Contribution ID: **65** Type: **Oral presentation (15min)**

Cryogenic design of a large superconducting magnet for astro-particle shielding on deep space travel missions

Thursday, 10 July 2014 17:30 (15 minutes)

The Space Radiation Superconducting Shield (SR2S) European project aims at studying a large superconducting toroid magnet to protect the human habitat from the ionizing radiations coming from Galactic Cosmic Ray during long term missions in deep space. Titanium clad MgB2 conductor is used to afford a bending power greater than 5 Tm at 10 K. A specific cryogenic design is needed to cool down this 10 m long and 12 m in diameter magnet.

A passive cooling system, using a v-groove sunshield, is considered to reduce the heat flux coming from the sun or Mars and lower the temperature to 40 K on the external side of the magnet. An active configuration, using pulse tube cryocoolers, will be linked to the 80 K thermal screen intercepting most of the heat fluxes coming from the human habitat. The toroid magnet will be connected also to cryocoolers to absorb the few watts reaching its surface.

Two kinds of thermal link are being considered to absorb the heat on the 80 K thermal screen. The first one is active, with a pump circulating helium gas in a network of exchange tubes. The second one is passive using long cryogenic pulse heat pipe (PHP) with the evaporator on the surface of the thermal screen and the condensor attached to the pulse tube. Moreover, a large amount of solid hydrogen, placed inside the magnet, as an enthalpy reserve, will keep the magnet at 13 K during two years in case of general electrical failure.

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Session Classification: Thu-Af-Orals Session 17

Track Classification: C-04: Space cryogenic applications