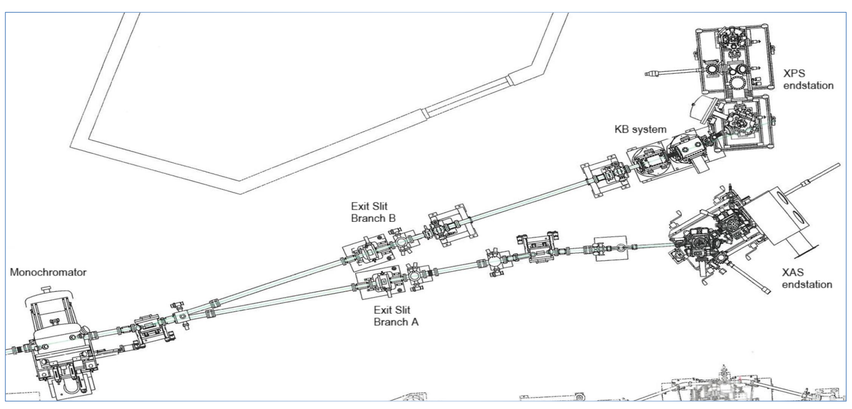
Commissioning Results from the newly installed KB Refocusing System for the VLS-PGM Beamline at the Canadian Light Source

Lucia Zuin, Dongniu Wang, Chithra Karunakaran Canadian Light Source, Saskatoon, Saskatchewan S7N 2V3, Canada

VLS-PGM beamline layout: optics and endstations



1. Y Hu *et al*, Rev. Sci. Instrum. **78** (2007) 083109
2. R Reininger *et al*, Rev. Sci. Instrum. **73** (2002) p.1489

The Variable Line Spacing-Plane Grating Monochromator (VLS-PGM) beamline [1, 2] at the Canadian Light Source (CLS) is a low energy undulator beamline covering the energy range 5-250eV.

In the original design, the monochromator has focusing optics to achieve sub-millimeter beam-spot sizes at the sample positions for both the downstream branches (A and B).

While this design is ideal for examining bulk properties of large samples, it limits the beamline's abilities to look at small samples, and to probe spatial distribution of elements and chemicals in the samples. In addition, the ~mm^2 beam spot results in a relatively low overall flux density, which can restrict the detection sensitivity of many count-rate dependent measurements.

In 2009, the Canadian Foundation for Innovation (CFI) awarded funding to the CLS to upgrade the VLS-PGM beamline with a micro-focusing system.

This upgrade involves the construction and installation of a Kirkpatrick-Baez (KB) refocusing system after the exit slit of the branch B. The new system allows to achieve micrometer size beam spot.

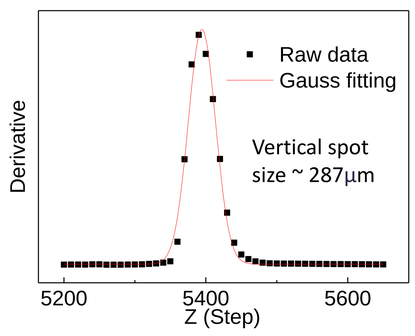
With the new focusing optics, theoretical results show that there will be an order of magnitude improvement in flux density with an optimum beam spot size of ~15 microns.

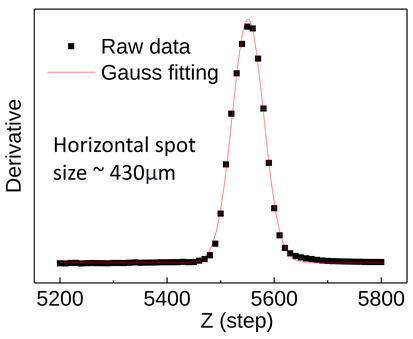
Experimental results
Spot sizes measured at the branch A with the original optic

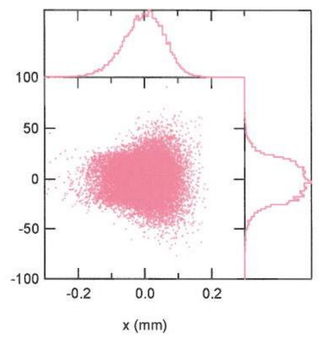
Spot size simulations
with the original optic with the KB system

Experimental results
Spot sizes measured at the branch B with the newly installed KB system

