IoLaser Status Update

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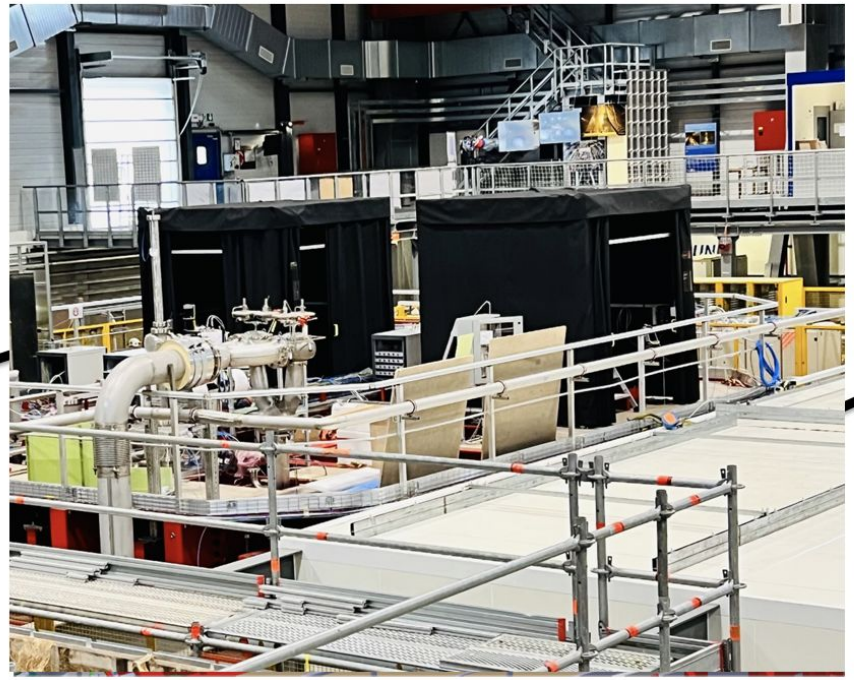
CALCI Consortium Meeting

March 21, 2024

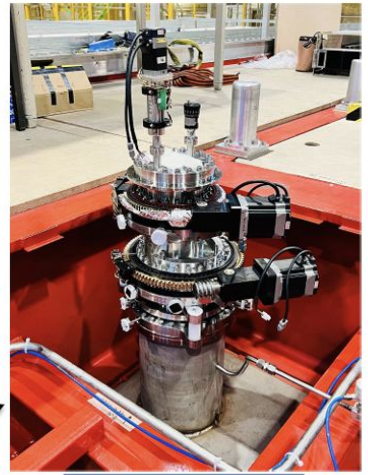
Contents

Ionization Laser System (IoLaser)

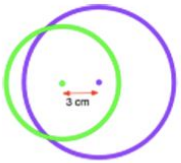
Periscope 1 (P1)



ProtoDUNE laser calibration systems



Periscope 2 (P2) / Endwall



- Feedthrough installations and practice installations for each periscope over the last year with great success (2022-2023)
- Laser tents assembled and installed in August – September 2023
- Final installation of both IoLaser periscopes into NP04 completed in January 2024

IoLaser Periscope Installation

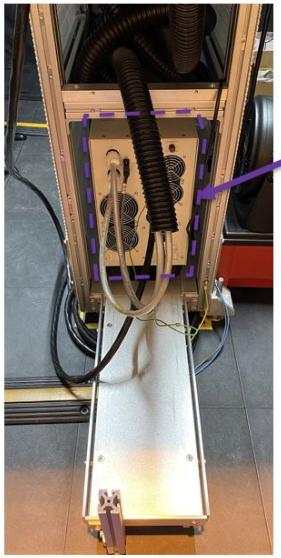
- **Completed in January:**
  - Jan. 8th-12th: Final preparations for Periscopes 1 & 2
  - Jan. 11th morning: Confined spaces training
  - Monday, Jan. 15th: Periscope 1 installation
  - Tuesday, Jan. 16th: Periscope 2 installation
  - Tuesday Jan. 23rd: Laser interlocks/safety (1st inspection)
- Alignment lasers installed and various tests conducted

