EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN - PS DIVISION

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PARAMETER LIST

for the

ANTIPROTON ACCUMULATOR COMPLEX

(AAC)

Edition 1994

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CONTENTS

INTRODUCTION

Genealogically, the present AAC Parameter List, edition 1994, is the descendant of AA Parameter List, 10th edition, August 1984, and ACOL Parameter List, 3rd edition, June 1985.

Since these last editions, the AC was constructed and brought into operation. Its design values are replaced by those used in practice. The AA was modified, to function together with the AC. This concerned mostly the aperture, which was reduced, and the stochastic cooling, enhanced to cope with a tenfold increase in antiproton flux.

A new parameter list, for the entire AAC, was due since long. We are glad to finally be able to offer it. Recto-only printing was chosen so as to leave ample space for annotations by the users for their personal updating and completion.

NOMENCLATURE

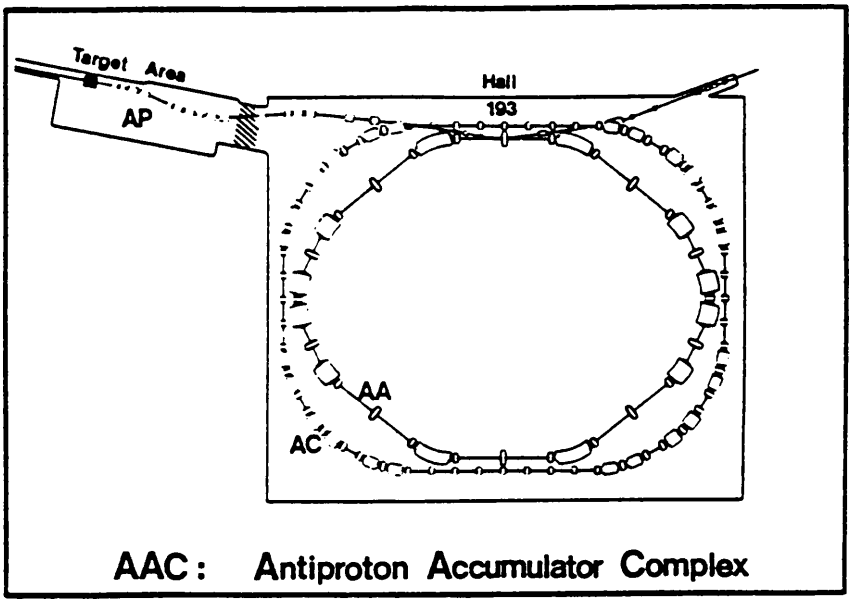
It is still worth clarifying the correct use of the terms AAC, AP, AA, AC and ACOL. The following is the nomenclature introduced in 1987 by the late E. Jones, then AA Group Leader and ACOL Project Leader.

In the beginning, 1980, there was the Antiproton Accumulator, or AA. The antiprotons were produced in the Target Area and transported to the Hall, in which the AA was, and still is, located.

Then ACOL was launched in 1984. ACOL is not a machine, it was a project with three branches:

- Construction of an Antiproton Collector, or AC, around the AA.
- Modification of the AA, to cope with the higher antiproton flux.
- Upgrade of the Antiproton Production, or AP.

ACOL is a thing of the past, the project ended in June 1987. The result was a new facility, the Antiproton Accumulator Complex, or AAC. It consists of 3 functional parts, in 2 geographical areas:



AAC: Antiproton Accumulator Complex

PERFORMANCE

Operational intensities and rates are representative for a reasonably good period, with the 20 mm Li-lens in use (except where indicated otherwise: *).
See also p. AAC-04 for beam properties.

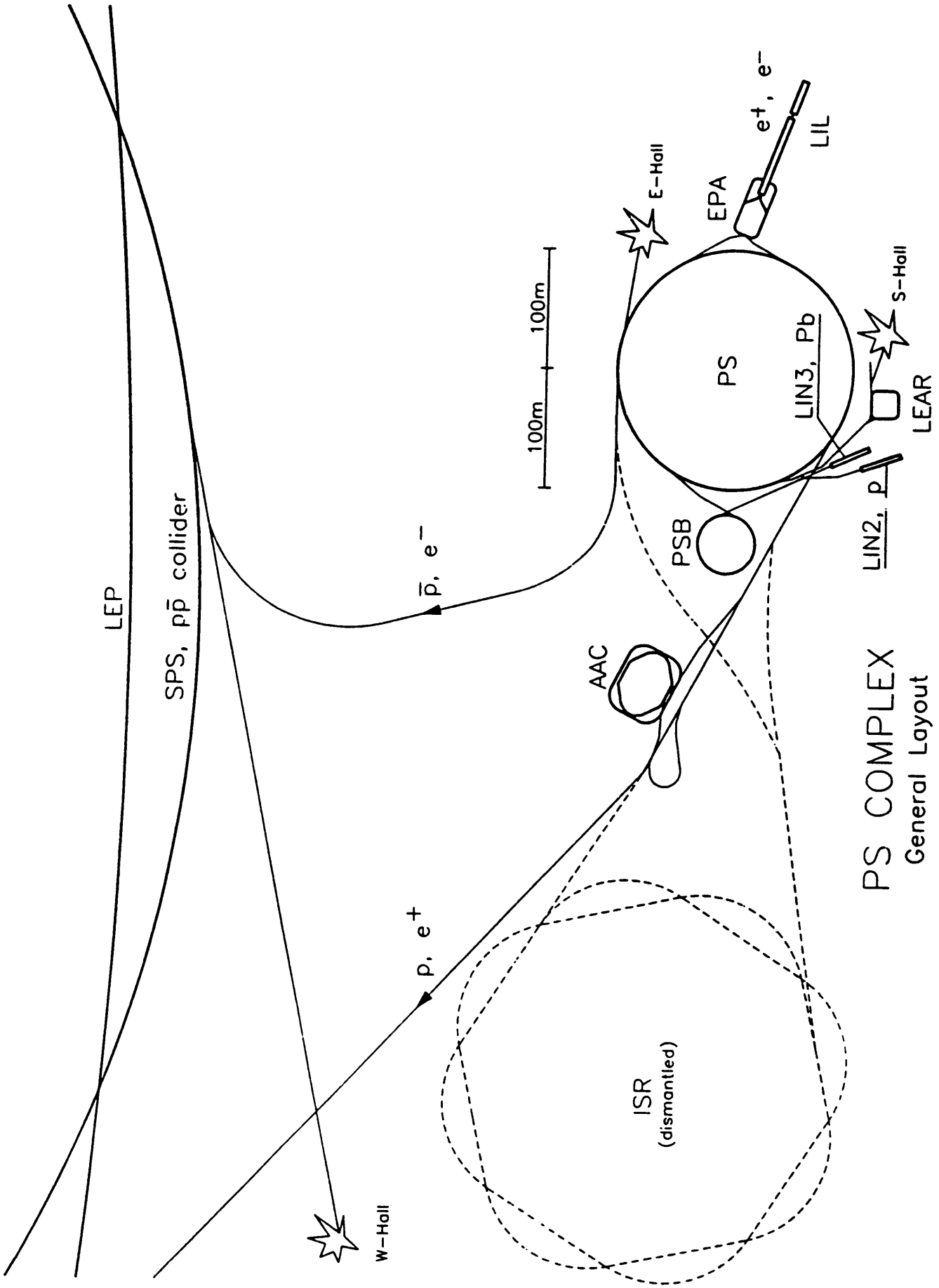
	operat.	best	
PS proton beam on target:			
momentum	26.019		GeV/c
intensity	1.4E13	1.85E13	p/pulse
nb. of bunches	5		
shortest repetition time	4.8		s
pbar accepted in AC	7.3E7		pbar/pulse
accumulation yield:			
pbar in AA stack / p on target	5.2E-6	5.8E-6	
normalized accum. rate (i.e. normalized			
to p on target every 4.8 s)	4.5E10		pbar/h
* with 34 mm Li-lens,			
for SPS p-pbar collider,			
best value on 13 October 1990	5.3E10	6.14E10	pbar/h
daily production	8.5E11	1.1E12	pbar
time to accumulate 1E12 pbar			
at normalized accum. rate	28	22	h
largest stack attained, 9 August 1989		1.31E12	pbar
ejected to PS, for LEAR:			
momentum (matched to PS field)	3.577		GeV/c
intensity, pilot	1E9		pbar
standard	3E9		pbar
big	4E10		pbar
nb. of bunches	1		
typical rep. time	1		h

BEAM CHARACTERISTICS

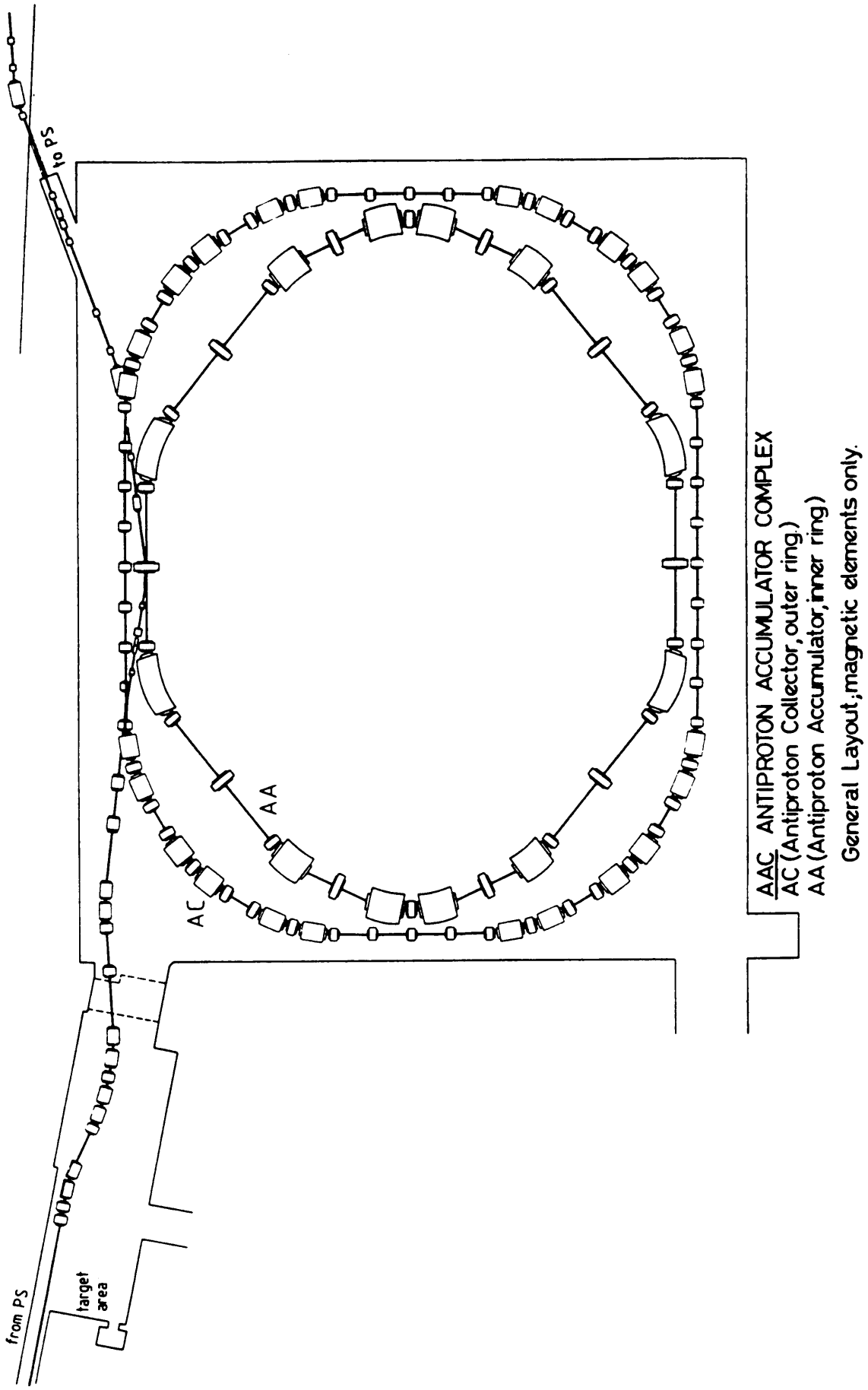
* At the various stages, emittances are measured in different ways. There is no uniform definition, but generally, emittances quoted contain at least 95% of the particles.
* At each stage, only altered parameters are given, for the unaltered ones see preceding stage(s).

PRIMARY BEAM	momentum		26.02	GeV/c
	repetition time		4.8	s
	number of bunches		5	
	protons on target		1.4E13	p/pulse
	bunch length		15-25	ns
	deltap/p		+-1.2E-3	
	emittance	hor	3.2*pi	mm*mrad
		vert	2.2*pi	mm*mrad
INJECTED INTO AC	momentum (central orbit)		3.5743	GeV/c
	bunches (h=6, 1 bucket empty)		5	
	pbar per pulse,	20mm Li lens	7E7	
		34mm Li lens	9E7	
		magnetic horn	6E7	
	deltap/p		+-3E-2	
	emittance	longitudinal	3.1-5.2	eV*s
		hor, vert	200*pi	mm*mrad
AC, AFTER BUNCH ROTATION AND DEBUNCHING				
	fraction of pbar surviving		92%	
	deltap/p (95% of surviving)		+-7.5E-3	
AC, AFTER STOCHASTIC COOLING				
	deltap/p (95% of pbar)		+-0.9E-3	
	emittance	longitudinal	3.7 eVs	
		hor, vert	5*pi	mm*mrad
AC, AFTER REBUNCHING FOR TRANSFER TO AA (at h=1)				
	bunch length		360	ns
	deltap/p		+-1.05E-3	
	emittance	longitudinal	3.9	eV*s
INJECTED INTO AA: same as in AC at transfer				
AA, AFTER PRECOOLING	deltap/p		+-0.26E-3	
AA STACK, AFTER DECELERATION, ACCUMULATION AND TAIL+CORE COOLING				
	momentum, stack-core		3.4114	GeV/c
	number of pbar		several E11	
	deltap/p	total stack ca.	1E-2	
		core	3E-3	
	emittance	hor, vert	2*pi	mm*mrad
AA, AFTER EXTRACTION FROM THE STACK, FOR TRANSFER TO PS AND LEAR				
	momentum (matched to PS field)		3.577	GeV/c
	number of pbar		1E9 - 4E10	
	number of bunches		1	
	bunch length		80	ns
	deltap/p		+-1E-3	
	emittance	longitudinal	<=0.25	eV*s
		hor, vert	2*pi	mm*mrad

