DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

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Note: **L-19**

DAY-ONE AND FI.NU.DA. INTERACTION REGIONS UPDATE

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The Day-One and FI.NU.DA. Interaction Regions contain a common quadrupole type (Q3 in Day-One[1] and Q3, Q4 in FI.NU.DA.[2]) whose magnetic length has been changed to 40 cm to decrease the effect of the fringing field on the off-axis trajectory[3].

The new optics are described in the following tables and figures.

DAY-ONE

The DAY-ONE IR optics is very similar to the one described in Ref. 1. Q0, Q1, Q2 quadrupoles are 30 cm long. Q4 is 40 cm long. Table I and Fig. 1 represent the linear optics with the rectangular model.

The linear optics has been computed also substituting the rectangular model by 1 cm long rectangular slices whose gradient follow the real field profile. Figure 2 represent this optics and it can be noticed that the difference is negligible. Figures 3 and 4 represent the linear optics with the field profile model and the compensator on corresponding to rotation angles of 11° and 22°. Table II summarizes the quadrupole gradients computed from the integrated value using the field profile model.

Table III gives the transport matrix of half IR in the three configurations computed with the field profile model. Table IV is a summary of the corresponding main optics parameters in the IR.

The optics is flexible enough in all the configurations to change the phase advances up to 20% of the nominal values. The presented configurations are an example of how the IR is compatible with the compensator, and are used to determine the maximum gradients needed for each quadrupole (bold in Table II).

TABLE I - DAY-ONE IR elements for half IR - rectangular model

	Length (m)	Position (m from IP)	Center position (m from IP)	K2 (m^{-2})	G (T/m)
Q0	0.15	0.00	0.00	2.90829	4.944
Drift	0.30	0.15			
Q1	0.30	0.45	0.60	-1.01394	1.724
Drift	0.30	0.75			
Q2	0.30	1.05	1.20	-4.86841	8.276
Drift	0.40	1.35			
Q3	0.40	1.75	1.95	2.03261	3.455
Drift	2.90	2.15			
End IR		5.05			

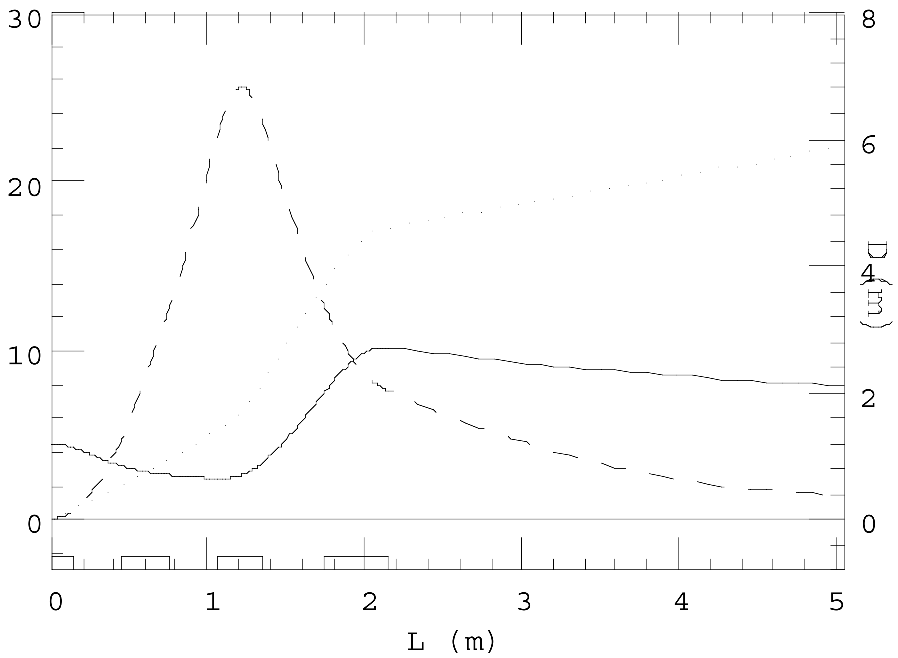

Fig. 1 - Optical functions and beam separation
(θ_{cross} = ±12.5 mrad) for half IR - rectangular model

