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FURTHER THOUGHTS ON THE CORRECTION MAGNETS FOR THE PSB

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1. Introduction

The choice, location and performance specification of these magnets have been discussed previously[1] and that report is still essentially valid[*]. However, the results of measurements of the prototype bending magnet and quadrupoles[2] and of further computations of stop-band width[3] lead to the following modifications of the original proposal.

2. Skew quadrupoles

In addition to the perturbations considered previously[1] (main quadrupoles, earth magnetic field, etc.), two further sources of unavoidable squew quadrupole fields have to be taken into account.

Firstly, any lack of symmetry with respect to the median plane in the position of the excitation coils of the (window-frame) main magnet introduces a field component $\partial B_z/\partial z$ (i.e. B_z depends on vertical position, see Ref. 2, Figs 9 to 16). With a tolerance of ± 0.2 mm on the coil positions it is hoped not to exceed

$$\frac{1}{\bar{B}_z} \frac{\partial B_z}{\partial z} = 3 \times 10^{-3}/\text{m}$$

over the useful aperture[4]. The r.m.s. value for all magnets would presumably be smaller, but as systematic production errors are not necessarily excluded, we base ourselves on the above value, i.e. 1.8×10^{-3} T/m at 800 MeV. Hence,

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*) (Minor) corrections are as follows:

- on page 5: read $\delta Q_H = 0.0063 \quad \delta Q_V = 0.019$
- on page 7 after Eq. 4: replace "simultaneously" by "with the same current but of opposite sign"
- on page 10, in Eq. 9: replace ΔQ_V by ΔQ_H and $z_{co}^2 - x_{co}^2$ by $2\beta\gamma(z_{co}^2 - x_{co}^2)$
- on page 11: read $\Delta Q_H = 0.008 \quad \Delta Q_V = 0.05$.

for compensation, we need approximately a gradient of

$$\frac{N_B \times L_B \times 1.8\ 10^{-3}}{N_{SQ} \times L_{SQ}} = \frac{32 \times 1.62 \times 1.8\ 10^{-3}}{8 \times 0.31} = 0.038\ \mathrm{T/m}\ .$$

Secondly, the lack of symmetry of the coil ends at the connection side of the main quadrupoles introduces a field perturbation which also contains a substantial skew quadrupole term[5]. After some studies made with K.H. Schindl (using the modified computer program simulating the beam behaviour in the PSB[6]) a reduction by a factor of about 6 can be obtained if the connections are suitably shifted from upstream to downstream (on the D quadrupoles per every two periods, for two periods, see Fig.). Thus, the effectively remaining skew gradient to be compensated is small (several 10^{-3}T/m).

In view of these new requirements it is proposed to provide the same excitation current for all skew quadrupoles and to standardize on the supply already planned for the "ninth harmonic" skew quadrupoles[7], giving a maximum gradient of 0.06 T/m for the zeroeth harmonic elements.

3. Sextupoles and octupoles

Numerical evaluation of the stopbands created by these correction elements showed that they were above the tolerance level[3], in particular the third order stop bands due to the combination of octupole lens-to-lens jitter and closed-orbit harmonics. As one could neither guarantee better fabrication tolerances on these air-core elements[8] nor a perfect orbit correction[9], it was decided to add a complete set (i.e. sin and cos pairs) of sextupole and octupole lenses to the existing quadrupoles in L1-type straight sections. One pair of lens units was shifted to the position shown in the figure in periods 3 and 11 to obtain simultaneoulsy the possibility of compensating the 9th gradient harmonic, the 14th sextupole harmonic and the 19th octupole harmonic*).

Though already stated previously[1] it is probably worth repeating that these lens units have to be considered as experimental tools, rather than as PSB components with a quantitatively specified task like e.g. the main bending magnets. In the course of running in and optimising the PSB it may well turn out that more, or differently located units are needed - or that less compensation is called for. In this spirit a single skew combination lens (quadrupole, sextupole, octupole) will be added for experimentation (not shown in the figure) as the "skewing" of the "normal" units turned out to be somewhat more difficult than anticipated.

