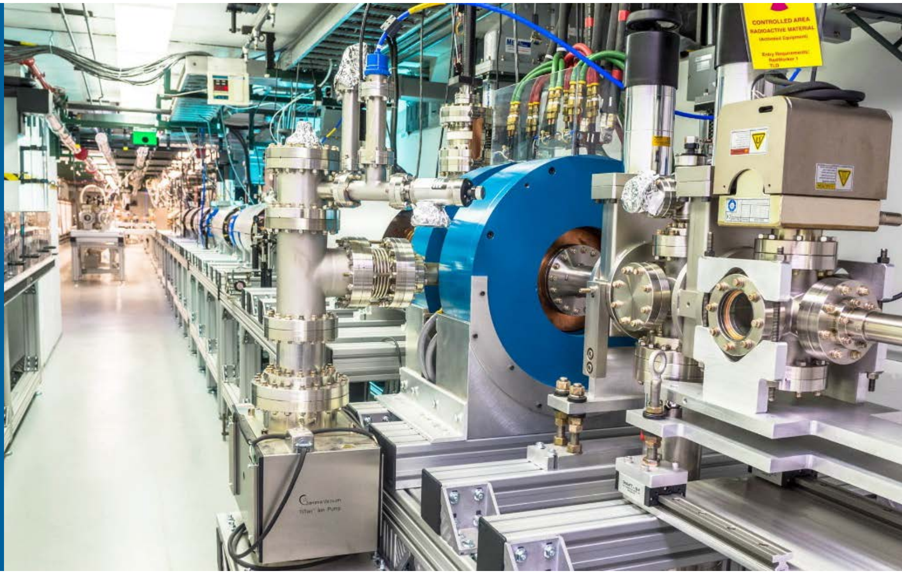
The Argonne Wakefield Accelerator (AWA) is a premier electron accelerator with the world's highest bunch charge to carry out fundamental accelerator research with an emphasis on wakefield acceleration.

HEP INDEPENDENT SAFETY REVIEW ARGONNE WAKEFIELD ACCELERATOR (AWA) OVERVIEW

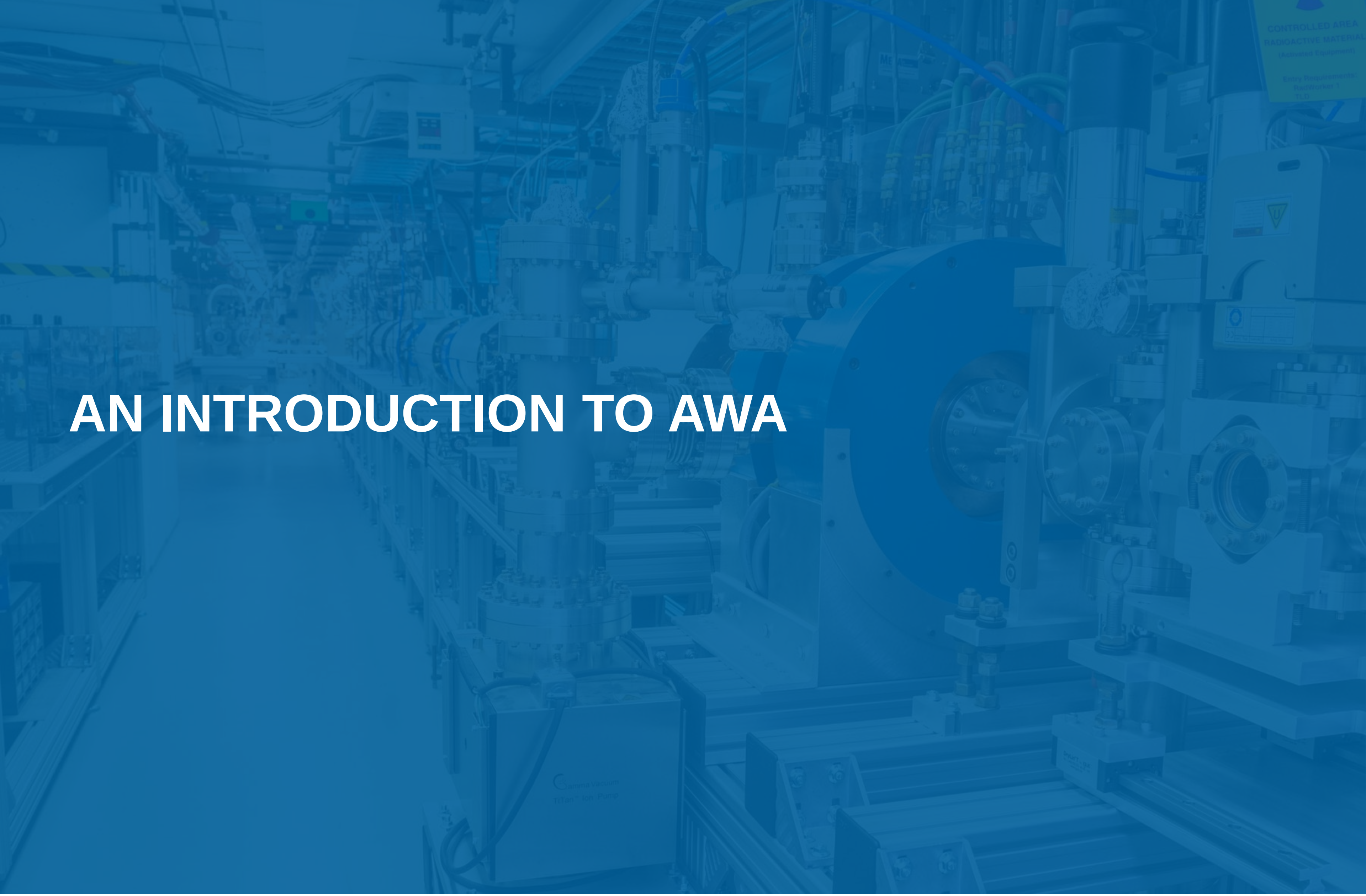


SCOTT DORAN
Mechanical Design and Eng.
AWA Operations and Support

www.anl.gov/awa

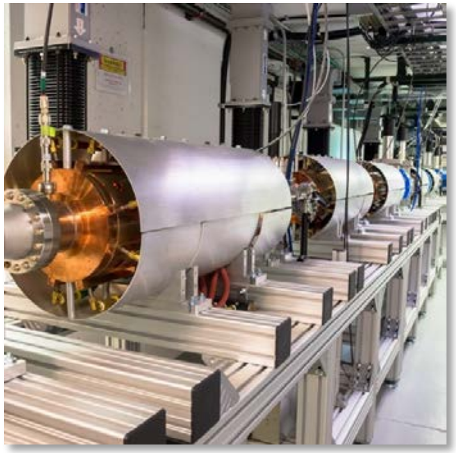
HEP Independent Safety Review
September 24-25, 2018
Argonne, IL

