RF DEFLECTOR: BEAM LOADING STUDIES

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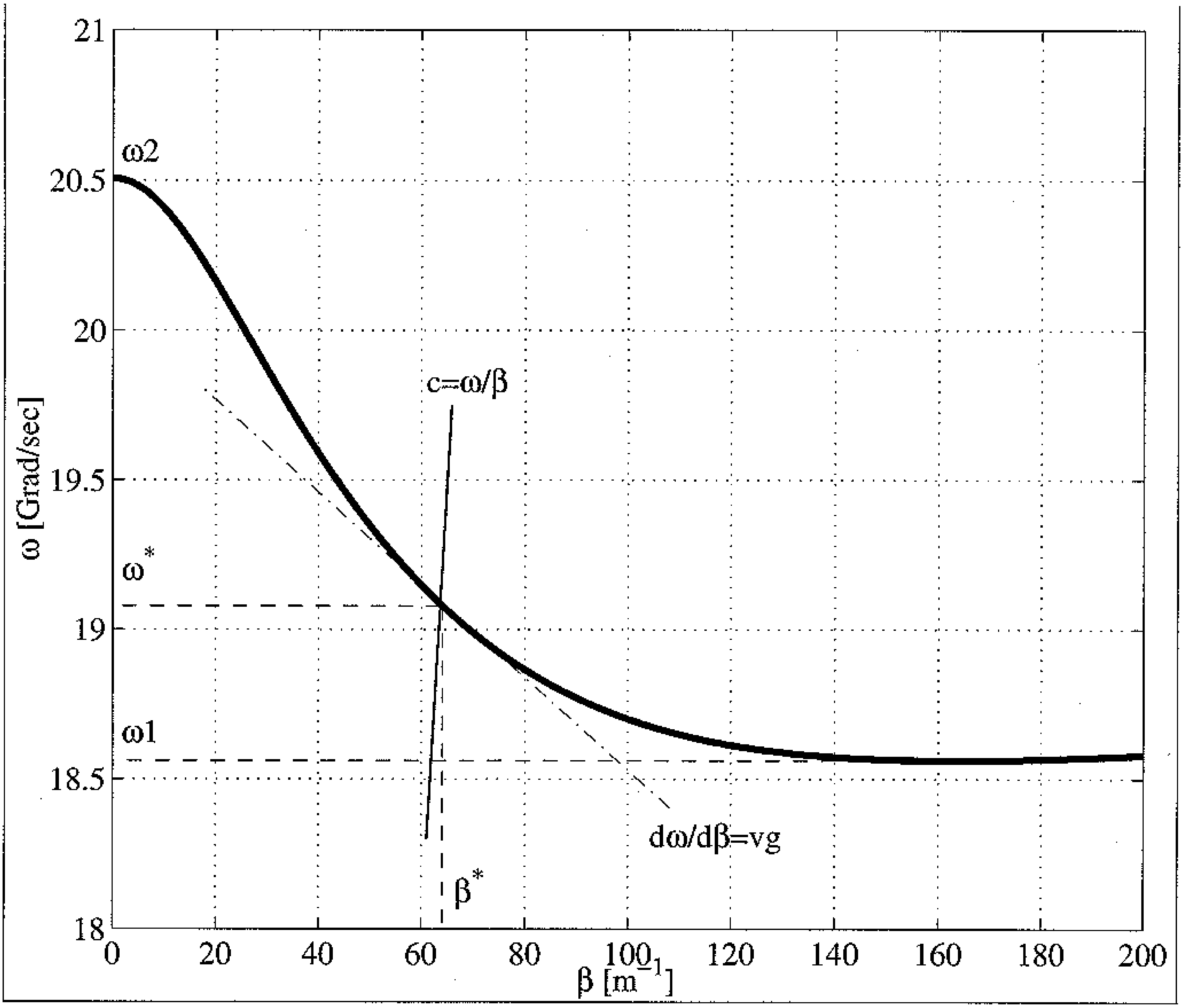
SINGLE PASSAGE WAKE IN A RF DEFLECTOR

RF STRUCTURE: LENGELER Type, 3 GHz
TW, Backward (v_g = -0.0244 c)
10 cells, $2\pi/3$ phase advance

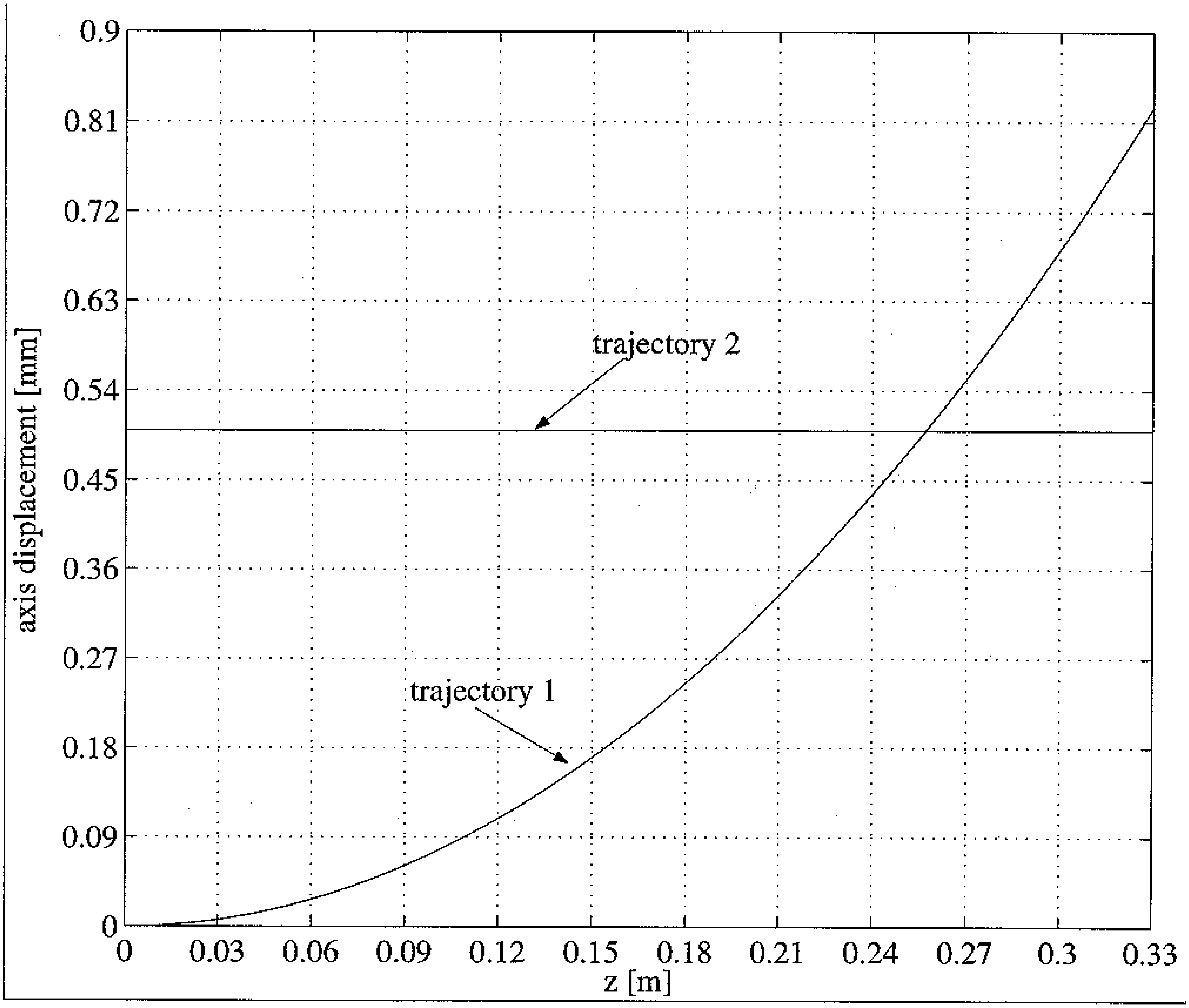
ASSUMPTIONS: Point-like charges
only "out-of-phase" wake

SOLUTIONS

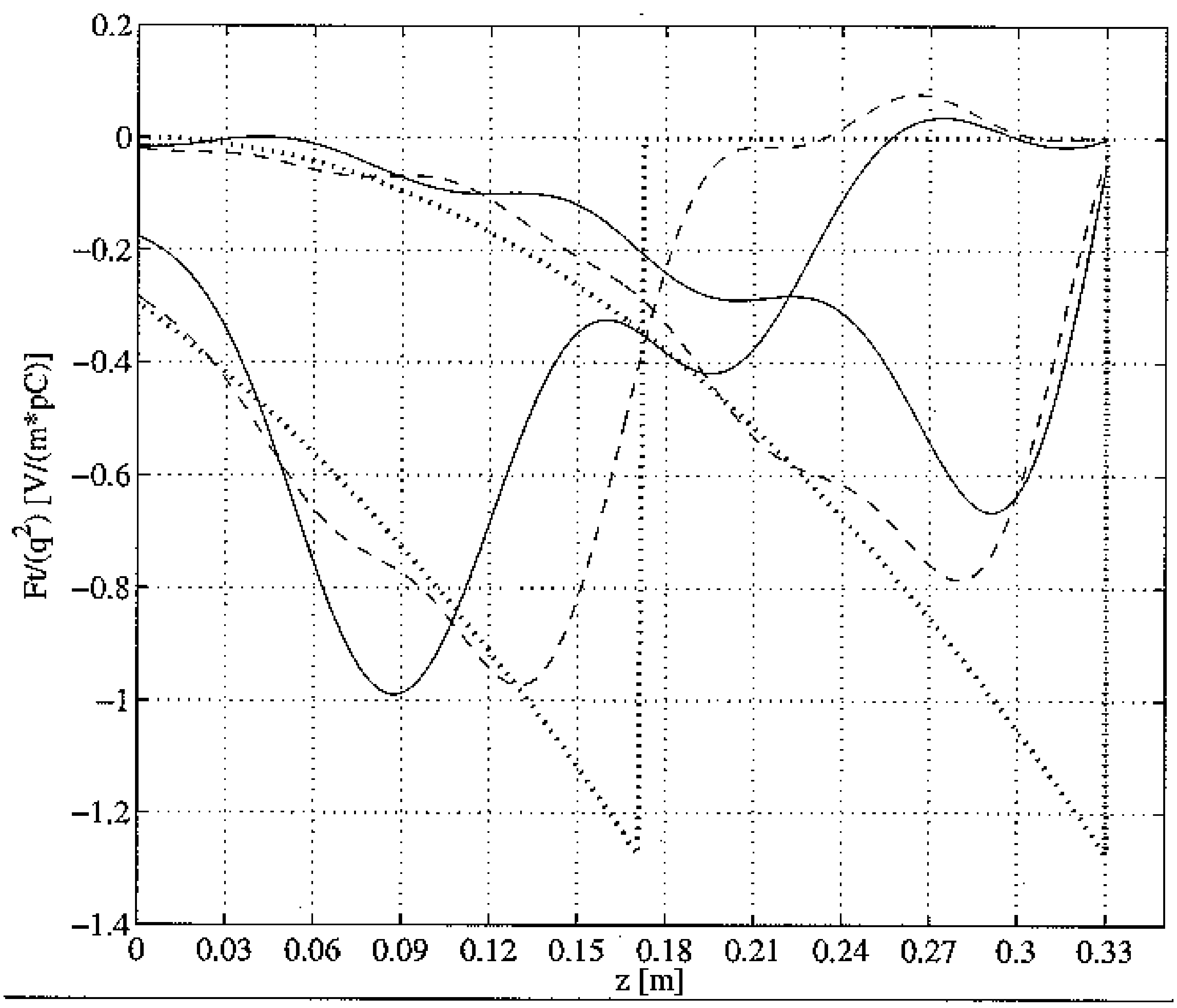
1. COMPLETE: detailed dispersion curve is considered. The solution is a superposition of the field distributions at any frequency in the band-pass;
2. PARTIAL: the dispersion curve is linearized over the band. Only the field distribution at resonance is considered;
3. SIMPLIFIED: the dispersion curve is linearized over an unlimited frequency range. The local excitation is proportional to the leading charge offset.



