UPGRADE OF IONIZATION PROFILE MONITOR (IPM) IN THE J-PARC 3-GeV RCS

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Abstract

Residual gas Ionization Profile Monitors (IPMs) are used in the J-PARC 3-GeV RCS for the observation of circulating transverse beam profile. In IPM system, the ions and electrons produced by the beam passing through chamber lead to Micro Channel Plate (MCP) by the external electric field, and the signals from the MCP are observed as the beam profile. The IPM system has an upgrade plan for the optimization of the electric fields and the observation of beam profile by the elections. This will be reported the upgrade concept and status of the IPM.

INTRODUCTION

The residual gas Ionization Profile Monitors (IPMs) are installed in 3-GeV RCS and MR [1]. The IPM have a monitor to observe a circulating transverse beam profile in the ring, and consists of the electrodes for external electric fields, magnets for external magnetic fields, Micro Channel Plates (MCPs) for detection of produced ions and electrons, and the Electron Generator Array (EGA) [2] for calibration of the MCP gain. Details of the RCS IPM system are given elsewhere [3]. The positively-charged ions or negatively-charged electrons produced by the beam passing through the residual gas lead to the MCP by the external electric field and the projected beam profile is observed from the MCP signals. The external electric fields with high uniformity are required to project the beam profile. There are two operation modes, which are ion and electron collection mode. At present, the ion collection mode are mainly used at the beam commissioning, however, the electron collection mode with magnetic field are needed in the high intensity beam operation from the view point of a high space charge force. From the beam commissioning, it is found that the present external electric field is distorted and the measured beam profile on the ion collection mode is also shrunk to a half. The present RCS IPMs have the issue for a non-uniformity of the external electric field and the solution is discussed by 3D electric field calculation [1]. The calculation is performed by the 3D calculation code of CST studio suite [4]

UPGRADE CONCEPT OF IPM

The recovery plan of the electric field is derived from the 3D electric field calculation. For the high uniformity of the external electric field, the structure and electric potential of electrodes are upgraded. In addition, the MCPs with new structure are located at a position of longitudinal direction with smaller longitudinal electric field. The electrodes and MCPs of two IPMs used at present will be replaced and new IPM for horizontal projection will be installed in the ring during summer shutdown 2012.

New Electrodes and Electric Potential

The electrodes of IPM consist of the up and down mesh structure electrodes, and each 14 electrodes at left and right side. Old and new structures of the 14 electrodes are shown in Fig.1. In the IPM system, the produced electric fields are also affected by the grounded beam chamber. Therefore, new electrodes have a shown geometry for longitudinal direction.

Electric potential on each electrode can be controlled by the connected resistor between these electrodes. The optimum resistance value can be derived by the 3D electric calculation. Gap ID in table has a numbering definition from the side of input HV. The calculated results of horizontal (Ex) and longitudinal electric field (Ez) for old and new structure are shown in Fig.2. From the result, the electric field by new structure has a high uniformity for horizontal plane in a region located MCP. On the other hand, the longitudinal electric field has a uniformity in only region of around z=0. This field is mainly caused by the grounded beam chamber located outside the electrodes. Therefore, the modification of the MCP arrangement is also required for the electron collection mode.

New MCP Structure and Location

Detector of this IPM consists of three MCPs. A MCP located at the centre is also used to observe the profile of beam core and two MCPs located at outside are also used to observe the profile of beam halo. From the view point of different source, it is required to operate each MCP with the different gain.

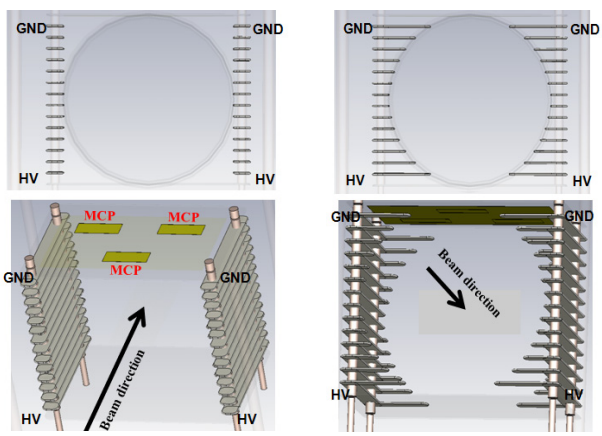

Figure 1: Old (left) and new (right) structure of electrodes.

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For the electron collection mode at a high intensity beam operation, it is required that the Ez has a high uniformity. Therefore, the MCP structure and location are modified and shown in Fig.3. In this position (around z=0), the Ez has a high uniformity and it is expected to observe the beam profile in the electron collection mode with a high intensity beam operation.

