Operation of the DØ Calorimeter During Run IIA of the Tevatron

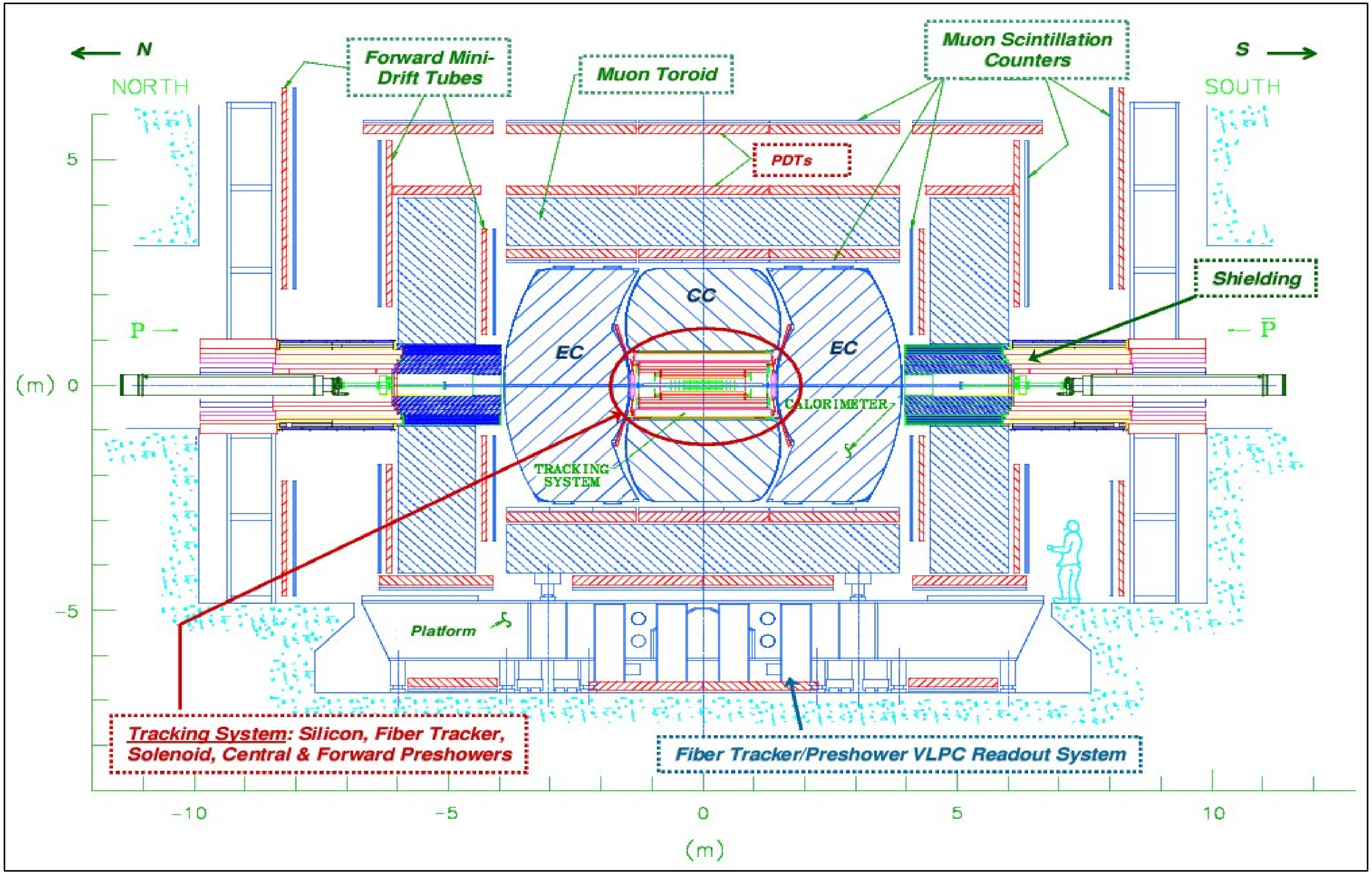
Norm Buchanan
(for the DØ Calorimeter Operations Group)
Florida State University

CALOR06 June 5-9 2006
Chicago, Illinois

Outline

- The DØ Calorimeter
- Calibration
- Monitoring
- Performance
- Summary

DØ Detector


N
NORTH
Forward Mini-Drift Tubes
Muon Toroid
Muon Scintillation Counters
S
SOUTH
PDTs
CC
EC
EC
Shielding
P
$\overline{P}$
CALORIMETER
TRACKING SYSTEM
Platform
Tracking System: Silicon, Fiber Tracker, Solenoid, Central & Forward Preshowers
Fiber Tracker/Preshower VLPC Readout System
(m)
5
0
-5
-10
-5
0
5
10
(m)

