ISR-BT/BdeR/EEK 26th February, 1971

ISR RUNNING-IN

Run 27, last part, from 22h to 24 h. (20 bunches) Scraping tests and a first attempt at luminosity measurements

The purpose of this run was to make some experiments in background reduction by scraping and to see if an absolute measurement of the effective beam height by vertically displacing one beam with respect to the other, as proposed by Van der Meer, looks feasible.

The smaller scintillators used previously in I4 had been replaced by 40 cm x 40 cm scintillator squares, split into two halves, each viewed by its own photomultiplier and with an oval hole so that they fitted closely around the oval vacuum chamber (see Fig. 1b). The scintillators were arranged in triple coincidence telescopes as shown in Fig. 1a. Background rates were obtained from the counting rates in each of the four telescopes, while colliding beam events (+ accidental coincidences) were obtained by requiring (U1 OR D1) AND (U2 OR D2).

The arrangement in I5 was as before, with 10 cm x 10 cm scintillators close to the vacuum chamber to measure the background and the large 800 mm Ø scintillator discs to measure colliding beam events.

The ISR magnetic field as indicated by the field display was B_o = 22.467 GeV/c. The working point in Ring 1, with the settings as left over from ISR studies before 22 h was ELSA with Q_H = 8.90, Q_V = 8.85 and rather strong sextupole excitation.

This working point was considered as being rather average for making good stacks, but it was kept so that the stack would also be of average quality and could be improved by scraping. We hope however, that it will be possible by a different choice of the working point to make in the future stacks that are cleaner than the one described below.

In Ring 2 a single shot of 71 mA was injected. When we tried to center it in the vacuum chamber by increasing the main magnetic field of Ring 2, the current dropped to about 50 mA. The experiment was repeated with the same loss, apparently caused by a resonance situated somewhere in between the injection orbit and the central orbit. The third time we injected a single shot and left it circulating on the injection orbit during the rest of the experiment. After 2 hours it had lost only a few tenths of mA and was still at 71.5 mA at the end of the experiment.

In Ring 1 a stack of 2.03 A was made without the shutter. The background in I4 and I5 due to spill-out was about 10 x beam-gas background. First the inner edge of the beam, which supposedly had been affected most by the inflector stray field, was scraped away up to r = -13 mm (radial position in the scraper straight section). The current decreased to 1.87 A and the background decreased about a factor 2. The outer edge was scraped until the current decreased to 1.80A but this did not decrease the background. The bottom edge of the stack was scraped until the current decreased to 1.74 mA. This decreased the background by about a factor 3, so that the remaining background then was in the range between 2x and 3x beam -gas background.

The beam dump was then moved vertically up to $z = + 9$ mm. This had little effect on the beam current or the background. The dump block was then lowered to $z = + 7$ mm and was left there for the rest of the experiment.

The currents in the horizontal field magnets had been ajusted in such a way after measurement of the vertical closed orbit with the pick-up electrodes, that both beams were at $z = 0$ in the crossing points I4 and I5. The next experiment was to make half wavelength bumps in I5 to displace beam 1 and beam 2 vertically by an amount z_1 and z_2 with always $z_1 = -z_2$. As soon as beam 1 was displaced to $z_1 = + 2$ mm the background in I5 increased almost two orders of magnitude, so that useful measurements became impossible. The same happened for $z_1 = -2$mm. Apparently beam 1 filled practically the full vertical aperture. The background in I4 also showed an enormous increase but the background rejection obtained by measuring coincidences between the scintillator telescopes around the two vacuum chamber branches downstream of the crossing point is such that the accidentals still did not exceed 5% of the colliding beam counting rate. The top curve in Fig. 2 shows how the colliding beam counting rate in I4 varied as a function of $(z_1 - z_2)$ in I5. The beams in I4 should ideally not be affected by a half wavelength bump centered on I5 and this is more or less confirmed by Fig. 2. At the end of this experiment, due to a wrong adjustment of the H magnets, beam 1 was by accident scraped vertically to a remaining current of 1.28A. The background rate then again dropped to within a factor 2 of beam-gas background when the beams were brought back to $z_1 = z_2 = 0$.

