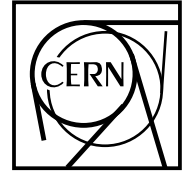**The Compact Muon Solenoid Experiment**

CMS Note

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September 23, 1996

Long -Term Irradiation of a MSGC Made of Gold Strips on Electron-Conducting C85-1 Glass Under Several Gas Mixtures and Cleanliness Conditions

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Abstract

The present study aims to create reproducible and controlled polluted conditions in a clean gas system in order to be able to compare the behaviour of a gold MSGC plate manufactured on electron–conducting glass and assembled with standard materials (araldit, stesalit, rubber O–rings, nylon) operating under Ar–DME and Ne–DME gas mixtures. The achievement of such conditions seems to be more difficult than it could be expected from the long–term behaviour shown by MSGCs years ago. The pollutants present in the gas rack, possibly originating the dramatic gain losses reported then, are not present anymore in the gas system after 4 years of continuous operation with the Ar–DME mixture.

No ageing has been detected operating with both mixtures, provided the gas distribution system is clean. The use of new and supposedly clean stainless steel gas pipes of small diameter might affect the chamber operation, although the lines are rapidly cleaned (~weeks) after been flushed with DME. The back–diffusion of pollutants due to the use of a Si–oil bubbler affects dramatically the chamber operation, which behaves slightly better with argon than with neon; in view of the other variables, we do not consider this difference as significative.

1. INTRODUCTION AND EXPERIMENTAL CONDITIONS

The ageing problem of Micro–strip gas chambers (MSGCs), known as a fast and usually irreversible degradation of their performance during irradiation, has been extensively studied [1–4]. Doses in excess of 100 mC/cm of strip, equivalent to more than 10 years of LHC operation at the highest luminosity, have been achieved under good experimental conditions; the nature of the MSGC substrate, and mainly the gas mixture, materials used to assembly the detectors and in the gas distribution system play a major role in the long–term behaviour of these devices. For high rate applications, some limitations have arisen: DME–based mixtures are better than hydrocarbons [5], and gas pollution whether coming from the gas cylinders. gas system or construction materials has to be avoided [2, 6].

Recently it has been suggested that Ne–DME mixtures can improve the long–term performance of MSGCs [7, 8], even if built with 'forbidden' materials [2] such as vetronite, mylar and nylon. Due to the lack of comparative experimental tests between argon– and neon–based mixtures, the present study aims to create reproducible polluting conditions in a clean and controlled gas system in order to be able to compare the behaviour of a MSGC plate operating with both gas mixtures. It has to be noted that the polluting conditions have to be artificially created to presumably age the MSGC plate due to the fact that in our present set–ups (> 4 years old clean systems) no ageing is detected up to very large doses [4].

The plate used for the measurements has an active area of 3×3 cm^2 with a 200 μm pitch, anodes and cathodes being 5 and 100 μm wide respectively. They were galvanically grown on 300 μm thick electron–conducting C85–1 glass (pulled) at SSPC NIIES, Novosibirsk; the measured resistivity is around 10^{11} Ω·cm. Three groups of 50 cathodes each can be connected to the read–out electronics; the anodes are ganged and connected to the HV power supply through protection resistors. The operating voltages were -1 kV in the drift (drift gap ~ 6 mm) and 565 V or 560 V on anodes to achieve a gain of 10^3 in Ar–DME [50–50] and Ne–DME [50–50] respectively.

The plate has been mounted in the so–called regular box built several years ago [2], which consists of a conventional stack of printed circuits and frames assembled with epoxy and synthetic rubber O–rings, with a mechanical mounting scheme developed in analogy with conventional MWPC detectors (Fig. 1); a mylar–aclar foil as window in the front side