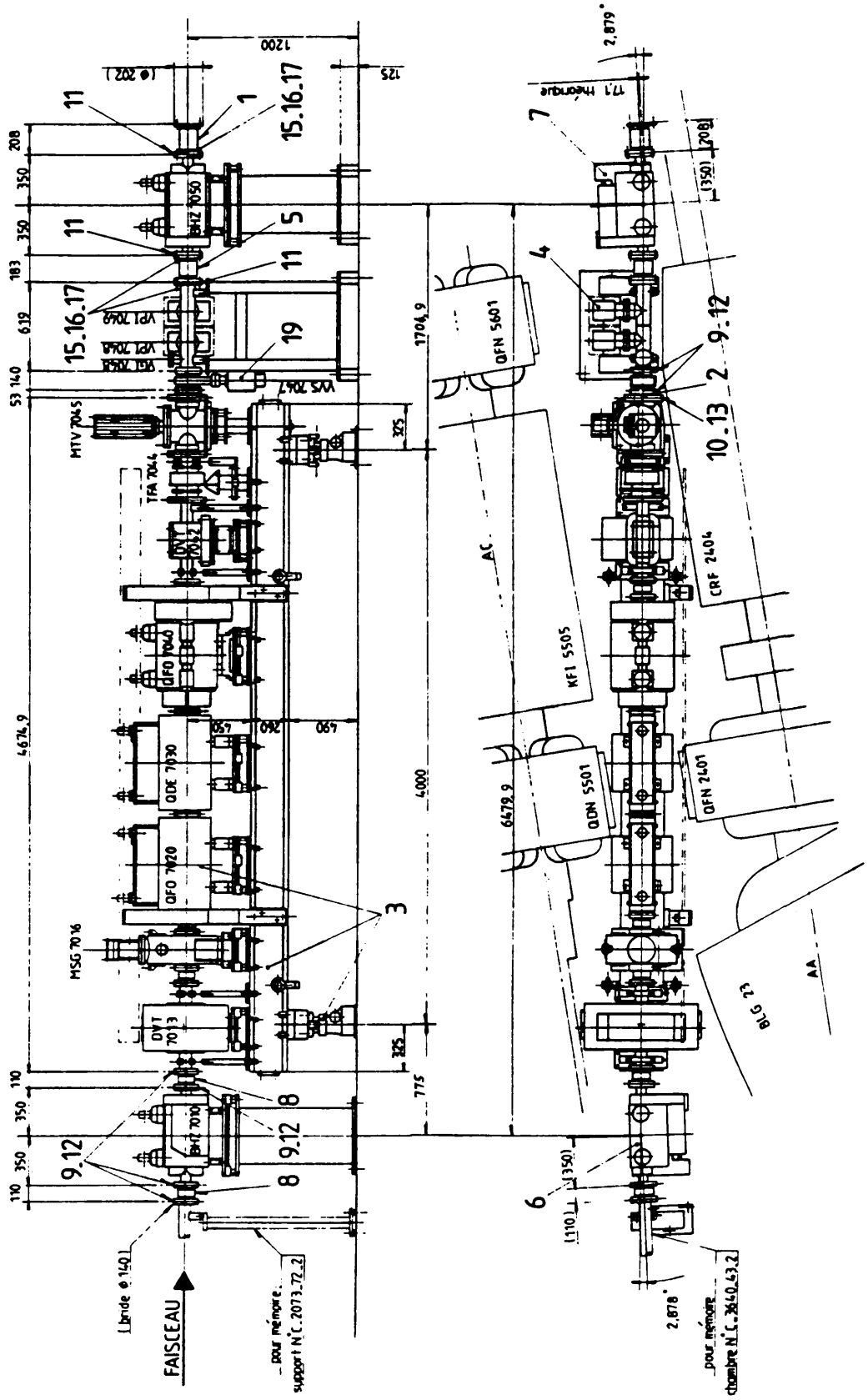
LAYOUT, PS COMPLEX



LAYOUT, ANTIPROTON ACCUMULATOR COMPLEX (AAC)



LAYOUT, AA - AC TRANSFER LINE



ANTIPROTON PRODUCTION

PROTON BEAM FOCUSING

2 pulsed quadrupoles	QDE9050	QFO9052
steel length	1 m	1 m
pulse current, peak	2198 A	2974 A
rise time (half-sine pulse)	3.2 ms	3.2 ms

beam passage: at peak current

PASSIVE TARGET

Iridium rod, embedded in graphite, with cooling fins (water + forced air)

length	60 mm
diameter	3 mm

ANTIPROTON COLLECTION LENSES:

LITHIUM LENS (in use today, for LEAR operation)

length	155 mm
diameter	20 mm
pulse current, peak	480 kA
current at beam passage	380 kA
rise time (half-sine pulse)	240 us
beam passage at	350 us
maximum pbar angle accepted	75 mrad

MAGNETIC HORN (back-up for 20 mm Li-lens)

current-sheet lens, made of 1.4 - 2 mm thick aluminium

pulse current, peak	400 kA
rise time (half-sine pulse)	15 us

beam passage: at peak current

maximum pbar angle accepted	82 mrad

LITHIUM LENS (for SPS-collider operation, until 1992)

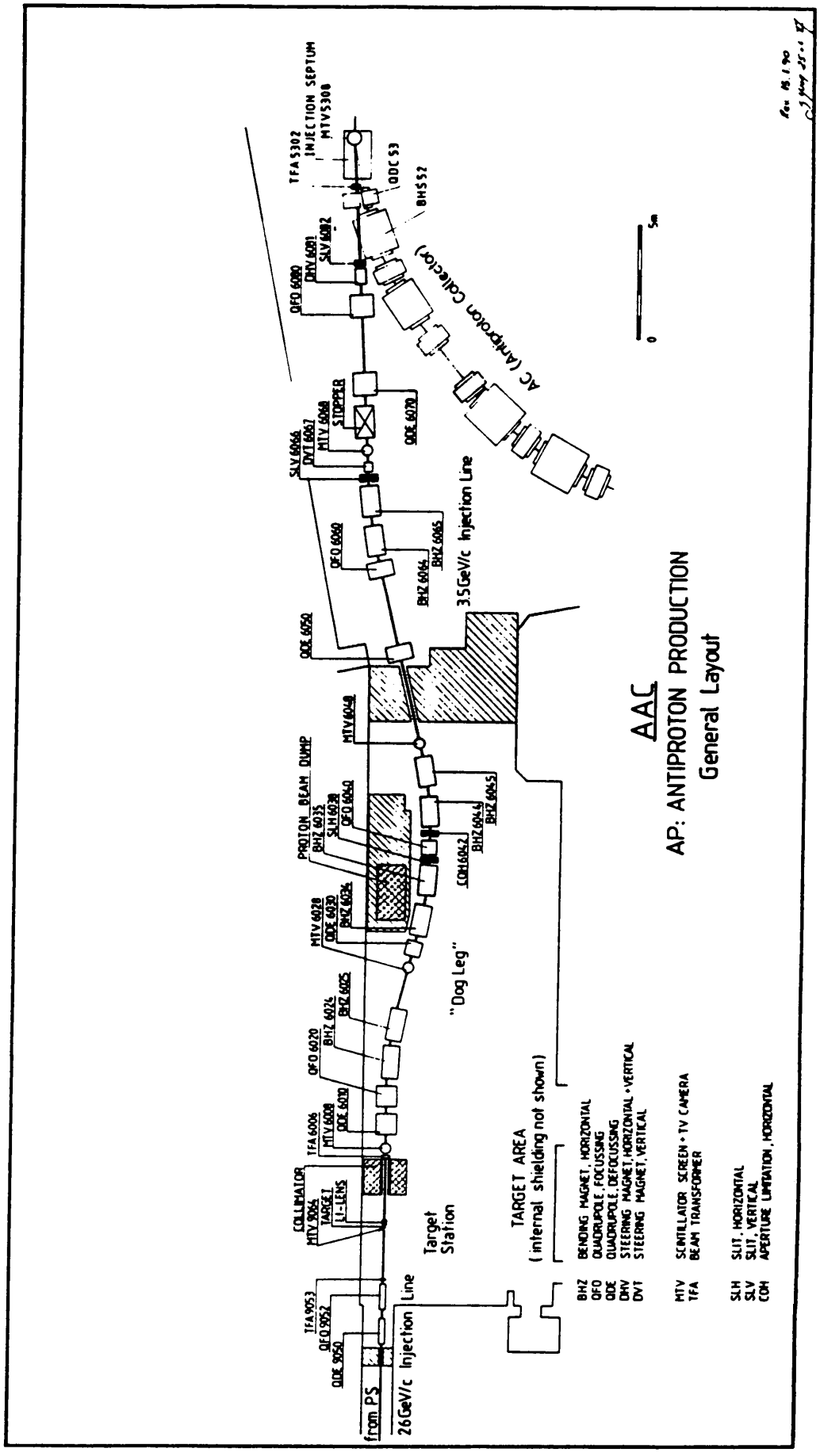
Li-rod, constituting single-turn secondary of a 23/1 pulse transformer.
Container made of Ti and stainless steel; Ti-windows; water cooling.

length	130 mm
diameter	34 mm
pulse current, peak	1000 kA
current at beam passage	850 kA
rise time (half-sine pulse)	900 us
beam passage at	1300 us
maximum pbar angle accepted	95 mrad

PLASMA LENS (in tests only, 1991 and 1992)

gas	He
pressure	0.8-1.4 Torr
length of plasma column	300 mm
diameter of plasma column	40 mm
pulser voltage	13 kV
pulse current rise time	8-10 us
current at beam passage	400 kA
maximum pbar angle accepted	100 mrad

ANTIPROTON PRODUCTION, LAYOUT



AC: GENERAL

see NOTE 1 and NOTE 2		ORBITS (see NOTE 4) max.	transfer to AA	central	min.	
momentum	p	3.68155	3.57754	3.57432	3.46709	GeV/c
	deltap/p0	30	0.9	0	-30	E-3
kin. energy		2.86096	2.76026	2.75714	2.65353	GeV
tot. energy		3.79924	3.69854	3.69542	3.59181	GeV
relativ. param.	beta	0.96902	0.96729	0.96723	0.96528	
	gamma	4.04915	3.94183	3.93851	3.82808	
magn. rigidity	B*rho	12.280	11.933	11.923	11.565	T*m
circumference		182.686	182.440	182.433	182.184	m
rev. frequency		1.590194	1.589478	1.589451	1.588410	MHz
rev. period		628.85	629.14	629.15	629.56	ns
current with E10 particles		2.5476	2.5465	2.5465	2.5448	mA

LATTICE: FODO, 2 superperiods
28 periods, ca 70 deg/period

working point	Qx	5.472	5.455	5.455	5.476	
(operat. val.)	Qz	5.449	5.435	5.435	5.424	
chromaticity	Q'x	---------- close to 0 ----------				
	Q'z	---------- close to 0 ----------				
transition	gammatr	4.569	4.674	4.674	4.773	
	eta	0.01306	0.01867	0.01867	0.02432	
beta (NOTE 3)	max. hor.	10.81	11.90	11.90	13.06	m
	max. vert.	12.06	11.65	11.65	11.62	m
alphap (NOTE 3)	max.	3.584	3.627	3.627	3.722	m
	long straights ------- close to 0 ----------					

acceptance, simultaneously:

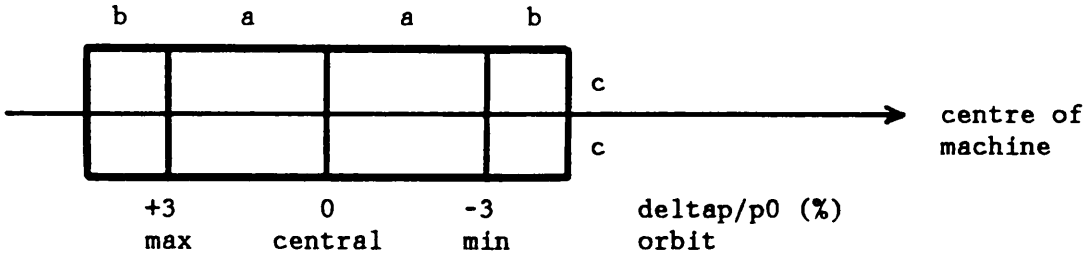
deltap/p0, on central orbit	+-3	%
longitudinal, on central orbit	131	eV*s
horizontal, all orbits	200*pi	mm*mrad
vertical, all orbits	200*pi	mm*mrad
hardware design, all orbits	240*pi	mm*mrad

NOTE 1: Values given here for the AC and on p. AA-01 for the AA, for momenta, frequencies and derived quantities, belong to a consistent set, derived from the premise that the AC central orbit has the correct design length and from the frequencies operationally used in AC and AA. They differ slightly from the theoretical design values given in the tables AC-11, AC-13, AA-10, AA-12.

NOTE 2: Bunch rotation requires AC rf to be equal to PS rf for the 26.02 GeV/c primary proton beam: 9.536868 MHz. AC rf is 6th harmonic of AC revolution frequency.

NOTE 3: At different momenta, maxima occur at different places in lattice

NOTE 4: Orbits and beam size: a = alphap * deltap/p0
b = SQR (beta hor * hor emittance/pi)
c = SQR (beta vert * vert emittance/pi)



AC: BENDING MAGNETS

		BHN narrow	BHW wide	
type		H	H	
number	see NOTE	16	8	
bending angle		245.799	245.799	mrad
bending power (on central orbit)		2.9314	2.9314	T*m
bending radius (on central orbit)		7.972	7.972	m
fieldstrength		1.496	1.496	T
effective length (along central orbit)		1.959	1.959	m
steel length (straight line)		1.794	1.794	m
overall length (straight line)		2.200	2.200	m
gap height (total, on central orbit)		0.114	0.114	m
pole width (total)		0.370	0.540	m
good field width (total, +-2E-4 in B)		0.210	0.370	m
overall width		1.546	1.964	m
overall height		1.253	1.339	m
current (BHW = BHN + trim, see p.AC-05)		2288.5	2291.8	A
resistance/magnet		9.3	11.0	mOhm
inductance/magnet		46	61	mH
power/magnet		48.7	57.8	kW
power, total		----- 1.24	-----	MW
steel weight/magnet		19	25	t
copper weight/magnet		2.40	2.50	t
COIL DETAILS				
coils/magnet		2	2	
turns/coil		30	30	
average length/turn		6.20	6.45	m
conductor cross section		27.8*27.8	27.8*27.8	mm*mm
hole diameter		7.0	7.0	mm
current density		3.11	3.11	A/mm2
water flow/magnet (10 atm)		0.90	0.87	1/s
water temperature rise		13	16	deg

NOTE:
1 of the 16 BHN, namely BHS 52 (S for special), differs in dimensions and and coil, because the injected beam passes through a hole in its outside yoke. Excitation current and action on the beam are identical to that of the 15 standard BHN.

AA: QUADRUPOLES

		QFN+QDN narrow	QFW+QDW wide
number	total	28 see NOTE 1	28
	F	12	16
	D	16	12

Data for the quadrupoles in the first quadrant (see also p. AC-12). The symmetric ones in the other quadrants have the same properties, with exceptions given in NOTE 1.

	QDN01 QFN02 QDN03 QDN15	QFN04 QFN14	QDN05 QDN13	QFW06 QFW12	QDW07 QDW11	QFW08 QFW10	QDW09	
G*eff.length	4.900	4.625	4.232	4.046	4.618	5.007	3.647	T
Gradient G, NOTE2	6.902	6.327	5.729	5.348	6.134	6.673	4.764	T/m
sextup.G'/G, NOTE3	0	0	0	1.43	1.43	0.60	1.43	m-1
eff. length	0.710	0.731	0.739	0.757	0.753	0.750	0.766	m
steel length	0.607	0.607	0.607	0.620	0.620	0.620	0.620	m
overall length	0.867	0.847	0.847	0.852	0.852	0.852	0.852	m
bore radius	0.110	0.110	0.110	0.132	0.132	0.132	0.132	m
offset, NOTE 4	0	+81.6	-49.6	0	0	0	0	mm
bending angle	0	30.0	18.0	0	0	0	0	mrad
current	1871	1871	1871	1860	1948	1827	1948	A
resistance/quad	10.0	8.5	7.5	11.3	12.4	14.2	9.2	mOhm
inductance/quad	9.3	7.3	5.9	8.6	10.5	15.4	6.2	mH
power/quad	35.0	29.8	26.3	39.1	47.1	47.4	34.9	kW
power, total	----------		2.22			----------		MW
weight	3630	3580	3550	5780	5820	5930	5720	kg
waterflow, 10atm	0.46	0.49	0.53	0.55	0.53	0.47	0.60	1/s
water temp. rise	18	15	12	17	21	24	14	deg
COIL DETAILS								
turns/pole	19	17	15	20	22	26	17	
cond.cross sect.	-- 15.0 * 23.0 --			------- 21.0 * 18.2 -----				mm*mm
hole diameter	------ 6.5 ------			---------- 7.5 ---------				mm
current density	6.00	6.00	6.00	5.50	5.76	5.40	5.76	A/mm2

NOTE 1:
2 of the 28 narrow quads have different design, but same current.
QDC 53: 2 half-quads, for circulating and injected beam, same action on circulating beam as QDN 05.
QFC 54: large half-quad, to accomodate and deflect injected beam, same action on circulating beam as QFN 04.
NOTE 2:
Gradient and eff. length for centre of lens. Core length is same for all QN and same for all QW, but different eff. lengths through end-shims.
NOTE 3:
This is the sextupole produced by pole shape. In addition, 6 QDN (03,15, 27,31,43,55) carry sextupole coils (6 single-turn), connected in series with quad coils: G'/G = 1.36 m-1.
NOTE 4:
4 narrow quads per quadrant not centred on central orbit. 1st quadrant: QFN 04, 14, QDN 05, 13. Offset + means lens displaced towards centre of ring. Bending action always in same direction as main bending magnets.

