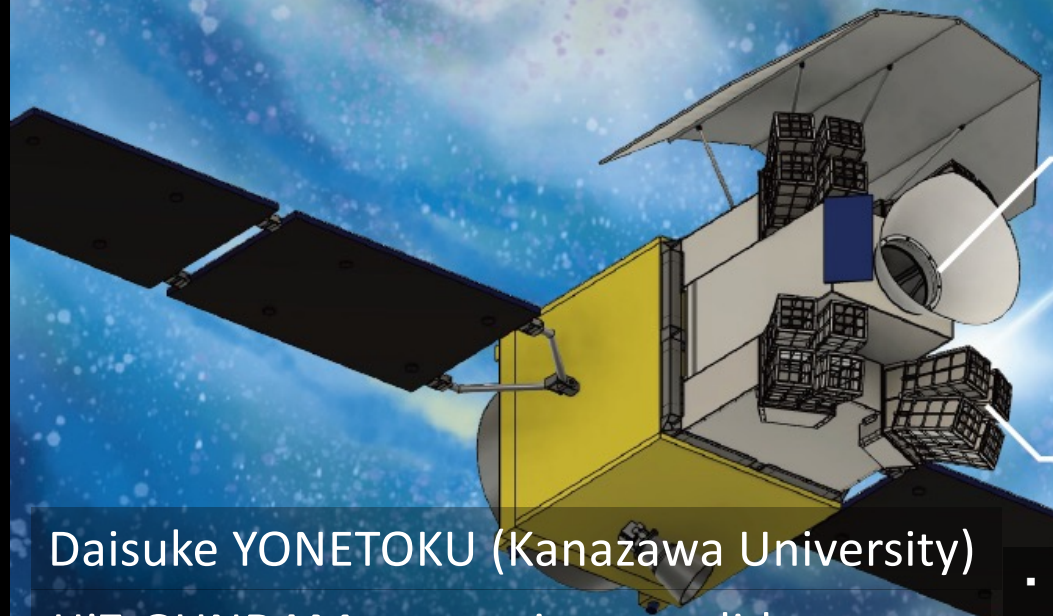
ガンマ線バーストを用いた初期宇宙・極限時空探査計画

HiZ-GUNDAM

High-z Gamma-ray bursts for Unraveling the Dark Ages Mission



近赤外線・可視光望遠鏡

MONSTER

Multiband Optical and Near-infrared Simultaneous Telescope for Efficient Response

広視野X線モニター

EAGLE

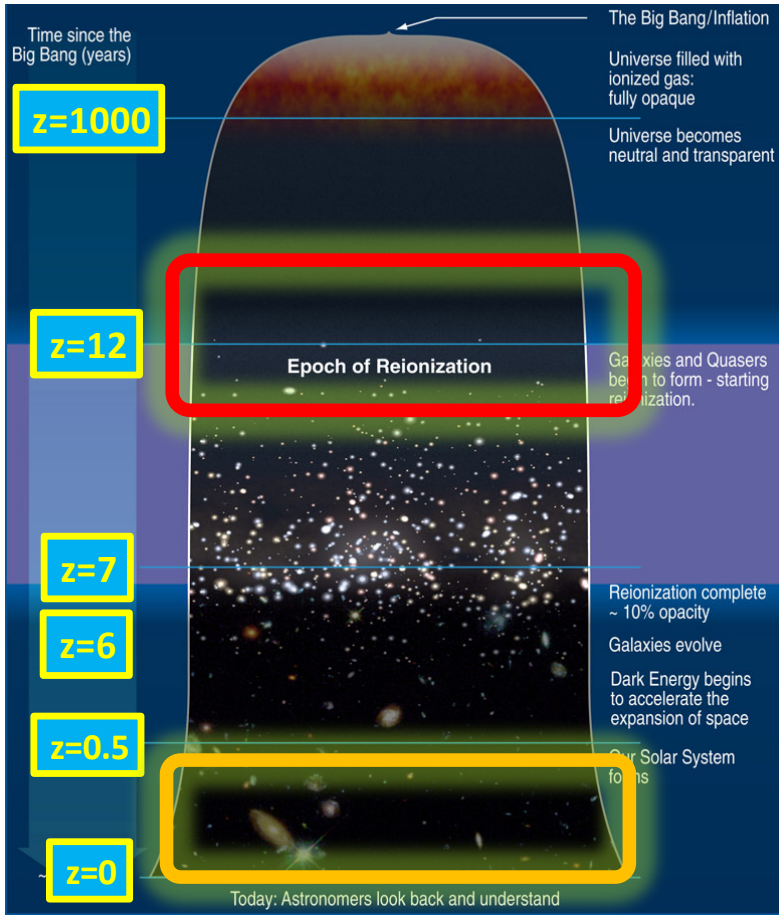
Exploration of Ancient GRBs with Lobster Eye

Daisuke YONETOKU (Kanazawa University)
HiZ-GUNDAM pre-project candidate team

- Competitive M-class mission (Epsilon mission) in JAXA
- Launch target is ~FY2034 …

2026/08/30 – 09/04 TeVPA @ Tendo, Yamagata, Japan

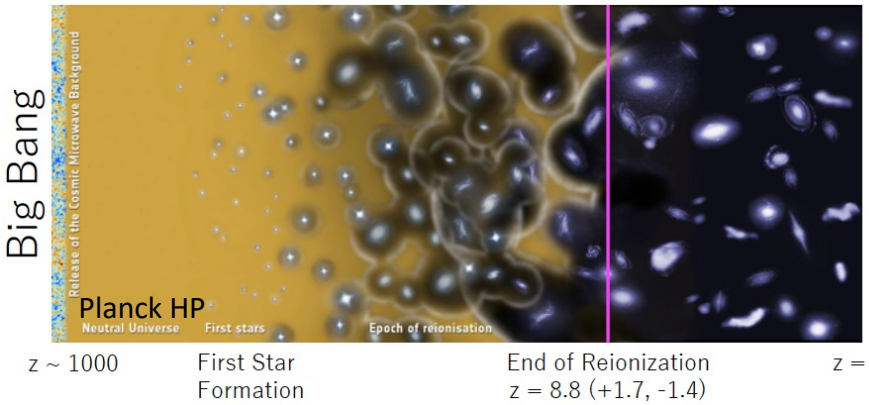
HiZ-GUNDAM : Promotion of Time Domain Astronomy



Key Science 1: Multi-Messenger Astronomy

(1) Identification/localization of E-M counterparts associated with GW and neutrino
(2) Transition from gravitational energy to heavy element (kilonova) and particles
(3) Diversities of multi messenger sources from X-ray to optical/NIR observation

Key Science 2: Exploration of early universe with GRB



(1) GRB rate at z > 6
(2) Reionization history
(3) First heavy metals
(4) Survey of Pop-III GRBs

These observations require both “wide field monitor” and “near-infrared follow-up”

HiZ-GUNDAM (High-z Gamma-ray bursts for Unraveling the Dark Ages Mission)

