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# REPORT ON BACKGROUND MEASUREMENTS AT THE PS IN PREPARATION OF THE SMALL ANGLE ISR ELASTIC SCATTERING EXPERIMENT

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## 1. Measurements and results

We report on background tests performed at the PS in connection with the small angle (< 10 mrad) proton-proton scattering experiment in preparation for the ISR [1,2].

For these tests three runs have been performed for a total time of 14 hours. The counters have been placed in section 15. The average machine intensity was about $5 \cdot 10^{11}$ protons/pulse, the momentum was 24 GeV/c and the flat top duration was about 400 ms. A much shorter gate (50 - 100 ms) was used to count background particles well within the flat top.

In the first run two counters in coincidence were moved in the vertical plane from a position very close to the standard vacuum pipe downwards. Thus, without modifying the vacuum pipe, we could go as close as 5.5 cm from the centre of the beam. The results of this run have already been presented in a memorandum to the ISRC[2] and are summarized in Fig. 1. Three series of measurements have been performed by raising the local pressure in five sections upstream of section 15 (this corresponds to a distance of about one quarter of betatron wavelength). The values of pressure quoted in Fig. 1 represent averages taken in the upstream region, where the pressure nonuniformity could not be reduced below 30 - 50% (in the second and third run the nonuniformity was even larger).

The region upstream contributes to the background flux with different weights according to the distance from section 15. These weights, moreover, vary with the distance of the counters from the beam. Hence one expects systematic errors when background rates are related according to the unweighted average pressure. For this reason the agreement of our points with the measurements of Hyams and Agoritsas[3], which in Fig. 1 are scaled to the smallest of our average pressures, is even too good.

The figure also shows that the rates are roughly proportional to the average pressure, so that the main contribution to the measured flux comes from beam-gas interactions. Moreover, it is seen that the 1/r law is roughly obeyed down to quite small distances.

The faster decrease of our data for $r > 20$ cm is presumably due to the shielding action of the magnet poles. This effect did not occur in the measurement of Hyams and Agoritsas, since they moved their counters in the horizontal plane.

For the second and third run a special section of vacuum chamber has be installed in section 15 (Fig. 2). This vacuum chamber is equipped with prototypes of the thin-walled pots to be used at the ISR, which, however, were fixed in position, instead of being movable as foreseen for the ISR experiment. The bottoms of the pots have been placed in section 15 just outside the PS aperture limits ($\pm$ 2.5 cm), which are given by the vacuum chamber aperture ($\pm$ 3.5 cm) scaled according to the square root of the ratio of the local betatron amplitude function $\beta$ to its maximum value.

Five counters have been placed in fixed positions as shown in Fig. 2. The dimensions were : $S_1 = 12 \times 15$ mm$^2$, $S_2 = S_3 = 5 \times 10$ mm$^2$, $S_4 = 20 \times 20$ mm$^2$, $S_5 = 10 \times 10$ mm$^2$. In order to vary the distance of the counters from the beam, we have used kicker magnets to move the beam vertically producing a 5 $\lambda/2$ closed orbit bump centered at section 14.

In these two runs data have been taken only at the normal pressure of the residual gas and the average pressure in the region upstream was about $4 \times 10^{-7}$ torr. In Fig. 3 the crosses represent the measured points taken from the first run of Fig. 1, while circles and dots correspond to the results obtained for $r > 2.5$ cm with the coincidence $S_1S_3$ in the second and third run respectively. The horizontal bars are the vertical dimensions of the counters. The measurements of the three runs are consistent on taking account of the already mentioned difficulty in comparing runs taken at about the same average pressure but with different pressure distributions.

During these runs the measured vertical beam dimension (defined as the size which contains 95% of the intensity) was $\pm$ 2.5 mm. The rates shown in Fig. 3 have been found to be almost unaffected by a stainless steel target placed in section 47 which produced a scraping of 10% of the beam. The target was introduced into the beam for about 50 ms and then withdrawn 50 ms before counting.

