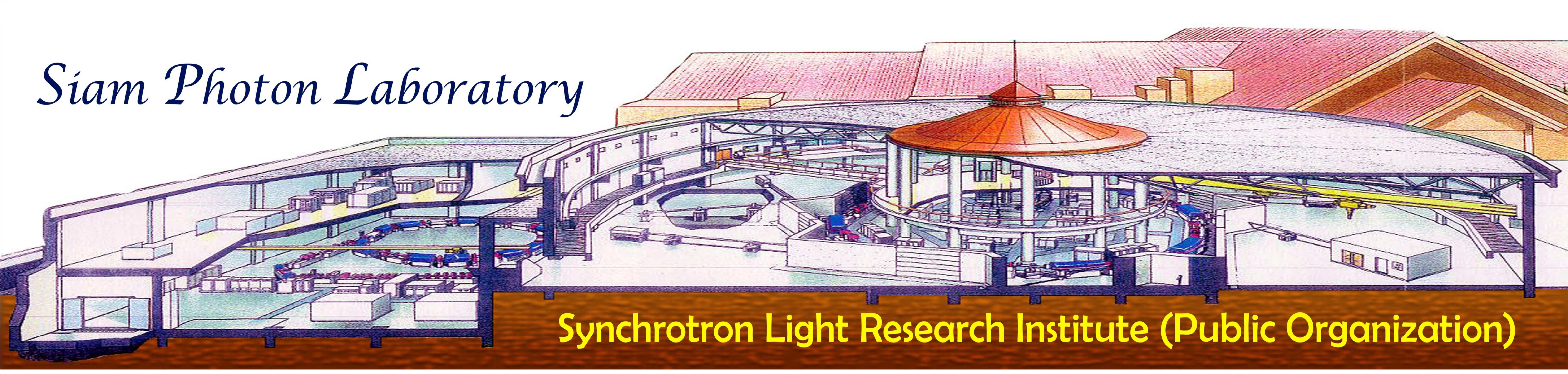

Design, Construction and Testing of a Multipole Wiggler Magnet Vacuum Chamber for the SLRI.

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ABSTRACT

This paper presents the design, construction and test of a prototype of a vacuum chamber for the SLRI multipole wiggler. With limitation of gap space, the thickness of the chamber has to be as thin as possible without any deformation. Therefore, the finite element method plays a vital role to perform mechanical stress and deformation simulation. 316L stainless steel has been used for this chamber in order to have a high mechanical strength and low magnetic permeability. The prototype was manufactured precisely in two halves with the dimension of 1325 mm in length and an internal aperture of 106 mm x 18 mm in horizontal and vertical axes, respectively. The wall thickness is 2 mm. The lateral duct is designed to be used as a pumping port connected to a sputtered ion pump. The chamber has been successfully tested at ultra high vacuum level of about 4 x 10-10 torr. Technical problems during construction of the chamber will be summarized.

1. INTRODUCTION

Almost all of the beamlines at SLRI synchrotron facility in Thailand are utilizing the radiation from bending magnets (1.44T with stored beam current at 100 mA and critical photon energy at 1.4 keV). The third insertion device of SLRI, a multipole wiggler (MPW) source can provide a high intensity photon beam for three branches x-ray beamlines. The multipole wiggler was originally designed and manufactured by ASTeC and Technology Department for the SRS in 2002 to produce the high magnetic field for a permanent magnet-based multipole wiggler, 2.4T, at the operating gap of 20 mm.

The appropriated location for MPW installation in the storage ring has been carefully considered, the vertical and horizontal acceptance of the storage ring will not be reduced by the MPW vacuum chamber. The chamber is 1325 mm long which correspond to the length of MPW. The internal aperture of chamber is about 106 mm x 18 mm in horizontal and vertical axes, respectively. The internal vertical size of the vacuum chamber is slightly larger than the vertical acceptance of storage ring (17 mm.) The MPW can provide SR within a horizontal fan of ±15.93 mrad and has been planned to utilize the SR at the operating gap of 23 mm. The exterior vertical dimension of the vacuum chamber is about 22 mm as shown in Fig. 1.

