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ACCUMULATOR MODELLING

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In order to describe the accumulator lattice a model is generally used where the dipole is represented by an ideal sector magnet with field index n and a parameter b, the fringe length, to take into account the effect of the fringing field on the vertical focusing, and the quadrupoles are described by a rectangular model. In this note, after a review of the measurements, a study of the accumulator lattice aimed at reproducing the measured tune values is presented. The optical functions plot and lattice parameters are presented in Appendix 1. Appendix 2 contains the parameter list of the accumulator.

1. TUNE MEASUREMENTS

A set of tune measurements has been performed during the last accumulator shifts (third weekend of December): in particular we will use those with a fixed variation of the current (± 1 or 2 %) in one quadrupole family at a time, with a beam current of 1 mA, for which the ion induced tune shift and spread are negligible and there were no synchrotron sidebands. After varying the current in each quadrupole family, the tunes with the nominal settings were measured again and about the same values were found:

$\nu_x^{meas} = 3.147$ $\nu_y^{meas} = 1.1605$ **sextupoles on**

$\nu_x^{meas} = 3.152$ $\nu_y^{meas} = 1.168$ **sextupoles off**

All the measurements were performed with sextupoles on and off. In the following Tables we summarise the results. We call QF1 and SF the first quadrupole and sextupole from the electron injection septum in the clockwise direction. The quadrupole strengths were computed assuming for the beam energy the value corresponding to the dipole current (594 A), that is: E = .5113 GeV, V_{RF} = 120 KV and F_{RF} = 368.39 MHz. The last column of Table II refers to the tunes measured again after setting the quadrupole family to the nominal set.

We recall here the constants used [1] for computing the quadrupole and sextupole strengths:

$K_i^2\ (m^{-2}) = I_i\ (A) * C_1\ /E\ (GeV)$ **quadrupole** $(C_1 = 9.1286*10^{-3})$
$K_i^2\ (m^{-2}) = I_i\ (A) * C_2\ /E\ (GeV)$ **quadrupole** $(C_2 = 9.1430*10^{-3})$
$K_i^2\ (m^{-2}) = I_i\ (A) * C_3\ /E\ (GeV)$ **quadrupole** $(C_3 = 9.1466*10^{-3})$

$K_i^2\ (m^{-2}) = I_i\ (A) * C_{SF}\ /E\ (GeV)$ **sextupole SF** $(C_{SF} = 2.0302*10^{-2})$
$K_i^2\ (m^{-2}) = I_i\ (A) * C_{SD}\ /E\ (GeV)$ **sextupole SD** $(C_{SD} = 2.0191*10^{-2})$

Table I - Quadrupole and Sextupole nominal settings (sign is arbitrary)

	SET VALUE (A)	**K^2 (m^{-2})**
QF1	250.	4.463165
QD	272.	-4.86358
QF2	248.	4.43619
SF	183.	-7.27
SD	150.	5.93
CHVA1001	+1. (only H)	-
CHVA1002	-3. (only H)	-

Table II - Tune measurements vs. ΔI, with sextupoles on.

	ν_x	ν_y	ν_x	ν_y	ν_x	ν_y
	SET + 1 %		**SET - 1 %**		**SET**	
QF1	.1630	.1428	.1318	.1776	.1471	.1605
QD	.1465	.2151	.1482	.1037	.1471	.1581
QF2	.1611	.1404	.1337	.1751	.1471	.1586

There is a difference of ≈ $1.9/2.4 \times 10^{-3}$ on the vertical tune with respect to the nominal one, after setting the power supplies to the nominal values.

Table III - Tune measurements vs. ΔI, with sextupoles off.

	ν_x	ν_y	ν_x	ν_y
	SET + 2 %		**SET - 2 %**	
QF1	.1824	.1330	.1202	.2033
QD	.1495	.1806	.1544	.055
	SET + 1 %		**SET - 1 %**	
QF2	.1672	.1489	.1374	.1843

From the values in Table II we can compute ΔK_i and the average β_x and β_y values at the quadrupoles, as listed in Table IV:

$$\beta_i = \frac{4\pi \, \Delta\nu_i}{\Delta K_i}$$

$\Delta\nu_i$ are the differences between the tunes measured with the excitation current changed by ±1 % (sextupoles on) and those measured at the nominal current setting.

