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Formation Flight Astronomical Survey Telescope (FFAST)

FFAST will reveal the evolution o f the universe

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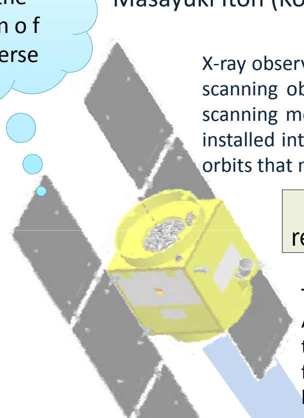
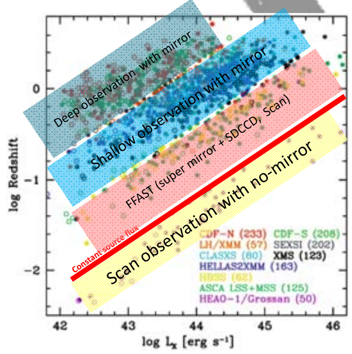
X-ray observation using X-ray focusing telescope is concentrated in the very narrow region in pointing mode. On the contrary, scanning observation for an entire sky is done by using non-focusing telescope. We plan to observe a large sky area in scanning mode by using a focusing super mirror covering the energy range up to 80keV. The mirror and the detector are installed into individual small satellites that will perform a formation flight by 20m. Two satellites will be put into Keplerian orbits that makes us possible to scan the sky. We will present the idea and the plan of the FFAST project.



Luminosity function for AGN will reveal the evolution of the universe



Lx-Redshift for AGN in soft X-ray

from Hasinger (2008)

The survey observation reveals many AGNs that makes us possible to study the evolution of the luminosity function. The left figure is obtained by soft X-ray observation (below 10keV) with many projects. When the observation plan is fixed, we find a detection limit line (red). Practically the sources detected scatter along this detection limit line. Therefore, we need various projects to reveal the entire luminosity function.

We know that there are many Compton thick AGNs that escape from being detected in soft X-ray. Therefore, we need hard X-ray (above 10keV) observation. Nu-star and ASTRO-H will cover the deep and shallow observations. We focus on the region that can be covered by scan observation with mirror (FFAST).

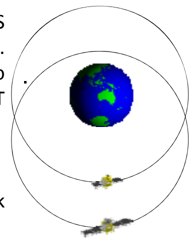
Formation Flight to form an X-ray telescope employed in FFAST

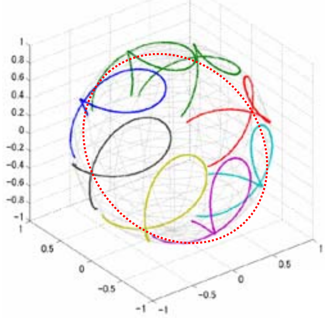
Formation Flight (FF) idea was employed in the XEUS and Simbol-X missions that are practically **cancelled**. They required to keep pointing a star, which needed to use a large amount of fuel. On the contrary, FFAST required two points

<u>Two satellites are in Keplerian orbits</u>

<u>Distance between them is constant</u>

There are two orbits available: one is an along track orbit and the other is **a relative circular orbit**.





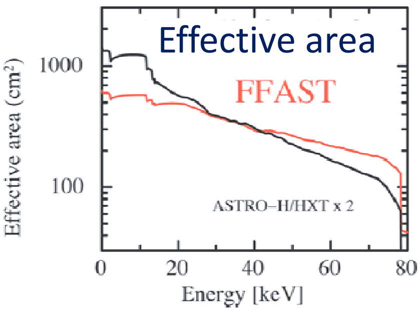
The above figure shows a concept of the **relative circular orbit**. One satellite is in a circular orbit and the other is in an eccentric orbit with the same orbital period. The FOV forms a locus of 8-shape, some part is earth-occulted as shown in the left figure. We can select the position of 8-shape (shown in various colors) along the orbit. We will select the orbit such that FFAST can cover some fraction of the sky. We found that a reasonable amount of fuel can keep the distance constant and select the sky region.

Super mirror with focal length of 20m

One small satellite will carry a **super mirror**. This is similar to that employed in ASTRO-H HXT while we extend a focal length from 12m to 20m. The mechanical design is similar to each other (left figure) while the support lib pattern is slightly modified. We will fabricate the super mirror for FFAST after the fabrication of the ASTRO-H super mirror. Therefore, FFAST will be ready to go around 2015.

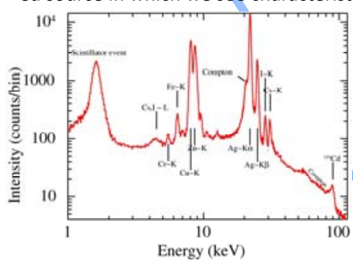
FFAST will employ one super mirror while ASTRO-H will use two. Geometrical area (low energy) of FFAST is just half that of ASTRO-H while It becomes two times larger at high energy as shown in the below figure. This is due that FFAST has longer focal length than that of ASTRO-H.

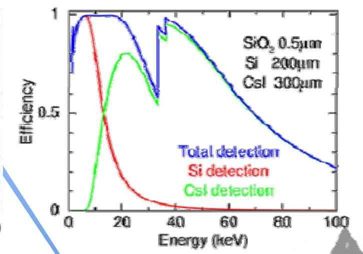
The mirror satellite shown in the top-left of this poster will have an attitude control system (MW and MTQ) with which the optical axis is always pointing to the detector satellite. The required accuracy is less than one arcmin, which is easy to achieve. The pointing direction is always moving while it always locks on the detector satellite. The mirror will be covered with thin Al film so that a direct sun-light does not affect the multi-layer surface. This will increase only in the low energy cut.



SDCCD has good spatial resolution with high detection efficiency up to 100keV

The other small satellite will carry an SDCCD that is a full-depleted CCD on which surface a thin scintillator (CsI) is directly attached. X-rays enter into the CCD. When they are detected in the CCD, we can obtain spectrum with CCD resolution while when they pass the CCD, they will be absorbed by CsI. The high energy X-rays can be detected in the SDCCD whose detection efficiency is shown in the below-right figure. The below-left figure shows a sample spectrum by using a ^{109}Cd source in which we see characteristic X-rays from Cs and I.

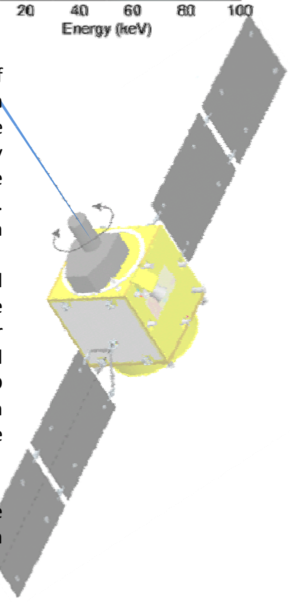




The detector satellite shown in the bottom-right of this poster will have an thruster system with which we can keep the distance between satellites to be 20m±10cm. The thruster system will employ several 1-N thrusters that will compensate the perturbation of the air-drag, light-pressure, J2-term. We expect that 20kg fuel will be enough to function properly for more than two years .

The FOV of the SDCCD is moving at some speed while we can control the detector such that the moving FOV can be parallel to the charge transfer direction of the CCD. The CCD will be fully coated with Al so that no visible light can enter. The SDCCD system is almost identical to that employed in ASTRO-H. Therefore, we can fabricate it after the fabrication of ASTRO-H.

We are funded to fabricate mirror and detector. We will apply FFAST to the small satellite project in JAXA next year so that FFAST can go after ASTRO-H.



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