Slow ground motion at SPring-8

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I. Introduction

Why do we care about slow motion?

1. SR Users

min - hour	"effective brightness"
hour - days	detector tuning

2. Accelerator

min - hour	machine stability
hour - days	machine-environment
days - year	allignment

3. Others

geodesy, geology, ...

What is slow ground motion caused by?

atmospheric pressure

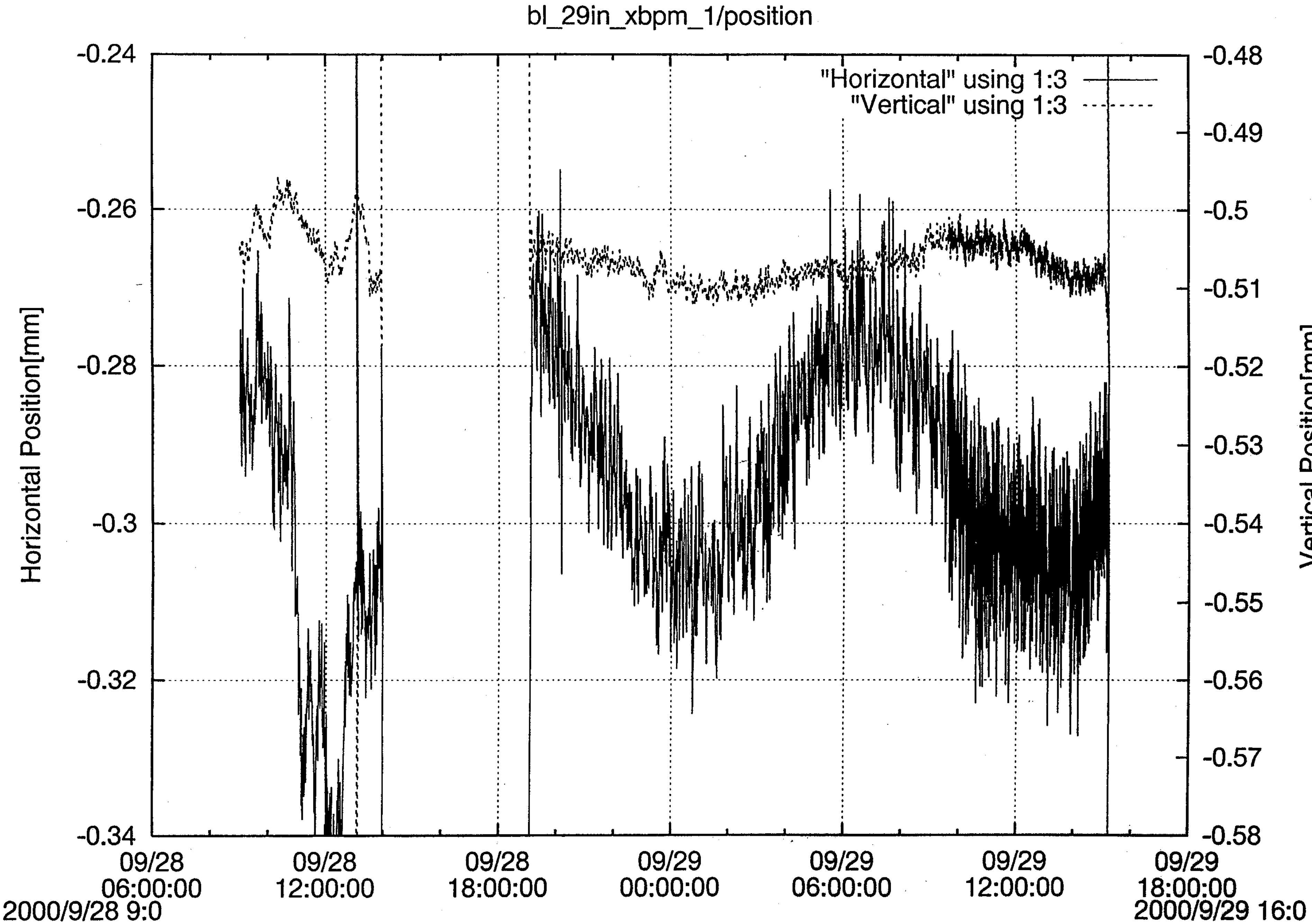
rain fall

earth tides

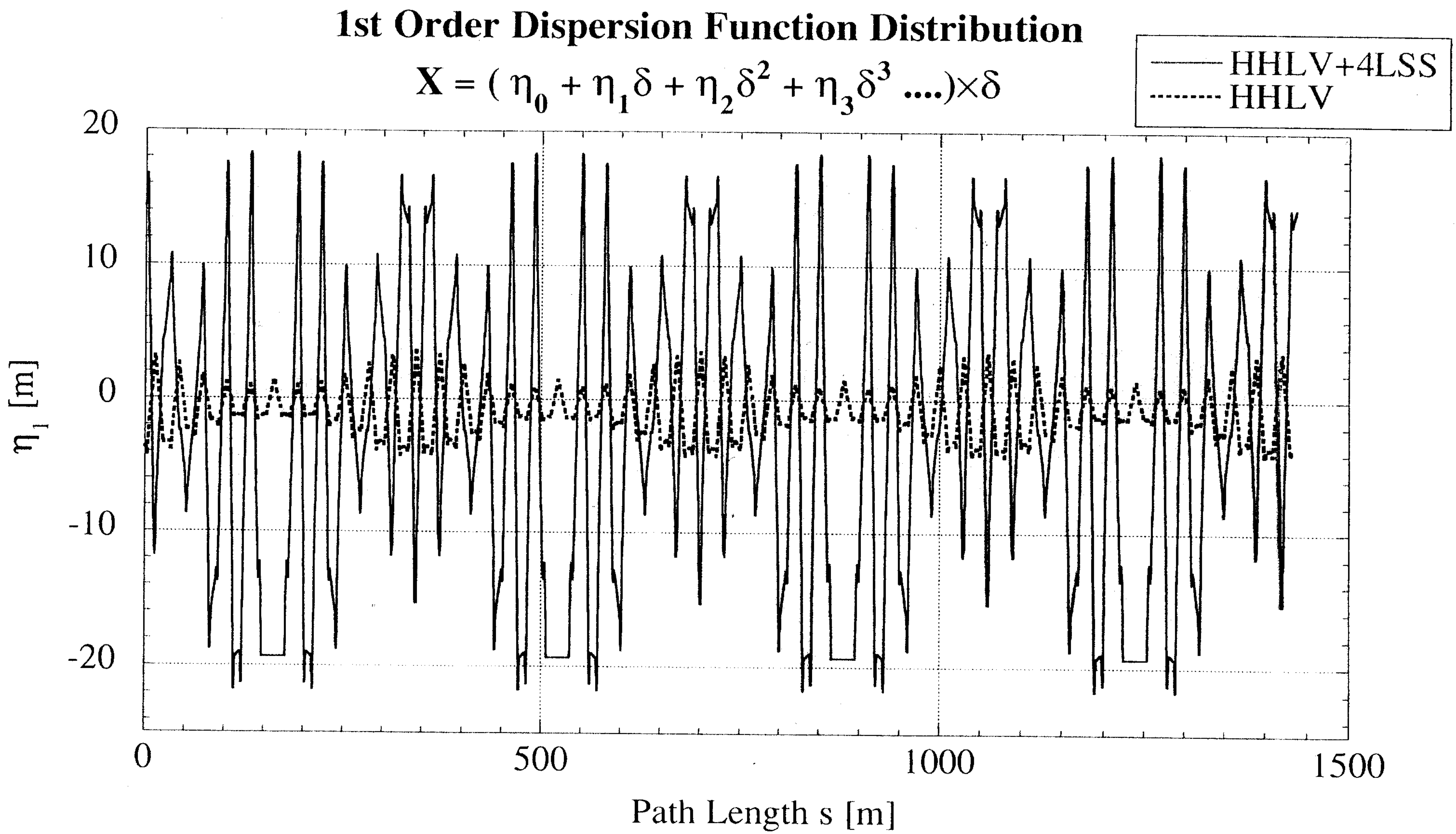
seasonal temperature change

local geographycal effect

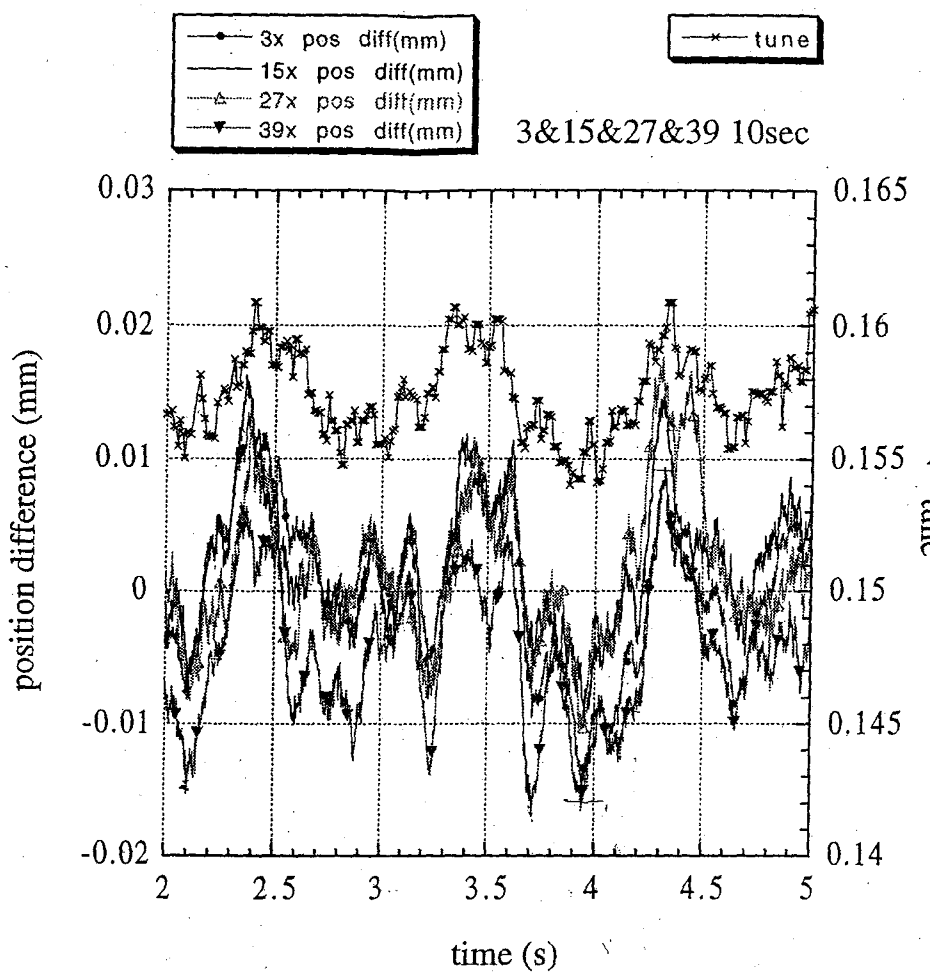
plate motion, sealevel, ...

