EXCEED data processing and pointing control

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SPRINT-A is an earth-orbiting extreme ultraviolet spectroscopic mission being developed by ISAS/JAXA. Two mission instruments are installed in EXCEED, an EUV spectrograph and a target guide camera. The guide camera is designed to capture a part of a target planet disk whose light is reflected from the front side of a slit. Mission data processor (MDP) acquires the image every 3 seconds, calculates the centroid position of the disk on the image, and sends it to the attitude control system. While the pointing accuracy of the bus system is at most ±1 arc-minutes, scientific requirement for spatial resolution is 10-arcsec. The attitude control system keeps the centroid position with an accuracy of ±5 arc-seconds to achieve the spatial resolution required. This pointing correction algorithm is applied to correct slow changes in the pointing direction which is mainly caused by changing thermal input from the sun and earth to the satellite. Though vibrations from reaction wheels installed in the bus system could cause random pointing error, the amplitude is estimated to be 1 arc-second. To test the algorithm, a pinhole image was taken by the guide camera with flight-model optical layout. The designed algorithm has been confirmed to work well and the stability of the centroid position was found to be 0.3 arc-second. Final interface test between EXCEED and attitude control system is planned on March 2013.

SPRINT-A

Launch :	Aug. 2013
Vehicle:	Epsilon Rocket
Bus:	Standard bus (SPRINT Bus)

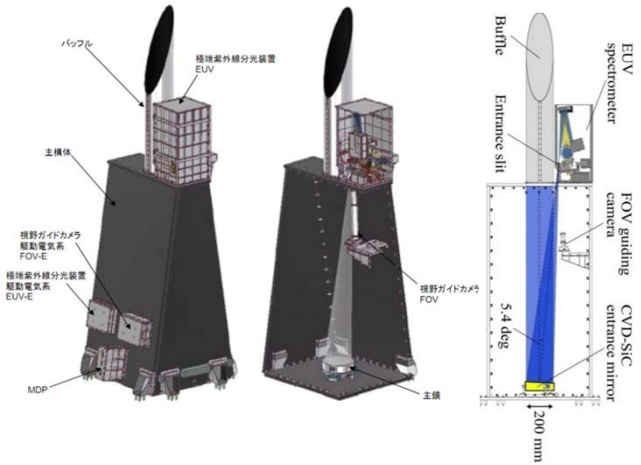
Specifications

Weight :	378kg (incl. margin)
Size :	1.4m × 1.4m × 3.8m (launch conf.)
Orbit :	950km × 1150km (LEO)
Inclination:	31deg.
Mission life :	> 1 year
Pointing accuracy :	2 arc-min

(improved to 10 arc-sec by using a taget guide camera)

EXCEED

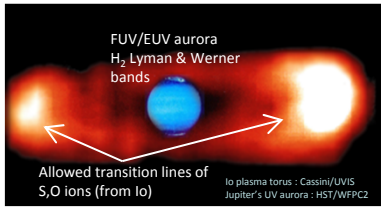
EUV spectroscope which is consist of
- EUV spectrograph (EUV)
- Target guide camera(FOV)
- Mission data processor (MDP)



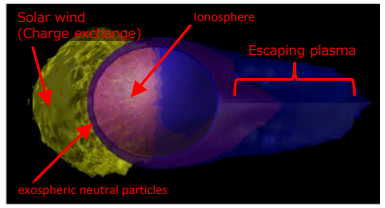
Scientific targets of EXCEED

Spatial resolution of 10-arcsec is required to find radial structure of IPT and detect emissions from ionosphere, exosphere and tail separately.