Table IV - Computed average β values at quadrupole vs. ΔI (sextupoles on)

	ΔI (%)	$\Delta\nu_x$	$\Delta\nu_y$	**β_x (m)**	**β_y (m)**
QF1	+1	+.016	-.0172	4.5	4.8
	-1	-.0152	+.0176	4.3	4.95
QD	+1	-.0005	+.0551	.13	14.3
	-1	+.0012	-.0563	.31	14.6
QF2	+1	+.0141	-.0196	4.	5.6
	-1	-.0133	+.0151	3.8	4.3

2. CHROMATICITY MEASUREMENT

A chromaticity measurement has been performed with sextupoles on, for ν_x = 3.147, ν_y = 1.160, by moving the RF frequency by a .005 MHz step. Table V summarises the results. F_x and F_y are the measured horizontal and vertical resonance frequencies.

Table V - Measured tunes vs. RF frequency (sextupoles on)

F_{RF} (MHz)	**F_x (MHz)**	**F_y (MHz)**	$\Delta\nu_x$	$\Delta\nu_y$
368.385	148.71	148.839	.1472	.1612
368.39	148.71	148.834	.1470	.1605
368.395	148.71	148.834	.1468	.1603

From these measurements we get:

$$\mathbf{C_x = +0.6, \quad C_y = +3.6}$$

assuming a momentum compaction value of .041. While the horizontal tune is linear around the "central" frequency, the vertical one is not, probably due to the large frequency interval measured. A measurement on a larger frequency range but with smaller frequency steps is needed to better measure the dependence of the tune on the beam energy.

The contribution to the chromaticity due to the lumped sextupoles only has been computed with the lattice functions listed in Table VI:

Table VI - Lattice functions at sextupoles

	β_x (m)	**β_y (m)**	**D_x (m)**	K **(m^{-2})**
SF	4.4	4.1	.73	-7.27
SD	1.25	9.05	.78	+5.93

From these values we get:

$$\mathbf{C_x = +5.6 \quad , \quad C_y = +6.4}$$

3. TUNE SHIFT DUE TO SEXTUPOLES

The tune measurements with and without sextupoles showed a tune shift:

$$\Delta\nu_x = -0.005 \ , \ \Delta\nu_y = -0.0075$$

From orbit measurements performed in previous shifts (Nov. 96) we could compute the tune-shift induced by an off-axis orbit in the sextupoles. It turned out that the effect of such a displacement is negligible. Moreover in the present runs the vertical orbit was almost corrected to zero by moving mechanically the position of the magnetic centre of two quadrupoles (QUAA2002 by -.3 mm, QUAA4002 by +.1 mm).

If we assume that the measured tune shifts are due to a displaced RF frequency with respect to the "central" one, we can estimete its new value. With the previously computed values of the sextupole contributions to the chromaticity, assuming $\alpha_c = .041$, we get:

$$\Delta p/p \approx 1\text{x}10^{-3}, \qquad \Delta F \approx -15 \text{ kHz}, \qquad F_{RF} = 368.375 \text{ MHz}$$

4. DISPERSION MEASUREMENTS

Dispersion measurements were also performed, by reading the horizontal orbit at two stripline monitors located at the injection straights, for two different RF frequencies, with a 1 mA beam. Table VII shows the data and results. The dispersion was computed assuming the model described in the following section. The last two measurements refer to two different quadrupole settings giving the same tune values but different computed dispersion at the injection straight.

Table VII - Dispersion measurements

Monitor	ν_x^{meas}	ν_y^{meas}	F_{RF} (MHz)	$<x_{oc}>$ (mm)	α_c	D_x^{cal} (m)	D_x^{meas}(m)
BPSA4001	3.147	1.16	368.34	-0.8	.041	0.13	0.131
BPSA4001			368.44	-1.67			
BPSA3001	3.147	1.16	368.34	+0.85	.041	0.13	0.185
BPSA3001			368.44	+2.075			
BPSA3001	3.10	1.15	368.34	-1.41	.044	0.13	0.248
BPSA3001			368.44	-2.94			
BPSA3001	3.10	1.15	368.34	+1.27	.044	0.0	0.153
BPSA3001			368.44	+0.33			

