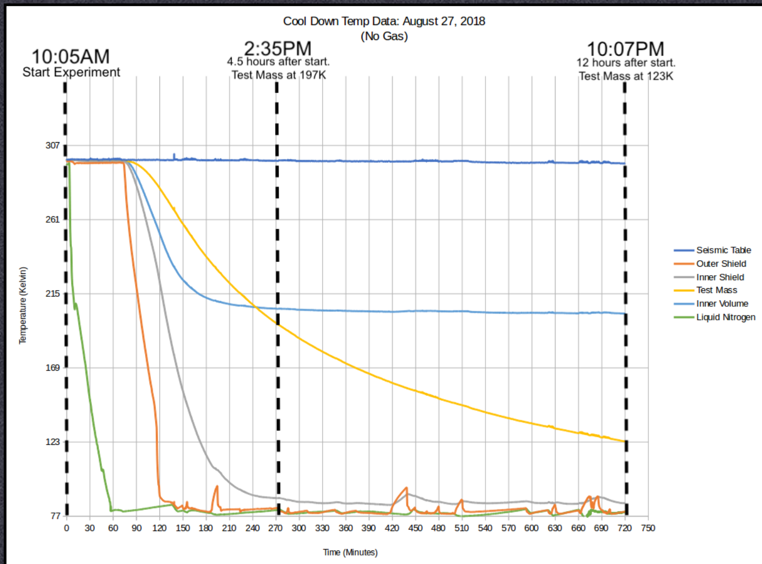
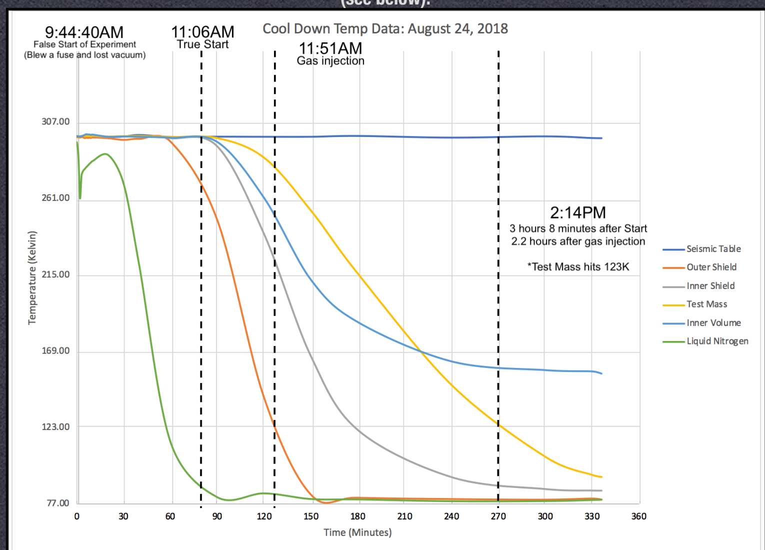
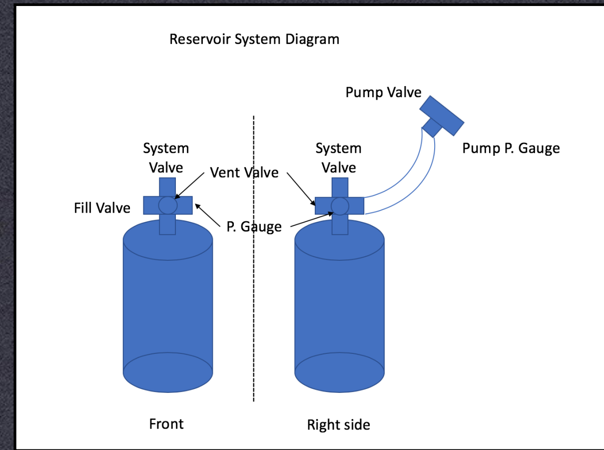


