Select Detector Support Group Projects

Patrizia Rossi and
the Detector Support Group
Tuesday, August 1, 2023

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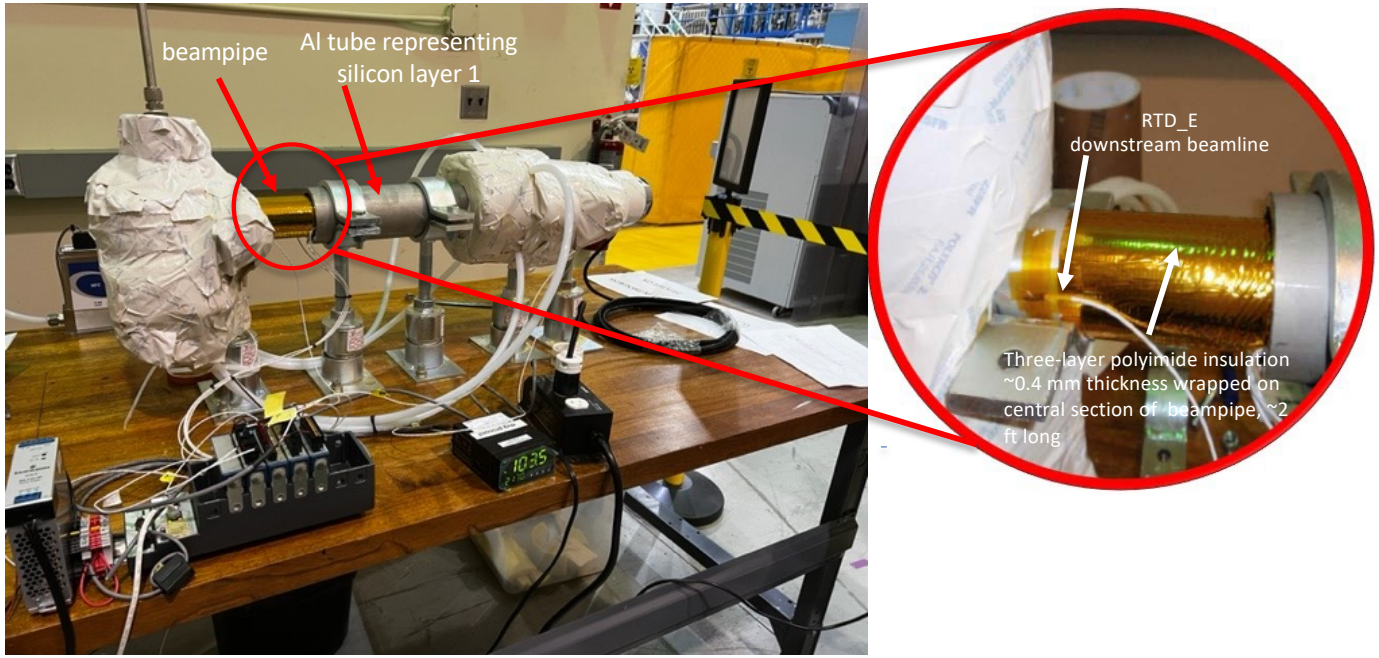
EIC Beampipe: Al Coated Polyimide Three-layer Insulation