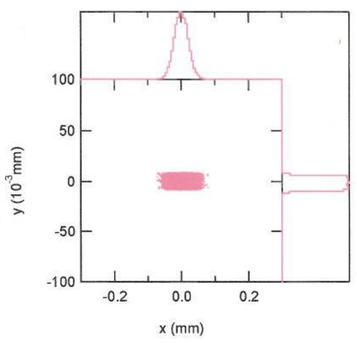
@ 120eV



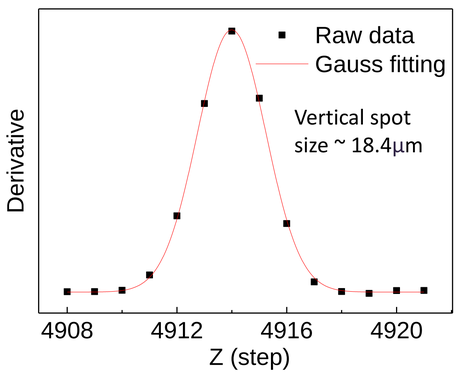


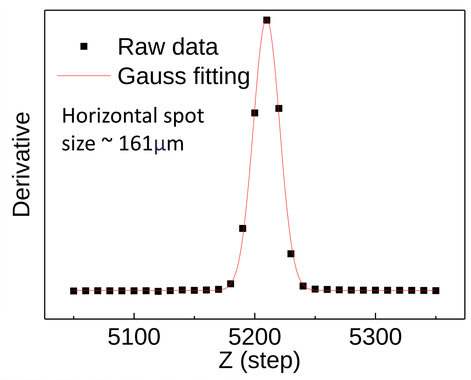


Vertical spot size = 100µm
Horizontal spot size = 360µm

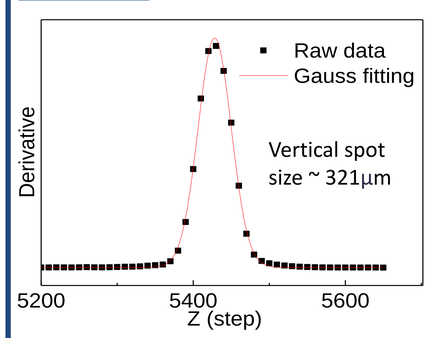


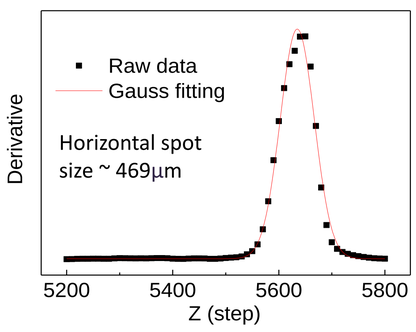
Vertical spot size = 17.5µm
Horizontal spot size = 140µm

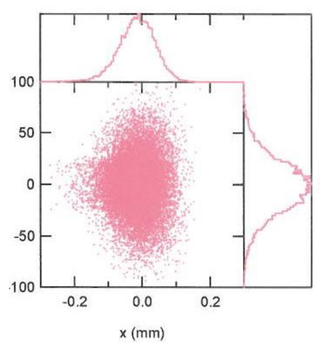




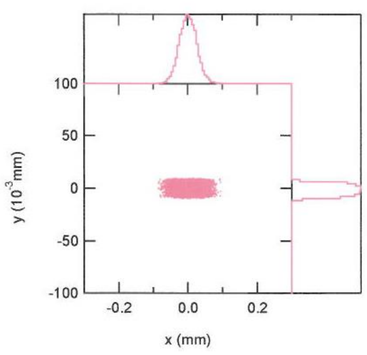
@ 70eV



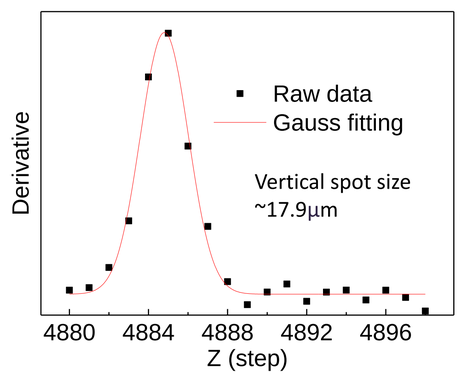


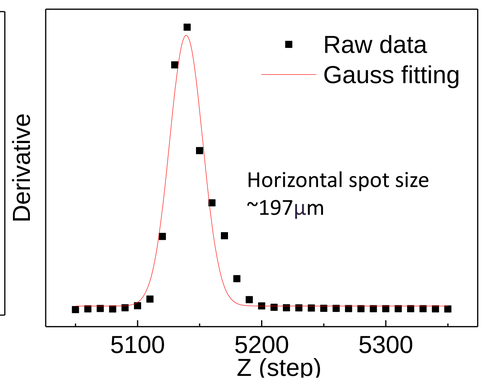


Vertical spot size = 150µm
Horizontal spot size = 325µm

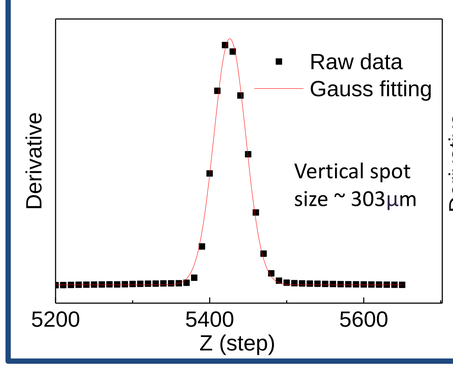


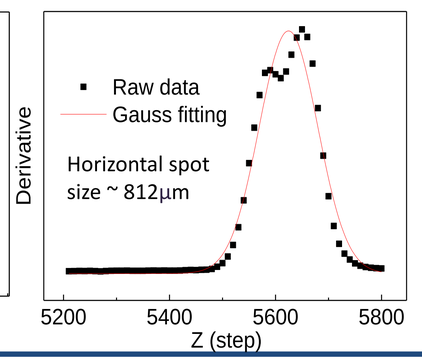
Vertical spot size = 19.0µm
Horizontal spot size = 155µm

