Status of the Calorimeters

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for the CDF Calorimeter Group

CALOR 2006
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Plan

• CDF II calorimetry
  • Mix of systems made during Run I, before Run II, and upgrades since the beginning of data taking
  • Not discussing the muon detectors, miniplug (extreme forward calorimeters), or the EM-timing system (talk by Max Goncharov after the coffee break)
  • Talks on specific systems were made at multiple conferences (CALOR02, Snowmass05, etc.)

• Operational experience
  • Problems discovered during data taking

• Selected recent physics results
  • Demonstrate the calorimeter capabilities
CDF II Calorimeters

- Phi - 15 degree wedges
- Same Central and Endwall calorimeters from Run I (scintillator plate with WLS bars)
- New for Run II
  - Plug Calorimeter: scintillator tile with WLS fibers replaced the Run I gas calorimetry
  - EM and HAD readout electronics
- Fall 2004
  - Central Preshower and Crack Detectors
Plug Calorimeter

Side view of the east end plug, the WHA, and portions of the solenoid, CEM, and CHA.
## Similar Technology for Plug and Central Calorimeters

<table>
<thead>
<tr>
<th></th>
<th>Central (Endwall)</th>
<th>Plug</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EM lead-scintillator sampling</strong></td>
<td>18 radiation lengths</td>
<td>23.2 radiation lengths</td>
</tr>
<tr>
<td></td>
<td>$\sigma_E/E = 13.5%/\sqrt{E} \oplus 1.5%$</td>
<td>$\sigma_E/E = 16%/\sqrt{E} \oplus 1%$</td>
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<tr>
<td></td>
<td>$</td>
<td>\eta</td>
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<tr>
<td><strong>HAD steel-scintillator sampling</strong></td>
<td>4.7 interaction lengths</td>
<td>6.8 interaction lengths</td>
</tr>
<tr>
<td></td>
<td>CHA $\sigma_E/E = 50%/\sqrt{E} \oplus 3%$</td>
<td>$\sigma_E/E = 80%/\sqrt{E} \oplus 5%$</td>
</tr>
<tr>
<td></td>
<td>WHA $\sigma_E/E = 75%/\sqrt{E} \oplus 4%$</td>
<td></td>
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<td>\eta</td>
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<tr>
<td><strong>Shower Maximum (ES)</strong></td>
<td>PWC for phi scintillating strips for Z $\sim 2$ mm res for W electrons</td>
<td>2 layers scintillating strip/WLS fiber $1.5$ mm wire res</td>
</tr>
<tr>
<td><strong>Pre-Shower (PR)</strong></td>
<td>12.5 x 12.5 x 2 cm tiles</td>
<td>1 cm thick tiles shadow PEM towers</td>
</tr>
</tbody>
</table>
• CPR - Central Pre-Radiator, tile-fiber system similar to the Plug
  
  • Occupancy of existing gas Pre-shower would have been too high
  
  • CCR - Central “Crack” gas detector
  
  • 7% of phi angle at edges of the wedges recovered

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Steve Kuhlmann  
(Argonne National Laboratory)

presented by: G. Introzzi (INFN & Univ. of Pavia)

ILC workshop - Snowmass - August 23, 2005
Pre-shower / Crack Detectors
Front End Readout Electronics

- 800 GeV range
- Low noise: 5-6 MeV for PEM/PHA
- 132 nsec charge integration
- QIE6: 10 bit ADC
- 4416 CAFÉs in detector hall
Readout Electronics

- Holds all of the CAFE cards for a wedge of the system
- Digital tower sums for L1 trigger
- Nearly no deadtime
- 240 ADMEMs in detector hall
FER Operational Issues

- 132 nsec charge integration gate collects 93.6% (HAD) or 97.4% (EM) of the charge
- CALOR02 reported failure rate
  - CAFE ~0.65% per year, (~30 units)
  - ADMEM ~3% per year (~8 units)
- Current failure rate is about half of that
  - would be even less, if not for the rare unscheduled power outages

150 GeV test beam PHA
FWHM 20 nsec
Jet Energy Scale

- “Determination of the Jet Energy Scale at the Collider Detector at Fermilab”, NIMPR accepted (hep-ex/0510047)
- EM tested with Z -> ee
- Had tested with 60 GeV pion test beam
Jet Energy Scale

- Pedro Movilla Fernandez will discuss the CDF calorimeter simulation
- $Z$ mass stable versus time to within 0.3%
- Mean muon energy from $W\rightarrow\mu\nu$ candidates within 1.5%
- For more information, refer to the paper

April 2002 - September 2004
Cross-talk for MAPMT

- Gap between fiber cookie and MAPMT for the PES was slightly larger than expected
  - 2.5mm, compared to 1mm for test stand
- 1 mm fibers
- Cross-talk was 6%, expected ~0.5%
- Installed baffles ("blinders")
  - Crosstalk ~ 1.4%
  - Signal reduction 8.5%
Plug PMT gain loss

- Monitor light energy response decrease, due to scintillator and PMT aging
- Unexpected PMT gain loss, largest for towers near the beamline
- Plug laser and radioactive source calibrations reveal that it is not from scintillator aging
- Not seen in the plug showermax (PES) or pre-shower (PPR) detectors

Losing light (as is CEM), WHA faster, but should last a few more years!
PMT Gain Loss

- Reduce integrated charge
- Lower gains for high eta tubes
- Leave HV on standby during beam scraping
- Didn’t eliminate the problem, but gain loss is acceptable for running through 2009
- Low eta towers: 1% loss in 2002, 3% loss in 2003
- High eta towers: ~20% loss in 2002, 8% loss in 2003
- Not completely understood

Tower gain drops seen in laser calibration in a 3 month span in 2002
Selected Results

“Top Quark Mass Measurement Using the Template Method in the Lepton + Jets Channel at CDF II”

“Measurement of the forward-backward charge asymmetry of electron-positron pairs in pbar-p collisions at \( \sqrt{s}=1.96 \) TeV”

PRD 71, 052002 (hep-ex/0411059)

Recent update with 5x integrated luminosity

preliminary

http://www-cdf.fnal.gov/physics/ewk/2006/afb
“Measurement of $\sigma(p-p\bar{p} \rightarrow W) \times BR(W \rightarrow e\nu)$ with electron identified by the Plug Calorimeter ($1.2 < \eta < 2.8$)"

preliminary

http://www-cdf.fnal.gov/physics/ewk/2006/plugw

Cross-section consistent with results using electrons in the Central Cal only. Missing $E_T$ resembles the electron $P_T$, overall measurement of recoil is good.
In Closing...

- Plug Calorimeter has been operating since the beginning of Run II
- All calorimeter upgrades for Run II have been completed
  - During the recent extended shutdown, only maintenance and fixes for dead channels
- Expect more results to take advantage of the upgrades
  - 380/pb --> Sept 2004
  - Results with up to 1/fb