SURVEY AND ALIGNMENT FOR THE SIAM PHOTON PROJECT

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Abstract

The Siam Photon Source (SPS) which is a synchrotron radiation research project is now in its final stage.

This paper presents a review of the survey procedures and alignment methods at the facilities of the SPS at the National Synchrotron Research Center (NSRC) in Thailand.

1 INTRODUCTION

The SPS accelerator consists of four major parts of the 1 GeV storage ring, the booster synchrotron, the beam transport line and the linac. The main facility is the storage ring, with a circumference of about 81 meters, is composed of eight bending cells. Each bending cell has dipoles of 45 degree. The ring has four short straight sections of about 6.2 meters and four long straight sections of about 9.8 meters (Fig.1).

The accelerator complex consists of four blocks mainly, synchrotron hall, the beam transport tunnel and the storage ring hall. The machine components would not align in each hall at the same time.

The elevation of the storage ring and the booster synchrotron are not the same plane (Fig.2). Therefore it determined the relative height for these planes between the storage ring and the booster synchrotron.

Each alignment error of survey monument must not concentrate on each hall. Therefore the survey work was carried out for whole of these halls. Then alignment for each component was carried out by the laser tracker.

The alignment process will consist of two phases.

The first phase is the prealignment. At this stage, each magnet will be aligned individually from the geodetic survey network previously described.

The next phase will be the final smoothing. This smoothing is made directly on the fiducials of the components, without any measurement from an external network.

2 THE SURVEY FOR THE WHOLE OF HALLS

2.1 The kinds of monument

The kinds of the survey monument are as the next.

(1) 1st order reference marks (1st RM)
First off all, we installed these marks in uniformed precision at the whole of accelerator halls. Because of the precision of these reference marks were not biased.

(2) 2nd order reference marks (2nd RM)
The purpose of the 2nd RM is the alignment for these machine components. These 2nd order reference marks settings were based on more than two 1st order reference marks.

