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The Compact Muon Solenoid Experiment

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Update on Discharge Studies in MSGCs

B. Boimska[1], R. Bouclier, M. Capeáns, W. Dominik[1], M. Hoch,
G. Million, L. Ropelewski, F. Sauli and A. Sharma[2]

[1] On leave of absence from Institute of Experimental Physics, University of Warsaw, Poland

[2] GRPHE, Université de Haute Alsace, Mulhouse, France

Abstract

The discharge problem in MSGCs reported by several groups can seriously affect the safety of operation of these detectors. In this note we describe recent short medium term measurements giving a more realistic assessment of the problem.

Discharge limit tests: Introduction

The discharge limits have been investigated for four MSGCs: one over-coated (DOC) and two under-coated (DUC1 and DUC2) with the usual size of 10 cm x 10 cm and geometry of 7 µm anodes, 100 µm cathodes and 200 µm pitch. The strips for these chambers were made of chromium, and a gold plated 100 µm glass was used as drift electrode. The fourth MSGC (DUG) was undercoated with DLC and had gold strips. Maximum voltage limits were determined without radiation with an Fe^{55} source and then repeated with alphas. Due to the larger amount of ionization the trip voltage was lower in the latter case thus simulating the limiting gain in the presence of highly ionizing particles. These short term measurements on DUC1 and DOC, where alpha particles depositing typically few 100 keV in the active gas volume were introduced by means of a special 3 µm Hostaphan film glued on a 1 mm thin slit in the window, have been summarized in [1,2]. In this work we present short and medium term measurements realized with the MSGCs DUC2 and DUG.

