D R A F T (Revised)
for internal use only

MPS/EP/64-4
5th March 1964

BEAM WORKING PARTY

FUTURE EQUIPMENT NEEDS

I. INTRODUCTION :

The object of this note is to look at the full exploitation of the present P.S. and halls and what this may require in terms of hardware. We do not consider specialised devices such as new horns, beam guides, superconducting magnets etc. The survey made in the appendix gives some crude pointers on which we base our first tentative recommendations assuming that work and payment are spread over 2-3 years.

II. RECOMMENDATIONS :

A/ Beam Transport :

Quadrupoles (see Asner's note of 24.2.1964)

a) Large Aperture Q's

Required 6 minimum — 400.000.- Fr.

b) Conventional

Required $\sim$ 10 Q 2 — 650.000.- Fr.

c) Ejection Q's

say 6 — 200.000.- Fr.

d) Other Q's (for ejected beams) — 200.000.- Fr.

e) Bending Magnets

These may be divided into conventional and non-conventional (included combined focussing and bending elements).

i) We should aim for 20m of bending power in conventional or semi-conventional magnets — 2.400.000.- Fr.

ii) Combined focussing and bending magnets, the utility of which must be studied — 500.000.- Fr.

iii) Other special magnets : unknown. 600.000.- Fr.
These to include small magnets for ejected beam.

B/ Power supplies - Beam transport :

a) Conventional supplies : 20 twin rectifiers. (1 Twin - 1 type III Generator or 2 type II).
(N.B. This could be too low if the new items are large power consumers). 2.750.000.- Fr.

b) Special, possibly pulsed supplies 500.000.- Fr.
for special magnets, including switching magnet.

C/ Separators and H.T. sets and Accessories :

a) E.S. separators
Modification of existing separators for improved performance. 150.000.- Fr.

b) 15-20m.of separator (possibly new type)
(The type of separator should be investigated in particular for electronics experiment) 1.000.000.- Fr.

c) H.T. Sets and accessories :
5 prs of H.T. sets etc. 750.000.- Fr.

D/ Large power supplies : Assuming that we will have by late 1965 (150.000 to be paid in 1964) 3MW (mobile) of D.C. 500.000.- Fr.
for T.C. use we should aim at a minimum of a further 3 MW.
If large magnets (e.g. of the type now being used or contemplated at Brookhaven) are ordered then we must review our D.C. sources. 650.000.- Fr.

E/ Water cooling :

A mobile supply (perhaps in units that can be separated fairly easily) for at least 6MW but better 7.5 MW is necessary to

match large magnet and beam transport power consumption ;
take 7.5 MW 750.000.- Fr.

F/ A.C. Supplies :

We need 18 KV supplies laid on to each area for the mobile
6 MW supplies: cables and breakers 200.000.- Fr.
(In addition, about IMVA of AC is needed to supply additional beam transport in east area) could be met from amount SB budget.

G/ Shielding :

1) 3.000tons of steel in good form for stacking without serious cracks at 550.-Fr/ton.

say 1.700.000.- Fr.

Total : 13.900.000.- Fr.

III. STAFF REQUIREMENTS :

	Scientific	Technical
a) Beam Transport all items		
Study	4 (1-2 yr.)	3 -4
Tendering and execution	2 yr.	2(1/2 yr.)
b) All Power Supplies (Large and B.T.)		
Study	2 (1 yr)	2(1 yr.)
Tendering and execution		
c) Separators etc.		
Study (Now going on in NPA)	3-4(1.2yr.)	3
Tendering and execution	2 (~1 yr.)	7

d) Water cooling :

Study and tendering	1 yr.	1(1/2 yr.)
execution	By contractor.	

e) A.C. power installations :

Study by S.B.	negligible (1 month)
Execution	Included in price given

Distribution :

M.P.S. Group Leaders
H.G. Hereward
M.G. Hine
K.H. Reich

APPENDIX I

A/ TRACK CHAMBERS :

Assume that it is reasonable to have 3 Track Chamber facilities corresponding to the number of existing chambers (excluding neutrino). This situation already exists in Brookhaven and cannot be considered revolutionary. Some of the suggestions are frankly speculative and would require detailed study : other combinations can be suggested .

Thus we might have either :

Combination I .

Facility No. 1. East Area

a) Ejected beam + R.F. separators

b) Combined high energy plus E.S. beam.

Not running at same time

Facility No. 2 North Hall

- Low momentum K's and $\bar{p}$ s

Facility No. 3 South Hall

Medium momentum k's and $\bar{p}$ s

or Combination II.-

Facilities No 1 and 2

a) Ejected beam : High energy and E.S. beam No. 1 for 2m H.B.C.

b) Ejected beam (same target) + E.S. beam No. 2 for say 80cm H.B.C.

