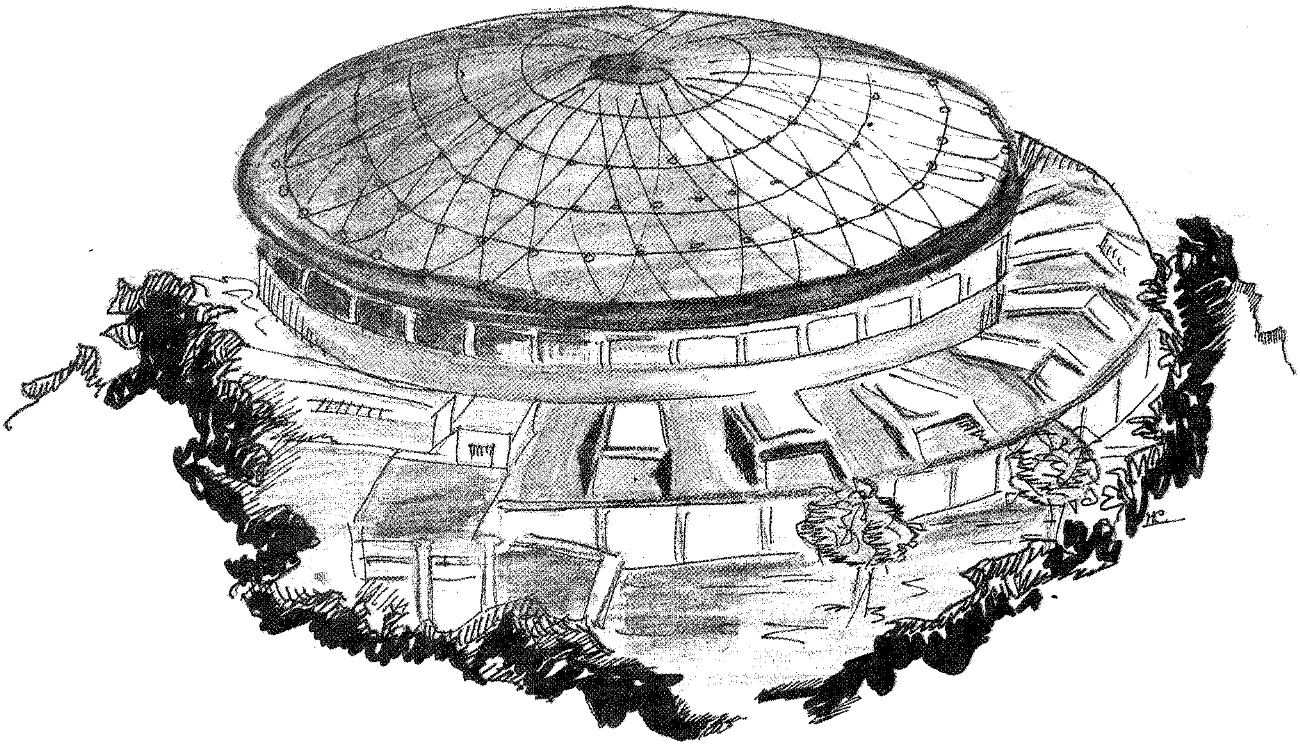
Laboratori Nazionali di Frascati

To be submitted to Nucl. Instr. & Meth. Phys. Res.

LNF-88/43(P)
11 Luglio 1988

R. Baldini-Celio, G. Bencivenni , F. Bossi, P. Campana, G. Capon, G. De Ninno, B. D'Ettorre Piazzoli, G. Felici, P. Laurelli, G. Mannocchi, F. Murtas, G.P. Murtas, G. Nicoletti, P. Picchi, H. Rigoni:

A STUDY OF LOW HYDROCARBON CONTENT GAS MIXTURES FOR STREAMER TUBES



Servizio Documentazione
dei Laboratori Nazionali di Frascati
P.O. Box, 13 - 00044 Frascati (Italy)

