PS/LP Note 94-51 (Min.)
14. 11. 1994

CLIC/PS

NEXT MEETING : FRIDAY 18November 1994

9.00hrs in the large PS Conference Room

J.H.B. Madsen

AGENDA

1. The CTF - beam emittance : measurements and computations by:
M. Comunian

2. Programme for ' Two days for a two - beam accelerator in the CTF 'or CTF-2
15 / 16 Dec. '94

3. Status with CTF run 3.

Distribution:

Autin B.	PS
Bossart R.	PS
Braun H.	PS
Brouet M.	AT
Chautard F.	PS
Chevallay E.	PS
Comunian M.	PS
Corsini Roberto	PS
Delahaye J.-P.	PS
Fischer Claude	SL
Garoby, R.	PS
Geissler K.K.	AT
Godot J.-Cl.	PS
Guignard G.	SL
Hübner K.	DG
Hutchins S.	PS
Jensen E.	PS
Johnson C. D.	PS
Kamber I.	PS
Koziol, H.	PS
Kugler H.	PS
Madsen J.H.B.	PS
Metral G.	PS
Michailichenko A.	PS
Millich A.	SL
Mourier J.	PS
Pearce P.	PS
Potier J.-P.	PS
Riche A.J.	PS
Riege Hans	AT
Rinolfi L.	PS
Rossat G.	PS
Schnell W.	Bât. 584
Schreiber S.	AT
Suberlucq G.	PS
Thomi J.C.	PS
Thorndahl L.	PS
Warner D.J.	PS
Wilson I.	SL
Wuensch W.	SL

PS/LP 94-51 (Min)

Summary on the CLIC/PS Meeting 04/11/1994

1. The bunch compressor and the CTF beam line 1995 by F. Chautard

With four quadrupoles at the bc outlet a round beam can be obtained at the entrance of the accelerating section, the 1 m long high gradient section of LAL. (called NAS or re baptised in SERA2).
Beam envelopes: fig.1,2 in Appendix 1

The bc magnets will be assembled and measured at CERN. Available: in January '95.

The space between SERA2 and TRS will be used for inserting equipment to be tested as BPM's, transfer structures.
BPM's testing requires making a small beam and this will be done with a triplet (see fig. 3).

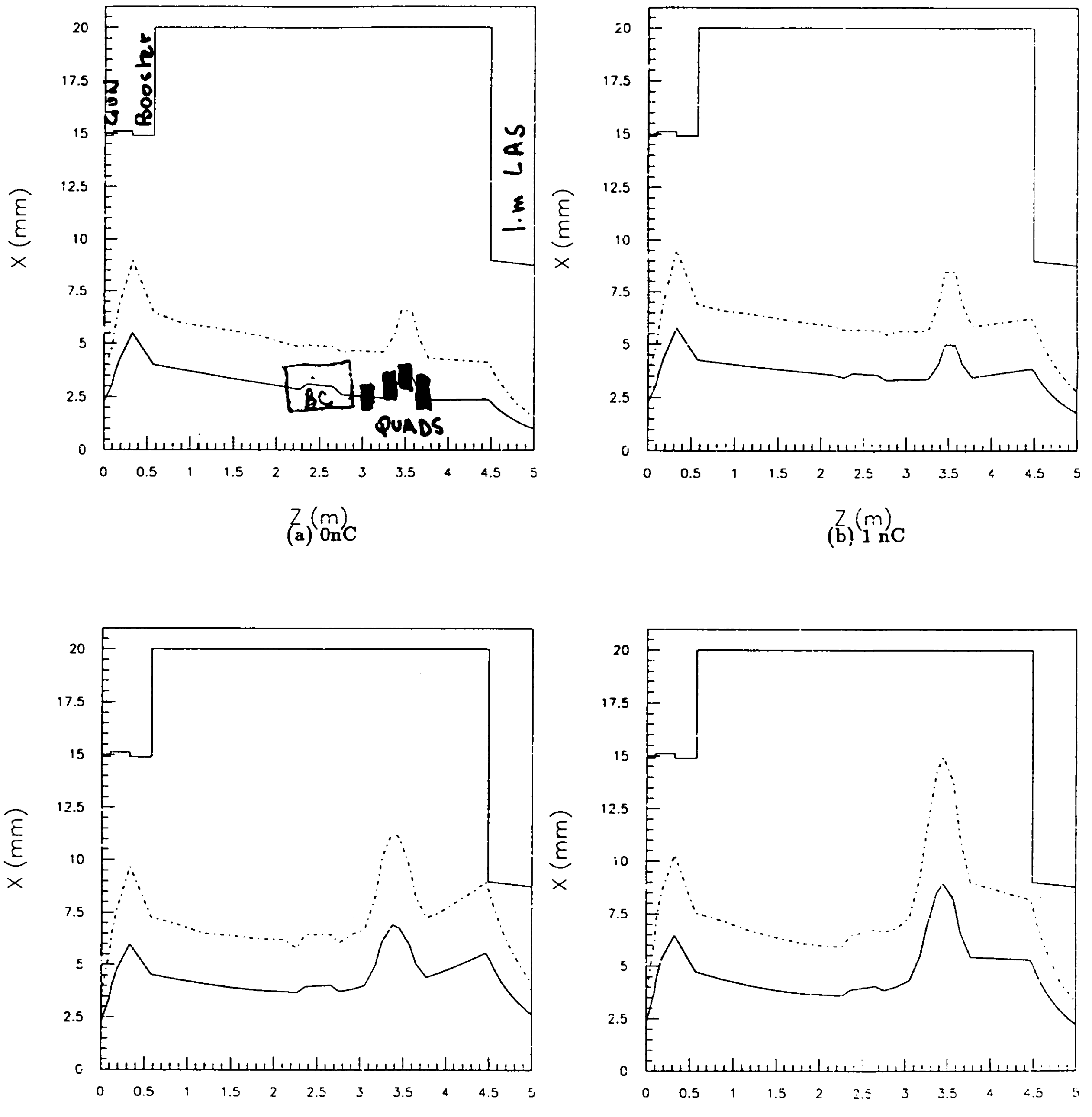
A small beam is made at TRS with a doublet in front of the spectrometer BHZ430. The arrangement chosen asks for a minimum of modifications to the existing line. Optics: 4 to 9.

2. A preliminary study for a beam recombination in the drive beam of CTF-2 by R. Corsini and L. Rinolfi (see Appendix 2).

Enclosures

App. 1

Bunch Compressor (BC)



(a) 0nC

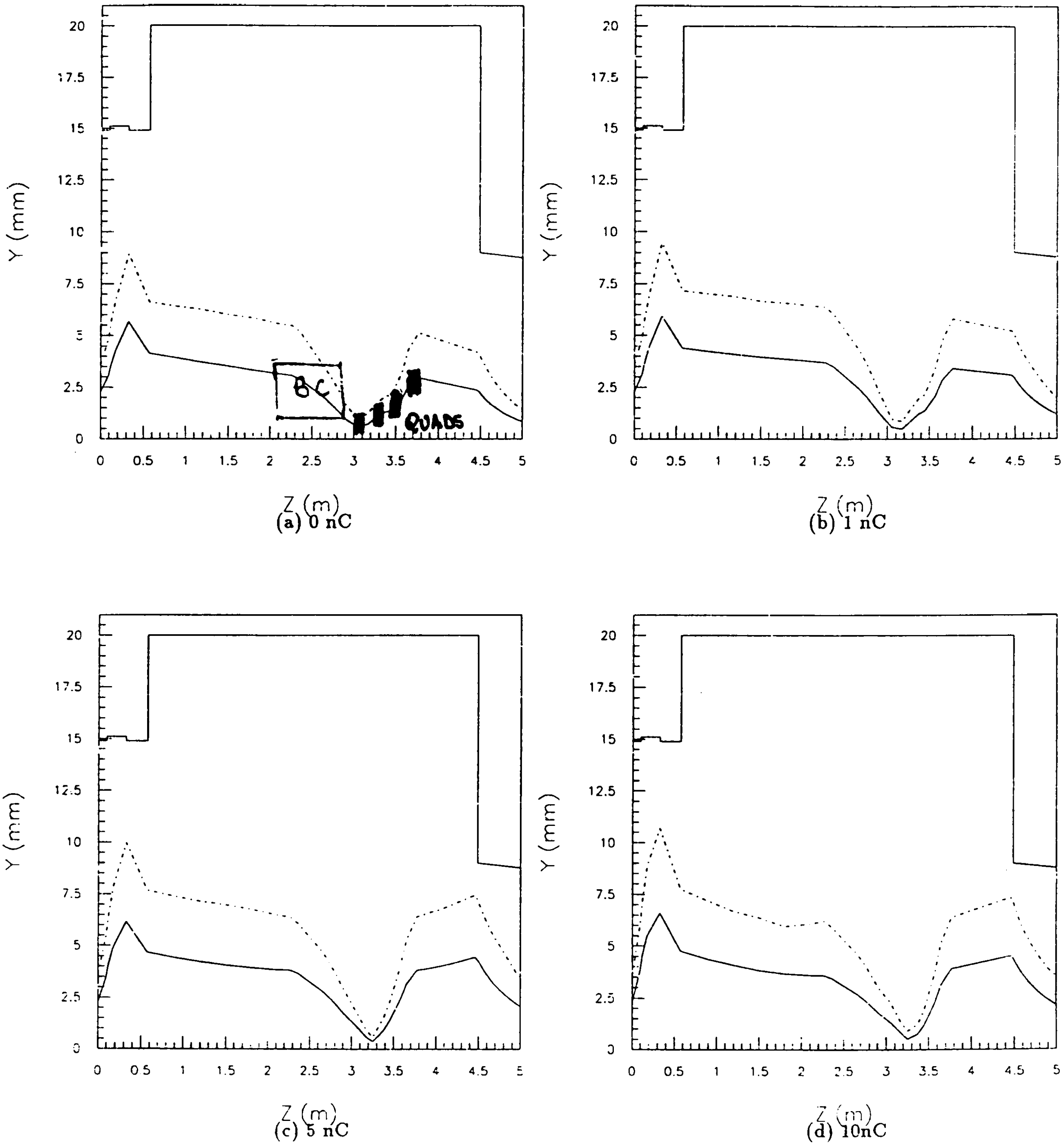
(b) 1 nC

(c) 5 nC

(d) 10 nC

Figure 1: Horizontal beam envelopes.
(. . .): 90% particles. (-): rms value.

