Calorimeter Operations in Run II at DØ

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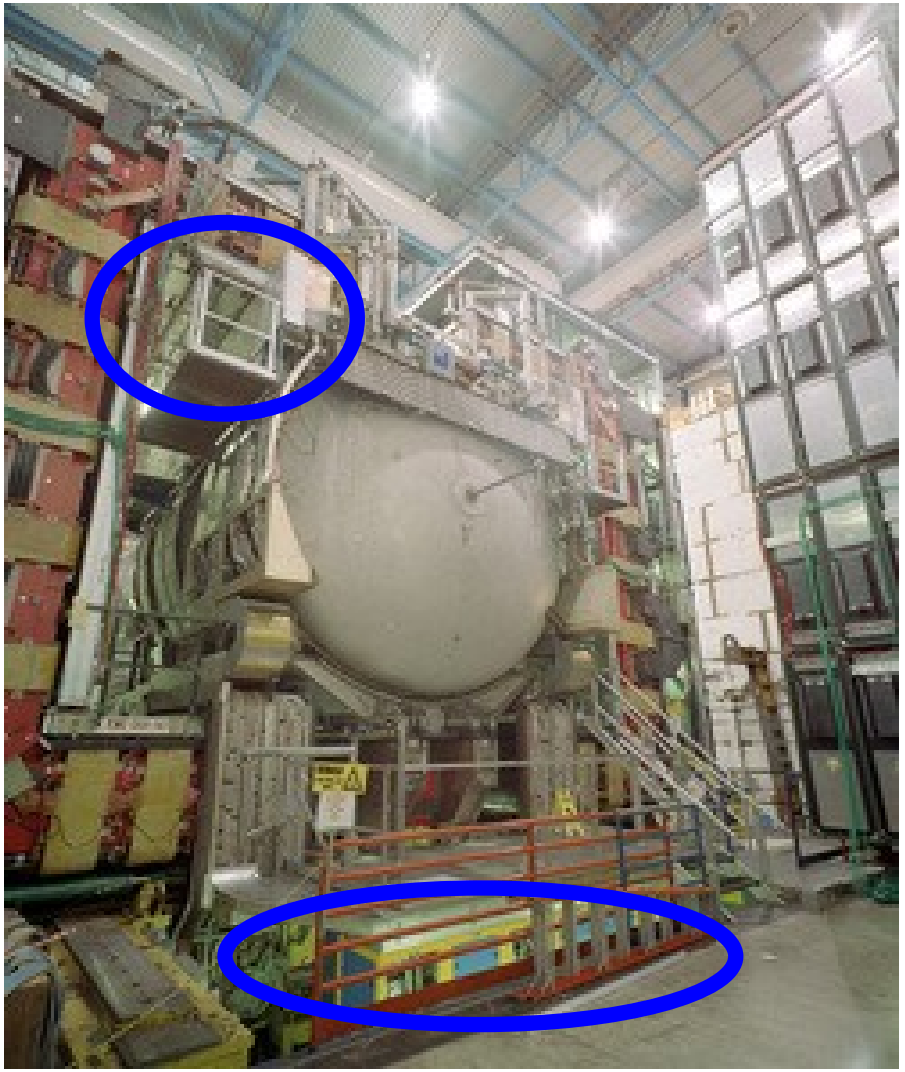
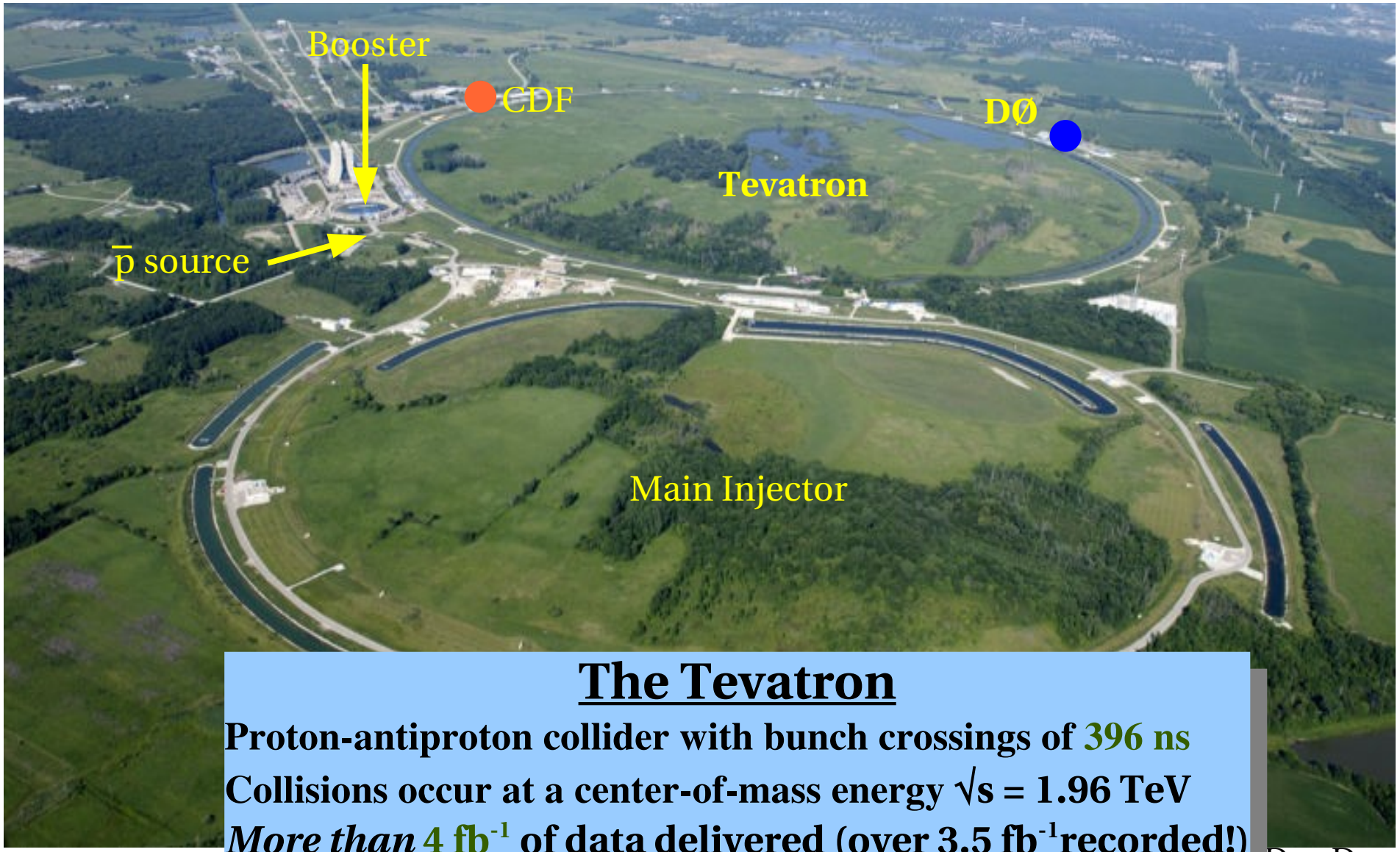
on behalf of the DØ Collaboration

Outline

- Design overview
- Online monitoring
- Data quality and noise issues
- Online calibrations and studies
- Insitu calibrations with collider data
- Conclusions



The Tevatron at Fermilab



The Tevatron

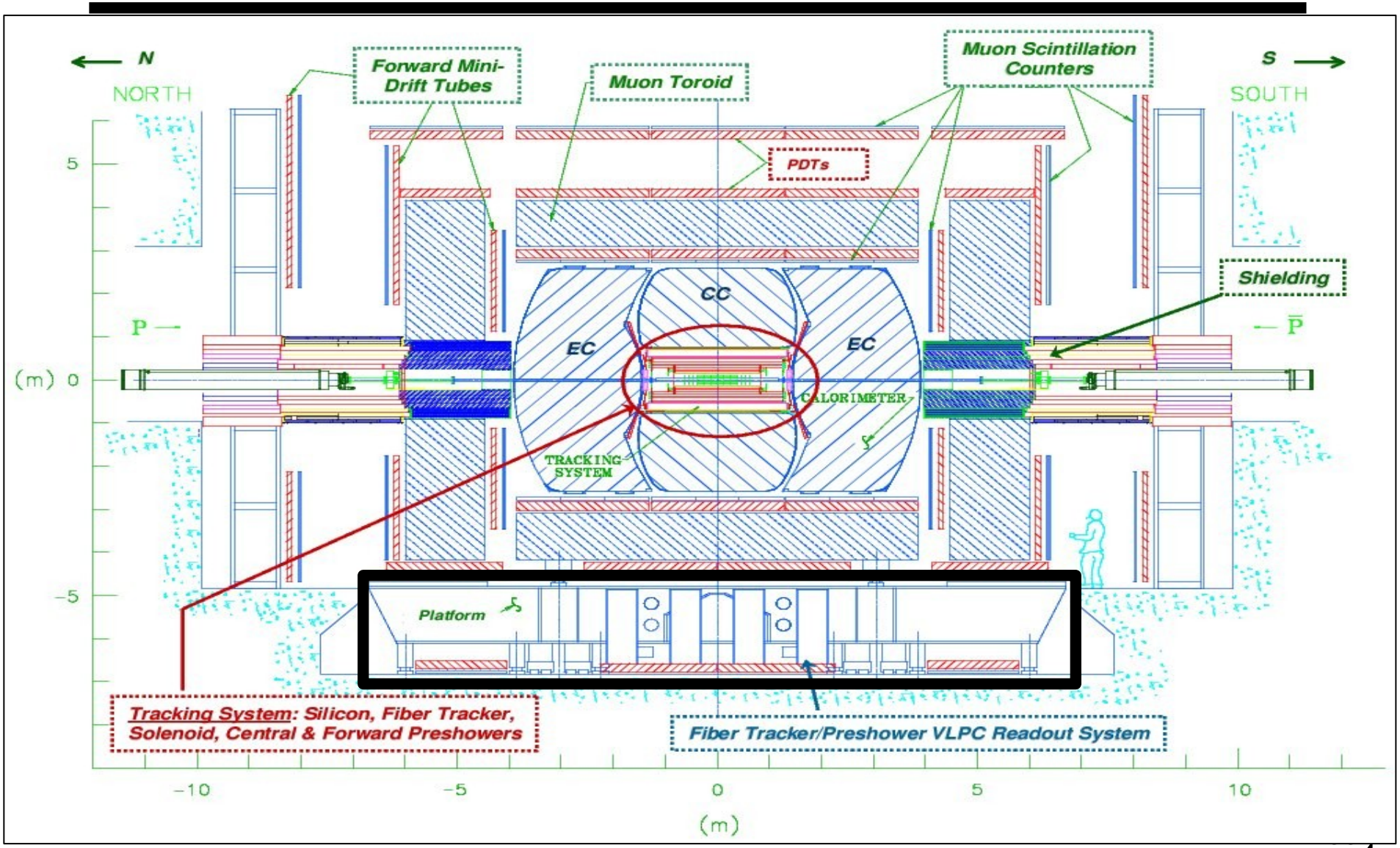
Proton-antiproton collider with bunch crossings of 396 ns