INFN - Laboratori Nazionali di Frascati
Servizio Documentazione

LNF-88/43(P)
11 Luglio 1988

A STUDY OF LOW HYDROCARBON CONTENT GAS MIXTURES FOR STREAMER TUBES

R. Baldini-Celio, G. Bencivenni , F. Bossi, P. Campana, G. Capon, G. De Ninno, B. D'Ettorre Piazzoli*, G. Felici, P. Laurelli, G. Mannocchi*, F. Murtas, G.P. Murtas, G. Nicoletti, P. Picchi,
INFN - Laboratori Nazionali di Frascati, P.O. Box 13, 00044 Frascati (Italy)

H. Rigoni
CERN, Geneva (Switzerland)

Several gas mixtures have been tested in order to reduce the hydrocarbon content for the operation of 1x1 cm^2 streamer tubes for the Aleph hadron calorimeter. It has been found that the use of n-hexane in place of n-pentane allows a safer operation of streamer tubes at reduced fractions of hydrocarbon. The use of non flammable gas mixtures is discussed.

Large hadron calorimeters made with streamer tubes make use of gas mixtures with an hydrocarbon content of ~ 30 % [1]. A reduction in the amount of the flammable component, without affecting the overall features of the detector, is required by safety. In this framework, we have investigated the possibility of reducing the amount of hydrocarbon in the 14/56/30 Ar/CO_2/n-pentane Aleph gas mixture for streamer tubes. This gas mixture turned out to be equivalent to the 30/70 Ar/isobutane standard one [1]. In addition we have investigated gas mixtures with n-hexane, which, due to its more complex structure, should exhibit a quenching capability higher than n-pentane, allowing a further reduction of the hydrocarbon content [2].

Singles counting rate plateaux (cosmic rays and local radioactivity), for different concentrations of n-pentane at different values of Ar/CO_2 ratio, are reported in Fig. 1. This set of gas mixtures permits

*and Istituto di Cosmogeofisica del CNR, Torino (Italy) the operation of streamer tubes at a working point close to that obtained with the standard one. The measurements have been performed with 1x1 cm^2 x 100 cm plastic streamer tubes, 100 μm wire, 10 mV/50Ω threshold, 1 μs shaping width. The non flammable mixture is the one with 7% of n-pentane (a similar limit holds for gas mixtures with n-hexane) [3].

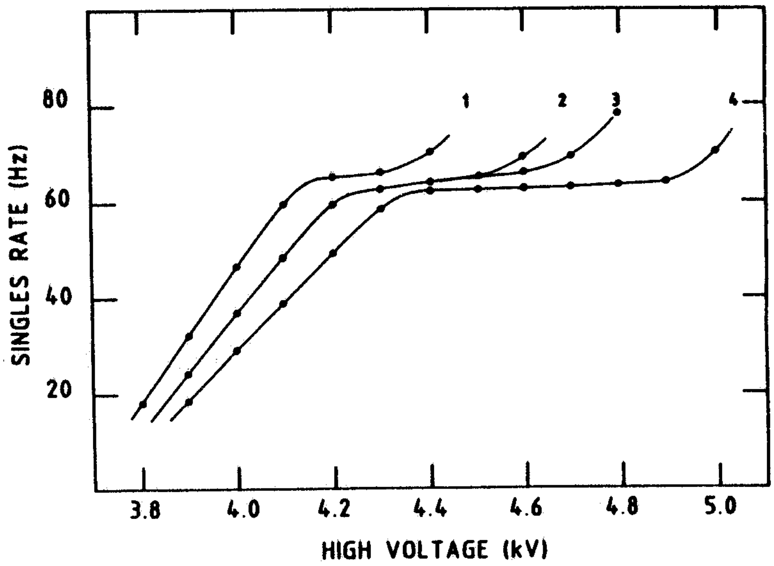


FIG. 1 Singles counting rate plateaux for different concentrations of n-pentane at different values of r=Ar/CO_2 ratio: 1- n-pentane 7%, r=15%; 2- n-pentane 10%, r=15%; 3- n-pentane 15%, r=20%; 4- n-pentane 30%, r=25%.