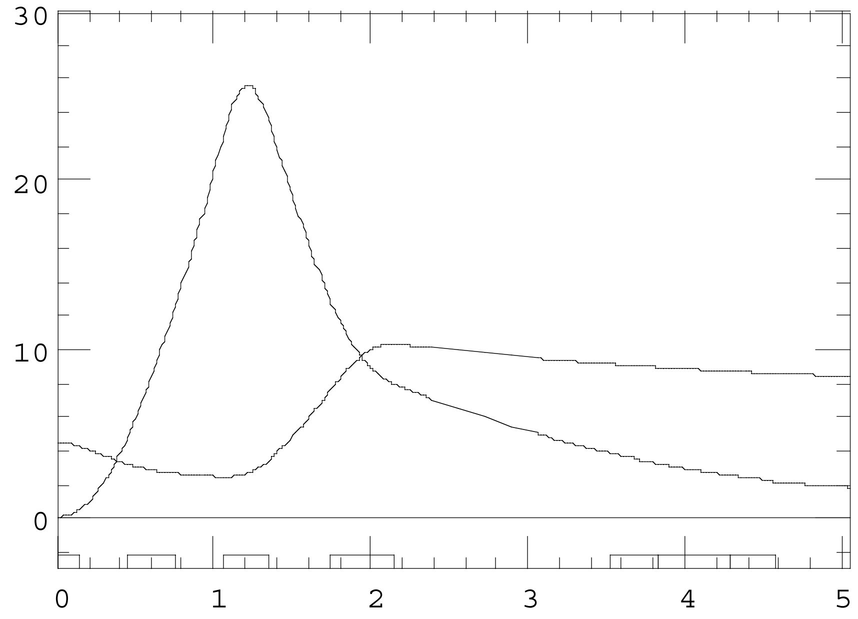

Fig. 2 - Optical functions for half IR - field profile model

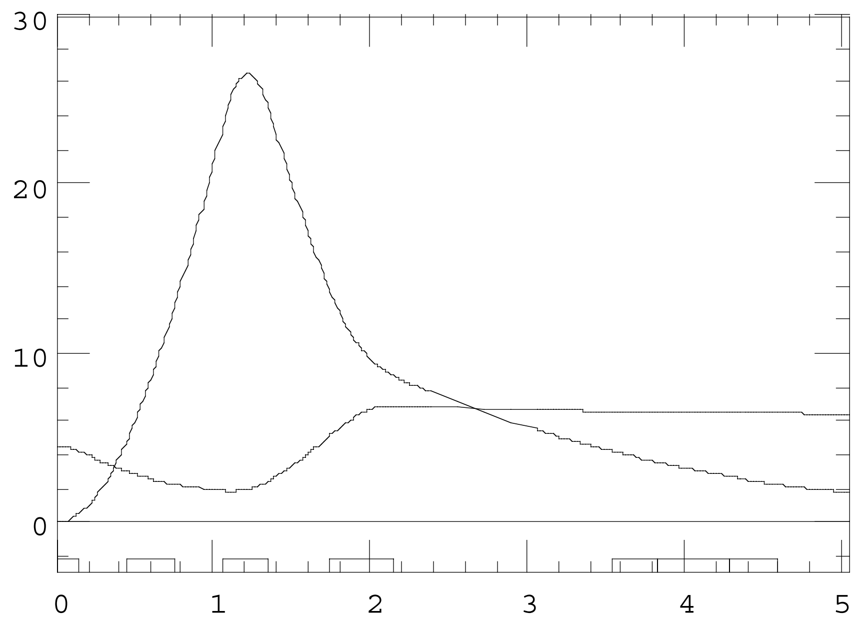

Fig. 3 - Optical functions in half IR with compensator on and $\Theta_{rot}=11°$

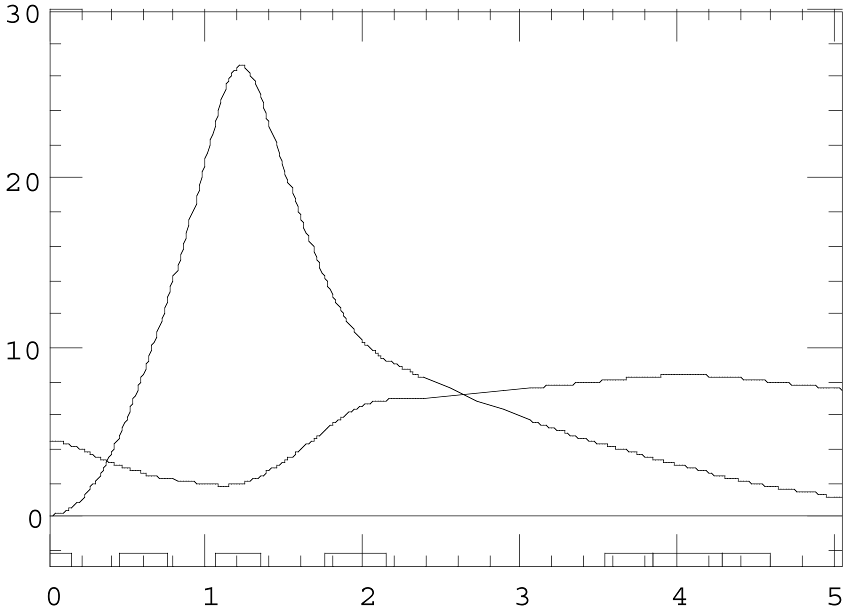

Fig. 4 - Optical functions in half IR with compensator on and Θ_{rot}=22°

TABLE II - DAY-ONE IR quadrupole parameters

Compensator	off	on	on
Θ_{rot}	0	11°	22°
K^2 (m^{-2})			
Q1	2.9116	3.4306	3.4306
Q2	-1.0152	-0.8804	-0.8807
Q3	-4.8686	-4.8508	-4.7319
Q4	2.0313	1.9262	1.6897
K^2 L (m^{-1})			
Q1	0.4367	0.5146	0.5146
Q2	-0.3045	-0.2641	-0.2642
Q3	-1.4606	-1.4552	-1.4196
Q4	0.8125	0.7705	0.6759
G (T/m)			
Q1	4.9497	**5.8320**	5.8320
Q2	**1.7258**	1.4967	1.4972
Q3	**8.2766**	8.2464	8.0442
Q4	**3.4532**	3.2745	2.8725

TABLE III - Half IR first order transport matrix

Compensator off

0.8584	4.7629	0.0000	0.0000
-0.1431	0.3711	0.0000	0.0000
0.0000	0.0000	-4.9410	0.1833
