Radiation tolerance tests and performance verification of pnCCD at high temperature for future satellite mission HiZ-GUNDAM

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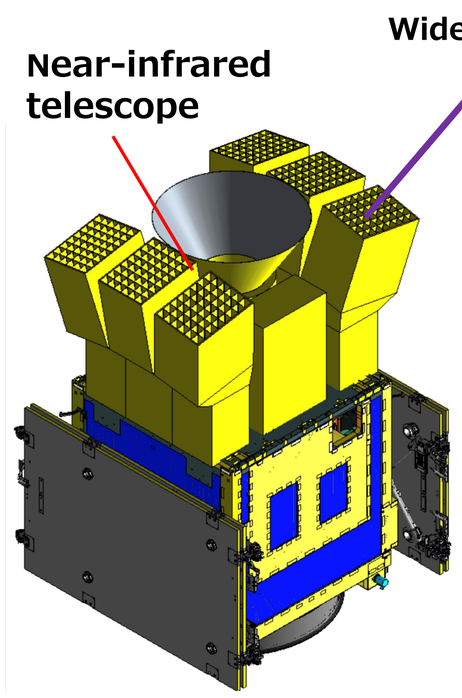
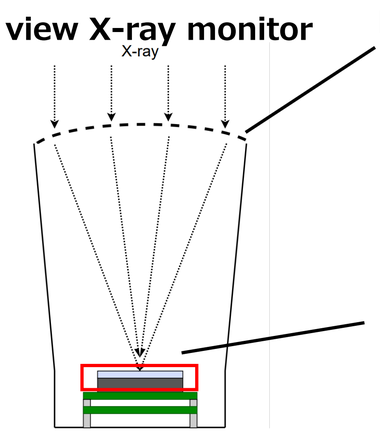
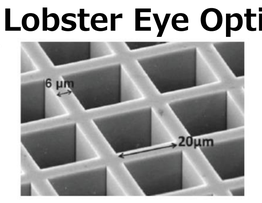
1.HiZ-GUNDAM and wide field view X-ray monitor





Lobster Eye Optics



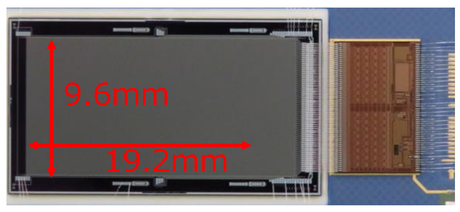
pnCCD

Content	Requirement
Energy range	0.4 keV to 4keV
Field of view	0.5 sr
Exposure time	0.01s to 0.1s(TBD)
Mission year	3yr to 5yr
Operating temperature	<-20 ℃

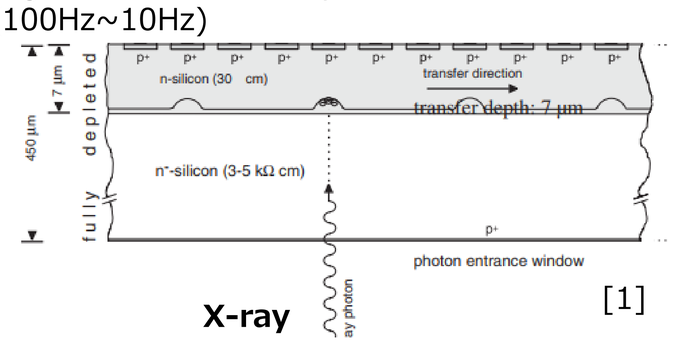
2.pnCCD

- One of back illuminated type CCD
- CCD which is capable of reading out all columns in parallel.
  - ✓ Fast framerate is realized. (100Hz~10Hz)
- FM: 5.5cm ×5.5cm pnCCDs

pnCCD for basic investigation



Pixel size	75um × 75um
Number of pixels	128 × 256 pixels
Depletion layer's depth	450um

