

PROTONS FOR PREVESSIN

Summary of meeting No. 6 - September 5, 1975

Present :

O. Barbalat, J. Boillot, D. Boussard, M. Boutheon, E. Brouzet,
M. Cornacchia, G. Dôme, P. Faugeras, J. Gareyte, W. Hardt,
G. von Holtey, H. Isch, A. Krusche, P. Lefèvre, G. Plass,
J.P. Riunaud (part-time), E.J.N. Wilson

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The meeting was mostly devoted to various aspects of matching the PS and SPS in the longitudinal phase space.

1. RESULTS OF THE NAL EXPERIMENTS

These experiments performed in May and June 1975 have been reported in detail by E.J.N. Wilson (NAL report EXP-74) and D. Boussard (Lab.II/RF/Int. Note 75-8). D. Boussard gave a brief summary, including relevant results of previous PS studies (Lab.II/RF/Int. 75-2)

a) Debunching

The same qualitative results as in the PS were observed, namely blow-up of the longitudinal emittance associated with a microwave instability. It was reconfirmed that the local and not the average value of intensity and momentum spread are the relevant parameters*. The observed frequency spectrum is similar to that seen in the PS (1 to 2 GHz) and agrees with the Hereward suggestion relating this phenomenon to the vacuum chamber discontinuities.

The coupling impedance (Z/n) was measured by two different methods (magnitude of blow-up and time of threshold crossing of the instability), giving both values which are half of the corresponding PS figures.

* The instability is not damped when the bunches begin to overlap in phase space and appears also when only a single bunch is circulating.

Since there is otherwise a factor 4 in favour of debunching in the SPS rather than in the PS (assuming equal coupling impedances), one can hope to retrap in the SPS before the instability has the time to develop substantially, since it was observed at NAL that the instability takes 40 ms to have a substantial effect.

At 5.10^{12} p/p one could without instability have a longitudinal emittance (before trapping) of 60 mrad; the limit is imposed by the voltage reduction possible with the PS cavities. (If the instability is allowed to develop, the emittance would rise to 140 mrad).

b) Retrapping

Strong oscillations were observed at NAL when trying to retrap at 8 GeV/c the injected debunched beam with 8.10^{12} p/p; they seemed insensitive to adjustments of the voltage profile or of the injection energy. Similar difficulties had been experienced on the PS during similar trials at high energy (10 GeV), both with 9.5 and 200 MHz, while things were much easier at lower energies (2-3 GeV). One must therefore expect a blow-up of 1.5 to 2 with a trapping efficiency of 80% which does not seem to be intensity dependent in the explored range. One can therefore expect a final emittance of 120 mrad at 5.10^{12} p/p in the SPS. This gives some margin but not much.

A beam with a large longitudinal emittance (210 mrad instead of 10/20 normally) was successfully accelerated to high energy at NAL without important losses even at transition.

2. IMPLICATIONS FOR SPS RUNNING-IN

- a) It is now clearly demonstrated that it will be easier to debunch in the SPS than in the PS. It is thus agreed to perform both the debunching and the 200 MHz retrapping in the SPS at least during the running-in period.
- b) Longitudinal emittance before 200 MHz trapping could be reduced below 60 mrad by having a 9.5 MHz system installed in the SPS where its action on the beam would be four times more effective than in the PS. A decision to install such a cavity would only be made once the running-in had given a clear indication of its utility.
- c) The 200 MHz system in the PS will only be used for beam observation by the SPS pick-up electrodes. Low intensity is enough for orbit measurements. In case of serious difficulties with the present system, (radiation sensitivity of PIN diodes used to short-circuit cavity) one could envisage to fit it with a mechanical short-circuiting device since low intensity is sufficient for orbit measurements.
- d) The eta increase scheme which would have helped if debunching were done in the PS is not needed at least in the coming running-in and initial SPS operation period. In any case this scheme would be useless without a powerful (> 200 kV) 200 MHz constant frequency RF system installed in the PS. It was therefore agreed to drop this scheme for the moment until the need arises. The planned triplet power supplies will therefore not be procured.