0.0000	0.0000	-1.6099	-0.1427

Compensator on - 11°

0.4864	4.8910	0.0000	0.0000
-0.1724	0.3222	0.0000	0.0000
0.0000	0.0000	-4.6042	0.1922
0.0000	0.0000	-1.4502	-0.1567

Compensator on - 22°

0.6004	5.1458	0.0000	0.0000
-0.1912	0.0266	0.0000	0.0000
0.0000	0.0000	-4.1088	0.1362
0.0000	0.0000	-1.0773	-0.2077

TABLE VII - IR optical parameters - field profile model

Θrot	**0**	**11°**	**22°**
@IP (normal modes in the rotated plane)			
β_x (m)	4.5	4.5	4.5
α_x	0.0	0.0	0.0
β_y(m)	0.045	0.045	0.045
α_y	0.0	0.0	0.0
Δx(m)	0.0	0.0	0.0
Δx'(mrad)	12.5	12.5	v
@ splitter input			
β_x (m)	8.3575	6.3804	7.5067
α_x	0.1599	0.0272	0.4862
β_y(m)	1.8452	1.7746	1.1718
α_x	0.2232	0.3686	.4292
Δx(cm)	5.9536	6.1137	6.4323
Δx'(mrad)	4.6385	4.0275	0.3330
For Half IR			
ΔQ_x	0.142	0.183	0.173
ΔQ_y	0.390	0.381	0.399

The Beam Stay Clear (BSC) with the compensator on are compatible with those corresponding to the layout without compensator.

