# JAXA & Athena
# -- Japan's contributions and Future plan --

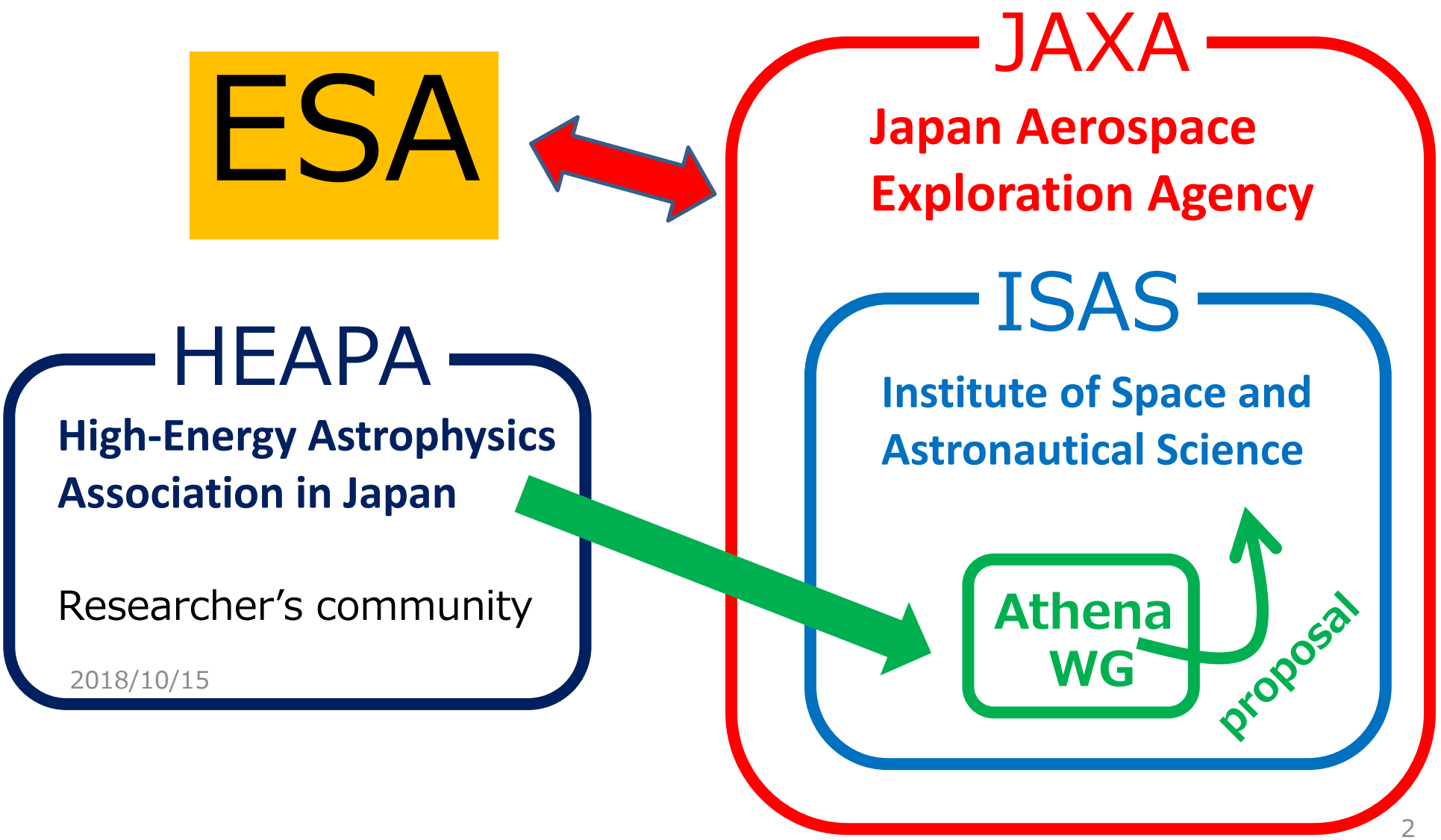
Hiro Matsumoto

Osaka U.