Peak field [T]	Gap [mm]
2.4	20.0
2.2	23.7
2.1	25.8
2.0	27.9

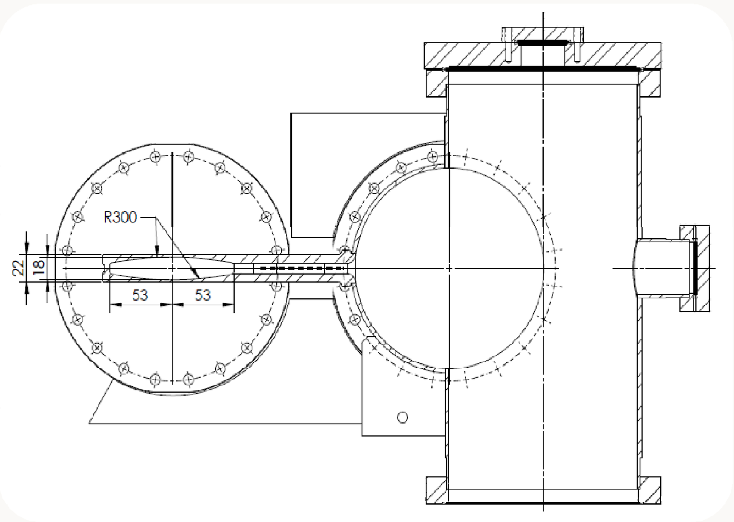

FIGURE 1. The vacuum chamber dimension and operating gap (mm)

2. DESIGN OF THE MAIN VACUUM CHAMBER

The main chamber was designed in two halves as upper and lower shell with the minimum wall thickness of 2 mm. In order to have a high mechanical strength and low magnetic permeability, 316L stainless steel was selected as the material to fabricate the main chamber.

The Finite Element Analysis (FEA) was performed by the commercial program SolidWorks Simulation. The baking temperature was assumed to be constant of 120 °C on the external surface and 115 °C for the internal surface of the vacuum vessel. The atmospheric pressure was applied on the external surface of the vacuum vessel. The effect of gravity was also considered for this simulation. Due to the symmetric design of the chamber (two symmetry planes), a one quarter model could be used for the simulation. Fig. 2 shows the results for thermal stress and thermal deformation.

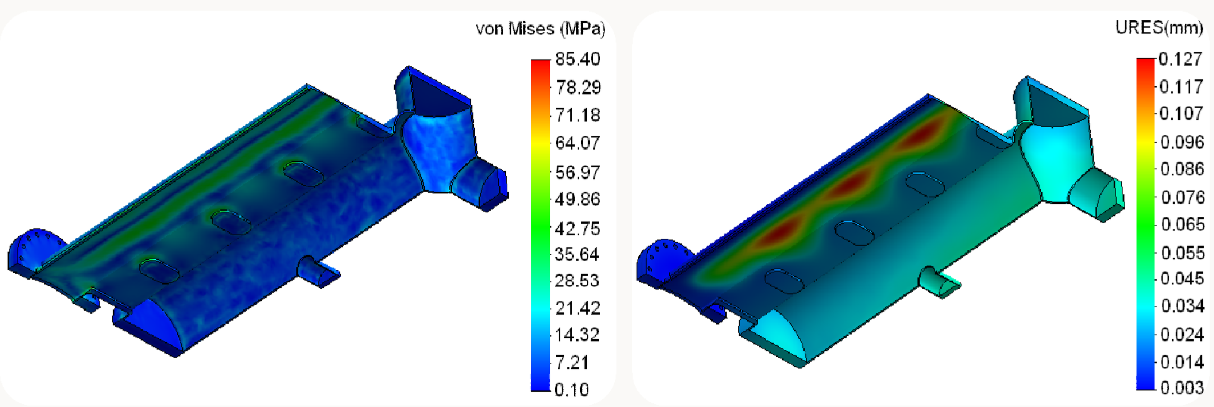

FIGURE 2. The FEM result for thermal stress(Left) and thermal deformation(Right) of vacuum chamber.

3. DESIGN OF MANIPULATOR AND VACUUM CHAMBER SUPPORT

The mechanical design of manipulator and support of the MPW vacuum chamber are considered to be able to move and rotate individually. The vacuum chamber is possessed with six manipulator axes (X, Y, Z, θx, θy, and θz) which can be controlled manually with the pitch of thread screws. The main chamber has to be attached together with a 500 l/s sputter ion pump as a rigid body and can be moved manually in X direction by four sliding blocks. The two main plates under the sliding blocks are supported by four sets of M16 set screws which allow the adjustment of the chamber in Y, Z direction and also for θx, θy, and θz.

