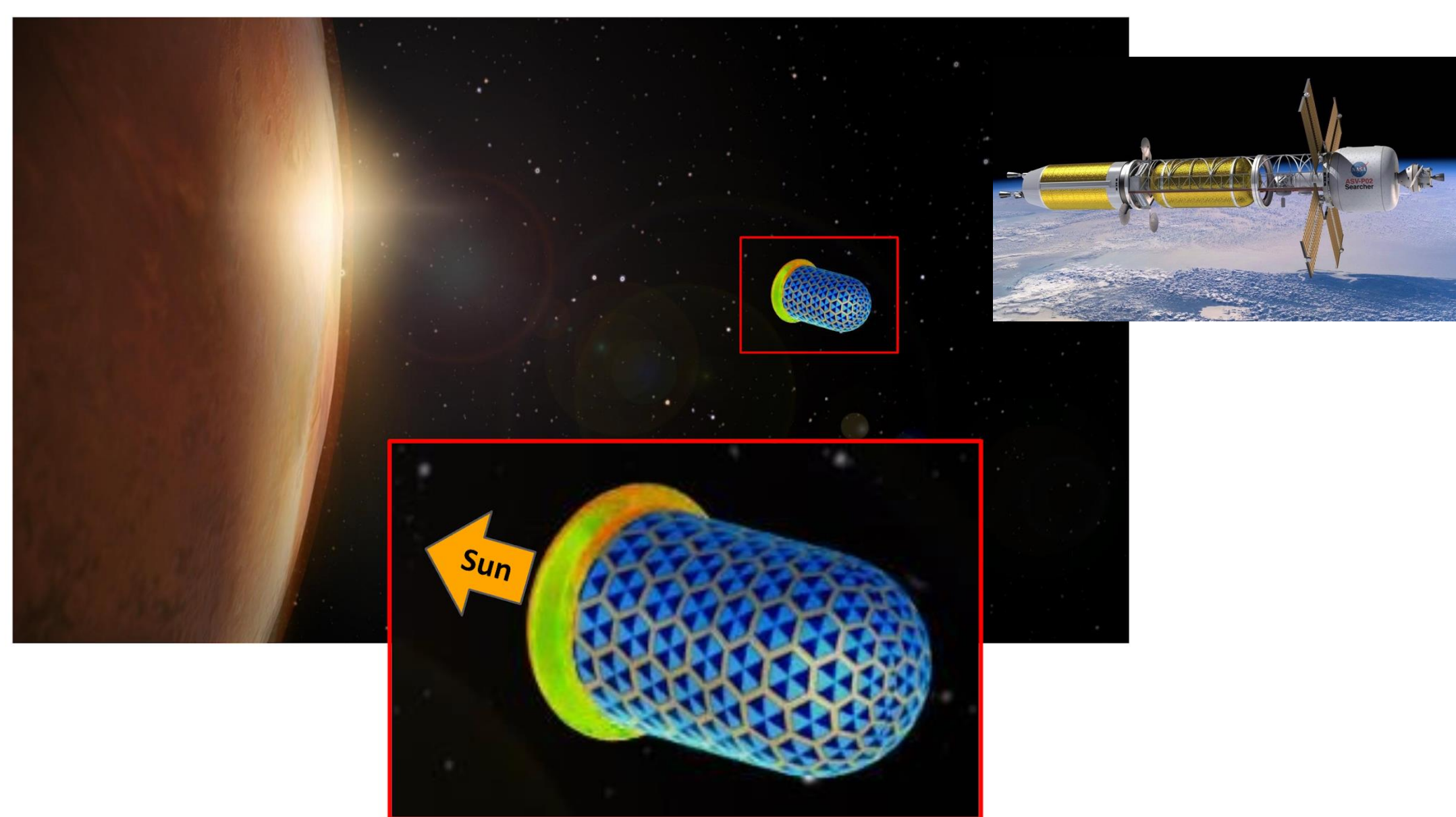
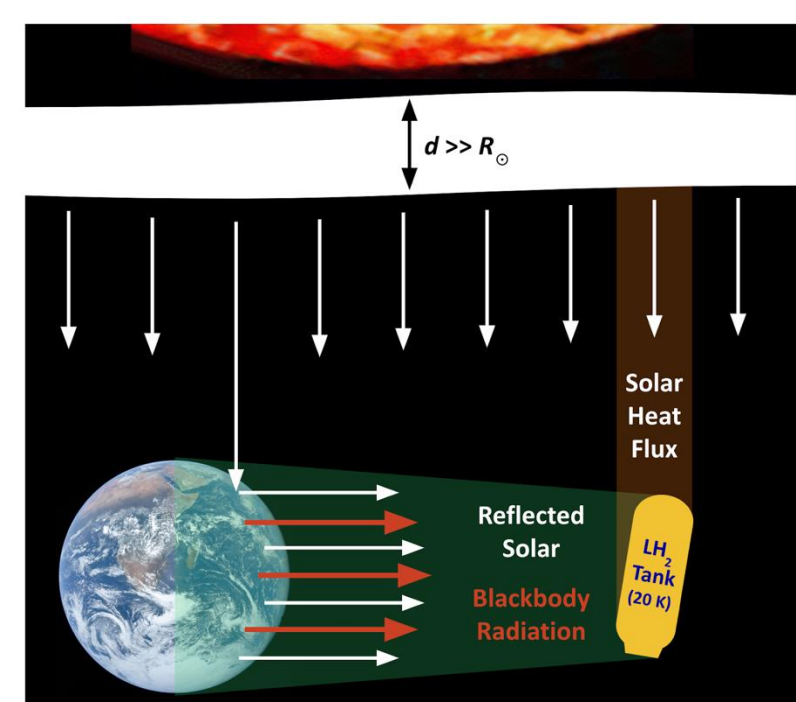


