CERN/PSCC/78-1
PSCC/M1

M E M O R A N D U M

To : Members of the PSCC

From : E. Lohrmann and G.L. Munday

Subject : Future possibilities of physics at the PS

I. INTRODUCTION

We examine the possibilities remaining for carrying out conventional PS physics (and that of low energy ps) from now onwards in terms of the availability of the PS, either as a percentage of the total running time or in the number of pulses/hour averaged over one year. Firstly we look at the effect on the PS physics during 1978-1981 when the project for the SPS Intensity Increase is being worked on; secondly, we try to evaluate the impact on PS physics of the antiproton programmes in the SPS and ISR. This problem was first brought up in a paper presented to the Workshop on the rôle of CERN in European Intermediate Energy Physics*. This note presents a simplified and somewhat more extended approach to the problem.

2. THE DEMANDS ON THE PS

2.1. The SPS Improvement Programme

We start with the situation in 1977 as a standard, together with some simplifying assumptions**. Then, during normal operation in 1977 there were usually 3 PS pulses for PS physics for each supercycle of 8.4 s length, giving 1284 pulses/hour with one SPS injection pulse per supercycle. This number of pulses available for PS physics in 1977

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*) See chapter 8 (Operational Limitations) from H. Haseroth L. Hoffmann (Editor), D. Möhl, G.L. Munday, K.H. Reich and Ch. Steinbach, "Present and possible future low momentum beams and experimental facilities at the PS".

**) Assume :
1) The running time of PS = SPS = ISR = 1,
2) A perfect schedule can be made (no lost time),
3) The time to fill the ISR (p) is neglected,
4) Access time is neglected for ISR (p and $\bar{p}$) and SPS ($\bar{p}$),
5) Injection of protons to the SPS continues whilst producing and accumulating antiprotons for the ISR, but the effect on cycle time is neglected,
6) The number of PS physics pulses/hour during SPS $\bar{p}p$ running is not changed from normal SPS p physics runs.

will form the 100% base line for comparison in the following analysis. Thus Table I shows what happens to the number of PS pulses available for PS physics until the SPS Intensity Improvement project is completed, sometime in 1980.

T A B L E I

Year	PS pulse/h for PS physics (Ave)	% of PS pulses for physics, 1977=100%	R e m a r k s
1977	1284	100	Normalisation : 3 PS pulses per 8.4 s supercycle
1978	1125	88	3 PS pulses per 9.6 s supercycle with two pulses to SPS
1979	1125	88	"
1980	975	75	3 PS pulses per 11.05 s supercycle with five pulses to SPS

Thus, during 1980 we expect to have 75% of the 1977 value of PS pulses available for PS physics.

2.2 The SPS is fed with antiprotons : 1981 onwards

For a fixed fraction (P) of the total running time given to $\bar{p}$ running the fractional availability of the PS for PS physics (S) will be dependent on the variable X_{SPS} where

$$X_{SPS} = \frac{\bar{p} \text{ running time in the SPS}}{\text{Accumulation time from the PS}}$$

The value of X_{SPS} is a function of the life time of the $\bar{p}$s in the SPS. Thus $S_1 = 1-P/X_{SPS}$ now compares with the situation in 1980 or for a comparison with 1977 we have :

$$S_2 = 0.75\left(1 - \frac{P}{X_{SPS}}\right)$$

Table II shows the percentage availability of the PS for PS physics when the fraction of $\bar{p}$ running time in the SPS is 0.2, 0.25 and 0.33 when X_{SPS} varies between 0.25 and 1. Thus, as an example, if the SPS runs for 25% of the total time on $\bar{p}$, say about 1000 h/year with X = 0.5 (that is to say 24 h $\bar{p}$ accumulation time for the PS, followed by 12 h $\bar{p}$ run for experimentation), the PS availability for PS physics is 37.5% of the 1977 level. This means a yearly average of 481 pulses/h. Now this figure is optimistic when compared with those quoted in an Open SPSC (Rubbia) when an $X \lesssim 0.3$ was considered. If we are more optimistic and take $X_{SPS} = 1$, then we have a PS availability of 56%.

