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A MONITOR FOR THE ISR

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At the start of operation of the I.S.R. there will be an immediate need for a means of monitoring the rate of beam-beam interactions at the intersection regions. A suitable monitor should be simple and not require any special vacuum boxes or beam conditions. It should operate at a high rate with a very good signal to noise ratio.

It is suggested that the scintillation counter arrangement shown in Fig. 1 will provide a very suitable monitor of the total rate of beam-beam interactions in an intersection region, which will be available for immediate use as a relative monitor and could later be calibrated by using Van der Meer's beam separation technique[1)] for absolute measurements. The system consists of four scintillation counters, 10 cm x 10 cm, arranged in two pairs, 1a, 1b and 2a, 2b, placed 25 cm above the I.S.R. beams, five metres downstream of an intersection. By demanding counts in all four counters at a time $t = 0$ with a coincidence time of ±2 nsec a high rejection of background is obtained. The timing of the counters effectively defines a source of counts about one metre long centred on the beam crossing point.

When considering a general monitoring facility there are some advantages in monitoring on neutral particles as the monitor can then be used in the presence of magnetic fields. However, in the proposed system the particles to be counted will have traversed six centimetres of steel, assuming a vacuum chamber wall thickness of three millimetres. To monitor on photons after three radiation lengths does not seem to be practical. For charged particles there will be some loss due to nuclear interactions (~30%) but the only important effect this will have will be that when used as an absolute monitor the calibration will depend on the vacuum pipe thickness. It will not be possible to calibrate the monitor at one intersection and use it at another.

In order to calculate the counting rate due to beam-beam interactions the charged particle distributions obtained by Andersson and Daum from the thermodynamic model[2] have been used. For a machine luminosity of 4×10^{30} the estimated coincidence counting rate is ~100/sec. If the luminosity is very much lower than this, larger counters could be used.

The background counts will come from beam-gas interactions in the following ways :

a) Genuine coincidence counts from beam-gas interactions in the intersection region. Again using angular distributions given by the thermodynamic model this rate is 2×10^{-4} counts per second for a residual gas pressure of 10^{-11} torr of H_2.

b) Accidental coincidences from the general flux of beam-gas secondaries. An estimate of this rate can be made from measurements at the P.S. extrapolated to I.S.R. beam and vacuum conditions. This gives a rate of 10^{-3}/sec.

c) Any other source of correlated counts such as showers containing slow scattered particles. It is difficult to predict such a rate, but it is also difficult to see how it can be larger than a) or b).

Hence the signal to noise ratio at full luminosity should be about 10^5 : 1. Since the background a) is proportional to beam intensity Ib and background b) is proportional to $(Ib)^2$, it follows that even for Ib = 1/100 Ib (max.) the signal to noise ratio is better than 10^3 : 1. As the signal to noise ratio is a very important feature of any proposed monitor it is intended to measure the background noise for the suggested counter configuration at the P.S. An extrapolation to I.S.R. conditions can then be made to check the calculated rate of a) and to measure the rate of the unknown mechanisms of c).

It is important that an integral monitor has a uniform efficiency for all positions of the intersection volume. The variation in efficiency along the length of the intersection volume is minimised by the use of counters placed on each side of the crossing point. With the configuration shown the variation in efficiency is ±1% for a one metre long intersection region. With the counters placed vertically above and below the beams as shown, the variation in efficiency with width and height is negligible.

The most attractive features of the suggested monitor are that it is simple, and has a very good signal to noise ratio. It should be possible to predict the background rates quite well from suitable measurements at the P.S. A check on the beam-beam counting rate must clearly wait for the operation of the I.S.R.

REFERENCES

1) S. van der Meer "Calibration of the effective beam height in the I.S.R." ISR - PO/68 - 31 (June 1968).

2) S. Andersson & C. Daum "The production of stable particles" ISR Users Meeting (June 1968).