AN INTRODUCTION TO AWA



HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Introduction



AWA ACCELERATING CAVITIES

AWA ACCELERATING STRUCTURE

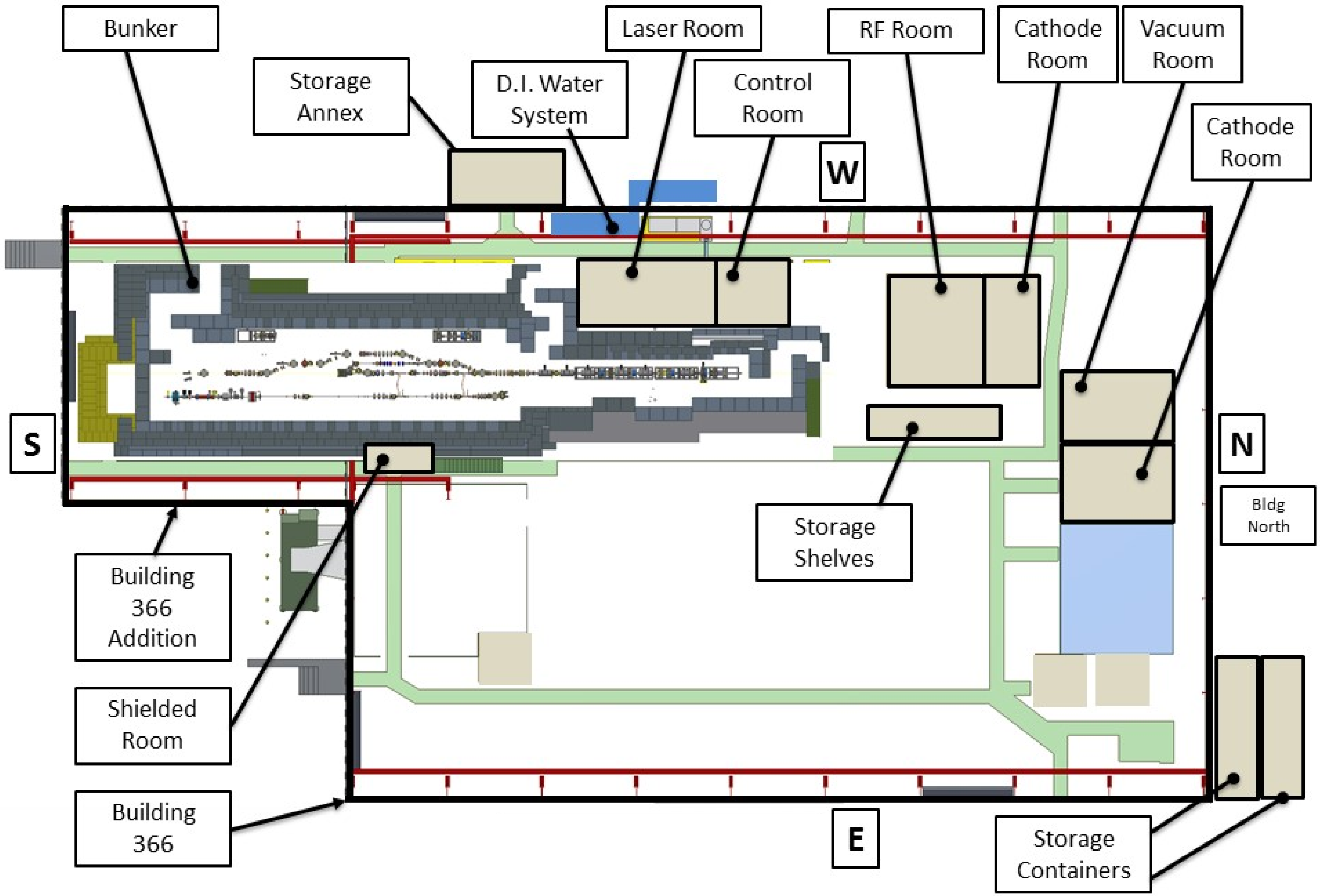
AWA MULTI LENS ARRAY (MLA)

AWA EXPERIMENTAL AREA

- AWA uses both solid state (dielectric and metallic) and plasma to perform electron beam driven acceleration.
- This technique generates acceleration from bunches of electrons.
- The leading bunches create a powerful wave (wakefield) in the media, the trailing bunches ride this wave and gain energy.
- There are practical limits to building longer an more expensive conventional accelerators.
- AWA produces an accelerating gradient that is many times stronger than conventional accelerators at shorter distances.
- AWA is unique. At places like APS users experiment with x-rays, at AWA the accelerator <u>is</u> the experiment.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Building 366 Overview



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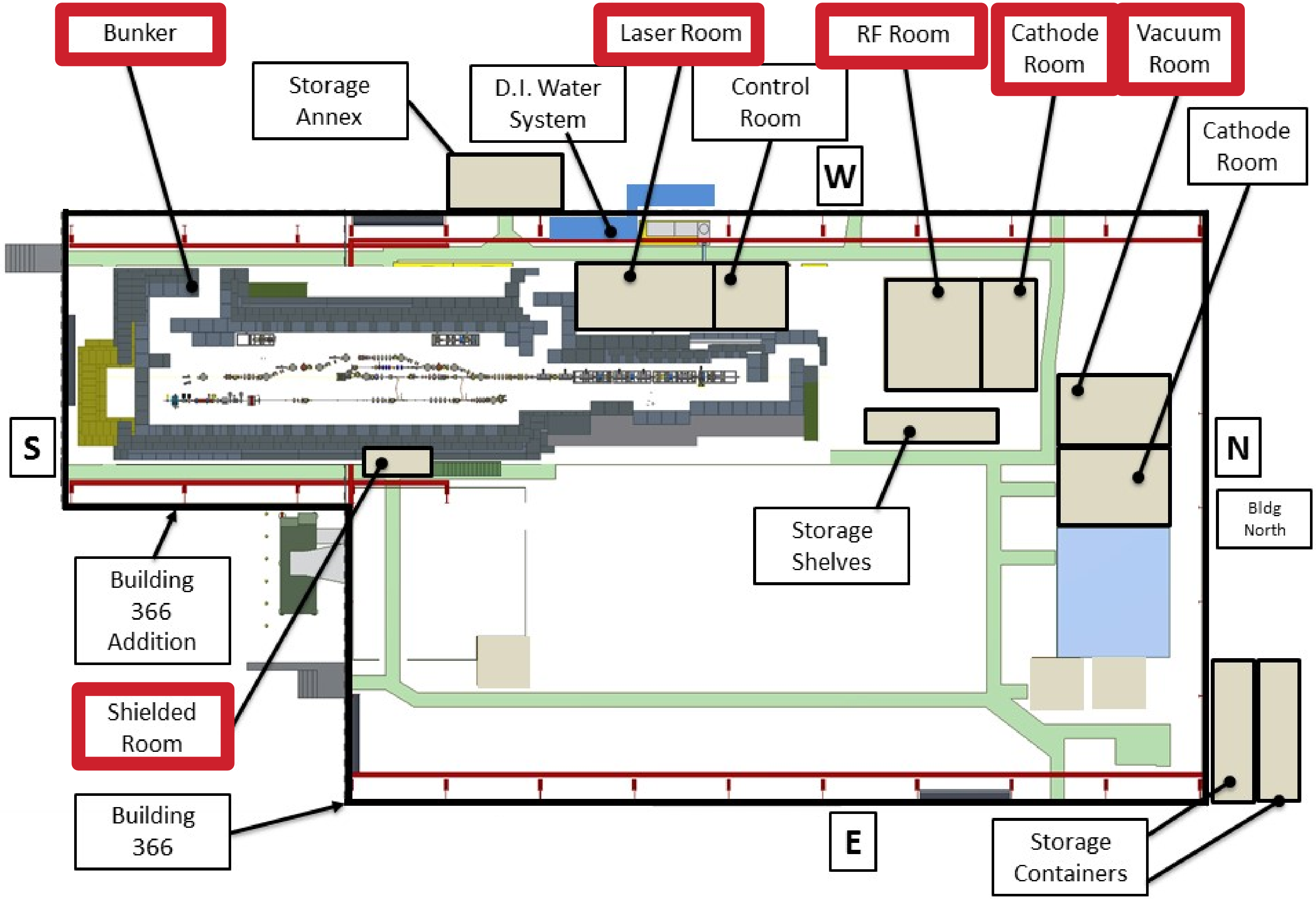
AWA OVERVIEW