Chair of Athena WG, ISAS

Athena Science Study Team

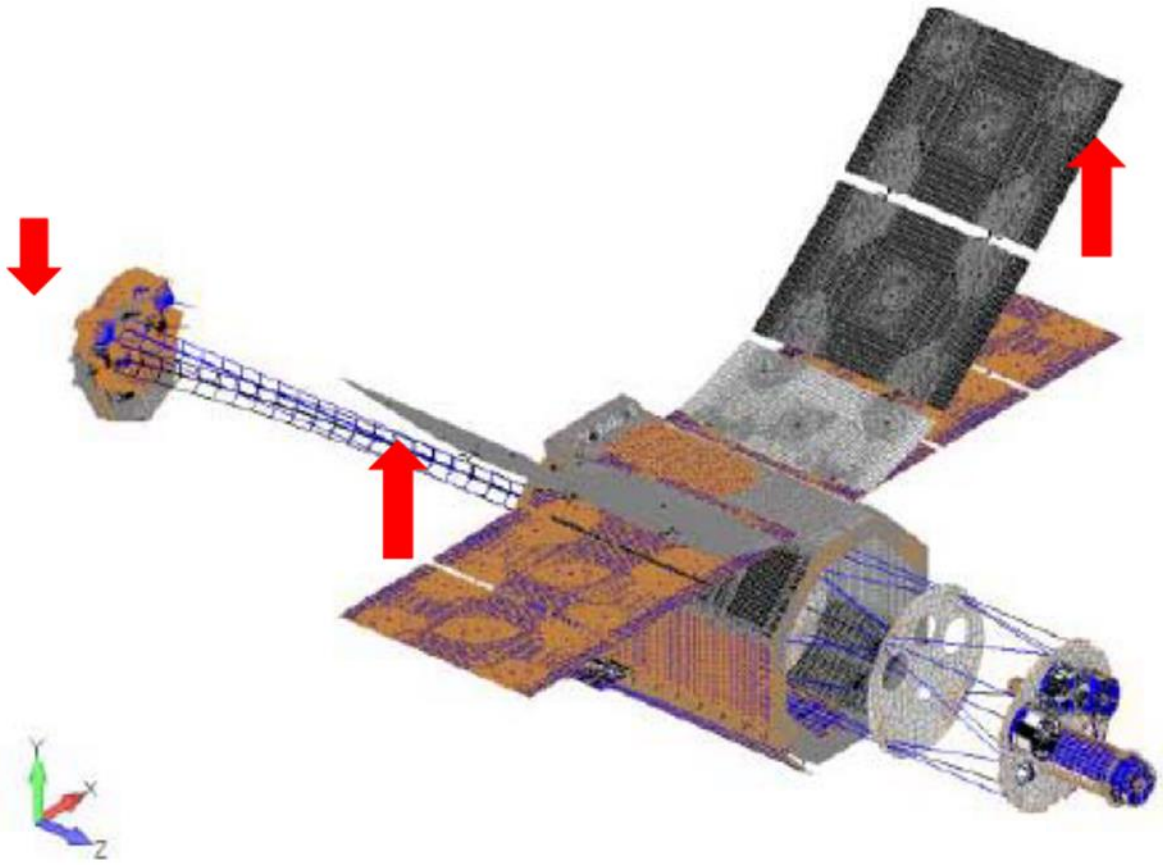
# Structure in Japan



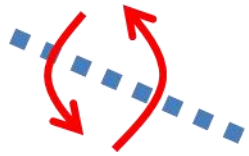
# At the last Athena conference in 2015

- ASTRO-H (Hitomi) will be launched in 2016.
- Athena is the first priority of HEAPA after AH.
- Athena will be an “S-class” project of ISAS/JAXA.
  - Budget for S-project: 10 MEuro/year including ALL S-class projects.

# But…



Spinning fast



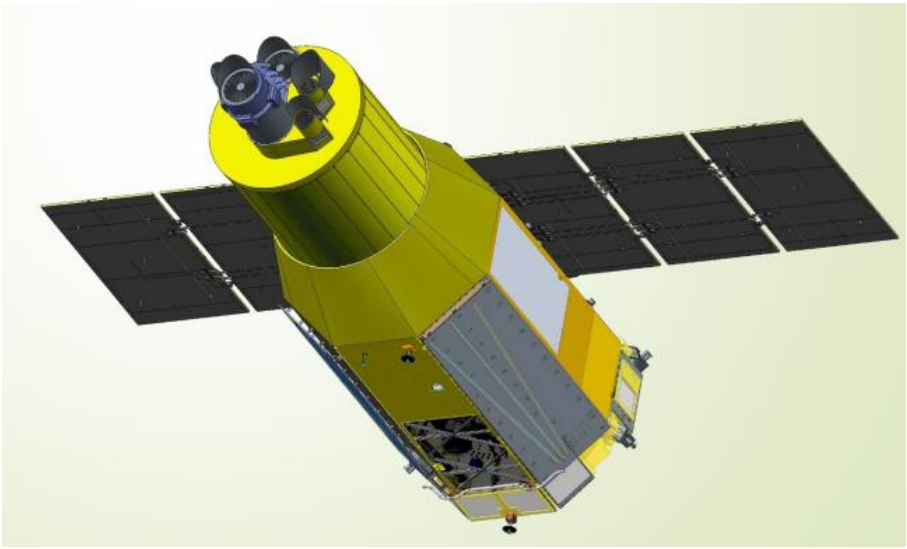
Loss of AH changed the situation.

# ASTRO-H→XRISM

ASTRO-H
(Hitomi)

Calorimeter, CCDs,
Hard X, Gamma

X-Ray Imaging
Spectroscopy Mission
(XRISM)



Concentrate on
calorimeter and CCDs

# XRISM

- Formerly known as “XARM”
- PI: M. Tashiro (Saitama U/JAXA)
- JAXA project started in July

**H. Yamaguchi’s talk on Tuesday**

| | | | |
|---|---|---|---|
| Calolimeter “Resolve” | 2.9’ | 6 × 6 | 7 eV (goal < 5 eV) |
| CCD “Xtend” | 28’ | 1280 × 1280 | <250 eV (EOL) |

# Athena in ISAS/JAXA in 2015

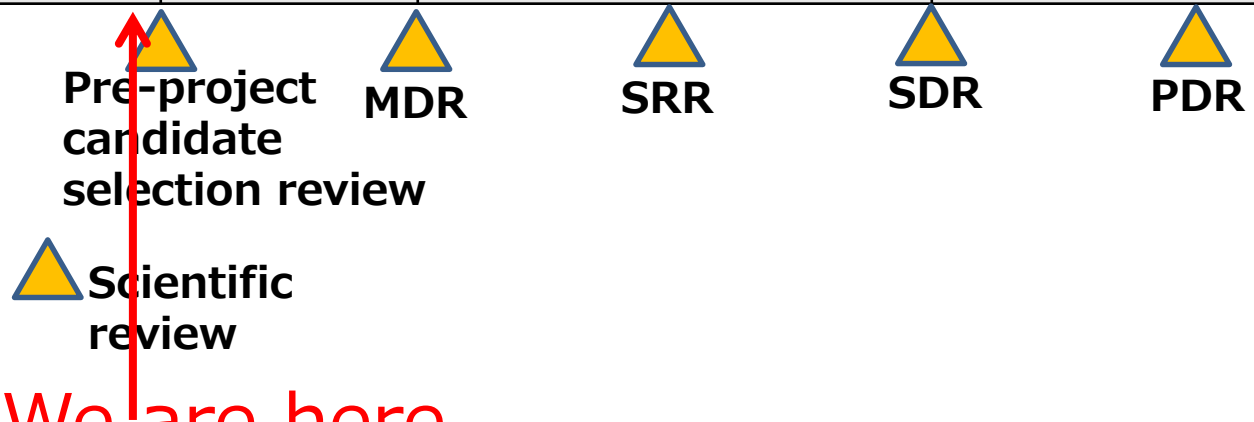
- Athena WG applied for the S-class project of ISAS in 2015
  - Space Science Committee's evaluation in 2015
    - Athena science is **very important**.
    - But the scale is **too large as an S-project**. The strategy of ISAS for Athena should be revised.
      - After the revision, Athena shall be reevaluated.
    - **Development of the Athena X-IFU cooling chain should be proceeded independently.**
      - That can be a key technology of ISAS/JAXA, which can be applied to SPICA, or LiteBIRD.

