Minutes of the AP FAT-CLIC meeting 29-Apr-02

Present: DS, SR, JJ, JG, MK, HB, RA, FZ, FR

1) Stefano Redaelli (see appended slides): Report on work

a) Oide effect with betatron oscillations

Stefano considered the effect of a betatron oscillation on vertical beam size at the IP (blow-up due to synchrotron radiation in the final quads). The increase of vertical spot size is expected to be 36% for a 1 sigma vertical betatron oscillation.

b) Increase of vertical spot depending on horizontal emittance

The energy spread induced from the second to last quadrupole generates a chromatic abberation at the IP, visible as an increase in vertical spot size. The expetced increase of the vertical spot size is 10% for a 30% increase in the horizontal emittance.

2) Daniel Schulte: Comparison between old and new BDS

Daniel showed integrated simulations using PLACET, comparing some features of the old and new (shorter collimation, smaller beta*) BDS of CLIC (static errors in linac, ideal BDS). In particular he pointed out that the vertical IP spot size was decreased from 1.0 nm to 0.7 nm, while the horizontal spot size was increase from 43 nm to 60nm. The new system seems to achieve the required performance.

There was a discussion about emittance budget and saftey margins. RA pointed out that while the emittance growth budget in the linac is 100%, the simulations only produce a 30% linac emittance growth. The linac emittance budget is therefore implicitely used to compensate for performance loss in the ideal BDS. This leaves no safety margin in the linac.

3) Maxim Korostelev (see appended slides): CLIC Damping Ring

Maxim has set up a MAD lattice for his DR solution. This now allows to run the Bjorken/Mtingwa IBS routine in MAD and to compare with his Piwinski routine. The lattice was optimized for final emittances (IBS) and damping times.

Basic parameters:

Circumference	347.37 m
Energy	2.424 GeV
Damping times	2.6/2.64/1.33 ms
Tunes	76.41/22.87
Wiggler length	150 m
Detuning factor	1
RF voltage	3.0 MV
U0	2.1 MeV
Bunch length	1.2 mm

The emittances in equilibrium come out to be (with 2% coupling):

H: 615 nm (480 nm Piwinski)
V: 8.6 nm
L: 3425 eVm

JJ asked why the detuning factor is 1 instead of 3/4, which should be better for dynamic aperture.

HB asked whether 3 MV is enough RF voltage, in view of the energy loss per turn.

JJ asked about the short bunch length and small momentum compaction. What are the consequences for dynamic aperture?

Next steps are to include sextupoles and to evaluate the dynamic aperture.

4) Next meeting:

The next meeting will be on Monday May 13th, 16h30.
Chairman: H. Burkhardt or G. Blair
Topic: Status and discussion of EPAC papers

FAT - CLIC Meeting

CERN – European Organization for Nuclear Research

CH-1211 Geneva 23, Switzerland

29 April 2002

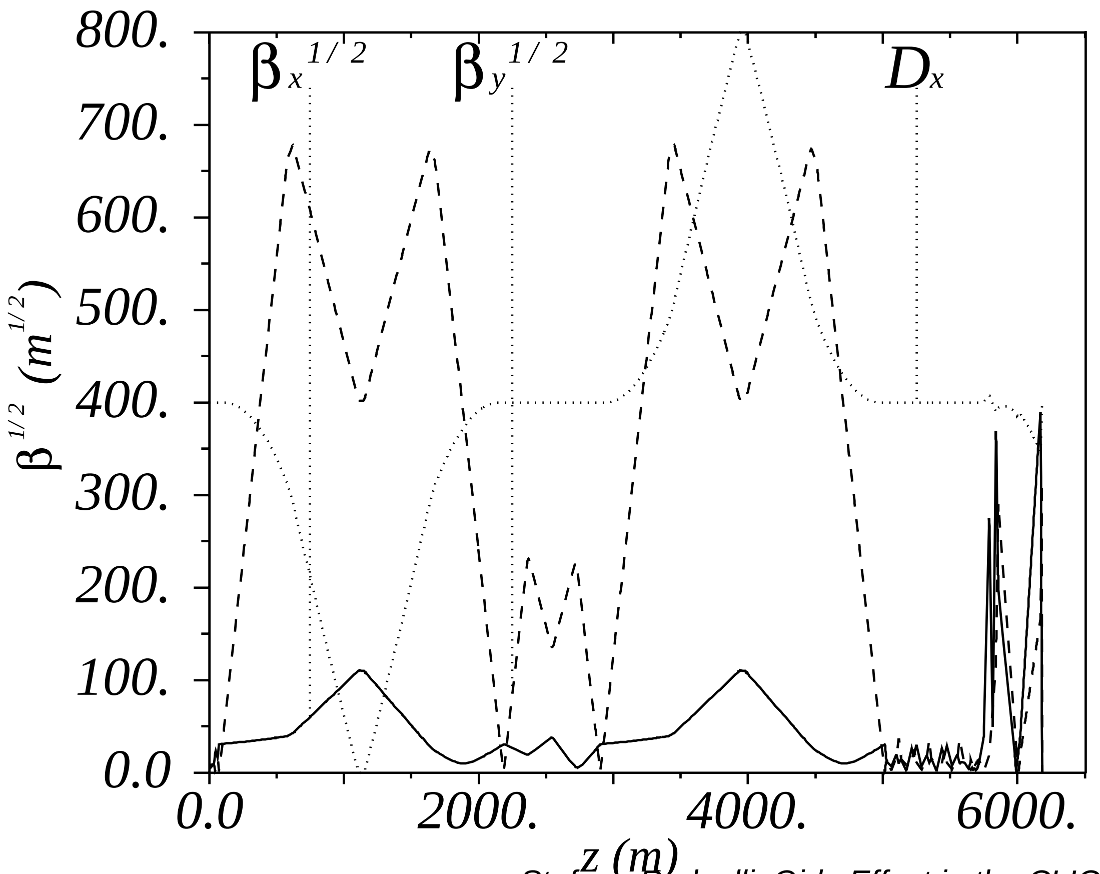
OIDE EFFECT IN THE CLIC BDS

Stefano Redaelli

1. Introduction – motivations
2. Oide effect
3. Simulations of the Oide effect for offset beams
4. Vertical beam size vs. horizontal emittance
5. Conclusions

1. Introduction – motivations

- Oide effect thought to be a possible limitation for the CLIC performance (O. Napoly to F. Z.).
- Optics for the CLIC – BDS: release **ffcol_v2fz** (compact design).
- Simulations done with Merlin (Acknowledgement to N. Walkers and A. Wolsky).



E= 1500 Gev

$\Delta E/E$=1 % (square distr.)

$\beta_x = 65\,\mathrm{m}$

$\beta_y = 18\,\mathrm{m}$

$\epsilon_x^* = 680\,\mathrm{nm}$

$\epsilon_y^* = 20\,\mathrm{nm}$

2. Oide effect

- *Offset particles* in the quadrupoles see a dipole “bending” field

  ⇒ Emission of Synchrotron Radiation ⇒ Energy loss

  ⇒ Aberration ⇒ Increase of the beam size at the IP.

- Vertical direction: Main contribution comes from the Final Doublet. Magnetic field is very strong (~390 T/m) – beam very large.

- Horizontal direction: Also contribution from the Dipoles.

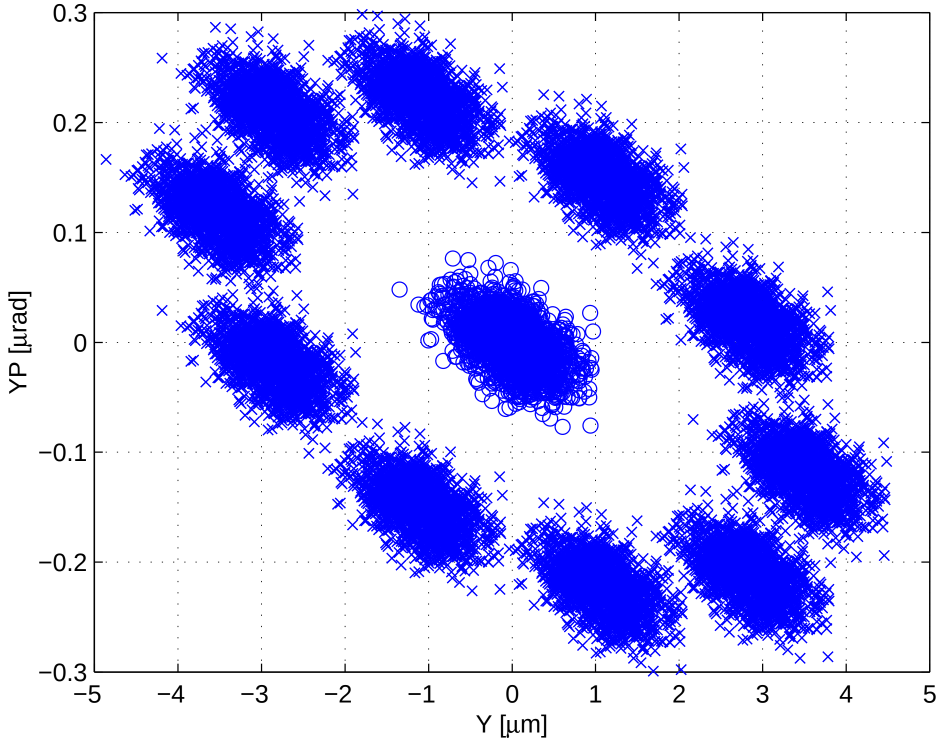
Effect of the SR emission on the beam size for perfect machine.

	Hor. spot size	Vert. spot size
No SR	47.99 nm	1.30 nm
SR	59.24 nm	2.20 nm
SR in FD only	52.43 nm	1.89 nm

- What if the beam centroid at the FD location is offset?

