Ionization Laser (IoLaser): Overview & Requirements

Sowjanya Gollapinni (LANL)

September 16, 2020
IoLaser Initial Design Review

Calibration & Cryogenic Instrumentation (CALCI) Organization & Scope

CALCI Consortium

Cons. leader: *J. Maneira*

Tech. Leads:

S. Gollapinni (CAL); A. Cervera (CI)

+…list of liaisons (not shown here)

PNS WG

WG Leader:

J. Wang

- PNS system

Laser WG

WG Leader:

S. Gollapinni

- **IoLaser System**
- LBLS Mirror System
- LBLS Pin diode System
- Photoelectron Laser

RSDS WG

WG Leader:

J. Reichenbacher

- RSDS system

CI WG

WG leader:

A. Cervera

- Purity Monitors
- Temperature systems
- Capacitive Level meters
- Instrumentation package
- Fluid flow simulations

Consortium Membership

1. MSU
2. LANL
3. LIP (Portugal)
4. Hawaii
5. Bern (Switzerland)
6. Iowa
7. SDSMT
8. Pittsburgh
9. Boston
10. UC Davis
11. IFIC (Spain)
12. UCL (UK)
13. UCI
14. Fermilab
15. KSU
16. SDSU
17. CIEMAT
18. ANL
19. Drexel
20. NotreDame
21. BNL
22. Idaho State

RSDS = Radioactive Source Deployment System

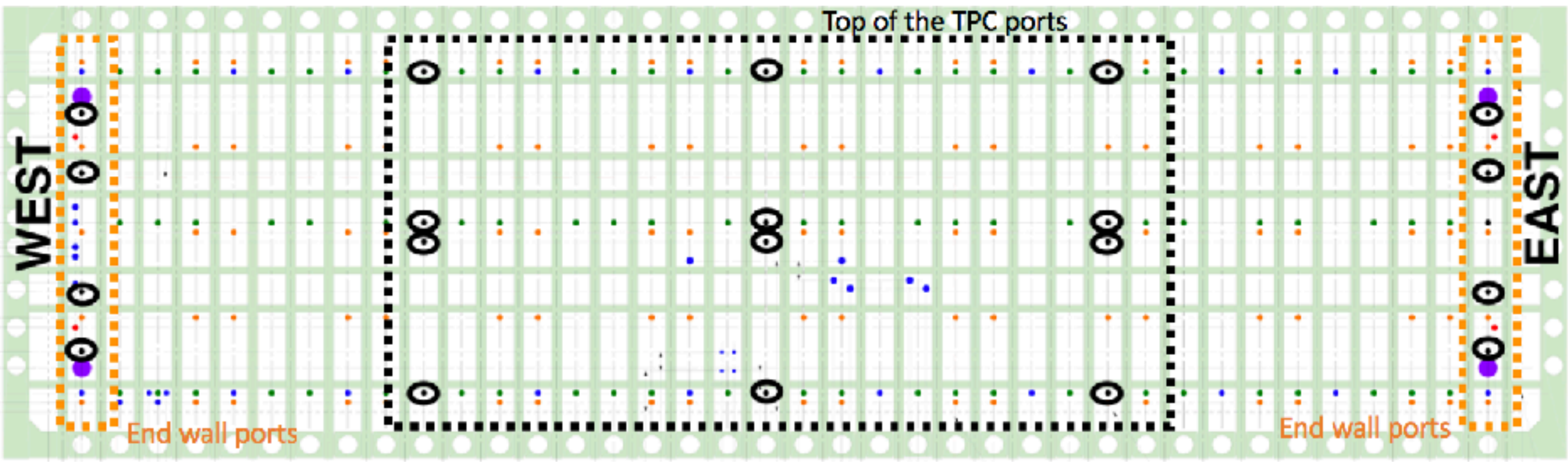
LBLS = Laser Beam Location System

PNS = Pulsed Neutron Source

Reminder: IoLaser Scope for ProtoDUNE & DUNE

- CALCI scope review workshop held in May 2020 provided a starting point of scope for various CALCI systems
- Scope review report is here (Doc-db#20008)
- IoLaser scope (ProtoDUNE-II)
  - *Two IoLaser systems (one top-FC and one end-wall)*
  - *Laser Beam Location System (LBLS) Mirror system*
  - *LBLS Pin diode system*
- IoLaser scope (DUNE FD)
  - *Single beam coverage of the full detector (8 top-FC systems)*
  - *Enhanced coverage in at least two regions of the detector with two-origin beams (e.g. corner and central region) i.e., 10 periscopes*
  - *Exact scope will be finalized based on ProtoDUNE-II experience and availability of resources*

Reminder: IoLaser Scope for ProtoDUNE & DUNE



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IoLaser Core Team

LANL

- S. Gollapinni (Scientist; main PI)
- M. Fani (Postdoc)
- J. Boissevain (Mech. Eng.)
- V. Sandberg (Physicist Eng., laser/electronics expert),
- E. Renner (Student Eng.)
- E. Guardincerri (Scientist; joining soon)
- Postdoc#2 (to be hired soon)

FNAL

- S. Chappa (elec. eng.)
- A. Ghosh (elec. eng.)
- Electrical Guidance: L. Bagby & T. Shaw

LIP (Portugal)

- J. Maneira (Scientist; main PI)
- N. Barros (Scientist)
- R. Alves (Mech. Eng.)
- F. Neves (Scientist)
- V. Solovov (Scientist)
- F. Barao (Faculty)

U. of Hawaii

- J. Maricic (Faculty)
- R. Dharmapalan (Postdoc)

KSU

- G. Horton-Smith (Faculty)

- Acquiring the critical mass needed for this effort over the last year: about 15 members now and growing
- Plus electrical engineering support from Fermilab (thanks to Eric & Terri!)
- For interfaces, support from other groups: HV, PDS, Tech. Coord., CERN, etc.
- *Big thanks to the U. of Bern team for their expertise and consulting time!*

Distribution of IoLaser Scope of Work

LANL

- Focus on top of the FC IoLaser Design
- Laser box + support structure
- IoLaser Electrical/Grounding
- Lead procurement, fabrication, Assembly of both periscopes
- Lead QA/QC for both periscopes
- Lead Installation, commissioning, data taking and analysis for both periscopes
- LBLS pin diode system (eng. support)

LIP (Portugal)

- Focus on end-wall IoLaser design
- IoLaser Software Interface
- IoLaser DAQ and Slow Controls
- LBLS mirror system
- Small scale testing
- Help with fabrication effort
- Personnel support for Installation, commissioning, data taking, and analysis

U. of Hawaii

- LBLS pin diode system
- Help with IoLaser fabrication effort
- Personnel support for Installation, commissioning, data taking, and analysis with LBLS pin diode system

KSU

- Periscope cameras + integration
- Inclinometers + interface

FNAL

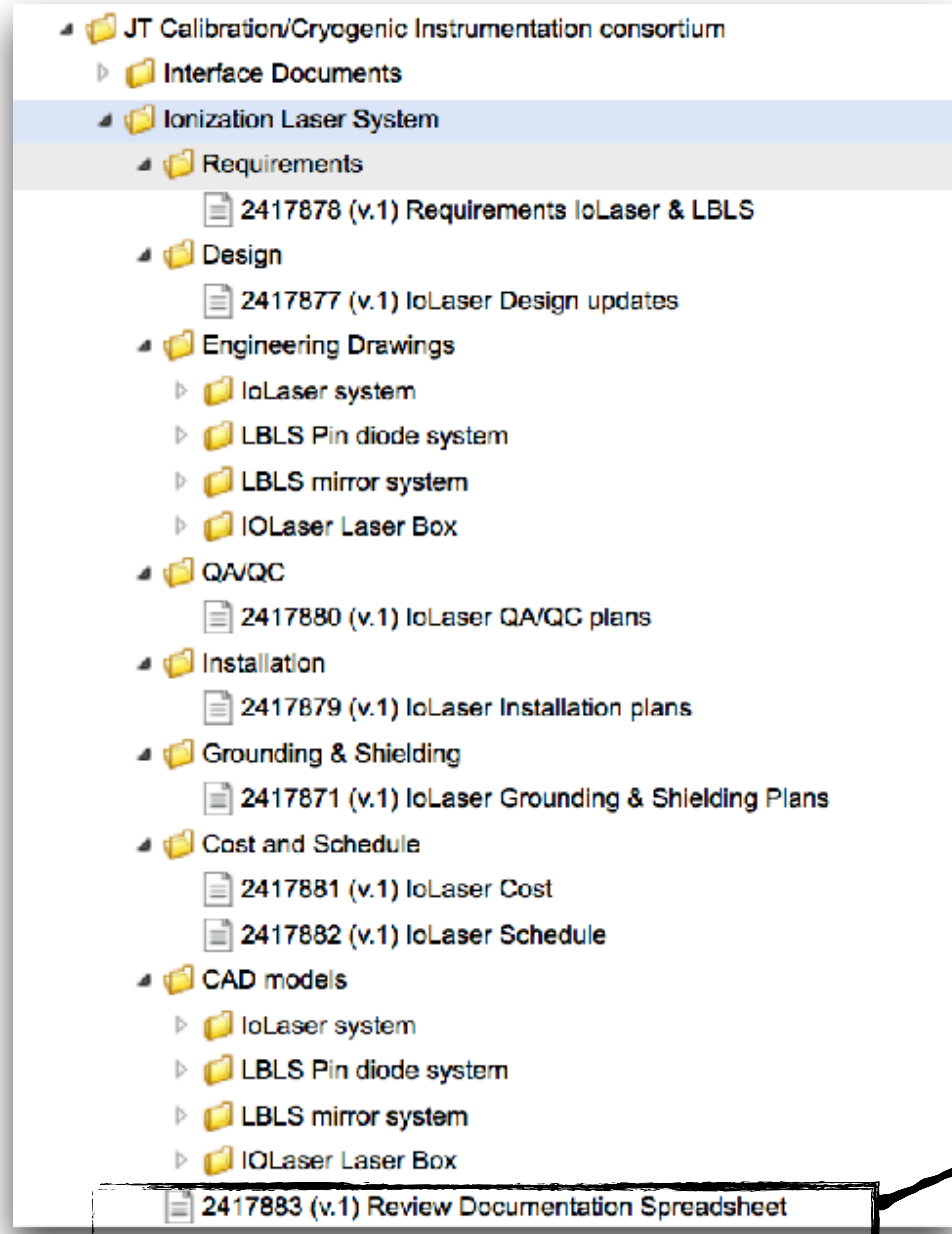
- Electrical engineering support for IoLaser grounding and shielding documentation/implementation
- Grounding/shielding plan guidance

Effort distributed across 5 institutes with LANL taking the lead for the overall system and effort

Focus of this Review

- Requirements
- Initial review of the IoLaser system design
  - *Laser Box (Laser + optics + enclosure)*
  - *IoLaser periscopes (top-FC and end-wall)*
  - *LBLS mirror system*
  - *LBLS pin diode system*
- CAD models and mechanical drawings
- QA/QC testing plans at LANL and collaborating institutes
- Grounding & Shielding Plans
- Installation/Integration Plans
- Preliminary cost and schedule

EDMS Documentation



- EDMS IoLaser folder: https://edms.cern.ch/project/CERN-0000206724
- EDMS IoLaser design review folder: https://edms.cern.ch/project/CERN-0000211673
- Both have same information; done for book keeping purposes (thanks to Steve for creating these for us!)

This has a list of documents and all EDMS links

Review Documentation Spreadsheet

Category	Document	EDMS	Controlled by (at time of Preliminary Design Review)	Description
Design Documents	TDR Chapter	TDR JINST	DUNE EB	Sub-system Design Report from TDR. Assumed to include some discussion of value engineering process.
	Design Updates	Documents describing design for IoLaser and LBLS systems 2417877	Consortium	Need to understand what documentation is needed to describe sub-system design changes subsequent to the release of the TDR (TDR addendum). Is this an updated, stand-alone version of the original TDR chapter (probably at least required for Final Design Review)?
V. Sandberg's talk Today	Grounding & Shielding Plan	2417871	DUNE TB	Short document describing plan for sub-system adherence with detector grounding & shielding requirements. Plan should have sign-off from DUNE Grounding & Shielding Committee (contact Terri Shaw at tshaw@fnal.gov).
	Mechanical CAD Model for Sub-system	Laser Box: 2417885; IoLaser (Top FC): 2417875; IoLaser (end wall): 2417864, 2417865; LBLS (mirror): 2417867; LBLS (pin diode): 2417876	Consortium	Updated CAD model for sub-system released in EDMS. As part of the process for releasing the sub-system model, it will be integrated and checked within global CAD model.
Design+drawings Laser Box (V. Sandberg's talk) Periscope (J. Maneira's talk) LBLS Mirrors (J. Maneira's talk) LBLS pin diodes (J. Maricic's talk) **(today & Friday)**	Mechanical Engineering Drawings	Laser Box: 2417884; IoLaser (Top FC): 2417874; IoLaser (end wall): 17868, 2417869; LBLS (mirror): 2417870; LBLS (pin diode): 2417872	Consortium	Engineering drawings for all sub-system mechanical components. Drawings do not need to be production quaility but should contain all crtical dimensions and tolerances. Drawings should be obtained directly from released sub-system CAD model and be marked "Draft/Not for Production". Drawings should also indicate component fabrication materials and masses consistent with EDMS 2281422. Drawings of any specialized components necessary for transporting or installing detector components should also be provided.