Mission : Time Domain Astronomy

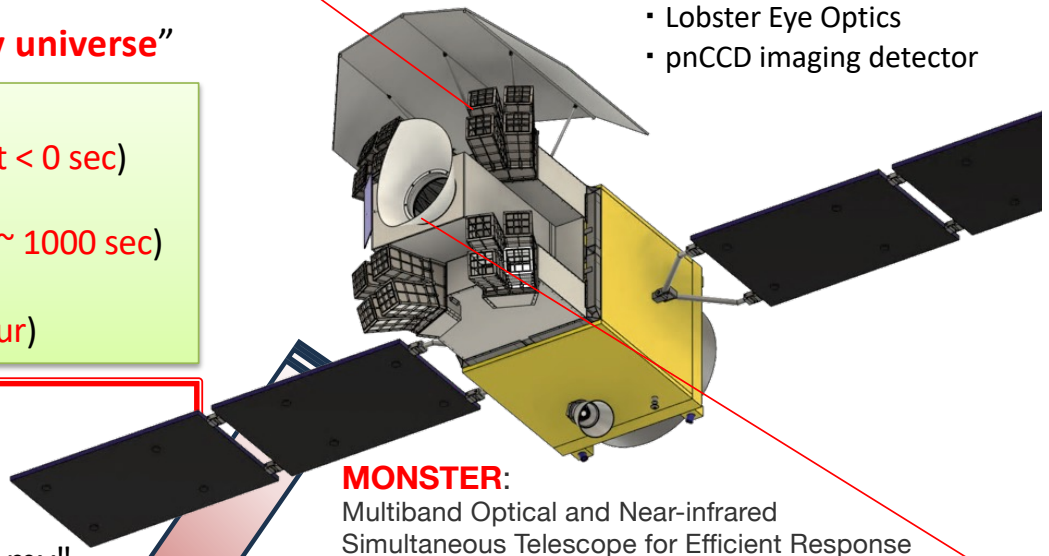
"**Multi-messenger astronomy**" and "**Exploration of the early universe**"

Observation strategy
(1) Discovery of GRBs/transients with the wide field X-ray monitor (t < 0 sec)
(2) Automatic repointing (t < 300 sec)
(3) Identification of counterpart with the near infrared telescope (t ~ 1000 sec)
(4) Alert message (t ~ 0 sec for X-ray, ~ 1800 sec for Opt/NIR)
(5) Spectroscopic observation with large area telescopes (t ~ 1.5 hour)

We will discover treasured targets from a large amount of transient sources, and provide important observation targets to large area telescopes.
We will promote "early space exploration" and "MM astronomy" with all the power of astronomy.

EAGLE: Exploration of Ancient GRBs with Lobster Eye

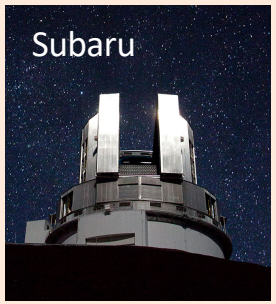
- Lobster Eye Optics
- pnCCD imaging detector

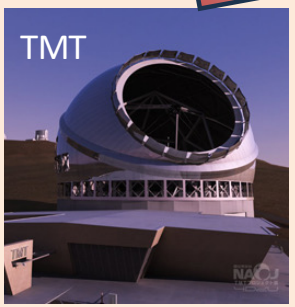


MONSTER:
Multiband Optical and Near-infrared Simultaneous Telescope for Efficient Response

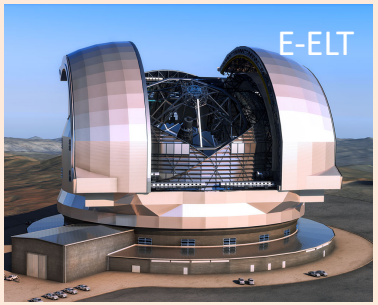
- Simultaneous 5-band photometry
- 0.5 – 2.5 um

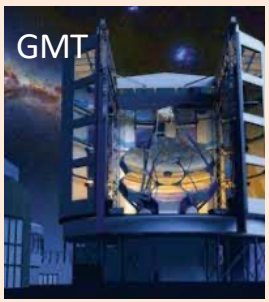
Space telescope





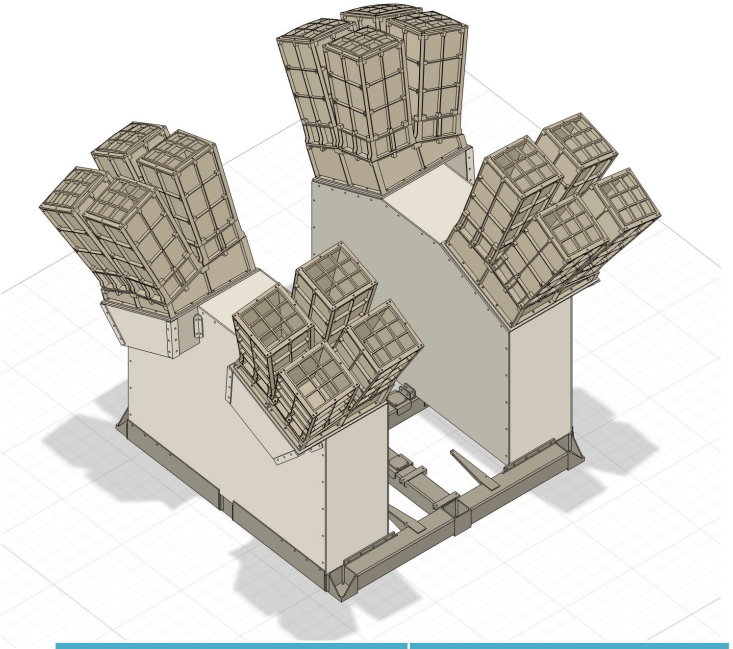
8m-class



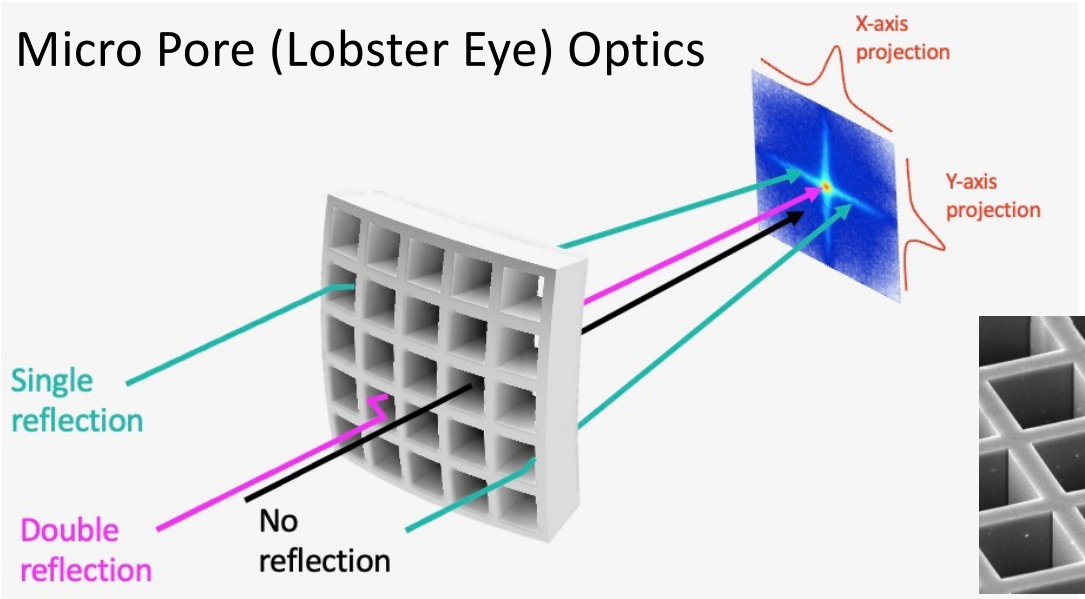


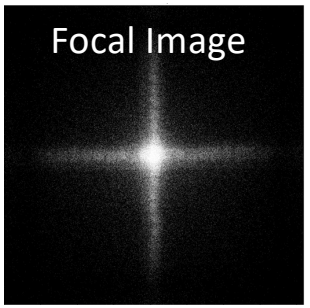
Future 30m-class

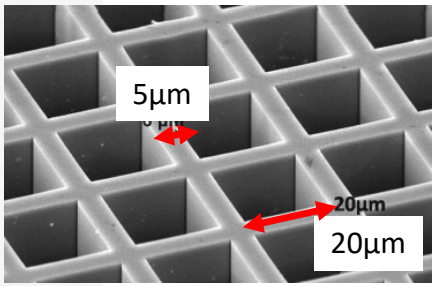
EAGLE (Wide Field X-ray Monitor)