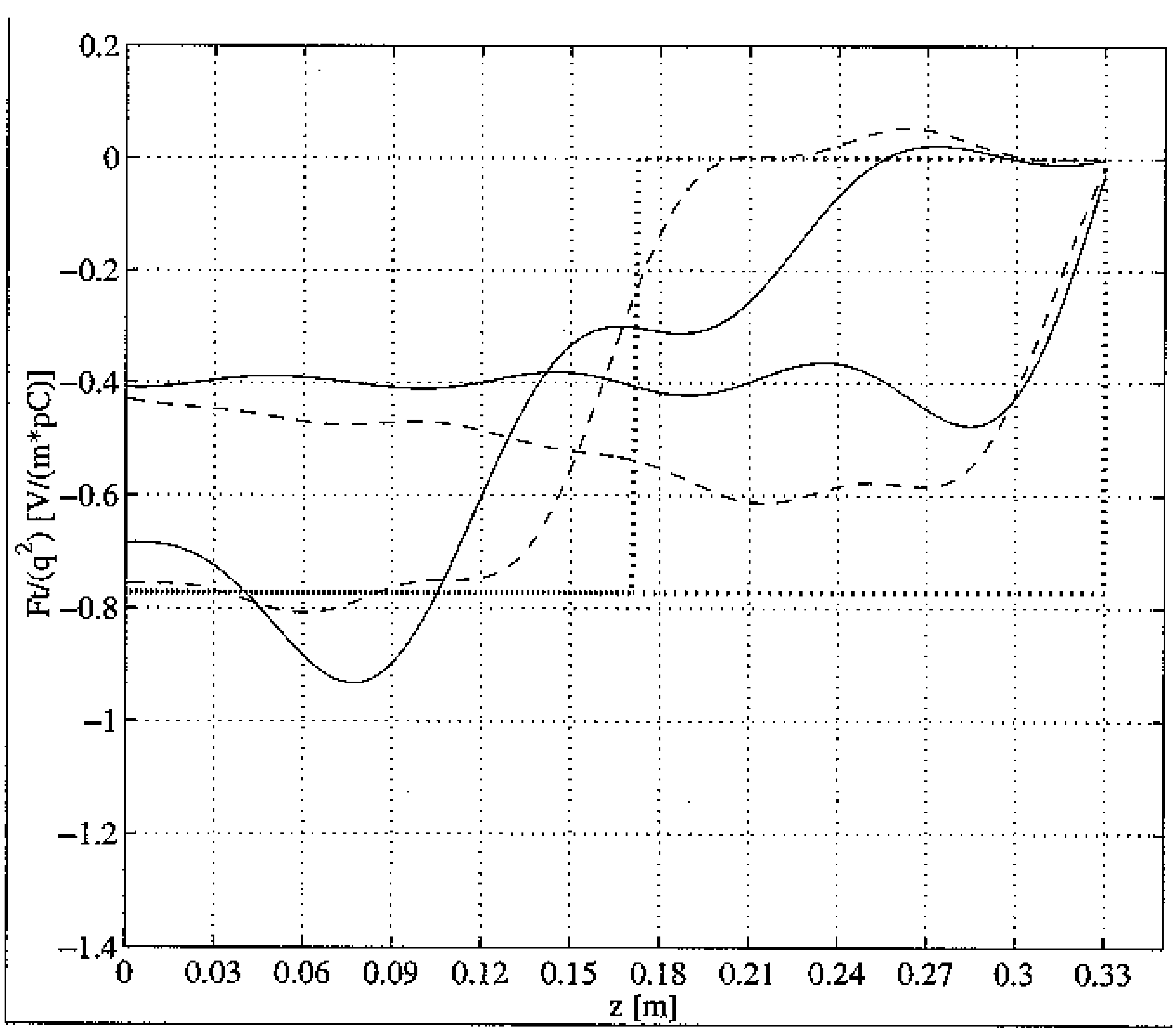
tipical dispersion curve for RF deflectors



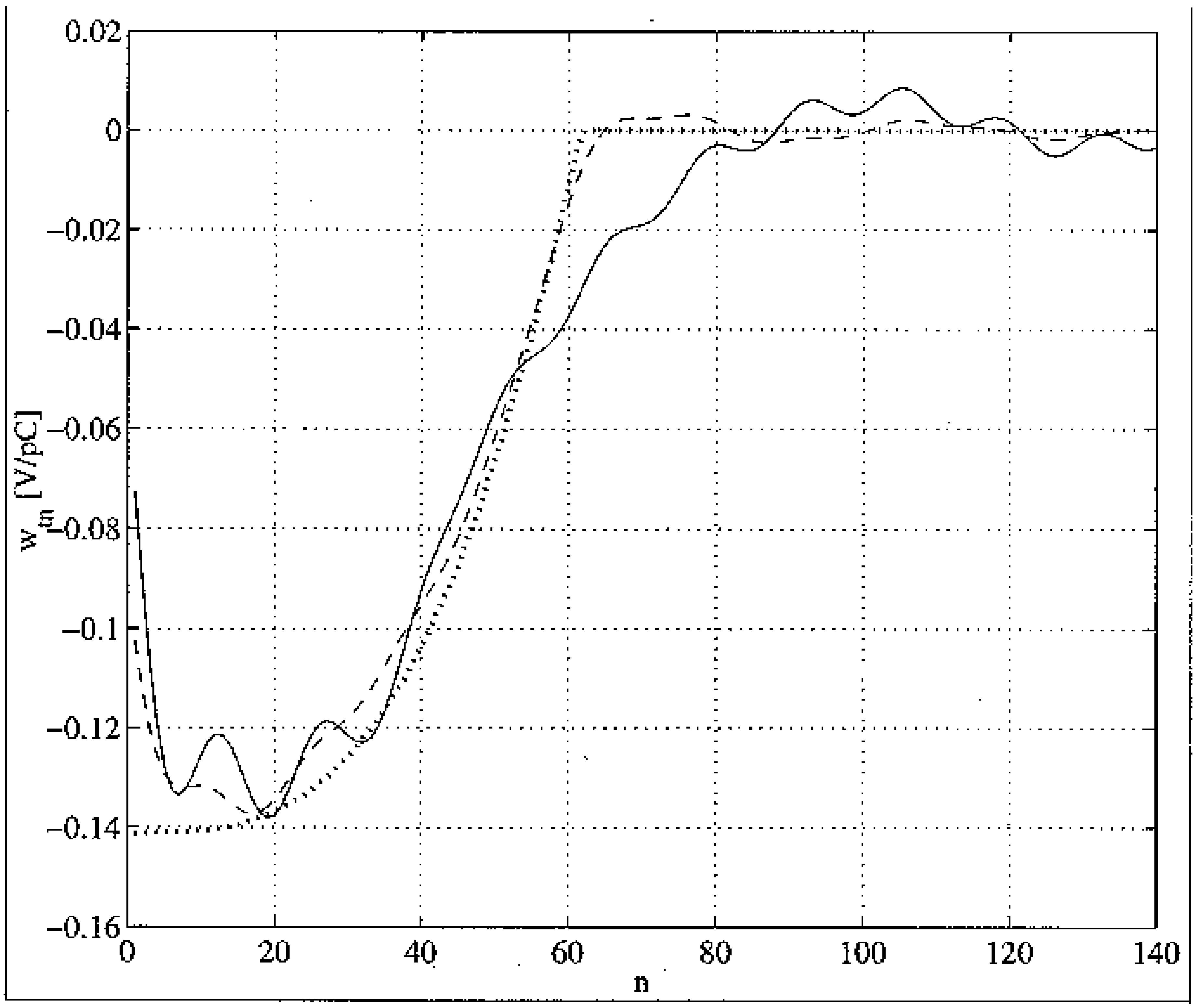
trajectories of the leading particle: trajectory 1 (r_{in}=0, r'_{in}=0 and $\Delta r'$=5 mrad); trajectory 2 (r_{in}=0.5 mm, r'_{in}=0 and $\Delta r'$=0)



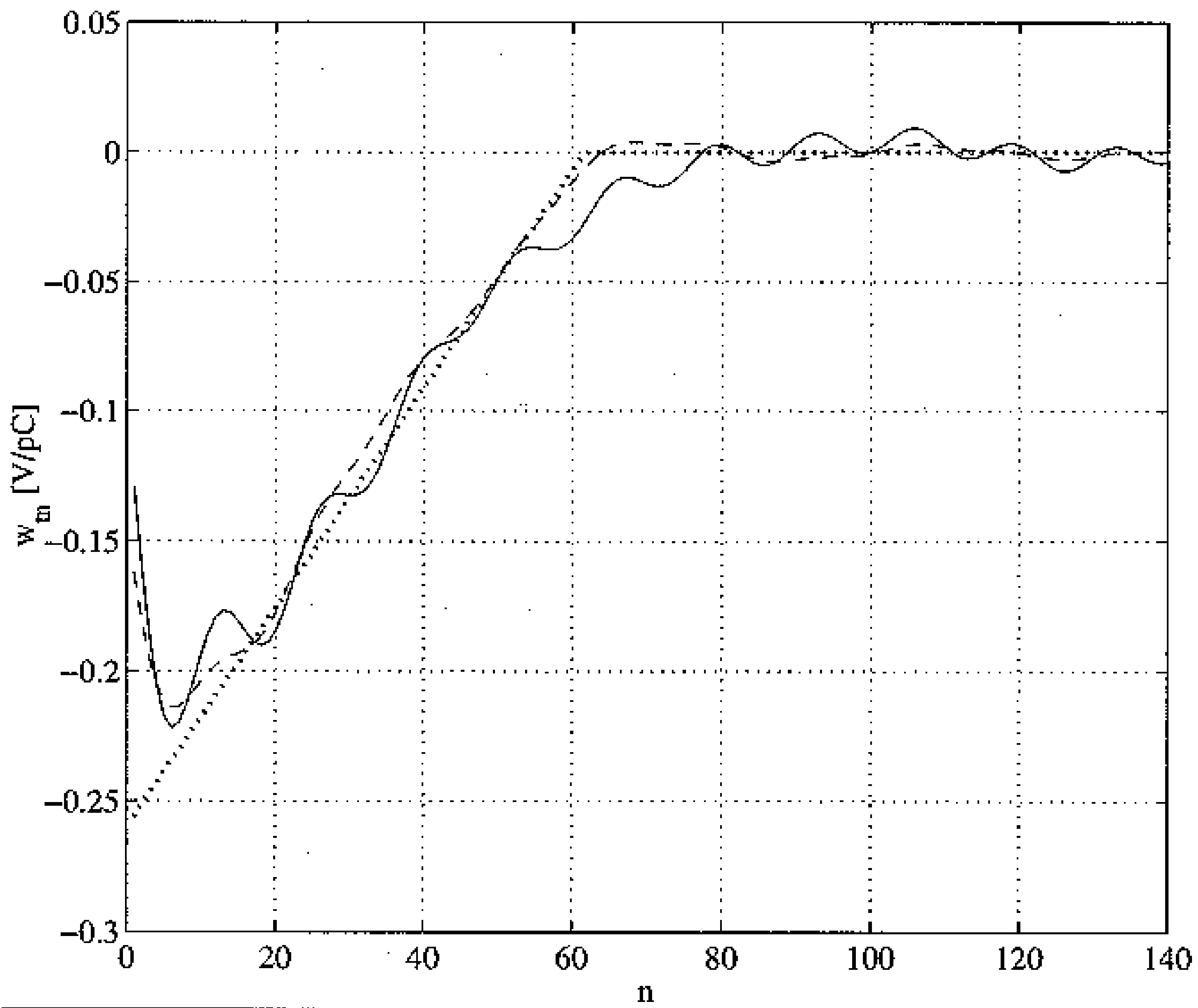
transverse force probed by a trailing particle that enter in the structure after a time $t_1^*=T/4$ and $t_2^*=T/4+\tau_f/2$ (trajectory 1 of the leading particle).



