Calibration Technical Update

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on behalf of the calibration group (Hawaii, MSU, SLAC)

March 8th, 2024

Outline

Preparation for SLAC run 2. Progress on changes/improvements underway.
Update on cathode

FSD fiber routing mock-up update.

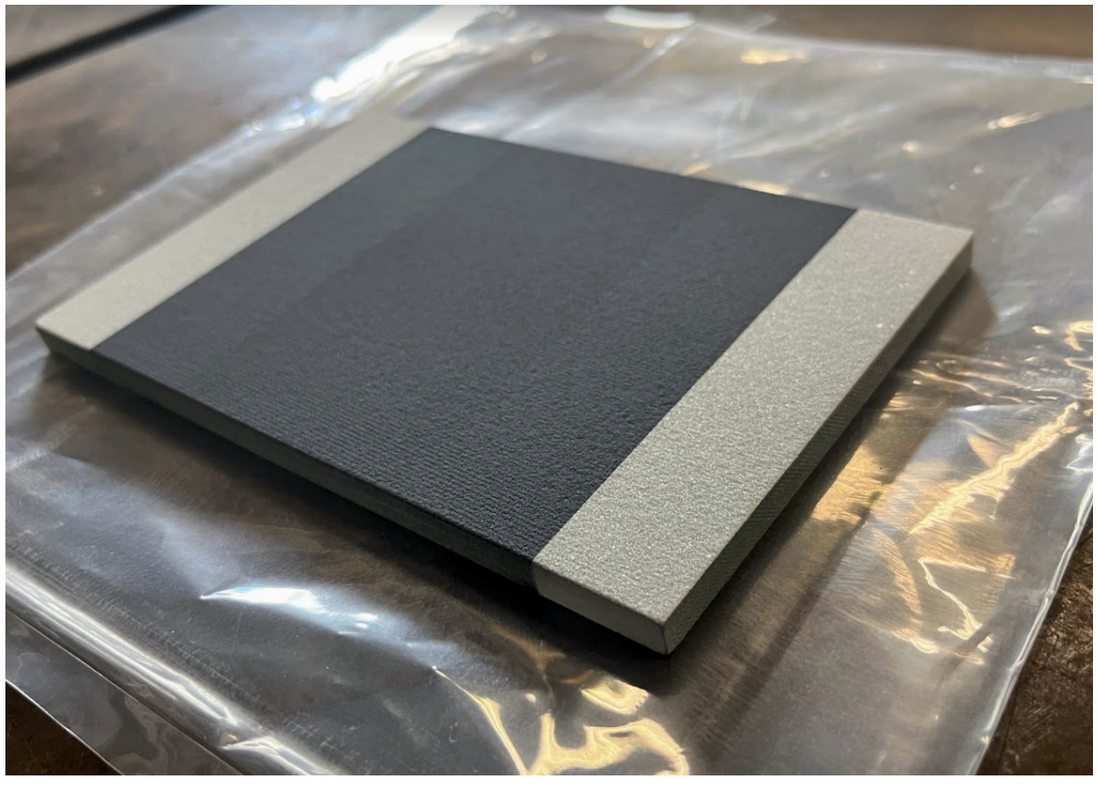
Calibration of light collections system with calibration laser system

Cathode Update

We cannot use carbon loaded epoxy at this stage (it might be viable in the future, but is not suitable for the FSD/ND).

Fallback is Zn coated cathode. Ti02 is a possibility

James will send a sample to Hawaii for testing



Plasma coated Ti02 (blueish grey color).
Higher work function likely.

