

# IoLaser Prototyping & QA/QC Plans

*Sowjanya Gollapinni (LANL)*

September 17, 2020  
IoLaser Initial Design Review



# Procurement, Fabrication & Assembly Plans towards ProtoDUNE

## Procurement

- **IoLaser**
  - Laser, Laser Box assembly & enclosures, support structure: LANL
  - Laser feedthrough & Periscopes: Everything by LANL for both top-FC & end-wall systems except for some at LIP (custom flanges, electronics board & DAQ communication).
- **LBLS mirror system:** LIP
- **LBLS pin diode system:** LANL, LIP

## Fabrication

- A lot of the IoLaser/LBLS parts are off the shelf with specs provided by the manufacturer e.g. laser, mirrors, camera, rotary/linear couplings, optical components etc.
- Some parts of the IoLaser will need to be machined e.g. laser box enclosure & support structure, laser beam enclosure, Stainless steel and PEEK periscope support structures etc.

# Procurement, Fabrication & Assembly Plans towards ProtoDUNE

## Fabrication (continued)

- **IoLaser**
  - Fabrication largely be carried out by LANL (probably sub-contracted to keep costs down; “Drake Plastics” a candidate machining company )
  - Modest fabrication support from collaborating institutes such as LIP Hawaii – currently exploring what expertise and resources are available
- **LCLS mirror system:** LIP
- **LCLS pin diodes:** Hawaii

## Assembly & Transportation

- **IoLaser**
  - While some pre-assembly will happen at collaborating institutes (LIP, Hawaii), final, full scale assembly will happen at LANL with collaborators traveling to LANL to participate in the activities (barring COVID-19 impacts)
- **LCLS Mirror System:** LIP
- **LCLS Pin diode system:** LANL, Hawaii

# Procurement, Fabrication & Assembly Plans towards ProtoDUNE

## Fabrication (continued)

- IoLaser
  - Fabrication largely be carried out by LANL (probably sub-contracted to keep costs down; “Drake Plastics” a candidate machining company )
- **Not discussing DUNE here since everything is aspirational for DUNE Calibration at this point and funding is undefined.**
- **Once a funding model is defined, detailed plans for procurement and fabrication will follow.**
- While some pre-assembly will happen at collaborating institutes (LIP, Hawaii), final, full scale assembly will happen at LANL with collaborators traveling to LANL to participate in the activities (COVID-19 may impact this)
- LBLS Mirror System: LIP
- LBLS Pin diode system: LANL, Hawaii

# Quality Assurance

- Full scale prototype tests planned at ProtoDUNE and lessons learned will provide QA for DUNE FD.
- ProtoDUNE will test all aspects of the system design, final assembly, installation, alignment, operation, interfaces with DAQ, slow controls and analysis, among others.
- The arrangement of the laser system on top of the cryostat and the design of one laser servicing two periscopes will also be tested at ProtoDUNE.
- In addition to the MicroBooNE tests planned, various grounding and shielding schemes will also be explored at ProtoDUNE including the need of a dielectric break in the periscope design.

# QC Test Categories

**These tests will be performed both for ProtoDUNE-II prototyping effort & DUNE**

- **Manufacturer provided** (will be verified)
- **Component testing**
  - Laser
  - Laser box & components
  - Laser feedthrough tests e.g. leak rate (warm & cold)
  - Laser periscope & components (warm & cold)
  - LBLS mirror system & components (warm & cold)
  - LBLS pin diode system & components (warm & cold)
- **Post fabrication tests** e.g. PEEK in LAr (warm & cold)
- **Post assembly tests** (warm & cold)
- **Full scale system testing** (warm & cold)
- **Integration tests** (warm & cold)
  - e.g. IoLaser with pin diode or mirrors; IoLaser with mock up FC penetration;
- **Post Transportation & Unpacking tests**
- **Final assembly tests** (onsite)
- **Installation tests & alignment** (onsite)

We have identified the QC tests needed, detailed plans on how to implement the tests and related design is actively underway

Detailed [EDMS document](#)  
on QA/QC

# QC Test Categories

These tests will be performed both for ProtoDUNE-II prototyping effort & DUNE

- **Manufacturer provided** (will be verified) LANL, LIP, Hawaii, KSU
- **Component testing** LANL, LIP, Hawaii, KSU
  - Laser LANL
  - Laser box & components LANL
  - Laser feedthrough tests e.g. leak rate (warm & cold) LANL, LIP
  - Laser periscope & components (warm & cold) LANL, LIP, KSU
  - LBLS mirror system & components (warm & cold) LIP
  - LBLS pin diode system & components (warm & cold) LANL, Hawaii
- **Post fabrication tests** e.g. PEEK in LAr (warm & cold) LANL, LIP
- **Post assembly tests** (warm & cold) LANL
- **Full scale system testing** (warm & cold) LANL
- **Integration tests** (warm & cold) LANL
  - e.g. IoLaser with pin diode or mirrors; IoLaser with mock up FC penetration;
- **Post Transportation & Unpacking tests** LANL, LIP, All
- **Final assembly tests** (onsite) LANL, LIP, All
- **Installation tests & alignment** (onsite) LANL, LIP, All

# QC Test Categories

These tests will be performed both for ProtoDUNE-II prototyping effort & DUNE

- Manufacturer provided (will be verified) LANL, LIP, Hawaii, KSU
- Component testing LANL, LIP, Hawaii, KSU
  - Laser LANL
  - Laser box & optical components LANL
  - Laser alignment LANL
  - Laser power LANL
  - Laser safety LANL
  - Laser enclosure LANL
  - Laser control LANL
  - Laser monitoring LANL
  - Laser maintenance LANL
  - Laser documentation LANL
  - Laser training LANL
  - Laser safety training LANL
  - Laser safety signage LANL
  - Laser safety procedures LANL
  - Laser safety audits LANL
  - Laser safety drills LANL
  - Laser safety meetings LANL
  - Laser safety reports LANL
  - Laser safety records LANL
  - Laser safety incident response LANL
  - Laser safety emergency procedures LANL
  - Laser safety first aid LANL
  - Laser safety fire extinguisher LANL
  - Laser safety eyewear LANL
  - Laser safety gloves LANL
  - Laser safety footwear LANL
  - Laser safety clothing LANL
  - Laser safety hairnets LANL
  - Laser safety face shields LANL
  - Laser safety earplugs LANL
  - Laser safety earbuds LANL
  - Laser safety hearing protection LANL
  - Laser safety communication LANL
  - Laser safety warning signs LANL
  - Laser safety warning labels LANL
  - Laser safety warning lights LANL
  - Laser safety warning sounds LANL
  - Laser safety warning messages LANL
  - Laser safety warning icons LANL
  - Laser safety warning symbols LANL
  - Laser safety warning text LANL
  - Laser safety warning graphics LANL
  - Laser safety warning animations LANL
  - Laser safety warning videos LANL
  - Laser safety warning audio LANL
  - Laser safety warning visual LANL
  - Laser safety warning haptic LANL
  - Laser safety warning olfactory LANL
  - Laser safety warning gustatory LANL
  - Laser safety warning tactile LANL
  - Laser safety warning auditory LANL
  - Laser safety warning olfactory LANL
  - Laser safety warning gustatory LANL
  - Laser safety warning tactile LANL
  - Laser safety warning auditory LANL
- Power testing LANL
- Power distribution LANL
- Power monitoring LANL
- Power safety LANL
- Full scale system testing (warm & cold) LANL
- Integration tests (warm & cold) LANL
  - e.g. IoLaser with pin diode or mirrors; IoLaser with mock up FC penetration;
- Post Transportation & Unpacking tests LANL, LIP, All
- Post Final assembly tests onsite LANL, LIP, All