The support was made from carbon steel but the main plates were fabricated from Al 7075. The support has been designed for easy transportation by the two sets of rear casters. The Fig. 3 shows the design of manipulator and vacuum chamber support.

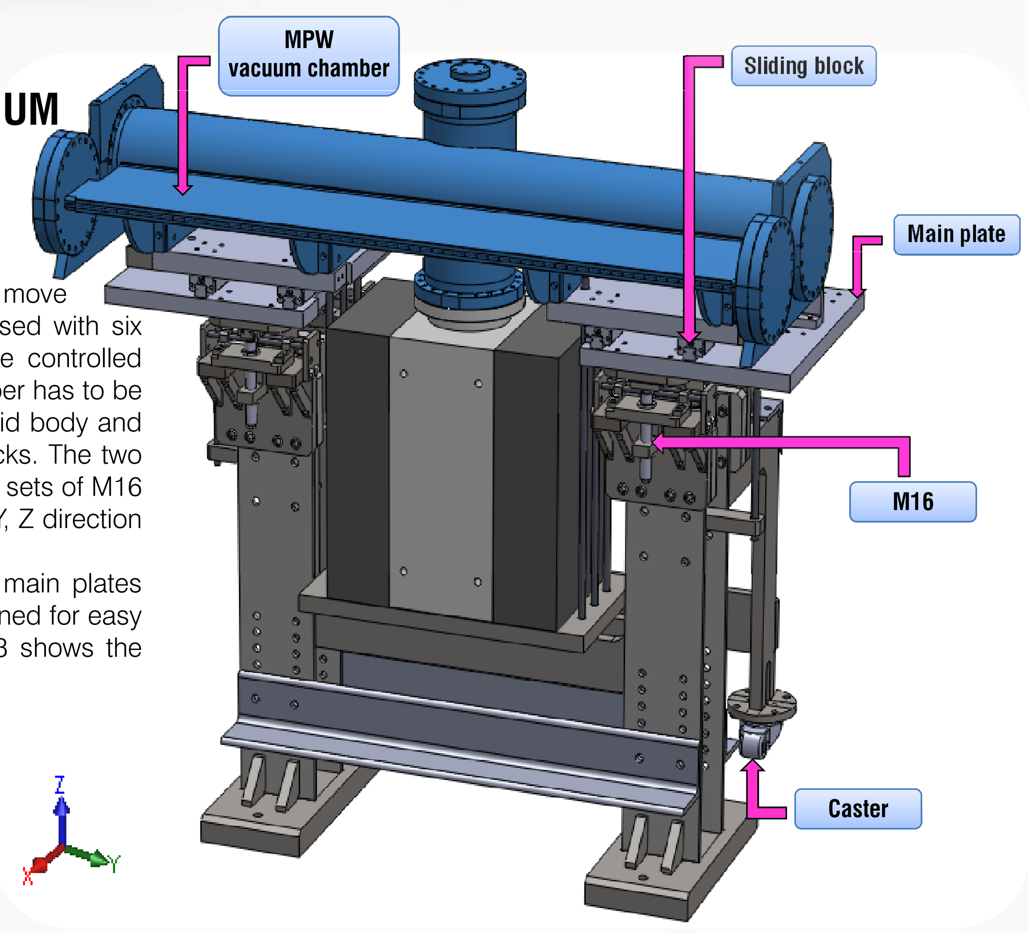

FIGURE 3. 3D CAD drawings of MPW vacuum chamber and its support.