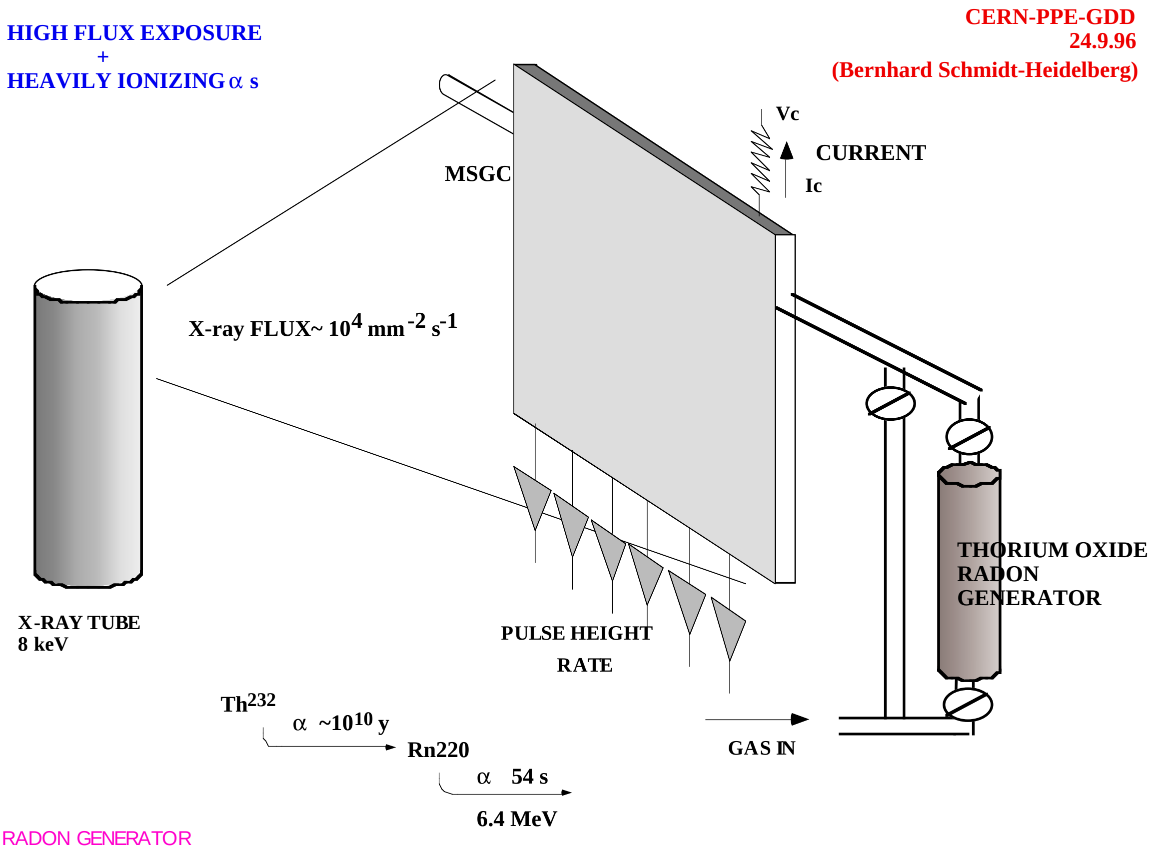


Fig. 1

Experimental Set up

The measurements described above suffer from two limitations: first, the alphas are introduced in a very local position of the MSGC active area, and second they were performed in the absence of other high flux of radiation. To overcome this, another set up was prepared for DUC2 & DUG, in which it was possible to illuminate the whole active surface (10 x10 cm^2) of the chamber, and in addition an α- active gas Rn^{220} decaying at the measured rate of 5 Hz/cm^2 , could be introduced as shown in fig. 1. This set up was used to determine the maximal safe voltage, thus limiting gain for chamber operation with the whole active area of the chamber connected. For the MSGC DUC, 30 out of the 32 groups were operational and for DUG this number was 28 (the missing groups being due to shorts or discharges).

Results and Discussion

Radon (Rn^{220}) emits α's of 6.4 MeV and we have measured in the thin chambers (3 mm gap) an energy loss spectrum with a peak at a few 100 keV and a tail up to few MeV, which is represented by the saturation of the readout electronics as shown in fig. 2. The solid histogram is the measured spectrum, while the bars represent results of simulations performed with an estimated range of 28 mm for the 6.4 MeV α's in the gas. The peak occurs at a few 100 keV since the most probable energy loss is the one arising from close to perpendicular tracks.

