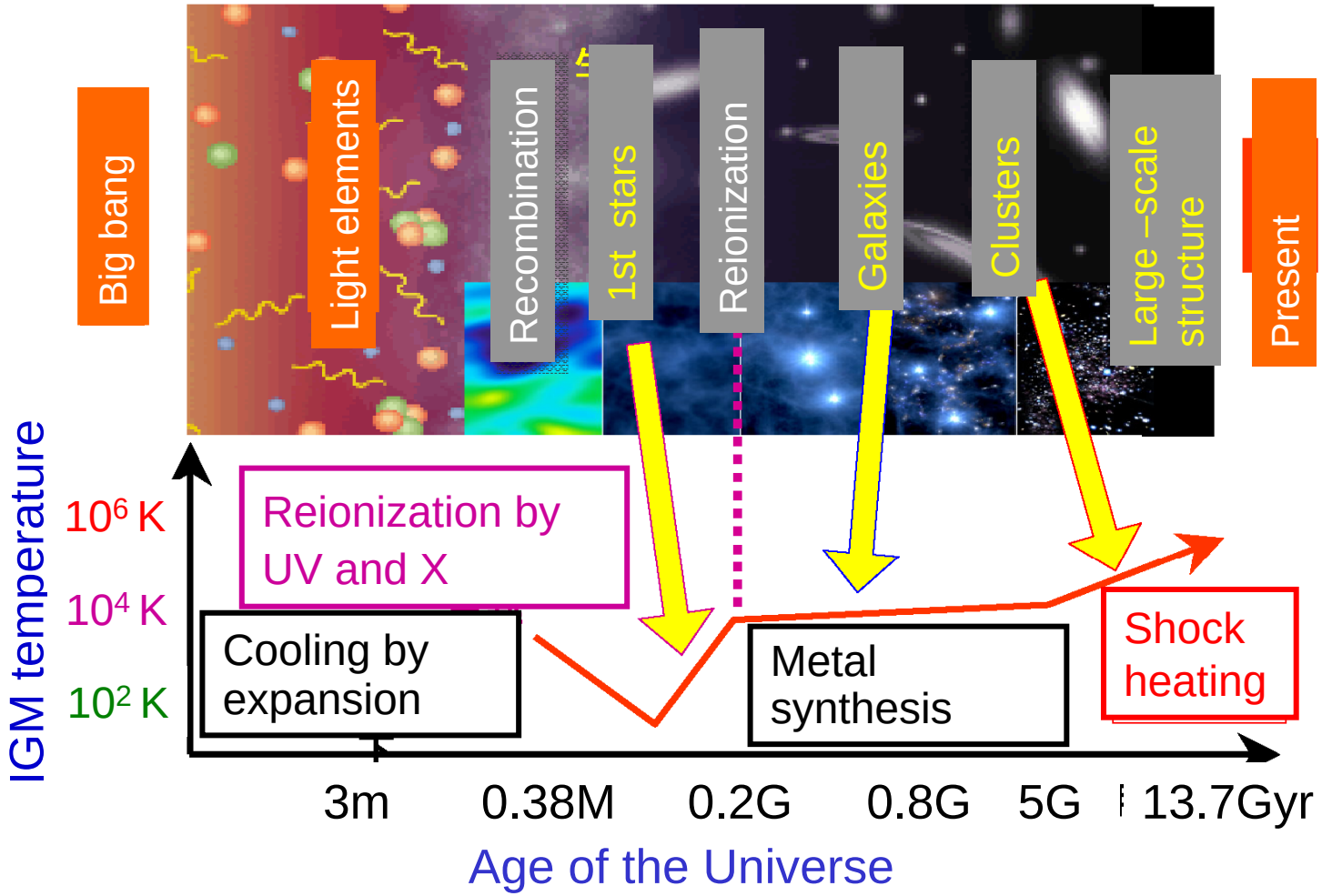
DIOS: An X-ray mission to survey missing baryons

T. Ohashi, Y. Tawara, K. Mitsuda,
N. Yamasaki and DIOS team

1. Dark baryons
2. DIOS satellite
3. Development and Schedule

Thermal history of the universe



WHIM (warm-hot intergalactic medium) will tell us the evolution of the hot-phase material in the universe

Cosmic structure

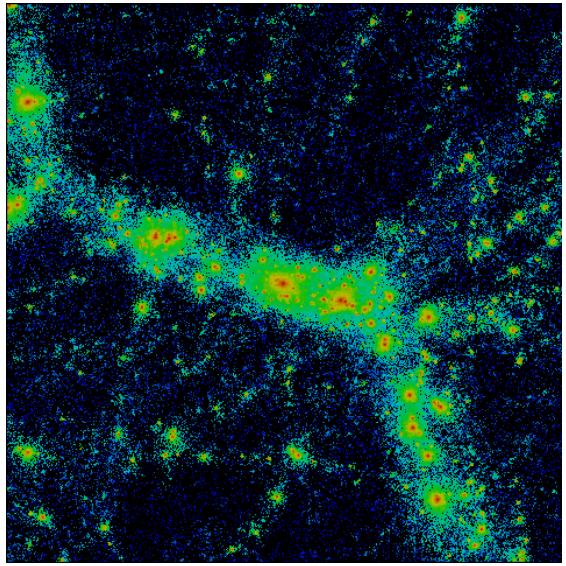
WHIM (10^5-10^7 K) traces the cosmic large-scale structure
= "Missing baryon"

