Telescope Tilt System for the POEMMA Balloon Radio Mission

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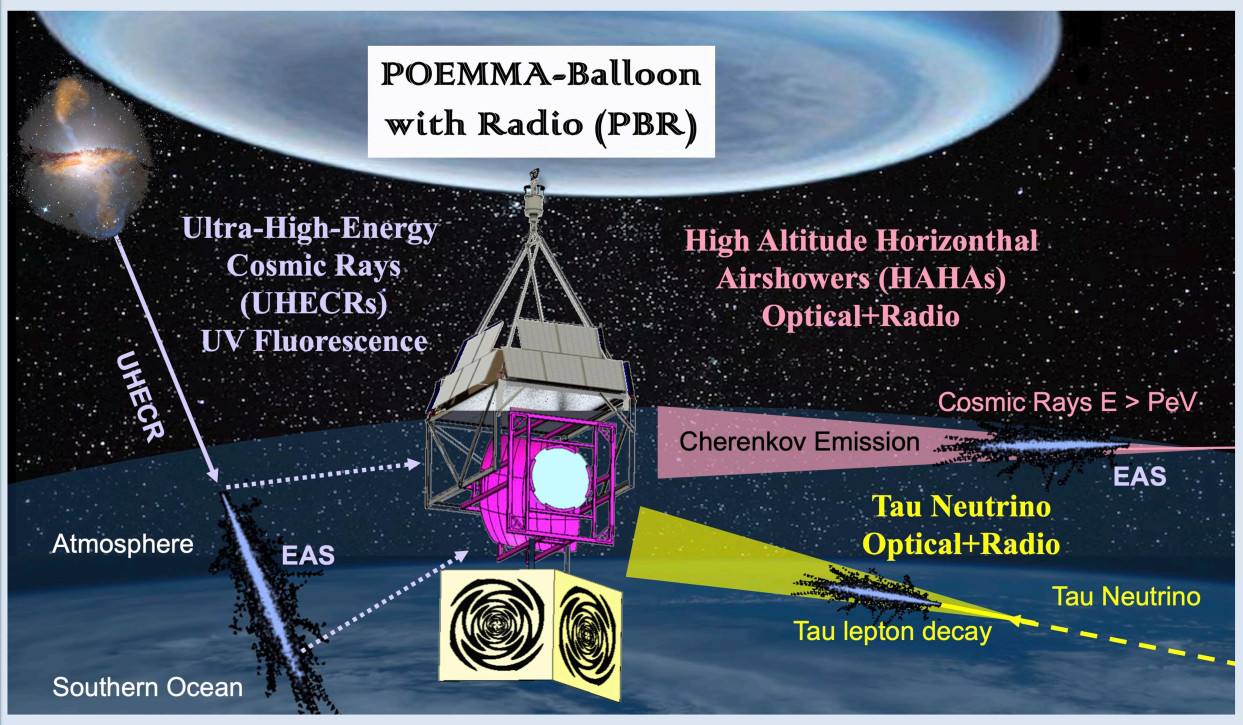
The PBR Mission

