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ABSTRACT

A comparison of the behaviour of several bakelite Resistive Plate Chambers (RPCs) with and without the linseed oil treatment of the internal electrodes will be presented. Currents and single rate are the quantities most affected by the surface treatment of the electrodes. A factor 4 less in currents and at least a factor 10 less in single rate is achieved using standard oiled RPCs. Efficiency, collected charge and cluster size distributions will be also compared to the ones of a standard oiled RPC.

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1. Introduction

Over the last few years a considerable amount of work has been done in the RPCs field related to the necessity for a good operativity in the LHC environment.

Leading order problems are likely solved: data on high rates capability[1], new type of freons and front-end electronics[2] are now available and they confirm the good behaviour of these detectors.

However the effectiveness of the linseed oil electrodes treatment[3] on the RPC performance has raised some concerns especially as far as the aging properties of such chemical agent in heavy background environment are concerned.

So any good behaviour inducted by the oiling agents on the RPCs has to be faced to the aging properties of the treatment itself.

Our experimental results indicate that the linseed oil layer deposited on the inner surface of the electrodes is necessary to maintain low currents and single rate, the measurement on the aging properties being still under way. The data presented have been collected in a test on cosmic rays.

2. Experimental Setup

The test has been carried out at the CERN T9b area and consisted (see Fig.1) of a telescope made of 5 double 2 mm gap RPC's 4 of which were at the beginning not oiled. Three scintillators defined a 10 x 10 cm^2 trigger area.

The detectors area was 50 x 50 cm^2. The bakelite plates, of resistivity $0.4\,x\,10^{11}\,\Omega\,cm$, were 0.2 cm thick.

The aluminum strips (1.3 cm wide) have been connected at both ends to different electronics for purpose of charge and time measurements. From one side 16 strips signals have been input to independent channels of CAEN C205A Analog Digital Converters (ADC), with a 0.25 pC channel sensitivity.

From the other side of the strips the same signals have been discriminated and brought to LeCroy 2228A Time Digital Converters (TDC) so as to have, event by event, simultaneous information on charge and time behaviour of the detectors.

This scheme permits in addition to double check the efficiency with two independent methods.

The RPCs were filled with an argon/isobutane/freon 13B1 (48/48/4) gas mixture. A standard (oiled) RPC has also been installed and instrumented as a reference detector for the various measurements .

3. Experimental results

In the following figures the non-oiled RPCs will be labelled 1 to 4 unless explicitly stated and "R" will be referred to the standard oiled reference detector when used. For the detectors have been operated in single gap mode the used gaps will be indicated with A and B (i.e. gap 3A means one gap of the RPC 3).

After a month of running RPC 1,3 and 4 were processed with the linseed oil treatment and after a period of conditioning a set of measurements performed to check for any changing in the behaviour with respect to the previous one.

3.1. Currents and Single Rate

Fig. 2a shows the currents of all the gaps as a function of the high voltage: the values correspond to the measured currents on 50 x 50 cm^2 area.

The effect of the surface treatment with the linseed oil on chambers 1,3 and 4 is shown in fig. 2b. The data again refer to the RPCs currents as a function of the high voltage as measured on the whole detectors and so they are directly comparable to those of fig. 2a. The new values are at least a factor 4 less than before. For comparison the corresponding values for the reference gap R are also shown.

Single rate has been measured counting the ORed signals coming from 8 strips of each gap; fig.3a shows the single rate as a function of the high voltage for all the non oiled gaps; the values have been scaled to a square meter area and have been collected with a discriminating threshold of $-80\,mV$. Gaps 4A and 1B have a significant better behaviour.

The fig. 3b refers instead the scaled OR rate of gaps 1,3 and 4 after the treatment with the linseed oil. Also in this case the reference gap behaviour is reported on. The oiled gaps currents are at least an order of magnitude less than in the previous case of fig. 3a.

It should be pointed out that in fig. 3b the discriminating threshold was $-50\,mV$ instead of $-80\,mV$ as in fig. 3a so one should expect a bigger scale factor at the same threshold.