# Athena in ISAS/JAXA in 2018

- Athena was moved from the S-class project, and is now **a candidate for "a strategic joint project with foreign agencies."**
  - ISAS is almost ready to write **the letter of commitment to the activities until the adoption of Athena**
  - ISAS would like to finalize the scope of JAXA's contribution before writing the letter.
- Development of the cooling chain of X-IFU is being led by **the Cooling Chain-Core Technology Program team of ISAS/JAXA**.

# Project Planning of ISAS/JAXA

| Pre-Phase A1 | Pre-Phase A2 | Phase A1 | Phase A2 | Phase B | Phase C | Phase D | Phase E |
|---|---|---|---|---|---|---|---|
| Mission Exploration Phase | Mission Definition Phase | Design Concept | Project Definition | Basic Design | Detailed Design | Production, test | Operation |
| ISAS WG | ISAS Pre-project candidate | JAXA Pre-Project | | JAXA Project | | | |

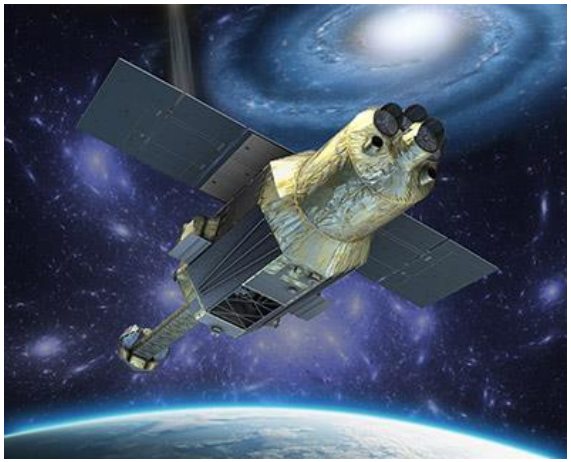


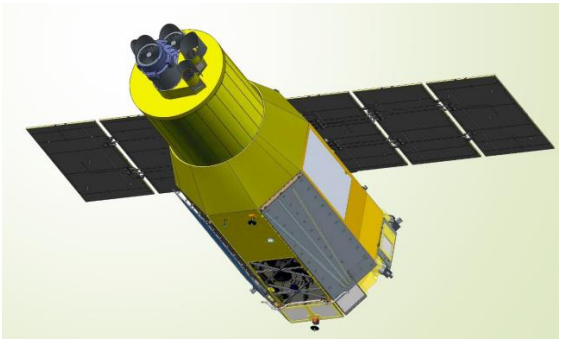

We are here.

Just before becoming an ISAS pre-project candidate

# Japan's Contributions to Athena

- Science with AH & XRISM
  - –Let's open a new field of "precise X-ray spectroscopy"
  - –Discover new science





Bases of Athena science

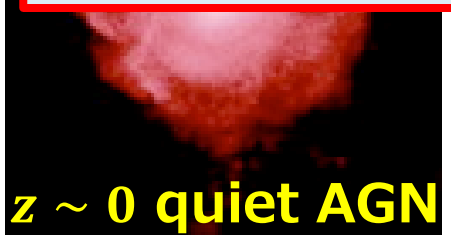
# XRISM→Athena

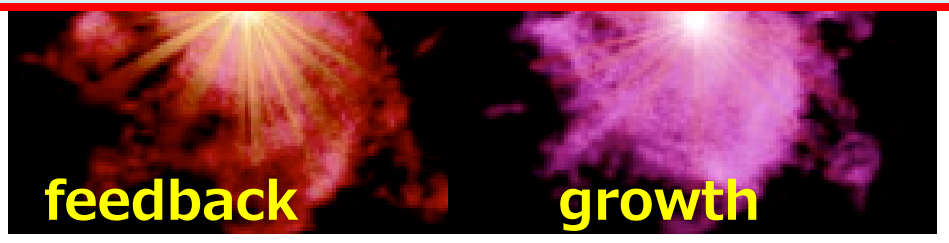


XRISM: Current Universe

- **H. Yamaguchi on Tuesday**
- **T. Reiprich on Tuesday**
- **T. Ohashi on Wednesday**


Athena: Adding the “time axis”