AC: MULTIPOLE CORRECTIONS

A. FOR CHROMATICITY AND DISPERSION
Sextupolar component in pole profile of all wide quads, QFW + QDW.
See also pp.AC-03 and AC-12.

quadrant:	1	2	3	4	G'/G	
SF1 on QFW	06,12	18,24	34,40	46,52	1.4294	m-1
SF2 on QFW	08,10	20,22	36,38	48,50	0.6031	m-1
SD on QDW	07,09,11	19,21,23	35,37,39	47,49,51	1.4294	m-1

B. FOR IMPROVEMENT OF THE DYNAMIC APERTURE (in conjunction with A.)
6 narrow defocusing quads, QDN 03,15,27,31,43,55, located in zero-dispersion regions, are fitted with sextupole coils. These consist of 6 single-turn windings, in series with the quadrupole windings.
At the nominal quadrupole current of 1871 A, they create a sextupole component G'/G = 1.36 m-1.

C. COMPENSATION OF SEXTUPOLAR NON-LINEAR COUPLING
4 sextupole lenses, rotatable around their axis.
For tests on "dynamic aperture", not used in operation.
No watercooling: nominal values can be sustained indefinitely,
maximum values for brief periods only.

number of sextupoles (XRC 13,16,41,44)		4	
G'	nom.	14	T/m2
	max.	84	T/m2
G'* eff.length	nom.	3.8	T/m
	max.	22.8	T/m
steel length		240	mm
overall length		348	mm
inscribed circle radius		96	mm
useful aperture radius		60	mm
current	nom.	15	A
	max.	90	A
resistance		0.334	Ohm
inductance		0.369	H
power	nom.	75	W
	max.	2700	W
weight		330	kg

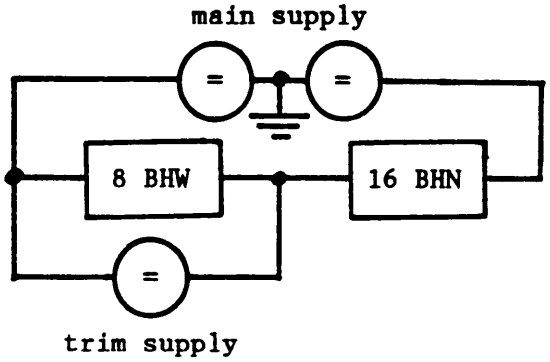
D. CORRECTION OF MAGNETIC IMPERFECTIONS
All bending magnets and quadrupoles have provisions for the fitting of end shims. The need never arose.

E. COMPENSATION OF COUPLING
skew quadrupole QSK 2805, at zero-dispersion
operational current 2.8 A

AC: POWER SUPPLIES

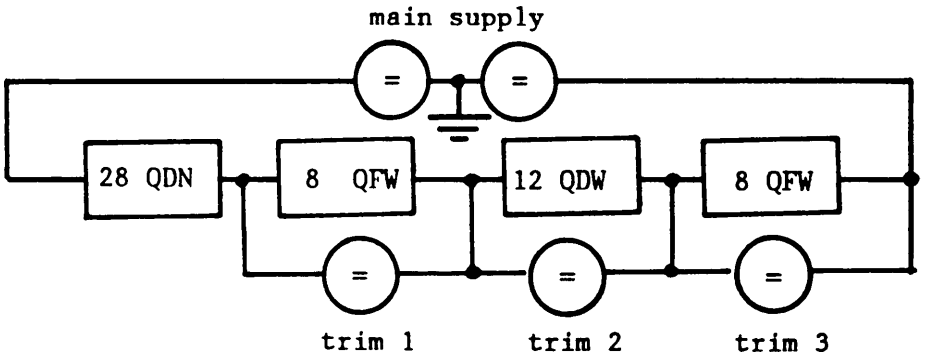
BENDING MAGNETS		main	trim	
current	operational	2288.5	3.3	A
	rated	2550	+-10	A
	stability, incl. ripple	+-1E-4	+-1E-3	
voltage	operational	595		
voltage	rated	700	250	V
power	operational	1362		kW
	rated	1785	2.5	kW

Floating trim supply, to adjust balance between BHN and BHW magnets:



QUADRUPOLES		main	trim 1	trim 2	trim 3	
current	operational	1883	-49	+16	-60	A
	rated	2050	+-100	+-100	+-100	A
	stability, incl. ripple	+-1E-4	+-1E-3	+-1E-3	+-1E-3	
voltage	operational	1224				V
	rated	1400	300	450	400	V
power	operational	2305				kW
	rated	2870	30	45	40	kW

4 different values of current are needed for the quads: 1 for all narrow, 3 different ones for the wide. The main supply is set for the narrow, 3 floating trim supplies establish the deviating values in the wide quads.



SEPTA, pulsed		injection 1 septum	ejection 2 septa in series	
current	operational	35.87	22.56	kA
	rated	38	27	kA
	stability	+-2E-4	+-2E-4	
voltage	rated	400	400	V
pulse length (half-sine)		6.0	3.0	ms

AC:· KICKERS

		injection	ejection	
number of tanks		2 (K55,K56)	2 (K35,K50)	
deflection angle per tank		9.34	5.35	mrad
kick-strength per tank		1114	638	G*m
remanent kick-strength per tank		1.9	1.6	G*m
kick rise/fall time (5-95%)		80	80	ns
flat top length		620	640	ns
kick variation on flat top		<2	<2	%
minimum pulse interval		2	2	s
PFN voltage	operational	68	62	kV
	max.	80	80	kV
electric principle		delay line + short circ.	delay line + short circ.	
impedance		15	15	Ohm
mechanical principle		stationary, full aperture	stationary, full aperture	
modules/tank (see table below)		K55: ABC K56: CBA	K35: DE K50: ED	

module type	A	B	C	D	E	
number of cells	27	20	20	24	24	
eff. module length	672	504	504	600	600	mm
nominal field strength	550	638	727	465	517	G
gap height	95	82	72	100	90	mm
gap width total	140	140	140	250	292	mm
for +-1% in field	79	87	97	54	66	mm

PFN: 1 coax cable per module, 15 Ohm, approx. 90 m long, SF6-filled

AC: SEPTA

		injection	ejection	
number		1	2	
deflection angle		8.57	3.744	deg
		149.6	65.34	mrad
bending power		1.784	0.7793	T*m
field strenghth		1.065	0.9562	T
effective length		1.676	0.815	m
overall length		1.714	0.859	m
gap height		90.0	30.0	mm
gap width	var.	111-119	75.0	mm
septum thickness			3.0	mm
effective septum thickness	var.	23-15		mm
number of turns		2	1	
peak current	operational	38.43	22.84	kA
	max.	38	27	kA
pulse length (half-sine)		6.0	3.0	ms
coil resistance		0.165	0.40	mOhm
coil inductance		11.0	2.5	uH
coupling transformer ratio		10	10	
average power (pulsing every 4.8 s)		109	108	W
water flow		0.63	0.62	l/min
water temperature rise		2.5	2.5	deg C

AC: RF SYSTEMS

BUNCH ROTATION + DEBUNCHING				
number of cavities			2	
gaps / cavity			1	
harmonic number			6	
frequency (transfer orbit, not necessarily central)			9.536868	MHz
voltage, sum of both cavities		max.	1.50	MV
RF power at max. voltage			867	kW
power of end-stage (pulsed for descent)			5	MW
stored energy at max. voltage			121	W*s
quality factor Q			8300	
shunt impedance			325	kOhm
configuration: disk-loaded pill-box				
material: Al (Anticorodal W)				
length			2060	mm
outer diameter			2400	mm
inner diameter, free for beam			160	mm
voltage for bunch rotation			1.12	MV
bucket half-height	in deltap/p	3%*SQR2 =	4.24	%
	in energy		147	MeV
bucket area (1 of 6)			19.6	eV*s
voltage programme for initial bunch length of 19 ns:				
- cavity filling time to 1.12 MV (before injection)			250	us
- flat top at 1.12 MV for 90 deg bunch rotation			50	us
- linear descent to 120 kV			40	us
- exponential decrease to 1 kV for adiabatic debunching			15	us
REBUNCHING after cooling, for transfer to AA				
number of cavities			1	
gaps / cavity			1	
harmonic number			1	
frequency (transfer orbit, not necessarily central)			1.589478	MHz
voltage	max.		3500	V
	for rebunching		722	V
power of end-stage			10	kW
quality factor Q			12	
shunt impedance			1000	Ohm
configuration: lambda/4, ferrite-loaded				
ferrite tuning current			150	A
length			1230	mm
outer diameter			600	mm
inner diameter, free for beam			158	mm

AC: VACUUM

all-metal system, no bake-out			
4 sectors, separated by valves			
average pressure, N2-equiv.		<1E-8	Torr
pumps, number * speed for N2:	rotary	7 * 8.3	l/s
		2 * 17	l/s
	turbomolecular	7 * 300	l/s
		2 * 1500	l/s
	sputter ion	6 * 60	l/s
		12 * 270	l/s
		21 * 400	l/s
	cryo	10 * 1500	l/s
number of gauges: Penning/Pirani		8/8	
number of mass spectrometers, 1 per sector		4	
chamber material, stainless steel:	in the magnets	316LN	
	tanks, etc.	316LN,304L	
average outgassing rate		1E-12	T*l/s/cm-2

AC: STOCHASTIC COOLING

see schematic layout on p. AC-16

COOLING PERFORMANCE

number of pbar/pulse	1E8	
initial emittances, hor, vert	200*pi	mm*mrad
initial deltap/p (after bunch rotation)	+-7.5E-3	
total cooling time (hor, vert, deltap/p, details below)	4.6	s
final emittances, hor, vert	5*pi	mm*mrad
final deltap/p	+-0.9E-3	
fraction of pbar within final deltap/p	98	%

PICK-UPS AND KICKERS

The total range of 1-3 GHz is divided into 3 bands. For each band there are 2 PUs and 2 kickers:

- From one PU, a horizontal difference signal is derived and sent to the corresponding kicker for horizontal cooling.
- From the other PU, a vertical difference signal is derived and sent to the corresponding kicker for vertical cooling.
- From both PUs together, a sum signal is derived and sent to both kickers for momentum cooling.

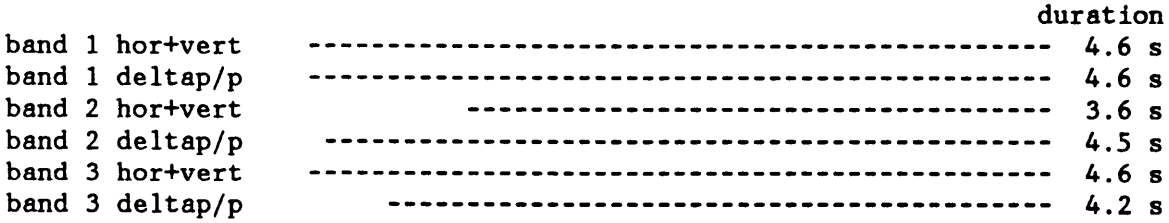
For each band, the electrode structures of the 2 PUs and the 2 kickers are all identical. Each of their "superelectrodes" consists of 2 lambda/4 coupling loups in series, and they are in pairs (left-right, or top-bottom). Their number per PU or kicker is given below.

The aperture of all PUs and kickers is tailored along their length to fit the variation in beamsize. Also, the aperture follows in a programmed mechanical movement the beamsize shrinkage during betatron cooling.

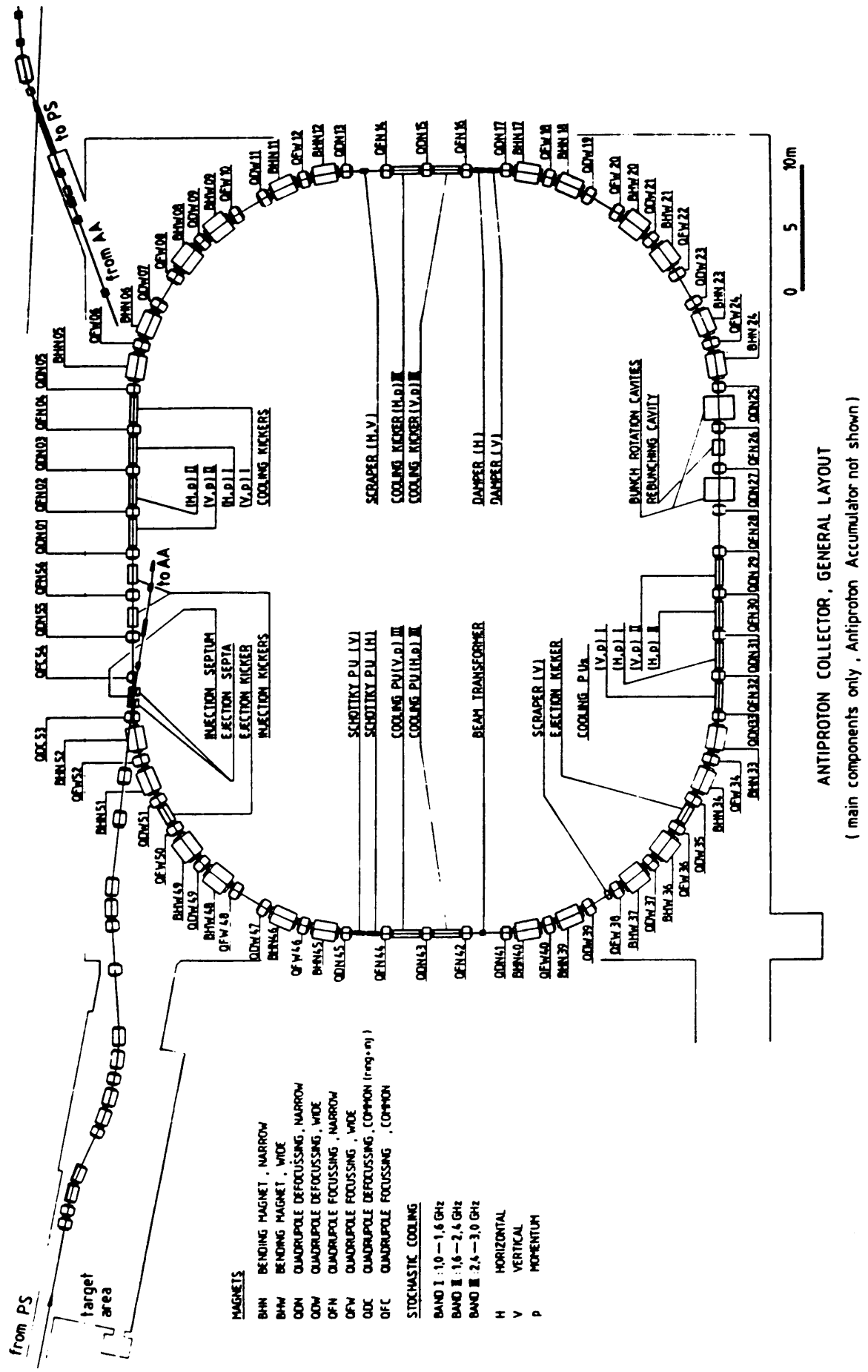
The various parts of the PUs are cryogenically cooled: electrodes (50 K), terminations (20 K), signal combiners (40 K), head-amplifiers (20 K).

	band 1	band 2	band 3	
frequency range: lower limit	1.00	1.65	2.40	GHz
upper limit	1.65	2.40	3.00	GHz
superelectrode pairs / PU or kicker	24	32	48	
characteristic impedance	50	50	50	Ohm
aperture, max. corresponds to	240*pi	240*pi	240*pi	mm*mrad
min. corresponds to	20*pi	20*pi	20*pi	mm*mrad
opening time at end of cycle	150	150	150	ms
AMPLIFIERS (all solid-state)				
headamplifiers / PU	2	2	2	
total noise temp. at input	60	60	60	deg K
power amplifiers / kicker	24	16	24	
rated power / amplifier	95	80	55	W
/ kicker	2280	1280	1320	W
/ band	4560	2560	2640	W
overall electronic gain, max.	148	148	148	db
FILTERS (coax-lines at room temp.)				
passive notch + active peak	1+1	1+1	1+1	

COOLING TIMES: The various bands begin their action at different times after injection. They all stop 4.6 s after injection.