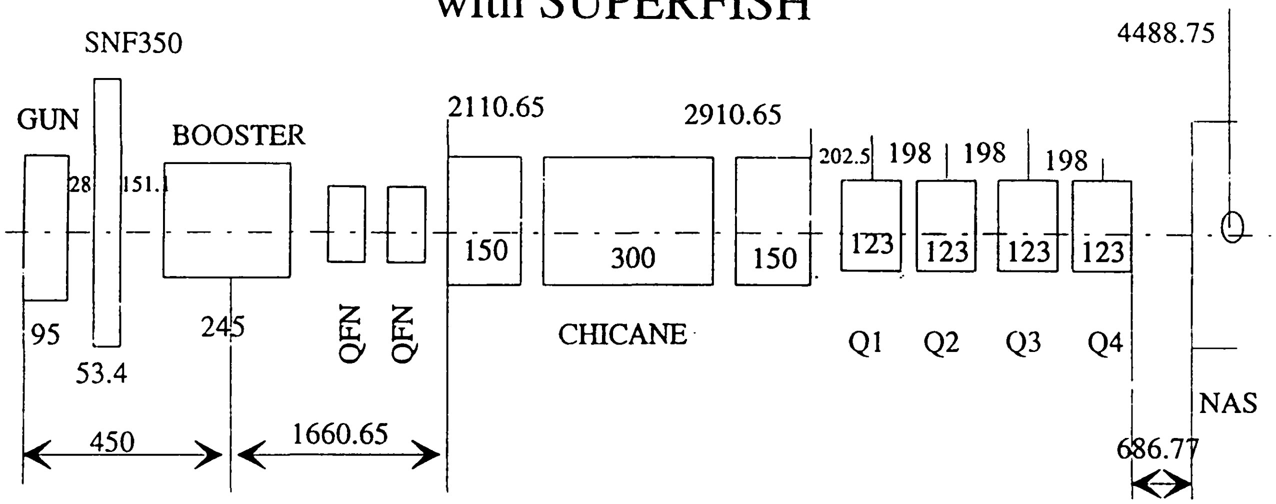
F. Chautard



(a) 0 nC (b) 1 nC (c) 5 nC (d) 10nC

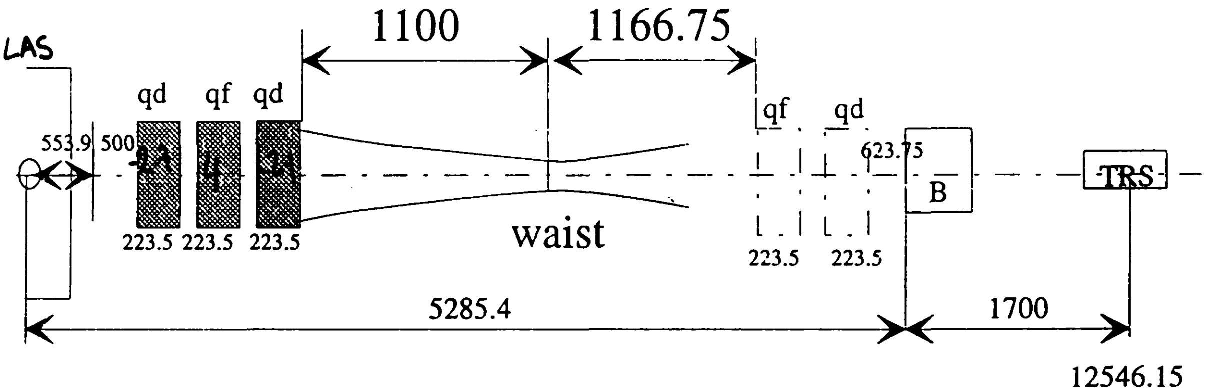
Figure 2: Vertical beam envelopes.
(...): 90% particles. (-): rms value.

LINE CTF 1995
with SUPERFISH

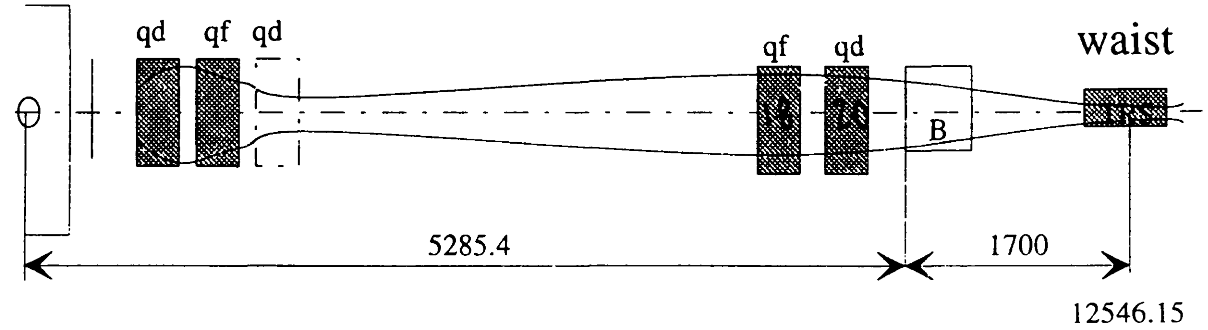


+2.718
from 19.383-16.667

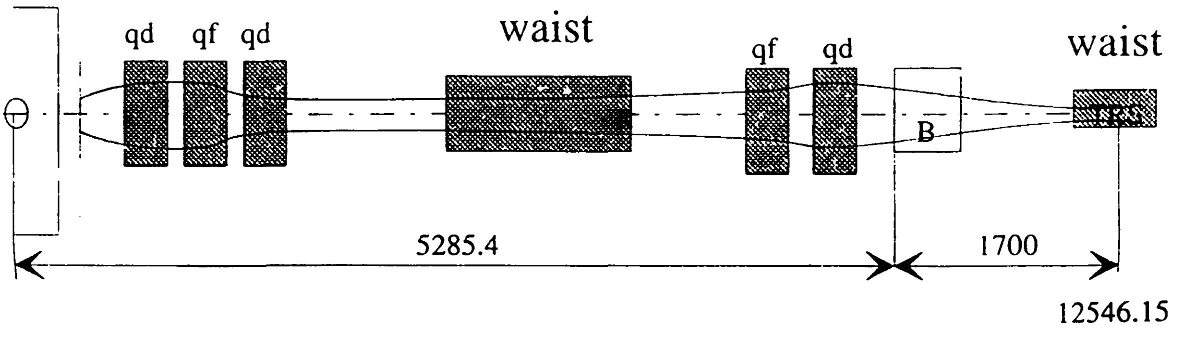
1°)

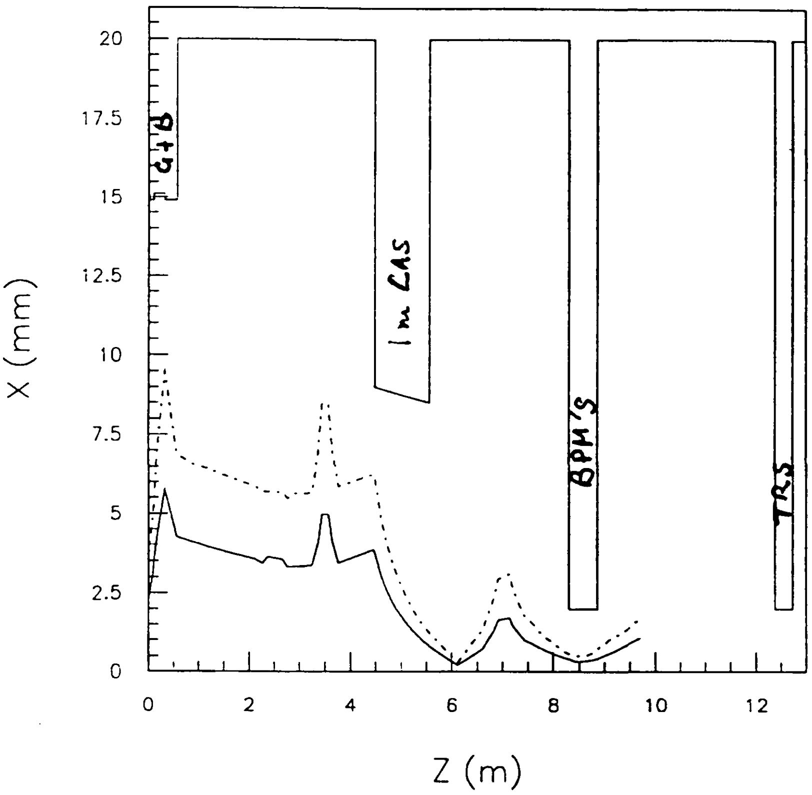


2°)