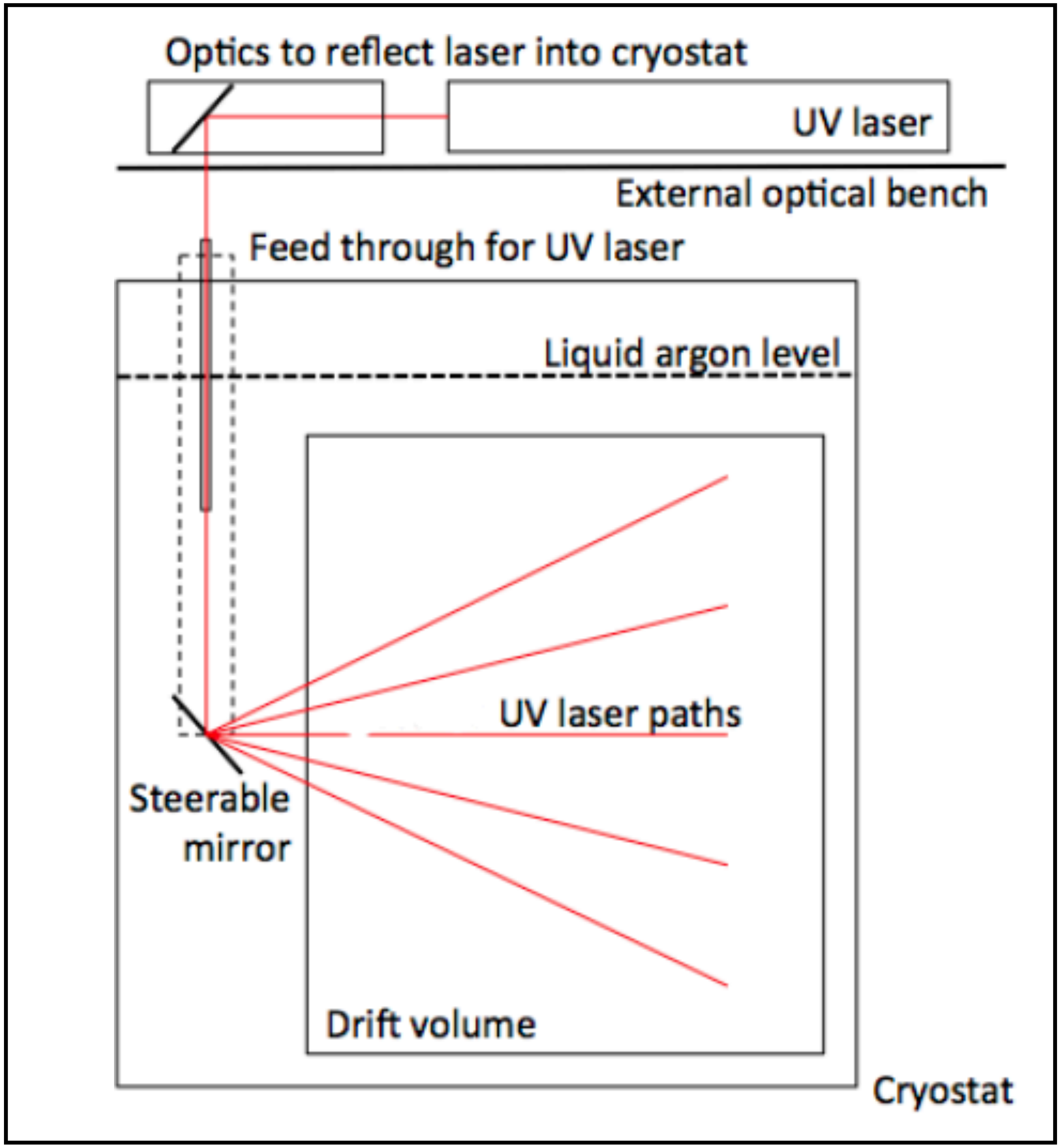
	Mechanical Assembly Drawings and Parts Lists	Laser Box: 2417884; IoLaser (Top FC): 2417874; IoLaser (end wall): 17868, 2417869; LBLS (mirror): 2417870; LBLS (pin diode): 2417872	Consortium	Assembly drawings and parts lists for all sub-system detector components. Drawings do not need to be production quality but should contain the baseline design and section views. Drawings should be marked "Draft/Not for Production", contain assembly masses consistent with EDMS 2281422, and indicate the center-of-gravity of the assembly (CG marker) . Parts lists should contain full specifications for any custon components.
	Electrical Schematics & Board Layouts	not yet available	Consortium	Schematics and board layouts for all sub-system electronics components. Along with the schematic and board layout files for each printed circuit board design, the additional board layout and manufacturing information typically sent to PCB manufactures (e.g. number and configuration of layers, required drill sizes and tolerances, hole plating requirements, and board trace widths and tolerances) should be provided.
partially covered in V. Sandberg's talk today	Specification of Electrical Cabling and Wiring Connections	2417871, 2314935	Consortium	Specification of all electrical connections between sub-system components. Needs to include complete information on all cables and connectors including maximum voltage and current ratings. Wiring diagrams should be provided as necessary such that all system inter-connections are fully defined.
	Bills of Materials for Electronic Board Components	not yet available	Consortium	Bills of materials including parts list with full manufacturer part numbers for each sub-system electronics component. As appropriate, information regarding the cryogenic qualification of specific parts should also be provided.
This talk Requirements Documents	EB-Held Requirements	2346091	DUNE EB	High-level detector requirements with impact on physics performance.
	TB-Held Requirements	2346092	DUNE TB	Next level detector requirements with potential impacts on multiple subsystems.
	Consortium-held Requirements	Also has updated EB-held and TB-held requirements (not submitted to EB/TB yet) 2417878	Consortium	Spreadsheet with four tabs for Integration, Installation, Fabrication, and Transportation requirements. These requirements should be pulled from Interface documents, Far Detector Installation Plan, QA/QC Plan, and Manufacturing Plan as appropriate.
This talk & design talks Installation Documents	Detector Installation Plan	2233449	Integration Office	Chapters detailing sub-system installation plans should be complete and updated.
	Detector Installation Plan Update	Summary of installation plans for IoLaser & LBLS 2417879	Consortium	A document summarizing updated placement and installation plans for IoLaser and LBLS systems

This talk & design talks **Interface Documents**	Consortium-Consortium	2145136, 2145137, 2145138, 2145142, 2145159, 2088741	DUNE TB	Released version of document detailing interfaces between detector sub-systems (APA, HV, SP-PD, SP-ELEC, DAQ, CALCI, COMP). Six in total for each consortium.
	Consortium-Installation	2145182, 2145185	Integration Office	Released version of document detailing detector sub-system interfaces with the detector installation plan.
	Consortium-DSS	2145174	Integration Office	Released version of document detailing detector sub-system interfaces with the Detector Support Structure (DSS)
	Consortium-Facilities	Facility interface document also includes DSS 2145168, 2145174	Integration Office	Released version of document detailing detector sub-system interfaces with facility infrastructure. Facility infrastructure includes cryostat penetrations, real estate on top of cryostat, racks on the detector and cryogenic mezzanines, as well as cryogenic systems and piping (both internal and external to the cryostat).
	Interface Drawings	2145142 (for HV-CALCI interfaces)	DUNE TB & Integration Office	Required interface drawings (both mechanical and electrical) are specified within each interface document. Interface drawings once completed should be posted as an additional material within the EDMS entry of the corresponding interface document.
Engineering Analysis Documents	Analysis Plan	not yet available	Compliance Office	Documents the load cases that need to be analyzed for the sub-system and the standards that will be used assess the structural calculations. This document is jointly signed-off on by the consortium and compliance office prior to starting any structural analysis.
	Structural Analysis Note(s)	not yet available	Consortium	Engineering notes detailing the structural analyses performed for each of the sub-system load cases defined in the analysis plan and comparison against identified standards.
	Independent Review Report(s)	not yet available	Compliance Office	Output from independent review of structural analysis note(s) performed by the Compliance Office. Report(s) should include recommendations for required updates needed prior to Final Design Review.
S. Gollapinni's talk on Thursday **QA/QC Documents**	Preliminary QA/QC Plan	2417880	Consortium	Short document describing consortium QA/QC plan with emphasis on sub-system testing plans covering fabrication, transport, storage, and installation stages. Kevin & Jim are in the process of producing a template (example) document.
	ProtoDUNE Lessons-Learned	N/A	Consortium	Short document detailing sub-system issues uncovered during ProtoDUNE and the steps being taken to address these.

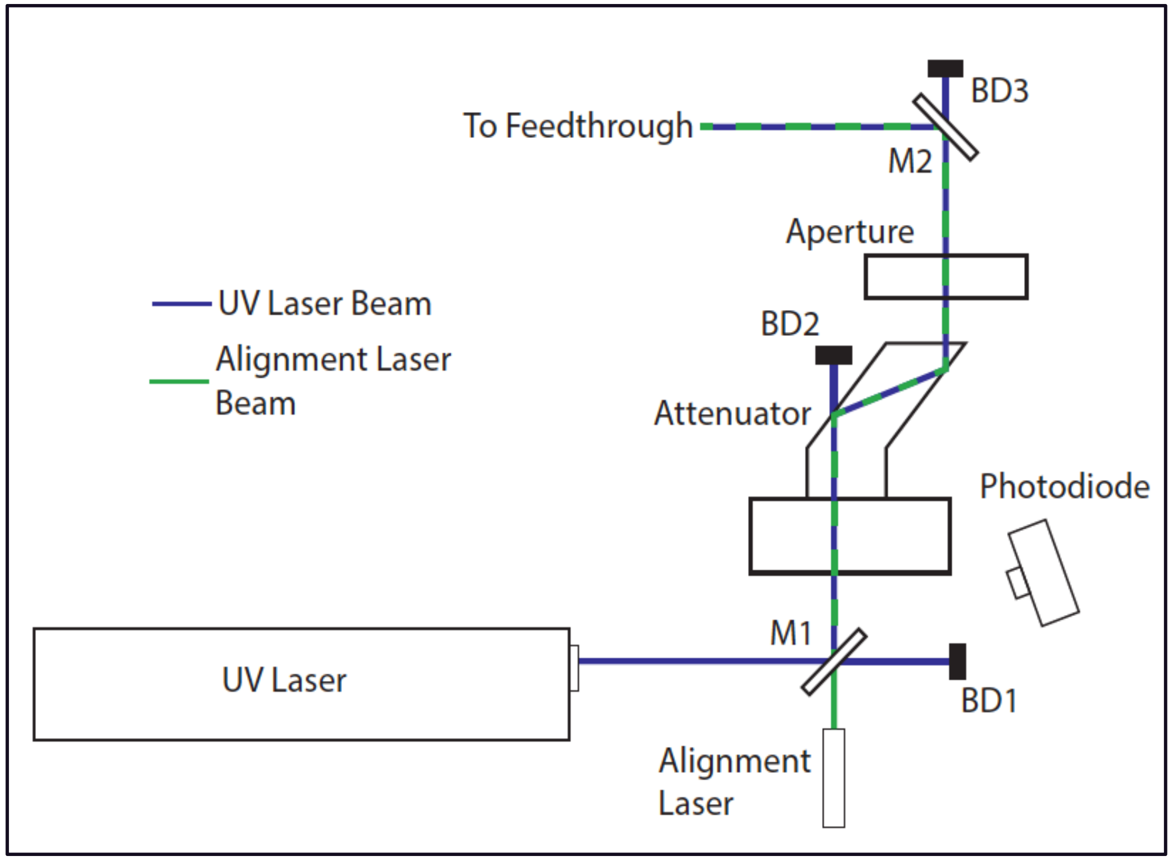
	Preliminary Manufacturing and Procurement Plan	not yet available	Consortium	Short document describing consortium plans for the procurement of needed materials, fabrication of detector components, and sub-system assembly. Kevin & Jim are working with Vic to produce a template (example) document.
	Plan for Prototyping Activities	2417880	Consortium	Short document describing consortium plans for prototyping activities moving forward from the Preliminary Design Review including any Ash River activities and ProtoDUNE-II. Description of sub-system specific Ash River activities should be consistent with that in document describing overall plan for Ash River activities (EDMS 2169069)
S. Gollapinni's talk on Thursday Cost/Schedule Documents	Cost Estimate	2417881	DUNE EB	Consortia sub-system cost estimates are prepared by the DUNE Resource Coordinator working closely with the consortia leadership teams. Effort is currently underway to incorporate cost estimates within P6 to enable production of annual M&S and Labor profiles. Resource Coordinator will determine format for sharing this information with review committee.
	Schedule Summary	2417882	DUNE TB	Need to define a format to be extracted from P6. Should include a summary of consortium milestones and connections to high-level ProtoDUNE-II and Far Detector milestones.
Tracking Documents	Responses to Past Review Recommendations	N/A	Review Office	Consortia should keep a spreadsheet of recommendations received from each stage of the review process. For each recommendation received, the consortia should provide within the spreadsheet a brief description of how the consortium has addressed the recommendation and an assessment of its current status (e.g. closed or in-progress). Review office should sign-off on previous review recommendations having been properly addressed.