3. Simulations of Oide effect for offset beams.

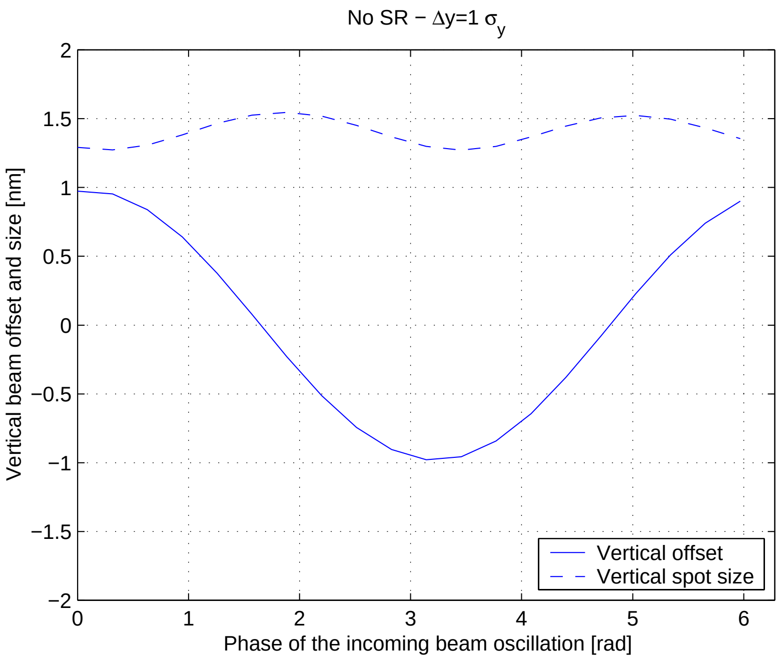
- We track beam with an initial offset – scan over the phase of the incoming beam jitter.
- We look for the phase that induces the maximum beam size at the IP.
- Bunches of 20000 particles, generated with a MatLab routine.

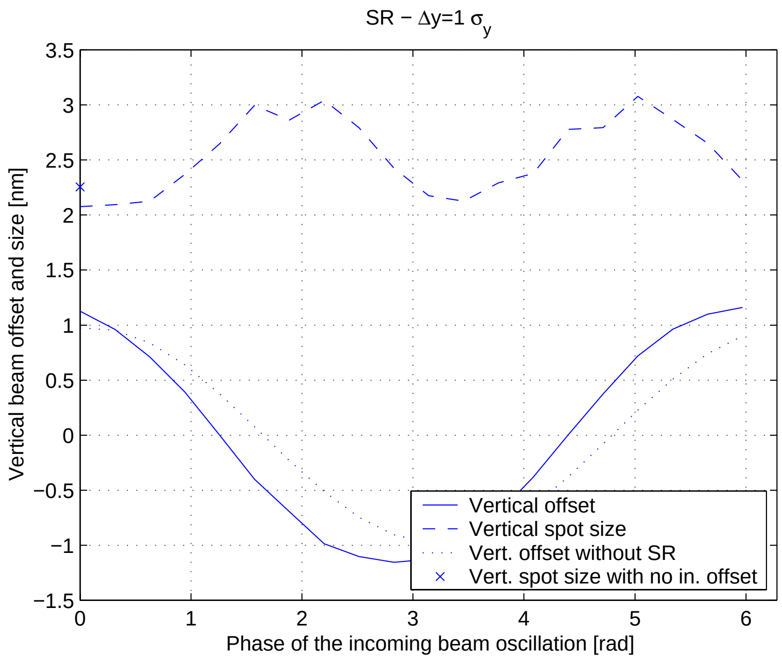


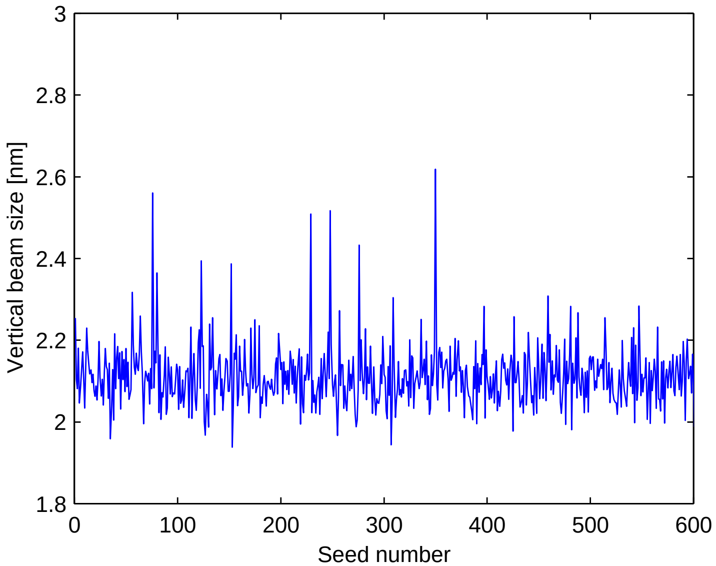

```
% Generation of the imperturbed particle distribution
Ix=-emx*log(rand(n,1));
Iy=-emy*log(rand(n,1));
phix=2*pi*rand(n,1);
phiy=2*pi*rand(n,1);
x=1e6*sqrt(2*betax*Ix).*cos(phix);
xp=-1e6*sqrt(2*Ix/betax).*(sin(phix)+alfx.*cos(phix));
y=1e6*sqrt(2*betay*Iy).*cos(phiy);
yp=-1e6*sqrt(2*Iy/betay).*(sin(phiy)+alfy.*cos(phiy));
z=randn(n,1)*sl*1E6;
%EE=rand(n,1);
%E=E0*(1+(EE-mean(EE))/mean(EE)*FWd/2);
E=E0.*ones(n,1);

n=20;
phi=2*pi/n.*([1:n]-1);
%
Dy0=4*std(y);
Jy=Dy0^2/2/betay;
for i=1:n
  Dy=sqrt(2*Jy*betay)*cos(phi(i));
  Dyp=-sqrt(2*Jy/betay)*(alfy*cos(phi(i))+sin(phi(i)));
  yy=y+Dy;
  yyp=yp+Dyp;
  plot(yy,yyp,'x')
  B=[E x yy z xp yyp];
  str=['save oidey',num2str(i),'.dat B -ascii'];
  eval(str);
end
```

Some check of the simulation output:



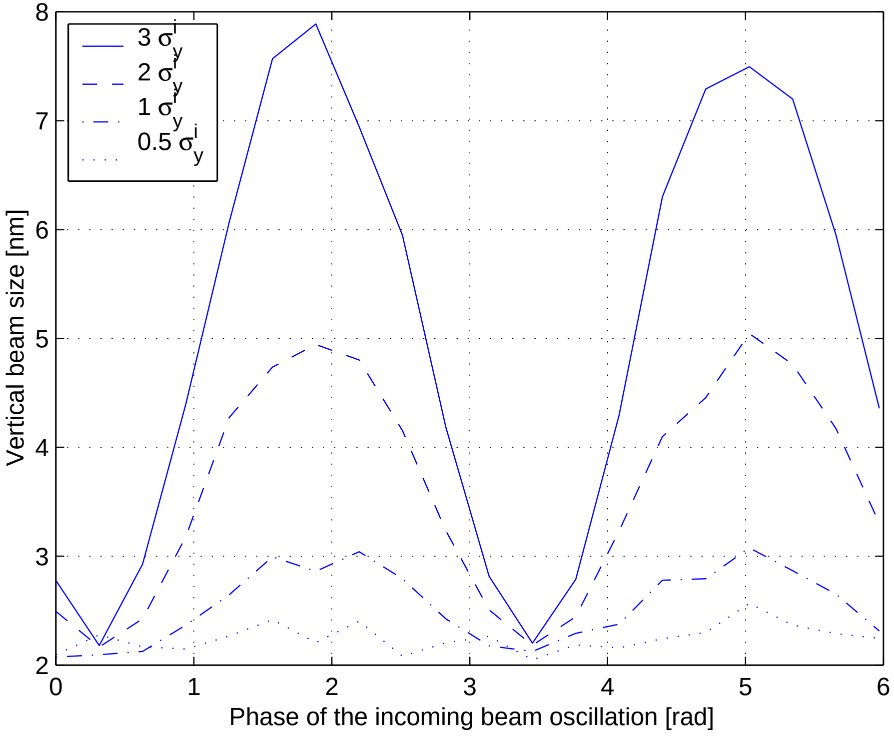


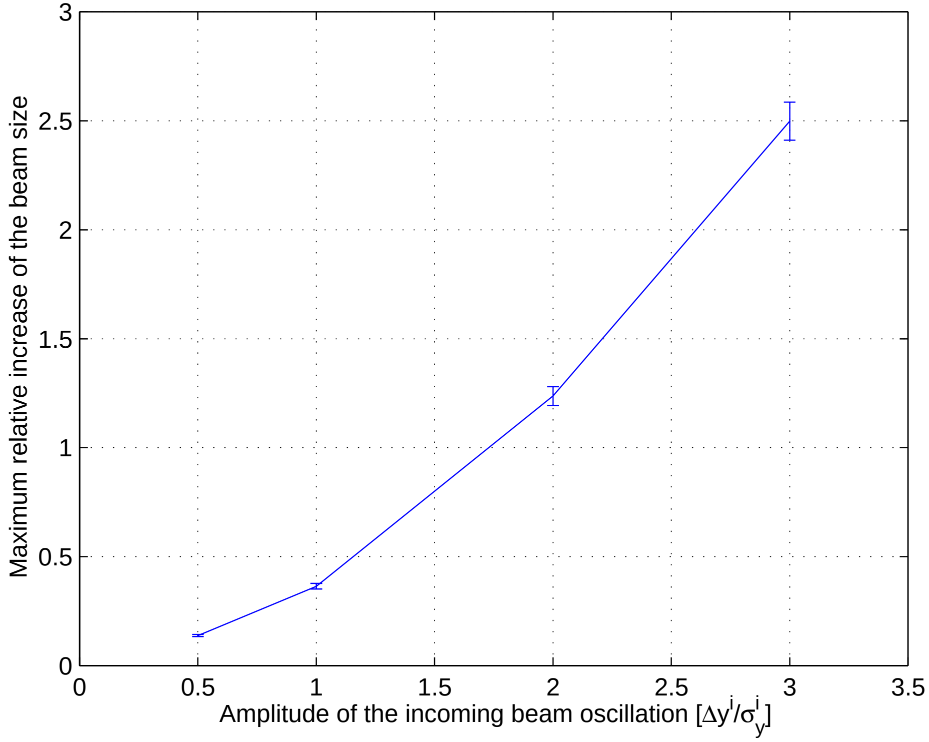


3.5 % relative error on the vertical spot size (calculation over ~600 seeds). Due to uncertainty on the photon emission.

