Magnet Issues, Circumference Drift

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(KEKB Magnet Group)

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1. Magnet Issues (wiggler magnet)
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1. Magnet Issues
(K. Egawa, M. Masuzawa)

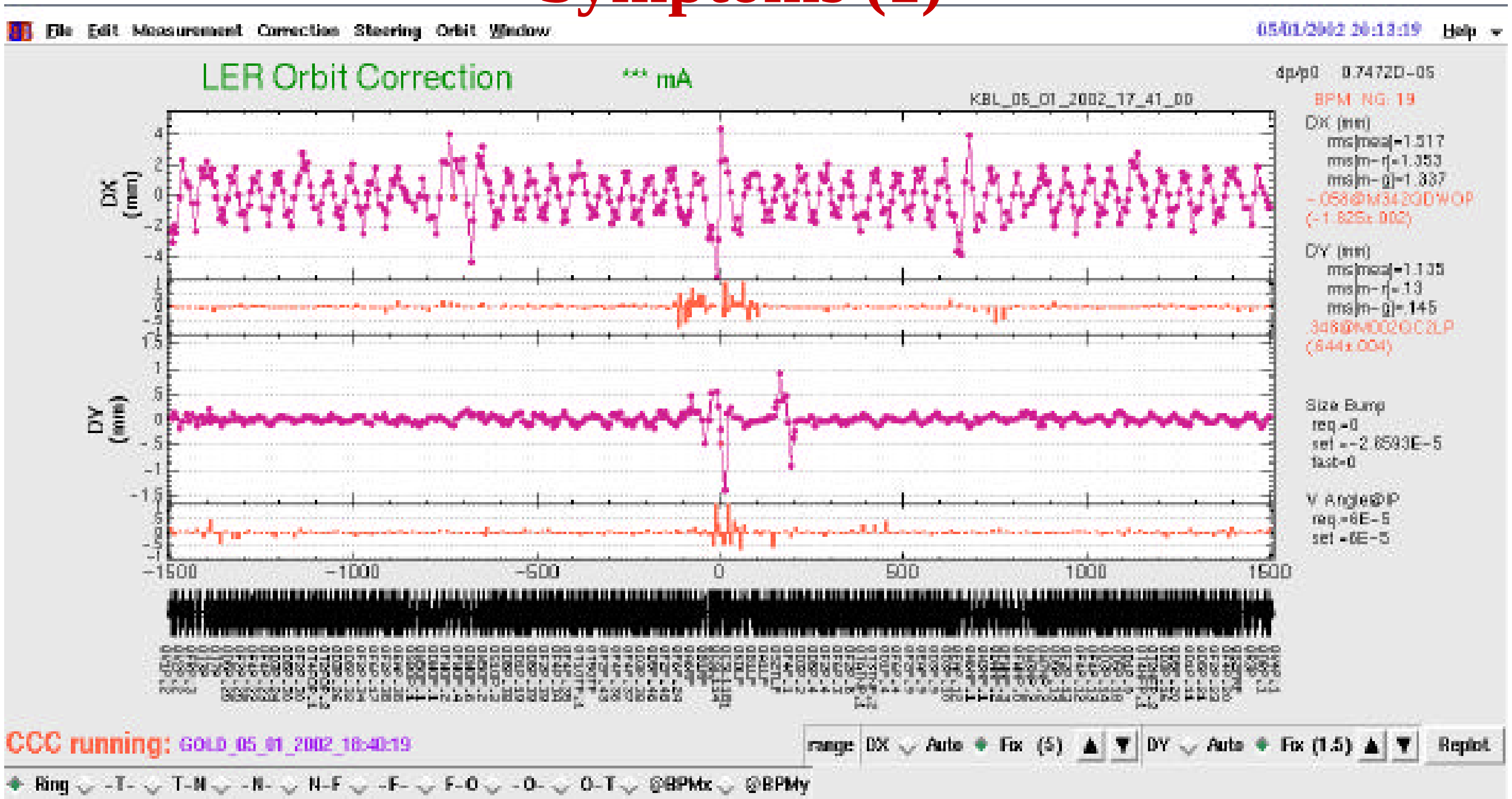
We had no major problems except:

2 wiggler magnets had layer short problems, one in the spring of 2001 and the other one in May 2002.

- Temporarily bypassed a pair of wiggler magnets.
  - (There are 76 pairs of wiggler magnets in the LER)
- Replaced them with spare coils during the following shutdown periods.

1. Magnet Issues

Symptoms (1)



- Horizontal orbit distortion appeared.
- An error-kick analysis pointed to a wiggler magnet.

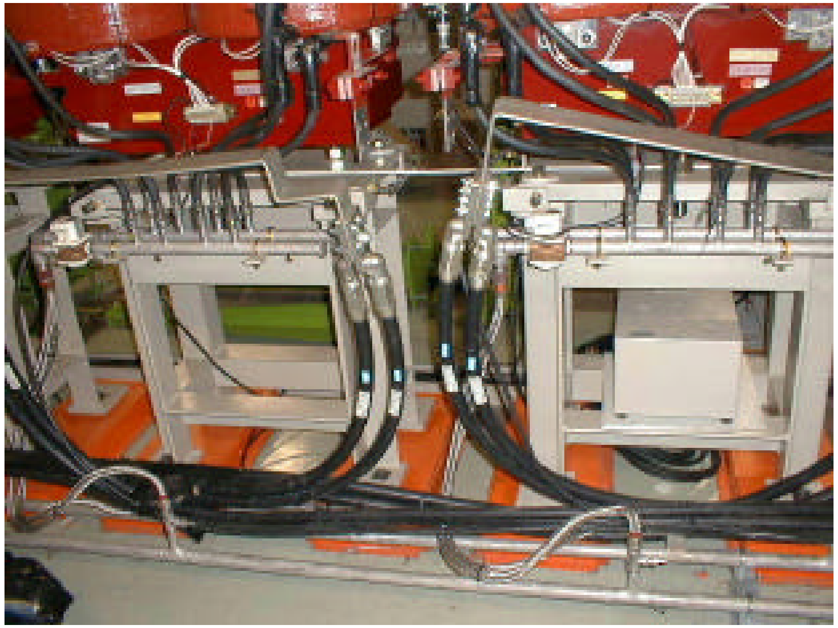
1. Magnet Issues

Symptoms (2)

V_coil(v)	RU	RD	LU	LD
BW1OLP_30	2.5131	3.0150	3.0332	3.0380
BW1OLP_29	3.0036	3.0025		

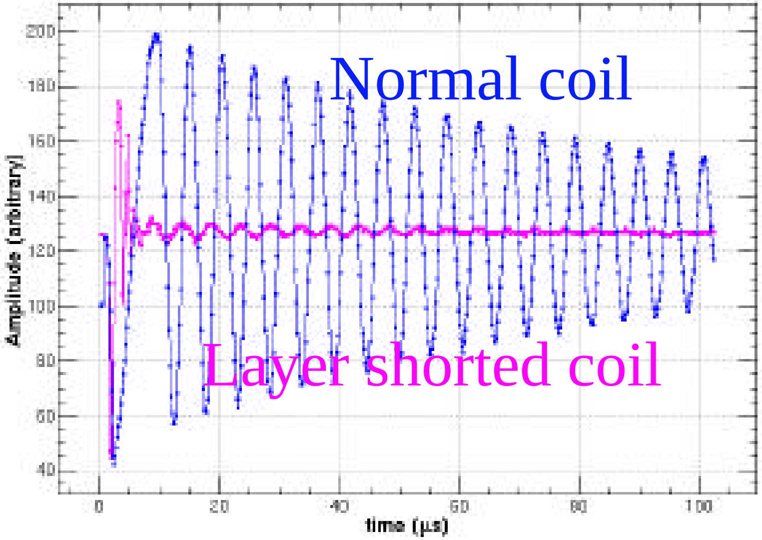
DC Voltage across one coil was lower than the others, indicating a layer short.

A pair of wiggler magnets bypassed.



1. Magnet Issues

Impulse test at the manufacturer



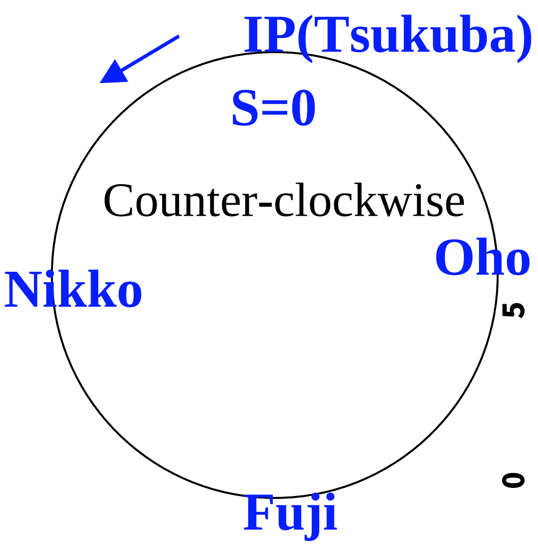
- They removed the insulating materials after the impulse test to search for burnt spots but did not find any.
- The investigation into the location and the causes of the problem is still continuing.