Collisions occur at a center-of-mass energy $\sqrt{s}$ = 1.96 TeV

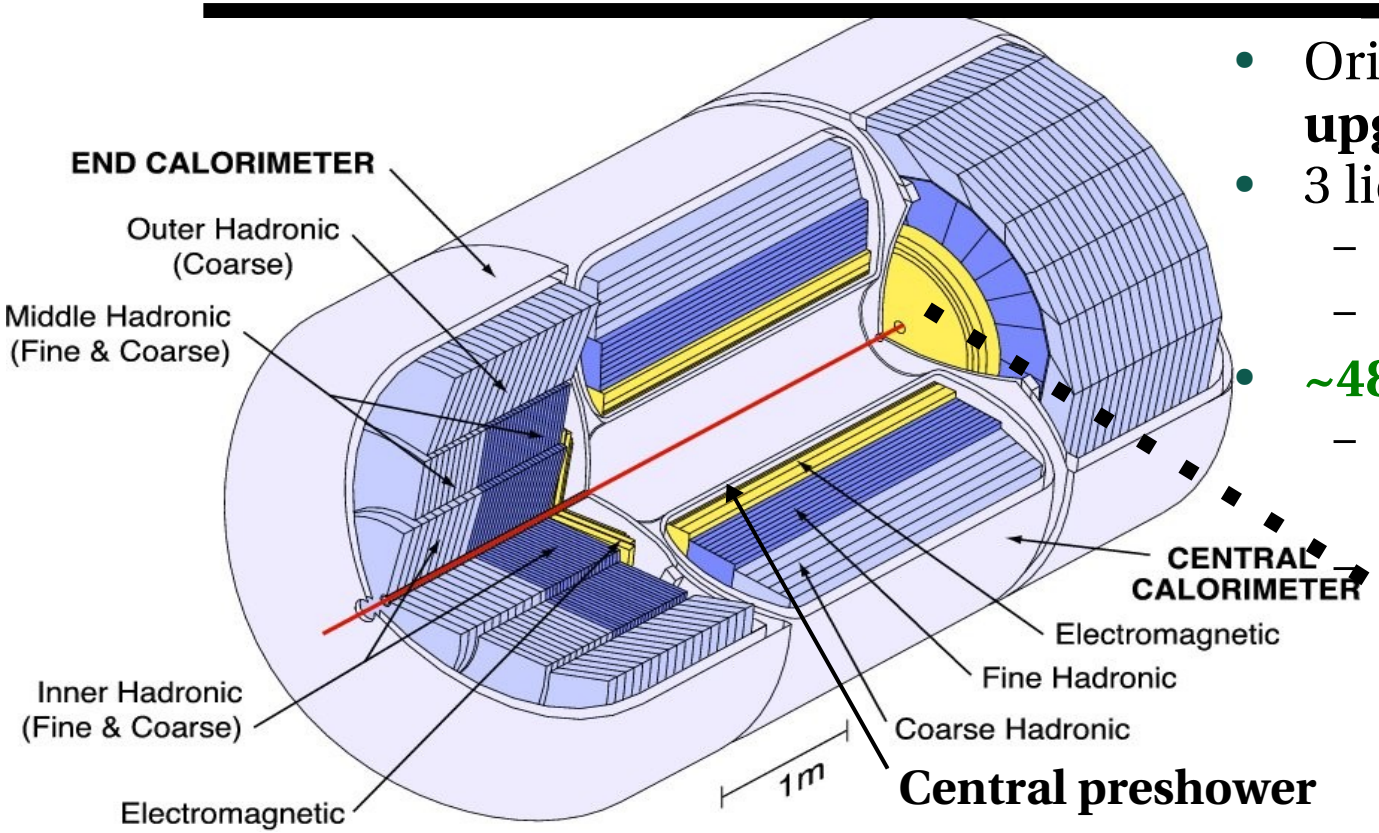
***More than* 4 fb^{-1} of data delivered (over 3.5 fb^{-1} recorded!)**

Instantaneous luminosities *greater than* 3x10^{32} cm^{-2}s^{-1}

DØ Detector

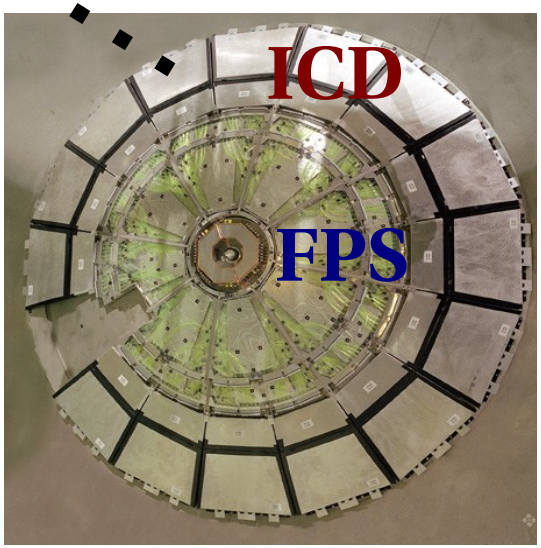

N
NORTH
S
SOUTH
Forward Mini-Drift Tubes
Muon Toroid
Muon Scintillation Counters
PDTs
Shielding
CC
EC
EC
CALORIMETER
TRACKING SYSTEM
P
P̄
Platform
Tracking System: Silicon, Fiber Tracker, Solenoid, Central & Forward Preshowers
Fiber Tracker/Preshower VLPC Readout System
5
(m) 0
-5
-10
-5
0
5
10
(m)

The DØ Calorimeter



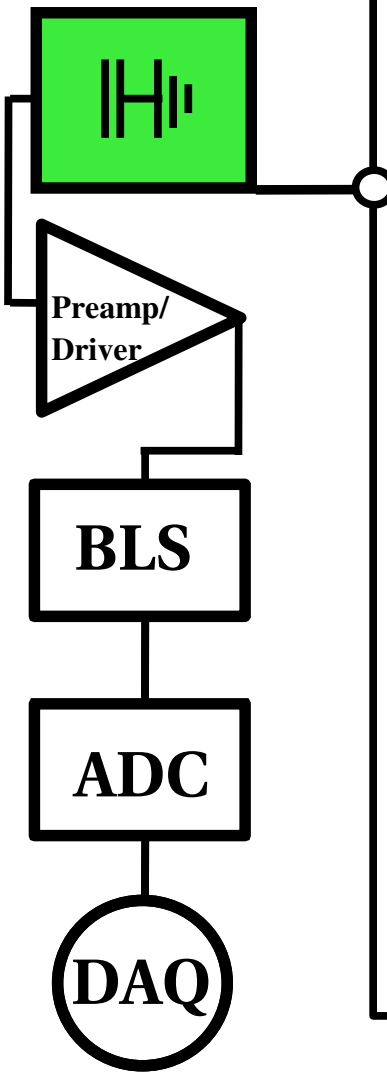
- Original Run I detector **with upgraded electronics**
- 3 liquid argon cryostats
  - 1 central, 2 endcap
  - Hermetic coverage $|\eta| < 4.2$
- **~48,000 readout channels**
  - Longitudinal segmentation
    - 14 layers in total

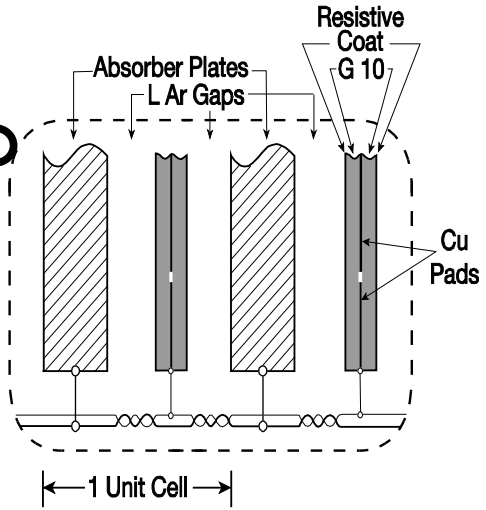
Up to 12 cells in a (η-ϕ) form pseudo-projective towers



