E-6

ISR-OP/FL/svw

24th January, 1973

PERFORMANCE REPORT

NOVEMBER AND DECEMBER PHYSICS RUNS ANALYSIS

- Analysis no. 5 -

1. Introduction

This report reviews the physics runs 251 to 272 from 14th November to 21st December 1972. Filling conditions with performances achieved, current decay rates and backgrounds during the physics runs are summarized. We will comment on these subjects in the following chapters.

2. Filling Conditions

Table 1 summarizes the filling conditions and the performances achieved.

During this period the ISR were filled with 11.8 (2 runs), 15.4 (4 runs), 22.5 (4 runs) and 26.6 GeV/c (7 runs).

A lot of spill out appeared during filling, decreasing with the shaving amount, but limiting the stacked currents especially at 11.8 and 15.4 GeV/c.

For the two lower energies FP lines (+25, -15 mm free spaces) available were used (see H. Laeger's Performance Report, 12th January, 73 for W.L. definitions) although it was generally 2C lines (+45, -15 mm) for higher energies. R7 (R1) and FP (R2) for run 258 and twice (runs 267 and 272) 5C lines (+50, -20 mm) were used. Use of these vacuum chamber decentred stacks implied 10 mm horizontal beam displacements in I2 for R201 spectrometer.

Using Terwilliger scheme limits currents to 6 Amps but with slow speed magnet current changes, only a few ten mA is lost (except for run 268 when beam 2 was lost during TW application). In addition final vertical bumps at intersections must be applied after TW scheme ON (luminosity of run 270 dropped with 50% in I5 and I6 when this procedure was not respected).

18 kV fluctuations or trips created difficulties for obtaining stable conditions for run 270 (both beams lost) and 271 (R1 refilled twice).

Better optimization and use of PS ejection parameters improved ISR injection efficiency (90 mA injected per pulse for run 272) and in addition with 5C lines developments gave the run 272 luminosity record with $L = 4.3\ 10^{30}\ cm^{-2}\ s^{-1}$.

Below are the initial luminosities :

ENERGY (GeV/c)	Initial Luminosity ($10^{30}\ cm^{-2}\ s^{-1}$)	
	Without Terw.	With Terw.
11.8	-	0.04 and 0.09
15.4	0.5	0.3 to 0.5
22.5	2.3 to 4.3	0.6 and 0.7
26.6	1.3 to 2.4	0.9

In Figure 1 luminosities are plotted assuring a linear decrease from the beginning to the end of the run, versus the square root of the current product of each run.

3. Physics Runs Behaviour

The running times available for physics were :

15.30 h.	(all with TW)	at 11.8 GeV/c during 2 runs
60 h.	(19 h. of which with TW)	at 15.4 GeV/c during 4 runs
59 h.	(22 h. " " ")	at 22.5 " " 4 "
128 h.	(15.30 h" " " ")	at 26.6 " " 7 "

A. Beam Current Decay Rates

Table 2 gives a summary of run durations, initial and final currents and decay rates, times and reason, if known, for instability periods.

11.8 GeV/c - 2 runs (with small intensities) worked well (but beam 2 was lost twice for no clear reason). Similarly 15.4 GeV/c runs were good in spite of R1 loss once for unknown reason (dump trigger fault?) and twice because 18 kV failure; the beams were refilled each time. Run 270 was stopped at 2.15 h. in the morning following loss of both beams for 18 kV failure.

During 22.5 GeV/c runs R1 behaviour was very good, just disturbed momentarily by R201 - EM1 fault, R202 - EM change and 150 mA lost during R2 scraping. R2 was good during luminosity measurements or at beginning of the runs but became very sensitive to experimental magnet changes afterwards and spikey in correlation with R2 $d\phi/dt$ fluctuations; decay rates increased sometimes for unknown reason - slight scrapings improved only momentarily.

At 26.6 GeV/c 4 runs were very good and only disturbed by identifiable faults: -R1 spikes induced by R201 - EM trips, by R202 - EM changes and at the same time as R1 reference magnet $d\phi/dt$ fluctuations (runs 256 and 257).