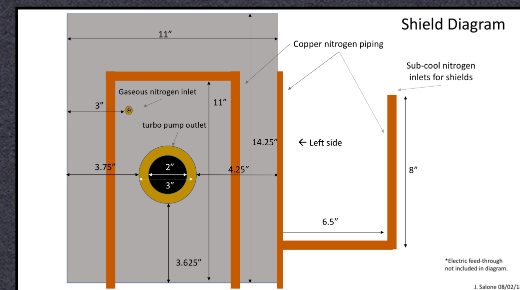
Trial without N2 gas. Note the time it takes for the Test Mass to reach 123K. The time scale is over 2 times longer than with gas. (see below).



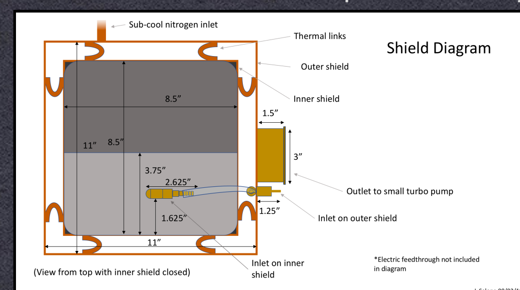
Trial with N2 gas. Note, the Seismic Table temperature remains within 1 K of room temperature, as shown by the horizontal dark blue line. This is an optimal outcome, indicating the rest of the apparatus is relatively unaffected by the N2 gas.



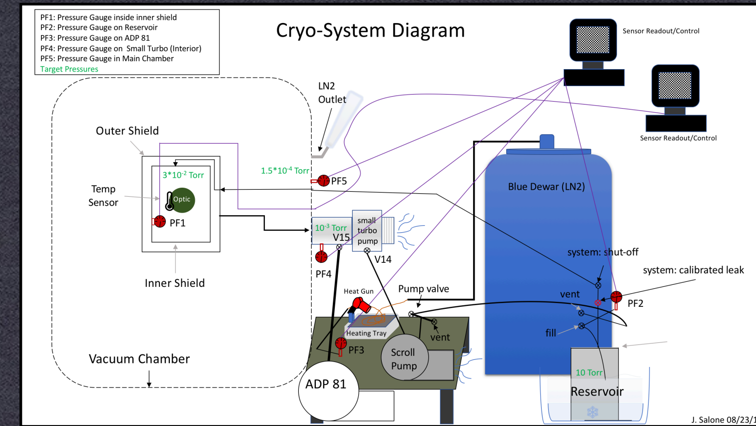
Step one was to assemble a gaseous N2 reservoir with controlled leaks to exploit choked flow conditions: a fill leak for the reservoir and a calibrated leak to the system. (3 weeks)



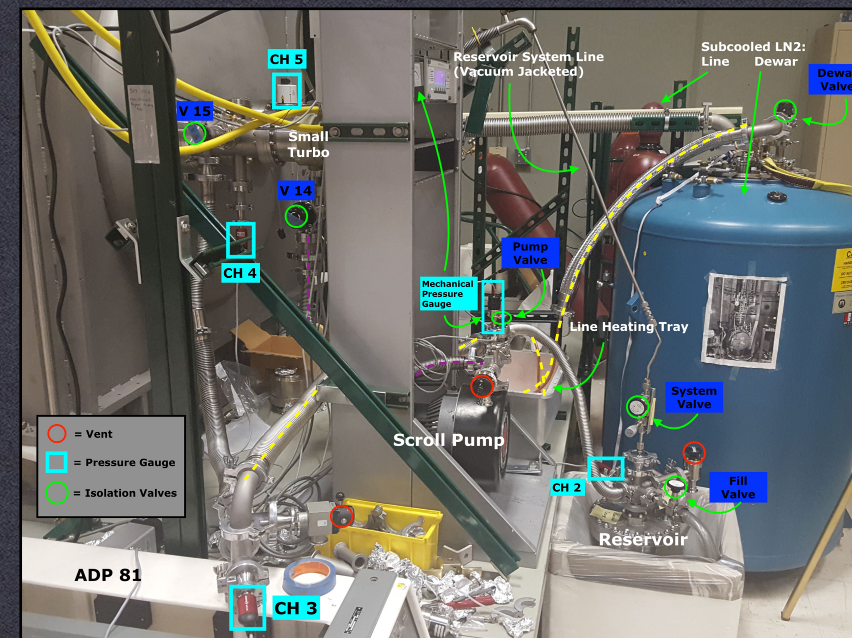
Under previous experiment conditions, the Outer Shield is cooled with sub-cool LN2. The Inner Shield is cooled with 'thermal links'. The Optic is cooled radiatively.