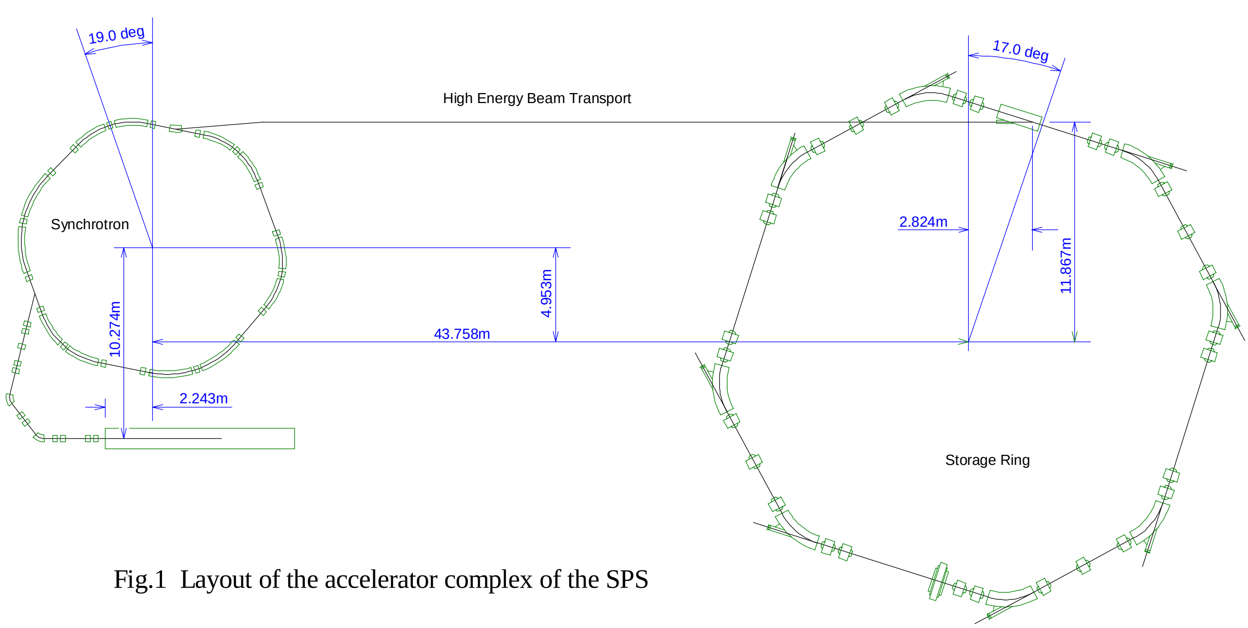

Fig.1 Layout of the accelerator complex of the SPS

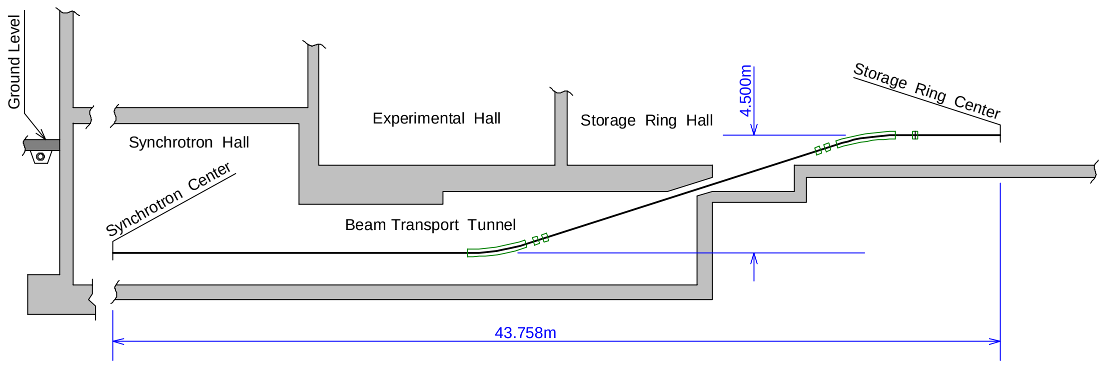

Fig.2 Profile of the acelerator complex of the SPS

(3) The level marks (LM)
The purpose of the level marks was referred for the height to machine components. These level marks settings based on floor level point.

When installing the control marks, a lower rank reference point based on the higher rank reference marks.

2.2 *Numbers of these monuments*

These numbers of these survey monuments are shown in table 1.

Table 1 The Number of each kind of Marks

	Number of marks
1st order reference marks	7
2nd order reference marks	14
Level marks	8

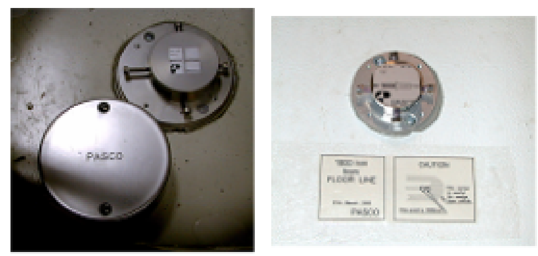

Fig.3 The structure of monument

Fig.3 shows the structure of the 1st order reference mark on the floor and the level mark on the wall.

2.3 The survey for the1st order reference mark

These 1st order reference marks had been surveyed by the survey network which is shown in Fig.5.

