BNL-104166-2014-TECH

AGS.SN290;BNL-104166-2014-IR

Stopband Correction of the AGS Booster Tune Space Survey at the Low Intensity (1)

C. Gardner

April 1993

Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

AGS Complex Machine Studies

(AGS Studies Report No. 290)

Stopband Correction of the AGS Booster Tune Space Survey at Low Intensity (1)

Study Period:	April 3, 5, 1993
Participants:	C. Gardner and Y. Shoji
Reported by:	Y. Shoji
Machine:	User1; MMPS: Low dB/dt Injection; Low intensity (middle 10 turns) (April 3 - 100 ns, April 5 - 200 ns)
Aim:	To know the contribution of the stopbands to the beam loss.

I Motivation

T. Roser, et al., had surveyed the tune space on April 3 with the high intensity (100turns 110degrees). The result said that the beam current had dependence on tune values (Fig.1). Especially at the lower vertical tune much beam was killed. We wanted to know whether that beam loss came from a stop band or not.

II Measurement on April 3

On that night, we observed the vertical tune dependence of survived beam current again but with lower intensity (10 turns injection). The situation of stop-band corrections were:

2Qx=9 :	function (5 points were connected with lines)
2Qy=9 :	DC (adjusted at 40ms after T0)
	file name : HIGH_INTENSITY MARCH28SHOJI
Qx+Qy=9 :	step function (2 steps)
Qx-Qy=0 :	correction function with strong dB/dt term

Other correction had not yet applied.

The sextupole corrections were out of order.

We recorded survived beam current in the Booster against the vertical tune. The vertical tune was scanned from 4.52 to 4.96 while the horizontal tune was kept constant at 4.78. The set tune values were constant through the cycle. The beam current was measured by the Booster CT and averaged by 10 times for each data point. A typical change of the beam current to time is shown in Fig.2. Gradual beam loss, which started at 2ms after the injection, occurred at any tune point. The maximum beam current and survived beam current at 2ms and 19ms after the injection were plotted to the vertical tune (set value) in Fig.3.

At that time the injection timing from T0 changed with vertical tune as shown in Fig.4. We do not know it was normal or not. It made the measurement a little bit complicated. We observed the same phenomenon through the following tune survey studies in May and June.

III Results on April 3

The positions of coherent resonances up to 3rd order and 4th order sum resonances were assigned in Fig.3. The tune difference between the beam loss and the assigned resonance was thought to be space charge tune shift. That difference was larger for a sum-resonance and was smaller for a differential resonance because the tune shifted in both Qx and Qy direction. A predicted tune spread by the space charge (theoretical calculation) was about 0.01 for the vertical direction.

Between two very strong resonances, Qy=5 and 2Qy=9, the third coupling resonance 2Qy+Qx=14 stands out. The vertical third integer resonance; 3Qy=14 also made a beam loss but that was smaller. The bunch of weak 4th order resonances formed a shallow and broad dip (beam loss). The loss by the integer coupling resonance; Qx-Qy=0 was not observed because the resonance was corrected. But the third order differential resonances; Qx-2Qy=-5 and -Qx+Qy=5 produced weak dips. We could see the large structure; the beam current was decreasing with the vertical tune. But this tendency was much weaker than that was at the higher intensity (Fig.1). The beam did not survive well at the area between 3Qx+Qy=14 and 2Qy=9, although there was no strong resonance in this area. There was un-identified resonance at Qy=4.83. The position of this resonance was close to the 5th integer resonance. But it would not be natural that the 5th order resonance had made such a large beam loss.

IV Measurement and Results on April 5

A similar survey took place on April 5 nightshift. Tune values were measured with Tune meter as shown in Fig.5. Before the tune survey measurement the correction currents of 2Qy=9 were readjusted at 35ms after the injection. And at this time we also surveyed the region below Qy=4.5. The results are shown in Fig. 6.

It was roughly the same as that on April 3 except the increase of the beam loss at the integer coupling resonance; Qx-Qy=0. It could have happened that this resonance was not properly corrected, because the connection of C5 back-leg winding had been changed on April 5 daytime.

