LPI peak performances recorded in December 89

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1. Introduction

LPI peak performances have been recorded on 1989 December 5, 6 and 20 after careful optimization of machine settings. On December 5, the Linac tuning was started from the reference values of 1989 August 25, and the "production" parameters were recovered. It was shown, once more, the reproducibility of the LIL.

The positrons were created with the classical W target of 5 mm diameter. The bunching system was optimized to drive a maximum charge at the end of LIL – V. The focusing and the steering of LIL – W were adjusted to produce and transport a maximum positrons at the end of LIL – W. Electron production was done directly through the 5mm hole of the converter. The transmission efficiency has been optimized near the maximum, over both linacs. A maximum charge was transported at the end of the LIL – W within EPA acceptance.

EPA setting up was done by starting from an axial injection on the nominal tunes Qh = 4.60 and Qv = 4.38 . The same day the vertical closed orbit was measured and corrected. The resulting orbit is shown here. On December 20 emittances with 8 bunches of electrons and clearing ON were recorded as well as life time

2. LPI peak performances for positrons

They are summarized on table 1

2.1 LIL performances

The buncher was adjusted in order to be close of 70% of efficiency [1] with a maximum gun current. The maximum charge transported up to the target i.e end of LIL – V was 3 10^{11} particles. Figure 1 gives the beam profile at the end of LIL – V and figure 2 at the end of LIL – W under these conditions.

A new record of 17.4 10^{8} positrons per pulse was obtained. However the EPA longitudinal acceptance is only $\pm$ 1 %, then a measured of e^{+}/e^{-} conversion efficiency has been made within this range. Figure 3 is a comparison of the conversion efficiency of design, nominal and peak values.

2.2 EPA performances

This new maximum of produced positrons has allowed to beat EPA accumulation rate record at 8.1 10^9 e^+/bunch*s or 6.5 10^{10} e^+/s. Axial injection which has been done prior to accumulation has given a 87% injection efficiency and a trapping without any detectable losses. It has to be mentioned as one can see on table 1 that between LIL tuning and EPA tuning a small drift of the unresolved production occurs without affecting the resolved current.

3. LPI peak performances for electrons

They are summarized on table 2

3.1 LIL performances at low charge

Starting with a low production of 9.4 E9 e− at the output of the gun, the whole transmission in both linacs was optimized.

The bunching efficiency is reduced to 52 % at low charge and the e^- pulse is transported with long tail along the linacs (the prebuncher and buncher are optimized for high current). The consequence is a transmission efficiency reduced to 80% when the pulse is bent in the transfer line, although the transmission efficiency between the output of the buncher and the end of LIL−W is 91%. However the e− beam intensity is large enough that it is not necessary to improve this transmission efficiency. Figure 4 shows the beam profile of the e− beam in the transfer line. 10 % of the beam is outside of EPA acceptance.

3.2 LIL performances at high charge

Although LIL−W was designed to accept a very low current (a few tens of mA), a trial has been made to transport 6.3 10^{10} e^- from the gun to the end of LIL−W. With this charge the bunching efficiency raises up to 63% and at the end of LIL−W, the transmission efficiency becomes 74%. Due to the beam loading this value drops to 61% when the e− pulses are deflected in the transfer line. The figure 5 gives the corresponding beam profile. The injection in EPA was done under slightly lower intensity as shown in table 2 "LIL characteristics for 1 bunch at transfer".

3.3 EPA performances

Performances at EPA injection are shown on table 2. One can see that we can have a good accumulation efficiency of 80% if we limit the momentum spread of the beam in $\pm$ 1%.

4. Electron beam properties in EPA

4.1 EPA electron beam emittances in 8 bunches mode with clearing ON

They have been recorded to check our vacuum status before the shut down, as well as to see the evolution of the vertical emittance at low current after the minimization of the vertical closed orbit (coupling effect of chromaticity sextupoles). Data with clearing ON and mainly in the vertical plane has been measured. On figure 6 one can find the evolution of the emittances, with for comparison, the data of last year. We can see immediately that 1989 vertical emittance curve is smoother that the older one. This is due to the installation of an optical x2 magnifier improving the resolution in the january 89 shutdown.

At ZERO intensity there is a tremendous decrease of vertical emittance from 20 10^{-9} PI*rad*m to 4 10^{-9} PI*rad*m. This is probably due to a decrease of vertical coupling by the minimization of the vertical closed orbit. As a cross check, some calculations of the effect of the vertical positions in our sextupoles have to be done. The "high intensity" vertical emittance is the same as last year, showing that EPA is roughly in the same vacuum state; this is confirmed by the following beam life-time measurements shown later.

4.2 Electron beam life time in 8 bunches mode clearing ON

At the same time as emittances measurement, beam life time has been recorded. As usual a plot of:

$$\frac{1}{\tau} = k1 \times N + k2$$

have been done. The plot and a least square fit of these data can be seen on figure 7 leading to fit values:

$$\frac{1}{\tau\,(h)} = 0.028 \times N \quad (in\ 10^{10}\ part) + 0.151$$

It gives a life time of 1.23h for our nominal intensity of 2 10^{11} in 8 bunches which is identical to 1988 value. If we work out the value $\tau * N$ from the coefficient k1, we find the same value as found in [3]

5. Closed orbit measurement

Although not being part of the LPI performances, we have recorded the EPA closed orbit as a measure of the status of the ring. On figure 8, present closed orbits can be seen for December 88 and December 89 for both planes.