- e) Although the longitudinal part of the transfer scheme can now be considered frozen, a number of simulation machine studies on the PS remain necessary and should be given priority, in particular to study the conditions of optimum trapping efficiency and ways to increase in a controlled way the longitudinal emittance to ease debunching in the SPS.
- f) Work to implement in a practical way this transfer scheme (control of adiabatic RF voltage reduction in the PS, selective switch off of RF cavities, signal connections to PS/MCR, etc.) should now proceed without delay.
- g) There is no need for the moment in further expensive work to reduce the Z/n in the PS.

3. OPTIONS FOR MULTIPULSE FILLING OF THE SPS

W. Hardt has considered some of the factors which should be taken into consideration if one wished to increase the SPS intensity by filling it with several PS pulses. One of them is the ratio of threshold bunch length θ for the longitudinal instability.

$$\theta_{\text{SPS}}/\theta_{\text{PS}} = \frac{(Z/n)_{\text{PS}}}{(Z/n)_{\text{SPS}}} \times \frac{\eta_{\text{SPS}}}{\eta_{\text{PS}}} \times 11 \times \frac{1}{N}$$

where N is the number of PS pulses used to fill the SPS.

With $N = 1$, there is a factor 4.3 (neglecting the injection gap and ignoring the fact that the Z/n is probably different and that the debunching occurs at opposite sides of transition), in favour of debunching in the SPS. With η increase in the PS one still has a factor 1.7 on the SPS side. For a small number of pulses ($N = 2$ or 3) it remains advantageous to debunch in the SPS. Only if a larger number of fillings were contemplated would this instability threshold consideration favour debunching in the PS. On the other hand, the possible gain in intensity per pulse would then be offset by the increased SPS cycle time.

When filling the SPS with several pulses one has to make provision for debunching the injected pulse while avoiding the batch spreading round the circumference. Two schemes can be envisaged :

a) 9.5 MHz holding system

This would require 80 to 100 kV with 9.5 MHz RF in the SPS, depending on the final RF voltage in the SPS. One could imagine using a few spare PS RF cavities to perform this operation, hence avoiding any new hardware procurement. Since they would operate at a fixed frequency no tuning would be needed and ferrite could be removed to relax the biasing requirements. It would be interesting to know what would be the maximum voltage they could provide under these conditions.

Even for single pulse filling of the SPS, a 9.5 MHz cavity in the SPS could be interesting to further reduce the momentum spread of the transferred PS bunches. As stated above for a given possible minimum RF voltage, momentum reduction would be four times more efficient in the SPS than in the PS.

b) 200 MHz suppressed buckets

The SPS RF Group has studied a way to suppress* the RF wave seen by a group of particles circulating on a fraction of the SPS circumference so as to let them debunch. This suppressed bucket scheme only involves low level electronics and does not require any significant additional hardware. Tests have shown that after 1 or 2 μ s the RF field is down to less than 0.5% of its normal level.

c) 200 MHz acceleration in the PS

Most problems would be solved both for single and multipulse filling if the PS could accelerate at 200 MHz from 800 MeV onwards. In fact, machine studies have shown that it would be sufficient to perform the frequency switch in the 2-3 GeV region where debunching and retrapping is still easy and efficient. Further studies would, however, be needed to find the optimum energy which should be as high as possible to minimize the RF frequency swing in the PS.

A minimum of 400 kV of RF voltage at 200 MHz would be necessary requiring at least 2 PS long straight sections. This would, however, be the most expensive alternative requiring several Megafrancs.

d) Other considerations

i) Multipulse filling would require RF information to synchronize the two machines either at 9.5 MHz or at 44 kHz. (A 3/8 Flexwell spare cable is foreseen by C. Beetham, but only up to BA1, see attached memo.)

ii) The SPS injector kicker is not designed for multipulsing. The pulse forming network would need modifications (faster rise time) and the DC charging supply replaced by a more powerful unit capable of faster recharging (1 s instead of 2 s). The cost of this seems however at first sight moderate (a few hundred kFr), compared with the potential intensity increase.

iii) The PS transfer system could work with a 1 sec repetition rate and the fast bumpers are powerful enough to extract the PS beam on any number of turns from 4 to 11.