2. Tunnel Level Changes
(R. Sugahara, Y. Ohsawa)

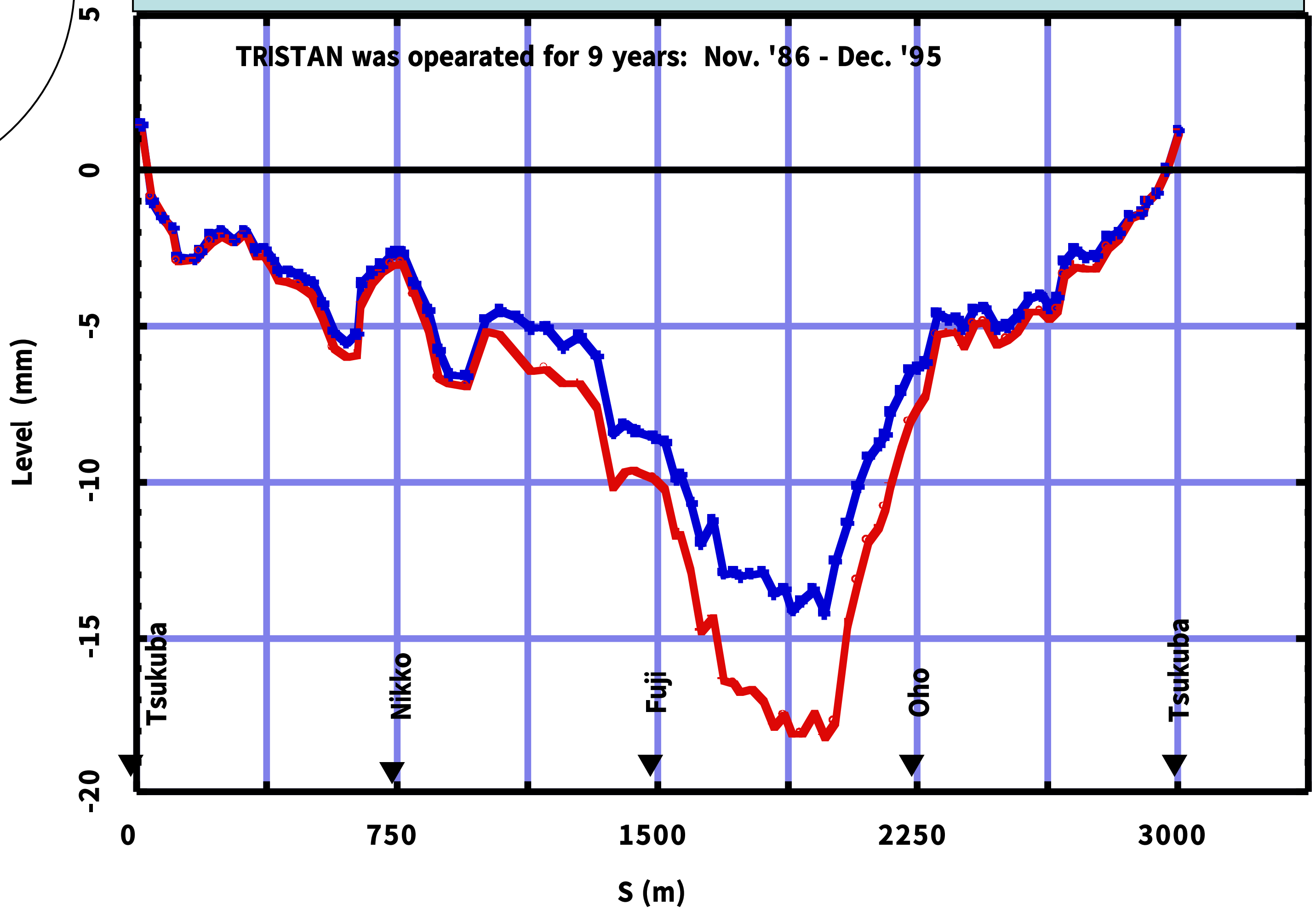
- The level markers on the tunnel wall have been surveyed 6 times since 1996.
  - **1st survey: June.1996**
  - **2nd survey: Aug.1997**
  - **3rd survey: Feb.1998**
  - **4th survey: Oct.1998**
  - **5th survey: Jul.2001**
  - **6th survey: Aug.2002**

- The results of these surveys are summarized.

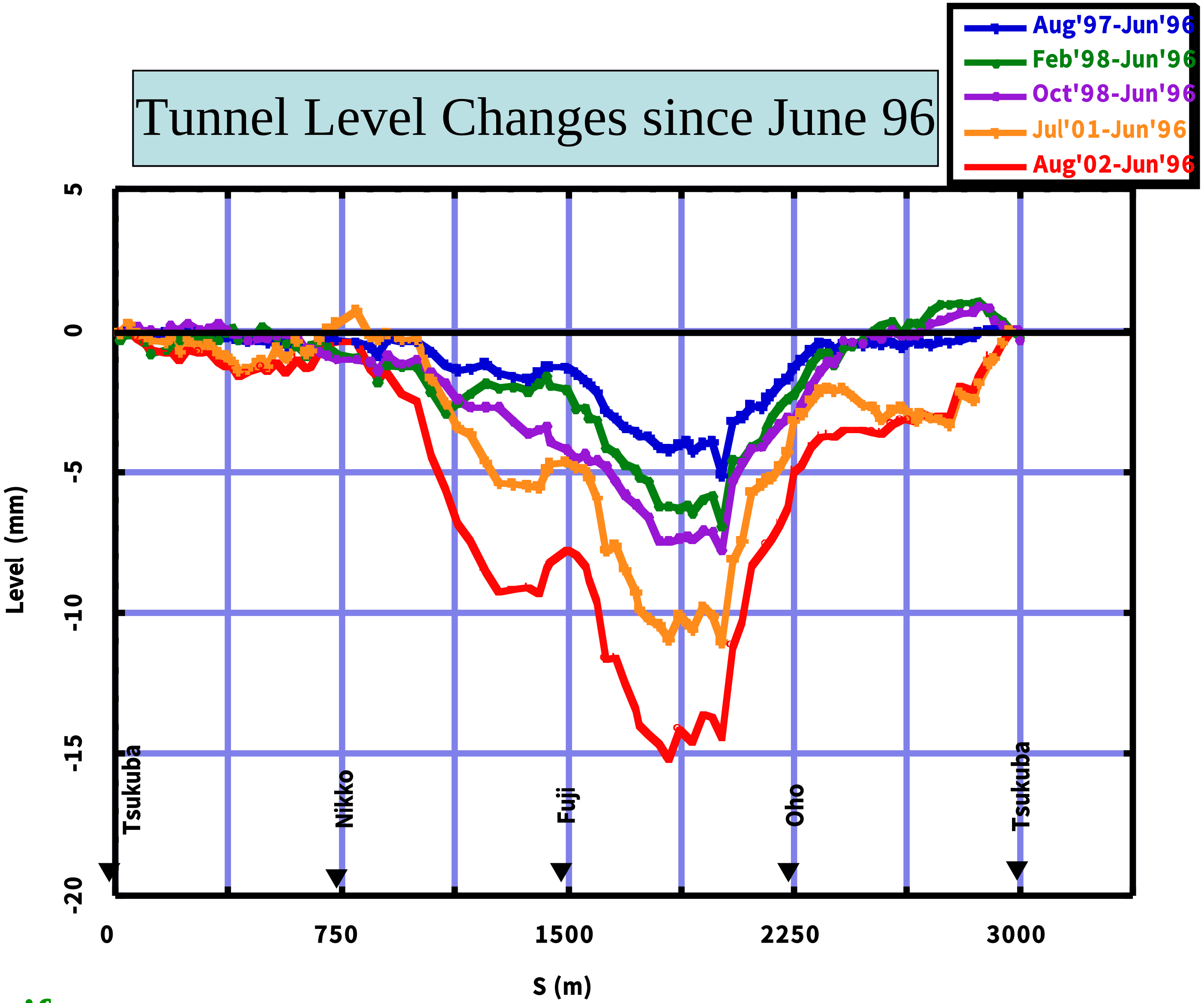
2. Tunnel Level Changes



Tunnel Level Changes (blue line) during the 9 years of TRISTAN operation.