- R2 spikes induced by 18 kV fluctuations (run 263) and R2 lost once (dump self discharge?) then refilled.

Both beams of the 3 other runs were unstable (decay rates very sensitive to exp. magnet changes) the reason for which could be either too much current (R7 + FP lines - run 258) or tops of the stacks too high (2 C lines - run 261 and 262).

External influences on the beams can be summarized in the following way :

a) <u>18 kV failures</u> gave loss of both beams (run 270) and of beam 1 only (run 271) but during run 263, 18 kV fluctuations (main part of the night) gave rise to decay rate spikes in R2 only (nothing in R2 ref. magnet).

b) Reference magnet $d\phi/dt$ spikes are sometimes correlated with decay rate spikes either in R1 (run 257) or in R2 (runs 266, 269 and 272) or in both rings (run 259 when beam 2 was lost). The reasons are not well established (see memo to next MOC from S. Myers).

c) Experimental magnet failure (R201 - EM1 during runs 256 and 267) or auxiliary power supplies faults (runs 258 and 267) induced beam current losses. Normal experimental magnet changes (if actual procedures are followed) gave spikes mainly when beams were unstable (limit of working lines condition) during 258, 261 and 262).

d) Titanium evaporation (Ti-ball) in I8 induced high level decay rates (and backgrounds) in both rings but decreasing titanium evaporation rate (0.075 g/hour since run 267) improved conditions.

Hydrogen leak for I6 is less critical.

These operations should be done at the end of the run.

B. Backgrounds and beam-beam counts

Table 3 summarizes the count rates (in k counts by second) at intersections. For each run we have the rates for each intersection at the beginning and at the end and where applicable the maximum achieved during the run. For this table we have classified runs according to energy. R103 group finished taking data on 1st December and no background are available in I1 after this date.

For better evaluation and comparison between the different runs we have drawn figure 2 where background figures are plotted versus beam intensities in Ring 1, Ring 2 for I1, I2, I5, I6 and I8 intersections at different energies. Only initial backgrounds are plotted.

We can see that background behaviour is similar for R1 and R2 and rather proportional to currents beyond 4 Amps even at 11 and 12 Amps.

Several remarks can be made : due to the I2 monitor configuration R2 background rates are correspondingly 2 times higher than those in R1.

Background counts contain beam-beam events (see T. Blumer's Performance Report of 5th December 1972) and so can explain the small exponential increase of the curves for high intensities ($BB \sim I_1 . I_2$).

Points outside the main distribution come mainly from runs 258 for both rings (high intensities for R7 and FP lines) and 263 for R2 (18 kV fluctuations all the run).

Background figures in I4 are difficult to follow during these physics periods and we can remark : 404T has new big counters with large forward solid angles and are very sensitive to a rather small background increase. A new "classical" monitor will be installed in February.

Background in I4 should be studied at the beginning of the next running period by using a directional MWPC set-up that will give the place in the machine near to I4, that is the source of this problem. H. Hoffmann has recently developed the value of this technique.

4. General Conclusion for Physics in this Period

Development of working lines allowing wider stacks in addition to shaving techniques giving small h_{eff} permitted high luminosities with acceptable backgrounds. In the case of off-centred stacks imposed by working line, use of radial bumps allows R201 to work properly.

Ring 2 remains sensitive to 18 kV spikes and the reasons for current losses in both rings in correlation with reference magnet $d\phi/dt$ spikes are not understood at this time.

Experimental magnet current changes at slow speed or with special procedures do not destroy the beams.

During this period there has been a demand for individual luminosities (I8, I6) followed by collective luminosity measurements (all intersections). This has proven to be valuable for those requiring precision lums (±2% R601) but it is operationally very time consuming. The establishment of 4 magnet bumps (ref. P. Bryant's Performance Report) has demonstrated in the same period that such individual luminosities are not necessary.

Hydrogen leak in I6 and Titanium evaporation for I8 produces increasing backgrounds everywhere during operation and dropping luminosity. This should be limited and placed at the end of the run.

Optimization of Dump block position and scraper protector position during MD and P will be continued for intercepting most of lost particles and for decreasing backgrounds due to induced radioactivity at intersections.

