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CERN - PS DIVISION

PS/ PA/ Note 93-07 (MD)

COMMISSIONING OF THE NEW FT61 LINE

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The MD session is aimed to properly recommission the FT61 line following the exchange of M101 and M226 in the 1993 shut-down made necessary by the slow extraction channel modifications (reduction in the number of septa) and optimization made in 1992 [1].

In particular, the magnets' settings have to be altered to ensure a proper operation on the test line (dump) following the optics and geometry changes made in the 1993 shutdown. The new settings should be defined such as to maximize tolerances for the test line mode [2].

Next, the influence of the fringe field of the beam line magnets has to be checked on the PS beam at low momentum as it was one of the main deciding factors for the magnet exchange [3]. This check needs to be done for both modes of operation, test and physics.

In the process, the complete transport line has been optimized in its physics working mode. The resulting settings are compared to the computer optics model. As a consequence, these files are slightly altered in order to reflect our findings.

Preliminary settings.

As soon as the slow extraction was available from the PS B cycles, we tried to get a satisfactory beam as observed on MTV02 using FT61Q-FO01 to get an H focus. We checked the beam was centered in the quadrupole using quadrupolar scan. The septa SE61-SMH57 and SE61-SMH61 and allowed proper positioning of the beam in FT61-QFO01, that is the beam centered in both position (SMH57) and angle (SMH61) in the horizontal plane. The actions of the septa are coupled, but small enough to allow a fairly quick convergence. The beam trajectory being correct when the horizontal center of gravity does not move when changing the force in the quadrupole.

Tuning of M101 and M226.

After approximate setting of FT61-QDE02, FT61-QFO03 and FT61-QDE04 in order to get a H focus and parallel V beam at the splitter, M101 and M226 were carefully adjusted for the beam to be properly centered, angle and position wise in the horizontal plane, in the physics channel. The starting point was taken from the MAD output. Successive approximations were made with the help of a short MAD program whose input was the observable (MTV02, 04, 05 and forces in both bends) and output was a best guess for the bending forces.

A similar procedure was used for the test line direction. However there is only one observation point on MTV03. The beam centering was optimized from the computed setting by bending the beam left or right hand with BHZ01 until the beam hit the vacuum tube as observed on the radiation monitors in section 66. Some regression was then done to ensure maximum clearance at the flange along with the spot centered on MTV03.

We finally checked the proper beam centering in the physics channel using the same procedure (checks against the flange clearance) and fine tuning of the two dipoles [2].

On test line (dump position) :

magnet		operation	
FT61-BHZ01	M101	408A/18.3mrad	(theoretical 21.3mrad)
FT61-BHZ02	M226	435A/30.9mrad	(theoretical 25.0mrad)

The experimental values were installed in the hardware as default settings for proper switching to the test line when the beam stoppers are inserted.

In physics mode, beam to East Hall targets :

FT61-BHZ01	M101	-55.3A/-2.6mrad	(theoretical -8.23mrad)
FT61-BHZ02	M226	-457.3A/-32.3	(theoretical -25.44mrad)

The slight discrepancy between computed values and observed ones probably implies a residual H error (order of 1mrad and some mm) at the entrance of M101.

Influence of the fringe field on the PS.

The effects of the fringe field of bhz01 and bhz02 on the PS beam at low energy have been checked on the PS and found to be negligible [4]. Thus, the main goal for exchanging those magnets is met. As expected, we also gained some freedom for tuning the beam and can now get proper optical conditions for physics runs.

Lines to East Hall targets.

The line can be roughly tuned up to the splitter magnet, with MTV04 and MTV05, without undue considerations to the downstream behavior. However, due to the lack of correcting elements in the north branch, slight modifications upstream the splitter may be needed. **This means that the north branch has to be tuned first.** As the variable gap, slope and height of the splitter were not operational at that time, **the splitting ratio had to be defined using FT61-DVT01 and FT61-DVT02,** taking care of the proper vertical alignment (observe position and shape of the splitter edge shadow on MTV05, preferably with the splitter OFF).