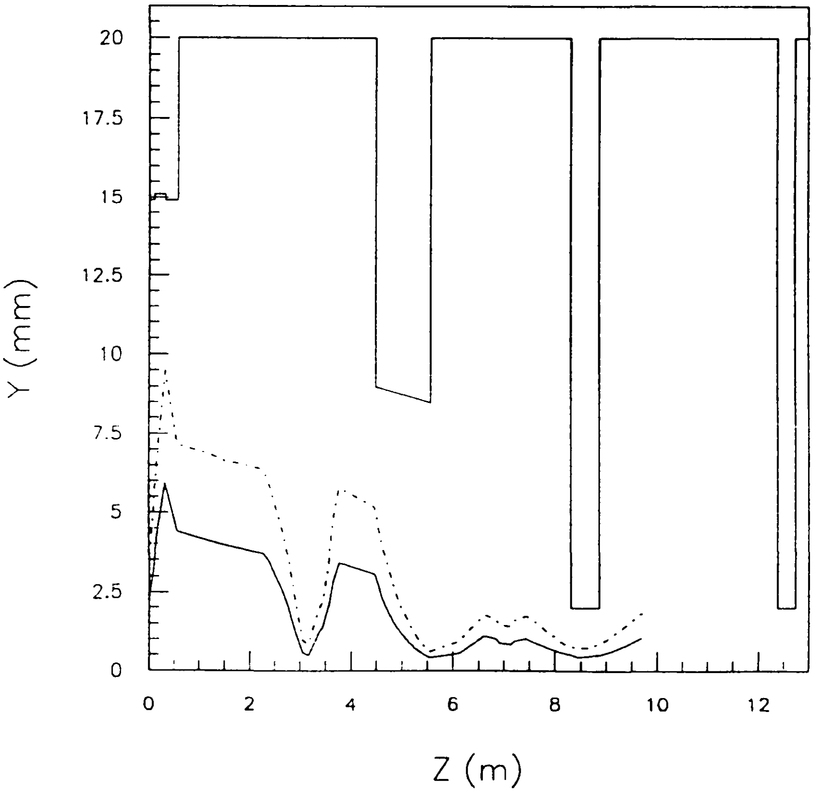


3°)