Typical matter density:
δ (=$n/\langle n_B \rangle$) = 10 - 100

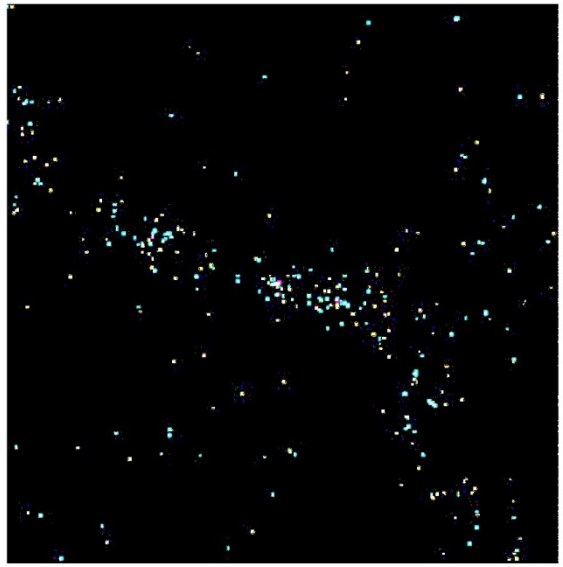
Yoshikawa et al. 2001, ApJ, 558, 520

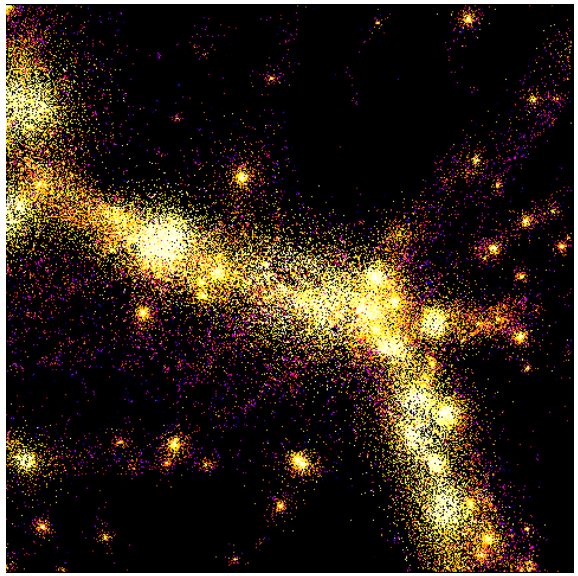
size = 30 h^{-1} Mpc
≈ 5 deg at z=0.1

Dark matter

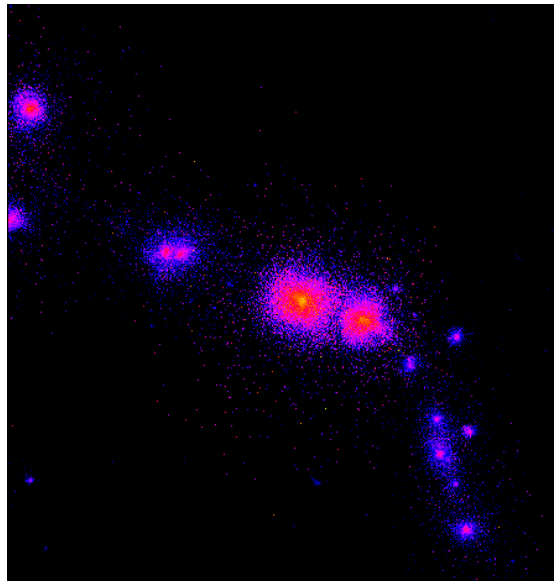


Galaxies (~10^4K)





IGM (10^5-10^7K)