Mission Vision

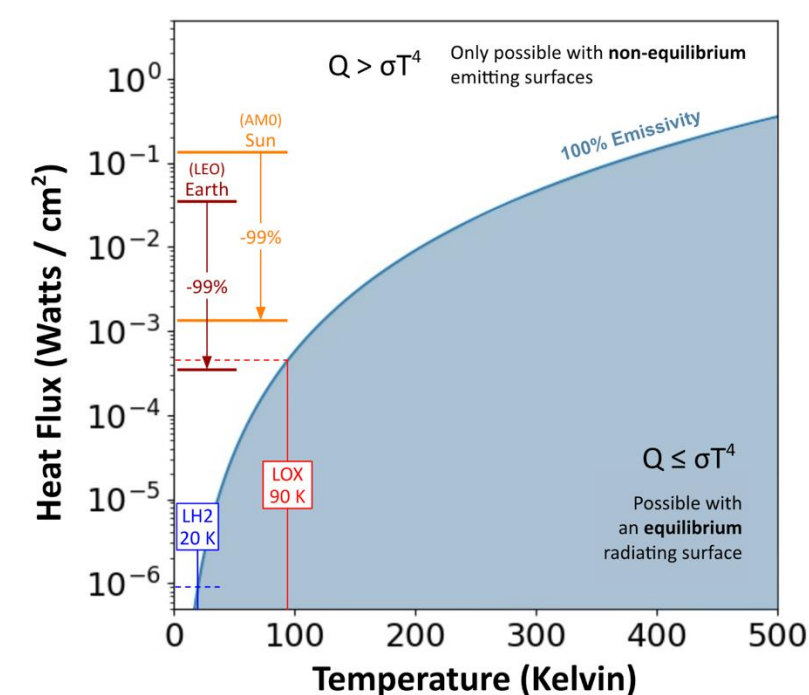


Our vision: Efficient round-trip manned Mars missions enabled by Zero Boil-Off (ZBO) conditions for cryogenic propellant. This is made possible by full offsetting heat leakage from the environment with **inductively powered LED cooling 'skin' that rejects non-equilibrium radiant heat directly to deep space.**