AWA Controlled Access Rooms



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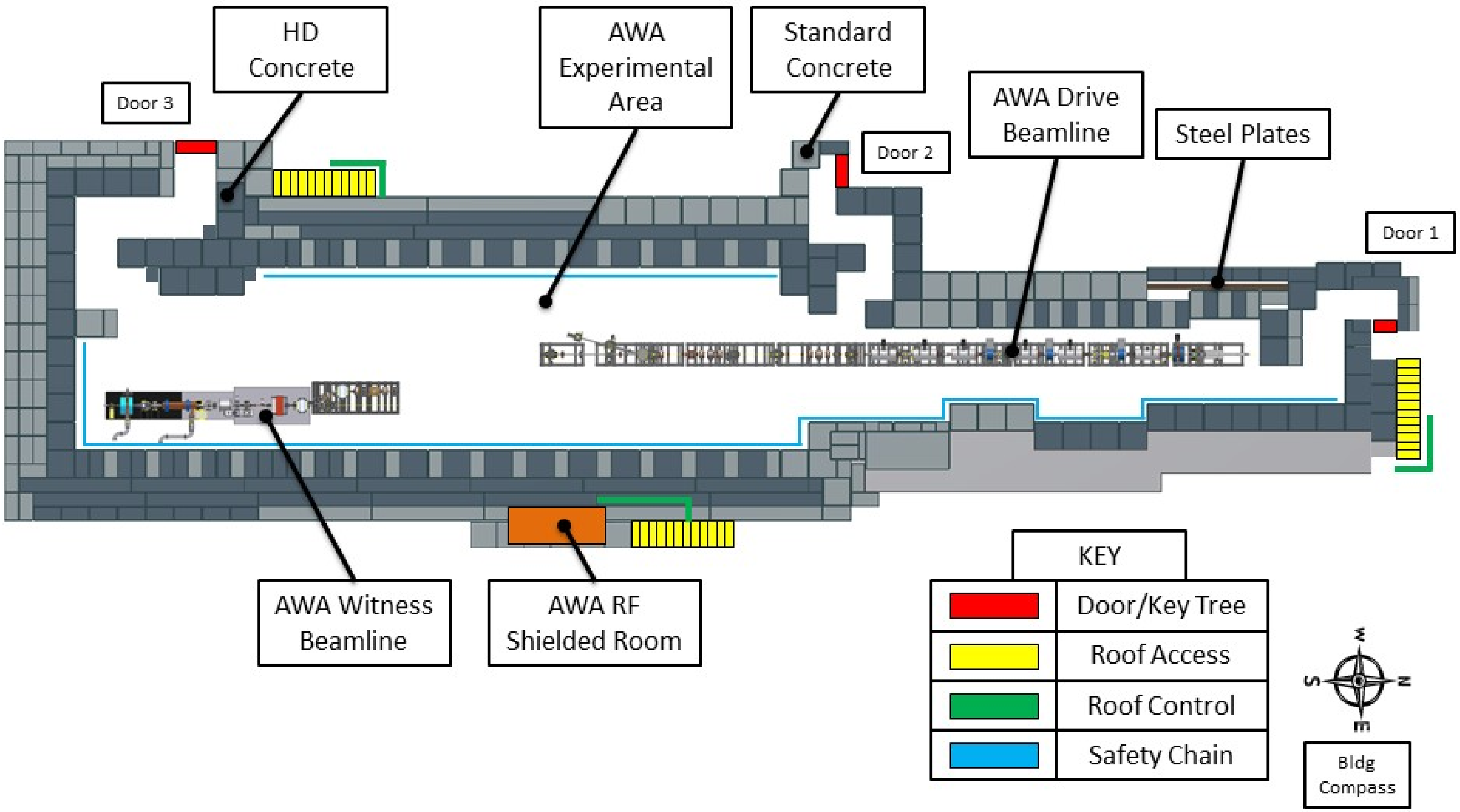
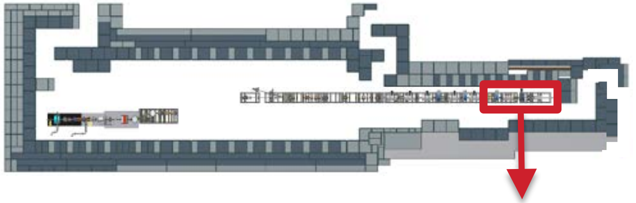
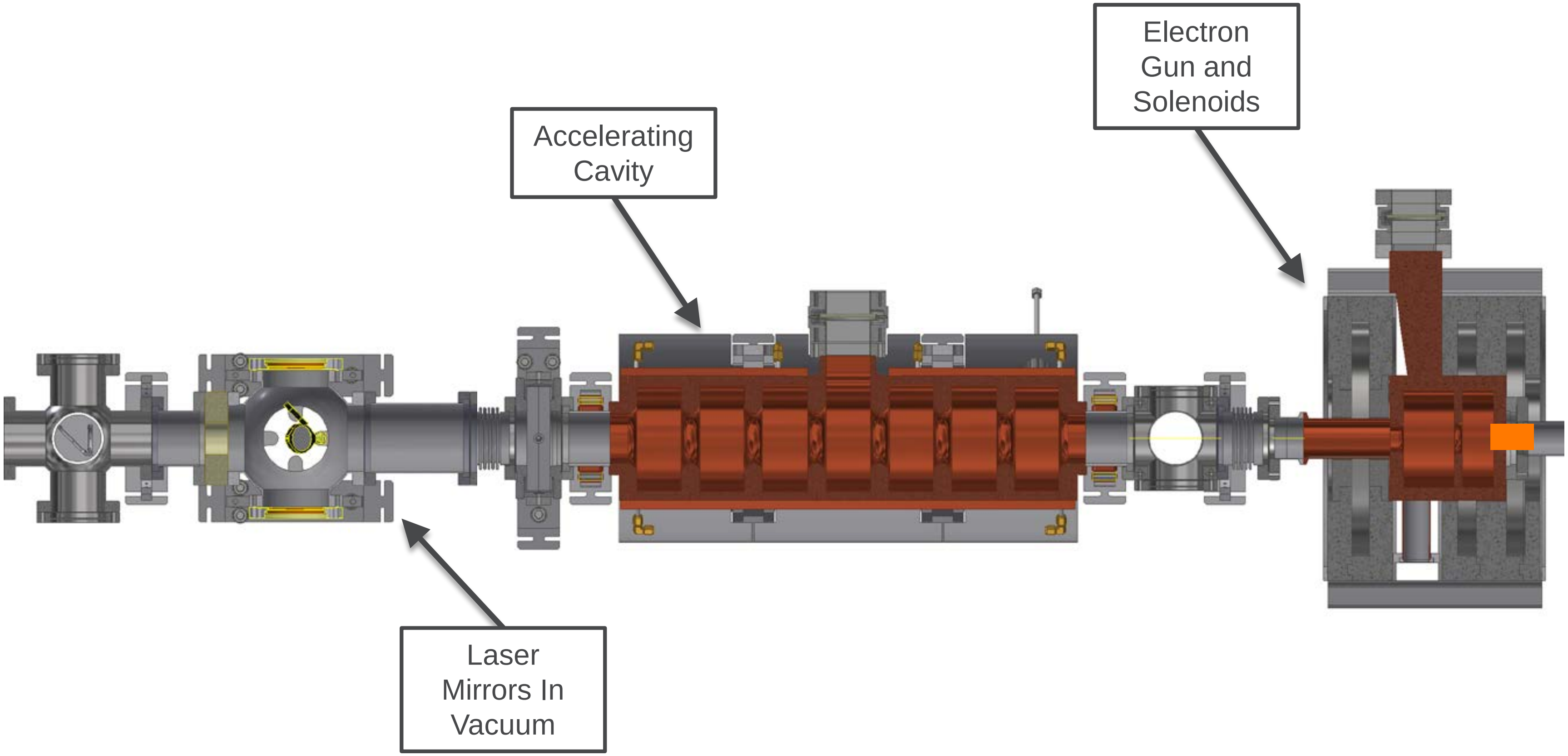
AWA OVERVIEW