The rest of the tuning, on both branches was standard line tuning, dipolar and quadrupolar and does not need further comments.

Tuning order and conditions : (common branch)

Condition	Control element	Check point	Specific
H focus on MTV02	FT61-QFO01	H size on MTV02	minimum H size
H centering in QFO01 (position)	SE61-SMH57	H centroïd on MTV02 (no shift)	quadrupolar scan with QFO01
H centering in QFO01 (angle)	SE61-SMH61	mean H position on MTV02	center in H
focus H, // V at splitter center	FT61-QFO03 & FT61-QDE04	MTV04 & MTV05, ~same sizes H&V	minimum H (~3mm) maximum V (~40mm)
splitter sharing ratio	FT61-DVT01 & FT61-DVT02	MTV05, splitter ON	ratio of both spots. Minimize shadow.

Results of the line setting, compared with the computed one.

Magnet	Computed	Operation
FT61-QFO01	635.8A	580.8A
FT61-QDE02	-156.3A	-175.0A
FT61-QFO03	-389.4A	-380.0A
FT61-BHZ01	[2] -174.1A	-57.9A
FT61-BHZ02	[2 -350.8A	-459.3A
FT61-QDE04	-381.8A	-363.0A
FT61-SMH01	260.6A	269.0A
FT61-BHZ03	1282.8A	1272.0A
FT61-QFO07	-412.9A	-530.0A
FT61-QDE08	600.9A	620.0A
FT61-QDE05	418.9A	421.0A
FT61-QFO06	-609.2A	-680.0A
FT61-BVT01	-568.0A	-488.0A

There remains some discrepancies between both sets. The probable cause being the very scarce knowledge we have of the beam behavior in the PS fringe field when leaving the machine.

Some detected problems :

The beam sweep during the spill is much more than expected from the initially computed optics and published p variation, up to ten times more as observed on MTV08.

The beam movement observed is obviously the result of all extraction errors and is not only dispersion driven. Search into the optics file (TRANSPORT) allowed us to find an error in the handling of dispersion. The modeling of the fringe field of the PS using output of the TRAJE program did not transmit the p variation. The result was that the dispersion induced in the beginning of the line (up to and including the first matrix) was traced as if the rest of the line was perfectly achromatic.

Once this problem was corrected, there remains, however, an unexplained factor of two. MD is planned in order to reduce the beam centroïd shift.

Conclusions.

This MD has allowed to bring back the FT61 line in operation, with proper alignment of the beam in its channels while almost cancelling the effects of the fringe field on the PS. It has pinpointed an omission in the theoretical optics files describing those lines; this has now been corrected. We then found a reasonably good agreement between the operation values (hand optimized) and the computed ones. However some work is still needed to understand and correct the cause and magnitude of the beam sweep during the spill, and be able to control it. The same hold for the quadrupolar differences (between theory and operation) on QFO01 and the last doublet in the south branch.

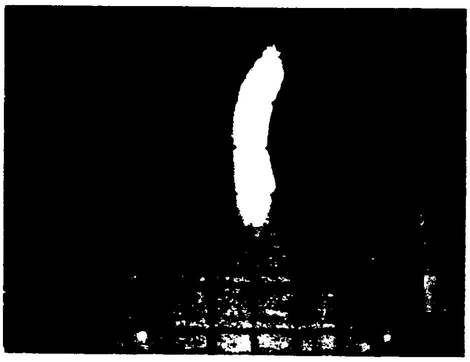
References

[1] Ch. Steinbach - "Beam optics at resonant extraction septa" - EPAC 92, Proceedings of the THIRD EUROPEAN PARTICLE ACCELERATOR CONFERENCE, Volume 1, pp 857-859.

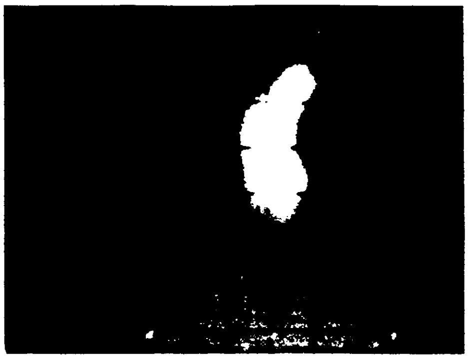
[2] J-Y. Hemery - "Swap of FT61-BHZ01 and 02 bending magnets" - PS/PA/Note 93-06.

