ASTRO-H: science goals, development status, and European contribution

Matteo Guainazzi (ASTRO-H ESA SOC)
on behalf of the ASTRO-H project

Outline

- ASTRO-H science
- ASTRO-H development status
- Support to the European users' community

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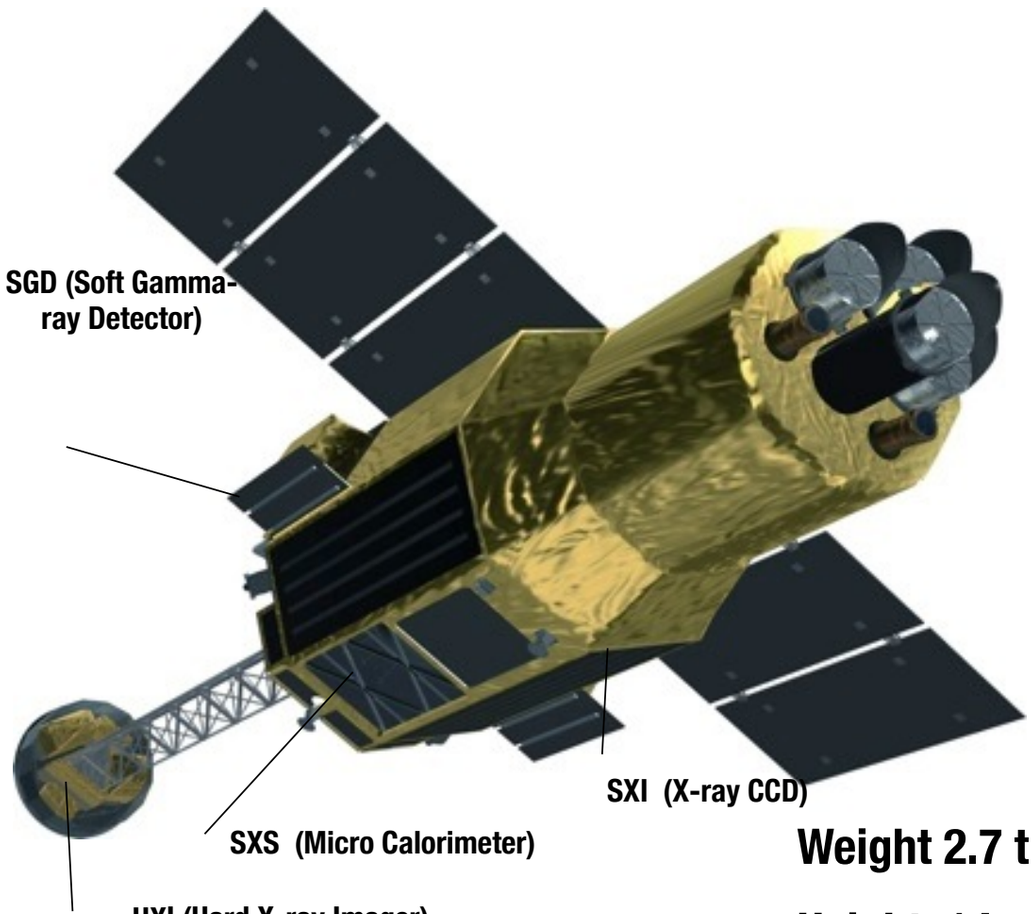
ASTRO-H in a nutshell

(Takahashi et al., 2012, SPIE, 8443, 1)

ASTRO-H is an international X-ray observatory, which is the 6th in the series of the X-ray observatories from Japan. More than 160 scientists from Japan/US/Europe/ Canada.



Weight 2.7 t

Height 14 m

- **Launch vehicle: JAXA H-IIA rocket**
- **Orbit Altitude: 550km**
- **Orbit Inclination: ~31 degrees**
- **Launch : 2015**

International Cooperations

NASA **Micro Calorimeter Array/ADR** **Two soft X-ray Telescopes** **Eight Science Advisors** **Pipeline Analysis**
SRON & U. of Geneva **Filter Wheel/MXS for SXS** **CEA/DSM/IRFU** **Contribution to BGO Shield/ASIC test** **ESA** **Three Science Advisors** **Contribution to mission instruments (SXS/HXI/SGD/HXT)** **User support in Europe**
CSA **Metrology System**

58 institutions (Japan 33)

266 scientists & leading engineers (Japan 152)

ASTRO-H science goals

- Universe large-scale structure and its evolution
    - Galaxy clusters: bulk motions and turbulence, dynamical evolution, non-thermal energy and chemistry, cosmological mass function
    - Evolution of (heavily obscured) supermassive black holes (SMBH)
- Accretion flow onto SMBH in the strong gravity regime
- Cosmic-rays acceleration in SuperNova Remnants and galaxy clusters
- Soft γ-ray polarimetry
- *Observatory science* (stars, XRBs, WDs, Galactic Centre ...)

Instruments' synopsis

(Takahashi, 2013, MmSAI, 84, 776)

Parameter	Hard X-ray Imager (HXI)	Soft X-ray Spectrometer (SXS)	Soft X-ray Imager (SXI)	Soft γ-ray Detector (SGD)
Detector technology	Si/CdTe cross-strips	micro calorimeter	X-ray CCD	Si/CdTe Compton Camera
Focal length	12 m	5.6 m	5.6 m	–
Effective area	300 cm^2@30 keV	210 cm^2@6 keV 160 cm^2 @ 1 keV	360 cm^2@6 keV	>20 cm^2@100 keV Compton Mode
Energy range	5 –80 keV	0.3 – 12 keV	0.5 – 12 keV	40 – 600 keV
Energy resolution (FWHM)	2 keV (@60 keV)	< 7 eV	150 eV (@6 keV)	4 keV (@40 keV)
Angular resolution	<1.7 arcmin	<1.3 arcmin	<1.3 arcmin	–
Effective Field of View	$\sim 9 \times 9$ $arcmin^2$	$\sim 3 \times 3$ $arcmin^2$	$\sim 35 \times 35$ $arcmin^2$	0.6×0.6 deg^2 (< 150 keV)
Time resolution	several 10 μs	several 10 μs	4 sec	several 10 μs
Operating temperature	−20°C	50 mK	−120°C	−20°C

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High-resolution spectroscopy

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High-resolution spectroscopy **Imaging up to 80 keV**

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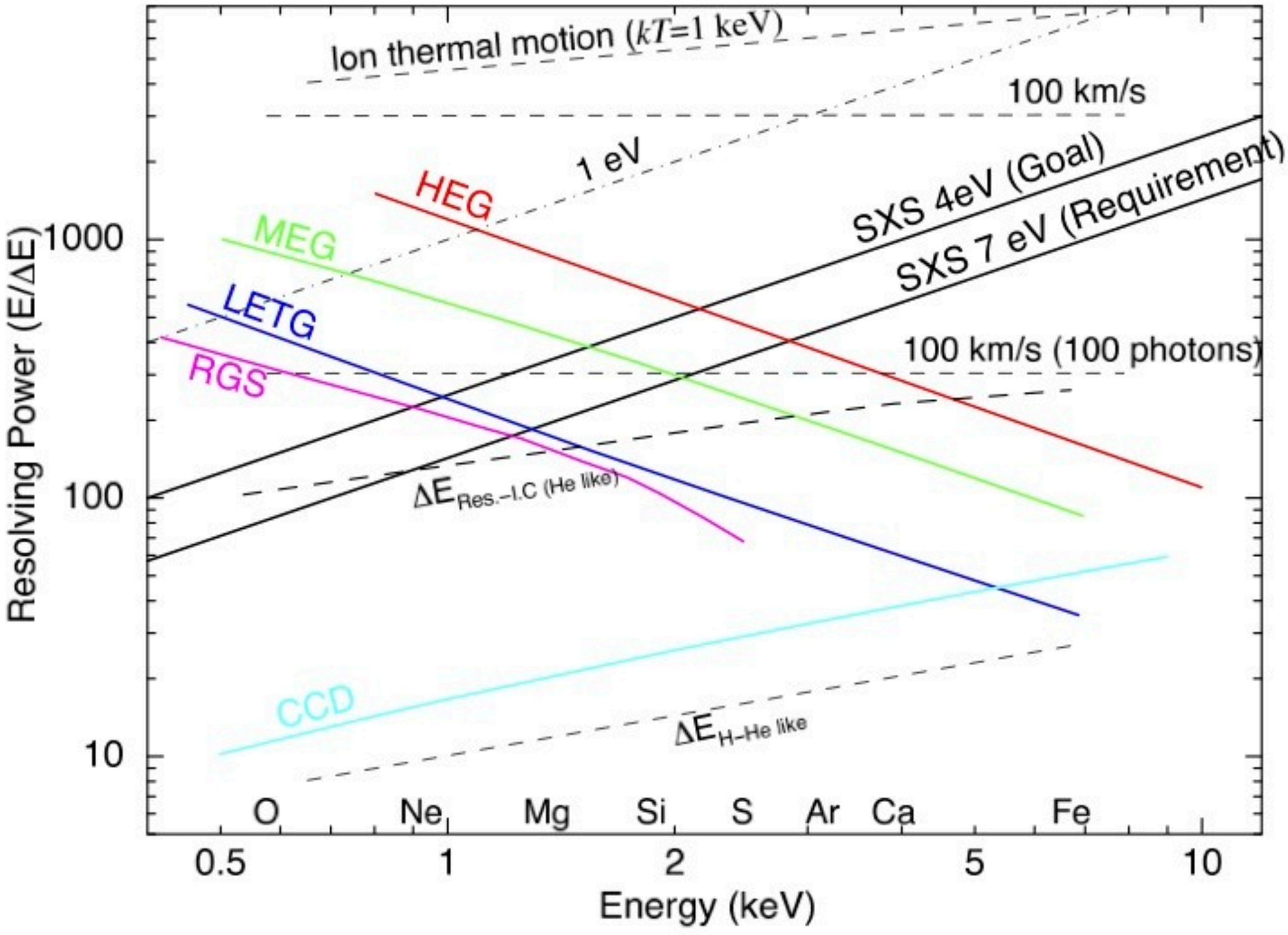
High-resolution spectroscopy **Imaging up to 80 keV** **Wide band, high sensitivity**