Installation of ionisation chambers all around the machine for losses detection and possible use of proportional chambers in I2, I4, I6 and I8 for directional information on backgrounds sources will help to improve running conditions.

F. Lemeilleur

RUN Nº	DATE	MOMEN. [GeV/c]	RING	Work. Line	[illegible]	CURRENT [Amps]	SHAVED STACKS %	STACKS POSITION [mm]	h eff [mm]	Lum. init. ×10^30 [cm^-2 s^-1]	Lum. [illegible] ×10^30 [cm^-2 s^-1]		COMMENTS
254	11 Oct.	11.8	1 2	FP	T	[illegible] 2.54	45 45	-13/+20 -15/+20	7.4	0.09	0.07	SS	
255	17-18	26.6	1 2	2C		8.1 8.1	60 60	-8/+40 -8/+40	3.3	2.0	.9	IS SS	R2 [illegible] with 6. [illegible]
256	18-19-20	26.6	1 2	2C		8.28 8.50	60 60	-8/+42 -10/+42	3.3	2.4	1.1	IS	
257	20-21	26.6	1 2	FP	T	6.0 6.4	50 50	-15/+18 -15/+18	4.1	.9		IS	
258	21-22	26.6	1 2	RF FP		8.5 8.5	50 50	-7/+26 -15/+25	3.0	2.4	1.35	SS	
259A	24-25	11.8	1 2	FP	T	2.0 1.9	5 5	-1/+25 -10/+26	18.5	.04	*.04	IS	R2 [illegible] [illegible] with [illegible] *before [illegible]
261	28-29	26.6	1 2	2C		8.29 8.59	50 50	-10/+45 -8/+43	3.2	1.9	1.2	IS	
262	29-30	26.6	1 2	2C		8.29 8.26	55 55	-8/+44 -11.5/+45	3.5	1.9	1.1	IS	
263	30-1 dec	26.6	1 2	2C		6.88 7.58	55 55	-12/+40 -10.5/+40	3.8	1.35	.95	SS	
265	11-12 dec	22.5	1 2	FP	T	5.38 5.43	60 60	-15/+20 -8/+20	5.0	.6*	.43	IS	*L decreased by [illegible] after [illegible] [illegible] this [illegible]
266	12-13	22.5	1 2	FP	T	5.48 5.50	50 50	-5/+20 -5/+20	4.3	.7	.47	SS	
267	14-15	22.5	1 2	5C		8.66 8.66	60 60	-12/+45 -8/+47	3.3	2.3	.94	SS	
268	15-16	15.4	1 2	FP	T	4.35 4.36	30 30	-10/+20 -15/+20	6.3	.3	.15	IS	Beam [illegible]
269	16-17	15.4	1 2	FP		5.28 4.88	50 50	-11/+25 -15/+25	5.3	.48	.25	SS	Beam [illegible] with [illegible]
270	18-19	15.4	1 2	FP	T	4.86 4.54	40 40	-8/+27 -14/+27	4.4	*.50	.20	SS	*dropped [illegible] and [illegible]
271	19-20	15.4	1 2	FP		5.42 4.83	40 40	-15/+25 -10/+25	5.2	.49	.44	SS	R2 [illegible]
272	21	22.5	1 2	5C		11.26 12.44	70 60	-24/+50 -17/+50	3.2	4.3	.81	SS	[illegible]