4. Alignment tolerances for correction elements

Alignment errors of the orbit-correcting dipoles and of the multipole lenses create extra orbit deformations and alignment errors of the multipoles widen the stop bands (in combination with closed orbit errors). Using the same techniques as for arriving at the tolerances for the main bending magnets and quadrupoles, the following values were specified:

Correction dipoles	no special precaution	(alignment to about 1 mm)
Ejection dipoles	precision alignment but with relaxed tolerances	(to a few tenth of a millimetre)
Multipole lens units (and p.u. stations)	standard precision alignment in H and V planes	(0.05 mm r.m.s.)

5. Power supplies

The simplified power supplies and controls (see Ref. 1 Add. 1) used

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*) To obtain a phase-adjustable harmonic p the separation between the two lenses of a given pair has to fulfil the relation

$$\Delta\Theta_1 = \frac{m_1 \pi}{p} \quad \text{(same sign of excitation current for } m_1 \text{ even)}$$

and the separation between pairs

$$\Delta\Theta_2 = \frac{m_2 \pi}{2p} \quad \text{with } m_2 \text{ odd.}$$

for the dipoles serve also as model for most of the other supplies (i.e. common large rectifier equipped with many transistor current regulators in parallel). The proposal by B. Godenzi[7] meets all initial needs, provided the option of 30 A is selected for the zeroeth harmonic skew quadrupoles.

Distribution (open)

List MPS-SI/2

REFERENCES

1. C. Bovet and K.H. Reich, Correcting magnets for the PSB: their choice, location and performance specifications, CERN/SI/Int. DL/69-3.and Add. 1.

2. M. Giesch, K.D. Lohmann and G. Schnell, Summary of first measurements on the bending magnet prototype, CERN/SI/Note MAE/69-16.

3. G. Guignard, Résonances des oscillations transverses dues aux champs multipolaires avec application au PSB, CERN/SI/Int. DL/70-3.

4. M. Giesch, Field errors in the booster bending magnets and quadrupoles and possible compensation methods, CERN/SI/Int. MAE/69-3.

5. F. Schaeff, Private communication.

6. C. Bovet and K. Schindl, PSB emittance blow up in non-linear fields, CERN/SI/Int. DL/70-4.

7. B. Godenzi, Proposition pour l'alimentation des éléments de correction du PSB, MPS/ED - Note/70-2.

8. M. Giesch, Design of the PSB correcting lenses (multipoles), SI/Note - MAE/70-3.

9. G. Guignard, Méthode et simulation numériques de la correction d'orbite fermée avec application au PSB, CERN/SI/Int. DL/70-2.

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	B1		QF1		QD		QF2		B2
L1		L2		L3	U D	L4		L5	
1 T.D | DH DV | 1PI + 2.PS I-SH | TV o	CB 3mm Special	o		M o	QD.U	ID		PG ø	
2 I-KF | I-D PI				M o	QD.U	DH DV		PI	
3 1,09 m M S PG				M o	QD.D	DH DV		PI	
4 PI					QD.D	DH DV		PG	
5 ø (RFC)		PI		M o	QD.U	DH DV		PI	
6 Reserved for gas curtain PI				M o o	QD.U	DH DV		PI	
7 R4 IBS-Special + PI / R1-R3 IBS-Normal PG				M o	QD.D	DH DV		PI	
8 M S | TR ø PI ø					QD.D	DH DV		PI	
9 TA PG				M o	QD.U	DH DV		PI	
10 PI				M o o	QD.U	DH DV		PI	
11 1,09 m M S | DH DV PG		PI ø		M o	QD.D	DH DV		PI	
12 KQ PI					QD.D	DH DV		PG	CB with special RF Connection
13 RFC	CB with special RF Connections	PI		M o	QD.U	DH DV		PG	
14 DH DV | 1.PI + 2.PS EK				M o	QD.U	EDø		PG	Special CS 3mm
15 1.PI + 2.PS TV | E-S | DH DV | E-D	BS Special			M o	QD.D	ED		PI	
16 M S | DH DV PI					QD.D	ID		PG	BS CB 3mm with special 1L1