IoLaser System Outline

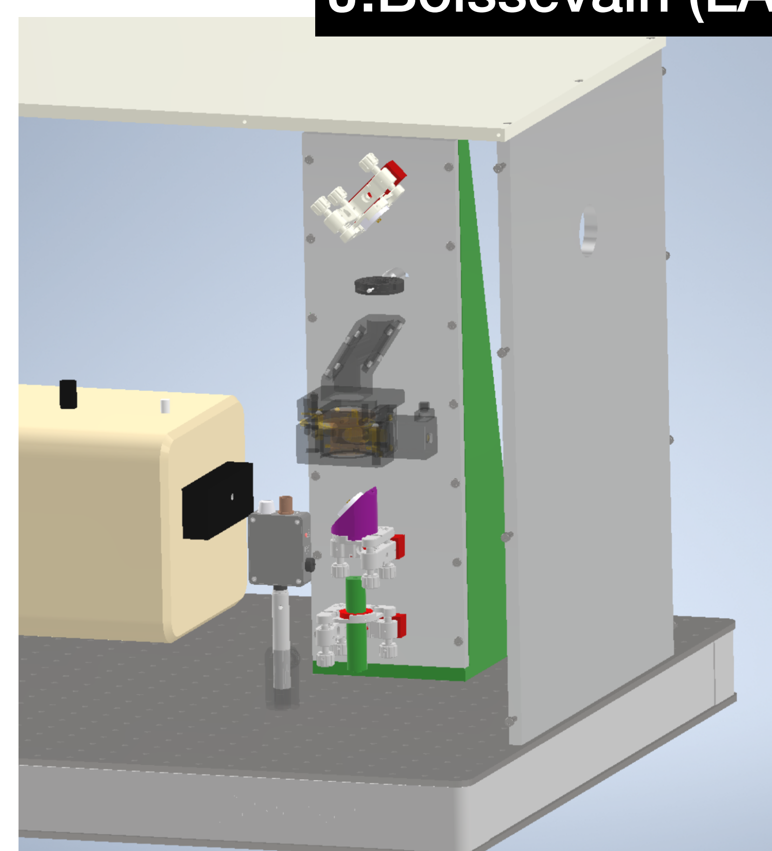
- High intensity UV laser (266 nm, 60 mJ/pulse), to ionize argon
- Two main parts:
    - *Optical cryostat feedthrough* and a *periscope* with steerable mirrors to aim laser tracks
    - A "*laser box*" housing the laser
- Based on existing designs
    - MicroBooNE, outside field cage
    - SBND, inside field cage
- Thanks to Bern team for sharing the uB/SBND designs with us!



Laser Box Design



J.Boissevain (LANL)



Based on MicroBooNE/SBND design

- Class-IV UV laser
- Attenuator to regulate intensity
- Aperture to limit beam spot
- Photodiode to monitor pulsing
- Visible laser to align all downstream mirrors
- Class-IV laser safety rated box enclosure

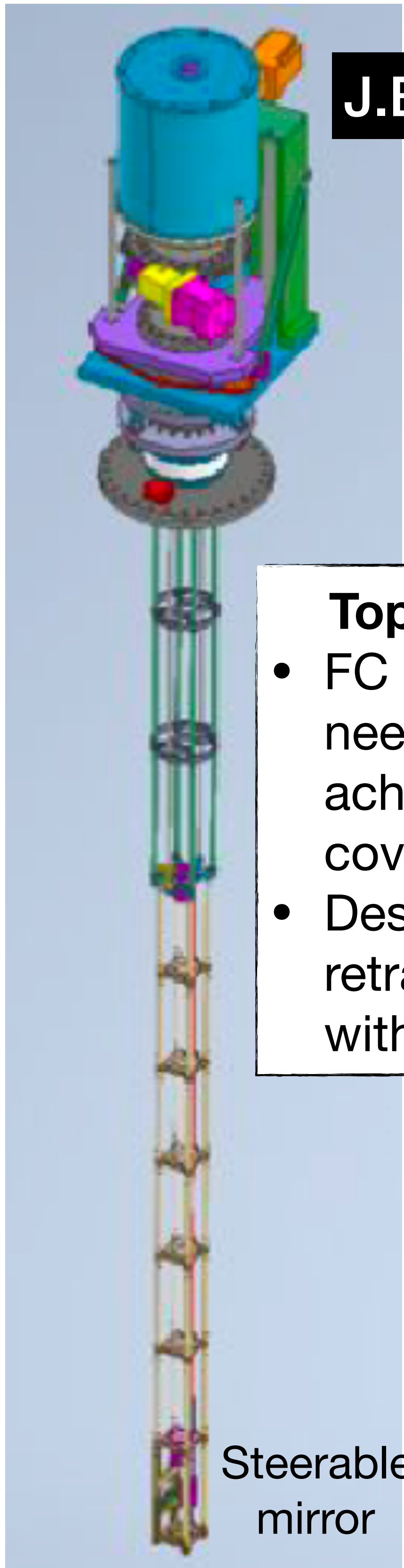
More in V. Sandberg's talk

Laser Periscope

(two designs: top-FC & End-wall)

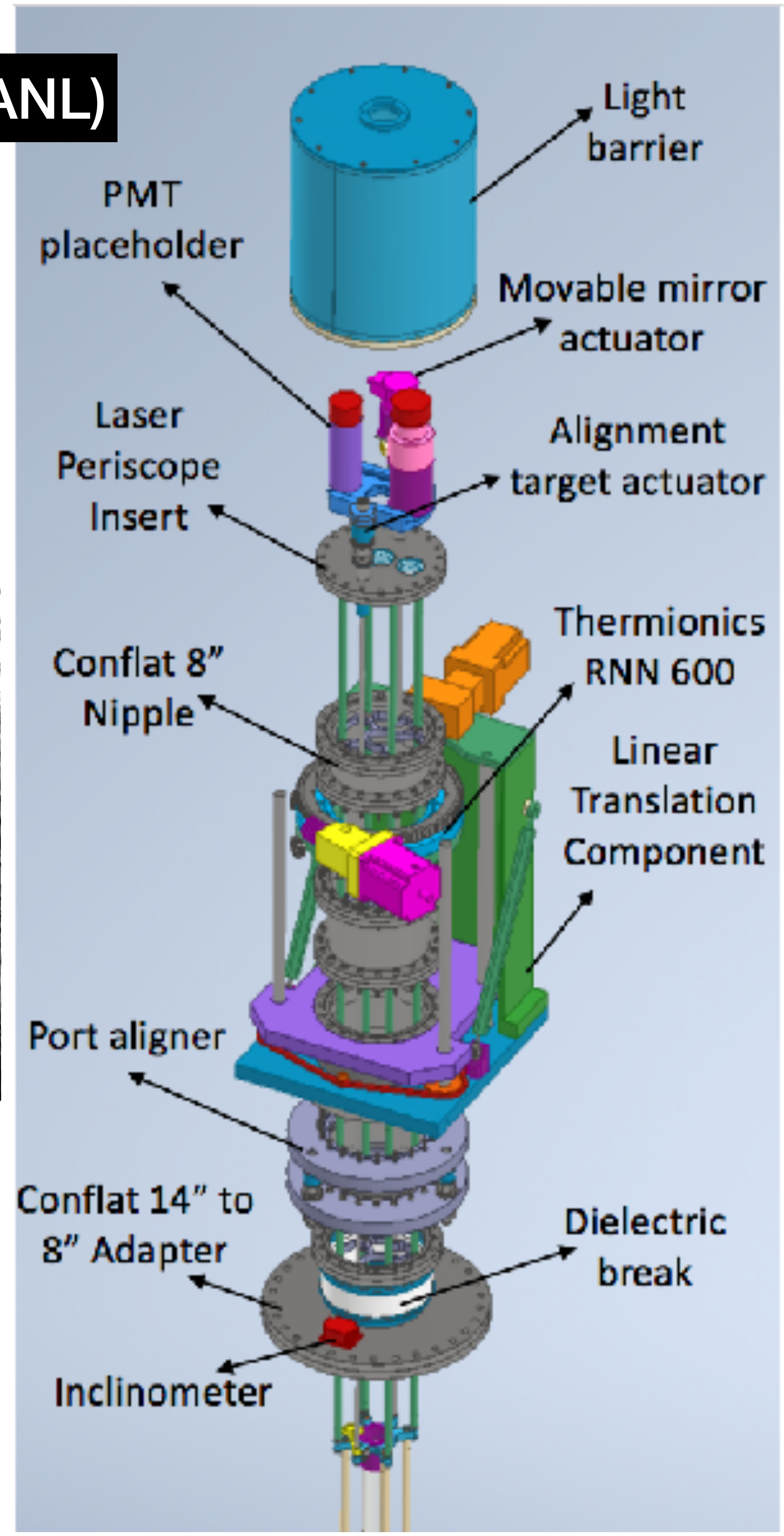
More in J. Maneira's talk

J.Boissevain (LANL)



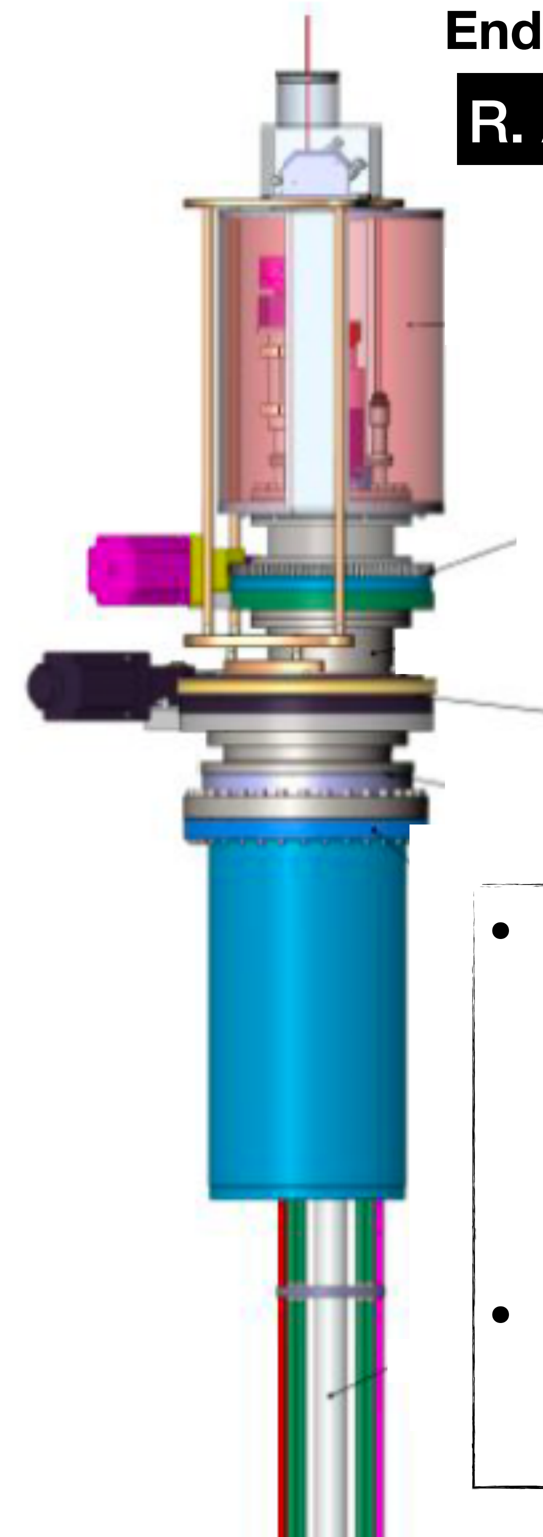
Top-FC design

- FC penetration needed to achieve required coverage
- Design includes retraction feature with 40 cm travel



End-wall design

R. Alves (LIP)

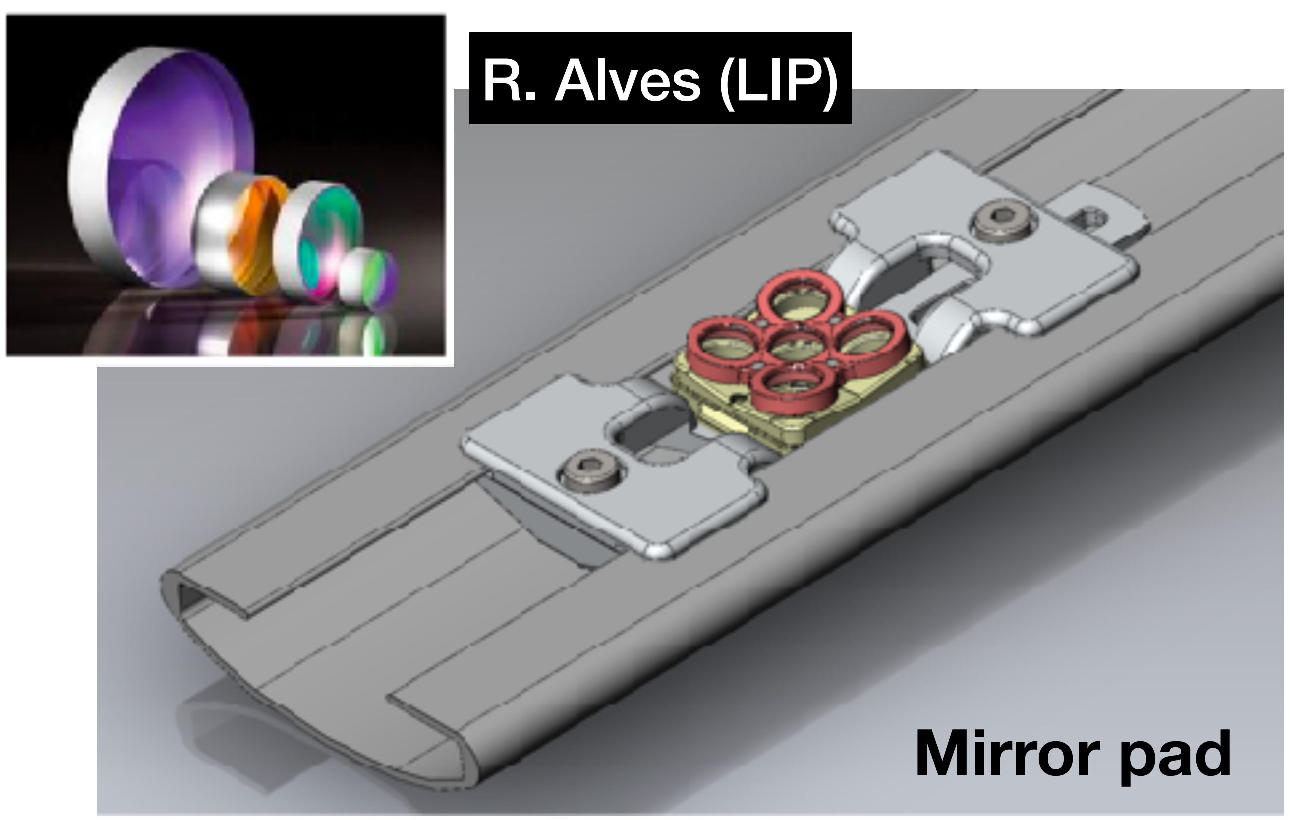


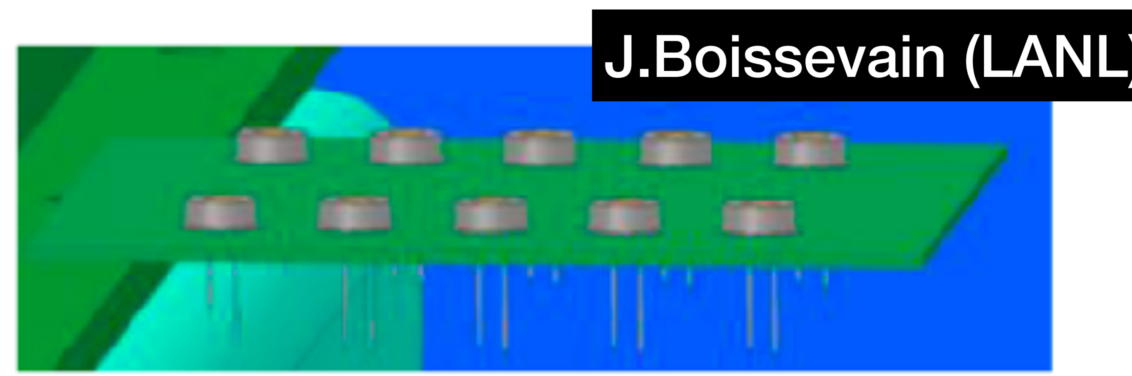
- The dual rotary system facilitates coverage through FC profiles;
- No FC penetration needed

