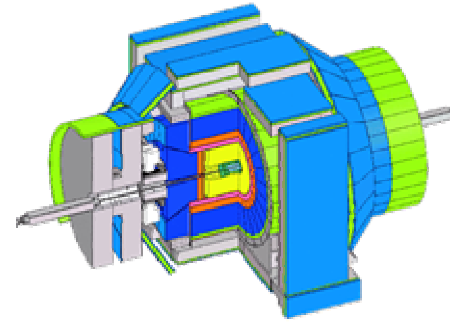


The Integrated Calorimetry Environment of CDF2

Robin Erbacher / The CDF Collaboration

Fermilab-- Batavia, Illinois U.S.A.

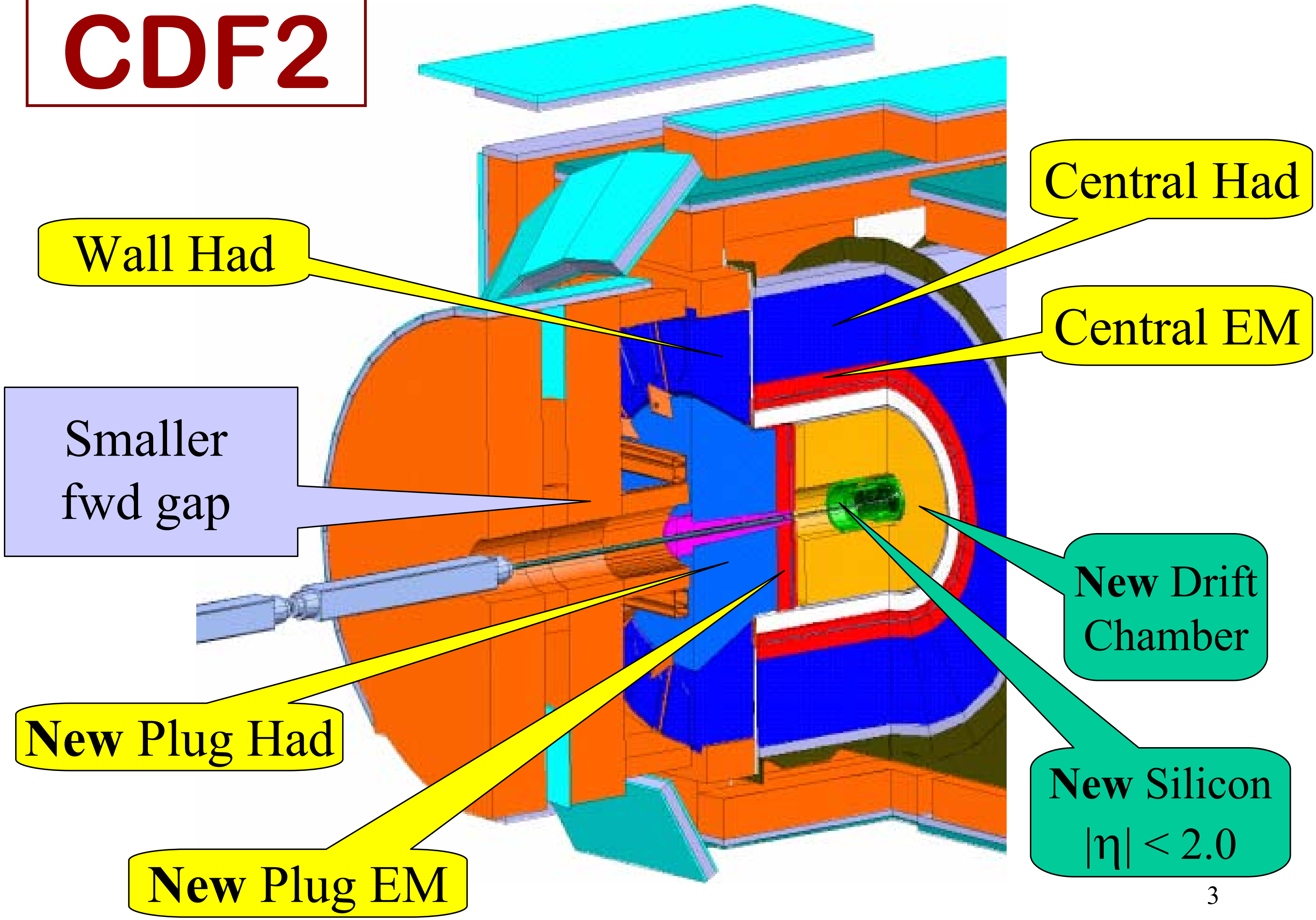
ICHEP: 31st International Conference on High Energy Physics
Amsterdam, Netherlands   July 24-31, 2002

Calorimeter Integration

- **Various Tevatron upgrades required changes to system, enabling integration:**
  - $\sqrt{s}$: 1.8 → 1.96 TeV (PMT signals double)
  - Bunch Xing: 3.5 μs → 132 ns (new FEE/trigger)
  - Lum: 2×10^{31} $cm^{-2}s^{-1}$ ('96) → 5×10^{32} (>'04)

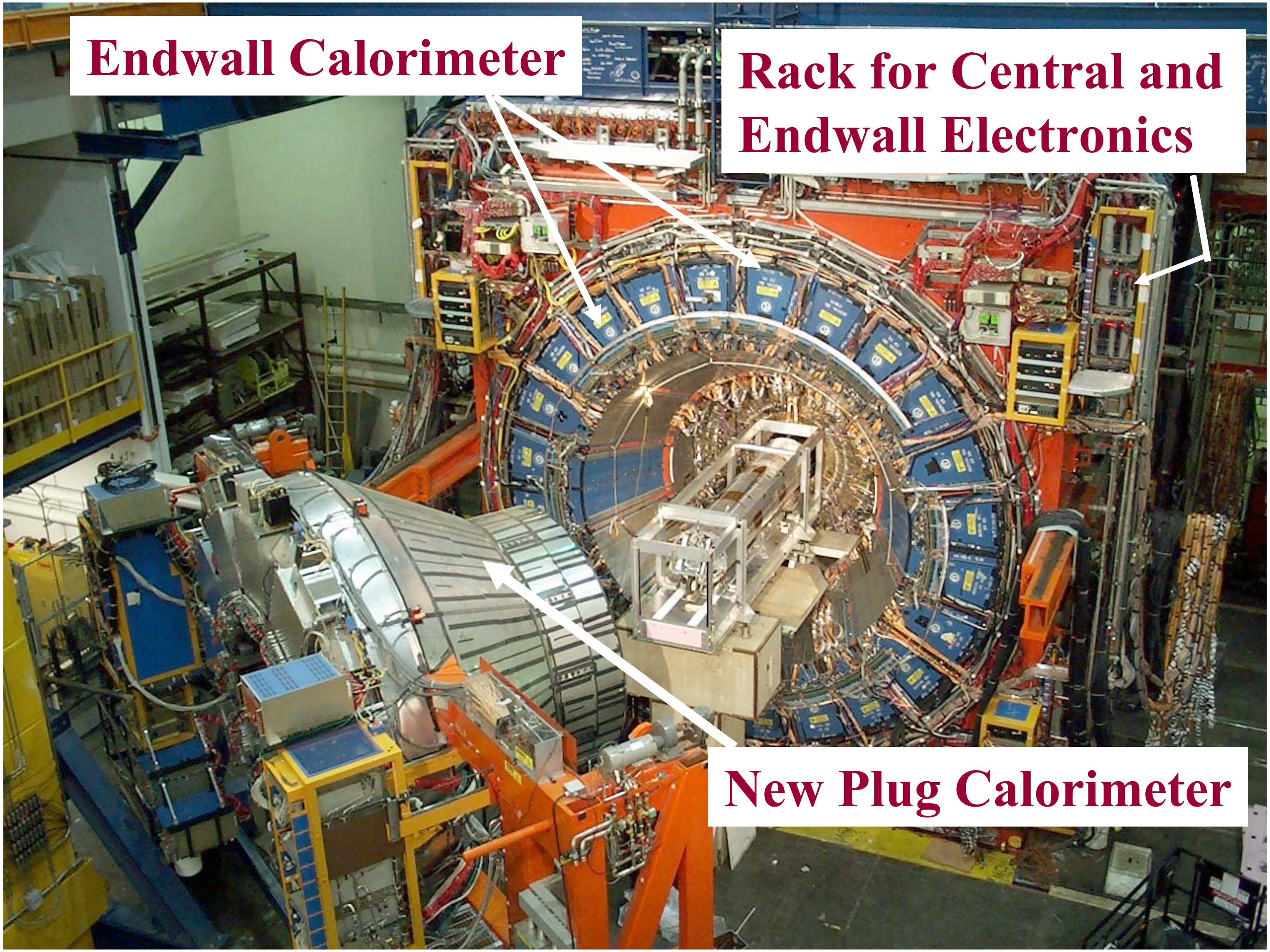
- **Replacement of old gas plug calorimeters**
  - Rate limitations at Tevatron Run 2
  - Forward noisy due to insufficient shielding
  - Unlike in the central, no EM pre-shower and no timing measurement.