* This is possible because the SPS accelerating cavities have a travelling wave structure.

e) Provisional conclusions

It was agreed to recommend to postpone any expensive activities (major hardware constructions) related to option for multipulsing until one would have acquired some practical experience with the SPS and to a time when one could more clearly assess the usefulness of higher intensities to the Physics Programme.

Nevertheless if circumstances were favourable (smooth running-in by the end of 1976), one might try out in a study period some of the above discussed schemes with the available hardware to have a better appreciation of its operational feasibility.

4. SPS ↔ CPS TIMING INTERCONNECTIONS

The present arrangements are detailed in the attached memorandum from C. Beetham. Comments or further requests should be made before October 1st.

5. SPS RUNNING-IN SCHEDULE

E.J.N. Wilson circulated the attached present schedule which is only one example of how things could be done, if the present planning holds :

- Magnet installation would be finished by the end of 1975.
- Full ring power tests could take place in January 1976.
- Optimistically the first beam tests might start by the end of March.

There is no request for pulse to pulse change in intensity for the SPS. Warning ahead of time will be given to PS when conditions need to be changed.

No use of a multipulse option is envisaged for 1976.

O. Barbalat

Distribution

Participants

MPS Group Leaders

SPS Management Board

MST, BPC

PSS, EiC

SPS Parameter Section

C. Beetham

D. Fiander

J. Jamsek

C. Mazeline

G.L. Munday

C.J. Zilverschoon

/ed

M E M O R A N D U M

To/A : Mr. J.P. Ruinaud

Copy to/Copie à:
see below

From/De : G. Beetham

Subject/: CPS ↔ SPS Timing Interconnections
Objet

The PS ↔ SPS timing signals are transmitted on two different cables as detailed below :-

1. 3/8 flexwell co-ax. CD50
 - 1.1 50 μsec pre-pulse SPSP
2. 6 pod twisted pair VA24
 - 2.1 PS → SPS
 - 2.1.1 300 msec warning pulse SPSW
 - 2.1.2 2 msec reset pulse SPSR
 - 2.1.3 PS cycle A1
 - 2.1.4 PS cycle A2
 - 2.2 SPS → PS
 - 2.2.1 1 msec SPS clock
 - 2.2.2 SPS Reset
 - 2.2.3 Event codes

In addition this cable contains the long distance General Purpose Multiplexer signals which transmit the computer information from the Injection computer situated in BA1. This replaces the standard computer / computer link originally envisaged.

The program lines are contained in a separate 26 twisted pair cable ND26. The following signals are transmitted via this cable :-

- 3.1 PS → SPS
 - 3.1.1 CPS Ready
 - 3.1.2 CPS Intercom
 - 3.1.3 TT2 safe for access
- 3.2 SPS → PS
 - 3.2.1 Enable PS Ejection (Beam Required)

Three other cables will be laid between BIY and the CPS.

- 4.1 26 Twisted pair ND26 for the SPS Intercom
- 5.1 6 pod VA24 for the TV signals
- 6.1 3/8 flexwell spare. This line could be used to resynchronize the CPS to the SPS during multiplexing.

All the above inter-connections are included in drawing SPS 1153/CO/GB/nm.

The necessary cables will be pulled up to the Y building by B. Sagnell who will also order the cables from the Y building to the CPS.