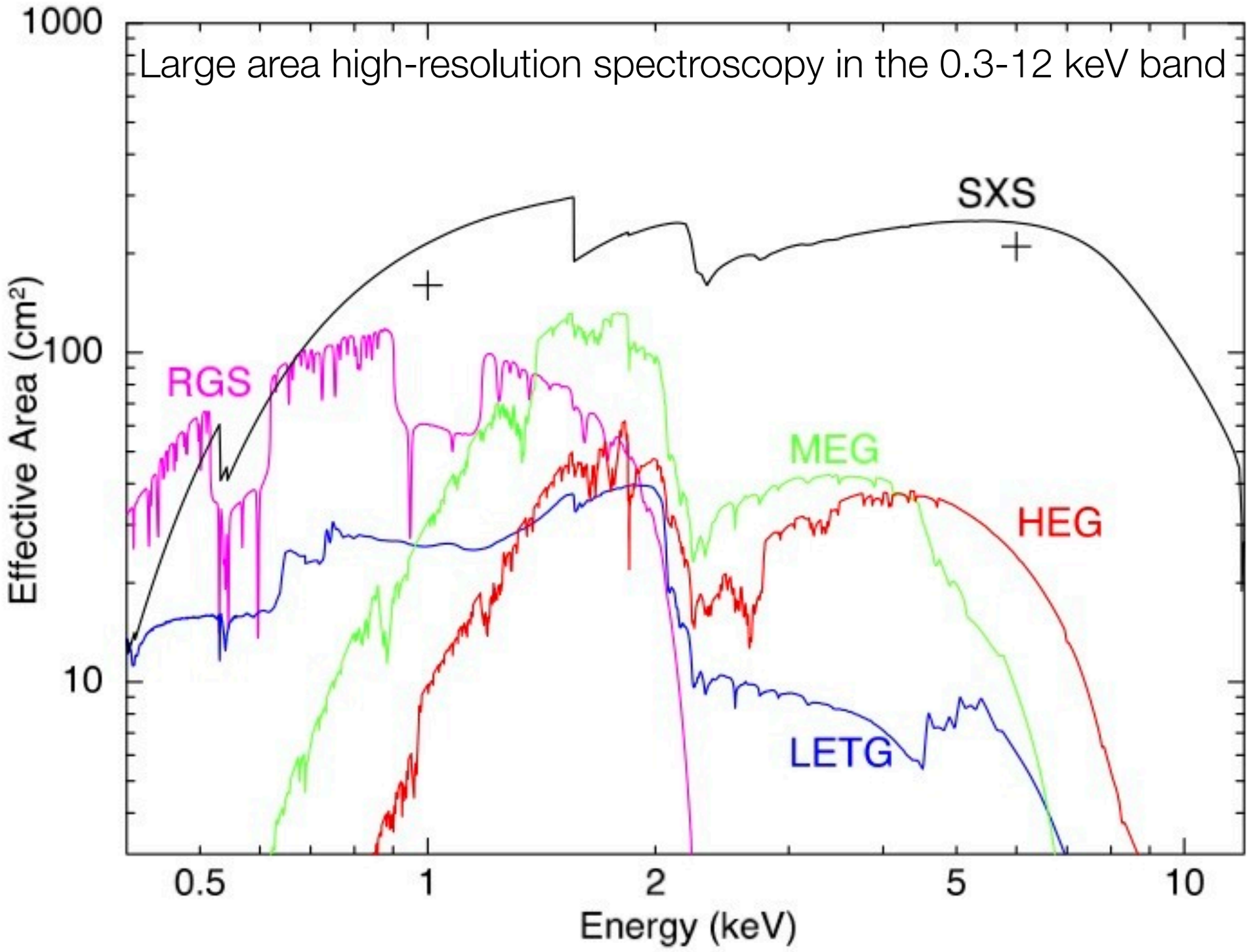
Resolving power

(Takahashi et al., 2012, SPIE, 8443, 1)



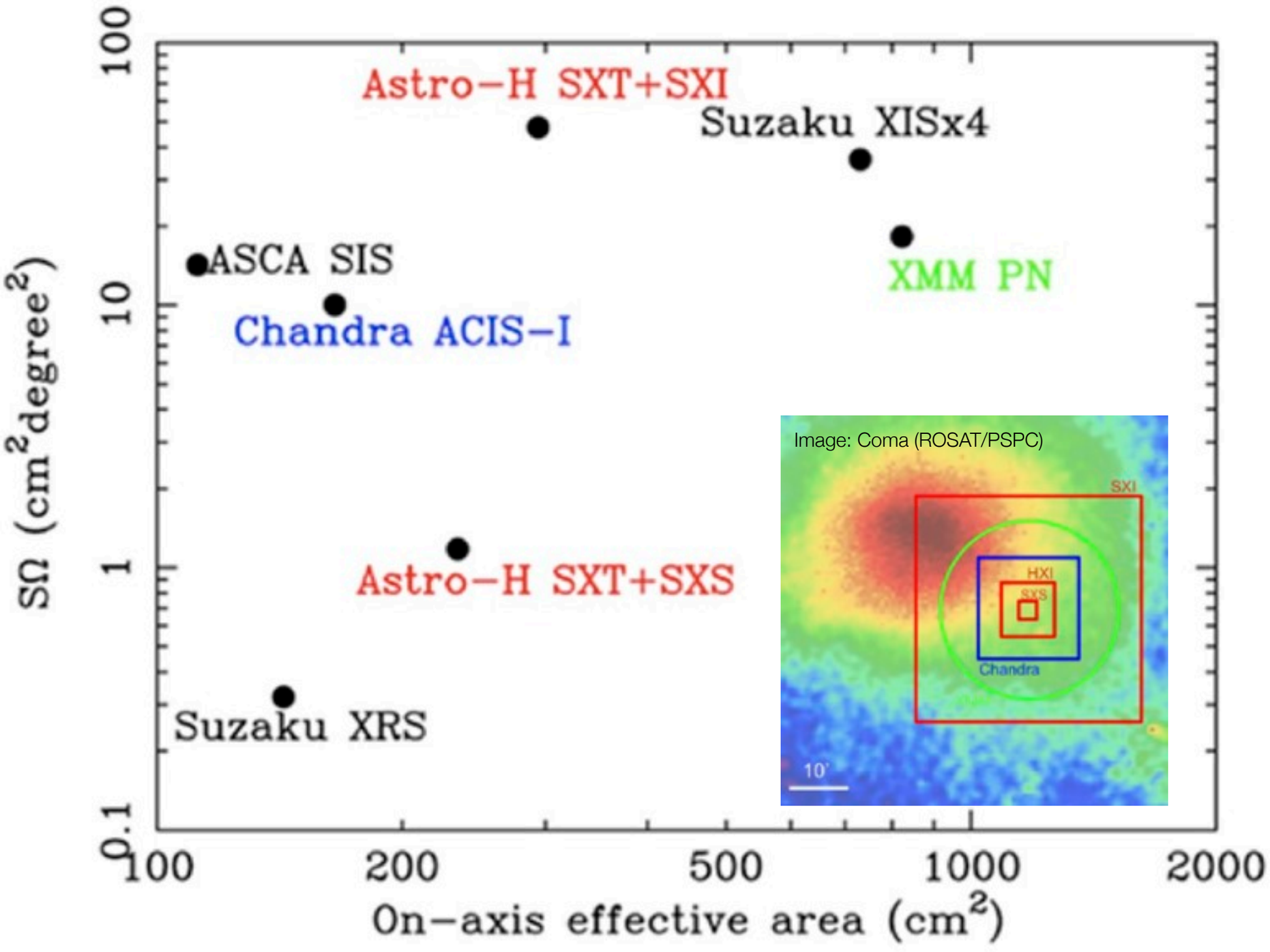
Effective area - I.

(Takahashi et al., 2012, SPIE, 8443, 1)



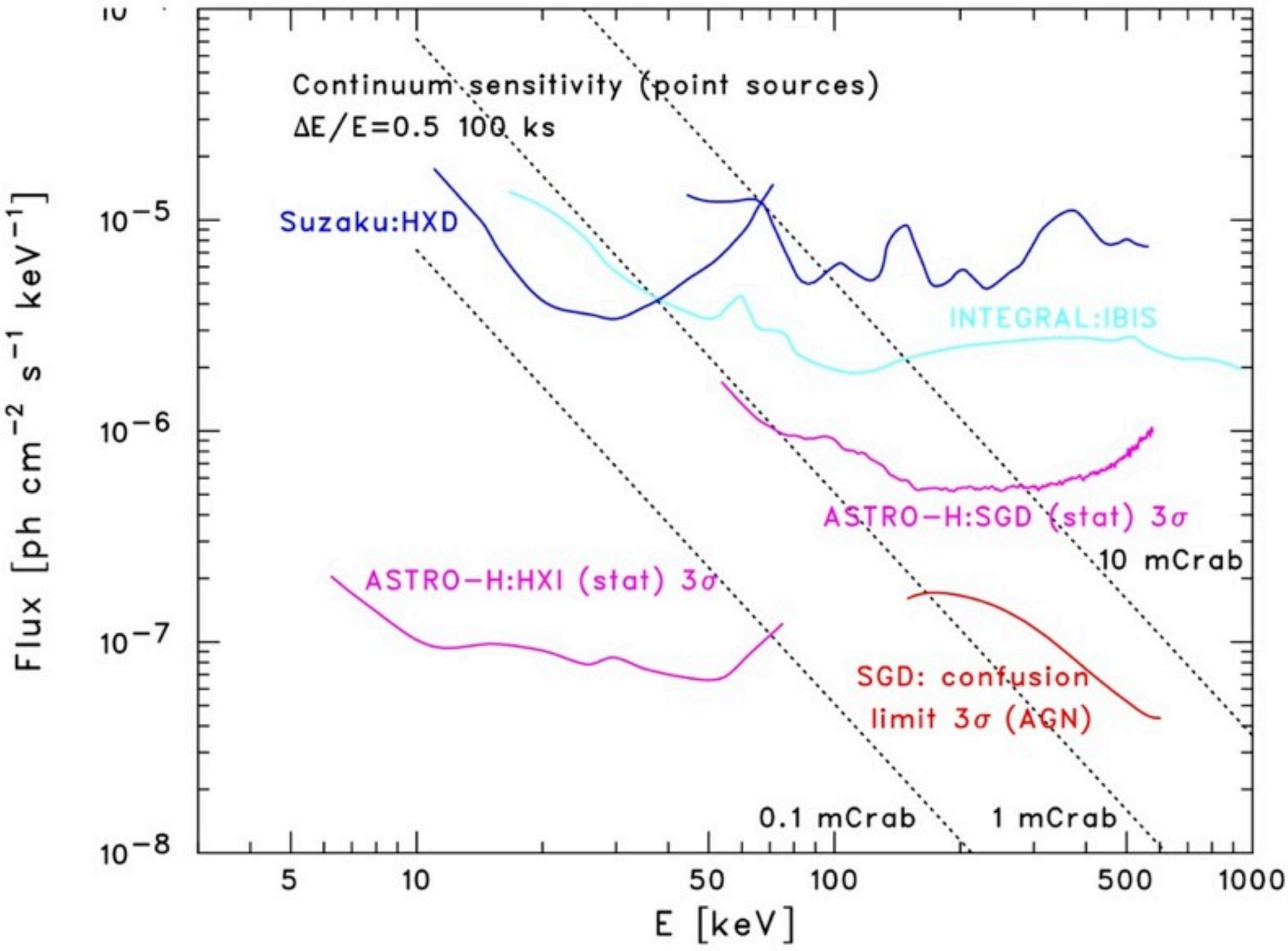
Effective area - II.