AWA Bunker Overview



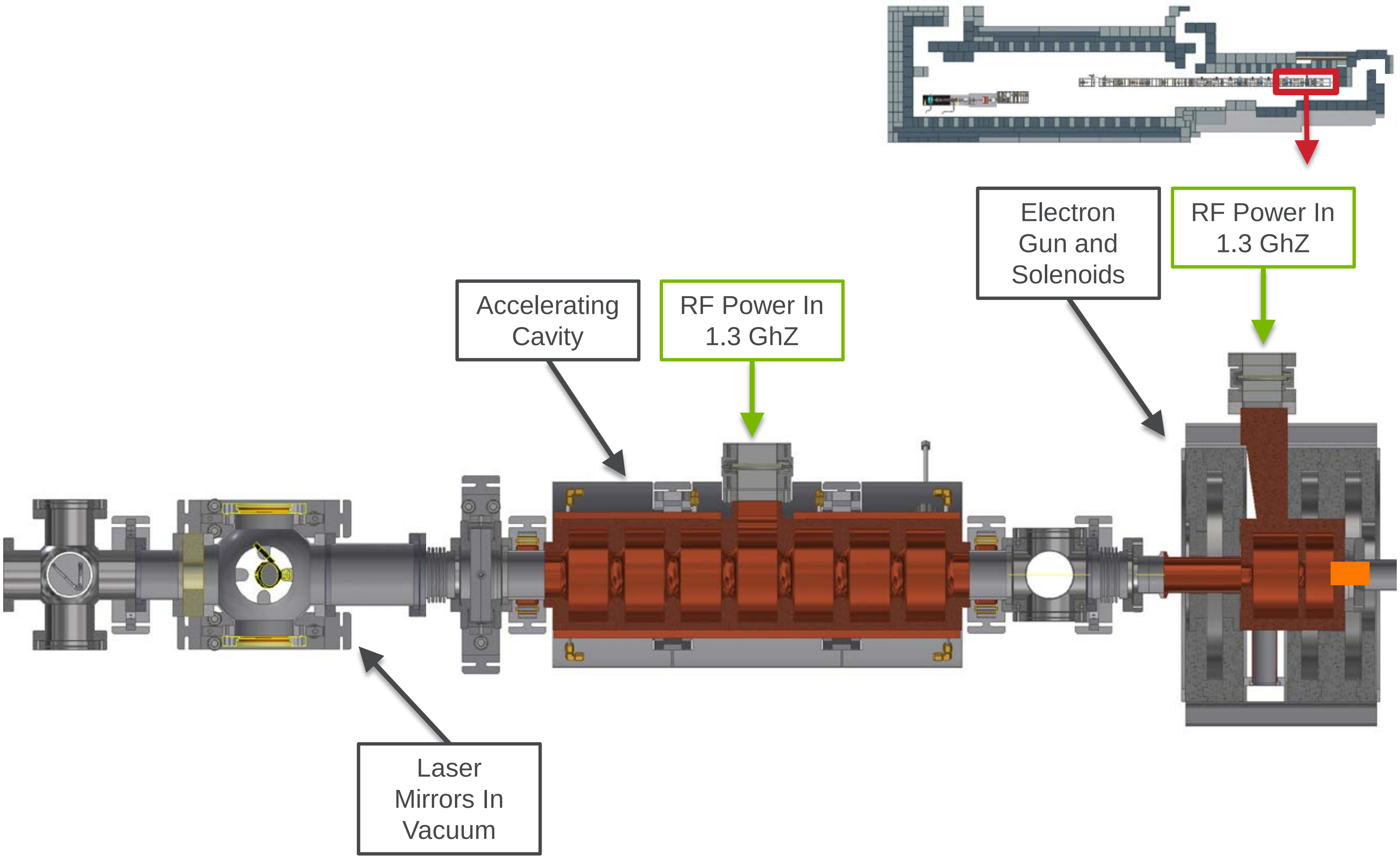
AWA Electron Beam Generation Schematic





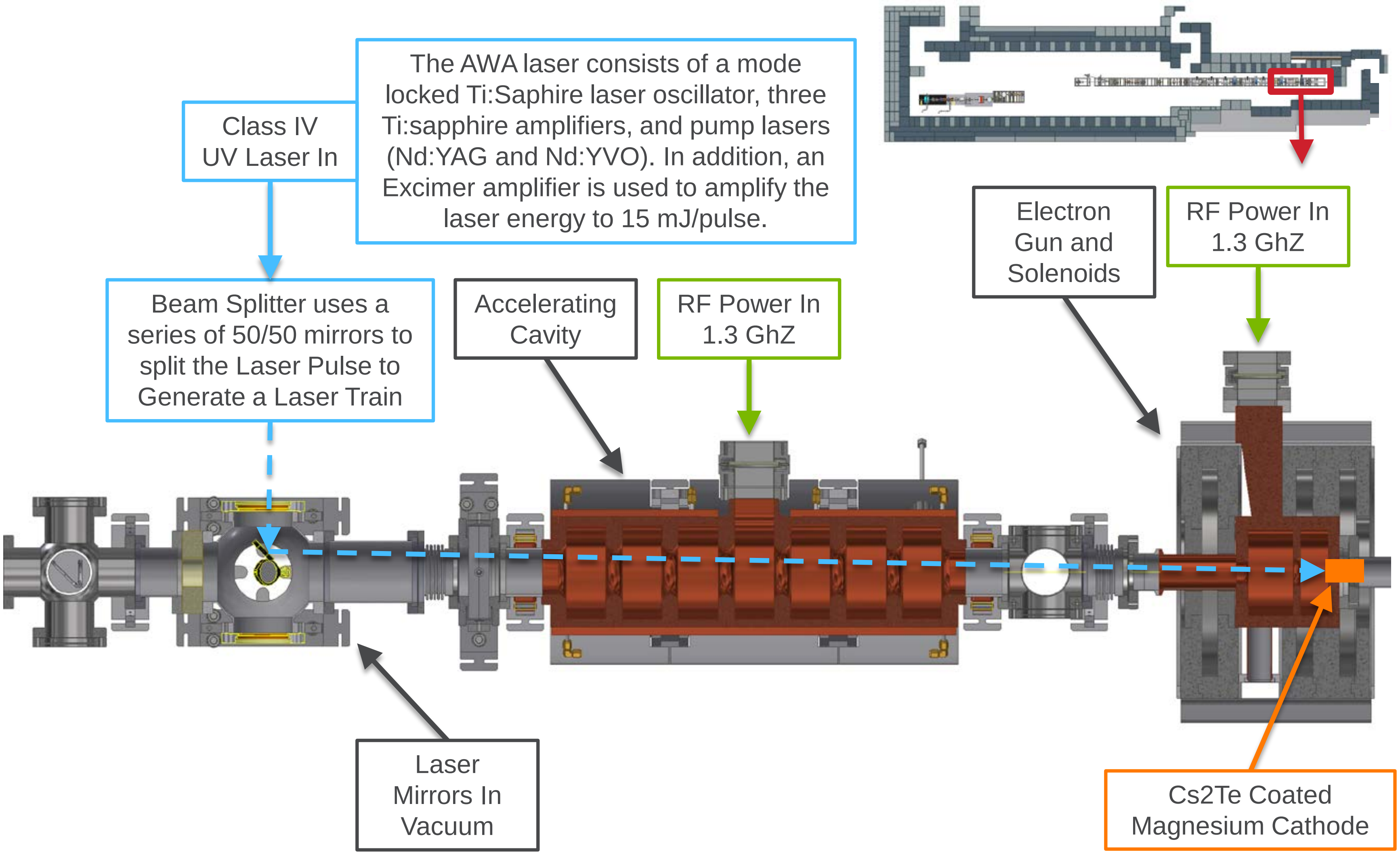
HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Electron Beam Generation Schematic



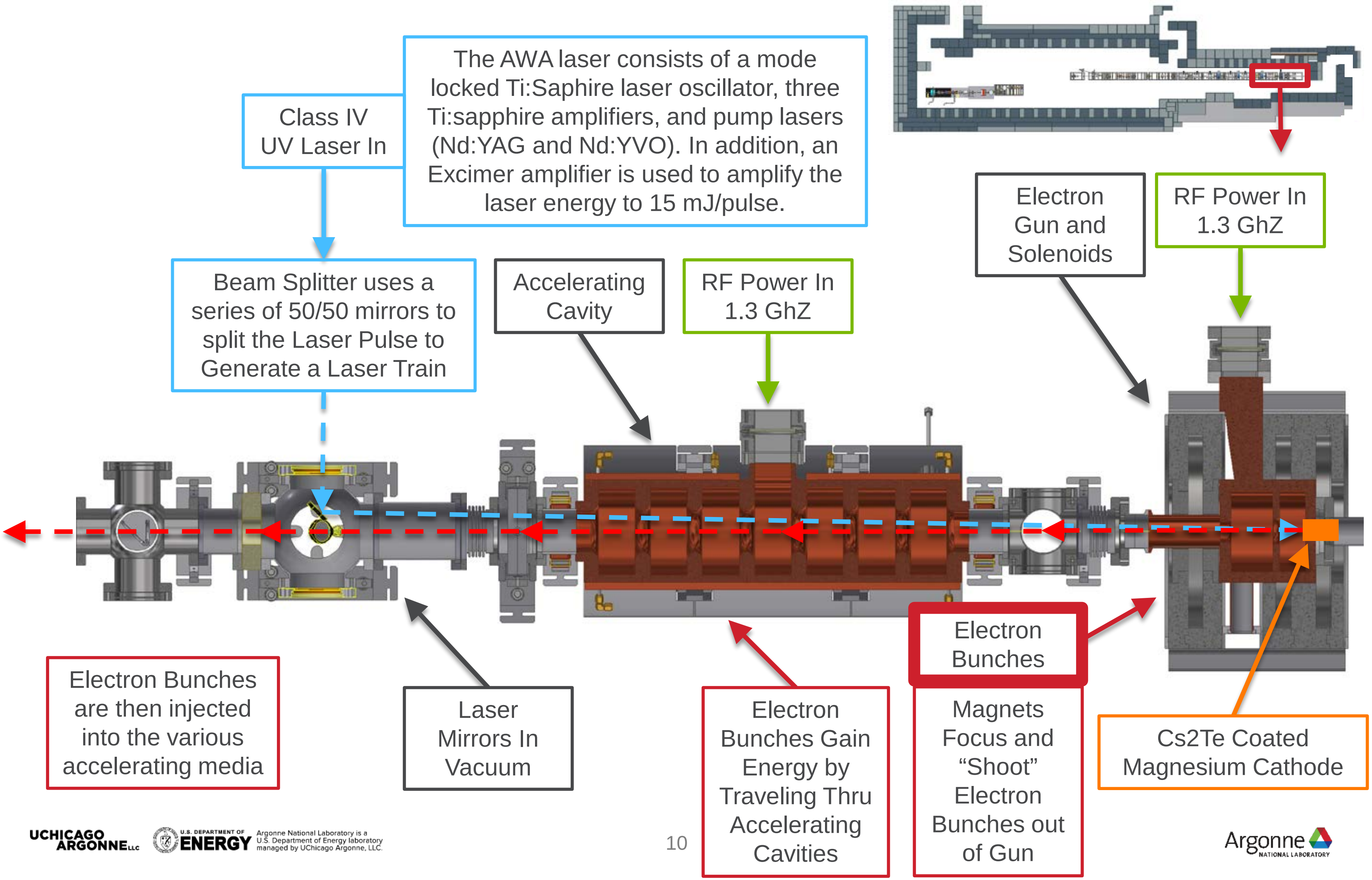
HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Electron Beam Generation Schematic



HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

AWA Electron Beam Generation Schematic



AWA SAFETY CONTROL DOCUMENTATION

HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

AWA and Argonne's Accelerator Safety Review Committee

ASRC MEMBERSHIP

- Manoel Conde, AWA Group Leader, is a member of the Argonne Accelerator Safety Review Committee (ASRC)
- The committee reports to the Deputy Laboratory Director for Operations through the Director, Environment, Safety and Quality Assurance.
- It's purpose is to act in an advisory capacity to support implementation of the Laboratory's accelerator safety program.