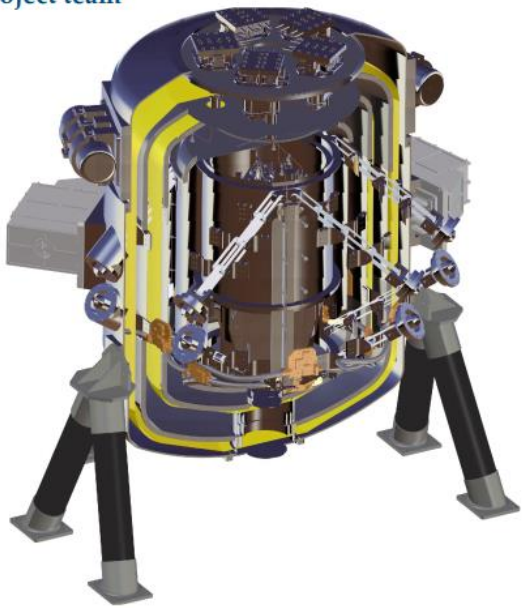




# Japan's Hardware contributions

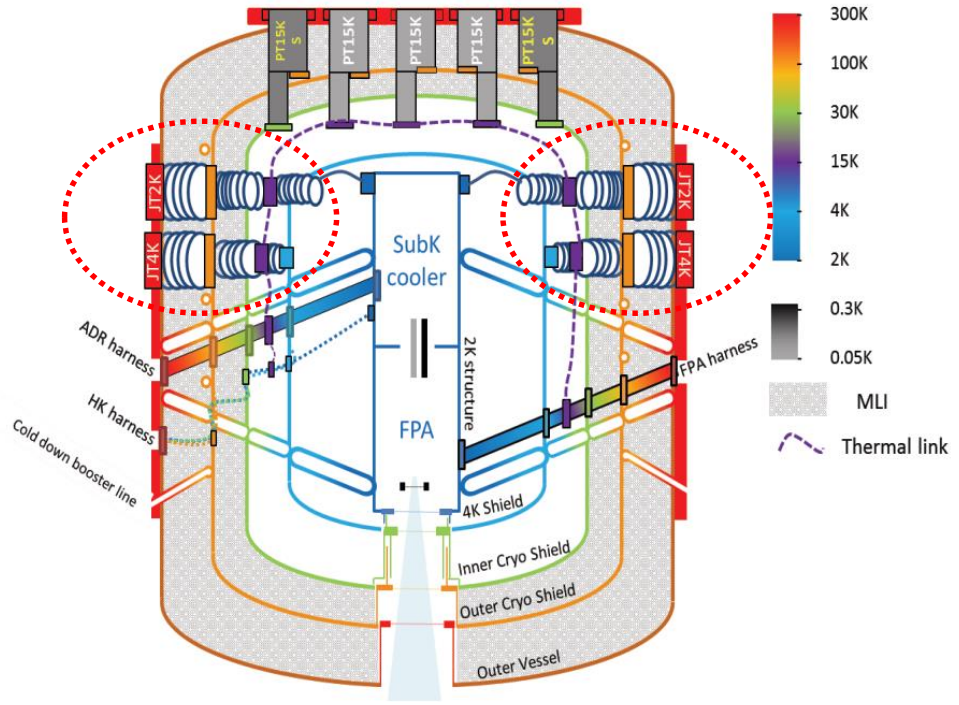
- Main: X-IFU cooling chain
  - Joule-Thomson coolers, drivers, contributions to design and test
- Options
  - X-IFU readout system (SQUID)
  - SPO, WFI
  - Calibrations, operations etc.

# X-IFU cooling chain

CNES project team



The X-IFU Dewar assembly — Subject to optimization




| | | |
|---|---|---|
| 15K pulse tube | 5 | ESA from ALAT |
| 4K Joule-Thomson | 2 | JAXA |
| 2K Joule-Thomson | 2 | Originally ESA from RAL<br>But JAXA may provide. |
| 50mK sorption ADR | 1 | CEA-SBT |