There is also a sensible local rate effect for the electrodes that were not oiled. Fig. 4a displays the strip rate distribution for each of these gaps at an applied voltage of $9\,kV$ and a discriminating threshold of $-80\,mV$:

The same local rate has changed significantly as shown in fig. 4b when the new oiled RPCs (1.3 and 4) single rate were plotted strip by strip in the same manner of fig. 4a. As in that case the voltage is the same ($9\,kV$) but now the threshold is $-50\,mV$ instead of $-80\,mV$.

The new oiled RPCs local behaviour is more homogeneous and better than in the previous case. The peaks are probably due to the presence of a spacer and one strip of chamber 4 was disconnected.

3.2. Efficiency

Efficiency has been calculated via the ADCs information by requiring a signal to be present after a certain threshold in the charge distribution (after pedestal subtraction). A threshold of a $50\,mV$ signal equivalent has been applied by assuming a triangular signal $20\,ns$ wide at its base.

With this approach we probably overestimate the efficiency at low voltage but the plateaux values are comparable with those obtained with other methods (via TDCs and scalers).

Fig.5a.5b.5c.5d and 5e show respectively the efficiency of the gaps 1A-B. 2A-B. 3A-B, 4A-B for the non oiled case. and RA-B for the reference oiled gaps. The absence of the surface agent on the internal electrodes seems to not influence the efficiency of the RPCs. In some cases however (see RPCs 1 and 4) the knee of the plateau is shifted $500\,V$ higher with respect to the reference gaps.

3.3. Charge distributions

The charge distributions have been obtained by integrating for $250\,ns$ any analogic signal inducted on 14 strips in coincidence with a trigger event.

For each channel the pedestals have been subtracted from the charge distribution and the rest of the distribution then summed over to obtain the total charge distribution collected over an area subtended by 14 strips.

The results are here presented as integral distributions into so called greater-than-charge histograms. For each charge value on the abscissa axis the corresponding ordinate value represents the percentage of events with charge above that value.

Fig.6 shows these distributions for the non-oiled gaps 1A, 2B, 4A and for the reference gap RA at an applied voltage of 8.5 KV.

3.4. Cluster size

Cluster size has been calculated via the TDC information: each discriminated strip signal arriving within 200 ns from the trigger leading edge contributed to the cluster size distribution.

As for the efficiency and collected charge also the cluster size seems not to be significantly influenced by the absence of the linseed oil.

Fig. 7 shows the distributions for the non oiled chambers 1A, 3A, 4A and for the reference gap RA at an operating voltage of 8.5 KV.

The long tails of these distributions have been checked to be due to the presence of cosmic rays showers which could not be excluded by our simple trigger logic.

4. Conclusions

Surface treatment of the internal bakelite electrodes is a necessary step to reduce the noise and the dark current of RPC's. The overall result seems infact to be the smoothness of the surface itself. However the absence of the oiling agent does not sensitively influence other parameters such as efficiency, cluster size and charge distributions.

It is probably true however that the effect of the linseed oil (that is the smoothness of the surface) could be directly obtained inside the industrial process in the bakelite foils production.

Another open question concerns the natural as well as the induced aging of the linseed oil; several measurements on this aspect are scheduled at the Triga Mark III Nuclear Reactor in Pavia and performed by a Bari-Roma-Pavia collaboration.