Laser Beam Location system

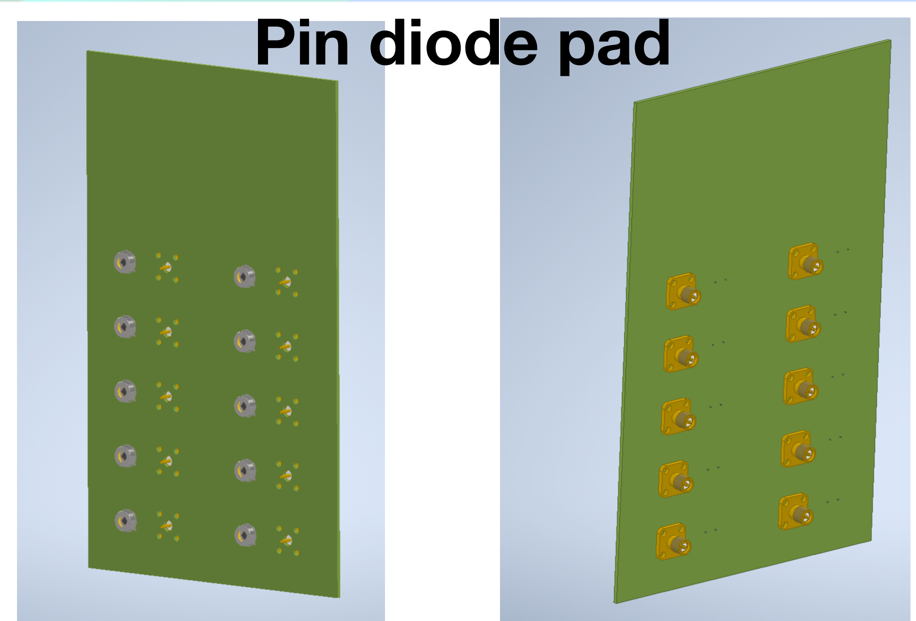
More in J. Maneira & J. Maricic talks (Friday)

- E-field measurement is based on measuring deviations from straightness of laser tracks
- Requirement of beam position uncertainty: **5 mm** (driven by TPC wire spacing)
  - Laser encoders pretty accurate: 2 mm @ 10 m (MicroBooNE)
  - But, need to have position relative to TPC also accurate and verifiable
- Two independent in-situ systems planned: PIN diode& Mirror pad System





Pin diode pad



Requirements: EB-held

New

(all new; not yet submitted to EB for approval)

	Name	Primary Text
✓	Laser calibration system **single beam coverage**	The number and coverage of the SP laser system periscopes shall be such that it covers, with at least one beam, **100% of the APA and CPA resistive panels (RP).**
✓	Laser calibration system **two beam coverage**	The number and coverage of the SP laser system periscopes shall be such that it covers with two beams **at least 1/8 of the SP detector.**

- We didn't have any requirements on calibration in EB-held requirements largely because a baseline was never defined
- Following the scope review recommendations, we have revised this, yet to bet submitted to EB for approval.

Requirements: TB-held

New

(all new; not yet submitted to TB for approval)

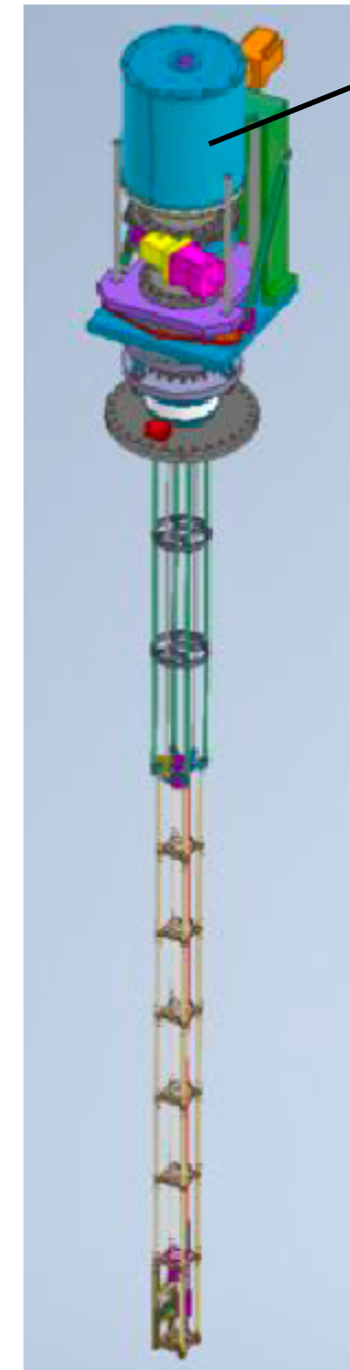
Status	Name	Primary Text
✓	SP CALCI/HV ionization laser **FC penetration**	There must be openings on the top FC modules allowing the laser periscopes to penetrate the active volume **to achieve 100% APA and CPA RP single laser beam coverage**. The periscopes must have a **retraction system**.
✓	SP CALCI **laser beam not pointing at PDS**	The laser system shall prevent the beams from being aimed at the PDS modules.
✓ **In progress**	More in N. Barros talk (Thursday) SP CALCI/DAQSC **calibration event tagging**	The calibration and DAQ systems shall have a two-way communication, allowing an external triggering of the DAQ by the calibration systems (to individually tag calibration events or timestream hits) and a DAQ-issued veto to the calibration (in case of SNB, for example).

- Only including requirements that impact multiple systems
- Most important interface is with HV for the top FC penetration for periscopes to penetrate
- Detailed Interface drawings by Kyle on EDMS: https://edms.cern.ch/document/2145142/3

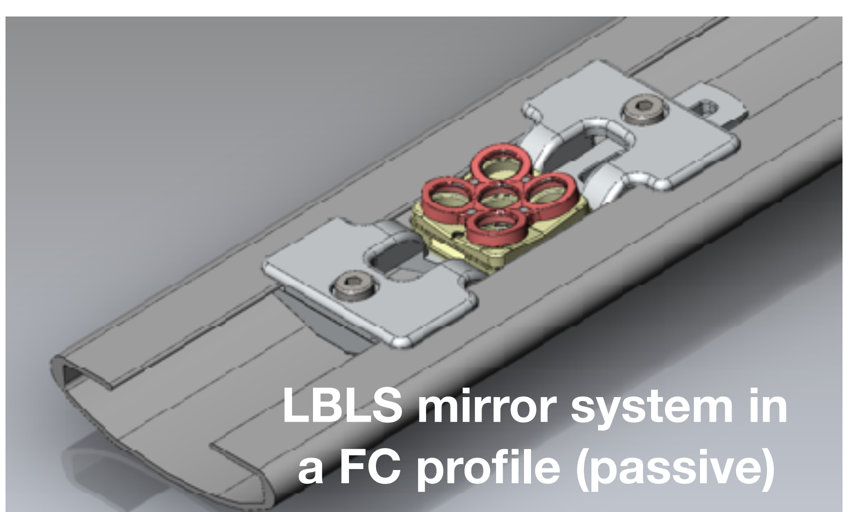
Requirements: Consortium-held, Integration

New | Updated

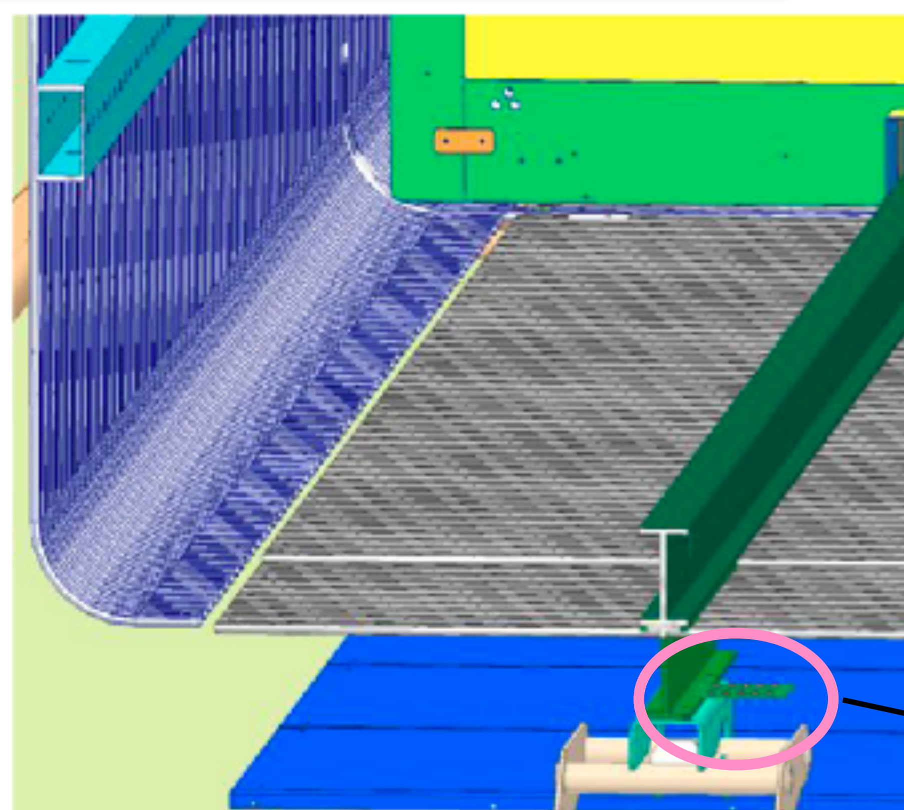
Status	Name	Primary Text
✓	SP CALCI **attachment of LBLS to FC**	LBLS will be attached to FC components in ways to **ensure HV safety and E-field uniformity.**
✓	SP CALCI laser **periscope openings closeable**	All light openings have to be closeable, in order **to maintain PDS data quality** while servicing the laser system for maintenance.
✓	SP CALCI **Max. E field** near calibration/instrumentation devices	EB-held req. 2264 applies here.
✓ In progress	SP CALCI **Noise** from calibration/instrumentation devices	EB-held req. 2265 applies here.



Light barrier



LBLS mirror system in a FC profile (passive)



LBLS pin diode on G10 beam

Interface Documents

	EDMS Doc#	
Consortium-Consortium	2145136, 2145137, 2145138, 2145142, 2145159, 2088741	DUNE TB
Consortium-Installation	2145182, 2145185	Integration Office
Consortium-DSS	2145174	Integration Office
Consortium-Facilities	Facility interface document also includes DSS 2145168, 2145174	Integration Office
Interface Drawings	2145142 (for HV-CALCI interfaces)	DUNE TB & Integration Office

Consortia-to-Consortia documents updated April 2020 in discussions with other consortia

- The interface documents to Facility, Installation, & DSS need more work and less mature compared to the consortia level documents
- More interface drawings will need to be produced

Requirements: Consortium-held, Design

New

Laser Box

Name	Primary Text
✓ **Combined trasmission** of laser optical path	The combined transmission of the optical elements in the laser optical path shall be **higher than 50%.**
✓ UV **reflectivity** of harmonic separator	The reflectivity at 266 nm of the harmonic separator located immediately at the exit of the laser should be **at least 95%.**
✓ UV **reflectivity** of mirrors	The reflectivity at 266 nm of each mirror in the path of the laser should be **at least 96%.**
✓ **Flatness** of mirrors	Any optical mirror in the laser path should have laser quality flatness, i.e. **lambda/10 or better.**

Applies to Laser periscope also

More in V. Sandberg's talk next on how the laser box design meets these requirements

- Flatness of mirrors important to not increase the divergence of the beam
- The reflectivity of mirrors should be combined with the expected transmission of the quartz/LAr/GAr/air interfaces (estimated at 69%) and the harmonic separator reflectivity (and vice versa) to obey the combined transmission requirement.