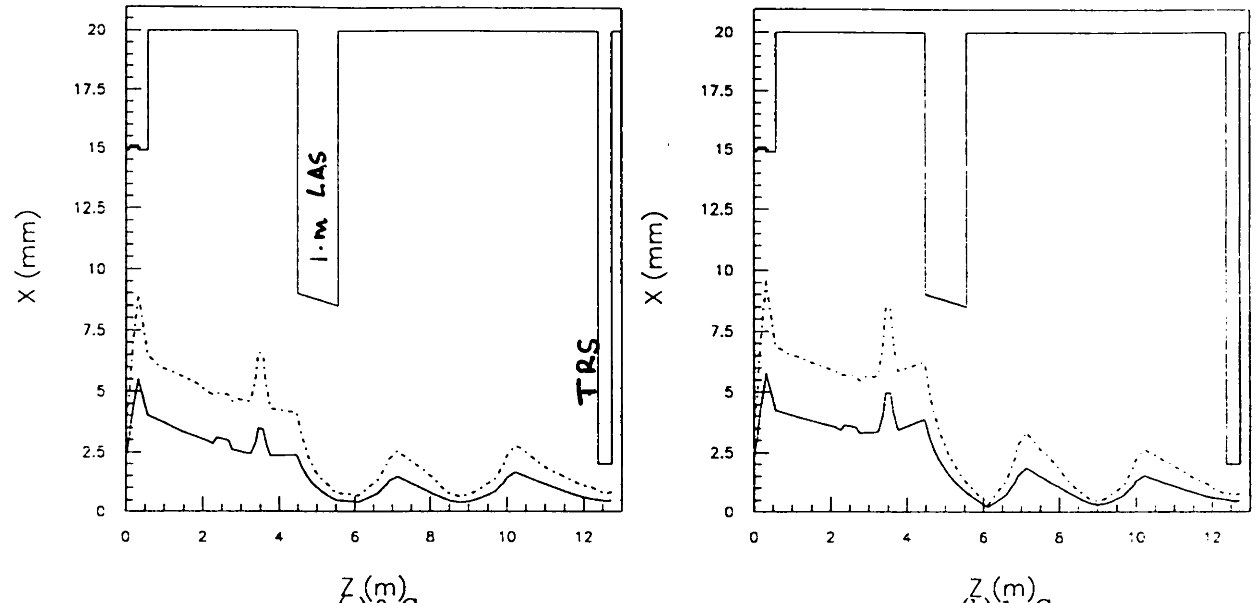



Q+B
1m LAS
BPM'S
TRS
X (mm)
Z (m)
0
2.5
5
7.5
10
12.5
15
17.5
20
0
2
4
6
8
10
12

(c) 1 nC

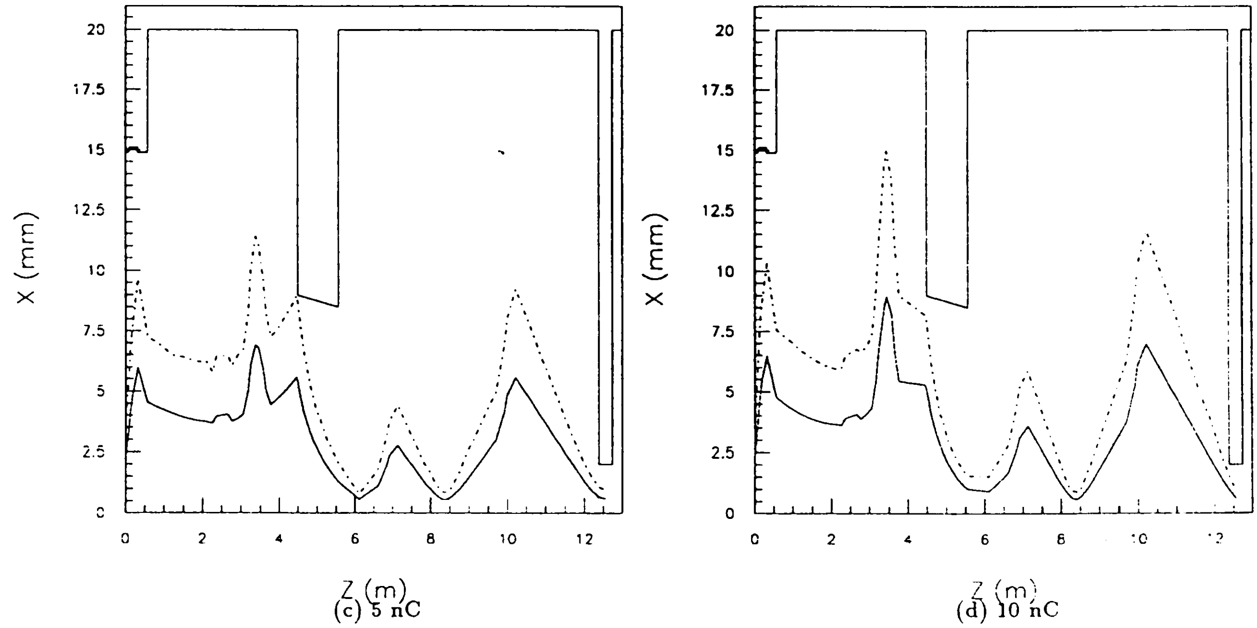

Y (mm)
Z (m)
0
2.5
5
7.5
10
12.5
15
17.5
20
0
2
4
6
8
10
12

(d) 1 nC



(a) 0nC

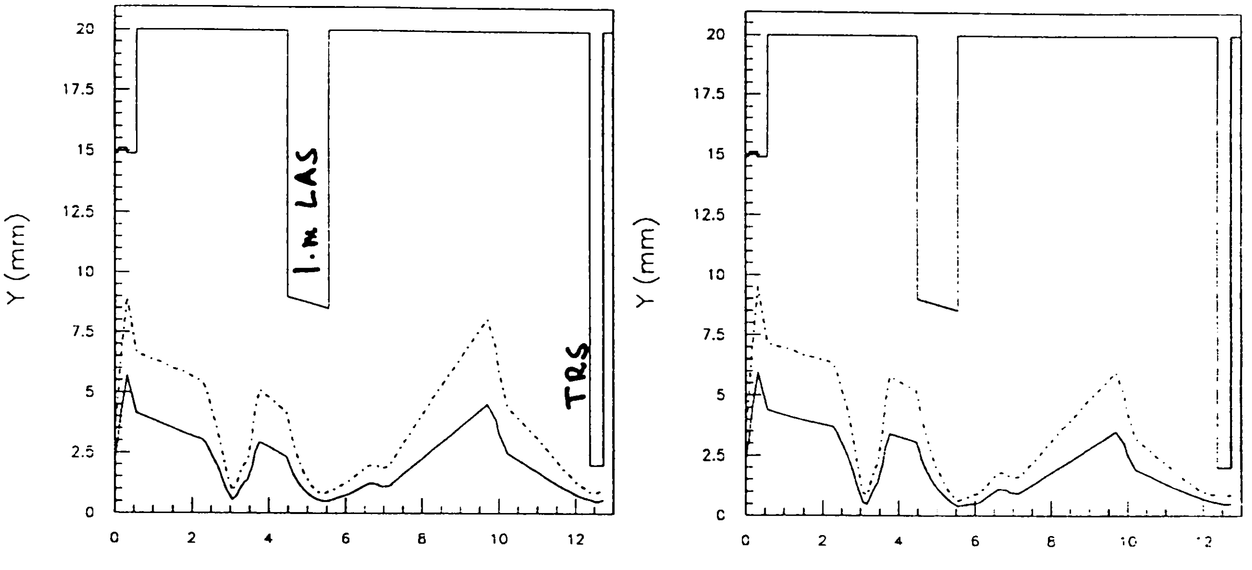
(b) 1 nC



(c) 5 nC

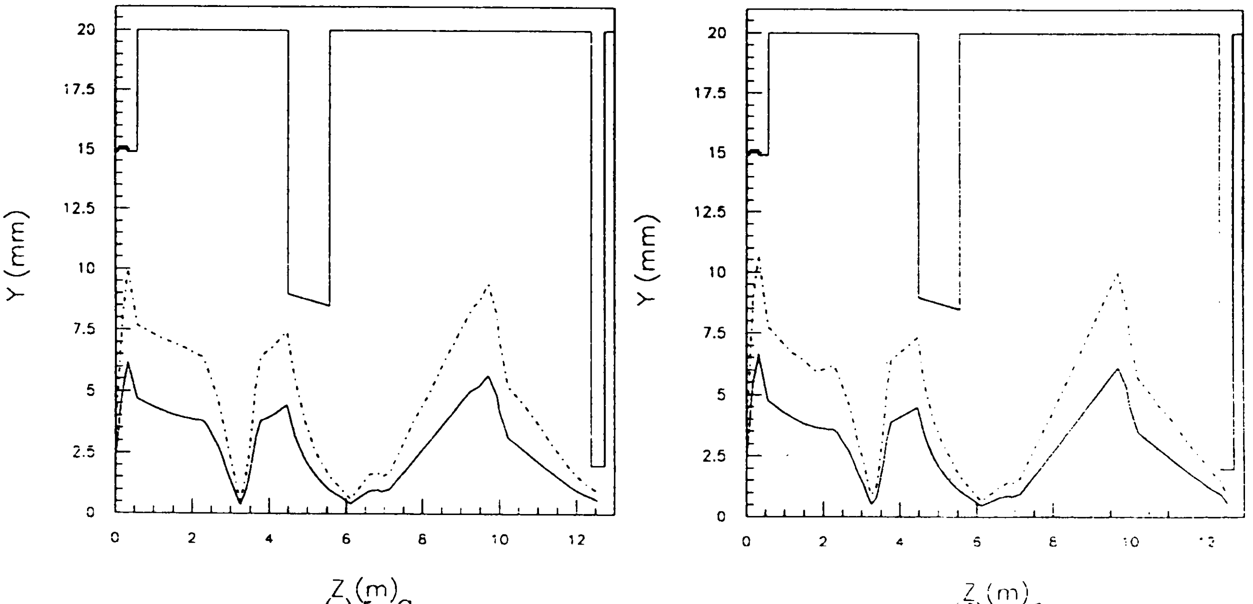
(d) 10 nC

Horizontal beam envelopes for the simplified CTF line.
(...): 90% particles. (-): rms value.



(a) 0 nC

(b) 1 nC



(c) 5 nC

(d) 10nC

Vertical beam envelopes for the simplified CTF line.
(...): 90% particles. (-): rms value.

Beam characteristics at the BPM's

For a 1 nC beam
in the middle of BPM :
($L_{BPM} = 50\,\text{cm}$)

σ_x = 0.33 mm

σ_y = 0.44 mm

δl = 0.21 mm

P_0 = 63.6 MeV/c

ε_x = 35 mm.mrad

ε_y = 46 mm.mrad

Beam characteristics at TRS

At 0 nC

σ_x = 0.47 mm

σ_y = 0.48 mm

δl = 0.2 mm

P_0 = 63.7 MeV/c

ε_x = 40 mm.mrad

ε_y = 62 mm.mrad

Transmission middle TRS: 100%

At 10 nC

σ_x = 0.9 mm

σ_y = 0.64 mm

δl = 0.5 mm

P_0 = 62.4 MeV/c

ε_x = 205. mm.mrad

ε_y = 78. mm.mrad

Transmission middle TRS: 85%

Momentum: P [MeV/c]	
At the exit of the gun:	4.36
At the exit of the booster:	10.57
At the exit of the bunch compressor:	–
At the entrance of the NAS:	–
At the exit of the NAS:	63.6
At the entrance of TRS:	–
Momentum spread: $\delta p/p$ [%]	
At the exit of the gun:	2.5
At the exit of the booster:	3.35
At the exit of the bunch compressor:	–
At the entrance of the NAS:	–
At the exit of the NAS:	0.54
At the entrance of TRS :	0.53
RMS transverse sizes [mm]	
At the exit of the gun:	x=y= 3.
At the exit of the booster:	x=y= 4.
At the exit of the bunch compressor:	x= 2.6 , y= 0.9
At the entrance of the NAS:	x= 2.3 , y= 2.3
At the exit of the NAS:	x= 0.5 , y= 0.5
At the entrance of TRS:	x= 0.56, y= 0.5
RMS transverse divergences [mrad]	
At the exit of the gun:	x'=y'= 17.
At the exit of the booster:	x'=y'= 0.9
At the exit of the bunch compressor:	x'=0.9 , y'= 4.8
At the entrance of the NAS:	x'= 0.9 , y'= 1.45
At the exit of the NAS:	x'= 0.94, y'= 1.
At the entrance of TRS:	x'= 0.7 , y'= 1.
RMS normalized beam emittances ϵ [mm.mrad]	
At the exit of the gun:	$\epsilon_x=\epsilon_y=$ 32.4
At the exit of the booster:	$\epsilon_x=\epsilon_y=$ 41.3
At the exit of the bunch compressor:	$\epsilon_x=$ 41 , $\epsilon_y=$ 52
At the entrance of the NAS:	$\epsilon_x=$ 41.9 , $\epsilon_y=$ 61
At the exit of the NAS:	$\epsilon_x=$ 42 , $\epsilon_y=$ 66
At the entrance of TRS:	$\epsilon_x=$ 40 , $\epsilon_y=$ 62
Longitudinal beam extention σ_z [mm]	
At the exit of the gun:	$\sigma_z=$ 1.2
At the exit of the booster:	$\sigma_z=$ 1.1
At the exit of the bunch compressor:	$\sigma_z=$ 0.22
At the entrance of the NAS:	$\sigma_z=$ 0.23
At the exit of the NAS:	$\sigma_z=$ 0.23
At the entrance of TRS:	$\sigma_z=$ 0.21

Table 1: Output data for 0 nC

Momentum: P [MeV/c]	
At the exit of the gun:	4.38
At the exit of the booster:	9.6
At the exit of the bunch compressor:	9.6
At the entrance of the NAS:	—
At the exit of the NAS:	62.5
At the entrance of TRS:	—
Momentum spread: $\delta p/p$ [%]	
At the exit of the gun:	1.6
At the exit of the booster:	4.7
At the exit of the bunch compressor:	3.0
At the entrance of the NAS:	4.8
At the exit of the NAS:	1.0
At the entrance of TRS :	1.8
RMS transverse sizes [mm]	
At the exit of the gun:	x=y= 3.9
At the exit of the booster:	x=y= 4.7
At the exit of the bunch compressor:	x= 4 , y= 1.8
At the entrance of the NAS:	x= 5 , y= 4.5
At the exit of the NAS:	x= 1 , y= 1
At the entrance of TRS:	x= 0.6 , y= 0.56
RMS transverse divergences [mrad]	
At the exit of the gun:	x'=y'= 25
At the exit of the booster:	x'=y'= 1.4
At the exit of the bunch compressor:	x'= 2.2 , y'= 4
At the entrance of the NAS:	x'= 1.8 , y'= 1.6
At the exit of the NAS:	x'= 2 , y'= 1.6
At the entrance of TRS:	x'= 3 , y'= 1.2
RMS normalized beam emittances ϵ [mm.mrad]	
At the exit of the gun:	$\epsilon_x = \epsilon_y =$ 52
At the exit of the booster:	$\epsilon_x = \epsilon_y =$ 56
At the exit of the bunch compressor:	$\epsilon_x =$ 104 , $\epsilon_y =$ 53
At the entrance of the NAS:	$\epsilon_x =$ 168 , $\epsilon_y =$ 62
At the exit of the NAS:	$\epsilon_x =$ 193 , $\epsilon_y =$ 88
At the entrance of TRS:	$\epsilon_x =$ 205 , $\epsilon_y =$ 79
Longitudinal beam extention σ_z [mm]	
At the exit of the gun:	$\sigma_z =$ 1.4
At the exit of the booster:	$\sigma_z =$ 1.4
At the exit of the bunch compressor:	$\sigma_z =$ 0.4
At the entrance of the NAS:	$\sigma_z =$ 0.5
At the exit of the NAS:	$\sigma_z =$ 0.5
At the entrance of TRS:	$\sigma_z =$ 0.5

