# Development of a GHz-Rate Detector for Synchrotron Radiation Research

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## INTRODUCTION

It has by now become obvious that the brightness of third-generation synchrotron radiation sources often exceeds the capabilities of the end-station detector systems to adequately handle the electron or photon fluxes resulting from a given experiment, thus preventing both the fullest utilization of the radiation and the carrying out of certain new types of experiments readily, if at all. Detector non-linearity is one problem that has been encountered [1], but there are many other examples for which beamline or spectrometer throughput must be decreased to prevent high countrate saturation, or the number of energy or angular channels that can be counted simultaneously severely limits a given experiment [2]. In recognition of this, a national-level initiative in detector development has been proposed by the multi-institutional "DetectorSync" group [2].

As a first example of what can be accomplished with advanced detector technology, a project to develop an ultrahigh-speed one-dimensional detector for electrons and vuv/x-ray photons is underway at the ALS.

## DESIGN PHILOSOPHY AND FIRST TEST RESULTS

This project takes advantage of unique expertise at LBNL for detector development in high-energy and nuclear physics, and involves the custom design and fabrication of application-specific integrated circuits (ASICs). The final goal is a 768-channel detector with 50 micron spacing between channels and a maximum linear countrate per channel of over 2 megaherz. The overall countrate will thus be in the 2 GHz range, and approximately 100 times faster than any other present one-dimensional or two-dimensional detector, with significantly improved spatial resolution as well compared to other existing detectors. First applications will be in electron spectroscopy, but others in x-ray absorption and x-ray emission spectroscopy are expected to follow.

A first prototype of this detector is shown in Fig. 1(a). Based on 12 pairs of 64-channel ASICs (an existing high-energy preamplifier chip (SDC) and a specially-designed buffered counter (DBC)), this detector has already demonstrated the ability to take spectra in a Scienta electron spectrometer located at the ALS (Fig. 2(a)), to resolve channels with a FWHM of 75 microns (Fig. 2(b)), and to count linearly at up to 1.0 GHz overall (Fig. 2(c)) [3].

Based on this experience, a next-generation detector with significant improvements in all elements from power supplies to ASICs to data acquisition is presently under development, with an expected completion date of late 2002. This will use 6 pairs of 128-channel ASICs (a newer high-energy preamplifier chip (CAFÉ-M) and a specially-designed buffer counter (BMC)), with optical coupling between detector and control/counting electronics to minimize noise and transients. The completion date for this project is estimated to be late 2002.

**ALS GHz-RATE DETECTOR PROJECT**

- **(a) Prototype:**
  - 768 channels (64 x 12 chip pairs)
  - Operation in real ALS environment
  - ~75 micron spatial resolution
  - 1 GHz overall linear countrate
  - demonstration of principle
- **(b) Next generation:**
  - 768 channels (128 x 6 chip pairs)
  - ~75 micron spatial resolution
  - >2 GHz overall linear countrate
  - spectral readout in as little as 60μs (time-resolved measurements)
  - programmable thresholds, readout format
  - more robust in all respects
  - size to fit current spectrometers

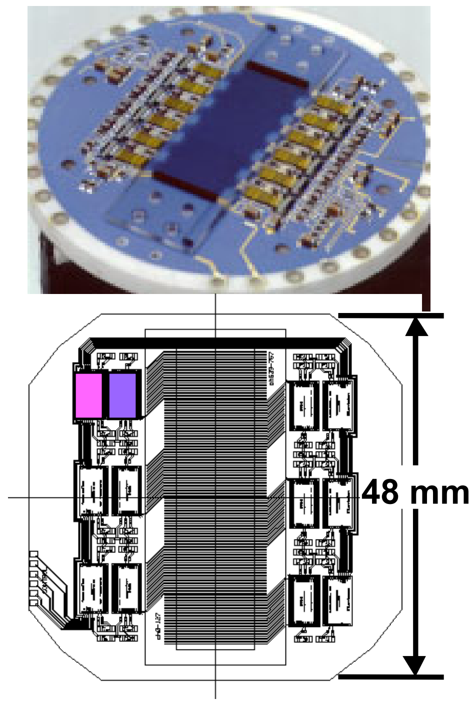


Figure 1--(a) Basic characteristics of the prototype GHz-rate detector developed as the first stage of this project, together with a photo of the ceramic substrate with 12 preamp-plus-counter chipsets mounted on it. The microchannel plates are not yet installed. (b) Basic characteristics of the next-generation detection now being designed and fabricated, together with a layour of its 6 chipsets and an indication of its size.