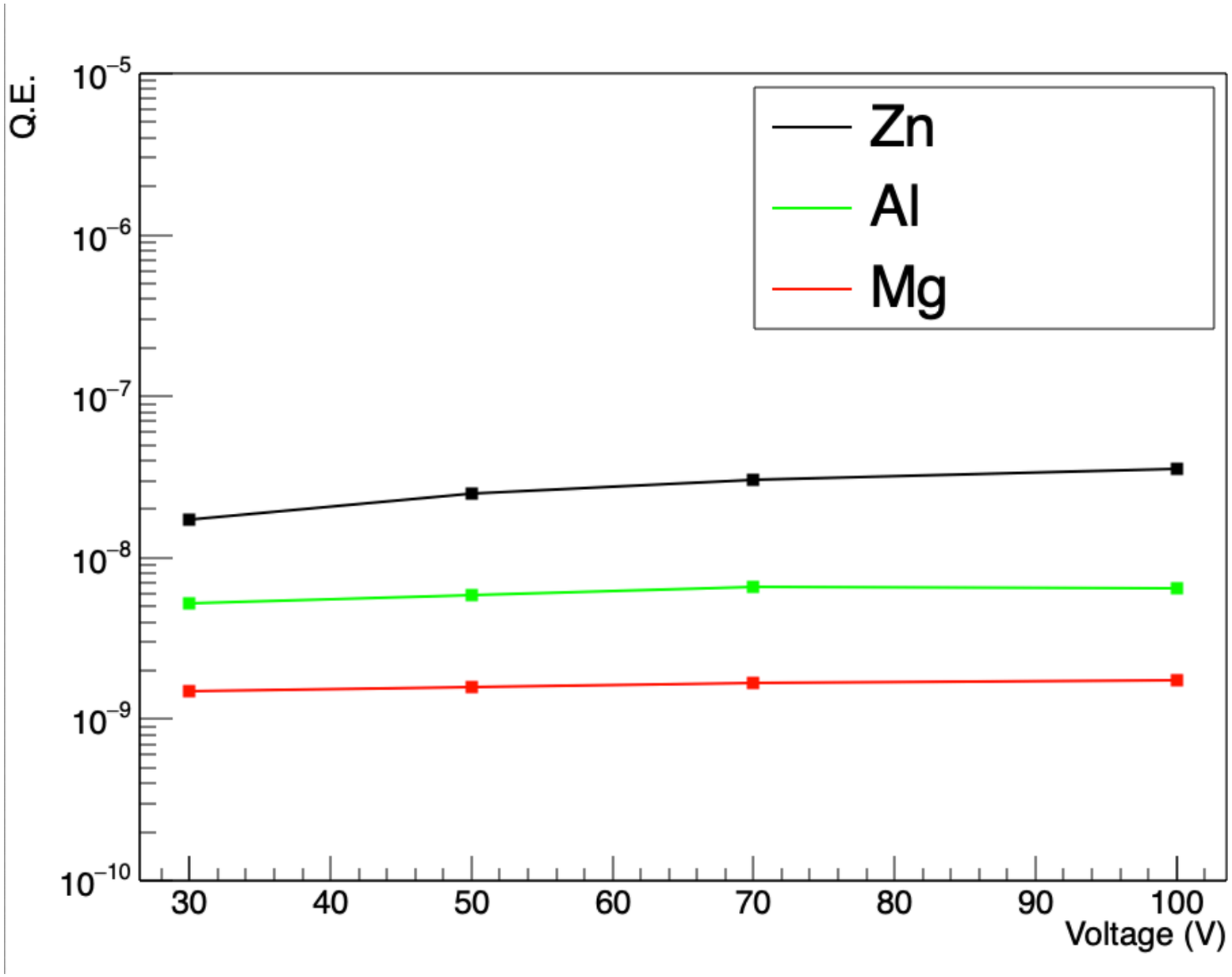
For PE Calibration we use 266nm (4.66 eV) photons to excite electrons off Al (less than ~4.2 eV).

Zn and Ti are reported to have 4.33 eV (many caveats depends on crystalline structure, oxide layer etc)

Cathode Update

At vacuum tests in Hawaii, we see signal from Zn but not Ti

Tests below done in preparation for carbon loaded Zn cathode



WF

3.74 eV
or 4.33 ev ??

4.2 eV

3.68 eV

4.33 eV
No signal

4.85 eV
No signal

Cathode Update

If Zn cathode, possibility of entire cathode lighting up with electrons. Specially if we use 266 nm light.

Kendall: Can we look for shadows? leave spots unmasked an G10 exposed.

Separately we are exploring using higher wavelength, 355 nm Nd:YAG laser output (3.49 eV photo energy) .

Less fiber damage

Higher power possible (33% more photons)

High power UV LEDs and lower cost.

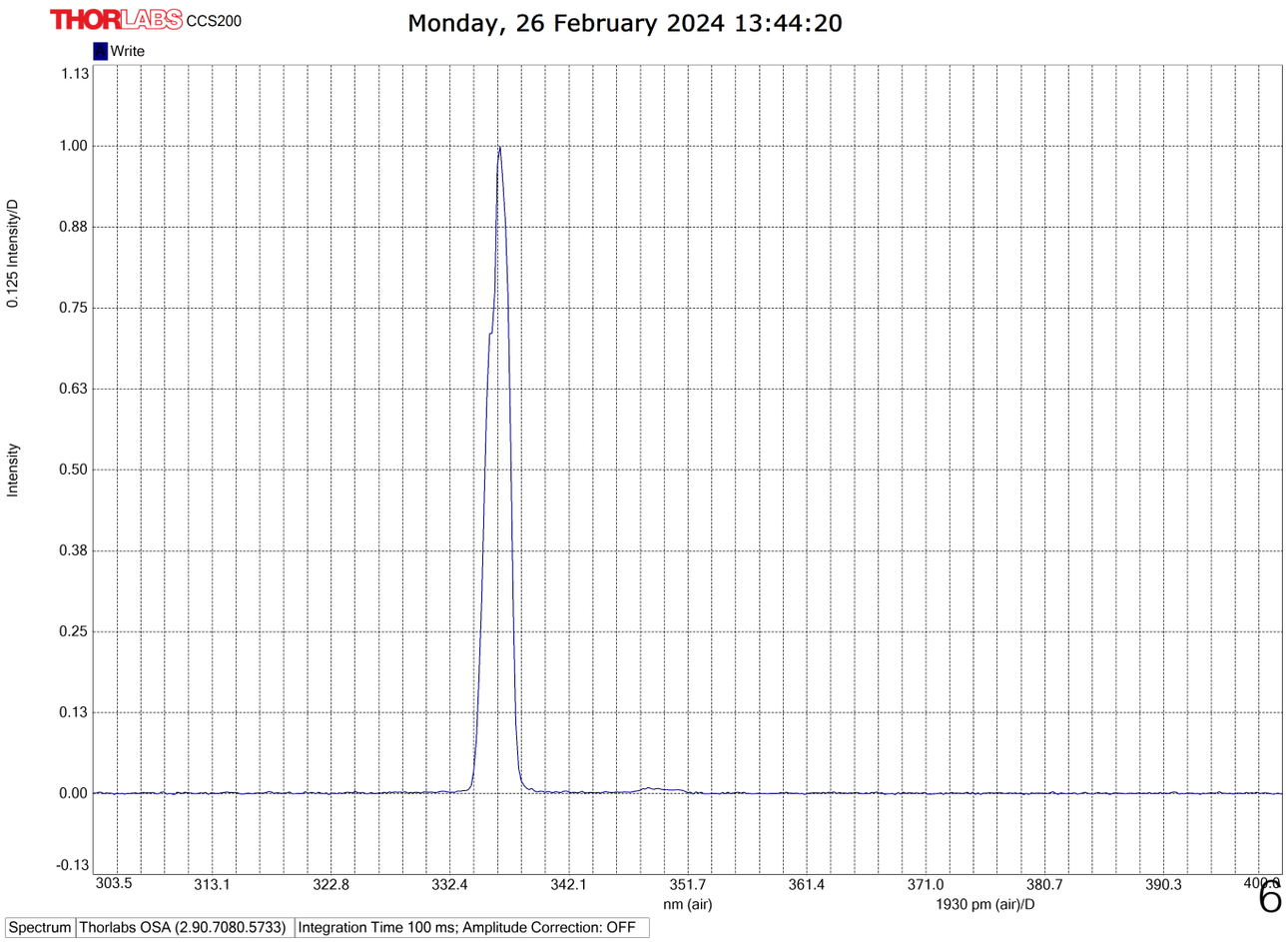
This will also help if Zn/TiO is the cathode