The two beams were then moved up and down in I4 with always $z_1 = - z_2$. For $z_1 = z_2 = 0$ the rate in I4 was about 300 counts per 100 sec for $I_1 = 1.28$A and $I_2 = 71$ mA. Figure 3 shows the total event rate obtained by requiring (U_1 OR D_1) AND

(U_2 OR D_2) as a function of $z_1 - z_2$. The curve has the shape that would be expected and dividing the area by the maximum counting rate gives an effective beam height of about 5 mm. In the course of this experiment the beam was once more by accident scraped vertically and the remaining current was 0.71A. The background then was quite close to beam-gas background. Figure 3 has measuring points (dots) from before and after (circles) the second accidental vertical scraping. The point for $z_1 = z_2 = 0$ is an average of both.

The rate of accidentals with the beams centered at $z_1 = z_2 = 0$ was about 1 count per second. It remained roughly constant in the range -8 mm $< z_1 - z_2 < +8$ mm but increased again very much for $z_1 - z_2 = 12$ mm at which separation there were no beam-beam coincidences left.

The data clearly indicate a substantial reduction in beam height due to the accidental scraping and a corresponding large improvement in background when beam 1 is moved up or down.

Figure 4 shows the "collinear event" rate in I4, obtained by requiring (U_1 AND D_2) OR (U_2 AND D_1). All elastic events and a fraction of the inelastic events satisfy this criterium. The rate is of the order of 200 counts per 100 sec. The shape of the curve is very similar to that of Figure 3. The accidental rate for this combination was again about 1 count per 100 sec in the range -8 mm $< z_1 - z_2 < +8$ mm but increased very much for $z_1 - z_2 = 12$ mm.

Figure 5 shows the background rate in the telescope above beam 1 and below beam in I4. Whereas beam displacements in the range $-4 < z_1 < 4$ mm produce a moderate increase in background, the beam clearly touches the vacuum chamber for $z_1 = +6$ mm since the background increases by two orders of magnitude.

With beam 1 scraped down to 0.7 A the two beams were again displaced relative to each other in I5, with $z_1 = - z_2$. Figure 6 shows the counting rate as a function of $z_1 - z_2$. Due to lack of time only 4 points could be measured and these 4 points look rather asymmetric. We feel that there is too little data to attach at this stage much importance to this asymmetry and therefore we have, using some fantasy, drawn a symmetrical curve in Fig. 6. During the latter experiment the colliding beam event rate was again monitored in I4 and, as shown by the circle forming the lower curve in Fig. 2, was found to be independent of the $(z_1 - z_2)$ in I5, as would be expected.

The colliding beam event rate in a crossing point, with the two beams centered, is

$$R = \frac{1}{ce^2 \mathrm{tg}\, \frac{\alpha}{2}} \cdot \frac{I_1 I_2}{h_{eff}} \sigma$$

The counting rate in the monitor is

$$R_M = \eta R$$

where η is the efficiency of the monitor for counting colliding beam events. From a single curve as in Fig. 3 measured with a fixed monitor geometry, one can find the maximum counting rate R_M and h_{eff} by dividing the area A under the curve by the maximum counting rate R_M. From this one can calculate $\eta\sigma$, or η if σ is supposed to be known.

Therefore, if a monitor incorporated in an experiment is made such that its efficiency is not sensitive to the beam height, for instance by using large scintillators that count only secondaries at relatively large angles from inelastic colliding beam events, then a single calibration run with a scraped down beam is sufficient to determine the absolute monitor efficiency so that it can be used as an absolute monitor independent of beam height.

We feel that the results obtained in this first attempt demonstrate that with the necessary refinements this method of measuring the absolute ISR luminosity is quite promising.