(Takahashi et al., 2012, SPIE, 8443, 1)



Effective area - III.

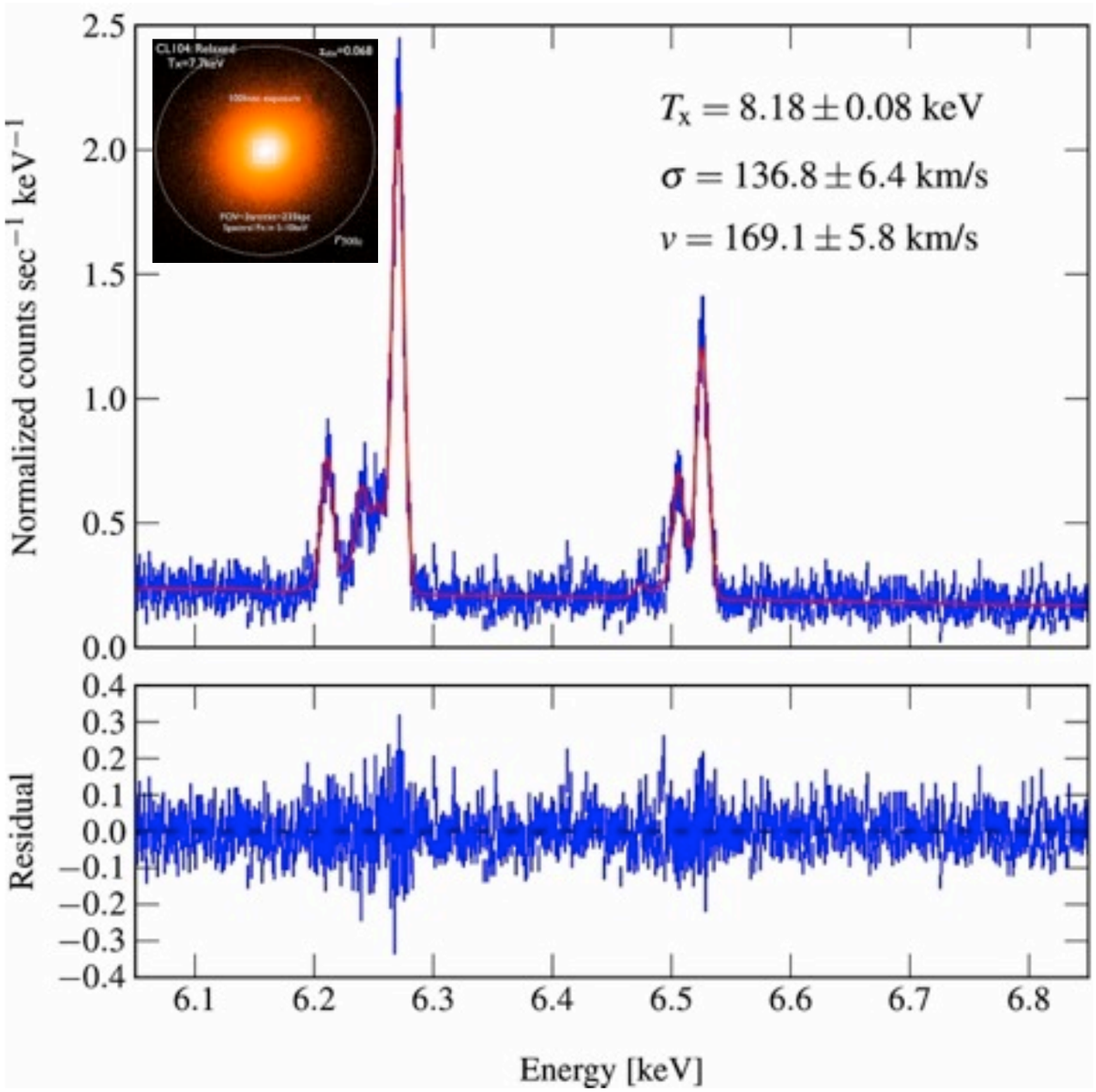
(Takahashi et al., 2012, SPIE, 8443, 1)



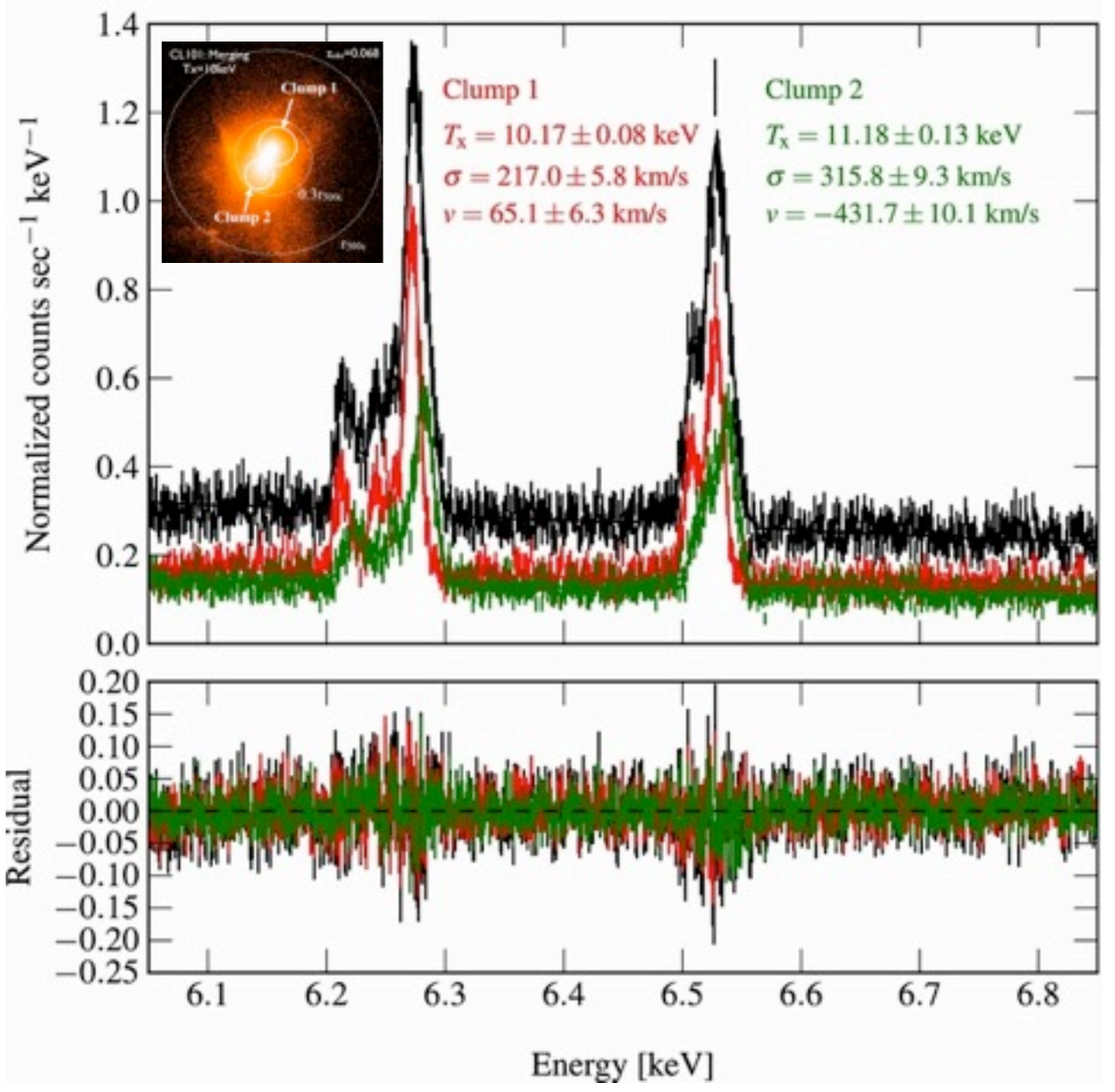
Science Goals I. : galaxy clusters

(Nagai et al., 2011, ApJ, 777, 137)

Unprecedentedly accurate measurements of streaming and turbulent gas motions - Non thermal X-ray emission from radio structures - Chemistry of rare elements - Cluster evolution up to z~1
Cosmology: hydrostatic equilibrium bias, signatures of dark matter, constraints on dark energy