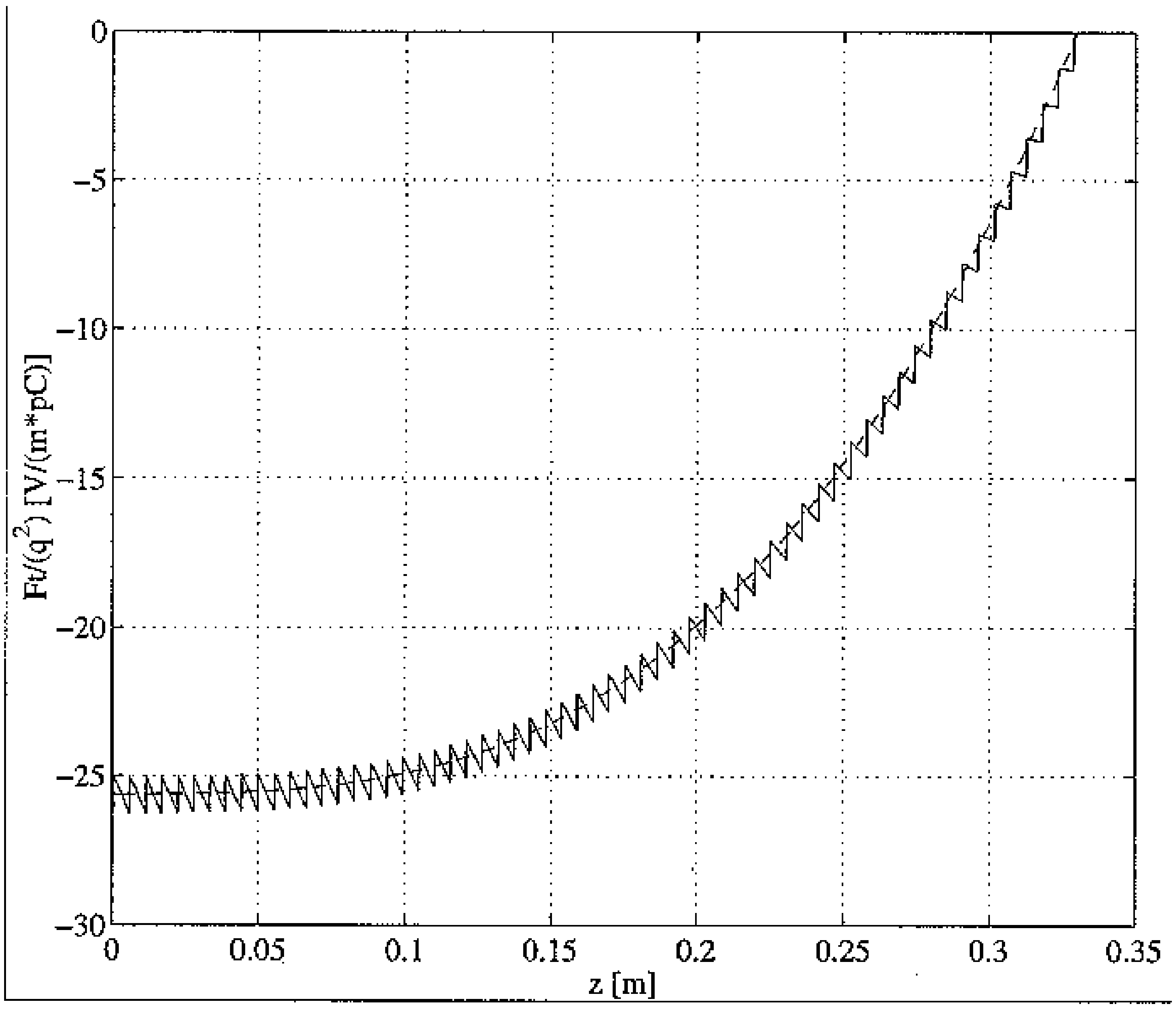
transverse force seen by a trailing particle that enter in the structure after a time $t_1^*=T/4$ and $t_2^*=T/4+\tau_f/2$ (trajectory 2 of the leading particle).



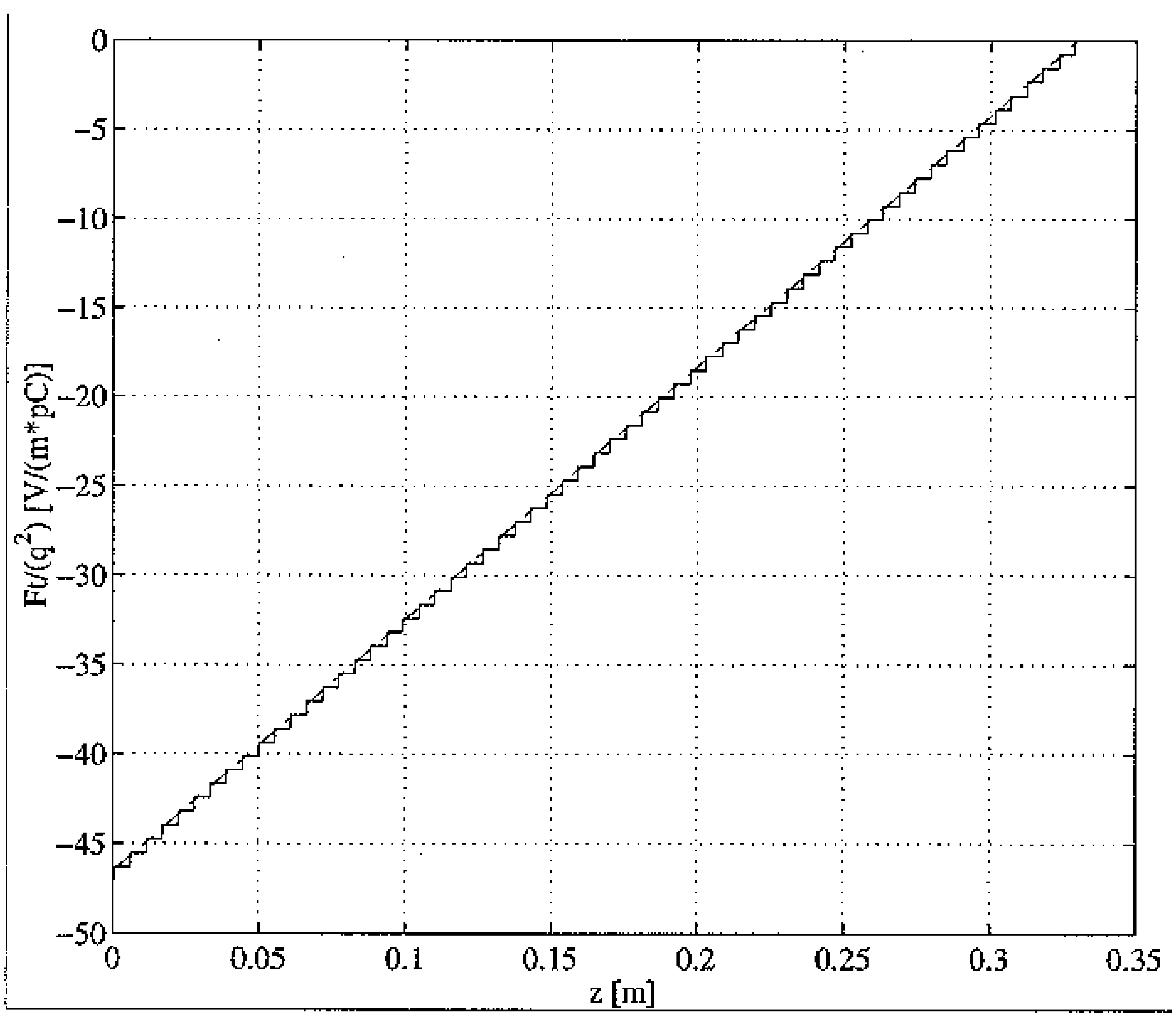
transverse wake probed by a trailing particle that enter in the structure after a time t_n^*=T/4+nT (trajectory 1 of the leading particle)



transverse wake probed by a trailing particle that enter in the structure after a time t_n^*=T/4+nT (trajectory 2 of the leading particle)



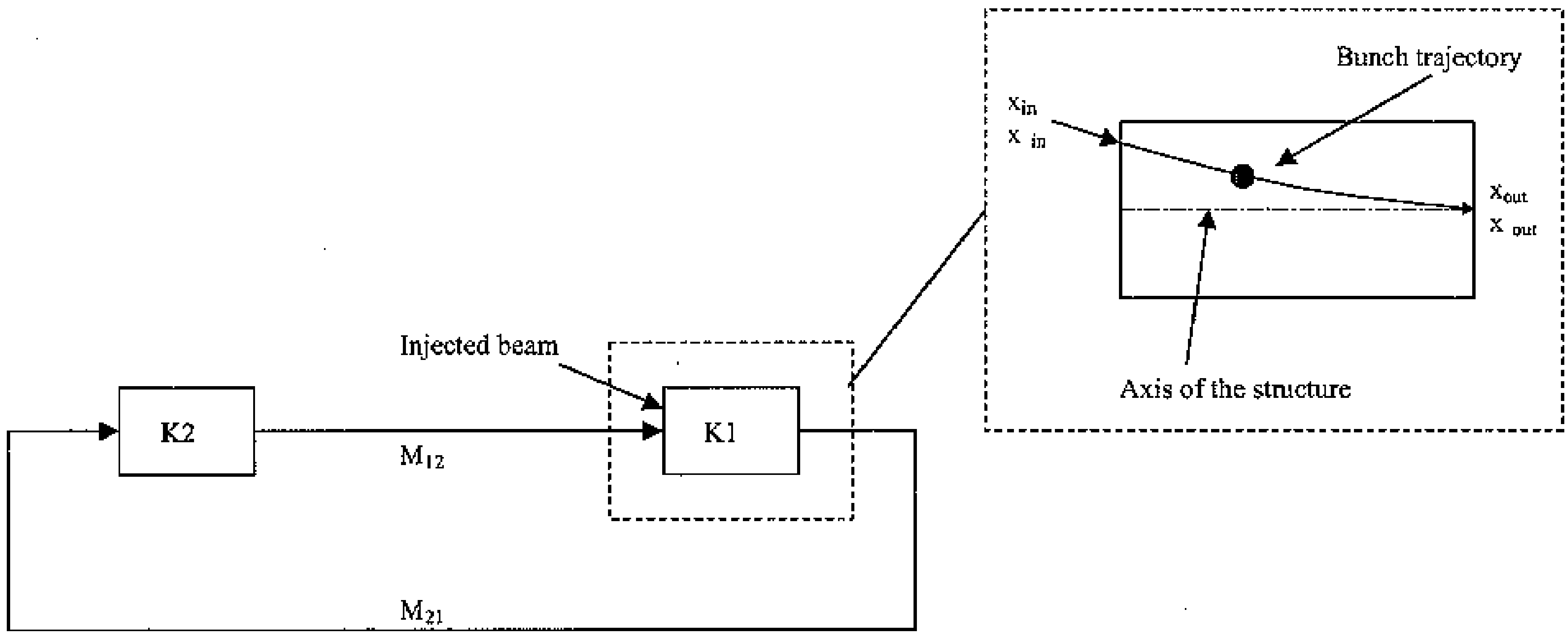
transverse force seen by a trailing particle after a time $t^{*}=T/4+nT$ in the case of steady state solution (trajectory 1 of the leading particle)



transverse force seen by a trailing particle after a time $t^{*}=T/4+nT$ in the case of steady state solution (trajectory 2 of the leading particle).

