PS/ACOL/Note 84-22 20 February 1984
LR/afm

ACOL MAGNETS WITH REFERENCE TO LATTICE No. 84-05

L. Rinolfi

Introduction

In order to find a solution for the injected/ejected beam, to simplify the design and reduce the total cost, the following changes have been decided:

- Build 2 types of dipole: BHN (narrow) and BHW (wide).
- All semi-quadrupoles (QS) have been converted into narrow quadrupoles (QN) except those two involved in the injection region (QDS 53 and QFS 54). These QN will be displaced in order to get the right bending angle.

The consequence is a small increase of the aperture of the QN in order to accept the beam in the previous QS regions. The aperture of the wide quadrupoles (QW) remains the same.

All sextupole magnets have been removed for chromaticity corrections. Consequences are:

i) Build sextupole components ~~in~~ into the profile of all QW's.

ii) ~~However~~, all PU electrodes ~~can remain~~ could be in defocusing quadrupoles~~, if necessary~~.

iii) The narrow QFN 6 (and symmetrics) becomes a wide QFW 6 because a sextupole component is needed at this location to get symmetric orbit throughout the $\Delta p/p = \pm 3\%$ and minimize the orbit distortions in the regions $\alpha_p = 0$.

Figure 1 shows the present ACOL layout.

Lattice

Annex 1 gives the optic parameters retained for the present lattice (84-05) and completed by B. Autin.

Geometry

Table 1 gives the geometry of the machine from the AGS program. The distance between ACOL axes and AA axes at injection region is 1.7855 (m).

Dipoles

Table 2 gives the characteristics for both types (BHN and BHW). No sextupole component will be built either in the pole or at the ends. Only shimming will be done ~~at the end~~ for small corrections. No prototype will be built for these 2 families.

Figure 2 shows the pole profile of a narrow dipole and Fig. 3 ~~shows the pole profile~~ of a wide one.

A spare coil for each type of dipoles will be built.

The field precision $\Delta B/B$ should be $\pm 2 \times 10^{-4}$ in the good field region. However, the spread $\Delta B/B$ over the 24 dipoles should be less than 10^{-4}.

At the ~~energy~~ p = 3.5752 GeV/c, the rigidity value is $B\rho$ = 11.9255835 Tm.

Table 2 - Dipole Parameters

		BHN	BHW
Number		8	16
Field	(T)	1.502	1.583
Effective length	(m)	1.9513	1.8513
Field × Eff. length	(Tm)	2.93131	2.93131
Bending radius	(m)	7.93857	7.53173
Deflection angle	(rd)	0.2458	0.2458
Gap height	(mm)	±50	± 58
Good field width	(mm)	147 + 60	±180
Good field height	(mm)	±45	± 52
Sagitta	(mm)	±30	± 28.4

*** ACOL RING LATTICE – VERSION 84.05 ***

WEDGE MAGNETS
X-, Y-COORDINATES OF THE EXITS OF THE ELEMENTS
THE ENTRANCE OF THE FIRST ELEMENT IS AT X = 0, Y = 0
PHI IS THE ANGLE BETWEEN THE ORBIT AND THE X-AXIS
PHI = 0 AT THE BEGINNING