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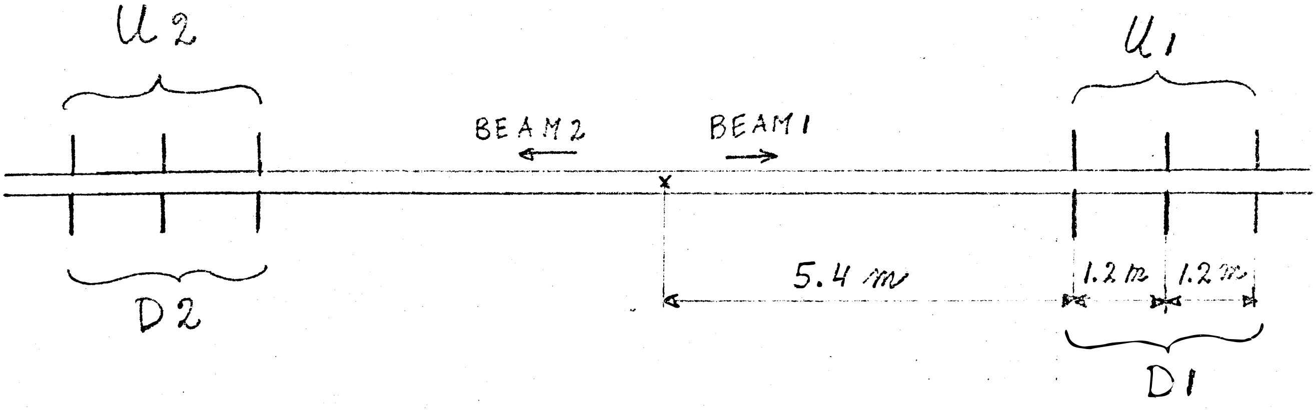