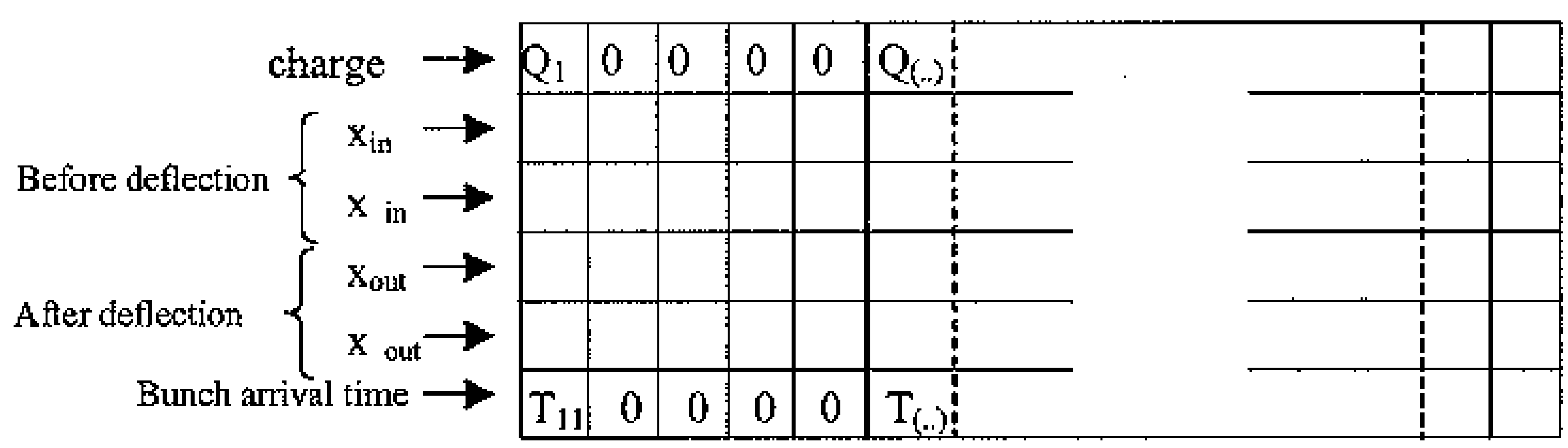
Tracking code scheme

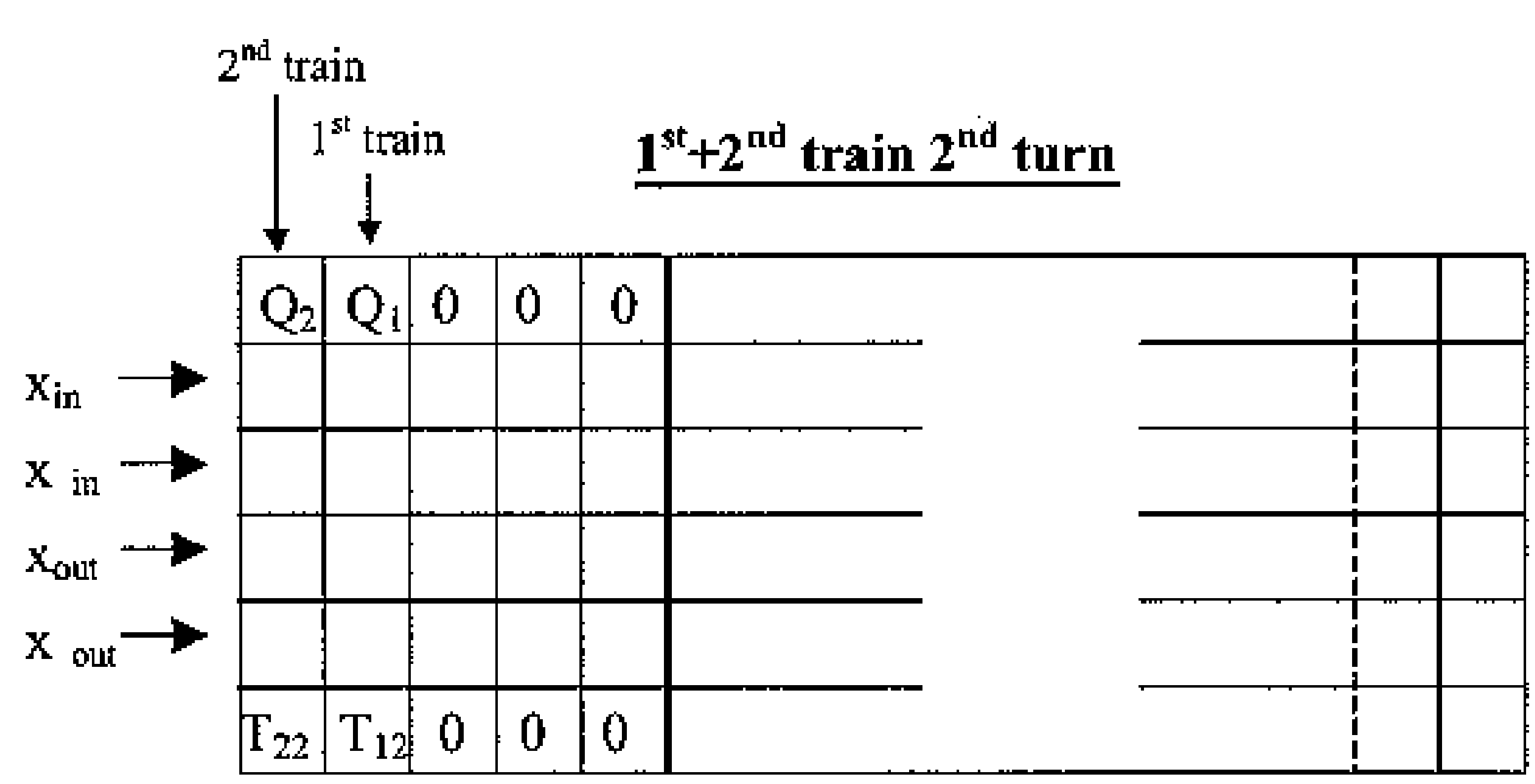
1) *Considered structure*:



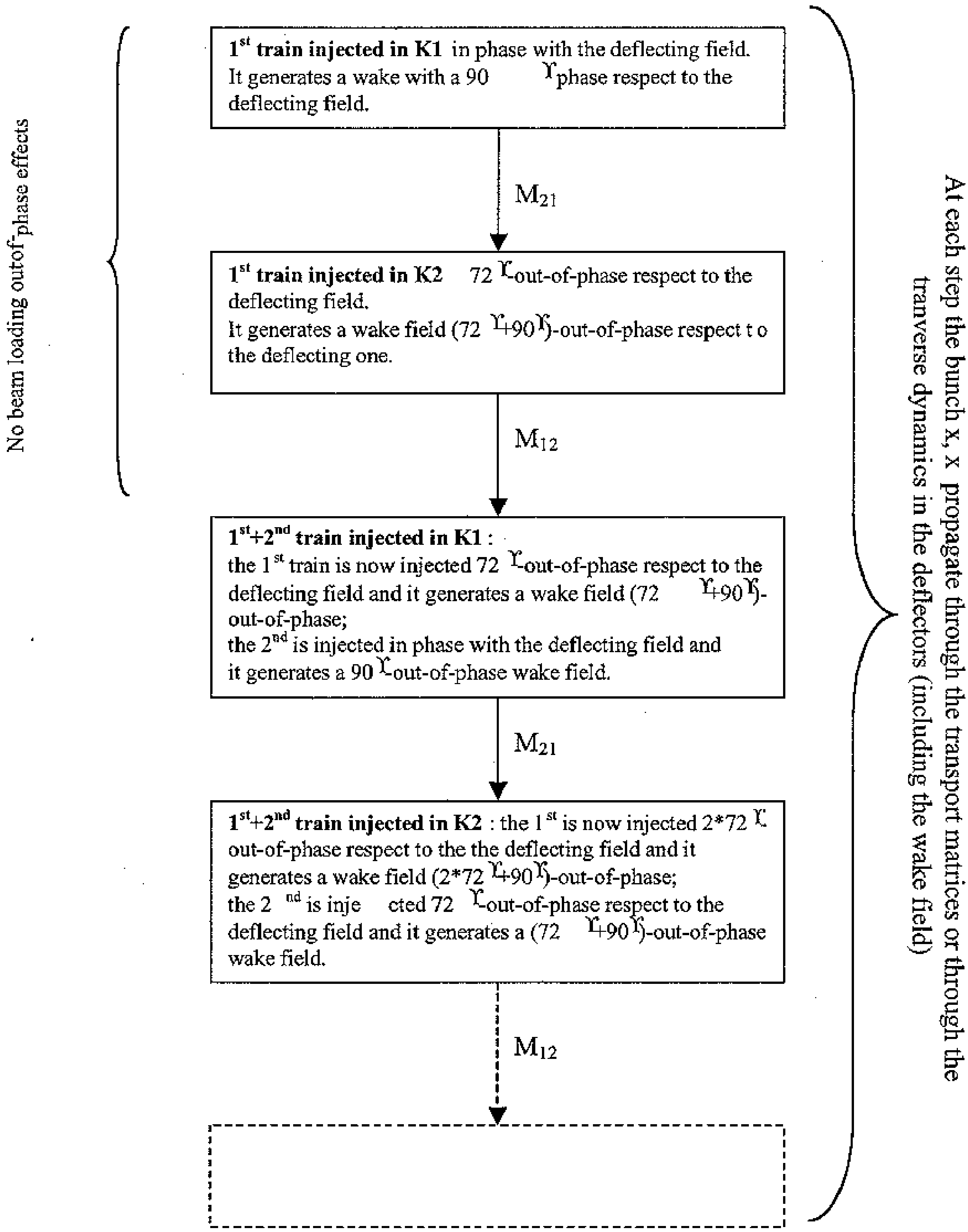
2) *Train representation*

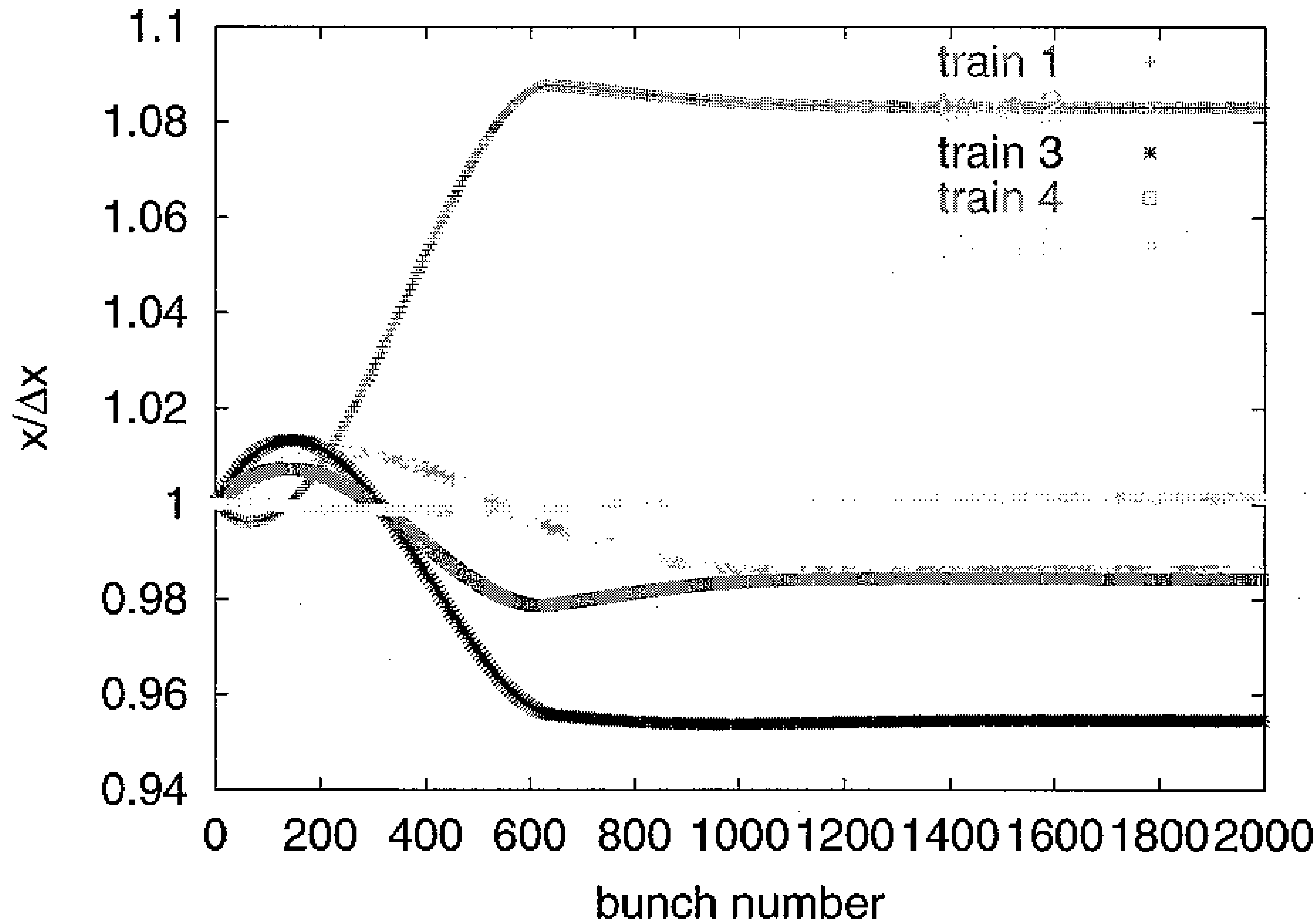
1st train 1st turn

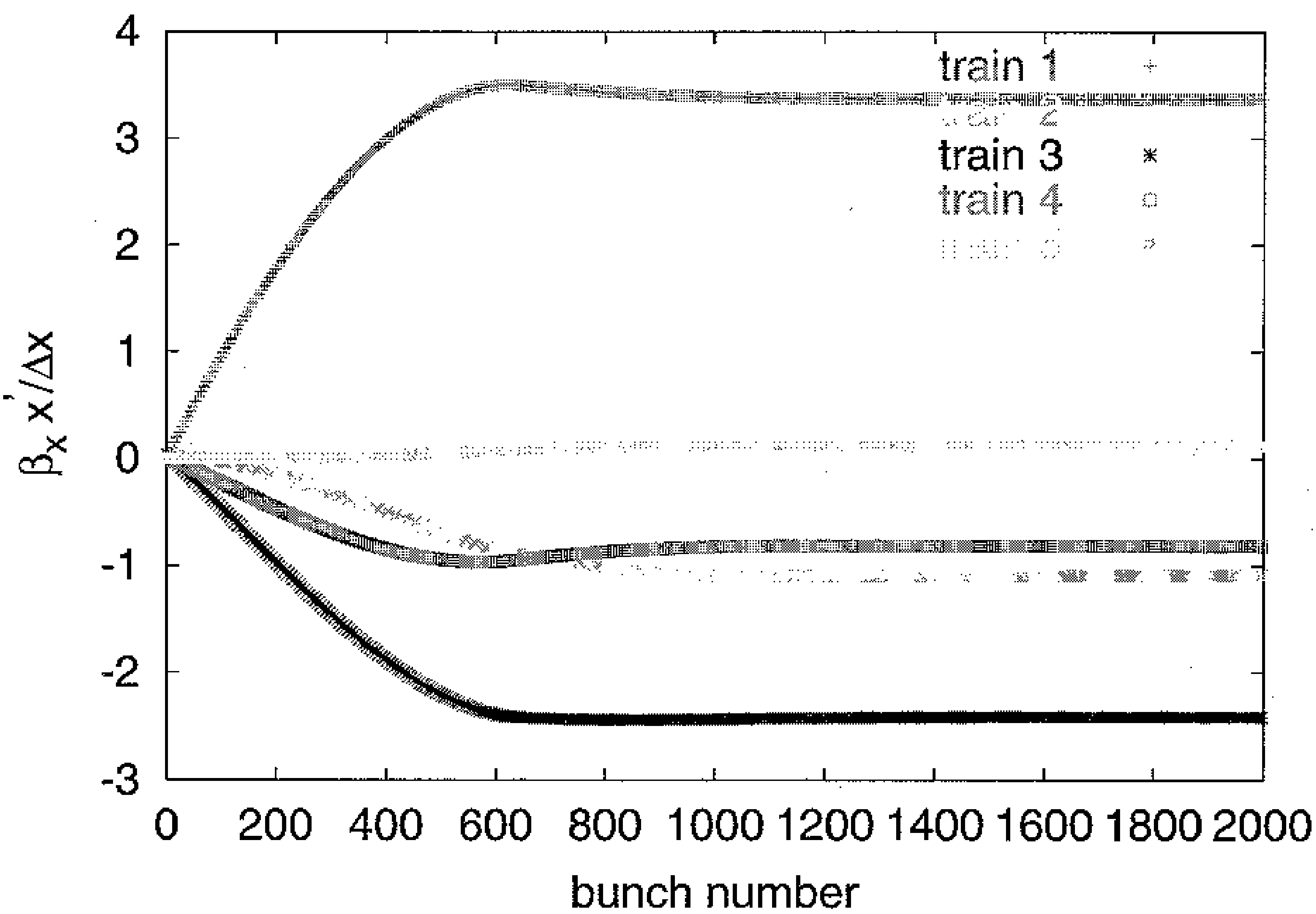




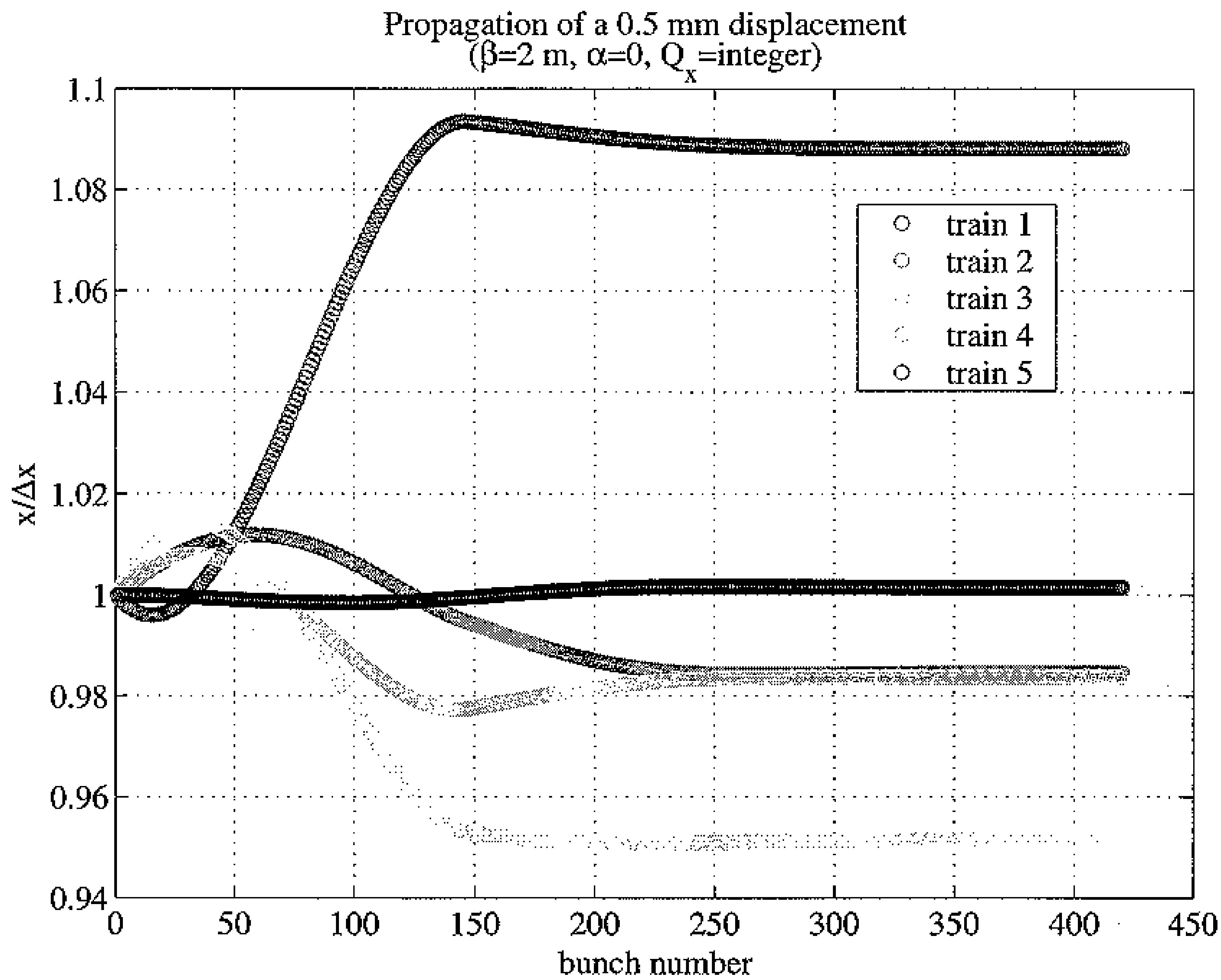
3) *Tracking*:

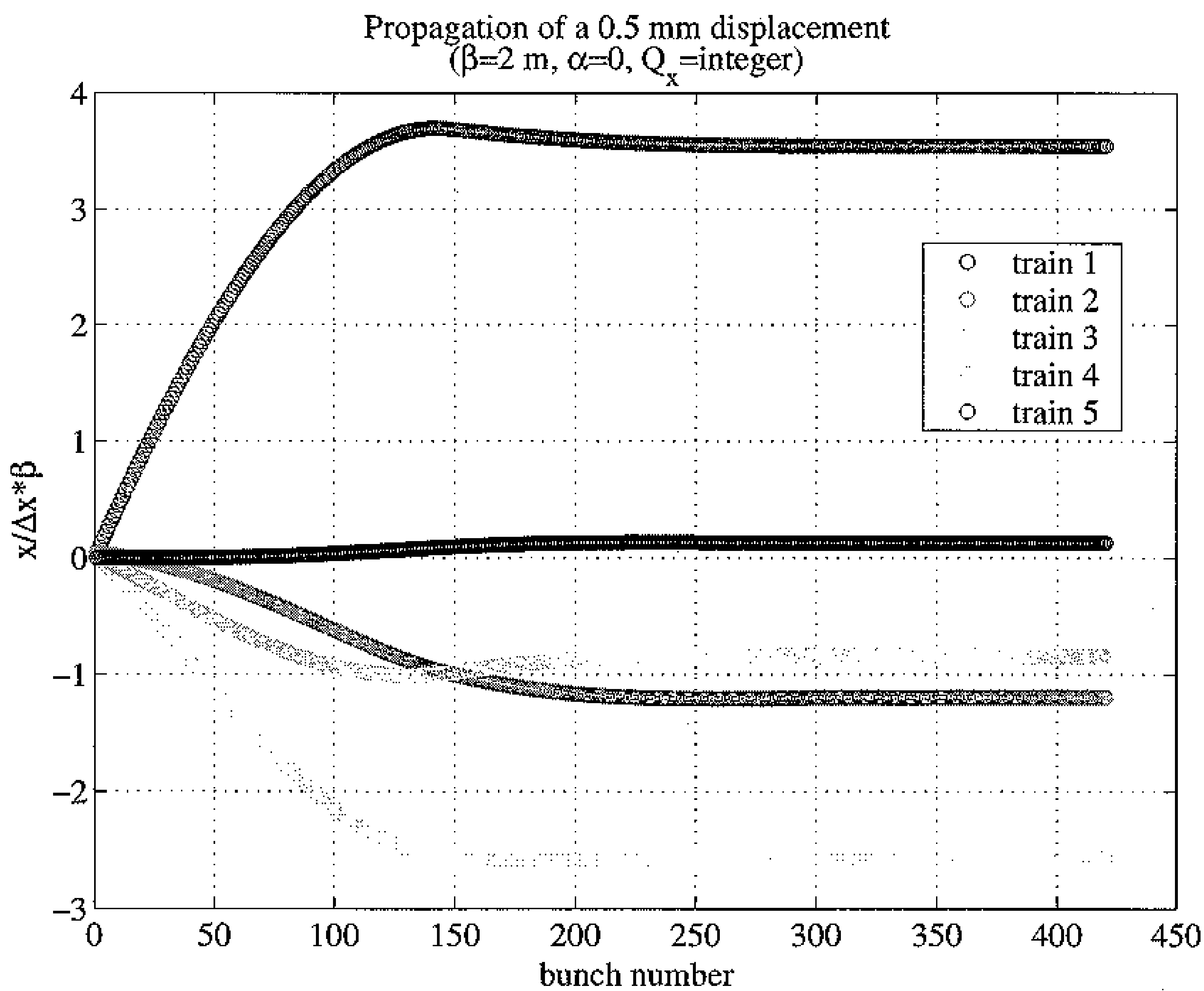

No beam loading out-of-phase effects
1st train injected in K1 in phase with the deflecting field. It generates a wake with a 90° phase respect to the deflecting field.
M21
1st train injected in K2 72° out-of-phase respect to the deflecting field. It generates a wake field (72°+90°)-out-of-phase respect to the deflecting one.
M12
1st+2nd train injected in K1: the 1st train is now injected 72° out-of-phase respect to the deflecting field and it generates a wake field (72°+90°)-out-of-phase; the 2nd is injected in phase with the deflecting field and it generates a 90° out-of-phase wake field.
M21
1st+2nd train injected in K2: the 1st is now injected 2*72° out-of-phase respect to the the deflecting field and it generates a wake field (2*72°+90°)-out-of-phase; the 2nd is injected 72° out-of-phase respect to the deflecting field and it generates a (72°+90°)-out-of-phase wake field.
M12
At each step the bunch x, x' propagate through the transport matrices or through the tranverse dynamics in the deflectors (including the wake field)