Taken as estimate of the intrinsic error of the SR simulation.

Results of the simulations.





- Maximum increase of vertical spot size of 36 % for 1σ_y offset incoming beam.
- Maximum increase of 250 % for 3σ_y offset.
- Is this a problem? The effect induces a relevant increase of the beam size.

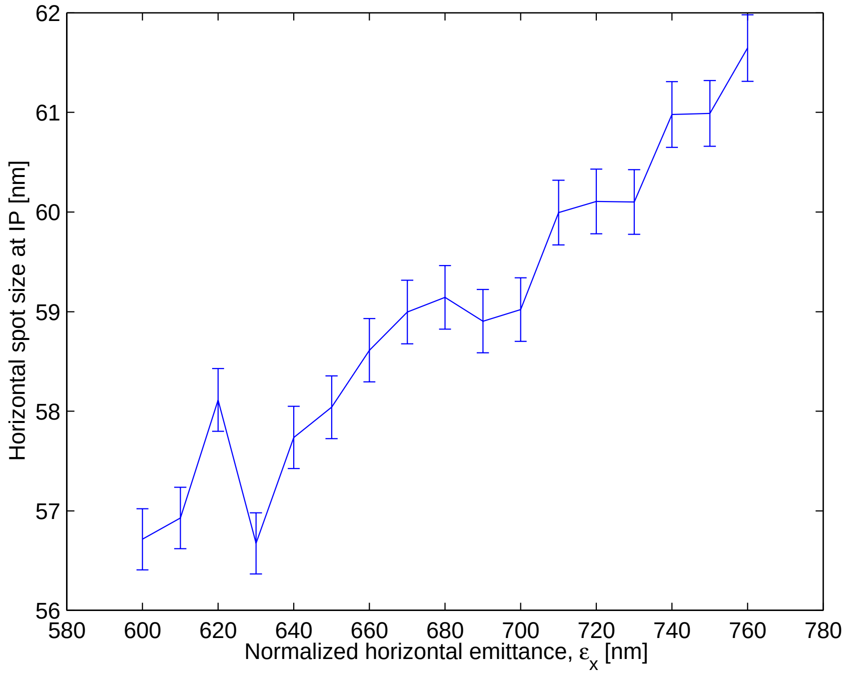
4. Variation of the vertical beam size due to variation of the horizontal emittance (after discussion with DS and FZ)

- Why effect of the horizontal emittance on the vertical spot size?

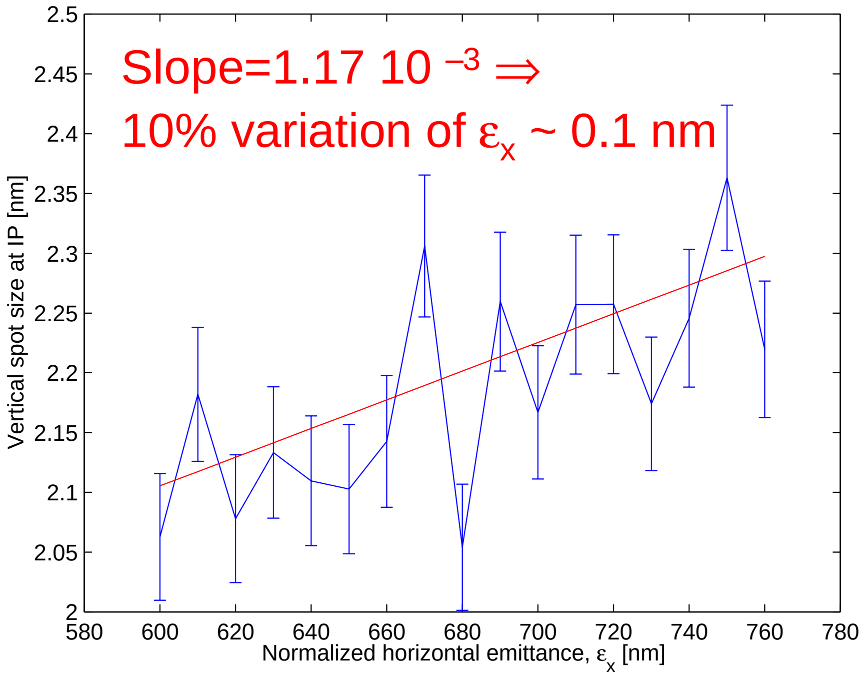
  Variation of the beam size in the first quad of the doublet ⇒ Variation Oide emission (hor. plane) ⇒ Different condition in the second quad ⇒ Variation also of the vertical beam size.

- Is this effect important?