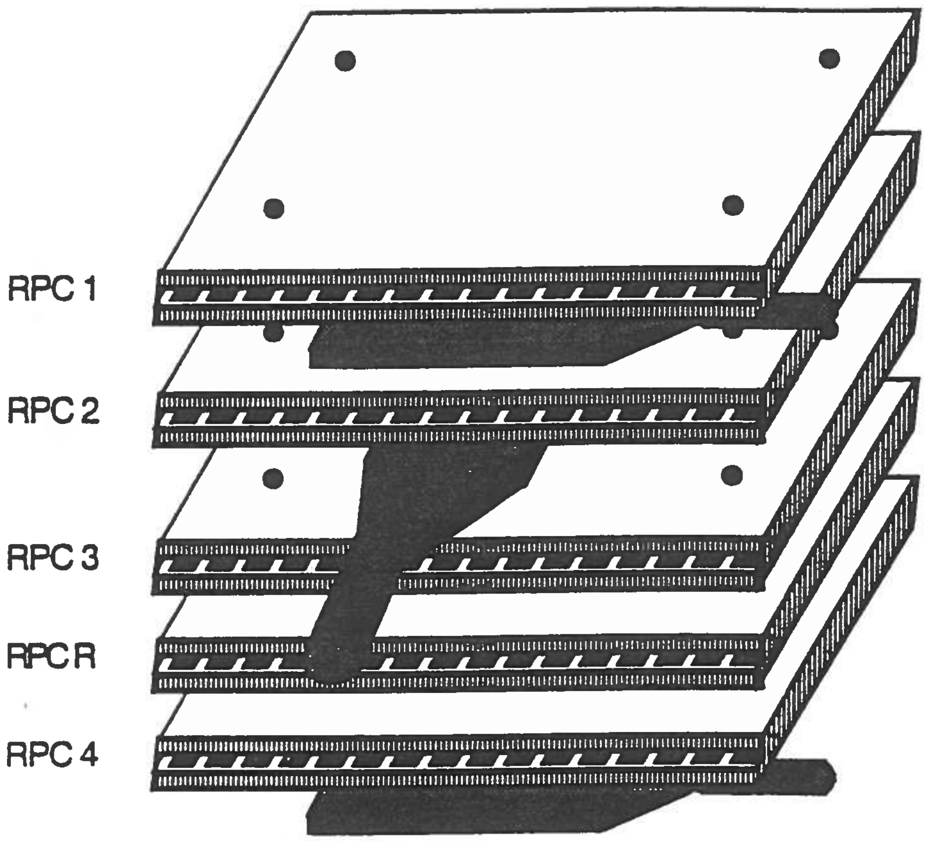

Figure 1: Scketch of the experimental setup: a telescope made of five double gap RPCs were triggered by a threefold scintillators coincidence. TDC's and ADC's electronics (not shown) have been connected as explained in the text.

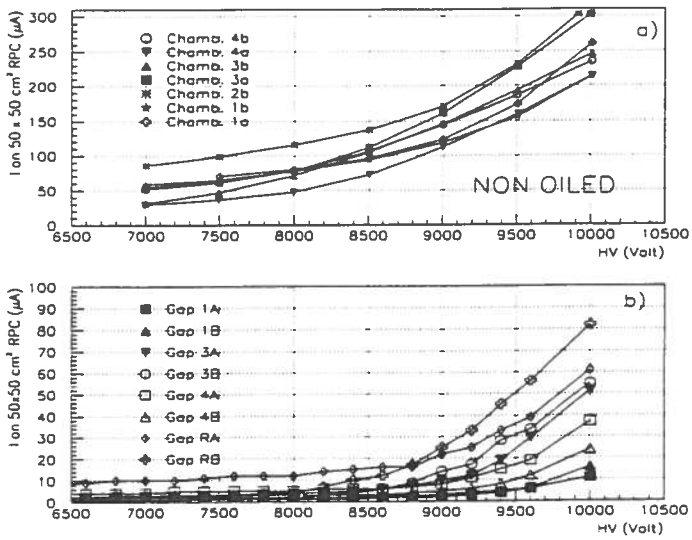

Figure 2: Measured currents vs high voltage; a) Non oiled gaps; the discriminating threshold was $-80\,mV$. b) Oiled gaps; the discriminating threshold was $-50\,mV$. The chamber R is shown as reference.

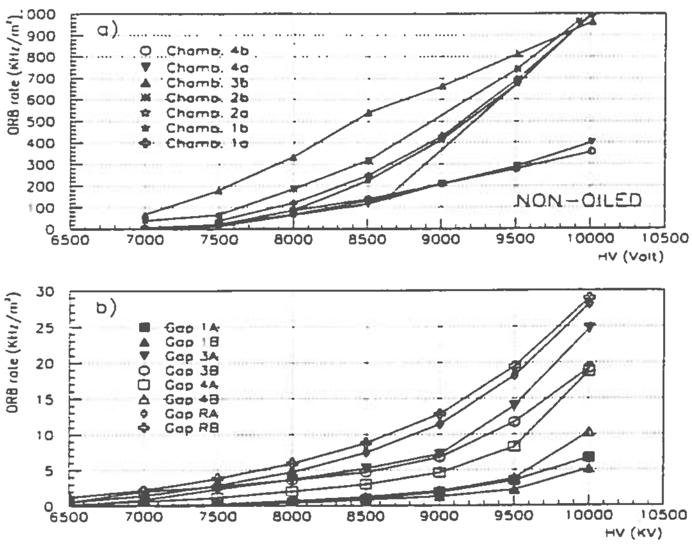

Figure 3: Single rate (as explained in the text) vs high voltage at a fixed discriminating threshold: a) Non oiled gaps; threshold $-80\,mV$. b) Oiled gaps; threshold $-50\,mV$. The chamber R is shown as reference.