DØ Calorimeter

Upgraded calorimeter for Run II

396 ns bunch separation – faster readout and triggering

additional material in front of calorimeter

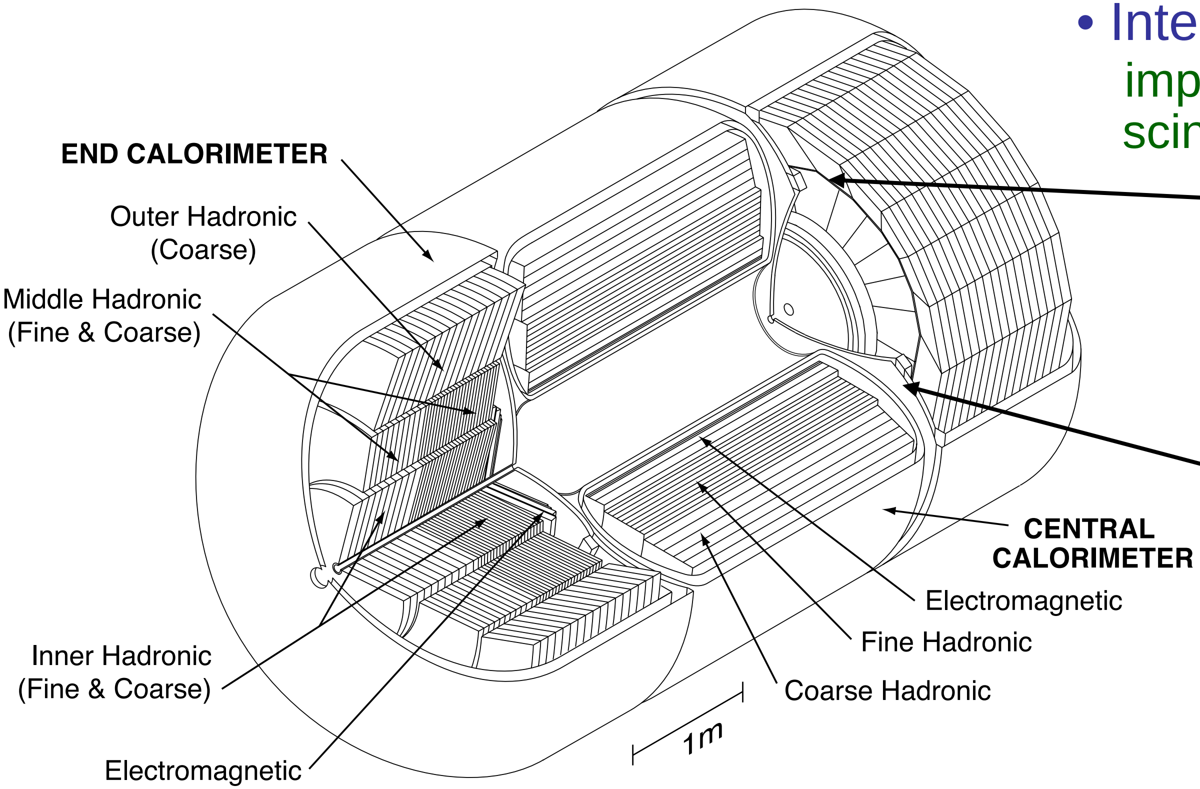
- Hermetic coverage: $|\eta| < 4.2$
- Fine segmentation:

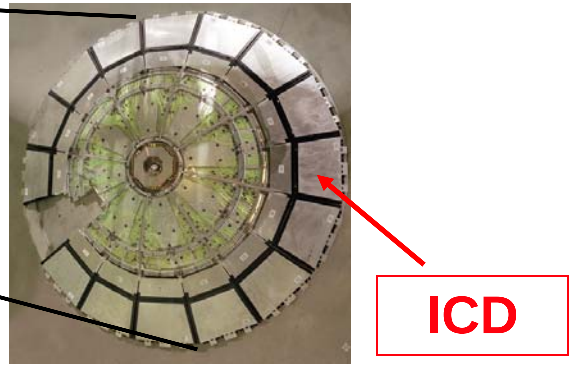
  $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

  (shower max: 0.05 x 0.05)
- Inter-cryostat detector (ICD):

