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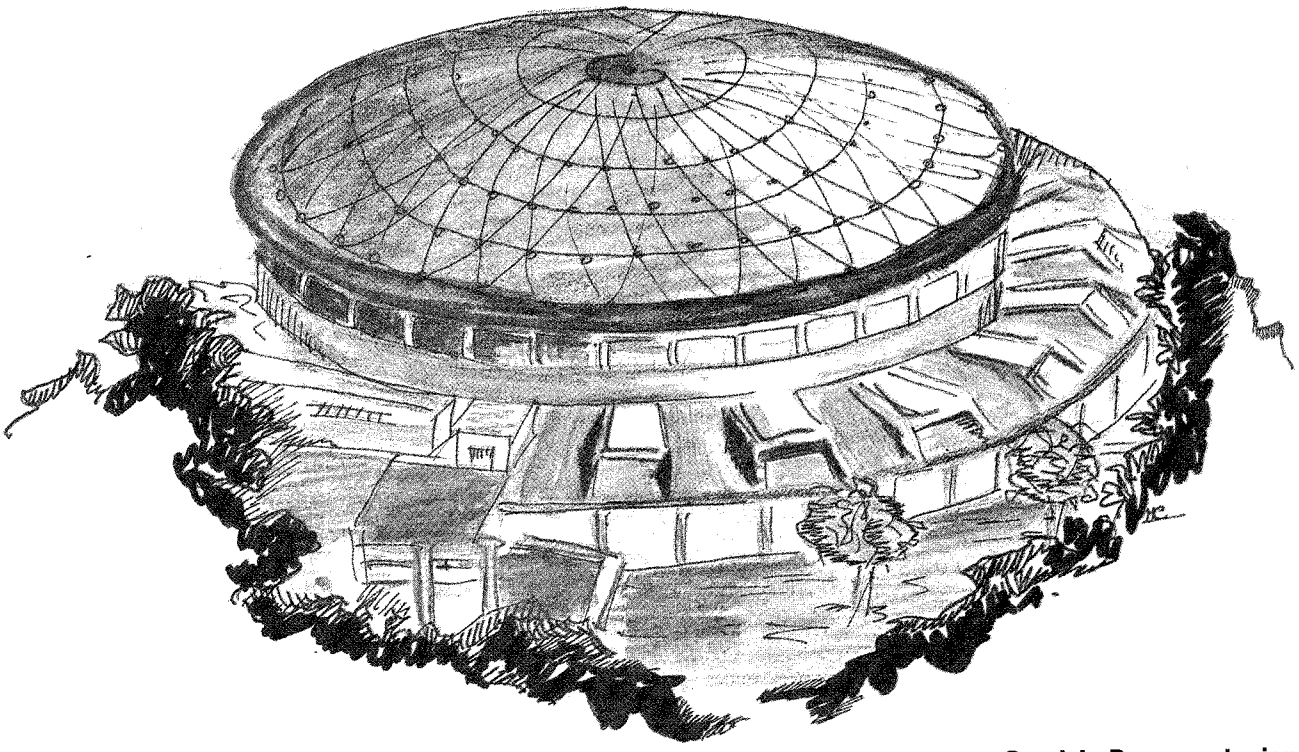

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THE USE OF n-HEXANE IN THE GAS MIXTURE FOR STREAMER TUBES.

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ABSTRACT

We have investigated the use of n-Hexane as a quencher in the gas mixtures for the streamer tubes. We discuss the advantages of this choice from the point of view of safety.

The present experiments in high energy physics using gaseous detectors such as streamer tubes, have to face the safety requirements imposed by the usual gas mixtures. This is of particular relevance for underground experiments[1], where the environment puts restrictions on safety conditions. Work is in progress in different laboratories to search for a possible non-flammable gas mixture, or at least a mixture very near the non-flammability limit, which could provide at the same time the operation features typical of the standard mixtures.

The standard Argon+isobutane gas mixture has been widely adopted in streamer tubes both for tests[2] and experiments[3]. A different gas mixture has been introduced in the NUSEX experiment at Mont Blanc[4], for safety purposes, by using Ar+CO_2+n-Pentane (15/60/25). It has been already shown that the heavier the hydrocarbon molecule, the better is the quenching property of the gas, and as a consequence, the stability operation range[5]. The same operation condition can be achieved with a reduced fraction of n-Pentane with respect to isobutane, more than compensating the total increase in flammability, which is substantially proportional to the number of Hydrogen bonds. The hydrocarbon fraction can be further reduced by the addition in the mixture of CO_2, which also exhibits some quenching capability. The main advantage of n-Pentane comes from the fact that at NPT it is a liquid, thus reducing the problems arising from the use of pressurized bottles.