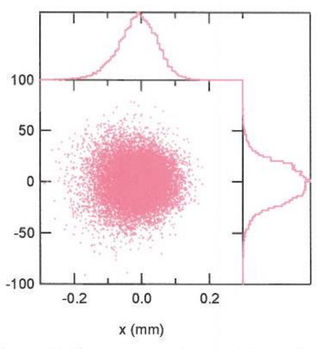




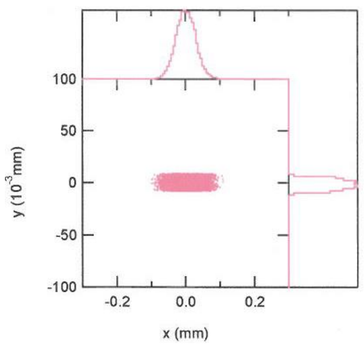
@ 25eV



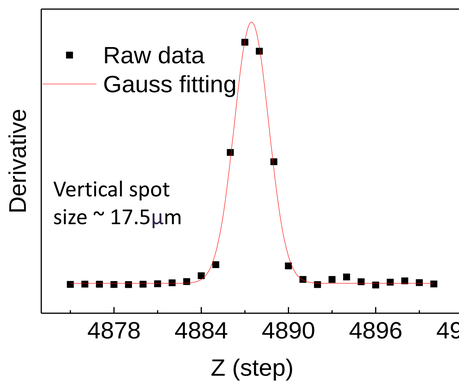


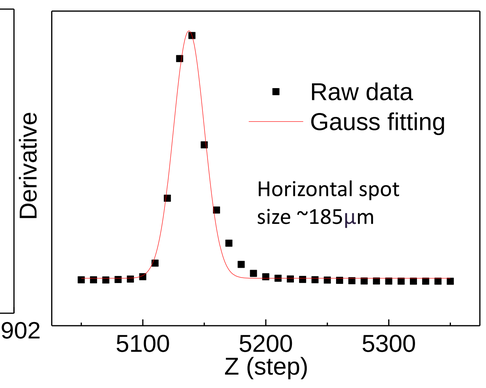


Vertical spot size = 100µm
Horizontal spot size = 350µm

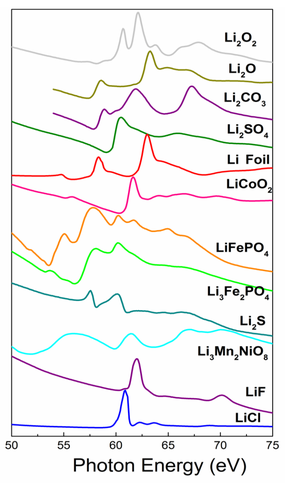


Vertical spot size = 19.0µm
Horizontal spot size = 169µm





Microfocusing together with the tunable polarization (new EPU planned to be installed in 2019) will advance the beamline to a new level for a large number of applications



A library of Li K-edge XANES spectra collected at the VLS-PGM beamline
doi.org/10.1016/j.jpowsour.2016.10.105

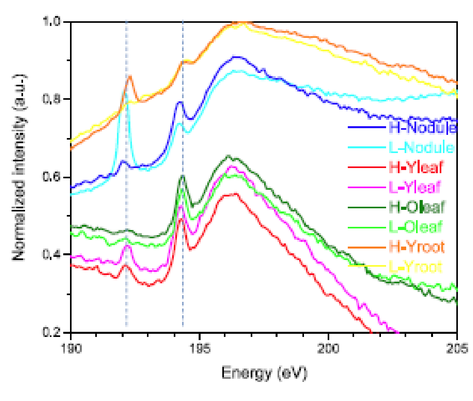
Soft X-ray spectroscopy techniques is already a rapid method to study element (phosphorus, sulfur, boron) speciation in different parts of plant such as nodules, roots, and leaves (http://www.wired.com/2012/08/nanoparticles-crop-pollution, C. Karunakaran *et al.,* in preparation) or lithium distributions in inhomogeneous materials such as catalysts and electrodes for batteries (D. Wang *et al.* Journal of Power Sources (2017) **337** 100) and in biological and in environmental specimens using the VLS-PGM beamline.

A new endstation is also being built to exploit the capabilities of the KB system.

The future capabilities of the VLS-PGM beamline: mapping and the micro beam, with an increased flux density of more than 8 times, will facilitate **detection of diluted samples**; it will allow the spectro-microscopy analysis of materials, especially for differentiation of the local structures, and their distribution in inhomogeneous materials.

Elemental/chemical maps with a spatial resolution of several microns could be realized.

Soybean plants



B K-edge XAS speciation measurements in soybean plant tissues treated with different levels of Mn.

Future capabilities: mapping boron K-, aluminum, sulphur and phosphorus L-edges in plant tissues
mapping lithium K-edge to reveal inhomogeneous sample distribution in batteries

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