CDF2

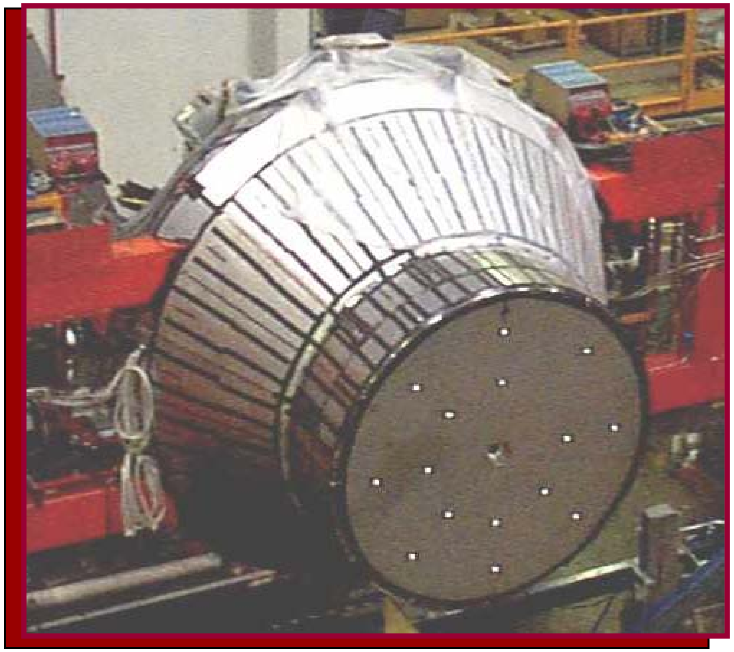


Central Had
Wall Had
Central EM
Smaller fwd gap
New Drift Chamber
New Plug Had
New Silicon |η| < 2.0
New Plug EM

The CDF2 Calorimeter System



EndPlug Upgrade

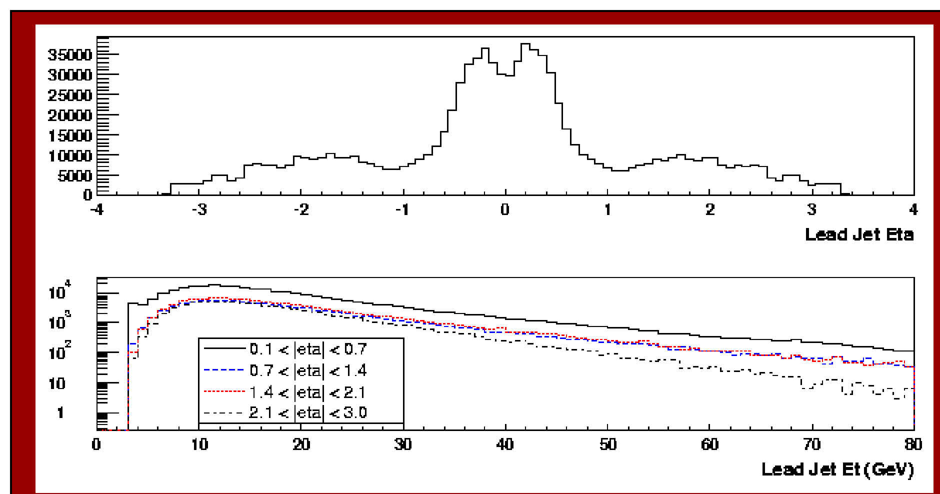


➢ New Plug Calorimeters

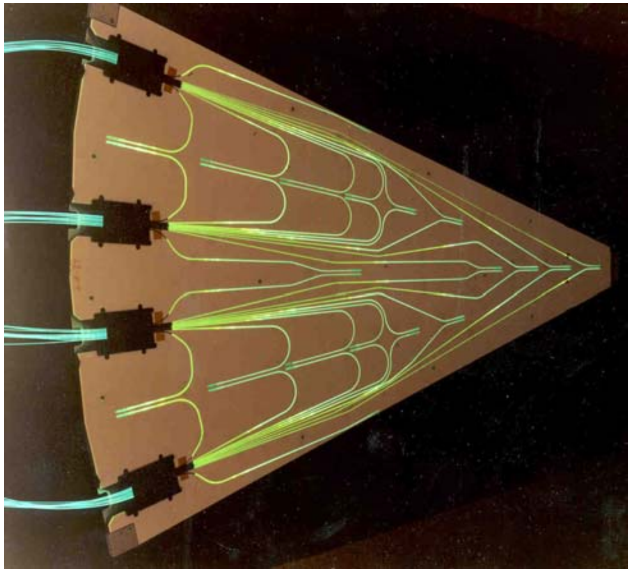
- Scintillator tile design: Fast ! plus better sampling fraction than Run I gas detector
- Same technology over full solid angle to $|\eta| = 3.6$
- More hermetic: 10° fwd gap gone, 30° reduced

➢ Central Calorimeters

- Kept Run I detectors
- Scintillator based→fast
- New readout electronics



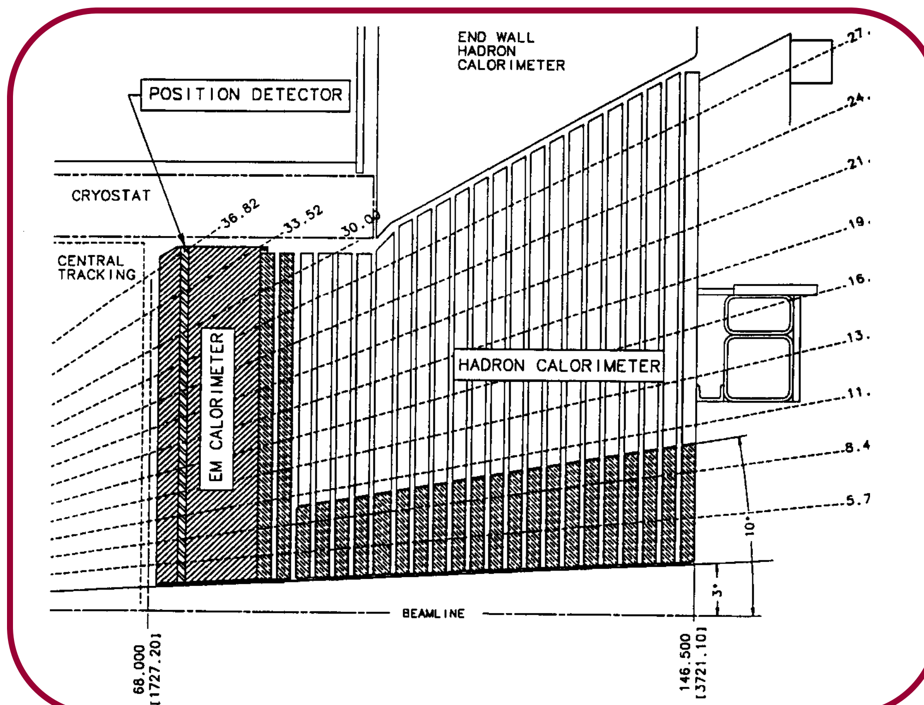
Similar Technology Across η



- All calorimeters now use scintillators plus WLS:
  - Central: plastic slab with lead/steel and WLS
  - Plug: scintillator tile with lead/steel and WLS