Jovian aurora and Io plasma torus
Radial energy transport in rotation dominant magnetosphere



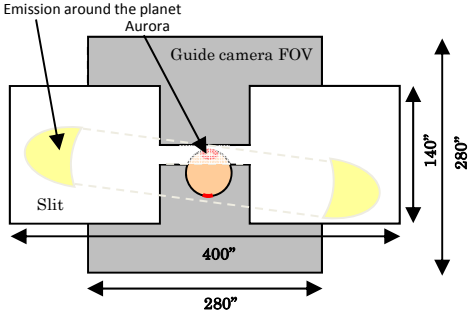
Venus and Mars
Escape of atmosphere to space



Target guide camera

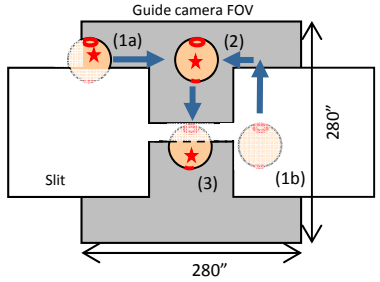
Field of view	280 x 280 arcsec
Spatial resolution	<5 arcsec
Exposure time	1sec (nominal)
Pixel number	256 pixel x 256 pixel
Wavelength range	550nm(width～20nm)

Field of view of slit and guide camera



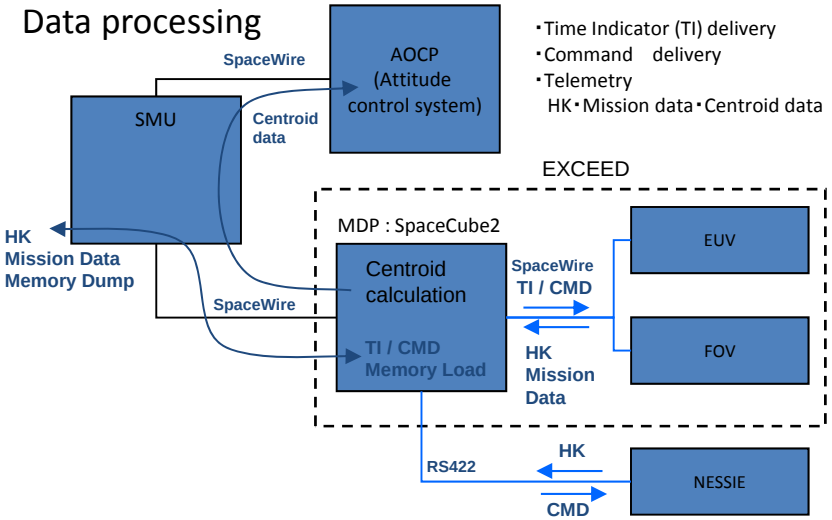
The target guide camera is designed to capture a part of a target planet disk whose light is reflected from the front side of a slit. Mission data processor (MDP) acquires the image every 3 seconds, calculates the centroid position of the disk on the image, and directory sends it to the attitude control system.

Algorithm of target finding & pointing stability



(1) Initial contact
(1) to (2) Maneuver to capture the full disk
(2) to (3) Maneuver to capture the target to the slit
(3) PID control to keep the centroid which is sent from MDP with the uplinked position.