George Jacobs, Marc McMullen, and Brian Eng

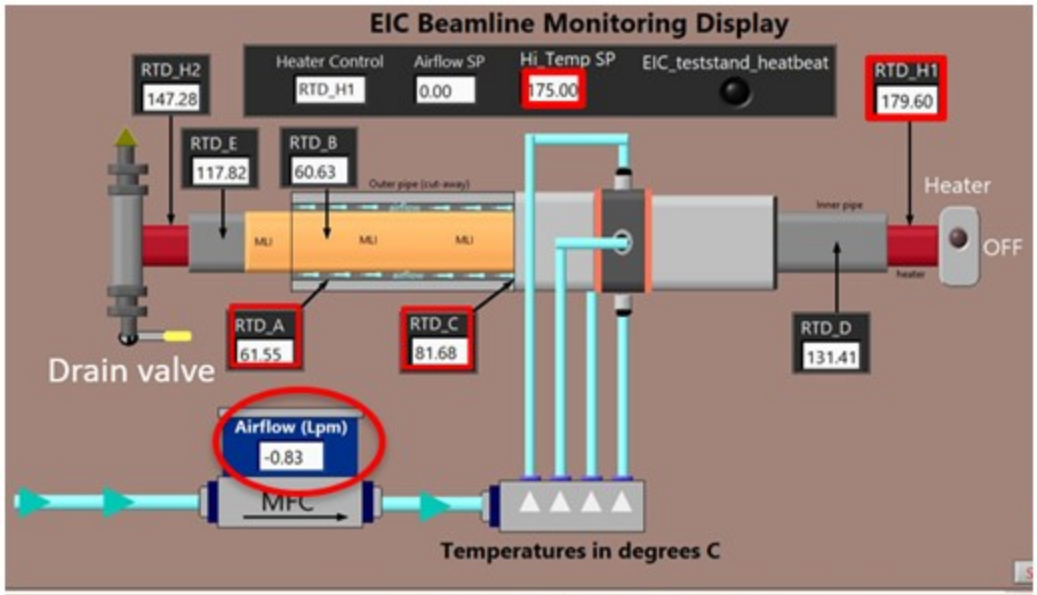


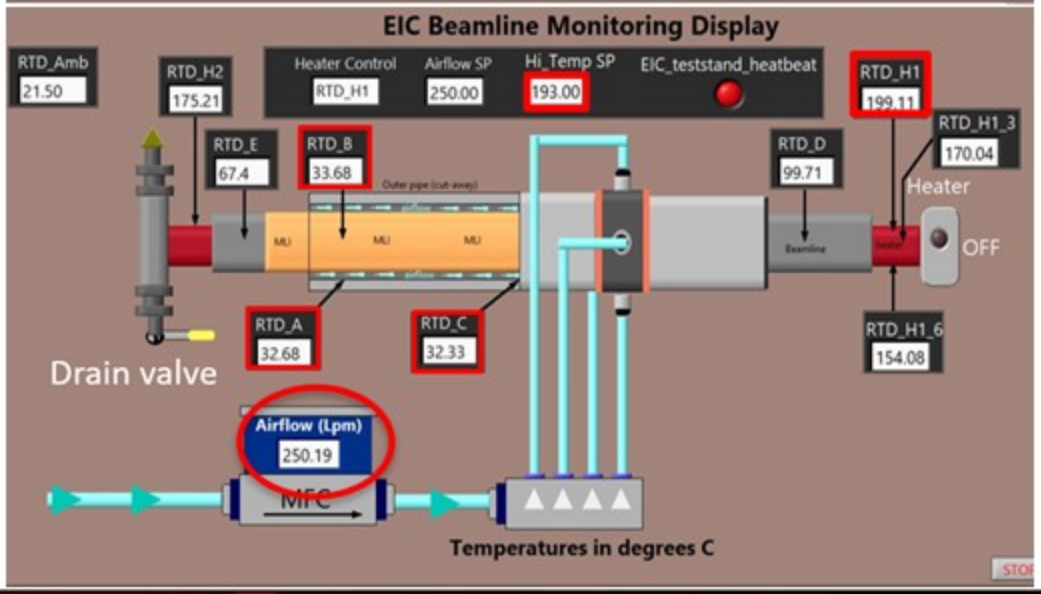
EIC beampipe test stand

- Goal: determine flowrate of 20°C air to keep silicon superlayer 1's (SL1) inside surface temperature ≤ 30°C with beampipe temperature held at ~100°C
  - **1st attempt: plain beam pipe**; couldn't maintain beampipe temp. at 100°C, temp dropped to ~60°C
  - **2nd attempt: beampipe insulated with Aerogel**; Aerogel became brittle and started to delaminate from beampipe
  - **3rd attempt: beampipe insulated with three-layer aluminized polyimide insulation**

EIC Beampipe: Control & Monitoring Software

Marc McMullen and Brian Eng





No airflow

- Even though high temperature setpoint is 175°C, RTD_H1 readback is 179°C because even after removing power, temperature rises a few °C
- SL1 temperatures measured by RTD-A, RTD_B, and RTD_C are about 62°C, 61°C, and 82°C, respectively

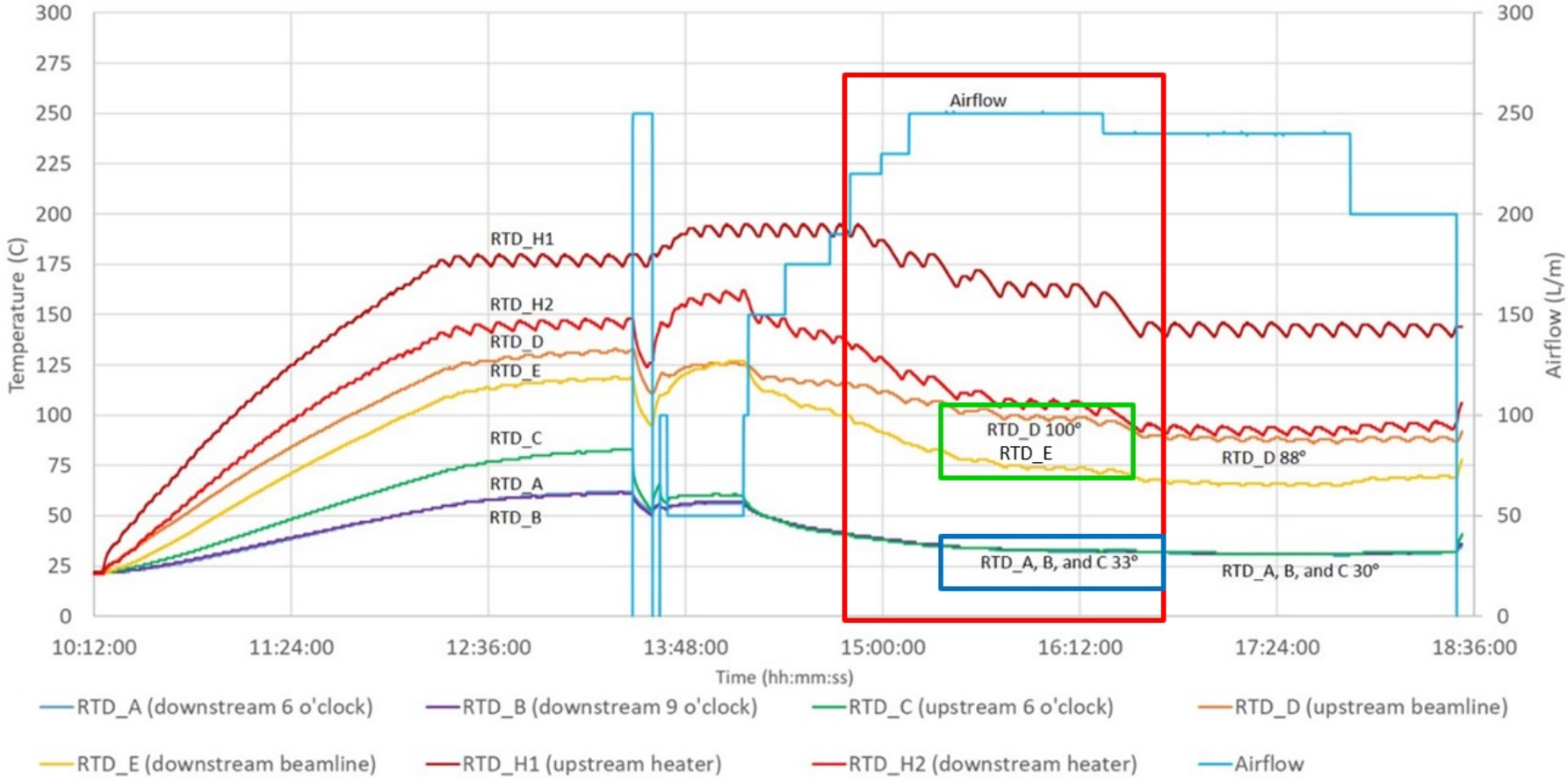
Beampipe target temp. 100°C
Ramping beampipe to 100°C takes about two hours
Airflow max 250 SLM, mass flow controller (MFC) limitation