  improves coverage $1.1 < \eta < 1.4$

  scintillator-based



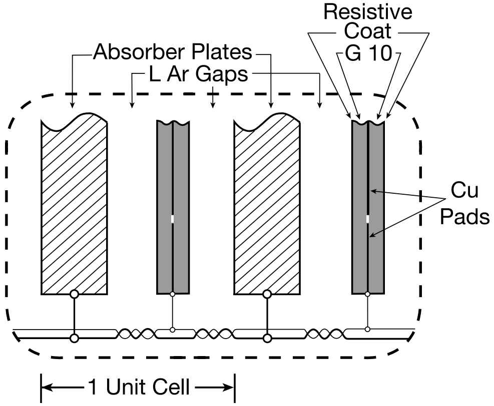


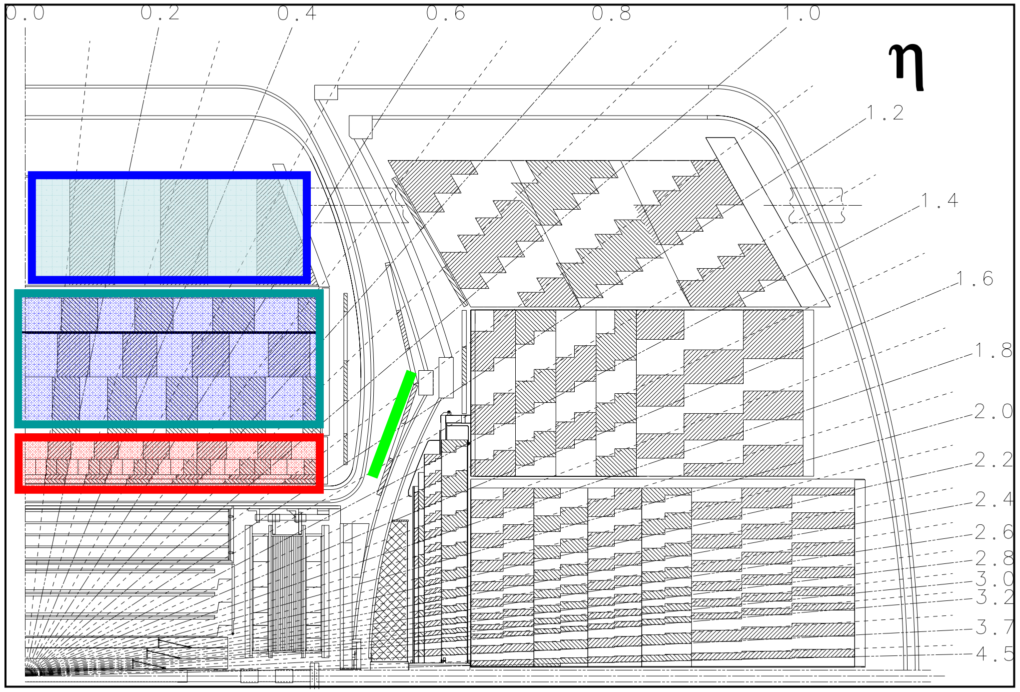
pseudo-rapidity η

$$\eta = -\log\left(\tan\frac{\theta}{2}\right)$$

DØ Calorimeter Cont…

- 3 cryostats – CC + 2EC
- Sectioned into EM + fine HAD + coarse HAD
- Plate geometry (2.3 mm LAr gap and 4.6 mm G10 electrodes)
- 2.0 kV and 450 ns drift time