Fig 1a

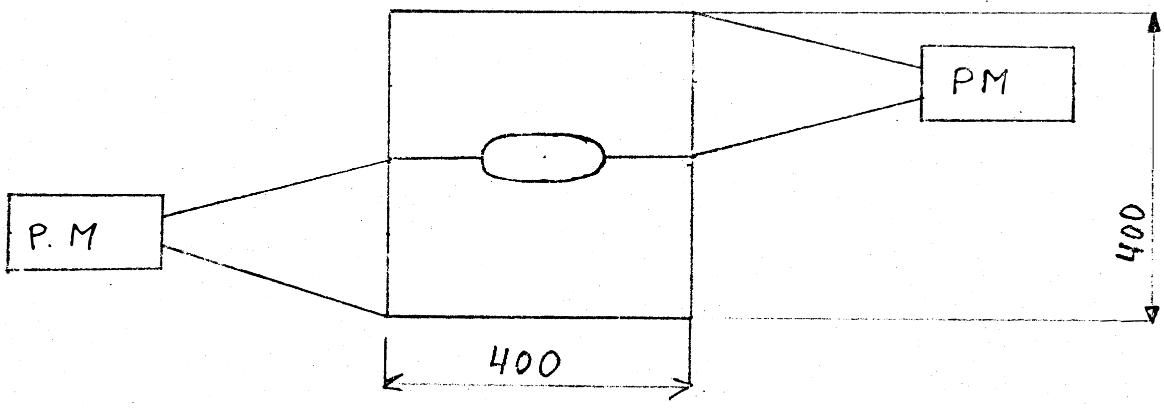

Fig 1b

Fig 1 Arrangement of scintillators in I 4

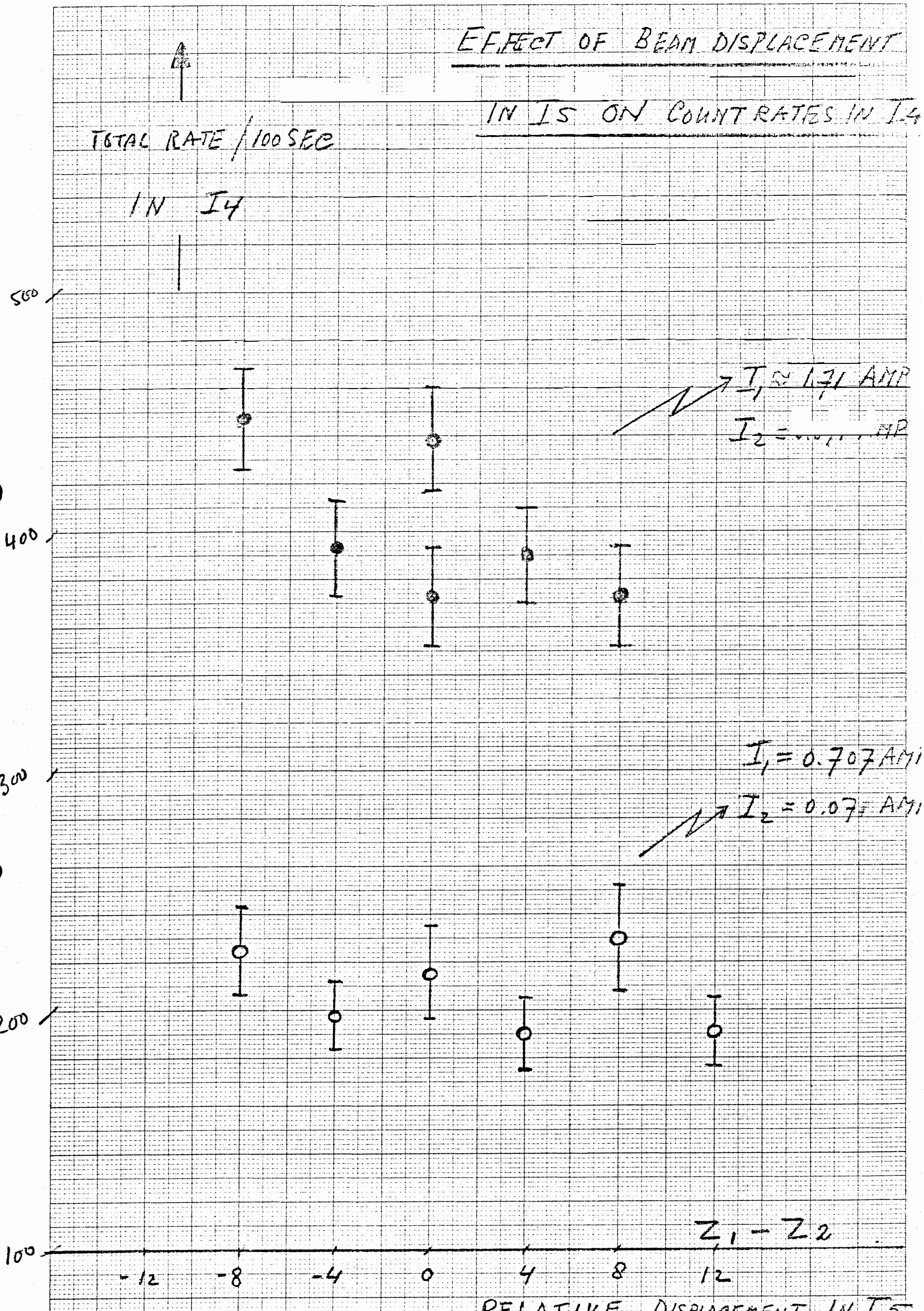
EFFECT OF BEAM DISPLACEMENT
IN I5 ON COUNTRATES IN I4
TOTAL RATE / 100 SEC
IN I4
500
400
300
200
100
$I_1 \simeq 1.71$ AMP
I_2 = AMP
$I_1 = 0.707$ AMP
$I_2 = 0.07$ AMP
$Z_1 - Z_2$
-12
-8
-4
0
4
8
12
RELATIVE DISPLACEMENT IN I5
mm