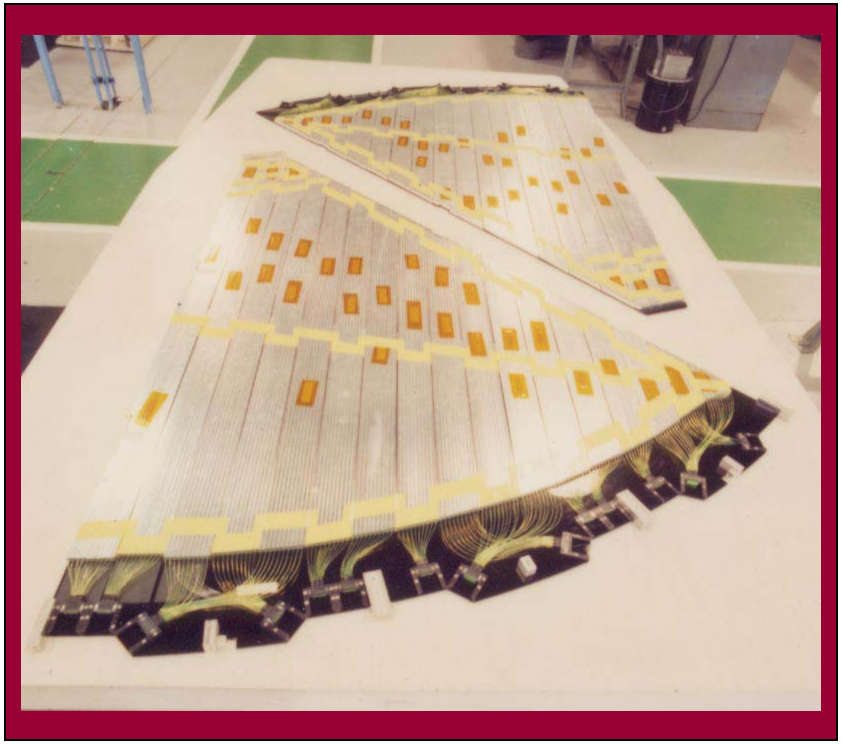
SEGMENTATION OF THE "PROJECTIVE" TOWERS

|η| range	Δφ size	Δη Size
0.-1.2	15°	0.1
1.2-1.8	7.5°	0.1
1.8-2.1	7.5°	0.16
2.1-3.6	15°	0.2-0.6



Shower Maximum Detectors

- **Central: Gas chambers w/ strips and wires**
  - Important for electron, photon, pion identification
  - New FE electronics: SMQIE chip
  - <1% prob. channels, no aging
  - Upgrade CPR for Run 2b

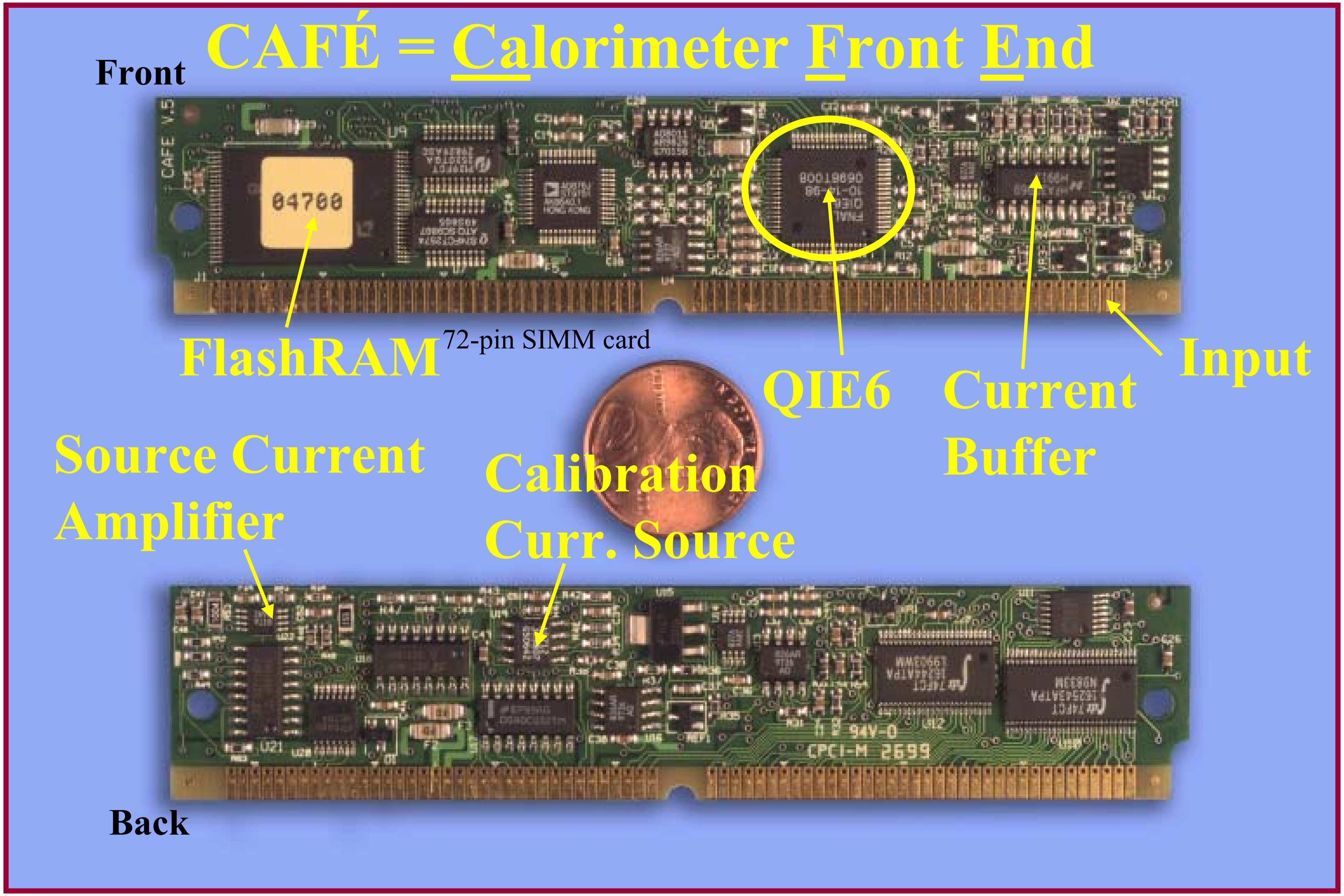


- **Plug PES/PPR new in Run 2**
  - Scintillating strip/WLS fiber
  - 2 layers ~6 rad lengths in
  - Energy in PES/PEM well-matched; position to 1.5 cm can improve with fwd silicon