Requirements: Consortium-held, Design

New Updated

Laser Periscope

Name	Primary Text
SP CALCI **laser beam location precision**	Beam location systems capable of measuring the laser beam direction with a precision of **0.5 mrad or smaller**.
Laser port installation **flatness compensation**	The periscopes installed above the top FC shall include devices capable of compensating deviations from flatness of the as-installed ports, with a range **up to 1 degree.**
FC opening tolerance for **laser port dynamical flatness**	and the periscope positioning inside them, must be wide enough to accommodate deviations of horizontality of the ports, due to changing operational pressure conditions, of **up to 0.1 deg.**
FC opening tolerance for **cool-down effects**	The top FC openings for the laser periscopes, and the periscope positioning inside them, must be wide enough to accommodate the **shrinking of the FC by up to 0.1%.**
Quartz discs **surfaces parallelism**	The two flat sufaces of the quartz discs along the path of the laser must be parallel **to about 0.02 mm over a 30 mm diameter**
Angular resolution of **bottom mirror** positioning	The relative angular position of the last mirror in the laser periscope must be known to **better than 0.2 mrad**
Angular resolution of the **position encoders**	The angular resolution of the motion encoders should be **better than 1 degree.**

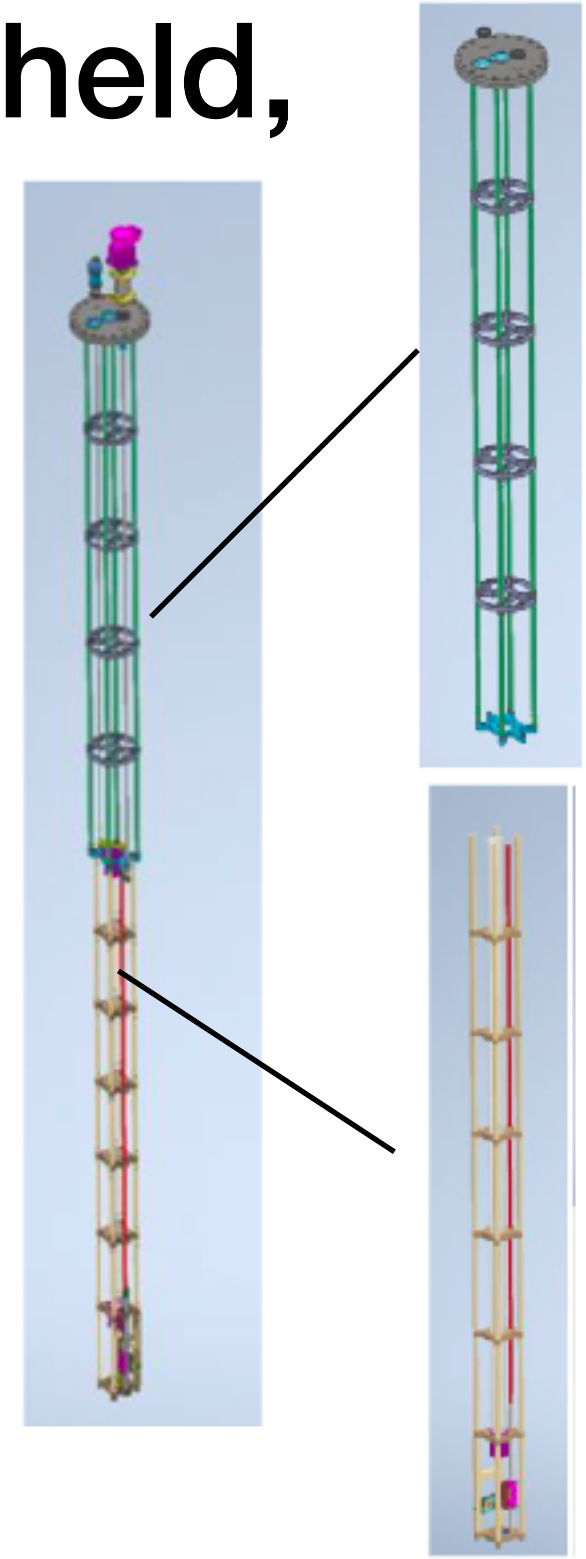
Applies only to the top of the FC periscope

More in J.Maneira's talk next on how the laser periscope design meets these requirements

Requirements: Consortium-held, Installation

New

	Name	Primary Text
✓	IoLaser **installation sequence**	The top IoLaser periscopes shall be installed immediately **after the FC modules** below them, and the end-wall periscopes just after the FC modules closer to them, **are**
✓	IoLaser **periscope length**	The IoLaser periscopes have to be **segmentable in parts smaller than ~2 m** in length.
✓	IoLaser periscopes and location system **warm survey**	The extremity of the periscopes and the LBLS must be part of a warm survey **at the end of installation.**
✓	**Proximity** of **laser box to power supply**	**7 m,** dictated by max length of umbilical provided by the laser manufacturer.
✓	LBLS **pin diode system HV safety**	The LBLS pin diode pads should be **close to the APA** to avoid high field regions and should be **attached to the FC support structure** using an appropriate **non-conductive material**.
✓	**LBLS pin diode** system **cable routing**	When routing the pin diode system cables from the bottom of the cryostat or FC structure to the top of the cryostat, care should be taken such that the **cables follow zero voltage** regions and are away from cold electronics.
✓	**LBLS mirrors positioning**	The LBLS mirror pads should be installed at a distance of **at least 40 cm away** from the **HV system support I-**

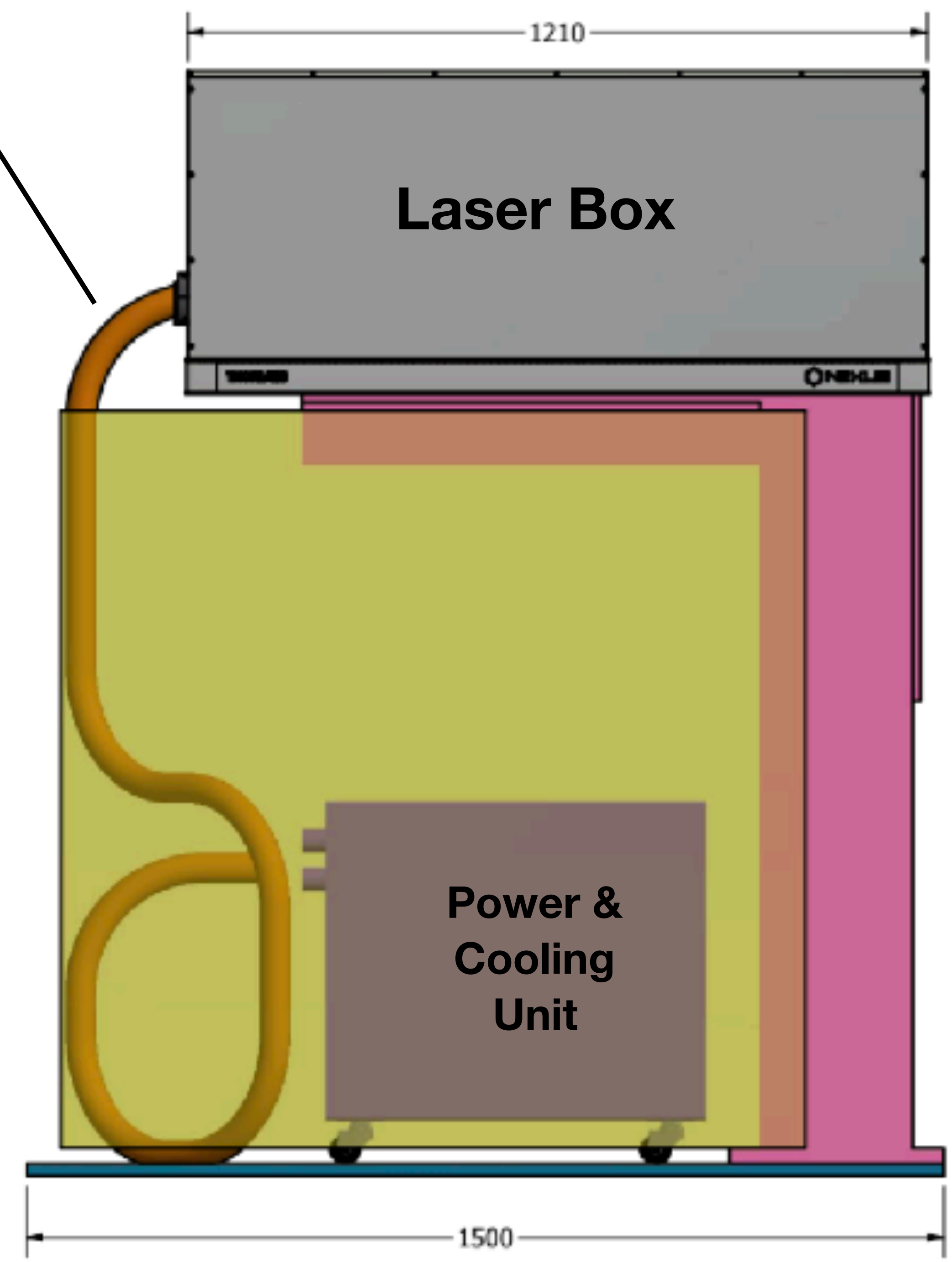


Laser periscope assembly segmented (~2m each) to address DUNE FD Installation requirements

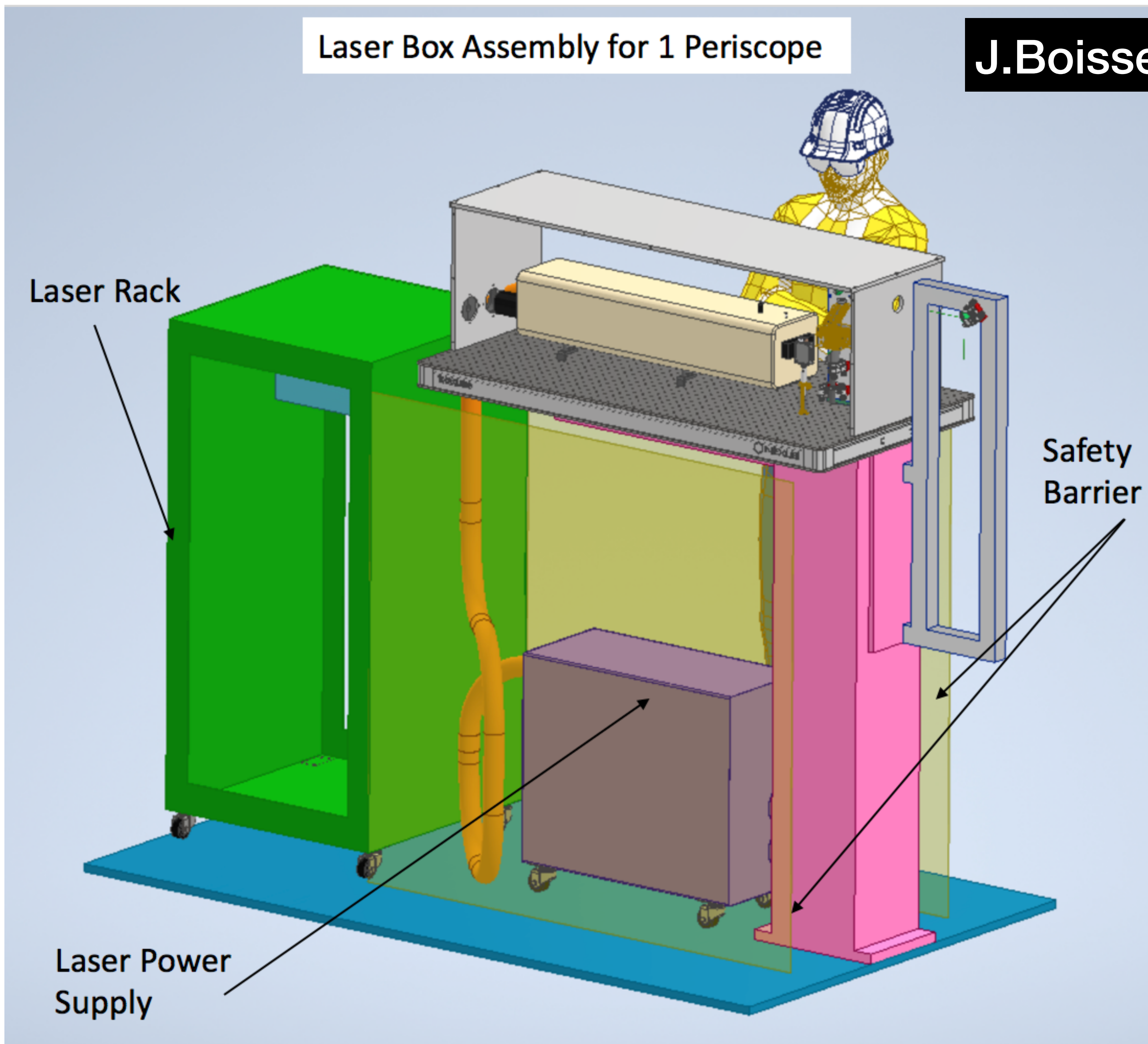
Proximity of Laser Box to Power & Cooling Unit

✓	**Proximity of laser box to power supply**	**7 m,** dictated by max length of umbilical provided by the laser manufacturer.