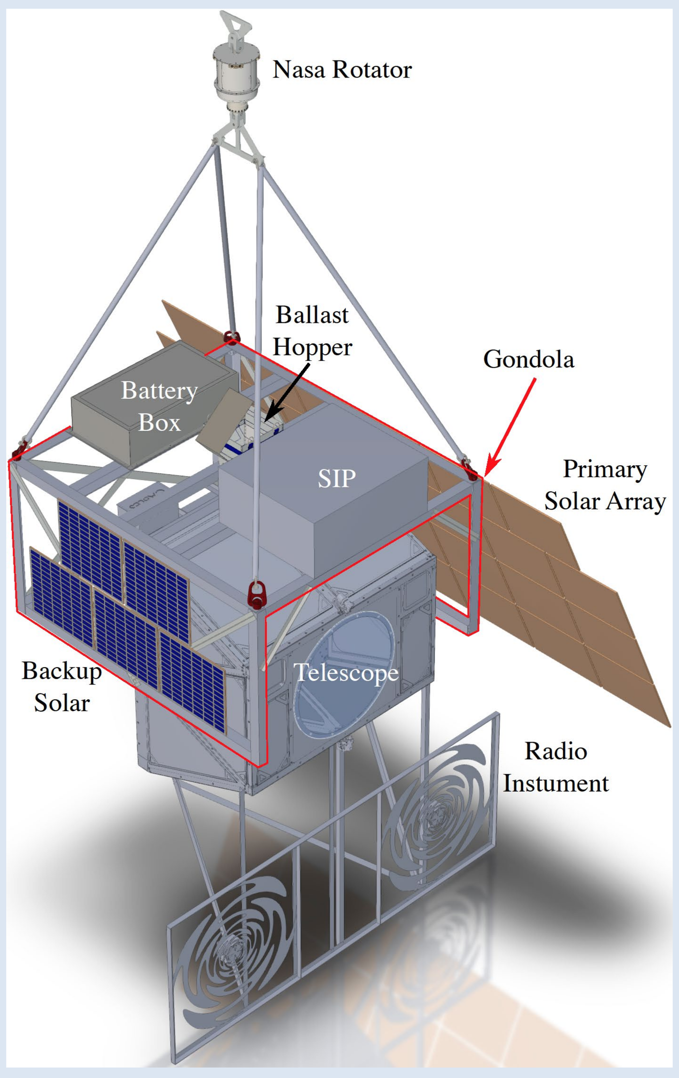


J. Eser, POEMMA-Balloon with Radio: An Overview (Oral #934)

PBR is a follow-up to the Extreme Space Observatory on a Super Pressure Balloon (EUSO-SPB2) and a precursor to a space-based satellite mission. PBR will measure EeV extensive air showers (EASs) from cosmic rays through Cherenkov emission and radio emission and via fluorescence emission, search for PeV astrophysical tau neutrinos via the earth-skimming technique using Cherenkov and radio methods. Of particular interest are searches for neutrino emission from transient astrophysical sources.

The payload is in preparation for a launch for a 2027 launch from NASA's balloon site in Wanaka New Zealand.

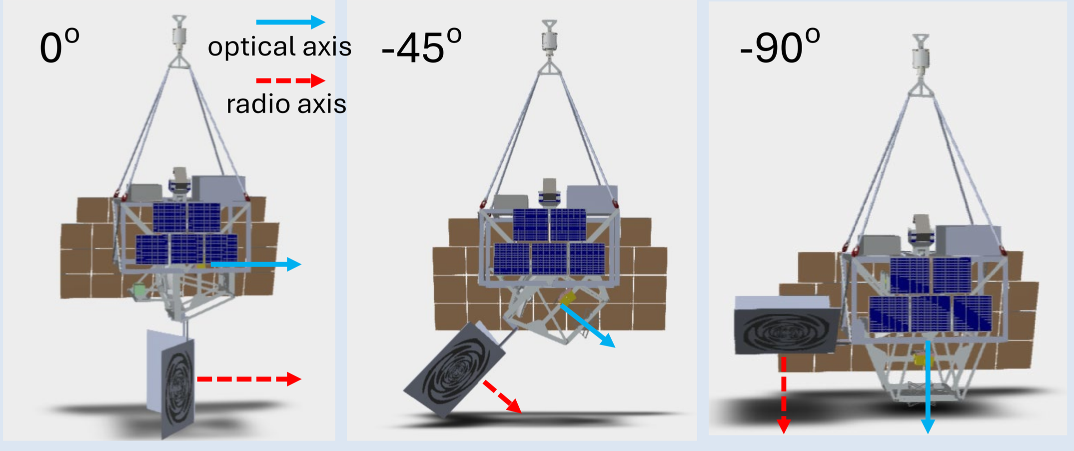
Payload



E. Mayote, The Optical and Mechanical Design of POEMMA Balloon with Radio (Poster 541)

The payload features a modified Schmidt telescope with a 1.1 m diameter entrance pupil, a segmented spherical primary mirror, and two high-speed custom camera systems at the focal surface. The Cherenkov camera (CC) system uses an array of silicon photomultiplier detectors, digitized at 200 MHz, to record the fast optical flashes of direct Cherenkov emission from EASs. The fluorescence camera (FC) is designed to record tracks of ultraviolet light produced by the development of EASs as viewed from the side. The FC uses multi-anode photomultipler modules digitized at 1 Mhz. The 2 antennas below are part of the EAS radio detector system.

Why telescope tilting during flight?