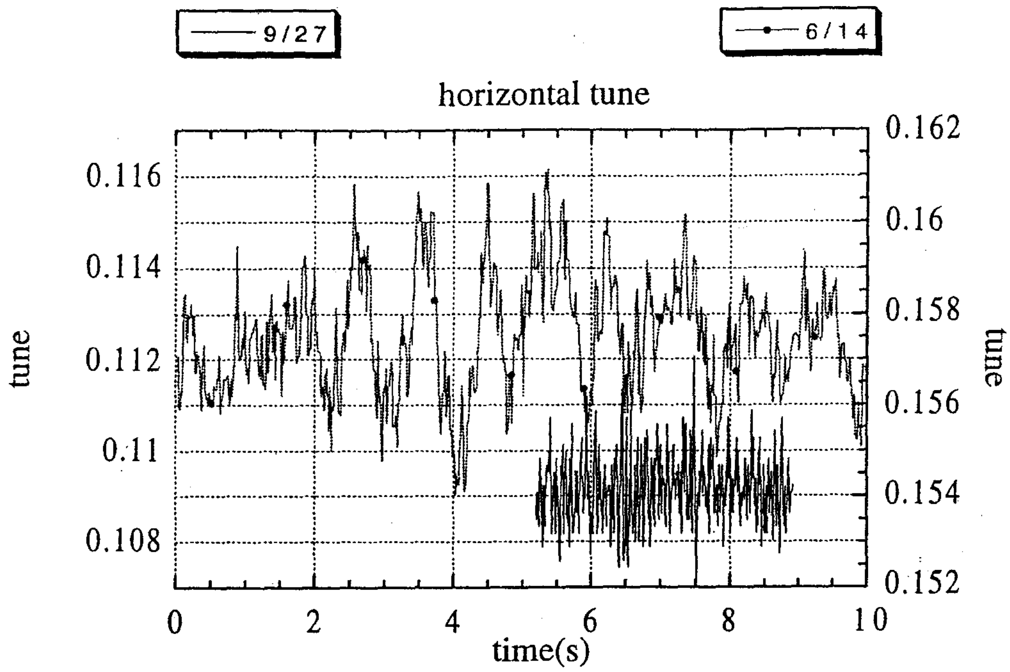


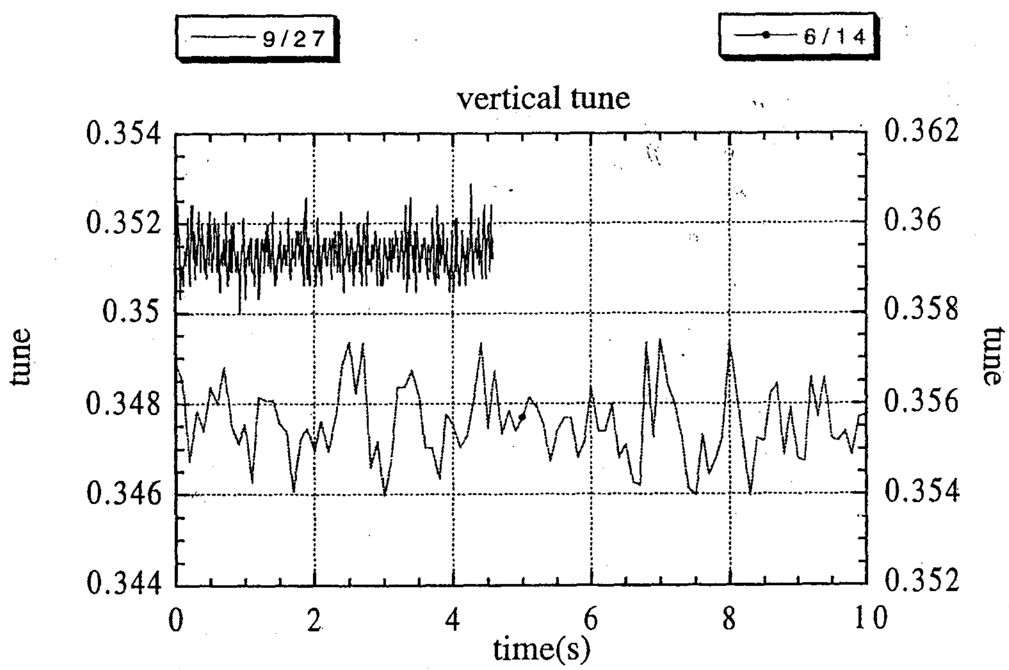
bl_29in_xbpm_1/position
"Horizontal" using 1:3
"Vertical" using 1:3
Horizontal Position[mm]
Vertical Position[mm]
-0.24
-0.26
-0.28
-0.3
-0.32
-0.34
-0.48
-0.49
-0.5
-0.51
-0.52
-0.53
-0.54
-0.55
-0.56
-0.57
-0.58
09/28 06:00:00
09/28 12:00:00
09/28 18:00:00
09/29 00:00:00
09/29 06:00:00
09/29 12:00:00
09/29 18:00:00
2000/9/28 9:0
2000/9/29 16:0



1st Order Dispersion Function Distribution
X = (η0 + η1δ + η2δ2 + η3δ3 ....)×δ
HHLV+4LSS
HHLV
20
10
0
-10
-20
η1 [m]
0
500
1000
1500
Path Length s [m]


3x pos diff(mm)
15x pos diff(mm)
27x pos diff(mm)
39x pos diff(mm)
tune
3&15&27&39 10sec
0.03
0.02
0.01
0
-0.01
-0.02
0.165
0.16
0.155
0.15
0.145
0.14
2
2.5
3
3.5
4
4.5
5
position difference (mm)
hor. tune
time (s)


9/27
6/14
horizontal tune
tune
tune
time(s)
0.116
0.114
0.112
0.11
0.108
0.162
0.16
0.158
0.156
0.154
0.152
0
2
4
6
8
10


9/27
6/14
vertical tune
tune
tune
time(s)
0.354
0.352
0.35
0.348
0.346
0.344
0.362
0.36
0.358
0.356
0.354
0.352
0
2
4
6
8
10

II. The SPring-8 storage ring

Structure of the storage ring

beam tunnel = temperature controlled (±1 deg)

