

## Getting the XRS Cold Script

### Clip from *Building the Coolest X-ray Satellite*

Video

CLIPS OF THE XRS DEWAR WITH FROST

Audio

NARRATIVE: To detect the minuscule amount of heat given off by a single x-ray, engineers must employ Cryogenics – the science of the super cold.

Video

TEXT: WHY SO COLD ???

CLIP OF CAROLINE IN BUNNY SUIT

Audio

CAROLINE: Now, in order to make a good spectrometer, the detector needs to be very cold.

Video

KEVIN OC

Audio

KEVIN: An ordinary object does not change much when an x-ray hits it; so making it cold helps in 2 ways. One: it means that the temperature change is a larger fraction of the temperature that it's sitting at and 2, the heat capacity of almost everything goes down very rapidly as you get close to absolute zero. So a little bit of energy causes the temperature to rise a lot. So we have to keep it very, very cold.

Video

CLIP OF CAROLINE IN BUNNY SUIT

TEXT: 0.060 KELVIN

ANIMATION SHOWING THE XRS PLACEMENT IN THE ASTRO-E2 SPACECRAFT

Audio

CAROLINE: We have to operate this detector at 60 millidegrees above absolute zero. So that's what the rest of the XRS instrument does – it makes this tiny detector cold.

Video

GRAPHIC: ABSOLUTE ZERO DEFINITION

0 KELVIN OR -273 CELSIUS OR -459 FAHRENHEIT

Audio

KEVIN: When you try to keep something that cold, you usually have to have a multi-stage system. We do that as well.

Video

CLIP SHOWING NEON DEWAR

TEXT: SOLID NEON IS: 17 KELVIN OR -256 CELSIUS

Audio

KEVIN: There's an outer layer of solid neon, that's 17 Kelvin. That's pretty cold for you and me, but that's still blazingly hot for our detectors.

Video

CLIP CONTINUES, WITH A HAND PULLING THE HELIUM DEWAR OUT OF THE NEON DEWAR

TEXT: LIQUID HELIUM GOES HERE

TEXT: LIQUID HELIUM IS: 1.3 KELVIN OR -271.9 CELSIUS

GRAPHIC OVERLAY SHOWING THE "INSIDE" OF THE HELIUM DEWAR AND THE PLACEMENT OF THE ADIABATIC DEMAGNETIZATION REFRIGERATOR

TEXT: ADIABATIC DEMAGNETIZATION REFRIGERATOR

TEXT: 0.060 KELVIN

Audio

KEVIN: So inside that, there's a layer of liquid helium. And that's helium, like helium in your helium balloons and that's at about 1.3 Kelvin. And then inside that there's what we call an adiabatic demagnetization refrigerator, which uses magnetic spins inside actual atoms and aligns them and de-aligns them in such a way to get us down to 60 millikelvin.

Video

CLIP OF WORK IN THE CLEAN ROOM

KEVIN OC

ANIMATION SHOWING A CUT-AWAY OF THE DEWAR WITH TWO WALLS AND OUTSIDE HEAT STOPPED BY THE OUTER WALL

TEXT: INVENTED BY SIR JAMES DEWAR IN 1892

Audio

KEVIN: The XRS detectors are placed inside a Dewar. A Dewar is like a thermos bottle. If you have a real glass thermos bottle to keep your coffee in, that's a Dewar. And it's 2 walls, and between the walls is vacuum, so the heat can't get through from one side to the other by conduction or convection. It can only go through by radiation and that's why it's – if you look inside your thermos bottle it's silver and that reflects the radiation.

Video

KEVIN OC

CLIP OF THE XRS AND ITS HOUSING

Audio

KEVIN: We have just a tiny amount of power and if there's a lot of heat – even if there is just a little bit of heat getting into the system, we won't be able to keep it cold. So you have to be very careful to isolate the inner structures that are very cold with the outer structures that are not so cold.