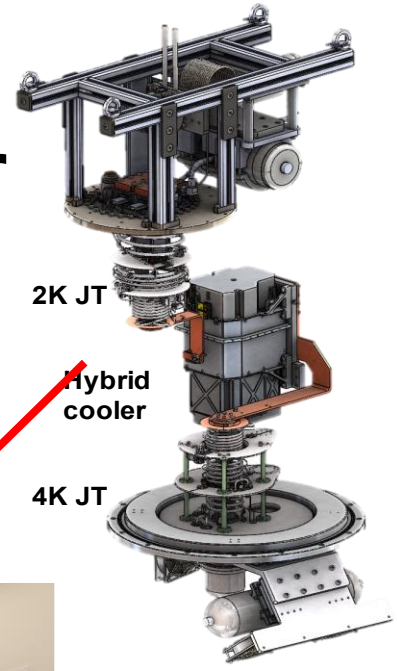
# Test in 2017

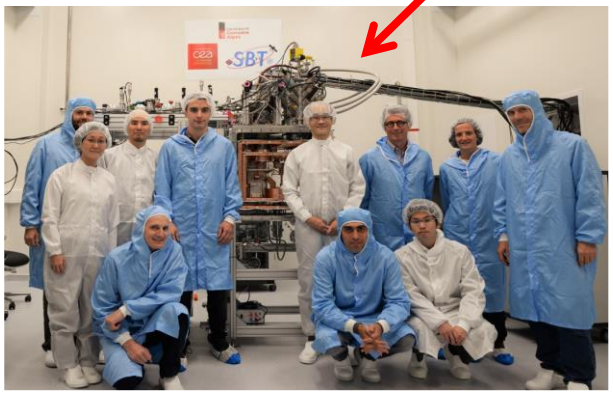
Cooling test > 160 days @ France

- No refrigerant
- 4KJT+2KJT+50mK cooler

Japan CEA

- Good results



**France-Japan collaboration team**
**+ X-IFU PI & PM**

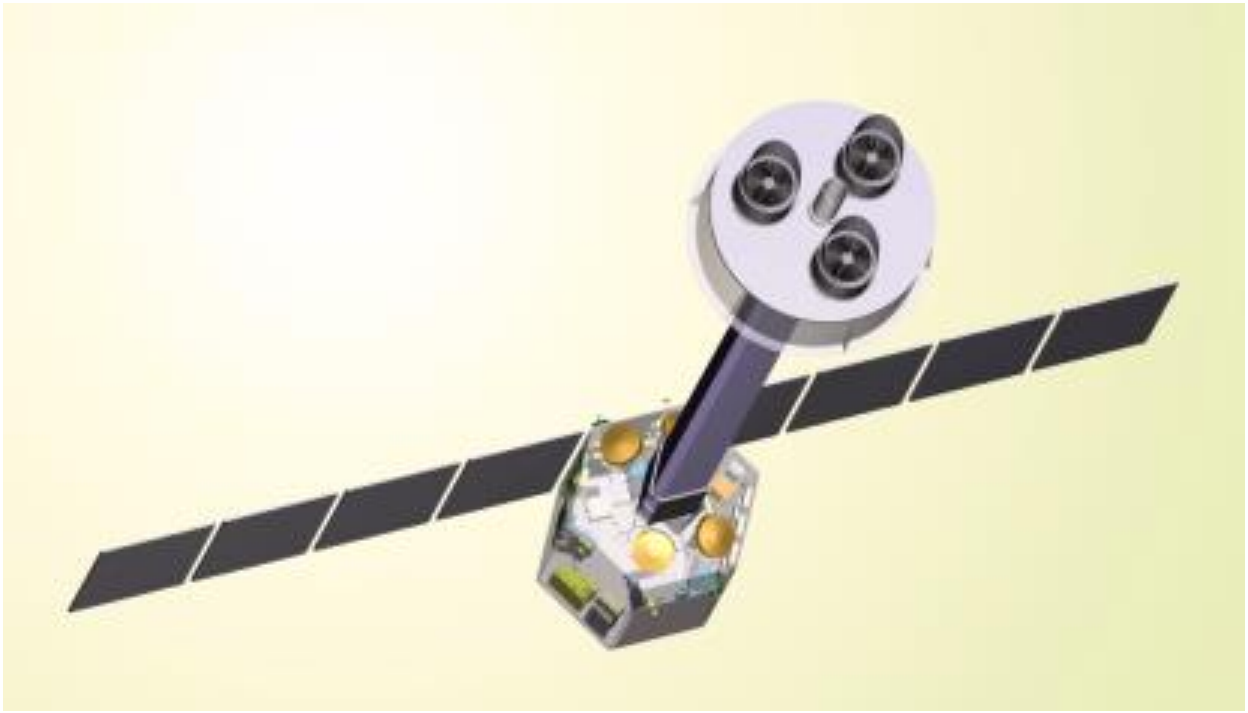
# Athena in HEAPA

- Athena is still the very important project after XRISM.
- Japan would like to realize a mission after mid-2020 that is complementary to Athena