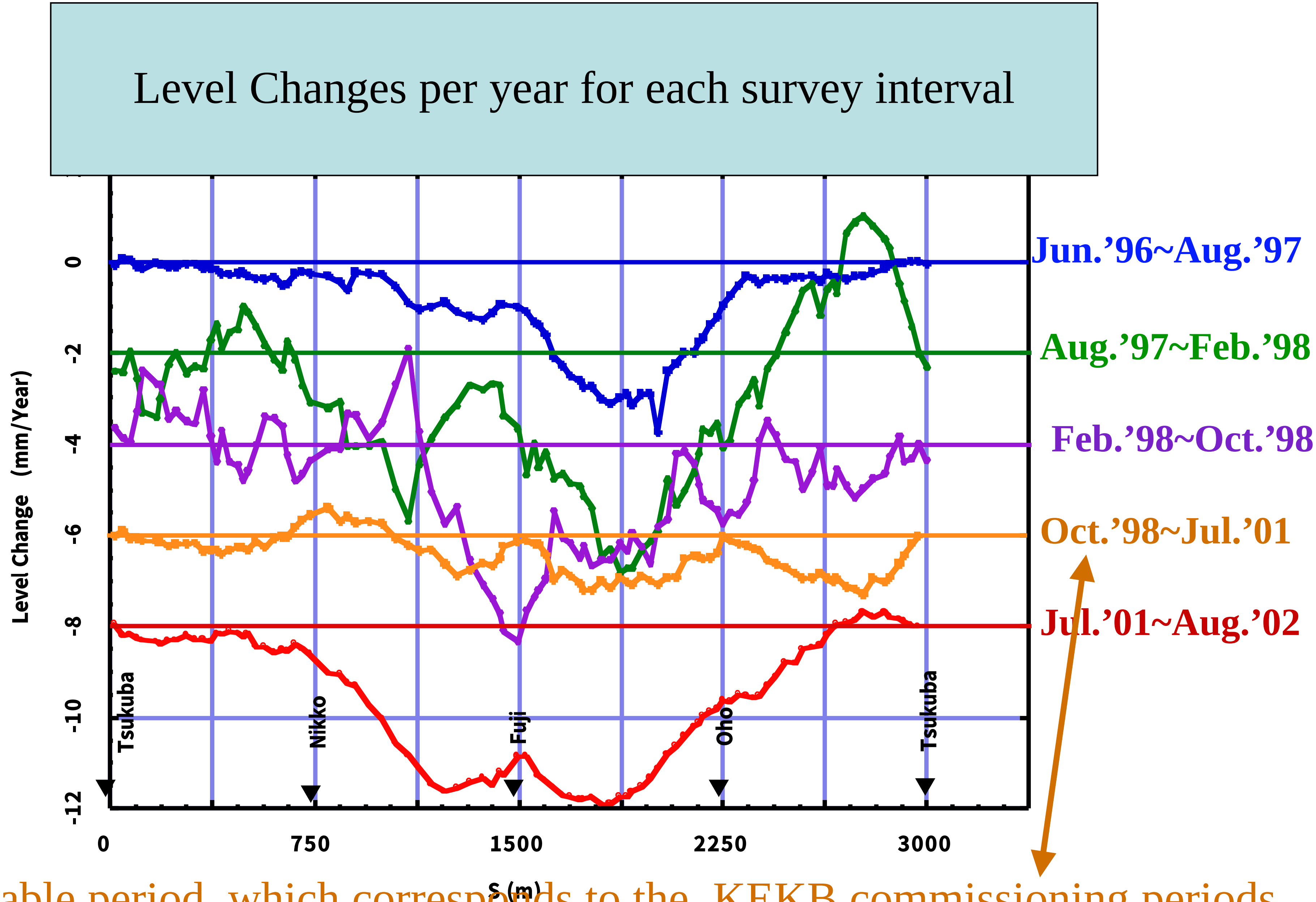
2. Tunnel Level Changes



(1)Not uniform

(2)Largest drift between Fuji and Oho (south tunnel), 2.5mm/year

2. Tunnel Level Changes



Stable period, which corresponds to the KEKB commissioning periods.

2. Tunnel Level Changes: Summary

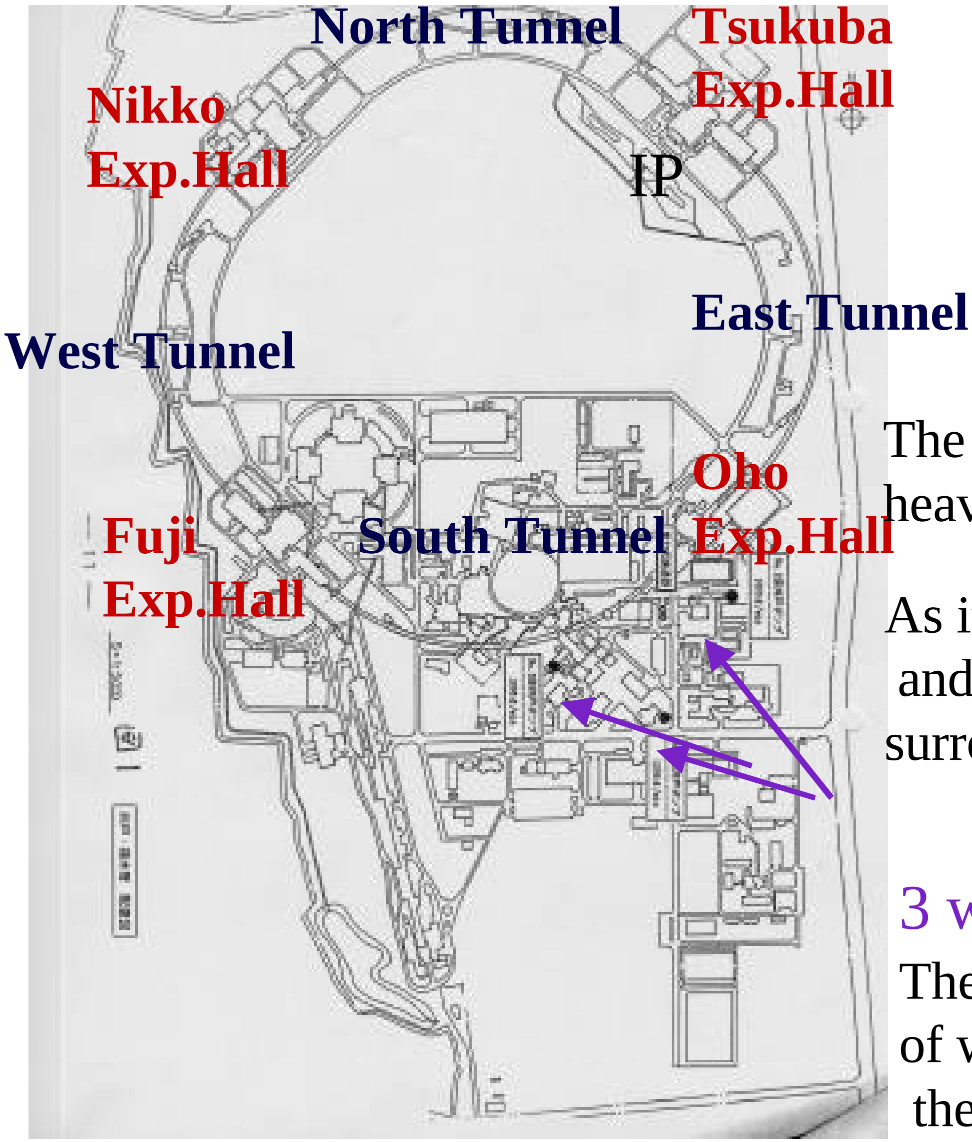
- **The south tunnel has been sinking with respect to the IP.**
- **(a)~4mm/year during the construction and in the summer of 2002.**
- **No tunnel air temperature control.**
- **(b)Very stable during the KEKB commissioning.**
- **Tunnel air temp. was kept constant within ~ +/-1℃.**

- Why south tunnel??

→ Well

→ Heavier (more likely?)

2. Tunnel Level Changes: Summary



The south tunnel section is more heavily built up.

As it goes through cycles of expansion and contraction, it loses its grip on the surrounding sub-soil?

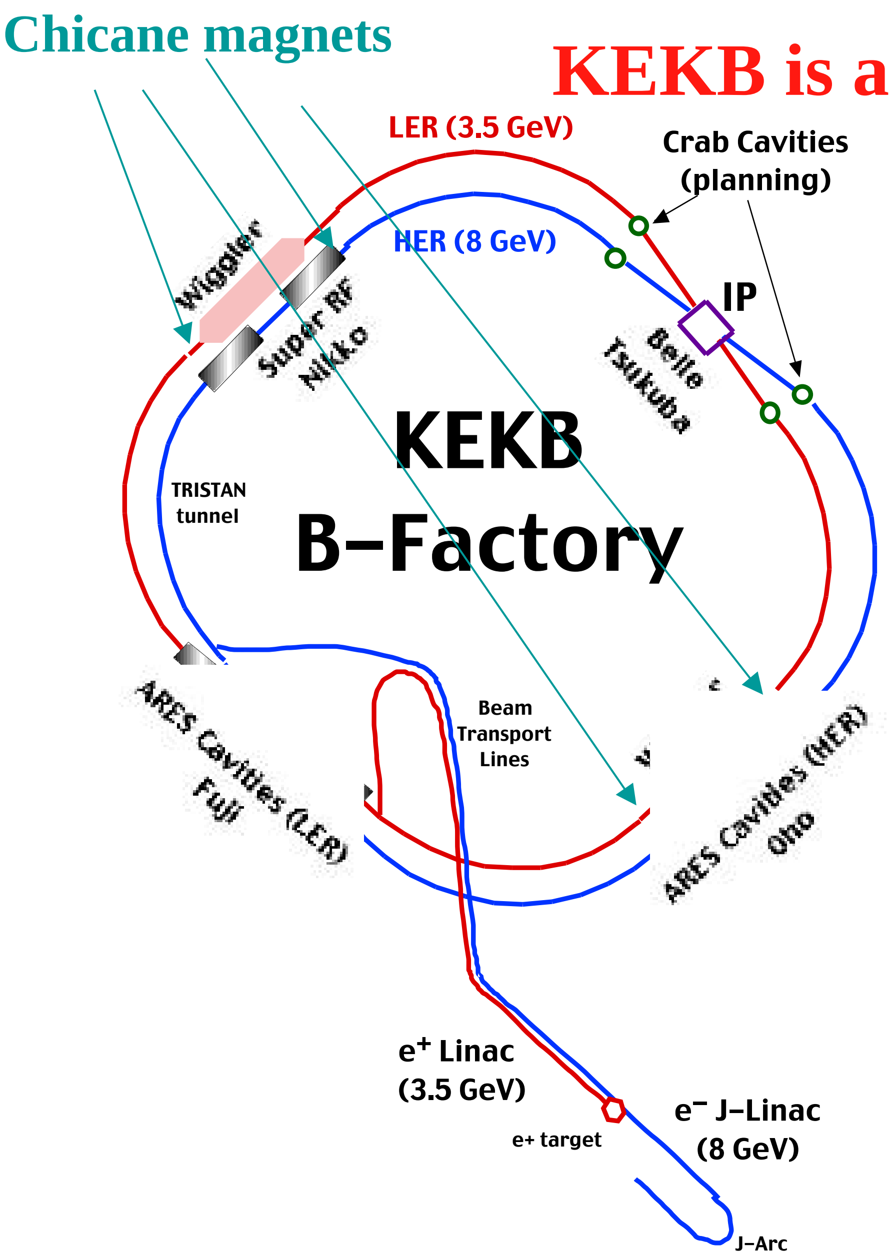
3 wells

The ground retains a large amount of water, which is pumped up at the rate of several hundred tons/day.