- **Inter-Cryostat Detector (ICD)**
  - Provides scintillator-based coverage **between** central and endcap cryostats
- **Central(CPS) and Forward(FPS) Preshowers**
  - *Additional* particle position and energy measurements **before** calorimeter

The Calorimeter Cell



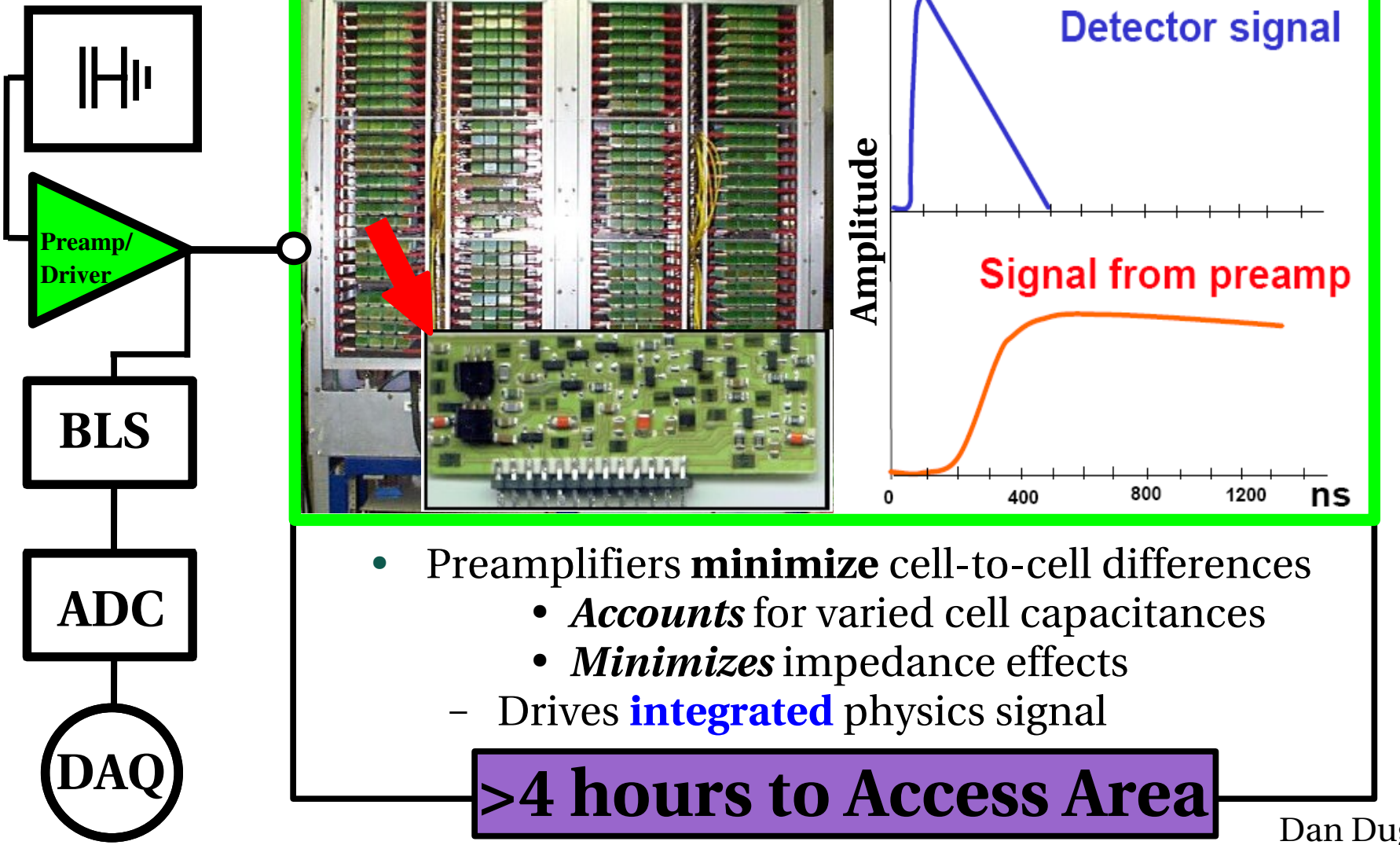


	Thickness in X_0	Absorber
CC **EM**	2+2+7+10	Uranium (3mm)
CC **FH**	1.3+1+0.9	Uranium (6mm)
CC **CH**	3	Copper (46.5mm)
EC **EM**	0.3+3+8+9	Iron (1.4mm) + Uranium (4mm)
EC **FH**	1.3+1.2+1.2 +1.2	Uranium (6mm)
EC **CH**	3+3+3	Iron (46.5mm)

- ~2 kVolt potential across **liquid argon** gaps
- Drift time ~450ns of electrons
- **Fine $\Delta\eta$ x $\Delta\phi$ segmentation (0.1 x 0.1)**
  - **0.05 x 0.05** in the 3rd EM layer

No Possible Access

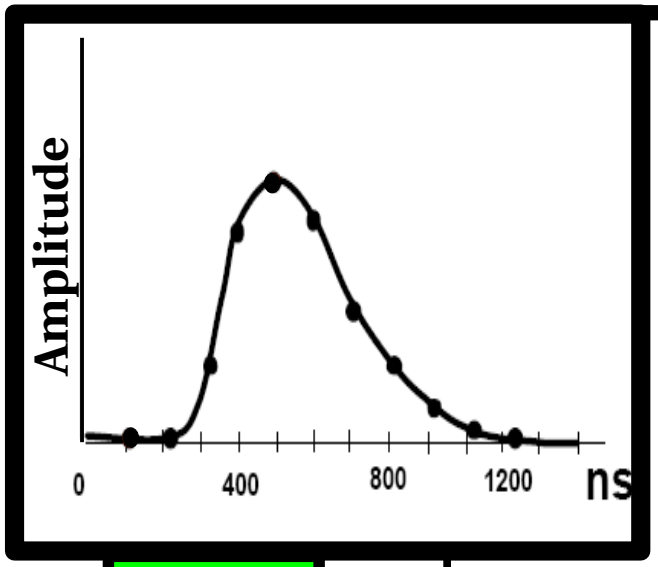
The Preamplifiers

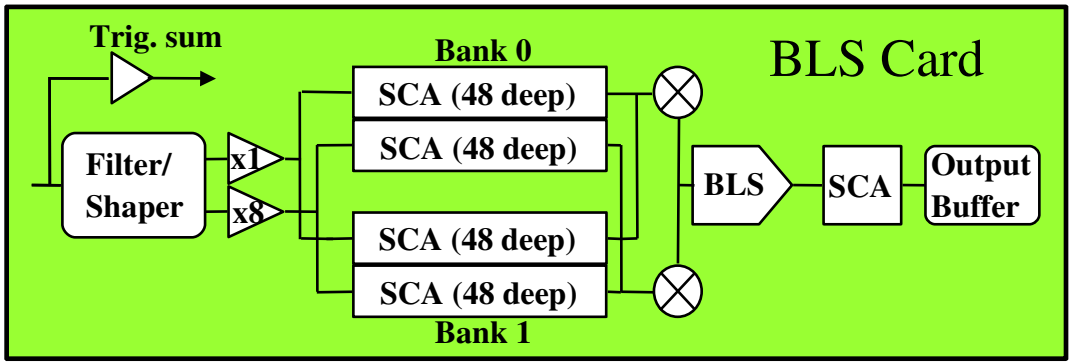


- Preamplifiers **minimize** cell-to-cell differences
  - ***Accounts*** for varied cell capacitances
  - ***Minimizes*** impedance effects
  - Drives **integrated** physics signal

>4 hours to Access Area

BaseLine Subtraction System





BLS

ADC

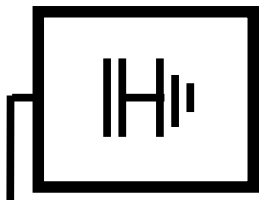
DAQ

- Analog trigger energy summing for L1 decisions
- Signal shaping for fast precision signal processing
- 2 signal paths provide 15 bit analog dynamic range
  - Switched Capacitor Arrays used to store events while waiting for trigger decisions

Access only without beam

Analog to Digital Converter

- **The analog signal is digitized**
  - **Noise is reduced by a 2.5 σ suppression**
  - Output sent for tower energy reconstruction
  - Also used for final trigger decision
- All electronics timing is controlled here
  - **Timing and control card**
    - **Communicates with accelerator clock**
    - Manages trigger signals and event memory