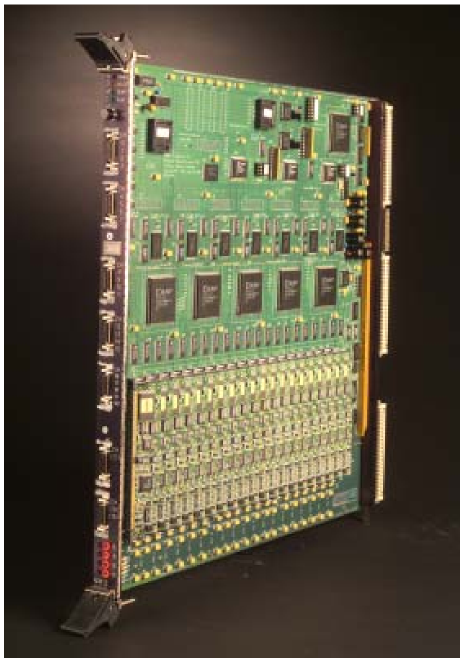
Front End Electronics

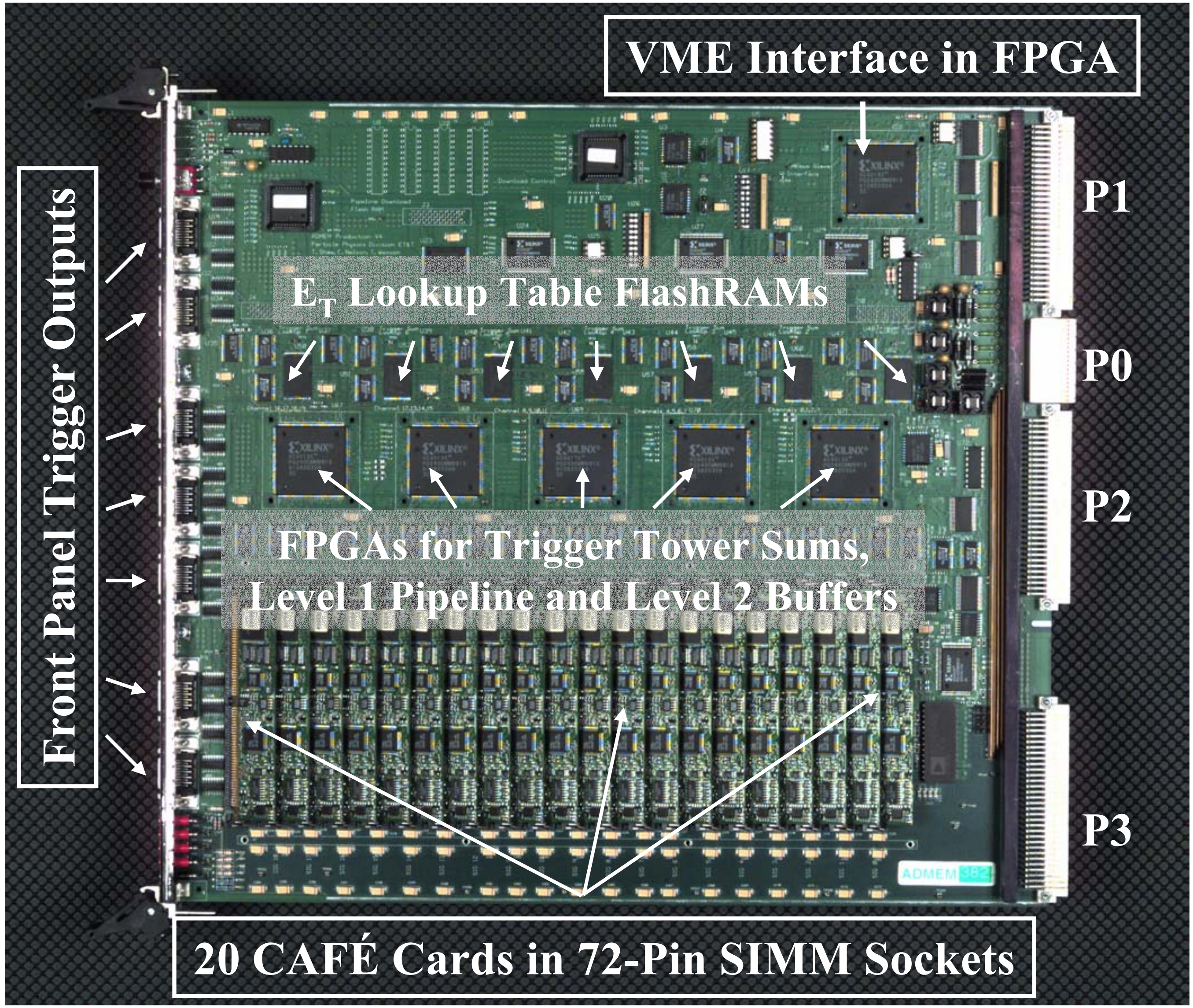
- **PMT Readout Based on QIE6 ASIC**
  - QIE6 uses binary-weighted splitter, 8 current ranges
  - Using 10-bit ADC gives 18 bits of dynamic range
  - QIE and ADC mounted on daughter CAFÉ card along with calibration and charge-injection circuits, & FADC.
- **ADMEM (ADC+Memory) boards hold 20 CAFÉ's**
  - Provides Level-1 trigger with transverse energy sums using Xilinx FPGAs, and provides 4-buffer Level-2 storage
  - Pipelined Level-1 buffer 42 clock-cycles (~5.5 μs) deep allows "deadtimeless" readout upon L1 accept