# FORCE

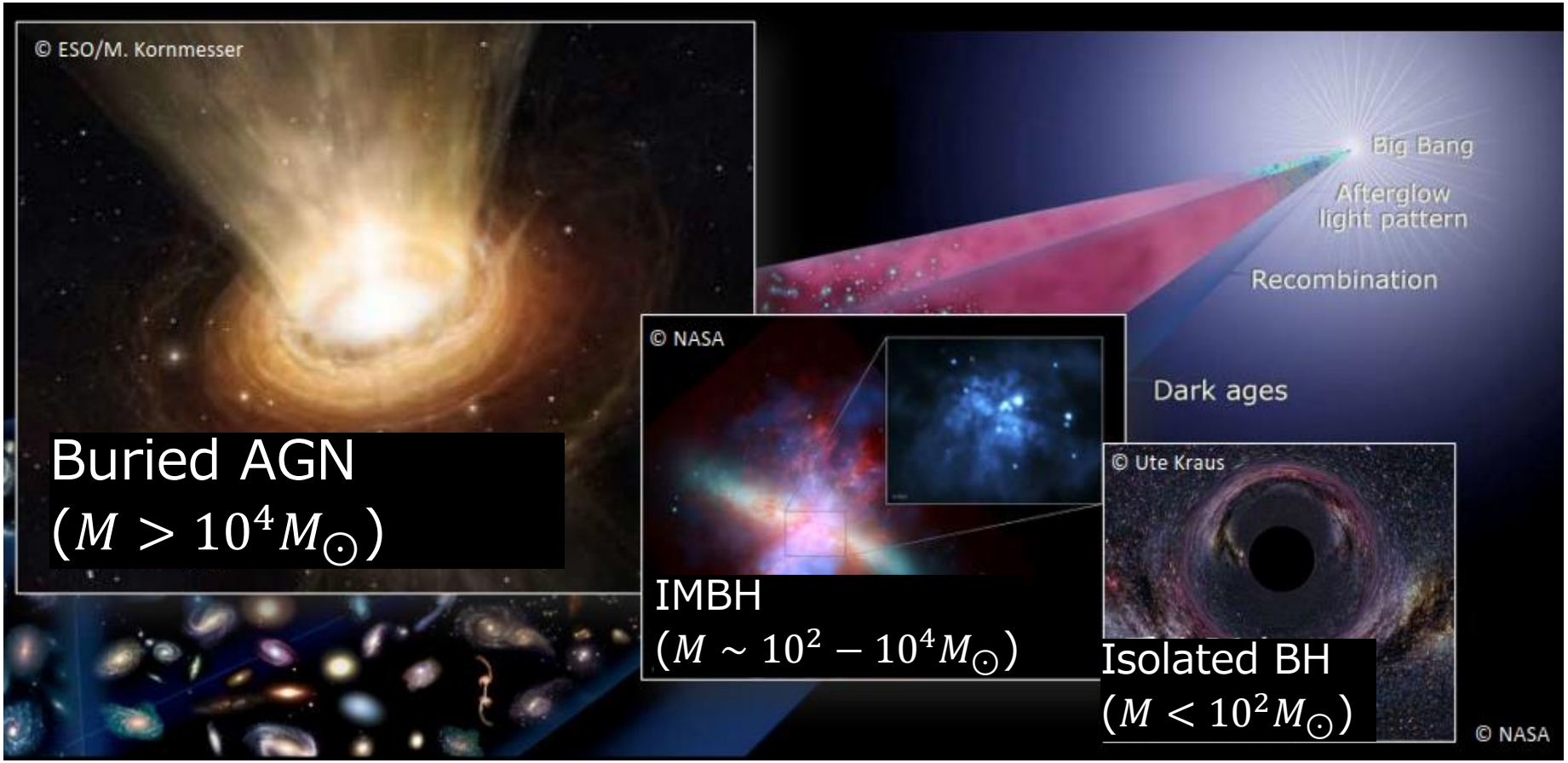
**PI. K. Mori**
**(Miyazaki U.)**

Focusing on Relativistic universe and Cosmic Evolution



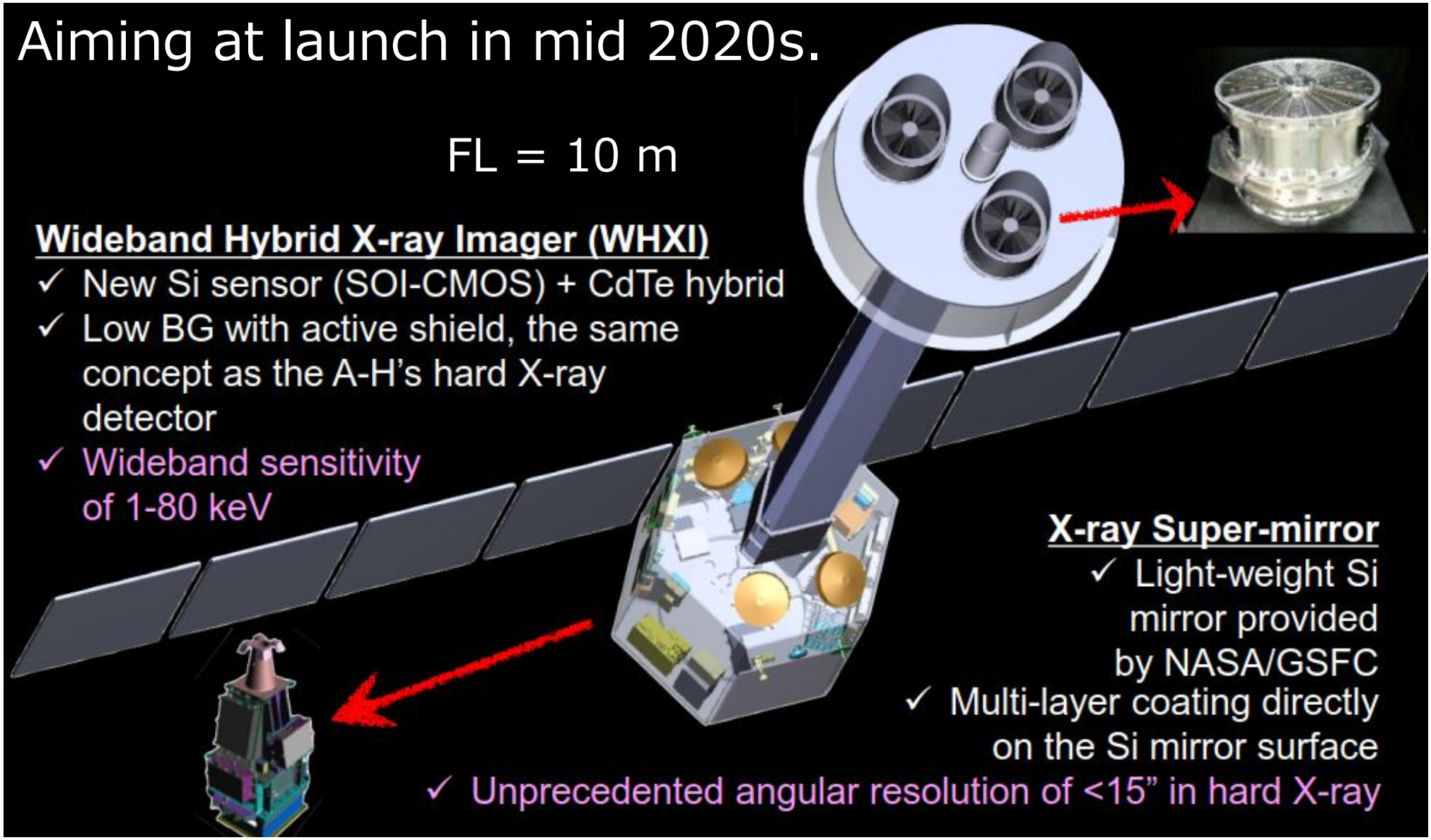
Wide energy range (1—80 keV) with 15”

# Key Science




Find “Missing” BHs in various mass ranges.

