DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

Frascati, April 27, 1992

Note: **I-8**

TRANSFER LINES FOR DAΦNE INJECTION

C. Biscari

Introduction

The DAΦNE injection system consists of a full energy linac and a damping ring. The layout of the complex is almost completely predetermined by the existing buildings and facilities.

A preliminary design of the transport lines from and to the three machines (Linac, Accumulator, Main Rings) was described in [1] and [2]. As there stretched, the main design concept is to reduce the number of components and redundant lines as much as possible.

A new design of the lines has been studied; an effort has been made to further reduce the number of quadrupoles, their field gradient, and specially the beam size leading to reduction of the magnet apertures and costs. The linear optics is presented. The study on sensitivity to magnet errors and multipole components is now in progress.

General design

The layout of the lines, sketched in Fig.1, is the same as described in [2]. The horizontal dipole magnet locations and fields have not changed; the three stronger magnets, of which two are pulsed, have become sector dipoles, to avoid the strong horizontal defocusing lens due to the edge effect. Apart from the Y magnet for the injection into the accumulator, all the other dipoles are rectangular; this allows to construct the same type of magnets also for slightly different bending angles.

The beam lines are on different levels: the Accumulator is 60 cm higher than the Linac, which in turn is 45 cm higher than DAΦNE. In addition the line to inject electrons into DAΦNE passes under the rings by 70 cm. The level differences are followed by vertical chicanes, obtained with an unique type of vertical dipole (rectangular type, 35 cm of magnetic length, 11° bending angle).

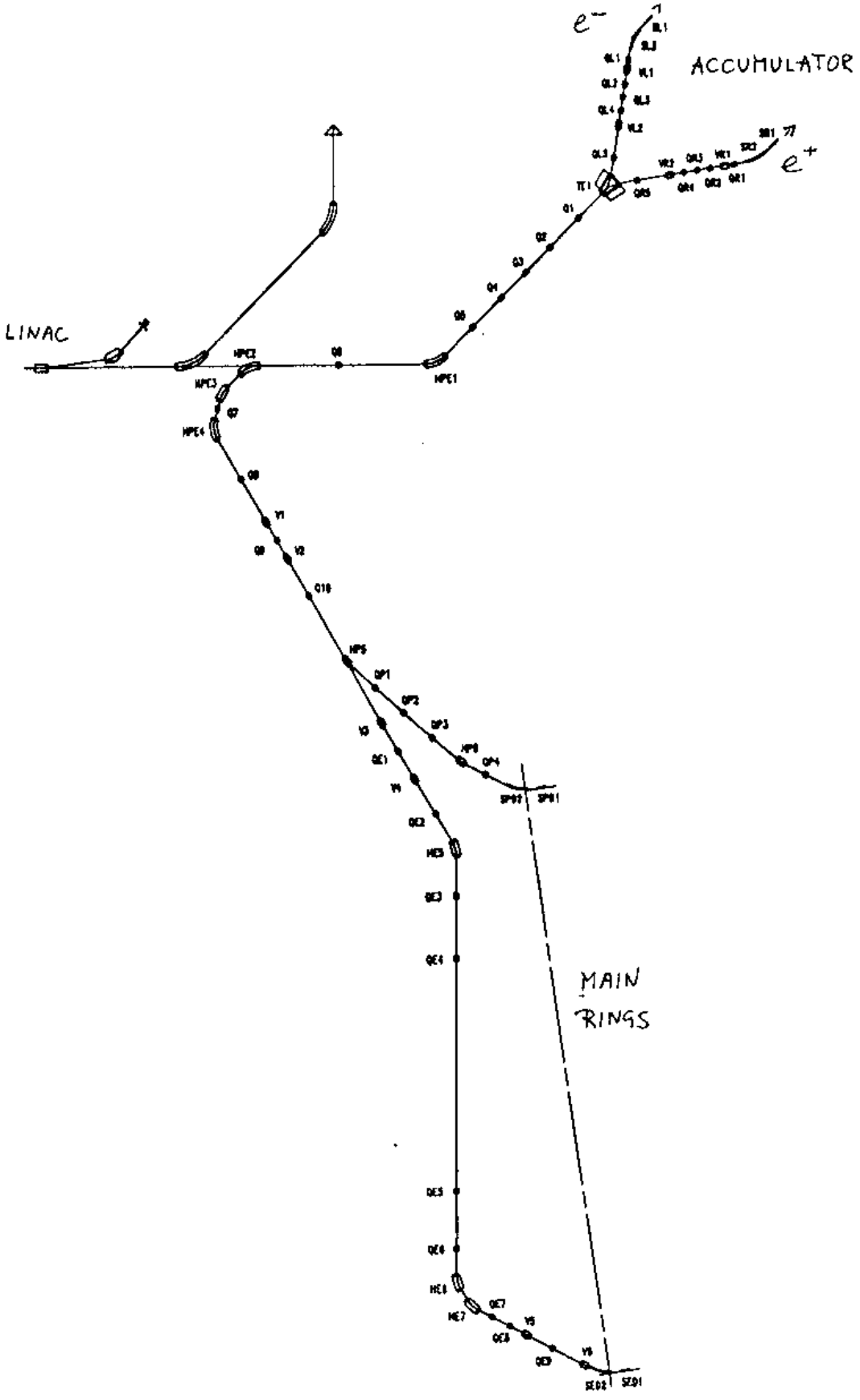

Fig. 1 - Layout of the transport lines.

The number of quadrupoles has been reduced by 25% with respect to the previous design; all the quadrupoles are 20 cm long; the maximum integrated gradient (G*length) has been reduced by almost a factor 3. Few different types of quadrupoles are foreseen, according to the requirements in aperture and in gradient, to optimize their cost and utilization.

In the Appendix a complete description of the lines, including element characteristics and positions, is given.

Lines Linac - Accumulator

In the philosophy of reducing elements and costs a part of the line will be used both for injection and extraction of the beam in and from the Accumulator (see Fig.1), without changing the field configuration because only few tens of milliseconds separate the passages of beam in - beam out. In addition the line for the beam in must be an achromat in both planes, this imposing strong restrictions on its flexibility.

