Canadian Light Source / Centre canadien de rayonnement synchrotron

A 5 DOF PEEM Table at the Canadian Light Source

S.Y. Chen, T. Johnson: Canadian Light Source, University of Saskatchewan

S.G. Urquhart, U. D. Lanke: Chemistry Department, University of Saskatchewan

Abstract

The Canadian Photoemission electron Research Spectromicroscope (CaPeRS) is one of the two end station on the Spectromicroscopy (SM) beam line at the Canadian Light Source (CLS), is a mobile PhotoEmission Electron Microscope (PEEM). This microscope is capable of performing spectroscopy as well as microscopy at a sub-micron resolution scale, with spatial resolution better than 25 nm in realistic working conditions. It has also been commissioned on other CLS beamlines such as Variable Line Spacing Plane Grating Monochromator (VLS-PGM), and Spherical Grating Monochromator (SGM).

The mobility of CaPeRS PEEM from one beamline to another requires time efficient and precise positioning of the microscope. Mounting the PEEM at the beamline focus is an extremely difficult and time consuming process. Hence, we were motivated to build a table that can bring the PEEM to the beamline focus in a time efficient manner, while maintaining stability and a low vibration environment. We are confident that this table, with its five degrees of freedom (DOF) motion, will enhance the accuracy and reproducibility of the overall microscope operation.

Background:

To get the optimum photon flux and high spatial resolution, the PEEM sample must be positioned at the beamline focus. The sample surface makes an angle of 16 degrees with respect to the x-ray beam direction. The beam size on the spectromicroscopy beamline is 35-100 μm height and 100-130 μm wide at the sample focus. The height of the focus spot relative to the floor differs between beamlines: SM 1420 mm; PGM 1355 mm, and SGM 1672 mm. The PEEM has to be positioned to this height and positioned precisely in the beam focus spot on each beamline. The current PEEM is on an extruded aluminum frame equipped with three kinematic mounts, as shown in Fig 1. Prior to making this table, we were using concrete bricks to reach the beamline height and then kinematic mounts are used to reach the final precise height. The adjustments depend on *manually* driving the feet screws. This is an extremely difficult and time consuming process to reach the focused spot. The non-uniform distribution of PEEM weight and positioning of the kinematic mounts around the edge of the PEEM frame causes severe coupling of PEEM motions. It is not possible to move the PEEM relative to the optical or sample coordinates without coupling of axes.

