The ATLAS Hadronic EndCap Calorimeter

- A copper-liquid argon sampling calorimeter.
- A collaboration of groups from Russia, Slovakia, Germany, Canada, and (China)
Overview of Presentation

- Highlights of the design
- Status of the project
- Test beam results
### Hadronic endcap parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z position of front of HEC</td>
<td>4262 mm</td>
</tr>
<tr>
<td>Z position of rear of HEC</td>
<td>6120 mm</td>
</tr>
<tr>
<td>Outer radius of HEC</td>
<td>2090 mm</td>
</tr>
</tbody>
</table>

### HEC wheel parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Front</th>
<th>Rear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wheels</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mass of wheels</td>
<td>67300 kg</td>
<td>89900 kg</td>
</tr>
<tr>
<td>Number of modules/wheel</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Gap between modules</td>
<td>2 mm</td>
<td>2 mm</td>
</tr>
</tbody>
</table>

### Module parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Front wheel</th>
<th>Rear wheel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of copper plates</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>Number of readout gaps</td>
<td>8+16=24</td>
<td>16</td>
</tr>
<tr>
<td>Number of readout towers</td>
<td>24+23=47</td>
<td>22</td>
</tr>
<tr>
<td>Thickness of standard copper plates</td>
<td>25 mm</td>
<td>50 mm</td>
</tr>
<tr>
<td>Separation of copper plates</td>
<td>8.5 mm</td>
<td>8.5 mm</td>
</tr>
<tr>
<td>Argon gap thickness</td>
<td>1.954 mm</td>
<td>1.954 mm</td>
</tr>
<tr>
<td>Honeycomb thickness</td>
<td>1.774 mm</td>
<td>1.774 mm</td>
</tr>
<tr>
<td>Number of calibration lines</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>Number of high voltage lines</td>
<td>4+4=8</td>
<td>4</td>
</tr>
</tbody>
</table>
Hadronic Endcap Module

Gap between Cu plates: 8.5 mm
Front wheel module: 2103 kg
25 mm Cu plates
Back wheel module: 2811 kg
50 mm Cu plates

Michel Lefebvre (Victoria)CALOR97 November 10-14 1997
Figure 11-i  1 MeV neutron fluence in the calorimeter and vicinity, integrated over a standard high luminosity year ($10^{41}$ cm$^{-2}$).

Figure 11-ii Yearly integrated dose (photons above 30 keV), for a standard high luminosity year.
Highlights of the Design

- Two wheels
  - 2m radius
  - 10 interaction lengths
- Electrostatic Transformer (EST)
  - Lower capacitance for same HV
  - Greater HV failure safety
- HV distributed by resistive coating
  - \(1\text{M}\Omega/\square\)
  - Reduces maximum voltage during a spark
    \(~1000\times\)
- Amplifiers in the cold, at outer radius of calorimeter
  - Low radiation area for amplifiers
  - Good signal to noise
  - 4 to 8 amplifiers per readout segment
Test Beam MC simulation of 200 GeV $\pi$ meson

Shower profile in module $\emptyset$ (X-Y plane)
Test Beam MC simulation of 200 GeV $\pi$ meson

Shower profile in module $\varnothing$ (Y-Z plane)
Positron
Resolution of HEC (pad cluster)

\[
A = (18.81 \pm 0.7) \% \sqrt{\text{GeV}}
\]

\[
B = (1.76 \pm 0.07) \%
\]

\[
C = 1.732 \text{ GeV} \quad \text{(fixed)}
\]

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- **fit on data**
- **fit on MC data**
- **data of pad cluster**
Project Status

- Engineering prototype:
  Built - Spring 1996
  Tested - Sep 1996

- Pre-production modules:
  Built in 1997: improved electronics, simplified mechanics
  Preliminary tests - Oct 1997
  Final tests - May 1998

- Production:
  Final design ready by year end
  Milestone: first modules to be delivered to CERN before end of 1998
  Completion of module production - 2002
    Final wheel constructed and installed in cryostat - 2003
JET ENERGY RESOLUTION

Jets at $\eta=2.45$

$\frac{\sigma}{\langle E \rangle}$, %

$\chi^2$/ndf

<table>
<thead>
<tr>
<th>$R$</th>
<th>$\chi^2$/ndf</th>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>1.996</td>
<td>81.62 ±</td>
<td>8.897</td>
</tr>
<tr>
<td>0.7</td>
<td>4.470</td>
<td>57.29 ±</td>
<td>5.087</td>
</tr>
<tr>
<td>∞</td>
<td>4.339</td>
<td>54.93 ±</td>
<td>3.341</td>
</tr>
</tbody>
</table>

$E_0$, GeV

$\sigma/E = P1/\langle E \rangle \oplus P2$

Energy dependence of the resolution for jets for various cone sizes
Test Beam Results

- Engineering module (1997):
  - Electron resolution
  - Pion resolution
- Production prototype
  - Less leakage