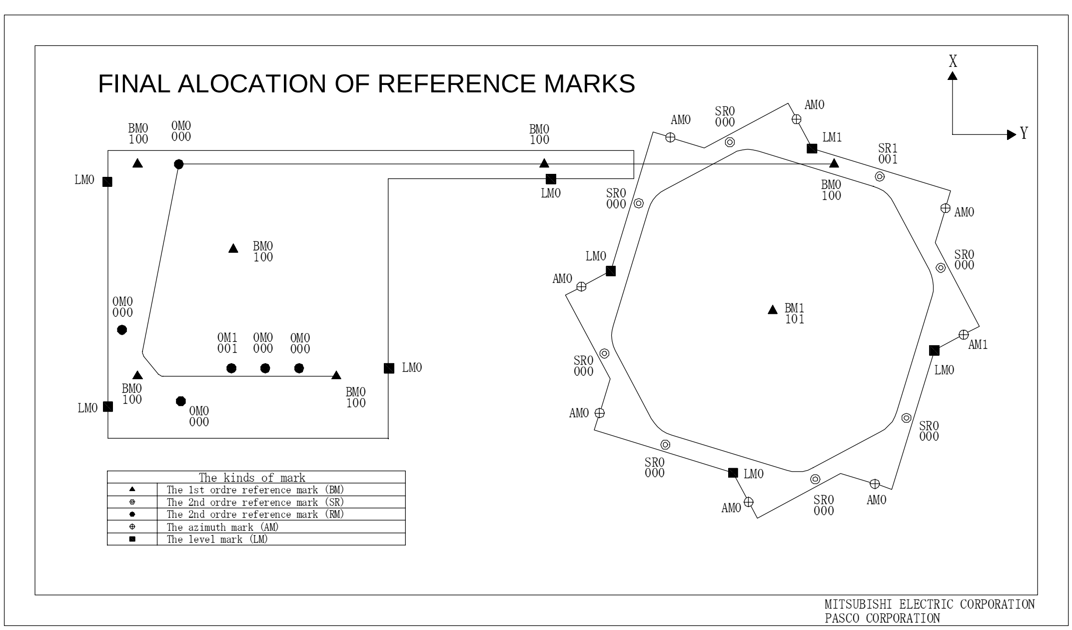

Fig.4 The allocation of monuments

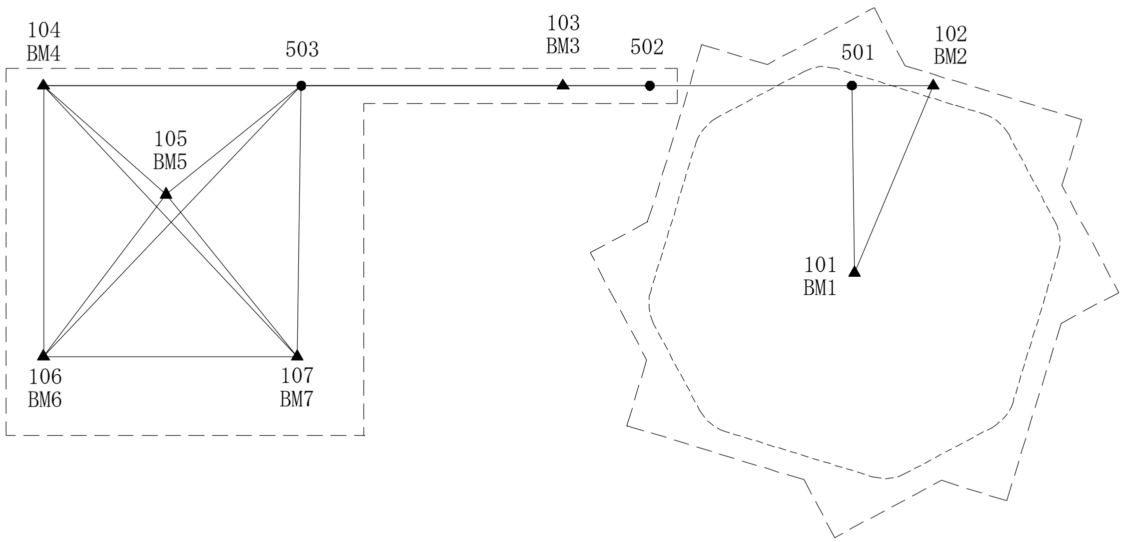

Fig.5 The Survey network for 1st order reference marks

2.4 The network Adjustment (Free network Adjustment)

Any measurement always has errors. Therefore, to minimize these errors, it must be measured with the precise survey instrument. This error what cannot eliminate with some precise survey instruments computes by the survey network adjustment to the optimal error processing. In this survey work at NSRC, the survey data were calculated by the survey network adjustment program PAG-U[1]. The method of network procedure was free network adjustment.

The 2nd Reference Marks about LINAC and LEBT were not a complicated survey network but composed of survey network by angles and distances what so called traverse survey. Therefore, it was not calculated by the free network adjustment but by the fixed network adjustment. The fixed stations were the 1st order reference marks.