The time structure of the beam loss was much different (Fig.2) probably because of the difference of injection parameters.

At that time the half integer resonance; 2Qy=9 was thought to be almost corrected with correction quadrupoles. But the residual beam loss at this resonance was much larger than the loss at any un-corrected third order resonance.

FIGURE CAPTIONS

Fig. 1 Tune space survey measured by T. Roser on April 3. [Booster/Proton Book V, 1993, p.139].

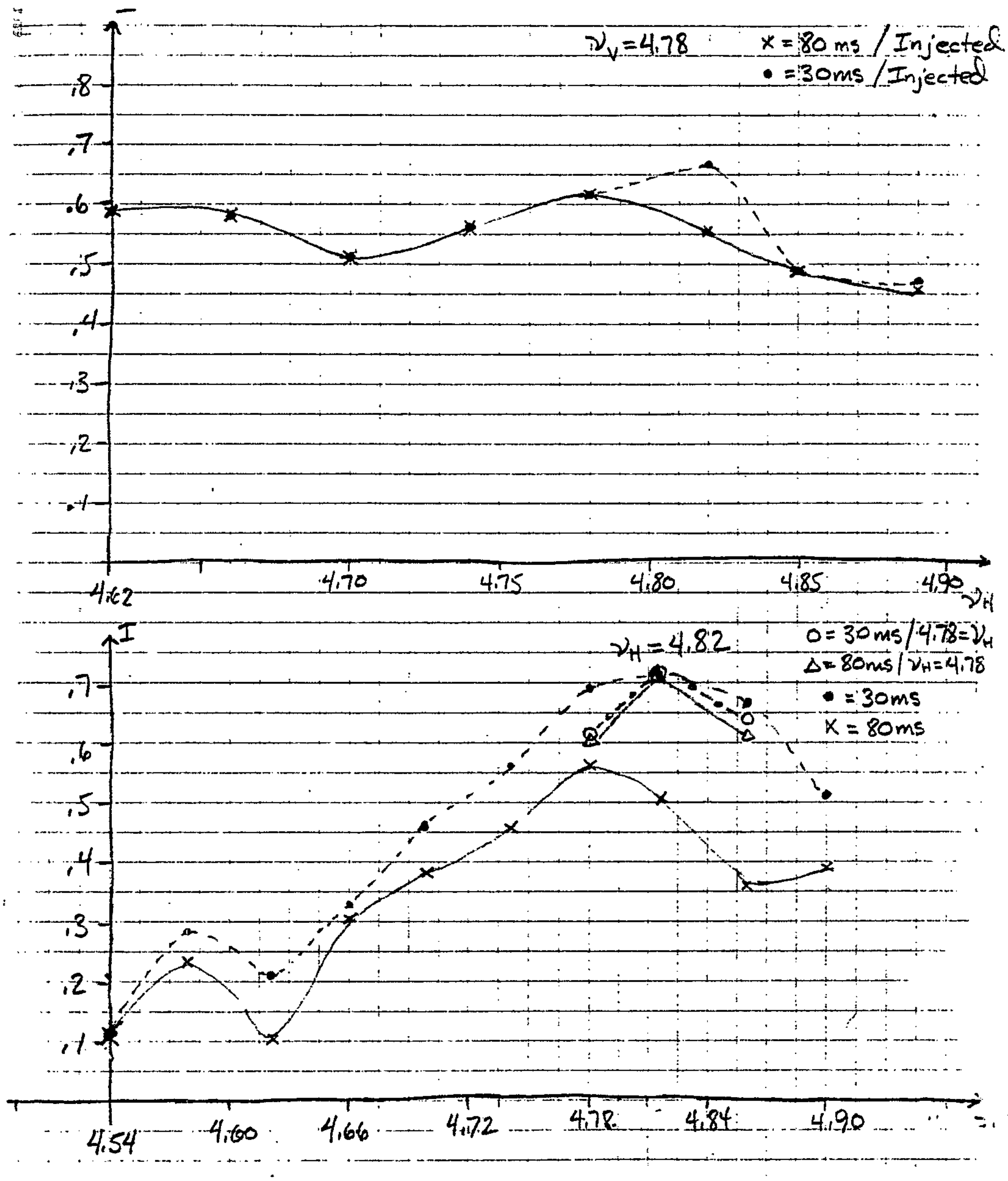
Fig. 2 Typical beam current monitored by the Booster CT on April 3 (above) and on April 5 (below).