3. Circumference Drift
(H. Koiso, K. Oide, R. Sugahara, N. Yamamoto,
M. Yoshioka, M. Masuzawa)

3-1. Overview

KEKB is a double ring collider



Four arc sections:
Founded on gravelly diluvial layer ~12m below the GL.

Four experimental buildings:
2 stories above ground, 4 stories below ground. The basement floors(16m below GL, diluvial clay strarum) are built on pile foundations, the piles extending to 40m below GL (gravelly layer).

Four straight sections:
Built on pile foundations.

There are expansion joints every 50-60 m in the arc and straight sections.

3-1. Overview

KEKB tunnel cross section

80 cm concrete

3-2. Circumference Correction Methods

Measurement and correction of Δl

Design dispersion

$$\frac{\Delta P}{P_0} = \frac{\sum_i x_i \eta_{xi}}{\sum_i \eta_{xi}^2}$$

Design circumference

$$\Delta l = \alpha \frac{\Delta P}{P_0} C_0$$

Momentum compaction factor ~3.4e-04

3-2. Circumference Correction Tools

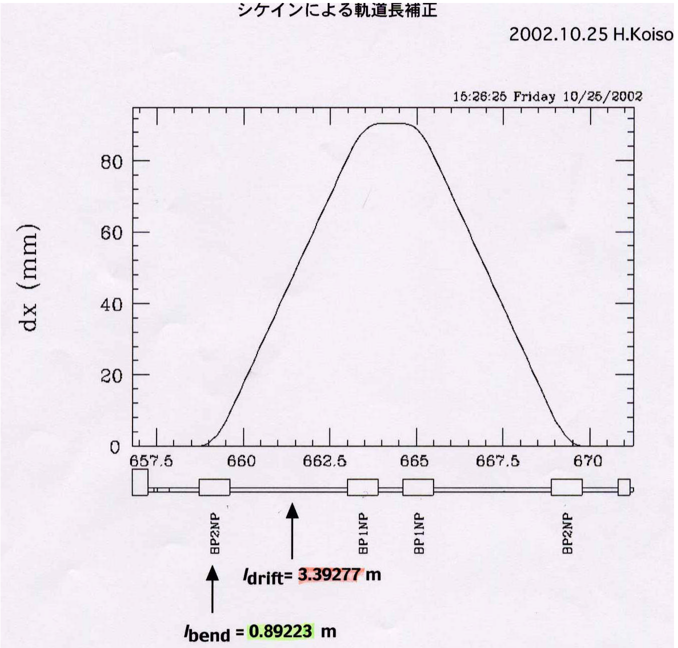
LER

– By changing the strength of the chicane magnets : 4 sets of bending magnets placed on both sides of the Nikko/Oho wiggler sections. The circumference correction system has been incorporated in the '**CCC**'(**C**ontinuous **C**losed orbit **C**orrection, every 20-30 seconds).

HER & LER

– By changing the RF frequency. RF phase can be locked or unlocked. When unlocked, CCC changes the RF frequency.

Circumference adjustment with chicane magnets (LER)



4 bending 'chicane' magnets

$$\Delta l_{chicane} = 4 l_{bend}\left(\frac{\vartheta}{\sin\vartheta} - 1\right) + 2 l_{drift}\left(\frac{1}{\cos\vartheta} - 1\right)$$

3-3. Analysis Results

Data logged

✓ **ΔCircumference**

– **Δ Chicane magnet strength**

– **Δ RF frequency**

Well controlled

✓ **Environmental variables**

– **Temperature :** tunnel air, outside air, building roof, ceiling space, magnet cooling water, etc.

– **Well depth**

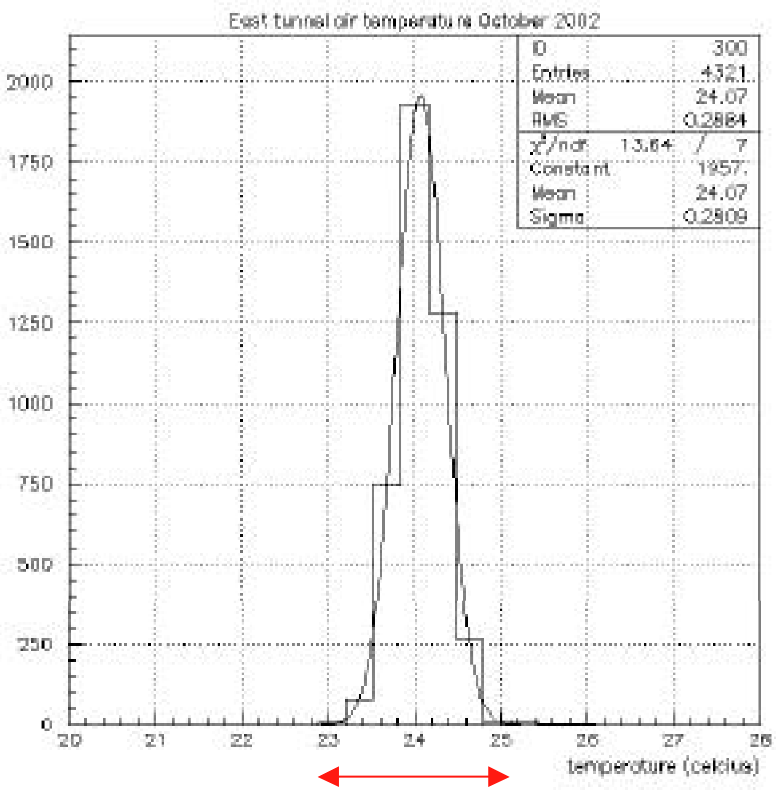
– **Atmospheric pressure**

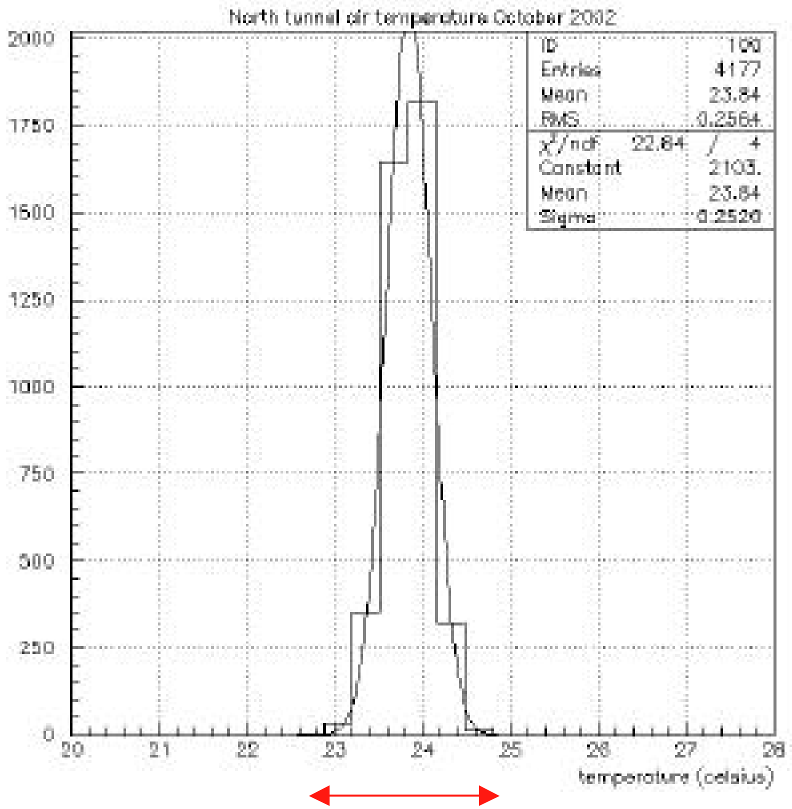
Newly added from Jan. 2003

Underground temperature,more sensors in the tunnel…

Tunnel air temperature
(At one location in the tunnel)
in October 2002

The tunnel air temperature is maintained at 24 +/- 1℃.