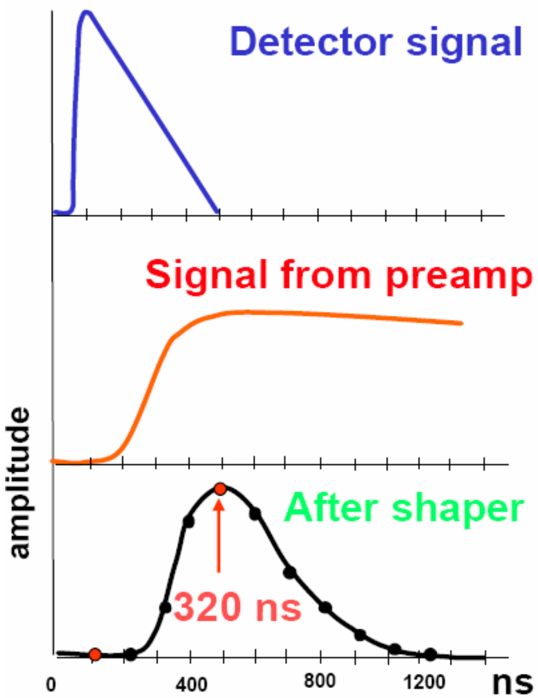




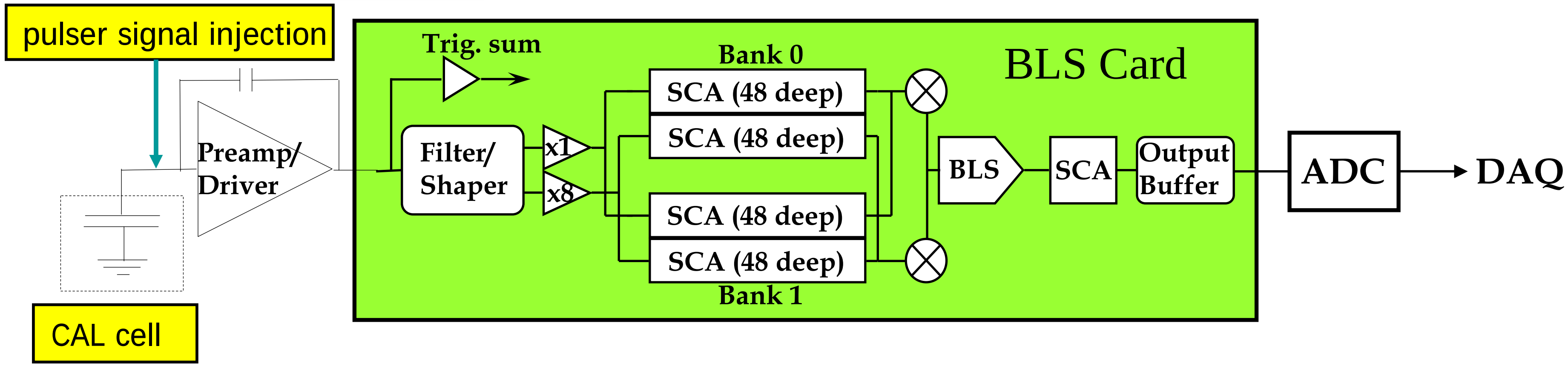
	Thickness in X_0	Absorber
CC EM	2+2+7+10	Ur (3mm)
CC FH	1.3+1+0.9	Ur (6mm)
CC CH	3	Cu (46.5mm)
EC EM	0.3+3+8+9	Fe (1.4mm) + Ur (4mm)
EC FH	1.3+1.2+1.2+1.2	U (6mm)
EC CH	3+3+3	Fe (46.5mm)

- ~55k readout channels
- <50 dead channels (broken cables)
- 4 projective towers form trig sums
- triggering possible out to |η| = 3.6

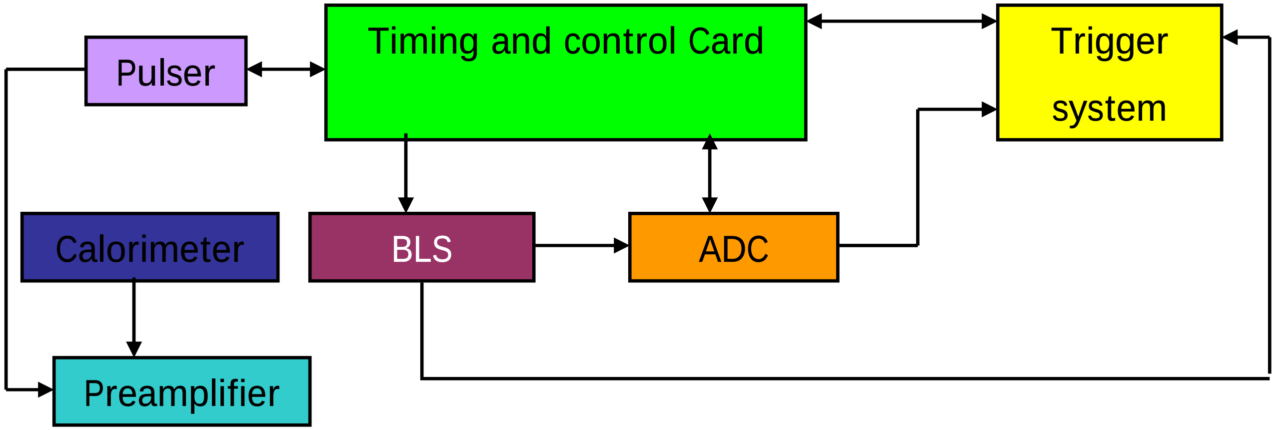
Readout Electronics

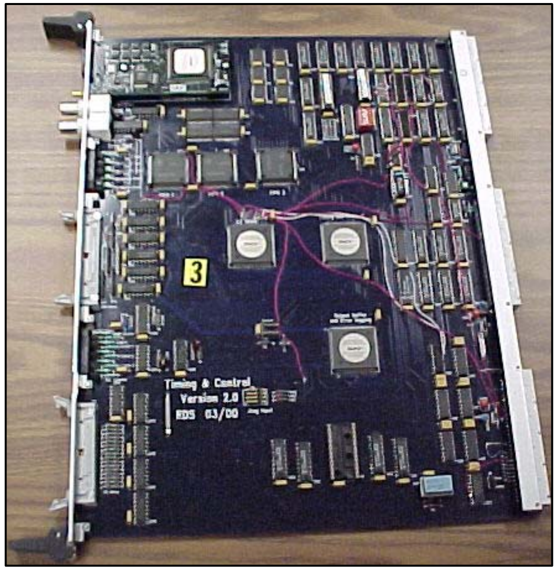


- 450 ns detector signal into preamps
- 0.25-4 nF compensation in 14 species
- >6 hrs required for repairs
- preamp output shaped and sampled/stored
- 2/3 of signal is integrated
- baseline subtracted on L1 accept
- 2 gain system x1 and x8 (15-bit dynamic range)
- stored in 2nd pipeline during L2 latency
- simple repairs in <1hr – require hall access
- signals sent for digitization on L2 accept
- successive approximation digitization (2.5μs)
- optional pedestal and zero suppression



Timing and Control





Receives trigger, accelerator, clock information

Samples shapers at the signal peak and base.