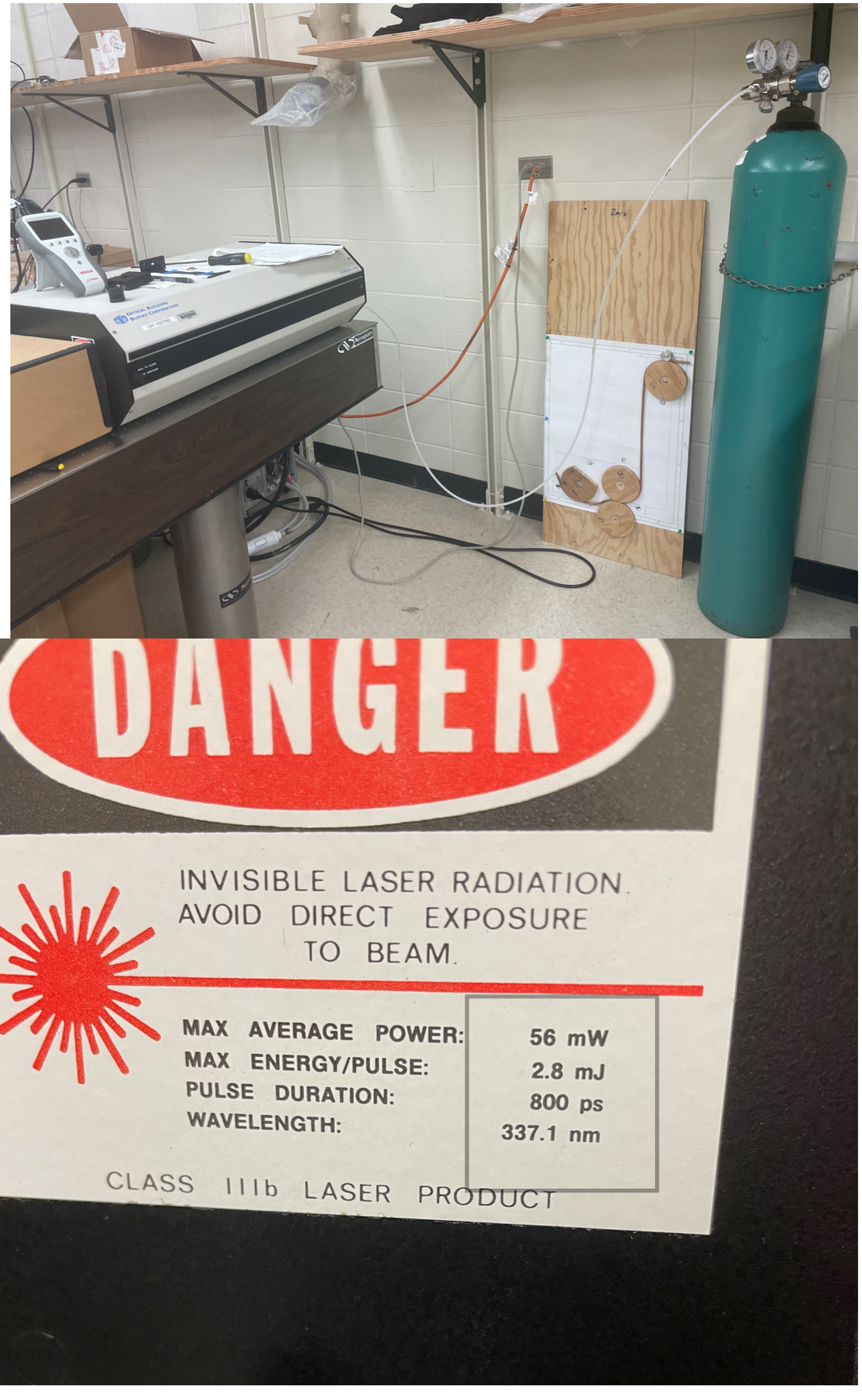
Higher wavelength light source Update

Order placed for 355 nm harmonic from Quantel. Some delay due to paperwork. Lead time 8 weeks.