5. TUNES FIT

The vertical tune can be easily fitted by adjusting a parameter *b*, which represents the fringing field length. We use a dipole (3x3) transfer matrix in rectangular approximation for the horizontal plane:

$$\mathbf{M_x} = \begin{pmatrix} \cos k_x s & \sin k_x s/k_x & (1-\cos k_x s)/\rho k_x^2 \\ -k_x \sin k_x s & \cos k_x s & \sin k_x s/\rho k_x \\ 0 & 0 & 1 \end{pmatrix}$$

where: $k_x = \frac{\sqrt{1-n}}{\rho}$, n = field index, ρ = bending radius, while for the vertical plane we added a thin lens to simulate the effect of the fringing:

$$\mathbf{M_y} = \begin{pmatrix} 1 & 0 \\ \frac{2b}{6\rho^2} & 1 \end{pmatrix} \begin{pmatrix} \cos k_y s & \sin k_y s/k_y \\ -k_y \sin k_y s & \cos k_y s \end{pmatrix} \begin{pmatrix} 1 & 0 \\ \frac{2b}{6\rho^2} & 1 \end{pmatrix}$$

where $k_y = \frac{\sqrt{n}}{\rho}$.

The dipole magnetic length is assumed L_B = .864 m, the nominal bending radius is ρ = 1.10008 m. From the dipole field measurements [2] a field index *n* = .47 at the magnet center was obtained, while its average value is $n \approx .42$.

For semplicity, being the three quadrupolar constants very similar, we assume in the following for the three families the same constant C_1, relative to the QF1 family.

If we choose as free parameters the field index *n* and the fringing length *b*, keeping the quadrupole constant C_1 fixed to its measured value for the QF1 family, to match the tunes 3.147, 1.1605 we get:

$$n = .452186 \qquad b = .116119$$

Another possibility is to fix the field index and let vary the quadrupole constant C_1.

In order to find the most suitable combination of free parameters to fit the tunes, we used all the tune measurements with sextupoles on, which are summarised in Table VIII.

Table VIII - Quadrupole settings and tune measurements @ 368.39 MHz, .511 GeV (sext. on).

	QF1	**QD**	**QF2**	ν_x^{meas}	ν_y^{meas}
I (A)	249.4	269.7	249.	3.1501	1.1074
I (A)	243.9	264.1	237.8	3.059	1.1111
I (A)	246.5	264.8	243.5	3.1037	1.0665
I (A)	247.	269.1	243.3	3.1038	1.1501
I (A)	250.	272.	248.	3.147	1.1605
I (A)	252.5	272	248.	3.1630	1.1428
I (A)	247.5	272	248.	3.1318	1.1776
I (A)	250.	274.7	248.	3.1465	1.2154
I (A)	250.	269.3	248.	3.1482	1.1037
I (A)	250.	272.	250.5	3.1611	1.1404
I (A)	250	272	245.5	3.1337	1.1751

We used two couples of different parameters: (n,b), leaving $C_1 = 9.1286\text{x}10^{-3}$ (measured value), CASE 1, and (C_1,b), leaving $n = .47$ (measured value), CASE 2. We then computed the average value of the two couple of parameters, and used them to check the computed tunes. The average values were:

CASE 1: $\langle n \rangle = .450495$, $\langle b \rangle = .11253$ $C_1 = 9.1286\text{x}10^{-3}$

CASE 2: $\langle C_1 \rangle = 9.2338\text{x}10^{-3}$, $\langle b \rangle = .158008$ $n = .47$

Table IX shows the differences in tunes found in the two cases. It is clear that the best couple of parameters is represented by CASE 1.

The largest discrepancy is for tunes close to the integer, in particular the vertical tune ($\Delta\nu_y = .009$). As a check we fit the measurements setting the constants for the three quadrupole families at their measured values (C_1,C_2,C_3) and performing the average again for CASE 1. We obtain:

$$\langle n \rangle = .451945, \quad \langle b \rangle = .11833,$$

$$C_1 = 9.1286\text{x}10^{-3}, \quad C_2 = 9.1430\text{x}10^{-3}, \quad C_3 = 9.1466\text{x}10^{-3}$$

In Table X a comparison of the results is presented.

