Dimension Measurement of Test Disks for RDDS1

KEK

Y.WATANABE

1. Measurement method

   . ZEISS CMM General view , specification etc.

2. Performance of CMM measurement

3. Measurement procedure of test disks

4. Typical measurement results

   & comparison to SLAC contour measurement

5. Results

6. Discussion

ZEISS UPMC-850 CARAT

. Measurement volume

X axis 850mm , Y axis 1200mm , Z axis 600mm

. Maximum weight

1500kg

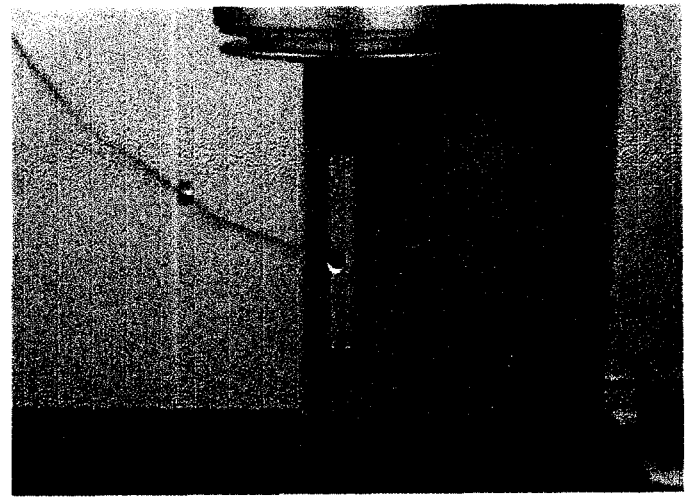
. Measurement accuracy (VDI / VDE 2617)

Every axis	U1	0.5+L / 900 μm ⇒ ~0.5 μm /60mm
Space	U3	0.8+L / 600 μm

- Running speed

  Maximum speed 65mm/sec

  Maximum acceleration 75mm/sec^2



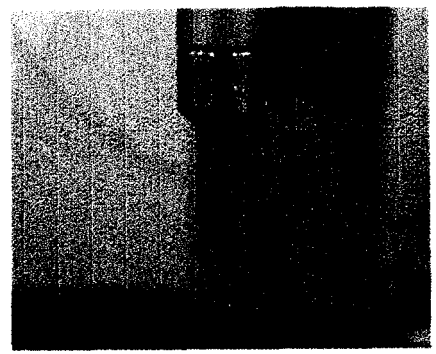
. Probe head

  Universal probe head

. Probe(for Universal probe head)

  Diameter ϕ 1mm

  Length 16mm



. CNC program

  From alignment to measurement & data output

Measurement of reference gauges

1. Block gauge

   *Industrial standard gauge grade 00

   (JIS grade00 60±0.00012 Parallelism 0.00006)

   * CMM agreed within 1 μm in X,Y

2. Reference cylinder (made of copper)

   * Made by KEK

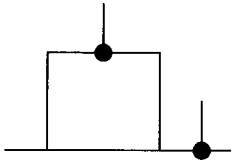
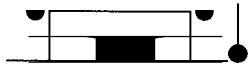
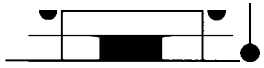
   * OD ϕ 61.000 ID ϕ 22.000

   * KEK CMM agreed with Mitsutoyo within 0.6 μm

   * Want to compare with SLAC CMM

Should be studied once more after maintenance of CMM

1. **Measurement of Block Gauges** (Probe ϕ 3,pressure 0.2N)

Gauges length	Z	X	Y
60mm	60.0017 ±0.00015	60.0009 ±0.0002	60.0003 ±0.0003
	Z-Z 	X-X 	Y-Y 

Measurement of TESTRDDS #102

	Make	now at	OD			2a		
			KEK	SLAC	Nikon	KEK	SLAC	Nikon
#1	KEK	KEK	-0.2 -0.3		+5.9 +6.3 +4.0	+5.5 +5.8		+10.8 +11.3 +13.0
#2	KEK	SLAC	-0.6 -0.8		+5.0 +5.2	+3.3 +2.9		+7.5 +7.8
#3	KEK	KEK		+1.3		+3.0 +2.8	-2.3	
#11	KEK	KEK	-1.1 -1.3		+4.0 +4.3	+2.9 +2.8		+8.2 +8.0

2. Measurement of Reference Gauges

(mm)

	Made by	OD(61.000/20℃)		ID(21.996/20℃)	
		KEK-CMM 20°C	Mitsutoyo 19.8℃	KEK-CMM 20°C	Mitsutoyo 19.8℃
REF1	KEK	61.0023 ±0.1		21.9969 ±0.1	
REF2	KEK	61.0017 ±0.1	61.0013 61.0013 61.0012	21.9985 ±0.1	21.9991 21.9990 21.9991
REF3	KEK	61.0018 ±0.2	61.0013 61.0014 61.0014	21.9993 ±0.1	21.9992 21.9993 21.9991

Disk measurement method

1. Temperature

* Room temperature 20℃±2℃

* Disk surface temperature (Before & after CMM all±0.5℃)

2. Measurement condition

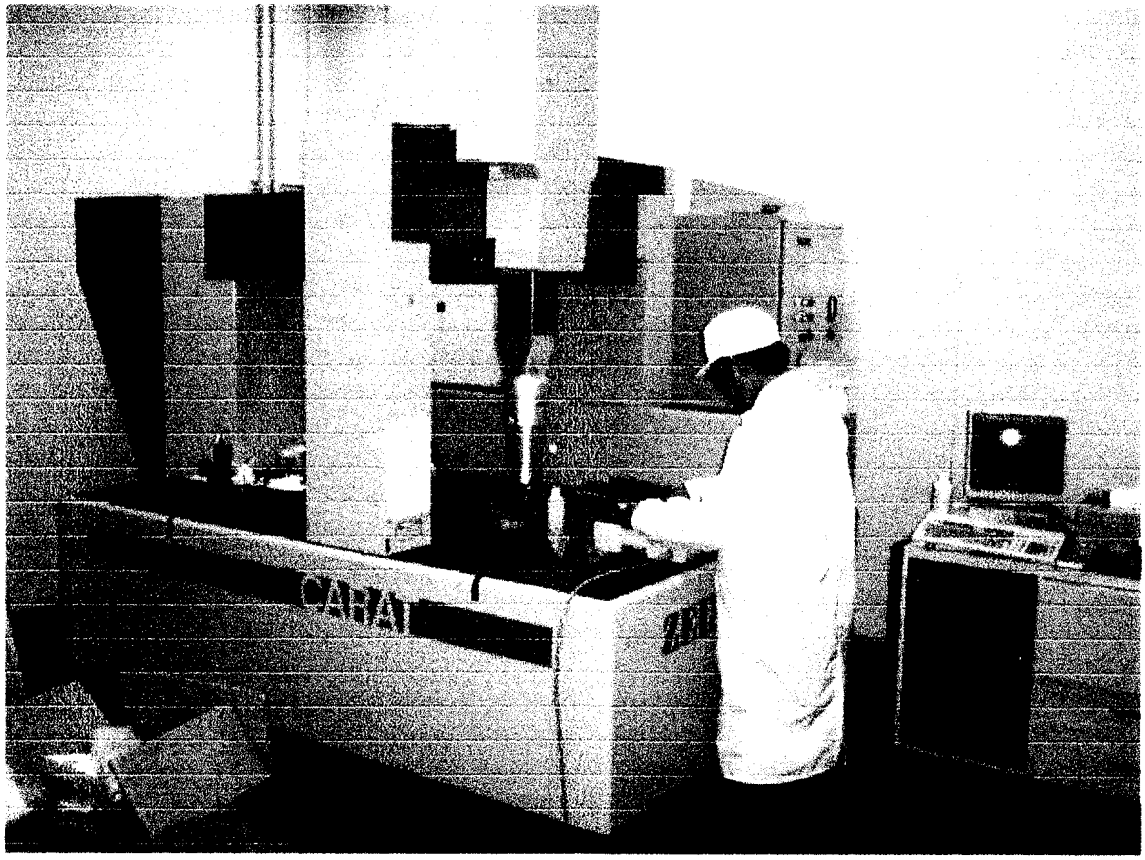
* Probe diameter ϕ lmm

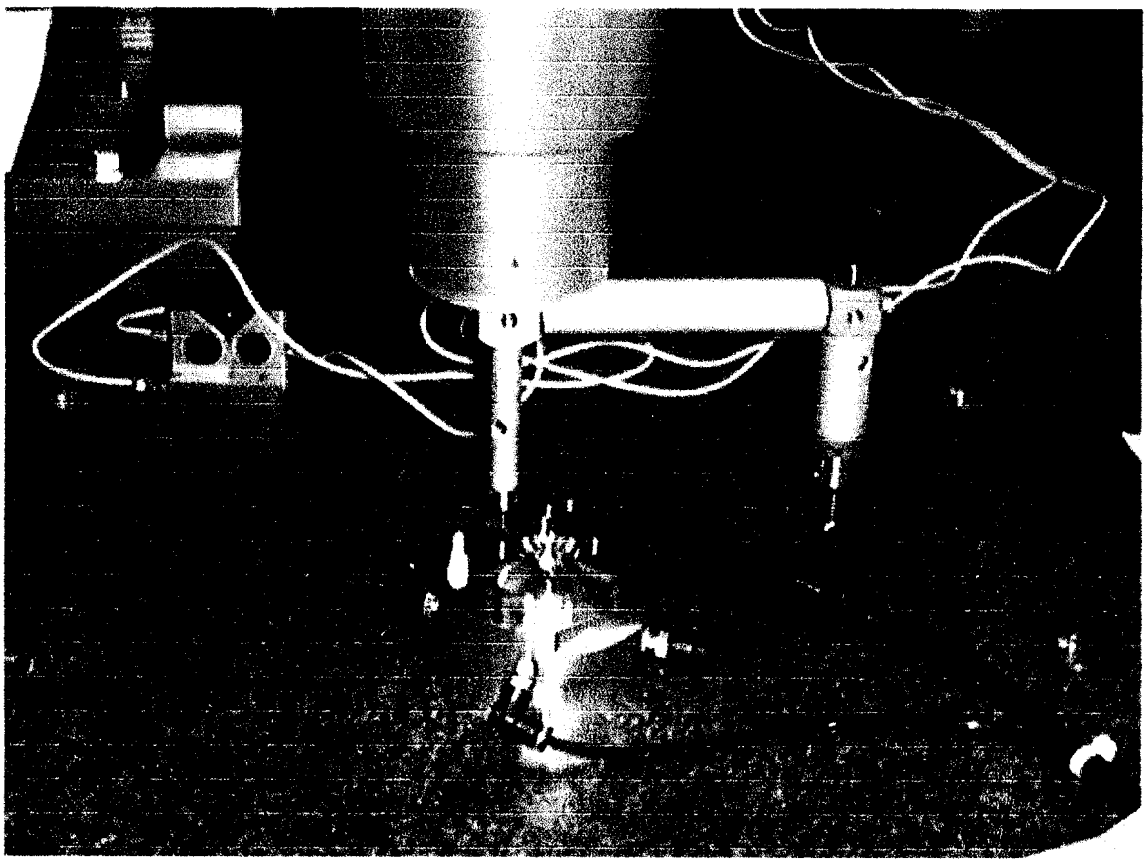
* Probing pressure 0.2N(variable 0.05N to 1N)

* Probing speed lmm/sec(set at almost minimum)

3. Probe calibration

* Calibration sphere Ceramics ϕ 15 6 points calibration





Vacuum chuck

Material A15052

Vacuum area $4 \times \phi 6$ Pressure $\sim$1kg

- Disk does not move by proving (Pressure>>Probing Pressure)
- Top surface is machined by Ultra-precision lathe before each batch
- Merit 1. Stability of disk against pressure