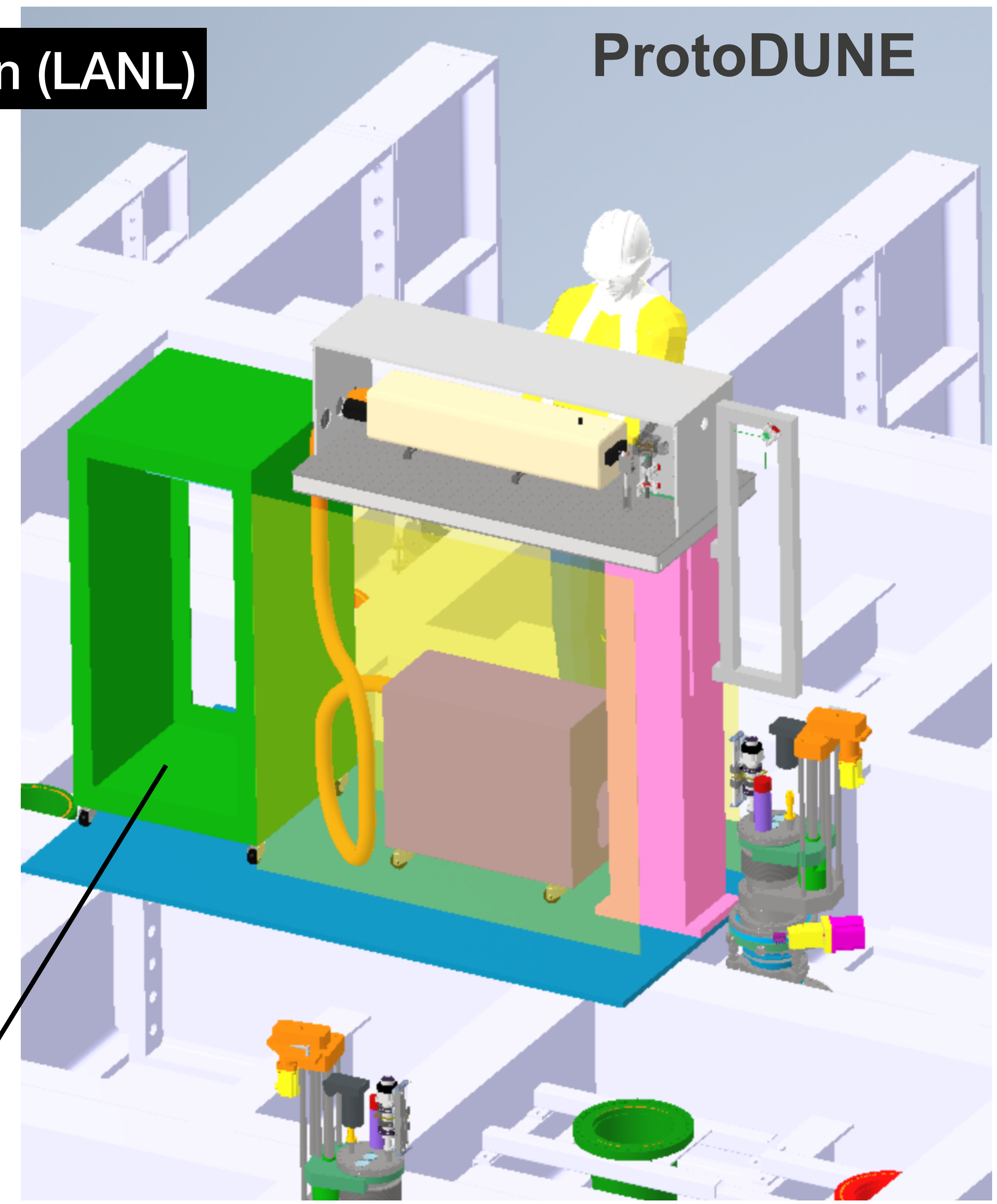
- This proximity requirement drives the arrangement of laser system on the cryostat
- They need to be within 7m of each other and located on the cryostat near the laser feedthrough
- Real estate space issues can be mitigated in some cases by sharing one laser between two periscopes
- This arrangement is linked to how we do the IoLaser grounding and shielding



Proposed Laser System Arrangement: One Periscope

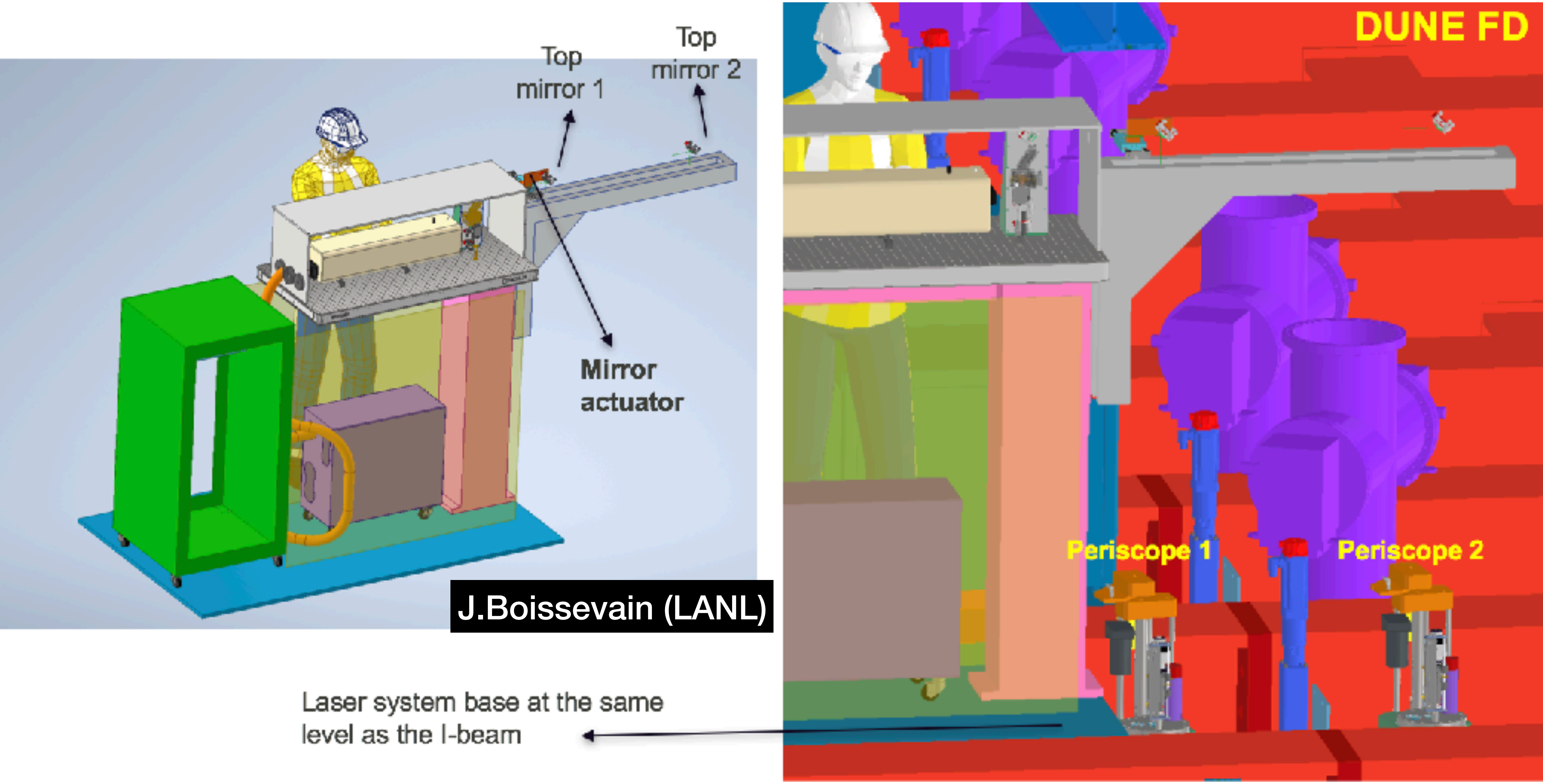


J.Boissevain (LANL)



This green laser electronics rack can be away from the box+power assembly if needed (no proximity constraints there)

One Laser for Two Periscopes Arrangement



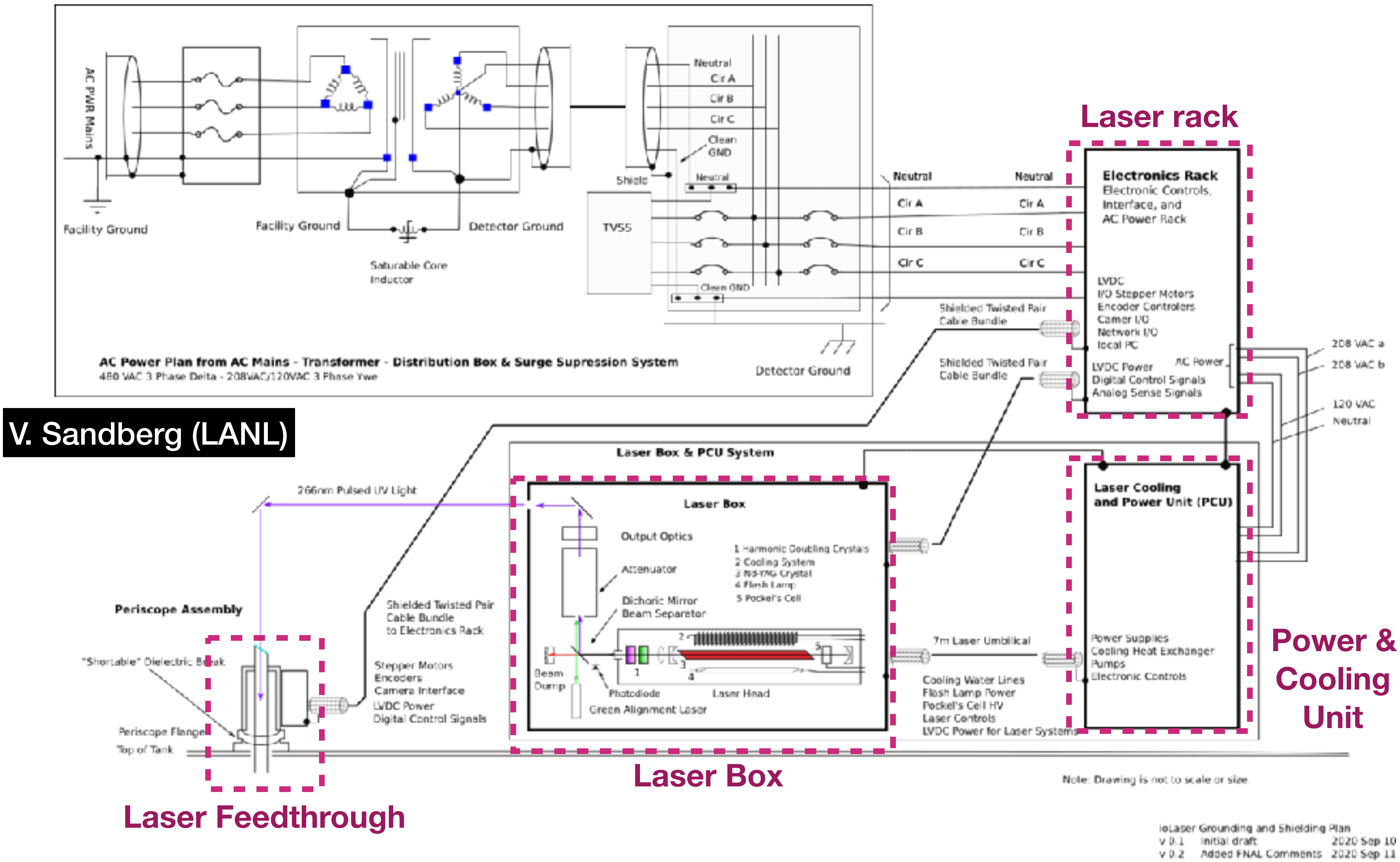
- How many lasers we can share with how many periscopes will be limited by the divergence of the beam;
- Detailed analysis is planned for this to be more economical in the #lasers used and to minimize installation issues

Grounding & Shielding

- In MicroBooNE, the laser is on building ground but this is not the recommended path for DUNE
- For ProtoDUNE/DUNE, the default plan is to put the system on detector ground
- Grounding tests are planned both at MicroBooNE and ProtoDUNE
  - At MicroBooNE, a proposal is underway to switch the grounding to detector and assess impact on noise on data (**LANL postdoc R. Fine** with Fermilab electrical engineering team and Bern team will lead the test)
  - At ProtoDUNE, we will test different grounding scenarios (including the need for a dielectric break at the flange)
- Regular meetings with DUNE Grounding & Shielding task force on this. Documentation being prepared
- LANL will work closely with S. Chappa and A. Ghosh of Fermilab on this for MicroBooNE, ProtoDUNE and DUNE tests

(More in V. Sandberg's Grounding talk)

Electrical Connection Diagram



Requirements: Consortium-held, Safety

Name	Primary Text
✓ **Periscope clearance from FC edges**	The laser periscope design should include **cameras** as a way **to visually inspect and confirm clearance** of the periscope from FC edges during installation and commissioning.
✓ **Laser and Laser beam enclosure**	Per class-IV laser safety requirements, the laser and the laser beam are **fully enclosed** in a **metal box** and **metal tube all along its path**, respectively. Metal enclosure is needed in order to fully contain the intesity of the laser used.
✓ **Laser training and PPE**	The laser alignment, operation and maintenance tasks can only be done by personnel who are fully trained for handling **class-IV UV lasers**. Aprropriate class-IV safety rated PPE (e.g. eye glasses, gloves) should be worn all the time when handling the laser.
Laser alignment	For each periscope, dedicated time is required to align the UV (Class 4) laser with the corresponding low power visible laser, with **Class 4 laser safety restrictions in the UG cavern**. This is needed not just for commisioning of the laser systems but for any eventual alignments or adjustiments needed throughout the life of the experiment.
Laser maintenance	Any work that requires opening the laser box (e.g. for alignment, optical component adjustments) resulting in exposing the laser will need to be **performed inside a class-IV safety rated laser enclosure** for the particular laser used and any laser beams from the laser should be fully enclosed by the enclosure.
Laser storage and handling	When not in use, the laser needs to be safety and securely stored away such that it is **not accessible to non-experts.** Manufacturer specfiied environment conditions should be met during storage. A **physical key**, only in the possession of laser experts, should be required to power the laser.

- Class-IV laser safety applies during assembly, installation, alignment and maintenance operations (e.g. laser power & cooling unit needs maintenance once a year)
- Powering up the laser itself will be a class-IV operation

Guidance from laser experts at CERN (ProtoDUNE) and SURF/Fermilab (DUNE) needed to develop and document procedures and ensure safe facilities

Requirements: Consortium-held, Fabrication/ Assembly/ Transportation

Name	Primary Text
Leak rate	The laser periscope flange seals to the cryostat should be **leak checked** according **to required specifications** to avoid leaks into the cryostat.
IoLaser pre-assembly	In order to **minimize installation and assembly time UG**, all componennts of the laser system that can be preassembled will be done either at the SURF surface facility or at collaborating institutes.
Laser **periscope pre-assembly**	Laser periscope will be partially assembled and shipped to SURF and the final assembly will take place UG. **All components except the periscope segments can be preassembled before arrival to SURF.**
Laser **periscope final assembly**	Given the long length of the periscope (~3.5 m), the final assembly will take place **in a clean room UG prior to installation.**
Laser Box pre-assembly	The laser box preassembly can only be done partially before being shipped to SURF and the **final assembly will be done UG**. This is to avoid damage to the components during transportation.