The nominal characteristics of the two beams from the Linac are given in Table 1. Obviously, the most critical beam transport is the one for positrons because of the larger emittance and higher energy spread; the line presenting a lower dispersion function has been chosen for the positron injection into the accumulator, and it corresponds to the counter clock-wise direction inside the ring (opposite to Ref. [2]).

Table 1 - Beams from Accumulator

	Positrons	Electrons
ε_x (m rad)	10^{-5}	10^{-6}
ε_y (m rad)	10^{-5}	10^{-6}
$\Delta p/p$	± 1.5 %	± 0.5 %

The injection into the accumulator[3] is in the horizontal plane, in a free dispersion region. The optimum betatron function, which minimizes the residual betatron oscillation of the injected beam, has been calculated following Ref. [4] and corresponds to:

$\beta_{opt} \approx 1.5$ m for positrons

$\beta_{opt} \approx 0.95$ m for electrons

for the present accumulator optics.

In the vertical plane the requirement of achromatism for the injected beam has been relaxed (a residual dispersion function of few cm produces an additional beam size of few mm), this giving a notable decreament in the field gradient of the vertical chicane quadrupoles, what translates in lower sensitivity to errors.

For completeness, the line is presented from the linac including the matching section described in [5]. The maximum gradient in the quadrupoles is 7.4 (7.0) T/m for the positron (electron) line. The initial and final values of the optical functions are given in Table 2 in the MAD format.

Table 2

LINAC----> ACCUMULATOR (POSITRONS)
TWISS PARAMETERS FOR BEAM LINE "LINPO"

ELEMENT SEQUENCE			I	HORIZONTAL					I	VERTICAL				
POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	I	BETAX [M]	ALFAX	MUX [2PI]	DX [M]	DX'	I	BETAY [M]	ALFAY	MUY [2PI]	DY [M]	DY'
BEGIN	LINPO	1	0.000		2.116	0.000	0.000	0.000	0.000		4.624	0.000	0.000	0.000	0.000
END	LINPO	1	56.438		1.520	-1.287	3.079	0.000	0.000		6.750	0.250	1.579	-0.063	0.090

TOTAL LENGTH = 56.438337	MUX	=	3.079145	MUY	= 1.579424
	MUX'	=	-18.500403	MUY'	= -2.638073
	BETAX (MAX)	=	52.897003	BETAY (MAX)	= 37.284633
	DX (MAX)	=	1.843386	DY (MAX)	= 0.572974

LINAC----> ACCUMULATOR (ELECTRONS)
TWISS PARAMETERS FOR BEAM LINE "LINEL"

ELEMENT SEQUENCE			I	HORIZONTAL					I	VERTICAL				
POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	I	BETAX [M]	ALFAX	MUX [2PI]	DX [M]	DX'	I	BETAY [M]	ALFAY	MUY [2PI]	DY [M]	DY'
BEGIN	LINEL	1	0.000		2.116	0.000	0.000	0.000	0.000		4.624	0.000	0.000	0.000	0.000
END	LINEL	1	56.438		0.998	-1.111	2.352	0.000	0.000		9.683	-0.732	1.934	0.100	0.187

TOTAL LENGTH = 56.438337	MUX	=	2.351964	MUY	= 1.934158
	MUX'	=	-7.707752	MUY'	= -4.033632
	BETAX (MAX)	=	34.830941	BETAY (MAX)	= 45.909465
	DX (MAX)	=	4.333677	DY (MAX)	= 0.576596

The betatron functions and beam sizes are represented in Figs. 2 and 3 for positrons and electrons respectively. The beam size, defined as

$$\sqrt{\varepsilon\beta + (D\,\Delta p/p)^2}$$

is less than 3 cm all along the line for positrons and less than 2 cm for electrons.

