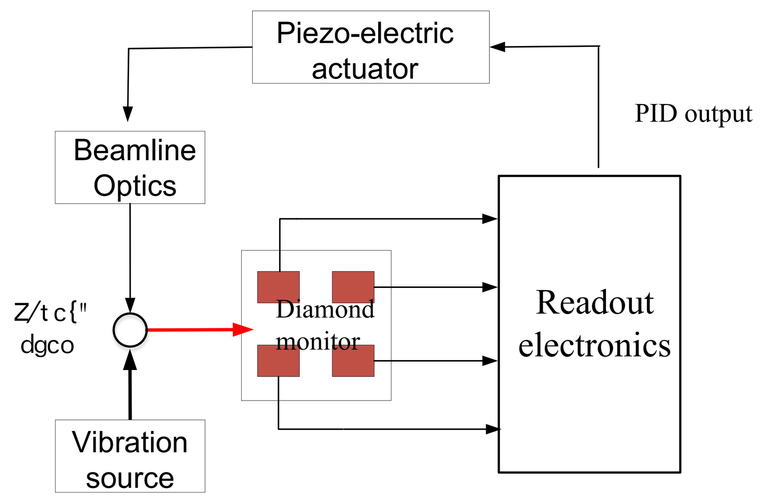
# R&D of the Readout Electronics for X-ray Beam-position Feedback System Of SAPS

L. Yu[1,2] Q. L. Xiu[1,2] X. C. Tian[1,2] S. J. Chen[1,2] L. X. Zeng[1,2] H. Luo[1,2]
H. B. Liu[1,2] W. G. Yin[1,2] J. Y. Ren[1,2] X. K. Wang[1,2] L. Xiao[1,2] P. X. Shen[1,2]
H. Y. Teng[1,2] Y. B. Zhao, [1,2,3 a)] and Z. J. Sun[1,2,3 a)]

## Introduction

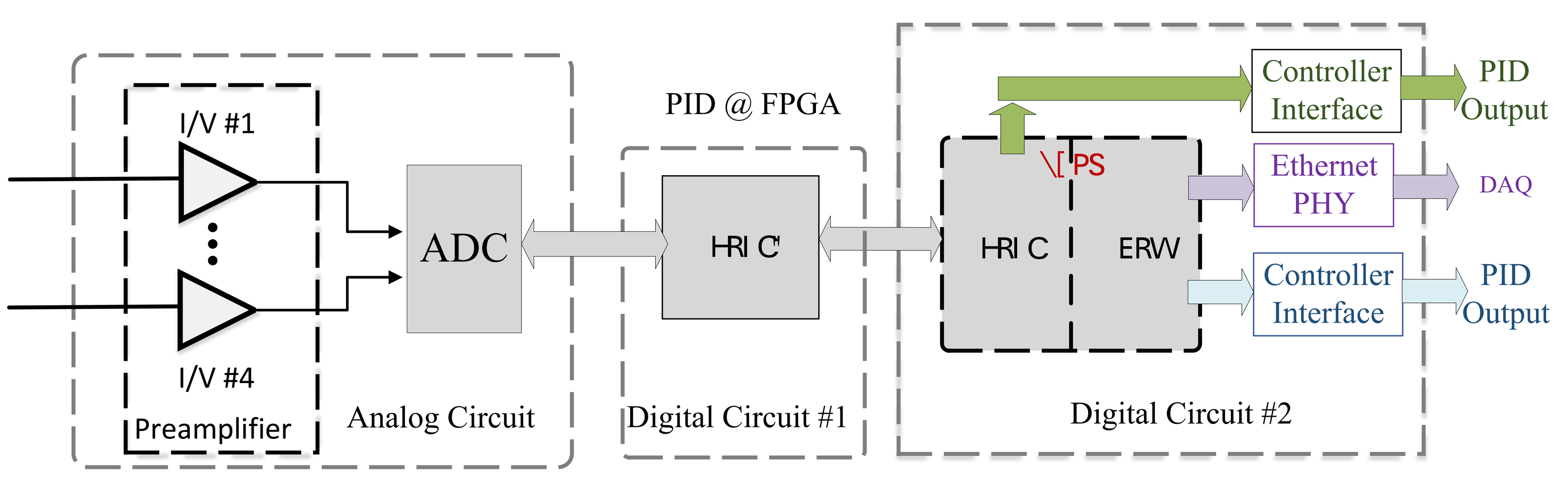
In 4th generation light sources, X-ray beam-position stability is one of the crucial factors for developing cutting-edge technology, as the measurement accuracy may decline significantly due to the beam position drift and vibrations. The traditional passive vibration isolation is not enough for further improving the beam position stability in 4th generation light sources . Consequently, active vibration isolation techniques based on feedback control technology has begun to play an important role in addressing the beam position stability problem in 4th generation light sources.