In a recent paper[6] non flammable gas mixtures for the streamer tubes have been proposed using Argon, CO_2, and isobutane. One of the most important points of merit of this work is to point

out that the flammability of the gas mixture is not simply measured by the fraction ratio isobutane/air, but also the CO_2 content must be considered. So the goal is achieved by using CO_2 -rich mixtures, and by adjusting the CO_2/Argon ratio to the isobutane/Argon ratio.

We have tested the same gas mixtures described in Ref. [6], and we succeeded in reproducing their results with the X-rays from an ^{55}Fe source. Poorer results are obtained with minimum ionizing particles, due to the appearance of abundant afterpulsing, as noticed by the authors themselves.The relevance of this phenomenon turns out to increase with the CO_2 concentration.

Here we present the results of our investigation to have a further reduction of the tolerable quencher/Argon ratio, by the exploitation of hydrocarbons heavier than isobutane. The advantages of n-Pentane have been already mentioned before. We have tested for the first time n-Hexane (n-C_6H_{14}) in the framework of the MACRO experiment, where we are using streamer tubes, 3x3 cm^2 in size[7]. As an example of the many possible gas mixtures, Figs. 1 and 2 show the singles counting rate curves for 6% and 10% n-Hexane concentration, plus Helium and CO_2 in different proportions. The use of Helium is dictated by the particular requirements of the MACRO experiment, but the results are practically the same if Argon is used instead. The curves have been obtained by selecting the streamer pulses only, using a discrimination threshold of 20 mV/50Ω. In this way the knee of the plateaux of the singles counting rate coincides with the beginning of the full efficiency region for streamer mode. With both gas mixtures the wire pulses, at the knee of the plateau, have the typical triangular shape of the streamer pulses, with 50 ns base width and 50 mV/50Ω minimum amplitude. The rising behavior of the counting rate in Fig. 1 (CO_2 rich) is due to the increasing afterpulsing mentioned before.

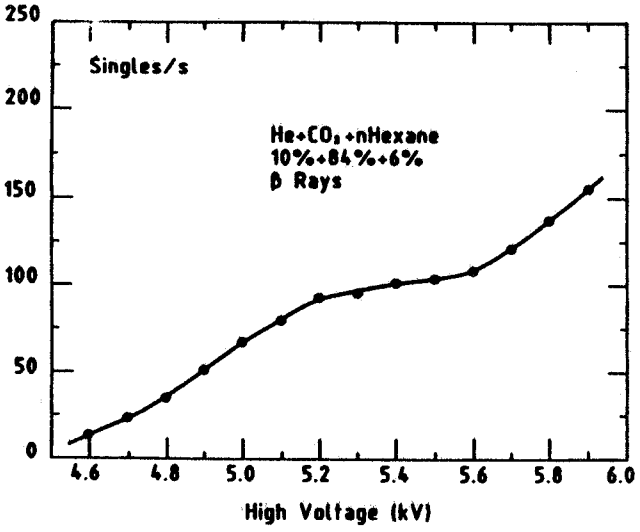

FIG. 1 - Singles counting rate as a function of high voltage as measured with ß rays.

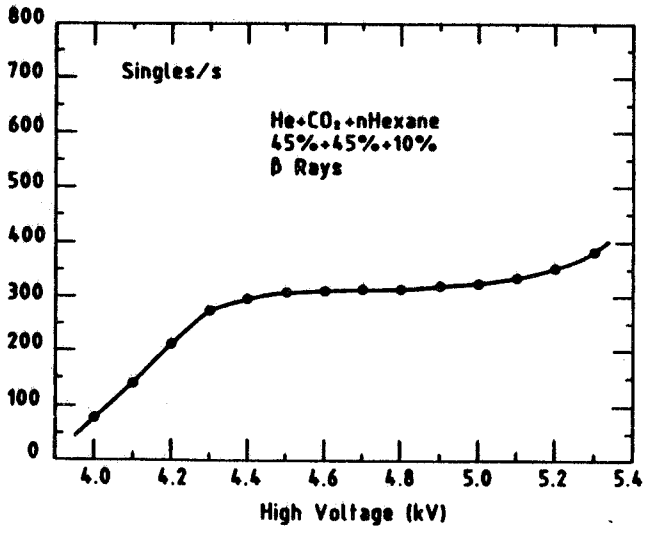

FIG. 2 . Singles counting rate as a function of high voltage as measured with ß rays.