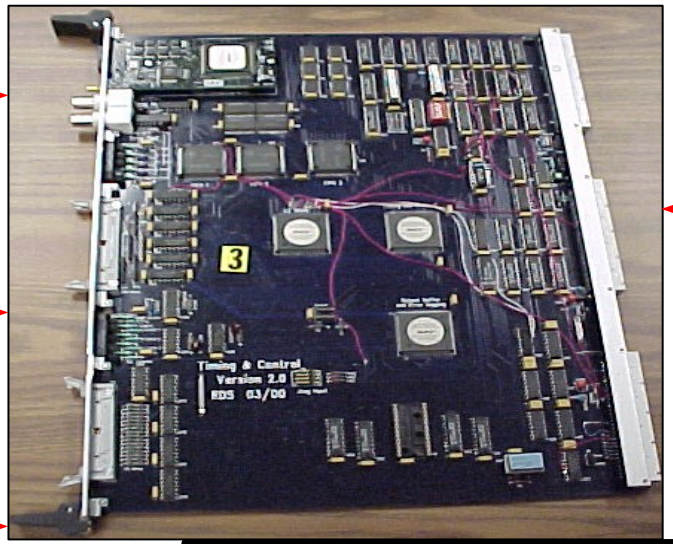


Preamp/
Driver

BLS

ADC

DAQ

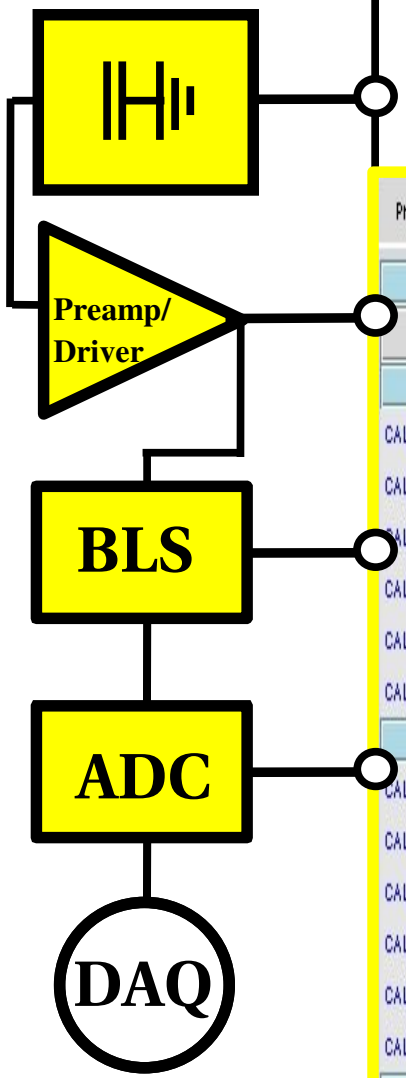


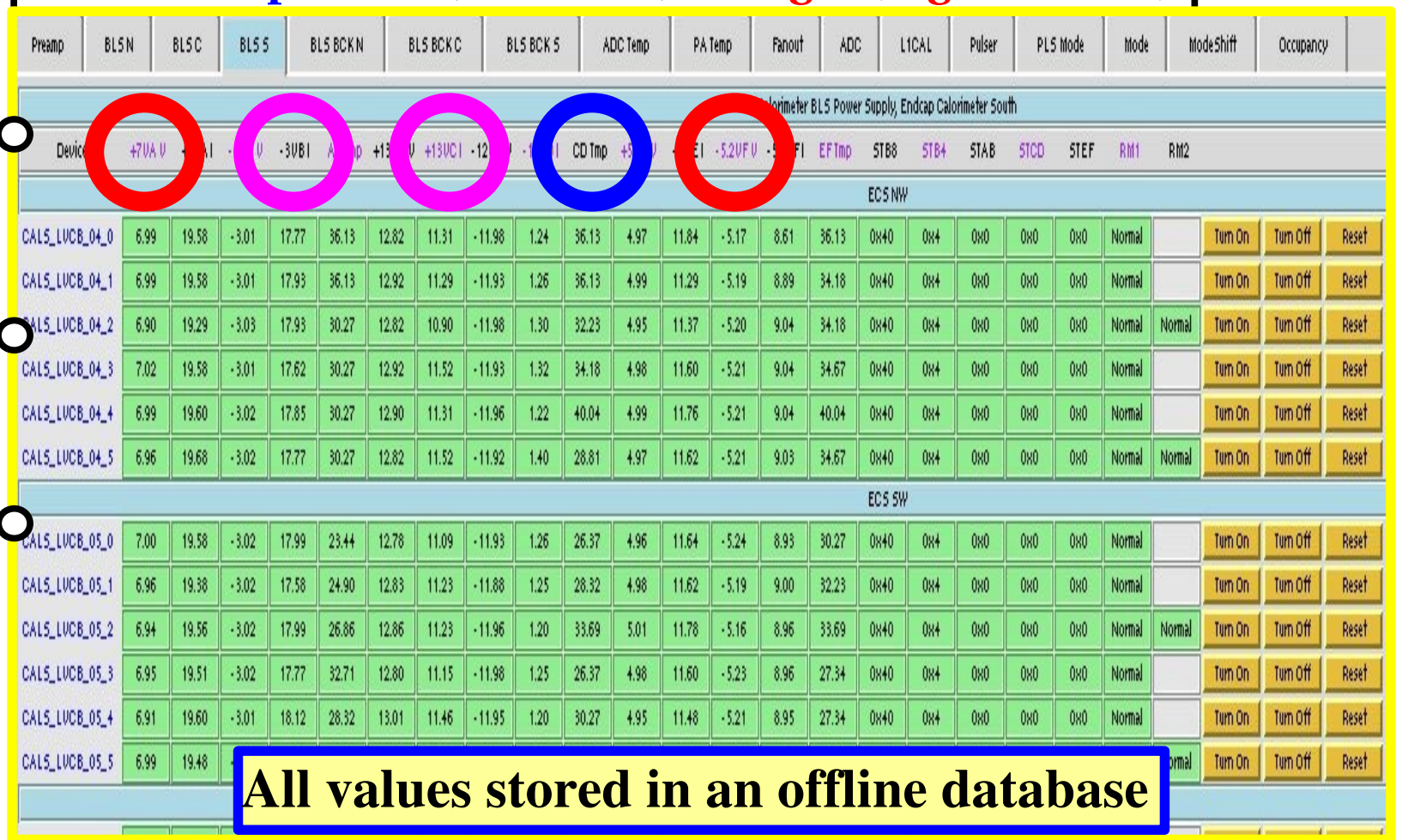
Accelerator
Clock

Unlimited Access

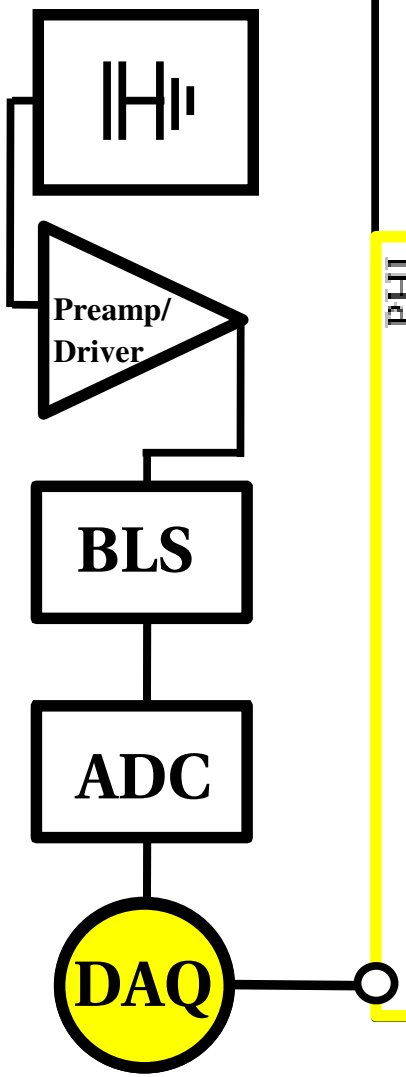
ONLINE Monitoring

- Electronics monitored by **direct hardware readout**
  - **Thousands of values at all levels** including **temperature**, **currents**, **voltages (high and low)**