allows the exposure of the detector to radiation (6 keV X-rays); araldit was used for gluing; the gas enters and leaves the chamber through 10 cm of nylon tubes with brass connectors connected to a clean, full metal gas rack which has been described elsewhere [9].
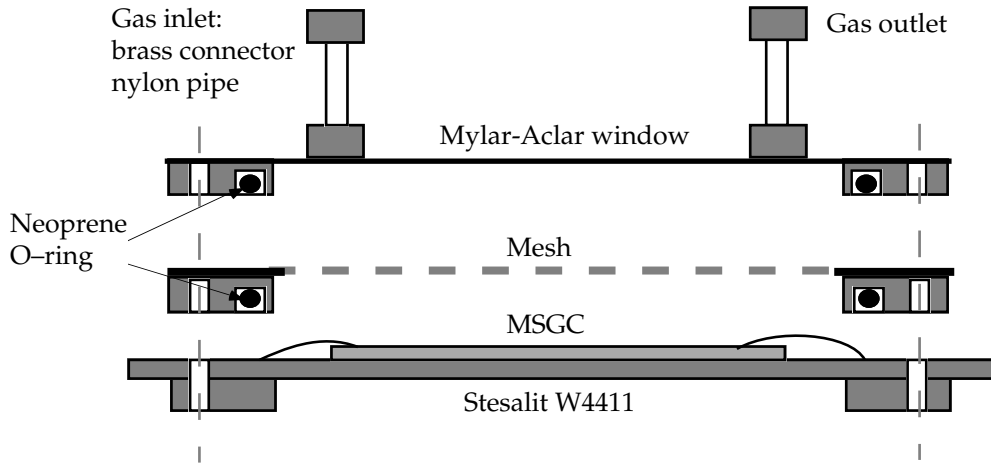
Epoxy: Araldit CIBA 106

Fig. 1. The fibreglass box

2. EXPERIMENTAL RESULTS

2.1 Chamber operation in a clean gas system

The chamber was firstly irradiated with Ne–DME and then with Ar–DME flowing through the clean gas system. Older measurements made with argon in a similar detector in the same set–up have shown a fast degradation of gain for doses as low as μC/cm [2]. Contradicting these results, the plate stands now more than 10 mC/cm without any sign of deterioration (Fig. 2), corroborated by optical inspection of the plate. Both mixtures behaves similarly, indicating that the purity of Neon (not controlled) is as good as the one for argon, that we have often monitored [4].

The origin of the faster ageing observed time ago was probably due to the gas system: stainless steel lines may be now presumably cleaner due to the continuos flushing of Ar–DME for 4 years, as well as the lack of outgassing from any component that could already have outgassed all the pollutants; it had been found for example [4] that the ball–bearing valves used in the gas rack released traces of freon 113; satisfactorily, valves had been disassembled and baked up to 100 °C in order to outgas the pollutant, before being relocated in the rack.
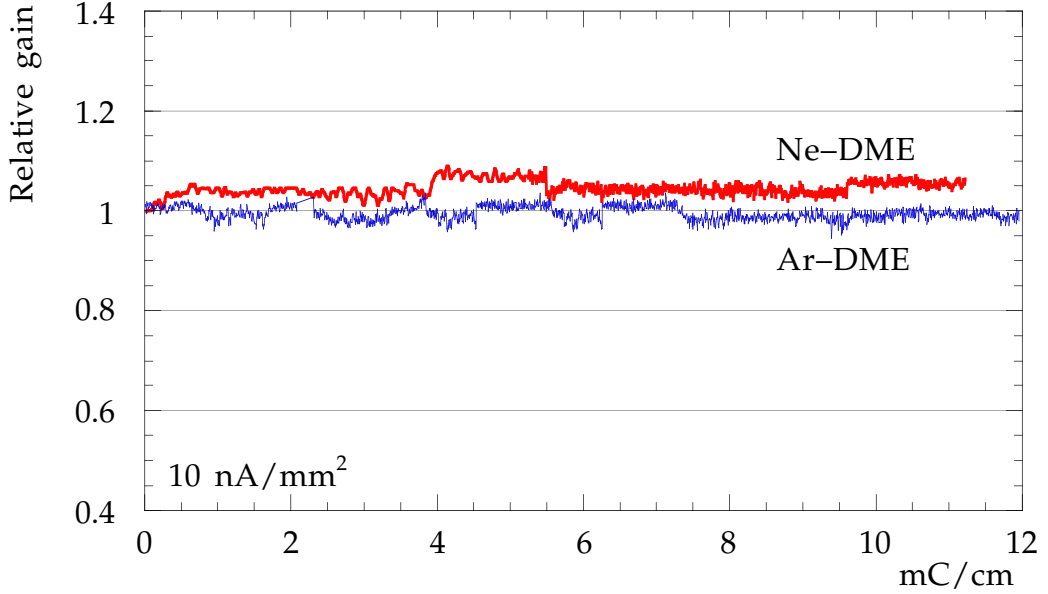
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Fig. 2. Gain as a function of collected charge when the chamber, assembled with regular materials, operates under clean gas conditions with argon and neon mixtures.