Micro Pore (Lobster Eye) Optics

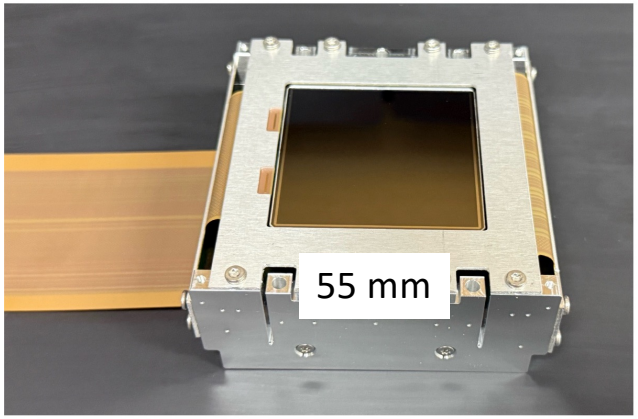






Items	Parameters
Energy band (keV)	**0.4 – 4 keV**
Telescope type:	Lobster Eye Optics
Number of Modules	16
Field of View	**0.53 str (16 modules)**
Focal length	300 mm
Focal plane detectors	pnCCD array
Time resolution	< 100 msec
Sensitivity	**~ 1e-10 (erg/cm2/s) For 100 sec**
Position accuracy	3 arcmin

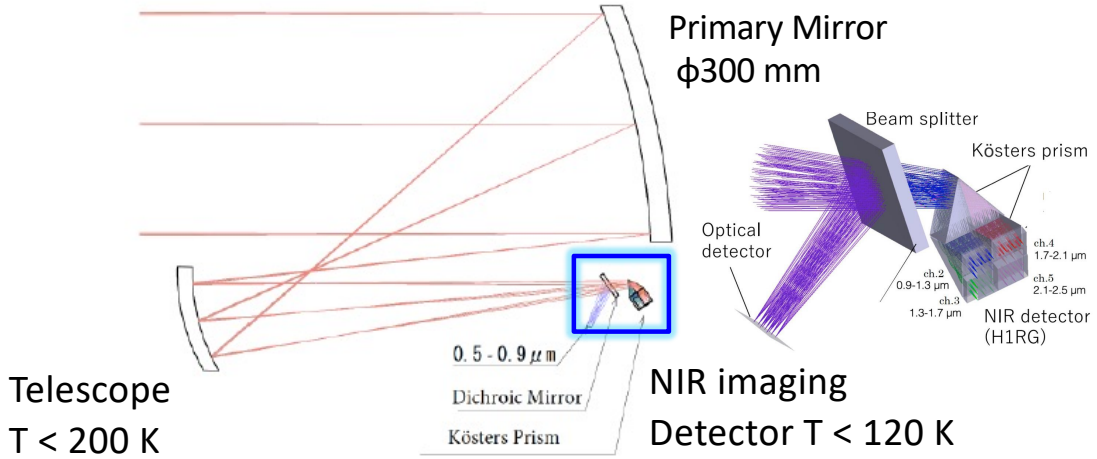
pnCCD (Focal Imaging Detector)



Requirements for the focal plane detector	
Sensitive Area	**> 55 × 55 mm²**
Pixel Size	108 µm
Depletion Layer	450 µm
Quantum efficiency	**> 90% @ 0.4 – 4 keV**
Frame rate	**≥ 10 fps**

MONSTER (Near Infrared Telescope)

