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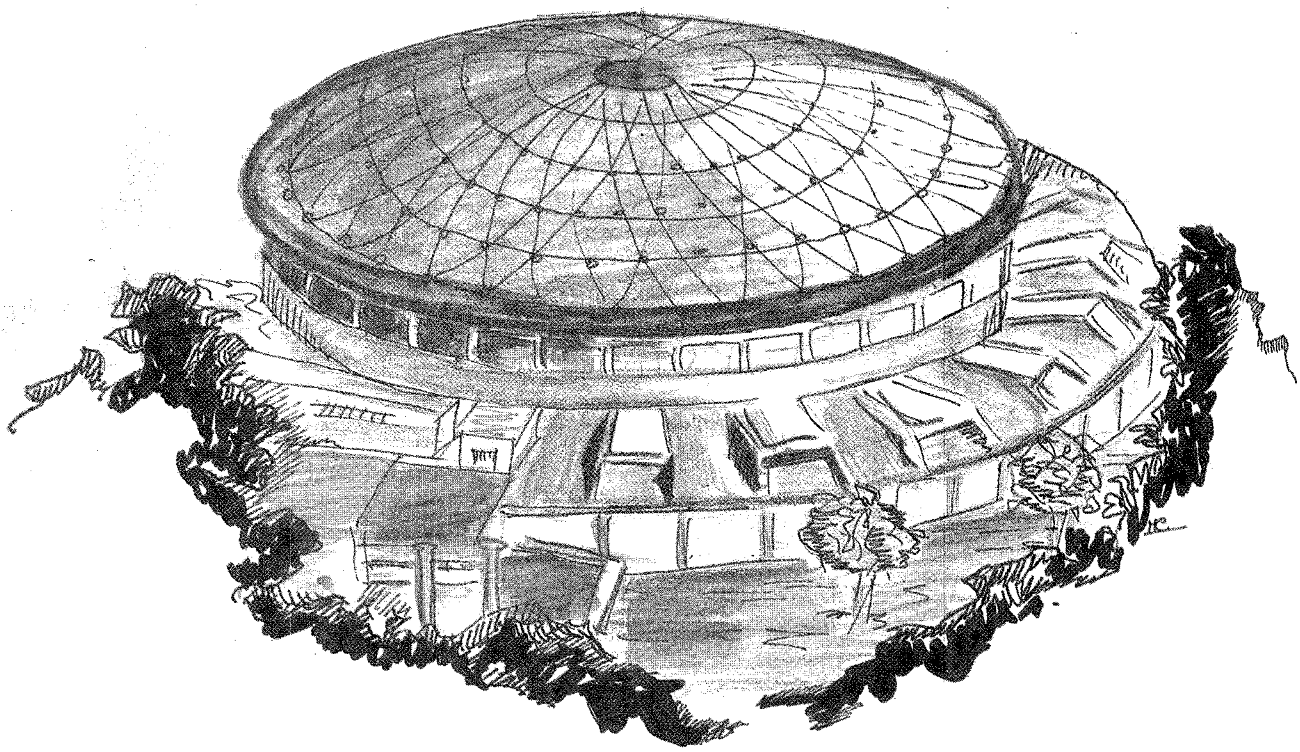

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OPERATION OF LIMITED STREAMER TUBES WITH LOW HYDROCARBON CONTENT GAS MIXTURES USING NEON AS NOBLE GAS

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The use of neon instead of argon in low hydrocarbon content gas mixtures for streamer tubes is investigated. The role of neon in the streamer development mechanism and the advantages of this choice on the performances of the streamer tubes are discussed.

Low hydrocarbon content gas mixtures for streamer tubes have been tested in order to reduce the amount of the flammable component[1]. One of the drawbacks of a heavy quenching gas reduction is a large streamer charge increase (up to a factor of two with respect to the high hydrocarbon content gas mixtures). This effect inducing a larger dead zone along the wire could deteriorate the calorimeter performances.

According to the standard models of the streamer avalanche development[2], the size of the streamer depends in a crucial way on the photoionization process. The efficiency of such a process is strictly related to the energy spectrum of the photons emitted in the recombination and in the radiative

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de-excitation processes of noble gas molecules(3,4), and to the photoionization cross section of the quenching gas molecules (hydrocarbons or CO_2)(5). The photons emitted by excited argon atoms and molecules lie in an energy range around 10 eV, while the photoabsorption cross sections of the hydrocarbons reach their maximum at about 16 eV. The partial overlap between the photon energy spectrum and the photoabsorption cross section, in the case of low hydrocarbon content gas mixtures, induces a very large streamer charge and gives rise to a considerable production of afterpulses with subsequent spoiling of the detector performances. Therefore a possibile reduction of the streamer charge, besides a more uncritical operation, can be obtained by replacing the argon with another noble gas as neon, which exhibits a photon energy spectrum with a peak at higher energy (about 15 eV)(6), and then better matched with the photoionization cross section of the hydrocarbons.