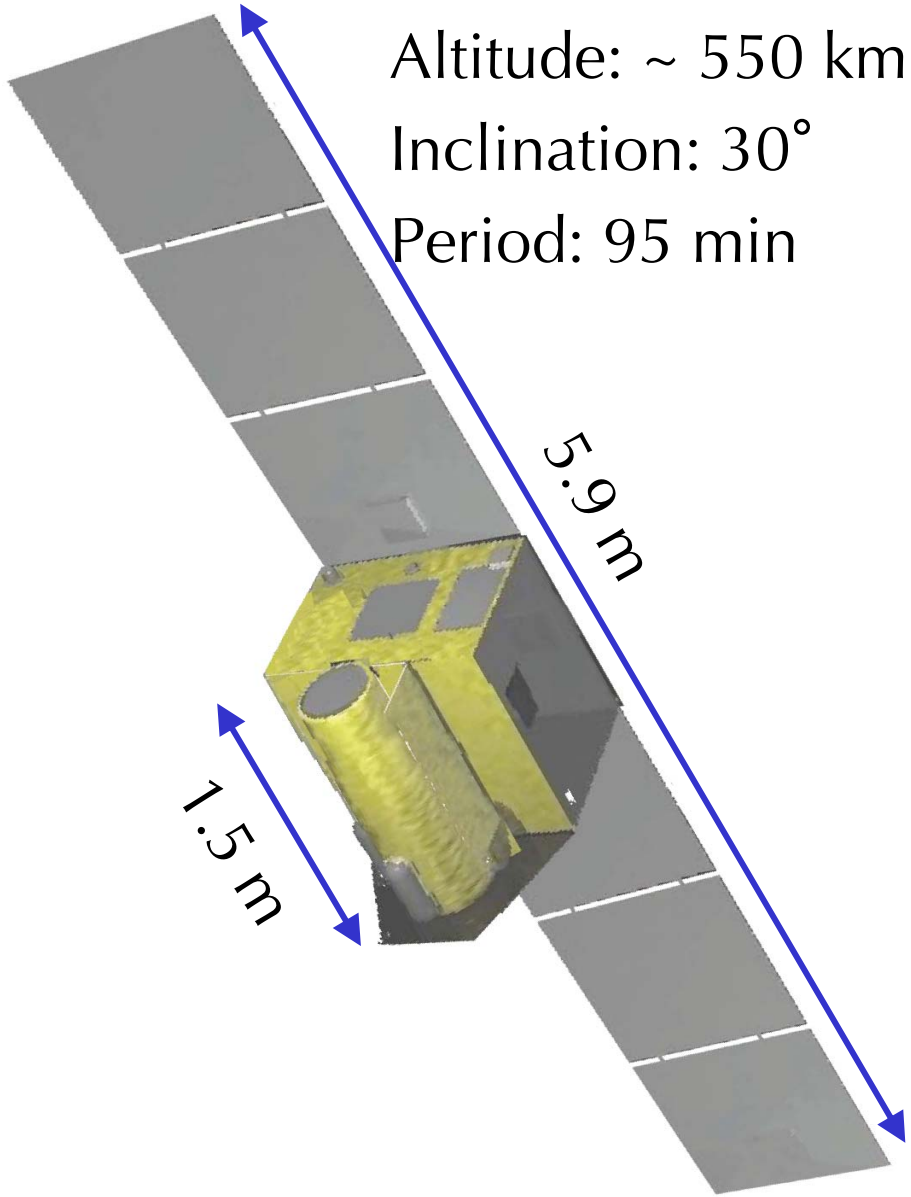


Cluster gas (10^7K)

DIOS Spacecraft

- Launch Target ~2015
  (after Astro-H in 2013)
- Launch Vehicle
  JAXA's new solid rocket (2011~)

Weight	Total	~ 400 kg
	Payload	~ 200 kg
Size	Launch	1.2 × 1.45 × 1.4 m
	In orbit	5.9 × 1.45 × 1.4 m
Attitude	Control	3-axis
	Accuracy	≦30 arcsec
Power	Total	500 W
	Payload	300 W

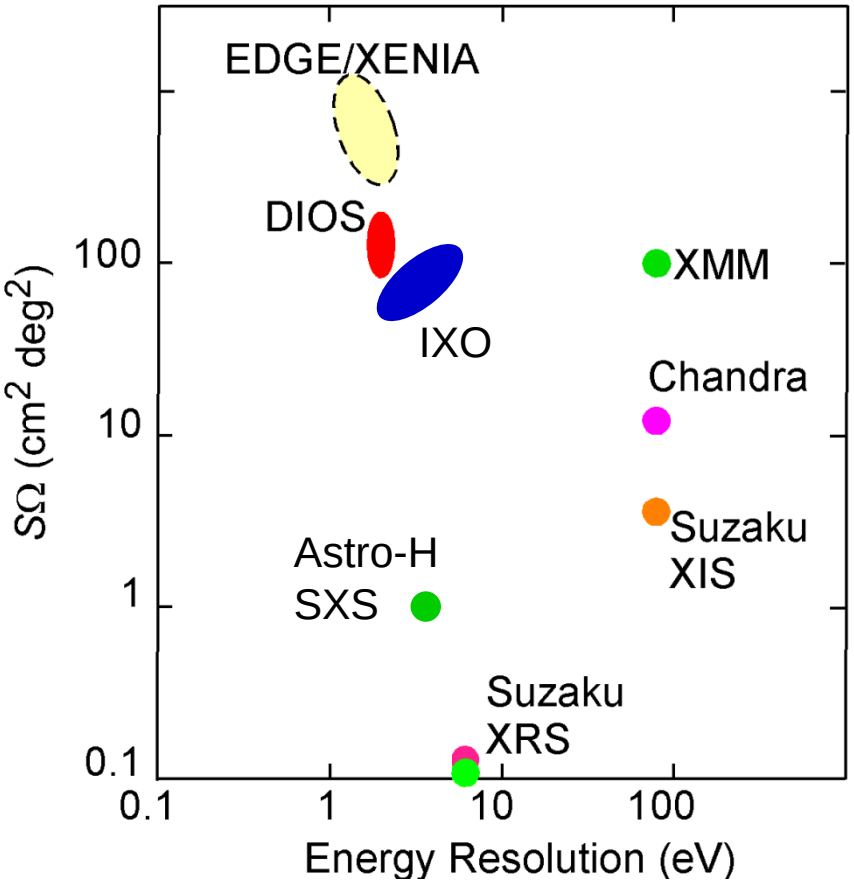


Altitude: ~ 550 km
Inclination: 30°
Period: 95 min

Incl. 20% contingency

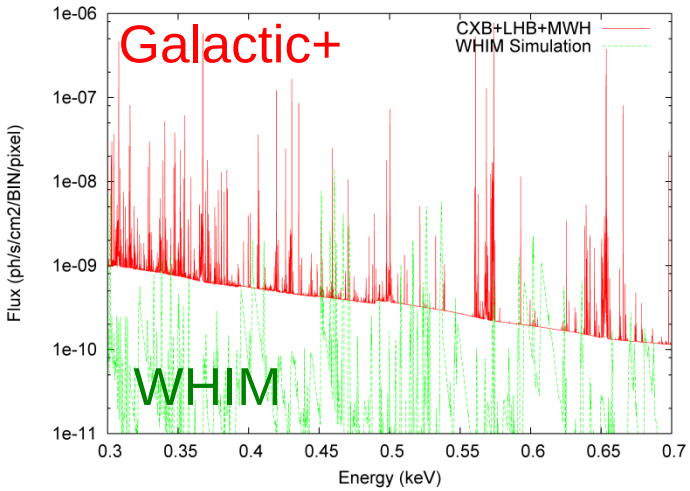
DIOS Performance

Effective area	> 100 cm^2
Field of view	50′ diameter
$S\Omega$	> 100 $cm^2 deg^2$
Angular resolution	3′ (16 x 16 pix)
Energy resolution	2 eV (FWHM)
Energy range	0.3 – 1.5 keV
Mission life	> 5 yr