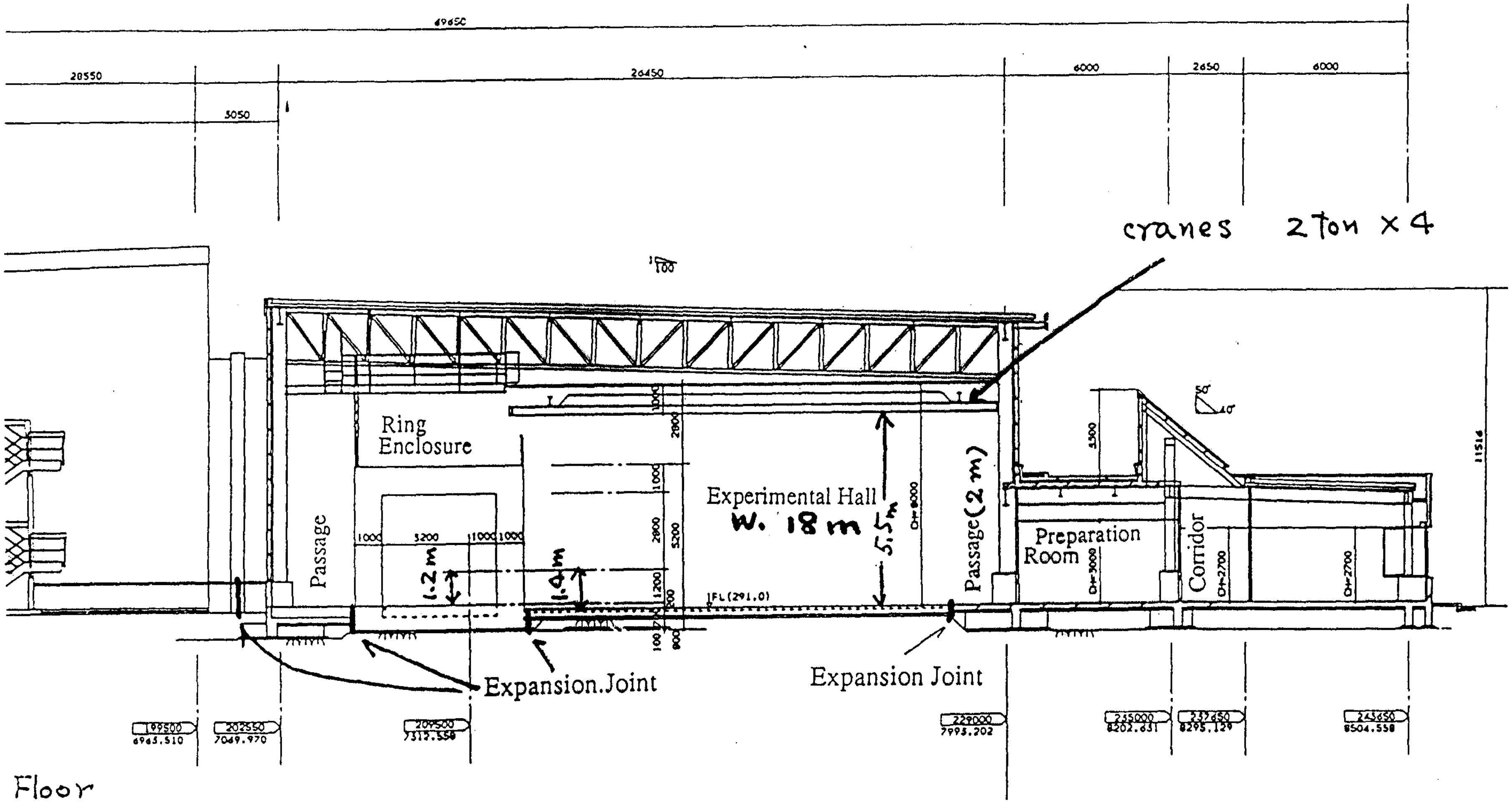
1 meter thick concrete tunnel

on

rigid granite base

The tunnel is separated by joint from other parts of the construction.

Cross Section of the Storage Ring



Floor
Enclosure 290.2m + 0.1m + 0.5m + 0.4m
Exp. Hall 290.6m + 0.1m + 0.2m + 0.1m.

Electron beams in the SPring-8 SR

1. Beam optics

$\varepsilon_H =$ 6-7 nmrad   H-V coupling   < 1 %

$\alpha = 1.4 \times 10^{-4}$

D = 0.27 m

$<\sqrt{\beta_{x,y}}>^2 \approx 16$ m   /   C = 1436 m

Term	Optics	ν_x ν_y	Symm
Sep. 1997 ~ Jul. 1999	Hybrid	51 16	48
Sep. 1999 ~ Jul. 2000	HHLV	43 21	48
Sep. 2000 ~	HHLV + LSS	40 18	4

2. Beam position stability

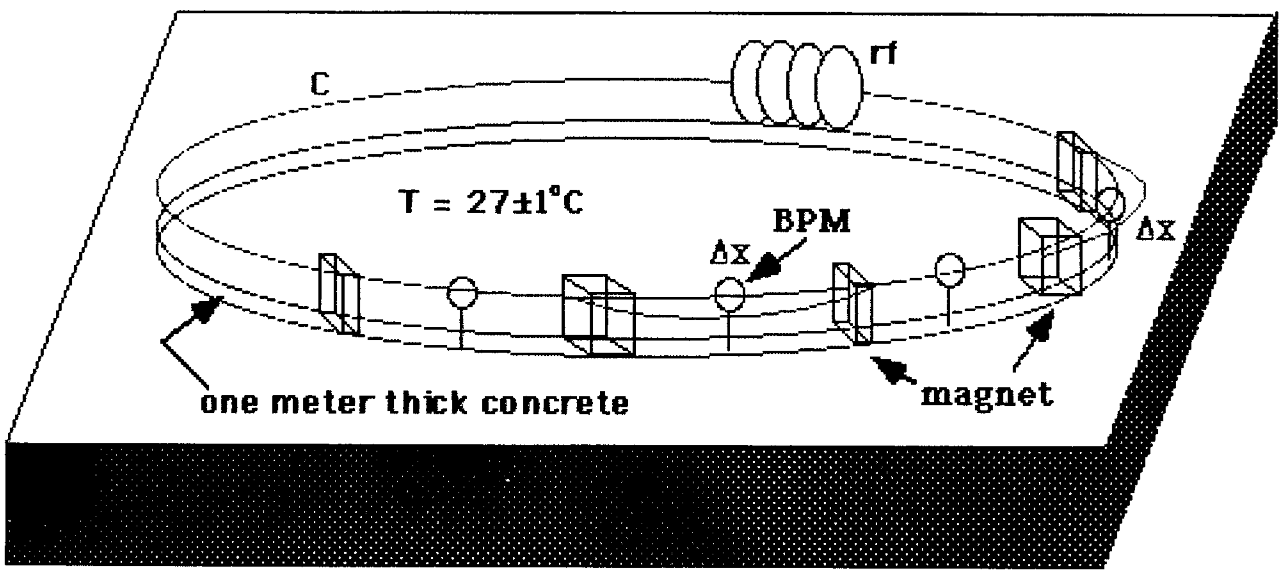
horizontal < 6 μm / week

vertical < 2 μm / week

COD correction / min

III. Earth tides and longer variations

Principle of measuring the ground motion in a circular accelerator



single granite plate

1. Circumference of the electron orbit

   rf = 508579360 Hz $\Rightarrow$ C_0 = 1435.94980 m

2. $C + \Delta C = C_0$

3. $\Delta x = \frac{D}{\alpha} \times \frac{\Delta C}{C_0} \left(= D \frac{\Delta E}{E} \right)$

SPring-8 : D = 266 mm $\alpha = 1.46 \times 10^{-4}$

Key apparatus in measuring ΔC

1. rf master oscillator

$$\frac{\delta\nu}{\nu_{rf}} \begin{cases} < 10^{-9} & \text{in 10 days} \\ < 10^{-8} & \text{in a year} \end{cases} \Bigg\} \text{ without GPS correction}$$

$$\frac{\delta\nu}{\nu_{rf}} = 10^{-9} \Rightarrow \delta C = 1.5\ \mu m$$

⟶ Fig.