The horizontal closed orbit has roughly the same phase as last year but with lower amplitude. No correction has been done on it this year.

On the vertical closed orbit we have done 2 corrections summarized below, with 1988 values for information:

EPA VERTICAL CLOSED ORBIT

Date	rms C.O.mm	peak to peak C.O. mm	Comment
13/12/88		5.8	before shut down
8/11/89	1.76	7.0	before 1st correction
6/12/89	0.78	2.6	after 2nd correction

These orbit corrections are described in [2]

6. Conclusions

LPI has reached new peak performances which allows comfortable margin for the next LEP run. All corresponding control values have been recorded and will be used for the startup of February 1990. However in the light of LEP 200 and a possible B-factory, the LPI performances should be improved, in particular the positrons production and accumulation.

7. References

1. R. Bossart, J.P. Delahaye, L. Rinolfi Influence of front-end parameters on the linac performances PS/LP Note 89-36

2. J.P. Potier EPA closed orbit correction (to be published)

3. ME report on status of EPA vacuum in 89

LPI Peak Performances in 1989 recorded december 6,1989 LR+JPP

POSITRON LIL PERFORMANCES

GUNV and buncher performances	Unit	Nominal	Dec-89
Pulse width ns FWHH	ns	12	20
VL.ECM01 current	A	6.0	4.6
VL.ECM01 number of part.	E8		5690
VL.WCM11 number of part.	E8		3760
Buncher efficiency	%		66
LILV performances			
Output energy	Mev	200	220
Pulse width ns FWHH	ns	12	20
VLUMA15 number of part.	E8	1880	2991
Total momentum dispersion	+ / - %		8.2
LILV transmission VL.UMA15/VL.WCM11	%	80	80
LILW performances			
Energy	MeV	600	500
HIPUMA22 total number of part.	E8		17.1
Total conversion efficiency HIP.UMA22/VL.UMA15	E-3		5.7
Conversion efficiency with dP/P in +/- 1%	E-3	3.2	4.3
HIP.UMA22 number of part.in dP/P= +/- 1%	E8	6	12.9
Ratio of LILW beam in dP/P = +/- 1%	%		70

POSITRON LPI OVERALL PERFORMANCES

LIL Charateristics for 1 bunch at transfer	Unit	Nominal	Dec-89
Energy	MeV	600	500
Lil number of particles Total	E8		15.7
Lil number of particles in dP/P : +/- 1%	E8	6.0	12.4

EPA characteristics	Unit	Nominal	Dec-89	
Number of bunches	-	**8**	**1**	**8**
Saturation number of particles /bunch	E10	2.6	18.0	8.1
Total saturation number of particles	E10	20.0	18.0	65.0
Total saturation current	mA	76.0	68.7	248.0
Accumulation rate up to I nominal / bunch*s	E9	2.2	8.1	8.1
Accumulation rate up to I nominal : total	mA/s	6.8	3.1	24.8
Accumulation efficiency : all LIL beam	%		34.5	39.8
Accumulation efficiency with LIL dP/P: +/- 1%	%	30.0	46.6	52.6

TABLE 1

LPI Peak Performances in 1989 recorded december 6,1989 LR+JPP

ELECTRON LIL PERFORMANCES

GUNV and buncher performances	Unit	Nominal	Dec-89
Pulse width ns FWHH	ns	12	12
VL.ECM01 current	mA	320	900
VL.ECM01 number of part.	E8		664
VL.WCM11 number of part.	E8		418
Buncher efficiency	%	50	63
LILV performances			
Output energy	Mev	200	220
VLUMA15 number of part.	E8	45	390
Total momentum dispersion	+ / - %		1.5
LILV transmission VL.UMA15/VL.WCM11	%	90	93
LILW performances			
Output energy	MeV	600	500
HIE.UMA22 total number of part.	E8	80	256
Total transmission HIE.UMA22/VL.WCM11	%		61
HIE.UMA22 number of part.in dP/P= +/- 1%	E8	30	148
Ratio of LILW beam in dP/P = +/- 1%	%	80	60