The special significance of the range r > 2.5 cm lies in the fact that the counters are not directly exposed to the halo which normally surrounds the beam because the pipe itself acts as a collimator for those particles which would have a vertical displacement larger than 2.5 cm in section 15. In order to compare to the proposed small angle scattering experiment[1,4] we remark that at the ISR the corresponding range is r > 1.5 cm for the counters in front of the first F magnet downstream of a crossing point, and r > 1.9 cm for the ones behind it. The corresponding ranges for the proton-proton scattering angles are $\theta$ > 1.7 mrad and $\theta$ > 1.4 mrad respectively, as discussed in the proposal[1].

The unit chosen for the flux in Fig. 3 is $\left(\frac{\text{coincidences}}{(5 \times 10^{11} \text{ protons cm}^2\text{s})}\right)$ and is such that at full ISR intensity ($4 \times 10^{14}$ protons) and nominal pressure ( $\sim 3 \times 10^{-10}$ torr) one expects roughly the same flux as reported in Fig. 3 if the gas in the ISR is mainly $N_2$, as in the PS. Since the measured composition of the ISR gas is ~ 90% $H_2$ and ~ 10% $N_2$, one expects fluxes smaller by about a factor of ten with respect to the fluxes appearing in Fig. 3.

In the third run we have also collected some data for r < 2.5 cm in an attempt to penetrate into the domain which is normally occupied by the halo. In these tests the above mentioned scraper proved to be of increasing effectiveness with increasing beam displacements and thus decreasing beam-counter distances. For instance, the scraping reduced by an order of magnitude the counting rate at r = 2.0 cm. However, uncertainties exist concerning the interpretation of the measured rates for r < 2.5 cm. In fact when the beam was made to approach the upper counters ($S_1$, $S_2$ and $S_3$), the coincidence rate of the lower counters ($S_4$, $S_5$) also increased. A similar phenomenon did not occur when the beam was moved towards the lower counters. An asymmetric scraping on the vacuum chamber walls upstream from the pots could lead to an effect of this sort. Lack of time did not allow us to verify this or other explanations.

## 2. Conclusions

Since it has been possible to put counters at the PS at the edge of the machine aperture, it seems reasonable to expect that the same will be feasible at the ISR. Scaling the measured rates to ISR conditions ($4\cdot 10^{14}$ protons, $3\cdot 10^{-10}$ torr average along the ring) the accidental rate between two telescopes looking at the crossing point and close to the machine aperture would be of the same order as the true small-angle elastic scattering rate. This would be true in the hypothesis that the residual gas in the ISR has the same composition as in the PS. It is known, however, that the residual gas in the ISR is about 90% hydrogen. This indicates that one is on the safe side as far as accidental rate is concerned down to distances from the beam of about 2.5 centimetres, which correspond to a scattering angle of about 2.5 milliradians. On the other hand it is necessary to stress that uncertainties are present in this scaling procedure when one extrapolates to even smaller distances because of the contribution to the background coming from Coulomb scattering on the residual gas along the ring.

This contribution is strongly dependent upon the distance of the counter from the beam and it was not possible to investigate it at the PS because of the larger machine aperture. Therefore this effect can only be studied at the ISR with detectors as near as possible to the beam. If difficulties should arise it is probable that this kind of background can be influenced by a careful scraping procedure. The PS tests have already demonstrated the effectiveness of a scraper in reducing the background at distances smaller than the machine aperture.

In conclusion we believe that, as a consequence of the PS tests reported in ref. 3 and here, ISR background is predictable down to a few centimetres from the beam.

However, for the small angle scattering experiment a knowledge of background to distances which cannot be reached, unambiguously, at the PS is essential.

Therefore we would like to continue this study on the ISR as soon as possible. The vacuum chamber presently installed in I6 is suitable for this test.

Acknowledgments

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References

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3. B.D. Hyams and V. Agoritsas : "Background in the ISR", CERN Internal Report AR/Int.SG/65-29 (1965).