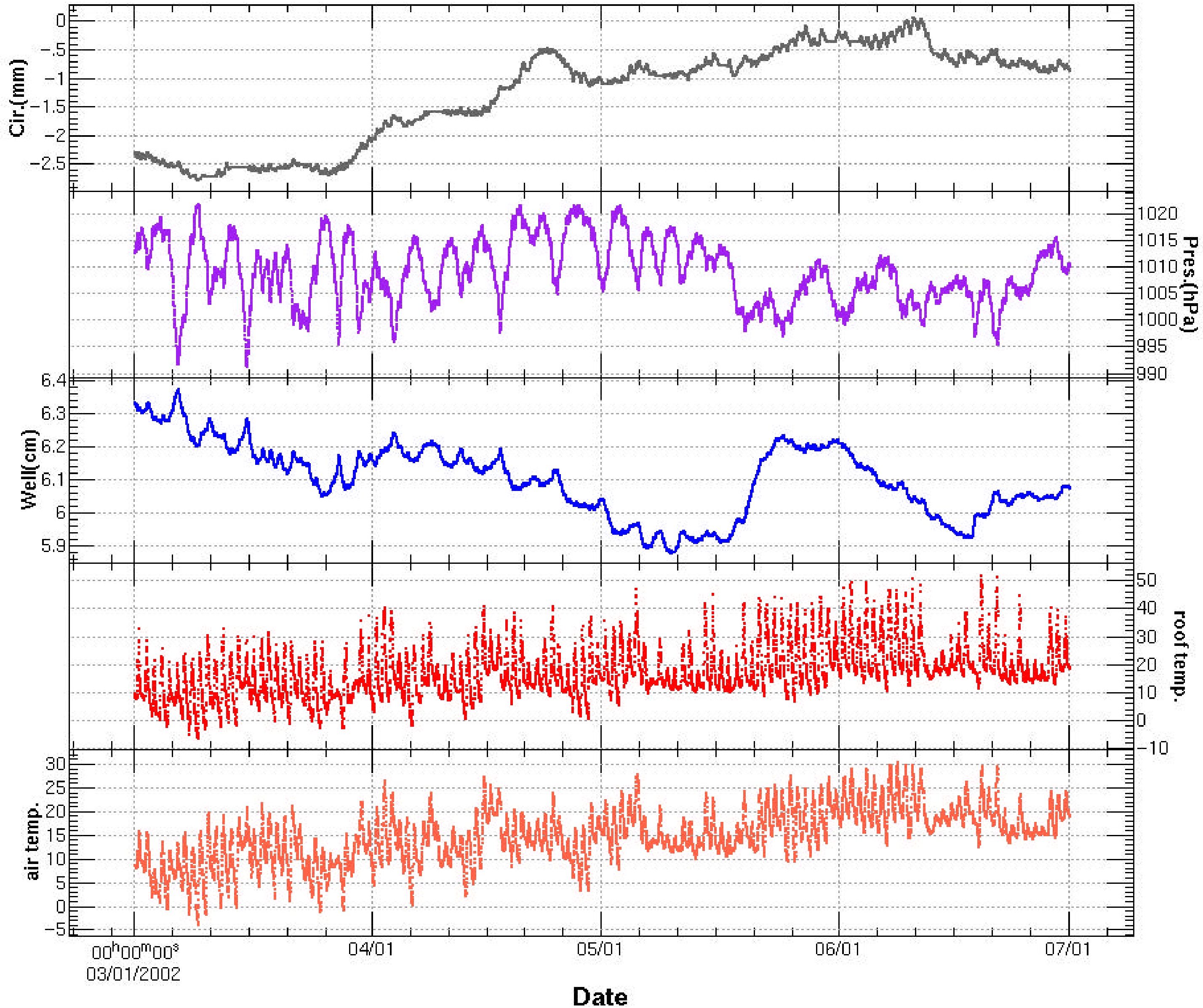




+/- 1 degree

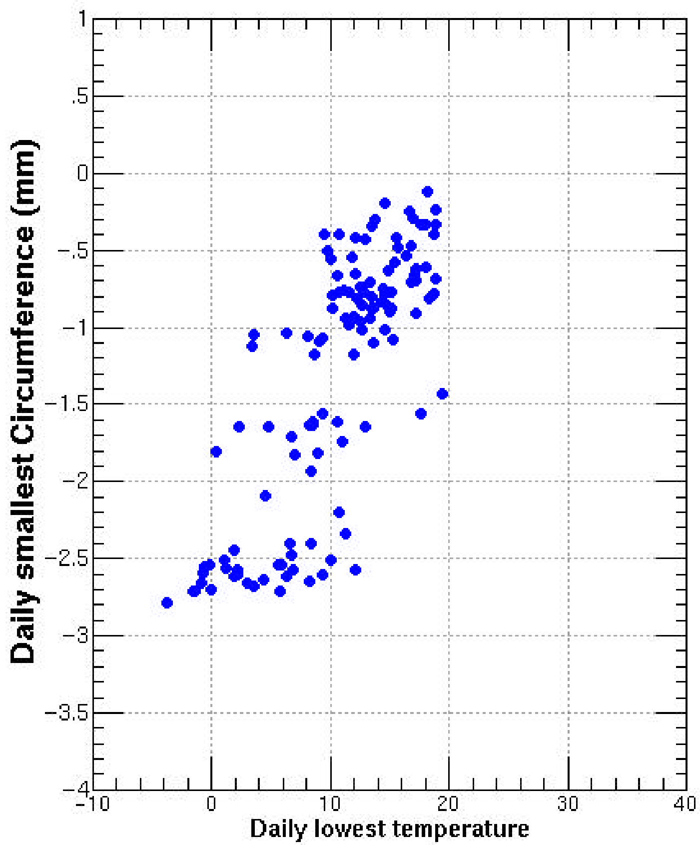
3-3. Analysis Results

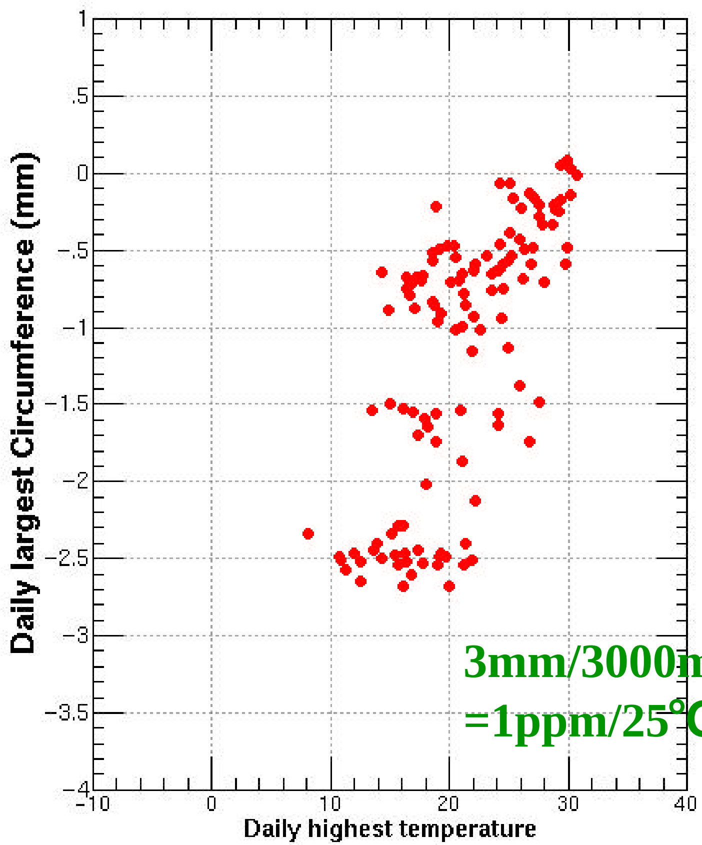
Spring run: environmental variables



3-3.Analysis results

Daily highest/lowest temp. and Δcircumference





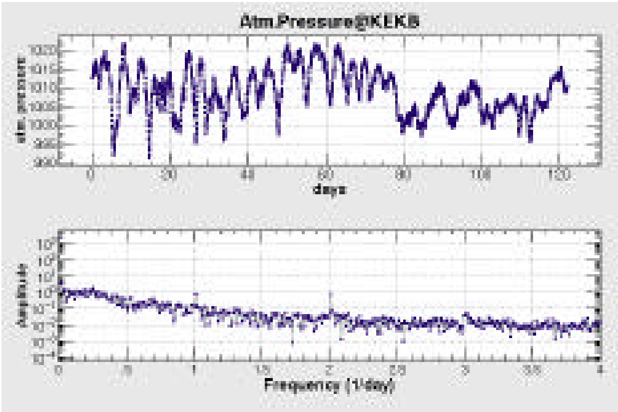
3mm/3000m/25°C
=1ppm/25°C

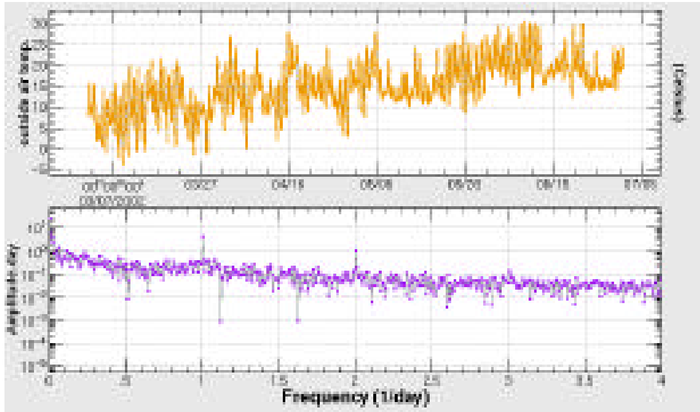
Δcircumference and outside air temp. is correlated, with wide spread.

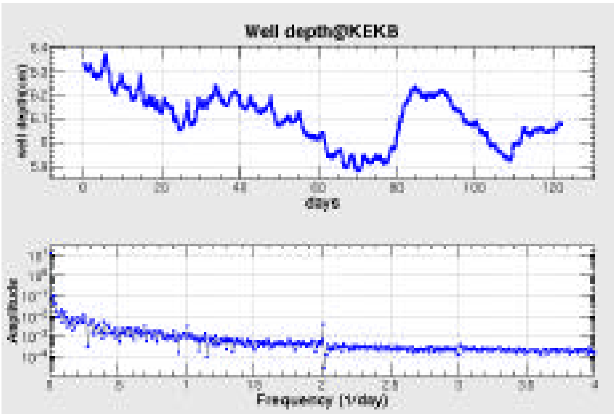
The wide spread might indicate some time lag between the two variables.