Name	Primary Text
Optical components transportation	Optical components of the periscope and laser box shall be transported UG before final assembly, with **appropriate packing precautions to avoid bending, breaking, scratching or other damage** during transportation (e.g. due to vibration) to SURF and to the UG cavern.

- Final assembly of the laser box (delicate optics) and periscope (long length) will happen in the UG cavern
- A clean room will be needed for periscope assembly
- A laser safe (class-IV) area will be needed for laser box final assembly

IoLaser Design Progress Summary

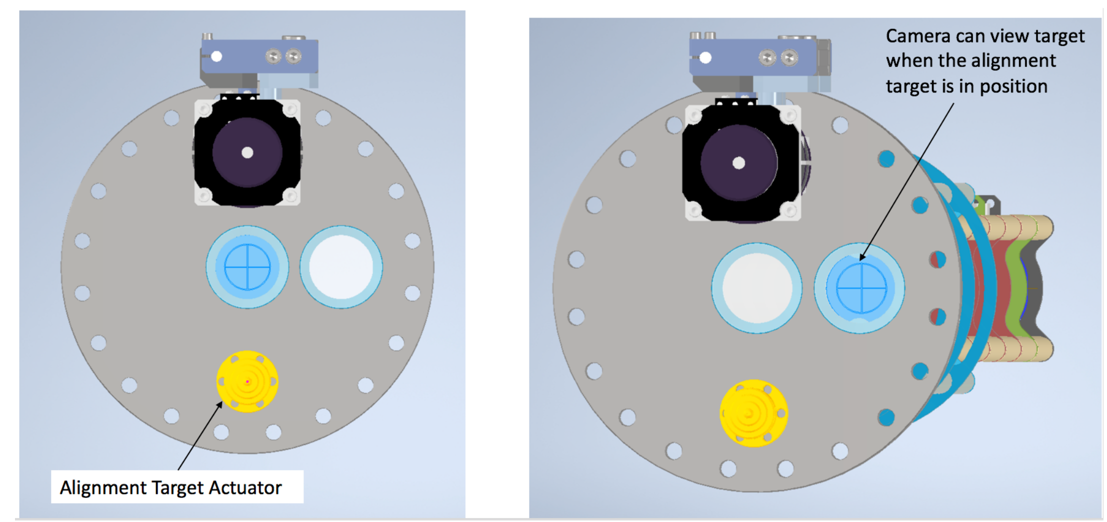
(more details in the next talks)

✓ Electrical break for the periscope

✓ Use large bottom mirrors for increased coverage and viewing

✓ Laser Alignment features

- Movable alignment target
- Two view ports (for camera, PMT)



✓ Periscope split design (two 1.5 m sections)

- Mitigates installation issues for the FD

✓ Value engineering

- Replace chimney side from Torlon to Steel
- Replace Torlon with Peek for the periscope support structure on the cold side (needs testing to finalize)

✓ Inclinometers & testing at ProtoDUNE-I

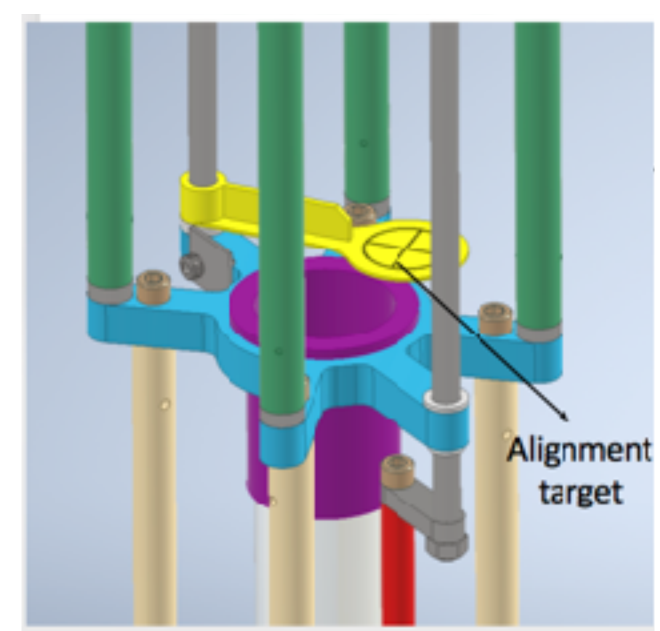
✓ Component selection & Procurement

- Vendors identified for most parts, quotes in hand, procurement has started

✓ Laser arrangement on the cryostat for ProtoDUNE and DUNE FD

✓ Laser rack, electrical and grounding interfaces

✓ IoLaser integration into ProtoDUNE-II model

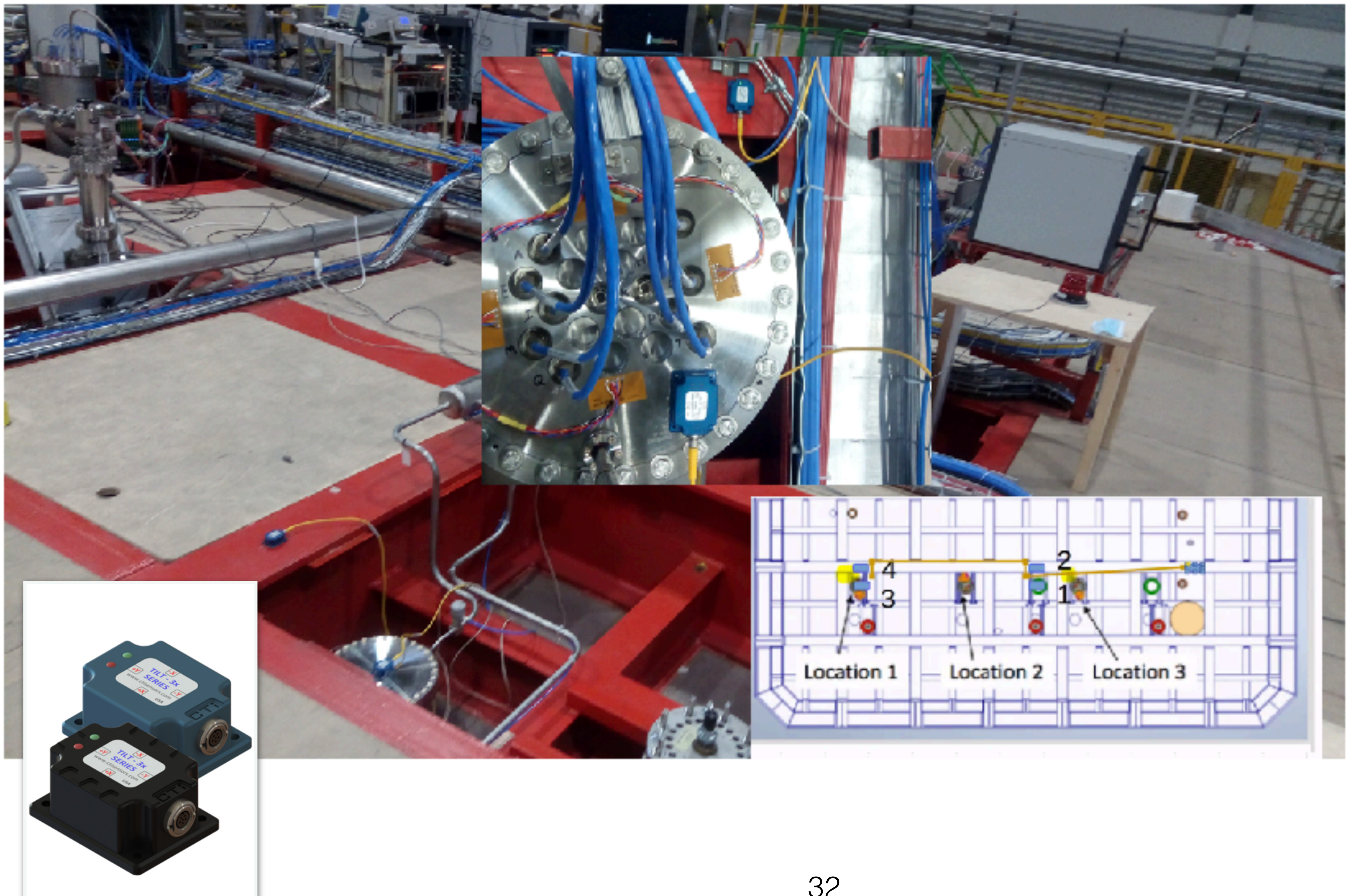


(More in J. Maneira & V. Sandberg's talks)

Inclinometers on ProtoDUNE-I

M. Fani (LANL)

- 4 inclinometers + interface hardware sent to CERN in July from LANL; Interface developed by KSU



Installed in ProtoDUNE-I on 15 July, a week before ProtoDUNE-I shut down

Thanks to Francesco and CERN team for their help

For more details, see Mattia's talk: https://indico.fnal.gov/event/44663/

Component Selection & Procurement Status at LANL & LIP

Ionization Laser System

- **Items Procured**
  - Surelite I-10 Laser (custom 7m umbilical) safely arrived in July! ~$43k
- **Orders placed**
  - A second laser (same configuration) also purchased with LANL funds for use at LANL ($39k) – arrives this FY
  - 1 Watt Pilot Attenuator ($1350), arrives in Oct. 2020
  - 2 Thermionics RNN 600 rotary stages ($20k total), order being placed, 14 weeks lead time
    - One set will be sent to LIP for software development
  - EPC A58HB absolute encoder (<$500), order will be placed soon
    - LIP will also purchase one for tests at LIP
- **Currently working on**
  - Selections for the RNN 600 rotary stage motor controller (to go with the encoder selection above)
  - Finalizing the linear translation stage selection (see next slide)
  - Will procure the ceramic electrical break soon (~$2k total with welding ; higher for end-wall system)

- **LBLS mirror pads:** LIP has procured mirrors and fabricated a prototype mirror system; soon to be tested at LIP

Fabrication & Assembly Plans

- A lot of the parts of the IoLaser are off the shelf with specs met by the manufacturer (will be verified as part of QC) 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.
- Fabrication will largely be carried out by LANL (probably sub-contracted to keep costs down e.g. Drake Plastics)
- Smaller scale fabrication will also take place at collaborating institutes such as LIP (Portugal), Hawaii — currently exploring what expertise and resources are available
- While some pre-assembly will happen at collaborating institutes (LIP, Hawaii), final, full scale assembly and testing will happen at LANL with collaborators traveling to LANL to participate in the activities (COVID-19 may impact this)

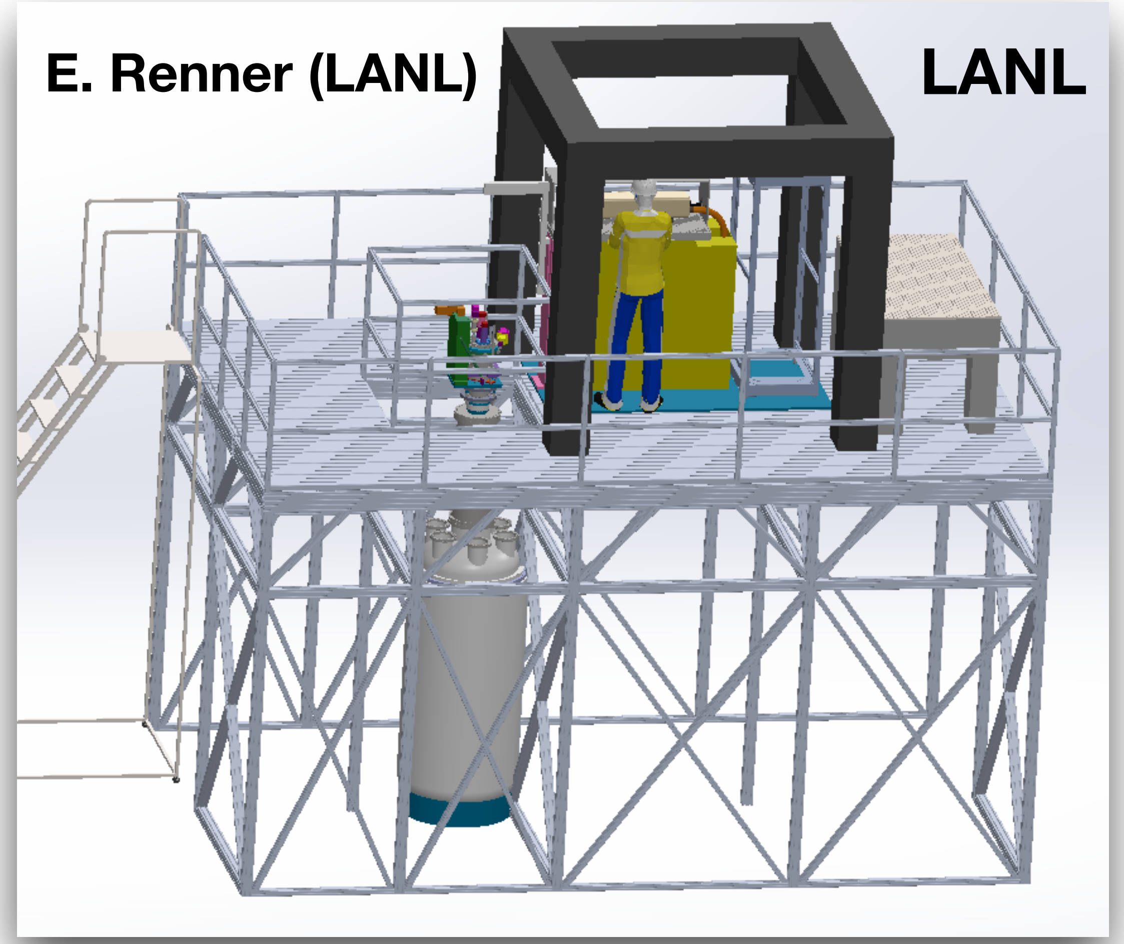
More in Gollapinni's talk (Thursday)