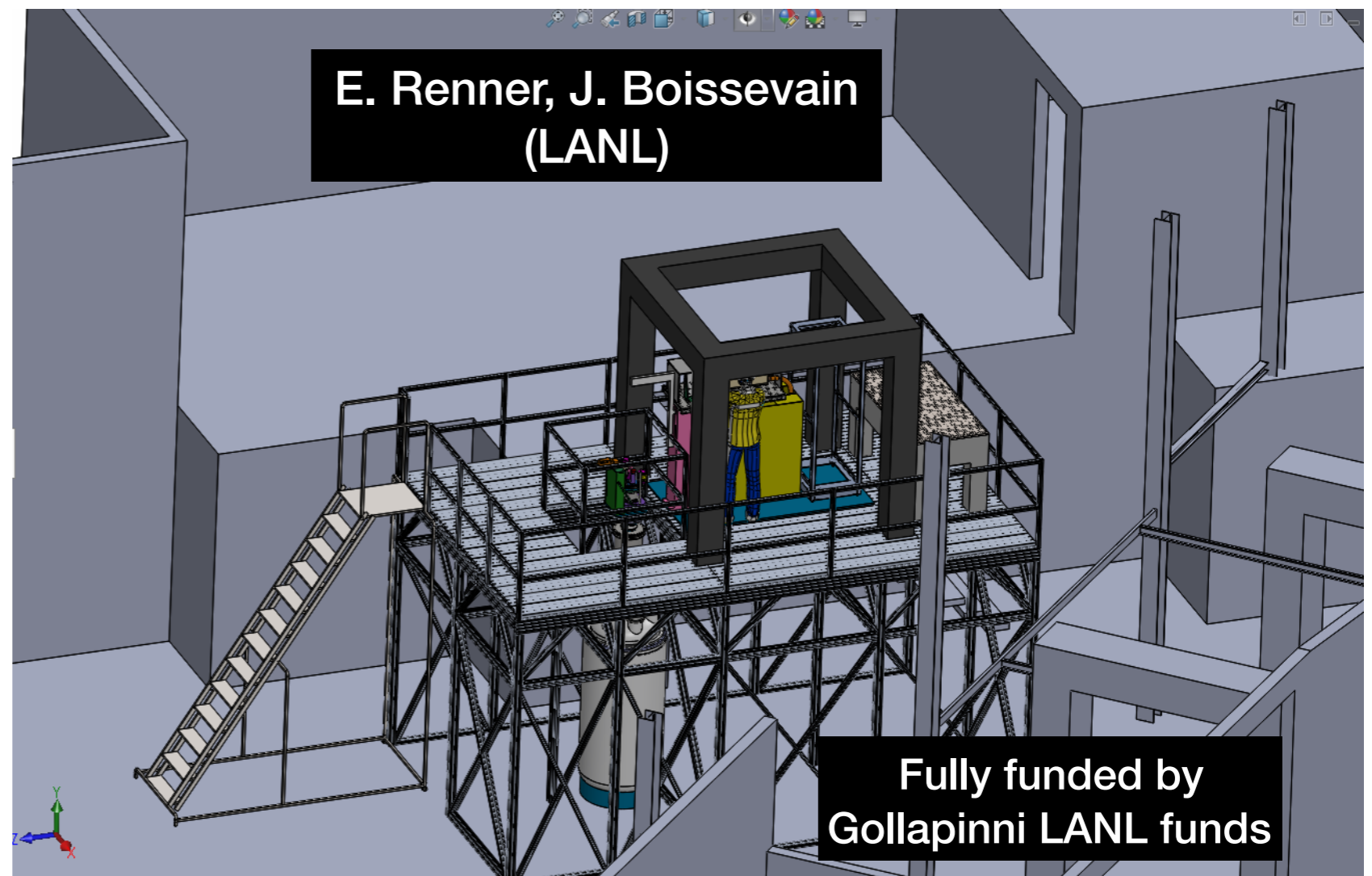
I will only cover IoLaser prototyping & QA/QC plans here. LBLS tests will be covered tomorrow in the two LBLS talks by J. Maneira and J. Maricic





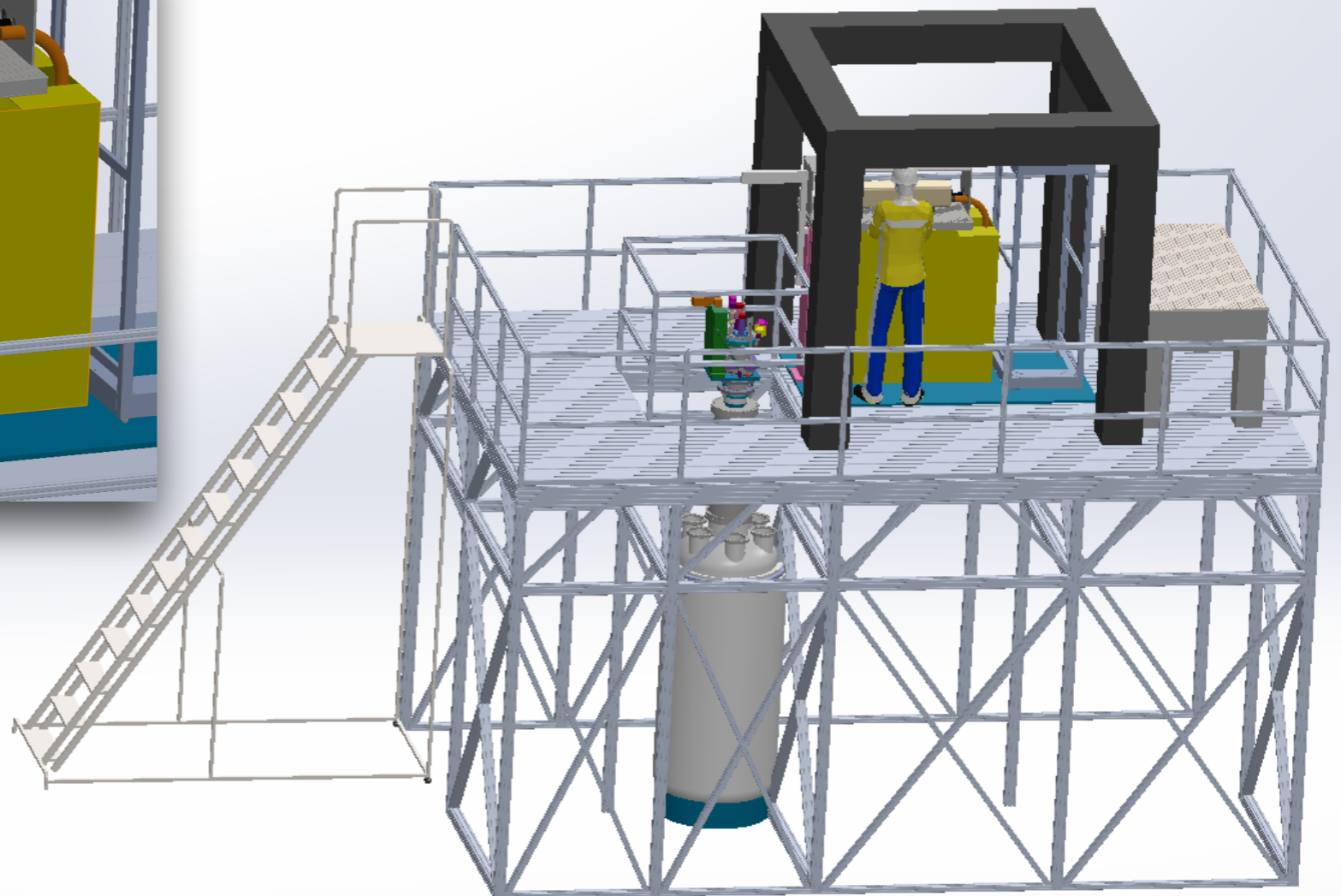
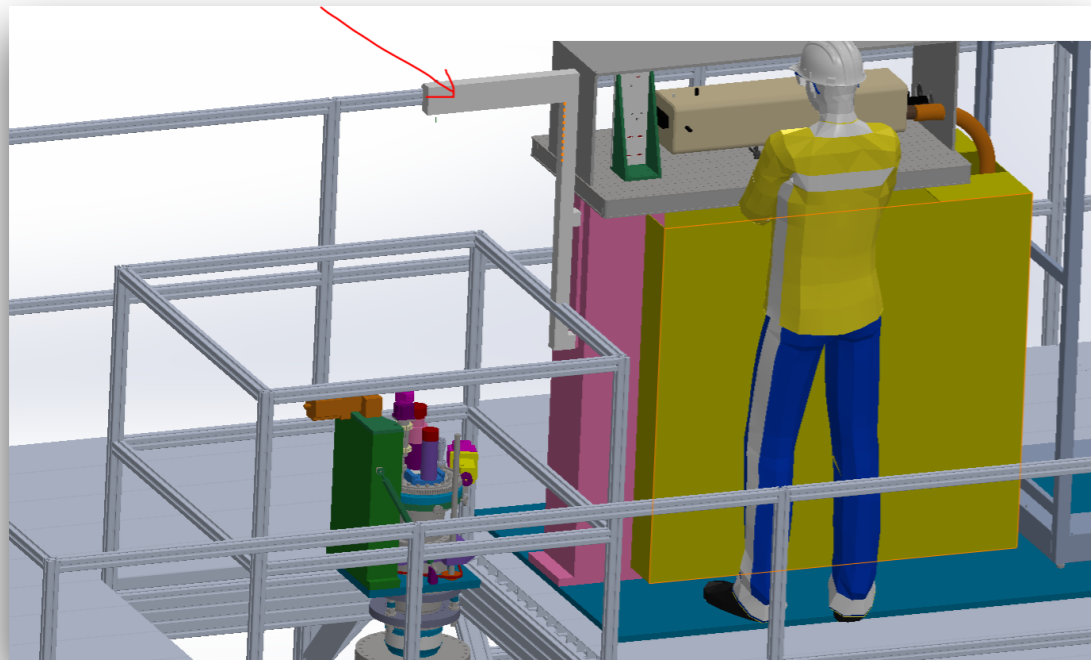
# Lab Spaces at LANL: Cryogenics Testing platform

