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THE STREAMER CHAMBER IN A QUARK EXPERIMENT AT THE CERN PROTRON SYNCHROTRON

by

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In a quark experiment at the C. P. S. /1/, an isotropic spark chamber has been used, together with other detectors, for the identification of such particles.

Experimental arrangement (fig. 1)

A chamber of 10x10x11 cm^3 was fed by a pulse of 250 kV peak amplitude of a width at half height of 5 nsec (fig. 2). It could be applied $\approx$ 350 nsec after the passage of the triggering particle. The chamber gas was 1 atm. of Henogal (70 o/o Ne ; 30 o/o He). The attachment time after 8 hours of operations was $>$ 10 μsec. After 8 hours of operation the attachment time was checked and the chamber gas renewed. The projection of the track perpendicular to the electric field was registered on a film and the corresponding applied H. T. pulse was also recorded. It was necessary to amplify the weak light output of the avalanches by means of an image intensifier ref. /2/. A typical track of a minimum ionising particle can be seen from fig. 3.

Ionization measurement

Working with an avalanche amplification sufficiently small ($\approx 10^8$) one is able to measure the primary ionization of a particle ref. /3/. Due to the finite size of a streak on the film, which represents a primary electron, it is impossible to distinguish all of them. Nevertheless, it is possible to determine the ionization by using the following formula :

$$N = \frac{n}{\ell - n\Delta}$$

N ≡ ionizations/unit length

n ≡ number of observed avalanches, taken into account

Δ ≡ interval, following a counted avalanche, in which for counting purposes all avalanches are ignored

ℓ ≡ track length

The distribution function is given by :

$$P(N,n) = \frac{e^{-(\ell - n\Delta)N} \left\{(\ell - n\Delta)N\right\}^{n}}{n\,!} + \frac{N}{(n-1)!}$$

$$\int_{\ell-\Delta}^{\ell} e^{-(x-(n-1)\Delta)N} \left\{(x-(n-1)\Delta)N\right\}^{n-1} dx$$

In fig. 4., are shown such distributions for charges $\frac{1}{3}$, $\frac{2}{3}$ and 1, based on the experimental value of $N=9.5/\text{cm}$ for charge one minimum ionising particles. Charges $\frac{1}{3}$ and 1 are completely separated.

Care has to be taken to eliminate error sources which might simulate a reduced ionization, i.e. :

1. Voltage pulses which have too small an amplitude or length.
2. Electrons which are lost by attachment onto electro-negative gases or onto the chamber walls.

Results

In the $q = -\frac{1}{3}$ run about 3400 photos have been taken. About 75 o/o of the pictures have shown a track. Because no considerable deviation of the electric pulse from the standard one, could be seen on any photo it could be concluded that 25 o/o of the triggers have been caused by cascade events, where no particle has passed through the chamber.

Samples of ionization measurements of two runs, 3 weeks apart from each other, can be seen in fig. 5.

The average ionization N for a single track is : 9.40 ± 1.41/cm and 9.64 ± 1.25/cm respectively. The discrepancy of 2.5 o/o between the two samples may be explained by a systematic error caused by the chamber gas density (temperature, pressure).

From the figure of about 9.5/cm for a charge one minimum ionizing particle, it follows that the probability for the production of only 10 primary electrons from a $q = -1$ particle is $\approx 10^{-23}$. Not one such event has been registered.

There remains only one event to discuss, whose ionization is far outside the statistical limits. It contains 18 counted primary electrons. The probability that a $q = -1$ particle is responsible for this track is $\approx 10^{-12}$, $\approx 10^{-3}$ for a $q = -\frac{1}{3}$ particle, and $\approx 6 \cdot 10^{-3}$ for a $q = -\frac{2}{3}$ particle.

No indication has been given by the pulse height counter telescope, that a fractionally charged particle was responsible for this track. An acceptable explanation is given by assuming that a particle has passed through the chamber at a distance of about 0.2 mm and an inclination between $\pm$ 1 mrad with respect to the wall. An estimate, drawn from the measured beam distribution and its divergence leads to a reasonable probability for such a track. A stereo view would be recommendable for a unique exclusion of such events.

References

1. J. Allaby et al., to be published in Nuovo Cimento "A search for fractionally charged particles at the CERN Proton Synchrotron.