2.2 Polluting the gas system with the installation of a new stainless steel gas pipe

In view of the previous results, a 4 m long 2×3 mm new stainless steel pipe was installed before the gas inlet of the MSGC to try to reproduce the conditions present in [2]. The pipe had been previously cleaned with alcohol and kept at 80 ^{O}C for one night to eliminate possible polluting residuals. Fig. 3 shows the result of three consecutive ageing tests done under this condition. The gain variation has been expressed through the quantity R [10]:

$$R = (-1/Q) \times (\Delta M / M_o) \qquad (1)$$

where Q is the total charge in $cm \cdot mC^{-1}$ and $\Delta M / M_o$ the relative gain change. Only the first test done with argon shows a gain drop (R = 0.012 $cm \cdot mC^{-1}$), detected also scanning at low rate the electrodes after resuming the test (Fig. 4).The further measurements done irradiating new positions of the plate, with Neon (R = -0.001 $cm \cdot mC^{-1}$) or a second one with argon (R = -0.002 $cm \cdot mC^{-1}$), did not show any gain degradation, suggesting that the line might be already cleaned by the action of DME during the first measurement (~1 month). Optical inspection of the three irradiated regions shows a dark coloration around the edge of the anodes, no matter if gain drop was detected or not.

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New attempts to reproduce the ageing condition replacing again a piece of gas pipe were unsuccessful. As shown in Fig. 5, the gain remains stable during a ageing test done presumably under the same conditions as described above, i.e., using another new 4 m stainless steel line. We have no control on the quality of the pipe before and after the cleaning.
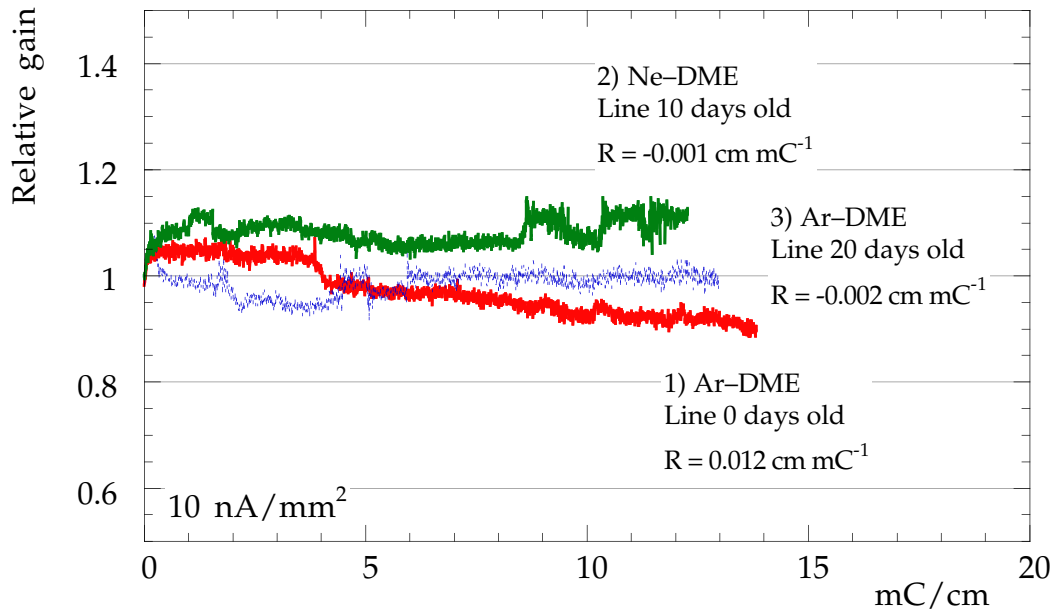