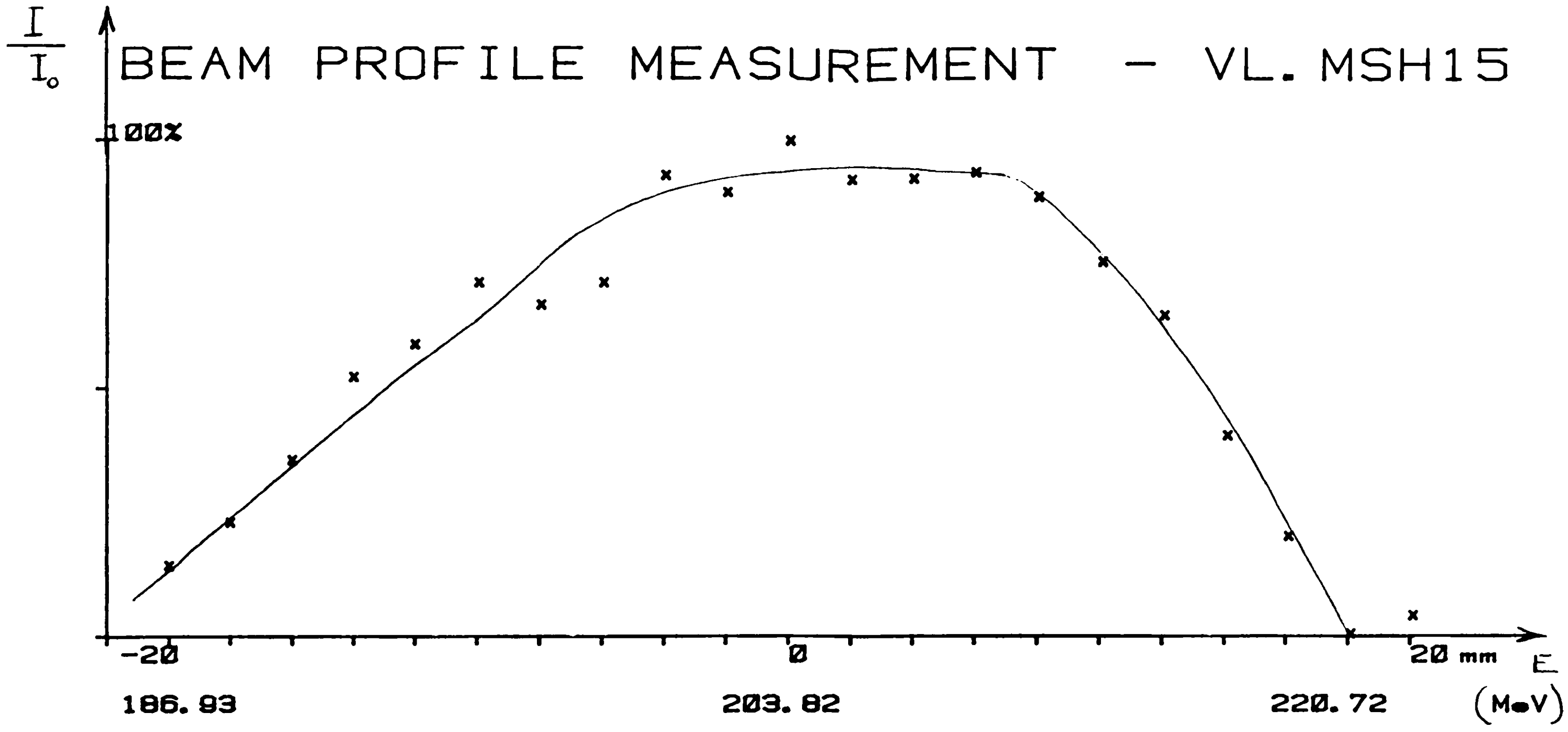
ELECTRON LPI OVERALL PERFORMANCES

LIL Charateristics for 1 bunch at transfer	Unit	Nominal	Dec-89
Energy	MeV	600	500
Lil number of particles Total	E8		165.0
Lil number of particles in dP/P : +/- 1%	E8	30.0	102.0

EPA characteristics	Unit	Nominal	Dec-89	
Number of bunches	-	8	1	8
Saturation number of particles /bunch	E10	1.3	30.0	11.2
Total saturation number of particles	E10	10.0	30.0	90.0
Total saturation current	mA	38.0	114.6	344.0
Accumulation rate up to I nominal / bunch*s	E9	11.0	120.0	120.0
Accumulation rate up to I nominal : total	mA/s	33.0	45.8	366.0
Accumulation efficiency : all LIL beam	%		58.5	58.5
Accumulation efficiency with LIL dP/P: +/- 1%	%	30.0	80.0	80.0

Nota : LILW UMA in electrons are saturated with operationnal sensitivity. Here we work without amplifier i.e. with the sensor calibration

TABLE 2



Central Energy 203.82 MeV

Digital Value at 100% 1463 (sat. 2047)

INTENSITY (UMA meas.) -134.484 1E8 part.