Relaxed cluster



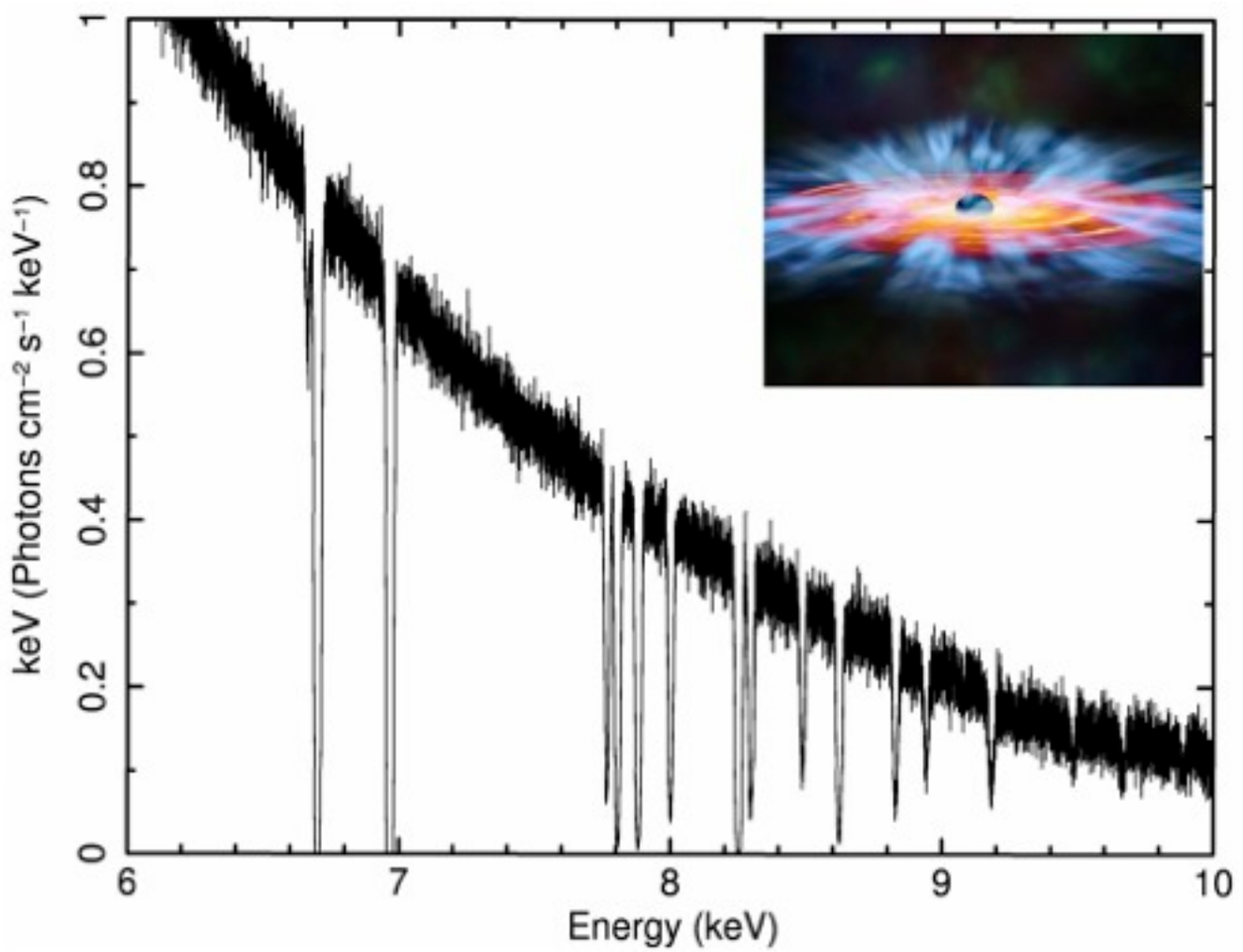
Merging cluster

Science Goals II. : SMBH outflows

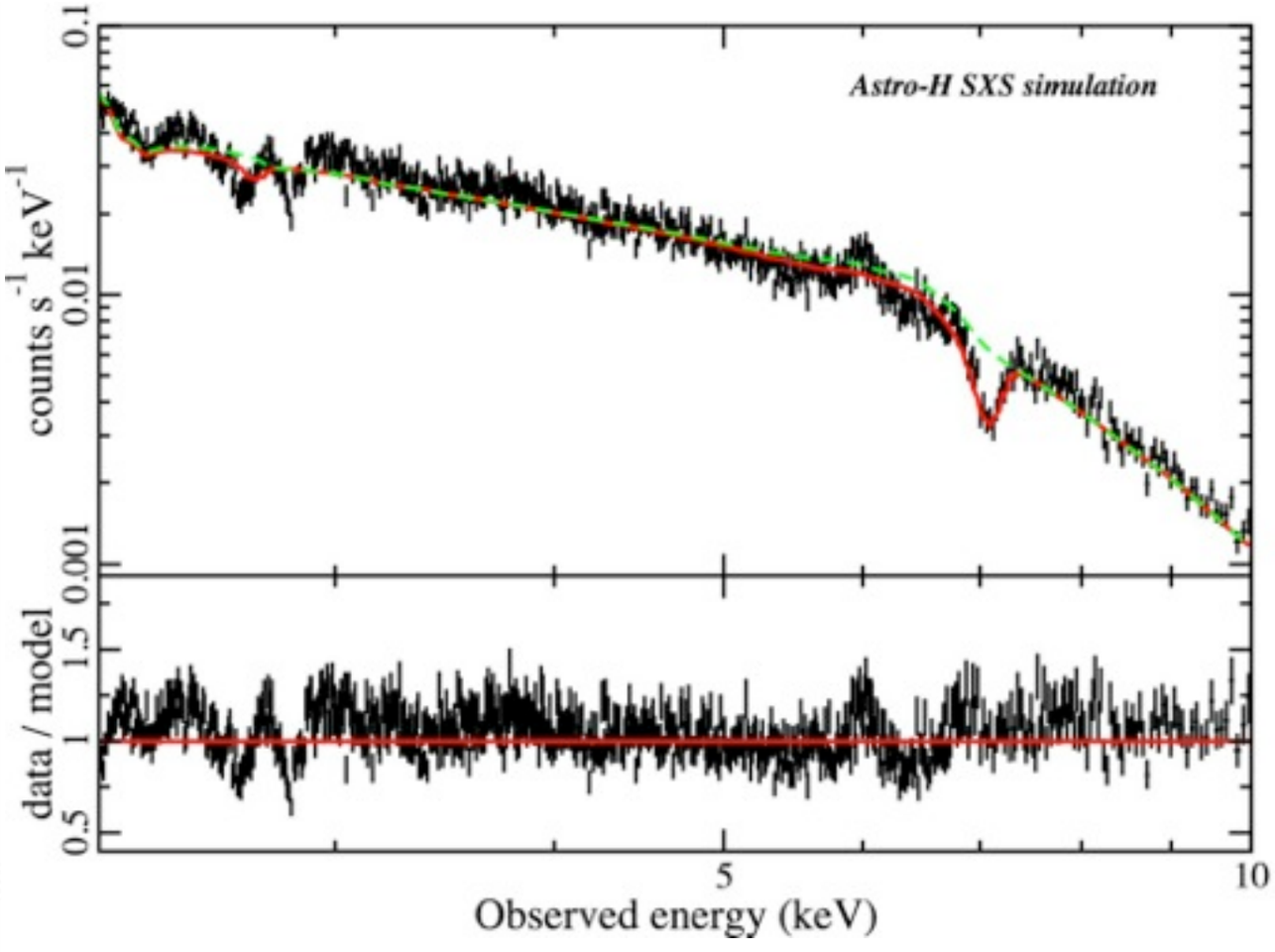
(Gallo & Fabian, 2013 MNRAS, 434, L66)

Measurement of wind velocity (outflow and circulation), density, covering fraction
AGN: host galaxy feed-back (UFOs); GBHC: disk/wind connection ⇒ driving mechanism