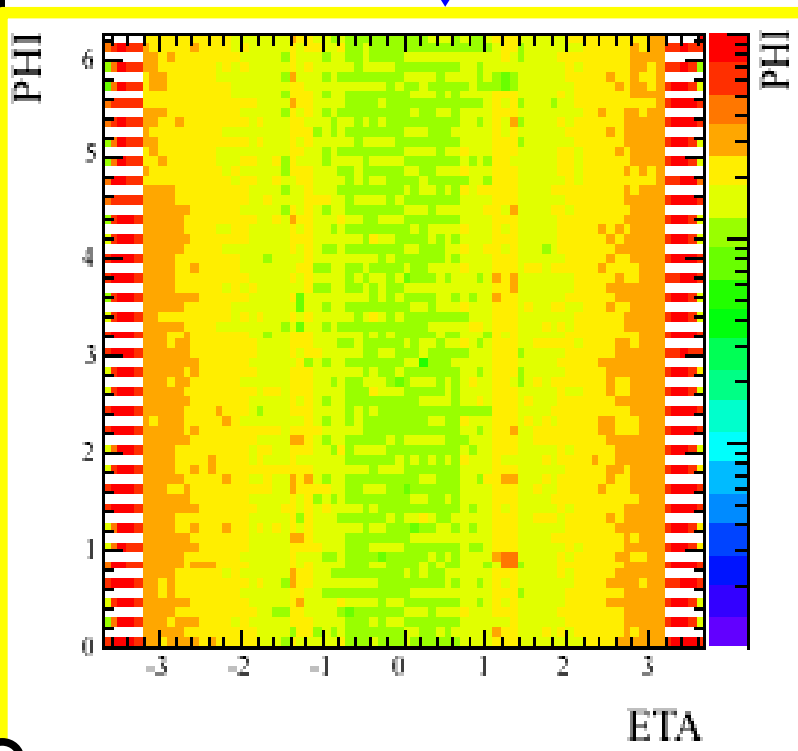


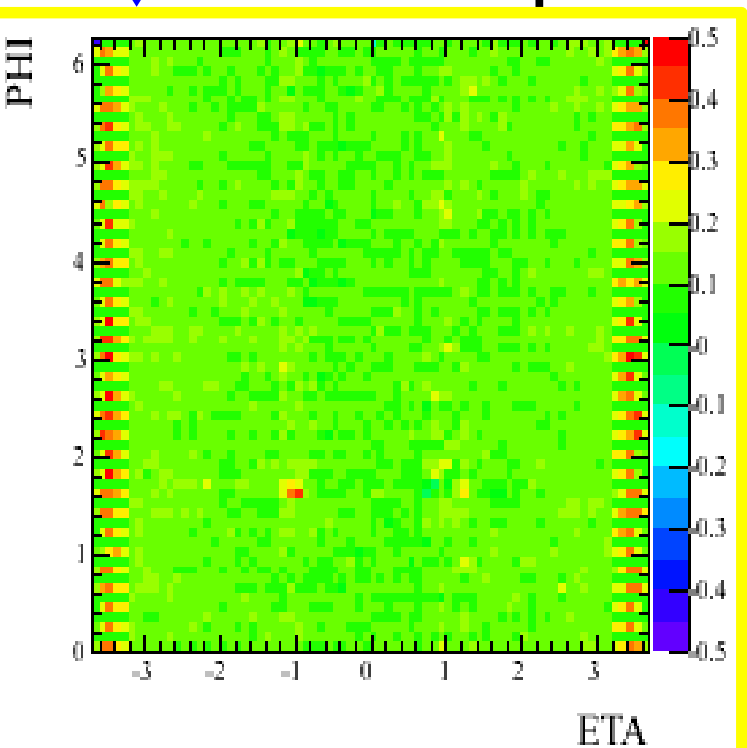


ONLINE Monitoring

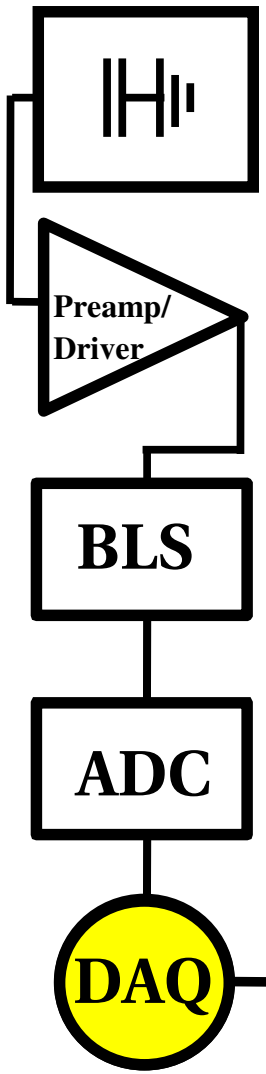


- Hardware is also monitored in the **signal output**:
  - **Signal output is shown in quantities such as:**
    - **Occupancy and energy mapping**

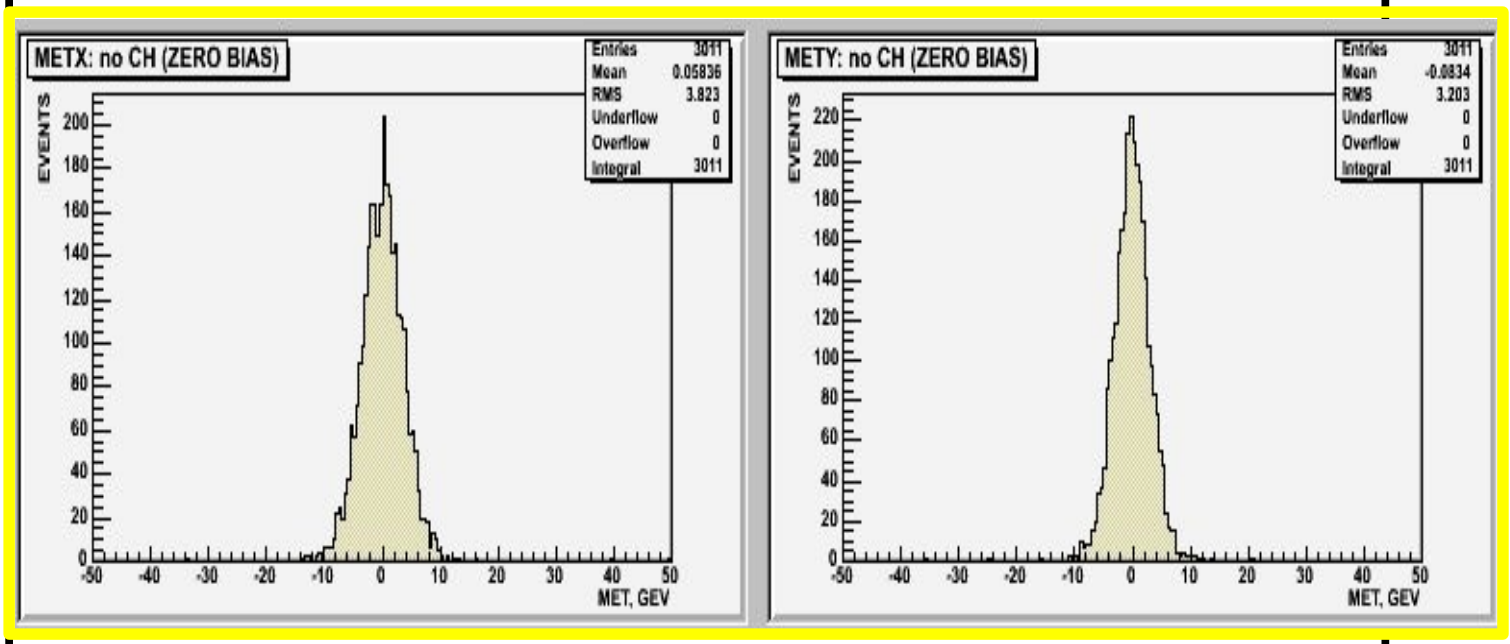




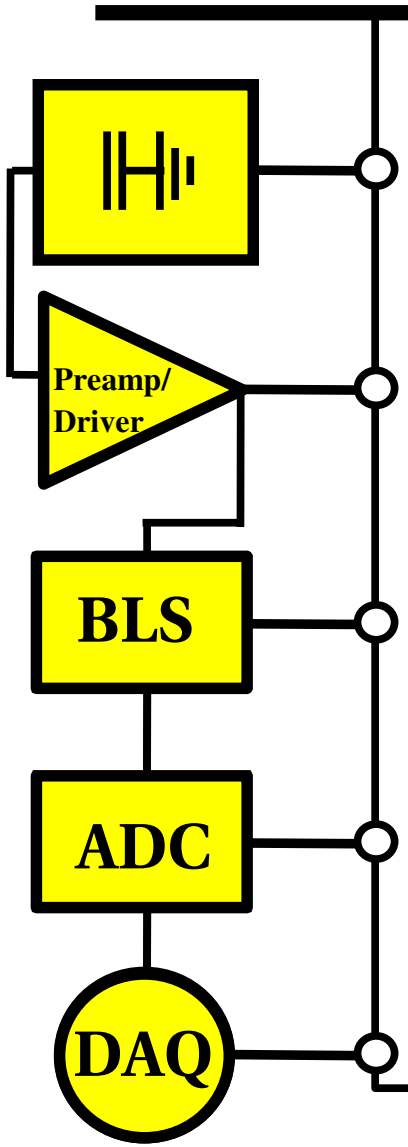
Electronics Monitoring

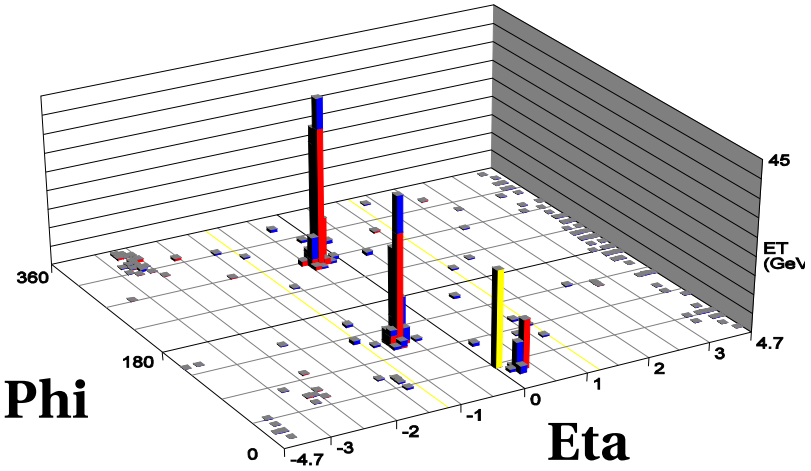


- Hardware is also monitored in the **signal output**:
  - **Signal output is shown in quantities such as:**
    - **Occupancy and energy mapping**
    - **Reconstructed missing energy (MET)**