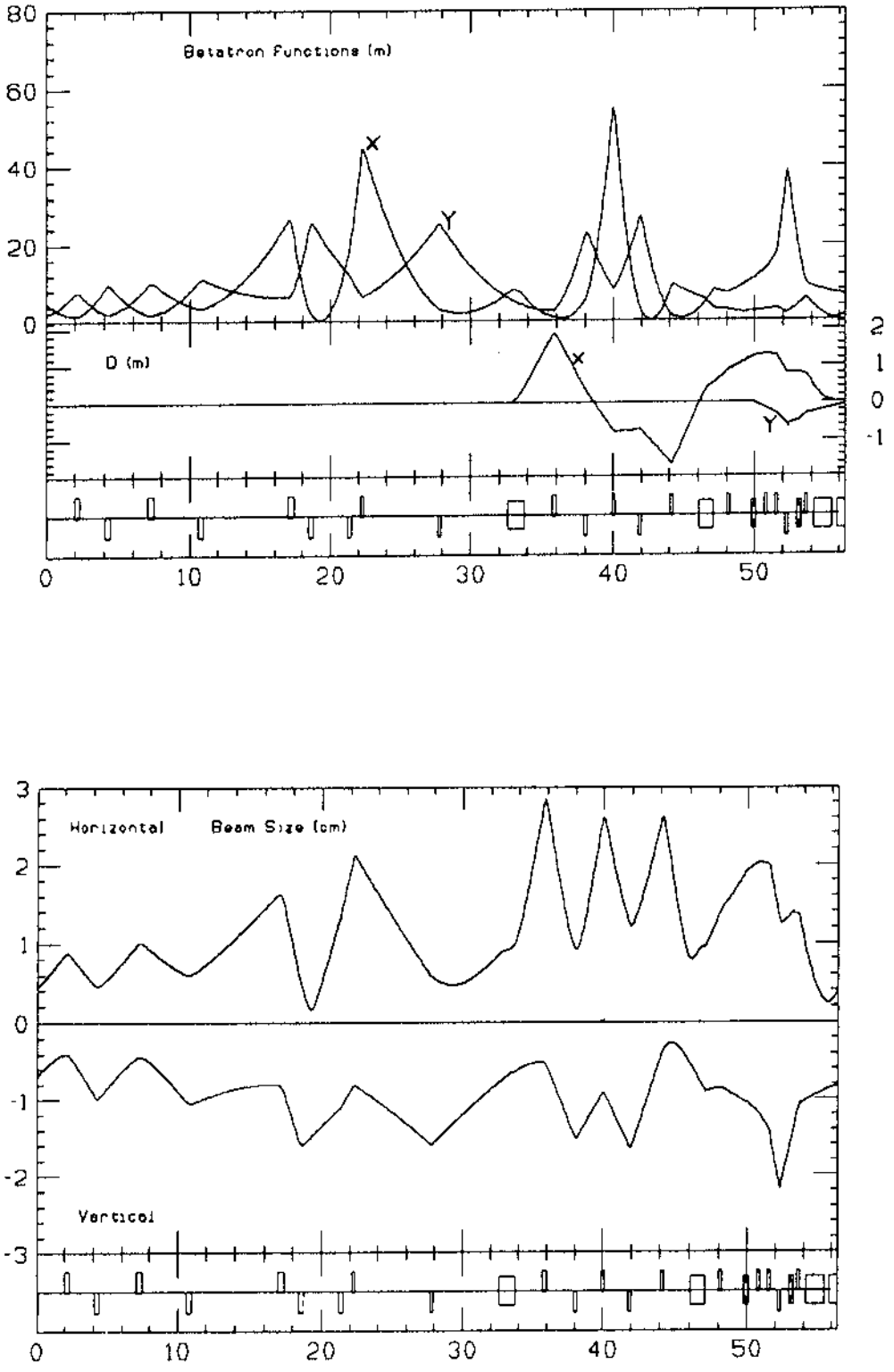

Fig. 2 - Optical functions and beam sizes along the transport line from Linac to Accumulator for positrons.

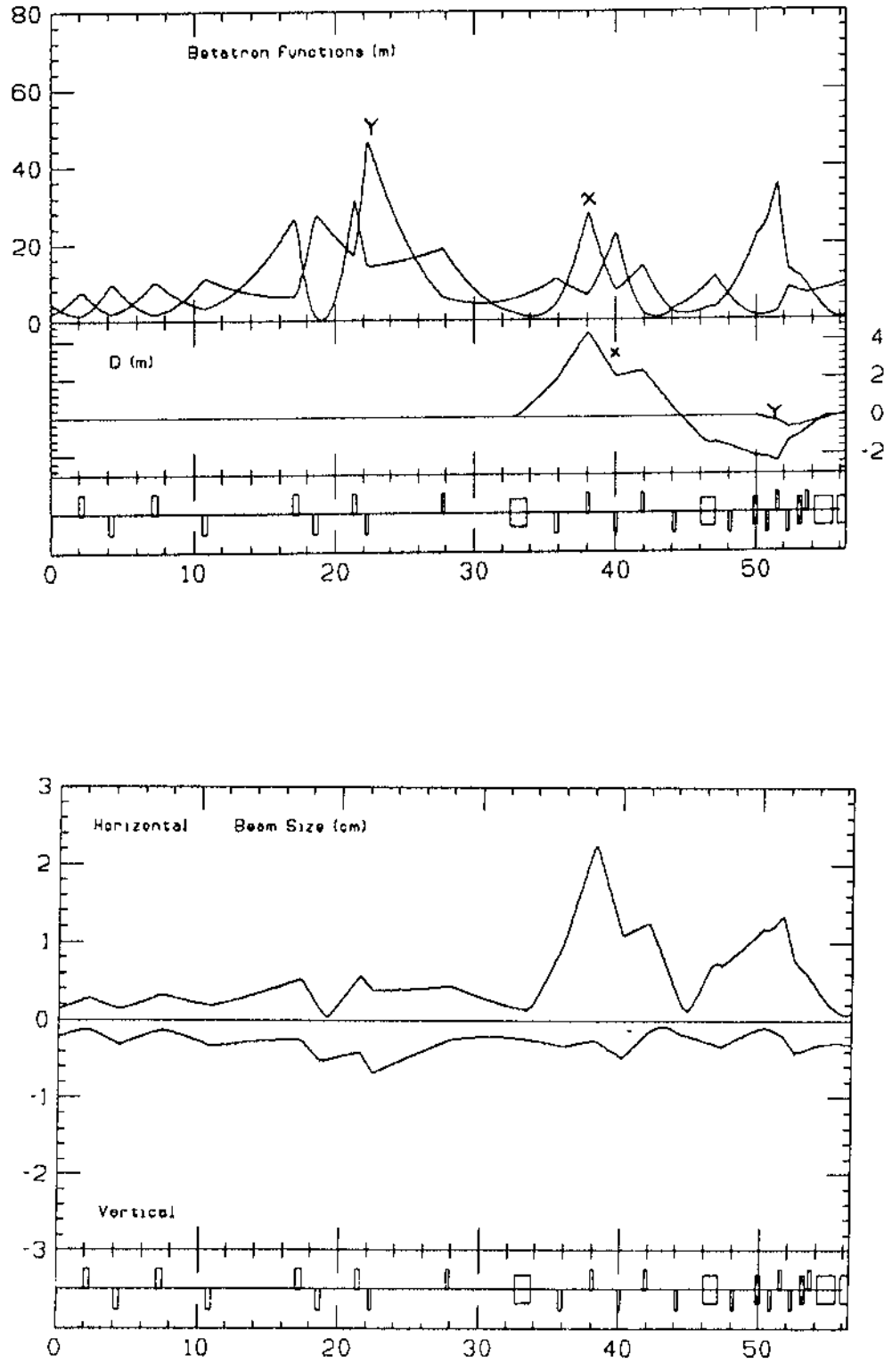

Fig. 3 - Optical functions and beam sizes along the transport line from Linac to Accumulator for electrons.

Lines Accumulator - DAΦNE

The beam extracted from the accumulator is characterized by the parameters given in Table 3[3]. The phase plane distribution is nearly gaussian; the beam envelope containing 99.7% of the beam is computed as

$$C\sqrt{\varepsilon\beta + (D\,\Delta p/p)^2}$$

with C = 3.