Number of measurements 100

Gain is .01

BSP 15 = 251.6 A

P_{03} = 13.9 MW

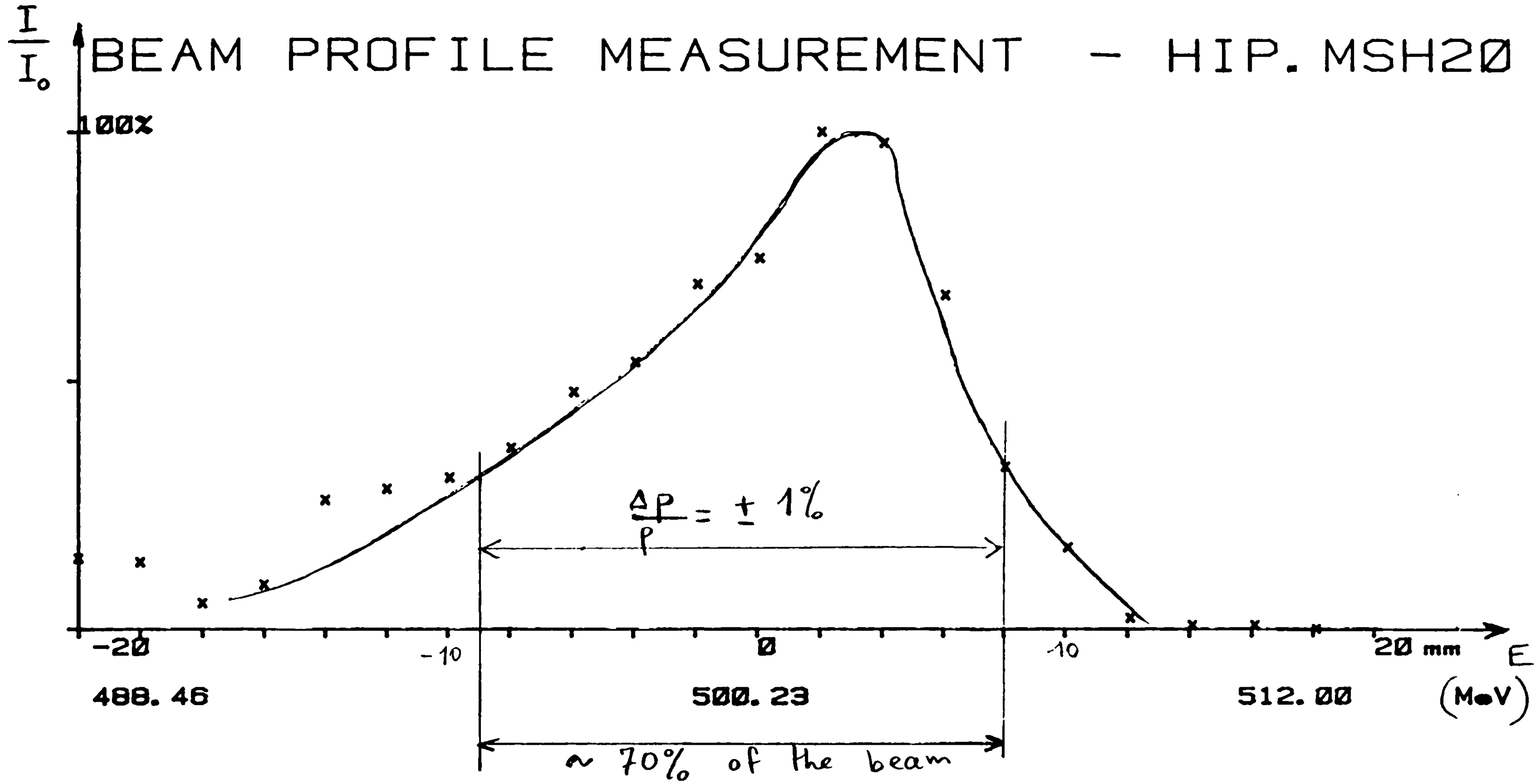
P_{13} = 24 MW

UMA 15 = UMA 25 = 3.10^{11} particules

Q = 48 nC

	ΔE (MeV)	E_0 (MeV)	$\frac{\Delta E}{E}$
Base	32.2	203.8	± 8 %
FWHM	23	203.8	± 5.6 %

Fig 1 : Energy dispersion of e^- beam hitting the target



Central Energy 500.23 MeV

Digital Value at 100%   134 (sat. 2047)

INTENSITY (UMA meas.)   6.56 1E8 part.

