IONISATION CHAMBER - NEUTRINO EVENT CORRELATION STUDY

This study was made to see if there is any justification for believing that a high rate indicated by the ionisation chamber is associated with a high rate of production of neutrino events.

1. Differential rates

The figures for the spark chamber were obtained by calculating the number of events during each "measurement" of about 8 hours, which had a visible apex respectively in the production region, magnet and 1st range region, and the 2nd range region. These were added to arrive at a total number of \( \nu \) events for each measurement. All events of dubious origin are excluded during the scanning, and a small number of true neutrino events which originated between the chambers are excluded from the total. Running time and integral of the ionisation chamber output were recorded for each "sub-measurement". They were summed to arrive at the total running time of the measurement and total integral output of the ionisation chamber. The integral was then divided by the running time to find the mean rate of the ionisation chamber output. The total number of neutrino events was divided by the running time to find the mean rate of neutrino events. The neutrino rate was then plotted against the ionisation chamber rate, (graph I). It is reasonable to accept that the neutrino events are a consequence of the presence of the ejected beam, as is also the output of the ionisation chamber. So whatever the law that relates these quantities, it should pass through the origin. (No ejected beam \( \rightarrow \) no neutrinos) Then a simple calculation of the mean \( \nu \) rate \( \rightarrow \) no \( \int I.C. \) \( \) and mean \( \int I.C. / \) sec for the whole run gives us a point which, with the origin, defines a simple straight line law. The horizontal line on the graph represents \( \pm 1 \) o/o accuracy of the ionisation chamber. As it stands, nine of the 21 scatter lines intercept the line representing the law. If each line were broadened to a rectangle to include the effect of errors on the horizontal axis, three more rectangles would intercept the law, making PS/4372
law we should expect a proportion \((1 - \frac{1}{e})\), or \(13\), intercepts. So we may say that there is a high probability of the plot representing random scatter about a linear law, with the possibility of a small systematic error. A "functional relationship" between the neutrino event rate and the ionisation chamber output can therefore be said to exist.

The bubble chamber correlation was made in a similar way. An interval of 10'000 photographs was decided upon to give both a reasonable number of points on the graph, and a reasonable number of events per point. Working from the scanning log book, all events due to \(\bar{\nu}, \nu\), or \(A_2\) type event were counted. From the data recorded by the spark chamber group a mean \(\int \text{IC/sec}\) rate was calculated for the period of time over which each 10'000 pictures were taken. The two rates, No of \(\nu\) events/10'000 pictures, mean \(\int \text{IC/sec}\) over period, were then plotted, (Graph II). Once again, assuming a linear law through the origin and the mean point, a line was drawn. Above and below this line, lines representing a limit of \(\pm \frac{1}{\sqrt{n}}\) \(\nu\) events were drawn. All points except one lie within or just outside the \(\pm \sqrt{n}\) limit. The odd point is derived from the events on only 4000 photographs at the end of the run, and the rate afterwards normalised to that for 10'000 pictures by multiplying by \(x 2.5\). So the error on this point is greater than for the others, and for this reason it was not included in the calculation of the mean point and the law.

This graph will be necessarily less accurate than that for the spark chamber for two reasons:

a) The number of events per sample is smaller, therefore the proportional random error is higher;

b) The recording of the ionisation chamber is not continuous, but only made over periods when a "sub-measurement" is in progress at the spark chamber. Therefore an average \(\int \text{IC rate}\) had to be deduced from that measured during the sub-measurements which nearest coincided with the period of 10'000 pictures. This takes no account of what may have happened to \(\int \text{IC}\) during moments when the spark chamber was not running.
2. Integral rates

The total number of neutrino events found in the spark chamber and the associated integral of the ionisation chamber output were then plotted at each stage of the run, (Graph III). The gradient of this line is then a efficiency of the spark chamber as a detector, assuming that the efficiency of the ionisation chamber is constant.

A similar plot was made for the bubble chamber. For this however the integral ion chamber result for each point had to be normalised. This is because it was taken from the spark chamber records, and these were recorded only for each "sub-measurement". So the total ionisation chamber reading over the sub-measurements which corresponded most nearly in time with the period of 10'000 pictures was taken, and this was then corrected to allow for the running time of the sub-measurements being different from 60'000 secs, (the ideal time for taking 10'000 pictures).

3. Conclusions

Graph I shows that the neutrino event rate and the ion chamber output vary together in fair agreement with a linear relationship.

If this linear relationship is imposed on graph II of the bubble chamber events, then these points lie for the most part within \( \pm \sqrt{\frac{2}{n}} \) of the expectation value. This scatter agrees with the random nature of neutrino events.

If the efficiency of the ion chamber as a detector of the muon flux is assumed to be constant, then graph III shows that the efficiency of the spark chamber as a detector of the neutrino flux remained constant throughout the run. Graph IV supports the same conclusion with regard to the bubble chamber; with the possible exception of the first 20'000 pictures, where the event rate was rather lower than for the rest of the run.

In general we may conclude that, with the ejected beam carefully focused on the horn target, and under the same conditions which pertained during
Neutrino Run 9 in other respects, it is a valid procedure to "tune" the beam until the ionisation chamber reading is maximised in the expectation that this will also maximise the neutrino event rate.

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Distribution: (open)

Scientific staff of N.P.A.
Number of events/10,000 pictures

Bubble Chamber

Mean flux \( \times 10^{-3} \) sec over period