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Flight model performance test results of a helium dewar for the soft X-ray spectrometer onboard ASTRO-H

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ABSTRACT

ASTRO-H is a Japanese X-ray astronomy satellite, scheduled to be launched in fiscal year 2015. The mission includes a soft X-ray spectrometer instrument (SXS), which contains an X-ray micro calorimeter operating at 50 mK by using an adiabatic demagnetization refrigerator (ADR). The heat sink of the ADR is superfluid liquid helium below 1.3 K. The required lifetime of the superfluid helium is 3 years or more. In order to realize this lifetime, we have improved the thermal performance from the engineering model (EM) while maintaining the mechanical performance. Then, we have performed a thermal test of the flight model (FM). The results were that the heat load to the helium tank was reduced to below 0.8 mW in the FM from 1.2 mW in the EM. Therefore, the lifetime of the superfluid helium is more than 3 years with 30 L of liquid helium.

In this paper, the thermal design and thermal test results are described.

1. Introduction

ASTRO-H is the 6th Japanese X-ray astronomical satellite. It is scheduled to be launched in fiscal year 2015 from the Tanegashima Space Center by H2A launch vehicle [1]. The SXS onboard ASTRO-H is a high resolution spectrometer [2]. The SXS is expected to reveal merging of galaxy clusters or particle acceleration in the universe.

The detector of the SXS is cooled down to 50 mK by an double stage ADR [3]. The Calorimeter Spectrometer Insert (CSI) which consists of the ADR and the detector is developed by NASA, and the cooling system up to 1.3 K cold stage is provided by Sumitomo Heavy Industries.

2. Dewar design

Requirements for the SXS dewar (SXS-DWR) are as follows: Provide a thermal bath below 1.3 K for the CSI with a lifetime of over 3 years in the nominal case, or 9 months lifetime in the cooler failure case. To meet these requirements, the SXS-DWR has two features. One is a suspension mechanism using straps. The other is a hybrid system using liquid helium and mechanical coolers.

A schematic of the cooling system and cross sectional view of the SXS-DWR are shown in Figs. 1 and 2, respectively. Its dimensions are 1.8 m in height, 1.4 m in diameter and its mass is 294 kg not including the cooler drive electronics. The SXS-DWR can store a maximum of 39.5 L of superfluid helium.

The CSI is located on the helium tank. It is cooled by conduction through the helium tank. Total heat load to the helium tank is estimated to be below 0.8 mW including the heat generated in the CSI in the nominal case. The Porous plug (PP) [4] is installed on the helium tank for phase separation of superfluid helium.

The SXS-DWR contains four Vapor Cooled Shields (VCS): namely a Joule–Thomson cooler shield (JTS), Inner VCS (IVCS), Middle VCS (MVCS) and Outer VCS (OVCS), with Multi Layer Insulation (MLI). 20 layers, 30 layers and 50 layers of MLI are attached on the IVCS, MVCS and the OVCS respectively.

The helium tank is suspended from the IVCS by 12 Carbon Fiber-Reinforced Plastic (Carbon FRP) straps, and the IVCS is suspended from the vacuum shell (MS) by 12 Glass Fiber-Reinforced Plastic (Glass FRP). We use manganin wires for signal lines, and

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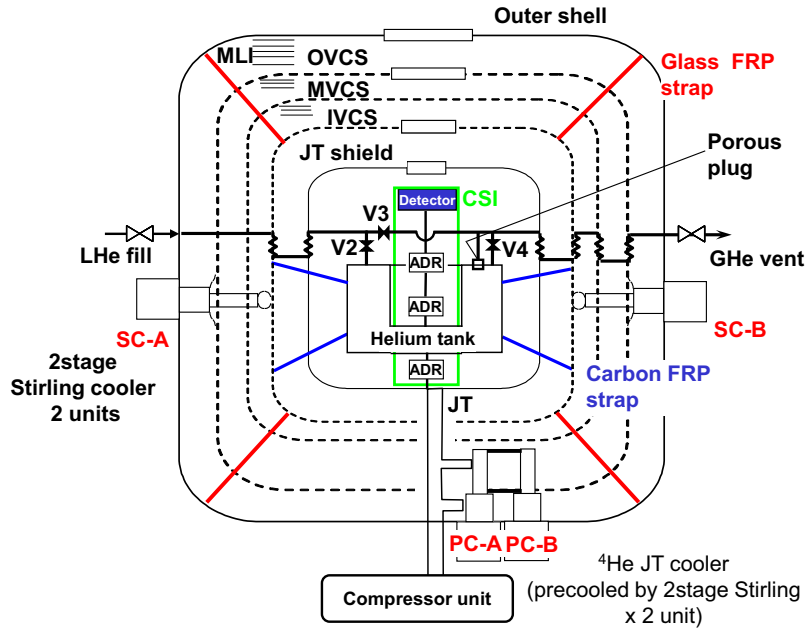

Fig. 1. Schematic of the cooling system.

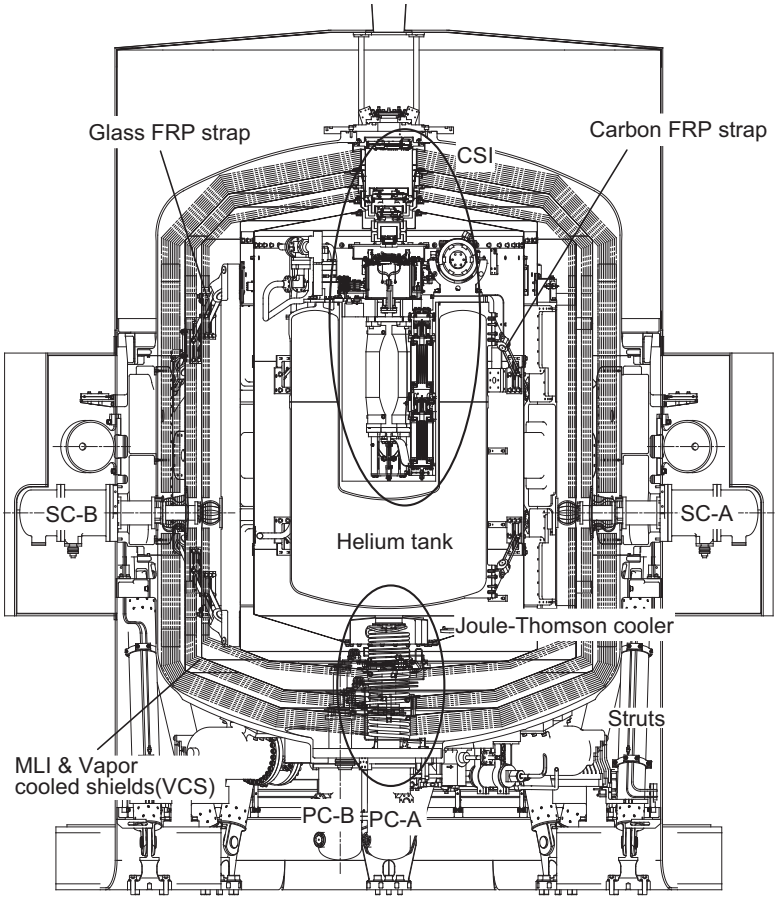

Fig. 2. Cross-sectional view of the SXS-DWR.