9.15 Space Research Applications

Photomultiplier tubes are widely used in space research applications, for example, detection of X-rays from space, planetary observation, solar observation, environmental measurement in inner or outer space and aurora observation. In addition, photomultiplier tubes are also used for spectral measurements of various radiation in the atmosphere or outer space and measurement of X-rays from supernovas.

9.15.1 Overview

Figure 9-62 illustrates the structure of ASUKA launched and placed in its orbit in February 1993, as the fourth astronomical satellite for X-ray observation in Japan. A gas imaging spectrometer (GIS) is used as the detector, which consists of a gas-scintillation proportional counter coupled to a photomultiplier tube (Hamamatsu R2486X).

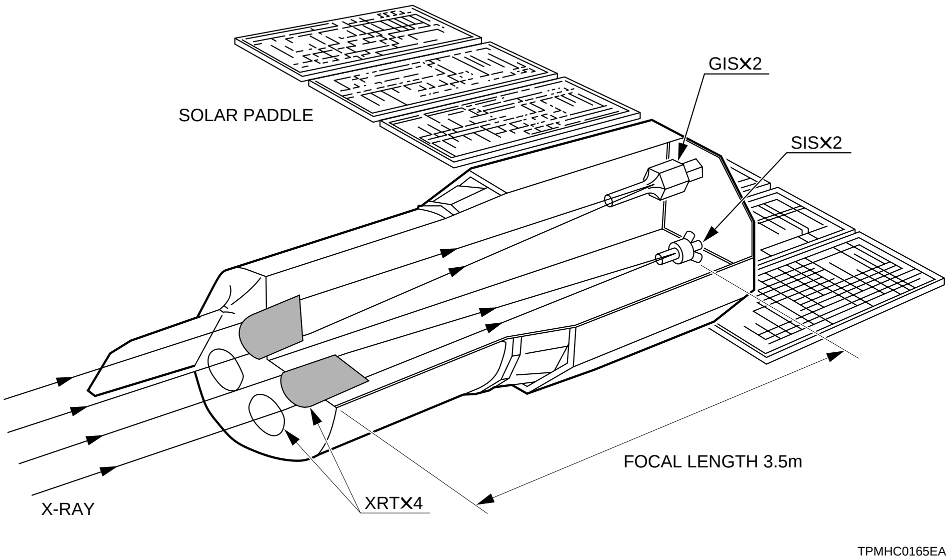

Figure 9-62: Astronomical satellite ASUKA for X-ray observation

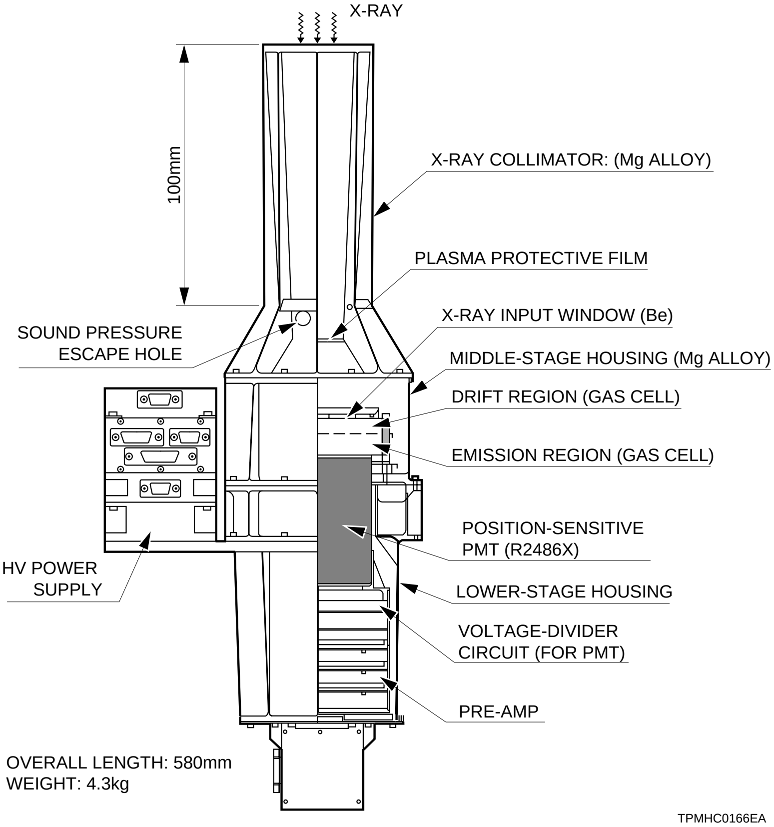

Figure 9-63: X-ray detector (GIS detector) mounted in the ASUKA

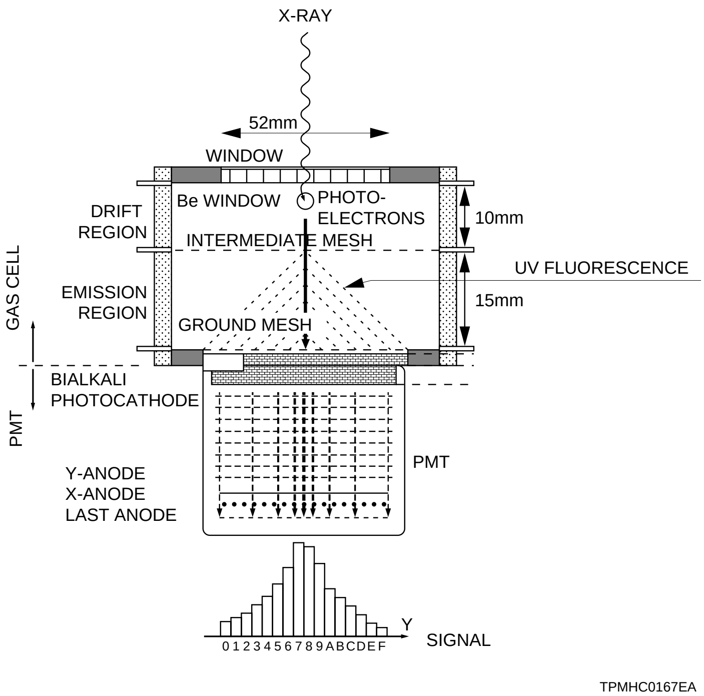

Figure 9-64: Principle of detection in the GIS detector

The ASUKA has succeeded in discovering various interesting facts, beginning from the detection of X-rays travelling from the supernova named "SN19993J", discovery of low-luminosity nucleus in the center of ordinary galaxy, and world's first detection of inverse Compton X-rays coming from a radio galaxy. Furthermore, the ASUKA successfully revealed that the low energy spectrum of CXB (cosmic X-ray background) is extending to 1keV as single photon fingers. This discovery is expected to elucidate the CXB, which is the primary object of the ASUKA.

9.15.2 Characteristics required of photomultiplier tubes

Photomultiplier tubes used in these applications must provide the following characteristics.

a) High energy resolution