2. Beam position monitor (BPM)

$$\sigma_{BPM} = 2.5\ \mu m\ /\ \text{BPM}$$

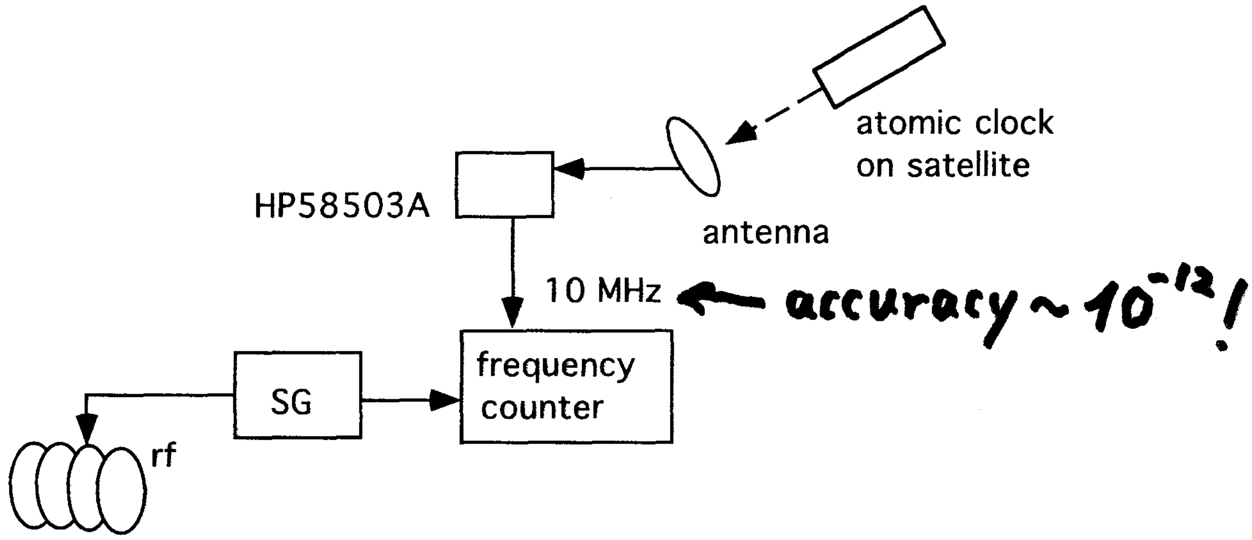
$$\Rightarrow \quad \sigma_{\Delta C} = 0.2\ \mu m \text{ with 88 BPMs}$$

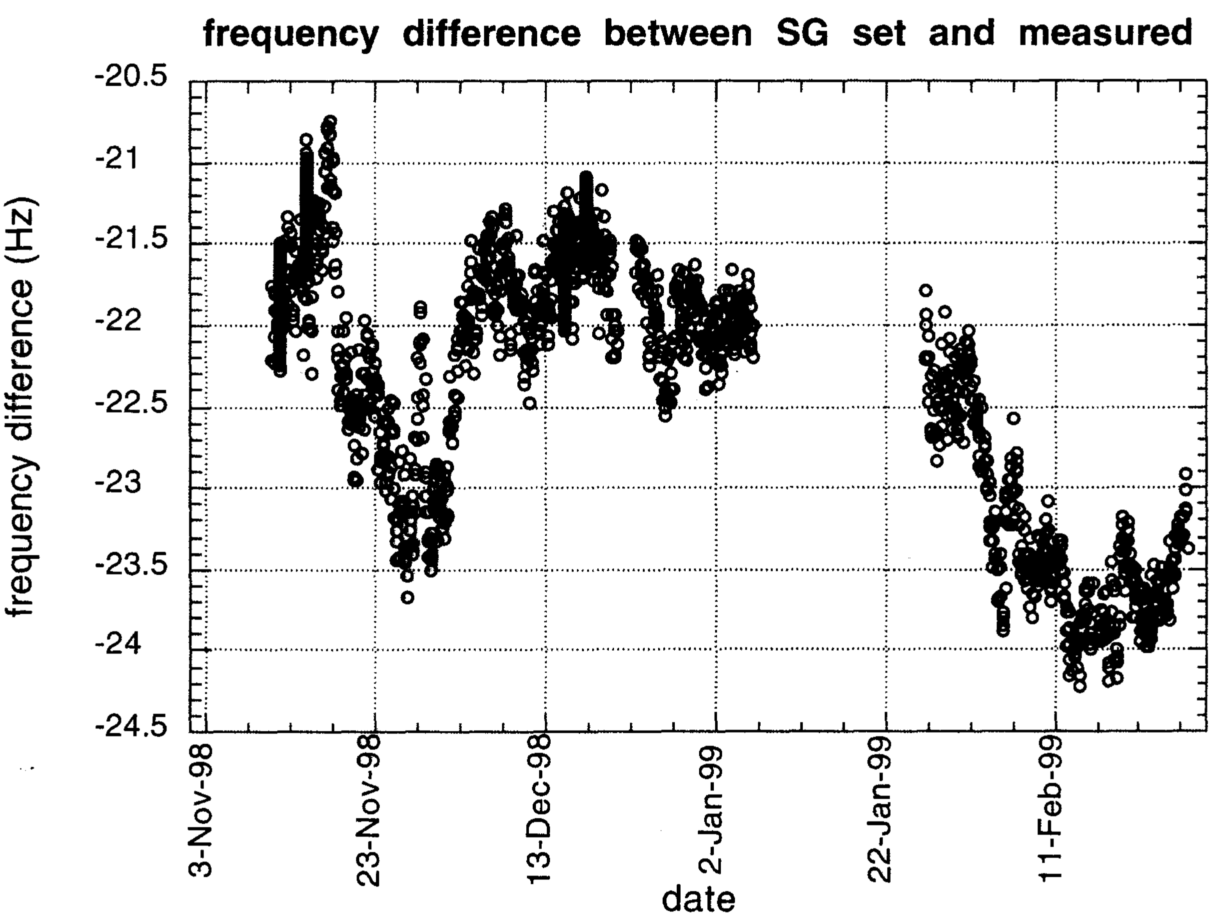
⟶ Fig.