QA/QC Plans

- 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, installation, alignment, operation, interfaces with DAQ, slow controls and analysis, among others
- QC Plans include both component and full system tests at LANL & Collaborating institutes
    - Laser and Laser Box tests
    - Laser feedthrough & periscope tests
    - Full scale tests in air & LAr

LANL

- Two lab spaces are currently being setup: a laser lab and a cryogenics testing platform
- Laser lab will be finished this FY; operational from Oct. 2020
- Cryogenics platform final stages of design & review; goal to have this ready by early next year
- Will allow both component & full scale testing



LIP

- Test rotary stages & encoder precision
- Leak rate tests
- Software interfaces, DAQ & Slow Controls
- LBLS mirror system testing

Hawaii: test LBLS pin diode system & characterize

KSU: Camera & inclinometer component testing

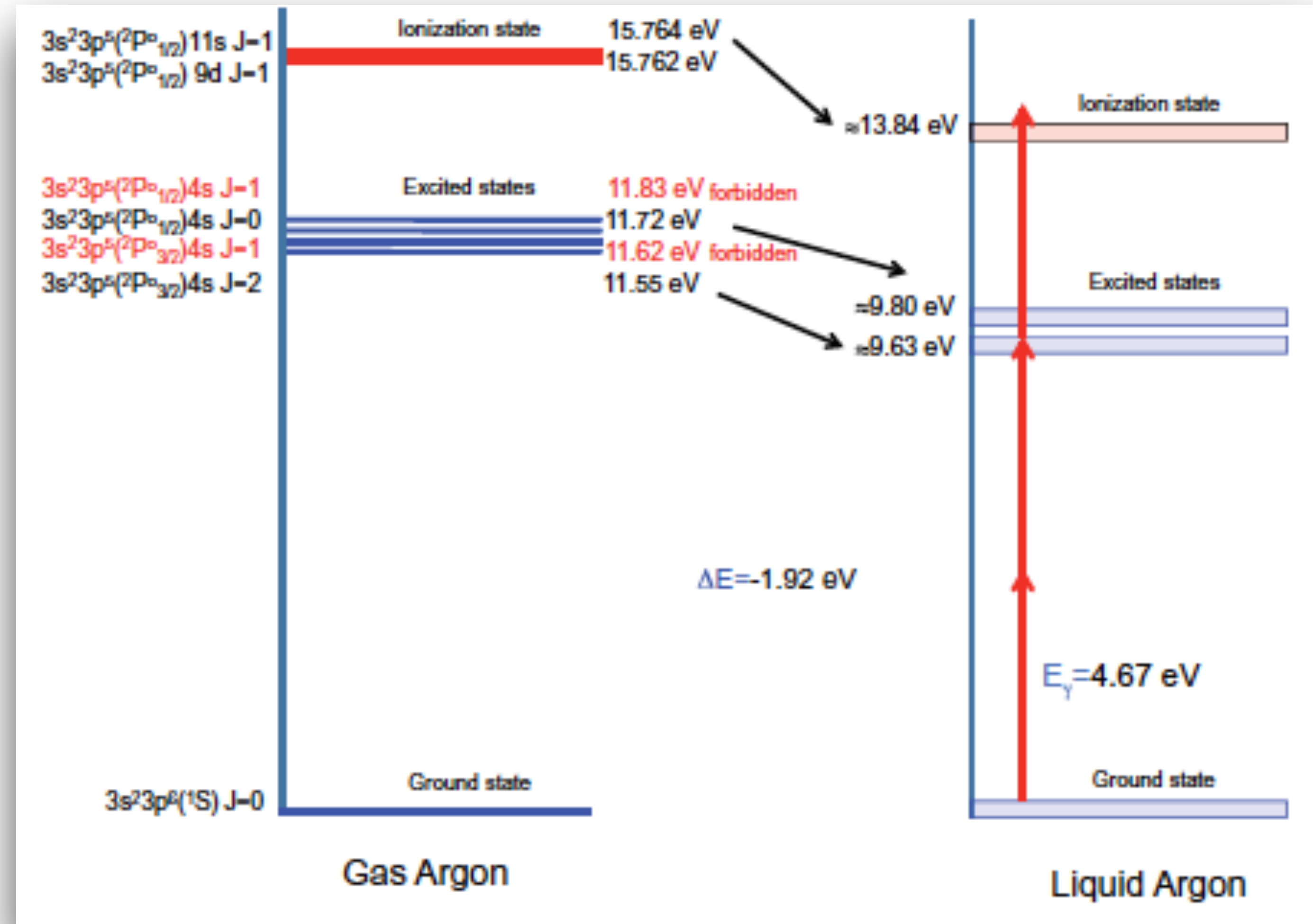
Summary

- IoLaser and LBLS designs have progressed significantly in the last few months (detailed drawings and CAD models in EDMS)
- Current designs address the requirements
- Recent focus on interfaces and integration (electrical, grounding, mechanical arrangement on the cryostat etc.)
- QA/QC plans being defined and lab spaces being established at LANL and collaborating institutes to meet ProtoDUNE timeline
- Component selection and procurement has started (early start due to long lead times due to COVID-19)
- The IoLaser+LBLS team is continuing to grow

BACKUP

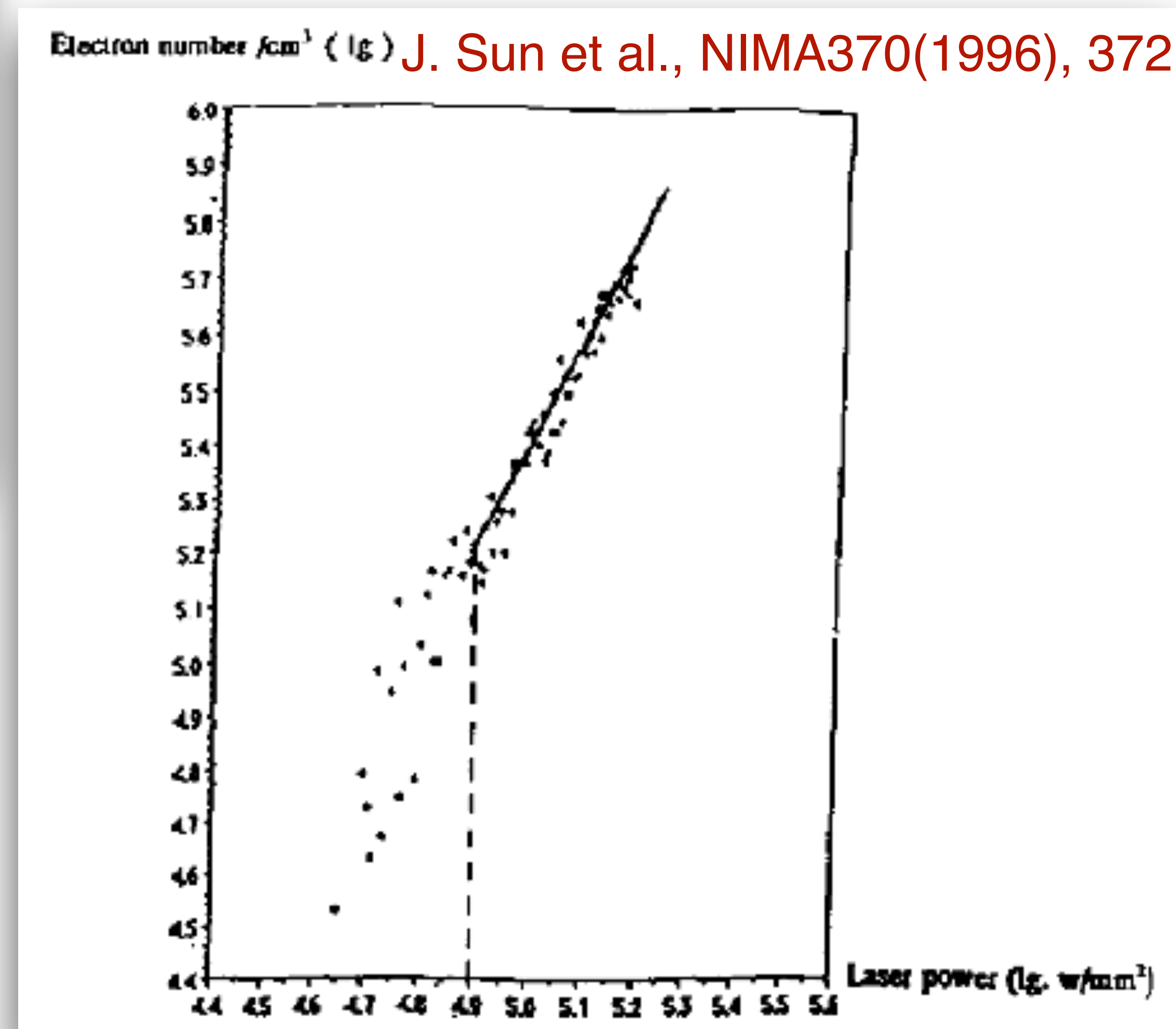
Laser Ionization of LAr

I. Badhrees et al., New J. Phys. 12 (2010) 113024



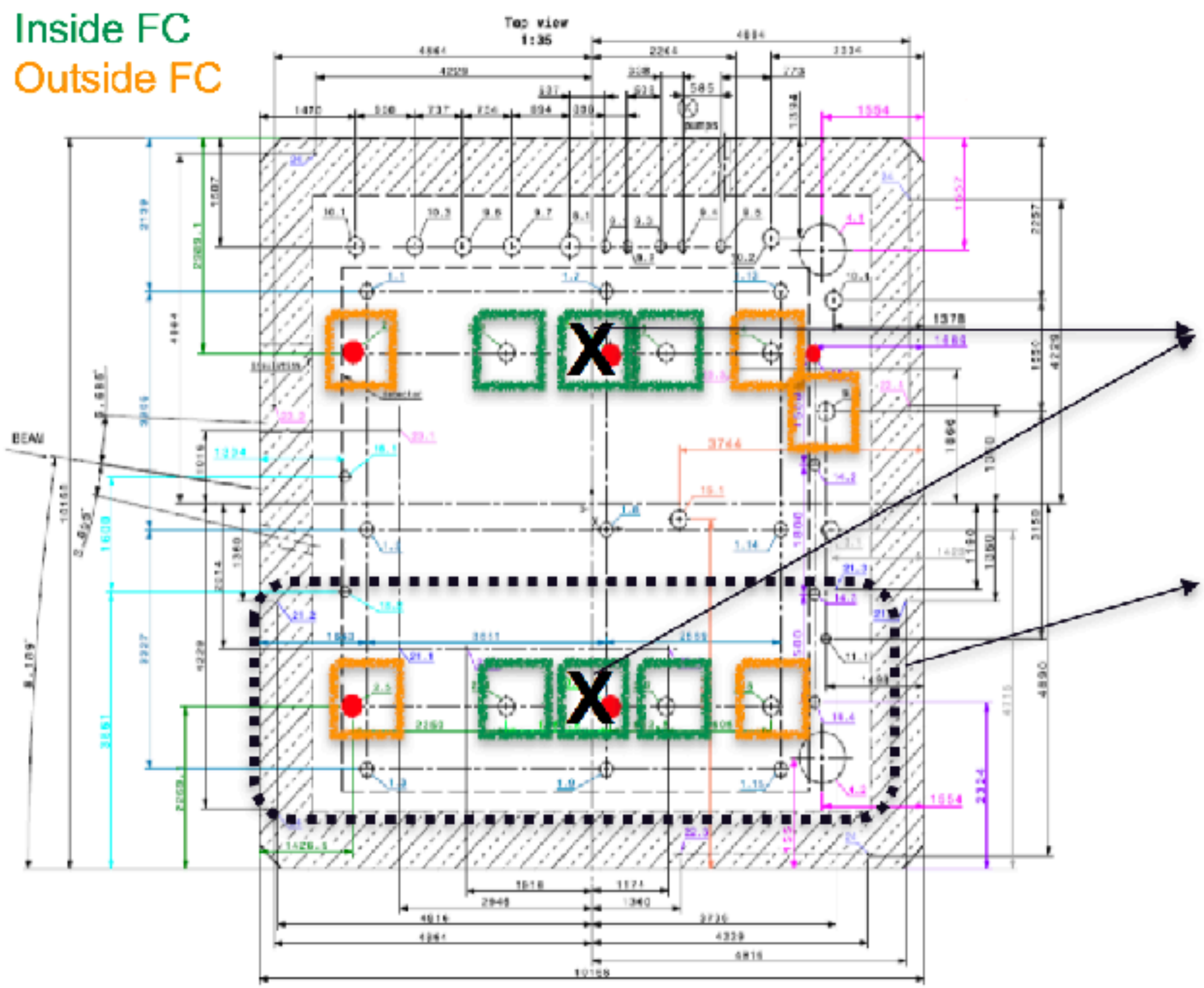
- 266 nm (4.67 eV) laser light can ionize argon through 2-photon excitation followed by single-photon ionization
- electron yield goes with the square of photon intensity (in typical regime)

J. Sun et al., NIMA370(1996), 372



- Possible to get a few x MIP signal with tens of mJ pulses

ProtoDUNE-II: Desirable Ports for Laser



These two currently have collisions with FC I-beams

This drift volume preferred since beam is in this volume

- Baseline laser in either internal port
- Endwall laser in either external port

Working with HV consortium on FC penetrations for these locations — no issues foreseen; need to make a detailed plan

ProtoDUNE II Desirable ports for Laser