In-orbit Neutron Background of the Hard X-ray Imager onboard *Hitomi*

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Introduction

In order to achieve higher sensitivities in hard X-ray band:

- Improving S/N ratio by focusing X-rays.
- ◎ Reducing non-X-ray background.

→ Need to understand the properties of background.

- The background component produced by atmospheric neutrons has been poorly understood, although it has significant contribution to the entire background. (Mizuno+10)
  → Aim of this work:
  Understanding the contribution of atmospheric neutron background quantitatively.

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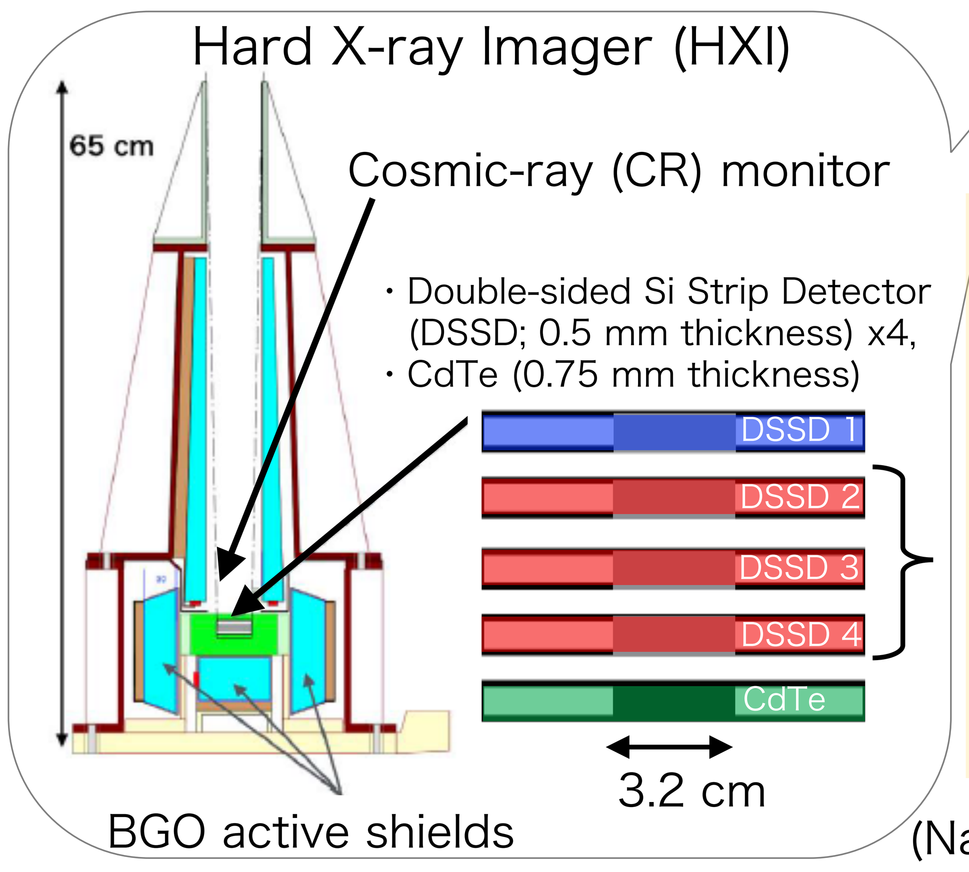


(Nakazawa+18)

Background components of each layer of the HXI onboard *Hitomi*

Electrons + Cosmic X-ray Background (CXB) (Hagino+18)

Seems to be dominated by atmospheric neutrons → Used in the analysis.

Proton-induced radioactivation (Odaka+18)