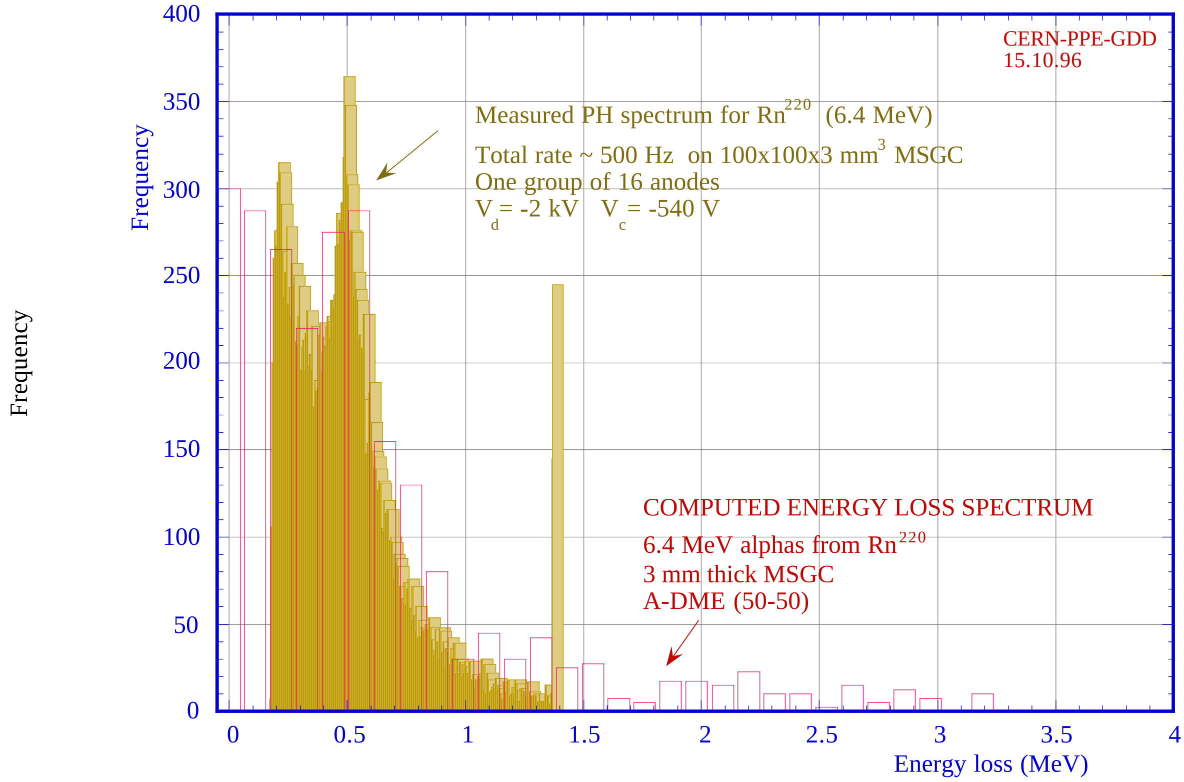
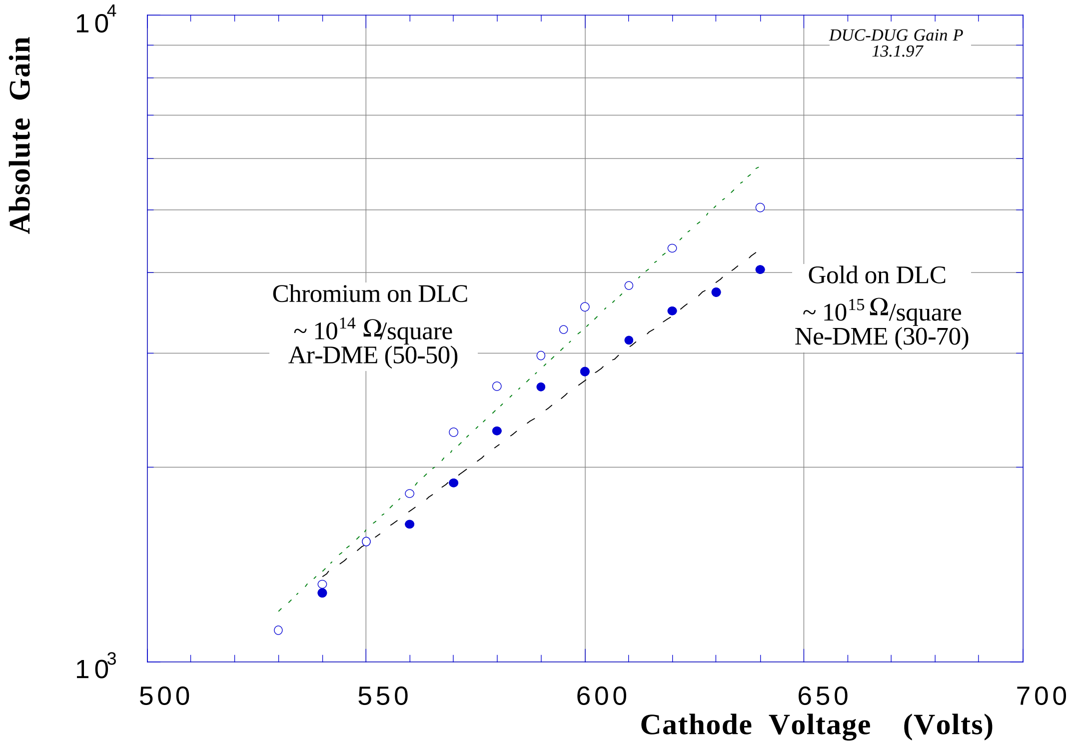


