Challenges on *Astro-H* Data Analyses & Software from *Suzaku* Lessons

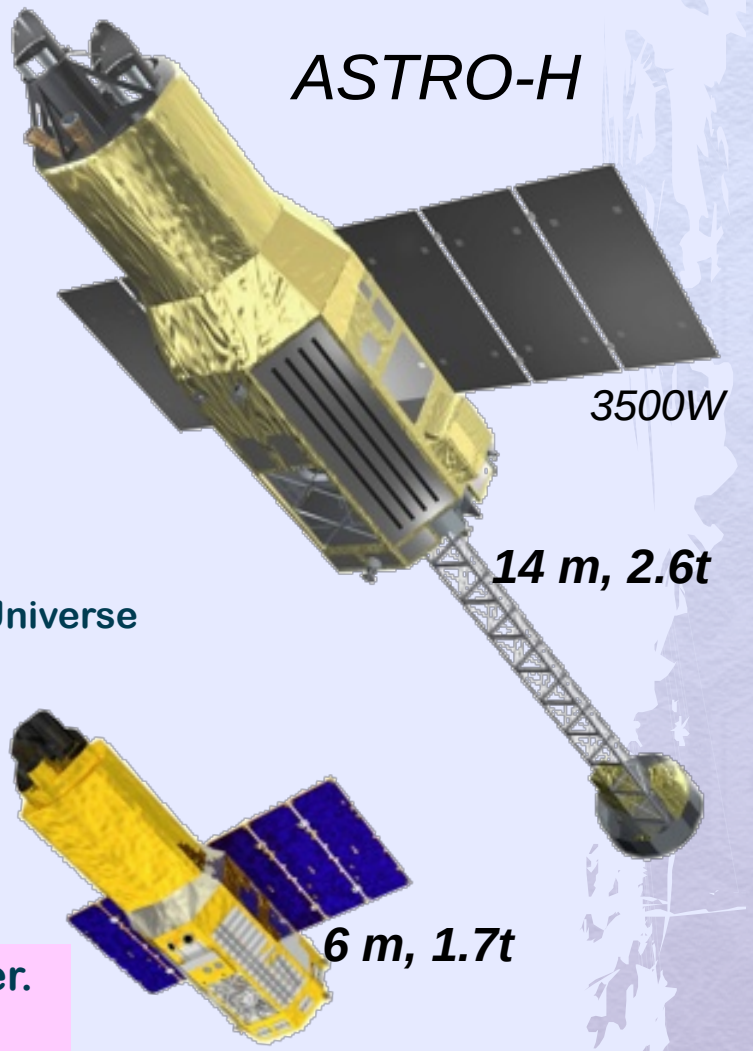
Yukikatsu Terada (Saitama Univ, Japan),
on behalf of
the Astro-H Software Calibration board

SKIP (Rob Introduction)

Overview of the *Astro-H* mission

The sixth series of the Japanese X-ray satellite.
Collaboration with JAXA, NASA, and ESA.
Launch Year : 2014

• Launch site: Tanegashima Space Center, Japan	
• Launch vehicle:	JAXA H-IIA rocket
• Orbit Altitude:	550km
• Orbit Type:	Approximate circular orbit
• Orbit Inclination:	~31 degrees
• Mission Lif:	> 3 years



Scientific objectives :

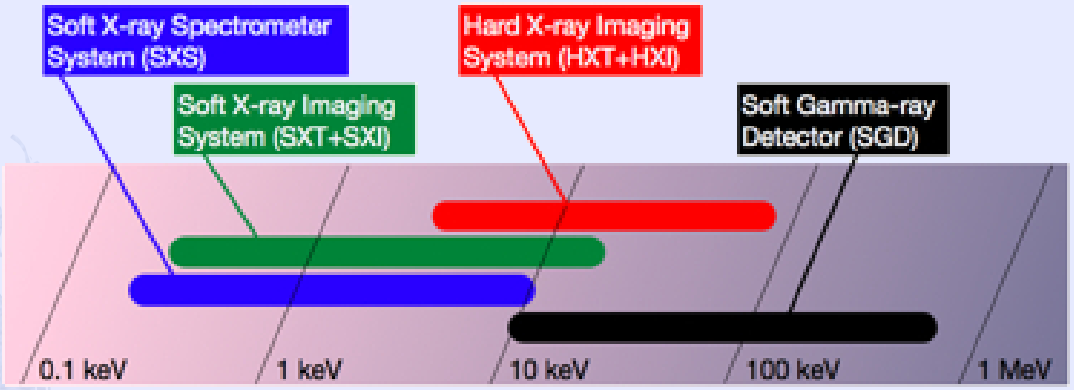
- Revealing the large-scale structure and its evolution of the Universe
- Understanding the extreme conditions in the Universe
- Exploring the diverse phenomena of non-thermal Universe
- Elucidating dark matter and dark energy