http://astro-h.isas.jaxa.jp/wp-content/uploads/2013/03/ahqr.pdf



100ks SXS simulation of GROJ1655-40



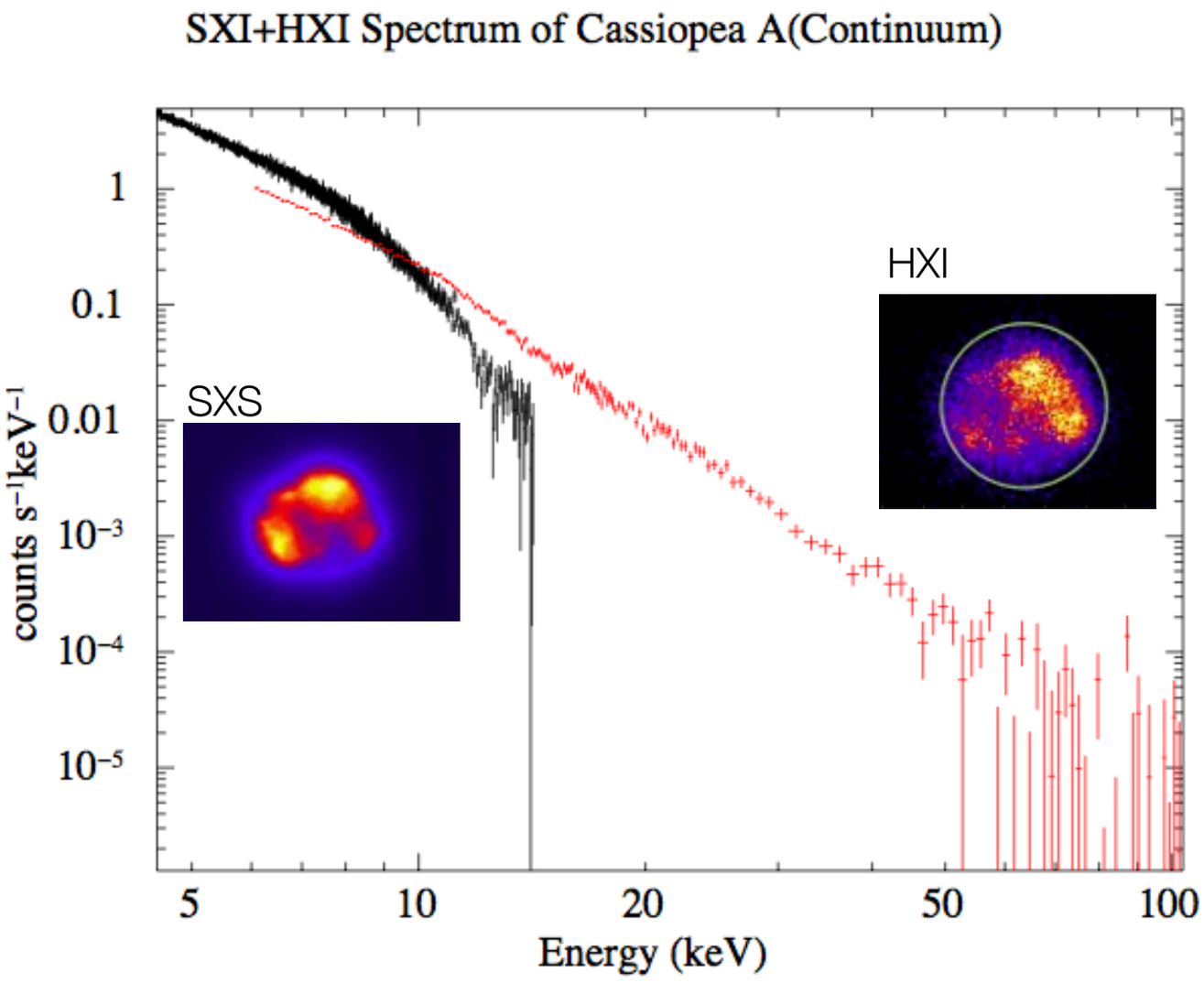
100ks SXS simulation of PG1211+143

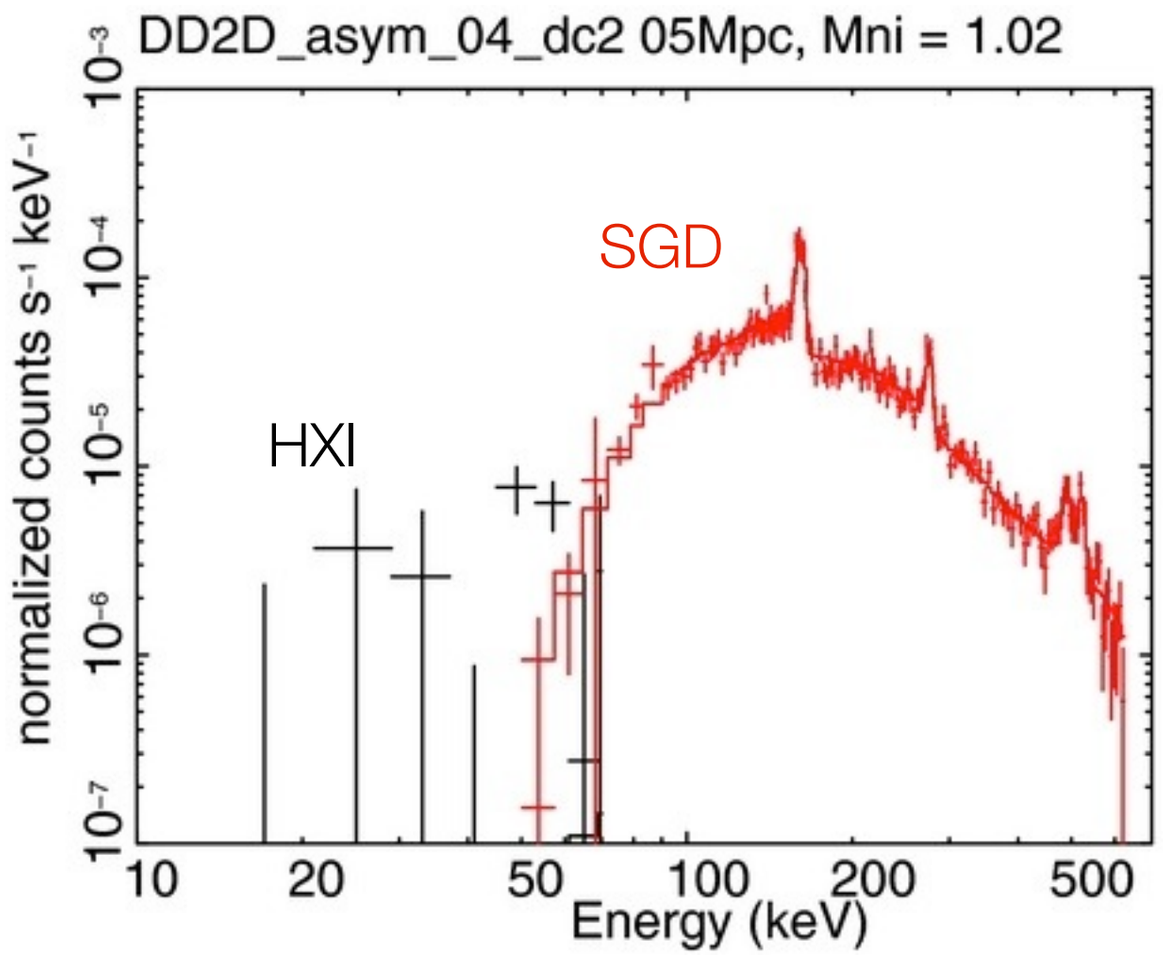
Science Goals III. : SNRs

(*Left*: Astro-H Shocks and Acceleration WP, in prep.
Right: Maeda et al., ApJ, 2011, 750, 64)

Synergy between SXS and HXI will allow measuring: a) acceleration efficiency; b) magnetic fields; c) maximum energy available at shocks sites ⇒ origin of Galactic cosmic rays

The SGD may detect the ^{56}Ni 158 keV lines in Sn_e Ia up to 25 Mpc (~a few per year)





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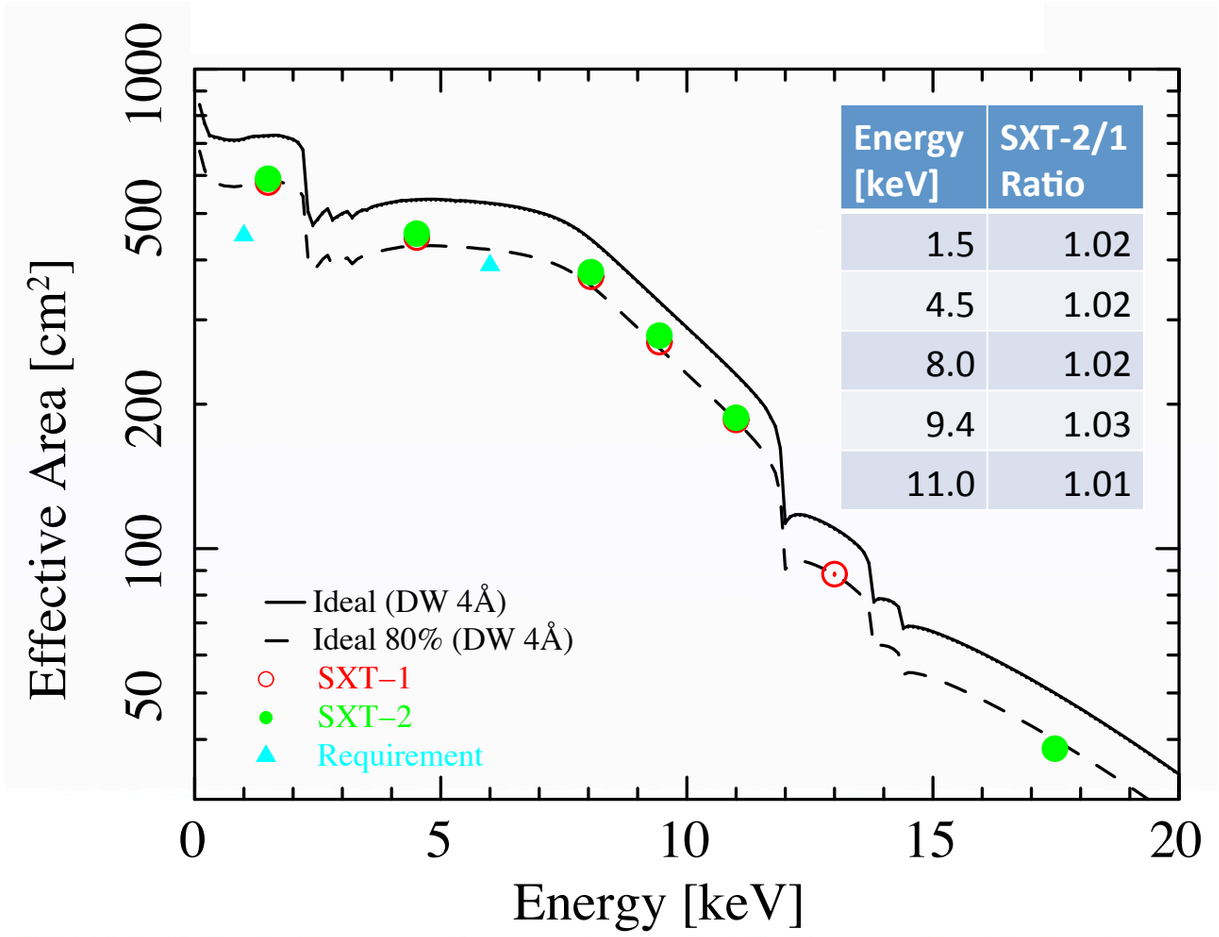
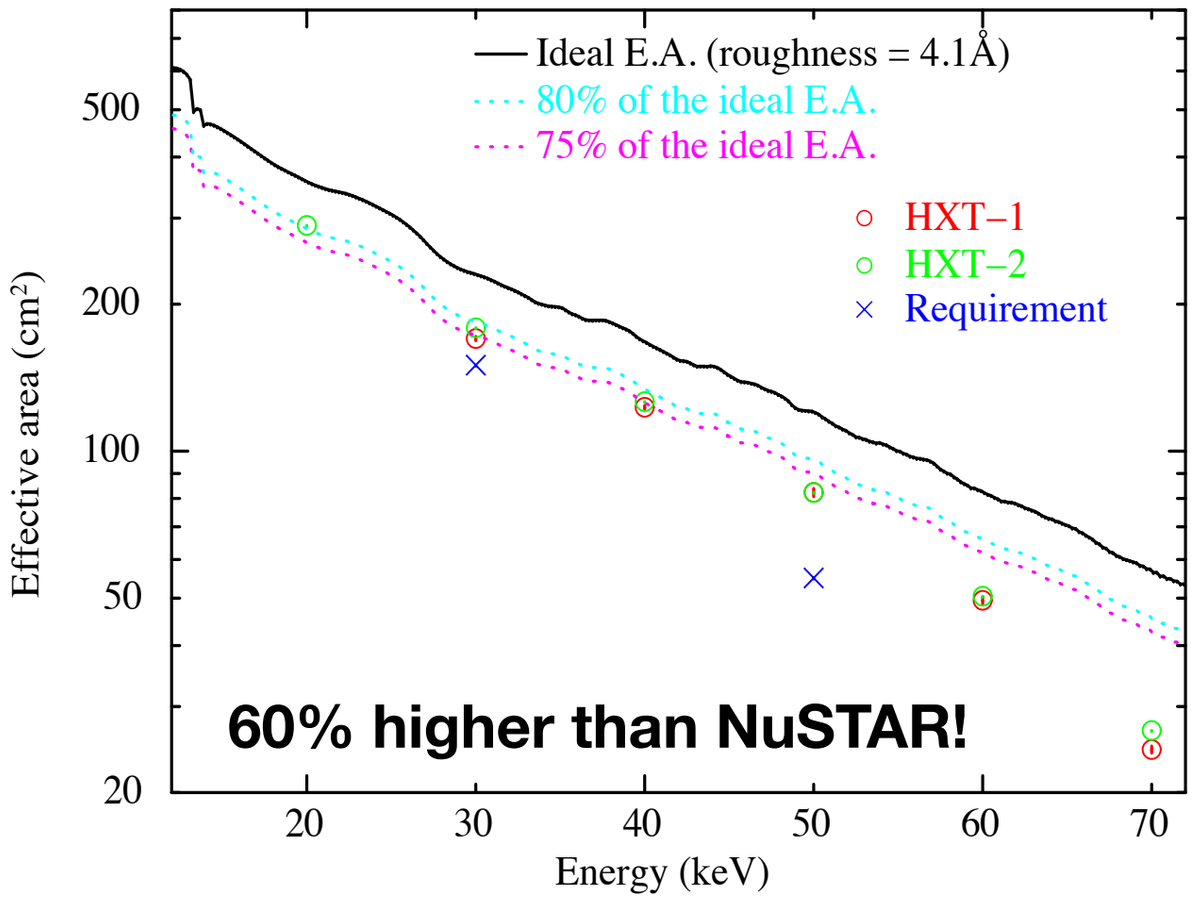
Telescope status

