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RECOMMENDATIONS OF THE WORKING GROUP FOR THE BEST USE OF THE PROTON SYNCHROTRON AFTER THE 1968 SHUT-DOWN

The above Working Group has met eight times between November 1967 and February 1968. At these meetings a large amount of dispersed information and facts was collected and correlated. As a result, ways of operating the PS after the 1968 shut-down emerged, taking into account on one hand the new facilities offered by the PS, and on the other hand the desires of the users. These studies also showed which pieces of hardware are essential to these operations.

Although these pieces of hardware are either under development or under construction, the aim of this note is nevertheless to draw the attention once more to their importance, so that proper priorities for these projects can be assessed.

We will give in this note the most salient facts, state some conclusions and finally, give our recommendations.

I. FACTS

a) PS Improvements

The main feature is the new power supply for the PS. The following table gives some examples of the new repetition time (sec) for several PS momenta and flat top lengths :

Momentum GeV/c	Flat Top (msec)						
	100	200	300		500		700
18.94	1.4	1.5	1.6		1.8		2.0
21.82	1.6	1.7	1.8		2.0		2.5
23.15	1.7	1.8	1.9		2.4		2.9
25.01	1.8	2.1	2.4		3.0		3.6
26.29	2.1	2.5	2.8		3.5		4.2
27.25	2.4	2.8	--		--		--

Below the line that steps across the table, power is the limitation and increasing the energy or the flat top is rather costly in repetition rate.

With cycles of less than two seconds, one can obtain flat tops of 500 msec up to 22 GeV/c and 200 msec up to 25 GeV/c. This will allow the PS to run at energies greater than the usual 19 GeV/c, permitting new experiments. Moreover, at every cycle it will be possible to make 2 or even 3 flat tops, each of different energy and different length. Improvements on the RF system will, in the next few years, lead to further decreases in the repetition time.

Improvements are being made to the NPA fast kicker. Expected performances for September 1968 are: maximum momentum about 21 GeV/c; feasibility of multi-kicking any number of bunches between 1 and 20 with a repetition time of 300 msec, variable from bunch to bunch and from burst to burst; the dead time at end of operation will be about 100 msec.

Development work is proceeding on the Full Aperture Kicker (FAK), By September 1968 it is hoped to meet the following specification: maximum momentum 20 GeV/c; possibility of kicking n or 20 bunches with a repetition time of 80 msec (n will be fixed to 1, 2 or 3, and not changeable); not changeable from bunch to bunch, neither from burst to burst; dead time at the end of operation less than 50 msec.

These kickers are needed for the fast ejection FE 58 (HBC 200) and FE 74 (HLBC 120).

Faster target mechanisms are under construction.

A new target (8) will be installed. It will not be possible to operate all experiments from targets 1, 6, and 8 simultaneously, because of the power and water limitations in the South area.

b) TC requirements

The innovation from the TC side is the possibility of multiple pulsing the 2 m bubble chamber (HBC 200). It should be possible to expand, from September 1968 onwards, 1, 2 or 3 times per machine burst, with a repetition time of about 100 msec. Multiple pulsing will be possible with the fast ejection (FE) system, but most likely not with the fast-slow (FSE) system. The HBC 200 is, as usual, planned to be in continuous operation, always seconded by one of the two other chambers, either the HBC 80 (North Hall, target 6) or the HLBC 120 (FE 74).

Although the fast ejection scheme can satisfy most of the TC requirements the fast-slow ejection will still be desired for high statistics experiments, the use of automatic measuring devices being greatly facilitated by a constant and well spread beam, feasible only with fast-slow ejection.

