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THE INJECTION OF THE PSB BEAM INTO THE CPS IN TRANSVERSE PHASE SPACE

(Summary of the results achieved
by the "Transversal" Working Party)

1. Introduction

The "Transversal" Working Party* has been set up in March 1969 to coordinate MPS and SI work on the transverse phase space aspects of the injection of the PSB beam into the CPS. During 8 meetings [1..8] the main parameters have been frozen. This note summarizes the results of the work done, defines the responsibilities and outlines the future work.

2. Injection scheme

The studies were based on the following specifications:

a) In a first stage only single-turn injection of 20 bunches is envisaged, which may be extended to the injection of 2 x 5 vertically combined bunches.
Two-turn injection for which additional hardware is needed may be introduced later in a second stage.

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*) Participants see Appendix.

As a consequence single-turn injection is considered with priority. Some thoughts on two-turn injection, however, are desirable to see its influence on the hardware layout now in order to avoid later modifications [1,2].

b) The transverse emittances of the PSB beam at injection into the CPS [9]:

in horizontal phase plane: $E_H \leqslant 33\,\pi\,10^{-6}$ rad m

in vertical phase plane:

for 20-bunch mode: $E_V \leqslant 12\,\pi\,10^{-6}$ rad m

for vertically combined bunches: $E_V \leqslant 30\,\pi\,10^{-6}$ rad m

c) The momentum spread at transfer (derived from $\Delta E = \pm 970$ kV)[10] :

$$\frac{\Delta p}{p} \leqslant \pm 1 ‰$$

d) The CPS closed orbit [5,8,11] :

horizontal plane:	mean radial position:	$0 \leqslant \overline{\Delta r} \leqslant + 10$ mm
	uncorrected closed orbit:	$\bar{x} \leqslant \pm 10$ mm equ.
		$\bar{x}' \leqslant \pm 10$ mm equ.
vertical plane:	uncorrected closed orbit:	$\bar{z} \leqslant \pm 8$ mm equ.
		$\bar{z}' \leqslant \pm 8$ mm equ.
	for pencil beam:	$\bar{z} \leqslant \pm 30$ mm equ.

e) The injection septum magnet is located in ss 42 [9].

To meet these specifications, the following injection scheme has finally been adopted [8,12] :

Having passed the so-called "injection point" [13,14] at the end of the transfer channel (at the azimuth of the centre of ss 41) the beam enters the stray field of magnet unit 41 through a shielded vacuum chamber [3,15]. A horizontal dipole is provided near the injection point to bring the beam in the wanted position at the septum. The septum magnet in ss 42 and the fast kicker in ss 45 bring the beam on the closed orbit horizontally. Vertical steering is provided by a pair of dipoles near the injection point [14]. The CPS orbit deformation to bring the circulating beam to the septum is produced by 4 bump magnets [12] in ss 40, 42, 43 and 44. In the 20-bunch mode 3-bump magnets may be sufficient. It is therefore agreed to choose the vacuum chamber dimensions as to allow both the 4-bumper and the 3-bumper scheme [8,12,15,16,17,18]. Space for a second fast kicker magnet as required for two-turn injection is provided in ss 45, which is one of 3 possible schemes [2,19,20]. A final choice will be made later, when PSB beam characteristics are known.

3. Hardware specifications and responsibilities

a) Separation of vacuum PSB - CPS [21]

This separation will be done by a vacuum valve supplied by SI immediately upstream MU 41.
Upstream this valve the design of vacuum chambers is SI responsibility (Ch. Rufer), downstream it is MPS responsibility (M. Lebeau).

b) External vacuum chamber in MU 41 [4] Responsible: M.Lebeau /MPS

Inner diameter : 95 mm
Upstream half shielded, shield to be specified by P. Bossard /SI,
From end of MU 41 to tank 42 inner diameter: 80 mm.

c) Special CPS vacuum chambers [8] Responsible: M. Lebeau /MPS

SS 40 : ceramic chamber [3] for bumper

MU 41 :	upstream half	73 + 105 mm
	downstream half	73 + 105 mm, vertically enlarged to > 70 mm at $\Delta r = + 45$ mm
SS 42 :	ceramic chamber for bumper and incoming beam chamber of 80 mm $\emptyset_i$, both connected to special tank housing the septum magnet and a television screen [2,8]	
MU 42 :	upstream half	73 + 105 mm, vertically enlarged to > 70 mm at $\Delta r = + 76.5$ mm
	downstream half	73 + 105 mm
	last 50 cm	80 + 105 mm
SS 43 :		85 + 105 mm, ceramic chamber for bumper
MU 43 :	first 100 cm	80 + 105 mm
	rest of magnet	73 + 105 mm
SS 44 :	ceramic chamber for bumper.	