(*Left*: Courtesy T.Okajima & the SXT Team
Right: Courtesy M.Ishida & the HXT Team)

Effective areas: measurements vs. requirements



Energy [keV]	SXT-2/1 Ratio
1.5	1.02
4.5	1.02
8.0	1.02
9.4	1.03
11.0	1.01



PSF Half Power Diameter:

SXT-1~1.3', SXT-2~1.2'

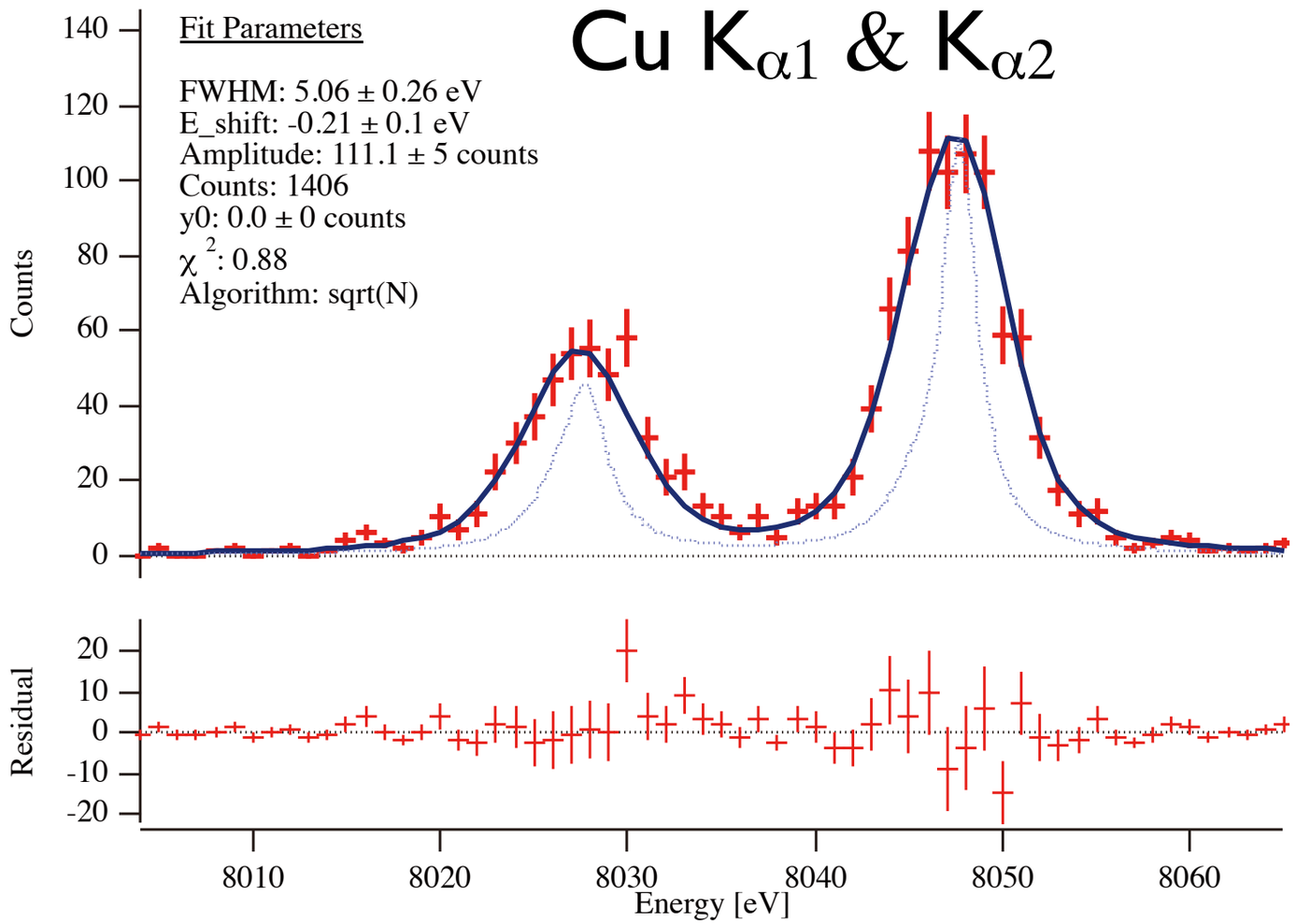
HXT-1~1.5'-1.9', HXT-2~1.6'-1.9' (lower at higher energies)

XCS status*

(Courtesy R.Kelley, NASA, and K.Mitsuda, ISAS/JAXA)

*SXS=SXT+XCS

- HgTe absorber micro-calorimeter, 0.3-12 keV band
- 36 pixels, ~3×3' field-of-view
- Operation temperature: 50mK±2μK per 24-hour cycle
- Constant resolution over the whole bandpass: ~5 eV (in the *Engineering Model*)
- Non-dispersive spectroscopy, unaffected by source angular size
- Filter+modulated X-ray source: 1-2 eV gain monitoring accuracy (*European contribution*: SRON & Un.Geneva)