Table IX - Fit and data deviations on all the measurements

			CASE 1		**CASE** 2	
	ν_x^{meas}	ν_y^{meas}	$\Delta\nu_x$	$\Delta\nu_y$	$\Delta\nu_x$	$\Delta\nu_y$
1	3.1501	1.1074	-.001	+.0025	-.001	+.004
2	3.059	1.1111	+.004	+.005	+.006	+.011
3	3.1037	1.0665	-.0011	+.0085	+.0007	+.016
4	3.1038	1.1501	-.0009	-.002	+.0005	-.0006
5	3.147	1.1605	-.0012	-.0004	-.001	-.003
6	3.1630	1.1428	-.001	-.0006	-.002	-.001
7	3.1318	1.1776	+.00003	-.002	+.0003	-.005
8	3.1465	1.2154	-.0007	-.0087	-.001	-.015
9	3.1482	1.1037	-.001	+.005	-.001	+.006
10	3.1611	1.1404	-.002	-.002	-.003	-.003
11	3.1337	1.1751	+.0006	-.005	+.001	-.008

Table X - Comparison between fitted data

			$C_1=C_2=C_3$		$C_1\neq C_2\neq C_3$	
	ν_x^{meas}	ν_y^{meas}	$\Delta\nu_x$	$\Delta\nu_y$	$\Delta\nu_x$	$\Delta\nu_y$
1	3.1501	1.1074	-.001	+.0025	-.001	+.003
2	3.059	1.1111	+.004	+.005	+.004	+.006
3	3.1037	1.0665	-.0011	+.0085	+.0011	+.010
4	3.1038	1.1501	-.0009	-.002	+.001	-.002
5	3.147	1.1605	-.0012	-.0004	-.0013	-.0007
6	3.1630	1.1428	-.001	+.0006	-.0013	+.0004
7	3.1318	1.1776	+.00003	-.002	+.0002	-.002
8	3.1465	1.2154	-.0007	-.0087	-.0008	-.0096
9	3.1482	1.1037	-.001	+.005	-.0011	+.005
10	3.1611	1.1404	-.002	-.002	-.002	-.002
11	3.1337	1.1751	+.0006	-.005	+.0005	-.005

The difference is negligible. Excluding the two measurements with the larger deviation (n. 3 and 8) and computing the average again we don't get substantial improvements. The difference between computed and measured tune is plotted in Figs. 1 and 2 for the horizontal and vertical one.

