Progress in development of resonant Schottky pickups with transverse sensitivity for the CR*

X. Chen[1], *M. S. Sanjari*[1,2], *J. Piotrowski*[3], *P. Hülsmann*[1], *Yu. A. Litvinov*[1,4], *F. Nolden*[1], *M. Steck*[1], *and Th. Stöhlker*[1,2,5]

[1]GSI, Darmstadt; [2]EMMI, Darmstadt; [3]AGH University, Kraków, Poland; [4]MPIK, Heidelberg; [5]HI-Jena, Jena

With its high-intensity and high-energy secondary beams, the FAIR facility will open a window to unexplored areas in atomic, nuclear, and particle physics. To take advantage of that, the ILIMA experimental program aims at high-precision mass and lifetime measurements of short-lived nuclides which will be accessible at the exit of the Super-FRS. The Collector Ring (CR) tuned into the isochronous ion-optical mode will be employed for this purpose. As a contribution to the ILIMA collaboration, our task is to develop an innovative resonant Schottky pickup with transverse sensitivity for the CR. The pickup will be used to measure the position of each stored ion, which in turn is essential for corrections of non-isochronous effects on a particle-by-particle basis.

Just like the previous Schottky pickup built for the ESR [1], we continue with a cavity-based design to achieve a high signal-to-noise ratio owing to its resonance nature. In general, three figures of merit are used to characterize such a cavity, i.e. *resonant frequency*, f, *quality factor*, Q, and *shunt impedance*, R.

Because of the boundary conditions in three dimensions, the EM waves in a cavity can only resonate at some discrete frequencies. The detection instrument will be tuned to one of these resonant frequencies in order to obtain the maximum induced signal. As a rule of thumb, it should not exceed the cut-off frequency of the ring to avoid any propagation outside the cavity. Due to the beam pipe considerations at the CR, we choose f to be about 400 MHz.

The quality factor describes how well a cavity stores electromagnetic energy at the resonant frequency. The less the EM power is dissipated away by heat conversion on the cavity wall, the higher the quality factor is. It is quantitated as: $Q = f/\Delta f_{3\text{dB}}$, where $\Delta f_{3\text{dB}}$ is the FWHM of the resonant peak in the frequency domain. For the sake of high sensitivity, we want the Q value to be as large as possible. Thus the material of the cavity should be a good electric conductor in order to reduce the energy loss due to heat.

Last but not least, the shunt impedance indicates the coupling strength between the cavity and the beam. Due to the same reason as for the quality factor, we want a high shunt impedance for the designed cavity. Additionally, we also require it to be distinct in respect of the transverse position, since the cavity has to identify the beam offsets. As a result, a mode geometry with a varying impedance vs. transverse position (such as the dipole mode) can be used.

Bearing these three important parameters in mind, we can obtain their values numerically by computer simulations. The simulation tool we are using is a commercial software CST STUDIO SUITE®. After the 3D model of the cavity is created and the boundary conditions are set properly, the *Eigenmode Solver* will calculate the EM field distribution at the resonant frequency. Then with the help of *Post Processing Templates*, we get the quality factor and the shunt impedance. We have studied several designs and accordingly simulated their features. Based on the simulation results, we have chosen an optimal design and have manufactured a model cavity.

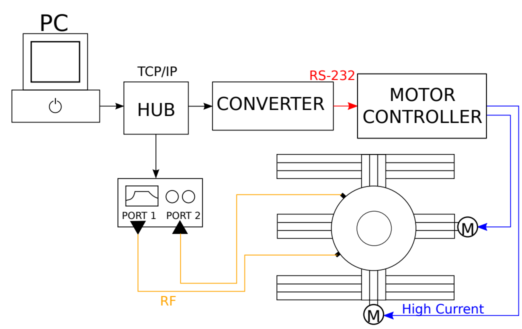

Figure 1: The schematic setup of the testing system for Schottky pickups. Taken from [2].

In parallel, we have also constructed an automatic computer-controlled testing system (Fig. 1) for the bench top measurements. Until now, we have performed the measurement of shunt impedances at different transverse positions in the beam pipe opening. We fixed the rod with two supports but moved the cavity instead. The cavity was placed on a motorized movement unit, which is controlled by a motor controller. It communicates with a PC over TCP/IP, via a converter to translate between Ethernet and RS-232. Also a Vector Network Analyzer (VNA) is connected to the PC by Ethernet cables. The automatic measurement is realized by a Java program, commanding the motor controller for cavity movements, the VNA for signal processing, and the PC for data acquisition. As a next step, we will perform the bead measurements to investigate the EM field distribution in the opening.

* This work is in part supported by the European Commission (PITN-GA-2011-289485), the Alliance Program of the Helmholtz Association (HA216/EMMI), and the Helmholtz-CAS Joint Research Group (HC-JRG 108).

References

[1] F. Nolden, *et al.*, *Nucl. Instrum. Meth. A*, **659** (2011) 69

[2] J. Piotrowski, BSc. Thesis, *AGH Univeristy*, (2013)

 doi:10.15120/GR-2014-1-FG-CR-04