Table 1: Old and New Electric Potentials and Resistors between Electrodes

	Old		New	
ID	Potential[kV]	R[MΩ]	Potential[kV]	R[MΩ]
01	3.0	100	4.5	84.4
02	3.0	100	4.5	84.4
03	3.0	100	4.5	84.4
04	3.0	100	3.0	56.3
05	3.0	100	3.0	56.3
06	3.0	100	3.0	56.3
07	3.0	100	3.0	56.3
08	3.0	100	3.0	56.3
09	3.0	100	3.0	56.3
10	3.0	100	2.5	46.9
11	3.0	100	2.4	45.0
12	3.0	100	1.2	22.5
13	3.0	100	1.2	22.5
14	3.0	100	0.6	11.3
15	3.0	100	0.6	11.3

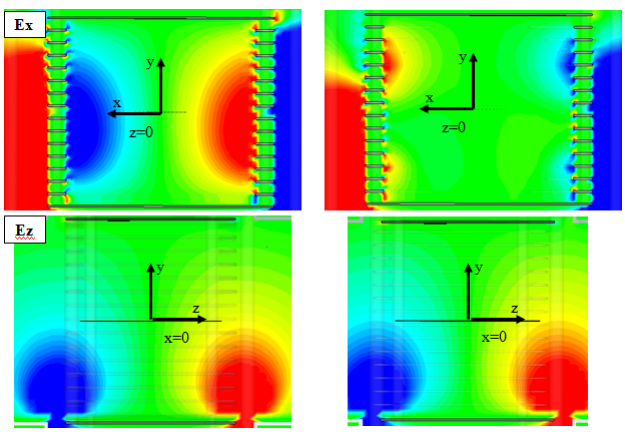

Figure 2: Calculated electric field for old (left) and new (right) structure. Top and bottom figures are horizontal and longitudinal electric field, respectively. Blue and red are a negative and positive gradient, respectively.

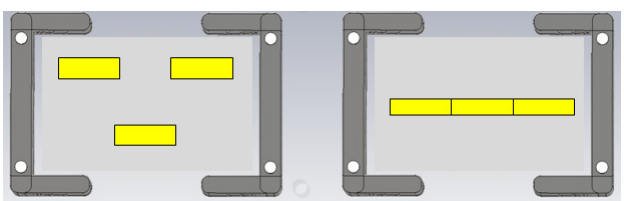

Figure 3: Old (left) and new (right) MCP structure and location. Yellow rectangles are MCPs.

UPGRADE STATUS OF IPM

New IPM Electrodes

The production of electrodes has completed according to our concept. In old system, it is realize that the front edge of support plates turns down by the load of itself and then deflection is 5mm. So, new support plates are thickened and new support insulators are added. New IPM structure with electrodes and support elements is shown in Fig.4. As the effect of the support elements, the deflection becomes to less than 0.1mm.

The metal elements of electrodes and support plates are also coated by TiN coating or Diamond-like Carbon (DLC) coating in order to reduce the production of secondary electron emission, which can be a beam loss.

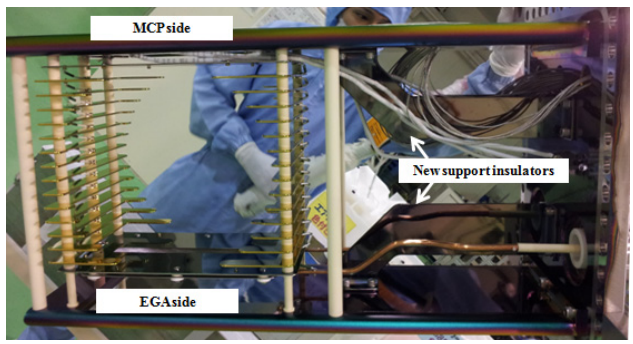

Figure 4: New IPM electrode structure.

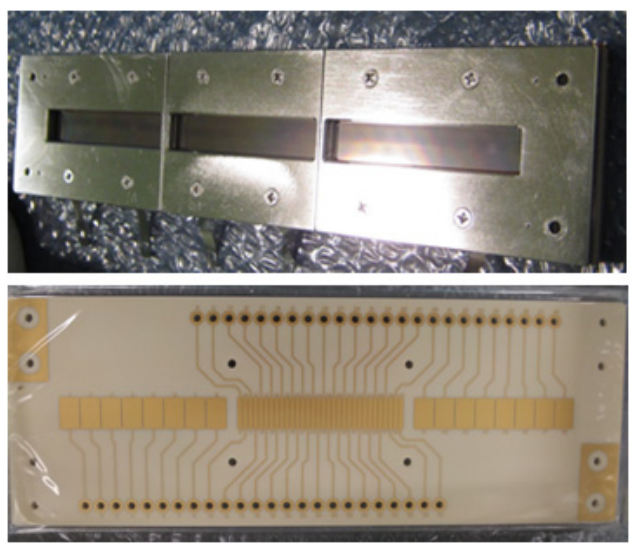

Figure 5: Developed MCP (top) and anode plate (bottom).

