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G.D.Alekseev, S.Cellar, B.A.Khomenko,
A.V.Korytov, P.A.Kulinich, G.V.Micelmacher,
Yu.V.Sedykh, R.Toledo

# HIGH VOLTAGE TESTS AND TRAINING OF PLASTIC STREAMER TUBES FOR THE DELPHI HADRON CALORIMETER

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At the current time, plastic streamer tubes for the DELPHI hadron calorimeter are being produced in the "DELPHI production area" in JINR. A procedure for mass testing of tubes with a productivity not less than that in the assembling section, i.e. not less than 120 detectors per day, was proposed in Ref. /1/. After approval of this procedure by the hadron calorimeter group it was realised in practice. It includes three stages: high voltage test and training, X-ray test (irradiating the detector surface, one checks its capability of operating under a large radiative load $100\ cm^{-2}s^{-1}$ and the signal homogeneity) and wire tension test in ready detectors. This paper presents results obtained at the stage of high voltage tests and training, other results will be described later.

For this moment all detectors for the barrel of the hadron calorimeter, i.e. about 10.5 thousand plastic streamer tubes (Fig. 1) 3.6 m long, had been made and tested. At the stage of high voltage tests, faulty tubes were rejected and the behaviour of such characteristics as mean dark current through tubes and maximal operational voltage was studied.

The work at the stage of high voltage testing is organised by the following way. The whole cycle for one group of tubes (120 or 180 detectors) takes 2 days. A group of tubes received from the assembling section is connected to the gas system and is pumped out (the limit pressure of 0.1-0.2 atm depends on the quality of tube connection to the gas system). Then tubes are quickly filled up (~ 300 liters per hour; the total volume of 120 tubes is about 280 liters) with the working gas mixture (Ar : $CO_2$ : $C_5H_{12}$ = 1 : 2 : 1). Fig. 2 demonstrates the dynamics of the filling of a group of detectors. All tubes are blown through parallelly. After the first filling there are no more than 30-50% of air in tubes. Tubes are fast blown through for 2 hours more. Then detectors are connected to the gas output of tubes under high voltage training and flow becames slow (about 30 liters per hour). During the first day tubes are blown through without high voltage. A whole gas exchange rate is about 5 volumes of a group by the end of first day. Next day, being under the same slow flow, the detectors are connected to the high-voltage system. During the second day a total gas exchange reaches a value of 7 volumes.

The equipment for high voltage training consists of a mini-computer, CAMAC electronics, a controllable high voltage source and a digital ampermeter (Fig. 3) . All streamer tubes are connected to the output of the high voltage source through 10 M resistors to confine currents. Positive high voltage is applied to wires, currents of detectors to be measured is taken from cathodes. The computer connects tubes one by one to the digital amper-meter through analog multiplexer, read a measured value of current, writes information either in the RAM or on a floppy disc and analyse the received data. For convenience the monitoring information is displayed on the colour monitor. Each tube is represented by a small square with a number; the square colour reflects a level of the current measured. There is also other information to help an operator to decide



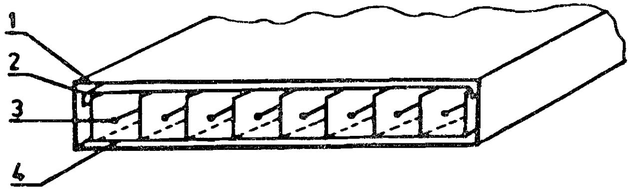


Fig. 1. Schematic view of a plastic streamer tube of the DELPHI hadron calorimeter.
1 - container
2 - cover
3 - anode wire 80 μm in diameter
4 - profile

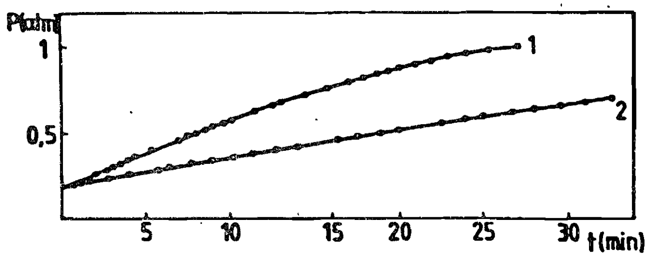


Fig. 2. Dynamics of filling a group of 120 tubes:
1 - fast flow + air leak-in
2 - air leak-in

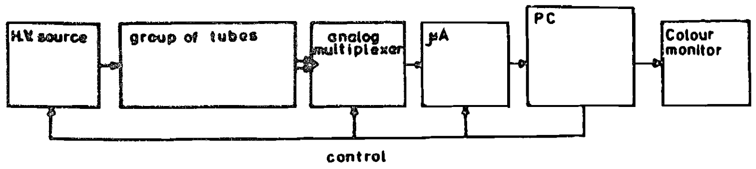


Fig. 3. Schematic diagram of the training procedure.

