# TPS SR KICKER PROTOTYPE INSTALLATION STATUS*

Yung-Hui Liu#, Chih-Sheng Yang, Keng-Hao Hsu, Che-Kai Chan,
Chin-Shen Chen, Yun-Liang Chu, Cheng-Ying Kuo , Hsin-Pai Hsueh,
Chien-Kuang Kuan,
NSRRC, 101Hsin-Ann Road, Hsinchu Science Park, 30076, Taiwan

*Abstract*

The purpose of this paper is to illustrate the installation sequence of TPS SR kicker. Because of adding the rotation function in row direction, the position of every component of kicker must be very precise. The kicker magnet and EMI enclosure were fastened on the rotation motor plate which could rotate ±3.0 mrad. The ceramic chamber remain fixed on the bottom plate in order to let the bellow stress free during rotation. After installation, the inductance measurement and the high voltage breakdown test were also tested. The experimental results showed the good uniformity and reached the expected request. The field mapping and EMI prevention schemes will be test in the future.

## INTRODUCTION

The TPS civil structure now is under construction; however, the whole subsystems for the accelerator are under manufacturing. Because of the whole components in the injection section were decided by home made, a prototype of SR kicker magnet became very important. According to the experiences of TLS and other synchrotron light sources, a new design of SR kicker was designed [1]. First, the kicker magnet itself and ceramic chamber must be strong and reliable. Second, for eliminating the horizontal field in the injection section, a rotational stage was design in the roll direction [2]. Third, in order to reducing the EM waves while kicker firing, an EMI enclosure was designed [3]. Base on the whole demands, a strong girder for kicker supporting and auto rotational stage were designed. Besides, for reducing ceramic chamber stress, bellow stress free, the support for vacuum chamber and magnet needed to be separate. The kicker magnet and EMI enclosure were mounted on the rotational stage. The ceramic chamber will remain fixed during kicker rotation.

## INJECTION SCHEME AND PARAMETERS OF SR KICKER

The TPS injection section is located the first long straight section. Figure 1 shows the injection scheme in the long straight [4]. There are 4 identical kickers and one set of AC+DC septum for the storage injection. Because of the concentric design for booster via storage ring in TPS and the circumference is larger than TLS, the injection angle is much smaller than TLS project. The off-axis beam injection and out-of-vacuum design for the TPS storage ring kickers/septum were chosen.

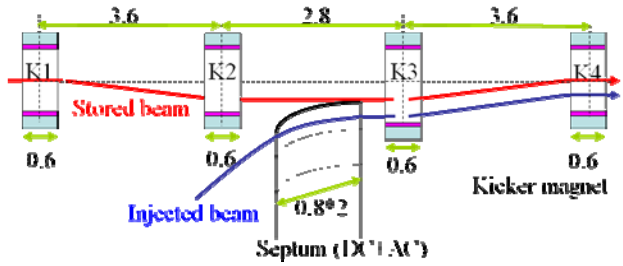


Figure 1: TPS SR Injection scheme.

Table 1 showed the parameters of TPS SR kicker. The repetition rate is 3 Hz and top-up injection also will be the operation mode in TPS. The bend angle for 4.5 mrad in 3 GeV energy level with 0.6 m effective length integrate 0.075 T for the SR kicker. The half sine wave form with 5.18 μsec pulse duration was designed. Because of the requirement for identically bump field for the 4 kickers, the field error between these 4 kickers need to be less than 0.5 %.