NO	NAME	LENGTH	ANGLE	K(V)	X	Y	PHI
1	QDN1	.3500	0.00000	.5800000	.350000	0.000000	0.000000
2	SS	2.6000	0.00000	0.0000000	2.950000	0.000000	0.000000
3	QFN2	.7000	0.00000	-.5800000	3.650000	0.000000	0.000000
4	SS	2.6000	0.00000	0.0000000	6.250000	0.000000	0.000000
5	QDN3	.7000	0.00000	.5800000	6.950000	0.000000	0.000000
6	SS	2.5000	0.00000	0.0000000	9.450000	0.000000	0.000000
7	QF*4	.7000	30.00000	-.5500000	10.149895	.010499	.030000
8	SS	2.5000	0.00000	0.0000000	12.648770	.085488	.030000
9	QD*5	.7000	18.00000	.5152200	13.348228	.112781	.048000
10	SS	.4250	0.00000	0.0000000	13.772739	.133173	.048000
11	BHN1	1.9513	245.80000	0.0000000	15.690776	.464194	.293800
12	SS	.4000	0.00000	0.0000000	16.073636	.580031	.293800
13	QFW6	.7500	0.00000	-.4457000	16.791498	.797224	.293800
14	SS	.4500	0.00000	0.0000000	17.222216	.927541	.293800
15	BHW2	1.8513	245.80000	0.0000000	18.910841	1.674960	.539600
16	SS	.4500	0.00000	0.0000000	19.296903	1.906167	.539600
17	QDW7	.7500	0.00000	.4905500	19.940338	2.291512	.539600
18	SS	1.8500	0.00000	0.0000000	21.527480	3.242029	.539600
19	QFW8	.7500	0.00000	-.5428100	22.170915	3.627373	.539600
20	SS	.4500	0.00000	0.0000000	22.556977	3.858580	.539600
21	BHW3	1.8513	245.80000	0.0000000	24.012975	4.994431	.785400
22	SS	.4500	0.00000	0.0000000	24.331173	5.312630	.785400
23	QDW9	.7500	0.00000	.3863100	24.861502	5.842961	.785400
24	SS	.4500	0.00000	0.0000000	25.179699	6.161160	.785400
25	BHW4	1.8513	245.80000	0.0000000	26.315546	7.617163	1.031200
26	SS	.4500	0.00000	0.0000000	26.546751	8.003225	1.031200
27	FW10	.7500	0.00000	-.5428100	26.932093	8.646662	1.031200
28	SS	1.8500	0.00000	0.0000000	27.882604	10.233807	1.031200
29	DW11	.7500	0.00000	.4905500	28.267946	10.877244	1.031200
30	SS	.4500	0.00000	0.0000000	28.499152	11.263306	1.031200
31	BHW5	1.8513	245.80000	0.0000000	29.246565	12.951934	1.277000
32	SS	.4500	0.00000	0.0000000	29.376880	13.382652	1.277000
33	FW12	.7500	0.00000	-.4457000	29.594071	14.100516	1.277000
34	SS	.4000	0.00000	0.0000000	29.709906	14.483376	1.277000
35	BHN6	1.9513	245.80000	0.0000000	30.040920	16.401414	1.522800
36	SS	.4250	0.00000	0.0000000	30.061311	16.825925	1.522800
37	D*13	.7000	18.00000	.5152200	30.088601	17.525383	1.540800
38	SS	2.5000	0.00000	0.0000000	30.163581	20.024258	1.540800
39	F*14	.7000	30.00000	-.5500000	30.174077	20.724153	1.570800
40	SS	2.5000	0.00000	0.0000000	30.174068	23.224153	1.570800
41	DN15	.3500	0.00000	.5800000	30.174067	23.574153	1.570800

THE COORDINATES OF THE MACHINE CENTRE ARE X = 3.300000, Y = 26.874055

MAXIMUM RADIUS = 30.128811

MINIMUM RADIUS = 26.876334

Table 1

Quadrupoles

Table 3 gives the characteristics for both types (QN and QW). Figure 4 shows the QN profile. Figures 5 show the QFW profile with sextupole components and beam sizes. Figures 6 show the QDW profile with sextupole components and beam sizes.

No prototype will be built for these 2 families. A spare quadrupole of each type will be built.

The two semi-quadrupoles at injection are under study.

Table 3 - Quadrupole Parameters

			QN	QW
Number			26	28
Strength	max.	(m^{-2})	0.58	0.54281
Gradient	max.	(T/m)	6.92	6.47
Effective length		(m)	0.7	0.75
Gradient × eff. length		(T)	4.84	4.85
Inscribed circle radius		(m)	0.110	0.132
Good field width		(mm)	±130	±160
Good field height		(mm)	± 60	± 60

The gradient precision $\Delta G/G$ should be $\pm 2 \times 10^{-3}$ in the good field region.

Table 4 gives the distribution of quadrupoles in focusing and defocusing families, assuming same current in each family.

Table 5 gives the distribution after an optimization of the number of turns. The ~~differences~~ consequences are:

i) inscribed circle radius for QW = 133.01 mm.

ii) quadrupoles ~~into circles~~ incircled will have shunts for ~~final~~ fine adjustments.

iii) a separate power supply will feed current in the QFN_4 and QDN_5 in series.

