УДК 539.1.074.23

INFLUENCE OF NITROGEN AND OXYGEN GAS ADMIXTURES ON THE RESPONSE OF THE DELPHI HCAL AND MUS DETECTORS

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The influence of different factors, such as gas flow parameters and admixture of oxygen, on the operation of the Hadron Calorimeter (HCAL) and Surrounding Muon Chambers (MUS) plastic tubes working in streamer and proportional modes is investigated. The dependence of the charge collected from the anode wires versus the amount of nitrogen in the working gas mixture was measured.

The investigation has been performed at the Laboratory of High Energies, JINR.

Влияние добавок азота и кислорода на отклик детекторов адронного калориметра и дополнительной мюонной системы установки ДЕЛФИ

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Исследовано влияние различных факторов, таких, как скорость протока газовой смеси и добавок кислорода, на работу пластиковых детекторов адронного калориметра и дополнительных мюонных камер в стримерном и пропорциональном режиме. Измерена зависимость величины заряда, снимаемого с анодных проволочек, от количества азота в рабочей газовой смеси.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

1. Introduction

The influence of different factors, such as small changes in gas mixture, atmospheric pressure, etc., on the operation of the DELPHI Hadron Calorimeter (HCAL) plastic streamer tubes was studied in [1].

These studies were performed for different concentrations of CO_2, C_4H_{10} (Iso), and Ar components. For the gas mixture CO_2: Iso: Ar (60:30:10), which was chosen for operation, the variation of the streamer charge with the variation of mixture components was found to be approximately exponential:

$$Q \simeq Q_0 \exp(-d_1\Delta C_1 - d_2\Delta C_2), \tag{1}$$

where ΔC_1 and ΔC_2 are absolute concentrations of CO_2 and Iso, respectively.

The dependence on these gas components is considerable ($d_1 = 0.11$, $d_2 = 0.19$). Therefore, to keep variations of the calorimeter response within $\leq 2-3\%$, the gas system should maintain the percentage of components with an absolute accuracy of a few 0.1% and ensure good gas components mixing before the distribution to the calorimeter modules.

The dependence of the mean streamer charge on pressure also follows an exponential law:

$$\overline{Q} \simeq \overline{Q}_0 \exp(-\beta\Delta p), \tag{2}$$

where $\beta \simeq 10^{-2}$/mbar.

For typical atmospheric pressure fluctuations of a few 10 mbar variation in the charge response is a few 10%.

To monitor the mean streamer charge response changes (in order to correct them afterwards) the HCAL gas system is equipped with a streamer monitor [2,3].

This system consists of 30 cm long plastic streamer tubes (similar to the HCAL detectors) equipped with a low intensity radioactive source.

The streamer tubes are periodically (30 min cycle) flushed with gas which is bypassed from the single input or individual outputs of all HCAL and MUS modules, and the charge response from the anode wires is measured.

The gas system of HCAL is an open circuit system described in [4]. The entire volume is replaced over a period varying between one and three days. The same gas system is used for the MUS detector where the change of the gas volume is between 10 and 30 hours.

To reduce the running cost, a new variant of the gas system with gas recirculation and purification was proposed. The proposed variant being relatively simple and inexpensive certainly has an advantage of economy without increasing the oxygen level in the working gas. However, with 80% gas recirculated (20% fresh) it is expected that the nitrogen level will increase up to 1—2% and it was important to understand the consequences of that in terms of the charge response.

In this note we present some results of the long term operation of HCAL and MUS gas system and measurement of the dependence of the charge response from anode wires versus the nitrogen admixture performed in a special test.

2. Results

The gas flow parameters of the HCAL and MUS gas system are presented in the Table.

The dependence of the oxygen level as a function of the time cycle (the time of replacement for the entire volume of the detector) is shown in Fig.1a. The behaviour is linear. One

Table. Gas Flow Parameters

Detector	Volume m^3	Channel volume m^3	Run flow 1995—96 l/h	Cycle hrs
Barrel HAC	26.8	0.56	6.5—11.5	50—86
End-Caps HAC	12.42	0.26	5—8	33—49
MUS	0.96	0.06	2—6	10—30

