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誘電体カロリーメータ用極低温動作低雑音増幅MMICの検討

- The Study of a LNA MMIC in Ultra-Low Temperature for a Dielectric Micro-Calorie Meter -

野地　拓匡[†‡]　宮地　晃平[‡]　菊地　貴大[‡]
星野　全俊[‡]　吉田 賢史[‡]　山崎 典子[‡]　満田 和久[‡]　大橋 隆哉[†]　川﨑 繁男[‡]
[†] *Toyo Metropolitan University,* [‡]*Japan Aerospace Exploration Agency*

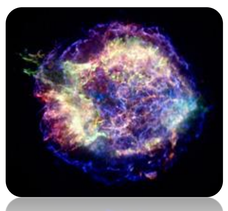
Background and Purpose:

X-ray satellites history in japan

- 1979 HAKUCHO
TENMA,GINGA,ASUKA
- 2005- SUZAKU
- 2014- Astro-H

X-ray phenomena

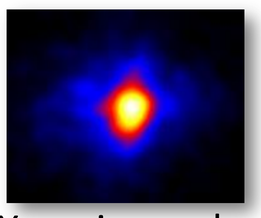
- Black-hole
- Supernova explosion
- Active galactic nuclei
- Space high-temperature plasma

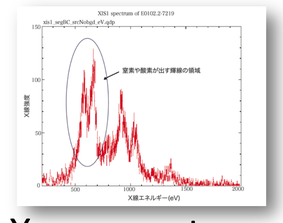

Supernova explosion


Active galactic nuclei

Important abilities of detectors for X-rays

- Imaging performance
- spectral performance


X-ray image by SUZAKU CCD



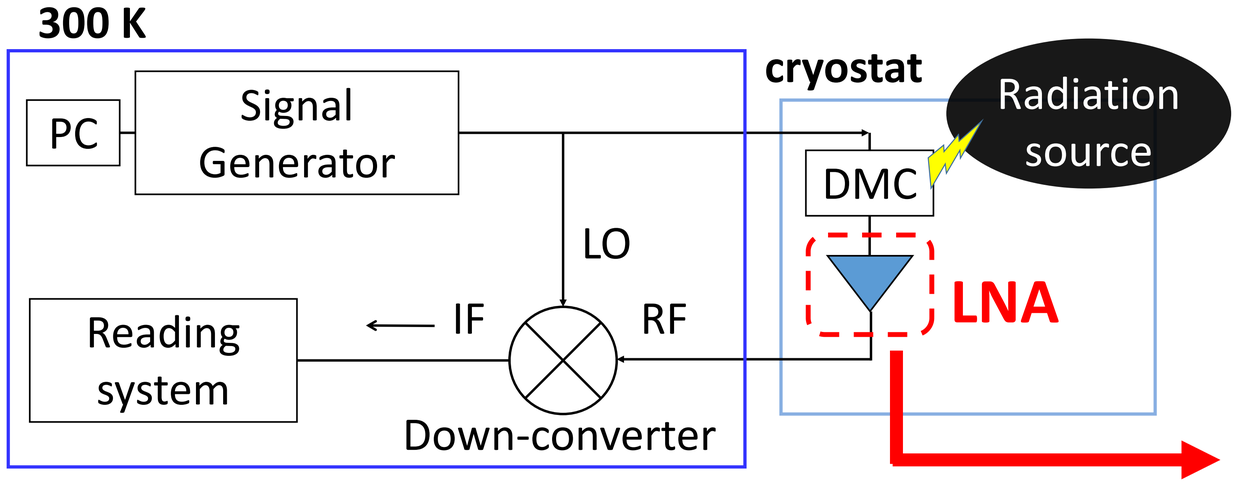
X-ray spectrum by SUZAKU CCD

Detectors type	CCD	Proportional counter	Diffraction grating	XRS	DMC system
Image	○	△	-	△	○
Spectrum	△	△	○	○	○

DMC system is expected to show high capacities in both imaging and spectroscopic performance.