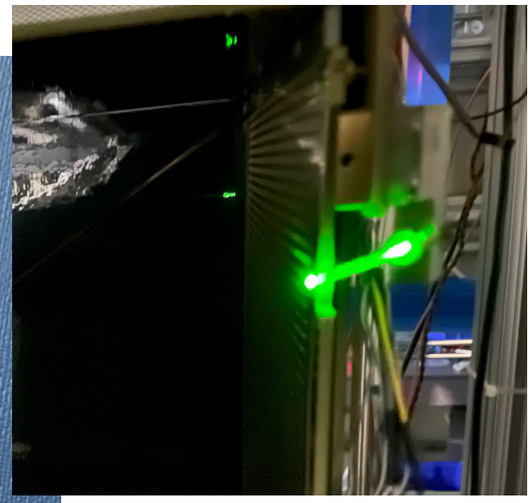
Nitrogen Laser (337.1 nm light) now operational.

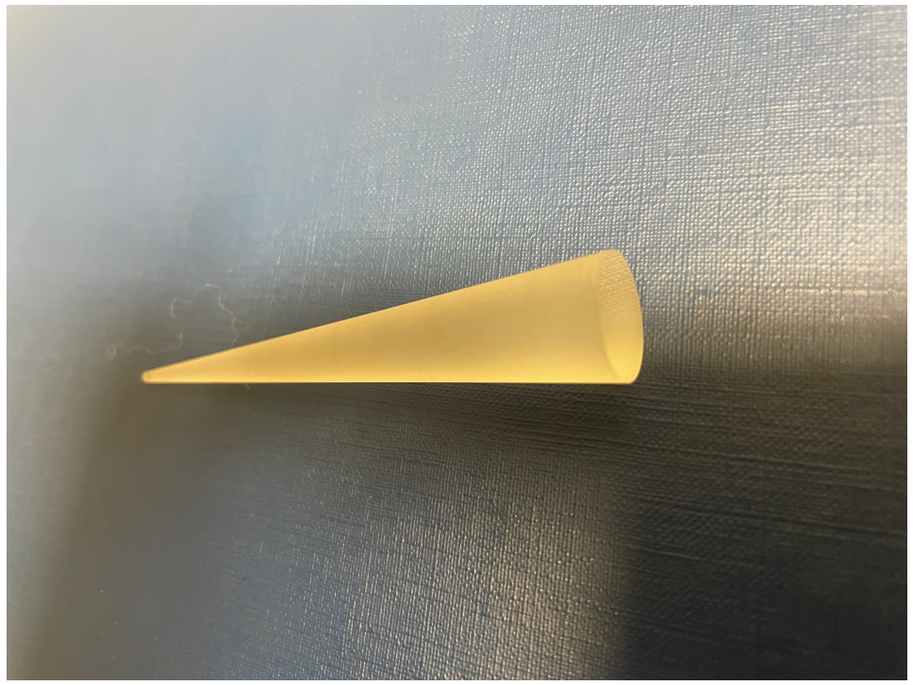
Saw signals with Yb (work function 2.6)
Other candidate metals:
Yt 3.1 eV
Sc 3.5 eV
Terbium 3.0 eV





Solutions for light loss in the optics

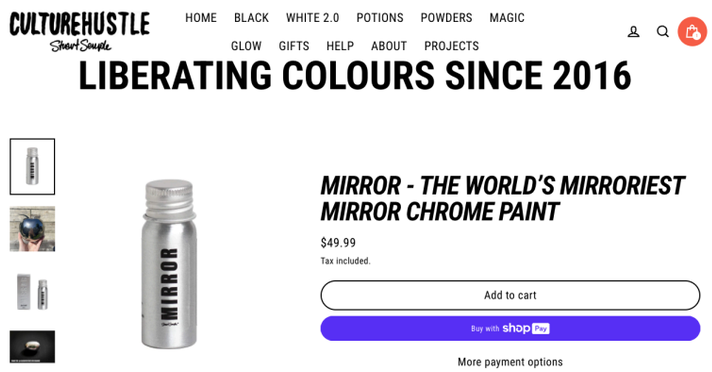




We saw light losses at the bends of the J-pipe during SLAC run

Ordered some “mirror paint” however now decided to vapor deposit. Questions on paint adhesion.

Lowest quote from Nova Electronic Materials, Texas. $1700 for 10 depositions.



We plan to also coat the quartz cone used inside the “Laser box”. Cone replaces the lenses for focussing light to the fiber tip