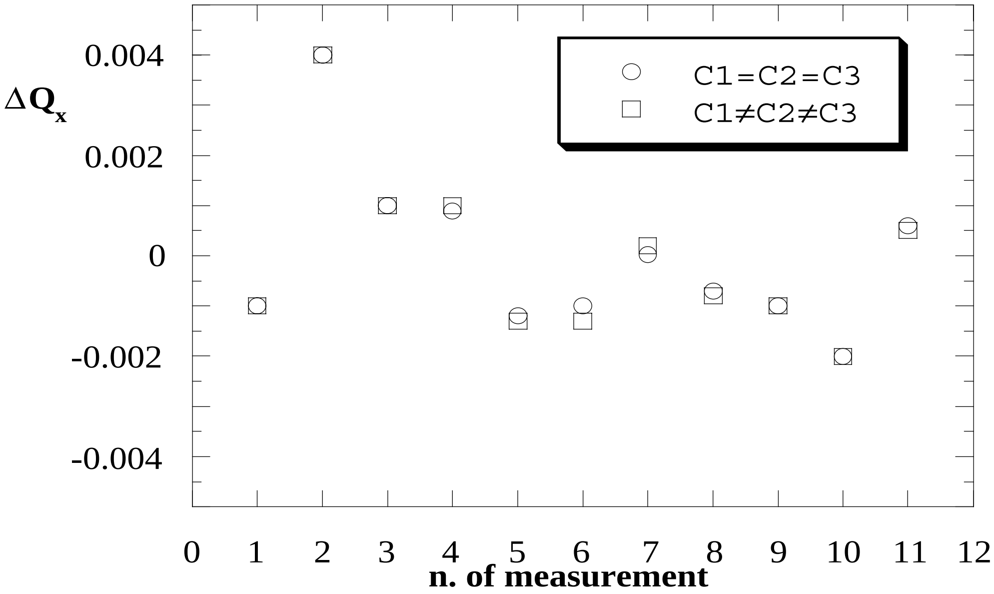

Fig. 1 - Horizontal tune deviations from fit

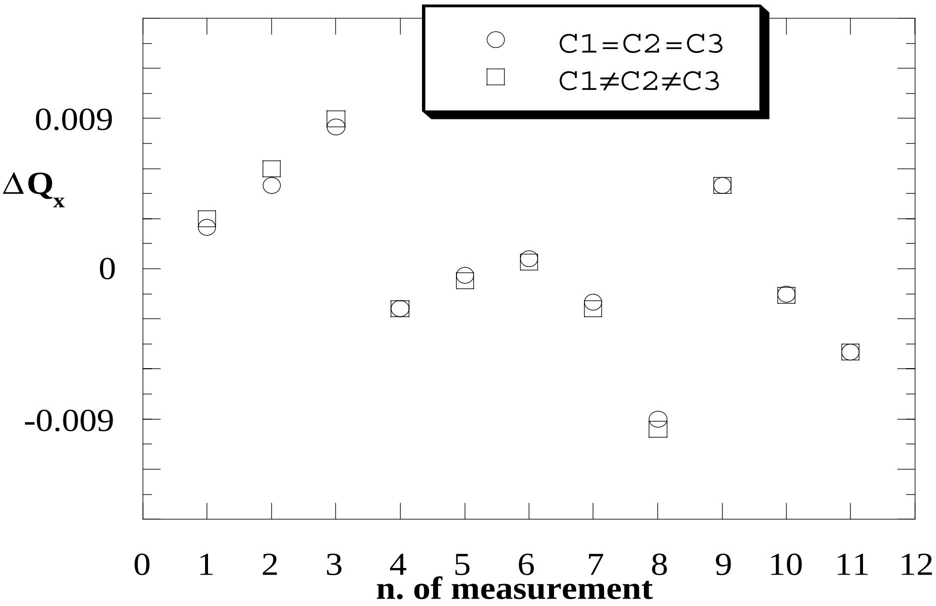

Fig. 2 - Vertical tune deviations from fit

To improve the fit a least square method was also applied, using as free parameters *n*, *b* and C_1. The results were not better than those obtained with the previous average.

A list of the lattice parameters, with a plot of the optical functions of one sector, is presented, for the nominal set 3.147, 1.1605, in Appendix 1. A copy of the accumulator parameter list is given in Appendix 2.

6. CONCLUSIONS

The proposed model is satisfactory if we use as free parameters the field index and the fringing length in the bending magnet. Some systematic measurements are still needed: tunes with and without sextupoles at different frequencies for an accurate chromaticity and central orbit frequency measurement.

REFERENCES

[1] C. Biscari, M. Preger, Numerical constants and initial set points for the first part of the DAΦNE injector commissioning, DAΦNE Tech. Note C-17, Apr. 95.

[2] A. Battisti et al., Measurement and tuning of the DAΦNE Accumulator dipole, DAΦNE Tech. Note MM-9, Aug. 95.

[3] B. Bolli et al., Measurements on Tesla Quadrupole prototype for the DAΦNE Accumulator and Main Ring, DAΦNE Tech. Note MM-4, Dec. 94.

[4] B. Bolli et al., Field quality and alignment of the DAΦNE Accumulator quadrupoles, DAΦNE Tech. Note MM-8, Aug. 95.

[5] C. Biscari, Quadrupole modelling, DAΦNE Tech. Note L-23, Mar. 96.

[6] M. Bassetti, C. Biscari, Analytical Formulae for Magnetic Multipoles, Particle Accelerators, 1996, Vol. 52, pp. 221-250.

APPENDIX 1 - Lattice Parameters

QX - QZ	3.147	1.161
tunes/period	1.574	0.5806

ETA (m)	**BX0 (m)**	**BZ0 (m)**	**ETAMAX (m)**	**BXMAX (m)**	**BZMAX (m)**
0.1340	1.526	3.372	0.9345	4.487	14.10

SYNCHROTRON RADIATION INTEGRALS (R.H.HELM et al.) :

I1 (m)	0.140414177D+01		
I2 (1/m)	0.571157659D+01		
I3 (1/m^2)	0.519196961D+01		
I4 (1/m)	-0.104880077D+01		
I5 (1/m)	0.373658343D+01		
D	-.1836	0.0000E+00	
JS,JX,JZ	1.816	1.184	1.000
DAMPINGS(ms)	11.15	17.10	20.24

TRANSFER MATRIX FOR ONE FULL PERIOD

-0.894859457D+00	-0.681138094D+00	0.253939890D+00
0.292490691D+00	-0.894859457D+00	-0.391981863D-01

-0.874577878D+00	-0.163488108D+01
0.143810787D+00	-0.874577878D+00

BEAM PAR & dN/dt FOR T=293K - P = 1nTorr - Z(biatomic)=8 :

REV. FREQUENCY (MHZ)	0.920738507D+01
HARMONIC NUMBER	0.800000000D+01
RF FREQUENCY (MHZ)	0.736590806D+02
VRF(KV)	0.100000000D+03
ENERGY (MEV)	0.511000000D+03
U0 (KeV)	0.548285388D+01
MOM. COMPACTION	0.431247473D-01
F SYNC.(KHz)	0.301590262D+02
RF ACCEPTANCE	0.181811692D-01
NAT.BUNCH LENGTH(cm)	0.299087170D+01
NAT. ENERGY SPREAD	0.438376940D-03