TABLE 4 - FILLING CONDITIONS

RUN Nº	Mom.[±] [GeV/c]	Running [h]	Ring Nº	CURRENTS [Amps] initial	CURRENTS [Amps] final	COR. DECAY RATES [ppm/min] initial	final	minim.	HIGH DECAY RATES PERIODS TIME	LEVEL [ppm/min]	REASONS	COMMENTS
251	11.8	8	1 2	2.73 2.34	2.73 2.30	2 5	<1 12	<1 5	8^{00}-9^{00} —"—	30 ~200	Ti évaporation in I8 —"——"——"—	
255	26.6	15	1 2	8.11 8.10	7.88 6.05*	3 1	14 22	3 1	21^{00}-23^{00} 21^{15}	50/300	During refilling of R2. beam 2 lost.	* R2 was lost for unknown reason 4 hours after beginning, and restacked with 6.1 amps 2 hours latter.
256	26.6	35	1 2	8.28 8.50	7.82 8.18	5 15	15 15	2 4	3^{30}(21-11)	160	R201 - E.K. tripped.	Beam 1 sensitive to Exp. mag. changes.
257	26.6	15^{30}	1 2	5.97 6.10	5.82 6.02	21 3	17 24	16 3	22^{00} 22^{20} 8^{00}	195 270 90	R201 - EM1+EM2 changes R1 Reference magnet spike unknown	
258	26.6	15^{00}	1 2	8.50 8.46	7.88 7.79	~35 ~10	~22 ~17	12 10	⟶ 6^{20}	1350	beam very sensitive to Exp. Mag. changes. 2H352 tripped.	both stacks at max. of currents for these working lines were very unstable.
259A	11.8	7^{30}	1 2	1.98 1.92	1.93 *~1.4	4 18	7 10	<1 11	6^{15} 8^{50}		Beam 2 lost - Small spikes on both Ref. magnet coils. Beam 2 lost - unknown reason	* this ring was refilled 2 times to ~1.4 Amps
261	26.6	15^{30}	1 2	8.29 8.58	8.13 7.94	6 14	52 69	2 5	19^{30} 5^{30}-6^{30} ⟶	85	R204 E.M cycling Spikes with ~4 min frequency. Beam very sensitive to Exp. Mag. changes.	Tops of the stacks (+45 and +43 mm) may be too high. 3 snapings R2 improved I4 background for ~1/2 hour only.
262	26.6	16^{30}	1 2	8.28 8.26	7.91 7.47	4 68	49 63	4 20	2^{45} ⟶	160	R201, EM1+EM2 changed. R2 dump block moved to decrease high decay rate level (+1.6 mm)	change speed too high, will be decreased. stack tops too high (+44 and +45 mm)
263	26.6	15^{30}	1 2	6.88 7.55	6.80 7.13	3 65	30 43	2 19	6^{30} ⟶ ⟶	40	R201, EM1 + EM2 changed (more slowly) dump block R2 moved to +1.5 mm to improve high d. r. level. 18 KV fluctuation all the night.	18 KV spikes seem filtered out by R1 aux. pow. supplies but not by R2's.

TABLE 9 (1st cont.) [illegible]

RUN Nº	Mom.+ GeV/c	Run. time [h]	Ring	CURRENTS initial	CURRENTS final	CUR. DECAY RATES ppm/min initial	CUR. DECAY RATES final	CUR. DECAY RATES min.	HIGH DECAY RATE PERIODS TIME	LEVEL ppm/m	REASONS	COMMENTS
265	22.5	9	1	5.38	5.25	6	5	3	$5^{30}/6^{30}$	230	Ti evaporation in I8	
			2	5.43	5.28	4	5	1	—"—	1300		
266	22.5	13	1	5.48	5.38	1	7	1	7^{30}		Ti evaporation in I8	
			2	5.50	4.98	19	18	1	All-run	high	R2 ref. magnet coil fluctuations	
267	22.5	33	1	8.66	8.07	15	23	10	11^{15}	150 mA	during R2 scraping.	
									13^{40}	130 mA	R201-EM1 failing.	
									14^{30}	30 mA	R202-EM change	
			2	8.66	7.10	20	61	14	$2^{30}/10^{00}$	20/70	slowly increasing without reason.	
									$11^{15}/17^{30}$		4 scrapings to improve backg. in I4.	
									20^{35} to 1^{33}	70/120	R201 and R202 EM change	
									3^{00}	500 mA	24352 fault.	
									8^{30}	80	Ti evaporation in I8.	0.075 g/h Ti evap. instead of 0.15 g/h before improvement
									9^{45}	130	R202 E.M. change.	
268	15.4	14	1	4.35	4.22	4	25	3	7^{00} to 8^{30}	high	Ti evaporation	
									9^{15}	320	Scraping for backg. improv. in I4.	
			2	4.36	4.73	2	14	1	⟶		As for R1.	
269	15.4	32	1	5.28	*4.86	3	30	2	20^{45}		Lost of beam 1, trigger dump fault?	*Ring 1 refilled at 22^{30} with 5 amps.
									3^{00}-4^{00} (?)	115	Ti evaporation in I8.	
			2	4.88	4.12	4	10	2	periodically	~15 mA	lost correlated with R2 ref. mag. coil.	
									3^{00}-4^{00}	250	Ti evaporation in I8.	
270	15.4	5	1	4.86	4.85	5	4	4	2^{15}		Both beams lost. 18KV failing.	No refilled
			2	4.51	4.49	10	7	5	2^{15}			
271	15.4	9	1	5.42	5.37	15	17	10	17^{50} to 19^{20}		Beam 1 lost (18KV failing)	18KV very unstable until 22^{00}.
			2	4.82	4.81	2	4	1				R1 refilled 2 times.
272	22.5	4	1	11.26	11.16	40	20	15				
			2	12.19	11.77	10	100	10	4^{10} to 5^{30}	200 to 70	Reference mag. coil R2 spikes	