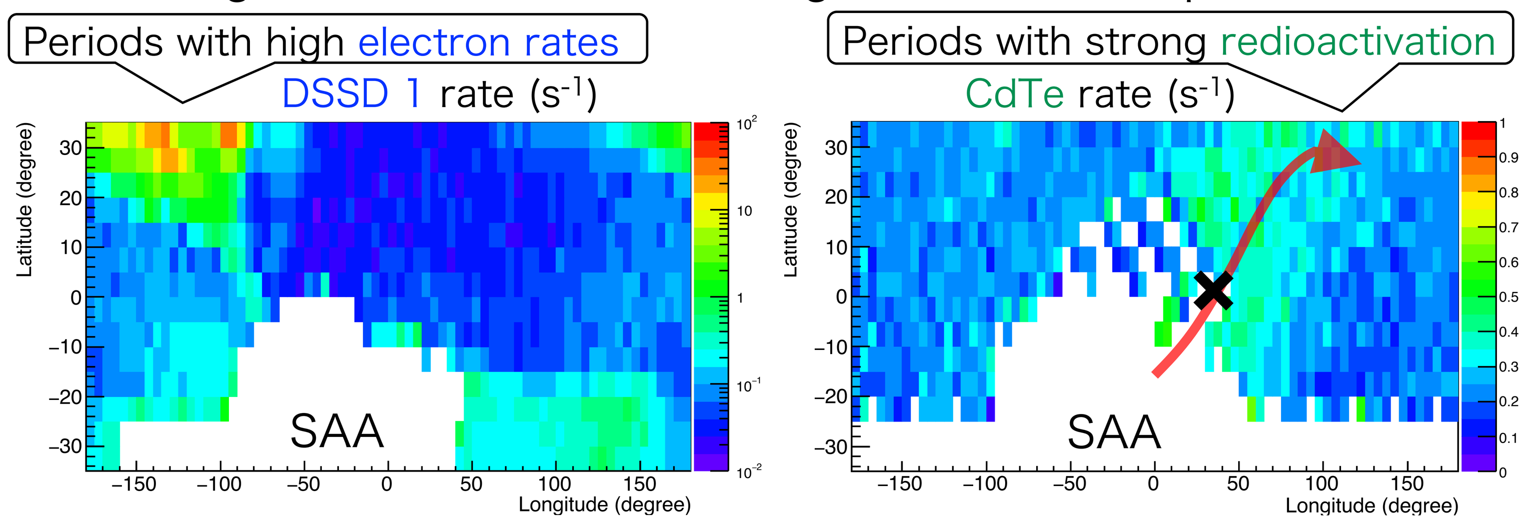
Data Reduction

- ➢ The data of blank-sky observations obtained with DSSD2-4 were used.
- ➢ Excluded from the data:
  Periods with high electron rates.
  Periods with strong radioactivation.

Logs of the blank-sky observations used in this work.

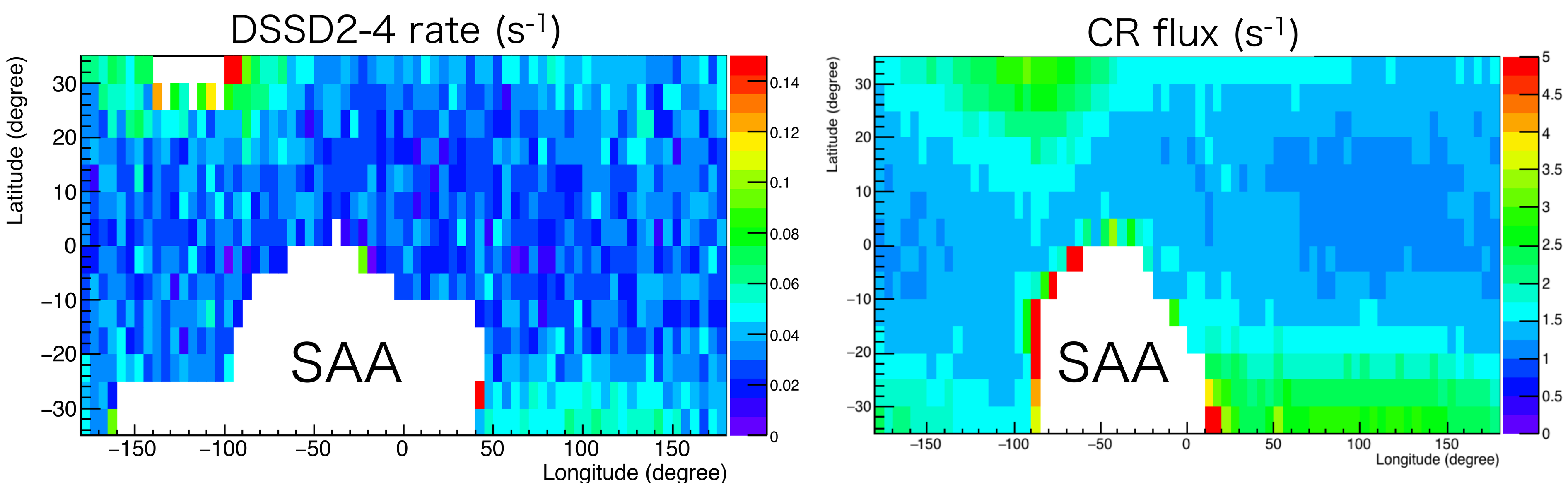
Observation period	OBSID	Target name
3/14 16:20–3/14 18:00	000007010	None2
3/14 18:00–3/15 17:56	000007020	None2
3/15 17:56–3/16 19:40	000008010–000008060	IRU Check out
3/16 19:40–3/19 19:00	100043010–100043040	RX J1856.5–3754
3/23 13:30–3/25 11:28	100043050–100043060	RX J1856.5–3754

High-electron-rate and strong-radioactivation periods.