[3] C. Saulnier - "Compte-rendu de Machine Development" - PS/OP/Note 92-17 & 92-21.

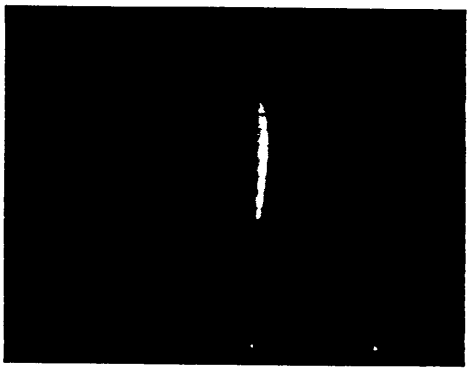
[4] C. Saulnier : "Compte-rendu de Machine Development" - PS/OP/Note 93-40.



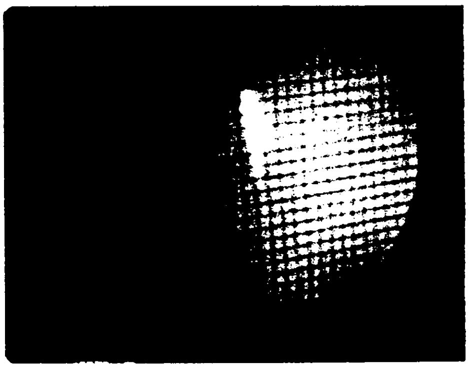
MTV02 QFO01 = 580A



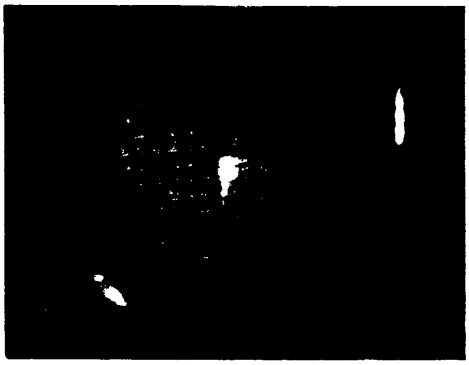
MTV02 QFO01 = 510A



MTV03 (testline)

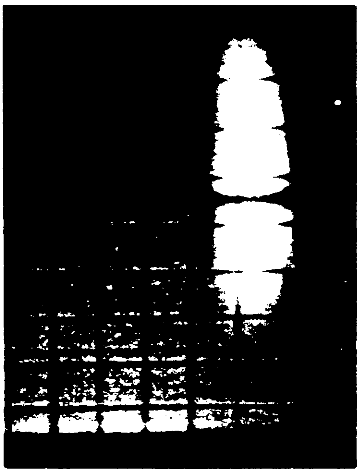


MTV04

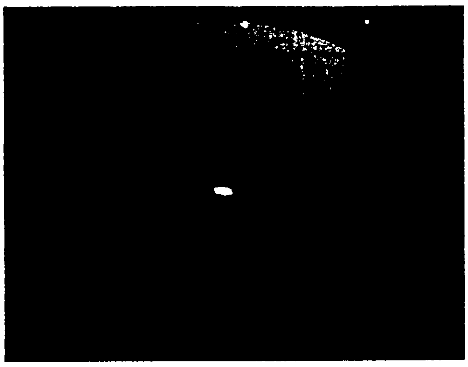


MTV05 (splitter ON)

MTV06 (splitter ON)