Table 3- Beams from Accumulator

	Positrons	Electrons
ε_x (m rad)	2.8×10^{-7}	2.8×10^{-7}
ε_y (m rad)	1.4×10^{-7}	1.4×10^{-7}
$\Delta p/p$	± 1 ‰	± 1 ‰

As in the previous design the shorter line has been dedicated to positrons and the longer to electrons.

An additional step of the line which takes care of the 45 cm difference in level between the Linac and DAΦNE has been included in the section common to electrons and positrons.

The injection scheme in DAΦNE is not completely defined; the same septa of the accumulator have been assumed; the optical functions are almost matched to the optical functions of the actual DAΦNE design[6]; the flexibility of the line allows to change the final values to adapt them to the definitive injection scheme.

The maximum gradient in the quadrupoles is 7.5 (6.5) T/m for the positron (electron) line. The initial and final values of the optical functions are given in Table 4. Optical functions and beam sizes are represented in Figs. 4, 5 for positrons and electrons respectively.

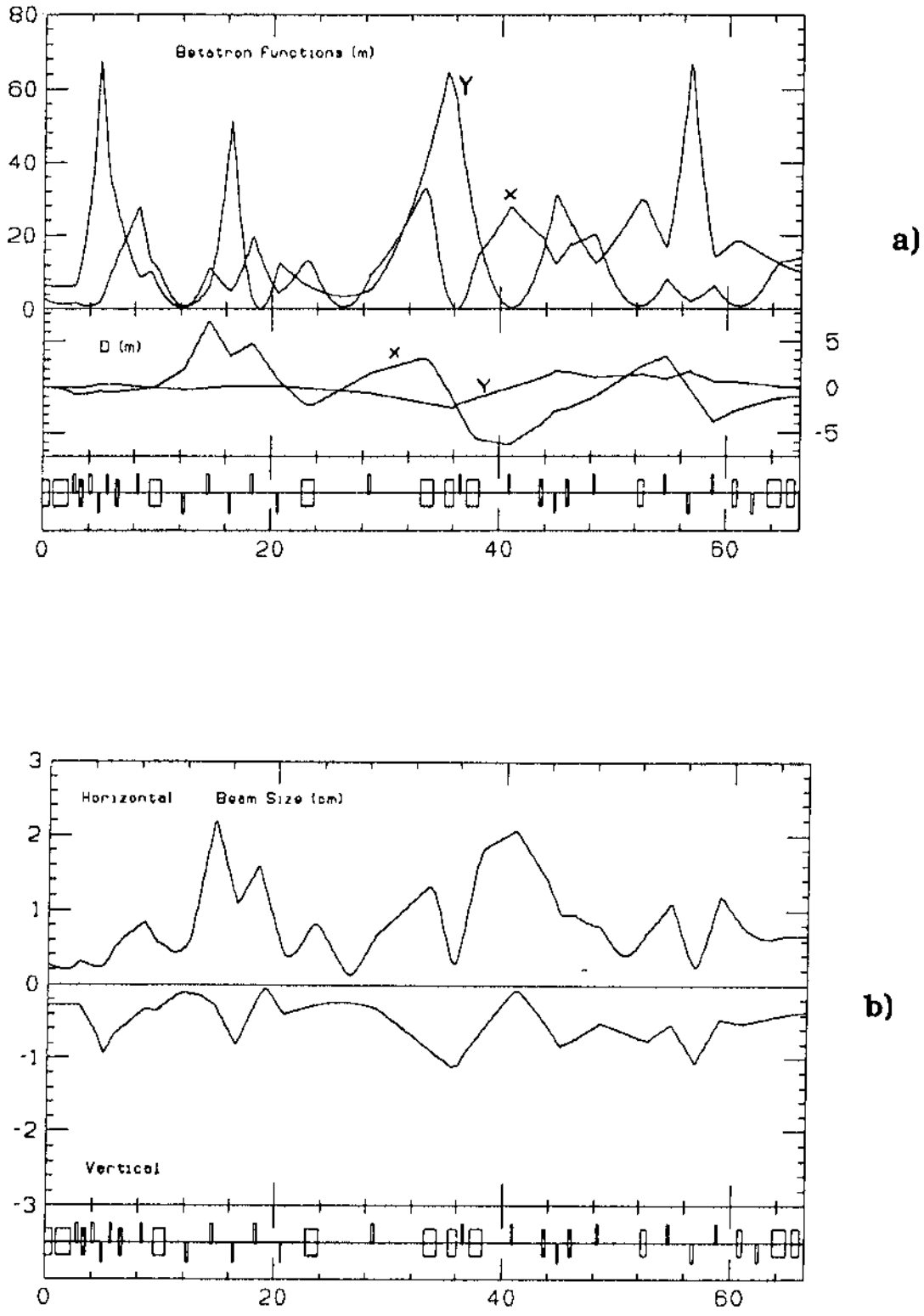

Fig. 4- Optical functions and beam sizes along the transport line from Accumulator to DAΦNE for positrons.