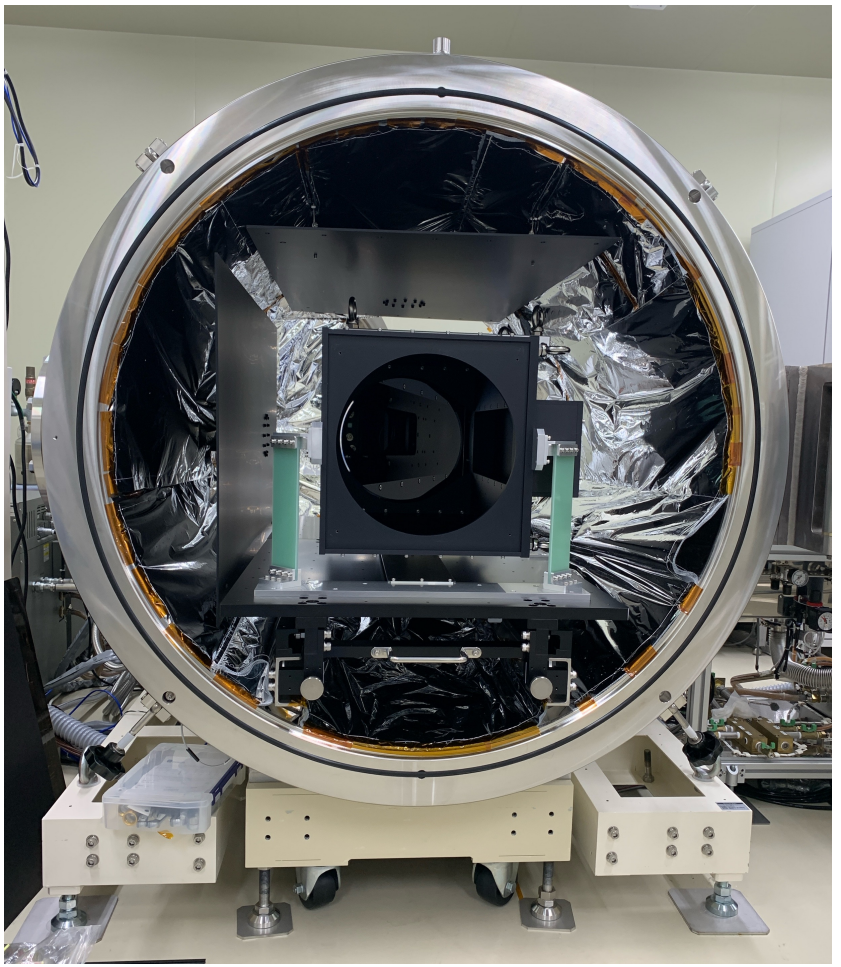
Kohji TSUMURA's Talk



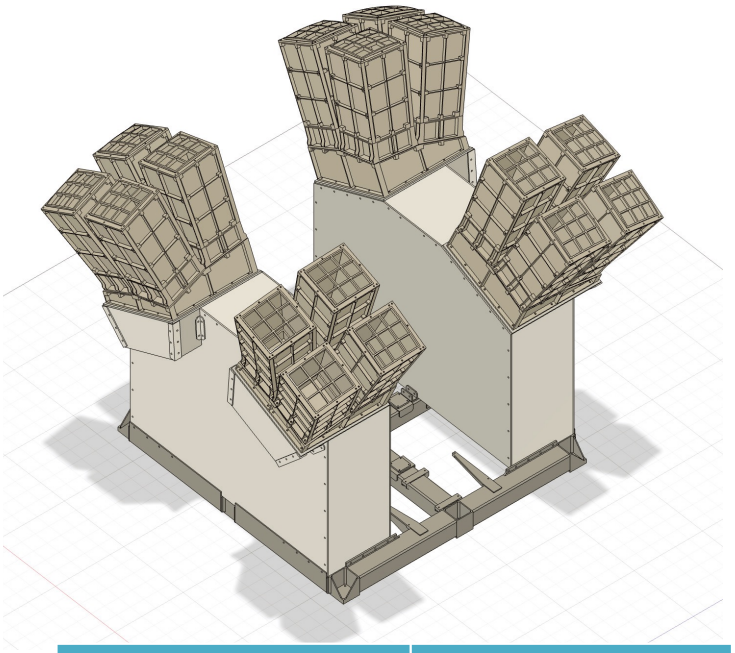
5-band simultaneous photometry

Items	Parameters				
Telescope type	Offset Optics				
Aperture size	**30 cm**				
Focal length	183.5 cm				
F number	F6.1				
Field of view	15 arcmin × 15 arcmin				
FoV per pixel	2 acsec × 2 arcsec				
Image size	3 pixel × 3 pixel				
Integration time	10 minutes (2 minutes x 5 frames)				
Observation Band (μm)	0.5–0.9	0.9–1.3	1.3–1.7	1.7–2.1	2.1-2.5
Limiting Magnitude mag (AB) 10min, 10σ	21.3	20.9	20.6	20.5	20.4
Focal detector	HyViSi	HgCdTe (H1RG)			

Thermal Vacuum Optical Test (2026.8 –)

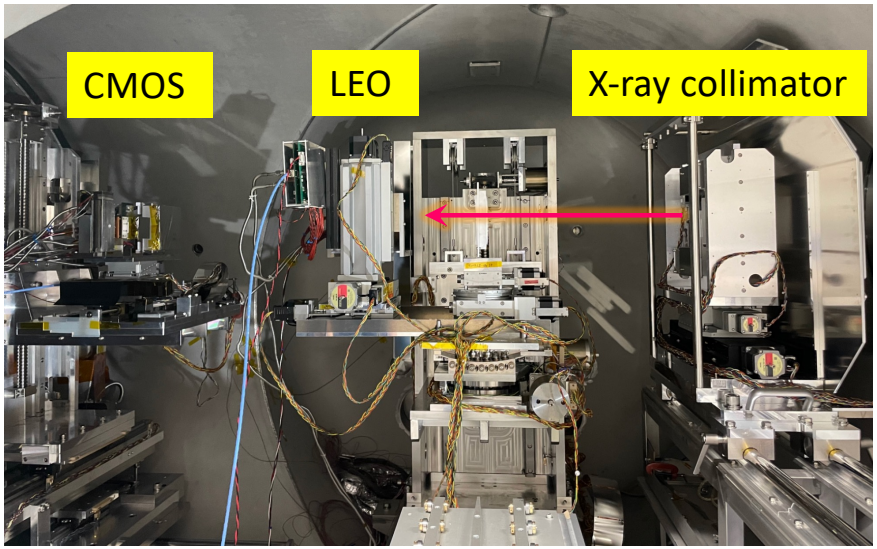


EAGLE (Wide Field X-ray Monitor)

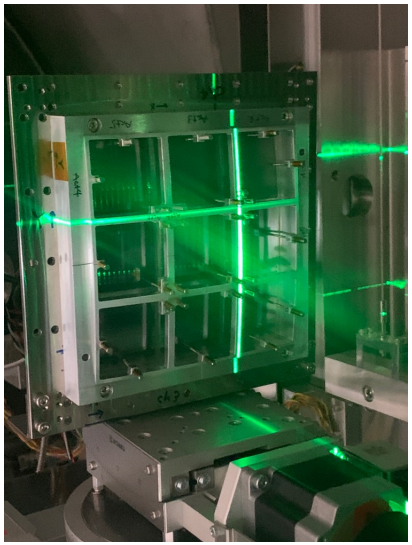


Items	Parameters
Energy band (keV)	**0.4 – 4 keV**
Telescope type:	Lobster Eye Optics
Number of Modules	16
Field of View	**0.53 str (16 modules)**
Focal length	300 mm
Focal plane detectors	pnCCD array
Time resolution	< 100 msec
Sensitivity	**~ 1e-10 (erg/cm2/s) For 100 sec**
Position accuracy	3 arcmin

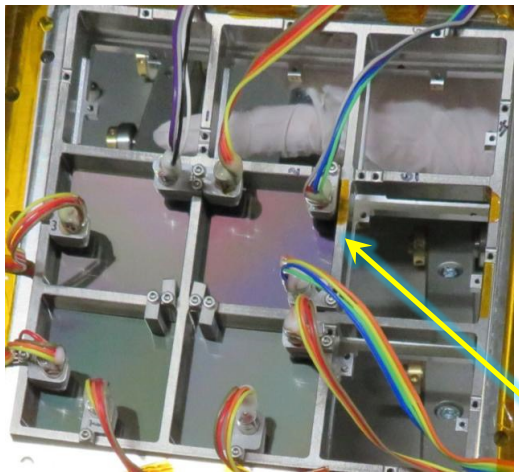
Micro Pore (Lobster Eye) Optics

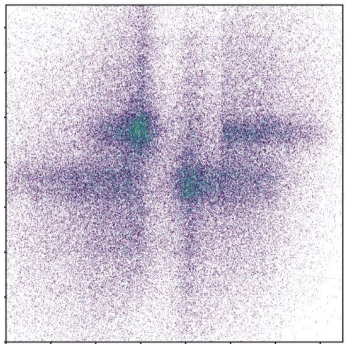


Bread Board Model

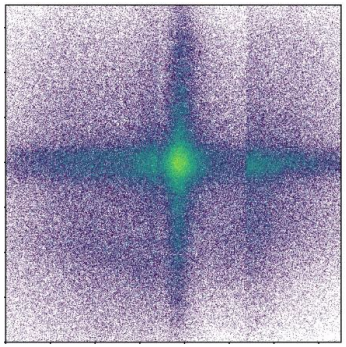


Alignment Adjustment



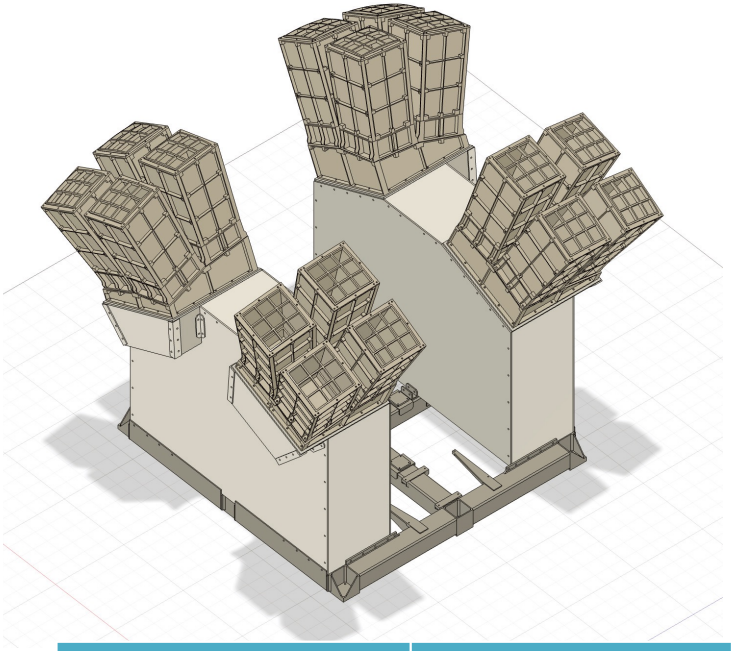


Before



After
~ 1 arcmin accuracy

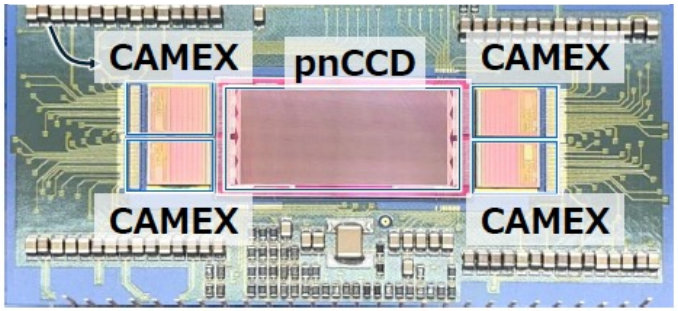
EAGLE (Wide Field X-ray Monitor)