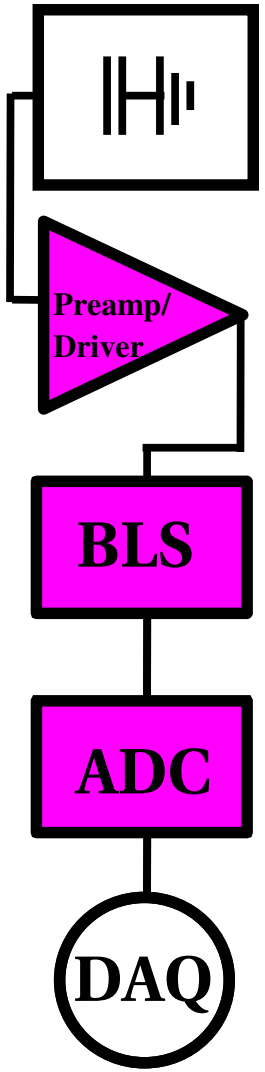
ONLINE Monitoring





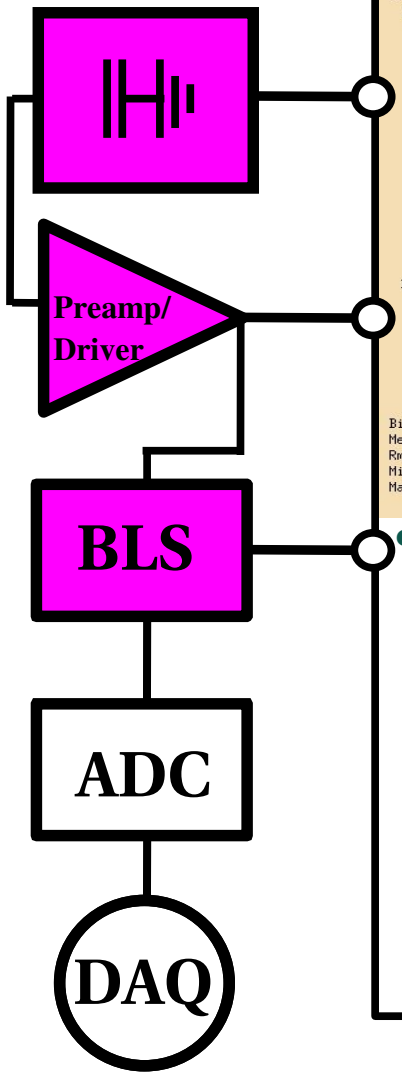
- **Shifters monitor system 24 hours a day**
  - **Problems are also linked to automated alarms**
  - **Event monitoring contain inline quality flags**
- **Pager-carrying experts handle the rest**
  - **2 experts always on call**
- **Online documentation, reports, and logs of data quality, repairs and problems maintained**

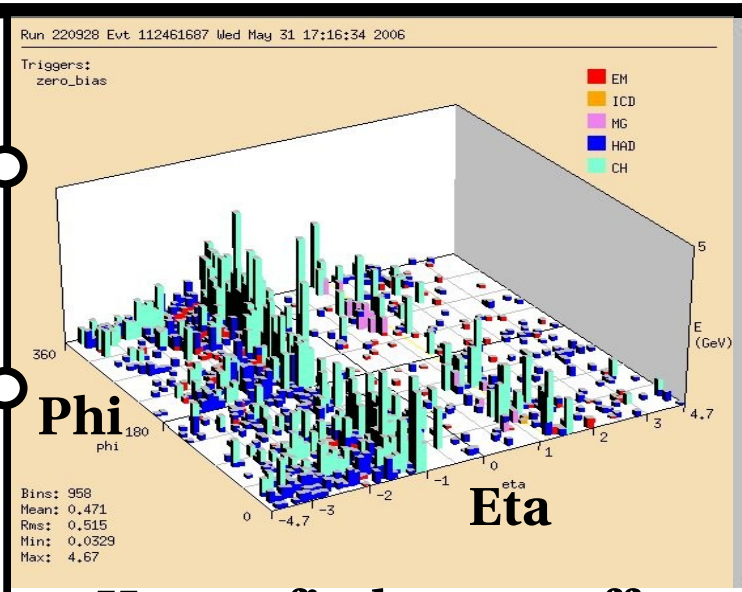
Hardware Stability

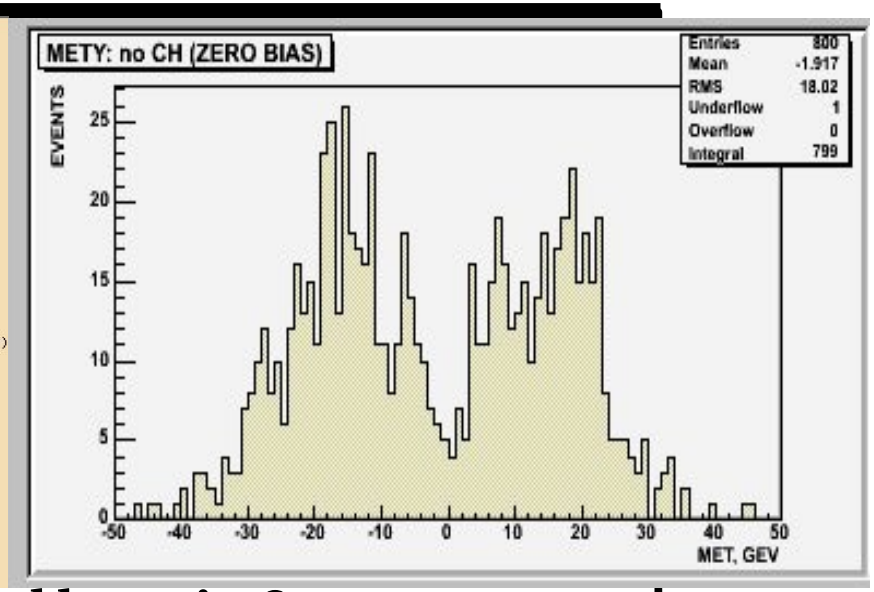


- **Hardware has shown remarkable stability in Run II**
  - **More than 99.8% of calorimeter operational**
- **Problems that do occur are**
  - Baseline Subtraction system
    - Daughtercards (**< 0.025% of all channels**)
      - ~1 failure/week, **30 minute replacement**
    - Motherboards (**< 0.1% of all channels**)
      - ~ 1 failure/month, **30 min. replacement**
    - Power supplies
      - ~1 failure per four months
      - **~2 hours needed for replacement**
  - Preamplifiers
    - Power supply failures
      - ~1 failure every three months
      - **~8-10 hours needed for replacement**
      - **Backup supplies are connected and in place in case of primary failure**

Noise and Failures

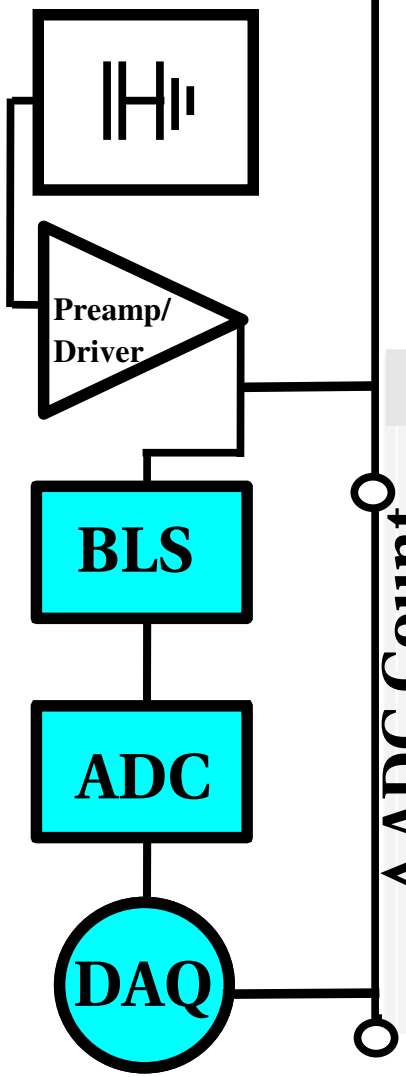




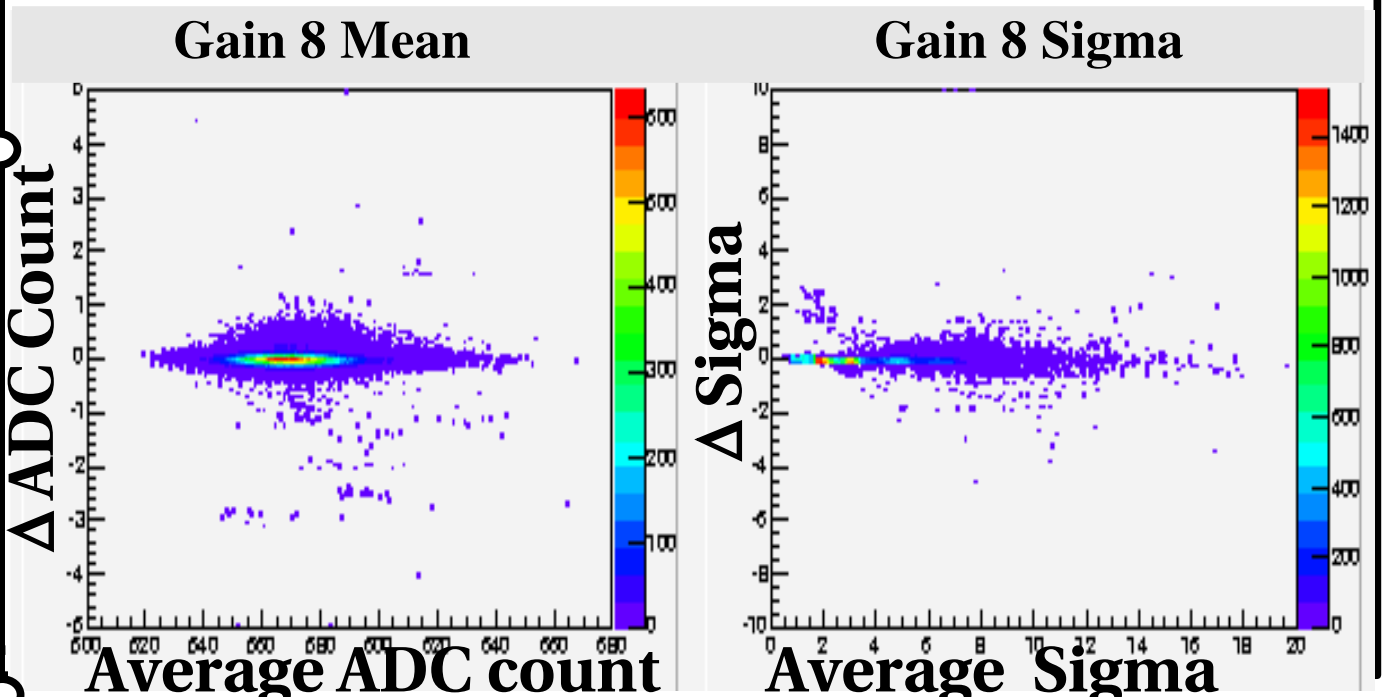


- How to find events affected by noise?
  - Online and offline algorithms implemented to scan data for contaminated events
    - Failures have distinct features
    - Most channel failures can be excluded to resume data taking within a few minutes
    - Performing frequent calibrations is the best preventative maintenance

