Development of large GRPC for a Semi-Digital Hadronic Calorimeter for ILC

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Output

- Motivation
- Design and constraints
- Gas distribution
- Resistivity issues
- Test Beam results
- Conclusion
Motivation

-The Semi-Digital HCAL is one of two options proposed in the ILD LOI. It uses gaseous detectors as sensitive medium with embedded readout electronics providing 1cm² lateral segmentation (PFA).

-A genuine mechanical structure is proposed for the SDHCAL.

GRPC was chosen as the baseline:
- Cost-effective
- High efficiency
- Adequate resolution

Challenges
- Homogeneity for large surfaces
- Thickness of only few mms
- Services from one side
- Embedded electronics

A prototype with 48 GRPC of 1 m² was conceived as a demonstrator.
The choice of ceramic balls rather than fishing lines aims at reducing both dead zones and noise.
Homogeneity study

To maintain the same distance between the two glass plates, spacers are used every 10 cm: 68 ceramic balls + 13 fiber glass disks.

Max. deformation: 44 μ

Included
• glass weigh
• electrostatic force

Not included
• Gas pressure
Gas distribution system

The services being on one side of the detector, a new gas distribution design is used. It allows to distribute the gas uniformly in the large chamber.

When diffusion is included → Homogeneity is even better
Resistive coating study

The resistive coating is needed to apply the HV on the two glass plates (electrodes). The resistivity value of this coating plays an important rôle of the pad multiplicity. The higher the resistivity the lower the multiplicity.

Three kinds of coatings were tested:

<table>
<thead>
<tr>
<th></th>
<th>Licron</th>
<th>Statguard</th>
<th>Colloidal Graphite type I</th>
<th>Colloidal Graphite type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface resistivity (MΩ/□)</td>
<td>~20</td>
<td>1-10</td>
<td>~0.5</td>
<td>Depends on mix ratio; choose ~0.7</td>
</tr>
<tr>
<td>Best application method</td>
<td>Spray</td>
<td>Brush</td>
<td>Silk screen printing</td>
<td>Silk screen printing</td>
</tr>
</tbody>
</table>

Results obtained with 33X8.3 cm² chambers.
Resistive coating study

Licron and Statguard are more appropriate for low pad multiplicity. However:
Licron: Loss of HV connection over time (1-2 months)
Statguard: long time constant for stable resistivity (2 weeks), poor homogeneity

The colloidal graphite of type II is less expensive and allows to choose the needed resistivity even if this is a delicate operation

Measured resistivity as a function of the mix ratio
Silk-screen print method provides very good uniformity
All data (70 glasses)
12 measurements/glass

R\(_{\text{Max}}\)/R\(_{\text{Min}}\) < 2 for any glass

5 glasses
Assembling procedure:

- 64 ch Hardroc ASIC
- 2-bit readout
- Power pulsed
- Thin packaging

Features:

- 9216 ch/m²
- 11 mm thickness

Gas inlet

Gas outlet

HV connection
Validation

A full cassette was successfully tested at T9-PS May 2010 and H4-SPS in September 2010

Gas mixture
TFE : 94.5 %
Isobutane : 5 %
SF6 : 0.5 %

HV : 7.4 kV
Validation

Noise was measured and found to be < 1 Hz/cm² outside the channeling tubes and HV connection zones.
Noise map of a 33×8.3 cm² GRP with a fishing line in the middle
A GRPC (33X50 cm2) was tested using the same readout electronics in a 3-Tesla magnet in the H2-SPS beam line. No effect was found.
Validation

Charge spectrum of our detector was carefully studied and understood. Polya distribution is successfully used to describe the data.

\[
Q = c \frac{(b+1)^{b+1}}{b!} \left( \frac{x}{a} \right)^b e^{-\frac{(b+1)x}{a}}
\]

Polya-distribution

\[
\chi^2 / \text{ndf} = 330.4 / 244
\]

\[
p_0 = 1.166 \pm 0.005
\]

\[
p_1 = 16.89 \pm 0.52
\]

\[
p_2 = 17.64 \pm 0.31
\]

**Charge Spectrum Cosmic Test Set Up**

64 Channels, trigger area < Channel area

Analog readout

64 Channels, trigger area < Channel area

Analog readout
50 Chambers are built and will be used in the SDHCAL prototype in the coming days..
The SDHCAL prototype is being assembled at CERN and will be exposed to pion beam at H2-SPS next week.
Conclusion & Perspectives

- An extensive development of GRPC as a sensitive medium for a Semi-Digital Hadronic CALorimeters has been conducted.

- A new design of spacers reducing both dead zones and noise is proposed. A scheme of gas distribution is designed. Resistive coatings are carefully studied and adequate products found.

- 50 detectors following the previous scheme are being built and will equip a prototype of 1m3.

- A dedicated study using a radioactive gas (Kr83) will be conducted to confirm the gas circulation simulation in large chambers.

- Larger GRPCs (2m3, 3m2) will be built and tested using the same readout electronics.
40 cassettes will be inserted before June 17th