Airflow set at 250 SLM

- Even though high temperature setpoint is 193°C, RTD_H1 is at 199°C because even after removing power, temperature rises a few °C
- SL1 temps measured by RTD-A, RTD_B, and RTD_C are about 33°C, 34°C, and 32°C, respectively

EIC Beampipe: Test Results

Marc McMullen, George Jacobs, and Brian Eng



Test Material	Heater Temp [°C]	Beampipe Temp [°C]	Airflow [SLM]	SL1 Temp [°C]
Aerogel	215	100	215	30
Kapton	199	100	250	33

- At beampipe temp of ~100°C **(RTD_D green box)** and airflow rate of 250 slm, SL1 inside surface is ~33°C (blue box)
  - Flowrate max. is 250 SLM because of mass flow controller limit

Cannot cool SL1 inside surface below ~ 30°C

EIC Beampipe: Linear Regression Python Program Results for Aerogel

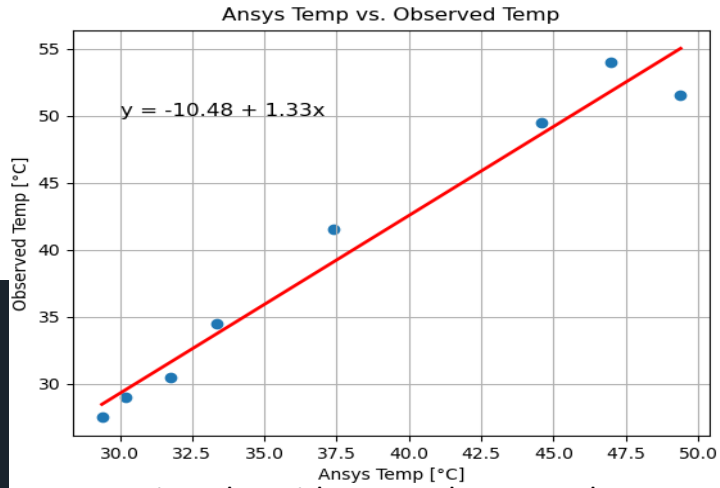
Pablo Campero

- To check Ansys Fluent simulation's validity against experimental data from the Aerogel insulated beampipe test