3-3.Analysis results

Spring run: environmental variables



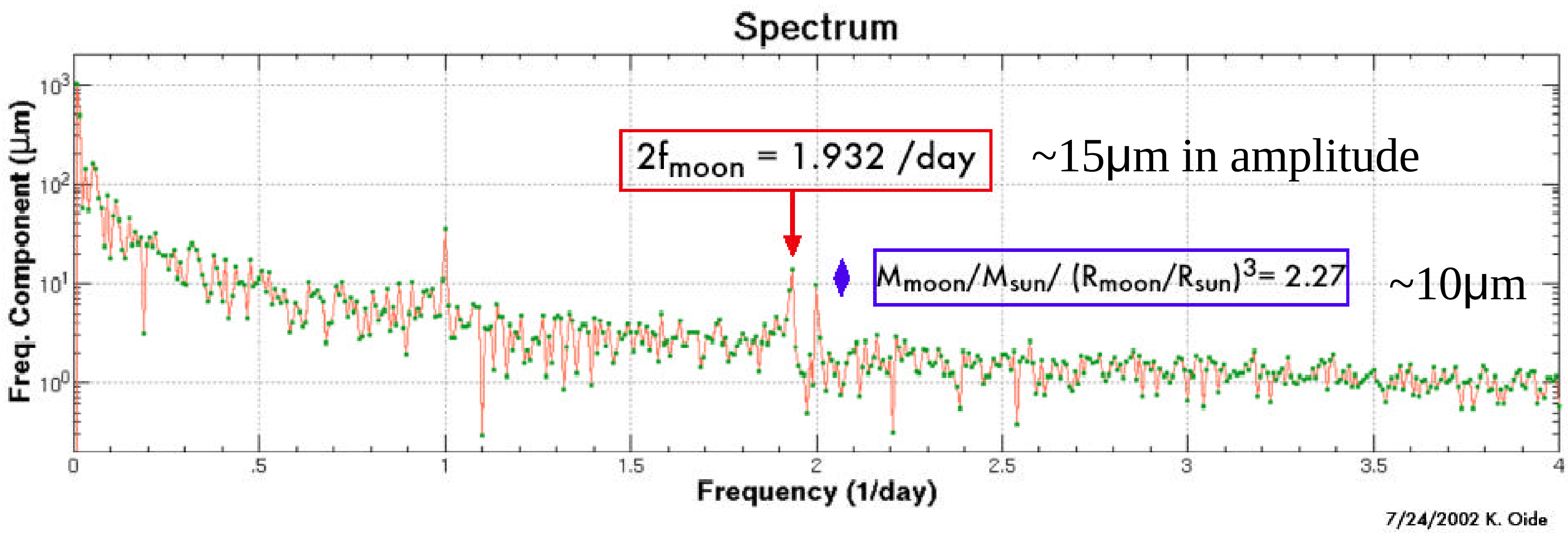




Semi-diurnal tidal effect on

- ✓ Atmospheric pressure →1hPa
- ✓ Well depth →50μm

ΔCircumference Spectrum analysis

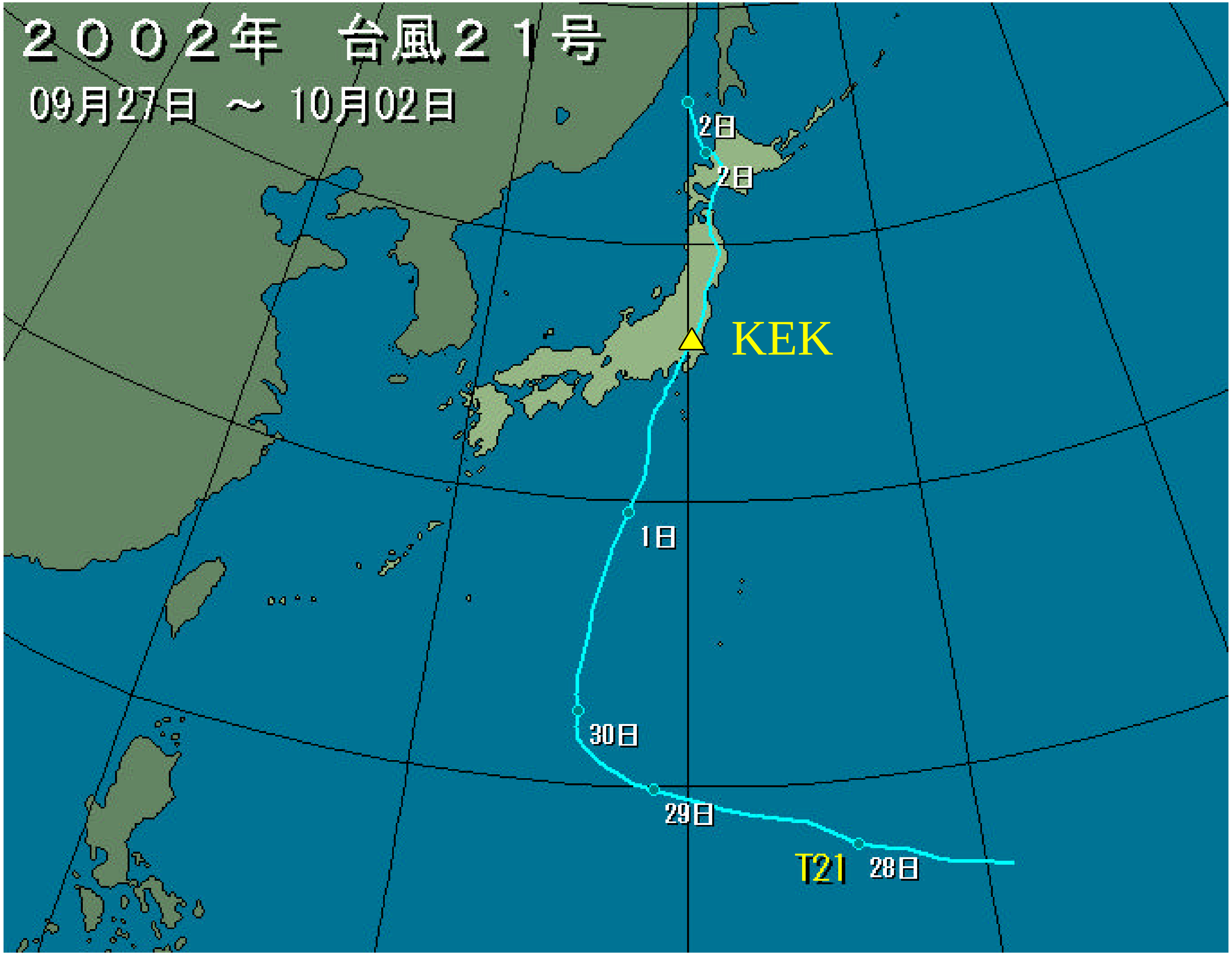


Spring8 (~1500m) also sees the tidal effects.
40μm peak to peak when largest.

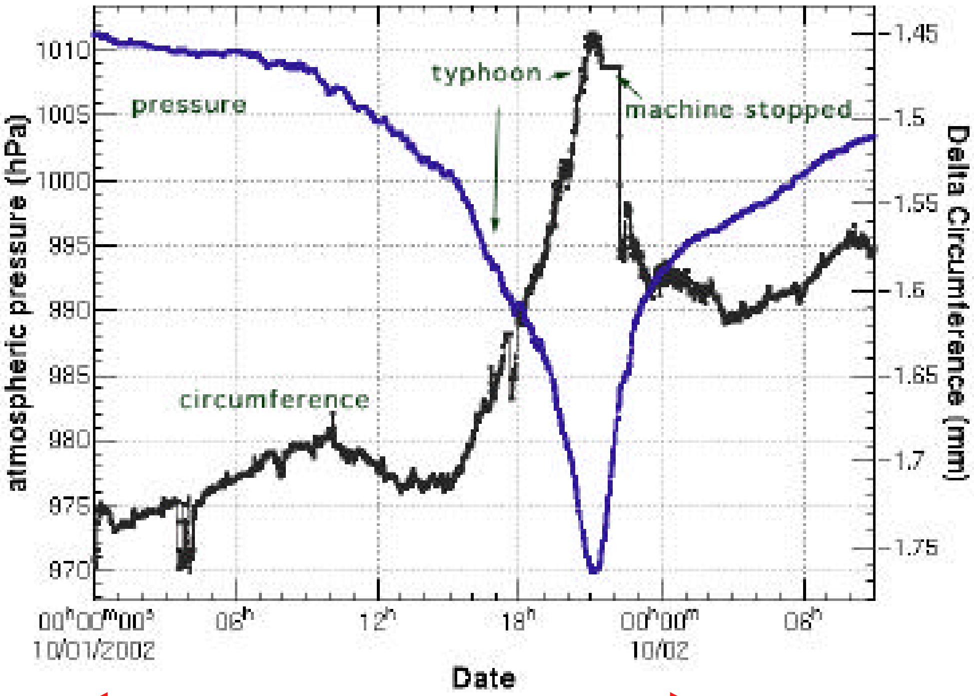
	parameters@equilibrium by Munk and MacDonald (1960)				
period		symbol	period(hours)	frequency(1/day)	coefficient
1 day	Principal lunar diurnal tide	O1	25.82	0.9295	0.377
		P1	24.07	0.9971	0.176
	luni-solar diurnal tide	K1	23.93	1.0029	0.531
1/2 day		N2	12.66	1.8957	0.174
	principal lunar semi-diurnal tide	M2	12.42	1.9324	0.908
	principal solar semi-diurnal tide	S2	12	2	0.425
		K2	11.97	2.005	0.115