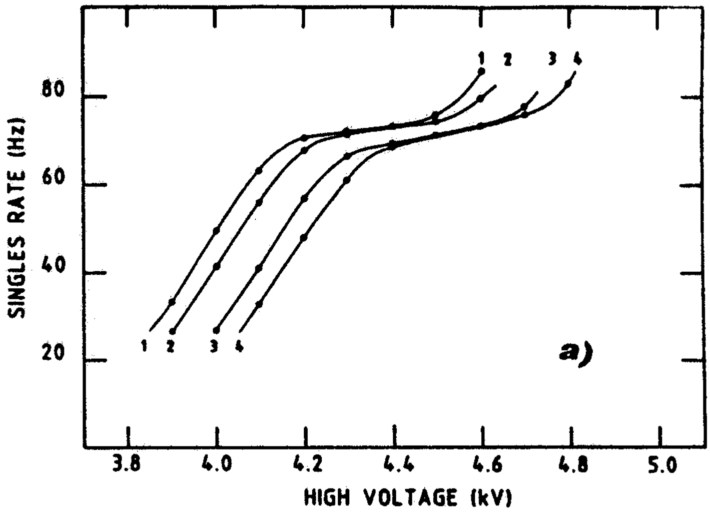
The narrowing of the plateau width shows that the increase of CO_2 does not fully compensate the reduction of the hydrocarbon content. Moreover, an effect of non-flatness of the plateau is induced by the use of large concentrations of CO_2 . This effect, as already discussed in a previous paper [1], is probably due to the generation of very delayed spurious counts, correlated with the neutralization on the cathode of CO_2 ions with subsequent electron emission.

At larger CO_2 concentrations, due to the smaller photoabsorption cross-section, the onset of discharges is observed soon after the full efficiency plateau is reached, together with a large afterpulse production.

Substituting the n-pentane with the n-hexane one obtains the singles counting rate plateaux shown in Fig. 2a for 7% n-hexane concentration and Fig. 2b for 11%. As shown in Fig. 3, where the plateau width (for a ratio of Ar/CO_2 ~ 10-15%) is plotted as a function of both n-hexane and n-pentane concentrations, the plateaux obtained with n-hexane gas mixtures are wider than those with n-pentane.

In Fig. 4 the average number of afterpulses per pulse is shown as a function of the voltage referred to the knee of the plateau both for the Aleph gas mixture and the non flammable n-pentane and n-hexane ones. The evaluation of the afterpulse amount was obtained by difference between the singles counting rate with 100 ns and 1μs shaping widths. As far as the non flammable gas mixtures are concerned, the generation of afterpulses is enhanced when the high voltage is increased and appears to affect to a larger extent the gas mixture with lower content of n-pentane.

This behaviour is confirmed by the charge spectra shown in Fig. 5. These distributions were obtained with nearly orthogonal minimum ionizing particles, at different voltages referred to the knee of the plateau with the previous gas mixtures. In order to evaluate the afterpulse contamination, 1 μs integration gate was used throughout the measurements. The contribution of afterpulses appears as an enhancement in the tail of the charge distributions. The peak charge of the non flammable gas mixtures is a factor of two larger with respect to the Aleph one, suggesting a larger dead zone along the wire. This effect can be seen in Fig. 6a, where the charge spectrum for the 7/82/11 Ar/CO_2/n-hexane gas mixture obtained with uncollimated ß source is presented. The shape of the distribution is somewhat different from the one obtained in similar conditions with the 30/70 Ar/isobutane standard gas mixture (Fig.6b). The occurence of single and multistreamer discharges, according to the angular spread of the ionizing tracks, is responsible for the shape of the histograms shown. In the case of low hydrocarbon content gas mixture the fluctuation of the streamer charge appears smaller. The results of a fit using a superposition of gaussians representing single, double and triple streamers with different weights suggest, in the case of n-hexane, a reduced multistreamer generation.