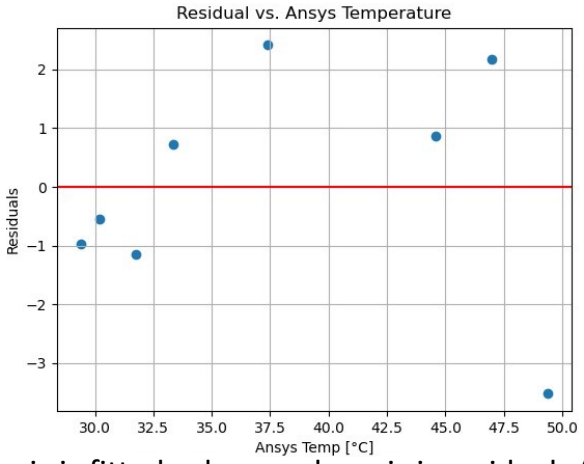
```
                            OLS Regression Results
==============================================================================
Dep. Variable:      Observed_Temp[°C]   R-squared:                       0.967
Model:                            OLS   Adj. R-squared:                  0.962
Method:                 Least Squares   F-statistic:                     177.1
Date:                Fri, 07 Jul 2023   Prob (F-statistic):           1.11e-05
Time:                        15:11:09   Log-Likelihood:                -16.189
No. Observations:                   8   AIC:                             36.38
Df Residuals:                       6   BIC:                             36.54
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const        -10.4763      3.848     -2.723      0.035     -19.892      -1.061
Ansys_Temp[°C]     1.3259      0.100     13.306      0.000       1.082       1.570
==============================================================================
Omnibus:                        0.572   Durbin-Watson:                   1.621
Prob(Omnibus):                  0.751   Jarque-Bera (JB):                0.371
Skew:                          -0.426   Prob(JB):                        0.831
Kurtosis:                       2.380   Cond. No.                         199.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

Python program output, $R^2 \approx 97\%$



Regression plot with Ansys-Fluent results vs. observed temperatures, best fit line (red).
y = -10.48 + 1.33x valid only in the measurement range (Offset *-10.48* unphysical).



x-axis is fitted values and *y*-axis is residuals (fitted value – measured value). Sum of residuals is 1.00E-06, indicating quality of regression model is good. Red line indicates average of residuals ~0

EIC DIRC: Laser Test Lab and Interlock Board

Tyler Lemon, Marc Mc Mullen, and Mindy Leffel

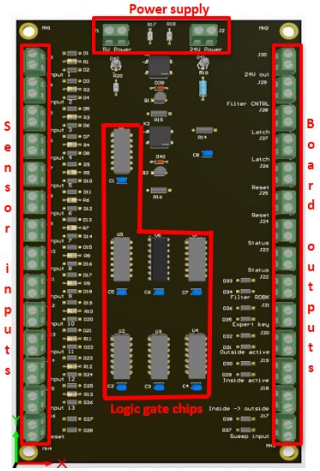
Designed laser test area

- Being constructed in EEL 108 to test light transmittance of the detector's quartz bars
  - Ideally, bars should transmit ≥ 99% of incident light

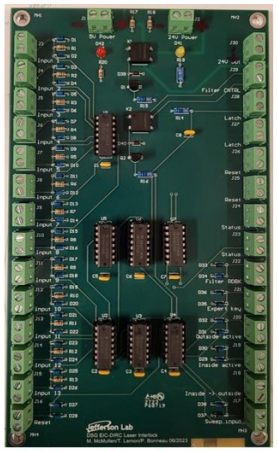
Interior of EIC DIRC's laser controlled area in EEL 108. Optical table (5'X10' with 1.5' sidewalls) is for the laser, optics, and motorized stages.

Designed and developed laser interlock circuit DSG Note 2023-01