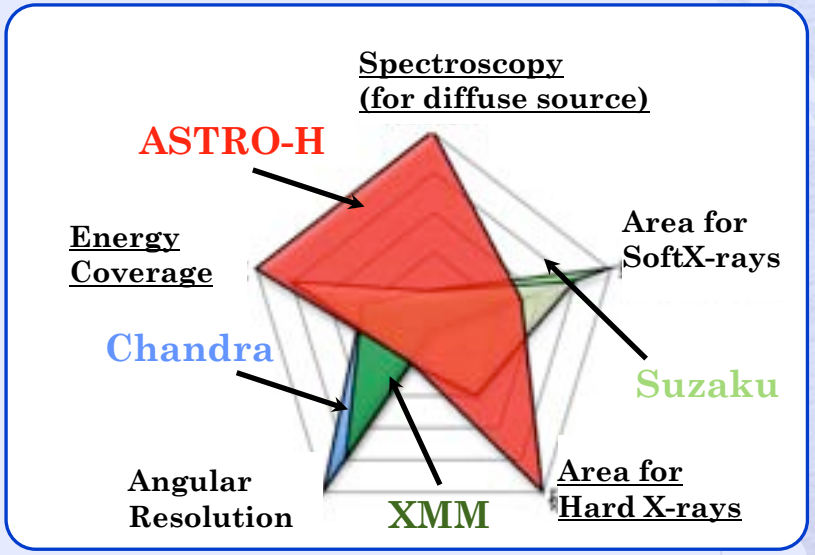
Key features :

1. The high energy resolution of the micro-calorimeter.
2. The hard X-ray telescope.
3. Sensitive wideband observation in the 0.3 to 600 keV.

SKIP (Rob Introduction)

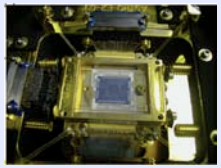
Instruments onboard *Astro-H*

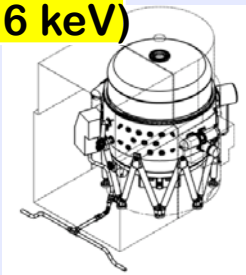




Soft X-ray Spectrometer System

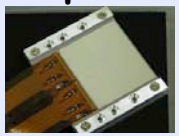
- 0.3-12 keV
- Large Area Soft X-ray Telescope
- X-ray micro calorimeter
- Super resolution (<7eV at 6 keV)





Soft X-ray Imaging System

- 0.5-12 keV
- Large FOV 38x38 arcmin^2
- CCD spectroscopy

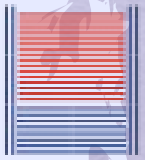


Hard X-ray Imaging System

- Hard X-ray Telescope (5-80 keV)
- Focal Length 12 m
- New CdTe Imager (Fine Pitch Cross Strip)

Soft Gamma-ray Detector

- 10-600 keV non-imaging
- Si/CdTe Compton Camera with Narrow FOV
- Most sensitive in gamma-ray
- Hard X-ray Polarization



Calibration & Software
From *Suzaku* to *Astro-H*

◆ **Lessons from Suzaku Calibration & User Supports**

✓ Software + Calibration activities should work together.

All information should be included (lessons from ASCA; successful in Suzaku)

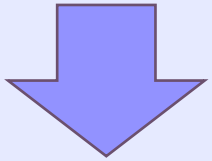
Not to delay the release of CALDB & tools (support Instrument team !)