In this paper a comparison between the behaviour of streamer tubes operated with Ar/CO_2/n-hexane and Ne/CO_2/n-hexane gas mixtures with low hydrocarbon fractions is presented. These gas mixtures using liquid hydrocarbons (n-hexane or n-pentane) have been obtained with the Aleph hadron calorimeter gas system described in a previous paper (7).

Singles counting rate plateaux for n-hexane concentration of 10% at different values of the ratio $r=Ar/CO_2$ (or Ne/CO_2) are reported in Figs. 1a and 1b. The measurements have been performed with 1x1 cm^2 x 100 cm plastic streamer tubes, 100 μm wire, 10 mV/50 Ω threshold and 1μs shaping width. The knee of the singles rate plateaux obtained using the neon gas mixtures is about 200 V shifted to higher voltage with respect to that obtained with argon ones, as shown in Fig. 2. In Fig. 3 the plateau width, defined as the voltage interval between the plateau knee and the voltage at which the singles counting rate is 15% larger than the counting rate at the knee, is plotted as a function of both Ar/CO_2 and Ne/CO_2 ratio.

The plateaux obtained with neon gas mixtures are about 150 V wider than those obtained with argon ones. All these observed features well agree with the previous general considerations about the streamer breeding and in particular with the expected role of the neon.

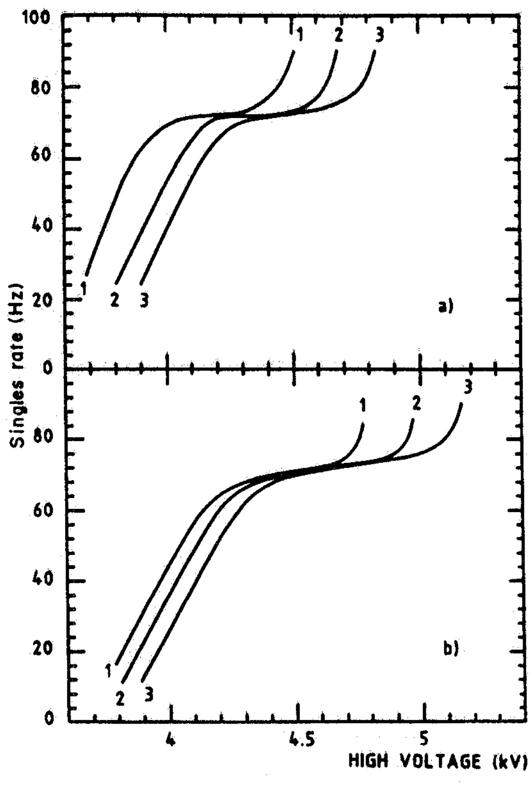

FIG. 1 - Singles counting rate plateaux for 10% n-hexane concentration at different values of a) Ar/CO_2 : 1- 25%; 2- 20%; 3- 12.5%; b) Ne/CO_2 : 1- 25%; 2- 20%; 3- 12.5%.

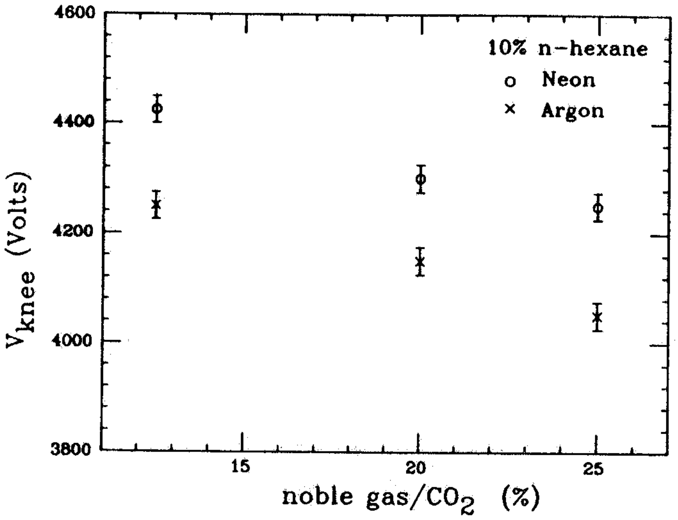

FIG. 2 - Singles rate plateau knee as a function of noble gas/CO_2 ratio for neon and argon at 10% n-hexane concentration.