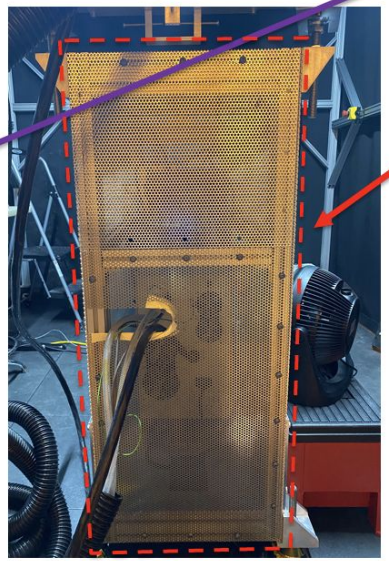
IoLaser Run Plans

- Teams from LANL, LIP, UHawaii at CERN will be present starting April 1st
- Large effort
  - **LANL:** David (2 months), Eric R. (Engineer; 2 weeks), Leon T. (Postbacc; 1 month), Sowjanya (as needed)
  - **LIP:** Wallison C. (PhD student; 6 months), Nuno B. (as needed), Jose (as needed), Vladimir S. (as needed)
  - **UHawaii:** TBD

IoLaser Stand Preparations

- Arrived at CERN: one UV laser, a laser stand, and a laser box to CERN