Table 1: Parameters of SR Kicker (for 4 kickers)

| Storage Ring Injection | Kicker |
|---|---|
| Repetition rate (Hz) | 3 Hz |
| Energy (GeV) | 3.0 |
| Bend angle (mrad) | 4.5 |
| Mag. aperture (mm) | 92*37 |
| Length (m) | 0.6 |
| Max. field (T) | 0.075 |
| Beam aperture (mm) | 68*20 |
| Max. current (A) | 2208 |
| Pulse shape | half sine |
| Pulse duration (μs) | 5.18 |
| Inductance (μH) | 2.35 |
| Capacitance (μF) | 1.155 |
| Drive voltage (kV) | 3.15 |
| Field error (%) | <0.5(shape) |

## KICKER COMPONENTS

The kicker prototype installation was tested for 3 times, because of requirement of ceramic chamber stress free. In order to reach this purpose, 1 mm gap between coil and ceramic chamber via gap between ferrite and ceramic chamber is determined. Also, for eliminating arcing phenomenon, the air gap between coil and ferrite via the

*Work supported by NSRRC
# iris@nsrrc.org.tw

gap between coil and grounding plate were set to be 5 mm. Figure 2 shows the engineering drawing for the kicker coil and ferrite. The vertical gap between ferrite is 37 mm and the horizontal gap between coil insulator (epoxy) is 92 mm. We had the experience of arcing for the injection kicker in TLS. Thus, the air gap between coil and other spices is needed.

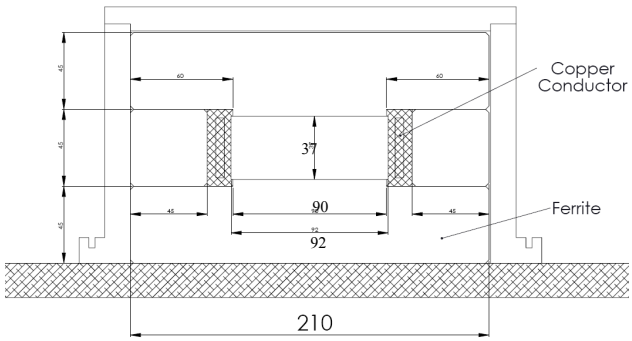


Figure 2: TPS SR kicker coil and ferrite.

Figure 3 showed the dimension of ceramic chamber. The ceramic chamber with Ti coating was manufactured by Kyocera. The horizontal dimension for the outer size of ceramic chamber is 90 mm and the vertical dimension is 35 mm. Compare the size with magnet coil and ferrite, the gap in the top and down/ right and left is 1 mm. The purpose of this gap is for avoiding the impact between ceramic chamber and magnet while kicker rotation.

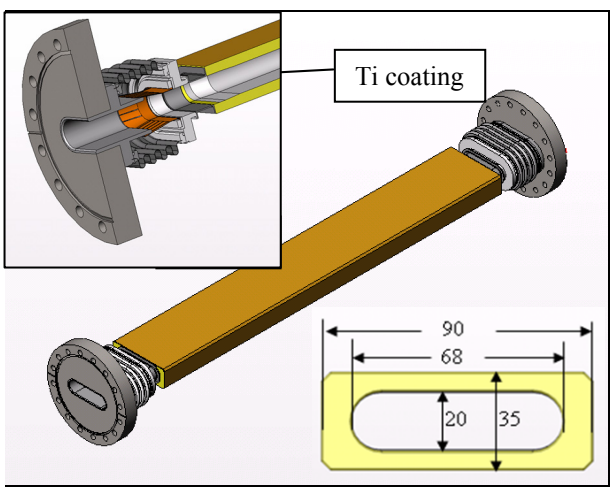


Figure 3: Kicker ceramic chamber.

## INSTALLATION STEPS

After 3 times trying, the kicker girder and rotation stage needed to be alignment first. The magnet components and EMI enclosures were fixed on the top plate of rotation stage. The pin hole is the fixed position for the magnet. Once the kicker stage is fixed, the whole magnet component also will be positioning consequently. After kicker stage alignment, the ceramic chamber installation is the next step. Because the ceramic chamber can not be moved during kicker rotation, the support of ceramic chamber must be installed separately. The support of ceramic chamber is fixed on the table of girder, which is independent of kicker magnet.

