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INTERSECTING STORAGE RINGS COMMITTEE

LUMINOSITY AND BACKGROUND STUDIES DURING THE RUNNING-IN PHASE OF THE ISR

by a Working Party consisting of:

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INTRODUCTION

A working party has been formed with the aim of setting up apparatus at the ISR during the running-in period of the machine in order to

1) provide data on the luminosity of the ISR under various conditions of operation, of interest in the framework of performance tests on the machine itself, and

2) to determine the rates and spatial distributions of secondaries resulting from beam/beam and beam/gas interactions, to the extent that such data are relevant to the design of several of the experiments which are presently under construction.

In accordance with this broad goal the working party comprises physicists which have either been engaged previously in background and beam studies at the PS or are actively involved in the preparation of experiments for which luminosity and background data are of importance. The list of participants is somewhat open-ended and may have to be modified as time goes on.

The proposed experiment has been planned with the boundary conditions in mind that interference with both the ISR running-in programme and the preparations of the programme of approved physics experiments is to be held to a minimum.

APPARATUS

It is proposed to install, in January 1971, in intersection I4, two sets of scintillators, one along each downstream pipe, and 2 sets of proportional chambers, to be placed at large angles with respect to the colliding beams in the horizontal and vertical plane. (See Fig. 1)

The proportional chambers are the ones used by the beam study group at the PS for the mapping of secondary beams from the PS. The associated computer, the interface and part of the software will be made available, either by the beam study group or by the CERN/BNL/COLUMBIA group in I1. The counters and associated electronics are available from the group which has previously measured backgrounds at the PS. Miscellaneous hardware is available from several other groups. The entire set-up can therefore be installed in less than one day.

I4 is suggested as the most suitable intersection, 1) since, contrary to I1 and in particular I2 and I6, relatively little heavy floorwork is foreseen in connection with the installation of the experiments early in 1971, 2) since no counting room is required, 3) since Terwilliger quadrupoles are available in this section, and 4) since the vacuum pipe is elliptical. The floor in I4 has to be raised with concrete blocks to ~1 - 1.5 m under the beam pipes.

MEASUREMENTS

The programme of measurements will be fully guided by the progress in the running-in of the machine itself. It is therefore difficult to define it in advance. One might anticipate that the following set of measurements would be done as part of the investigation.

A. THE LUMINOSITY

1) The downstream telescopes (C_1 and C_2) are placed one above, one below the pipe. The coincidence rate is largely due to beam/beam collisions.

2) 2 proportional chambers (P_1 and P_2) are placed at 90° in the horizontal plane, P_3 and P_4 are placed at 90° below the intersection.

3) The beams are lifted away from each other [1]; the rate per unit displacement, N_1, and the accumulated rate, N_2, in C_1,C_2 and (for tracks emerging from the intersection) in P_1,P_2 and in P_3,P_4 are recorded. The effective beam height is then equal to the maximum in N_2 divided by the maximum in N_1. The three measurements must agree.

4) The luminosity measurement is repeated for a given momentum in each ring and for partially stacked beams as a function of radius of stacked orbit(s), of Q_V, Q_H at fixed radius, for DC, bunched, rebunched beams, with Terwilliger quadrupoles on/off, etc.

5) The luminosity measurement is repeated for combinations of momenta 10/10 GeV → 25/25 GeV, 10/15, 10/20, 10/25, 15/10, 20/10, 25/10 GeV and for combinations of currents 1 → 20 A for each ring.

6) The luminosity measurement is repeated for full stacks at various positions in the vacuum chamber.

B. THE HEIGHT OF ONE BEAM

1) P_1 and P_2 are placed near the upstream arm of beam 1, P_3 and P_4 near the upstream arm of beam 2.

2) Secondaries emerging at $\sim 45^{\circ}$ with respect to beam 1(2) are recorded in $P_1 P_2$ ($P_3 P_4$). If the rate (see below) is not sufficient, gas is let into the pipe. The vertical beam profile is then obtained with a precision which is limited mainly by the thickness of the vacuum pipe. Possible improvements can be obtained by "hardening" the spectrum of particles accepted by small solid or liquid Cerenkov counters (available) and/ or absorbers, always keeping the rate at a reasonable level by adjusting the gas pressure.