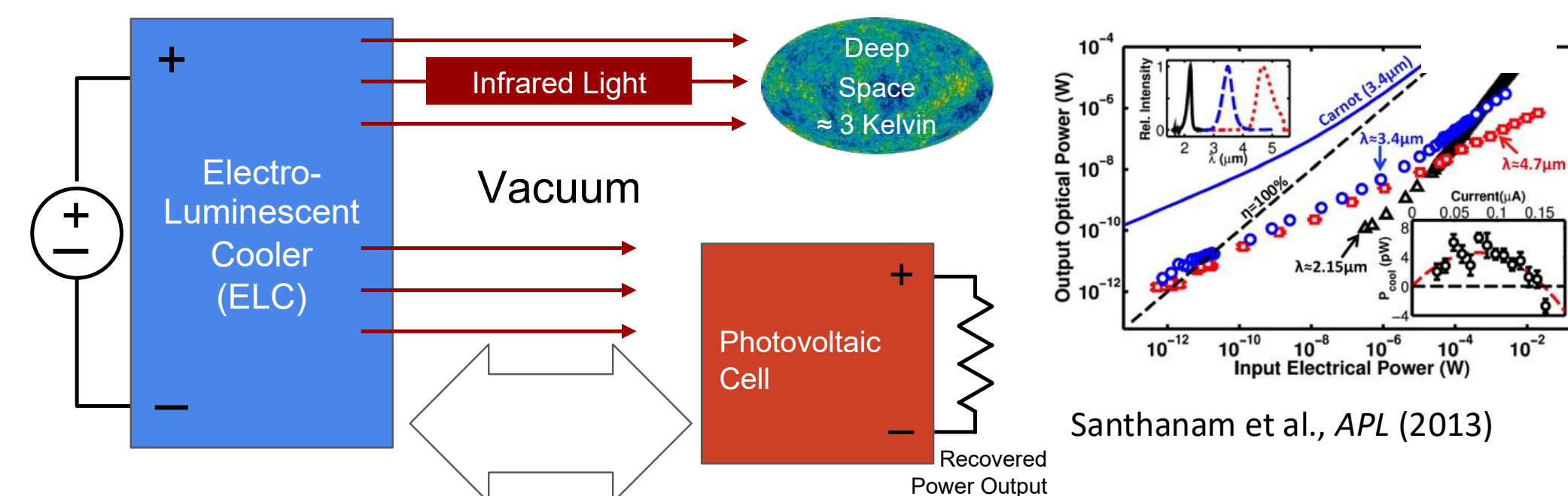
A well-designed cryogenic propellant storage tank can reflect the vast majority of photons incident on the spacecraft, but not all. In thermal environments like Low Earth Orbit (LEO), there is residual heating due to light directly from the Sun, sunlight reflected off Earth, and blackbody thermal radiation from Earth.

This leads to some of the propellant molecules heating up to the gas phase, and being released into space to prevent build-up of pressure in the tank. This slow "boil-off" process leads to significant losses of the cryogenic liquid into space, potentially leaving it with insufficient mass and greatly limiting Mars missions.



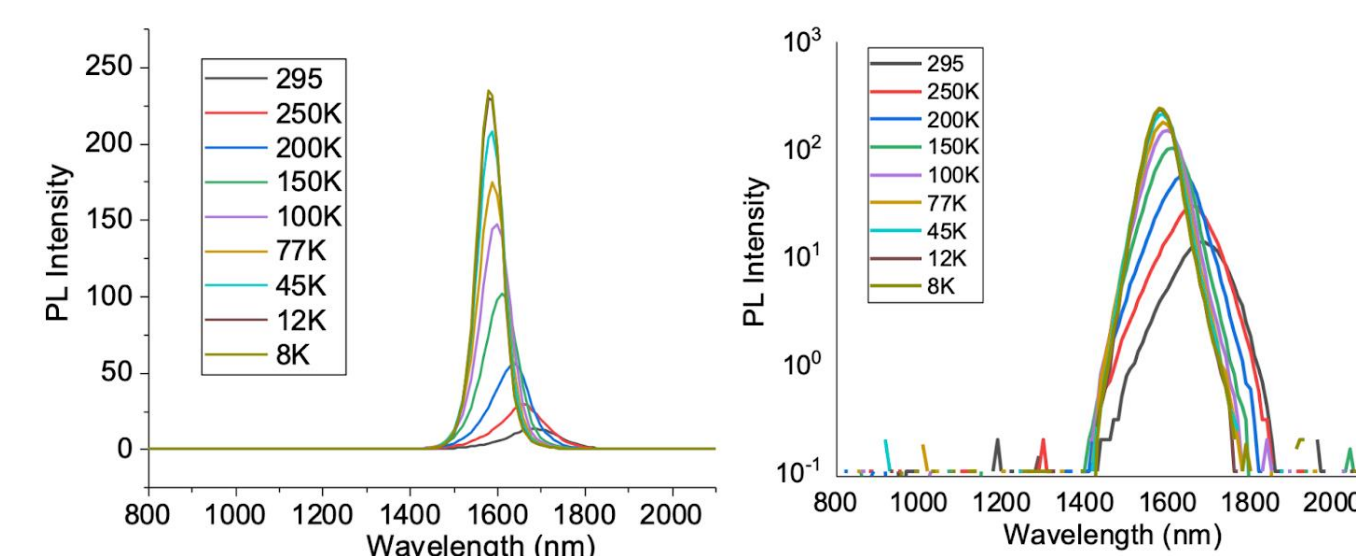
LED Cooling: Carrying Heat Away as Light