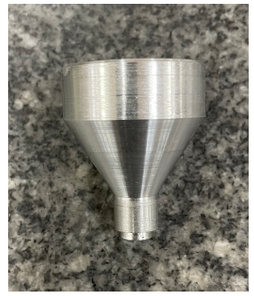
Optics correction for higher wavelength

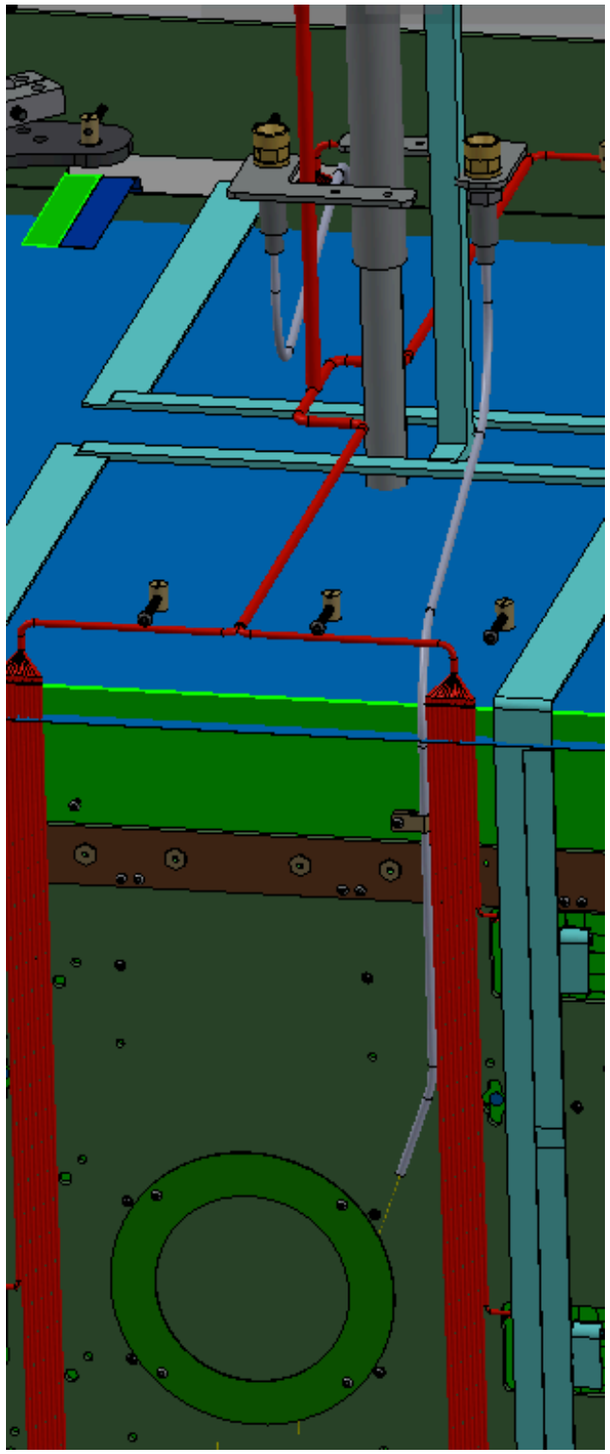
If we switch to higher wavelength (355 nm) light, need to correct the lenses (in the laser box—if quartz cone not efficient) — Morgan will rerun Zemax to get the new numbers.

This will also change the light cone size in the detector. Combination of theoretical and mock studies, like before.

FSD Fiber routing Mockup

Fibers are here. Purchased by Kendall (MSU)