Quadrupole distribution (1)

	QF				
	QFN		QFW		QFS54
	QFN_2	QFN_4	QFW_6	QFW_8	
l_{eff} (m)	0,70	0,70	0,75	0,75	0,70
K (m^{-2})	-0,58	-0,55	-0,4457	-0,54281	-0,55
$\delta = K \cdot l_{eff}$	-0,406	-0,385	-0,33427	-0,4071	-0,385
r (mm)	110	110	132	132	127
G (T/m)	6,92	6,56	5,31	6,47	6,56
B_{pole} (T)	0,76	0,721	0,701	0,854	0,83
n (turns)	19	18	(21,3)	(25.6)	24
N (number of magnets)	4	7	8	8	1

	QD				
	QDN		QDW		QDS53
	QDN_1	QDN_5	QDW_7	QDW_9	
l_{eff} (m)	0,7	0,7	0,75	0,75	0,7
K (m^{-2})	0,58	0,51522	0,49055	0,38631	0,51522
$\delta = K \cdot l_{eff}$	0,406	0,3606	0,3679	0,2897	0,3606
r (mm)	110	110	132	132	110,4
G (T/m)	6,92	6,14	5,85	4,60	6,14
B_{pole} (T)	0,76	0,67	0,77	0,60	0,67
n (turns)	19	(16,8)	(23,5)	(18,5)	17
N (number of magnets)	8	7	8	4	1

Table 4

Quadrupole distribution (2)

	QF				
	QFN		QFW		QFS54
	QFN_2	QFN_4	QFW_6	QFW_8	
l_{eff} (m)	0,70	0,70	0,75	0,75	0,7
K (m^{-2})	−0,58	−0,55	−0,4457	−0,54281	−0,55
$\delta = K \cdot l_{eff}$	−0,406	−0,385	−0,33427	−0,4071	−0,385
r (mm)	110	110	133,01	133,01	126,17
G (T/m)	6,92	6,56	5,31	6,47	6,56
B_{pole} (T)	0,76	0,721	0,701	0,854	0,83
n (turns)	19	19	22	26	25
N (number of magnets)	4	7	8	8	1
I (A)	1752,6	1662	1752,6	1752,6	1662

	QD				
	QDN		QDW		QDS53
	QDN_1	QDN_5	QDW_7	QDW_9	
l_{eff} (m)	0,7	0,7	0,75	0,75	0,7
K (m^{-2})	0,58	0,51522	0,49055	0,38631	0,51522
$\delta = K \cdot l_{eff}$	0,406	0,3606	0,3679	0,2897	0,3606
r (mm)	110	110	133,01	133,01	110,6
G (T/m)	6,92	6,14	5,85	4,60	6,14
B_{pole} (T)	0,76	0,67	0,77	0,60	0,67
n (turns)	19	18	24	19	18
N (number of magnets)	8	7	8	4	1
I (A)	1752,6	1662	1752,6	1752,6	1662

