in eta-phi space.
- it is not so efficient and introduces bias to physics signature.

# HCAL Pulse Shape and Time Resolution

## Pulse Shape

ADC count (linearized) in 10 time slice with different Phase setting (HB)

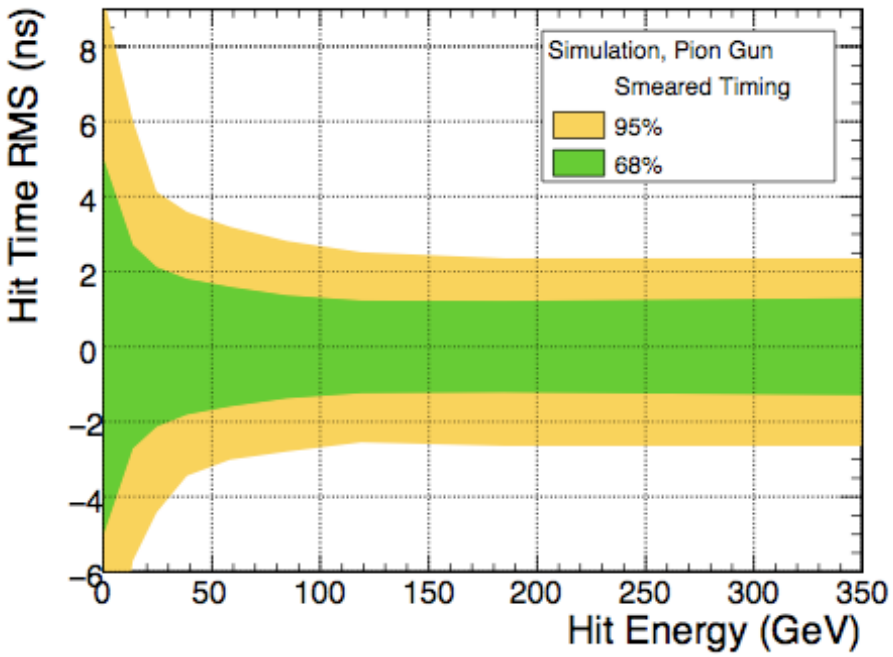



**Two time slices contain 78-88% of total energy depending on phase setting. Many of HCAL noises are much wider and some much narrower.**