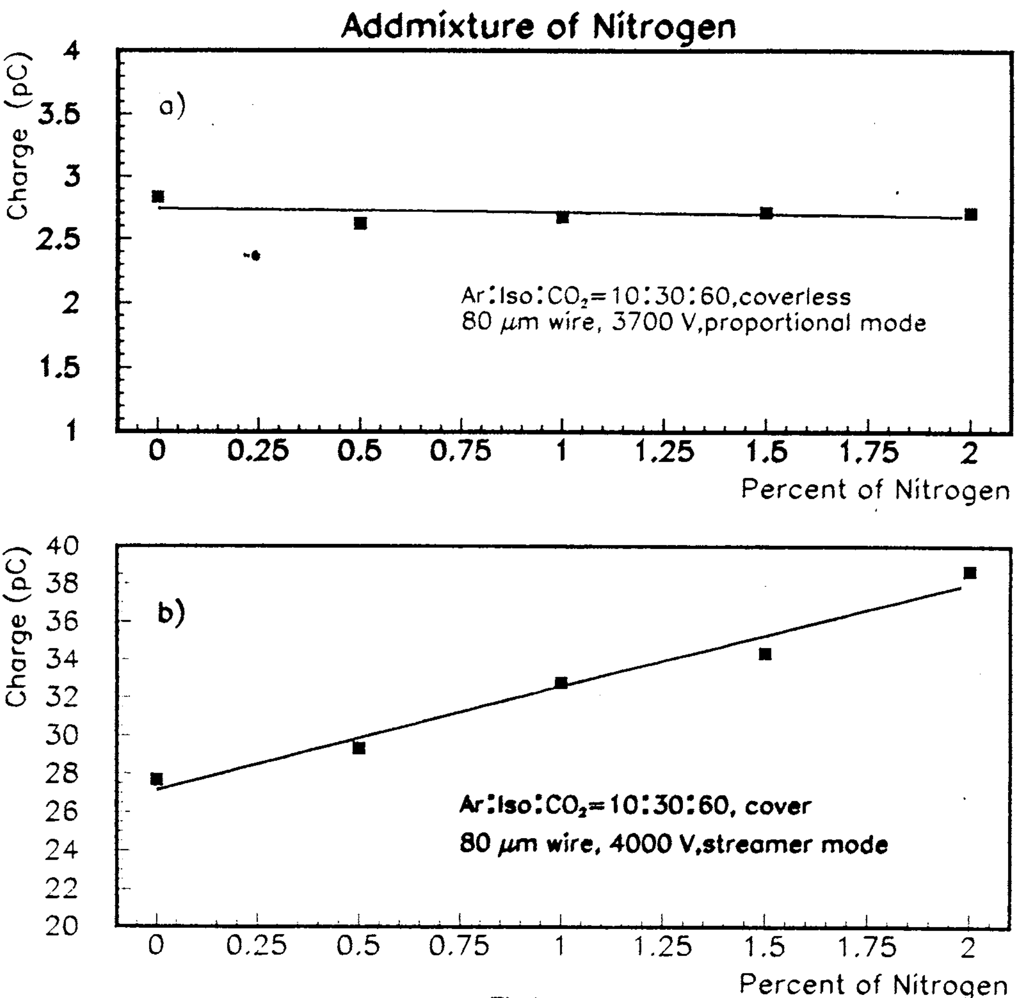

Fig.1

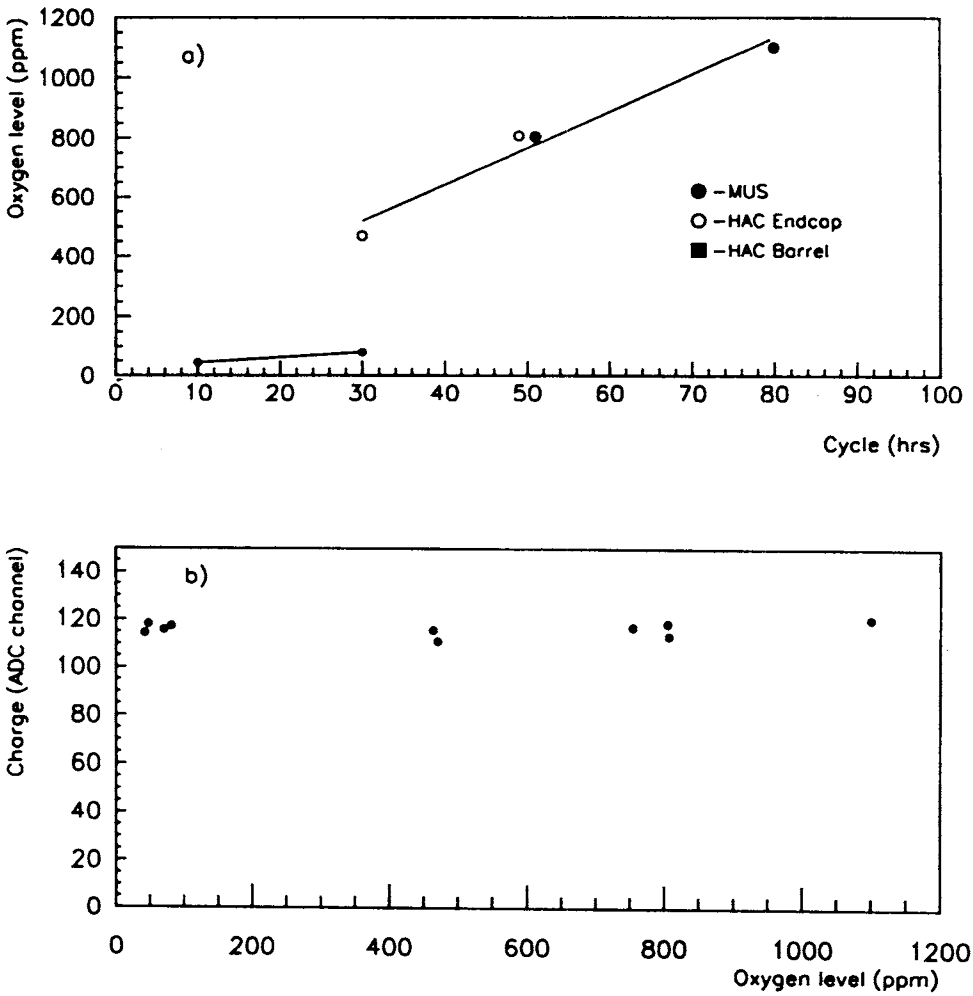

Fig.2

can see, that the oxygen level reaches more than 1000 ppm for a three days cycle time. The streamer charge response measured by streamer monitor versus the oxygen level is represented in Fig.1b. No variation of the charge response for this range of oxygen level was observed.

The measured level of oxygen of about 1000 ppm means that at the same time the level of nitrogen in the gas is about 0.3%. Therefore, for the gas system with 80% of the gas recirculation this level will increase five times.

The study of the influence of the nitrogen admixture in the operating gas was performed with plastic tubes from 80 to 120 cm long, which were produced in 1987 for the DELPHI HCAL end-cap modules [5], and in 1993 for the DELPHI MUS [6]. In our test the tubes were running in the same regime as in the experiment at conditions [7,8], i.e., at 4000 V for tubes with covers (HCAL variant, streamer mode) and at 3700 V for coverless tubes (MUS variant, proportional mode).

We have used the same experimental set-up as in [9] for the measurement of the tube response to cosmic muons.

Figure 2a shows the dependence of the charge from the anode wires for the proportional mode of operation. In this case the charge depends weakly on the admixture of nitrogen.