Fig. 3 The maximum beam current (solid line) and the survived beam current at 2ms (broken line) and 19ms (dotted line) after the injection. Data were taken on April 3. Two lines for each timing present the two scans at the different time.

Fig. 4 The time difference between T0 (User3 reset) and the Booster User3 injection.

Fig. 5 Set value of vertical tune and measured tunes by the tune meter at 36 ms after T0.

Fig. 6 The maximum beam current (solid line) and the survived beam current at 2ms (broken line) and 19ms (dotted line) after the injection. Data were taken on April 5.



$\nu_V = 4.78$
x = 80 ms / Injected
• = 30ms / Injected
.8
.7
.6
.5
.4
.3
.2
.1
4.62
4.70
4.75
4.80
4.85
4.90
ν_H
I
$\nu_H = 4.82$
O = 30ms / 4.78 = ν_H
Δ = 80ms / ν_H = 4.78
• = 30ms
X = 80ms
4.54
4.60
4.66
4.72
4.78
4.84
4.90

Fig. 1

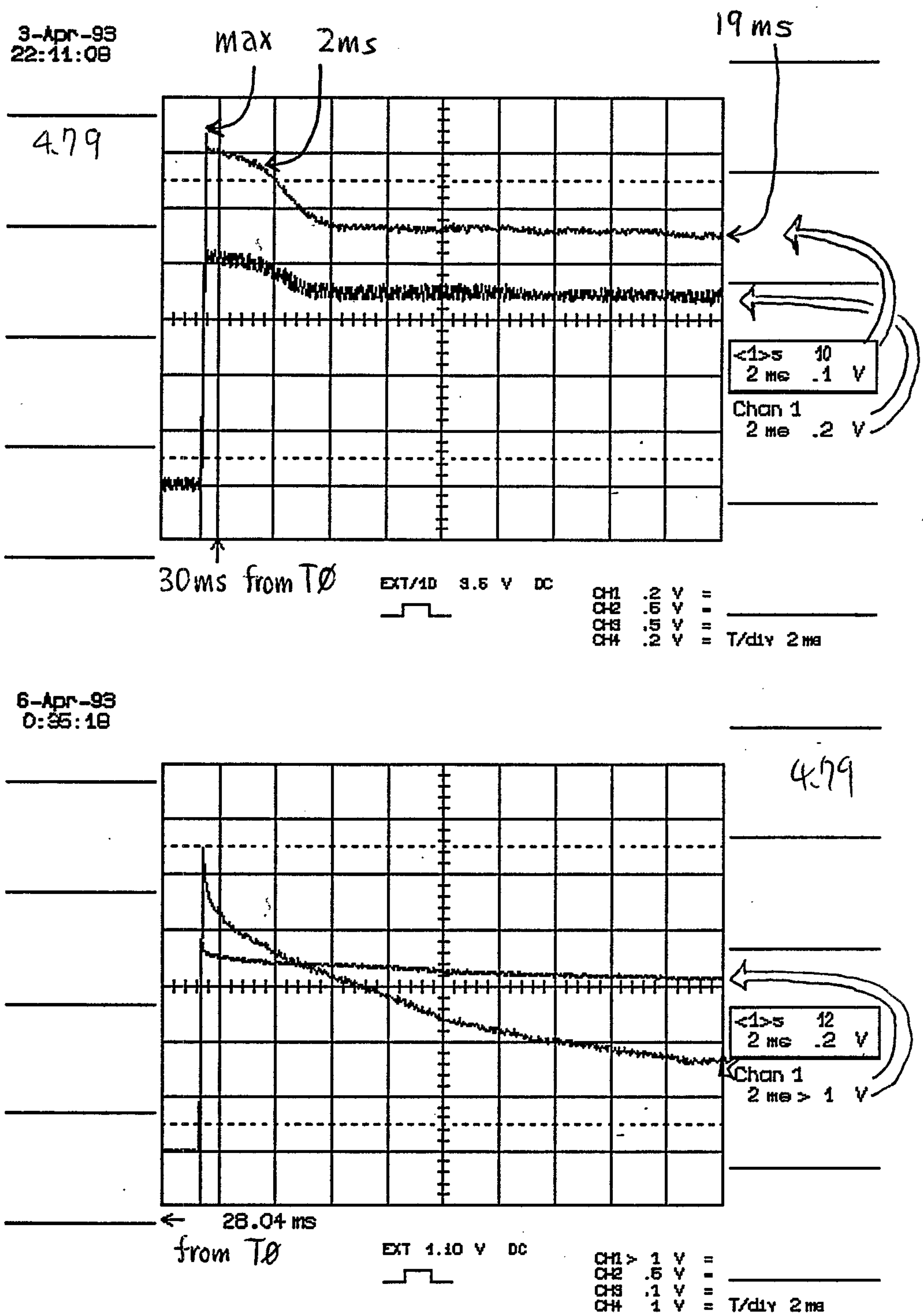

3-Apr-93
22:11:08
max
2ms
19ms
4.79
<1>s 10
2 ms .1 V
Chan 1
2 ms .2 V
30ms from TØ
EXT/10 3.5 V DC
CH1 .2 V =
CH2 .5 V =
CH3 .5 V =
CH4 .2 V = T/div 2 ms
6-Apr-93
0:35:18
4.79
<1>s 12
2 ms .2 V
Chan 1
2 ms > 1 V
← 28.04 ms
from TØ
EXT 1.10 V DC
CH1 > 1 V =
CH2 .5 V =
CH3 .1 V =
CH4 1 V = T/div 2 ms