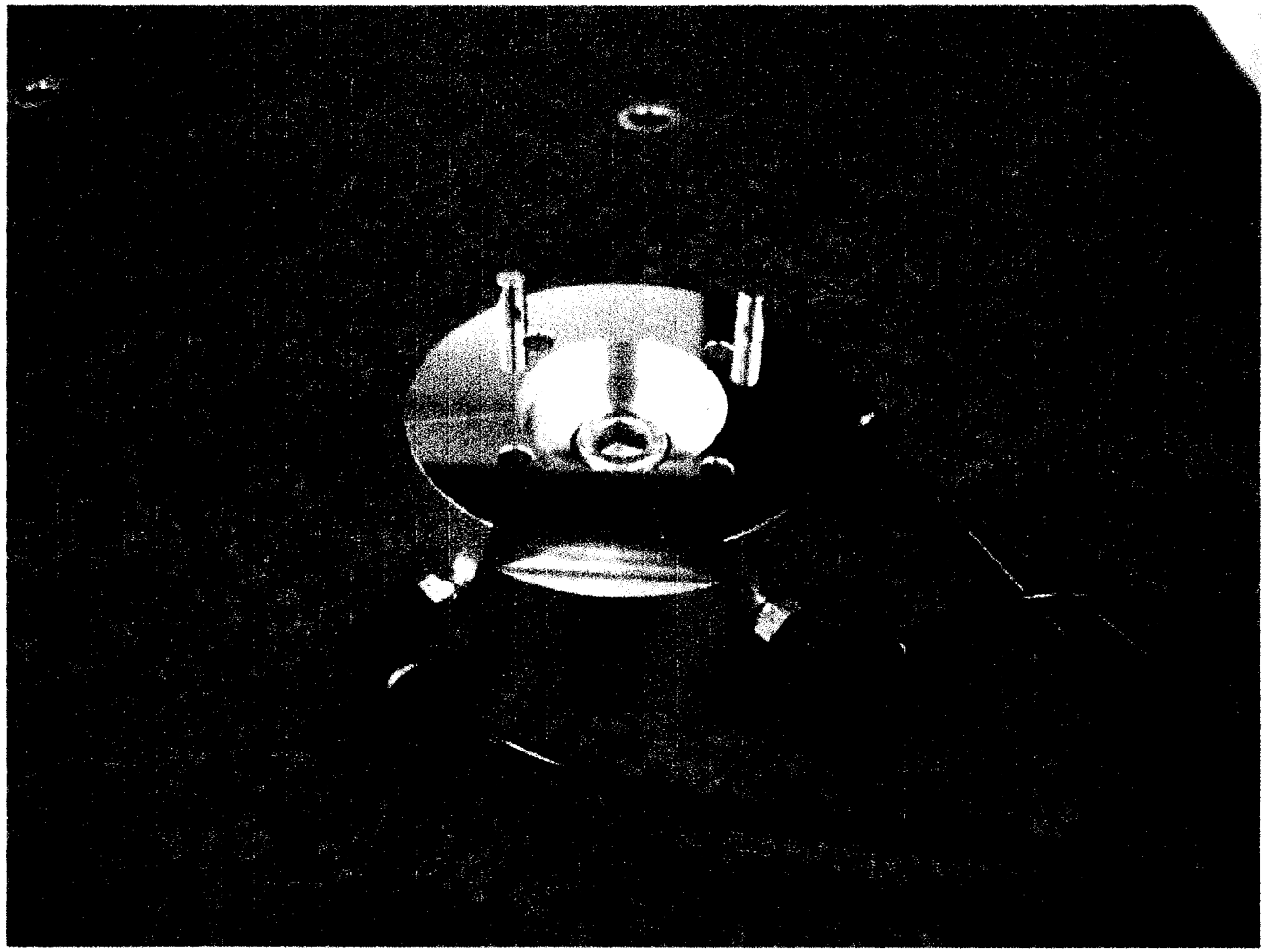
  2. Less distortion due to fixing

  3. Full of experience in turning lathe machining

. Demerit 1. The thickness cannot be measured directly

  2. Both sides cannot be measured at once

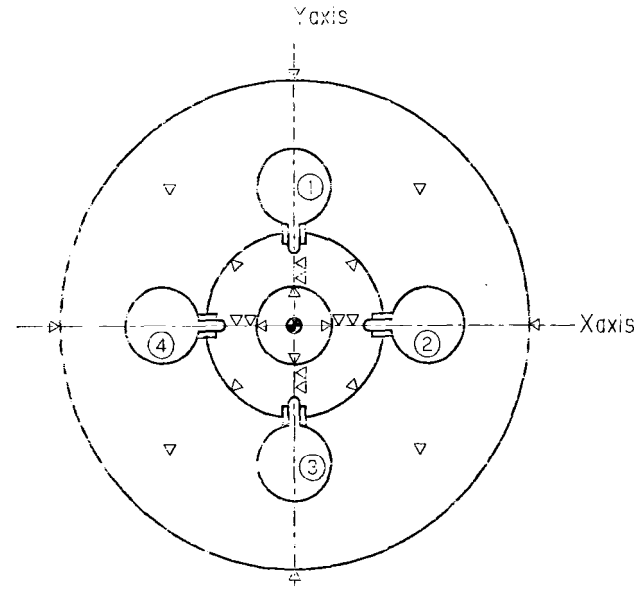
Vacuum chuck

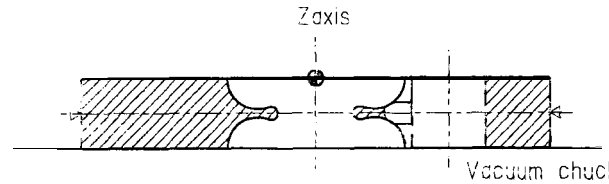


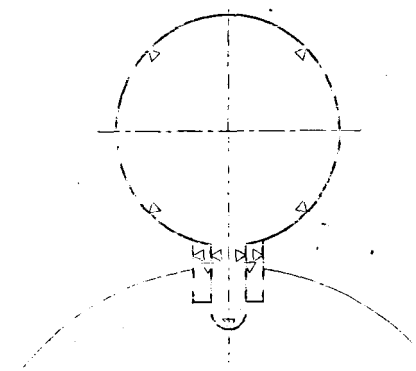
Measurement process of rough machining disk

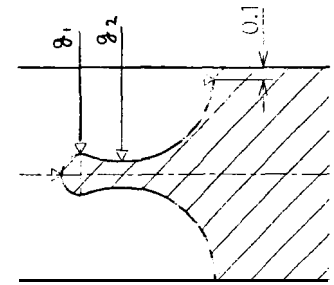
Alignment	SURFACE	4point	ZEROPOINT,TR.SPACE
	CIRCLE	4point	ZEROPOINT
HOM ①	CIRCLE	3point	
HOM ③	CIRCLE	3point	
			ADR PROG23
Measurement			
. OD	CIRCLE	4point	
. P	POINT	4point	(Surface of
• 2a	CIRCLE	4point	Vacuum Chuck)
• 2b(Z-0.1)	CIRCLE	lpoint	
• g1	POINT	4point	
• g2	POINT	lpoint	
• HOM ① d	CIRCLE	4point	
. HOM ② d	CIRCLE	4point	
. HOM ③ d	CIRCLE	4point	
• HOM ④ d	CIRCLE	4point	
. Slit ① 3mm	POINT	Zpoint	
1.5mm	POINT	Zpoint	
h	POINT	lpoint	
. Slit ② 3mm	POINT	Zpoint	
1.5mm	POINT	Zpoint	
h	POINT	lpoint	
• Slit ③ 3mm	POINT	2point	
1.5mm	POINT	2point	
h	POINT	lpoint	
. Slit ④ 3mm	POINT	2point	
1.5mm	POINT	2point	
h	POINT	lpoint	
. Slit ① Depth +-	POINT	± lpoint	
* Slit ④ Depth +-	POINT	± lpoint	
. Slit ③ Depth t −	POINT	± lpoint	
. Slit ② Depth −+	POINT	± lpoint	

CMM measurement point (rough cut cell)







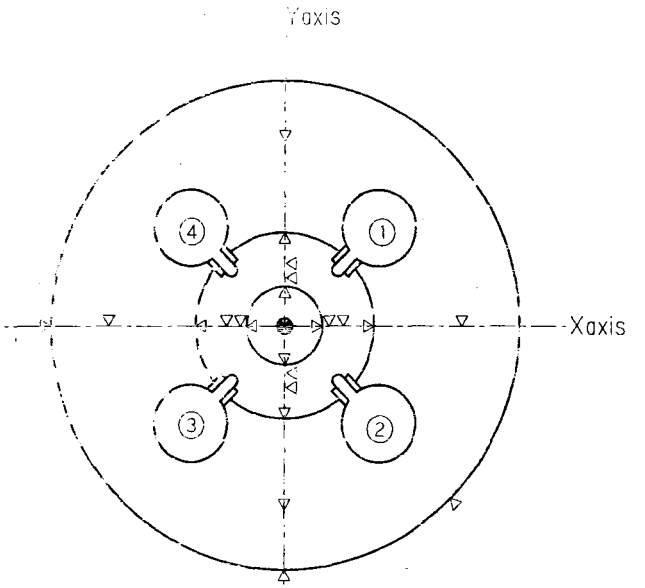


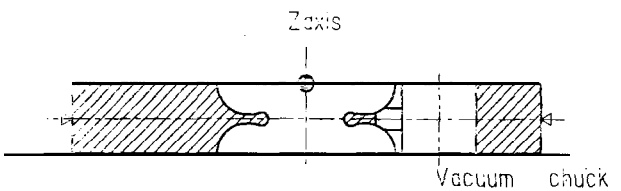
Measurement process of final machining disk

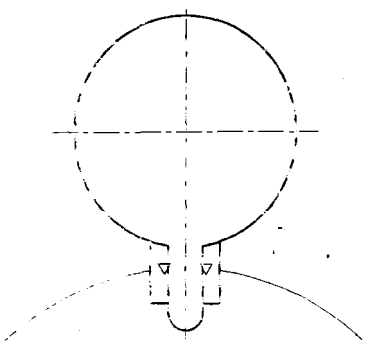
Alignment	SURFACE	lpoint	ZEROPOINT,TR.SPACE
	CIRCLE	lpoint	ZEROPOINT
HOM ②	CIRCLE	lpoint	
HOM ③	CIRCLE	4point	
			SYMMETRY
			ADR PROG23
Measurement			
. OD	CIRCLE	4point	
• P	POINT	lpoint	(Surface of
. 2a	CIRCLE	lpoint	Vacuum Chuck)
. 2b(Z-0.1)	CIRCLE	4point	
• 2b(Z-0.3)	CIRCLE	4point	
. g1	POINT	lpoint	
. g2	POINT	lpoint	
. Slit ④ Depth	POINT	2point	
. Slit ③ Depth	POINT	2point	
. Slit ② Depth	POINT	2point	
. Slit ① Depth	POINT	2point	

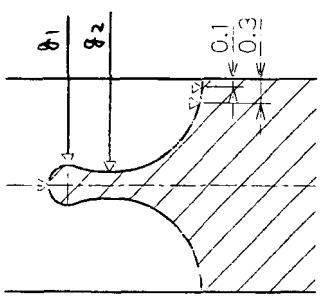
CMM measurement point (final cut cell)

Probe φ1









Time of measurement

* Setting	5 minutes	
* Edit of program	2h / 1 type	
* Alignment and Measurement	1	Rough : 20 minutes / disk Final : 10 minutes / disk
* Output data	2 minutes	

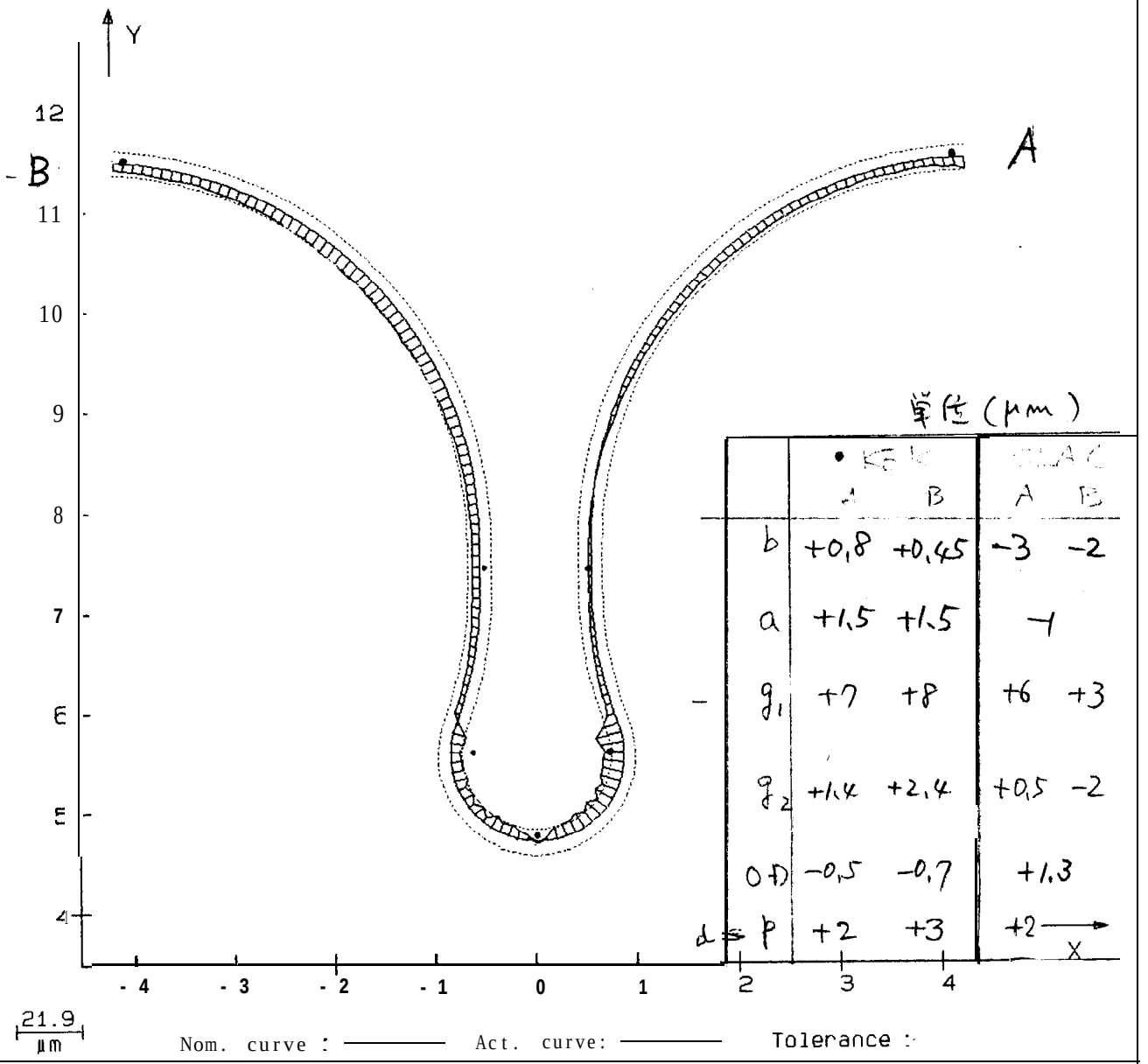
Comparison of typical data of #102,#153
Those taken by KEK and SLAC

a,b,g1,g2,OD

all consistent within 2-3 pm

except #102B

RDDS1 Test Cell #102 (TEST/003)