✓ Management of the calibration.

step-1: calibration planning by Instrument Team → SCT+Sci+IT

step-2: ensure calibration quality by SWG ? → SCT

step-3: execute calibration by Instrument Team → IT + calibrator



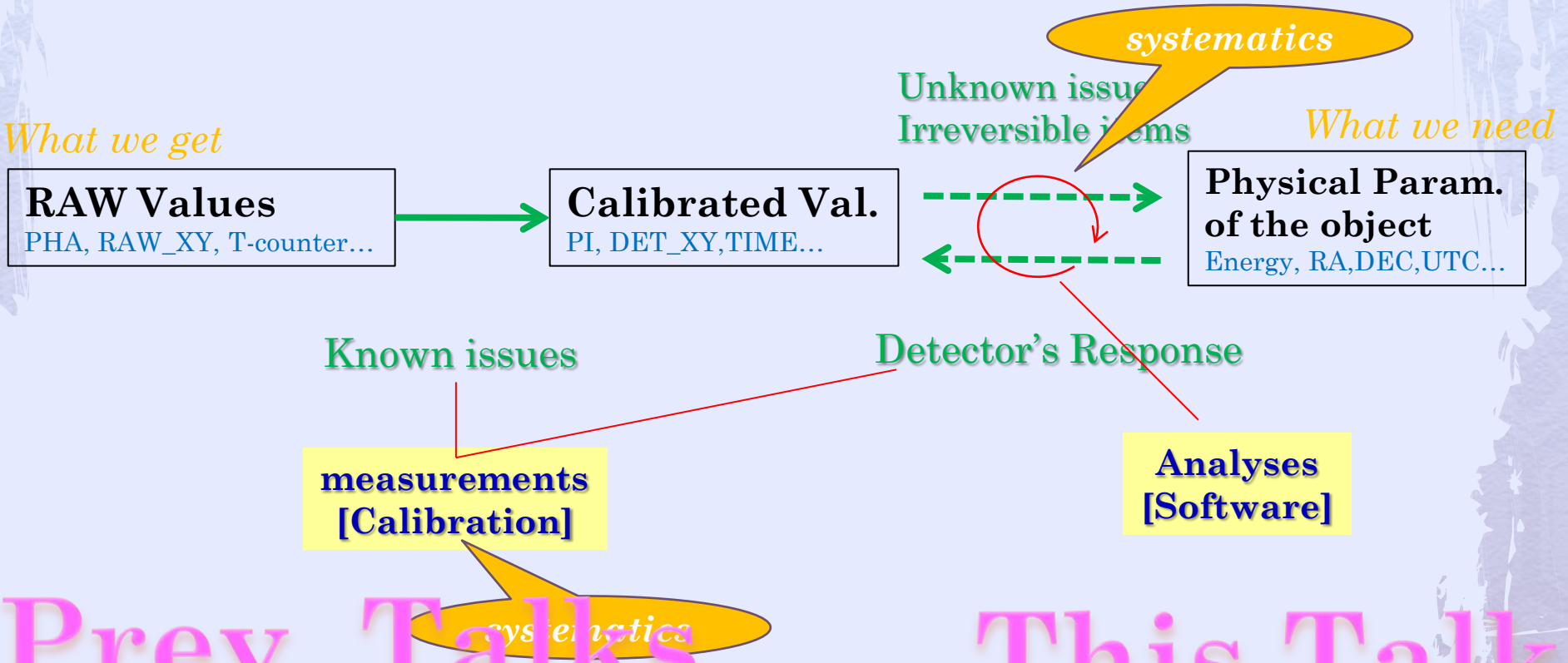
◆ **"Trial" on the Astro-H**

✓ define "**Software + Calibration team**"

- Pair structure of scientists and engineers for Software development
- Control calibration tasks on ground/in-orbit
- Calibration Plan Panel between SCT, science team and IT, with Science advisory & Calibration advisory

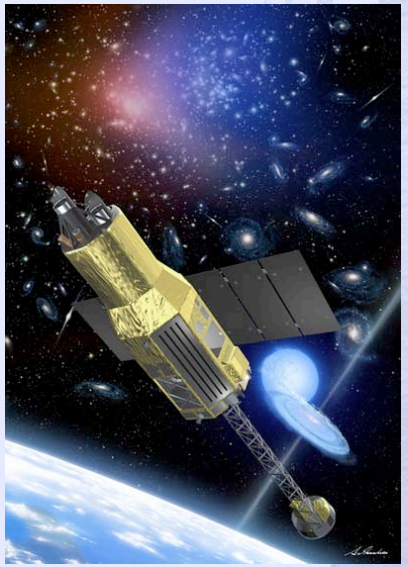
Calibration part & Software part

Goal: Measurements of physical parameters of objects



Key for us all (IACHEC):
How we reduce the systematic errors !