New MCP and Anode Plate

New MCP and its anode plate are shown in Fig.5. The MCP is developed by the PHOTONIS Ltd. The withstand voltage between MCPs is 200V. The anode plate consists of Alumina plate and Au metalized parts. The emitted electrons from MCP out plane are also detected at the metalized parts.

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The attached MCP, anode plate and signal cables are shown in Fig.6. MCP has a life time. Therefore, it is required to replace the MCP as easily as possible. The MCP with anode plate has the structure with easy replacement. Additionally, the support plate has the positioning plate and the MCP position is ensured.

For calibration of MCP, the same structure EGA is need. The EGA are produced by the PHOTONIS Ltd.

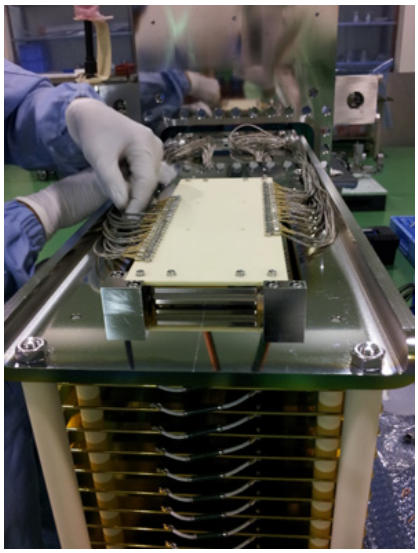

Figure 6: Attached MCP, anode plate and signal cables.

Offline Tests

After the attachment of all elements, new IPM electrode sets in a vacuum chamber. The following offline tests are performed and there is no problem.

- Vacuum test
- Withstanding voltage test of electrodes up to 45kV.
- Signal detection test of MCP and EGA

The uniformity of horizontal electric field (Ex) will be checked in the beam commissioning after the IPM installation.

FUTURE PLAN

The electrodes and MCPs of two IPMs used at present will be replaced in the ring during summer shutdown 2012. The present IPMs for horizontal and vertical projection are located at an area with horizontal dispersion function, and then the beam profile for horizontal plane includes the momentum shift and spread of the beam. So, new IPM will be installed at an area with no dispersion function in the same shutdown period.

After the replacement and installation of IPMs, the beam commissioning will be started at October 2012. In the beam commissioning, the uniformity of horizontal electric field (Ex) will be checked by the response of the observed beam center for a local bump orbits in the ion collection operating mode. The beam profile in the electron collection operating mode with magnetic field will be measured and compared with the results of ion collection operating mode. Additionally, the dependence of beam intensity will be measured in both modes.

SUMMARY

The IPM of J-PARC 3-GeV RCS are also used in the beam commissioning as a monitor to observe a circulating transverse beam profile in the ring. At present, the ion collection mode are mainly used at the beam commissioning, however, the electron collection mode with magnetic field are needed in the high intensity beam operation from the view point of a high space charge force. From the beam commissioning and 3D electric field calculation, it is found that the present external electric field is distorted and the measured beam profile on the ion collection mode is also shrunk to a half. For the high uniformity of the external electric field, the new structure and electric potential of electrodes are also produced. Additionally, the MCP with new structure is also developed. Up to now, the offline tests are completed with no problem.

As future schedule, the electrodes with new MCP of two IPMs used at present will be replaced in the ring during summer shutdown 2012, and then new another IPM will be installed in the same shutdown. At October 2012, the uniformity of horizontal electric field (Ex) will be checked at the ion collection operating mode in the beam commissioning. For the electron collection operating mode with magnetic field, the beam profile will be check. Our final goal is observation of beam profile in a high intensity beam operation. Additionally, the dependence of beam intensity will be measured in both modes.

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REFERENCES

[1] K. Satou et al., HB2010, p 506 (2010).
[2] Electron Generator Array is a cold electron source using MCP technique produced by the PHOTONIS Ltd.
[3] K. Satou et al., EPAC08, p. 1276 (2008).
[4] Computer Simulation Technology (CST) studio, the program complex includes electric and magnetic 3D filed simulator and 3D particle tracking.