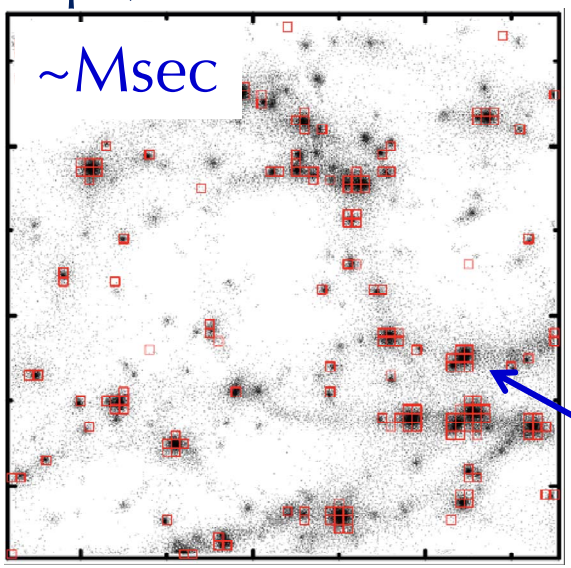


Expected results

Incident spectrum



5 deg x 5 deg at $z = 0.2$ (60 Mpc)



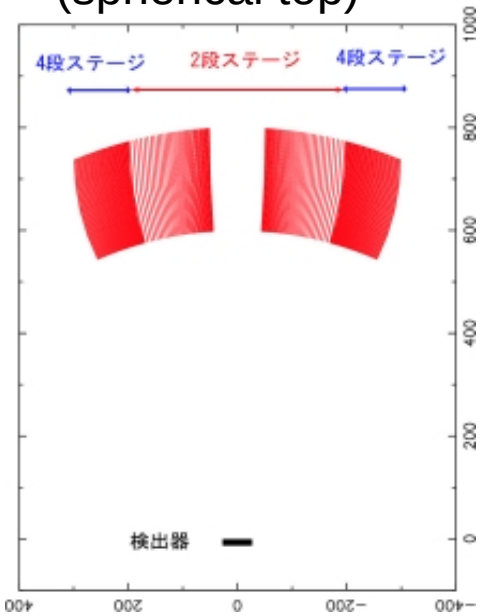
- ≥ Msec exposure with DIOS ($S\Omega$ > 100 cm^2 deg^2) gives significant detection of WHIM filaments
- Combined detection of OVII and OVIII lines suppresses spurious features
- Filaments tracing the large-scale structure can be detected

OVII & OVIII > 3σ

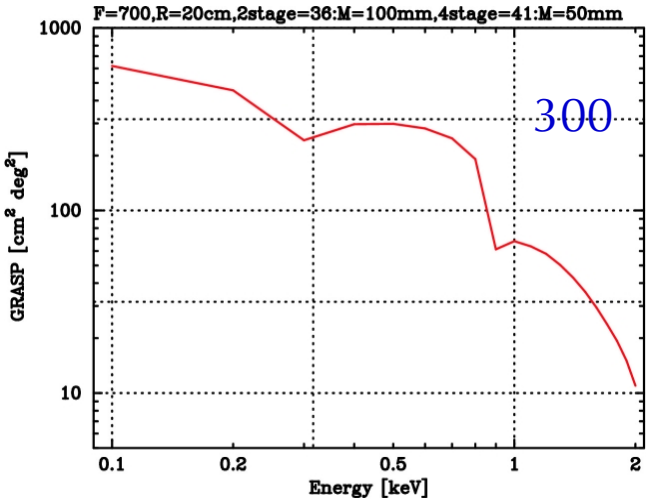
X-ray optics for DIOS

Walter I + 4 reflection: 2 and 4 reflection

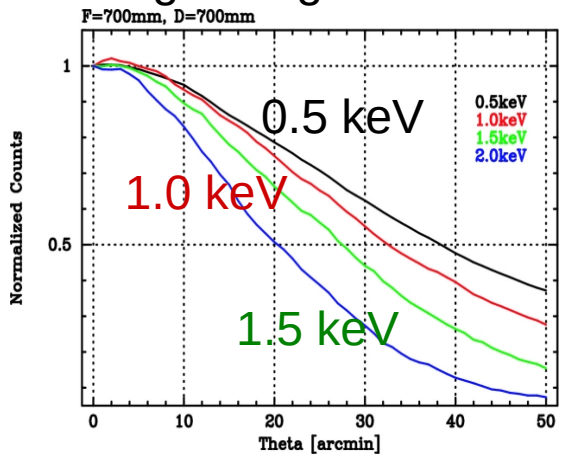
Mirror configration
(spherical top)