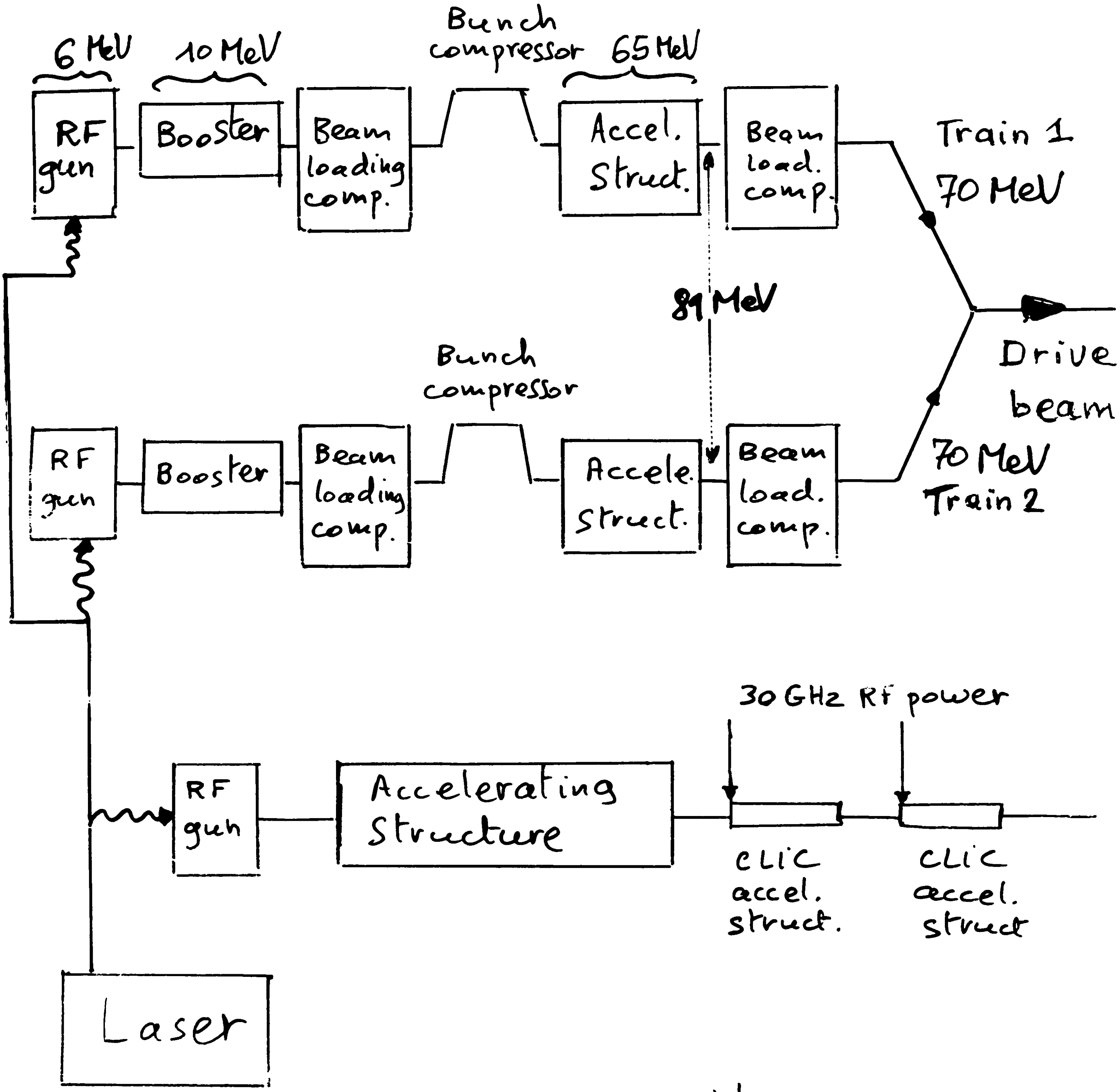
Table 1: Output data for 10 nC

App. 2

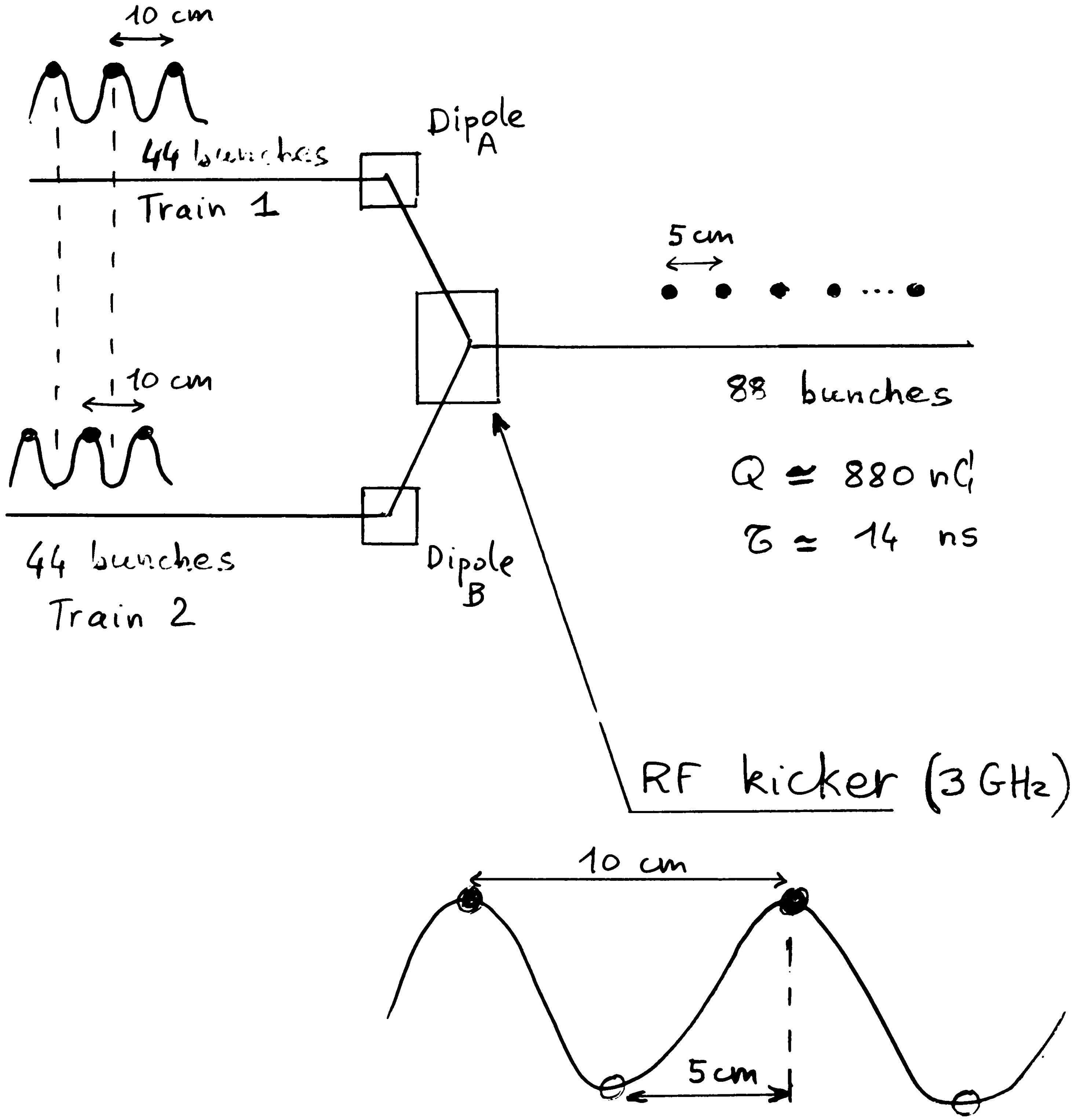
A preliminary study for a beam recombination in the drive beam of CTF - 2

R. Corsini, L. Rinolfi

- Requirements
- An RF dipole for recombination
- Geometrical solution
- Beam optics (dispersion, isochronici
- Focusing
- Preliminary conclusions



One possible simplified layout for CTF-2



Longitudinal recombination with a RF kicker

RF kicker studied at 3 GeV/c for long and short range wake fields

L. Thorndahl, A. Millich

10 cells and 17 MW
provide 0.6 mrad

⇓ scaling at 70 MeV

Deflection angle $\alpha = 26$ mrad

⇓ relax constraints

$\alpha = 10$ mrad

Iris diameter : 47 mm

Total length (10 cells) : 150 mm
including beam pipes

Rough estimation for the transverse wakes

Voltage for 10 mrad and 70 MeV

$$\underset{[V]}{E.\ell} = [\tan\theta]\cdot \underset{[GeV/c]}{p}\cdot\beta$$

$$\mathbf{E\cdot\ell = 700\ kV}$$

Voltage for transverse wake fields

Train of bunches spaced by 1 cm and 10 nC / bunch

2.83 kV/mm (A. Millich)

Train of bunches spaced by 5 cm and 10 nC / bunch

0.56 kV for 1 mm of transverse offset.

A existing RF dipole for LIL and CTF

G. Carron, L. Thorndahl

Iris diameter : 23 mm

Total length : 267 mm
(6 cells)

$$\underset{(rad)}{\theta} = 0.814 \frac{\sqrt{P\,(MW)}}{p\,(MeV/c)}$$

$P = 1\ MW \longrightarrow \theta = 12$ mrad

$P_{max} = 30\ MW \longrightarrow \theta_{max} = 64$ mrad

Beam characteristics

Energy : 70 MeV

Charge : 10 nC / bunch

Energy spread : 3 %

Beam sizes : $\frac{x}{2} \simeq \frac{y}{2} \simeq 5$ mm

Beam emittances : $\varepsilon_h \simeq 140\pi$ mm.mrac

(normalized rms) $\varepsilon_v \simeq 60\pi$ mm.mrac

Geometrical solution with a double septum magnet

Double septum

Deflection angle : 70 mrad
Septum tickness : 2 mm
Beam width : 13 mm
Beam height : 9 mm
Integrated field : 0.016 T
Effective length : 0.800 m
Field : 0.02 T
Current : 4200 A

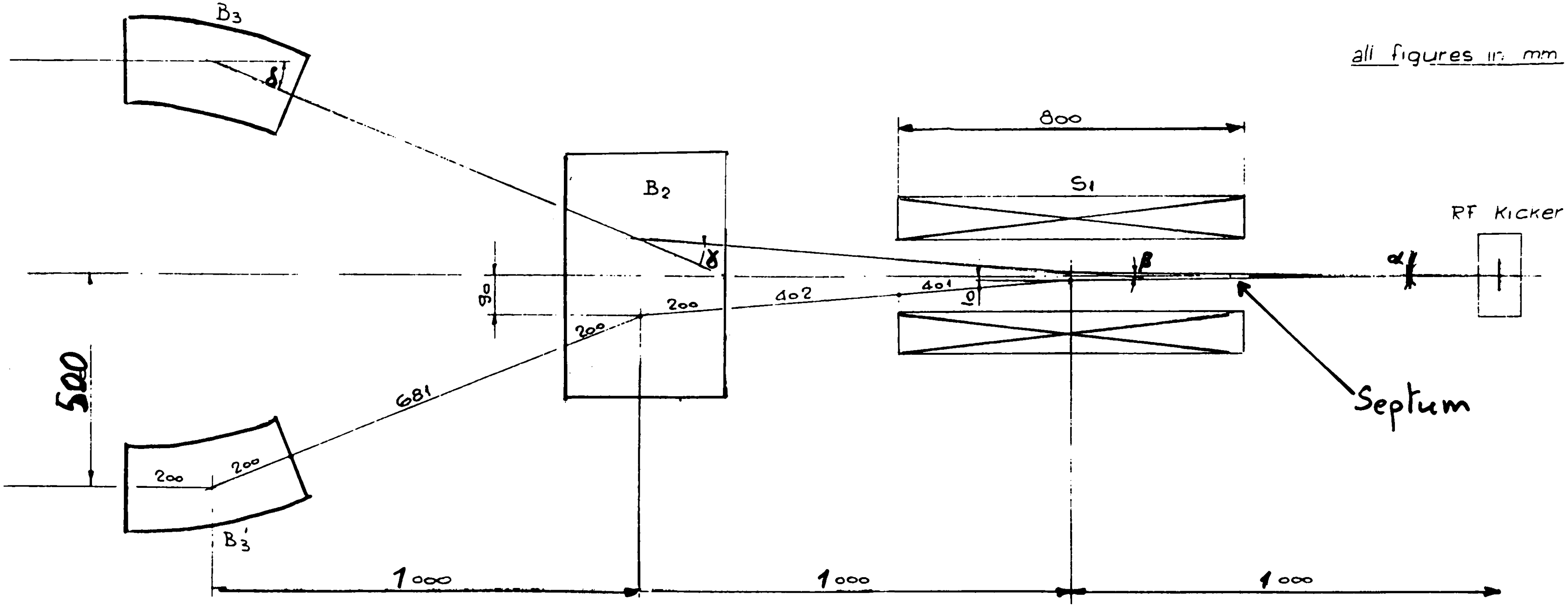
α = 10 mrad

β = 70 mrad

γ = 316 mrad

δ = 390 mrad

all figures in mm



Echelle 1:10 19 10. 94 Puck

Fig. 7 Layout with a double septum magnet

Existing double septum
BTSMV 30 at the
Booster machine

(J.P. Delahaye)