Figure 5 shows the BSC corresponding to the case with maximum compensator field (Θ_{rot} = 22°) (dotted line), compared to the BSC without compensator (solid lines). Both are computed for a crossing angle of ±15 mrad and a vertical bump of 2.5 mm at the IP.

Table V gives the requested magnetic element apertures of the IR.

TABLE V - Full aperture (mm) of IR magnets

Q0	90
Q1	90
Q2	90
Q3	200
Compensator	240

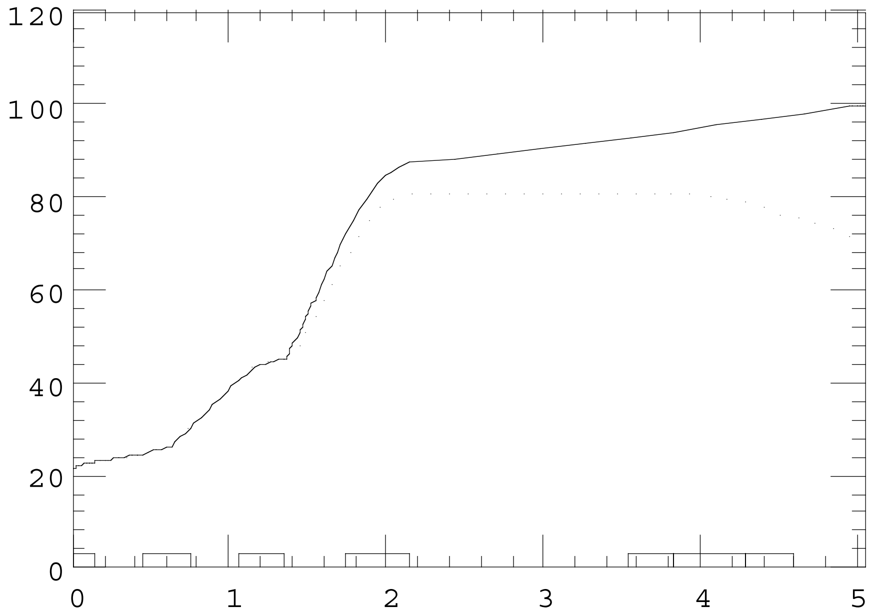

Fig. 5 - BSC with compensator on (Θ_{rot}=22°) (dotted line) and without compensator (solid line)

FI.NU.DA.

In the FI.NU.DA. IR optics the quadrupole center position remains unchanged with respect to the one described in Ref. 2. The optics has been designed for the nominal field detector ($\int$ B dl = 2.6 T m), and for 80 % of its value. The element characteristics are listed in Table VI for the two configurations and the optical functions plotted in Fig. 6 for the nominal configuration and in Fig. 7 for the reduced field configuration. The first permanent quadrupole Q1 has the same gradient for the two configurations, while a gradient correction of ~3 % is necessary on the second permanent quadrupole Q2 for the second configuration.

Table VII lists the transport matrices for half IR and Table VIII the optical parameters. The requested apertures are listed in table IX, and the BSC are plotted in Fig. 8.

TABLE VI - FI.NU.DA. IR elements for half IR.

Nominal detector field

Element	Lengths (m)	Position (m from IP)	Center position (m from IP)	K2 (m^{-2})	G (T/m)	Θ (deg)
S.F.*	0.350	0.000				
Q1+ S.F.*	0.150	0.350	0.425	5.79000	9.84	9.0137
S.F.*	0.150	0.500				
Q2 + S.F.*	0.275	0.650	0.7875	-7.02689	11.95	14.9499
S.F.*	0.575	0.925				
Drift	0.550	1.500				
Q3	0.400	2.050	2.250	1.850001	3.15	22.6197
Drift	0.200	2.450				
Q4	0.400	2.650	2.850	-1.15020	1.96	22.6197
Drift	0.435	3.050				
Compensator	1.150	3.485	4.060			
Drift	0.415	4.635				
Total length	5.050					