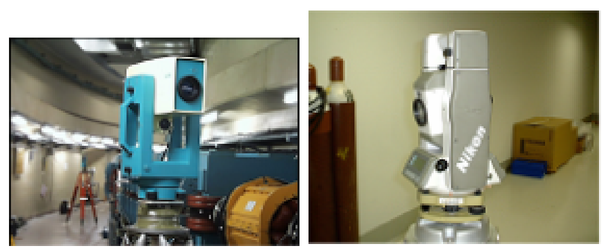

Fig.6 MEKOMETER ME5000 and Theodlite Nikon GF1

Fig.7 Centering by optical plummet on the auxiliary pillar

[1] PAG–U: Universal Program for Adjustment of any Geodetic network which was developed by PASCO Corporation.

2.5 The results of 1st order reference marks

The result of each 1st order reference mark is shown in table 2

Table 2 Summary of results of 1st order reference marks

Station Name		Setting Coordinate S [m]	Standard Deviation ±S.D. [mm]	Design Coordinate D [m]	Difference of Coordinate S -D [mm]
BM1	X	0.00009	0.04	0.00000	+0.09
101	Y	0.00020	0.09	0.00000	+0.20
BM2	X	11.86693	0.05	11.86700	-0.07
102	Y	4.99998	0.06	5.00000	-0.02
BM3	X	11.86698	0.03	11.86700	-0.02
103	Y	-18.51794	0.04	-18.51800	+0.06
BM4	X	11.86711	0.03	11.86700	+0.11
104	Y	-51.53296	0.04	-51.53289	-0.07
BM5	X	4.95295	0.04	4.95300	-0.05
105	Y	-43.75817	0.05	-43.75800	-0.17
BM6	X	-5.32101	0.04	-5.32100	-0.01
106	Y	-51.53288	0.07	-51.53289	+0.01
BM7	X	-5.32105	0.06	-5.32100	-0.05
107	Y	-34.92799	0.07	-34.92800	+0.01

2.6 The survey for the 2nd order reference mark in the storage ring hall

Eight 2nd order reference marks at the storage ring hall for the alignment for the storage ring had been surveyed by the network like symmetrical polygon as shown in Fig.8 and computed to adjust the result of observed for these distances of each side. It observed only distances by MEKOMETER ME5000. It had been observed the survey network which included reference marks No.101, No102 (Fig.4, 5, 8). Finally, it hade been computed the survey network which excluded the reference mark No.102 (Fig.9). The reason for excluding No.102 from the computation of net adjustment is to make it distributing equally for the Root of Q that the survey network shape what composed with eight 2nd order reference marks. Therefore, it excluded the maldistribution about the precision of each reference mark from the unsymmetrical of the survey network shape.

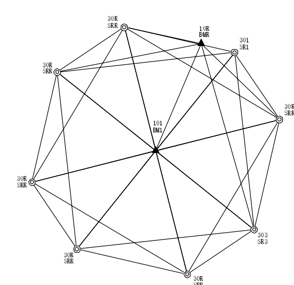

Fig.8 The survey network at the storage ring hall

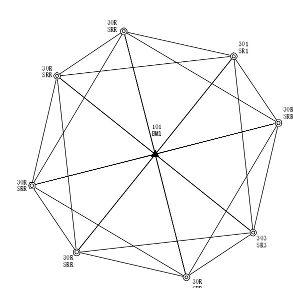

Fig.9 The computation of net adjustment for the alignment of storage ring

2.7 The results of 2nd order reference mark in the storage ring hall

The result of each 2nd order reference mark is shown in table 3

Table 3 Summary of results of 2nd reference marks at the storage ring hall

Station Name		Setting Coordinate S [m]	Standard Deviation ±S.D. [mm]	Design Coordinate D [m]	Difference of Coordinate S-D [mm]
SR1	X	10.86560	0.06	10.86554	+0.06
301	Y	8.69975	0.06	8.69969	+0.06
SR2	X	3.47207	0.06	3.47214	-0.07
302	Y	13.65235	0.06	13.65227	+0.08
SR3	X	-8.69971	0.06	-8.69969	-0.02
303	Y	10.86547	0.06	10.86554	-0.07
SR4	X	-13.65231	0.06	-13.65227	-0.04
304	Y	3.47230	0.06	3.47214	+0.16
SR5	X	-10.86551	0.06	-10.86554	+0.03
305	Y	-8.69973	0.06	-8.69969	-0.04
SR6	X	-3.47210	0.06	-3.47214	+0.04
306	Y	-13.65226	0.06	-13.65227	+0.01
SR7	X	8.69982	0.06	8.69969	+0.13
307	Y	-10.86559	0.06	-10.86554	-0.05
SR8	X	13.65214	0.06	13.65227	-0.13
308	Y	-3.47229	0.06	-3.47214	-0.15