Fig. 2

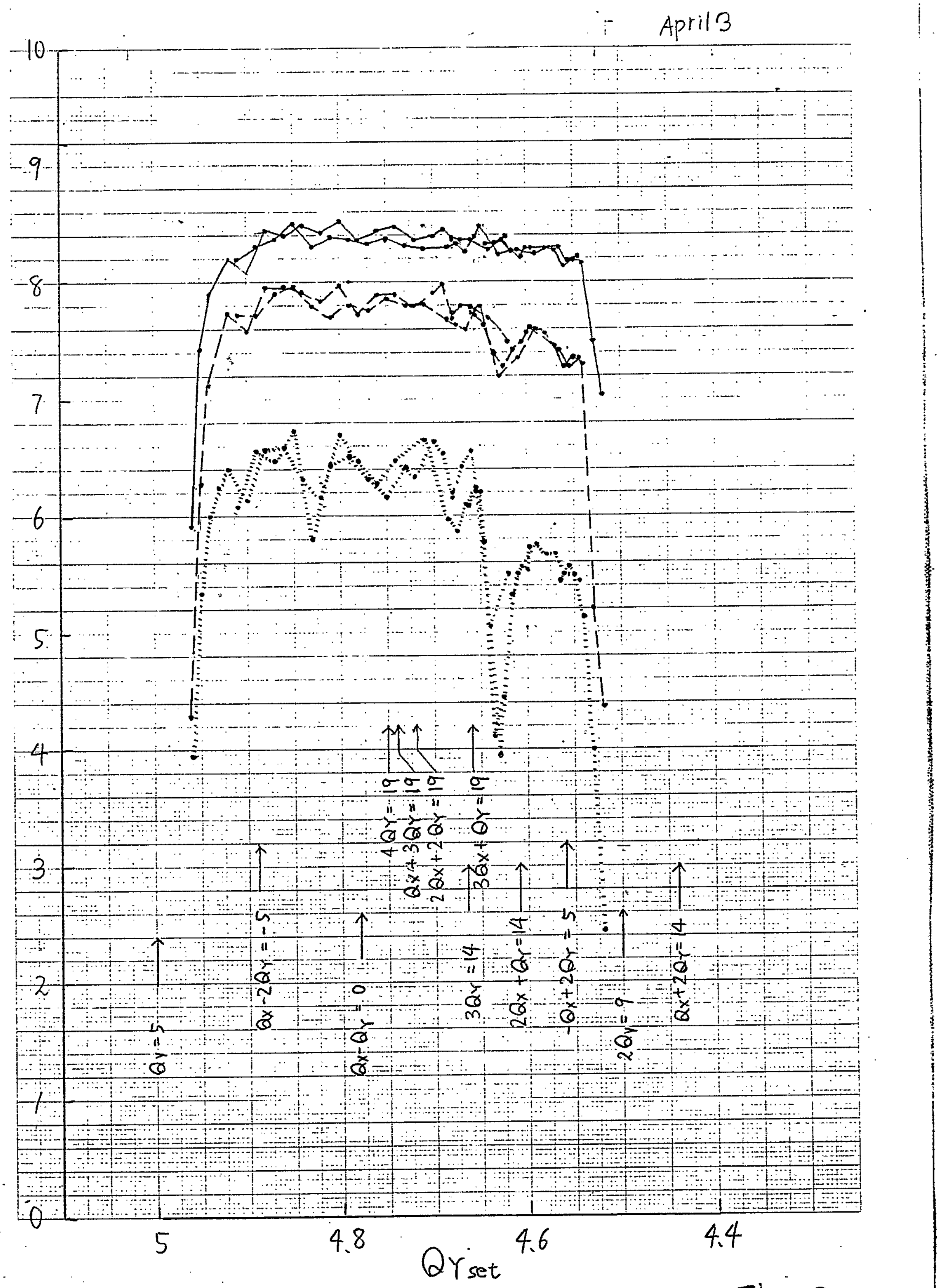

April 3
10
9
8
7
6
5
4
3
2
1
0
5
4.8
4.6
4.4
QYset
Qy=5
Qx-2Qy=-5
Qx-Qy=0
4QY=19
Qx+3QY=19
2Qx+2QY=19
3Qx+QY=19
3QY=14
2Qx+QY=14
-Qx+2QY=5
2QY=9
Qx+2QY=14