Keeps track of the memory location of crossings.

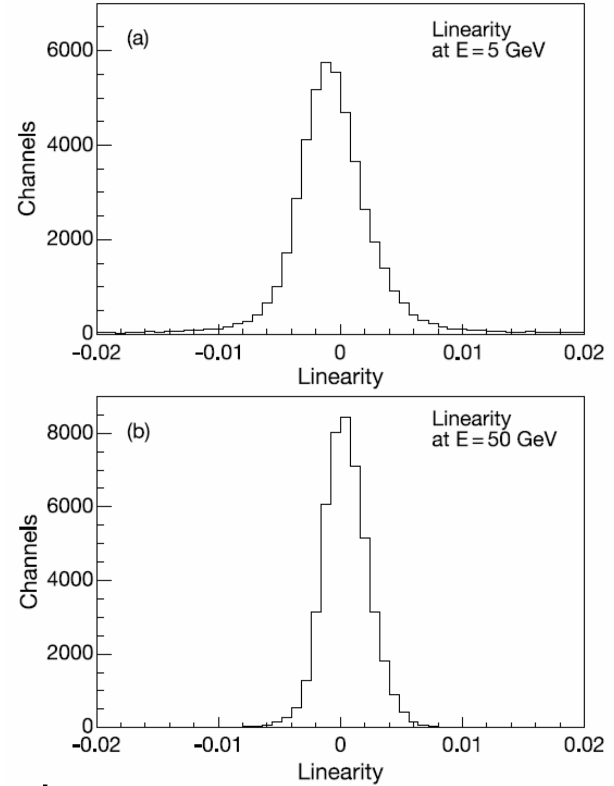
Generates busy signal when system is not ready.

Coordinates pulser calibration.

12 T&C boards+ 1 controller

Calibration I

- Charge injected on preamp inputs
- DC load diverted to ground by switch
- 6X16 currents & 6 command lines with prog. delay
- 18-bit DAC controls intensity – individual enables
- linear to better than 0.2% over system
- Higher order corrections also determined with these calibrations
- calibrate > 2/month (requires 30 min quiet time)



power supply

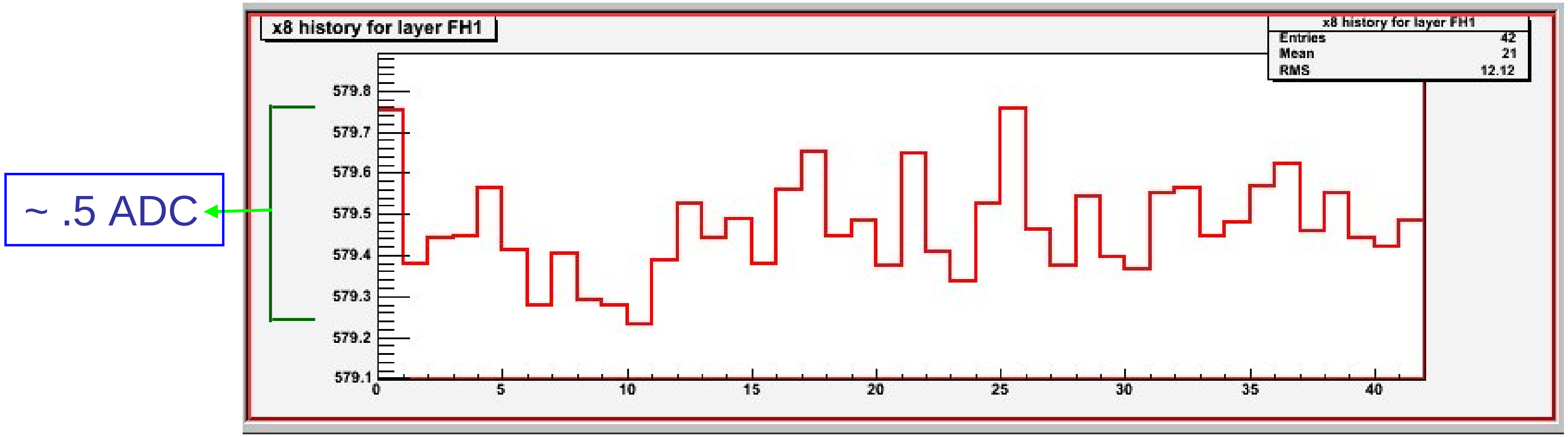
X12 + ICD

pulser control

$$\frac{ADC_{meas}}{ADC_{fit}} - 1$$

Calibration II

- Pedestal calibrations performed between stores ~1/day
- 10k events taken to gather means and RMSs
- calculated online (L3 filters) – takes about 10 minutes
- stable over time – good to better than 1 ADC count for most channels