c) NP requirements

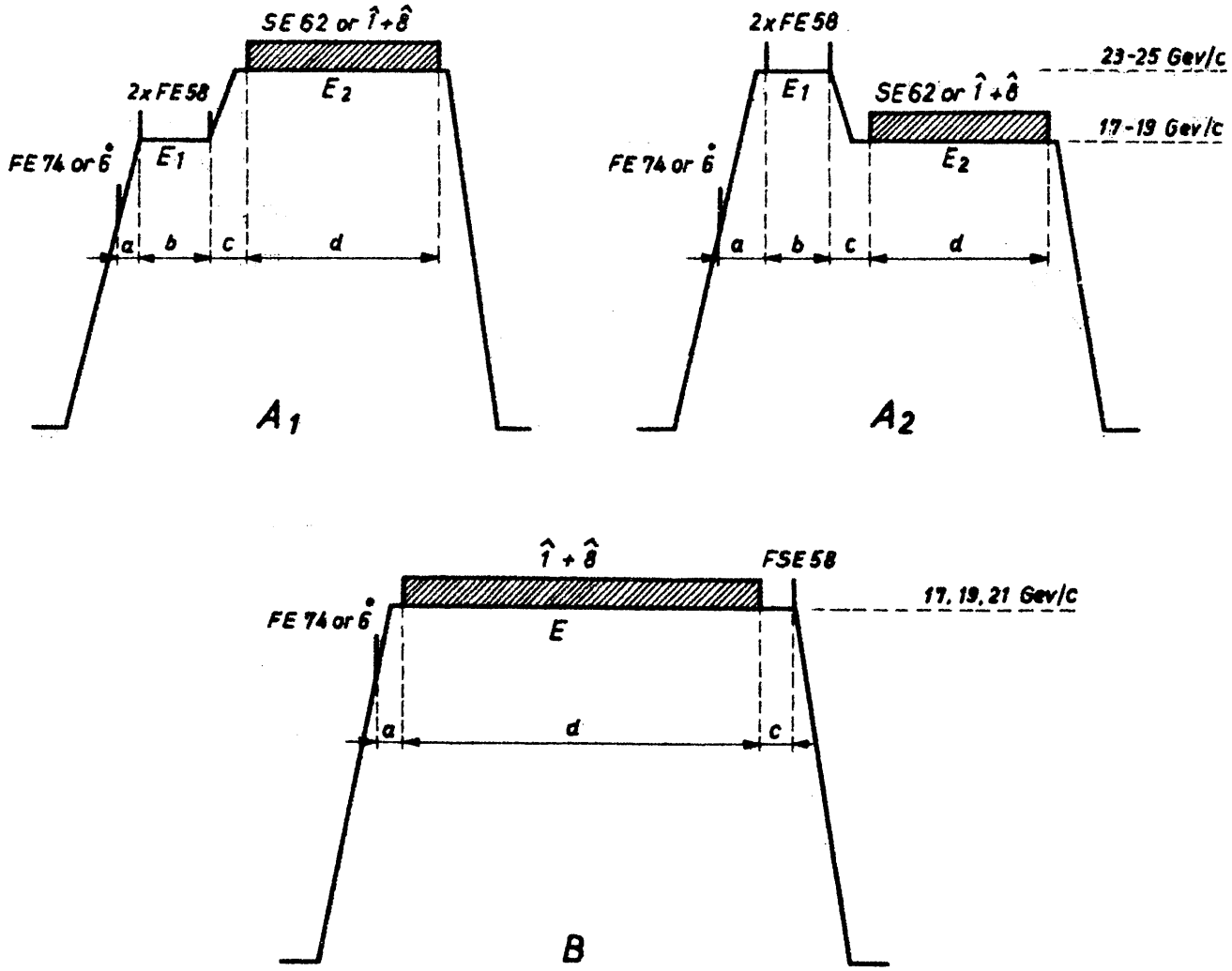
The great change for counter physics has already taken place, viz. the feeding of all experiments in the East Area from the slow ejected (SE 62) beam e_3. As is well known, there is still much scope for improvement on this facility (time structure in the burst, ejection efficiency, stability of operation, some reasonably efficient mode of sharing with targets).

In the South Hall an extra target (target 8) will come into operation. It is foreseen that target 1 and 8 will usually operate simultaneously.

The e_3 complex, being basically a high-energy facility, will often require the PS to operate around 25 GeV/c. In the South Hall only one high energy beam is foreseen, viz. the d beam from target 1. The South Hall will presumably therefore often prefer PS operation around 20 GeV/c, in order to profit from the shorter repetition time.

II. OPERATION OF THE PS

As a result of our deliberations it appears that the schemes A_1 and A_2 will form the basic model of the targeting and ejection operations after the 1968 shut-down (parasitic operations are not considered). We hope that also scheme B can be maintained after the PS shut-down (see paragraph I.b), but it should be remembered that this FSE is a very inefficient way of extracting protons.



N.B. 1) The energies are examples.

2) There is a limit to the percentage that can be taken by 6 when sharing with SE 62. Nevertheless this is a very useful mode of operation because of the power limitation in the South/North Area (I(a), page 3).