单位 (µm)

	KEK A	KEK B	SLAC A	SLAC B
b	+0,8	+0,45	-3	-2
a	+1,5	+1,5	-4	
g_1	+7	+8	+6	+3
g_2	+1,4	+2,4	+0,5	-2
OD	-0,5	-0,7	+1,3	
d = p	+2	+3	+2	

Dscrption: RODS TEST CELL X102
Ser. No. : TEST/003
customer : JUWEN WAN6

File No. : *****
Draw. No.: PF-290-287-39 E

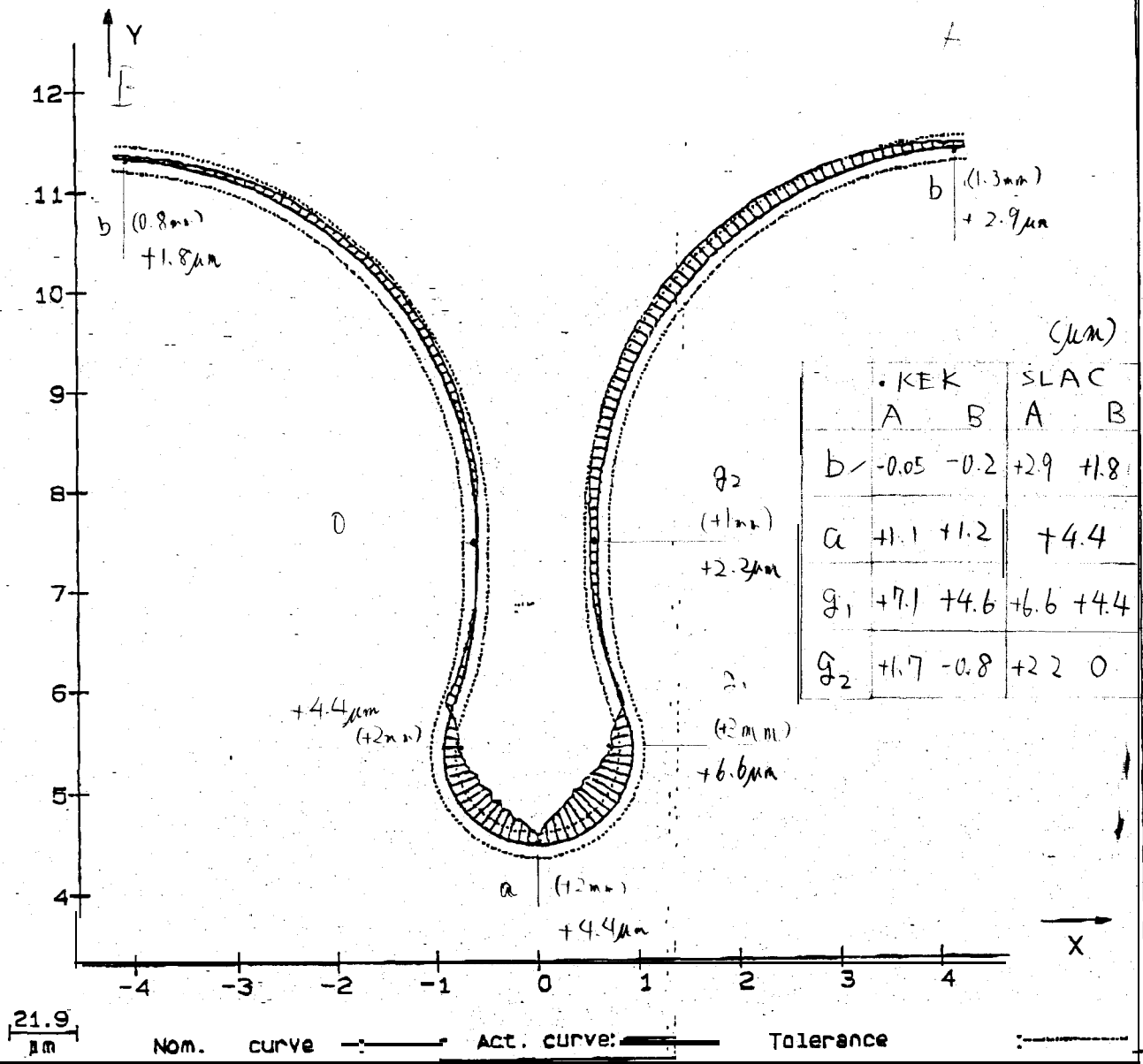
Element : PROFILE_CURV
Department: MET-06Q

			X	Y	Z	Nr.
Farm 0.01313	Min. Deviat.:	-0.00848	0.632	5.790	0.000	79
Lower Toler. :-0.00400	Max. Deviat.:	0.00464	-1.467	10.154	0.000	157
Upper Toler. : 0.00400						
Error Magnif.: 30						
No. of points: 188						

SLAC MET Inspection Department - 06Q - Established 1962

2D CON OUR

Inspector.: STARKEY M.D
Date .....: 3-DEC-98
Time .....: 11: 13: 10



(μm)

	KEK A	KEK B	SLAC A	SLAC B
b	-0.05	-0.2	+2.9	+1.8
a	+1.1	+1.2	+4.4	
g_1	+7.1	+4.6	+6.6	+4.4
g_2	+1.7	-0.8	+2.2	0

Dscription: RDDS TEST CELL #153
Ser. No. : T-NO.1 File No. : *****
Customer : JUWEN WANG Draw. No.: PF-290-287-39 E

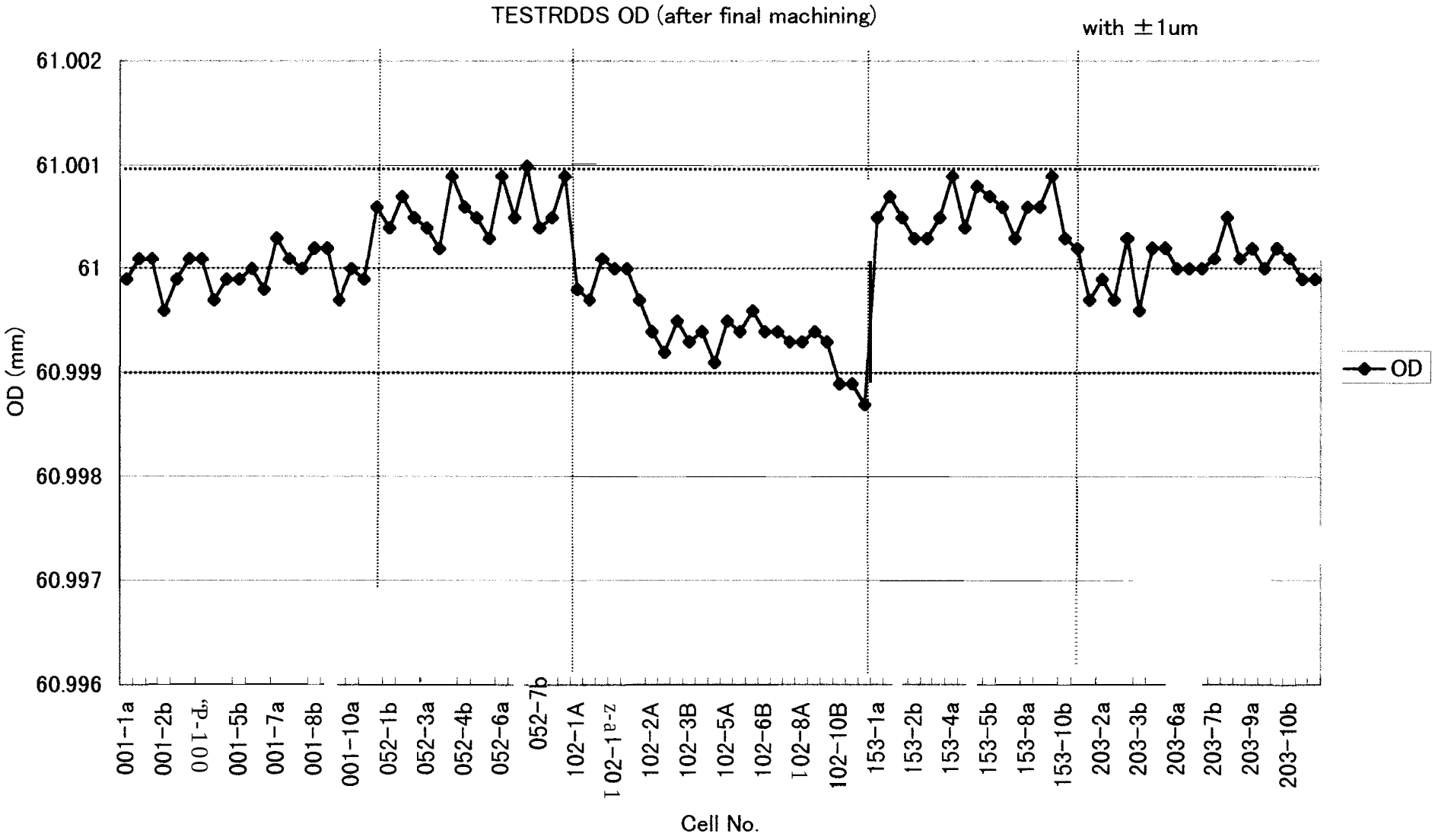
Element : PROFILE_CURV
Department: MET-06Q

			X	Y	Z	Nr.
Form	0.01678	Min. Deviat.: -0.01408	0.644	2.868	-3.734	88
Lower Toler. :	-0.00400	Max. Deviat.: 0.00270	-0.798	3.612	-4.702	115
Upper Toler. :	0.00400					
Error Magnif.:	30					
No. of points:	188					

SLAC MET Inspection Department - 06Q - Established 1962

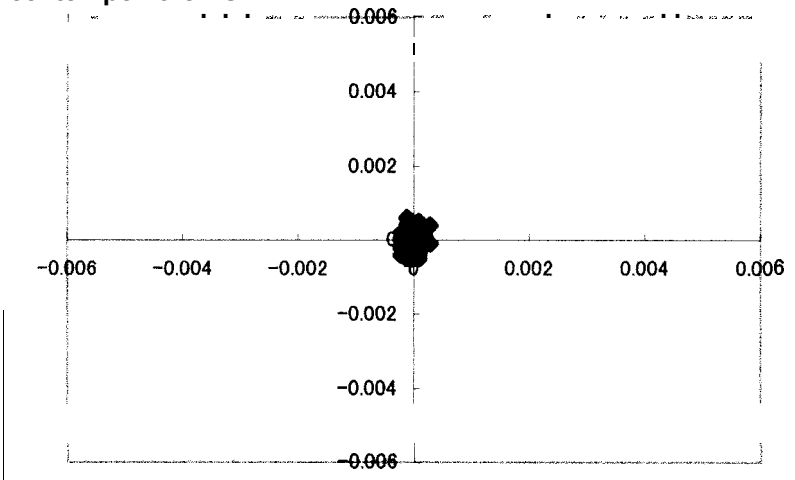
2D - CONTOUR

Inspector.: STARKEY M.D
Date .....: 12-JAN-99
Time .....: 12:20:52

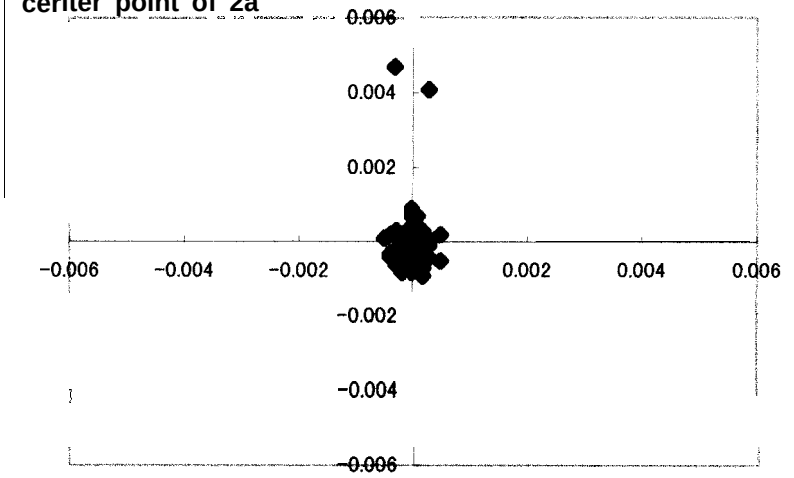

TESTRDDS OD (after final machining)
with ±1um
61.002
61.001
61
60.999
60.998
60.997
60.996
OD (mm)
OD
001-1a
001-2b
001-5b
001-7a
001-8b
001-10a
052-1b
052-3a
052-4b
052-6a
052-7b
102-1A
102-2A
102-3B
102-5A
102-6B
102-8A
102-10B
153-1a
153-2b
153-4a
153-5b
153-8a
153-10b
203-2a
203-3b
203-6a
203-7b
203-9a
203-10b
Cell No.