C. BEAM/GAS BACKGROUND

1) Data obtained at the PS show roughly a $^{1}/R$ dependence down to distances of ~ 2.5 cm[4]. The ISR beam/gas rate near the intersection may not follow this dependence as a result of the large pressure difference between the intersection and the rest of the machine. The ϑ - dependence seen at the PS can also be compared with ISR conditions.

2) Beam/beam and beam/gas ratios can be measured at $\sim 50^{\circ}$ and $\sim 90^{\circ}$. These data can be scaled to what will be seen in the monitor, in the wide-angle spectrometer and in the large muon detector in I2 and in the apparatus of I1. The data in B 2) above can be scaled to the conditions of the monitor in the total cross section experiment in I6.

3) A rough selection on particle velocity of the secondaries in beam/ beam collisions can be obtained by Cerenkov counters, absorbers and time of flight.

COUNTING RATES

The rates depend on the configuration of the set-up. Two examples are given here:

1) Beam gas rate at 45^0 with respect to the upstream pipe. Proportional chambers 10 x 10 cm at 1 m from pipe. Solid angle 10^{-2} sterad.

For H_2 gas, the rate of beam/gas collisions at full luminosity is given by:

$$R = N_p \, n \, \sigma \, x \, P$$

with

$$N_p = \frac{4\times10^{14}}{3\times 10^{-6}} = 1.3 \times 10^{20} \text{ protons/sec} = 20 \text{ A}$$

$$n = \frac{6\times 10^{23}}{22.4\times 10^{3}} = 0.27 \times 10^{20} \; H_2 \text{ gas atoms/cm}^3$$

x = length of beam, seen by the proportional chamber set-up $\approx$ 15 cm.

P = pressure relative to 1 atm = 10^{-13} for 10^{-10} Torr H_2.

σ = total cross section for $H_2 \approx 30\times 10^{-27}$ cm^2.

Thus

$$R = 160 \text{ beam/gas collisions/sec/15 cm path at full luminosity and } 10^{-10} \text{ Torr.}$$

From the thermodynamical model one obtains, at 45^0 [1]:

0.3 secondary particle/sterad/beam/gas collision. Hence the rate in the telescope of proportional chambers is given by

$$R_{sec} = 0.3 \times 160 \times 10^{-2} = 0.5/\text{sec}.$$

2) Beam/beam and beam/gas rate at 90^0.
Proportional chambers (10$\times$10 cm) at 2 m: $d\Omega = 2.5\times 10^{-3}$.
Total number of interactions at 20 A : 1.6×10^5/sec.
Fraction of diamond seen by telescope 10 cm/60 cm = $^1/_6$.
Number of secondaries produced at 90^0 [1]: 0.4 secondaries/ster/int.p.
Hence number of counts in telescope due to beam/beam collisions:

$$R_{bb} = 1.6 \times 10^5 \times 2.5 \times 10^{-3} \times {}^1/_6 \times 0.4 = 27 \text{ secondaries/sec.}$$

For beam/gas collisions we have the empirical number of the PS background studies [2]), scaled to 10^{-10} Torr H_2 and 4×10^{14} protons:

$$3 \times 10^{-3} \text{ counts/sec/cm path/msr} .$$

Hence, in the telescope, which has $d\Omega = 2.5$ msr and sees $\sim$ 10 cm path we have for the number of beam/gas interactions, for two beams:

$$2 \times 3 \times 10^{-3} \times 2.5 \times 10 = 0.15 \text{ counts/sec.}$$

Hence, at full current the ratio

$$\frac{\text{beam/beam}}{\text{beam/gas}} = \frac{27}{0.15} = 180$$

This ratio decreases linearly with beam current so that at 100 mA stacked current in each ring it becomes equal to 1.

The main problem in these tests is the thickness of the vacuum chamber, in particular at 90°.

After having gained some experience in running with the present chamber a change-over to a thin-walled device might well be the next step.

REFERENCES

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2) CERN/Holland/Lancaster/Manchester Collaboration, CERN/ISRC/69-5, Fig. 19.

3) K.M. Potter, private communication.

4) U. Amaldi, R. Biancastelli, C. Bosio, G. Matthiae, E. Jones, P. Strolin, CERN/ISRC/70-25.

INTERSECTION I4