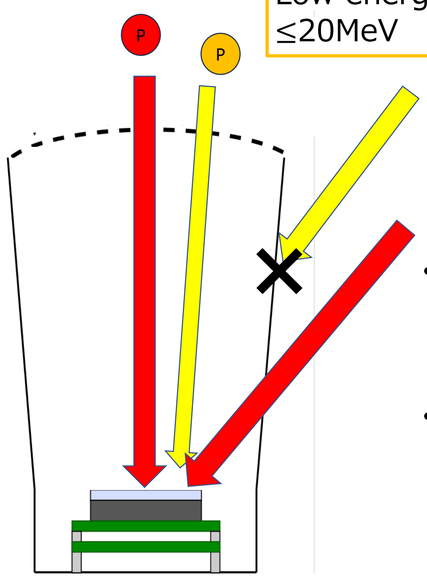


- Spec of pnCCD will be degraded by radiation in the space.
- I'll introduce about degrade of the Spec
  - ✓ **Dark current.**
  - ✓ **Energy resolution**
  - ✓ **CTI**

3. Radiation tolerance of pnCCD .

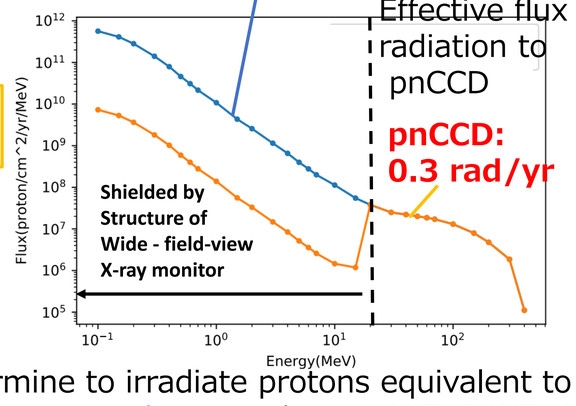
High energy proton ≥20MeV

Low energy protons ≤20MeV

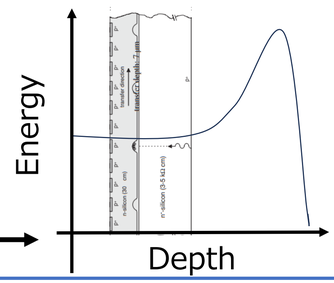


Flux of radiation in the orbit

Effective flux of radiation to pnCCD



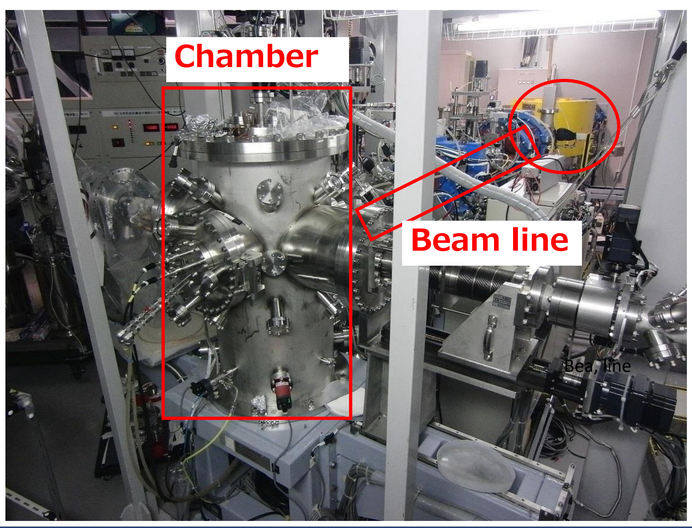
- We determine to irradiate protons equivalent to 3month, 1year and 3years dose at HiZ-GUNDAM orbit.
- 10MeV protons was selected to radiation tolerance test.
  - ✓ 10MeV proton's Bragg peak



4.Radiation tolerance test

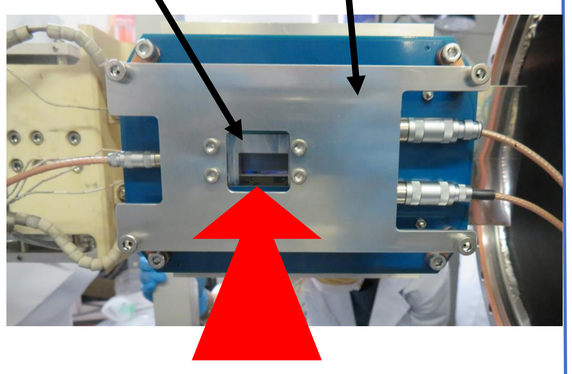
- The Wakasa Wan Energy Research Center
- 10 MeV proton, 0.9 rad (3yr in orbit)
- Flux: ~1×10^{6} cm^{2} /s