TABLE 2 (2nd part). CURRENT DECAY RATES BEHAVIOUR.

RUN No	MOMENT GeV/c	Ring	Current A		I1 kc/s init. – fin.	max	I2 kc/s init. – fin.	max	I4 kc/s init. – fin.	max	I5 kc/s init. – fin.	max	I6 kc/s init. – fin.	max	I8 kc/s init. – fin.
251	11.8	1	2.73	B1	1.8 - 1.8		0.50 - 0.68		4.1 - 16.6		1.7 - 1.7		1.1 - 1.1		0.34 - 0.31
		2	2.34	B2	2.1 - 2.1		1.6 - 1.5		5.1 - 14.3		1.1 - 1.2		1.1 - 10		0.26 - 0.20
				BB	0.26 - 0.22		0.08 - 0.09		6.4 - 12.3		0.05 - 0.04		0.3 - 0.3		0.04 - 0.04
259A	11.8	1	2.0	B1	1.4 - 1.4		0.38 - 0.38		0.02 - 0.04		1.7 - 1.7		0.9 - 0.7		0.2 - 0.2
		2	1.9	B2	1.6 - 1.8		1 - 0.9		0.05 - 0.03		1 - 1		1.4 - 1		0.13 - 0.12
				BB	0.13 - 0.13		0.03 - 0.04		0.4 - 0.3		0.02 - 0.02		0.11 - 0.11		0.02 - 0.03
268	15.4	1	4.35	B1	/		2 - 2		0.3 - 0.3		2.6 - 2.5		3.8 - 3.1		1.5 - 1.6
		2	4.36	B2			5 - 4.7		- -		2.2 - 2		4.7 - 3.8		1.1 - 1
				BB			0.5 - 0.45		1.9 - 1.8		0.18 - 0.16		1.4 - 1.3		0.2 - 0.18
269	15.4	1	5.28	B1	/		4 - 2		0.06 - 0.14		3.6 - 3		4.5 - 2.4		1.6 - 1.6
		2	4.88	B2			7 - 4		0.03 - 0.02		3 - 2		6 - 4		1.5 - 1.5
				BB			0.7 - 0.4		3 - 1		0.30 - 0.14		2 - 1		0.3 - 0.14
270	15.4	1	4.86	B1	/		2.2 - 2		0.4 - 2		1.8 - 1.8		2.8 - 2.5		1.2 - 1.1
		2	4.51	B2			5 - 5		0.1 - -		5 - 5	2.7	4 - 3.4		1 - 1
				BB			0.5 - 0.4		2.5 - 1.8		0.15 - 0.14		1.4 - 1.2		0.2 - 0.2
271	15.4	1	5.42	B1	/		3.3 - 3.2		0.08 - 0.14		4.2 - 3.9		3.8 - 3.5		1.3 - 2.4
		2	4.82	B2			6.4 - 6		0.03 - 0.04		2.5 - 2.4		5 - 5		1.2 - 1.2
			*	L			5 - 4.5		4.2 - —		5.1 - 4.4		4.6 - 4.3		4.8 - 5
265	22.5	1	5.38	B1	/		7 - 6		6 - 7.6	1.6	5.5 - 5		11 - 6		3 - 2
		2	5.43	B2			14 - 9		0.7 - 0.9		4.5 - 3.5		14 - 8		3 - 2
				BB			2 - 1		10 - 6		0.6 - 0.4		6 - 4		0.4 - 0.2
266	22.5	1	5.48	B1	/		7 - 7		0.5 - 1.2		6 - 6		9 - 6		2.4 - 2.1
		2	5.50	B2			14 - 10		0.9 - 3		5 - 4		11 - 8		2.4 - 2