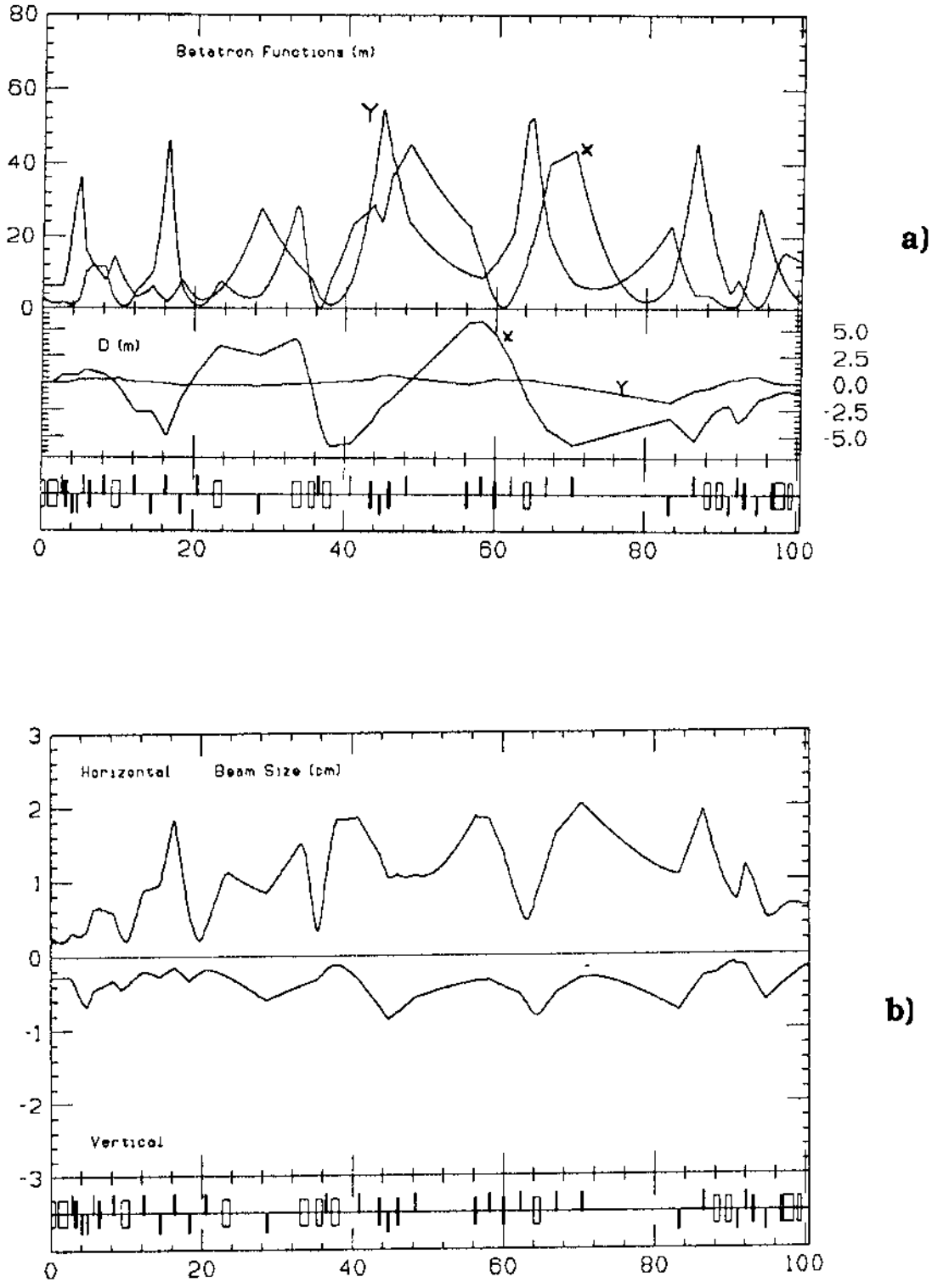

Fig. 5- Optical functions and beam sizes along the transport line from Accumulator to DAΦNE for electrons.

Table 4

ACCUMULATOR ----> DAFNE (POSITRONS)
TWISS PARAMETERS FOR BEAM LINE "POUTT"

ELEMENT SEQUENCE				HORIZONTAL						VERTICAL				
POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	BETAX [M]	ALFAX	MUX [2PI]	DX [M]	DX'		BETAY [M]	ALFAY	MUY [2PI]	DY [M]	DY'
BEGIN	POUTT	1	0.000	2.960	0.960	0.000	0.000	0.000		6.378	0.246	0.000	0.000	0.000
END	POUTT	1	66.542	14.000	-0.403	3.214	-0.940	0.100		9.986	0.497	2.066	-0.078	-0.121

TOTAL LENGTH = 66.542349

MUX	=	3.214232	MUY = 2.066072
MUX'	=	-4.193330	MUY' = -10.147400
BETAX(MAX)	=	31.972491	BETAY(MAX) = 65.005653
DX(MAX)	=	7.000940	DY(MAX) = 2.130804

ACCUMULATOR ----> DAFNE (POSITRONS)
TWISS PARAMETERS FOR BEAM LINE "EOUTT"

ELEMENT SEQUENCE				HORIZONTAL						VERTICAL				
POS. NO.	ELEMENT NAME	OCC. NO.	DIST [M]	BETAX [M]	ALFAX	MUX [2PI]	DX [M]	DX'		BETAY [M]	ALFAY	MUY [2PI]	DY [M]	DY'
BEGIN	EOUTT	1	0.000	2.960	0.960	0.000	0.000	0.000		6.378	0.246	0.000	0.000	0.000
END	EOUTT	1	100.581	13.206	0.413	3.756	-0.832	-0.061		2.000	0.500	2.513	-0.090	-0.060

TOTAL LENGTH = 100.580562

MUX	=	3.756366	MUY = 2.512791
MUX'	=	-7.608582	MUY' = -7.993864
BETAX(MAX)	=	44.999673	BETAY(MAX) = 54.146031
DX(MAX)	=	5.879617	DY(MAX) = 1.730577

References

[1] T. Tanabe - I-3 - Sept. 1991.
[2] T. Tanabe - I-7 - Feb. 1992.
[3] C. Milardi, M.Preger - Work in progress.
[4] Tazzari - 'Apertures for injection' - ESRF 83.
[5] F. Sannibale, S. Vescovi - LC-3 - Feb. 1992.
[6] DAΦNE project Team - 'DAΦNE Status Report' - EPAC 92.

APPENDIX

The line elements are listed with the description of their length, position and fields.

The letter P (E) in the name of the elements stays for positrons (electrons). The quadrupole QL is the last quadrupole of the Linac; the quadrupoles QLMi are used for the matching between the Linac, the spectrometer lines and the transfer lines; they are described in Ref. [6]. Apart from these quadrupoles, the elements are numbered from the Accumulator to DAΦNE.

The quadrupoles Q1/Q6 are used per each beam both for the injection and for the extraction in and from the Accumulator, without changing the field configuration.