AC: LAYOUT


to PS
from AA
to AA
from PS
target area
INJECTION SEPTUM
EJECTION SEPTA
EJECTION KICKER
INJECTION KICKERS
COOLING KICKERS
SCRAPER (H,V)
COOLING KICKER (H,p) II
COOLING KICKER (V,p) II
DAMPER (H)
DAMPER (V)
BUNCH ROTATION CAVITIES
REBUNCHING CAVITY
SCHOTTKY P.U. (V)
SCHOTTKY P.U. (H)
COOLING PU (V,p) III
COOLING PU (H,p) III
BEAM TRANSFORMER
SCRAPER (V)
EJECTION KICKER
COOLING P.Us
0 5 10m
ANTIPROTON COLLECTOR, GENERAL LAYOUT
(main components only, Antiproton Accumulator not shown)
MAGNETS
BHN BENDING MAGNET, NARROW
BHW BENDING MAGNET, WIDE
QDN QUADRUPOLE DEFOCUSSING, NARROW
QDW QUADRUPOLE DEFOCUSSING, WIDE
QFN QUADRUPOLE FOCUSSING, NARROW
QFW QUADRUPOLE FOCUSSING, WIDE
QDC QUADRUPOLE DEFOCUSSING, COMMON (ring-ø)
QFC QUADRUPOLE FOCUSSING, COMMON
STOCHASTIC COOLING
BAND I : 1,0 — 1,6 GHz
BAND II : 1,6 — 2,4 GHz
BAND III : 2,4 — 3,0 GHz
H HORIZONTAL
V VERTICAL
p MOMENTUM

*** ACOL LATTICE PARAMETERS *** (RINGAC2)

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

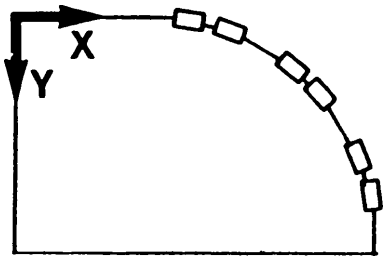
AGS VERSION 84.03 20/02/85 17.43.49.
The coordinates of the machine centre are
x = 0 , y = 23.575482

NO	NAME	LENGTH	ANGLE	K(V)	X	Y	PHI
1	QD1	.3500	0.00000	.5800000	.350000	0.000000	0.000000
2	SS	2.6000	0.00000	0.0000000	2.950000	0.000000	0.000000
3	QF2	.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	QD3	.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	QF4	.7000	30.00000	-.5500000	10.149895	.010499	.030000
8	SS	2.5000	0.00000	0.0000000	12.648770	.085488	.030000
9	QD5	.7000	18.00000	.5152200	13.348228	.112781	.048000
10	SS	.4250	0.00000	0.0000000	13.772739	.133173	.048000
11	BN5	1.9513	245.79900	0.0000000	15.690776	.464193	.293799
12	SS	.4000	0.00000	0.0000000	16.073636	.580030	.293799
13	QF6	.7500	0.00000	-.4457000	16.791499	.797222	.293799
14	SS	.4000	0.00000	0.0000000	17.174359	.913059	.293799
15	BN6	1.9513	245.79900	0.0000000	18.954198	1.700848	.539598
16	SS	.4000	0.00000	0.0000000	19.297365	1.906365	.539598
17	QD7	.7500	0.00000	.4905500	19.940801	2.291708	.539598
18	SS	1.8500	0.00000	0.0000000	21.527944	3.242222	.539598
19	QF8	.7500	0.00000	-.5428100	22.171381	3.627565	.539598
20	SS	.4000	0.00000	0.0000000	22.514547	3.833082	.539598
21	BW8	1.9513	245.79900	0.0000000	24.049196	5.030284	.785397
22	SS	.4000	0.00000	0.0000000	24.332039	5.313126	.785397
23	QD9	.7500	0.00000	.3863100	24.862370	5.843455	.785397
24	SS	.4000	0.00000	0.0000000	25.145213	6.126298	.785397
25	BW9	1.9513	245.79900	0.0000000	26.342418	7.660944	1.031196
26	SS	.4000	0.00000	0.0000000	26.547935	8.004110	1.031196
27	QF10	.7500	0.00000	-.5428100	26.933280	8.647545	1.031196
28	SS	1.8500	0.00000	0.0000000	27.883798	10.234686	1.031196
29	QD11	.7500	0.00000	.4905500	28.269142	10.878122	1.031196
30	SS	.4000	0.00000	0.0000000	28.474660	11.221287	1.031196
31	BN11	1.9513	245.79900	0.0000000	29.262454	13.001125	1.276995
32	SS	.4000	0.00000	0.0000000	29.378291	13.383985	1.276995
33	QF12	.7500	0.00000	-.4457000	29.595485	14.101847	1.276995
34	SS	.4000	0.00000	0.0000000	29.711322	14.484707	1.276995
35	BN12	1.9513	245.79900	0.0000000	30.042347	16.402743	1.522794
36	SS	.4250	0.00000	0.0000000	30.062740	16.827254	1.522794
37	QD13	.7000	18.00000	.5152200	30.090035	17.526712	1.540794
38	SS	2.5000	0.00000	0.0000000	30.165029	20.025587	1.540794
39	QF14	.7000	30.00000	-.5500000	30.175530	20.725482	1.570794
40	SS	2.5000	0.00000	0.0000000	30.175536	23.225482	1.570794
41	QD15	.3500	0.00000	.5800000	30.175537	23.575482	1.570794

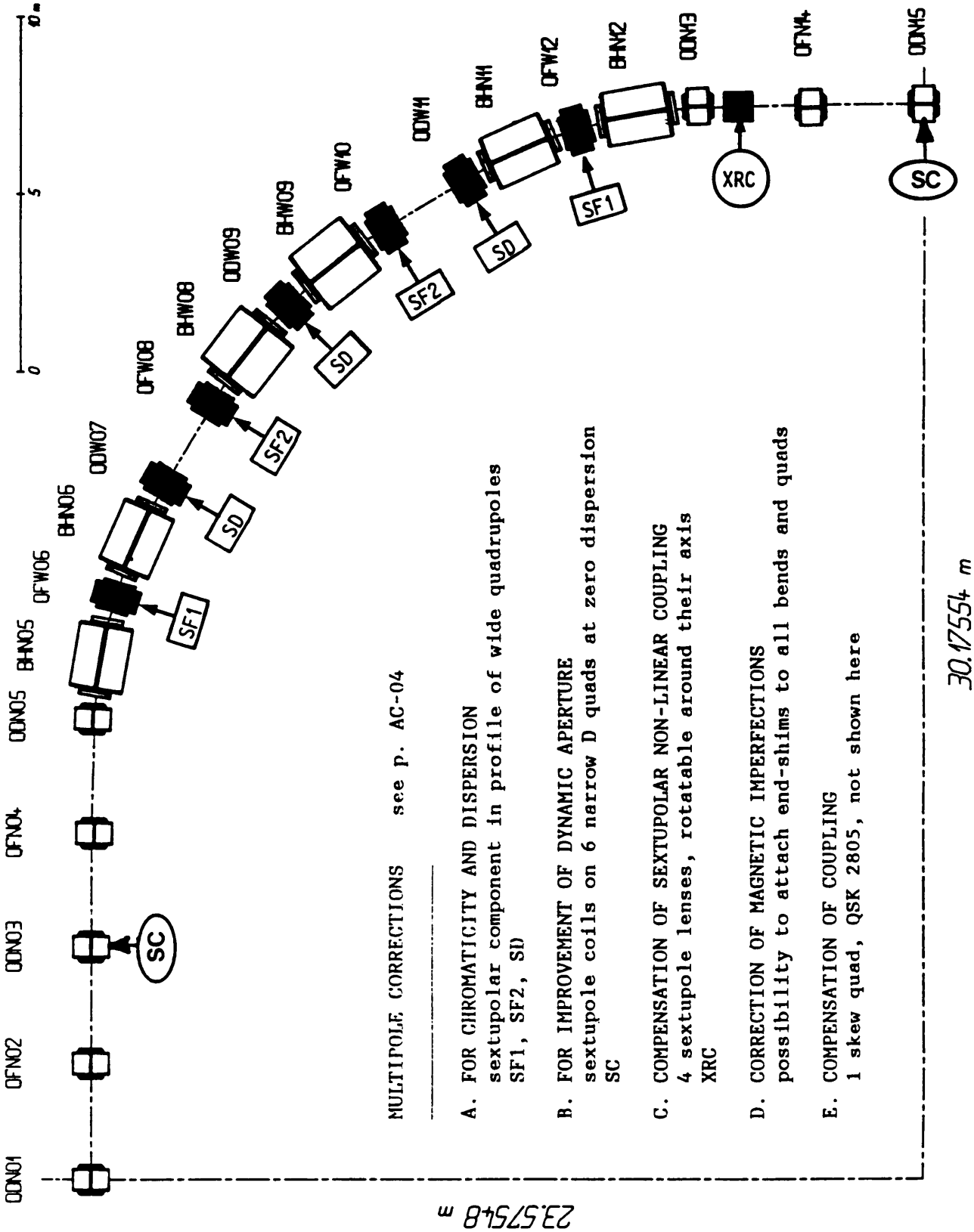
ANTIPROTON
COLLECTOR

GEOMETRY

DEFINITION OF
COORDINATES



AC: QUADRANT / MULTIPOLE LATTICE CORRECTIONS



MULTIPOLE CORRECTIONS see p. AC-04

A. FOR CHROMATICITY AND DISPERSION
sextupolar component in profile of wide quadrupoles
SF1, SF2, SD

B. FOR IMPROVEMENT OF DYNAMIC APERTURE
sextupole coils on 6 narrow D quads at zero dispersion
SC

C. COMPENSATION OF SEXTUPOLAR NON-LINEAR COUPLING
4 sextupole lenses, rotatable around their axis
XRC

D. CORRECTION OF MAGNETIC IMPERFECTIONS
possibility to attach end-shims to all bends and quads

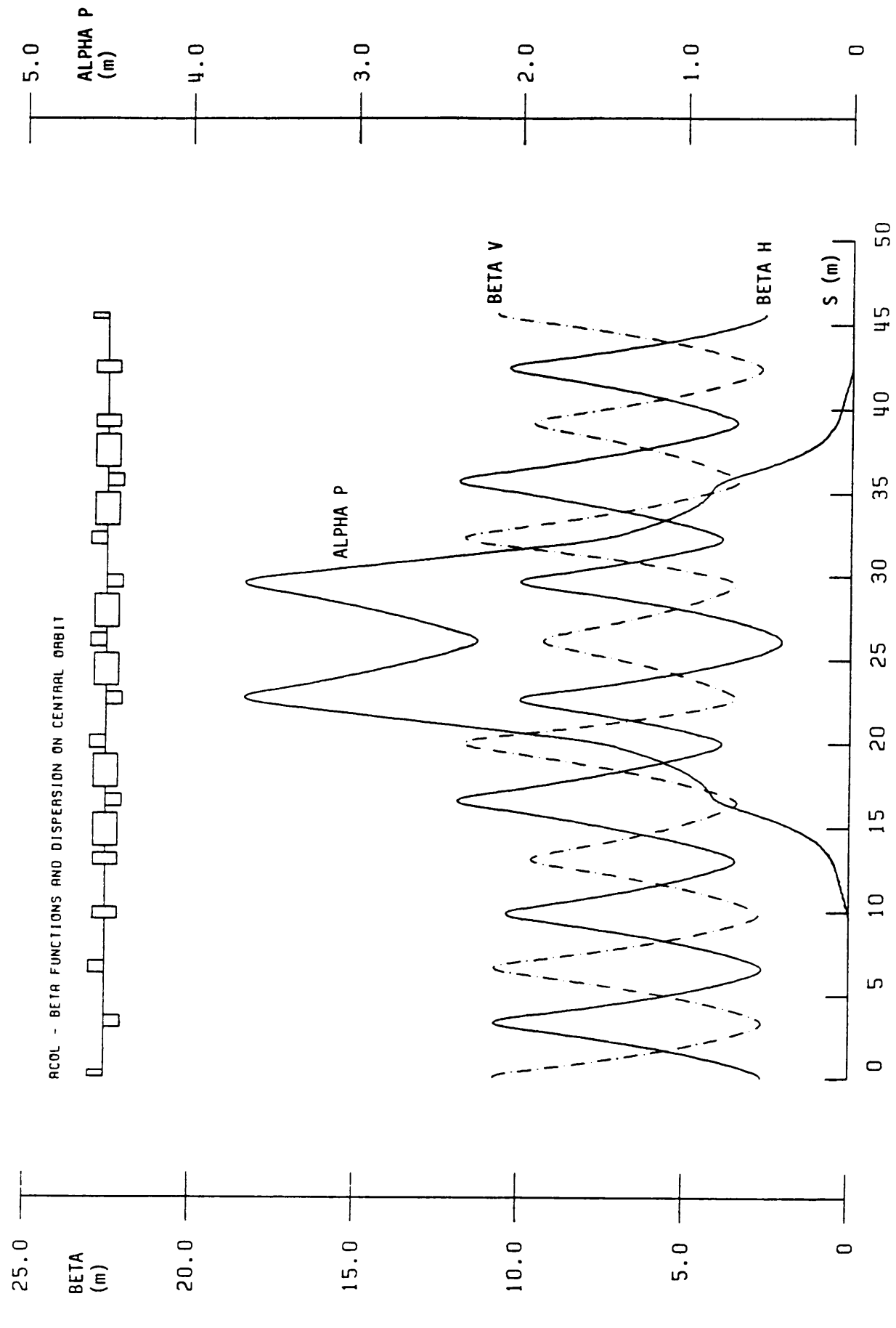
E. COMPENSATION OF COUPLING
1 skew quad, QSK 2805, not shown here