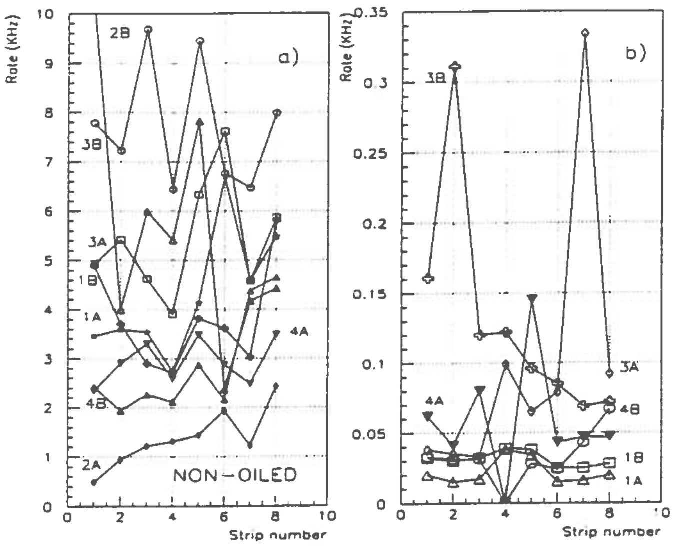

Figure 4: a) Comparison of the strip rate distribution for the non oiled gaps at an applied voltage of $9\,kV$ and for a discriminating threshold of $-80\,mV$; b) Strip rate distribution for the oiled gaps 1,3 and 4 at an applied voltage of $9\,kV$ and for a discriminating threshold of $-50\,mV$.

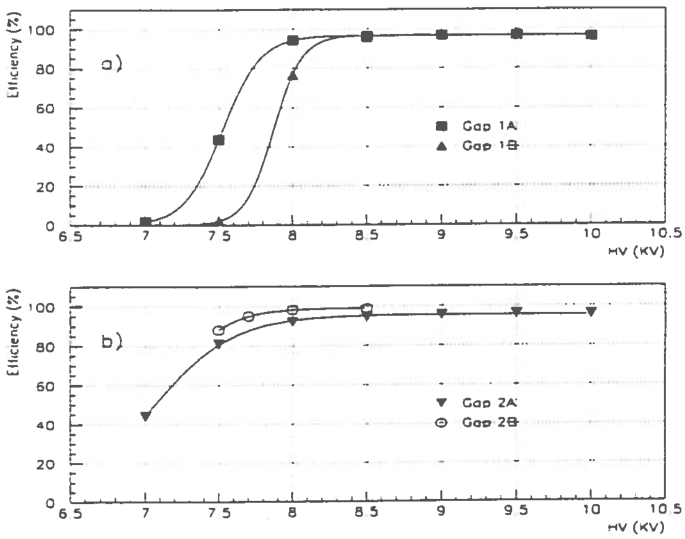

Figure 5: Efficiency curve as a function of the applied voltage for the non oiled gaps (simulated threshold as explained in the text: $-50\,mV$): a) Chamber 1; b) Chamber 2

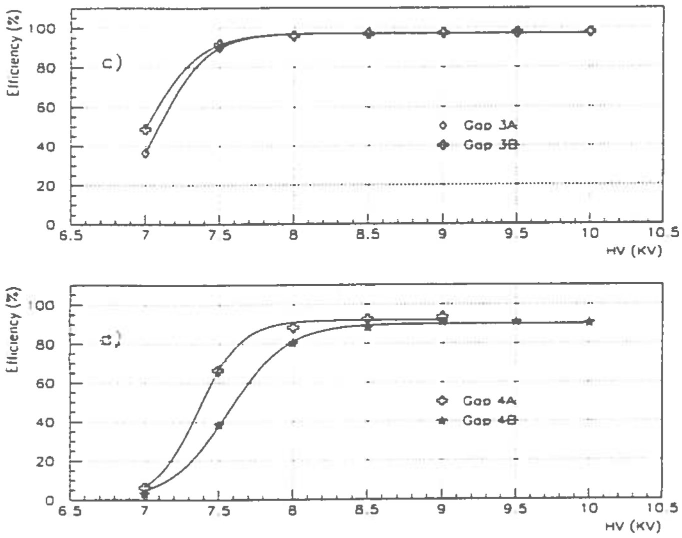

Figure 5: Efficiency curve as a function of the applied voltage for the non oiled gaps (simulated threshold as explained in the text: $-50\,mV$): c) Chamber 3; d) Chamber 4.