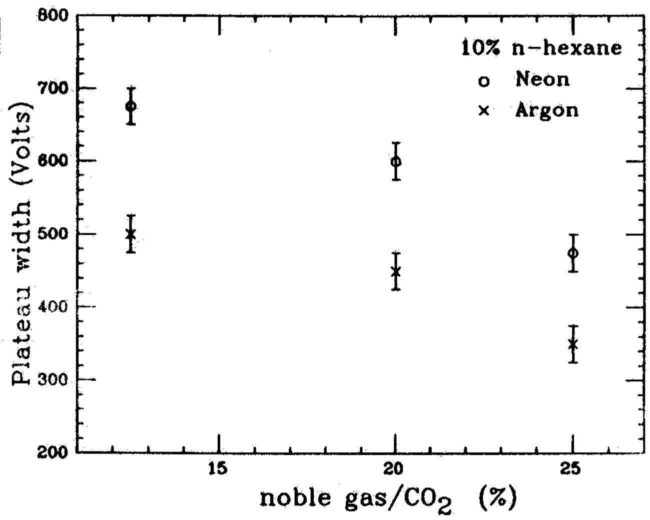

FIG. 3 - Plateau widths both for argon and neonas a function of the noble gas/CO_2 ratio for 10% n-hexane concentration

The use of neon in a non flammable gas mixture (7% of n-hexane) has been also investigated. In Fig. 4 the singles counting rate plateaux for a Ar/CO_2 and Ne/CO_2 ratio of 13.5% are compared. For these gas mixtures the average number of afterpulses per pulse as a function of the voltage referred to the knee of the plateau is shown in Fig. 5. The evaluation of the afterpulses amount was obtained by difference between the singles counting rate with 100 ns and 1μs shaping widths. The generation of afterpulses in neon gas mixtures is approximately three times lower than that observed in argon ones at a working voltage of about 100 V above the knee of the singles rate plateaux.

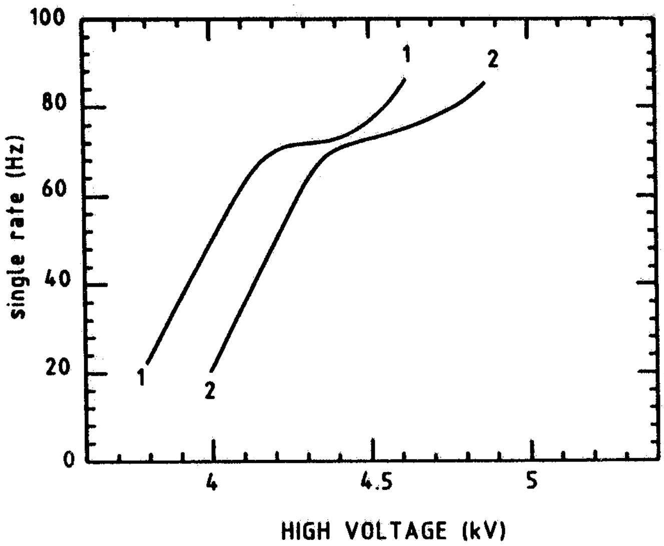

FIG. 4 - Singles counting rate plateaux for 7% n-hexane concentration at 1- Ar/CO_2=13.5%; 2- Ne/CO_2 = 13.5%.

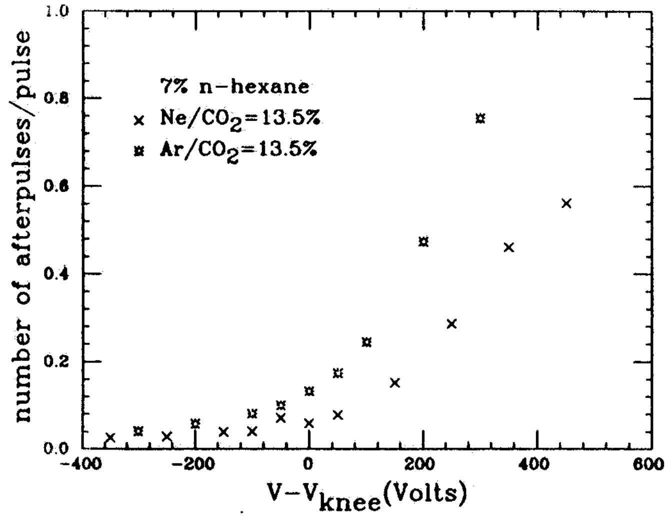

FIG. 5 - Average number of afterpulses per pulse as a function of the high voltage for neon and argon at 7% n-hexane concentration.