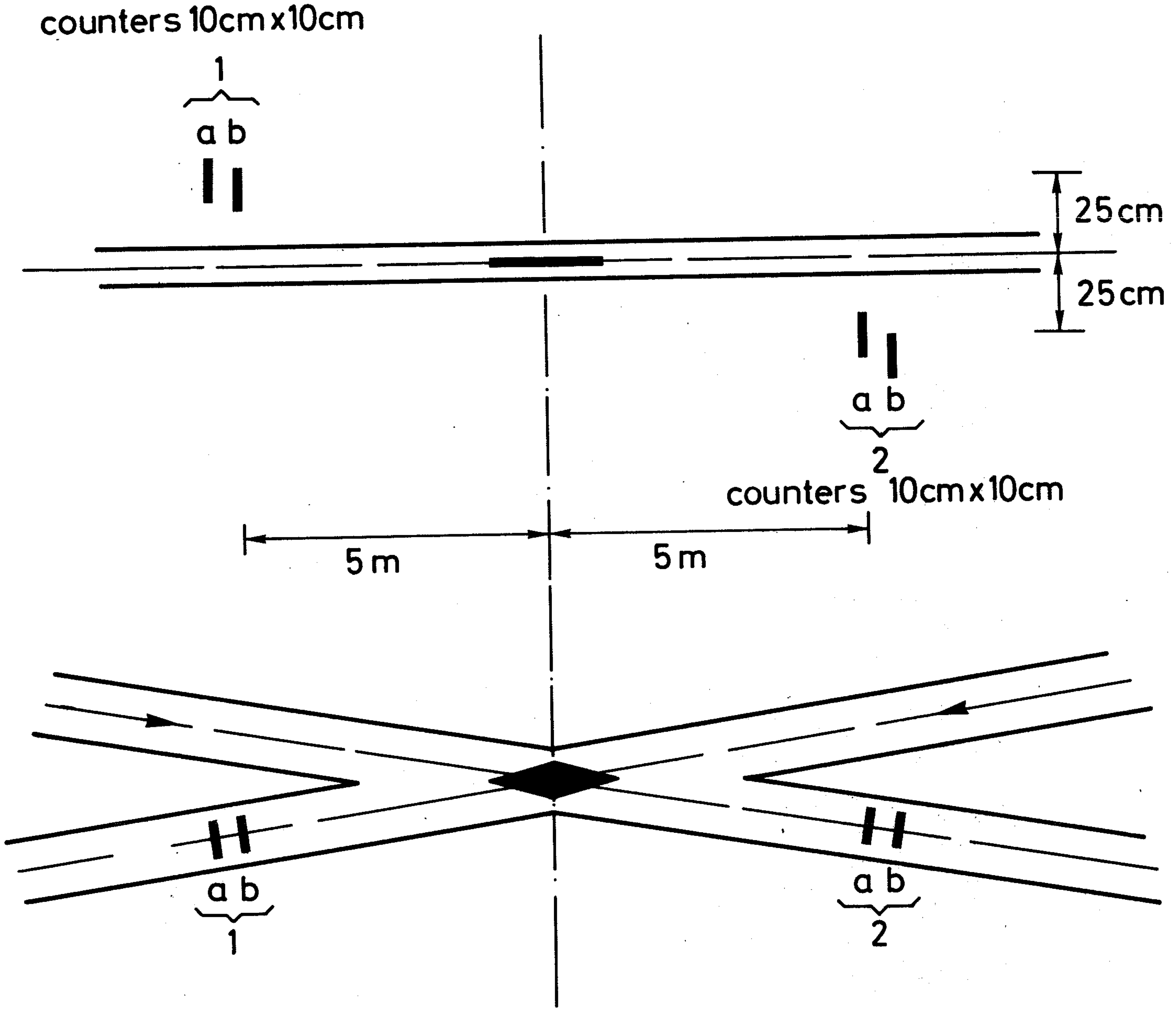
counters 10cm x 10cm
1
a b
25cm
25cm
a b
2
counters 10cm x 10cm
5 m
5 m
a b
1
a b
2

FIG.1