Number of measurements 99

Gain is .1

Scraper HIP.SLH20 (Aperture) : 49 (49) mm

Fig 2. Energy dispersion of e^+ beam at the end of linac

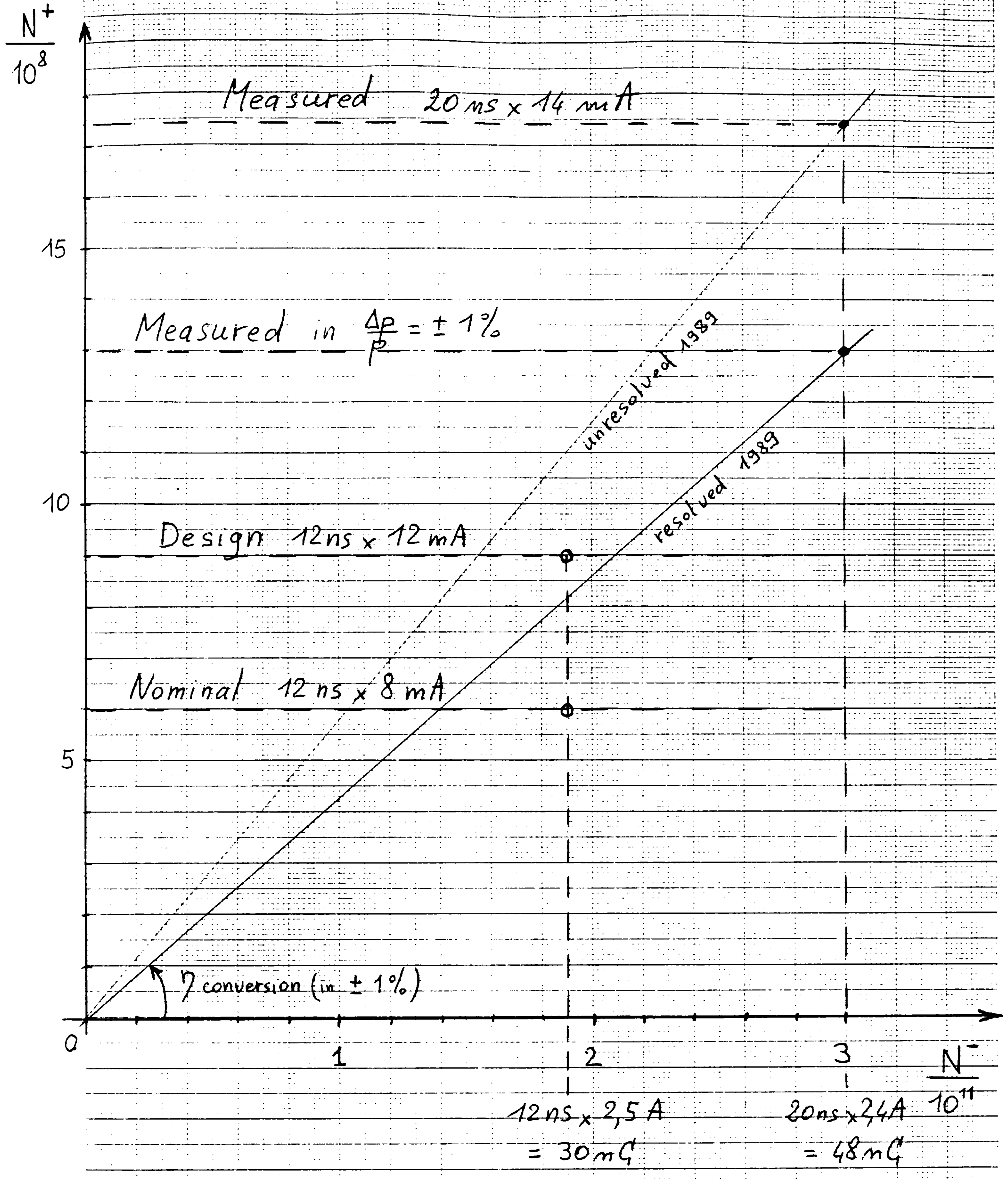
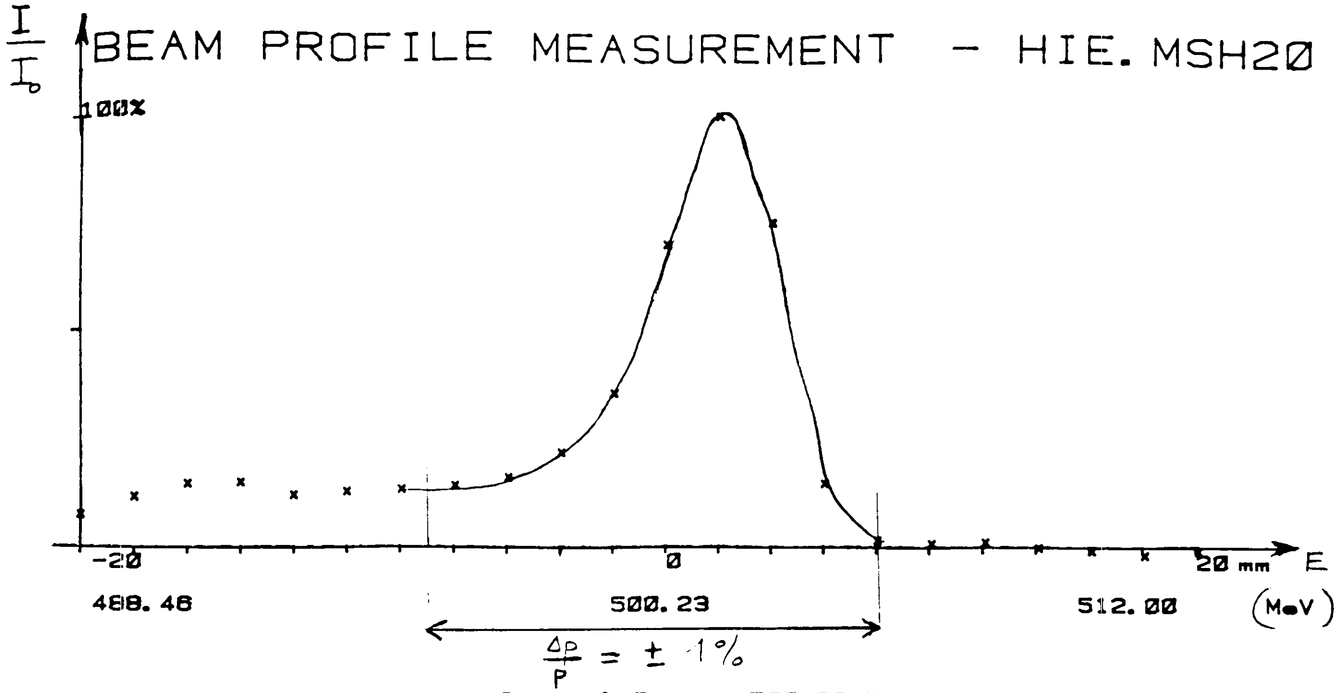


Fig 3 Comparison of peak performances with nominal and design values



Central Energy 5ØØ. 23 MeV

Digital Value at 1ØØ% 1259 (est. 2Ø47)

INTENSITY (UMA meas.) -48. 578 1E8 part.