In Electro-Luminescent Cooling (ELC), a **Light Emitting Diode (LED)** emits more energy away as photons than the electrical energy IV used to drive it. The LED is taking energy away from its lattice via Peltier heat exchange in minority carrier injection and cooling itself down.



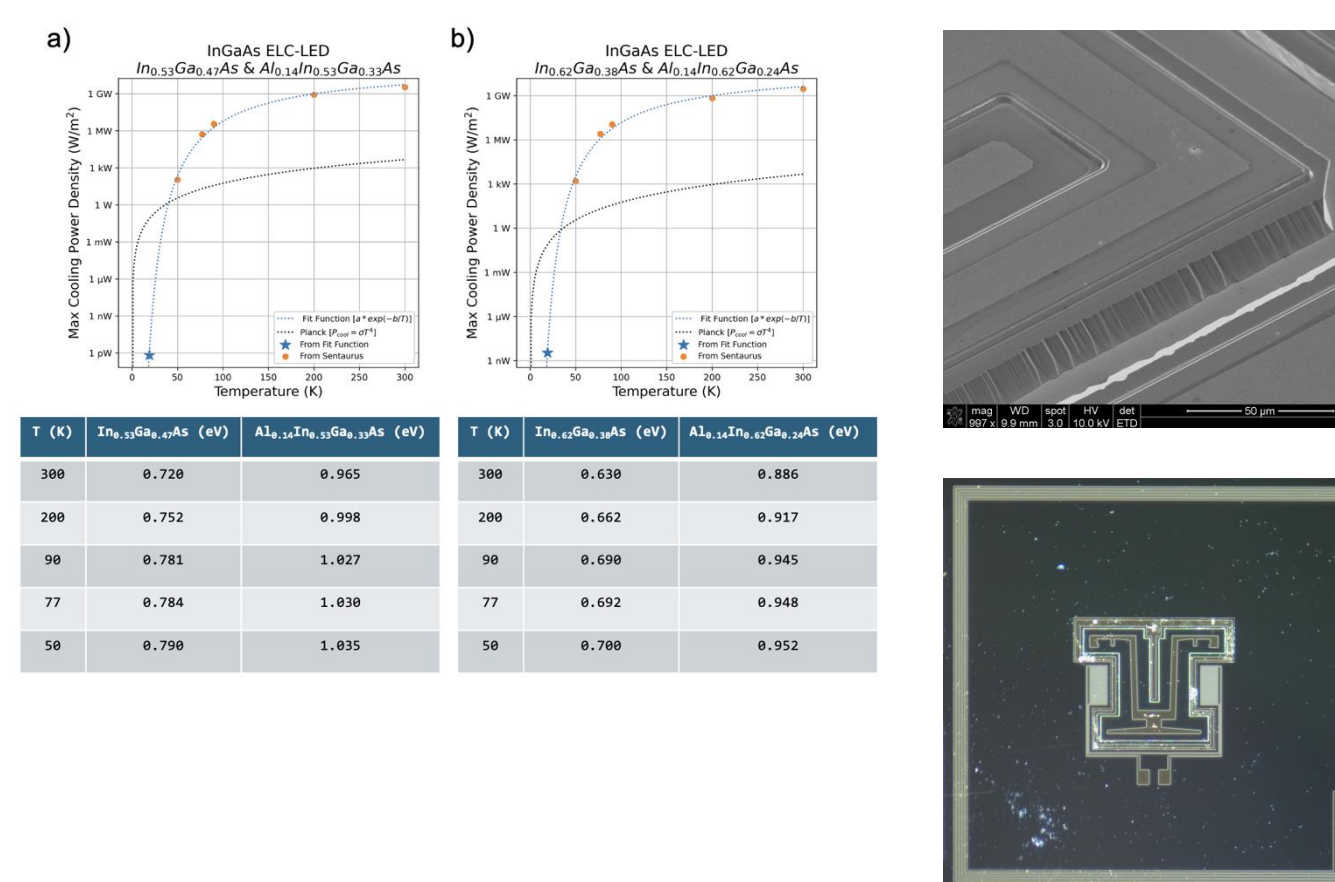
LED cooling is ideal for space-based applications since they actively pump heat away as photons. Since radiation is the only means of ultimately removing heat from a spacecraft, competing technologies that typically utilize thermal conduction or convection to sink away waste heat in terrestrial applications must be combined with passive radiator panels that increase the size, weight, and system complexity of spacecraft.