Table 5

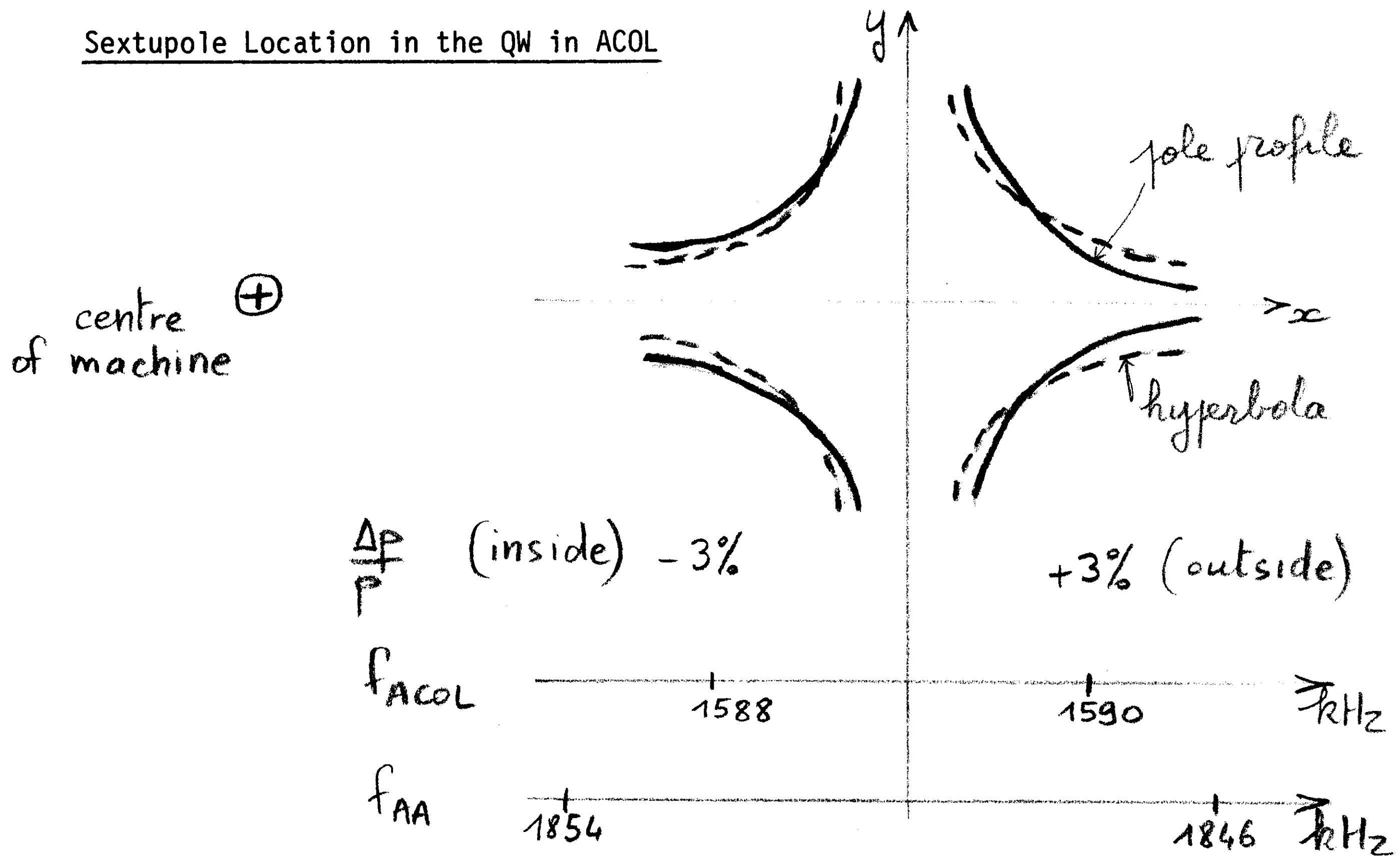


Figure 7

For each QW in ACOL the narrower gap is situated towards the outside of the machine.

Permeability

Figure 8 shows the permeability curve used by RAL and CERN.

Magnet Sizes

Table 6 below gives a rough approximation of magnet dimensions.

Table 6

		BHN	BHW	QN	QW
l_{eff}	(m)	1.9513	1.8513	0.700	0.750
l_{Fe}	(m)	1.812	~~1.69~~ 1,765	0.60	0.64
Overall length	(m)	~~2.4~~ 2,2	~~2.2~~ 2,140	0.84	0.85
Overall width	(m)	~~1.0~~ 1,4	~~1.9~~ 2,050	1.10	1.4
Overall height	(m)	~~1.0~~ 1,15	~~1.5~~ 1,215	1.10	1.3

β Variations across Aperture

Figure 9 shows the β variations with momentum according to the results from ORBIT program (B. Autin). These variations are plotted in one dipole (BHN1) and in one qudrupole (QFW6). The maximum $\Delta\beta/\beta$ is 18%.

Figure 10 shows the η variations with momentum and Figure 11 gives the Q_H, Q_V variations with momentum.

Bean Monitoring

It is possible to put PU electrodes in each focusing quadrupole except in QFS 54. ~~A new study will be made by H. Koziol.~~

Vacuum Chambers

Figures 2 to 6 show possible vacuum chambers. An updated design will be done by F. Malthouse ~~and R. Bennett (RAL)~~.