b) Resistance to vibration and shock

c) Solar blind response (in the case of vacuum UV to UV detection)

As discussed in Chapter 8, photomultiplier tube resistance to vibration and shock differs depending on the tube size and dynode structure. Normal photomultiplier tubes are resistant to a vibration of 5 to 10G, while ruggedized tubes can endure up to 15 to 30G. Table 9-5 classifies the grades of measurement conditions. Note that these grades are based on the sinusoidal vibration test, so random vibration tests should also be taken into account as well. Hamamatsu Photonics performs vibration tests according to the user's needs in order to design and manufacture vibration-proof, ruggedized photomultiplier tubes.

Grade	Acceleration G	Frequency	Photomultiplier Tube
A	5.0	10 to 55	Normal type
B	5.0	10 to 500	Normal type
C	7.5	10 to 500	Normal type
D	10	10 to 1000	Normal type
E	15	10 to 2000	Ruggedized type
F	20	10 to 2000	Ruggedized type
G	25	10 to 2000	Ruggedized type
H	30	10 to 2000	Ruggedized type

Table 9-5: Vibration test conditions

In the measurement of radiation traveling from space, photomultiplier tubes must have high sensitivity in the vacuum UV to UV range but also have a solar blind response. Since the detection limit on the short wavelength side is determined by the transmittance of the window material used for the photomultiplier tube, proper selection of window material is also important. Figure 9-65 shows transmittance characteristics of various window materials and Figure 9-66 shows spectral response characteristics of solar blind photocathodes specifically intended for UV detection.

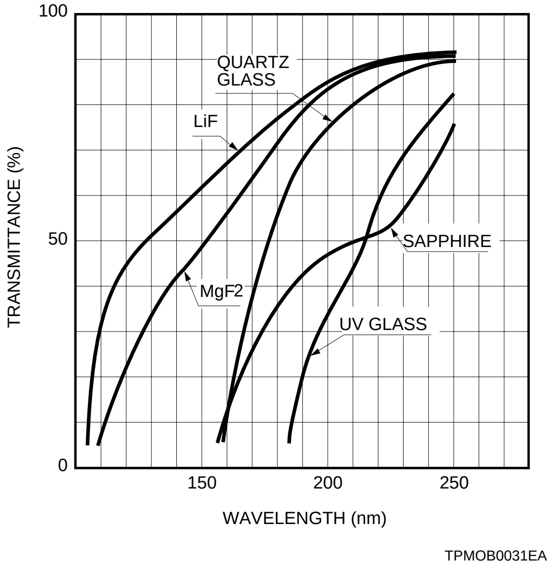

Figure 9-65: Transmittance characteristics of various window materials

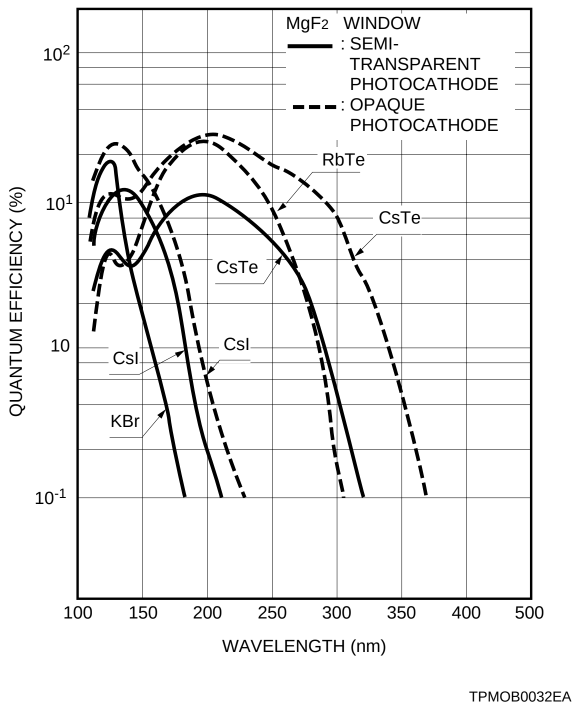

Figure 9-66: Spectral response characteristics of solar blind photocathodes