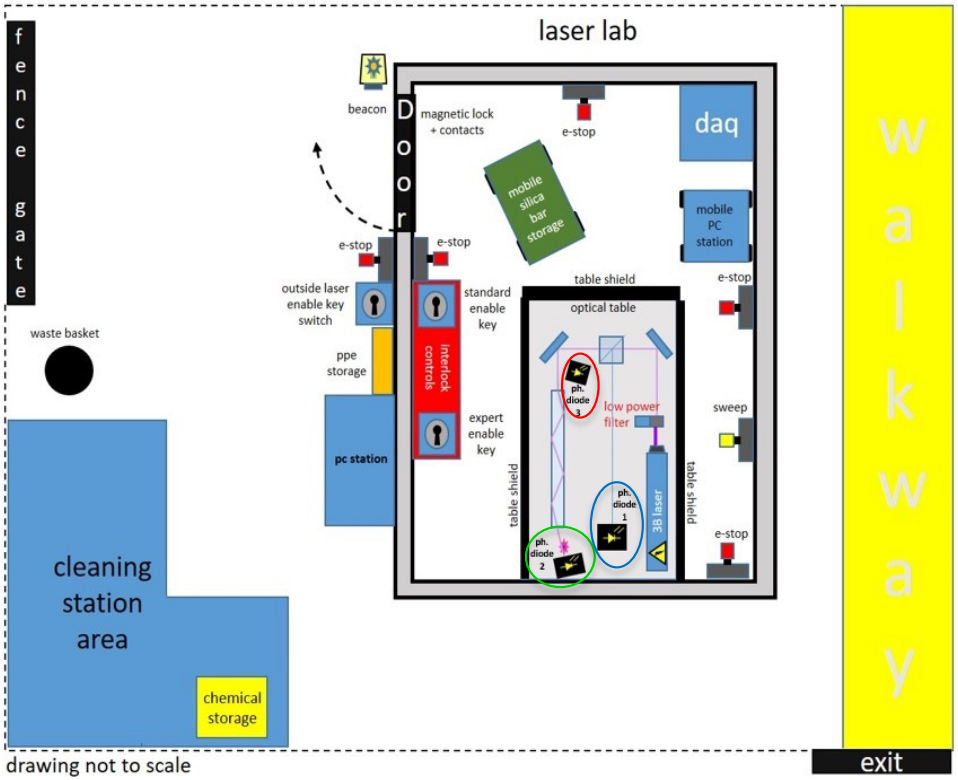
- To provide
  - Access controls and monitoring
  - Emergency stop capabilities
  - Move in/out power-reduction filter
- Status
  - Circuit and PCB design completed
  - Sent for fabrication and received boards
- Interlock board to be located in enclosure on inside wall of laser test lab and checked after installation



Altium 3D rendering of laser interlock PCB



Fabricated laser interlock PCB

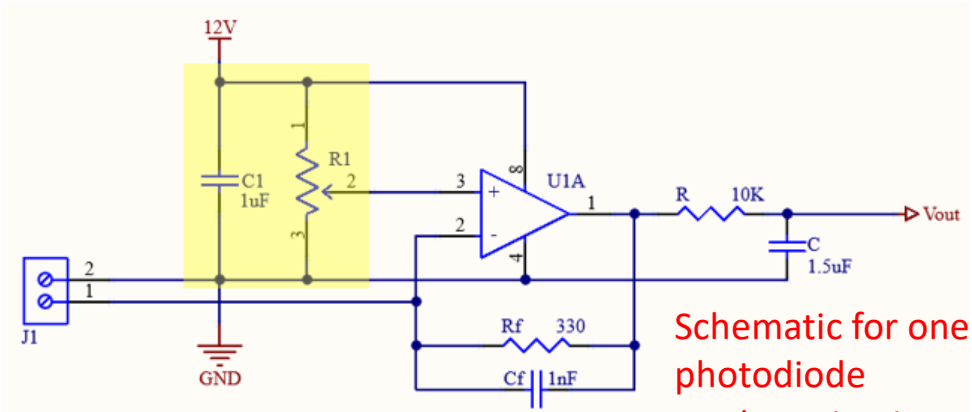


EIC DIRC: Data Acquisition Board Development

Tyler Lemon

Designing DAq board for Laser Tests

- To determine transmittivity of quartz bars, photodiode current response is measured before and after transmittance through bar
- Trans-impedance amplifier and filtering circuit developed to read photodiode current response
  - Op-amp circuit converts photodiode current to voltage that is read using two ADS1115 ADCs
  - Data displayed on local LCD screen
  - Data also communicated to remote PC using serial communication
- Circuit design and prototyping completed



Schematic for one photodiode readout circuit.

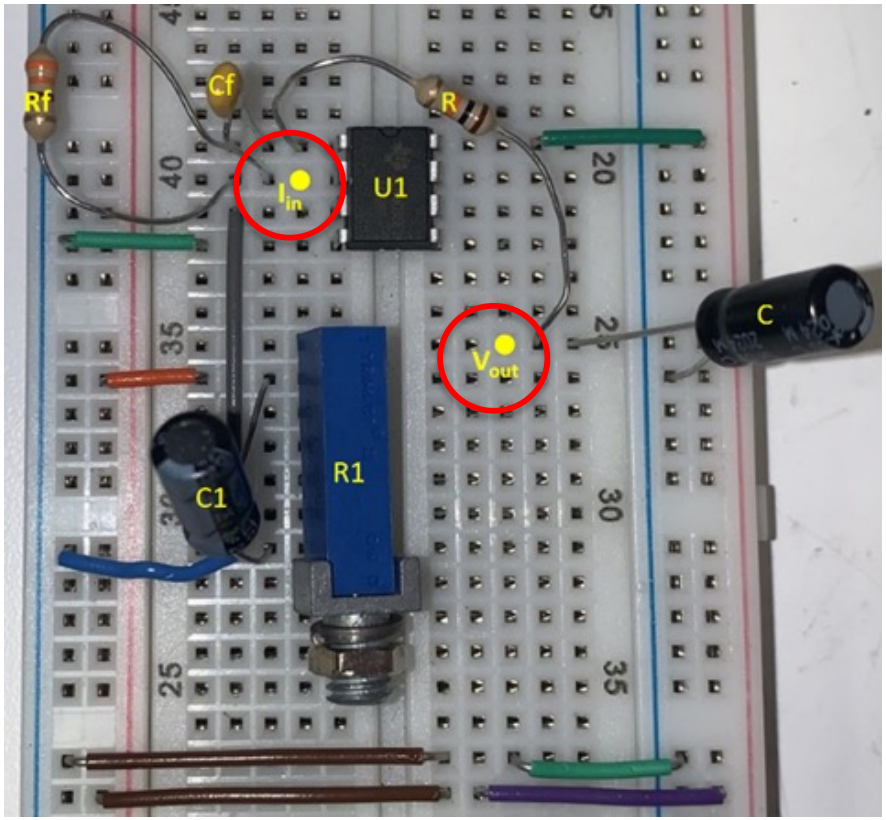


Photo of DAQ circuit breadboard.
Points in circuit where input current and output voltage can be measured are noted by I_{in} and V_{out}, respectively.

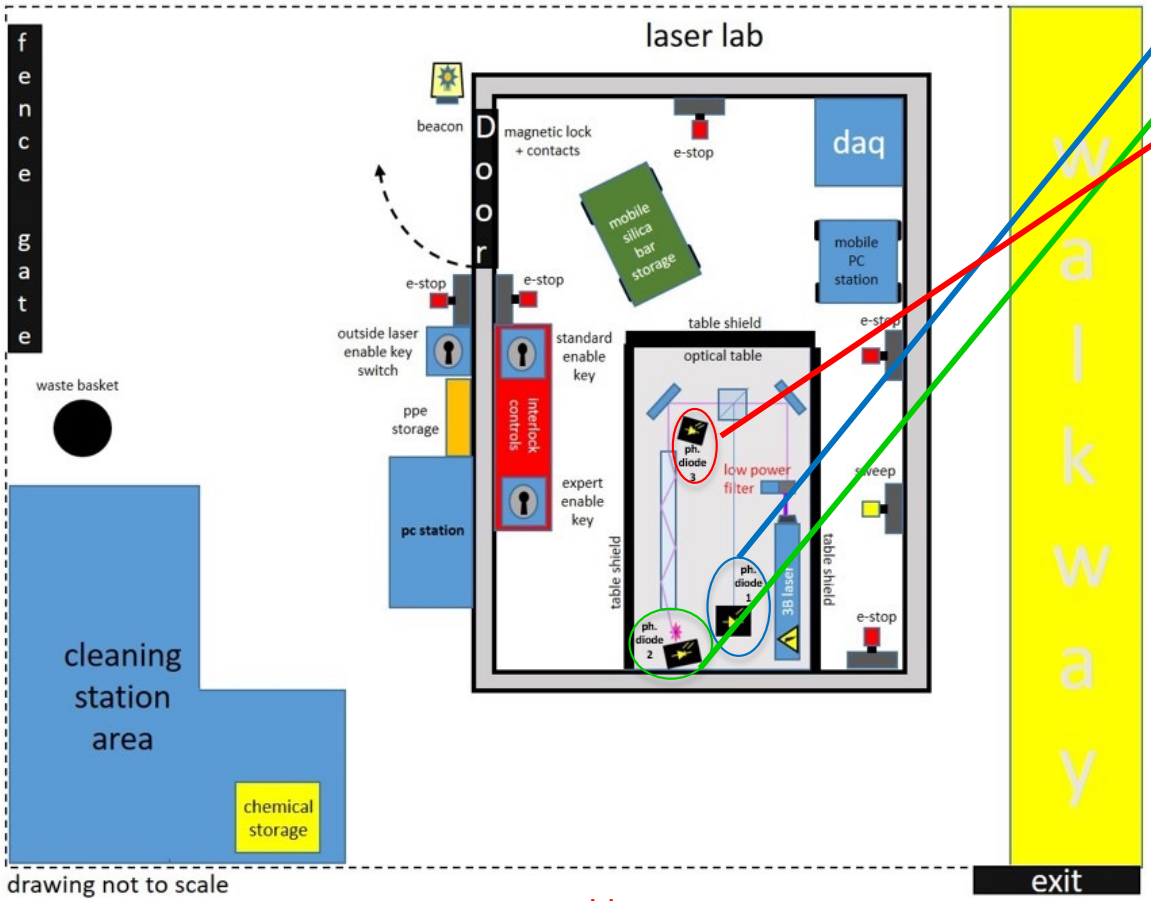
DSG Notes 2023-14 & 2023-17

EIC DIRC: Remote User Interface

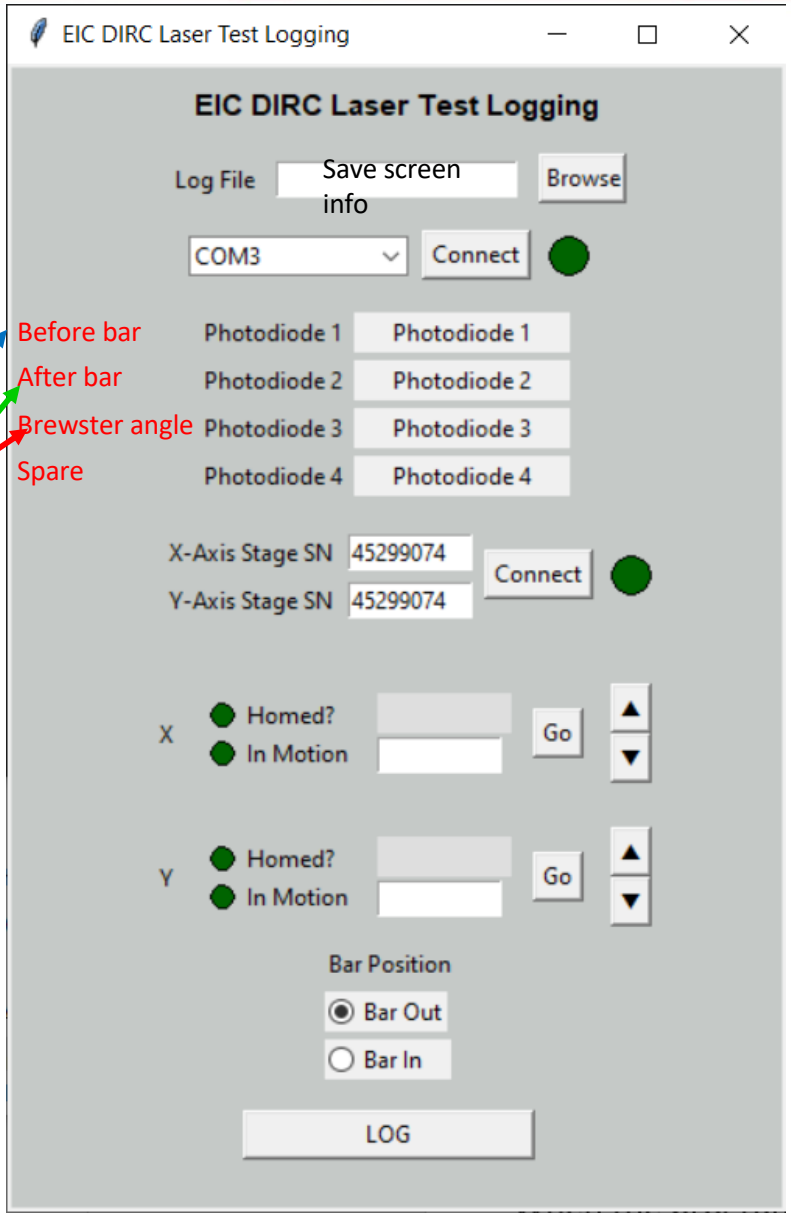
Tyler Lemon

Laser Acceptance Test Remote User Interface

- Developing user interface for remotely configuring, monitoring, and controlling photodiode readouts and motorized stages
- User interface created using Python and Tk interface library
  - Program handles all widget placement on screen and widget functions



Laser teststand layout



Screenshot of user interface during development.

NPS Activities : Thermal Readback Phoebus Screens

Mary Ann Antonioli, Peter Bonneau, and Aaron Brown

2023-07-18 13:17:

Front Crystal Zone Temperatures

Monitoring

Crystal	T [°C]	Avg [°C]	σ [°C]	Intlk status	Latch status	Crystal	T [°C]	Avg [°C]	σ [°C]	Intlk status	Latch status
0	21.10	21.16	0.02			540	20.93	21.00	0.03		
5	21.16	21.13	0.01			550	20.96	21.02	0.03		
10	21.15	21.13	0.01			560	21.03	21.09	0.03		
15	21.16	21.13	0.01			570	21.19	21.24	0.02		
20	21.16	21.14	0.01			684	21.12	21.17	0.02		