Fig 2

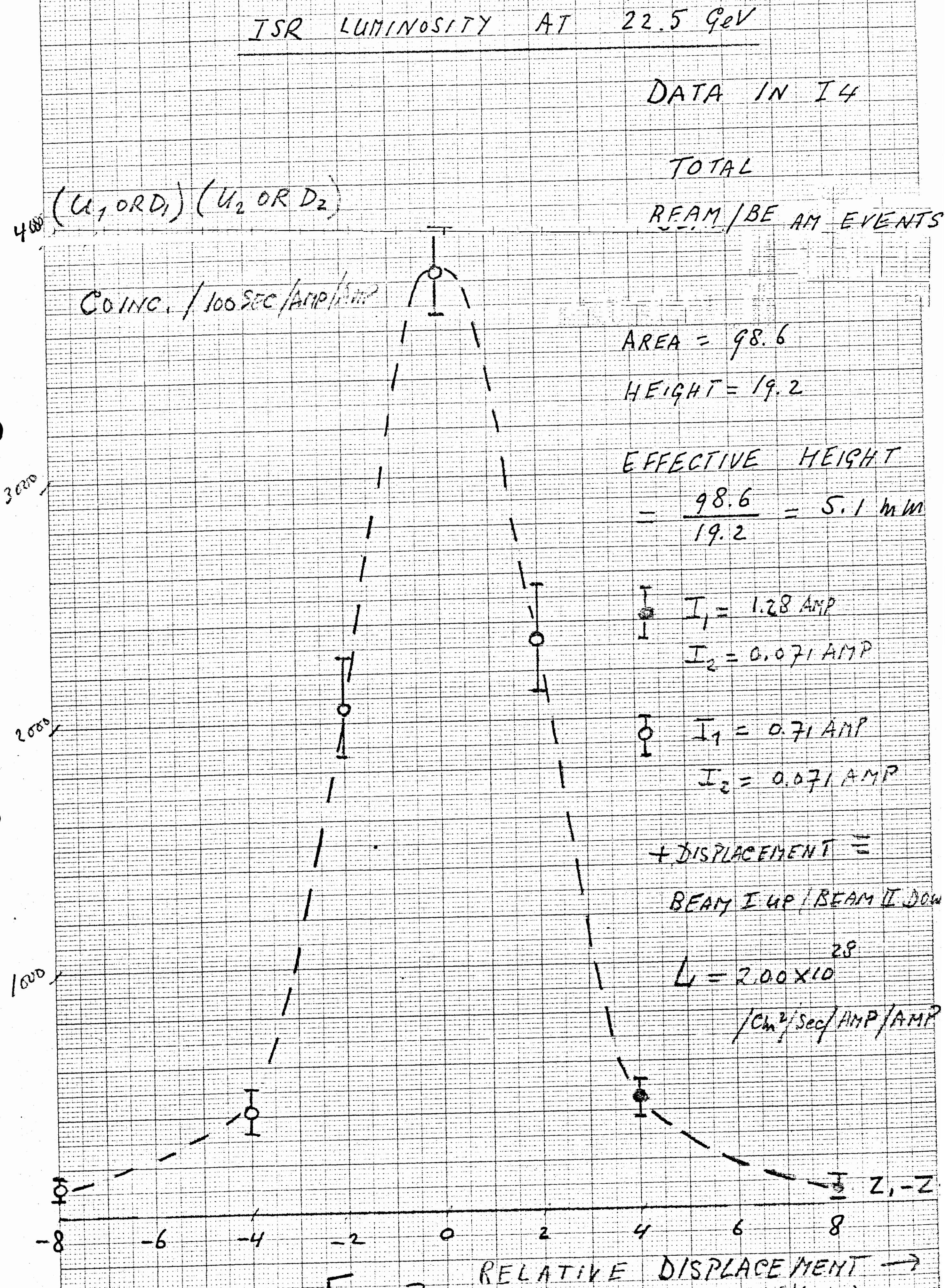
ISR LUMINOSITY AT 22.5 GeV
DATA IN I4
TOTAL
BEAM/BEAM EVENTS
(U1 OR D1) (U2 OR D2)
COINC. / 100 SEC/AMP/AMP
4000
3000
2000
1000
AREA = 98.6
HEIGHT = 19.2
EFFECTIVE HEIGHT
= 98.6 / 19.2 = 5.1 mm
I1 = 1.28 AMP
I2 = 0.071 AMP
I1 = 0.71 AMP
I2 = 0.071 AMP
+ DISPLACEMENT =
BEAM I UP / BEAM II DOW
L = 2.00 x 10^28
/cm²/sec/AMP/AMP
Z, -Z
-8
-6
-4
-2
0
2
4
6
8
RELATIVE DISPLACEMENT →
(mm)