Horizontal beam size at IP



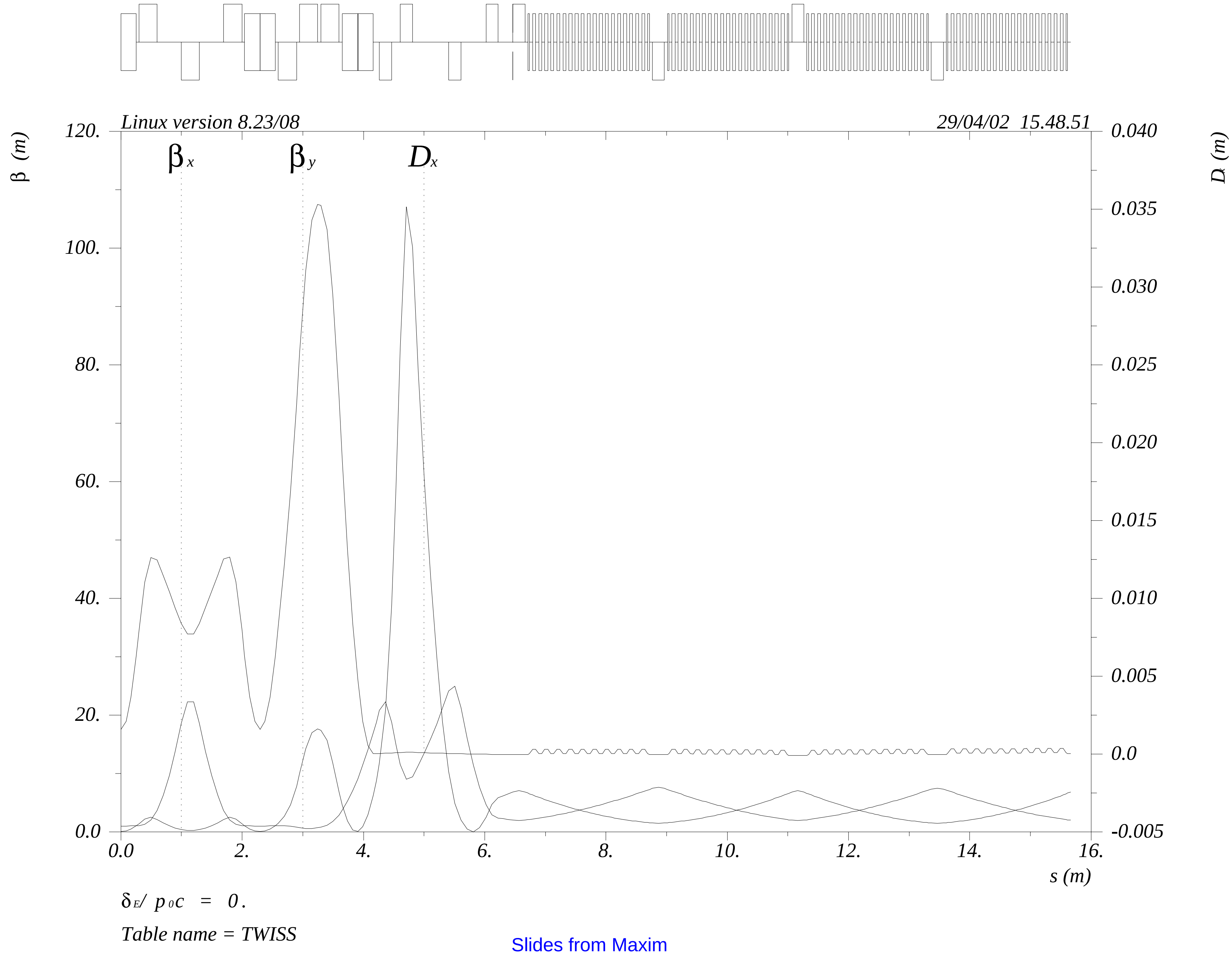
Vertical beam size at IP



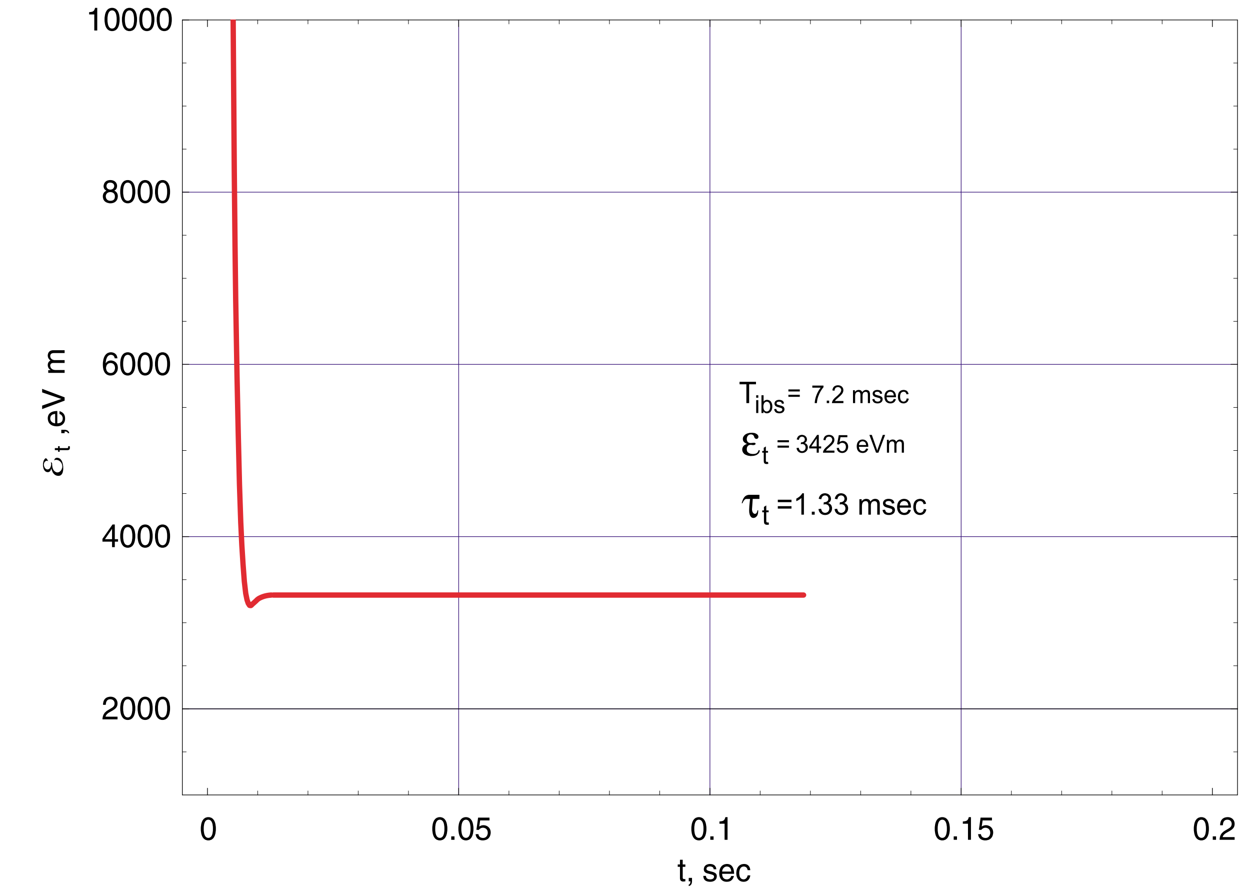
4. Conclusions and outlook

- Effect of Oide emission estimated for the CLIC BDS, for the *compact design*.
- The main effect is an increase of the beam size.
- Vertical direction: main effect comes from the FF quadrupoles.
- Beam offset in the FF quad $\Rightarrow$ considerable increase of the beam size (maximum of ~40 % for an incoming beam with 1 σ_y offset).
- Calculations must be repeated for the latest release of the BDS (No big differences expected – the FFS is the same).
- Variation of the vertical beam size vs. horizontal emittance quantified.

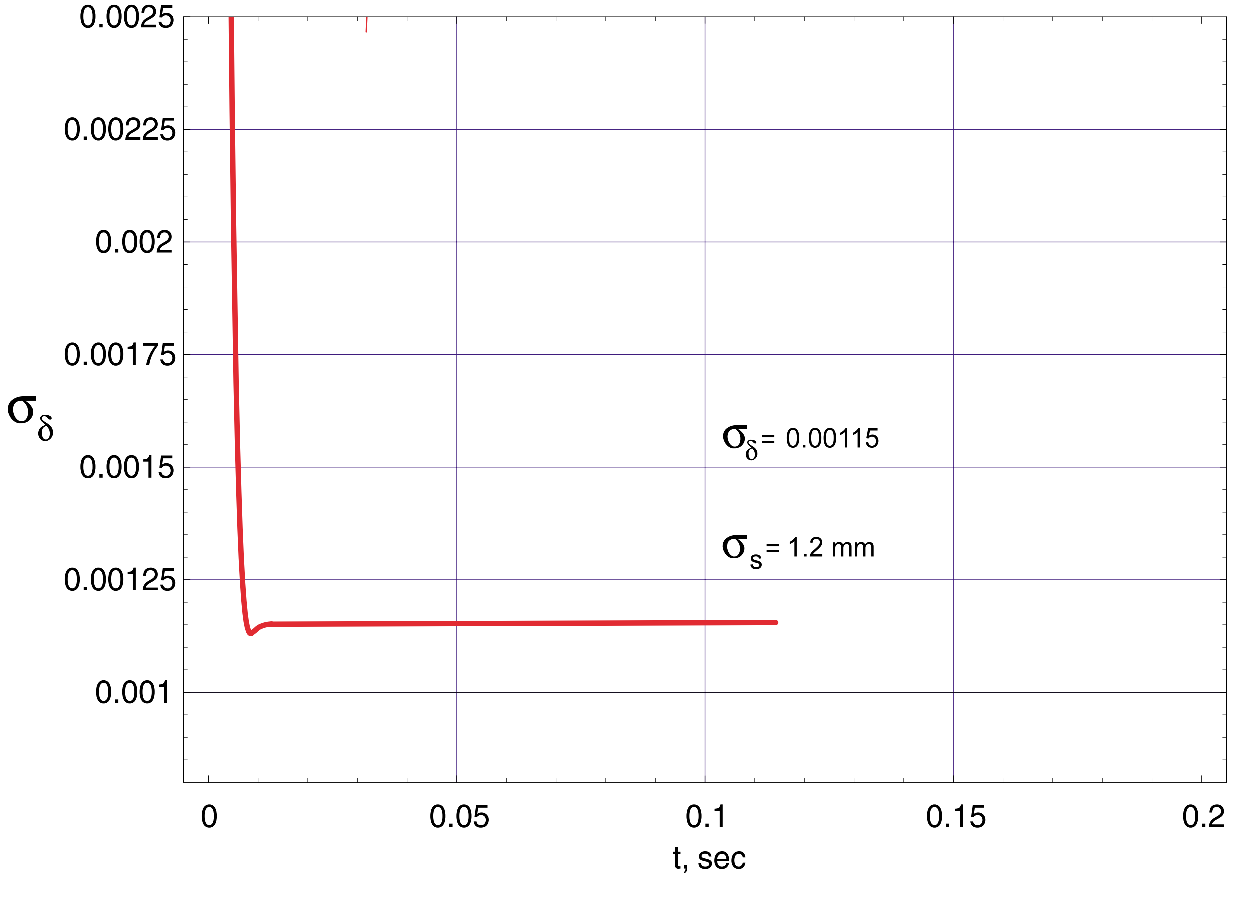
  More statistics required to have reliable results.