25	21.16	21.12	0.01			689	21.02	21.08	0.03		
30	21.15	21.13	0.01			694	20.99	21.04	0.03		
35	21.21	21.10	0.01			699	20.94	21.01	0.03		
180	21.10	21.08	0.01			704	20.95	21.01	0.03		
185	21.05	21.25	0.01			709	20.98	21.03	0.03		
190	21.00	21.21	0.01			714	21.05	21.09	0.03		
195	20.99	21.21	0.01			719	21.17	21.24	0.02		
200	21.01	21.21	0.01			864	21.19	21.20	0.01		
205	21.01	21.22	0.01			869	21.13	21.15	0.01		
210	21.08	21.26	0.01			874	21.09	21.12	0.02		
215	21.15	21.18	0.01			879	21.09	21.11	0.02		
360	21.10	21.06	0.01			884	21.08	21.11	0.02		
365	21.01	21.22	0.01			889	21.10	21.13	0.02		
370	20.95	21.18	0.01			894	21.14	21.17	0.01		
375	20.91	21.16	0.01			899	21.29	21.29	0.01		
380	20.96	21.20	0.01			1044	21.21	21.23	0.01		
385	20.98	21.21	0.01			1049	21.21	21.22	0.01		
390	21.04	21.26	0.01			1054	21.21	21.23	0.01		
395	21.19	21.21	0.01			1059	21.24	21.25	0.01		
509	21.14	21.11	0.01			1064	21.27	21.28	0.01		
519	21.02	21.23	0.01			1069	21.26	21.29	0.01		
529	20.96	21.19	0.01			1074	21.29	21.31	0.01		
539	20.95	21.17	0.01			1079	21.31	21.32	0.01		

Control

Crystal	Alarm limit [°C] low	Alarm limit [°C] high	Sensor enable	Avg enable	# of pts. to avg	Intlk enable	Trip delay enable	Trip delay time [s]	Crystal	Alarm limit [°C] low	Alarm limit [°C] high	Sensor enable	Avg enable	# of pts. to avg	Intlk enable	Trip delay enable	Trip delay time [s]
0	0	30	Enabled	Enabled	300	Enabled	Enabled	30	540	0	30	Enabled	Enabled	300	Enabled	Enabled	30
5	0	30	Enabled	Enabled	300	Enabled	Enabled	30	550	0	30	Enabled	Enabled	300	Enabled	Enabled	30
10	0	30	Enabled	Enabled	300	Enabled	Enabled	30	560	0	30	Enabled	Enabled	300	Enabled	Enabled	30
15	0	30	Enabled	Enabled	300	Enabled	Enabled	30	570	0	30	Enabled	Enabled	300	Enabled	Enabled	30
20	0	30	Enabled	Enabled	300	Enabled	Enabled	30	684	0	30	Enabled	Enabled	300	Enabled	Enabled	30
25	0	30	Enabled	Enabled	300	Enabled	Enabled	30	689	0	30	Enabled	Enabled	300	Enabled	Enabled	30
30	0	30	Enabled	Enabled	300	Enabled	Enabled	30	694	0	30	Enabled	Enabled	300	Enabled	Enabled	30
35	0	30	Enabled	Enabled	300	Enabled	Enabled	30	699	0	30	Enabled	Enabled	300	Enabled	Enabled	30
180	0	30	Enabled	Enabled	300	Enabled	Enabled	30	704	0	30	Enabled	Enabled	300	Enabled	Enabled	30
185	0	30	Enabled	Enabled	300	Enabled	Enabled	30	709	0	30	Enabled	Enabled	300	Enabled	Enabled	30