**Cut of E(2ts)/E(10ts)**

## Time Resolution

**(MC plot tuned with test beam data.)**

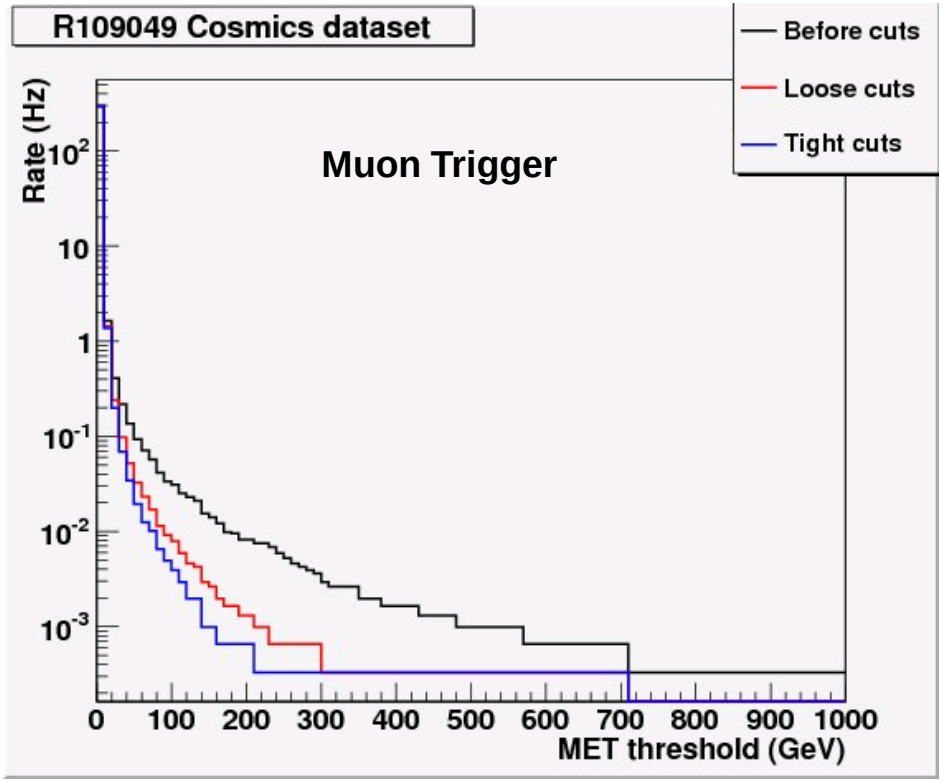


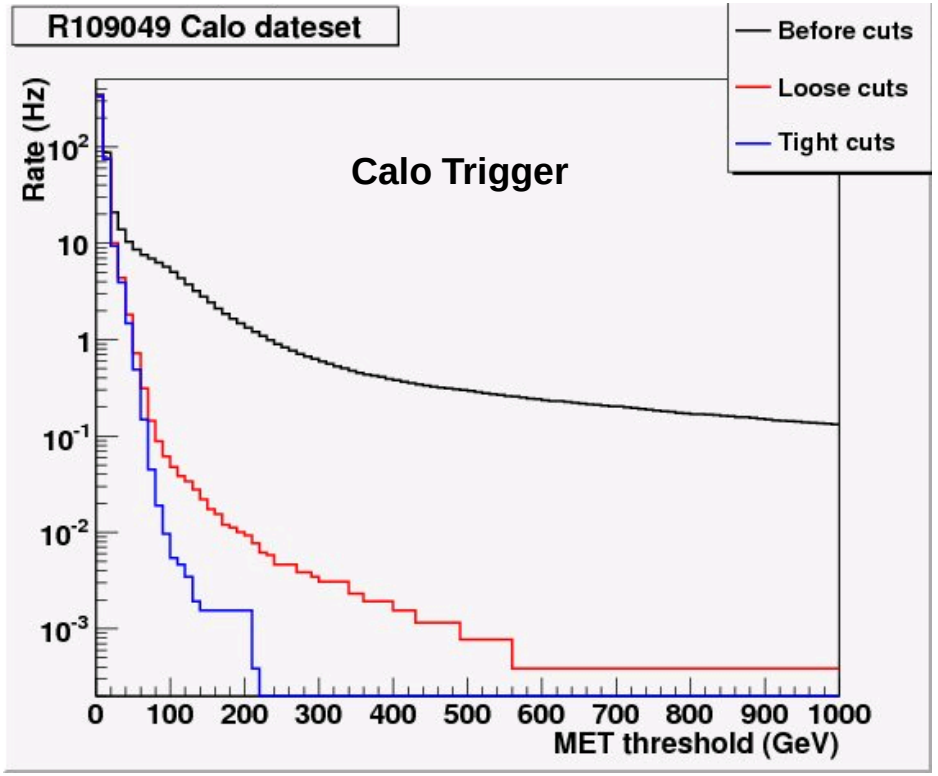

**HCAL timing is adjusted for all particles from pp collisions to produce signal at same time, while cosmic muon background and noises are random.**

**Cut on Rechit time (10nsec window.)**

# MET rates in CRAFT09

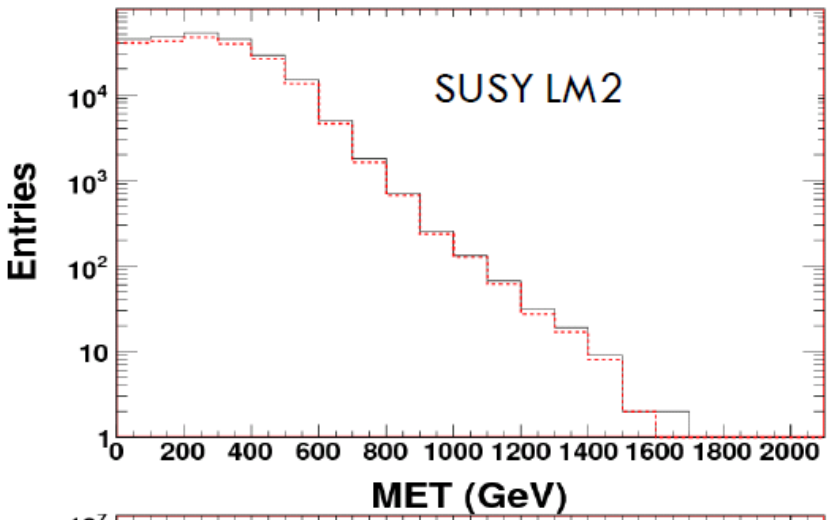
| | Rate for MET threshold at 100GeV<br>Cosmics Dataset | <br>Calo Dataset | |
|---|---|---|---|
| No cut | 0.030 Hz | 5.000 Hz | |
| Loose cut | 0.008 | 0.050 | ← usable at HLT, if needed. |
| Tight cut | 0.004 | 0.006 | |
| EMF&CHF cut | ? | ? | ← hopefully 0 Hz |