* S.F. = Detector Solenoidal Field

80% of detector field

Element	Lengths (m)	Position (m from IP)	Center position (m from IP)	K2 (m^{-2})	G (T/m)	Θ (deg)
S.F.*	0.350	0.000				
Q1+ S.F.*	0.150	0.350	0.425	5.790	9.84	6.6218
S.F.*	0.150	0.500				
Q2 + S.F.*	0.275	0.650	0.7875	-7.200	12.24	11.6666
S.F.*	0.575	0.925				
Drift	0.550	1.500				
Q3	0.400	2.050	2.250	1.620	2.75	17.5180
Drift	0.200	2.450				
Q4	0.400	2.650	2.850	-0.630	1.07	17.5180
Drift	0.435	3.050				
Compensator	1.150	3.485	4.060			
Drift	0.415	4.635				
Total length	5.050					

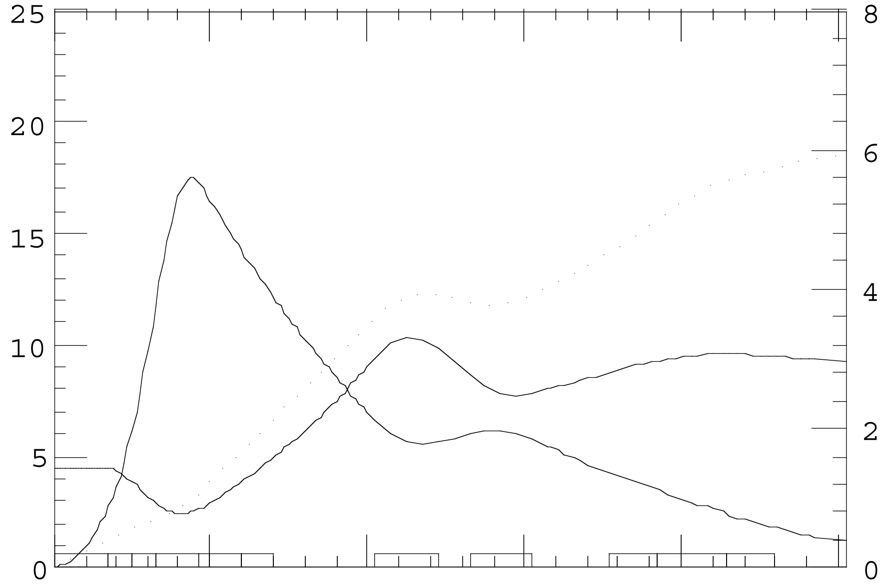

Fig. 6 - Optical functions and beam separation (θ_{cross} = ±12.5 mrad) for half IR - nominal detector field

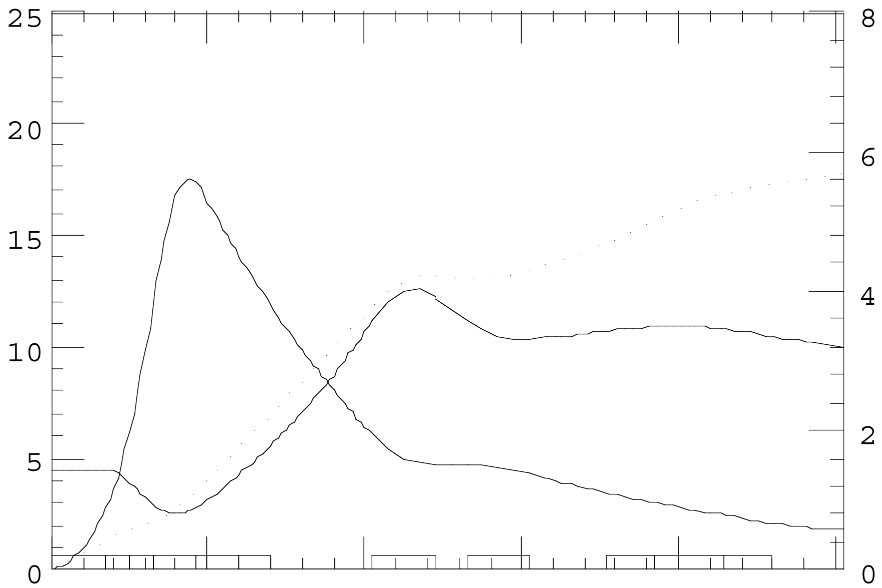

Fig. 7 - Optical functions and beam separation (θ_{cross} = ±12.5 mrad) for half IR - 80% of the detector field