DP= 0.00000 ANTIPROTON COLLECTOR, LATTICE PARAMETERS ON CENTRAL ORBIT

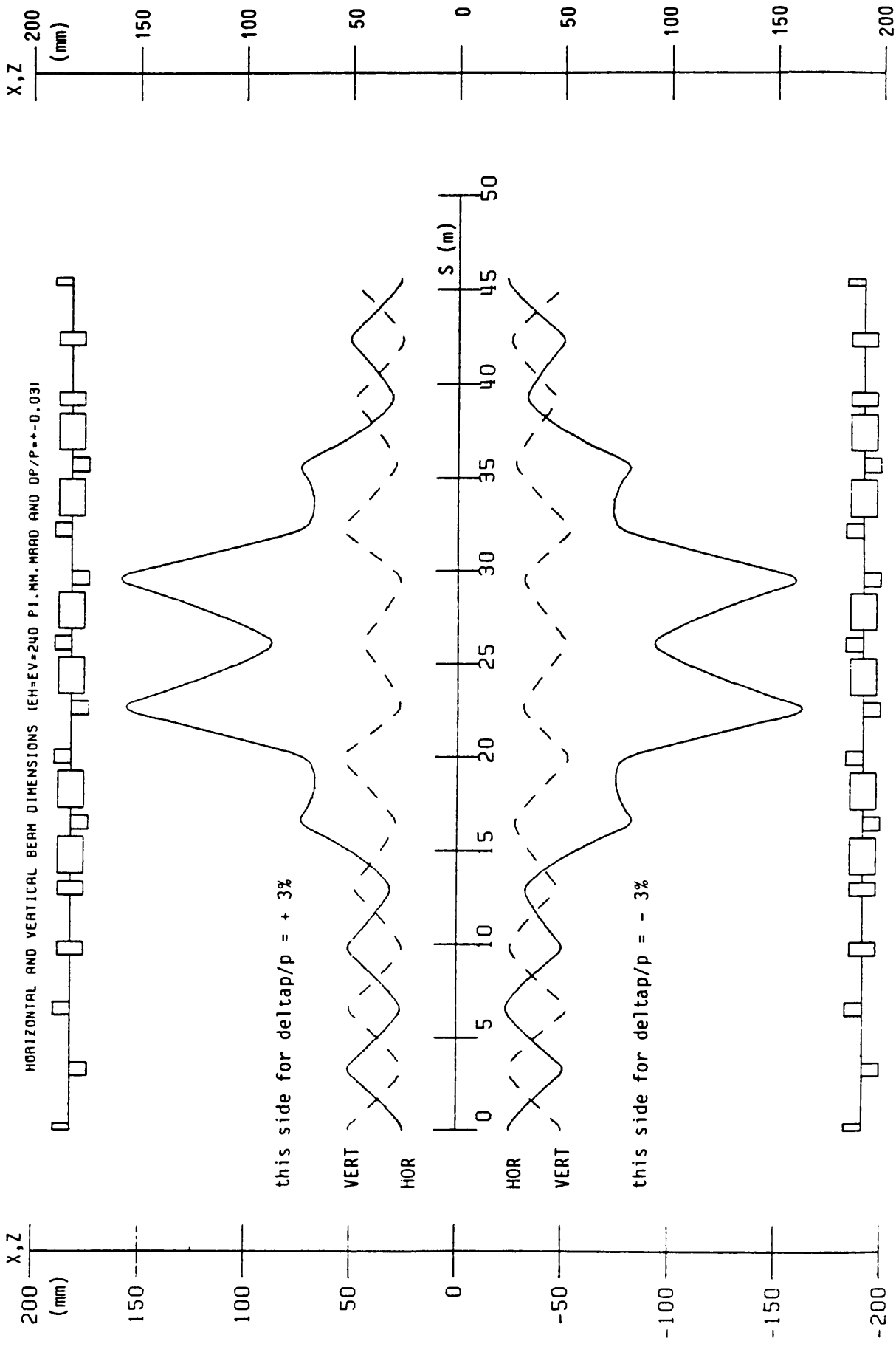
NO	EL	L(M)	PHI(RAD)	K(M-2)	KP/K(M-1)	DIST(M)	T(NS)	BY(M)	BX(M)	AY	AX	MY/2PI	MX/2PI	DX	DXP	XO(M)
0		0.0000	0.000000	0.00000	0.00000	0.0000	0.0000	10.39	2.83	0.00	0.00	0.0000	0.0000	-.004	0.000	0.00000
1	DN	.3560	0.000000	.57104	0.00000	.3560	1.2277	9.66	3.09	1.98	-.74	.0056	.0194	-.004	-.001	0.00000
2	SS	2.5880	0.000000	0.00000	0.00000	2.9440	10.1527	2.83	10.24	.66	-2.03	.0880	.0956	-.006	-.001	0.00000
3	FN	.7120	0.000000	-.57104	0.00000	3.6560	12.6081	2.88	10.14	-.74	2.15	.1301	.1062	-.005	.002	0.00000
4	SS	2.5880	0.000000	0.00000	0.00000	6.2440	21.5330	10.29	2.72	-2.13	.72	.2090	.1881	-.001	.002	0.00000
5	DN	.7120	0.000000	.57104	0.00000	6.9560	23.9884	10.31	2.67	2.10	-.64	.2195	.2328	-.000	.001	0.00000
6	SS	2.4830	0.000000	0.00000	0.00000	9.4390	32.5513	3.12	9.09	.80	-1.95	.2917	.3168	.003	.001	0.00000
7	F*	.7220	.030000	-.53413	0.00000	10.1610	35.0413	2.99	9.35	-.60	1.62	.3315	.3287	.014	.029	.07598
8	SS	2.4735	0.000000	0.00000	0.00000	12.6345	43.5714	8.77	3.71	-1.73	.66	.4118	.3976	.085	.029	.07598
9	D*	.7310	.018000	.46945	0.00000	13.3655	46.0923	9.10	3.82	1.32	-.81	.4243	.4300	.124	.081	-.05354
10	SS	.4095	0.000000	0.00000	0.00000	13.7750	47.5045	8.07	4.55	1.20	-.99	.4319	.4457	.158	.081	-.05354
11	BN	1.9513	.245799	0.00000	0.00000	15.7263	54.2338	4.21	9.98	.72	-1.83	.4862	.4919	.554	.329	-.05354
12	SS	.3960	0.000000	0.00000	0.00000	16.1223	55.5994	3.70	11.50	.58	-2.00	.5022	.4978	.684	.329	-.05354
13	FW	.7580	0.000000	-.43713	1.42938	16.8803	58.2134	3.90	11.62	-.87	1.85	.5356	.5078	.838	.071	0.00000
14	SS	.3960	0.000000	0.00000	0.00000	17.2763	59.5791	4.66	10.21	-1.05	1.70	.5504	.5136	.866	.071	0.00000
15	BN	1.9513	.245799	0.00000	0.00000	19.2276	66.3083	10.07	5.07	-1.64	.96	.5963	.5569	1.242	.318	0.00000
16	SS	.3980	0.000000	0.00000	0.00000	19.6256	67.6809	11.43	4.36	-1.79	.81	.6022	.5704	1.369	.318	0.00000
17	DW	.7540	0.000000	.50509	1.42938	20.3796	70.2811	10.85	4.50	2.49	-1.02	.6125	.5990	1.821	.911	0.00000
18	SS	1.8477	0.000000	0.00000	0.00000	22.2273	76.6531	3.92	9.79	1.26	-1.85	.6582	.6439	3.505	.911	0.00000
19	FW	.7510	0.000000	-.54774	.60306	22.9783	79.2430	3.36	9.54	-.45	2.15	.6931	.6556	3.627	-.595	0.00000
20	SS	.3995	0.000000	0.00000	0.00000	23.3778	80.6207	3.78	7.91	-.59	1.92	.7110	.6629	3.390	-.595	0.00000
21	BW	1.9513	.245799	0.00000	0.00000	25.3291	87.3499	7.14	2.71	-1.08	.78	.7723	.7315	2.480	-.348	0.00000
22	SS	.3950	0.000000	0.00000	0.00000	25.7241	88.7121	8.04	2.19	-1.20	.54	.7806	.7575	2.342	-.348	0.00000
23	DW	.7600	0.000000	.39699	1.42938	26.4841	91.3331	8.06	2.14	1.18	-.48	.7951	.8169	2.342	.346	0.00000
24	SS	.3950	0.000000	0.00000	0.00000	26.8791	92.6953	7.17	2.61	1.06	-.70	.8033	.8437	2.478	.346	0.00000
25	BW	1.9513	.245799	0.00000	0.00000	28.8304	99.4245	3.86	7.47	.59	-1.81	.8638	.9158	3.385	.593	0.00000
26	SS	.3995	0.000000	0.00000	0.00000	29.2299	100.8022	3.44	9.00	.45	-2.04	.8813	.9236	3.622	.593	0.00000
27	FW	.7510	0.000000	-.54774	.60306	29.9809	103.3921	4.02	9.26	-1.29	1.73	.9154	.9360	3.499	-.911	0.00000
28	SS	1.8477	0.000000	0.00000	0.00000	31.8286	109.7641	11.07	4.33	-2.52	.93	.9600	.9831	1.817	-.911	0.00000
29	DW	.7540	0.000000	.50509	1.42938	32.5826	112.3643	11.65	4.27	1.84	-.85	.9701	1.0126	1.364	-.319	0.00000
30	SS	.3980	0.000000	0.00000	0.00000	32.9806	113.7369	10.24	5.01	1.69	-1.01	.9759	1.0263	1.237	-.319	0.00000
31	BN	1.9513	.245799	0.00000	0.00000	34.9319	120.4661	4.68	10.42	1.08	-1.79	1.0214	1.0694	.859	-.072	0.00000
32	SS	.3960	0.000000	0.00000	0.00000	35.3279	121.8317	3.90	11.90	.89	-1.95	1.0361	1.0750	.830	-.072	0.00000
33	FW	.7580	0.000000	-.43713	1.42938	36.0859	124.4458	3.66	11.85	-.55	2.01	1.0696	1.0848	.676	-.327	0.00000
34	SS	.3960	0.000000	0.00000	0.00000	36.4819	125.8114	4.15	10.33	-.69	1.84	1.0858	1.0905	.546	-.327	0.00000
35	BN	1.9513	.245799	0.00000	0.00000	38.4332	132.5407	7.87	4.80	-1.16	1.02	1.1413	1.1347	.153	-.080	0.00000
36	SS	.4095	0.000000	0.00000	0.00000	38.8427	133.9529	8.87	4.04	-1.28	.85	1.1491	1.1495	.121	-.080	0.00000
37	D*	.7310	.018000	.46945	0.00000	39.5737	136.4738	8.55	3.93	1.69	-.69	1.1619	1.1802	.082	-.028	-.05354
38	SS	2.4735	0.000000	0.00000	0.00000	42.0472	145.0039	2.95	9.63	.57	-1.61	1.2439	1.2460	.012	-.028	-.05354
39	F*	.7220	.030000	-.53413	0.00000	42.7693	147.4939	3.11	9.29	-.82	2.04	1.2840	1.2576	.001	-.000	.07598
40	SS	2.4830	0.000000	0.00000	0.00000	45.2523	156.0568	10.50	2.58	-2.16	.66	1.3555	1.3424	.001	-.000	.07598
41	DN	.3560	0.000000	.57104	0.00000	45.6083	157.2845	11.29	2.35	-.00	.00	1.3607	1.3658	.001	-.000	0.00000

DP/P	LENGTH	FR(MHZ)	GAMMA	GAMMAT	GAMMA-2	GAMMAT-2	ETA	QH	QV	DEPENDENCE ON
-.04000	182.10198	1.58802	3.79226	4.80408	.06953	.04333	.02621	5.45802	5.45834	MOMENTUM
-.03000	182.18431	1.58844	3.82903	4.77345	.06821	.04389	.02432	5.46035	5.45134	
-.00750	182.37059	1.58924	3.91186	4.69988	.06535	.04527	.02008	5.46287	5.44314	
-.00100	182.42475	1.58945	3.93581	4.67772	.06456	.04570	.01885	5.46301	5.44261	
0.00000	182.43310	1.58948	3.93949	4.67429	.06443	.04577	.01867	5.46302	5.44260	
.00100	182.44145	1.58951	3.94318	4.67085	.06431	.04584	.01848	5.46301	5.44261	
.00750	182.49584	1.58969	3.96714	4.64833	.06354	.04628	.01726	5.46288	5.44313	
.03000	182.68573	1.59022	4.05016	4.56910	.06096	.04790	.01306	5.46109	5.45080	
.04000	182.77099	1.59041	4.08710	4.53362	.05986	.04865	.01121	5.45978	5.45696	