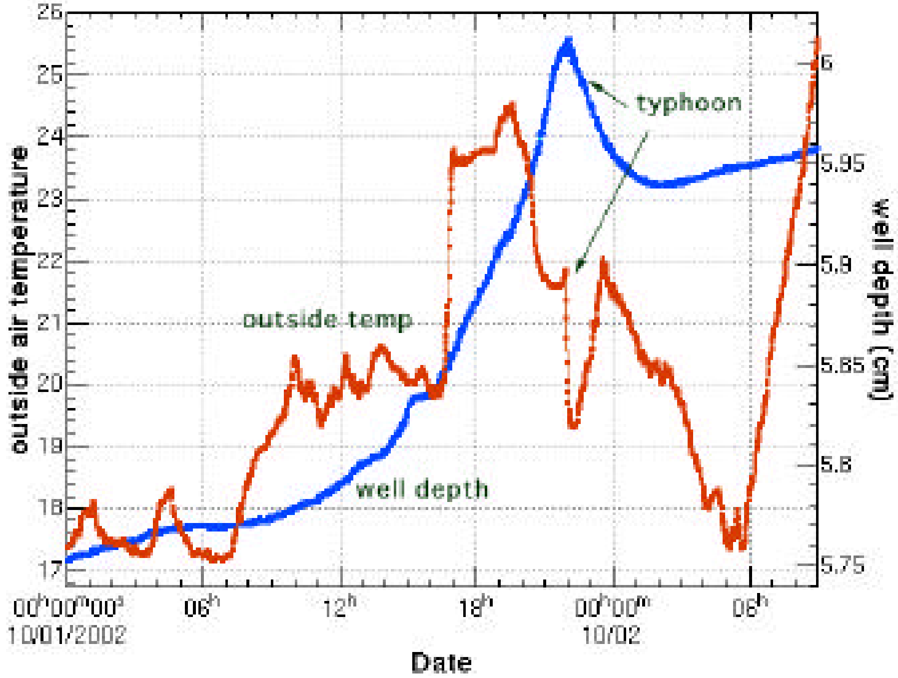
3-3. Analysis Results

Fall run: Typhoon !!



Typhoon 21 hit the area on 10/1/2002





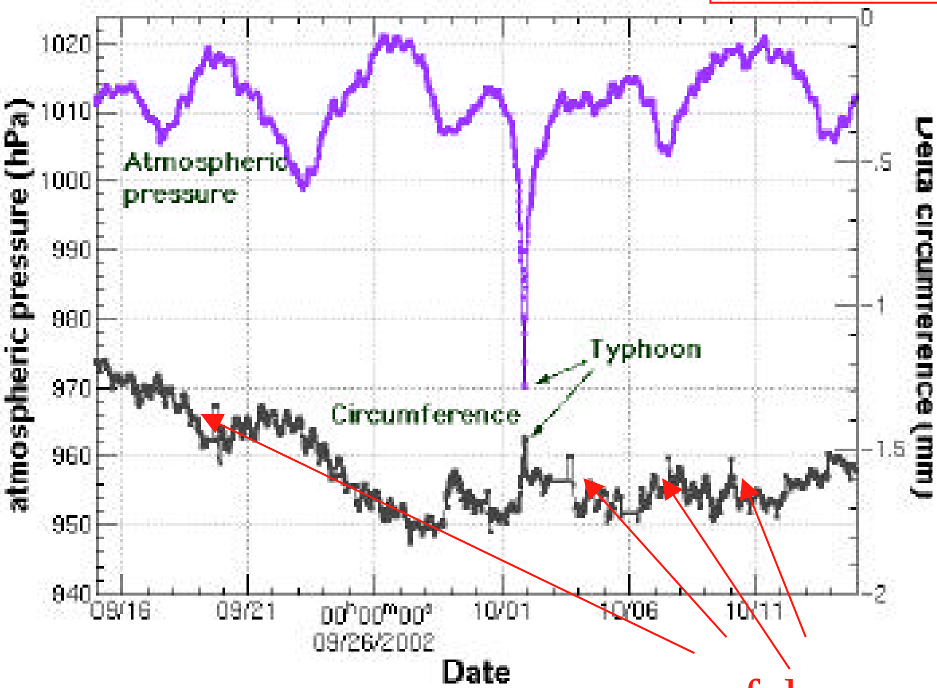
24 hour period

24 hour period

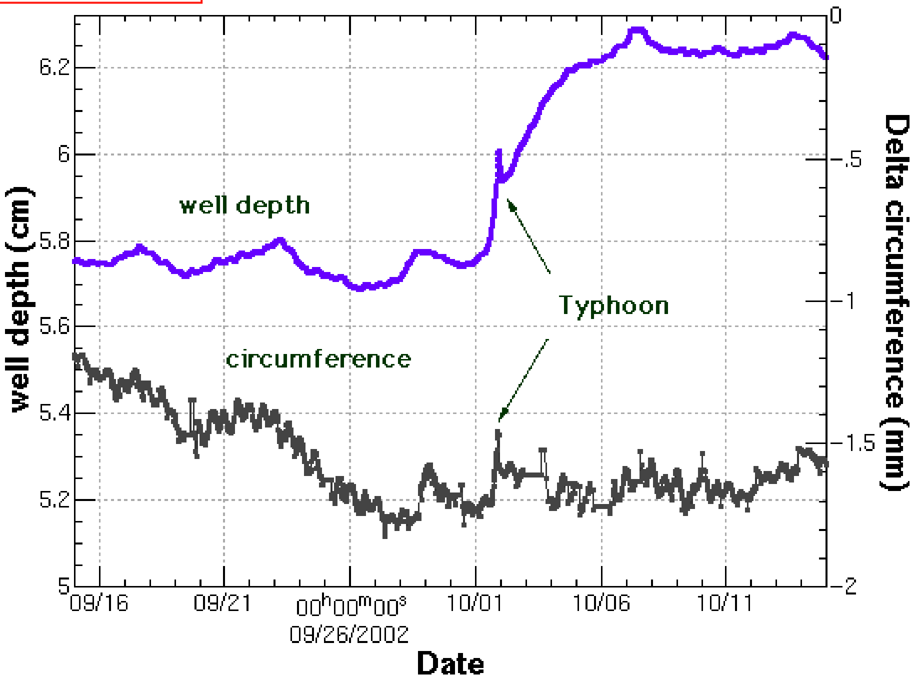
- The circumference expanded ~200 μm (an order of magnitude larger than tidal expansion).
- Pressure or water level??

Longer term trend plots of atmospheric pressure, well depth and Δcircumference

1 month period



fake

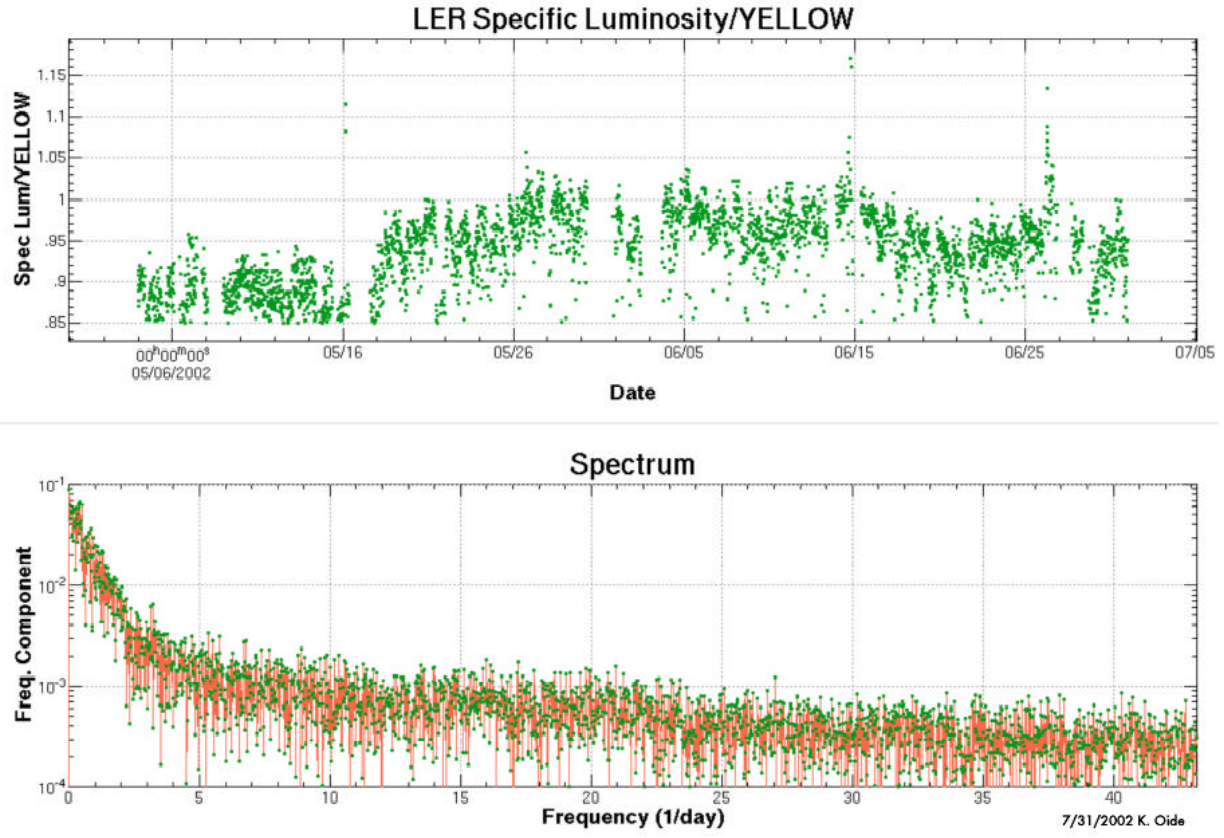


It could be argued that the circumference expanded because of the uprising of the water level on Oct.1st. The water level went up by ~0.5cm after the Typhoon and stayed high. If the water level is the main source for the expansion, we should see a similar trend in Δcircumference trend plot, but we do not.