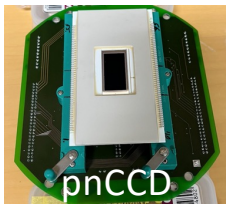
Items	Parameters
Energy band (keV)	**0.4 – 4 keV**
Telescope type:	Lobster Eye Optics
Number of Modules	16
Field of View	**0.53 str (16 modules)**
Focal length	300 mm
Focal plane detectors	pnCCD array
Time resolution	< 100 msec
Sensitivity	**~ 1e-10 (erg/cm2/s) For 100 sec**
Position accuracy	3 arcmin

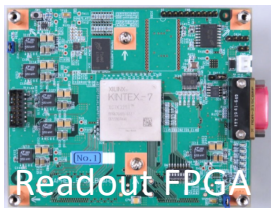
pnCCD (Focal Imaging Detector)

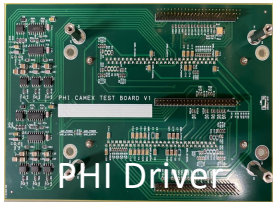
Small pnCCD and Readout LSIs

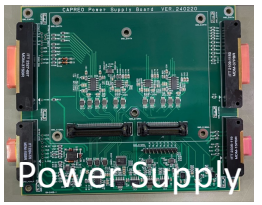


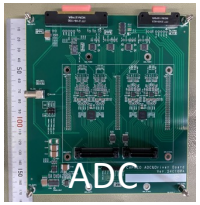
In-house Electronics



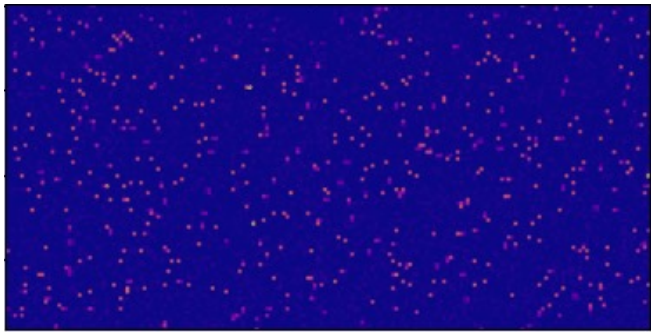




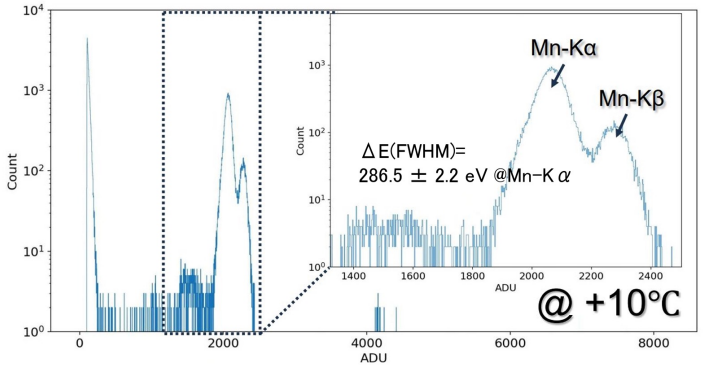




X-ray imaging movie



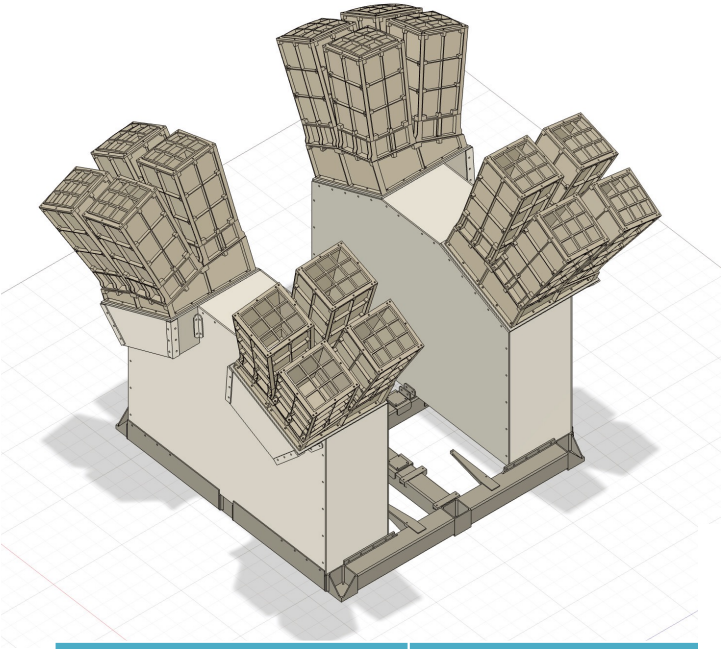
X-ray spectrum of Mn-Kα/β



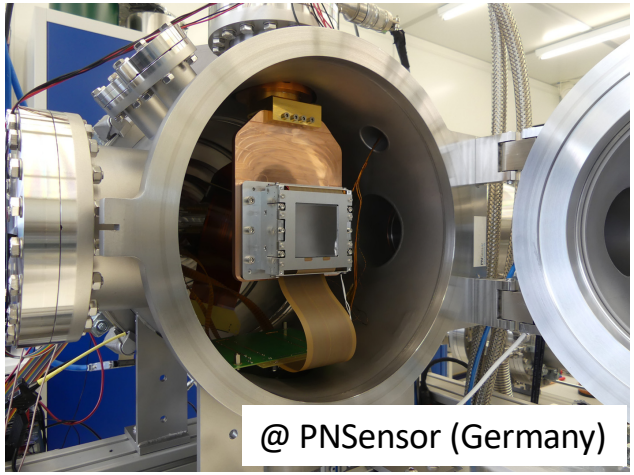
We have obtained pnCCD driving technology using in-house electronics.