2. E. Gygi, F. Schneider, CERN 66-14 "Isotopic spark chamber development in the AR Division".

3. F. Schneider, ISR-GS/69-2 "Precision of spark chamber track parameters".

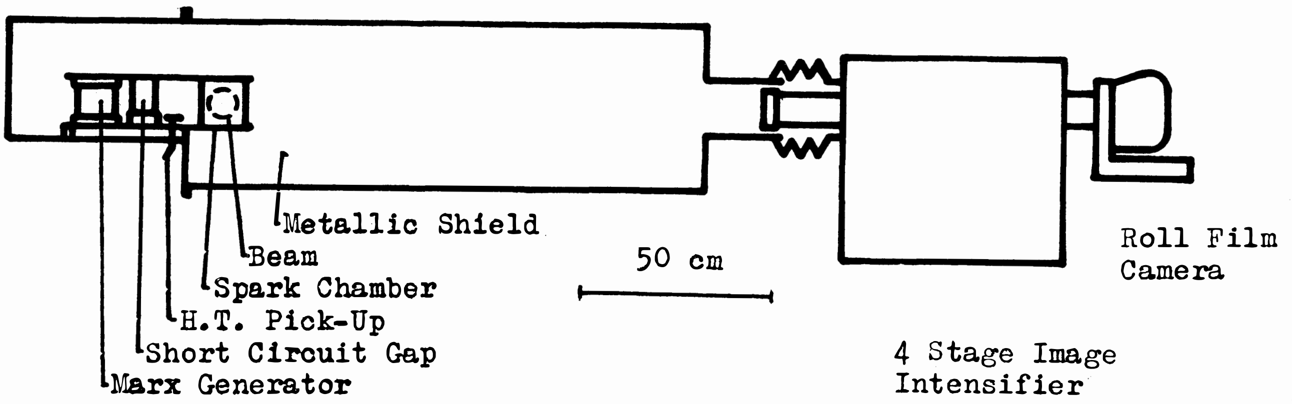

fig. 1 SKETCH OF THE APPARATUS

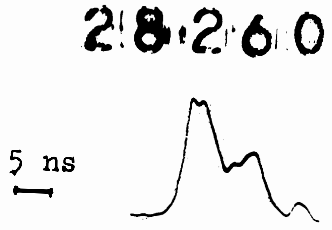

fig. 2 H.T. Pulse

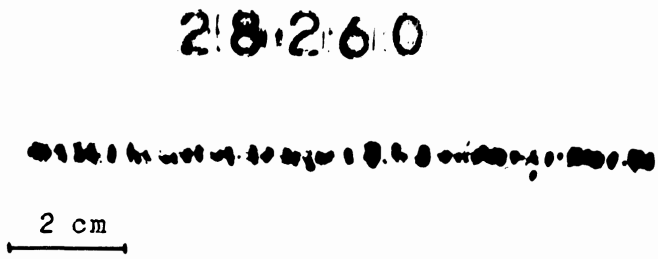

fig. 3 Typical Track

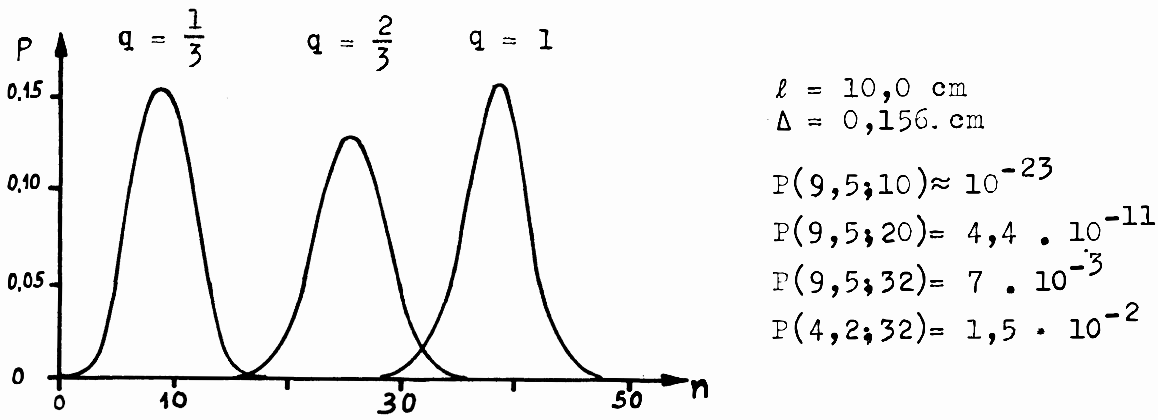

fig. 4 Distribution functions

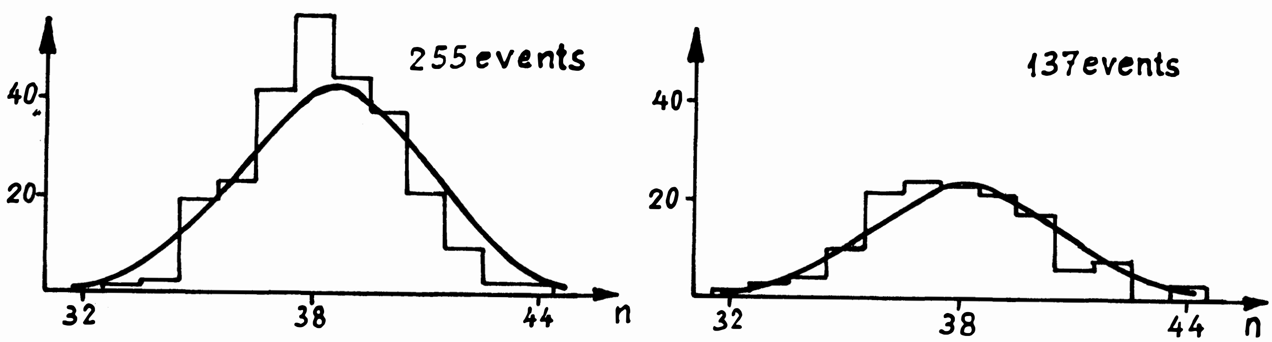

fig. 5 Measured distributions