Set up go into chamber



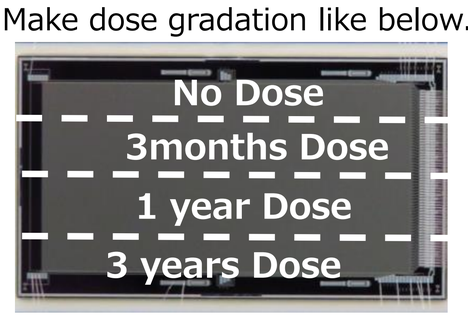
Shield (Al jig)

Jig Stopper



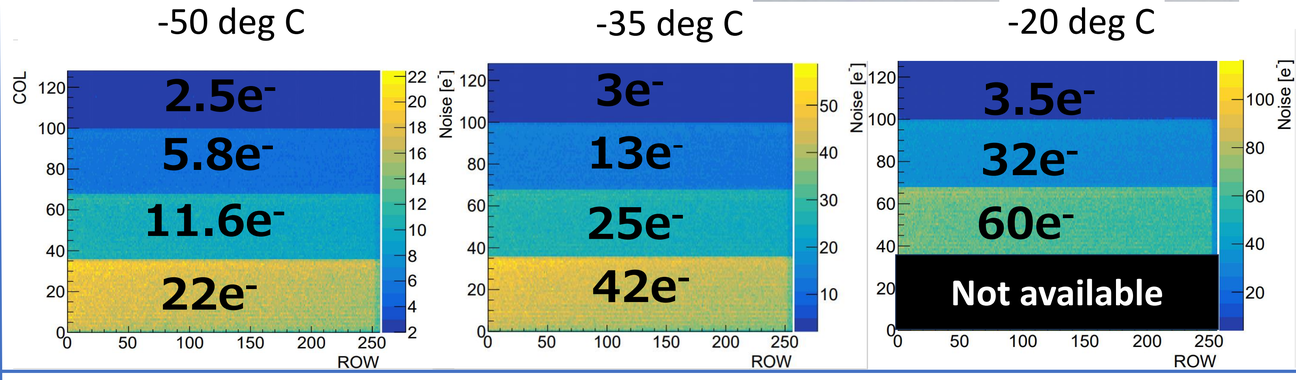
10MeV protons

- Make dose gradation like below.