The right branch of the line to the accumulator is used for injecting e^+ and for extracting e^-; viceversa for the left branch.

Line Linac - Accumulator (positrons)

TYPE	NAME	LENGTH (m)	IN.POS (m)	K (m^{-2})	ANGLE (radians)	E1 (radians)	E2 (radians)
QUADRUPO	QL	0.125	0.000	-2.44000			
DRIFT	DL1	1.850	0.125	0.00000			
QUADRUPO	QLM1	0.400	1.975	1.40000			
DRIFT	DL2	1.700	2.375	0.00000			
QUADRUPO	QLM2	0.400	4.075	-1.41800			
DRIFT	DL3	2.600	4.475	0.00000			
QUADRUPO	QLM3	0.400	7.075	0.96950			
DRIFT	DL4	3.100	7.475	0.00000			
QUADRUPO	QLM4	0.400	10.575	-0.73490			
DRIFT	DL5	6.000	10.975	0.00000			
QUADRUPO	QLM5	0.400	16.975	1.66262			
DRIFT	DL6	1.000	17.375	0.00000			
QUADRUPO	QLM6	0.400	18.375	-1.23799			
DRIFT	DL7	2.500	18.775	0.00000			
QUADRUPO	QLM7	0.200	21.275	-0.72176			

DRIFT	DL8	0.700	21.475	0.00000			
QUADRUPO	QLM8	0.200	22.175	2.71262			
DRIFT	DL9	0.951	22.375	0.00000			
DRIFT	D17	4.349	23.326	0.00000			
QUADRUPO	Q6	0.200	27.675	-1.07745			
DRIFT	D16	4.750	27.875	0.00000			
BEND	HPE1	1.113	32.625	0.00000	0.7854	0.0000	0.0000
DRIFT	D15	2.020	33.738	0.00000			
QUADRUPO	Q5	0.200	35.758	3.82942			
DRIFT	D14	2.035	35.958	0.00000			
QUADRUPO	Q4	0.200	37.993	-2.65601			
DRIFT	D13	1.720	38.193	0.00000			
QUADRUPO	Q3	0.200	39.913	3.91143			
DRIFT	D12	1.720	40.113	0.00000			
QUADRUPO	Q2	0.200	41.833	-3.08760			
DRIFT	D11	2.020	42.033	0.00000			
QUADRUPO	Q1	0.200	44.053	3.99759			
DRIFT	D10	1.820	44.253	0.00000			
BEND	TPE1	1.000	46.073	0.00000	-0.6283	0.0000	-0.6283
DRIFT	D9	0.965	47.073	0.00000			
QUADRUPO	QR5	0.200	48.038	0.80861			
DRIFT	D8	1.550	48.238	0.00000			
VERT BEND	VR2	0.350	49.788	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D7	0.550	50.138	0.00000			
QUADRUPO	QR4	0.200	50.688	0.39603			
DRIFT	D6	0.550	50.888	0.00000			
QUADRUPO	QR3	0.200	51.438	2.55299			
DRIFT	D5	0.543	51.638	0.00000			
QUADRUPO	QR2	0.200	52.182	-4.32899			
DRIFT	D4	0.550	52.382	0.00000			
VERT BEND	VR1	0.350	52.932	0.00000	0.1920	0.0960	0.0960
DRIFT	D3	0.250	53.282	0.00000			
QUADRUPO	QR1	0.200	53.532	3.51265			
DRIFT	D2	0.475	53.732	0.00000			
BEND	SR2	1.233	54.207	0.00000	0.5934	0.0000	0.0000
DRIFT	D1	0.375	55.440	0.00000			
BEND	SR1	0.623	55.815	0.00000	0.0379	0.0000	0.0000

Line Linac - Accumulator (electrons)

TYPE	NAME	LENGTH (m)	IN.POS (m)	K (m^{-2})	ANGLE (radians)	E1 (radians)	E2 (radians)
QUADRUPO	QL	0.125	0.000	-2.44000			
DRIFT	DL1	1.850	0.125	0.00000			
QUADRUPO	QLM1	0.400	1.975	1.40000			
DRIFT	DL2	1.700	2.375	0.00000			
QUADRUPO	QLM2	0.400	4.075	-1.41800			
DRIFT	DL3	2.600	4.475	0.00000			
QUADRUPO	QLM3	0.400	7.075	0.96950			
DRIFT	DL4	3.100	7.475	0.00000			
QUADRUPO	QLM4	0.400	10.575	-0.73490			
DRIFT	DL5	6.000	10.975	0.00000			
QUADRUPO	QLM5	0.400	16.975	1.77140			
DRIFT	DL6	1.000	17.375	0.00000			
QUADRUPO	QLM6	0.400	18.375	-1.17537			
DRIFT	DL7	2.500	18.775	0.00000			
QUADRUPO	QLM7	0.200	21.275	4.12513			
DRIFT	DL8	0.700	21.475	0.00000			
QUADRUPO	QLM8	0.200	22.175	-2.89001			
DRIFT	DL9	0.951	22.375	0.00000			
DRIFT	D17	4.349	23.326	0.00000			
QUADRUPO	Q6	0.200	27.675	0.96200			
DRIFT	D16	4.750	27.875	0.00000			
BEND	HPE1	1.113	32.625	0.00000	0.7854	0.0000	0.0000
DRIFT	D15	2.020	33.738	0.00000			
QUADRUPO	Q5	0.200	35.758	-1.10562			
DRIFT	D14	2.035	35.958	0.00000			
QUADRUPO	Q4	0.200	37.993	2.69228			
DRIFT	D13	1.720	38.193	0.00000			
QUADRUPO	Q3	0.200	39.913	-3.16783			
DRIFT	D12	1.720	40.113	0.00000			
QUADRUPO	Q2	0.200	41.833	2.26528			
DRIFT	D11	2.020	42.033	0.00000			
QUADRUPO	Q1	0.200	44.053	-2.01516			
DRIFT	D10	1.820	44.253	0.00000			