L. H. Beathorn

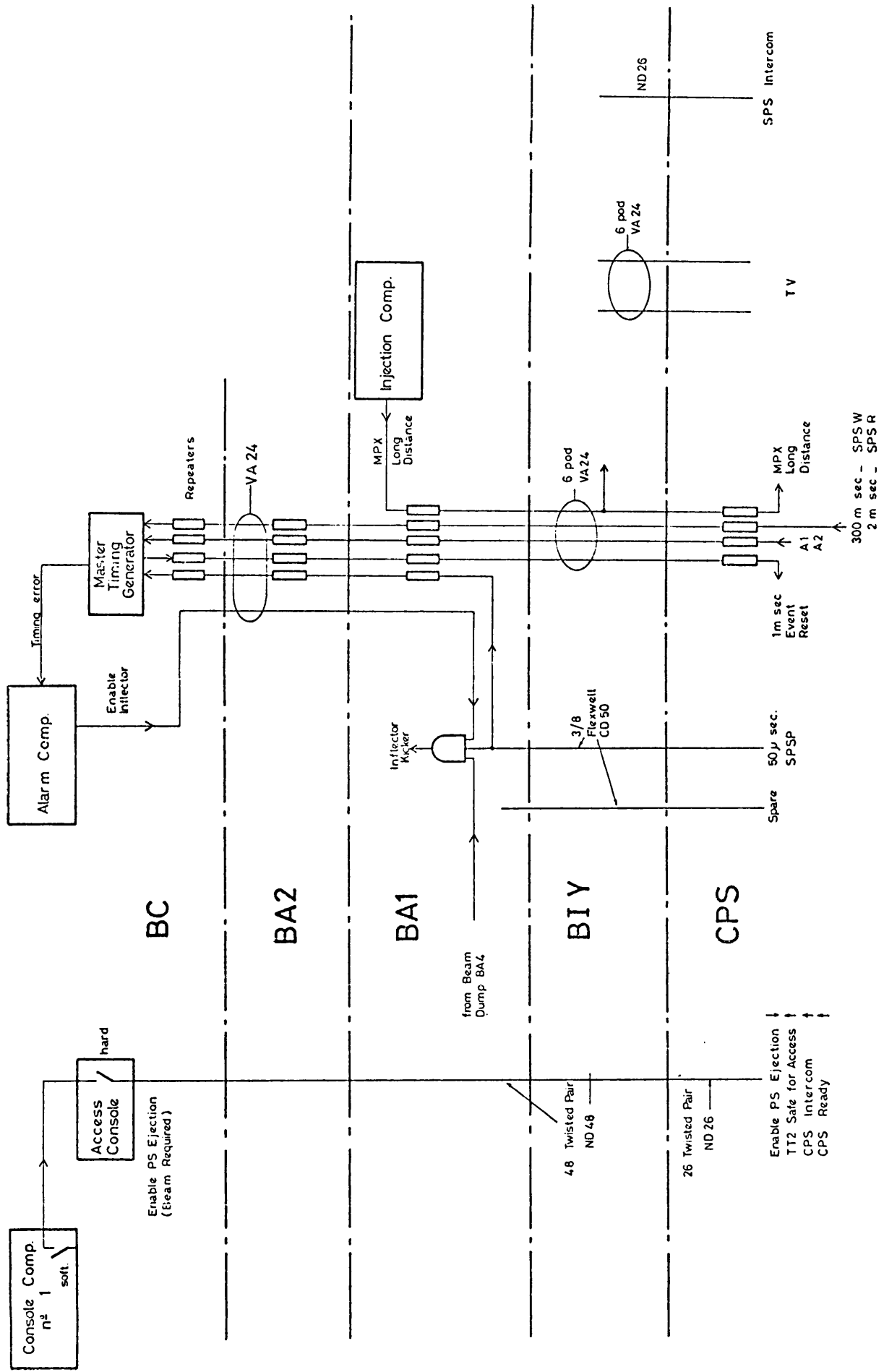
cc Lab II

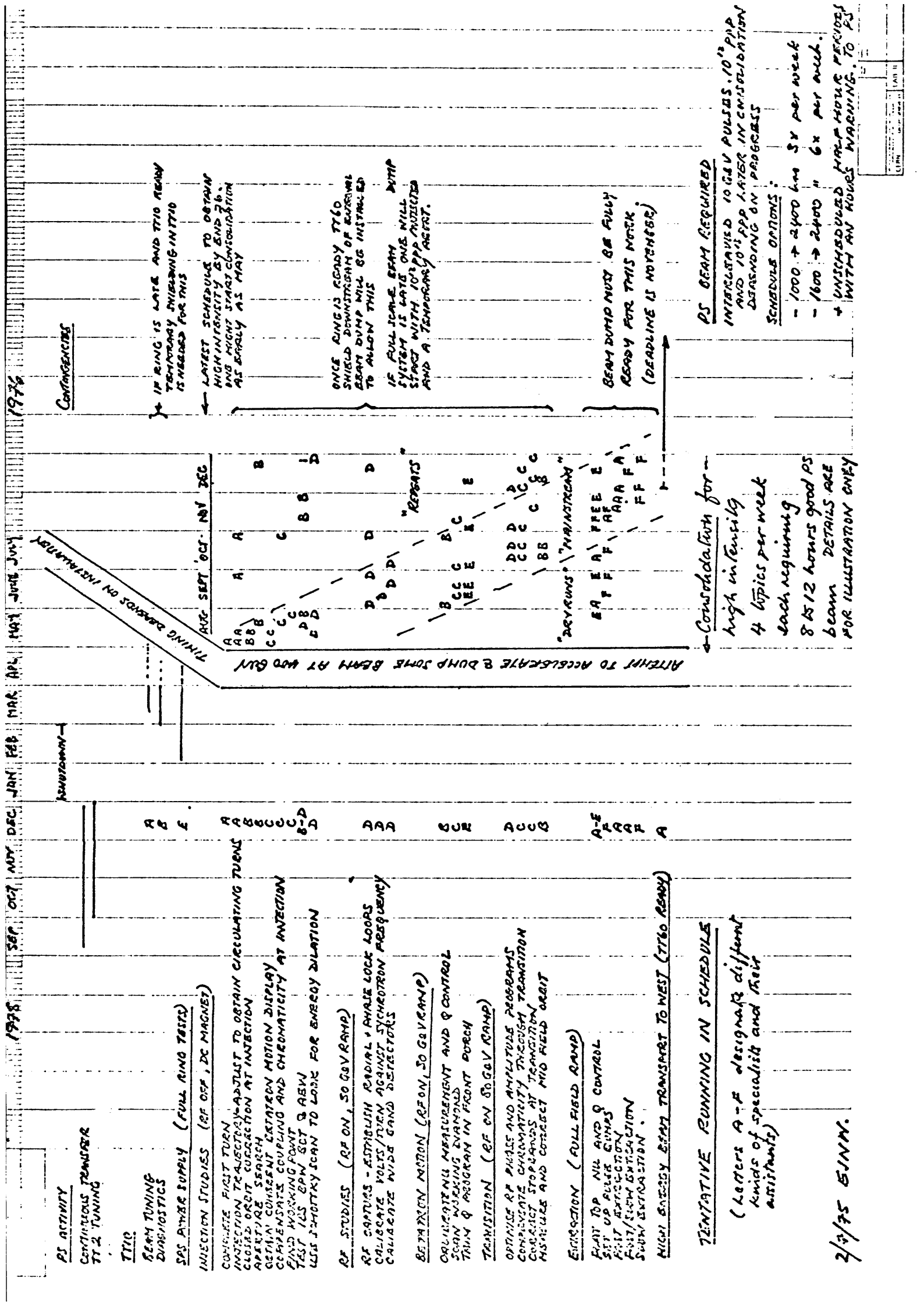
M.C. Crowley-Milling
B. Sagnell
E. Wilson
R. Rausch
M. Cornacchia
P. Faugeras
L. Burnod
J. Bosser

Lab I

J. Boillot
G. Rosset
D. Dekkers
P. Pearce
J. Boucheron
D. Fiander

CPS ↔ SPS Timing and Control Inter-connections





CONTINGENCIES

IF RING IS LATE AND TT10 READY
TEMPORARY SWELDERING INITIO
IS NEEDED FOR THIS

LATEST SCHEDULE TO OBTAIN
HIGH INTENSITY BY END 76.
ONE MIGHT START CONSOLIDATION
AS EARLY AS MAY

ONCE RINGS READY TT60
SHIELD DOWNSTREAM OF EXTERNAL
BEAM DUMP WILL BE INSTALLED
TO ALLOW THIS

IF FULL SCALE BEAM DUMP
SYSTEM IS LATE ONE WILL
START WITH 10% PPA PULSES
AND A TEMPORARY AGEST.