EAGLE (Wide Field X-ray Monitor)

Large-format pnCCD (Focal Imaging Detector)



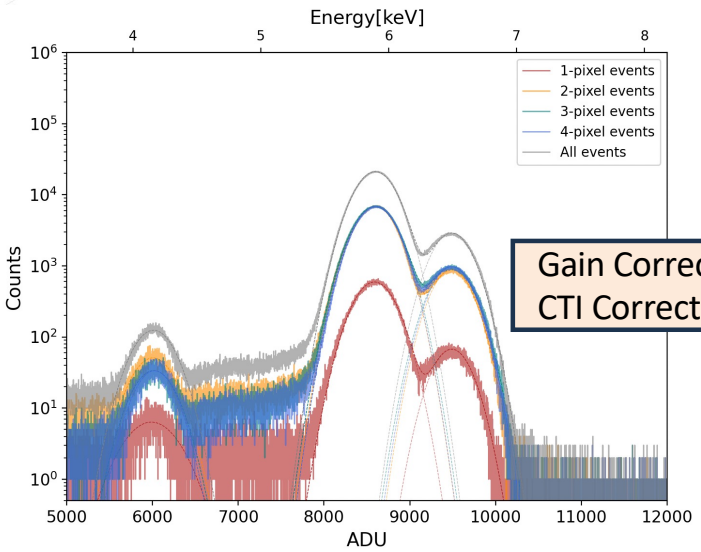
Items	Parameters
Energy band (keV)	**0.4 – 4 keV**
Telescope type:	Lobster Eye Optics
Number of Modules	16
Field of View	**0.53 str (16 modules**
Focal length	300 mm
Focal plane detectors	pnCCD array
Time resolution	< 100 msec
Sensitivity	**~ 1e-10 (erg/cm2/s) For 100 sec**
Position accuracy	3 arcmin



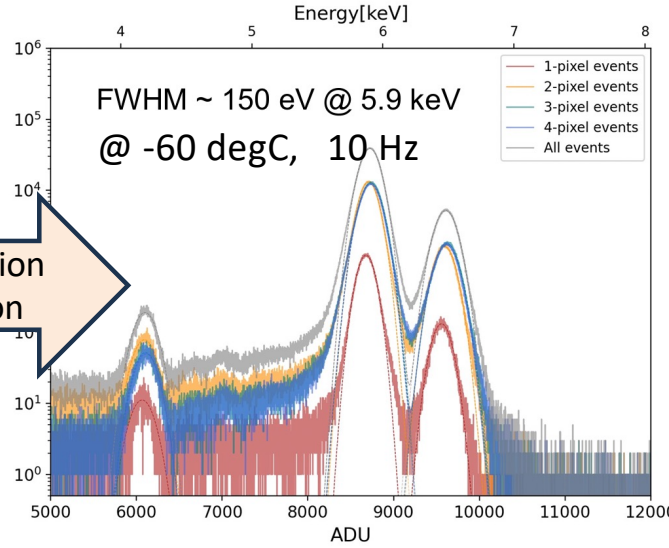
We started the development of large-format pnCCDs.

We evaluated requirements are satisfied

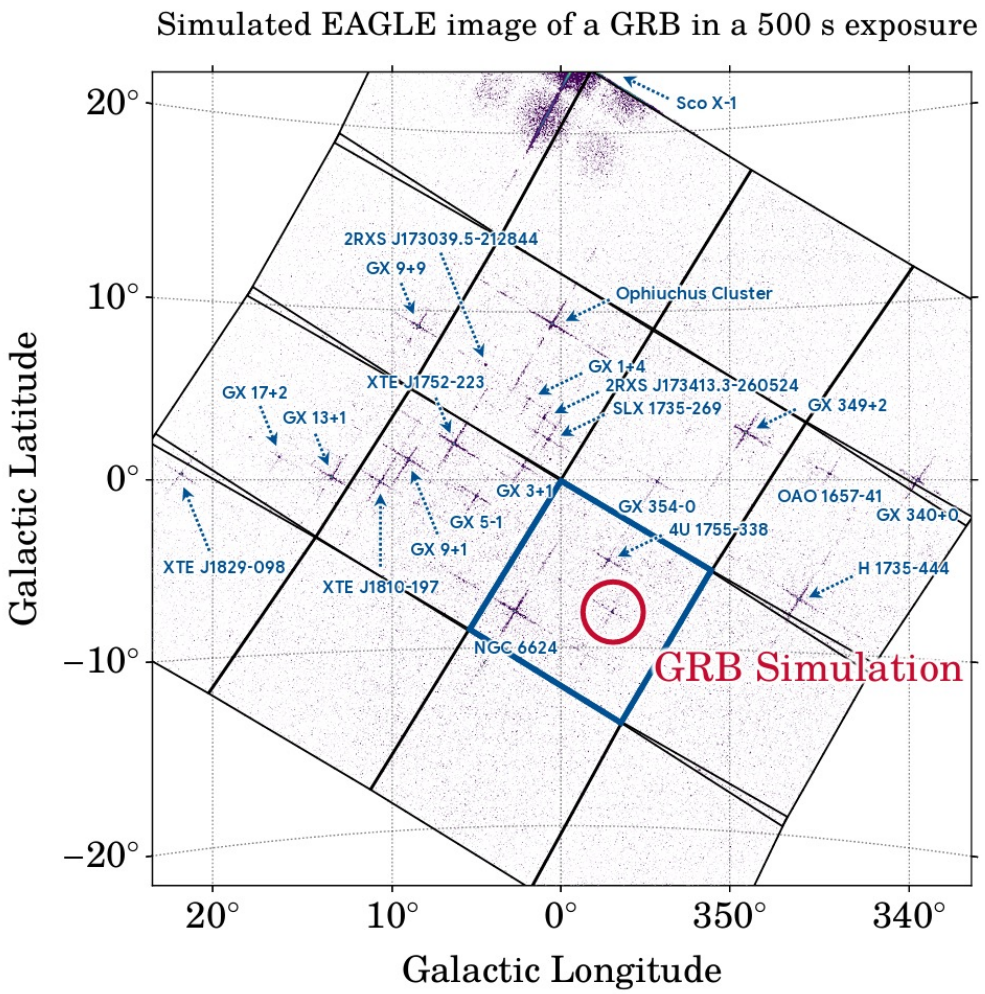
- Lower detection limit (LD) **< 0.3 keV**
- Energy resolution **~ 150 eV @ 5.9 keV**

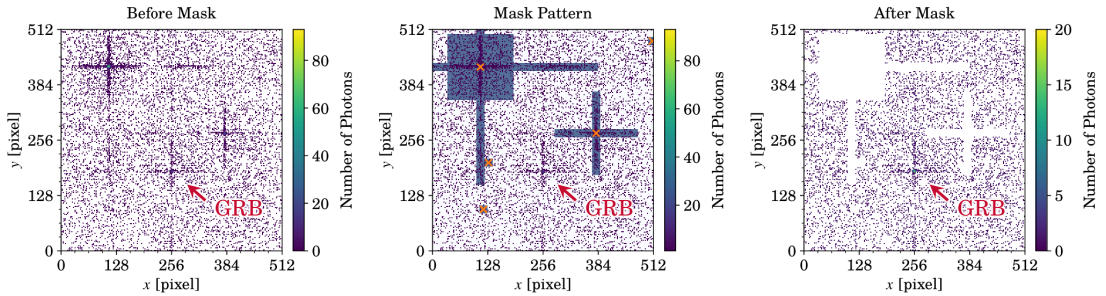


Gain Correction
CTI Correction

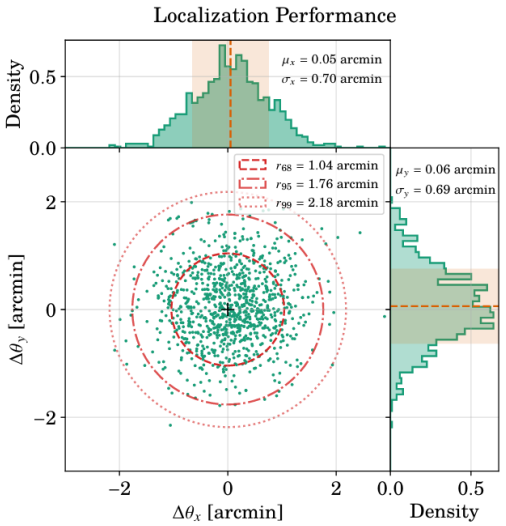


Simulation Studies for Trigger Algorithms



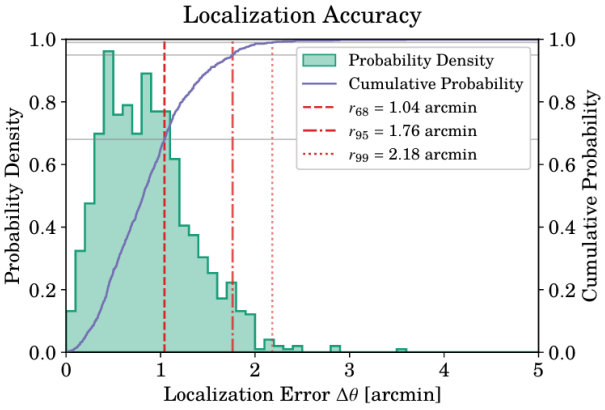


- Masking the known bright X-ray sources
- Search for NEW X-ray sources using a fixed-size window that is shifted across the X-ray image.