Fig 3

ISR LUMINOSITY AT 22.5 GeV

DATA IN I4

UP/DOWN AND

DOWN/UP DATA ONLY

AREA = 62.8

HEIGHT = 12.5

EFFECTIVE HEIGHT

$= \frac{62.8}{12.8} = 5.0$ mm

$I_1 = 1.28 \rightarrow 0.71$ AMP

$I_2 = 0.071$ AMP

+ DISPLACEMENT ≡

BEAM I UP / BEAM II DOWN

$L = 2.02 \times 10^{28}$ /cm²/sec/AMP/AMP

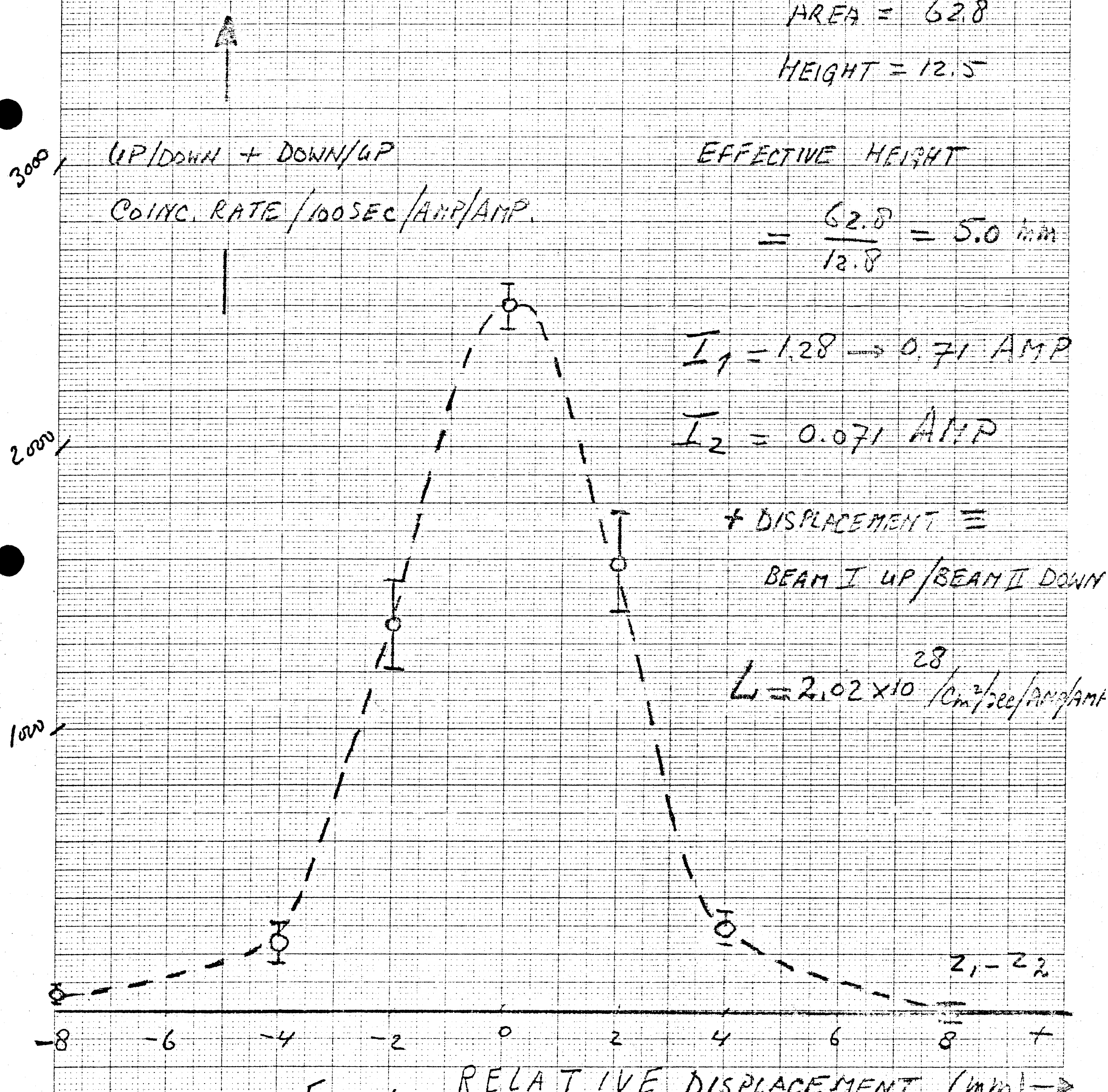

Fig 4

DATA IN I 4

EFFECT OF DISPLACEMENT OF BEAM I ON RATES IN RING I TELESCOPES.