T A B L E II

P Fraction of SPS time given to $\bar{p}$	X_{SPS} = $\bar{p}$ running time (ISR) / $\bar{p}$ accumulation time (PS)	% Availability of PS (1977 = 100 %)	Ave PS Physics Pulses/h
0.2	1	60	770
	0.5	45	577
	0.33	30	385
	0.25	15	193
0.25	1	56.3	723
	0.5	37.5	481
	0.33	18.75	241
	0.25	-	-
0.33	1	50	642
	0.5	25	321
	0.33	-	-
	0.25	-	-

2.3. In addition the ISR is fed with antiprotons

Now the fractional availability of the PS for PS physics in comparison to 1977 is given by :

$$S_3 = 0.75 \left[1 - \left(\frac{P}{X_{SPS}} + \frac{P_1}{X_{ISR}} \right) \right]$$

Where P_1 is the fraction of the total running time given to antiprotons in the ISR and X_{ISR} is given by :

$$\frac{\bar{p} \text{ running time in the ISR}}{\text{Accumulation time from the PS}}$$

Now the lifetime of the $\bar{p}$s in the ISR is probably 1-2 days thus values of X_{ISR} of 1 or 2 can be expected. Whilst accumulating $\bar{p}$ for the ISR, PS physics is once more reduced. Of course, one could envisage accumulating fewer $\bar{p}$ for ISR, but this would correspondingly lengthen the time needed to accumulate a given integrated luminosity and would not change the argument if one keeps the amount of $\bar{p}$ physics done with ISR fixed.

To illustrate this situation, see Fig. 1, where with SPS running $\bar{p}$ for 25% of the time (say about 1000 h/y), and we also have ISR running $\bar{p}$ firstly for 25% (about 1000 h/y) and secondly for 50% of the time