Fig. 3. Gain as a function of collected charge for three consecutive ageing tests done after installing 4 m of a new stainless line in the clean gas system.
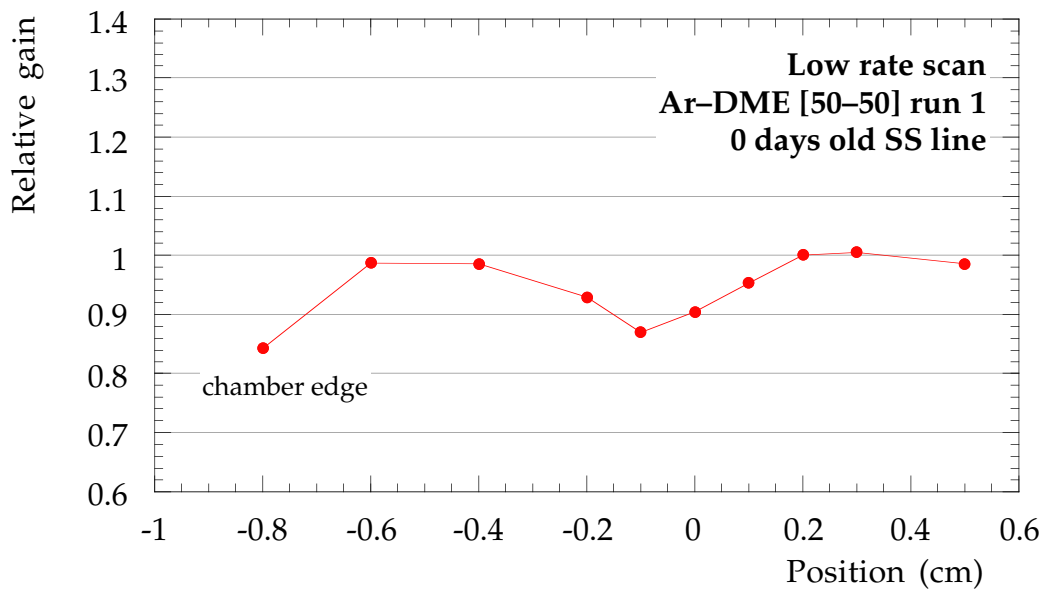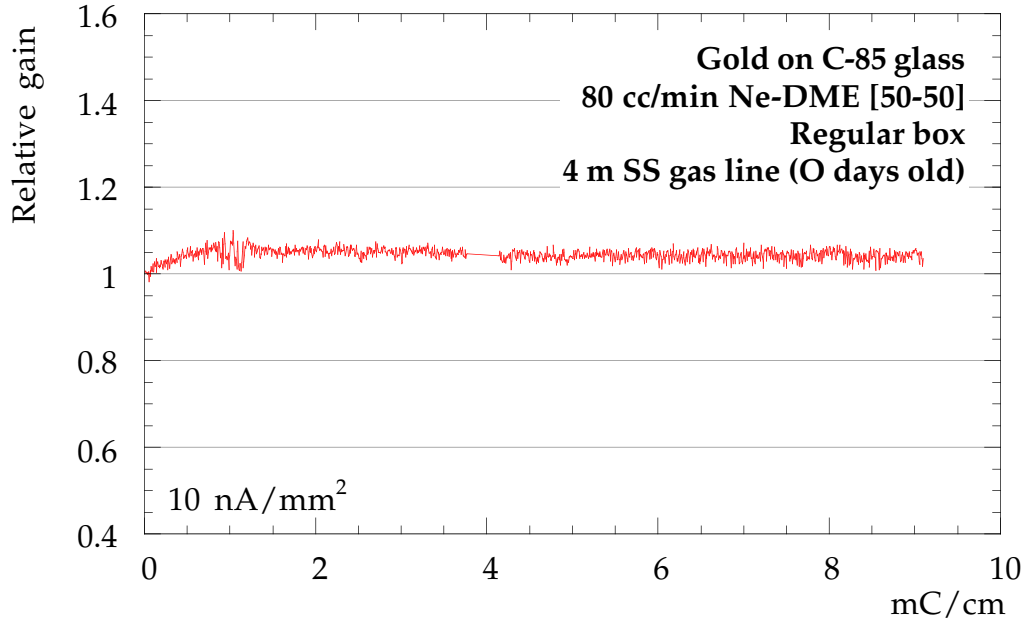

Fig. 4. Gain along the strips recorded after stopping the ageing test. A 10% drop is detected in the irradiated position (2 mm spot around position 0 in the plot).