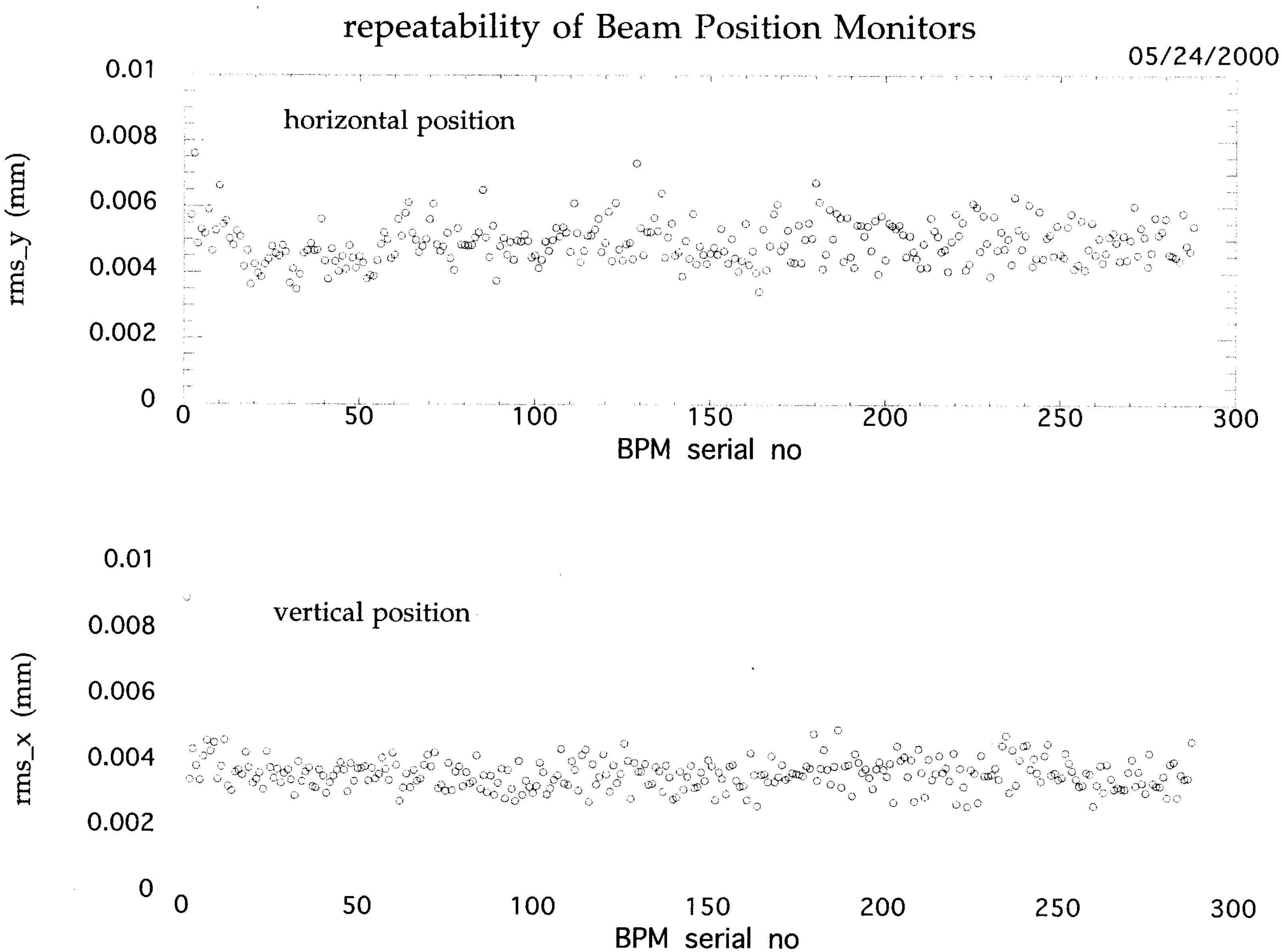
Note: effect of the earth tides $\sim 10^{-8}$

$$\Rightarrow \quad \Delta C \sim 10\ \mu m$$

Stability of the rf master generator






repeatability of Beam Position Monitors
05/24/2000
horizontal position
rms_y (mm)
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250
300
BPM serial no
vertical position
rms_x (mm)
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250
300
BPM serial no

is the nominal energy of the beam and reference value of the machine circumfer-

this mechanism and an assumption that of BPMs with respect to that of Q's re- hanged during the deformation, we may the signatures observed in X_0 are at- :o changes in the machine circumference ct the amount of the change ΔC.
;iven in Eq. (1) with $n = 0$ is composed of ibution from the horizontal COD in the : regions, $x_{\rm disp}$, and one from that in the rsive regions, $x_{\rm nondisp}$. If the signatures in :tually due to the changes in the machine ence, they should not show up in $x_{\rm nondisp}$. ats lying in the upper region in Fig. 2 are