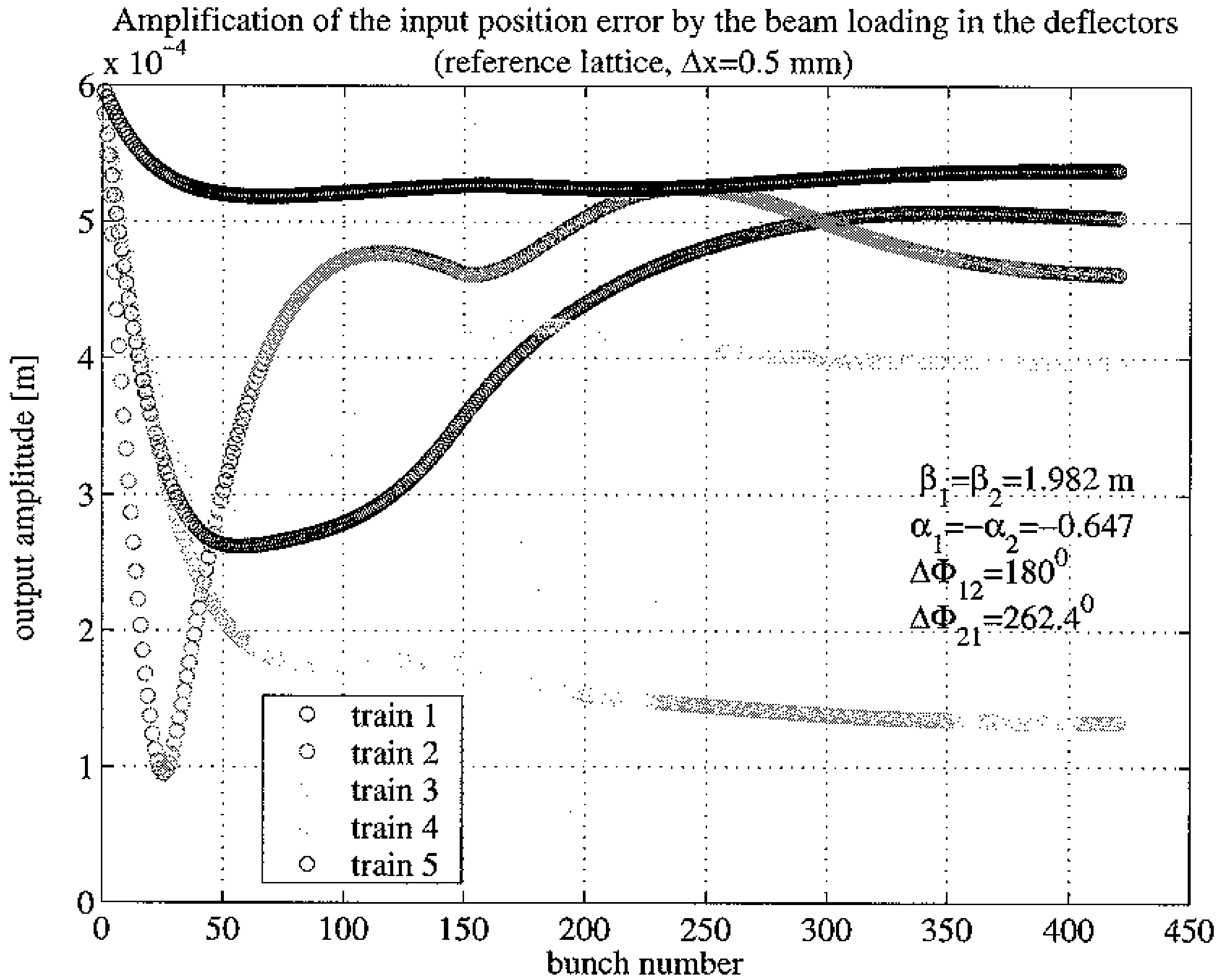


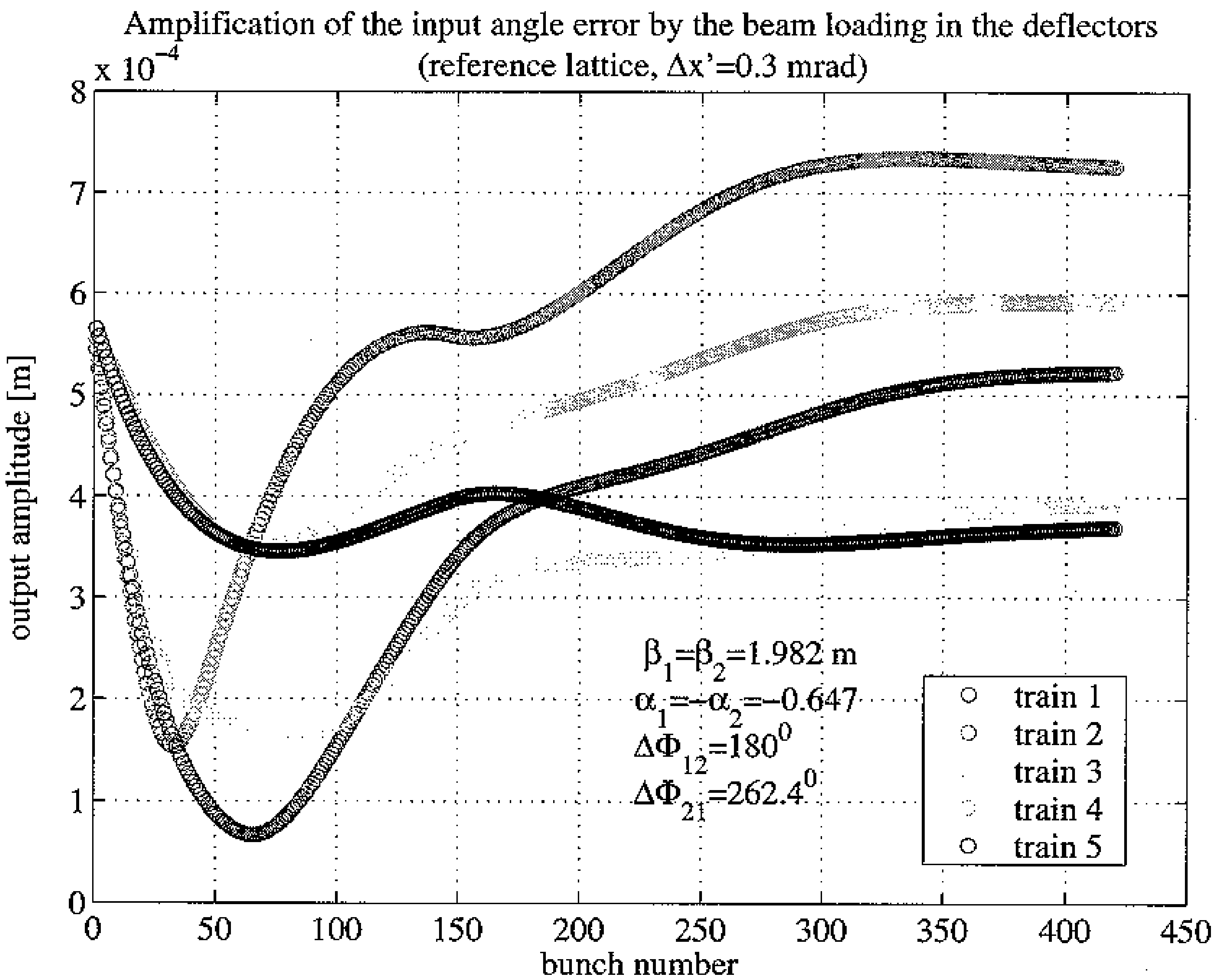


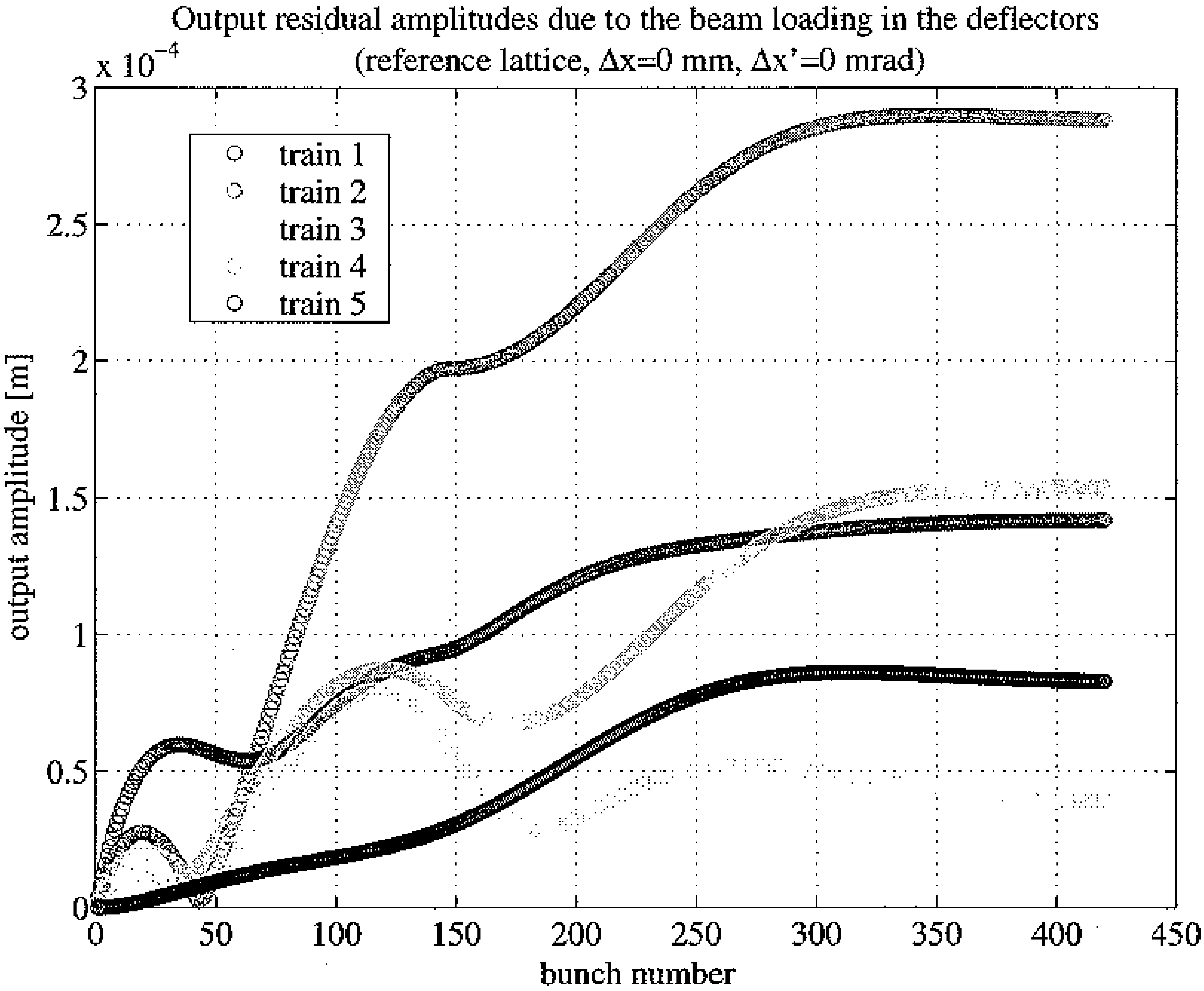
Daniel's simulations

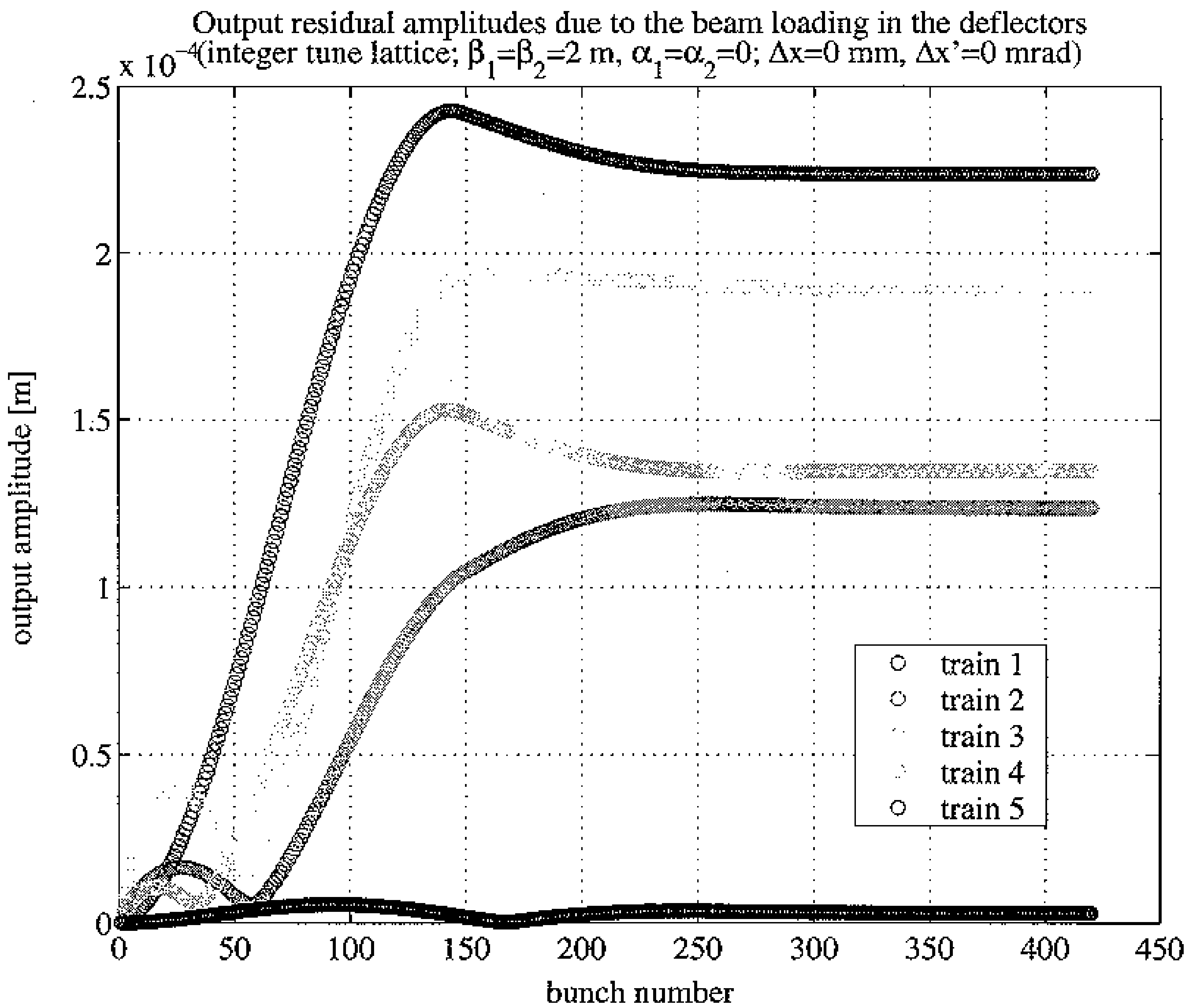

Propagation of a 0.5 mm displacement
(β=2 m, α=0, Q_x=integer)
x/Δx
bunch number
train 1
train 2
train 3
train 4
train 5