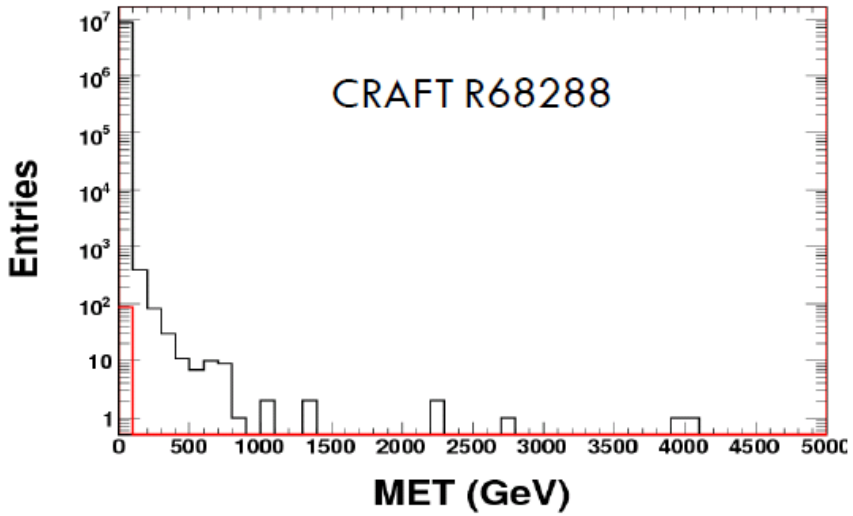


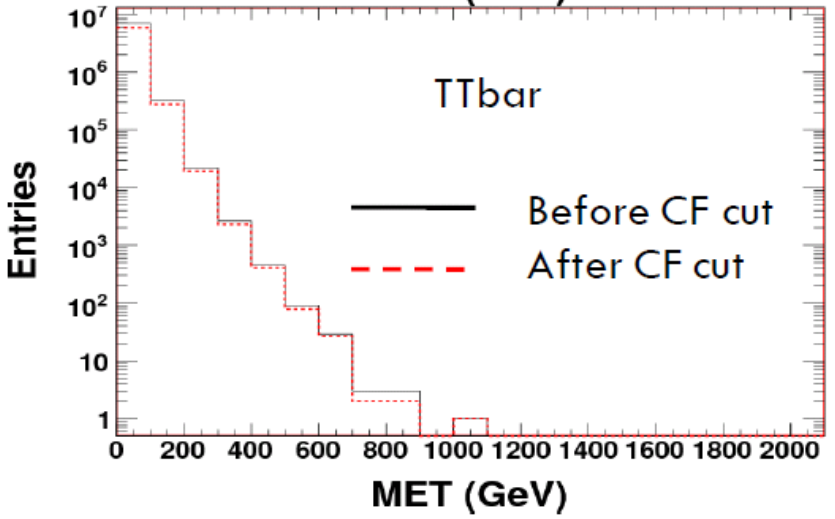



# CHF: Charge Fraction Cut

- How should CF be applied?
  - On a per jet basis, a cut on CF will produce very good "real" object efficiencies (>99%)
  - Suppose "anomalous" events are selected by requiring >=1 jet with CF<0.05, $E_T$>20, $|\eta|$<2.5. This will produce "real" event efficiencies that are lower than we hope to achieve:
    - SUSY LM2 event efficiency ~ 95%
    - TTBar event efficiency ~ 92%
    - CRAFT R68288 event efficiency <<1%
  - The proper use will depend on the goal