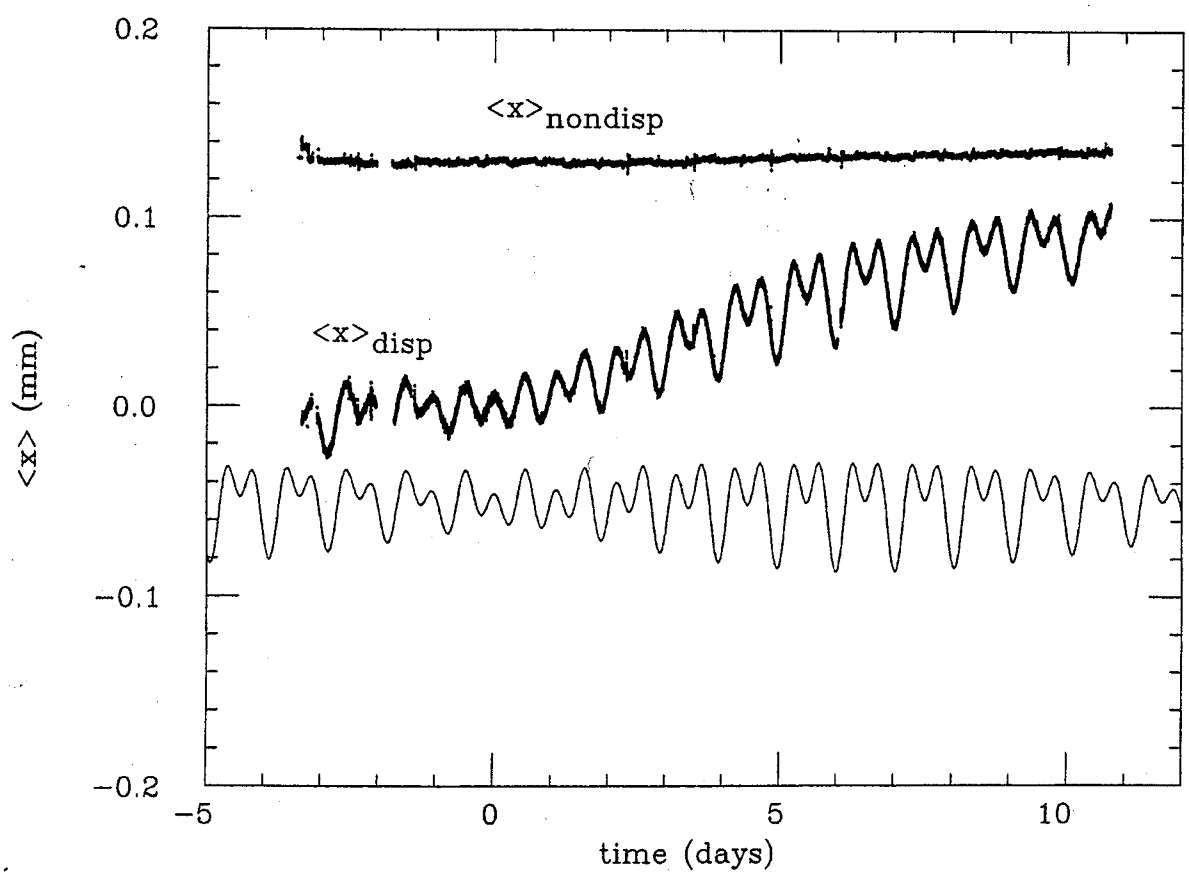
also observed in Fig. 1. In this plot, we do n observe the signatures of the pseudoperiodic ch: nges in $x_{\rm nondisp}$ as expected.

Changes in $x_{\rm disp}$ due to the changes in the m: chine circumference can be written as

$$\Delta x_{\rm disp} = -\frac{D}{\alpha}\frac{\Delta C}{C_0}, \qquad ($$

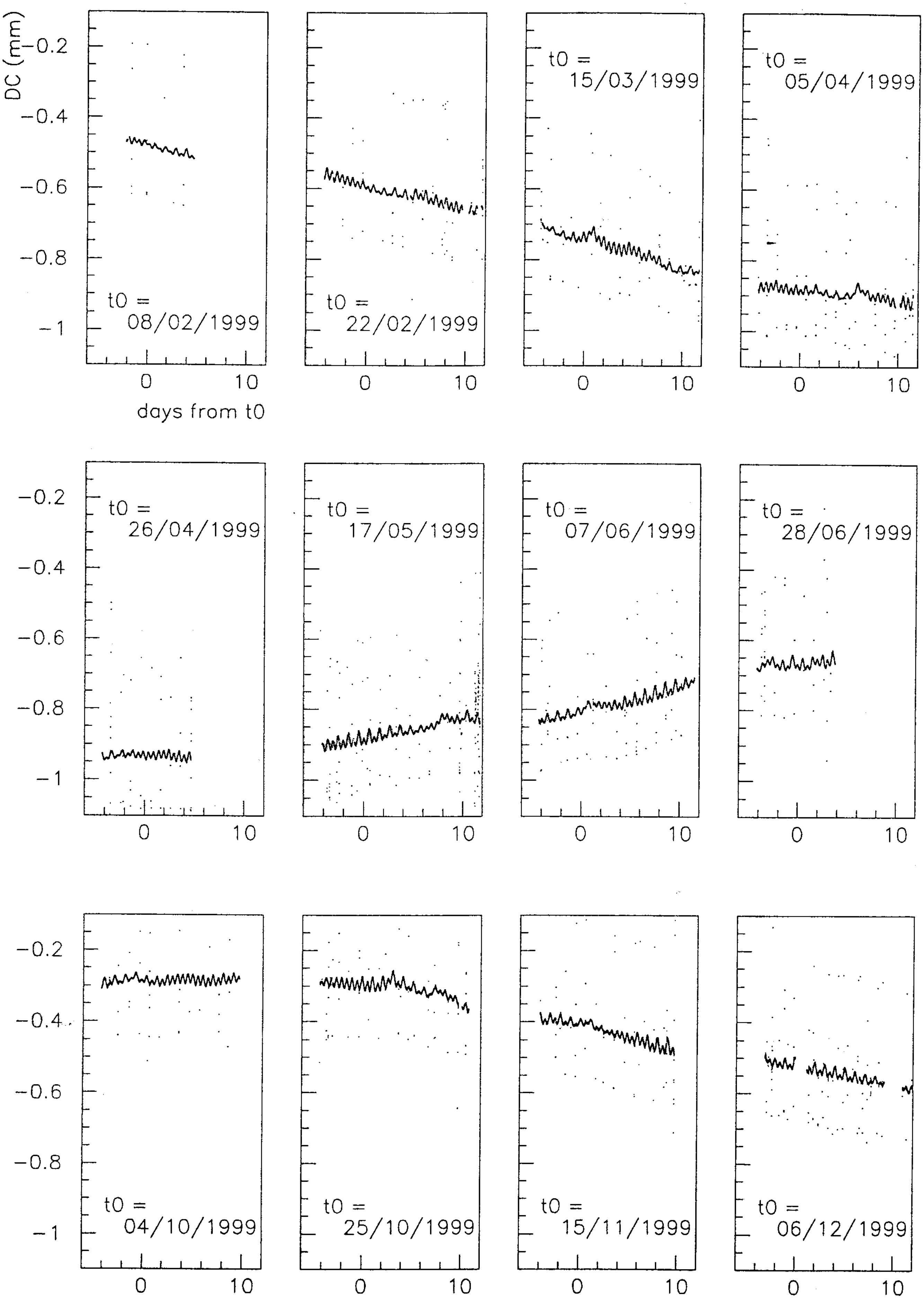
where D denotes the local dispersion function at tl position of the measurement. In the SPring-8 sto age ring, parameters in the above equation a: given as $\alpha = 1.460 \times 10^{-4}$, $D = 0.266\,\mathrm{m}$ and C_0 : 1435.948 m and we have a relation