Number of measurements 1ØØ

Gain is .1

Scraper HIE. SLH2Ø (Aperture) : 5Ø (5Ø) mm

(Position) : Ø (Ø) mm

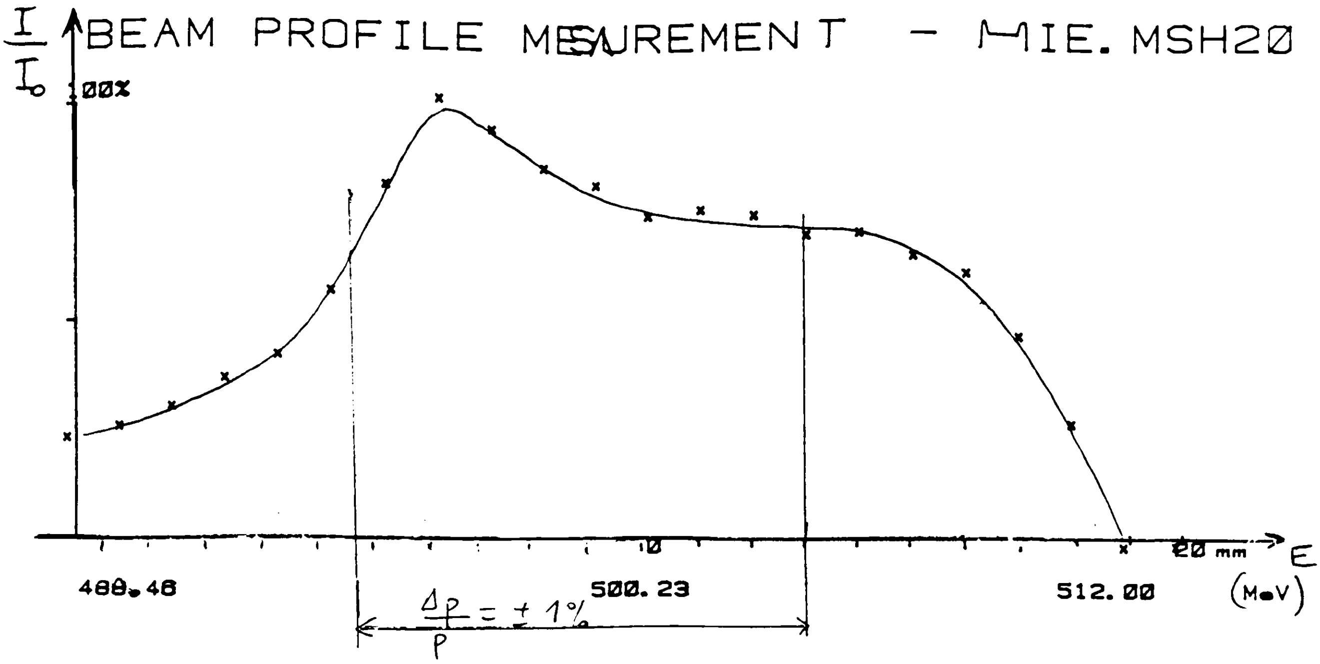
$\Delta E = 6.5$ MeV

$\frac{\Delta E}{E} = \pm 0.65\ \%$

Fig 4 : Energy dispersion of e^- beam at the end of linac

90% of the particules are inside a $\frac{\Delta p}{p} = \pm 1\%$

$Q = 0{,}74\ nC \simeq 12\ ns \times 62\ mA$



Central Energy 500.23 MeV

Digital Value at 100% 312 (sat. 2047)