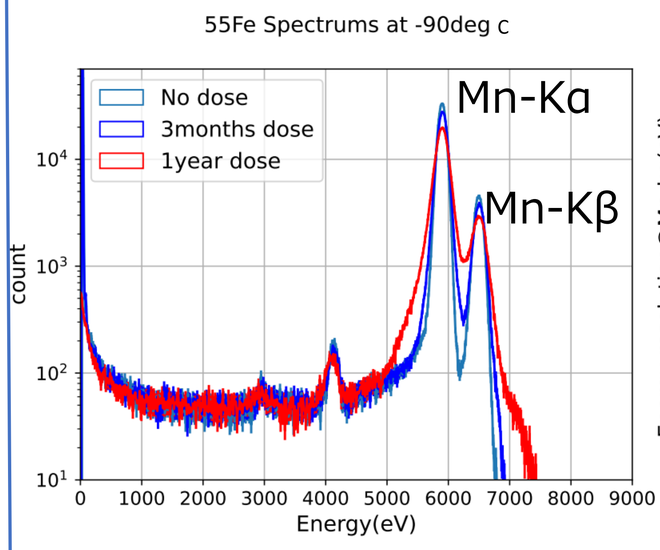
5.Dark noise distribution

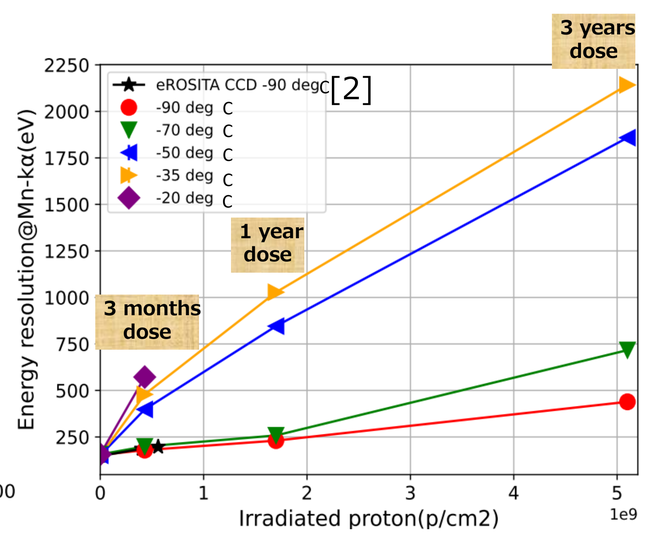
- We calculated dark current at each area of pnCCD.
- Dark current is proportional to dose and temperatures.



6.Spectrum

- We research Energy resolution by make spectrum.
- Energy resolution is proportional to dose and temperature

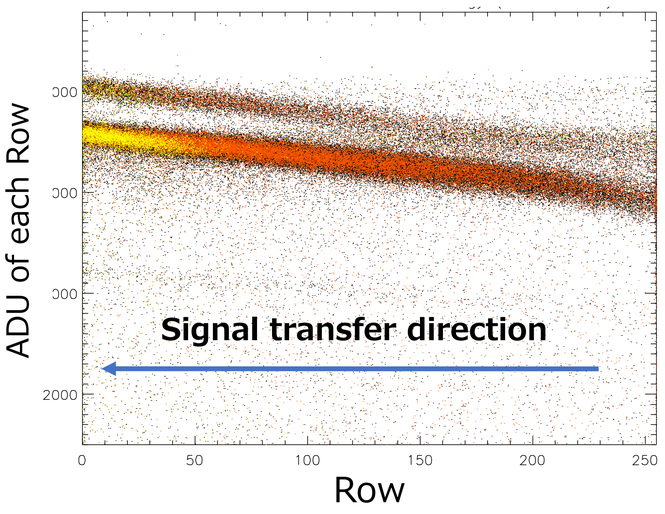




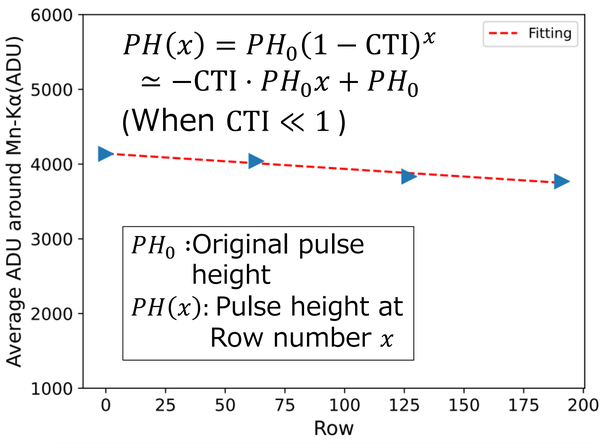
7.CTI (Charge transfer inefficiency)

Signal charges are trapped by generated defect in the silicon lattice.

ADU vs Row at -90deg C after 1year irradiation.



CTI calculation from left data



Dose	CTI
No dose	$0\pm8.88\times10^{-5}$
3 months dose	$7.58\pm8.46\times10^{-5}$
1 year dose	$4.94\pm0.73\times10^{-4}$

8.Conclusion and future plan

Conclusion

- We investigate radiation tolerance of pnCCD by irradiating protons.
  - ✓3months,1year and 3years dose at HiZ-GUNDAM orbit.
- We researched Dark current , Energy resolution and CTI.
  - ✓ These results are important to future development.

Future plan

- More detailed research is needed about effects of high energy and low energy protons individually.

9.Reference

[1]Meidinger.et al. "pnCCD for photon detection from near-infrared to X-rays" Nuclear Instruments and Methods in Physics Research A 565 (2006) 251–257
[2] Meidinger.et al. "CCD Detector Development for the eROSITA Space Telescope "IEEE Symposium on Nuclear Science. DOI: 10.1109/NSSMIC.2010.5873711