				BB			2 - 1		9 - 5		0.5 - 0.4		6 - 4		0.28 - 0.23
267	22.5	1	8.66	B1	/		28 - 21		8 - 8		18 - 16		26 - 13		7 - 3.5
		2	8.66	B2			38 - 25		20 - 18		25 - 27	33	38 - 20		7 - 3.5
				BB			5 - 2		20 - 13		2 - 0.75		14 - 7		0.8 - 0.4
272	22.5	1	11.26	B1	/		70 - 35		/		45 - 30		57 - 50		/
		2	12.14	B2			65 - 50				27 - 55		75 - 60		
				BB			9.3 - 7.5				3.4 - 2.8		22.8 - 21		
255	26.6	1	8.1	B1	36 - 21		24 - 20		0.15 - 0.23		21 - 15		35 - 15		7 - 3
		2	8.1	B2	38 - 22		35 - 16				18 - 11		73 - 18		7 - 3
				BB	10 - 4.4		5 - 2.2				2 - 0.9		10 - 6		0.8 - 0.4
256	26.6	1	8.28	B1	40 - 35		25 - 55		0.2 - 0.3	0.6	22 - 18		31 - 18		7 - 4.5
		2	8.50	B2	43 - 36		38 - 34	30	0.3 - 1		19 - 15		36 - 20		7 - 4.3
				BB	10 - 6		5.4 - 3		16 - 10		2 - 1		14 - 8		0.7 - 0.9
257	26.6	1	6.0	B1	22 - 18		16 - 15.5		0.5 - 0.4		10 - 11		11.5 - 13.5		3.7 - 3.4
		2	6.1	B2	20 - 20		15 - 15		0.7 - 1.3		8.3 - 9		12 - 14		3.2 - 3
				BB	4.2 - 4		2 - 1.8		8 - 6.5		0.6 - 0.7		5 - 5		0.4 - 0.3
258	26.6	1	8.5	B1	61 - 38		65 - 26		30 - 0.5		33 - 15		36 - 19	40	12 - 6
		2	8.5	B2	65 - 43		42 - 26		8.5 - 0.5		21 - 14	30	35 - 20		10 - 5
				BB	14 - 7		6.5 - 4		26 - 14		3 - 1		13 - 9		1 - 0.6
261	26.6	1	8.29	B1	42 - 33		29 - 24	83	0.6 - 0.65	3.5	23 - 19		36 - 20		9 - 7
		2	8.59	B2	45 - 35		44 - 29	84	4.6 - 1.9	14	20 - 15		55 - 22		7 - 6
				BB	11 - 7		5 - 3		20 - 12		2 - 1.4		10 - 10		0.8 - 0.7
262	26.6	1	8.28	B1	40 - 31		24 - 20	99	0.5 - 1.8	5.6	22 - 18		29 - 18		7 - 5
		2	8.26	B2	46 - 38	96	35 - 25	56	1.8 - 9.5		19 - 17		44 - 21	50	7 - 5
				BB	10 - 7		5 - 3		19 - 16		2.1 - 1.3		11 - 8		0.75 - 0.5
263	26.6	1	6.88	B1	29 - 24		37 - 22	16	0.9 - 1.3	2.1	18 - 16		23 - 16		5.4 - 4.5
		2	7.55	B2	44 - 36	67	84 - 50		7.2 - 4.2	11	16 - 12		47 - 20		5 - 4
				BB	8 - 6		3.6 - 2.6		15 - 10		1.5 - 1.2		8 - 8		0.6 - 0.4