A comparison of the charge distributions obtained both for argon and neon gas mixtures at 10% and 7% n-hexane concentrations, for a Ar/CO_2 and Ne/CO_2 ratio of 20% and 13.5% respectively, is shown in Figs. 6 and 7. A suitable telescope selecting nearly orthogonal cosmic rays has been used for charge spectra measurements. In agreement with the analysis on the afterpulses based on the singles counting rate, the neon spectra show a reduced tail with respect to the argon ones, this difference being more accentuated at lower hydrocarbon concentrations. In addition the peak charge amplitudes for neon gas mixtures turn out to be about 20% smaller than those obtained with the argon ones, Figs. 8a and 8b.

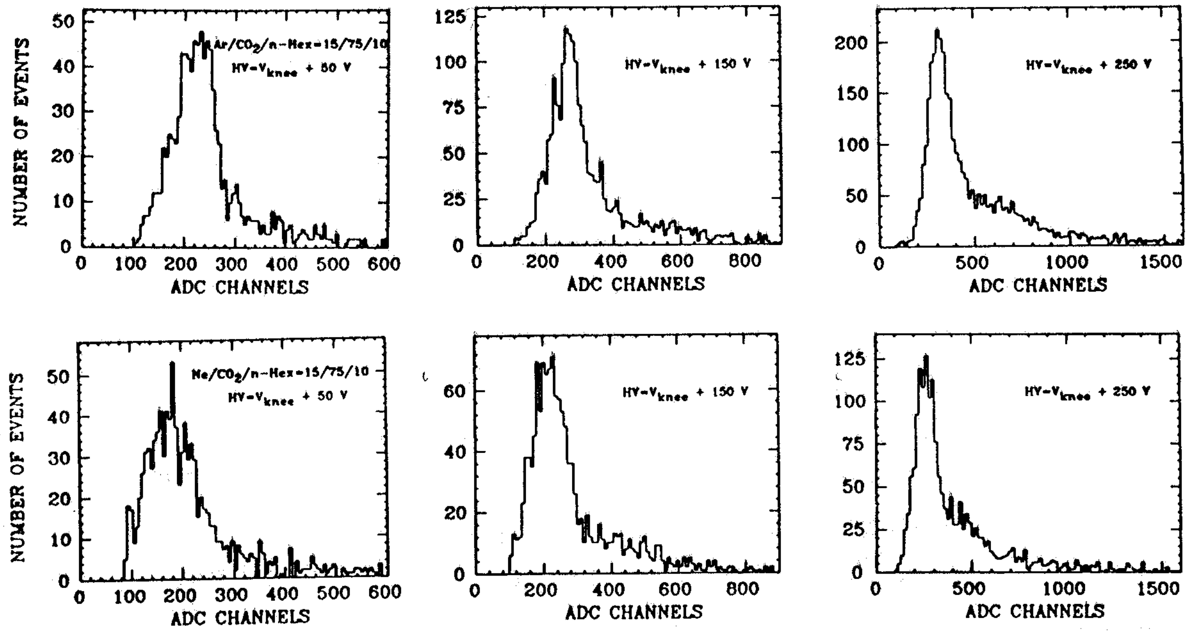

FIG. 6 - Singles streamer charge distributions for neon and argon at 10% n-hexane concentration.