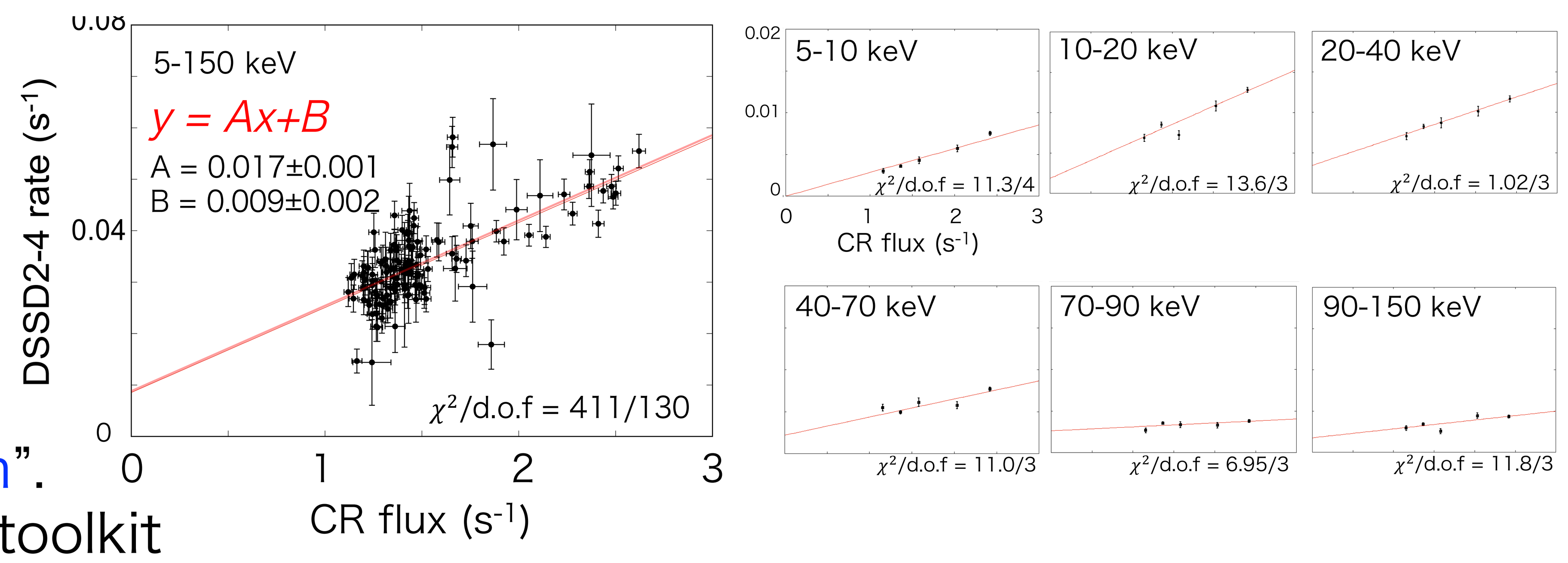


Results

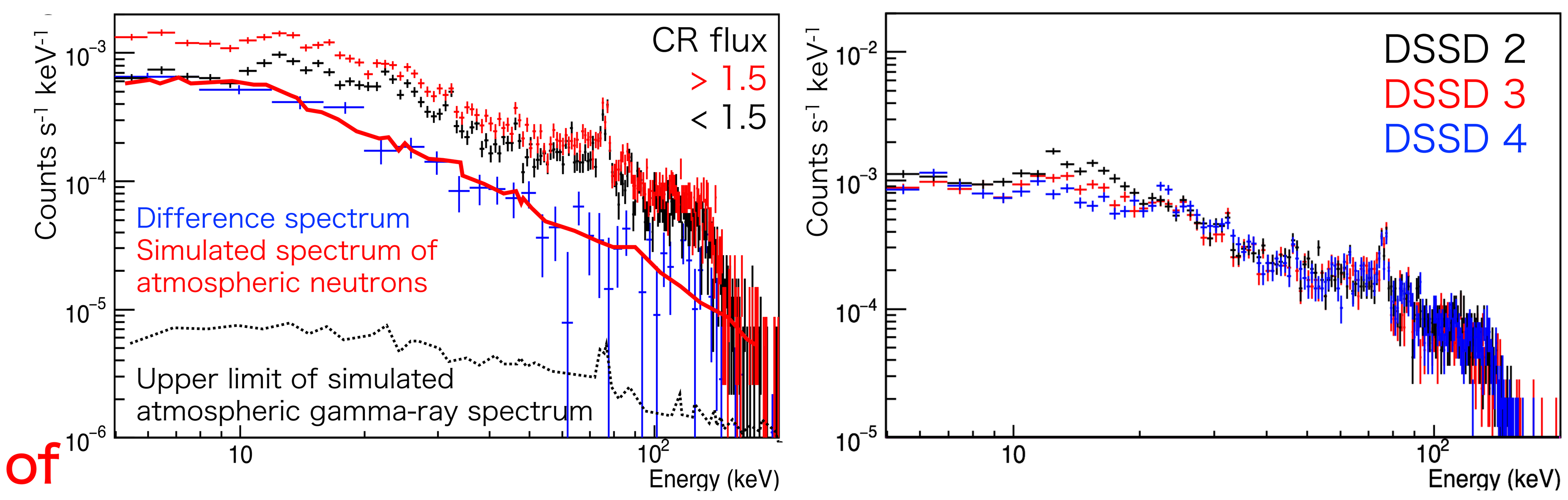
- ➢ DSSD2-4 rate showed a spatial correlation with CR flux obtained with the CR monitor.
  → DSSD2-4 backgorund seems to be dominated by atmospheric particles (neutrons and gamma-rays).



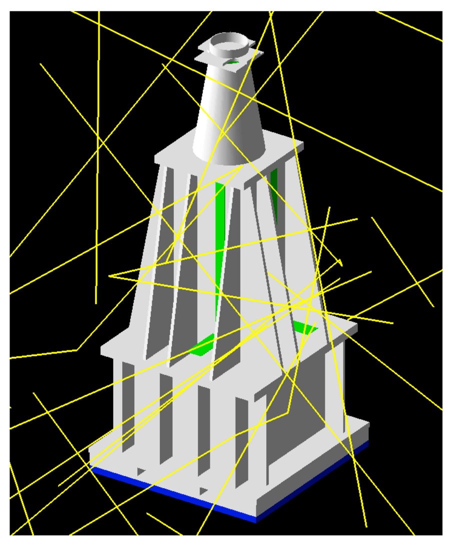
- ➢ Linear function correlations between CR fluxes and DSSD 2-4 rates were found in all of the six energy ranges.
  → Atmospheric particles should be the proportional component (Ax).



- ➢ We subtracted the spectrum in low-CR periods from that in high-CR periods, to obtain "Difference spectrum".
- ➢ We conducted a Monte-Carlo simulation using Geant4 toolkit to estimate the spectrum of atmospheric particles. (Armstrong+73, Odaka+18)
  The shape of the difference spectrum required pure atmospheric neutron spectrum.
- ➢ Spectral differences among DSSD2, 3, 4 were small.
  = Background particles had high penetrating power.
  → Consistent with that the atmospheric neutron background is dominant.
- ➢ We determined the contribution and spatial variations of atmospheric neutrons. → Feedback to simulations.



Conclusion & Future work