ASRC RESPONSIBILITIES

Some responsibilities include:

- Conduct triennial reviews of all accelerator facilities listed in LMS PROC-188, Accelerator Safety.
- Advise the Environment, Safety, and Quality Assurance Division (ESQ) director in the development of new or revised accelerator safety requirements.
- Provide requested technical expertise in interpretation of DOE accelerator safety directives and evaluation of proposed solutions for accelerator safety issues.

- AWA documentation and procedures have been reviewed by ASRC.

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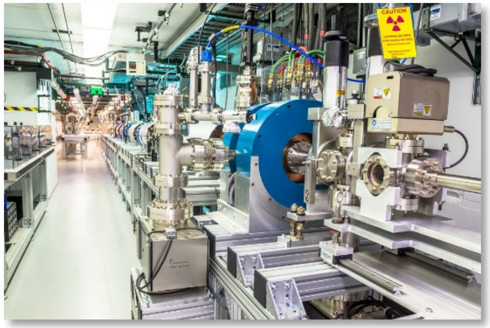
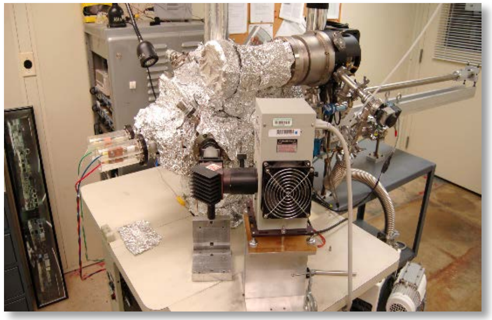
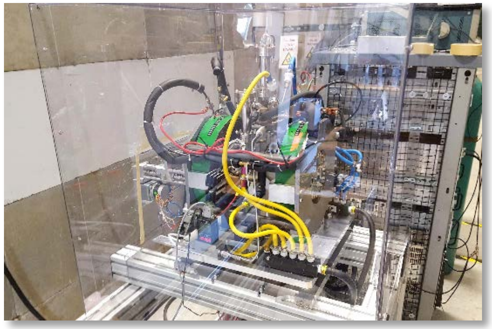
AWA OVERVIEW

AWA Safety Control Documents

In order to accomplish our experimental goals safely, AWA operates under several safety control documents.

- Work Control Document (WCD)# 27979 Commissioning and Operation of the AWA Accelerators
  - Contains Several Documents Within
    - Safety Assessment Document (SAD)
    - Radiological Considerations
    - Bunker Access Control Procedure
- Work Control Document (WCD)# 50518
  - AWA Photocathode Deposition
- Work Control Document (WCD)# 55954
  - AWA/UCLA Plasma Source
- Work Control Document (WCD)# 44654.0
  - Personnel Task-based Hazard Analysis
- Work Control Document (WCD)# 44654.1 (draft)
  - Personnel Task-based Hazard Analysis

HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

AWA Safety Assessment Document (SAD)

Safety Assessment Document (SAD) describes the contents and operations of the various AWA spaces and systems

- Bunker and Accelerators
- Control room
- Laser room
- Lab space
- RF System
- Sulfur Hexafluoride
- Deionized water
- Bunker roof
- Shielded room

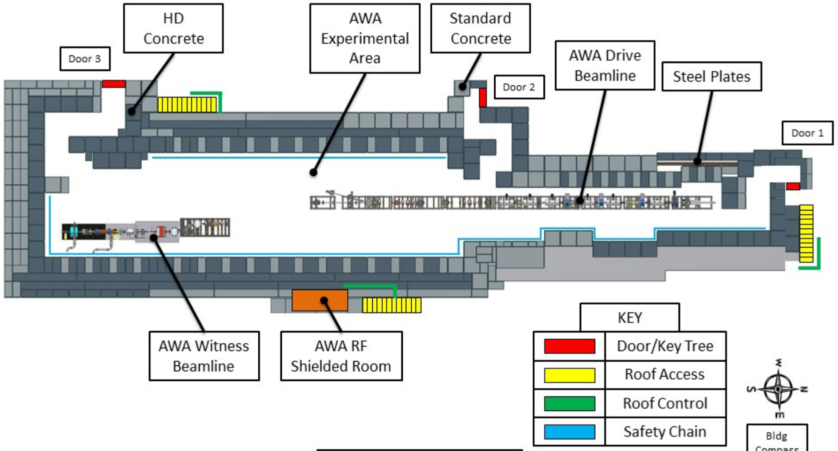


Fig. 2
AWA Beamline Schematic

- 7.5 foot thick concrete walls 3 foot thick concrete roof
- Two main electron beams
- Experimental area
- High radiation area during operations
- Radiation monitors inside and out
- Regular access requires dosimetry
- Interlocked doors and roof access

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AWA OVERVIEW

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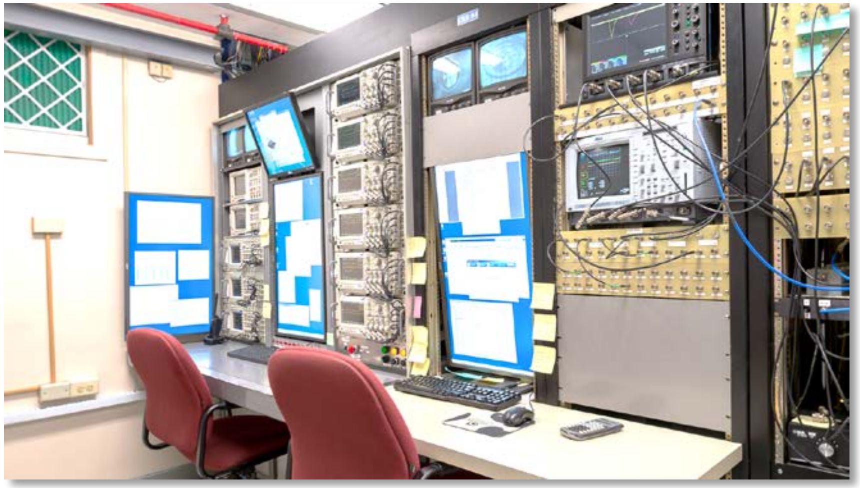

- Houses all the remote capabilities to control and monitor the RF system, electron beam parameters, magnets, power supplies, and the accelerator beamlines.
- Data acquisitions.
- Access to Laser Room
- Main keyed interlock system.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- Shielded room

- Class IV UV Laser
- Controlled Access to prevent accidental exposure
- Second emergency door
- Must have ESH 120 Laser Safety Training
- List of authorized users
- Interlocked with warning lights

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- The RF Laboratory is the preparation and testing laboratory for various components prior to installation onto the AWA accelerator beamlines.
- Photocathode Lab consists of an ultra-high vacuum deposition chamber to grow high-quantum efficiency photocathodes for the Drive RF Gun. WCD# 50518
- The Vacuum Laboratory is the location where various vacuum parts are prepared and assembled before they are installed into the AWA accelerator beamlines.
- All are controlled areas.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- Four separate RF amplifier systems supplying RF power at 1.3 GhZ to photoinjector guns and accelerating cavities. Each RF amplifier system consists of a 25 MW or a 30 MW klystron amplifier and modulator.
- RF power is delivered to components by pressurized waveguide.
- Extensive surveys by Health Physics have been done ensuring that the shielding is adequate. No known radiation above background.
- Doors, vacuum, klystron filament, and power supplies interlocked.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- Evacuates and Pressurizes waveguide to ~14 psi of SF6 to prevent arcing
- Recovery of SF6 minimizes loss
- Regular environmental reporting
- Monitored and interlocked with pressure switches and relief valves

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- Deionized water
- Bunker roof
- Shielded room