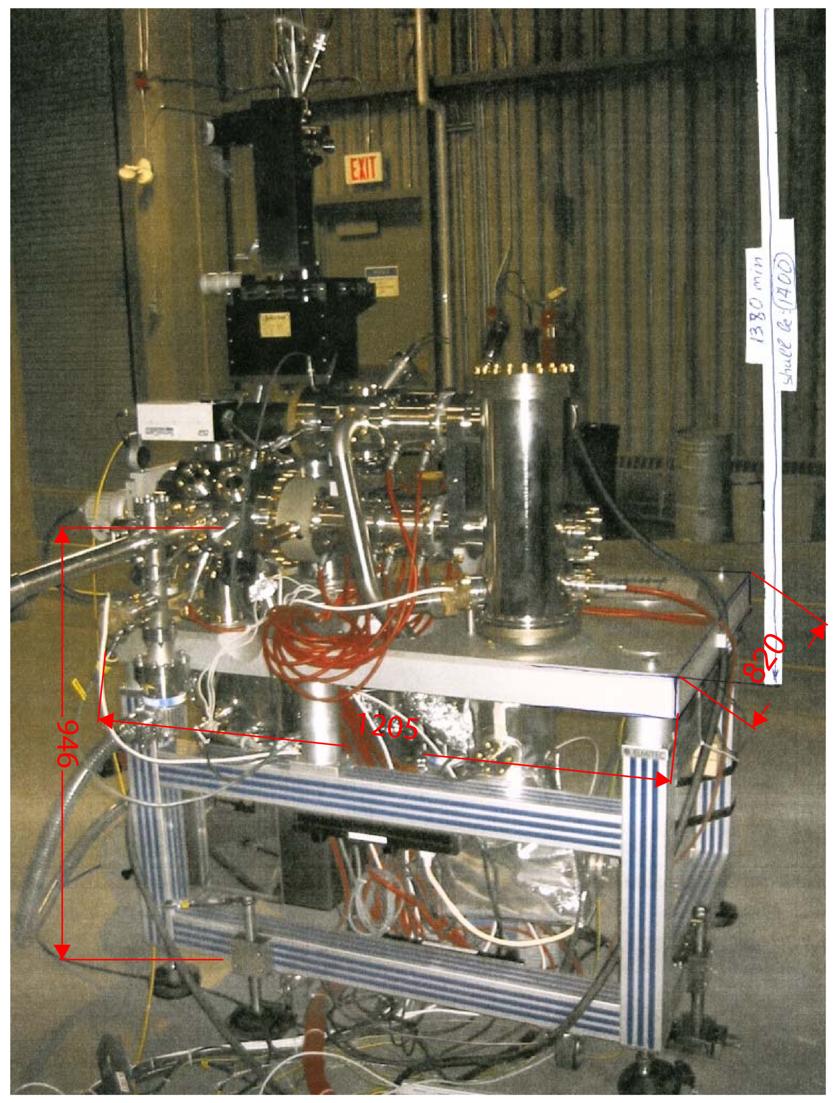


Fig.1 The Canadian Photoemission electron Research Spectromicrosocpe (CaPeRS)

General requirements for the table:

Low friction, high resolution motorized 5 DOF movements

- High stiffness
- Anti vibration
- Hold and able to manoeuvre total PEEM weight of about 1000 kg. This includes two Ion pump with TSPs (200 kg), aluminum platform (222 Kg), extruded aluminum frame (100 kg) and vacuum components (400 kg).

Motion range and resolution requirements

DOF	Range	Resolution	Repeatability	Accuracy
X (fine)	0-30 mm	10 μm/step	50 μm	50 μm
Y (fine)	no	n/a	n/a	500 μm
Z (fine)	+/-25 mm	1 μm/step	50 μm	50 μm
Rx (fine) Pitch	+/- 1 °	Depends on motion Z	n/a	n/a
Ry (fine) Roll	+/- 1 °	Depends on motion Z	n/a	n/a
Rz (fine) Yaw	+/- 1 °	Depends on motion X	n/a	n/a
Z (rough)	0-63	manual	n/a	n/a
Rx,Ry,Rz (rough)	Table top surface can be adjusted horizontal in +/-1 ° error			

X: Horizontal transverse; Y: beam direction; Z: Vertical
Rx, Ry, Rz: Rotations around X, Y and Z respectively

Mechanism

The PEEM table consists of bottom frame, three stages and top frame. The bottom frame provides a strong rigid foundation for these stages. The bottom frame is specially designed to get the desired vertical height. The four 1.25"-20 UNF struts has 80 mm rough adjustment height to accommodate PEEM onto different beam lines.

Stage I, mounted beneath the microscope focus point, has a vertical motorized motion and a horizontal motorized motion, perpendicular to the beam axis. Stage II also has vertical and horizontal (perpendicular to the beam) motorized motions, with free horizontal motion oriented along the beam direction. Stage III is motorized in the vertical motion and has free motion in the two horizontal directions. Stage I, II and III are the three end points of a right angled triangle.