TABLE 3 - INTERSECTION COUNTING RATES

B1: bckg coming from Beam 1
B2: " " 2
BB: beam - beam events or * L: luminosit

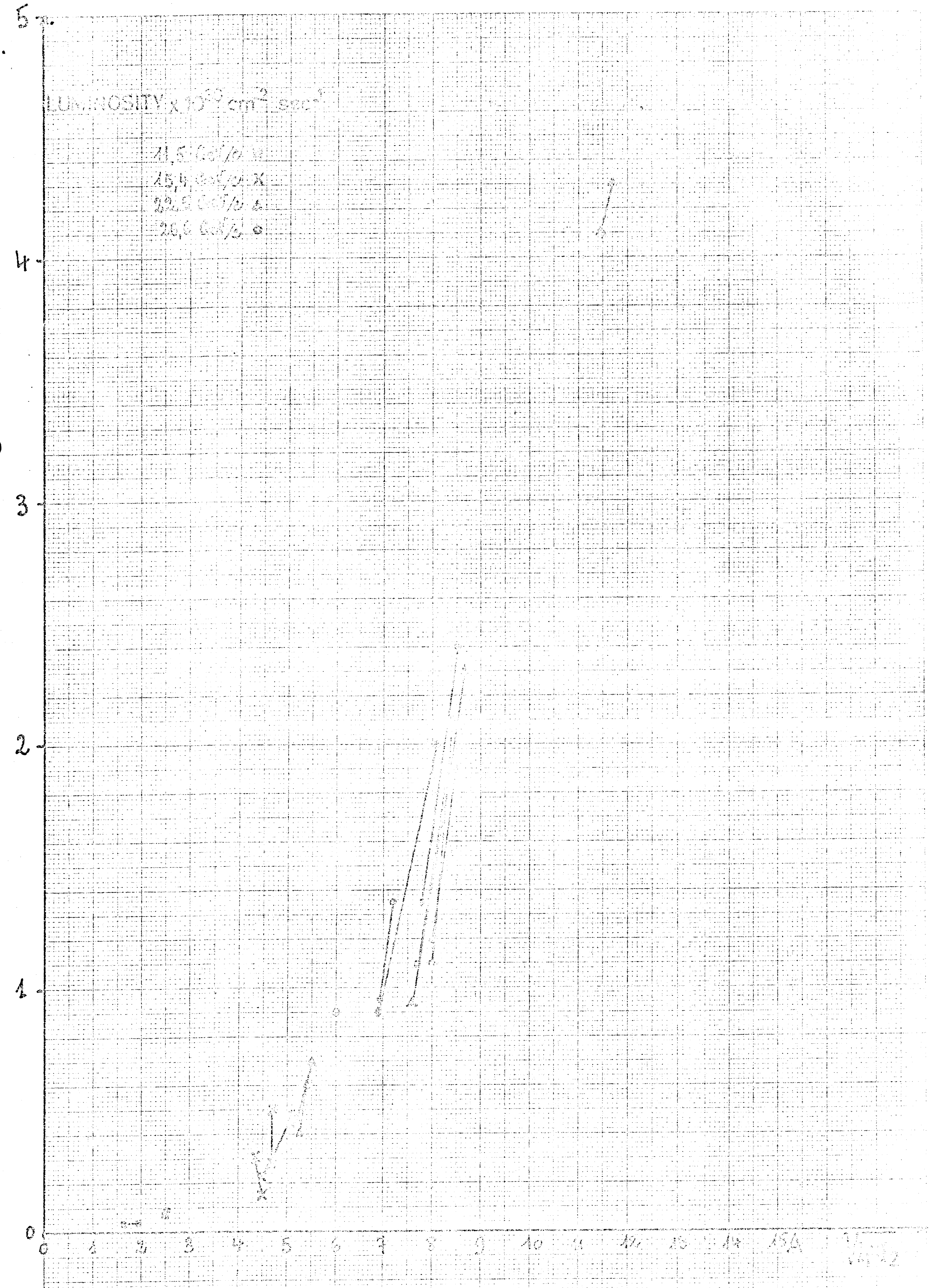

Figure 1 LUMINOSITIES INITIAL and FINAL (1[illegible]-11 au 21-12-72)