Concentricity of 2a,2b with respect of OD

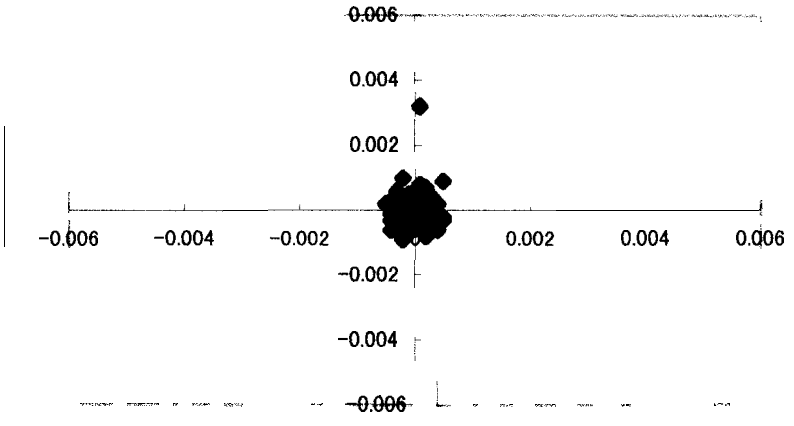
'center point of OD

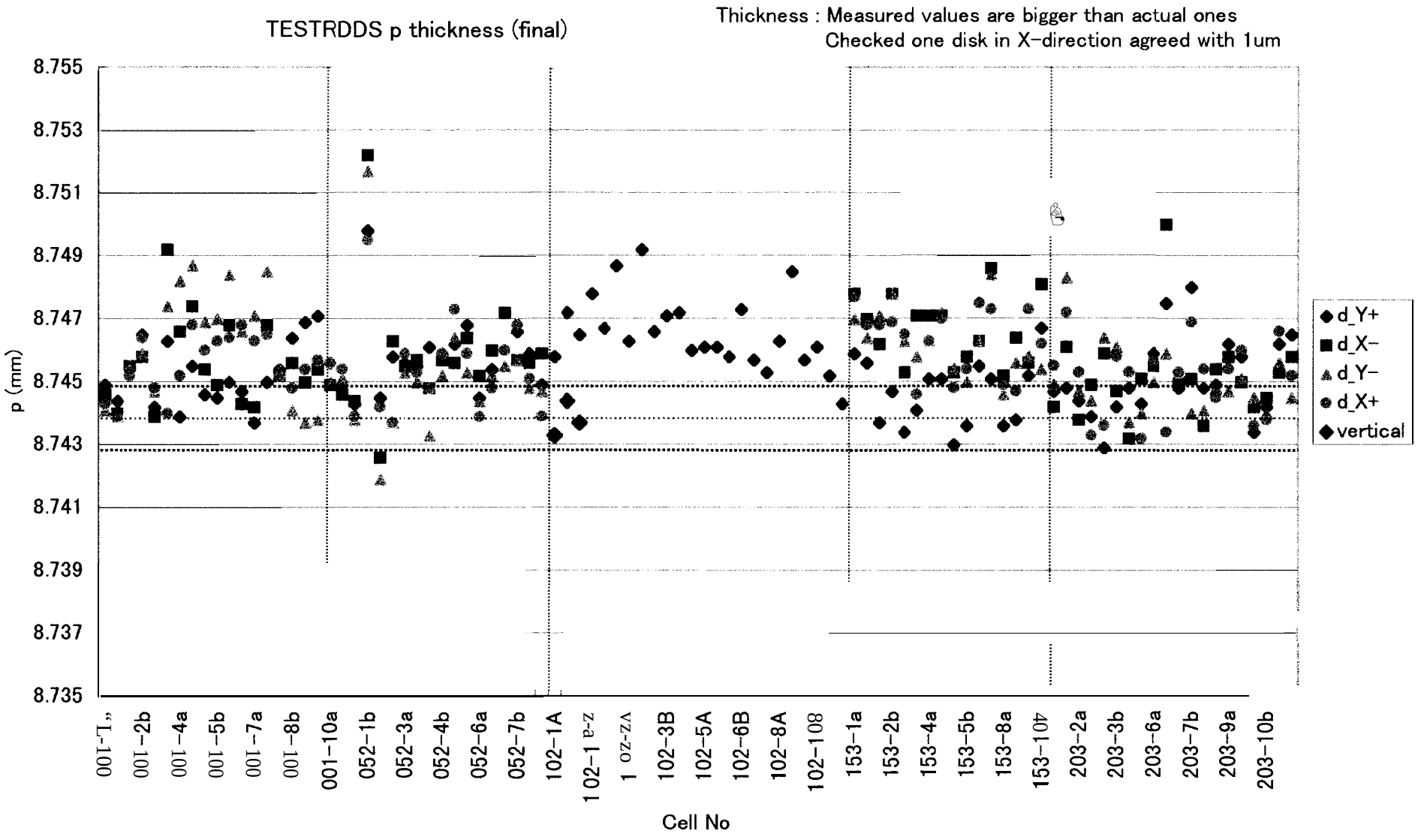


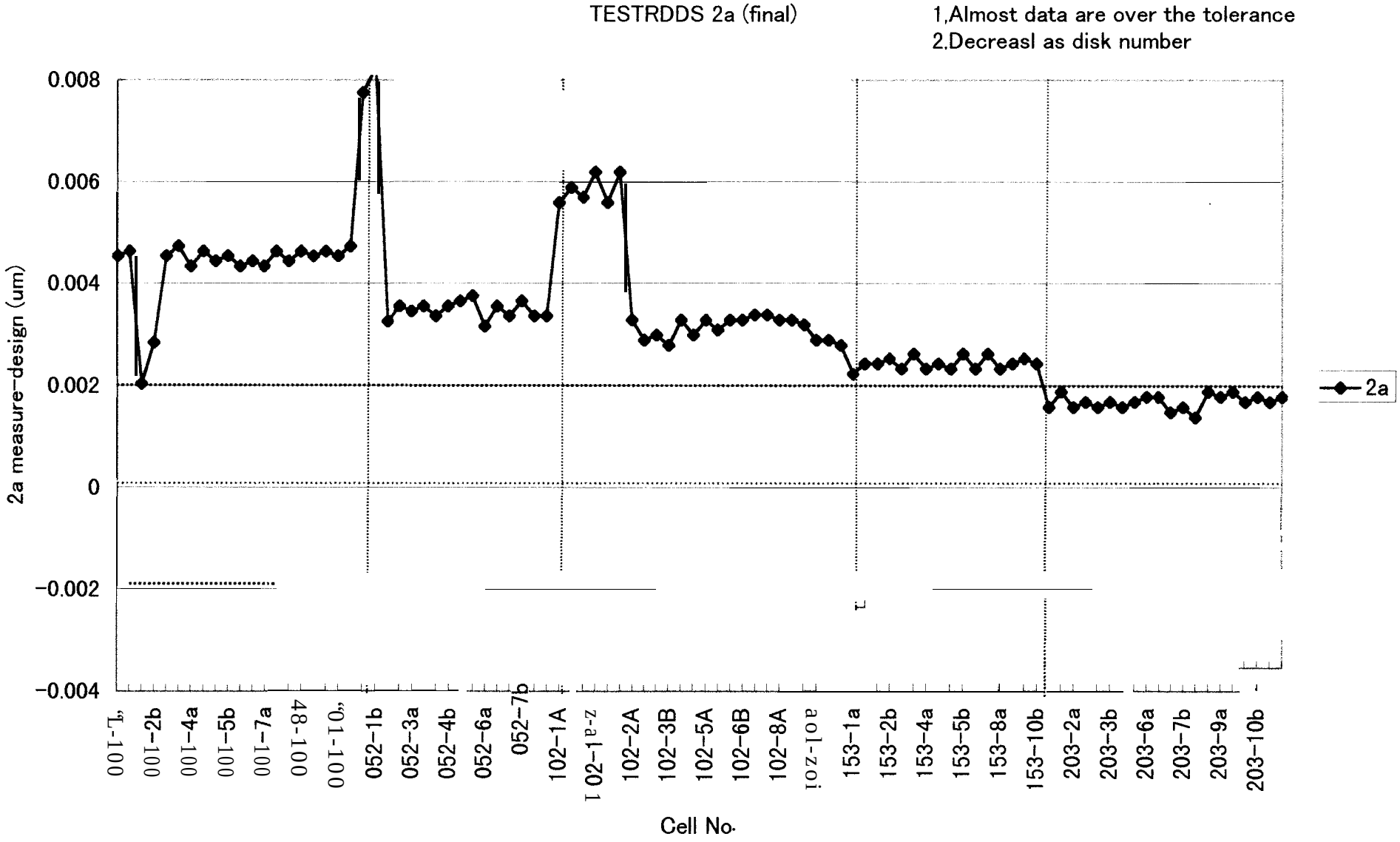
ceriter point of 2a

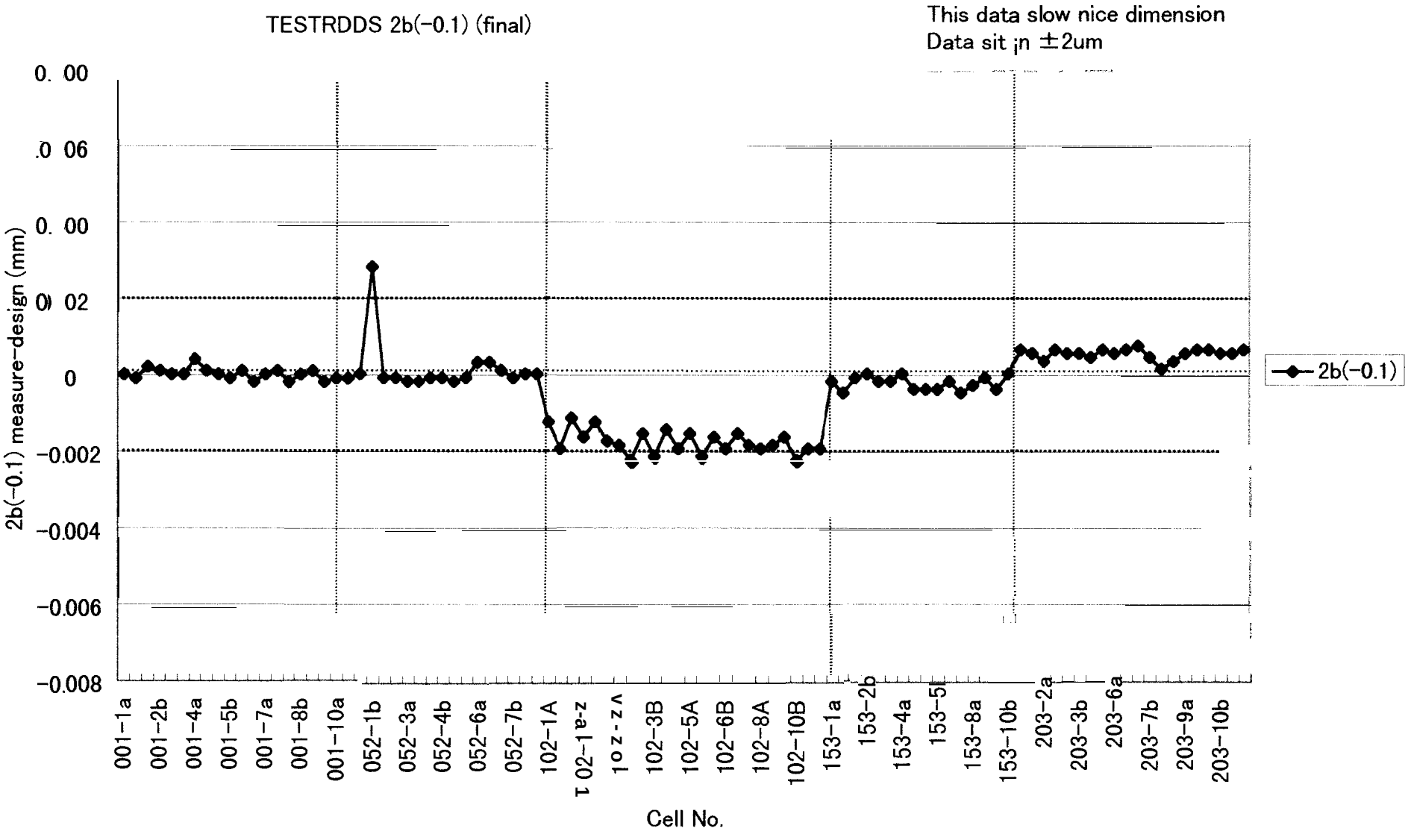


center point of 2b(0.1)