Fig. 3

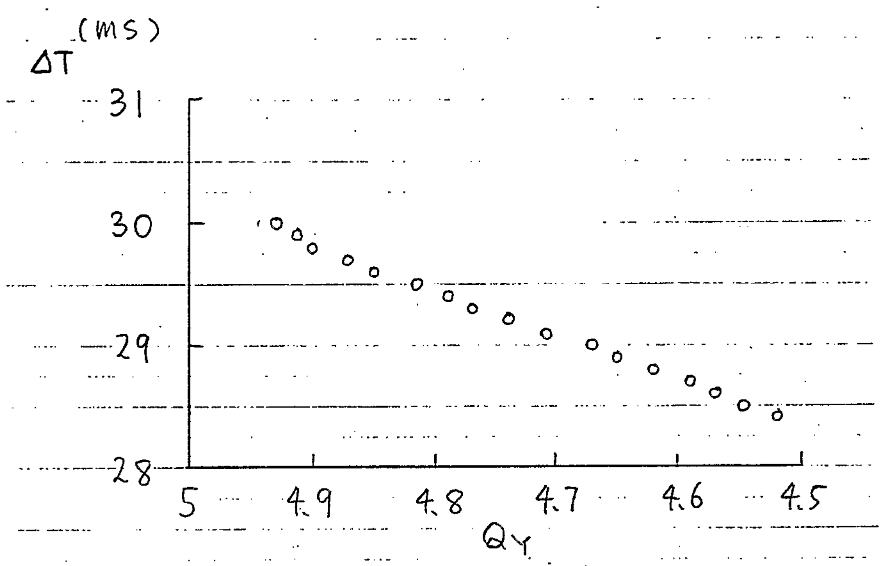

ΔT (ms)
31
30
29
28
5
4.9
4.8
4.7
4.6
4.5
QV

Fig. 4

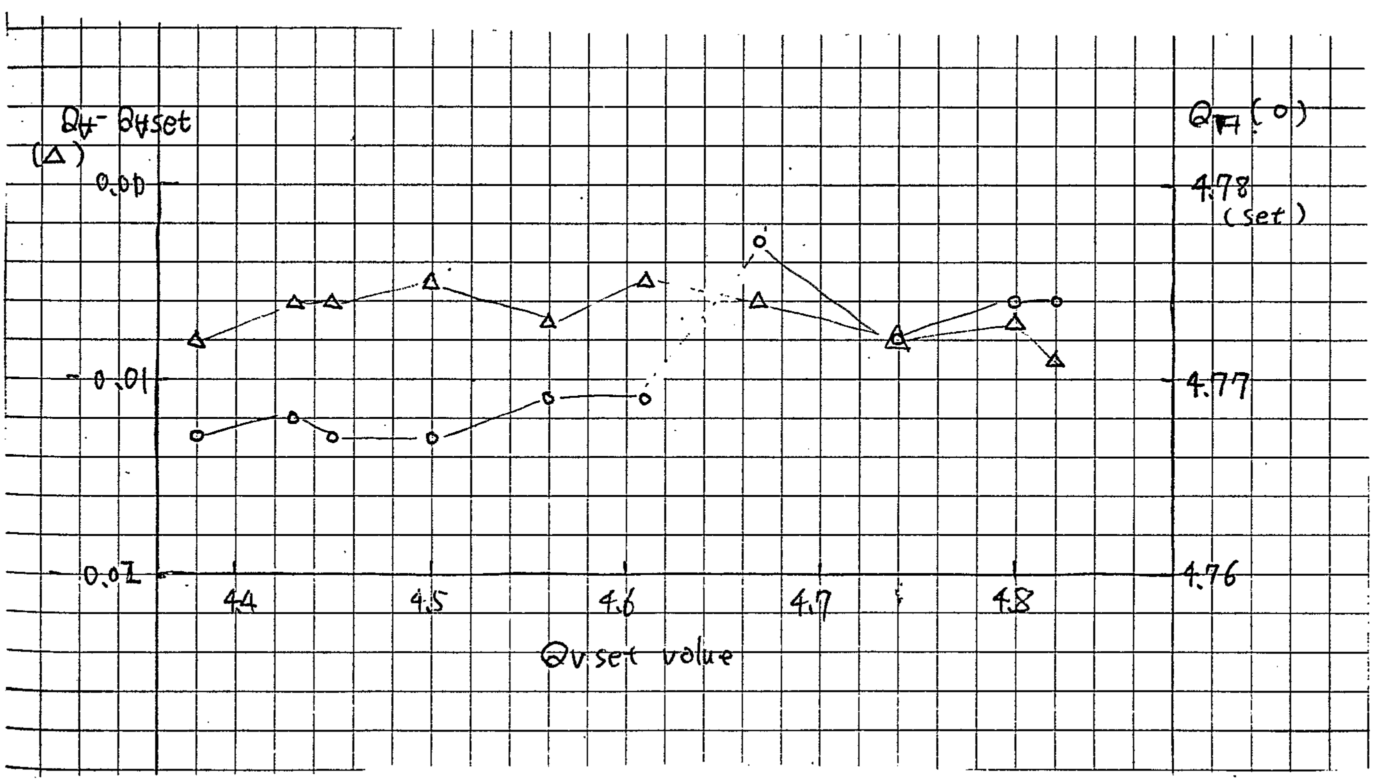

QV - QVset (Δ)
0.00
-0.01
-0.02
QH (o)
4.78 (set)
4.77
4.76
4.4
4.5
4.6
4.7
4.8
QVset value