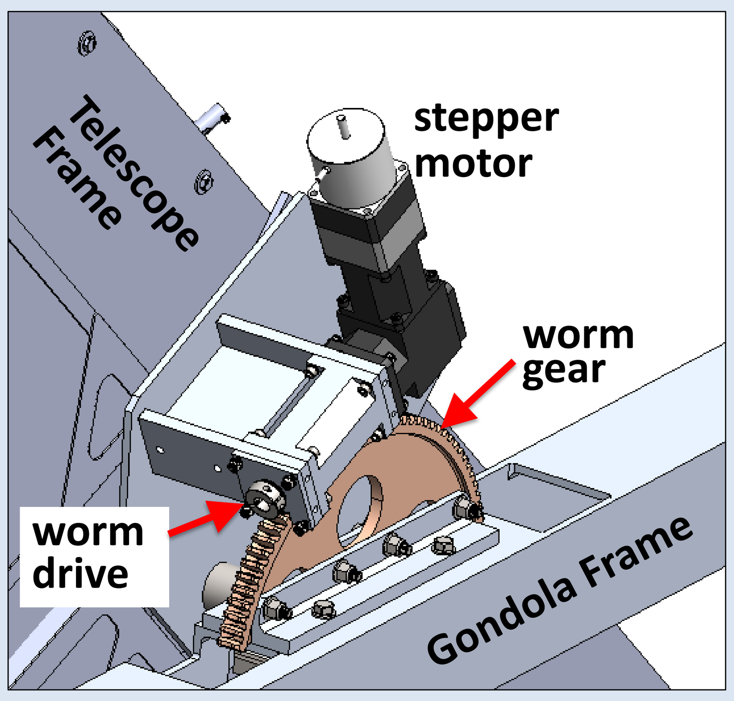
Science	Cam.	Telescope Tilt	Notes
Stars	FC	+15° to 0°	Check optical focus with starlight
PeV Cosmics	CC	+10° to -2°	Bonus: situ checks of CC
(Earth's limb)		-5.8°	From 33 km balloon altitude
PeV Neutrinos	CC	-5.8° to -15°	Target of Opportunity Searches
HAHAs	FC	-10° to -30°	High Altitude Horizontal Air Showers
EeV Cosmics	FC	-90°	Lowest Energy threshold at 90°
BSM	CC	-90°	

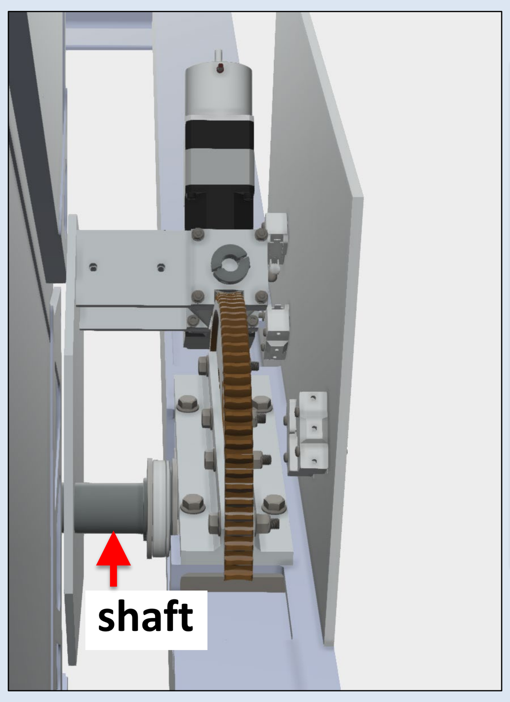
The tilting mechanism for the PBR telescope is motivated by scientific objectives and in situ instrument characterizations. In addition, the 1364~kg (3000~lb) weight limit allocated to "science" on the 0.5x10^6 m^3 (18 MCF) super-pressure balloons flown from Wanaka NZ limits the size and indirectly the field of view of the PBR telescope.