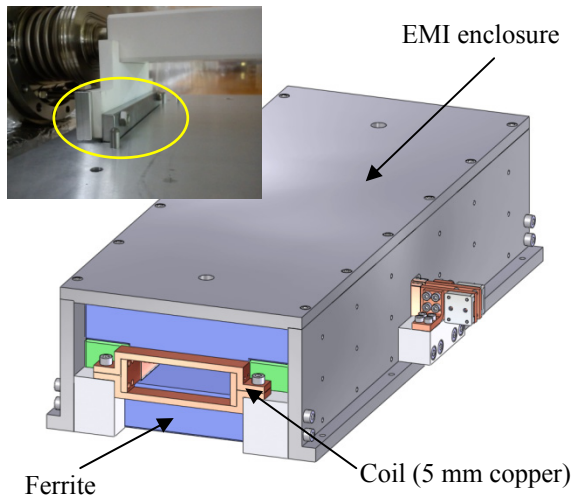


Figure 4: Kicker prototype engineering drawing and gap between kicker magnet and ceramic chamber.

After these 2 steps, the kicker base plate ,which is made by 18 mm aluminium, is put on the rotation stage using align pin hole. Next, the ceramic chamber is just put on the ceramic support with 1 mm gap in both sides. The gap between ceramic support and kicker base plate is 1 mm showed in Fig. 4. After that, the coil and ferrite in the bottom is put on the kicker base plate. The side and top ferrites were put on the position consequently. The EMI enclosure is finally installed and the installation procedure is finished.

## HIGH VOLTAGE BREAKDOWN AND KICKER INDUCTANCE TESTS

The insulation effectiveness for the pulsed magnets is very important. After installation of kicker prototype, the high voltage breakdown test is necessary. The nominal operation voltage for the SR kicker is 3.15 kV in TPS and the on-axis injection for the maximum voltage is 6.73 kV. The insulation test used in this paper is CHAUVIN ARNOUX ISOL 5002, which could drive 5 kV DC voltage. The range of the resistance is up to 3000 GΩ. Although the highest voltage is not high enough for the maximum drive, the experimental results still give some reliable data. The experimental results showed a good insulation performance for the kicker prototype (> 500 GΩ under 5 kV DC voltage).

The inductance measurement for the kicker prototype was also tested. We used 2 LCR meters to confirm the inductance of the kicker, which are HP 4284A 20Hz – 1MHz precision LCR meter and WAYNE KERR 4236 LCR meter. Because of the kicker magnet behave almost

pure inductance during kicker firing, and the pulse duration is 5.18 μs half sine waveform. The 100 kHz driving frequency was used and the experimental set up showed in Fig. 5. The inductance tests showed 2.31 μH and 2.30 μH for the different installation and LCR meter. The variation between inductance tests are about 0.477% ~ 0.535%. The showed a good uniformity for the SR kicker in TPS.

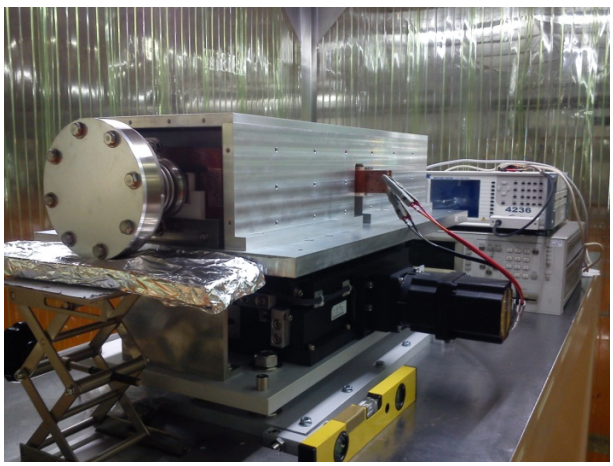

Figure 5: Kicker prototype completion and inductance measurement.