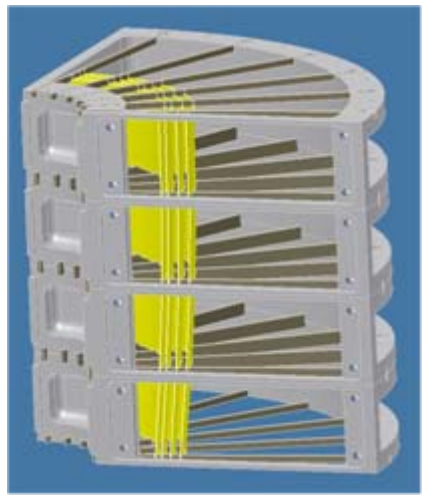
GRASP (cm^2 deg^2)



Vignetting function



Focal length	70 cm
Diameter	60 cm
2 refl. to 4 refl. change	20 cm
Surface	C 25Å + Ni 25Å + Pt 300Å
# of shells	36（2 refl） + 41 (4 refl)
Detctor size	10 mm ×10 mm



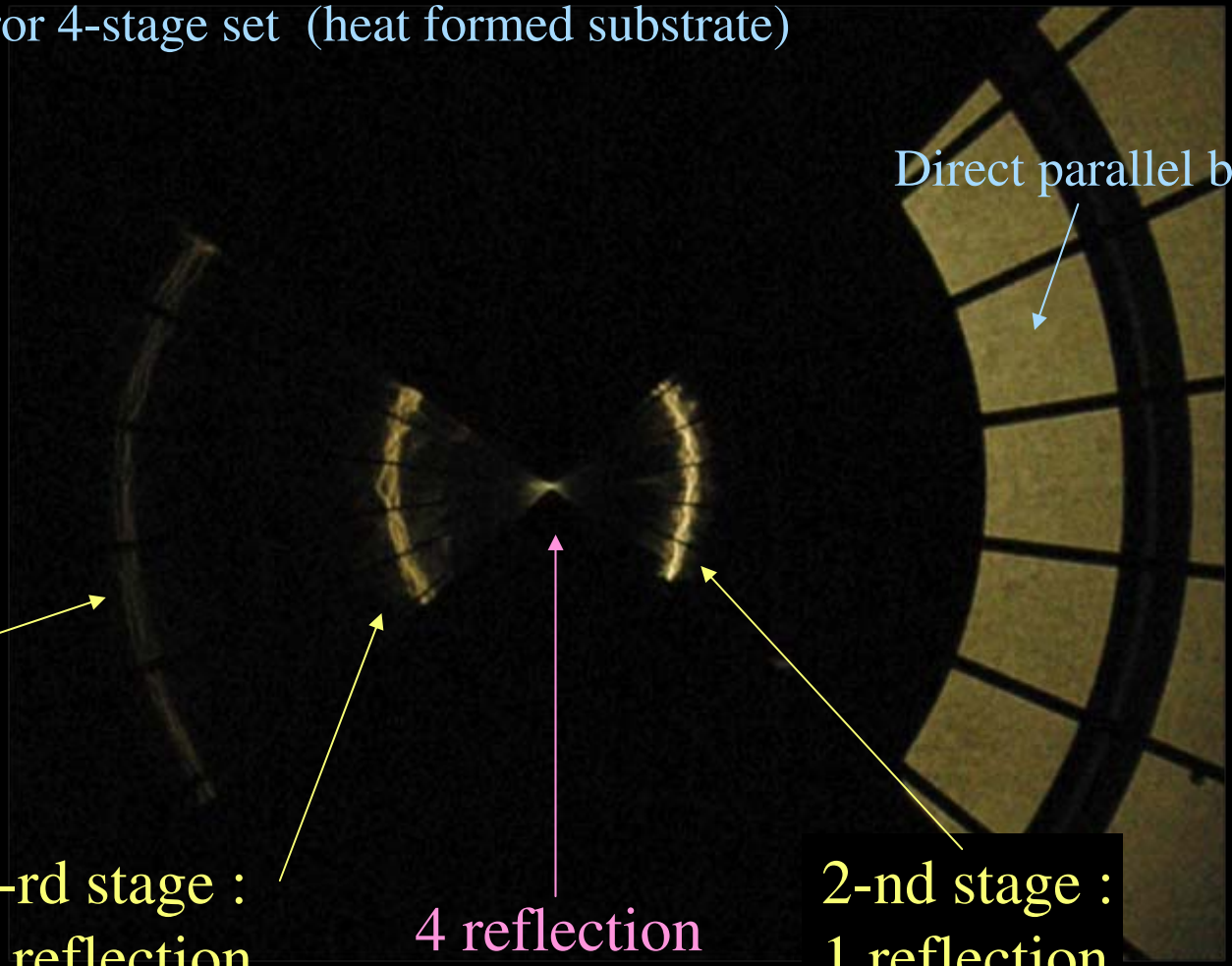
Housing:

2‘ accuracy

Optical images :

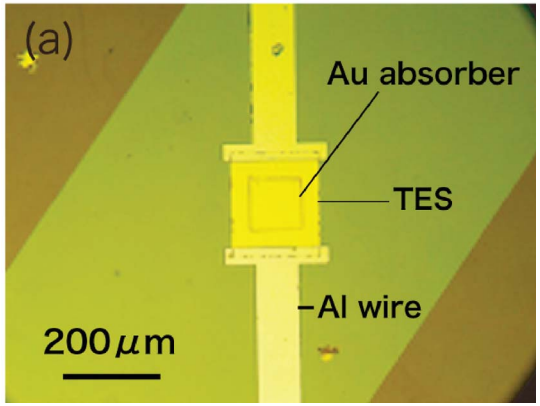
180 mm dia mirror 4-stage set (heat formed substrate)