These ways of operation are dictated by the necessity of having all fast ejection operations finished before the beam can be debunched for the counter needs.

Apart from the time needed for a certain rise or fall in energy the time intervals involved are governed by the following:

a is determined by the kicker repetition time, in case one kicker is used for both FE 74 and FE 58, or by the time needed to retract the first kicker or target 6 and bring the fast kicker for FE 58 into operation; if not too long, a may be covered by the rise-time.

b is determined by the kicker repetition time and the bubble chamber repetition time, the latter being about 100 msec.

c is the dead time needed for retracting the kicker and/or bringing targets $\bar{1}$ + $\bar{8}$ or SE 62 into operation.

d is the burst length required by the counter groups, for which one should aim generally at 300 msec at least.

In order to have the scheme outlined above working efficiently, a large amount of hard and soft ware has to be available. In this respect three topics have to be mentioned:

1) Fast kickers

Remembering that the FAK kicker will initially only have a very limited scope, the NPA kicker will have to be relied on for many operations. From the numbers quoted before it then follows that b = 300 msec, c $\tilde{>}$ 100 msec, d $\geqslant$ 300 msec, so that the total flat top length will have to be longer than 700 msec (assuming for simplicity that $E_1 = E_2$). Most of this time will be spent just waiting. Such an operation is clearly impossible above about 19 GeV/c. For optimum operations the repetition time, b, of all fast kickers should be matched to the HBC 200 cycle, i.e., 100 msec, and the dead time, c, should be as small as possible, say 50 msec.

Also, for getting high energy secondary beams, at least one kicker should be able to run at 25 GeV/c or more, and the numbers of bunches should be adjustable from week to week (and independent in successive ejections if the same kicker is to supply both FE 74 and 58).

2) Slow ejection

For the slow ejection SE 62 the difficulties after the 1968 shut-down will lie in the repetition time of the septum. The present power supply allows only a 4 °/o duty factor at 25 GeV/c, and 10 °/o at 19 GeV/c. Thus for a 200 msec ejected beam burst - the minimum conceivable for the counter groups in the East Area - a repetition time of 5 sec is needed at 25 GeV/c and 2 sec at 19 GeV/c. These times are longer than the future repetition time of the PS. Apparently, it is difficult to expect improvements from the power supply (Schneider-Westinghouse) but septa that are thicker than the present ones might allow a better duty factor. The use of thicker septa should be acceptable since the thin septum lens has been successfully tested.

3) PS intensity

To take full advantage of longer flat tops the intensity per burst of many counter beams can be proportionately increased, and the bubble chambers will on the average use more protons than now (double expansion for the HBC 200, one other chamber running). Thus an increase in PS intensity per pulse would be very welcome.

In all the above considerations only a "normal" operation of the PS has been considered, the protons being shared between bubble chambers and counter experiments. Obviously, there will sometimes be special operation, in which all the beam is consumed by one experiment (neutrino, for instance).

III. RECOMMENDATIONS

In the course of the studies of this Working Group it emerged that the fast kickers and the duty cycle of the slow ejection septum form possible limitations on the most efficient use of the PS after the 1968 shut-down. It is recommended that high priorities be given to the following developments :

1) Fast Kickers. The requirements are
   - maximum momentum $\geq$ 25 GeV/c (not yet possible)
   - multi-kicking, with 100 msec repetition time, 50 msec dead time at start and end of operation (possible with FAK)
   - number of bunches for FE 74 and FE 58 independent and adjustable (possible with NPA kicker).

   These aims could be achieved by one kicker performing all operations or by sharing the various operations between the two kickers.

2) Slow ejection SE 62. Apart from the well-known needs for improved operation (structure, ejection efficiency, stability, efficient sharing) the duty factor of the septum will need an improvement by at least a factor 2 in order to be compatible with the increased repetition rate of the PS after the shut-down.

3) General facilities. An increase in PS intensity per burst is highly desirable, if possible without increasing the beam size. It would also be very useful to remove the power and water limitations in the experimental areas.

The Working Group does not want to pretend that the facts covered by these recommendations are new. All of them were known at least a year ago to some people and work on them has been going on already for a long time. Nevertheless, we are not assured that in September 1968, by the end of the 1968 shut-down, the facilities mentioned above will be available. To this latter fact, we want to draw attention, as it should still be early enough to apply some remedies.

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