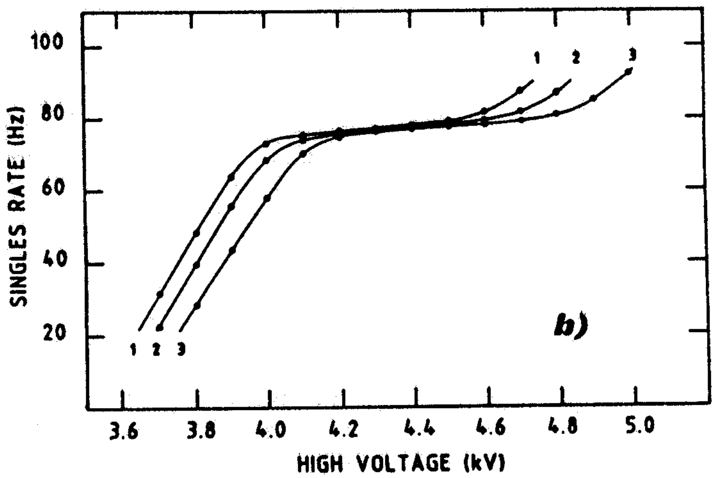


FIG. 2 - Singles counting rate plateaux for: a) 7% n-hexane concentration at different values of r=Ar/CO_2 ratio: 1- r=13.5%; 2- r=10.5%; 3- r=6.5%; 4- r=4%; b) 11% n-hexane concentration at different values of r=Ar/CO_2 ratio: 1- r=17%; 2- r=14%; 3- r=8%.

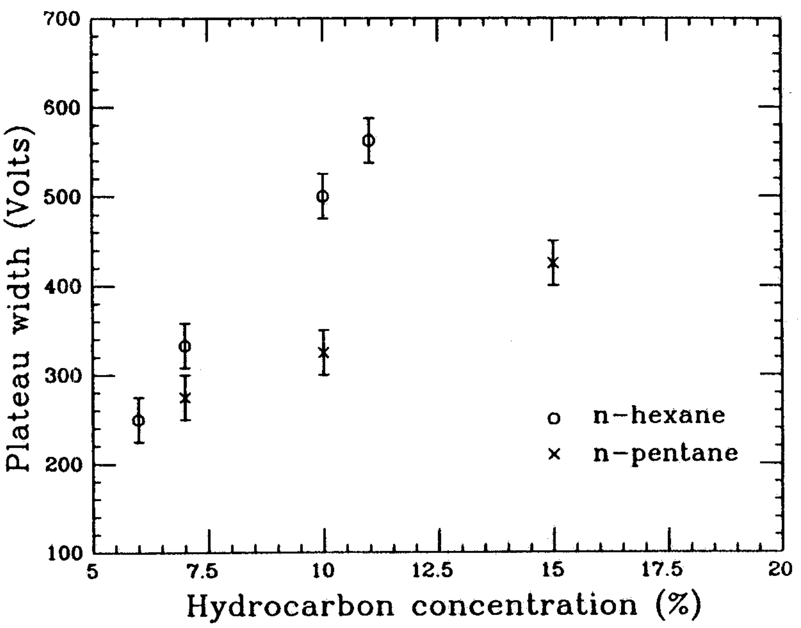


FIG. 3 - Plateau widths as a function of the hydrocarbon concentration for a Ar/CO_2 ratio of about 10-15%.