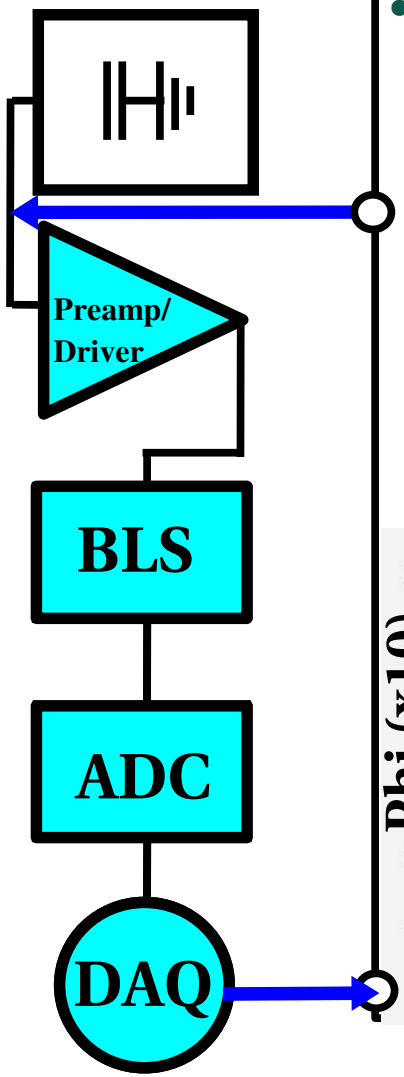
Online Calibrations



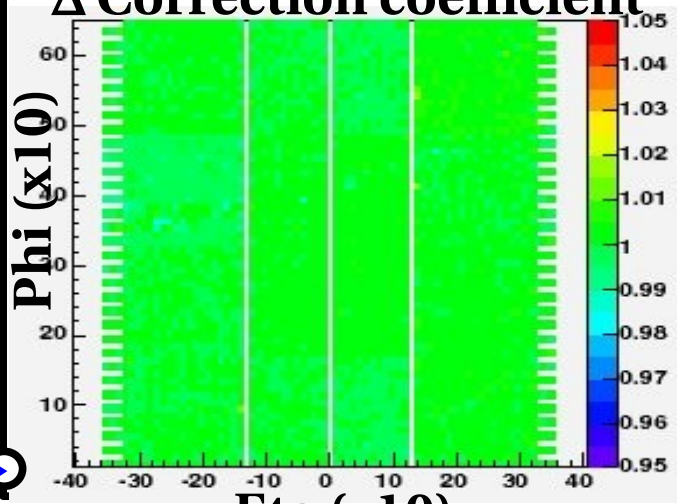
- **Pedestal calibrations:**
  - **Performed daily for both gain paths**
  - **Measure average values without beam**
  - **Changes in pedestal values from a reference set as a stability cross-check**

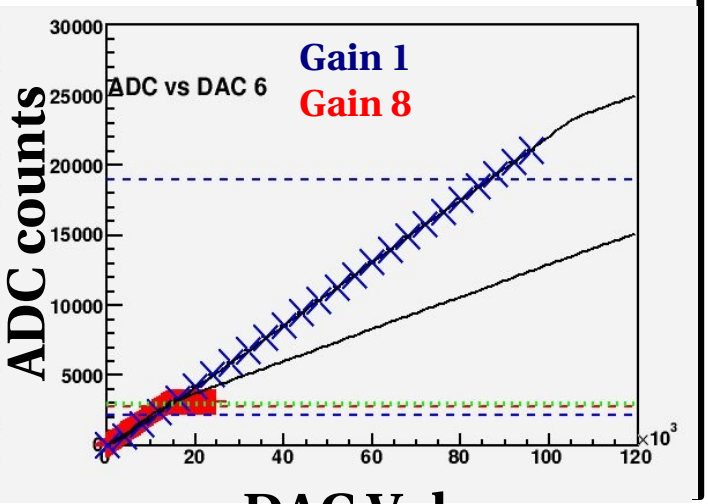


Online Calibrations

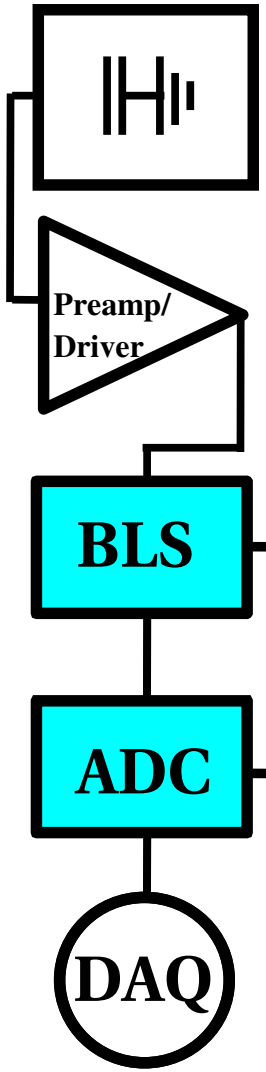


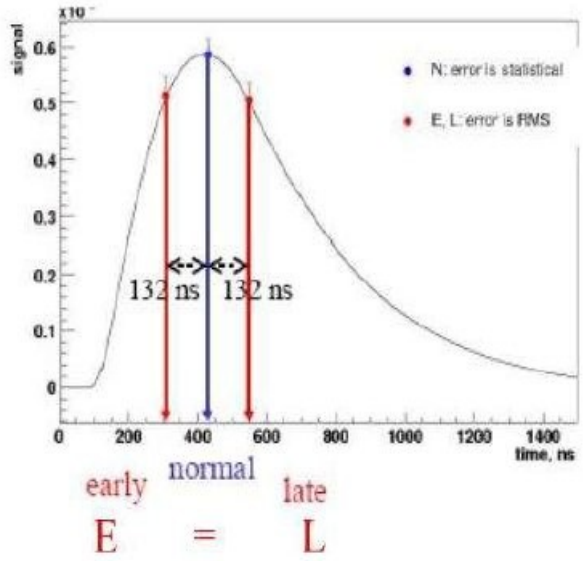
- **Pulser energy calibrations:**
  - **Always performed after hardware changes**
    - Insert known charge at the preamps
    - Compare to response of electronics
  - **Test channel by channel response**
    - Sample over entire dynamic range
    - Derive higher order corrections
    - **Overall stability of response also tested**

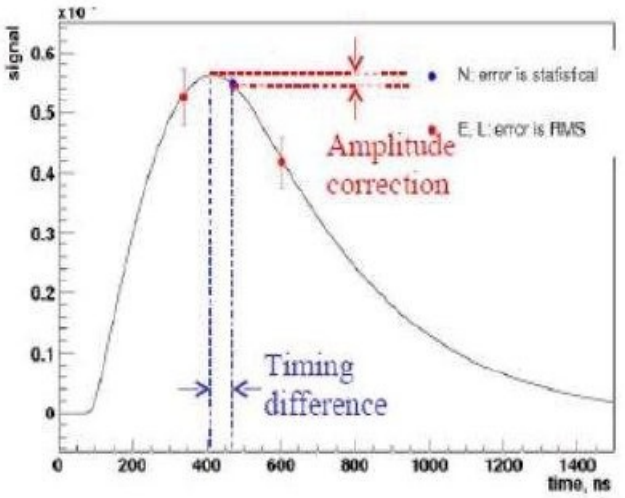




Triple Timing Study

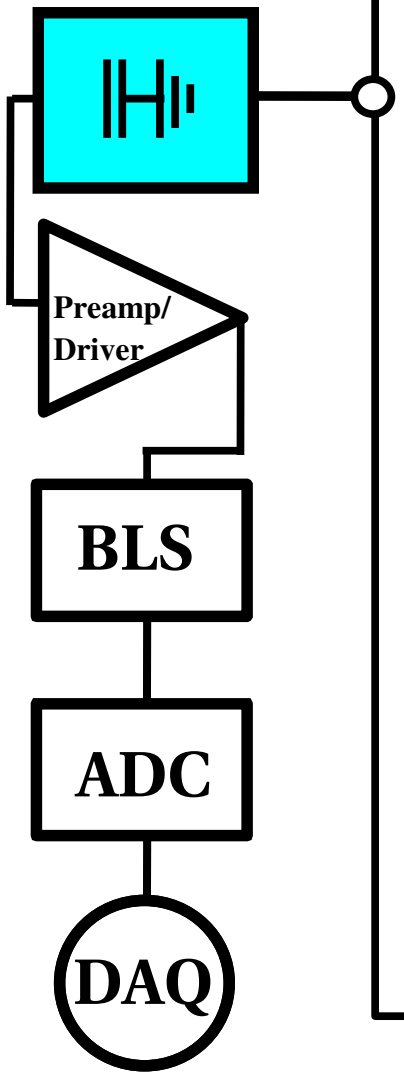






- **The correct cell energy depends on *timing***
  - Sample amplitude before, at and after signal peak
  - Performed channel by channel
- **90% of all channels see a 0.5% difference or less**
- **Performed every 6 months**
  - **Overall results very stable with time**