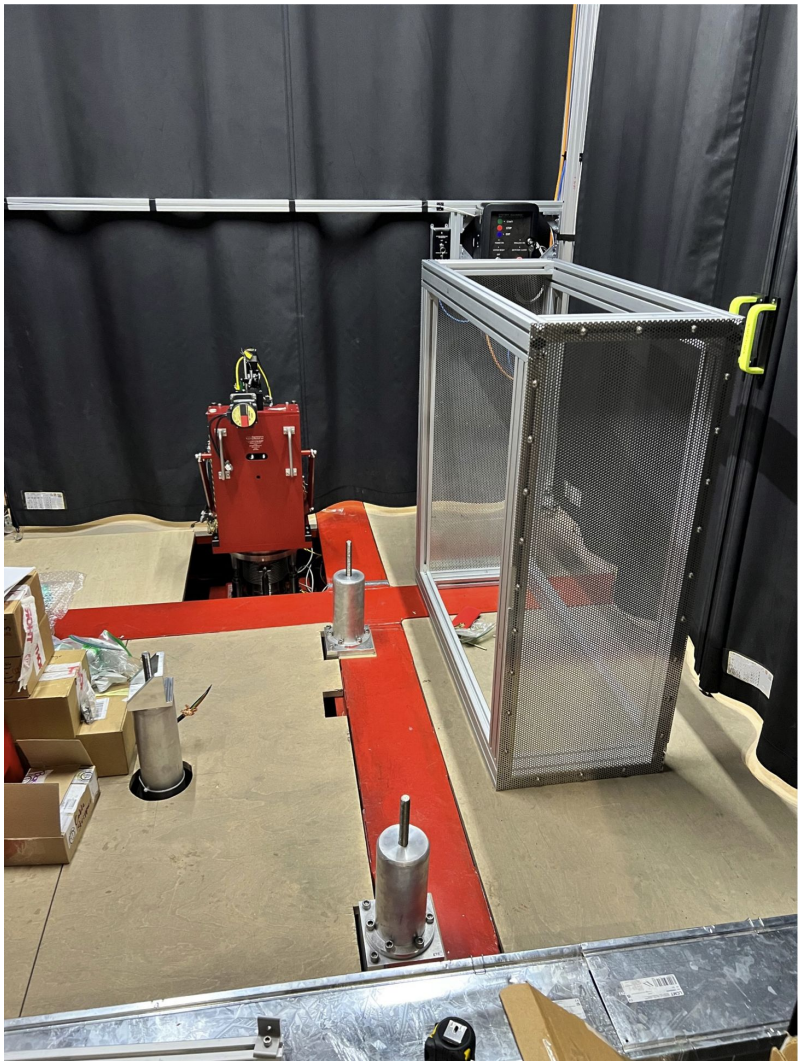


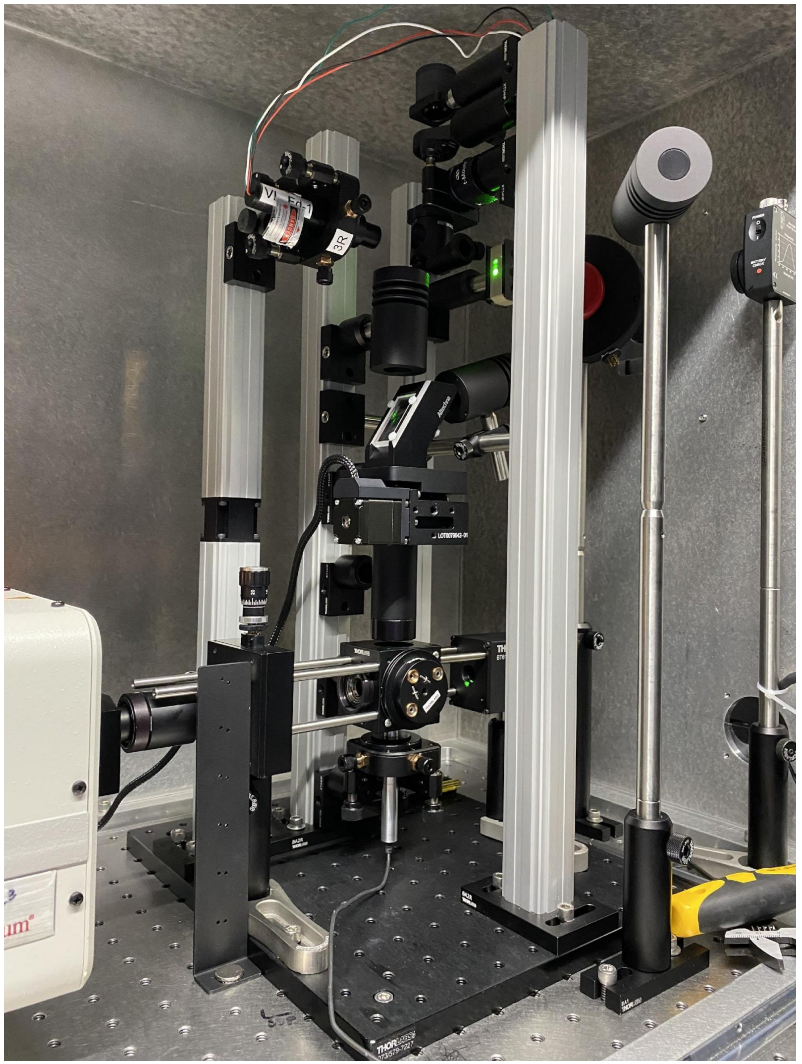
Laser Power Supply mounted and loaded into laser stand

Laser head inside the laser box. Access panel open (left). Fully enclosed (right)

- First laser stand shipped to CERN, second one will be shipped later this month along with a second laser
- Assembly and installation of the lasers will take place in the first 3 weeks of April
- This will allow the laser safety/interlocks inspection and approvals to proceed