Deflection angle : 2.6 mrad

Septum tickness : 1 mm

Total gap : 2 x 69 mm

Integrated field : 0.0127 T.m

Effective length : 0.400 m

Field : 0.03 T

Current : 3036 A

Geometrical solution with a quadrupole

Defocusing quadrupole:

Deflecting angle : 40 mrad
Inscribed radius : 20 mm
Beam width : 13 mm
Beam height : 9 mm
Strength : 11.1 m^{-2}
Gradient : 2.6 T/m
Effective length : 0.4 m
Focal length $(\frac{1}{f})$: 4.4 m^{-1}
Integrated gradient : 1 T

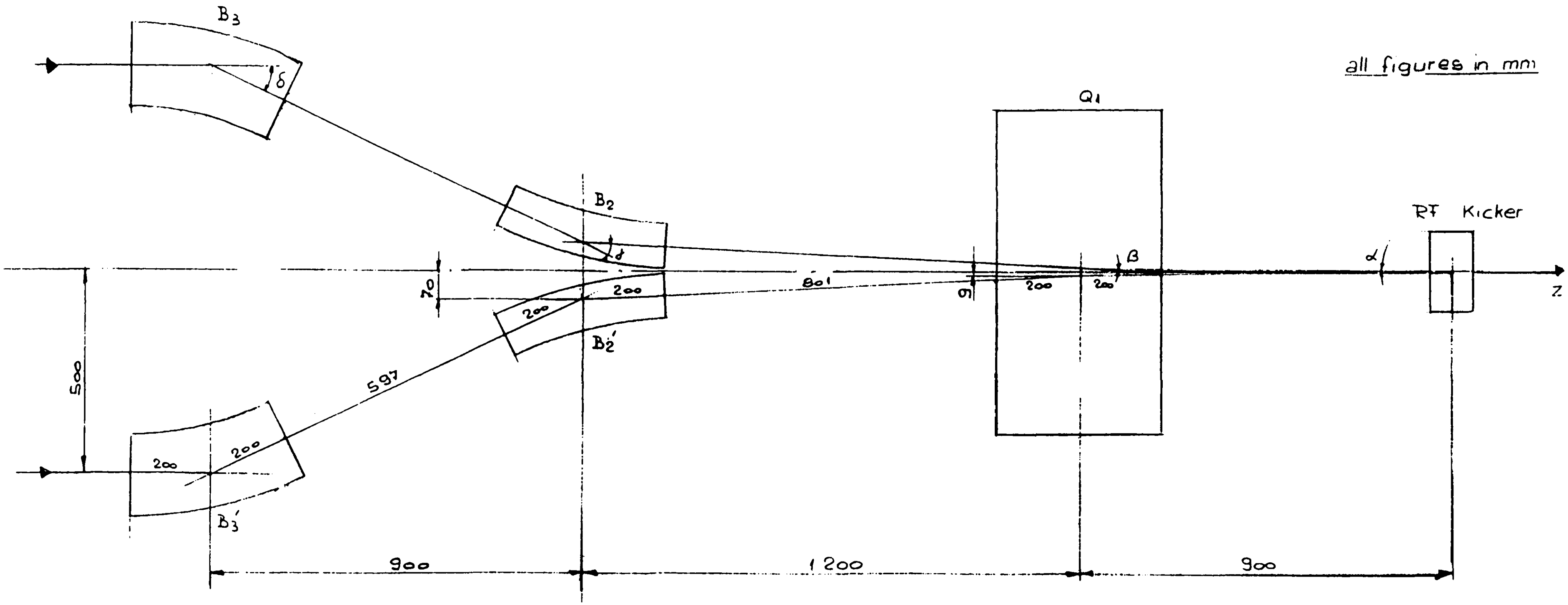
α = 10 mrad

β = 40 mrad

γ = 395 mrad

δ = 445 mrad

all figures in mm



Echelle 1:10

19.10.94

Fig 8 Layout with a quadrupole QD

Dipoles B_2 and B_3

Deflecting angle : δ_{min} = 310 mrad

δ_{max} = 445 mrad

Beam width :	13 mm
Beam height :	9 mm
Dipole field :	0.26 T
Effective length :	0.4 m
Gap :	40 mm
Integrated field :	0.1 T

Dipole B_2 could be a double window frame (P. Bossard)