Fig 3 and 4 show the charge spectra for wire pulses for the two mixtures, 50 V above the knee of the plateaux, with two different integration gate widths. The increasing tail at high charge for the longest integration gate is again due to the afterpulsing process.

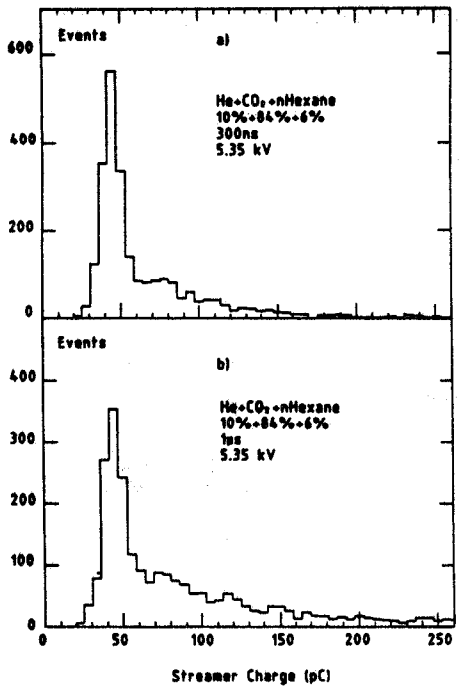

FIG. 3 - Streamer charge distribution of wire pulses, as measured with non collimated ß rays with a) 300 ns and b) 1μs integration time, for the gas mixture relative to Fig. 1.

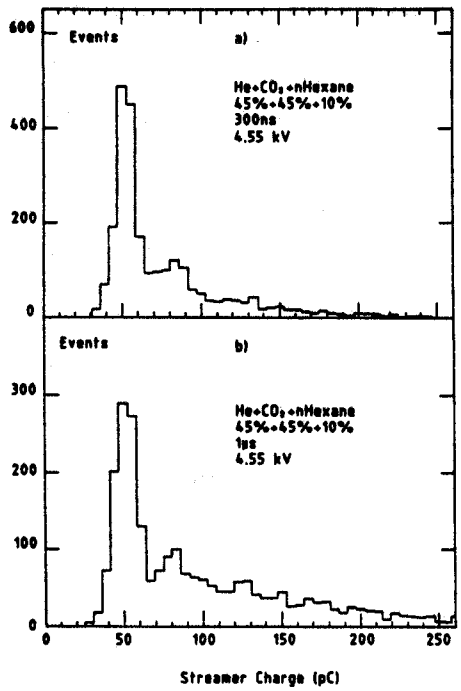

FIG. 4 - Streamer charge distribution of wire pulses, as measured with non collimated ß rays with a) 300 ns and b) 1μs integration time, for the gas mixture relative to Fig. 2

The mixture of Fig.1 is estimated to be in the non-flammable region (n-Hexane/CO_2 1:14), while the other of Fig. 2 is near the limit. The relevant point is that n-Pentane, not to speak of isobutane, cannot give the same quenching power and consequent operation stability at the same percentages, while the flammability limits of n-Hexane are not far from the ones of n-Pentane[8]. Thus we have obtained two main advantages: i) a substantial reduction of the total quantity of flammable component, both in the detector volume and in the gas mixing system, which remains the critical point for underground experiments, even in the case of the non-flammable mixtures of the type described here and in Ref. [6]; and ii) a lower vapor pressure, for equal temperature, with respect to n-Pentane (the flash-point is -22° C for n-Hexane versus -40° C for n-Pentane), so that the advantage of the liquid state is also more effective from the safety point of view.

We would also like to point out how CO_2 affects the detector operation. The addition of CO_2 reduces the drift velocity[9] and, in particular for large concentrations, we are far from the typical saturation exhibited by the standard Argon+isobutane gas mixtures. Figs. 5 and 6 show the drift time distributions for the two gas mixtures considered in this work, as measured with cosmic rays near the vertical with the 3 cm size tubes. A maximum drift time around 1 μs is obtained, to be compared with a value of about 350 ns as obtained with an Argon+isobutane 1:1 standard mixture. The increase of the drift time is also a possible explanation for the afterpulsing production mentioned before. Beyond the usual afterpulse generation by electrons extracted from the cathode, there could also be photoionization of the gas mixture, giving pulses randomly distributed in time, within 1 μs, after a

single streamer. This interpretation is favoured by the smaller photoabsorption cross section of the CO_2 with respect to hydrocarbons[11]. Another possible mechanism which could give rise to the same effect is the multi-streamer generation by tracks inclined with respect to the wires.

As a final remark we report the results of a degeneration test performed following the procedure described in Ref. [9]. No particular aging effect has been noticed which could be attributed to the use of n-Hexane instead of n-Pentane.