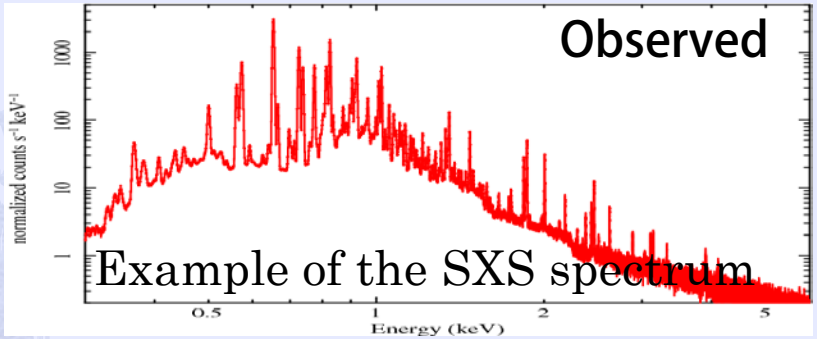
— My talk plan —
Astro-H Key features = Challenges

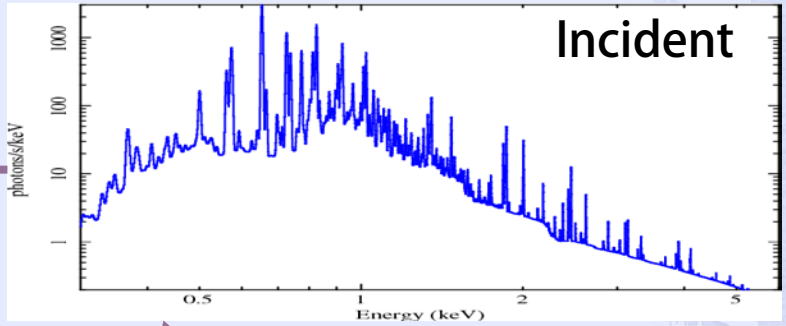


- **High Energy resolution Spectroscopy with the SXS**
  → Challenge 1
- **Imaging Spectroscopy with HXI+HXT and SXI**
  → Challenge 2
- **High sensitive measurement in Gamma-ray with the SGD**
  → Challenge 3

Challenge 1: High Energy resolution Spectroscopy with SXS

◆**Spectra with Super High resolution**





✓ Too many channels

✓Large RSP files
✓Systematics in the emission models

✓ Complex Spectra! (many lines, broadening, red shifts, multi-kT…)

→ **Many local minima in χ^2 fitting !**

◆ **New for Astro-H: "observe diffuse hot plasmas"**

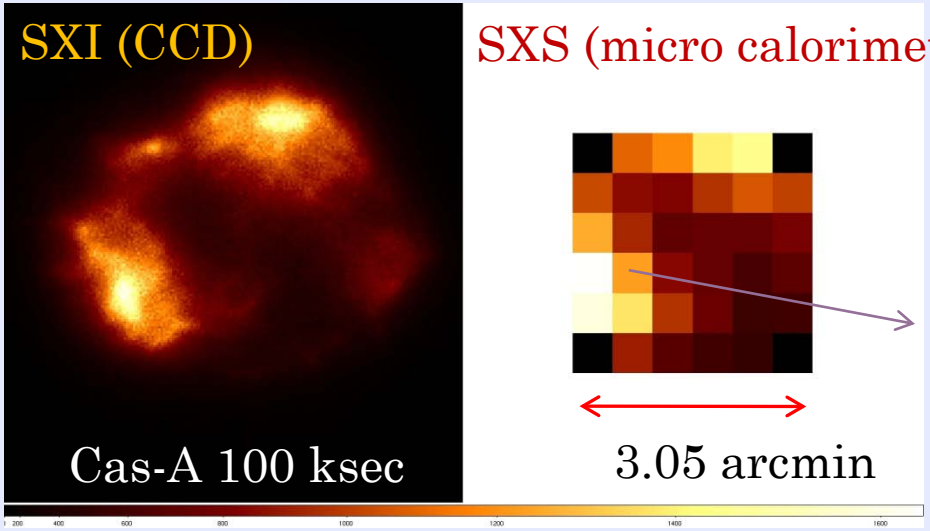
→ **More numbers of freedom !**

✓ blend of hot plasmas!

Need New Methods for high resolution spectroscopy?
IMPORTANT : Collaboration with experts of Grating instruments and theoreticians of the plasma codes in IACHEC !!