The working process of beam-position feedback system is show in Figure. The paper presents readout electronics of beam-position feedback control system for southern advanced photon source (SAPS) .




## IMPLEMENTATION

### ➢ Structure of Readout electronics:

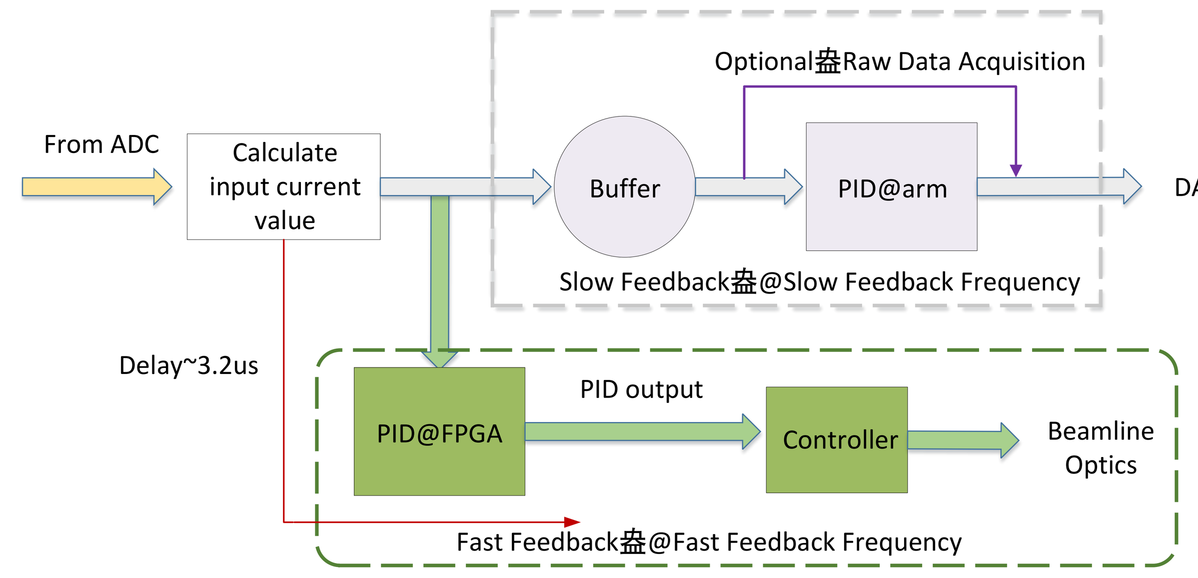



The analog conditioning block of the signals coming from each pixel of the monitor is made up of frontend electronics based on the femtoampere input bias current electrometer amplifier ADA4530 and 24-bit A/D converter AD7172. Based on the compliance of functions and duties, the digital part are divided into two circuits. The Kintex FPGA from Xilinx forms the core of digital circuit 1. It provides control signals to the analog conditioning block, and receives and processes the data provided by the ADC. The signals output by the analog module are digitized and processed inside the FPGA based on the current calculation module and the PID controller.

The ZYNQ from Xilinx is the core of digital circuit 2. It integrates the software programmability of ARM core and the hardware programmability of FPGA. The digital circuit 2 is a system-on-chip (SoC) solution, which facilitates various functionalities, including: digital signal processing, communication and providing embedded Linux system for software development.

### ➢ Data processing :

A detailed research regarding the vibrations in the foundations of the proposed site of SAPS shown that the frequency band with 5Hz has the largest contribution in the vibrations of the foundation. And the gain of the feedback control system of it is about 0.66.