INTENSITY (UMA meas.) -17.712 1E8 part. x14.4

Number of measurements 18

$\Delta E \simeq 20$ MeV

$\frac{\Delta E}{E} = \pm 2\%$

Gain is .01

Scraper HIE.SLH20 (Aperture) : 50 (50) mm

(Position) : 0 (0) mm

Fig 5 : Energy dispersion of e^- beam at the end of linac

60% of the particules are inside a $\frac{\Delta p}{p} = \pm 1\%$

$Q = 4\ nC \simeq 12\ ms \times 350\ mA$

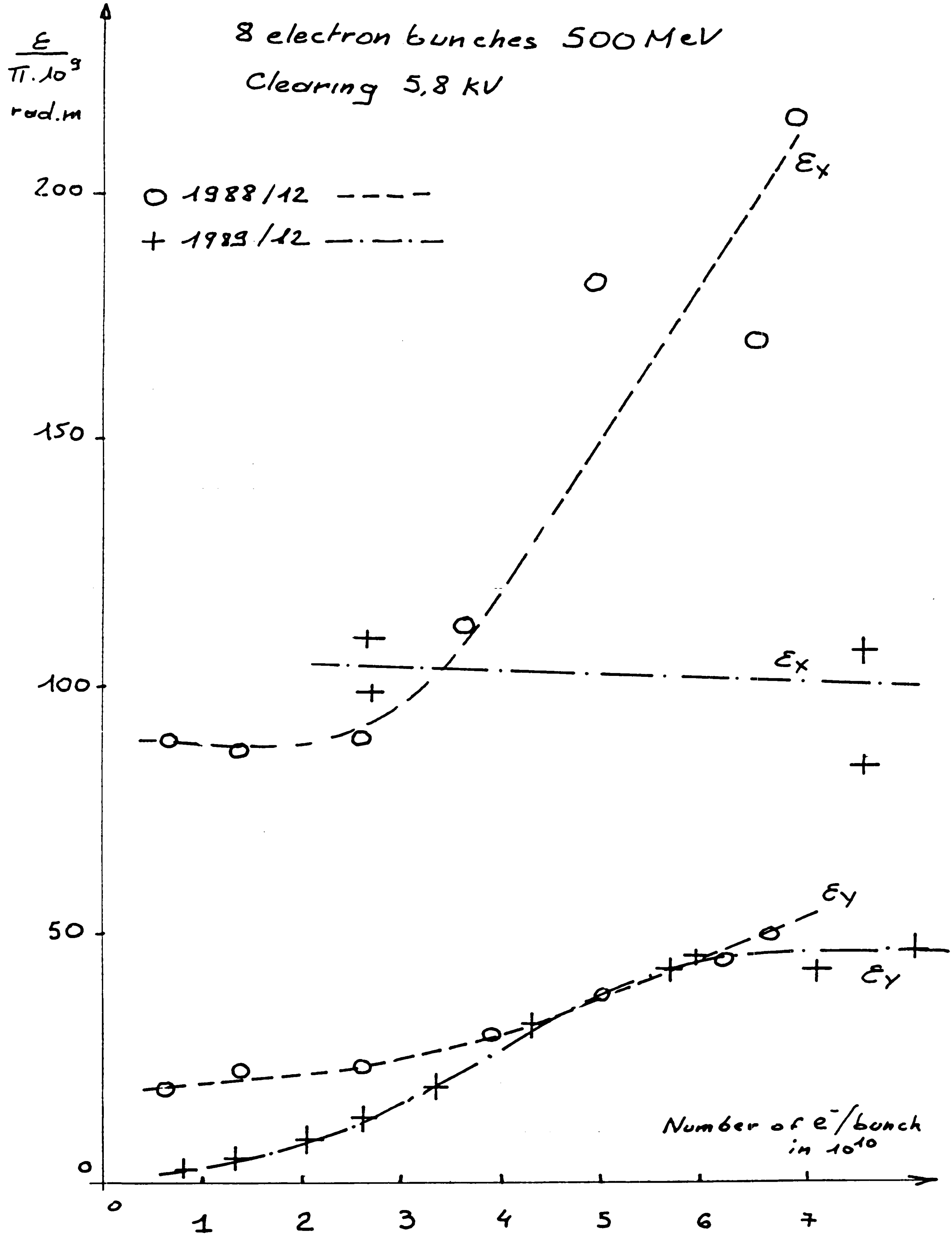
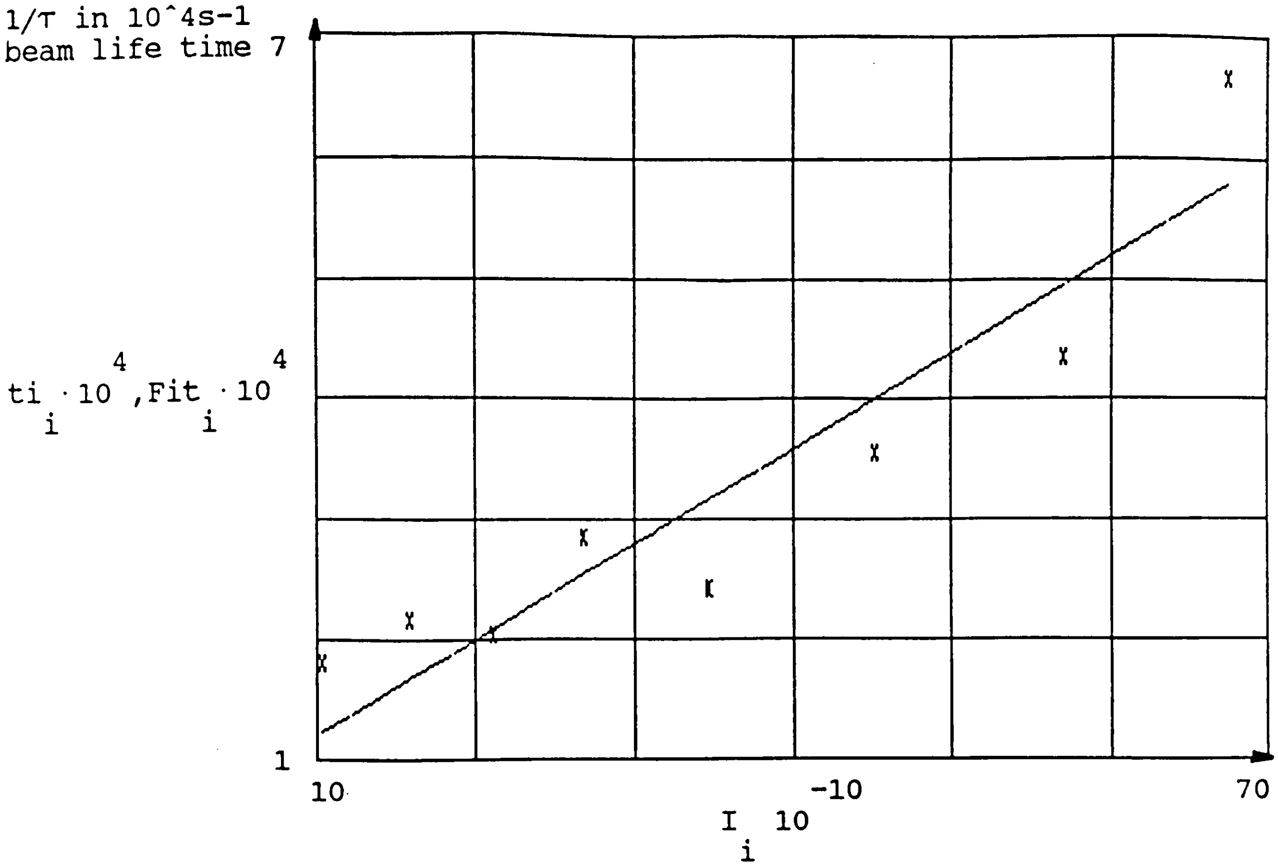