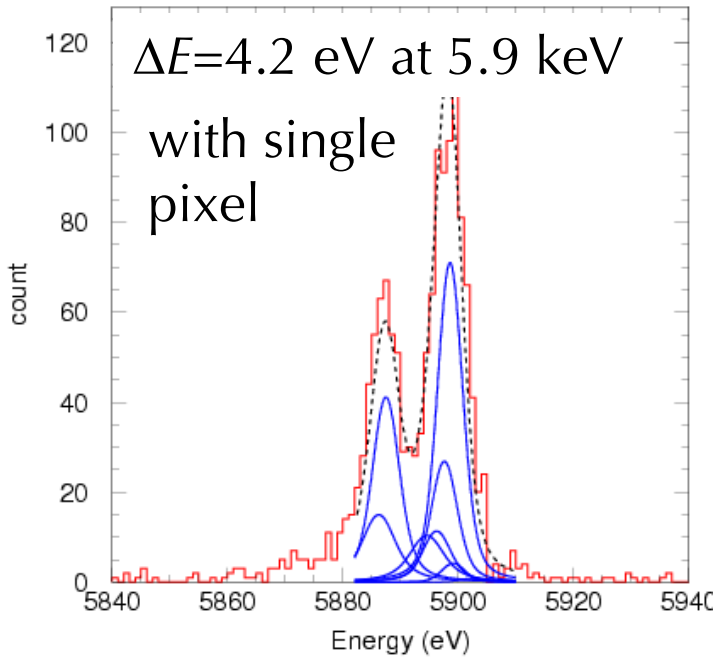
One quadrant



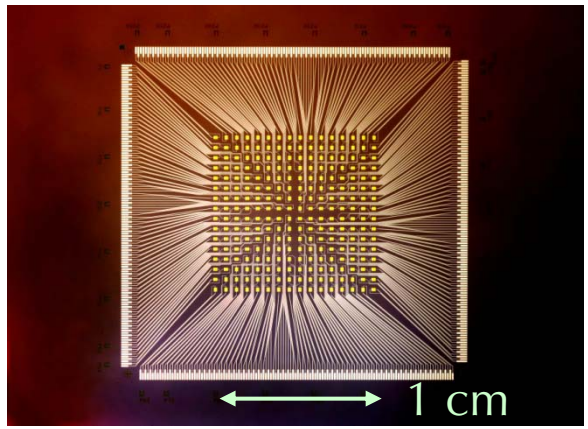
Development of TES array detector

In-house product of TES

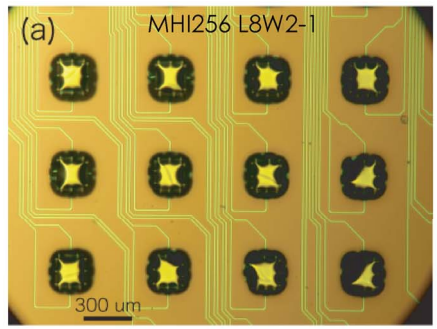


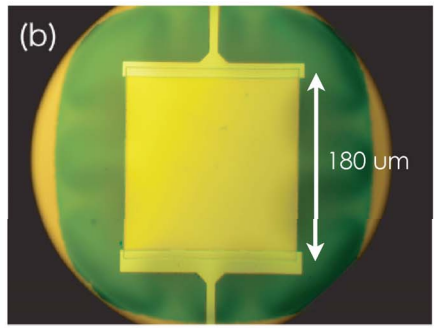


256 pixel array: ΔE ~ 11 eV
without X-ray absorber



Close-up view of array pixels





Cooling system

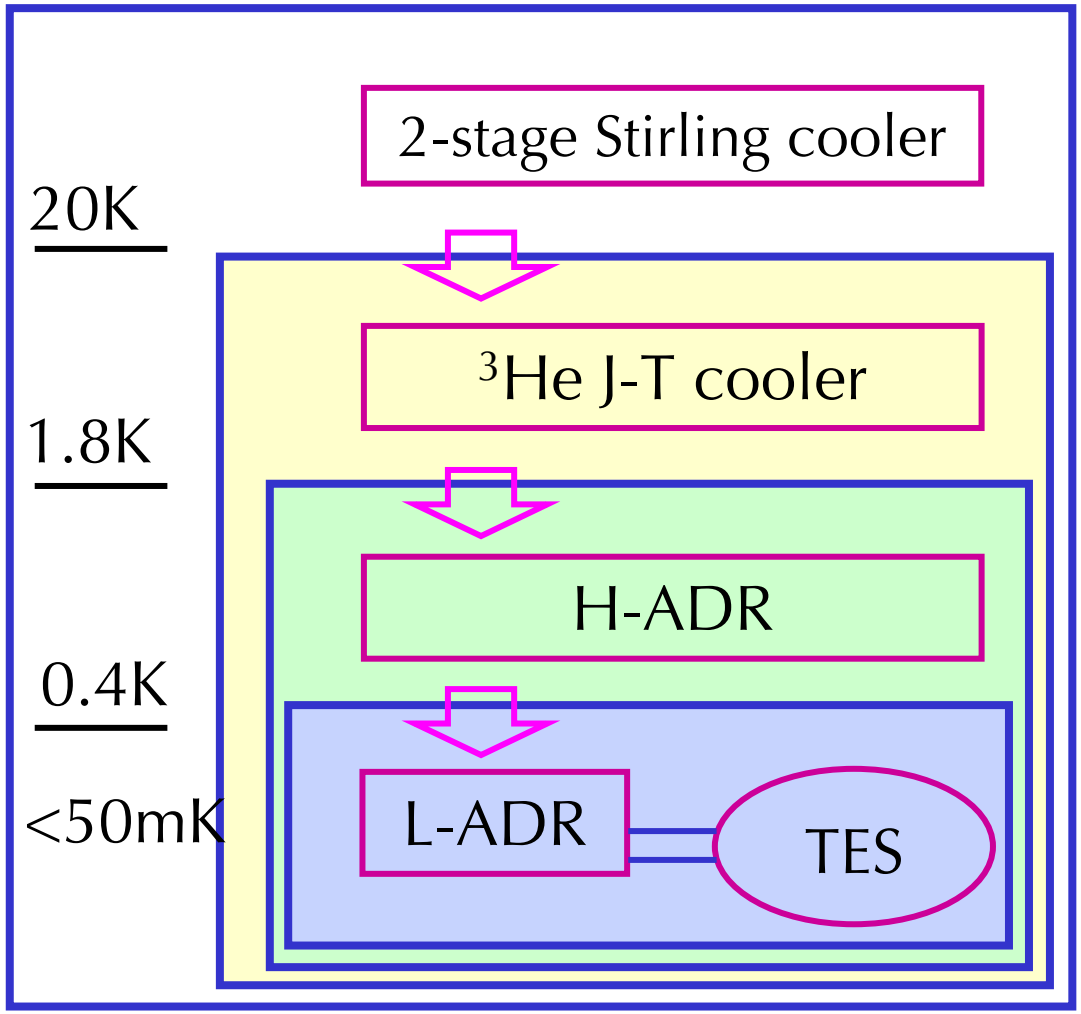
No expendable cryogen, warm launch

Radiation

225-300 K