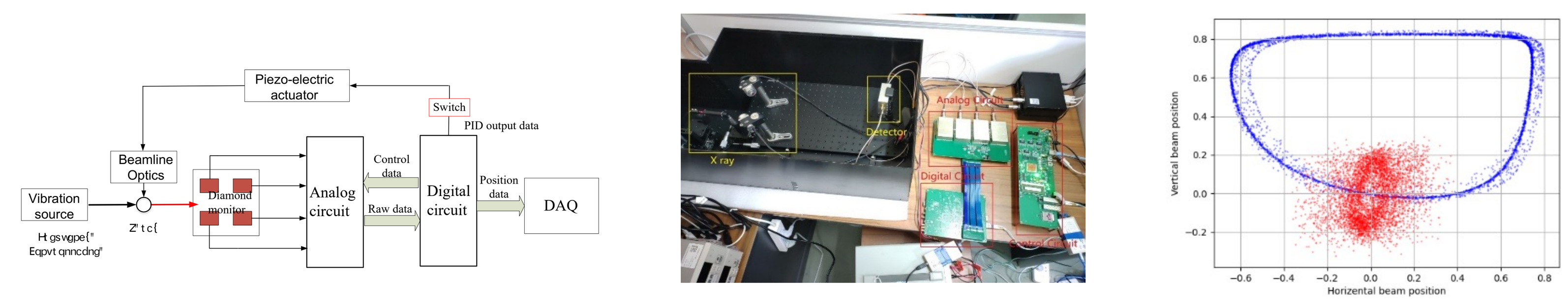



Therefore, the readout electronics implemented in this work focus on processing the beam-position change caused by this particular frequency band vibration.

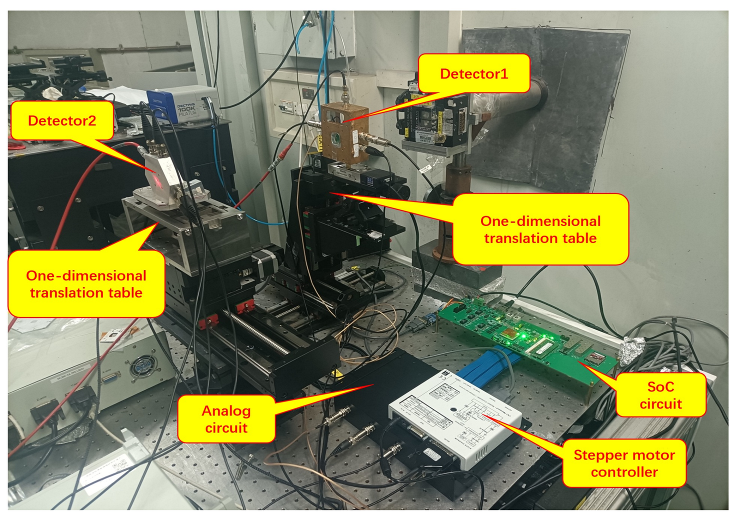
In order to effectively process the output data of the analog circuit, two branches of data flow in the digital part of the circuit are designed in parallel, thus allowing the user to perform different measurements simultaneously, as shown in Figure.

## EXPERIMENTS AND VERIFICATION

In order to evaluate the readout electronics, several tests were performed in the laboratory. The testing equipment and testing platform are presented in Figure.



The test demonstrate that the readout electronics is feasible as it can mitigate the influence of the vibration sources with a frequency of 1Hz on X-ray beam.

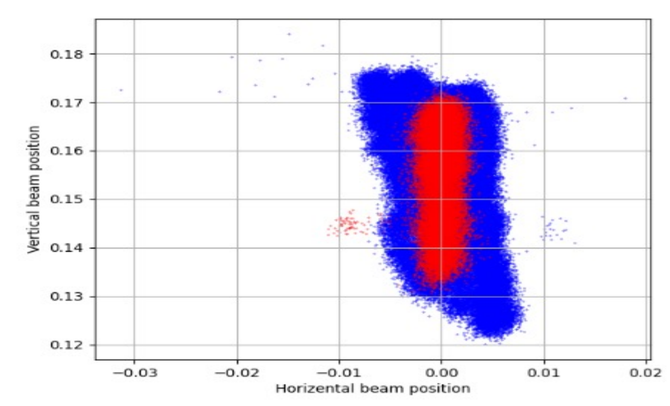



Since the SAPS has not been built yet, the feedback control system has been evaluated and tested in the Macromolecular Crystallography Beamline 1W2B at BSRF. The testing equipment and testing platform are presented in left Figure:

Detector 1: using the readout electronics developed in this paper to form a one-dimensional closed-loop feedback control.

Detector 2: using the commercial electronics (6482 picoammeter of Keithley) to form a one-dimensional closed-loop feedback control.

Detector 1 uses a stepper motor to achieve closed-loop feedback control in the horizontal direction, and there is no feedback control in the vertical direction. It can be seen from the test results in right Figure that the feedback control system has effectively eliminated the periodic jitter of the beam, and the distribution of the horizontal light spot has become significantly smaller.




## Conclusions

In this work, we present a readout electronics design that is implemented based on a diamond monitor for SAPS. We perform several tests for verifying the designed readout electronics. The results show that it can effectively correct the X-ray beam-position caused by the vibration sources below 5Hz. Especially, the introduction of SoC architecture makes the readout electronics platform a more modern system, which can flexibly perform data analysis and physical information extraction. It also provides a brand-new perspective regarding the process of developing next-generation X-ray stations' software and hardware readout system.



Contact: yuli@ihep.ac.cn