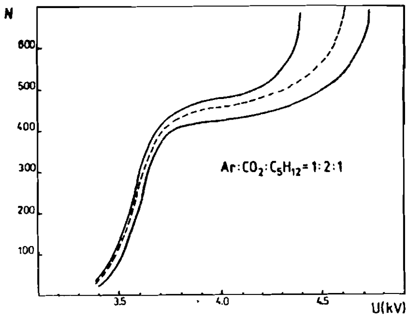


Fig. 4. Typical counting curve (dotted line) and bounds of counting curves for 30 tubes (solid lines). Cosmocs. Level 15 mV/50 Ohm. Dead time of shaper 450 ns.

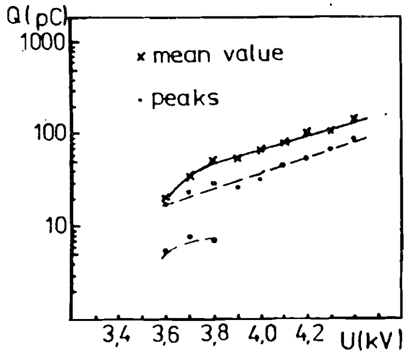


Fig. 5. Charge characteristics (time of current integration is 200 ns). Cosmics.
x – mean value of charge
• – peaks of limited-proportional and streamer discharges.

whether to switch off any tube or to continue training, to increase high voltage or not, etc. Three speeds may be used for current scanning and current measurement from an individual tube changes as 0.01 s, 0.1 s and 1 s.

In Fig. 4,5 one can see typical characteristics of plastic streamer tubes obtained with cosmic. A signal is



taken from eight anode wires connected together. It is seen that the plateau of the counting curve begins at U ≃ 3.75 kV.

After trying several ways of training, the following one was chosen. Tubes stay under high voltage for one day (20-24 hours). After first day of gas flowing tubes are connected to the high voltage system and during 1-3 hours the voltage is increased to the working range (3.7-3.8 kV). Obviously bad tubes with abrupt increase of currents are switched off (usually these tubes turn out to be spoilt at assembling).

During next 10 hours, voltage is increased to 4.3-4.4 kV (that is 500-600 V higher than the working point). Every 15 minutes high voltage is abruptly decreased (for several seconds) to the value of 1 kV and then is restored to the initial value. Thus selfsustaining discharges, if any, are quenched. If a large current is measured (more than 4 μA) the frequency of such flops is automatically increased. The high voltage control can be performed by the computer or by an operator. High voltage of 4.3-4.4 kV is held during about 10 hours. At the end of the training procedure high voltage is decreased to 4.0 kV (that is 200-300 V higher than the working point) and final rejecting of bad tubes takes place. If detector current at 4.3 kV is less than 2 μA and at 4.0 kV is less than 0.5 μA, the detector is regarded as a good one and is permitted to go to the next stage (X-rays test).

Fig. 6 demonstrates that for any fixed voltage value one observes a monotonous decrease of the mean dark current through the tubes. Here large currents over 4 μA (leaps or continuous currents) observed in some tubes in the process of training are not taken into account because their behaviour is not typical. A half-life of a mean current

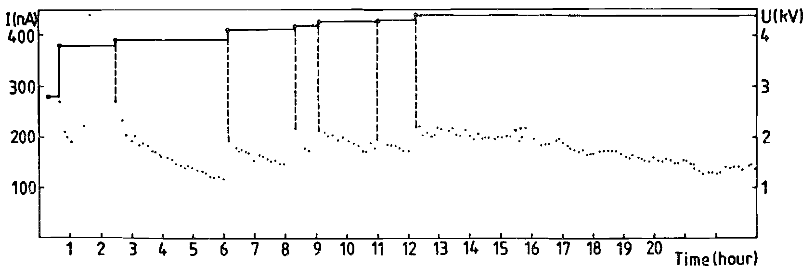


Fig. 6. Mean value of dark current through tubes (120 )
and high voltage vs training time.