**CHF cut removes Calorimeter Noise Events and Cosmic Muon back ground events.**

# Plans for Fake MET Rejection

**Plans for 2009**

**Collect Calorimeter noise events and Cosmic muon events using start-up Trigger Menu during CRAFT09.**

**Mix the CRAFT09 events with MC physics events using DataMixer.**

**Add < 7 min-bias events > to the mixed events for L=1.6 x 10^32 sample. (Pile-up)**

**Tune the background rejection algorithm using above CRAFT + MC sample → release a default filter code.**

**Plans for 2010**

**Re-tune the background rejection algorithm using CRAFT + pp data sample.**

| Stage | Energy[TeV] | Bunch Configuration | $\beta^*[m]$ | Luminosity$[\mathrm{cm}^{-2}\mathrm{s}^{-1}]$ | Event rate/crossing |
|---|---|---|---|---|---|
| A | 0.9 | $2 \times 2$ | 11 | $2.6 \times 10^{27}$ | 0.006058 |
| A' | 10 | $2 \times 2$ | 11 | $2.9 \times 10^{28}$ | 0.0974 |
| A' | 10 | $2 \times 2$ | 2 | $1.6 \times 10^{29}$ | 0.5375 |
| A' | 10 | $43 \times 43$ | 2 | $6.9 \times 10^{30}$ | 1.0780 |
| A' | 10 | $156 \times 156$ | 2 | $2.49 \times 10^{31}$ | 1.0723 |
| A' | 10 | $156 \times 156$ | 1 | $1.615 \times 10^{32}$ | 6.9550 |

# CMSSW 32x

- Used for HLT and RECO of CRAFT09 data.
- New for calorimeter
  - Anomalous signal information
    - Rechit flags
      - Dead, hot, saturated hits, …
    - CaloTower flag
      - Combined flags for ecal+hcal
    - HCALNoiseRBX
      - Information on pulse shape and timing for hits in problematic RBX's
    - HCALNoiseSummary
      - event-by-event noise flag on HCAL noise (not fully implemented yet)
- Simple example code for analysis
  - Hcal Template Analysis code
    - https://twiki.cern.ch/twiki/bin/view/CMS/HcalSoftwareAnalysisTools#Making_Template_Analysis

# Conclusion

- **CRAFT09 has started. We have already a lot of data to analyze.**
- **Let's analyze the data thoroughly. It is a good opportunity to gain experience with real data and to know other detectors.**
- **I am a HCAL person. Certainly I am learning a lot by analyzing CRAFT09 data, e.g. about muon tracks, ECAL, triggers, datasets and software.**
- **It is important to give quick feedback to data taking in order to have good quality of data.**

# References


**CRAFT08 Analysis Workshop, Torino 11-13 March, 2009**
http://indico.cern.ch/conferenceOtherViews.py?view=cdsagenda&confId=50961

**ECAL Stability in CRAFT08, G.Franzoni, T T de Fatis, 20-May-2009**
http://indico.cern.ch/conferenceDisplay.py?confId=59088

**ECAL reconstruction (channel status flag) in 31X/32X, Federico Ferri, 20-July-2009**
http://indico.cern.ch/conferenceDisplay.py?confId=64436

**ECAL inter-channel synchronization, Jason Haupt, 07-May-2009**
http://indico.cern.ch/conferenceDisplay.py?confId=58430

**ECAL time reconstruction, Daniel del Re, 30-July-2009**
http://indico.cern.ch/conferenceDisplay.py?confId=64706

**HCAL Rec Flag assignment**
https://twiki.cern.ch/twiki/bin/view/CMS/HcalRecHitFlagAssignments

**HCAL Noise Identification Software and Algorithm, John Paul Chou and Jian Wang, 16-July-2009**
http://indico.cern.ch/conferenceDisplay.py?confId=64530

**Charge Fraction Cut, Alfredo Gurrola, 23-April,2009**
http://indico.cern.ch/conferenceDisplay.py?confId=57434


**More to be added.**