## ROTATING STAGE TEST

In order to confirmed the gap change between ceramic chamber and ferrite during kicker rotation. The gap tests were also measured, which showed in Fig. 6. The ±3.0 mrad rotation in roll direction was measured. The gap changed gradually up and down during rotation and the max. 0.1 mm change is preformed for 3.0 mrad position. The gap changed identically in upstream and downstream direction. Compare with the 1 mm gap between ceramic chamber and magnet, the rotation for the kicker is safe for the whole system.

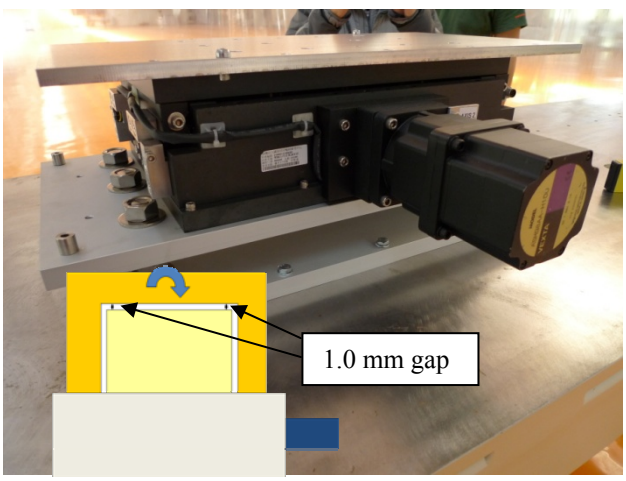


Figure 6: Kicker rotating stage (±3.0 mrad).

## KICKER FIELD MEASUREMENT

Finally, the magnetic field mapping was test. Figure 7 showed the experimental results for 3 kV driving voltage. Although the kicker pulser still not stable for prototype, the results will b the base for the future testing.

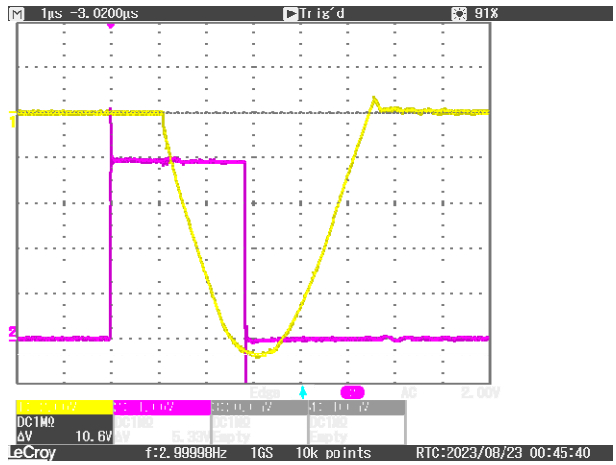


Figure 7: Kicker field testing.

## CONCLUSIONS

This paper illustrated the installation procedure for the TPS SR kicker prototype. After trying for many times, the installation could be fast and smooth. This will be helpful for TPS construction because of limited time for future commission. The insulation measurement and inductance test showed good results because the TPS kicker improved many aspects than before design. The structure of magnet became stronger and the ceramic chamber uniformity is better than TLS. The EMI influence elimination was also under consideration. The field mapping and EMI prevention schemes will be test in the future.

## REFERENCES

[1] C H Gough, "SRK Design Report series", PAUL SCHERRER Institute, 2001.

[2] K. Fukami, et. Al., "Remote Tilt-Control System of Injection Bump Magnet in the SPring-8 Storage Ring", 2008 European Particle Accelerator Conference (EPAC2008), Genoa, Italy.

[3] Y.-H. Liu, et. al., "The EMI Reduction of Pulsed Magnet in NSRRC" 2010 International Particle Accelerator Conference (IPAC2010), Kyoto, Japan.

[4] C.-K. Chan, et. al., "Design of the TPS Injection System" 2009 Particle Accelerator Conference (PAC2009), Vancouver, Canada.