# Aiming at launch in mid 2020s.

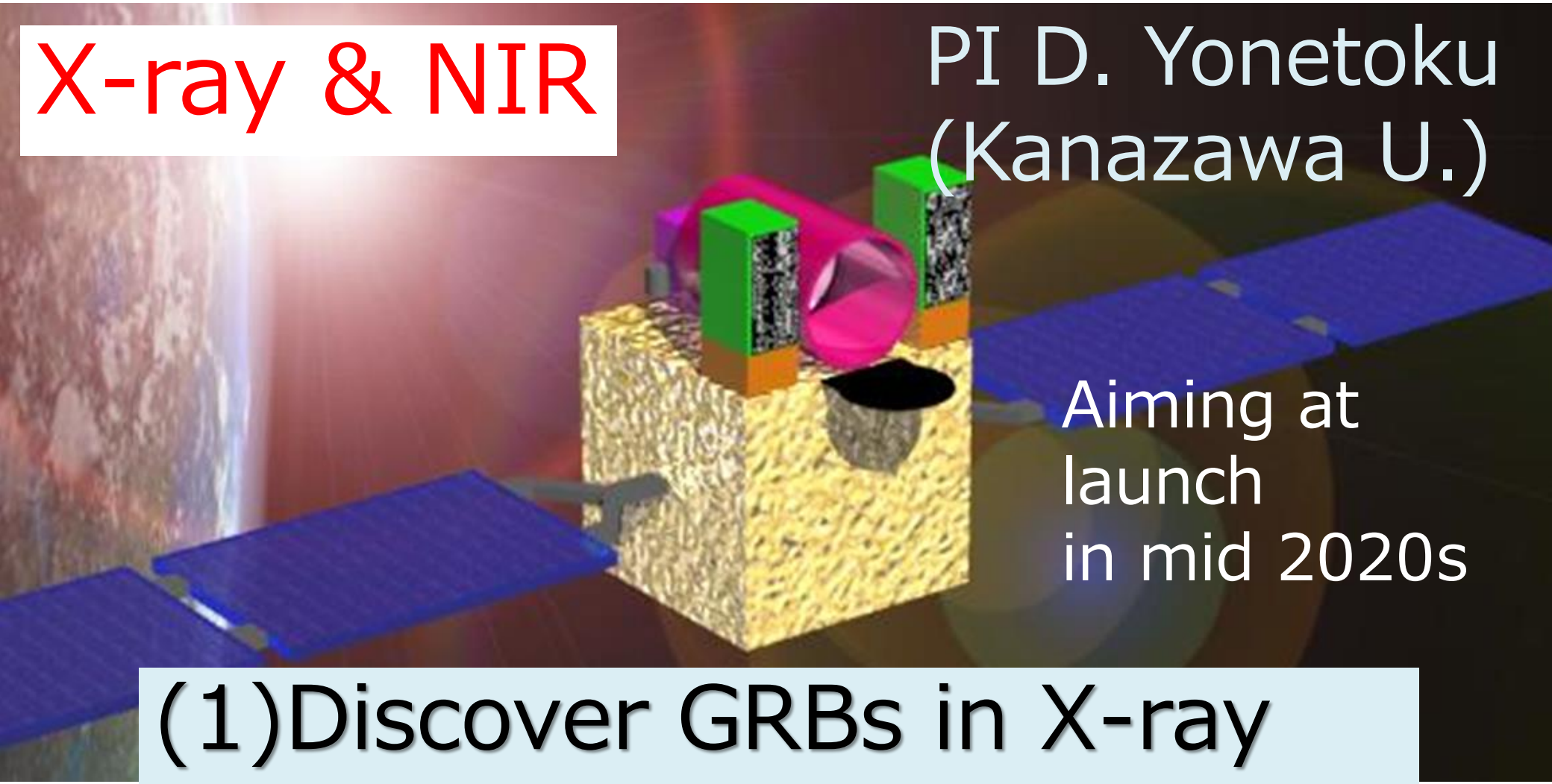


# DIOS→Super DIOS

| Super DIOS performance | |
|---|---|
| Weight | 2000-3000 kg |
| Rocket | H2-H3 |
| Area at 0.6 keV | > 1000 $cm^2$ |
| Focal length | about 3-4 m |
| Angular resolution | 10 arcsecond |
| Energy resolution | < 2 eV @ 1 keV |
| TES pixels | ~30000 |
| FOV | 30 arcmin |

- Formerly “DIOS”
  - DIOS WG was dissolved to concentrate on XRISM.
  - Instruments and concept of DIOS are being revisited.
- Clarify the physical status of WHIM by survey observations with TES calorimeter.
- Aiming at launch in early 2030s