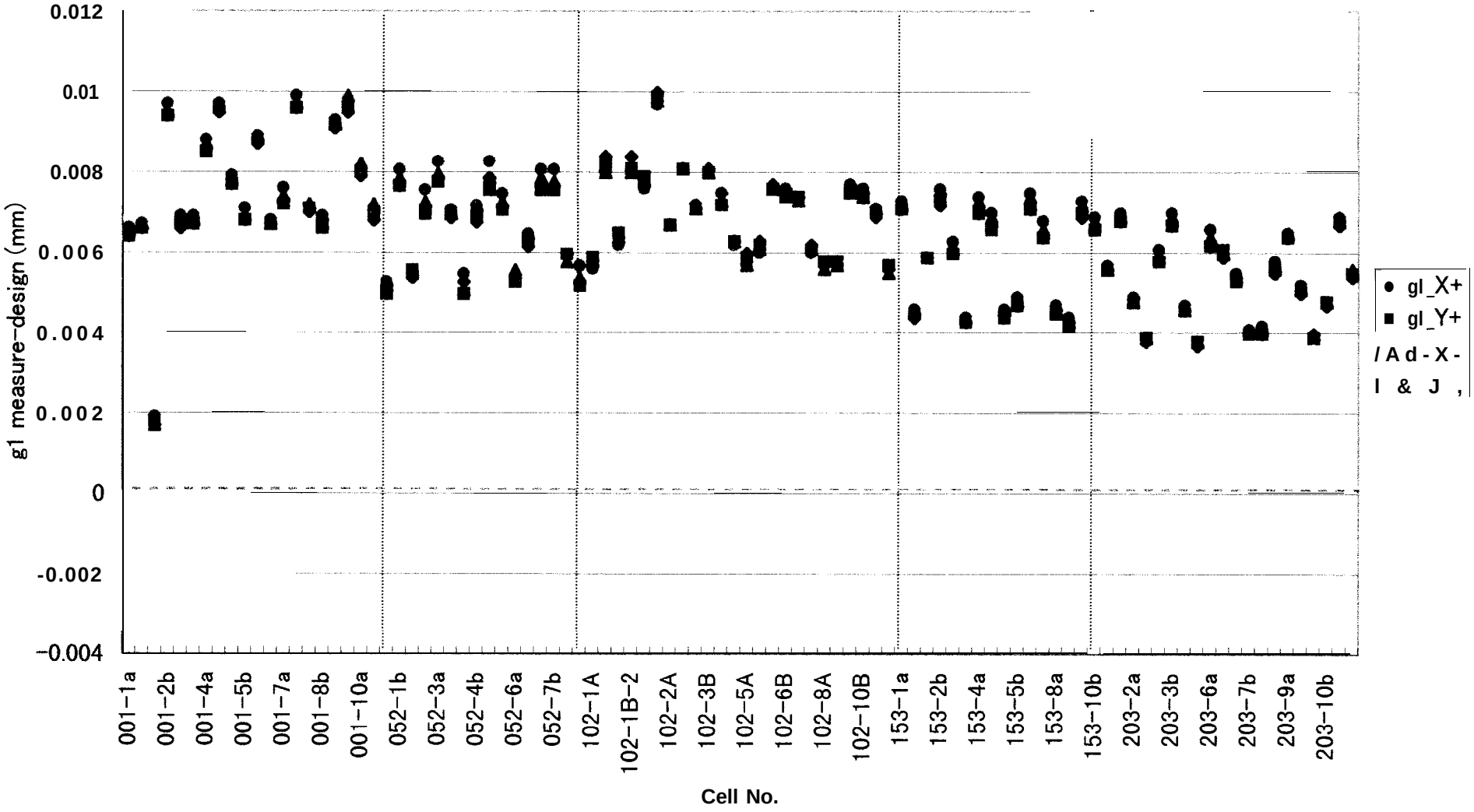

TESTRDDS p thickness (final)
Thickness : Measured values are bigger than actual ones
Checked one disk in X-direction agreed with 1um
8.755
8.753
8.751
8.749
8.747
8.745
8.743
8.741
8.739
8.737
8.735
p (mm)
d_Y+
d_X-
d_Y-
d_X+
vertical
001-10a
052-1b
052-3a
052-4b
052-6a
052-7b
102-1A
102-3B
102-5A
102-6B
102-8A
153-1a
153-2b
153-4a
153-5b
153-8a
203-2a
203-3b
203-6a
203-7b
203-9a
203-10b
Cell No

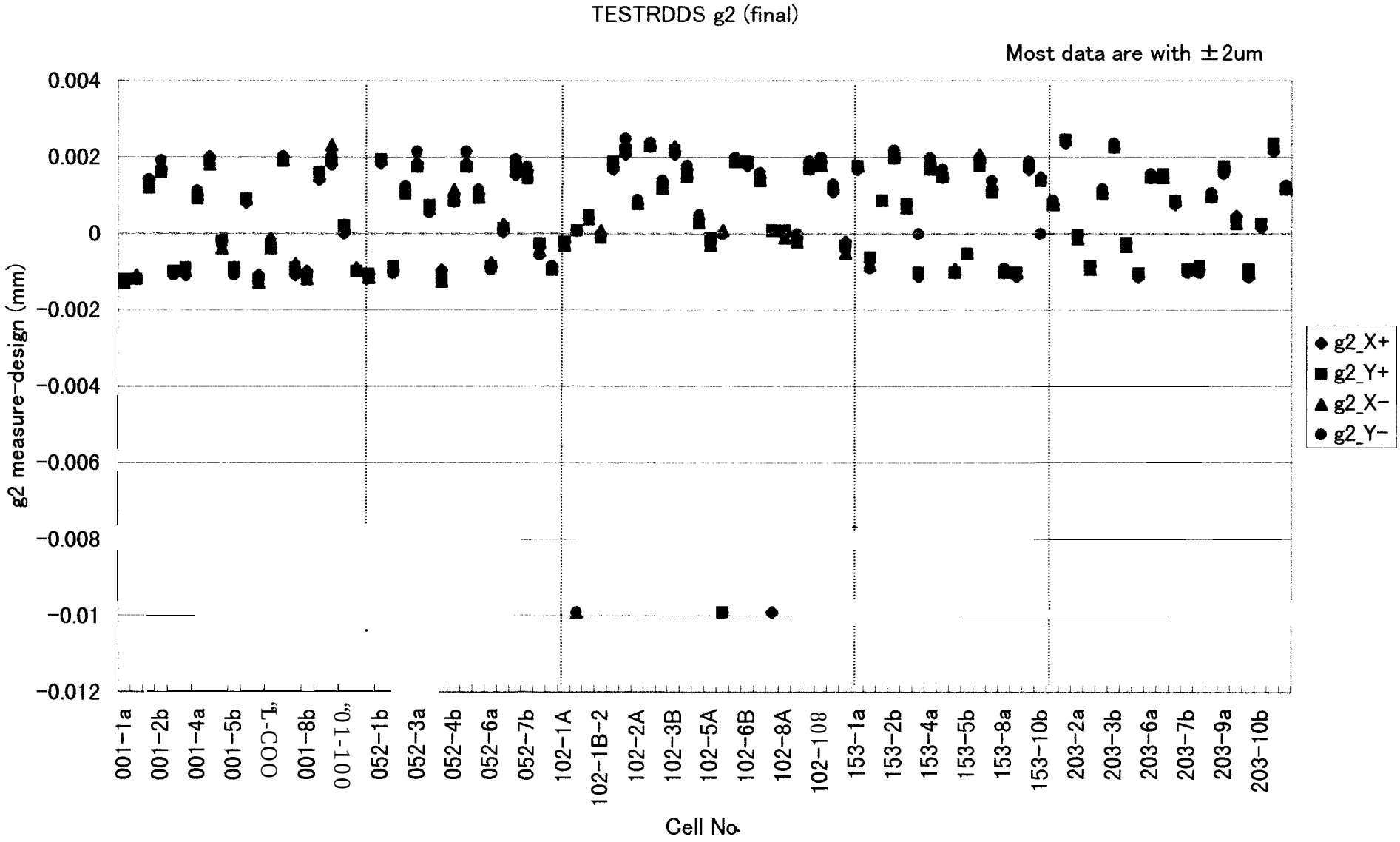

TESTRDDS 2a (final)
1,Almost data are over the tolerance
2,Decreasl as disk number
0.008
0.006
0.004
0.002
0
-0.002
-0.004
2a measure-design (um)
2a
Cell No.

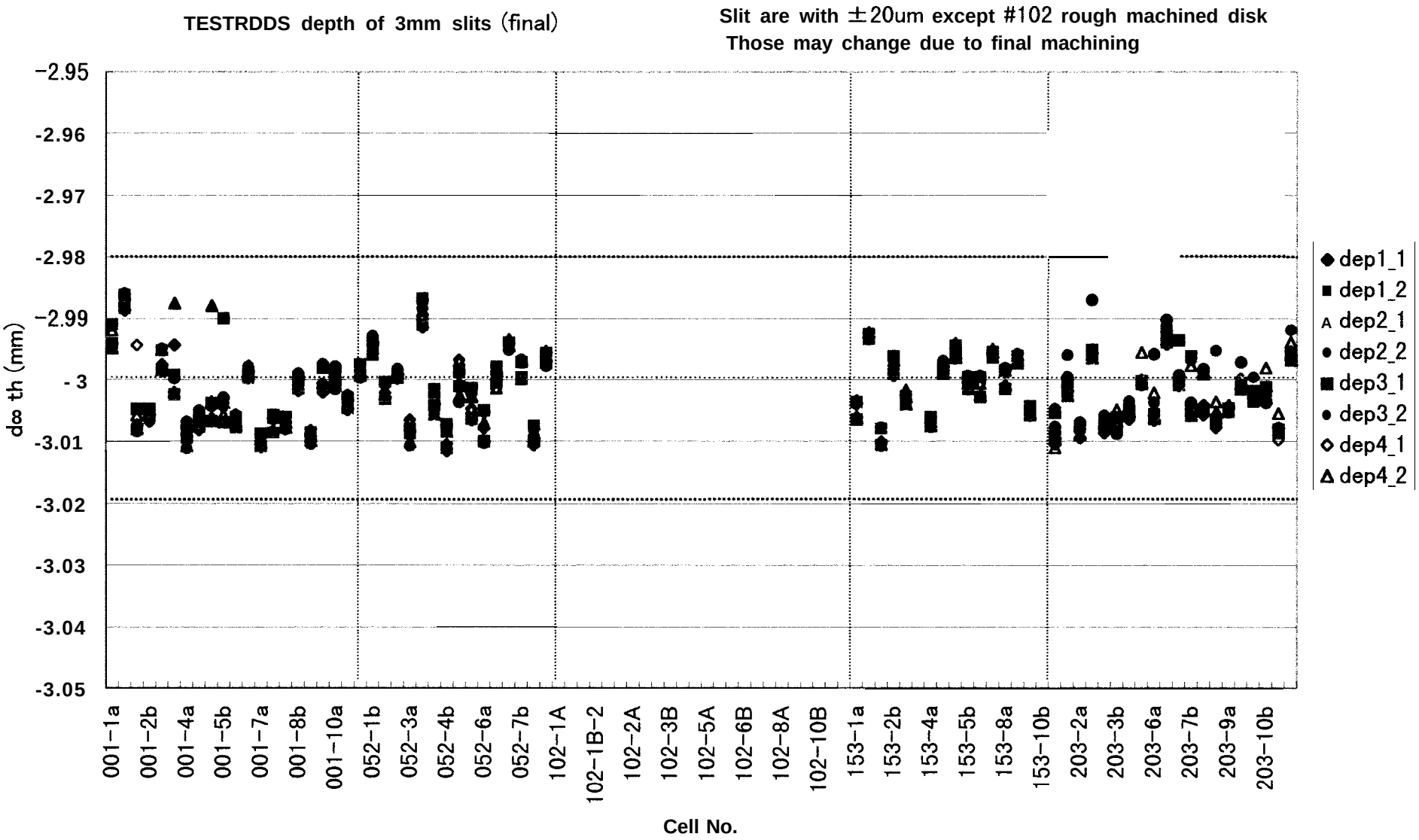

TESTRDDS 2b(−0.1) (final)
This data slow nice dimension
Data sit ¡n ±2um
0. 00
.0 06
0. 00
0) 02
0
−0.002
−0.004
−0.006
−0.008
2b(−0.1) measure−design (mm)
2b(−0.1)
001−1a
001−2b
001−4a
001−5b
001−7a
001−8b
001−10a
052−1b
052−3a
052−4b
052−6a
052−7b
102−1A
102−3B
102−5A
102−6B
102−8A
102−10B
153−1a
153−2b
153−4a
153−8a
153−10b
203−2a
203−3b
203−6a
203−7b
203−9a
203−10b
Cell No.