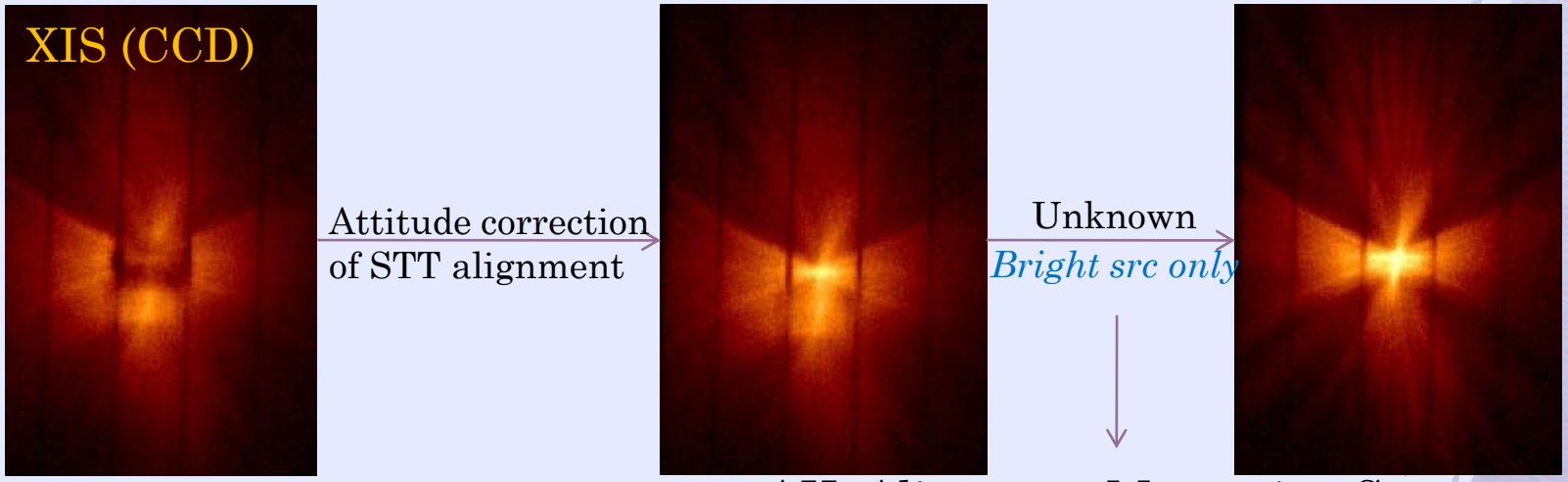
Challenge 2: Imaging Spectroscopy

✓ **[a] Number of Pixels of SXS is limited**



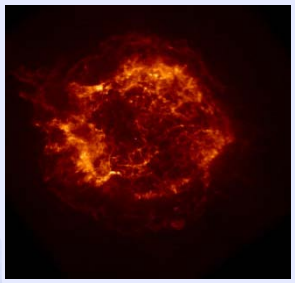
✓ **[b] Fluctuation of the alignment of the HXI+HXT**

Suzaku example of RX J1752-233 (Black Hole, Feb 2010, 40 ks)

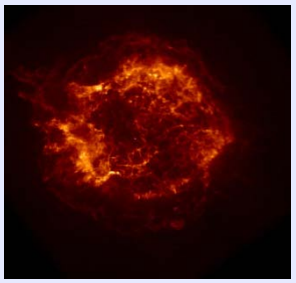


Non-measurable uncertainties (systematics) exist.

How to reduce the uncertainties?



Incident object
Image&Spectra



✓ Image Model
✓ Spectral Model

parameters

Real Optics

✓PSF
✓Vignetting
✓Alignment
✓Pixelize (digitization)

✓Unknown items

Irreversible

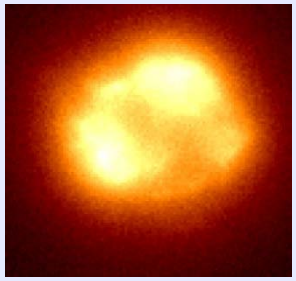
systematics

Simulator

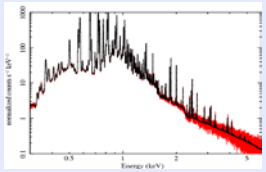
✓PSF = calib.
✓Vignetting
✓Alignment
✓Pixelize etc

✓Unknown = param.