Insitu Calibration with Data



- **Calibrate cells in ϕ rings to equalize response**
  - **Assume physics to be ϕ independent**
  - Beams from Tevatron come unpolarized
  - Dependences from detector itself
- **Calibrate overall cell energy response**
  - **Performed after all other calibrations have been taken into account**
- **Calibrations use ~5-15 million events**
  - **Data taken parasitically with normal running**
  - **Stability checks performed every six months**
  - **Variations in time periods are very small and overall the system is very stable**
    - **Uncertainties in central region are ~0.7%**

Conclusions

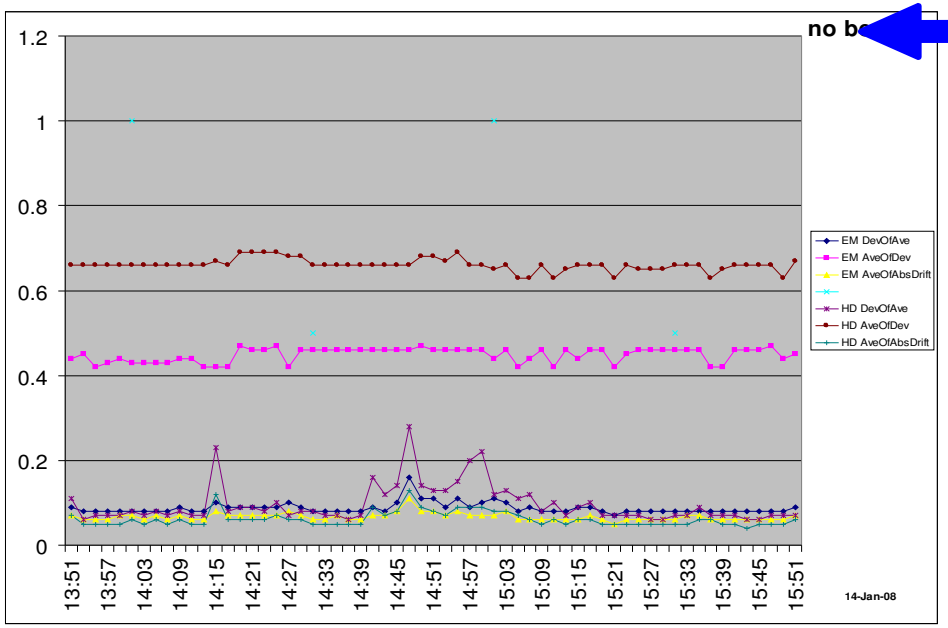
- DØ calorimeter has performed efficiently and reliably
  - > 90% efficiency for the entire detector for the Tevatron Run II period
- Data quality is thoroughly monitored
  - Performed online and offline for both hardware and reconstructed events
  - Potential noise sources closely watched
- Calibration and overall stability are the priority
  - Daily online calibrations and higher level studies routinely performed
  - >99.8% of all channels perform well
  - Problems that occur typically affect < 0.2% of channels and are quickly fixed
- We look forward to more data and continued highly efficient running!

L1 Calorimeter

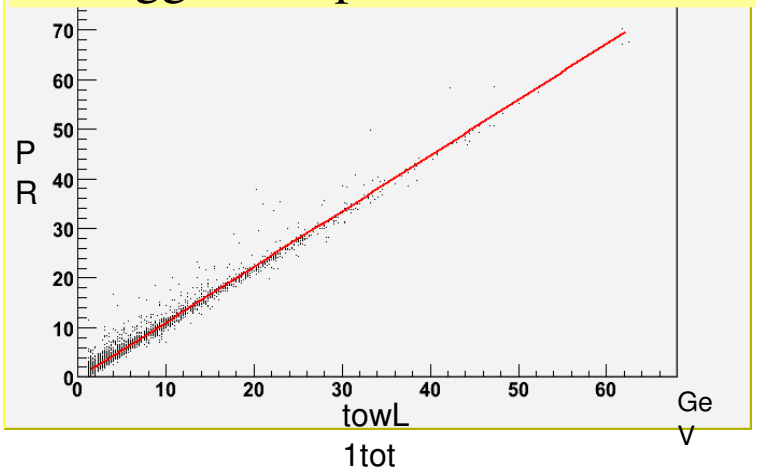
Upgraded in 2006

- Dynamic Pedestal Calibrations
  - Tower energy offsets

New values derived every ~2-3 minutes
Removes instantaneous luminosity effects

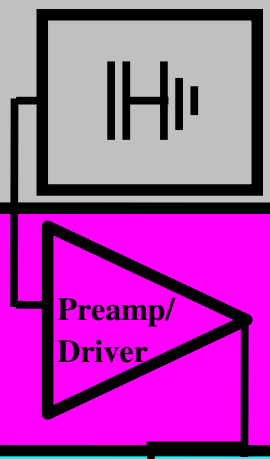


Very good agreement between the trigger and precision readout



- Online operations
  - Currently five excluded trigger towers (< 0.5% of all towers)
  - Automated run pausing alarms included online

The Calorimeter Chain



Calorimeter Cells — No Possible Access

Preamplifiers — >4 hours to Access Area

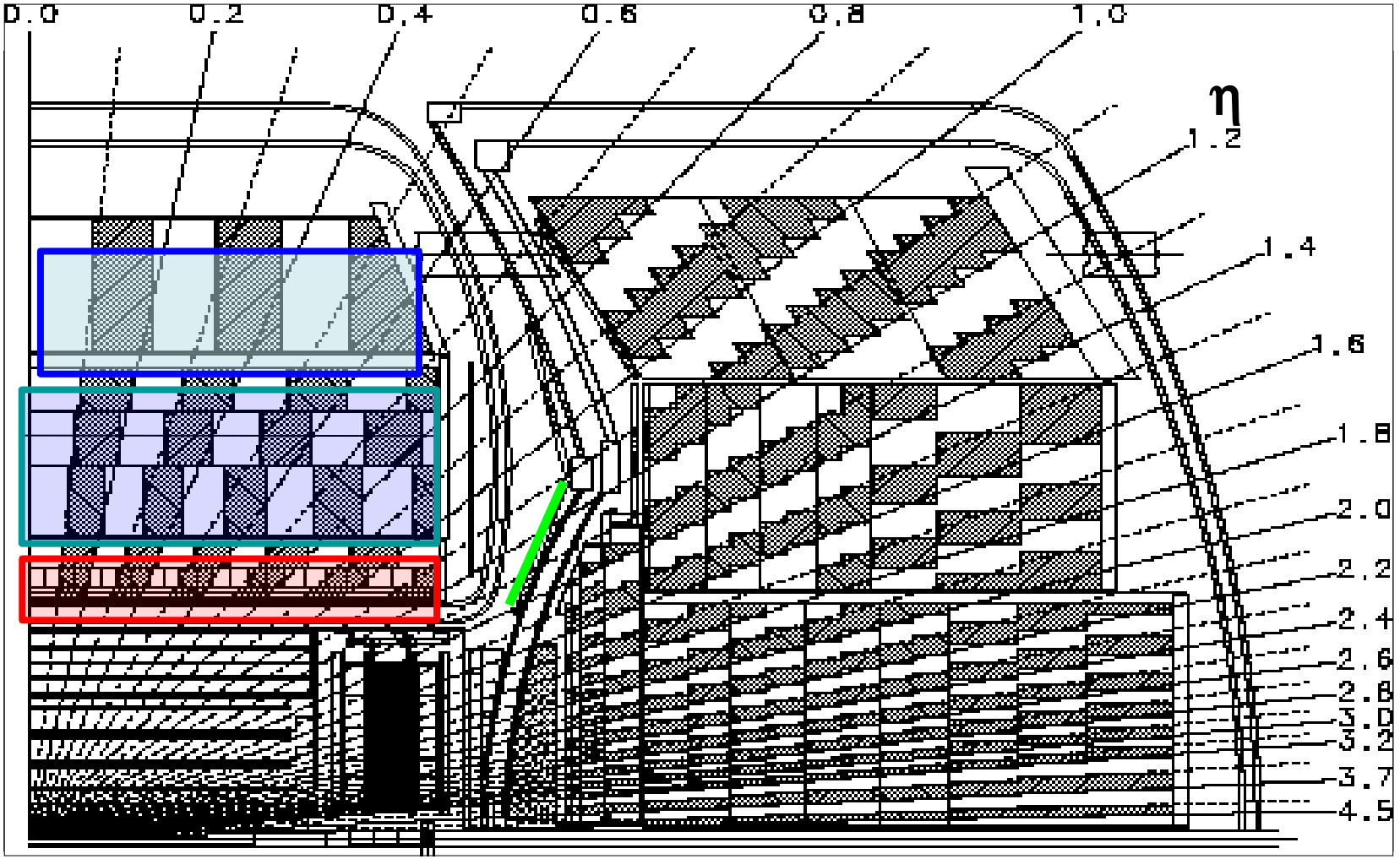
Baseline Subtraction — Access only without beam

L1 Trigger System — Unlimited Access

Analog to Digital Converters

To Data Acquisition System

Calorimeter Profile



Calorimeter Layer Mapping