Conceptual Design and Development History of the 6K MIRI Cryocooler on JWST

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The Mid Infrared Instrument (MIRI) of the James Webb Space Telescope (JWST) is a demanding application for the use of space cryocoolers. Used to cool JWST's 90 kg MIRI instrument down to 6 K, it is critical to enabling the mission's long-wave infrared science associated with studying the post-Big Bang early formation of the Universe.

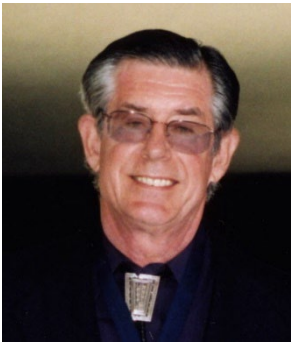
The selection and design of MIRI and its cryocooler started with the successes and limitations of JWST's precursor, the Hubble Space telescope. Planned as the follow-on to Hubble, JWST abandoned Hubble's astronaut-accessible low-Earth orbit for a colder and better-science environment a million miles from Earth. Targeted for its L2 location meant no servicing missions would be possible, and reliability and life would be critically important. JWST's increased size, with a 7-meter diameter mirror, meant significant deployments would be required post launch to allow the observatory to unfurl from its launch-vehicle shroud and separate the cold telescope from its hot and noisy spacecraft bus.

The design of the MIRI cryocooler had to accommodate these mission constraints by positioning its hot and vibration-generating compressor inside the spacecraft bus, while the MIRI instrument and the cryocooler's cold-end was positioned 10 meters away in the Science Instrument Module on the back of the telescope mirror. Accommodating the 2-meter deployment of the telescope away from the spacecraft and minimizing any vibration transmitted up the connecting refrigerant lines was a driving requirement on the cryocooler. Providing MIRI's large refrigeration load at 6 K, while simultaneously cooling MIRI 18K radiation shield required an all-new hybrid Pulse Tube/Joule Thomson cryocooler design implemented by

Northrop Grumman Space Systems and a whole team of folks from NASA/GSFC and the Jet Propulsion Laboratory.

This paper provides an overview of the MIRI cooler concept and development history as it evolved to meet these demanding JWST requirements over its nearly 20 year development. During this period it drew heavily on ongoing Pulse Tube cooler development at NGSS as well as a history of earlier hybrid J–T coolers addressed to the European First and Planck missions. With the successful launch and deployment of JWST this spring, we look forward to the successful operation and long life of this unique MIRI 6K cryocooler.

The Speaker



Dr. Ron Ross has over 50 years' experience researching and developing flight spacecraft hardware with an emphasis over the past 30 years on developing and integrating cryocoolers into space-science instruments. From 1988 until 2007 he managed JPL's cryocooler development group, including being the AIRS instrument cryocooler manager from 1990 to 2002 and NASA's 6K ACTDP cooler development manager from 2001 to 2005. When an ACTDP cryocooler was selected for MIRI on JWST, Ron became JPL's Subject Matter Expert (SME) for the MIRI 6 K cryocooler during its flight development phase. He has authored over 200 technical publications covering cryocooler design and performance, cryogenic instrument design, electronic packaging and solder fatigue, reliability physics, structural dynamics, and photovoltaics