In **Phase 1** we identified key performance gains achievable at cryogenic temperatures:

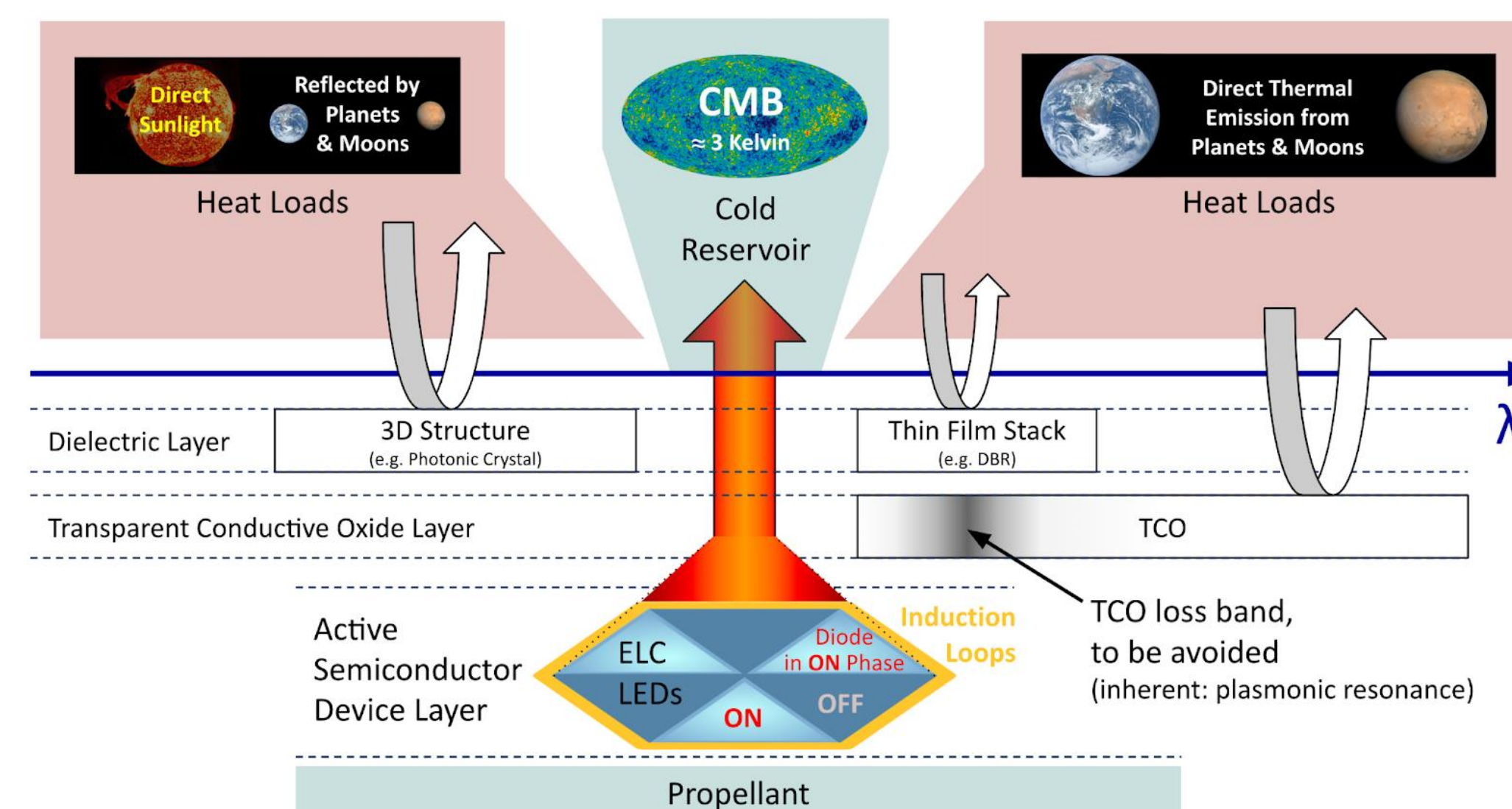


Reducing bandgap allows for improved performance