CAFÉ Front End Module



ADMEM VME Boards

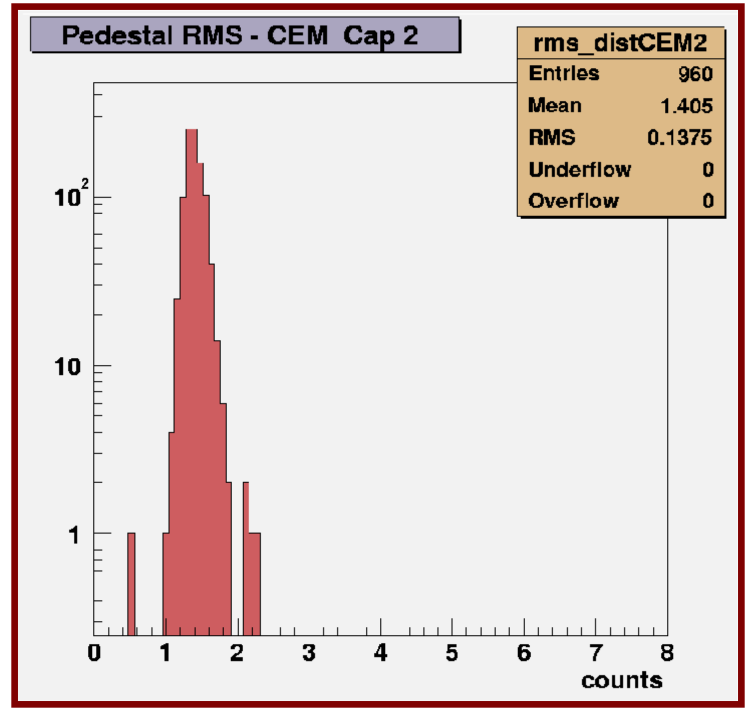


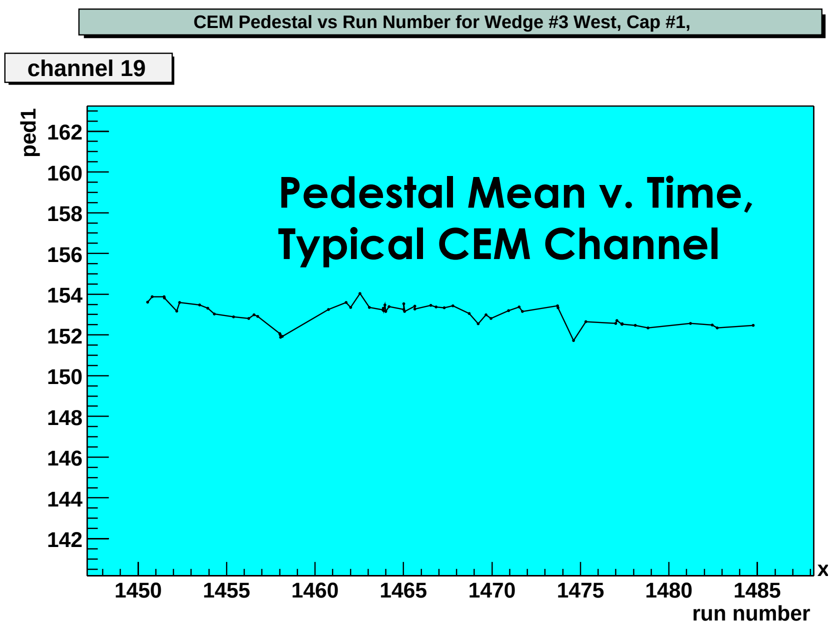


System Noise

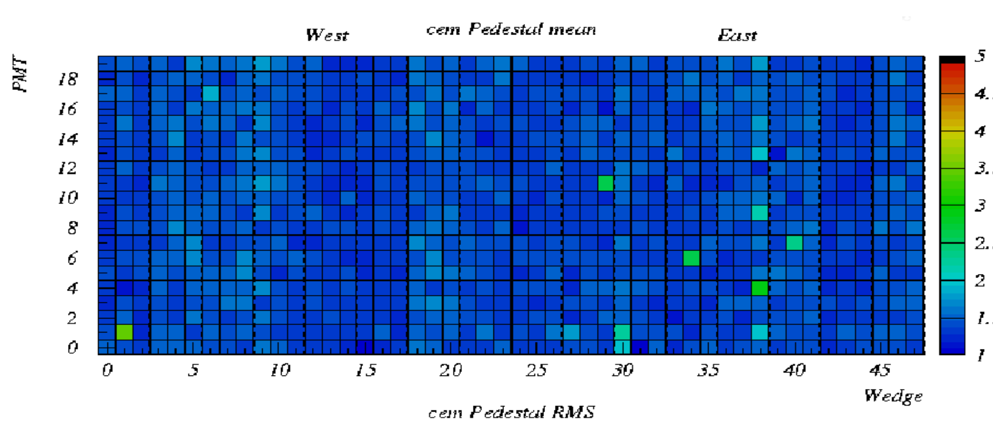
Calorimeter system is now very quiet and stable

PEM, PHA, CEM, CHA, WHA detectors have typical ped RMS values of 1.5-2.5 counts (~5-6 MeV or 10-15 fC)