Data processing



SLIT

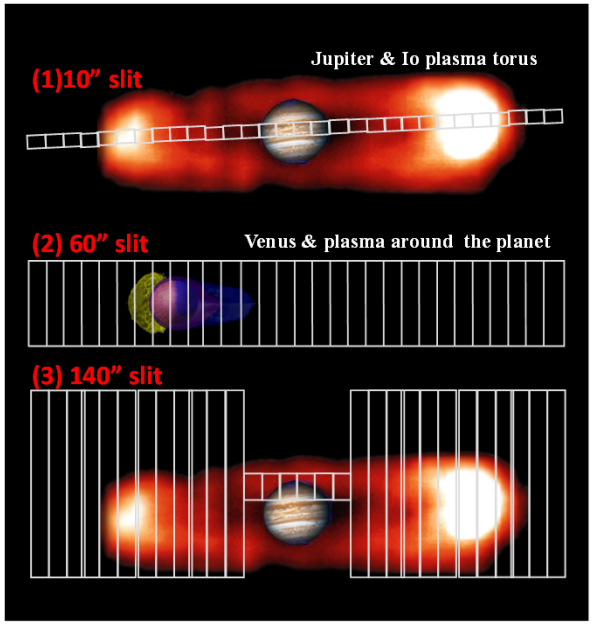
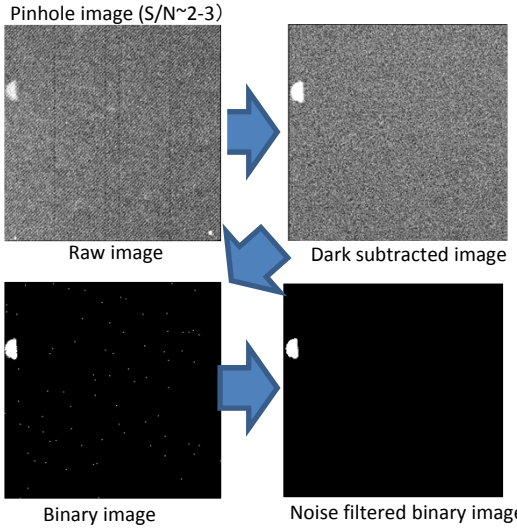
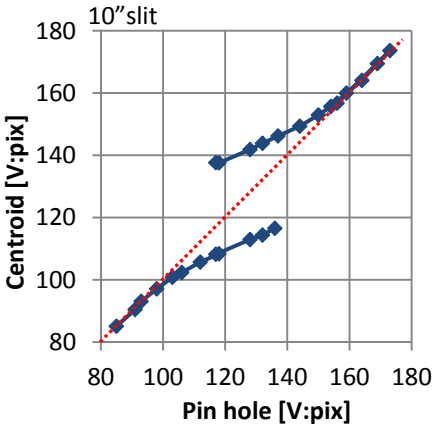
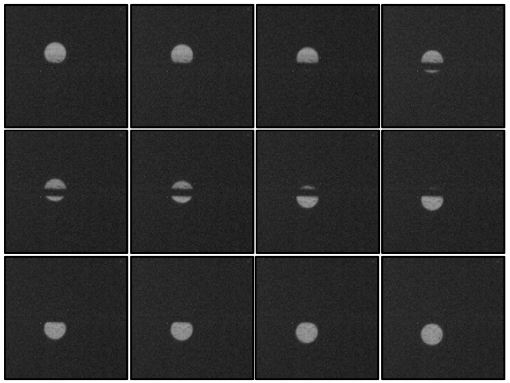


Image processing & Centroid calculation

(1)Acquisition of the camera image
(2)Image processing
(2-1) Dark image subtraction
(2-2) Median filter
(2-3) Smoothing
(2-4) Binaries
(2-5)Noise filter
(4)Centroid calculation
(5) Sending the centroid
to the attitude control system

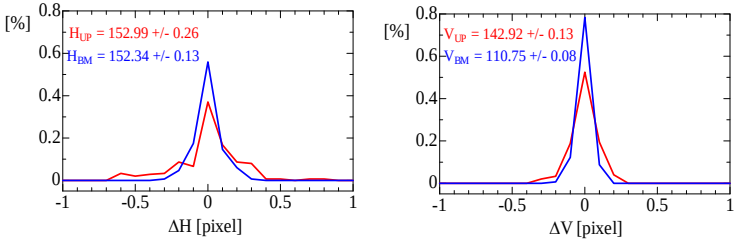






Non-linear relationship between the pinhole position and centroid which is calculated by MDP

Stability of the centroid



Stability of the centroid position of fixed pinhole target.
The stability is confirmed to be 0.3 arc-second.

Summary & Future Plan

Quantification of EUV spectrograph and a target guide camera onboard SPRINT-A has been completed in the beginning of 2013. The target guide camera is used to correct the pointing direction of the optical axis with an accuracy of ±5 arc-seconds. The test of centroid calculation algorithm shows stability of the centroid position to be less than 0.3 arc-second.
Final interface test between EXCEED and attitude control system is planned on March 2013.
SPRINT-A will be launched on August 2013 and will begin observation of Venus and Jupiter on October.