at cryogenic temperatures, as does tailored doping

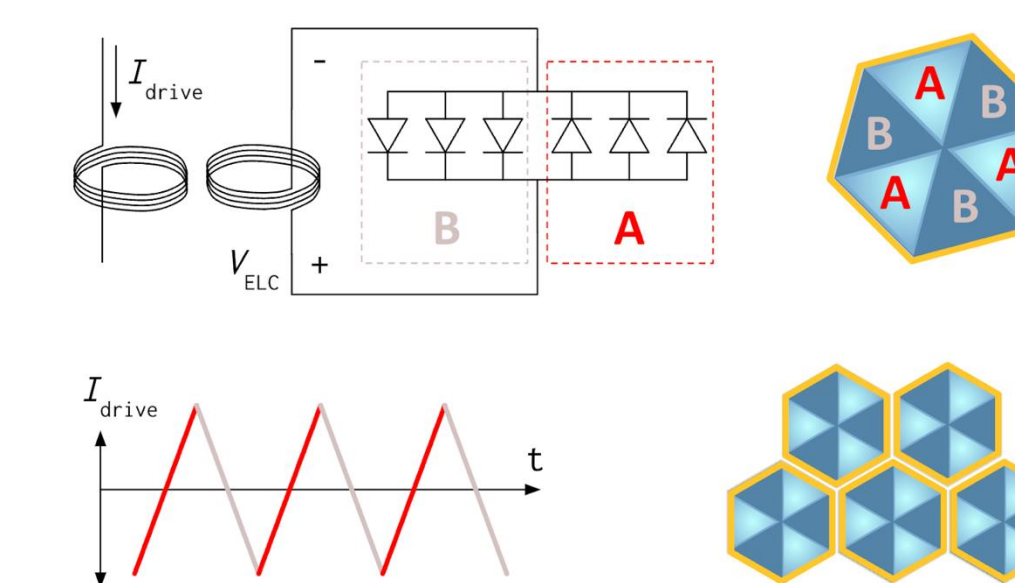
Joule heating from wiring/ contacts is a significant parasitic that must be mitigated