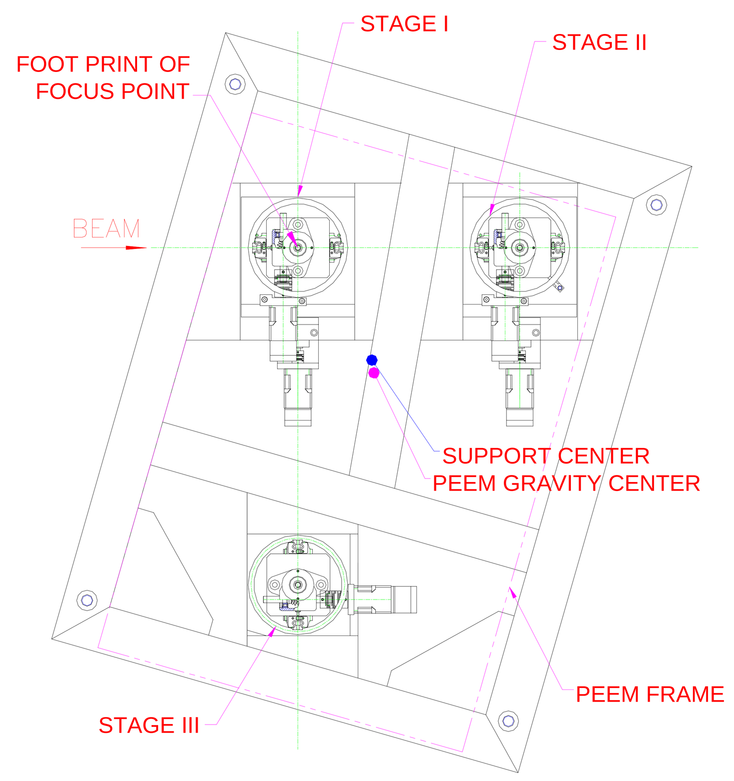
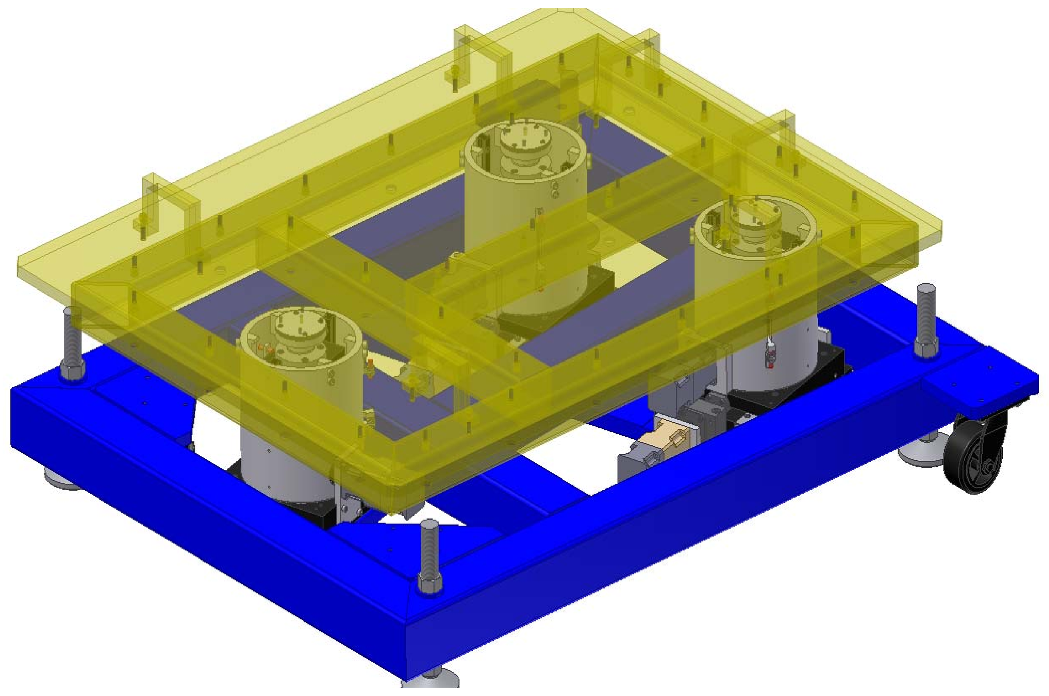


Fig.2 Plane sketch

One right angle side is along the beam direction, another right angle side is perpendicular to the beam. The triangle center is approximately coincident to the PEEM center of gravity shown in fig 2. Thus, we can get uniform and steady support to the microscope. By driving the stage II, we can adjust the PEEM pitch angle, without affecting the sample height and roll angle. Vertical driving the stage III we can adjust the roll angle without change the sample height and pitch angle.

The three stages are the same vertical motion mechanism. 1 ton Power jack with 5 mm raising pitch, 1:20 worm driving ratio and 80 mm motion stroke is used as elevating element. Two THK precision linear bearing mounted on the cylinder are used as vertical guide. The bearings are preloaded and can carry 5 degrees' load. A Parker HV motor and a low backlash 1:3 gearbox drive the jack.