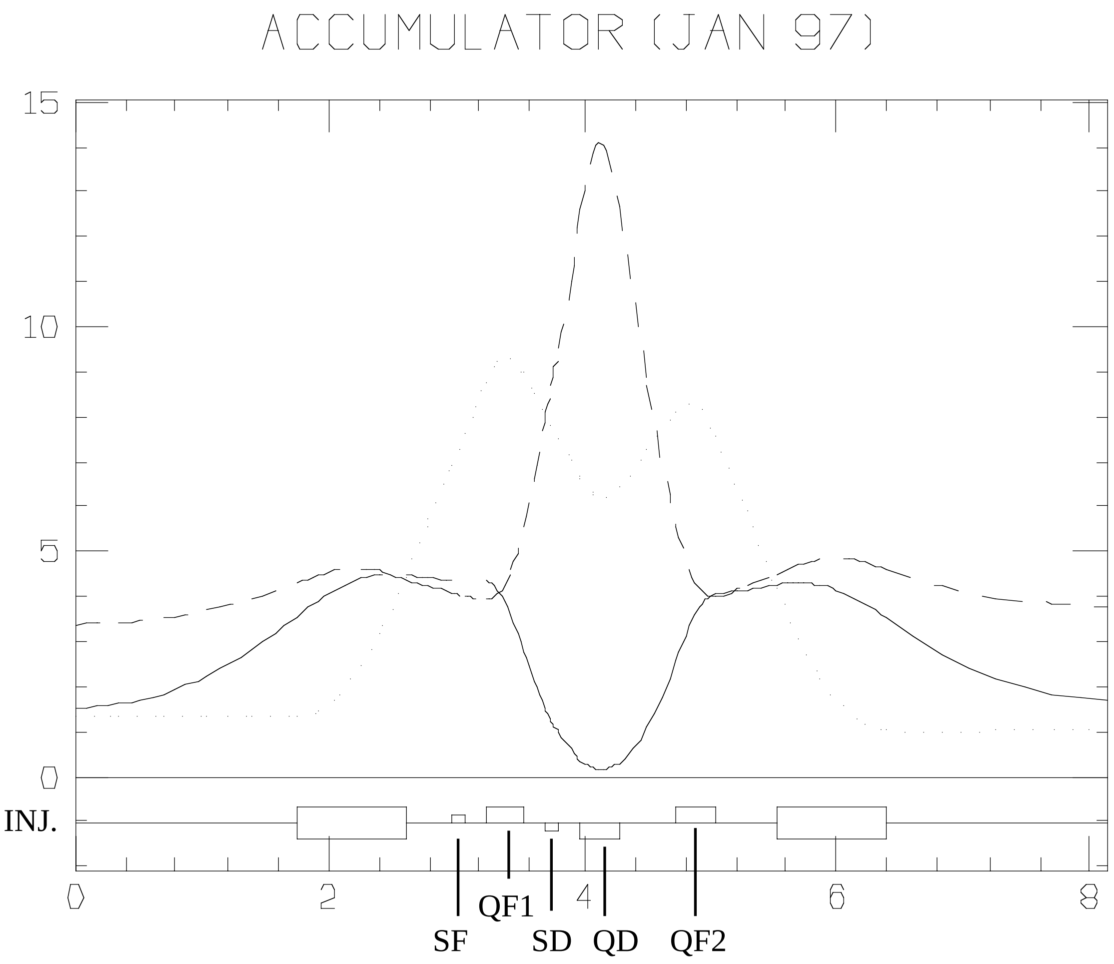

Fig. A1 - One period optical functions

APPENDIX 2 - Accumulator Parameters List

The K^2 values are relative to the fit presented in this note for $\nu_x = 3.147$, $\nu_y = 1.1605$. The monitor and corrector lengths are set to zero. A_x and A_y are the full pipe aperture along the ring.