2.8 The survey for level marks

Fig.10 The Invar Staff comes through the floor hole from the downstairs in order to connect to the height between downstairs and upstairs.

2.9 The results of level marks

The result of each level mark is shown in table 4

Table 4 Summary of results for level marks

No.	Setting Height [mm]	Design Height [mm]	Difference of Height [mm]
LM1	6300.10	6300.00	+0.10
LM2	6300.02	6300.00	+0.01
LM3	6299.99	6300.00	-0.01
LM4	6300.10	6300.00	+0.10
LM5	1799.84	1800.00	-0.16
LM6	1800.03	1800.00	+0.03
LM7	1799.92	1800.00	-0.08
LM8	1799.94	1800.00	-0.06

3 THE ALIGNMENT FOR THE STORAGE RING

3.1 Prealignment

The prealignment is a first phase of the alignment. Each machine component will be aligned individually from the geodetic survey coordinate. In NSRC, these coordinates are the 1st order reference marks and the 2nd order reference marks.

3.2 Parameters for alignment

The next phase of the alignment is the precise alignment and the final smoothing. Therefore, it is necessary to transform into the coordinate system of each component from the geodetic survey coordinate system.

Fig.11 shows parameters for alignment with each component. The alignment for *S*, *X* and yawing had been measured with the laser tracker. This laser tracker is a Coordinate Measuring Machine (CMM) which measures a three dimensional coordinates precisely.

The Alignment for rolling and pitching had been measured with digital inclimeter. And the alignment for H has been measured with the tilting level N3.

With this coordinate transformation, the alignment becomes possible to close in the area where is surrounded with 1st order reference marks and 2nd order reference marks.

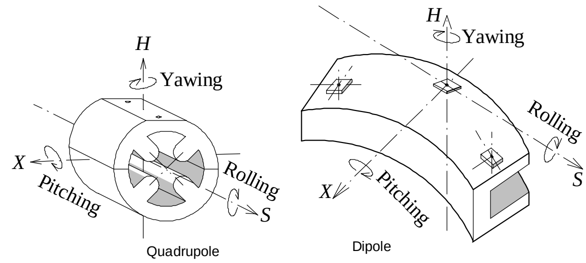

Fig.11 parameters for alignment

3.3 The tolerance of alignment for each component

Table 5 shows the tolerance of alignment for each component.

Table 5 The tolerance of alignment

Components	Reference components or marks	Required precisions (mm)		Tilt mm/m
		X and Y	Beam stream	
Dipoles	Dipoles Reference Marks Level marks	0.2	0.2	0.2
Multipoles	Dipoles (mainly) (Reference Marks Level Marks)	0.2	0.2	0.2
Steering Magnets	Quadrupoles	0.5	0.5	0.5
Beam Position Monitors	Quadrupoles (Reference Marks Level Marks)	0.5	0.5	0.5

3.4 The method for the alignment

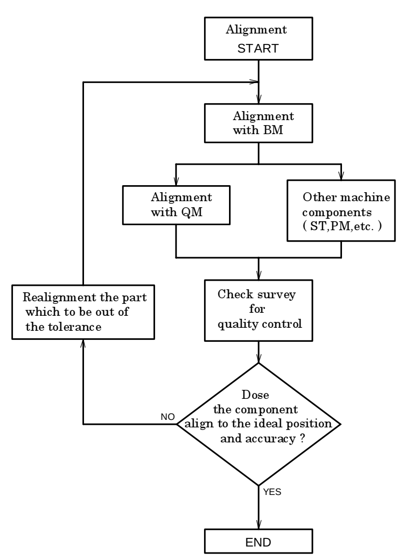

Fig.12 The flowchart of the alignment for the each storage ring component

The alignment process of each component, dipoles, multipoles, and the other components was following as Fig.12.