190	0	30	Enabled	Enabled	300	Enabled	Enabled	30	714	0	30	Enabled	Enabled	300	Enabled	Enabled	30
195	0	30	Enabled	Enabled	300	Enabled	Enabled	30	719	0	30	Enabled	Enabled	300	Enabled	Enabled	30
200	0	30	Enabled	Enabled	300	Enabled	Enabled	30	864	0	30	Enabled	Enabled	300	Enabled	Enabled	30
205	0	30	Enabled	Enabled	300	Enabled	Enabled	30	869	0	30	Enabled	Enabled	300	Enabled	Enabled	30
210	0	30	Enabled	Enabled	300	Enabled	Enabled	30	874	0	30	Enabled	Enabled	300	Enabled	Enabled	30
215	0	30	Enabled	Enabled	300	Enabled	Enabled	30	879	0	30	Enabled	Enabled	300	Enabled	Enabled	30
360	0	30	Enabled	Enabled	300	Enabled	Enabled	30	884	0	30	Enabled	Enabled	300	Enabled	Enabled	30
365	0	30	Enabled	Enabled	300	Enabled	Enabled	30	889	0	30	Enabled	Enabled	300	Enabled	Enabled	30
370	0	30	Enabled	Enabled	300	Enabled	Enabled	30	894	0	30	Enabled	Enabled	300	Enabled	Enabled	30
375	0	30	Enabled	Enabled	300	Enabled	Enabled	30	899	0	30	Enabled	Enabled	300	Enabled	Enabled	30
380	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1044	0	30	Enabled	Enabled	300	Enabled	Enabled	30
385	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1049	0	30	Enabled	Enabled	300	Enabled	Enabled	30
390	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1054	0	30	Enabled	Enabled	300	Enabled	Enabled	30
395	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1059	0	30	Enabled	Enabled	300	Enabled	Enabled	30
509	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1064	0	30	Enabled	Enabled	300	Enabled	Enabled	30
519	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1069	0	30	Enabled	Enabled	300	Enabled	Enabled	30
529	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1074	0	30	Enabled	Enabled	300	Enabled	Enabled	30
539	0	30	Enabled	Enabled	300	Enabled	Enabled	30	1079	0	30	Enabled	Enabled	300	Enabled	Enabled	30

- Testing front crystal zone's Phoebus screen
  - Control and monitoring screens combined into a single screen
  - Alarm limits and delays are placeholders; can be changed if needed
  - Rolling average calculated over 300 data entries
  - EPICS IOC developed to enable EPICS alarms
    - Epics alarm limits < LabView interlock alarm limits

NPS Activities: Ansys Mechanical Transient Thermal Analysis of Central Crystal

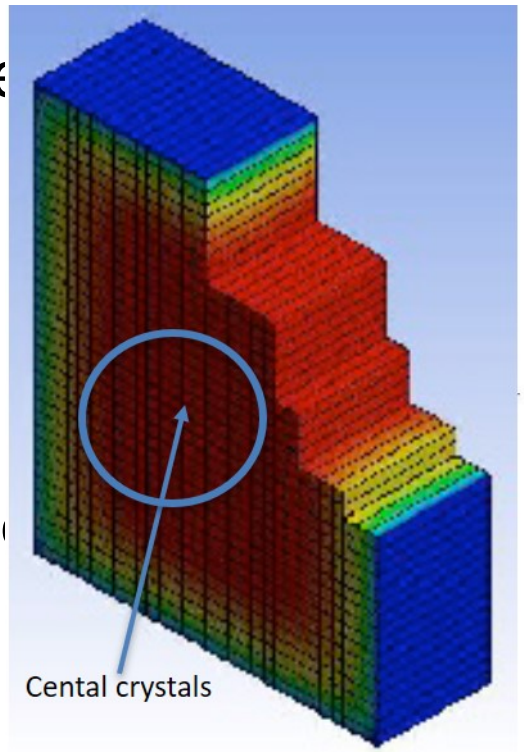
Aaron Brown

- Ansys fluent transient is still being performed to check ansys mechanical transient

Ansys				