3-4. Circumference Drift: Summary

- **Tidal effects have been observed in circumference variations at KEKB. Lunar and solar semi-diurnal tidal effects have been clearly distinguished.**
- **The diurnal component observed in the circumference variation is several times larger than the expected diurnal tidal effect. The outside air temperature might be the main source of the enhancement.**
- **A long-term drift in circumference has also been observed. This drift shows more correlation with the outside air temperature than with other observed environmental variables.**
- **The circumference temporarily expanded by ~200μm when Typhoon 21 hit the area. The expansion coincides with the corresponding rapid atmospheric pressure drop.**
- **Further analysis is required to quantify the contribution of each environmental variable on the expansion/contraction of the circumference of the rings.**

No significant peaks in the luminosity spectrum observed



Simple model

$$U = gKbf(\vartheta)\cos[\beta(\lambda, t)]$$

$$K = \frac{3}{2}\frac{m}{M}\frac{a^3}{r^3}a = 53.7\ cm$$

$$U' = U \times (1 + k)$$

Displacement

$$\Delta \quad = h \times \frac{1}{g} \times U'$$

$$\Delta // = l \times \frac{1}{g} \times U'$$

$$f(\vartheta) = \frac{1}{2}\sin^2\vartheta = 0.327 \quad @\vartheta = 90 - 36 = 54^\circ$$

$$|\Delta \quad| = 0.610 \times 53.7 \times 0.908 \times 0.327 \times 1.281 \sim 12(cm)$$

$$\frac{12(cm)}{6370(km)} \times 3(km) \sim 60\mu m$$

For pressure drop,

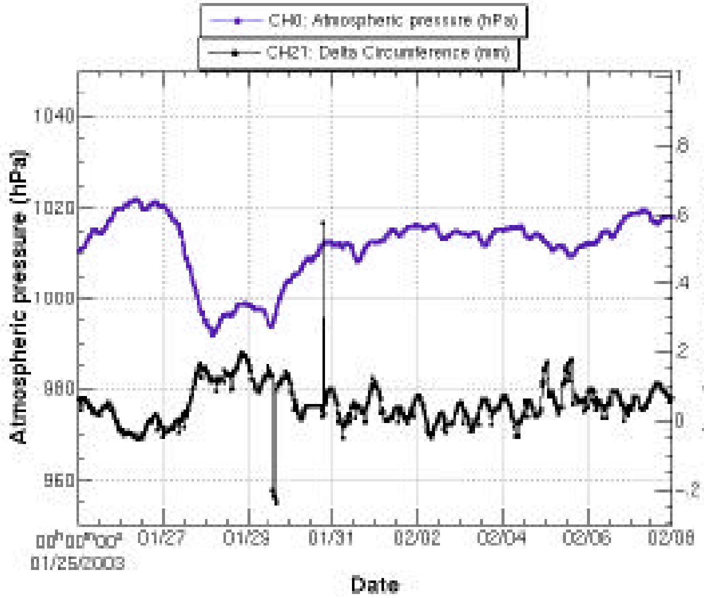
(40cm if acted upon water)

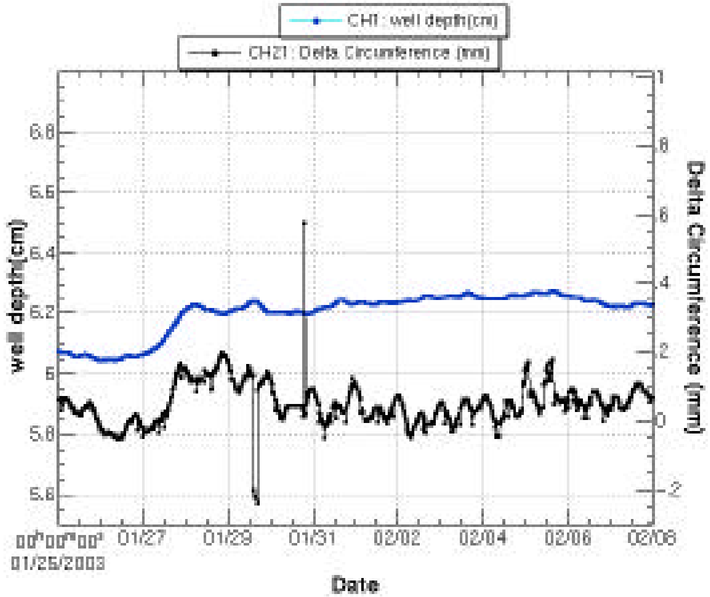
Δp=40hPa

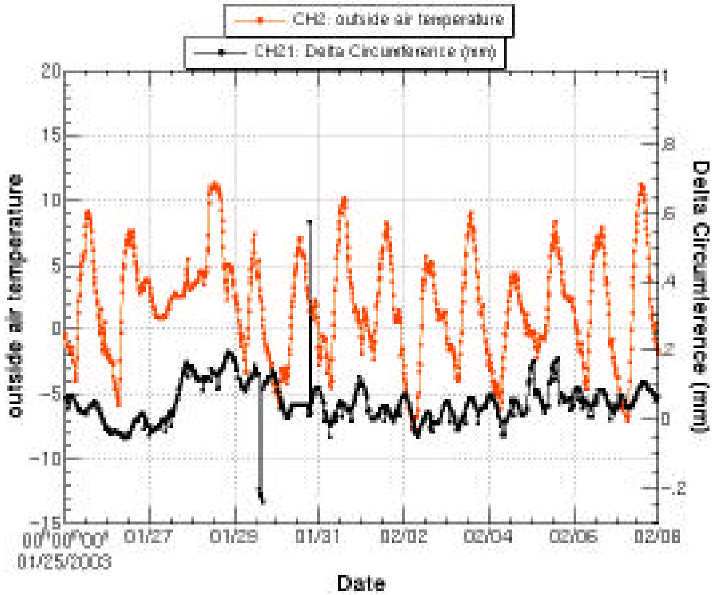
$$|\Delta \quad| = 0.610 \times 40\,cm \times 1.281 \sim 31(cm)$$

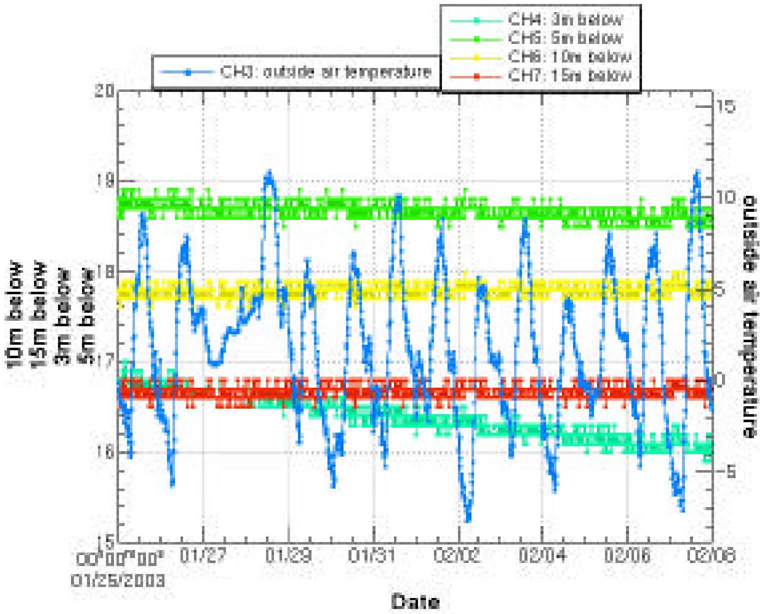
$$\frac{31(cm)}{6370(km)} \times 3(km) \sim 150\mu m$$

Jan.25~Feb.8


CH0: Atmospheric pressure (hPa)
CH21: Delta Circumference (mm)
Atmospheric pressure (hPa)
Delta Circumference (mm)
00h00m00s 01/25/2003
01/27
01/29
01/31
02/02
02/04
02/06
02/08
Date


CH1: well depth(cm)
CH21: Delta Circumference (mm)
well depth(cm)
Delta Circumference (mm)
00h00m00s 01/25/2003
01/27
01/29
01/31
02/02
02/04
02/06
02/08
Date


CH2: outside air temperature
CH21: Delta Circumference (mm)
outside air temperature
Delta Circumference (mm)
00h00m00s 01/25/2003
01/27
01/29
01/31
02/02
02/04
02/06
02/08
Date


CH3: outside air temperature
CH4: 3m below
CH5: 5m below
CH6: 10m below
CH7: 15m below
10m below
15m below
3m below
5m below
outside air temperature
00h00m00s 01/25/2003
01/27
01/29
01/31
02/02
02/04
02/06
02/08
Date