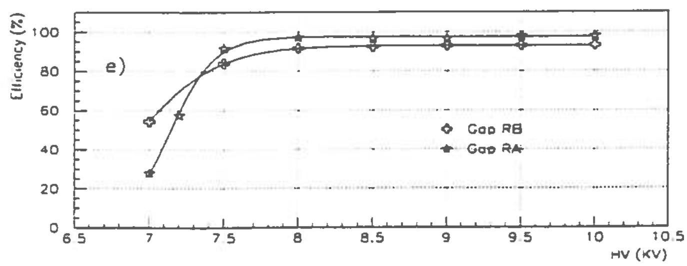

Figure 5: e) Efficiency curve as a function of the applied voltage for the reference chamber R (simulated threshold as explained in the text: $-50\,mV$).

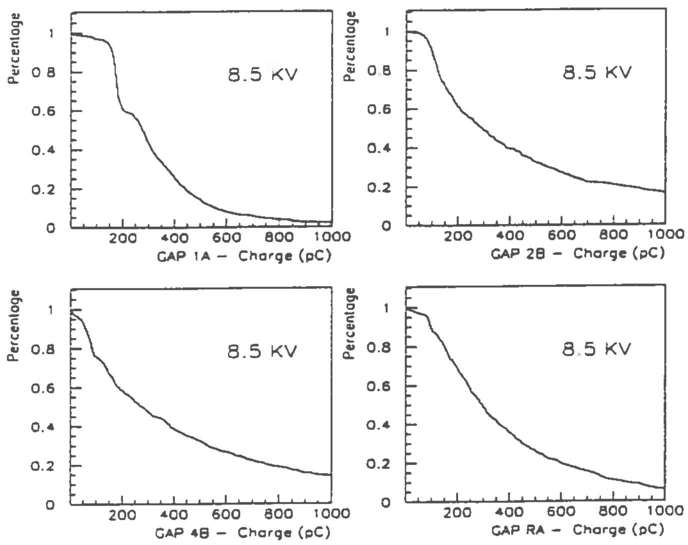

Figure 6: Greater-than-charge distributions. Histograms for gaps 1A, 2B, 4B refer to the non oiled case. For each value on the abscissa the corresponding ordinate represents the percentage of events for which the measured charge was greater than that value.

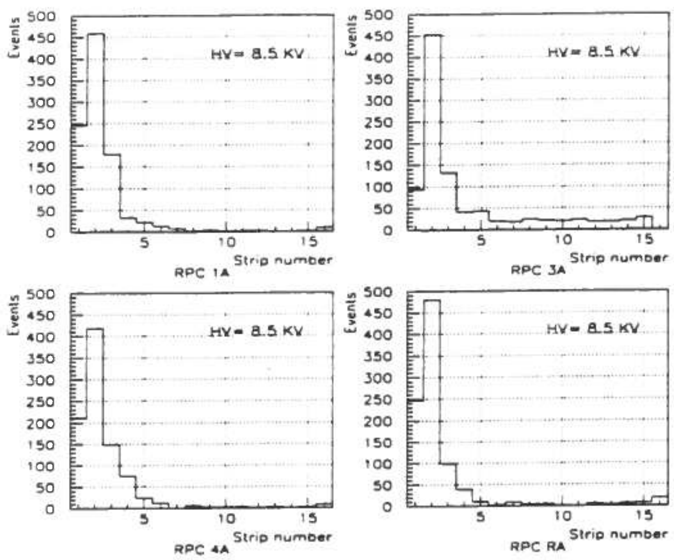

Figure 7: Cluster size distributions. Histograms for gaps 1A, 3A, 4A refer to the non oiled detectors while the histogram for gap RA correspond to the reference chamber.

5. References

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