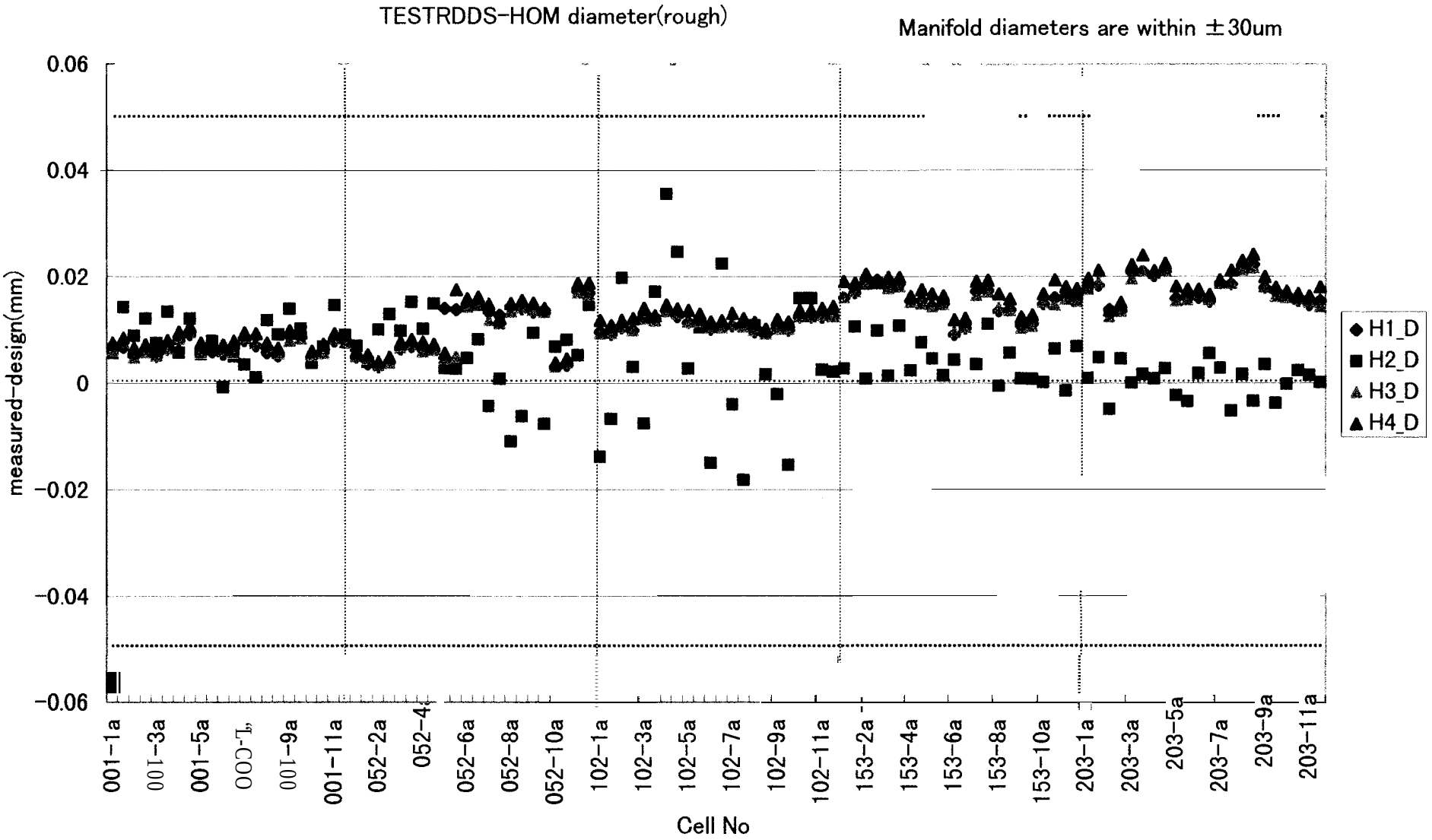
TESTRDDS gl (final)

Most data are with larger than design by 4 to 10 microns

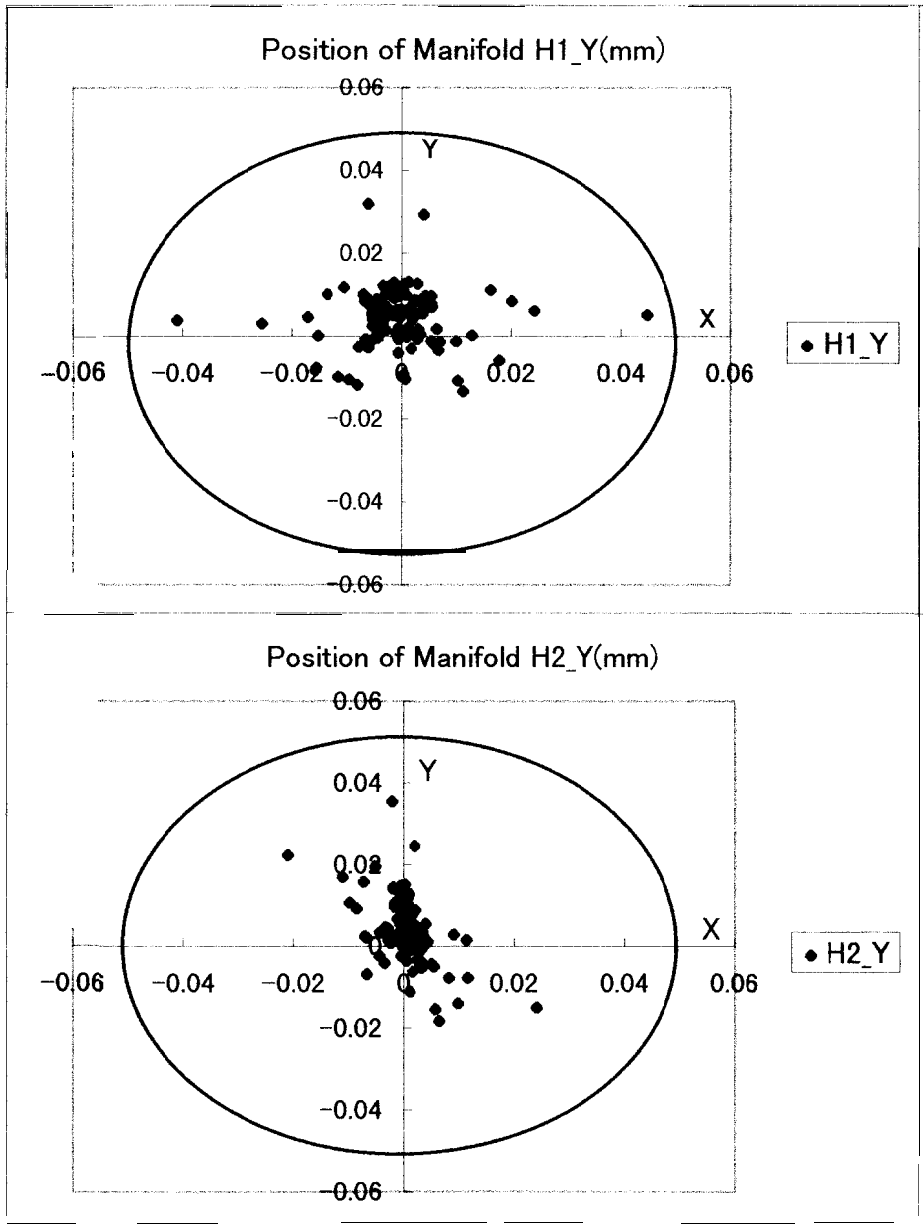


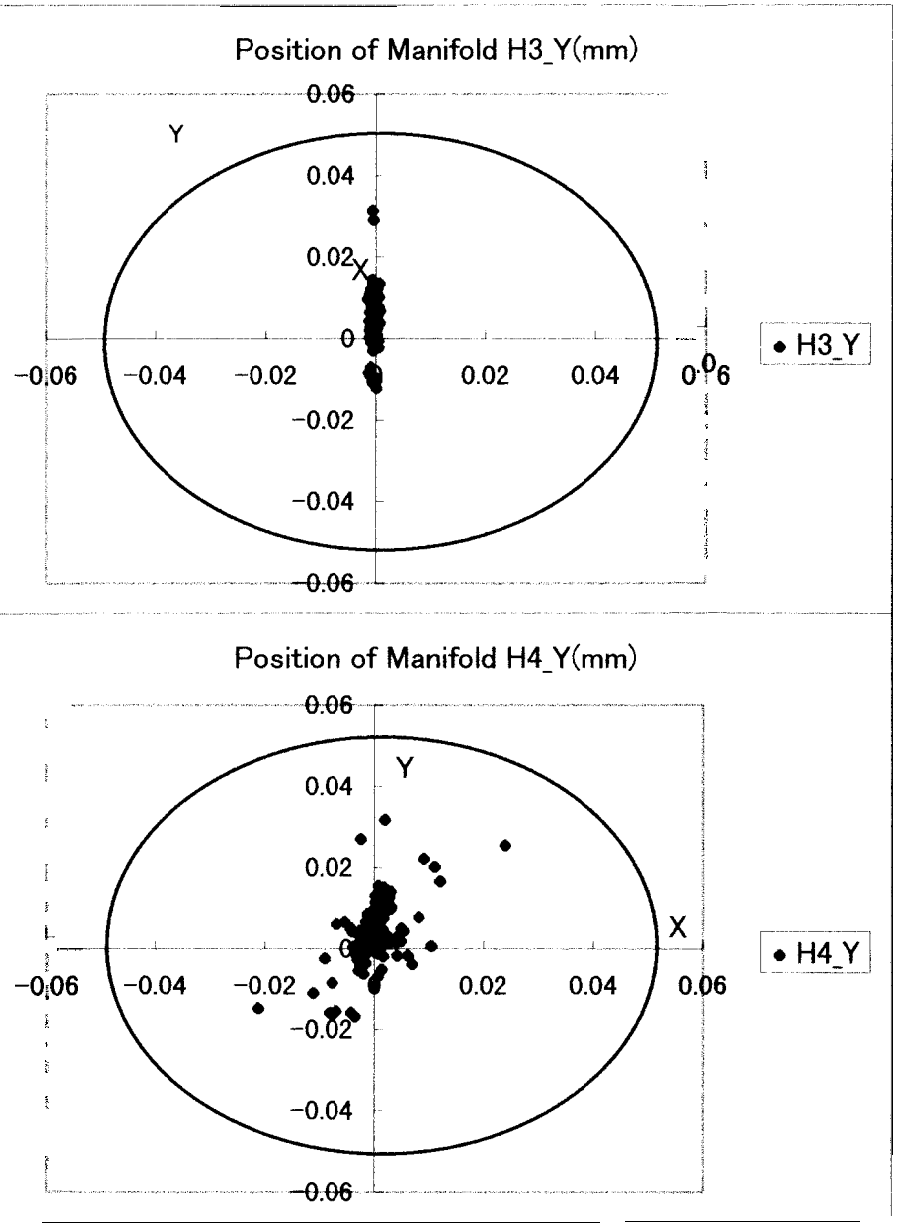

TESTRDDS g2 (final)
Most data are with ±2um
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
g2 measure-design (mm)
g2_X+
g2_Y+
g2_X-
g2_Y-
001-1a
001-2b
001-4a
001-5b
001-8b
052-1b
052-3a
052-4b
052-6a
052-7b
102-1A
102-1B-2
102-2A
102-3B
102-5A
102-6B
102-8A
153-1a
153-2b
153-4a
153-5b
153-8a
153-10b
203-2a
203-3b
203-6a
203-7b
203-9a
203-10b
Cell No.