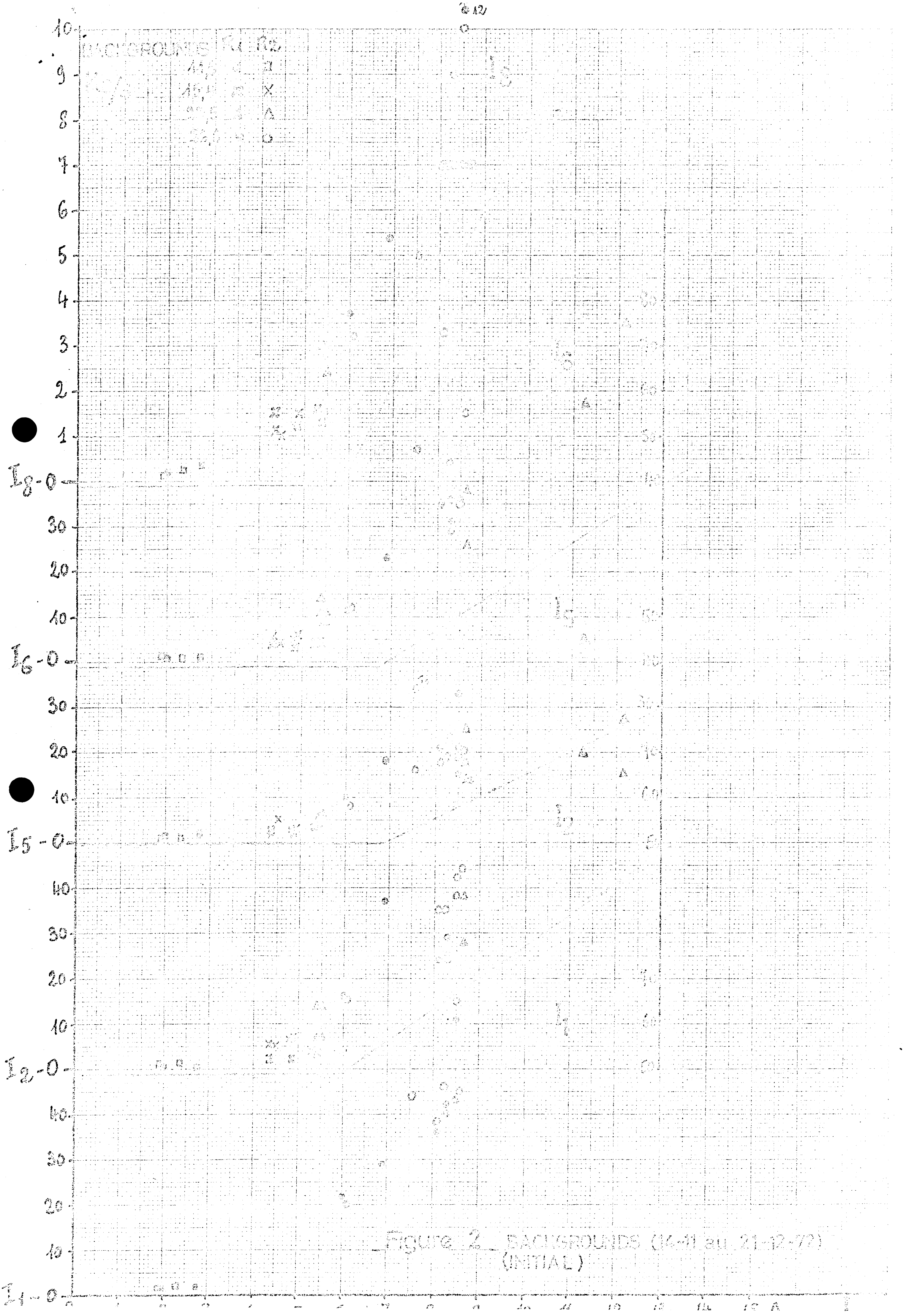

Figure 2 _ BACKGROUNDS (14-11 au 21-12-72)
(INITIAL)