We Augmented the Shields To Inject the N2 Directly Into the Inner Shield and Connect a Small Turbo Pump directly to the Outer Shield as to not flood gas into the Vacuum System.



The final diagram for the system used in the trials. Not pictured: the external LN2 dewars that connected to the Blue Dewar. See Shield Diagrams for shield LN2 inlet and outlet.



Labelled photo of the Cryo System Prototype.

PROJECT

CRYOGENIC OPTIC COOLING PROTOTYPE FOR LIGO VOYAGER

THIS SUMMER, under advisor Dr. Brian Lantz with the guidance of PhD candidate Edgard Bonilla, I assembled and integrated a prototype of a Nitrogen Reservoir System that will assist in the initial cool-down of the optic in LIGO Voyager, the 3rd generation of the Laser Interferometer Gravitational-Wave Observatory (LIGO). Cooling down the optic limits 'noise' caused by thermal expansion and "Brownian thermal noise". The goal of this R&D project is to test a new method for reducing the time it takes to cool a 1kg silicon test mass down to the optic's intended operating temperature of 123 K.

MY PROJECT is to test the applicability of utilizing flowing gaseous nitrogen inside the optic cooling shields as a thermal conductor to assist the radiative cooling of the test mass by the shields, all without disrupting the temperature or pressure in the rest of the apparatus. This is very important because the other isolation systems in the interferometer rely on isothermal conditions to function properly.

WHAT IS AN INTERFEROMETER? An interferometer is an apparatus that measures interference! A laser interferometer splits a beam of light in two directions then recombines the two waves, looking for constructive or destructive interference which might be caused by a ripple in space-time ~GRAVITATIONAL WAVES~ , or the movement of plumbing from flushing a toilet.

"At its most sensitive state, LIGO will be able to detect a change in distance between it's mirrors 1/10,000th the width of a proton!"*

It's THAT sensitive! To reduce the majority of the extra movement that creates noise in the Gravitational-Wave Observatory's interferometer, LIGO scientists use two stages of seismic isolation, four stages of suspension (both actively controlled), operate under vacuum, and in the versions of the apparatus in development, will be cooling the optics to mitigate the noise arising from thermal sources. This and many more methods on the cutting edge of stillness.

AFTER A COUPLE MONTHS of construction and system calibration, we were ready to measure whether the conducting gas influenced the cooling rate of the test mass in a statistically significant way. By controlling the flow rate of gaseous nitrogen into the inner shield and tracking the temperature of the silicon test mass down to 123 K, then comparing that data to the cooling of the test mass without the gaseous nitrogen in the system, we could tell whether the gaseous nitrogen actually sped the cooling process and quantify its influence.

I FOUND that our trial with the gaseous nitrogen was more than 3 times faster than the trial that solely utilized radiative cooling (decreasing trial duration from 10.9 hours to 3.1 hours) and kept the vacuum chamber within pressure ranges conducive to isothermal operation of the rest of the apparatus (temperature fluctuation within 1 K). It is also worth noting that the gaseous nitrogen was not injected at the commencement of the trial, so there is a likelihood that this cool-down method can produce even faster results.

DATE SUMMER 2018 LIGO-G1801629-x0
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*www.ligo.caltech.edu/page/facts