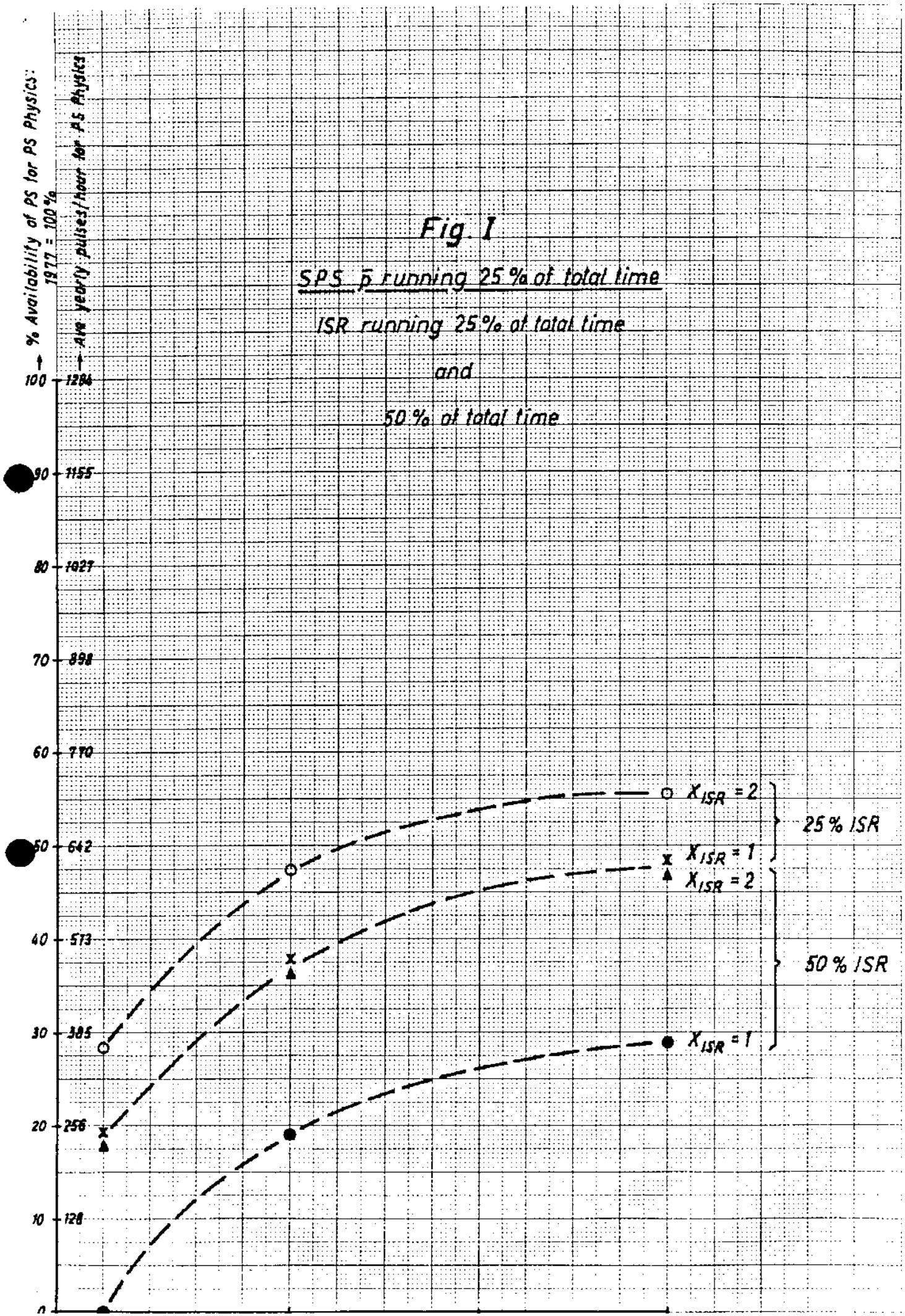
(about 2000 h/y). The X_{ISR} values are taken as 1 or 2 (i.e. for 24 hour accumulation time the $\bar{p}$ running time is either 24 h or 48 h). The percentage availability of the PS for PS physics is then plotted against X_{SPS}. We see that for ISR at 50% $\bar{p}$ running time with $X_{ISR} = 1$ we only have about 19% availability (1977 = 100%) for $X_{SPS} = 1$ (Equal accumulation and running time); this means a yearly average of 241 pulses/hour available for PS physics compared with 1284 p/h in 1977.

3. CONCLUSION

From now until the "SPS Intensity Improvement" becomes fully operational during the course of 1980, there will be some reduction in the number of pulses/h available for PS physics. However, once the $\bar{p}$ facility becomes operational, firstly with the SPS and secondly with the ISR, there will be a marked reduction in the average number of pulses/h available for conventional PS physics and/or subsequently for a special low energy $\bar{p}$ physics facility.

The number of protons available for PS physics is dependent on the percentages of $\bar{p}$ time dedicated to SPS and ISR physics whilst the parameter X (the ratio of $\bar{p}$ running time in the SPS and/or ISR to the accumulation time), clearly has a strong influence on the number of PS protons available for physics other than that of the SPS and ISR.

In this note we have neither taken into account the detailed arguments that could follow from the $\bar{p}$ Design Report (CERN/PS/AA 78-3) nor have we considered the notion of post acceleration in the PS. The latter, if retained, will at least during the first year or two of operation further diminish PS proton availability. However, the general arguments will remain valid.


% Availability of PS for PS Physics:
1977 = 100 %
Ave yearly pulses/hour for PS Physics
100
1286
90
1155
80
1027
70
898
60
770
50
642
40
513
30
385
20
256
10
128
0
Fig. I
SPS p̄ running 25 % of total time
ISR running 25 % of total time
and
50 % of total time
X ISR = 2
25 % ISR
X ISR = 1
X ISR = 2
50 % ISR
X ISR = 1