Telescope Tilt System

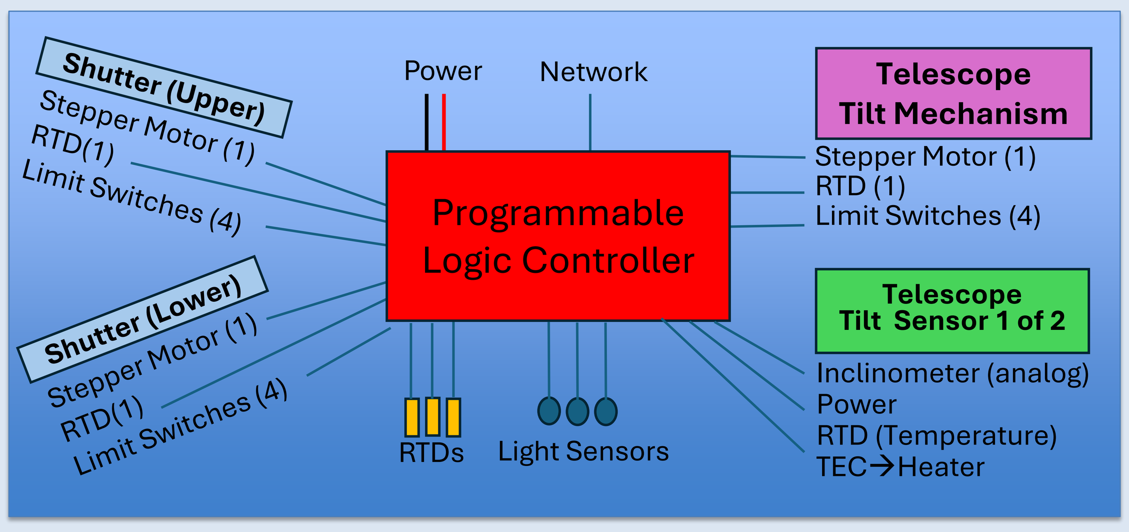
Item	Specification	Notes
Tilt Range	+15° to -90°	relative to horizontal at balloon
Temperature Range	+30C to -60C	
Pressure Range	sea level to 690 PA (33 km)	7 mbar, (110,000 ft)
Tilt angle measurement	± 0.1°	mechanical axis
Telescope Balance	center of mass +/- 25 mm	About tilt rotation axis
Select Components		
Motor type	stepper	NEMA 23
Controller	programmable logic controller	Siemens 6AG12141AG402XB0
Tilt Sensor	gravity referenced	Rieker H6MM 2-axis

PBR telescope tilt system specifications



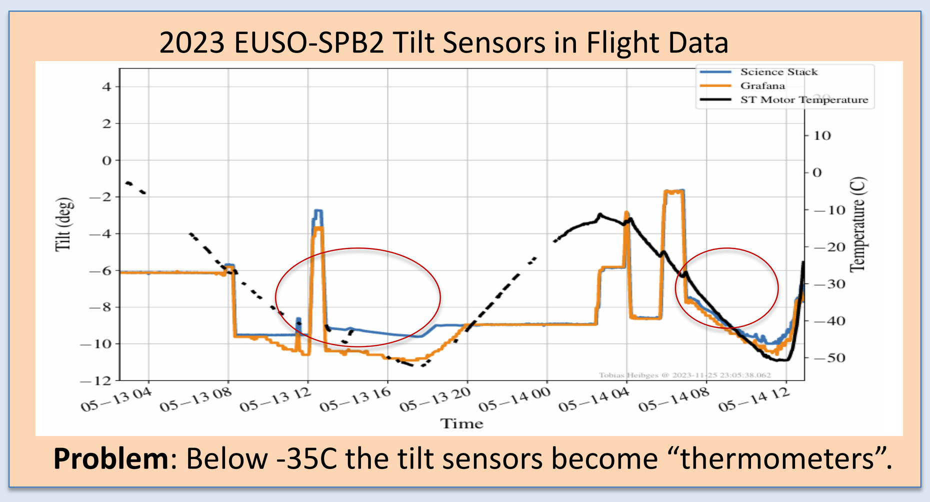


The PBR telescope tilt mechanism uses a **worm drive** turned by a **stepper motor** to rotate the telescope about a **worm gear** connected to the gondola frame. Two short **shafts**, one on each side of the telescope, connect the telescope to the gondola. Each shaft rotates in a custom bearing assembly connected to the gondola. There is one tilt mechanism.

