A5 (GEP=4)

X-ray imaging and spectroscopy with astronomical semiconductor devices

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GPPU Experimental Point (GEP): 4

Goal of Study

(1) To understand the principles of X-ray detection using semiconductor devices
(2) To understand the setup of X-ray detection experiments and how to perform X-ray imaging spectroscopy using astronomical semiconductor detectors
(3) To experience the X-ray measurements and the image and spectral analyses

Contents

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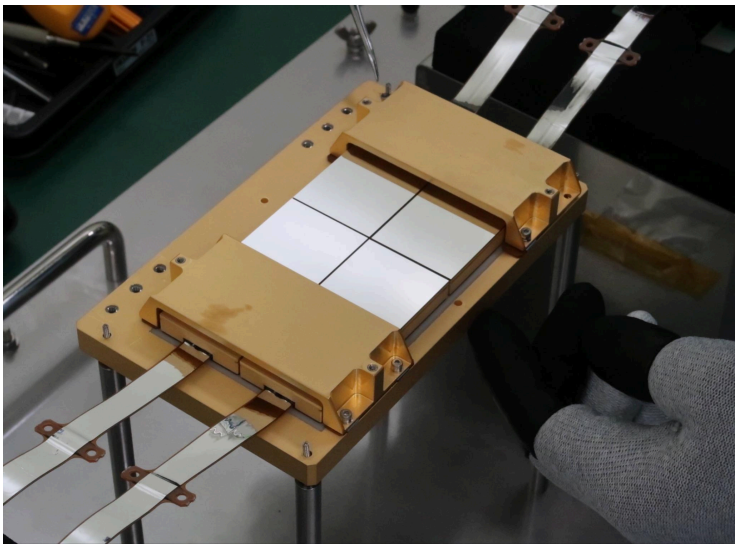
X-ray astronomy is a research field which investigates hot and high-energy astrophysical phenomena by observing X-ray signals from the universe. Since cosmic X-rays are absorbed by the atmosphere of the Earth, X-ray detectors must be placed aboard flying objects such as satellites. One of the main types of X-ray detectors onboard astronomical satellites is semiconductor-based devices, such as X-ray charge-coupled devices (CCDs) and complementary metal-oxide semiconductors (CMOSs). These detectors enable both imaging and spectroscopic observations of X-rays at the same time.
In this lecture, students will first learn the principles of X-ray detection in astronomical instruments. Then, a detector system equivalent to the Soft X-ray Imager (SXI)[1] onboard the X-ray Imaging and Spectroscopy Mission (XRISM) will be set up (In some cases, a CMOS-based system[2] or a silicon drift detector may be used as a substitute). Students will conduct an X-ray detection experiment using, for example, an Fe-55 radioactive source, followed by data analysis to perform X-ray imaging and spectroscopy.



Textbook and References

[1] Noda et al. "Soft X-ray Imager of the Xtend system onboard XRISM", Publications of the Astronomical Society of Japan, psaf011 (2025)
[2] Asakura et al. "X-ray imaging polarimetry with 2.5-um pixel CMOS sensor for visible light at room temperature", Journal of Astronomical Telescopes, Instruments, and systems, Volume 5, id 035002 (2019)

Progress Schedule

- ✧ Day 1
  Introduction of the principles of X-ray detection (Lecture)
  The structure of X-ray detectors and the configuration of their systems (Lecture)
  How to perform X-ray imaging spectroscopy (Lecture)
  Setup systems of semiconductor devices (Experiment)
- ✧ Day 2
  Vacuum evacuation and detector cooling (Experiment)
  Setup driving parameters of semiconductor devices (Experiment)
  X-ray data acquisition (Experiment)
- ✧ Day 3
  Data analyses on X-ray images and spectra (Experiment)
  Final wrap up (Presentation)

Other Details

Course Period	Winter 2025/2026
Place	Experimental room (Science Complex C, N504)
Number of Students	1−3
Evaluation method	The evaluation will be made based on the participation to the lecture (30%) and quality of the final report made by each participant (70%)

In Addition

Each participant is requested to perform his/her own analysis and make a report.