Fig. 2

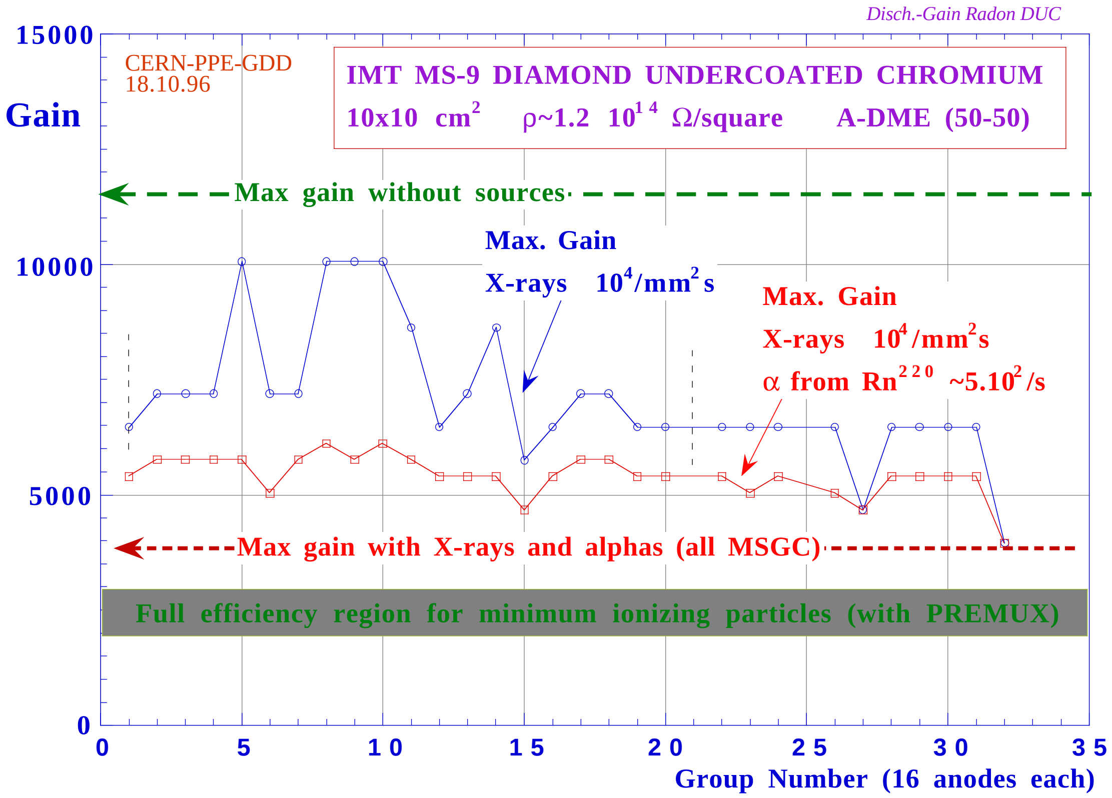
Fig. 3 shows the absolute gain measured as a function of cathode voltage for DUC2 and DUG. The discharge limiting current in each case was set ~ 10 % above the total (leakage + radiation) current. For the chamber with lower resistivity the total leakage current was ~ 8 μA, and the radiation current was 3 μA at a gain of a few 1000, with the X-ray flux of 10^4/mm^{2}s; the trip limit was set to a total current of ~ 12 μA. For the chamber with higher resistivity however, the leakage current was < 1 μA, the total current was 3 μA and the trip limit was set to 4 μA. The drift voltage was set to 2 kV for all measurements.