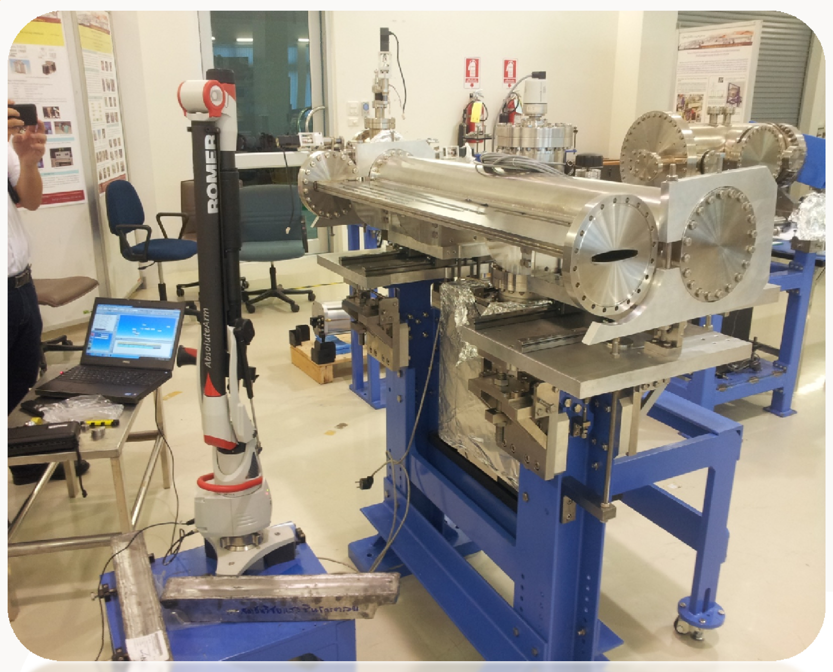

FIGURE 4. Inspection of MPW vacuum chamber

4. FABRICATION AND TESTING OF MPW VACUUM CHAMBER

The MPW vacuum chamber and its accessories were cautiously fabricated as in-house fabrication except the upper and lower shells of the main chamber which were longer than the capability of the machine in SLRI machine shop. The chamber was inspected for mechanical distortion, which may occurred during the fabrication or cleaning process, by using a portable coordinate measurement machine (CMM) as shown in Fig. 4.

The electron beam duct (L4-2) needed modification for high heat loads induced by the hard x-ray from MPW. The inner surface of electron beam duct (L4-2) will be in contact with a part of the incidence x-ray from the MPW. Therefore, in order to remove this heat loads from L4-2 beam duct, the lateral cooling tube and additional heat absorber have to be designed carefully. Al 6063-T51 was selected for this cooling tube and heat absorber. The Al welding technique needed to be performed precisely by a high skilled technician. The detailed 3D CAD drawing of L4-2 is shown in Fig. 6.

FIGURE 5. The MPW vacuum chamber was being tested for UHV condition

Due to the limitation of working space inside the shielding wall, the vacuum chamber and its support were necessarily designed to be as compact as possible for containing peripheral components as shown in figure 6. The chamber and its accessories needed to be tested for vacuum leakage by using a He leak detector to ensure that the chamber can be ready for UHV testing in the next step.

In order to achieve vacuum pressure in the range of UHV condition, the chamber had to be baked at high temperature (<120 C°) for a week. During the first baking process, vacuum pressure reached to 9×10^{-9} Torr (as shown in Fig. 5) by using a 500 l/s sputtered ion pump. After the second baking process, the vacuum pressure of 4×10^{-10} Torr was obtained.