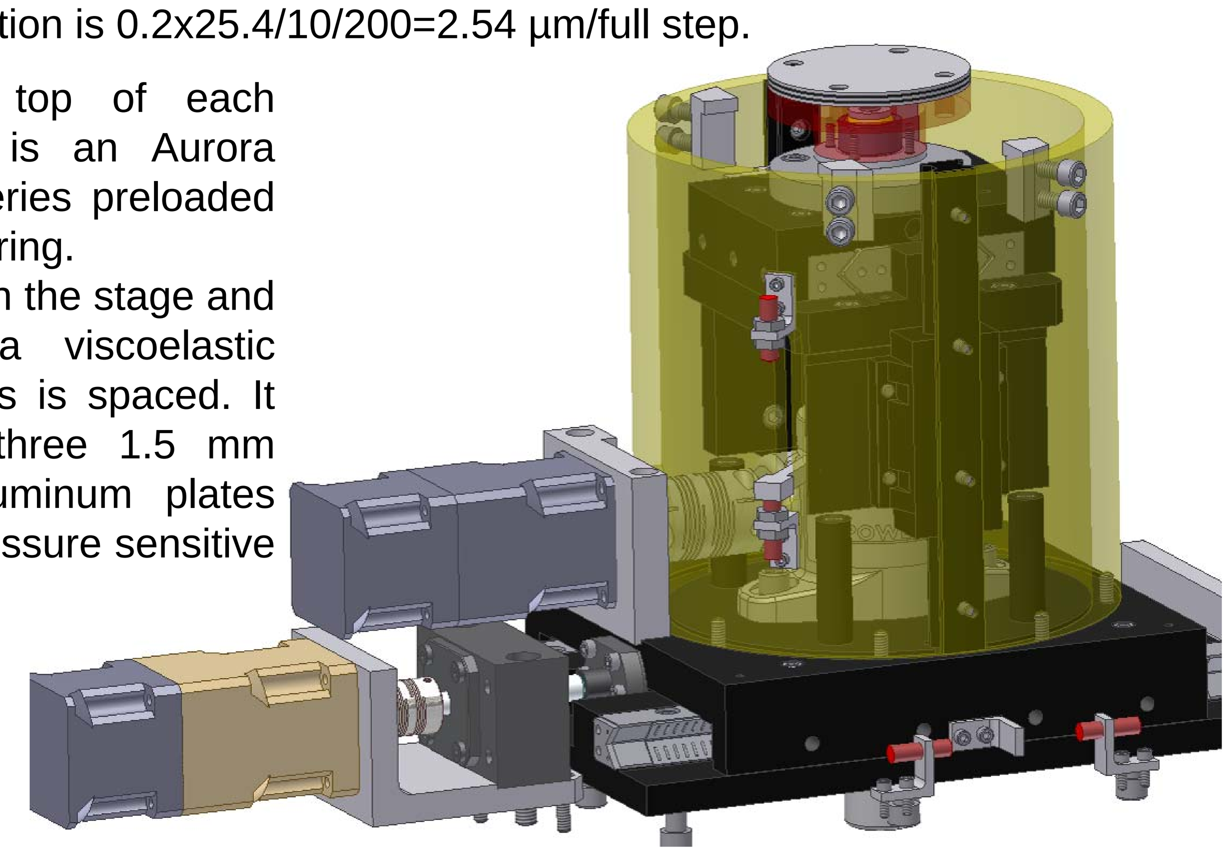
The vertical driving resolution is 5/20/3/200=0.42 μm/full step. Because the stage II and stage III has free horizontal motions, the vertical guides are not necessary crucially parallel. This benefit the components fabricating and assembly.

All the guides of the stage horizontal motions are INA M/V flat cage bearings used in pairs. The rollers line contact with the guideway. They has compact dimension and can be arranged the distance to get a stable stage. The friction factor is 0.0003. The preload of the M/V flat cage bearing can be adjusted .

The stage I and II horizontal driving are the same. NOOK 0631-0200 XPR ball screw with SSN preloaded ball nut system is used as driving element. A Parker HV stepper motor and 1:10 gear box actuate the ball screw system. The motion resolution is 0.2x25.4/10/200=2.54 μm/full step.

At the top of each stage there is an Aurora aerospace series preloaded spherical bearing.

Between the stage and top frame a viscoelastic damping pads is spaced. It consists of three 1.5 mm thickness aluminum plates joined by pressure sensitive adhesive film.



Discussion

The control system to test the motors is under way and hence we have not got an opportunity to test all the 5 DOF movements. By manual driving, the linear strokes can reach the design requirements.

In the design, three ways are considered to control the vibration. Strong support, preloaded needle rollers bearing and damping pads. The effect will be verified when the control system is ready. Thick damping pads (springs) are not recommended by some PEEM table users. Some investigation is necessary.

From the vibration aspect, a wedge lift unit will be better than a Jack. This PEEM table has a limited height to give us a chance to configure this wedge. A plain slide layer was considered to replace the needle roller cage in the M/V bearing system, but was not implemented due to the lack of stick-slip test data.

Change the dimension of the supporting frame, the table can used in different applications.

References and Acknowledgement

John P. Henderson, *The effects of radiation and creep on viscoelastic damping materials* North American Conference on Smart Structures and Materials 1995.

D. Mangra, S. Sharma and C. Doose, *Performance of the Vibration Damping Pads in the APS Storage Ring,* 1st MEDSI July, 2000.

Jennifer Renninger, *Understanding Damping Techniques for Noise and Vibration Control*

Many thanks to Tolek Tyliszczak in ALS and Frithjof Nolting in PSI - Swiss Light Source for share their experience with end station tables.

Our Operating Funding Partners

NSERC CRSNG — Canada — National Research Council Canada / Conseil national de recherches Canada — University of Saskatchewan — CIHR IRSC Canadian Institutes of Health Research / Instituts de recherche en santé du Canada — Saskatchewan Industry and Resources — Canada — Western Economic Diversification Canada / Diversification de l'économie de l'Ouest Canada

www.lightsource.ca