●	UP I RATE	$I_1 = 1.28$ A
o	" " "	$I_1 = 0.7$ A
x	DOWN I "	$I_1 = 1.28$ A
⊗	" " "	$I_1 = 0.7$ A.

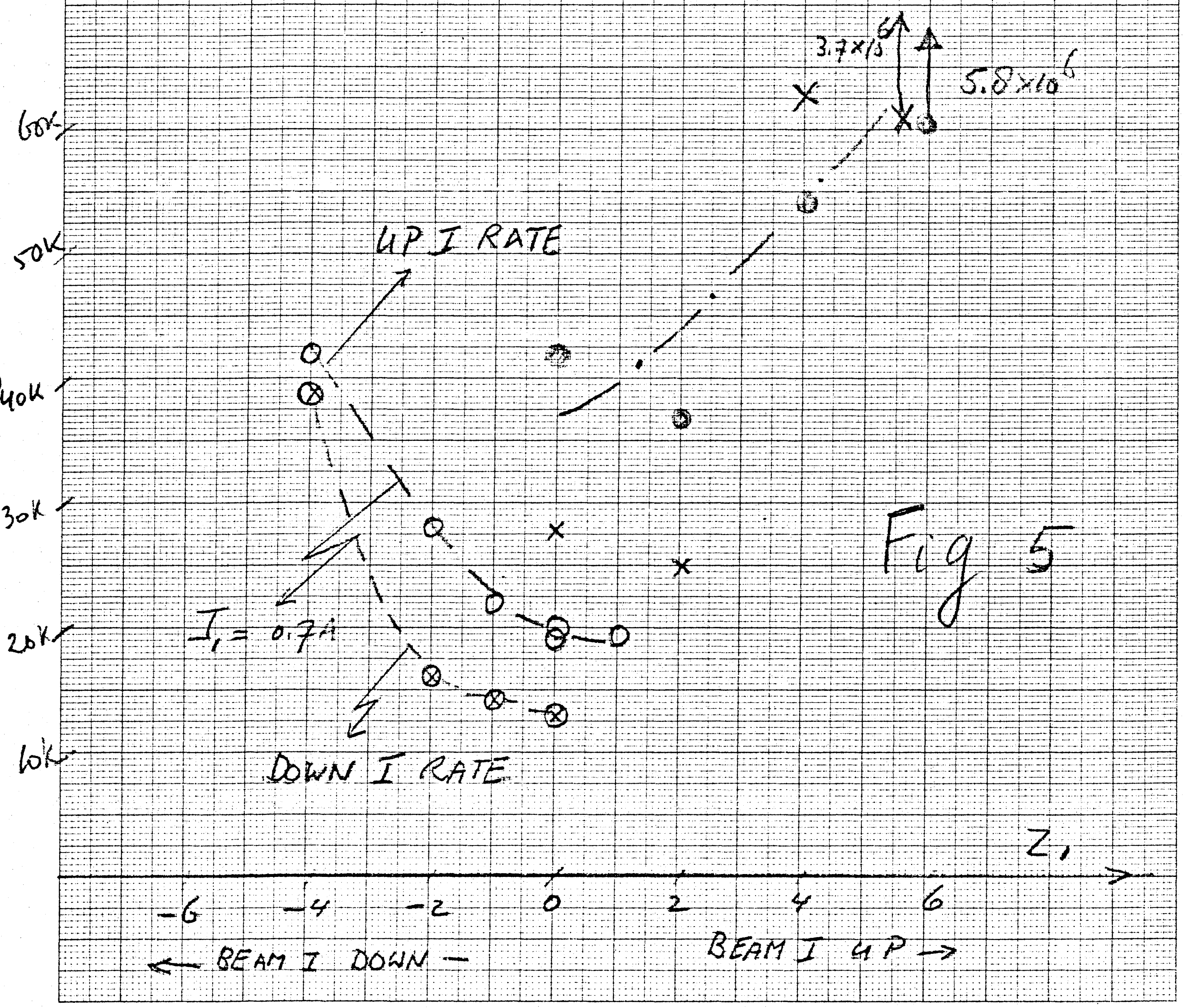

Fig 5

Fig 6

Luminosity measurement in I5

$I_1 = 0.7$ A

$I_2 = 71$ mA