## CONCLUSIONS

A prototype one-dimensional electron and photon detector operating linearly up to the GHz countrate level and with a resolution of 75 microns over 768 channels has been successfully developed and tested. An improved version of this detector is under development, with the same resolution and number of channels, but improved performance, programmability, and robustness in general user environments relative to the prototype. The next-generation detector should find use in several areas of synchrotron radiation research.

## REFERENCES


[1] A.W. Kay, F.J. Garcia de Abajo, S.-H. Yang, E. Arenholz, B.S. Mun, N. Mannella, Z. Hussain, M.A. Van Hove, and C.S. Fadley, Phys. Rev. B 63, 115119 (2001); D. Nordlund, M.G. Garnier, N. Witkowski, R. Denecke, A. Nilsson, M. Nagasono, N. Martensson, A. Fohlisch, Phys. Rev. B 63, 121402 (2001); and abstract in the 2001 Compendium by N. Mannella et al.

[2] Local participants in the DetectorSync initiative include A. Thompson, H.A. Padmore, and C.S. Fadley, and the group's website is at--http://www-esg.lbl.gov/esg/meetings/detectorsync/index.html, with a more detailed white paper on detector needs also downloadable from this source.

[3] A.W. Kay, Ph.D. thesis (University of California, Davis, September, 2000), LBNL report 46885, and to be published.

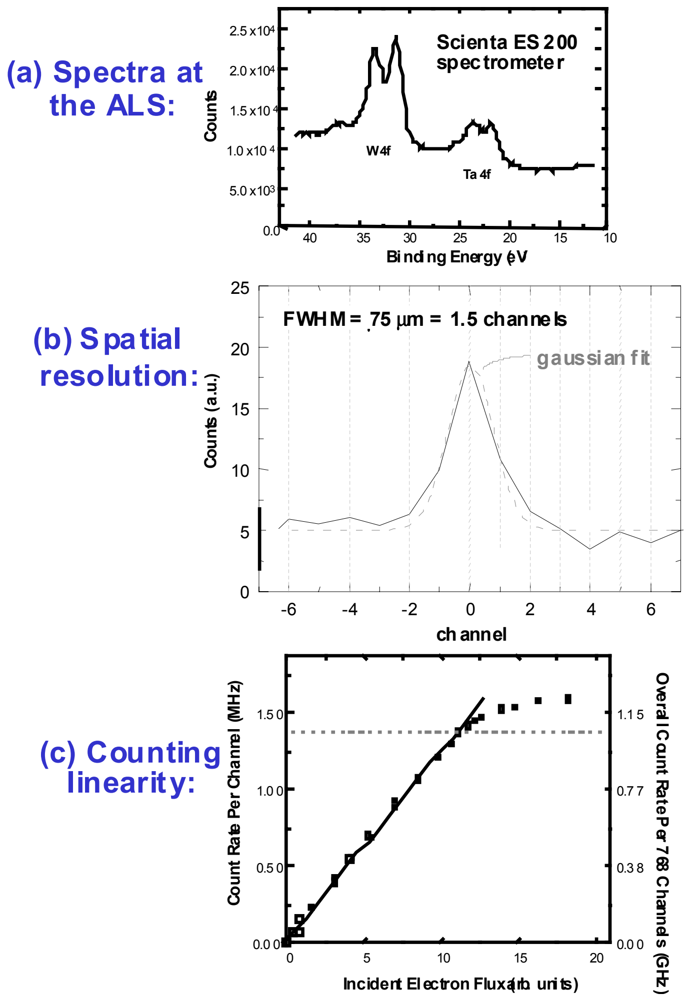


Figure 2--Test data from the first prototype detector shown in Fig. 1(a). (a) Test spectra obtained with the detector mounted in a Scienta SES 200 spectrometer at ALS beamline 9.3.2. (b) Spatial resolution determination via a collimated electron beam source. Each channel is 50 microns. (c) Counting linearity per channel (ledt scale) and over all channels (right scale) as determined with an electron gun.

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