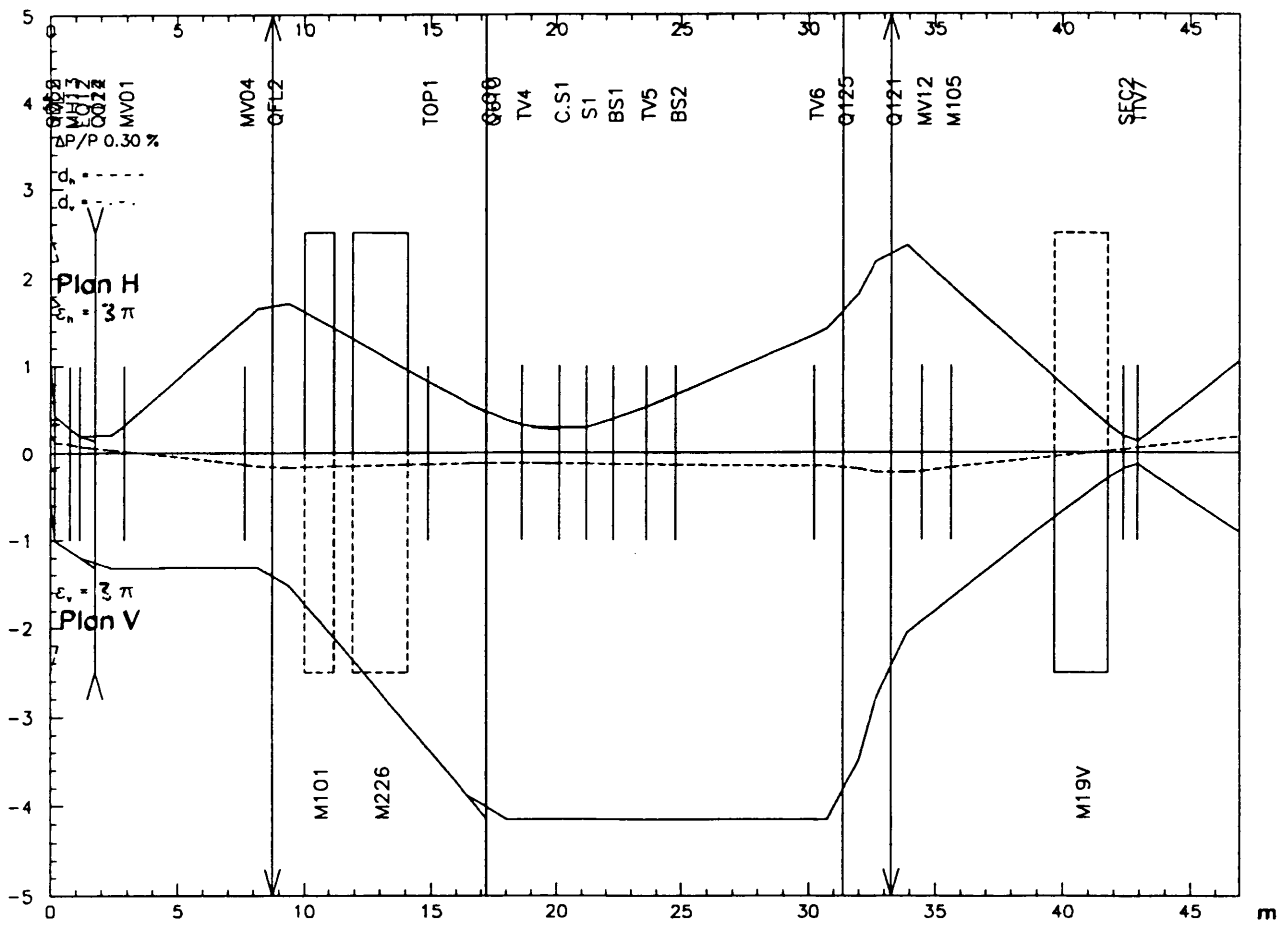


MTV06 (splitter OFF)