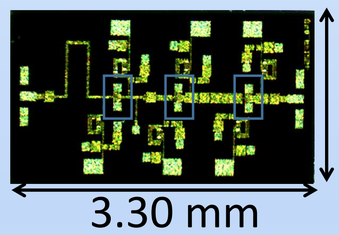
LNA of DMC system:

DMC system Block diagram

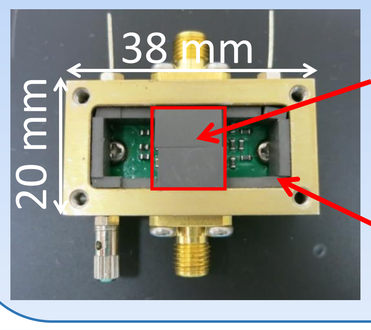


We propose a LNA for the DMC system.

LNA MMIC and Module



GaAs -pHEMT 3 stage



Package MMIC

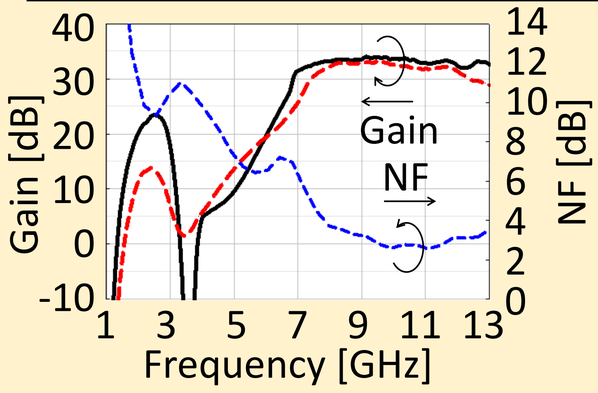
RF absorber

Objectives of the LNA

1. Compact and lightweight
2. Cryogenic operation
3. NF < 1 dB under cryogenic temperature
4. Broadband frequency
5. high gain and low noise
6. Radiation-Hardness

Measurement and results:

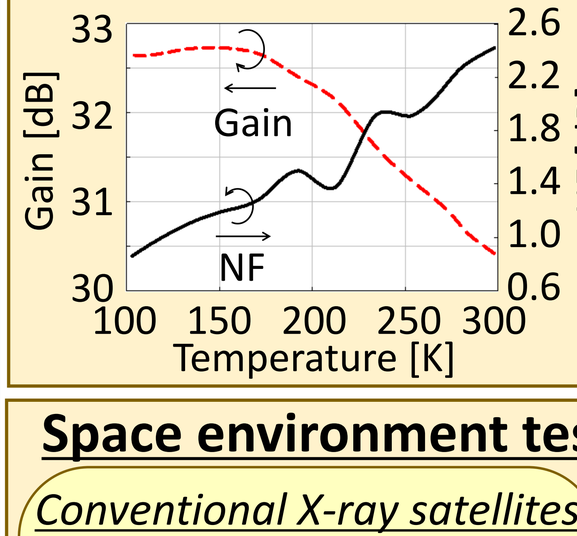
Gain & NF characteristics



Gain @ 77 K
Gain @ 300 K
NF @ 300 K

@10 GHz	300 K	77 K
Gain [dB]	32.7	33.8
NF [dB]	2.6	-

Temperature dependence

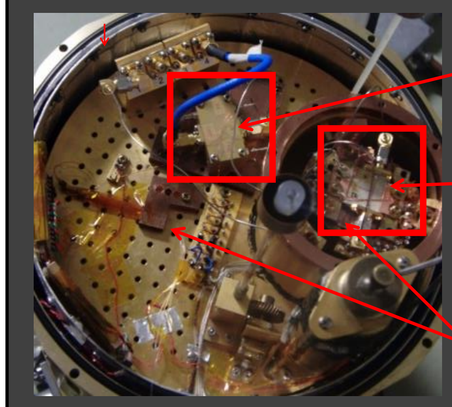


@10 GHz	300 K	103 K
Gain [dB]	30.5	32.6
NF [dB]	2.4	0.86

Under 1dB
Over 30dB

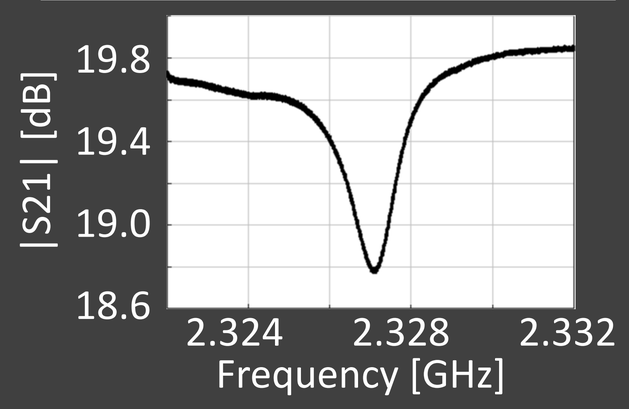
Result of detected rays

- DMC and LNA combined
- Detected Infrared rays (9×10^6 keV) as fundamental experiment of X-rays (0.1 -10 keV)
- Operation at 4 K

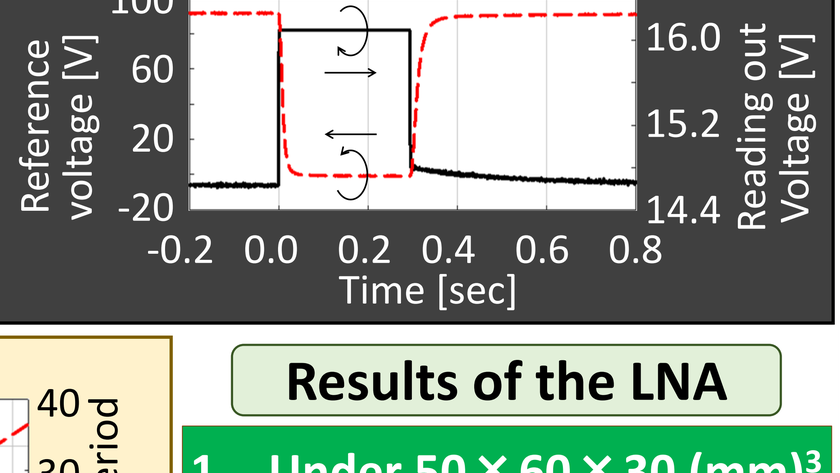


Detected Infrared rays

DMC and LNA transmission characteristic



Reference signal and detected signal



Space environment test (TID test)

Conventional X-ray satellites

- Operational period : Within 10 years
- Orbit : about 550km

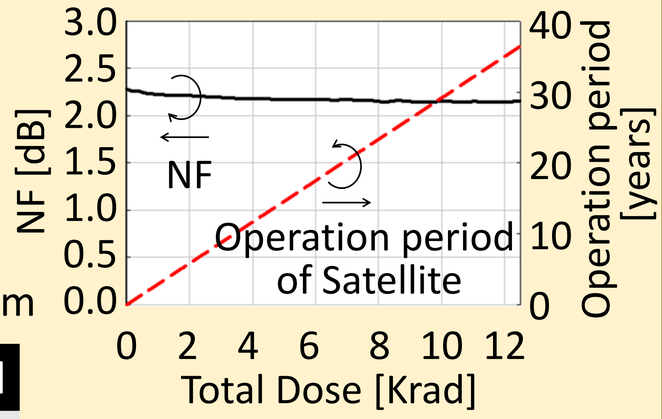
This experiment condition

- Operational period : Over 30 years
- Orbit : 570km

This TID test condition

- Radiation source: ^{60}Co
- Radiation time（h）: 16 hs
- Radiation rate: 7.8 krad/h
- Total dose: 12.5 krad
- Distance from the source: 80 cm

@10GHz	0rad	12.5Krad
Gain [dB]	36.1	36.1
NF [dB]	2.28	2.16



Radiation resistance (no degradation)

Results of the LNA

1. Under 50 × 60 × 30 $(mm)^3$
2. 4 K operation
3. NF = 0.86 dB @103 K
4. Over 30dB : 7-13GHz
5. Gain > 30 dB, NF < 1 dB
6. Radiation resistance during 30 years operation