Fig. 4 summarizes the results of measurements of short term discharge limits of DUC2. In this chamber, which had an average resistivity of 1.2 10^{14} Ω/square, anodes



Absolute Gain
10^4
10^3
DUC-DUG Gain P
13.1.97
Chromium on DLC
~ 10^{14} Ω/square
Ar-DME (50-50)
Gold on DLC
~ 10^{15} Ω/square
Ne-DME (30-70)
500
550
600
650
700
Cathode Voltage (Volts)

Fig. 3



Disch.-Gain Radon DUC
Gain
15000
10000
5000
0
CERN-PPE-GDD
18.10.96
IMT MS-9 DIAMOND UNDERCOATED CHROMIUM
10x10 cm^2 ρ~1.2 10^{14} Ω/square A-DME (50-50)
Max gain without sources
Max. Gain
X-rays $10^4/mm^2s$
Max. Gain
X-rays $10^4/mm^2s$
α from Rn^{220} ~$5.10^2/s$
Max gain with X-rays and alphas (all MSGC)
Full efficiency region for minimum ionizing particles (with PREMUX)
0
5
10
15
20
25
30
35
Group Number (16 anodes each)

Fig. 4

were connected in groups of 16 and each group could be accessed individually. When there is no source of radiation, one can reach voltages as high as 685 V on the cathodes connecting each group of the anodes one by one to ground (stopping for safety reasons). This corresponds to the top dashed line in the figure equivalent to ~ few 10^4 in gain, extrapolating by an exponential fit from the curve in fig. 3. With an X-ray flux of ~10^4/mm^{2}s this limit is reduced to values ranging 620-660 V over the groups thus lowering the gain achievable as shown. A single poor anode group will be responsible for lowering of the operational voltage of the whole chamber.

When the radon generator is switched on, this safe voltage is further reduced to 605-635 V over all the groups reducing the maximum attainable gain limit in the presence of highly ionizing particles to be ~ 3500 which we consider quite marginal for operating in a high flux of MIPs with full efficiency governed by the signal/noise of the readout electronics. In the figure, we have represented (dashed region) the gain required for full efficiency of MIPs detection.

Coming to the more realistic situation, the chamber was left on voltage with both the flux of X-rays @ 10^4/mm^{2}s and Radon at 5 Hz/cm^2 for a longer time at a working voltage giving a gain of 3000, which seems a safe working point from the short term study shown in fig. 3. As is seen from Fig. 5, 30 trips are observed in the first 10 hours, and the rate of trips is continuously increasing. After some number of trips, the chamber did not hold the voltage and discharged continuously: the measurements were then suspended. The chamber could not hold the voltage even without the source (up to gain > 3000) and one had to wait for several hours before voltage could be applied and the X-ray switched on.