Figure 6

26/1/90

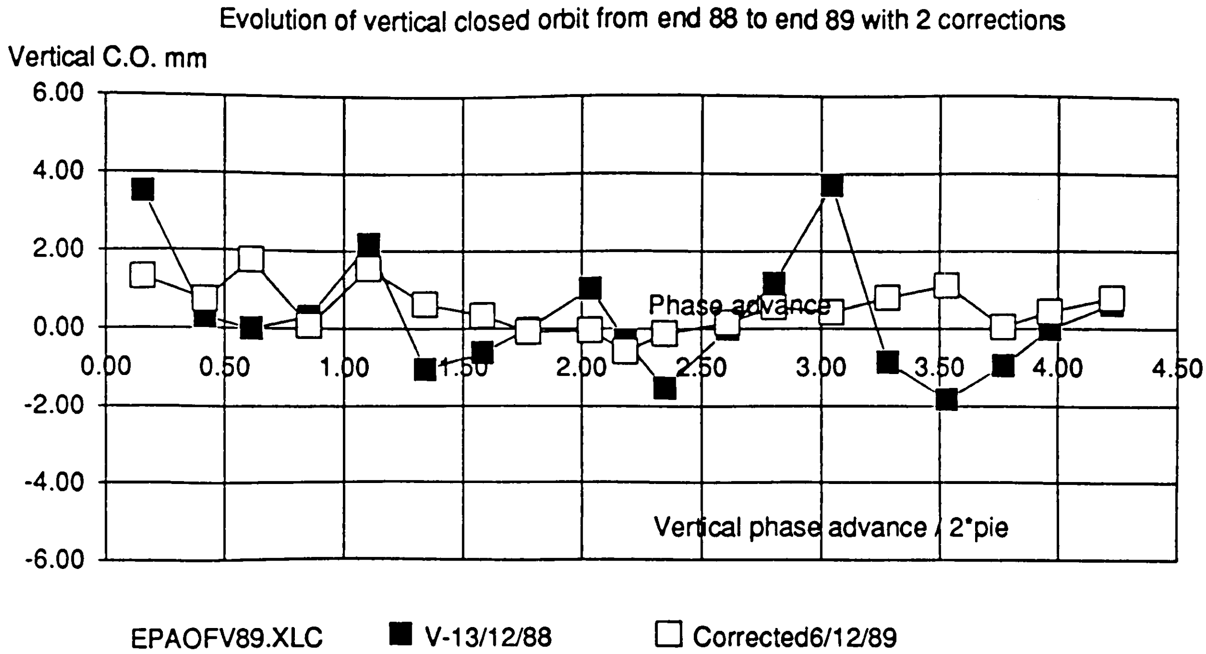


Beam decay rate versus total intensity
for 500Mev electrons in 8 bunches Clearing 5.7 kV

Fit result $1/\tau\ (h) = 0.028 * N^{10} + 0.151$

Figure 7

26/1/90



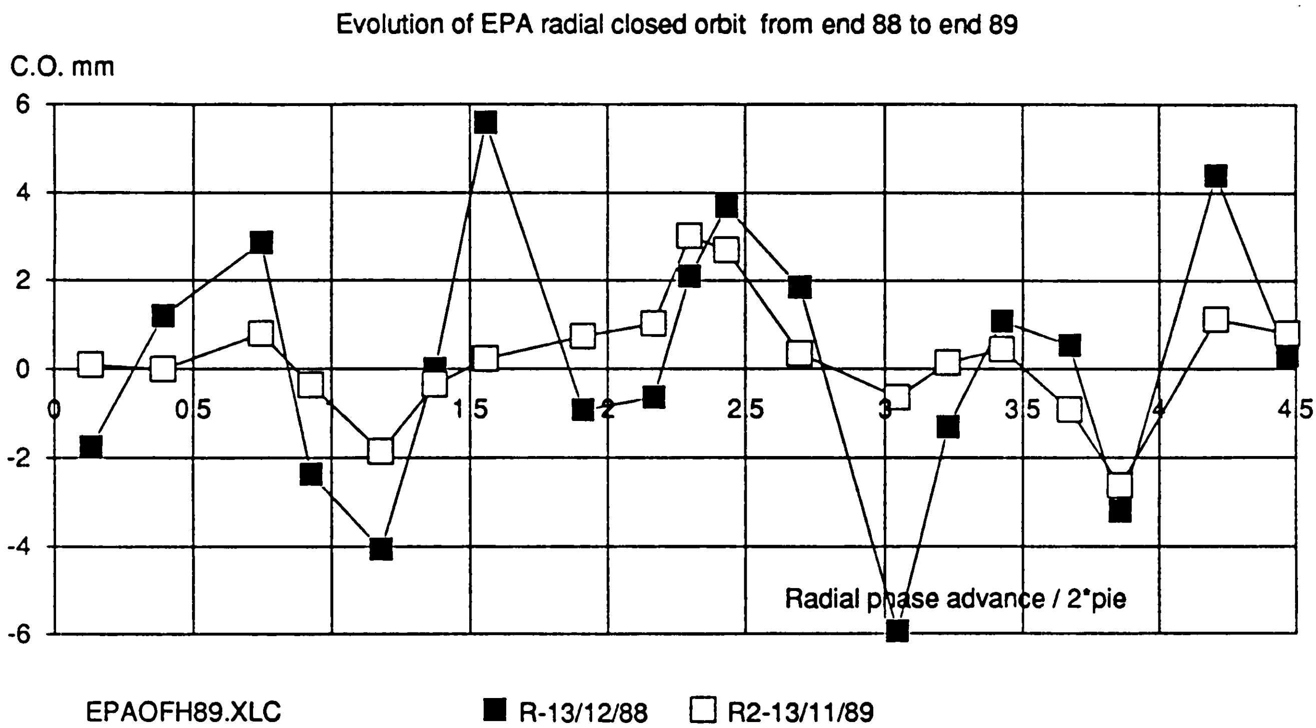


Figure 8

26/11/90