Power Supplies

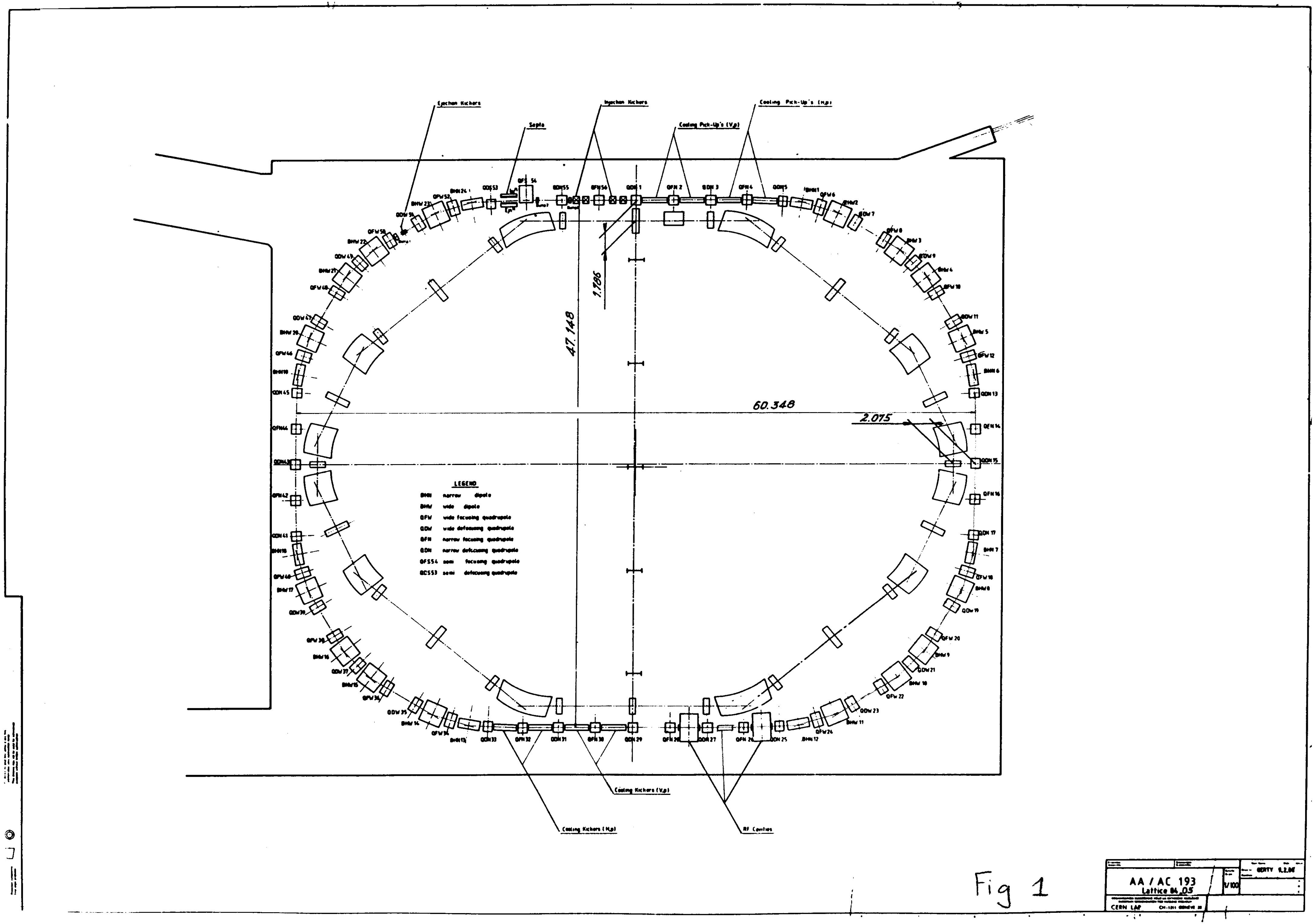
For dipoles, a main power supply will be necessary along with a trim power supply. For quadrupoles, two main power supplies (~2000 A each) for QF and QD. Another main power supply (~2000 A) will feed current in all the QFN's and QDN's which are displaced in the machine.

~~According to the solution found~~ for QDS 53 and QFS 54, two small trim power supplies (~50 A) may be necessary.

All adjustments will be done by ~~changing~~ the number of turns on requested quadrupole families. The final adjustments will be made by small shunts and/or shims.

In the long term, the necessity to put small sextupole magnets in the machine for resonance corrections will be studied. If they are needed, two more small power supplies would have to be built.

An updated proposal will be made by F. Völker.



Ejection Kickers
Septa
Injection Kickers
Cooling Pick-Up's (V,p)
Cooling Pick-Up's (H,p)
Cooling Kickers (V,p)
Cooling Kickers (H,p)
RF Cavities
47.148
1.786
60.348
2.075
LEGEND
BHN narrow dipole
BHW wide dipole
QFW wide focusing quadrupole
QDW wide defocusing quadrupole
QFN narrow focusing quadrupole
QDN narrow defocusing quadrupole
QFS54 semi focusing quadrupole
QDS53 semi defocusing quadrupole
AA / AC 193
Lattice 84.05
1/100
CERN LAP

Fig 1