FLAVOR (VERSION)	**ANALYSIS**	**RELATIONSHIP**	**ANALYSIS**	**COMMENTS**
MECHANICAL	STEADY STATE	agrees with	TRANSIENT	BOTH ANALYSES EQUILIBRATE AT AMBIENT TEMPERATURE
FLUENT	STEADY STATE NOT STARTED	N/A	TRANSIENT IN PROGRESS; TO CHECK ANSYS MECH TRANSIENT RESULTS	WAITING FOR RESULTS

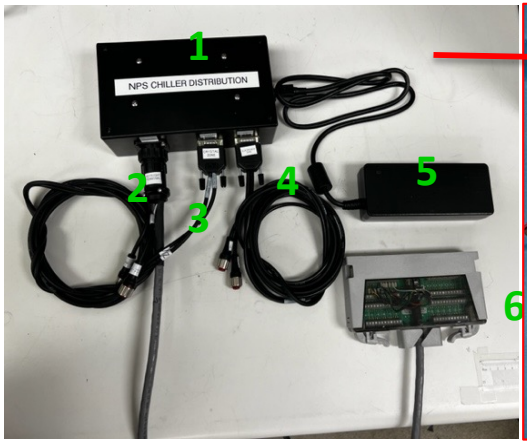
NPS Activities: Ansys Mechanical Transient Analysis Corrections

- Issues that caused previous transient results to differ from steady-state results
  - Incorrect heating method: used heat flux instead of heat flow
  - Incorrect materials: all components of the transient simulation were assigned structural steel
- These issues have been addressed and the ste transient simulations agree
- The ambient temperature drives the temperature of the central crystals
  - LCW cooling around the crystal array does not affe the central crystals

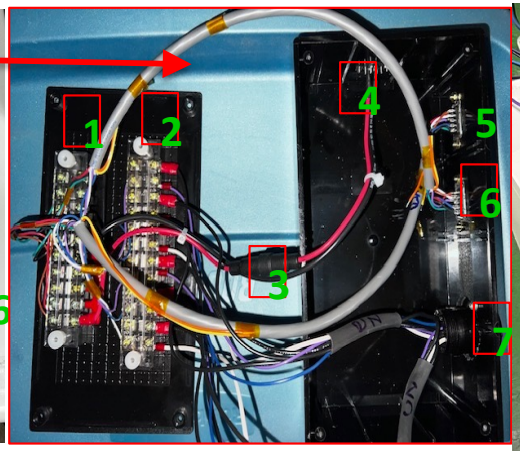


NPS Activities: Chiller Environmental Sensor Distribution Box

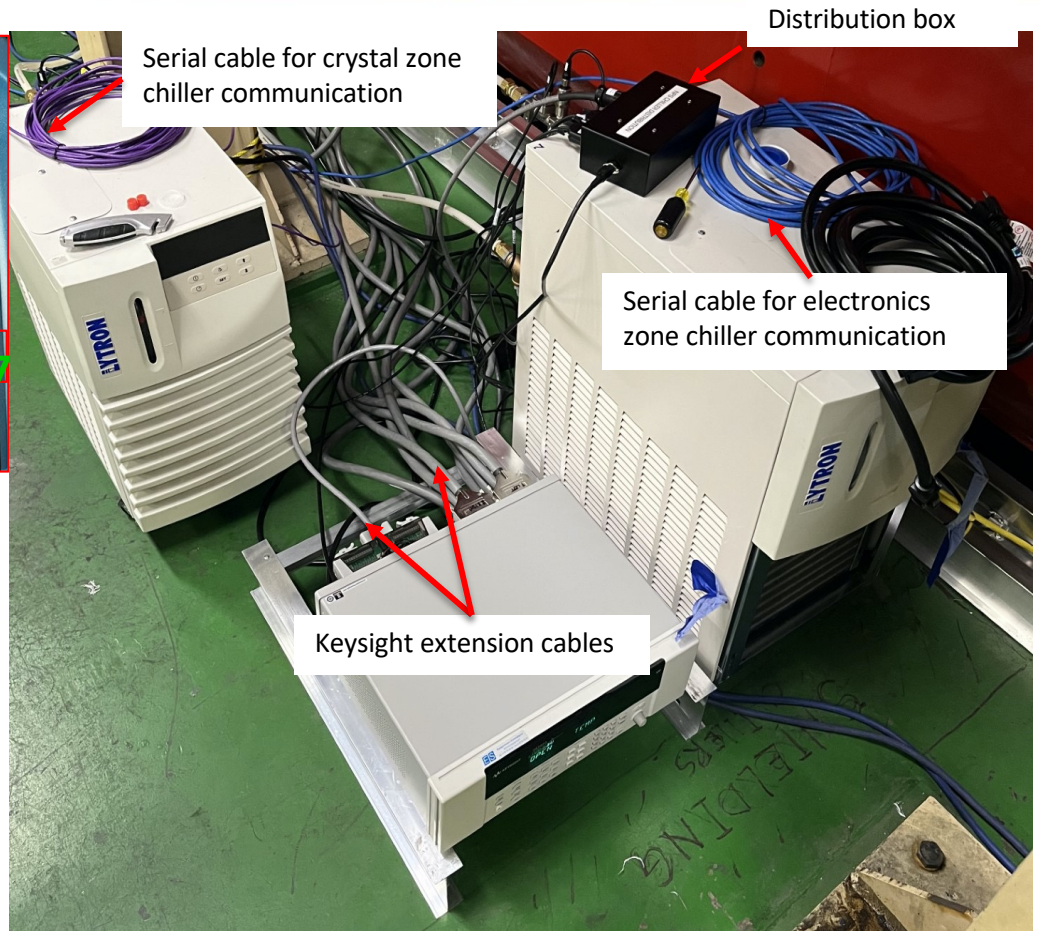
Mindy Leffel, Marc McMullen, and Aaron Brown



1. Distribution box, 2. cable to Keysight terminal block, 3. cable to crystal zone chiller sensor, 4. cable to electronics zone chiller sensor, 5. external 24 V power supply, 6. Keysight terminal block



Inside distribution box
1. Power distribution block, 2. signal distribution block, 3. fuse (0.1 A), 4. 24 V power supply connector, 5. electronics zone sensor connector, 6.crystal zone sensor connector, 7. Keysight terminal block connector



- Designed and fabricated distribution box to provide power to the Proteus Industries V7000 temperature, flow, and pressure sensors on the flowmeter on the outlet of the chiller
  - Distribution box receives voltage signals [0 V - 5 V] from sensors and sends signals to Keysight terminal block

- Designed, fabricated cables, and instrumented chiller setup
  - Chiller instrumentation being tested in the hall

Summary

- **EIC Beampipe**
  - Unable to cool SL1 below 30°C
  - Next steps
    - Use ceramic standoffs to isolate system
    - Add another mass flow controller to increase flowrate above 250 SLM
- **EIC DIRC**
  - Laser test lab almost ready
  - Testing interlock circuit boards
  - Developing DAq
- **NPS activities**
  - Control and monitoring screen completed
  - Checking thermal readback and chiller controls in Hall
  - Designing and fabricating necessary hardware