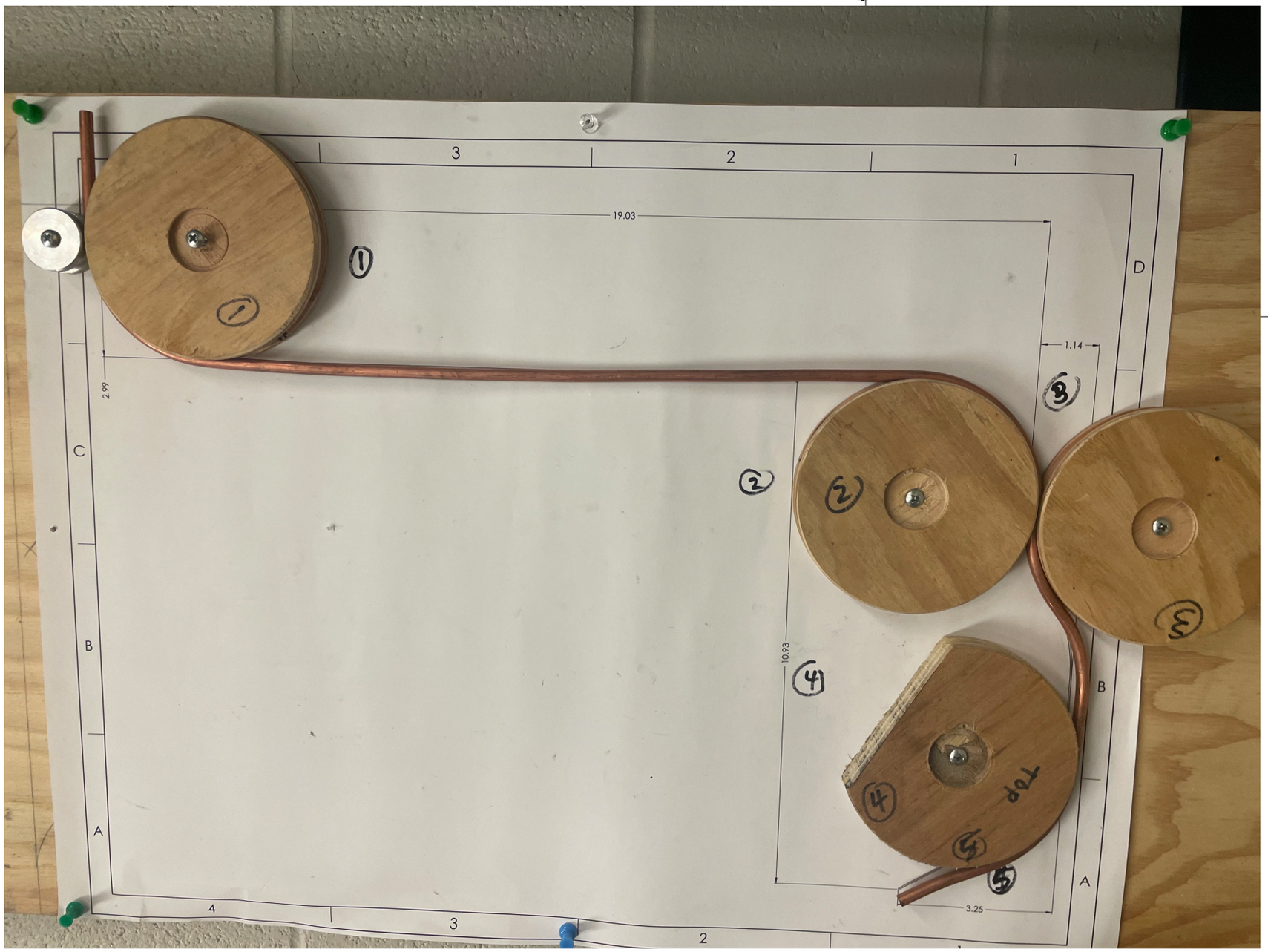




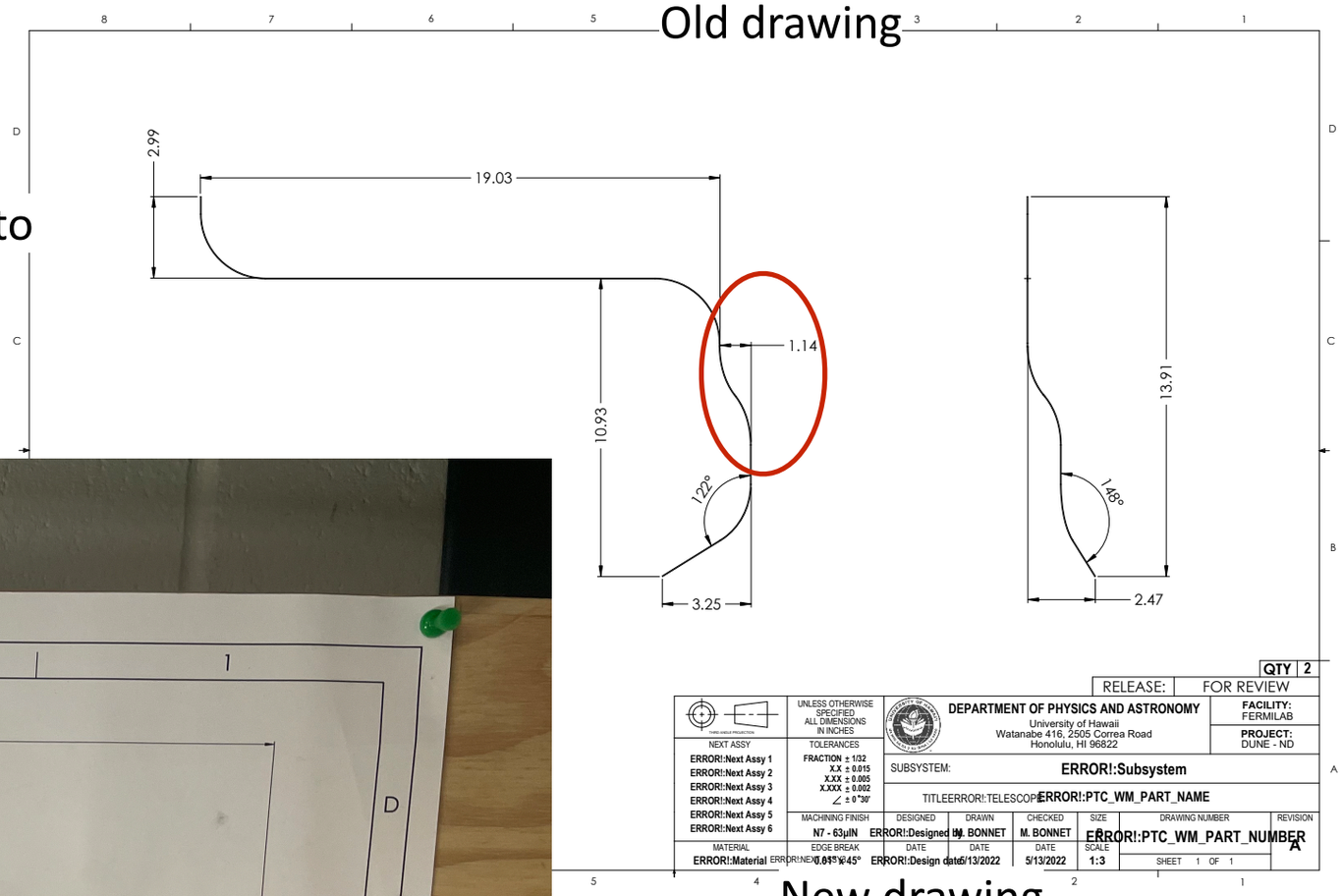
Mock up stand.