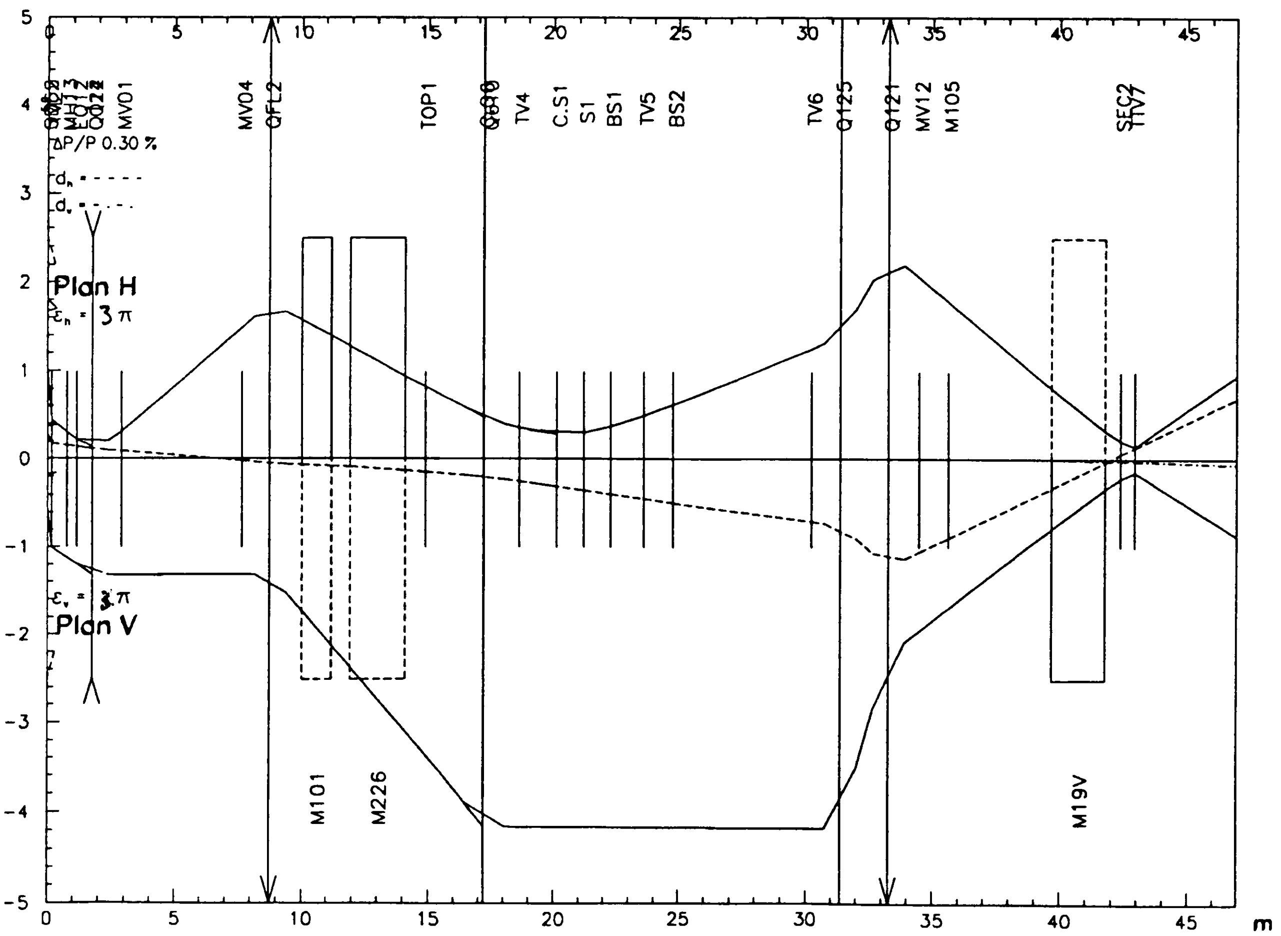