Fig. 5

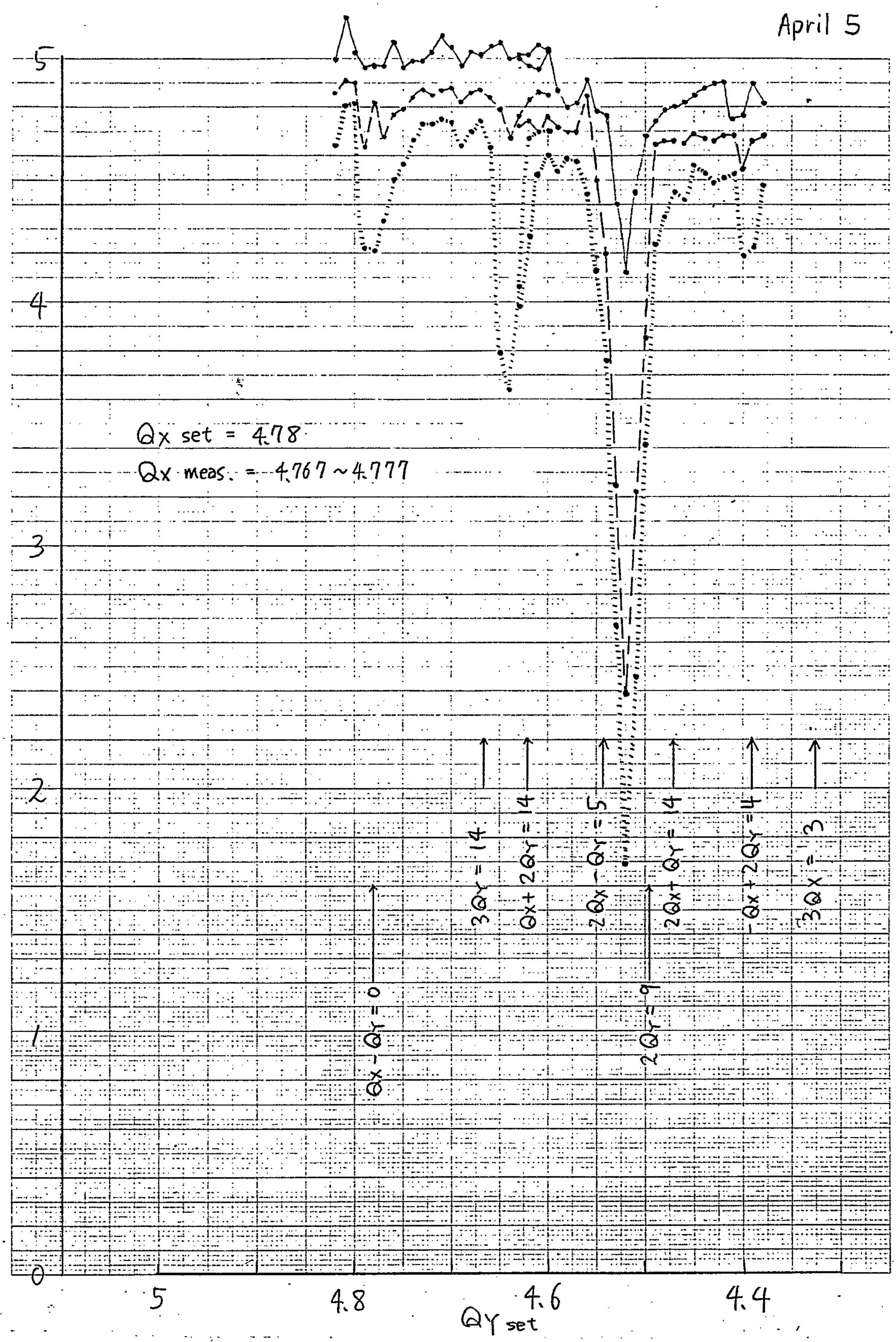

April 5
Qx set = 4.78
Qx meas. = 4.767 ~ 4.777
5
4
3
2
1
0
5
4.8
4.6
4.4
QY set
Qx - QY = 0
3QY = 14
Qx + 2QY = 14
2Qx - QY = 5
2QY = 9
2Qx + QY = 14
-Qx + 2QY = 4
3Qx = 13

Fig. 6