Laser Stand & Laser Box

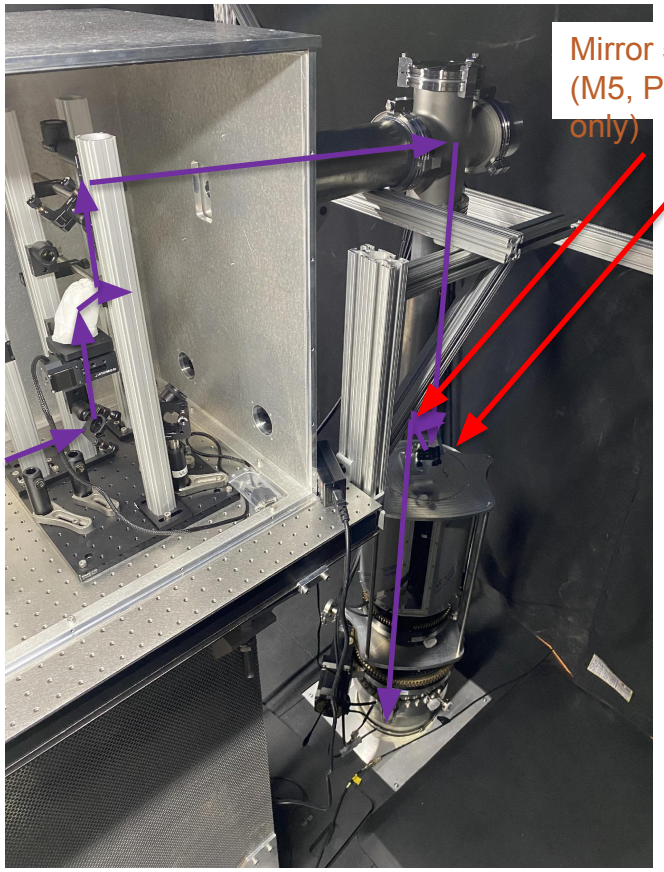




Continued

- One laser stand to be assembled on first week of April
  - On roof or (alternatively) crane over to laser tent 2
- Crane optical breadboard
- Assemble laser box
- Assemble laser turret
- Install vertical setup
- Install Calibration Interface Board and all other laser instrumentation
- Install the laser