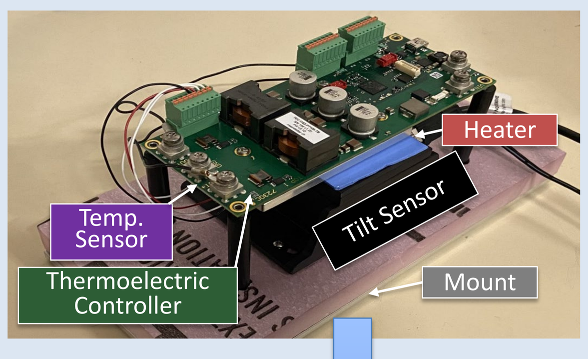


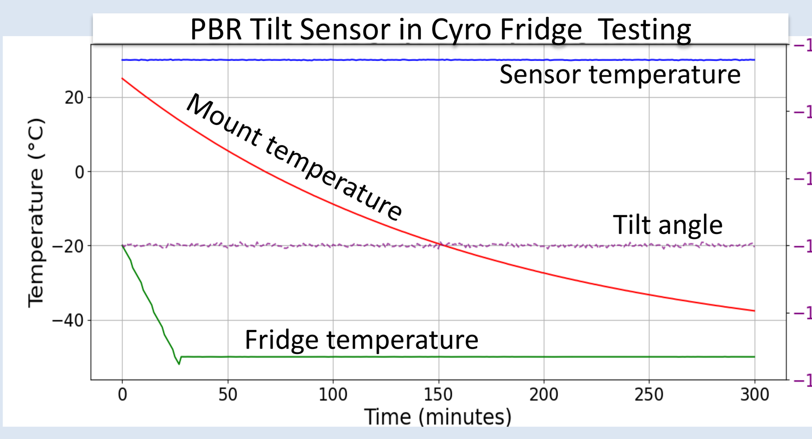
PBR telescope tilt system control architecture is an expanded version of the control system flown on EUSO-SPB2. The programmable logic controller (PLC) accepts a short list of simple commands and returns a system status packet. A PLC is used for reliability. PLCs are used in traffic light systems and elevators, for example.