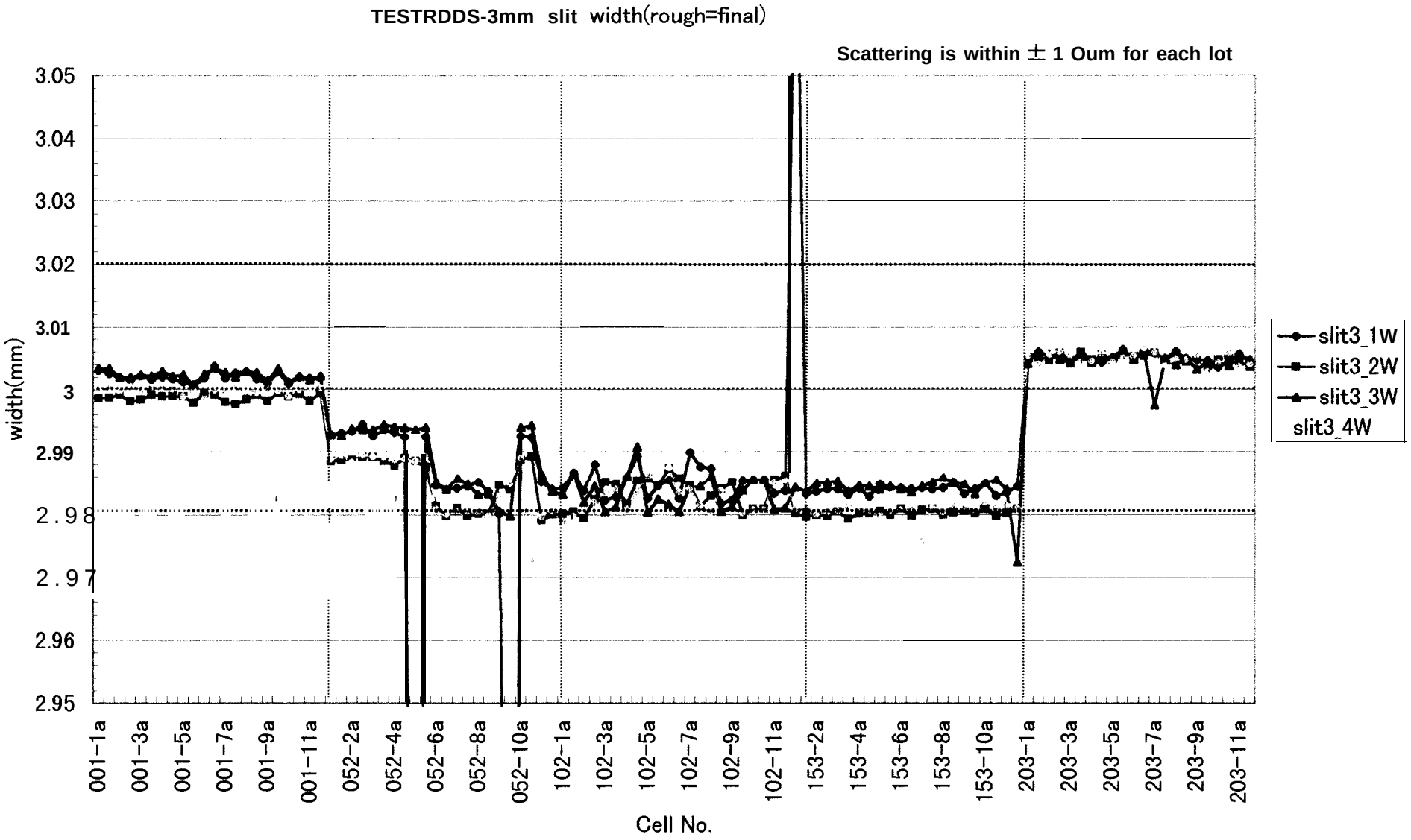

TESTRDDS depth of 3mm slits (final)
Slit are with ±20um except #102 rough machined disk
Those may change due to final machining
-2.95
-2.96
-2.97
-2.98
-2.99
- 3
-3.01
-3.02
-3.03
-3.04
-3.05
dθ th (mm)
001-1a
001-2b
001-4a
001-5b
001-7a
001-8b
001-10a
052-1b
052-3a
052-4b
052-6a
052-7b
102-1A
102-1B-2
102-2A
102-3B
102-5A
102-6B
102-8A
102-10B
153-1a
153-2b
153-4a
153-5b
153-8a
153-10b
203-2a
203-3b
203-6a
203-7b
203-9a
203-10b
Cell No.
dep1_1
dep1_2
dep2_1
dep2_2
dep3_1
dep3_2
dep4_1
dep4_2


TESTRDDS-HOM diameter(rough)
Manifold diameters are within ±30um
measured-design(mm)
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
H1_D
H2_D
H3_D
H4_D
001-1a
001-3a
001-5a
001-9a
001-11a
052-2a
052-6a
052-8a
052-10a
102-1a
102-3a
102-5a
102-7a
102-9a
102-11a
153-2a
153-4a
153-6a
153-8a
153-10a
203-1a
203-3a
203-5a
203-7a
203-9a
203-11a
Cell No

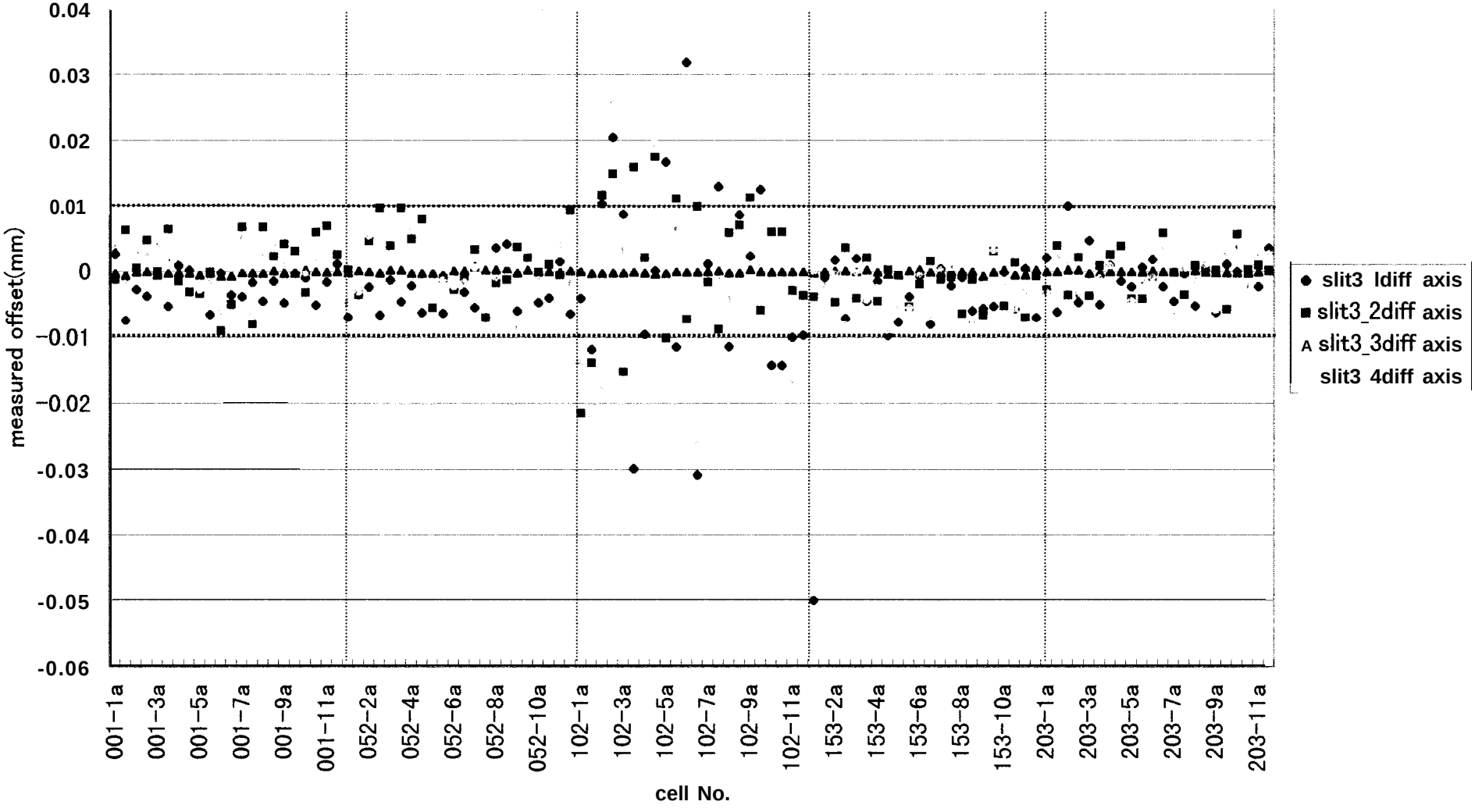
Position of manifold within ±50um

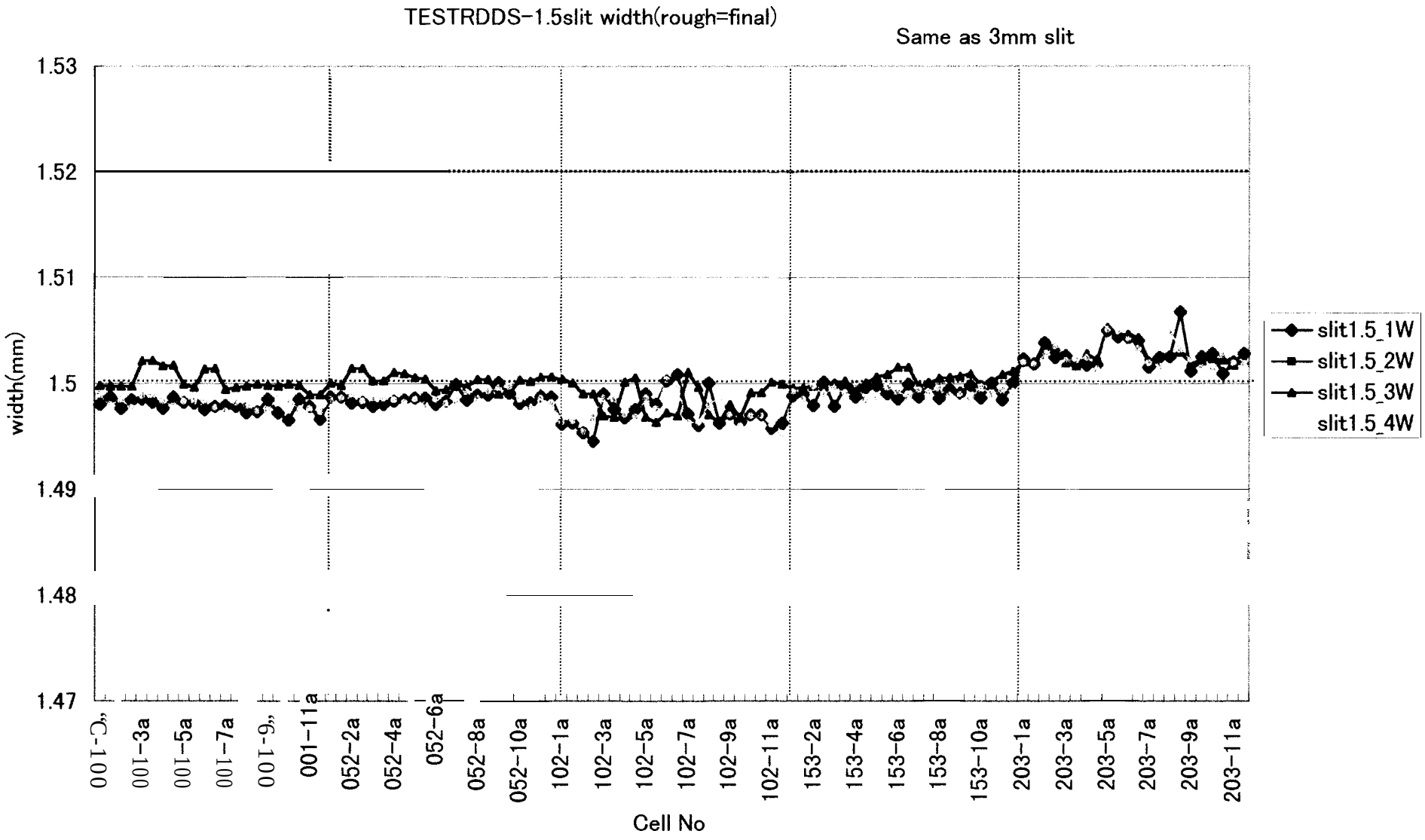


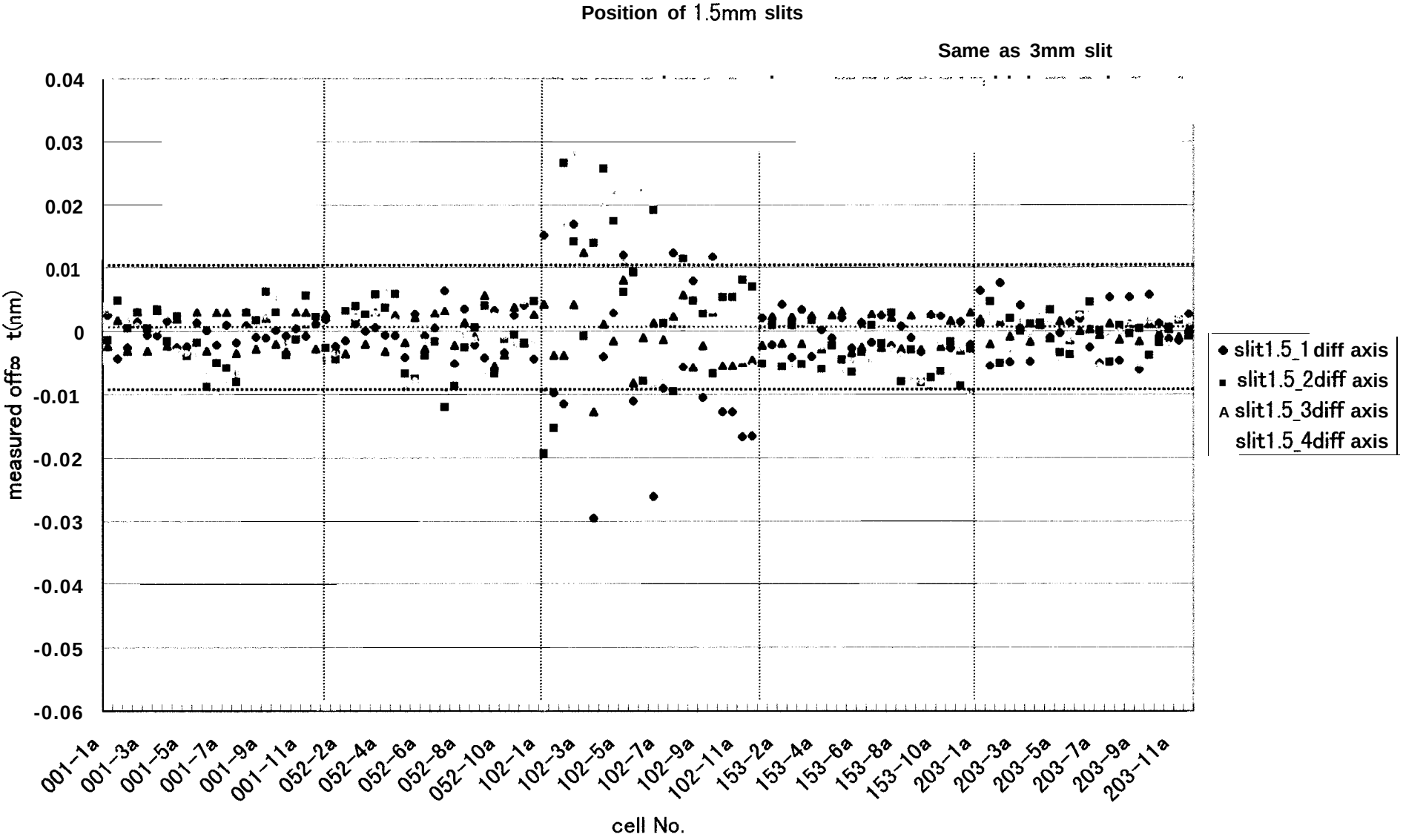



TESTRDDS-3mm slit width(rough=final)
Scattering is within ± 1 Oum for each lot
width(mm)
3.05
3.04
3.03
3.02
3.01
3
2.99
2.98
2.97
2.96
2.95
001-1a
001-3a
001-5a
001-7a
001-9a
001-11a
052-2a
052-4a
052-6a
052-8a
052-10a
102-1a
102-3a
102-5a
102-7a
102-9a
102-11a
153-2a
153-4a
153-6a
153-8a
153-10a
203-1a
203-3a
203-5a
203-7a
203-9a
203-11a
Cell No.
slit3_1w
slit3_2W
slit3_3W
slit3_4W