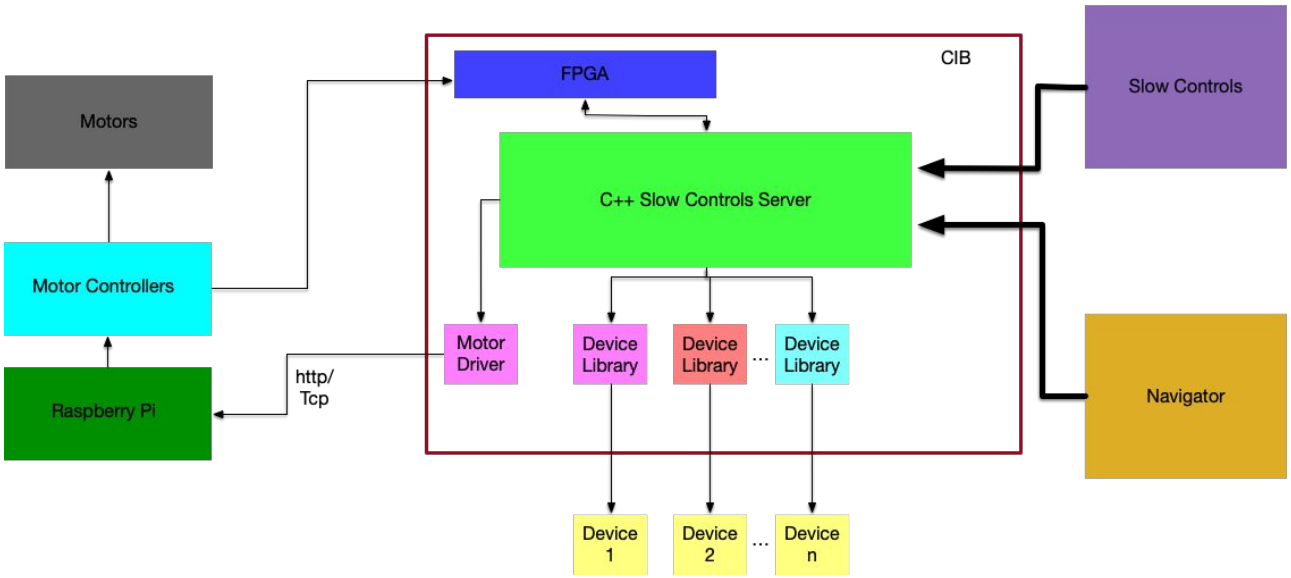
- Repeat for second periscope



Horizontal beam tube, 4-way cross (turret) and M4/M5 installation

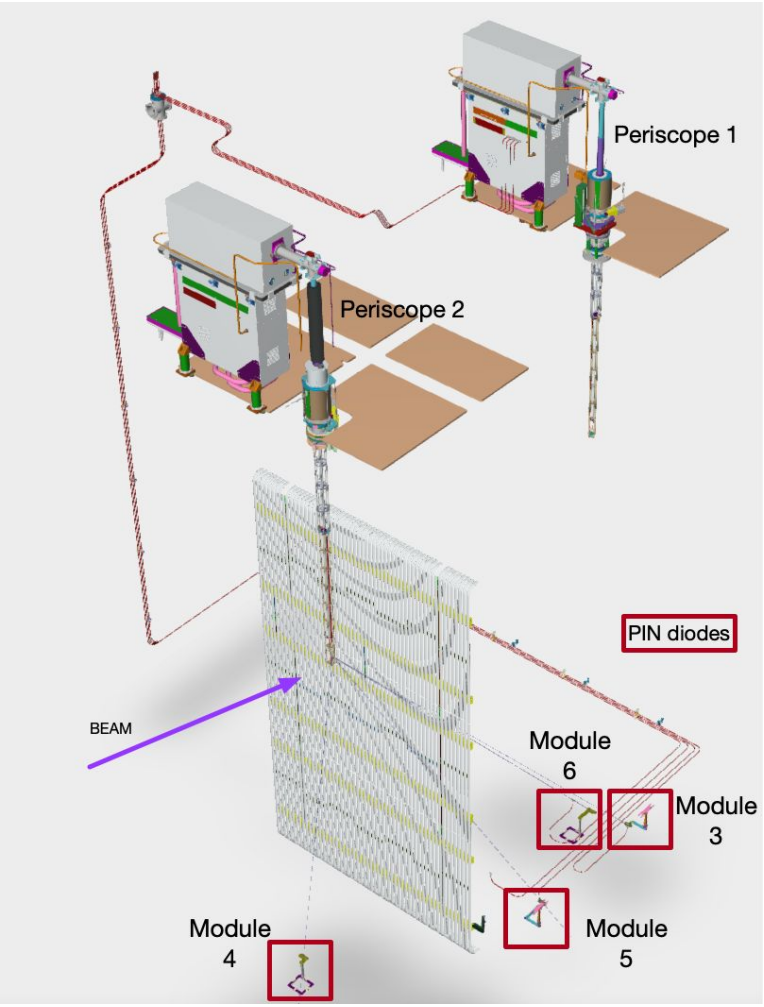
Hardware/Firmware Commissioning

- Tentatively planned for late April
- Tests with the CIB that include all laser system devices
  - Laser, laser shutter, motors, laser attenuator
- Tests of the DAQ & Slow Controls interface with the CIB
- Tests of the GeoNavigator interface with the CIB for running a scan
  - Validate the matching between geometry CAD (once liquid level is sufficiently high to submerge the periscopes)