Facility No. 3 North Hall

Low energy K's and $\bar{p}$ s

Combination III.

Facilities No. 1 and 2 . East Area

a) Low momentum k and $\bar{p}$ beam to 2m chamber (transport ejected beam to within $\sim$ 25m of chamber and give it only small percentage of P.S. protons)

b) E.S. separate beam to say 80 cm H.B.C. taking most of the protons on a target near to the machine.

This would require a switching magnet.

c)

Facility No. 3 South Hall

Separated beam of momentum lower than (b)

The requirements are listed (approximately only) in Tables I, II and III.

This in the case of combination one could imagine that, with careful beam design and from time to time some modification, most of the momentum range from say 700 Mev/c to 15GeV/c for K's and $\bar{p}$' s could be obtained.

It is assumed that the 2m H.B.C. is working all or nearly the time (75%) and that for say 30% of the time two or even (15%) three chambers are operating together.

Thus we could have $\sim \leq 5.10^6$ pictures/year of 40 weeks (20 shifts) at average repetition rate of 1 per 2.7 sec and 70 % efficiency, i.e. about twice the output of 1963.

Points to be looked at :

1) Cost of running such a programme in consumable items e.g. Power, film, liquid N_2 and H_2.

2) Analysis facilities in Europe.

B/ ELECTRONIC EXPERIMENTS :

Comments on Wetherell's note of 25.2.1964 (copy attached as Appendix II)

a) Beams a) High energy π in S.H. A second π beam could be made from target 2 if the neutrino experiment disappeared. It seems impossible to add a further beam from target 1.

b) East area beams : g, h, i, j, k : g and h and other variants have been dealt with under Track Chamber requirements. If these exist then one can probably only have i (slow ejected proton) and high energy π or μ beam. The latter is not considered further (it could be the classical channel or a beam guide, see Van Der Meer).

c) Beams e or f of N. H. could presumably be used either by T.C. or by counters. For purposes of estimating beam transport etc. one of these beams (f) is considered as being used by T.C.

d) T.C. is considered as having a branch of beam (h) say, eauivalent to a version of m_4 and this is not counted in the table of beam transport for electronic experiments.

Table IV depicts a rough estimate of the requirements of the hardware required for the Electronics' Beams but excluding the case where the neutrino is absent. As equipment for spectrometers and other special analysing magnets is excluded the estimation is like to be on the low side.

COMMENTS ON THE OVERALL PROGRAMME :

1) Generators :

As to the number of beams running simultaneously and hence the number of generators and rectifiers required it is impossible to predict accurately. However, one can imagine that some of the rather shaky target sharing techniques of today (e.g. one short burst and 3 long burst targets per pulse) will be improved and extended in the course of the next year or two. Moreover generators (for B-T) are at present an important limitation on beam sharing and it is clear than a fairly large increase in the number of rectifiers is necessary for full exploitation of the existing halls.

2) Beam Transport :

a) lenses : If one excludes a conventional muon channel and an additional S.H.

beam the quantities are barely adequate. We can easily be short of about 10 Q2's if we follow what might be the most interesting solution for T.C. (combination I)

There is a need for some (8) large aperture lenses (Ø 30-40cm) for E.S. separated beams and in certain cases with conventional transport systems : see A. Asner's note of 24.2.1964.

G.L. Munday

PS/4298 /hm

APPENDIX II

A POSSIBLE FUTURE BEAM SITUATION FOR ELECTRONIC EXPERIMENTS

South Hall

Beam	Type	D.C. Separated	Numb.	Exists now
a) High-energy π beam ($\gtrsim$ 10 Gev/c)	d	No	2	Yes (1)
b) Medium energy $\bar{p}$, K beam ($\lesssim$ 3 Gev/c)	m	Yes	1	Yes
c) Low-energy π beam ($\sim$ 1 Gev/c)	q	Yes	1	Yes
d) A test beam	s	No	1	Yes
North Hall				
e) Medium energy $\bar{p}$, K beam	m	Yes	1	No
f) Low-energy $\bar{p}$, K beam (1 Gev/c)	k	Yes	1	No
East Area				
Bubble chamber beams				
g)(1) High energy separated	o	Yes and R.F.	1	Yes
h)(2) High energy separated produced fr. fast ejection		R.F.	1	No
Counter beams				
i) slow ejected proton			1	No
j) High-energy π ($\gtrsim$ 10 Gev/c)	d	No	1	Yes
k) High-energy μ beam		No	1	No

the extra beams demanded by this list are

(1) 2 high-energy π beams

(2) A medium energy separated $\bar{p}$, K beam

(3) A new separated low-energy $\bar{p}$, K beam

(4) The slow extracted proton beam

(5) A high-energy μ beam.