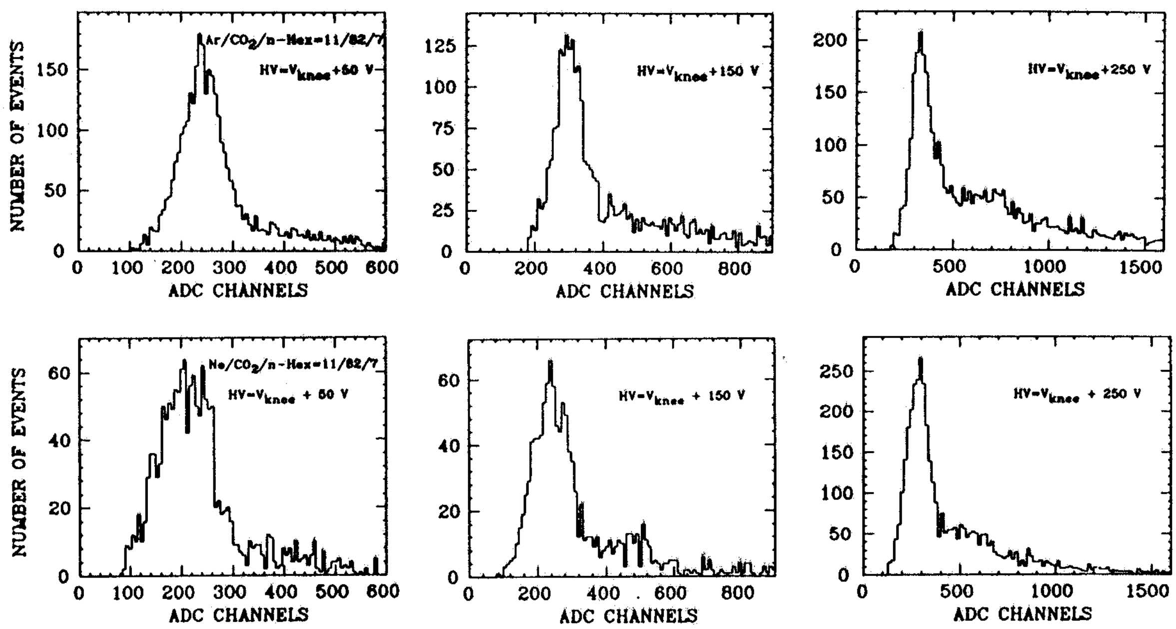

FIG. 7 - Singles streamer charge distributions for neon and argon at 7% n-hexane concentration.

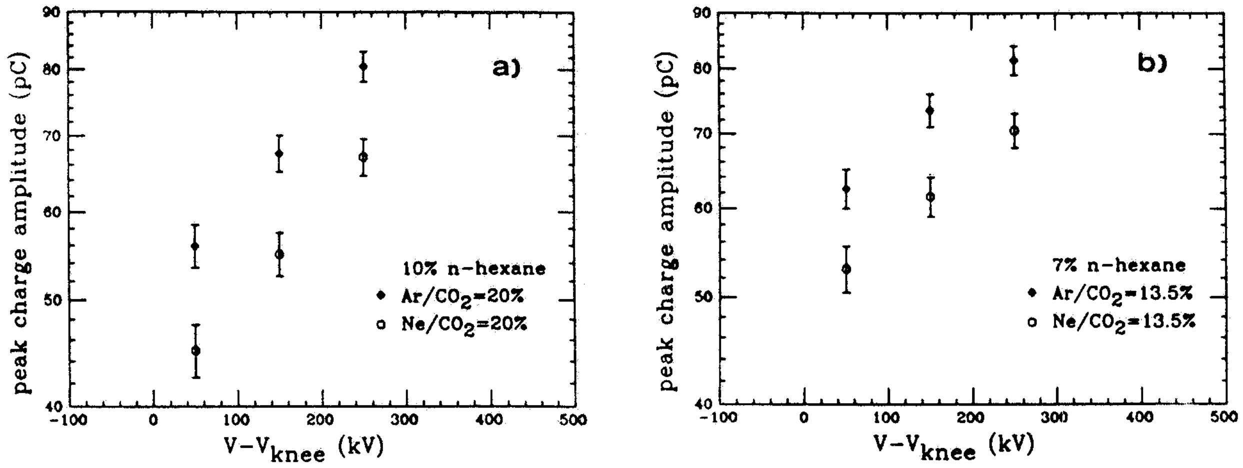

FIG. 8 - Peak of the charge distributions as a function of the voltage for: a) 10% n-hexane concentration, Ar/CO_2 - Ne/CO_2 = 20%; b) 7% n-hexane concentration, Ar/CO_2 - Ne/CO_2 = 13.5%.

In conclusion, the use of neon in low hydrocarbon content gas mixtures permits to obtain a wider plateau and a reduced afterpulses generation besides an appreciable streamer charge reduction.

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REFERENCES

(1) R. Baldini-Celio et al., A study of low hydrocarbon content gas mixtures for streamer tubes, LNF Report 88/43(P) (1988), (submitted to Nucl. Instr. and Meth.).

(2) G. Battistoni et al., Nucl. Instr. and Meth. **164** (1979) 57; G.D. Alekseev et al., Nucl. Instr. and Meth. **177** (1980) 385; M.Atac et al., Nucl.Instr. and Meth.**200** (1982) 345; E.P. De Lima et al., Nucl.Instr. and Meth. **A263** (1988) 375.

(3) M. Suzuki and S. Kubota, Nucl. Instr. and Meth. 164 (1979) 197.

(4) T.J. Sumner et al., IEEE Trans. on Nucl. Sci., NS-29, (1982) 1410.

(5) J. Berkowitz, Photoabsorption, Photoionization and Photoelectron Spectroscopy; Academic Press (1979).

(6) Y. Tanaka et al., J. Opt. Soc. Am., **48** (1958) 304.

(7) G. Bagliesi et al., Nucl. Instr. and Meth. **A268** (1988) 144.