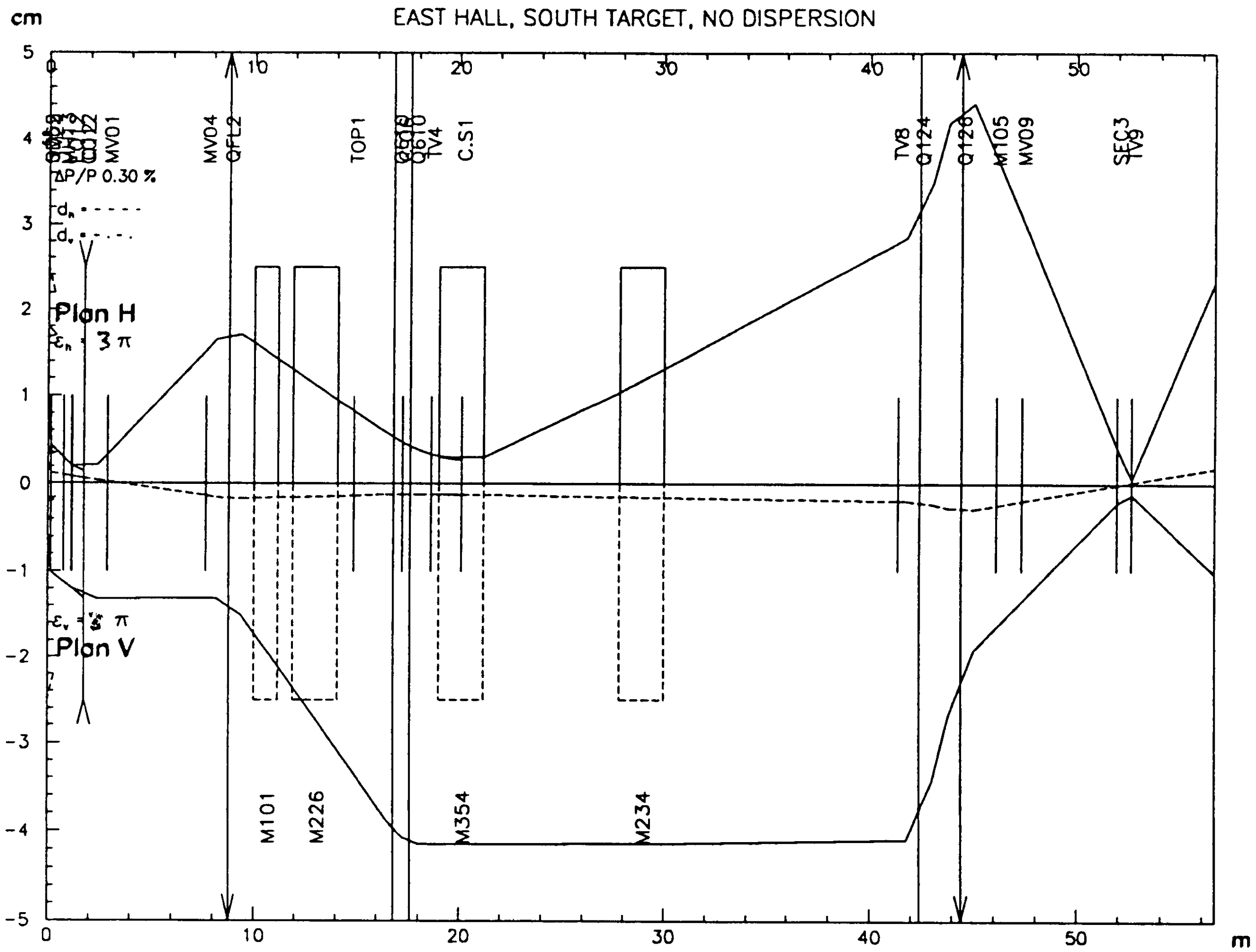
MTV09 (south target)