- Currently finishing the design and structural analysis; Vendors identified and costs estimated. Procurement will start once safety/facility folks sign off
- The dewar bucket has already been ordered and will arrive mid-October
- Can do full scale system testing in cryogenic environment
- Located in a high bay area for full scale testing of periscope installation and retraction operations in a mock-up arrangement as DUNE FD



# Lab Spaces at LANL: Cryogenics Testing platform

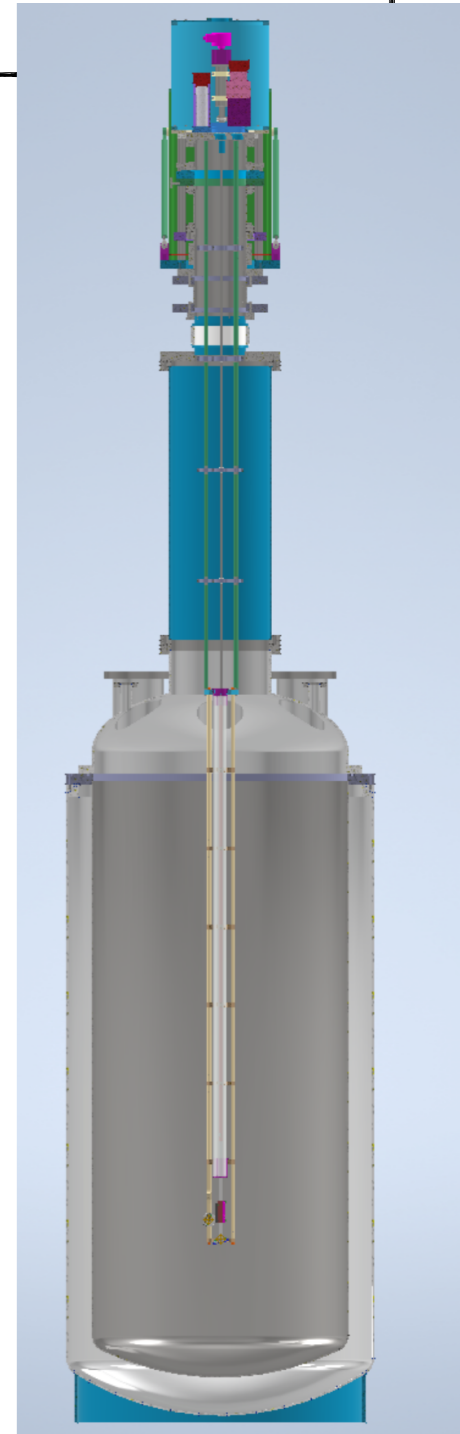
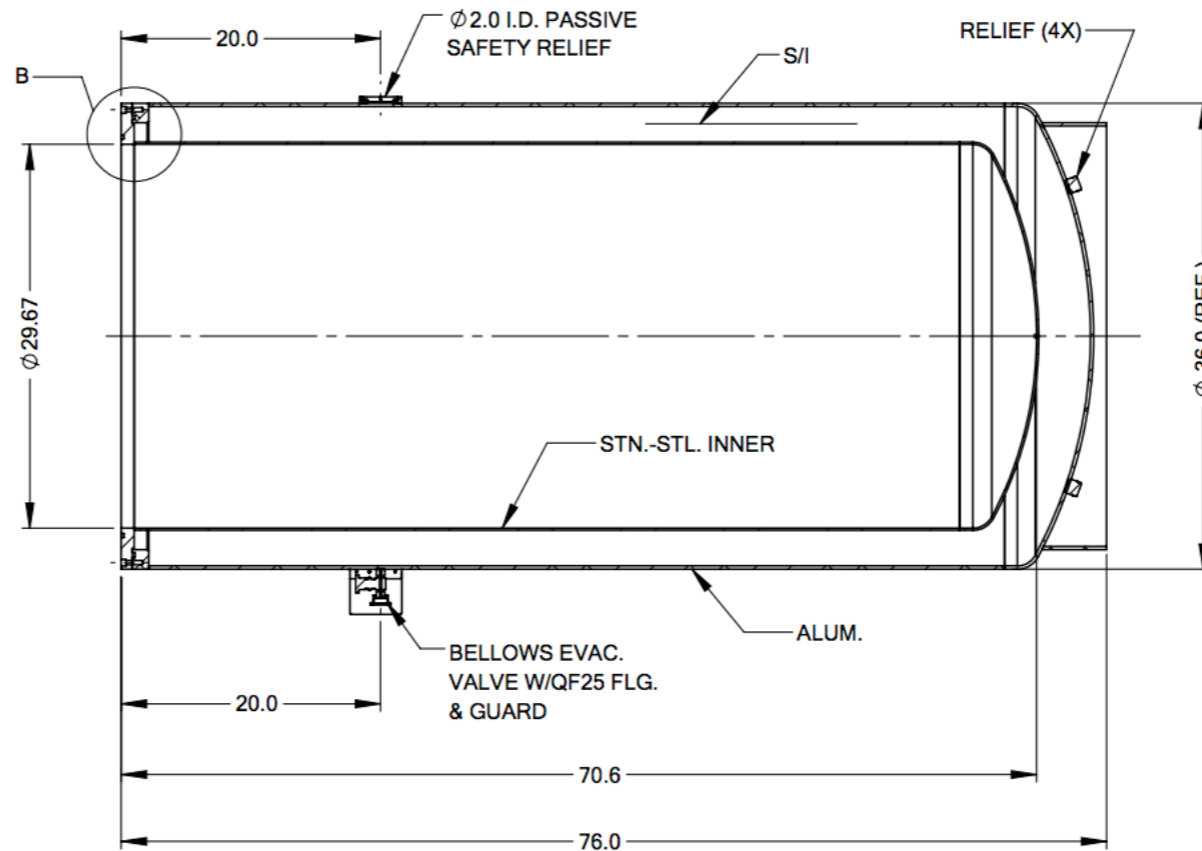
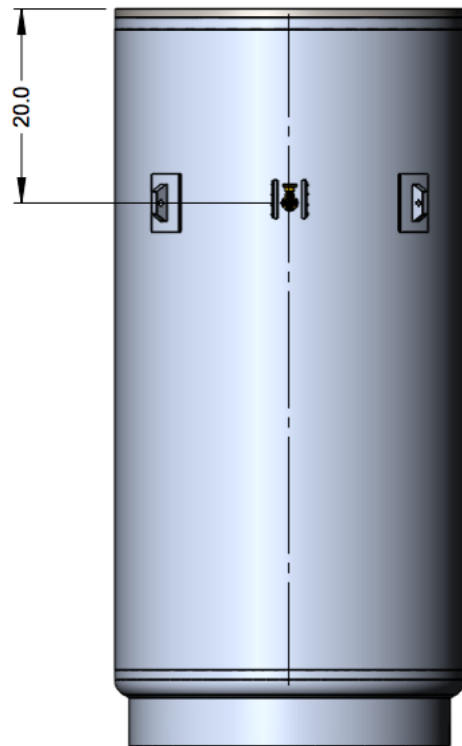
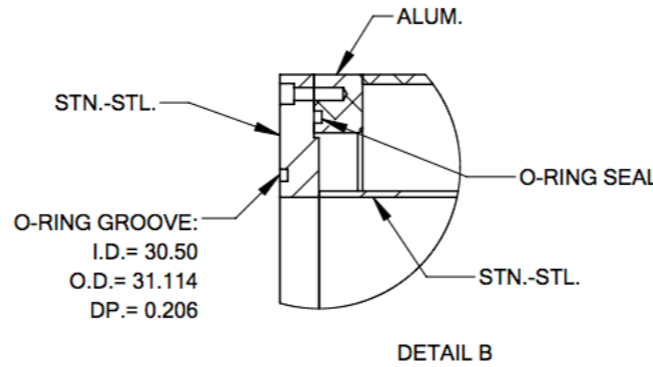
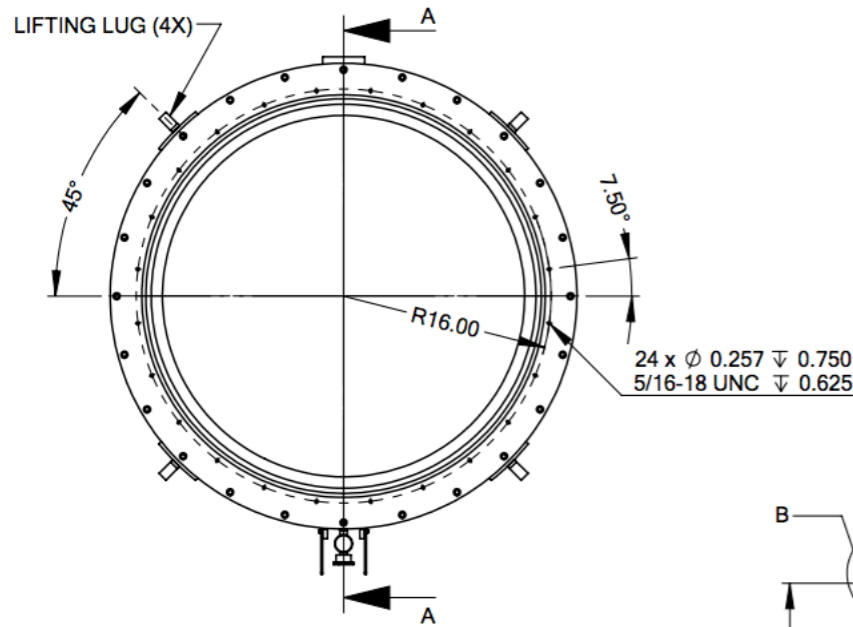
- Space under the platform will be enclosed by poly to create a clean room space for periscope assembly
- A laminar flow bench will be added to the space for optical cleaning and storage