First of all, these machine components were adjusted the height to the beam height and they were adjusted the tilting to the horizontal plane at the same time. They were adjusted alternately to the beam height and the horizontal plane. And the machine components have converged to the ideal beam height and the horizontal plane.

Then they have been adjusted these components by the laser tracker to the direction of the beam stream and on the beam line. It adjusts to be longitudinal at the component on the real horizontal plane.

3.4 The alignment for the dipoles

First, it has been adjusted these dipoles (Fig.13). This is the reason why the alignment at the straight section in the storage ring is based on these dipoles.

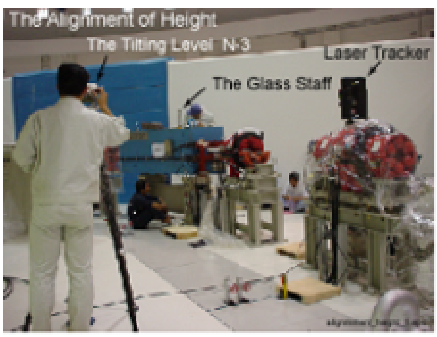

Fig.13 The alignment for the dipole

3.5 Results of the alignment for dipoles

Fig.14 shows results of alignment for eight dipoles. It shows these differences from final aligned positions to designed positions.

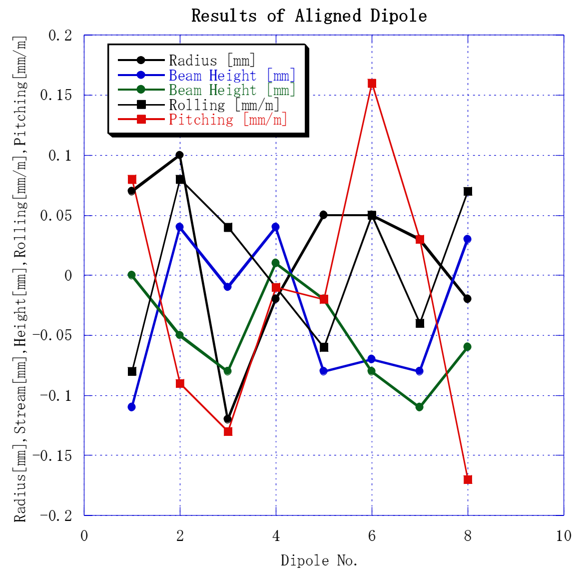

Fig.14 Results of the alignment for dipoles

These results of alignment are satisfying the tolerance for these dipoles (table 5), with maximum displacement of 0.17 [mm/m] in the pitching.

3.6 The alignment for the quadrupoles

Next it adjusted quadrupoles which were based on dipoles.