FSD Fiber routing Mockup

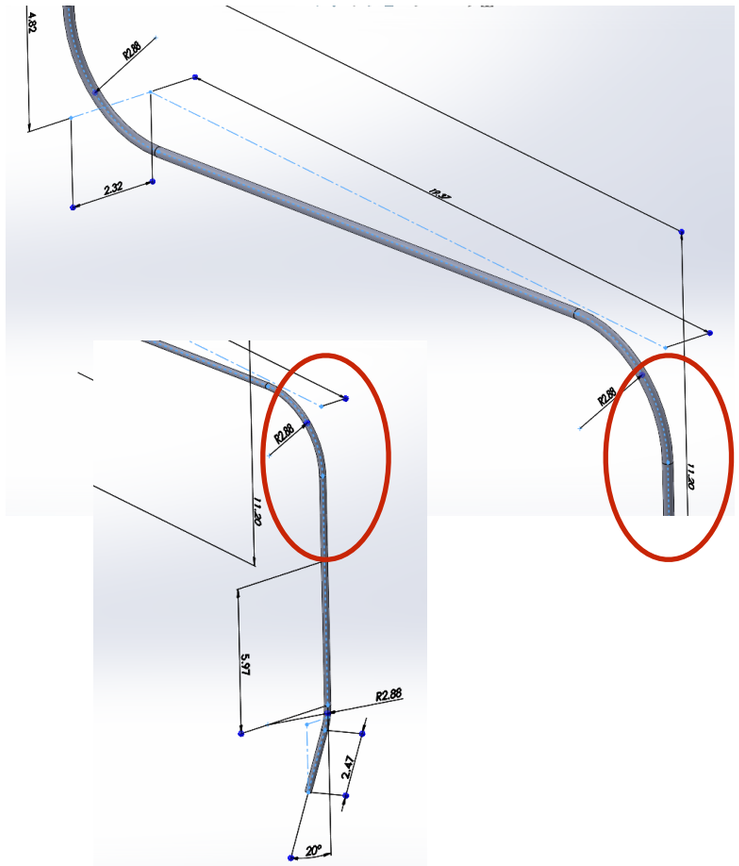
Earlier version of tube had additional bend. Will have to correct before test.



Old drawing



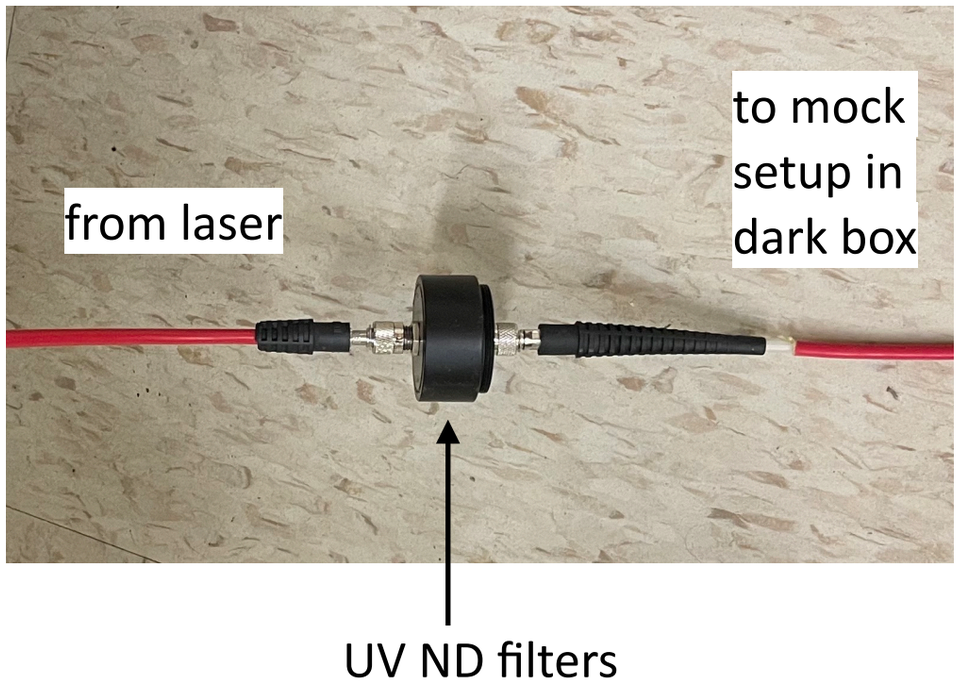
New drawing



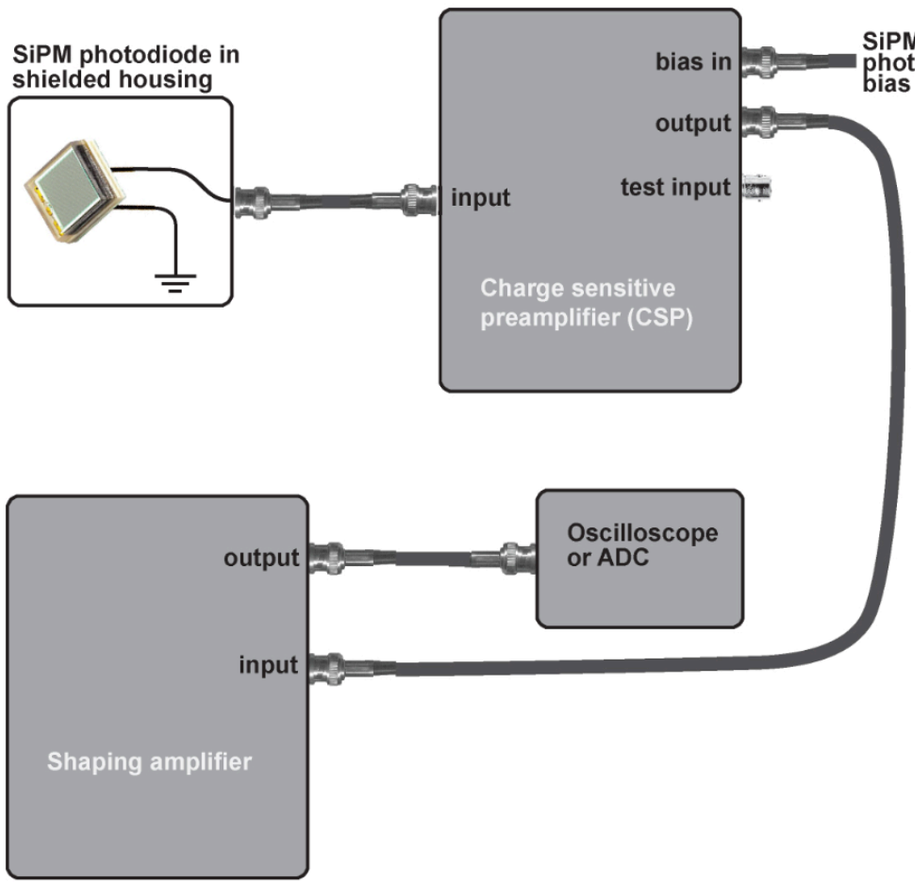
Low light source for light collection system with calibration laser