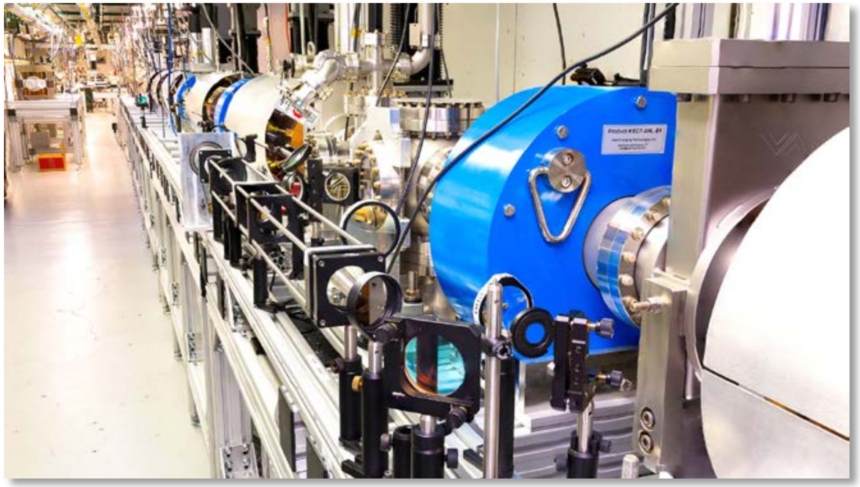
- Di Water system is an interlocked closed-loop deionized cooling water system that is used to cool solenoids, klystrons, etc.
- Bunker Roof is interlocked and has waveguide, power supplies, water lines, chillers, and other equipment.
- Shielded room is prevents EMI/RF noise for more sensitive data taking.

HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

AWA Safety Assessment Document (SAD)

Safety Assessment Document (SAD) provides hazard analysis.

- Radiation from electron beams
- Accelerator Safety Envelope
- Prompt radiation
- Activation of materials, air, and water



- Electron beams from AWA can produce large amounts of radiation. Calculations were performed in order to estimate the level of radiation that might reach the outside of the bunker during AWA operation. The results of these calculations are presented in the report “Radiological Considerations for the Argonne Wakefield Accelerator Phase II Expansion”.
- Since these initial independent calculations Health Physics has made many measurements to ensure that the AWA Safety Envelope complies with Argonne’s ALARA policy.

“Radiological Considerations for the Argonne Wakefield Accelerator Phase II Expansion”, B.J. Micklich, 19 March 2014.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

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- Accelerator Safety Envelope
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- Activation of materials, air, and water

Beamline	Drive	Witness
Charged particles	Electrons	Electrons
Energy	80 MeV	110 MeV
Average current	12 μA	0.1 μA
Repetition rate	10 Hz	10 Hz
Hours of operation	2000 Hrs/Year	2000 Hrs/Year

- All analysis on shielding and radionuclide production are based on Drive Beam parameters. These values are slightly higher than the maximum values of the parameters that the electron beams can achieve.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Safety Assessment Document (SAD)

Safety Assessment Document (SAD) provides hazard analysis.

- Radiation from electron beams
- Accelerator Safety Envelope
- Prompt radiation
- Activation of materials, air, and water

- Extensive surveys by Health Physics have been done ensuring that the shielding around the accelerator is adequate and complies with Argonne's ALARA policy.
- Passive radiation monitors are placed around the bunker and checked regularly with dosimetry. No known activation above background.
- An active radiation monitor is inside the bunker with a read-out at door #1.

HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

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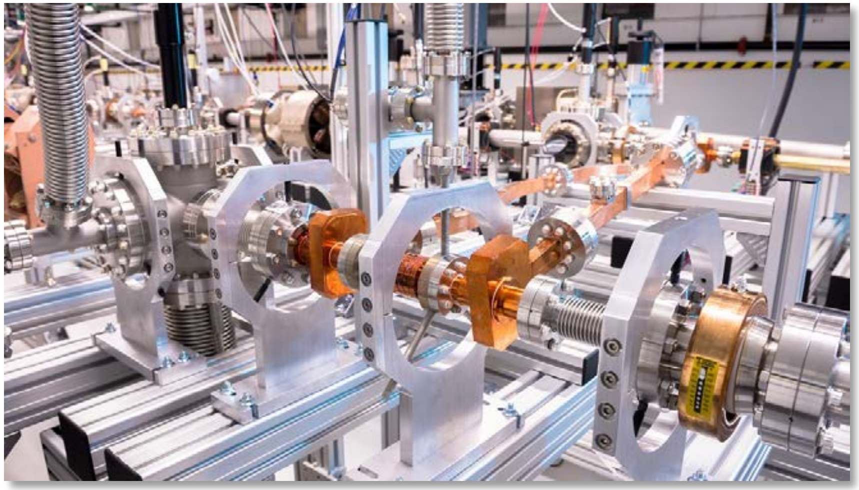
Safety Assessment Document (SAD) provides hazard analysis.

- Radiation from electron beams
- Accelerator Safety Envelope
- Prompt radiation
- Activation of materials, air, and water



- Under certain circumstances low dose activation may occur.
- Beamline components are allowed a time delay then surveyed prior to handling and surveyed by Health Physics prior to removal from the bunker.
- Air activation is mitigated by a bunker entrance time delay and the operation of air blowers to evacuate the air.
- Cooling water has shown no activation above background.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Safety Assessment Document (SAD) Hazard Analysis Summary

More Details Listed in the SAD.

Table 3.1. AWA Hazard/Safety Analysis Summary

PERSONAL SAFETY HAZARDS	MAXIMUM CONSEQUENCE(S)	MITIGATION MEANS	COMMENTS
Photocathode gun and Linac x-ray emissions, personnel exposure	minor radiation exposure	access control system, shielding, interlocks	access not normally permitted. Interlock system prevents inadvertent/ accidental access to bunker while RF is on.
Exposure of personnel to x-ray emissions from RF equipment	minor radiation exposure	access control system, lead shielding monitors, alarms, interlocks	local shielding permanently installed
Prompt neutron/gamma emission from wakefield beamlines and beam dump	severe radiation exposure	shielding, labyrinths, access control system, local component shielding, interlocks, radiation monitors	
Induced radioactivity in the accelerator, air, or shielding	minor radiation exposure	shielding, access control, interlocks, ventilation, delayed entry after beam operations	
Inadvertent entrapment of personnel within shielding	severe radiation exposure	access control system, search procedure, warning systems, manual shutdowns via safety switches, interlocks	
Electric shock/burns (primary power)	death	electrical safety program, design to codes	normal industrial/laboratory hazard
Electric shock/burns from RF power supply (high RF power and/or high DC voltages)	death	electrical safety program, design to codes access control system, RF power leak monitoring	normal industrial/laboratory hazard
Electric shock/burns from laser power supplies	death	electrical safety program, design to codes, interlocks, training	normal industrial/laboratory hazard
Excessive RF/microwave	injury	good design, operating practice, and maintenance. Monitor RF leakage. Limit access to RF supply cabinets. Interlocks.	normal industrial/laboratory hazard
Personnel exposure to laser (Class IV)	eye injury, burns	Interlocks to laser room and accelerator bunker. Use of appropriate eye protection. Adherence to laser safety rules.	normal industrial/laboratory hazard
Personnel exposure to laser gases	moderate injury	venting system for gases	not a significant threat to public or workers
Ozone generation in bunker	moderate injury	adequate ventilation in bunker; beam path length in air is minimized	not a significant threat to public or workers
Fire, ignition of combustible materials in the AWA bunker or control/laser room	significant damage, injury	control of combustibles, welding, solvents, smoking. Smoke/heat sensors, sprinkler system. Building evacuation plan.	not a significant threat to the public
Collision or hoist failure during lifting/ handling operations.	death, significant equipment damage	good design/operating procedures, follow Argonne hoisting and rigging policies, operator training	normal industrial/laboratory hazard
High pressure gas cylinder death, breach/explosion	significant equipment damage	gas cylinders secured inside gas cabinet. Follow good practice in changing gas bottles.	normal industrial/laboratory hazard
Contact with cryogenic liquids	injury	follow Argonne handling requirements	not a significant threat to public or workers
Loss of accelerator vacuum with air entry	component damage	good design, operation, fast beam abort system, interlock switches	not a significant threat to public or workers
Loss of cooling water or cooling water flow	component damage	good design, operation, instrumentation, fast beam abort system	not a significant threat to public or workers
Electric power failure	downtime	systems designed to be failsafe on loss of electric power. Emergency lighting provided in laser and control rooms and accelerator bunker.	
EMI from RF system	downtime, degraded operations and accelerator performance	adequate shielding and grounding of RF supply cabinets and control electronics	