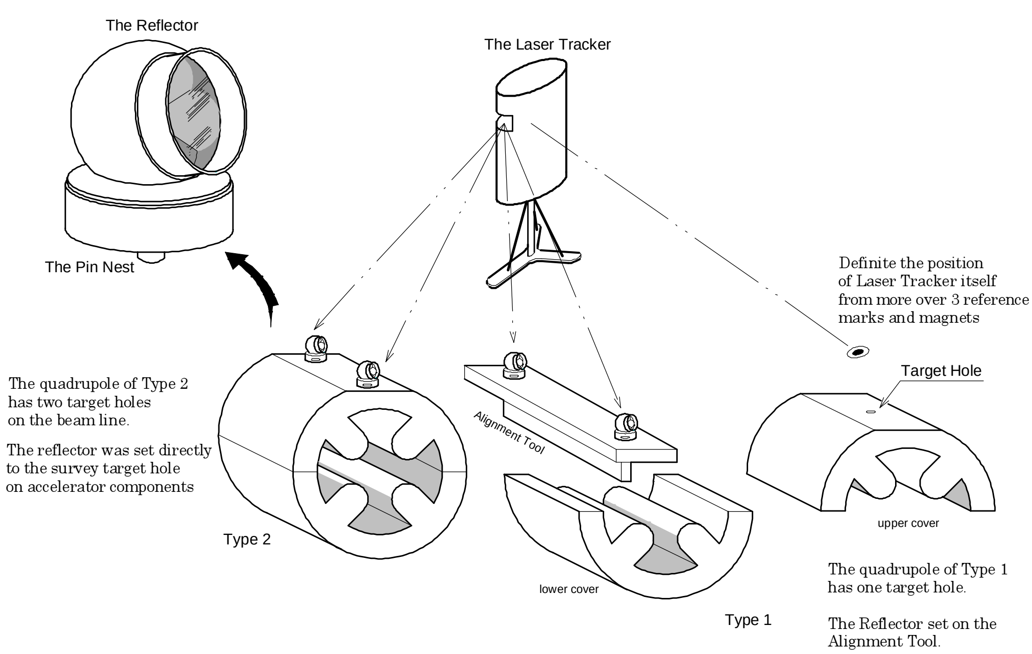

Fig.15 Scheme of alignment by the laser tracker

These quadrupoles have two types which is shown in the type 1 is used at SORTEC and the type 2 is made newly for the NSRC.

Fig.16 Two types of the quadrupoles

The type 1 has a target hole (fiducial point) for the alignment and the type 2 has two target holes for it.

Therefore, in the case of the type 1, these quadrupoles were aligned with the tools what so called "The Alignment Tool" which is shown in Fig.15.

This alignment tool has two target holes its both side which is shown in Fig.15. Therefore, these quadrupoles were aligned in horizontal by the laser tracker.

As the type 2 has two target holes, it had been aligned that the reflector set to both holes.

These type 2 quadrupoles have data of the difference between magnetic center and mechanical center. Therefore these type 2 quadrupoles have been aligned by magnetic center with considering offset from the mechanical center. It is very convenient for the laser tracker to determine component's position with such a differences.

3.7 Results of the alignment for quadrupoles

Fig.17 shows results of alignment for 24 quadrupoles. It shows these differences from final aligned positions to designed positions.

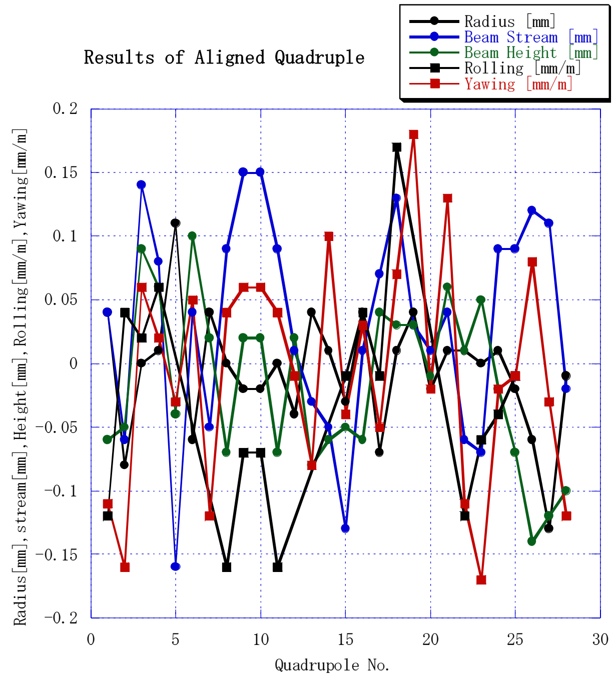

Fig.17 Results of the alignment for quadrupoles

These results of alignment are satisfying the tolerance for these quadrupoles (table 5), with maximum displacement of 0.18 [mm/m] in the yawing.

4 CONCLUSION

In March 2000, we performed survey for the 1st order reference mark and 2nd order reference mark. And, in December 2000, we performed alignment for the machine components. These components are not always suitable for the procedure of the modern alignment at the fiducial points. However the result we obtained is the most satisfactory.

REFERENCES

[1] Mitsubishi Elec., PASCO Corp., "The report for the survey for the reference marks and the alignment for the storage ring components on the National Synchrotron Research Center in Thailand", May 2001.

[2] Chao ZHANG, Sakuo MATUI, and Satoshi HASHIMOTO, "Alignment for NEW SUBARU Ring", IWAA'99, 1999