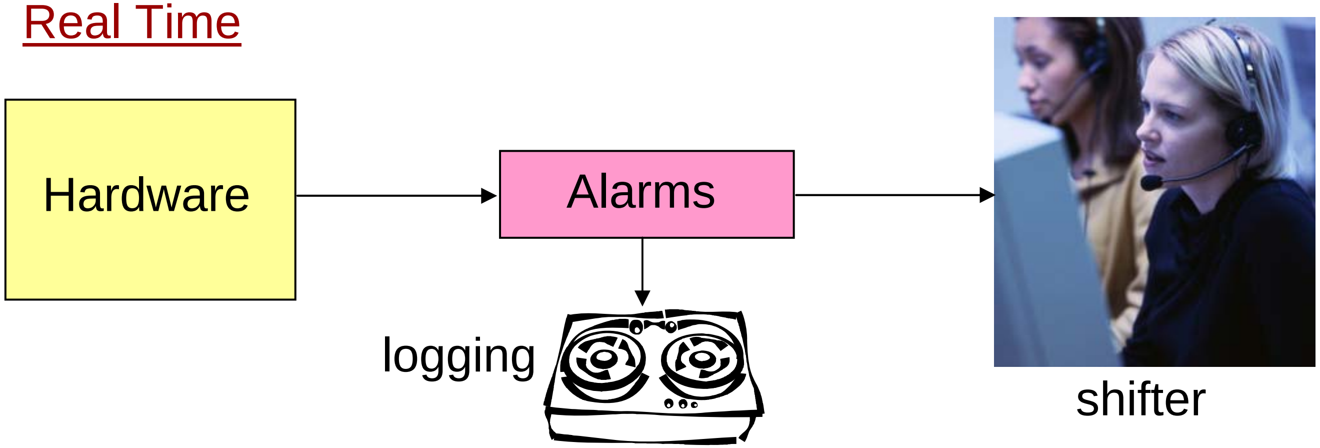
about 4 months of pedestals

- RMS varies with capacitance – central EM ~ 3-4 ADC
- Zero suppression at 1.5 σ in hardware, (offline 2.5 σ)
- Use calibration to “kill” out of spec. channels until repairs made

Monitoring (hardware)

Hardware is monitored in real time and in dedicated runs

Real Time



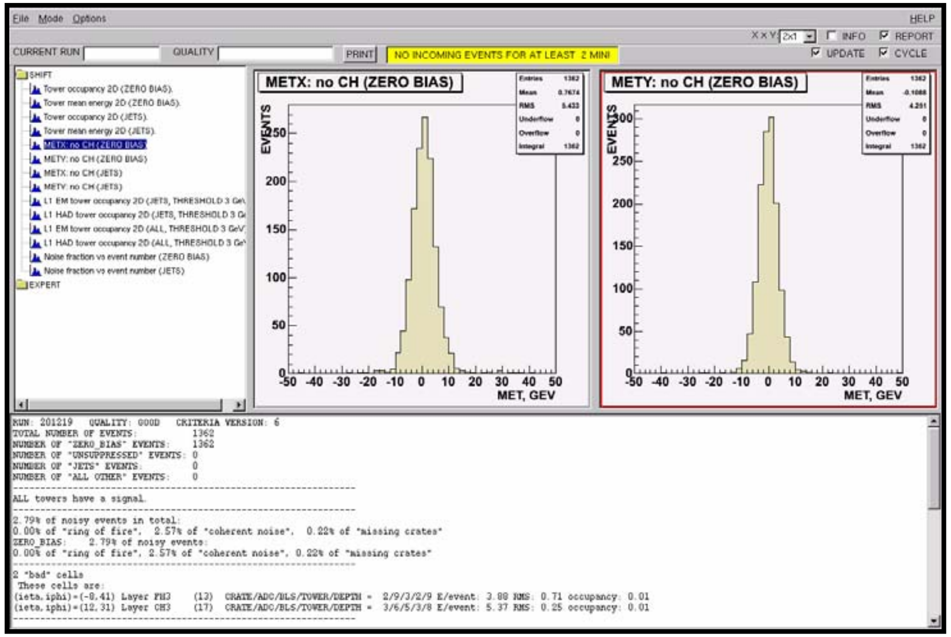
- hundreds of parameters monitored (i, v, T, status)
- logged and archived
- many alarms “run pausing”, eg. HV trip
- alarms come with procedural instructions
- hot channels can be handled in minutes – requires pedestal re-download to hardware