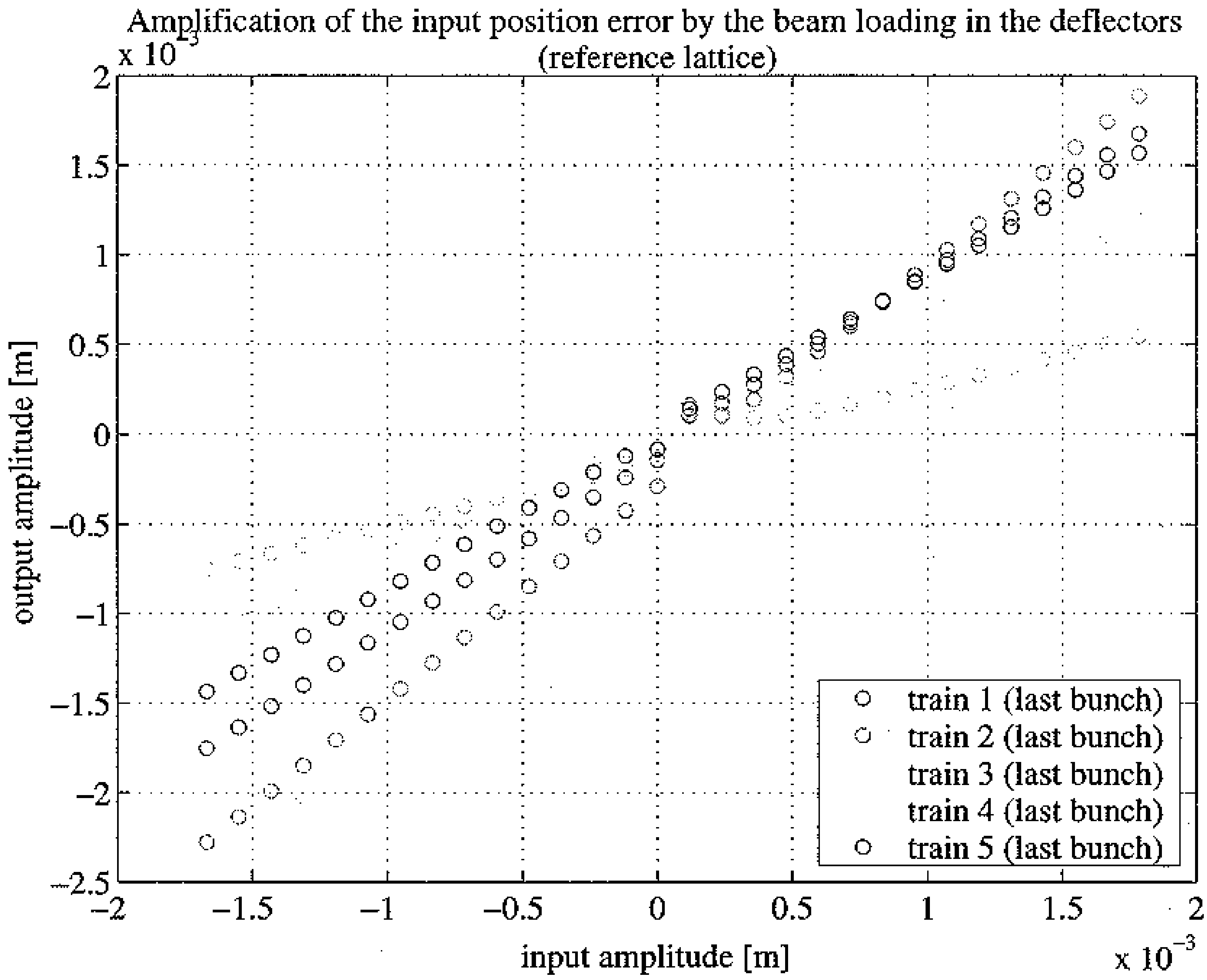

Propagation of a 0.5 mm displacement
(β=2 m, α=0, Q_x=integer)
x/Δx*β
bunch number
train 1
train 2
train 3
train 4
train 5

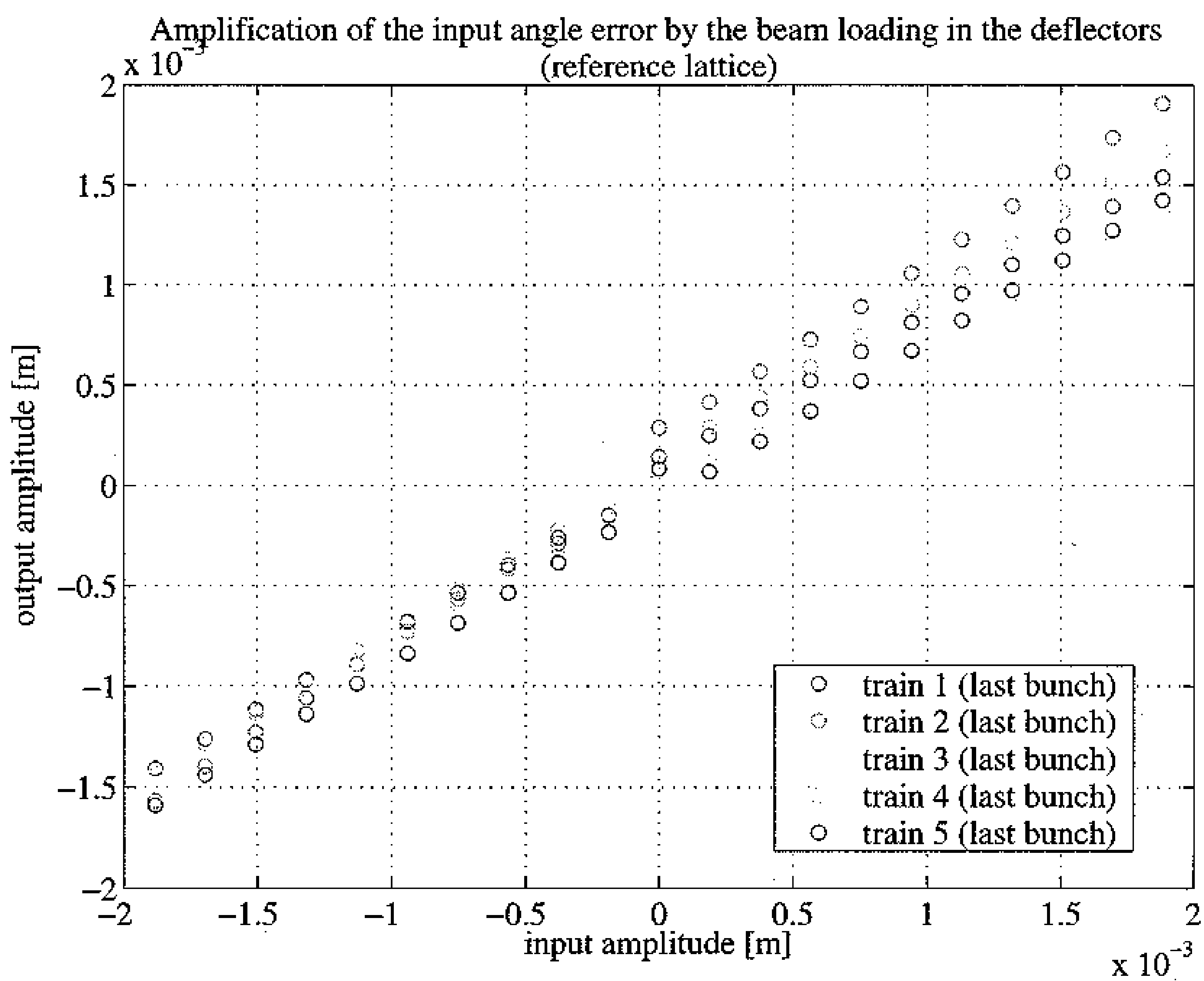

Amplification of the input position error by the beam loading in the deflectors
(reference lattice, Δx=0.5 mm)
x 10^-4
output amplitude [m]
bunch number
β1=β2=1.982 m
α1=−α2=−0.647
ΔΦ12=180°
ΔΦ21=262.4°
train 1
train 2
train 3
train 4
train 5

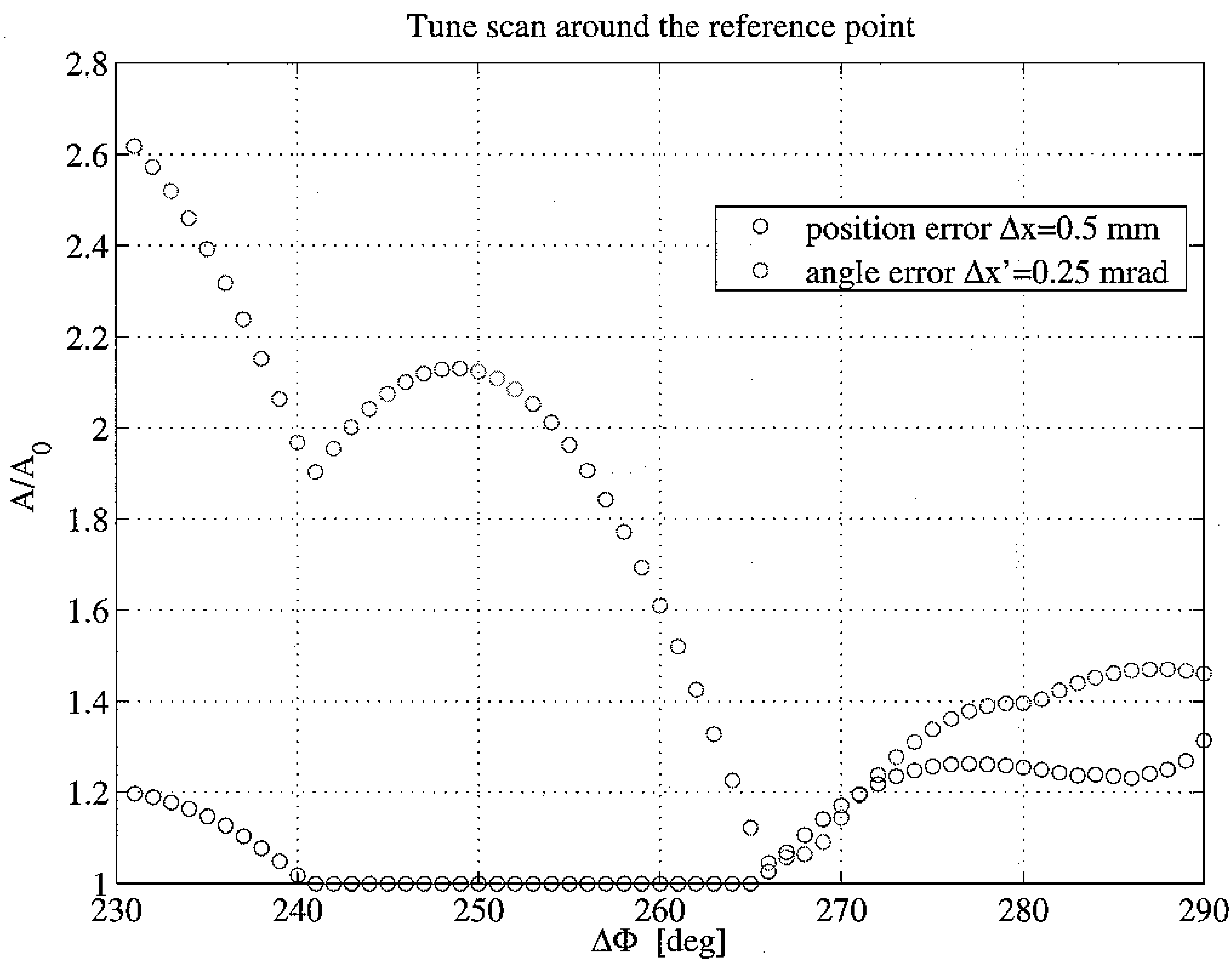

Amplification of the input angle error by the beam loading in the deflectors
(reference lattice, Δx'=0.3 mrad)
x 10^-4
output amplitude [m]
bunch number
β1=β2=1.982 m
α1=−α2=−0.647
ΔΦ12=180°
ΔΦ21=262.4°
train 1
train 2
train 3
train 4
train 5


Output residual amplitudes due to the beam loading in the deflectors
(reference lattice, Δx=0 mm, Δx'=0 mrad)
x 10^-4
output amplitude [m]
bunch number
train 1
train 2
train 3
train 4
train 5


Output residual amplitudes due to the beam loading in the deflectors
x 10^-4 (integer tune lattice; β1=β2=2 m, α1=α2=0; Δx=0 mm, Δx'=0 mrad)
output amplitude [m]
bunch number
train 1
train 2
train 3
train 4
train 5


Amplification of the input position error by the beam loading in the deflectors
(reference lattice)
x 10^-3
output amplitude [m]
input amplitude [m]
x 10^-3
train 1 (last bunch)
train 2 (last bunch)
train 3 (last bunch)
train 4 (last bunch)
train 5 (last bunch)


Amplification of the input angle error by the beam loading in the deflectors
(reference lattice)
x 10^-3
output amplitude [m]
input amplitude [m]
x 10^-3
train 1 (last bunch)
train 2 (last bunch)
train 3 (last bunch)
train 4 (last bunch)
train 5 (last bunch)



Tune scan around the reference point
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
A/A0
position error Δx=0.5 mm
angle error Δx'=0.25 mrad
230
240
250
260
270
280
290
ΔΦ [deg]