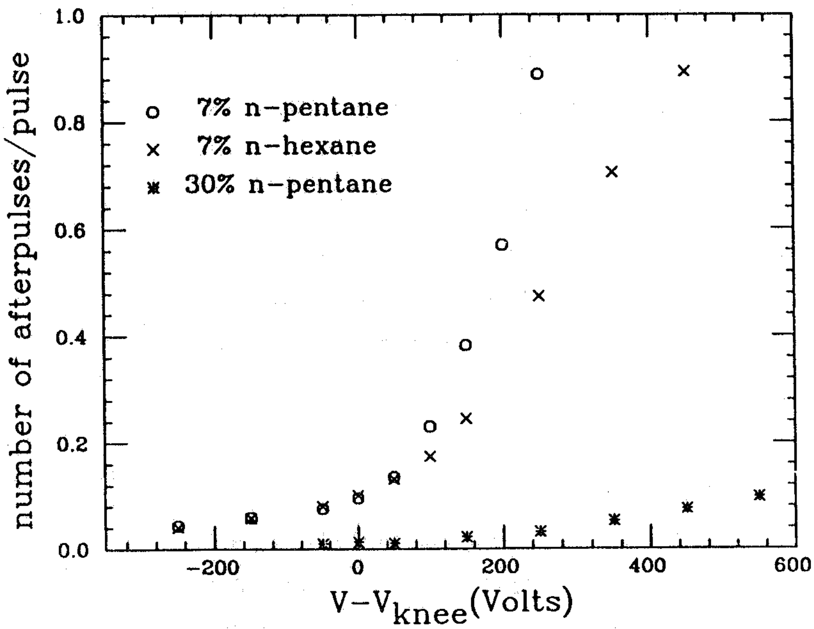


FIG. 4 - Comparison of the average number of afterpulses per pulse as a function of the high voltage between the Aleph gas mixture and the non flammable n-pentane and n-hexane ones.

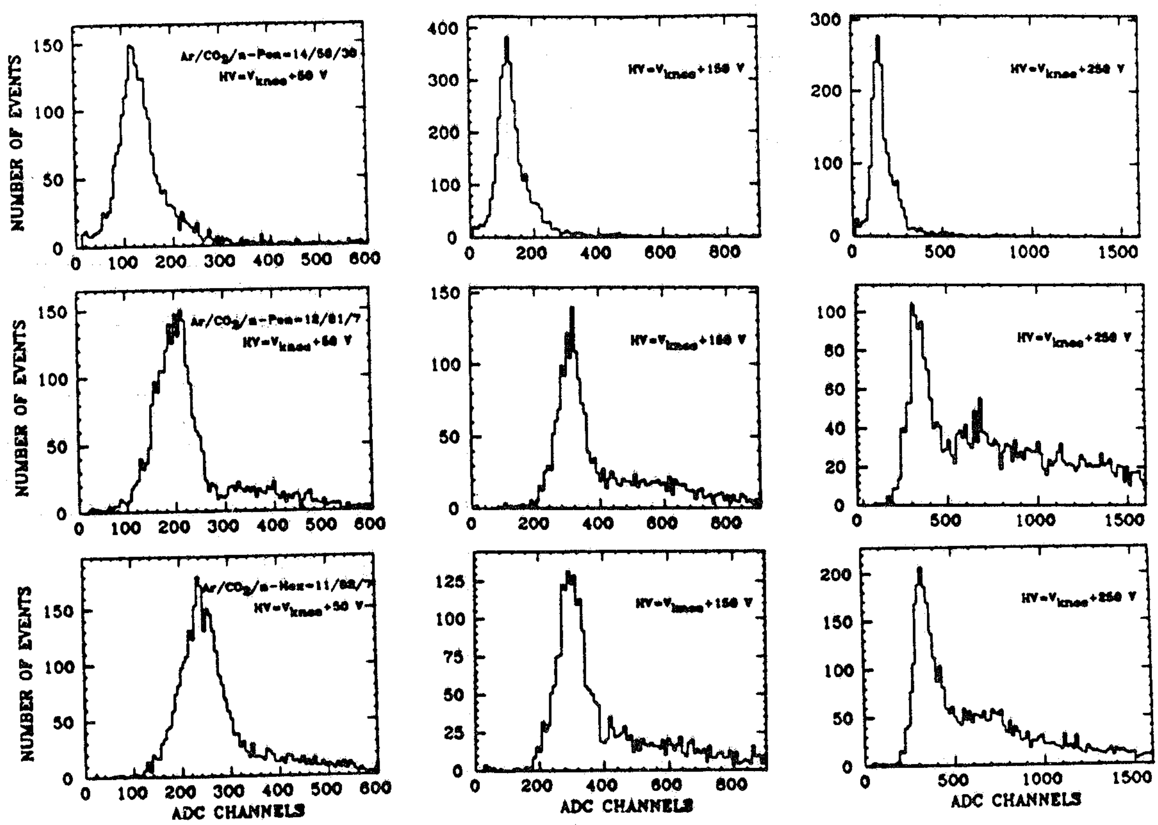


FIG. 5 - Comparison of the single streamer charge distributions between the Aleph gas mixture and the non flammable n-pentane and n-hexane ones.