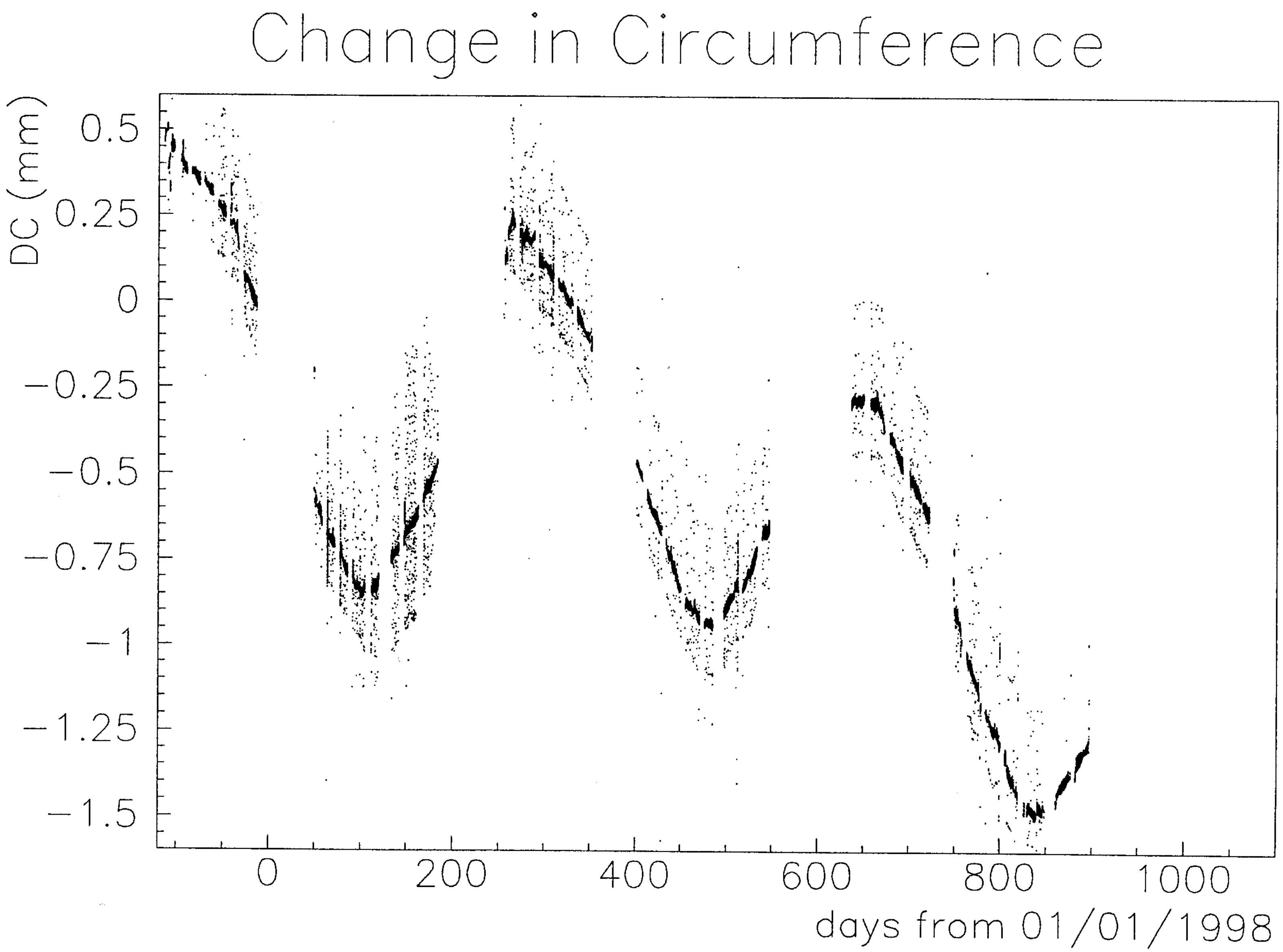
$$\Delta C = -0.79 \times \Delta x_{\rm disp}. \qquad ($$



·age of the horizontal COD in the nondispersive regions (upper points) and the dispersive regions (lower points) plott . The data for the nondispersive regions are shifted upward by 0.1 mm by a technical reason of drawing. The data were tak s during a term from 4 to 18 December, 1997. The origin of time on the horizontal axis is at 00:00:00 on 8 December 19(ırve is the theoretical expectation for phases and relative strengths of changes in $x_{\rm disp}$.

Change in Circumference




Change in Circumference
DC (mm)
0.5
0.25
0
−0.25
−0.5
−0.75
−1
−1.25
−1.5
0
200
400
600
800
1000
days from 01/01/1998

V. Summary and discussion

- Slow ground motion of the order of 10^{-9} is visible at SPring-8 through variations in machine circumference of the SR. It is sometime useful.

- There is no long term drift in the GPS corrected rf. The long term drift in the BPM system is a matter to be justified.

- The long term behaviour of the circumference is not fully understood. It may be a good idea to introduce a SG in the site and see the correlation between them.