- A 8'x8'x8' laser tent with 3'x6' optical bench in the nearby space for laser operations and alignment tests as needed

# Cryogenic Dewar Specs. (LANL)

- Only the bucket is ordered (~2m high and ~0.7 m diameter) from Precision Cryogenics Inc. \$24k
- Top hat configuration being finalized



**PRECISION CRYOGENIC SYSTEMS, INC.**

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TITLE: PCS-DUNE LASER PERISCOPE TEST DEWAR

DATE: 08/06/2020    DWG. NO.: 080620-6-LL

SIZE: A    SCALE:    REV:    SHEET: 1 OF 1

# Testing at LIP, Hawaii & KSU

## LIP

- Will perform tests for both IoLaser and LBLS
- Test IoLaser rotary stages & encoder precision
- Leak rate tests
- Post-fabrication tests of some IoLaser components possible
- Software interfaces, DAQ & Slow Controls
- LBLS mirror system testing & characterization

## Hawaii

- LBLS pin diode system testing & characterization
- PDS tests with IoLaser (Hawaii has a class-IV laser not the exact model we will use in ProtoDUNE/DUNE but can do useful tests)
- Post-fabrication tests of some IoLaser components possible

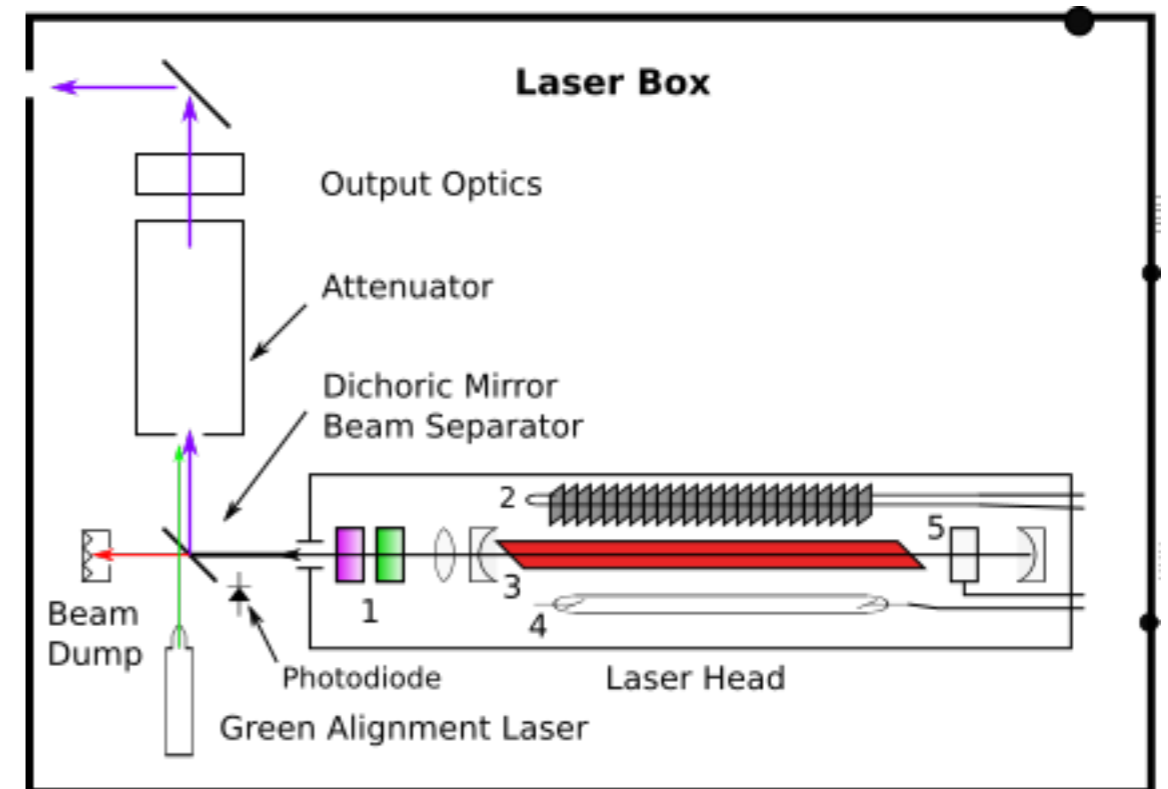
## KSU

- Periscope Camera tests
- Inclinator tests & interfacing

# QC Tests: Laser & Laser Box

*(all tests at LANL)*