Localization Accuracy

- 80 photons, 1,000 simulations



Nominal Operation

Coverage : > 90 %
Latency : ~ 0 sec
max delay : 5 min

Inmarsat

geostationary orbit

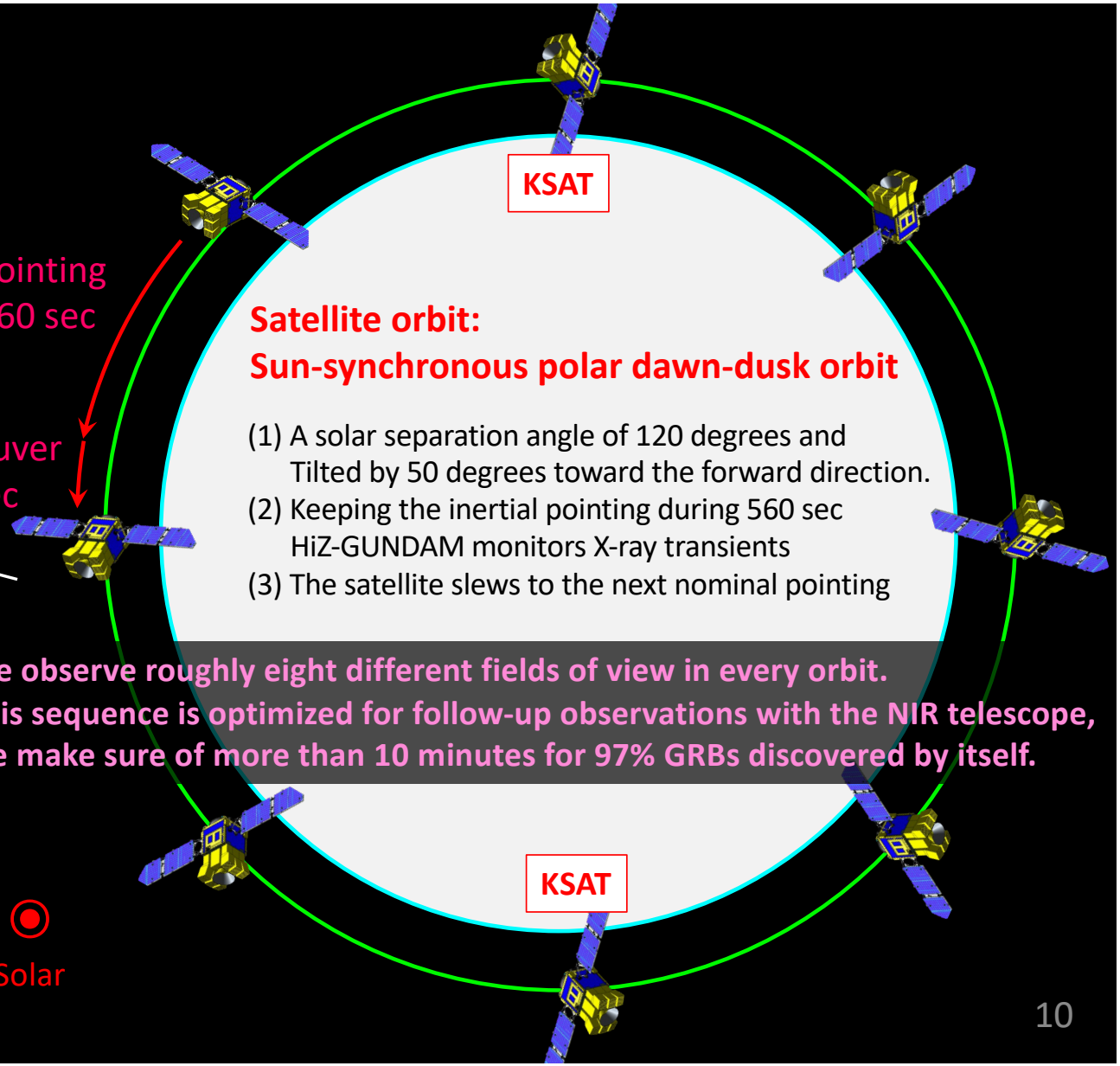
Alert message

Pointing
560 sec

Maneuver
150 sec

Inmarsat Ground Station → HiZ-GUNDAM Project Server → GCN, Atel

Solar



Satellite orbit:
Sun-synchronous polar dawn-dusk orbit

(1) A solar separation angle of 120 degrees and Tilted by 50 degrees toward the forward direction.
(2) Keeping the inertial pointing during 560 sec HiZ-GUNDAM monitors X-ray transients
(3) The satellite slews to the next nominal pointing

We observe roughly eight different fields of view in every orbit.
This sequence is optimized for follow-up observations with the NIR telescope, we make sure of more than 10 minutes for 97% GRBs discovered by itself.

Future Schedule

Fiscal Year	Plans and Milestones
Current	Development of BBM (front loading)
FY2027	Down Selection Review for 3 candidates (HiZ-GUNDAM / LAPYUTA / Silvia) Establishment of Pre-Project Team
FY2028	Mission Definition Review
FY2029	System Definition Review Establishment of Project Team
FY2029 – 30	EM phase, System Definition Review
FY2030 – 32	FM phase
FY2034	Launch

High-z Gamma-ray bursts for Unraveling the Dark Ages Mission

Mission Aim: Strong Promotion of
"**Time Domain**" & "**Multi-Messenger Astronomy**".

Key Science1: Progress of Multi messenger Astronomy

- Localization of X-ray transients from MM sources
- Energy transition from gravity to particles/elements

Key Science2: Probing the Early Universe

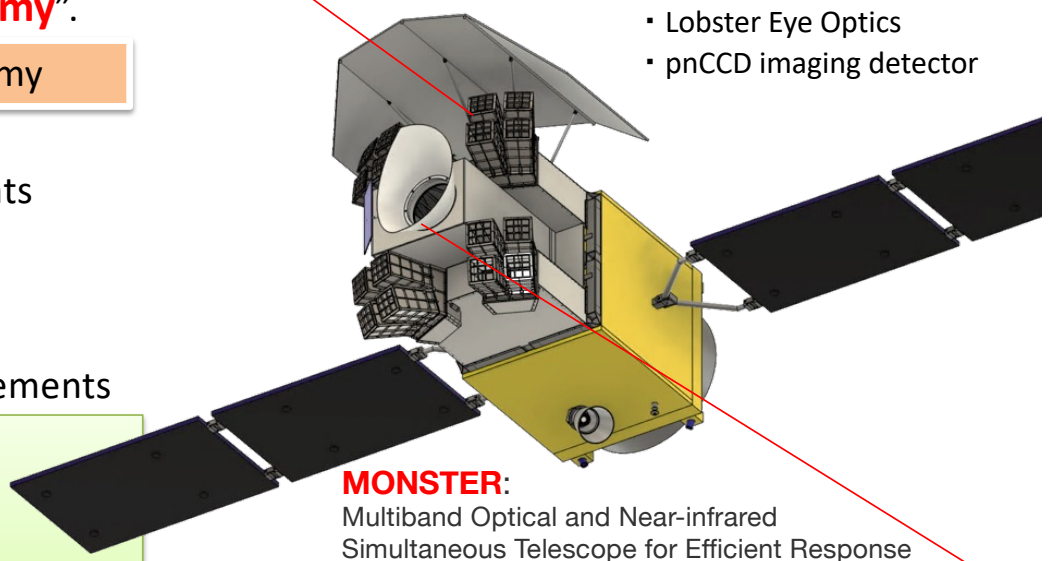
- Detection of high-redshift GRBs (6 < z < 13 … 20)
- Probing the reionization history and first metal elements