BEAM DUMP MUST BE FULLY
READY FOR THIS MONTH
(DEADLINE IS MOVING)

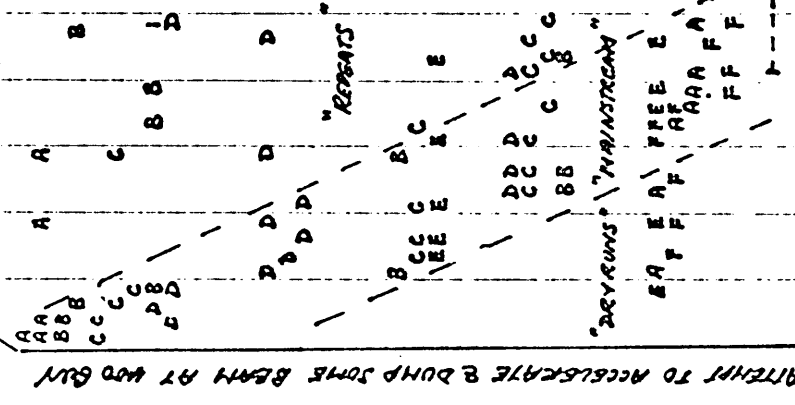
PS BEAM REQUIRED

INTERLAVED 10 GV PULSES 10¹² PPA
AND 10¹² PPA LAYER IN CONSOLIDATION
DEPENDENT ON PROGRESS

SCHEDULE OPTIONS

- 1000 → 2400 km 3x per week
- 1600 → 2400 " 6x per week
- + UNSCHEDULED HALF HOUR PERIODS
WITH AN HOUR WARNING TO PS

NOV SEPT OCT NOV DEC



Consolidation for

- high intensity
- 4 topics per week
- each requiring
- 8 to 12 hours good PS
- beam details are
- FOR ILLUSTRATION ONLY

PS ACTIVITY

CONTINUOUS TRANSFER
TT 2 TUNING

TT10

BEAM TUNING
DINAMISTICS

SPS POWER SUPPLY (FULL RING TEST)

INJECTION STUDIES (RF OFF, DC MAGNET)

COMPLETE FIRST TURN
INJECTION TRAJECTORY ADJUST TO OBTAIN CIRCULATING TURNS
CLOSED ORBIT CORRECTION AT INJECTION
APERTURE SEARCH
OBTAIN CORRECT LATERAL MOTION DISPLAY AT INJECTION
COMPENSATE COUPLING AND CHROMATICITY AT INJECTION
FIND WORKING POINT
TEST 10% EPW SCT & AEW
USE JHOTKY SCAN TO LOOK FOR ENERGY DILATION

RF STUDIES (RF ON, 50 GV RAMP)

RF CAPTURES - ESTABLISH RADIAL & PHASE LOCK LOOPS
CALIBRATE VOLTS/TURN AGAINST SYNCHROTRON FREQUENCY
CALIBRATE WIDE BAND DETECTORS

BEYACON MOTION (RF ON, 50 GV RAMP)

ORBITATIONAL MEASUREMENT AND Q CONTROL
SCAN WORKING ENVELOPE
TUNE Q PROGRAM IN FRONT PORCH

TRANSITION (RF ON 50 GV RAMP)

OPTIMIZE RF PHASE AND AMPLITUDE PROGRAMS
COMPLETE CHROMATICITY THROUGH TRANSITION
CORRECT STOPBANDS AT TRANSITION
MEASURE AND CORRECT MID FIELD ORBIT

EXTRACTION (FULL FIELD RAMP)

FLAT TOP NIL AND Q CONTROL
SET UP FULLER CUMPS
FAST EXTRACTION
FAST EXTRACTION
SLOW EXTRACTION

HIGH ENERGY BEAM TRANSFER TO WEST (TT60 READY)

TENTATIVE RUNNING IN SCHEDULE

(Letters A-F designate different
kinds of specialist and their
assistants)

2/7/75 SJMM.