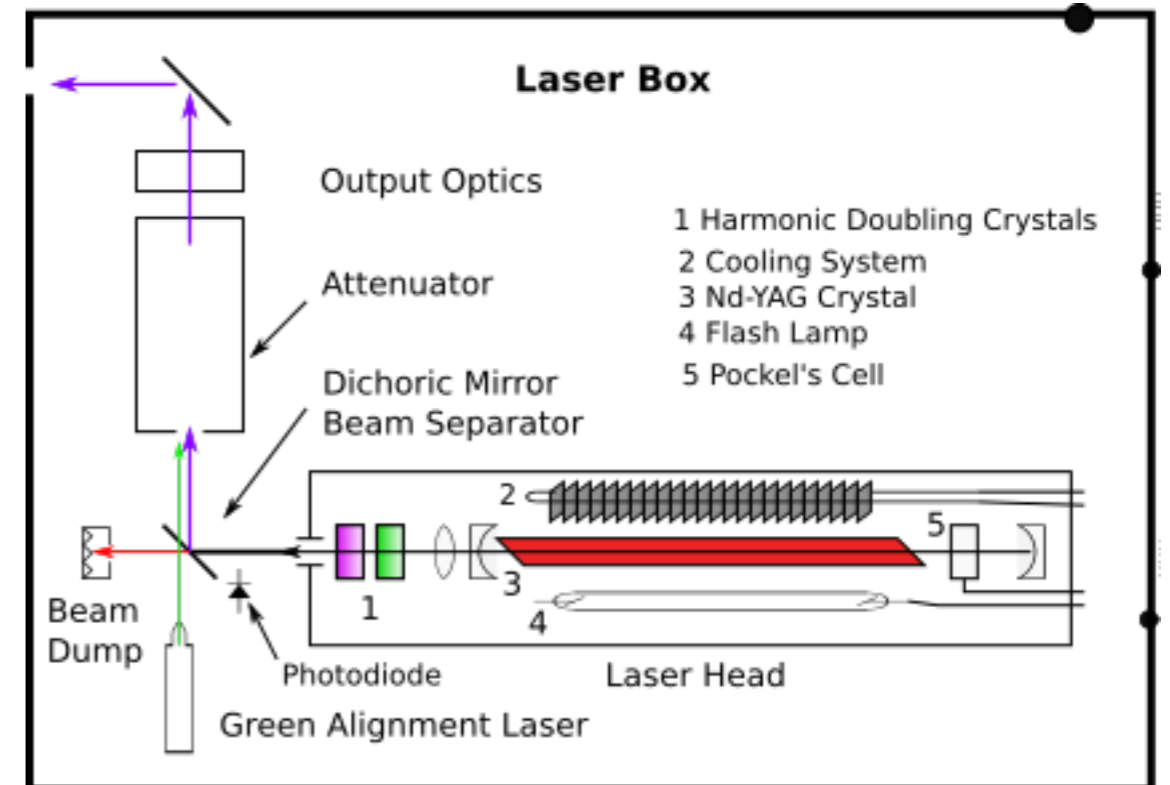
1. Fatness of mirrors should be  $\lambda/10$  or better (Manufacturer provided)
2. Test 266 nm frequency separation from the beam separator & confirm negligible contamination from other frequencies (Manufacturer provided)
3. Test reflectivity at 266 nm of the beam separator is  $>95\%$
4. Test that the reflectivity at 266 nm of each mirror in the laser path is  $>96\%$ . (top-FC: 5 mirrors; end-wall: 6 mirrors). Tests to also understand how polarization effects reflectivity (re: Stephen's comments from yesterday)



# QC Tests: Laser & Laser Box

(all tests at LANL)

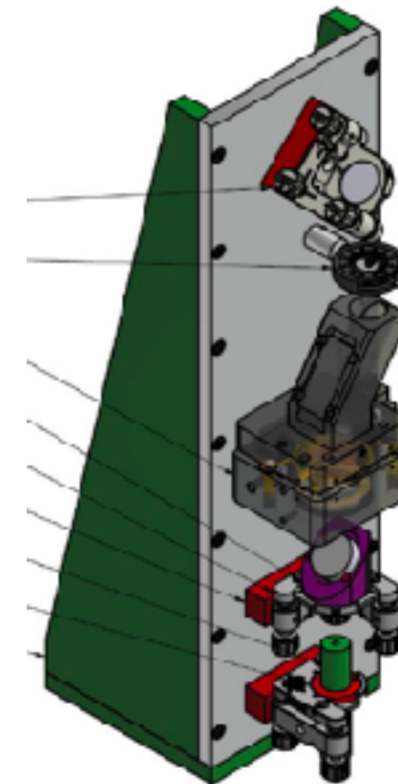
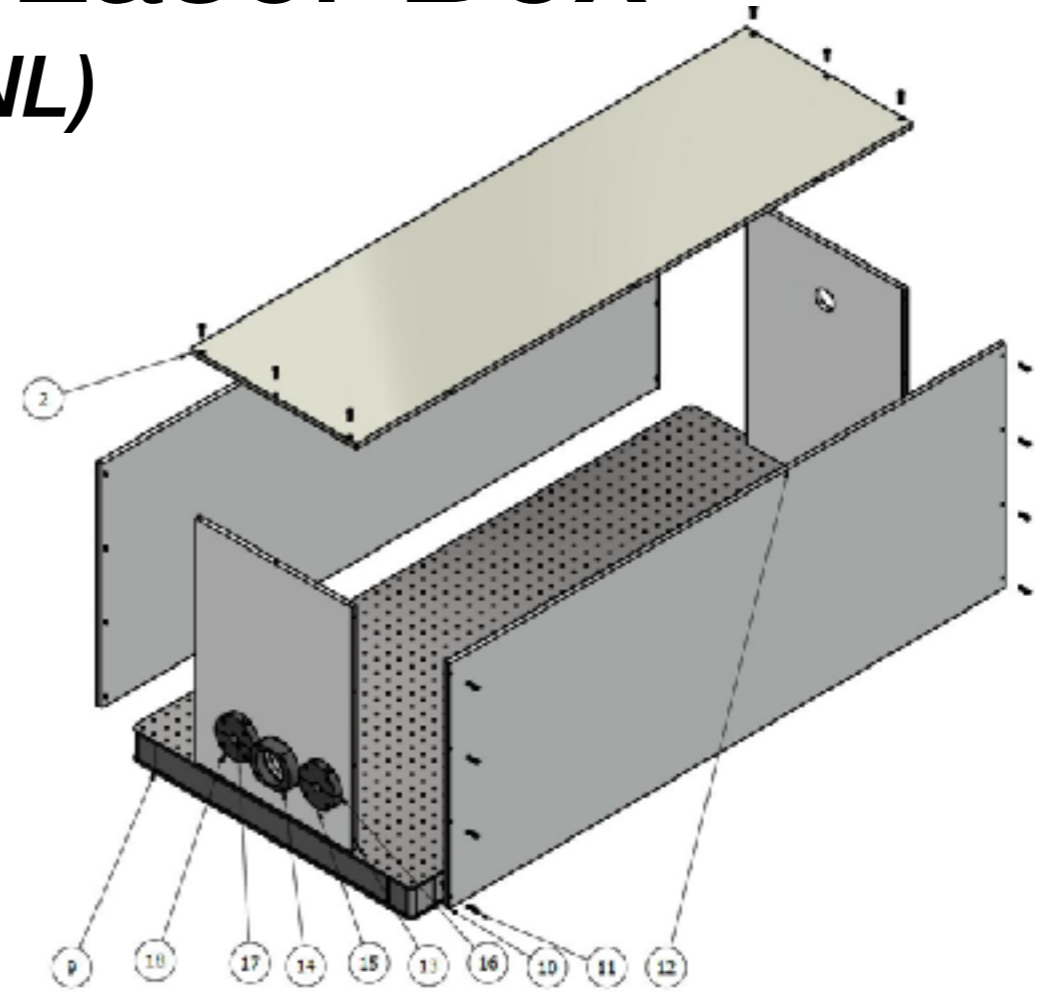
1. Test attenuator and optimize operating range for final intensity requirements
2. Collimation tests with Iris to achieve 1 to 2 mm beam diameter
3. Test alignment of UV laser with visible laser and develop procedures
4. Photodiode testing for triggering and dynamic operation range light tightness and no leakage
5. Perform a series of tests to understand and verify the laser can hit different materials (e.g. paper, mirrors, pin diodes etc.). This test will be performed both at component level and during full scale testing in cryogenic liquids.