Beam optics
with a double septum magnet
and
2 focusing quadrupoles

Conditions on the dispersion at the RF kicker

$$D_x = 0$$

$$D'_x = 0$$

Condition of isochronocity

$$\Delta l \simeq 0$$

for $\frac{\delta p}{p} = \pm 2.5\%$

$$M_{56} \cong 0$$

For Dispersion and isochronicity

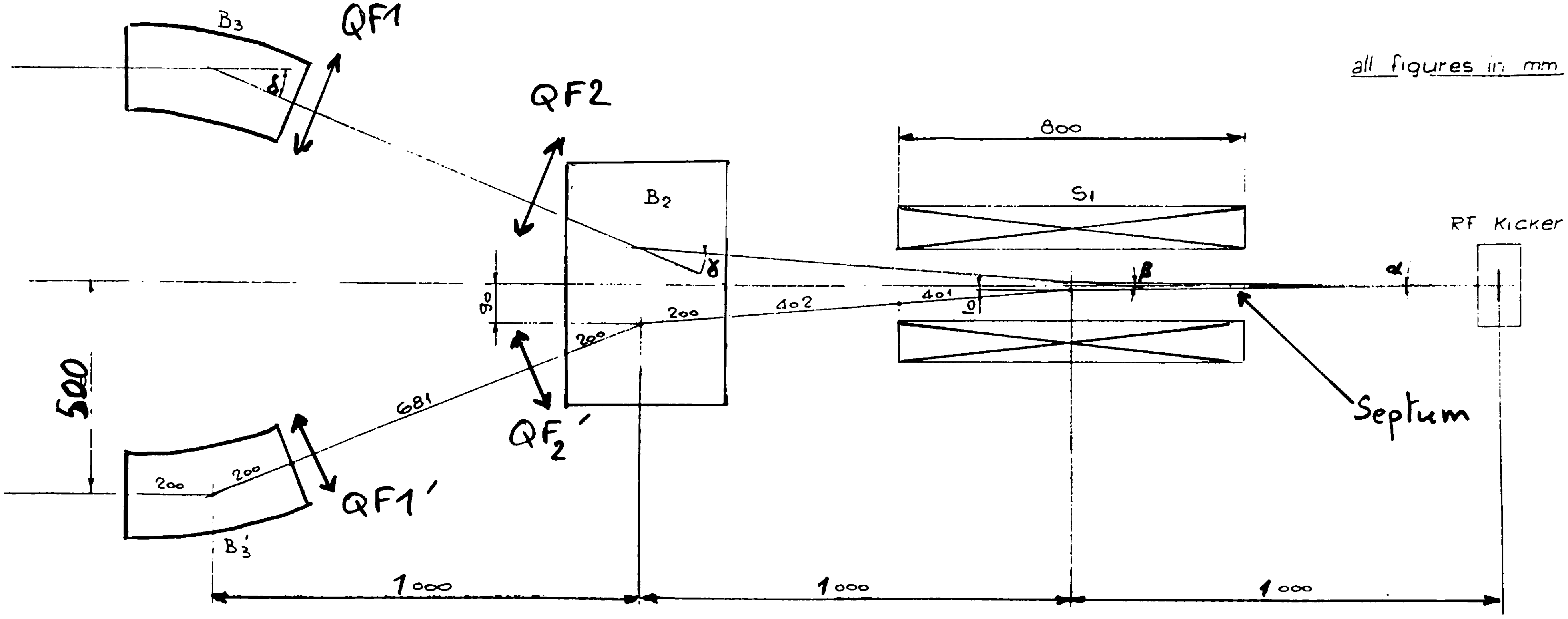
$\alpha = 10$ mrad

$\beta = 70$ mrad

$\gamma = 316$ mrad

$\delta = 390$ mrad

all figures in mm



Echelle 1:10 19.10.94 Pluck

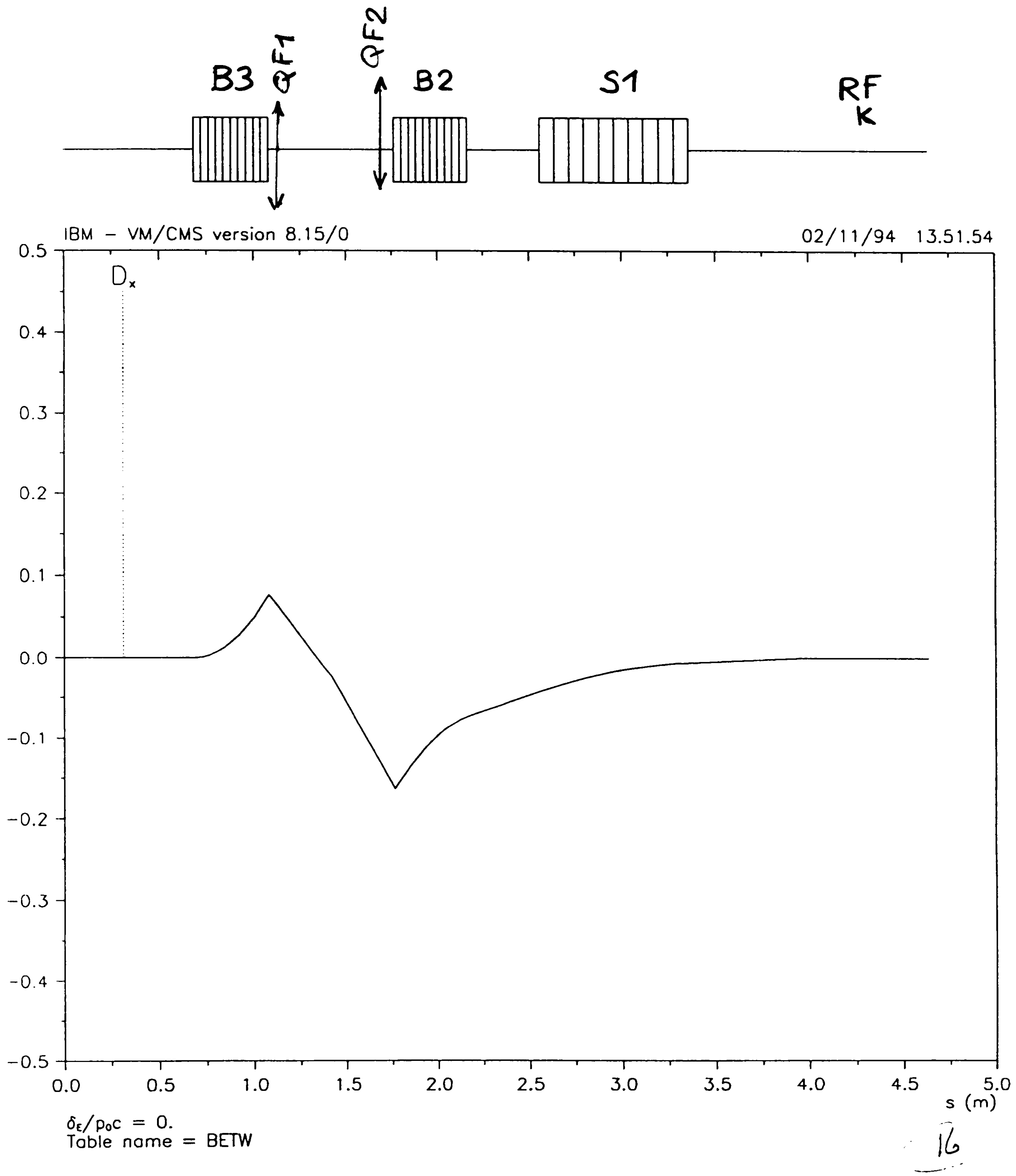
Fig. 7 Layout with a double septum magnet

$d_{QF1} = 29$ mm

$d_{QF2} = 52$ mm

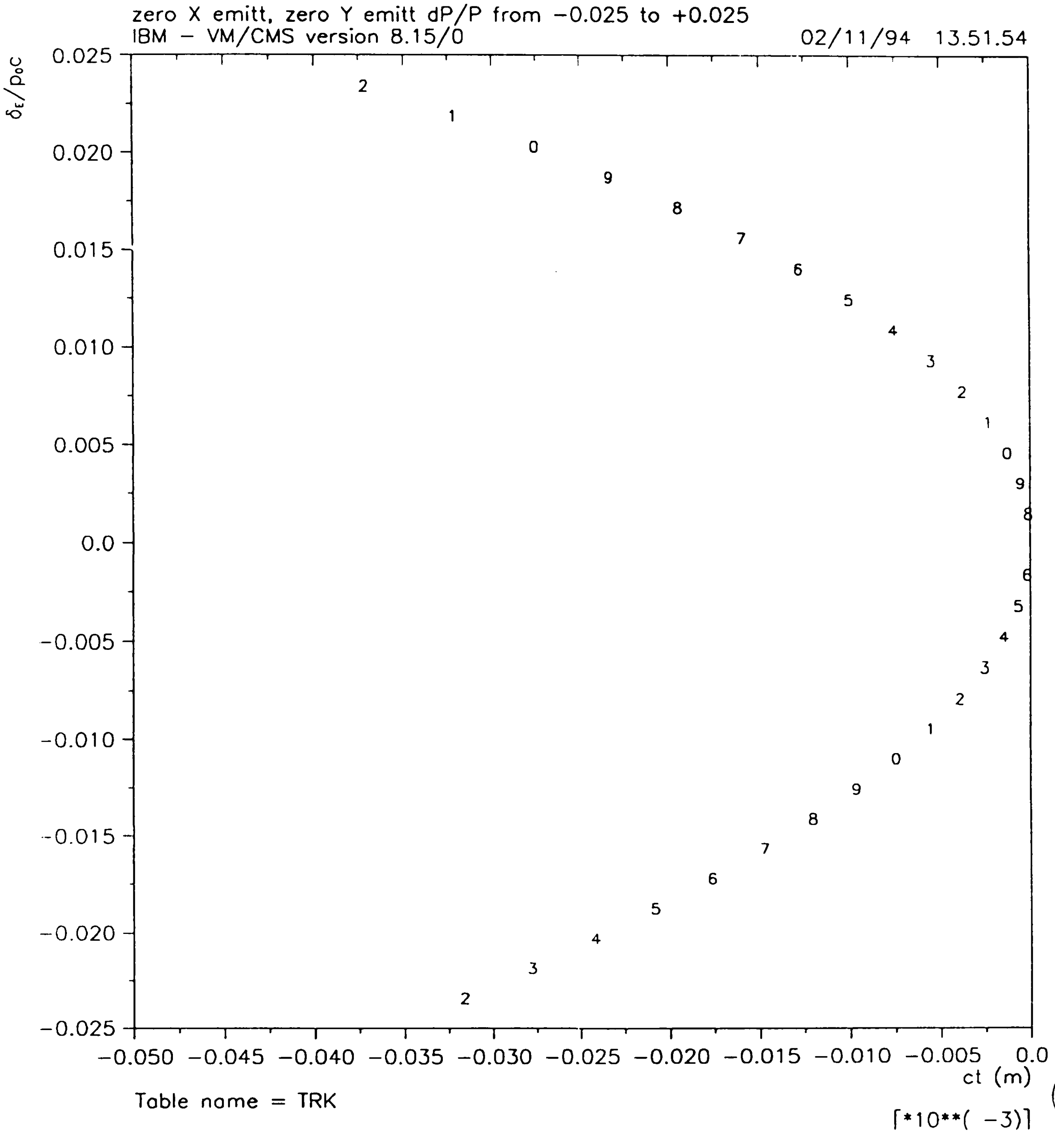
Dispersion curve

$$\left.\begin{array}{l} D_x = 0 \\ D'_x = 0 \end{array}\right\} \text{ at RF dipole}$$