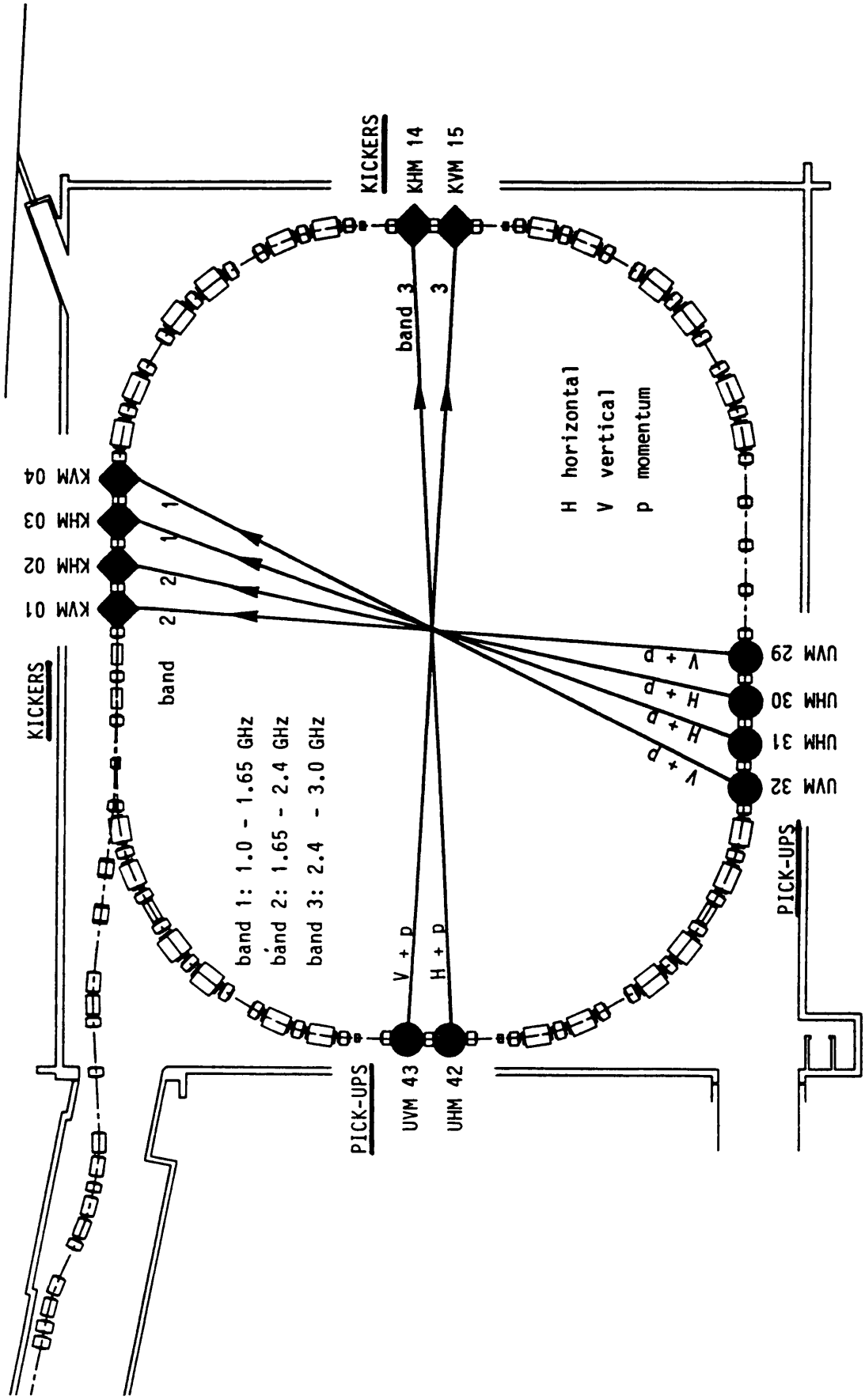
AC: LATTICE PARAMETERS



AC: BEAM DIMENSIONS



AC: STOCHASTIC COOLING, SCHEMATIC

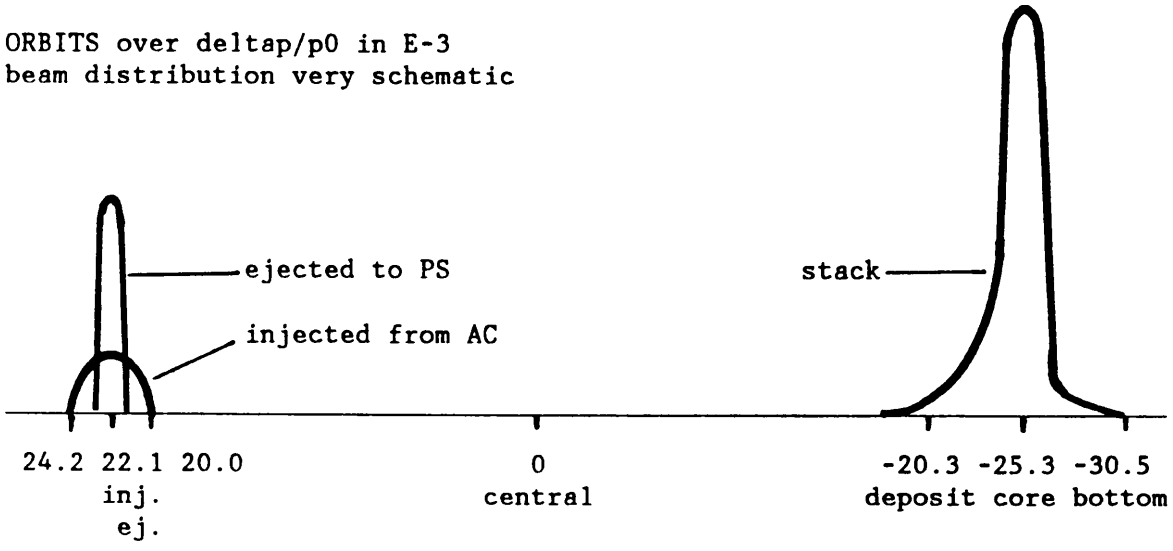


STOCHASTIC COOLING - SCHEMATIC LAYOUT
Arrows are in the direction from pick-up to kicker

AA: GENERAL

See NOTE		ORBITS (see bottom of page) injection from AC	ejection to PS	central	core	
momentum	p	3.57754	3.57721	3.50000	3.41145	GeV/c
	deltap/p0	22.15	22.06	0	-25.3	
kin.energy		2.76026	2.75994	2.68531	2.59985	GeV
tot. energy		3.69854	3.69822	3.62359	3.53813	GeV
relativ. param.	beta	0.96729	0.96728	0.96589	0.96420	
	gamma	3.94183	3.94149	3.86195	3.77087	
magn. rigidity	B*rho	11.933	11.932	11.675	11.379	T*m
circumference		157.101	157.099	156.492	155.818	m
rev. frequency		1.845845	1.845865	1.850363	1.855100	MHz
rev. period		541.76	541.75	540.43	539.05	ns
current with E10 particles		2.9572	2.9573	2.9645	2.9721	mA
LATTICE : FODO (see p.AA-12)						
transition	gammatr	2.345	2.345	2.405	2.469	
	eta	-0.1176	-0.1176	-0.1058	-0.0938	
working point	Qx	2.2555	2.2555	2.2539	2.2544	
(operat. val.)	Qz	2.2565	2.2565	2.2542	2.2598	
chromaticity	Q'x, Q'z	---------- close to zero ----------				
dispersion in long s.s.		---------- < 0.2 ----------				m
acceptance, simultaneously:						
	deltap/p	+-7.5E-3				
	Ax	25*pi	25*pi	25*pi	25*oi	mm*mrad
	Az	25*pi	25*pi	25*pi	12*pi	mm*mrad

ORBITS over deltap/p0 in E-3
beam distribution very schematic



NOTE: Values given here for the AA and on p. AC-01 for the AC, for momenta, frequencies and derived quantities, belong to a consistent set, derived from the premise that the AC central orbit has the correct design length and from the frequencies operationally used in AC and AA. They differ slightly from the theoretical design values given in tables AC-11, AC-13, AA-10, AA-12. Also, the AA ejection orbit length, as given above, is slightly inconsistent with a PS central orbit length of exactly 200*pi m.

AA: BENDING MAGNETS (ring)

	BLG (long)	BST (short)	
type	H	WF	
number	4	8	
bending angle	0.6806	0.4451	rad
bending power (on central orbit)	7.946	5.1965	T*m
bending radius (on central orbit)	7.302	6.493	m
fieldstrength	1.599	1.795	T
effective length (along central orbit)	4.969	2.895	m
steel length (straight line)	4.70	2.71	m
overall length (straight line)	5.29	3.13	m
gap height (total, on central orbit)	0.1575	0.1400	m
good field width (total)	0.240	0.564	m
overall width (total, at end plate)	1.85	2.56	m
resistance/magnet at 30 deg	45.3	32.9	mOhm
inductance/magnet	0.30	0.32	H
current see NOTE 1	1944	1953	A
power/magnet	171	125	kW
steel weight/magnet	65	70	t
copper weight/magnet	5.6	4.9	t
COIL DETAILS		see NOTE 2	
turns/pole	54	i 12	
		o 42	
conductor cross section	23.5*23.5	i 18.0*32.0	mm*mm
		o 23.2*24.9	mm*mm
hole diameter	8.8	i 5.6	mm
		o 6.6	mm
average length/turn	11.7	i 8.25	m
		o 9.52	m
waterflow/magnet (12 atm)	2.3	1.6	l/s
water temperature rise	18	i 17	deg
		o 19	deg

NOTE 1:
Current in BST = 1944 A from main supply + 9 A from trim supply. Trim current adjusts ratio in bending power between BLG and BST. See p. AA-04.

NOTE 2:
BST has 1 inner coil (i) in the median plane and 2 outer coils (o), one on each pole.

AA: QUADRUPOLES (ring)

			QFN+QDN (narrow)	QFW+QDW (wide)	
number			4+11	8+1	
field geometry			circular	elliptic	
gradient*eff.length (on axis)		F	1.869	1.869	T
		D	1.372	1.372	T
sextupole (QFW only,	G'/G	F	0	0.140	m-1
pole shape)	k'*1	F	0	0.0222	m-2
steel length			0.540	0.540	m
overall length			0.825	0.825	m
inscribed circle radius			0.1808	0.2186	m
good field width (total)			0.420	0.680	m
good field height (total)			0.076	0.130	m
overall width (total)			1.424	2.31	m
resistance/quad at 30 deg			13.1	23.2	mOhm
inductance/quad			11	36	mH
current		F	1466	1466	A
		D	1060	1060	A
power/quad		F	28.2	49.9	kW
		D	14.7	26.1	kW
steel weight/quad			4.4	10	t
copper weight/quad			0.56	1.0	t
COIL DETAILS					
turns/pole			24	32	
conductor cross section			23*15	23*15	mm*mm
hole diameter			8.0	8.0	mm
average length/turn			2.23	2.96	m
waterflow/quad (12 atm)			0.24	0.47	l/s
water temperature rise		F	28	25	deg
		D	15	13	deg

AA: MULTIPOLE CORRECTIONS

POLE SHAPE : sextupole on all QFW, see above and p. AA-11

END SHIMS : on quads and bends, see p. AA-11

CORRECTION COIL F4: on all QFW of type 2: 06, 08, 18, 20
2 turns, 1 on each outside pole
acts on alphap and chromaticity over injection range

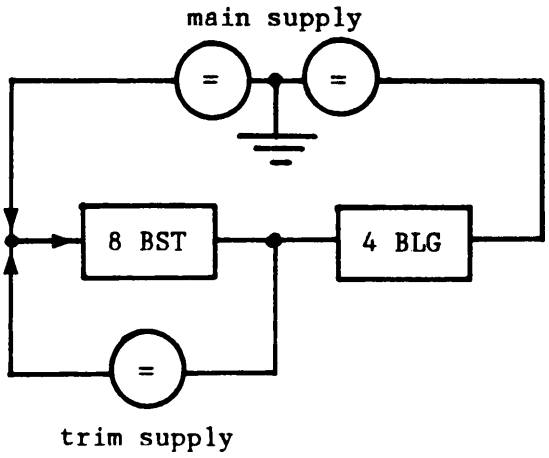
SKEW QUADRUPOLE : 1, in period 13, where alphap=0
current: small stacks: -2.7 A, large stacks: -5.0 A

AA: POWER SUPPLIES (ring)

MAIN SUPPLIES	bends BLG+BST	F-quads QFN+QFW	D-quads QDN+QDW	
operational current	1944	1466	1060	A
stability	2E-5	1E-4	1E-4	
rated current	2000	1750	1300	A
rated voltage	1000	450	330	V
rated output power	2.0	0.79	0.43	MW
voltage drop: coils	864	349	177	V
cables	2.0	2.5	1.8	V
busbars	15	7	6	V
margin	119	92	145	V
power dissipation in coils	1.68	0.51	0.19	MW

TRIM SUPPLY floating, on the 8 BST-magnets, see page AA-02

operational current, adds to main current	9	A
rated current	20	A
stability, fraction of rated current	1E-3	
resolution, fraction of rated current (10-bit DAC)	1E-3	
rated voltage (must overcome voltage drop due to main current)	700	V



AA: KICKERS

		injection	ejection	
number of tanks		1	1	
deflection angle		7.496	5.09	mrad
kick strength		8938	607	G*m
remanent kick strength		3	0.4	G*m
kick fall time, 95-5%		150		ns
kick rise time, 2-98%			190	ns
flat top length		620	600	ns
kick variation on flat top		<+-2	<+-2	%
minimum pulse repetition interval		1	1	s
PFN voltage, operational		57	ca.56	kV
maximum		80	70	kV
electric principle		delay line	lumped imp.	
characteristic impedance		15	15	Ohm
mechanical principle		stationary full apert.	plunging	
number of modules		4	1	
cells/module		17	1	
eff. module length		432	560	mm
operational field strength		517	1064	G
gap height (open C shape)	on inj. orbit	45	23	mm
	min.	45	20	mm
useful aperture width (>95% field)		90	52	mm
overall tank length		2.508	0.908	m

AA: SEPTUM MAGNETS they serve for injection and ejection

number of septum magnets		2	
deflection angle per magnet		51.50	mrad
bending power = field strength * effective length		0.6142	T*m
field strength		0.6469	T
effective length		0.9496	m
overall length		1.001	m
gap height (total)		76	mm
gap width (total)		335	mm
free gap width (total)		296	mm
septum thickness		11	mm
eff. septum thickness (incl. vacuum chamber)		20	mm
number of turns		10	
current (dc)	operational	3880	A
	max.	4000	A
current ripple		<1E-4	
coil resistance		6.9	mOhm
coil voltage drop		27.3	V
water pressure drop		12	atm
waterflow		1	l/s
water temperature rise		25	deg C

AA: RF SYSTEM

NOTE 1: Voltages given are always the sum of the voltages on the 2 gaps.
NOTE 2: Longitudinal emittance in Hz is the total width in frev which the beam would occupy after perfect debunching. Bucket area in Hz is to be understood similarly. This is a convenient definition when the beam is observed through its Schottky spectrum.
NOTE 3: For extraction from the stack, capturing frequency and bucket size are determined on the basis of stack intensity and number of pbar to be extracted.

CAVITY

number of cavities		1	
number of gaps		2	
harmonic number		1	
frequency	around	1.85	MHz
voltage, peak (sum of 2 gaps)	max.	12000	V
	min.	5	V
power of end stage		10	kW
quality factor, Q		50	
impedance seen by beam		200	Ohm
ferrite tuning current, constant		50	A

STACKING

pre-cooled beam:	deltap/p		+-1.5E-3	
	emittance		5.6	eV*s
adiabatic trapping:	frequency		1.845845	MHz
	voltage		3400	V
	bucket area		5.7	eV*s
			620	Hz
deceleration:	voltage (programmed)	max.	7850	V
	gamma = sin phis	max.	-0.2	
	bucket area (constant)		5.7	eV*s
			620	Hz
adiabatic debunching:	deposit, final frequency		1854.40	kHz

EXTRACTION

deltap/p of stack core		ca.	3.0E-3	
corresponding emittance			5.3	eV*s
capturing bucket, moving (see NOTE 3)				
		min.	max.	
	frequency, around	1.855	1.855	MHz
	voltage	30	110	V
	gamma = sin phis	0.77	0.62	
	area	0.073	0.25	eV*s
		8	27	Hz
stationary bucket on ejection orbit:				
	frequency	1.845865	1.845865	MHz
	bucket area	10.65	10.65	eV*s
		1162	1162	Hz
	voltage	12000	12000	V
	bunch length	32	57	ns
	bunch deltap/p	+-0.42E-3	+-0.74E-3	

AA: VACUUM

average pressure, N2-equiv.			7E-11	Torr
residual gas composition	H2		80	%
	N2+CO		15	%
pumps, number * speed for N2:	rotary	9 *	8.3	l/s
	turbomolecular	9 *	270	l/s
	sputter ion	42 *	435	l/s
	Ti-sublimation	93 *	1300	l/s
number of gauges: Bayard-Alpert/Penning/Pirani			38/15/15	
number of mass spectrometers			3	
chamber material, stainl. steel:	in the magnets		316LN	
	tanks, etc.		316LN,304L	
average outgassing rate			1E-12	T*l/s/cm-2
bake-out temperature (in situ)	operational		200	deg C
	max.		300	deg C
clearing field	clearing electrodes		46	
	PU electrode pairs		24	
	applied voltage		400	V

AA: STOCHASTIC COOLING

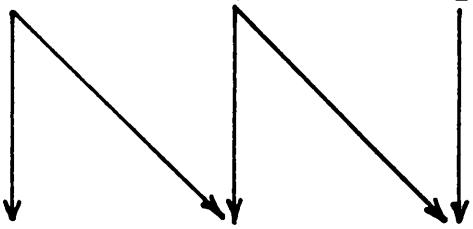
see schematic layout on p. AA-15

PRECOOLING (momentum and vertical)			
number of particles injected/pulse		6E7	
initial deltap/p		+-1.05E-3	
final deltap/p		+-0.26E-3	
fraction of injected particles surviving		100	%
	within final deltap/p	90	%
cooling time, vertical: on throughout		4.4	s
momentum:	phase 1 (passive notch filter)	2.0	s
	phase 2 (passive notch+active peak)	2.4	s
number of tanks: pick-up + kicker		2 + 1	
number of loop pairs / tank (pick-up or kicker)		96	
effective impedance of loops (pick-up or kicker)		100	Ohm
noise-figure of pick-up preamplifiers		1	dB
overall bandwidth		900 - 2400	MHz
output power, approx.	due to beam Schottky signal	100	W
	due to systems noise	300	W
	rated	600	W

STACK COOLING (tail and core)		
deltap/p of particles deposited by RF	+-0.26E-3	
overall stack-width, deltap/p	28E-3	
width of stack core, deltap/p	3E-3	
transverse emittance (95% of pbar), H and V, initial	6*pi*mm*mrad	
final	2*pi*mm*mrad	
cooling time for a stack of 1E11 pbar	1000	s