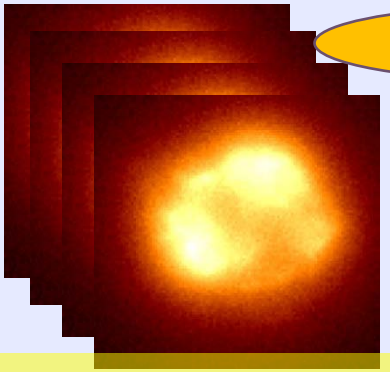
parameters

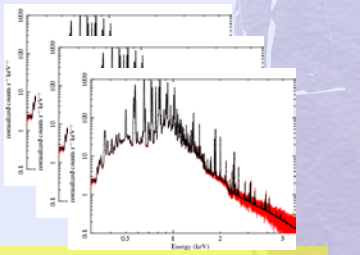


Observed
Data



Compare





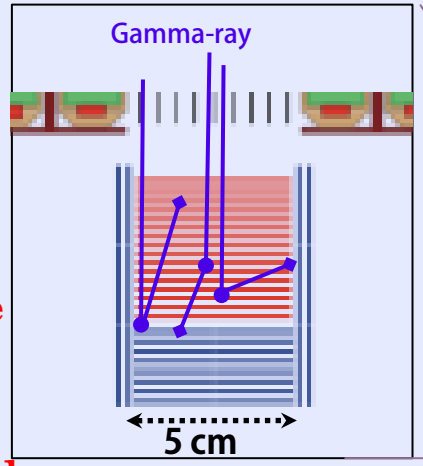
Forward Method will be effective. (KEY is the ray-tracing simulator.)

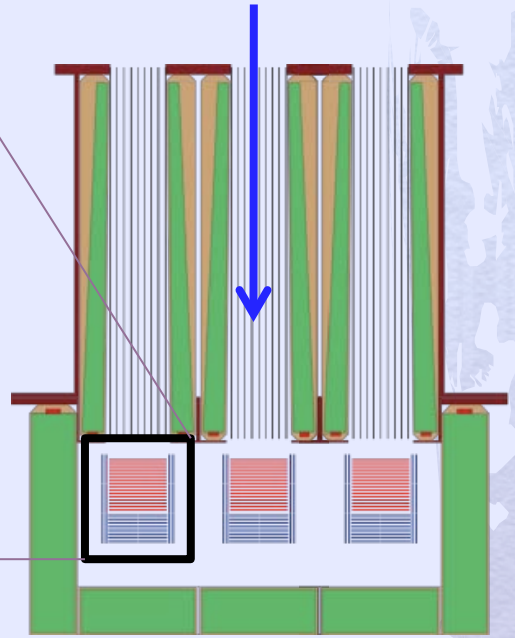
Challenge 3:
High sensitive gamma-ray observation with SGD
-- as a new type detector --

■**Compton Camera with Narrow field of View**

Imaging → Sensitivity

Effective background reduction in the reconstruction process

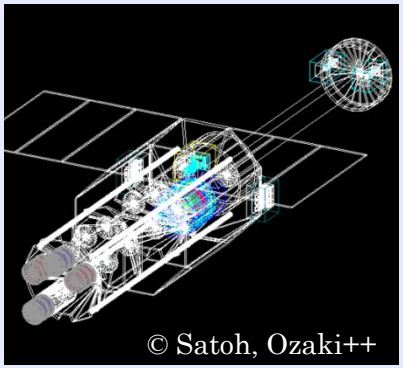




KEY

- **Calculation of the Energy Response**
  event selection from 35,000 ch data
  → # of dead ch affects the response.
- **Estimation of non X-ray background**
  cosmic-ray particle, activation background, albedo, …

■**Monte Carlo Simulator is KEY for the SGD**



✓rsp) Geant4 Mass Model, verification with on-ground/in-orbit calibration

✓nxb) "Physical (Geant4 +.)" and/or "Phenomenological " approach
← Phenomenological approach was successed for the *Suzaku* HXD
Only physical approach is available on ground (pre-flight phase).

Collaboration in Geant4 area is also very important!

Summary and proposal

- The X-ray satellite, *Astro-H*, will be launched in 2014.
  The key features of the *Astro-H* are followings;
  1) imaging spectroscopy with super high energy resolution
  2) hard X-ray imaging spectroscopy
  3) wide-band high sensitive observation with 0.3 – 600 keV

- We have started the software and calibration activities on *Astro-H*.

- Key features are, at the same time, the challenges for calibration and software.

- Most important thing for us, the IACHEC members, is
  continuous collaboration with each other !

One proposal from this talk from the software point of view:
set up **Systematic Working Group**
for preparation of simulators and analyses methods.