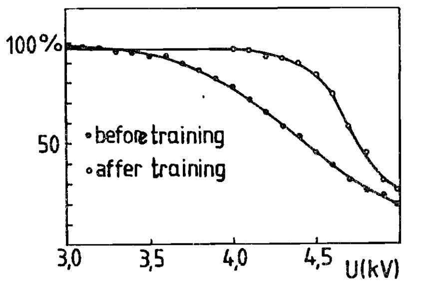


Fig. 7. Test at maximum voltage before and after training for 600 tubes.

is about 1-2 hours at the beginning of training and about 10 hours at its end. It should be emphasized that the value of current about 0.1 $\mu$A through a tube is almost completely due to leak currents rather than to streamer discharges from cosmics (about 0.01 $\mu$A ~ 100 particles per s x 100 pC in a streamer).

It is important to know quantitative characteristics of improvement of detectors due to the training. Fig. 7 shows the results of tests at maximum high voltage for 600 tubes before and after training. The maximum voltage was defined by the value at which the current through a tube exceeds 1 $\mu$A. It is seen that after training tubes become more stable.



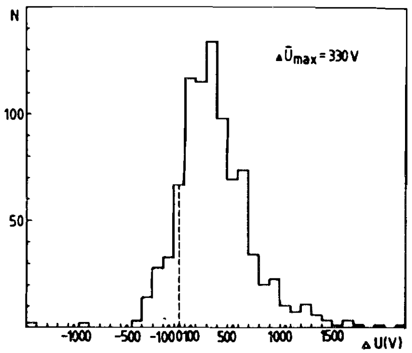


Fig. 8. Distribution of shifts of maximum voltage due to training. Statistics is 880 tubes.

It is important that the effect is mainly due to high voltage training rather than to a simple increase of gas exchange (the whole gas exchange varies from 5 to 7 volumes of a detector group during training). Additional 6 volumes of gas flow after training did not change curves as those in Fig. 7. An increase of gas exchange before training from 5 to 7 volumes also did not practically change these curves.

It is interesting that there are some detectors capable of operating at quite high voltages (~5 kV). This reveals potentialities of detectors of this kind. Remember that DELPHI streamer tubes have a polished graphite cathode with resistivity 50-2000 kOhm/□ /2/. Fig. 8 illustrates the high voltage training effect by another way. It is a distribution of shifts of maximum voltages due to the training. It is clear that an average increase of operating voltage range is about 300 V for our way of training.

Processes that occur in detectors under training are not clear. But experience shows that any wire detector under gas flow and at high voltage improves its characteristics (for instance, levels of dark currents or noise impulses usually fall down). But this occurs in a peculiar way for each detector. So the above improvement of tubes in process of training is related to tubes of given construction.

After testing about 10.5 thousand plastic streamer tubes for the DELPHI hadron calorimeter 3% detectors were rejected (2% are due to assembling reasons and 1% is due to discharges which are probably related to cathode properties).

The distinct effect of high voltage training is observed, it may be expressed as a monotonous decrease of dark current during training and an increase of ranges of operational voltages by more than 300 V (on the average).

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Алексеев Г.Д. и др. E13-87-399

Высоковольтные испытания
и тренировка стримерных трубок
адронного калориметра ДЕЛФИ

Приведены результаты высоковольтных испытаний и тренировки пластиковых стримерных трубок адронного калориметра ДЕЛФИ, полученные на участке контрольных испытаний в ОИЯИ. Наблюдается отчетливый эффект высоковольтной тренировки, который количественно выражается в увеличении области напряжений (плато) более, чем на 300 В.

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High Voltage Tests and Training of Plastic Streamer
Tubes for the DELPHI Hadron Calorimeter

The results of high voltage tests and training of plastic streamer tubes of the DELPHI hadron calorimeter, obtained at the section of mass control tests in JINR, are presented. A distinct affect of high voltage training is observed: a region of operational high voltage increases by a value more than 300 V.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

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