Within ± 1 Oum
Those #102 may be due to training stage in CMM or machining?

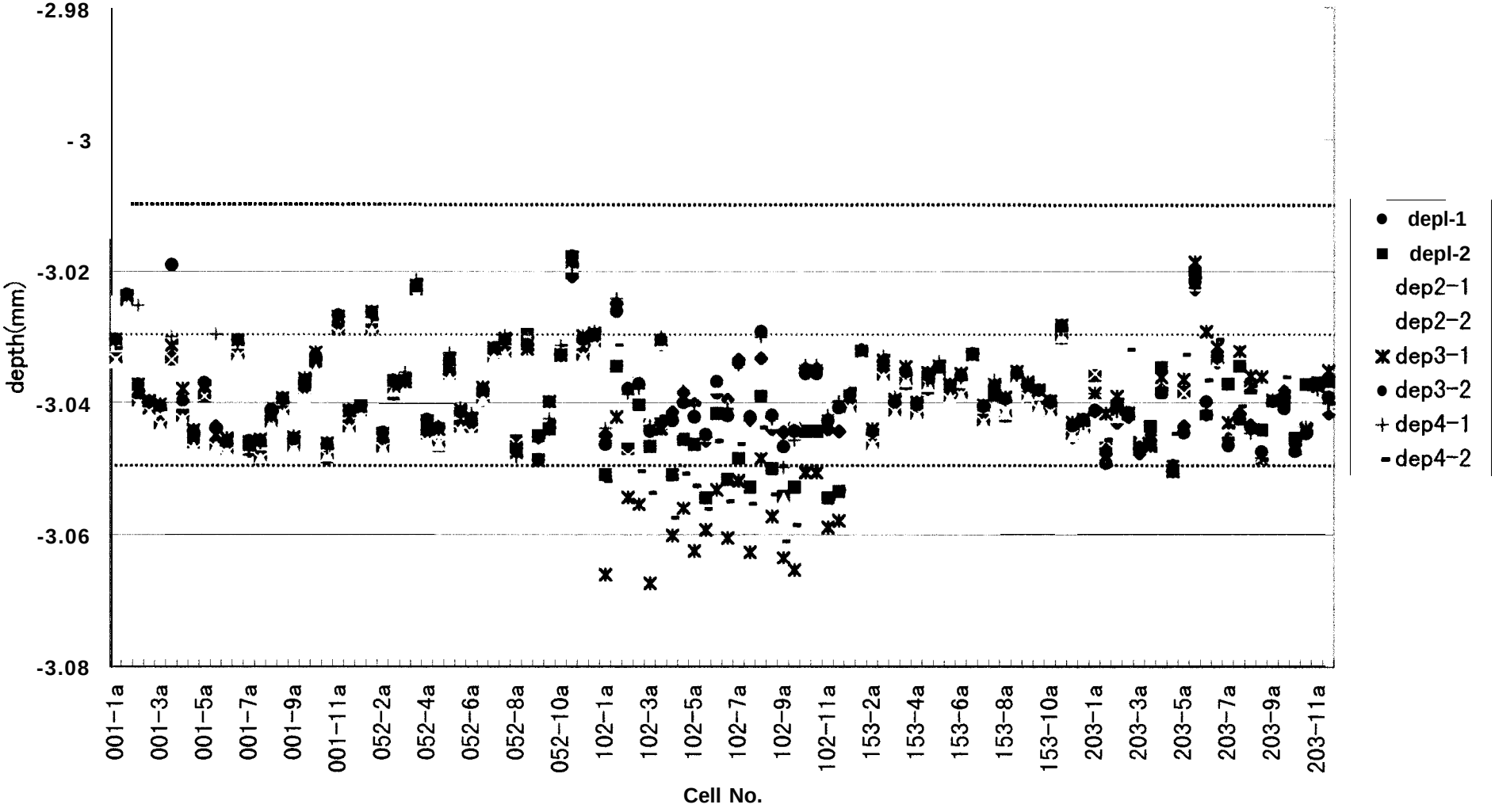


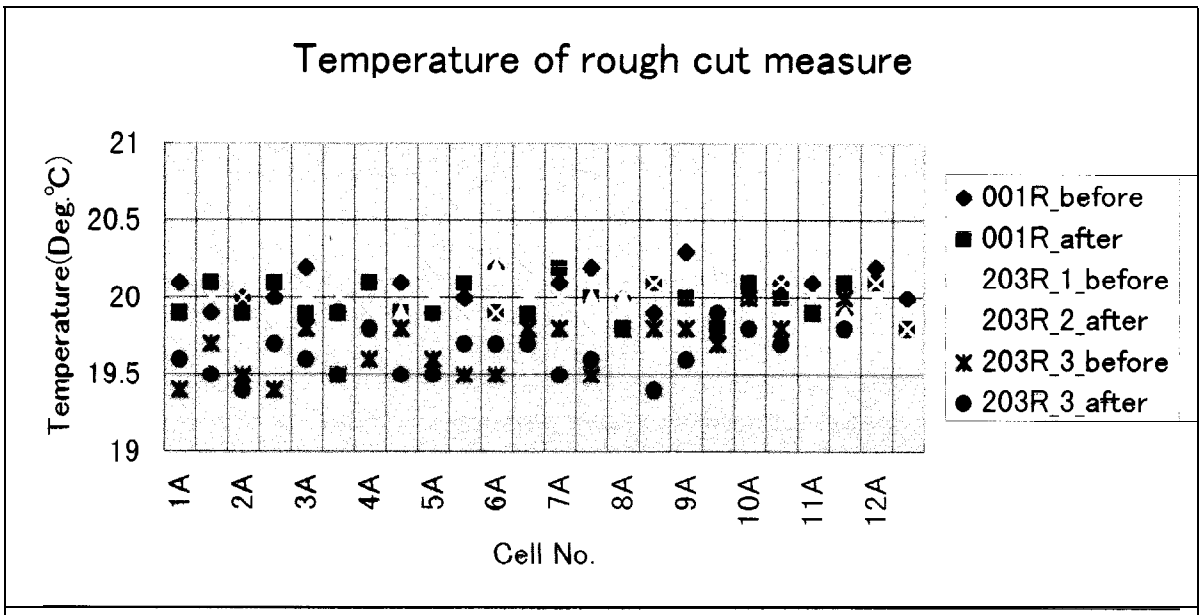

TESTRDDS-1.5slit width(rough=final)
Same as 3mm slit
width(mm)
1.53
1.52
1.51
1.5
1.49
1.48
1.47
slit1.5_1W
slit1.5_2W
slit1.5_3W
slit1.5_4W
001-3a
001-5a
001-7a
001-11a
052-2a
052-4a
052-6a
052-8a
052-10a
102-1a
102-3a
102-5a
102-7a
102-9a
102-11a
153-2a
153-4a
153-6a
153-8a
153-10a
203-1a
203-3a
203-5a
203-7a
203-9a
203-11a
Cell No

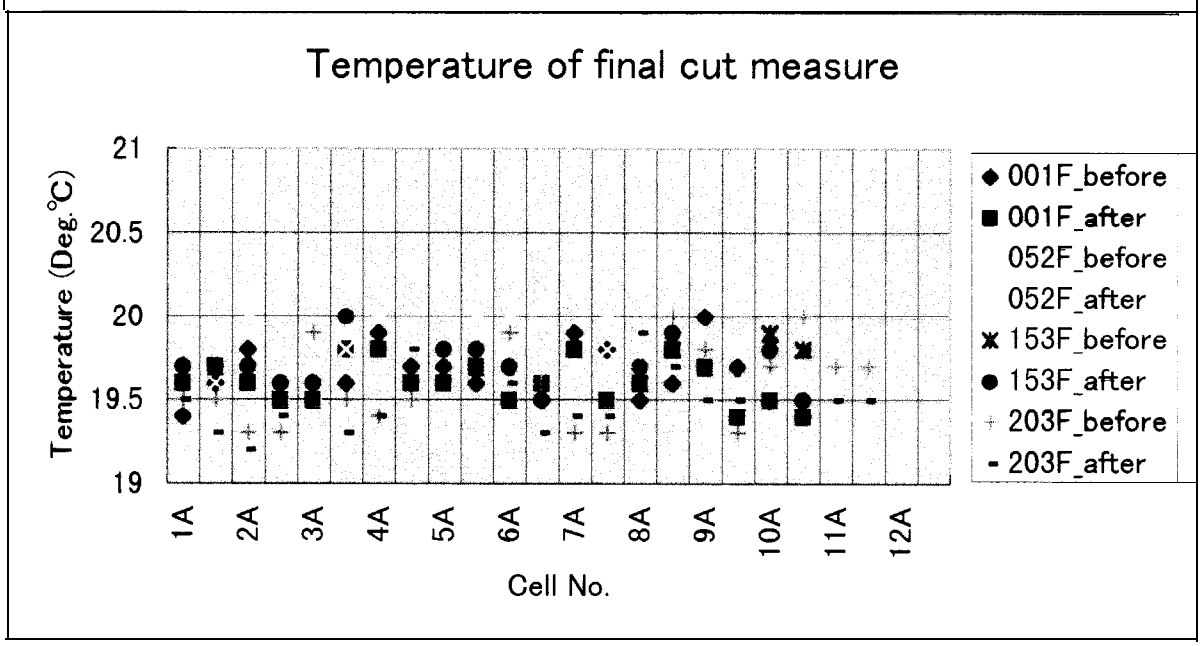

Position of 1.5mm slits
Same as 3mm slit
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
measured offset(nm)
001-1a
001-3a
001-5a
001-7a
001-9a
001-11a
052-2a
052-4a
052-6a
052-8a
052-10a
102-1a
102-3a
102-5a
102-7a
102-9a
102-11a
153-2a
153-4a
153-6a
153-8a
153-10a
203-1a
203-3a
203-5a
203-7a
203-9a
203-11a
cell No.
slit1.5_1diff axis
slit1.5_2diff axis
slit1.5_3diff axis
slit1.5_4diff axis

TESTRDDS-3mm slits depth(as of rough machining)

Slit are within ± 20um except #102 rough machined disk those may change due final machining




Temperature of rough cut measure
Temperature(Deg.°C)
21
20.5
20
19.5
19
1A
2A
3A
4A
5A
6A
7A
8A
9A
10A
11A
12A
Cell No.
001R_before
001R_after
203R_1_before
203R_2_after
203R_3_before
203R_3_after


Temperature of final cut measure
Temperature (Deg.°C)
21
20.5
20
19.5
19
1A
2A
3A
4A
5A
6A
7A
8A
9A
10A
11A
12A
Cell No.
001F_before
001F_after
052F_before
052F_after
153F_before
153F_after
203F_before
203F_after

Conclusion

1. We can measure disk using ZEISS at KEK

   with precision of about 1 pm in diameter , width , depth etc.

2. Precision of thickness measure is bad. About several pm

3. One disk can be measured using the present method

   in 2-hours programming and 0.5-hour measurement for

   rough and final in total

Development of the measuring RDDS1

¶ We need to establish a fixture by

Re-designing the chuck to measure thickness

Studying of fixture to set disk vertically

To precisely measure thickness

To measure both sides at once

¶ Software for 200 different disks

Present CMM is Difficult to edit program for each discrete data

Very time consuming to program

Should we investigate the usage of other machine?