These may be regarded as interim improvements, if it proves technically possible to put into operation long pulse R.F. particle separation the higher energy D.C. separated beams would be changed in this way.

New experimental area :

1) A fast extracted beam area for ν experiments and the μ storage ring

2) A general area built so as to be able to use internally produces beams but with the possibility of using slow extraction for external production in special cases.

A. M. Wetherell

- GLOSSARY -

Q 30	30 cm length	lens.	Standard
Q 50	50 cm	lens.	Standard
Q 75	75 cm	lens.	figure of eight
Q 1	1m	lens.	standard
Q 150	1,50m	lens.	split pole
Q 2	2m	lens.	Standard
Q_E	ejection type lens.		high gradient
M_E	Magnets for ejected beam - small aperture		
M 1	1 m	)	
		)	Magnets standard or slim
M 2	2 m	)	
E.S. 3m	3 m	Electrostatic separator N.P.A.	
E.S. 6m	6 m	E.S. composed of two of above (N.P.A.)	
E.S.10m	10 m	E.S. separator N.P.A.	
H.T. pos.		600 Kv H.T. complete with accessories.	

TABLE I

T. C. COMBINATION I.

Beam / Element	East Area Facility No. 1 a	East Area Facility No. 1 b	South Area Facility No. 2	South Area Facility No. 3	Max. Total(33) Gen. used. S.A.	Δ S. A.	Max. Total(28) E.A.	Δ E.A.	Recti-fiers	total needed	total availa-ble	Δ For NP	REMARKS
Q 30				5						5	6	1	Equipment likely to be
Q 50				2						2	16	14	available early 1965
Q 75										-	(6)	(6)	
Q 1	4	7	9							20	42	22	
Q 150										-	(6)	(6)	
Q 2	17	7								24	26	2	
M 1	2	2		2						6	13	7	
M 2	4	6	4							14	28	14	
Q_E	3									3	6	3	
M_E	4									4	8	4	
E.S 3m	-			1						1	2	1	
E.S. 6 m.	-			1						1	1	0	
E. S. 10m.	-	3	2							5	5	0	
H.T.600kv prs.	-	3	2	2						7	6	-1	
R.F. Sep.	3									3	2/3	0,	
Generators	25	20	15	10	25	+ 8	25	+ 3	20				
Special Shielding	No	No	No	No									

PS/4298

TABLE II

T. C. COMBINATION II .

Beam / Element	East Area Facility Nol,2 a	East Area Facility Nol,2 b	South Area Facility No. 3		Max. Total(33) Gen.used S.A.	△ South Area	Max. Total(28) E.A.	△ E.A.	Recti-fiers	Total needed	Total avai-lable	△ For NP	REMARKS
Q 30			5							5	6	1	Equipment likely to be
Q 50			2							2	16	14	available early 1965
Q 75										-	(6)	(6)	
Q 1	7	9								16	42	26	
Q 150										-	(6)	(6)	
Q 2	7									7	26	19	
M 1	2		2							4	13	9	
M 2	6	5								11	28	17	
Q E	3									3	(6)	(3)	
M E	4									4	(8)	(4)	
E.S. 3m.			1							1	2	1	
E.S. 6m.			1							1	1	0	
E.S. 10m.	3	2								5	5	0	
H.T.600kv prs	3	2	2							7	6	-1	
R.F.Sep.	-									-	2/3	2/3	
Generator	23	16	10		10	23	39	-11	20				
Special Shielding	No	No	No										

TABLE III

T.C. COMBINATION III.

Beam / Element	East Area Facility No. 1	East Area Facility No. 2	South Area Facility No. 3	Max Total(33) Gen.S.A.	Δ S.A.	Max Total(28) Gen.E.A.	Δ E.A.	Recti-fiers	Total needed	Total avai-lable	Δ For NF	REMARKS
Q 30	5								5	6	1	Equipment likely to be
Q 50	2								2	16	14	available early 1965.
Q 75									-	(6)	(6)	
Q 1	6	9	9						24	42	18	
Q 150									-	(6)	6	An extra 3 MW and appro-
Q 2	3	4							7	26	19	priate water cooling
M 1			1						1	13	12	(3MW chamber + ~ 1 MW
M 2	4	6	3						13	28	15	beam transport) is re-
Q_E	3								3	6	3	quired.
M_E	4								4	8	4	This can probably be
E.S. 3 m.	1								1	2	1	met from 1964/1965
E.S. 6m.	1		1						1	1	0	budget and is not consi-
E.S. 10 m.	-	2	2						4	5	1	dered further.
H.T.600kv prs	2	2	2						6	6	0	
R.F. Sep.	-		-						-	-	-	
Generator	20	20	15	15	+ 18	40	- 7	20				
Special Mag.	Yes								1	0		
Special Shielding	Yes	Probably No	No									

PS/4298