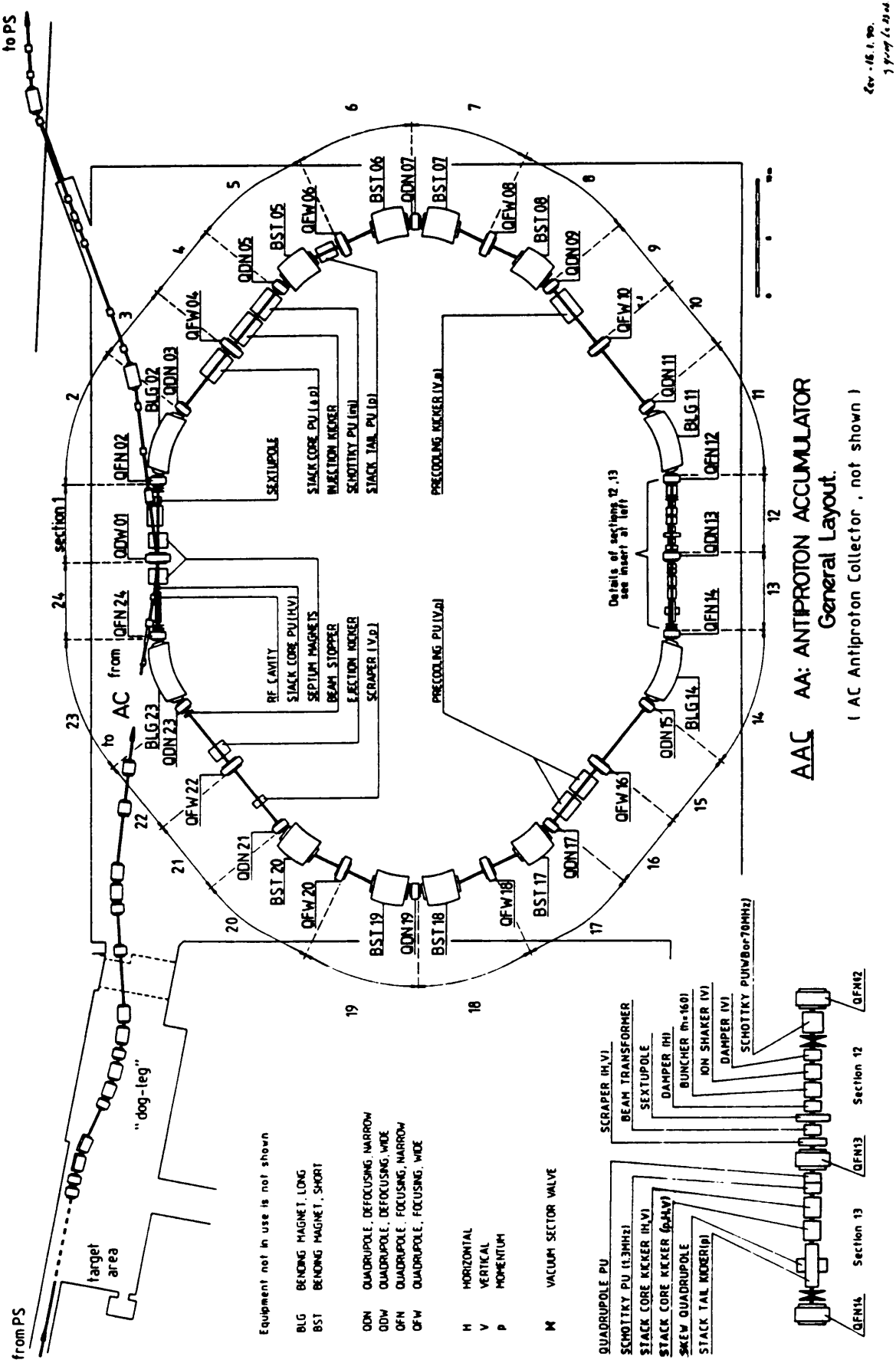
PICK-UP	UCT2406 core H+V	UCM0308 core p	UTM0509 tail p	
bandwidth	2 - 8	1 - 4	0.9 - 1.65	GHz
type of pick-up	4 slot lines	4 slot lines	36 loop pairs	
effective impedance	50	50	100	Ohm
notch filters (coax.)	0	0	2	

SIGNAL FLOW



KICKER	KCT1304 core H+V		KCM1307 core H+V+p			KTC1308 tail+core p		
bandwidth	4 - 8		2 - 4			1 - 2		GHz
type of kicker	4 slot lines		4 slot lines			4 slot lines		
effective impedance	50		50			50		Ohm
output power, approx.	H	V	H	V	p	tail p	core p	
from beam Schottky signal	<10	<5	<5	<5	<10	100	<10	W
from systems noise	1	0.5	0.5	0.5	1	200	1	W
rated	200	20	10	10	20	400	100	W

AA: LAYOUT


to PS
from PS
target area
"dog-leg"
to AC
from AC
section 1
AA: ANTIPROTON ACCUMULATOR
General Layout.
(AC Antiproton Collector , not shown)
Details of sections 12,13 see insert at left
Equipment not in use is not shown
BLG BENDING MAGNET, LONG
BST BENDING MAGNET, SHORT
QDN QUADRUPOLE, DEFOCUSING, NARROW
QDW QUADRUPOLE, DEFOCUSING, WIDE
QFN QUADRUPOLE, FOCUSING, NARROW
QFW QUADRUPOLE, FOCUSING, WIDE
H HORIZONTAL
V VERTICAL
p MOMENTUM
VACUUM SECTOR VALVE
QUADRUPOLE PU
SCHOTTKY PU (1.3MHz)
STACK CORE KICKER (H,V)
STACK CORE KICKER (p,H,V)
SKEW QUADRUPOLE
STACK TAIL KICKER(p)
SCRAPER (H,V)
BEAM TRANSFORMER
SEXTUPOLE
DAMPER (H)
BUNCHER (n=160)
ION SHAKER (V)
DAMPER (V)
SCHOTTKY PU(V)for70MHz)
Section 12
Section 13
SEXTUPOLE
STACK CORE PU (s.p)
INJECTION KICKER
SCHOTTKY PU (H)
STACK TAIL PU (p)
PRECOOLING KICKER (V,p)
PRECOOLING PU (V,p)
RF CAVITY
STACK CORE PU (H,V)
SEPTUM MAGNETS
BEAM STOPPER
EJECTION KICKER
SCRAPER (V,p)

ANTIPROTON ACCUMULATOR 12 PERIODS D/2 F D/2 AGS VERSION 75.03

GEOMETRY

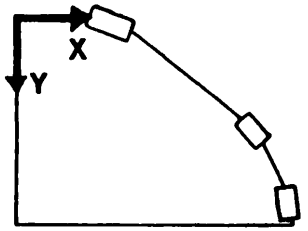
X-,Y-COORDINATES OF THE EXITS OF THE ELEMENTS
THE ENTRANCE OF THE FIRST ELEMENT IS AT X = 0, Y = 0
PHI IS THE ANGLE BETWEEN THE ORBIT AND THE X-AXIS
PHI = 0 AT THE BEGINNING

NO	NAME	magnetic LENGTH (m)	ANGLE (mrad)	K(V) (m^{-2})	X (m)	Y (m)	PHI (rad)
1	D	.3750	0.00000	.1558955	.375000	0.000000	0.000000
2	S3	1.9235	0.00000	0.0000000	2.298500	0.000000	0.000000
3	S3	1.9235	0.00000	0.0000000	4.222000	0.000000	0.000000
4	S3	1.9235	0.00000	0.0000000	6.145500	0.000000	0.000000
5	F	.3750	0.00000	-.2138321	6.520500	0.000000	0.000000
6	F	.3750	0.00000	-.2138321	6.895500	0.000000	0.000000
7	S4	.4003	0.00000	0.0000000	7.295750	0.000000	0.000000
8	B2	4.970068	0.61113	0.0000000	11.890830	1.627029	.680611
9	SD	.1000	0.00000	0.0000000	11.968549	1.689956	.680611
10	S5	.3003	0.00000	0.0000000	12.201938	1.878925	.680611
11	D	.3750	0.00000	.1558955	12.493384	2.114901	.680611
12	D	.3750	0.00000	.1558955	12.784830	2.350876	.680611
13	S3	1.9235	0.00000	0.0000000	14.279751	3.561273	.680611
14	S3	1.9235	0.00000	0.0000000	15.774673	4.771671	.680611
15	S3	1.9235	0.00000	0.0000000	17.269595	5.982068	.680611
16	F	.3750	0.00000	-.2138321	17.561040	6.218043	.680611
17	F	.3750	0.00000	-.2138321	17.852486	6.454019	.680611
18	S3	1.9235	0.00000	0.0000000	19.347408	7.664416	.680611
19	S3	1.9235	0.00000	0.0000000	20.842329	8.874813	.680611
20	S3	1.9235	0.00000	0.0000000	22.337251	10.085211	.680611
21	D	.3750	0.00000	.1558955	22.628696	10.321186	.680611
22	D	.3750	0.00000	.1558955	22.920142	10.557162	.680611
23	S1	.2775	0.00000	0.0000000	23.135812	10.731784	.680611
24	SD	.1000	0.00000	0.0000000	23.213531	10.794710	.680611
25	B1	2.890044	5.09260	0.0000000	24.988094	13.045499	1.125704
26	S2	2.5030	0.00000	0.0000000	26.065739	15.304634	1.125704
27	F	.3750	0.00000	-.2138321	26.227192	15.643098	1.125704
28	F	.3750	0.00000	-.2138321	26.388645	15.981562	1.125704
29	S6	2.4030	0.00000	0.0000000	27.423236	18.150439	1.125704
30	SF	.1000	0.00000	0.0000000	27.466290	18.240697	1.125704
31	B1	2.890044	5.09260	0.0000000	28.098901	21.036216	1.570796
32	SD	.1000	0.00000	0.0000000	28.098901	21.136216	1.570796
33	S1	.2775	0.00000	0.0000000	28.098901	21.413716	1.570796
34	D	.3750	0.00000	.1558955	28.098901	21.788716	1.570796

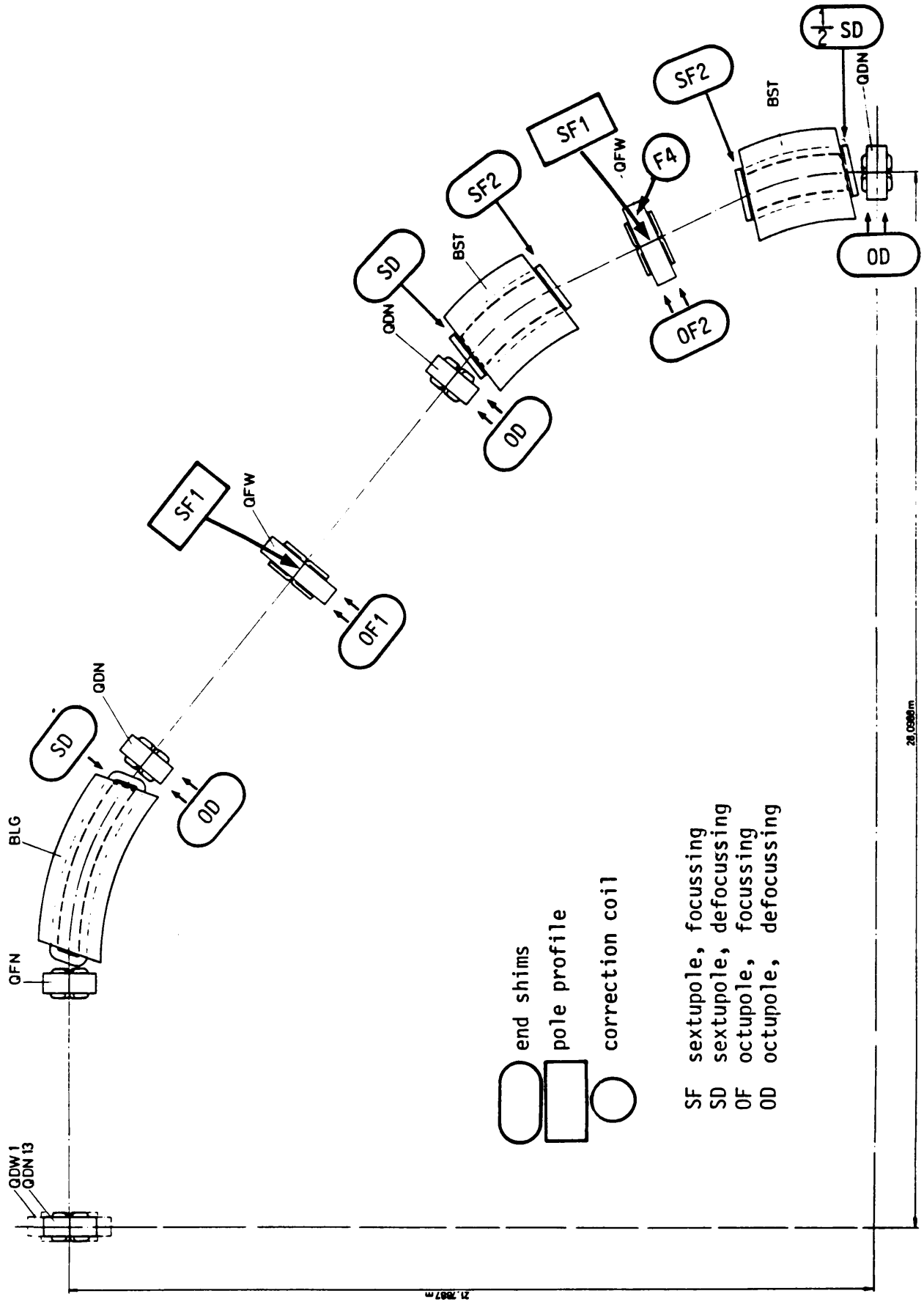
THE COORDINATES OF THE MACHINE CENTRE ARE X = 0.000000, Y = 21.788716