BEND	TPE1	1.000	46.073	0.00000	0.6283	0.0000	0.6283
DRIFT	D9	0.965	47.073	0.00000			
QUADRUPO	QL5	0.200	48.038	-0.12077			
DRIFT	D8	1.550	48.238	0.00000			
VERT BEND	VL2	0.350	49.788	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D7	0.550	50.138	0.00000			
QUADRUPO	QL4	0.200	50.688	-0.69930			
DRIFT	D6	0.550	50.888	0.00000			
QUADRUPO	QL3	0.200	51.438	3.83869			
DRIFT	D5	0.543	51.638	0.00000			
QUADRUPO	QL2	0.200	52.182	-3.86931			
DRIFT	D4	0.550	52.382	0.00000			
VERT BEND	VL1	0.350	52.932	0.00000	0.1920	0.0960	0.0960
DRIFT	D3	0.250	53.282	0.00000			
QUADRUPO	QL1	0.200	53.532	0.56507			
DRIFT	D2	0.475	53.732	0.00000			
BEND	SL2	1.233	54.207	0.00000	-0.5934	0.0000	0.0000
DRIFT	D1	0.375	55.440	0.00000			
BEND	SL1	0.623	55.815	0.00000	-0.0379	0.0000	0.0000

Line Accumulator - DAΦNE (positrons)

TYPE	NAME	LENGTH (m)	IN.POS (m)	K (m-2)	ANGLE (radians)	E1 (radians)	E2 (radians)
BEND	SL1	0.623	0.000	0.00000	-0.0379	0.0000	0.0000
DRIFT	D1	0.375	0.623	0.00000			
BEND	SL2	1.233	0.998	0.00000	-0.5934	0.0000	0.0000
DRIFT	D2	0.475	2.231	0.00000			
QUADRUPO	QL1	0.200	2.706	4.38408			
DRIFT	D3	0.250	2.906	0.00000			
VERTBEND	VL1	0.350	3.156	0.00000	0.1920	0.0960	0.0960
DRIFT	D4	0.550	3.506	0.00000			
QUADRUPO	QL2	0.200	4.056	1.04052			
DRIFT	D5	0.543	4.256	0.00000			
QUADRUPO	QL3	0.200	4.800	-4.05859			
DRIFT	D6	0.550	5.000	0.00000			
QUADRUPO	QL4	0.200	5.550	1.47852			
DRIFT	D7	0.550	5.750	0.00000			
VERTBEND	VL2	0.350	6.300	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D8	1.550	6.650	0.00000			
QUADRUPO	QL5	0.200	8.200	2.36997			
DRIFT	D9	0.965	8.400	0.00000			
BEND	TPE1	1.000	9.365	0.00000	0.6283	0.6283	0.0000
DRIFT	D10	1.820	10.365	0.00000			
QUADRUPO	Q1	0.200	12.185	-3.99759			
DRIFT	D11	2.020	12.385	0.00000			
QUADRUPO	Q2	0.200	14.405	3.08760			
DRIFT	D12	1.720	14.605	0.00000			
QUADRUPO	Q3	0.200	16.325	-3.91143			
DRIFT	D13	1.720	16.525	0.00000			
QUADRUPO	Q4	0.200	18.245	2.65601			
DRIFT	D14	2.035	18.445	0.00000			
QUADRUPO	Q5	0.200	20.481	-3.82942			
DRIFT	D15	2.020	20.681	0.00000			
BEND	HPE1	1.113	22.701	0.00000	0.7854	0.0000	0.0000
DRIFT	D16	4.750	23.813	0.00000			
QUADRUPO	Q6	0.200	28.563	1.07745			
DRIFT	D17	4.349	28.763	0.00000			

BEND	HPE2	1.113	33.112	0.00000	-0.7854	0.0000	0.0000
DRIFT	D18	1.077	34.225	0.00000			
BEND	HPE3	0.757	35.302	0.00000	-0.5236	-0.2618	-0.2618
DRIFT	D19	0.400	36.059	0.00000			
QUADRUPO	Q7	0.200	36.459	0.40087			
DRIFT	D20	0.476	36.659	0.00000			
BEND	HPE4	1.113	37.134	0.00000	-0.7854	0.0000	0.0000
DRIFT	D21	2.500	38.247	0.00000			
QUADRUPO	Q8	0.200	40.747	0.82222			
DRIFT	D22	2.500	40.947	0.00000			
VERT BEND	V1	0.350	43.447	0.00000	0.1920	0.0960	0.0960
DRIFT	D23	0.907	43.797	0.00000			
QUADRUPO	QP9	0.200	44.705	-1.84441			
DRIFT	D24	0.900	44.905	0.00000			
VERT BEND	V2	0.350	45.805	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D25	2.100	46.155	0.00000			
QUADRUPO	Q10	0.200	48.255	1.44276			
DRIFT	D26	3.832	48.455	0.00000			
BEND	HP5	0.451	52.287	0.00000	-0.3188	-0.1594	-0.1594
DRIFT	D27	1.800	52.738	0.00000			
QUADRUPO	QP1	0.200	54.538	3.27257			
DRIFT	D28	1.900	54.738	0.00000			
QUADRUPO	QP2	0.200	56.638	-2.57009			
DRIFT	D29	1.900	56.838	0.00000			
QUADRUPO	QP3	0.200	58.738	3.18994			
DRIFT	D30	1.691	58.938	0.00000			
BEND	HP6	0.452	60.629	0.00000	-0.2365	-0.1182	-0.1182
DRIFT	D31	1.200	61.081	0.00000			
QUADRUPO	QP4	0.200	62.281	-0.07100			
DRIFT	D32	1.205	62.481	0.00000			
BEND	SPD2	1.233	63.686	0.00000	-0.5934	0.0000	0.0000
DRIFT	D33	0.500	64.919	0.00000			
BEND	SPD1	0.623	65.419	0.00000	-0.0379	0.0000	0.0000
DRIFT	D34	0.500	66.042	0.00000			

Line Accumulator - DAΦNE (electrons)