Figure 2b demonstrates the same dependence for the streamer mode of operation. One can see an increase of charge with the increase of admixture of nitrogen. In this case the dependence is similar to the one measured for argon admixtures. Therefore, an increase in the calorimeter response up to 15% is expected for 1—2% of nitrogen.

In summary, the introduction of the recuperation system will not influence the operation of tubes in the proportional mode (MUS) but for a streamer mode operation (HCAL) it is expected that the response will change by about 15%. In this latter case, the monitoring of nitrogen is desirable.

3. Acknowledgements

We are very much obliged to R.C.A.Brown and F.Hahn for providing the possibility of working in the test area and for help. We would like to thank H.Herr, A.Olchevski, A.M.Wetherell and the whole HCAL group for useful discussions of the results.

References

1. Alekseev G.A. et al. — NIM, 1990, v.A292, p.551.
2. Alexeev G. et al. — Streamer Monitor, 1992, unpublished.
3. Augustinus A. — The Hadron Calorimeter Streamer Tube Readout System. Users manual version 1993.01, 20 October 1993.
4. Brown R.C.A. — DELPHI note 87-14 GAS 13; R.C.A.Brown et al. — Distributed Controls for the DELPHI Gas Supply System, IEEE Trans on Nucl. Scien., 1989, v.36, No.1.
5. DELPHI technical proposal, CERN/LEPC/83-3(1983).
6. DELPHI Collaboration. — DELPHI note 92-139 TRACK 71.

7. DELPHI Collaboration, Aarnio P. et al. — NIM, 1991, v.A303, p.233.
8. DELPHI Collaboration, Abreu P. et al. — NIM, 1996, v.A378, p.57.
9. Krumstein Z. et al. — DELPHI note 95-15 CAL 124.

Received on June 11, 1997.