We wish to thank prof. E. Iarocci for having suggested this measurement.

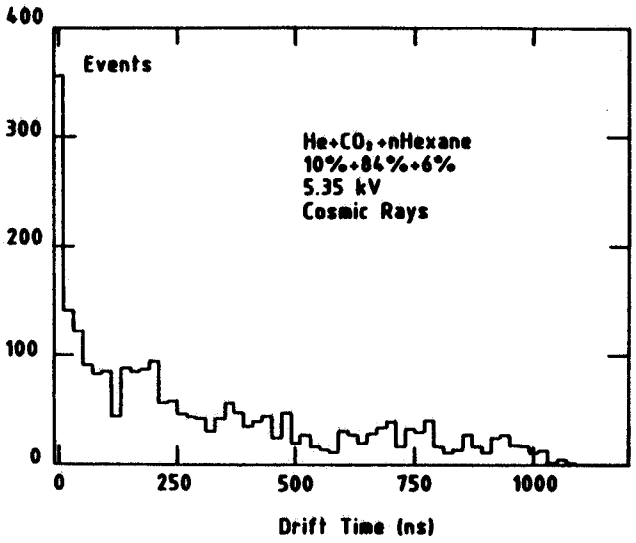

FIG. 5 - Drift time distribution as measured with cosmic rays around the vertical direction, for the gas mixture relative to Fig. 1.

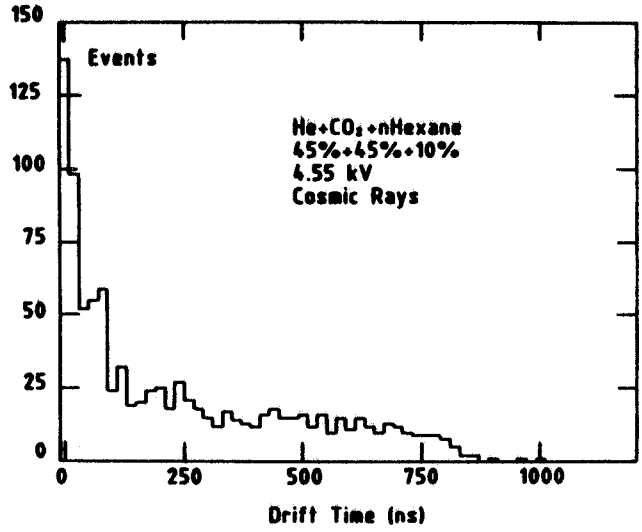

FIG. 6 - Drift time distribution as measured with cosmic rays around the vertical direction, for the gas mixture relative to Fig. 2.

References

1) M. Calicchio et al., Nucl. Instr. & Meth. **A264** (1988) 18; G. Alberini et al., Nuovo Cimento **9C** n. 2 (1986) 237.
2) See for instance: G. Battistoni et al., Nucl. Instr. & Meth. **164** (1979) 57; G.Battistoni et al, Proc. of the Int. Conf. on Istrumentation for Colliding Beam Physics, SLAC, USA, 1982,195; M.G. Catanesi et al, Nucl. Instr. & Meth. **A247** (1986) 438.
3) C. Bacci et al., Phys. Lett., **86B** (1979) 234; M. Jonker et al., Nucl. Instr. & Meth. **215** (1983) 361; M. Baldo Ceolin, Proc. of the ICOBAN Meeting, Bombay, 1982; J.E. Augustin et al., Physica Scripta **23** (1981) 623; G. Bauer et al., Nucl. Instr. & Meth. **A253** (1987) 179.
4) G. Battistoni et al., Nucl. Instr. & Meth. **A245** (1986) 277.
5) E. Iarocci,Nucl. Instr. & Meth. **217** (1983) 30.
6) T. Uebayashi et al., Nucl. Instr. & Meth. **A265** (1988) 457.
7) M. Calicchio et al., Proc. of the XXth Int. Conf on Cosmic Ray Physics, Mosca, 1987, Vol. 6, 510.
8) B. Lewis and G. von Elbe, Combustion, Flame and Explosions of Gases (Academic Press, New York, 1961).
9) A.Peisert and F. Sauli, CERN 84-08.
10) G. Battistoni, Proc. of the Gas Sampling Calorimetry Workshop II, Fermilab, USA, 1985, 594.
11) J. Berkowitz, Photoabsorption, Photoionization and Photoelectron Spectroscopy, Academic Press, New York,1979; T.J. Summer et al., Nucl. Instr. & Meth. **224** (1984) 477.