- ➢ We investigated background produced by atmospheric neutrons, which has a significant contribution to the entire non-X-ray background but has been poorly understood.
- ➢ We found that the screened background rate had positive correlation with the CR flux in orbit, suggesting that the background was dominated by the atmospheric neutrons.
- ➢ Using this correlation, we extracted the spectrum and spatial variations of the neutron background.
- ➢ Comparison between the extracted neutron background measurement and estimates by our Monte-Carlo simulations confirmed that the extracted background could be explained by atmospheric neutrons.
- ➢ In future missions, background can be reduced significantly by neutron shields, using more plausible estimations.

References:
Armstrong, T. W. and Chandler, K. C. and Barish, J., 1973, Journal of Geophysical Research, 78, 16;
Hagino, K., Nakazawa, K., Sato, G., et al. 2018, Journal of Astronomical Telescopes, Instruments, and Systems, 4, 021409;
Mizuno, T., Hiragi, K., Fukazawa, Y., Proc.SPIE, 77323C;
Nakazawa, K., Sato, G., Kokubun, M., et al. 2018, Journal of Astronomical Telescopes, Instruments, and Systems, 4, 021410;
Odaka, H., Asai, M., Hagino, K., et al. 2018, Nuclear Instruments and Methods in Physics Research A, 891, 92