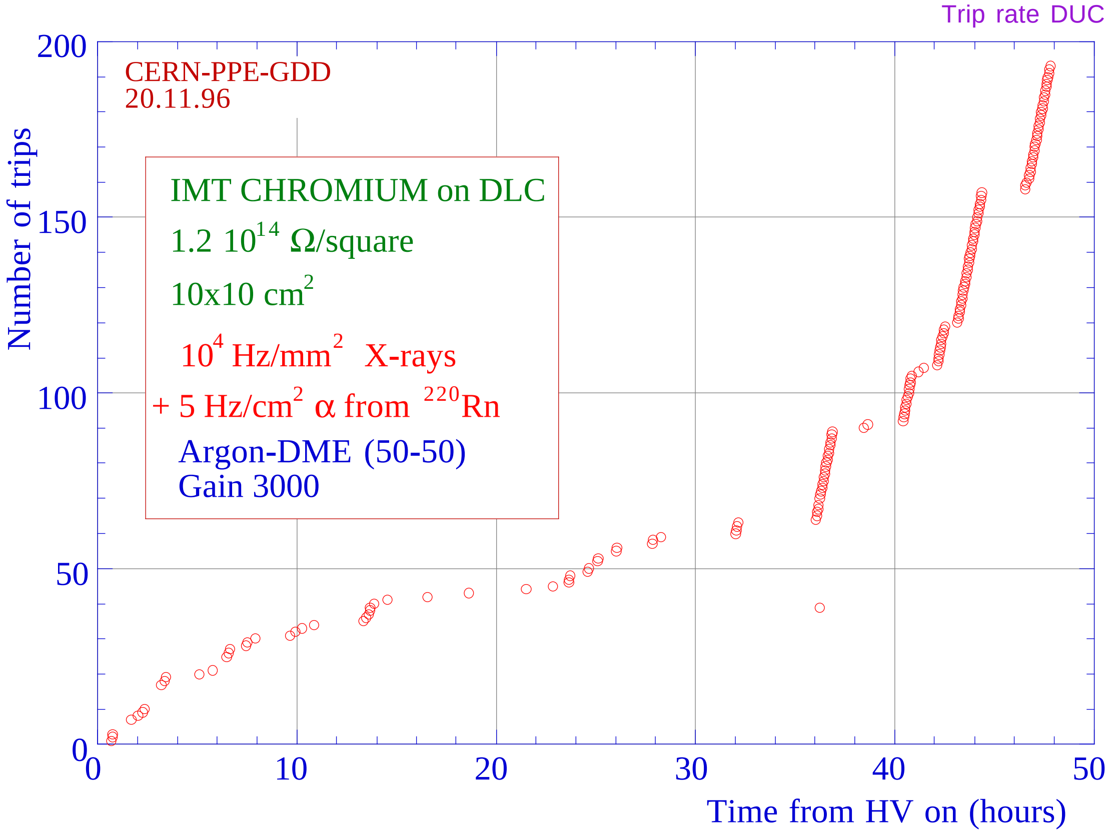


Fig. 5

The study was repeated at gains 1800 and 1500 where the trips in the first 10 hours were smaller in number (see later), but once trips set in the behaviour was the same even after increasing the waiting period for reset the voltage after a trip has occurred from 1 min. to 10 mins.

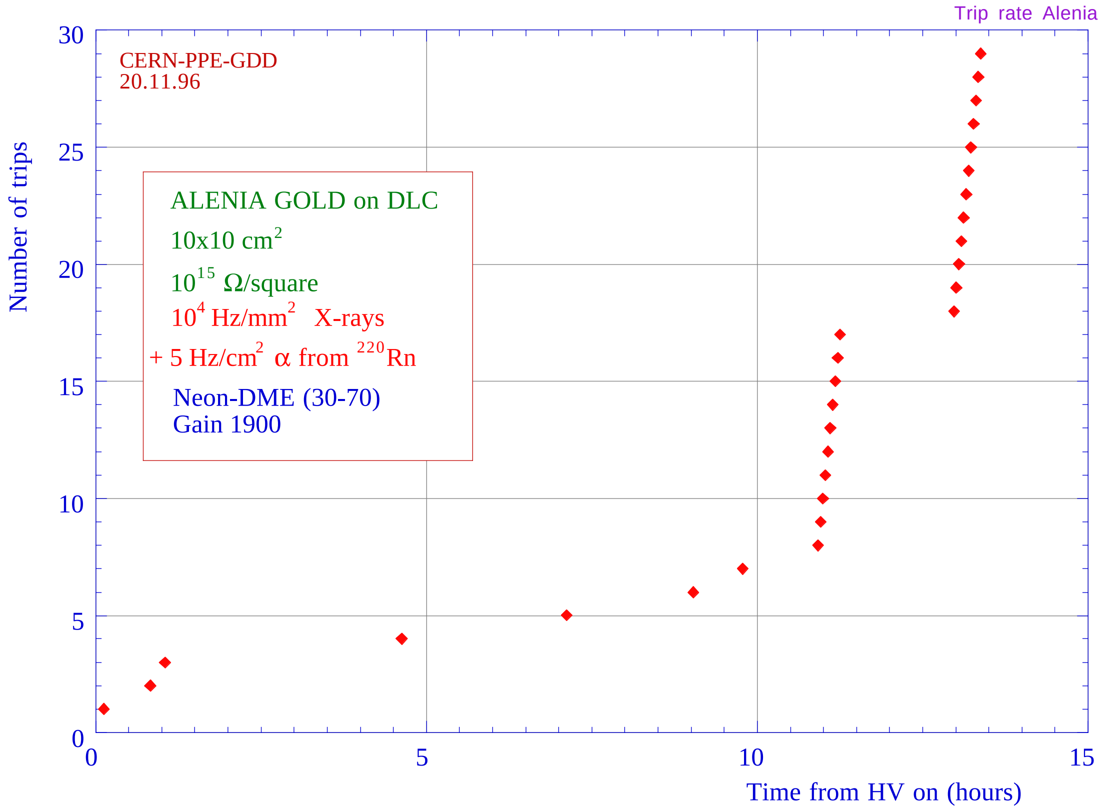
All these measurements were done with Ar-DME (50-50); with Ne-DME (50-50) and essentially the same behaviour was found.