Table VII - Transport matrices for half IR

Nominal field detector

0.9716	4.7487	0.0000	0.0000
-0.1365	0.3619	0.0000	0.0000
0.0000	0.0000	-4.3659	0.1226
0.0000	0.0000	-0.6791	-0.2100

80% of field detector

1.0957	4.5383	0.0000	0.0000
-0.1555	0.2686	0.0000	0.0000
0.0000	0.0000	-5.3824	0.1474
0.0000	0.0000	-1.2158	-0.1525

Table VIII - Beam optic parameters

B **detector**	**100%**	**80%**
@IP		
β_x (m)	4.5	4.5
α_x	0.0	0.0
β_y(m)	0.045	0.045
α_y	0.0	0.0
Δx(m)	0.0	0.0
$\Delta x'$(mrad)	12.5	12.5
@ splitter input		
β_x (m)	9.259	9.979
α_x	0.215	0.496
β_y(m)	1.192	1.787
α_x	0.439	0.205
Δx(cm)	5.933	5.673
$\Delta x'$(mrad)	4.524	3.358
For Half IR		
ΔQ_x	0.132	0.118
ΔQ_y	0.411	0.413

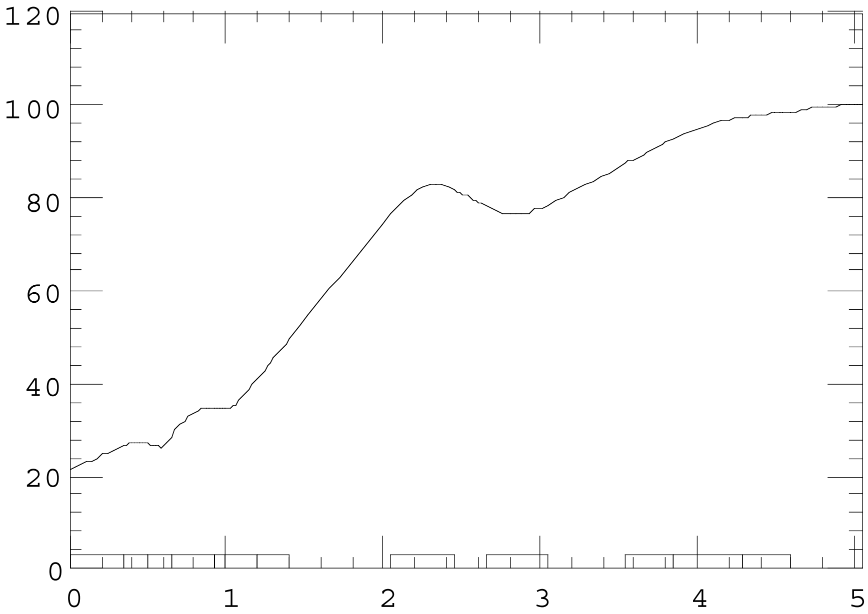

Fig. 8 - BSC in half IR

TABLE IX - Full aperture (mm) of IR magnets

Q1	86
Q2	86
Q3	200
Q4	200
Compensator	240

REFERENCES

[1] C.Biscari. 'Optimization of the Day One Interaction Region' - DAΦNE Technical Note L-17, 1994.

[2] C.Biscari. 'FI.NU.DA. Interaction Region' - DAΦNE Technical Note L-15, 1994.

[3] C.Biscari. 'Low Beta Quadrupole Fringing Field Effect On Off Axis Trajectory' - Proceedings off the Workshop on "Non Linear Dynamics in Particle Accelerators: Theory and Experiments" Arcidosso, September 4-9, 1994 - to be published.