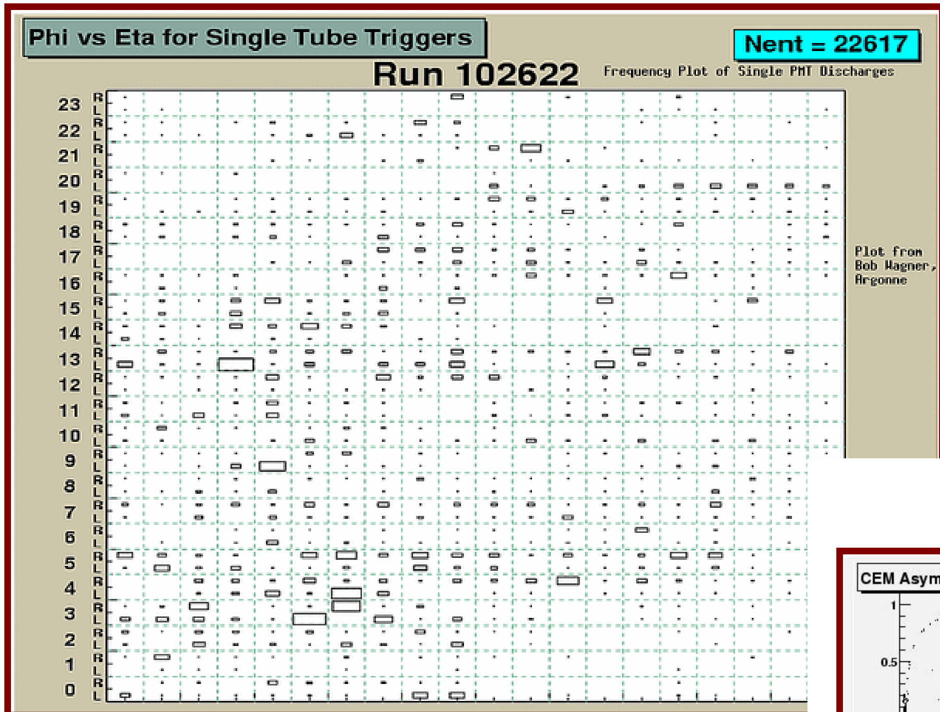


>3 month period



η v. φ map of CEM pedestal RMS

PMT Spikes in Central Cal

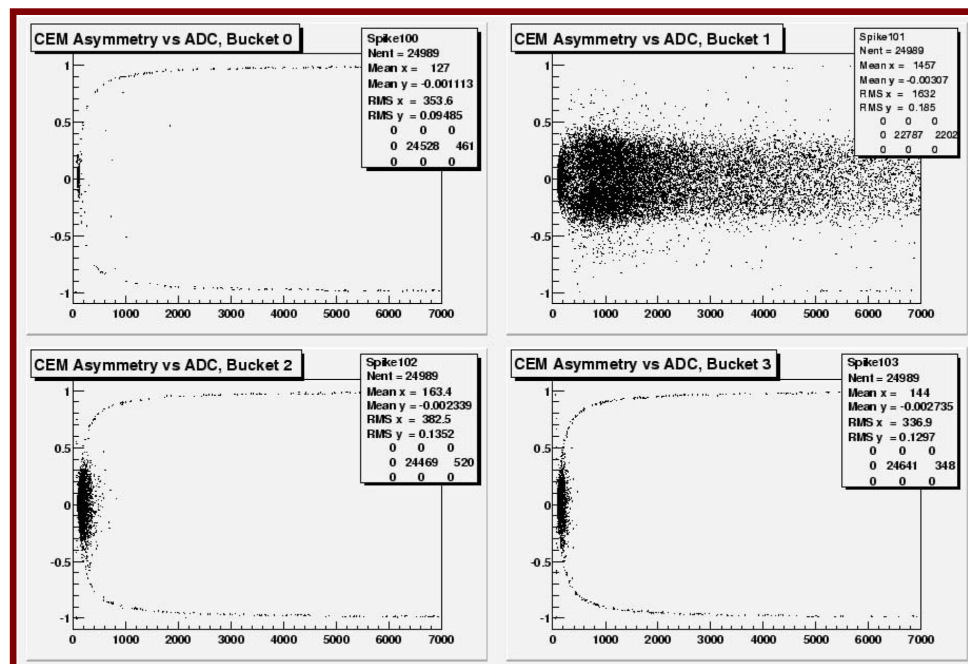


PMT discharges (spikes) continue to be a problem in Run 2, mainly in CEM

Map of spikes from Commissioning run on left shows noisiest tubes

Spike-Killer has been implemented in the trigger and in offline

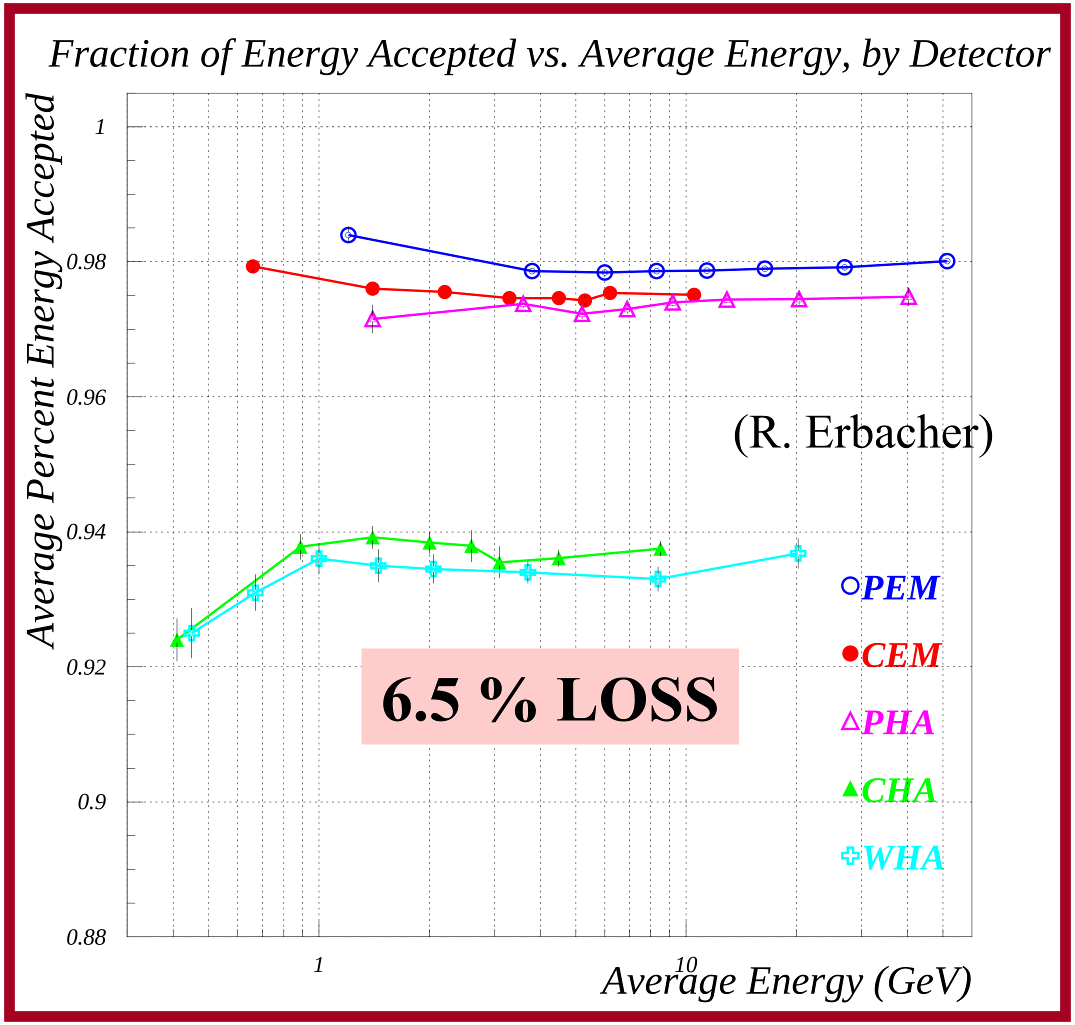
Can identify spikes fairly easily as seen on right in out-of-time events



Signal Loss Outside Gate

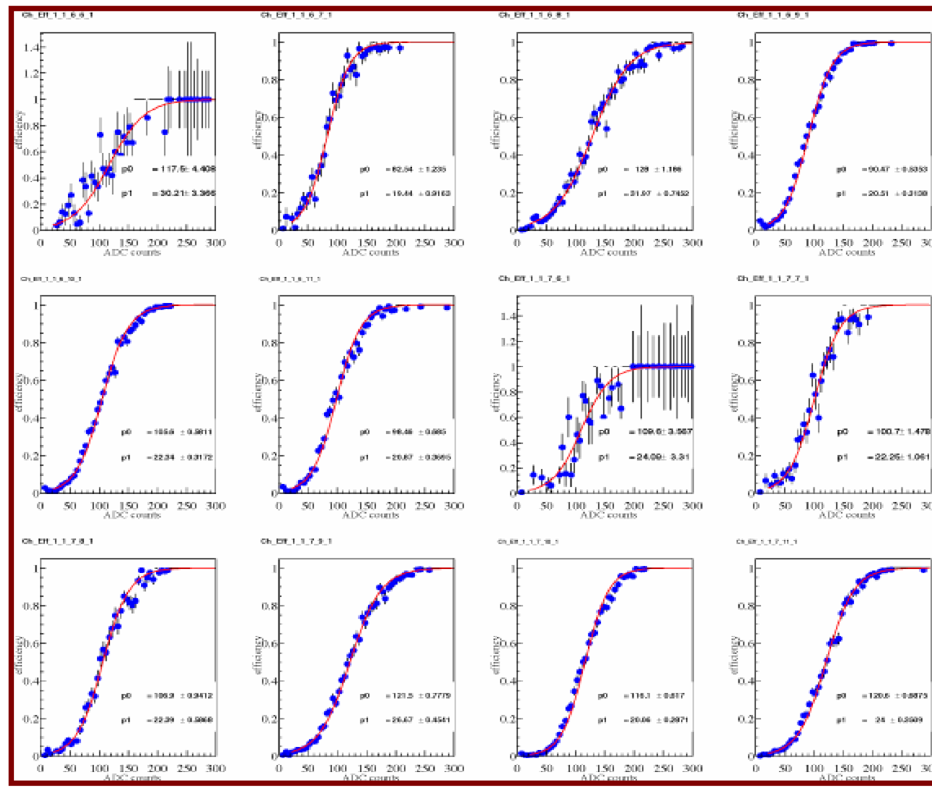
ADC Integration Gate reduced: 1200→132ns

- Fraction of total event energy in gate measured using jets and muons
- Unexpected loss of signal into next time slices; central hadron detectors worst (~6.5%)
- Longer τ_2 component of the WHA and CHA scintillator likely



Hadron Event Timing

- ➢ **New Had TDCs and Discriminators for Run 2**
  - Crucial in Run 1 for removal of cosmics and beam losses
  - Endplug now also has Hadron TDC timing information



- ➢ **EM TDC upgrade planned for Run 2b**
  - Rejection of cosmics essential in rare SUSY searches using e's and γ's
  - Until now, used time leakage of EM showers into hadron: low efficiency

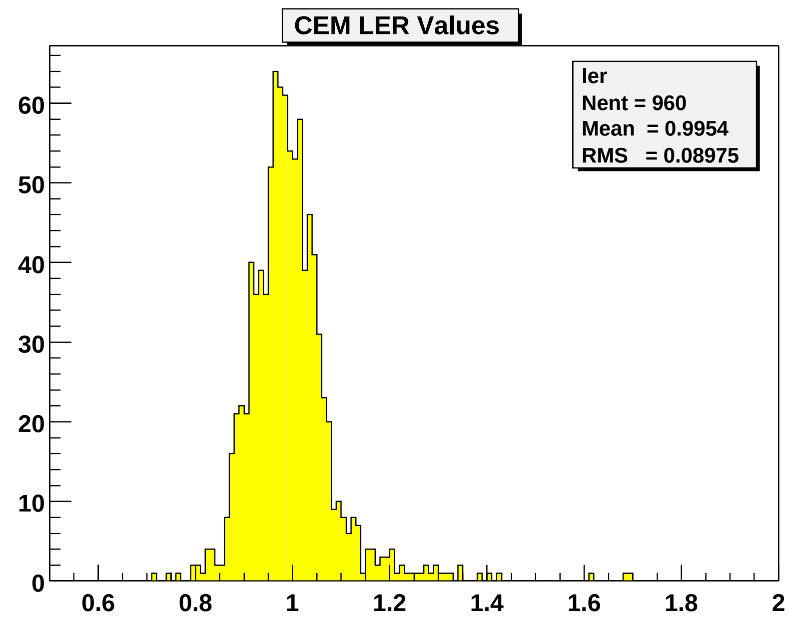
Calibration Systems

➢ Absolute Energy Scales

- Original test beam calibrations maintained w/ sourcing
- ^{137}Cs system refurbished for central; ^{60}Co used in plug
- Verify scales with data

➢ Relative Energy Scales

- PMT gain variations corrected for, then tracked w/ light pulsers
- Laser/LED flashers used for HAD; LED/Xe flashers for EM