AWA OVERVIEW

AWA Bunker Access Control

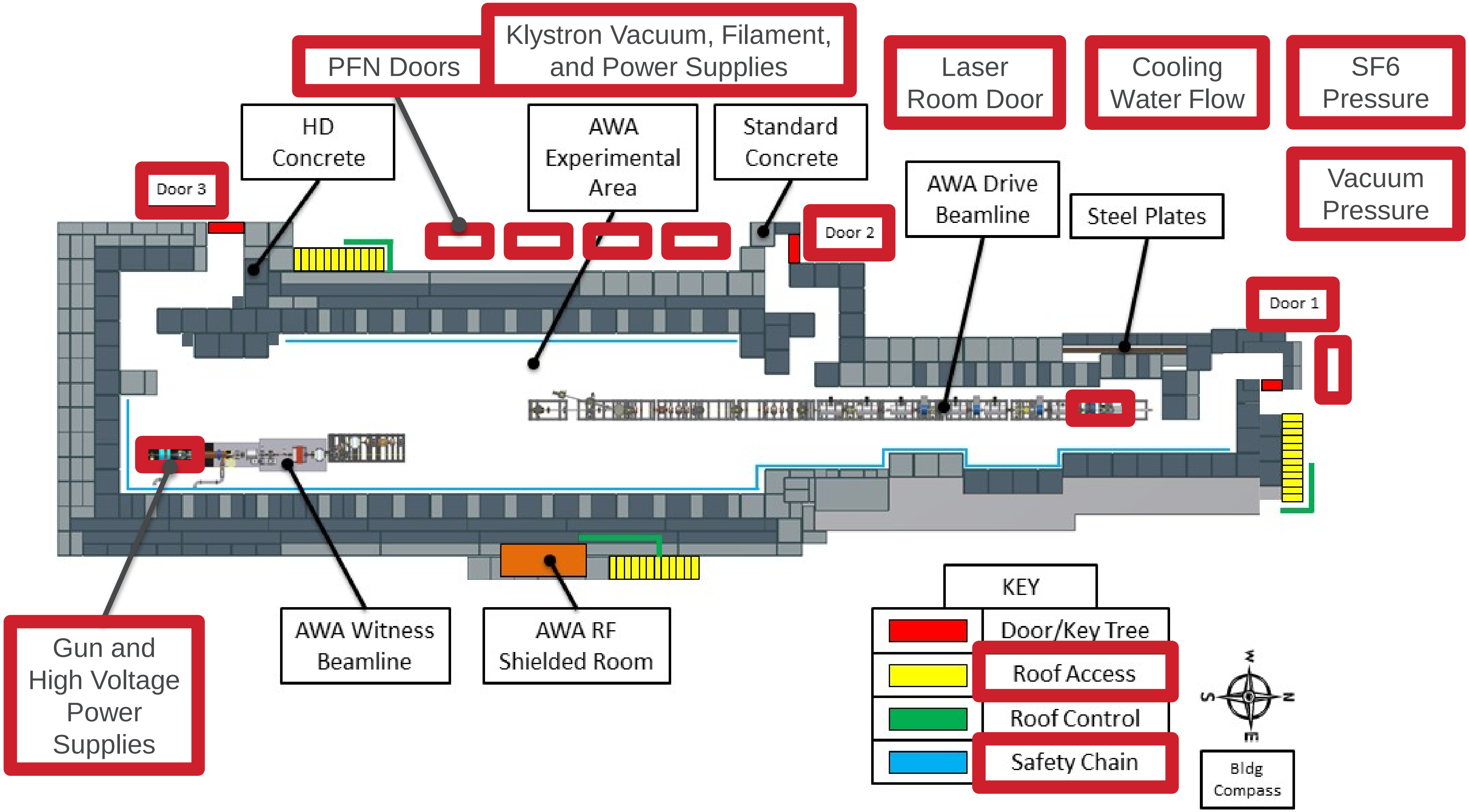
The AWA Bunker Access Control Procedure describes the procedure to search and lock the AWA bunker and its roof, and also the procedure to enter the bunker after operation of the accelerators.

- The AWA interlock system has four modes of operation: **laser mode**, **RF mode**, **beam mode** and **bunker open mode**. A switch in the control room is used to select which mode is in effect.
- These modes are to create a certain level of flexibility in the facility and yet maintain safe operations.

- A physical survey inside the bunker and on the bunker roof must be performed prior to beamline operation.
- A loud beeping sound emits during these surveys.
- The doors are locked and only after all the safety interlocks are satisfied, AND the operator key is in position, will the beamline be ready for operation.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

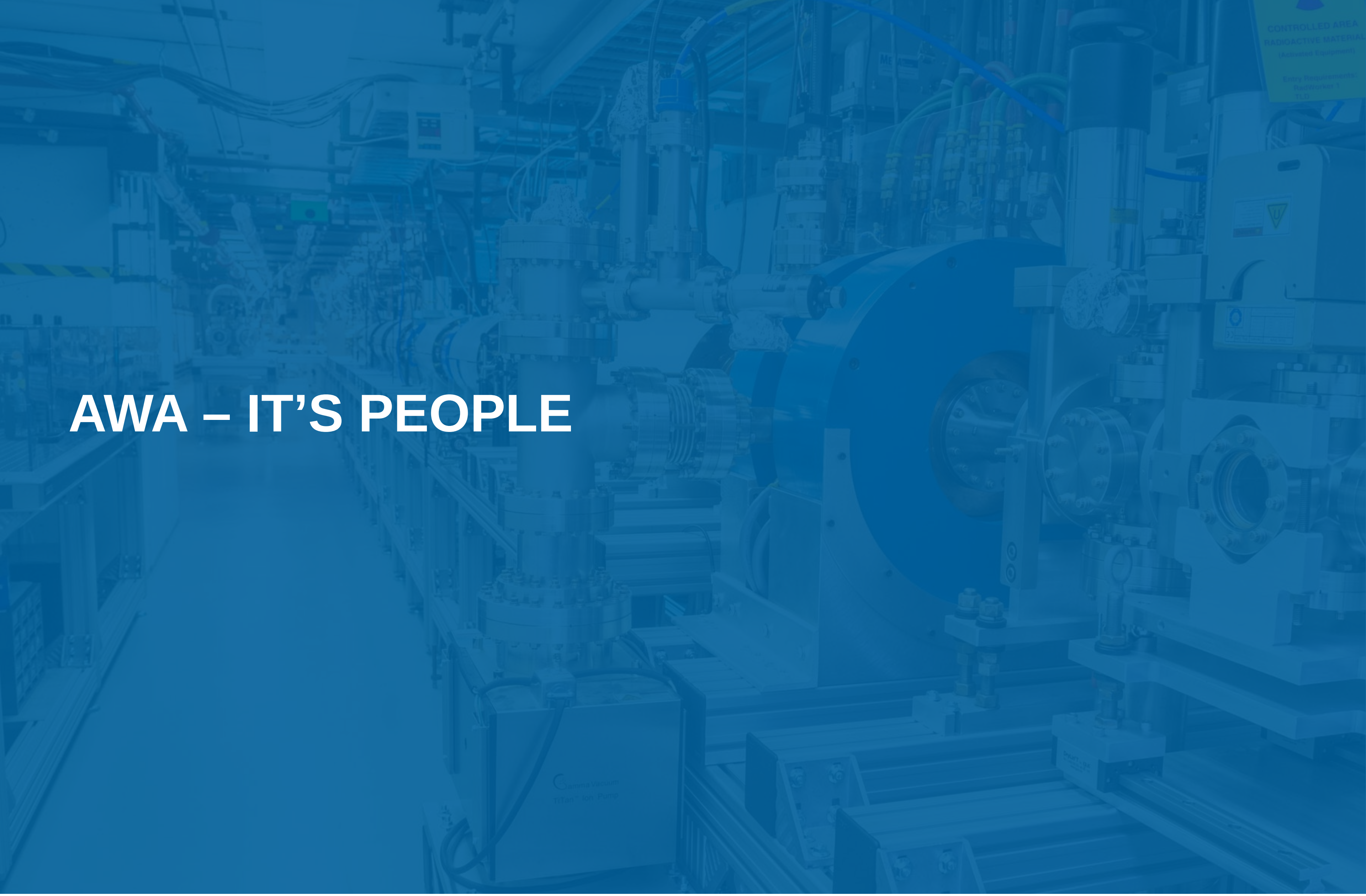
AWA Has Many Systems Working Together - Major Safety Interlocks



HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA General Hazard Mitigation – Communication is the Key