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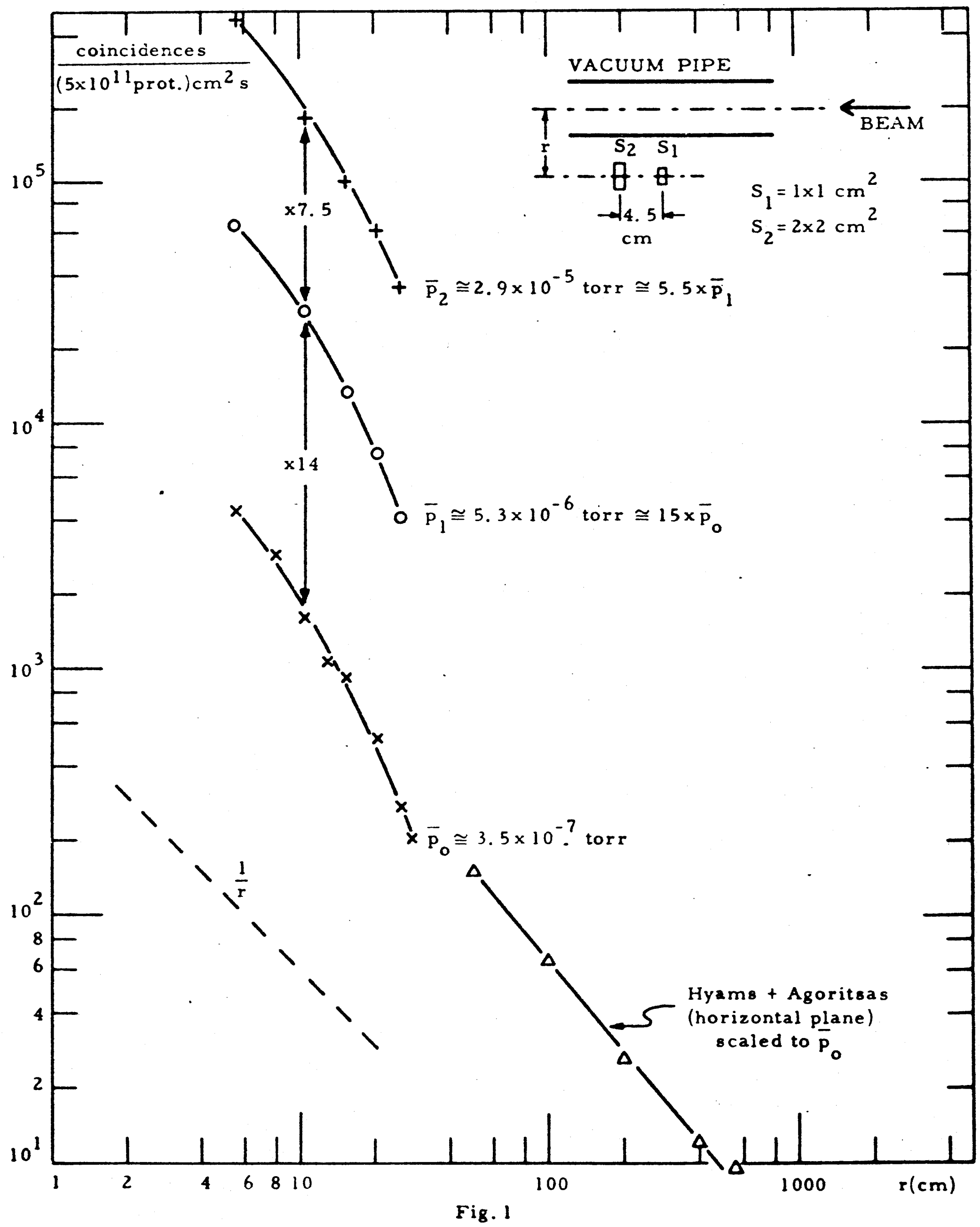

coincidences
(5x10^11 prot.)cm^2 s
VACUUM PIPE
BEAM
r
S2 S1
4.5 cm
S1 = 1x1 cm2
S2 = 2x2 cm2
x7.5
x14
p2 ≅ 2.9 x 10^-5 torr ≅ 5.5 x p1
p1 ≅ 5.3 x 10^-6 torr ≅ 15 x p0
p0 ≅ 3.5 x 10^-7 torr
1/r
Hyams + Agoritsas
(horizontal plane)
scaled to p0
10^5
10^4
10^3
10^2
8
6
4
2
10^1
1
2
4
6
8
10
100
1000
r(cm)