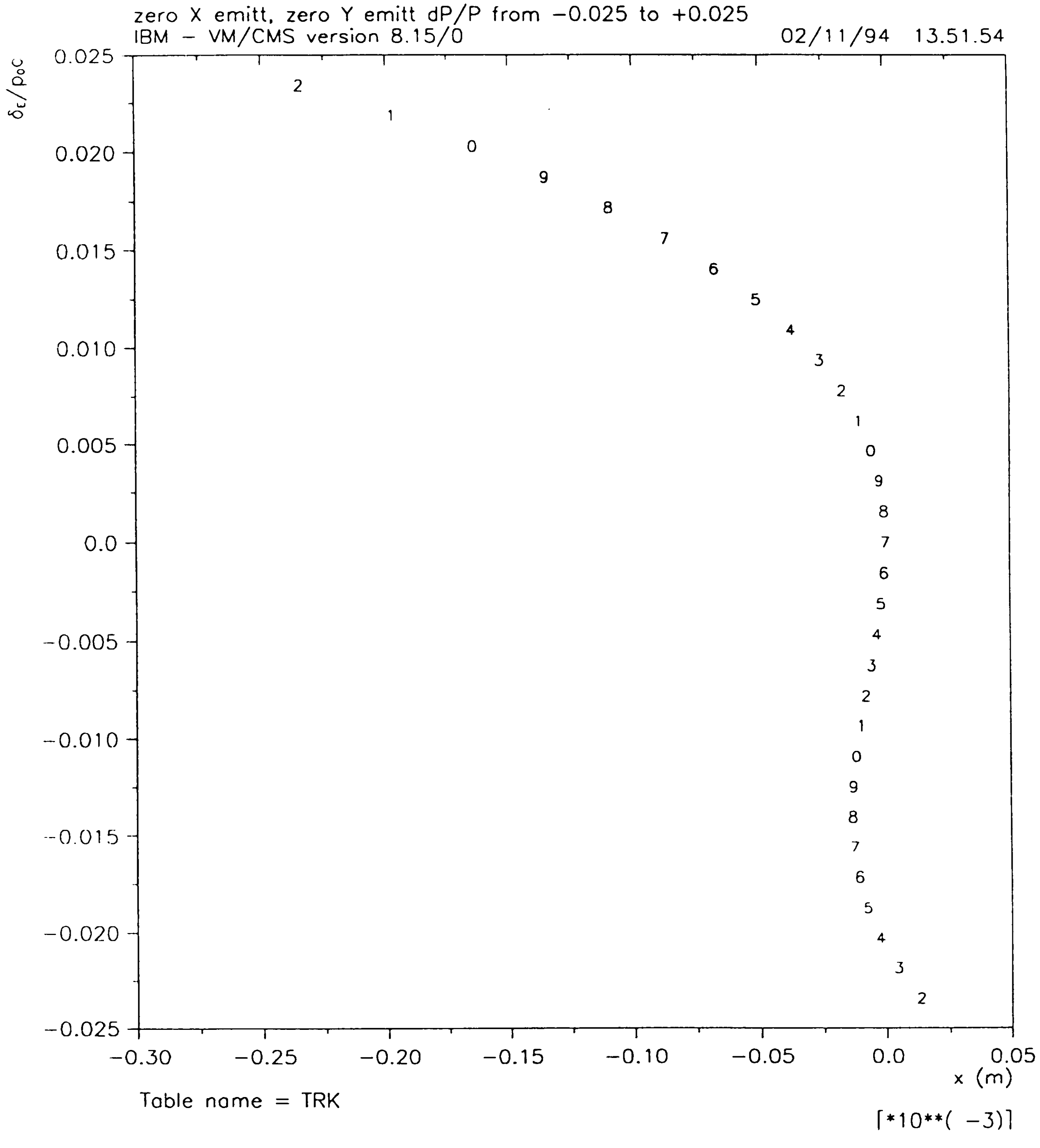
Isochronicity

$\Delta l \simeq 0.03$ mm



Dispersion contribution

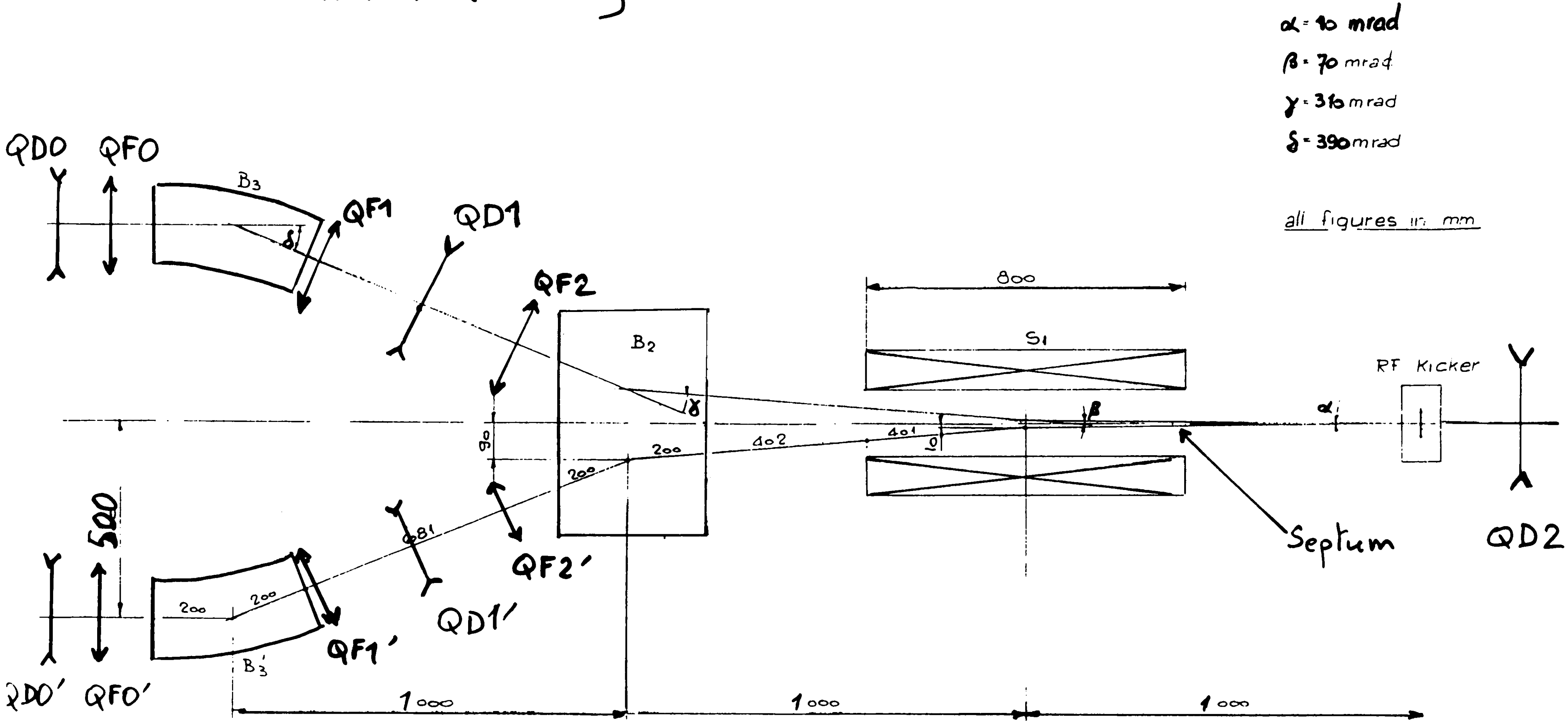
$\Delta x \simeq 0.25$ mm



Quadrupoles for Dispersion and isochronicity

	QF1	QF2	
Focal length $\left(\frac{1}{f}\right)$	6.38	3.57	m
Effective length	0.100	0.100	m
Strength	63.8	35.7	m
Gradient	14.8	8.3	T/
Integrated gradient	1.48	0.8	T
Incribed radius	40	40	mm
Transverse offset	29	52	mm
Deflecting angle	187	187	mra

For focusing
and matching



α = 10 mrad
β = 70 mrad
γ = 316 mrad
δ = 390 mrad

all figures in mm

Echelle 1:10 19.10.94 Rck

Fig 7 Layout with a double septum magnet

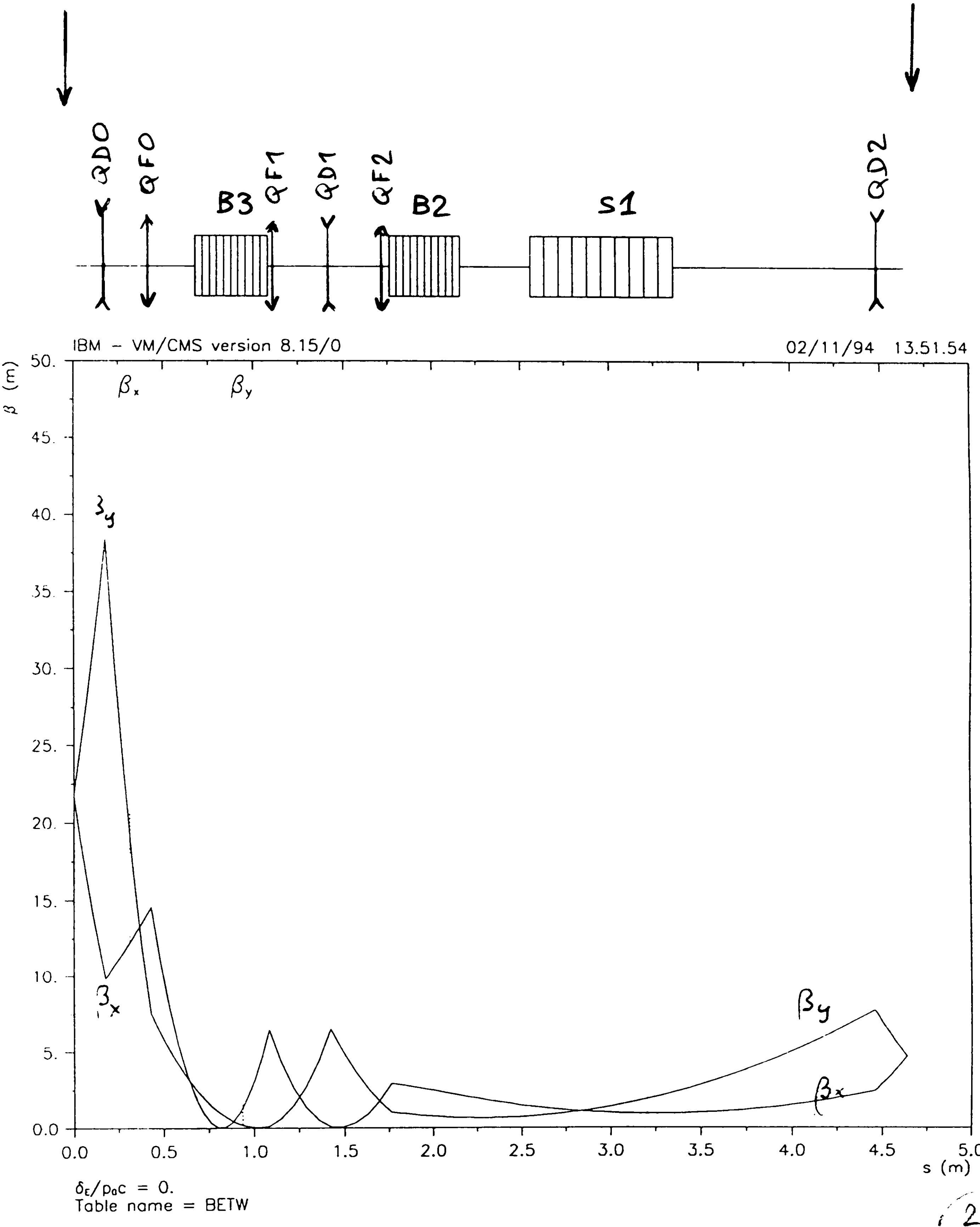
Betatron matching

$\beta_x = \beta_y = 21.8$ m

$\alpha_x = -\alpha_y = 39.8$

$\beta_x = \beta_y = 4.8$ m

$\alpha_x = -\alpha_y = -7.5$



Advantages

1) A compact injection region is achievable ($\sim$ 3 m)

2) All elements are standard and realisable at a relative low cost

3) The 2 beams have the same energy

Disadvantages

1) The phase shift between the 2 train cannot be varied

2) The RF kicker requires MW of RF power

3) A beam loading compensation should be implemented.

Conclusion

- The recombination with a RF dipole provides a compact injection region

- An optics solution is found for the dispersion function, the isochronous condition (at the first order) and for the focusing.

- The best solution between the double septum magnet and the defocusing quadrupole should be investigated.

- The real magnets and the second order contributions should be implemented in the model.