d) Septum magnet [8,9,22] Responsible: R. Keizer/SI

DC excitation	
total length	700 mm
aperture (width x height)	100 x 60 mm^2
nominal bending angle	60 mrad
maximum bending angle	66 mrad
nominal bending strength	2.9 kGm
septum thickness	6 mm
number of turns	12

e) Power supply for septum magnet [8,22,23] Responsible: B. Godenzi/MPS

DC supply	
nominal current	1800 A
maximum current	2200 A
voltage	55 V
current stability	$\pm 10^{-4}$
resolution of current adjustment	2.5×10^{-4}

f) Tank for septum magnet [2,3,4,8] Responsible: M. Lebeau/MPS

At the downstream end of the magnet a screen with 3 possible positions (out, external and circulating beam) will be placed. The positioning of the magnet is:

radial position: nominal Δr = + 54 mm
range of remote adjustment Δr = + 45 to + 70 mm

angle in horizontal plane: centre of rotation at downstream edge of septum
range of remote adjustment at Δr = + 54 mm
0 to - 20 mrad

vertical position: range of remote adjustment: ± 10 mm

The longitudinal axis of the magnet has to be adjusted during assembly.

Electrical controls of positioning: Responsible: P. Bossard / R. Keizer / SI

g) Bump magnets [8] Responsible: P. Bossard /SI

Maximum gap dimensions (width x height) [24]: 240 x 90 mm^2
length (overall) 200 mm
septum thickness 13 mm
(septum is required because of space limitation in SS 42)

bump strength including 10 % margin:

	mrad	Gm
bumper 40	7.15	349
bumper 42	23.80	1160
bumper 43	22.06	1080
bumper 44	11.56	565

Despite these different bump strengths it should be tried to have one unique type of magnet. Special attention has to be paid to the stray field outside the septum for bumper 42 and to homogeneity of the gap field.

h) Power supply for bumper [2,8] : Responsible ?

There should be individual supplies for each bumper, working on the principle of resonance discharge of a condenser bank with frequencies between 100 and 300 Hz. The voltage should possibly not exceed 500 V to facilitate the insulation of the septum. The maximum repetition rate is 1 s. The negative current half-wave should either pass when no beam is present or should be bypassed by an auxiliary circuit.
The overall stability (amplitude, phase, frequency) should be $\pm 10^{-3}$.

i) Fast full aperture kicker + supply + tank [7,8,9,25,26]

Responsible: A. Brückner /SI
Vacuum: P. Riboni /MPS

Total length of vacuum tank	1070 mm (1080 mm flange)
length of kicker module	266 mm
number of modules	3
aperture (width x height)	150 x 54 mm^2
nominal bending angle	3.7 mrad
maximum admissible* kick	4.4 mrad
nominal bending strength	0.18 kGm
rise time	300 ns
fall time	50 ns
pulse duration	2.5 μs
magnet voltage (nominal)	25 kV
"Line" voltage (nominal)	50 kV
pulse to pulse jitter	< 2·‰
ripple	< ± 2 %

* with some restriction [8]

The power supply and auxiliary equipment will be housed in a barrack on top of the CPS ring.

Responsible: G. Chevallier /SI

j) Modifications of CPS installations [1)]

SS 40 : the high energy quadrupole has to be replaced by a water cooled short quadrupole (space for bumper 40)
Responsible: F. Rohner /MPS

MU 40 : to be changed against a unit with inside yoke
Responsible: F. Rohner /MPS

SS 42 : the beam current transformer has to be removed.
Responsible: S. Battisti /MPS

SS 44 : the sextupole or octupole has to be removed (space for bumper 44)
Responsible: Y. Baconnier /MPS
F. Rohner /MPS

SS 45 : Sextupole and octupole have to be removed (space for kicker)
Responsible: F. Rohner /MPS

k) CPS closed orbit corrections at 800 MeV Responsible: P. Lefèvre /MPS

The existing magnetic corrections at injection are being completed by new elements and modified to adapt the system to 800 MeV.

4. Time Schedule

All the hardware should be ready for installation in the CPS by the end of 1971. Installation will take place during a CPS shutdown starting probably in January 1972. The system has to be operational by July 1972.

5. Open problems

a) Discussion of the injection procedure as proposed by P. Lefèvre [11].
Responsibilities for running-in and operation of injection.

b) Responsibilities for remote control of injection comprising: septum deflection, septum position, kicker deflection and timing, orbit bumps, vertical and horizontal steering magnets, injection timing.

c) Specification of beam observation in the CPS. Responsibilities.

d) Injection timing. Responsibilities.

e) Responsibility for bump supplies.

f) Planning. Responsible: L. Brouwers, U. Jacob.

U. Jacob

Distrubition:

List MPS-SI/2

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APPENDIX

Participants of the Transversal Working Party

A. Ašner	
Y. Baconnier	part time
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P. Bossard	part time
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