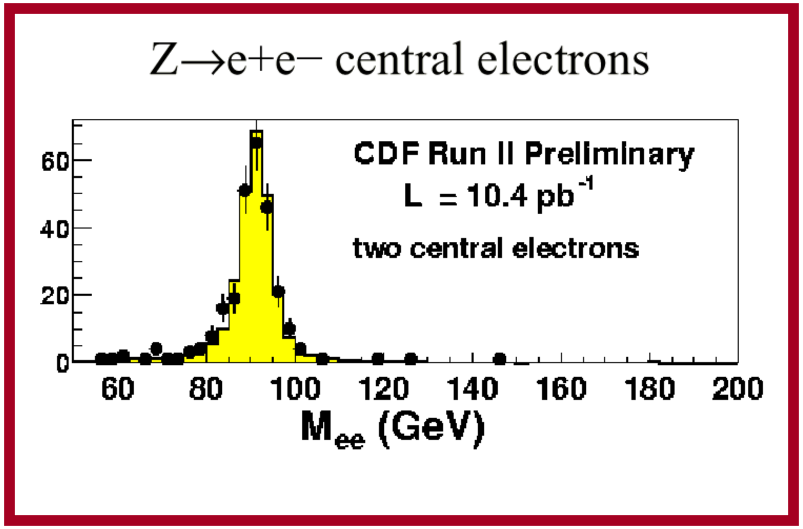


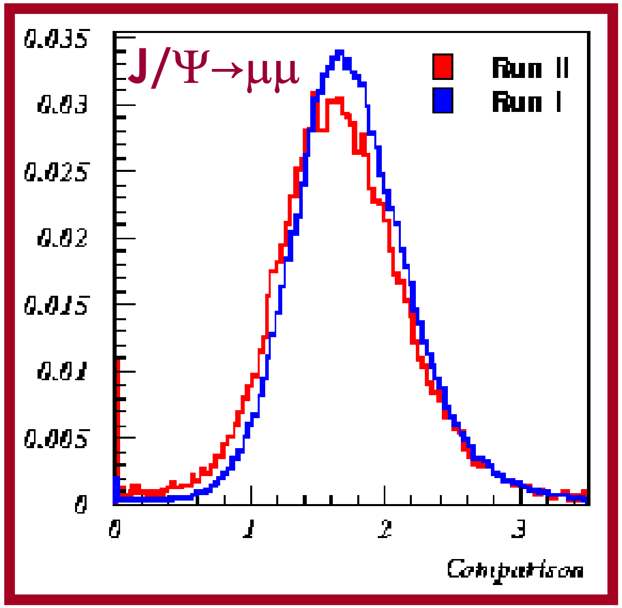
Distribution of CEM correction factors for tower-to-tower gain variations

Energy Scales and Jets

Use M(Z) and M(W) to verify EM energy scale

M(Z) ~ 91 GeV





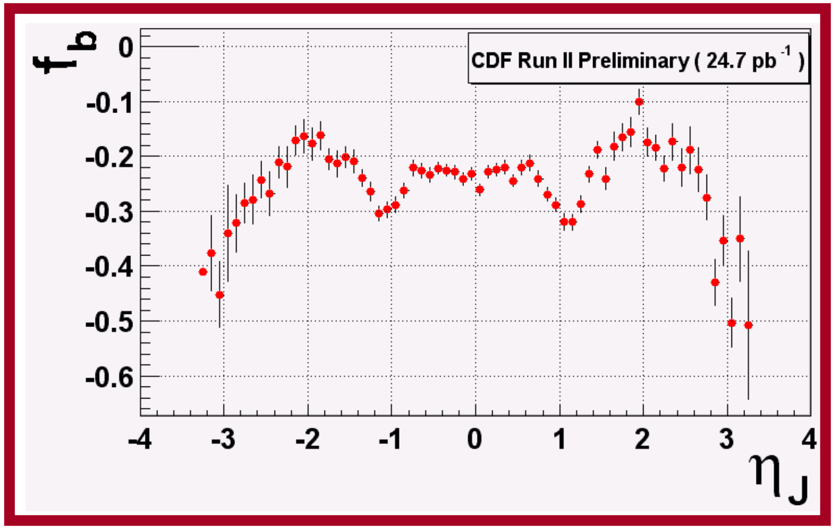
Check HAD energy scale with MIPs

MIP_2/MIP_{1b}=0.96 ± 0.005

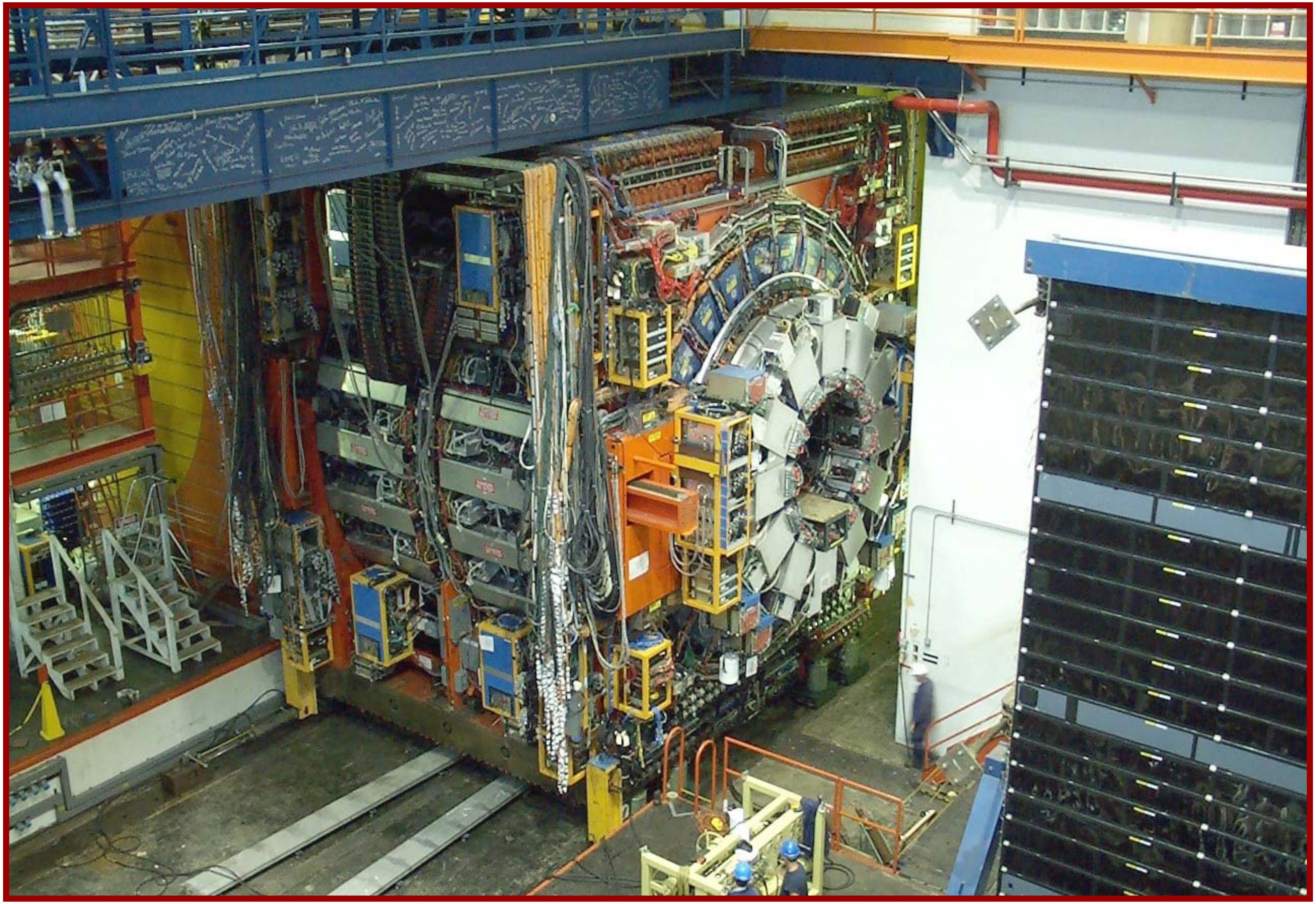
Use γ-jet p_T balancing to find jet scale wrt Run 1