Observation Strategy

(1) Discovery of high-energy transient with EAGLE
(2) Automatic/Comprehensive follow-up with MONSTER
(3) Sending Quasi-Realtime Alert Messages
(4) Spectroscopy with Large Area Telescopes for selected events

EAGLE: Exploration of Ancient GRBs with Lobster Eye

- Lobster Eye Optics
- pnCCD imaging detector



MONSTER:
Multiband Optical and Near-infrared
Simultaneous Telescope for Efficient Response

- Simultaneous 5-band photometry
- 0.5 – 2.5 um

Wide Field X-ray Monitor

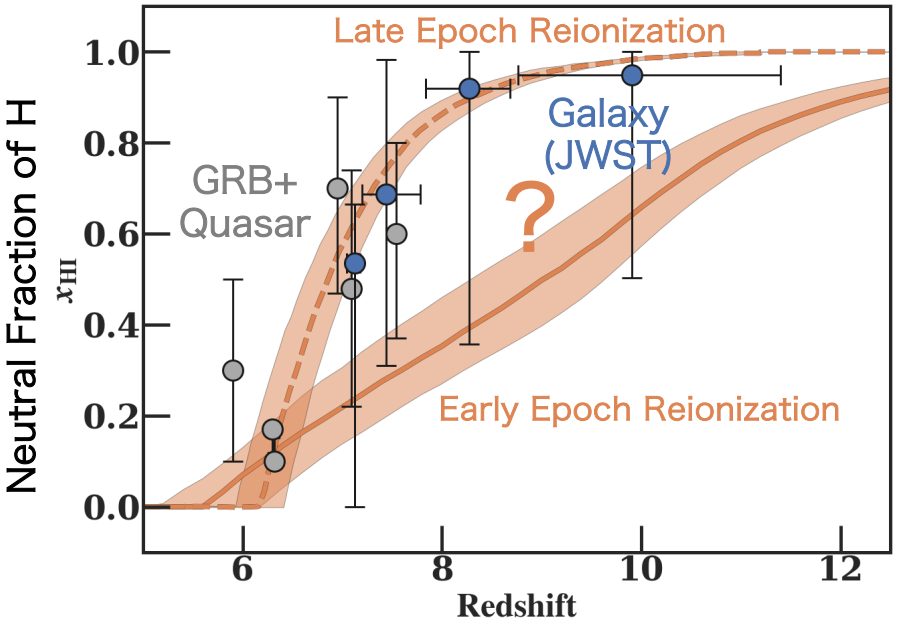
Items	Parameters
Energy band (keV)	0.4 – 4 keV
Field of View	0.53 str (16 modules)
Sensitivity	~1 e-10 (erg/cm2/s) For 100 sec exposure
Position accuracy	3 arcmin
Time resolution	< 100 msec

Near Infrared Telescope

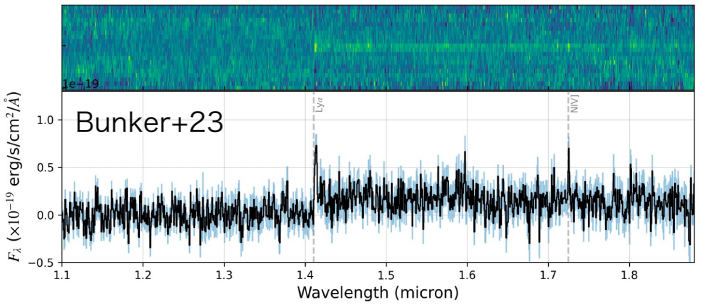
Items	Parameters				
Aperture size	30 cm				
Field of view	15 arcmin × 15 arcmin				
Integration time	10 minutes (2 minutes x 5 frames)				
Observation Band (μm)	0.5–0.9	0.9–1.3	1.3–1.7	1.7–2.1	2.1-2.5
Limiting mag (AB)	21.3	20.9	20.6	20.5	20.4

Backup Slides

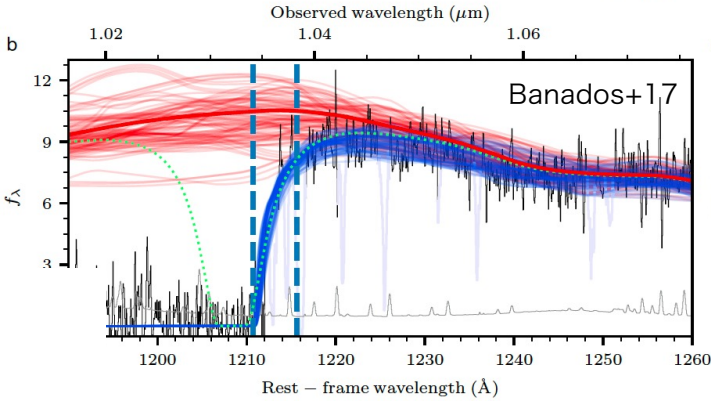
Cosmic Reionization

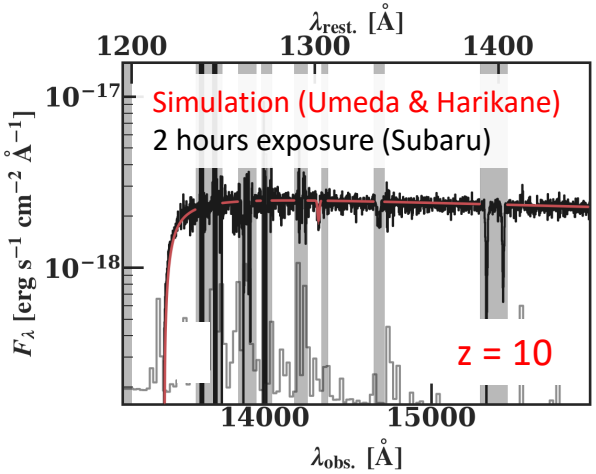


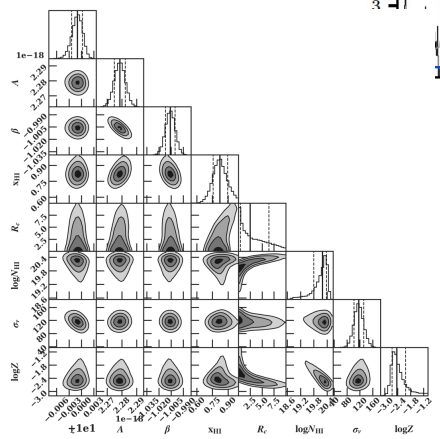
Brightest galaxy GN-z11, z=10.60
6 hours exposure (JWST)



Quasar z=7.5 (8 hours exposure)







High-redshift GRBs are
- Enough bright
- Simple spectrum
  redshift, x_{HI}, galactic neutral gas, metallicity, ionization bubble size, etc.

Detection Sensitivity