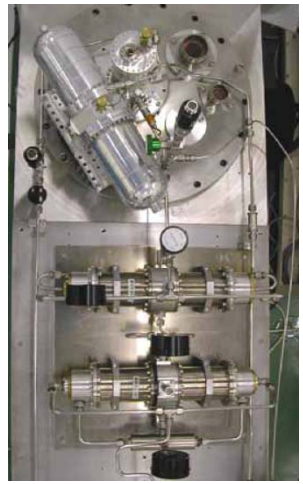
> 1.1 m^2

Attitude flipping in every orbit

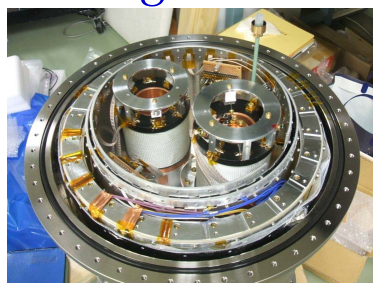


Stirling cooler

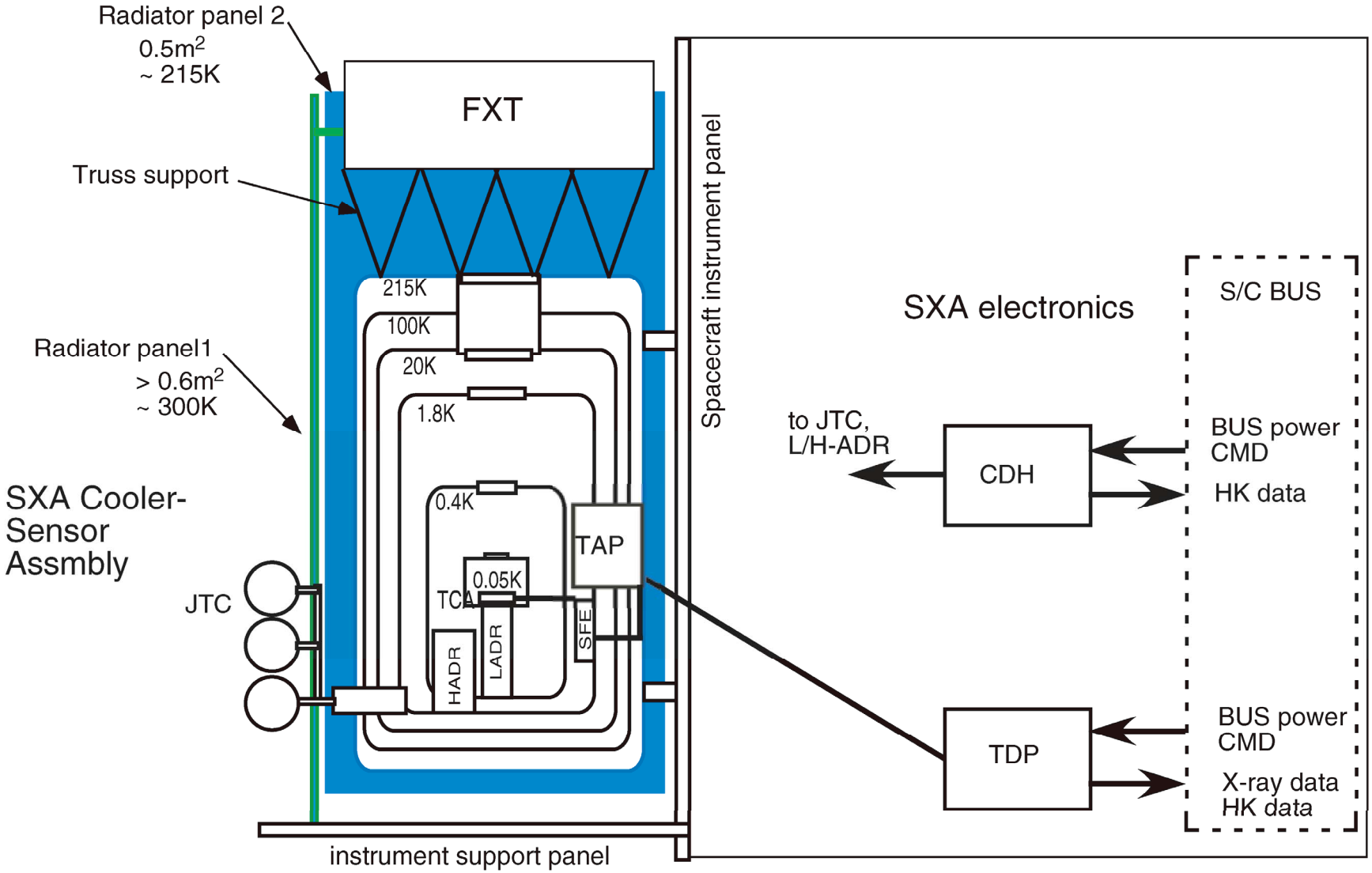
J-T cooler



2-stage ADR

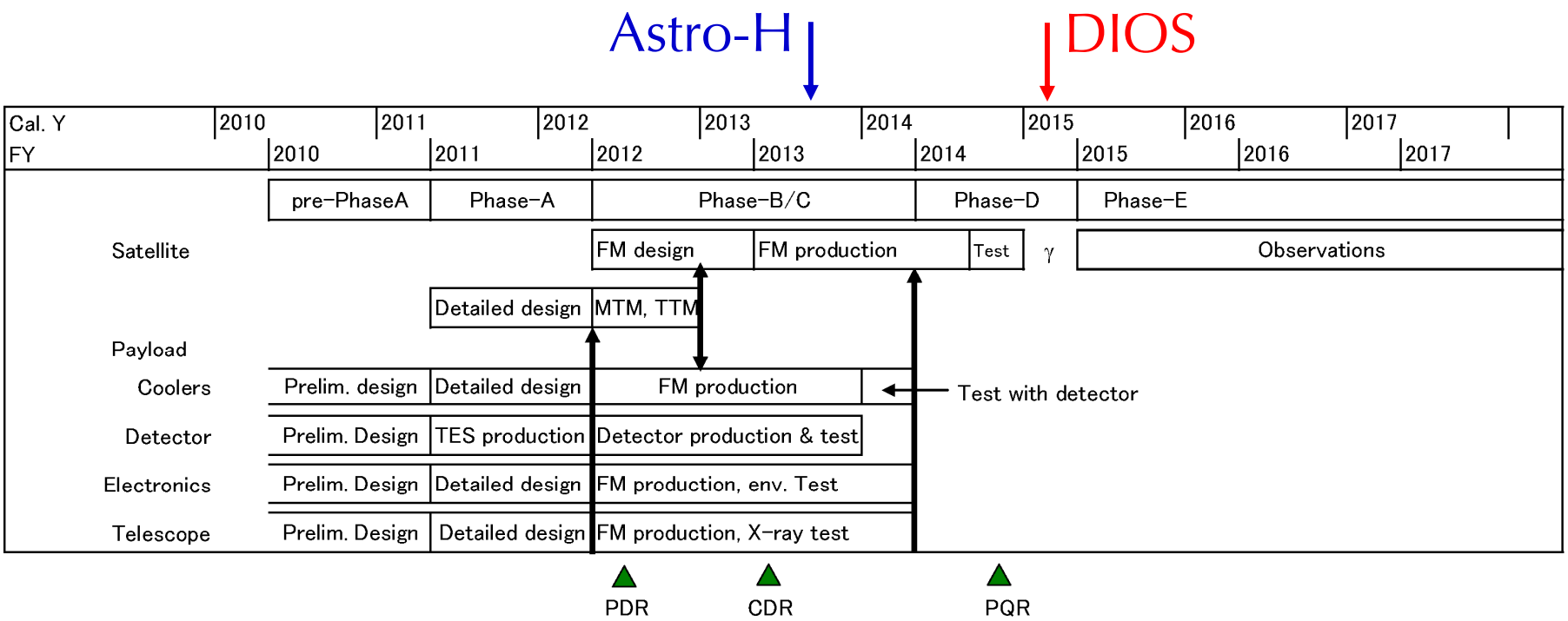


Instrument and control electronics



Schedule

- DIOS will come later than Astro-H (2013)
- Proto-type model of the mechanical coolers for Astro-H will be used for DIOS
- International collaboration is important



Summary of DIOS mission

- DIOS, a JAXA's small satellite, can be a pathfinder for a larger WHIM mission and demonstration for TES technology, with unique scientific capability.
- Moderate mass (~400 kg), power (500 W total), size (< 1.5 m cube), and budget (< 0.1 times Astro-H).
- International collaboration will be important.
- WHIM survey: sky area of a few degrees in 2-3 yr
  Survey of Galactic hot gas: in about half year
  Other pointing observations: a few more yr