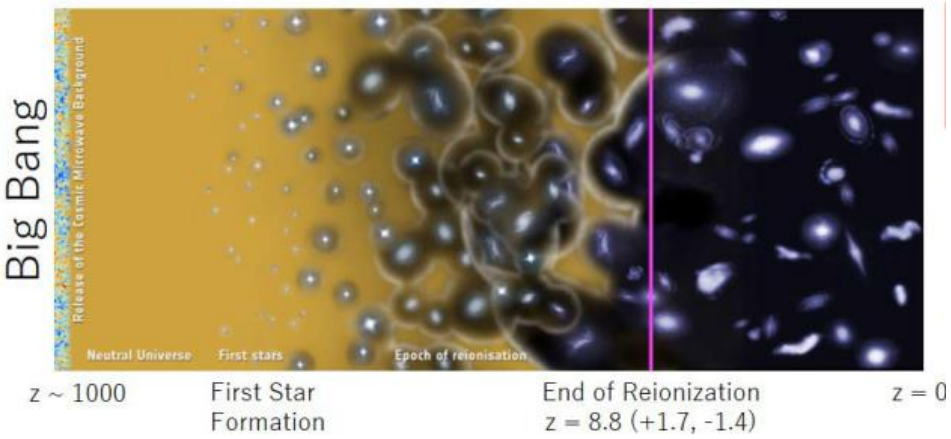
# HiZ-GUNDAM



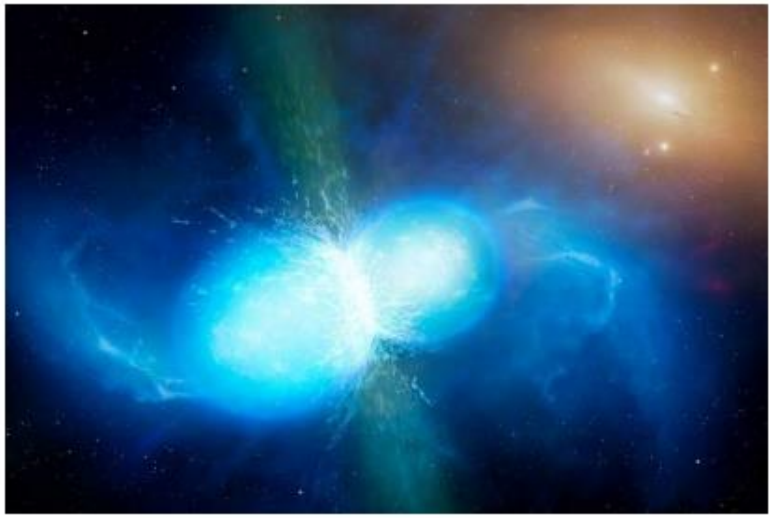

(1)Discover GRBs in X-ray
(2)Locate GRBs in NIR & Opt

# Key Science

Probe hi-z universe using GRBs

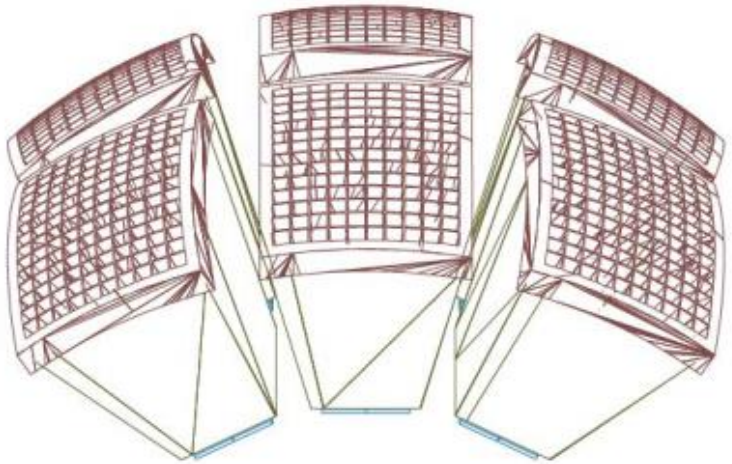



Find X-ray counterparts of Gravitational wave objects



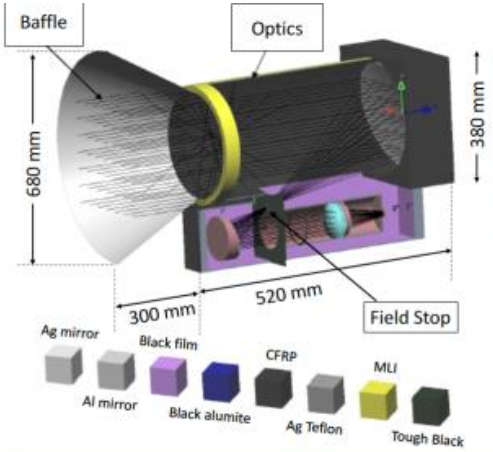
# HiZ-GUNDAM

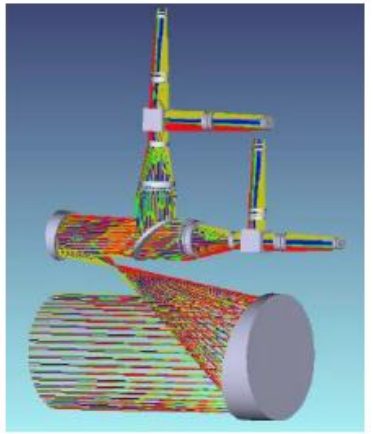
## X-ray: Lobster Eye+ CMOS



| Items | Parameters |
|---|---|
| Energy band (keV) | 0.4 – 4 keV |
| Telescope type: | Lobster Eye Optics |
| Optics aperture | 240 x 320 mm² |
| Number of Unit | 6 |
| Field of View | ~ 1.2 str (6 units) |
| Focal length | 300 mm |
| Focal plane detectors | CMOS array |
| Number of CMOS | 24 (4 CMOS x 6 units) |
| Sensitivity | 1e-10 (erg/cm2/s)<br>For 100 sec |
| Point Spread Function | 3 arcmin |
| Angular accuracy | ~ 60 arcsec |

## Opt/NIR: 4 band



| Items | Parameters | | | |
|---|---|---|---|---|
| Telescope type | Offset Gregorian | | | |
| Aperture size | 30 cm | | | |
| Focal length | 183.5 cm | | | |
| F number | F6.1 | | | |
| Field of view | 34 arcmin ×34 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 | 0.9–1.5 | 1.5–2.0 | 2.0–2.5 |
| Band width | 0.4 μm | 0.6 μm | 0.5 μm | 0.5 μm |
| Limiting Magnitude mag (AB) | 21.4 | 21.3 | 20.9 | 20.7 |
| Focal detector | HyViSi | HgCdTe | HgCdTe | HgCdTe |

# PhoENiX

Physics of Energetic and Non-thermal Plasmas in the X-region

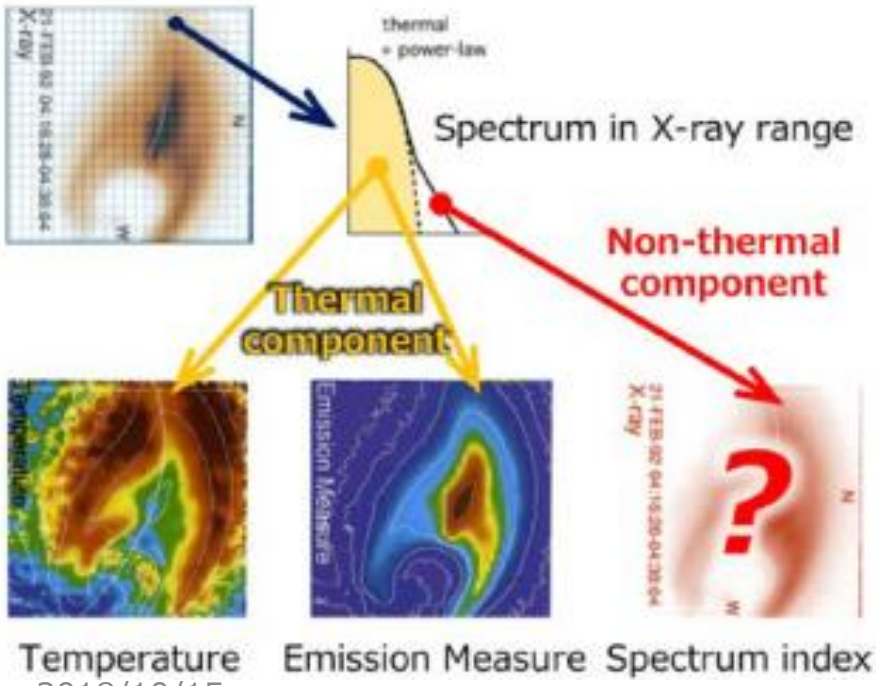

X- and gamma-ray obs. of solar flares

PI. N. Narukage (NAOJ)

# Key Science

## Particle acceleration by magnetic reconnection

### Solar Flare




Soft X (0.5—10keV)

- Image, Spectrum

Hard X (5—30keV)

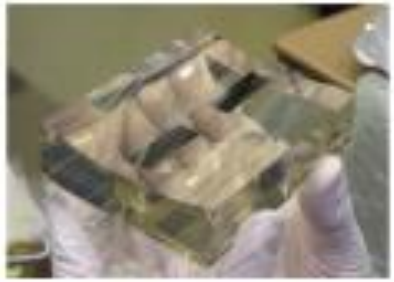
- Image, Spectrum

Soft $\gamma$ (20—600 keV)

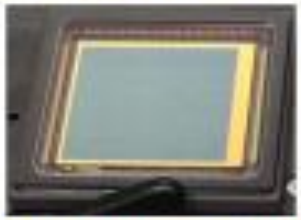
- Spectrum, Polarization

# PhoENiX

## Soft X-ray imaging-spectrometer



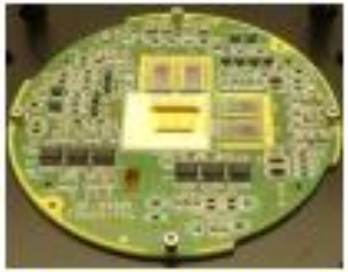
Precision X-ray grazing mirror
Spatial resolution : 1 arcsec
Low scattering : $10^4$ @ 20 arcsec



Soft X-ray high speed camera
Back illuminated CMOS

## Hard X-ray imaging-spectrometer

X-ray grazing mirror (same as FOXSI-3)
Spatial resolution : 5 arcsec (FWHM)



Hard X-ray camera
CdTe detector (same as FOXSI-3)


**Soft γ-ray detector** ASTRO-H SGD: Si/CdTe Compton camera
Energy range : ~ 600 keV polarization measurement (> 60 keV)

From Narukage, N.

# Summary

- Athena is an important project after XRISM for ISAS/JAXA and HEAPA.
- Main contributions are science and X-IFU cooling chain.
- There are several mission candidates after mid-2020s