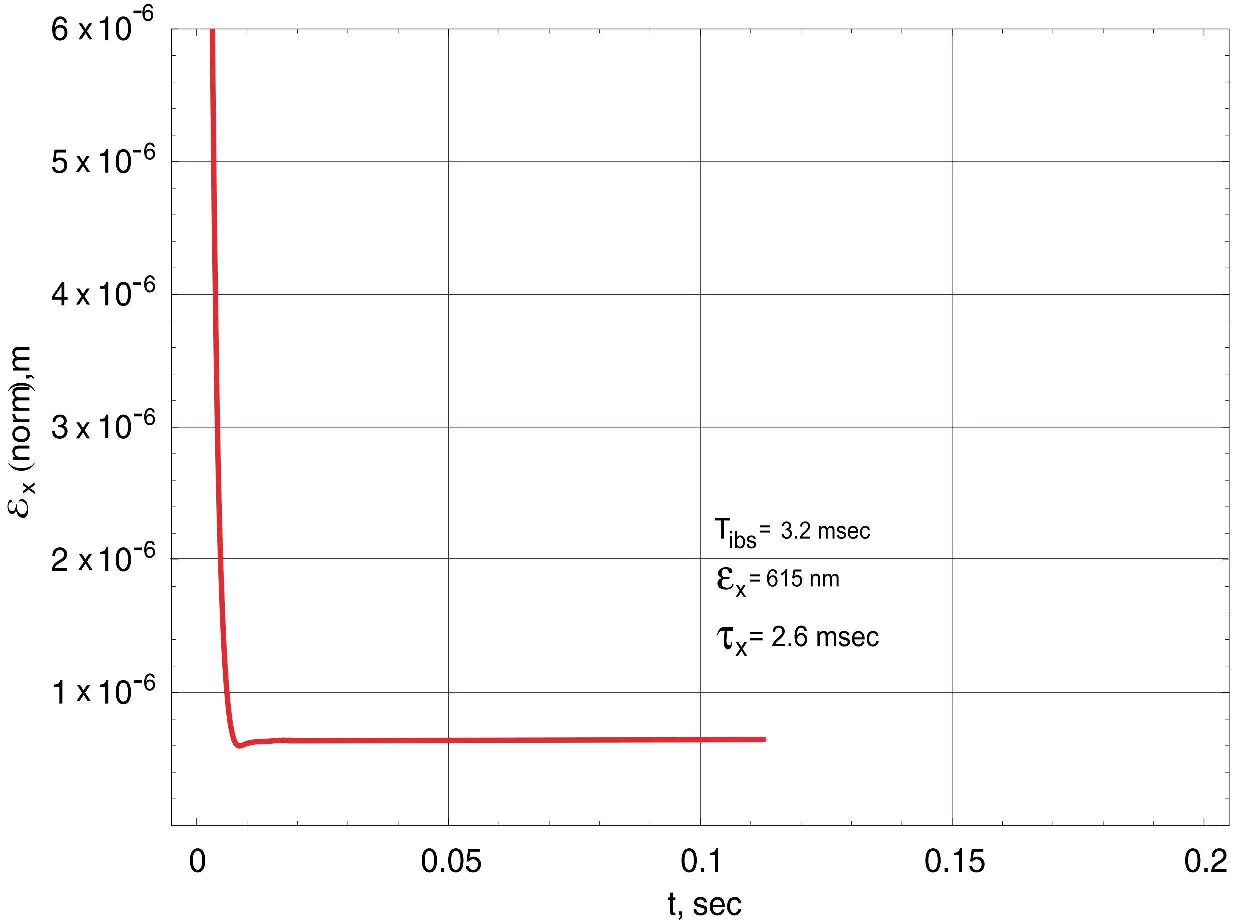
Slides from Maxim



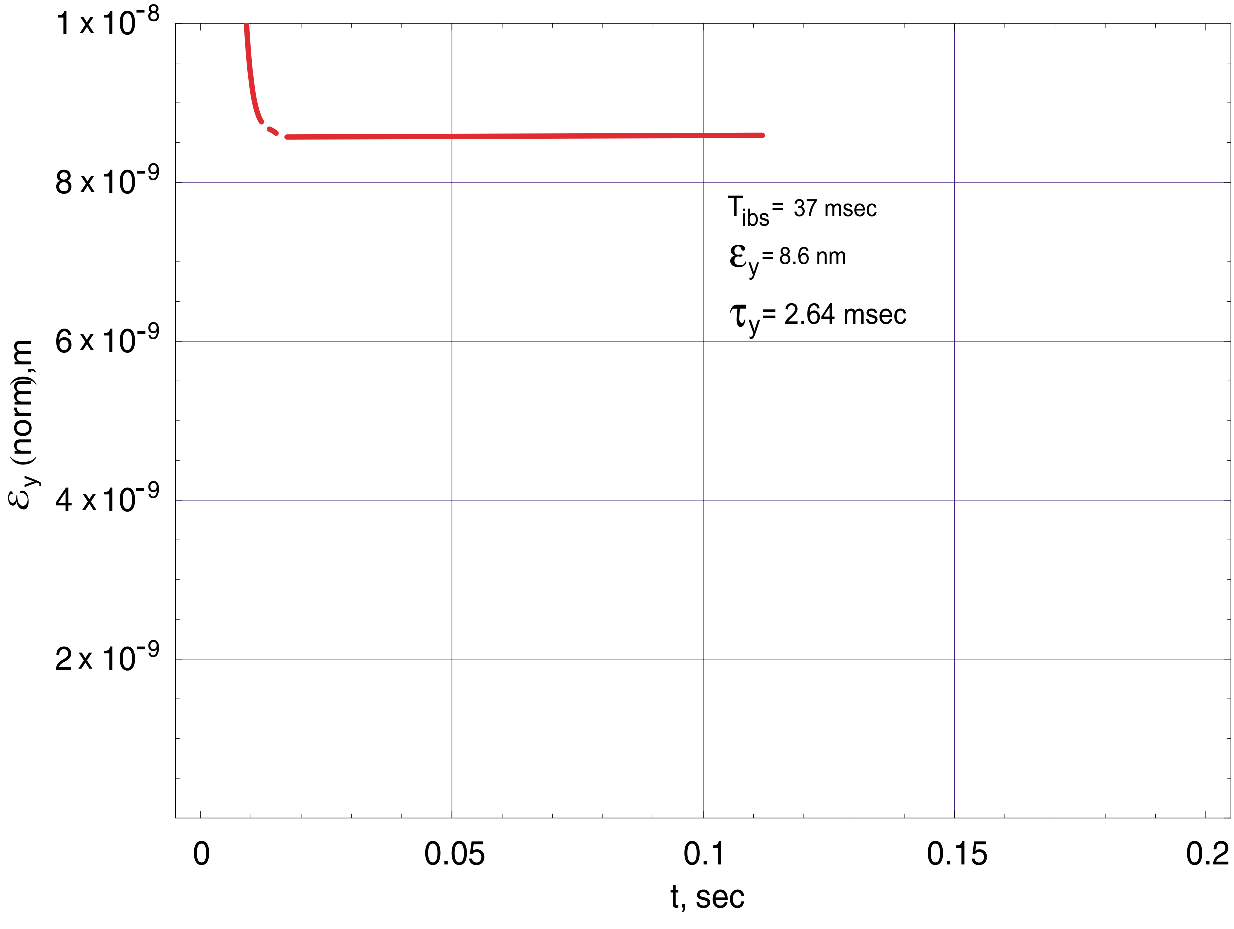
10000
8000
6000
4000
2000
ε_t ,eV m
T_{ibs}= 7.2 msec
ε_t = 3425 eVm
τ_t =1.33 msec
0
0.05
0.1
0.15
0.2
t, sec



0.0025
0.00225
0.002
0.00175
0.0015
0.00125
0.001
σ_δ
σ_δ= 0.00115
σ_s= 1.2 mm
0
0.05
0.1
0.15
0.2
t, sec



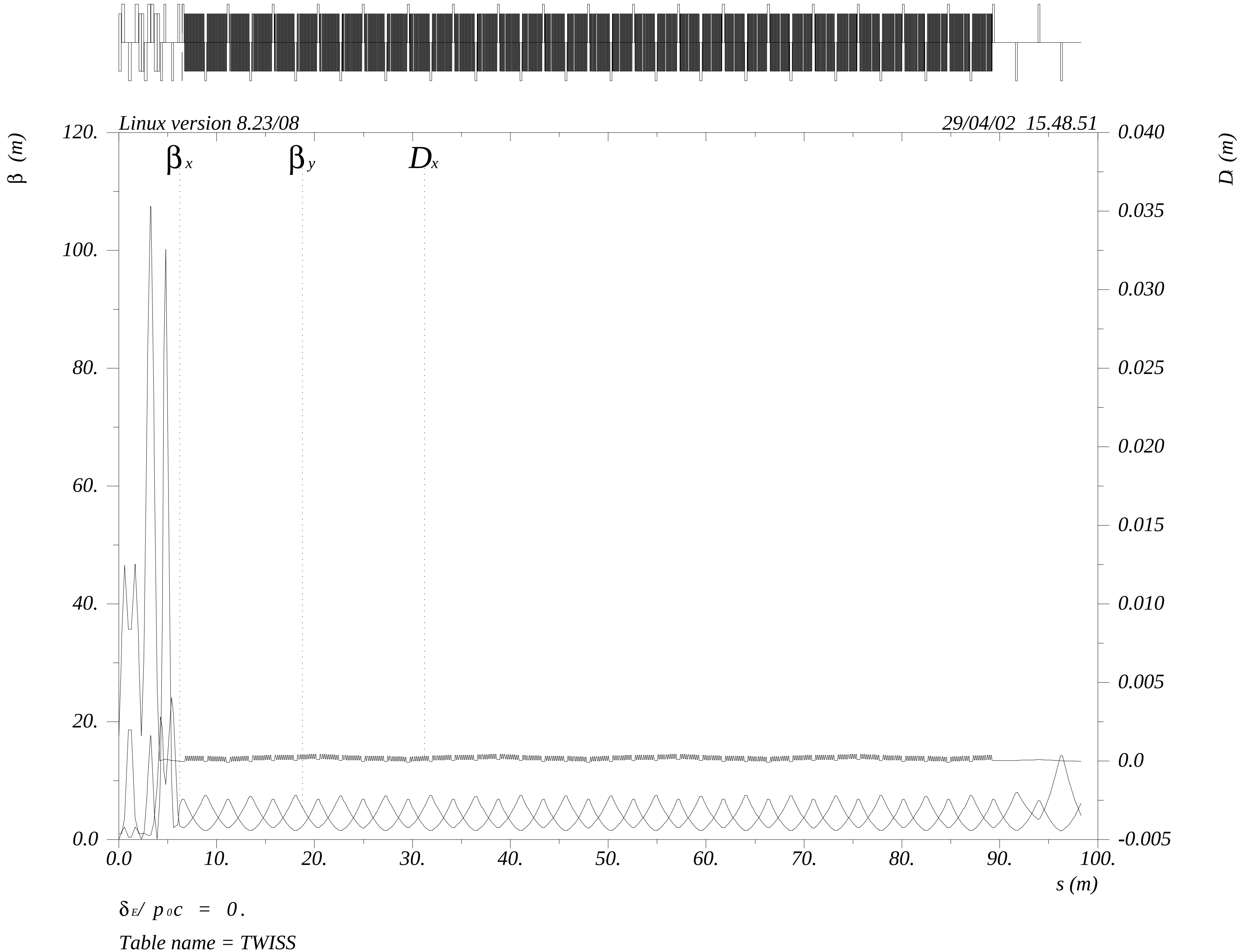
6 x 10^-6
5 x 10^-6
4 x 10^-6
3 x 10^-6
2 x 10^-6
1 x 10^-6
ε_x (norm),m
T_ibs = 3.2 msec
ε_x = 615 nm
τ_x = 2.6 msec
0
0.05
0.1
0.15
0.2
t, sec



1 x 10^-8
8 x 10^-9
6 x 10^-9
4 x 10^-9
2 x 10^-9
ε_y (norm),m
T_ibs = 37 msec
ε_y = 8.6 nm
τ_y = 2.64 msec
0
0.05
0.1
0.15
0.2
t, sec