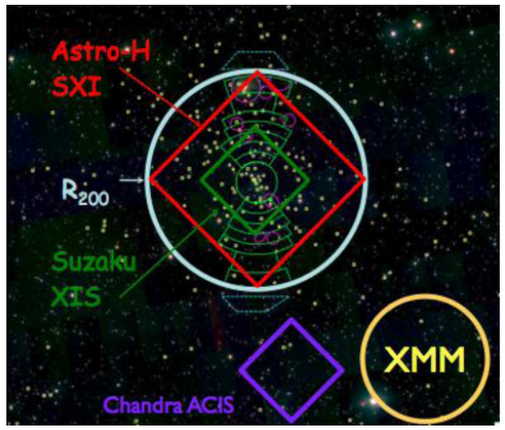


Resolution measurement during the calibration of the engineering module

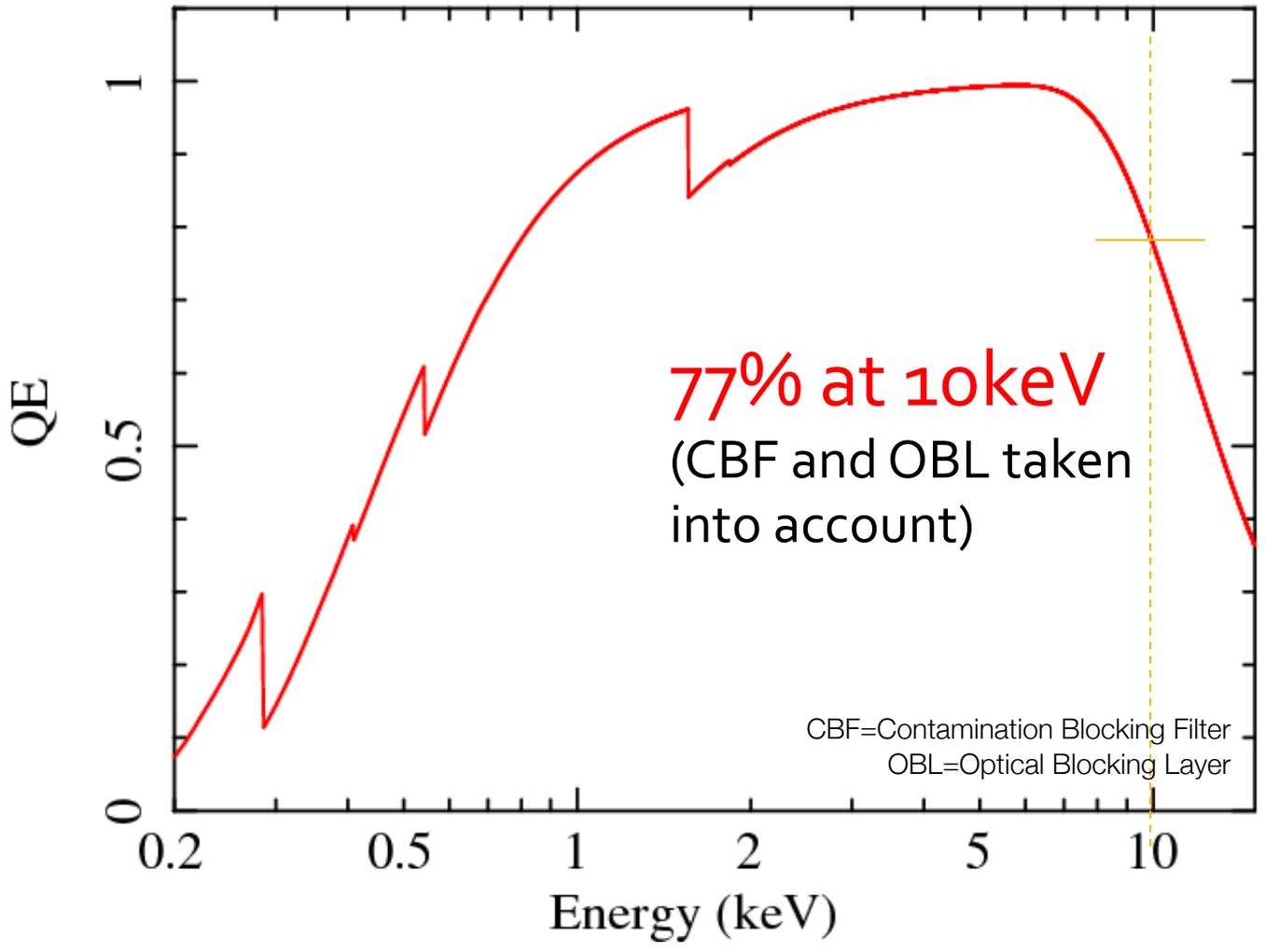
SXI status

(Courtesy H.Tsunemi, Osaka University)

- 4 P-channel CCDs mosaic, 200μm depletion layer, -120ºC operation temperature



- 38'×38' field-of-view, large grasp
- Back-illuminated CCD: good soft X-ray quantum efficiency and resilience against micro-meteroid impact

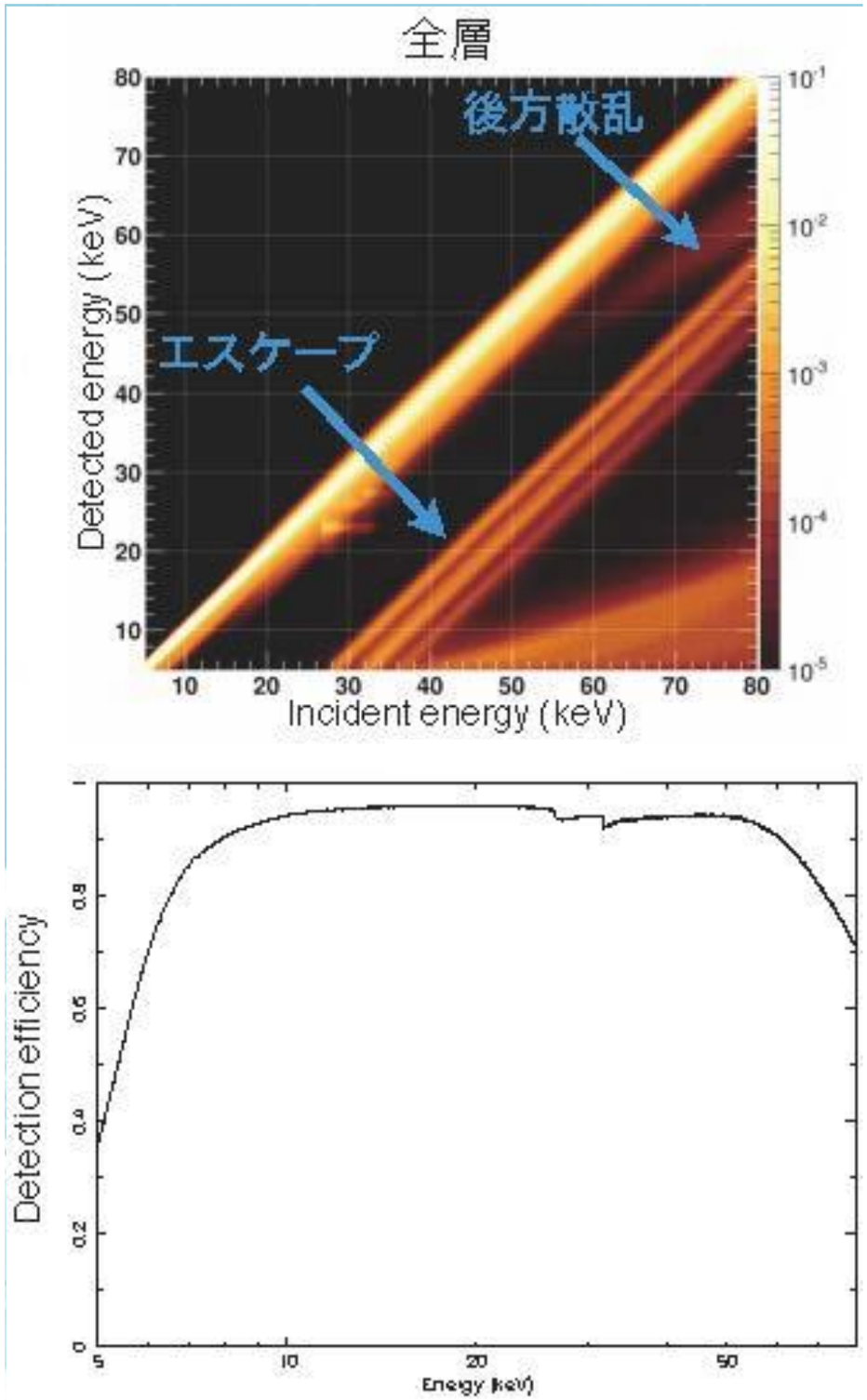


- FWHM: ~140/160 eV @5.9 keV for grades 0/0-6
- Various clocking modes
- Charge injection anticipated (as in the *Suzaku*/XIS)

HXI status

(Courtesy M.Kokubun and the HXI Team)

- 2 units, 5 layers each to optimise the energy-dependent detection and reduce volume, *i.e*. soft background
- 4 layers of 0.5mm thick Double-sided Silicon Strip Detectors (<30 keV)
- 1 layer of 0.7mm thick CdTe (20-80 keV)
- Active BGO scintillator shield to further remove background events
- ~2 keV energy resolution @60 keV

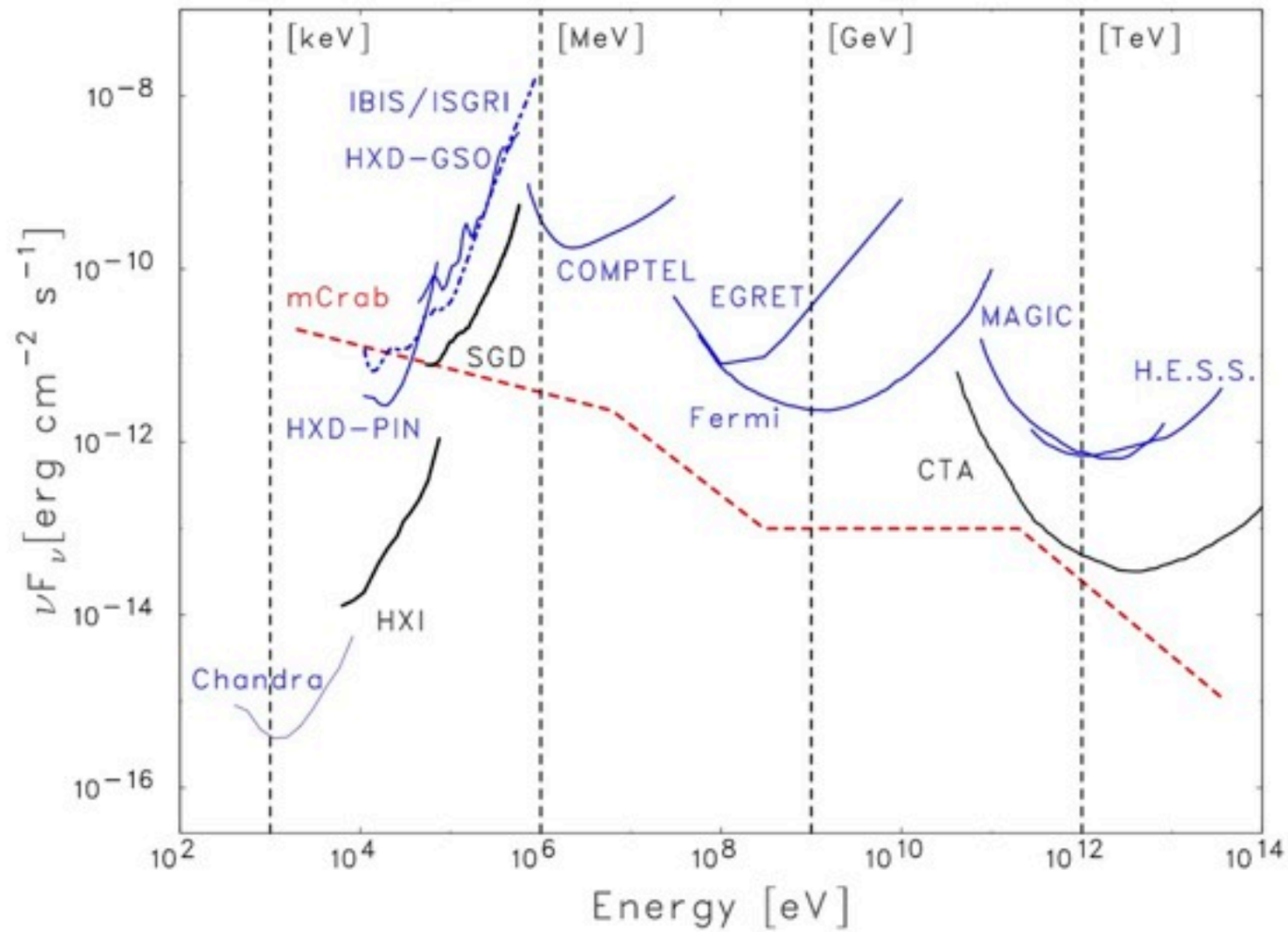


SGD status

(Takahashi et al., 2012, SPIE, 8443, 1; courtesy Poshak Gandhi, Durham Un.)