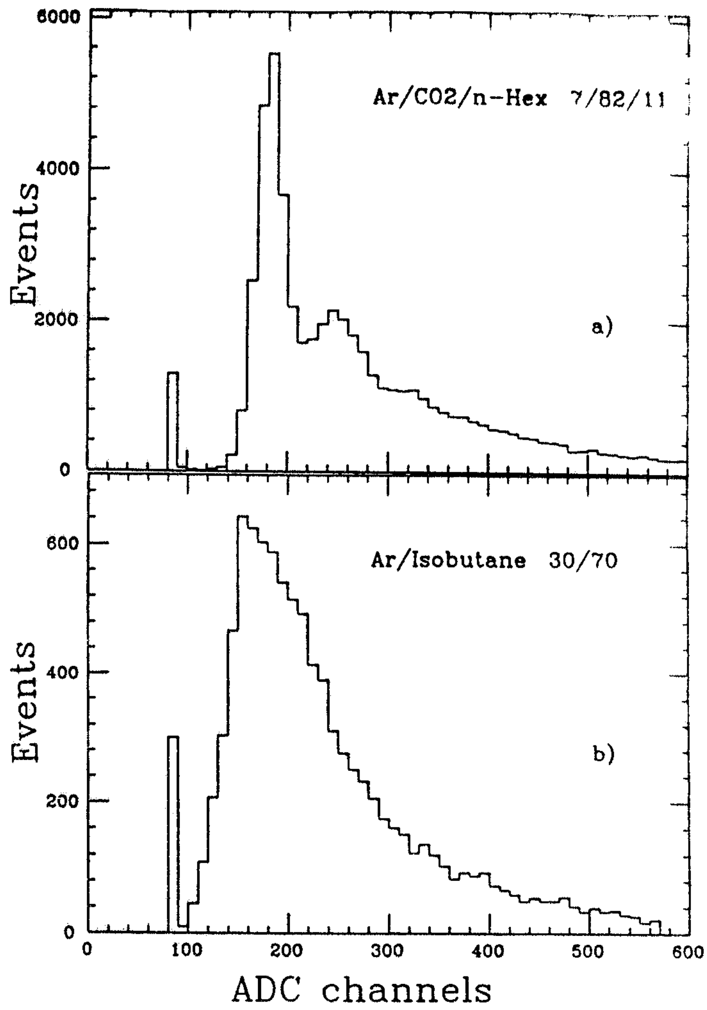


FIG. 6 - Charge spectra obtained with uncollimated ß source for: a) 7/82/11 Ar/CO_2/n-hexane; b) 30/70 Ar/isobutane. The working point is about 50 V above the knee of the efficiency plateau.

The understanding of this feature is of great relevance for the use of these gas mixtures in high energy calorimetry. In fact one of the most important characteristics in sampling calorimeters using streamer tubes is the proportionality between the total number of streamers and the shower track length in the calorimeter. A large dead zone could reduce the detector sensitivity to shower track length with subsequent deterioration of the calorimeter performances. The use of low hydrocarbon content gas mixtures looks promising but further investigations are needed to understand the behaviour of linearity and energy resolution in a calorimeter operated with such gas mixtures.

We are indebted to Prof. E. Iarocci and to Dr. G.Battistoni for many useful discussions. We would like to thank Mrs. M. Anelli, G. Corradi and M. Santoni for their help and assistance during the measurements.

References

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

[2] G. Battistoni et al., The use of n-hexane in the gas mixture for streamer tubes, LNF Report 88/29(P) (1988).

[3] G. Zabetakis, Flammability Characteristics of Combustibile Gases and Vapors, Washington, US Dept. of the Interior, Bureau of Mines, 1965, Bulletin 627.