$f_b = (P_T^{Jet} - P_T^{\gamma})/P_T^{\gamma}$

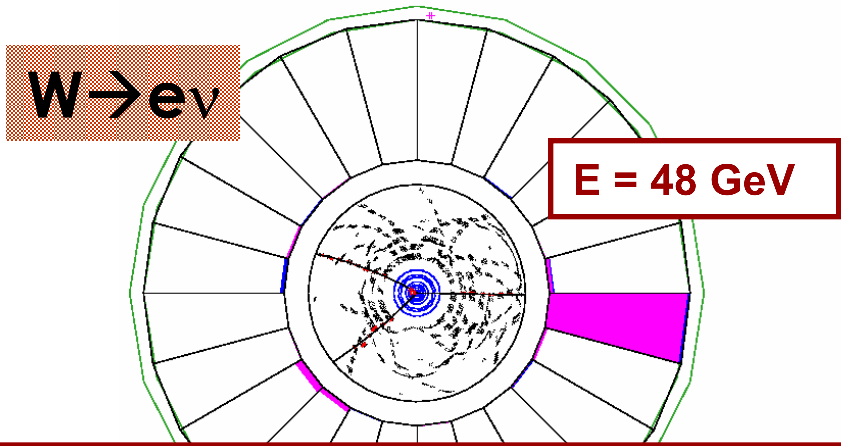
$\Delta f_b = (4.0 \pm 0.4)\%$

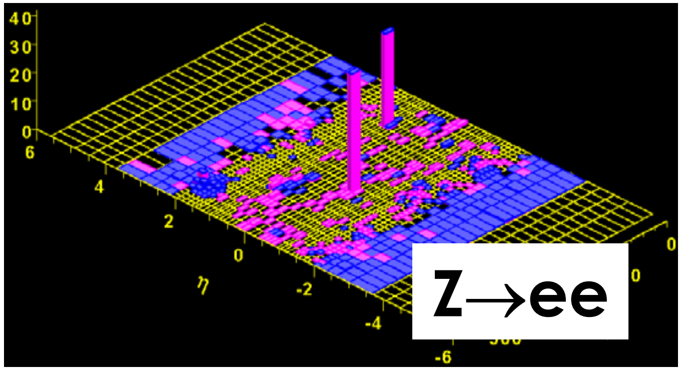


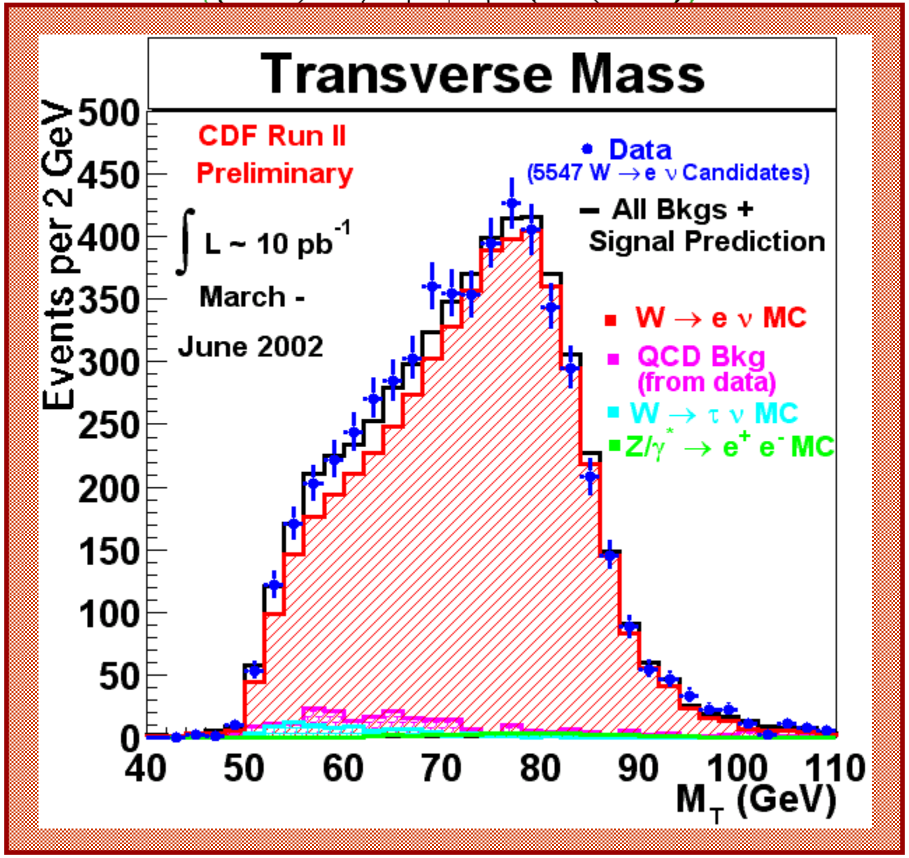
Rolling in for Collisions

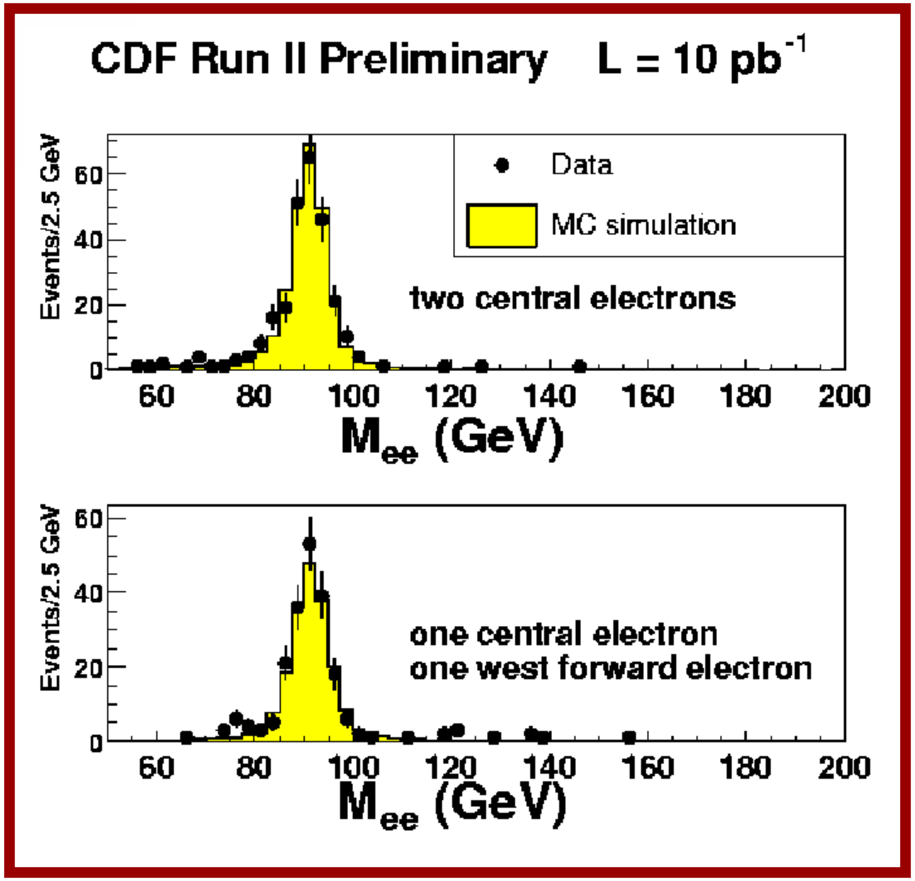


W and Z Candidates









Summary and Prospects

The calorimeter upgrade for CDF2 was successful

- Replacing the endplug with similar technology to the central detectors has allowed us to achieve an integrated calorimetry environment
- Common electronics for all of the calorimeters, and similar readout for the shower maximum, has provided stable running from early on
- With the small upgrades for Run 2b, we expect to have a strong calorimetry environment through this decade
- CDF has new data!