Dedicated runs

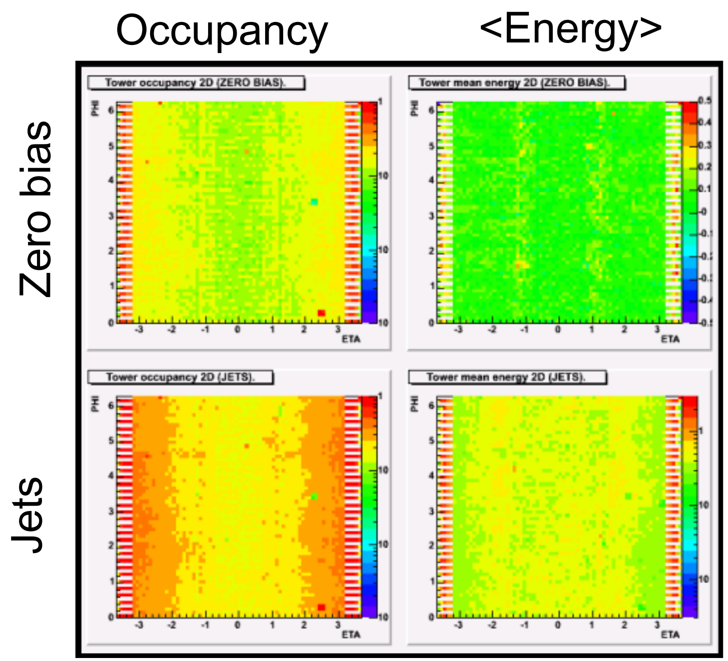
- display <ADC>, RMS, occupancy, etc… to verify problems/fixes
- special filters employed to scan for poor hardware performance, eg. print a list of channels with anomalous gain switching behavior

Monitoring (data)

Monitored globally and by the calorimeter shifter



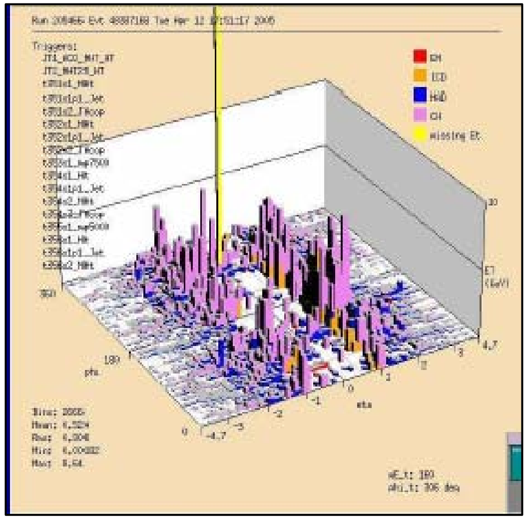
- Monitored by run (and between stores)
- MET, η,ϕ hitmaps, trigger, etc…
- 1 Hz zero-bias, <<1 Hz unsuppressed
- Noise events monitored
- Hot cells tagged for offline
- Warnings displayed for shifter



- root-based and easy to add new plots
- L1 and precision monitored separately
- connecting monitors to alarm system
- work closely with offline data-quality group

Noise

- Must be very careful of ground loops – much improvement since 2003



- noise that appeared when a welder was operated
  (fortunately no welding during store!)
- caused by grounding error – fixed 2004 shutdown
- special trigger developed for “sniffing” out noise
- external noise has largely been eradicated
- several days allotted for grounding and general noise studies each shutdown

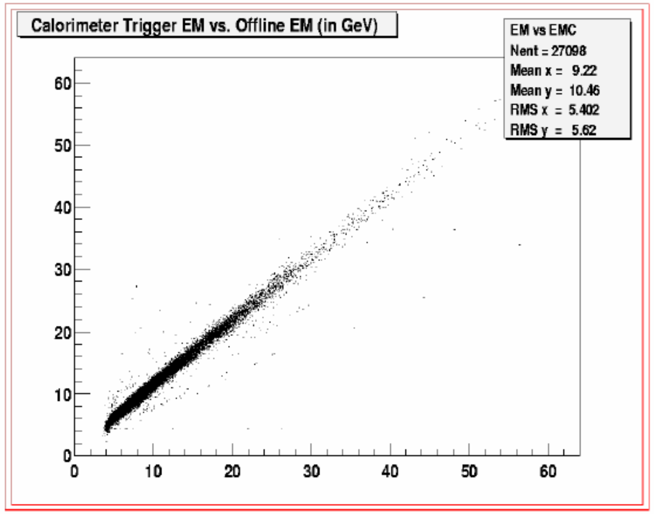
- Tag noisy events – analyzers can filter on them or study them offline
- Data and Monte-Carlo used to derive criteria
- No observed increase in noise with luminosity (instantaneous or integrated)
- Always working to reduce noise – with time we get more picky