TYPE	NAME	L tot (m)	L (m)	K2 (m^{-2})	TETA (deg)	RO (m)	Ax (mm)	Ay (mm)
1	O	0.905375	0.905375				100	30
7	SPTA1002	1.530375	0.625000				100	30
99	FL2A1001	1.530375	0.000000				100	30
1	O	1.750375	0.220000				103	30
99	SIPA1001	1.750375	0.000000				103	30
4	DHSA1001	2.614375	0.864000	-.373466	45.0	1.100079	103	30
99	SIPA1002	2.614375	0.000000				103	30
1	O	2.801375	0.187000				103	30
50	BPBA1001	2.801375	0.000000				103	110
1	O	2.982375	0.181000				103	86
3	SXPA1001	3.082375	0.100000	-7.27			103	86
1	O	3.240375	0.158000				103	86
2	QUAA1001	3.540375	0.300000	4.463165			103	86
1	O	3.710375	0.170000				103	86
3	SXPA1002	3.810375	0.100000	5.93			103	86
1	O	3.980375	0.170000				103	86
2	QUAA1002	4.280375	0.300000	-4.86358			103	86
99	VUGA1001	4.280375	0.000000				103	86
1	O	4.736375	0.456000				103	86
2	QUAA1003	5.036375	0.300000	4.43619			103	86
1	O	5.206375	0.170000				103	80
50	BPSA1001	5.206375	**0.000000**				103	80
1	O	5.226375	0.020000				103	80
56	CHVA1001	5.226375	**0.000000**				103	80
1	O	5.526375	0.300000				103	30
99	SIPA1003	5.526375	0.000000				103	30
4	DHSA1002	6.390375	0.864000	-.373466	45.0	1.100079	103	30
1	O	6.577375	0.187000				103	30
50	BPBA1002	6.577375	0.000000				103	30
1	O	6.697250	0.119875				103	30
70	KCKA1001	7.542250	0.845000				186	136
1	O	7.914750	0.372500				140	140
99	SIPA1004	7.914750	0.000000				140	140
56	CHVA1002	7.914750	**0.000000**				140	140

TYPE	NAME	L tot (m)	L (m)	K2 (m^{-2})	TETA (deg)	RO (m)	Ax (mm)	Ay (mm)
1	**O**	8.140750	0.226000				140	140
1	**O**	8.366750	0.226000				140	140
1	**O**	8.739250	0.372500				140	140
70	**KCKA2001**	9.584250	0.845000				186	136
1	**0**	9.704125	0.119875				103	30
50	**BPBA2001**	9.704125	0.000000				103	30
1	**O**	9.891125	0.187000				103	30
4	**DHSA2001**	10.755125	0.864000	-.373466	45.0	1.100079	103	30
99	**SIPA2001**	10.755125	0.000000				103	30
1	**O**	11.055125	0.300000				103	75
56	**CHVA2001**	11.055125	**0.000000**				103	75
1	**O**	11.075125	0.020000				103	75
50	**BPSA2001**	11.075125	0.000000				103	75
1	**O**	11.245125	0.170000				103	86
2	**QUAA2001**	11.545125	0.300000	4.43619			103	86
99	**VUGA2001**	11.545125	0.000000				103	86
1	**O**	12.001125	0.456000				103	86
2	**QUAA2002**	12.301125	0.300000	-4.86358			103	86
1	**O**	12.471125	0.170000				103	86
3	**SXPA2001**	12.571125	0.100000	5.93			103	86
1	**O**	12.741125	0.170000				103	86
2	**QUAA2003**	13.041125	0.300000	4.463165			103	86
1	**O**	13.199125	0.158000				103	86
3	**SXPA2002**	13.299125	0.100000	-7.27			103	86
1	**O**	13.480125	0.181000				103	86
50	**BPBA2002**	13.480125	0.000000				103	86
1	**O**	13.667125	0.187000				103	30
99	**SIPA2002**	13.667125	0.000000				103	30
4	**DHSA2002**	14.531125	0.864000	-.373466	45.0	1.100079	103	30
99	**SIPA2003**	14.531125	0.000000				103	30
1	**O**	14.751125	0.220000				100	30
99	**FL2A2001**	14.751125	0.000000				100	30
7	**SPTA2001**	15.376125	0.625000				100	30
1	**O**	16.281500	0.905375				103	86
1	**0**	17.501875	1.220375				86	75
99	**DCMA3001**	17.501875	0.000000				86	75
56	**CHVA3001**	17.501875	**0.000000**				86	75
1	**O**	17.721875	0.220000				86	75
50	**BPSA3001**	17.721875	**0.000000**				86	77
1	**O**	18.031875	0.310000				103	30
99	**SIPA3001**	18.031875	0.000000				103	30
4	**DHSA3001**	18.895875	0.864000	-.373466	45.0	1.100079	103	30