Fig. 1

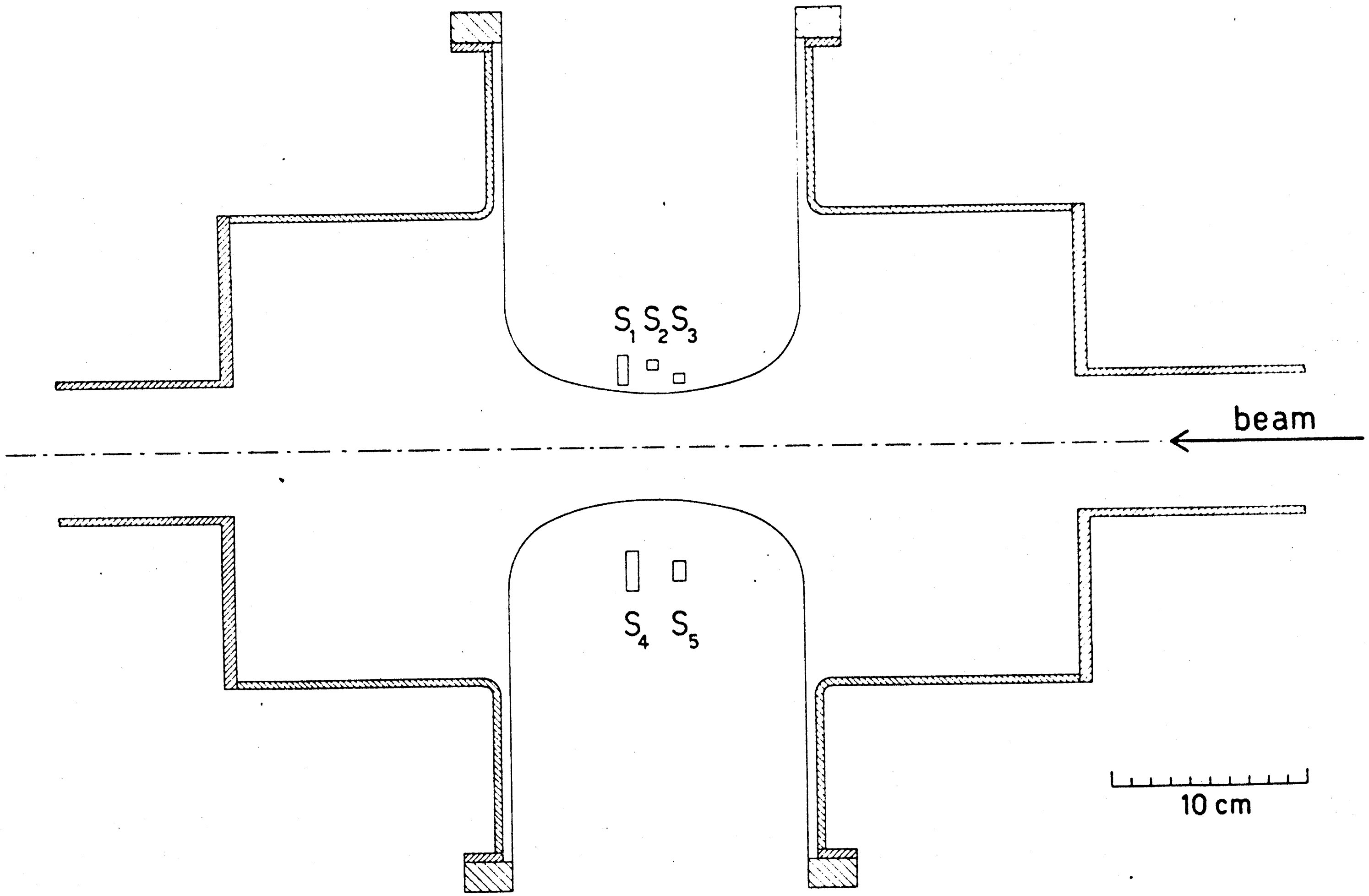
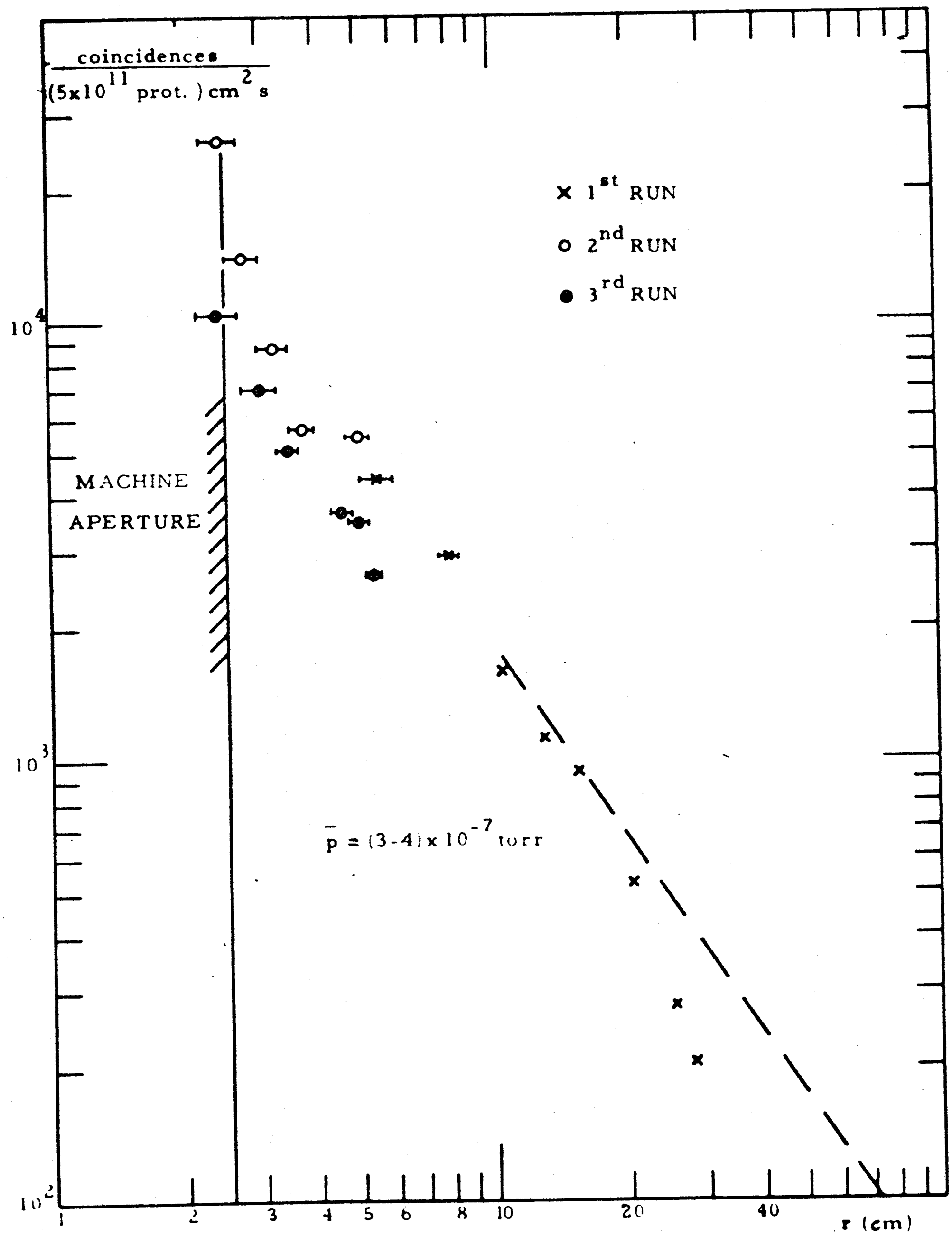



Fig. 2



coincidences / (5x10^11 prot.) cm^2 s
1st RUN
2nd RUN
3rd RUN
10^4
10^3
10^2
MACHINE
APERTURE
p̄ = (3-4) x 10^-7 torr
1
2
3
4
5
6
8
10
20
40
r (cm)


Fig. 3