Fig. 6

Fig. 6 shows the results of a similar investigation with the MSGC made by Alenia, gold strips on diamond coated D263 glass (DUG), operating with a Ne-DME (30-70) gas mixture. As implied by the figure, the maximum safe operating gain is close to 3000; somewhat lower than for the previous chamber, for all the anode groups of the chamber. This is a short term measurement.

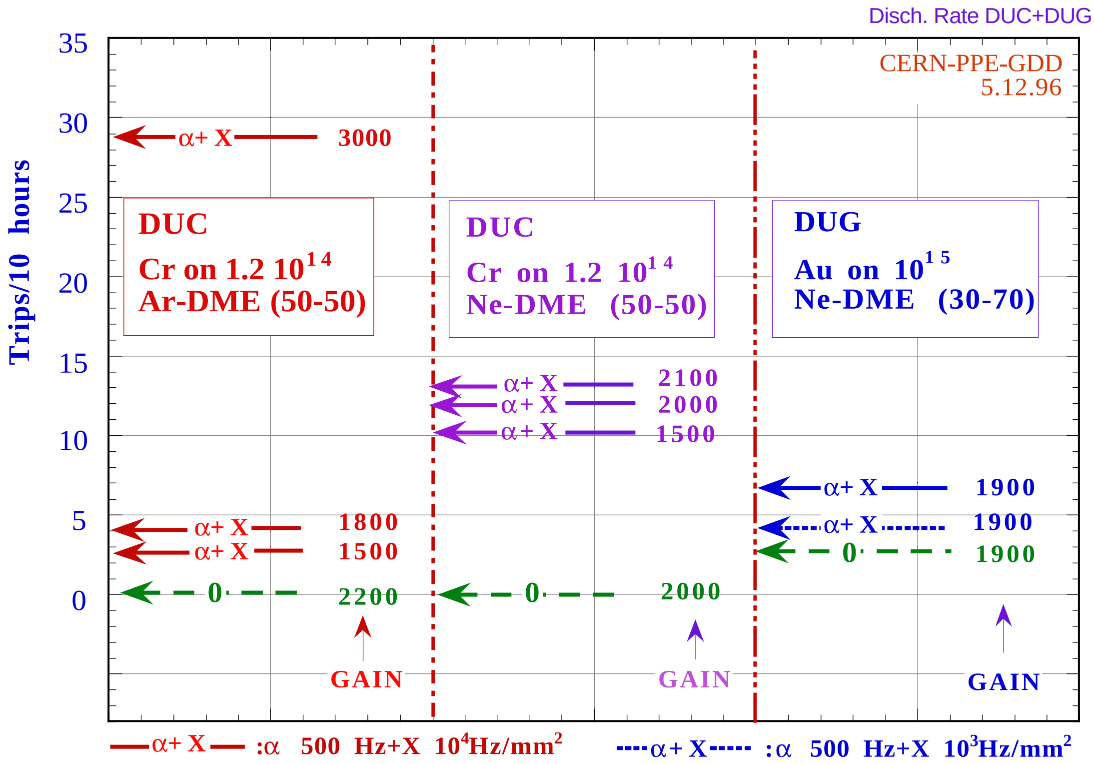
Fig. 7 shows the results of long term tests with this Alenia gold chamber operational at a gain of 1900, presumably safe from the previous figure, with an X-ray flux of 10^4/mm^{2}s and Radon simultaneously over all the active surface. We find that in the first 10 hours there is a rate of ~ 1 discharge per hour, increasing after some number of trips, whence continuous discharges set in as previously experienced with the DUC chamber.