TYPE	NAME	L tot (m)	L (m)	K2 (m^{-2})	TETA (deg)	RO (m)	Ax (mm)	Ay (mm)
99	**SIPA3002**	18.895875	0.000000				103	30
1	**O**	19.082875	0.187000				103	30
50	**BPBA3001**	19.082875	0.000000				103	30
1	**O**	19.263875	0.181000				103	30
3	**SXPA3001**	19.363875	0.100000	-7.27			103	30
1	**O**	19.521875	0.158000				103	30
2	**QUAA3001**	19.821875	0.300000	4.463165			103	86
1	**O**	19.991875	0.170000				103	86
3	**SXPA3002**	20.091875	0.100000	5.93			103	86
1	**O**	20.261875	0.170000				103	86
2	**QUAA3002**	20.561875	0.300000	-4.86358			103	86
1	**O**	21.017875	0.456000				103	86
2	**QUAA3003**	21.317875	0.300000	4.43619			103	86
1	**O**	21.487875	0.170000				103	86
1	**O**	21.537875	0.050000				103	86
56	**CHVA3002**	21.537875	**0.000000**				103	86
1	**O**	21.807875	0.270000				103	30
99	**SIPA3003**	21.807875	0.000000				103	30
4	**DHSA3002**	22.671875	0.864000	-.373466	45.0	1.100079	103	30
99	**SIPA3004**	22.671875	0.000000				103	30
1	**O**	22.858875	0.187000				103	30
50	**BPBA3002**	22.858875	0.000000				103	30
1	**O**	23.047250	0.188375				103	30
70	**KCKA3001**	23.597250	0.550000				186	136
1	**O**	24.422250	0.825000				103	30
99	**SIPA3005**	24.422250	0.000000				103	30
99	**VUGA3001**	24.422250	0.000000				103	30
100	**RFCA3001**	24.422250	**0.000000**				103	30
1	**O**	25.087250	0.665000				103	30
56	**CHVA4001**	25.087250	**0.000000**				103	30
1	**O**	25.247250	0.160000				103	30
70	**KCKA4001**	25.797250	0.550000				186	136
1	**0**	25.985625	0.188375				103	30
50	**BPBA4001**	25.985625	0.000000				103	30
1	**O**	26.172625	0.187000				103	30
99	**SIPA4001**	26.172625	0.000000				103	30
4	**DHSA4001**	27.036625	0.864000	-.373466	45.0	1.100079	103	30
99	**SIPA4002**	27.036625	0.000000				103	30
1	**O**	27.306625	0.270000				103	86
56	**CHVA4002**	27.306625	**0.000000**				103	86
1	**O**	27.356625	0.050000				103	86
1	**O**	27.526625	0.170000				103	86

TYPE	NAME	L tot (m)	L (m)	K2 (m^{-2})	TETA (deg)	RO (m)	Ax (mm)	Ay (mm)
2	QUAA4001	27.826625	0.300000	4.43032			103	86
1	O	28.282625	0.456000				103	86
2	QUAA4002	28.582625	0.300000	-4.86358			103	86
1	O	28.752625	0.170000				103	86
3	SXPA4001	28.852625	0.100000	5.93			103	86
1	O	29.022625	0.170000				103	86
2	QUAA4003	29.322625	0.300000	4.463165			103	86
1	O	29.480625	0.158000				103	86
3	SXPA4002	29.580625	0.100000	-7.27			103	86
1	O	29.761625	0.181000				103	30
50	BPBA4002	29.761625	0.000000				103	30
1	O	29.948625	0.187000				103	30
99	SIPA4003	29.948625	0.000000				103	30
4	DHSA4002	30.812625	0.864000	-.373466	45.0	1.100079	103	30
99	SIPA4004	30.812625	0.000000				103	30
1	O	31.122625	0.310000				103	77
50	BPSA4001	31.122625	**0.000000**				86	75
1	O	31.342625	0.220000				86	75
56	CHVA4003	31.342625	**0.000000**				86	75
99	KHTA4001	31.342625	0.000000				86	75
99	KVTA4001	31.342625	0.000000				86	75
99	WCMA4001	31.342625	0.000000				86	75
99	PHTA4001	31.342625	0.000000				86	75
99	PVTA4001	31.342625	0.000000				86	75
1	O	31.822625	0.480000				75	75
1	O	32.563000	0.740375				103	86