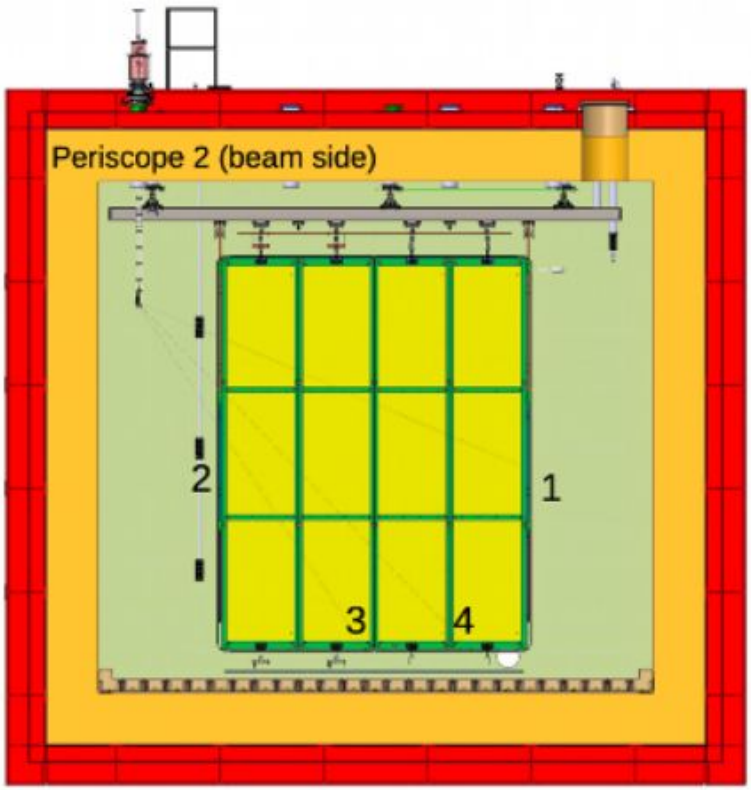
PIN Diode Readout Board Commissioning

- Four-module readout board for UHawaii expected to be ready in Mid-April
- Coordinate commissioning tests with the CIB at the end of April
- Slow controls integration tests will continue beyond April



Commissioning Runs

- Without HV and high purity:
  - Hit PIN diode channels with both periscopes by performing slow scans around the noted positions prior to filling
  - 16 channels for P2
  - 4 channels for P1
- With HV and high purity:
  - Aim at LBLS mirrors
  - Tentatively scheduled to start in mid-May



Run plan

- The laser beam localization systems (LBLS): PIN diode and mirror pads, previously installed in the detector
  - Obtained reference positions with both periscopes by aiming the laser beam at these systems and getting visual confirmation (+ signals from the PIN diodes)
  - PIN diode tests conducted in late February – March (Wallison + Nuno) prior to fill start, but with gaseous argon in NP04

- Commissioning run plans being refined; proposed:
  - Alignment tests in Air/GAr with LBLS (HV/DAQ/LAr not needed) – took place in January and late February into March.
  - Alignment tests in LAr with LBLS (no HV/DAQ needed; low purity is fine; but bottom portion of the periscope should fully submerge in the liquid - will require some liquid level monitoring with slow controls)
    - Class 3B laser and eventually Class 4 laser w/ UV attenuated
  - UV laser tests in LAr (need all systems in place; high purity and HV achieved)
  - Need to coordinate with PDS during laser runs; implement interlocks b/n laser and liquid level/PDS

Tentative IoLaser Data Run Plans

- Once alignment tests are done and as high purity is achieved
  - **Beginning of data taking**: two, 8hr-days (per periscope) to determine that aiming of the lasers is consistent with the charge readout data.
  - **End of data taking:** repeat the same, two 8hr-days, for final checks on the detector and for comparison over time
  - **During beam running**:
    - ~4 hr long calibration runs each day (ideally)
    - ~2-4 hr long calibration runs every few days (minimally)
- Plans will be refined in the coming days - not a final plan
- DAQ and slow controls interfaces actively being worked on in parallel

Data Footprint

- 10 Hz laser rate
- Two APAs
- 2,560 channels per APA
- 2 MHz sampling rate for cold electronics
- 12-bit ADC, but say two bytes or 16 b per sample
- 4 hr x (10 Hz) x 5120 chan x 2 B/chan x 2 MHz * 3 ms = 144,000 evt / 4 hour run x (61.44 MB/evt) = 8.847 TB/4 hr run
- 109 days between May 15 and August 31
- Total volume would be something like: 964 TB

For this level of data we would likely want to do significant data reduction

Data Reduction

- Ideally: Define an ROI around the laser track (we know start and direction) + margins to cover distortions from SCE effects
- Do-able as an *offline* service
- Proposal: The service would look for the laser track and if it is successfully identified where expected, the service would construct an ROI around the laser track and set everything else to 0