# QC Tests: Laser & Laser Box

*(all tests at LANL)*

1. Impact of laser on PDS tests (destructive tests; effect of laser beam at an angle on PDS etc.). Samples to be received from Ettore. (Hawaii can help as well)
2. Test pre-assembly and final assembly steps for the laser box
3. Post fabrication and assembly, test of the laser box and laser beam pipe enclosures for light tightness and no leakage





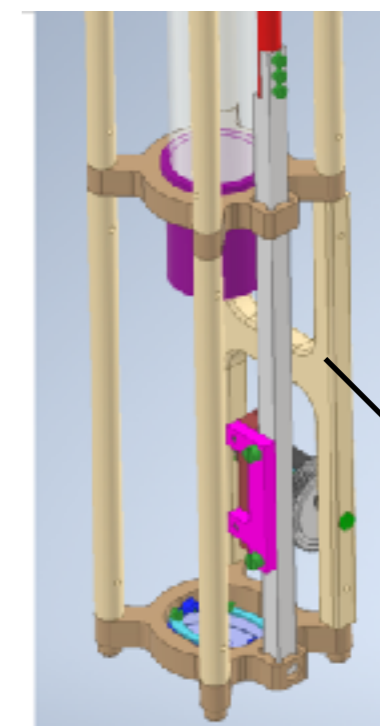
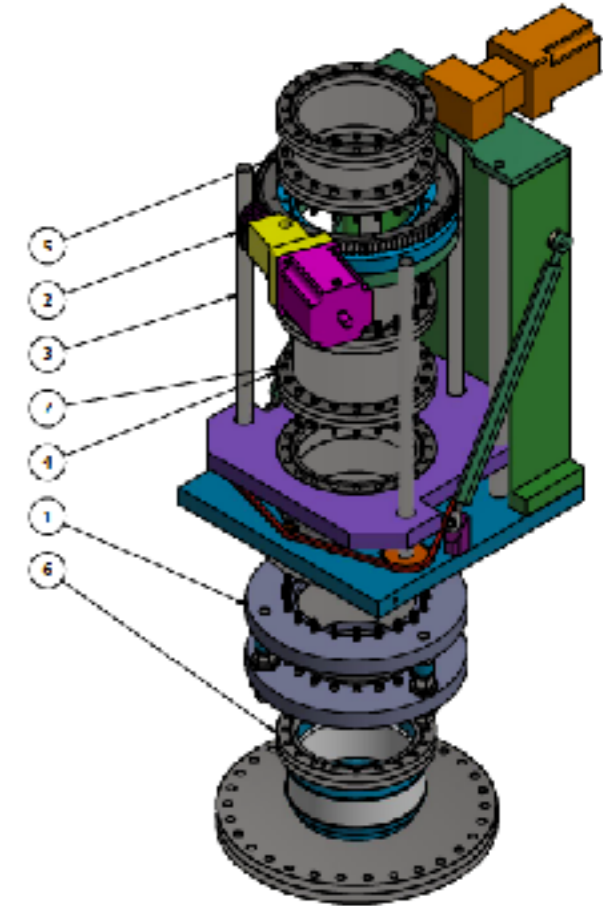
# QC Tests: Laser Periscope & Component Tests

(at LANL, LIP, KSU)

1. Leak check all laser periscope flange seals to the cryostat. *leak rate specification:  $1E-08$  mBar.liter/sec (local leaks);  $1E-06$  mBar.liter/sec (whole cryostat).* (LANL, LIP)
2. He leak check any machined mechanical part that performs as a barrier between the cryostat ullage and the lab air (LANL, LIP)
3. PEEK is used for periscope support structure; test response of PEEK in LAr (LANL)
4. Perform tests with camera for imaging, coverage and resolution as a function of distance in air and liquid argon (LANL, KSU)



Lower half  
is PEEK

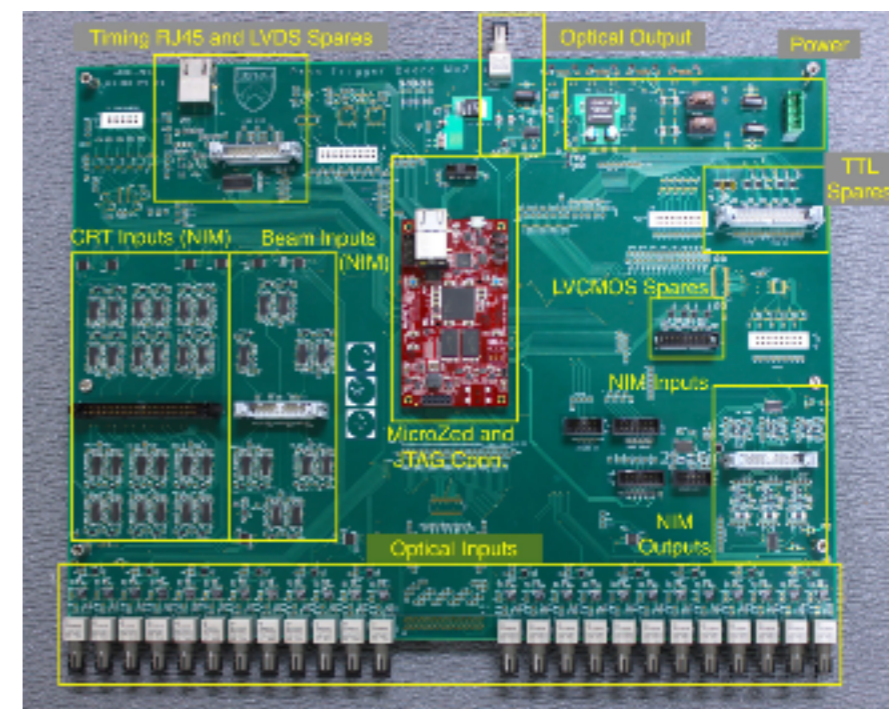
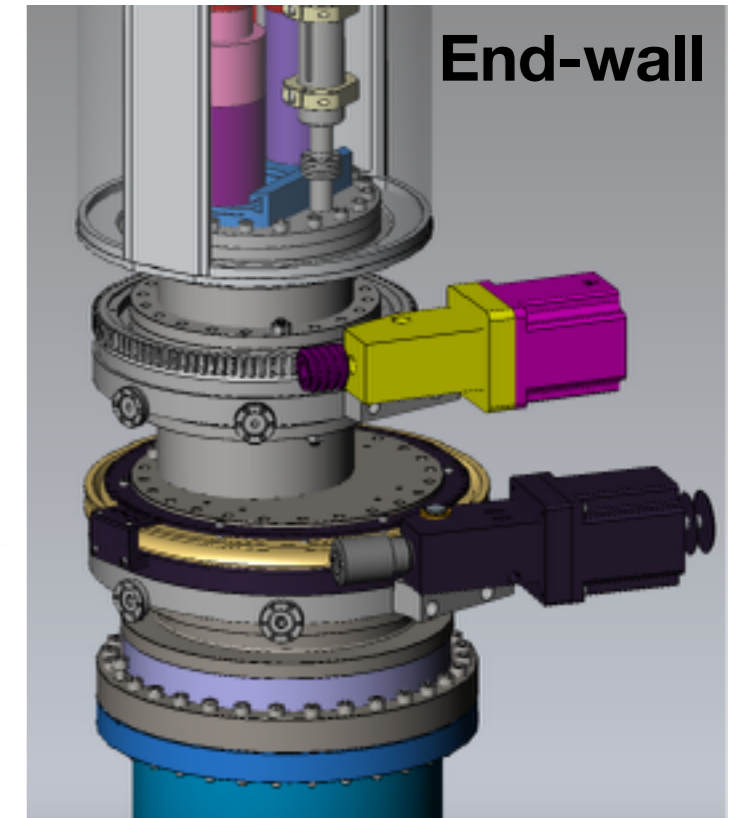
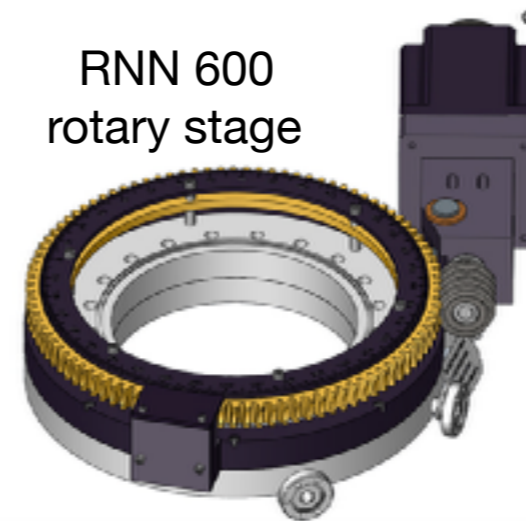