Fig. 5. Gain as a function of collected charge during a test done after installing a second 4 m of new stainless line in the clean gas system.

2.3 Polluting the gas system with the installation of a Si–oil bubbler

In order to achieve more stable ageing conditions and motivated by the idea that ageing could be induced by oily residuals in the the gas pipes a silicon–oil bubbler was connected with a 20 cm long PVC tube right after the MSGC gas outlet. The back diffusion of the Si–oil should steadily affect the chamber operation in a rather dramatic way [10, 11]. Fig. 6 shows the result of three consecutive ageing tests in different positions, showing degradation in all cases, although faster in the neon tests. Fig. 7 shows the X-rays pulse height spectra before starting the argon run and after accumulation of 55 mC/cm; a 20% decrease in gain is detected, matching the drop in current detected along the run.

The three irradiated spots were optically detectable, appearing to be wider than the X–rays collimator size (2 mm ø). It seems that each irradiated position consist of a clean 2 mm diameter spot surrounded by a darker halo increasing the spot size up to around 4 mm in the direction of the strips and 5 mm perpendicular to them. The size of this 'increase' is clearly correlated with the accumulated charge per spot. The damage when the Si–oil bubbler was installed is different and much more dramatic than the one due to the use of new stainless steel lines. In the former case a liquid-like substance covers the anodes, as well as the cathodes in the more damaged regions.
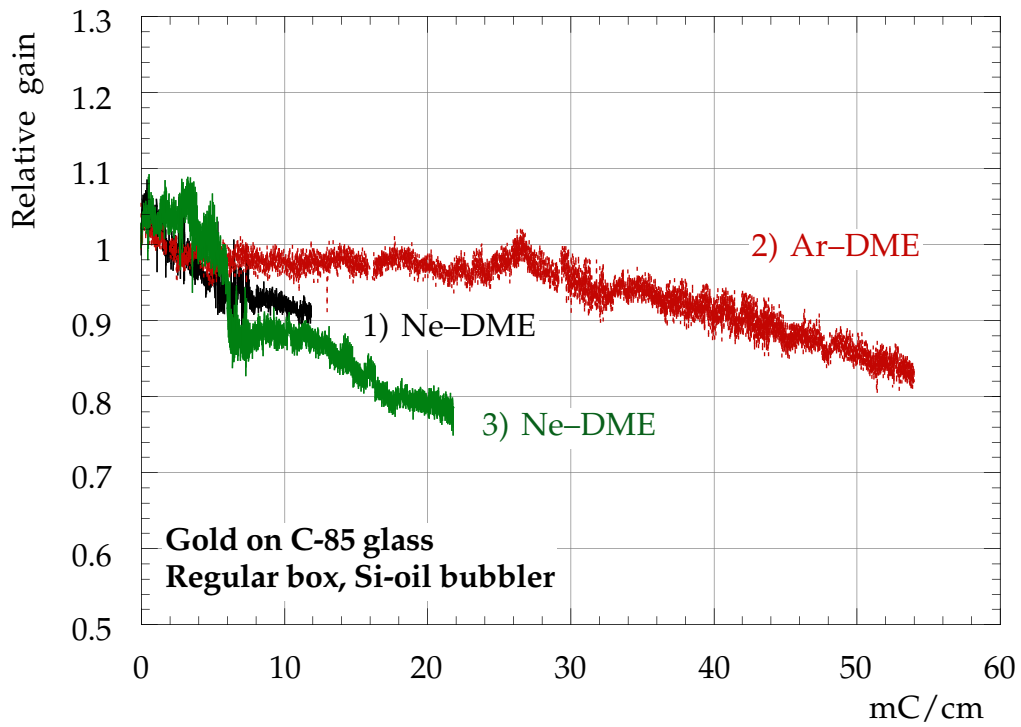
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Fig. 6. Gain as a function of collected charge for three consecutive ageing tests done with a Si–oil bubbler right after the MSGC gas outlet.
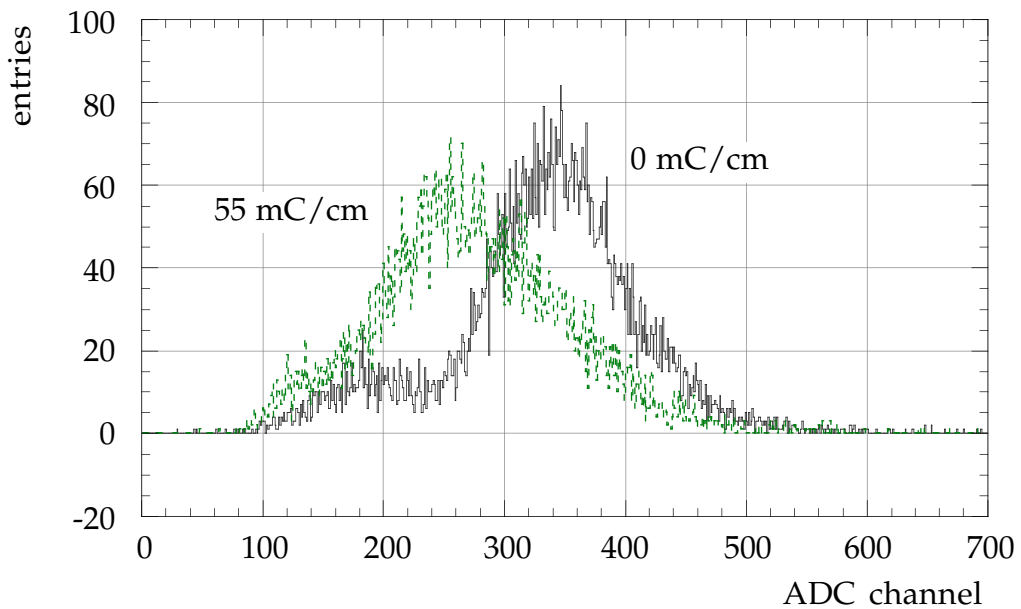