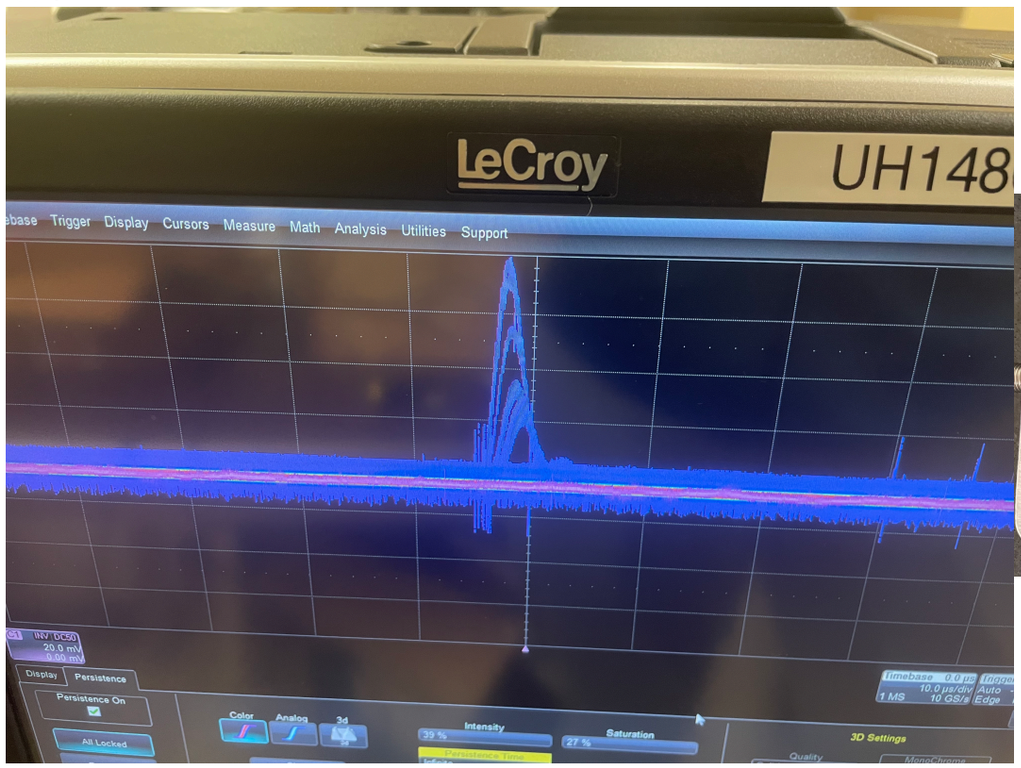
Single to ~few photons for calibration.

Plan:
Single photo energy= 7.5 E-19 J (266 nm) or 5.9E-19 J (337 nm).
Lowest energy measurable by power meter ~10 pJ. Then use successive sets of Neutral Density filters to achieve few photo level.

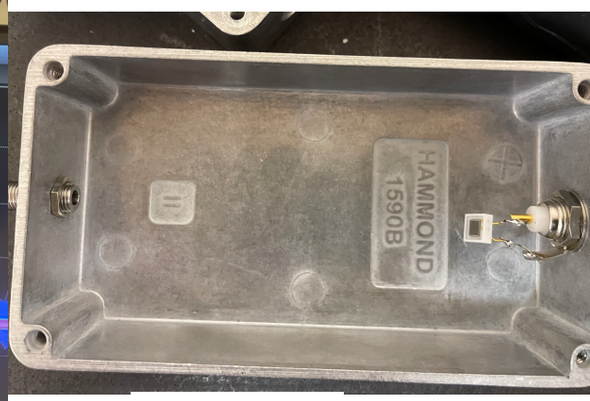


Circuit





Observing few photons on scope



test setup

Low light source for light collection system with calibration laser

Single to ~few photons for calibration.

<u>Next steps:</u>

Build a mock setup inside dark box. Use J-pipe at fiber end.

Place SiPM approximately at location of light collection system.

Attenuate laser and see single photons with scope.

Timeline to SLAC run 2 (May 2024)

* Delivery date of the 355 nm harmonic from Quantel. 8 weeks.
* Start the discussion with SLAC laser safety. We will be using a different laser, but higher wavelength.
* Looking at beginning of May. Actual laser run probably be less than a day.

Timeline towards FSD (Summer 2024)

* Testing of cathode material Zn/TiO (soon).
* Decide on target metal or some other solution. Decide in next few weeks and test at SLAC run 2.
* Fiber routing tests soon. Additional fiber penetration locations identified.
* Optical feedthrough accommodates 7 fibers one. Additional feedthrough needed if we end up using more fibers.

Questions/Comments