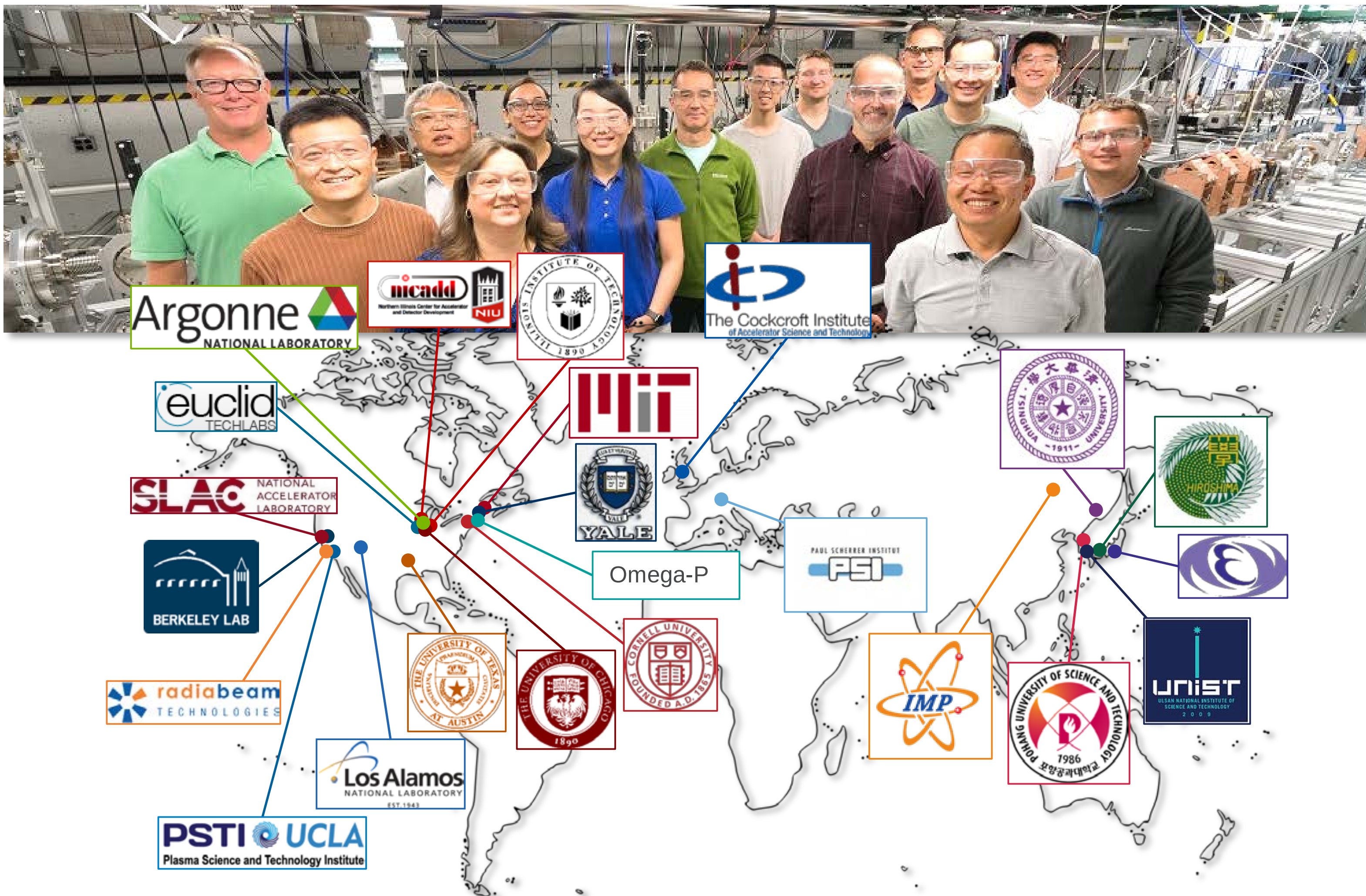
ISSUE	SOLUTIONS
With several complex systems working together, even with all of the safety measures in place, it is extremely important for the group to communicate in order to mitigate risks in our every day work. Here are some of the ways we do this.	▪ Weekly group meetings where we discuss the many facets of an upcoming experiments. ▪ Discuss in detail the specific type of work to be done; laser work, vacuum work, or electrical work, to ensure everyone is aware and are able to operate safely. ▪ We remind each other of proper PPE, training, and procedures, and ensure that our JHQ's meet the given requirements for each task. ▪ Share safety tips over email. ▪ ASRC Reviews ▪ Assistance with compliance and procedure from Leon Reed



AWA – IT'S PEOPLE

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA is part of a world wide collaborative effort.
We want AWA to be and remain a safe place for science.



HEP INDEPENDENT SAFETY REVIEW AWA OVERVIEW

AWA Staff, Collaborators, Post Docs, and Students
Our Job Hazard Questionnaire (JHQ) Drives Our Required Training

CATEGORY	REQUIREMENTS
▪ AWA Staff, Post Doc, Long term PhD Candidate Student ▪ Internal Collaborator ▪ External Collaborator, Visiting Physicist ▪ Short term Student	▪ Evaluate Roll and Project ▪ Complete JHQ ▪ Training ▪ On the Job Training ▪ Currently AWA has three staff members with QEW 2, one student with QEW 1, and seven Accelerator Operators.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Staff, Collaborators, Post Docs, and Students
Our Job Hazard Questionnaire (JHQ) Drives Our Required Training

CATEGORY	REQUIREMENTS
▪ AWA Staff, Post Doc, Long term PhD Candidate Student ▪ Internal Collaborator ▪ External Collaborator, Visiting Physicist ▪ Short term Student	▪ Internal Collaborators generally just observe and input their expertise in the control room. ▪ They usually have the requisite training from their own division and experience. ▪ Evaluate on case-by-case basis.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Staff, Collaborators, Post Docs, and Students
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CATEGORY	REQUIREMENTS
▪ AWA Staff, Post Doc, Long term PhD Candidate Student ▪ Internal Collaborator ▪ External Collaborator, Visiting Physicist ▪ Short term Student	▪ External Collaborators generally just observe and input their expertise in the control room. ▪ They are generally escorted through 366 due to the security entrance. ▪ Evaluate on case-by-case basis.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Staff, Collaborators, Post Docs, and Students
Our Job Hazard Questionnaire (JHQ) Drives Our Required Training

CATEGORY	REQUIREMENTS
▪ AWA Staff, Post Doc, Long term PhD Candidate Student ▪ Internal Collaborator ▪ External Collaborator, Visiting Physicist ▪ Short term Student	▪ Evaluate Roll and Project ▪ Complete JHQ ▪ Training ▪ Since their time here is limited, Short Term Students usually fall into a similar category as external collaborator. ▪ Evaluate on case-by-case basis.

HEP INDEPENDENT SAFETY REVIEW
AWA OVERVIEW

AWA Current Personnel
Our Job Hazard Questionnaire (JHQ) Drives Our Required Training

AWA requires more than just the standard training. Below are some specialized training and certifications for AWA Personnel.

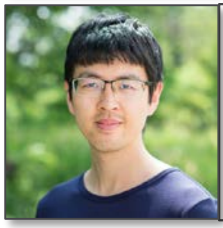
Manoel Conde
Group Leader
ANL Accelerator Safety
Accelerator Operator
Qualified Electrical Worker 2
RF and Microwave S.A.

Chunguang Jing
Resident Associate
Accelerator Worker
RF and Microwave S.A.
Radiological Worker 1
Electrical Safety Awareness

Nicole Neveu
PhD Candidate
Accelerator Worker
Radiological Worker 1
Electrical Safety Awareness
Laser Safety

John Power
Facility Manager
Laser Control Area Supervisor
Accelerator Operator
RF and Microwave S.A.

Eric Wisniewski
Resident Associate
Accelerator Operator
Safe Supervision Students
Radiological Worker 1
Argonne Pressure Systems



Lianmin Zheng
PhD Candidate
RF and Microwave S.A.
Electrical Safety Awareness

Wanming Liu
Electrical Engineer
Accelerator Operator
Qualified Electrical Worker 2
Capacitor Training
Lockout/Tagout

Jiahang Shao
Post Doc
Accelerator Operator
Radiological Worker 1
Critical Safety Awareness

Ryan Roussel
PhD Candidate
RF and Microwave S.A.
Qualified Electrical Worker 1
Capacitor Training
Argonne Pressure Systems

Scott Doran
Engineering Specialist
Accelerator Worker
Radiological Worker 1
Lockout/Tagout
Laser Safety

Gwanghui Ha
Post Doc
Accelerator Operator
Accelerator Worker
Radiological Worker 1
Laser Safety

Charles Whiteford
Accelerator Operator
Qualified Electrical Worker 2
Machine Tool
Capacitor Training
Crane Operator

AWA IS COMMITTED TO PROVIDING A SAFE WORK ENVIRONMENT

THANK YOU FOR YOUR TIME