(S)DHCAL
Status & plans

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Outline

✓ Gaseous HCAL

Status and pans :

✓ DHCAL

✓ SDHCAL-RPC

✓ SDHCAL-Micromegas

✓ Conclusion
DHCAL-RPC (54 units):

- Large detectors: 33X100 cm² RPC → assembled to have 1m²
- Electronics: DCAL, embedded
- Readout: both sides of the 1m²
- Cassette design: ok, copper plate to diffuse ASIC heating
- DAQ: ok
SDHCAL RPC (50 units)

- Large detectors: 100X100 cm$^2$ RPC
- Electronics: HARDROC, embedded
- Readout: one side of the 1m$^2$
- Cassette design: ok, part of the absorber
- DAQ: ok, not the final
Micromegas (4 units)
- Large detectors: 33X50 cm² MM → assembled by set of 6 to have 1 m²
- Electronics: Microroc, embedded
- Readout: one side of the 1 m²
- Cassette design: ok, part of the absorber
- DAQ: ok, not the final one (same as for the SDHCAL-RPC)
DHCAL-GRPC
plans
2-glass RPCs

1-glass RPCs

Offers many advantages
- Pad multiplicity close to unity
  → easier to calibrate
- Better position resolution
  → if smaller pads are desired
- Thinner
  → $t = t_{\text{chamber}} + t_{\text{readout}} = 2.4 + \sim 1.5$ mm
  → saves on cost (coil)
- Higher rate capability
  → roughly a factor of 2

Status

Built several large chambers
Tests with cosmic rays very successful
→ chambers ran for months without problems
Both efficiency and pad multiplicity look good
High-rate Bakelite RPCs

Bakelite

Is laminated and does not break like glass but changes $R_{\text{bulk}}$ depending on humidity but needs to be coated with linseed oil.

High-rate RPCs

Use of Bakelite with low $R_{\text{bulk}} \sim 10^8 - 10^{10} \ \Omega \text{cm}$ and/or Bakelite with resistive layer close to gas gap.

Status

Several chambers built at ANL First rate tests at GIF being evaluated.
Development of semi-conductive glass

Co-operation with COE college (Iowa) and University of Iowa

World leaders in glass studies and development

Vanadium based glass

- Bulk resistivity tunable
- Procedure aimed at industrial manufacture (not expensive)

First samples

- Very low resistivity $R_{\text{bulk}} \sim 10^8 \ \Omega \text{cm}$

New glass plates

- $R_{\text{bulk}} \sim 10^{10} \ \Omega \text{cm}$ produced
- Plates still need to be polished
- Production procedure being optimized
High Voltage Distribution System

Generally

Any large scale imaging calorimeter will need to distribute power in a safe and cost-effective way

HV needs

RPCs need of the order of 6 – 7 kV

Specification of distribution system

Turn on/off individual channels
Tune HV value within restricted range (few 100 V)
Monitor voltage and current of each channel

Status

Iowa started development
First test with RPCs encouraging
Work stopped due to lack of funding
Gas Recycling System

DHCAL’s preferred gas

<table>
<thead>
<tr>
<th>Gas</th>
<th>Fraction [%]</th>
<th>Global warming potential (100 years, CO₂ = 1)</th>
<th>Fraction * GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freon R134a</td>
<td>94.5</td>
<td>1430</td>
<td>1351</td>
</tr>
<tr>
<td>Isobutan</td>
<td>5.0</td>
<td>3</td>
<td>0.15</td>
</tr>
<tr>
<td>SF₆</td>
<td>0.5</td>
<td>22,800</td>
<td>114</td>
</tr>
</tbody>
</table>

**Recycling mandatory for larger RPC systems**

Development of ‘Zero Pressure Containment’ System

Work done by University of Iowa/ANL

Status

First parts assembled...
SDHCAL-GRPC

plans
High-Rate GRPC may be needed in the very forward region

- Semi-conductive glass ($10^{10}$ $\Omega$.cm) produced by our collaborators from Tsinghua University was used to build few chambers.
- 4 chambers were tested at DESY as well as standard GRPC (float glass)

Performance is found to be excellent at high rate for GRPCs with the semi-conductive glass and can be used in the very forward of ILD region if the rate exceeds 100 Hz/cm$^2$ in future ILD upgrades as well as for CLIC.
Large GRPC for ILD model:

GRPC with a surface \( \leq 3 \text{ m}^2 \) are needed.

We intend to build a $2m^2$ GRPC.

We are currently studying the gas distribution system to ensure a good gas renewal.

Once the first large detector is built, the gas circulation of the new scheme will be controlled using radioactive $^{183m}\text{Kr}$. 
This a new version of the HARDROC ASIC has:
- 64 independent channels, zero suppression
- I2C link
- PLL: Input frequency 2.5 MHz => output frequency: 10, 20, 40, and 80 MHz
- Bandgap: new one with a better temperature sensitivity
- Triple voting
- Roll mode
- Temperature sensor: tested in a building block, slope – 6mV/°C
Die size ~ 30 mm2 (6.3 x 4.7 mm2)
Packaged in a TQFP208
The ASIC was produced and tested. All functionalities were successfully tested. A minor problem was found with the I2C scheme (buffer stuck to zero) This I2C was however successfully tested after a BIF.
ANALOG PART: FSB LINEARITY

FSB0: 5σ noise limit = 15 fC

FSB1: Up to 10 pC

FSB2: Up to 50 pC
New SDHCAL DIF main features

• Only one DIF per plane. For the maximum length plane (1x3m) the DIF will handle 432 HR3 chips

• Slow control through the new HR3 I2C bus

• Data transmission to DAQ by Ethernet using commercial switches for concentration

• Clock and synchronization by TTC

• USB 2.0 for debugging

• Synergy with R&D on fast links R&D of LHC(GBT)
New ASU layout options

As there will be only one DIF per plane, the distribution of the ASU boards in the plane will be rearranged to reduce the number of connections between the DIF and the plane.

- In option B the common signals for the plane have to be sent twice (one per slab) while in option B they can be sent only once.
- But, option A looks more risky from the point of view of the feasibility of the 1m long ASU boards.
- In both options the ASUs connected to the DIF will be a bit longer to host the connectors and the buffers for driving the long lines. This extension provides more freedom for the connectors selection and moves the drivers heat disipation to the ventilation area.
Made by Electron Beam Welding process in Vacuum.
Welding deep of 5 mm.
(Realizado mediante soldadura por haz de electrones en vacío.
Profundidad de la soldadura de 5 mm)

Setup for use.
(Disposición final de utilización)
Welding techniques

Made by Electron Beam Welding process in Vacuum. Welding deep of 5 mm.
SDHCAL-MICROMEGA plans
Design 1: Resistive vias configuration (independent pad)

Design 2: Resistive lines configuration (connected pads)
Resistive Micromegas (1/2)

Improvements of existing large prototypes

Avoid discharges (measured probability = $10^{-6}$ / showering pion / m$^2$) with resistive layers

Simplify PCB by removing current-limiting diodes

Challenge 1: do not change efficiency/multiplicity → specific R-strip patterns
Challenge 2: Maintain rate capability as high as possible

Rate effects in resistive prototypes seen but remain small
Analysis on-going to understand & model the underlying mechanisms
Conclusion

Gaseous hadronic calorimeters have started last round

Rate capability of RPC are addressed (DHCAL, SDHCAL)

Very large detectors are being conceived and will be shortly build (SDHCAL-RPC)

Third generation electronics and new electronics readout are being developed.