Table 1: List of CLIC damping ring parameters

Nominal electron-positron ring energy	γmc^2	2.424
No. of bunche trains stored	N_{train}	9
Ring circumference	C	347.37 [m]
Number of cells	N_{cell}	84
Betatron coupling	$\varepsilon_y/\varepsilon_x$	2.1%
Extracted horizontal emittance (norm. rms)	$\gamma\varepsilon_{nx}$	615 [nm]
Extracted vertical emittance (norm. rms)	$\gamma\varepsilon_{ny}$	8.6 [nm]
Extracted longitudinal emittance (norm. rms)	$\gamma\varepsilon_{nt}$	3425 [eV×m]
Extracted energy spread (rms)	σ_δ	1.15×10^{-3}
Damping time τ_x		2.60 [msec]
Damping time τ_y		2.64 [msec]
Damping time τ_t		1.33 [msec]
Extracted horizontal emittance without IBS (norm. rms)	$\gamma\varepsilon_{x0}$	405 [nm]
Field of bending magnet	B_a	11.76 [kG]
Field of wiggler	B_w	17.64 [kG]
Wiggler period	λ_w	20 [sm]
Length of bending magnet	L	0.506 [m]
Total length of wiggler section	L_w	145 [m]
Energy loss per turn	U_0	2.126 [MeV]
RF voltage	V_0	3.0 [MV]
Harmonic number	h	1735
Momentum compaction	α_p	0.5×10^{-4}



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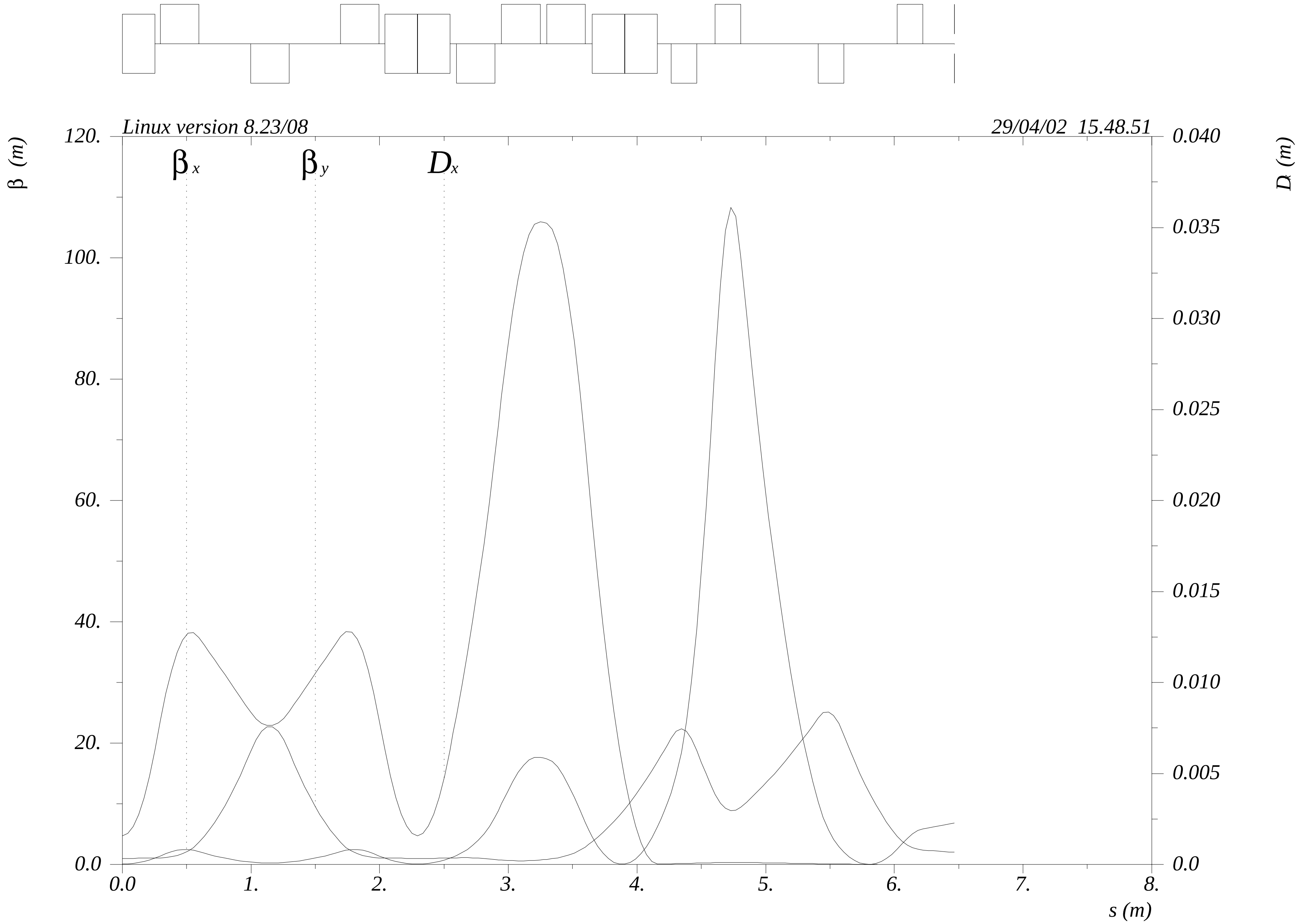
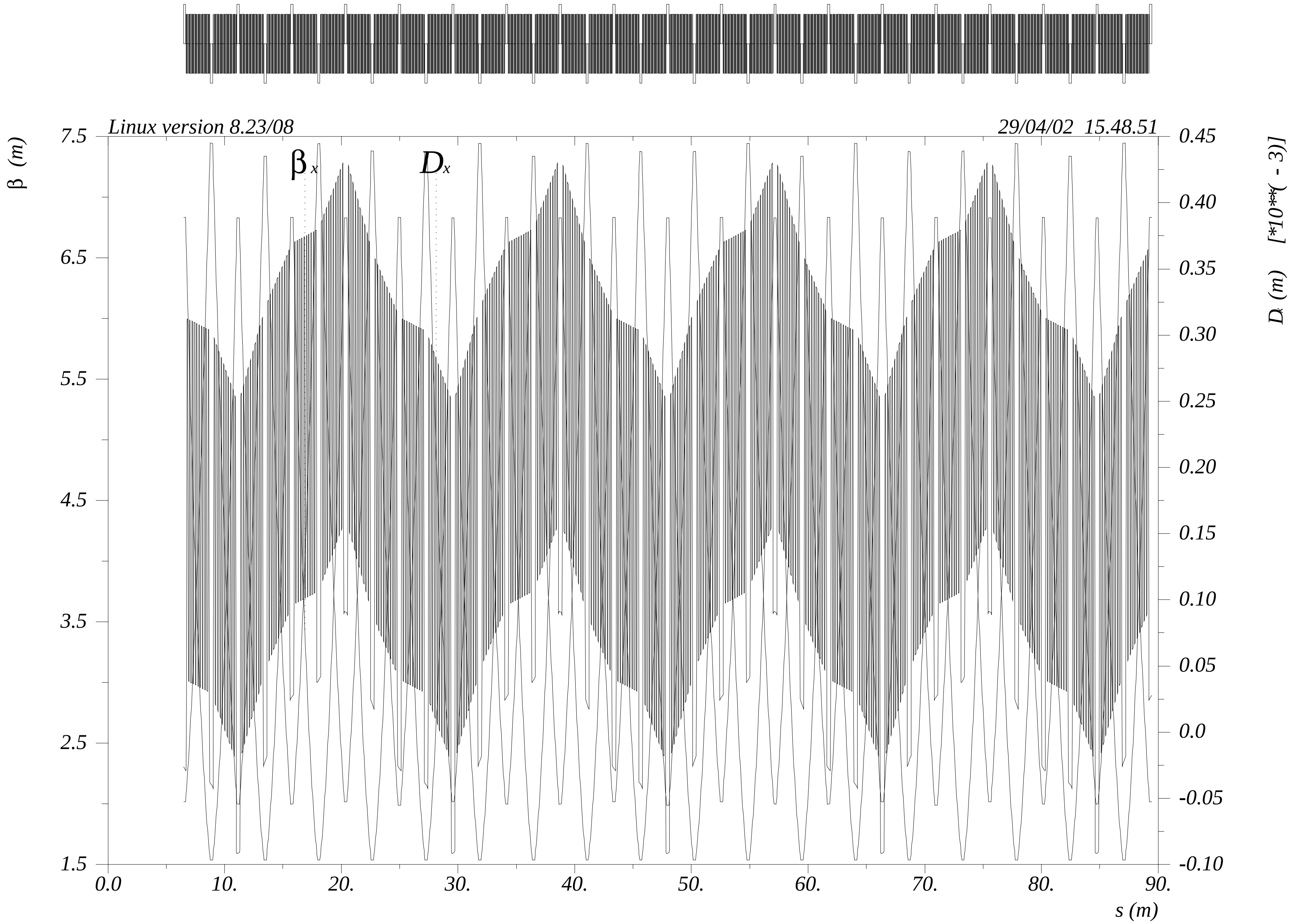
β (m)
D_x (m)
β_x
β_y
D_x
120.
100.
80.
60.
40.
20.
0.0
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.0
-0.005
0.0
10.
20.
30.
40.
50.
60.
70.
80.
90.
100.
s (m)
$\delta_E / p_0 c$ = 0.
Table name = TWISS