PD-VD

PD-VD status

- Procurement of all feedthrough and laser periscope components – Complete
  - Feedthrough and stainless steel components machined at LIP, received LANL
  - Torlon machined at LANL
- Test assembly for both periscopes – Complete
- Laser stand, laser box, and laser breadboard being procured

Other

Cryogenic Motors

- I received funding for a project to test a candidate cryogenic motor for use in our calibration systems
  - MANY applications!
- Funds have been awarded through the Engineering Institute at LANL
  - PI: David Rivera
  - Co-I: Eric Renner (Engineer)
- Project: Pushing the Neutrino Frontier with Cold Robotics

Timeline

- 6 month timeline
- The order has been placed and we expect to receive the motor and all accessories by the end of June
- First step is to design a gearbox to couple the motor to a mirror holder
  - designs are forthcoming

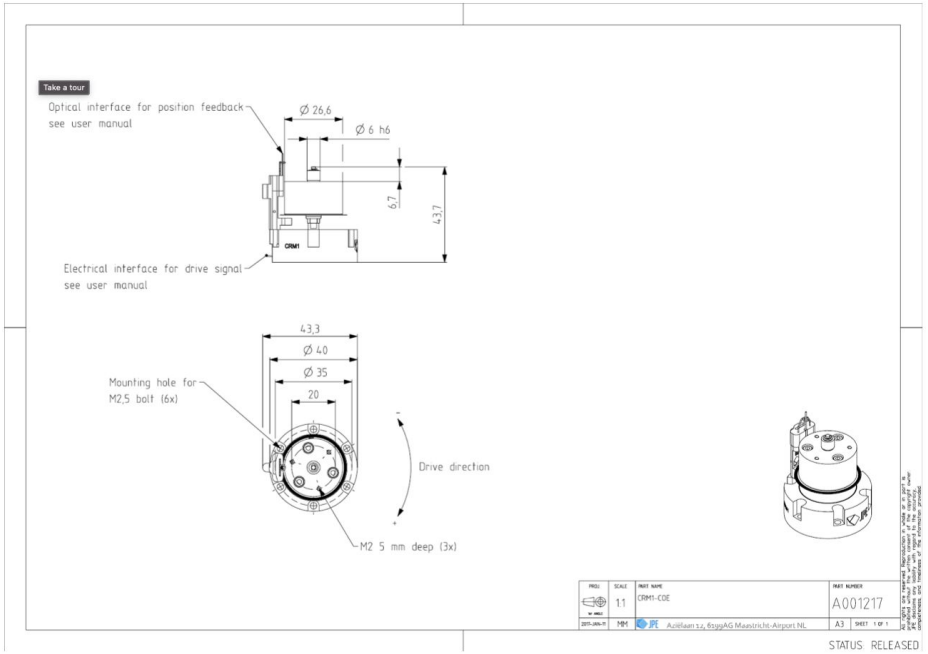
JPE's (Netherlands company) CRM1 motor specs

Specifications

General info	
Type of motion	Rotational
Dimensions	See drawings below
Operational environmental conditions	20 mK to 375 K, ambient to UHV
Weight	170 g, -COE adds 10 g
Stepping motion	
Travel range	Endless
Velocity @ 300 K	30 deg/s
Velocity @ 4 K	6 deg/s
Scanning motion	
Scanning range @ 300 K	2,5 mrad
Scanning range @ 4 K	0,5 mrad
Minimal step size	nrad
Drive voltage @ 300 K	-30 V to 120 V
Drive voltage @ 4 K	-30 V to 120 V
Forces and load capacity	
Driving torque	15 Nmm
Load capacity, vertical rotation axis	200 g
Materials	
Main body	Stainless steel 316L, phosphor bronze
Piezo actuator	Low voltage multilayer, ceramic insulated
Model specific information	
-COE	Cryo Optical Encoder, 850 pulses per revolution
Electronics CPSC	

Additional features:

- Cryo-optical encoder for position feedback
- Non-magnetic rotating parts
- Custom cable possible
  - Allow us to implement shielding appropriately



BACKUP