Operational Performance

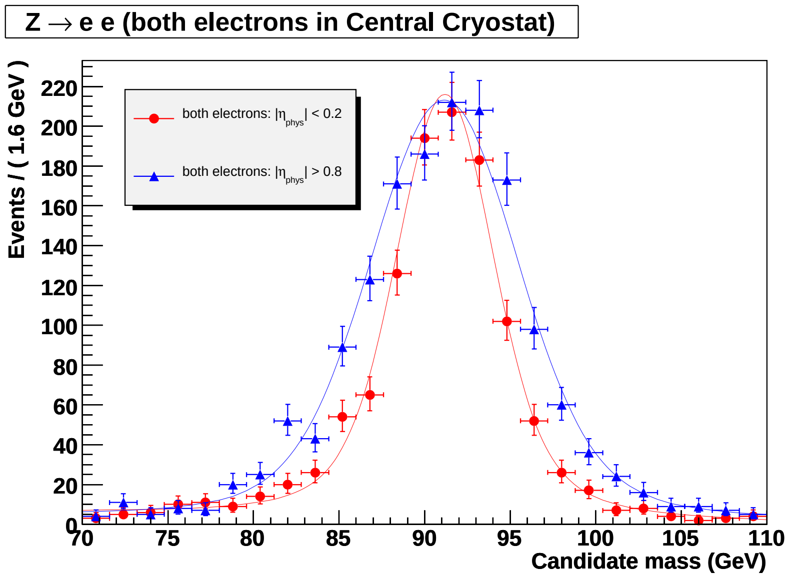
(for physics performance see talks by K. Peters and J. Kvita)

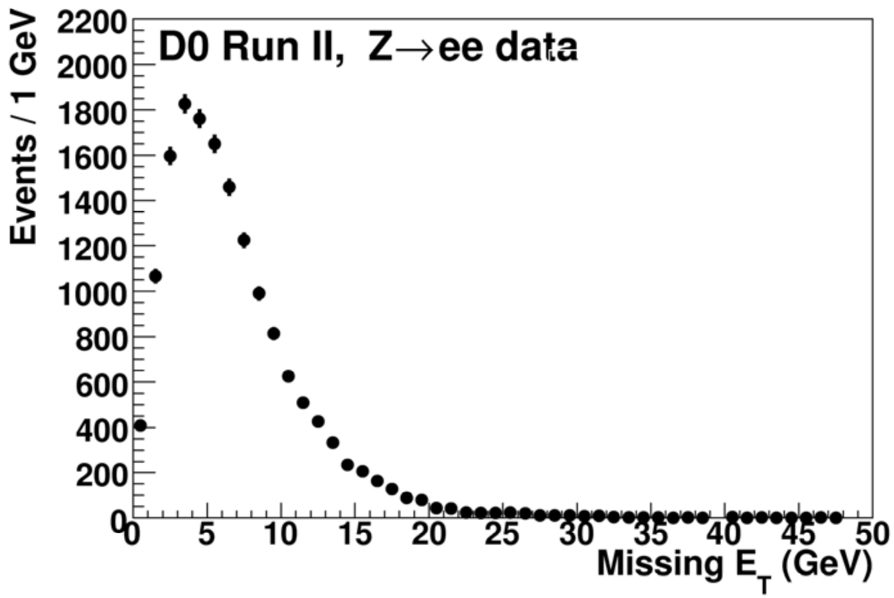
- Since 2004 shutdown, less than 10 stores without full calorimeter
- DQ improving annually, in 2005 ~93% calorimeter data good for analysis
  - data quality now determined by luminosity-block (few 1000 events)
  - power supply failures cause most significant data loss – remainder of store lost
- Typical maintenance:
  - SCA failure ~2 per month, 15 min fix – requires hall access (1-12 channels)
  - Baseline subtraction card replacement 1-48 channels <1 per month
  - BLS LV power supply failure ~1 per 1-2 months - ~1hr fix (also req. access)
    (vastly improved reliability since 2003 due to a hardware modification)
- Preamps and preamp power supplies very stable (1 access required for power supply replacement during 2005) – thanks to redundancy
- Very stable operation, has improved with increased automation
  - use of alarms and monitoring warnings/messages alert shifter quickly
  - calibration process removes channels which would adversely affect data quality
  - as higher order problems uncovered monitoring can be quickly adapted

More on performance



- L1CAL vs precision readout agree well
- good measure of L1CAL and cal readout performance
- new L1CAL for run IIB – expect similar agreement





Summary

- Ran during RunIIA with high efficiency and excellent data quality
  - few stores missed since previous shutdown and data continually improving
- No observed luminosity dependent operation issues – none expected
- Much effort spent on automating calorimeter operation
- Noise is always a concern and we continue to be vigilant
  - external noise essentially gone
  - routinely take dedicated “noise” runs (out of store)
  - significant effort made to avoid grounding issues during detector work
- We are now able to work on higher order issues, i.e. non-linear calibration corrections
- There is much excitement about our new L1CAL trigger and we expect to collect excellent quality calorimeter data throughout RunIIB!