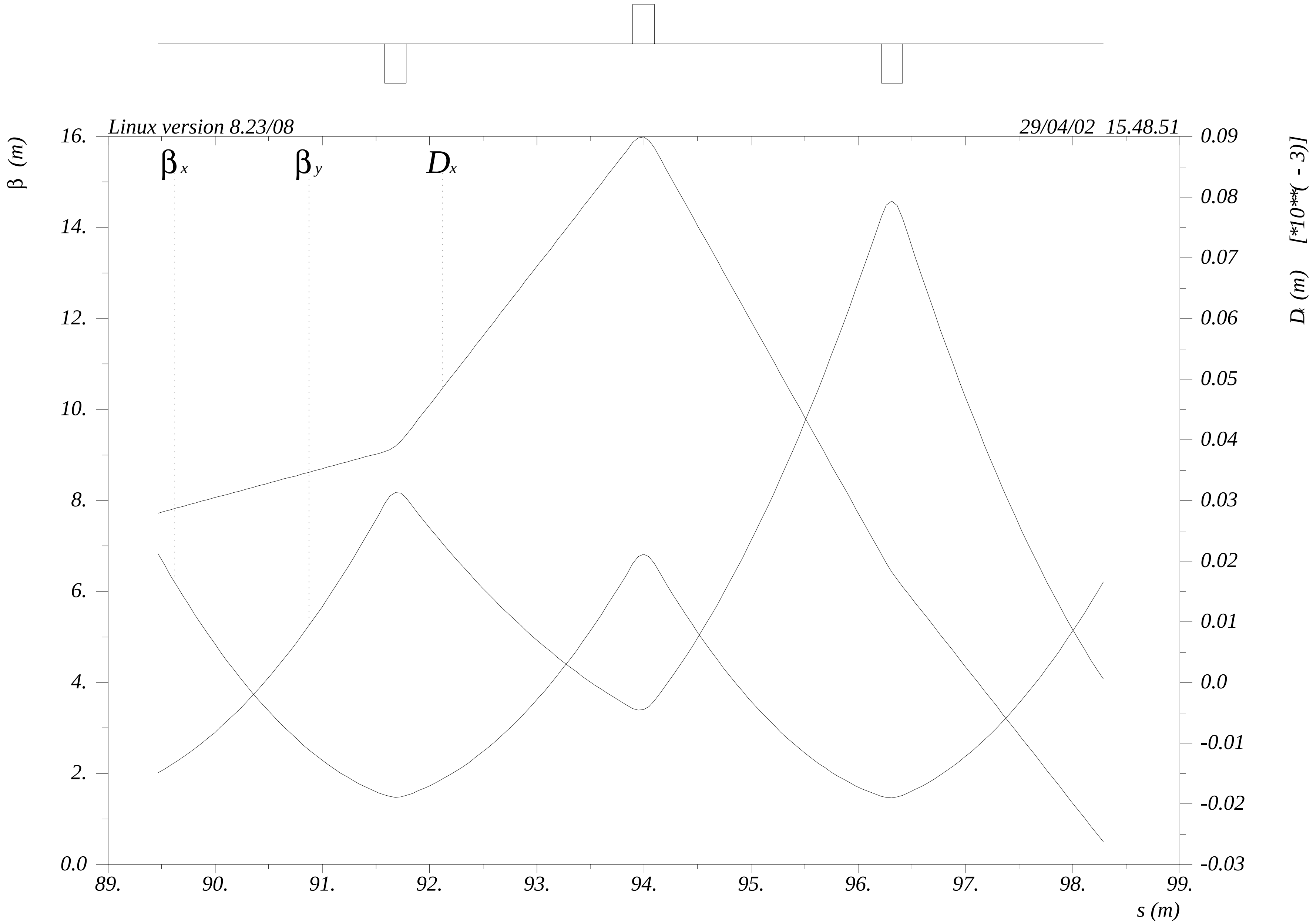
$\delta_E / p_0c = 0.$

Table name = TWISS



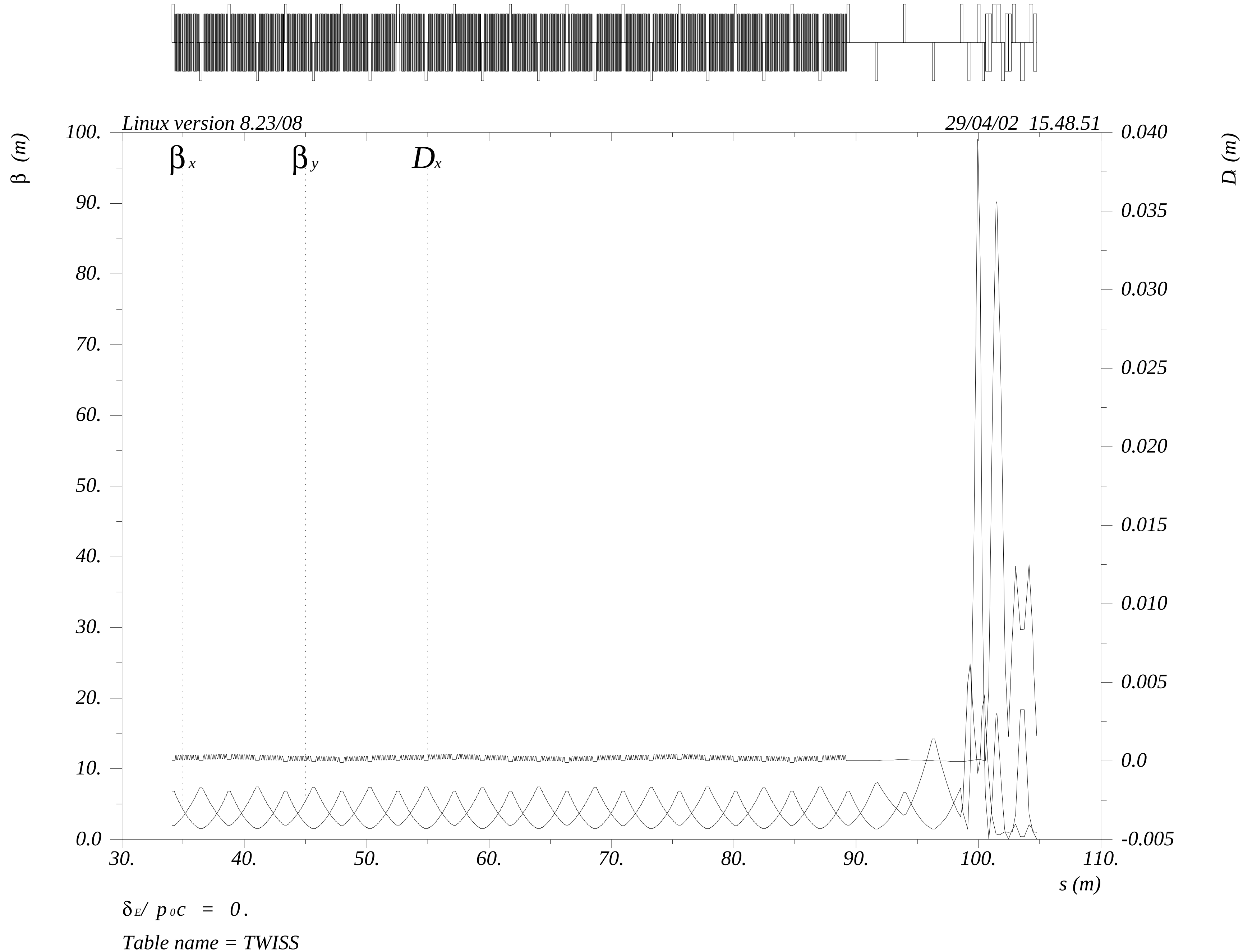
$\delta_E / p_0 c = 0.$

Table name = TWISS



$\delta_E / p_0 c = 0.$

Table name = TWISS



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β (m)
D_x (m)
β_x
β_y
D_x
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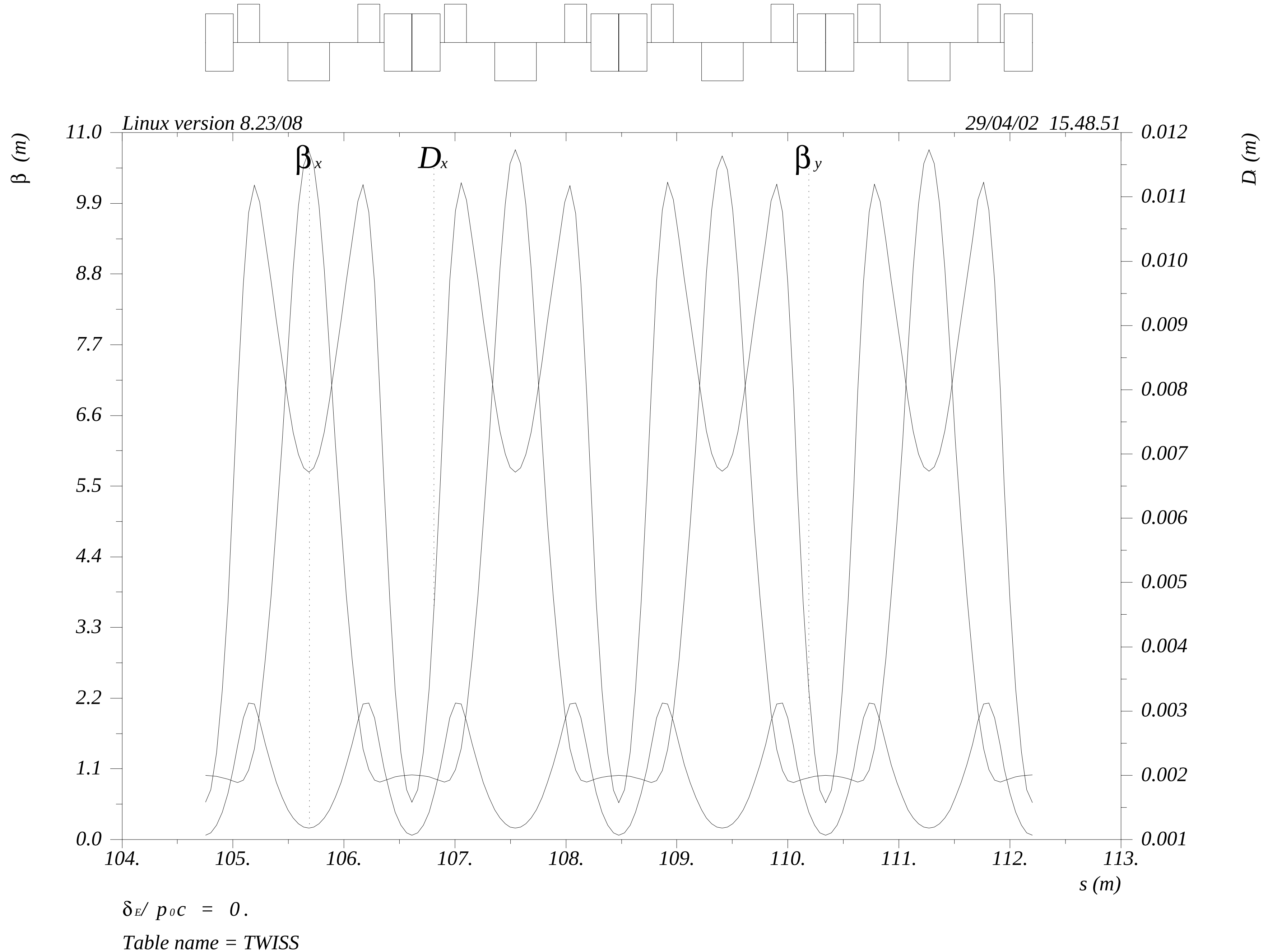
s (m)
$\delta_E / p_0 c = 0.$
Table name = TWISS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β (m)
D (m)
β x
Dx
β y
11.0
9.9
8.8
7.7
6.6
5.5
4.4
3.3
2.2
1.1
0.0
0.012
0.011
0.010
0.009
0.008
0.007
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0.005
0.004
0.003
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104.
105.
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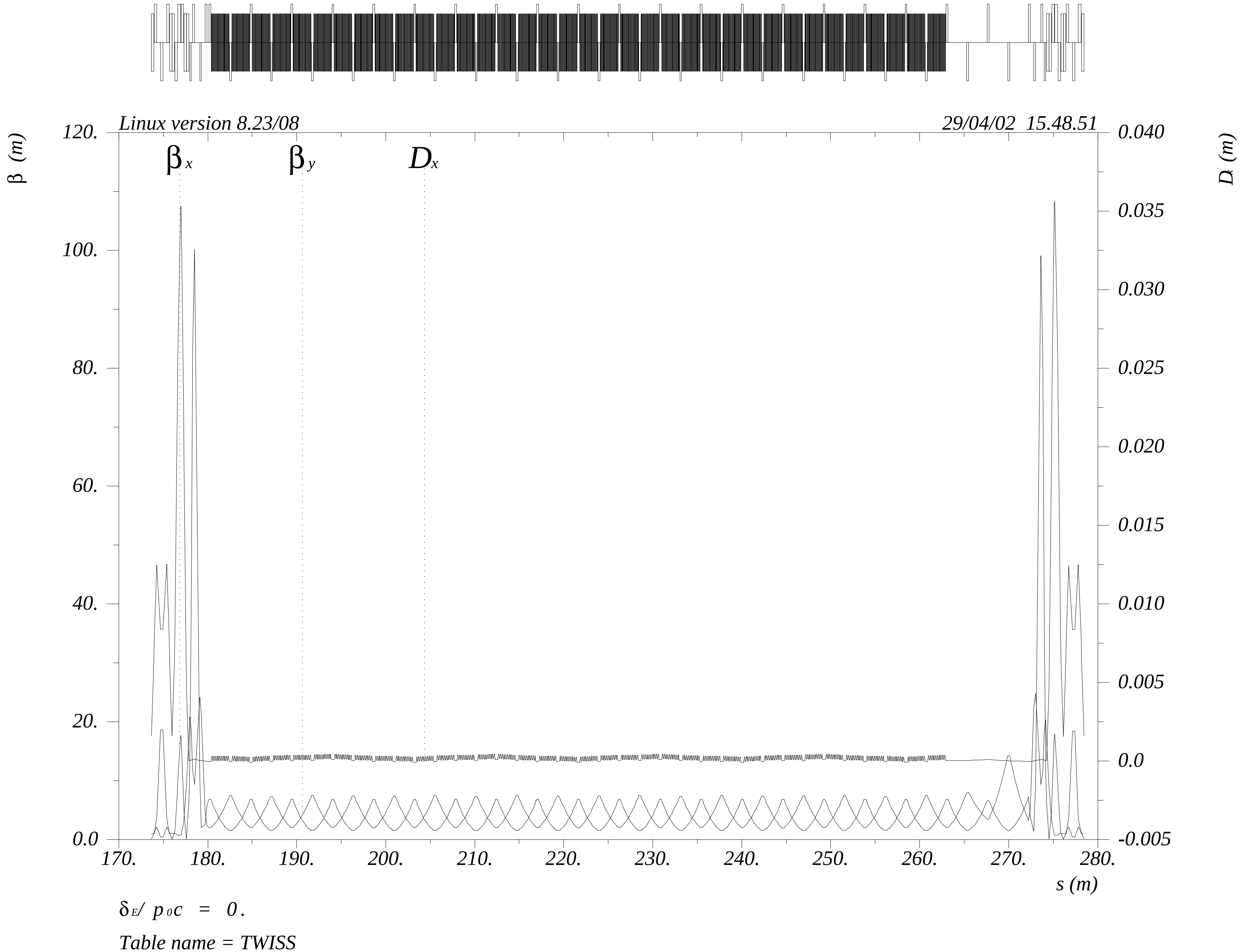