It may be noted, however, even with no source of irradiation on the chamber, the Alenia gold chamber DUG, has shown some trips over a relatively long period of time (4 in 10 hours) as shown by the arrow in the third column of fig. 8. Here the gain is marked on the right of the arrow and the conditions of exposure are marked on the arrow. It may be emphasized that the number of trips has a statistical nature; depending on the length of time one waits, or the period during which one counts the number of trips, these numbers may vary considerably.



Trip rate Alenia
CERN-PPE-GDD
20.11.96
ALENIA GOLD on DLC
10x10 cm²
10¹⁵ Ω/square
10⁴ Hz/mm² X-rays
+ 5 Hz/cm² α from ²²⁰Rn
Neon-DME (30-70)
Gain 1900
Number of trips
Time from HV on (hours)
0
5
10
15
20
25
30
0
5
10
15

Fig. 7



Disch. Rate DUC+DUG
CERN-PPE-GDD
5.12.96
Trips/10 hours
DUC
Cr on 1.2 10¹⁴
Ar-DME (50-50)
DUC
Cr on 1.2 10¹⁴
Ne-DME (50-50)
DUG
Au on 10¹⁵
Ne-DME (30-70)
α+ X 3000
α+ X 1800
α+ X 1500
0 2200
α+ X 2100
α+ X 2000
α+ X 1500
0 2000
α+ X 1900
α+ X 1900
0 1900
GAIN
GAIN
GAIN
α+ X :α 500 Hz+X 10⁴Hz/mm²
α+ X :α 500 Hz+X 10³Hz/mm²
35
30
25
20
15
10
5
0

Fig. 8

Conclusions and Summary

The sparking or discharge in MSGCs in the presence of highly ionizing particles has been investigated, and a severe limitation has been found in the short and long term operation of these devices. Several MSGCs with gold and chromium strips on diamond coated D263 glass were used for short term measurements. Two of them: one IMT diamond undercoated with chromium strips and resistivity ~ $1.2.10^{14}$ Ω/❑, and the other prepared by Alenia with undercoated diamond (resistivity ~ 10^{15} Ω/❑) and gold strips were exposed over their full area (10 x 10 cm^2) to a high flux 10^4 /mm^2s of X-rays and a flux of 500 Hz of α from Rn^{220} to simulate the realistic scenario of CMS conditions.

Discharges appear in these conditions both in short term as well as long term working of both chambers at relatively low voltages, considerably reducing the region of full efficiency operation for minimum ionizing particles.

Attention may be drawn to the fact that, even in the so-considered “safe” operating region, under a mixed field of sustained radiation emulating real CMS conditions, we observe a non-negligible rate of fatal discharges (one per hour, leading to HV cut-off and permanent damages). We consider the margins between safe operation and discharge voltages to be too critical for reliable long term operation: a substantial research effort should be undertaken to solve these problems.

References:

[1] R. Bouclier et al CMS TN/96-018.
[2] R. Bouclier et al CMS TN/96-016.