PEEK

# QC Tests: Laser Periscope & Component Tests

(at LANL, LIP, KSU)

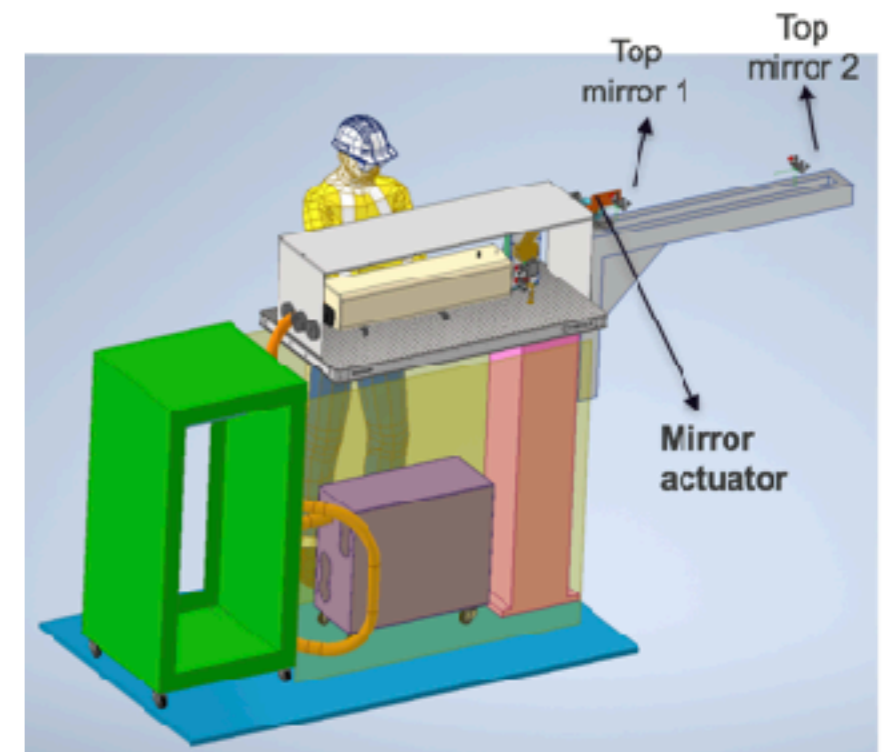
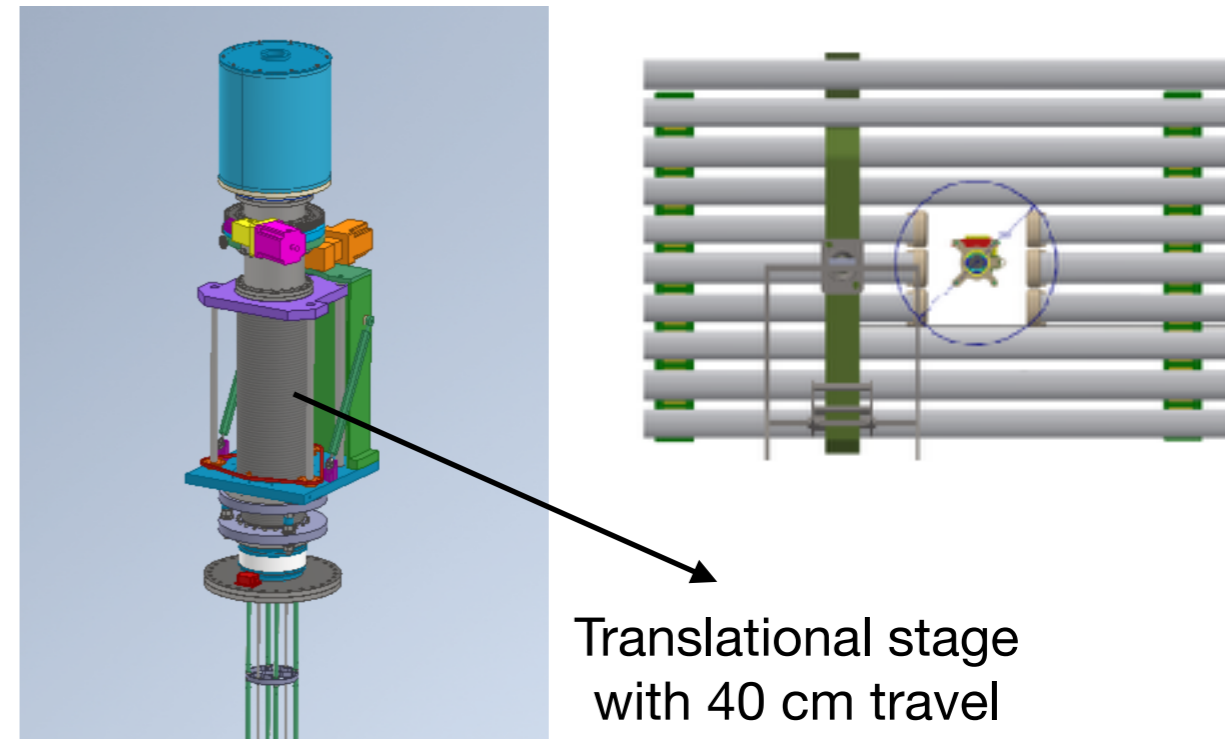
1. Test movement of rotary stages with motor controllers and encoder readout (LIP)
  - validate the correct motor control parameters (current, timing) and encoder readout settings
  - test movement precision and consistency between motor commands and encoder readout, including as a function of load and velocity
  - study possible electromagnetic noise interference
2. Develop and test software interfaces for the IoLaser (LIP)
3. Develop and test the DAQ electronics board and triggering scheme (LIP)



# QC Tests: Full Scale System Tests

*(All at LANL)*

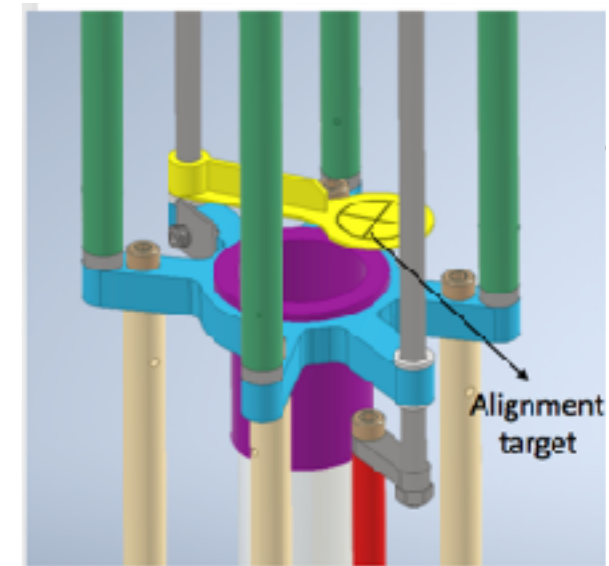
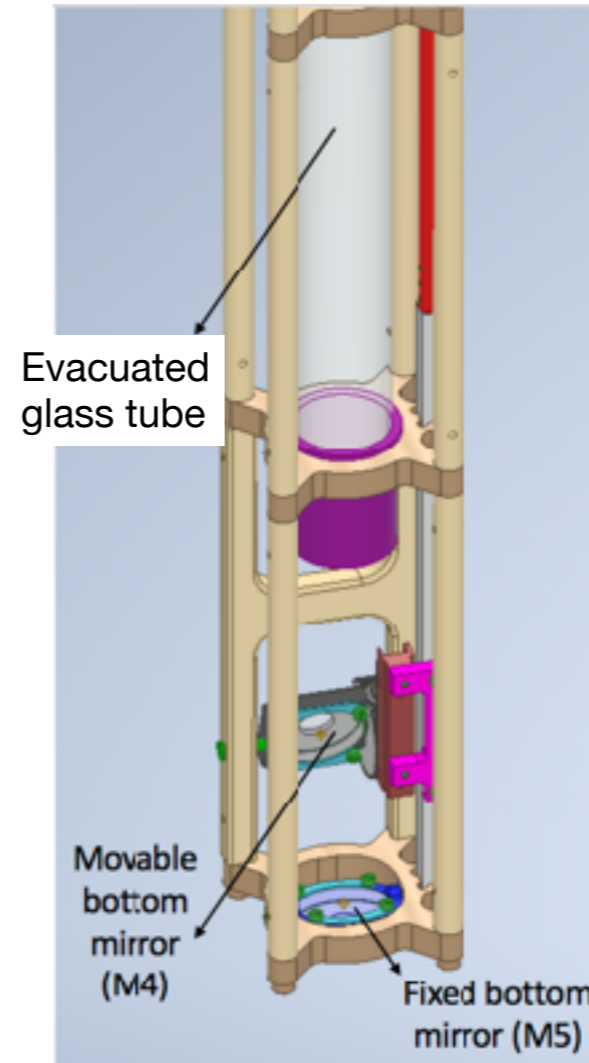
1. Characterize the laser beam in liquid argon by placing some detector material samples in argon e.g. degradation, reflection, scattering etc. (LANL)
2. Test the design of one laser box serving two periscopes
  - modify the laser beam pipe to be longer and include a mirror actuator.
3. Test top-FC periscope retraction operation both in air and LAr
  - Also using a mockup of the FC penetration
  - Test the usage of view ports and camera for visual inspections and adjustments
4. Test the dual rotary motion of the end-wall periscope both in air and LAr