Fig. 7. Pulse height before and after accumulating 55 mC/cm in the argon run with the Si–oil bubbler in the gas rack.

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3. CONCLUSIONS

In reasonable clean conditions of the gas system is possible to successfully operate without noticeable difference a gold MSGC made on electron–conducting glass, assembled with regular materials and operating under Ar–DME [50–50] and Ne–DME [50–50].

The achievement of controlled polluted conditions seems to be more difficult than it could be expected from the long–term behaviour shown by MSGCs years ago. The pollutants present in the gas rack, possibly originating the dramatic gain losses reported then, are not present anymore in the gas system after 4 years of continuous operation with the Ar–DME mixture. The use of new and supposedly clean stainless steel gas pipes of small diameter might affect the chamber operation, although the lines are rapidly cleaned (~weeks) after been flushed with DME. The back–diffusion of pollutants due to the use of a Si–oil bubbler affects dramatically the chamber operation, which behaves slightly better with argon than with neon; in view of the other variables, we do not consider this difference as significative.

Table 1 provides a summary of the measurements.

Position (cm)	Run id.	Gas mixture	Remarks	Result
5.9	001U	Ne–DME	–	OK
7.0	002U	Ar–DME	–	OK
7.4	003U	Ar–DME	SS line I	10% G drop @ 14 mC/cm
6.5	004U	Ne–DME	SS line I	OK
7.8	005U	Ar–DME	SS line I	OK
6.2	006U	Ne–DME	SS line II	OK
6.2	007U	Ne–DME	SS line III	OK
6.2	008U	Ne–DME	Si–oil bubbler	10% G drop @ 12 mC/cm
6.7	009U	Ar–DME	Si–oil bubbler	OK
7.2	010U	Ne–DME	Si–oil bubbler	20% G drop @ 22 mC/cm
6.7	011U	Ar–DME	Si–oil bubbler	20% G drop @ 25 mC/cm

Table 1: summary of the measurements.

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Rererences

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[3] J. Bateman et al., RAL-94-114 (1994).

[4] R. Bouclier et al., CERN–PPE/96–33 (1996).

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[7] F. Angelini et al., NIM **A362** (1995) 273.

[8] F. Angelini et al., Proc. Int. Workshop on MSGCs, Lyon, (1995) 307.

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