- Si/CdTe Compton camera, 40-600 keV, ~10 times more sensitive than *Suzaku*/HXD
- Compton kinematics allows the calculation of energy and provenance cone-in-the-sky
- Drastic background reduction through a narrow-FOV (~30') Compton telescope concept (BGO shield+PCuSn collimator)
- Can measure soft-γ polarization for sources ≳a few 10^{-2} Crab, ≳10% polarized

HXI and SGD sensitivity compared to the mCrab and other instruments



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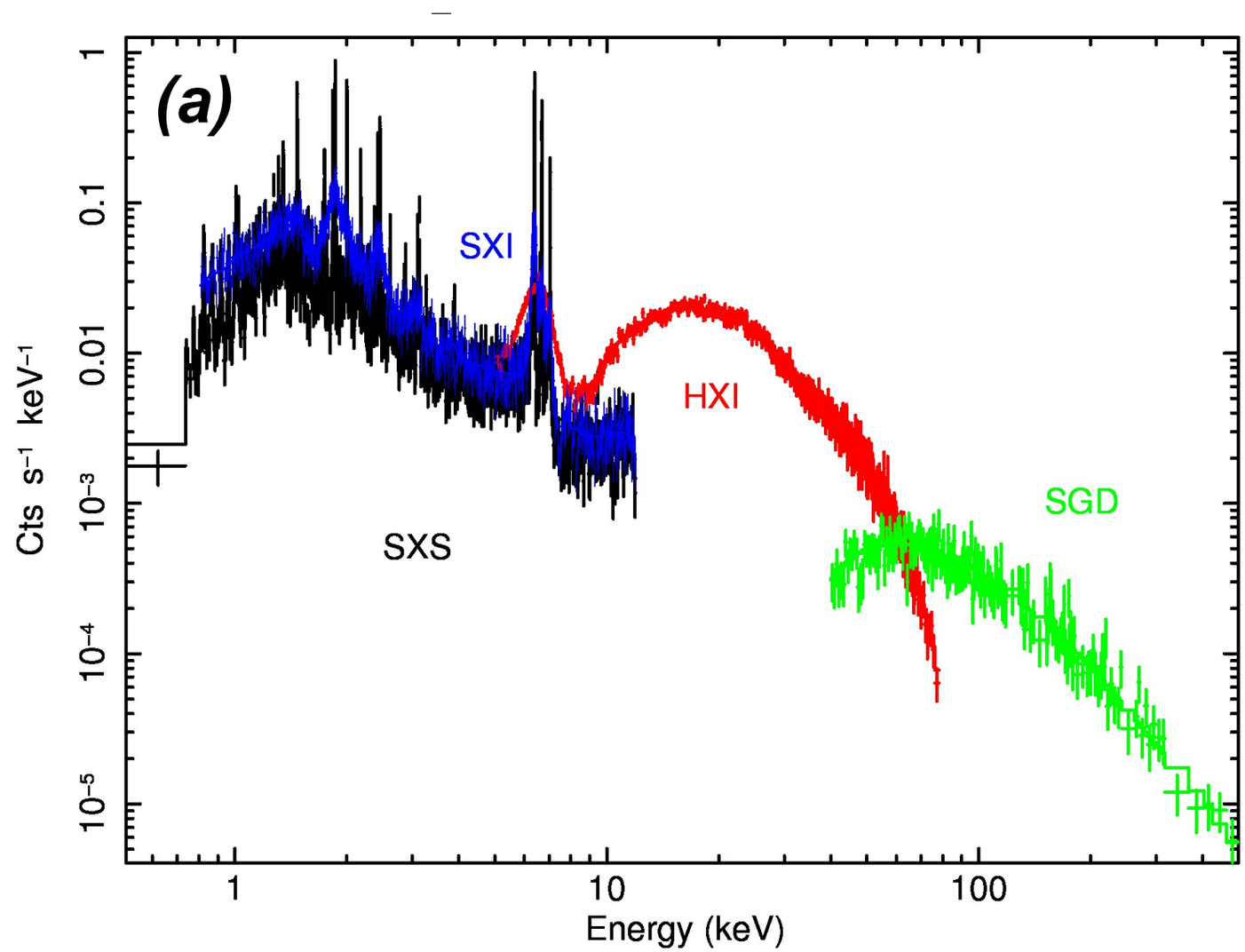
100 ks simulation of NGC4945
starburst-Seyfert 2 composite galaxy



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European contribution to ASTRO-H

(ESA/SPC(2011)6)

- Cooperation agreement with JAXA approved by the 132nd ESA Science Programme Committee Meeting (February 2011):
  - Procurement of payload hardware element
  - Provision of technical support, especially on hardware contribution and cryogenic chain
  - Testing of detectors at European facilities
  - Sponsoring three ASTRO-H Science Team members
  - *Provision of user support for the European community*:
    - 1 fte at ESAC + 1 fte at JAXA + 2 fte at the University of Geneva (1.5 paid by Swiss funds)

ASTRO-H user support for the European community

(Audard et al., poster at *this Symposium*)

Science Operations Centre (SOC) at ESAC

- Handling of European Announcement of Opportunities, proposal technical evaluation, OTAC support
- Liaison with JAXA for the implementation of European proposals and cross-calibration observations
- Storage and dissemination of data
- Support to calibration and operations at JAXA

ESAC, Spain

Current personnel:
Matteo Guainazzi (@JAXA)
Peter Kretschmar
Celia Sanchez

Science Support Centre (ESSC) at UNIGE

- Promotion in Europe (w/SOC)
- Expert knowledge on ASTRO-H instruments for European users
- Review user's documentation
- Training activities for European astronomers
- Contribute to the validation of calibration and data analysis software

Écogia, Versoix, Switzerland

Current personnel:
Marc Audard
Carlo Ferrigno
Stephane Paltani

Project Scientist: David Lumb (ESA-ESTEC)

European ASTRO-H HelpDesk

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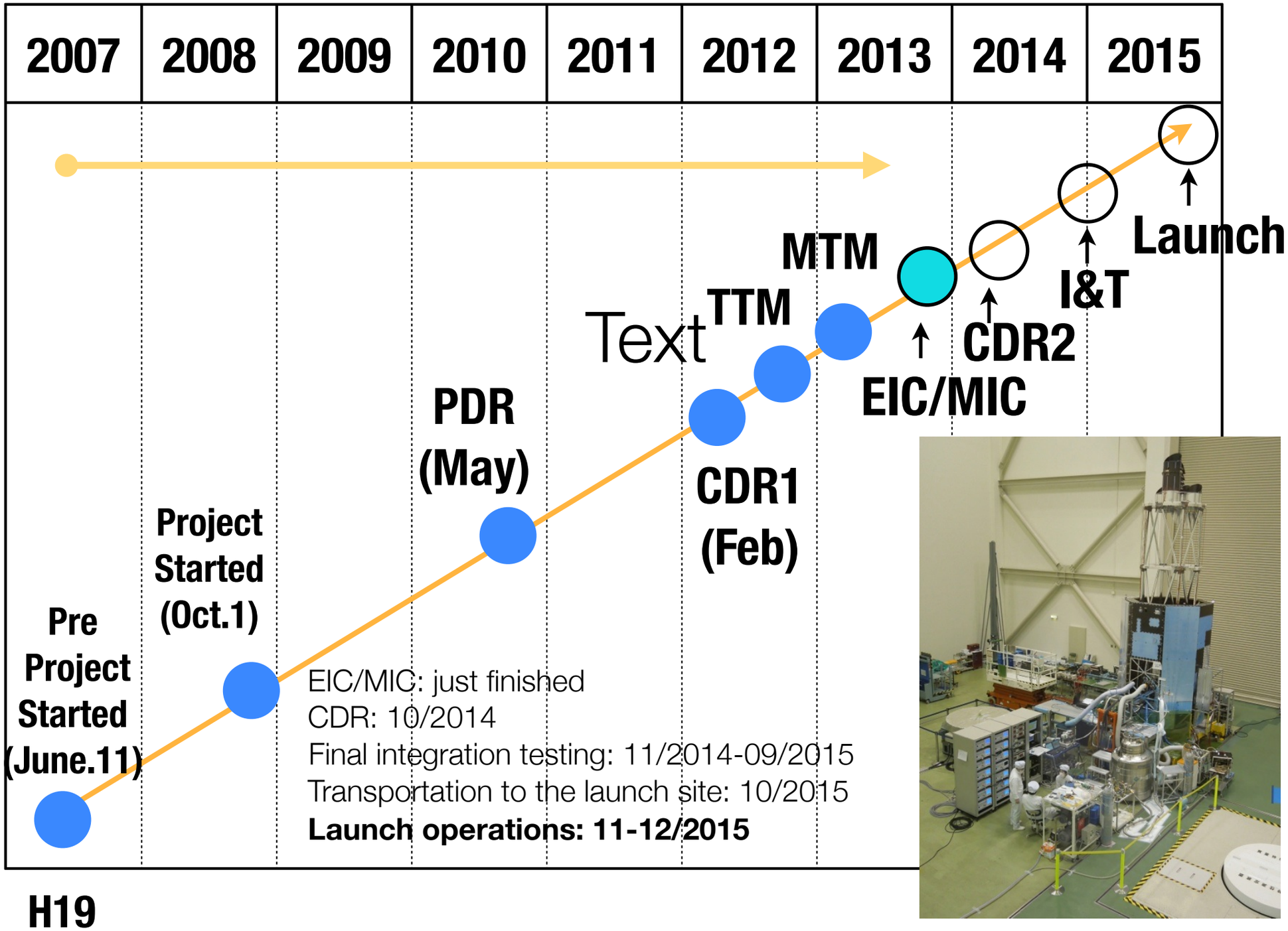
View Tickets — Hide Resolved Tickets

Ticket ID	Last Update	Last Replier	Department	Type	Status	Priority
SXS responses						
12	09 May 2014 10:59 AM	Matteo Guainazzi (user)	Soft X-ray Spect...	Issue	Closed	Normal

Operated by ESSC and (wo)manned by ESSC/SOC astronomers: `http://astroh.unige.ch/helpdesk`

ASTRO-H timeline

(Courtesy T.Takahashi, JAXA)



The real thing ...

(Courtesy T.Takahashi, JAXA)

EIC/MIC just completed!