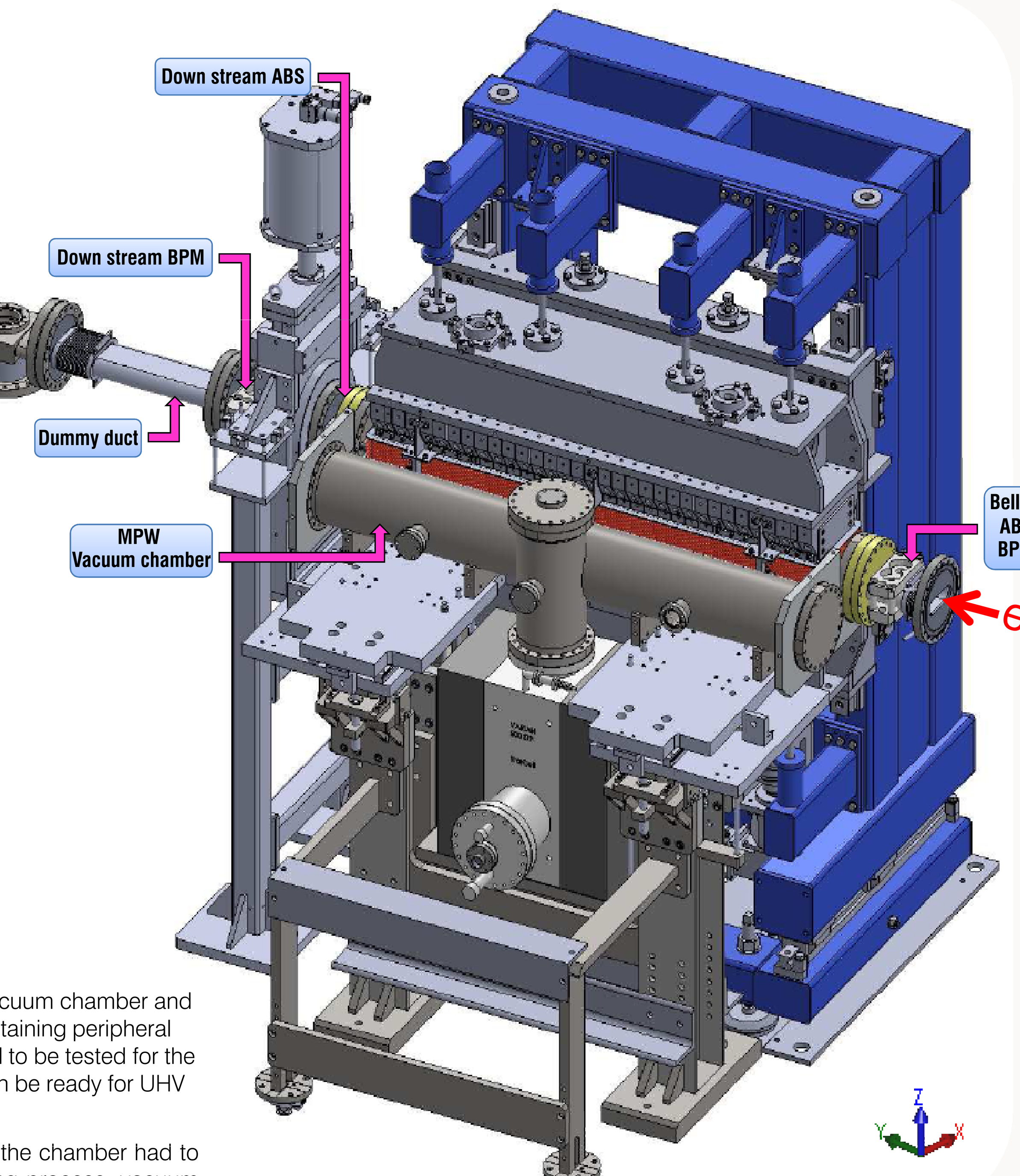

FIGURE 6. The detailed 3D CAD drawing of MPW vacuum chamber and peripheral components

5. TECHNICAL PROBLEMS

The construction, testing and installation of this vacuum chamber encountered many technical problems which needed to be cautiously solved: It took time and effort to fabricate the complicated mechanical part and to weld the chamber with the smallest thermal deformation. After the welding process a dimension check was carried out by using the portable coordination measurement machine (CMM) to ensure that the prototype vacuum chamber can be accepted. The inner-surface quality of chamber was imperfect for vacuum pressure due to limited fabrication capability. The baking process for the chamber took a long time to ensure that the vacuum pressure can reach to UHV level. For the installation of the MPW and its support the floor at the area of installation needed to be excavated at least 10 cm in order to make the height level of the pole equal to the height of electron beam in the storage ring.

6. CONCLUSION

The vacuum chamber has been designed and fabricated with the exterior vertical dimension of the vacuum chamber is about 22 mm and a minimum operating gap of 23 mm which correspond to the magnetic field of 2.2 Tesla approximately. The vacuum chamber and its accessories consisting of a lateral pumping port, sputtered ion pump, six manipulator axes and the support was developed for the third insertion device at the Synchrotron Light Research Institute. All parts for the vacuum chamber were designed and fabricated as in house except upper and lower shell of the chamber. The chamber distortion inspection has been performed by using a coordinate measurement machine(CMM).The vacuum pressure testing of the chamber was completed for UHV condition. After installation the electron beam can be stored properly in the storage ring without unexpected conditions. Commissioning of the storage ring will be carried out with hard X-rays from the 2.2 Tesla MPW to evaluate the actual performance of this insertion device.

7. ACKNOWLEDGEMENT

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