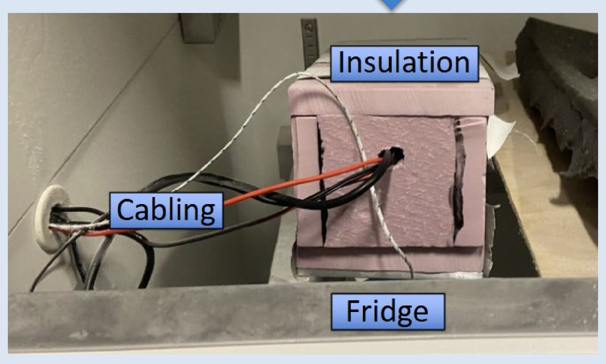
Tilt Sensors and Temperature Testing

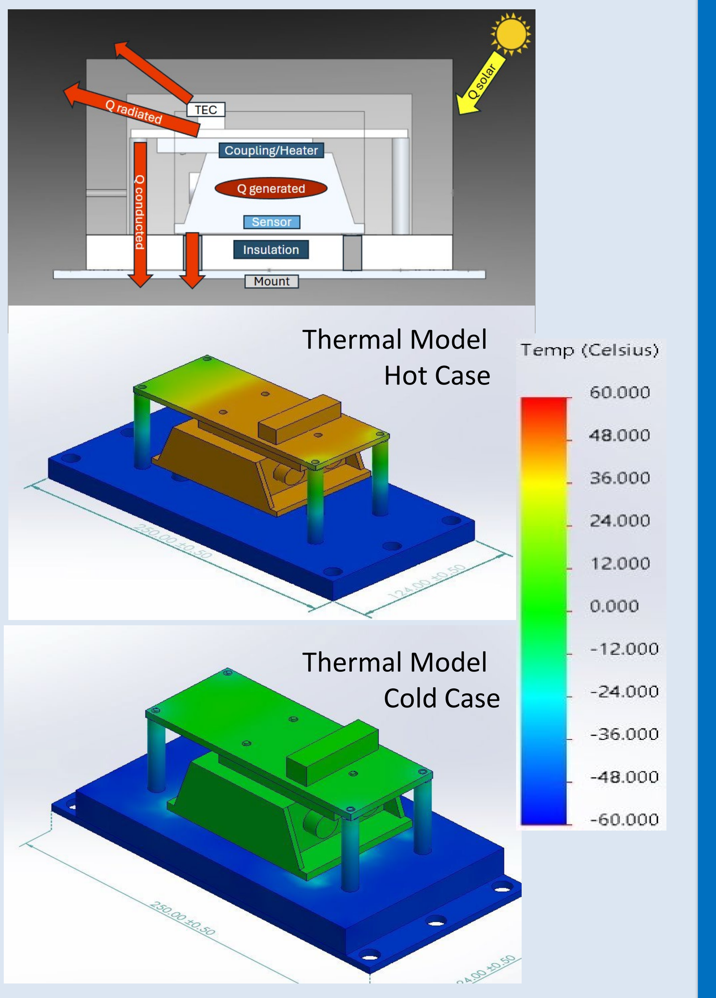


Problem: Below -35C the tilt sensors become "thermometers".



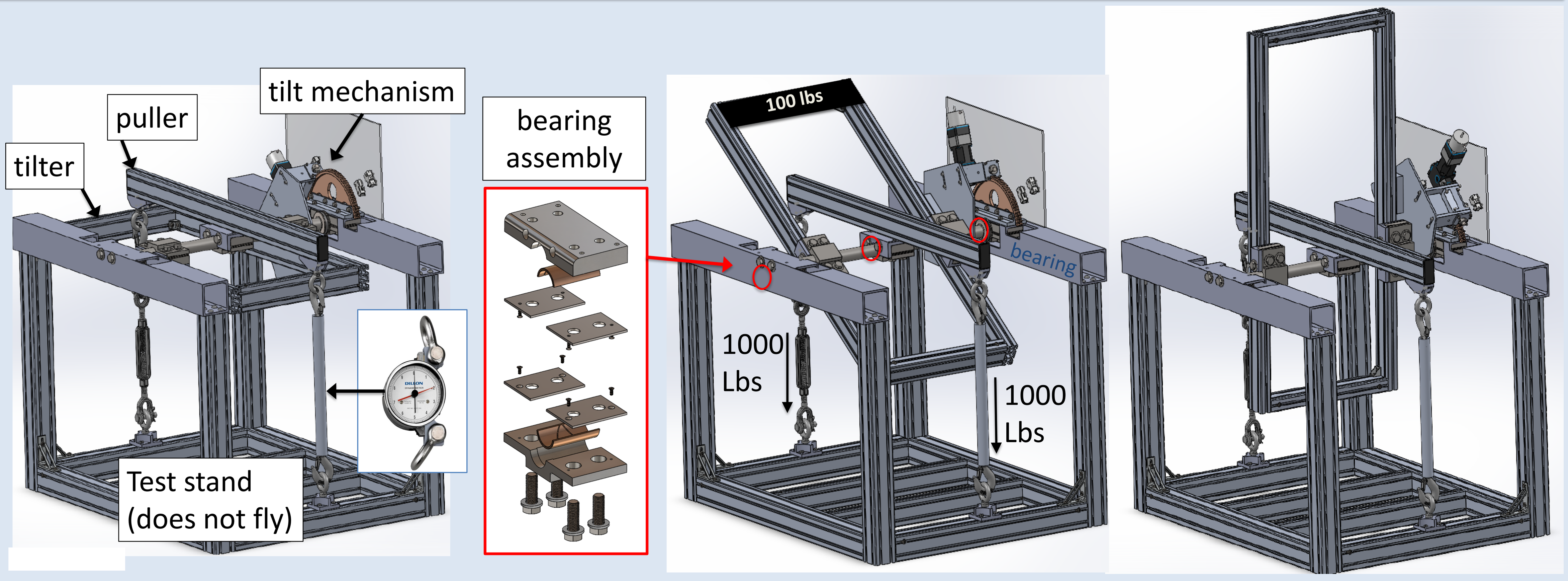






Solution: Add heater with thermoelectric controller and insulation, thermal modeling, and test in cyro-fridge.

Thermal Vacuum Testing Preparations



To test the PBR tilt system, including the tilt mechanism, bearing assembly, tilt sensors and control system, at 600 PA and -60C and under the expected mechanical load of the 900 kg (2000 Lb.) telescope, a custom test stand is under construction. The stand allows the range of rotation expected for flight, and is designed to fit in the "BEMCO chamber at NASA's CSBF facility.

Acknowledgements

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