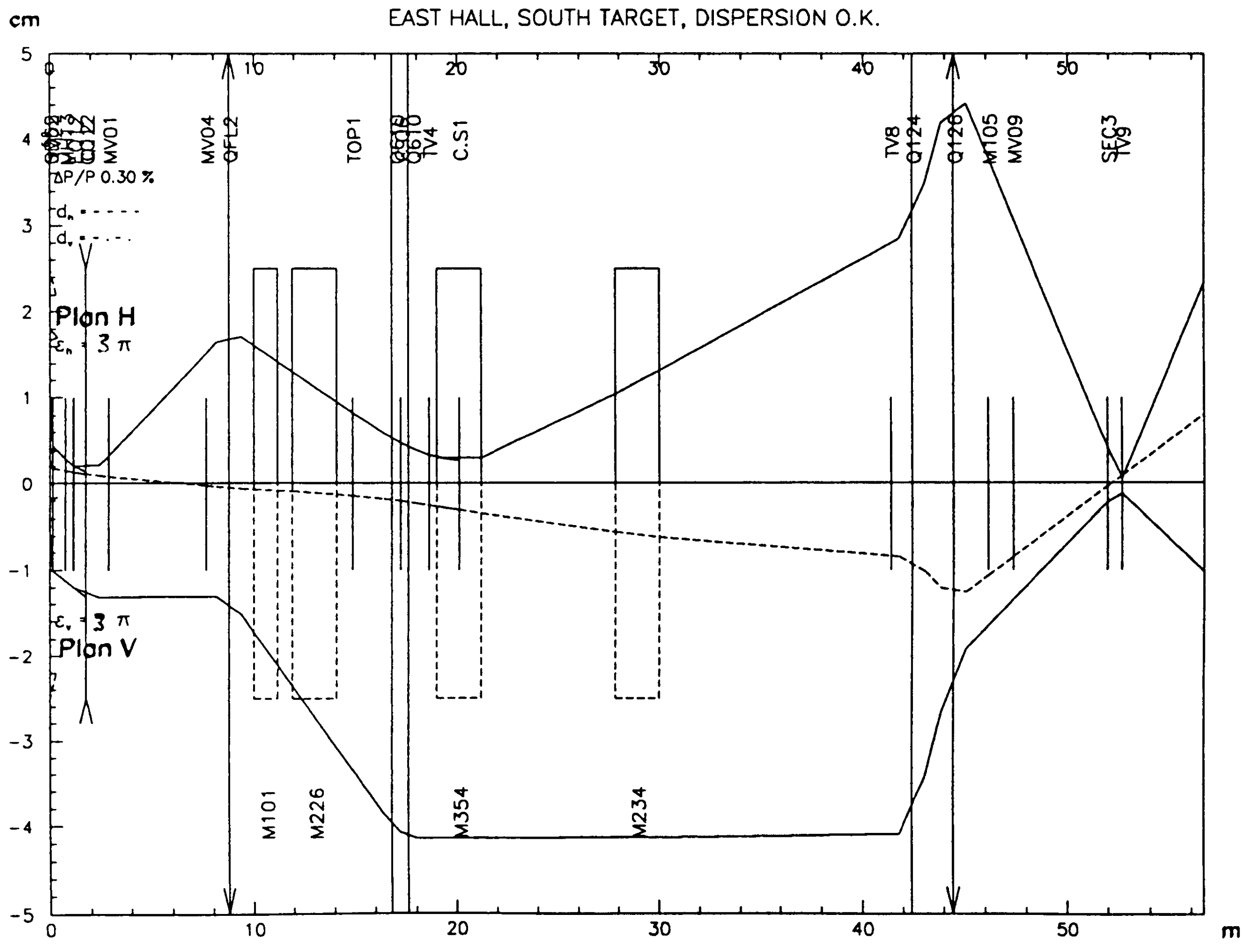
EAST HALL, NORTH TARGET, NO DISPERSION

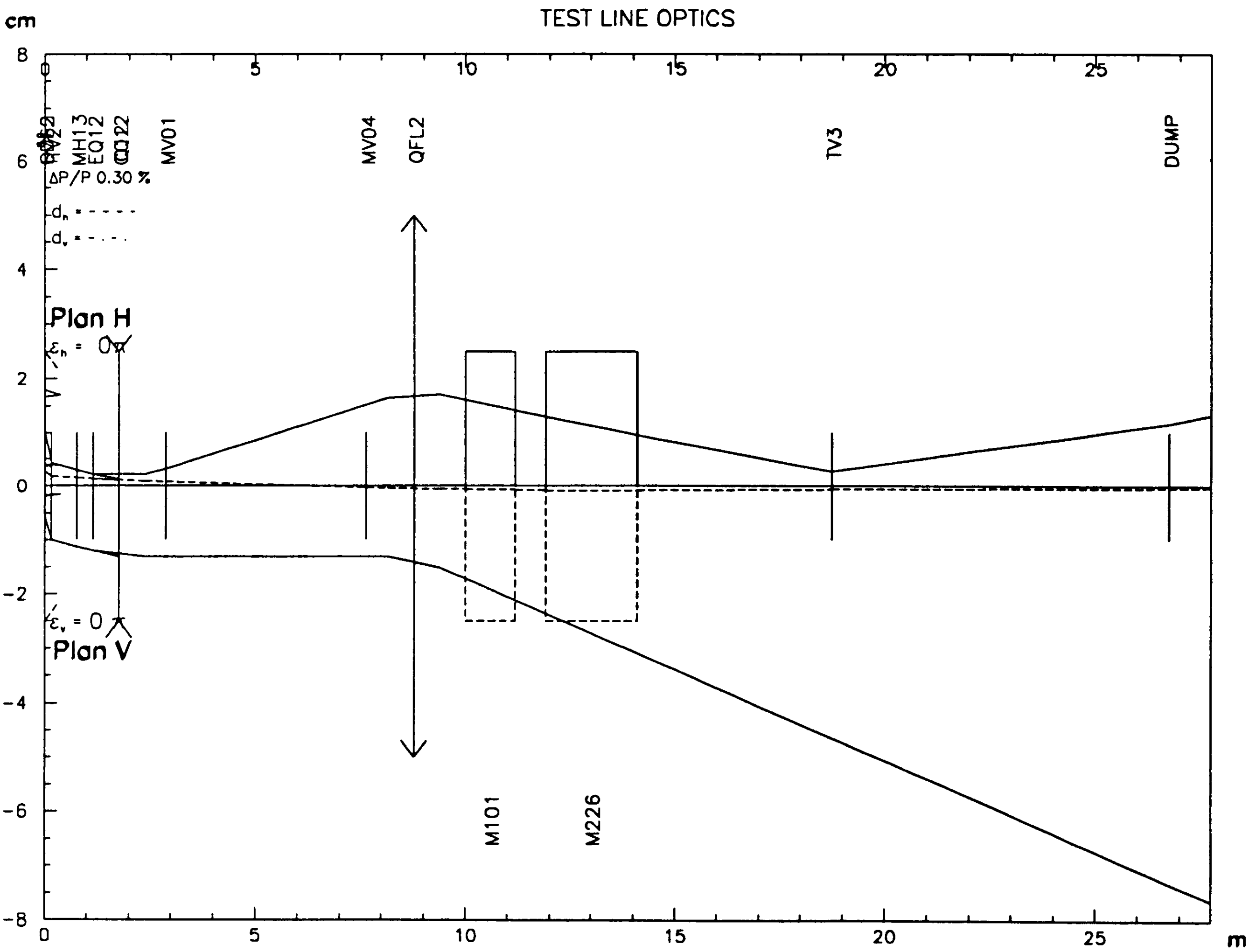


EAST HALL, NORTH TARGET, DISPERSION O.K.




cm
EAST HALL, SOUTH TARGET, NO DISPERSION
MV01
MV04
QFL2
TOP1
Q610
TV4
C.S1
TV8
Q124
Q126
M105
MV09
SEC3
TV9
ΔP/P 0.30 %
Plan H
Plan V
M101
M226
M354
M234
m


cm
EAST HALL, SOUTH TARGET, DISPERSION O.K.
MV01
MV04
QFL2
TOP1
Q610
TV4
C.S1
TV8
Q124
Q126
M105
MV09
SEC3
TV9
ΔP/P 0.30 %
Plan H
Plan V
M101
M226
M354
M234
m



TEST LINE OPTICS
cm
m
MV04
QFL2
TV3
DUMP
MH13
EQ12
MV01
ΔP/P 0.30 %
Plan H
Plan V
M101
M226