s (m)
δE/ p0c = 0.
Table name = TWISS



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β (m)
D_x (m)
β_x
β_y
D_x
120.
100.
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60.
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0.035
0.030
0.025
0.020
0.015
0.010
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180.
190.
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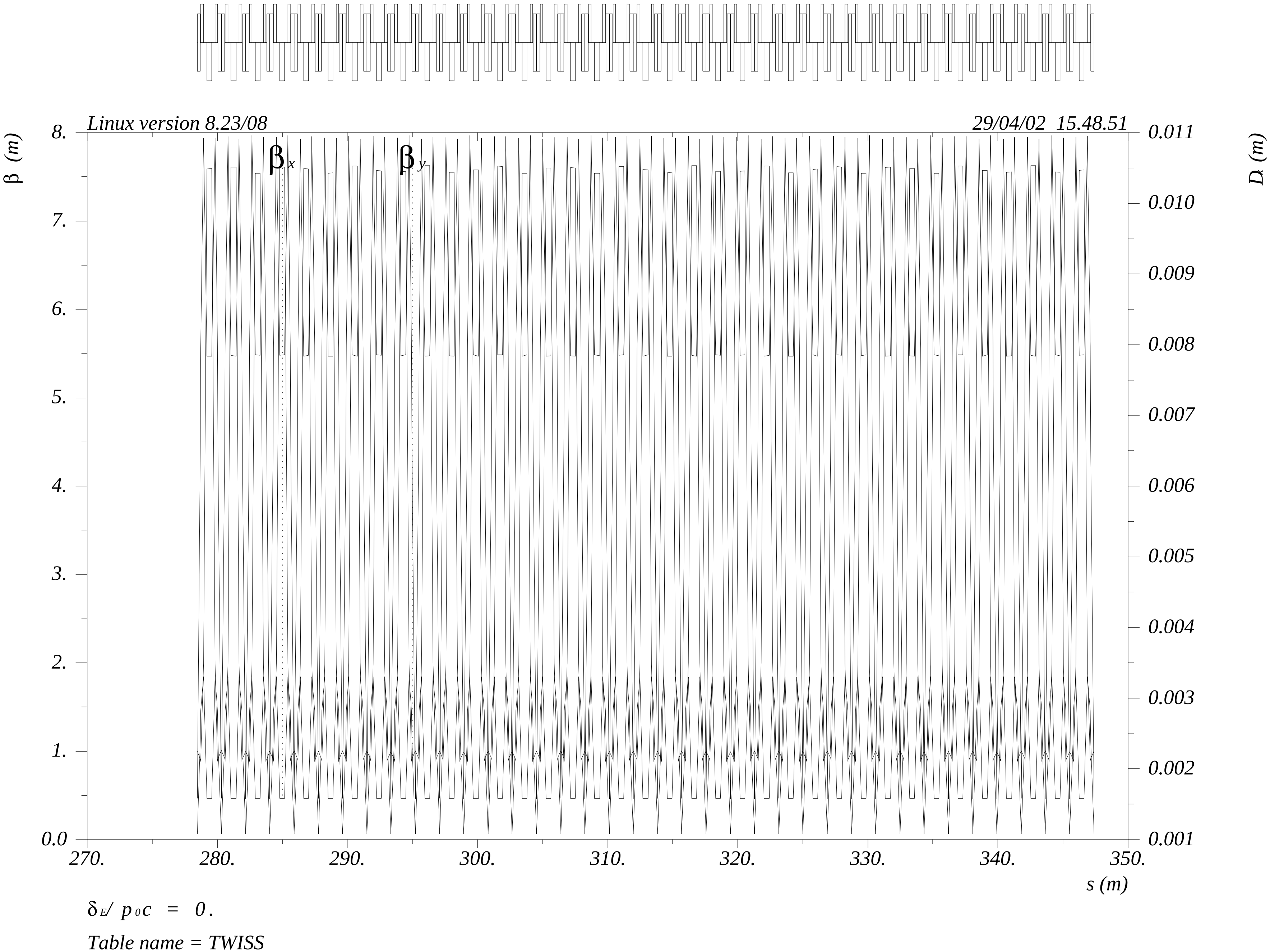
280.
s (m)
$\delta_E / p_0 c$ = 0 .
Table name = TWISS



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29/04/02 15.48.51
β (m)
D (m)
βx
βy
8.
7.
6.
5.
4.
3.
2.
1.
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310.
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340.
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s (m)
δE/ p0c = 0.
Table name = TWISS