TYPE	NAME	LENGTH (m)	IN.POS (m)	K (m-2)	ANGLE (radians)	E1 (radians)	E2 (radians)
BEND	SR1	0.623	0.000	0.00000	0.0379	0.0000	0.0000
DRIFT	D1	0.375	0.623	0.00000			
BEND	SR2	1.233	0.998	0.00000	0.5934	0.0000	0.0000
DRIFT	D2	0.475	2.231	0.00000			
QUADRUPO	QR1	0.200	2.706	3.79745			
DRIFT	D3	0.250	2.906	0.00000			
VERT BEND	VR1	0.350	3.156	0.00000	0.1920	0.0960	0.0960
DRIFT	D4	0.550	3.506	0.00000			
QUADRUPO	QR2	0.200	4.056	-0.95162			
DRIFT	D5	0.543	4.256	0.00000			
QUADRUPO	QR3	0.200	4.800	-3.25384			
DRIFT	D6	0.550	5.000	0.00000			
QUADRUPO	QR4	0.200	5.550	2.83488			
DRIFT	D7	0.550	5.750	0.00000			
VERT BEND	VR2	0.350	6.300	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D8	1.550	6.650	0.00000			
QUADRUPO	QR5	0.200	8.200	2.42684			
DRIFT	D9	0.965	8.400	0.00000			
BEND	TPE1	1.000	9.365	0.00000	-0.6283	-0.6283	0.0000
DRIFT	D10	1.820	10.365	0.00000			
QUADRUPO	Q1	0.200	12.185	2.01516			
DRIFT	D11	2.020	12.385	0.00000			
QUADRUPO	Q2	0.200	14.405	-2.26528			
DRIFT	D12	1.720	14.605	0.00000			
QUADRUPO	Q3	0.200	16.325	3.16783			
DRIFT	D13	1.720	16.525	0.00000			
QUADRUPO	Q4	0.200	18.245	-2.69228			
DRIFT	D14	2.035	18.445	0.00000			
QUADRUPO	Q5	0.200	20.481	1.10562			
DRIFT	D15	2.020	20.681	0.00000			
BEND	HPE1	1.113	22.701	0.00000	0.7854	0.0000	0.0000
DRIFT	D16	4.750	23.813	0.00000			
QUADRUPO	Q6	0.200	28.563	-0.96200			
DRIFT	D17	4.349	28.763	0.00000			
BEND	HPE2	1.113	33.112	0.00000	-0.7854	0.0000	0.0000
DRIFT	D18	1.077	34.225	0.00000			
BEND	HPE3	0.757	35.302	0.00000	-0.5236	-0.2618	-0.2618
DRIFT	D19	0.400	36.059	0.00000			
QUADRUPO	Q77	0.200	36.459	1.32428			
DRIFT	D20	0.476	36.659	0.00000			
BEND	HPE4	1.113	37.134	0.00000	-0.7854	0.0000	0.0000
DRIFT	D21	2.500	38.247	0.00000			
QUADRUPO	Q8	0.200	40.747	0.57646			
DRIFT	D22	2.500	40.947	0.00000			

VERT BEND	V1	0.350	43.447	0.00000	0.1920	0.0960	0.0960
DRIFT	D23	0.907	43.797	0.00000			
QUADRUPO	Q9	0.200	44.705	-1.29726			
DRIFT	D24	0.900	44.905	0.00000			
VERT BEND	V2	0.350	45.805	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D25	2.100	46.155	0.00000			
QUADRUPO	Q10	0.200	48.255	0.43149			
DRIFT	D26	3.832	48.455	0.00000			
DRIFT	D51	3.945	52.287	0.00000			
VERT BEND	V3	0.350	56.232	0.00000	0.1920	0.0960	0.0960
DRIFT	D52	1.558	56.582	0.00000			
QUADRUPO	QE1	0.200	58.140	0.71152			
DRIFT	D53	1.560	58.340	0.00000			
VERT BEND	V4	0.350	59.900	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D54	1.950	60.250	0.00000			
QUADRUPO	QE2	0.200	62.200	1.06371			
DRIFT	D55	1.699	62.400	0.00000			
BEND	HE5	0.757	64.099	0.00000	0.5236	0.2618	0.2618
DRIFT	D56	2.100	64.856	0.00000			
QUADRUPO	QE3	0.200	66.956	0.70153			
DRIFT	D57	3.200	67.156	0.00000			
QUADRUPO	QE4	0.200	70.356	0.56643			
DRIFT	D58	5.800	70.556	0.00000			
DRIFT	D59	6.800	76.356	0.00000			
QUADRUPO	QE5	0.200	83.156	-1.34365			
DRIFT	D60	3.000	83.356	0.00000			
QUADRUPO	QE6	0.200	86.356	1.77179			
DRIFT	D61	1.386	86.556	0.00000			
BEND	HE6	0.757	87.942	0.00000	-0.5411	-0.2705	-0.2705
DRIFT	D62	0.736	88.699	0.00000			
BEND	HE7	0.757	89.435	0.00000	-0.5411	-0.2705	-0.2705
DRIFT	D63	0.762	90.192	0.00000			
QUADRUPO	QE7	0.200	90.954	-3.81603			
DRIFT	D64	0.870	91.154	0.00000			
QUADRUPO	QE8	0.200	92.024	2.93651			
DRIFT	D65	0.770	92.224	0.00000			
VERT BEND	V5	0.350	92.994	0.00000	-0.1920	-0.0960	-0.0960
DRIFT	D66	1.358	93.344	0.00000			
QUADRUPO	QE9	0.200	94.701	-2.23964			
DRIFT	D67	1.760	94.901	0.00000			
VERT BEND	V6	0.350	96.661	0.00000	0.1920	0.0960	0.0960
DRIFT	D68	0.213	97.011	0.00000			
BEND	SED2	1.233	97.224	0.00000	-0.5934	0.0000	0.0000
DRIFT	D69	0.500	98.457	0.00000			
BEND	SED1	0.623	98.957	0.00000	-0.0379	0.0000	0.0000
DRIFT	D70	1.000	99.581	0.00000			