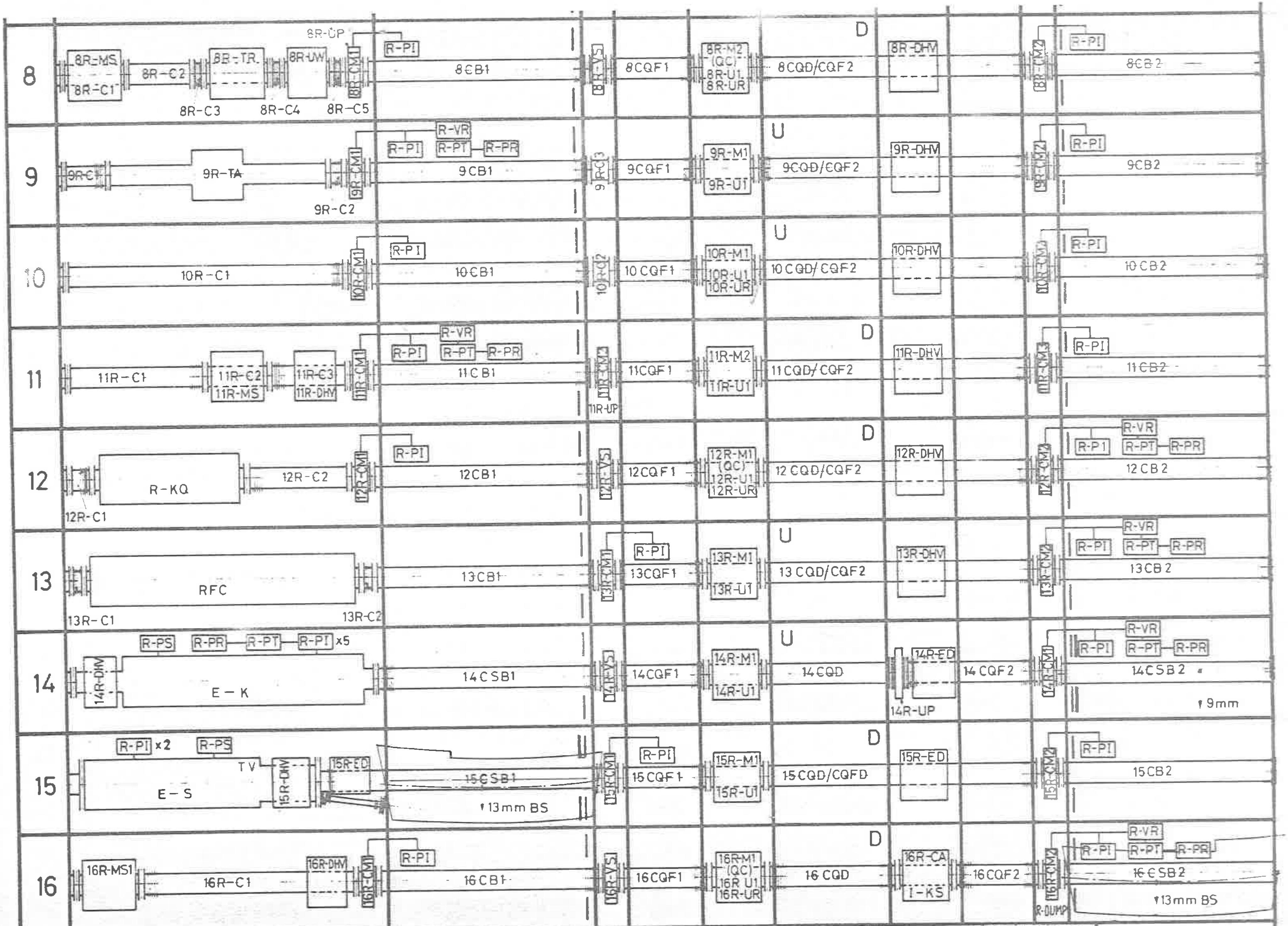
(FOR ABBREVIATIONS SEE SI/NOTE ME/69-31)

o PICK UP ELECTRODE
o RADIAL CONTROL ELECTRODE
|ø| PHASE ELECTRODE INCLUDING MANIFOLD
ø WIDE BAND ELECTRODE

IN P.S.13

BEAM STOPPER
BEAM SCRAPER
SECTOR VALVE
MANIFOLD

SI.1.40.1020.41



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" SPECIAL

LAYOUT OF VACUUM SYSTEM & BEAM TRANSPORT SYSTEM - P.S.B.
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