DEFINITION OF CO-ORDINATES:

see p.AA-11



AA: QUADRANT / MULTIPOLE LATTICE CORRECTIONS



LATTICE PARAMETERS ON CENTRAL ORBIT

DP= 0.00000

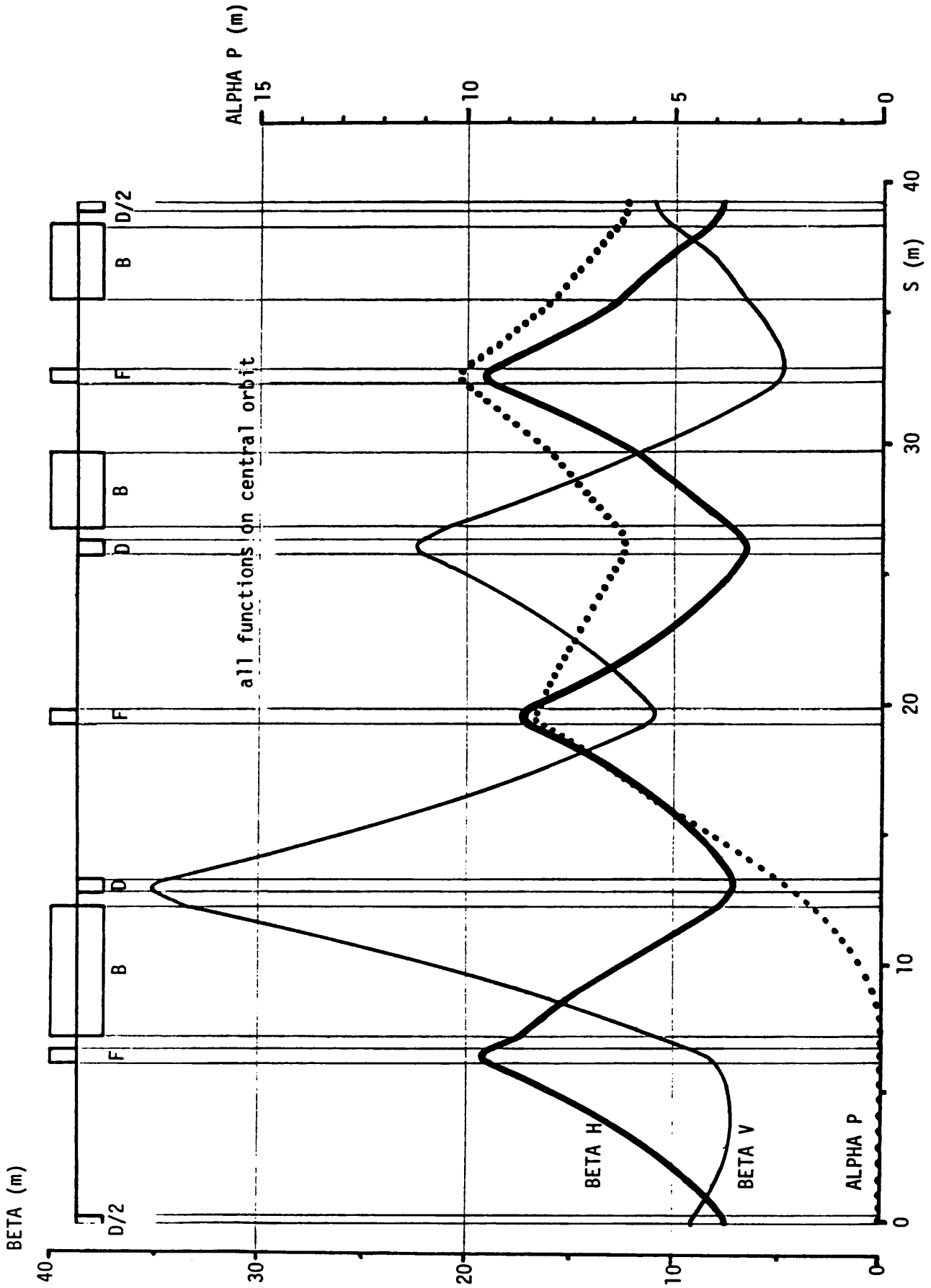
$\alpha = -\frac{1}{2}\beta'$

NO	EL	L(M)	D2L/DX2	DIST(M)	ANG(MR)	K(M-2)	DK/DX	D2K/DX2	β_V(m)	β_H(m)	α_V	α_H	$\mu_V/2\pi$	$\mu_H/2\pi$	α_p(m)	α'_p
0		0.0000	0.0000	0.0000	0.000	0.00000	0.00000	0.00000	9.20	7.36	0.0000	0.0000	0.0000	0.0000	.00	.00
1	QD	.3750	0.0000	.3750	0.000	.15692	0.00000	0.00000	9.01	7.54	.4931	-.4913	.0065	.0080	.00	.00
2	SS	5.7705	0.0000	6.1455	0.000	0.00000	0.00000	0.00000	7.91	18.69	-.3031	-1.4408	.1263	.0888	.00	.00
3	QF	.7500	0.0000	6.8955	0.000	-.21419	0.00000	0.00000	9.48	18.61	-1.8670	1.5464	.1404	.0951	.00	-.00
4	SS	.4003	0.0000	7.2958	0.000	0.00000	0.00000	0.00000	11.05	17.40	-2.0564	1.4734	.1466	.0986	.00	-.00
5	B	4.9700	.4014	12.2658	680.611	0.00000	0.00000	0.00000	33.66	7.71	-1.4080	.6361	.1881	.1635	1.63	.71
6	SS	.4003	0.0000	12.6661	0.000	0.00000	0.00000	0.00000	34.80	7.23	-1.4435	.5632	.1899	.1721	1.91	.71
7	QD	.7500	0.0000	13.4161	0.000	.15692	0.00000	-.02761	33.91	7.10	2.6005	-.3809	.1933	.1890	2.54	.97
8	SS	5.7705	0.0000	19.1866	0.000	0.00000	0.00000	0.00000	11.52	16.87	1.2795	-1.3122	.2405	.2775	8.14	.97
9	QF	.7500	0.0000	19.9366	0.000	-.21419	-.03350	-.20266	11.02	16.81	-.5880	1.3769	.2513	.2844	8.37	-.37
10	SS	5.7705	0.0000	25.7071	0.000	0.00000	0.00000	0.00000	21.87	6.66	-1.2927	.3831	.3119	.3762	6.23	-.37
11	QD	.7500	0.0000	26.4571	0.000	.15692	0.00000	-.02761	21.89	6.75	1.2680	-.5147	.3173	.3943	6.23	.36
12	SS	.3775	.4014	26.8346	0.000	0.00000	0.00000	0.00000	20.95	7.17	1.2230	-.5854	.3201	.4030	6.36	.36
13	B	2.8900	-.0498	29.7246	445.093	0.00000	0.00000	0.00000	11.63	11.91	1.6815	-1.1089	.3497	.4519	7.99	.81
14	SS	2.5030	0.0000	32.2276	0.000	0.00000	0.00000	0.00000	5.28	18.63	.8581	-1.5777	.4015	.4788	10.02	.81
15	QF	.7500	0.0000	32.9776	0.000	-.21419	-.03350	-.02886	4.74	18.76	-.1113	1.4164	.4259	.4850	10.02	-.82
16	SS	2.5030	-.0498	35.4806	0.000	0.00000	0.00000	0.00000	6.63	12.67	-.6460	1.0152	.4996	.5110	7.97	-.82
17	B	2.8900	.2007	38.3706	445.093	0.00000	0.00000	0.00000	10.54	8.25	-.5700	.5672	.5557	.5551	6.33	-.36
18	SS	.3775	0.0000	38.7481	0.000	0.00000	0.00000	0.00000	10.98	7.84	-.6175	.5067	.5613	.5625	6.20	-.36
19	QD	.3750	0.0000	39.1231	0.000	.15692	0.00000	-.02761	11.22	7.65	-.0000	-.0000	.5667	.5703	6.13	.00

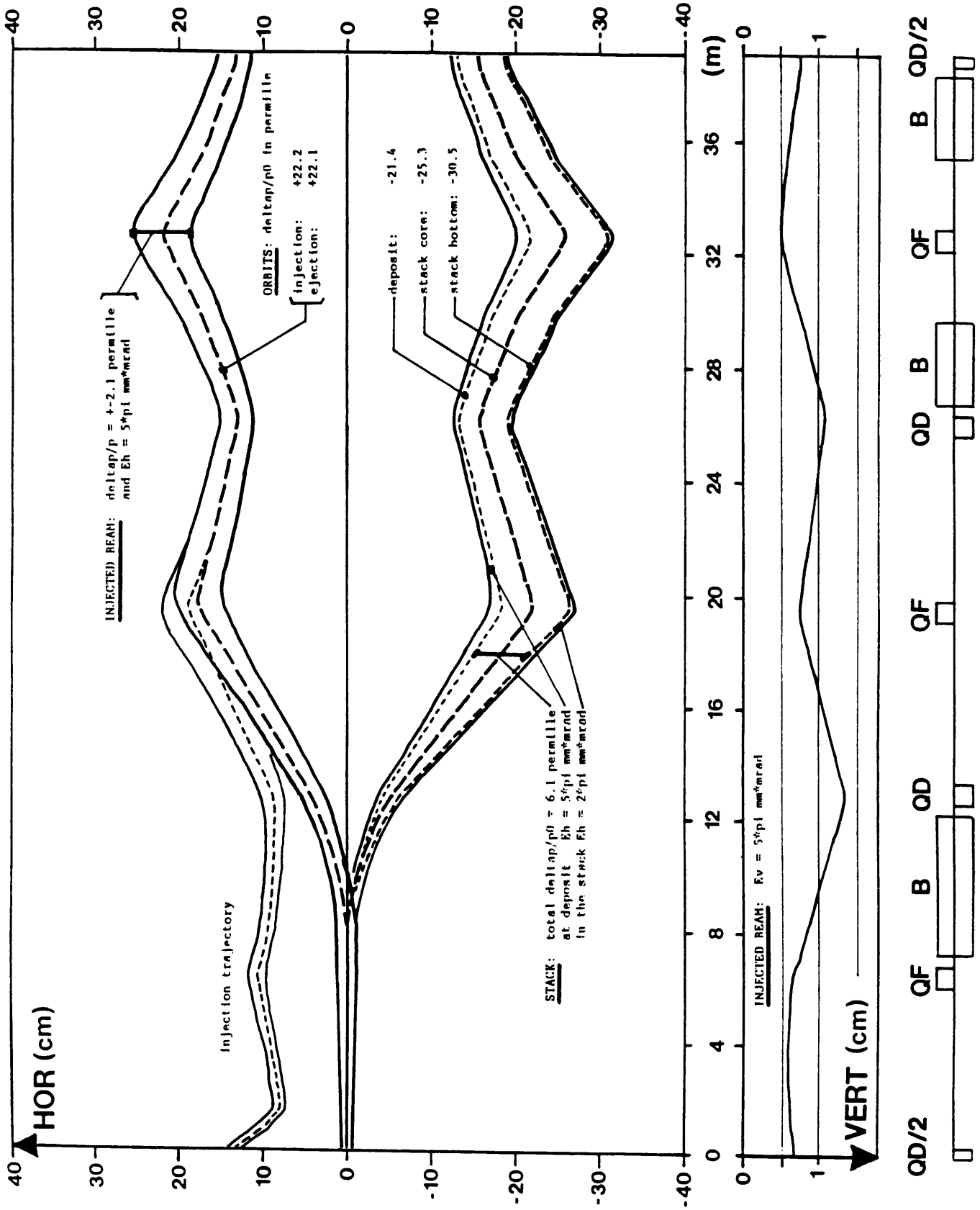
DEPENDENCE ON MOMENTUM

DP/P	CIRCUMF	FR(MHZ)	GAMMA	GAMMATR	ETA
-.03050	155.70339	1.85577	3.75225	2.59040	-.07800
-.03000	155.71538	1.85570	3.75404	2.58499	-.07869
-.02490	155.84009	1.85490	3.77238	2.53550	-.08528
-.02000	155.96360	1.85408	3.79001	2.49674	-.09080
-.01000	156.22425	1.85228	3.82601	2.43948	-.09972
-.00200	156.43838	1.85076	3.85482	2.41077	-.10477
0.00000	156.49240	1.85037	3.86202	2.40558	-.10576
.01000	156.76380	1.84838	3.89807	2.38980	-.10929
.01400	156.87244	1.84758	3.91249	2.38768	-.11008
.02000	157.03487	1.84638	3.93413	2.38838	-.11069
.02150	157.07531	1.84608	3.93955	2.38922	-.11075
.02900	157.27616	1.84458	3.96661	2.39708	-.11048
.03000	157.30273	1.84439	3.97022	2.39856	-.11038

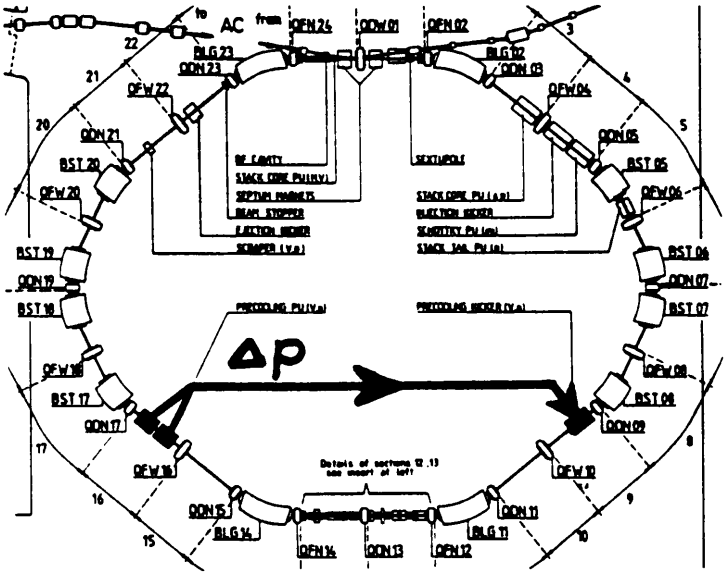
AA: LATTICE PARAMETERS



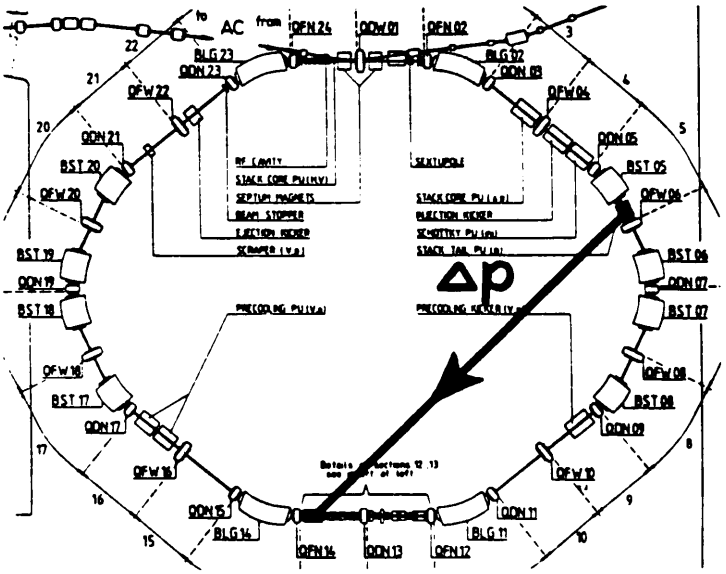
AA: BEAM DIMENSIONS



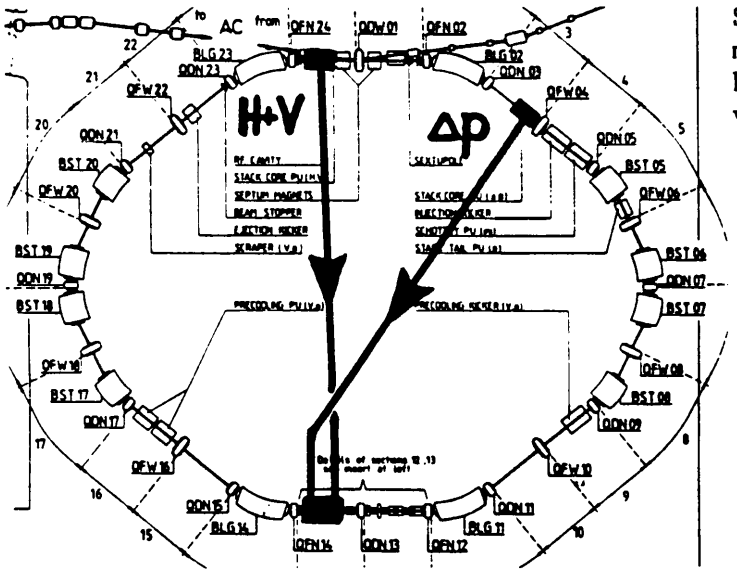
AA: STOCHASTIC COOLING, SCHEMATIC arrows are from pick-up to kicker



PRECOOLING
on injection orbit
momentum: 0.8 - 2.4 GHz



STACK-TAIL COOLING
momentum: 0.9 - 1.65 GHz



STACK-CORE COOLING
momentum : 1 - 4 GHz
horizontal: 2 - 8 GHz
vertical : 2 - 8 GHz