# QC Tests: Full Scale System Tests

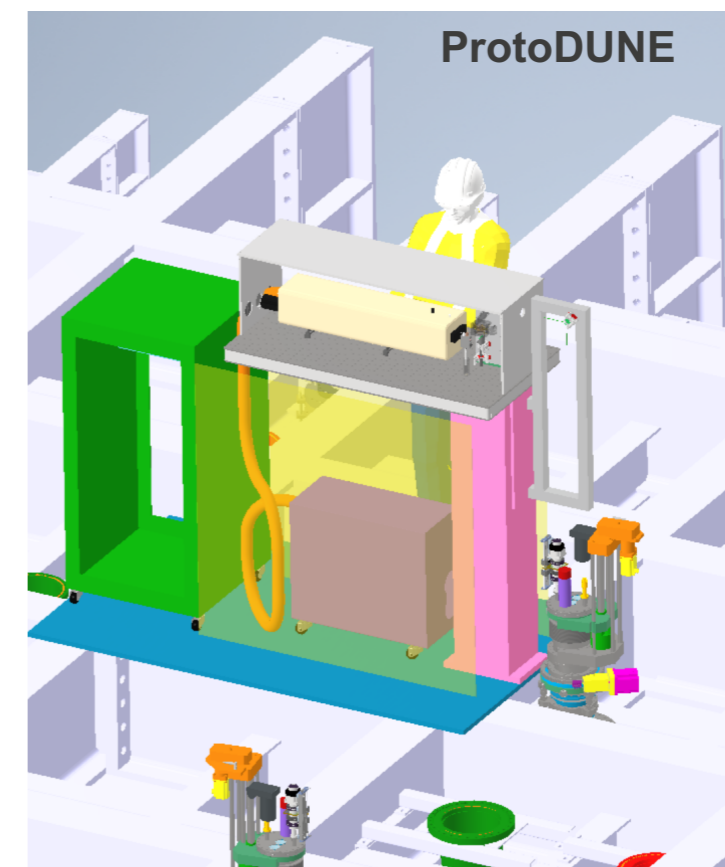
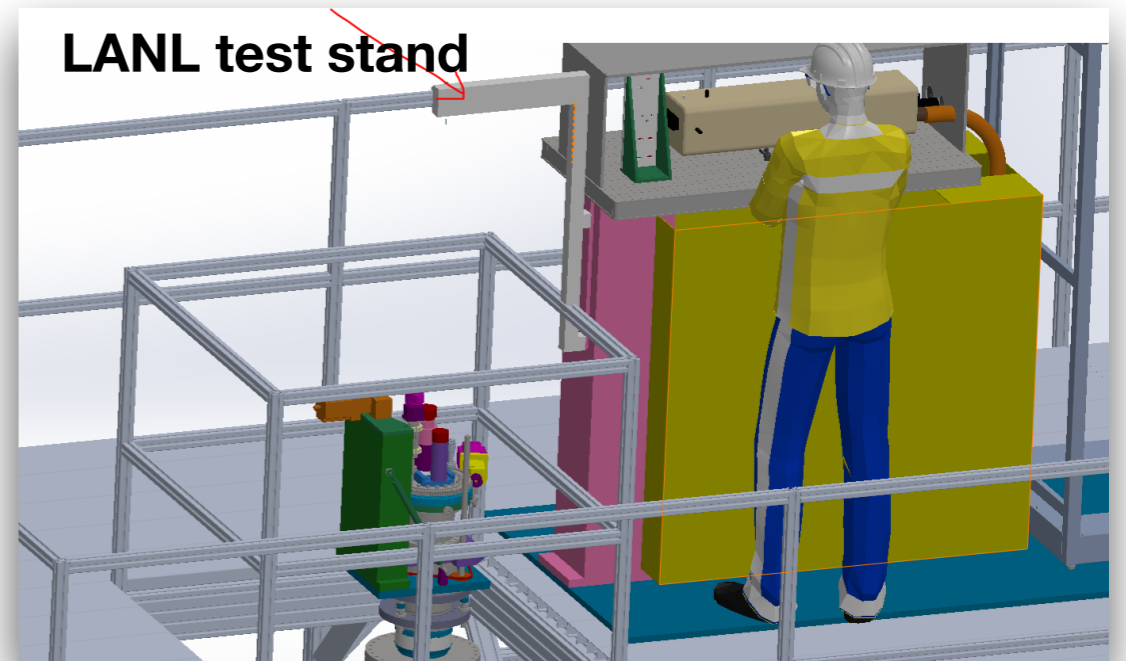
*(All at LANL)*

1. Introduce an intentional tilt of the flange and test adjustment using the port aligner
2. Install an inclinometer on the flange and verify detection of tilts
3. For both top-FC and end-wall periscopes, test motion of the periscope mirrors in air and liquid argon
4. Perform a series of tests to ensure laser can hit materials e.g. paper or alignment target and visually check with periscope camera
5. Perform alignment tests with the full scale system in liquid argon and develop procedures
6. Test the electronics rack arrangement and communication between the laser rack, laser box and periscope and corresponding controls.
7. Grounding & Shielding tests



# QC Tests: Assembly, Installation & Safety (at LANL, LIP, KSU)

1. Test pre-assembly and final assembly steps of the laser feedthrough and periscope assembly
2. Test installation of the split periscope design in a mockup of the DUNE arrangement (LANL)
3. Test laser safety procedures for installation, alignment, commissioning, and maintenance operations.



# QC Tests: Post shipping & Unpacking

*(Applies to CERN & SURF UG)*

For the DUNE FD, QA/QC tests will also be performed post shipping and unpacking at SURF, at surface and UG facility. (same applies for CERN)

- Optical components of the Laser system transported UG before final assembly, will be checked for damage during transportation to SURF and to the UG cavern.
- The final assembly of the laser box will be done UG in a class-IV laser safe area
- After final assembly of the laser box, tests will be performed to ensure all the components are set up and operating as intended.
- Given the long length of the periscope, the final assembly can only happen in the UG cavern. Tests will be performed after final assembly to ensure all components are installed correctly and are operating without issues.
- A clean room is needed for periscope final assembly and testing.

# Summary

- IoLaser procurement & fabrication plans defined for ProtoDUNE-II
- Lab spaces currently being established at LANL and collaborating institutes to perform QA/QC tests
- QA/QC plans maturing and will be further defined for implementation
- In contact with K. Fahey and J. Mateyack for documentation on QA/QC (a summary document exists on EDMS now)
- Scope of QA/QC tests at various institutions being defined
- Prototype tests at ProtoDUNE-II and tests leading to it will give us confidence in QA for DUNE

**Backup**