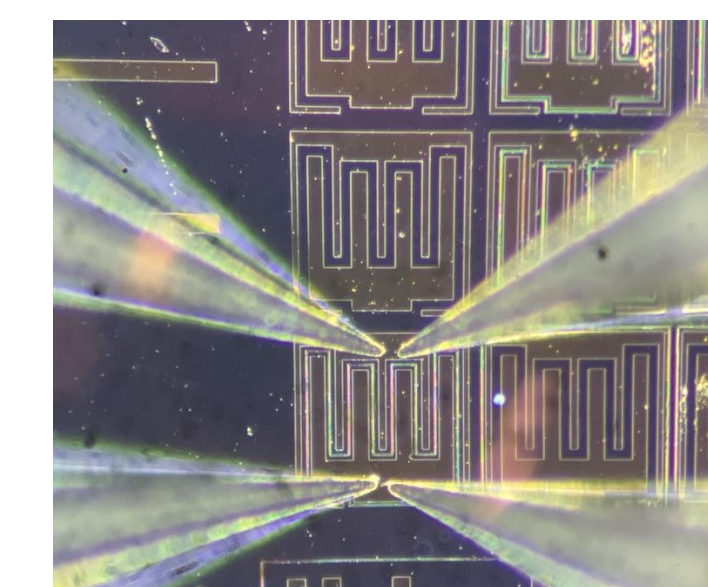
Phase 2 Architecture & Plan



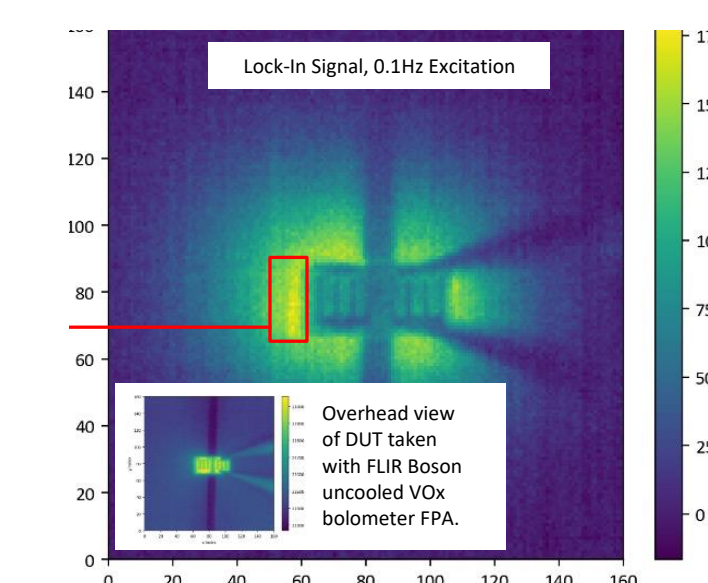
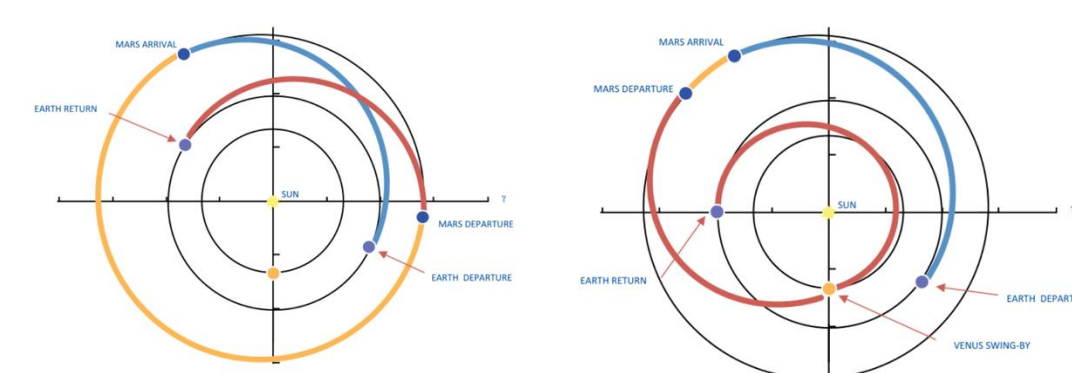
Inductive coupling of LEDs to minimize heating



Demonstrate LED cooling skin prototype at cryogenic temperatures



Identifying optimal mission profiles and propellant loads/ benefits



Impacts

Nominal targets: ELC Panels ~ 10 W/m² – 30 m² panels needed for ZBO → Lower mission costs, faster mission cadence

Cryogenic cooling applications: CubeSats, terrestrial scenarios